WETA VALLEJO FERRY TERMINAL RECONFIGURATION PROJECT

HYDROACOUSTIC ASSESSMENT

Vallejo, California

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INTRODUCTION

The San Francisco Bay Area Water Emergency Transportation Authority (WETA) proposes to reconfigure the existing ferry terminal in Vallejo, California to reduce or eliminate maintenance dredging and to increase operational safety in support of continued ferry service between the cities of San Francisco and Vallejo. Figure 1 shows the vicinity map of the existing ferry terminal location.

FIGURE 1 Vicinity Map of the existing Valley Ferry Terminal

Source: Kimley Horn Project Description document

The proposed Vallejo Ferry Terminal would be located on the eastern shore of the Mare Strait, within the footprint of the existing ferry terminal and basin area. The proposed terminal includes reconfiguration of an existing ferry terminal, including the removal of the existing fixed pier/gangway, and passenger float and replacing it with a new fixed pier/gangway and a passenger float. The existing terminal in Vallejo would be relocated outside of the current ferry basin to improve terminal operations and to reduce the frequency of dredging. The existing gangway and passenger float are accessible by a gate on the walkway that surrounds the terminal basin area, a paved portion of the San Francisco Bay Trail. The existing facilities are currently used for standard WETA ferry operations that transport passengers to and from Downtown San Francisco and Mare Island. The existing gangway and passenger float would be removed during project construction. Figure 2 shows the existing setting at the ferry terminal.

FIGURE 2 Existing setting at the Vallejo Ferry Terminal

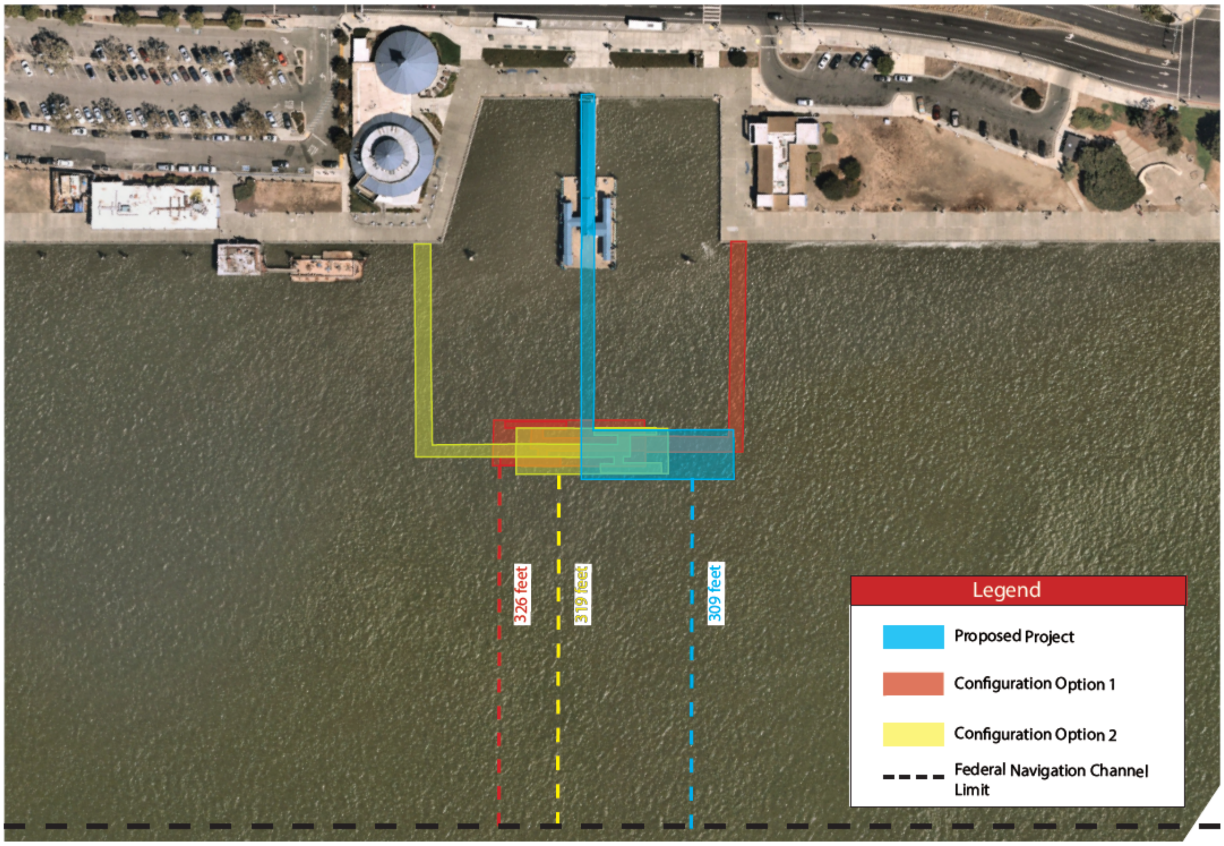
Source: Kimley Horn Project Description document

A Proposed Project and two different configuration options have been proposed to determine an option that provides safer operations, more efficient ferry berthing, and is cost efficient. Figure 3 shows the three proposed ferry terminal layout options.

Demolition of the existing facility would be required prior to installation of any new waterside terminal components. The demolition work includes removal of the piles, gangway, and float. Piles would be removed by either pulling the pile or cutting the piles off below the mud line. Project components to be constructed include a new gangway, piles and a new standard WETA float including 36-inch steel pipe piles with concrete caps and 12-inch steel pipe piles.

This study is an assessment of potential underwater noise levels generated by planned construction activities involved with the refurbishment of the Vallejo Ferry Terminal. The study supports regulatory biologists in assessing underwater sound impacts on fish and marine species that may be present in the area when construction occurs. This assessment is based on information provided by project designers consisting of a location map, draft layout sheets, estimated pile-driving data, a review of potential construction activities to be conducted at the site, a review of related studies, the modeling, and a quantitative analysis of underwater noise levels. This study focuses on the sound impacts associated with potential pile-driving and pile removal activities that could affect aquatic species. This study does not address environmental impacts associated with the project.

