Elliott Bay Seawall Project

Noise and Vibration Discipline Report

FINAL

October 2012

Submitted to:

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Elliott Bay Seawall Project

NOISE AND VIBRATION DISCIPLINE REPORT

Agreement No. T09-24

FINAL

OCTOBER 2012

This Discipline Report provides detailed background and analysis to support the City of Seattle's SEPA (Washington State Environmental Policy Act) Environmental Impact Statement for the Elliott Bay Seawall Project. This report also serves the same role to support the USACE's NEPA (National Environmental Policy Act) environmental analysis for the Elliott Bay Seawall Project. Thus, both SEPA and NEPA references and considerations are included.

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Noise and Vibration Discipline Report

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ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

AWVSRP	Alaskan Way Viaduct and Seawall Replacement Program
BMP	Best Management Practice
BSP	braced soldier pile
Caltrans	California Department of Transportation
City	City of Seattle
dB	decibel
dBA	A-weighted decibel
DNL	Day-Night Sound Level
DOE	Washington State Department of Ecology
DPD	City of Seattle Department of Planning and Development
EBSP	Elliott Bay Seawall Project
EIS	Environmental Impact Statement
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
Hz	Hertz
I	interstate
L_{avg}	average sound level
L_{eq}	equivalent sound level
L_{max}	maximum sound level
µPA	microPascal
NAVD	North American Vertical Datum
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
PPV	peak particle velocity
RCNM	Roadway Construction Noise Model
RMS	root mean squared
SDOT	Seattle Department of Transportation
SEL	Sound Exposure Level
SEPA	State Environmental Policy Act
SMC	Seattle Municipal Code
SPU	Seattle Public Utilities Department
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
WAC	Washington Administrative Code
WSDOT	Washington State Department of Transportation

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EXECUTIVE SUMMARY

This Noise and Vibration Discipline Report describes the background conditions present in the Elliott Bay Seawall Project (EBSP) vicinity and the anticipated operational and construction effects of the EBSP on the noise and vibration environment. The EBSP would consist primarily of rebuilding the existing Elliott Bay Seawall and creating habitat improvements. This Discipline Report addresses the No Action Alternative and the three build alternatives: A, B, and C. Alternatives A and C use a soil improvement structural option and Alternative B uses a braced soldier pile structural option, but either structure may be substituted in either build alternative as conditions require. The build alternatives include various habitat improvements, such as placement of material for shallow-water intertidal habitats along the seawall in Elliott Bay.

Existing traffic on the Alaskan Way Viaduct is a predominant source of noise in the project area. Existing sources of noise are mainly road traffic, with some localized industry as well as high-altitude aircraft overflights. The study area can be categorized as urban. Natural noises such as leaves rustling, modest wave action, and bird vocalizations are limited at these locations. Retail, office, transportation, public services (e.g., fire) and recreational uses dominate on the west side of Alaskan Way where natural noises are limited during peak driving times.

The analysis of noise and vibration impacts associated with the EBSP focuses on effects from construction activities. The Elliott Bay Seawall is expected to have only minor operational noise impacts and requires few routine operational activities other than periodic inspection and maintenance. For all three build alternatives, the noise levels for four categories of construction equipment is anticipated to exceed the daytime and nighttime noise-level limits outlined by the City of Seattle (City) Noise Ordinance (Noise Ordinance; Seattle Municipal Code [SMC], Chapter 25.08. Construction activities during nighttime hours that exceed these levels require a noise variance from the City. Daytime construction activity is allowed to exceed the noise-level limits in SMC 25.08.425 by 25 decibels (dBA). These sources of noise are temporary and would end once construction is complete. Construction activities would not result in substantive changes to local traffic conditions; therefore, overall noise-level changes due to these sources and roadway detours would be negligible (less than 1 dBA). It is expected that both construction methods would include the use of heavy construction equipment and pile driving for the support of the cantilever walkway. In general, overall noise and its effects would be comparable for all build alternatives.

The project will apply for a noise variance for any exceedances to nighttime exterior noise limits established in the Noise Ordinance. In coordination with the City, construction noise mitigation requirements would be developed and specified in the noise variance(s). Measures to reduce noise and vibration from impact pile driving are identified in Chapter 5. Impact pile driving would be the most prominent source of noise and vibration during project construction. The Noise Ordinance prohibits pile driving between 5 p.m. and 8 a.m. on weekdays and between 5 p.m. and 9 a.m. on weekends and legal holidays; however, the noise variance(s) may allow for pile driving to occur from 7 a.m. to 10 p.m. throughout the week if there is a demonstrated need.

Underwater noise impacts from pile-driving activity could affect fish and wildlife, and are generally described in this Discipline Report, but are discussed in more detail in the Fish, Wildlife, and Vegetation Discipline Report (SDOT 2012a).

Ground vibration associated with construction equipment and construction activities are evaluated using analysis procedures recommended by the California Department of Transportation (Caltrans). Critical distances at which construction vibration could exceed human response and structural damage thresholds were estimated. Ground vibration associated with impact pile driving would be barely perceptible at a distance of 333 feet, and distinctly perceptible at distances of 112 feet. All historic buildings in the study area are identified in the Cultural, Historic, and Archaeological Resources Discipline Report (SDOT 2012b). Ground vibration associated with impact pile driving would begin to cause cosmetic damage to historic structures at a distance of 26 feet, and other newer buildings at distances less than 13 feet. Fire Station No. 5 and Piers 54, 55, 56, 57 and 59 are within the critical distance for damage on historic structures from the proposed pile-driving activities. Damage would likely be cosmetic, and if it were to occur it would likely be in the form of plaster cracking and window breaking. Although unlikely, if general construction equipment were to operate within 11 feet of a historic structure it is possible that it could cause similar effects. Effects of vibration on historic structures would be slight. Impact pile driving would be the most prominent source of vibration for this project, and would be perceptible to humans and begin to cause cosmetic damage to historic structures at close range. Ground vibration associated with general construction equipment would be substantially less than ground vibration caused by an impact pile driver. Measures to reduce vibration from impact pile driving were identified.

Noise generated by EBSP construction primarily would be confined to the Seattle waterfront commercial/residential district, and would end once construction was completed. Therefore, it is not expected that the implementation of any of the three alternatives would have indirect impacts to noise or vibration (i.e., secondary impacts at any other location or at any other time).

CHAPTER 1. PROJECT DESCRIPTION

1.1 PROJECT BACKGROUND

The City of Seattle Department of Transportation (SDOT) is proposing to construct the Elliott Bay Seawall Project (EBSP), which will replace the existing seawall along the shoreline of downtown Seattle. Extending from S. Washington Street to Broad Street, the seawall supports and protects the adjacent upland areas, which contain residences, commercial businesses and restaurants, parks and public facilities, transportation infrastructure (including sidewalks, streets, and a rail line), and a large number of utilities (Figure 1-1). The harbor area in Elliott Bay is used by ferries, cruise ships, and commercial vessels, as well as for recreation. Overall, the waterfront is an important center of commerce and recreation for the entire city and region.

Figure 1-1. Elliott Bay Seawall Project Area

The existing seawall includes three types of structures, all constructed between 1911 and 1936 and ranging in size from approximately 15 to 60 feet wide. Over time, these structures have deteriorated as a result of various natural and physical processes. The seawall's poor condition makes it vulnerable to significant damage during a major storm or seismic event. Therefore, the EBSP is a critical public safety project. The completed seawall will provide protection from coastal storm damages, seismic damages, and shoreline erosion, and will thereby contribute to the preservation of Seattle's downtown, the local economy, and the region's economic competitiveness and quality of life. Seawall replacement will also provide the foundation and structural support for the downtown Seattle waterfront, including improvements planned as part of Waterfront Seattle.

The project's purpose is to reduce the risks of coastal storm and seismic damages and to protect public safety, critical infrastructure, and associated economic activities along Seattle's central waterfront. Additionally, the project will improve the degraded ecosystem functions and processes of the Elliott Bay nearshore in the vicinity of the existing seawall.

Construction of a new seawall would have both beneficial and adverse effects on environmental resources. This discipline report will examine the effects of the project on noise and vibration as part of the project's overall environmental documentation.

1.2 PROJECT AREA LIMITS AND ZONES

The project area for the EBSP extends from S. Washington Street to Broad Street, from the eastern edge of pavement below State Route (SR) 99 to the waters of Elliott Bay. The project has been divided into six zones. Zones 1 through 4 constitute the Central Seawall Study Area. The two remaining zones, Zones 5 and 6, make up the North Seawall Study Area. A delineation of the zones is provided in Figure 1-2 and concept plans are included at the end of this chapter.

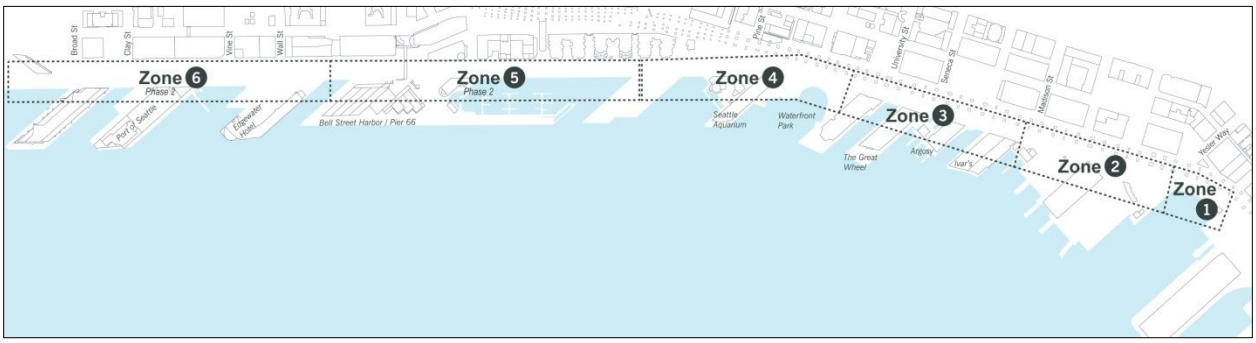

Figure 1-2. Elliott Bay Seawall Zone Designations

Central Seawall Study Area (S. Washington Street to Virginia Street):

- Zone 1, the Pioneer Square/Washington Street Boat Landing Zone, runs from S. Washington Street to Yesler Way.
- Zone 2, the Ferry Terminal Zone, stretches from Yesler Way to Madison Street, and includes the Colman Dock ferry terminal and Fire Station No. 5.
- Zone 3, the Central Pier Zone, includes the historic waterfront piers (Piers 54 to 57) and runs from Madison Street to just north of University Street.
- Zone 4, the Park/Aquarium Zone, includes Waterfront Park, the Seattle Aquarium, and Piers 62/63. This zone runs from north of University Street to approximately Virginia Street.

North Seawall Study Area (Virginia Street to Broad Street):

- Zone 5, the Bell Harbor Zone, runs from Virginia Street to Battery Street. This zone includes the Bell Harbor Conference Center, Cruise Ship Terminal, and Marina.
- Zone 6, the North Pier Zone, stretches from Battery Street to Broad Street, and includes the Edgewater Hotel, Port of Seattle Offices, and Pier 70.

1.3 PROJECT ALTERNATIVES

The EBSP Environmental Impact Statement (EIS) evaluates a No Action Alternative and three build alternatives for the project. As required by the National Environmental Policy Act (NEPA) and the Washington State Environmental Policy Act (SEPA), the build alternatives represent different ways of accomplishing the project purpose. Evaluating alternatives allows SDOT decision-makers, with input from the public, agencies, and tribes, to consider environmental impacts in conjunction with other decision factors such as cost, schedule, and feasibility.

The build alternatives for the EBSP are:

- **Alternative A**, which would reconstruct the seawall as close to its existing alignment as possible. Jet grouting, a subsurface soil improvement, would be used to form the seawall's structural support. Habitat improvements would include the addition of shoreline enhancements, installation of a continuous habitat bench, and intermittent light-penetrating surfaces (LPS) at piers.
- **Alternative B**, which would move the seawall up to 75 feet landward of its current location. Braced soldier piles (BSP) would be used to build an underground wall structure. Moving the seawall inland would allow the construction of expanded habitat enhancements and mostly continuous LPS, in addition to the habitat improvements and continuous habitat bench described for Alternative A.
- **Alternative C**, which would move the seawall up to 15 feet landward of its current location. This alternative would use subsurface soil improvements (likely including both jet grouting and deep soil mixing) to provide structural support. Alternative C would provide a continuous habitat bench and continuous LPS, in addition to shoreline enhancements similar to Alternative B.

These three build alternatives encompass a range of design ideas to establish "bookends" for the project, thus capturing a suite of potential options, impacts, and effects. Features of the alternatives could be blended in future design phases to reflect public, agency, and stakeholder input.

The following section (Section 1.4) describes the No Action Alternative. Section 1.5 discusses the features that are common to the three build alternatives and Section 1.6 provides an overview of project construction. Section 1.7 provides additional detail on specific features that differ among the build alternatives.

1.4 NO ACTION ALTERNATIVE

NEPA, SEPA, and the City of Seattle's (City's) implementing regulations (Seattle Municipal Code [SMC] 25.05) require that a No Action Alternative is evaluated in addition to the build alternatives in the EIS. The No Action Alterative provides a baseline against which the potential effects of the build alternatives can be compared.

The No Action Alternative is projected over the next 50 years. Given the age and condition of the seawall, continued deterioration and some level of failure will likely occur within the 50-year timeframe. Because the existing seawall is vulnerable to various types of damage, the No Action Alternative must

anticipate the possibility of degrees of seawall failure. Therefore, three No Action scenarios have been evaluated:

1. Minimal Damage: This scenario would not require a significant repair of the seawall, and any needed repairs could be undertaken by the City. Small failures caused by tidal erosion (as are currently happening today) or minor seismic events would result in settlement of the wall or collapse of the roadway or sidewalk on Alaskan Way. This scenario assumes continued operation of the seawall with ongoing maintenance as needed.
2. Loss of Functionality: This scenario would result from sustained damage, and the seawall would no longer be considered safe for public access and could no longer perform the majority of its essential functions. As with the Minimal Damage scenario, this scenario could result from either tidal or seismic events.
3. Collapse of the Seawall: This scenario would occur only as a result of seismic damage; however, collapse resulting from a seismic event could trigger additional damage from tidal erosion. Seawall failure would have significant impacts on the public, Seattle, the Puget Sound region, Washington State, and the nation. Loss of the seawall's function would disrupt or destroy the critical transportation infrastructure that runs along the Seattle waterfront, potentially displacing hundreds of thousands of vehicles on roadways, 30,000 daily ferry passengers who use Colman Dock ferry terminal, and 24 freight trains and six passenger trains that run near the waterfront. It would also jeopardize critical utility corridors that serve downtown Seattle and the region, and would impair the viability of the waterfront as a major tourist destination and regional economic engine.

Conditions without the project were defined as part of a separate Elliott Bay Seawall Feasibility Study, conducted by the United States Army Corps of Engineers (USACE). The "without project" conditions serve a similar purpose in the feasibility study as does the No Action Alternative under SEPA. The without project conditions are summarized below to provide additional detail about the No Action scenarios.

- The City would continue to repair minimal damage failures unless three or more sections of the seawall fail in a single year, at which point the seawall is assumed to have lost its functionality.
- The City would stabilize the shoreline following seawall collapse to minimize erosion impacts. This stabilization would help to prevent the permanent loss of landward structures, utilities, and the Burlington Northern Santa Fe (BNSF) rail line to erosion.
- If functionality of the seawall were lost, the City would construct a trestle bridge to maintain access to Colman Dock Ferry Terminal and Fire Station No. 5.
- If functionality of the seawall were lost, the City would repair or relocate affected utilities.

1.5 DESIGN FEATURES COMMON TO THE BUILD ALTERNATIVES

If implemented, the EBSP would replace the failing seawall that runs along Elliott Bay and underneath Alaskan Way and would restore and enhance aquatic habitat along the seawall's new face. A new

seawall would reduce the risk of seismic damage and protect Seattle's downtown waterfront from wind-driven storm waves and erosive tidal forces; safeguard major public and private utilities, including power for downtown Seattle and the region, natural gas, and telecommunications; support SR 99, Colman Dock ferry terminal, and rail lines; and enhance habitat for juvenile salmon and other marine life. Additionally, the project would be compatible with future improvements currently being planned at and near the waterfront.

All build alternatives encompass three major categories of design features: the new seawall itself, improvements to aquatic habitat, and improvements to upland areas. Each of these categories is described briefly below.

1.5.1 Seawall

The primary function of the new seawall is to provide protection from storm and wave erosion, impacts from floating objects, and resistance from lateral pressures such as those caused by an earthquake. A new seawall face would generally be placed either close to or somewhat landward of its current position. Depending on the build alternative selected, the final location of the seawall face would vary from approximately 3 feet waterward to 75 feet landward of the existing alignment. It would be most efficient to leave the existing seawall in place during construction of the new seawall and to build the new structure either behind or in front of the existing face.

The new seawall would also reduce the risks related to seismic activity. How these risks are reduced would differ between the alternatives. Soil improvement in the form of jet grouting with or without deep soil mixing (Alternatives A and C) would minimize the risk of liquefaction by physically stabilizing liquefiable soils behind the seawall, while the BSP method (Alternative B) would not prevent liquefaction but rather would resist the lateral spreading and migration of soil that results from liquefaction. Both methods would stabilize the seawall during seismic events. The design life of the new seawall is 75 years.

1.5.2 Habitat Improvements

Rebuilding the seawall would provide the opportunity to improve adjacent aquatic habitat. Habitat improvement measures would be implemented as part of each build alternative. These measures would be designed to restore a functional intertidal migration corridor along the seawall for juvenile salmonids, and would also improve ecosystem productivity to enhance the marine nearshore food web. Figure 1-3 shows a conceptual rendering of the proposed habitat improvements.

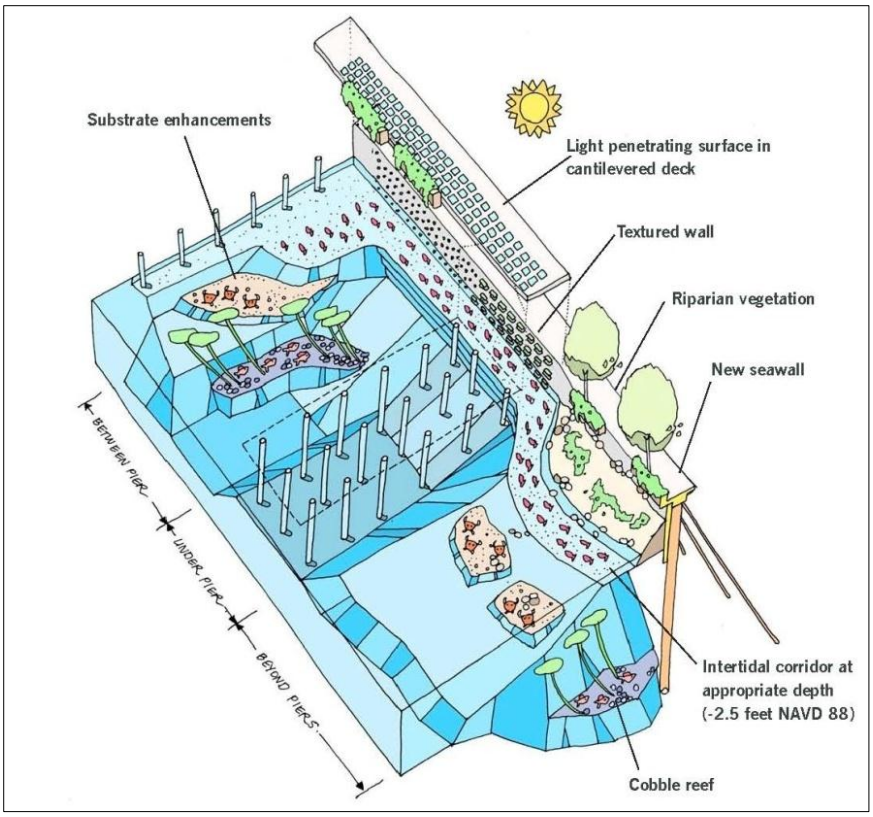

Figure 1-3. Conceptual Rendering of Proposed Habitat Improvements

The intertidal migration corridor for juvenile salmonids would be improved by:

- Modifying substrate depths to create a habitat bench and achieve appropriate intertidal and shallow-water habitat elevations;
- Improving the diversity of off-shore substrate by supplementing it with coarse substrate;
- Increasing textures on the seawall face to encourage the development of marine nearshore habitat and attachment of aquatic organisms;
- Adding riparian plants along the wall and sidewalk to provide food (insects and detritus) for migrating salmon; and
- Increasing daylight illumination of the habitat bench and other nearshore habitat by including LPS in a cantilevered or pile-supported sidewalk.

Enhanced ecosystem productivity would generally be accomplished by:

- Enhancing substrate by supplementing it with cobble, pea gravel, and shell hash; and
- Constructing the textured wall face, riparian plantings, LPS, and suitable bench substrate.

1.5.3 Upland Improvements

In addition to replacing the seawall and restoring aquatic habitat, the three build alternatives would provide a number of upland improvements. The existing Alaskan Way roadway, multi-use trail, and parking would be restored to their original function and capacity after construction. The restored

sidewalk along the waterfront would range from 15 to 30 feet in width and include a cantilevered portion with LPS that would benefit the marine habitat below. Viewing areas would be provided waterward of the sidewalk and would offer opportunities for public gathering space. New railings, formal and informal seating, bicycle racks, wayfinding elements, and other design amenities would also be included as project improvements. All build alternatives would restore the historic Washington Street Boat Landing, either maintaining its current location or moving it 15 feet waterward.

Currently, there are no water quality facilities for treating surface water runoff from Alaskan Way. Stormwater drainage pipes in the project area would be reconstructed and stormwater quality would be improved through the installation of treatment to meet code by removing the bulk of suspended solids, oils, and greases. These actions would improve water quality in the nearshore of the project area. It would be expected that new stormwater structures would initially require less maintenance than those currently in place and, as a result, have fewer detrimental impacts on the environment. As the project design moves forward, other stormwater management strategies could be identified that provide greater environmental benefit without increasing environmental impacts.

1.6 PROJECT CONSTRUCTION

1.6.1 Construction Schedule

Central Seawall construction is expected to begin in fall of 2013 and would progress from north to south, beginning in Zone 4 and ending in Zone 1. Based on current schedules, Central Seawall construction would last three to five construction seasons depending on the alternative, with construction seasons extending from approximately Labor Day to Memorial Day to avoid major disruption during the peak tourist season. The North Seawall would be built as a separate construction phase and would require an additional four construction seasons.

1.6.2 Temporary Roadway and Construction Work Zone

To accommodate construction activities during replacement of the seawall, the existing Alaskan Way roadway would be relocated beneath the Alaskan Way Viaduct. Three lanes of traffic would be maintained underneath the viaduct throughout construction. The resulting space along the waterfront would be used as a work zone during construction of the Central Seawall (Figure 1-4). During North Seawall construction, this dedicated construction work zone would not be available, and the temporary roadway would be accommodated in the available right-of-way.

