3.10 Greenhouse Gases/Global Climate Change

This section discusses potential greenhouse gas (GHG) and global climate change impacts from the Proposed Action and alternatives. The analysis related to climate change was organized into two distinct categories: 1) issues related how climate change would affect the Proposed Action, and 2) issues related to the quantification of GHG emissions. This section describes the affected environment/environmental setting, analysis methods, significance criteria, and impacts for each of the alternatives. Appendix N provides detailed GHG emission calculations.

3.10.1 Area of Analysis

The area of analysis is the Klamath Basin, which includes multiple counties in northern California and southern Oregon. A quantitative analysis of GHG emissions associated with implementation of the Klamath Hydroelectric Settlement Agreement (KHSA) was restricted to Siskiyou and Shasta Counties in California and Klamath and Jackson Counties in Oregon. This area was defined to encompass GHG emissions associated with dam removal activities and construction-related vehicle trips (e.g., trucks and construction worker commuting).

A qualitative analysis of GHG impacts was completed for the aforementioned counties, as well as Del Norte, Humboldt, Modoc, and Trinity Counties in California and Curry County in Oregon. These counties would encompass areas affected hydrologically by implementation of the KHSA and the Klamath Basin Restoration Agreement (KBRA). In other words, regions that could be affected by the effects of climate change, such as increased temperature, changes in precipitation, and reduced snowpack, were evaluated.

Although project-related emissions are restricted to the area of analysis described above, data on the existing GHG emissions are only available at the state-level for California and Oregon (California Air Resources Board [CARB] 2009; Oregon 2010). The climate change analysis is based on global circulation models that typically do not have resolutions finer than the region or state. As a result, it was necessary to use a larger region than that included the area of analysis to establish existing conditions.

3.10.2 Regulatory Framework

Greenhouse gas and global climate change are governed by several federal and state laws and policies, which are listed below.

3.10.2.1 Federal Authorities and Regulations

- Department of the Interior Secretarial Order No. 3289
- Prevention of Significant Deterioration and Title V Greenhouse Gas Tailoring Rule (75 FR 31514)

3.10.2.2 State Authorities and Regulations

- California Executive Order S-3-05
- California Executive Order S-13-8
- California Executive Order S-14-08
- California Executive Order S-21-9
- California Global Warming Solutions Act of 2006 (Assembly Bill [AB] 32)
- California Renewable Energy Resources Act (Senate Bill 2, First Extraordinary Session [SBX1 2])
- California Environmental Quality Act (CEQA) Guidelines (14 CCR §15064)
- Oregon House Bill 3543

3.10.3 Existing Conditions/Affected Environment

Data generated from global circulation models are used to project changes to climate. Climate change projections are based on varying global circulation models and emissions scenarios documented in reports, as described below. Because each report is based on different models and scenarios, each has varying levels of uncertainty associated with the projected changes. For this analysis, the ranges of projected changes published in each report are presented. In addition, the models used for each report were conducted at different scales (regional, state or local), as indicated in the descriptions below.

- **The United States Global Change Research Program (USGCRP)[1] climate impact analyses (USGCRP 2009):** The foundation for the USGCRP report is a set of 21 Synthesis and Assessment Products, as well as other peer-reviewed scientific assessments, including those of the Intergovernmental Panel on Climate Change (IPCC), the United States Climate Change Science Program, the United States National Assessment of the Consequences of Climate Variability and Change, the Arctic Climate Impact Assessment, the National Research Council's Transportation Research Board report on the Potential Impacts of Climate Change on United States Transportation, and a variety of regional climate impact assessments (USGCRP 2009). The scale of the USGCRP results is for the Northwest.

- **The Oregon Climate Assessment Report by the Oregon Climate Change Research Institute (OCCRI) (OCCRI 2010):** The Oregon Climate Assessment Report draws on research on climate change impacts in the western United States from the Climate Impacts Group at the University of Washington and the California Climate Action Team (OCCRI 2010). The scale for the OCCRI results is for the state of Oregon.

[1] United States Global Change Research Program is a consortium of 13 federal departments and agencies authorized by Congress in 1989 through the Global Change Research Act (P.L. 101-606). The USGCRP coordinates and integrates federal research on changes in the global environment and their implications for society.

- **The regional climate change effects synthesized by the Federal Highway Administration (FHWA 2010):** The FHWA report is based on the USGCRP report and the supporting database (CMIP3), as well as publicly available publications and literature on model results. In addition, FHWA high-resolution temperature and precipitation projections for the continental United States developed through statistical downscaling of the results of 16 climate models of the CMIP3 database were provided for low and moderately high emission scenarios for three future projections, including near-term, mid-century, and end-of-century. The scale of the FHWA results is for the Northwest.

- **Impacts to the Klamath Basin prepared by the National Center for Conservation Science and Policy; and the Climate Leadership Initiative (Barr et al. 2010):** For the Klamath Basin by the National Center for Conservation Science and Policy and the Climate Leadership Initiative, three global climate models–CSIRO, MIROC, and HADCM–and a vegetation model (MC1) predicted future temperature, precipitation, vegetation, runoff, and wildfire in the Klamath Basin (Barr et al. 2010). The scale of the results for this report is for the Klamath Basin.

- **Hydrologic, hydraulic, and sediment transport studies conducted by The Reclamation Technical Service Center, upon request of the Reclamation Mid-Pacific Regional Office to support the Secretarial Determination on Klamath Dam Removal and Basin Restoration (Bureau of Reclamation [Reclamation] 2010):** For the hydrologic, hydraulic, and sediment transport studies conducted by the Reclamation Technical Service Center, five different future climate scenarios were simulated. The scenarios were chosen to bracket the range of results predicted by global circulation models. Four scenarios correspond to combinations of the 25th and 75th quantiles of the precipitation and temperature predicted by the global circulation models for the Upper and Lower Klamath Basins. The fifth is the 50th quantile of the precipitation and temperature. The precipitation and temperature predicted by the global circulation models were downscaled to the Upper and Lower Klamath Basin. See Section 3.6, Flood Hydrology.

Summary

The projected changes in climate conditions are expected to result in a wide variety of effects in the Pacific Northwest[2] and the Klamath Basin with regard to the Proposed Action and the alternatives. The most relevant consequences related to the Proposed Action include changes to stream flow, temperature, precipitation, groundwater, vegetation changes, and flow. In general, climate model predictions include:

- Increased average ambient air and water temperature
- Increased number of extreme heat days

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[2] The Pacific Northwest is defined by the USGCRP as Washington, Oregon, Idaho, and western Montana. Although the USGCRP "Pacific Northwest" region does not include California, it has the climate most representative of the Klamath Basin. The USGCRP region that contains California is the "Southwest" climate region, which includes California, Nevada, Arizona, Utah, and parts of New Mexico, Colorado, and Texas. The Southwest data represents the desert climates, which is not applicable to the Klamath Basin.

- Changes to annual and seasonal precipitation, including increased frequency and length of drought, less winter snow and more winter rain, and changes in water quality
- Increased heavy precipitation
- Reduced snow pack
- Vegetation changes
- Groundwater hydrology changes
- Changes to annual stream flow

These projected changes are discussed in detail in the following paragraphs. The potential impacts related to the Proposed Action are discussed in Section 3.10.4.3 - Effects Determination.

Increased Temperature

Future regional average annual air temperatures in Oregon are projected to increase by 0.2 to 1°F per decade depending on future GHG emissions, as compared to temperatures in the 20th century (OCCRI 2010). Projected temperature increases for the Pacific Northwest and the Klamath Basin are presented in Table 3.10-1.

Table 3.10-1. Projected Changes in Air Temperature under Existing Conditions

Region	Next Two Decades	Mid-21st Century	End of 21st Century
Pacific Northwest	+3.0 °F	+3.6 to 5.0 °F	+5.1 to 8.3 °F
Klamath Basin	---	+2.1 to 3.6 °F	+4.6 to 7.2 °F

Source: United States Global Change Research Program 2009, Barr et al. 2010

Baseline conditions for the Pacific Northwest are based on data from 1961 to 1979 (USGCRP 2009). Baseline conditions for the Klamath Basin are based on data from 1961 to 1990 (Barr et al. 2010).

In addition, the results of the hydraulic, hydrologic and sediment studies conducted to support this document show an average temperature increase of 2.5 to 4.0 °F in the Upper Klamath Basin between 2020 and 2069, as compared to temperatures during the period 1950 –1999 (Reclamation 2010).

Increased temperature may result in a variety of general consequences for the Pacific Northwest and the Klamath Basin:

- Increased evaporation rates (USGCRP 2009).
- Increased incidence of wildfire (OCCRI 2010).
- Increased occurrence of short-term and long-term drought conditions (USGCRP 2009).
- Changing water quality of natural surficial water bodies, including higher water temperatures, decreased and fluctuating dissolved oxygen content (Barr et. al 2010), and increased cycling of detritus.

- Earlier, longer, and more intense algae blooms (Barr et al. 2010).
- Changes to soil moisture (USGCRP 2009), which may lead to soil subsidence under structures.
- Increased energy demand for cooling, refrigeration and water transport (Barr et al. 2010; USGCRP 2009).
- Buckling of pavement or concrete structures (USGCRP 2009).
- Decreased lifecycle of equipment or increased frequency of equipment failure (USGCRP 2009).
- Increased frequency of freeze-thaw cycles in winter months (USGCRP 2009).
- Changes to salmon populations due to increased water temperatures and other water quality changes (USGCRP 2009).
- Drought stresses and higher temperatures that could decrease tree growth and change habitat in most low- and mid-elevation forests (Barr et al. 2010).
- Warmer winters and longer growing seasons that may increase the frequency and intensity of insect attacks, such as those of the mountain pine beetle (Barr et al. 2010).
- Disruption of the coordination between predator-prey or plant-pollinator life cycles that may lead to declining populations of many native species (Barr et al. 2010).
- Increased water temperature (Barr et al. 2010).

As discussed in Section 3.3, Aquatic Resources, high water temperatures are detrimental to anadromous species when eggs or juveniles are present. High water temperatures have also been associated with fish kills in the Klamath River downstream of Iron Gate Dam.

Increased Number of Extreme Heat Days

By mid-century, heat events are projected to increase in the Pacific Northwest (FHWA 2010). By mid-century, the Pacific Northwest could experience an additional one to three heat waves annually (i.e., three or more days with the daily heat index exceeding 90°F), with other locations experiencing up to one additional heat wave each year under a moderate emission scenario (Salathe et al. 2009).

Increases in the number of extreme heat days may result in declining air quality due to increased ozone concentrations and increased incidence of heat-related illness and death.

Annual Precipitation

Over the next century, mean precipitation is projected to change gradually from existing precipitation averages. By mid-century (2035-45), the annual precipitation projections in the Klamath Basin exhibit a large range, from an 11 percent reduction to a 24 percent increase overall (Barr et al. 2010). Baseline conditions for the Klamath Basin are based on data from 1961 to 1990 (Barr et al. 2010).

The results of the hydraulic, hydrologic and sediment studies conducted to support this document show a change in total precipitation under the climate change scenarios ranging from five percent less to five percent greater precipitation between 2020 and 2069, as compared to precipitation during the period 1950 – 1999 (Reclamation 2010).

Precipitation changes associated with climate change are complicated by the El Niño Southern Oscillation (ENSO). ENSO produces a cool, dry winter in the Klamath Basin and has cycles of 2–7 years of building and declining precipitation (Independent Science Advisory Board 2007). Climate change could affect the frequency or severity of ENSO events, which would change precipitation patterns in the Klamath Basin (Kiparksy and Gleick 2003). In addition, the Klamath Basin is at the southern edge of a low pressure cell during ENSO events, with the primary effect being a shift of storms southward towards southern California (National Oceanic and Atmospheric Administration Fisheries Service [NOAA Fisheries] 2008). Climate change could move the low pressure area northward, which could change the types of ENSO effects within the basin from producing a drier winter to producing more intense winter storms.

Changes to Seasonal Precipitation

While only a slight increase in precipitation (defined as annual total precipitation divided by the number of "wet" days where precipitation exceeds 1 millimeter per day) is projected for the Pacific Northwest (Salathe et al. 2009), changes in seasonal precipitation, including winter rain replacing winter snow, are projected to result in earlier and higher spring stream flows and lower late summer stream flows (USGCRP 2009; Barr et al. 2010). Table 3.10-2 summarizes projected seasonal changes in precipitation for the Pacific Northwest and the Klamath Basin.

Table 3.10-2. Projected Seasonal Changes in Precipitation

Region	Season	Next Two Decades	Mid-21st Century	End of 21st Century
Pacific Northwest	Winter	+3 to +5%	+5 to +7%	+8 to +15%
	Spring	+3%	+3 to +5%	+5 to +7%
	Summer	-6%	-8 to -17%	-11 to -22%
	Fall	+3 to +5%	+5%	+7 to +9%
Klamath Basin	Summer	---	-15 to -23%	-3 to -37%
	Winter	---	+1 to +10%	-5 to +27%
	Annual	---	-9 to +2%	-11 to+24%

Source: United States Global Change Research Program 2009, Barr et al. 2010

Baseline conditions for the Pacific Northwest are based on data from 1961 to 1979 (USGCRP 2009). Baseline conditions for the Klamath Basin are based on data from 1961 to 1990 (Barr et al. 2010).

Summer months in the Klamath Basin are projected to have precipitation decreases ranging from 15 to 23 percent from historic baseline (1961-1990) (Barr et al. 2010). However, less than 12 percent of the average annual precipitation in the Klamath Basin falls from June-August (Western Regional Climate Center 2010), so the effect on average actual summer precipitation would be small (less than 0.2 inches). In the Upper Klamath Basin, dry-season (April to September) and summer (July to September) stream flow have already declined 16 percent and 38 percent, respectively, during the period between 1961-2009 (Mayer and Naman 2011).

Changes to seasonal precipitation may result in a variety of general consequences for the Pacific Northwest and Klamath Basin, which are listed below.

- Shifting stream flow patterns, including higher and earlier peak spring flows and lower late summer flows may alter the timing of fish migration (Barr et al. 2010).
- Decreased summer water supply (OCCRI 2010).
- Increased fine sediment in streams may result in negative impacts on the spawning of native fish that build their nests in the areas of clean rocks and gravel (Barr et al. 2010).
- Cessation of flow from springs fed by groundwater may reduce the amount of refuge that these areas provide for fish survival (Barr et al. 2010).
- More variable flow from smaller groundwater springs may occur, with potential disappearance in the driest years (Barr et al. 2010).
- Increased frequency and severity of flooding may occur (USGCRP 2009).
- Increased runoff may lead to surface water quality changes, including increased turbidity, increased organic content, color changes, and alkalinity changes (Barr et al. 2010).