FIGURE 3 Project Configurations



Source: Nearmap, 2023

Figure 3: Project Configurations
WETA Vallejo Ferry Terminal Reconfiguration Project

Not to scale Kimley»Horn

UNDERWATER SOUNDS FROM PILE-DRIVING ACTIVITIES

Fundamentals of Underwater Noise

Vibratory pile installation and removal produces continuous underwater sounds. Impact pile driving can produce high underwater sound levels. When a pile-driving hammer strikes a pile, a pulse is created that propagates through the pile and radiates sound into the water, the ground, and the 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 root-mean-square (RMS) pressure, and the sound exposure level (SEL). The peak pressure 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 comprises that portion of the waveform containing the sound energy (Richardson et al. 1995; ISO 18406:2017(E).). The pulse RMS has been approximated in the field for pile-driving sounds by measuring the signal with a precision sound level meter set to the “impulse” RMS setting and is typically used to assess impacts to marine mammals. Another measure of the pressure waveform that can be used to describe the pulse is the sound energy itself. The total sound energy in the pulse is referred to in many ways, most commonly as the “total energy flux” (Finerran 2002). The “total energy flux” is equivalent to the un-weighted SEL for a plane wave propagating in a free field, a common unit of sound energy used in airborne acoustics to describe short-duration events. The unit used is decibels (dB) re 1 micropascal $(\mu Pa)^2$-second (sec). In this report, peak pressure levels are expressed as the absolute maximum pressure of a pulse in dB re 1 µPa; however, in other literature, peak pressure levels can take varying forms, such as pascals or pounds per square inch. The total sound energy in an acoustical impulse accumulates over the duration of that pulse and the duration of a pile driving event. Figure 4 illustrates the acoustical characteristics of an underwater pile-driving pulse. Table 1 includes the definitions of terms commonly used to describe underwater sounds.

The variation of instantaneous pressure over the duration of a sound event is referred to as the waveform. The waveform can provide an indication of rise time or the rapidity with which pressure fluctuates with time; however, rise time differences are not clearly apparent for pile-driving sounds because of the numerous rapid fluctuations that are characteristic of this impulse type. A plot showing the accumulation of sound energy over the duration of the pulse (or at least the portion of time during which much of the energy accumulates) illustrates the differences in source strength and rise time. An example of the underwater acoustical characteristics of a typical pile-driving pulse is shown on Figure 4.

SEL is the acoustic metric that provides an indication of the amount of acoustical energy contained in a sound event. For pile driving, the typical event can be one pile-driving pulse or many pulses, such as pile driving for one pile or for one day of pile driving. Typically, SEL is measured for a single strike and a cumulative condition. The cumulative SEL associated with the driving of a pile can be estimated using the single-strike SEL value and the number of pile strikes through the following equation:

$$SEL_{cumulative} = SEL_{single-strike} + 10log(\#of\ pile\ strikes)$$

For example, if a single-strike SEL for a pile is 165 dB, and it takes 1,000 strikes to drive the pile, the cumulative SEL is 195 dBA (165 dB + 30 dB = 195 dB), where 10 * $Log_{10}(1000) = 30$.

Underwater Sound Thresholds

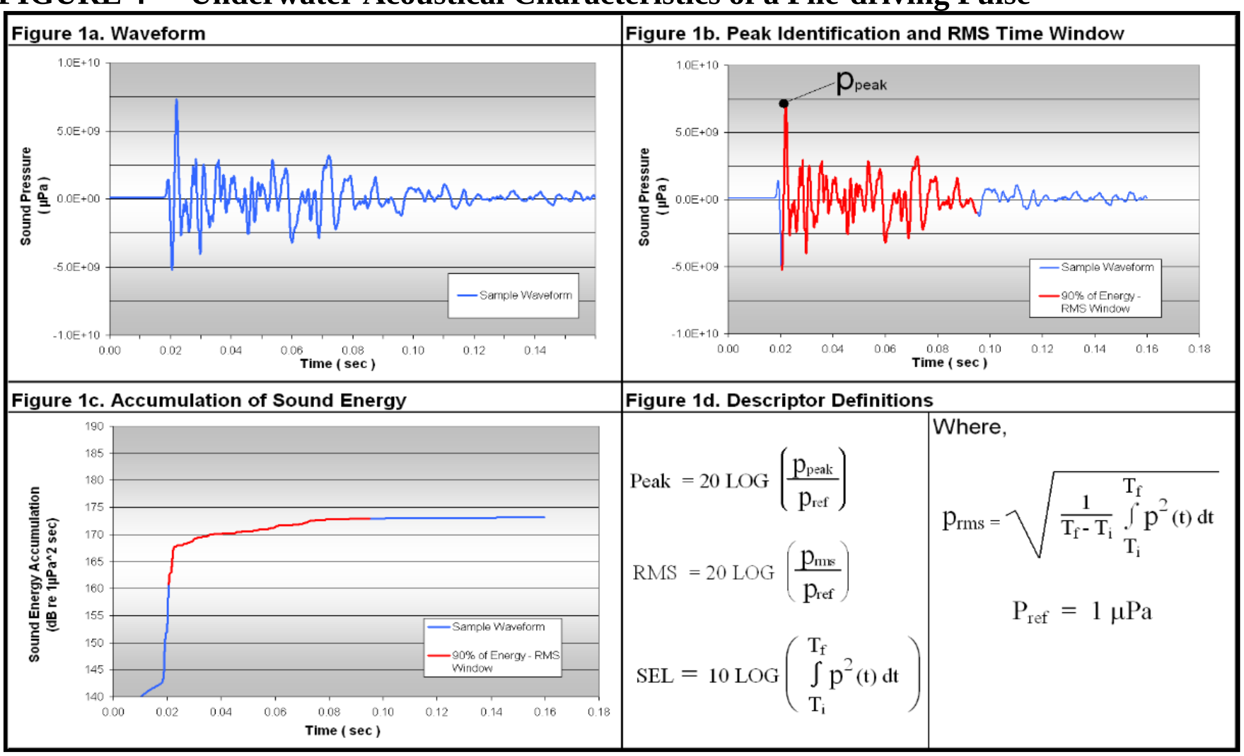
Fish

In 2008, NOAA’s NMFS; U.S. Fish and Wildlife Service; California, Oregon, and Washington Departments of Transportation; California Department of Fish and Game; and the U.S. Federal Highway Administration agreed in principle to interim criteria to protect fish from pile-driving activities. The agreed-upon criteria are presented in Table 2.

TABLE 1 Definition of Underwater Acoustical Terms

Term	Definition
Peak Sound Pressure, unweighted (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.
RMS Sound Pressure Level, (NMFS Criterion) dB re 1 μPa	The squared root of the average of the squared pressures over the time that comprises that portion of the waveform containing 90 percent of the sound energy for one pile-driving impulse.[1] This measure is typically used to assess acoustical impacts on marine mammals.
SEL, dB re 1 μPa^2-sec	Proportionally equivalent to the time integral of the squared pressure 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 SEL standardized in airborne acoustics to study noise from single events.
Cumulative SEL	Measure of the total energy received through a pile-driving event (here defined as pile driving that occurs within a day).
Waveforms, μPa over time	A graphical plot illustrating the time history of positive and negative sound pressures of individual pile strikes shown as a plot of μPa over time (i.e., seconds).
Frequency Spectra, dB over frequency range	A graphical plot illustrating the distribution of sound pressure vs. frequency for a waveform; dimension in RMS pressure and defined frequency bandwidth.

