APPENDIX M

Air Quality and Noise Appendix

FERC DIRECTED ACOUSTIC ANALYSIS OF PILE DRIVING.

A second acoustic analysis was conducted to assess potential noise impacts resulting from pile driving activities at NSAs. Noise produced by pile-driving activities was evaluated employing a computer simulation. DataKustic GmbH's CadnaA, the computer-aided noise abatement program (2019 MR1), was used to model pile driving noise. CadnaA is a comprehensive software model that conforms to the International Organization for Standardization (ISO) standard ISO 9613-2, Attenuation of Sound during Propagation Outdoors. The engineering methods specified in this standard consist of full (1/1) octave band algorithms that incorporate geometric spreading due to wave divergence, reflection from surfaces, atmospheric absorption, screening by topography and obstacles, ground effects, source directivity, heights of both sources and receptors, seasonal foliage effects, and meteorological conditions.

Terrain conditions, vegetation type, ground cover, the density and height of foliage can also influence the absorption that takes place when sound travels over land or water. Topographical information was imported into the acoustic model using the official United States Geological Survey (USGS) digital elevation dataset to accurately represent terrain in three dimensions. In addition, the ISO 9613-2 standard accounts for ground absorption by assigning a numerical coefficient of G=0 for acoustically hard, reflective surfaces and G=1 for absorptive surfaces and soft ground. If the ground is hard-packed dirt, typically found in industrial complexes, pavement, bare rock or for sound traveling over bodies of water, the absorption coefficient is defined as G=0 to account for reduced sound attenuation. In contrast, ground covered in vegetation, including suburban lawns, will be acoustically absorptive and aid in sound attenuation, i.e., G=1.0. The ground absorption for areas of water was set to 0 (fully reflective), 0.1 for the facility ground (mostly reflective), and at 0.5 (mixed ground) for the balance of ground areas. The sound model propagation calculation parameters are summarized below.

Model Input	Parameter Value
Standards	ISO 9613-2, Acoustics – Attenuation of sound during propagation outdoors.[1]
Engineering Design	Conceptual Facility Layout (Proposed Pile Locations) as provided by Jordan Cove
Grid Spacing	25 m
Terrain Description	USGS topography
Ground Absorption	0.5 (semi-reflective), 0.0 (reflective) for waterbodies, 0.1 for facility grounds
Receiver Characteristics	1.52 m (5 ft) above ground level
Meteorological Factors	Omnidirectional downwind propagation / mild to moderate atmospheric temperature inversion
Temperature	50°F
Relative Humidity	70%
Search radius	Approximately 5 miles

CadnaA allows for three basic types of sound sources to be introduced into the model: point, line, and areas sources. For the pile driving acoustic analysis the sound sources were represented as point sources. It is anticipated that there would be a maximum of 14 impact pile installation rigs and 6 vibratory pile installation rigs operating simultaneously; therefore, 20 point sources were positioned within the Terminal site boundary. The impact pile-driving activities and vibratory pile-

[1] Propagation calculations under the ISO 9613 standard incorporate the effects of downwind propagation from facility to receptor) with wind speeds of 1 to 5 m per second (3.6 to 18 kilometers per hour) measured at a height of 3 to 11 m above the ground.

driving activities are expected to generate elevated sound levels. Representative octave band sound power data was used in the modeling analysis based on information from previous studies. The pile-driving sound source levels are presented below.

Frequency (Hz)	Octave Band Sound Power Level (dBA)									Broadband (dBA)
	31.5	63	125	250	500	1000	2000	4000	8000	
Impact Pile Driving	105	108	119	124	131	148	120	112	102	148
Vibratory Pile Driving	162	149	143	123	127	123	129	128	131	136

Table 4.12.2.3-2 in section 4.12 of the EIS presents the existing ambient sound level during both daytime and nighttime hours at each NSA, the modeled sound contribution of attributed to pile driving, the resulting combined sound level of all sources and predicted change in sound level resulting from pile driving activities relative to existing sound levels. It should be noted that each NSA may represent hundreds of homes/residences, especially those in North Bend, Coos Bay and Glasgow, Oregon. Figure 4.12-3 in section 4.12 displays the Project pile-driving acoustic modeling results as sound contours in 5 dBA increments on scaled USGS orthophoto maps. The sound contour isopleths are plotted at a height of 1.52 meters above ground level (AGL), which is approximately the ear height of a standing person.

The sound contribution from pile driving activities is represented in terms of the maximum sound level (L_{max}). This metric is used to describe the instantaneous sound impact, which is appropriate for impulsive sound sources such as pile driving. Modeling results indicate considerable increases in sound level relative to existing conditions at NSAs during both daytime and nighttime hours. It should be noted that we did not impose any noise penalty used for noise that would occur from 10 p.m. to 7 a.m.

