Section 5
Summary and Findings

This Overview Report and numerous technical reports were developed for the Secretarial Determination by scientists and engineers from Federal agencies working within the Department of the Interior (DOI), the Department of Commerce (DOC), the U.S. Department of Agriculture (USDA), and the U.S. Environmental Protection Agency (USEPA). These agencies worked collaboratively with state agencies from California and Oregon through nine sub-teams of the Technical Management Team (TMT) covering broad topical areas of the Secretarial Determination process. The TMT developed and carried out scientific, engineering, and other technical studies to fill information gaps and address the four questions which inform the Klamath Secretarial Determination identified in the KHSA. These questions are: (1) Would dam removal and KBRA implementation advance salmonid fisheries and other fisheries in the Klamath Basin; (2) What would dam removal entail, what mitigation measures may be needed, and what would these actions cost; (3) What are the major potential risks and uncertainties associated with dam removal; and (4) Would dam removal and implementation of the KBRA be in the public interest?

A summary of major findings from the TMT studies (the reports of which are shown in Table 3-1), and findings from other existing reports (these reports are listed in Section 6, *References*), are summarized for these four questions in this section.

5.1 WILL DAM REMOVAL AND KBRA ADVANCE RESTORATION OF SALMONID AND OTHER FISHERIES OF THE KLAMATH BASIN OVER A 50-YEAR TIME FRAME?

Anadromous fish and other native fish populations in the Klamath Basin have declined markedly from historical levels, primarily as a result of blocked access to their historical habitat; overfishing; degraded freshwater and marine habitat; fish disease; degraded water quality (including temperature); and, altered hydrology. During the Secretarial Determination process, the TMT used a variety of analytical tools, both qualitative and quantitative, including convening a series of four expert panels, to assess the expected effects of a dams out with KBRA implementation scenario on salmonid (salmon, steelhead, and trout) and other fish populations. In general, the TMT concluded that dam removal and KBRA implementation would improve anadromous fish populations primarily by increasing access to historical habitat, restoring mainstem and tributary habitat,

and improving key biological and physical factors that heavily influence fish populations (e.g. flow conditions, bedload and sediment, transport, water quality, fish disease, toxic algal blooms, and water temperature). Table 5-1 summaries many of these key factors, as well as the certainty and uncertainty level for each.

In the short-term, reservoir drawdown associated with dam removal would result in the release of high suspended sediment concentration (SSC). Although short in duration, this suspended sediment release is expected to result in some lethal and sub-lethal effects on a portion of fish populations. In particular, steelhead trout in the mainstem Klamath River downstream of Iron Gate Dam could experience 28 percent basin-wide mortality for adults and 19 percent mortality for juveniles if dam removal occurred during a dry year (worse case scenario). The worst case basin-wide mortalities for coho and Chinook (both adults and juveniles) are all less than 10 percent. The timing of reservoir drawdown (early January through mid March) was selected to coincide with periods of naturally high SSC in the Klamath River, to which aquatic species have adapted by avoiding or tolerating. In addition, based on the distribution and life-history timing of aquatic species in the basin, only a portion of some populations are likely to be present in the mainstem Klamath River during the period of greatest SSC (January through mid March), with several species located in tributaries, further downstream where concentrations would be diluted by accretion of flows, or in the Pacific Ocean. In spite of some short-term mortalities associated with suspended sediment releases, salmon, steelhead trout and other native anadromous species are anticipated to increase in abundance and viability in the long-term under the dams out and implementation of the KBRA scenario.

The TMT performed an extensive evaluation of the feasibility of reservoir sediment removal through dredging to reduce the short-term impacts from released suspended sediment on fish downstream of Iron Gate Dam. Based on a number of factors, including the small reductions in fish mortality, the land disturbance that would occur for sediment containment structures, the potential disturbance of sensitive cultural resources, and the likely high cost, dredging reservoir bottom sediments was deemed infeasible. In lieu of dredging, mitigation measures (e.g. trapping and relocating potentially affected fish during reservoir drawdown and dam removal) were identified to minimize these effects to aquatic species.

Table 5-1: Certainty of ecological conditions affecting future salmonid (salmon, steelhead and trout) populations with dam removal and KBRA implementation

Current and Future Ecological Conditions Affecting Basin Fisheries with Dams Remaining	Anticipated Change in Ecological Function Expected with Dam Removal and KBRA	Predicted Certainty of Response or Action with Dam Removal and KBRA	Discussion
Dams block access to over 420 miles of potential salmonid habitat upstream of Iron Gate Dam.	Over 420 miles of habitat would be available to anadromous salmonids including access to cold water refugia in the upper basin and improved habitat quality from KBRA restoration actions.	Moderate to High	Quantitative modeling and multiple studies demonstrate with high certainty that additional usable stream habitat and important cold water refugia would become available; the amount of habitat used by individual species would differ. The amount of habitat used by fish could vary based on the success of KBRA implementation, representing moderate uncertainty on miles of new habitat used.
Dams diminish bedload sediment transport and gravel recruitment in the Hydroelectric Reach and downstream of Iron Gate Dam.	Reservoir removal and variable flows would improve bedload transport and gravel recruitment downstream of Iron Gate Dam.	High	Quantitative modeling and multiple studies indicate dam removal would improve stream-bed mobility and gravel transport, creating better salmonid spawning and rearing areas, and decreasing juvenile salmon disease.
Fish habitat is degraded at various locations within the Klamath Basin. Improvements in future habitat quality are uncertain, but competition for natural resources will likely place increasingly greater stress on Klamath fisheries. Tribal water rights being adjudicated in Oregon may result in greater allocation of water to support fisheries but the outcome remains uncertain.	KBRA Fisheries Program, based on the principles of adaptive management, would improve fish habitat in key areas of the basin and distribute water to support fisheries in Upper Klamath Lake and the Klamath River.	Moderate	Multiple studies demonstrate that restoring fish habitat improves fisheries; habitat restoration is a priority of the KBRA. However, specific restoration actions are not identified and some rely on private land owner cooperation to implement. Ideal flows and timing needed to enhance fish populations following dam removal are uncertain but represent an adaptive management opportunity for potentially controlling juvenile salmon disease and preventing adult die offs.
Iron Gate Hatchery provides Chinook, coho, and steelhead recruits adding to fisheries abundance. The continued operation of this conservation hatchery is certain.	Iron Gate Hatchery will likely not be used to augment Chinook, coho, or steelhead trout populations after 2028 when PacifiCorp funding for the hatchery would end.	Low to Moderate	The exact response of the ecosystem by 2028 is not certain, being dependent upon several highly variable factors (e.g. weather, flow, and ocean conditions). It is possible that an analysis of KBRA fish monitoring data may indicate the need for an extension of this hatchery's operation beyond 2028 for one or more species.
Iron Gate Hatchery dilutes natural spawning populations reducing diversity of Chinook, coho, and steelhead.	Fish diversity would increase without augmentation from the Iron Gate Hatchery and because salmonids would spawn, rear, and return to a wider geographic area.	Moderate to High	Multiple studies demonstrate hatcheries reduce the diversity of wild fish. The Trinity River Hatchery would continue production adding to a system-wide diversity reduction. There is high certainty that expanding the geographic range of fish habitat will increase their diversity.
High incidence of juvenile salmon disease below Iron Gate Dam from current flow conditions, limited bed mobility, diminished sediment transport, polychaete food supply from reservoirs, and limited salmon carcass dispersal will likely continue in some years.	Reduced juvenile salmon disease would likely occur with dam removal through a combination of increased flow variability, increased bed mobility and suspended sediment transport, and dispersal of salmon carcasses.	Moderate to High	Disease in the infectious zones below Iron Gate Dam would decrease by disrupting the life cycle requirements of the protozoan parasites through increased flow variability, bed mobility and suspended sediment transport, and dispersal of salmon carcasses. While it is possible that the current infectious nidus (reach with the highest infectivity) may move upstream where salmon spawning congregations occur, and there is associated uncertainty, the likelihood of this happening is remote.

