National Marine Fisheries Service

Application for Incidental Harassment Authorization for Marine Mammals

TREASURE ISLAND / YERBA BUENA ISLAND REDEVELOPMENT PROJECT

CITY AND COUNTY OF SAN FRANCISCO, CALIFORNIA

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SECTION 1: DESCRIPTION OF SPECIFIED ACTIVITY

A detailed description of the specific activity or class of activities that can be expected to result in incidental taking of marine mammals.

San Francisco Bay is a shallow estuary located in northern California, and drains water from a significant portion of the state. San Francisco Bay is approximately 1,500 square miles in size, and is one of the busiest ports in the United States. Port facilities include those in San Francisco, Oakland, Redwood City, Richmond, and Stockton. In addition to vessel traffic resulting from shipping activity, ferry terminals currently operate in multiple locations in San Francisco Bay, including terminals in Alameda, Oakland, Richmond, Tiburon, Angel Island, Sausalito, and Larkspur. These terminals are all located within 20 miles of the Treasure Island / Yerba Buena Redevelopment Project. Project work associated with this IHA is taking place on Treasure Island, a flat island within San Francisco Bay that was constructed from fill between 1936 and 1939. The U.S. Navy took possession of Treasure Island from the City and County of San Francisco in 1941 and operated a military base, Naval Station Treasure Island, until it was closed in 1997. Treasure Island encompasses approximately 367 acres of residential, open space/recreation, community/institutional, office/retail, and an approximately 100-slip marina is located along the southern shoreline of Treasure Island in Clipper Cove.

Yerba Buena Island, a natural feature in the San Francisco Bay Central Bay, is markedly different from Treasure Island. It is approximately 150 acres in size. The island has been used by private parties and by the U.S. Army, Navy, and the U.S. Coast Guard since the 1840s. Existing land uses on Yerba Buena Island include residential, open space and recreation facilities, California Department of Transportation facilities and a U.S. Coast Guard Station and Sector Facility on Yerba Buena Island.

The south side of Yerba Buena Island is the nearest harbor seal haul out area, approximately 0.85 shoreline miles from the project site (Figure 2). Although seals haul out year round on Yerba Buena Island, it is not considered a pupping site for harbor seals (although pups are occasionally seen there) (Kopec and Harvey, 1995). There is an established harbor seal haul out and pupping area located approximately 8 miles northwest of Treasure Island, immediately south of the Richmond Bridge. This, along with another pupping location along Mowry Slough (located in Southern San Francisco Bay approximately 30 miles southeast of Treasure Island) represent the primary haul out and pupping areas. Sea lions haul out primarily on floating docks at Pier 39 in the Fisherman's Wharf area and may be found on buoys elsewhere in the Bay.

A number of other projects in San Francisco have recently applied for and received an IHA. Examples of these projects include the Downtown San Francisco Ferry Terminal Expansion Project (IHA issued in 2017), the Exploratorium Relocation Project, a science museum that relocated to the Embarcadero, an area along the waterfront of San Francisco (IHA issued in 2011), and the WETA Central Bay Operations and Maintenance Facility construction project in Alameda, California (IHA issued in 2015).

The Treasure Island Yerba Buena Redevelopment Project is constructing a ferry terminal on the southwest side of Treasure Island (Project) in San Francisco County, California. The Water Emergency Transportation Authority (WETA) is expected to operate and service the ferry. It is anticipated that initial runs will occur at approximately 60-minute intervals. The goal will be to provide service to downtown San Francisco at 15-minute intervals at peak periods from 5am to 9pm at full build-out of the Project. The ferry terminal is also designed to provide emergency access for Treasure Island and Yerba Buena Islands.

In 2020, Project elements will include installation and construction of the ferry pier, north breakwater, temporary mooring piles, a fireboat access pier, and dilapidated pier removal. A temporary water taxi landing will be constructed on the ferry pier that will be operated while ferry terminal offers service using one ferryboat. When ferry service increases to use two ferryboats, the temporary water taxi landing will be removed. Pile driving to support the construction of the ferry terminal and associated structures has the potential to result in harm or harassment of marine mammals through acoustic disturbance.

The Project ferry terminal and supporting utilities include an approximately 5,175-square-foot float with a temporary water taxi landing supported by 36-inch-diameter steel piles and an approximately 1,170-square-foot gangway; an approximately 2,400-square foot section of a pier with a canopy supported by 48-inch-diameter steel piles (driven using a combination of vibratory and impact); a fireboat access platform with supporting utilities consisting of a 2,500 square foot pier supported by 48" diameter steel piles and 36-inch-diameter steel piles; and a breakwater, approximately 820 feet long supported by 24-inch-diameter concrete batter piles, as well as 14" by 48" sheetpiles north of the terminal with an approximately 2,400-square-foot rock revetment connecting the breakwater to the shoreline (Figure 2). The temporary water taxi landing is to allow smaller watercraft ferry dock landing access when the ferry service is limited to one ferryboat. Temporarily accommodating water taxis is consistent with the Project aim of minimizing reliance on the San Francisco – Oakland Bay Bridge to access the islands. The Project will also remove an approximately 11,684-square-foot pier ("Pier 23"), including 12-inch-diameter timber piles and bents and an approximately 258-square-foot gangway. A number of temporary 14" by 89' steel template piles (h-piles) will be driven using a vibratory hammer, as well as temporary 14" by 89' steel template batter piles (h-piles) to be driven using a vibratory hammer. Temporary 36-inch-diameter steel mooring piles will be driven using a vibratory hammer, and 14" by 89' mooring batter piles (steel h-piles) will be driven using a vibratory hammer. Temporary piles will also be removed by vibratory hammer.

A portion of this work was completed in 2019. Work completed in 2019 included the installation of a number of piles in support of the North breakwater, including twenty-one 24" octagonal piles and seventy 14" by 48" concrete sheetpiles.

The piles that will be installed / removed in 2020 are described in further detail in Table 1 below.

Table 1. Summary of Pile Activities

ACTIVITY		**PILES**	
	Location	**Number (maximum)**	Type
Install Piles for Ferry Pier (impact and vibratory)	Ferry Pier	4	36" steel pipe (mooring piles)/ vibratory
	Ferry Pier	2	48" steel pipe vibratory & impact
	Ferry Pier	2	36" steel pipe (fender piles)/ vibratory
Install Temporary Steel Template Piles (Vibratory)	Ferry Pier	20	14"x89' steel H-piles
Remove Temporary Steel Template Piles (Vibratory)	Ferry Pier	20	14"x89' steel H-piles

Install Octagonal for North Breakwater (impact)	North Breakwater	52	24” octagonal concrete
Install Sheetpiles for North Breakwater (impact)	North Breakwater	120	14”X48” concrete sheetpiles
Install Temporary Steel Template Piles (Vibratory)	North Breakwater	108	14”x89’ steel H-piles
Remove Temporary Steel Template Piles (Vibratory)	North Breakwater	108	14”x89’ steel H-piles
Install Temporary Steel Template Batter Piles(Vibratory)	North Breakwater	46	14”x89’ steel H-piles
Remove Temporary Steel Template Batter Piles(Vibratory)	North Breakwater	46	14”x89’ steel H-piles
Install Temporary Mooring Piles (Vibratory)	Mooring	2	36” steel pipe
Remove Temporary Mooring Piles (Vibratory)	Mooring	2	36” steel pipe
Install Temporary Mooring Batter Piles (Vibratory)	Mooring	4	14”x89’ steel H-piles
Remove Temporary Mooring Batter Piles (Vibratory)	Mooring	4	14”x89’ steel H-piles
Install Crew Access Piles (Vibratory)	Mooring	2	14”x89’ steel H-piles
Remove Crew Access Piles (Vibratory)	Mooring	2	14”x89’ steel H-piles
Install Fireboat Access Pier (Vibratory & Impact)	North Breakwater	3	48” steel pipe
Install Fireboat Access Pier (Vibratory & Impact)	North Breakwater	2	36” steel pipe
Install Temporary Fireboat Steel Template Piles (Vibratory)	North Breakwater	16	14”x89’ steel H-piles
Remove Temporary Fireboat Steel Template Piles (Vibratory)	North Breakwater	16	14”x89’ steel H-piles
Remove Existing Pier (vibratory or crane cable)	Pier	198	12” timber
TOTAL		779	**n/a**

Piles will be installed with the use of either a vibratory or an impact hammer under the following parameters.

- Vibratory Hammer: Piles will be installed with the use of a vibratory hammer with an energy output of 6,000 ft-lb and a variable frequency between 0 and 1,400 vibrations per minute and will be operated from a barge-mounted crane. The piles will be installed to an estimated depth of embedment of 50-90 feet below the bay bottom, to be confirmed by geotechnical investigation. Steel pile driving will occur until refusal or design tip elevation is reached.
- Impact Hammer: Piles will be installed with the use of a diesel powered impact hammer with approximately 100,000 ft-lb energy output operated from a barge-mounted crane to an estimated depth of embedment of 50-90 feet below the bay bottom, to be confirmed by geotechnical investigation.

The pile driving equipment will be deployed and operated from barges, on water. Materials will be delivered on barges. Between 3 and 8 piles will be placed daily (with the larger piles taking more time to install, and therefore fewer will be installed per day). Temporary piles will be placed to assist in the installation of the supporting piles for each structure. The temporary piles will be removed when the associated permanent piles are installed. The actual pile driving duration will vary depending on pile and hammer types.

Pile installation will be completed with the use of 2-3 cranes, at times operating simultaneously to allow for the Project to remain on schedule. Pile driving activities related to installation of the ferry pier, north breakwater, mooring piles, and fireboat access pier will create underwater acoustic sound and that may result in a change in behavior of marine mammals. Pile driving steel pipes, concrete, and sheet piles with vibratory and impact hammer will create varying underwater sound levels dependent on hammer type and material. Sound levels, noise thresholds, and estimated take are further discussed in Section 6.

Removal of existing wood piles will be performed with a vibratory hammer or a crane cable. Work for pier removal will be completed from a barge and all debris will be removed. Up to fifteen piles will be removed in a 24-hour period. Piles will be pulled or vibrated out entirely unless broken. Broken piles will be cut 3 ft. below the mudline. Pier removal activities that require vibratory hammer will create underwater sound and acoustic pressure that may affect marine mammals. Other pier removal activities including deck and bent removal will occur out of water. Deck height in the area is at elevations that are generally too high to facilitate marine mammal haulout. Therefore, removal of the existing pier decking and bents is not likely to result in harm or harassment of marine mammals.

Work is proposed on the following schedule:

- Ferry pier pile and North breakwater template H pile driving – 27 days in June 2020
- North breakwater sheetpile, template H pile driving – 162 days in July 2020 to January 15, 2021
- Pier 32 timber piles will be removed during the 162-day north breakwater driving from July 2020 to December 2020.

A detailed summary of the proposed pile driving is presented by work day in Section 6, Table 7.

SECTION 2: DATES, DURATION, AND SPECIFIED GEOGRAPHIC REGION

The date(s) and duration of such activity and the specified geographical region where it will occur.

The Project is located on the western shoreline of Treasure Island in San Francisco County, California on the border of the San Francisco North and Oakland West US Geological Survey quadrangles (Project Area). The specific geographic location is depicted in Figure 2. Ferry terminal work is in a Fleet Anchorage Area used by the US Coast guard, as noted in Attachment 3. The Project is not within designated critical habitat under jurisdiction of the U.S. Fish and Wildlife Service (USFWS 2019). The Project is located within critical habitat for Central California Coast Coho salmon, Sacramento River Winter-run Chinook salmon, Central Valley Spring-run Chinook salmon, Central Valley DPS steelhead, Central California Coast steelhead, and Southern DPS Green sturgeon. There is a known seal haul out location at Yerba Buena Island on the southern shoreline. The haul out is characterized by a cobble beach backed by a steep cliff. The area supports a greater number of seals during winter months, and is not typically used for pupping (Spencer 1997). The Project location is separated from the haul out by approximately 0.85 miles of shoreline. Because Yerba Buena Island extends out further west than Treasure Island, the haul out is not within line of sight of the Project.

Construction activities will occur from June 1, 2020 to January 15, 2021, with an anticipated 189 workdays. After November 30, when more seals may be present at the Yerba Buena haul out, only concrete piles or vibratory driven/extraction steel piles will be driven. Pile driving will occur during daylight hours.

SECTION 3: SPECIES AND NUMBERS OF MARINE MAMMALS

The species and numbers of marine mammals likely to be found within the activity area.

At least eight species of marine mammals occur in San Francisco Bay. Of these, three are likely to be found within the vicinity of the Project Area and may be taken by the Project. In 2018, over the course of 33 monitoring days (approximately 265 hours), the following marine mammals were observed in and around the Project Area: 324 harbor seals, 5 California sea lions, and 2 harbor porpoises. The remaining species are rare in the San Francisco bay and may occasionally occur in the vicinity of the Project Area. Species that may occur in the area, along with Endangered Species Act (ESA) and Marine Mammal Protection Act (MMPA) status and population size[1], are provided below in Table 2.

Table 2. Marine Mammals that May be Present in the Vicinity of the Project

Common name	Stock	ESA/MMPA Status	Occurrence in the San Francisco Bay	Abundance Estimate	Scale of Estimates
Pacific harbor seal	California	none	Common	30,968	All of California
California sea lion	U.S. (Pacific Temperate)	none	Common	257,606	California, Oregon, Washington, and north into Canada
common bottlenose dolphin	California	none	Rare	453	San Francisco to Ensenada

[1] Population sizes as listed in the NOAA Pacific Marine Mammal Stock Assessments (Carretta et al, 2019)

harbor porpoise	San Francisco/ Russian River	none	Common	9,886	San Francisco to Russian River
gray whale	Eastern North Pacific	none	Occasional	26,960	Eastern North Pacific
humpback whale	California/ Oregon/ Washington	MMPA depleted	Occasional	2,900	California, Oregon and Washington
northern elephant seal	California	none	Rare	179,000	All of California
northern fur seal	California	none	Rare	14,050	All of California

Species Not Anticipated to be Taken

Humpback whale: Humpback whales (*Megaptera novaeangliae*) feed along the California, Oregon and Washington coasts in spring, summer and fall. Humpback whales incidentally enter the San Francisco Bay, but not in high numbers.

SECTION 4: AFFECTED SPECIES STATUS AND DISTRIBUTION

A description of the status and distribution, including seasonal distribution (when applicable), of the species or stocks of marine mammals likely to be affected by such activities.

Pacific harbor seal

Harbor seals (*Phoca vitulina*) range from Cedros Island (Baja California) along the Pacific coasts of the United States, Canada and Alaska, through the Aleutian Islands to the Pribilof Islands. Based on the most recent harbor seal counts (20,109 in May-July 2012) and the Harvey and Goley correction factor, the harbor seal population in California is estimated to number 30,968 (Harvey and Goley 2011, Carretta et al. 2019). Approximately 500-600 harbor seals are resident to San Francisco Bay (NPS, 2016)

Harbor seals spend about half their time in the water, where they typically dive for seven minutes in relatively shallow waters to feed on a variety of prey items, including flounder, sculpin, herring and squid (TMMC 2019). In California, approximately 400-500 harbor seal haul out sites are widely distributed along the mainland and on offshore islands, including intertidal sandbars, rocky shores and beaches (Hanan 1996). The Golden Gate National Recreation Area (GGNRA) contains a number of haul out areas for this species, including locations on Alcatraz Island, Point Bonita and Bolinas Lagoon (NPS 2016). The south side of Yerba Buena Island is the nearest haul out area to the Project Area, approximately 0.85 shoreline miles from the project site. Although seals haul out year round on Yerba Buena Island, it is not considered a pupping site for harbor seals (although pups are occasionally seen there) (Kopec and Harvey, 1995). Additionally, harbor seal pups are typically born between February and April, with Project work to occur outside this window. Observed foraging areas for this species based on data collected during project work in 2019 are outlined in Figure 2. Harbor seals are not listed under the ESA or considered strategic under the MMPA.

California sea lion

California sea lions reside in the Eastern North Pacific Ocean in shallow coastal and estuarine waters. Sandy beaches are preferred for haul out sites. In California, they haul out on marina docks as well as jetties and buoys (TMMC 2019). In the San Francisco Bay, sea lions haul out primarily on floating docks at Pier 39 in the Fisherman's Wharf area and may be found on buoys elsewhere in the Bay. California sea lions will typically dive for less than three minutes in less than 80 meters of water to feed on prey items such as squid, herring, rockfish and small sharks (Feldkamp et al. 1989). The 2018 NMFS stock assessment report estimates there are approximately 257,606 sea lions in the U.S. (Carretta et al. 2019). They are not listed as depleted under the MMPA or as endangered or threatened under the ESA.

