TRANSMITTAL

Date: September 2, 2014

To: Jacalen Printz, USACE Seattle District
Regulatory Branch
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Jim Muck, NOAA and U.S. Fish and Wildlife Service Liaison
National Marine Fisheries Service Northwest Region
7600 Sand Point Way NE, Building 1
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Benjamin Laws, Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, MD 98115

cc: Jessica Murphy, SDOT

From: Mark Mazzola, SDOT

Subject: Elliott Bay Seawall Project (NWS-2011-778-WRD and NWR-2013-10650)
Marine Mammal and Acoustic Monitoring Season 1 Annual Report

We are sending you:

X	Enclosures		Shop Drawings		Specifications		Prints
	Copy of letter		Other:				

No. of Copies	Description
1	Marine Mammal Monitoring Season 1 Annual Report
1	Acoustic Monitoring Season 1 Annual Report

	For Your Information		For Your Signature		For Your Approval	X	For Your Use

Remarks:
In compliance with the Endangered Species Act Incidental Take Statement and the Marine Mammal Protection Act Letter of Authorization, the Seattle Department of Transportation is submitting the Marine Mammal Monitoring Season 1 Annual Report and Acoustic Monitoring Season 1 Annual Report. Season 1 encompasses the 2013/2014 in-water work window.

Date: September 2, 2014

To: Mark Mazzola, City of Seattle Department of Transportation (SDOT)

From: Calvin Douglas, Anchor QEA, LLC

Cc: Maureen Meehan, SDOT
Jody Robinson, Jacobs
Jennifer Horwitz and Heather Page, Anchor QEA, LLC

Re: Elliott Bay Seawall Project (NWS-2011-778-WRD and NWR-2013-10650)
Marine Mammal Monitoring Season 1 Annual Report

This report provides the marine mammal monitoring results for Season 1 (2013/2014 in-water work window) for the Elliott Bay Seawall Project (EBSP). In compliance with the Endangered Species Act (ESA) and the Marine Mammal Protection Act (MMPA), marine mammal monitoring was conducted during all in-water impact and vibratory pile driving activities for the EBSP. As part of the MMPA compliance, National Marine Fisheries Service (NMFS) issued a Letter of Authorization (LOA) and ESA Incidental Take Statement, which allows take of marine mammals by harassment incidental to pile driving activities in Elliott Bay.

Marine mammal monitoring during vibratory and impact pile driving was performed by trained Anchor QEA marine mammal monitors for a total of 27 days, between February 11 and March 11, 2014. Overall, two of the eight anticipated marine mammal species were observed in the Level B Harassment Zone during pile driving: California sea lions and harbor seals. Total takes documented during the monitoring included 186 California sea lions and 23 harbor seals. No marine mammals entered the Exclusion Zone during pile installation.

MARINE MAMMAL MONITORING METHODS

Marine mammal monitoring methods and protocols were established per agency guidelines and permits, based on information in the following EBSP monitoring plan and permit documents:

- *Marine Mammal Protection Act and Endangered Species Act Updated Marine Mammal Monitoring and Mitigation Plan* (City of Seattle 2013)
- *National Marine Fisheries Service Endangered Species Act Incidental Take Statement for the Elliott Bay Seawall Project* (NOAA 2013a)
- *Marine Mammal Protection Act Letter of Authorization for the Elliott Bay Seawall Project* (NOAA 2013b)

The marine mammal monitoring included the following eight species, which are organized into three groups:

- Pinnipeds (seals)
  - California sea lion (*Zalophus californianus*)

  - Harbor seal (*Phoca vitulina*)
  - Steller sea lion (*Eumetopias jubatus*)
- Small cetaceans (porpoises)
  - Dall's porpoise (*Phocoena dalli*)
  - Harbor porpoise (*Phocoena phocoena*)
- Large cetaceans (whales)
  - Gray whale (*Eschrichtius robustus*)
  - Humpback whale (*Megaptera novaeangliae*)
  - Killer whale Southern Resident (*Orcinus orca*)
  - Killer whale transient

The monitoring area included two zones designated as Exclusion Zone and Level B Harassment Zone. The two zones varied by the type of pile work and marine mammal species. The Exclusion Zone included areas where a stop-work order was to be issued if species were present. Within the Level B Harassment Zones, marine mammals are closely monitored and take is documented, but work is allowed to continue. The Exclusion Zones and Level B Harassment Zones are presented on Table 1 and shown on Figure 1 in Attachment A.

TABLE 1. EXCLUSION ZONE AND LEVEL B HARASSMENT ZONE MONITORING THRESHOLDS BY SPECIES GROUP AND PILE INSTALLATION TYPE

Zone Threshold	Location to Monitor	Species Group
Vibratory/Steel Sheet Piles		
Exclusion Zone (Stop Work Order)	2.5 miles (4.0 kilometers [km]) to Source	Large Cetaceans
Level B Harassment Threshold (Take)	From 3.9 miles to 2.5 miles (6.3 km to 4.0 km)	Large Cetaceans
Level B Harassment Threshold (Take)	2.5 miles (4.0 km) to Source	Pinnipeds and Small Cetaceans
Impact/Steel Sheet Piles		
Exclusion Zone (Stop Work Order)	3,280 feet (1.0 km) to Source	Large Cetaceans
Exclusion Zone (Stop Work Order)	200 feet (61.0 meters [m]) to Source	Pinnipeds and Small Cetaceans
Level B Harassment Threshold (Take)	3,280 feet to 200 feet (1.0 km to 61.0 m)	Pinnipeds and Small Cetaceans
Impact/Concrete Piles		
Exclusion Zone (Stop Work Order)	3,280 feet (1.0 km) to Source	Large Cetaceans
Exclusion Zone (Stop Work Order)	50 feet (15.2 m) to Source	Pinnipeds and Small Cetaceans
Level B Harassment Threshold (Take)	400 feet to 50 feet (121.9 m to 15.2 m)	Pinnipeds and Small Cetaceans

All monitoring was performed by land-based observers. The number of land-based observers was determined by the type of pile driving activity. One observer was located at the project site during impact and vibratory pile driving. During vibratory pile driving, two additional observers were located at designated viewpoints on the north and south entrance of Elliott Bay with unobstructed views of the

bay. The south monitoring point is located at the Hamilton Viewpoint Park pier, identified as the Alki monitoring site. The north monitoring point is located at the West 32nd Avenue City pump station, identified as the Magnolia monitoring site. The monitoring locations are shown on Figure 2 in Attachment A.

Trained Anchor QEA marine mammal monitors used binoculars to search the monitoring zone for the presence of marine mammals during pile driving activities and 30 minutes prior to and following pile driving activities. Observations and positions of marine mammals were recorded on a daily monitoring data sheet. The daily data sheet was developed prior to program implementation and was used to record the following information: date; weather conditions; time and location of environmental conditions that could deter or prevent marine mammal detections; observation time period; marine mammal species observed; time, duration, and location of marine mammals observed; observable species behavior during pile driving activities; pile-related activities taking place during the monitoring; communication between the observers and the contractor or SDOT; and, if applicable, why a stop work order was or was not initiated. The locations of marine mammal sightings were also identified on grid maps.

MARINE MAMMAL MONITORING RESULTS

Marine mammal monitoring during vibratory and impact pile driving was performed by trained Anchor QEA marine mammal monitors for a total of 27 days, between February 11 and March 11, 2014. Overall, two of the eight marine mammal species were observed in the Level B Harassment Zone during pile driving: California sea lions and harbor seals. Total takes documented during the monitoring included 186 California sea lions and 23 harbor seals. The locations of observed California sea lions and harbor seals are identified on Figure 3 in Attachment A. No marine mammals entered the Exclusion Zone during pile installation, and therefore no stop work order was initiated during the monitoring period.

No observable changes in behavior in the California sea lions or harbor seals were noted during pile driving activities. The majority of the California sea lion observations occurred from the Alki monitoring site (184 out of 186). There are two mooring buoys located in the southwest area of Elliott Bay (Figure 3 in Attachment A). California sea lions were observed resting on these buoys on every monitoring day. The number of sea lions observed each monitoring day ranged from 2 to 15 and the average number observed per monitoring day was 7. On many of the monitoring days, sea lions occupied these mooring buoys during the entire monitoring period. Overall, the sea lion group that occupies these mooring buoys accounted for the vast majority of takes documented during the monitoring period.

The 186 California sea lion takes documented during the Year 1 monitoring exceeds the 175 maximum number of takes per year authorized in the monitoring plan (City of Seattle 2013) and incidental take statement (NOAA 2013a). As described previously, 184 of the 186 documented takes of California sea lion were associated with the mooring buoys located near the Alki monitoring site. This group of sea lions (average of seven) was observed daily, typically during the entire monitoring period, and no observable change in behavior was documented during pile driving activities during the monitoring period.

Monitoring information documented on the daily monitoring forms is included in Attachment B. Table B-1 provides a daily summary of pile driving activity and weather conditions during the monitoring period. Table B-2 provides a daily summary of marine mammal species observed, time and duration of observations, distance from pile driving activities, and species behavior per monitoring site. Table B-3 provides a daily summary of takes per species and monitoring site. Table B-4 provides a summary of takes documented during the monitoring period. As noted in Table B-1, some monitoring days included fog, rain, and wind conditions that made monitoring more challenging than during clear weather periods; however, no environmental conditions occurred during the monitoring period that warranted a stop or delay of pile driving activities because marine mammal species could not be observed. Because no marine mammal species entered an Exclusion Zone during the monitoring, no stop work order was initiated and no associated communication with the contractor or SDOT occurred.

REFERENCES

City of Seattle, 2013. *Marine Mammal Protection Act and Endangered Species Act Updated Marine Mammal Monitoring and Mitigation Plan*. Elliott Bay Sewall Project.

NOAA (National Oceanic and Atmospheric Administration), 2013a. *National Marine Fisheries Service Endangered Species Act Incidental Take Statement for the Elliott Bay Seawall Project*.

NOAA, 2013b. *Marine Mammal Protection Act Letter of Authorization for the Elliott Bay Seawall Project*. National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

