Elliott Bay Seawall Project

Air Quality Discipline Report

FINAL

October 2012

Submitted to:

City of Seattle
Department of Transportation
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Elliott Bay Seawall Project

AIR QUALITY DISCIPLINE REPORT

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FINAL

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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 United States Army Corps of Engineer'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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City of Seattle

Air Quality Discipline Report

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ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

AWV	Alaskan Way Viaduct
AWVRP	Alaskan Way Viaduct Replacement Project
BACT	Best Available Control Technology
BNSF	BNSF Railway
BSP	braced soldier pile
CCAR	California Climate Action Registry
CFR	Code of Federal Regulations
CNG	compressed natural gas
CO	carbon monoxide
DPM	diesel particulate matter
EBSP	Elliott Bay Seawall Project
Ecology	Washington State Department of Ecology
EIS	Environmental Impact Statement
GHG	greenhouse gas
HAP	hazardous air pollutant
IPCC	Intergovernmental Panel on Climate Change
LNG	liquefied natural gas
LPG	liquefiable petroleum gas
LPS	light-penetrating surfaces
NAVD	North American Vertical Datum
NEPA	National Environmental Policy Act
NESHAP	National Emission Standard for Hazardous Air Pollutants
NOx	nitrogen oxides
NSPS	New Source Performance Standards
NSR	New Source Review
O_3	ozone
$PM_{2.5}$	fine particulate matter
PM_{10}	inhalable particulate matter
ppm	parts per million by volume
PSCAA	Puget Sound Clean Air Agency
PSD	Prevention of Significant Deterioration
RCW	Revised Code of Washington
ROG	reactive organic gases
SDOT	Seattle Department of Transportation
SEPA	State Environmental Policy Act
SIP	State Implementation Plan
SO_x	sulfur oxides
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
VMT	vehicle miles traveled
VOC	volatile organic compound
WAC	Washington Administrative Code
WSDOT	Washington State Department of Transportation

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EXECUTIVE SUMMARY

The Elliott Bay Seawall Project (EBSP) would reconstruct or replace the existing seawall between S. Washington Street on the south and Broad Street on the north. Three construction alternatives have been analyzed for the joint National Environmental Policy Act (NEPA)/Washington State Environmental Policy Act (SEPA) Environmental Impact Statement (EIS). In Alternative A, the seawall would be reconstructed more or less in its existing alignment to facilitate construction without requiring the removal of the existing wall first. Construction methods for Alternative A would utilize soil improvement techniques that include the use of jet grouting to stabilize soils and sediments behind the seawall. In Alternative B, the seawall would be pulled back to the east of its existing alignment. Construction methods for Alternative B would utilize braced soldier pile (BSP) construction techniques to stabilize soils and sediments behind the seawall. Alternative C is a true hybrid alternative, utilizing the same soil improvement construction techniques proposed for Alternative A but pulling the wall back east of its existing alignment; thus representing features from both Alternatives A and B (see Table 1-1).

Current ambient air quality conditions in the project vicinity are in compliance with all federal and state ambient air quality standards. Historically, the urbanized western portion of King County experienced violations of the federal carbon monoxide air quality standards, and is consequently designated as a carbon monoxide maintenance area. The existing carbon monoxide maintenance area designation for the urbanized western portion of King County means that federal agency actions in the project area are subject to the United States Environmental Protection Agency (USEPA) general conformity regulations. Under those regulations, federally assisted or approved projects that have maximum annual carbon monoxide emissions of 100 tons per year or more would need to undertake a formal Clean Air Act conformity determination to ensure that the project does not cause or contribute to new violations of the federal ambient air quality standards for carbon monoxide.

The No Action Alternative would require periodic seawall inspection and maintenance activities. Those activities would result in variable amounts of annual emissions from vehicle and equipment use. Due to the age and condition of the existing seawall, ongoing operational maintenance activities would be expected to be more frequent than would be required for the EBSP under Alternatives A, B, or C. Because the frequency and nature of such maintenance activities under the No Action Alternative would be dependent on tidal erosion and seismic events that are not reasonably predictable, no quantitative estimates of maintenance activity emissions have been prepared for this Air Quality Discipline Report.

Under the No Action Alternative, the project would not be constructed; therefore, the only operational effects would be those caused by required future maintenance and repairs if the seawall fails in part or in whole. Also included is a discussion of measures that could be implemented to avoid, minimize or mitigate the operational effects. With a new seawall, repairs should be less frequent than under the No Action existing conditions, and thus result in lower operational emissions than the No Action Alternative.

Annual construction-related emissions for Alternatives A, B, and C are summarized in Table ES-1 and ES-2, respectively. Due to distinct similarities in construction schedule, duration and equipment requirements, Alternatives A and C are assumed to be identical with regards to air quality modeling for

the purposes of this Discipline Report. Alternative C would result in the same construction-related emissions as Alternative A. The emission estimates in Table ES-1 and ES-2 include emissions from on-site construction activity, off-site construction-related truck traffic, and off-site construction worker commute traffic for the three alternatives.

TABLE ES-1. OVERALL CONSTRUCTION-RELATED EMISSIONS FOR ALTERNATIVES A AND C BY CALENDAR YEAR

Calendar Year	Combined On-site and Off-site Construction-Related Emissions, Tons per Year						
	ROG	NOx	CO	SOx	PM_{10}	$PM_{2.5}$	DPM
2013	7.02	15.34	56.93	2.54	3.40	1.98	1.32
2014	11.37	24.11	86.51	4.35	2.56	2.06	1.93
2015	9.74	18.67	67.89	3.36	3.66	2.17	1.46
2016	3.62	6.76	23.47	1.39	0.72	0.58	0.53
2017	3.43	4.54	19.02	1.09	2.18	0.98	0.34
2018	4.70	6.16	23.56	1.69	0.62	0.47	0.40
2019	6.10	7.55	27.86	1.98	1.01	0.68	0.50
2020	4.40	5.09	17.58	1.18	0.50	0.37	0.29
2021	4.30	4.50	16.50	1.19	0.72	0.45	0.28
2022	0.88	1.08	3.18	0.20	0.14	0.10	0.08
Totals	**55.55**	**93.80**	**342.51**	**18.98**	**15.50**	**9.85**	**7.13**

Notes: Emissions presented in this table include those from on-site construction activity, off-site construction-related truck traffic, and off-site construction worker commute traffic.
ROG – reactive organic gases; NOx – oxides of nitrogen; CO – carbon monoxide; SOx – sulfur oxides
PM_{10} – inhalable particulate matter; $PM_{2.5}$ – fine particulate matter; DPM – diesel particulate matter
These results were based on initial conservative construction durations. Recently, possible shorter construction durations have been identified. However, the shorter construction durations would not have an appreciable effect on emissions or air quality.

TABLE ES-2. OVERALL CONSTRUCTION-RELATED EMISSIONS FOR ALTERNATIVE B BY CALENDAR YEAR

Calendar Year	Combined On-site and Off-site Construction-Related Emissions, Tons per Year						
	ROG	NOx	CO	SOx	PM_{10}	$PM_{2.5}$	DPM
2013	5.02	10.25	41.19	1.80	2.69	1.49	0.91
2014	6.58	16.03	52.40	3.05	1.59	1.37	1.37
2015	6.48	11.24	45.26	2.23	1.54	1.12	0.95
2016	4.68	9.55	32.60	2.12	0.93	0.79	0.77
2017	6.23	8.94	35.36	2.10	1.44	0.93	0.68
2018	6.15	8.84	33.01	2.47	0.82	0.69	0.63
2019	5.05	6.08	23.45	1.64	2.40	1.12	0.44
2020	4.41	4.71	17.16	1.15	0.45	0.35	0.28
2021	5.11	6.24	21.32	1.48	0.82	0.56	0.43
2022	4.10	4.04	14.50	0.91	0.38	0.29	0.22
2023	3.91	4.26	15.50	0.85	0.41	0.31	0.24
2024	2.36	2.86	10.18	0.47	0.28	0.22	0.19
Totals	**60.09**	**93.03**	**341.94**	**20.27**	**13.74**	**9.25**	**7.09**

Notes: Emissions presented in this table include those from on-site construction activity, off-site construction-related truck traffic, and off-site construction worker commute traffic.
ROG – reactive organic gases; NOx – oxides of nitrogen; CO – carbon monoxide; SOx – sulfur oxides
PM_{10} – inhalable particulate matter; $PM_{2.5}$ – fine particulate matter; DPM – diesel particulate matter
These results were based on initial conservative construction durations. Recently, possible shorter construction durations have been identified. However, the shorter construction durations would not have an appreciable effect on emissions or air quality.

Cumulative emissions over the full duration of seawall construction would be similar under all three of the build alternatives. Due to a combination of a longer construction period and different construction techniques, Alternative B would have lower maximum annual construction emissions than Alternatives A and C. The highest overall annual construction emissions under Alternative A, B or C would occur in 2014 (for most pollutants) or 2013 (for inhalable particulate matter [PM_{10}] and fine particulate matter [$PM_{2.5}$]). Maximum annual carbon monoxide emissions would occur in 2014 under all build alternatives. Those emissions (86.51 tons under Alternatives A and C, and 52.40 tons under Alternative B) would be less than the Clean Air Act conformity threshold of 100 tons per year. Consequently, no formal Clean Air Act conformity determination would be required for any of the build alternatives.

Maximum annual emissions associated with construction of the Elliott Bay Seawall under any of the build alternatives represent a fraction of one percent of the King County 2005 emission inventory for the corresponding pollutant. Based on the magnitude of estimated construction emissions in comparison to Clean Air Act conformity de minimis thresholds and the magnitude of current King County emissions, seawall construction under any of the build alternatives would not have a significant impact on air quality conditions in the Seattle area.

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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 air quality 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.

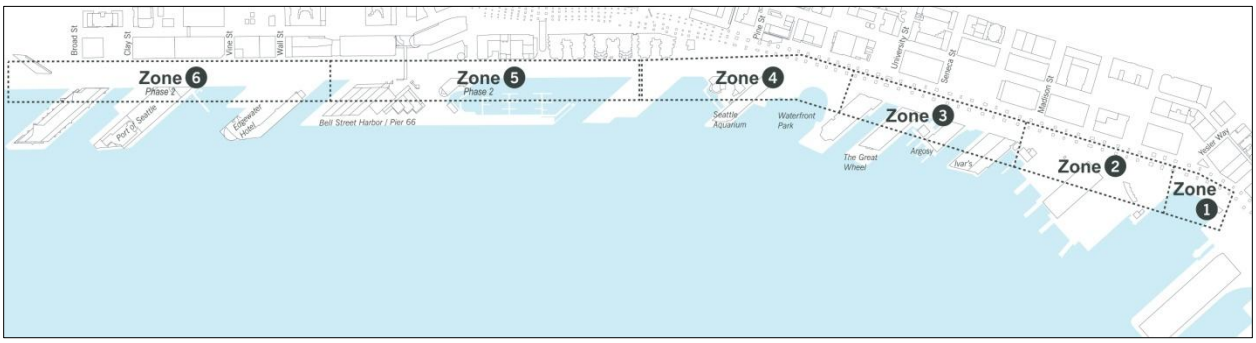


Figure 1-2. Elliott Bay Seawall Zone Designations

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.

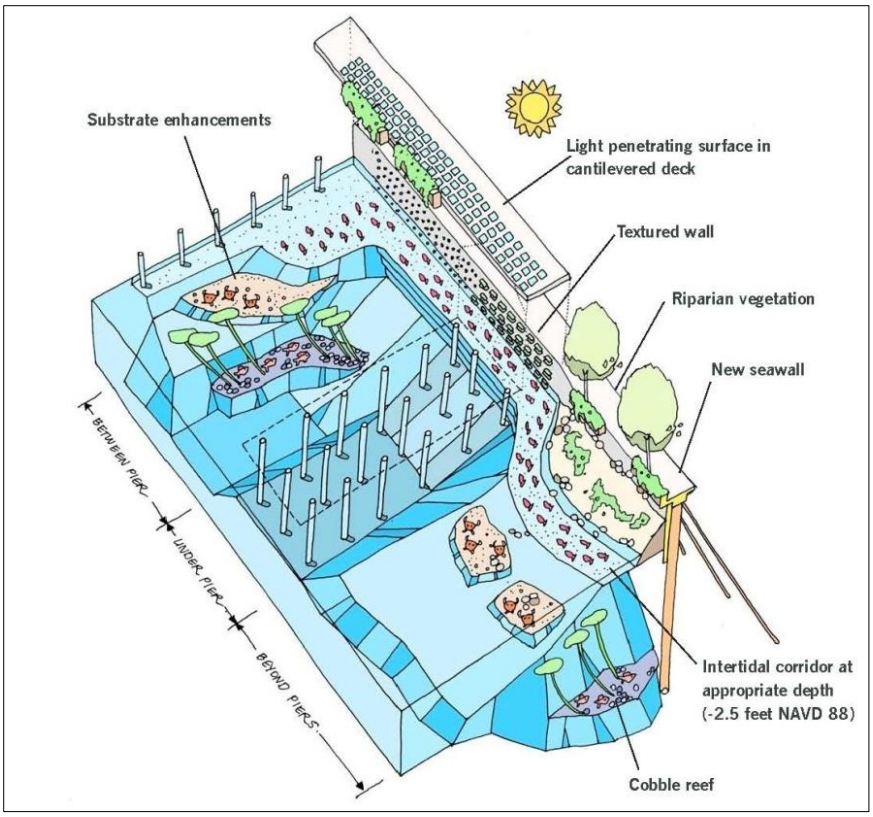


Figure 1-3. Conceptual Rendering of Proposed Habitat Improvements

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.

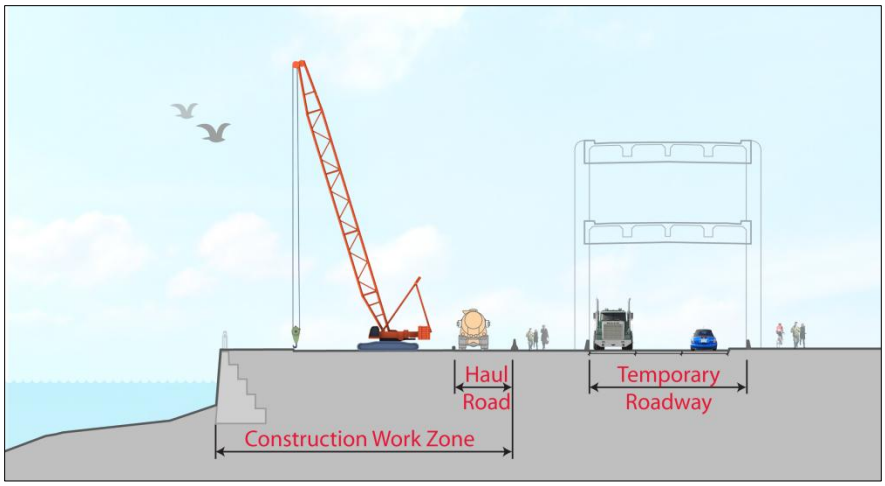


Figure 1-4. Construction Work Zone and Temporary Roadway

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.

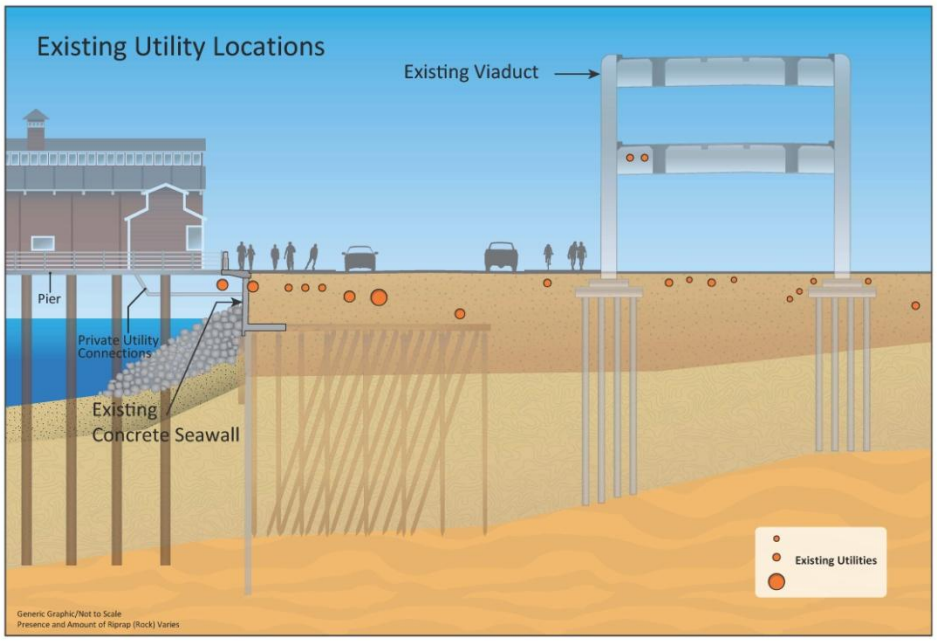


Figure 1-5. Representative Cross Section Showing Typical Existing Utility Locations within Project Limits

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.

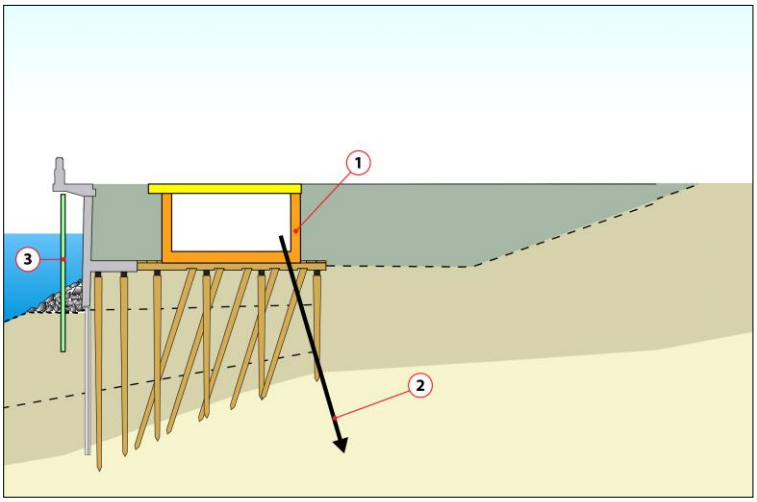
1.7.1.5 Construction and Schedule

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.

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

[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.