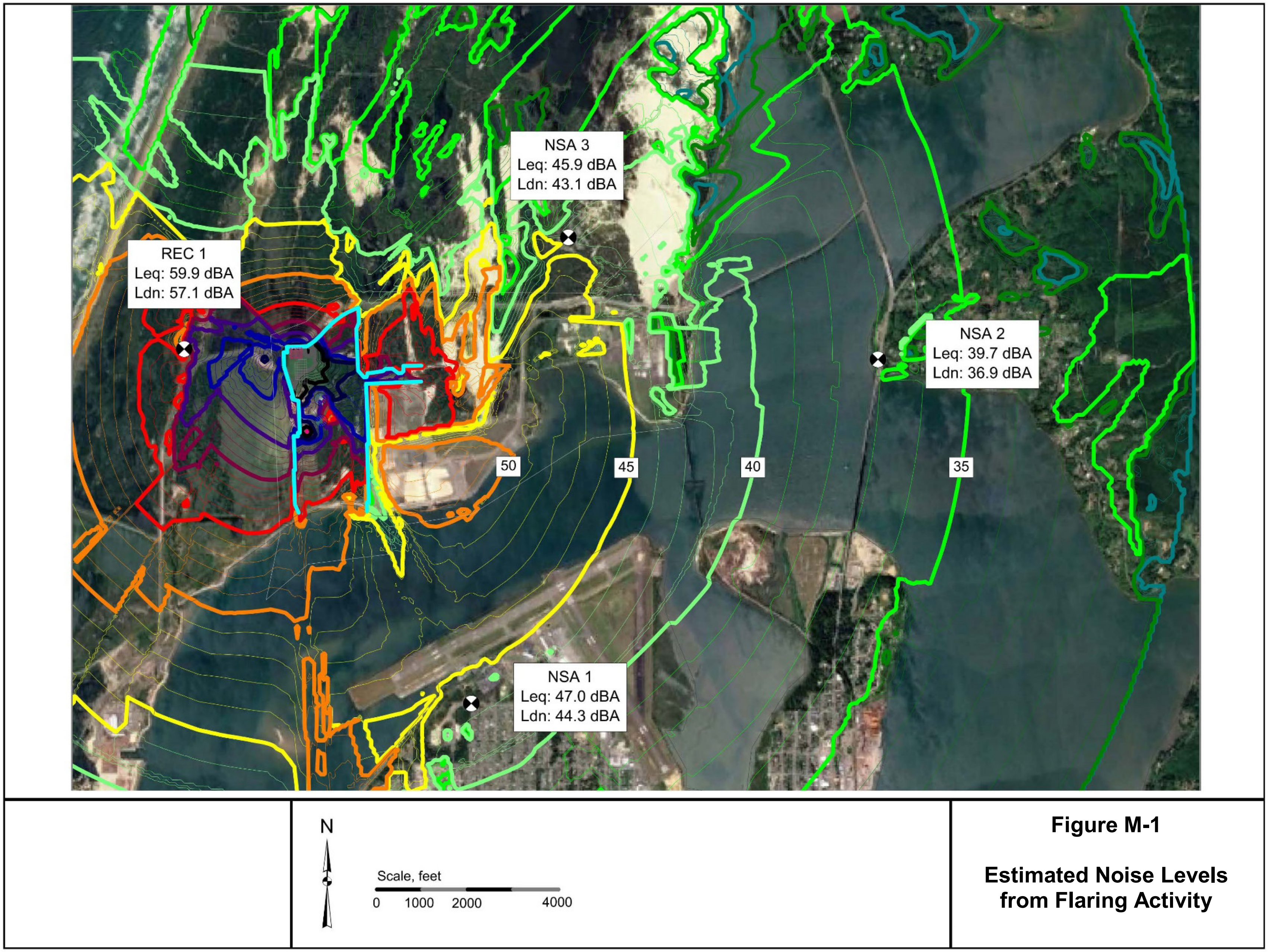

Figure M-1

Estimated Noise Levels from Flaring Activity

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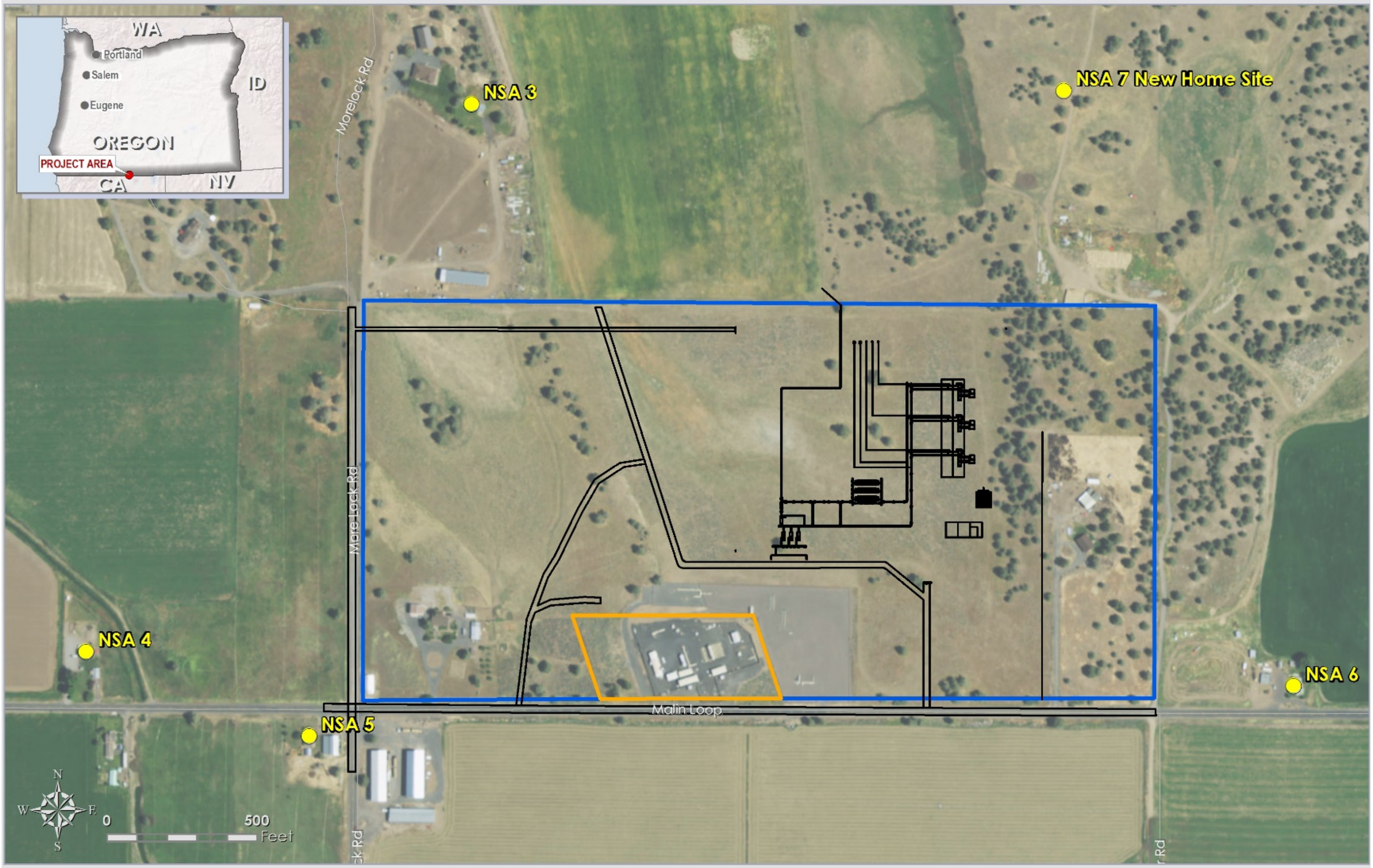