FIGURE 4 Underwater Acoustical Characteristics of a Pile-driving Pulse



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[1] The underwater sound measurement results obtained during a Pile Installation Demonstration Project indicated that most pile-driving impulses occurred over a 50- to 100-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) used by NMFS.

Notes: msec = millisecond(s)
NMFS = National Marine Fisheries Service

TABLE 2 Adopted Fish Criteria

Interim Criteria for Injury	Sound Levels Agreed-upon in Principle
Peak	206 dB re 1 μPa (for all sizes of fish)
Cumulative SEL	187 dB re 1 μPa^2-sec – for fish size of 2 grams or greater[a] 183 dB re 1 μPa^2-sec – for fish size of less than 2 grams[a]

[a] Applies to pile strikes of 150 dB SEL (single strike) or greater.

The adopted criteria listed in Table 2 are for pulse-type sounds (e.g., impact pile driving) and do not address sound from vibratory driving. The SEL criteria are not applied to vibratory driving sounds for assessing impacts to fish. The in-water areas with project sound levels above 150 dB RMS are considered by NMFS to be acoustically affected, given possible behavioral changes in fish; however, these levels are not anticipated to trigger any mitigation requirements (Caltrans 2020).

Marine Mammals

For this project location, marine mammals are not usually present, although, otariid pinnipeds (California sea lions) may transit the area at certain times. Under the Marine Mammal Protection Act, NMFS has defined levels of harassment for marine mammals. Level A harassment 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 B harassment 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.”

Impact pile driving produces impulsive sounds that correspond to those that are typically transient, brief (typically less than 1 second), broadband and consist of high peak sound pressure with rapid rise time and decay. Vibratory pile installation or removal is considered non-impulsive or continuous sounds as those that could be broadband, narrowband or tonal, brief or prolonged, continuous or intermittent and usually do not have a high peak sound pressure with rapid rise and decay times (NMFS 2018). NMFS uses behavior thresholds rather than TTS thresholds for assessing Level B harassment for pile driving (NMFS 2023).

Table 3 outlines the current adopted Level A and Level B (behavioral harassment) criteria. NMFS has provided marine mammal acoustic technical guidance for predicting the onset of permanent threshold shift (PTS) and temporary threshold shifts in marine mammal hearing from sound sources (NMFS 2018). The onset of PTS is considered by NMFS to be Level A harassment. For impact 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. Similarly, much of the acoustic energy for vibratory driving is in the frequency range below 2.5 kHz. The underwater acoustic criteria for phocid and otariid pinnipeds are provided in Table 3. Table 4 lists the functional hearing groups and their hearing ranges as defined by the NMFS guidance (NMFS 2018).

The application of the 120-dB RMS threshold for Level B harassment is used to address vibratory pile driving (or pile removal). This level can sometimes be problematic because this threshold level can be either at or below the ambient noise level of certain locations. In the event that ambient sound levels exceed 120 dB, per NMFS guidance, the ambient sound levels become the Level B harassment threshold. For continuous sounds, NMFS Northwest Region has provided guidance for reporting RMS sound pressure levels. RMS levels are based on a time-constant of 10 seconds; RMS levels should be averaged across the entire event. For impact pile driving, the pulse RMS level is characterized by integrating sound for each acoustic pulse across 90 percent of the acoustic energy in each pulse and taking the median RMS value of all pulses.

TABLE 3 Underwater Acoustic Criteria for Pinnipeds

Species	**Underwater Noise Thresholds (dB re 1 µPa)**				
	Vibratory Pile-driving Disturbance Threshold (*Level B Harassment*)	**Impact Pile-driving Disturbance Threshold (*Level B Harassment*)**	**Marine Mammal Hearing Group (see Table 4)**	**PTS SEL_{cum} Threshold Peak – dB re 1 µPa SEL_{cum} – dB re 1 μPa^2-sec**	
				Impulsive (*Impact Pile Driving*)	**Non-Impulsive (*Vibratory Pile Driving*)**
Pinnipeds	120 dB RMS	160 dB RMS	Phocid	218 dB Peak 185 dB SEL_{cum}	201 dB SEL_{cum}
			Otariid	232 dB Peak 203 dB SEL_{cum}	219 dB SEL_{cum}

TABLE 4 Definition of Marine Mammal Hearing Group for Pinnipeds

Marine Mammal Hearing Groups	
Functional Hearing Group	**Functional Hearing Range**
Phocid Pinnipeds – true seals, including harbor seals	50 Hz to 86 kHz
Otariid Pinnipeds – sea lions and fur seals	60 Hz to 39 kHz

Note: Hz = hertz

PROJECT UNDERWATER SOUND-GENERATING ACTIVITIES

The primary type of activity that has the potential to elevate underwater noise levels is the installation of piles using an impact pile driver. Vibratory pile installation or removal could harass marine mammals if they are present. For this project, piles are expected to be installed using both vibratory and impact installation. Pile removal may be conducted using vibratory means. Pile installation activities for the project are summarized for the Proposed Project and two configuration options below.

a) Proposed Project
   - Sixteen (16) 36-inch steel pipe piles installed in water via vibratory driving and proofed using impact driving.
   - Four (4) 12-inch steel pipe piles installed in water via vibratory driving and proofed using impact driving.

b) Configuration Option 1

- Seventeen (17) 36-inch steel pipe piles installed in water via vibratory driving and proofed using impact driving.
- Eight (8) 12-inch steel pipe piles installed in water via vibratory driving and proofed using impact driving.

c) Configuration Option 2
- Seventeen (17) 36-inch steel pipe piles installed in water via vibratory driving and proofed using impact driving.
- Eight (8) 12-inch steel pipe piles installed in water via vibratory driving and proofed using impact driving.

Pile driving in the water causes sound energy to radiate directly into the water by vibrating the pile between the surface of the water and the substrate, and indirectly as a result of ground-borne vibration at the riverbed. Airborne sound does not make a substantial contribution to underwater sound levels because of the attenuation of sound at the air/water interface. A minimum water depth is required to allow sound to propagate. For pile-driving sounds, the minimum depth would be about one m (3 feet).

Table 5 summarizes the proposed pile-driving activities, the number of piles anticipated per day, and the duration of the pile driving activity for vibratory driving.

