Appendix T

Noise and Vibration Impact Analysis

This appendix describes basic noise and vibration concepts and the methods used to assess the potential construction and vehicle noise impacts. Attachment 1 presents the results of the construction noise impact analysis. Attachment 2 includes the vibration impact analysis. Traffic noise modeling inputs and outputs are presented in Attachment 3.

T.1 Noise Concepts

Sound is mechanical energy characterized by the rate of oscillation of sound waves (frequency), the speed of propagation, and the pressure level (amplitude). The human brain perceives pressure on the ear as sound. The sound pressure level is the logarithmic ratio of that perceived pressure to a reference pressure, and it is expressed in decibels (dB). Approximately zero dB corresponds to the threshold of human hearing.

Environmental sounds are measured with the A-weighted scale of a sound level meter. The A-weighting approximates the frequency response of the average young ear when listening to most everyday sounds. When people make relative judgments of the loudness or annoyance of a sound, their judgments correlate well with the A- weighting sound levels of those sounds (California Department of Transportation [Caltrans] 2013). A-weighted sound levels are designated as dBA. Table T-1 shows the sound levels (dBA) of and human response to common indoor and outdoor noise sources.

As sounds in the environment usually vary with time, they cannot be described with a single number. The equivalent noise level (L_{eq}) is the constant sound level that, in a given period, has the same sound energy level as the actual time-varying sound pressure level. L_{eq} allows noise from various sources to be combined into a measure of cumulative noise exposure. It is commonly used by regulatory agencies to evaluate noise impacts.

In addition to evaluating noise impacts based on compliance with noise standards, project noise impacts are also assessed by annoyance criteria, or the incremental increase in the existing noise level. The impact of increasing or decreasing noise levels is presented in Table T-2. For example, Table T-2 shows that a change of 3 dBA is barely perceptible but that a 10 dBA increase or decrease would be perceived by a person to be a doubling or halving of the loudness.

Table T-1. Sound Levels and Human Response.

Sound Source	Noise Level	Response	Hearing Effects	Conversational Relationships
	150		Contribution to hearing impairment begins	
Carrier deck Jet operation	140	Painfully loud		
	130	Limit amplified speech		
Jet takeoff (200 feet)	120	Maximum vocal effort		
Auto horn Riveting machine Jet takeoff (2,000 feet) Garbage truck	110			
	100			Shouting in ear
NY subway station Heavy truck (50 feet)		Very annoying Hearing damage (8 hours)		Shouting (2 feet)
	90			
Pneumatic drill (50 feet) Alarm clock		Annoying		Very loud conversation (4 feet)
	80			Loud conversation (2 feet)
Freight Train (50 feet) Freeway traffic (50 feet)	70	Telephone use difficult		
Air conditioning unit (20 feet)	60	Intrusive		Loud conversation (4 feet)
Light auto traffic (100 feet)	50	Quiet		Normal conversation (12 feet)
Living room Bedroom	40			
Library Soft whisper (15 feet)	30	Very quiet		
Broadcasting studio	20			
		Just audible		
	10			
	0	Threshold of hearing		

Source: Siskiyou County 1978

Table T-2. Decibel Changes, Loudness, and Energy Loss.

Sound Level Change (dBA)	Relative Loudness	Acoustical Energy Loss (%)
0	Reference	0
-3	Barely perceptible change	50
-5	Readily perceptible change	67
-10	Half as loud	90
-20	1/4 as loud	99
-30	1/8 as loud	99.9

Source: Federal Highway Administration (FHWA) 2011

The following general guideline was used to assess daily on-site construction noise impacts, as compared to existing ambient levels:

- A less than 3 dBA increase in sound level is considered no impact;
- A 3 to 5 dBA increase in sound level is considered a slight impact;
- A 6 to 10 dBA increase in sound level is considered a moderate impact; and
- A greater than 10 dBA increase in sound level is considered a severe impact.

This analysis assumed that an increase greater than 10 dBA would be significant and would require evaluating construction noise mitigation measures.

