Appendix O

Greenhouse Gases

The greenhouse gases impact modeling described in this appendix is reproduced from the 2012 EIS/EIR analysis. Although there have since been some modifications to the project schedule, the 2011 greenhouse gases impact modeling is reproduced herein because the construction-related emissions-generating activities for the Proposed Project are materially similar to those modeled below. Minor changes in construction activities between the 2012 EIS/EIR analysis and the Proposed Project are primarily due to the timing of the peak construction period associated with removing each dam (Table 2.6-13). The Proposed Project and the data modeled as part of the 2012 EIS/EIR in this attachment are within the thresholds noted in Lower Klamath Project EIR Section 3.10.3 *[Greenhouse Gases] Significance Criteria* and analyzed in Section 3.9.5 *[Greenhouse Gases] Potential Impacts, Impacts, and Mitigation*.

<table>
<tr><th colspan="2">Alternative Name Key</th></tr>
<tr><th>2012 EIS/EIR Alternative Name</th><th>Lower Klamath Project EIR Alternative Name</th></tr>
<tr><td rowspan="3">Proposed Action</td><td>Proposed Project</td></tr>
<tr><td>Three Dam Removal (Iron Gate, Copco No. 1, and Copco No. 2)</td></tr>
<tr><td>No Hatchery</td></tr>
<tr><td>Partial Facilities Removal</td><td>Partial Removal</td></tr>
<tr><td>Remove Two Dams
(Iron Gate and Copco No. 1)</td><td>Two Dam Removal (Iron Gate and Copco No. 1)</td></tr>
<tr><td>Fish Passage at Four Dams</td><td>Continued Operations with Fish Passage</td></tr>
</table>

O.1 Assessment Methods

This section describes the methodology used to calculate greenhouse gas (GHG) emissions from construction activity related to the decommissioning of the Lower Klamath Project dam developments.

Since the project proposes construction activity related to the decommissioning of the Lower Klamath Project dam developments that would be completed at the end of 2021, it does not include long-term operational emissions. Direct GHG emissions associated with the reduced operation of Iron Gate Fish Hatchery combined with the re-instated operation of Fall Creek Hatchery were assumed to be the same as existing operation conditions at Iron Gate Hatchery for eight years following dam removal. This is due to the fact that the existing functions at the Iron Gate Hatchery that will be eliminated as part of dam removal activities, will be replaced by the reopening and operation of the Fall Creek Hatchery and by making improvements to the Iron Gate Hatchery Section 2.7.6 *Hatchery Operations*).

Emissions of carbon dioxide (CO_2), CH_4, and nitrous oxide (N_2O) were estimated for construction activity to evaluate GHG impacts. 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 were not estimated for the proposed project. It is likely that sulfur hexafluoride (SF_6) would be released during deconstruction because the circuit breakers from the power facilities would be emptied. Although SF_6 has a relatively high GWP, sufficient data is not available to quantify the emissions.

Non-CO_2 pollutants have global warming potential (GWP) factors that reflect the degree to which these pollutants affect climate change, as compared to CO_2. The product of each GHG emissions and its GWP is known as Carbon Dioxide equivalent (CO_2e). The value of GWPs is continually being modified by the Intergovernmental Panel on Climate Change (IPCC) as climate change science is refined. Although the IPCC is currently working on the Fifth Assessment Report, most mandatory and voluntary reporting registries require the use of the GWPs published in the Second Assessment Report (IPCC 1996); therefore, the GWPs from the Second Assessment Report were used to maintain consistency with the international standard.

O.1.1 Emission Calculation Methodology for Dam Removal Activities

The GHG emission sources from dam and powerhouse deconstruction activities that were estimated as part of this analysis include the following:

- Exhaust from off-road (onsite) mobile construction equipment and stationary sources (e.g., generators)
- Exhaust from on-road (offsite) mobile vehicles, including haul trucks and construction worker commuting

Emissions from dam removal construction activities were estimated from appropriate emission factors, number of facilities, and features being worked, and the associated schedules that were provided by the project consultants. The following sections provide additional discussion of emission estimation methodologies used for each source group.

O.1.1.1 On-site (Off-Road) Equipment Engine Exhaust Emissions

Emissions would occur from the combustion of fuel during operation of the off-road construction equipment at each of the dams. As was previously stated, separate emission factor models (i.e., OFFROAD2007 and NONROAD2008a) are used to estimate emissions in California and Oregon.

Preliminary estimates of the type, size (horsepower), and quantity of construction proposed to be used at each of the dam locations was provided by the project consultants. Engine load factors are also incorporated into the emission factor models. Emission factors for each piece of equipment were then selected based on the equipment type (e.g., cranes, excavators, loaders, etc.) and the engine size. It was conservatively assumed that all equipment located at a dam site could operate simultaneously for the entire shift. The total hours of operation for each piece of equipment was also provided with the equipment list provided by the project consultants. Annual emissions were then calculated from the total hours of operation.