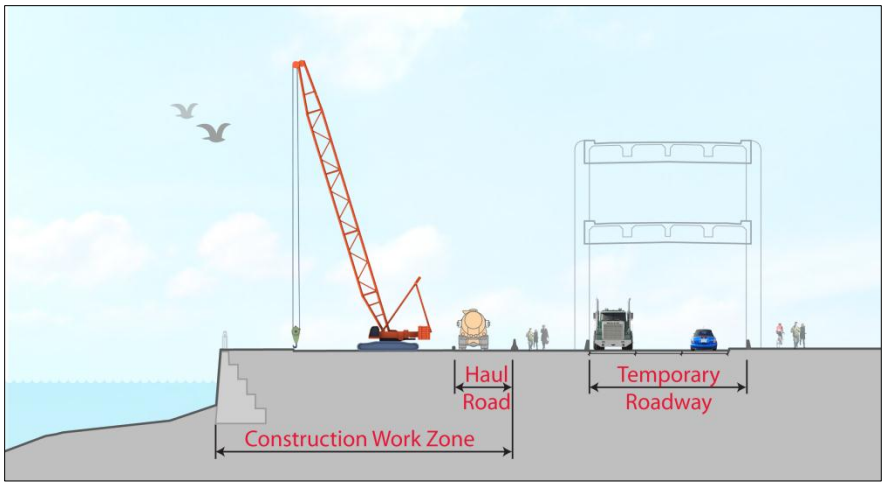

Figure 1-4. Construction Work Zone and Temporary Roadway

The construction work zone would extend from the western edge of the existing multi-use path on Alaskan Way to the water. Existing street trees would be removed to provide additional space within this area and would either be replaced as riparian plantings with the EBSP or replaced during future waterfront improvement projects. The existing streetcar tracks that run along Alaskan Way would also be removed during construction.

Construction would be staged from several locations within the work zone. Staging areas would vary in size and would be used for delivery and storage of construction materials and equipment. The staging areas would be sited to avoid disrupting access to piers, residences, and businesses along the waterfront. In addition to the upland staging areas, construction activities may also be staged from barges and tugs in Elliott Bay.

During Central Seawall construction, some temporary parking spaces could be provided as part of each construction stage. During the first stage of construction, parking could be provided on the existing Alaskan Way roadway south of the active work zone. During the later stages when construction has progressed to the southern portion of the project area, parking could be provided on the restored roadway to the north of active construction. During North Seawall construction, a similar program of temporary parking would be implemented, to the extent possible.

To the greatest extent possible, construction materials and personnel would be transported to the construction work zone and staging areas via freeways and arterials. However, other city streets could provide access to the site when needed. The eastern border of the construction work zone along Alaskan Way would serve as a haul road to channel truck traffic within the project area.

The existing multi-use trail would be maintained (with the potential for temporary detours), and access to the piers would be maintained throughout construction.

1.6.3 Construction Methods

The seawall would be replaced using soil improvement, BSP, or a combination of these two methods. A brief description of each method is provided below.

1.6.3.1 Soil Improvement

Soil improvement is a general term for a variety of techniques that are used to stabilize existing soils by improving their internal structure and strength. Two techniques that are being considered for the EBSP are jet grouting and deep soil mixing. Jet grouting consists of adding grout to existing soils to form a "block" of improved soil mass that extends down to the competent foundation below. This technique has been identified as a feasible way to strengthen the material underlying the project area, which includes an existing timber relieving platform, buried timber piles, utilities, and other potential obstructions.

Jet grouting creates circular columns of soil cement by means of a hollow drill pipe measuring a few inches in diameter that is inserted into the soil. Grout is then sprayed into the surrounding soil under high pressure through horizontal nozzles in the rotating drill pipe. This process cuts the existing soil and mixes the soil with the grout. The strength of the soil would be substantially improved through this process, thus greatly reducing the soil's potential for liquefaction during an earthquake.

The grout columns would be constructed in a grid pattern to create a block of improved soil. The grid pattern would be installed between the timber piles of the existing seawall to eliminate the need to remove the existing piles. The finished arrangement of the grouted columns would create a "spine" for the new seawall. The grouting process generates spoils that would be disposed of using appropriate means, in accordance with applicable regulations.

Deep soil mixing, another technique that could be used for soil improvement, uses an auger that penetrates the ground surface to mix and consolidate the underlying soils to a depth of up to 20 feet. With deep soil mixing, no grout is applied under pressure and there are minimal spoils for disposal.

1.6.3.2 Braced Soldier Piles

BSP is an alternative structural stabilization method. This method would involve drilling large holes (approximately 8 feet in diameter) to a depth of approximately 75 feet below the present street level of Alaskan Way where the firm layer of glacial till is located. An oscillator, a specialized piece of drilling equipment, would install a steel casing as the drilling progresses to prevent the holes from collapsing and to contain the soils to be excavated. The leading edge of the casing would be equipped with cutting teeth to carve through the timber boards and piles of the existing relieving platform and into the soils below.

Once the holes have been drilled and excavated to the final depth, a steel reinforcing cage would be placed into the shaft casing and the casing would be filled with concrete. The casing would be extracted as the concrete is poured and would leave behind a reinforced concrete cylinder, or soldier pile. A line of these soldier piles would be constructed to form the spine of the seawall. Soil anchors would then be installed to brace or tie back these soldier piles.

1.6.4 Soil Dewatering and Spoils Disposal

Regardless of the construction method that is selected, excavations into soils in the construction zone would need to be dewatered, which generally involves disposing of the wastewater offsite or pumping

the excess water to a location where it can be settled and/or before discharge. Wet spoils from jet grouting or other soil improvement activities must be managed or disposed of as well. SDOT is currently exploring various methods for managing and disposing wastewater and jet grout spoils, which would be detailed in the project's dewatering and erosion control submittals required as part of the Clean Water Act Section 401 and National Pollutant Discharge Elimination System (NPDES) construction general stormwater permit processes, as well as by the City's standard construction specifications.

1.6.5 Utility Protection and/or Relocation

The project area contains a large number of utilities, including water, sanitary sewer, combined sewer, stormwater, electrical transmission and distribution, steam, gas, fire alarm, and numerous telecommunication systems. These utilities range from major transmission lines serving portions of Seattle and the region to individual connections serving adjacent properties. As shown in Figure 1-5, some of these utilities are directly beneath the Alaskan Way roadway and sidewalk and above the relieving platform of the existing seawall, while others extend through the seawall to the piers.

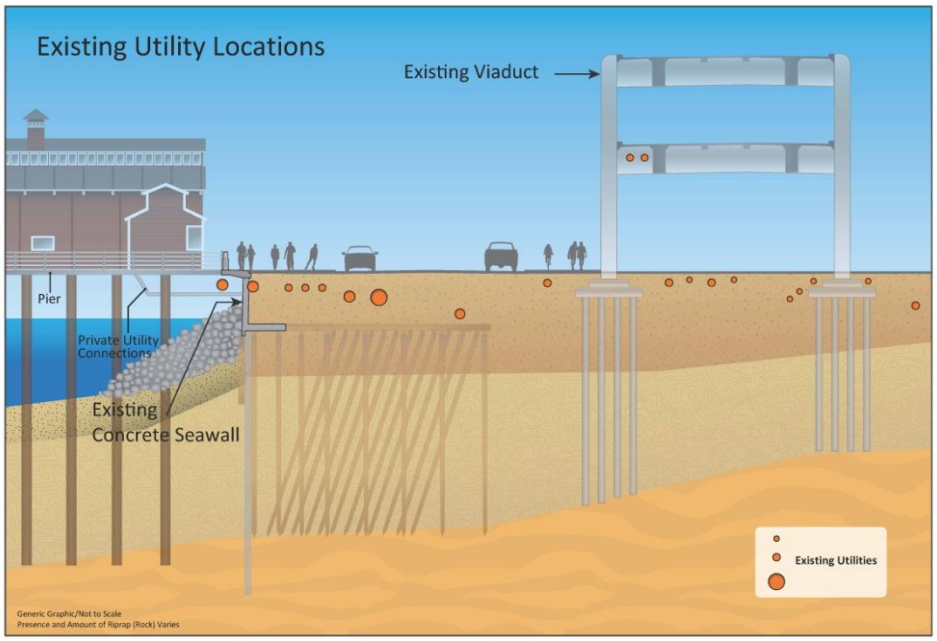

Figure 1-5. Representative Cross Section Showing Typical Existing Utility Locations within Project Limits

SDOT's objective will be to maintain utility service to the greatest extent possible during construction, although the means and methods for doing so would vary depending on the construction method used. Alternatives A and B assume that all soil overlying the relieving platform would need to be excavated. Excavation would require temporary or permanent relocation of the majority of existing utilities. Alternative C assumes that most soil improvement could be accomplished through small penetrations at street level, which would allow the majority of the utility lines above the relieving platform to remain in place during that construction activity. With either method, most individual service lines would be temporarily relocated and reinstalled in their final locations as seawall construction progresses. Final points of service to the waterfront piers would remain the same to alleviate the need to update the

facilities to the current Uniform Building Code. The final construction method chosen will not preclude the ability of utilities to provide future new services to the downtown waterfront area.

1.7 BUILD ALTERNATIVES

The preceding sections provided information on project elements that would be similar among the three build alternatives. The following discussion focuses on the primary differences among Alternatives A, B, and C in terms of the seawall's location, the configuration of Alaskan Way, habitat improvements, public amenities, and construction sequence and schedule. Table 1-1 (at the end of this chapter) compares key features of the alternatives.

1.7.1 Alternative A

Alternative A would reconstruct the seawall as close to its existing alignment as possible, with jet grouting forming the structural support. Habitat improvements would include the addition of shoreline enhancements and the installation of a continuous habitat bench and LPS at piers. Figures 1-18 and 1-19 at the end of this chapter depict Alternative A.

1.7.1.1 Seawall

In Alternative A, the new seawall would be reconstructed as close to the alignment of the existing seawall as possible, with only a minimal setback (as outlined in the bulleted list below). This placement would allow construction to proceed without requiring the removal of the existing wall first.

The approximate proposed location of the seawall face for Alternative A relative to the existing seawall face would be:

- Zone 1 – in place (no change),
- Zone 2 – 15 feet landward,
- Zone 3 – 3 feet waterward, and
- Zones 4, 5, and 6 – 10 feet landward.

In Zone 1, the seawall would be reconstructed in its existing location to minimize potential conflicts with construction of the SR 99 bored tunnel, which is being built as part of a separate project. In Zones 2, 4, 5, and 6, the new wall would be constructed behind (east of) the existing wall, and then the existing seawall west of the new seawall face would be demolished. In Zone 3, the new seawall structure would be constructed to the west of the existing wall, resulting in the new seawall face being set three feet waterward of its current location.

1.7.1.2 Roadway

The existing Alaskan Way is generally four lanes (two lanes in each direction), except in the vicinity of Colman Dock (Yesler Way to Spring Street), where it consists of one northbound lane and two

southbound lanes. Alternative A would add a permanent northbound lane between S. Washington and Madison Streets[1] to handle traffic in this segment headed to Colman Dock and through to other destinations. A temporary second northbound lane (constructed by the Washington State Department of Transportation [WSDOT]) is currently in place. Parking and loading zones in the finished configuration would be similar to today.

A sidewalk of approximately the same width as the existing sidewalk (15 to 20 feet) would be provided on the west side of the street. The sidewalk would be cantilevered or pile supported in Zones 2 through 6 and would extend back to the piers in all zones, with LPS provided where feasible. The mixed-use trail on the east side of Alaskan Way would be extended from its existing terminus north to Clay Street. At Clay Street, the trail would cross Alaskan Way and continue on the west side of Alaskan Way to Broad Street, where it would connect to the existing trail system that runs along Olympic Sculpture Park and Myrtle Edwards Park.

1.7.1.3 Habitat Improvements

Alternative A would provide an effective intertidal corridor along the seawall to support juvenile salmonid migration and would enhance ecosystem productivity. Habitat benches, a sidewalk with LPS, a textured wall face, subtidal substrate enhancements, cobble reefs, and riparian plants would be installed. No net loss of ecological function or intertidal elevation would occur.

1.7.1.4 Upland Improvements

Under Alternative A, public amenities would include the restored historic Washington Street Boat Landing, improved water-viewing opportunities at various locations, new or replaced railings, new sidewalks, waterfront planters, and street plantings. Reconstructed sidewalks would extend from the curb line of the restored Alaskan Way to the western edge of the existing sidewalk. These improvements would add variety to the waterfront by defining gathering spaces, viewing areas, and building entries.

1.7.1.5 Construction and Schedule

Under Alternative A, the construction method proposed for the primary structural element of the seawall is soil improvement. With this method, construction of the Central Seawall would require approximately three construction seasons with two summer shutdown periods. Construction of the North Seawall would require an additional four construction seasons with three summer shutdown periods. The current plan for Alternative A is to begin construction of the Central Seawall in Zone 4, move southward to Zone 3, and then progress to Zones 2 and 1. The Central Seawall construction would be followed by the North Seawall construction in Zones 6 and 5.

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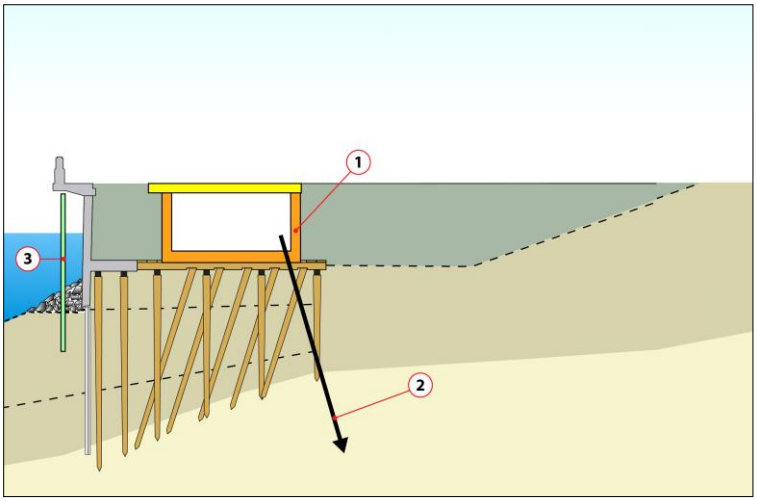
[1] The Elliott Bay Seawall Project would build the additional lane from S. Washington Street to Madison Street. The portion between S. King Street and S. Washington Street would be constructed as part of the Alaskan Way Viaduct Replacement Project.

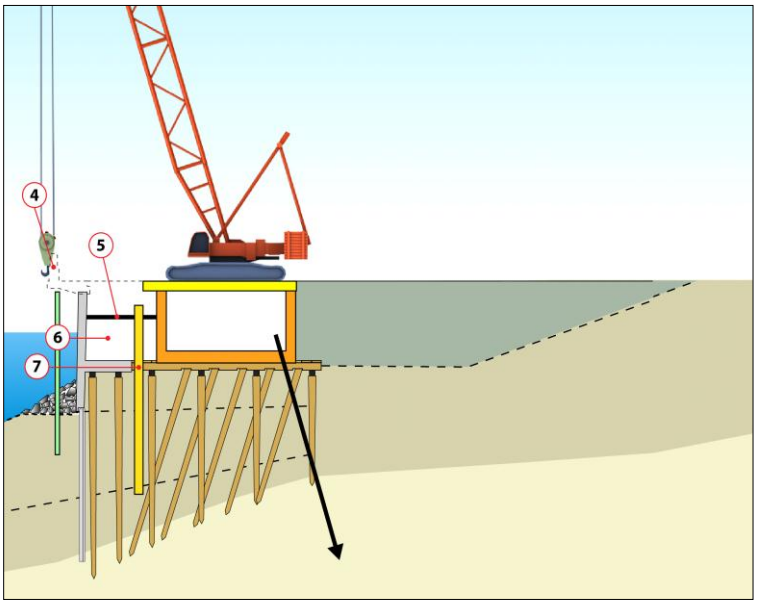
The anticipated construction activities and probable sequence for Alternative A, using jet grouting for the soil improvement, are depicted in Figures 1-6 through 1-9. The figures describe four primary stages of work that would occur along the waterfront. The construction activities within each zone would vary depending on the type of existing seawall. The figures depict the Type A seawall. (Type A seawall is a sheet-pile supported, reinforced, concrete face panel, which is tied back to a buried timber relieving platform supported by vertical and battered timber piles.) For Alternative A, it was assumed that the area above the existing relieving platform would be excavated before jet grouting begins.



Alternative A, Stage 1

1. Excavate to the top of relieving platform, relocate utilities, and install shoring
2. Install soil anchors
3. Remove existing riprap and install temporary containment wall

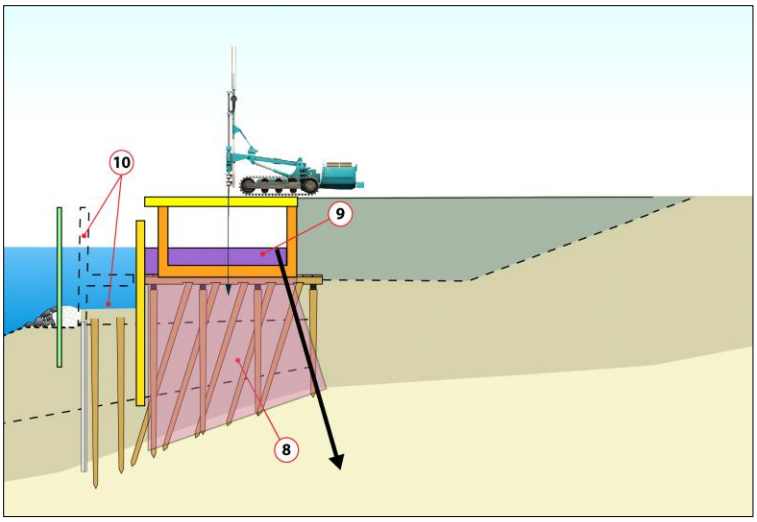
Figure 1-6. Alternative A, Stage 1



Alternative A, Stage 2

4. Remove existing cantilever sidewalk
5. Brace existing concrete face panel
6. Excavate remaining soil
7. Install concrete face panel

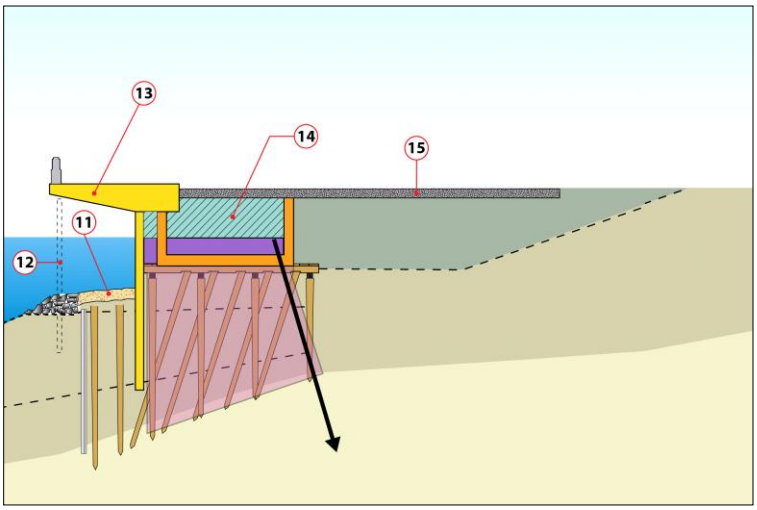
Figure 1-7. Alternative A, Stage 2



Alternative A, Stage 3

8. Install soil improvement (jet grouting)
9. Install anchor slab
10. Remove portion of existing wall

Figure 1-8. Alternative A, Stage 3



Alternative A, Stage 4

11. Place substrate
12. Remove temporary containment wall
13. Install sidewalk
14. Restore utilities and backfill
15. Complete restored roadway

Figure 1-9. Alternative A, Stage 4

1.7.2 Alternative B

Alternative B would move the seawall up to 75 feet landward of its current location, with BSP forming an underground wall structure to protect against coastal storm damage and seismic forces. In addition to the habitat improvements described for Alternative A, this alternative would construct a continuous habitat bench and continuous LPS at the piers. Figures 1-20, 1-21, and 1-22 at the end of this chapter depict Alternative B.

1.7.2.1 Seawall

Under Alternative B, the new seawall would be constructed up to 75 feet east of the existing seawall alignment and would provide a range of potential design opportunities. The approximate proposed location of the seawall face for Alternative B, relative to the existing seawall face, would be:

- Zone 1 – 0 to 15 feet landward,
- Zone 2 – 15 feet landward,
- Zone 3 – 30 feet landward,
- Zone 4 – 30 to 75 feet landward following the restored road curb alignment, and
- Zones 5 and 6 – 10 feet landward.

In Zones 1, 2, 5, and 6, the new wall would be constructed 10 to 15 feet east of the existing wall. In Zones 3 and 4, the new wall would be constructed 30 to 75 feet farther east, allowing greater flexibility for future habitat and public amenity spaces. This eastward realignment would largely reshape the downtown Seattle waterfront. After the new seawall was in place, the existing seawall would be demolished.

1.7.2.2 Roadway

Under Alternative B, the lane configuration of Alaskan Way would remain identical to the current configuration because of the confined space that would be available between the location of the seawall (eastward of the existing seawall) and the existing Alaskan Way Viaduct structure. A temporary northbound lane between Yesler Way and Spring Street has been installed by WSDOT, and it may be used during seawall construction.

Similar to the other build alternatives, the existing roadway, sidewalk, and multi-use trail would be restored to their original function and capacity after construction, with the multi-use trail connecting to the existing trail system that runs along Olympic Sculpture Park and Myrtle Edwards Park. However, due to space constraints, southbound parking and loading in Zone 3 may be restricted between University and Madison Streets.

1.7.2.3 Habitat Improvements

Alternative B would include the installation of habitat benches, a sidewalk with LPS, a textured wall face, subtidal substrate enhancements, cobble reefs, and riparian plants. However, the intertidal habitat

would be larger because the seawall would be set back farther east (landward). Alternative B would provide substantial enhancements within the new aquatic land available in Zones 1, 3, and 4.

Zone 1 would include an intertidal habitat bench and backshore that would be bordered by riparian plants, rocks, and drift logs. In Zone 3, the 30-foot seawall setback would allow the installation of a confined-substrate habitat bench with LPS installed above. In Zone 4, the 75-foot seawall setback would allow expanded upland riparian planting or increased intertidal habitat.

1.7.2.4 Upland Improvements

Alternative B would improve water viewing at various locations and provide additional public gathering spaces, as well as interpretive, recreational, and cultural opportunities. The new sidewalks would be enhanced with LPS and reconfigured with planters and new or replaced railings along the length of the seawall. These additional and enhanced gathering and overlook spaces would be provided in Zones 1, 3, 4, 5, and 6.