T.2 Construction Noise Impact Assessment Method

Methods described in FHWA's Roadway Construction Noise Model User's Guide (2006) were used to estimate noise impacts associated with construction equipment, blasting, and waste hauling that are expected to be used in the action alternatives. Table T-3 presents noise levels of common construction equipment operating at full power (L_{max}) measured 50 feet from the source, the percent of time the equipment would be operated at full power (usage factor), and the equivalent noise level over a construction shift (FHWA 2006). To comply with the Siskiyou County General Plan (1978), , the maximum allowable noise level in the General Plan (1978) was used for equipment whose L_{max} in the Roadway Construction Noise Model exceeds the Siskiyou County regulation. The L_{eq} noise levels were calculated for each construction equipment using Equation 1.

Equation 1: $$L_{eq\_equipment} = 10 \log_{10} [10^{(Lmax\_equipment/10)} \times UF_{equipment}]$$

Where:

- Lmax is the maximum sound level for each type of equipment (dBA); and
- UF is the daily usage fraction of time that equipment is used at full power (%).

Table T-3. Construction Operations, Equipment Types, and Their Noise Levels.

Equipment Types	Usage Factor (%)	L_{max} at 50 feet (dBA)	L_{eq} at 50 feet (dBA)
Air compressor	40	78	74
Backhoe	40	78	74
Blasting	1	94	74
Compactor	20	83	76
Concrete mixer truck	40	79	75
Concrete pump truck[1]	20	81	74
Crane	16	81	73
Dozers[1]	40	81	77
Dump truck	40	77	73
Excavator	40	81	77
Front end loader	40	80	76
Generator	50	81	78
Generator (<25 kVA)	50	73	70
Grader	40	85	81

Equipment Types	Usage Factor (%)	L_{max} at 50 feet (dBA)	L_{eq} at 50 feet (dBA)
Jackhammer[1]	20	81	74
Mounted impact hammer (hoe)	20	90	83
Pickup truck	40	75	71
Pumps	50	77	74
Scraper	40	84	80
Tractor[1]	40	81	77

Source: FHWA 2006, Siskiyou County 1978

[1] Maximum allowable noise levels from construction equipment at 100 feet from Siskiyou County's General Plan converted to noise levels at 50 feet.

Noise levels were calculated for all equipment expected to be used during peak deconstruction or construction day at each dam, including blasting. Detailed equipment usage for non-peak days was not available at the time of the analysis. The individual L_{eq} of each piece of equipment was combined to obtain the total L_{eq} noise level at each construction site using Equation 2.

Equation 2: $L_{eq\_total\ source} = 10 \log_{10} [\Sigma\ 10^{(L_{eq\_equipment}/10)}]$

Natural noise attenuation resulting from distance between the construction sites and receptors, atmospheric absorption, and terrain were subtracted from the total L_{eq} of all equipment. The equivalent L_{eq} noise levels at each noise-sensitive receptor were calculated using Equation 3:

Equation 3: $L_{eq\_receptor} = L_{eq\_total\ source} – A_{div} – A_{ground} – A_{air} – IL_{barrier}$

Where:

- L_{eq}_total source is the estimated total L_{eq} noise level at 50 feet (dBA) calculated using Equation 2;
- Adiv is the geometrical divergence, or the distance attenuation (dBA) calculated using Equation 4;
- Aground is the attenuation caused by interference between direct and ground-reflected sound (dBA) calculated using Equation 5;
- Aair is the attenuation due to atmospheric absorption (dBA); and
- ILbarrier is the attenuation due to barrier, including natural terrain, (dBA) calculated with Equations 5 through 7.

Equation 4: $A_{div} = 20 \log_{10} (d/50)$

Where:

- d is the distance from the construction site to the noise-sensitive receptor (feet).

This formula results in a six dBA loss for each doubling of distance due to spherical divergence. The distances were measured from the construction site to the closest noise-sensitive receptor.

Ground attenuation is dependent on the ground surface characteristics, distance, and source and receptor heights. Constants in Equation 5 are based on a typical construction equipment noise frequency of 500 hertz (Hz) and noise source and receptor heights (h_s = source height [feet] and h_r = receptor height [feet]) of approximately five feet. The first term is the ground attenuation in the source zone, which extends from the source to 30 hs toward the receptor. The second term is the ground attenuation in the receptor zone, which extends from the receptor to 30 hr toward the source. The third term is the ground attenuation in the zone between the source and receptor zones. The ground factor (G) for each zone is zero if the ground surface consists of asphalt or concrete pavement, water, or any hard ground with low porosity. The ground factor for soft ground, or porous ground that is covered by vegetation or loose materials such as snow and pine needles, is zero. For zones with a mixture of soft and hard ground surface areas, the ground factor is the fraction of the ground that is soft.

