Waterfront Repairs at USCG Station Monterey, California
ACOUSTICAL MONITORING PLAN

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INTRODUCTION

This monitoring plan describes acoustic measurements planned during pile extraction and driving activities involved with the waterfront repairs at the United States Coast Guard (USCG) Station Monterey (Station), in Monterey, California. The USCG proposes to remove and replace the 17 timber piles supporting the patrol boat pier (Pier); replace the existing potable water line; and improve associated structures to maintain the structural integrity of the Pier and potable water line. The purpose of the project is to provide repairs and maintenance of these structures to support the operational requirements of the Station, as well as a National Oceanic and Atmospheric Administration (NOAA) boat, which also uses these facilities.

The proposed project would involve removing the existing timber deck, timber stringers, steel pile caps, steel support beams, and hardware to access the 17 timber piles. The timber piles would then be removed through use of a vibratory extractor. Each timber pile would be replaced with up to 18-inch-diameter steel-pipe pile that would be positioned and installed in the footprint of the extracted timber pile. The majority of the pile driving would be conducted with a vibratory hammer, and an impact hammer would be used for proofing the piles. The new steel-pipe piles would not be filled with concrete. Other material and hardware removed to conduct the pile replacement would be replaced with in-kind materials. This project is proposed for construction in the 2013 fiscal year.

Both underwater and airborne sound levels would be measured during pile extraction and driving. This monitoring plan follows the draft monitoring plan template recently developed by the Washington Department of Transportation (Battelle, 2004).

PROJECT AREA

The Station is located at 100 Lighthouse Avenue in the City and County of Monterey, California.

The Pier is on the eastern portion of the Station's waterfront facility, along a Jetty that extends approximately 1,300 feet east into Monterey Harbor (Jetty). The Pier and floating docks are on the south side of the Jetty. A paved access road runs approximately 800 feet along the Jetty. The Pier access road is accessible to the general public; however, the USCG facilities are secured by fencing. The eastern end of the Jetty is not accessible to the public. This area is inhabited throughout most of the year by seabirds, which use the Jetty for nesting during spring and summer; and by California sea lions, which use the Jetty as a haul-out site. Pacific harbor seals also use rocky outcroppings and waters within Monterey Harbor.

LOCATION OF WORK

The USCG proposes to remove and replace 17 timber piles supporting the Pier; replace the existing potable water line; and improve associated structures to maintain the structural integrity of the Pier and potable water line.

The proposed project would involve removing the existing timber deck, timber stringers, steel pile caps, steel support beams, and hardware to access the 17 timber piles that need to be replaced. The timber piles, which are approximately 14 to 16 inches in diameter, would be removed through use of a vibratory extractor.

Each timber pile would then be replaced with a steel-pipe pile that would be up to 18 inches in diameter, with ½-inch-thick walls, and be positioned and installed in the footprint of the extracted timber pile.

Due to dense substrate at the project site, much of the steel-pipe pile installation may require impact pile driving; however, pile driving would be conducted with a vibratory hammer to the extent feasible, with an impact hammer used for proofing the piles. Pre-drilling would be permitted and would be discontinued when the pile tip is approximately 5 feet above the required pile tip elevation.

A bubble curtain would be used during all pile driving with an impact hammer. The bubble curtain creates an underwater wall of air around the pile to dissipate in-water sound waves.

PILE EXTRACTION AND INSTALLATION

The purpose of the acoustical monitoring plan (Plan) is to collect underwater and airborne sound level information at both near and distant locations during vibratory pile extraction and installation and impact pile installation. The Plan provides a protocol for both airborne and hydroacoustic measurements during pile extraction and driving operations.

The Plan has the following objectives:

1) Measure underwater and airborne sounds generated from project activities to verify modeled injury and behavior disturbance zones for marine mammals and fish.

    a) Levels of harassment for marine mammals are defined in the Marine Mammal Protection Act of 1972, as follows:

        i) Level A: Level A is defined as "Any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild." Level A injury thresholds for impact pile driving and vibratory pile driving activities are 180 decibels (dB) re: 1 micro Pascal (µPa) root mean square (RMS) for cetaceans (i.e., whales, dolphins, and porpoises); and 190 dB re: 1 µPa RMS for pinnipeds (i.e., seals and sea lions). In the absence of an official criterion, the Level A underwater noise threshold for cetaceans will be used for southern sea otters.