In Zone 1, Washington Street Boat Landing would be restored and reinstalled within the Washington Street right-of-way, west of its current location to improve its connection to the water. A new gangway and short-stay boat moorage could be created to restore the landing's historic connection with Elliott Bay. North of the boat landing, steps and a boardwalk (Option 1) or boulders (Option 2) could be added for seating and for physical access to or viewing of the new intertidal habitat bench.

Zones 3, 5, and 6 would include viewpoints between the piers. These viewpoints would create opportunities for public gathering, seating, and water viewing. The viewpoints would be parallel with the adjacent piers, thereby directing the view out to Elliott Bay. The viewpoints would include seating steps and stairs to bring people closer to the water.

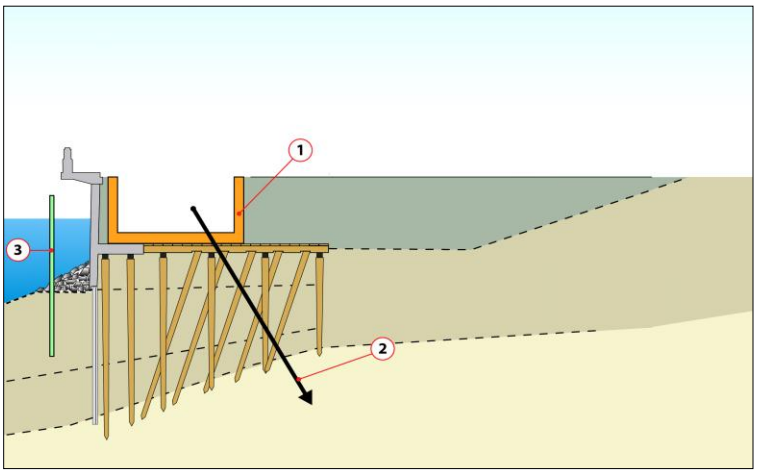
In Zone 4, the proposed seawall setback of 30 to 75 feet would provide two types of opportunities: a water plaza (Option 1) or a land plaza (Option 2). In Option 1, openings in the expansive plaza and walk would allow users to view tide pools and aquatic life below. In Option 2, raised planters would be filled with riparian plants, logs, and stones that would be reminiscent of Puget Sound shorelines.

1.7.2.5 Construction and Schedule

Under Alternative B, the design option proposed for the primary structural element of the seawall is BSP installed by means of a drilled-shaft construction method. With this method, construction of the Central Seawall would require approximately five construction seasons with four summer shutdown periods. Construction of the North Seawall would require an additional four construction seasons, similar to Alternatives A and C, although the duration may be slightly longer.

Access during construction would be more difficult than for either Alternatives A or C because the eastward setback of the seawall would restrict the construction staging areas to the project ends (i.e., north and south extents), instead of alongside the construction work zone. Under Alternative B, it would not be possible to maintain a continuous construction haul road because of the seawall setback in Zones 3 and 4. The construction of a land plaza or water plaza in Zone 4 would increase the duration of construction.

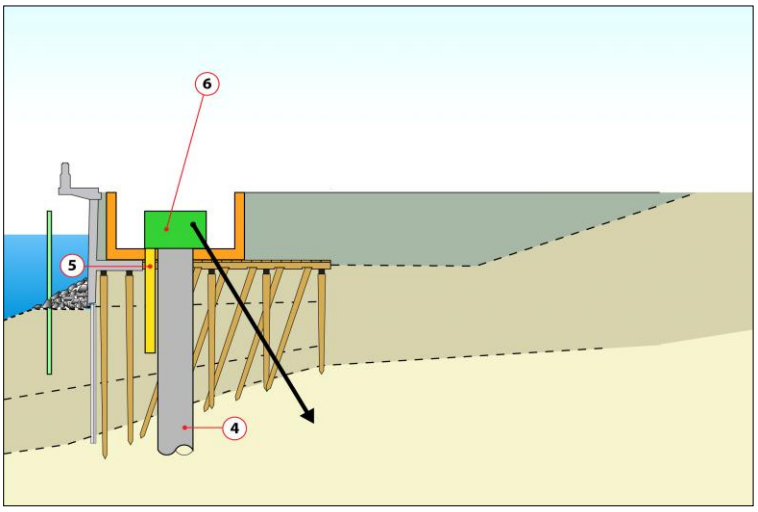
Construction of the Central Seawall would begin in Zone 4, move southward to Zone 3, and then progress to Zones 2 and 1. The Central Seawall construction would be followed by the North Seawall construction in Zones 6 and 5. The anticipated construction stages for Alternative B (assuming a Type A existing seawall) are shown in Figures 1-10 through 1-13.



Alternative B, Stage 1

1. Excavate to top of relieving platform, relocate utilities, and install shoring
2. Install soil anchors
3. Remove existing riprap and install temporary containment wall

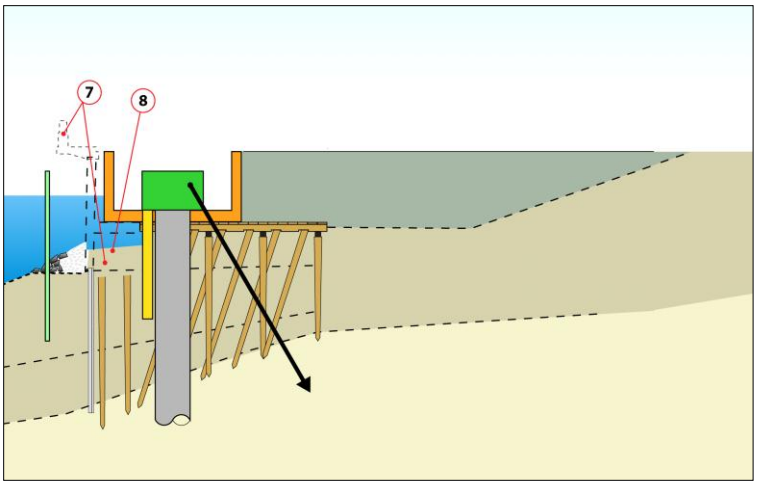
Figure 1-10. Alternative B, Stage 1



Alternative B, Stage 2

4. Drill shaft
5. Install concrete face panel
6. Cast concrete anchor cap

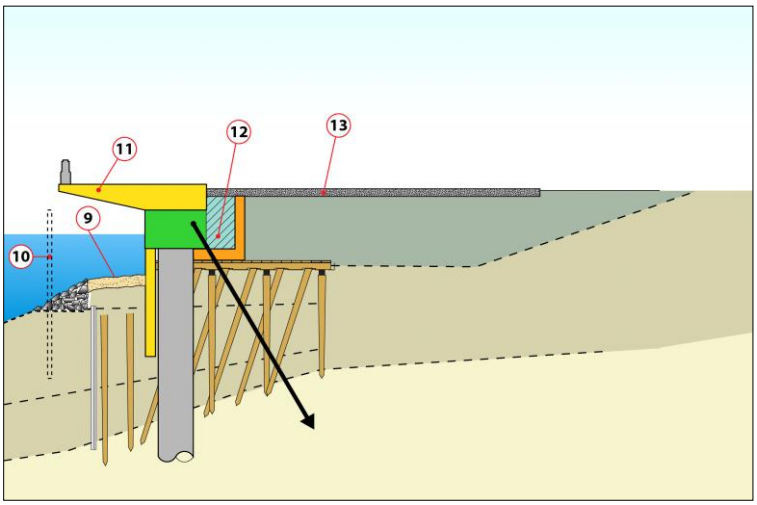
Figure 1-11. Alternative B, Stage 2



Alternative B, Stage 3

7. Remove existing cantilever sidewalk
8. Remove portion of existing wall

Figure 1-12. Alternative B, Stage 3



Alternative B, Stage 4

9. Place substrate
10. Remove temporary containment wall
11. Install sidewalk
12. Restore utilities and backfill
13. Complete restored roadway

Figure 1-13. Alternative B, Stage 4

1.7.3 Alternative C

Alternative C would move the seawall up to 15 feet landward of its current location and would use soil improvements (likely including both jet grouting and deep soil mixing) to provide structural support. Alternative C would also provide a continuous habitat bench and continuous LPS in addition to shoreline enhancements. Figures 1-23 and 1-24 at the end of this chapter depict Alternative C.

1.7.3.1 Seawall

Under Alternative C, the seawall would be constructed approximately 10 to 15 feet landward of the existing seawall alignment along its entire length. The setback proposed for Alternative C would allow soil improvements to proceed without first removing the existing seawall. The approximate proposed location of the seawall face for Alternative C relative to the existing seawall face would be:

- Zones 1 and 2 – 15 feet landward,
- Zone 3 – 10 to 15 feet landward, and
- Zones 4, 5, and 6 – 10 feet landward.

1.7.3.2 Roadway

The existing roadway is generally four lanes (two lanes in each direction), except in the vicinity of Colman Dock (Yesler Way to Spring Street), where it consists of one northbound lane and two southbound lanes. Alternative C would add a permanent northbound lane between S. Washington and Madison Streets[2] to support traffic bound for Colman Dock and other destinations. A temporary second northbound lane (constructed by WSDOT) is currently in place and could be used during seawall construction. Parking and loading zones would be similar to those present today.

A sidewalk of approximately the same width as the existing sidewalk (15 to 20 feet) would be provided on the west side of the street after construction. The sidewalk alignment would be cantilevered or pile supported and would extend back to the piers in all zones. The mixed-use trail on the east side of Alaskan Way would be extended north from its existing terminus to Clay Street, where it would cross Alaskan Way and continue on the west side of the street to Olympic Sculpture Park and Myrtle Edwards Park.

1.7.3.3 Habitat Improvements

Like Alternatives A and B, Alternative C would include a number of habitat improvements. These improvements would extend 10 to 45 feet from the face of the new seawall. An intertidal bench would be installed at the base of the seawall to form a shallow angle to the seafloor and provide shallower water for juvenile salmon migration. Installation of a textured seawall face panel would support the

[2] The Elliott Bay Seawall Project would build the additional lane from S. Washington Street to Madison Street. The portion between S. King Street and S. Washington Street would be constructed as part of the Alaskan Way Viaduct Replacement Project.

development of marine nearshore habitat. Restoration of riparian areas along the back beach area in Zone 1 would include species of riparian and beach shrubs native to Puget Sound.

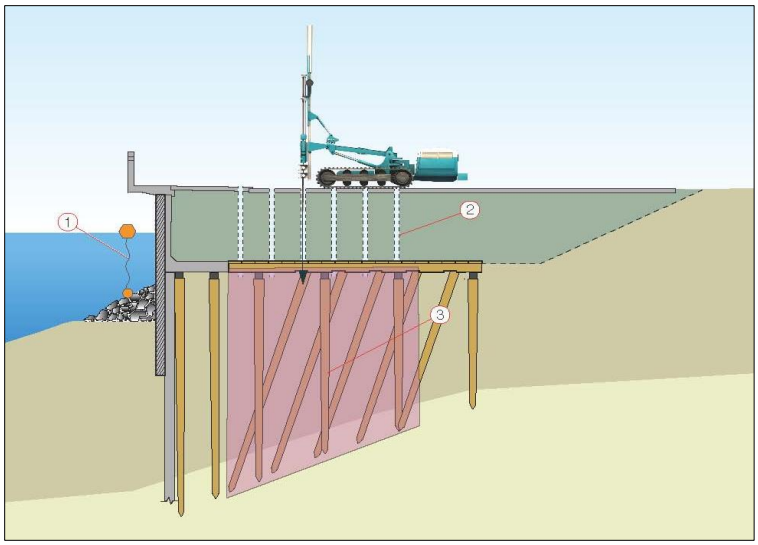
1.7.3.4 Upland Improvements

Under Alternative C, the restored sidewalk space would be enhanced with LPS and include new or upgraded railings, historic elements, wayfinding features, and lighting. Water-viewing opportunities would be preserved or enhanced at various locations, and additional viewing opportunities would be included at Spring and University Streets in Zone 3. In Zone 1, the Washington Street Boat Landing would be restored and reinstalled within the S. Washington Street right-of-way.

1.7.3.5 Construction and Schedule

For Alternative C, the construction method proposed for the primary structural element of the seawall is soil improvement. Alternative C assumes that the soil improvement would be accomplished from street level, without excavating the soils over the relieving platform. After seawall stabilization, the area above the relieving platform would be excavated to allow for installation of the new seawall face and sidewalk. With this method, construction of the Central Seawall would require approximately three construction seasons with two summer shutdown periods. Subsequent construction of the North Seawall would require an additional four construction seasons.

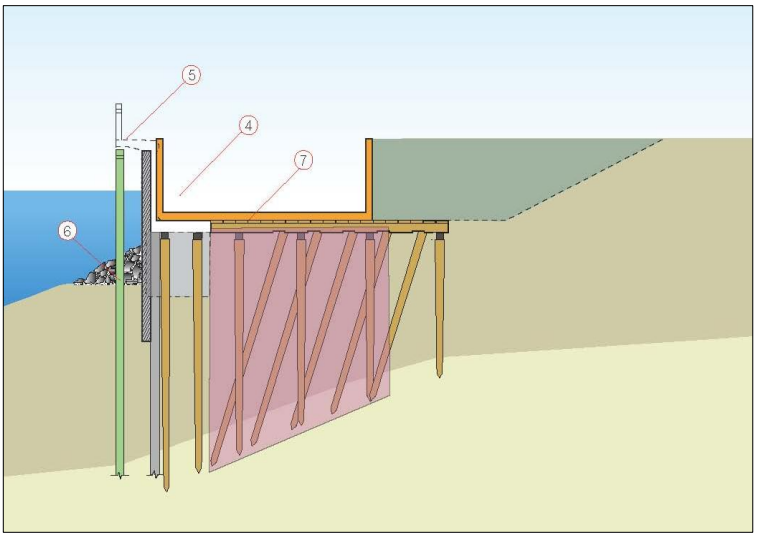
The anticipated construction activities and probable sequence for Alternative C, using soil improvement, are depicted below. The figures describe four primary stages of work that would occur along the waterfront. The activities within each zone would vary depending on the type of existing seawall present. Figures 1-14 through 1-17 are representative of the expected Alternative C construction sequence and depict the Type A seawall.



Alternative C, Stage 1

1. Place in-water containment curtain
2. Pre-drill and fill existing voids beneath timber relieving platform
3. Install soil improvement (jet grout)

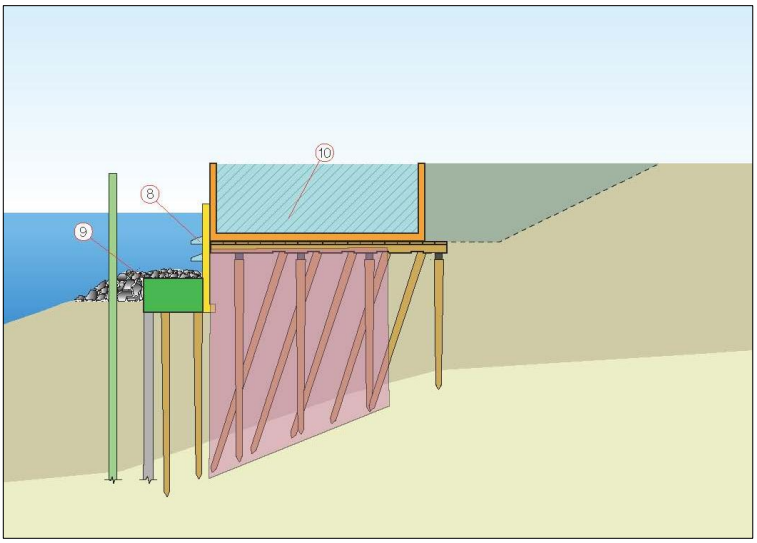
Figure 1-14. Alternative C, Stage 1



Alternative C, Stage 2

4. Relocate utilities
5. Remove existing sidewalk and pavement
6. Install temporary containment wall
7. Excavate to timber relieving platform

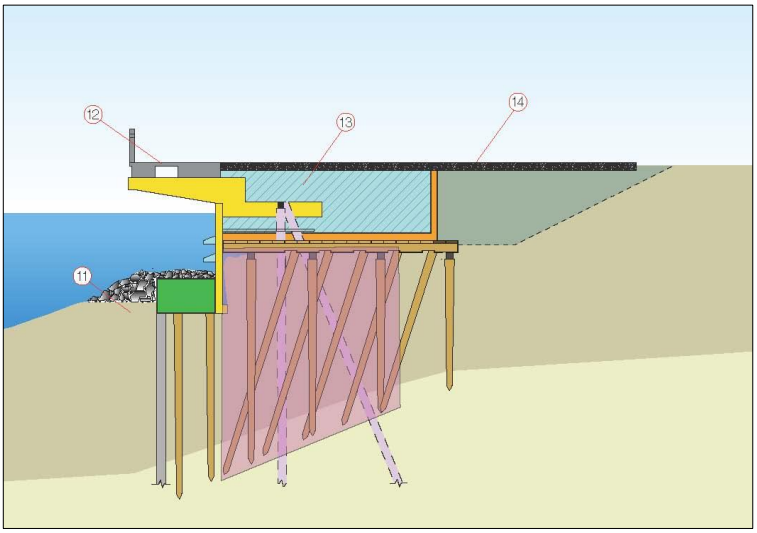
Figure 1-15. Alternative C, Stage 2



Alternative C, Stage 3

8. Remove portion of existing wall and install new face panels and habitat shelves
9. Place habitat bench

Figure 1-16. Alternative C, Stage 3



Alternative C, Stage 4

11. Remove temporary containment wall
12. Install cantilevered sidewalk with light penetrating surface
13. Restore utilities
14. Restore roadway for local traffic

Figure 1-17. Alternative C, Stage 4

TABLE 1-1. COMPARISON OF FEATURES OF THE THREE ELLIOTT BAY SEAWALL PROJECT BUILD ALTERNATIVES

Project Feature	Alternative A	Alternative B	Alternative C
Construction Method	Soil improvement	Braced soldier piles	Soil improvement
Central Seawall Construction Duration	3 construction seasons	5 construction seasons	3 construction seasons
North Seawall Construction Duration	4 construction seasons	4 construction seasons	4 construction seasons
Zone 1			
Face of Seawall Location	Existing location	0 to 15 feet landward	15 feet landward
Habitat Improvements	• Riparian plantings • Substrate enhancement • Cobble reef • Textured seawall face	• Riparian plantings • Substrate enhancement • Cobble reef • Expanded habitat bench and backshore	• Riparian plantings • Substrate enhancement • Expanded habitat bench and backshore
Upland Improvements	• Washington Street Boat Landing restoration • New or restored railings	• Washington Street Boat Landing restoration (up to 15 feet waterward of existing location) • Steps, boardwalk, and overlook (Option 1) • Short-stay boat moorage • New or restored railings	• Washington Street Boat Landing restoration (up to 15 feet waterward of existing location) • New or restored railings
Transportation Features	• Restored sidewalk • Restored multi-use trail • Restored roadway with additional northbound lane from S. Washington to Madison Street	• Restored sidewalk • Restored multi-use trail • Restored roadway	• Restored sidewalk • Restored multi-use trail • Restored roadway with additional northbound lane from S. Washington to Madison Street
Zone 2			
Face of Seawall Location	15 feet landward	15 feet landward	15 feet landward
Habitat Improvements	• Confined substrate habitat bench • Textured seawall face • Intermittent LPS	• Confined substrate habitat bench • Textured seawall face • Continuous LPS	• Confined substrate habitat bench • Textured seawall face • Continuous LPS
Upland Improvements	• Same as existing	• Same as existing	• Same as existing
Transportation Features	• Restored sidewalk • Restored multi-use trail • Restored roadway with additional northbound lane from S. Washington to Madison Street	• Restored sidewalk • Restored multi-use trail • Restored roadway	• Restored sidewalk • Restored multi-use trail • Restored roadway with additional northbound lane from S. Washington to Madison Street

Project Feature	Alternative A	Alternative B	Alternative C
Zone 3			
Face of Seawall Location	3 feet waterward	30 feet landward	10 to 15 feet landward
Habitat Improvements	• Confined substrate habitat bench and expanded habitat bench • Textured seawall face • Intermittent LPS at piers • Riparian plantings	• Confined substrate habitat bench and expanded habitat bench • Textured seawall face • Continuous LPS • Riparian plantings	• Confined substrate habitat bench and expanded habitat bench • Textured seawall face • Continuous LPS
Upland Improvements	• New or restored railings • Street plantings • Viewing area	• New or restored railings • Street plantings • Enhanced viewpoints with seating	• New or restored railings • Street plantings • Enhanced viewpoints
Transportation Features	• Restored sidewalk • Restored multi-use trail • Restored roadway	• Restored sidewalk • Restored multi-use trail • Restored roadway	• Restored sidewalk • Restored multi-use trail • Restored roadway
Zone 4			
Face of Seawall Location	10 feet landward	30 to 75 feet landward	10 feet landward
Habitat Improvements	• Confined substrate habitat bench and expanded habitat bench • Substrate enhancements • Textured seawall face • Intermittent LPS at piers • Cobble reefs • Riparian plantings	• Confined substrate habitat bench and expanded habitat bench • Substrate enhancements • Textured seawall face • Continuous LPS • Cobble reefs • Riparian plantings • Daylighting of water plaza	• Confined substrate habitat bench and expanded habitat bench • Substrate enhancements • Textured seawall face • Continuous LPS • Daylighting of portions of cantilevered sidewalk
Upland Improvements	• New or restored railings • Street plantings • Viewing area	• New or restored railings • Street plantings • Creation of a land or water plaza • Enhanced viewpoints	• New or restored railings • Street plantings
Transportation Features	• Restored sidewalk • Restored multi-use trail • Restored roadway	• Restored sidewalk • Restored multi-use trail • Restored roadway	• Restored sidewalk • Restored multi-use trail • Restored roadway

Project Feature	Alternative A	Alternative B	Alternative C
Zone 5			
Face of Seawall Location	10 feet landward	10 feet landward	10 feet landward
Habitat Improvements	• Confined substrate habitat bench • Riparian plantings • Textured seawall face	• Confined substrate habitat bench • Riparian plantings • Textured seawall face	• Confined substrate habitat bench • Riparian plantings • Textured seawall face • Continuous LPS
Upland Improvements	• New or restored railings • Street plantings • Viewing area	• New or restored railings • Street plantings • Expanded viewpoints	• New or restored railings • Street plantings • Enhanced viewpoints
Transportation Features	• Restored sidewalk • Restored multi-use trail • Restored roadway	• Restored sidewalk • Restored multi-use trail • Restored roadway	• Restored sidewalk • Restored multi-use trail • Restored roadway
Zone 6			
Face of Seawall Location	10 feet landward	10 feet landward	10 feet landward
Habitat Improvements	• Confined substrate habitat bench and expanded habitat bench • Substrate enhancement • Textured seawall face • Riparian plantings • Intermittent LPS at piers • Cobble reefs	• Confined substrate habitat bench and expanded habitat bench • Substrate enhancement • Textured seawall face • Riparian plantings • Intermittent LPS at piers • Cobble reefs	• Confined substrate habitat bench and expanded habitat bench • Substrate enhancement • Textured seawall face • Riparian plantings • Continuous LPS
Upland Improvements	• Restored or new railings • Viewing area	• Restored or new railings • Enhanced viewpoints	• Restored or new railings • Enhanced viewpoints
Transportation Features	• Restored sidewalk • Extended multi-use trail • Restored roadway	• Restored sidewalk • Extended multi-use trail • Restored roadway	• Restored sidewalk • Extended multi-use trail • Restored roadway