Equation 5: $A_{ground} = (6.5G_s – 1.5) + (6.5G_r – 1.5) – 3\{1-[30(h_s + h_r)/d]\}(1-G_m)$

Where:

- Gs is the ground factor for the source zone (source to 30 hs toward the receptor);
- Gr is the ground factor for the receptor zone (receptor to 30 hr toward the source);
- hs is the source height (feet);
- hr is the receptor height (feet);
- d is the distance between the source and the receptor; and
- Gm is the ground factor for the middle zone (between source and receptor zones).

Terrain attenuation was calculated using the Equations 6 through 8. Aground in Equation 8 cancels out the term in Equation 3.

Equations 6 through 8:

Equation 6: $N = (2 / \lambda)(d_1 + d_2 – d)$

Equation 7: $K = \exp\{-0.0005 \sqrt{[(d_1 d_2 d) / (N\lambda)]}\}$

Equation 8: $IL_{barrier} = 10 \log_{10}(3 + 10NK) – A_{ground}$

Where:

- λ is the wavelength of the sound wave (feet);
- d_1 is the distance between the top of the hill and the noise source (feet);
- d_2 is the distance between the top of the hill and the noise receptor (feet);
- d is the distance between the source and the receptor (feet);
- N is called the Fresnel number (a dimensionless number used in predicting the attenuation of a noise barrier located between a noise source and receiver) (Caltrans 2013);
- K is the atmospheric correction factor for d > 100 meters; and
- A_{ground} is the ground attenuation, which eliminates the A_{ground} term in Equation 3.

Attenuation associated with atmospheric absorption is dependent on temperature, relative humidity, and frequency of the sound waves. It should be noted that as humidity decreases, the atmospheric attenuation increases because dry air is a poor conductor of sound compared to humid air. Based on an average air temperature of 50ºFarenheit and 50 percent humidity sound attenuates at 1.9 dB per kilometer (0.0006 dB per feet) at 500 Hz (Harris 1998).

The construction noise level calculated with the above equations must be added to the existing noise levels at the receptor to determine the noise level at the receptor resulting from construction activities. The basic concept of Equation 2 was used to add construction noise impact to existing noise levels at the receptor, as shown in Equation 8. Average daytime L_{eq} and nighttime L_{eq} noise levels for rural residential areas found in the *U.S. EPA Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety* (USEPA 1974) were used to estimate ambient noise levels at selected receptor locations. These levels are 40 dBA during the day (7 a.m. to 10 p.m.) and 30 dBA at night (10 p.m. to 7a.m.). Nighttime existing level is used at Iron Gate Dam and Copco No. 1 Dam receptors, where there is possible impact from nighttime construction activities.

Equation 8: $L_{eq\_receptor} = 10 \log_{10} [10^{(Leq\_total\ equipment/10)} + 10^{(Leq\_existing/10)}]$

Where:

- L_{eq}_total equipment is the equivalent total L_{eq} noise level at the receptor due to construction activities after distance, terrain, and atmospheric attenuation are taken (dBA); and
- L_{eq}_existing is 40 dBA for daytime noise analysis and 30 dBA for nighttime noise analysis (dBA).

The existing L_{eq} was subtracted from the resulting total L_{eq} at the receptor to calculate the increase in noise levels due to construction activity. This impact was compared against the criteria of 10 dBA to determine significance.

Attachment 1 presents the results of the construction noise impact analysis.

T.3 Construction-Related Traffic Noise Impact Assessment Methodology

Peak hour traffic noise levels for the Existing, No Action, and Action Alternatives were estimated for construction workers' commuting vehicles, delivery trucks, and trucks hauling waste materials using the FHWA Traffic Noise Model, Version 2.5 (TNM2.5). TNM2.5 is capable of modeling noise impacts from automobiles, medium trucks (two axles), heavy trucks (three or more axles), buses, and motorcycles by factoring in vehicle volume, vehicle speed, roadway configuration, distance to the noise-sensitive receptors, atmospheric absorption, and ground attenuation characteristics (FHWA 1998a, 2004a). The model is based on measurements collected by the Volpe National Transportation Systems Center Acoustics Facility and is generally considered to be accurate within +/- 3 dB (FHWA 1998b).