TABLE 5 Pile-driving Activities for the Proposed Project

New Structure	Pile Type	Pile Location	Duration/Estimated Blows per Pile[1]	Piles per Day
Gangway, Dolphin, New Standard WETA Float, Monopiles	36-inch steel pipe	In Water	120 minutes vibrate 450 strikes impact	4
Monopiles (Marker Piles)	12-inch steel piles	In Water	120 minutes vibrate 450 strikes impact	4

[1] Impact driving assumes about 15 minutes of driving with a total of about 450 strikes per pile.

Predicted Underwater Sound Levels from Construction

This assessment predicts underwater sound levels associated with the different piling activities that are anticipated. Piling activities include the impact and vibratory installation and removal of steel pipe piles. Removal of piles is anticipated to have similar sound levels as installation of a similar size pile.

Pile installation would be conducted using vibratory pile driving methods that minimize impacts to fish. It is assumed that an impact pile driver would be necessary to complete pile installation and provide engineering information to verify design parameters (i.e., proof the piles).

The prediction of sound levels from pile-driving activities proposed for this project relies on data collected from the vicinity of this site and other sites with similar conditions. Table 6 below shows the studies used to aid in predicting underwater noise levels and calculating distances to thresholds for fishes and marine mammals discussed in this report.

Underwater Sound Levels from Project Pile Driving

Data in the following studies were reviewed for the various pile-driving activities summarized in Table 6. The values in Table 6 are for sound levels measured at 10 m (33 feet) from the piles for conditions similar to those that would occur at this project. Detailed information on the measurements that make up these levels below are provided in the references.

TABLE 6 Measured Levels for Pile-driving Activities

Driving Method	Pile Type	Size	Sound Pressure Level in dB re 1 µPa at 10 Meters			Notes
			Peak	RMS	SEL	
Impact	Steel pipe pile in water	12-inch	199	179	169	Based on 14-in steel pile levels in Caltrans 2020. Note there is a lack of representative data for 12-in steel piles.
Impact	Steel pipe pile in water	36-inch	211	193	183	Caltrans 2020 as recommended by NMFS (see 88 FR 56595)
Vibrate	Steel pipe pile in water	12-inch	171	155	155	13-in steel piles measured at Mad River Slough, Arcata, CA due to lack of data for vibrated 12-in piles
Vibrate	Steel pipe pile in water	36-inch	200	168	168	Anchorage Port Modernization Program – Test Pile Program (POA 2016)

* Estimated as 10 dB below measured RMS level

Table 7 shows the predicted sound levels expected at 10-meters (33-foot) distances from different pile-driving activities expected from the project. Included are the unattenuated sound levels (peak, RMS, SEL) expected, also at 10 m (33 feet) from the piles. Table 7 also shows expected attenuated levels that correspond to a 5-dB reduction because of different attenuation mechanisms like bubble curtains or isolation casing that may be used during the in-water pile-driving activities. These levels, which have been taken from past projects, provide an estimate of the levels to be expected from the pile-driving activities proposed for the project. Impacts on fishes and marine mammals are then calculated using these levels (both unattenuated and attenuated).

Note, that the 36-in attenuated levels in Table 7 assume a 10-dB reduction from the unattenuated levels in Table 6. Noise measurements made in 2015[2] at the project site indicate a range of measured 36-in steel pile levels from 172 to 205 dB peak, 149 to 183 dB RMS and 139 to 171 dB SEL for impact pile driving with a bubble curtain. These levels indicate an attenuation of up to 30 dB provided by the bubble curtain, when compared to published unattenuated levels. In order to be in compliance with NMFS recommendations for estimating bubble curtain performance, a conservative 10-dB attenuation is assumed. Use of these higher values also avoid under predicting impacts.

[2] Pommerenck, K., Roberts J. Illingworth & Rodkin, Inc. - WETA North Bay Maintenance and Operations Facility Vallejo, CA August to September 2015

TABLE 7 Sound Levels Used for Predicting Underwater Sound Impacts

Driving Method	Pile Type	Size	Sound Pressure Level Measured in dB re 1 µPa at 10 Meters					
			Unattenuated			Attenuated[a]		
			Peak	RMS	SEL	Peak	RMS	SEL
Impact	Steel pipe pile in water	12-inch	199	179	169	194	174	164
Impact	Steel pipe pile in water	36-inch	211	193	183	201	183	173
Vibrate	Steel pipe pile in water	12-inch	171	155	155	<5 dB attenuation expected from vibrated piles		
Vibrate	Steel pipe pile in water	36-inch	200	168	168	<5 dB attenuation expected from vibrated piles		

[a] Attenuated condition assumes minimum 5-dB lower sounds for 12-inch piles. For 36-inch piles, a conservative estimate of 10-dB attenuation is assumed.

Predicted Impacts on Fishes

Table 8 shows the anticipated distances (in meters and in feet) to the various adopted interim fish thresholds[3]. Distances are shown for both unattenuated and attenuated piles (5- to 10-dB attenuation). Also, when the piles are installed with a vibratory hammer, the cumulative SEL thresholds for fish do not apply, and the 150-dB RMS level provides an estimated zone of possible acoustic effects. The distance to each threshold was computed using the transmission loss coefficient of 15 times the Log_{10} of the distance, as recommended by NMFS when there is no site-specific information for the area. Cumulative SEL was further computed by adding 10 times the Log_{10} of the number of impact pile strikes. Impact strikes used in these computations are the sum of the anticipated strikes per pile times the number of piles per day.

Note that sound propagation in the vicinity of the Vallejo Ferry Terminal is constrained by bends in the Napa River, which is oriented southeast to northwest. Sound would only propagate up and down the channel. Therefore, the distance for noise impact from this project is limited to 3,280 meters north directly upstream and 5,600 meters south directly downstream under the worst-case conditions.

[3] Distances to Adopted Interim fish thresholds calculated using Optional Multi Species Pile Driving Calculator Version 1.2 (2022) - https://www.fisheries.noaa.gov/s3/2023-05/BlankMultiSpecies-August2022b-Public-OPR1.xlsx . Screenshots of calculated results shown in Attachment B

TABLE 8 Distance to Adopted Fish Thresholds for All Piles

Driving Method	Pile Type	Size	Piles per Day	Estimated No. of Strikes per Pile	Condition[a]	Distance to Adopted Fish Thresholds			
						Peak 206 dB[b]	RMS 150 dB[b]	Cumulative SEL	
								187 dB[c]	183 dB[c]
Impact	Steel pile in water	12-in	4	450[e]	Unattenuated	--[d]	858 m *[2,814 ft]*	93 m *[306 ft]*	173 m *[566 ft]*
					Attenuated	--[d]	398 m *[1,306 ft]*	43 m *[142 ft]*	80 m *[263 ft]*
Impact	Steel pile in water	36-in	4	450[e]	Unattenuated	22 m *[71 ft]*	3,280/5,600 m[g] *[10,761/ 18,373 ft]*	801 m *[2,627 ft]*	1,480 m *[4,855ft]*[g]
					Attenuated	--[d]	1,585 m *[5,200 ft]*	173 m *[566 ft]*	319 m *[1,046ft]*
Vibrate	Steel pile in water	12-in	4	--[f]	Unattenuated	--[d]	22 m *[71 ft]*	N/A	N/A
Vibrate	Steel pile in water	36-in	4	--[f]	Unattenuated	--[d]	159 m *[520 ft]*	N/A	N/A