        ii) Level B: Level B is defined as "Any act of pursuit, torment, or annoyance which has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including but not limited to migration, breathing, nursing, breeding, feeding, or sheltering." The Level B harassment thresholds for both cetaceans and pinnipeds are 160 dB re: 1 µPa RMS for impact pile driving, and 120 dB re: 1 µPa RMS for vibratory pile driving. In the absence of an official criterion, these thresholds will also be used for southern sea otters.

iii) Airborne Noise Impacts: The airborne harassment threshold range is 90 dB re: 20 µPa RMS for harbor seals, and 100 dB RMS for all other pinnipeds. An airborne harassment threshold has not been established for cetaceans. In the absence of an official criterion, the 100 dB airborne threshold will also be used for southern sea otters.

b) Zone of adverse physiological and behavioral effects to fish species:

i) On June 12, 2008, the National Marine Fisheries Service (NMFS); the U.S. Fish and Wildlife Service (USFWS); California, Oregon, and Washington Departments of Transportation; the California Department of Fish and Game (now called the California Department of Fish and Wildlife); and the U.S. Federal Highway Administration agreed in principle to interim criteria to protect fish from pile driving activities. The agreed-upon threshold criteria for impulse-type noise to harm fish have been set at 206 dB re: 1 µPa peak, as well as 187 dB re: 1 μPa^2 per second accumulated sound exposure level (SEL) for fish over 2 grams (0.07 ounce).

ii) Threshold for potential adverse behavioral effects to fish species: NMFS considers sounds of 150 dB re: 1µPa to potentially affect fish behavior.

2) Compute the rate that sounds drop off with distance from the source (spreading loss) so that, along with measured levels, impact zones described in (1) above can be estimated. This plan includes the methodology to:

a) Achieve acoustic measurements for both the stationary and vessel-based hydrophones at appropriate locations.

b) Record information that will be vital to the success of the plan's implementation (i.e., timing of data collection, environmental conditions, and information the acoustic engineer shall gather from the contractor).

3) This plan describes post-analysis procedures for the following:

a) Sound level signal processing
b) Data analysis
c) Reporting

Acoustic monitoring will be conducted for a minimum of five pile extractions and five pile installations. Piles chosen to be monitored will be representative of mid-channel or typical water depths where piles will be driven.

The location of the specific piles to be monitored and the approximate hydrophone locations for each pile being monitored will be determined in the field with the approval of the Project Engineer. At each location, a hydrophone will be positioned at one depth, with a clear line-of-sight between the pile and the hydrophone at the following distances:

1. 10 meters.

2. Between 20 meters and 50 meters (depending on water depth at the pile).[1]

[1] The distance from the pile will be approximately three times the water depth.

3. Between 200 meters and 1,000 meters at mid-water column depth measured concurrently with the close-in measurements (i.e., 10-meter and 20- to 50-meter) to estimate the site-specific transmission loss.

Airborne measurements will be taken from two positions: at a height of 1.5 to 3 meters above ground, or above the wharf:

1. 15 to 30 meters from each pile.

2. At the location of the haul-out along the Jetty (a fixed position approximately 80 to 150 meters from the piles).

FUNDAMENTALS OF SOUND

Sound is typically described by the *pitch* and *loudness*. *Pitch* is the height or depth of a tone or sound, depending on the relative rapidity (frequency) of the vibrations by which it is produced. *Loudness* is intensity of sound waves combined with the reception characteristics of the auditory system. Intensity may be compared with the height of an ocean wave in that it is a measure of the amplitude of the sound wave. The term "noise" is typically used when the sound in question is unwanted.

In addition to the concepts of pitch and loudness, there are several measurement scales which are used to describe sound. A dB is a unit of measurement describing the amplitude of sound equal to 20 times the logarithm to the base 10 of the ratio of the pressure of the sound measured to the reference pressure. For underwater sounds, a reference pressure of 1 µPa is commonly used to describe sounds in terms of dB. Therefore, 0 dB on the decibel scale would be a measure of sound pressure of 1 µPa. For airborne sounds, a 20 µPa reference pressure is used. Sound levels in dBs are calculated on a logarithmic basis; for instance an increase of 10 dB represents a ten-fold increase in acoustic energy, while an increase of 20 dB is 100 times more intense.