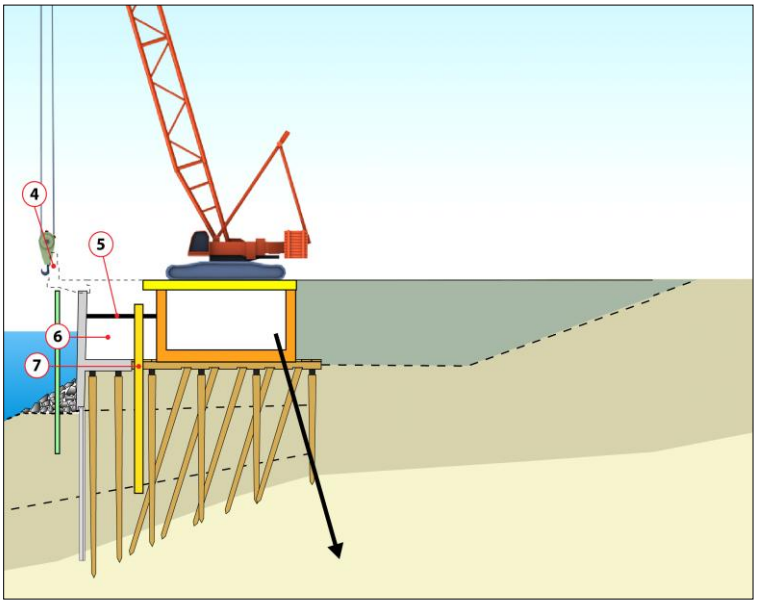
of work that would occur along the waterfront. The construction activities within each zone would vary depending on the type of existing seawall. The figures depict the Type A seawall. (Type A seawall is a sheet-pile supported, reinforced, concrete face panel, which is tied back to a buried timber relieving 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

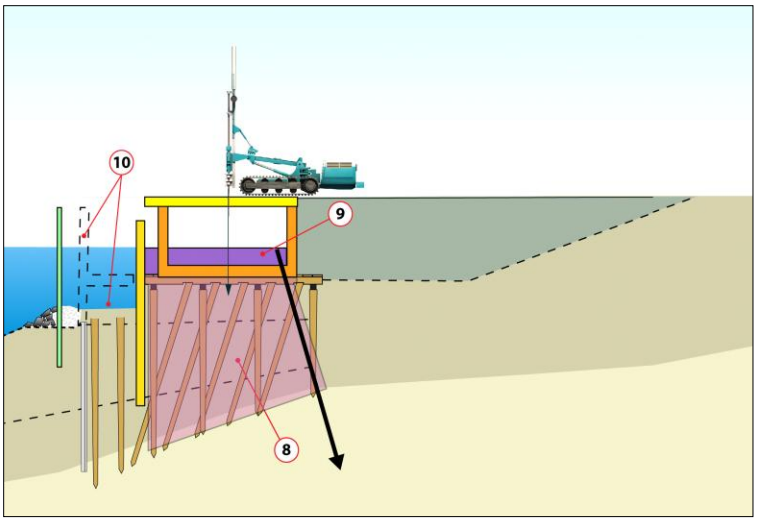
Figure 1-6. Alternative A, Stage 1



Alternative A, Stage 2

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

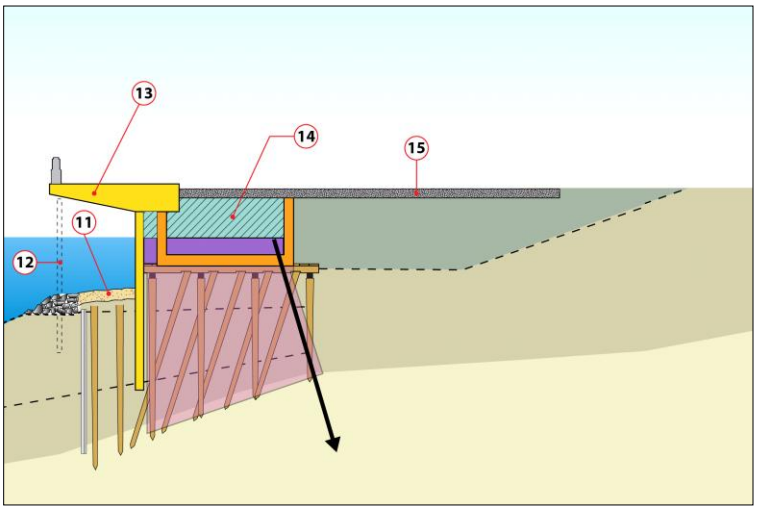
Figure 1-7. Alternative A, Stage 2



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.

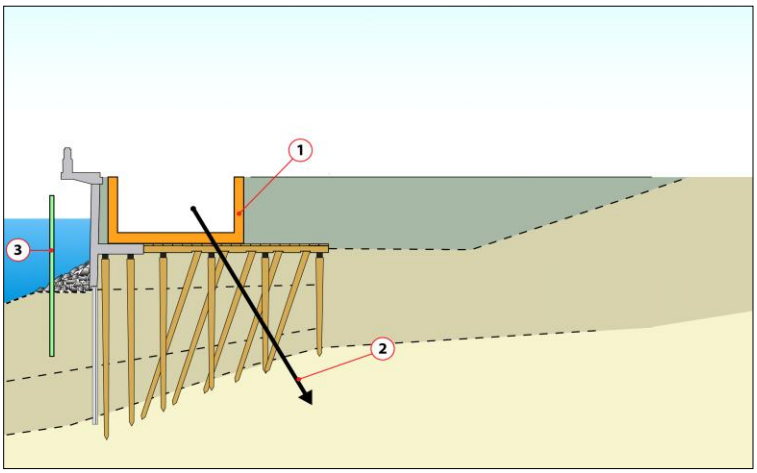
In Zone 4, the proposed seawall setback of 30 to 75 feet would provide two types of opportunities: a water plaza (Option 1) or a land plaza (Option 2). In Option 1, openings in the expansive plaza and walk would allow users to view tide pools and aquatic life below. In Option 2, raised planters would 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.

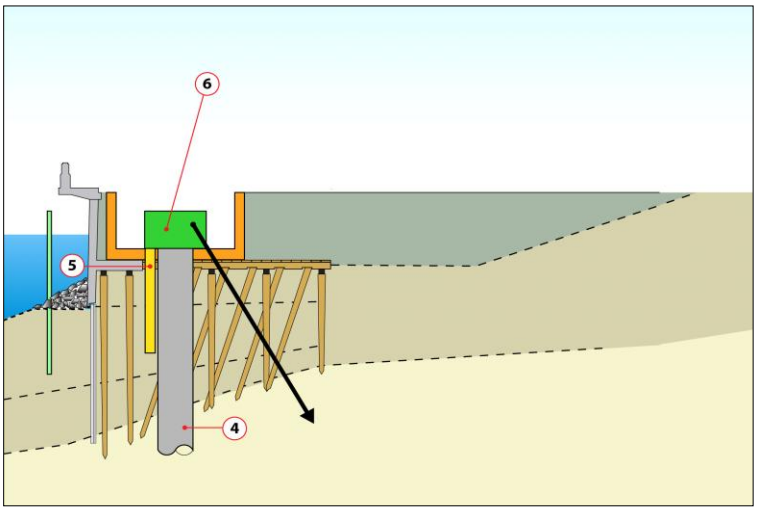
Construction of the Central Seawall would begin in Zone 4, move southward to Zone 3, and then progress to Zones 2 and 1. The Central Seawall construction would be followed by the North Seawall construction in Zones 6 and 5. The anticipated construction stages for Alternative B (assuming a Type A existing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

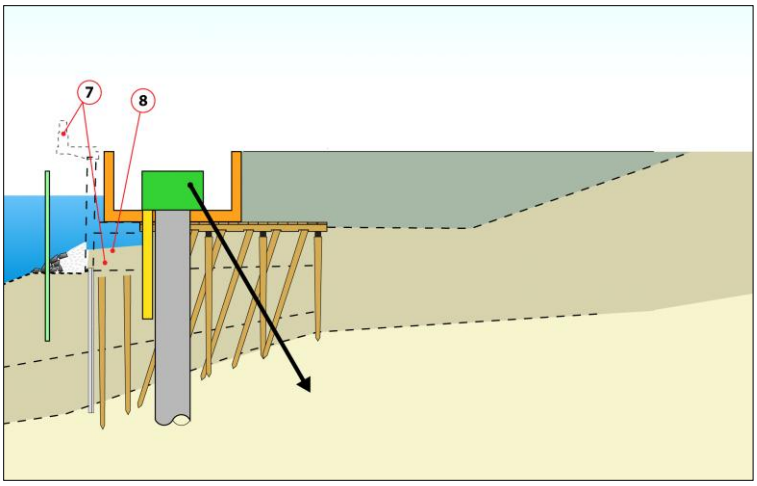
Figure 1-10. Alternative B, Stage 1



Alternative B, Stage 2

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

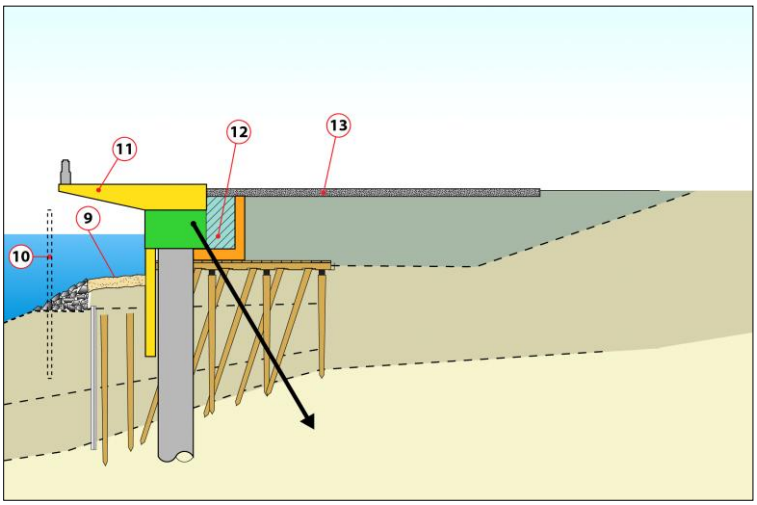
Figure 1-11. Alternative B, Stage 2



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.

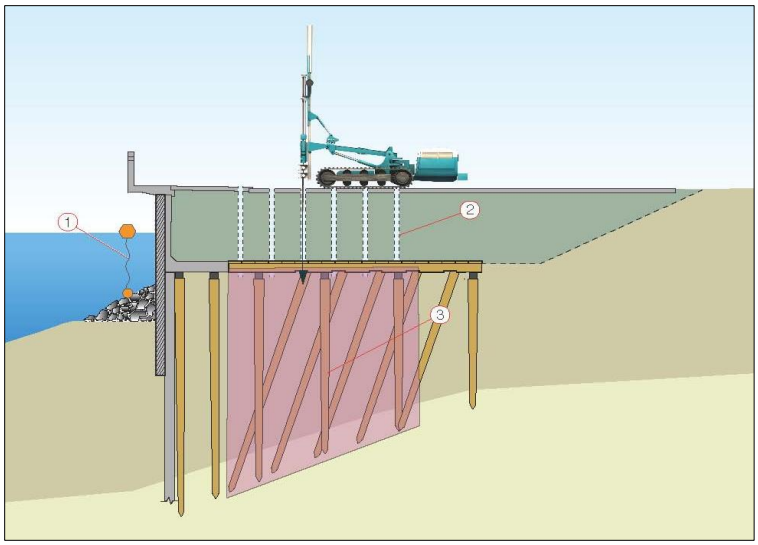
1.7.3.4 Upland Improvements

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.

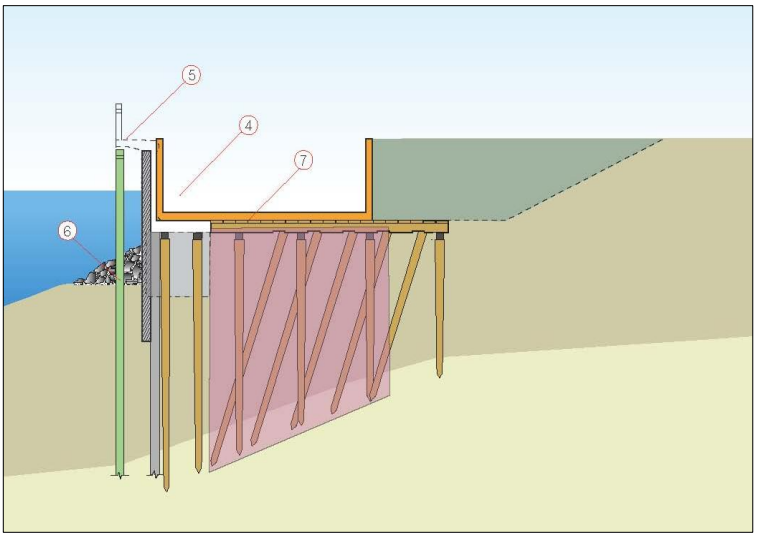
The anticipated construction activities and probable sequence for Alternative C, using soil improvement, are depicted below. The figures describe four primary stages of work that would occur along the waterfront. The activities within each zone would vary depending on the type of existing seawall present. 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)

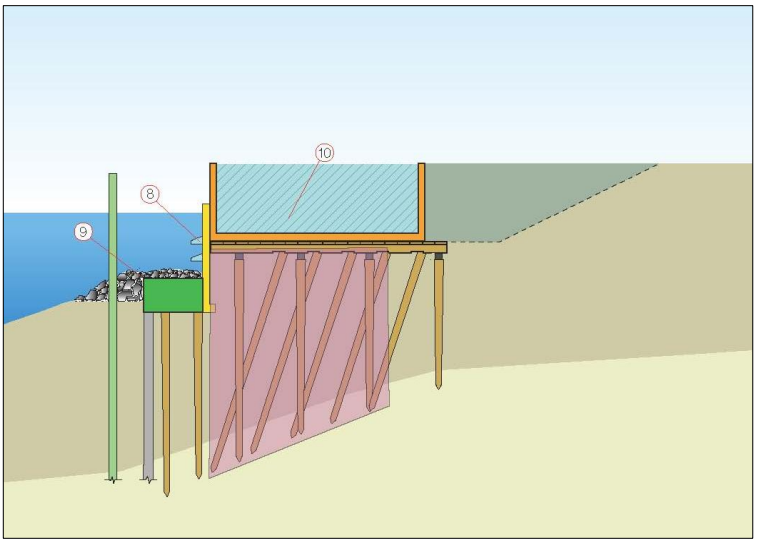
Figure 1-14. Alternative C, Stage 1



Alternative C, Stage 2

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

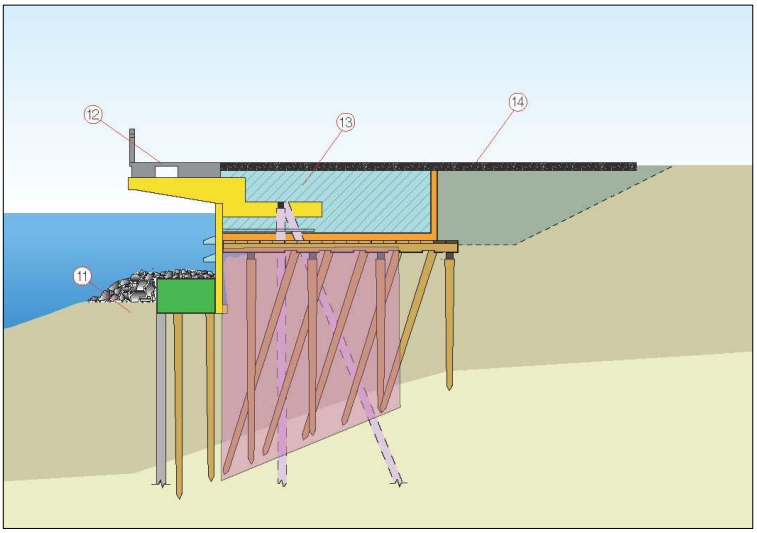
Figure 1-15. Alternative C, Stage 2



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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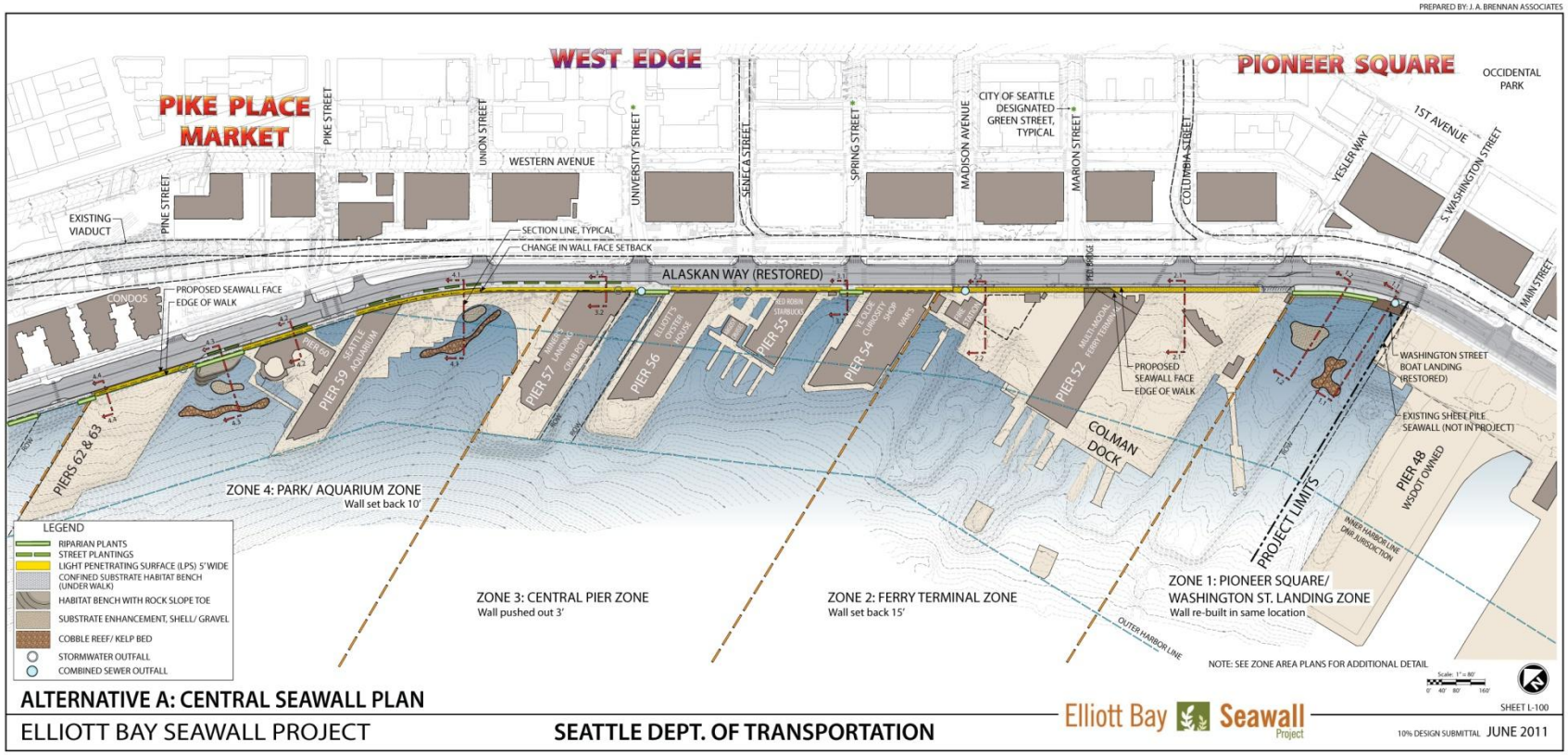