To simplify the analysis, bus and motorcycle volumes were assumed to be negligible and attenuation from the natural terrain and vegetation were not included. It was assumed that there would be equal volumes of traffic on each direction of a roadway and peak hour traffic coincides with the worst one-hour L_{eq}. Peak hour noise levels were modeled for generic receptors 50 and 500 feet from the edge of the road. 50 feet represents the minimum possible distance for a receptor along any roadway, and 500 feet is the maximum recommended receptor distance for traffic noise models (Caltrans, 2006). The modeled roadway segment should be longer than eight times the maximum source to receptor distance (FHWA 2004b). The maximum distance between the source and receptor is 500 feet; therefore, an approximately 5,000 feet road segment was modeled.

Average daily traffic counts published by Caltrans (2010) provided the basis for estimating the existing noise levels on US Interstate 5. Existing one-hour L_{eq} for Topsy Grade Road and Copco Road and vehicle distributions were provided by the transportation engineers (J. Key, pers. comm., December 13, 2010). Based on a review of published ODOT and Caltrans traffic counts, peak hour traffic volume was typically 10 to 20 percent of the average daily traffic volume. Changes in noise levels would be greater when the baseline traffic counts are lower; therefore, for a conservative analysis, the analysis assumed that peak hour traffic is 10 percent of average daily traffic. As free-flow speeds were not available, posted speed limits were entered in the model to be conservative. As measured traffic counts on U.S. Interstate 5 between Yreka and Anderson, California, are generally higher than those north of Yreka, significance for the Yreka-Anderson segment was based on the significance of the segment north of Yreka, California. Traffic counts and characteristics of Topsy Grade Road were used to model noise levels on Ager-Beswick Road because they have a similar level of service (LOS). It was assumed that there would be no increase in regional traffic between Existing Conditions and No-Action Alternative.

Under the Proposed Project, trucks would haul recyclable metal waste to Weed, California for waste originating in California[13]. Wood waste from Copco No. 2 Dam would likely be hauled to a hazardous waste landfill in Anderson, California. For the alternatives requiring fish passage construction, rebar and wood would be supplied from Medford, Oregon, and concrete would be transported from the Yreka, California. The haul routes would likely be U.S. Interstate 5, US 97, OR 66, Copco Road, Topsy Grade Road, and Ager-Beswick Road. Details regarding the roadways affected by this Proposed Action are presented in the Transportation Section (Section 3.22 *Traffic and Transportation*). The greater number of trucks available for each material or the peak daily haul truck volumes divided by eight was used as the hourly truck volume. The estimated construction work shift length is eight hours. The hourly truck volumes were added to the existing/no-action peak hour traffic volumes. This analysis assumes that off-site hauling to suppliers and disposal areas would only occur during the daytime. All new truck trips are assumed to consist of heavy trucks, those with three axles or greater for use in the TNM2.5 model.

[13] This assumption from the 2011 noise modeling is no longer accurate. Actually, the recyclable metal waste would be taken to the Yreka Transfer Station in Yreka California. The trip to Yreka follows the same route as the trip to Weed except it is shorter. Therefore, the analysis is still valid.

Construction workers would likely commute from Yreka, California, or Medford, Oregon, to Iron Gate, Copco No. 1, and Copco No. 2 sites and from Keno or Klamath Falls, Oregon to the J.C. Boyle site according to the Population and Housing Section (Section 3.17 *Population and Housing*). The maximum number of construction workers for J.C. Boyle was added to automobile traffic on US 97, OR 66, and Topsy Grade Road. Maximum total construction workers for Iron Gate, Copco No. 1, and Copco No. 2 were added to automobile traffic volume on Copco Road and U.S. Interstate 5. As the distribution of workers from Medford, Oregon, and Yreka, California, on U.S. Interstate 5 are unknown, the maximum number of workers commuting to the California dams were added to both segments of US Interstate 5 for a conservative analysis.

For Alternatives 2, 3, and 5, truck and commute trips for all dams using the same road were combined. For Alternative 4, the maximum number of trucks and passenger vehicles traveling each road was used because construction is scheduled to occur one dam at a time.

Significance is defined as an increase of 12 dBA in California (Caltrans 2006) or more above existing one-hour L_{eq} for traffic-induced noise.