Note: LPS – light-penetrating surfaces

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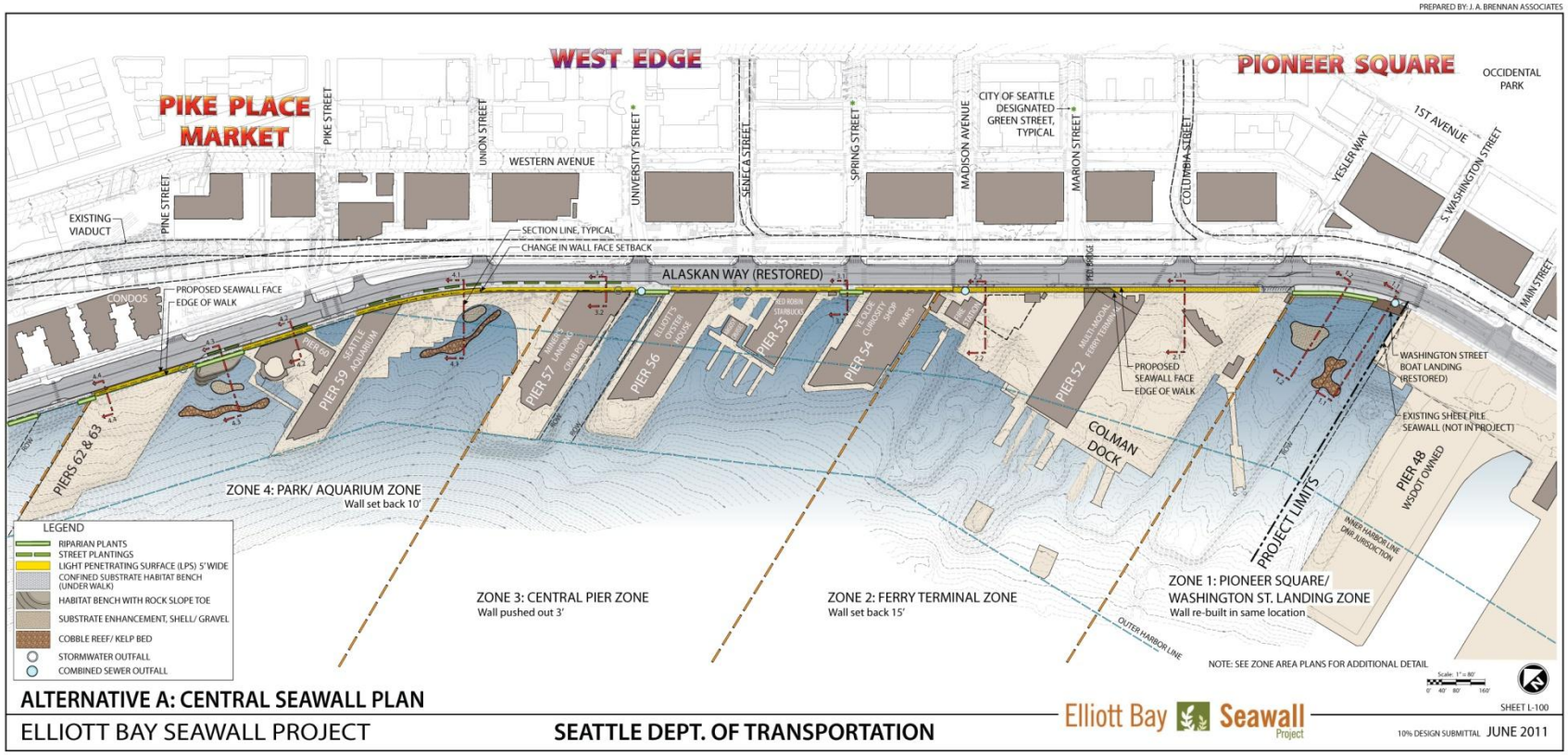