Figure 1-18. Alternative A: Central Seawall Plan

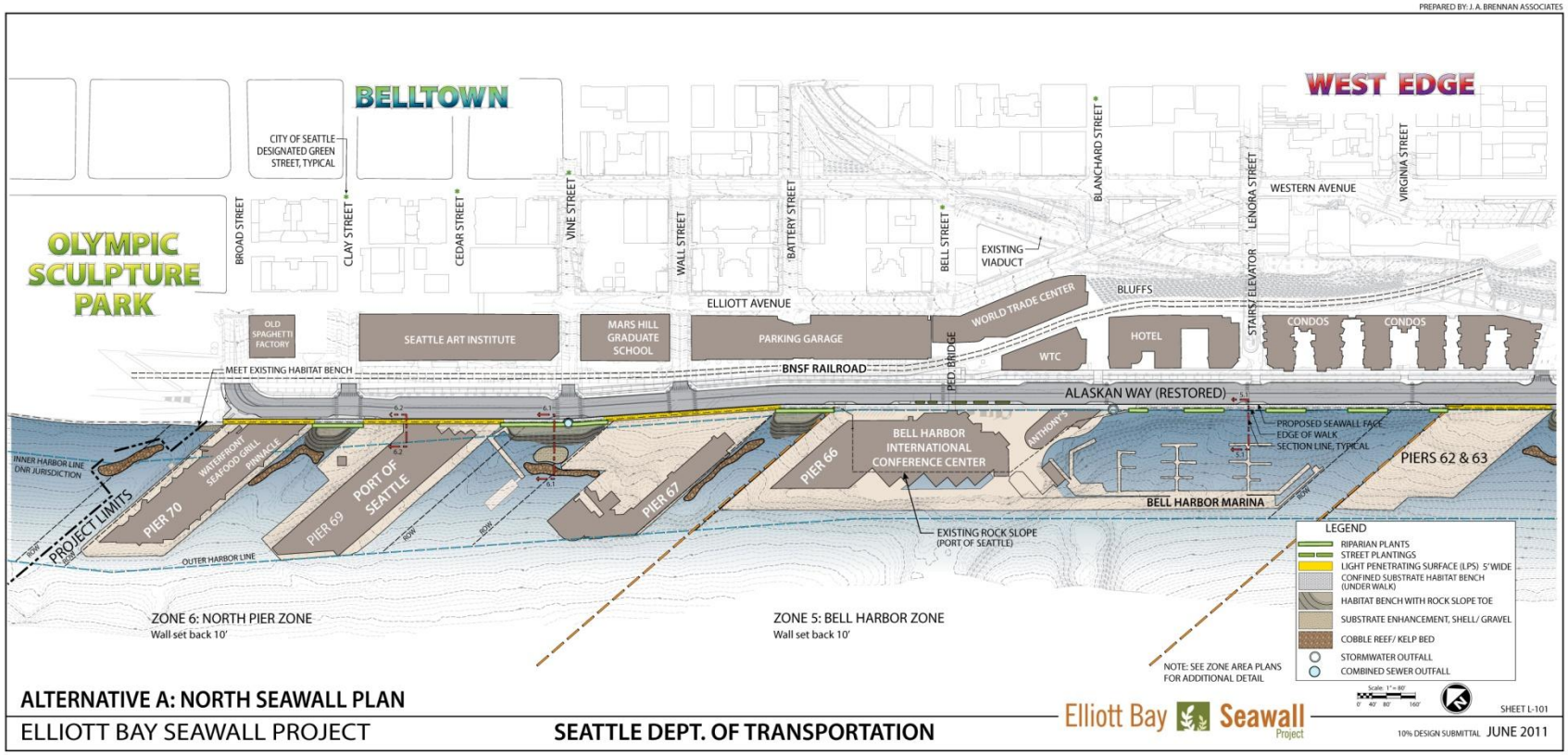

Figure 1-19. Alternative A: North Seawall Plan

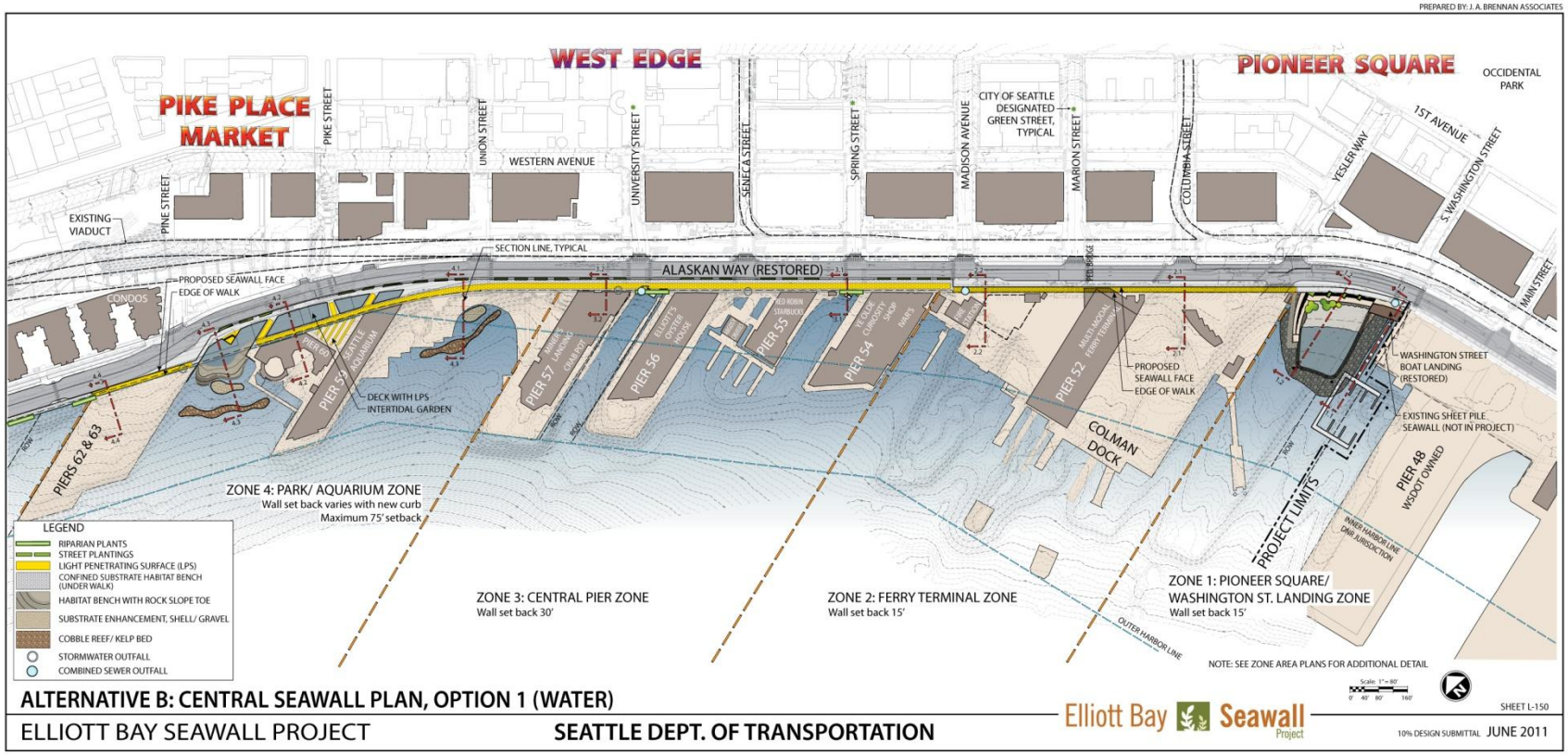

Figure 1-20. Alternative B: Central Seawall Plan, Option 1

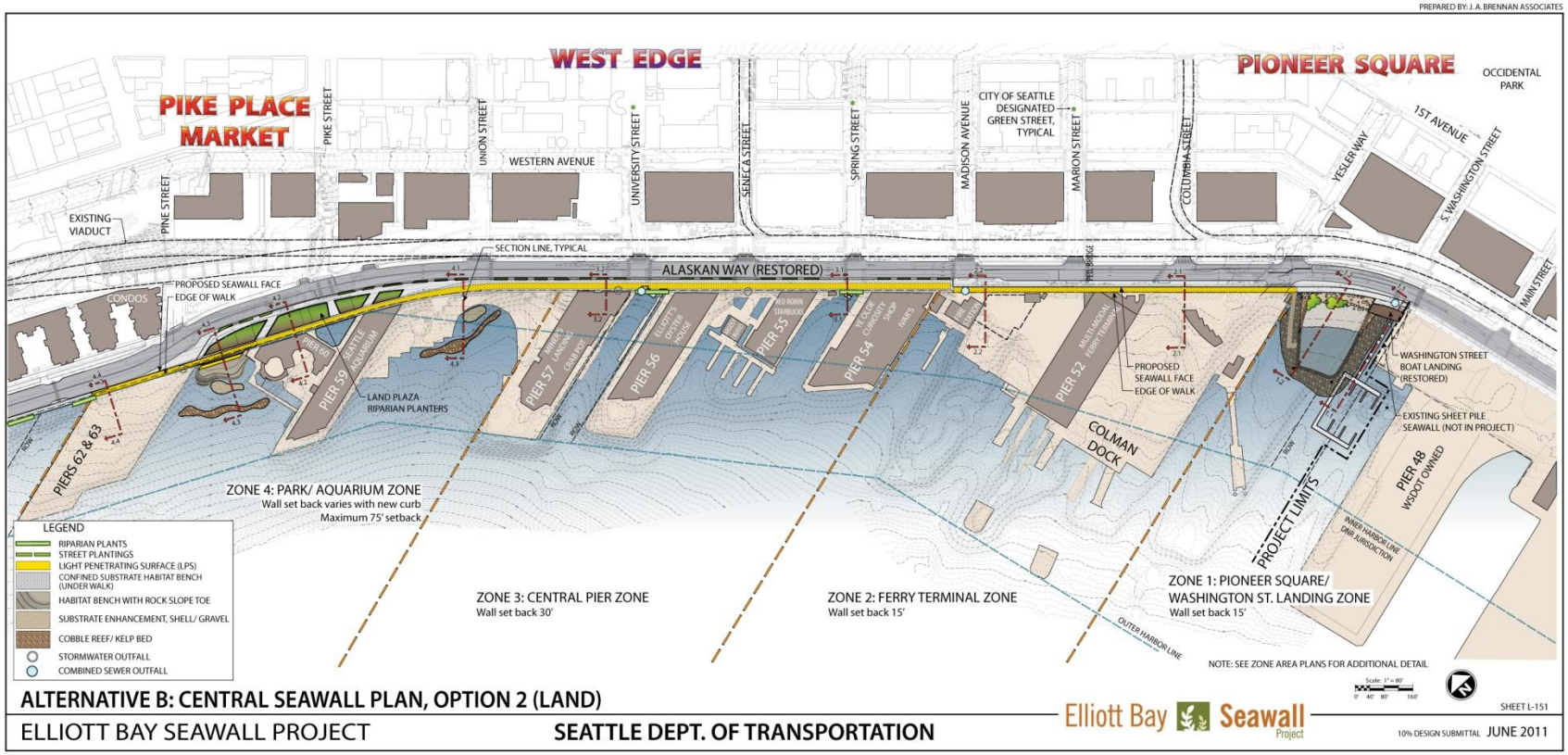

Figure 1-21. Alternative B: Central Seawall Plan, Option 2

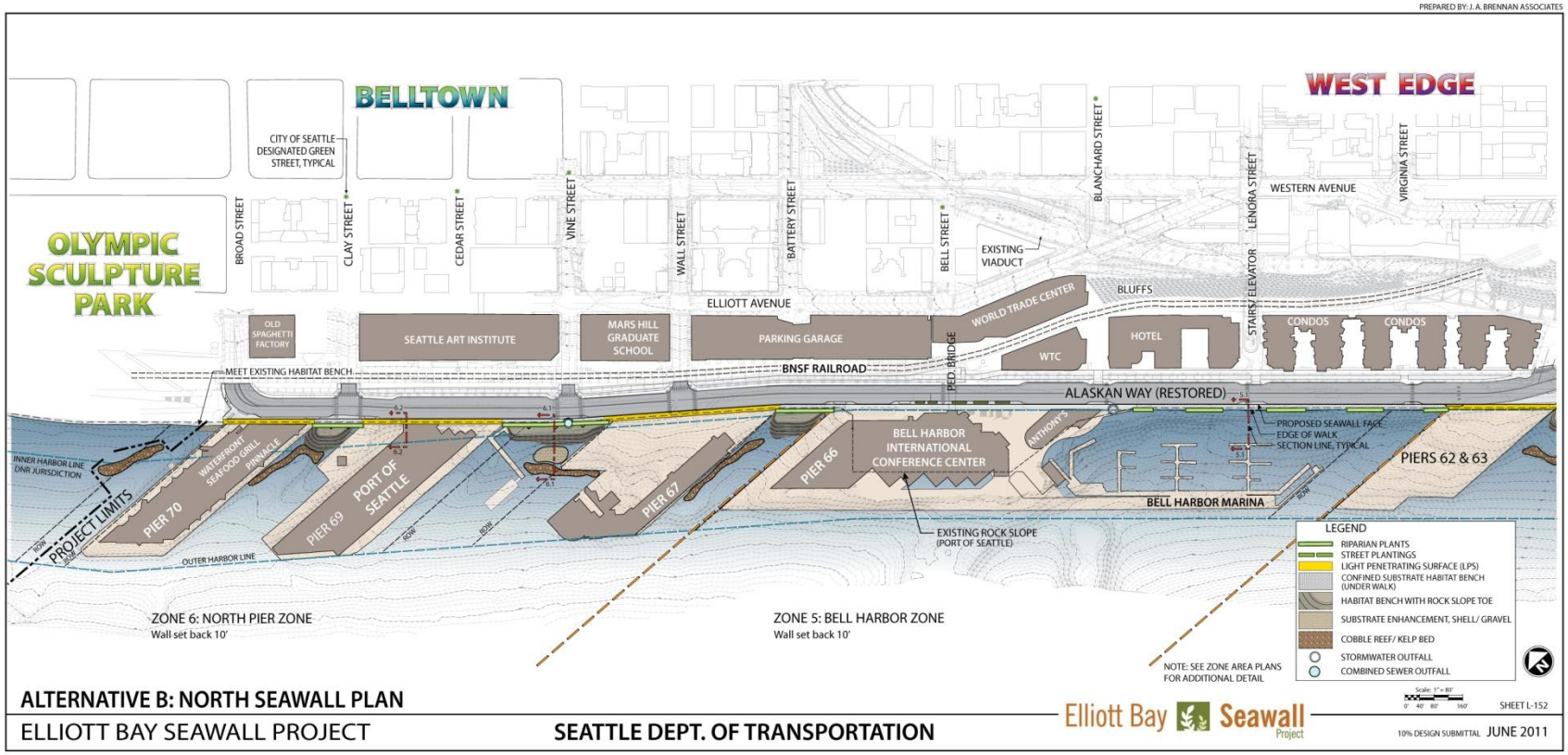

Figure 1-22. Alternative B: North Seawall Plan

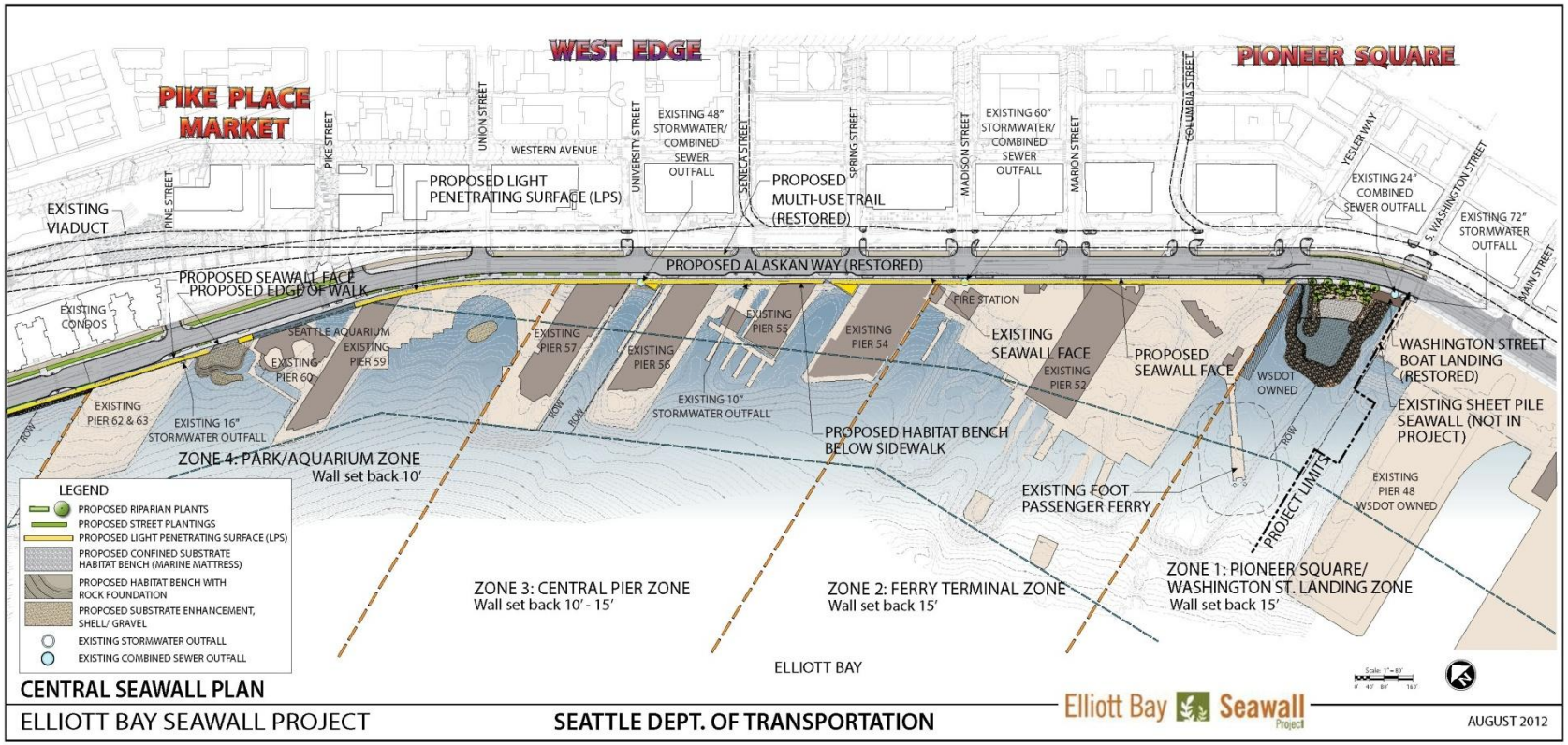

Figure 1-23. Alternative C: Central Seawall Plan

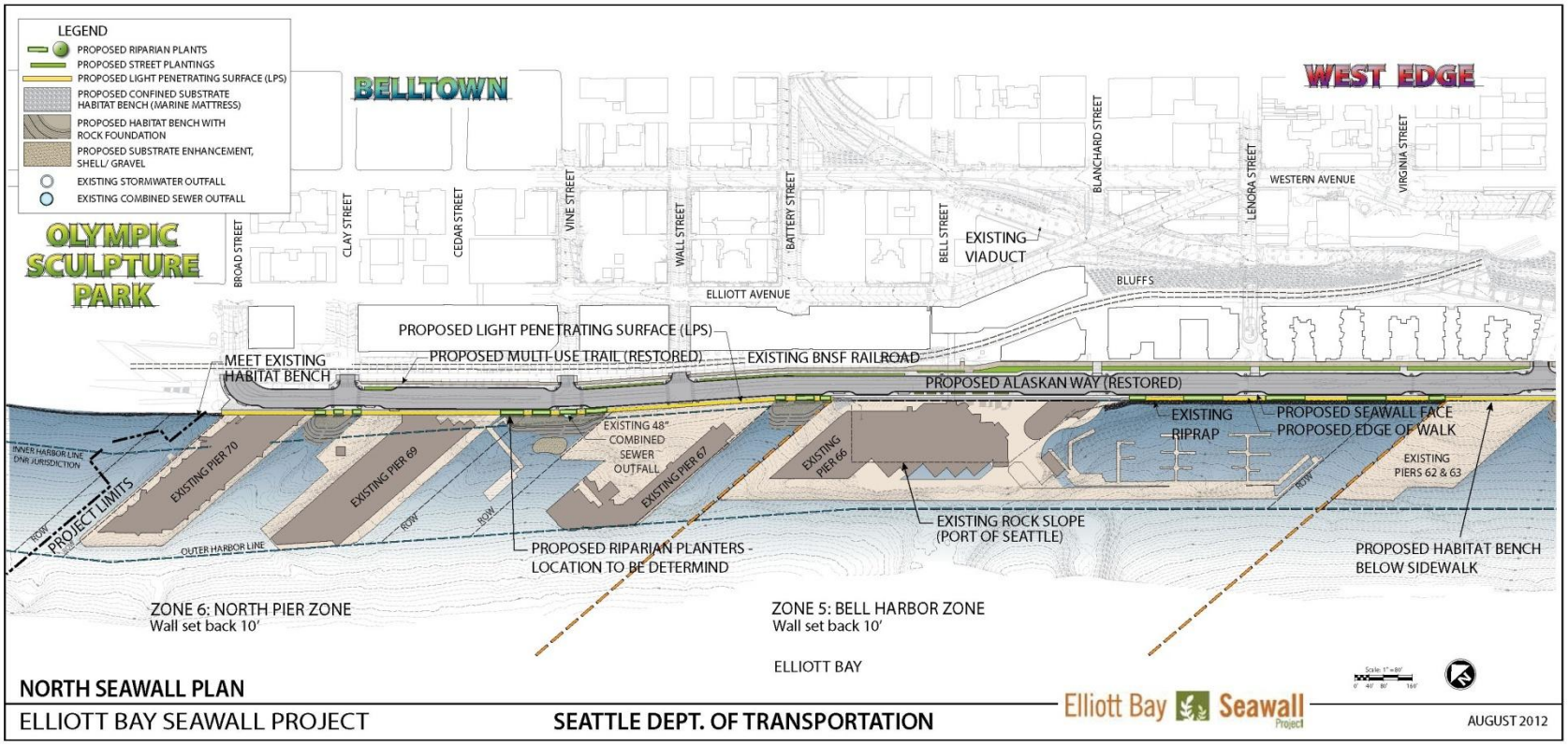

Figure 1-24. Alternative C: North Seawall Plan

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CHAPTER 2. COORDINATION AND INFORMATION SOURCES

Information on existing air quality conditions in the Seattle area was obtained from the Puget Sound Clean Air Agency and the Washington State Department of Ecology (Ecology) websites. Regulatory information was derived from various federal, state and local agency websites. As discussed in Chapter 3, Methodology, construction equipment requirements and schedules were provided by BergerABAM.

A background discussion of air quality terminology, air quality management programs, ambient air quality standards, and regulatory considerations is provided below to facilitate public understanding of the technical analyses included in the Air Quality Discipline Report.

2.1 AIR QUALITY TERMINOLOGY

The term "pollutant emissions" refers to the amount (usually stated as a weight) of one or more specific compounds introduced into the atmosphere by a source or group of sources. In practice, most pollutant emissions data are presented as "emission rates": the amount of pollutants emitted during a specified increment of time or during a specified increment of emission source activity. Typical measurement units for emission rates on a time basis include pounds per hour, pounds per day, or tons per year. Typical measurement units for emission rates on a source activity basis include pounds per thousand gallons of fuel burned, pounds per ton of material processed, and grams per vehicle mile of travel.

The term "ambient air quality" refers to the atmospheric concentration of a specific compound (amount of pollutants in a specified volume of air) actually experienced at a particular geographic location that may be some distance from the source of the relevant pollutant emissions. The ambient air quality levels actually measured at a particular location are determined by the interactions among three groups of factors:

- Emissions: the types, amounts, and locations of pollutants emitted into the atmosphere;
- Meteorology: the physical processes affecting the distribution, dilution, and removal of these pollutants; and
- Chemistry: any chemical reactions that transform pollutant emissions into other chemical substances.

In a regulatory context, “ambient air” refers to outdoor locations to which the general public has access. Ambient air quality data are generally reported as a mass per unit volume (e.g., micrograms per cubic meter of air) or as a volume fraction (e.g., parts per million by volume).

Air pollutants are often characterized as being "primary" or "secondary" pollutants. Primary pollutants are those emitted directly into the atmosphere (such as carbon monoxide, sulfur dioxide, lead particulates, and hydrogen sulfide). Secondary pollutants are those (such as ozone, nitrogen dioxide, and sulfate particles) formed through chemical reactions in the atmosphere; these chemical reactions usually involve primary pollutants, normal constituents of the atmosphere, and other secondary pollutants. Those compounds which react to form secondary pollutants are referred to as reactive pollutants, pollutant precursors, or precursor emission products. Some air pollutants (such as many

organic gases and suspended particulate matter) are a combination of primary and secondary pollutants.

2.2 FEDERAL CLEAN AIR ACT

The first federal air quality legislation was the Air Pollution Control Act of 1955, which provided funding to the U.S. Public Health Service for research into air pollution and air pollution control. The 1955 Act was amended and renamed the Clean Air Act in 1963. The 1963 federal Clean Air Act provided grants to state and local air pollution control agencies, but limited direct federal activity to research, education, and advisory functions, plus a mediation role for interstate disputes. The federal role was expanded in 1965 with Congressional authorization for uniform federal emission standards for motor vehicles, although no motor vehicle standards were adopted until after the 1970 amendments to the Clean Air Act. In 1967, Congress authorized federal enforcement procedures for air pollution problems caused by interstate transport of pollutants.

The 1970 amendments to the Clean Air Act effectively re-wrote the Act, and established a significant federal air quality regulatory role. The 1970 amendments to the Clean Air Act established several planning and regulatory programs, including:

- Adoption of national ambient air quality standards;
- Requirements for states to establish ambient air quality monitoring programs;
- Requirements for states to implement planning programs to achieve the national ambient air quality standards by fixed deadlines;
- Adoption of emission standards for motor vehicles and other types of mobile sources;
- Adoption of emission standards for major new industrial facilities as new source performance standards (NSPS);
- Adoption of national emission standards for hazardous air pollutants (NESHAP);
- Pre-construction review of major new industrial facilities or major modifications to existing facilities as the new source review (NSR) program for nonattainment areas, and the prevention of significant deterioration (PSD) program for attainment areas;
- Continued federal grant programs to state and local air pollution control agencies; and
- Authorized citizen suits to enforce provisions of the Act (Section 304).
- The United States Environmental Protection Agency (USEPA) was created in 1971, and was given responsibility for implementing the Clean Air Act.

The 1977 amendments to the Clean Air Act revised and expanded some of the regulatory programs established by the 1970 amendments. The 1990 amendments to the Clean Air Act made further revisions to the established regulatory programs and added some new regulatory and planning programs:

- Operating permits for major industrial facilities (Title V permits);
- Additional programs to regulate an extensive list of hazardous air pollutants;

- Emissions allocation programs to regulate sulfur emissions from electrical power generation facilities;
- Programs to reduce emissions of compounds that deplete stratospheric ozone levels; and
- Requirements for federal agencies to demonstrate that actions they undertake are consistent with federally mandated state implementation plans (SIPs).

In addition, the 1990 amendments to the Clean Air Act recognized the authority of Tribal governments to establish air quality management programs and to enforce those portions of the Clean Air Act applicable to Tribal lands.

In general, states have assumed primary responsibility for enforcing most federal industrial source emission standards and industrial source review requirements, with USEPA exercising formal review and oversight responsibilities. Many states, including Washington, have delegated air quality management responsibilities to regional or local agencies, especially for larger metropolitan areas. Many states also have air quality permit programs that extend to emission sources not covered by federal NSR or PSD requirements. State air quality permit requirements generally are integrated with federal NSR, PSD, and Title V requirements, resulting in a consolidated permit program. Under most consolidated permit programs, basic state permit requirements apply to all sources that are not specifically exempted. Additional NSR and/or PSD program requirements (including USEPA review of the permit) become applicable if sources exceed various size or emission thresholds. The Puget Sound Clean Air Agency (PSCAA) is the regional agency with primary air quality management responsibilities for King, Kitsap, Pierce, and Snohomish Counties.

2.3 AIR QUALITY STANDARDS

Federal and state air quality management programs have evolved using two distinct management approaches:

- The State Implementation Plan process of setting ambient air quality standards for acceptable exposure to air pollutants, conducting monitoring programs to identify locations experiencing air quality problems, and then developing programs and regulations designed to reduce or eliminate those problems.
- The Hazardous Air Pollutant (HAP) regulatory process identifying specific chemical substances that are potentially hazardous to human health, and then setting emission standards to regulate the amount of those substances that can be released by individual commercial or industrial facilities or by specific types of equipment.