Table 5-1 (Continued): Certainty of ecological conditions affecting future salmonid (salmon and trout) populations with dam removal and KBRA implementation

Current and Future Ecological Conditions Affecting Basin Fisheries with Dams Remaining	Anticipated Change in Ecological Function Expected with Dam Removal and KBRA	Predicted Certainty of Response or Action with Dam Removal and KBRA	Discussion
Copco 1 and Iron Gate reservoirs support the growth of toxin producing phytoplankton blooms.	Toxin producing phytoplankton blooms in Copco 1 and Iron Gate reservoirs would be eliminated.	High	Multiple literature studies indicate that reservoir removal would eliminate the production of algal toxins.
Copco 1 and Iron Gate reservoirs create unfavorable water temperatures for salmonids; warmer in late summer/fall and cooler in the spring.	Seasonal water temperature lags and dampened daily water temperature fluctuations caused by the large reservoirs would be eliminated, returning the river to a more natural condition for fish.	High	Multiple temperature modeling studies demonstrate an improvement in seasonal and daily water temperatures with dam removal.
Reservoir operations create low dissolved-oxygen concentrations just below Iron Gate Dam that are unfavorable for salmonids.	Reservoir generated low dissolved-oxygen problems just below Iron Gate Dam would be eliminated by dam removal.	High	Multiple studies and quantitative modeling demonstrate an improvement in dissolved oxygen concentrations with dam removal.
Upper basin water quality is seasonally poor in Upper Klamath Lake and Keno Impoundment.	KBRA restoration plans may improve water quality in the upper basin, benefiting resident and migrating salmonids.	Moderate	TMDL and KBRA restoration actions would improve water quality in Upper Klamath Lake and the Keno Impoundment. However, the degree of improvements and their timing are uncertain because restoration plans are yet to be developed.
J.C. Boyle, Copco 1, and Iron Gate reservoirs store both fine and coarse sediment.	There is a high degree of certainty that suspended sediment released during dam removal would produce short-term lethal conditions for some salmon and steelhead. Steelhead adults and juveniles would have the highest 1-year basin-wide mortalities (about 14 percent in median flow years). Salmon mortalities would be less than 10 percent.	High	Quantitative modeling was used to estimate impacts to adult and juvenile Chinook, coho, and steelhead. Variable flow conditions at the time of dam removal were modeled to assess the possible range of lethal conditions. A dry year would produce worst-case mortalities. Mitigation measures have been identified to reduce fisheries impacts, and could reduce actual mortalities predicted by the model.
Climate change will likely produce warmer water temperatures and earlier spring runoff. Changes in precipitation amounts may be small, but there is uncertainty in this analysis. The magnitude of future ecosystem response is uncertain but warmer water temperature would likely increase stress on fish.	There is a high degree of certainty that climate change would produce warmer water temperatures (excluding groundwater influenced areas) and earlier spring runoff. Changes in precipitation amounts may be small, but there is uncertainty in this analysis. The magnitude of future ecosystem response to climate change is uncertain but warmer water temperature would likely increase stress on fish. There is high certainty that dam removal would provide access to large cold-water refuge areas (springs and tributaries in the Hydroelectric Reach and the Upper Klamath Basin), reducing climate change impacts on migrating salmonids.	Low to High	Stream temperature modeling was used to predict effects of climate change on water temperatures and runoff, using output from a range of global circulation models (climate models). These climate models predict that future precipitation amounts could be less than or greater than current conditions, depending on the climate model. Cold water refuge areas from large natural springs and tributaries are well documented.
Hydroelectric peaking diminishes trout and benthic macroinvertebrate habitat in the Hydroelectric Reach.	Hydroelectric peaking would be eliminated.	High	Multiple studies demonstrate adverse impacts to habitat and native fish populations associated with peaking operations.
Turbine entrainment in the Hydroelectric Reach causes mortality to resident fish, including trout.	Turbine entrainment would be eliminated.	High	Multiple studies demonstrate fish mortality associated with turbine entrainment.

It is extremely difficult to predict with certainty the long-term effects of the dams in scenario on native fish populations. Although fish populations have declined markedly, it is difficult to know with certainty whether these declines have stabilized, whether further declines are likely, or whether improvements are possible owing to ongoing restoration actions. Ongoing actions include addressing water quality concerns under the Clean Water Act (nine separate TMDLs), providing Klamath River flows and Upper Klamath Lake water elevations that are protective of three ESA listed fish, and restoring fish habitat basin-wide. Moreover, it is equally difficult to predict whether climate change over the study period (2012 through 2061) would offset any gains made by these restoration actions or whether climate change impacts on water temperatures, water quality, and flows in the Klamath Basin would cause further declines in fish populations. Consequently, because of the large uncertainties, and because of the numerous offsetting factors that complicate an analysis, the TMT assumed for the purpose of this analysis that the current status of fish populations in the Klamath Basin would continue into the future if dams remain and KBRA was not implemented.

In contrast to dams remain, the short-term and long-term effects (both positive and negative) of dam removal and implementation of KBRA are expected to be relatively large for some fish populations. Overall, the long-term effects of dam removal and implementation of KBRA are expected to advance salmonid fisheries. Summaries of the potential effects of dam removal and KBRA implementation on selected fish populations, and the associated levels of uncertainty, are provided in Table 5-2.

Table 5-2: Species Specific Response and Certainty to Dam Removal and KBRA Implementation

Species	Benefits of Dam Removal and KBRA
Chinook Salmon	There is a high degree of certainty, based on available science (and the lack of contrary studies), that in the long-term Klamath dam removal would expand usable habitat for Chinook salmon and would significantly increase their abundance as compared to leaving dams in place (Oosterhout, 2005; Huntington 2006; FERC 2007; Hetrick et al. 2009; Goodman et al. 2011; Hamilton et al. 2011; Hendrix 2011; and Lindley and Davis 2011). Researchers, however, differ on the likely range of this response based on differing assumptions about the amount and quality of useable habitat above Keno Dam, the abundance and productivity of spring Chinook salmon, how effectively KBRA would be implemented, and the likely trajectory of Chinook salmon if dams were left in place. Modeling results from 2033 through 2061 indicate, with a greater than 95 percent level of certainty, that dam removal and KBRA implementation would increase median Chinook adult production by 81 percent. Annual median increases in production, however, varied considerably among years. For the period 2033 through 2061, corresponding to the period after dam removal and after the effects of Iron Gate Hatchery releases, annual median increase in production ranged from 50 to 189 percent. Chinook salmon harvests would also increase in this period, with median increases of 55 percent for tribal harvest, 46 percent for ocean commercial and sport fisheries harvest, and 9 percent for the river sport fishery harvest. Model results demonstrated that fisheries harvest would vary from year to year, but would always be greater with dam removal and KBRA than with the dams remaining scenario.
Coho Salmon	There is a high degree of certainty, based on available science (and the lack of contrary studies), that coho salmon would benefit from dam removal and implementation of KBRA by restoring fish access to approximately 76 additional miles of historical habitat (main stem river and tributaries) above Iron Gate Dam (NRC 2004; FERC 2007; Dunne et al. 2011; and Hamilton et al. 2011). There are uncertainties associated with the magnitude of population increases, the level of response possible with effective implementation of KBRA, and the magnitude in reduction of juvenile coho disease below Iron Gate Dam if dams were removed. There is a high degree of certainty that KBRA and dam removal would help reduce the future risk of coho salmon extirpation from the Klamath Basin.

Table 5-2: Species Specific Response and Certainty to Dam Removal and KBRA Implementation

Species	Benefits of Dam Removal and KBRA
Steelhead	There is a high degree of certainty, based on available science (and the lack of contrary conclusions), that dam removal and implementation of KBRA would benefit steelhead trout by recolonizing historical habitat upstream of Iron Gate Dam (Fortune et al. 1966; Chapman 1981; Huntington 2006; FERC 2007; Dunne et al. 2011; Hetrick et al. 2009; and Hamilton et al. 2011). Several factors point to a high degree of recolonization certainty for steelhead. These factors include: steelhead are genetically resistant to the juvenile fish disease *C. Shasta,* they are relatively tolerant of warmer water temperatures, their life-history strategy does not include "spawn and die" increasing their opportunity of utilizing all of the reopened historical habitat, and a similar species (resident redband/rainbow trout) are doing well in the upper basin (Hetrick et al. 2009; Hamilton et al. 2011; Huntington 2006). There are uncertainties associated with the magnitude of the likely increases. Dunne et al. (2011) was optimistic that dam removal coupled with an effective implementation of KBRA would increase their abundance and distribution compared to current conditions. The degree of success would center on how well KBRA was implemented, to what degree poor summer and fall water quality conditions affected their migration, and their competing interactions with resident redband/rainbow trout.
Redband/ Rainbow Trout	Available literature indicates, with a moderate amount of certainty, that dam removal would substantially increase high-quality, contiguous redband and rainbow trout habitat below Keno Dam and through the Hydroelectric Reach, increasing their abundance (Hamilton et al. 2011; Buchanan et al. 2011). Trout are currently abundant in parts of this reach, and would do better in the absence of entrainment into turbines and in reaches currently subjected to hydroelectric peaking flows. Existing redband trout and colonizing anadromous steelhead are expected to co-exist, as they do in other watersheds, although there may be shifts in abundance related to competition for space and food. Resident trout above Keno Dam may also increase in abundance because of KBRA restoration actions, including improvements in water quality, water quantity, and the riparian corridor. The magnitude of this response has a significant amount of uncertainty because details of KBRA have not been defined. Past restoration efforts above Upper Klamath Lake have demonstrated benefits to resident trout and if these types of action are repeated and expanded under KBRA they would be expected to increase resident trout habitat and abundance.
Pacific Lamprey	The response of Pacific lamprey to dam removal and implementation of KBRA is inherently uncertain largely because these species are not well studied, their habitat requirements and historical distribution are not well known, and their life cycle is complex. Close et al. (2011) examined the available lamprey information and concluded that relatively small increases in production were possible for Pacific lamprey (1 to 10 percent). The process of recolonization upstream of Iron Gate Dam could take decades, but this timeframe is uncertain.
Lost River and Shortnose Suckers	Dam removal itself would have little appreciable effect on Federally listed suckers. However, implementation of KBRA, including greater in-stream flows above Upper Klamath Lake, improvements in near-shore water quality in Upper Klamath Lake, and restoration of degraded riparian corridors, may improve conditions for these endangered species (Buchanan et al. 2011). The magnitude of beneficial effects on sucker abundance has a high degree of uncertainty partly because of the current lack of specificity of KBRA restoration actions and partly because factors contributing to their endangered status are not fully understood. The expert panel covering suckers (Buchanan et al. 2011) concluded that dam removal and implementation of KBRA "provides greater promise [than leaving dams in place] for preventing extinction of these species and for increasing overall population abundance and productivity."
Eulachon	Dam removal and KBRA implementation will have an uncertain effect on eulachon in the Klamath Estuary. Eulachon were historically abundant, but currently are rarely observed in the Lower Klamath River and Estuary. There are few to no studies on eulachon life history in the Klamath Estuary or causation behind their declines. It is anticipated that habitat restoration efforts under KBRA and water quality improvements could directly contribute to recovery of any remnant eulachon populations in the estuary but the degree of their recovery and timing is highly uncertain.
Green Sturgeon	Dam removal and KBRA implementation will have an uncertain effect on green sturgeon in the lower 67 miles of the Klamath River. Little is known about their presence and abundance in the Klamath River. Dam removal and KBRA implementation would return the Klamath River water temperatures and flow regime to a condition that more closely mimics historical patterns; however, these flow and temperature changes would be relatively small in the reach of the river used by green sturgeon. Overall, dam removal and KBRA actions would be expected to accelerate TMDL water quality benefits for this species, including the elimination of algal toxins produced in the Hydroelectric Reach reservoirs. The benefit to green sturgeon populations from these water quality improvements is uncertain.