Harbor Porpoise

Harbor porpoises are found in coastal and inland waters, traveling in small groups, up to ten individuals (NOAA, 2020). Harbor porpoise sightings in the San Francisco Bay declined in the 1930's and were functionally extirpated shortly after. In 2008, harbor porpoises began reoccupying the bay, with sightings becoming increasingly common (Stern et al. 2017). This species has been observed from the Golden Gate Bridge during all months of the year. The San Francisco-Russian River stock is estimated at 9,886 individuals (Carretta et al. 2019). This species is not listed as depleted under the MMPA or threatened or endangered under the ESA. Central San Francisco Bay observation studies have observed approximately 20 porpoises per hour (Stern et al, 2017).

Gray whale

In the fall, Gray Whales (*Eschrichtius robustus*) migrate from their summer feeding grounds, heading south along the coast of North America to spend the winter in their breeding and calving areas off the coast of Baja California, Mexico. From mid-February to May, the Eastern North Pacific stock of gray whales can be seen migrating northward with newborn calves along the West Coast of the U.S. During the migration, gray whales will occasionally enter rivers and bays (such as San Francisco Bay) along the coast but not in high numbers.

Northern elephant seal

Northern elephant seals (*Mirounga angustirostris*) breed at offshore islands, with the nearest documented rookeries at the Farallon Islands, Ano Nuevo, and Point Reyes (Lowry et al., 2014). The San Francisco bay is not known to support large populations. This species may occasionally make brief stops in the San Francisco bay.

Northern fur seal

Northern fur seals (*Callorhinus ursinus*) breed primarily at offshore islands, including the San Miguel Islands off Southern California, and most recently in the Farallon Islands off the coast of San Francisco Bay, where the first pup was born there in over 100 years in the mid 1990's. This species feeds primarily on open ocean fish species, and rarely comes ashore unless distressed (TMMC 2019).

Common bottlenose dolphin

Common bottlenose dolphins (*Tursiops truncatus*) are found in most of the world's warm temperate and tropical seas. In California, bottlenose dolphins stay close to shore between Cabo San Lucas to just north of San Francisco (TMMC 2019).

SECTION 5: TYPE OF INCIDENTAL TAKING AUTHORIZATION REQUESTED

The type of incidental taking authorization that is being requested (i.e., takes by harassment only; takes by harassment, injury and/or death) and the method of incidental taking.

Under Section 101 (a)(5)(D) of the MMPA, the Project requests an authorization from NMFS for incidental take by Level A and B harassment (as defined by Title 50 Code of Federal Regulations, Part 216.3) of small numbers of marine mammals—specifically, Level A and Level B take for Pacific harbor seals, California sea lions, and Common Bottlenose dolphin, and Level B take for Harbor porpoise, Northern Fur Seal, Northern Elephant seal, and Gray Whale during pile-driving activities associated with ferry terminal construction on Treasure Island. With implementation of the measures outlined in Section 11, although unlikely, torment or annoyance with the potential to cause injury (Level A harassment) to marine mammals could result from the Project.

SECTION 6: TAKE ESTIMATES FOR MARINE MAMMALS

By age, sex, and reproductive condition (if possible), the number of marine mammals (by species) that may be taken by each type of taking identified in Section 5, and the number of times such takings by each type of taking are likely to occur.

In 2018, NMFS revised the Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (NMFS 2018). This document establishes guidelines regarding the underwater thresholds for the onset of permanent and temporary threshold shifts that are considered take under the MMPA.

Thresholds for marine mammals are presented in Table 3 (NMFS 2018). These thresholds from the technical guidance document were used to determine Level A and Level B harassment zones for marine mammals that are likely to be affected by the Project.

Table 3. Species Thresholds

	Impulse (impact) (NMFS 2018)		**Non-impulse (vibratory)** (NMFS 2018)	
Species	**Level A/ PTS**	**Level B**	**Level A/ PTS**	**Level B**
High-frequency Cetaceans (harbor porpoise)	155 dB Peak: 202 dB	160 dB RMS	173 dB	120 dB RMS

Mid-frequency Cetaceans	185 dB Peak: 230 dB	160 dB RMS	198 dB	120 dB RMS
Low-frequency Cetaceans	183 dB Peak: 219 dB	160 dB RMS	199 dB	120 dB RMS
Phocid pinnipeds (harbor seals)	185 dB Peak: 218 dB	160 dB RMS	201 dB	120 dB RMS
Otariid pinnipeds (California sea lion)	203 dB Peak: 232 dB	160 dB RMS	219 dB	120 dB RMS

The Project is within an urban environment subject to regular underwater noise disturbance from recreational and commercial boat traffic, as well as in-water construction. Measurements at San Francisco Bay Oakland outer harbor ranged from 120-155 dB peak and 133 dB RMS levels (CalTrans 2015) suggesting that background underwater sound levels generally present in San Francisco Bay and the Project Area frequently exceed Level B thresholds for both cetaceans and pinnipeds. Smaller vessels that frequently pass by the Project Area such as rigid hull inflatable boats can create source sound levels of 130-160 dB, while larger vessels such as ferries and container ships can create source sound levels of over 200 dB (Erbe et al. 2019). The location of the Project itself limits the extent to which sound could travel, with the Project being approximately 1.8 miles northeast of the San Francisco waterfront, 3.7 miles south east of Angel Island, and generally contained within the larger land masses of San Francisco Bay. Apart from sound traveling outside San Francisco Bay, the longest distance that sound could travel underwater before encountering a land mass would be approximately 9.3 miles, between the Project Area and Silva Island (north west of the Project Area). Given that there is no site-specific ambient noise information available for the Project Area, the standard thresholds in Table 3 will be used. Because ambient noise levels in the vicinity of the project frequently exceeds 120 dB, the actual area of Level B harassment for continuous sources is likely much smaller than what is modeled and presented below.

Using sound measurements specific to pile and hammer type, species thresholds, and environmental conditions, underwater sound levels were estimated using the User Spreadsheet provided by NMFS to determine whether and over what distance the thresholds would be exceeded. Number of strikes or duration of pile driving is variable and dependent upon type of pile. Weighting Factor Adjustments are 2 for impact hammering and 2.5 for vibratory hammering.

Avoidance and minimization measures are detailed in Section 11. Biological monitoring will ensure that marine mammals will not enter Level A harassment areas during pile driving activities. Attenuation devices with be used during impact hammering of steel piles. Cushion blocks will be placed between the hammer and the pile. An unconfined, three-stage bubble curtain will be used if either sound pressures outside the immediate Project Area exceed 160 dB at 500 meters from the source or avoidance behavior by marine mammals or fish is observed by the on-site biologist (City, 2011).

The bubble curtain design will include an unconfined three-stage ring system, as depicted in Attachment 6, Figure 1 – Air-curtain System Schematic. The Caltrans Compendium of Underwater Sound Data included in the Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish (Compendium; Buehler et al. 2015) was referenced

to estimate the effectiveness of a bubble curtain for sound attenuation for the Project. Comparable attenuation systems were described in Sections I.3.13 and I.3.23, which resulted in a 5-22 dB reduction and an 8-17 dB reduction, respectively. Both of these examples involved 24-inch steel pipe. The bubble curtain is anticipated to have a smaller reduction for the Project, as curtains are less effective as the size of the pipe increases (Buehler et al. 2015). The effectiveness of the attenuation device may also be impacted by currents within the Project Area. The nearest NOAA Current Station is located at Oakland Inner Harbor (s10010), approximately 1.5 miles east of the Project Area. Currents at Oakland Inner Harbor typically do not exceed 1.8 knots at 14-27 foot depths. Piles will be driven in the Project Area in water depths of approximately 6-25 feet. It is anticipated that the Project Area will be subject to similar currents, which are relatively mild. Based on the average effectiveness of similar attenuation devices and a potential reduction in effectiveness due to occasional strong currents and larger pile size, the bubble curtain is expected to reduce sound levels by 5 dB, as reflected in Table 5. A bubble curtain will not be used during all pile driving activity and the expected reduction in sound levels is not used to estimate sound production or calculate take.

Isopleths were calculated under the following pile driving equipment assumptions: The diesel powered impact hammer has an approximate 100,000 ft-lb energy output with 0.1 seconds per blow on average. The vibratory hammer has an approximate energy output of 6,000 ft-lb and a variable frequency between 0 and 1,400 vibrations per minute. Estimated sound production for each pile material and pile-driving method (vibratory or impact) is detailed below.

ESTIMATED SOUND PRODUCTION

Sound production for each pile type was estimated by referencing data from similar projects, including those included in the Compendium (Buehler et al. 2015). In addition, data was collected by Illingworth and Rodkin, Inc. at Treasure Island during impact pile driving of concrete piles for the Project in 2019. The estimated sound production for each pile type that will be used for the Project is summarized in Tables 4 and 5, and described in more detail below.

Table 4. Predicted Sound Source Levels for Pile Types

Pile Driving Activity		**Estimated sound source level at 10 meters without attenuation**			**Data Source**
Hammer Type	**Pile Type**	**dB RMS**	**dB SEL**	**dB peak**	
Impact	36” steel pipe	193	183	210	Compendium pg. 131 (Buehler et al. 2015)
	48” steel pipe	195	185	210	Compendium pg. 132 (Buehler et al 2015)
	24” octagonal concrete	170	164	189	Measurements at Pile 3B, 9/10/2019 at Alameda Seaplane Lagoon Project (Illingworth and Rodkin, Inc., 2019)
	14”x48” concrete sheetpile	156	146	167	Treasure Island (Illingworth and Rodkin, Inc., 2019)

Vibratory	36” steel pipe	170			Compendium pg. 129 (Buehler et al 2015)
	48” steel pipe	170*			Pile-Driving Noise Measurements at Atlantic Fleet Naval Installations (Illingworth and Rodkin, Inc., 2017)
	14”x89’ steel H-piles	150			Compendium pg. 129 (Buehler et al 2015)
Vibratory Removal	12” timber piles (measured from 15.8’)	150			Port Townsend Dolphin Timber Pile Removal (WSDOT 2011)

*No sound source level information for vibratory driving for 48” steel pipes is available in the Compendium. Sound source levels of 48” piles for the Atlantic Fleet Naval Installations (162 dB) were lower than those listed for 36” piles in the Compendium (170 db). Sound source levels for 48” piles are expected to be at least as high as those measured for 36” piles. As such, 170 dB was used for isopleth calculations for 48” piles.

Table 5. Predicted Sound Source Levels with Use of Bubble Curtain during Impact Hammering

Pile Type	**Sound source level at 10 meters with attenuation***		
	dB RMS	**dB SEL**	**dB peak**
36” steel pipe	188	178	205
48” steel pipe	190	180	200

*A bubble curtain will not be used during all pile driving activity and the expected reduction in sound levels is not used to estimate sound production or calculate take below.

Simultaneous Pile Driving Activity

It is possible that the Project will deploy multiple hammers simultaneously, though these occurrences would be infrequent and likely would occur for short durations on a given day. For the operation of multiple impact hammers, it is unlikely that two impact hammers will strike at the exact moment, and as such, impact hammering sound source levels are not combined for multiple hammers in operation simultaneously. For multiple vibratory hammers operating simultaneously, or vibratory and impact hammers operating at the same time, the sound levels may overlap and create a higher sound level. The combined sound levels are dependent on the pile size and materials driven simultaneously. The following rules were used for combining sound levels, as described for the Hampton Roads Bridge-Tunnel Expansion Project in Hampton-Norfolk, Virginia (HDR Engineering and Mott Macdonald 2020).

Table 6. Rules for Combining Sound Levels for Simultaneous Pile Driving

Hammer Type	**Difference in Sound Source Level**	**Level A zones**	**Level B zones**
Vibratory / Impact	Any	Use Impact zone	Use vibratory zone
Vibratory/ Vibratory	0-1	Add 3 dB to higher source level	Add 3 dB to higher source level
	2-3	Add 2 dB to higher source level	Add 2 dB to higher source level

	4-9	Add 1 dB to higher source level	Add 1 dB to higher source level
	10+	Add 0 dB to higher source level	Add 0 dB to higher source level

*Rules sourced from Hampton Roads Bridge-Tunnel Expansion Project, HDR Engineering and Mott Macdonald 2020

The combination of hammer type and pile type is highly variable from day to day, where some work days may have only one pile driven. It is estimated that up to 8 piles could be driven on a likely maximum exposure day, and only 3 piles driven on a likely average exposure day (Table 7). It is unlikely that three vibratory hammers would operate at a given time, as in-water pile installation is an intermittent activity that typically occurs in short increments and is subject to starts and stops.

Table 7. Daily Exposure Scenarios

Date	Location	Total Days	Piles driven during 24 hours	Drive Type	Pile Type	Loudest Potential Sound Source Combination	
						Level A	Level B
EXAMPLE MAXIMUM EXPOSURE DAYS							
June	Ferry Pier	7	2	Impact	48” steel pipe	Impact 48“ steel pipe	2 vibratory 14X89’ steel H-pile
	North Breakwater		4	Vibratory	14”x89’ steel H-piles		
July to January 15	North Breakwater	50	4	Impact	24” octagonal concrete or 14X48” concrete sheetpiles	Impact 24” octagonal concrete	2 vibratory 14X89’ steel H-pile
			4	Vibratory	14”x89’ steel H-piles		
EXAMPLE AVERAGE EXPOSURE DAYS							
June	Ferry Pier	20	1	Vibratory	48” steel pipe	2 vibratory (48” and 38”) steel pipes	2 vibratory (48” and 36”) steel pipes
			1	Vibratory	36” steel pipe (fender and/or mooring piles)		
			2	Vibratory	14”x89’ steel H-piles		
July to January 15	North Breakwater	112	1	Impact	14X48” concrete sheetpiles	Impact 14X48”	2 vibratory 14X89’ steel H-pile
			2	Vibratory	14”x89’ steel H-piles		
Existing Timber Pier Removal		14*	15	Vibratory	12” Timber Piles	12” Timber Pile Vibratory Removal	12” Timber Pile Vibratory Removal

*Pier removal will overlap with work days in July to December 2020, but is kept separate as it is located north of the Project Area. Based on the rules from Table 6, vibratory pile removal would not add to total sound source levels when combined with other stimuluous because the sound source levels are low, respectively.

Level A Isopleth Calculations

Using the sound source levels from Tables 4 and 5 and the rules for combining sound source levels in Table 6, the Level A isopleth thresholds were calculated for example work days as

described in Table 7. For an example maximum exposure day in June, it is possible for 14"x89' steel H-piles to be driven simultaneously with a vibratory hammer while a 48" steel pipe is driven with an impact hammer. Following the rules in Table 6, the isopleth would be calculated for Level A by using the sound source level for the 48" steel pipe during impact hammering. The California Environmental Quality Act (CEQA) review mitigation and monitoring plan requires a bubble curtain to be implemented on a maximum exposure day during operation of an impact hammer if sound pressures exceeded 160 db at 500 meters from the source or avoidance behavior by marine mammals or fish was observed by the on-site biologist (City, 2011). As bubble curtains will not be used at all times, predicted sound source levels without the use of a bubble curtain (Table 7) were used for calculating Level A isopleths. These steps were repeated for the remaining example maximum exposure and average exposure work days. Level A isolpeths were calculated using the NMFS Technical Guidance User Spreadsheet; Inputs for the Technical Guidance User Spreadsheet are detailed below in Table 8. Resultant Level A Isopleths are listed in Table 9 and Figure 3.