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ATTACHMENT A – FIGURES

ATTACHMENT B – TABLES

ATTACHMENT A
FIGURES

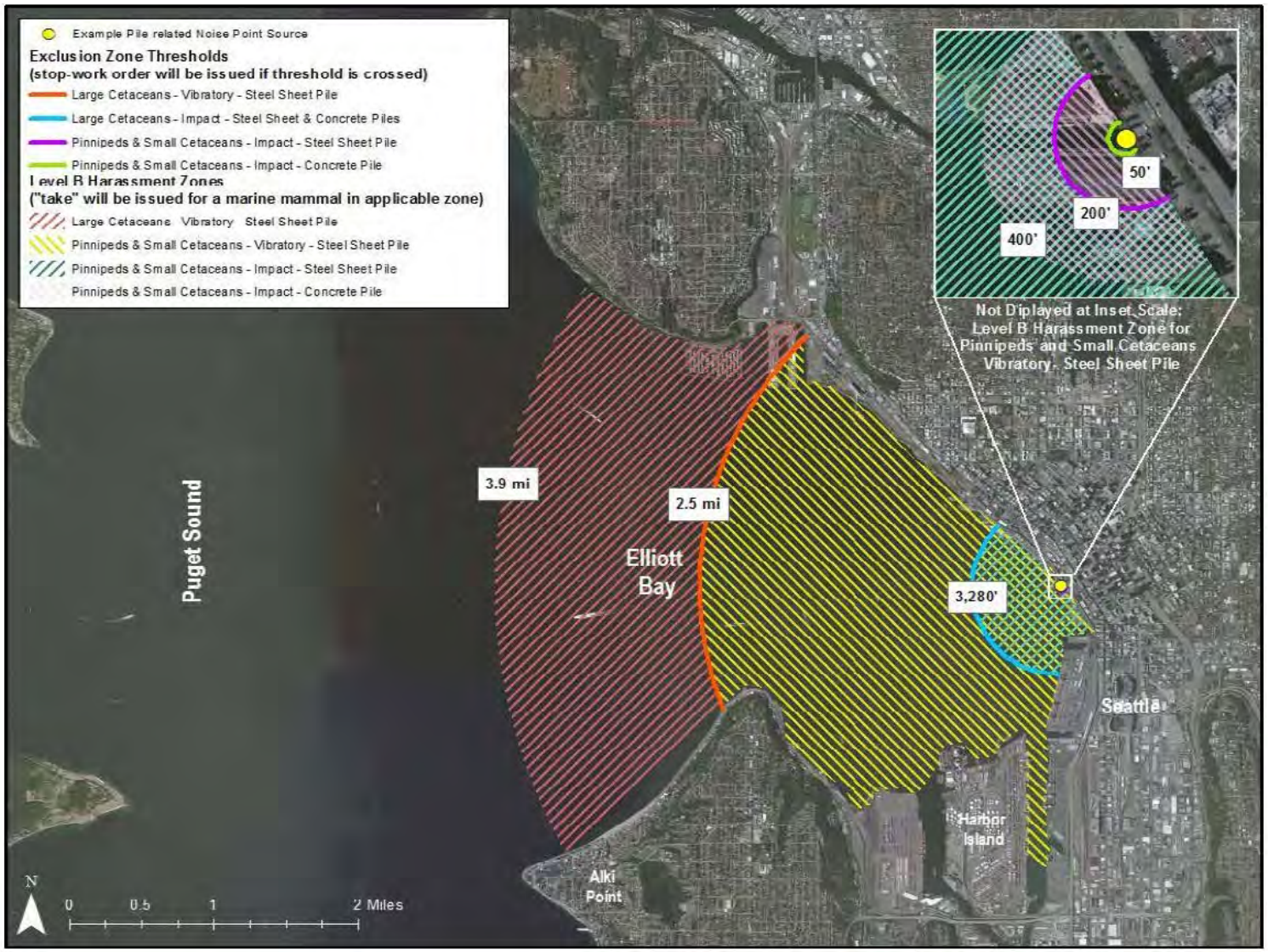

Figure 1. Exclusion Zones and Level B Harassment Zones

Figure 2. Marine Mammal Monitoring Area and Monitoring Locations

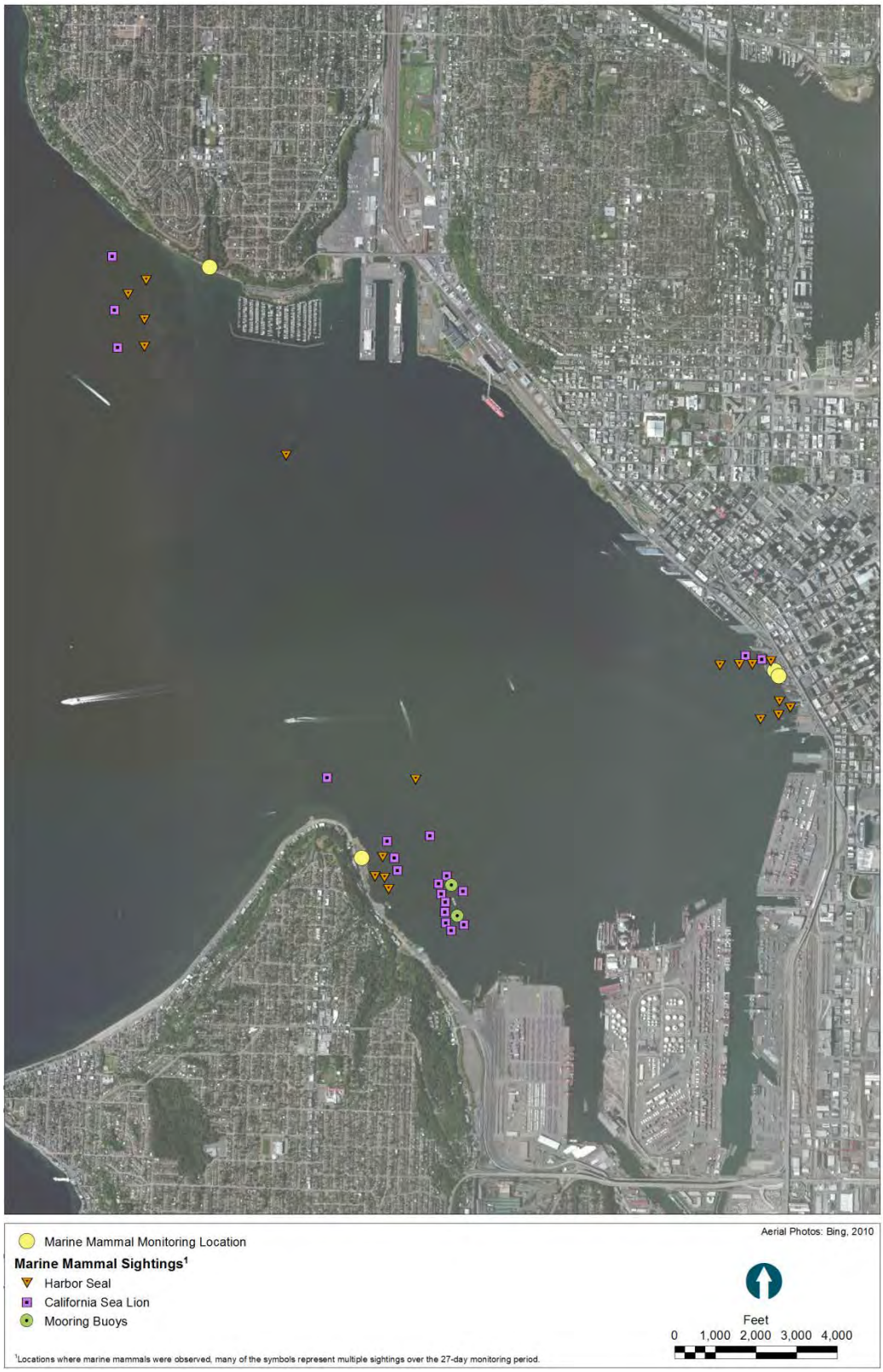

Figure 3. Locations of Marine Mammals Observed during the Monitoring

ATTACHMENT B
TABLES

TABLE B-1. DAILY SUMMARY OF PILE DRIVING ACTIVITY AND WEATHER CONDITIONS DURING THE MARINE MAMMAL MONITORING

Date	Pile Driving Activity[a]	Weather Conditions
Tuesday, February 11, 2014	Vibratory from 0930 to 1530	Overcast, upper 40°F (4°C), rain in afternoon
Wednesday, February 12, 2014	Vibratory from 1200 to 1700	Partly cloudy, upper 40°F (4°C), clear in afternoon
Thursday, February 13, 2014	Vibratory from 0830 to 1630	Partly cloudy, upper 40°F (4°C), wind gusts in morning, clear in afternoon
Friday, February 14, 2014	Vibratory from 0730 to 1630	Rain in morning, upper 40°F (4°C), wind gusts and clear in afternoon
Saturday, February 15, 2014	Vibratory from 0900 to 1740	Overcast with rain off and on during day, upper 40°F (4°C)
Sunday, February 16, 2014	Vibratory from 0800 to 1700	Overcast with rain off and on during day, upper 40°F (4°C)
Monday, February 17, 2014	Vibratory and impact (concrete) from 1030 to 1745	Overcast with rain off and on during day, upper 40°F (4°C), wind gusts
Tuesday, February 18, 2014	Vibratory and impact (concrete) from 0730 to 1700	Overcast with rain off and on during day, upper 40°F (4°C), wind gusts
Wednesday, February 19, 2014	Vibratory and impact (concrete) from 0900 to 1800	Partly cloudy in morning, upper 40°F (4°C), clear to cloudy in afternoon
Thursday, February 20, 2014	Impact (concrete) from 0700 to 1015	Partly cloudy, upper 40°F (4°C), wind gusts
Friday, February 21, 2014	No pile driving due to mechanical issues	Overcast with rain off and on during day, upper 40°F (4°C)
Saturday, February 22, 2014	Vibratory and impact (concrete) from 1000 to 1700	Overcast with rain most of day, upper 40°F (4°C)
Sunday, February 23, 2014	Vibratory and impact (concrete) from 0745 to 1745	Overcast with rain most of day, upper 40°F (4°C)
Monday, February 24, 2014	Vibratory and impact (concrete) from 0800 to 1755	Overcast with rain and wind gusts most of day, upper 40°F (4°C)
Tuesday, February 25, 2014	Vibratory and impact (concrete) from 0800 to 1745	Mostly clear skies, upper 40°F (4°C)
Wednesday, February 26, 2014	Vibratory from 0745 to 1620	Mostly clear skies, upper 40°F (4°C)
Thursday, February 27, 2014	Vibratory from 0840 to 1705	Partly cloudy in morning, upper 40°F (4°C), clear to cloudy in afternoon
Friday, February 28, 2014	Vibratory from 1300 to 1755	Mostly clear, mid 50°F (10°C)
Saturday, March 01, 2014	Vibratory from 0820 to 1645	Overcast, mid 50°F (10°C)
Sunday, March 02, 2014	No pile driving occurred	
Monday, March 03, 2014	Vibratory from 1000 to 1730	Overcast with light showers, mid 50°F (10°C)
Tuesday, March 04, 2014	Vibratory from 0900 to 1740	Overcast with rain in morning, overcast in afternoon, mid 50°F (10°C)
Wednesday, March 05, 2014	Vibratory and impact (concrete) from 0800 to 1435	Overcast with light showers, mid 50°F (10°C)
Thursday, March 06, 2014	Vibratory and impact (concrete) from 0930 to 1740	Overcast with rain off and on during day, wind gusts, mid 50°F (10°C)
Friday, March 07, 2014	Vibratory and impact (concrete) from 0800 to 1730	Overcast, mid 50°F (10°C)
Saturday, March 08, 2014	Vibratory from 0740 to 1420	Overcast with rain most of day, upper 40°F (4°C)
Sunday, March 09, 2014	No pile driving occurred	
Monday, March 10, 2014	Vibratory from 0730 to 1500	Rain in morning, mid 50°F (10°C), cloudy in afternoon
Tuesday, March 11, 2014	Vibratory from 0900 to 1300	Partly cloudy, mid 50°F (10°C)

a Time shows approximate beginning and end of pile driving activity. All pile driving days included breaks in pile driving. Some days breaks lasted several hours.

TABLE B-2. DAILY SUMMARY OF SPECIES OBSERVED, TIME, DURATION, DISTANCE FROM PILE DRIVING, AND SPECIES BEHAVIOR PER MONITORING SITE

Date	Monitoring Site	Species Observed (number)	Time and Duration Observed	Distance from Pile Driving	Behavior
Tuesday, February 11, 2014	Construction Site	CSL (1)	1305 to 1306 (1 Minute)	>400 ft (>122 m)	Swimming briefly above surface toward shoreline. Occurred more than 30 minutes prior to or following active PD and therefore was not included in the take tally count.
		HS (1)	1320 to 1321 (1 Minute)	>350 ft (>107 m)	Swimming briefly above surface parallel to shoreline. Occurred more than 30 minutes prior to or following active PD and therefore was not included in the take tally count.
	Alki Site	CSL (5)	0930 to 1530 (6 Hours)	>10,000 ft (>3 km)	Resting on mooring buoy and swimming in water near buoy. No observable change in behavior during PD.
		HS (1)	1145 to 1200 (15 Minutes)	>10,000 ft (>3 km)	Swimming. No observable change in behavior during PD. Assumed same individual as next observations.
		HS (1)	1215 to 1230 (15 Minutes)	>10,000 ft (>3 km)	Swimming. No observable change in behavior during PD. Assumed same individual as previous observation.
	Magnolia Site	None	NA	NA	NA
Wednesday, February 12, 2014	Construction Site	None	NA	NA	NA
	Alki Site	CSL (1)	0700 to 0701 (1 Minute)	>10,000 ft (>3 km)	Swimming parallel to shore. Occurred more than 30 minutes prior to or following active PD and therefore was not included in the take tally count.
		CSL (7)	0700 to 0730 (30 Minutes)	>10,000 ft (>3 km)	Resting on mooring buoy. Occurred more than 30 minutes prior to or following active PD and therefore was not included in the take tally count.
		CSL (8)	1000 to 1500 (6 Hours)	>10,000 ft (>3 km)	Resting on mooring buoy and swimming in water near buoy. No observable change in behavior during PD.
		CSL (1)	1330 to 1331 (1 Minute)	>10,000 ft (>3 km)	Swimming parallel to shore. Part of the previously documented mooring buoy group and therefore was not added to the take tally count. No observable change in behavior during PD.
		CSL (1)	1420 to 1421 (1 Minute)	>10,000 ft (>3 km)	Swimming parallel to shore. Part of mooring buoy group. No observable change in behavior during PD.
		CSL (1)	1448 to 1450 (2 Minutes)	>10,000 ft (>3 km)	Swimming parallel to shore. Part of mooring buoy group. No observable change in behavior during PD.
		HS (1)	0700 to 0715 (15 Minutes)	>10,000 ft (>3 km)	Swimming briefly above surface parallel to shoreline. Occurred more than 30 minutes prior to or following active PD and therefore was not included in the take tally count.
	Magnolia Site	None	NA	NA	NA

TABLE B-2. DAILY SUMMARY OF SPECIES OBSERVED, TIME, DURATION, DISTANCE FROM PILE DRIVING, AND SPECIES BEHAVIOR PER MONITORING SITE

Date	Monitoring Site	Species Observed (number)	Time and Duration Observed	Distance from Pile Driving	Behavior
Thursday, February 13, 2014	Construction Site	None	NA	NA	NA
	Alki Site	CSL (7)	0800 to 0945 (1 Hour 45 Minutes)	>10,000 ft (>3 km)	Resting on mooring buoy. No observable change in behavior during PD.
		CSL (2)	0800 to 0945 (1 Hour 45 Minutes)	>10,000 ft (>3 km)	Resting on second mooring buoy. No observable change in behavior during PD.
		CSL (2)	0830 to 0831 (1 Minute)	>10,000 ft (>3 km)	Resting on mooring buoy and swimming in water near buoy. No observable change in behavior during PD.
		CSL (1)	0910 to 0911 (1 Minute)	>10,000 ft (>3 km)	Swimming parallel to shore. Part of the previously documented mooring buoy group and therefore was not added to the take tally count. No observable change in behavior during PD.
		CSL (1)	1420 to 1421 (1 Minute)	>10,000 ft (>3 km)	Swimming parallel to shore. Part of mooring buoy group. No observable change in behavior during PD.
		CSL (7)	0945 to 1515 (5 Hours 30 Minutes)	>10,000 ft (>3 km)	Alternating between resting on mooring buoy and swimming. No observable change in behavior during PD.
		CSL (2)	0945 to 1515 (5 Hours 30 Minutes)	>10,000 ft (>3 km)	Alternating between resting on second mooring buoy and swimming. No observable change in behavior during PD.
		CSL (1)	1448 to 1450 (2 Minutes)	>10,000 ft (>3 km)	Swimming parallel to shore. Part of the previously documented mooring buoy group and therefore was not added to the take tally count. No observable change in behavior during PD.
		HS (1)	1505 to 1506 (1 Minute)	>11,000 ft (>3.4 km)	Swimming briefly above surface parallel to shoreline. No observable change in behavior during PD.
	Magnolia Site	HS (1)	0836 to 0840 (4 Minutes)	>15,000 ft (>4.6 km)	Swimming in north direction outside Level B Harassment Zone and therefore not included in the take tally count.
Friday, February 14, 2014	Construction Site	CSL (1)	1352 to 1353 (1 Minute)	>350 ft (>107 m)	Swimming briefly above surface toward shoreline. Occurred more than 30 minutes prior to or following active PD and therefore was not included in the take tally count.
	Alki Site	CSL (7)	0730 to 1700 (9 Hours 30 Minutes)	>10,000 ft (>3 km)	Alternating between resting on mooring buoy and swimming. No observable change in behavior during PD.
		CSL (2)	0730 to 1700 (9 Hours 30 Minutes)	>10,000 ft (>3 km)	Alternating between resting on second mooring buoy and swimming. No observable change in behavior during PD.
		CSL (1)	1352 to 1353 (1 Minute)	>10,000 ft (>3 km)	Swimming parallel to shore. Not part of mooring buoy group. No observable change in behavior during PD.
		HS (1)	1435 to 1437 (2 Minutes)	>11,000 ft (>3.4 km)	Swimming briefly above surface parallel to shoreline. No observable change in behavior during PD.
	Magnolia Site	None	NA	NA	NA

TABLE B-2. DAILY SUMMARY OF SPECIES OBSERVED, TIME, DURATION, DISTANCE FROM PILE DRIVING, AND SPECIES BEHAVIOR PER MONITORING SITE

Date	Monitoring Site	Species Observed (number)	Time and Duration Observed	Distance from Pile Driving	Behavior
Saturday, February 15, 2014	Construction Site	HS (1)	1018 to 1021 (3 Minutes)	>200 ft (>61 m)	Swimming briefly above surface parallel to shoreline. Occurred more than 30 minutes prior to or following active PD and therefore was not included in the take tally count.
		HS (1)	1429 to 1430 (1 Minute)	>200 ft (>61 m)	Swimming briefly above surface parallel to shoreline. Occurred more than 30 minutes prior to or following active PD and therefore was not included in the take tally count.
		HS (1)	1632 to 1633 (1 Minute)	>100 ft (>30 m)	Swimming briefly above surface parallel to shoreline. Occurred more than 30 minutes prior to or following active PD and therefore was not included in the take tally count.
	Alki Site	CSL (6)	0830 to 1730 (9 Hours)	>10,000 ft (>3 km)	Alternating between resting on mooring buoy and swimming. No observable change in behavior during PD.
		CSL (5)	0830 to 1730 (9 Hours)	>10,000 ft (>3 km)	Alternating between resting on second mooring buoy and swimming. No observable change in behavior during PD.
		CSL (1)	1700 to 1730 (30 Minutes)	>10,000 ft (>3 km)	Swimming parallel to shore. Part of the previously documented mooring buoy group and therefore was not added to the take tally count. No observable change in behavior during PD.
		HS (1)	1113 to 1245 (32 Minutes)	>10,000 ft (>3 km)	Resting on rock near shoreline. No observable change in behavior during PD.
	Magnolia Site	CSL (1)	1036 to 1040 (4 Minutes)	>15,000 ft (>4.6 km)	Swimming in west direction outside Level B Harassment Zone and therefore not included in the take tally count.
		HS (1)	1115 to 1122 (7 Minutes)	>15,000 ft (>4.6 km)	Swimming in east direction outside Level B Harassment Zone and therefore not included in the take tally count.
		HS (1)	1734 to 1735 (1 Minute)	>15,000 ft (>4.6 km)	Swimming in east direction outside Level B Harassment Zone and therefore not included in the take tally count.
Sunday, February 16, 2014	Construction Site	CSL (1)	1420 to 1421 (1 Minute)	>300 ft (>91 m)	Swimming briefly above surface parallel to shoreline. Occurred more than 30 minutes prior to or following active PD and therefore was not included in the take tally count.
		HS (1)	1305 to 1306 (1 Minute)	>400 ft (>122 m)	Swimming briefly above surface parallel to shoreline. Occurred more than 30 minutes prior to or following active PD and therefore was not included in the take tally count.
	Alki Site	CSL (7)	0830 to 1700 (8 Hours 30 Minutes)	>10,000 ft (>3 km)	Alternating between resting on mooring buoy and swimming. No observable change in behavior during PD.
		CSL (2)	0830 to 1700 (8 Hours 30 Minutes)	>10,000 ft (>3 km)	Alternating between resting on second mooring buoy and swimming. No observable change in behavior during PD.
	Magnolia Site	None	NA	NA	NA