5.2 WHAT WOULD DAM REMOVAL ENTAIL, WHAT MITIGATION MEASURES MAY BE NEEDED, AND WHAT WOULD THESE ACTIONS COST?

The TMT developed a detailed deconstruction plan, titled *Detailed Plan for Dam Removal – Klamath River Dams* (Reclamation 2012e). This plan largely integrated requirements in the KHSA for continued hydroelectric operations through 2019; considered the full range of flow conditions that could be encountered during dam removal; and considered the unique features of each dam and reservoir.

Reservoir drawdown and removal of the Four Facilities was designed with the goals of minimizing impacts on fish species and protecting threatened coho salmon. These goals resulted in the formation of a plan that calls for drawdown of the three larger reservoirs at a rate of 1 to 3 feet per day in the winter of a single year (2020). The plan maximizes the likelihood that the majority of reservoir sediments are transported downstream in January through March 15 when coho salmon, along with several other native fish species, are not present in large numbers in the mainstem of the Klamath River. This time period also corresponds to higher river flows needed to erode and transport the fine-grained reservoir sediments to the Pacific Ocean.

The dam embankments and structures would be removed over the remainder of 2020, taking into account river hydrology and safety considerations. Primary among these factors is the removal of the Iron Gate Dam embankment starting in June, after the spring runoff, when flows in the Klamath River are significantly reduced and, thereby providing protection against the risk of embankment overtopping during dam deconstruction.

After reservoir drawdown in early 2020, the dam removal entity (DRE) would undertake revegetation efforts in the spring and again in the fall with the goal of establishing sustainable riparian, wetland, and upland habitats on the newly exposed reservoir bottoms as early as feasible. Hydroseeding would be employed with a mixture of native grasses; riparian and wetland areas would be planted with native plants as well.

As described previously, the TMT also evaluated partial removal of the Four Facilities to achieve a free flowing river. Partial facilities removal would remove most features of the Four Facilities while some other features (e.g. pipelines, penstocks, and powerhouses) would remain in place. Leaving certain features of the Four Facilities in place would result in the same short-term and long-term effects on the aquatic environment as full facility removal but would require long-term maintenance costs (primarily to limit public access for safety) while reducing construction and mitigation costs.

The removal of Iron Gate Dam would compromise the existing water supply pipeline to the City of Yreka, CA. Under terms of the KHSA, the DRE would modify the pipeline to allow continued water supply service to the City of Yreka. Preliminary designs for an elevated pipeline and steel pipeline bridge, as well as modifications to the water supply intake at Fall Creek, were prepared in order to

estimate costs. If dam removal proceeds, final designs for the City of Yreka pipeline would be prepared in consultation with the city.

5.2.1 Mitigation Measures

Table 5-3 lists several mitigation measures that were identified to help reduce the effects of dam removal. Additional mitigation measures may be identified at a later date in a "Definite Plan" for dam removal if there is an Affirmative Secretarial Determination, which could change the estimated cost of dam removal.

Table 5-3: Dam Removal Mitigation Measures

Mitigation Measure	Action of the DRE
Aquatic Species Relocation	Capture out-migrating juvenile salmonids and Pacific lamprey from several tributaries and release them at other locations to avoid the effects of high SSC. Mussels in the Hydroelectric Reach and in the lower Klamath River downstream of Iron Gate Dam would be relocated to tributary streams or upstream of J.C. Boyle Reservoir. Endangered suckers found in reservoirs would be captured and released into the upper basin.
Protection of Downstream Water Intakes	Modify water intake and pump sites in the lower Klamath River to reduce the temporary effects of high SSC from dam removal.
Protection of Culturally Significant Sites	Protect historic and prehistoric cultural sites eligible for inclusion on the National Register of Historic Places and California and/or Oregon Registers. Protect tribal artifacts and grave sites, if encountered, from theft, vandalism and construction activities.
New or Modified Recreation Facilities	Identify new recreational facilities and river access points to replace facilities removed with the dams and reservoirs. Coordinate with stakeholders during planning.
Bridge and Culvert Relocation	Replace or relocated the Jenny Creek Bridge (Iron Gate Reservoir) and some culvert crossings along Copco Road that could be compromised by reservoir removal.
Bat Habitat Replacement	Construct bat habitat near each dam site to replace habitat lost by removing the structures associated with the Four Facilities.
Replace or Deepen Groundwater Wells	Deepen or replace groundwater wells to restore production rates affected by groundwater level declines around Copco 1 and Iron Gate reservoirs due to facility removal.
Reservoir Bottom (Parcel B Land) Fencing	Install fencing around newly exposed reservoir bottoms to protect revegetation and restoration efforts.
Replace Lost Wetlands	Mitigate or replace wetlands associated with construction activities, estimated at less than 20 total acres.
Changes in the 100-year Floodplain Downstream of Iron Gate Dam (River Miles 190-172)	Work with willing land owners to flood-proof, relocate, or protect against the increase in flood risk at affected structures (estimated to be less than six residences). The 100-year flood peak discharge just downstream of Iron Gate Dam would increase about seven percent if dams were removed.
Flood Warning System	Inform FEMA of a planned major hydraulic change to the Klamath River that could affect the 100-year floodplain. Inform the National Weather Service's River Forecast Center of the potential change in the system so they could develop new flood-routing models for their flood-warning system.

5.2.2 Estimated Dam Removal Costs

Table 5-4 presents a summary of the total costs for the full facilities removal scenario including mitigation measures. The most probable cost is estimated at $291.6 million (2020 dollars). The partial facilities removal scenario was estimated to be $234.6 million, with an additional life cycle cost (annual maintenance through 2061) of $12.4 million (2020 dollars) (See Table 5-5).

A Monte Carlo-based simulation process was used to determine the one percent probability minimum and maximum cost ranges shown in Tables 5-4 and 5-5. The Monte Carlo-based simulation is a problem-solving technique used to approximate the probability of certain outcomes by running multiple trials using random variable simulations. It is based on a computerized mathematical technique that accounts for risk in quantitative analysis and decision-making.

Table 5-4: Summary of Costs for Full Removal of all Four Facilities (2020 dollars)

	Forecast Range		
	Minimum (Less than a 1% Chance the Actual Cost will be Below this Estimate)	**Maximum (Less than a 1% Chance the Actual Cost will be Above this Estimate)**	**Most Probable[1]**
Dam Facilities Removal			76,618,994
Reservoir Restoration			21,728,000
Recreational Facilities Removal			797,305
Yreka Water Supply Modifications			1,765,910
Mobilization and Contingencies[2]			50,728,393
Escalation to January 2020			36,461,398
Subtotal (Field Costs)	**157,600,000**	**301,200,000**	**188,100,000**
Engineering (20%)[3]			37,600,000
Mitigation (35%)[4]			65,900,000
Total Construction Cost	**238,000,000**	**493,100,000**	**291,600,000**

1 The most probable costs were used in the economic analysis.
2 Mobilization and contingencies includes the mobilization of construction equipment to the dam site, design and construction contingencies.
3 Engineering costs include design data, engineering designs, permitting, procurement, construction management, and closeout activities.
4 Mitigation includes environmental mitigation, monitoring, and cultural resources protection or preservation.