[a] Attenuated condition assumes 5-dB lower sounds for 12-inch piles and 10-dB lower sounds for 36-inch piles
[b] dB re 1 µPa
[c] dB re 1 µPa^2-sec
[d] Within the near-field of the sound source - < 10 meters [33 feet]
[e] Assuming impact hammer usage for 15 mins with about 450 strikes per pile.
[f] Piles vibrated in at 120 minutes each (7,200 sec.).
[g] Constrained by bends in the Napa River near the Vallejo Ferry Terminal, 3,280 m [10,761 ft] north and 5,600 m [18,373 ft] south.

Predicted Impacts on Marine Mammals

The following threshold distances were computed to assess impacts on pinnipeds:

- Distance to onset PTS isopleth for each hearing group (considered Level A impacts)
    - Unattenuated
    - Attenuated
- Distance for unweighted 120-dB vibratory and 160-dB impulse behavior isopleth (considered Level B impacts)
    - Unattenuated
    - Attenuated

The Multi-Species Pile Driving Calculator (Version 1.2 [2022])[4] to the *NMFS Technical Guidance for Assessing the Effects of Anthropogenic Noise on Marine Mammal Hearing* was used to predict zones where the onset of PTS to marine mammal hearing could occur. A spreading loss calculation is included in the spreadsheet to predict the distance to the onset PTS from accumulated SEL and peak sound pressure. The spreadsheet incorporates a frequency weighting function that accounts for sensitivity for different hearing groups when computing the accumulated SEL. These are referred to as weighting frequency adjustments. The default weighting frequency adjustments are

[4] Distances to Marine Mammal thresholds also calculated using Optional Multi Species Pile Driving Calculator Version 1.2 (2022) - https://www.fisheries.noaa.gov/s3/2023-05/BlankMultiSpecies-August2022b-Public-OPR1.xlsx . Screenshots of calculated results shown in Attachment B

2 kHz for impact pile driving and 2.5 kHz for vibratory driving. Because the onset of PTS based on SEL_{cum} is computed as further from the pile than it would be using peak sound pressure computations, the onset of PTS is based on SEL computations; therefore, the onset of PTS based on peak sound levels is not provided in this assessment.

The extent of the Level B Zone was calculated using the 10-meter (33-foot) sound levels and applying a transmission loss coefficient of 15 times the Log_{10} of the distance, as recommended by NMFS when there is no site-specific information for the area.

Table 9 presents the anticipated distances to the adopted marine mammal thresholds (Level A and Level B Zones). When the piles are installed with a vibratory hammer, the cumulative SEL thresholds apply for sounds greater than 150 dB (re 1 μPa^2-sec) SEL. The peak PTS thresholds that apply to marine mammals will not be reached. Distances are shown for both unattenuated and attenuated pile-driving activities expected from the project, for the estimated number of strikes and piles per day proposed.

Attenuation Methods

Air bubble curtains, either confined or un-confined, have been shown to reduce sound pressure levels for impact pile driving in water by up to about 5 to 20 dB within 300 meters of the pile. Caltrans guidance recommends a 5-dB reduction was used for calculating the distances to the fish and marine mammal thresholds (Caltrans 2020). Measurements in the area indicate greater than 10 dB attenuation for driving of 36-inch piles[5]. The amount of attenuation may be more, especially at distant locations from the pile because of the contribution of sound propagating through the bottom substrate.

The design of the specific bubble ring configuration will depend on several factors, such as the depth of water and the water current, and must be designed appropriately. Air bubble curtain systems are used during production pile driving to reduce underwater sound pressures. Typically, a system consists of stacked rings to generate air bubbles throughout the entire water column surrounding the piles, even with currents. It is critical to ensure bubble flux throughout the entire water depth, especially near the bottom. A bubble curtain system is generally composed of air compressors, supply lines to deliver the air, distribution manifolds or headers, perforated aeration pipes, and a frame. The frame is used to facilitate transportation and placement of the system, keep the aeration pipes stable, and provide ballast to counteract the buoyancy of the aeration pipes during pile-driving operations. Bubble curtain designs consist of single or multiple concentric layers of perforated aeration pipes (stacked vertically). Pipes in any layer are arranged in a geometric pattern that allows the pile-driving operation to be completely enclosed by bubbles for the full depth of the water column. The lowest layer of perforated aeration pipe is designed to ensure contact with the mud line without sinking into the bottom substrates. A proper combination of bubble density and closeness of bubbles to the pile is most effective. Numerous smaller bubbles are more effective because they displace more water between the bubbles. Again, this pattern has to be maintained throughout the water column.

[5] Pommerenck, K., Roberts J. Illingworth & Rodkin, Inc. - WETA North Bay Maintenance and Operations Facility Vallejo, CA August to September 2015

TABLE 9 Distance to the Adopted Marine Mammal Thresholds for Different Pile-driving Activities – Level A and B Zones

Driving Method	Pile Type	Size	Piles per Day	Estimated No. of Strikes per Pile	Condition[a]	Level A Injury Zone Using SEL_{cum} Threshold – Pinnipeds – Phocid	Level A Injury Zone Using SEL_{cum} Threshold – Pinnipeds – Otariid	Level B Harassment Zone
Impact	Steel pipe pile in water	12-inch	4	450[e]	Unattenuated	92 m *[303 ft]*	--[b]	185 m *[606 ft]*
					Attenuated	43 m *[140 ft]*	--[b]	86 m *[281 ft]*
Impact	Steel pipe pile in water	36-inch	4	450[e]	Unattenuated	791 m *[2,595 ft]*	58 m *[189 ft]*	1,585 m *[5,200 ft]*
					Attenuated	170 m *[559 ft]*	12 m *[41 ft]*	342 m *[1,120 ft]*
Vibrate	Steel pipe pile in water	12-inch	4	--[c]	Unattenuated	--[b]	--[b]	2,154 m *[7,068 ft]*
Vibrate	Steel pipe pile in water	36-inch	4	--[c]	Unattenuated	49 m *[160 ft]*	--[b]	3,280/5,600 m [d] *[10,761/ 18,373 ft]*

[a] Attenuated condition assumes 5-dB lower sounds for 12-inch piles and 10-dB lower sounds for 36-inch piles
[b] Within the near-field of the sound source - < 10 meters [33 feet]
[c] Piles vibrated in at 120 minutes each.
[d] Constrained by bends in the Napa River near the Vallejo Ferry Terminal, 3,280 m [10,761 ft] north and 5,600 m [18,373 ft] south
[e] Assuming impact hammer usage for 15 mins with about 450 strikes per pile.