LEGEND

Klamath Compressor Station Layout

NSAs

Site Perimeter and Parcel Ownership

KLAMATH COMPRESSOR STATION PROPERTY

PACIFIC GAS TRANSMISSION CO

Figure M-2

Noise Sensitive Areas in the Vicinity of the Klamath Compressor Station

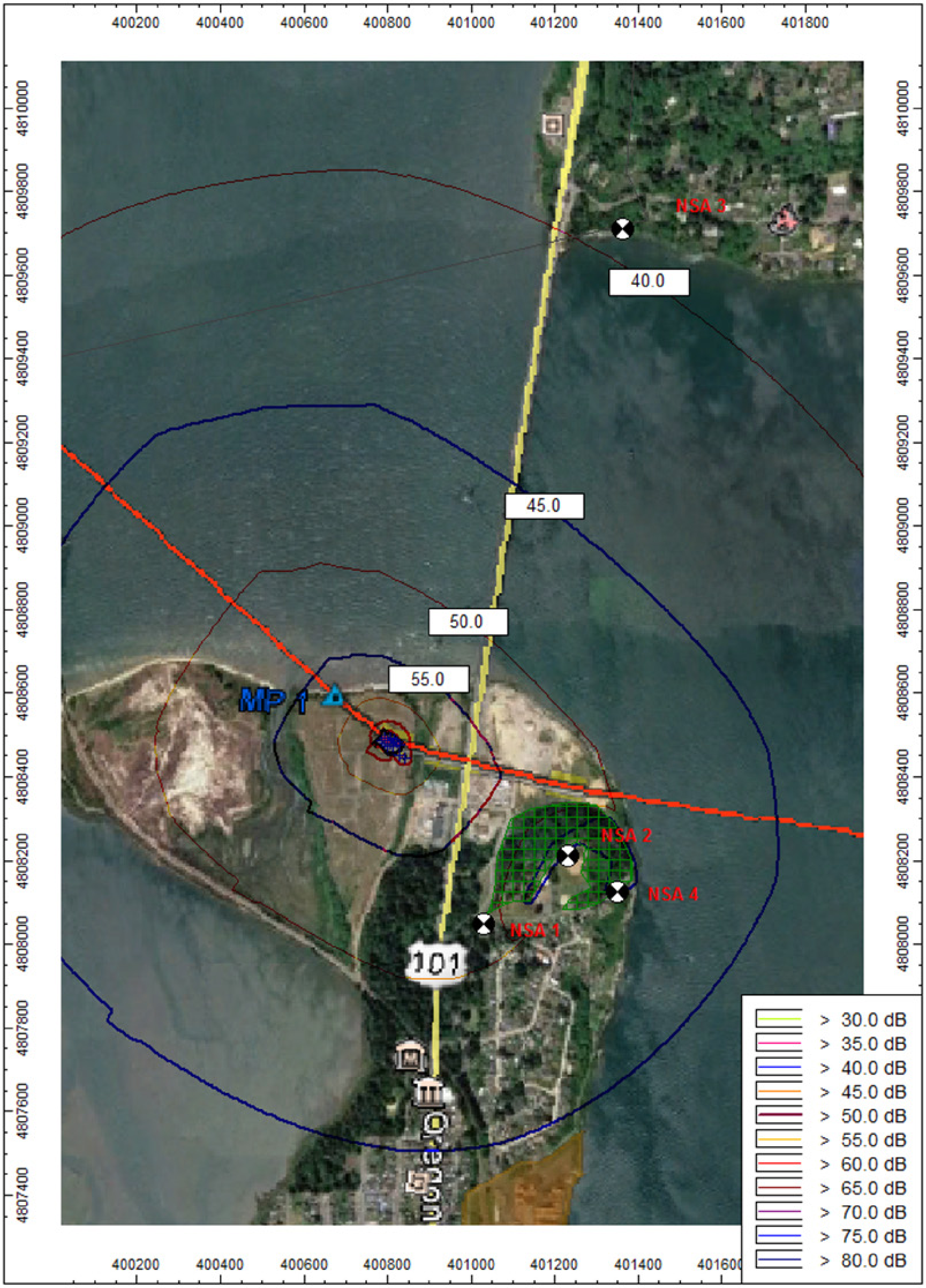


Figure M-3. Coos Bay West Crossing HDD Noise Levels

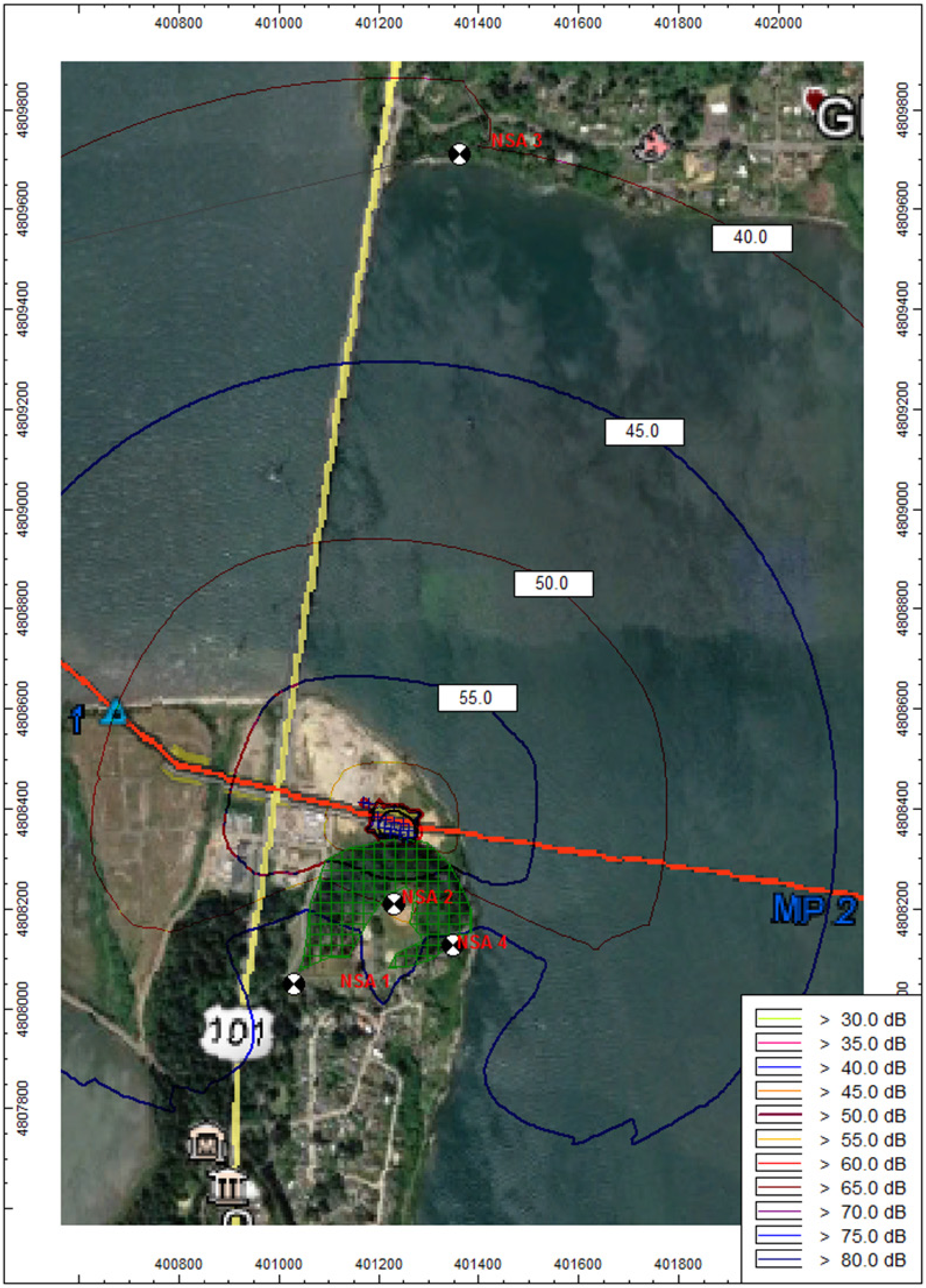


Figure M-4. Coos Bay East Crossing HDD Noise Levels

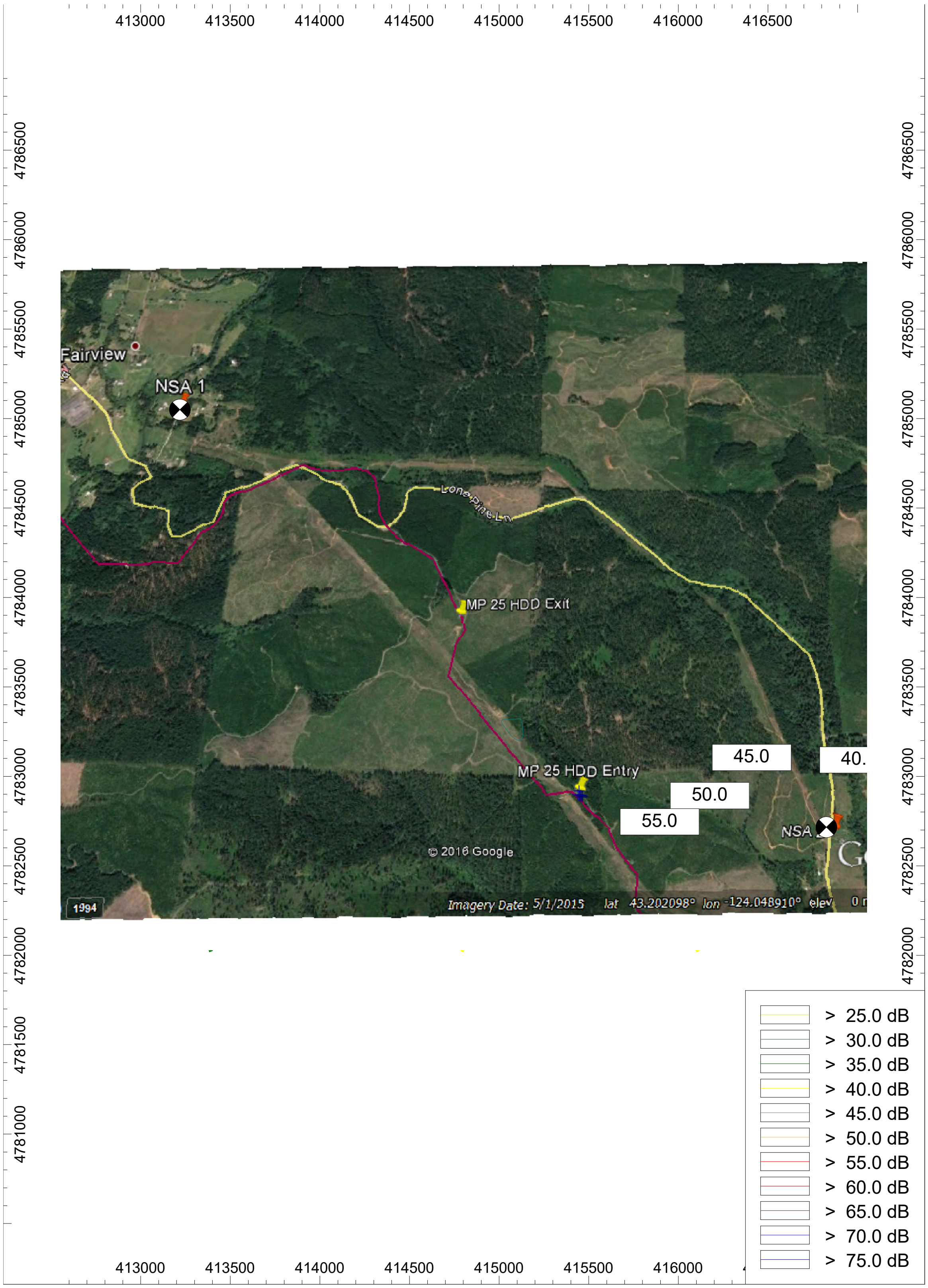