Table 5-5: Summary of Costs for Partial Removal of all Four Facilities (2020 dollars)

	Forecast Range		
	Minimum (Less than a 1% Chance the Actual Cost will be Below this Estimate)	**Maximum (Less than a 1% Chance the Actual Cost will be Above this Estimate)**	**Most Probable[1]**
Dam Facilities Removal			52,096,172
Reservoir Restoration			21,728,000
Recreational Facilities Removal			797,305
Yreka Water Supply Modifications			1,765,910
Mobilization and Contingencies[2]			38,830,385
Escalation to January 2020			27,582,228
Subtotal (Field Costs)	**116,600,000**	**230,200,000**	**142,800,000**
Engineering (20%)[3]			28,400,000
Mitigation (45%)[4]			63,400,000
Total Construction Cost	**185,100,000**	**403,600,000**	**234,600,000**
Total Life Cycle Cost[5]	**9,000,000**	**26,800,000**	**12,350,000**

1 The most probable costs were used in the economic analysis.
2 Mobilization and contingencies includes the mobilization of construction equipment to the dam site, design and construction contingencies.
3 Engineering costs include design data, engineering designs, permitting, procurement, construction management, and closeout activities.
4 Mitigation includes environmental mitigation, monitoring, and cultural resources protection or preservation.
5 Life cycle costs are the long-term cost of ownership over a defined period of time (50 years).

The states of Oregon and California collectively agreed to fund dam removal at a cost of up to $450 million (2020 dollars) as defined in the KHSA. Of this amount, PacifiCorp customers in Oregon and California would pay $200 million of this amount via a surcharge. The most probable cost estimates for full and partial facilities removal fall beneath this $450 million cost cap. The maximum (one percent probability) projected cost for full facilities removal would exceed the cost cap by $43 million (total $493 million) (2020 dollars), and would trigger a meet and confer process among the KHSA parties (as defined in the KHSA) to either reduce costs or identify additional funding.

5.3 WHAT ARE THE MAJOR POTENTIAL RISKS AND UNCERTAINTITIES ASSOCIATED WITH DAM REMOVAL?

The removal of large dams involves inherent risks and uncertainties. Through development of the Detailed Plan (Reclamation 2012e) and other studies, the TMT identified four primary areas that the Dam Removal Entity (DRE) should focus upon when developing and executing a Definite Plan (as defined in Section 7.2 of the KHSA) for Klamath dam removal if there is an Affirmative Secretarial Determination. A Definite Plan would build upon the Detailed Plan, providing refinements and additional details regarding facilities removal tasks, cost estimates, scheduling, construction management, mitigation planning, and information necessary for obtaining permits and other authorizations needed for dam removal. A Definite Plan would also focus on reducing uncertainties and minimizing risks. Many dam removal uncertainties and risks have been described elsewhere in this Overview Report; the ones below warrant some additional focus and evaluation if a Definite Plan for dam removal is prepared.

5.3.1 Effects to Aquatic Species and Fisheries from Extended Downstream Sediment Transport

Downstream sediment transport could result in risks to aquatic resources beyond those already anticipated (see Section 5.1, *Will Dam Removal and KBRA Advance Restoration of Salmonid and Other Fisheries of the Klamath Basin over a 50-Year Time Frame?*), if mitigation, engineering and/or technical difficulties during dam removal extend the reservoir drawdown period. If the planned timeline for reservoir drawdown (January through February) is not achieved, aquatic species would be exposed to high SSC potentially extending into critical fish migratory and rearing periods or into a second year. Extended exposure to SSC could negatively affect fish in consecutive year classes and could have corresponding effects on commercial, tribal, and recreational fisheries.

Due to the uncertainty regarding the length of time over which high SSC would occur if a problem arose during dam removal, the exact effects on aquatic resources and on basin fisheries is not known. To reduce this uncertainty, the Definite Plan for dam removal (to be developed in the case of an Affirmative Determination) would place an emphasis on provisions, planning, and extensive preparation to ensure high SSC associated with reservoir drawdown would not extend past March 15. A particular focus for the Definite Plan would be ensuring that all old diversion tunnels and bypasses could be successfully

reopened on January 1, 2020 in order to begin reservoir drawdown. Aquatic species relocation mitigation measures (briefly described in Table 5.2) could be expanded or lengthened to remove fish from effects of high SSC if it extends beyond March 15.

5.3.2 Cost Exceedence to a Federal DRE

The large and complex construction activities associated with removal of the Four Facilities have the potential to include unexpected changes or unforeseen events, which could result in project costs greater than those originally estimated. Also, project challenges could impede the dam removal process or extend the project timeline, and could result in the accrual of additional project costs.

Risk to a Federal DRE would occur during facilities removal if the DRE anticipated exceeding the state cost cap for dam removal but was unable to stop a portion of facilities removal due to safety considerations. For example, Iron Gate Dam must be completely removed in the dry summer months once removal activity commences and could not be delayed through a winter season and risk overtopping. Under these conditions, the Federal DRE could be incurring dam removal expenses without a known source of funding. As stated in the KHSA, the Federal government is not responsible for any dam removal costs. To reduce this potential risk, the DRE construction management team would utilize construction cost forecasting continuously during facilities removal to determine early whether cost overruns were likely and to give the signatories to the KHSA time to address funding issues in a timely manner.

5.3.3 Short-term Flooding

There is a remote risk that the earthen embankment structures at J.C. Boyle and Iron Gate dams could fail during reservoir drawdown and dam removal. Flooding risks during dam removal are associated with initial reservoir drawdown and dam excavation at either Iron Gate or J.C. Boyle dams stemming from (1) an overly rapid drawdown rate resulting in embankment instability and failure, or slumping of the exposed dam face; or (2) the possibility of flows from a large event exceeding the available water bypass capacity and overtopping the earthen dam embankment during dam removal. It is important to note that the Four Facilities also have a small risk of failure if left in place. The TMT did not assess whether the risk of catastrophic failure during dam removal would be greater or less than leaving the dams in place through 2061.

To address these risks the *Detailed Plan for Dam Removal - Klamath River Dams* (Reclamation 2012e) specifies that the embankment sections at Iron Gate and J.C. Boyle dams be removed beginning June 1, 2020, with the full removal completed by September 15, 2020. This period corresponds to the lowest river flows and would allow for the construction of coffer diversion dams to route flows around the earthen embankments greatly reducing the risk of overtopping. The *Detailed Plan for Dam Removal- Klamath River Dams* also specifies the maximum reservoir drawdown rates (1 to 3 feet per day) to reduce the chance of embankment failure; drawdown rates are subject to confirmation by additional slope stability analysis conducted for a Definite Plan.

5.3.4 Cultural and Historic Resources

Dam removal and reservoir drawdown could affect known historic and prehistoric properties and cultural resource and human burial sites listed or potentially eligible for listing on the National Register for Historic Places. Areas where these sites could be affected include the construction footprint around the Four Facilities and reservoir drawdown zones, and along the edges of the Klamath River between J.C. Boyle Dam downstream to the confluence with Shasta River. Anticipated impacts include damage from construction activities; erosion and exposure from reservoir drawdown; damage from river erosion; and potential vandalism and theft of exposed cultural and historic resources. Numerous prehistoric sites and historic properties have been identified beneath the reservoirs or within the footprint of the dam removal activities. Dam removal and reservoir drawdown could affect these sites as well as other unknown sites. Additional identification efforts, effects assessments, and potential mitigation measures would be addressed through additional NHPA Section 106 consultations if there was an Affirmative Secretarial Determination.

Encountering human remains, cultural, or historic resources could affect the timeline and cost of dam removal. The Definite Plan should include detailed contingency planning and extensive preparations for the possibility of encountering any of these sites during dam removal.

5.4 IS FACILITIES REMOVAL IN THE PUBLIC INTEREST, WHICH INCLUDES, BUT IS NOT LIMITED TO, CONSIDERATION OF POTENTIAL IMPACTS ON AFFECTED LOCAL COMMUNITIES AND TRIBES?

Dam removal and KBRA implementation would provide substantial social and economic benefits to the Klamath Basin. However, dam removal would also alter or change the availability or quality of some resources and would negatively affect specific recreational resources, localized jobs, and real estate values closely associated with the dams and reservoirs. Provided below is a summary of the potential effects of dam removal and KBRA implementation on national, regional, tribal, and local communities, including economic and non-economic effects.

5.4.1 Summary of Effects to National Economic Development (NED)

The National Economic Development (NED) analysis measures the beneficial and adverse monetary effects (i.e., economic benefits and costs) of the dam removal and KBRA scenario (which can also be assumed to include partial facilities removal) in terms of changes in the net economic value of the national output of goods and services. The period of economic analysis is 50 years, beginning in year 2012 with the first KBRA activity, and continuing through 2061. All benefits and costs were discounted back to year 2012 using the 2011 Federal water resources planning rate of 4.125 percent.

Economic benefits were quantified and are provided below for the following categories.

Commercial fishing – The Four Facilities affect stocks of SONCC coho salmon ESU and Klamath River fall- and spring-run Chinook salmon. Troll harvest of Klamath Chinook salmon is expected to increase by an average 43 percent (2012 to 2061 time period)[1] with dam removal. Annual net revenue associated with total Chinook salmon harvest (all stocks) would increase under dam removal. The difference in annual net revenue between the dam removal and dams remain scenarios would be an increase of $7.296 million (2012 dollars) or a total of $134.5 million for the 50-year period of analysis. Under dam removal, coho retention (capture and keep of the fish) would likely continue to be prohibited in the California and Oregon south of Cape Falcon and is not projected to result in additional economic output.