Increase in Heavy Precipitation

Projections show that by mid-century, heavy precipitation, defined as annual total precipitation divided by the number of "wet" days where precipitation exceeds one millimeter per day, would increase slightly in the Pacific Northwest (FHWA 2010). The fraction of precipitation that falls on days where precipitation exceeds the 95^{th} percentile was projected to decrease along the leeward side of the Cascade Mountains (Salathe et al. 2009). The characteristics along the leeward side of the Cascade Mountains are comparable to the Klamath Basin. Diffenbaugh (2005) projected an increase of up to 10 extreme precipitation events per year in the Pacific Northwest (up to a 140 percent increase) under a higher emission scenario with some variation depending on location within the region.

Increases in heavy precipitation may result in a variety of general consequences for the Pacific Northwest:

- Increased fine sediment in streams may result in negative effects on the spawning of native fish that build their nests in the areas of clean rocks and gravel (Barr et al. 2010).
- Increased frequency and severity of flooding may occur (USGCRP 2009).
- Increased runoff may lead to surface water quality changes including increased turbidity, increased organic content, color changes, and alkalinity changes (Barr et al. 2010).

Reduced Snowpack

By the 2040s, April 1st snowpack is projected to decline by as much as 40 percent in the Cascade Mountains (Payne et al. 2004) and between 37 percent and 65 percent in the Klamath Basin (Hayhoe et al. 2004). Cascade snowpack is projected to be less than half of what it was in the 20th century, with lower elevation snowpack being most vulnerable (OCCRI 2010). Projections show that by mid-century, warm-season runoff will decrease by 30 percent or more on the western slopes of the Cascade Mountains and by 10 percent in the Rocky Mountains (USGCRP 2009). By the end of the century, snowpack is projected to decline by 73 percent to 90 percent (Hayhoe et al. 2004).

Similarly, the results of the hydraulic, hydrologic and sediment studies conducted to support the Secretarial Determination on the Klamath Dam Removal and Basin Restoration show a more rapid snow melt for all climate change simulations.

Reduced snowpack may result in a variety of general consequences for the Pacific Northwest, including increased incidence of short- and long-term drought and limited inundation periods for side channels, which serve as nurseries for young fish and other aquatic animals (Barr et al. 2010). Summer water supply will also decrease as a result of reduced snowpack (OCCRI 2010).

Groundwater Hydrology

Projected increases in temperature and changes to seasonal precipitation will impact groundwater hydrology. Projected changes in groundwater hydrology include alterations of the timing and amount of recharge, increases in evapotranspiration, lowering of heads in boundaries such as streams, lakes, and adjacent aquifers, sea-level rise, and increased pumping demand, which will be exacerbated by population growth (OCCRI 2010). The high Cascade basins that are primarily fed by deep groundwater systems could sustain low flow during summer months (OCCRI 2010). Basins in the east of the Cascades are projected to have low summer flow in a distant future as groundwater recharge declines over time (OCCRI 2010).

Groundwater hydrology changes may result in a variety of general consequences for the Pacific Northwest and Klamath Basin, including the following:

- Decreased stream flows for rivers and streams that are primarily fed by groundwater supplies (Barr et al. 2010).
- Decreased availability of groundwater for agricultural use and water supply (USGCRP 2009).
- Reduced cool water refuge for aquatic animals due to the decline of springs fed by groundwater and the cessation and increased variability of flow to smaller springs (Barr et al. 2010).

Vegetation Changes

Conditions in the Upper Klamath Basin are projected to favor grasslands in areas that are currently suitable for sagebrush and juniper (Barr et al. 2010). In the Lower Klamath Basin, conditions suitable for oaks and madrone may expand while those suitable for maritime conifer forest could decrease (Barr et al. 2010). The percentage of the Klamath Basin burned by wildfire is expected to increase from current levels by 11 percent to 22 percent per year by the end of the 21st century (Barr et al. 2010). In addition, decreased soil moisture and increased evapotranspiration may result in the loss of wetland and riparian habitats (Barr et al. 2010).

Vegetation changes may result in a variety of general consequences for the Pacific Northwest and Klamath Basin, including the following:

- Changes in water quality (e.g., sediment) from burn area runoff (Barr et al. 2010).
- Changes in the tree canopy that affect rainfall interception, evapotranspiration, and infiltration of precipitation, affecting the quantity of runoff (Barr et al. 2010).
- Changes in the shading over surface waters, which may affect surface water temperatures and other water quality characteristics (USGCRP 2009).
- Changes in wood and organic debris recruitment, which may affect water quality and channel morphology and complexity (Barr et al. 2010).
- Reduced ability to respond to flooding due to changes in wetland and riparian zone plant communities and hydraulic roughness (USGCRP 2009).
- Increased stress on species populations due to loss of wetland and riparian habitats (USGCRP 2009).
- Shifting distribution of plant and animal species on land, with some species becoming more or less abundant (OCCRI 2010).
- Rare or endangered species may become less abundant or extinct (OCCRI 2010).
- Insect pests and invasive species may become more abundant (OCCRI 2010).

Flow

Future annual stream flow effects calculations based on projected precipitation amount and timing changes are particularly difficult to predict. Annual stream flows (the volume of flow in a year) were evaluated by comparing future model-estimated flows (based on runoff estimates from the three climate models) against actual stream flow measurements. Annual stream flows at the four stations evaluated (Iron Gate, Sprague River, Shasta River, and Salmon River) were “similar” to past records when comparing the frequency of “particularly” high and low flow events. The three models’ results vary regarding projections of higher or lower annual flows – two models projecting lower flows and one projecting higher annual flows as compared to current flows (Barr et al. 2010).

Similarly, the results of the hydraulic, hydrologic and sediment studies conducted to support this document show that the climate change scenarios are not sufficiently refined to determine effects to peak flows and therefore it is difficult to determine if climate change will have a significant impact on flood risk or geomorphology. However, if the future climate is wetter and with a faster snowmelt runoff during the spring, then peak flows would likely increase as well. However, if the climate is drier, faster snowmelt may result in peak flows that are not substantially higher (Reclamation 2010).

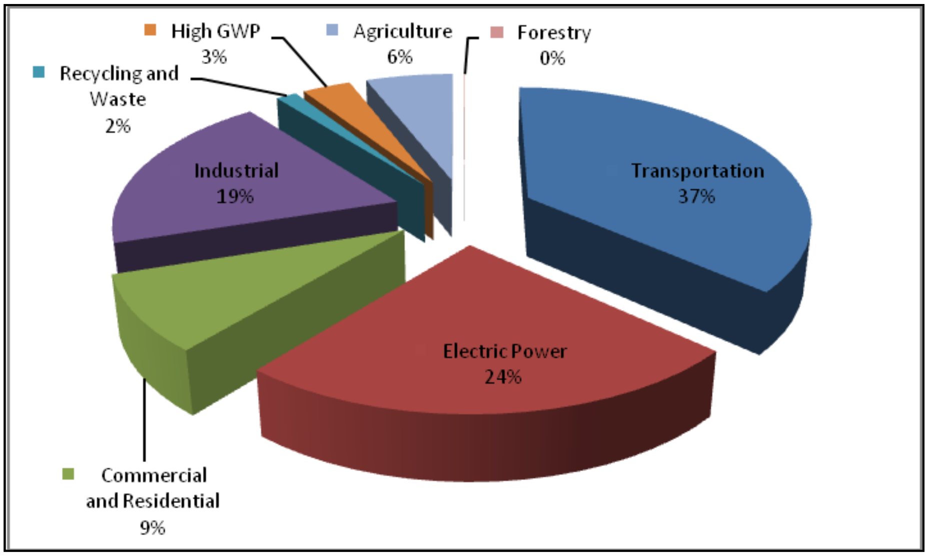
Though the model used to project future flows did not identify a consistent trend, it is known that free-flowing rivers respond better to changes in climate conditions due to the ability to adjust to and absorb disturbances through flow adjustments that buffer against impacts (Palmer et al. 2008). A natural riverine system is in constant, dynamic equilibrium, absorbing highly variable flow forces by changing channel morphology and dissipating energy via sediment transport and woody debris. A natural river system is capable of using those "tools" to gradually adjust to flow regime changes due to climate–induced precipitation change. Consequently, the more physical changes the river system has been subjected to, such as changes in sediment budgets and flow regimes due to dams or land clearing, the less capable the system is of responding to or absorbing changed flow regime.

Existing Conditions – Greenhouse Gases

The GHG analysis completed for the Klamath Facilities Removal Environmental Impact Statement/Environmental Impact Report (EIS/EIR) evaluated the following three pollutants: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O). The other two pollutants commonly evaluated in various mandatory and voluntary reporting protocols, hydrofluorocarbons and perfluorocarbons, are not expected to be emitted in large quantities and are not discussed further in this section.

Worldwide, California[3] is the twelfth to sixteenth largest emitter of CO_2 (based on data source), and is responsible for approximately two percent of the world's CO_2 emissions (California Energy Commission [CEC] 2006b). As shown in Figure 3.10-1, transportation is responsible for 37 percent of the State's GHG emissions, followed by electricity generation (24 percent), the industrial sector (19 percent), commercial and residential (9 percent), agriculture and forestry (6 percent) and other sources (5 percent). Emissions of CO_2 and N_2O are largely byproducts of fossil fuel combustion. Methane, a highly potent GHG, results largely from off-gassing associated with agricultural practices and landfills. Sinks of CO_2, which are sources that absorb more CO_2 then release CO_2, include uptake by vegetation and dissolution into the ocean. California GHG emissions in 2008 (the last year inventoried) totaled approximately 474 million metric tons CO_2 equivalent ($MMTCO_2e$) (CARB 2009).

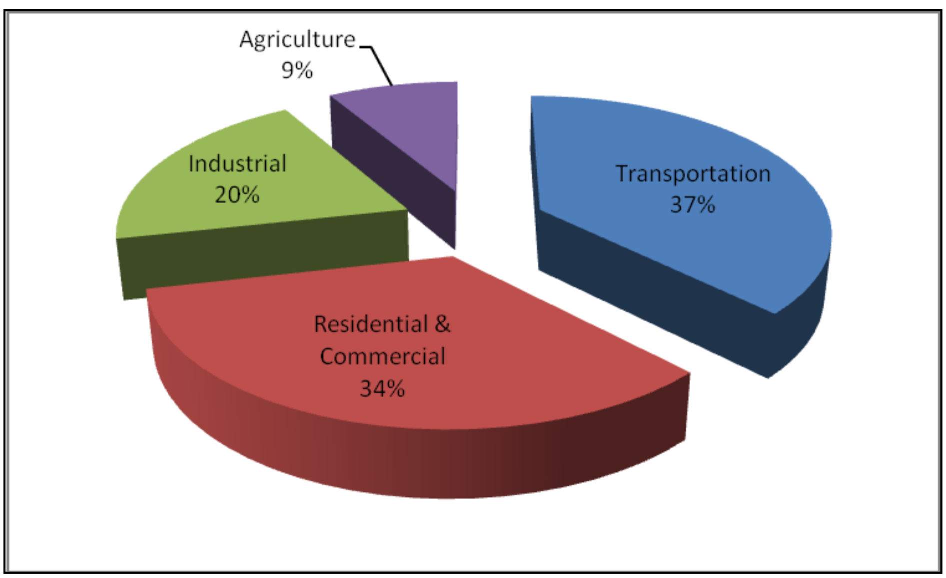
[3] Although the area of analysis for the project is restricted to portions of northern California and southern Oregon, GHG emissions data is not available at this level of detail; therefore, background emissions data (i.e., existing conditions) is presented at the state-level for both California and Oregon.



Source: California Air Resources Board 2009.

Figure 3.10-1. California GHG Emission Sources (as of 2008)

As shown in Figure 3.10-2, the distribution of emission sources in Oregon is similar to that in California, with the majority of emissions occurring from the transportation sector (37 percent), followed by the residential and commercial sector (34 percent), then by industrial sources (20 percent), and agriculture (9 percent). Oregon GHG emissions in 2007 (the last year inventoried) totaled approximately 68 $MMTCO_2e$ (Oregon 2010).



Source: Oregon 2010.

Figure 3.10-2. Oregon GHG Emission Sources (as of 2007)

3.10.4 Environmental Consequences

By its very nature, climate change is a cumulative phenomenon, and it is not possible to link a single project to specific climatological changes. The Proposed Action and alternatives would result in temporary GHG emissions from construction-related activities. Total GHG emissions from deconstruction or construction activities at the three dams in California (Iron Gate, Copco 1, and Copco 2 Dams) would make up 0.0007 to 0.002 percent of statewide emissions, depending on the alternative. Emissions associated with activities at J.C. Boyle Dam in Oregon would make up 0.001 to 0.004 percent of statewide emissions, depending on the alternative.

3.10.4.1 Environmental Effects Determination Methods

The analysis related to climate change was organized into two distinct categories: 1) issues related to how climate change would affect the Proposed Action, and 2) issues related to the quantification of GHG emissions.

The quantification of GHG emissions was performed similarly to the one for the air quality (Section 3.9) analysis with a few exceptions. Project-related emissions were compared to applicable thresholds of significance to evaluate environmental impacts from GHG.

Direct GHG emissions include those associated with on- and off-site construction equipment, construction worker commuting, and haul truck emissions. Indirect GHG emissions include changes that could occur from alterations in land use, agricultural resources, and recreation from implementation of the KHSA and KBRA. See Section 3.9, Air Quality, for additional detail relevant to the estimation of these emissions. In addition, consideration is provided in this section to the potential emissions associated with other power sources that may be used to replace the hydropower associated with the Four Facilities.

This analysis also evaluates how the GHG emissions resulting from the project might affect global climate change. GHG emissions are quantified or qualitatively described, as discussed above, for the changes associated with each project alternative, including land use changes and changes to recreational use.

Climate Change

The purpose of this climate change analysis is to determine how projected changes to climate conditions might affect the Proposed Action and alternatives. The Lead Agencies used the results of global climate models from leading institutions around the world, combined with publicly available, peer-reviewed studies, to identify the projected climate change effects and their consequences specific to the Pacific Northwest region and the Klamath Basin.

The main resources for identifying the project effects and general consequences were the USGCRP climate impact analyses (USGCRP 2009), the Oregon Climate Assessment Report by the OCCRI (OCCRI 2010), the regional climate change effects synthesized by the FHWA (FHWA 2010), the climate change impacts analysis prepared specifically for the Klamath Basin by the National Center for Conservation Science and Policy; and the Climate Leadership Initiative (Barr et al. 2010). The 2009 California Climate Change Strategy also provided guidance for the analysis. For consequences specific to the project alternatives, publications by Palmer et al. (2008), Dinse et al. (2009), and Reclamation (2010) were used to evaluate the effect of dams on a natural system's ability to adjust to and absorb disturbances caused by potential changes in climate conditions.