TABLE B-2. DAILY SUMMARY OF SPECIES OBSERVED, TIME, DURATION, DISTANCE FROM PILE DRIVING, AND SPECIES BEHAVIOR PER MONITORING SITE

Date	Monitoring Site	Species Observed (number)	Time and Duration Observed	Distance from Pile Driving	Behavior
Monday, February 17, 2014	Construction Site	HS (1)	1440 to 1510 (90 Minutes)	>200 ft (>61 m)	Swimming, surfacing, and foraging. No observable change in behavior during PD.
	Alki Site	CSL (7)	1050 to 1800 (7 Hours 10 Minutes)	>10,000 ft (>3 km)	Alternating between resting on mooring buoy and swimming. No observable change in behavior during PD.
		CSL (2)	1050 to 1130 (40 Minutes)	>10,000 ft (>3 km)	Alternating between resting on second mooring buoy and swimming. Moved off buoy when cargo ship tied up to buoy. No observable change in behavior during PD.
		CSL (1)	1730 to 1731 (1 Minute)	>10,500 ft (>3.2 km)	Swimming parallel to shore. Part of the previously documented mooring buoy group and therefore not included in the take tally count. No observable change in behavior during PD.
	Magnolia Site	None	NA	NA	NA
Tuesday, February 18, 2014	Construction Site	HS (1)	1100 to 1250 (1 Hour 50 Minutes)	>450 ft (>137 m)	Swimming, submerging, and surfacing. No observable change in behavior during PD. Outside Level B Harassment Zone and occurred more than 30 minutes prior to or following active PD and therefore was not included in the take tally count..
		HS (1)	1530 to 1600 (30 Minutes)	>450 ft (>137 m)	Swimming, submerging, and surfacing. No observable change in behavior during PD. Outside Level B Harassment Zone and occurred more than 30 minutes prior to or following active PD and therefore was not included in the take tally count..
	Alki Site	CSL (3)	0705 to 1700 (9 Hours 55 Minutes)	>10,000 ft (>3 km)	Alternating between resting on mooring buoy and swimming. No observable change in behavior during PD.
		CSL (3)	1705 to 1700 (9 Hours 55 Minutes)	>10,000 ft (>3 km)	Alternating between resting on second mooring buoy and swimming. No observable change in behavior during PD.
		CSL (1)	0710 to 0725 (15 Minutes)	>10,500 ft (>3.2 km)	Swimming parallel to shore. Not part of mooring buoy group. No observable change in behavior during PD.
		CSL (1)	1530 to 1540 (10 Minutes)	>10,500 ft (>3.2 km)	Swimming parallel to shore. Not part of mooring buoy group. No observable change in behavior during PD.
	Magnolia Site	None	NA	NA	NA
Wednesday, February 19, 2014	Construction Site	HS (1)	0930 to 1025 (55 Minutes)	>500 ft (>152 m)	Swimming, submerging, and surfacing. No observable change in behavior during PD. Outside Level B Harassment Zone and occurred more than 30 minutes prior to or following active PD and therefore was not included in the take tally count.
		HS (1)	1705 to 1710 (5 Minutes)	>600 ft (>183 m)	Swimming, submerging, and surfacing. No observable change in behavior during PD. Outside Level B Harassment Zone and occurred more than 30 minutes prior to or following active PD and therefore was not included in the take tally count.
	Alki Site	CSL (5)	1700 to 1600 (9 Hours)	>10,000 ft (>3 km)	Alternating between resting on mooring buoy and swimming. No observable change in behavior during PD.
		CSL (3)	0700 to 1600 (9 Hours)	>10,000 ft (>3 km)	Alternating between resting on second mooring buoy and swimming. No observable change in behavior during PD.
		CSL (1)	1015 to 1040 (25 Minutes)	>10,500 ft (>3.2 km)	Swimming parallel to shore. Not part of mooring buoy group. No observable change in behavior during PD.
	Magnolia Site	None	NA	NA	NA

TABLE B-2. DAILY SUMMARY OF SPECIES OBSERVED, TIME, DURATION, DISTANCE FROM PILE DRIVING, AND SPECIES BEHAVIOR PER MONITORING SITE

Date	Monitoring Site	Species Observed (number)	Time and Duration Observed	Distance from Pile Driving	Behavior
Thursday, February 20, 2014	Construction Site	HS (1)	0950 to 1005 (15 Minutes)	>450 ft (>137 m)	Swimming, submerging, and surfacing. No observable change in behavior during PD. Outside Level B Harassment Zone and therefore was not included in the take tally count.
	Alki Site	Impact pile driving only, no outer monitors			
	Magnolia Site	Impact pile driving only, no outer monitors			
Friday, February 21, 2014	No pile driving due to mechanical issues. Monitors on stand-by all day.				
Saturday, February 22, 2014	Construction Site	CSL (1)	1545 to 1700 (75 Minutes)	>300 ft (>91 m)	Swimming parallel to shore. No observable change in behavior during PD.
		HS (1)	1000 to 1015 (15 Minutes)	>250 ft (>76 m)	Swimming parallel to shore. No observable change in behavior during PD.
	Alki Site	CSL (4)	0700 to 1800 (11 Hours)	>10,000 ft (>3 km)	Alternating between resting on mooring buoy and swimming. No observable change in behavior during PD.
		CSL (5)	0700 to 1800 (11 Hours)	>10,000 ft (>3 km)	Alternating between resting on second mooring buoy and swimming. No observable change in behavior during PD.
		HS (1)	1300 to 1315 (15 Minutes)	>9,000 ft (>2.7 km)	Swimming off shoreline. No observable change in behavior during PD.
	Magnolia Site	None	NA	NA	NA
Sunday, February 23, 2014	Construction Site	HS (1)	1445 to 1452 (7 Minutes)	>800 ft (>244 m)	Swimming, submerging, and surfacing. No observable change in behavior during PD. Outside Level B Harassment Zone and therefore was not included in the take tally count.
	Alki Site	CSL (9)	0700 to 1800 (11 Hours)	>10,000 ft (>3 km)	Alternating between resting on mooring buoy and swimming. No observable change in behavior during PD.
		CSL (6)	0700 to 1800 (11 Hours)	>10,000 ft (>3 km)	Alternating between resting on second mooring buoy and swimming. No observable change in behavior during PD.
		CSL (1)	0815 to 0830 (15 Minutes)	>10,500 ft (>3.2 km)	Swimming off shore. Part of the previously documented mooring buoy group and therefore was not included in the take tally count. No observable change in behavior during PD.
		CSL (1)	1600 to 1625 (15 Minutes)	>10,500 ft (>3.2 km)	Swimming off shore. Part of the previously documented mooring buoy group and therefore was not included in the take tally count. No observable change in behavior during PD.
		CSL (1)	1620 to 1625 (5 Minutes)	>10,500 ft (>3.2 km)	Swimming near buoy. Part of the previously documented mooring buoy group and therefore was not included in the take tally count. No observable change in behavior during PD.
		CSL (1)	1640 to 1646 (6 Minutes)	>10,500 ft (>3.2 km)	Swimming near buoy. Part of the previously documented mooring buoy group and therefore was not included in the take tally count. No observable change in behavior during PD.
		HS (1)	0700 to 1800 (11 Hours)	>10,500 ft (>3.2 km)	Resting on beach. No observable change in behavior during PD.
		HS (1)	0800 to 0830 (30 Minutes)	>10,000 ft (>3 km)	Swimming off shoreline. No observable change in behavior during PD.
		HS (1)	1335 to 1345 (10 Minutes)	>10,000 ft (>3 km)	Swimming off shoreline. Assume same as previously documented and therefore not included in the take tally count. No observable change in behavior during PD.

TABLE B-2. DAILY SUMMARY OF SPECIES OBSERVED, TIME, DURATION, DISTANCE FROM PILE DRIVING, AND SPECIES BEHAVIOR PER MONITORING SITE

Date	Monitoring Site	Species Observed (number)	Time and Duration Observed	Distance from Pile Driving	Behavior
	Magnolia Site	HS (1)	0758 to 0804 (6 Minutes)	>15,000 ft (>4.6 km)	Swimming near shore outside Level B Harassment Zone and therefore was not included in the take tally count. No observable change in behavior during PD.
		HS (1)	0850 to 0851 (1 Minute)	>15,000 ft (>4.6 km)	Swimming near shore outside Level B Harassment Zone and therefore was not included in the take tally count. No observable change in behavior during PD.
		HS (1)	0933 to 0934 (1 Minute)	>15,000 ft (>4.6 km)	Swimming near shore outside Level B Harassment Zone and therefore was not included in the take tally count. No observable change in behavior during PD.
		HS (1)	1515 to 1722 (2 Hours 7 Minutes)	>15,000 ft (>4.6 km)	Swimming, submerging, and surfacing outside Level B Harassment Zone and therefore was not included in the take tally count. No observable change in behavior during PD.
Monday, February 24, 2014	Construction Site	None	NA	NA	NA
	Alki Site	CSL (9)	0700 to 1800 (11 Hours)	>10,000 ft (>3 km)	Alternating between resting on mooring buoy and swimming. No observable change in behavior during PD.
	Magnolia Site	None	NA	NA	NA
Tuesday, February 25, 2014	Construction Site	None	NA	NA	NA
	Alki Site	CSL (6)	0700 to 1800 (11 Hours)	>10,000 ft (>3 km)	Alternating between resting on mooring buoy and swimming. No observable change in behavior during PD.
	Magnolia Site	None	NA	NA	NA
Wednesday, February 26, 2014	Construction Site	None	NA	NA	NA
	Alki Site	CSL (6)	0700 to 1800 (11 Hours)	>10,000 ft (>3 km)	Alternating between resting on mooring buoy and swimming. No observable change in behavior during PD.
		CSL (1)	1015 to 1045 (30 Minutes)	>10,000 ft (>3 km)	Swimming parallel to shore. Not part of mooring buoy group. No observable change in behavior during PD.
	Magnolia Site	CSL (1)	0705 to 0715 (10 Minutes)	>15,000 ft (>4.6 km)	Swimming near shore outside Level B Harassment Zone and therefore was not included in the take tally count. No observable change in behavior during PD.
		CSL (1)	0920 to 0927 (7 Minutes)	>15,000 ft (>4.6 km)	Swimming near shore outside Level B Harassment Zone and therefore was not included in the take tally count. No observable change in behavior during PD.
		CSL (1)	1530 to 1534 (9 Minutes)	>15,000 ft (>4.6 km)	Swimming near shore outside Level B Harassment Zone and therefore was not included in the take tally count. No observable change in behavior during PD.
Thursday, February 27, 2014	Construction Site	HS (1)	1605 to 1610 (5 Minutes)	>600 ft (>183 m)	Swimming, submerging, and surfacing. No observable change in behavior during PD.
	Alki Site	CSL (7)	0700 to 1700 (11 Hours)	>10,000 ft (>3 km)	Alternating between resting on mooring buoy and swimming. No observable change in behavior during PD.
		CSL (1)	1315 to 1320 (5 Minutes)	>10,500 ft (>3.2 km)	Swimming parallel to shore. Not part of mooring buoy group. No observable change in behavior during PD.
	Magnolia Site	HS (1)	1200 to 1230 (30 Minutes)	>12,000 ft (>3.7 km)	Swimming, submerging, and surfacing. No observable change in behavior during PD.

TABLE B-2. DAILY SUMMARY OF SPECIES OBSERVED, TIME, DURATION, DISTANCE FROM PILE DRIVING, AND SPECIES BEHAVIOR PER MONITORING SITE

Date	Monitoring Site	Species Observed (number)	Time and Duration Observed	Distance from Pile Driving	Behavior
Friday, February 28, 2014	Construction Site	None	NA	NA	NA
	Alki Site	CSL (2)	1400 to 1500 (1 Hour)	>10,000 ft (>3 km)	Alternating between resting on mooring buoy and swimming. No observable change in behavior during PD.
		CSL (1)	1600 to 1815 (2 Hours 15 Minutes)	>10,000 ft (>3 km)	Alternating between resting on mooring buoy and swimming. Assume part of the previously documented buoy group and therefore was not included in the take tally count. No observable change in behavior during PD.
	Magnolia Site	None	NA	NA	NA
Saturday, March 01, 2014	Construction Site	HS (1)	1125 to 1200 (35 Minutes)	>1,000 ft (>305 m)	Swimming, submerging, and surfacing. No observable change in behavior during PD.
	Alki Site	CSL (4)	0700 to 1500 (8 Hours)	>10,000 ft (>3 km)	Alternating between resting on mooring buoy and swimming. No observable change in behavior during PD.
	Magnolia Site	CSL (1)	1702 to 1710 (8 Minutes)	>12,000 ft (>3.7 km)	Swimming west near shoreline. No observable change in behavior during PD.
Sunday, March 02, 2014	No pile driving occurred.				
Monday, March 03, 2014	Construction Site	HS (1)	1210 to 1214 (4 Minutes)	>700 ft (>213 m)	Swimming, submerging, and surfacing. No observable change in behavior during PD.
	Alki Site	CSL (5)	0700 to 1800 (11 Hours)	>10,000 ft (>3 km)	Alternating between resting on mooring buoy and swimming. No observable change in behavior during PD.
		CSL (1)	1235 to 1240 (5 Minutes)	>10,000 ft (>3 km)	Swimming parallel to shore. Not part of mooring buoy group. No observable change in behavior during PD.
	Magnolia Site	CSL (1)	1710 to 1715 (5 Minutes)	>15,000 ft (>4.6 km)	Swimming near shore outside Level B Harassment Zone and therefore was not included in the take tally count. No observable change in behavior during PD.
Tuesday, March 04, 2014	Construction Site	None	NA	NA	NA
	Alki Site	CSL (4)	0700 to 1650 (9 Hours 50 Minutes)	>10,000 ft (>3 km)	Alternating between resting on mooring buoy and swimming. No observable change in behavior during PD.
	Magnolia Site	None	NA	NA	NA
Wednesday, March 05, 2014	Construction Site	HS (1)	0817 to 0822 (5 Minutes)	>900 ft (>274 m)	Swimming, submerging, and surfacing. No observable change in behavior during PD.
	Alki Site	CSL (6)	0700 to 1530 (8 Hours 30 Minutes)	>10,000 ft (>3 km)	Alternating between resting on mooring buoy and swimming. No observable change in behavior during PD.
	Magnolia Site	None	NA	NA	NA
Thursday, March 06, 2014	Construction Site	None	NA	NA	NA
	Alki Site	CSL (10)	1705 to 1720 (15 Minutes)	>10,500 ft (>3.2 km)	Group swimming north off shore. No observable change in behavior during PD.
	Magnolia Site	None	NA	NA	NA

TABLE B-2. DAILY SUMMARY OF SPECIES OBSERVED, TIME, DURATION, DISTANCE FROM PILE DRIVING, AND SPECIES BEHAVIOR PER MONITORING SITE