In-river sport fishing – The Four Facilities affect stocks for in-river recreational fisheries, including salmon, steelhead and redband trout, and the recreational sucker fishery (which has been closed since 1987). In-river recreational harvest of Klamath Chinook salmon is expected to increase by 8 percent (2012 to 2061 time period)[1]. Annual net economic value would increase by $126,000 per year (2012 dollars) for a total value of $1.75 million (2012 dollars) for the 50-year period of analysis. The recreational sucker fishery is not projected to recover in the period of analysis for a recreational fishery for either the dams remain or dam removal scenarios and thus would not result in additional economic output. The in-river sport fishing economic value of the steelhead and redband/rainbow trout fisheries was not quantified but is projected to increase. Consequently, the total in-river sport fisheries economic value with dam removal is likely underestimated.

Ocean sport fishing - The Four Facilities affect stocks of SONCC coho salmon ESU and Klamath River fall- and spring-run Chinook salmon. The ocean recreational harvest of Klamath Chinook salmon is expected to increase by 43 percent (2012 to 2061 time period) [1] under dam removal. The average annual increase in net economic value under a dams out scenario is $2.744 million (2012 dollars) for a discounted present value of $50.5 million (2012 dollars) for the 50-year period of analysis. Regulations restricting recreational coho salmon fishery in California and Oregon are assumed to continue over the period of analysis under both the dams remain or dam removal scenarios and are not projected to result in additional economic output.

Irrigated agriculture – Increased water supplies during dry and drought years under the dam removal and KBRA implementation scenario would increase gross farm revenues from irrigated agriculture, which would result in economic benefits in about one out of every 10 years. The difference in net revenue for irrigated agriculture between the dam removal and dams remain scenarios

[1] These values include on average the improvement to the fisheries that would occur from 2012 to 2020 prior to dam removal with the implementation of the KBRA measures. These averages would have been larger, as reflected in Section 5.1, if only the 42-year period following dam removal was used.

would be an increase of $29.89 million (2012 dollars) over the 50-year period of analysis.

Refuge recreation – Dam removal and KBRA implementation is projected to increase waterfowl abundance at refuges and hunting trips to the refuges. Increased hunting trips would result in increased economic value related to waterfowl hunting activities. The difference in the value of net revenue between the dam removal and dams remain scenarios would be an increase of $4.3 million (2012 dollars) over the 50-year period of analysis. Refuge wildlife viewing was not quantified, but is projected to increase. Consequently, the total economic value of refuge recreation under a dams out and KBRA scenario are likely underestimated.

Nonuse values – Nonuse values were estimated using a stated preference (SP) survey. The survey collected information from households in three strata: the 12-County Klamath Area; the rest of Oregon and California; and the rest of the nation. Through their stated willingness to pay for specific scenarios for ecosystem restoration within the Klamath Basin, survey respondents indicated they placed significant value on the KBRA, KHSA, and restoration of Klamath Basin resources. Overall, the study results indicated that the majority of respondents in all three strata are concerned about declines of Chinook salmon and steelhead trout that return to the Klamath River and the potential extinction of fish species in the Klamath Basin. And they agree that restoration should be guided by an action plan that includes Klamath dam removal, water sharing agreements, and basin restoration. Using a conservative methodology for determining the nonuse value associated with Klamath dam removal and restoration of Klamath Basin resources by isolating the potential extinction of coho salmon, the survey identified $15.6 billion in nonuse benefits for the nation.

Table 5-6 summarizes estimated economic benefits for the above categories. The NED analysis compares economic benefits and costs of the dam removal with KBRA implementation scenario with the dams remain without the KBRA scenario. Costs include construction costs related to dam removal, site mitigation, and KBRA implementation. In addition to costs incurred from dam removal, there would be some costs savings related to lowered operation, maintenance and replacement (OM&R) costs of the Four Facilities following dam removal. Some economic benefits, including in-river steelhead fishing, redband trout fishing, and refuge wildlife viewing could not be readily quantified and monetized because sufficient data for an analysis was not available. Improved Klamath Basin fisheries would also provide benefits that cannot be quantified to Indian tribes because of the expansive and integral value of fish to tribal members and tribal culture. Given the positive effects of dam removal on fishery resources and refuge recreation, it is expected that tribal benefits associated with these categories would also be positive.

Table 5-6: Total Net Benefits and Costs Summary for Dam Removal (Full Facilities Removal) and Implementation of the KBRA

Benefit and Foregone Benefit Categories	Period of Analysis (2012-2061) Discounted Value – Difference between Dams Out and Dams In ($ millions; 2012 dollars)
Commercial Fishing (Klamath Chinook Salmon Harvest)	134.5
In-River Sport Fishing (Chinook Salmon Fishery)	1.8
Ocean Sport Fishing	50.5
Irrigated Agriculture	29.9
Refuge Recreation	4.3
Hydropower (foregone)	-1,320.1
Whitewater Boating (foregone)	-6.0
Reservoir Recreation (foregone)	-35.4
Nonuse Values	
12-County Klamath Area in OR and CA	
Total Nonuse Value	67.0
Total Economic Value	217.0
Rest of OR and CA	
Total Nonuse Value	2,091.0
Total Economic Value	9,071.0
Rest of the U.S.	
Total Nonuse Value	13,487.0
Total Economic Value	74,983.0
Unquantified Benefits	
Tribal Commercial Fisheries	Insufficient data to quantify benefits.
Tribal Cultural Values (including ceremonial and subsistence uses)	Applying a traditional economic framework is not appropriate.
In-river Steelhead and Redband Trout Sport Fishing	Insufficient data to quantify benefits
Refuge Wildlife Viewing	Insufficient data to quantify benefits
Cost Categories (Total Quantified Costs)	**Period of Analysis (2012-2061) Discounted Value – Difference between Dams Out and Dams In ($ millions; 2012 dollars)**
KBRA Restoration	474.1
Facility Removal	129.1
Site Mitigation	37.7
OM&R (cost savings)	-188.9
Unquantified Costs	
Real Estate Values	Insufficient data to quantify costs
Hydropower Ancillary Services	Explicit consideration of ancillary services was outside the scope of this analysis.
Regional Powerplant Emissions	The hydropower analysis described in this document does not fully consider the effect, if any, of changing hydropower production levels on system-wide powerplant emissions or regional air quality.

Dam removal would also result in some foregone benefits which occur when the dam removal scenario provides fewer benefits than the dams remain scenario. Foregone benefits occur in the following categories:

- **Hydropower** – The Four Facilities would generate an average of 895,847 megawatt hours of electricity annually over the period 2012-2061 if the existing dams were left in place and planned efficiency upgrades were completed. Under the dams out scenario, the Four Facilities would operate normally during 2012–2019 (8 years). After this time period, the production of electrical energy at the Four Facilities would be zero from January 1, 2020

through the end of 2061 (42 years). Under a dams out scenario, the estimated mean present value of hydropower economic benefits was approximately $289.2 million (2012 dollars), over the 50-year period of analysis. Relative to the dams remain scenario, this represents a mean reduction in economic benefits from hydropower of approximately $1.32 billion (2012 dollars).

- **Whitewater boating –** With dam removal, whitewater boating activity on the upper Klamath River would decrease beginning in 2020 because of the dependence of water releases from the J.C. Boyle Powerhouse to provide sufficient and predictable flows in the heavily used Hell's Corner Reach. The average number of days with acceptable flows for whitewater boating on the Hell's Corner Reach would decline by up to 43 percent for kayaking and 57 percent for commercial boating during the five month period from May through September. The total reduction in economic value for whitewater boating recreation with dams out is estimated at $6.0 million (2012 dollars) for the 50-year period of analysis.

- **Reservoir recreation** - With dam removal, the use of reservoirs for flat-water boating, fishing and other uses would be lost. The dams out scenario results in a loss of 2.03 million total recreation days at these reservoirs. The total loss in economic value for reservoir recreation is estimated at $35.4 million (2012 dollars) for the 50-year period of analysis.

The NED benefit cost analysis (BCA) indicates that the net economic benefits of dam removal and implementation of the KBRA are strongly positive. For both partial and full facilities removal, the NED BCA ranges from approximately nine to one to forty-eight to one (See Table 5-7). This implies that the dam removal and implementation of the KBRA (including the partial facilities removal option) is justified from an economic perspective. Table 5-7 summarizes NED benefits and costs.

Table 5-7: Benefit Cost Analysis Summary for Dam Removal and Implementation of the KBRA[1]

	Costs ($ Millions)		**Benefits** ($ Millions)		**Net Economic Benefits** ($ Millions)		**Benefit/Cost Ratio**	
	Low	**High**	**Low**	**High**	**Low**	**High**	**Low[2]**	**High[2]**
Full Facilities Removal	1,772.1	1,813.5	15,866.0	84,435.4	14,052.5	82,663.3	8.7 to 1	47.6 to 1
Partial Facilities Removal	1,746.4	1,787.8	15,866.0	84,435.4	14,078.2	82,689.0	8.9 to 1	48.3 to 1

[1] The costs and benefits presented here represent quantifiable costs and benefits; there are also unquantifiable costs and benefits (as shown in Table 5-6) that are not possible to include in the calculation of total costs and benefits. The most probable dam removal costs as shown in Tables 5-4 and 5-5 were used in the economic analysis.