Table 8. NMFS Technical Guidance User Spreadsheet Input to Calculate Level A Isopleths for a Combination of Pile Driving

	Maximum Exposure Day		**Average Exposure Day**		
	June	**July-January**	**June**	**July-January**	
Loudest Pile Type	**48" Steel Pipe Impact**	**24" Octagonal Concrete Impact**	**48" Steel Pipe & 36" Steel Simultaneous Vibratory**	**14X48" Concrete Sheet Pile Impact**	**Vibratory Removal of 12" Timber Pile**
Source Level (RMS SPL)	190	170	173	156	150
Source Level (Peak)	210	189		167	
Weighting Factor Adjustment (kHz)	2	2	2.5	2	2.5
Number of Piles per day	2	4	2*	1	15
Strike Duration	0.1	0.1		0.1	
Number of Strikes per Pile/ Duration to drive a single pile	225	1000	45 minutes	600	5 minutes
Propagation (xLogR)	15	15	15	15	15
Distance of source level measurement (m)	10	10	10	33	15.8

*2 combined piling events, 4 piles total

Table 9. Level A Isopleths

Pile Driving Activity			Low-Frequency Cetaceans (distance in meters)	Mid-Frequency Cetaceans (distance in meters)	High-Frequency Cetaceans (distance in meters)	Phocid Pinnipeds (distance in meters)	Otariid Pinnipeds (distance in meters)
Maximum Exposure Day	**June**	48" steel pipe impact	797.2	28.4	949.5	426.6	31.1
	July - January	24" Octagonal Concrete Impact	73.7	2.6	87.8	39.4	2.9
Average Exposure Day	**June**	48" steel and 36" steel simultaneous vibratory	56.5	5.0	83.5	34.3	2.4
	July - January	14"48" concrete sheet pile impact	8.0	0.3	9.5	4.3	0.3
	Vibratory Removal of 12" Timber pile		2.3	0.2	3.4	1.4	0.1

Level B Isopleth Calculations

To calculate Level B isopleths, the practical spreading model (TL=B*Log10 [R1/R2]) was used. On an average maximum exposure day from July to January, up two 14X89' steel H-piles may be driven by vibratory hammer and one 24" concrete sheetpile by impact hammer simultaneously. Using the rules in Table 6, the combined sound source level for two 14X89' steel H-piles would be used to calculate the Level B isopleth. The combined sound source level is determined by adding 3 dB to the sound source level of a single 14X89' steel H-pile during vibratory driving, which equals 153. These steps were repeated for the remaining example maximum exposure and average exposure work days. Inputs for the practical spreading model are detailed below in Table 10.

Table 10. Inputs for Practical Spreading Model to Calculate Level B Isopleths

	Maximum exposure Day		Average exposure Day		
	June	**July-January**	**June**	**July-January**	**Vibratory Removal of 12" Timber Pile**
Loudest Pile Type	**2 vibratory 14X89' steel H-pile**	**2 vibratory 14X89' steel H-pile**	**2 vibratory (48" and 38") steel pipes**	**2 vibratory 14X89' steel H-pile**	
Source Level (RMS SPL)	153	153	173	153	150
TL	-33	-33	-53	-33	-30

B	15	15	15	15	15
R1	10	10	10	10	10
R2 (Resultant Level B Isolpleth) meter	**1585**	**1585**	**34,164**	**1585**	**1000**

ESTIMATION OF TAKE

Take estimates for each species were determined based on the calculated Level B and Level A isopleths and observational data of marine mammal distribution in the vicinity of the Project Area. From August 29 to October 21, 2019, marine mammals observed in the vicinity of the Project Area during pile driving were documented. However, because the 2019 monitoring did not cover the range of the Project dates projected for 2020, density data was referenced from the San Francisco-Oakland Bay Bridge Project (SFOBB; CalTrans 2015).

Effects of the project on marine mammals are anticipated to be short-term disturbances or temporary displacement. Mitigation measures described in Section 11 will further minimize impacts to marine mammals and include the use of a bubble curtain during impact driving, work windows, marine mammal monitoring during pile driving, and soft start techniques. Bubble curtain use will reduce sound during impact hammer steel pile installation if sound pressures outside the immediate project area exceed 160 dB at 500 meters from the source or avoidance behavior by marine mammals or fish is observed by the on-site marine biologist (City, 2011). At all times, a default, minimum 33-foot (10 meter) exclusion zone will apply to all pile driving activities. A 328-foot (100 meter) shutdown zone will be established for pile driving activities with Level A thresholds larger than 33 feet (Figure 3). Marine mammals may enter Level A isopleths outside of the shutdown zone, or may enter Level A isopleths without being detected, Level A take is being requested for species with higher potential to occur in the Project Area (harbor seal, California sea lion, harbor porpoise). Take estimates for each species are detailed below.

Table 11. Level B Take Estimates

		Harbor Seal	Sea Lion	Harbor Porpoise	Bottlenose Dolphin	Elephant Seal	Gray Whale	Fur Seal
SFOBB Species density (animals/ square kilometer)		3.96	0.16	0.17	NA	NA	NA	NA
Days of Pile Driving	**2 vibratory 14X89' steel H-pile / 1585 m isopleth**	169	169	169	169	169	169	169
	2 vibratory (48" and 38") steel pipes / 34,164 m isopleth	20	20	20	20	20	20	20
Area of Isopleth in square kilometers	**2 vibratory 14X89' steel H-pile / 1585 m isopleth**	3.42	3.42	3.42	3.42	3.42	3.42	3.42
	2 vibratory (48" and 38") steel pipes / 34,164 m isopleth	129	129	129	129	129	129	129
Per day take Level B	**2 vibratory 14X89' steel H-pile / 1585 m isopleth**	13.5	0.5	0.6	NA	NA	NA	NA
	2 vibratory (48" and 38") steel pipes / 34,164 m isopleth	510.8	20.6	21.9	NA	NA	NA	NA
Total Level B Take Calculated		12,506	505	537	NA	NA	NA	NA
Total Level B Take Requested		500 per day	505	537	63	10	10	5

Requested Level B Take for Harbor Seal, Sea Lion, and Harbor Porpoise

Requested take numbers for harbor seal, sea lion, and harbor porpoise was calculated using species-appropriate density in Table 11, using the take per day based on 169 days of pile driving with a 1585 m isopleth, and 20 days of pile driving with a 34,164 m isopleth (189 total days of pile driving).

Requested Level B Take for Bottlenose Dolphin, Elephant Seal, Gray Whale, and Fur Seal

Take numbers for species rarely observed in San Francisco Bay are requested based on the paucity of published literature and the observations and experience of organizations like the Marine Mammal Center. More detail is provided below.

Pacific Harbor Seal

Marine mammal monitors observed a total of 324 Pacific harbor seals over the course of 264 monitoring hours during Project activities within the 1000 foot Project Area exclusion zone (6.12 mammals per square kilometer per hour). Data from the recent nearby SFOBB project showed 372 observations of this species over 47 days of monitoring in 2017 (CalTrans 2018), or an average of 8 per day. The SFOBB project animal density monitoring covered a larger area and date range and as such was used to calculate take estimates for the Project. As detailed in Table 11, it is estimated that 12,506 harbor seals will enter the Level B isopleths during pile driving activities through the duration of the Project.

The applicant requests Level B take of the entire San Francisco Bay estimated population of 500 harbor seals *per day*, based on San Francisco Bay population numbers of 500-600 individuals (NPS, 2016).

It is estimated that approximately nine harbor seals may enter the Level A isopleth during the Project (Table 12). While a monitor will be present and stop work if individuals enter the Level A shutdown zones, there is potential that underwater mammals may go undetected in the shutdown zones, and may enter the Level A Isopleths during estimated seven days of 48-inch steel pile impact pile driving.

2019 marine mammal monitoring observed Pacific harbor seals at a rate of 6.12 mammals per square kilometer per hour. Using the largest Table 12 isopleth of 0.27 km, and seven 10-hour work days:

6.12 seals per square km/hour X 0.27 km X 70 hours = 116 Pacific harbor seals

The applicant requests Level A harassment take of 116 harbor seals.

Table 12. Estimated Level A Take for harbor seal

	June	July-January	June	July-January	Vibratory Removal of 12" Timber Pile
	48" Steel Pipe Impact	24" Octagonal Concrete Impact	48" Steel Pipe & 36" Steel Simultaneous Vibratory	14X48" Concrete Sheet Pile Impact	
Isopleth (m)	426.6	39.4	34.3	1.3	1.4
Isopleth area (km^2)	0.27	0.004876883	0.003696052	5.30929E-06	6.15752E-06
density	3.96	3.96	3.96	3.96	3.96
calculated take per day	1.0692	0.019312456	0.014636367	2.10248E-05	2.43838E-05
number of work days	7	50	20	112	14
total calculated take per pile type	7.4844	0.965622789	0.292727345	0.002354777	0.000341373
total calculated take	8.7				
total requested take	116				

California Sea Lion

Marine mammal monitors observed a total of five California sea lions over the course of 264 monitoring hours within the 1000 foot Project Area exclusion zone. Based on these observations, there was an average of 0.019 sea lions present within the established 1000-foot exclusion zone per monitoring hour. Data from the recent nearby SFOBB project showed 83 observations of this species over 257 days of monitoring between 2000 and 2017 (CalTrans 2018). The SFOBB project animal density monitoring covered a larger area and date range and as such was used to calculate take estimates. As detailed in Table 11, it is estimated that 505 California sea lions will enter the Level B isopleths during pile driving activities through the duration of the Project. The applicant requests the Level B take of 505 California sea lion.

It is estimated that less than one California sea lion may enter the Level A isopleth during the Project (Table 13). While a monitor will be present and stop work if individuals enter the Level A shutdown zones, there is potential that underwater mammals may go undetected in the shutdown zones, and may enter the Level A Isopleths during estimated seven days of 48-inch steel pile impact pile driving.

Given that 2019 observations recorded five sea lions over 264 hours, or 0.019 per hour, we request take equivalent to this rate (0.019 per hour) over the entire project time period of 189 days (1890 hours). The level A isopleth for this species is 31 meters, which covers a smaller area than what was monitored in 2019. As such, the applicant requests Level A take of fifteen (15) California sea lion.

Table 13. Estimated Level A Take for California sea lion

	June	July-January	June	July-January	Vibratory Removal of 12" Timber Pile
	48" Steel Pipe Impact	24" Octagonal Concrete Impact	48" Steel Pipe & 36" Steel Simultaneous Vibratory	14X48" Concrete Sheet Pile Impact	
Isopleth (m)	31.1	2.9	2.4	0.1	0.1
Isopleth area (km^2)	0.00303858	2.64208E-05	1.80956E-05	3.14159E-08	3.14159E-08
density	0.16	0.16	0.16	0.16	0.16
calculated take per day	0.000486173	4.22733E-06	2.89529E-06	5.02655E-09	5.02655E-09
number of work days	7	50	20	112	14
total calculated take per pile type	0.003403209	0.000211366	5.79058E-05	5.62973E-07	7.03717E-08
total calculated take	0.004				
total requested take	15				

Harbor Porpoise

Marine mammal monitors observed a total of two harbor porpoises over the course of 264 monitoring hours within the 1000 foot Project Area exclusion zone. Based on these observations, there was an average of 0.008 harbor porpoises present within the established 1000 foot exclusion zone per monitoring hour. Data from the recent nearby SFOBB project showed 15 observations of this species over 6 days of monitoring in 2017 (CalTrans 2018). The SFOBB project animal density monitoring covered a larger area and date range and as such was used to calculate take estimates. It is estimated that 537 harbor porpoises will enter the Level B isopleths during pile driving activities through the duration of the Project as detailed in Table 11.

The applicant requests the Level B take of 537 harbor porpoise.

It is estimated that less than one harbor porpoise may enter the Level A isopleth during the Project (Table 14). While a monitor will be present and stop work if individuals enter the Level A shutdown zones, there is potential that underwater mammals may go undetected in the shutdown zones, and may enter the Level A Isopleths during estimated seven days of 48-inch steel pile impact pile driving.

Harbor porpoise travel in groups up to 10 individuals. Given that 2019 observations recorded two porpoise over 264 hours, or 0.008 per hour, we request take equivalent to this rate (0.008 per hour) over the entire project period of 189 days (1890 hours). As such, the applicant requests Level A take of fifteen (15) harbor porpoise.

Table 14. Estimated Level A Take for harbor porpoise

	June	July-January	June	July-January	Vibratory Removal of 12" Timber Pile
	48" Steel Pipe Impact	24" Octagonal Concrete Impact	48" Steel Pipe & 36" Steel Simultaneous Vibratory	14X48" Concrete Sheet Pile Impact	
Isopleth (m)	949.5	87.7	83.5	2.9	3.4
Isopleth area (km^2)	1.19	0.0241629	0.021903969	2.64208E-05	3.63168E-05
density	0.17	0.17	0.17	0.17	0.17
calculated take per day	0.2023	0.004107693	0.003723675	4.49154E-06	6.17386E-06
number of work days	7	50	20	112	14
total calculated take per pile type	1.4161	0.205384651	0.074473496	0.000503052	8.6434E-05
total calculated take	1.7				
total requested take	15				

Common bottlenose dolphin

Marine mammal monitors did not observe any common bottlenose dolphins over the course of 264 monitoring hours within the 1000 foot Project Area exclusion zone. Data from the recent nearby SFOBB project showed two observations of this species over 6 days of monitoring in 2017 (CalTrans 2018). One dolphin is sighted with regularity near Alameda since 2016 (GGCR, 2016). Based on the regularity of the sighting in Alameda and the SFOBB observations of approximately 0.33 dolphin a day, the applicant requests the Level B take equivalent to 0.33 dolphin per day for the proposed days of the Project (189 days), or sixty-three (63) common bottlenose dolphin.

Northern elephant seal

Marine mammal monitors did not observe any northern elephant seals over the course of 264 monitoring hours within the 1000 foot Project Area exclusion zone. Data from the recent nearby SFOBB project showed zero observations of this species over 257 days of monitoring between 2000 and 2017 (CalTrans 2018).

Out of the approximate 100 yearly juvenile northern elephant seal strandings in San Francisco Bay, approximately ten individuals are stranded at Yerba Buena Island and Treasure Island each year (TMMC, 2020). Therefore, the applicant requests the Level B take of ten northern elephant seals.

Gray whale

Marine mammal monitors did not observe any gray whales over the course of 264 monitoring hours within the 1000 foot Project Area exclusion zone. Data from the recent nearby SFOBB project showed zero observations of this species over 257 days of monitoring between 2000 and 2017 (CalTrans 2018).

Approximately 12 gray whales were stranded in San Francisco Bay from January to May of 2019 (TMMC, 2019). NOAA has declared this an ongoing Unusual Mortality Event due to strandings

along the west coast and Alaska. (NOAA, 2020). Because recent observations are not well understood, and as a conservative measure, the applicant requests Level B take of 10 gray whales.

Northern fur seal

Marine mammal monitors did not observe any northern fur seals over the course of 264 monitoring hours within the 1000 foot Project Area exclusion zone. Data from the recent nearby SFOBB project showed zero observations of this species over 257 days of monitoring between 2000 and 2017 (CalTrans 2018).

The Marine Mammal Center rescues about 5 northern fur seals in a year, and they occasionally rescue them from Yerba Buena Island and Treasure Island (TMMC, 2019). Based on the average Marine Mammal Center observed strandings, the applicant requests level B take of 5 northern fur seals.

SECTION 7: ANTICIPATED IMPACT OF THE ACTIVITY

The anticipated impact of the activity to the species or stock of marine mammal.

Project construction at Treasure Island may temporarily impact marine mammal species through temporary avoidance and disruption of foraging behavior as a result of pile driving, but no long term impacts to the species or stock are expected to occur as a result of the project. The underwater noise produced by the proposed project has potential to harass marine mammals as described in Section 6, however the estimated level of take by this harassment is low as compared to the overall marine mammal stocks as described above.

The species of marine mammals described in this document are generally considered solitary foragers. However, the underwater communication these species conduct has the potential to be disrupted during pile-driving, and this could lead to adverse impacts to individuals. The majority of pinniped communication happens in low-frequency signals, while harbor porpoises typically communicate between 200 Hz and 180 kilohertz. The highly industrialized nature of San Francisco Bay, including ship traffic, and other anthropogenic noise would effectively mask any construction sounds coming from the work at Treasure Island. This would decrease the potential behavioral impacts that project work would have on resident marine mammals.

The Project involves vibratory and impact pile-driving, both of which are likely to result in short term temporary changes to the typical behavior of marine mammals, including potential avoidance of the Project Area. Marine mammals may exhibit behavior that indicates they are startled by noise, and they may swim away from the Project Area. This may result in increased swimming by marine mammals, increased time spent out of water, including haul out time and surface time, which may result in a temporary decrease in their foraging in the affected area. This avoidance would be short term in duration, and upon conclusion of pile driving, it is anticipated that marine mammal activity would return to baseline levels. Since any pile driving would occur for only a few hours per day, it is unlikely that project work would result in a permanent displacement of marine mammals from the area. No population-level impacts are anticipated to the species within San Francisco Bay, nor are any population-level impacts anticipated to the long-term fitness of any of the marine mammal species covered in this application.

SECTION 8: ANTICIPATED IMPACTS ON SUBSISTENCE USES

The anticipated impact of the activity upon the habitat of the marine mammal populations and the likelihood of restoration of the affected habitat.

Marine mammals in San Francisco Bay are not harvested for subsistence use. Therefore no impact would occur to subsistence uses.