Air quality programs based on ambient air quality standards typically address air pollutants that are produced in large quantities by widespread types of emission sources and which are of public health concern because of their toxic properties. The USEPA has established ambient air quality standards for several different pollutants, which often are referred to as criteria pollutants (ozone, nitrogen dioxide, carbon monoxide, sulfur dioxide, suspended particulate matter, and lead). Standards for suspended particulate matter have been set for two size fractions: inhalable particulate matter (PM_{10}) and fine particulate matter ($PM_{2.5}$). Federal ambient air quality standards are based primarily on evidence of acute and chronic health effects. Federal ambient air quality standards apply to outdoor locations where

the general public has access. The State of Washington also has adopted state ambient air quality standards for ozone, nitrogen dioxide, carbon monoxide, sulfur dioxide, and suspended particulate matter. USEPA and State of Washington ambient air quality standards are summarized in Table 2-1.

Air pollutants covered by federal and state ambient air quality standards can be categorized by the nature of their toxic effects as:

- Irritants (such as ozone, particulate matter, nitrogen dioxide, sulfur dioxide, sulfate particles, hydrogen sulfide, and vinyl chloride) that affect the respiratory system, eyes, mucous membranes, or the skin;
- Asphyxiants (such as carbon monoxide and nitric oxide) that displace oxygen or interfere with oxygen transfer in the circulatory system, affecting the cardiovascular and central nervous systems;
- Necrotic agents (such as ozone, nitrogen dioxide, and sulfur dioxide) that directly cause cell death; or
- Systemic poisons (such as lead particles) that affect a range of tissues, organs, and metabolic processes.

Ozone, suspended particulate matter, and carbon monoxide are the air pollutants of greatest concern in most parts of the country, including the Puget Sound region. Ozone is a strong oxidizing agent that reacts with a wide range of materials and biological tissues. Ozone is a respiratory irritant that can cause acute and chronic effects on the respiratory system. Recognized effects include reduced pulmonary function, pulmonary inflammation, increased airway reactivity, aggravation of existing respiratory diseases (such as asthma, bronchitis, and emphysema), physical damage to lung tissue, decreased exercise performance, and increased susceptibility to respiratory infections. In addition, ozone is a necrotic agent that causes significant damage to leaf tissues of crops and natural vegetation. Ozone also damages many materials by acting as a chemical oxidizing agent. Because of its chemical activity, the extent of physical surfaces on which chemical reactions can occur, and the fact that those chemical reactions remove ozone from the air, indoor ozone levels are usually much lower than outdoor levels.

Suspended particulate matter represents a diverse mixture of solid and liquid material having size, shape, and density characteristics that allow the material to remain suspended in the air for meaningful time periods. The physical and chemical composition of suspended particulate matter is highly variable, resulting in a wide range of public health concerns.

Many components of suspended particulate matter are respiratory irritants. Some components (such as crystalline or fibrous minerals) are primarily physical irritants. Other components are chemical irritants (such as sulfates, nitrates, and various organic chemicals). Suspended particulate matter also can contain compounds (such as heavy metals and various organic compounds) that are systemic toxins or necrotic agents. Suspended particulate matter or compounds adsorbed on the surface of particles can also be carcinogenic or mutagenic chemicals.

TABLE 2-1. STATE AND NATIONAL AMBIENT AIR QUALITY STANDARDS APPLICABLE IN WASHINGTON

Pollutant	Averaging Time	Standards in Parts per Million by Volume (ppm)		Standards in Micrograms per Cubic Meter		Violation Criteria	
		Washington	National	Washington	National	Washington	National
Ozone	1 Hour	0.12	No standard	235	No standard	If exceeded on more than 1 day per year	Not applicable
	8 Hours	No standard	0.075	No standard	147	Not applicable	If exceeded by the mean of annual 4th highest daily values for a 3-year period
Carbon Monoxide	1 Hour	35	35	40,000	40,000	If exceeded more than once per year	If exceeded on more than 1 day per year
	8 Hours	9	9	10,000	10,000	If exceeded more than once per year	If exceeded on more than 1 day per year
Sulfur Dioxide	Annual Average	0.02	0.03	No standard	80	If exceeded	If exceeded
	24 Hours	0.10	0.14	No standard	365	If exceeded more than once per year	If exceeded on more than 1 day per year
	3 Hours	No standard	0.5	No standard	1,300	Not applicable	If exceeded on more than 1 day per year
	1 Hour	0.40	0.075	No standard	197	If exceeded more than once per year	If exceeded by the mean of annual 99th percentile of daily max values over 3 years
	1 Hour	0.25		No standard		If exceeded more than twice in a 7-day period	
Nitrogen Dioxide	Annual Average	0.05	0.053	100	100	If exceeded	If exceeded
	1 Hour	No standard	0.100	No Standard	188	Not applicable	If exceeded by the mean of annual 98th percentile of daily max values over 3 years
Inhalable Particulate Matter (PM_{10})	Annual Arithmetic Mean	Not applicable	Not applicable	50	No standard	If exceeded	Not applicable

Pollutant	Averaging Time	Standards in Parts per Million by Volume (ppm)		Standards in Micrograms per Cubic Meter		Violation Criteria	
		Washington	National	Washington	National	Washington	National
Inhalable Particulate Matter (PM_{10})	24 Hours	Not applicable	Not applicable	150	150	If exceeded on more than 3 days in 3 years	For 1997 non-attainment areas, if exceeded on more than 1 day per year. For other areas, if exceeded by the mean of annual 99th percentile values over 3 years
Fine Particulate Matter ($PM_{2.5}$)	Annual Arithmetic Mean	Not applicable	Not applicable	15.0	15.0	If exceeded	If exceeded as a 3-year spatial average of data from designated stations
	24 Hours	Not applicable	Not applicable	35	35	If exceeded by the mean of annual 98th percentile values over 3 years	If exceeded by the mean of annual 98th percentile values over 3 years
Total Suspended Particulate Matter (TSP)	Annual Geometric Mean	Not applicable	Not applicable	50	No standard	If exceeded	Not applicable
	24 Hours	Not applicable	Not applicable	150	No standard	If exceeded more than once per year	Not applicable
Lead Particles (TSP sampler)	Calendar Quarter	Not applicable	Not applicable	No standard	1.5	Not applicable	If exceeded
	Rolling 3-Month Average	Not applicable	Not applicable	No standard	0.15	Not applicable	If exceeded during a 3-year period
	30 Days	Not applicable	Not applicable	1.5	No standard	If exceeded	Not applicable

Sources: 40 CFR Parts 50, 53, and 58; USEPA 2010; National Ambient Air Quality Standards (NAAQS); Ecology 2010. Ambient Air Quality Standards in Washington State

Notes: All standards except the national PM10 and PM2.5 standards are based on measurements corrected to 25 degrees C and atmosphere pressure.
The national PM_{10} and $PM_{2.5}$ standards are based on direct flow volume data without correction to standard temperature and pressure.
Decimal places shown for standard reflect the rounding or truncating conventions used for evaluating compliance.
The "10" in PM_{10} and the "2.5" in $PM_{2.5}$ are not particle size limits; these numbers identify the particle size class (aerodynamic diameter in microns) collected with 50% mass efficiency by certified sampling equipment. The maximum particle size collected by PM10 samplers is about 50 microns. The maximum particle size collected by $PM_{2.5}$ samplers is about 6 microns.
The national 3-month rolling average standard for lead was adopted in November 2008.
The national calendar quarter standard for lead will remain in effect for at least one year after the 3-month rolling average standard takes effect.
The national 1-hour sulfur dioxide standard was adopted in June 2010 and became effective in August 2010.
The national annual average and 24-hour average sulfur dioxide standards will remain in effect for at least one year after nonattainment designations for the 1-hour standard take effect.

Public health concerns for suspended particulate matter focus on the particle size ranges likely to reach the lower respiratory tract or the lungs. Inhalable particulate matter (PM_{10}) represents particle size categories that are likely to reach either the lower respiratory tract or the lungs after being inhaled. Fine particulate matter ($PM_{2.5}$) represents particle size categories likely to penetrate to the lungs after being inhaled. The "10" in PM_{10} and the "2.5" in $PM_{2.5}$ are not upper size limits. These numbers refer to the particle size range collected with 50 percent mass efficiency by certified sampling devices; larger particles are collected with lower efficiencies and smaller particles are collected with higher efficiencies.

In addition to public health impacts, suspended particulate matter causes a variety of material damage and nuisance effects: abrasion; corrosion, pitting, and other chemical reactions on material surfaces; soiling; and transportation hazards due to visibility impairment.