[2] Low estimate (Low Benefit Estimate divided by High Cost Estimate): these estimates are based on nonuse value. High estimate (High Benefit Estimate divided by Low Cost Estimate): these estimates are based on total economic value.

5.4.2 Summary of Effects to Regional Economics (RED)

Dam removal actions have short-term and long-term positive and negative effects on jobs in the regional economy. Construction activities associated with dam removal, mitigation actions, and implementation of KBRA programs would add jobs, labor income, and economic output to the region in the short-term (2012 -2026). For example, jobs associated with KBRA implementation spending would span 15 years, jobs associated with dam removal would likely span just a single year, and jobs associated with mitigation measures would span about 8 years. Over the longer term, dam removal and KBRA programs would result in the addition of jobs in the region related to irrigated agriculture, commercial fishing, in-river sport fishing, ocean sport-fishing, and refuge recreation. Added jobs in these areas would increase regional labor income and economic output; producing a long-term positive effect on regional economic development.

Dam removal would eliminate long-term jobs related to annual operation and maintenance (O&M) expenditures associated with the Four Facilities. In addition, changes to whitewater boating opportunities and loss of open-water and flat-water recreation activities at the Klamath Hydroelectric Project reservoirs would also result in lost regional jobs.

Implementation of the KHSA and KBRA would add regional short-term and long-term jobs and would increase labor income and regional economic output. Added jobs include full time, part time, and temporary positions. Table 5-8 summarizes the changes in jobs, labor income, and regional output for the specific region modeled (color coding is used to differentiate the regions) and the timeframe of the jobs. This regional economic analysis compares two scenarios: dam removal and implementation of the KBRA versus leaving the dams in place without implementation of the KBRA. Jobs, labor income, and regional output were generated using the IMPLAN model, which estimates regional impacts based on the makeup of the economy at the time of the underlying IMPLAN data (2009)(CDM 2011b). It is important to note that regional impacts were analyzed by scenario specific definitions, periods of occurrence, and other factors; therefore, the potential impacts (such as jobs) should not be summed across a category or region.

The largest decrease in annual average jobs (estimated at 49) and average annual regional output (- $5 million) associated with dam removal would occur because of reduced spending on O&M of the Four Facilities between 2020 and 2061 (see Table 5-8). In addition, a long-term decrease in annual average jobs would occur in the recreational areas of whitewater boating (14 jobs) and reservoir recreation (4 jobs) between 2020 and 2061, decreasing average annual regional output by $0.89 and $0.31 million, respectively.

The largest increases in jobs and regional output would occur with dam decommissioning, implementation of mitigation actions, implementing KBRA programs, and the resultant improvements in agricultural (during drought years) and commercial fishing. Dam decommissioning would result in an estimated 1,400 regional jobs and a regional output of $163 million; these would occur

during the single year of dam decommissioning in 2020. Implementing mitigation measures would result in an estimated 217 short-term jobs and regional output of $30.86 million between 2018 and 2025; annual jobs and annual regional output would vary year by year proportionate to actual regional spending. Implementation of KBRA programs would result in about 300 annual jobs (4,600 jobs over 15 years) and $29.6 million in average annual regional output from 2012 through 2026. Jobs and regional output estimates would also vary year by year proportionate to actual KBRA regional spending. Through the KBRA Water Program, agriculture would be sustained during drought years (which occur about once every 10 years) and would result in an estimated 70 to 695 more jobs (depending on the severity of the drought) with dams out and implementation of the KBRA. The corresponding range of the estimated increase in regional output would be $9 to $84 million for individual drought years (in 2012 dollars). Dam removal and the KBRA would improve commercial fishing in five management areas along the Oregon and California coastlines. The three largest average annual increases in jobs and annual economic output would be in the San Francisco Management Area (219 jobs and $6.6 million), Central Oregon Management Area (136 jobs and $4.07 million), and Fort Bragg Management Area (69 jobs and $2.41 million) (see Table 5-8).

Table 5-8: Average Annual Change in Jobs (Full Time, Part Time, or Temporary), Labor income, and Output for Dam Removal and KBRA Implementation (by Region, Activity, and Timeframe)[1]

Economic Region	Activities under Dams Out with KBRA Scenario	Regional Full Time, Part Time or Temporary Jobs - Dams Out with KBRA Scenario (Incremental Change in Jobs from Dams In Scenario)	Regional Labor Income (Incremental Change in Million $; 2012 dollars)	Regional Output (Incremental Change in Million $; 2012 dollars)	Timeframe[2]
Klamath County OR; Siskiyou County CA	Dam Decommissioning	1,400[3]	60	163	2020
Klamath County OR; Siskiyou County CA	O&M	-49	-2.05	-5	2021 – 2061
Klamath County OR; Siskiyou County CA	Mitigation	217[4] (total jobs 2018 to 2025)	10.01	30.86	2018 – 2025
San Francisco Management Area (San Mateo, San Francisco, Marin and Sonoma Counties CA)	Commercial Fishing	218	2.56	6.6	2012 – 2061
Fort Bragg Management Area (Mendocino County CA)	Commercial Fishing	69	1.05	2.41	2012 – 2061
KMZ-CA (Humboldt and Del Norte Counties CA)	Commercial Fishing	19	0.07	0.19	2012 – 2061
KMZ-OR (Curry County OR)	Commercial Fishing	11	0.06	0.13	2012 – 2061
Central Oregon Management Area (Coos, Douglas and Lane Counties OR)	Commercial Fishing	136	1.74	4.07	2012 – 2061
Klamath County OR; Siskiyou County CA	Reservoir Recreation	-4	-0.13	-0.31	2021 – 2061
Klamath County OR; Del Norte, Humboldt, and Siskiyou Counties CA	In River Sport Salmon Fishing	3	0.07	0.15	2012 – 2061
KMZ-CA (Humboldt and Del Norte Counties CA)	Ocean Sport Fishing	5.5	0.18	0.48	2012 – 2061
KMZ-OR (Curry County OR)	Ocean Sport Fishing	1.2	0.02	0.09	2012 – 2061
Klamath and Jackson counties OR; Humboldt and Siskiyou counties CA	Whitewater Boating	-14	-0.43	-0.89	2021 – 2061

Table 5-8: Average Annual Change in Jobs (Full Time, Part Time, or Temporary), Labor income, and Output for Dam Removal and KBRA Implementation (by Region, Activity, and Timeframe)[1]

Economic Region	Activities under Dams Out with KBRA Scenario	Regional Full Time, Part Time or Temporary Jobs - Dams Out with KBRA Scenario (Incremental Change in Jobs from Dams In Scenario)	Regional Labor Income (Incremental Change in Million $; 2012 dollars)	Regional Output (Incremental Change in Million $; 2012 dollars)	Timeframe[3]
Klamath County OR; Siskiyou and Modoc Counties CA	Irrigated Agriculture[5]	2027: 112 2043: 695 2045: 397 2051: 187 2059: 70	2027: 2 2043: 11 2045: 7 2051: 4 2059: 2	2027: 13 2043: 84 2045: 41 2051: 20 2059: 9	2027, 2043, 2045, 2051, 2059
Klamath County OR; Siskiyou County CA	Refuge Recreation	5	0.12	0.27	2012 – 2061
Klamath County OR; Siskiyou, Modoc, Humboldt, and Del Norte Counties CA	KBRA Fisheries Program	261	12.4	25	2012 – 2026
Klamath County OR; Siskiyou, Modoc, Humboldt, and Del Norte Counties CA	KBRA Water Resources Program	16	0.7	1.6	2012 – 2026
Klamath County OR; Siskiyou, Modoc, Humboldt, and Del Norte Counties CA	KBRA Regulatory Assurances	10	0.5	1	2012 – 2026
Klamath County OR; Siskiyou County CA	KBRA County Programs	Klamath County: $3.2 million would increase jobs, labor income and output. Siskiyou County: $20 million would increase jobs, labor income and output.	--	--	
Klamath County OR; Siskiyou, Modoc, Humboldt, and Del Norte Counties CA	KBRA Tribal Programs	Karuk: 8 Klamath: 8 Yurok: 10	Karuk: 0.35 Klamath: 0.39 Yurok: 0.45	Karuk: 0.55 Klamath: 0.64 Yurok: 0.81	2012 – 2026

[1] It is not appropriate to add jobs across years, as the job estimates provided represent average annual changes rather than annual changes that accumulate in each year of the study period. Jobs for the Direct KBRA Activities were average over the 15 year timeframe and could be higher or lower in any year.

[2] These employment impacts are anticipated to occur on the first day of the timeframe identified and persist over the period. For example, dam decommissioning is estimated to have an employment impact of 1,400 jobs. These jobs would start on January 1, 2020 and persist until December 31, 2020. Similarly, the loss of 49 operation and maintenance jobs would be anticipated to start on January 1, 2020.

[3] Jobs created during dam removal would occur for one year in 2020.

[4] Jobs reported related to mitigation spending are reported as a total over the mitigation period of 2018-2025.

[5] Regional economic impacts stemming from irrigated agriculture were estimated to be equal in all years except for the years in the hydrologic model that correspond with the drought years of 1975, 1992, 1994, 2001, and 2008. The values presented are annual totals for the modeled drought years.