The results of the traffic noise modeling analysis are presented in Attachment 3.

T.4 Vibration Concepts

Vibration is caused by oscillatory waves that propagate through the ground. Ground-borne vibration can cause building floors to shake, windows to rattle, hanging pictures to fall off walls, and in some cases damage buildings.

Like noise, vibration from a single source may consist of a range of frequencies. The magnitude of vibration is commonly denoted as the peak particle velocity (PPV) and is expressed in inches per second (in/sec). The PPV is the maximum velocity experienced by any point in a structure during a vibration event and indicates the magnitude of energy transmitted through vibration. PPV is an indicator often used in determining potential damage to buildings from vibration associated with blasting and other construction activities.

Table T-4 summarizes the levels of vibration from construction equipment and the typical effects on people and buildings based on a review of published vibration levels and effects (Caltrans 2004). Although blasting is considered a transient source, human response may vary widely depending on the event duration, frequency of occurrence, startle factor, level of personal activity at the time of the event, health of the individual, time of day, orientation of the individual (standing up or lying down), and political and economic perception of the blasting operation. Ground vibration as low as 0.1 in/sec due to a blasting operation may be considered distinctly to strongly perceptible by a person.

Table T-4. Summary of Construction Equipment Vibration Levels and Effects on Humans and Buildings.

Effects	Peak Particle Velocity (in/sec)	
	Transient	Continuous/Frequent Intermittent Sources
Potentially Damaged Structure Type		
Extremely fragile historic buildings, ruins, ancient monuments	0.12	0.08
Fragile buildings	0.2	0.1
Historic and some old buildings	0.5	0.25
Older residential structures	0.5	0.3
New residential structures	1.0	0.5
Modern industrial/commercial buildings	2.0	0.5
Human Response		
Barely perceptible	0.04	0.01
Distinctly perceptible	0.25	0.04
Strongly perceptible	0.9	0.10
Severe	2.0	0.4

Source: Caltrans 2004
Notes:
1 Transient sources create a single isolated vibration event, such as blasting and drop balls.
2 Continuous/frequent intermittent sources include impact pile drivers, vibratory pile drivers, and vibratory compaction equipment.

Vibration from construction and traffic typically does not contribute to building damage, with the occasional exception of blasting and pile-driving during construction.

U.S. Bureau of Mines and Office of Surface Mining Reclamation and Enforcement have developed a blast vibration limit ranging from 0.5 to 2.0 in/sec depending on vibration frequency and distances to protect buildings with various structure type and condition. Studies have shown that blast vibration typically does not damage residential structures even at levels exceeding U.S. Bureau of Mines and Office of Surface Mining Reclamation and Enforcement blast vibration limits (Caltrans 2004).

Average vibration amplitude is a more appropriate measure for human response as it takes time for the human body to respond. Average particle velocity over time is zero so the root-mean-square amplitude called the vibration velocity level (L_v) in vibration decibels (VdB) is used to quantify annoyance. For a person in their residence, the low threshold for annoyance is 72 VdB. The L_v equivalent of the 0.12 in/sec damage criteria for fragile historic buildings is 90 VdB, a much higher value than what a person may perceive as “annoying” (Federal Transit Administration [FTA] 2006).

Vibration impacts from the project were considered significant if the peak particle velocity exceeded 0.3 in/sec based on the damage level for older residential structures. Vibration velocity level was considered significant if it exceeded the 72 VdB annoyance level.

T.5 Construction Vibration Impact Assessment Method

Vibration from construction projects is caused by general equipment operations, and is usually highest during pile driving, soil compacting, jack hammering, demolition, and blasting activities. Although it is conceivable for ground-borne vibration from construction projects to cause building damage, the vibration from construction activities is almost never of sufficient amplitude to cause even minor cosmetic damage to buildings. The primary concern is that the vibration can be intrusive and annoying to people nearby. Table T-5 presents the vibration levels for typical construction equipment published in FTA Transit Noise and Vibration Impact Assessment (2006).

Table T-5. Vibration Levels for Construction Equipment.