Carbon monoxide is a public health concern because it combines readily with hemoglobin in the blood, and thus reduces the amount of oxygen transported to body tissues. Relatively low concentrations of carbon monoxide can significantly affect the amount of oxygen in the blood stream since carbon monoxide binds to hemoglobin 200 to 250 times more strongly than oxygen. Both the cardiovascular system and the central nervous system can be affected when 2.5 to 4.0 percent of the hemoglobin in the blood is bound to carbon monoxide rather than to oxygen. Because of its low chemical reactivity and low solubility, indoor carbon monoxide levels usually are similar to outdoor levels.

Air quality programs based on regulation of other hazardous substances typically address chemicals used or produced by limited categories of industrial facilities. Programs regulating hazardous air pollutants focus on: substances that alter or damage the genes and chromosomes in cells (mutagens); substances that affect cells in ways that can lead to uncontrolled cancerous cell growth (carcinogens); substances that can cause birth defects or other developmental abnormalities (teratogens); substances with serious acute toxicity effects; and substances that undergo radioactive decay processes, resulting in the release of ionizing radiation. Federal air quality management programs for hazardous air pollutants focus on setting emission limits for particular industrial processes rather than setting ambient exposure standards.

2.4 AIR QUALITY PLANNING PROGRAMS

The federal Clean Air Act requires each state to identify areas that have ambient air quality in violation of federal standards. States are required to develop, adopt, and implement a SIP to achieve, maintain, and enforce federal ambient air quality standards in these nonattainment areas. Deadlines for achieving the federal air quality standards vary according to air pollutant and the severity of existing air quality problems. The SIP must be submitted to and approved by USEPA. SIP elements are developed on a pollutant-by-pollutant basis whenever one or more air quality standards are being violated.

The status of areas with respect to federal ambient air quality standards is categorized as nonattainment, attainment (better than national standards), unclassifiable, or attainment/cannot be classified. For most air pollutants, initial federal status designations are made using only two categories (either nonattainment and unclassifiable/attainment, or nonattainment and attainment/cannot be classified). For simplicity and clarity, the federal unclassifiable and attainment/cannot be classified designations will be called unclassified in this document. The unclassified designation includes

attainment areas that comply with federal standards as well as areas for which monitoring data are lacking. Unclassified areas are treated as attainment areas for most regulatory purposes.

Simple attainment designations generally are used only for areas that transition from a nonattainment status to an attainment status. Areas that have been reclassified from nonattainment to attainment of federal air quality standards are automatically considered "maintenance areas," although this designation is not always noted in status listings.

The project study area does not have any federal non-attainment designations, but is considered a carbon monoxide maintenance area. The project study area previously was a maintenance area for the former 1-hour federal ozone standard, but all nonattainment and maintenance designations for that standard were eliminated when the federal 1-hour ozone standard was revoked and replaced with the current 8-hour ozone standard.

2.5 CLEAN AIR ACT CONFORMITY REQUIREMENTS

Section 176(c) of the Clean Air Act requires federal agencies to ensure that actions undertaken in nonattainment or maintenance areas are consistent with the Clean Air Act and with federally enforceable air quality management plans. USEPA has promulgated separate rules that establish conformity analysis procedures for highway/mass-transit projects (40 CFR Part 93, Subpart A) and for other (general) federal agency actions (40 CFR Part 93, Subpart B). General conformity requirements are potentially applicable to many federal agency actions, but apply only to those aspects of an action that involve on-going federal agency responsibility and control over direct or indirect sources of air pollutant emissions.

The USEPA conformity rule establishes a process that is intended to demonstrate that the proposed federal action:

- Would not cause or contribute to new violations of federal air quality standards;
- Would not increase the frequency or severity of existing violations of federal air quality standards; and
- Would not delay the timely attainment of federal air quality standards.

The USEPA general conformity rule applies to federal actions occurring in nonattainment or maintenance areas when the total direct and indirect emissions of nonattainment pollutants (or their precursors) exceed specified thresholds. The emission thresholds that trigger requirements of the conformity rule are called de minimis levels. Emissions associated with stationary sources that are subject to permit programs incorporated into the SIP are not counted against the de minimis threshold.

Compliance with the conformity rule can be demonstrated in several ways. Compliance is presumed if the net increase in direct and indirect emissions from a federal action would be less than the relevant de minimis level. If net emissions increases exceed the relevant de minimis value, a formal conformity determination process must be followed. Federal agency actions subject to the general conformity rule cannot proceed until there is a demonstration of consistency with the SIP through one of the following mechanisms:

- By dispersion modeling analyses demonstrating that direct and indirect emissions from the federal action would not cause or contribute to violations of federal ambient air quality standards;
- By showing that direct and indirect emissions from the federal action are specifically identified and accounted for in an approved SIP;
- By showing that direct and indirect emissions associated with the federal agency action are accommodated within emission forecasts contained in an approved SIP;
- By showing that emissions associated with future conditions would not exceed emissions that would occur from a continuation of historical activity levels;
- By obtaining a commitment from the relevant air quality management agency to amend the SIP to account for direct and indirect emissions from the federal agency action;
- By arranging emission offsets to fully compensate for the net emissions increase associated with the action; or
- In the case of regional water or wastewater projects, by showing that any population growth accommodated by such projects is consistent with growth projections used in the applicable SIP.

Dispersion modeling analyses can be used to demonstrate conformity only in the case of primary pollutants such as carbon monoxide or directly emitted PM10. Modeling analyses cannot be used to demonstrate conformity for secondary pollutants such as ozone or photochemically generated particulate matter because the available modeling techniques generally are not sensitive to site-specific emissions.

The EBSP would be subject to the general conformity regulations since the project area is a carbon monoxide maintenance area. The relevant de minimis emission level assigned by USEPA via 40 CFR 93.153 for carbon monoxide maintenance areas is 100 tons per year of carbon monoxide emissions.

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CHAPTER 3. METHODOLOGY

The final *Elliott Bay Seawall Project Air Quality Technical Memorandum* (SDOT 2011) contains a detailed description of the methodology used for this discipline report. The following sections summarize the methodology used to assess direct project effects on air quality in the project area, as well as secondary (indirect) effects of other projects on air quality.

3.1 CONSTRUCTION EMISSIONS ANALYSIS METHODOLOGY

Emissions from construction and demolition activities were estimated using a detailed spreadsheet model (CNSTEMIS). The CNSTEMIS spreadsheet model calculates criteria pollutant emissions, diesel particulate emissions, and greenhouse gas (GHG) emissions from construction or demolition activities and equipment. Criteria pollutant emission estimates are provided for reactive organic compounds, nitrogen oxides, carbon monoxide, sulfur oxides, inhalable particulate matter (PM_{10}), fine particulate matter ($PM_{2.5}$), and diesel particulate matter (DPM). Exhaust emissions of PM_{10} from construction and demolition equipment provide the estimate of diesel particulate matter emissions. In addition to engine exhaust emissions, fugitive PM_{10} emissions have been incorporated into the equipment emission rates for rock drills, jackhammers, pavement breakers, pavement scarifiers, concrete/industrial saws, and abrasive blasting equipment. Metal fume emissions have been incorporated into the PM_{10} emission rates for welders and cutting torches. GHG emission estimates generated by the CNSTEMIS model are presented in the Energy Resources Discipline Report (SDOT 2012).

The CNSTEMIS also calculates fugitive emissions physical site disturbance and other construction-related sources:

- Fugitive dust emissions from general construction and demolition site disturbance;
- Fugitive dust from mechanical or explosive building demolition;
- Fugitive dust from construction blasting;
- Volatile organic compound emissions from the curing of asphalt pavement;
- Volatile organic compound emissions from paints and surface coatings; and
- PM_{10} aerosol emissions from spray painting activities.

The CNSTEMIS spreadsheet model uses a conventional approach to estimating emissions from construction equipment and activity, typically involving the following steps:

- Dividing the construction or demolition project into activity phases that have similar equipment requirements.
- Identifying equipment types needed for each construction or demolition phase.
- Identifying how many items of each type would be needed, the typical horsepower rating for the item (model provides defaults), and the typical engine load factor (model provides defaults).
- Identifying the hours per day with active use for each equipment item.

- Identifying the fraction of each use hour when the equipment would actually be operating (model provides defaults).
- Identifying the overall disturbed area size for each phase of construction or demolition activity.
- Identifying the duration of each construction or demolition phase.
- Identifying the typical area size that would be disturbed on a given day during each phase of construction or demolition activity.
- Identifying typical fugitive dust emission rates for each phase of construction or demolition activity (model provides defaults).
- Identifying which construction or demolition phases overlap with each other.

The equipment database in the CNSTEMIS model was expanded for this analysis to better reflect different types of pile drivers (diesel, hydraulic, and vibratory) and jet grouters (truck-mounted and crawler-mounted). It was assumed for this analysis that hydraulic pile drivers and vibratory pile drivers would be used instead of diesel pile drivers. The analysis also assumed the use of auxiliary power units for hydraulic pile drivers. Jet grouters used for Alternatives A and C were assumed to be crawler-mounted units.

Fugitive dust emission estimates provided by the CNSTEMIS model account for active construction site dust control programs (normally periodic sprinkling from water trucks) as well as natural dust control from seasonal precipitation patterns. Precipitation frequency by calendar quarter was estimated using meteorological data from Boeing Field (Western Regional Climate Center 2008).

Additional information on the CNSTEMIS spreadsheet model is provided in Appendix 1. BergerABAM developed estimates of required construction equipment, construction schedules and construction-related truck traffic for Alternatives A and B. Alternatives A and C are assumed to be identical with respect to the required construction equipment, construction schedules and construction-related truck traffic. The inclusion of a short-stay boat moorage and larger habitat bench in Zone 1 for Alternative B has only negligible effects on overall emissions and is not discussed further. The estimates provided by the design team as a result of 10% conceptual design were used as the primary input to the CNSTEMIS spreadsheet analyses, with adjustments made to those estimates where warranted.

For all three build alternatives, construction activities would be limited to the winter, spring, and fall months; construction activities would be shut down during summer months. As noted previously, construction activities would begin in the Central Seawall area, progressing from Zone 4 to Zone 1. Construction activities in the North Seawall would occur following completion of the Central seawall. Construction activities would take three (Central Seawall) to four seasons (North Seawall) for Alternatives A and C and four (North Seawall) to five (Central Seawall) seasons for Alternative B. For all build alternatives, construction activity would occur in two 10-hour shifts per day. Separate CNSTEMIS analyses were prepared for each calendar year of construction activity in each construction zone for Alternatives A and C, and for Alternative B.

Construction activities for Alternatives A and C were evaluated in terms of the following construction phases:

- Mobilization,
- Remove cantilevered sidewalk,
- Install soldier piles and shored excavation work,
- Clear riprap for temporary containment wall,
- Install temporary containment wall,
- Excavate and install lagging for precast platform,
- Install precast platform,
- Install Soilcrete seal columns,
- Install soil anchors,
- Set precast facia wall panels,
- Remove temporary containment wall,
- Jet grouting,
- Temporarily restore Alaskan Way surface street for summer shutdown period,
- Place anchor slabs,
- Remove spoils pit and backfill, and
- Replace cantilevered slab and restore Alaskan Way surface street.

Habitat improvements would occur as part of the various construction phases that involve in-water work. Restoration of Alaskan Way at the end of construction in Zones 1 and 2 would include the addition of a second northbound traffic lane between Madison Street and S. Washington Street.

Minor variations in the sequencing of construction phases would occur in different seawall zones depending on the schedule for starting construction and the timing of the summer shutdown periods, as well as on minor design variations between Alternatives A and C. Mobilization activities would occur primarily at staging areas rather than in the seawall construction zone. Consequently, some mobilization activities could occur during the summer construction shutdown period.

The assumed schedule for the purposes of air quality modeling for seawall construction under both Alternatives A and C is:

- Zone 4: July 2013 into February 2015,
- Zone 3: September 2013 into February 2015,
- Zone 2: February 2015 into May 2016,
- Zone 1: September 2015 into January 2016,
- Zone 6: July 2017 into October 2019, and
- Zone 5: October 2019 into February 2022.

Note: These results were based on initial conservative construction durations. Recently, possible shorter construction durations have been identified. However, the shorter construction durations would not have an appreciable effect on emissions or air quality

Construction activities for Alternative B were evaluated in terms of the following construction phases:

- Mobilization,
- Remove cantilevered sidewalk,
- Install face panel piles and shored excavation work,
- Clear riprap for temporary containment wall,
- Remove Ekki wood,
- Excavate and install lagging for precast platform,
- Install soil anchors,
- Install containment wall at master piles,
- Install timber braces to soldier pile wall,
- Backfill, cut, and remove tie rods,
- Temporarily restore Alaskan Way surface street for summer shutdown period,
- Install soldier-pile wall frame,
- Drill secant piles,
- Replace cantilevered slab and restore Alaskan Way surface street, and
- Construct waterfront and habitat improvements.

Minor variations in the sequencing of construction phases would occur in different seawall zones depending on the schedule for starting construction and the timing of the summer shutdown periods. Mobilization activities would occur primarily at staging areas rather than in the seawall construction zone. Consequently, some mobilization activities could occur during the summer construction shutdown period.

The assumed schedule for the purposes of air quality modeling for seawall construction under Alternative B is:

- Zone 4: July 2013 into May 2015,
- Zone 3: August 2015 into June 2017,
- Zone 2: August 2017 into March 2019,
- Zone 1: November 2017 into April 2018,
- Zone 6: July 2019 into October 2021, and
- Zone 5: October 2021 into June 2024.

Note: These results were based on initial conservative construction durations. Recently, possible shorter construction durations have been identified. However, the shorter construction durations would not have an appreciable effect on emissions or air quality

3.2 TRAFFIC EMISSIONS ANALYSIS METHODOLOGY

The CNSTEMIS spreadsheet model results provided estimates of construction truck trips and construction worker commute trips. Construction truck trip estimates were based on a combination of data provided by BergerABAM, estimated equipment transporter requirements, and other adjustments as deemed appropriate. Construction worker numbers were estimated as a combination of heavy equipment operators, supervisors, and other construction workers. The construction worker commute trip estimate incorporated an assumption that 75 percent of construction workers would arrive and depart in single-occupant vehicles, and that 25 percent would arrive and depart in two-occupant carpools. To retain a conservative analysis basis, no further adjustments were made for potential use of public transit services.

Emissions from construction-related traffic were estimated using USEPA's MOBILE6.2 vehicle emission rate model (USEPA 2003). Separate vehicle emission rate estimates were developed for construction truck traffic and construction worker commute traffic for each year from 2013 through 2024. The MOBILE6.2 model default assumptions for vehicle type mixes, vehicle speed mixes, and VMT by roadway type were considered reasonable for purposes of this analysis. Temperature and humidity parameter estimates were developed as input to the MOBILE6.2 model using data from Boeing Field (Western Regional Climate Center 2009). BergerABAM provided estimated construction truck trip distances by truck type for each phase of construction activity. One-way trip distance estimates ranged from about 12 miles to 40 miles for different types of truck trips. An average one-way trip distance of 15 miles was used for construction worker commute travel.

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CHAPTER 4. AFFECTED ENVIRONMENT

4.1 AMBIENT AIR QUALITY CONDITIONS

Ecology and PSCAA operate a network of ambient air quality monitoring stations in the Seattle area. The monitoring station closest to the EBSP is located at Olive Way and Boren Avenue. Other monitoring stations relatively close to the EBSP study area are located on 15th Avenue South near Beacon Reservoir (the Beacon Hill monitoring station), 4752 East Marginal Way South (the Duwamish monitoring station), and 400 East Garfield Street (the Queen Ann Hill monitoring station). All of these monitoring stations currently measure $PM_{2.5}$ concentrations. The Beacon Hill monitoring station also measures concentrations of carbon monoxide, ozone, nitrogen oxides, and sulfur dioxide. PSCAA stopped monitoring PM_{10} concentrations after 2006, but the Duwamish monitoring station measured both PM_{10} and $PM_{2.5}$ prior to that. PSCAA publishes annual reports of air quality monitoring data, with the most recent report covering data from 2008. Ambient air quality data collected between 2003 and 2008 from the four monitoring stations noted above are summarized in Table 4-1. None of the data from those monitoring stations show any violations of current federal ambient air quality standards. Maximum pollutant concentrations measured during this period were:

- Carbon monoxide: a peak 1-hour concentration of 2.8 parts per million (ppm) in 2003 and a peak 8-hour average concentration of 1.9 ppm in both 2003 and 2005, all at the Beacon Hill monitoring station. Relevant federal and state air quality standards are 35 ppm for a 1-hour concentration and 9 ppm for an 8-hour average concentration.
- Ozone: a peak 8-hour average concentration of 0.059 ppm in 2004 at the Beacon Hill monitoring station. The relevant federal and state air quality standard is 0.075 ppm as a three-year average of annual 98th percentile data values.
- Nitrogen oxides: a peak 1-hour concentration of 0.08 ppm in 2007 and a peak annual average concentration of 0.019 ppm in 2003 at the Beacon Hill monitoring station. Relevant federal air quality standards are 0.10 ppm for a 1-hour concentration and 0.053 ppm for an annual average concentration. The relevant state air quality standards are 0.05 ppm for an annual average concentration.
- Sulfur dioxide: a peak 24-hour concentration of 0.021 ppm in 2004 and an annual average concentration of 0.004 ppm in both 2005 and 2006 at the Beacon Hill monitoring station. The relevant federal air quality standards are 0.14 ppm for a 24-hour concentration and 0.03 ppm for an annual average concentration. The relevant state air quality standards are 0.10 ppm for a 24-hour concentration and 0.02 ppm for an annual average concentration.
- PM_{10}: a peak 24-hour concentration of 104 micrograms per cubic meter measured in 2004 at the Duwamish monitoring station and a 98th percentile value for 24-hour concentrations of 69 micrograms per cubic meter measured in 2003 at the Duwamish monitoring station. The relevant federal and state air quality standards are 150 micrograms per cubic meter as a 98th percentile value of 24-hour concentrations.
- $PM_{2.5}$: a peak 24-hour concentration of 44 micrograms per cubic meter measured in 2004 at the Olive Way and Boren Avenue monitoring station; a 98th percentile value of 24-hour concentrations of 36 micrograms per cubic meter measured in 2004 at the Queen Ann Hill monitoring station; and an annual average concentration of 12.1 micrograms per cubic

meter measured in 2006 at the Duwamish monitoring station. The relevant federal and state air quality standards are 35 micrograms per cubic meter as a three-year average of 98th percentile 24-hour values, and 15 micrograms per cubic meter as an annual average concentration. While 2004 data from the Queen Ann Hill monitoring station had a 98th percentile value above 35 micrograms per cubic meter, the highest three-year average of such values at this location was 26 micrograms per cubic meter. Consequently, there have been no violations of the federal or state 24-hour $PM_{2.5}$ standards at the monitoring stations near the EBSP study area.