In addition to the mobile construction equipment, several stationary generators would be present at each of the dam locations to provide power for electric-operated equipment. Emission factors from Chapter 3.3 (U.S. Environmental Protection Agency 1995) of AP-42 were used to estimate emissions from these generators.

O.1.1.2 Off-site (On-Road) Haul Truck Engine Exhaust Emissions and Paved Road Dust

The haul truck engine exhaust emissions were calculated based on EMFAC2007 and MOBILE6.2 emission factors for heavy-duty diesel trucks in Siskiyou County, California and Klamath County, Oregon, respectively. Information on the project total round trips was provided by the project consultants. The total project trips were assumed to occur evenly throughout the project schedule. The total vehicle miles traveled was determined from the number of trips and estimated distance to haul each component (e.g., earth, concrete, metal, etc.).

Emission factors vary by year based on changes in the vehicle fleet mix by older engines retiring from service and improved emission control technologies and standards in newer engines joining the fleet. As a result, two different emission factors are provided by location (state) and pollutant to reflect these changes in the fleet mix.

O.1.1.3 Construction Worker Commuting

Emissions associated with construction workers commuting to and from the various dam locations were also estimated. It was assumed that construction worker vehicles would consist of a mix of passenger cars and light-duty trucks. The combination of diesel and gasoline (catalyst and non-catalyst) vehicles from the various emission factor models was retained in the emission factor estimates. As explained in Section O.1.1.2 for trucks, the EMFAC2007 and MOBILE6.2 emission factor models were used to estimate emissions.

O.1.2 Emission Calculation Methodology for Other Project Activities

As part of this analysis, GHG emissions were estimated for the other project activities, which include the following:

- Restoration Activities
- Relocation and Demolition of Recreation Facilities
- Yreka Water Supply Pipeline Relocation

O.1.2.1 Restoration Activities

Restoration activities may use, in part, helicopters or other small aircraft and barges for reseeding. A combination of techniques was used to estimate emissions from the restoration activities. Emissions from landing and takeoff operations associated with aerial seed application were estimated using the Federal Aviation Administration's Emissions and Dispersion Modeling System. Emissions from hydroseeding barges were estimated using the following sources listed below.

- Analysis of Commercial Marine Vessels Emissions and Fuel Consumption Data (USEPA 2000)
- AP-42, Compilation of Air Pollutant Emission Factors, Chapter 3.3: Gasoline and Diesel Industrial Emissions (USEPA 1996)
- Title 17 California Code of Regulations, Section 93115.7: Air Toxic Control Measure for Stationary Compression Ignition Engines – Stationary Prime Diesel-Fueled Compression Ignition Engine (>50 bhp) Emission Standards
- Title 13 California Code of Regulations, Section 2423: Exhaust Emission Standards and Test Procedures—Off-Road Compression-Ignition Engine

O.1.2.2 Relocation and Demolition of Recreation Facilities

The California Emissions Estimator Model (CalEEMod), Version 2011.1.1, was used to estimate exhaust emissions that would occur from grading activities associated with restoring parking lots associated with recreational facilities proposed for relocation and demolition. CalEEMod makes general assumptions about the quantity and types of construction equipment needed to grade a site based on its size (acreage).

O.1.2.3 Yreka Water Supply Pipeline Relocation

The Sacramento Metropolitan Air Quality Management District's Road Construction Emissions Model, Version 6.3.2 (2009), was used to estimate exhaust emission factors associated with relocation of the Yreka water supply pipeline (USBR and CDFG 2012). The Siskiyou County Air Pollution Control District does not have a comparable model to estimate emissions from linear projects like the proposed pipeline relocation action.

O.1.3 Emission Calculation Methodology for Methane Emissions from Reservoirs

The Karuk Tribe (2006) estimated the total amount of CH_4 released from Keno, J.C. Boyle, Copco, and Iron Gate reservoirs in its comments on the Draft Environmental Impact Statement (EIS) for relicensing and/or decommissioning of the Klamath

Hydroelectric Project. The emissions estimation method presented by the Karuk Tribe was adapted for this analysis to estimate CH_4 emissions from impounded water. Emissions were estimated by multiplying the reservoirs' area by areal emissions rates from reservoirs around the world with similar characteristics (poor water quality). Using this methodology, it was determined that the methane produced by the reservoirs associated with the Lower Klamath Project dam developments ranges from 4,000 to 14,000 metric tons of CO_2e annually. With the removal of the Lower Klamath Project reservoirs, this source of methane emissions would be eliminated.