Figure M-5. Milepost 25 BPA Powerline Corridor HDD Noise Levels

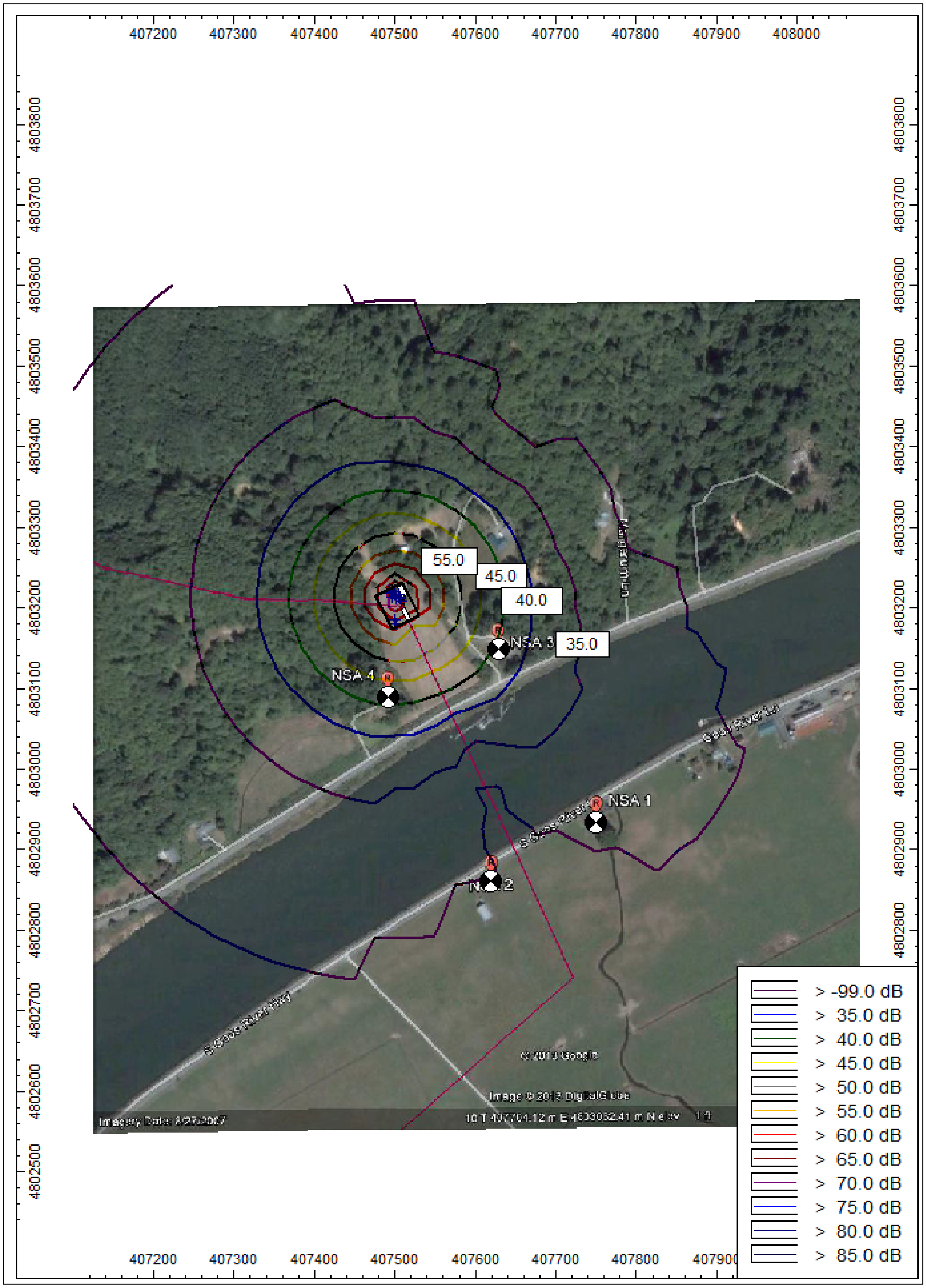


Figure M-6. Coos River Crossing HDD Noise Levels

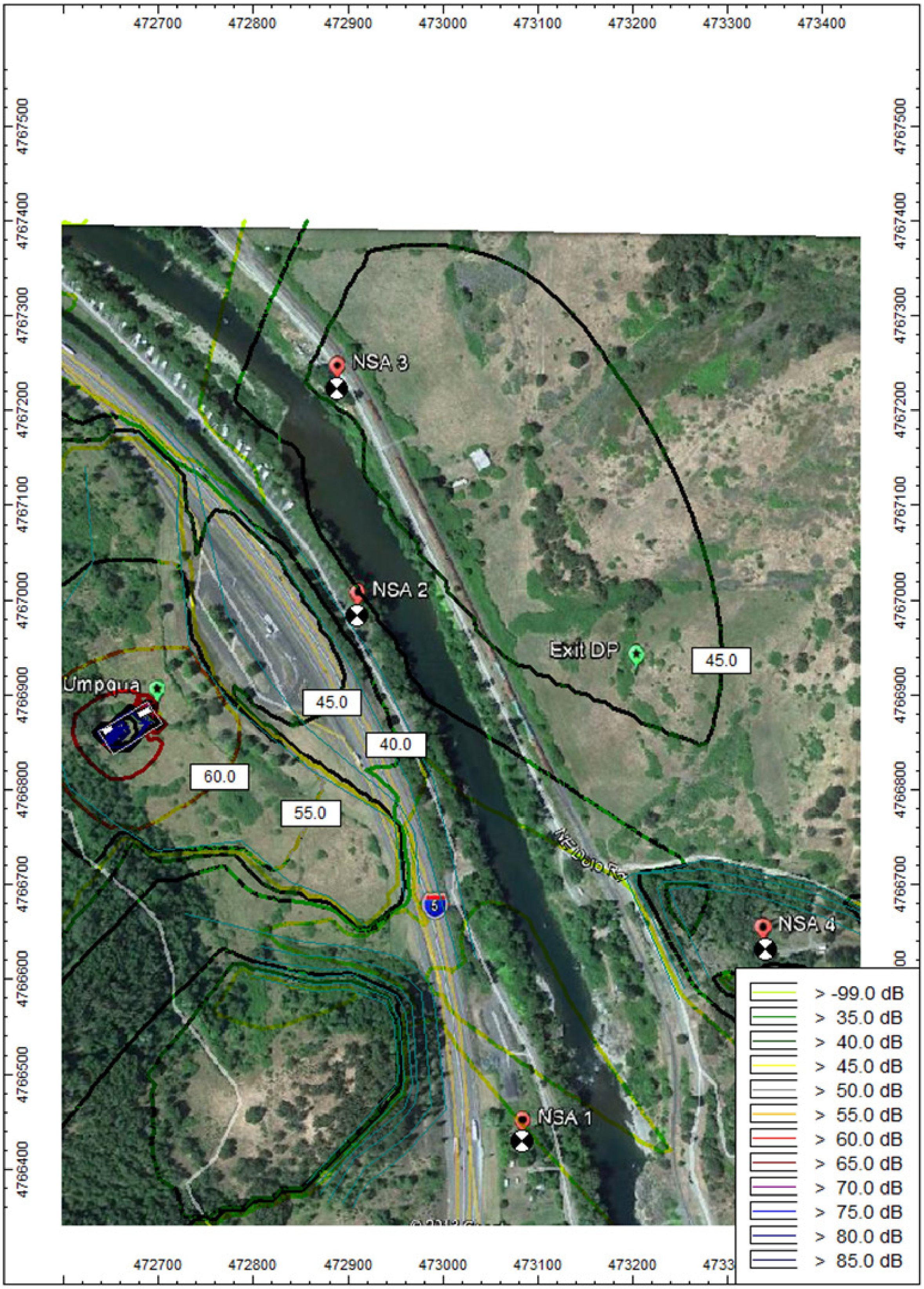