The urbanized western portion of King County is designated as a carbon monoxide maintenance area. Prior to 2008, most of King County was also designated as a maintenance area for the federal 1-hour ozone standard. The federal 1-hour ozone standard was replaced with the current 8-hour standard in 2008. The change to the 8-hour ozone standard eliminated nonattainment and maintenance area designations for the 1-hour ozone standard as they related to Clean Air Act conformity requirements. King County is currently considered to be unclassified or in attainment for all other federal ambient air quality standards. The existing carbon monoxide maintenance area designation for the urbanized western portion of King County means that the EBSP is subject to the USEPA general conformity regulations.

4.2 EMISSIONS IN KING COUNTY

The most recent emission inventory developed by PSCAA (2008a) identifies estimated 2005 emissions of criteria pollutants in King County as:

- 80,173 tons per year of reactive organic gases (an ozone precursor),
- 74,840 tons per year of nitrogen oxides (ozone and nitrogen dioxide precursors),
- 573,790 tons per year of carbon monoxide,
- 4,290 tons per year of sulfur oxides (sulfur dioxide precursors), and
- 8,230 tons per year of $PM_{2.5}$.

Table 4-2 provides a more detailed summary of the King County 2005 emission inventory. The PSCAA emission inventory is in the process of being updated; however, the release of the update is unknown. Different types of emission sources are the dominant contributors for different pollutants. On-road vehicle traffic is a dominant contributor for emissions of ozone precursors (reactive organic gases and nitrogen oxides) and carbon monoxide. Aircraft, rail, and maritime equipment are the dominant sources of sulfur oxide emissions. Fugitive dust (from roadways, construction sites, and other sources) and indoor wood burning are the largest contributors to $PM_{2.5}$ emissions.

TABLE 4-1. AMBIENT AIR QUALITY DATA FOR THE ELLIOTT BAY SEAWALL PROJECT STUDY AREA

Monitoring Station	Pollutant and units	Averaging Time	2003	2004	2005	2006	2007	2008
Beacon Hill 15th Avenue S. and Charlestown Street	CO, ppm	1 hour	2.8	2.7	2.7	2.3	1.4	1.6
		8 hours	1.9	1.8	1.9	1.5	1.0	1.0
	NO_x, ppm	1 hour	0.055	0.059	0.050	0.033	0.051	0.052
		Annual average	0.076	0.073	0.078	0.078	0.080	0.065
	O_3, ppm	8 hours	0.019	0.018	0.018	0.018	0.015	0.015
	SO_2, ppm	24 hours	0.011	0.021	0.020	0.020	0.007	0.011
		Annual average	0.002	0.003	0.004	0.004	0.001	0.001
	$PM_{2.5}$, micrograms per cubic meter	24 hours	25	33	28	No data	No data	21
		98th percentile of 24 hour data	21.0	26.0	20.0	No data	No data	15.2
		Annual average	7.9	8.5	7.9	No data	No data	5.7
Duwamish 4752 E. Marginal Way S.	PM_{10}, micrograms per cubic meter	24 hours	69	104	91	71	No data	No data
		99th percentile of 24 hour data	69	62	63	54	No data	No data
	$PM_{2.5}$, micrograms per cubic meter	24 hours	37	43	31	35	37	34
		98th percentile of 24 hour data	28.0	29.0	30.0	33.0	26.0	24.0
		Annual average	10.6	11.6	11.6	12.1	9.6	9.0
Olive Way and Boren Avenue	$PM_{2.5}$, micrograms per cubic meter	24 hours	34	44	32	29	26	23
		98th percentile of 24 hour data	23.0	33.0	23.0	20.0	20.4	14.8
		Annual average	7.5	9.8	7.8	6.7	6.9	5.9

Monitoring Station	Pollutant and units	Averaging Time	2003	2004	2005	2006	2007	2008
Queen Ann Hill 400 E. Garfield Street	$PM_{2.5}$, micrograms per cubic meter	24 hours	31	36	32	31	30	24
		98th percentile of 24 hour data	21.0	36.0	21.0	20.0	21.4	14.7
		Annual average	7.3	7.8	7.0	7.4	6.5	5.2

Sources: Puget Sound Clean Air Agency (2004, 2005, 2006, 2007, 2008b, 2009)

Notes: CO – carbon monoxide (1 hour standard = 35 ppm; 8-hour standard = 9 ppm)
NO_x – oxides of nitrogen (1 hour standard = 0.1 ppm; annual average standard = 0.053 ppm)
O_3 – ozone (8-hour standard = 0.075 ppm)
SO_2 – sulfur dioxide (24 hour standard = 0.14 ppm; annual average standard = 0.03 ppm)
PM_{10} – inhalable particulate matter (24 hour standard = 150 micrograms per cubic meter)
$PM_{2.5}$ – fine particulate matter (24 hour standard = 35 micrograms per cubic meter; annual average standard = 15 micrograms per cubic meter)
ppm – parts per million by volume

TABLE 4-2. 2005 EMISSION INVENTORY FOR KING COUNTY

Emission Source Category	Estimated 2005 Emissions, Tons per Year				
	ROG	NOx	CO	SOx	$PM_{2.5}$
On-Road vehicle traffic	30,040	45,860	371,220	920	820
Aircraft, rail, and maritime equipment	1,870	8,940	17,000	2,030	370
Non-road equipment	9,050	10,020	152,980	250	780
Recreational boats	2,070	500	9,830	30	10
Electricity production sources	10	440	120	20	10
Other large stationary sources	2,010	5,110	2,950	680	230
Area source fossil fuel use	160	3,643	1,760	310	260
Indoor wood burning	8,000	280	15,120	40	1,990
Open burning	400	70	2,830	20	560
Wastewater treatment	10	0	0	0	0
Road dust and other fugitive dust	0	0	0	0	2,290
Commercial charbroiling	130	0	0	0	930
Surface coatings (architectural, industrial, other)	8,990	0	0	0	0
Petroleum products distribution	3,000	0	0	0	0
Consumer and household items	7,090	0	0	0	0
Other evaporation sources	3,560	0	0	0	0
King County Totals	**80,173**	**74,840**	**573,790**	**4,290**	**8,230**

Source: Puget Sound Clean Air Agency 2008a

Notes: ROG – reactive organic gases; NO_x – oxides of nitrogen; CO – carbon monoxide; SO_x – sulfur oxides
$PM_{2.5}$ – fine particulate matter
Column values do not sum to the totals due to rounding of individual source category entries.

CHAPTER 5. CONSTRUCTION EFFECTS AND MITIGATION

The analysis of air quality effects associated with the EBSP has focused on criteria pollutant emissions from construction activities and associated construction-related vehicle traffic. This chapter details the analysis used to determine that maximum annual emissions associated with construction of Alternatives A, B, and C would represent a fraction of one percent of the King County 2005 emission inventory for the corresponding pollutant. Based on the magnitude of estimated construction emissions in comparison to Clean Air Act conformity de minimis thresholds and the magnitude of current King County emissions, the EBSP would have minimal emissions under any of the proposed alternatives.

5.1 CONSTRUCTION AIR QUALITY IMPACTS OF ALTERNATIVES A AND C

Annual on-site construction emissions for Alternatives A and C are summarized in Table 5-1. As previously noted, these two alternatives have the same proposed construction schedule and are assumed to require the same amount of construction workers, construction truck trips, and construction worker commute trips; therefore, they are assumed to be indistinguishable with regard to air quality impacts. Both Alternatives A and C would have construction site emission quantities that vary by calendar year. For purposes of air quality modeling, under either alternative, construction activities for the Central Seawall portion of the EBSP would occur from 2013 through 2016. Construction activities for the North Seawall portion of the EBSP would occur from 2017 through 2022. The highest annual on-site construction emissions would occur in 2014 (for most pollutants) or 2015 (for PM_{10} and $PM_{2.5}$) for both Alternatives A and C. Annual on-site construction emissions from 2016 through 2022 would be significantly less than those from 2013 through 2015. These dates and results were based on initial conservative construction durations. Recently, possible shorter construction durations have been identified. However, the shorter construction durations would not have an appreciable effect on emissions or air quality. Maximum annual on-site construction emissions would be:

- 10.78 tons of reactive organic gas emissions,
- 19.05 tons or nitrogen oxide emissions,
- 82.28 tons of carbon monoxide emissions,
- 4.33 tons of sulfur oxide emissions,
- 3.52 tons of PM_{10} emissions,
- 2.08 tons of $PM_{2.5}$ emissions, and
- 1.83 tons of diesel particulate matter emissions.

TABLE 5-1. CONSTRUCTION SITE EMISSIONS FOR ALTERNATIVE A AND C BY CALENDAR YEAR

Calendar Year	On-Site Construction Emissions, Tons per Year						
	ROG	NOx	CO	SOx	PM_{10}	$PM_{2.5}$	DPM
2013	6.66	12.00	54.15	2.52	3.30	1.91	1.25
2014	10.78	19.05	82.28	4.33	2.41	1.95	1.83
2015	9.17	14.13	63.78	3.34	3.52	2.08	1.38
2016	3.42	5.32	22.04	1.38	0.67	0.55	0.51
2017	3.25	3.49	17.67	1.08	2.14	0.96	0.32
2018	4.45	4.68	21.82	1.68	0.56	0.44	0.37
2019	5.76	5.82	25.53	1.97	0.94	0.64	0.47
2020	4.16	3.92	16.05	1.17	0.45	0.34	0.27
2021	4.14	3.93	15.08	1.19	0.70	0.43	0.27
2022	0.81	0.80	2.75	0.19	0.13	0.09	0.07
Totals	**52.61**	**73.15**	**321.16**	**18.87**	**14.82**	**9.40**	**6.74**

Notes: ROG – reactive organic gases; NOx – oxides of nitrogen; CO – carbon monoxide; SOx – sulfur oxides
PM_{10} – inhalable particulate matter; $PM_{2.5}$ – fine particulate matter; DPM – diesel particulate matter
These results were based on initial conservative construction durations. Recently, possible shorter construction durations have been identified. However, the shorter construction durations would not have an appreciable effect on emissions or air quality.

Annual emissions associated with construction-related traffic would be much less than corresponding on-site construction activity emissions from either Alternative A or C. The highest annual off-site emissions from construction-related traffic would occur in 2014 (for most pollutants) or 2015 (for sulfur oxides). Emissions from construction-related traffic are summarized in Table 5-2. Maximum annual on-site construction emissions resulting from either Alternative A or C would be:

- 0.59 tons of reactive organic gas emissions,
- 5.06 tons or nitrogen oxide emissions,
- 4.23 tons of carbon monoxide emissions,
- 0.02 tons of sulfur oxide emissions,
- 0.15 tons of PM_{10} emissions,
- 0.11 tons of $PM_{2.5}$ emissions, and
- 0.10 tons of diesel particulate matter emissions.

TABLE 5-2. CONSTRUCTION-RELATED TRAFFIC EMISSIONS FOR ALTERNATIVES A AND C BY CALENDAR YEAR

Calendar Year	Off-Site Construction-Related Traffic Emissions, Tons per Year						
	ROG	NOx	CO	SOx	PM_{10}	$PM_{2.5}$	DPM
2013	0.362	3.331	2.781	0.011	0.101	0.075	0.071
2014	0.585	5.056	4.226	0.019	0.154	0.109	0.100
2015	0.572	4.544	4.109	0.020	0.138	0.094	0.082
2016	0.200	1.445	1.427	0.007	0.046	0.030	0.026
2017	0.173	1.055	1.354	0.006	0.036	0.023	0.019
2018	0.257	1.483	1.741	0.010	0.053	0.032	0.025
2019	0.336	1.730	2.331	0.013	0.067	0.039	0.029
2020	0.240	1.168	1.531	0.010	0.049	0.028	0.020
2021	0.154	0.568	1.421	0.006	0.026	0.014	0.010
2022	0.068	0.273	0.425	0.003	0.013	0.007	0.005
Totals	**2.947**	**20.652**	**21.346**	**0.107**	**0.683**	**0.451**	**0.386**

Notes: Emissions estimates presented in this table represent combined construction-related truck traffic emissions and construction worker commute traffic emissions.
ROG – reactive organic gases; NOx – oxides of nitrogen; CO – carbon monoxide; SOx – sulfur oxides
PM_{10} – inhalable particulate matter; $PM_{2.5}$ – fine particulate matter; DPM – diesel particulate matter
These results were based on initial conservative construction durations. Recently, possible shorter construction durations have been identified. However, the shorter construction durations would not have an appreciable effect on emissions or air quality.

Table 5-3 summarizes overall annual construction emissions from the EBSP under Build Alternatives A and C. The emission estimates presented in Table 5-3 include both on-site construction emissions and off-site emissions from construction-related traffic. The highest overall annual construction emissions under either alternative would occur in 2014 (for most pollutants) or 2015 (for PM_{10} and $PM_{2.5}$). Overall annual construction emissions from 2016 through 2022 would be significantly less than those from 2013 through 2015. These dates and results were based on initial conservative construction durations. Recently, possible shorter construction durations have been identified. However, the shorter construction durations would not have an appreciable effect on emissions or air quality. Maximum annual overall construction emissions would be:

- 11.37 tons of reactive organic gas emissions,
- 24.11 tons or nitrogen oxide emissions,
- 86.51 tons of carbon monoxide emissions,
- 4.35 tons of sulfur oxide emissions,
- 3.66 tons of PM_{10} emissions,
- 2.17 tons of $PM_{2.5}$ emissions, and
- 1.83 tons of diesel particulate matter emissions.

TABLE 5-3. OVERALL CONSTRUCTION-RELATED EMISSIONS FOR ALTERNATIVES A AND C BY CALENDAR YEAR

Calendar Year	Combined On-site and Off-site Construction-Related Emissions, Tons per Year						
	ROG	NOx	CO	SOx	PM_{10}	$PM_{2.5}$	DPM
2013	7.02	15.34	56.93	2.54	3.40	1.98	1.32
2014	11.37	24.11	86.51	4.35	2.56	2.06	1.93
2015	9.74	18.67	67.89	3.36	3.66	2.17	1.46
2016	3.62	6.76	23.47	1.39	0.72	0.58	0.53
2017	3.43	4.54	19.02	1.09	2.18	0.98	0.34
2018	4.70	6.16	23.56	1.69	0.62	0.47	0.40
2019	6.10	7.55	27.86	1.98	1.01	0.68	0.50
2020	4.40	5.09	17.58	1.18	0.50	0.37	0.29
2021	4.30	4.50	16.50	1.19	0.72	0.45	0.28
2022	0.88	1.08	3.18	0.20	0.14	0.10	0.08
Totals	**55.55**	**93.80**	**342.51**	**18.98**	**15.50**	**9.85**	**7.13**

Notes: Emissions presented in this table include those from on-site construction activity, off-site construction-related truck traffic, and off-site construction worker commute traffic.
ROG – reactive organic gases; NOx – oxides of nitrogen; CO – carbon monoxide; SOx – sulfur oxides
PM_{10} – inhalable particulate matter; $PM_{2.5}$ – fine particulate matter; DPM – diesel particulate matter
These results were based on initial conservative construction durations. Recently, possible shorter construction durations have been identified. However, the shorter construction durations would not have an appreciable effect on emissions or air quality.

Maximum annual carbon monoxide emissions would occur in 2014 for Alternatives A and C. Those emissions (86.51 tons) would be less than the Clean Air Act conformity threshold of 100 tons per year. Consequently, Alternatives A and C would not require a formal Clean Air Act conformity determination.

A more detailed summary of emissions by construction zone and calendar year is provided in Table A-1 (Appendix A). Additional documentation of the construction analysis for Alternatives A and C is provided in Tables A-2 through A-5 (Appendix A). Tables A-2 and A-3 summarize construction activity and off-site construction traffic data by zone and calendar year. Tables 13 and 14 provide overall calendar year summaries of construction activity and construction-related traffic. Appendix C notes that full electronic file versions of the CNSTEMIS and MOBILE6.2 analyses for Alternatives A and C are available on request.

While carbon monoxide is the only criteria pollutant subject to formal Clean Air Act conformity analysis in the EBSP study area, Clean Air Act conformity de minimis thresholds applicable to maintenance areas for other criteria pollutants provide an indication of the relative significance of those emissions. Clean Air Act conformity de minimis thresholds per 40 CFR 93.153 for other criteria pollutants are generally 100 tons per year per pollutant. As indicated in Table 5-3, maximum annual emissions of these other pollutants would be well below that threshold under Alternatives A and C.

An additional perspective on the relative significance of construction emissions under Alternatives A and C is provided by comparison to the 2005 emissions inventory for King County (summarized previously). Maximum annual emissions associated with construction of EBSP Alternative A represent:

- 0.014 percent of the 2005 emission inventory value for reactive organic compounds;
- 0.032 percent of the 2005 emission inventory value for nitrogen oxides;
- 0.015 percent of the 2005 emission inventory value for carbon monoxide;
- 0.101 percent of the 2005 emission inventory value for sulfur oxides; and
- 0.026 percent of the 2005 emission inventory value for $PM_{2.5}$.

Maximum annual emissions associated with construction of EBSP Alternatives A and C represent a fraction of one percent of the King County 2005 emission inventory for the corresponding pollutant. Based on the magnitude of estimated construction emissions in comparison to Clean Air Act conformity de minimis thresholds and the magnitude of current King County emissions, neither Alternative A nor Alternative C would have a significant impact on air quality conditions in the Seattle area.

5.2 CONSTRUCTION AIR QUALITY IMPACTS OF ALTERNATIVE B

Annual on-site construction emissions for Alternative B are summarized in Table 5-4. Alternative B would have construction site emission quantities that vary by calendar year. Construction activities for the Central Seawall portion of the EBSP would occur from 2013 through 2019. Construction activities for the North Seawall portion of the EBSP would occur from 2019 through 2024. The highest annual on-site construction emissions from Alternative B would occur in 2014 (for most pollutants), 2013 (for PM_{10} and $PM_{2.5}$), or 2015 (for reactive organic gases). These dates and results were based on initial conservative construction durations. Recently, possible shorter construction durations have been identified. However, the shorter construction durations would not have an appreciable effect on emissions or air quality. Maximum annual on-site construction emissions would be:

- 6.20 tons of reactive organic gas emissions,
- 12.47 tons or nitrogen oxide emissions,
- 49.42 tons of carbon monoxide emissions,
- 3.04 tons of sulfur oxide emissions,
- 2.62 tons of PM_{10} emissions,
- 1.44 tons of $PM_{2.5}$ emissions, and
- 1.30 tons of diesel particulate matter emissions.