When a pile driving hammer strikes a pile a pulse is created that propagates through the pile and radiates sound into the water, substrate, and air. Sound pressure pulse as a function of time is referred to as the waveform. In terms of acoustics, these sounds are described by the peak pressure, the RMS, and the SEL. The peak pressure (Peak) is the highest absolute value of the measured waveform, and can be a negative or positive pressure peak. For pile driving pulses, RMS level is determined by analyzing the waveform and computing the average of the squared pressures over the time that comprise that portion of the waveform containing the vast majority of the sound energy (Richardson et al., 1995). SEL is an acoustic metric that provides an indication of the amount of acoustical energy contained in a sound event such as a pile driving strike. For impact pile driving, the typical event can be one pulse (i.e., pile driving for one pile) or many pulses (e.g., one day of driving multiple piles). Typically, SEL is measured for a single strike and a cumulative condition (i.e., multiple strikes). Table 1 includes the definitions of terms commonly used to describe underwater sounds.

Table 1
Definitions of Underwater Acoustical Terms

Term	Definition
Decibel (dB)	A unit describing, the amplitude of sound, equal to 20 times the logarithm to the base 10 of the ratio of the pressure of the sound measured to the reference pressure. The reference pressure is 1 micro Pascal (µPa) for underwater, and 20 µPa for air.
Equivalent Sound Level (L_{eq})	The average sound level during the measurement period.
L_{max}	The maximum RMS sound pressure level recorded during the measurement period.
L_{01}, L_{10}, L_{50}, L_{90}	The sound levels that are exceeded 1%, 10%, 50%, and 90% of the time during the measurement period.
Peak (dB)	Peak sound pressure level based on the largest absolute value of the instantaneous sound pressure. This pressure is expressed in this report as a dB (referenced to a pressure of 1 µPa) but can also be expressed in units of pressure, such as µPa or pounds per square inch.
Root Mean Square (RMS) Sound Pressure	The root mean square of instantaneous pressures measured over a fixed time period (e.g., 1 second).
RMS Sound Pressure Level, (NMFS Criterion)	For underwater noise from impact pile driving, this is the average of the squared sound pressures over the time that comprise that portion of the waveform containing 90 percent of the sound energy for one pile driving impulse.[2] For underwater noise from vibratory pile driving, the National Marine Fisheries Service (NMFS) Northwest Region interprets this as the arithmetic average of the root mean square of sound pressures measured over successive 10-second periods during the event. An interpretation of the RMS sound pressure level used to assess airborne RMS levels for vibratory or impact pile driving is not defined. Therefore, the maximum 1/8th second RMS level (L_{max}) and the L_{eq} for a pile driving event will be reported.
Sound Exposure Level (SEL) [dB re 1 µPa^2 sec]	Used to describe underwater noise from impact pile driving. Proportionally equivalent to the time integral of the pressure squared and is described in this report in terms of dB re: 1 µPa^2 sec over the duration of the impulse. Similar to the unweighted Sound Exposure Level standardized in airborne acoustics to study noise from single events.
$SEL_{cumulative}$	Measure of the total energy received through an interval of impact pile driving event (herein defined as pile driving over one day). This metric is used by NMFS to assess potential impacts to fish.
Waveforms (µPa over time)	A plot illustrating the time history of positive and negative sound pressure of individual pile strikes shown as a plot of µPa over time (i.e., seconds).
Frequency Spectra (dB over frequency range)	A plot illustrating the distribution of sound pressure vs. frequency for a waveform, dimension in RMS pressure and defined frequency bandwidth.

[2] The underwater sound measurement results obtained during the Pile Installation Demonstration Project indicated that most pile driving impulses occurred over a 50- to 100-millisecond (msec) period. Most of the energy was contained in the first 30 to 50 msec. Analysis of that underwater acoustic data for various pile strikes at various distances demonstrated that the acoustic signal measured using the standard "impulse exponential-time-weighting" (35-msec rise time) correlated to the RMS (impulse) level measured over the duration of the impulse.

METHODOLOGY

Underwater

Three locations for hydrophone systems are proposed to record sound and the data would be used to compute the spatial sound level decrease. Measurements would be taken at one depth: the mid-water column or at least 3 feet above the bottom. One hydrophone will be located 10 meters from the pile being driven and a second hydrophone will be located between 20 meters and 50 meters from the pile being driven with a clear line-of-sight between the pile and the hydrophones. The intent of the 20- to 50-meter measurement is to measure at a distance equal to three times the water depth at the pile. The third hydrophone will be placed from a vessel and will be placed at mid-water column depth at a distance between 200 and 1,000 meters from the pile, to assist in finding the marine mammal Level B harassment zone for both impact and vibratory pile driving.