Illustration of Impacts

Attachment A includes Google Earth maps displaying the extent of both fish injury zones and marine mammal Level A and B Zones around the proposed project site for the piles driven. Attachment B includes screenshots from the NMFS Multi-Species Calculator tool that was used to calculate distances to fish and marine mammal thresholds.

REFERENCES

California Department of Transportation (Caltrans). 2020. Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish. Prepared by ICF International and Illingworth & Rodkin, Inc. Report No. CTHWANP-RT-20-365.01.04. October. https://dot.ca.gov/-/media/dot-media/programs/environmental-analysis/documents/env/hydroacoustic-manual.pdf.

Finerran, J.J. 2002. "Temporary Shift in Masked Hearing Thresholds in Odontocetes after Exposure to Single Underwater Impulses from a Seismic Watergun." Journal of the Acoustical Society of America. Vol. 111. June 4. https://doi.org/10.1121/1.1479150.

ISO 18406:- Underwater acoustics — Measurement of radiated underwater sound from percussive pile driving

Richardson, W.J., C.R. Greene, C.I. Malme, and D.H. Thomson. 1995. Marine Mammals and Noise. Academic Press.

National Marine Fisheries Service (NMFS). 2018. 2018 Revision to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0) - Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts. April. https://media.fisheries.noaa.gov/dam-migration/tech_memo_acoustic_guidance_(20)_(pdf)_508.pdf

National Marine Fisheries Service (NMFS) 2022 Optional Multi-Species Pile Driving Calculator Version 1.2 (August 2022)

National Marine Fisheries Services (NMFS). 2023. *National Marine Fisheries Services: Summary of Marine Mammal Protection Act Acoustic Thresholds.* February. Available at https://www.fisheries.noaa.gov/s3/2023-02/MMAcousticThresholds_secureFEB2023_OPR1.pdf Accessed Sep 15, Accessed Sep. 15, 2023.

National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA), Commerce. 2023. 88 FR 56595, pages 56595-56606 (12 pages). August 18.

POA (Port of Anchorage). 2016. Anchorage Port Modernization Program Test Pile Program Report of Findings. Prepared by HDR, Inc., Anchorage, AK for the Port of Anchorage under contract to CH2M.

Attachment A

Maps Illustrating the 187-dB Cumulative SELs, 206-dB Peak Adopted Fish Injury Zones and Marine Mammal Level A and B Zones (Source: Google Earth 2024)

FIGURE A1 **Distance to Adopted Fish Thresholds for Unattenuated 12-inch steel piles impact driven (Google Earth 2024)**

FIGURE A2 Distance to Adopted Fish Thresholds for Unattenuated 36-inch steel piles impact driven (Google Earth 2024)

FIGURE A3 Distance to Marine Mammal Thresholds for 12-inch steel piles impact driven (Google Earth 2024)

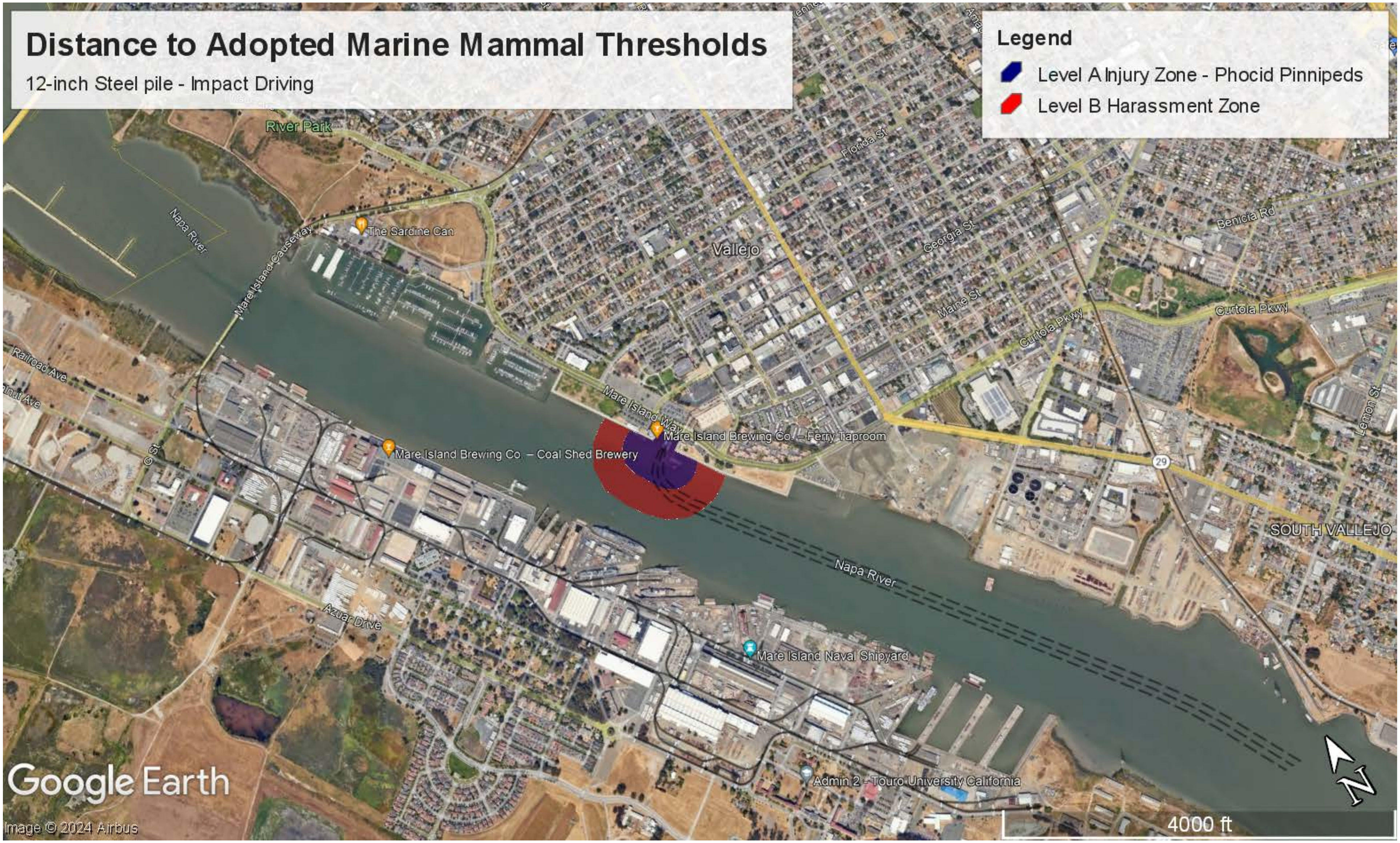

FIGURE A4 Distance to Marine Mammal Thresholds for 12-inch steel piles using vibratory hammer (Google Earth 2024)