Date	Monitoring Site	Species Observed (number)	Time and Duration Observed	Distance from Pile Driving	Behavior
Friday, March 07, 2014	Construction Site	None	NA	NA	NA
	Alki Site	CSL (4)	0730 to 1100 (3 Hours 30 Minutes)	>10,000 ft (>3 km)	Alternating between resting on mooring buoy and swimming. No observable change in behavior during PD.
		CSL (4)	1450 to 1800 (3 Hours 10 Minutes)	>10,000 ft (>3 km)	Alternating between resting on mooring buoy and swimming. Assume same individuals as previously documented mooring group and therefore was not included in the take tally count. No observable change in behavior during PD.
	Magnolia Site	CSL (1)	1734 to 1746 (12 Minutes)	>15,000 ft (>4.6 km)	Swimming near shore outside Level B Harassment Zone and therefore not included in the take tally count. No observable change in behavior during PD.
Saturday, March 08, 2014	Construction Site	HS (1)	0704 to 0705 (1 Minute)	>1,000 ft (>305 m)	Swimming, submerging, and surfacing. Occurred more than 30 minutes prior to or following active PD and therefore not included in the take tally count.
		HS (1)	0832 to 0833 (1 Minute)	>800 ft (>244 m)	Swimming, submerging, and surfacing. No observable change in behavior during PD.
	Alki Site	CSL (8)	0700 to 1200 (5 Hours)	>10,000 ft (>3 km)	Alternating between resting on mooring buoy and swimming. No observable change in behavior during PD.
		CSL (1)	0915 to 0920 (5 Minutes)	>10,000 ft (>3 km)	Swimming near shoreline. Assume to be part of the previously documented mooring group observations and therefore not included in the take tally count. No observable change in behavior during PD.
	Magnolia Site	HS (1)	0911 to 0914 (5 Minutes)	>11,000 ft (>3.4 km)	Swimming, submerging, and surfacing near shoreline. No observable change in behavior during PD.
		HS (1)	1134 to 1231 (57 Minutes)	>11,000 ft (>3.4 km)	Swimming, submerging, and surfacing near shoreline. No observable change in behavior during PD.
Sunday, March 09, 2014	No pile driving occurred.				
Monday, March 10, 2014	Construction Site	HS (1)	0857 to 0901 (4 Minutes)	>1,000 ft (>305 m)	Swimming, submerging, and surfacing parallel to shoreline. No observable change in behavior during PD.
		HS (1)	1330 to 1331 (2 Minutes)	>800 ft (>244 m)	Swimming, submerging, and surfacing parallel to shoreline. No observable change in behavior during PD.
	Alki Site	HS (1)	1730 to 1500 (7 Hours 30 Minutes)	>10,000 ft (>3 km)	Resting on marina dock. No observable change in behavior during PD.
		CSL (3)	1730 to 1500 (7 Hours 30 Minutes)	>10,000 ft (>3 km)	Alternating between resting on mooring buoy and swimming. No observable change in behavior during PD.
	Magnolia Site	None	NA	NA	NA

TABLE B-2. DAILY SUMMARY OF SPECIES OBSERVED, TIME, DURATION, DISTANCE FROM PILE DRIVING, AND SPECIES BEHAVIOR PER MONITORING SITE

Date	Monitoring Site	Species Observed (number)	Time and Duration Observed	Distance from Pile Driving	Behavior
Tuesday, March 11, 2014	Construction Site	HS (1)	1021 to 1025 (4 Minutes)	>1,000 ft (>305 m)	Swimming, submerging, and surfacing parallel to shoreline. No observable change in behavior during PD.
	Alki Site	CSL (5)	1930 to 1330 (4 Hours)	>10,000 ft (>3 km)	Alternating between resting on mooring buoy and swimming. No observable change in behavior during PD.
		HS (1)	0930 to 0940 (10 Minutes)	>11,000 ft (>3.4 km)	Swimming, submerging, and surfacing near shoreline. No observable change in behavior during PD.
		HS (1)	1310 to 1317 (7 Minutes)	>11,000 ft (>3.4 km)	Swimming, submerging, and surfacing near shoreline. No observable change in behavior during PD.
	Magnolia Site	HS (1)	0915 to 1112 (1 Hour 57 Minutes)	>15,000 ft (>4.6 km)	Swimming, submerging, and surfacing outside Level B Harassment Zone and therefore not included in the take tally count. No observable change in behavior during PD.

Notes:

CSL = California Sea Lion

HS = Harbor Seal

PD = Pile Driving

NA = Not Applicable

ft = feet

km = kilometer

m = meter

TABLE B-3. DAILY SUMMARY OF DOCUMENTED TAKES PER SPECIES AND MONITORING SITE

Date	California Sea Lion				Harbor Seal			
	Construction Site	Alki Site	Magnolia Site	Total Takes	Construction Site	Alki Site	Magnolia Site	Total Takes
Tuesday, February 11, 2014	0	5	0	**5**	0	1	0	**1**
Wednesday, February 12, 2014	0	8	0	**8**	0	0	0	**0**
Thursday, February 13, 2014	0	9	0	**9**	0	1	0	**1**
Friday, February 14, 2014	0	10	0	**10**	0	1	0	**1**
Saturday, February 15, 2014	0	11	0	**11**	0	1	0	**1**
Sunday, February 16, 2014	0	9	0	**9**	0	0	0	**0**
Monday, February 17, 2014	0	9	0	**9**	1	0	0	**1**
Tuesday, February 18, 2014	0	8	0	**8**	0	0	0	**0**
Wednesday, February 19, 2014	0	9	0	**9**	0	0	0	**0**
Thursday, February 20, 2014	0	NA	NA	**0**	0	NA	NA	**0**
Friday, February 21, 2014	NA	NA	NA	**0**	NA	NA	NA	**0**
Saturday, February 22, 2014	1	9	0	**10**	1	1	0	**2**
Sunday, February 23, 2014	0	15	0	**15**	0	2	0	**2**
Monday, February 24, 2014	0	9	0	**9**	0	0	0	**0**
Tuesday, February 25, 2014	0	6	0	**6**	0	0	0	**0**
Wednesday, February 26, 2014	0	7	0	**7**	0	0	0	**0**
Thursday, February 27, 2014	0	8	0	**8**	1	0	1	**2**
Friday, February 28, 2014	0	2	0	**2**	0	0	0	**0**
Saturday, March 01, 2014	0	4	1	**5**	1	0	0	**1**
Sunday, March 02, 2014	NA	NA	NA	**0**	NA	NA	NA	**0**
Monday, March 03, 2014	0	6	0	**6**	1	0	0	**1**
Tuesday, March 04, 2014	0	4	0	**4**	0	0	0	**0**
Wednesday, March 05, 2014	0	6	0	**6**	1	0	0	**1**
Thursday, March 06, 2014	0	10	0	**10**	0	0	0	**0**
Friday, March 07, 2014	0	4	0	**4**	0	0	0	**0**
Saturday, March 08, 2014	0	8	0	**8**	1	0	2	**3**
Sunday, March 09, 2014	NA	NA	NA	**0**	NA	NA	NA	**0**
Monday, March 10, 2014	0	3	0	**3**	2	1	0	**3**
Tuesday, March 11, 2014	0	5	0	**5**	1	2	0	**3**
Total	**1**	**184**	**1**	**186**	**10**	**10**	**3**	**23**
Average	**0.04**	**7.36**	**0.04**	**6.41**	**0.38**	**0.40**	**0.12**	**0.79**

NA = Not Applicable, no pile driving or impact pile driving only so no outer monitors.

TABLE B-4. SUMMARY OF DOCUMENTED TAKES PER SPECIES AND MONITORING SITE

California Sea Lion				Harbor Seal			
Construction Site	Alki Site	Magnolia Site	Total Takes	Construction Site	Alki Site	Magnolia Site	Total Takes
1	184	1	186	10	10	3	23

ELLIOTT BAY SEAWALL PROJECT SEASON 1 (2014)
ACOUSTIC MONITORING REPORT
(NWS-2011-778-WRD and NWR-2013-10650)

August 27, 2014

Prepared For:

City of Seattle Department of Transportation

Prepared By:

THE GREENBUSCH GROUP, INC.

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1.0 EXECUTIVE SUMMARY

This technical report presents the results of airborne and underwater sound level measurements conducted between February 12 and 24, 2014 during impact pile driving of 11 concrete piles and vibratory driving of 12 steel sheet piles during Season 1 (2013/2014 in-water work window) of the Elliott Bay Seawall Project ("Project").

Impact driven concrete piles had broadband underwater peak values between 144 and 202 decibels (dB) re: 1 micropascal (µPa) and 90% root mean square (RMS) values between 134 and 179 dB re: 1 µPa. Vibratory driven steel sheet piles had broadband underwater peak values between 140 and 193 and RMS values between 130 and 168 dB re: 1 µPa.

The average distance required for underwater sound levels to reach the 160 dB isopleth was 341 meters for impact driven concrete piles installed in Zone 1, located south of Colman Dock and 35 meters in Zone 4, located near Waterfront Park. Figure 3.1 presents the locations of Zone 1 and Zone 4 graphically. The average distance required for the RMS sound levels from vibratory sheet pile installation to reach the 120 dB isopleth was 11,188 meters in Zone 1 and 9,321 meters in Zone 4. The average distance to reach background sound level was 215 meters for impact concrete piles and 15 meters for vibratory steel sheets in Zone 1, and 1,610 meters for impact piles and 932 meters and vibratory sheets in Zone 4.

2.0 INTRODUCTION

This technical report presents the results of airborne and underwater sound levels measured during vibratory and impact pile driving activities associated with Season 1 (2013/2014 in-water work window) of the Elliott Bay Seawall Project ("Project").

Per the National Marine Fisheries Service (NMFS) Marine Mammal Protection Act Letter of Authorization (LOA) and Endangered Species Act (ESA) Incidental Take Statement, sound level monitoring is required for the first five steel piles and the first five concrete piles driven at the start of each construction season. This acoustic monitoring technical report fulfills the requirements of the LOA and ESA Incidental Take Statement.

Installation of steel and concrete piles took place in two different construction zones during Season 1 (see Section 3.0 of this technical report). Airborne and underwater sound levels were measured at both of these locations between February 12 and 24, 2014. Marine mammal monitoring began on February 11, 2014. The start of acoustic monitoring did not coincide with the beginning of marine mammal monitoring because activities on February 11 were limited to installation of the sheet pile guide, which was considered falsework and did not require acoustic monitoring. During Season 1, sound levels from 12 steel sheet piles (vibratory installation) and 11 concrete piles (impact installation) were measured. While the LOA only requires monitoring of the first five steel piles and first five concrete piles per construction season, site conditions and measured underwater sound levels in excess of the limits established in the LOA warranted monitoring of additional steel piles to verify the effectiveness of mitigation measures implemented to reduce underwater pile driving sound levels.

3.0 PROJECT AREA

The construction area is located on Alaskan Way between Washington Street and Virginia Street in Seattle, Washington.

During Season 1, construction pile driving activities took place in two separate locations as shown in Figure 3.1. The southern location was in Zone 1, which is located south of Colman Dock and the northern location was in Zone 4, which is located near Waterfront Park. The Figure below illustrates the project location and the locations of Zones 1 and 4.

Figure 3.1 Season 1 Construction Zones

Source: The Greenbusch Group, Google Earth Pro, Anchor QEA

4.0 NOMENCLATURE

The auditory response to sound is a complex process that occurs over a wide range of frequencies and intensities. Decibel levels, or "dB," are a form of shorthand that compresses this broad range of levels with a convenient numerical scale. The dB scale is logarithmic. For example, using the dB scale, a doubling or halving of energy causes the sound level to change by 3 dB, it does not double or half the perceived loudness as might be expected.

Decibels are defined as the squared ratio of the sound pressure level (SPL) with a reference sound pressure. The reference pressure for airborne sound is 20 micropascals (μPa) and for underwater sound the reference pressure is 1 μPa. The use of 20 μPa in air is convenient because 1 dB re: 20 μPa correlates to the human threshold for hearing. It is important to note that because of these different reference pressures airborne and underwater sound levels cannot be directly compared.

The following descriptors are referenced in this Report:

- **Ambient Sound Level**

  The ambient sound level is the sound pressure level that describes the sound environment at a specified location during a specified time period and is also referred to as "background sound levels". The measured sound levels include contributions from all sound sources, both local and distance, excluding specific sound sources of interest or under investigation. Average background RMS sound levels measured during Season 1 were 163 dB in Zone 1 and 135 dB in Zone 4.

- **Peak**

  The peak sound pressure level is the instantaneous absolute maximum pressure observed during a measured event. Peak pressure can be presented as a pressure or dB referenced to a standard pressure (20 μPa for airborne and 1 μPa for underwater). Peak sound pressure is commonly used during hydroacoustic monitoring to assess the potential injuries to fish.

- **Root Mean Square (RMS)**

  The RMS level is the square root of the average squared-pressure over a given time period. In hydroacoustics, the RMS level has been used by the National Marine Fisheries Service (NMFS) in criteria for assessing impacts to marine mammals.

5.0 REGULATORY CRITERIA

The LOA and ESA Biological Opinion identify maximum permissible underwater sound level limits for in-water pile driving activities. These sound level limits are presented in Table 5.1.

Table 5.1 Underwater Sound Level Limits, dB re: 1 μPa

Pile Type and Approximate Size	Method	Relative Water Depth of Piles	Average Sound Pressure Measured in dB	
			Peak	RMS
16.5 inch diameter precast concrete octagonal pile	Impact	~15 meters	188	176
Steel sheet pile pair, 48 inches long per pair	Vibratory (Installation and Removal)	~15 meters	182	165
Steel sheet pile pair, 48 inches long per pair	Impact (Installation Proofing)	~15 meters	205	190

Source: MMPA Letter of Authorization Rule (California Department of Transportation, Washington State Department of Transportation)

These sound level limits are established 10 meters from the pile. The peak sound pressure level is the highest absolute value of the instantaneous pressure measured by the hydrophones, at a distance of 10 meters. The RMS sound pressure is the root-mean-square pressure that contains 90% of the energy within the pile strike.

6.0 METHODOLOGY

6.1 Equipment

Equipment used for airborne and underwater noise measurements is identified in Table 6.1.

Table 6.1 Airborne and Underwater Sound Measurement Equipment

Make and Model	Quantity	Description	Serial Number
Airborne			
Bruel and Kjaer 2250	1	Sound Level Analyzer	2679351
Bruel and Kjaer 4189	1	Microphone	2550228
Bruel and Kjaer ZC 0032	1	Preamplifier	9437
Bruel and Kjaer Type 4231	1	Acoustic Calibrator	0013
Underwater			
Reson TC-4013	4	Hydrophone	2513054
			712213
			2513074
			1812260
Bruel and Kjaer Type 2647 A	3	Charge Converter (1mV/pC)	2638259
			2638260
			2582112
Bruel and Kjaer Type 2647 B	1	Charge Converter (10mV/pC)	2293151
G.R.A.S. Pistonphone	1	Calibrator	160184
National Instruments NI USB-4431	1	4 Channel DAQ	14F31A5
Getac S400	1	Laptop Computer	RBB39S0072

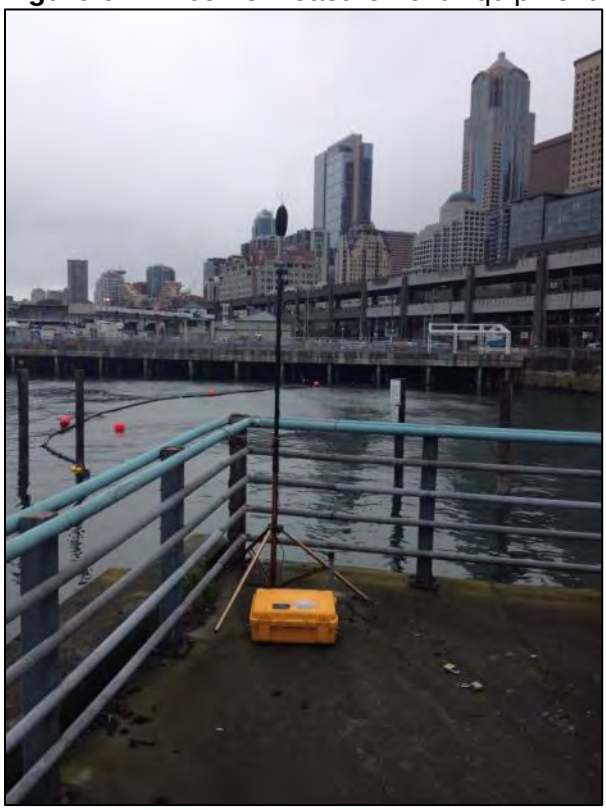
Source: The Greenbusch Group

All equipment was factory calibrated within 1 year of the measurement date. Field calibration measurements were performed before each day of monitoring and verified at the end of the day. Calibration tones were also recorded from each hydrophone before every day of monitoring. Hydrophones were calibrated using the G.R.A.S. pistonphone.