Either a depth finder or a weighted tape measure will be used to determine the depth of the water. The hydrophones will be attached to a nylon cord or a steel chain. One end of the nylon cord or chain will be attached to an anchor that will keep the hydrophone at the specified distance from the pile. The opposite end of the nylon cord or chain will be attached to a float or tied to a static line at the surface at the specified recording distance from the pile. The distance will be measured by a tape measure, where possible, or a range finder. To the extent practicable, there will be a direct line of sight between the pile and the hydrophones

Ambient underwater sound levels will be measured for at least 1 minute prior to initiation of pile extraction or installation, as well as in the absence of construction activities during other periods of monitoring days. Ambient levels will be reported as RMS, and a spectral analysis of the frequencies will be developed. The inspector/contractor will need to inform the acoustics specialist when pile driving is about to start to ensure proper measurements are taken.

Underwater sound levels will be continuously monitored during the duration of pile extraction or installation. NMFS Northwest Region has defined the estimated auditory bandwidth for marine mammals.[3] For this project location, the functional hearing groups are low-frequency cetaceans (humpback and gray whales), high-frequency cetaceans (harbor porpoises), pinnipeds (Stellar and California sea lions, harbor and northern elephant seals), and the southern sea otter. For pile driving, the majority of the acoustic energy is confined to frequencies below 2 kilohertz (kHz), and there is very little energy above 20 kHz. Underwater acoustic criteria for marine mammals are shown in Table 2. In the absence of an official criterion, the underwater noise thresholds for cetaceans will be used for southern sea otters.

[3] Note that NMFS Southwest Region has not provided guidance for measuring sound levels from pile driving, so guidance from the Northwest Region is used in this assessment.

Table 2
Underwater Acoustic Criteria for Marine Mammals[4]

Species	Underwater Sound Thresholds (dB re: 1µPa)			
	Vibratory Pile Driving Disturbance Threshold (Level B)	**Impact Pile Driving Disturbance Threshold (Level B)**	**Injury Threshold (Level A)**	**Frequency Range to be Measured**
Cetaceans[1]	120 dB RMS	160 dB RMS	180 dB RMS	7 Hz to 20 kHz (Low) 150 Hz to 20 kHz (Mid) 200 Hz to 150 kHz (High)
Pinnipeds	120 dB RMS	160 dB RMS	190 dB RMS	75 Hz to 20 kHz

Source: NMFS, 2009

Note:

[1] In the absence of an official criterion, the underwater noise thresholds for cetaceans will be used for southern sea otters.

The current NMFS threshold criteria for impulse-type noise to harm fish has been set at 206 dB Peak, as well as 187 dB $SEL_{cumulative}$ for fish weighing more than 2 grams (0.07 ounces) (FHWG, 2008). There is a separate threshold for fish weighing less than 2 grams; however, the project site is not considered spawning habitat, and fish less than 2 grams are not expected to be found in this area. NMFS does not consider noise that produces an SEL per strike of less than 150 dB to accumulate and cause injury. The adopted $SEL_{cumulative}$ criteria are for pulse-type noise (e.g., pile driving with an impact hammer) and does not address noise from vibratory driving of piles. The $SEL_{cumulative}$ criteria are not applied to vibratory driving noise and there are no acoustic thresholds that apply to the lower amplitude noise produced by vibratory pile driving.

For impact pile driving, the Peak, RMS, and SEL level of each strike will be monitored in real time using sound level meters (SLMs). The $SEL_{cumulative}$ will be subsequently computed. For vibratory pile driving, the 1-second RMS would be continuously measured and the average of the 10-second RMS values for each driving event would be computed subsequently.

Airborne Measurements

Two locations for airborne noise measurement systems are planned. One system would be located at 15 to 30 meters from the pile driving operation to provide near-source noise measurements. This would likely be a fixed position with an intended clear view of pile driving operations, so the distance for each pile may vary from 15 to 30 meters. The second system would be established at the haul-out area on the Jetty. The actual position would be determined

[4] Based on NOAA 77 FR 43049, July 23, 2012. Takes of Marine Mammals Incidental to Specified Activities; Taking Marine Mammals Incidental to a Pile Replacement Project.

in the field, depending on access and security issues. This position is anticipated to be 80 to 150 meters from the piles driven. Airborne acoustic criteria for marine mammals are shown in Table 3.