Figure 1-18. Alternative A: Central Seawall Plan

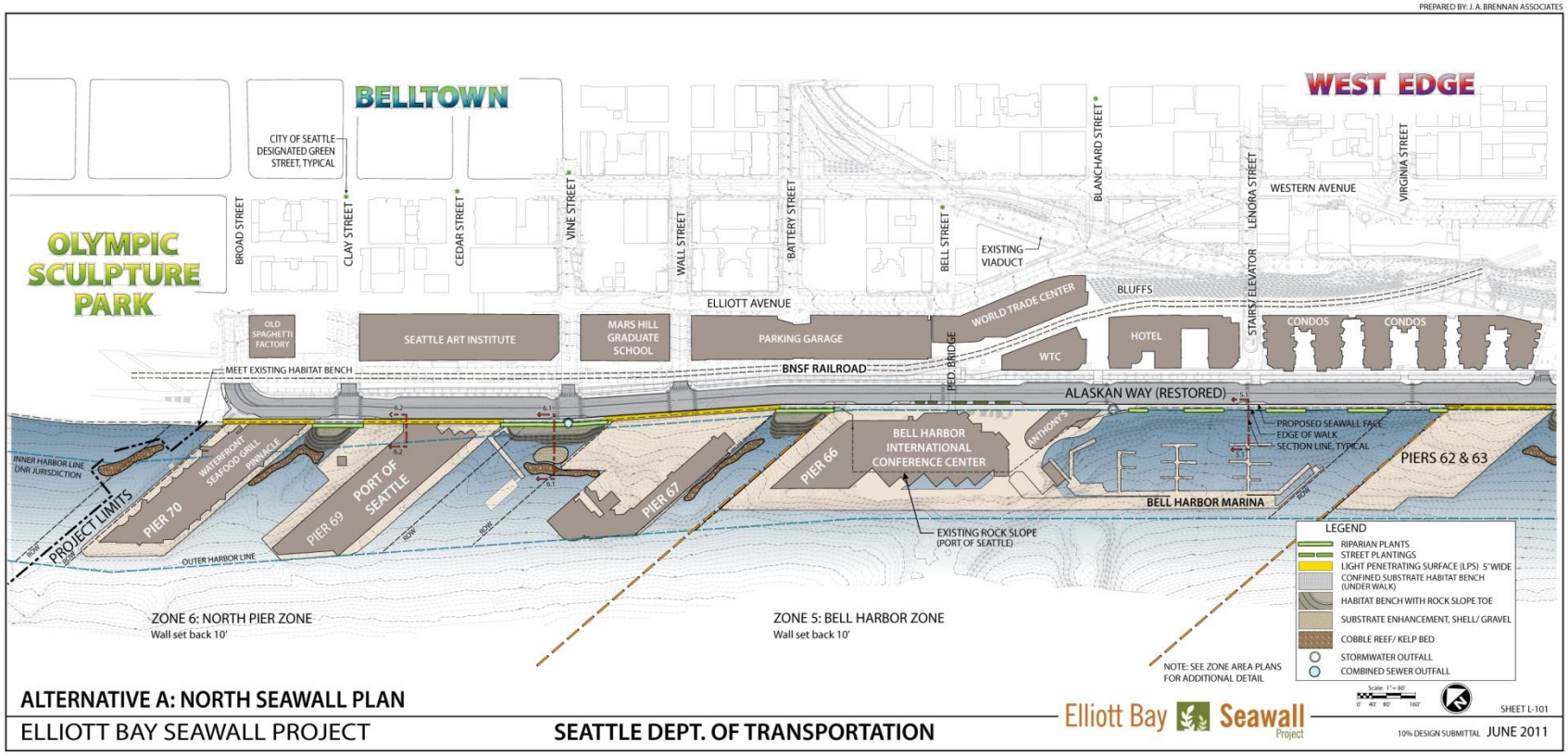

Figure 1-19. Alternative A: North Seawall Plan

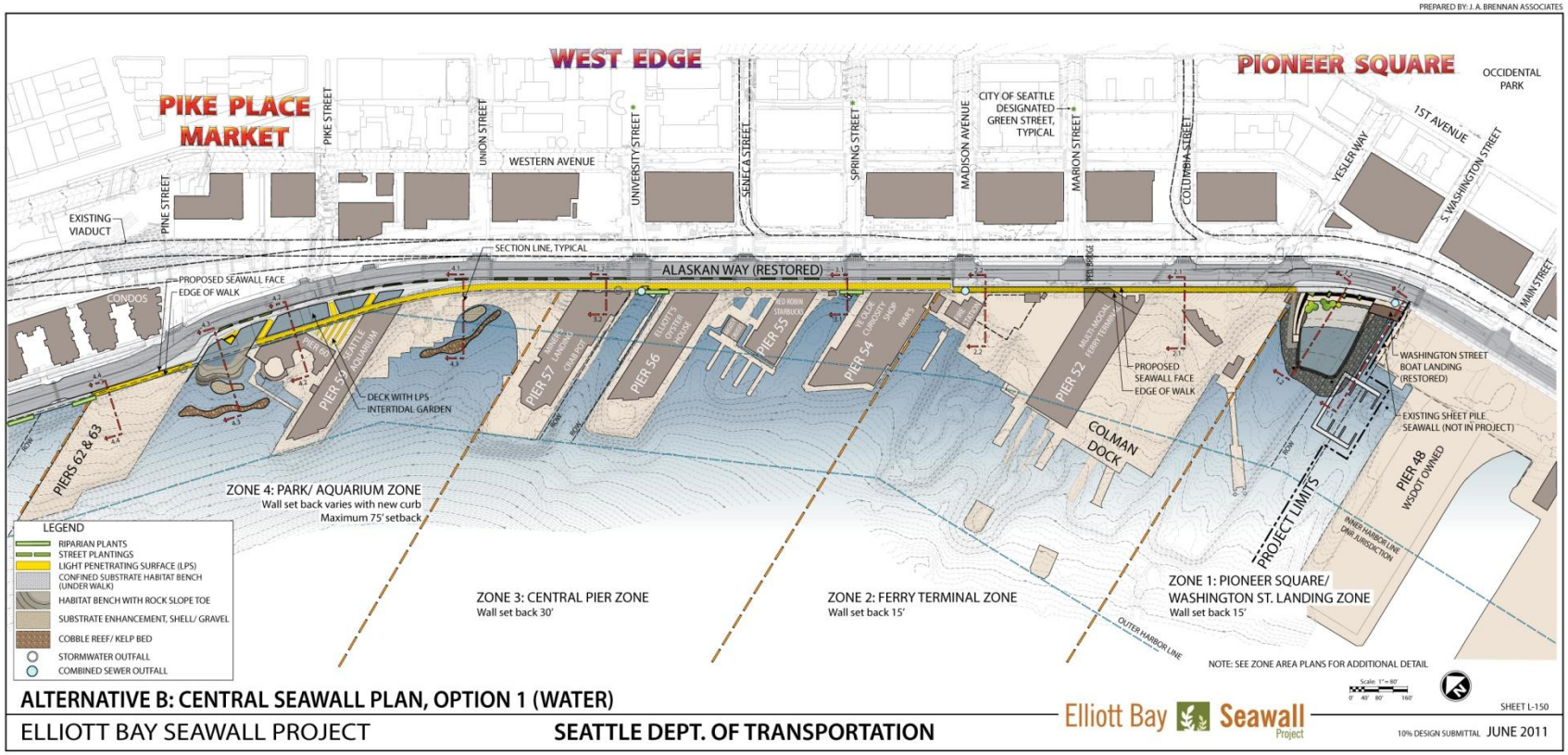

Figure 1-20. Alternative B: Central Seawall Plan, Option 1

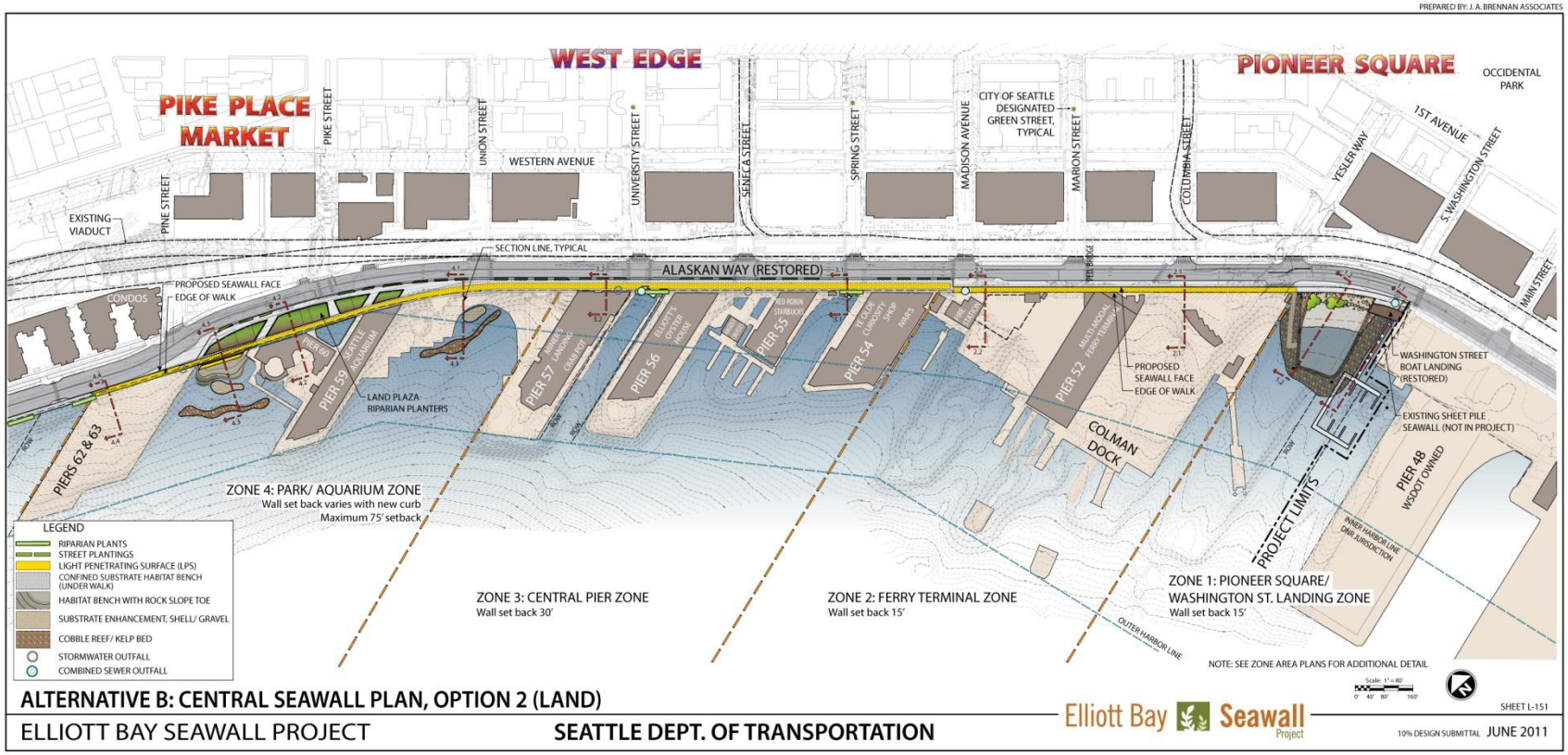

Figure 1-21. Alternative B: Central Seawall Plan, Option 2

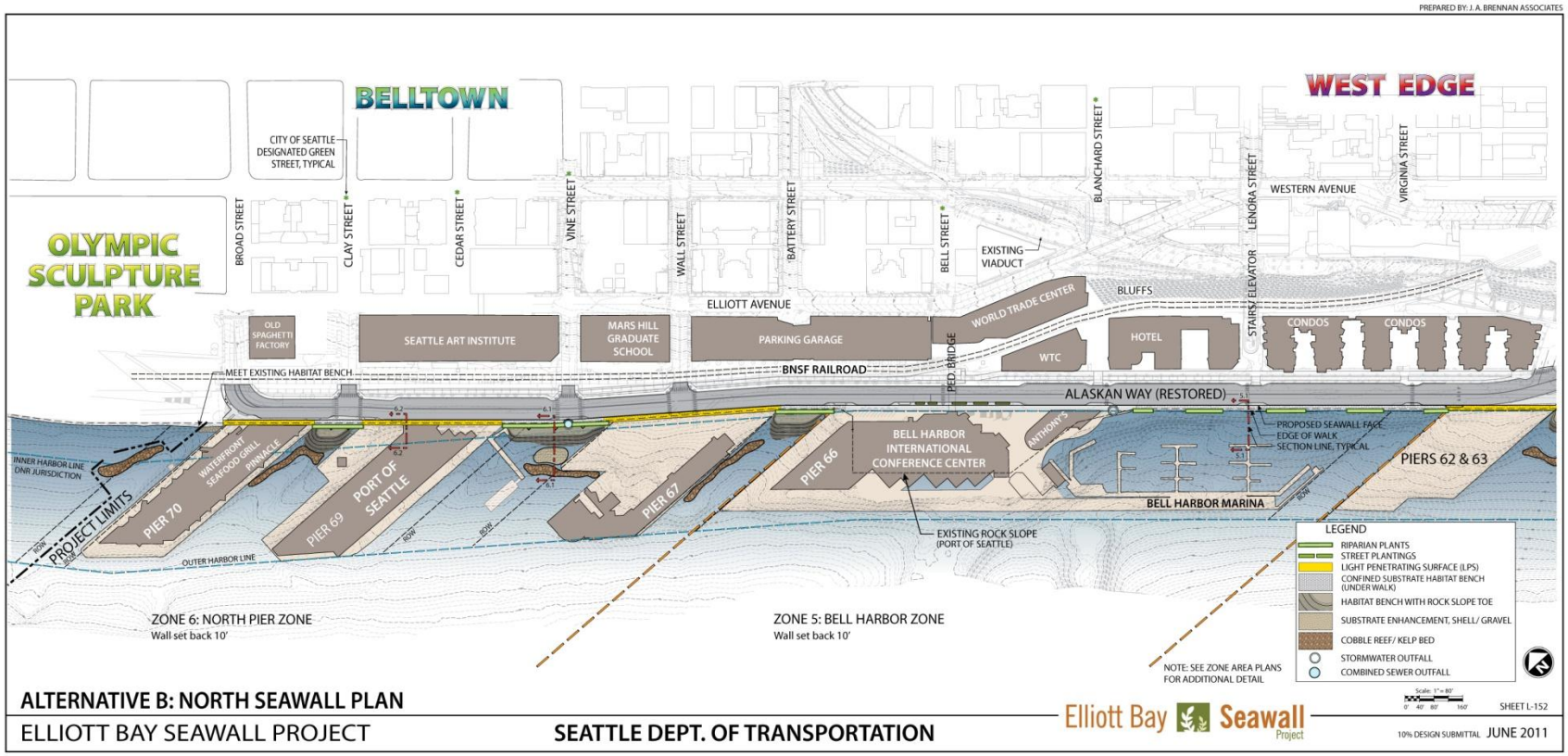

Figure 1-22. Alternative B: North Seawall Plan

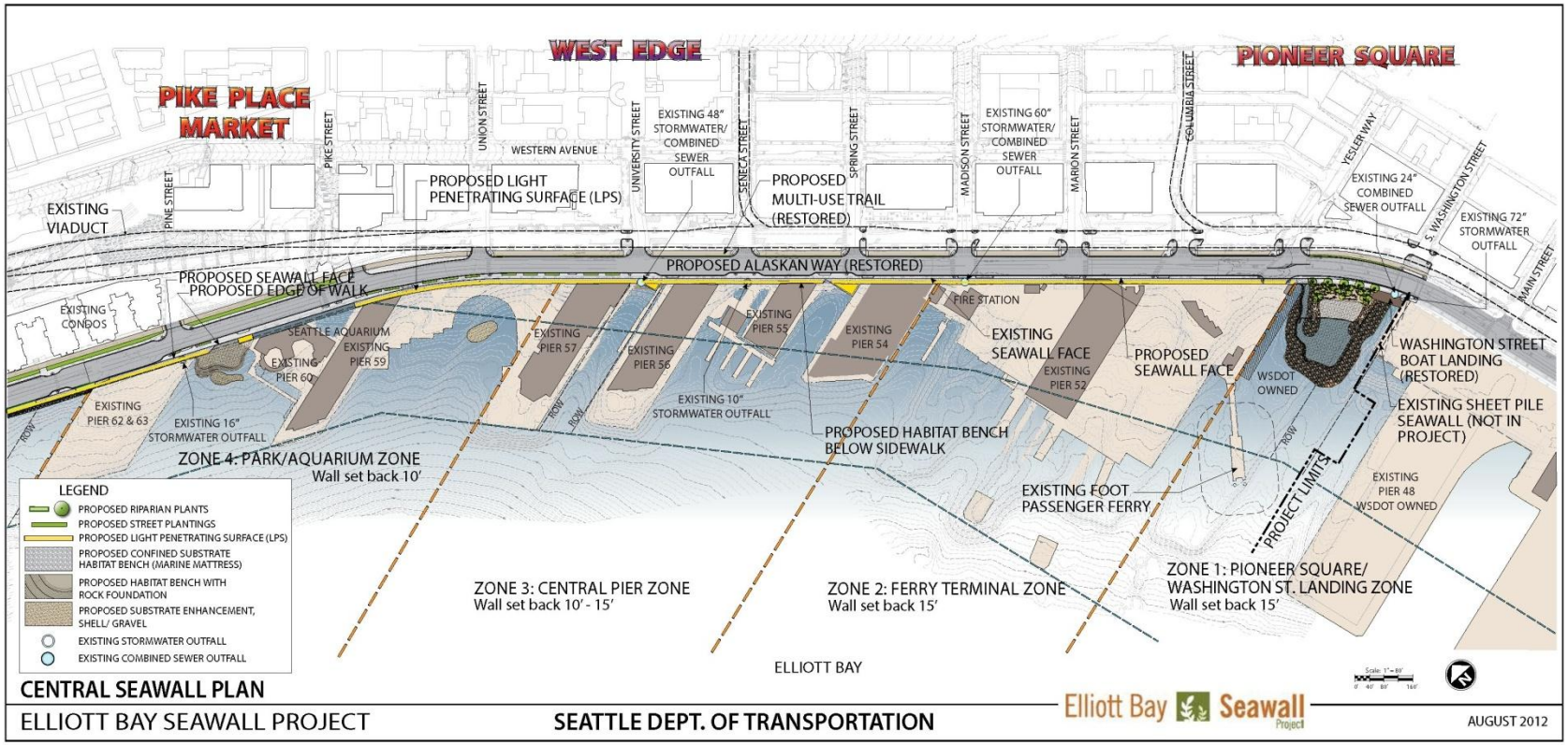

Figure 1-23. Alternative C: Central Seawall Plan

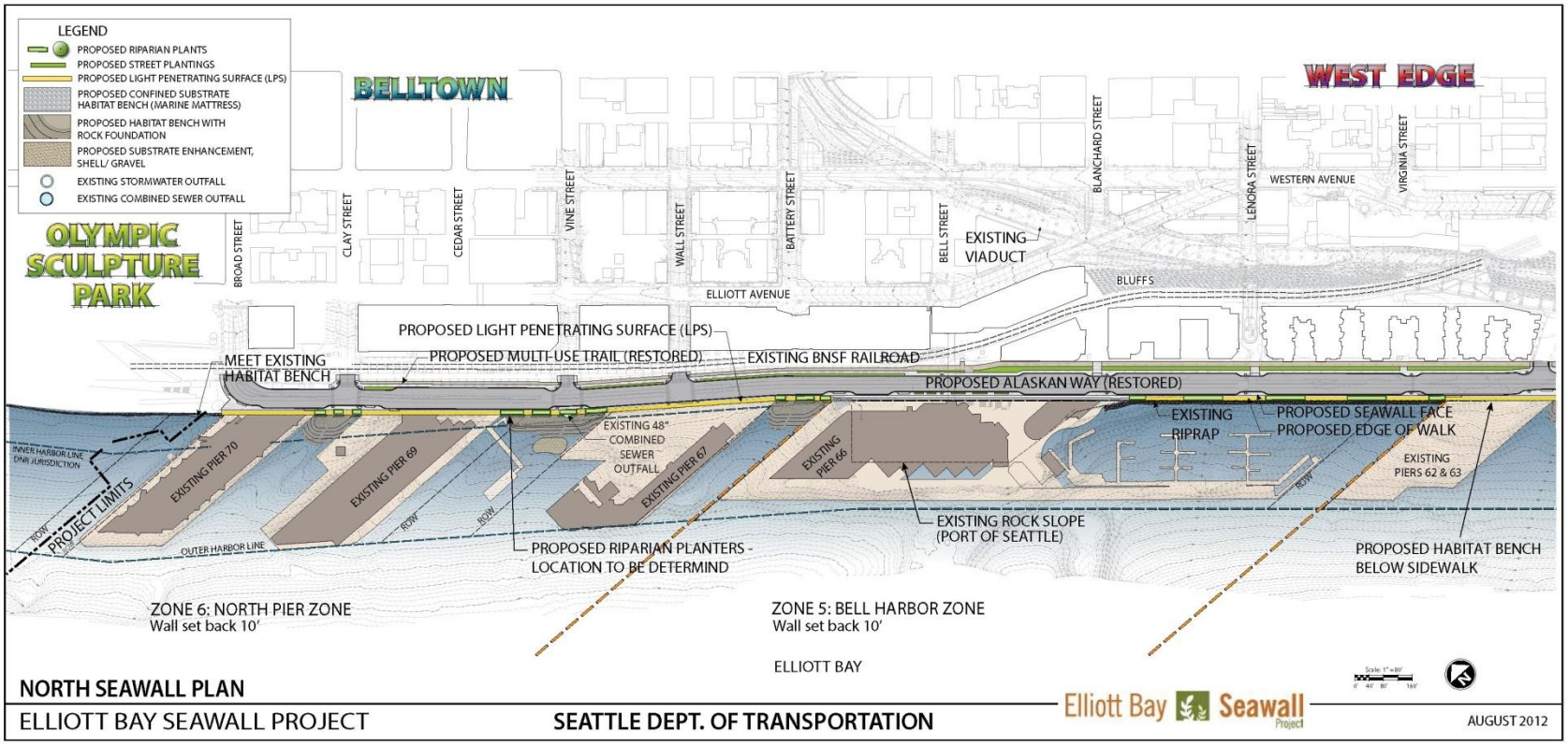

Figure 1-24. Alternative C: North Seawall Plan

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CHAPTER 2. METHODOLOGY

The *Elliott Bay Seawall Project Noise and Vibration Methodology Technical Memorandum* (SDOT 2011) contains a detailed description of the methodology used for this Discipline Report. The objective of this Discipline Report is to first describe the existing conditions in the study area and then to identify operational and construction effects that the EBSP could have on the noise and vibration environment.

2.1 STUDY AREA

Seawall design, construction procedures, and aquatic-habitat restoration activities may vary for different zones. In general, this Discipline Report emphasizes on-shore locations within about 1,000 feet of the seawall construction zone, but evaluates in-water and more distant on-shore locations as warranted. Airborne noise and ground vibration levels decrease rapidly with increasing distance from the source, resulting in a geographically limited area of potential impacts. Existing traffic on the Alaskan Way Viaduct is a major source of existing noise for Zones 1 through 4. Noise from traffic on the Alaskan Way Viaduct is more distant and reduced in Zones 5 and 6. The high existing noise levels near the Alaskan Way Viaduct have the potential for masking most seawall construction noise at locations east of the Alaskan Way Viaduct, especially during daytime hours (7:00 a.m. to 10:00 p.m.). Cumulative impact considerations related to existing and future traffic conditions along the Alaskan Way surface street and the Alaskan Way Viaduct corridor may extend the noise study area eastward of the Alaskan Way Viaduct corridor.

The potential for underwater noise and vibration effects on the aquatic environment west of the seawall were generally evaluated based on the types of equipment and pilings to be used. The focus of these analyses is on underwater pile-driving noise and the areas surrounding the pile-driving activities, since that is the most significant underwater noise source likely to be associated with seawall construction.

2.2 ANALYSIS OF EXISTING CONDITIONS

A background discussion of noise and vibration terminology, general information on effects, and typical environmental noise and vibration levels are provided to facilitate understanding of the technical analyses. Additional discussion is provided to explain differences between airborne and underwater noise. The discussion of effects of noise includes effects on people, fish, marine mammals and wildlife.

Existing federal, state, and local noise guidelines and regulations are summarized to provide a planning and regulatory context for the noise analyses. Examples of state and local noise regulations that are applicable to the EBSP include the City of Seattle Noise Ordinance (Noise Ordinance; SMC Chapter 25.08), and Washington Administrative Code (WAC) Chapter 173-60, Maximum Environmental Noise Levels.

Caltrans guidance outlining vibration criteria for human response and for potential cosmetic building damage is used to analyze the potential effects of vibration on structures. Seattle Public Utilities (SPU) uses a vibration criterion of 0.50 inch per second peak particle velocity which is consistent with the Caltrans vibration criteria.

WSDOT and the City of Seattle Department of Planning and Development (DPD) were contacted to obtain all available noise and vibration-monitoring data collected for NEPA/SEPA analyses of other downtown Seattle projects. Ambient noise data at 25 sites and vibration data at 17 sites collected for other projects were used to characterize background noise levels in the vicinity of the EBSP construction corridor. In addition, ambient noise monitoring was conducted for this study to supplement existing data, primarily in the immediate vicinity of planned seawall construction activities.

2.3 ANALYSIS OF ENVIRONMENTAL EFFECTS

The analysis of noise and vibration impacts associated with the EBSP focuses on effects from construction activities. Noise and vibration levels associated with construction equipment and activities were evaluated quantitatively. The Elliott Bay Seawall is not expected to have any operational noise impacts and requires few routine operational activities other than periodic inspection and maintenance.

2.3.1 In-Air Construction Noise and Vibration Analyses

Noise impacts from construction activity were estimated using the Federal Highway Administration (FHWA) Roadway Construction Noise Model (RCNM) (FHWA 2011). The RCNM is a state-of-the-art computer program that enables the prediction of construction noise levels for a variety of construction operations based on a compilation of empirical data and the application of acoustical propagation formulas. The program enables the calculation of construction noise levels in more detail than manual methods while avoiding the need to collect extensive amounts of project-specific input data. RCNM incorporates an extensive construction equipment noise database, and analyzes multiple pieces of equipment simultaneously and defines multiple receptor locations, including land-use type and baseline noise levels.

Ground vibration conditions associated with construction equipment and construction activities was evaluated using analysis procedures recommended by Caltrans. These procedures are similar to but more conservative than those used by the Federal Transit Administration (FTA) and FHWA. The significance of estimated ground vibration levels was evaluated using Caltrans vibration criteria, which vary according to the repetition pattern of vibration events, human response versus cosmetic building damage potential, and type of building for cosmetic building damage issues. Particular attention was given to potential vibration impacts to historic structures near the construction zone.

2.3.2 Underwater Construction Noise Analyses

Calculation procedures developed by the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) were used to generally evaluate underwater noise generated by pile-driving activities associated with the project. These procedures were taken from the WSDOT Biological Assessment Guidance (WSDOT 2011a). The results of the analyses were provided for use in the Fish, Wildlife and Vegetation Discipline Report for evaluation of effects on fish and wildlife resources (see SDOT 2012a).

2.3.3 Traffic Noise Analyses

Construction activities would not result in significant changes to local traffic conditions. The restored roadway (post-seawall construction) is not expected to be in a substantially different location than the current roadway; therefore, additional detailed traffic noise analysis is not necessary.

2.3.4 Indirect Effects

The evaluation of indirect or secondary impacts are based on noise and/or vibration effects that may occur later in time or further removed in distance as a result of this project. Examples of such secondary effects from the proposed project due to noise and vibration could include potential health and safety issues such as occupational hearing damage, and building foundation and structural issues from micro-cracking in buildings near pile-driving activities.

2.3.5 Mitigation Measures

Construction noise mitigation requirements would be incorporated into any required noise variances. Coordination with DPD will help ensure consistency between noise variance requirements for the EBSP and other separate and independent projects in or near the study area, such as the Alaskan Way Viaduct Replacement Project. As an example, DPD may require noise monitoring during seawall construction. In addition, mitigation measures would be incorporated into any in-water environmental approvals and permits (i.e., Endangered Species Act, Shoreline Permit, and/or Hydraulic Project Approval).

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CHAPTER 3. COORDINATION AND INFORMATION SOURCES

Noise and vibration monitoring data from past Alaskan Way Viaduct and Seawall Replacement Program (AWVSRP) studies were reviewed to identify data from locations in or near the EBSP noise and vibration study area. The City was contacted to identify additional noise and vibration data from NEPA/SEPA documents on other projects in or near the study area. Most of the noise monitoring conducted to date in connection with AWVSRP studies has involved monitoring durations of 15 minutes. Additional short-term (generally 1 hour or longer) and long-term (24 hours or longer) noise monitoring was conducted in the EBSP noise and vibration study area to provide additional baseline noise data for businesses, residences, and public use areas that may be impacted by noise from project-related construction activities. In addition, noise data were collected as part of the noise variance application preparation process (see Section 4.1.2). Vibration monitoring data collected for other AWVSRP elements will provide adequate data regarding baseline ground vibration conditions. No additional vibration monitoring data collection was conducted.

Information on construction schedules, construction methods, and required construction equipment was provided by the design team and included in the noise and vibration analysis. Information on underwater noise levels associated with pile driving and other activities was obtained from various references such as those listed in the references section of this document. The effects on fish and wildlife were determined with support from the authors of the Fish, Wildlife, and Vegetation Discipline Report (SDOT 2012a). Information on vibration levels associated with pile driving and other activities was obtained from various references such as those listed in the references section of this document, and the effects were determined with support from the authors of the Cultural, Historic, and Archaeological Resources Discipline Report (SDOT 2012b).

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CHAPTER 4. AFFECTED ENVIRONMENT

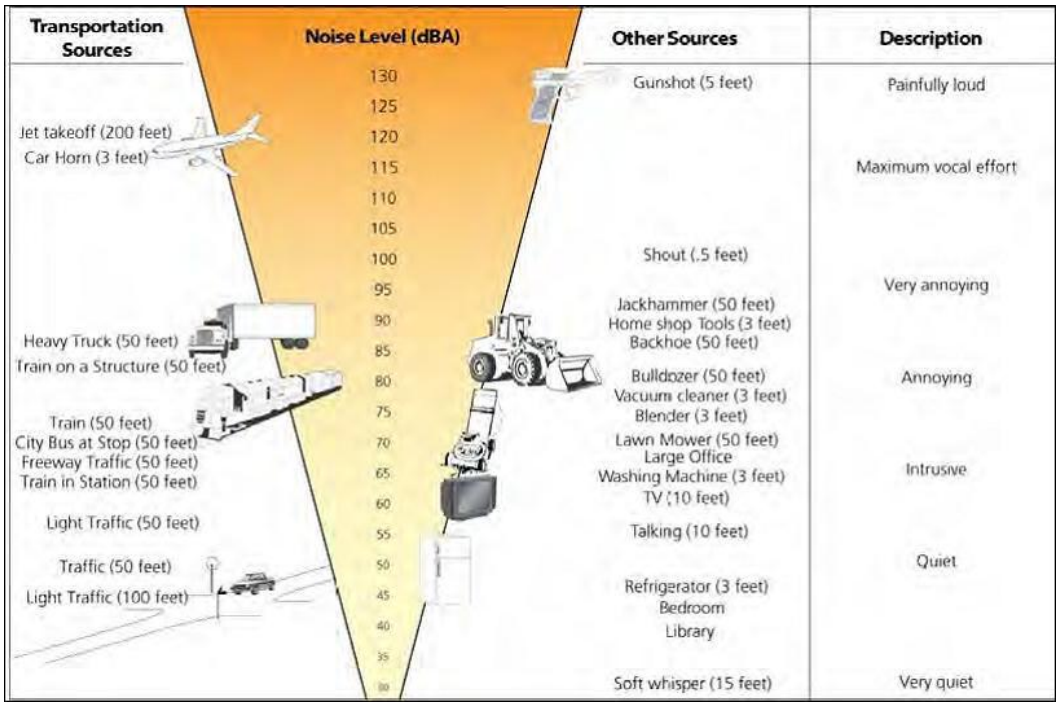
The noise and vibration conditions along the study area were evaluated by reviewing available information and performing noise monitoring in the study area specific to this project. This information was used to develop a description of the existing noise and vibration environment that may be affected by the EBSP.

4.1 NOISE

Noise is defined as any sound that is undesirable because it interferes with communication, is intense enough to damage hearing, or is otherwise intrusive. Human response to noise varies depending on the type and characteristics of the noise; distance between the noise source and the receptor; receptor sensitivity; and time of day. Noise is often generated by activities essential to a community's *quality of life*, such as construction or vehicular traffic. Environmental noise affects human welfare by interfering with sleep, thought, and conversation.

Sound is a physical phenomenon consisting of vibrations that travel through a medium, such as air, and are sensed by the human ear. Sound varies by both intensity and frequency. Sound pressure level, described in decibels (dB), is used to quantify sound intensity. The dB is a logarithmic unit that expresses the ratio of a sound pressure level to a standard reference level. Hertz (Hz) are used to quantify sound frequency. The human ear responds differently to different frequencies. "A-weighing", measured in A-weighted decibels (dBA), approximates a frequency response expressing the perception of sound by humans. Typical A-weighted sound levels from various sources are presented in Figure 4-1. These sound sources, which range from a quiet whisper or light wind at 30 dBA to a jet takeoff at 120 dBA, demonstrate the range of the human ear. A typical conversation is in the range of 50 to 60 dBA.

The dBA noise metric describes steady noise levels, although very few noises are, in fact, constant. Therefore, other noise metrics such as Equivalent Sound Level and Day-night Sound Level have been developed. Equivalent Sound Level (L_{eq}) is the average sound level in dB, and a measure of the average sound energy during a specified period, is often used to describe the overall noise environment. In addition, Day-night Sound Level (DNL) is defined as the average sound energy in a 24-hour period with an additional 10 dB added to the nighttime levels (10 p.m. to 7 a.m.). DNL is a useful descriptor for noise because: (1) it averages ongoing yet intermittent noise, and (2) it measures total sound energy over a 24-hour period. Typical outdoor sound levels are shown in Table 4-1. Short-term noise, such as those from heavy construction equipment or pile driving, can be described by the highest noise level that occurs during the event. The maximum sound level (L_{max}) is the greatest short-duration sound level that occurs during a single event.



Sources: USDOT 1995, USEPA 1971, 1974

Figure 4-1. Typical A-Weighted Sound Levels

TABLE 4-1. TYPICAL OUTDOOR SOUND LEVELS IN VARIOUS ENVIRONMENTS

Qualitative Description	Day-night Sound Level (dBA)
City Noise (downtown major metropolis)	85 80 75
Very Noisy Urban	70
Noisy Urban	65
Urban	60
Suburban	55
Small Town and Quiet Suburban	50 45 40

Source: USEPA 1974.

4.1.1 Regulations and Guidelines

The Noise Control Act of 1972 (PL 92-574) directs federal agencies to comply with applicable Federal, state, interstate, and local noise control regulations. The Noise Ordinance is the only regulation that governs construction noise at the site, and contains the most appropriate thresholds for determining impacts of the proposed construction activities. The City limits noise levels at property lines of neighboring properties (SMC 25.08.410). The maximum permissible sound level depends on the land

uses of both the noise source and the receiving property (Table 4-2). Notably, the City ordinance is consistent with the State of Washington's noise regulation (WAC Chapter 173-60).

TABLE 4-2. CITY OF SEATTLE MAXIMUM PERMISSIBLE SOUND LEVELS

Land Use	District of Receiving Property			
	Residential (dBA)		Commercial (dBA)	Industrial (dBA)
	Day	Night		
Residential	55	45	57	60
Commercial	57	47	60	65
Industrial	60	50	65	70

Source: SMC 25.08.410.

It is currently assumed that work weeks would be six days a week, with two 10-hour shifts per day. It is possible that work could occur seven days a week, and up to 24 hours a day. Regardless, some construction is anticipated during the nighttime hours. Construction activities from 7:00 a.m. to 10:00 p.m. on weekdays and from 9:00 a.m. to 10:00 p.m. on weekends and legal holidays are allowed to exceed the property line standards per the following limits, measured at 50 feet from the equipment or the property line, whichever is farther (SMC 25.08.425):

- Earth-moving or other equipment on construction sites may exceed the applicable property line noise limit by 25 dBA.
- Portable powered equipment in temporary locations in support of construction may exceed the limit by 20 dBA.
- Impact equipment, such as jackhammers, may not exceed an L_{eq} (1 hour) of 90 dBA continuously or an L_{eq} (7.5 minutes) of 99 dBA and may be used only from 8:00 a.m. to 5:00 p.m. weekdays and from 9:00 a.m. to 5:00 p.m. on weekends and legal holidays, unless otherwise allowed by a noise variance.

4.1.2 Existing Noise

Zones 1 through 4 are primarily commercial and transit oriented. Traffic on the AWV is a predominant source of noise in the project area for Zones 1 through 4. Existing sources of noise near Zones 1 through 4 is mainly road traffic, with some localized industry as well as high-altitude aircraft overflights. The noise environment consists of routes of relatively heavy or fast automobile and truck traffic along the AWV and Alaskan Way, and natural noises such as leaves rustling, modest wave action, and bird vocalizations are limited. Retail, office, transportation, public services (fire) and recreational uses dominate on the west side of Alaskan Way where natural noises can be limited during peak commute times.

Zones 5 and 6 have more residential areas and hotels than Zones 1 through 4. Noise from traffic on the AWV is more distant and reduced in Zones 5 and 6. Zones 5 and 6 are more traditional mixed-use areas with both residential and commercial uses with the Edgewater Hotel, Seattle Marriot Waterfront Hotel, and the Port of Seattle. Existing sources of noise are local road traffic, vessel engines, high-altitude aircraft overflights, and natural noises such as light surf, and bird vocalizations.

Ambient noise data at 25 sites collected for other projects were used to characterize existing conditions in the vicinity of the EBSP construction corridor. In addition, ambient noise monitoring was conducted to supplement existing data, primarily in the immediate vicinity of planned seawall construction activities. The additional noise monitoring involved a combination of short-term and long-term monitoring. Short-term monitoring typically lasted for one to two hours, while long-term monitoring typically lasted for 24 to 48 hours. Figures 4-2 and 4-3 show the noise sensitive areas considered, as well as the noise monitoring locations. Table 4-3 outlines nearby noise sensitive areas, noise monitoring locations, and existing background noise levels.

Measurements were also conducted at two additional locations during the preparation of the noise variance application: (1) along the Central Seawall at Waterfront Place, 1009 Western Avenue, adjacent to noise monitoring location number 8 as shown in Figure 4-2, and (2) along the North Seawall at Waterfront Landings, 2000 Alaskan Way adjacent to noise monitoring location number 18 as shown in Figure 4-3. These additional locations were chosen based on sensitivity of nighttime use (condominiums, apartments, etc.). The existing noise levels at these additional monitoring locations are outlined in Table 4-4. Ambient sound levels at these locations are consistent with other nearby locations.

Notably, sound levels in air are typically used to assess impacts to humans and thus are weighted (A weighting) to correspond to the same frequency range that humans hear. Sound levels underwater are not weighted and thus account for the entire frequency range of interest. Sound pressure levels outlined in the model are underwater and have a reference pressure of 1 microPascal (µPA). The calculation of an equivalent airborne noise involves subtracting 26 dB.

Underwater noise levels during the daytime are dominated by the presence of ferry traffic and occasional outboard motorboats. Thirty-five vessels access the Seattle ferry terminal at Colman Dock (Pier 52) during spring weekdays. Root Mean Square (RMS) background noise levels are reported in terms of the 30-second average continuous sound level and have been computed. The background sound levels for all frequencies measured between 20 Hz and 20 KHz ranged between 105 and 145 dB (re 1 µPA) with the 50th percentile occurring at 128 dB (re 1 µPA) (WSDOT 2011b).