SECTION 9: ANTICIPATED IMPACTS ON HABITAT

The anticipated impact of the activity upon the habitat of the marine mammal populations, and the likelihood of restoration of the affected habitat.

No permanent impacts are expected to marine mammals or their habitat. Any impacts will be temporary in nature and are associated with pile driving and construction noise disturbance and would not require restoration. Site conditions are anticipated to be substantively unchanged from existing conditions for marine mammals following project implementation. Additionally, the Project will not represent a significant barrier to movement for marine mammals within the Project Area.

Impacts to marine mammals could include a temporary loss of foraging habitat if marine mammals avoided the Project Area during pile driving activities, or if work impacted marine mammal foraging habitat within the Project Area. Both harbor seals and California sea lions have the highest potential to be transiting the Project Area while feeding on a variety of prey items. Occasional foraging activity by both species has been observed adjacent to the Project Area in 2019. Observations were made by the Project's onsite marine mammal observer starting in August, 2019. There is no observation data at this location prior to project start. During the winter months, primarily December and February, Pacific herring spawning activity, should it occur within the Project Area, could potentially increase pinniped feeding activity. Project work that will take place between June 1st and November 30th will avoid the herring spawning period. However, the work that extends past November 30th will include measures as outlined in Section 11 to avoid impacts to Pacific herring.

CDFW regulates activities in San Francisco Bay with the potential to affect Pacific herring (*Clupea pallasi*) breeding, and special work windows have been established to avoid potential impacts to Pacific herring spawning activities. To protect for Pacific herring, in-water work is not permitted by CDFW between December 1 and February 28 in a given year without first completing surveys to ensure that no herring spawning activity is occurring. Specifically, a biological monitor trained by CFDW to monitor Pacific herring will be present on site during pile installation conducted between December 1 and February 28. If a herring spawning event is observed, work will cease for a period of two weeks following the spawning event. The area will be surveyed by the biological monitor prior to resumption of work to ensure that further work will not impact spawning or newly hatched Herring in addition to marine mammals. This measure is anticipated to avoid impacts to marine mammal prey species within the Project Area.

Any increase in turbidity from the Project is expected to be short term, localized, and lower than thresholds typically associated with impacts to fish species. Turbidity produced from pile driving or removal are generally below those levels that have adverse effects on fish (Burton 1993; Wilver and Clarke 2001). Turbidity produced from Project activities is expected to disperse quickly with tidal action.

The acoustic energy produced from pile driving has the potential to disturb fish present within the Project Area, and as a result, could potentially reduce the amount of available foraging habitat for pinnipeds. This reduction in forage area will be temporary, and any disturbed fish are anticipated to return to the area upon the completion of pile driving. The area of foraging habitat that could be temporarily impacted from pile driving represents an extremely small portion of available pinniped foraging habitat within the San Francisco Bay. Sound levels measured by onsite monitors during impact hammer driving of 4' concrete sheet piles in 2019 measured no SEL levels over ambient levels at 515m from the source, and no SEL levels over 150dB were measured at 33m from the source during impact driving (Illingworth and Rodkin, Inc., personal communication, November 1, 2019).

High noise levels cause by pile driving activities may exclude fish from the vicinity of the project. Fish will typically move to avoid damaging sound levels (Hastings and Popper 2005). While foraging fish may be temporarily excluded from the vicinity, this represents a small percentage of the foraging habitat available to marine mammals that may be within the Project Area.

SECTION 10: ANTICIPATED EFFECTS OF HABITAT IMPACTS ON MARINE MAMMALS

The anticipated impact of the loss or modification of the habitat on the marine mammal populations involved.

The Project is not anticipated to have any significant or long-term effects on marine mammal habitat. The project will temporarily increase noise levels in the area. The Project Area is approximately 14 acres and constitutes a negligible percentage of each species' home range. Once pile driving ceases, functionality of habitat within the Project Area is not anticipated to be altered. The Project will result in 0.15 acres of permanent fill, and will not have a measurable effect on habitat.

There is a known haul out location at Yerba Buena Island on the southern shoreline (Figure 2). The Project location is separated from the haul out by approximately 0.85 miles of shoreline. Because Yerba Buena Island extends out further west than Treasure Island, the haul out is not within line of site of the Project. The haul out is not known to support pupping. The Project will not alter the condition of haul out or pupping habitat.

SECTION 11: MITIGATION MEASURES TO PROTECT MARINE MAMMALS AND THEIR HABITAT

The availability and feasibility (economic and technological) of equipment, methods, and manner of conducting such activity or other means of effecting the least practicable adverse impact upon the affected species or stocks, their habitat, and their availability for subsistence uses, paying particular attention to rookeries, mating grounds, and areas of similar significance.

The project is anticipated to result in Level A harassment and Level B harassment of marine mammals. All pile driving activities will adhere to a minimum 33-foot exclusion buffer (to be in place for all in-water work activities). The majority of Level A thresholds calculated for Project activities fall within the 33-foot exclusion zone (Figure 3, Table 7).

A 328-foot (100 meter) shutdown zone will be established for pile driving activities with Level A thresholds larger than 33 feet (Figure 3). A marine mammal monitor will stop work if marine mammals enter the shutdown zone. Pile driving will be accomplished using vibratory and impact hammers. Level B harassment would be temporary in duration, and is not expected to result in any long-term effects to marine mammal stocks or habitat in the region. The following measures will be implemented to minimize Project impacts to marine mammals.

General

- Construction activities will be limited to daylight hours (7:00 AM to 8:00 PM), when marine mammals can be more easily observed;
- Steel piles will be installed, including the final seating with impact hammer, during the work window between June 1 and November 30.
- All refueling and maintenance activities will occur at a dedicated area that is equipped with containment improvements and readily available spill control equipment and products. Overtopping construction equipment fuel gas tanks will be avoided;
- Equipment inspection will be performed daily to check for possible leaks;
- Fresh cement or concrete will only be allowed to enter San Francisco Bay after completely cured (a minimum of 28 days) or once treated with a non-reactive sealant;
- During routine maintenance of construction equipment, properly contain and remove grease and oils; and properly dispose of discarded containers of fuels and other chemicals;
- All construction debris must be removed from the project site. If any construction material escapes or is placed in an area subject to tidal action of the Bay, it must immediately be retrieved and removed;
- The project's Environmental Protection Plan (EPP) further addresses hazardous material management, contaminant prevention, spill control and response, air pollution control and noise pollution control and includes relevant environmental protective measures. The EPP will be available on site during construction activities.

Monitoring

- A NMFS approved marine mammal monitor will be present during all pile driving activities.
- Marine mammal monitoring should begin 30 minutes before pile driving starts, and end 30 minutes after pile driving has ceased for the day. The marine mammal monitor shall have no other assigned tasks during monitoring periods;
- The monitor will make observations (with binoculars and the naked eye) of marine mammals within 1500 meters of the pile driving area, including species identification, behavior, and response to pile driving;
- At all times, a default, minimum 33-foot (10 meter) shutdown zone will apply to all pile driving activities and in-water construction, heavy machinery activities other than pile driving. A 328-foot (100 meter) shutdown zone will be established for pile driving activities with Level A thresholds larger than 33 feet (Figure 3). If a marine mammal is observed within the shutdown zone, or appears likely to enter the zone based on its movement trajectory, the Applicant must cease operations and reduce vessel speed to the minimum level required to maintain steerage and safe working conditions. Relevant work will halt until either the animal has voluntarily left and been visually confirmed beyond the shutdown zone; 15 minutes have passed without subsequent detections of small cetaceans and pinnipeds; or 30 minutes have passed without subsequent detections of large cetaceans.

- If a marine mammal is entering or is observed within an established shutdown zone, pile driving must be halted or delayed. Pile driving may not commence or resume until either the animal has voluntarily left and been visually confirmed beyond the shutdown zone; 15 minutes have passed without subsequent detections of small cetaceans and pinnipeds; or 30 minutes have passed without subsequent detections of large cetaceans.
- If any northern elephant seal, grey whale, or humpback whale are observed within a mile of the pile driving activity, all pile driving will cease until the animal has left the area.
- On-site biologists will keep a daily log that outlines when marine mammals were observed within a relevant zone, the location of the animal, and when the observation event was resolved (i.e., the animal was observed outside of the relevant zone or was not observed for 15 continuous minutes);
- Pinniped presence during herring runs can be sporadic and unpredictable. A biological monitor will be present on site during pile installation conducted between December 1 and February 28[2]. If a Herring spawning event is observed, work will cease for a period of 21 days following the spawning event. The area will be surveyed by the biological monitor prior to resumption of work to ensure that further work will not impact spawning or newly hatched herring in addition to marine mammals;

Vibratory Hammer

- A soft-start technique will be required at the beginning of each day's in-water vibratory pile installation or removal activities, and also when pile driving activities have ceased for 1 hour (60 minutes) or longer. The soft-start requires contractors to initiate noise from a vibratory driver for 15 seconds at reduced energy followed by a 1-minute waiting period. The procedure will be repeated two additional times, before full energy is employed;
- Vibratory hammer will be used for all steel piles. Steel piles will be driven with a vibratory hammer until refusal or design tip elevation is reached.
- The pile driving will halt whenever a marine mammal enters the Level A 33-foot (10 meter) shutdown zone or 328-foot (100 meter) shutdown zone for Level A thresholds larger than 33 feet (Figure 3).
- The halt will remain in place until 15 minutes have passed without subsequent detections of small cetaceans and pinnipeds; or 30 minutes have passed without subsequent detections of large cetaceans.

Impact Hammer

- Attenuation devices with be used during impact hammering of steel piles. Cushion blocks will be placed between the hammer and the pile. A bubble curtain will either be used if sound pressures outside the immediate project area exceed 160 dB at 500 meters from the source or avoidance behavior by marine mammals or fish is observed by the on-site biologist.;
- If hydroacoustic monitoring observes that a sound threshold of 160 dB RMS is exceeded at a distance of 500 meters, a bubble curtain shall be used to attenuate pile driving sound;
- A soft start shall be implemented at the start of driving, or after driving resumes after having ceased for at least 30 minutes, to allow animals within the area a chance to leave before full energy is reached. (A soft start consists of an initial set of reduced energy strikes, a 30 second waiting period for marine life to clear the area, followed by 2 more reduced energy strikes);

[2] Peak spawning activity has historically been December through February (Conner et al.).

- No more than 450 strikes to steel pipe piles with an impact hammer will be utilized per day;
- An impact hammer will only be used as a last resort for steel pipe pile driving only (rather than for pile extraction);
- The pile driving will halt whenever a marine mammal enters the Level A 33-foot (10 meter) shutdown zone or 328-foot (100 meter) shutdown zone for Level A thresholds larger than 33 feet (Figure 3).
- The halt will remain in place until 15 minutes have passed without subsequent detections of small cetaceans and pinnipeds; or 30 minutes have passed without subsequent detections of large cetaceans.

SECTION 12: MITIGATION MEASURES TO PROTECT SUBSISTENCE USES

Where the proposed activity would take place in or near a traditional Arctic subsistence hunting area and/or may affect the availability of a species or stock of marine mammal for Arctic subsistence uses, you must submit either a plan of cooperation (POC) or information that identifies what measures have been taken and/or will be taken to minimize any adverse effects on the availability of marine mammals for subsistence uses.

Not applicable. Activity will not take place in or near a traditional Arctic subsistence hunting area.

SECTION 13: MONITORING AND REPORTING

The suggested means of accomplishing the necessary monitoring and reporting that will result in increased knowledge of the species, the level of taking or impacts on populations of marine mammals that are expected to be present while conducting activities and suggested means of minimizing burdens by coordinating such reporting requirements with other schemes already applicable to persons conducting such activity. Monitoring plans should include a description of the survey techniques that would be used to determine the movement and activity of marine mammals near the activity site(s) including migration and other habitat uses, such as feeding.

Marine Mammal Monitoring

As detailed in Section 11, a marine mammal monitor will be on-site during pile driving activities to search for marine mammals within the vicinity of the Project Area, from 30 minutes prior to pile driving start to 30 minutes after pile driving has ceased.

The marine mammal monitor will observe pile driving from the Treasure Island shoreline adjacent to the Project work, generally west and south of Building 1 and seaward of Avenue of the Palms.

A second marine mammal monitor may be used during the estimated 20 days of 48” steel and 36” steel pipe pile simultaneous vibratory driving, to monitor the calculated Level B isopleth area (34,164 square meter area). The second marine mammal monitor would be stationed in San Francisco around Pier 33.

The marine mammal monitor will keep a daily log that outlines when marine mammals were observed within a relevant zone, the location of the animal, the behavior of the animal, and when

the observation event was resolved (i.e., the animal was observed outside of the relevant zone or was not observed for 30 continuous minutes).

Marine Mammal Report

The marine mammal report must contain the informational elements described here including, but not limited to:

- Dates and times (begin and end) of all marine mammal monitoring.
- Construction activities occurring during each daily observation period, including how many and what type of piles were driven or removed and by what method (i.e., impact or vibratory).
- Weather parameters and water conditions during each monitoring period (e.g., wind speed, percent cover, visibility, sea state).
- The number of marine mammals observed, by species, relative to the pile location and if pile driving or removal was occurring at time of sighting.
- Age and sex class, if possible, of all marine mammals observed.
- Marine mammal monitor locations during marine mammal monitoring.
- Distances and bearings of each marine mammal observed to the pile being driven or removed for each sighting (if pile driving or removal was occurring at time of sighting).
- Description of any marine mammal behavior patterns during observation, including direction of travel and estimated time spent within the Level A and Level B harassment zones while the source was active.
- Number of individuals of each species (differentiated by month as appropriate) detected within the monitoring zone, and estimates of number of marine mammals taken, by species (a correction factor may be applied to total take numbers, as appropriate).
- Detailed information about any implementation of any mitigation triggered (e.g., shutdowns and delays), a description of specific actions that ensued, and resulting behavior of the animal, if any.
- Description of attempts to distinguish between the number of individual animals taken and the number of incidences of take, such as ability to track groups or individuals.
- An extrapolation of the estimated takes by Level B harassment based on the number of observed exposures within the Level B harassment zone and the percentage of the Level B harassment zone that was not visible.
- Submit all Marine mammal monitor datasheets and/or raw sighting data (in a separate file from the Final Report)

Hydroacoustic Monitoring

Hydroacoustic monitoring will be performed for the driving of a minimum of two piles of each type (48” steel piles, 36” steel piles, 14”x89’ steel H piles, 24” octagonal concrete piles, and 14x48” concrete sheetpiles) to verify 160 dB RMS is not exceeded at a distance of 500 meters, and to calculate transmission loss.

Hydroacoustic Report

A final report to substantiate compliance will be prepared after completion of Hydroacoustic monitoring. The acoustic monitoring report must, at minimum, include the following:

- Hydrophone equipment and methods: recording device, sampling rate, distance (m) from the pile where recordings were made; depth of recording device(s).
- Type of pile being driven, substrate type, method of driving during recordings, and if a sound attenuation device is used.
- For impact pile driving and/or DTH drilling: Pulse duration and mean, median, and maximum sound levels (dB re: 1µPa): cumulative sound exposure level (SELcum), peak sound pressure level (SPLpeak), , and single-strike sound exposure level (SELs-s).
- For vibratory driving/removal: Mean, median, and maximum sound levels (dB re: 1µPa): root mean square sound pressure level (SPLrms), cumulative sound exposure level (SELcum).
- Number of strikes (impact) or duration (vibratory) per pile measured, one-third octave band spectrum and power spectral density plot.

SECTION 14: SUGGESTED MEANS OF COORDINATION

Suggested means of learning of, encouraging, and coordinating research opportunities, plans, and activities relating to reducing such incidental taking and evaluating its effects.

All marine mammal data gathered during construction will be made available to NMFS, researchers and other interested parties as specified in Section 11 and 13 above. The Project will coordinate activities as needed with relevant federal and state agencies (i.e. NMFS, CDFW).