Equipment Types	PPV at 25 feet (in/sec)	L_V at 25 feet (VdB)
Clam shovel drop	0.20	94
Vibratory roller	0.21	94
Large bulldozer/Hoe ram	0.08	87
Caisson drilling	0.08	87
Loaded trucks	0.07	86
Jackhammer	0.03	79

Source: FTA 2006

Total PPV at each construction site is the sum of PPV for all equipment at the construction site. Equation 9 was used to calculate the construction equipment vibration levels at the receiver, based on a reference vibration at 25 feet.

Equation 9: $PPV_{receptor} = PPV_{source}\ (25/d)^{1.5}$

Where:

- PPVsource is the total vibration level at 25 feet (in/sec); and
- d is the distance from the equipment to the receptor (ft).

Vibration levels expressed as VdB are treated similarly to noise levels. Equation 10 was used to calculate the total L_v from all construction equipment. The equivalent L_v at the receptor was calculated using Equation 11.

Equation 10: $L_{V\_total} = 20 \log_{10} \Sigma\ 10^{(L_{V\_equipment}/20)}$

Equation 11: $L_{V\_receptor} = L_{V\_source} - 30 \log_{10} (d/25)$

Where:

- d is the distance from the construction site to the noise-sensitive receptor (feet).

Vibration levels associated with blasting are site-specific and are dependent on the amount of explosive used, soil conditions between the blast site and the receptor, and the elevation where blasting would take place (specifically, the below surface elevation where bedrock would be encountered). Blasting below the surface would produce lower vibration levels at a receptor due to additional attenuation provided by distance and transmission through soil and rock. Vibration from blasting was estimated using the Blast Vibration Prediction Curves published by L. L. Oriard in 1999 and 2000 (Caltrans 2004). One can estimate the PPV of blasting based on the square root scaled distance (Equation 12). The estimated PPV was converted to L_v using Equation 13. Actual blasting procedures would be dictated by site-specific conditions as determined by the construction contractor prior to construction and through monitoring during construction.

Equation 12: $D_S = d / \sqrt[3]{W}$

Where:

- d is the distance from the construction site to the noise-sensitive receptor (feet); and
- W is the charge weight (pounds).

Equation 13: $L_V = 20 \text{ Log}_{10}(PPV/10^6) - 12$ (assuming a crest factor of 4)

Calculated PPV and L_v were compared against the criteria of 0.3 in/sec and 72 VdB, respectively, to determine significance.

T.6 References

Caltrans. 2004. Transportation- and Construction-Induced Vibration Guidance Manual. June. Available at: http://www.dot.ca.gov/hq/env/noise/pub/vibrationmanFINAL.pdf. Accessed on: February 10, 2011.

Caltrans. 2006. Traffic noise analysis protocol. August. Available at: http://www.dot.ca.gov/hq/env/noise/pub/2006_protocol.pdf. Accessed on February 10, 2011.

Caltrans. 2010. Traffic and Vehicle Data Systems Unit: 2009 All Traffic Volumes on California State Highway System. Available at: http://traffic-counts.dot.ca.gov/2009all/2009TrafficVolumes.htm. Accessed on November 19, 2010.

Caltrans. 2013. Technical noise supplement to the traffic noise analysis protocol. Sacramento, California.

FHWA (Federal Highway Administration). 1998a. FHWA Traffic Noise Model® User's Guide. January.

FHWA. 1998b. FHWA Traffic Noise Model® Technical Manual. February.

FHWA. 2004a. FHWA Traffic Noise Model® User's Guide (Version 2.5 Addendum). April. Available at: http://www.fhwa.dot.gov/environment/noise/traffic_noise_model/tnm_v25/users_manual/TNM25UsersGuideAddendum.pdf. Accessed on February 10, 2011.

FHWA. 2004b. Traffic noise model: frequently asked questions. April. Available at: http://www.fhwa.dot.gov/environment/noise/traffic_noise_model/tnm_faqs/faq06.cfm#miroadways. Accessed on February 10, 2011.

FHWA. 2006. Roadway Construction Noise Model User's Guide. January. Available at: http://www.fhwa.dot.gov/environment/noise/construction_noise/ rcnm/rcnmcover.cfm. [Accessed on February 10, 2011].

FHWA. 2011. Highway traffic noise: analysis and abatement guidance. January. Available at: http://www.fhwa.dot.gov/environment/noise/regulations_and_guidance/ analysis_and_abatement_guidance/revguidance.pdf. [Accessed on February 10, 2011].