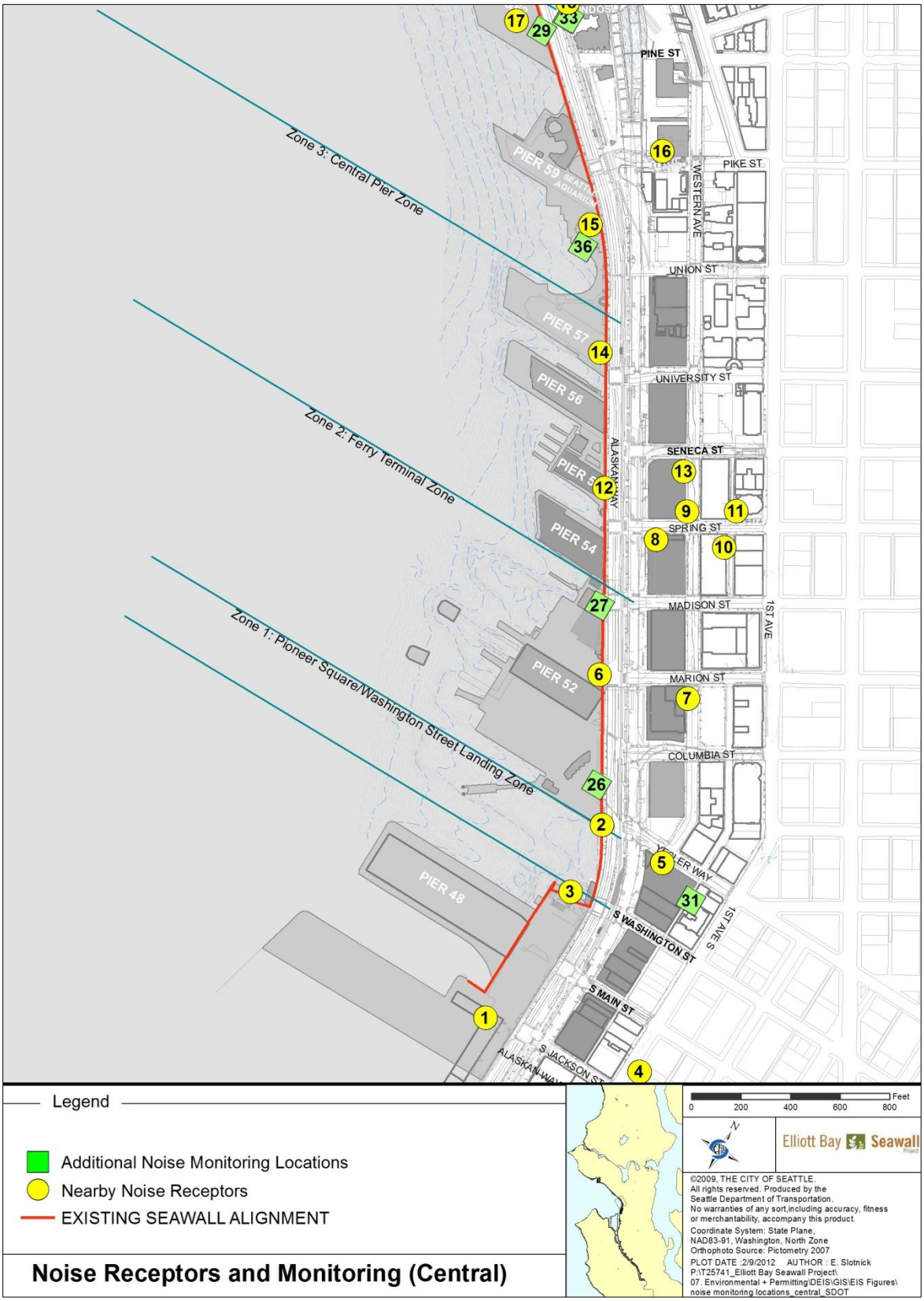


Figure 4-2. Nearby Noise Receptors and Additional Monitoring Locations, Central Seawall

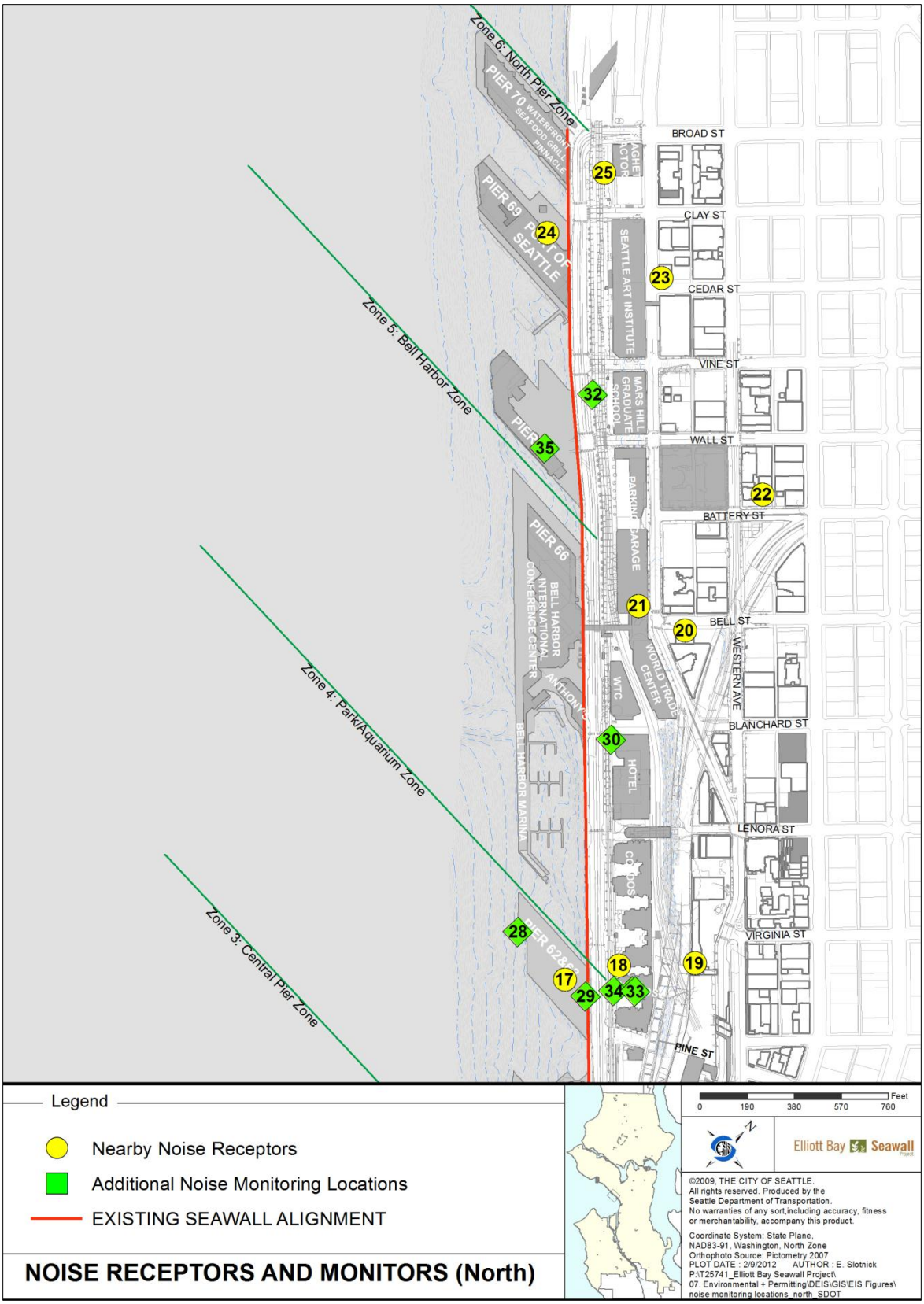


Figure 4-3. Nearby Noise Receptors and Additional Monitoring Locations, North Seawall

TABLE 4-3. NEARBY NOISE SENSITIVE AREAS AND EXISTING NOISE

Receptor Number	Zone	Site Description	Existing Noise Levels (L_{eq} [dBA])
1	1	Alaskan Way and S. Jackson Street	73
2	2	Pier 50	75
3	1	Washington Street Boat Landing	75
4	1	First Avenue S. and S. Main Street	70
5	2	Pioneer Square Hotel street level	70
6	2	Colman Dock	75
7	2	Marion Street pedestrian bridge	80
8	3	Spring Street and Alaskan Way	79
9	3	Western Avenue and Spring Street	72
10	3	Spring Street and Post Avenue	70
11	3	Spring Street and First Avenue	70
12	3	Elliott's Oyster House	72
13	3	Alaskan Way bicycle path at Seneca Street	77
14	4	Waterfront Park boardwalk	72
15	4	Waterfront Park	71
16	4	Hill Climb Court	76
17	4	Pier at Pine Street	66
18	5	Waterfront Landing (ground level)	68
19	5	Victor Steinbrueck Park (bench area)	77
20	6	Elliott Point (ground level)	76
21	6	Belltown Loft (ground level)	73
22	6	Site 15 - 312 residential units	72
23	6	Fountain Court Apartments	70
24	6	Port of Seattle terrace	65
25	6	Western Avenue and Cedar Street	68
26	2	Colman Dock	74
27	1	Fire Station No. 5	75
28	4	Pier 62/63 Pier End	61
29	4	Pier 62/63 Street	68
30	5	Seattle Marriott	75
31	1	Terry Denny Lofts	70
32	6	Vine Street Streetcar Stop	69
33	4	Waterfront Condos 515 (Indoor)	36
34	4	Waterfront Condos 515 (Outdoor)	65
35	6	Edgewater Hotel	65
36	4	Waterfront Park	72

Source: WSDOT 2011a.

TABLE 4-4. EXISTING NOISE LEVELS AT ADDITIONAL MONITORING LOCATIONS

	Weekday Noise Levels (Leq 1-hour)			Weekend Noise Levels (Leq 1-hour)		
Location	Daytime	Nighttime	Late Nighttime	Daytime	Nighttime	Late Nighttime
Waterfront Place, top floor balcony	73–79	64–74	65–71	73–77	65–75	64–72
Waterfront Landings, rooftop	65–70	56–67	56–67	64–69	58–66	58–64

Source: SDOT 2012c.

4.2 VIBRATION

Ground vibration can be a concern for occupants of nearby buildings during construction activities. However, it is unusual for vibration from sources such as buses and trucks to be perceptible, even in locations close to major roads. The most common sources of ground vibration are trains, buses on rough roads, and construction activities such as blasting, pile driving, and operation of heavy earth-moving equipment. The effects of ground vibration include perceptible movement of the building floors, rattling of windows, shaking of items on shelves or hanging on walls, and rumbling sounds. Building damage is not normally a factor for construction projects, with the occasional exception of blasting, pile driving, and demolition of structures. One method used to quantify vibration is peak particle velocity (PPV), which is defined as the maximum instantaneous peak of the vibration signal and is normally measured in inches per second.

In general, temporary vibration effects may occur from the use of pile drivers, jackhammers, hoe rams, soil compactors, and other heavy equipment. Buildings near construction sites respond to vibrations with varying results, ranging from barely perceptible at low levels, distinctly perceptible at moderate levels, and possible structural damage at the highest levels. Vibrations from construction activities rarely reach the levels that can damage structures but can reach moderate levels in buildings very close to a site. Impact pile drivers generally cause the highest vibration levels compared to other types of equipment.

4.2.1 Regulations and Guidelines

Ground vibration levels were evaluated using Caltrans vibration criteria, which vary according to the repetition pattern of vibration events, human response versus cosmetic building damage potential, and type of building for cosmetic building damage issues (Table 4-5). Notably, SPU has in-house vibration criteria for protection of cast iron water mains using lead joints. Previous AWVSRP reports indicate that SPU uses a vibration criterion of 0.50 inches per second peak particle velocity, which is consistent with the Caltrans criteria.

TABLE 4-5. SUMMARY OF CALTRANS VIBRATION CRITERIA

Human Response Thresholds				
		Critical Distance (feet)		
Human Response	**Peak Particle Velocity (inches/second)**	**Vibratory Pile Driver**	**Impact Pile Driver**	**General Construction Equipment**
Barely perceptible	0.04	315	333	112
Distinctly perceptible	0.25	59	53	21
Strongly perceptible; may be annoying to some people in buildings	0.9	18	14	6
Severe; unpleasant for people in buildings; unacceptable to pedestrians on bridges	2	9	6	3
Structural Damage Thresholds				
		Critical Distance (feet)		
Structure and Condition	**Peak Particle Velocity (inches/second)**	**Vibratory Pile Driver**	**Impact Pile Driver**	**General Construction Equipment**
Extremely fragile historic buildings, ruins, and ancient monuments	0.12	116	111	41
Fragile buildings	0.2	73	66	26
Historic and some old buildings	0.5	31	26	11
Older residential structures	0.5	31	26	11
Newer residential structures	1	16	13	6
Modern commercial/industrial buildings	2	9	6	3

Sources: Caltrans 2004, 2002.

4.2.1 Existing Vibrations

Ambient ground vibration data collected for other projects within the study area were used as appropriate to characterize existing conditions. Background vibration monitoring was conducted at seventeen sites in the vicinity of the EBSP construction corridor (Table 4-6). These measurements were taken along the AWV and within 3,000 feet of the existing seawall. Given that the AWV is the primary source of vibration in the area, it is expected that background vibrations along the EBSP corridor would be somewhat lower than those shown herein; especially in Zones 5 and 6. The average PPV of all measurements was 0.040 inches per second, with a maximum PPV of 0.128 inches per second and minimum PPV of 0.017 inches per second. Human response to existing vibration levels would range from "not perceptible" to "barely perceptible." Existing vibration levels would be below the threshold of effects for fragile buildings; however, would exceed the threshold for structural effects for *extremely fragile historic buildings, ruins, and ancient monuments* as described in Table 4-5. As outlined in the Cultural, Historic, and Archaeological Resources Discipline Report (SDOT 2012b), no buildings that meet this description are in the study area.

TABLE 4-6. EXISTING GROUND VIBRATIONS

Background Vibrations in the Vicinity of the Elliott Bay Seawall Project	Peak Particle Velocity (inches/second)	Human Response
Maximum	0.128	Barely perceptible
Minimum	0.017	Not perceptible
Average	0.040	Barely perceptible

Sources: FHWA et al. 2011, Caltrans 2004.

CHAPTER 5. CONSTRUCTION EFFECTS AND MITIGATION

The following sections present discussions of different types of construction effects and related mitigation measures for all alternatives.

5.1 NO ACTION ALTERNATIVE

No construction is proposed for the No Action Alternative, thus there are no anticipated effects. Refer to Section 6.1 for a discussion of operational and continued maintenance likely to occur for the No Action Alternative.

5.2 ALTERNATIVE A

5.2.1 Noise

Short-term moderate adverse effects on the noise environment would be expected from construction activities under Alternative A. These effects would be primarily due to in-air and underwater construction noise. Although heavy equipment and pile-driving noise would end once construction was complete and would not be concentrated in any one area over the duration of the project, the construction would take place over several years and affect a wide variety of both residential and commercial properties; therefore, these effects would be moderate.

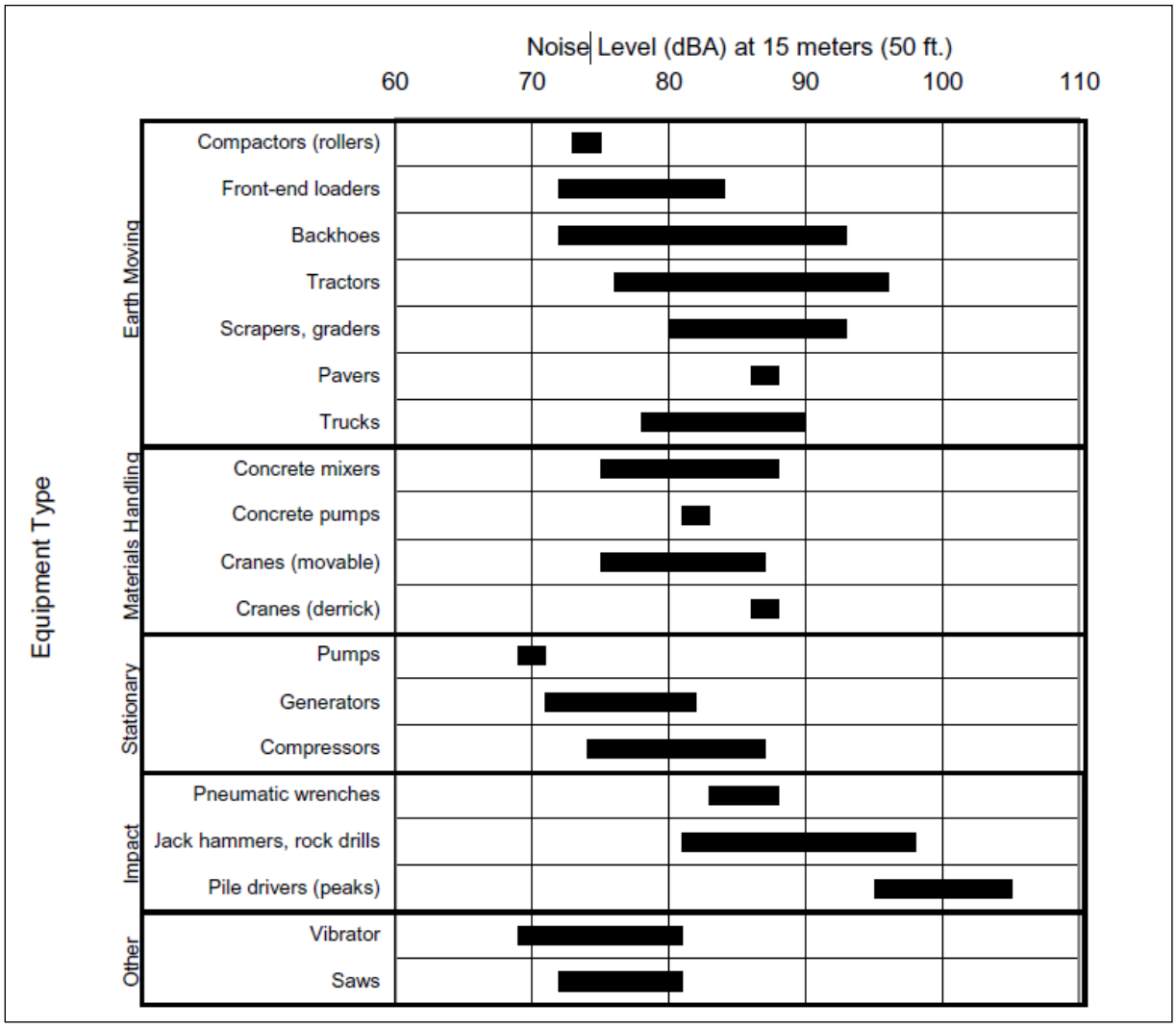
5.2.1.1 In-Air Construction Noise

The most prevalent source of noise would be heavy construction equipment and pile drivers. Mobile equipment operates in a cyclic fashion, but stationary equipment (e.g., pumps, generators, and compressors) generate sound levels that are fairly constant. Other noise sources would include impact equipment and tools such as pile drivers and jackhammers. The typical noise levels of construction equipment at a distance of 50 feet are presented in Figure 5-1.

Construction equipment would not be fixed in one location but would progress along the seawall from zone to zone as construction progressed. Construction noise would be temporary and would subside at any particular location as activities progressed to subsequent segments of the seawall. Pile driving for the containment wall and pile-supported cantilevered sidewalk would generate the most intense noise associated with construction. Pile driving can be an impact type activity, which generates noises of high intensity and a very short duration that can be particularly intrusive.

Noise levels for four categories of construction equipment (i.e., average, loud, very loud and impact pile driver) and their potential to exceed the Noise Ordinance during daytime hours are outlined in Table 5-1. Daytime construction activity is anticipated to exceed the noise-level limits in SMC 25.08.425 by greater than 25 dBA. Nighttime noise levels are anticipated to exceed the limits outlined by the Noise Ordinance. Construction activities during nighttime hours that exceed these levels require a noise variance from the City. In addition the estimated levels were in most cases appreciably above the average background level and it is expected that they would not be substantially masked particularly during quiet periods. Most construction equipment such as backhoes, excavators, bulldozers, and

concrete mixers would fall into the *Average Construction Equipment* category. Loud and very loud construction equipment normally would have a special use such as a concrete saw (loud) or a vibratory pile driver (very loud). Impact pile drivers were carried forward for detailed analysis because they are the loudest piece of equipment expected at the site; this piece of equipment is specifically addressed in the Noise Ordinance. Construction noise analysis is based upon thresholds outlined in SMC 25.08.410, Exterior Sound Level Limits. These limits were adjusted based on procedures outlined in SMC 25.08.425, Sounds Created by Construction and Maintenance Equipment, by adding 25 dBA during the daytime hours for standard construction equipment and specific thresholds for impact equipment outlined in the code.



Source: USEPA 1971.

Figure 5-1. Typical Noise Levels from Construction Equipment

TABLE 5-1. CONSTRUCTION NOISE LEVELS BY LOCATION AND EQUIPMENT TYPE FOR ALTERNATIVE A

Receptor	Zone	Site Description	Distance to Work Zone (feet)	Average Construction Equipment	Loud Construction Equipment	Very Loud Construction Equipment	Impact Pile Driver
Central Seawall							
1	1	Alaskan Way S. and S. Jackson Street	176	74.1	78.6	89.9	90.3
3	1	Washington Street Boat Landing	140	76.1	80.6	91.9	92.3
4	1	First Avenue S. and S. Main Street	688	63.6	68.2	79.4	77.3
31	1	Terry Denny Lofts	513	64.8	69.4	80.6	79.5
2	2	Pier 50	15	95.5	100	111.3	111.7
5	2	Pioneer Square Hotel street level	324	68.8	73.3	84.6	82.7
6	2	Colman Dock	15	95.5	100	111.3	111.7
7	2	Marion Street pedestrian bridge	491	65.2	69.7	81	79.8
26	2	Colman Dock	15	95.5	100	111.3	111.7
8	3	Spring Street and Alaskan Way	298	69.5	74.1	85.3	83.3
9	3	Western Avenue and Spring Street	505	64.9	69.5	80.7	79.6
10	3	Spring Street and Post Avenue	699	62.1	66.7	77.9	77.2
11	3	Spring Street and First Avenue	721	61.8	66.4	77.6	77
12	3	Elliott's Oyster House	15	95.5	100	111.3	111.7
13	3	Alaskan Way bicycle path at Seneca Street	378	67.4	72	83.2	81.7
27	3	Fire Station No. 5	21	92.5	97.1	108.4	108.8
14	4	Waterfront Park boardwalk	59	83.6	88.1	99.4	99.8
15	4	Waterfront Park	75	81.5	86.1	97.3	97.7
36	4	Waterfront Park	21	95.5	100	111.3	98.2
16	4	Hill Climb Court	392	67.1	71.7	82.9	81.4
17	4	Pier at Pine Street	137	76.2	80.8	92.1	92.5
28	4	Pier 62/63 Pier End	409	66.7	71.3	82.6	83
29	4	Pier 62/63 Street	15	95.5	100	111.3	111.7
33	4	Waterfront Condos 515 (Indoor)	71	82	86.5	97.8	90.6
34	4	Waterfront Condos 515 (Outdoor)	71	82	86.5	97.8	90.6

Receptor	Zone	Site Description	Distance to Work Zone (feet)	Average Construction Equipment	Loud Construction Equipment	Very Loud Construction Equipment	Impact Pile Driver
North Seawall							
18	5	Waterfront Landing (ground level)	85	80.4	85.0	96.2	89.9
19	5	Victor Steinbrueck Park (bench area)	519	64.7	69.3	80.5	79.4
30	5	Seattle Marriott	61	83.3	87.9	99.1	91.1
20	6	Elliott Point (ground level)	497	65.1	69.6	80.9	79.7
21	6	Belltown Loft (ground level)	226	71.9	76.5	87.8	85
22	6	Site 15 312 residential units	994	59	63.6	74.9	74.5
23	6	Fountain Court Apartments	446	66	70.6	81.8	80.5
24	6	Port of Seattle terrace	120	77.4	82	93.2	93.7
25	6	Western Avenue and Cedar Street	182	73.8	78.4	89.6	86.2
32	6	Vine Street Streetcar Stop	30	89.4	94	105.3	93
35	6	Edgewater Hotel	187	73.5	78.1	89.4	89.8

Source: FHWA et al. 2011.
Note: Shaded cells indicate a potential exceedance of the City of Seattle Noise Ordinance during daytime hours.