FIGURE A5 Distance to Marine Mammal Thresholds for 36-inch steel piles impact driven (Google Earth 2024)

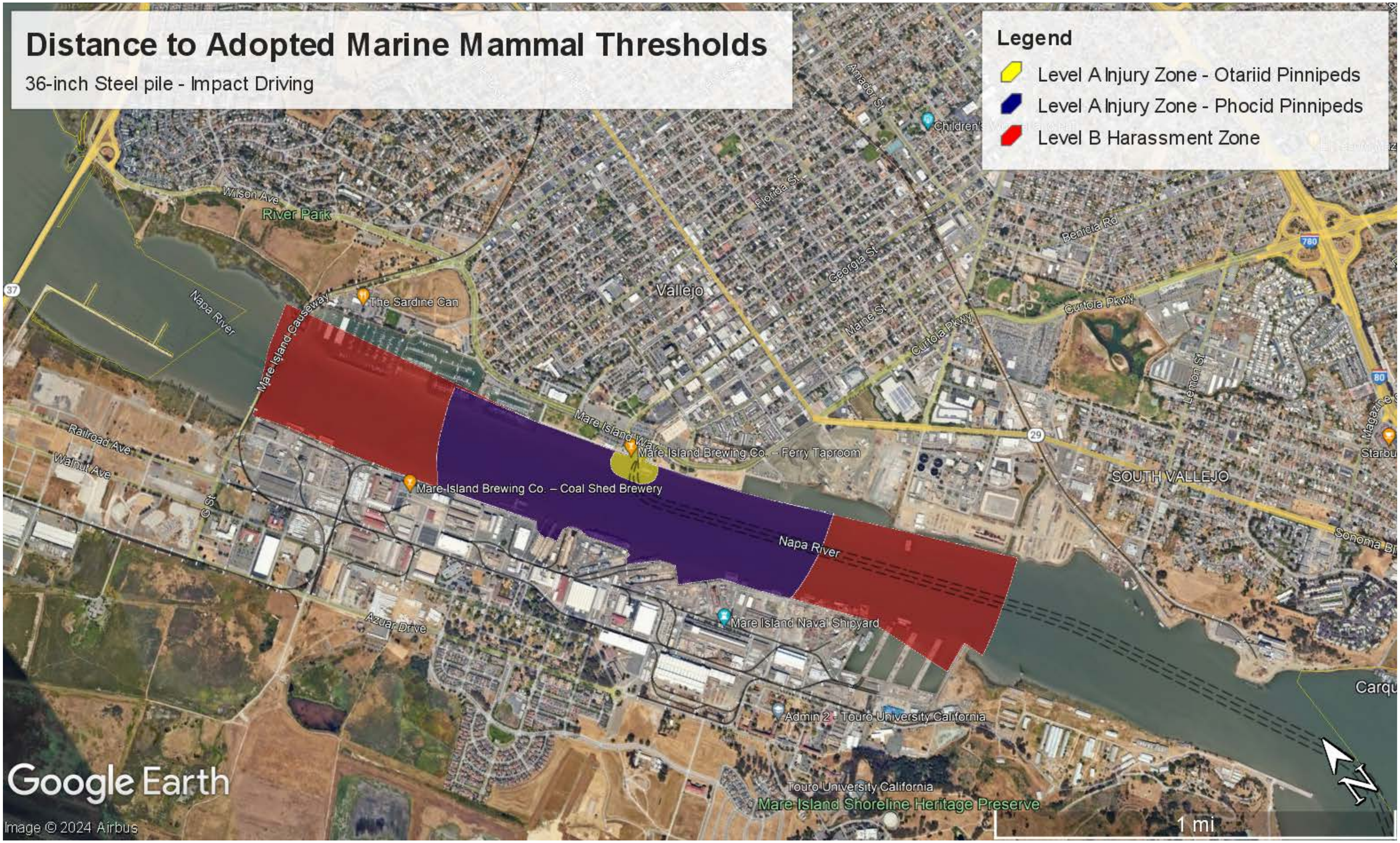

FIGURE A6 Distance to Marine Mammal Thresholds for 36-inch steel piles using vibratory hammer (Google Earth 2024)

Attachment B
Screenshots from NMFS Optional Multi Species Pile Driving Calculator
Version 1.2 (2022)

FIGURE B1 NMFS Multi-Species Calculator Spreadsheet Screenshot – 12-inch steel piles impact driven

IMPACT PILE DRIVING REPORT

VERSION 1.2-Multi-Species: 2022

WETA Vallejo

PRINT IN LANDSCAPE TO CAPTURE ENTIRE SCREEN

(if OTHER INFO or NOTES get cut-off, please include information elsewhere)

PROJECT INFORMATION	PEAK	SELss	RMS
Single strike level (dB)	199	169	179
Distance associated with single strike level (meters)	10	10	10
Transmission loss constant	15		
Number of piles per day	4		
Number of strikes per pile	450		
Number of strikes per day	1800		
Cumulative SEL at measured distance	202		

OTHER INFO: 12-inch steel piles

NOTES: 0

Attenuation: 0

RESULTANT ISOPLETHS

(Range to Effects)

FISHES

	ONSET OF PHYSICAL INJURY			BEHAVIOR	
	Peak Isopleth	SEL_{cum} Isopleth: Fish ≥ 2 g	SEL_{cum} Isopleth: Fish < 2 g	RMS Isopleth	
ISOPLETHS (meters)	3.4	93.4	172.5	857.7	Fishes present
Isopleth (feet)	11.2	306.3	566.0	2,814.0	

SEA TURTLES

	PTS ONSET		BEHAVIOR	
	Peak Isopleth	SEL_{cum} Isopleth	RMS Isopleth	
ISOPLETHS (meters)	0.1	6.9	18.5	NO SEA TURTLES
Isopleth (feet)	0.2	22.6	60.6	