Hydrophones were attached to charge converters. These charge converters were then attached to a laptop-based 4-channel data acquisition system. The laptop recorded the time waveforms from each pile driving event for subsequent signal analysis. This equipment setup allowed for real-time approximations of peak sound levels while the measurements were being performed.

Photos illustrating the airborne and hydroacoustic measurement equipment are provided below.

Figure 6.1 Airborne Measurement Equipment



Source: The Greenbusch Group, Inc.

Figure 6.2 Hydroacoustic Equipment

Source: The Greenbusch Group, Inc.

6.2 Measurement Locations

Airborne sound levels measurements were conducted at a stationary location during all measured pile driving events. The distance from the measurement location to the pile was recorded to allow the data to be normalized to a standardized required reference distance of 50 feet (15 meters).

Hydroacoustic monitoring was performed using up to four hydrophones at various depths and distances from the piles. The number of hydrophones used and their locations varied depending upon the depth of the water, pile location, and safety concerns.

The airborne and hydroacoustic measurement locations for Zones 1 and 4 are discussed in the Report Sections below.

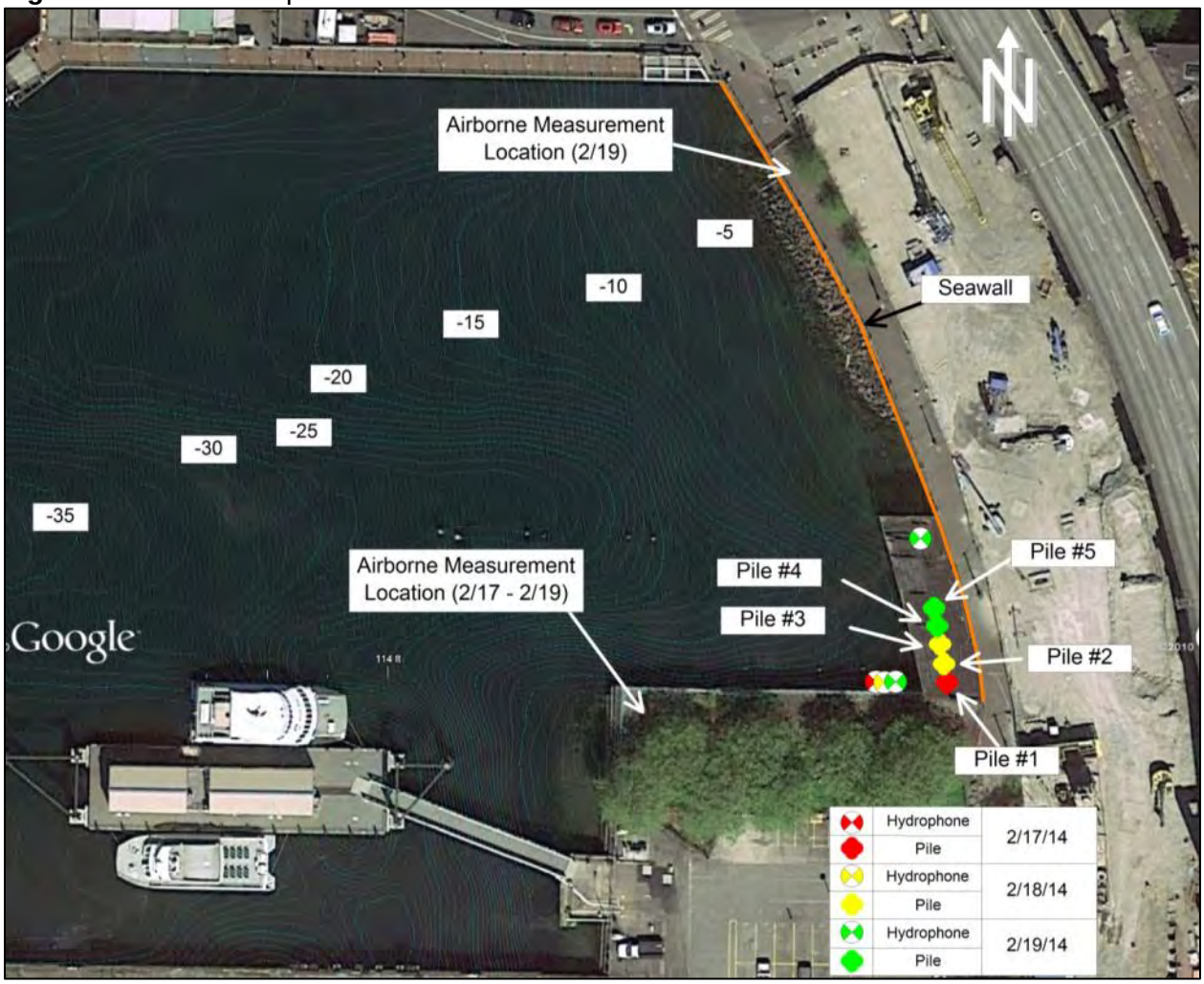
6.2.1 Zone 1

Measurements of impact-driven concrete piles were performed in Zone 1 between February 17 and February 19, 2014. Vibratory sheet pile monitoring was conducted on February 24, 2014.

6.2.1.1 Impact-Driven Concrete Piles

Airborne and underwater measurements of sound generated by impact-driven concrete piles in Zone 1 were conducted between February 17 and February 19, 2014. One hydrophone was deployed approximately 33 feet (10 meters) from the piles at a depth of 3 feet (1 meter) below the surface. The hydrophone was relocated for each pile to maintain a distance of 33 feet (10 meters) from the pile. Figure 6.3 illustrates the locations of the piles, airborne sound level meter, and hydrophone during impact pile driving in Zone 1.

Figure 6.3 Zone 1 - Impact Pile and Measurement Locations

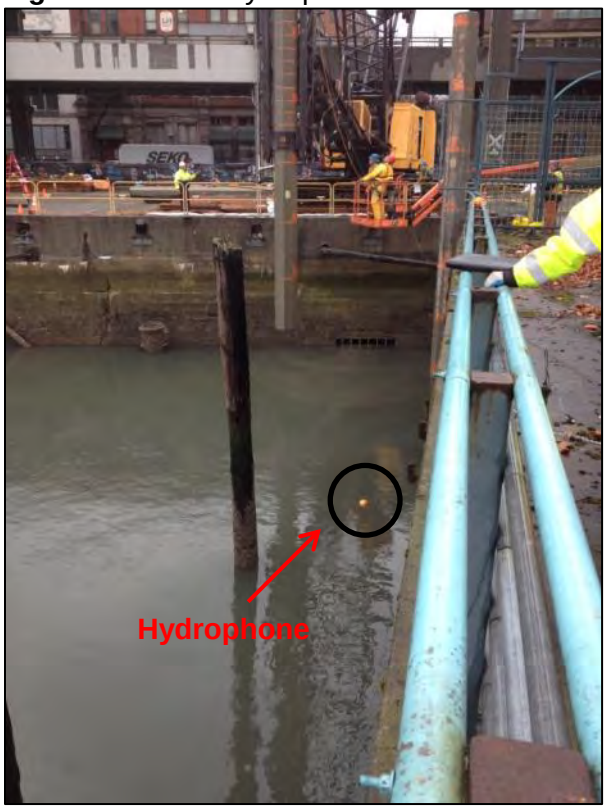


Source: The Greenbusch Group Inc.

The hydrophone was deployed to the west and southwest of the first four concrete piles. However, due to safety concerns the hydrophone was relocated north of Pile 5 on February 19, 2014. A direct line of acoustic transmission was maintained between the hydrophone and the

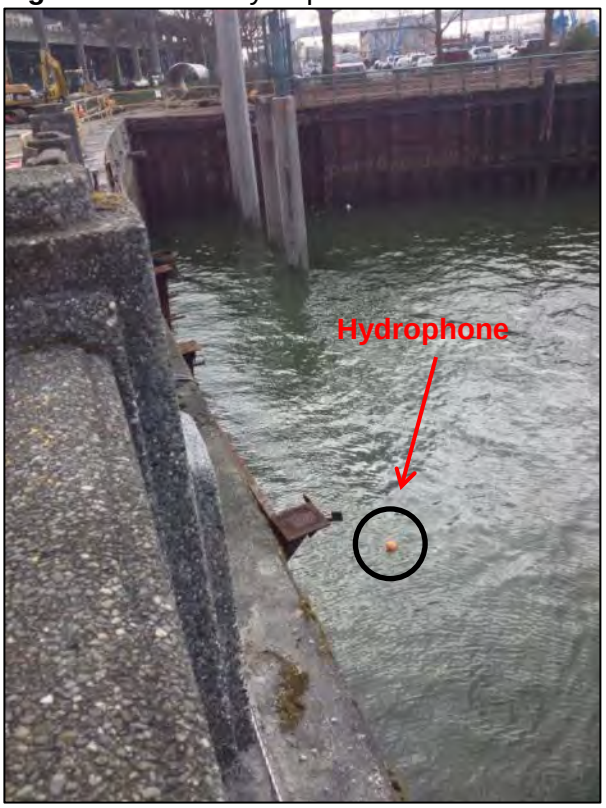
pile being driven. Photos of the western hydrophone deployment location and the north hydrophone location are shown below.

Figure 6.4 West Hydrophone Location



Source: The Greenbusch Group, Inc.

Figure 6.5 North Hydrophone Location



Source: The Greenbusch Group, Inc.

Table 6.2 presents the depth of the hydrophone, water depth, and distance between the hydrophone and the pile.

Table 6.2 Zone 1 Hydrophone Location Information for Impact-Driven Concrete Piles

Pile	Water Depth	Hydrophone Depth	Distance to Pile
Pile #1	~8 feet	~3 feet	~33 feet
Pile #2	~8 feet	~3 feet	~33 feet
Pile #3	~8 feet	~3 feet	~33 feet
Pile #4	~8 feet	~3 feet	~33 feet
Pile #5	~8 feet	~3 feet	~33 feet

Source: The Greenbusch Group, Inc.

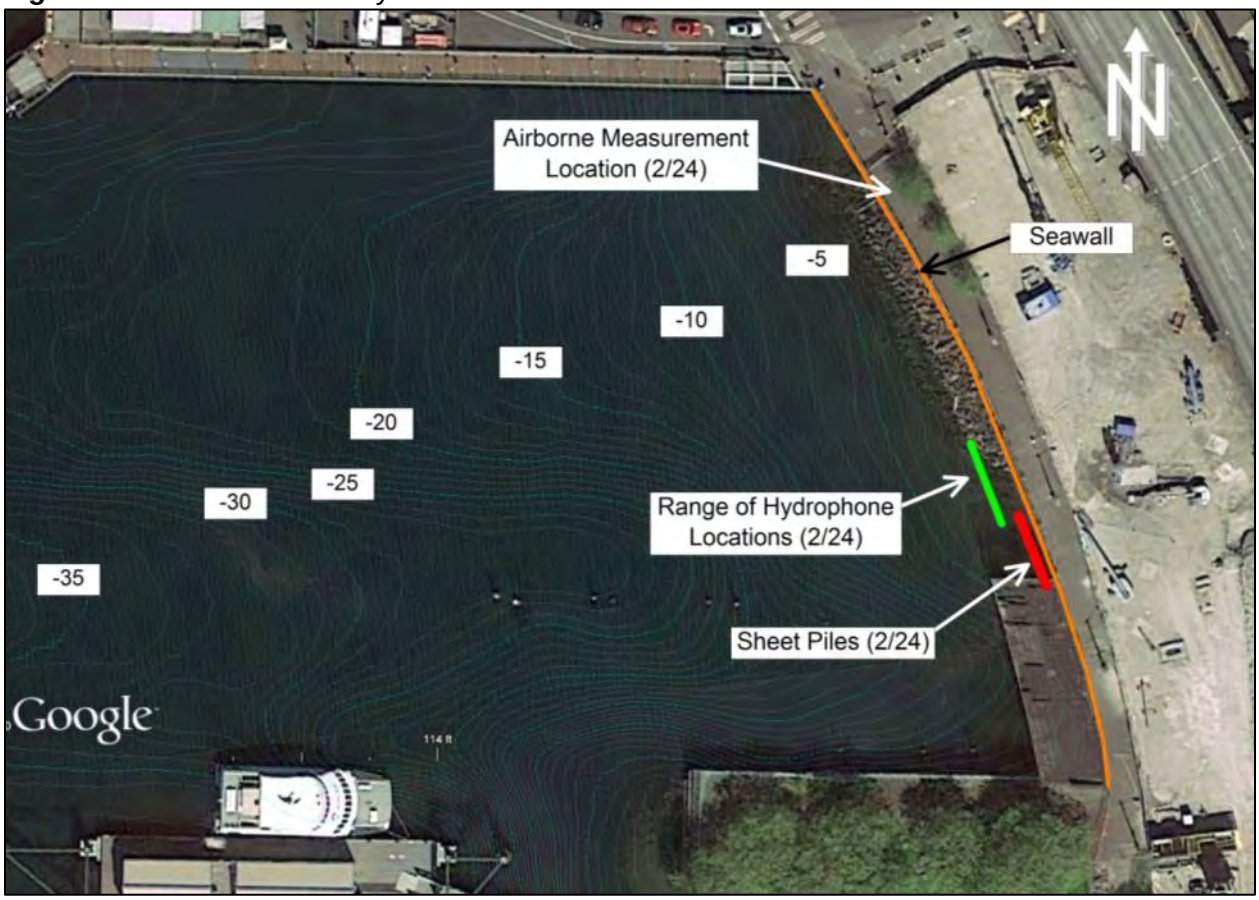
6.2.1.2 Vibratory Steel Sheet Piles

Airborne and underwater measurements were conducted to measure sound generated by vibratory steel pile installation on February 24, 2014. While the first five vibratory sheet piles were also monitored in Zone 4, a clear line of acoustic transmission could not be obtained in Zone 4 due to access restrictions. As a result, National Oceanic and Atmospheric Administration (NOAA) requested additional monitoring in Zone 1 to measure sound levels with a direct line of acoustic transmission between the hydrophone and sheet piles.

Measurements made during vibratory steel pile installation took place north of the sheet piles. Sheet piles were installed beginning to the south and working north throughout the day. The hydrophone was deployed north of the sheet piles and was relocated before each pile drive to maintain a 33 foot (10 meter) distance from the northern edge of the sheet piles. The hydrophone maintained a depth of 3 feet (1 meter) below the surface for the duration of the measurements. A direct line of acoustic transmission was maintained between the hydrophone and the sheet pile being driven. Data was logged continuously with summary periods of 10 seconds.

Figure 6.6 illustrates the locations of the vibratory piles, hydrophone deployment locations and airborne measurement location.

Figure 6.6 Zone 1 – Vibratory Steel Sheet Pile and Measurement Locations



Source: The Greenbusch Group, Inc.

Table 6.3 presents the depth of the hydrophone, water depth, and distance between the hydrophone and the pile.

Table 6.3 Zone 1 Hydrophone Location Information for Vibratory Sheet Pile Installation

Sheet	Water Depth	Hydrophone Depth	Distance to Pile
Sheet #1	~8 feet	~3 feet	~33 feet
Sheet #2	~8 feet	~3 feet	~33 feet
Sheet #3	~7 feet	~3 feet	~33 feet
Sheet #4	~7 feet	~3 feet	~33 feet
Sheet #5	~7 feet	~3 feet	~33 feet
Sheet #6	~6 feet	~3 feet	~33 feet
Sheet #7	~6 feet	~3 feet	~33 feet

Source: The Greenbusch Group, Inc.