Critical distances at which the construction noise would exceed the daytime limits outlined by the Noise Ordinance were estimated. Noise receptors in land use categories closer than these distances to the construction activities would likely be exposed to noise levels higher than those outlined in the Noise Ordinance. Table 5-2 provides the critical distance for each land use category by construction type. The Seattle Aquarium is within the critical distance for loud construction equipment, very loud construction equipment, and impact pile drivers. While construction occurs in this area, it would be clearly audible to patrons, staff, and animals at the Seattle Aquarium. Notably, the Noise Ordinance allows for pile-driving activity to be louder than other construction activities during the daytime hours. Therefore, it has a lower critical distance when compared to very loud construction equipment.

TABLE 5-2. ESTIMATED CRITICAL DISTANCE BY LAND USE CATEGORY

Land Use Category	Estimated Critical Distance For Varying Levels of Construction Equipment (feet)			
	Average Construction Equipment	Loud Construction Equipment	Very Loud Construction Equipment	Impact Pile Driver
Residential	200	250	600	300
Commercial	175	195	500	300
Industrial	155	175	400	300
Examples of Equipment	Backhoe, Compressor, Loader, Concrete Pump, Generator, Dump Truck, Tractor, Crane, Dozer, Excavator, Grader, Paver, Roller, Scraper, Vibrating Hopper	Hydra Break Ram, Mounted Impact Hammer, Clam Shovel	Concrete Saw, Vibratory Pile Driver	Impact Pile Driver

Source: FHWA et al. 2011

Although it was assumed the viaduct would still be in place, noise from construction activities would exceed those from the associated traffic in the area. The viaduct is expected to remain open to traffic through 2015, coinciding with construction is Zones 4, 3, and possibly Zone 2. While the viaduct likely will remain standing through completion of work in Zone 1, there may no longer be traffic on the viaduct in the out years. The compilation of background data was sufficient to determine the general level of the soundscape throughout the study area, which ranged from 60 to 70 dBA L_{eq} and is normal for an urban area. The continuous background levels with viaduct traffic would be lower than the maximum levels of construction noise at nearby sensitive receptors and the construction noise would not be entirely masked by the existing urban sounds.

5.2.1.2 Underwater Construction Noise

Underwater noise impacts from pile-driving activity were assessed using data and procedures from the WSDOT biological assessment guidance (WSDOT 2011a). Analysis procedures included calculations developed by NMFS and USFWS to estimate critical distances at which marine mammals and fish are affected by in-water pile-driving activities. Although NMFS and USFWS developed the spreadsheet used by WSDOT, this analysis is not restricted to species listed under the Endangered Species Act. The approach provides an empirical database to assist in predicting underwater sound levels from marine pile-driving projects and determining the effectiveness of measures used to control the noise. Both vibratory hammers and impact pile drivers would be used to place both temporary and permanent piles associated with the project. Both types of pile drivers are discussed below.

Vibratory hammers vibrate the pile into the sediment by use of an oscillating hammer placed on top of the pile. The vibratory action causes the sediment immediately surrounding the pile to liquefy and the pile can be driven through the sediment. Peak noise levels can exceed 180 dB; however, the sound generated is not an impact noise as the rise time is relatively slow. Vibratory driving noise levels are generally 10 to 20 dB lower than impact hammer driving. Vibratory installation of steel piles in a river in California resulted in sound pressure levels that were not measurable above the background noise created by the current. Impacts on fishes or other aquatic organisms have not been observed in

association with vibratory hammers. This may be due to the slower rise time and the fact that the energy produced is spread out over the time it takes to drive the pile (WSDOT 2011a). An impact pile driver would be used for both concrete steel piles to support the cantilevered walkway and to proof steel sheet piling after it was initially driven with a vibratory hammer. Table 5-3 outlines thresholds for onset of physical injury and behavioral changes, and the critical distance at which these effects may occur. Notably, existing background levels monitored in Elliott Bay are much lower than the noise levels outlined in Table 5-3 (WSDOT 2011a), and would not change the critical distances outlined below. The exiting sources of noise would not mask underwater noise from the pile-driving activities except when an individual was very close to that source; for example a fish right next to the motor of a boat. The Fish, Wildlife, and Vegetation Discipline Report contains a description of the potential effects on fish and wildlife, including those from underwater construction noise (see SDOT 2012a).

As with in-air effects, construction equipment would not be fixed in one location but would progress along the seawall from zone to zone as construction progressed. Construction noise would be temporary and would subside at any particular location as activities progressed to subsequent segments of the seawall. In addition, much of the pile driving would take place behind the containment wall. This would reduce the noise levels and limit the critical distances shown herein.

TABLE 5-3. CRITICAL DISTANCE FOR UNDERWATER EFFECTS FROM PILE-DRIVING NOISE

Driving Concrete Piles[a]							
	Peak Level	**SEL**	**RMS**	**Effective Quiet[b]**			
Measured single strike sound level (dB)[b]	192	174	176	150			
Measured distance (feet)	32.8	32.8	32.8	N/A			
Effect	**Onset of Physical Injury**					**Behavior**	
Noise Metric	**Peak Level**	**SEL**		**RMS**		**RMS**	
Functional Hearing Group	All Fish	Fish ≥ 2 g	Fish < 2 g	Cetaceans	Pinnipeds	Fish	Cetaceans and Pinnipeds
Threshold (dB)	206	187	183	180	190	150	160
Critical Distance (feet)	3.2	1073	1,306	17.7	3.9	1,774	382
Proofing Steel Sheet Piles[c]							
	Peak Level	**SEL**	**RMS**	**Effective Quiet[b]**			
Measured single strike sound level (dB)[b]	212	189	181	150			
Measured distance (feet)	32.8	32.8	32.8	N/A			
Effect	**Onset of Physical Injury**					**Behavior**	
Noise Metric	**Peak Level**	**SEL**		**RMS**		**RMS**	
Functional Hearing Group	All Fish	Fish ≥ 2 g	Fish < 2 g	Cetaceans	Pinnipeds	Fish	Cetaceans and Pinnipeds
Threshold (dB)	206	187	183	180	190	150	160
Critical Distance (feet)	3.2	207	384	38.3	8.2	3,825	824

Sources: WSDOT 2011a, WSDOT 2009, WSDOT n.d.

Notes: dB – decibel, N/A – not applicable, RMS – root mean squared level, SEL – sound exposure level

a. Assumes a 24-inch octagonal concrete pile.

b. Effective Quiet. When the received SEL from an individual pile strike is below a certain level, then the accumulated energy from multiple strikes would not contribute to injury, regardless of how many pile strikes occur. This SEL is referred to as "effective quiet," and is assumed to be 150 dB (re: 1 µPa2*sec). Effective quiet establishes a limit on the maximum distance from the pile where injury to fishes is expected: the distance at which the single-strike SEL attenuates to 150 dB. Existing noise levels are below 150 dB.

c. Assumes a 24-inch steel pile as a surrogate for steel sheet piles.

5.2.1.3 Traffic Noise

Construction activities would not result in significant changes to local traffic conditions. The volume of traffic would need to double in order to increase noise levels by three dBA, a change that is barely perceptible to the human ear. The study area and in particular the viaduct has heavy traffic conditions. Additional traffic due to construction activities would be a small addition to the existing traffic in the

area. In addition, the realignment of the temporary access roadway would result in a slight decrease in noise around the seawall and piers, and a slight increase in the noise toward the viaduct. The overall sound levels changes due to these sources and roadway reconfigurations would be negligible (less than 1 dBA). Notably, these sources of noise are temporary and would end with the construction phase. Therefore, the effects would be minor.

5.2.2 Vibration

Ground vibration conditions associated with construction equipment and construction activities were evaluated using analysis procedures recommended by Caltrans. These procedures are similar to but more conservative than those used by FTA and FHWA. Caltrans procedures have the advantage of accounting for different types of ground and sediment conditions. The significance of estimated ground vibration levels was evaluated using Caltrans vibration criteria, which vary according to the repetition pattern of vibration events, human response versus cosmetic building damage potential, and type of building for cosmetic building damage issues. Particular attention was given to potential impacts to historic structures near the construction zone. All historic buildings in the study area are identified in the Cultural, Historic, and Archaeological Resources Discipline Report (see SDOT 2012b).

Critical distances at which the construction vibration would exceed human response and structural damage thresholds were estimated (Table 5-4). Ground vibration associated with impact pile driving would be barely perceptible at a distance of 333 feet, and distinctly perceptible at a distance of 112 feet. Ground vibration associated with impact pile driving would begin to cause cosmetic damage to historic structures at a distance of 26 feet, and other newer buildings at distances less than 13 feet. Impact pile driving would be the most prominent source of vibration for this project, and would be perceptible to humans and begin to cause cosmetic damage to historic structures at close range. Ground vibration associated with general construction equipment would be substantially less than that caused by an impact pile driver. Lead-jointed water mains are also susceptible to vibration damage.

The Seattle Aquarium is within the critical distance for construction equipment, vibratory pile drivers, and impact pile drivers. While construction occurs in this area, vibration from pile-driving activities would be between barely perceptible and distinctly perceptible to patrons, staff, and animals at the Seattle Aquarium depending on the type of activity and the distance to the facility.

TABLE 5-4. CRITICAL DISTANCE FOR HUMAN RESPONSE AND STRUCTURAL DAMAGE FROM CONSTRUCTION VIBRATION

Human Response Thresholds				
		Critical Distance (feet)		
Human Response	**Peak Particle Velocity (inches/second)**	**Vibratory Pile Driver**	**Impact Pile Driver**	**General Construction Equipment**
Barely perceptible	0.04	315	333	112
Distinctly perceptible	0.25	59	53	21
Strongly perceptible; may be annoying to some people in buildings	0.9	18	14	6
Severe; unpleasant for people in buildings; unacceptable to pedestrians on bridges	2	9	6	3
Structural Damage Thresholds				
		Critical Distance (feet)		
Structure and Condition	**Peak Particle Velocity (inches/second)**	**Vibratory Pile Driver**	**Impact Pile Driver**	**General Construction Equipment**
Extremely fragile historic buildings, ruins, and ancient monuments	0.12	116	111	41
Fragile buildings	0.2	73	66	26
Historic and some old buildings	0.5	31	26	11
Older residential structures	0.5	31	26	11
Newer residential structures	1	16	13	6
Modern commercial/industrial buildings	2	9	6	3

Sources: Caltrans 2002, 2004, and 2007.

Table 5-5 outlines the vibration effects of impact pile drivers to nearby historic structures. Fire Station No. 5 and Piers 54, 55, 56, 57, and 59 are within the critical distance for damage on historic structures from the proposed pile-driving activities. Damage would likely be cosmetic and if it were to occur it would likely be in the form of plaster cracking and window breaking. Notably, not all historic buildings are the same. Although historic structures, none of these buildings would be considered fragile because they are of heavy timber construction, set on pilings, and have no plaster or ornament such as terra cotta to be damaged. Although unlikely, if general construction equipment were to operate within 11 feet of a historic structure it could possibly cause similar cosmetic effects. This analysis assumes that the piers would be affected as if they would react in a similar nature as other structures build directly on the ground. Effects of vibration on historic structures would be moderate.

TABLE 5-5. VIBRATION EFFECTS OF IMPACT PILE DRIVER TO NEARBY HISTORIC STRUCTURES

Current (Historic) Name of Receptor	Structural Damage Thresholds (inches/second)	Distance (feet)	Estimated Vibration (inches/second)	Exceeds Vibration Damage Threshold (Yes/No)	Human Response
Alaskan Way Viaduct and Battery Street Tunnel	0.5	164	0.237	No	Barely perceptible
Burlington Northern Railroad Tunnel	0.5	492	0.071	No	Barely perceptible
One Yesler Building (Bedford Hotel)	0.5	164	0.237	No	Barely perceptible
Western Building	0.5	295	0.124	No	Barely perceptible
Polson Building	0.5	197	0.194	No	Barely perceptible
Fire Station No. 5[a]	**0.5**	**33**	**1.391**	**Yes**	**Strongly perceptible**
Maritime Building	0.5	328	0.111	No	Barely perceptible
Pier 54[b] (Northern Pacific Railroad 3/ Galbraith Dock)	**0.5**	**33**	**1.391**	**Yes**	**Strongly perceptible**
Pier 55[b] (Northern Pacific Railroad 4/ Arlington Dock)	**0.5**	**33**	**1.391**	**Yes**	**Strongly perceptible**
Pier 56[b] (Frank Waterhouse House)	**0.5**	**33**	**1.391**	**Yes**	**Strongly perceptible**
(Olympic Warehouse)	0.5	328	0.111	No	Barely perceptible
(Pacific Net and Twine Building)	0.5	230	0.164	No	Barely perceptible
Pier 57[b] (John P. Agen's/ Milwaukee Dock)	**0.5**	**33**	**1.391**	**Yes**	**Strongly perceptible**
Pier 59[b]	**0.5**	**33**	**1.391**	**Yes**	**Strongly perceptible**
Fix Building	0.5	295	0.124	No	Barely perceptible
Heritage House/garage	0.5	394	0.090	No	Barely perceptible
Old Spaghetti Factory (Ainsworth & Dunn)	0.5	344	0.105	No	Barely perceptible

Sources: Caltrans, 2002, 2004, and 2007.

a. Fire Station No. 5 is a modern (1963) concrete building that probably falls in the sturdiest category of buildings in Table 5-4, with a damage threshold of 2 rather than 0.5.

b. Piers 54 through 59 are all heavy timber structures sitting on pilings.

5.3 ALTERNATIVE B

5.3.1 Noise

As with Alternative A, and for similar reasons, Alternative B would have short-term, moderate, adverse effects on the noise environment. These effects would be primarily due to in-air and underwater construction noise. Although heavy equipment and pile-driving noise would end once construction was complete and would not be concentrated in any one area over the duration of the project, the construction would take place over several years and affect a wide variety of both residential and commercial properties; therefore, these effects would be moderate.

5.3.1.1 In-Air Construction Noise

Noise levels for four categories of construction equipment (average, loud, very loud and impact pile driver) and their potential to exceed the Noise Ordinance under Alternative B are outlined in Table 5-6. Although there would be a minor shift in the construction site under Alternative B the critical distances associated with different types of construction equipment would be identical to those outlined under Alternative A, and noise levels at any individual receptor would be very close to those outlined under Alternative A. Daytime construction activity is anticipated to exceed the noise-level limits in SMC 25.08.425 by greater than 25 dBA. Nighttime noise levels are anticipated to exceed the limits outlined by the Noise Ordinance. Construction activities during nighttime hours that exceed these levels require a noise variance from the City.

TABLE 5-6. CONSTRUCTION NOISE LEVELS BY LOCATION AND EQUIPMENT TYPE FOR ALTERNATIVE B

Receptor	Zone	Site Description	Distance to Work Zone (feet)	Average Construction Equipment	Loud Construction Equipment	Very Loud Construction Equipment	Impact Pile Driver
Central Seawall							
1	1	Alaskan Way S. and S. Jackson Street	176	74.1	78.6	89.9	90.3
3	1	Washington Street Boat Landing	140	76.1	80.6	91.9	92.3
4	1	First Avenue S. and S. Main Street	673	62.4	67	78.2	77.5
31	1	Terry Denny Lofts	498	65	69.6	80.9	79.7
2	2	Pier 50	15	95.5	100	111.3	111.7
5	2	Pioneer Square Hotel street level	309	69.2	73.8	85.0	83
6	2	Colman Dock	15	95.5	100	111.3	111.7
7	2	Marion Street pedestrian bridge	476	65.4	70	81.2	80
26	2	Colman Dock	15	95.5	100	111.3	111.7
8	3	Spring Street and Alaskan Way	268	70.4	75	86.2	83.9
9	3	Western Avenue and Spring Street	475	65.4	70	81.3	80.1
10	3	Spring Street and Post Avenue	669	62.5	67.1	78.3	77.5
11	3	Spring Street and First Avenue	691	62.2	66.8	78	77.3
12	3	Elliott's Oyster House	15	95.5	100	111.3	111.7
13	3	Alaskan Way bicycle path at Seneca Street	348	68.1	72.7	84	82.2
27	1	Fire Station No. 5	21	92.5	97.1	108.4	108.8
14	4	Waterfront Park boardwalk	59	83.6	88.1	99.4	99.8
15	4	Waterfront Park	75	81.5	86.1	97.3	97.7
36	4	Waterfront Park	15	95.5	100	111.3	98.2
16	4	Hill Climb Court	342	68.3	72.9	84.1	82.3
17	4	Pier at Pine Street	137	76.2	80.8	92.1	92.5
28	4	Pier 62/63 Pier End	409	66.7	71.3	82.6	83
29	4	Pier 62/63 Street	15	95.5	100	111.3	111.7
33	4	Waterfront Condos 515 (Indoor)	21	92.5	97.1	108.4	93.6
34	4	Waterfront Condos 515 (Outdoor)	21	92.5	97.1	108.4	93.6

Receptor	Zone	Site Description	Distance to Work Zone (feet)	Average Construction Equipment	Loud Construction Equipment	Very Loud Construction Equipment	Impact Pile Driver
North Seawall							
18	5	Waterfront Landing (ground level)	75	81.5	86.1	97.3	90.4
19	5	Victor Steinbrueck Park (bench area)	509	64.8	69.4	80.7	79.6
30	5	Seattle Marriott	51	84.8	89.4	100.6	91.7
20	6	Elliott Point (ground level)	487	65.2	69.8	81	79.9
21	6	Belltown Loft (ground level)	216	72.3	76.9	88.1	85.3
22	6	Site 15 - 312 residential units	984	59.1	63.7	74.9	74.5
23	6	Fountain Court Apartments	436	66.2	70.8	82	80.7
24	6	Port of Seattle terrace	120	77.4	82	93.2	93.7
25	6	Western Avenue and Cedar Street	172	74.3	78.8	90.1	86.6
32	6	Vine Street Streetcar Stop	20	93	97.5	108.8	93.7
35	6	Edgewater Hotel	187	73.5	78.1	89.4	89.8

Source: FHWA et al. 2011.
Note: Shaded cells indicate a potential exceedance of the City of Seattle Noise Ordinance during daytime hours.

5.3.1.2 Underwater Construction Noise

Underwater noise impacts from pile-driving activity would be similar to, although slightly greater than those outlined under Alternative A. Under Alternative B the estimated number of strikes per day, and therefore the critical distance for underwater effects from pile-driving noise would be the same as those outlined in Table 5-4. However, more piles would likely be driven to extend the cantilevered structures from the maximum setback locations of the seawall to the existing piers. The Fish, Wildlife, and Vegetation Discipline Report (SDOT 2012a) contains a description of the potential effects on fish and wildlife, including those from underwater construction noise.

As with in-air effects, construction equipment would not be fixed in one location but would progress along the seawall from zone to zone as construction progressed. These effects would be present on more days under Alternative B. Construction noise would be temporary and would subside at any particular location as activities progressed to subsequent segments of the seawall. In addition, much of the pile driving would take place behind the containment wall. This would reduce the noise levels and limit the critical distances shown herein.

5.3.1.3 Traffic Noise

As with Alternative A, and for similar reasons, construction activities would not result in substantive changes to local traffic conditions. The overall sound levels changes due to these sources and roadway reconfigurations would be negligible (less than 1 dBA). Notably, these sources of noise would be temporary and would end with the construction phase. These effects would be minor.

5.3.2 Vibration

As with Alternative A and for similar reasons, groundwork vibration from construction activities would have moderate adverse effects. These effects would be primarily due to the potential effects of impact pile-driving activity on historic structures. All historic buildings in the study area are identified in the Cultural, Historic, and Archaeological Resources Discipline Report (SDOT 2012b). Lead-joint water mains are also susceptible to vibration damage.

Although there would be a minor shift in the construction site under Alternative B, the critical distances associated with the effects of impact pile driving on historic structures would be identical to those outlined under Alternative A, and vibration levels in any individual receptor would be very close to those outlined under Alternative A. Fire Station No. 5, and Piers 54, 55, 56, 57 and 59 are within the critical distance for damage on historic structures from the proposed pile-driving activities. Damage would likely be cosmetic and if it were to occur it would likely be in the form of plaster cracking and window breaking. Although unlikely, if general construction equipment were to operate within 11 feet of a historic structure it could possibly cause similar cosmetic effects. Effects of vibration on historic structures would be moderate.

5.4 ALTERNATIVE C

5.4.1 Noise

As with Alternatives A and B, and for similar reasons, Alternative C would have short-term, moderate, adverse effects on the noise environment. These effects would be primarily due to in-air and underwater construction noise. Although heavy equipment and pile-driving noise would end once construction was complete and would not be concentrated in any one area over the duration of the project, the construction would take place over several years and affect a wide variety of both residential and commercial properties; therefore, these effects would be moderate.

5.4.1.1 In-Air Construction Noise

Noise levels for four categories of construction equipment (average, loud, very loud and impact pile driver) and their potential to exceed the Noise Ordinance under Alternative C are outlined in Table 5-7. Although there would be a minor shift in the construction site under Alternative C, the critical distances associated with different types of construction equipment would be identical to those outlined under Alternatives A and B, and noise levels at any individual receptor would be very close to those outlined under Alternatives A and B. Daytime construction activity is anticipated to exceed the noise-level limits in SMC 25.08.425 by greater than 25 dBA. Nighttime noise levels are anticipated to exceed the limits

outlined by the Noise Ordinance. Construction activities during nighttime hours that exceed these levels require a noise variance from the City.