Table 3
Adopted Airborne Criteria for Marine Mammals[5]

Species	Disturbance Airborne Sound Thresholds for Impact and Vibratory Pile Driving (dB re: 20 µPa)
Cetaceans	None
Pinnipeds	90 dB RMS (un-weighted) for harbor seals 100 dB RMS (un-weighted) for sea lions and all other pinnipeds[1]

Note:

[1] In the absence of an official criterion, the 100 dB airborne threshold will also be used for southern sea otters.

Airborne sound levels will be continuously monitored for the duration of pile extraction or installation. The maximum 1/8-second average (i.e., L_{max}) of each 1 second (or pile strike) and the energy average level (L_{eq}) for each pile will be measured in real time. Airborne sound levels will be measured in dB referenced to 20 µPa.

The appropriate airborne sound thresholds for behavioral disturbance for all pinnipeds except harbor seals is 100 dB re: 20 µPa RMS, the threshold for harbor seals is 90 dB re: 20 µPa RMS. In the absence of an official criterion, the 100 dB airborne threshold will also be used for southern sea otters. Similar to underwater sounds, these sounds will be measured over the frequency range of 75 Hz to 20,000 Hz, and are assumed to be similar to C-weighted sound levels, which are broadband sound levels that are weighted at very low frequencies below 100 Hz.[6] This plan assumes that pinnipeds, like humans, are not sensitive to sounds below 100 Hz. The SLMs shall be set so as to measure the C-weighted 1-second L_{max} and the 1-second L_{eq} sound pressure levels.

Other Measurements

Prior to and during the pile extraction or driving monitoring, environmental data will be gathered, including but not limited to: wind speed and direction, air temperature, water depth, wave height, weather conditions, and other factors (e.g., presence of aircraft, boats that could influence underwater sound levels. Start and stop times of each pile driving event will be recorded.

A minimum of five pile extractions and installations will be monitored. Table 4 details the equipment specifications that will be adhered to during measurement of sound pressure levels.

[5] Based on NOAA 77 FR 43049, July 23, 2012. Takes of Marine Mammals Incidental to Specified Activities; Taking Marine Mammals Incidental to a Pile Replacement Project.

[6] C-weighting is based on a curve defined by IEC 61672:2003 relating to the measurement of sound pressure level. The weighting is employed by arithmetically adding a table of values for one third-octave bands, to the measured levels. There is generally no weighting applied to sounds between about 80 and 8,000 Hz.

Table 4
Equipment Specifications for Sound Monitoring

Item	Approximate Specifications	Quantity	Usage
Hydrophone	Receiving Sensitivity – 211dB ±3dB re 1V/µPa	3	Capture underwater sound pressures and convert to voltages that can be recorded/analyzed by other equipment.
Signal Conditioning Amplifier	Amplifier Gain – 0.1 mV/pC to 10 V/pC Transducer Sensitivity Range – 10-12 to 103 C/MU	3	Adjust signals from hydrophone to levels compatible with recording equipment.
Calibrator (pistonphone-type)	Accuracy – IEC 942 (1988) Class 1	1	Calibration check of hydrophone and microphones in the field.
SLM and Solid State Recorder	Sampling Rate – 24K Hz or greater	5	Measure and record acoustic data.
Microphone (free field type)	Range – 30 to 120 dBA Sensitivity- -29 dB ± 3 dB (0 dB = 1 V/Pa)	2	Monitor airborne sounds from pile driving activities
Real Time and Post-Analysis software	–	1	Post-analysis of sound signals to provide spectra and time series data.

Monitoring equipment will be set to sample sounds at a rate of 44,000 Hz. To facilitate analysis of data, the underwater signal will be recorded as wave file.

The inspector/contractor will inform the acoustics specialist when pile driving is about to start to ensure that the monitoring equipment is operational. Sound levels will be continuously monitored during the entire duration of each pile drive. Peak levels of each strike will be monitored in real time.