Greenhouse Gas Emissions Quantification

Emissions of GHG were quantified using the same emission factor models identified in the air quality section (Section 3.9). Emissions of CO_2, CH_4, and N_2O were estimated for on- and off-site combustion sources, including mobile and stationary sources.

Each GHG contributes to climate change differently, as expressed by its global warming potential (GWP). GHG emissions are discussed in terms of carbon dioxide equivalent (CO_2e) emissions, which express, for a given mixture of GHG, the amount of CO_2 that would have the same GWP over a specific timescale. CO_2e is determined by multiplying the mass of each GHG by its GWP[4]. This analysis uses the GWP from the IPCC *Second Assessment Report* (IPCC 1996) for a 100-year time period to estimate CO_2e. Although subsequent assessment reports have been published by the IPCC, the international standard, as reflected in various federal, state, and voluntary reporting programs, is to use GWPs from the *Second Assessment Report*.

GHG emissions were calculated for construction activities related to dam demolition and/or fish passage construction including heavy equipment use, hauling of demolition debris to landfill, as well as worker transportation.

If a United States Environmental Protection Agency (USEPA)-approved emissions factor model (e.g., EMFAC2007, MOBILE6.2, OFFROAD, or NONROAD) does not predict emissions of a particular pollutant, then emission factors were obtained, if possible, from the Federal Mandatory Reporting of Greenhouse Gases Rule (40 CFR Part 98).

The analysis provides a quantitative comparison between removing a renewable source of energy from the hydroelectric dams and estimated emissions that may result from use of an alternative power source, such as fossil fuels, biomass, or other renewable energy sources.

Both Oregon and California have Renewable Portfolio Standard (RPS) goals that seek to increase the amount of renewable energy resources used by certain utilities. The RPS goal for California is to have 33 percent of an electricity seller's load served with renewable power by 2020 (Executive Order S-14-08; and SBX1 2), while Oregon's RPS goal is for 25 percent of a utility's retail sales of electricity to be from renewable energy by 2025 (Senate Bill 838). PacifiCorp is currently on track to meet its Oregon RPS target, but is not expected to meet California's RPS target without the use of tradable renewable

[4] As an example, CH_4 has a GWP of 21, as specified in the Intergovernmental Panel on Climate Change's *Second Assessment Report* (1996). One metric ton of CH_4 is equal to 21 metric tons of CO_2e (1 metric ton x 21).

energy credits (PacifiCorp 2011). Since PacifiCorp is on a trajectory to increase its use of renewable energy, any modifications to the Four Facilities, either by demolition or power generation reductions, would decrease the amount of renewable power that PacifiCorp has in its portfolio. Although short-term effects could occur from modifications to the hydroelectric dams, these effects would be offset in the long-term because PacifiCorp would need to continue increasing its renewable energy share to meet the RPS goals in the two states.

3.10.4.2 Significance Criteria

At the present time, neither of the lead agencies has adopted significance thresholds for the analysis of GHG emissions. However, the CEQA Guidelines instructs:

"A lead agency should consider the following factors, among others, when assessing the significance of impacts from greenhouse gas emissions on the environment:

1. The extent to which the project may increase or reduce GHG emissions as compared to the existing environmental setting.
2. Whether the project emissions exceed a threshold of significance that the lead agency determines applies to the project.
3. The extent to which the project complies with regulations or requirements adopted to implement a statewide, regional, or local plan for the reduction or mitigation of GHG emissions." (14 C.C.R. § 15064.4.)

In reference to factor number 1 stated above, the Klamath Facilities Removal Project would produce a temporary increase in direct GHG emissions by virtue of the construction and restoration activities, but once activities are complete, direct project emissions be reduced. With complete facilities removal, there would be no continuing operation or maintenance since the area occupied by the facilities would be returned to natural riverine and riparian setting. The partial facilities removal alternatives would still continue to have operation and maintenance emissions, but to a lesser degree than the No Action/No Project Alternative. Indirect GHG emissions would increase with the project as a result of replacing hydropower produced at the dams with power that is likely to be produced, at least in part, from fossil fuels through other regional sources.

As for factor number 2 (above) from the CEQA guidelines, the nature of the GHG emissions from the Klamath Facilities Removal Project differs from most projects considered highest priority for curbing emissions either on a statewide or regional basis. Typical emission sources considered for quantitative thresholds of significance involve construction and ongoing operational emissions from stationary industrial projects with high rates of combustion emissions (for example, refineries, power plants, other processing that utilizes industrial boilers) or the construction and increased power and transportation needs from newly constructed residential/commercial projects. In these cases ongoing emissions from combustion and transportation are likely to be cumulatively considerable.

For the Proposed Action and alternatives, there are no direct operational GHG emissions. Appreciable direct emissions would occur only for a limited time as a result of construction (dam deconstruction and/or fish passage construction) and restoration. However, the Proposed Action would indirectly produce ongoing GHG emissions through conversion from the electricity produced by the local hydropower facilities to regional power from a mixture of sources likely including GHG-emitting fossil fuels.

Currently, there are no adopted numerical thresholds of significance in California that are specifically applicable to the Klamath Facilities Removal Project. The South Coast Air Quality Management District (SCAQMD) and the Bay Area Air Quality Management District have adopted numerical CEQA thresholds of significance for industrial stationary source GHG emissions; both districts use a threshold of 10,000 $MTCO_2e$ per year (Bay Area Air Quality Management District 2011; SCAQMD 2008). Only the SCAQMD's threshold addresses construction emissions. SCAQMD amortizes construction emissions over a thirty-year period. The annual quantity is combined with a project's annual operational emissions and compared to the 10,000 $MTCO_2e$ per year threshold to determine significance.

Regarding the statewide plan for reducing GHG emissions for factor number 3 from the CEQA guidelines, a GHG impact could be considered significant if emissions from either the Proposed Action or the alternatives exceed at least one of the two thresholds utilized in this EIS/EIR for GHG emissions. The first threshold is based on SCAQMD's methodology and as a result, GHG emissions would be significant if they exceed 10,000 $MTCO_2e$ in a year. SCAQMD developed its threshold to address emissions from stationary source/industrial projects. However, because there are no adopted numerical thresholds for construction emissions, and the SCAQMD threshold incorporates construction emissions to its determination, using the SCAQMD method for the current project is justified.

The second manner in which a GHG impact would be significant is if GHG emissions from either the Proposed Action or the alternatives would substantially obstruct compliance with the GHG emission reductions in AB 32 and Executive Order S-3-05. Compliance with the AB 32 goal of reducing California’s GHG emissions by 2020 to 1990 levels requires cutting at least 29 percent of business-as-usual emissions (i.e., emissions projected by CARB for the year 2020 without any emission reduction measures) (CARB 2008). Executive Order S-3-05 further reduces the state’s emissions to 80 percent below 1990 levels by 2050. Thus, the calculated emissions from Proposed Action or from any alternative should be compared to emissions that would be produced if implemented in accordance with the assumptions CARB used to calculate its business-as-usual scenario. If emissions from the Proposed Action or alternatives are at least 29 percent below business-as-usual in 2020, impacts could be considered less than significant. For purposes of this EIS/EIR, the calculated GHG emissions from the Proposed Action or alternatives will be compared to existing numerical thresholds of significance for industrial and residential projects (factor 2) and to the statewide plan for reducing emissions outlined in AB 32 and Executive Order S-3-05.

3.10.4.3 Effects Determinations

Emissions of GHG would occur from construction activities associated with either removing dams or constructing fish passage facilities. Direct emissions of GHG would occur from engine exhaust emissions from off-road construction equipment, on-road trucks, and construction worker commuting vehicles. Emissions were estimated using various emission factor models, including CARB's EMFAC2007 and OFFROAD2007 for on- and off-road exhaust emissions and USEPA's MOBILE6.2 and NONROAD2008 for engine exhaust emissions. Fugitive dust emissions were also estimated using CARB's URBEMIS2007 (version 9.2.4) model and additional calculations from AP-42 (USEPA 1995). Detailed calculations from each alternative are provided in Appendix N.

Indirect GHG emission changes could also occur from alterations in land use, agricultural resources (including the creation of new agricultural areas), and recreation from implementation of the KHSA and KBRA. These emission changes could occur from changing open water reservoirs to one of the following categories that could replace the reservoirs:

- Grassland/pasture (including cattle grazing)
- Wetlands (with increased sequestration)[5]
- Re-planting of forests (including riparian vegetation)

Changes in recreational activities, such as decreases in motorized vehicles and increases in non-motorized vehicles, would also occur from the potential removal of the dams. It is expected that the removal of the dams would result in a decrease in motorized recreation activities from the elimination of the open water reservoirs, which would consequently result in a reduction of GHG emissions.

Sediments in reservoirs contain carbon that is formed from the decomposition of accumulated dead plankton and other debris that could be released when a dam is decommissioned. If anoxic digestion causes the carbon to be released in the form of CH_4, then there could be a net negative impact of the existing reservoirs associated with the dams because of the higher GWP of CH_4 as compared to CO_2 (Pacca 2007).

Except for emissions from power plant operations and maintenance, GHG emissions from hydropower are negligible because no fuels are burned; however, plant matter can decay in the reservoir, causing the buildup and release of CH_4 (USEPA 2007). Analyzing the magnitude of these CH_4 emissions is difficult, but it is important to understand that open water reservoirs associated with hydropower may have a certain level of CH_4 emissions from their operation. The Klamath Hydroelectric Project reservoirs have characteristics that would favor high CH_4 emissions: they receive massive organic/nutrient loads from upstream, have large in-reservoir algal blooms, and have anoxic hypolimnions (See Section 3.2, Water Quality).

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[5] Sequestration is the process of removing carbon from the atmosphere and storing it in carbon sink.

The USEPA has also estimated carbon sequestration rates from a variety of agricultural and forestry practices. Table 3.10-3 summarizes the carbon sequestration rates documented by the USEPA. Insufficient information is available to estimate the exact carbon sequestration that could occur from the conversion of the open water reservoirs to one of these other land uses; however, it is expected that a net reduction in carbon emissions could occur from the land use conversion.

Table 3.10-3. Representative Carbon Sequestration Rates and Saturation Periods for Key Agricultural and Forestry Practices

Activity	Representative Carbon Sequestration Rate (metric tons of C per acre per year)	Time Over Which Sequestration May Occur Before Saturating[1]
Afforestation[2]	0.6 – 2.6[3]	90–120+ years
Reforestration[4]	0.3 – 2.1[5]	90–120+ years
Changes in forest management	0.6 – 0.8[6]	If wood products included in accounting, saturation does not necessarily occur if C continuously flows into products
	0.2[7]	
Conservation of riparian buffers	0.1 – 0.3[8]	Not calculated
Conversion from conventional to reduced tillage	0.2 – 0.3[9]	15–20 years
	0.2[10]	25–50 years
Changes in grazing land management	0.02 – 0.5[11]	25–50 years
Biofuel substitutes for fossil fuels	1.3 – 1.5[12]	Saturation does not occur if fossil fuel emissions are continuously offset

Source: United States Environmental Protection Agency 2010a.

Notes:

1 Values refer to the level of time during which sequestration could be occurring. After the stated period, then there would cease to be a positive effect from the carbon sink.

2 Values are for average management of forest after being established on previous croplands or pasture.

3 Value calculated over 120-year period. Low value is for spruce-fir forest type in lake states; high value is for Douglas Fir on Pacific Coast. Soil carbon accumulation is included in estimate.

4 Values are for average management of forest established after clear-cut harvest.

5 Values calculated over 120-year period. Low value is for Douglas Fir in Rocky Mountains; high value is for Douglas Fir in Pacific Coast. No accumulation in soil carbon is assumed.

6 Select examples, calculated over 100 years. Low value represents change from 25-year to 50-year rotation for loblolly pines in Southeast; high value is change in management regime for Douglas Fir in Pacific Northwest. Carbon in wood products included.

7 Forest management here encompasses regeneration, fertilization, choice of species, and reduced forest degradation. Average estimate here is not specified to US, but averaged over developed countries.

8 Assumed that carbon sequestration rates are the same as average rates for lands under United States Department of Agriculture Conservation Reserve Program.

9 Estimates include only conversion from conventional to no-till for all cropping systems except for wheat-fallow systems, which may not produce net carbon gains. Estimates of changes in other GHG not included.

10 Assumed that average carbon sequestration rates are the same for conversion from conventional till to no-till, mulch till, or ridge till. Estimates of changes in other GHG not included.

11 See Improve/Intensity Management section in Table 16.1 of Follett et al. (2001). Low end is improvement of rangeland management; high end is changes in grazing management on pasture, where soil organic carbon is enhanced through manure additions. Estimates of flux changes in other GHG not included.

12 Assumes growth of short-rotation woody crops and herbaceous energy crops, and that burning this biomass offsets 65 to 75 percent of fossil fuel in CO_2 estimates. Estimates of changes in other GHG not included.

Key:

C = carbon

If the land behind the removed dams is converted to agricultural use such a cattle grazing, certain agricultural practices could result in an increase in GHG emissions. For example, grasslands and pastures could serve as carbon sinks, but cattle grazing could actually counteract some of these sinks. Section 4.9 of the Federal Energy Regulatory Commission (FERC) EIS discusses this issue further. Emissions from the digestion of cattle feed and manure management would result in net GHG emissions. Additional information on the number of head of cattle and the total size of the land conversion would be necessary to estimate whether there would be a net benefit or adverse impact from possible cattle grazing.

Alternative 1: No Action/No Project Alternative

Effects of Climate Change on the No Action/No Project Alternative

The No Action/No Project Alternatives would likely require greater management actions, policies, and mitigation measures to protect the surrounding ecosystems and communities as compared to actions that include dam removal because the Klamath Basin is more likely to experience a greater magnitude of consequences from the projected changes in climate conditions than if the dams were removed. The situation might require costly future projects to prevent or respond to the consequences of climate change. For example, disturbances caused by drought, changes to vegetation, changes to water quality characteristics, and changes to fish and shellfish populations and patterns might not be able to be adjusted to or absorbed as easily with the dams in place as without them. The baseline temperatures on the mainstem of the Klamath River are stressful for fish, and fish rely on small areas of refugia (typically near tributary inflow). Increased ambient temperatures could increase water temperatures. Therefore climate change is likely to reduce or possibly eliminate these refugia, making the temperature in the mainstem of the river unsuitable for fish rearing and movement during critical times of the year. Increased energy expenditure for rescuing fish or removing them to controlled (hatchery-type) situations may then be necessary for maintaining viable fish populations in the Klamath Basin.