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ATTACHMENT 1

Figures

Figure 1. Project Vicinity

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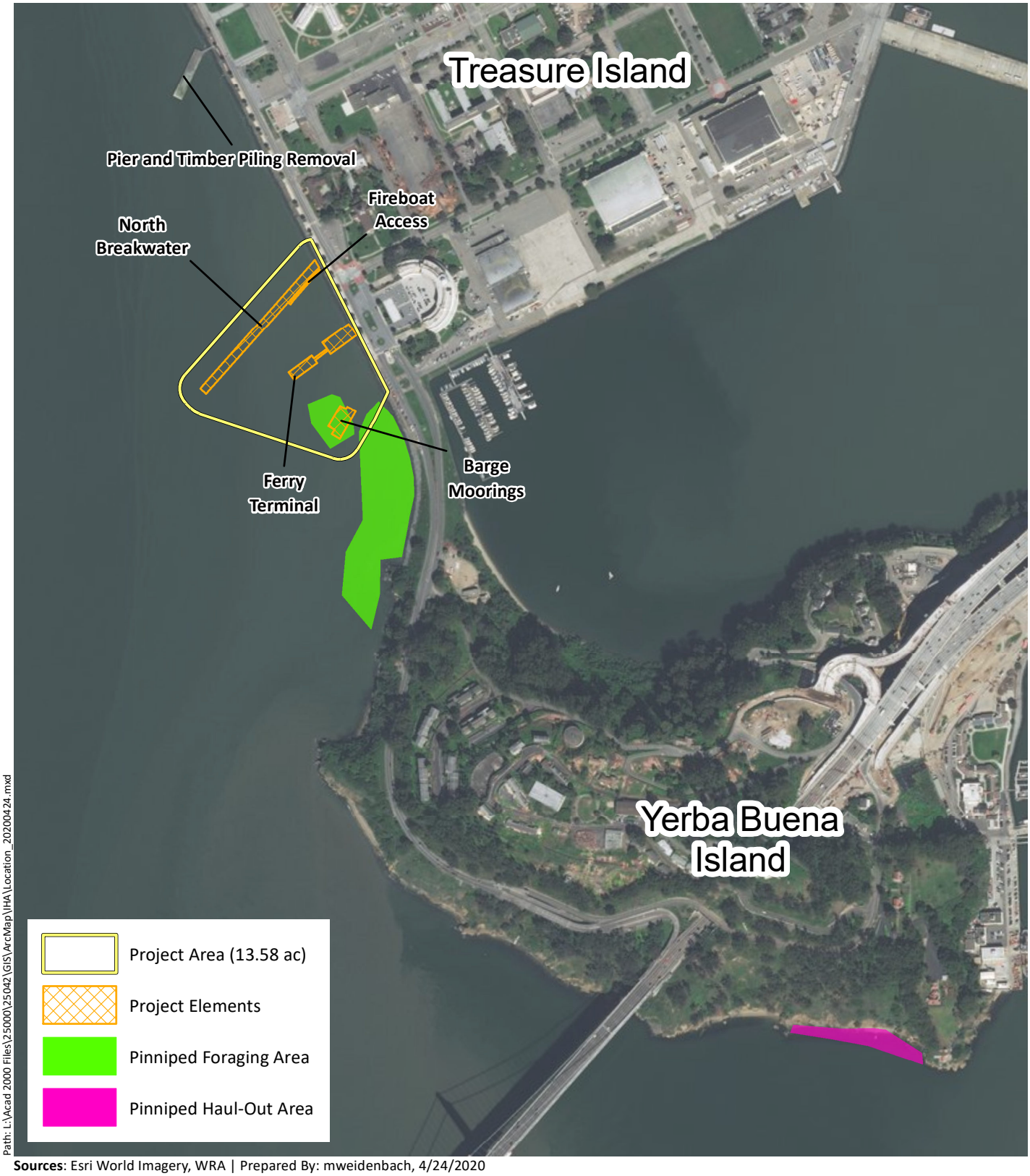
Treasure Island Yerba Buena Island Redevelopment Project
San Francisco County, California

Map Prepared Date: 3/23/2015
Map Prepared By: pkobylarz
Base Source: Esri, National Geographic
Data Source(s): WRA

Path: L:\Acad 2000 Files\25000\25042\GIS\ArcMap\Figure 1 Location.mxd



Sources: Esri World Imagery, WRA | Prepared By: mweidenbach, 4/24/2020

Figure 2. Project Area Location

Treasure Island Yerba Buena Island Redevelopment Project
San Francisco County, California

0 100 200 Meters

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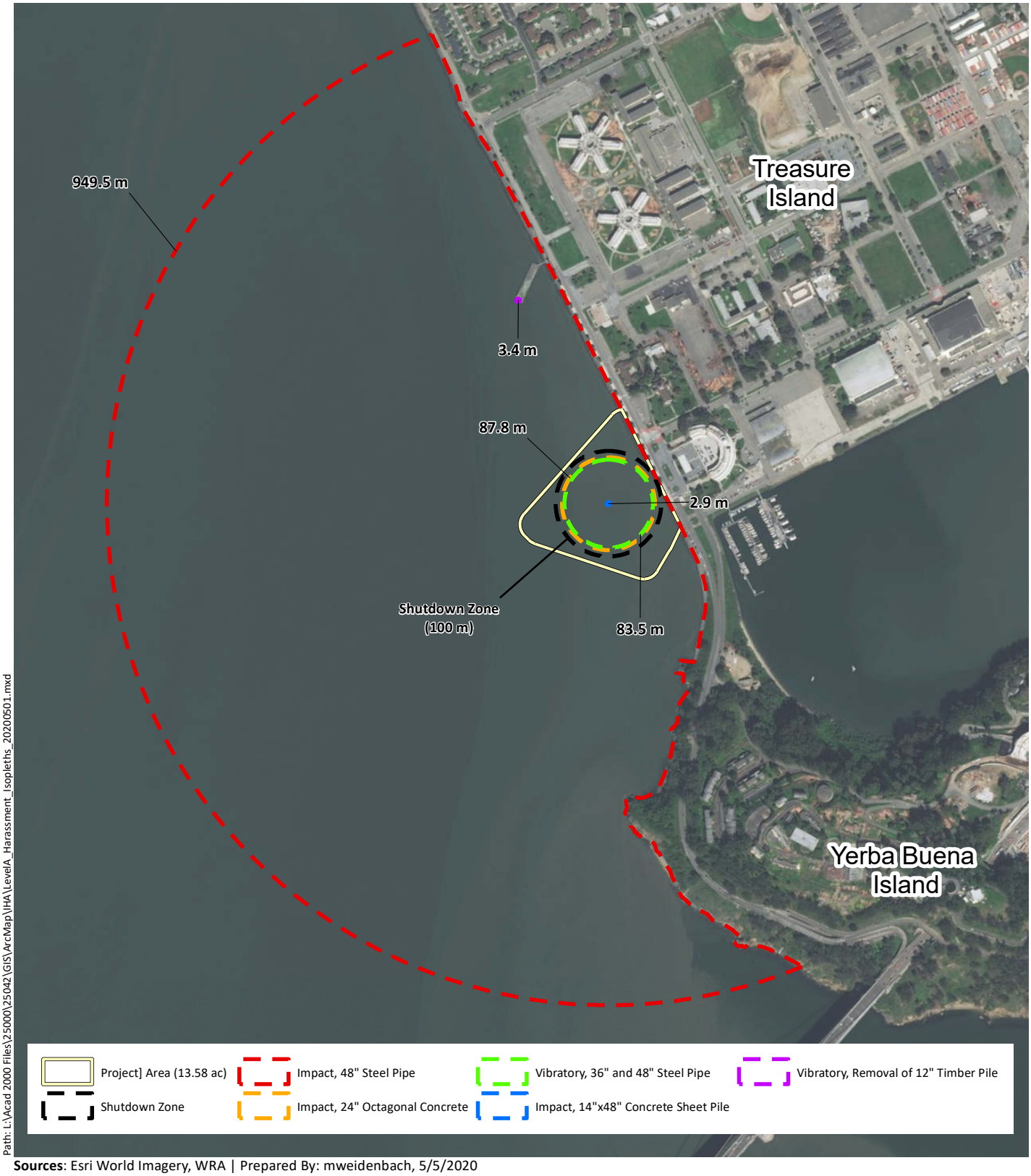
ENVIRONMENTAL CONSULTANTS



Path: L:\Acad 2000 Files\25000\25042\GIS\ArcMap\IHA\LevelA_Harassment_Isopleths_20200501.mxd

Sources: Esri World Imagery, WRA | Prepared By: mweidenbach, 5/5/2020

Figure 3. Level A Harassment Isopleths

Treasure Island Yerba Buena Island Redevelopment Project
San Francisco County, California

0 100 200 Meters

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ATTACHMENT 2

Photographs

Photograph 1. View of the Project Area facing northwest from the shoreline including a barge operating an impact hammer. View of dilapidated pier to the north in background.

Photograph 2. Placement of a 14” X 48” concrete sheetpile in the Project Area.

Photograph 3. Impact driving of a 14” X 48” concrete sheetpile in the Project Area.

ATTACHMENT 3

US Coast Guard Anchorage Area Correspondence

U.S. Department of Homeland Security
United States Coast Guard

Commander
Eleventh District

US Coast Guard Island
Bldg 50-2
Alameda, CA 94501-5100
Staff Symbol: dpw
Phone: (510) 437-5984
Fax: (510) 437-5836
Email: Colleen.M.Ryan@uscg.mil

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DEC 20 2016

U.S. Army Corps of Engineers
San Francisco District
Mr. Justin J. Yee, Project Manager
1455 Market Street, 16th Floor
San Francisco, CA 94103-1395

Dear Mr. Yee:

This letter is in response to the proposal to construct a ferry terminal and make improvements to outfalls along the shoreline of Treasure Island and Yerba Buena Island (permit request 2014-00373S). This request proposes to place 2 break waters on the north and south of the terminal located on the west side of Treasure Island near Anchorage Number 7 in the vicinity of Latitude 37.8221° N, Longitude -122.3698° W.

My staff conducted an evaluation of the proposed site(s). For our review of the proposed project, we conducted an initial risk assessment to determine potential navigational safety risks. We looked at six criteria to make our determination: location, vessel traffic activity, capabilities of the local maritime response community, anticipated environmental factors, severe weather events, and potential hydrological effects to the waterway.

Coast Guard Eleventh District has consulted with the San Francisco Bay Harbor Safety Committee about this public notice and was informed that there are no further concerns for this project. Coast Guard Eleventh District has determined that the proposed location of the breakwaters and terminal is within San Francisco Bay Anchorage No. 7, Treasure Island (33 CFR 110.224(e)(4)). The proposed terminal is located in shallow waters near Treasure Island and appears to be low risk to vessel traffic activity, Coast Guard Eleventh District will keep apprised of future vessel traffic and asses the need for any amendments to the anchorage boundaries and/or ferry schedules.

A review was completed with all criteria meeting the low risk category. As a result, the Coast Guard does not object to the project as proposed. If you have any questions concerning this matter please contact LTJG Colleen Ryan at (510) 437-5984 or Colleen.M.Ryan@uscg.mil.

Sincerely,

A. E. Wirts
Commander, U. S. Coast Guard
Chief, Waterways Management Branch
By direction

Copy: Commander, Coast Guard Sector San Francisco

ATTACHMENT 4

Technical Acoustic Guidance User Spreadsheet Tool output – Level A

A.1: Vibratory Pile Driving (STATIONARY SOURCE: Non-Impulsive, Continuous)

VERSION 2.0: 2018

KEY

	User Provided Information
	NMFS Provided Information (Technical Guidance)
	Resultant Isopleth

STEP 1: GENERAL PROJECT INFORMATION

PROJECT TITLE	TY/YBI
PROJECT/SOURCE INFORMATION	

Please include any assumptions

PROJECT CONTACT	

STEP 2: WEIGHTING FACTOR ADJUSTMENT

		Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value
Weighting Factor Adjustment (kHz)¥	2.5	

¥ Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab

† If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 48), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

*** BROADBAND Sources: Cannot use WFA higher than maximum applicable frequency (See GRAY tab for more information on WFA applicable frequencies)**

STEP 3: SOURCE-SPECIFIC INFORMATION

Source Level (RMS SPL)	173
Number of piles within 24-h period	2
Duration to drive a single pile (minutes)	45
Duration of Sound Production within 24-h period (seconds)	5400
10 Log (duration of sound production)	37.32
Propagation (xLogR)	15
Distance from source level measurement (meters)	10

Unless otherwise specified, source levels are referenced 1 m from the source.

NOTE: The User Spreadsheet tool provides a means to estimates distances associated with the Technical Guidance's PTS onset thresholds. Mitigation and monitoring requirements associated with a Marine Mammal Protection Act (MMPA) authorization or an Endangered Species Act (ESA) consultation or permit are independent management decisions made in the context of the proposed activity and comprehensive effects analysis, and are beyond the scope of the Technical Guidance and the User Spreadsheet tool.

RESULTANT ISOPLETHS

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	199	198	173	201	219
PTS Isopleth to threshold (meters)	**56.5**	**5.0**	**83.5**	**34.3**	**2.4**

WEIGHTING FUNCTION CALCULATIONS

Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
a	1	1.6	1.8	1	2
b	2	2	2	2	2
f_1	0.2	8.8	12	1.9	0.94
f_2	19	110	140	30	25
C	0.13	1.2	1.36	0.75	0.64
Adjustment (dB)†	**-0.05**	**-16.83**	**-23.50**	**-1.29**	**-0.60**

$$W(f) = C + 10\log_{10}\left\{\frac{(f/f_1)^{2a}}{[1+(f/f_1)^2]^a[1+(f/f_2)^2]^b}\right\}$$

E.1: IMPACT PILE DRIVING (STATIONARY SOURCE: Impulsive, Intermittent)

VERSION 2.0: 2018

KEY

	User Provided Information
	NMFS Provided Information (Technical Guidance)
	Resultant Isopleth

STEP 1: GENERAL PROJECT INFORMATION

PROJECT TITLE	TY/YBI
PROJECT/SOURCE INFORMATION	

Please include any assumptions

PROJECT CONTACT	

STEP 2: WEIGHTING FACTOR ADJUSTMENT

		Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value
Weighting Factor Adjustment (kHz)¥	2	

¥ Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab

† If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 75), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

*** BROADBAND Sources: Cannot use WFA higher than maximum applicable frequency (See GRAY tab for more information on WFA applicable frequencies)**

STEP 3: SOURCE-SPECIFIC INFORMATION

NOTE: Choose either E1-1 OR E.1-2 method to calculate isopleths (not required to fill in sage boxes for both)

E.1-1: METHOD TO CALCULATE PK AND SEL_{cum} (USING RMS SPL SOURCE LEVEL)

SEL_{cum}

Source Level (RMS SPL)	195
Number of piles per day	2
Strike Duration^ (seconds)	0.1
Number of strikes per pile	225
Duration of Sound Production (seconds)	45
10 Log (duration of sound production)	16.53
Propagation (xLogR)	15
Distance of source level measurement (meters)	10

^Window that makes up 90% of total cumulative energy (5%-95%) based on Madsen 2005

Unless otherwise specified, source levels are referenced 1 m from the source.

PK

Source Level (PK SPL)	210
Distance of source level measurement (meters)	10
Source level at 1 meter	225.0

Unless otherwise specified, source levels are referenced 1 m from the source.

NOTE: The User Spreadsheet tool provides a means to estimates distances associated with the Technical Guidance's PTS onset thresholds. Mitigation and monitoring requirements associated with a Marine Mammal Protection Act (MMPA) authorization or an Endangered Species Act (ESA) consultation or permit are independent management decisions made in the context of the proposed activity and comprehensive effects analysis, and are beyond the scope of the Technical Guidance and the User Spreadsheet tool.

RESULTANT ISOPLETHS*

*Impulsive sounds have dual metric thresholds (SELcum & PK). Metric producing largest isopleth should be used.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	183	185	155	185	203
PTS isopleth to threshold (meters)	**797.2**	**28.4**	**949.5**	**426.6**	**31.1**
PK Threshold	219	230	202	218	232
PTS PK isopleth to threshold (meters)	**2.5**	**NA**	**34.1**	**2.9**	**NA**

E.1-2: ALTERNATIVE METHOD TO CALCULATE PK AND SEL_{cum} (SINGLE STRIKE EQUIVALENT)

Unweighted $SEL_{cum\ (at\ measured\ distance)}$ = SEL_{ss} + 10 Log (# strikes)	#NUM!

SEL_{cum}

Source Level (Single Strike SEL)	
Number of strikes per pile	
Number of piles per day	
Propagation (xLogR)	
Distance of single strike SEL measurement (meters)	

Unless otherwise specified, source levels are referenced 1 m from the source.

PK

Source Level (PK SPL)	
Distance of source level measurement (meters)	
Source level at 1 meter	#NUM!

Unless otherwise specified, source levels are referenced 1 m from the source.