TABLE 5-4. CONSTRUCTION SITE EMISSIONS FOR ALTERNATIVE B BY CALENDAR YEAR

Calendar Year	On-Site Construction Emissions, Tons per Year						
	ROG	NOx	CO	SOx	PM_{10}	$PM_{2.5}$	DPM
2013	4.78	8.09	39.20	1.79	2.62	1.44	0.86
2014	6.17	12.47	49.42	3.04	1.49	1.30	1.30
2015	6.20	9.30	42.92	2.22	1.48	1.08	0.92
2016	4.39	7.45	30.50	2.11	0.86	0.75	0.73
2017	5.92	7.04	32.95	2.09	1.37	0.89	0.64
2018	5.77	6.67	30.28	2.45	0.74	0.64	0.59
2019	4.73	4.50	21.16	1.63	2.34	1.09	0.41
2020	4.22	3.89	15.72	1.14	0.41	0.33	0.27
2021	4.76	4.70	19.03	1.47	0.75	0.53	0.40
2022	3.92	3.39	13.10	0.90	0.35	0.27	0.21
2023	3.69	3.47	13.94	0.84	0.37	0.29	0.23
2024	2.15	2.17	8.92	0.46	0.24	0.20	0.18
Totals	**56.71**	**73.13**	**317.16**	**20.15**	**13.02**	**8.80**	**6.73**

Notes: ROG – reactive organic gases; NOx – oxides of nitrogen; CO – carbon monoxide; SOx – sulfur oxides
PM_{10} – inhalable particulate matter; $PM_{2.5}$ – fine particulate matter; DPM – diesel particulate matter
These results were based on initial conservative construction durations. Recently, possible shorter construction durations have been identified. However, the shorter construction durations would not have an appreciable effect on emissions or air quality.

Annual emissions associated with construction-related traffic from Alternative B would be much less than corresponding on-site construction activity emissions. The highest annual off-site emissions from construction-related traffic would occur in 2014 (for most pollutants) or 2021 (for sulfur oxides). Emissions from construction-related traffic are summarized in Table 5-5. Maximum annual on-site construction emissions would be:

- 0.41 tons of reactive organic gas emissions,
- 3.56 tons or nitrogen oxide emissions,
- 2.98 tons of carbon monoxide emissions,
- 0.01 tons of sulfur oxide emissions,
- 0.11 tons of PM_{10} emissions,
- 0.08 tons of $PM_{2.5}$ emissions, and
- 0.07 tons of diesel particulate matter emissions.

TABLE 5-5. CONSTRUCTION-RELATED TRAFFIC EMISSIONS FOR ALTERNATIVE B BY CALENDAR YEAR

Calendar Year	Off-Site Construction-Related Traffic Emissions, Tons per Year						
	ROG	NOx	CO	SOx	PM_{10}	$PM_{2.5}$	DPM
2013	0.245	2.157	1.985	0.007	0.066	0.048	0.045
2014	0.412	3.562	2.982	0.014	0.108	0.077	0.070
2015	0.277	1.942	2.336	0.009	0.059	0.040	0.035
2016	0.292	2.106	2.098	0.011	0.067	0.044	0.038
2017	0.311	1.899	2.411	0.011	0.065	0.041	0.034
2018	0.385	2.172	2.723	0.015	0.078	0.047	0.036
2019	0.315	1.577	2.288	0.012	0.061	0.036	0.027
2020	0.186	0.821	1.444	0.007	0.034	0.020	0.014
2021	0.350	1.539	2.296	0.015	0.069	0.039	0.027
2022	0.177	0.654	1.396	0.007	0.032	0.017	0.012
2023	0.224	0.785	1.558	0.010	0.042	0.022	0.015
2024	0.206	0.688	1.266	0.010	0.040	0.021	0.013
Totals	**3.380**	**19.902**	**24.782**	**0.128**	**0.722**	**0.452**	**0.365**

Notes: Emissions estimates presented in this table represent combined construction-related truck traffic emissions and construction worker commute traffic emissions.
ROG – reactive organic gases; NOx – oxides of nitrogen; CO – carbon monoxide; SOx – sulfur oxides
PM_{10} – inhalable particulate matter; $PM_{2.5}$ – fine particulate matter; DPM – diesel particulate matter
These results were based on initial conservative construction durations. Recently, possible shorter construction durations have been identified. However, the shorter construction durations would not have an appreciable effect on emissions or air quality.

Table 5-6 summarizes overall annual construction emissions from the EBSP under Alternative B. The emission estimates presented in Table 5-6 include both on-site construction emissions and off-site emissions from construction-related traffic. Cumulative emissions over the full duration of seawall construction under Alternative B would be very similar to the cumulative emissions for Alternatives A and C. Due to a combination of a longer construction period and different construction techniques, Alternative B would have lower maximum annual construction emissions than Alternatives A and C. The highest overall annual construction emissions under Alternative B would occur in 2014 (for most pollutants) or 2013 (for PM_{10} and $PM_{2.5}$). Maximum annual overall construction emissions would be:

- 6.58 tons of reactive organic gas emissions,
- 16.03 tons or nitrogen oxide emissions,
- 52.40 tons of carbon monoxide emissions,
- 3.05 tons of sulfur oxide emissions,
- 2.69 tons of PM_{10} emissions,
- 1.49 tons of $PM_{2.5}$ emissions, and
- 1.37 tons of diesel particulate matter emissions.

TABLE 5-6. OVERALL CONSTRUCTION-RELATED EMISSIONS FOR ALTERNATIVE B BY CALENDAR YEAR

Calendar Year	Combined On-site and Off-site Construction-Related Emissions, Tons per Year						
	ROG	NOx	CO	SOx	PM_{10}	$PM_{2.5}$	DPM
2013	5.02	10.25	41.19	1.80	2.69	1.49	0.91
2014	6.58	16.03	52.40	3.05	1.59	1.37	1.37
2015	6.48	11.24	45.26	2.23	1.54	1.12	0.95
2016	4.68	9.55	32.60	2.12	0.93	0.79	0.77
2017	6.23	8.94	35.36	2.10	1.44	0.93	0.68
2018	6.15	8.84	33.01	2.47	0.82	0.69	0.63
2019	5.05	6.08	23.45	1.64	2.40	1.12	0.44
2020	4.41	4.71	17.16	1.15	0.45	0.35	0.28
2021	5.11	6.24	21.32	1.48	0.82	0.56	0.43
2022	4.10	4.04	14.50	0.91	0.38	0.29	0.22
2023	3.91	4.26	15.50	0.85	0.41	0.31	0.24
2024	2.36	2.86	10.18	0.47	0.28	0.22	0.19
Totals	**60.09**	**93.03**	**341.94**	**20.27**	**13.74**	**9.25**	**7.09**

Notes: Emissions presented in this table include those from on-site construction activity, off-site construction-related truck traffic, and off-site construction worker commute traffic.
ROG – reactive organic gases; NOx – oxides of nitrogen; CO – carbon monoxide; SOx – sulfur oxides
PM_{10} – inhalable particulate matter; $PM_{2.5}$ – fine particulate matter; DPM – diesel particulate matter
These results were based on initial conservative construction durations. Recently, possible shorter construction durations have been identified. However, the shorter construction durations would not have an appreciable effect on emissions or air quality.

Maximum annual carbon monoxide emissions would occur in 2014. Those emissions (52.40 tons) would be less than the Clean Air Act conformity threshold of 100 tons per year. Consequently, Alternative B of the EBSP would not require a formal Clean Air Act conformity determination.

A more detailed summary of emissions by construction zone and calendar year is provided in Table A-6 (Appendix A). Additional documentation of the construction analysis for Alternative B is provided in A-7 through A-19 (Appendix A). Tables A-7 and A-8 summarize construction activity and off-site construction traffic data by zone and calendar year. Tables A-9 and A-10 provide overall calendar year summaries of construction activity and construction-related traffic. Appendix C notes that full electronic file versions of the CNSTEMIS and MOBILE6.2 analyses for Alternative B are available on request.

While carbon monoxide is the only criteria pollutant subject to formal Clean Air Act conformity analysis in the EBSP study area, Clean Air Act conformity de minimis thresholds applicable to maintenance areas for other criteria pollutants provide an indication of the relative significance of those emissions. Clean Air Act conformity de minimis thresholds for other criteria pollutants are generally 100 tons per year per pollutant. As indicated in Table 5-6, maximum annual emissions of these other pollutants would be well below that threshold under Alternative B.

An additional perspective on the relative significance of construction emissions under Alternative B is provided by comparison to the 2005 emissions inventory for King County (summarized previously). Maximum annual emissions associated with construction of EBSP Alternative B represent:

- 0.008 percent of the 2005 emission inventory value for reactive organic compounds;
- 0.021 percent of the 2005 emission inventory value for nitrogen oxides;
- 0.009 percent of the 2005 emission inventory value for carbon monoxide;
- 0.071 percent of the 2005 emission inventory value for sulfur oxides; and
- 0.018 percent of the 2005 emission inventory value for $PM_{2.5}$.

Maximum annual emissions associated with construction of EBSP Alternative B represent a small fraction of one percent of the King County 2005 emission inventory for the corresponding pollutant. Based on the magnitude of estimated construction emissions in comparison to Clean Air Act conformity de minimis thresholds and the magnitude of current King County emissions, Alternative B would not have a significant impact on air quality conditions in the Seattle area.

5.3 AIR QUALITY IMPACTS OF THE 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 effects and continued maintenance likely to occur for the No Action Alternative.

5.4 INDIRECT AND SECONDARY AIR QUALITY EFFECTS

Indirect effects on air quality associated with the construction of any of the three build alternatives are not anticipated. Indirect effects are those that are reasonably foreseeable and caused by one or more of the build alternatives, but would occur at a different time or place. Construction emissions are localized and are not anticipated to occur at a different time or place.

5.5 AIR QUALITY MITIGATION MEASURES

Normal fugitive dust control practices (primarily periodic sprinkling of exposed open areas with water trucks) have been assumed in the analysis of construction emissions for Alternatives A, B, and C. While weather conditions will periodically eliminate the need for active dust control through water sprinkling, the CNSTEMIS modeling analyses assumed daily sprinkling of exposed soil areas and daily street sweeper cleanup of dirt and mud tracked onto local roadways. More frequent sprinkling and street sweeping was assumed during temporary and final restorations of the Alaskan Way surface street. Because Alternatives A, B, and C do not have any significant air quality impacts, no additional mitigation measures are necessary.

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CHAPTER 6. OPERATIONAL EFFECTS AND MITIGATION

Operational emissions for any EBSP build alternative would be limited to vehicle and equipment emissions associated with periodic seawall inspection and maintenance activities along with any project-induced increases in transportation emissions. Annual emissions from inspection or seawall maintenance activities under any of the three build alternatives would be expected to be much lower than any of the annual emission levels associated with seawall construction. These annual operational emissions would be minimal, and would not have a significant impact on air quality conditions in the Seattle area. With a new seawall, repairs should be less frequent than under existing conditions, and thus should result in lower operational emissions than the No Action Alternative.

6.1 AIR QUALITY IMPACTS OF THE NO ACTION ALTERNATIVE

The No Action Alternative would require periodic seawall inspection and maintenance activities. Those activities would result in variable amounts of annual emissions from vehicle and equipment use.

For purposes of the EBSP Draft EIS, three No Action scenarios are proposed for evaluation, each of which describes the conditions and present a range of impacts resulting from a without project alternative for the EBSP. These scenarios include Minimal Damage, Loss of Functionality, and Collapse of the Seawall. Each No Action scenario carries operational implications for the future maintenance of the existing seawall. The following items are assumed to be part of the without project condition:

- The City would continue to repair minimal damage failures unless three or more sections fail in a single year, at which point the wall is assumed to have lost its functionality;
- The City of Seattle would stabilize the shoreline following wall collapse as soon as possible to minimize erosion impacts. This stabilization would prevent the permanent loss of landward structures and the BNSF rail line to erosion;
- Following loss of wall functionality, the City would construct a trestle bridge to maintain access to the Ferry Terminal and Fire Station No. 5; and
- Following loss of wall functionality, the City would relocate utilities beneath Alaskan Way.

The No Action Alternative is projected over a 50-year period for purposes of environmental analysis. Given the condition of the seawall, it is likely that the seawall would continue to deteriorate and that damage would occur during this period. Table 6-1 describes the maintenance-type activities which could have an impact on air quality in the project area and are likely to occur based on the three No Action scenarios.

TABLE 6-1. OPERATIONAL ACTIVITIES BY NO ACTION SCENARIO

Operational Activity	Minimal Damage	Loss of Functionality	Collapse
Annual operations and maintenance	Y	N	N
Tidal repairs	Y	N	N
Seismic repairs	Y	N	N
Transportation impacts	N	Y	Y
Utility impacts	N	Y	Y
Damages to Alaskan Way Surface Street	N	Y	Y
Temporary reroute of Sounder Commuter Rail (Seattle–Everett)	N	N	Y
Temporary reroute of Amtrak service (Seattle– Vancouver; Seattle– Spokane– Chicago)	N	N	Y
Environmental contamination	N	N	Y
City Shoreline Stabilization Needed	N	N	Y

Source: USACE 2011, Figure 22.

Due to the age and condition of the existing seawall, ongoing operational maintenance activities in the Minimal Damage scenario would be expected to be more frequent than would be required under Alternatives A, B, or C. Because the frequency and nature of such maintenance activities under the No Action Alternative would be dependent on tidal erosion and seismic events that are not reasonably predictable, no quantitative estimates of maintenance-activity air quality impacts have been prepared, although the impacts of such maintenance activities on air quality in the study area are not anticipated to be significant.

Under the Loss of Functionality scenario, effects of reconstructing portions of the seawall would be similar to the construction effects of Alternatives A, B, and C because shoreline stabilization and reconstruction would be necessary along much of the seawall alignment on a scale similar to that proposed for the build alternatives.

In the Collapse of the Seawall scenario, effects of reconstructing the seawall would be similar to the construction effects of Alternatives A, B, and C because shoreline stabilization and reconstruction would be necessary along all of the seawall alignment on a scale similar to that proposed for the build alternatives.

Overall, the adverse operational effects of the No Action Alternative would be short term and minor, depending on how much of the seawall fails or collapses.

6.2 BUILD ALTERNATIVES

Once construction is completed, Alternatives A, B, and C would result in similar average daily criteria pollutant emissions as those under 2010 existing conditions.

Alternatives A and C would provide an additional northbound through lane on Alaskan Way between S. Washington Street and Madison Street.[3] This additional northbound lane would represent an increase in northbound capacity, thus eliminating a future bottleneck on northbound Alaskan Way at Yesler Way and S. King Street and improving vehicle travel times though the corridor when compared to the No Action Alternative. While Alternatives A and C would add surface area to Alaskan Way and marginally increase maintenance requirements on that particular stretch of the roadway, the changes would create more efficient driving conditions and somewhat reduce the amount of fuel consumed by drivers; therefore, the project under Alternatives A and C would not adversely affect air quality emissions from transportation, and may serve to reduce emissions from transportation in the area.

Aside from the additional lane proposed in Alternatives A and C, the build alternatives would be expected to have minimal, beneficial operational impacts on air quality. Annual emissions from inspection or seawall maintenance activities are expected to be a small fraction of the annual emission levels associated with seawall construction. Furthermore, there likely would be an overall reduction in operational emissions associated with equipment use for repairs given that the new seawall would require less repair and maintenance work than the existing structure. As a result, the operation of the seawall is not expected to have any significant adverse impacts on air quality within the study area, and therefore would not require mitigation.

6.3 INDIRECT AND SECONDARY EFFECTS

Indirect effects on air quality associated with the operation of any of the three build alternatives are not anticipated. Indirect effects are those that are reasonably foreseeable and caused by one or more of the build alternatives, but would occur at a different time or place. Operational emissions associated with minor maintenance are localized and are not anticipated to occur at a different time or place.

6.4 MITIGATION MEASURES

The operation of the seawall is not expected to have any significant adverse effects on air quality within the project area and, therefore, would not require mitigation.

[3] 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.

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CHAPTER 7. REFERENCES

Code of Federal Regulations (CFR) Title 40 Part 50: National Primary and Secondary Ambient Air Quality Standards.

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APPENDIX A.
SUPPLEMENTAL DETAILED CONSTRUCTION EFFECTS TABLES[4]

October 2012

[4] These results were based on initial conservative construction durations. Recently, possible shorter construction durations have been identified. However, the shorter construction durations will not have an appreciable effect on emissions or air quality.

TABLE A-1. CONSTRUCTION SITE EMISSIONS FOR ALTERNATIVES A AND C BY ZONE AND CALENDAR YEAR

Zone	Year	Construction Site Emissions, Tons per Year						
		ROG	NOx	CO	SOx	PM_{10}	$PM_{2.5}$	DPM
1	2015	2.43	4.02	17.08	0.97	0.57	0.44	0.40
	2016	0.20	0.33	1.25	0.08	0.04	0.03	0.03
	Subtotal	**2.63**	**4.34**	**18.33**	**1.05**	**0.61**	**0.47**	**0.43**
2	2015	4.56	6.16	31.51	1.52	2.47	1.23	0.59
	2016	3.22	4.99	20.79	1.31	0.64	0.51	0.47
	Subtotal	**7.78**	**11.15**	**52.30**	**2.83**	**3.11**	**1.75**	**1.06**
3	2013	2.42	4.67	19.66	0.98	0.69	0.54	0.50
	2014	4.68	7.86	35.40	1.75	0.94	0.77	0.72
	2015	1.16	2.09	8.08	0.45	0.24	0.21	0.21
	Subtotal	**8.26**	**14.62**	**63.13**	**3.19**	**1.88**	**1.52**	**1.43**
4	2013	4.24	7.33	34.49	1.54	2.61	1.37	0.75
	2014	6.10	11.19	46.88	2.57	1.46	1.18	1.11
	2015	1.02	1.86	7.11	0.40	0.24	0.20	0.19
	Subtotal	**11.36**	**20.39**	**88.48**	**4.51**	**4.31**	**2.75**	**2.05**
5	2019	2.58	2.47	11.20	0.86	0.39	0.27	0.21
	2020	4.16	3.92	16.05	1.17	0.45	0.34	0.27
	2021	4.14	3.93	15.08	1.19	0.70	0.43	0.27
	2022	0.81	0.80	2.75	0.19	0.13	0.09	0.07
	Subtotal	**11.69**	**11.12**	**45.09**	**3.42**	**1.66**	**1.14**	**0.82**
6	2017	3.25	3.49	17.67	1.08	2.14	0.96	0.32
	2018	4.45	4.68	21.82	1.68	0.56	0.44	0.37
	2019	3.18	3.36	14.33	1.11	0.55	0.37	0.27
	Subtotal	**10.88**	**11.52**	**53.82**	**3.87**	**3.26**	**1.77**	**0.96**
TOTAL		**52.61**	**73.15**	**321.16**	**18.87**	**14.82**	**9.40**	**6.74**

Notes: ROG – reactive organic gases; NOx – oxides of nitrogen; CO – carbon monoxide; SOx – sulfur oxides
PM_{10} – inhalable particulate matter; $PM_{2.5}$ – fine particulate matter; DPM – diesel particulate matter

TABLE A-2. CONSTRUCTION SITE ACTIVITY FOR ALTERNATIVES A AND C BY ZONE AND CALENDAR YEAR

Zone	Year	Net Working Days	Acres Subject to Disturbance	Maximum Number of Equipment Items	Hours of On-Site Equipment Use
1	2015	113	1.4	49	16,708
	2016	10	0.4	49	1,555
	Subtotal	**123**	**1.8**	**98**	**18,263**
2	2015	206	6.0	41	28,760
	2016	142	1.8	49	23,611
	Subtotal	**348**	**7.8**	**90**	**52,371**
3	2013	79	4.9	35	15,175
	2014	199	1.9	49	30,501
	2015	52	1.9	49	8,611
	Subtotal	**330**	**8.8**	**133**	**54,287**
4	2013	178	6.6	35	25,013
	2014	229	2.4	49	39,960
	2015	49	2.4	49	7,616
	Subtotal	**456**	**11.5**	**133**	**72,588**
5	2019	82	6.8	35	21,308
	2020	229	3.3	41	34,738
	2021	226	3.3	49	34,970
	2022	42	3.3	45	7,321
	Subtotal	**579**	**16.5**	**170**	**98,337**
6	2017	156	7.0	35	23,060
	2018	229	2.9	46	36,661
	2019	177	2.9	49	26,524
	Subtotal	**562**	**12.8**	**130**	**86,244**
TOTAL		**1,950**	**59.2**	**754**	**382,091**

Notes: Construction periods for different zones would overlap to various degrees.
In general, a maximum of 229 working days would be available in any given calendar year.