Also, free-flowing rivers, in general, respond better to changes in climate conditions due to the ability to adjust to and absorb disturbances through flow adjustments that buffer against impacts (Palmer et al. 2008). A natural riverine system is in constant, dynamic equilibrium, absorbing highly variable flow forces by changing channel morphology and dissipating energy via sediment transport and woody debris. A natural river system is capable of using those “tools” to gradually adjust to flow regime changes due to climate–induced precipitation change. Consequently, the more physical changes the river system has been subjected to, such as changes in sediment budgets and flow regimes due to dams or land clearing in the basin or riparian zones, the less capable the system is of responding to or absorbing changed flow regime.

As described in Section 3.2, Water Quality, climate change would cause general increases in water temperature that could decrease the 100 percent saturation level for dissolved oxygen. This decrease in dissolved oxygen concentration at saturation would act in opposition to successful total maximum daily load implementation. Climate change would increase the possibility of continued exceedance of the minimum dissolved oxygen objectives in the region.

As described in Section 3.3, Aquatic Resources, the temperature in the Klamath River Estuary and Pacific Ocean would remain similar to the existing conditions and climate change would continue to play a role in future temperatures. Warmer water temperatures associated with climate change would increase the frequency and duration of stressful water temperatures for cold-water species, including all anadromous fish and salmonids in the basin. For warm-water species, little effect would likely result from this level of warming.

Effects of the No Action/No Project Alternative on Climate Change

Vehicle exhaust from operation and maintenance of the Four Facilities and continued water impoundment in the reservoirs could result in GHG emissions. Under the No Action/No Project Alternative, none of the activities under the KHSA would be completed. Since the removal of the dams or the construction of fish passages would not occur, there would be no emissions associated with construction; however, ongoing CH_4 emissions from anaerobic decay in the impoundment would still occur under the No Action/No Project Alternative. Continual emissions would also occur from equipment use and worker commute for operation and maintenance of facilities.

The Karuk Tribe (2006) estimated the total amount of CH_4 released from Keno, J.C. Boyle, Copco, and Iron Gate Reservoirs, calculated by multiplying the reservoirs' area by areal emissions rates from reservoirs around the world with similar characteristics (poor water quality). The resulting estimate ranged from approximately 8,000 to 29,000 $MTCO_2e$ per year[6]. Without Keno Impoundment, CH_4 emissions would be approximately 4,000 to 14,000 $MTCO_2e$ per year for Iron Gate, Copco, and J.C. Boyle Reservoirs. Under the No Action/No Project Alternative, releases of CH_4 from the reservoirs would continue at the same levels. See Appendix N for detailed calculations. **There would be no change from existing conditions from GHG emissions from vehicle emissions or continued impoundment of water relative to existing conditions.**

Activities associated with several interim measures (IMs) could result in short-term and temporary increases in GHG emissions from vehicle exhaust. Several IMs would be implemented under the No Action/No Project Alternative. Several of these measures could result in increased GHG emissions:

- IM 7: J.C. Boyle Gravel Placement and/or Habitat Enhancement
- IM 8: J.C. Boyle Bypass Barrier Removal

IM 7 would require PacifiCorp to place suitable gravels in the J.C. Boyle Bypass and Peaking reaches using a passive approach before high flow periods or to provide for other

[6] The emission estimation ranges provided in this section are based on a GWP of 21 for CH_4; the original Karuk Tribe calculation assumed a GWP of 23, but the calculation was changed to be consistent with the rest of the report.

habitat enhancement. The No Action/No Project Alternative includes only one year of this measure. GHG emissions could occur from trucks hauling gravel to the J.C. Boyle Bypass and Peaking reaches; however, the number of trucks required to deliver gravel is expected to be minor.

IM 8 requires the removal of the sidecast rock barrier located approximately 3 miles upstream of the J.C. Boyle Powerhouse in the J.C. Boyle Bypass Reach. Potential GHG emissions are expected to be less than those quantified for the removal of Copco 1 from demolition activities.

Based on the limited amount of construction equipment expected to be used simultaneously, it is likely that emissions from implementation of the IMs would not exceed the significance criteria. **The impact on GHG emissions and climate change from implementing the IMs would be less than significant.**

Reducing a renewable source of power could result in GHG impacts from possible non-renewable alternate sources of power. Under the No Action/No Project Alternative, the Four Facilities would continue to operate under annual licenses. Continued operation would not change existing GHG emissions from the Four Facilities. While the No Action/No Project Alternative assumes annual renewal of licenses, relicensing of the Four Facilities could result in the need for replacement power and subsequent changes in GHG emissions from any changes in renewable sources of power. If relicensing occurred, the amount of electricity produced could reduce as a result of redirecting a certain quantity of river flow from power generation to bypass or fish passage. For example, the FERC EIS (2007) determined that power generation under the Staff Alternative with Mandatory Conditions would produce 141,859 less megawatt-hours per year than PacifiCorp's proposal. If relicensing were to require the annual average electricity output to be reduced, then the reduction in power would need to be replaced with another source. As explained below under Alternative 2, the production of replacement electric generation would, in the near term, result in increased GHG emissions. Such other sources may result in increased GHG emissions (i.e., coal-fired power plant(s)). **Under the No Action/No Project Alternative that assumes annual licensing, there would be no change from existing conditions from GHG emissions relative to existing conditions.**

Vehicle exhaust from several ongoing restoration actions could increase GHG emissions. Under the No Action/No Project Alternative, some restoration actions in the Klamath Basin are currently underway and would be implemented regardless of the Secretarial Determination on the removal of the Four Facilities. The Fish Habitat Restoration activities could result in GHG emissions. This project would involve some limited construction activities that could result in short-term temporary GHG emissions in the Upper Basin. In addition, the Climate Change Assessment would ensure that long-term climate change in the Klamath Basin is assessed early and continuously. **The GHG emissions related to construction of ongoing restoration actions would be less than significant.**

Alternative 2: Full Facilities Removal of Four Dams (Proposed Action)

Effects of Climate Change on the Proposed Action

The projected changes in precipitation would result in drier summers and increased frequency and severity of extreme events (USGCRP 2009; Barr et. al. 2010; OCCRI 2010). These precipitation changes would produce some adverse effects in the Klamath Basin. Adverse effects could include increased flooding, decreasing water quality (due mainly to the effects of higher water temperatures and changing vegetation), higher fire potential (with subsequent water quality impacts), and adverse low flow conditions due to summer droughts.

Average annual air temperatures are projected to increase by 3°F to over 8°F in the next century. Temperature changes would increase water temperature; water temperature increases could create stressful conditions for fish during some times of the year and reduce the migration window. The Proposed Action would create initial decreases in water temperature by removing dams and increasing river flows, but climate change could partially offset some of these temperature improvements.

The Proposed Action is positioned to respond to the changes in climate conditions compared to the No Action/No Project Alternative. Dam removal can increase ecosystem resiliency by restoring floodplain wetlands, which allow the river system to handle the projected changes in seasonal precipitation (Dinse et al. 2009). Also, sediment budgets may return to pre-controlled conditions, revegetation of the watershed can replace missing large woody debris, and more dynamic flow regimes can diversify channel morphology and increase habitat complexity.

Benefits of full dam removal would begin to offset the projected changes and impacts from climate change. These benefits include additional floodplain and riparian zone to reduce peak flooding impacts; improved water quality by removing large quiescent water areas that are subject to temperature increases and evaporation; increased woody debris and restored natural sediment budget to improve in-channel habitat diversity; more available stream channel habitat; a migration corridor for fish to move further upstream to find cooler water; access to the largest concentration of cold springs and spring-dominated tributaries in the Klamath Basin; and improved habitat quality, water quality, and riparian and floodplain functionality in and above Upper Klamath Lake. In contrast, the No Action/No Project Alternative would require modified management and dam operations to off-set flow regime changes; provide no new opportunities for new in-channel or riparian/floodplain habitat; and be subject to greater water quality impacts due to projected temperature increases.

As described in Section 3.2, Water Quality, removal of the reservoirs under the Proposed Action would result in a 1 to 2 degrees Celsius (^{o}C) increase in spring water temperatures and a 2 to 10 ^{o}C decrease in late-summer/fall water temperatures immediately downstream of Iron Gate Dam. These effects would decrease in magnitude with distance downstream of the dam and would not be evident by the Salmon River confluence (approximately river mile [RM] 66) (PacifiCorp 2004, Dunsmoor and Huntington 2006, North Coast Regional Water Quality Control Board 2010, Perry et al. 2011). General warming of water temperatures under climate change is projected to be on the order of 1 to 3°C in the Klamath Basin (Bartholow 2005, Perry et al. 2011), which would partially offset anticipated water temperature improvements from the Proposed Action, particularly further downstream of Iron Gate Dam where the improvements would be of smaller magnitude. However, overall the primary effect of dam removal is still anticipated to be the return of approximately 160 miles of the Klamath River, from J.C. Boyle Reservoir (RM 224.7) to the Salmon River (RM 66), to a natural thermal regime. This return would also include increased daily fluctuations in water temperature immediately downstream of Copco 1 and Iron Gate Dams, as water temperatures once again achieve equilibrium with (and reflect) daily fluctuations in ambient air temperatures. In contrast, in the Bypass Reach downstream of J.C. Boyle Dam, daily fluctuations in water temperature would decrease under the Proposed Action, as hydropower peaking flows would not occur.

As described in Section 3.3, Aquatic Resources, improvement in the river thermal regime by the Proposed Action would likely moderate the anticipated stream temperature increases resulting from climate change.

Effects of the Proposed Action on Climate Change

Vehicle exhaust from dam removal activities could increase GHG emissions in the short-term to levels that could exceed the significance criteria. The emission sources would include off-road construction equipment, on-road trucks, and construction worker commuting vehicles. These emissions would be temporary, occurring only during the dam removal period of nine months (January through September 2020). Table 3.10-4 summarizes uncontrolled annual emissions (not controlled by any mitigation measures) associated with the Proposed Action. Appendix N contains detailed GHG emissions calculations.

Table 3.10-4. Uncontrolled Direct GHG Emissions Inventories for Proposed Action – Full Facilities Removal

Location	Project Emissions ($MTCO_2e$/year)[1]			
	CO_2	CH_4	N_2O[2]	Total
	2020			
Iron Gate	4,106	4	n/a	4,110
Copco 1	1,459	1	n/a	1,461
Copco 2	970	1	n/a	971
J.C. Boyle	2,016	<1	n/a	2,016
Total Emissions	**8,551**	**6**	**n/a**	**8,558**
California Total	6,535	6	n/a	6,542
Oregon Total	2,016	n/a	n/a	2,016

Notes:
[1] GWPs from the IPCC's *Second Assessment Report* (1996) were used in the emission calculations. GWPs of 1, 21, and 310 were used for CO_2, CH_4, and N_2O, respectively.
[2] N_2O emissions are not estimated directly from the various emission calculation models; therefore, emissions estimates are zero for most equipment.
Key:
CO_2 = carbon dioxide
CH_4 = methane
N_2O = nitrous oxide
$MTCO_2e$/year = metric tons carbon dioxide equivalent per year

Cofferdams would be constructed at the Four Facilities during deconstruction activities. Concrete rubble, rock, and earthen materials that would come from the dam removal activities would be used as possible to construct the cofferdams. Construction of the cofferdams from materials salvaged from the dam demolition activities would reduce the need for importing new construction materials.

It is likely that sulfur hexafluoride (SF_6) would be released during deconstruction because the breakers would be emptied. Although SF_6 has a relatively high GWP, sufficient data was not available at the time of this writing to quantify emissions.

As Table 3.10-4 shows, there would be a net increase in GHG emissions from deconstruction of the dams; however, these emissions would be temporary and would not contribute to long-term emissions.

Construction related activities associated with decommissioning of the dams would contribute 8,558 $MTCO_2e$ to California's GHG emission for one year[7]. Amortizing these construction emissions over thirty years results in approximately 285 $MTCO_2e$ per year, well below the 10,000 $MTCO_2e$ threshold. Moreover, even without amortizing construction emissions over thirty years such emissions are 1,442 $MTCO_2e$ below the threshold. The 1990 GHG emissions level (and so the 2020 emissions target ascribed by AB 32) is 427 million metric tons of CO_2e ($MMTCO_2e$). The emissions from dam removal would be 0.002 percent of the target emissions. In 1990, GHG emissions from construction were 0.67 $MMTCO_2e$; therefore, the Proposed Action would equal approximately 1 percent of allowable construction emissions. **The one year construction emissions would not exceed the established significance threshold for ongoing industrial emissions. Therefore, the GHG emissions related to construction would be less than significant.**

Construction of a new, elevated City of Yreka water supply pipeline and steel pipeline bridge to support the pipe above the river could result in short-term and temporary GHG emissions from vehicle exhaust. On- and off-road construction equipment would be used to complete the relocation and construction of the Yreka water supply pipeline. Sufficient information is not currently available to quantify emissions; however, the quantity of equipment required to complete the construction would be less than that required to complete dam demolition activities because of the scale of the two activities. Also, these emissions would occur in 2019 and would not overlap with other construction or demolition activities. Since dam demolition activities would be less than significant, it is likely that emissions from the construction of the Yreka water supply pipeline would also not exceed the significance criteria. **The impact on GHG emissions and climate change**

[7] The value of 8,558 $MTCO_2e$ includes emissions from the JC Boyle Dam. Although JC Boyle Dam is located in Oregon, CEQA requires project impacts to be evaluated for significance. Since the Proposed Action includes the removal of JC Boyle Dam, emissions from its removal were included in the significance determination.

from the construction of the Yreka water supply pipeline would be less than significant.

Activities associated with several IMs could result in short-term and temporary increases in GHG emissions from vehicle exhaust. Prior to construction, IMs as described in the KHSA (KHSA Section 1.2.4) would be implemented and would control operations of the hydroelectric facilities. Several of the IMs in the Proposed Action could result in increased GHG emissions:

- IM 7: J.C. Boyle Gravel Placement and/or Habitat Enhancement
- IM 16: Water Diversions

IM 7 would require PacifiCorp to place suitable gravels in the J.C. Boyle Bypass and Peaking reaches using a passive approach before high flow periods or to provide for other habitat enhancement. The Proposed Action includes seven years of implementing this measure. GHG emissions could occur from trucks hauling gravel to the J.C. Boyle Bypass and Peaking reaches; however, the number of trucks required to deliver gravel is expected to be minor.