MARINE MAMMALS

	LF Cetacean	MF Cetaceans	HF Cetaceans	PW Pinniped	OW Pinnipeds
PTS ONSET (Peak isopleth, meters)	0.5	0.1	6.3	0.5	0.1
PTS ONSET (Peak isopleth, feet)	1.5	0.3	20.7	1.8	0.2
PTS ONSET (SEL_{cum} isopleth, meters)	172.3	6.1	205.2	92.2	6.7
PTS ONSET (SEL_{cum} isopleth, feet)	565.2	20.1	673.3	302.5	22.0
	ALL MM	NO MF CET.	NO HF CET.	Phocids present	Otariids present
Behavior (RMS isopleth, meters)	184.8	NO LF CET.			
Behavior (RMS isopleth, feet)	606.2				

FIGURE B2 **NMFS Multi-Species Calculator Spreadsheet Screenshot – 12-inch steel piles using vibratory hammer**

VIBRATORY PILE DRIVING REPORT

VERSION 1.2-Multi-Species: 2022

PRINT IN **LANDSCAPE** TO CAPTURE ENTIRE SCREEN

(if OTHER INFO or NOTES get cut-off, please include information elsewhere)

WETA Vallejo

PROJECT INFORMATION	RMS
Sound pressure level (dB)	155
Distance associated with sound pressure level (meters)	10
Transmission loss constant	15
Number of piles per day	4
Duration to drive pile (minutes)	120
Duration of sound production in day	28800
Cumulative SEL at measured distance	200

OTHER INFO: 12-in vibrate

NOTES: extra information

Attenuation: 0

RESULTANT ISOPLETHS
(Range to Effects)

FISHES

Fishes present	BEHAVIOR RMS Isopleth
ISOPLETHS (meters)	21.5
ISOPLETHS (feet)	70.7

SEA TURTLES

NO SEA TURTLES	PTS ONSET SEL_{cum} Isopleth	BEHAVIOR RMS Isopleth
ISOPLETHS (meters)	0.4	0.5
ISOPLETHS (feet)	1.4	1.5

MARINE MAMMALS

	LF Cetacean	MF Cetaceans	HF Cetaceans	PW Pinniped	OW Pinnipeds
PTS ONSET (SELcum isopleth, meters)	10.9	1.0	16.1	6.6	0.5
PTS ONSET (SELcum isopleth, feet)	35.7	3.2	52.8	21.7	1.5
	ALL MM	NO MF CET.	NO HF CET.	Phocids present	Otariids present
Behavior (RMS isopleth, meters)	2,154.4	NO LF CET.			
Behavior (RMS isopleth, feet)	7,068.4				

FIGURE B3 NMFS Multi-Species Calculator Spreadsheet Screenshot – 36-inch steel piles impact driven

IMPACT PILE DRIVING REPORT

VERSION 1.2-Multi-Species: 2022

WETA Vallejo

PRINT IN LANDSCAPE TO CAPTURE ENTIRE SCREEN

(if OTHER INFO or NOTES get cut-off, please include information elsewhere)

PROJECT INFORMATION	PEAK	SELss	RMS
Single strike level (dB)	211	183	193
Distance associated with single strike level (meters)	10	10	10
Transmission loss constant	15		
Number of piles per day	4		
Number of strikes per pile	450		
Number of strikes per day	1800		
Cumulative SEL at measured distance	216		

OTHER INFO: 36-in steel pile

NOTES: 0

Attenuation: 0

RESULTANT ISOPLETHS

(Range to Effects)

FISHES

	ONSET OF PHYSICAL INJURY			BEHAVIOR	
	Peak Isopleth	SEL_{cum} Isopleth		RMS Isopleth	
		Fish ≥ 2 g	Fish < 2 g		
ISOPLETHS (meters)	21.5	800.8	1,479.7	7,356.4	Fishes present
Isopleth (feet)	70.7	2,627.2	4,854.7	24,135.2	

SEA TURTLES

	PTS ONSET		BEHAVIOR	
	Peak Isopleth	SEL_{cum} Isopleth	RMS Isopleth	
ISOPLETHS (meters)	0.4	59.0	158.5	NO SEA TURTLES
Isopleth (feet)	1.3	193.4	520.0	

MARINE MAMMALS

	LF Cetacean	MF Cetaceans	HF Cetaceans	PW Pinniped	OW Pinnipeds
PTS ONSET (Peak isopleth, meters)	2.9	0.5	39.8	3.4	0.4
PTS ONSET (Peak isopleth, feet)	9.6	1.8	130.6	11.2	1.3
PTS ONSET (SEL_{cum} isopleth, meters)	1,477.7	52.6	1,760.2	790.8	57.6
PTS ONSET (SEL_{cum} isopleth, feet)	4,848.1	172.4	5,774.8	2,594.5	188.9
	ALL MM	NO MF CET.	NO HF CET.	Phocids present	Otariids present
Behavior (RMS isopleth, meters)	1,584.9	NO LF CET.			
Behavior (RMS isopleth, feet)	5,199.8				

FIGURE B4 **NMFS Multi-Species Calculator Spreadsheet Screenshot – 36-inch steel piles using vibratory hammer**

VIBRATORY PILE DRIVING REPORT

VERSION 1.2-Multi-Species: 2022

WETA Vallejo

PRINT IN **LANDSCAPE** TO CAPTURE ENTIRE SCREEN

(if OTHER INFO or NOTES get cut-off, please include information elsewhere)

PROJECT INFORMATION	RMS
Sound pressure level (dB)	168
Distance associated with sound pressure level (meters)	10
Transmission loss constant	15
Number of piles per day	4
Duration to drive pile (minutes)	120
Duration of sound production in day	28800
Cumulative SEL at measured distance	213

OTHER INFO	36-in vibrate
NOTES	extra information
Attenuation	0

RESULTANT ISOPLETHS
(Range to Effects)

FISHES

Fishes present	BEHAVIOR RMS Isopleth
ISOPLETHS (meters)	158.5
ISOPLETHS (feet)	520.0

SEA TURTLES

NO SEA TURTLES	PTS ONSET SEL_{cum} Isopleth	BEHAVIOR RMS Isopleth
ISOPLETHS (meters)	3.2	3.4
ISOPLETHS (feet)	10.5	11.2

MARINE MAMMALS

	LF Cetacean	MF Cetaceans	HF Cetaceans	PW Pinniped	OW Pinnipeds
PTS ONSET (SELcum isopleth, meters)	80.0	7.1	118.3	48.6	3.4
PTS ONSET (SELcum isopleth, feet)	262.5	23.3	388.1	159.6	11.2
	ALL MM	NO MF CET.	NO HF CET.	Phocids present	Otariids present
Behavior (RMS isopleth, meters)	15,848.9	NO LF CET.			
Behavior (RMS isopleth, feet)	51,997.8				