Figure M-7. South Umpqua Crossing HDD Noise Levels

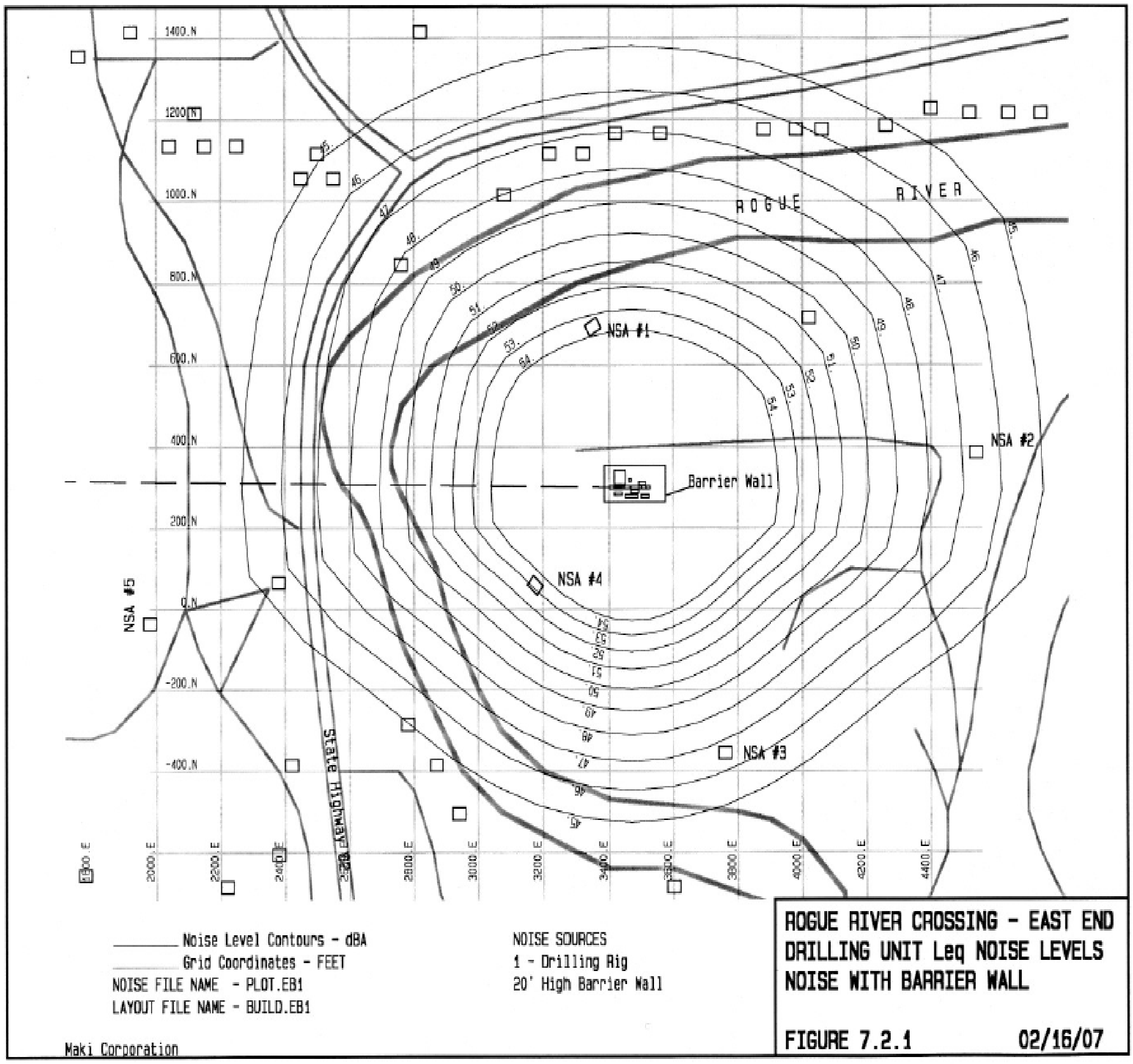


Figure M-8. Rogue River Crossing HDD Noise Levels

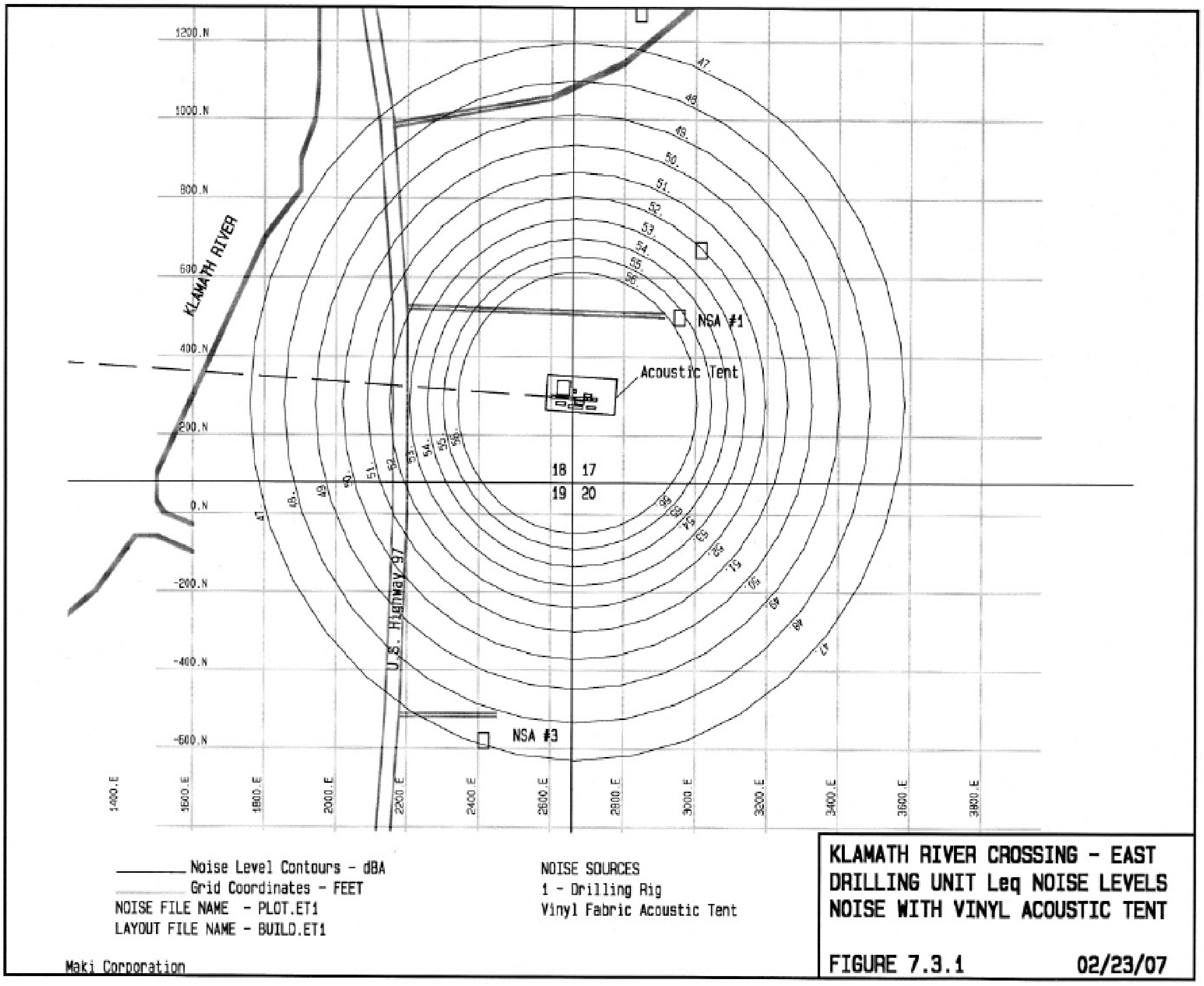
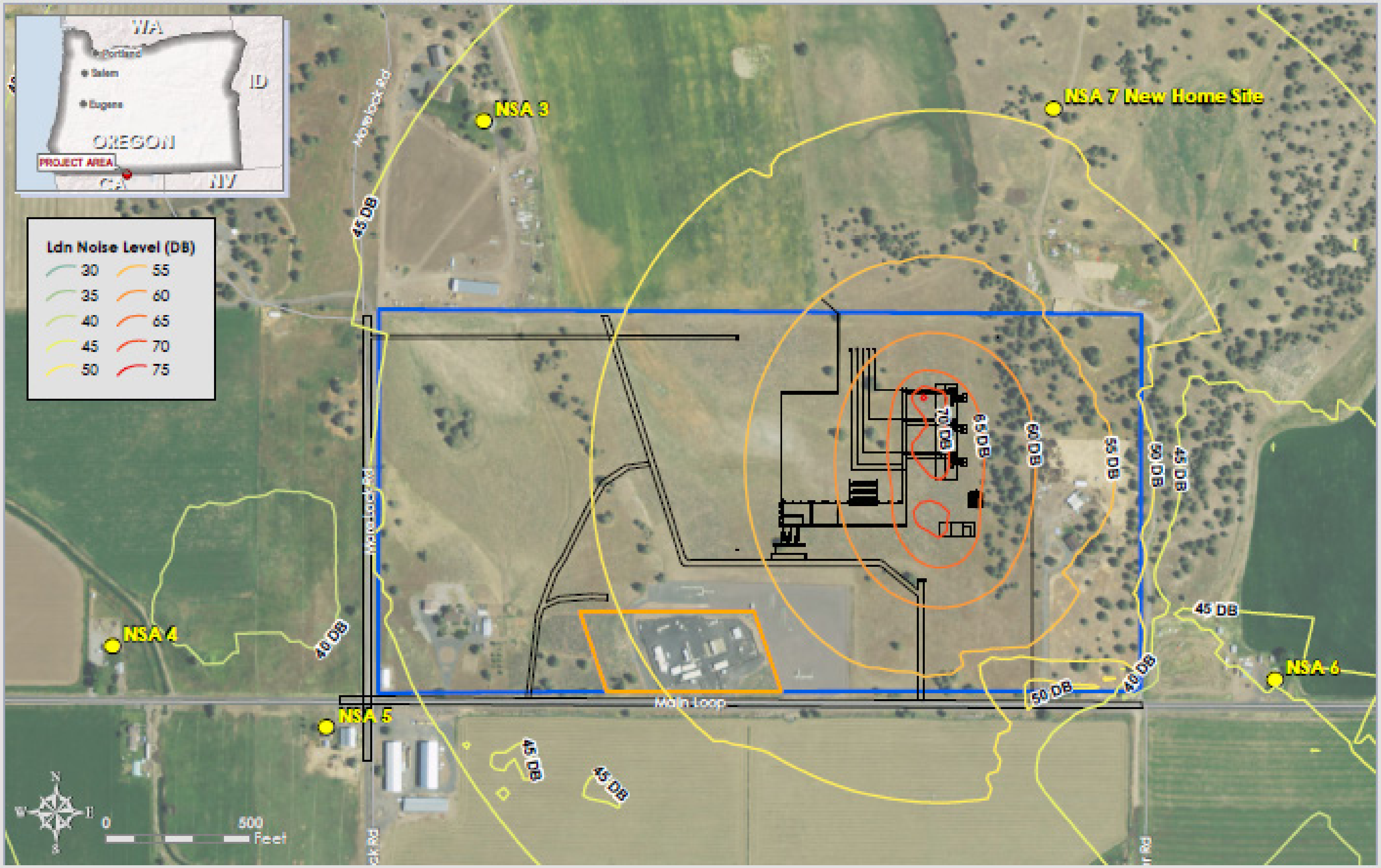