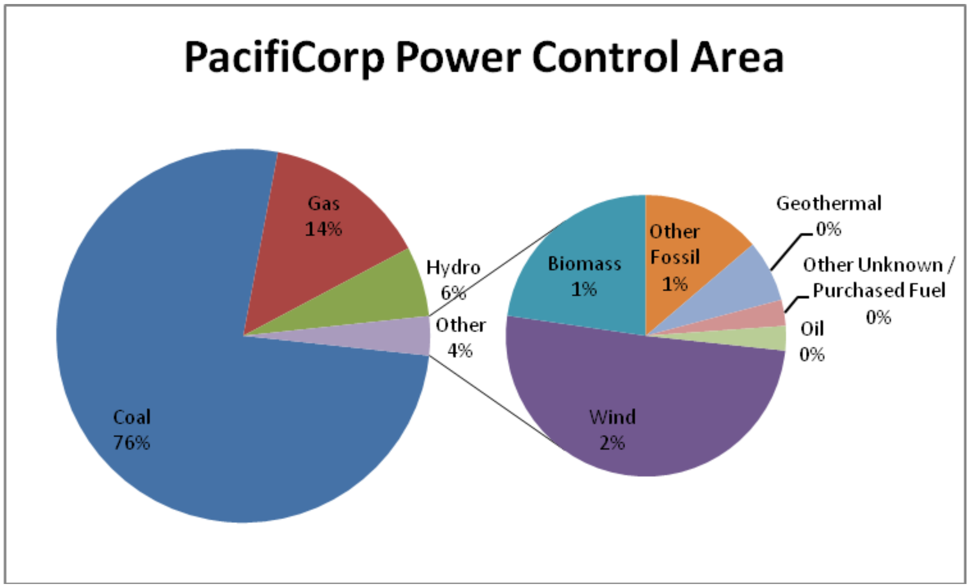
IM 16 would eliminate three screened diversions from Shovel and Negro Creeks and would also require the installation of screened irrigation pump intakes, as necessary, in the Klamath River. Limited construction equipment and haul trucks would be required to remove the screened diversions.

Since dam demolition activities would be less than significant, and the scale of emissions expected from the IMs is expected to be substantially less than dam removal, it is likely that emissions from implementation of the IMs would also not exceed the significance criteria. **The impact on GHG emissions and climate change from implementing the IMs would be less than significant.**

Restoration actions could result in short-term and temporary increases in GHG emissions from the use of helicopters, trucks, and barges. Following drawdown of the reservoirs, revegetation efforts would be initiated to support establishment of native wetland and riparian species on newly exposed sediment. Upper areas would be reseeded from a barge until the reservoir levels become too low to operate and access the barge. Aerial application would be necessary for precision applications of material near sensitive areas and the newly established river channel. Aerial hydroseeding is scheduled to begin on March 15, 2020 and last for 10 days at Iron Gate and 20 days at Copco. Trucks would also be used as necessary to provide seeding. Additional fall seeding may be necessary to supplement areas were spring hydroseeding was unsuccessful. Sufficient information is not currently available to quantify emissions; however, emissions are not expected to impede compliance with AB 32. The short duration of hydroseeding would minimize any emissions that would occur. Furthermore, the addition of new grassland and other vegetation would sequester CO_2 emissions in the long-term, but the sequestered CO_2 would likely not offset all of the emissions occurring during restoration on an annual basis. It is possible that the addition of emissions from the barges and trucks to other dam demolition activities could cause emissions to exceed the 10,000 $MTCO_2e$ per year threshold; however, even if emissions doubled, amortized emissions over thirty years would not exceed the applicable threshold. **The impact on GHG emissions and climate change from revegetation would be less than significant.**

Relocation and demolition of various recreation facilities could result in short-term and temporary increases in GHG emissions from vehicle exhaust. The demolition of the Four Facilities would change recreational opportunities from reservoir-based recreation to river-based recreation. This change would require several recreation facilities to be relocated or demolished. On- and off-road construction equipment would be used to complete these activities, which would occur after the dam demolition actions. Sufficient information is not currently available to quantify emissions; however, the quantity of equipment required to relocate or demolish recreation facilities would be less than that required to complete dam demolition activities because of the scale of the two activities. Since dam demolition activities would be less than significant and changes to the recreation facilities would not overlap, it is expected that emissions from these activities would also not exceed the significance criteria. **The impact on GHG emissions and climate change from the relocation and demolition of recreation facilities would be less than significant.**

Removing a renewable source of power by removing the dams could result in increased GHG emissions from possible non-renewable alternate sources of power. GHG emissions could occur in the event that the renewable source of power represented by the Four Facilities was replaced by other emissions sources. As shown in Figure 3.10-3, the 2007 electricity generation resource mix for the PacifiCorp Power Control Area (PCA), which is a region of the power grid in which all power plants are centrally dispatched, is dominated by coal (76 percent), natural gas (14 percent), and hydroelectricity (6 percent). The data provided is the most recent data available from the USEPA (2010b) and represents the resource mix that would be available if any replacement energy was obtained from PacifiCorp's resource mix as of 2007. It is acknowledged that PacifiCorp's current resource mix is different than the 2007 data (PacifiCorp 2011), specifically with a decrease in the reliance on coal and an increase in reliance on natural gas, hydroelectricity, and other renewable energy sources; however, the information in the 2011 Integrated Resource Plan (PacifiCorp 2011) is not sufficient to develop emission factors.



Source: United States Environmental Protection Agency 2010b.

Figure 3.10-3. PacifiCorp Power Control Area Generation Resource Mix (as of 2007)

Although using the 2007 data provides emissions results that would be higher than the current resource mix, using Emissions & Generation Resource Integrated Database (eGRID) data is consistent with inventory requirements of multiple voluntary and mandatory reporting protocols; therefore, the 2007 eGRID data was used for the analysis.

Electricity originally produced from the Four Facilities, if removed, would likely be replaced with another source within the PacifiCorp PCA because the amount of electricity provided by the Four Facilities is approximately 2 percent of PacifiCorp's total generation capacity (CEC 2006a). Emission rates from the grid were estimated assuming that all power sources within the PCA would remain except for East Side, West Side, J. C. Boyle, Copco 1, Copco 2, Iron Gate Dams.

PacifiCorp's 2011 Integrated Resource Plan provides an overview of the company's available generation capacity. According to the Integrated Resource Plan, PacifiCorp will be at "summer peak resource deficit" beginning in 2011 (PacifiCorp 2011). This deficit is to be met in the short term with additional renewable, demand-side programs, and market purchases from other generating companies (PacifiCorp 2011). PacifiCorp outlined a series of actions in the plan to meet the widening resource deficit, including the addition of 800 megawatts (MW) of wind resources by 2020, the acquisition of 1,200 MW of demand side management programs by 2020, acquisition of 8.7 MW of solar, and economic investigation of 30 MW from solar hot water heating resources and over 100 MW of geothermal resources (PacifiCorp 2011). Although it may be possible for PacifiCorp to replace the existing hydropower from the Four Facilities with additional renewables, this analysis assumes the replacement power will come from the resource mix shown in Figure 3.10-3 of PacifiCorp power sources to provide a worst-case analysis of emissions. The analysis was adjusted so that the base load was assumed to be served by this resource mix, while peaking power would be supplied by natural gas.

In the long-term, PacifiCorp is under obligation to meet the Renewable Portfolio Standard (RPS) goals in California and Oregon. The RPS goal for California is to have 33 percent of an electricity seller's load served with renewable power by 2020 (Executive Order S-14-08; and SBX1 2), while Oregon's RPS goal is for 25 percent of a utility's retail sales of electricity to be from renewable energy by 2025 (Senate Bill 838). PacifiCorp is currently on track to meet its Oregon RPS target, but it expected to be under California's RPS target (PacifiCorp 2011). PacifiCorp plans on using flexible compliance mechanisms (e.g., banking, earmarking, and tradable renewable energy credits) to meet California's RPS standards. In the long-term, it is expected that PacifiCorp would be able to eventually replace the lost energy from the dams with other sources of renewable energy.

Emissions were calculated assuming that PacifiCorp met its RPS obligations (i.e., 33 percent renewable power in California). As a result, the off-peak emissions were calculated assuming that 33 percent of the power would be served by renewable power (an increase from the existing portfolio assumption of approximately nine percent renewable power).

The average annual electricity generation from the Klamath Hydroelectric Project is 716,800 megawatt-hours (MWh). This includes generation from the following developments: East Side, West Side, J.C. Boyle Dam, Copco 1 Dam, Copco 2 Dam, Fall Creek Dam, and Iron Gate Dam. Since East Side, West Side, and Fall Creek Dam are not part of the Proposed Action, then the total amount of power that would need to be replaced would be equal to 686,000 MWh[8].

Data from eGRID was used to estimate GHG emissions from a potentially different mix of energy sources (USEPA 2010b). It is recognized that the FERC EIS used carbon intensity factors from Hadley and Sale (2000); however the carbon intensity factors were

[8] The GHG analysis is based on an estimate of the annual reliable hydroelectric power generation for the PacifiCorp Klamath Hydroelectric Project. Power generation was estimated using annual electricity generation estimates provided for each alternative in Chapter 4 of the Federal Energy Regulatory Commission (FERC) Final Environmental Impact Statement (EIS) for Hydropower License (2007). The FERC EIS power generation results allowed for a quantitative comparison of GHG effects for all alternatives considered in this EIS/EIR using information publically available on June 14, 2010 when the notice of intent was published. Since that time, United States Department of the Interior (DOI) modeled annual reliable hydroelectric power generation with updated hydrology and inclusion of planned upgrades that would improve the efficiency and maximum capacity of the hydroelectric project (for the Alternative 1: No Action/No Project Alternative and Alternative 2: Proposed Action (DOI 2011a; DOI 2011b). Under the Alternative 1: No Action/No Project Alternative, annual reliable hydroelectric power generation is greater than the annual generation estimates in the FERC EIS. Therefore, under the Alternative 2: Proposed Action, the DOI model generated increased annual reliable hydropower generation, increasing the estimated replacement power needed to compensate for decommissioning of power facilities, and in turn increasing the overall GHG production attributed to the Proposed Action as compared to the FERC EIS. However, increased GHG production would not change the findings in this EIS/EIR because the significance determination for Alternative 2: The Proposed Action remains significant and unavoidable after mitigation. Therefore, evaluating GHG production using the DOI model to estimate annual production is not essential to a reasoned choice among the alternatives.

based on the entire Western Electricity Coordinating Council and represented CO_2 emissions only. The eGRID method of estimating emissions is consistent with the recommendations in multiple general and mandatory reporting protocols and was based on electricity generated by PacifiCorp-owned facilities. As a result, it reflects a conservative estimate of emissions.

The lead agencies acquired data for all of the plants within the PacifiCorp PCA and derived emission factors from this source with the applicable dams removed from the mix. The power plants within the PacifiCorp PCA are in California, Colorado, Idaho, Montana, Oregon, Utah, Washington, and Wyoming; all or most of the emissions from these plants would occur outside of the area of analysis. Table 3.10-5 summarizes replacement power emissions that would be associated with the removal of the dams assuming that the current power resource mix was used. Table 3.10-6 summarizes replacement power emissions that would be associated with the removal of the dams assuming that PacifiCorp's RPS obligations were met.

Iron Gate, Copco 1, and Copco 2 are California RPS-eligible facilities (CEC 2011)[9]. The reduction in renewable energy sources is contrary to implementation of AB 32 but the significance would diminish as new renewable sources are developed. Although it is expected that PacifiCorp would add new sources of renewable power that would replace the removed dams, this analysis provides a conservative assumption that emissions could still occur when the dams are removed.

Table 3.10-5. Electricity Generation GHG Emissions from Replacement Sources after Removal of Four Dams (Existing Resource Mix)

Location	Generation (MWh)[1]	Annual Emissions (metric tons per year)[2]			Annual CO_2e Emissions ($MTCO_2$e/year)[3]			
		CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	Total
Iron Gate	116,000	66,802	2	1	66,802	38	219	67,059
Copco 1	106,000	61,043	2	1	61,043	35	200	61,278
Copco 2	135,000	77,744	2	1	77,744	44	255	78,043
J.C. Boyle	329,000	189,465	5	2	189,465	107	622	190,194
Total	686,800	395,054	11	4	395,054	224	1297	396,575

Notes:
1 Generation based on FERC EIS (based on 2007 generation data).
2 Emissions assume that 64 percent of power would be generated on-peak using natural gas; the remaining 36 percent would be generated off-peak using the PacifiCorp PCA resource mix. Off-peak emission factors were calculated from the annual emissions and generation for all sources within the PacifiCorp PCA (USEPA 2010b) except for the dams proposed to be removed.
3 GWPs from the IPCC's *Second Assessment Report* (1996) were used in the emission calculations. GWPs of 1, 21, and 310 were used for CO_2, CH_4, and N_2O, respectively.

Key:
CO_2 = carbon dioxide
CO_2e = carbon dioxide equivalent
CH_4 = methane
N_2O = nitrous oxide
MWh = megawatt hour
lb/MWh = pounds
lb/GWh = pounds per gigawatt-hour
GWP = global warming potential
$MTCO_2$e/year = metric tons carbon dioxide equivalent per year

9 For a hydroelectric facility to qualify for California's RPS, it must be 30 megawatts (MW) or less. Since JC Boyle's rated capacity is 98.7 MW, it does not qualify as a small hydroelectric facility.

Table 3.10-6. Electricity Generation GHG Emissions from Replacement Sources after Removal of Four Dams (33 Percent RPS)

Location	Generation (MWh)[1]	Annual Emissions (metric tons per year)[2]			Annual CO_2e Emissions ($MTCO_2e$/year)[3]			
		CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	Total
Iron Gate	116,000	57,545	2	1	57,545	35	173	57,753
Copco 1	106,000	52,585	2	1	52,585	32	158	52,774
Copco 2	135,000	66,971	2	1	66,971	41	201	67,212
J.C. Boyle	329,000	163,210	5	2	163,210	99	489	163,799
Total	686,800	340,311	10	3	340,311	207	1020	341,539

Notes:

[1] Generation based on FERC EIS (based on 2007 generation data).

[2] Emissions assume that 64 percent of power would be generated on-peak using natural gas; the remaining 36 percent would be generated off-peak using the PacifiCorp PCA resource mix. Off-peak emission factors were calculated from the annual emissions and generation for all sources within the PacifiCorp PCA (USEPA 2010b) except for the dams proposed to be removed. It was also assumed that PacifiCorp would meet its RPS obligation.

[3] GWPs from the IPCC's *Second Assessment Report* (1996) were used in the emission calculations. GWPs of 1, 21, and 310 were used for CO_2, CH_4, and N_2O, respectively.