6.2.2 Zone 4

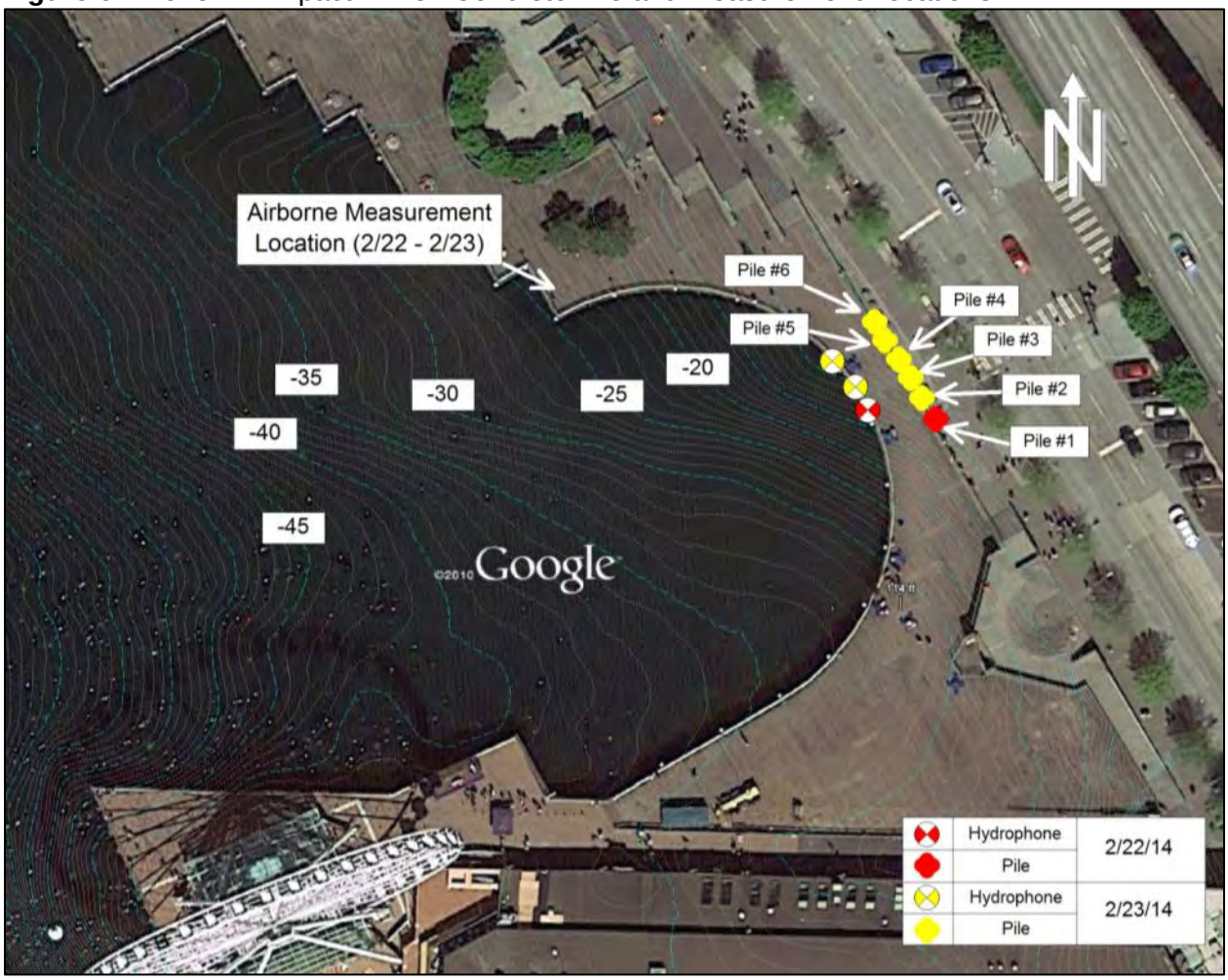
Measurements of impact-driven concrete piles were performed in Zone 4 on February 22 and February 23, 2014. Vibratory sheet pile monitoring was conducted on February 12 and February 13, 2014.

6.2.2.1 Impact-Driven Concrete Piles

The first five concrete piles were monitored in Zone 1, however underwater sound levels exceeded the limits specified in MMPA LOA by as much as 14 dB. Concrete piles in Zone 1 were driven near the intersection of the Seawall and a sheet pile wall located at the south side of Zone 1. Because the piles were driven near the corner of the existing seawall and sheet pile wall, it was unclear if the measured sound levels were being artificially increased by reflections off of these walls. To determine whether the exceedances of sound limits specified in the MMPA LOA measured in Zone 1 were the result of these site specific conditions, measurements were also made during impact driven concrete pile installation in Zone 4.

Measurements of impact-driven concrete piles were performed on February 22 and February 23, 2014. Three hydrophones were used to measure underwater sound levels in Zone 4. Two hydrophones were deployed approximately 33 feet (10 meters) away from the piles. One hydrophone was 3 feet (1 meter) below the surface and the other maintained a depth of approximately 10 feet (3 meters). Water depth near the hydrophone was approximately 12 feet (3.7 meters). Figure 6.7 illustrates the locations of the piles, airborne sound level meter, and hydrophones during impact pile driving in Zone 4.

Figure 6.7 Zone 4 – Impact-Driven Concrete Pile and Measurement Locations



Source: The Greenbusch Group, Inc.

Table 6.4 presents the depth of the hydrophone, water depth, and distance between the hydrophone and the pile.

Table 6.4 Zone 4 Hydrophone Location Information for Impact-Driven Concrete Piles

Pile	Water Depth	Hydrophone	Hydrophone Depth	Distance to Pile
Pile #1	~13 feet	Upper	~3 feet	~33 feet
		Lower	~10 feet	
Pile #2	~12 feet	Upper	~3 feet	~33 feet
		Lower	~10 feet	
Pile #3	~12 feet	Upper	~3 feet	~33 feet
		Lower	~10 feet	
Pile #4	~12 feet	Upper	~3 feet	~33 feet
		Lower	~10 feet	
Pile #5	~10 feet	Upper	~3 feet	~33 feet
		Lower	~10 feet	
Pile #6	~10 feet	Upper	~3 feet	~33 feet
		Lower	~10 feet	

Source: The Greenbusch Group, Inc.

6.2.2.2 Vibratory Steel Sheet Piles

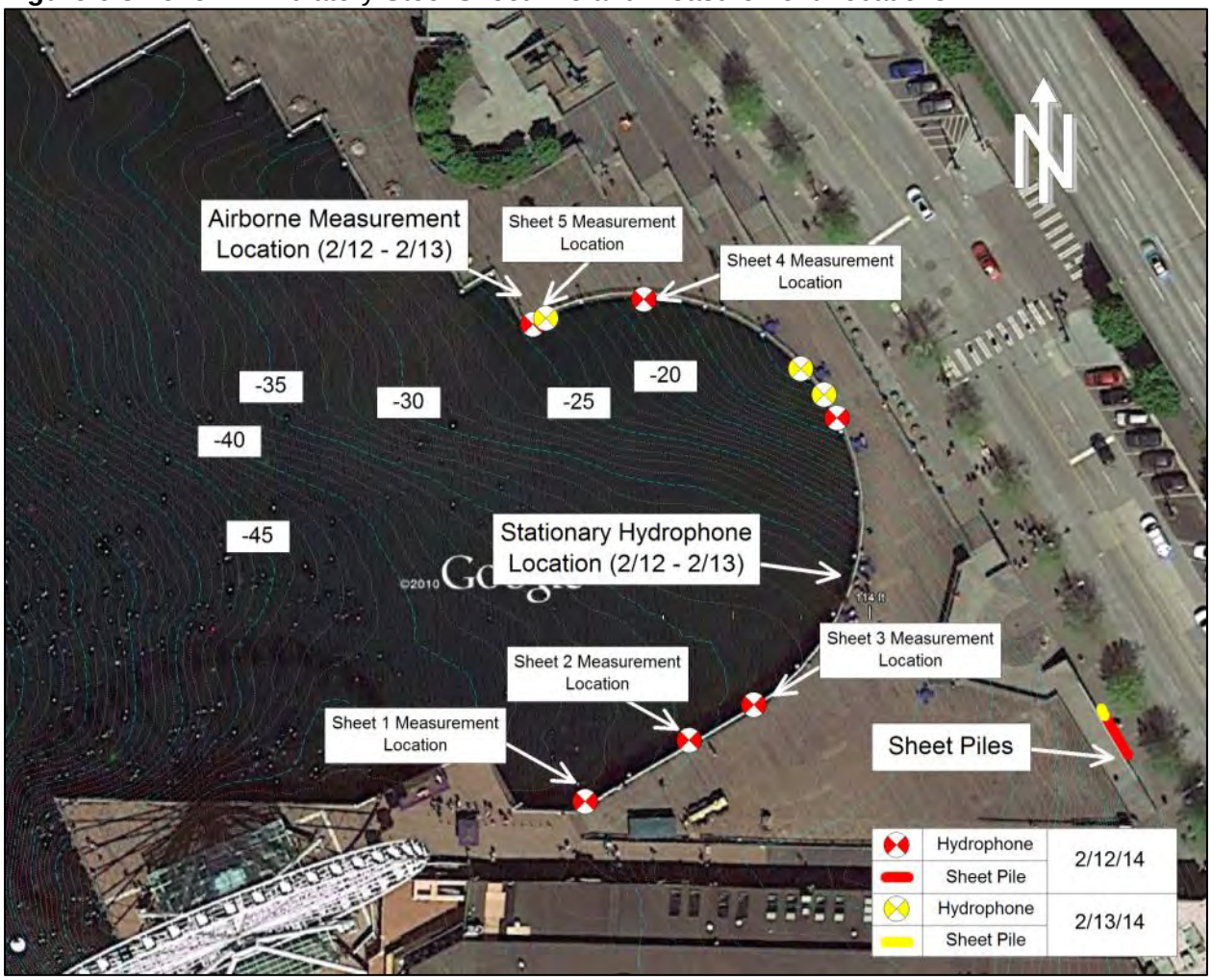
Measurements were conducted for vibratory steel sheet pile installation in Zone 4 on February 12 and February 13, 2014. Two hydrophones were positioned at a depth of 3 feet (1 meter) and two were positioned at 70% to 85% of the total water depth.

During the measurements, one set of hydrophones were positioned as close to the vibratory steel sheet installation as possible, approximately 140 feet (43 meters) away. The other set of hydrophones changed locations between the pile drives to achieve multiple samples at different distances from the piles for calculation of the transmission loss in Zone 4.

The sheet piles were installed on the landward side of the Waterfront Park dock. The existing dock pilings prevented the hydrophones from being deployed to maintain a direct line of acoustic transmission. Further vibratory steel sheet pile measurements were conducted in Zone 1 where a direct line of acoustic transmission was able to be achieved.

Figure 6.8 illustrates the locations of the vibratory piles, hydrophone deployment locations, and airborne measurement locations.

Figure 6.8 Zone 4 – Vibratory Steel Sheet Pile and Measurement Locations



Source: The Greenbusch Group, Inc.

The depths of the hydrophones at each measurement location are presented in Table 6.5.

Table 6.5 Zone 4 Hydrophone Location for Vibratory Steel Pile Installation

Sheet Pile Measurement Location	Hydrophone Location	Hydrophone Depth	Distance between Hydrophones	Distance to Piles	Total Water Depth
Stationary	Upper	~3 feet	24 feet	~112-131 feet	~38 feet
	Lower	~27 feet			
Location 1	Upper	~3 feet	29 feet	~226 feet	~40 feet
	Lower	~32 feet			
Location 2	Upper	~3 feet	29 feet	~180 feet	~40 feet
	Lower	~32 feet			
Location 3	Upper	~3 feet	29 feet	~148 feet	~45 feet
	Lower	~32 feet			
Location 4	Upper	~3 feet	29 feet	~259 feet	~30 feet
	Lower	~32 feet			
Location 5	Upper	~3 feet	22 feet	~282 feet	~30 feet
	Lower	~25 feet			

Source: The Greenbusch Group, Inc.

6.3 Pile and Driving Information

Concrete piles were driven with an APE Model D62-42 Single Acting Diesel Impact Hammer with a maximum striking energy of 153,799 foot-pounds. The weight of the ram was 13,671 pounds with a rated stroke of 11.25 feet and generated between 34 and 53 blows per minute. A six inch plywood pile cushion was used on top of the 24-inch concrete piles. A cut sheet of the hammer and pile cushion can be found in the Appendix of this Report.

Steel sheet piles were driven using an APE Model 250VM Vibratory Driver/Extractor operating at 1,750 VPM generating a driving force of 196 US tons. The suspended weight with clamp and 75 feet of hose is 17,500 pounds. A cut sheet of the vibratory driver can be found in the Appendix of this Report.

The following Sections contain information about the piles driven in Zone 1 and Zone 4.

6.3.1 Zone 1

Sound levels were measured for five 56-foot-long, 24-inch-diameter, pre-stressed octagonal concrete piles in Zone 1 between February 17 and February 19, 2014. Piles were driven to a depths ranging between approximately 18 feet to 36 feet (see Table 6.6).

In addition to the five concrete piles, sound levels were also measured for seven pairs of 50-foot-long, 24-inch steel sheet piles on February 24, 2014. Measured sheet piles were driven to a depth of approximately 25 feet (see Table 6.7).

The substrate the concrete and sheet piles were driven into in Zone 1 was hard and rocky.

6.3.1.1 Impact-Driven Concrete Piles

Table 6.6 below presents a summary of the concrete piles which were driven in Zone 1 during airborne and underwater sound monitoring.

Table 6.6 Zone 1 Impact-Driven Concrete Piles

Pile Number	Pile Size and Type	Sound Attenuation	Date Driven	Water Depth	Distance to Water's Edge	Depth into Substrate	Number of Strikes
1	24" Diameter Concrete	6" Pile Cushion	2/17/14	~3 feet	~12 feet	18 feet	411
2	24" Diameter Concrete	6" Pile Cushion	2/18/14	~3 feet	~12 feet	25 feet	482
3	24" Diameter Concrete	6" Pile Cushion	2/18/14	~3 feet	~12 feet	36 feet	846
4	24" Diameter Concrete	6" Pile Cushion	2/19/14	~3 feet	~12 feet	35 feet	739
5	24" Diameter Concrete	6" Pile Cushion	2/19/14	~3 feet	~12 feet	30.5 feet	640

Source: The Greenbusch Group, Inc., Manson Construction, Anchor QEA

6.3.1.2 Vibratory Steel Sheet Piles

Table 6.7 below presents a summary of the sheet piles which were driven in Zone 1 during airborne and underwater monitoring.

Table 6.7 Zone 1 Vibratory Steel Sheet Piles

Sheet Number	Pile Size and Type	Sound Attenuation	Date Driven	Water Depth	Distance from Pile to Water's Edge	Depth into Substrate	Drive Time (min.)
1	AZ26-700N Pair	None	2/24/14	~3 feet	~6 feet	25 feet	15
2	AZ26-700N Pair	None	2/24/14	~3 feet	~6 feet	25 feet	12
3	AZ26-700N Pair	Reduced throttle setting	2/24/14	~3 feet	~6 feet	25 feet	22
4	AZ26-700N Pair	Reduced throttle setting	2/24/14	~3 feet	~6 feet	25 feet	13
5	AZ26-700N Pair	Reduced throttle setting	2/24/14	~3 feet	~6 feet	25 feet	12
6	AZ26-700N Pair	Reduced throttle setting	2/24/14	~3 feet	~6 feet	25 feet	12
7	AZ26-700N Pair	Reduced throttle setting	2/24/14	~3 feet	~6 feet	25 feet	15

Source: The Greenbusch Group, Inc., Manson Construction, Anchor QEA

As described in Section 7.1.3 measured underwater sound levels during Pile 1 and Pile 2 exceeded the sound level limits identified in the LOA and ESA Biological Opinion. In response

to these exceedances, the energy of the vibratory driver was reduced until compliance with the sound level limits was achieved.

6.3.2 Zone 4

Six 74-foot-long, 24-inch-diameter, pre-stressed octagonal concrete piles were measured in Zone 4 on February 22 and February 23, 2014. Piles were driven to depths ranging from approximately 44 to 52 feet (see Table 6.8).