TABLE 5-7. CONSTRUCTION NOISE LEVELS BY LOCATION AND EQUIPMENT TYPE FOR ALTERNATIVE C

Receptor	Zone	Site Description	Distance to Work Zone (feet)	Average Construction Equipment	Loud Construction Equipment	Very Loud Construction Equipment	Impact Pile Driver
Central Seawall							
1	1	Alaskan Way S. and S. Jackson Street	176	74.1	78.6	89.9	90.3
3	1	Washington Street Boat Landing	140	76.1	80.6	91.9	92.3
4	1	First Avenue S. and S. Main Street	673	62.4	67	78.2	77.5
31	1	Terry Denny Lofts	498	65	69.6	80.9	79.7
2	2	Pier 50	15	95.5	100	111.3	111.7
5	2	Pioneer Square Hotel street level	324	68.8	73.3	84.6	82.7
6	2	Colman Dock	15	95.5	100	111.3	111.7
7	2	Marion Street pedestrian bridge	491	65.2	69.7	81	79.8
26	2	Colman Dock	15	95.5	100	111.3	111.7
8	3	Spring Street and Alaskan Way	253	69.8	74.4	85.6	83.6
9	3	Western Avenue and Spring Street	460	65.2	69.8	81	79.9
10	3	Spring Street and Post Avenue	654	62.4	67	78.2	77.5
11	3	Spring Street and First Avenue	676	62.1	66.7	77.9	77.3
12	3	Elliott's Oyster House	-30	95.8	100.3	111.6	112
13	3	Alaskan Way bicycle path at Seneca Street	333	67.7	72.3	83.5	82
27	1	Fire Station No. 5	21	92.5	97.1	108.4	108.8
14	4	Waterfront Park boardwalk	59	83.6	88.1	99.4	99.8
15	4	Waterfront Park	75	81.5	86.1	97.3	97.7
36	4	Waterfront Park	21	95.5	100	111.3	98.2
16	4	Hill Climb Court	392	67.1	71.7	82.9	81.4
17	4	Pier at Pine Street	137	76.2	80.8	92.1	92.5
28	4	Pier 62/63 Pier End	409	66.7	71.3	82.6	83
29	4	Pier 62/63 Street	15	95.5	100	111.3	111.7
33	4	Waterfront Condos 515 (Indoor)	71	82	86.5	97.8	90.6
34	4	Waterfront Condos 515 (Outdoor)	71	82	86.5	97.8	90.6

Receptor	Zone	Site Description	Distance to Work Zone (feet)	Average Construction Equipment	Loud Construction Equipment	Very Loud Construction Equipment	Impact Pile Driver
North Seawall							
18	5	Waterfront Landing (ground level)	85	80.4	85.0	96.2	89.9
19	5	Victor Steinbrueck Park (bench area)	519	64.7	69.3	80.5	79.4
30	5	Seattle Marriott	61	83.3	87.9	99.1	91.1
20	6	Elliott Point (ground level)	497	65.1	69.6	80.9	79.7
21	6	Belltown Loft (ground level)	226	71.9	76.5	87.8	85
22	6	Site 15 - 312 residential units	994	59	63.6	74.9	74.5
23	6	Fountain Court Apartments	446	66	70.6	81.8	80.5
24	6	Port of Seattle terrace	120	77.4	82	93.2	93.7
25	6	Western Avenue and Cedar Street	182	73.8	78.4	89.6	86.2
32	6	Vine Street Streetcar Stop	30	89.4	94	105.3	93
35	6	Edgewater Hotel	187	73.5	78.1	89.4	89.8

Source: FHWA et al. 2011.
Note: Shaded cells indicate a potential exceedance of the City of Seattle Noise Ordinance during daytime hours.

5.4.1.2 Underwater Construction Noise

Underwater noise impacts from pile-driving activity would be similar to those outlined under Alternatives A and B. Under Alternative C, the estimated number of strikes per day and therefore the critical distance for underwater effects from pile-driving noise would be the same as those outlined in Table 5-4. However, more piles would likely be driven to extend the cantilevered structures from the maximum setback locations of the seawall to the existing piers in Zone 3. The Fish, Wildlife, and Vegetation Discipline Report (SDOT 2012a) contains a description of the potential effects of noise and vibration on fish and wildlife, including effects from underwater construction noise.

As with in-air effects, construction equipment would not be fixed in one location but would progress along the seawall from zone to zone as construction progressed. These effects would be present on fewer days under Alternative C when compared to Alternative B. Construction noise would be temporary and would subside at any particular location as activities progressed to subsequent segments of the seawall. In addition, much of the pile driving would take place behind the containment wall. This would reduce the noise levels and limit the critical distances shown herein.

5.4.1.3 Traffic Noise

As with Alternatives A and B, and for similar reasons, construction activities would not result in substantive changes to local traffic conditions. The overall sound-level changes due to these sources and roadway reconfigurations would be negligible (less than 1 dBA). These sources of noise are temporary, would end with the construction phase, and the effects would be minor.

5.4.2 Vibration

As with Alternatives A and B and for similar reasons, groundwork vibration from construction activities would have moderate adverse effects. These effects would be primarily due to the potential effects of impact pile-driving activity on historic structures. All historic buildings in the study area are identified in the Cultural, Historic, and Archaeological Resources Discipline Report (SDOT 2012b). Lead-joint water mains are also susceptible to vibration damage.

Although there would be a minor shift in the construction site under Alternative C, the critical distances associated with the effects of impact pile driving on historic structures would be identical to those outlined under Alternative A, and vibration levels in any individual receptor would be very close to those outlined under Alternative A. Fire Station No. 5, and Piers 54, 55, 56, 57 and 59 are within the critical distance for damage on historic structures from the proposed pile-driving activities. If there were damage it would likely be cosmetic and if it were to occur it would likely be in the form of plaster cracking and window breaking. Although unlikely, if general construction equipment were to operate within 11 feet of a historic structure it could possibly cause similar cosmetic effects. Effects of vibration on historic structures would be moderate.

5.5 INDIRECT EFFECTS OF THE BUILD ALTERNATIVES

Indirect effects are those that could occur later in time or more geographically distant from the project area as a result of the project. Indirect effects would not be expected. Impacts on noise would be primarily due to the construction of the EBSP. Noise generated by EBSP construction would be primarily confined to the waterfront commercial/residential district, and would end once construction was completed. Therefore, it is not expected that the implementation of Alternatives A, B, or C would have indirect impacts to noise or vibration at any other location or at any other time.

5.6 MITIGATION MEASURES

Mitigation measures for the construction effects are based on the site information and standard design and construction procedures in use at the time this discipline report was prepared, and apply to all three build alternatives.

5.6.1 Noise

The project will apply for a noise variance(s). In coordination with DPD; construction noise mitigation requirements would be developed and specified in the noise variance(s). To reduce construction noise at nearby receptors, the following are examples of in-air mitigation measures that could be incorporated into construction plans, specifications, and variance requirements:

- Develop a construction noise management and monitoring plan that establishes specific noise levels that may not be exceeded for various activities during specific times. This would establish a set of noise limits that could be met during construction while still protecting the public from excessive noise effects. Limit the noisiest construction activities to between 7 a.m. and 10 p.m. on weekdays and between 9 a.m. and 10 p.m. on weekends and legal holidays to reduce construction noise levels during nighttime hours.
- Limit use of impact equipment, such as jackhammers, to between 8 a.m. and 5 p.m. on weekdays and between 9 a.m. and 5 p.m. on weekends and legal holidays. A noise variance from the City DPD would also be required for impact equipment used for construction between 5 p.m. and 8 a.m. on weekdays and between 5 p.m. and 9 a.m. on weekends and legal holidays.
- Equip construction equipment engines with mufflers, intake silencers, and/or engine enclosures.
- Use electric equipment in lieu of pneumatic or diesel (reduction varies).
- Limit engine idling to not more than five minutes when vehicle or equipment is not directly engaged in work activity, such as on-site pickup trucks and cued export haul trucks.
- Use the least intrusive broadband backup warning devices, or the Contractor may use backup observers in lieu of backup warning devised as allowed by WAC 96-155-610 (2)(e). Pure-tone back-up alarms are prohibited as part of the noise variance process (for nighttime construction) and would therefore not be used on this project between the hours of 10 p.m. and 7 a.m. on weekdays and 10 p.m. and 9 a.m. on weekends and legal holidays. Back-up alarms are the most obvious type of alarm to use, but there are several other warning-type alarms that have pure-tone characteristics (e.g., pump truck hopper and boom alarms, personnel lift equipment).
- Utilize rubber-tired equipment in lieu of track-type equipment whenever possible and safe to do so.
- Equip all trucks performing export haul with rubber bed liners, or keep 1 foot of dirt in the bottom of the dump bed to reduce impact noise from loading excavated material between the hours of 10 p.m. and 7 a.m. on weekdays and 10 p.m. and 9 a.m. on weekends and legal holidays.
- Locate or direct stationary equipment such as lighting, generators, air compressors and similar equipment away from sensitive receiving properties.
- Construct temporary noise barriers or curtains around stationary equipment and long-term work areas located close to residences to decrease noise levels at nearby sensitive receptors. This could reduce equipment noise by 5 to 10 dBA.
- Provide a 24-hour noise complaint hotline.
- Notify nearby residents and businesses prior to periods of intense nighttime construction.
- Where amenable, provide heavy window coverings or other temporary soundproofing material on adjacent buildings or structures for nighttime noise-sensitive locations where prolonged periods of intense nighttime construction would occur.
- Any material or debris that spills on the pavement shall be removed by hand sweeping; no scraping type equipment or activity shall be used to clean pavement surfaces. In addition,

no street sweeping machinery shall operate between the hours of 10 p.m. and 7 a.m. on weekdays and 10 p.m. and 9 a.m. on weekends and legal holidays.

- Vacuum trucks would not be allowed unless they demonstrate they can meet the objective noise standard in the Noise Ordinance for construction and maintenance equipment.
- Radios would be used for all long-range communication on site; no yelling would be permitted except in the case of an emergency.

5.6.2 Vibration

Impact pile driving could be the most prominent source of vibration for this project. The following measures to reduce ground vibrations could be used, when appropriate for specific site conditions:

- Jetting – The use of a mixture of air and water pumped through a high-pressure nozzle to erode the soil adjacent to the pile to facilitate placement of the pile.
- Predrilling – Predrilling a hole for a pile can be used to place the pile at or near its design depth, eliminating most or all impact driving.
- Pile cushioning – A resilient material placed between the driving hammer and the pile.
- Alternative non-impact drivers – Several types of proprietary pile-driving systems have been designed specifically to reduce the impact-induced vibration by using torque and down-pressure or hydraulic static loading.
- Vibration from other construction activities can be reduced by either restricting their operation to predetermined distances from historic structures or other sensitive receivers, or the use of alternative equipment or construction methods.
- Vibration monitoring may be required at nearby historic structures. The monitored data will be compared to the project's vibration criteria to ensure that vibration levels do not exceed the damage risk criteria for buildings.

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CHAPTER 6. OPERATIONAL EFFECTS AND MITIGATION

Operational effects are those that will occur during the long-term operation of the EBSP. The following sections discuss the operational effects, mitigation, and benefits of the EBSP alternatives.

6.1 NO ACTION ALTERNATIVE

Under the No Action Alternative there would be no appreciable operational sources of noise or vibration. It is likely that there would be additional maintenance activities such as repair of sinkholes, potholes, and other settlement effects if the seawall is not replaced. Until 2016, the AWV would continue to be the primary source of noise in the area. Noise associated with expected on-going maintenance would be comparable to the existing conditions. If there is a seawall failure, reconstruction effects would be similar to those described for the build alternatives in Chapter 5.

6.2 ALTERNATIVES A, B, AND C

Under Alternatives A, B, and C there would be no appreciable operational sources of noise or vibration, and it is likely that there would be less maintenance activities when compared to the No Action Alternative. Nevertheless, the traffic would continue to be the primary source of noise in the area, and noise associated with maintenance would be comparable to the existing conditions.

No indirect operational noise or vibration effects are likely as a result of construction of any of the three build alternatives.

6.3 MITIGATION MEASURES

Since there are no long-term operational noise impacts from operation of the EBSP, no mitigation is required.

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CHAPTER 7. REFERENCES

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City of Seattle

Elliott Bay Seawall Project Noise and Vibration Discipline Report

APPENDIX A.
OVERVIEW OF BACKGROUND NOISE MONITORING AND EQUIPMENT

October 2012

Ambient noise monitoring data collected for other projects within the Alaskan Way Viaduct and Seawall Replacement Program were used as appropriate to characterize existing noise conditions. While noise-monitoring data have been collected from numerous locations in the Elliott Bay Seawall corridor, most of these data involved monitoring durations of only 15 minutes, and thus do not provide much information on hourly patterns of noise levels. Some existing data were collected for 24-hour periods, but previously published AWVSRP reports provide only 24-hour sound pressure levels (L_{eq}) results, not hourly noise level variations.

Long-term monitoring was conducted at locations where instruments could be left unattended for one or two days. Short-term monitoring was conducted at locations where unattended monitoring was not feasible. All monitoring was conducted with sound level meters mounted on tripods extended to a height of about five feet. Locations for noise monitoring were dictated by site accessibility, cooperation of property owners, avoidance of safety hazards, and avoidance of interference with pedestrian circulation patterns.

Most of the short-term and some long-term monitoring was conducted using Type 2 data logging instruments. Two brands of readily available Type 2 sound level meters were used: the Center Technologies model 322 meter and the Reed Instruments ST-173 sound level data logger. Most of the long-term monitoring was conducted with rented Type 1 Larson Davis model 820 integrating sound level meters. Noise monitoring was conducted at times when weather conditions were appropriate (no anticipated precipitation, wind speeds generally less than 12 mph, and temperatures above freezing). Long-term monitoring using the Type 1 Larson Davis rental equipment was conducted in Spring 2011 to avoid weather-related problems. The lists and figures at the end of this appendix provide additional information on these sound level meters and the field measurements.

The project team conducted a series of short-term (generally 1 hour or longer) and long-term (24 hours or longer) noise monitoring in the study area to provide baseline noise data for businesses, residences, and public use areas that may be impacted by noise from project-related construction activities. The data collected are meant to supplement and improve monitoring data from previous projects from locations in or near the EBSP study area. The EBSP primary field data collection was conducted over a six month period between December 2010 and May 2011. In general, the data collection occurred within about 1,000 feet of the seawall construction zone, primarily because airborne noise and ground vibration levels decrease rapidly with increasing distance from the source, resulting in a geographically limited area of potential impacts.

Based on a qualitative account of the results, existing traffic on the Alaskan Way Viaduct is a predominant source of existing noise in the project area for Zones 1 through 4. Noise from traffic on the Alaskan Way Viaduct is more distant and reduced in Zones 5 and 6, and significantly lower noise levels were recorded in those areas.

Ambient noise monitoring was conducted to supplement existing data, primarily in the immediate vicinity of planned seawall construction activities, and involved a combination of short-term and long-term monitoring. All monitoring was conducted with sound level meters mounted on tripods extended to a height of about five feet, with meter microphones generally facing towards the existing seawall.

Long-term monitoring locations included:

- A west-facing roof-level balcony of a private residence in the Pioneer Square neighborhood (Zone 1);
- The roof of Fire Station No. 5 (Zone 3);
- Inside and on the balcony of a private resident at the Waterfront Landing Condominiums (Zone 5);
- Inside and on the balcony of room 446 at the Seattle Marriott Waterfront Hotel (Zone 5); and
- The roof of the Edgewater Hotel (Zone 6).

Short-term monitoring locations included:

- Pier 48 from the sidewalk just north of Washington Street Boat Landing (Zone 1);
- Landscaped seating area at Washington State Ferries' Colman Dock (Pier 52) (Zone 2);
- East of the surface street at Seneca Street (Zone 3);
- Public seating area near Argosy terminal at Pier 55 (Zone 3);
- Open public area on the north side of Fire Station No. 5 (Zone 3);
- Open public seating area at Waterfront Park (Zone 4);
- The Pier 62/63 area, both at the end of the pier and along the edge of the sidewalk abutting Alaskan Way (Zone 4);
- Pier 66 along Alaskan Way at Anthony's Fish House, and at the west end of the pier at the Bell Harbor Marina (Zone 5);
- East of the Alaskan Way Viaduct at Vine Street (Zone 6);
- Pier 70 at the west end of the pier (Zone 6); and
- Landscaped area at the south end of Olympic Sculpture Park (Zone 6).

Locations for noise monitoring were dictated by site accessibility, cooperation of property owners, avoidance of safety hazards, and avoidance of interference with pedestrian circulation patterns. Safety issues and potential interference with pedestrian circulation precluded placement of long-term monitoring equipment directly on public sidewalks. A summary of the noise monitoring sites, dates, and times is included in Table A-1, below. In addition, measurements were also conducted at two additional locations during the preparation of the noise variance application: (1) along the Central Seawall at Waterfront Place, 1009 Western Avenue, and (2) along the North Seawall at Waterfront Landings. These additional locations were chosen based on sensitivity of nighttime use (condominiums, apartments, etc.).

All Larson Davis and Reed meters were calibrated to 94db with a Class 2 Larson Davis external acoustical calibrator in advance of each monitoring event. Beginning with the data collected on April 29, 2011, the Center meters were calibrated to 94db before and after data collection. Before these data, the

calibration on the Center meters was not recorded; a test on Center Meter #1916 before the April 29, 2011 collection read 93.6db.

The compilation of background data was sufficient to determine the general level of the soundscape throughout the study area, which ranged from 60 to 70 dBA Leq in the daytime and is normal for an urban area. The continuous background levels in both the daytime and the nighttime would be lower than the maximum levels of construction noise at nearby sensitive receptors and the construction noise would not be entirely masked by the existing urban sounds. Since the Noise Ordinance is based on maximum levels, it is expected that the construction noise will be above the background noise during the nighttime hours.

TABLE A-1. ELLIOTT BAY SEAWALL PROJECT NOISE MONITORING DATES AND LOCATIONS

Date	Time (Start, End)	Address/ Location	Meter Make	Monitor ID	ST/ LT
20110201	3:25:26 p.m., 4:46:10 p.m.	Pier 66	Center 322	1916	ST
20110201	3:21:20 p.m., 4:46:34 p.m.	Pier 66	Center 322	4392	ST
20110201	1:36:48 p.m., 3:09:04 p.m.	Pier 70	Center 322	1916	ST
20110201	1:35:42 p.m., 3:07:23 p.m.	Pier 70	Center 322	4392	ST
20110209	1:56:53 p.m., 3:27:14 p.m.	Pier 48	Center 322	1916	ST
20101203	2:21:52 p.m., 3:48:01 p.m.	East of Alaskan Way and Seneca Street	Center 322	1916	ST
20101203	2:21:46 p.m., 3:48:12 p.m.	East of Alaskan Way and Seneca Street	Center 322	4392	ST
20101203	1:52:37 p.m., 2:19:13 p.m.	Pier 55	Center 322	1916	ST
20101203	1:52:38 p.m., 2:19:10 p.m.	Pier 55	Center 322	4392	ST
20110317	10:11:59 a.m., 11:45:07 a.m.	Colman Dock	Center 322	1916	ST
20110317	10:16:51 a.m., 11:48:23 a.m.	Fire Station No. 5	Center 322	4392	ST
20110317	3:33:53 p.m., 4:52:09 p.m.	Pier 62/63	Center 322	1916	ST
20110317	3:32:40 p.m., 4:43:10 p.m.	Pier 62/63	Center 322	4392	ST
20110419	2:00:31 p.m., 3:34:29 p.m.	Waterfront Park	Center 322	1916	ST
20110429	2:49:31 p.m., 4:07:12 p.m.	Vine Street	Center 322	1916	ST
20110518	2:20:14 p.m., 3:40:32 p.m.	4th Avenue and Battery Street	Center 322	1916	ST
20110420		111 1st Avenue S.	Larson Davis 820	1643	LT
20110420		111 1st Avenue S.	Larson Davis 820	1670	LT
20110503		Marriott - Indoor	Larson Davis 820	1670	LT
20110503		Marriott - Outdoor	Larson Davis 820	1643	LT
20110503	05-03-11/1:04:37 p.m., 05-04-11/05:44:36	Marriott - Indoor	Reed ST 173	9924	LT
20110503	05-03-11/13:01:18, 05-04-11/05:41:17	Marriott - Outdoor	Reed ST 173	9004	LT
20110518	Appx. 09:45 a.m.	Edgewater Hotel - Roof	Larson Davis 820	1670	LT
20110518	05-18-11/09:45:24, 05-19-11/02:25:23	Edgewater Hotel - Roof	Reed ST 173	9004	LT
20110523	05-23-11/Appx 15:09, 05-24-11/Appx 14:39	Waterfront Landing Condominiums - Indoor	Larson Davis 820	1670	LT
20110523	05-23-11/15:09:37, 05-24-11/09:54:43	Waterfront Landing Condominiums - Indoor	Center 322	1916	LT
20110523	05-23-11/14:10:46, 05-24-11/14:39:16	Waterfront Landing Condominiums - Outdoor	Center 322	4392	LT
20110423	05-23-11/Appx 15:46, 05-24-11/Appx 08:26	Fire Station No. 5 - Roof	Larson Davis 820	1643	LT
20110423	05-23-11/15:46:40, 05-24-11/08:26:39	Fire Station No. 5 - Roof	Reed ST 173	9004	LT

Note: LT – long-term monitoring, ST – short-term monitoring

CENTER TECHNOLOGIES MODEL 322 SOUND LEVEL METER

Key features of the Center 322 sound level meter:

- Type 2 (general purpose) sound level meter;
- Detachable free-field microphone and preamplifier (31.5 Hz to 8,000 Hz response range);
- A choice of A- or C-weighting;
- A choice of slow or fast response settings;
- A choice of three fixed measurement ranges or auto ranging;
- An overall measurement range of 30 dBA to 130 dBA;
- Logging of spot sound pressure level (SPL) readings at intervals of 1 second to 60 seconds;
- Internal memory for 32,000 data records;
- Ability to log multiple data sets within the internal memory limit;
- Operates about 24 hours on an internal 9-volt alkaline battery, or over 48 hours on an internal 9-volt lithium battery; and
- An operating temperature range of 32°F to 104°F.

REED MODEL ST-173 SOUND LEVEL DATA LOGGER

Key features of the Reed ST-173 sound level meter:

- Type 2 (general purpose) sound level meter;
- Fixed free-field microphone and preamplifier (31.5 Hz to 8,000 Hz response range);
- A choice of A- or C-weighting;
- A choice of slow or fast response settings;
- Auto ranging measurement range of 30 dBA to 130 dBA;
- SPL sampling rate of 20 times per second;
- Choice of 1-second L_{avg} or 1-second L_{max} data logging
- Data logging interval choices of 1 second to 60 seconds, 1 minute to 60 minutes, or 1 hour to 24 hours;
- Internal memory for 129,920 data records;
- Logged data must be in a single, uninterrupted data set;
- Operates about 200 hours on an internal lithium 3.6-volt battery; and
- An operating temperature range of 32°F to 104°F.

LARSON DAVIS MODEL 820 INTEGRATING SOUND LEVEL METER

Key features of Larson Davis 820 sound level meter:

- Type 1 (precision) integrating sound level meter;
- Detachable free-field microphone and preamplifier (4 Hz to 40,000 Hz response range);
- A single dynamic measurement range of 20 dBA to 130 dBA;
- A choice of A- or C-weighting for primary data, with dual peak detectors for weighted and unweighted instantaneous peak dB;
- A choice of slow, fast, or impulse response settings;
- A choice of 3, 4, 5, or 6 dB exchange rates for data integration;
- Separate logging of L_{eq} time histories, user-set time interval statistics, and exceedance events;
- 256 kilobytes (KB) of internal memory, with data stored in binary format;
- Ability to log multiple data sets within the internal memory limit;
- A choice of programmable or manual start and stop operations;
- An operating temperature range of 14°F to 122°F;
- Operates about 24 hours on an internal 9-volt alkaline battery, or over 48 hours on an internal 9-volt lithium battery; and
- Provision for use of external 12-volt batteries to allow extended monitoring durations.

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