Key:

CO_2 = carbon dioxide
CO_2e = carbon dioxide equivalent
CH_4 = methane
N_2O = nitrous oxide
MWh = megawatt hour
lb/MWh = pounds
lb/GWh = pounds per gigawatt-hour
GWP = global warming potential
$MTCO_2e$/year = metric tons carbon dioxide equivalent per year

As previously described for the No Action/No Project Alternative, CH_4 would be released from the reservoirs because of poor water quality conditions. Under the No Action/No Project Alternative, CH_4 emissions from the reservoirs would range from 4,000 to 14,000 $MTCO_2e$ per year, which is equivalent to approximately 1 to 4 percent of replacement power emissions[10] of the 396,575 $MTCO_2e$ per year (based on the current electricity mix)[11]. Under the Proposed Action, these CH_4 emissions would cease to be a factor and would partially offset the possible increase in emissions from power replacement. Table 3.10-7 summarizes the expected range in emissions from power replacement that would occur when this emissions offset is considered.

[10] Emissions range is valid for both renewable portfolio standard assumptions (i.e., current grid mix or 33 percent renewable power).

[11] Approximately 2 to 8 percent of the 341,539 $MTCO_2e$ per year would be emitted assuming that the renewable portfolio standard goal of 33 percent was met. Emissions range is valid for both renewable portfolio standard assumptions (i.e., current grid mix or 33 percent renewable power).

Table 3.10-7. Adjusted Power Replacement Emissions Without Methane Emissions from Reservoirs

Scenario	Annual CO_2e Emissions ($MTCO_2$e/year)	CH_4 Emissions from Reservoirs ($MTCO_2$e/year)		Adjusted Emissions ($MTCO_2$e/year)[1]	
		Low	High	Low	High
Current Grid Mix	396,575	4,000	14,000	392,575	382,575
33 Percent RPS	341,539	4,000	14,000	337,539	327,539

Notes:
[1] Adjusted emissions reflect the difference between each scenario and the estimated CH_4 emissions from the reservoirs.
Key:
CO_2e = carbon dioxide equivalent
$MTCO_2$e/year = metric tons carbon dioxide equivalent per year

Restoration activities at the dam sites are expected to increase the carbon sequestration in the area. As shown in Table 3.10-3, restoration of formerly inundated areas could sequester 0.3 metric tons of carbon per acre per year, while conservation of riparian buffers could sequester 0.1 metric tons of carbon per acre per year. The total amount of acreage wetland/riparian and upland acreage expected to be restored at JC Boyle, Copco, and Iron Gate Dams would be 272 acres and 1,602 acres, respectively. As a result, the total amount of sequestered carbon would be approximately 508 metric tons of carbon per year, or 1,862 metric tons of CO_2 per year (based on equivalent weights of carbon and CO_2). Although this sequestration would minimize the effects of GHG emissions, it would not eliminate the increased emissions from replacement power.

CARB expects that implementation of its Scoping Plan (2008) would reduce 21.3 $MMTCO_2$e by 2020 (from 2005 baseline) from California's RPS; therefore, the possible increase in emissions from removing the dams would account for three percent of the expected emissions reduction. Under a business-as-usual scenario, which assumes that the Scoping Plan would not be implemented, this would impede California's ability to meet its emission reduction goal. **Emissions from power replacement would therefore be a significant impact**. **Mitigation Measures CC-1 through CC-3 would be implemented to reduce emissions from replacement power. Although these measures are expected to lessen the degree of significance, it is expected that GHG emissions would remain significant and unavoidable in the short term until PacifiCorp adds new sources of renewable power that would replace the removed dams.**

Keno Transfer

Implementation of the Keno Transfer could cause short-term and temporary increases in GHG emissions. The Keno Transfer is a transfer of title for the Keno Facility from PacifiCorp to the United States Department of the Interior (DOI). This transfer would not result in the generation of new impacts on greenhouse gases compared with existing facility operations. Following transfer of title, DOI would operate the Keno Facility in compliance with applicable law and would provide water levels upstream of Keno Dam for diversion and canal maintenance with agreements and historic practice (KHSA Section 7.5.4). **Therefore, implementation of the Keno Transfer would result in no change from existing conditions.**

East and West Side Facility Decommissioning

Decommissioning the East and West Side Facilities could cause short-term and temporary increases in GHG emissions. Decommissioning of the East and West Side canals and hydropower facilities of the Link River Dam by PacifiCorp as a part of the KHSA would redirect water flows currently diverted at Link River Dam in to the two canals, back into the Link River. Construction equipment used in the decommissioning action would be substantially less than the equipment required to complete dam demolition activities and the decommissioning action would be conducted in the years prior to 2020. Since dam demolition activities would be less than significant, it is likely that emissions from the decommissioning action would also not exceed the significance criteria. **The impact on GHG emissions and climate change from the East and West Side Facility Decommissioning would be less than significant.**

KBRA

The KBRA has several programs that could cause temporary increases in GHG emissions. The following KBRA programs could cause GHG and climate change impacts from various construction activities:

- Phases I and II Fisheries Restoration Plans
- Fisheries Reintroduction and Management Plan
- Wood River Wetland Restoration
- On-Project Plan
- Power for Water Management
- Climate Change Assessment and Adaptive Management
- Water Use Retirement Program
- Fish Entrainment Reduction
- Drought Plan

Construction activities associated with the KBRA programs involving construction could cause temporary increases in GHG emissions and climate change. The above KBRA programs may cause some GHG emission impacts from the use of heavy equipment. Potential KBRA construction activities include channel construction, mechanical thinning of trees, road decommissioning, fish passage and facilities construction, breaching levees, and fish hauling. Emissions would occur both from on-site construction operations with heavy equipment and from off-site activities like the trap-and-haul of fish required under the Fisheries Reintroduction and Management Plan. Sufficient information is not currently available to quantify emissions; however, the quantity of equipment and associated emissions required to complete these activities is expected to be less than the equipment and resulting less than significant emission quantities required to complete the facility removal activities analyzed above. Emissions generated by these construction actions are not expected to exceed the SCAQMD's threshold of significance for industrial emissions (10,000 $MTCO_2e$ per year), especially when amortized over thirty years. When considered together the emissions associated with KBRA construction actions and facility removal would also not be expected to exceed the SCAQMD's threshold of significance. **The impact on GHG emissions and climate change from construction activities associated with implementing the KBRA would be less than significant. Implementation of specific plans and projects described in the KBRA will require future environmental compliance as appropriate**.

Operational activities associated with the Fisheries Reintroduction and Management Plan could result in temporary increases in GHG emissions from vehicle exhaust associated with trap-and-haul activities. Potential operational emissions could occur from haul trucks moving fish around Keno Impoundment and Link River. Upstream-migrating fish would be collected downstream from Keno Dam and relocated to Upper Klamath Lake or its tributaries. Downstream-migrating fish would be collected at Link River Dam (and the East Side and West Side canals) and relocated downstream from Keno Dam. Operational emissions are not expected to exceed the SCAQMD's threshold of significance, especially when amortized over thirty years, because of the limited amount of haul trucks that would be expected to be used. When considered together the emissions associated with KBRA construction actions and facility removal, the total operational emissions would also not be expected to exceed the SCAQMD's threshold of significance. **The impact on GHG emissions and climate change from operational emissions associated with implementing the KBRA would be less than significant. Implementation of specific plans and projects described in the KBRA will require future environmental compliance as appropriate**.

Implementation of the Power for Water Management Program of the KBRA could create new renewable energy sources which would provide affordable electricity to allow efficient use, distribution, and management of water. This could also involve the development of renewable energy sources, which would provide green energy. However, given the uncertainty as to how the Power for Water Management Program would ultimately be implemented, this analysis will not consider the program as a mitigation measure. The Power for Water Management Program could however offset some of the effects of hydroelectric facility removal. **Implementation of the Power for Water Management Program could result in beneficial effects. Implementation of specific plans and projects described in the KBRA will require future environmental compliance as appropriate**.

Implementation of the Drought Plan and the Climate Change Assessment and Adaptive Management Plan could affect climate change-related impacts. The Drought Plan will identify water and resource management actions to minimize risk associated with drought, which is a projected climate change impact for the Klamath Basin and the Pacific Northwest. The Climate Change Assessment and Adaptive Management Plan includes early and frequent assessment of the existing and future impacts of climate change. The Climate Change Assessment and Adaptive Management Plan is also intended to develop actions to respond to climate change and protect the resources of the basin. These plans will assist the region in planning and responding to the climate change impacts identified in this EIS/EIR over the short-term, mid-term, and long-term horizons. The Climate Change Assessment and Adaptive Management Plan could offset some of the effects of hydroelectric facility removal. **Implementation of these plans is expected to result in reduction in impacts of climate change to the resources and would have beneficial effects. Implementation of specific plans and projects described in the KBRA will require future environmental compliance as appropriate**.

Alternative 3: Partial Facilities Removal of Four Dams Alternative

Effects of Climate Change on the Alternative

The Partial Facilities Removal Alternative would result in the creation of a free-flowing, unimpeded river, and the effects of climate change on this alternative would be the same as for the Proposed Action.

Effects of the Alternative on Climate Change

Vehicle exhaust from dam removal activities could increase GHG emissions in the short-term to levels that could exceed the significance criteria. Under the Partial Facilities Removal Alternative some of the structures at J. C. Boyle, Copco 1, Copco 2, and Iron Gate Dams would remain in place. Predicted GHG emissions are generally lower for this alternative than for the Proposed Action because this alternative would generate fewer materials that would need to be removed from the sites, and hence, less truck traffic. Please see Section 3.22, Traffic and Transportation, for additional analysis of expected truck trips.

Table 3.10-8 summarizes uncontrolled annual emissions inventories for the Partial Facilities Removal Alternative. Appendix N provides detailed calculations.

Table 3.10-8. Uncontrolled Direct GHG Emissions Inventories for Partial Facilities Removal

Location	Project Emissions ($MTCO_2e$/year)[1]			
	CO_2	CH_4	N_2O[2]	Total
	2020			
Iron Gate	4,114	4	n/a	4,118
Copco 1	1,459	1	n/a	1,460
Copco 2	829	1	n/a	830
J.C. Boyle	1,341	<1	n/a	1,341
Total Emissions	**7,742**	**6**	**n/a**	**7,748**
California Total	6,401	6	n/a	6,408
Oregon Total	1,341	n/a	n/a	1,341

Notes:

[1] GWPs from the IPCC's *Second Assessment Report* (1996) were used in the emission calculations. GWPs of 1, 21, and 310 were used for CO_2, CH_4, and N_2O, respectively.

[2] N_2O emissions are not directly estimated from the various emission calculation models; therefore, emissions are estimated as zero for most equipment.

Key:
CO_2 = carbon dioxide
CH_4 = methane
N_2O = nitrous oxide
$MTCO_2e$/year = metric tons carbon dioxide equivalent per year

It is likely that SF_6 would be released during deconstruction because the breakers would be emptied. Although SF_6 has a relatively high GWP, sufficient data was not available at the time of this writing to quantify emissions.

As Table 3.10-8 shows, there would be a net increase in GHG emissions from deconstruction of the dams; however, these emissions would be temporary and would not contribute to long-term emissions. Demolition activities associated with the decommissioning of the dams would contribute 7,748 $MTCO_2e$ to GHG emission for one year[12]. Amortizing these construction emissions over thirty years results in approximately 258 $MTCO_2e$ per year, well below the 10,000 $MTCO_2e$ threshold. Moreover, even without amortizing construction emissions over thirty years such emissions are 2,252 $MTCO_2e$ below the threshold. The 1990 GHG emissions level (and so the 2020 emissions target ascribed by AB 32) is 427 million metric tons of CO_2e ($MMTCO_2e$). The emissions from dam removal would be 0.002 percent of the target emissions. In 1990, GHG emissions from construction were 0.67 $MMTCO_2e$; therefore, the Proposed Action would equal approximately 1 percent of allowable construction emissions. **The one year construction emissions would not exceed the established significance threshold for ongoing industrial emissions. Therefore, the GHG emissions related to construction would be less than significant.**

Construction of a new, elevated City of Yreka water supply pipeline and steel pipeline bridge to support the pipe above the river would result in short-term and temporary increases in GHG emissions from vehicle exhaust. GHG emission impacts associated with the water supply pipeline construction would be the same as those discussed for the Proposed Action. **The impact on GHG emissions and climate change from the construction of the Yreka water supply pipeline would be less than significant.**

Activities associated with several IMs could result in short-term and temporary increases in GHG emissions from vehicle exhaust. GHG emission impacts associated with implementation of IMs would be the same as those discussed for the Proposed Action. **The impact on GHG emissions and climate change from implementing the IMs would be less than significant.**

Restoration actions would result in short-term and temporary increases in GHG emissions from the use of helicopters, trucks, and barges. GHG emission impacts associated with the restoration actions would be the same as those discussed for the Proposed Action. **The impact on GHG emissions and climate change from revegetation would be less than significant.**

Relocation and demolition of various recreation facilities would result in short-term and temporary increases in GHG emissions from vehicle exhaust. GHG emission impacts associated with the recreation facilities would be the same as those discussed for the

[12] The value of 7,748 $MTCO_2e$ includes emissions from the JC Boyle Dam. Although JC Boyle Dam is located in Oregon, CEQA requires project impacts to be evaluated for significance. Since the Proposed Action includes the removal of JC Boyle Dam, emissions from its removal were included in the significance determination.

Proposed Action. **The impact on GHG emissions and climate change from the relocation and demolition of recreation facilities would be less than significant.**

Removing a renewable source of power by removing the dams could result in increased GHG emissions from possible non-renewable alternate sources of power. As with the Proposed Action, the Partial Facilities Removal Alternative would result in decreased capacity to generate electricity from all of the dams. Although some of this infrastructure would remain under this alternative, the power-generating ability of the dams would be eliminated. As a result, electricity generation would need to be replaced from other sources of power.

As discussed for the Proposed Action, in the long-term, it is expected that PacifiCorp would be able to eventually replace the lost energy from the dams with other sources of renewable power. Furthermore, some degree of GHG emissions could be offset with reforestation, but the increased carbon sequestration would not be sufficient to counteract increased emissions that may result from use of an alternative power source. The expected increase in GHG emissions from replacing these four dams with a different energy source would be the same as those shown in Table 3.10-5 and Table 3.10-6. The expected emissions increases that could occur when water is no longer impounded in the reservoirs would be the same as those shown in Table 3.10-7. **Emissions from power replacement would therefore be a significant impact. Mitigation Measures CC-1 through CC-3 would be implemented to reduce emissions from replacement power. Although these measures are expected to lessen the degree of significance, it is expected that GHG emissions would remain significant and unavoidable in the short term until PacifiCorp adds new sources of renewable power that would replace the removed dams.**

Keno Transfer

The effects of the Keno Transfer would be the same as those for the Proposed Action.