The Project Engineer will provide the acoustics specialist with a description of the substrate composition, approximate depth of significant substrate layers, hammer model and size, initial hammer energy settings and any changes to those settings during the pile driving monitoring, depth the pile was driven, blows per foot for the piles monitored, and total number of strikes to drive each pile that is monitored.

CALIBRATION

Calibration of measurement systems shall be established prior to use in the field each day. An acoustical piston phone and microphone or hydrophone coupler would be used along with manufacturer calibration certificates. An acoustically certified piston phone and coupler that fits the hydrophone or microphone would directly calibrate the measurement system. The volume correction of the coupler for each hydrophone or microphone would be known so that the piston phone would produce a known signal that would be compared against the measurement system response. The response of the measurement system would then be noted in the field book and applied to all subsequent measurements.

For underwater acoustic recordings, the SLMs are calibrated to the calibration tone prior to use in the field. The tone is then measured by the SLM and is recorded on to the beginning of the digital audio recordings that will be used. The system calibration status would be checked by measuring the calibration tone and recording the tones. The recorded calibration tones are used for subsequent detailed analyses of recorded pile strike sounds.

SIGNAL PROCESSING

Post-signal analysis should only be required for impact pile driving. SLMs are anticipated to provide direct measurements of L_{max} and L_{eq} sound pressure levels for underwater vibratory pile driving and airborne impact and vibratory pile driving. Post-signal analysis of the underwater impact sound level signals will include measurement of the maximum absolute value of the instantaneous pressure within each strike, RMS value for each pile strike, mean and standard deviation of the RMS for all pile strikes of each pile, the SEL per strike, mean and standard deviation of the SEL for all pile strikes of each pile, and the $SEL_{cumulative}$ for each pile. A frequency spectrum between 20 and 10,000 Hz for up to eight successive strikes with similar sound levels would be prepared and reported.

ANALYSIS

Analysis of the impact pile driving sound data from the San Francisco-Oakland Bay Bridge Pile Driving Demonstration project (PIDP) indicated that 90 percent of the acoustic energy for most pile driving impulses occurred over a 50- to 100-millisecond period, with most of the energy concentrated in the first 30 to 50 milliseconds (Illingworth and Rodkin, 2001). The RMS values for this project will be computed over the duration between where 5 percent and 95 percent of the energy of the pulse occurs, based on the measurement over a 150-millisecond time window that captures the entire acoustic pulse.

In addition, a waveform analysis of the individual absolute peak pile strikes will be performed to illustrate any effects to the waveform with the use of bubble curtains. The frequency content with the bubble curtain will be presented.

REPORTING

A draft report including data collected and summarized from all monitoring positions will be submitted to the USFWS and NMFS within 60 days of the completion of acoustic monitoring. The results will be summarized in graphical form and will include summary statistics and time histories of impact sound values for each monitored pile. A final report will be prepared and submitted to the USFWS and NMFS within 30 days following receipt of comments on the draft. The report shall include:

1. The size and type of piles removed and installed.
2. A detailed description of the type(s) of noise attenuation device used, including design specifications.
3. The make, model, and energy rating of the impact hammer used to drive the piles.
4. A description of the sound monitoring equipment used.
5. The distance between hydrophone(s) and pile.
6. The depth of the hydrophone(s) and depth of water at hydrophone locations.
7. The distance from the piles to the water's edge.
8. The depth of water in which each pile was driven.
9. The depth into the substrate that each pile was driven.
10. The physical characteristics of the bottom substrate into which the piles were driven.
11. The total number of strikes or seconds of vibratory driving required extracting or installing each pile monitored.
12. The background sound pressure level reported as the 50 percent cumulative distribution function (already measured and reported).
13. The results of the hydroacoustic monitoring, including the frequency spectrum, ranges and means including standard deviation for Peak and RMS sound pressure level, single-strike and $SEL_{cumulative}$, and an estimate of the distance at which the Peak and $SEL_{cumulative}$ values reach their respective thresholds, and the distance at which the RMS values reach the relevant marine mammal thresholds and background sound levels. Vibratory monitoring results will include the maximum and average RMS calculated from 10-second RMS values during the drive of each pile.
14. The results of the airborne measurements will include the maximum and overall L_{eq} (energy average) RMS measured during the drive of each pile.
15. A description of any observable fish, marine mammal, or bird behavior in the immediate area; and if possible, correlation to underwater sound levels occurring at that time.

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