In addition to the six concrete piles, five pairs of 60-foot-long, 24-inch steel sheet piles were also measured between February 12 and 13, 2014. Measured sheet piles were driven to a depth of approximately 33 feet (see Table 6.9).

The substrate the concrete and sheet piles were driven into in Zone 4 was softer than Zone1.

6.3.2.1 Impact-Driven Concrete Piles

Table 6.8 presents a summary of the concrete piles which were driven in Zone 4 during airborne and underwater sound level monitoring.

Table 6.8 Zone 4 Impact-Driven Concrete Piles

Pile Number	Pile Size and Type	Sound Attenuation	Date Driven	Water Depth	Distance from Pile to Water's Edge	Depth into Substrate	Number of Strikes
1	24" Diameter Concrete	6" pile cushion	2/22/14	~4 feet	~6 feet	52 feet	575
2	24" Diameter Concrete	6" pile cushion	2/23/14	~4 feet	~6 feet	48.5 feet	630
3	24" Diameter Concrete	Reduced fuel setting, 6" pile cushion	2/23/14	~4 feet	~6 feet	47 feet	501
4	24" Diameter Concrete	Reduced fuel setting, 6" pile cushion, new pile cushion inserted part way through drive	2/23/14	~4 feet	~6 feet	45 feet	387
5	24" Diameter Concrete	Reduced fuel setting, 6" pile cushion, new pile cushion inserted part way through drive	2/23/14	~4 feet	~6 feet	45 feet	458
6	24" Diameter Concrete	Reduced fuel setting, two 6" pile cushions installed at beginning of drive	2/23/14	~4 feet	~6 feet	44 feet	433

Source: The Greenbusch Group, Inc., Manson Construction, Anchor QEA

In response to measured underwater sound levels exceeding the sound level limits identified in the LOA and Biological Opinion by as much as 5 dB on the initial piles, mitigation measures were implemented during the drives of Piles 3 through 6.

During Pile 3, a lower fuel setting was used on the hammer (fuel setting 2), but the sound level measurements showed the peak sound level limits was still exceeded by 3 dB. In response to the exceedance, the Contractor attempted to utilize the lowest fuel setting (fuel setting 1), but was unable to maintain proper operation of the hammer in this condition. Between Pile 3 and Pile 4, maintenance was performed on the hammer and the lowest fuel setting (fuel setting 1) was able to be maintained. During the drive of Pile 4, the lowest fuel setting was used and a new pile cushion was inserted between the pile and the existing cushion partway through the drive. However, the peak level was still exceeded by 3 dB on the first strike after the new cushion was inserted. The remaining pile strikes were all below the peak threshold and it was decided this attenuation technique would be attempted on Pile 5.

Pile 5 and Pile 6 were driven using the same noise attenuation techniques as Pile 4, with the exception that instead of inserting a new pile cushion partway through the drive, Pile 6 started with two 6-inch pads. Pile 5 and Pile 6 were compliant with noise thresholds.

6.3.2.2 Vibratory Steel Sheet Piles

Table 6.9 presents a summary of the sheet piles which were driven in Zone 4 during airborne and hydroacoustic monitoring.

Table 6.9 Zone 4 Vibratory Steel Sheet Piles

Sheet Number	Pile Size and Type	Sound Attenuation	Date Driven	Water Depth	Distance from Pile to Water's Edge	Depth into Substrate	Drive Time (min.)
1	AZ38-700N Pair	None	2/12/14	~4 feet	~5 feet	33 feet	25
2	AZ38-700N Pair	None	2/12/14	~4 feet	~5 feet	33 feet	25
3	AZ38-700N Pair	None	2/12/14	~4 feet	~5 feet	33 feet	25
4	AZ38-700N Pair	None	2/12/14	~4 feet	~5 feet	33 feet	25
5	AZ38-700N Pair	None	2/13/14	~4 feet	~5 feet	33 feet	25

Source: The Greenbusch Group, Inc., Manson Construction, Anchor QEA

7.0 RESULTS

Measurement data collected during the pile installations in Zone 1 and Zone 4 was analyzed to determine the extent of underwater sound isopleths, site specific sound attenuation over distance, and the range and average sound levels relative to species specific criteria.

Monitoring results are presented in the Sections below.

7.1 Zone 1

The results of airborne and underwater noise measurements from Zone 1 during the impact driving of concrete piles and vibratory installation of steel sheet pile are presented below.

7.1.1 Airborne Sound Levels

Airborne sound levels measured in Zone 1 are presented as un-weighted levels normalized to a distance of 50 feet from the piles.

Table 7.1 Zone 1 Airborne RMS Sound Levels, dB re: 20 μPa

Pile/Sheet Number	Date	Mitigation Type	Maximum RMS[1]
Impact-Driven Concrete Piles			
1	2/17/14	6" Pile Cushion	123
2	2/18/14	6" Pile Cushion	120
3	2/18/14	6" Pile Cushion	126
4	2/19/14	6" Pile Cushion	115
5	2/19/14	6" Pile Cushion	121
Vibratory Steel Sheet Piles			
1	2/24/14	None	109
2	2/24/14	None	108
3	2/24/14	Reduced throttle setting	108
4	2/24/14	Reduced throttle setting	107
5	2/24/14	Reduced throttle setting	104
6	2/24/14	Reduced throttle setting	108
7	2/24/14	Reduced throttle setting	110

1. *Linear frequency weighting with exponential time constant of 125 milliseconds*

Source: The Greenbusch Group, Inc.

As shown in Table 7.1 impact pile driving resulted in higher sound pressure levels when compared to vibratory pile driving. The MMPA LOA does not establish airborne sound level limits.

7.1.2 Impact-Driven Concrete Piles

The results of underwater sound level measurements during impact pile driving in Zone 1 are presented below.

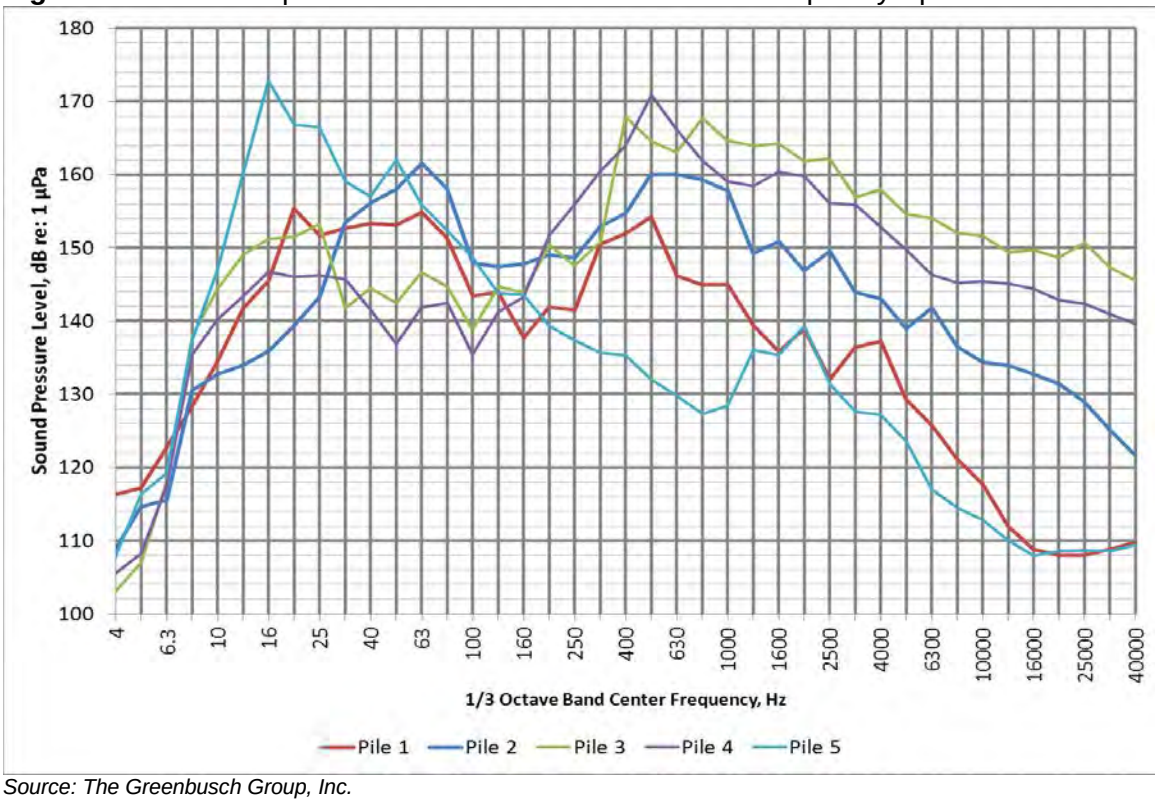
Table 7.2 Zone 1 Underwater Impact Sound Levels, dB re: 1 μPa

Pile	Date	Mitigation Type	Peak Strike Levels (limit = 188 dB)			RMS Strike Levels (limit = 176 dB)		
			Max	Min	Avg	Max	Min	Avg
1	2/17/14	6" Pile Cushion	190	144	184	179	150	164
2	2/18/14	6" Pile Cushion	193	153	187	178	148	166
3	2/18/14	6" Pile Cushion	202	149	193	175	149	169
4	2/19/14	6" Pile Cushion	199	168	191	174	152	169
5	2/19/14	6" Pile Cushion	198	144	181	177	142	171

Source: The Greenbusch Group, Inc.

Figure 7.1 presents the frequency spectrum for the highest RMS level events measured during Zone 1 impact pile driving.

Figure 7.1 Zone 1 Impact Concrete Piles Maximum RMS Frequency Spectra



Source: The Greenbusch Group, Inc.

7.1.3 Vibratory Steel Sheet Piles

The results of underwater sound level measurements during vibratory pile driving of sheet piles in Zone 1 are presented in Table 7.3 below.

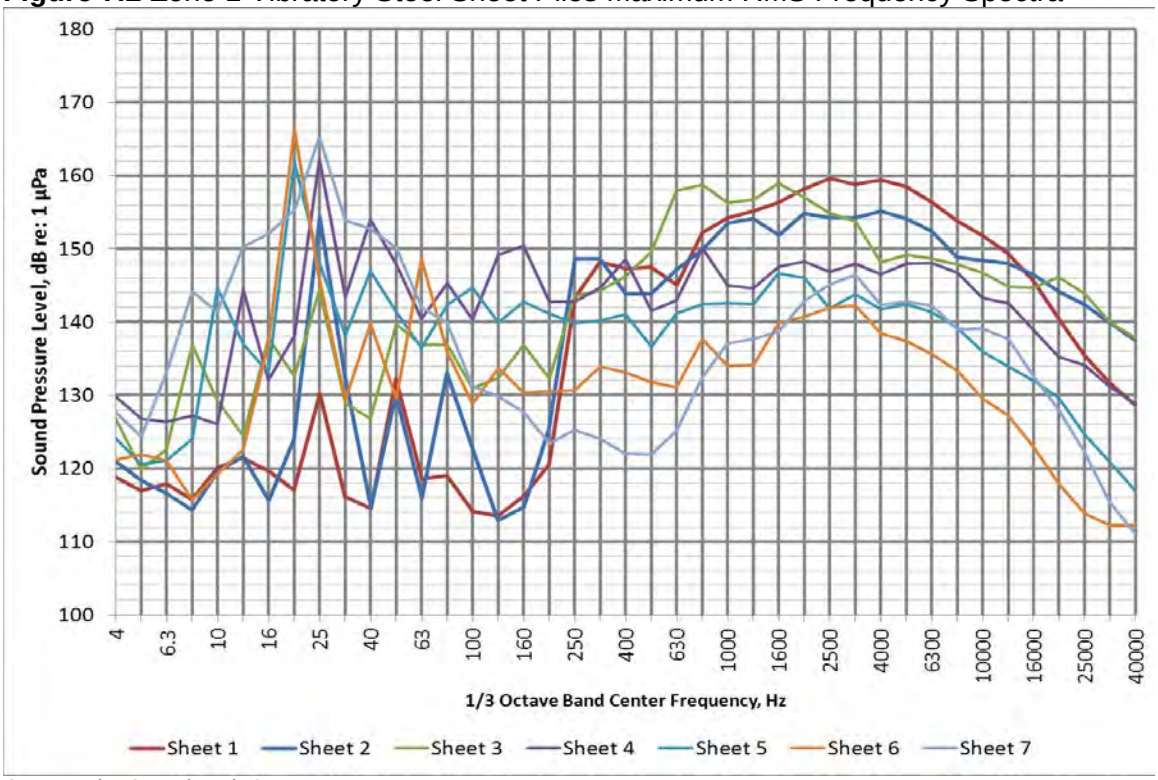
Table 7.3 Zone 1 Underwater Vibratory Sound Levels, dB re: 1 μPa

Sheet	Date	Mitigation Type	10-second Peak Levels (limit = 182 dB)			10-second RMS Levels (limit = 165 dB)		
			Max	Min	Avg	Max	Min	Avg
1	2/24/14	None	193	148	185	166	138	160
2	2/24/14	None	187	149	177	165	139	160
3	2/24/14	Reduced throttle setting	188	145	171	167	134	155
4	2/24/14	Reduced throttle setting	178	150	171	165	139	158
5	2/24/14	Reduced throttle setting	177	145	169	163	134	156
6	2/24/14	Reduced throttle setting	178	140	171	166	130	158
7	2/24/14	Reduced throttle setting	179	143	170	167	131	161

Source: The Greenbusch Group, Inc.

Figure 7.2 below presents the frequency spectrum for the highest RMS level events measured during Zone 1 vibratory pile driving.

Figure 7.2 Zone 1 Vibratory Steel Sheet Piles Maximum RMS Frequency Spectra



Source: The Greenbusch Group, Inc.

7.2 Zone 4

The results of airborne and underwater noise measurements made in Zone 4 during the impact driving of concrete piles and vibratory steel sheet pile installation are presented below.

7.2.1 Airborne Sound Levels

Airborne sound levels measured in Zone 4 are presented as un-weighted levels normalized to a distance of 50 feet from the piles.

7.2.1.1 Airborne Sound Levels from Impact-Driven Concrete Piles and Vibratory Steel Sheet Piles

Table 7.4 Zone 4 Airborne RMS Sound Levels, dB re: 20 μPa

Pile/Sheet Number	Date	Mitigation Type	Maximum, RMS[1]
Impact			
1	2/22/14	6" pile cushion	112
2	2/23/14	6" pile cushion	109
3	2/23/14	Reduced fuel setting, 6" pile cushion	111
4	2/23/14	Reduced fuel setting, 6" pile cushion, new pile cushion inserted part way through drive	110
5	2/23/14	Reduced fuel setting, 6" pile cushion, new pile cushion inserted part way through drive	110
6	2/23/14	Reduced fuel setting, two 6" pile cushions installed at beginning of drive	110
Vibratory			
1	2/12/14	None	124
2	2/12/14	None	128
3	2/12/14	None	123
4	2/12/14	None	120
5	2/13/14	None	117

1. *Linear frequency weighting with exponential time constant of 125 milliseconds*

Source: The Greenbusch Group, Inc.

As shown in Table 7.4, airborne sound pressure levels were higher for vibratory piles than impact piles. The vibratory sheet piles were driven without noise mitigation, which may have resulted in higher sound levels than those produced by the concrete piles. The LOA does not establish airborne sound level limits.

7.2.2 Impact-Driven Concrete Piles

The results of underwater sound level measurements during impact-driven concrete piles in Zone 4 are presented in Table 7.5 below.