RESULTANT ISOPLETHS*

*Impulsive sounds have dual metric thresholds (SELcum & PK). Metric producing largest isopleth should be used.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	183	185	155	185	203
PTS isopleth to threshold (meters)	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
PK Threshold	219	230	202	218	232
PTS PK isopleth to threshold (meters)	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!

WEIGHTING FUNCTION CALCULATIONS

Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
a	1	1.6	1.8	1	2
b	2	2	2	2	2
f_1	0.2	8.8	12	1.9	0.94
f_2	19	110	140	30	25
C	0.13	1.2	1.36	0.75	0.64
Adjustment (dB)†	**-0.01**	**-19.74**	**-26.87**	**-2.08**	**-1.15**

$$W(f) = C + 10\log_{10}\left\{\frac{(f/f_1)^{2a}}{[1+(f/f_1)^2]^a[1+(f/f_2)^2]^b}\right\}$$

E.1: IMPACT PILE DRIVING (STATIONARY SOURCE: Impulsive, Intermittent)

VERSION 2.0: 2018

KEY

	User Provided Information
	NMFS Provided Information (Technical Guidance)
	Resultant Isopleth

STEP 1: GENERAL PROJECT INFORMATION

PROJECT TITLE	TY/YBI
PROJECT/SOURCE INFORMATION	

Please include any assumptions

PROJECT CONTACT	

STEP 2: WEIGHTING FACTOR ADJUSTMENT

Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value

Weighting Factor Adjustment (kHz)¥	2	

¥ Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab

† If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 75), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

*** BROADBAND Sources: Cannot use WFA higher than maximum applicable frequency (See GRAY tab for more information on WFA applicable frequencies)**

STEP 3: SOURCE-SPECIFIC INFORMATION

NOTE: Choose either E1-1 OR E.1-2 method to calculate isopleths (not required to fill in sage boxes for both)

E.1-1: METHOD TO CALCULATE PK AND SEL_{cum} (USING RMS SPL SOURCE LEVEL)

SEL_{cum}

Source Level (RMS SPL)	170
Number of piles per day	4
Strike Duration^ (seconds)	0.1
Number of strikes per pile	1000
Duration of Sound Production (seconds)	400
10 Log (duration of sound production)	26.02
Propagation (xLogR)	15
Distance of source level measurement (meters)	10

^Window that makes up 90% of total cumulative energy (5%-95%) based on Madsen 2005

Unless otherwise specified, source levels are referenced 1 m from the source.

PK

Source Level (PK SPL)	189
Distance of source level measurement (meters)	10
Source level at 1 meter	204.0

Unless otherwise specified, source levels are referenced 1 m from the source.

NOTE: The User Spreadsheet tool provides a means to estimates distances associated with the Technical Guidance's PTS onset thresholds. Mitigation and monitoring requirements associated with a Marine Mammal Protection Act (MMPA) authorization or an Endangered Species Act (ESA) consultation or permit are independent management decisions made in the context of the proposed activity and comprehensive effects analysis, and are beyond the scope of the Technical Guidance and the User Spreadsheet tool.

RESULTANT ISOPLETHS*

*Impulsive sounds have dual metric thresholds (SELcum & PK). Metric producing largest isopleth should be used.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	183	185	155	185	203
PTS isopleth to threshold (meters)	**73.7**	**2.6**	**87.8**	**39.4**	**2.9**
PK Threshold	219	230	202	218	232
PTS PK isopleth to threshold (meters)	**NA**	**NA**	**1.4**	**NA**	**NA**

E.1-2: ALTERNATIVE METHOD TO CALCULATE PK AND SEL_{cum} (SINGLE STRIKE EQUIVALENT)

Unweighted $SEL_{cum\ (at\ measured\ distance)}$ = SEL_{ss} + 10 Log (# strikes)	#NUM!

SEL_{cum}

Source Level (Single Strike SEL)	
Number of strikes per pile	
Number of piles per day	
Propagation (xLogR)	
Distance of single strike SEL measurement (meters)	

Unless otherwise specified, source levels are referenced 1 m from the source.

PK

Source Level (PK SPL)	
Distance of source level measurement (meters)	
Source level at 1 meter	#NUM!

Unless otherwise specified, source levels are referenced 1 m from the source.

RESULTANT ISOPLETHS*

*Impulsive sounds have dual metric thresholds (SELcum & PK). Metric producing largest isopleth should be used.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	183	185	155	185	203
PTS isopleth to threshold (meters)	**#NUM!**	**#NUM!**	**#NUM!**	**#NUM!**	**#NUM!**
PK Threshold	219	230	202	218	232
PTS PK isopleth to threshold (meters)	**#NUM!**	**#NUM!**	**#NUM!**	**#NUM!**	**#NUM!**

WEIGHTING FUNCTION CALCULATIONS

Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
a	1	1.6	1.8	1	2
b	2	2	2	2	2
f_1	0.2	8.8	12	1.9	0.94
f_2	19	110	140	30	25
C	0.13	1.2	1.36	0.75	0.64
Adjustment (dB)†	**-0.01**	**-19.74**	**-26.87**	**-2.08**	**-1.15**

$$W(f) = C + 10\log_{10}\left\{\frac{(f/f_1)^{2a}}{[1+(f/f_1)^2]^a[1+(f/f_2)^2]^b}\right\}$$

E.1: IMPACT PILE DRIVING (STATIONARY SOURCE: Impulsive, Intermittent)

VERSION 2.0: 2018

KEY

	User Provided Information
	NMFS Provided Information (Technical Guidance)
	Resultant Isopleth

STEP 1: GENERAL PROJECT INFORMATION

PROJECT TITLE	TY/YBI
PROJECT/SOURCE INFORMATION	

Please include any assumptions

PROJECT CONTACT	

STEP 2: WEIGHTING FACTOR ADJUSTMENT

Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value

Weighting Factor Adjustment (kHz)¥	2	

¥ Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab

† If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 75), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

*** BROADBAND Sources: Cannot use WFA higher than maximum applicable frequency (See GRAY tab for more information on WFA applicable frequencies)**

STEP 3: SOURCE-SPECIFIC INFORMATION

NOTE: Choose either E1-1 OR E.1-2 method to calculate isopleths (not required to fill in sage boxes for both)

E.1-1: METHOD TO CALCULATE PK AND SEL_{cum} (USING RMS SPL SOURCE LEVEL)

SEL_{cum}

Source Level (RMS SPL)	156
Number of piles per day	1
Strike Duration^A (seconds)	0.1
Number of strikes per pile	600
Duration of Sound Production (seconds)	60
10 Log (duration of sound production)	17.78
Propagation (xLogR)	15
Distance of source level measurement (meters)	33

^AWindow that makes up 90% of total cumulative energy (5%-95%) based on Madsen 2005

Unless otherwise specified, source levels are referenced 1 m from the source.

PK

Source Level (PK SPL)	167
Distance of source level measurement (meters)	33
Source level at 1 meter	189.8

Unless otherwise specified, source levels are referenced 1 m from the source.

NOTE: The User Spreadsheet tool provides a means to estimates distances associated with the Technical Guidance's PTS onset thresholds. Mitigation and monitoring requirements associated with a Marine Mammal Protection Act (MMPA) authorization or an Endangered Species Act (ESA) consultation or permit are independent management decisions made in the context of the proposed activity and comprehensive effects analysis, and are beyond the scope of the Technical Guidance and the User Spreadsheet tool.

RESULTANT ISOPLETHS*

*Impulsive sounds have dual metric thresholds (SELcum & PK). Metric producing largest isopleth should be used.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	183	185	155	185	203
PTS isopleth to threshold (meters)	**8.0**	**0.3**	**9.5**	**4.3**	**0.3**
PK Threshold	219	230	202	218	232
PTS PK isopleth to threshold (meters)	**NA**	**NA**	**NA**	**NA**	**NA**

E.1-2: ALTERNATIVE METHOD TO CALCULATE PK AND SEL_{cum} (SINGLE STRIKE EQUIVALENT)

Unweighted $SEL_{cum\ (at\ measured\ distance)}$ = SEL_{ss} + 10 Log (# strikes)	**#NUM!**

SEL_{cum}

Source Level (Single Strike SEL)	
Number of strikes per pile	
Number of piles per day	
Propagation (xLogR)	
Distance of single strike SEL measurement (meters)	

Unless otherwise specified, source levels are referenced 1 m from the source.

PK

Source Level (PK SPL)	
Distance of source level measurement (meters)	
Source level at 1 meter	#NUM!

Unless otherwise specified, source levels are referenced 1 m from the source.

RESULTANT ISOPLETHS*

*Impulsive sounds have dual metric thresholds (SELcum & PK). Metric producing largest isopleth should be used.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	183	185	155	185	203
PTS isopleth to threshold (meters)	**#NUM!**	**#NUM!**	**#NUM!**	**#NUM!**	**#NUM!**
PK Threshold	219	230	202	218	232
PTS PK isopleth to threshold (meters)	**#NUM!**	**#NUM!**	**#NUM!**	**#NUM!**	**#NUM!**

WEIGHTING FUNCTION CALCULATIONS

Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
a	1	1.6	1.8	1	2
b	2	2	2	2	2
f_1	0.2	8.8	12	1.9	0.94
f_2	19	110	140	30	25
C	0.13	1.2	1.36	0.75	0.64
Adjustment (dB)†	**-0.01**	**-19.74**	**-26.87**	**-2.08**	**-1.15**

$$W(f) = C + 10\log_{10}\left\{\frac{(f/f_1)^{2a}}{[1+(f/f_1)^2]^a\,[1+(f/f_2)^2]^b}\right\}$$

A.1: Vibratory Pile Driving (STATIONARY SOURCE: Non-Impulsive, Continuous)

VERSION 2.0: 2018

KEY

	User Provided Information
	NMFS Provided Information (Technical Guidance)
	Resultant Isopleth

STEP 1: GENERAL PROJECT INFORMATION

PROJECT TITLE	TY/YBI
PROJECT/SOURCE INFORMATION	WDOT 2011

Please include any assumptions

PROJECT CONTACT	

STEP 2: WEIGHTING FACTOR ADJUSTMENT

		Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value
Weighting Factor Adjustment (kHz)¥	2.5	

¥ Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab

† If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 48), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

*** BROADBAND Sources: Cannot use WFA higher than maximum applicable frequency (See GRAY tab for more information on WFA applicable frequencies)**

STEP 3: SOURCE-SPECIFIC INFORMATION

Source Level (RMS SPL)	150
Number of piles within 24-h period	15
Duration to drive a single pile (minutes)	5
Duration of Sound Production within 24-h period (seconds)	4500
10 Log (duration of sound production)	36.53
Propagation (xLogR)	15
Distance from source level measurement (meters)	15.8

Unless otherwise specified, source levels are referenced 1 m from the source.

NOTE: The User Spreadsheet tool provides a means to estimates distances associated with the Technical Guidance's PTS onset thresholds. Mitigation and monitoring requirements associated with a Marine Mammal Protection Act (MMPA) authorization or an Endangered Species Act (ESA) consultation or permit are independent management decisions made in the context of the proposed activity and comprehensive effects analysis, and are beyond the scope of the Technical Guidance and the User Spreadsheet tool.

RESULTANT ISOPLETHS

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	199	198	173	201	219
PTS Isopleth to threshold (meters)	**2.3**	**0.2**	**3.4**	**1.4**	**0.1**

WEIGHTING FUNCTION CALCULATIONS

Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
a	1	1.6	1.8	1	2
b	2	2	2	2	2
f_1	0.2	8.8	12	1.9	0.94
f_2	19	110	140	30	25
C	0.13	1.2	1.36	0.75	0.64
Adjustment (dB)†	**-0.05**	**-16.83**	**-23.50**	**-1.29**	**-0.60**

$$W(f) = C + 10\log_{10}\left\{\frac{(f/f_1)^{2a}}{[1+(f/f_1)^2]^a[1+(f/f_2)^2]^b}\right\}$$