Figure M-9. Klamath River Crossing HDD Noise Levels



LEGEND

Klamath Compressor Station Layout

NSAs

Site Perimeter and Parcel Ownership

KLAMATH COMPRESSOR STATION PROPERTY

PACIFIC GAS TRANSMISSION CO

Figure M-10

Received Sound Levels, Klamath Compressor Station Operation

TABLE M-1

Construction Equipment Noise Emission Levels for Pile Installation and Dredging

Equipment Type	Make/ Model	Usage (%)	L_{max} at 50 feet dBA	L_{eq} at 50 feet dBA	Units Operating Simultaneously
Pickup Trucks	Ford F-150	40%	75	71	35
Large Trucks	Ford F-350	40%	75	71	61
Offroad Trucks	Caterpillar 740	40%	77	73	3
RT Cranes	Grove RT770E	16%	81	73	42
Dozers	Caterpillar D6	40%	82	78	7
Forklifts	Xtreme XR3034	40%	79	75	43
Loaders	Caterpillar 966F	40%	79	75	3
Tractors	Caterpillar Challenger 65	40%	84	80	3
Lifts / Hoists	80' Manlift	20%	75	68	63
Rollers	Caterpillar 563 - 84"	20%	80	73	2
Scrapers	Caterpillar 657	40%	84	80	1
Motor Graders	Caterpillar 14H	40%	85	81	1
Backhoes	Caterpillar 330, John Deere 330	40%	78	74	3
Compressors	Air Compressor (185 CFM)	40%	78	74	18
Generators / Light Plants	Portable Light Plant	50%	81	78	11
Welders	Welder (400-450 Amp)	40%	74	70	30
Crawler Cranes	Manitowoc 999	16%	81	73	13
Augers/Soil Mix Equipment	Soilmec SR 90 Rotary Drill	50%	80	77	17
Pumps	Centrifugal Pump (10")	50%	81	78	1
Excavator	Caterpillar 390F L	40%	81	77	0
Concrete Pumps	BSA 14000 Series	20%	81	74	3

TABLE M-2

Typical Compressor Station Construction Noise Levels at Reference Distances

Construction Equipment	Quantity	Usage Factor %	L_{max} SPL @ 50 Feet (dBA)	Sound Pressure Level at Distance, L_{eq} (dBA)			
				250	500	1000	1500
Tractor W/Trailer	2	40	84	69	63	57	53
Air Compressor	2	40	78	63	57	51	47
Generator	3	50	81	69	63	57	53
Ext-Boom RT Hoe	1	40	78	60	54	48	44
RT Forklift	1	40	75	57	51	45	41
Welding Rigs	10	40	74	66	60	54	50
60 ft Manlift	2	20	75	57	51	45	41
Ramax Compactor	1	20	83	62	56	50	46
Excavator	2	40	81	66	60	54	50
Side boom	3	16	85	68	62	56	52
Crane	2	16	81	62	56	50	47
Haul Truck	5	40	76	65	59	53	49

a/ Source: FHWA 2006

TABLE M-3

Summary of Typical Non-HDD Pipeline Construction Noise Levels (L_{eq})

Phase Number a/	Pipeline Construction Sequence	Equipment Expected b/	Equipment Noise (dBA L_{max}) Level at 50 feet	Composite Noise (dBA L_{eq}) at 50 feet	Composite Noise (dBA L_{eq}) at 100 feet	Composite Noise (dBA L_{eq}) at 300 feet
1	Right-of-Way Acquisition and Survey	Pickup Truck Chain Saw	75 84	81	73	60
2	Clearing and Grading	Pickup Truck Chain Saw Excavator Dozer Flatbed Truck Loader Shovel Logger-Cutter Skidder Crawler-Chipper	75 84 81 82 74 79 87 84 84 79	87	79	67
3	Fencing	Pickup Truck Auger Drill Rig	75 84	78	70	57
4	Centerline Survey of Ditch	Pickup Truck	75	71	63	50
5	Ditching (Rock-Free)	Pickup Truck Backhoe Excavator Dozer Flatbed Truck Dump Truck Tracked Ditcher	75 78 81 82 74 76 80	83	75	63
6	Ditching (Rock)	Pickup Truck Backhoe Excavator Dozer Flatbed Truck Auger Drill Rig Impact Hammer Rock Drill Blasting (Mitigated) Dump Truck	75 78 81 82 74 84 90 81 98 76	95	87	74
7	Padding Ditch Bottom	Pickup Truck Backhoe Excavator Dump Truck	75 78 74 81	82	74	61
8	Stringing	Pickup Truck Excavator Flatbed Truck Crane	75 81 74 81	80	72	59
9	Bending	Pickup Truck Excavator Dozer	75 81 82	83	75	62
10	Line Up, Stringer Bead and Hot Pass	Pickup Truck Excavator Dozer Side-Boom Welder/Torch	75 81 82 75 74	82	74	61

TABLE M-3 (continued)

Summary of Typical Non-HDD Pipeline Construction Noise Levels (L_{eq})

Phase Number a/	Pipeline Construction Sequence	Equipment Expected b/	Equipment Noise (dBA L_{max}) Level at 50 feet	Composite Noise (dBA L_{eq}) at 50 feet	Composite Noise (dBA L_{eq}) at 100 feet	Composite Noise (dBA L_{eq}) at 300 feet
11	Fill and Cap Weld	Pickup Truck Welder/Torch	75 74	77	69	56
12	As-Built Footage	Pickup Truck Welder/Torch	75 74	75	67	55
13	X-Ray and Weld Repair	Pickup Truck Welder/Torch	75 74	74	66	53
14	Coating Field and Factory Welds	Pickup Truck Welder/Torch	75 74	74	66	53
15	Inspection (Jeeping) and Repair of Coating	Pickup Truck	75	71	63	50
16	Lowering In and Tie-Ins	Pickup Truck Backhoe Excavator Dozer	75 81 74 76	83	75	62
17	As-Built Survey	Pickup Truck	75	71	63	50
18	Pad and Backfill	Pickup Truck Backhoe Excavator Dozer Dump Truck	75 78 74 82 76	83	75	63
19	Test and Final Tie-In	Pickup Truck Backhoe Pumps	75 78 81	82	74	61
20	Replace Topsoil and Cleanup	Pickup Truck Backhoe Excavator Dozer Tractor	75 78 81 82 84	84	76	63

a/ Equipment expected, based on "typical" pipeline construction requirements at a given location.
b/ Estimated Cumulative Noise at 50 feet is based on equipment-specific noise values (WSDOT 2015; FHWA 2006).