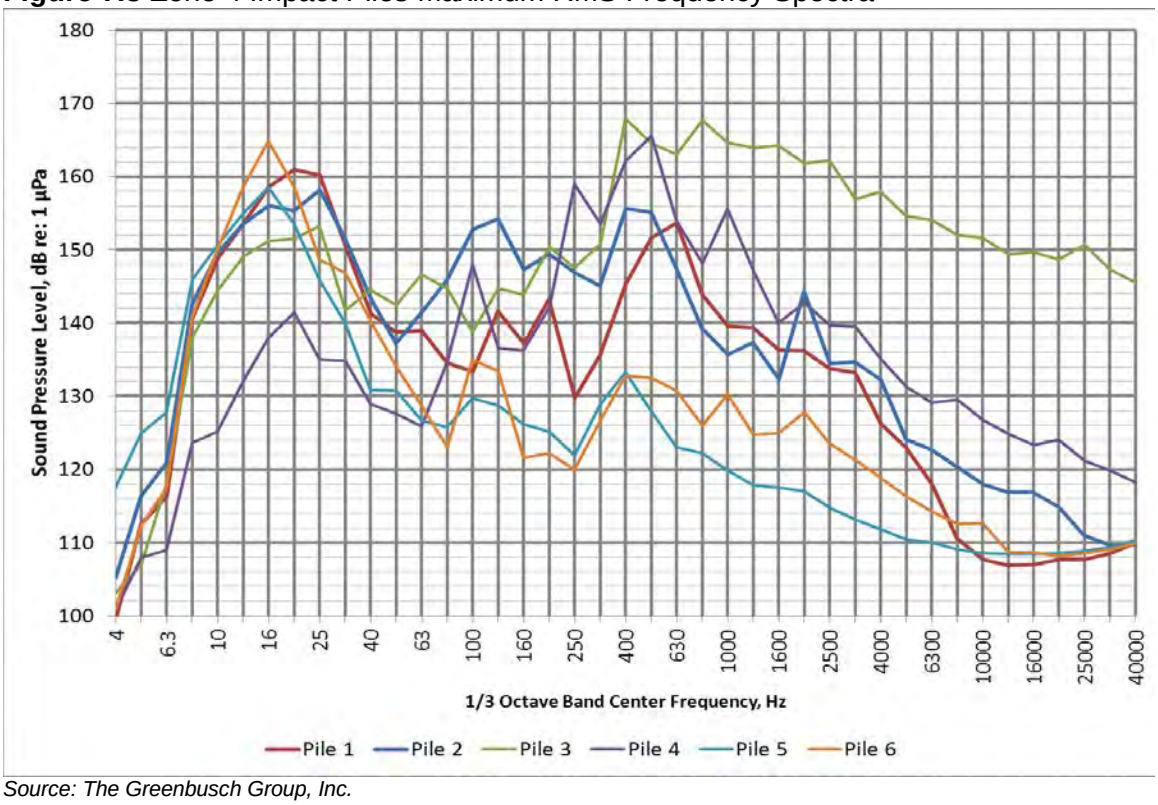
Table 7.5 Zone 4 Underwater Impact Sound Levels, dB re: 1 μPa

Pile	Date	Mitigation Type	Peak Strike Levels (limit = 188 dB)			RMS Strike Levels (limit = 176 dB)		
			Max	Min	Avg	Max	Min	Avg
1	2/22/14	6" pile cushion	193	164	182	167	149	164
2	2/23/14	6" pile cushion	187	165	182	167	152	163
3	2/23/14	Reduced fuel setting, 6" pile cushion	191	167	181	167	152	163
4	2/23/14	Reduced fuel setting, 6" pile cushion, new pile cushion inserted part way through drive	191	153	176	171	147	164
5	2/23/14	Reduced fuel setting, 6" pile cushion, new pile cushion inserted part way through drive	179	156	172	166	145	160
6	2/23/14	Reduced fuel setting, two 6" pile cushions installed at beginning of drive	179	155	171	169	148	161

Source: The Greenbusch Group, Inc.

Figure 7.3 below presents the frequency spectrum for the highest RMS level events measured during Zone 4 impact pile driving.

Figure 7.3 Zone 4 Impact Piles Maximum RMS Frequency Spectra



Source: The Greenbusch Group, Inc.

7.2.3 Vibratory Steel Sheet Piles

The results of underwater sound level measurements during vibratory pile driving in Zone 4 are presented in Table 7.6 below, normalized to a distance of 10 meters from the piles. While NOAA recommends a typical transmission loss coefficient of 15, field measurements determined a site-specific transmission loss coefficient of 10.5. This site-specific transmission loss coefficient was used to normalize the measured underwater sound levels to the values at 10 meters. Overall, the pier support piles in Zone 4 did not appear to significantly influence measured underwater sound levels.

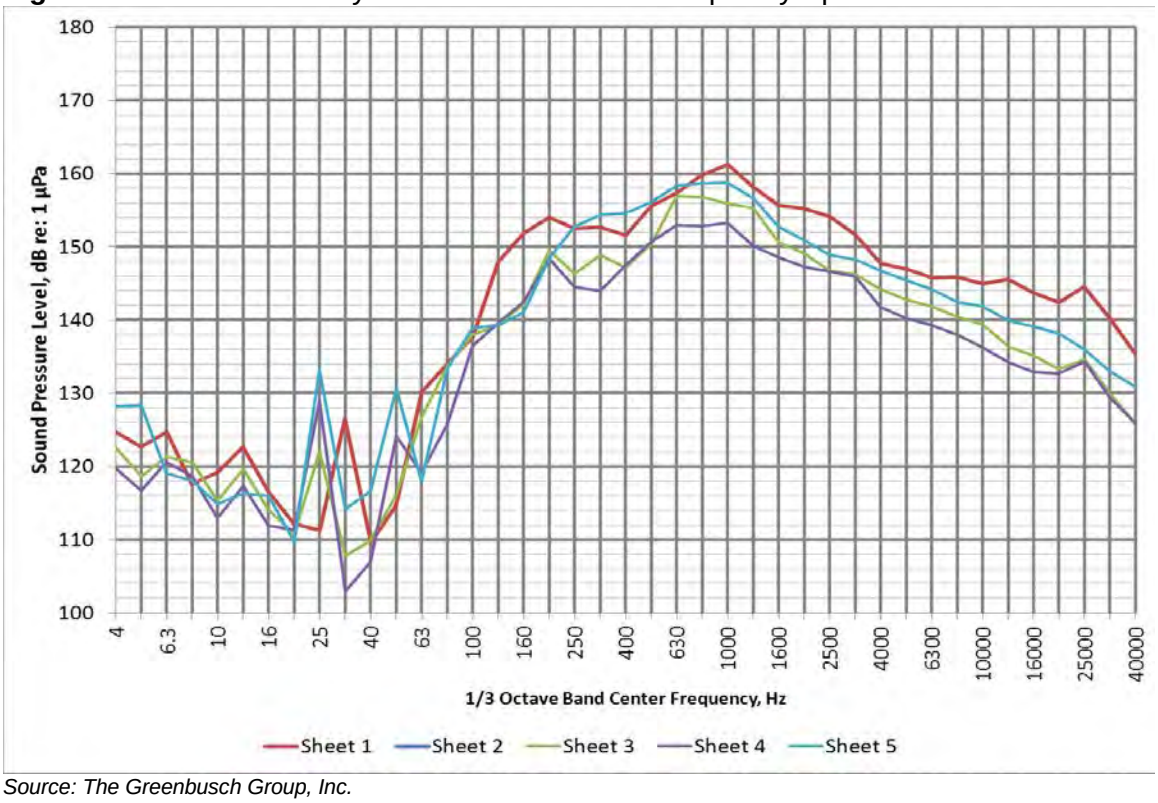
Table 7.6 Zone 4 Underwater Vibratory Sound Levels, dB re: 1 μPa

Sheet	Date	Mitigation Type	10-second Peak Levels (limit = 182 dB)			10-second RMS Levels (limit = 165 dB)		
			Max	Min	Avg	Max	Min	Avg
1	2/12/14	None	186	143	162	168	132	145
2	2/12/14	None	179	146	165	158	134	145
3	2/12/14	None	181	145	164	165	133	149
4	2/12/14	None	178	144	163	161	132	147
5	2/13/14	None	186	146	176	166	138	160

Source: The Greenbusch Group, Inc.

Figure 7.4 presents the frequency spectrum for the highest RMS level events measured during Zone 4 vibratory pile driving, normalized to a distance of 10 meters from the piles.

Figure 7.4 Zone 4 Vibratory Piles Maximum RMS Frequency Spectra



Source: The Greenbusch Group, Inc.

7.3 Marine Mammal Detection Distances

NOAA has established sound thresholds for marine mammals. These thresholds are defined for disturbance and injury, and are based on RMS values. These thresholds are presented in Table 7.7.

Table 7.7 Marine Mammal Detection Thresholds, dB re: 1 µPa (RMS)

Functional Hearing Group	Species	Underwater Noise Thresholds		
		Vibratory Pile Driving Disturbance Threshold	Impact Pile Driving Disturbance Threshold	Injury Threshold
Cetaceans	Harbor Porpoise	120	160	180
	Dall's Porpoise			
	Killer Whale			
	Gray Whale			
	Humpback Whale			
Pinnipeds	Harbor Seal	120	160	190
	California Sea Lion			

Source: NOAA

Based on the marine mammal detection thresholds, the distances for sound generated by pile driving activities to reach the disturbance thresholds for each functional hearing group were calculated. Distances were calculated from the maximum RMS values for vibratory and impact piles using the "practical spreading loss" currently used by WSDOT and NOAA. The distances are presented in Table 7.8 below.

Table 7.8 Distances to Marine Mammal Detection Thresholds, Meters

Functional Hearing Group	Distance to Disturbance Threshold					
	Vibratory Sheets (120 dB)			Impact Piles (160 dB)		
	Max	Min	Avg	Max	Min	Avg
Zone 1						
Cetaceans	13,673	7,399	11,188	186	86	134
Pinnipeds	13,673	7,399	11,188	186	86	134
Zone 4						
Cetaceans	15,941	3,434	9,321	54	25	35
Pinnipeds	15,941	3,434	9,321	54	25	35

Source: The Greenbusch Group, Inc.

7.4 Background Sound Level Distances

Background sound levels were measured in Zone 1 and Zone 4 in the absence of in-water pile installation. Table 7.9 below presents the results of measured underwater background sound levels in Zone 1 and Zone 4.

Table 7.9 Measured Background Underwater Sound Levels, dB re: 1 μPa (RMS)

Zone	Maximum	Minimum	Average
1[1]	215	106	163
4[2]	140	132	135

1. Results from long term monitoring data. Proximity to Coleman Dock, and active ferry terminal, was expected to contribute to the ambient levels in this area.
2. Results from short-term monitoring data.

Source: The Greenbusch Group, Inc.

As shown in Table 7.9 above, the average sound level in Zone 1 is 43 dB above the 120 dB disturbance threshold for Pinnipeds and Cetaceans.

The distances required to reach the average background sound levels are presented in Table 7.10 below.

Table 7.10 Distances to Background Sound Levels, Meters

Functional Hearing Group	Distance to Disturbance Threshold					
	Vibratory			Impact		
	Min	Max	Avg	Min	Max	Avg
Zone 1	10	19	15	47	544	215
Zone 4	343	1,594	932	1,173	2,527	1,610

Source: The Greenbusch Group, Inc.

7.5 Marine Mammal Monitoring

Monitors observed California sea lions and harbor seals; however these animals did not exhibit any changes in behavior. Details of mammal monitoring are presented in a separate report.

8.0 APPENDIX

Figure A1. Impact Pile Driver Information

APE Model D62-42 Single Acting Diesel Impact Hammer

D62-42 in a stand-off driving Kingpile

Optional Variable Throttle Control

Drive Base Assembly

MODEL D62-42 (6.2 metric ton ram)

SPECIFICATIONS

Stroke at maximum rated energy	135 in (343 cm)
Maximum rated energy (Setting 4)	153,799 ft-lbs (207.63 kNm)
Setting 3	127,653 ft-lbs (172.33 kNm)
Setting 2	101,507 ft-lbs (137.03 kNm)
Minimum rated energy (Setting 1)	76,899 ft-lbs (103.81 kNm)
(Variable throttle allows for infinite fuel settings)	
Maximum obtainable stroke	157 in (381 cm)
Maximum obtainable energy	178,862 ft-lbs (243 kNm)
Speed (blows per minute)	34-53

WEIGHTS

Ram	13,671 lbs (6,200 kg)
Anvil	2,425 lbs (1,100 kg)
Anvil cross sectional area	367.94 in² (2373.80 cm²)
Hammer weight (includes trip device)	29,100 lbs (13,300 kg)
Typical operating (weight with DB32 and pipe insert)	34,402 lbs (15,602 kg)

CAPACITIES

Fuel tank (runs on diesel or bio-diesel)	25.5 gal (96.52 liters)
Oil tank	8.2 gal (31 liters)

CONSUMPTION

Diesel or Bio-diesel fuel	5.2 gal/hr (19.68 liters/hr)
Lubrication	0.52 gal/hr (1.96 liters/hr)
Grease	8 to 10 pumps every 45 minutes of operation time

STRIKER PLATE

Weight	1,036 lbs (470 kg)
Diameter	25 in (57.15 cm)
Area	491 in² (3167.74 cm²)
Thickness	8 in (20.32 cm)

CUSHION MATERIAL

Type/Qty	Micarta / 2 each
Diameter	25 in (57.15 cm)
Thickness	1 in (25.4 mm)
Type/Qty	Aluminum / 3 each
Thickness	1/2 in (12.7 mm)
Diameter	25 in (57.15 cm)
Total Combined Thickness	3.5 in (8.89 cm)
Area	491 in² (3167.74 cm²)
Elastic-modulus	285 ksi (1,965 mpa)
Coeff. of restitution	0.8

DRIVE CAP

DB 32:	2,436 lbs (1,104 kg)

INSERT WEIGHT

H-Beam insert for 12" (305 mm) and 14" (355 mm):	948 lbs (430 kg)
Large pipe insert for sizes 12" to 24" diameter:	1,830 lbs (830 kg)

MINIMUM BOX LEAD SIZE/OPERATING LENGTH

Minimum box leader size	8 in x 32 in (20.32 cm x 81.28 cm)
Operating length as described above	374 in (949.96 cm)

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Note: All specifications are subject to change without notice 05/20/2012

Figure A2. Vibratory Pile Driver Information

APE Model 250VM Vibratory Driver/Extractor

SPECIFICATIONS	DATA
Eccentric Moment	4,500 in-lbs (52 kgm)
Frequency	1,750 VPM
Driving Force @ 1,750 VPM	196 US tons (177.8 tons)
Driving Force @ 1,950 VPM	243 US tons (220.4 tons)
Amplitude without Attachment	0 to 1.25 in (32 mm)
Max Line Pull	150 US tons (136.1 tons)
Suspended Weight w/ Clamp and 75 ft Hose	17,500 lbs (7,936 kg)
Dynamic Weight w/ Clamp	9,625 lbs (4,365 kg)
Length	125 in (318 cm)
Width at Throat	14 in (35 cm)
Width	17 in (43 cm)
Height	100 in (254 cm)
Hydraulic Hose Length	150 ft (45 m)
Hydraulic Hose Weight 50 ft with Oil	2,000 lbs (907 kg)

SPECIFICATIONS	DATA
Power Unit Engine	C18 ACERT Tier III Certified
Hydraulic Tank (reserve)	60 gal (227 L)
Hydraulic Tank (main)	475 gal (1798 L)
Fuel Capacity	165 gal (625 L)
Clamp Flow	10 gpm (41 lpm)
Clamp Pressure (sheet clamp)	310 bar (4500 psi)
Maximum Hyd. Flow-Reverse	0-196 gpm (0-741.86 lpm)
Maximum Hyd. Flow-Forward	0-215 gpm (0-813.78 lpm)
Maximum Drive Pressure	4500 psi (310 bar)
Maximum Power	700 hp (514.86 kW)
Operating Speed	800 to 2100 rpm
Height	94 in (238.76 cm)
Width	82.25 in (208.92 cm)
Length	152 in (386.08 cm)
Weight	19,000 lbs (8618.26 kg)