FTA (Federal Transit Administration). 2006. Transit Noise and Vibration Impact Assessment. May. Available at: http://www.fta.dot.gov/documents/FTA_Noise_and_Vibration_Manual.pdf. [Accessed on February 10, 2011.]

Harris, C. M. 1998. Handbook of acoustical measurements and noise control. 3rd edition. Acoustical Society of America.

ODOT (Oregon Department of Transportation). 2009. Noise manual. March. Available at: ftp://ftp.odot.state.or.us/techserv/Geo-Environmental/Environmental/ Procedural%20Manuals/Air%20and%20Noise/ODOT%20Noise%20Manual.pdf. [Accessed on February 10, 2011.]

ODOT. 2010. 2009 traffic volumes on state highways. Available at: http://www.oregon.gov/ODOT/TD/TDATA/tsm/docs/2009_TVT.pdf. [Accessed on November 19, 2010.]

Siskiyou County. 1978. Siskiyou County General Plan Noise Element. December 6. Available at: http://www.co.siskiyou.ca.us/phs/planning/docs/generalplan/ Noise%20Element.pdf. [Accessed on February 10, 2011.]

USEPA (U.S. Environmental Protection Agency). 1974. Information on levels of environmental noise requisite to protect public health and welfare with an adequate margin of safety. March. Available at: http://nepis.epa.gov/Exe/ ZyPURL.cgi?Dockey=2000L3LN.txt. [Accessed on February 10, 2011.]

This page left blank intentionally.

Attachment 1

Construction Noise Impact Analysis

The noise and vibration impact modeling described in this attachment is reproduced from the 2012 EIS/EIR analysis. Although there have since been some modifications to the project schedule, the 2011 noise and vibration impact modeling is reproduced herein because the construction-related noise and vibration-generating activities for the Proposed Project would be 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 associated with removing Iron Gate Dam, Copco No. 1 Dam, and Copco No. 2 Dam. 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 3.23.3 *[Noise] Significance Criteria* and analyzed in Section 3.23.5 [Noise] *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, 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, Copco No. 1)</td></tr>
<tr><td>Fish Passage at Four Dams</td><td>Continued Operations with Fish Passage</td></tr>
</table>

Attachment 2

Construction Vibration Impact Analysis

The noise and vibration impact modeling described in this attachment is reproduced from the 2012 EIS/EIR analysis. Although there have since been some modifications to the project schedule, the 2011 noise and vibration impact modeling is reproduced herein because the construction-related noise- and vibration-generating activities for the Proposed Project would be 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 associated with removing Iron Gate Dam, Copco No. 1 Dam, and Copco No. 2 Dam. 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 3.23.3 *[Noise] Significance Criteria* and analyzed in Section 3.23.5 [Noise] *Impacts and Mitigation*.

Alternative Name Key	
2012 EIS/EIR Alternative Name	**Lower Klamath Project EIR Alternative Name**
Proposed Action	Proposed Project
	Three Dam Removal (Iron Gate, Copco No. 1, Copco No. 2)
	No Hatchery
Partial Facilities Removal	Partial Removal
Remove Two Dams (Iron Gate and Copco No. 1)	Two Dam Removal (Iron Gate, Copco No. 1)
Fish Passage at Four Dams	Continued Operations with Fish Passage

Attachment 3

Traffic Noise Impact Analysis

The noise and vibration impact modeling described in this attachment is reproduced from the 2012 EIS/EIR analysis. Although there have since been some modifications to the project schedule, the 2011 noise and vibration impact modeling is reproduced herein because the construction-related noise- and vibration-generating activities for the Proposed Project would be 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 associated with removing Iron Gate Dam, Copco No. 1 Dam, and Copco No. 2 Dam. 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 3.23.3 *[Noise] Significance Criteria* and analyzed in Section 3.23.5 [Noise] *Impacts and Mitigation*.

Alternative Name Key	
2012 EIS/EIR Alternative Name	**Lower Klamath Project EIR Alternative Name**
Proposed Action	Proposed Project
	Three Dam Removal (Iron Gate, Copco No. 1, Copco No. 2)
	No Hatchery
Partial Facilities Removal	Partial Removal
Remove Two Dams (Iron Gate and Copco No. 1)	Two Dam Removal (Iron Gate, Copco No. 1)
Fish Passage at Four Dams	Continued Operations with Fish Passage