East and West Side Facility Decommissioning

The effects of the East and West Side Facilities removal would be the same as those described for the Proposed Action.

KBRA

Construction activities associated with the KBRA programs involving construction could cause temporary increases in GHG emissions and climate change. Similarly to the Proposed Action, under this alternative the KBRA would be fully implemented. The effects of implementing the KBRA would be the same as those described in the Proposed Action**. The impact on GHG emissions and climate change from implementing the KBRA would be less than significant.**

Implementation of the Power for Water Management Program, the Drought Plan, and the Climate Change Assessment and Adaptive Management Plan could result in climate change-related impacts. Implementation of the Power for Water Management Program of the KBRA could create new renewable energy sources as described for the Proposed

Action. Additionally, the KBRA includes two plans to assess and address climate change impacts as described in the KBRA discussion for the Proposed Action. **Implementation of these plans may cause beneficial effects to climate change.**

Alternative 4: Fish Passage at Four Dams Alternative

Effects of Climate Change on the Alternative

The Fish Passage at Four Dams Alternative would likely result in a greater magnitude of consequences associated with climate change than the Full Facilities Removal Alternative. Greater needs for management actions, policies, and mitigation measures to protect the surrounding ecosystems and communities would likely be required without dam removal, and could result in costly future projects to either prevent or respond to the consequences of climate change. For example, disturbances caused by drought, changes to vegetation, and changes to water quality characteristics patterns might not be able to be adjusted to or absorbed as easily with the dams in place as without them.

Under existing conditions, summer and early fall water temperatures in the Klamath River regularly exceed the range of chronic effects temperature thresholds for full salmonid support (Section 3.2.3.2). The exception to this occurs in the J.C. Boyle Bypass Reach during daily powerhouse peaking periods, when warm reservoir discharges are diverted from the Bypass Reach allowing cold spring flows to dominate hydrology and water temperatures. Under the Fish Passage at Four Dams Alternative, water temperatures in the Hydroelectric Reach and the Klamath River downstream of Iron Gate Dam would not change from existing conditions (i.e., they would still exceed chronic effects thresholds during summer months), with the exception of the J.C. Boyle Bypass Reach where the extreme daily temperature fluctuations due to hydropower peaking flows would occur less frequently (i.e., weekly rather than daily) and would approach the (warmer) natural thermal regime of the river. Areas adjacent to the coldwater springs in the Bypass Reach would continue to serve as thermal refugia for aquatic species because the springs themselves would not be affected by the Fish Passage at Four Dam Alternative. Overall, this would be beneficial.

Effects of the Alternative on Climate Change

Vehicle exhaust from construction of fish passage could increase GHG emissions in the short-term to levels that could exceed the significance criteria. This alternative does not result in the removal of any excavated material from the sites, and instead only includes a reduced amount of material being hauled to the sites. Table 3.10-9 summarizes uncontrolled annual emissions inventories for the Fish Passage at Four Dams Alternative. Detailed calculations are provided in Appendix N.

Table 3.10-9. Uncontrolled Direct GHG Emissions Inventories for Fish Passage at Four Dams

Location	Project Emissions ($MTCO_2e$/year)[1]			
	CO_2	CH_4	N_2O[2]	Total
Iron Gate (2023)	1,599	1	n/a	1,600
Copco 1 (2025)	1,307	1	n/a	1,308
Copco 2 (2024)	302	<1	n/a	302
J.C. Boyle (2022)	820	<1	n/a	820
Maximum Annual Emissions[3]	1,599	1	n/a	1,600

Notes:
[1] GWPs from the IPCC's *Second Assessment Report* (1996) were used in the emission calculations. GWPs of 1, 21, and 310 were used for CO_2, CH_4, and N_2O, respectively.
[2] Nitrous oxide (N_2O) emissions are not directly estimated from the various emission calculation models; therefore, emissions are estimated as zero for most equipment.
[3] Construction of the fish ladders occur during different years and activities for each dam site do not overlap; therefore, the maximum emissions are shown to evaluate significance.

Key:
CO_2 = carbon dioxide
CH_4 = methane
N_2O = nitrous oxide
$MTCO_2e$/year = metric tons carbon dioxide equivalent per year

As Table 3.10-9 shows, there would be a net increase in GHG emissions from construction of fish passages; however, these emissions would be temporary and would not contribute to long-term emissions. Constructing fish passage would contribute a maximum of 1,600 $MTCO_2e$ to California's GHG emissions for one year. Amortizing these construction emissions over thirty years results in approximately 53 $MTCO_2e$ per year, well below the 10,000 $MTCO_2e$ threshold. Moreover, even without amortizing construction emissions over thirty years such emissions are 8,400 $MTCO_2e$ below the threshold. The 1990 GHG emissions level (and so the 2020 emissions target ascribed by AB 32) is 427 million metric tons of CO_2e ($MMTCO_2e$). The emissions constructing fish passage would be 0.0009 percent of the target emissions. In 1990, GHG emissions from construction were 0.67 $MMTCO_2e$; therefore, Alternative 4 would equal less than 1 percent of allowable construction emissions. **The one year construction emissions for fish passage would not exceed the established significance thresholds for ongoing industrial emissions. Therefore, the GHG emissions related to fish passage construction would be less than significant.**

Reducing a renewable source of power by developing fish passage could result in increased GHG emissions from possible non-renewable alternate sources of power. GHG emission effects could also occur following replacement of a renewable source of electricity with other, emission-generating sources of electric power. Although the dams would not be removed, there would be a decrease in power generation, which is necessary for successful operation of the fish passage. The FERC EIS (2007) states that the installation of fish passage would allow the Klamath Hydroelectric Project to generate an average of 533,879 MWh of electricity annually. Since the baseline generation (Iron Gate, Copco 1, Copco 2, and J.C. Boyle) is 686,000 MWh, the amount of power that may need to be replaced would equal 152,121 MWh per year. Table 3.10-10 summarizes replacement power emissions that would be associated with the replacement power needed after fish passage construction assuming that the current power resource mix was used. Table 3.10-11 summarizes replacement power emissions that would be needed after fish passage construction assuming that PacifiCorp's RPS obligations were met.

Table 3.10-10. Electricity Generation GHG Emissions from Replacement Sources after Fish Passage Construction (Current Resource Mix)

Alternative	Generation (MWh)[1]	Annual Emissions (metric tons per year)[2]			Annual CO_2e Emissions ($MTCO_2e$/year)[3]			
		CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	Total
On-Peak	97,792	41,858	2	<1	41,858	36	56	41,951
Off-Peak	54,329	45,332	<1	<1	45,332	14	229	45,575
Total	152,121	87,190	2	1	87,190	50	286	87,525

Notes:

1 Generation based on FERC EIS (2007). The Fish Passage generation is based on the FERC EIS for the Staff Alternative with Mandatory Conditions (533,879 MWh).

2 Emissions assume that 64 percent of power would be generated on-peak using natural gas; the remaining 36 percent would be generated off-peak using the PacifiCorp PCA resource mix. Emission factors were calculated from the annual emissions and generation for all sources within the PacifiCorp PCA (USEPA 2010b).

3 GWPs from the IPCC's *Second Assessment Report* (1996) were used in the emission calculations. GWPs of 1, 21, and 310 were used for CO_2, CH_4, and N_2O, respectively.

Key:

CO_2 = carbon dioxide — lb/MWh = pounds per megawatt-hour
CH_4 = methane — lb/GWh = pounds per gigawatt-hour
N_2O = nitrous oxide — GWP = global warming potential
MWh = megawatt hour — $MTCO_2e$/year = metric tons carbon dioxide equivalent per year

Table 3.10-11. Electricity Generation GHG Emissions from Replacement Sources after Fish Passage Construction (33 Percent RPS)

Alternative	Generation (MWh)[1]	Annual Emissions (metric tons per year)[2]			Annual CO_2e Emissions ($MTCO_2e$/year)[3]			
		CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	Total
On-Peak	97,792	41,858	2	<1	41,858	36	56	41,951
Off-Peak	54,329	33,302	1	1	33,302	10	168	33,481
Total	152,121	75,161	2	1	75,161	46	225	75,431

Notes:

1 Generation based on FERC EIS (2007). The Fish Passage generation is based on the FERC EIS for the Staff Alternative with Mandatory Conditions (533,879 MWh).

2 Emissions assume that 64 percent of power would be generated on-peak using natural gas; the remaining 36 percent would be generated off-peak using the PacifiCorp PCA resource mix. Off-peak emission factors were calculated from the annual emissions and generation for all sources within the PacifiCorp PCA (USEPA 2010b) except for the dams proposed to be removed. It was also assumed that PacifiCorp would meet its RPS obligation.

3 GWPs from the IPCC's *Second Assessment Report* (1996) were used in the emission calculations. GWPs of 1, 21, and 310 were used for CO_2, CH_4, and N_2O, respectively.

Key:

CO_2 = carbon dioxide — lb/MWh = pounds
CO_2e = carbon dioxide equivalent — lb/GWh = pounds per gigawatt-hour
CH_4 = methane — GWP = global warming potential
N_2O = nitrous oxide — $MTCO_2e$/year = metric tons carbon dioxide equivalent per year
MWh = megawatt hour

As previously described for the No Action/No Project Alternative, CH_4 would be released from the reservoirs because of poor water quality conditions. Since the dams would remain in place under this alternative, CH_4 from the impounded water would continue to be emitted. CH_4 emissions from the reservoirs would range from 4,000 to 14,000 $MTCO_2e$ per year. Table 3.10-12 summarizes the expected range in emissions that could occur from power replacement and CH_4 released from the reservoirs.

Table 3.10-12. Adjusted Power Replacement Emissions With Methane Emissions from Reservoirs

Scenario	Annual CO_2e Emissions ($MTCO_2e$/year)	CH_4 Emissions from Reservoirs ($MTCO_2e$/year)		Adjusted Emissions ($MTCO_2e$/year)[1]	
		Low	High	Low	High
Current Grid Mix	87,525	4,000	14,000	91,525	101,525
33 Percent RPS	75,431	4,000	14,000	79,431	89,431

Notes:
[1] Adjusted emissions reflect the difference between each scenario and the estimated CH_4 emissions from the reservoirs.
Key:
CO_2e = carbon dioxide equivalent
$MTCO_2e$/year = metric tons carbon dioxide equivalent per year

In the long-term, it is expected that PacifiCorp would be able to eventually replace the lost energy from the dams with other sources of renewable energy.

CARB expects that implementation of its Scoping Plan (2008) would reduce 21.3 $MMTCO_2e$ by 2020 (from 2005 baseline) from California's RPS; therefore, the possible increase in emissions from the replacement power generation allowing decreased electricity produced by the dams would account for one percent of the expected emissions reduction. Under a business-as-usual scenario, which assumes that the Scoping Plan would not be implemented, this would impede California's ability to meet its emission reduction goal. **Emissions from power replacement would therefore be a significant impact**. **Mitigation Measures CC-1 through CC-3 would be implemented to reduce emissions from replacement power. Although these measures are expected to lessen the degree of significance, it is expected that GHG emissions would remain significant and unavoidable in the short term until PacifiCorp adds new sources of renewable power that would replace the removed dams.**

Trap and Haul – Programmatic Measure

Implementation of trap and haul measures could result in temporary increases in GHG emissions from vehicle exhaust. Potential operational emissions could occur from haul trucks moving fish around Keno Impoundment and Link River. Upstream-migrating fish would be collected downstream from Keno Dam and relocated to Upper Klamath Lake or its tributaries. Downstream-migrating fish would be collected at Link River Dam (and the East Side and West Side canals) and relocated downstream from Keno Dam. Operational emissions are not expected to exceed the SCAQMD's threshold of significance, especially when amortized over thirty years, because of the limited amount of haul trucks that would be expected to be used. **The impact on GHG emissions and climate change from operational emissions associated with trap and haul measures would be less than significant.**

Alternative 5: Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative

Effects of Climate Change on the Alternative

The Fish Passage at Two Dams Alternative would result in the removal of two dams and the retention of two dams; the types of climate change effects from this alternative would be within the range of those described for the Proposed Action and the Fish Passage at Four Dams Alternatives. Temperature effects would likely be more similar to the Proposed Action than the Fish Passage at Four Dams Alternative because the Fish Passage at Two Dams Alternative would result in the removal of the two largest dams, which would have a greater role in warming the river water than the smaller dams.

Effects of the Alternative on Climate Change

Vehicle exhaust from dam removal activities or construction of fish passage could increase GHG emissions in the short-term to levels that could exceed the significance criteria. This alternative would essentially be a combination of the Proposed Action and the Fish Passage at Four Dams Alternative, and would have similar effects. Table 3.10-13 summarizes uncontrolled annual emissions inventories for the Fish Passage at Two Dams, Remove Copco 1 and Iron Gate Alternative. Appendix N provides detailed calculations.

As Table 3.10-13 shows, there would be a net increase in GHG emissions from deconstruction of the dams; however, these emissions would be temporary and would not contribute to long-term emissions. The decommissioning of the dams would contribute 6,445 $MTCO_2e$ to California's GHG emission for one year.[13] Amortizing these construction emissions over thirty years results in approximately 215 $MTCO_2e$ per year, well below the 10,000 $MTCO_2e$ threshold. Moreover, even without amortizing construction emissions over thirty years such emissions are 3,555 $MTCO_2e$ below the threshold. The 1990 GHG emissions level (and so the 2020 emissions target ascribed by AB 32) is 427 million metric tons of CO_2e ($MMTCO_2e$). The emissions from dam removal would be 0.002 percent of the target emissions. In 1990, GHG emissions from construction were 0.67 $MMTCO_2e$; therefore, the Proposed Action would equal approximately 1 percent of allowable construction emissions. **The one year construction emissions would not exceed the established significance threshold for ongoing industrial emissions. Therefore, the GHG emissions related to construction would be less than significant.**

[13] The value of 6,445 $MTCO_2e$ includes emissions from the J.C. Boyle Dam. Although J.C. Boyle Dam is located in Oregon, CEQA requires project impacts to be evaluated for significance. Since the Proposed Action includes the removal of J.C. Boyle Dam, emissions from its removal were included in the significance determination.

Table 3.10-13. Uncontrolled Direct GHG Emissions Inventories for Fish Passage at Two Dams, Remove Copco 1 and Iron Gate

Location	Project Emissions ($MTCO_2e$/year)[1]			
	CO_2	CH_4	N_2O[2]	Total
	2020			
Iron Gate	3,944	4	n/a	3,949
Copco 1	1,474	1	n/a	1,475
Copco 2	269	1	n/a	269
J.C. Boyle	752	<1	n/a	752
Total Emissions (2020)	6,439	6	n/a	6,445
California Total	5,687	6	n/a	5,693
Oregon Total	752	n/a	n/a	752

Notes:

[1] GWPs from the IPCC's *Second Assessment Report* (1996) were used in the emission calculations. GWPs of 1, 21, and 310 were used for CO_2, CH_4, and N_2O, respectively.