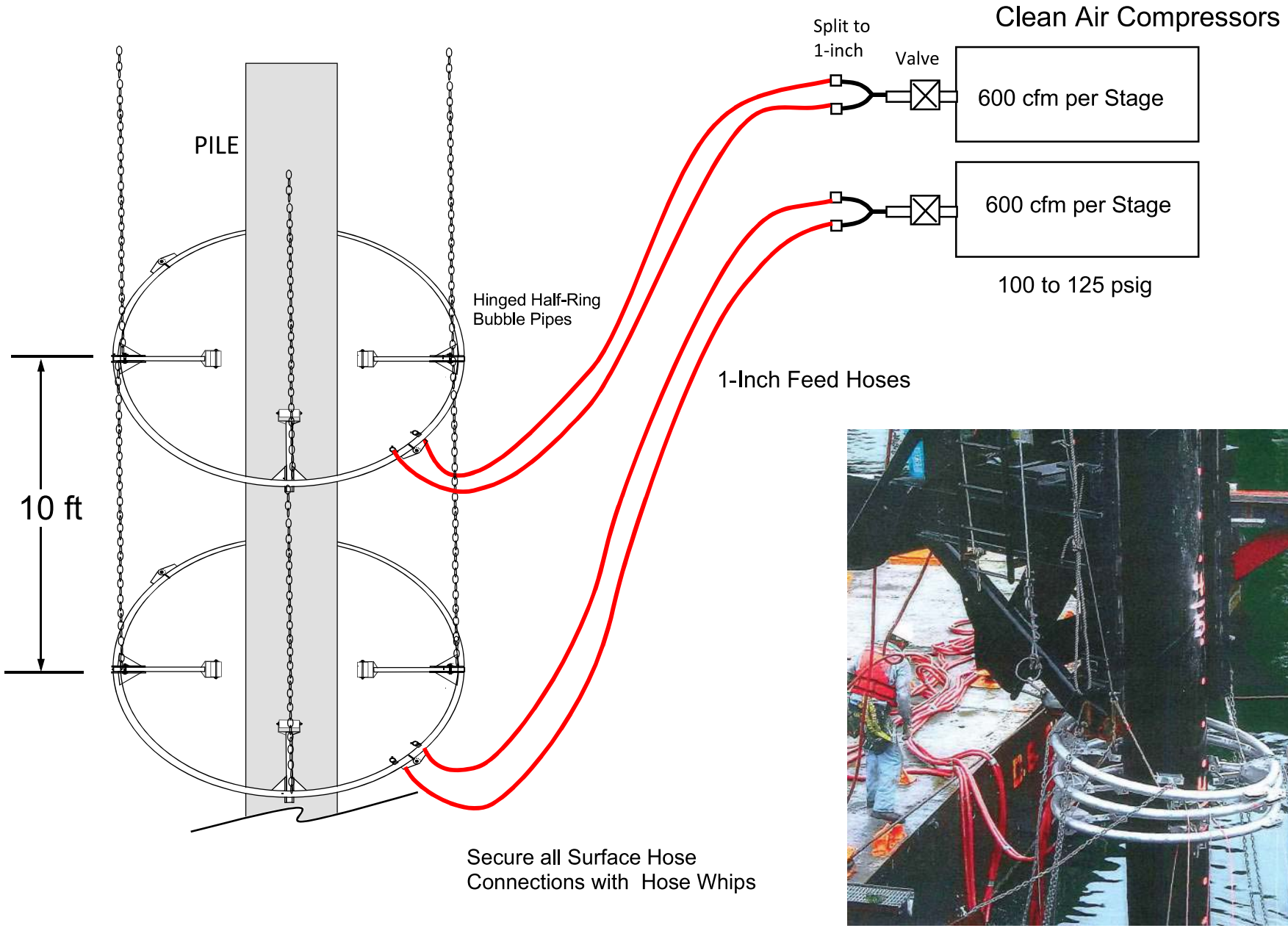
ATTACHMENT 5

Digital Files

ATTACHMENT 6

Bubble Curtain Design Plans

FIGURE 1 - AIR-CURTAIN SYSTEM SCHEMATIC



Bubble Rings on a Pipe Pile

Figure 2 - Conceptual Bubble Pipe Construction

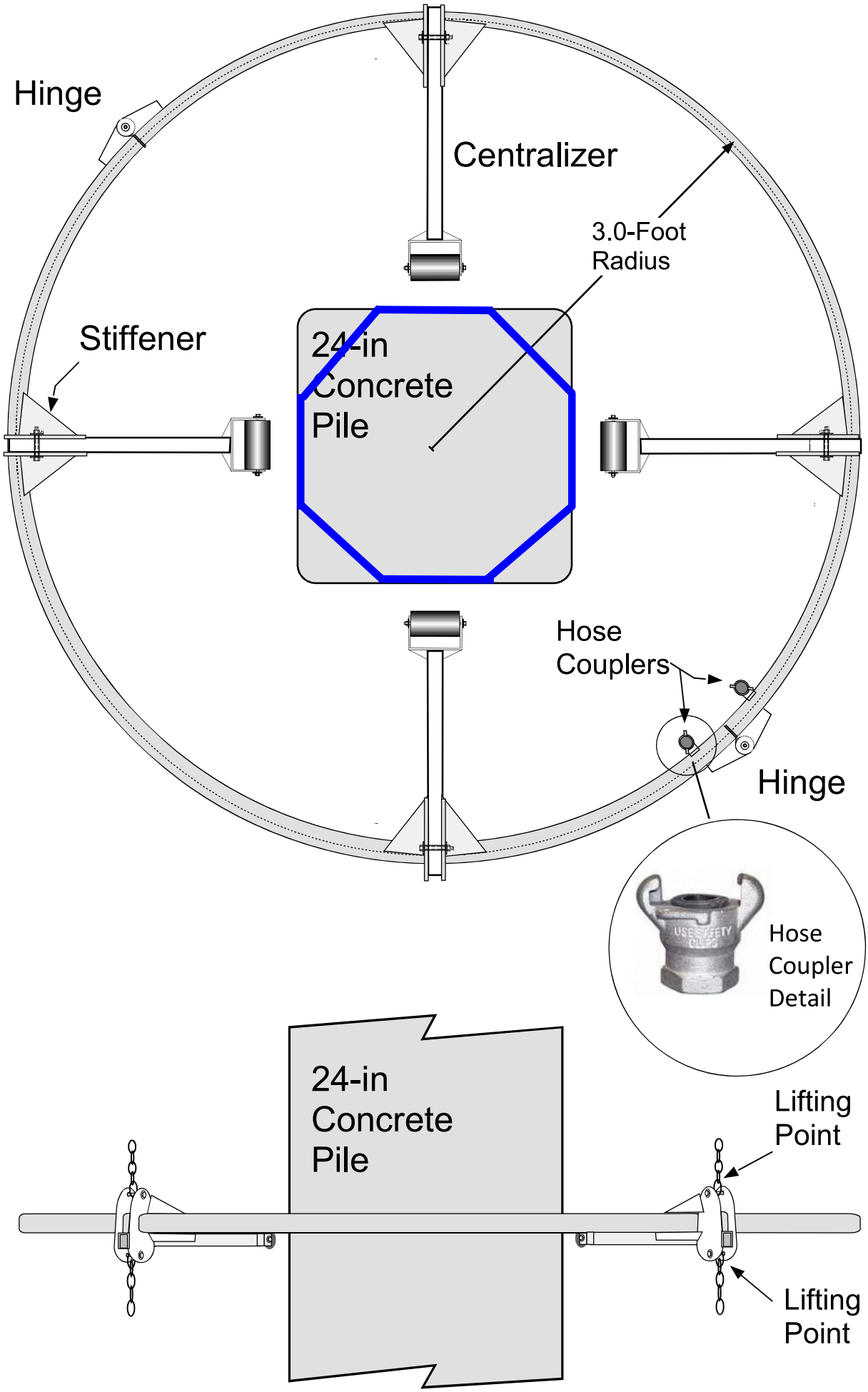


Figure 3 - Bubble Pipe Hinge and Hose Coupler Details

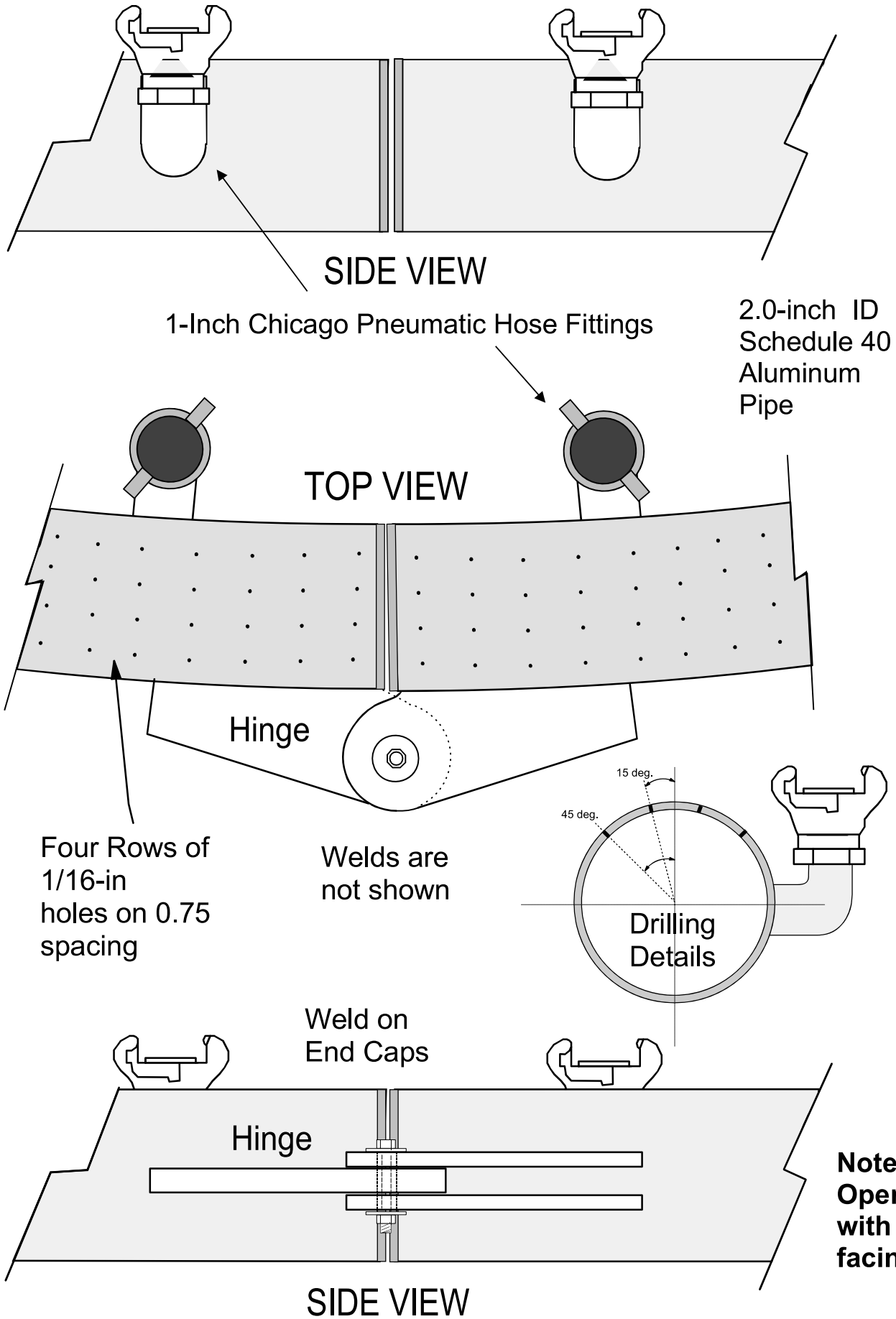
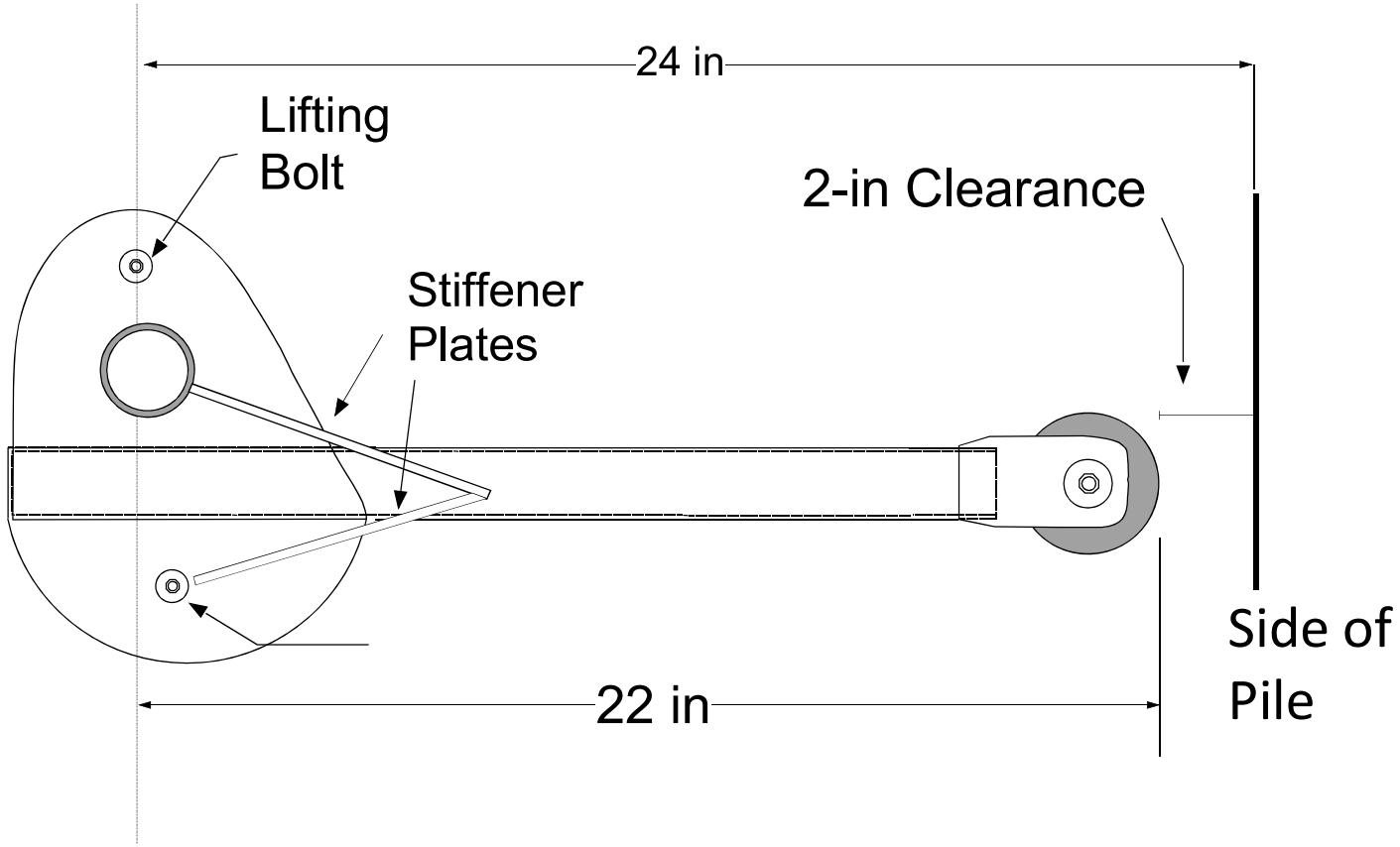
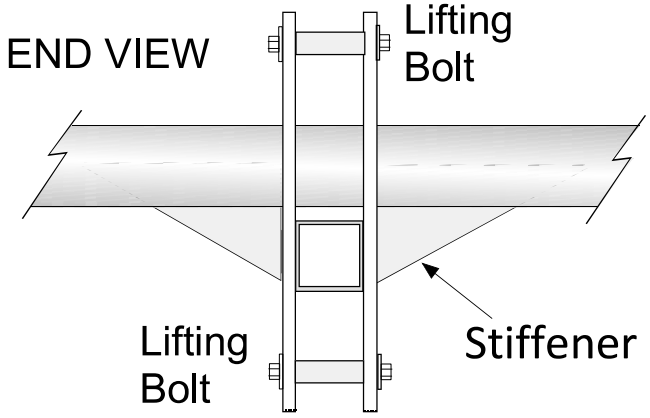
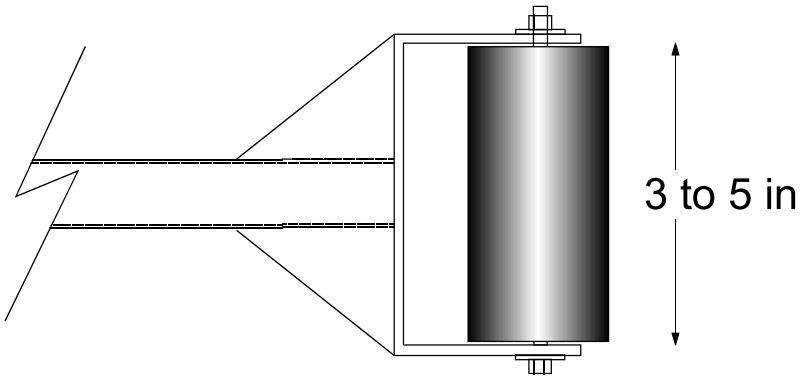


Figure 4 - Bubble Pipe Centralizer Arms





The Fabricator should modify the design as needed to simplify Construction



ROLLER DETAIL

Attachment II

Air-flow Calculations for the 24-Inch Pile Attenuation System

MARINE PILE DRIVING ENERGY ATTENUATOR AIR FLOW CALCULATIONS - CHEVRON RICHMOND REFINERY 6-Foot-Dia. Bubble Pipes

For Operating Water Depth of:	30.0 ft	9.1 m

Compressor Operating Pressure = 100.00 psig

Apperture Dia. =	0.06250 (in)	Compressed Air Volume (Q_a) =	76.90 acfm
Orifice opening Area (A) =	0.00307 in^2	Gas Constant for air (R) =	53.33
Gage Pressure at Bottom Pipe Inlet (P_1) =	41.85 psig	Water Pressure at Mudline=	13.29 psig
Constant Adiabatic Temperature (T) =	530 R^o	Air Density at Manifold (d_p) =	0.5843573 lb/ft^3
Coefficient of Flow (C)=	0.61	Orifice Holes Spacing =	0.750 in
Water Depth (D) =	30.0 ft	Max. No. of Operating Bubble Rings =	3
Cell Volume (1 row of holes) =	0.00136 ft^3	Total air volume per Stage =	600.0 scfm
Air Mass Loss Pressure Drop Coefficient =	0.9999	Metric Bubble Flow Rate =	3.0 $(m^3/min)/m$
Calculated Bubble-Pipe Air-Run Length =	9.425 ft	Imperial Bubble Flow Rate =	1.18 $(yd^3/min)/ft$
Pipe - Water Pressure Differential =	28.56 psi	Salt Water Density =	63.8 (lb/ft^3)
		Stage Separation Height =	10 ft
		Pipe Inside Diameter =	2.000 in
		Friction Loss in Bubble Pipes =	1.64 psi/100 feet
		Number of Bubble Holes per Row =	4
		Number of Air Inlet Points per Stage =	2
		Number of Air-Travel Runs (Splits) from Inlet Points =	1

AIR MASS FLOW BALANCE PER FLOW RUN

Total air loss:	22.46744	lb/min
Total Air in:	22.46744	lb/min
Balance Difference:	0.000	lb/min

Stage	Operating	Bubble Pipe Feed Pressure (psig)	Water Pressure (psig)	Pipe - Water Pressure Diff. (psi)	Total Delivered air mass (lb/min)	*Air volume Rate (acfm)	Depth of Stage Below Water (ft)
1	yes	41.85	13.29	28.56	0.0	0.0	30.00

Feed Hoses and Pipes Pressure Drop Calculations

Atmosperic Pressure = 14.7 psi

Air Volume to Feed Hoses (Q) 300 scfm

Feed Pipe/Hose Dia. (D) 1.0 in

Stage	Air Pressure at Bubble Pipe Inlet (psi)	Approx. Manifold Gauge Inlet Pressure (Pi - psig)	*Effective Length of Hose/Pipe & Fittings (ft)	Pressure Drop in Hoses (psi)	Compression Ratio (r):	Balance Press. Difference (psi)	Air Flow from Compressor (scfm)
1	56.55	100.6	180.0	58.79	7.85	0.0	600.00
2	52.12	97.7	180.0	60.31	7.65	0.0	600.00
3	47.69	94.9	180.0	61.88	7.45	0.0	600.00

*Underwater hose/pipe length = depth from water surface to inlets + 20 feet for fittings TOTAL: 1800.00

$$Pressure\ Drop\ (PD) = 0.1025\,LQ^2 / 3600\,r\,D^{5.31} \qquad Compression\ Ratio\ (r) = (P_i + P_a) / P_a$$

Quasi-static Condition Analysis from Standard Gas Equations of State

Inlet	56.55	0.000393	38.4481	11.07748	0.28812	0.0000000	0.0000000

STAGE 1 Water Depth = 30 ft Water Pressure = 27.99 psi Absolute

Hole Row	Quasi-static Pressure (psi)	Quasi-static cell-mass (lb)	Air Flow (acfm)	Air mass per min. (lb)	Air Density lb/ft^3	Air-mass Loss (lb/min)	Air-vol. Loss (acfm)	Distance From Inlet (ft)