LEGEND:	
	Klamath County OR; Siskiyou County CA
	San Francisco Management Area
	Fort Bragg Management Area
	KMZ-CA
	KMZ-OR
	Central Oregon Management Area
	Klamath County OR; Del Norte, Humboldt, and Siskiyou Counties CA
	Klamath and Jackson counties OR; Humboldt and Siskiyou counties CA
	Klamath County OR; Siskiyou and Modoc Counties CA
	Klamath County OR; Siskiyou, Modoc, Humboldt, and Del Norte Counties CA

5.4.3 Tribal

Dam removal and implementation of the KBRA would help protect tribal trust resources and help address various social, economic, cultural, and health problems identified by the six federally recognized Indian tribes in the basin (Klamath, Karuk, Yurok, Resighini Rancheria, Quartz Valley, and Hoopa Valley). In particular, the Klamath Tribes of the upper basin have experienced their 92nd year (period starting with initial dam construction) without access to salmon and have continued to limit their harvest of suckers to only ceremonial use for the 25th consecutive year because of exceptionally low numbers and ESA protection.

Indian tribes of the Klamath Basin self-characterize themselves around a "Salmon Culture," with ways of life and an economy intricately tied to the historical runs of salmon, and other fish and natural resources of the Klamath Basin. Klamath Basin tribes have social, cultural, and economic ties to each other due, in large part, to their shared reliance on Klamath River natural resources and its fisheries. Their social fabric and culture is tied to the Klamath River as evidenced by their traditional ceremonial and spiritual practices that focus on the river, its fish, wildlife, and plants. Salmon far exceed other resources in its importance to the diet and culture of the Klamath Basin Indian tribes (Swezey and Heizer 1977; Warburton 1966).

The Four Facilities have contributed to reduced fish stocks and poor river water quality that have directly affected tribal cultural practices. Reduced fish stocks have diminished Klamath Basin tribes' salmon based economy and in the case of the Klamath Tribes have completely elliminated their access to salmon and steelhead. These factors have contributed to high levels of poverty and diet based health problems among the Klamath Basin Indian tribes. Poor river water quality and reduced fish stocks have also disrupted river and fish based spiritual ceremonies and other traditional cultural practices, which has fragmented cultural identity.

Dam removal and the KBRA would have beneficial effects on water quality, fisheries, terrestrial resources, and traditional cultural practices. Primary among these are greater anadromous fish harvests for some tribes in the lower basin, a return of Chinook salmon and steelhead to the upper basin for the Klamath Tribes, and restoration efforts of the Klamath Tribes sucker fisheries in Upper Klamath Lake and its tributaries. In addition, dam removal would enhance downstream water quality and the ability of Klamath Basin Indian tribes to conduct traditional ceremonies and other cultural practices. Implementation of the KBRA would provide funds to the signatory tribes (Klamath, Yurok, and Karuk) for restoration and monitoring projects that would create jobs for tribal members, helping to alleviate tribal poverty rates. Table 5-9 list the benefits of dam removal and KBRA common to all tribes in the Klamath Basin.

Table 5-9: Common Benefits to all Indian tribes with Dam Removal and Implementation of the KBRA

Major Water and Aquatic Resource Benefits of Dam Removal and KBRA Implementation	
Water Resources	
Hydrology	More natural river hydrology. Natural flushing flows would benefit aquatic species and riparian vegetation.
Water Quality	Natural temperature regime and improved water quality would benefit aquatic life.
Toxic Blue Green Algae	Free flowing river segments would deter conditions that lead to toxic algal blooms and reduce human health concerns.
Aesthetics	Improvements in water quality would improve aesthetics and ceremonial opportunities that require a healthy river.
Aquatic Resources	
Traditional Lifestyle	Greater fisheries abundance would bolster opportunities for transmitting traditional knowledge to successive generations, including the important practice of giving fish to elders. Improved social cohesion and function among Indian populations through strengthened sense of tribal identity.
Cultural and Religious Practices	Improved fish abundance would facilitate the tribes' ability to reinstate and continue to practice ceremonies in their historic, complete forms at the appropriate times of the year, thereby improving tribal identity.
Standard of Living	Increased fish abundance would contribute to greater food supply and food security for the Indian population, enhancing standard of living.
Health	Greater opportunity for healthy food consumption associated with increased subsistence fishing opportunities, which would improve overall health conditions.

5.4.4 Previous PacifiCorp Analyses of Relicensing versus Removal of the Four Facilities and Public Utilities Commission Rulings

A prerequisite to the $200 million (2020 dollars) customer surcharges necessary for KHSA implementation was concurrence from the California Public Utilities Commission (CPUC) and the Oregon Public Utilities Commission (OPUC) with PacifiCorp's analysis that implementing the KHSA would be in the best interest of their customers and that the incremental increases were fair and reasonable. PacifiCorp's records and testimony before both commissions compared two scenarios: (1) customers' cost and risks under the KHSA dam removal, and (2) customers' cost and risks from FERC relicensing of the Four Facilities. (It is important to note that the TMT did not evaluate the potential costs or risks to PacifiCorp customers for relicensing the dams.)

PacifiCorp reported that relicensing would require implementing new mandatory flow conditions for the project (decreasing power generation by 20 percent and reducing peaking-power opportunities), constructing and operating fish passage at the dams, and addressing water-quality issues in and below the reservoirs. PacifiCorp estimated these actions would cost in excess of $460 million (2010 dollars) in capital and operating expenses. PacifiCorp also reported that these costs are uncertain and uncapped, and that FERC relicensing represents a substantial financial risk to its customers. For example, if fish passage measures at the Four Facilities proved unsuccessful, then upgraded facilities, altered operations, and/or dam decommissioning may be required. If these additional uncapped expenses were required, they would likely be borne by PacifiCorp customers.

In PacifiCorp's analysis of the financial impacts of dam removal, they assumed that customer costs associated with dam removal would be capped at $172 million in 2010 dollars (or $200 million in 2020 dollars). Implementing interim measures (as defined in KHSA Appendix C and D) would cost about $79 million (2010 dollars); these costs would be largely capped and would carry only a small financial risk for its customers. PacifiCorp customers would still be obligated to pay for replacement power needed after removal of the Four Facilities in 2020.

Table 5-10 provides a summary of PacifiCorp's analysis of FERC relicensing and KHSA dam removal in terms of operational changes, costs, risks, and liabilities to their customers. PacifiCorp's analysis submitted to the CPUC and OPUC demonstrated that the KHSA resulted in less cost and less risk for its customers as compared to FERC relicensing, even with the inclusion of costs associated with replacement power. The CPUC concluded that if "the KHSA surcharge is not instituted….ratepayers would be exposed to an uncertain amount of costs" associated with relicensing. The OPUC concluded that the KHSA "mitigates the risks associated with decommissioning and removal of the [four] facilities for PacifiCorp, and is therefore the least risky alternative for customers compared to relicensing" (OPUC 2011). Based on PacifiCorp's analysis and testimony, both PUCs agreed with this analysis and approved collection of the customer surcharges necessary to fund the removal of the Four Facilities in 2020, as described in KHSA.

Table 5-10: Operations, Costs, Risks, and Liabilities for FERC Relicensing and Removal of the Four Facilities, Based on PacifiCorp Analyses

PacifiCorp's Future Hydroelectric Project Scenario	Operations at the Four Facilities	Operations, Risks, and Liabilities PacifiCorp's estimated customer costs	PacifiCorp customer risks and liabilities
FERC Relicensing	Four Facilities continue to operate, but mandatory FERC relicense conditions would require construction and operation of fish passage facilities (screens and ladders), resulting in a 20 percent loss of hydropower and the majority of power peaking at J.C. Boyle. Requirements to remedy water quality and temperature issues below Iron Gate Dam.	In excess of $400 million in capital costs; in excess of $60 million in O&M over a 40-year license term.	Uncapped financial liability. Costs could exceed $460 million, particularly if fish passage proves ineffective or if water quality does not meet OR or CA state standards. FERC could require PacifiCorp to decommission the facilities if it's unable to issue a new license with costs borne by PacifiCorp customers.
KHSA Removal of the Four Facilities	Continue operation under annual FERC licenses through 2019. Power generation would cease in January 2020 with transfer of the Four Facilities to a DRE. Interim measures (Appendix C and D of KHSA) would be implemented between 2012 and 2020 to enhance flow variability, water quality and fish habitat/health.	$172 million for dam removal ($200 million in 2020 dollars). Funds would be collected with a 9-year, 2 percent (or less) surcharge on OR and CA customers. Customers would be responsible for KHSA interim measures at $9 million in capital costs and $70 million in O&M; and the costs for replacement power.	Customer financial liability for dam removal is capped at $172 million ($200 million in 2020 dollars). Costs for interim measures are largely capped at $79 million (2010 dollars).

Sources: Scott 2010 and KHSA 2010

5.4.5 Other Social and Environmental Effects from Dam Removal

In addition to the effects of dam removal on fisheries, national and regional economic development, tribal resources, and PacifiCorp customers, there are several other important social and environmental resource considerations addressed in the Overview Report that will inform a determination on whether dam removal and implementation of KBRA is in the public interest. Table 5-11 summarizes these additional resource considerations associated with dam removal and KBRA implementation.