O.2 Emission Inventories

As described in the previous sections, construction emissions were calculated for various project activities including dam and powerhouse deconstruction, restoration activities, relocation and demolition of recreational facilities, and the Yreka supply pipeline relocation. Table O-1 summarizes the total uncontrolled emissions associated with the Proposed Project activities.

Table O-1. Uncontrolled GHG Emissions from the Proposed Project.

Project Activity	Project Emissions ($MTCO_2e$)
Dam and Powerhouse Deconstruction	8,558
Restoration Activities	704
Recreation Facilities	160
Yreka Supply Pipeline Relocation	33
Total Emissions	**9,455**

Source: Appendix N

As shown in Table O-1, total uncontrolled GHG emissions from the Proposed Project are estimated to be approximately 9,455 $MTCO_2e$. The sections below provide more detailed information about the emissions from the various project activities.

O.2.1 Emissions from Dam and Powerhouse Deconstruction

Table O-2 summarizes the uncontrolled emissions associated with the dam and powerhouse deconstruction activities.

Table O-2. Uncontrolled GHG Emissions from Dam and Powerhouse Deconstruction.

Location	Project Emissions ($MTCO_2e$)			
	CO_2	CH_4	N_2O	Total
Iron Gate	4,106	4	0	4,110
Copco No. 1	1,459	1	0	1,461
Copco No. 2	970	1	0	971
J.C. Boyle	2,016	<1	0	2,016
Total Emissions	**8,551**	**6**	**0**	**8,558**
California Total	6,535	6	0	6,542
Oregon Total	2,016	n/a	0	2,016

Source: Appendix N

As Table O-2 shows, deconstruction of the dams would contribute approximately 8,558 $MTCO_2e$ of GHG emissions during the deconstruction period.

O.2.2 Emissions from Restoration Activities

Table O-3 summarizes the uncontrolled emissions associated with the restoration activities.

Table O-3. Uncontrolled GHG Emissions from Restoration Activities.

Location	Project Emissions ($MTCO_2e$/)			
	Ground Equipment	Barges	Aerial	Total
Iron Gate	29	88	149	266
Copco No. 1 and Copco No. 2	32	88	298	419
J.C. Boyle	19	n/a	n/a	19
Total Emissions	**80**	**177**	**447**	**704**

Source: Appendix N

As Table O-3 shows, the GHG emissions from restoration activities would result in approximately 704 $MTCO_2e$ of GHG emissions.

O.2.3 Emissions from Recreation Facilities

Table O-4 summarizes the uncontrolled emissions associated with the relocation and demolition of recreation facilities.

Table O-4. Uncontrolled GHG Emissions from Recreation Facilities.

Location	Project Emissions ($MTCO_2e$)			
	CO_2	CH_4	N_2O	Total
Siskiyou County	153.51	0	0	153.71
Klamath County	5.94	0.01	0	5.95
Total Emissions	**159.5**	**0.01**	**0**	**159.7**

As Table O-4 shows, the GHG emissions from the relocation and demolition of recreation facilities would result in approximately 160 $MTCO_2e$ of GHG emissions (Appendix N).

O.2.4 Emissions from Yreka Water Supply Pipeline Relocation

According to the modeling results, approximately 33 $MTCO_2e$ of GHG emissions would be emitted during relocation of the Yreka water supply pipeline (USBR and CDFG 2012).

Detailed emission inventories for the Proposed Project are included as attachments to Appendix N (Air Quality Supplemental Methodology Information and Detailed Impact Analyses).

O.3 References

FERC (Federal Energy Regulatory Commission). 2007. Final Environmental Impact Statement for Hydropower License. Volume I. Klamath Hydroelectric FERC Project No. 2082-0278. November.

IPCC (Intergovernmental Panel on Climate Change). 1996. Climate Change 1995: The Science of Climate Change. Contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, Great Britain: Press Syndicate of the University of Cambridge.

Karuk Tribe of California. 2006. Comments on Draft EIS in Klamath Hydroelectric Project Docket for Filing: P-2082-027 (Klamath). Submitted to FERC by the Karuk Tribe of California, Orleans, CA. 60 p. Accessed on July 7, 2011. Available online at: http://www.klamathwaterquality.com/documents/karuk_comments_20061201-5040(16445270).pdf.

USBR and CDFG (U.S. Bureau of Reclamation and California Department of Fish and Game). 2012. Klamath Facilities Removal Final Environmental Impact Statement/Environmental Impact Report. Volume 1. December 2012. https://klamathrestoration.gov/sites/klamathrestoration.gov/files/Additonal_Files/VolumeI_FEIS.pdf

USEPA (U.S. Environmental Protection Agency). 1995. Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources. AP-42, Fifth Edition. Accessed on January 31, 2011. Available at: http://www.epa.gov/ttn/chief/ap42/.