TABLE M-4

HDD Equipment Sound Power Level Data

HDD Equipment	Quantity	Sound Power (Lw) / Octave Band Frequency 31.5	63	125	250	500	1000	2000	4000	8000	dBA
630 Hp Power Unit	2	110	109	108	108	109	110	110	105	108	116
630 Hp Mud Pump	2	110	109	108	108	109	110	110	105	108	116
360 hp Crane	1	80	83	85	79	81	82	79	75	65	86
Power Unit Exhaust	2	96	85	76	72	66	65	67	70	64	75
Crane Exhaust	1	100	91	80	71	71	64	64	60	50	75
360 hp Mud Cleaner	1	104	101	102	97	89	85	83	79	82	94
Mud Cleaner Exhaust	2	100	91	80	71	71	64	64	60	50	73
Shale Shaker	1	104	99	99	100	99	93	89	83	81	99
Mud Pump Exhaust	2	96	85	76	72	66	65	67	70	64	75

TABLE M-5

Compressor Station Sound Power Data

Compressor Station Equipment	Quantity	Sound Power (Lw) / Octave Band Frequency 63	125	250	500	1000	2000	4000	8000	dBA
Air Intake	3	115	104	91	87	84	77	71	87	94
Centrifugal Compressor	3	97	99	94	96	96	98	96	92	103
Centrifugal Compressor Baseplate	3	88	89	85	87	87	89	87	83	94
Exhaust Duct	3	118	111	106	97	92	91	88	87	102
Exhaust Outlet	3	123	117	105	91	84	82	95	118	117
Gas Turbine Baseplate	3	111	111	102	95	89	90	81	53	100
Gas Turbine Enclosure Ext Ventilation	3	122	113	106	98	89	96	94	98	105
Gas Turbine Enclosure Inlet Ventilation	3	123	113	106	100	91	93	90	103	106
Gas Turbine Vent Discharge	3	108	96	80	66	62	59	55	86	88
Gas Turbine	3	120	114	104	100	88	96	94	94	104
Inlet Duct	3	108	97	85	77	76	92	72	81	94
Inlet Filter House	3	116	102	89	85	76	75	67	91	94

TABLE M-6

Compressor Station Insert Loss Values

Description	Octave Band Center Frequencies (Hz)/Loss (dB) 31.5	63	125	250	500	1000	2000	4000	8000
Inlet Silencer	0	-8	-24	-53	-65	-68	-79	-77	-50
Inlet Duct Walls	0	-21	-27	-35	-41	-39	-39	-46	-52
Inlet Filter House Walls	0	-8	-13	-20	-24	-29	-30	-30	-29
Double Exhaust Silencers Klamath	-4	-16	-24	-44	-78	-84	-88	-64	-48
Exhaust Duct Walls	0	-30	-35	-40	-48	-53	-50	-55	-58
Building Attenuation	-17	-19	-24	-34	-43	-50	-55	-55	-55

JORDAN COVE'S PILE-DRIVING ANALYSIS

As indicated in section 4.12.2.3 of the EIS, Jordan Cove provided a noise analysis for pile driving.

Jordan Cove, in response to our environmental information request to provide more detailed information on the pile driving noise, provided an analysis of the noise impacts in the North Bend and Coos Bay areas around the LNG terminal. We are providing this summary information in this appendix to provide a full accounting.

In order to reduce noise impacts due to pipe pile driving, Jordan Cove proposes to install 40 to 50 percent of the total installation depth using a vibratory hammer, rather than a hydraulic impact hammer, which Jordan Cove anticipates would reduce noise levels by 15-20 dB. Jordan Cove would then complete the installation of pipe piles to the final design depth using a hydraulic impact hammer. Jordan Cove would also install 11,900 sheet piles with installation depths of 11 feet to 80 feet using a vibro-hammer. To reduce sound levels, Jordan Cove would pre-drill sheet-piling to be installed greater than 30 feet. Up to six vibratory hammers would be in use to install the sheet piles. Jordan Cove modelled the equivalent, continuous sound levels and maximum sound level data from the equipment manufacturer in the impact sheet/pile-driving analysis, assuming peak pile driving activities. Pile hammers were modeled using an L_{max} level of between 106 dBA and 116 dBA at a distance of 23 feet having applied a variable usage factor based on the expected use of the pile hammers throughout the construction period.

Table M-7 presents the predicted sound levels associated with pile driving activities at NSAs having accounted for all pile driving equipment operating at peak use during daytime or nighttime periods and accounting for two daytime and nighttime hours during which there are no planned pile-driving activities due to the crew shift change. Additionally, table M-7 provides the predicted L_{max} values of pile driving activities. The L_{dn} is a useful metric when evaluating continuous noise sources; however, for impulsive sound sources, L_{max} better represents the sound impacts of short and intense noise sources.

TABLE M-7

Predicted Pile Driving Noise Levels at NSAs (dBA)

Receptor	Ambient L_d	Ambient L_n	Ambient L_{dn}	Pile Driving Noise Level, Daytime (Including Shift Change), L_d	Pile Driving Noise Level, Nighttime (Including Shift Change), L_n	Pile Driving Noise Level (Including Shift Change), L_{dn}	Future Combined Level, L_{dn}	Increase over Ambient, L_{dn}	Predicted Maximum Level, L_{max}
NSA 1	47	47	53	52	44	53	56	3	61
NSA 2	36	36	67	63	58	66	69	2	50
NSA 3	39	39	62	58	40	60	63	1	54
REC 1	48	48	55	51	48	69	58	3	67

Based on the noise levels provided in table M-7, Jordan Cove predicted that pile-driving operations could result in an increase of 3 dB L_{dn} on the ambient noise level at two NSAs. Additionally, using the L_{max} values, pile-driving activities would result in noise impacts at all NSAs at or greater than our noise criterion of 48.6 dBA L_{eq}[2]. As described above, Jordan Cove proposed pre-drilling and vibratory installation to reduce sound levels due to sheet/pile driving activities. Jordan Cove also reviewed the feasibility of additional noise mitigation measures, such as pile caps/cushions, noise shrouds, and noise bellows, but determined these measures would lengthen construction time, and therefore did not commit to implement them.

[2] Note that a L_{dn} of 55 dBA is equivalent to a continuous noise level of 48.6 dBA L_{eq} for facilities that operate at a constant level of noise.