Table 5-11: Summary of Other Social and Environmental Effects of Dam Removal and KBRA Implementation

Issue	Effect of Dam Removal and KBRA
Prehistoric and Historic Cultural Resources (Section 4.4.3): Numerous Indian tribal and early settler development sites in the Klamath River Basin are potentially eligible for inclusion on the National Register of Historic Places. These sites are part of the cultural and historic heritage of the area. Specifically, the Klamath Hydroelectric Project dams and facilities are recommended for inclusion on the National Register.	Removal of dams and associated hydroelectric facilities would permanently remove these resources from eligibility to the National Register. Additionally, dam removal could affect other sites. Consultations under Section 106 of the National Historic Preservation Act (NHPA) are being conducted and would continue, as appropriate, throughout planning and implementation if dam removal were to proceed in order to identify and protect these resources.
Wild and Scenic River (Section 4.4.5): The US Forest Service, BLM and the National Park Service are responsible for Klamath Wild and Scenic River (WSR) management and are required by the WSR Act to make a determination whether dam removal is consistent with its river-resource protection requirements on the two components of the Klamath WSR.	Federal projects such as the potential removal of the Four Facilities are consistent with the WSRA's Section 7(a) protections when they do not "invade", or intrude within, the WSR boundary, nor "unreasonably diminish" its scenery, recreation, fish and wildlife values as they existed at the date of WSR designation. The Oregon component of the WSR below J.C. Boyle Powerhouse would experience a loss in whitewater boating opportunities as a direct result of dam removal. Overall, dam removal would improve scenery, recreation, and fish and wildlife values associated with the Oregon and California components of the Klamath WSR.
Recreation (Section 4.4.6): The Four Facilities' reservoirs (excluding Copco 2) provide recreational opportunities including whitewater boating below J.C. Boyle powerhouse, power boating, waterskiing, lake swimming, flat-water boat angling, sightseeing, camping, and wildlife viewing.	The removal of the Four Facilities would result in a change to recreation opportunities. Open water recreation and camping at J.C. Boyle, Copco 1, and Iron Gate reservoirs would be permanently lost. These losses could be partially replaced by other regional recreation resources. Whitewater boating would be reduced in the popular Hell's Corner Reach. Flat-water fishing opportunities would be lost at the reservoirs. Dam removal and KBRA would increase in-river fishing opportunities for salmon, steelhead, and redband trout basin-wide.

Table 5-11: Summary of Other Social and Environmental Effects of Dam Removal and KBRA Implementation

Issue	Effect of Dam Removal and KBRA
Real Estate (Section 4.4.7): Private development around Copco 1 and Iron Gate reservoirs occurred largely as a result of proximity to the reservoirs and their recreational/scenic values. Dam removal would change this important value attached to property values.	Loss of reservoir amenities (views, frontage, and access) would negatively affect private parcel values around Iron Gate and Copco 1 reservoirs. Affected lands include 668 parcels that have frontage, proximity, or view of the reservoirs. Of these parcels, about 19 percent (127 parcels) have been developed as single-family residences. About 518 parcels are currently vacant residential land. Based upon a limited data set covering 3 years (2004, 2006, and 2008) of land sales data for reservoir and non-reservoir parcel data, a discount in land value was found based on a potential change from reservoir view to no view, or reservoir frontage to river view, ranging from 25 to 45 percent, and averaging about 30 percent. The after dam removal condition values assume the river and land under the reservoirs are restored to their native condition; however, there would be a period after dam removal and before this restoration process is complete when it is anticipated that land values would be even lower. It is unknown how long this restoration would take and what the property value impacts would be during this interim period. The aggregate decrease in value for the 668 potentially affected land parcels would be about $2.2 to 2.7 million dollars. Parcels downstream of Iron Gate Dam that experience river water quality improvements and/or improved fisheries from dam removal and implementation of the KBRA may experience positive changes in value in the long-term. However, data was not available on the timing, magnitude, and spatial extent of these changes to quantify effect to parcel values.
Refuges (Section 4.4.8): The Lower Klamath National Wildlife Refuge does not have a water allocation and experiences water delivery uncertainty and shortages in the critical April through October time period, particularly in dry years, which reduces wildlife species diversity and abundance.	Dam removal and KBRA implementation would allow the refuges within Reclamation's Klamath Project to have greater certainty about water allocations and flexibility in water deliveries. Full refuge needs would likely be met in 88 percent of years. Historically, full refuge water needs in the April through October period have been met in less than 10 percent of the years. Dam removal with KBRA implementation would also define and maintain the habitat benefits of "walking wetlands" and provide the refuges revenues from lease lands. Additional water deliveries with increased predictability would improve bird numbers. • Waterfowl carrying capacity of fall migrating ducks would increase from 189,000 to 336,000. • Additional wetland habitat for more than 8,000 additional nongame waterbirds (shorebirds, gulls, terns, cranes, rails, herons, grebes, egrets, and ibis) in an average water year, and 20,000 in drier years. • Greater waterfowl numbers would provide a larger and more reliable food base for wintering bald eagles.

Table 5-11: Summary of Other Social and Environmental Effects of Dam Removal and KBRA Implementation

Issue	Effect of Dam Removal and KBRA
Chemicals in Reservoir Sediments (Section 4.4.9): Reservoir sediments contain low levels of contaminants that needed to be evaluated to determine if they could be eroded and transported downstream without adverse impacts to humans or other biota. In addition, the impact of human exposure to sediments not eroded downstream needed to be evaluated.	Impounded sediments were generally found to contain low levels of potentially harmful chemicals. A total of 77 sediment cores were collected at various reservoir and estuary locations; 501 chemical concentrations were quantified. Contaminant levels in sediments are below critical threshold levels for their disposal and thus do not preclude their downstream release if dams were removed. A screening level evaluation, which considered five pathways of potential exposure, concluded that long-term adverse effects for humans or biota would be unlikely from the chemicals present in sediments deposited in the river channel, deposited along river banks, or left behind on exposed reservoir terraces.
Algal Toxins (Section 4.4.10): Large algal blooms occur in Copco 1 and Iron Gate reservoirs during the summer months and produce the algal toxin microcystin; these reservoirs have posted health advisories warning against recreational use (water contact), drinking, and fish consumption. These health advisories extend to the lower Klamath River and at times, into the Klamath Estuary. Algal toxins in the Klamath River have impaired the ability of the Klamath, Resighini Rancheria, Karuk, Hoopa, Quartz Valley Indian Community and Yurok Indian tribes to use the river for cultural purposes.	Dam removal would eliminate large, seasonal blooms of toxic algae in Copco 1 and Iron Gate reservoirs and facilitate the downstream use of the Klamath River for multiple human health related beneficial uses, including traditional Indian cultural practices, recreation, agriculture, shellfish harvesting, and commercial, tribal, and sport fishing.
Greenhouse Gasses (Section 4.4.11): Dam removal would require power replacement in 2020 that would result in a net increase of greenhouse gas (GHG) emissions.	The Four Facilities would generate on average 909,835 MWh annually in 2020 through 2061 that would need to be replaced by other power sources if dams were removed. If PacifiCorp meets its California's Renewable Portfolio Standard (RPS) goal in 2020 of 33 percent renewable, the metric tons of carbon dioxide equivalent ($MTCO_2e$) emitted from replacement power, is approximately 451,000 $MTCO_2e$ per year. Removal of the reservoirs would reduce these emissions by approximately 4,000 to 14,000 $MTCO_2e$ per year (less than 1 percent) based on the reduction of methane gas emitted from reservoir bottom sediments.

Table 5-11: Summary of Other Social and Environmental Effects of Dam Removal and KBRA Implementation

Issue	Effect of Dam Removal and KBRA
Societal views on dam removal and the KBRA (Section 4.4.12): Klamath dam removal and KBRA implementation could only move forward with fiscal resources from PacifiCorp customers, California taxpayers, and US taxpayers. What value do individuals and households place on Klamath Basin fisheries recovery and restoration?	Local Ballot Measures Local voting (November 2, 2010) results in Klamath County and Siskiyou County appear to be mixed, with a slight majority of Klamath County supporting participation in KBRA (52 percent) and a large majority of Siskiyou County not supporting dam removal (79 percent). Nonuse Value Survey Responses Responses to the nonuse value survey questions indicate a majority of respondents place a relatively high level of importance on improving the fisheries in the Klamath River Basin. This importance was indicated at the 12-County Klamath Area level, for the rest of Oregon and California, and for the rest of the United States. In response to a question inquiring about the level of concern with declines in the number of Chinook salmon and steelhead trout that return to the Klamath River each year, the majority of respondents expressed concern. • From the 12-County Klamath Area, 73.8% expressed concern. • For the rest of Oregon and California, 82.5% expressed concern. • For the rest of the United States, 78.8% expressed concern. Respondents surveyed indicated that an action plan to remove the dams and restore the basin was preferred to no-action. No-action was defined as not implementing an agreement that includes dam removal, fish restoration, and a water sharing agreement. • From the 12-County Klamath Area, 54.7% favored an action plan • For the rest of Oregon and California, 71.3% favored an action plan • For the rest of the United States, 66.3% favored an action plan

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