Hole Row	Quasi-static Pressure (psi)	Quasi-static cell-mass (lb)	Air Flow (acfm)	Air mass per min. (lb)	Air Density lb/ft^3	Air-mass Loss (lb/min)	Air-vol. Loss (acfm)	Distance From Inlet (ft)
1	56.552379	0.000393	77.9808	22.46744	0.28812	0.151765	0.526752	0.0000
2	56.545699	0.000393	77.4632	22.31568	0.28808	0.151738	0.526721	0.0625
3	56.539019	0.000393	76.9456	22.16394	0.28805	0.151712	0.526691	0.1250
4	56.532340	0.000393	76.4279	22.01223	0.28801	0.151685	0.526660	0.1875
5	56.525662	0.000393	75.9102	21.86054	0.28798	0.151658	0.526630	0.2500
6	56.518985	0.000392	75.3925	21.70888	0.28794	0.151632	0.526599	0.3125
7	56.512308	0.000392	74.8747	21.55725	0.28791	0.151605	0.526569	0.3750
8	56.505632	0.000392	74.3570	21.40565	0.28788	0.151578	0.526538	0.4375
9	56.498956	0.000392	73.8391	21.25407	0.28784	0.151551	0.526508	0.5000
10	56.492281	0.000392	73.3213	21.10252	0.28781	0.151525	0.526477	0.5625
11	56.485607	0.000392	72.8034	20.95099	0.28777	0.151498	0.526447	0.6250
12	56.478933	0.000392	72.2855	20.79949	0.28774	0.151471	0.526416	0.6875
13	56.472260	0.000392	71.7676	20.64802	0.28771	0.151445	0.526386	0.7500
14	56.465588	0.000392	71.2496	20.49658	0.28767	0.151418	0.526355	0.8125
15	56.458917	0.000392	70.7316	20.34516	0.28764	0.151391	0.526324	0.8750
16	56.452246	0.000392	70.2136	20.19377	0.28760	0.151365	0.526294	0.9375
17	56.445575	0.000392	69.6955	20.04240	0.28757	0.151338	0.526263	1.0000
18	56.438906	0.000392	69.1774	19.89107	0.28754	0.151311	0.526233	1.0625
19	56.432237	0.000392	68.6593	19.73975	0.28750	0.151285	0.526202	1.1250
20	56.425569	0.000392	68.1412	19.58847	0.28747	0.151258	0.526171	1.1875
21	56.418901	0.000392	67.6230	19.43721	0.28744	0.151231	0.526141	1.2500
22	56.412234	0.000392	67.1048	19.28598	0.28740	0.151205	0.526110	1.3125
23	56.405568	0.000392	66.5865	19.13478	0.28737	0.151178	0.526080	1.3750
24	56.398903	0.000392	66.0683	18.98360	0.28733	0.151151	0.526049	1.4375
25	56.392238	0.000392	65.5500	18.83245	0.28730	0.151125	0.526018	1.5000
26	56.385573	0.000392	65.0316	18.68132	0.28727	0.151098	0.525988	1.5625
27	56.378910	0.000391	64.5133	18.53022	0.28723	0.151071	0.525957	1.6250
28	56.372247	0.000391	63.9949	18.37915	0.28720	0.151045	0.525926	1.6875
29	56.365585	0.000391	63.4764	18.22811	0.28716	0.151018	0.525896	1.7500
30	56.358923	0.000391	62.9580	18.07709	0.28713	0.150991	0.525865	1.8125
31	56.352262	0.000391	62.4395	17.92610	0.28710	0.150965	0.525834	1.8750
32	56.345602	0.000391	61.9210	17.77513	0.28706	0.150938	0.525804	1.9375
33	56.338943	0.000391	61.4024	17.62420	0.28703	0.150911	0.525773	2.0000
34	56.332284	0.000391	60.8839	17.47329	0.28699	0.150885	0.525742	2.0625
35	56.325625	0.000391	60.3653	17.32240	0.28696	0.150858	0.525712	2.1250
36	56.318968	0.000391	59.8466	17.17154	0.28693	0.150831	0.525681	2.1875
37	56.312311	0.000391	59.3279	17.02071	0.28689	0.150805	0.525650	2.2500
38	56.305655	0.000391	58.8092	16.86991	0.28686	0.150778	0.525620	2.3125
39	56.298999	0.000391	58.2905	16.71913	0.28682	0.150752	0.525589	2.3750
40	56.292344	0.000391	57.7718	16.56838	0.28679	0.150725	0.525558	2.4375
41	56.285690	0.000391	57.2530	16.41765	0.28676	0.150698	0.525527	2.5000
42	56.279036	0.000391	56.7341	16.26695	0.28672	0.150672	0.525497	2.5625
43	56.272384	0.000391	56.2153	16.11628	0.28669	0.150645	0.525466	2.6250
44	56.265731	0.000391	55.6964	15.96564	0.28665	0.150618	0.525435	2.6875
45	56.259080	0.000391	55.1775	15.81502	0.28662	0.150592	0.525404	2.7500
46	56.252429	0.000391	54.6586	15.66443	0.28659	0.150565	0.525374	2.8125
47	56.245779	0.000391	54.1396	15.51386	0.28655	0.150539	0.525343	2.8750
48	56.239129	0.000391	53.6206	15.36332	0.28652	0.150512	0.525312	2.9375
49	56.232480	0.000390	53.1015	15.21281	0.28649	0.150485	0.525281	3.0000
50	56.225832	0.000390	52.5825	15.06232	0.28645	0.150459	0.525251	3.0625
51	56.219184	0.000390	52.0634	14.91187	0.28642	0.150432	0.525220	3.1250
52	56.212537	0.000390	51.5443	14.76143	0.28638	0.150406	0.525189	3.1875
53	56.205891	0.000390	51.0251	14.61103	0.28635	0.150379	0.525158	3.2500
54	56.199246	0.000390	50.5059	14.46065	0.28632	0.150352	0.525127	3.3125
55	56.192601	0.000390	49.9867	14.31030	0.28628	0.150326	0.525097	3.3750
56	56.185956	0.000390	49.4675	14.15997	0.28625	0.150299	0.525066	3.4375
57	56.179313	0.000390	48.9482	14.00967	0.28621	0.150273	0.525035	3.5000
58	56.172670	0.000390	48.4289	13.85940	0.28618	0.150246	0.525004	3.5625
59	56.166028	0.000390	47.9095	13.70915	0.28615	0.150219	0.524973	3.6250
60	56.159386	0.000390	47.3902	13.55893	0.28611	0.150193	0.524942	3.6875
61	56.152745	0.000390	46.8708	13.40874	0.28608	0.150166	0.524912	3.7500
62	56.146105	0.000390	46.3513	13.25858	0.28605	0.150140	0.524881	3.8125
63	56.139465	0.000390	45.8319	13.10844	0.28601	0.150113	0.524850	3.8750
64	56.132826	0.000390	45.3124	12.95832	0.28598	0.150086	0.524819	3.9375

Hole Row	Quasi-static Pressure (psi)	Quasi-static cell-mass (lb)	Air Flow (acfm)	Air mass per min. (lb)	Air Density lb/ft^3	Air-mass Loss (lb/min)	Air-vol. Loss (acfm)	Distance From Inlet (ft)
65	56.126188	0.000390	44.7929	12.80824	0.28594	0.150060	0.524788	4.0000
66	56.119550	0.000390	44.2733	12.65818	0.28591	0.150033	0.524757	4.0625
67	56.112913	0.000390	43.7537	12.50814	0.28588	0.150007	0.524726	4.1250
68	56.106277	0.000390	43.2341	12.35814	0.28584	0.149980	0.524695	4.1875
69	56.099641	0.000390	42.7145	12.20816	0.28581	0.149954	0.524665	4.2500
70	56.093006	0.000390	42.1948	12.05820	0.28577	0.149927	0.524634	4.3125
71	56.086372	0.000389	41.6751	11.90828	0.28574	0.149900	0.524603	4.3750
72	56.079738	0.000389	41.1553	11.75838	0.28571	0.149874	0.524572	4.4375
73	56.073106	0.000389	40.6356	11.60850	0.28567	0.149847	0.524541	4.5000
74	56.066473	0.000389	40.1158	11.45865	0.28564	0.149821	0.524510	4.5625
75	56.059842	0.000389	39.5960	11.30883	0.28561	0.149794	0.524479	4.6250
76	56.053211	0.000389	39.0761	11.15904	0.28557	0.149768	0.524448	4.6875
77	56.046580	0.000389	38.5562	11.00927	0.28554	0.149741	0.524417	4.7500
78	56.039951	0.000389	38.0363	10.85953	0.28550	0.149715	0.524386	4.8125
79	56.033322	0.000389	37.5164	10.70982	0.28547	0.149688	0.524355	4.8750
80	56.026693	0.000389	36.9964	10.56013	0.28544	0.149661	0.524324	4.9375
81	56.020066	0.000389	36.4764	10.41047	0.28540	0.149635	0.524293	5.0000
82	56.013439	0.000389	35.9563	10.26083	0.28537	0.149608	0.524262	5.0625
83	56.006812	0.000389	35.4363	10.11122	0.28534	0.149582	0.524231	5.1250
84	56.000187	0.000389	34.9162	9.96164	0.28530	0.149555	0.524200	5.1875
85	55.993562	0.000389	34.3960	9.81209	0.28527	0.149529	0.524169	5.2500
86	55.986937	0.000389	33.8759	9.66256	0.28523	0.149502	0.524138	5.3125
87	55.980313	0.000389	33.3557	9.51305	0.28520	0.149476	0.524107	5.3750
88	55.973690	0.000389	32.8354	9.36358	0.28517	0.149449	0.524076	5.4375
89	55.967068	0.000389	32.3152	9.21413	0.28513	0.149423	0.524045	5.5000
90	55.960446	0.000389	31.7949	9.06471	0.28510	0.149396	0.524014	5.5625
91	55.953825	0.000389	31.2746	8.91531	0.28507	0.149370	0.523983	5.6250
92	55.947205	0.000389	30.7542	8.76594	0.28503	0.149343	0.523952	5.6875
93	55.940585	0.000388	30.2339	8.61660	0.28500	0.149317	0.523921	5.7500
94	55.933966	0.000388	29.7135	8.46728	0.28496	0.149290	0.523890	5.8125
95	55.927348	0.000388	29.1930	8.31799	0.28493	0.149264	0.523859	5.8750
96	55.920730	0.000388	28.6726	8.16873	0.28490	0.149237	0.523828	5.9375
97	55.914113	0.000388	28.1521	8.01949	0.28486	0.149211	0.523797	6.0000
98	55.907497	0.000388	27.6315	7.87028	0.28483	0.149184	0.523766	6.0625
99	55.900881	0.000388	27.1110	7.72110	0.28480	0.149158	0.523735	6.1250
100	55.894266	0.000388	26.5904	7.57194	0.28476	0.149131	0.523704	6.1875
101	55.887651	0.000388	26.0698	7.42281	0.28473	0.149105	0.523673	6.2500
102	55.881038	0.000388	25.5491	7.27370	0.28469	0.149078	0.523642	6.3125
103	55.874424	0.000388	25.0284	7.12463	0.28466	0.149052	0.523610	6.3750
104	55.867812	0.000388	24.5077	6.97557	0.28463	0.149025	0.523579	6.4375
105	55.861200	0.000388	23.9870	6.82655	0.28459	0.148999	0.523548	6.5000
106	55.854589	0.000388	23.4662	6.67755	0.28456	0.148972	0.523517	6.5625
107	55.847979	0.000388	22.9454	6.52858	0.28453	0.148946	0.523486	6.6250
108	55.841369	0.000388	22.4246	6.37963	0.28449	0.148919	0.523455	6.6875
109	55.834760	0.000388	21.9037	6.23071	0.28446	0.148893	0.523424	6.7500
110	55.828151	0.000388	21.3828	6.08182	0.28443	0.148866	0.523393	6.8125
111	55.821543	0.000388	20.8619	5.93295	0.28439	0.148840	0.523361	6.8750
112	55.814936	0.000388	20.3410	5.78411	0.28436	0.148813	0.523330	6.9375
113	55.808330	0.000388	19.8200	5.63530	0.28432	0.148787	0.523299	7.0000
114	55.801724	0.000387	19.2990	5.48652	0.28429	0.148760	0.523268	7.0625
115	55.795119	0.000387	18.7779	5.33775	0.28426	0.148734	0.523237	7.1250
116	55.788514	0.000387	18.2568	5.18902	0.28422	0.148707	0.523206	7.1875
117	55.781910	0.000387	17.7357	5.04031	0.28419	0.148681	0.523174	7.2500
118	55.775307	0.000387	17.2146	4.89163	0.28416	0.148654	0.523143	7.3125
119	55.768705	0.000387	16.6934	4.74298	0.28412	0.148628	0.523112	7.3750
120	55.762103	0.000387	16.1722	4.59435	0.28409	0.148601	0.523081	7.4375
121	55.755502	0.000387	15.6510	4.44575	0.28406	0.148575	0.523050	7.5000
122	55.748901	0.000387	15.1297	4.29717	0.28402	0.148549	0.523018	7.5625
123	55.742301	0.000387	14.6085	4.14863	0.28399	0.148522	0.522987	7.6250
124	55.735702	0.000387	14.0871	4.00010	0.28395	0.148496	0.522956	7.6875
125	55.729103	0.000387	13.5658	3.85161	0.28392	0.148469	0.522925	7.7500
126	55.722505	0.000387	13.0444	3.70314	0.28389	0.148443	0.522893	7.8125
127	55.715908	0.000387	12.5230	3.55470	0.28385	0.148416	0.522862	7.8750
128	55.709312	0.000387	12.0016	3.40628	0.28382	0.148390	0.522831	7.9375

Hole Row	Quasi-static Pressure (psi)	Quasi-static cell-mass (lb)	Air Flow (acfm)	Air mass per min. (lb)	Air Density lb/ft^3	Air-mass Loss (lb/min)	Air-vol. Loss (acfm)	Distance From Inlet (ft)
129	55.702716	0.000387	11.4801	3.25789	0.28379	0.148363	0.522800	8.0000
130	55.696120	0.000387	10.9586	3.10953	0.28375	0.148337	0.522768	8.0625
131	55.689526	0.000387	10.4370	2.96119	0.28372	0.148311	0.522737	8.1250
132	55.682932	0.000387	9.9155	2.81288	0.28369	0.148284	0.522706	8.1875
133	55.676339	0.000387	9.3939	2.66460	0.28365	0.148258	0.522675	8.2500
134	55.669746	0.000387	8.8723	2.51634	0.28362	0.148231	0.522643	8.3125
135	55.663154	0.000387	8.3506	2.36811	0.28358	0.148205	0.522612	8.3750
136	55.656563	0.000386	7.8289	2.21990	0.28355	0.148178	0.522581	8.4375
137	55.649972	0.000386	7.3072	2.07172	0.28352	0.148152	0.522549	8.5000
138	55.643382	0.000386	6.7855	1.92357	0.28348	0.148126	0.522518	8.5625
139	55.636793	0.000386	6.2637	1.77545	0.28345	0.148099	0.522487	8.6250
140	55.630204	0.000386	5.7419	1.62735	0.28342	0.148073	0.522455	8.6875
141	55.623616	0.000386	5.2200	1.47927	0.28338	0.148046	0.522424	8.7500
142	55.617029	0.000386	4.6982	1.33123	0.28335	0.148020	0.522393	8.8125
143	55.610442	0.000386	4.1763	1.18321	0.28332	0.147993	0.522361	8.8750
144	55.603856	0.000386	3.6544	1.03521	0.28328	0.147967	0.522330	8.9375
145	55.597270	0.000386	3.1324	0.88725	0.28325	0.147941	0.522299	9.0000
146	55.590686	0.000386	2.6104	0.73931	0.28322	0.147914	0.522267	9.0625
147	55.584102	0.000386	2.0884	0.59139	0.28318	0.147888	0.522236	9.1250
148	55.577518	0.000386	1.5663	0.44351	0.28315	0.147861	0.522205	9.1875
149	55.570935	0.000386	1.0443	0.29564	0.28311	0.147835	0.522173	9.2500
150	55.564353	0.000386	0.5221	0.14781	0.28308	0.147809	0.522142	9.3125
					Stage 1 Total:	**22.467442**	lb	