[2] Nitrous oxide (N_2O) emissions are not directly estimated from the various emission calculation models; therefore, emissions are estimated as zero for most equipment.

Key:
CO_2 = carbon dioxide
CH_4 = methane
N_2O = nitrous oxide
$MTCO_2e$/year = metric tons carbon dioxide equivalent per year

Construction of a new, elevated City of Yreka water supply pipeline and steel pipeline bridge to support the pipe above the river would result in short-term and temporary increases in GHG emissions from vehicle exhaust. GHG emission impacts associated with the Yreka water supply pipeline would be the same as those described for the Proposed Action. **The impact on GHG emissions and climate change from the construction of the Yreka water supply pipeline would be less than significant.**

Restoration actions would result in short-term and temporary increases in GHG emissions from the use of helicopters, trucks, and barges. GHG emission impacts related to restoration activities would be similar to those described for the Proposed Action but would only occur near the Iron Gate and Copco 1 dam sites. **The impact on GHG emissions and climate change from revegetation would be a significant impact. Available mitigation measures are not expected to reduce emissions to less than significant levels; therefore, emissions would remain significant and unavoidable.**

Relocation and demolition of various recreation facilities would result in short-term and temporary increases in GHG emissions from vehicle exhaust. Recreation facilities near J.C. Boyle Reservoir would stay intact, and the Copco 2 area does not have any developed recreation facilities. Recreation facilities at Iron Gate and Copco 1 would be removed. Demolition activities would occur after dam demolition activities and are expected to be minimal. **The impact on GHG emissions and climate change from the relocation and demolition of recreation facilities would be less than significant.**

Removing or reducing a renewable source of power by removing the dams or developing fish passage could result in increased GHG emissions from possible non-renewable *alternate sources of power.* It is expected that removing the existing hydropower capability from the two dams (Copco 1 and Iron Gate) would reduce power generation. Replacement power generation may result in changes in emissions. Although J.C. Boyle and Copco 2 Dams would not be removed, there would be a decrease in power generation, which is necessary for successful operation of the fish passage. The FERC EIS (2007) states that after retiring Copco 1 and Iron Gate the Klamath Hydroelectric Project would generate an average of 443,694 MWh of electricity annually. Since the baseline generation (Iron Gate, Copco 1, Copco 2, and J.C. Boyle) is 686,000 MWh, the amount of power that may need to be replaced would equal 242,306 MWh per year. Table 3.10-10 summarizes replacement emissions that would be associated with the replacement power needed after construction of this alternative.

Electricity that was originally produced from these dams would likely be replaced using another source within the PacifiCorp PCA; therefore, emission rates from the grid were estimated assuming that all power sources within the PCA would remain except for Copco 1 and Iron Gate Dams. Data from eGRID was used to estimate GHG emissions from the use of different energy resources (USEPA 2010b). The lead agencies acquired data for all of the plants within the PacifiCorp PCA and derived emission factors were derived from this source with the applicable dams removed from the mix. Table 3.10-14 summarizes the increase in emissions that could result from the use of replacement power from other sources assuming that the current power resource mix was used.
Table 3.10-15 summarizes the increase in emissions that could result from the use of replacement power from other sources assuming that PacifiCorp met is RPS obligations.

Table 3.10-14. Electricity Generation GHG Emissions from Replacement Sources after Removal of Two Dams (Current Resource Mix)

Alternative	Generation (MWh)[1]	Annual Emissions (metric tons per year)[2]			Annual CO_2e Emissions ($MTCO_2e$/year)[3]			
		CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	Total
On-Peak	155,768	66,674	3	<1	66,674	57	90	66,821
Two Dams	86,538	72,435	1	1	72,435	22	366	72,824
Total	242,306	139,109	4	1	139,109	79	456	139,644

Notes:
[1] Generation based on FERC EIS (2007). The Two Dams Removed generation is based on the FERC EIS for the alternative that would retire Copco 1 and Iron Gate (443,694 MWh).
[2] Emissions assume that 64 percent of power would be generated on-peak using natural gas; the remaining 36 percent would be generated off-peak using the PacifiCorp PCA resource mix. Emission factors were calculated from the annual emissions and generation for all sources within the PacifiCorp PCA except for the dams proposed to be removed.
[3] GWPs from the IPCC's *Second Assessment Report* (1996) were used in the emission calculations. GWPs of 1, 21, and 310 were used for CO_2, CH_4, and N_2O, respectively.
Key:
CO_2 = carbon dioxide
CH_4 = methane
N_2O = nitrous oxide
MWh = megawatt hour
lb/MWh = pounds per megawatt-hour
lb/GWh =pounds per gigawatt-hour.
eGRID = Emissions & Generation Resource Integrated Database
$MTCO_2e$/year = metric tons carbon dioxide equivalent per year

Table 3.10-15. Electricity Generation GHG Emissions from Replacement Sources after Removal of Two Dams (33 Percent RPS)

Alternative	Generation (MWh)[1]	Annual Emissions (metric tons per year)[2]			Annual CO_2e Emissions ($MTCO_2e$/year)[3]			
		CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	Total
On-Peak	155,768	66,674	3	<1	66,674	57	90	66,821
Two Dams	86,538	53,213	1	1	53,213	16	269	53,499
Total	242,306	119,888	4	1	119,888	73	359	120,320

Notes:
1 Generation based on FERC EIS (2007). The Two Dams Removed generation is based on the FERC EIS for the alternative that would retire Copco 1 and Iron Gate (443,694 MWh).
2 Emissions assume that 64 percent of power would be generated on-peak using natural gas; the remaining 36 percent would be generated off-peak using the PacifiCorp PCA resource mix. Emission factors were calculated from the annual emissions and generation for all sources within the PacifiCorp PCA except for the dams proposed to be removed. It was also assumed that PacifiCorp would meet its RPS obligation.
3 GWPs from the IPCC's *Second Assessment Report* (1996) were used in the emission calculations. GWPs of 1, 21, and 310 were used for CO_2, CH_4, and N_2O, respectively.

Key:
CO_2 = carbon dioxide
CH_4 = methane
N_2O = nitrous oxide
MWh = megawatt hour
lb/MWh = pounds per megawatt-hour
lb/GWh =pounds per gigawatt-hour.
eGRID = Emissions & Generation Resource Integrated Database
$MTCO_2e$/year = metric tons carbon dioxide equivalent per year

CH_4 emissions would occur from water impounded in the reservoirs. Since Iron Gate and Copco 1 Dams would be removed under this alternative, the only remaining reservoir that would contribute to CH_4 emissions from impounded water would be at J.C. Boyle Dam. Assuming that this would be the only source of emissions, CH_4 emissions would range from 700 to 3,000 $MTCO_2e$ per year for the J.C. Boyle Reservoir, equivalent to approximately 0.5 to 2 percent of replacement power emission[14]. See Appendix N for detailed calculations. Table 3.10-16 summarizes the adjusted power replacement emissions that could occur when CH4 emissions from impounded water at J.C. Boyle Reservoir is considered.

Table 3.10-16. Adjusted Power Replacement Emissions With Methane Emissions from Reservoirs

Scenario	Annual CO_2e Emissions ($MTCO_2e$/year)	CH_4 Emissions from Reservoirs ($MTCO_2e$/year)		Adjusted Emissions ($MTCO_2e$/year)[1]	
		Low	High	Low	High
Current Grid Mix	139,644	700	3,000	140,344	142,644
33 Percent RPS	120,320	700	3,000	121,020	123,320

Notes:
1 Adjusted emissions reflect the difference between each scenario and the estimated CH_4 emissions from the reservoirs.

Key:
CO_2e = carbon dioxide equivalent
$MTCO_2e$/year = metric tons carbon dioxide equivalent per year

14 Emissions range is valid for both renewable portfolio standard assumptions (i.e., current grid mix or 33 percent renewable power).

In addition to the emissions from possible natural gas combustion, there could also be emissions associated with SF_6 leaks. Although there would be a decrease in SF_6 associated with the removal of transmission lines under this alternative, these emissions could be counteracted by increases from new power supplies that would be used to replace the existing power. As a result, determining the net SF_6 emissions is not possible. **Emissions from power replacement would be significant and unavoidable.**

Trap and Haul – Programmatic Measure

Implementation of trap and haul measures could result in temporary increases in GHG emissions from vehicle exhaust. The trap and haul measures around Keno Impoundment and Link River would have the same impacts under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative as the Fish Passage at Four Dams Alternative. **The impact on GHG emissions and climate change from operational emissions associated with trap and haul measures would be less than significant.**

3.10.4.4 Mitigation Measures

As required by the KHSA, PacifiCorp would cooperate in the investigation or consideration of joint development and ownership of renewable generation resources, and purchase by PacifiCorp of power from renewable energy projects developed by Klamath Water and Power Authority or other parties. Although this effect cannot be quantified, the development of this power would help of offset the significant impacts expected from any use of replacement power following removal of the dams.

Mitigation Measure by Consequence Summary

CC-1 – Use the market mechanism under development as part of AB 32 development when feasible to mitigate GHG emissions impacts. The market mechanism program under AB 32 is targeted for implementation in 2012.

CC-2 – Establish an energy audit program to enable local residences and business to determine how much energy they currently consume and to identify measures that would reduce energy consumption.

CC-3 – Establish an energy conservation plan to reduce the region's reliance on purchased electricity.

Effectiveness of Mitigation in Reducing Consequence

The effectiveness of the various mitigation measures would vary based on the type of measures that would be implemented. Market-based measures could potentially be 100 percent effective at offsetting the significant emissions, but may not be cost-effective depending on the availability of carbon credits. Plus, this measure would be contingent on the availability of carbon credits on the open market. If credits are scarce when they need to be purchased, then it may be difficult to offset the entire amount.

The effectiveness of the energy audits and conservation programs would vary based on the improvements that would be made following the audit. While the audits can identify deficiencies in the energy efficiency of a residential or commercial source, there is no guarantee that the identified improvements would be made. The California Air Pollution Control Officers Association published a resource called *Quantifying Greenhouse Gas Mitigation Measures* (2010) that quantifies the effectiveness of various GHG emission reduction measures. For example, if a non-residential building is constructed to be more energy efficient than the 2008 Title 24 standards, the GHG emissions from electricity can be reduced up to 0.40 percent for every 1 percent improvement over 2008 Title 24. Installing energy efficient appliances could reduce GHG emissions up to 2.59 percent.

Table 3.10-17 summarizes the GHG emissions that would be expected from power replacement activities following dam removal. All alternatives would result in significant impacts from use of replacement power following removal of the dams or reductions necessary to properly maintain fish passage. Table 3.10-18 summarizes GHG emissions that would be predicted to occur from power replacement activities with CH_4 that would be produced from impounded water.

Table 3.10-17. Impact Summary Table (Without Methane Generation from Reservoirs)

Alternative	Emissions (metric tons CO_2e/year)		
	Deconstruction	Power Replacement	
		(Current Resource Mix)	(33% RPS)
2	8,558	396,575	341,539
3	7,748	396,575	341,539
4	1,600	87,525	75,431
5	6,445	139,644	120,320

Key:
CO_2e = carbon dioxide equivalent
RPS = Renewable Portfolio Standard

Table 3.10-18. Impact Summary Table (With Methane Generation from Reservoirs)

Alternative	Power Replacement and CH_4 from Impounded Reservoirs Emissions (metric tons CO_2e/year)			
	(Current Resource Mix)		(33% RPS)	
	Low[1]	High[2]	Low[1]	High[2]
2	392,575	382,575	337,539	327,539
3	392,575	382,575	337,539	327,539
4	91,525	101,525	79,431	89,431
5	140,344	142,644	121,020	123,320

Notes:
1 Low power replacement refers to minimum CH_4 emissions predicted to be emitted by the reservoirs.
2 High power replacement refers to maximum CH_4 emissions predicted to be emitted by the reservoirs.
Key:
CH_4 = methane
CO_2e = carbon dioxide equivalent
RPS = Renewable Portfolio Standard

Agency Responsible for Mitigation Implementation

The Dam Removal Entity would be responsible for implementing mitigation measures CC-1, CC-2, and CC-3.

Remaining Significant Impacts

Following implementation of the mitigation measures specified for a given alternative, GHG emissions would remain significant and unavoidable for all four action alternatives for power replacement.

Mitigation Measures Associated with Other Resource Areas

Mitigation Measures AR-1, 2, 5-7 would cause temporary increases in GHG emissions. These mitigation measures would involve trap and haul of fish and mollusks to protect them from the reservoir drawdown and dam demolition activities. It is anticipated that as many as 150 truck trips would be required to transport juveniles from areas downstream of Iron Gate Dam to the confluence of the Klamath and Trinity Rivers between February and April 2020. The increase in daily truck trips is expected to be minor (approximately 2 trips per day) and would not contribute substantially to the existing emissions. **The impacts associated with increases in GHG emissions from these mitigation measures would be less than significant.**

Mitigation Measure TR-1 could cause a temporary increase in GHG emissions. Relocation of Jenny Creek Bridge and culverts near Iron Gate Reservoir would occur before the other construction phases of dam removal. On- and off-road construction equipment would be used to complete the necessary construction, but would be minor compared to the dam demolition emissions. **The impacts associated with increases in GHG emissions from Mitigation Measure TR-1 would be less than significant.**

Mitigation Measure REC-1 could cause a temporary increase in GHG emissions. REC-1 calls for the preparation of a plan to develop new recreational facilities along the new river channel once the reservoirs are removed. On- and off-road construction equipment would be used to complete the necessary construction, but would be minor compared to the dam demolition emissions, and would occur after the demolition was complete. **The impacts associated with increases in GHG emissions from Mitigation Measure REC-1 would be less than significant.**

Several other mitigation measures may require construction, including Mitigation Measure H-2 (move or elevate structures with flood risk), GW-1 (deepen or replace wells), and WRWS-1 (modify water intakes). These measures could produce temporary impacts on GHG emissions during construction activities within localized areas. These activities would take place before or after the primary construction and deconstruction activities associated with the Proposed Action and action alternatives. The same or similar elements as for the Proposed Action and action alternatives would be incorporated into these construction activities to avoid or reduce impacts on wildlife and plants, including special-status species, and sensitive habitats. **Impacts on GHG emissions from the implementation of H-2, GW-1, and WRWS-1 would be less than significant.**

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