TABLE A-3. CONSTRUCTION TRAFFIC ESTIMATES FOR ALTERNATIVES A AND C BY ZONE AND CALENDAR YEAR

Zone	Year	Total 1-Way Truck Trips	Total 1-Way Construction Worker Vehicle Trips	Total Off-Site VMT by Construction Trucks	Total VMT by Construction Worker Vehicles
1	2015	9,713	3,298	263,861	49,477
	2016	1,296	400	38,880	6,000
	Subtotal	**11,009**	**3,698**	**302,741**	**55,477**
2	2015	16,663	6,503	508,109	97,549
	2016	14,598	4,722	385,317	70,834
	Subtotal	**31,260**	**11,226**	**893,425**	**168,383**
3	2013	8,259	3,131	227,787	46,969
	2014	18,617	5,886	486,982	88,289
	2015	7,100	2,168	213,014	32,521
	Subtotal	**33,977**	**11,185**	**927,783**	**167,780**
4	2013	13,816	5,628	406,870	84,422
	2014	24,359	7,679	647,443	115,188
	2015	6,326	1,960	189,789	29,400
	Subtotal	**44,502**	**15,267**	**1,244,102**	**229,010**
5	2019	11,264	4,422	306,329	66,330
	2020	21,020	6,257	602,336	93,859
	2021	19,743	6,595	314,766	98,930
	2022	5,996	1,812	179,883	27,182
	Subtotal	**58,023**	**19,087**	**1,403,314**	**286,300**
6	2017	12,178	5,314	353,119	79,712
	2018	22,205	6,784	591,636	101,759
	2019	17,944	5,114	474,755	76,713
	Subtotal	**52,328**	**17,212**	**1,419,509**	**258,184**
TOTAL		**231,099**	**77,676**	**6,190,876**	**1,165,134**

Notes: VMT – vehicle miles traveled
Construction worker vehicle trips assume that 75% of workers commute in single-occupant vehicles and that 25% commute in 2-person carpools.

TABLE A-4. CONSTRUCTION SITE ACTIVITY FOR ALTERNATIVES A AND C BY CALENDAR YEAR

Year	Net Working Days	Acres Subject to Disturbance	Maximum Number of Equipment Items	Hours of On-Site Equipment Use
2013	229	11.5	70	40,188
2014	229	4.4	98	70,460
2015	229	11.7	188	61,695
2016	152	2.3	98	25,166
2017	156	7.0	35	23,060
2018	229	2.9	46	36,661
2019	229	9.7	84	47,832
2020	229	3.3	41	34,738
2021	226	3.3	49	34,970
2022	42	3.3	45	7,321
TOTAL	**1,950**	**59.2**	**754**	**382,091**

Notes: Construction periods for different zones would overlap to various degrees.
In general, a maximum of 229 working days would be available in any given calendar year.

TABLE A-5. CONSTRUCTION TRAFFIC FOR ALTERNATIVES A AND C BY CALENDAR YEAR

Year	Total 1-Way Truck Trips	Total 1-Way Construction Worker Vehicle Trips	Total Off-Site VMT by Construction Trucks	Total VMT by Construction Worker Vehicles
2013	22,075	8,759	634,657	131,391
2014	42,977	13,565	1,134,425	203,477
2015	39,802	13,930	1,174,773	208,947
2016	15,894	5,122	424,197	76,834
2017	12,178	5,314	353,119	79,712
2018	22,205	6,784	591,636	101,759
2019	29,209	9,536	781,085	143,043
2020	21,020	6,257	602,336	93,859
2021	19,743	6,595	314,766	98,930
2022	5,996	1,812	179,883	27,182
TOTAL	**231,099**	**77,676**	**6,190,876**	**1,165,134**

Notes: VMT – vehicle miles traveled
Construction worker vehicle trips assume that 75% of workers commute in single-occupant vehicles and that 25% commute in 2-person carpools.

TABLE A-6. CONSTRUCTION SITE EMISSIONS FOR ALTERNATIVE B BY ZONE AND CALENDAR YEAR

Zone	Year	Construction Site Emissions, Tons per Year						
		ROG	NOx	CO	SOx	PM_{10}	$PM_{2.5}$	DPM
1	2017	0.67	0.68	3.62	0.22	0.24	0.13	0.06
	2018	1.88	2.10	9.56	0.76	0.23	0.20	0.19
	Subtotal	**2.55**	**2.77**	**13.18**	**0.98**	**0.47**	**0.33**	**0.25**
2	2017	2.51	2.79	13.95	0.90	0.73	0.42	0.26
	2018	3.89	4.57	20.73	1.69	0.51	0.43	0.40
	2019	1.34	1.80	7.17	0.60	0.21	0.18	0.18
	Subtotal	**7.73**	**9.16**	**41.84**	**3.19**	**1.44**	**1.04**	**0.84**
3	2015	3.64	5.55	25.54	1.41	1.06	0.73	0.58
	2016	4.39	7.45	30.50	2.11	0.86	0.75	0.73
	2017	2.75	3.57	15.38	0.98	0.40	0.34	0.31
	Subtotal	**10.77**	**16.57**	**71.43**	**4.50**	**2.32**	**1.81**	**1.62**
4	2013	4.78	8.09	39.20	1.79	2.62	1.44	0.86
	2014	6.17	12.47	49.42	3.04	1.49	1.30	1.30
	2015	2.56	3.75	17.38	0.81	0.42	0.36	0.34
	Subtotal	**13.51**	**24.31**	**106.01**	**5.64**	**4.53**	**3.09**	**2.50**
5	2021	1.96	1.49	6.50	0.51	0.37	0.22	0.13
	2022	3.92	3.39	13.10	0.90	0.35	0.27	0.21
	2023	3.69	3.47	13.94	0.84	0.37	0.29	0.23
	2024	2.15	2.17	8.92	0.46	0.24	0.20	0.18
	Subtotal	**11.73**	**10.52**	**42.46**	**2.71**	**1.33**	**0.98**	**0.74**
6	2019	3.40	2.71	14.00	1.03	2.13	0.90	0.23
	2020	4.22	3.89	15.72	1.14	0.41	0.33	0.27
	2021	2.80	3.21	12.53	0.96	0.37	0.31	0.27
	Subtotal	**10.42**	**9.80**	**42.24**	**3.13**	**2.91**	**1.54**	**0.77**
TOTAL		**56.71**	**73.13**	**317.16**	**20.15**	**13.02**	**8.80**	**6.73**

Notes: ROG – reactive organic gases; NOx – oxides of nitrogen; CO – carbon monoxide; SOx – sulfur oxides
PM_{10} – inhalable particulate matter; $PM_{2.5}$ – fine particulate matter; DPM – diesel particulate matter

TABLE A-7. CONSTRUCTION SITE ACTIVITY FOR ALTERNATIVE B BY ZONE AND CALENDAR YEAR

Zone	Year	Net Working Days	Acres Subject to Disturbance	Maximum Number of Equipment Items	Hours of On-Site Equipment Use
1	2017	33	5.4	35	4,615
	2018	110	0.4	54	16,664
	Subtotal	**143**	**5.8**	**89**	**21,279**
2	2017	113	3.9	35	18,230
	2018	229	1.8	54	35,996
	2019	75	1.8	54	13,759
	Subtotal	**417**	**7.6**	**143**	**67,985**
3	2015	114	4.1	35	24,117
	2016	229	1.9	54	36,789
	2017	139	1.9	54	21,450
	Subtotal	**482**	**8.0**	**143**	**82,356**
4	2013	157	6.0	35	27,573
	2014	229	2.4	54	45,169
	2015	129	2.4	45	16,894
	Subtotal	**515**	**10.9**	**134**	**89,635**
5	2021	89	6.4	35	15,309
	2022	229	3.3	34	32,479
	2023	226	3.3	53	35,081
	2024	134	3.3	51	22,493
	Subtotal	**678**	**16.2**	**173**	**105,363**
6	2019	178	6.2	35	25,368
	2020	229	2.9	40	33,572
	2021	175	2.9	54	28,765
	Subtotal	**582**	**12.0**	**129**	**87,705**
TOTAL		**2,578**	**60.4**	**811**	**454,323**

Notes: Construction periods for different zones would overlap to various degrees.
In general, a maximum of 229 working days would be available in any given calendar year.

TABLE A-8. CONSTRUCTION TRAFFIC ESTIMATES FOR ALTERNATIVE B BY ZONE AND CALENDAR YEAR

Zone	Year	Total 1-Way Truck Trips	Total 1-Way Construction Worker Vehicle Trips	Total Off-Site VMT by Construction Trucks	Total VMT by Construction Worker Vehicles
1	2017	2,718	1,057	81,073	15,858
	2018	10,486	3,426	303,475	51,395
	Subtotal	**13,204**	**4,484**	**384,548**	**67,254**
2	2017	9,282	4,043	269,588	60,644
	2018	21,950	7,378	560,335	110,665
	2019	12,559	3,389	347,428	50,838
	Subtotal	**43,791**	**14,810**	**1,177,350**	**222,147**
3	2015	11,334	5,387	325,548	80,806
	2016	24,589	7,551	617,938	113,258
	2017	10,265	4,332	285,619	64,984
	Subtotal	**46,187**	**17,270**	**1,229,105**	**259,048**
4	2013	13,689	6,475	409,087	97,127
	2014	29,740	9,578	799,128	143,677
	2015	5,820	3,248	169,192	48,714
	Subtotal	**49,249**	**19,301**	**1,377,407**	**289,517**
5	2021	8,698	3,464	253,541	51,962
	2022	14,972	6,341	420,019	95,117
	2023	21,636	6,973	578,406	104,591
	2024	20,244	5,578	566,503	83,665
	Subtotal	**65,551**	**22,356**	**1,818,470**	**335,334**
6	2019	12,130	6,138	361,696	92,067
	2020	14,520	6,306	415,319	94,590
	2021	24,304	6,250	637,024	93,756
	Subtotal	**50,955**	**18,694**	**1,414,039**	**280,414**
TOTAL		**268,937**	**96,914**	**7,400,919**	**1,453,714**

Notes: VMT – vehicle miles traveled
Construction worker vehicle trips assume that 75% of workers commute in single-occupant vehicles and that 25% commute in 2-person carpools.

TABLE A-9. CONSTRUCTION SITE ACTIVITY FOR ALTERNATIVE B BY CALENDAR YEAR

Year	Net Working Days	Acres Subject to Disturbance	Maximum Number of Equipment Items	Hours of On-Site Equipment Use
2013	157	6.0	35	27,573
2014	229	2.4	54	45,169
2015	229	6.6	80	41,011
2016	229	1.9	54	36,789
2017	229	11.2	124	44,295
2018	229	2.3	108	52,660
2019	229	8.0	89	39,127
2020	229	2.9	40	33,572
2021	229	9.3	89	44,074
2022	229	3.3	34	32,479
2023	226	3.3	53	35,081
2024	134	3.3	51	22,493
TOTAL	**2,578**	**60.4**	**811**	**454,323**

Notes: Construction periods for different zones would overlap to various degrees.
In general, a maximum of 229 working days would be available in any given calendar year.

TABLE A-10. CONSTRUCTION TRAFFIC FOR ALTERNATIVE B BY CALENDAR YEAR

Year	Total 1-Way Truck Trips	Total 1-Way Construction Worker Vehicle Trips	Total Off-Site VMT by Construction Trucks	Total VMT by Construction Worker Vehicles
2013	13,689	6,475	409,087	97,127
2014	29,740	9,578	799,128	143,677
2015	17,154	8,635	494,740	129,520
2016	24,589	7,551	617,938	113,258
2017	22,265	9,432	636,279	141,487
2018	32,436	10,804	863,810	162,060
2019	24,689	9,527	709,123	142,905
2020	14,520	6,306	415,319	94,590
2021	33,002	9,715	890,565	145,718
2022	14,972	6,341	420,019	95,117
2023	21,636	6,973	578,406	104,591
2024	20,244	5,578	566,503	83,665
TOTAL	**268,937**	**96,914**	**7,400,919**	**1,453,714**

Notes: VMT – vehicle miles traveled
Construction worker vehicle trips assume that 75% of workers commute in single-occupant vehicles and that 25% commute in 2-person carpools.

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City of Seattle

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APPENDIX B.
OVERVIEW OF THE CNSTEMIS SPREADSHEET MODEL

October 2012

Emissions from construction and demolition activities will be estimated using a detailed spreadsheet model (CNSTEMIS). The CNSTEMIS spreadsheet model calculates criteria pollutant emissions, diesel particulate emissions, and greenhouse gas (GHG) emissions from construction or demolition activities and equipment. Criteria pollutant emission estimates are provided for reactive organic compounds, nitrogen oxides, carbon monoxide, sulfur oxides, inhalable particulate matter (PM_{10}), and fine particulate matter ($PM_{2.5}$). Particulate matter emissions from diesel engines contain known and suspected carcinogens, and consequently have been designated as a toxic air contaminant by the California Air Resources Board. Exhaust emissions of PM_{10} from construction and demolition equipment provide the estimate of diesel particulate matter emissions. GHG emission estimates are provided for carbon dioxide, methane, and nitrous oxide. The overall global warming potential of GHG emissions also is calculated in terms of carbon dioxide equivalents.

The CNSTEMIS spreadsheet model uses a conventional approach to estimating emissions from construction equipment and activity that entails the following steps:

- Dividing the construction or demolition project into activity phases that have similar equipment requirements.
- Identifying equipment types needed for each construction or demolition phase.
- Identifying how many items of each type would be needed, the typical horsepower rating for the item (model provides defaults), and the typical engine load factor (model provides defaults).
- Identifying the hours per day with active use for each equipment item.
- Identifying the fraction of each use hour when the equipment would actually be operating (model provides defaults).
- Identifying the overall disturbed area size for each phase of construction or demolition activity.
- Identifying the duration of each construction or demolition phase.
- Identifying the typical area size that would be disturbed on a given day during each phase of construction or demolition activity.
- Identifying typical fugitive dust emission rates for each phase of construction or demolition activity (model provides defaults).
- Identifying which construction or demolition phases overlap with each other.

The version of the CNSTEMIS model used for this study includes a user-modifiable emission rate database of 549 entries covering 121 basic equipment types. Entries for each equipment type are subdivided into engine size and fuel type categories that correlate with emission standards that have been adopted in recent years by the U.S. Environmental Protection Agency (USEPA) and the California Air Resources Board (CARB). In addition to equipment powered by conventional diesel, gasoline, and compressed gas (propane/CNG/LNG/LPG) engines, the database includes information for electric arc welders, oxy-fuel welders, oxy-fuel cutting torches, plasma cutting torches, stationary diesel engines, large equipment powered by diesel-electric or turbine engines, and stationary gas turbine generators.

Database entries also address multi-engine equipment designs for scrapers, concrete pavers, concrete finisher-vibrators, and off-road haul trucks. Metal fume emissions have been incorporated into the PM10 emission rates for welders and cutting torches. Fugitive PM_{10} emissions have been incorporated into the emission rates for rock drills, jackhammers, pavement breakers, pavement scarifiers, concrete/industrial saws, and abrasive blasting equipment. Default database entries are provided for the appropriate range of small, medium, and large engine sizes for each equipment type. The current database provides default data for 549 combinations of equipment type, engine size range, and fuel type. Default engine sizes are representative of current equipment models from several major manufacturers (Caterpillar, Komatsu, Terex, John Deere, Case, Bobcat, Gradall, GOMACO, LeeBoy, TSE, Vermeer, APE, Hercules, and others) as well as older equipment models that are still in use.

GHG emission rates used in the CNSTEMIS model are based on Appendix C of the California Climate Action Registry (CCAR) 2007 general GHG emissions reporting protocol. Most of the GHG emission rates in the CCAR protocol document are based on equipment or vehicle fuel consumption rates. Equipment fuel consumption estimates used in the CNSTEMIS model are derived from horsepower-hour based fuel use data presented in documentation reports for the 2005 version of the USEPA NONROAD model. The CNSTEMIS model computes the overall global warming potential of carbon dioxide, methane, and nitrous oxide emissions using carbon dioxide equivalence factors identified by the Intergovernmental Panel on Climate Change (IPCC). Users can select from the 1995, 2001, or 2007 IPCC equivalence factor data sets. The 2007 data set is the default selection.

The main calculation sheet of the CNSTEMIS model allows construction or demolition projects to be divided into four activity phases. Multiple CNSTEMIS workbooks can be used for projects involving more than four activity phases. Separate CNSTEMIS workbooks by calendar year are encouraged when construction or demolition activity would occur in more than one calendar year. The main calculation sheet provides for simple data entry by the user: lookup table codes for equipment types by engine size range and fuel type; number of items of each type by construction activity phase; and active hours per day for each equipment type by construction activity phase. Default equipment parameters (engine horsepower, average load factor, and typical use time within active hours) are automatically loaded into the calculation sheet. The user can modify default equipment parameters under each activity phase. An optional calculation section is provided for computing cut and fill balances and associated bulldozer and scraper requirements if that information is not available from other sources.

CNSTEMIS users can select from three primary emission rate datasets: emission rates based on the original 1991 USEPA non-road equipment database (useful only for estimates of emission rates in the absence of emission standards); emission rates adjusted for California and USEPA emission standards and fuel sulfur limits (for projects in California); or emission rates adjusted for USEPA emission standards and fuel sulfur limits (for projects in states other than California). When the user specifies the construction activity year, the equipment database sheet calculates appropriate average emission rates for the mix of older and newer equipment models of each equipment entry, recognizing the nominal lifetime for each equipment type and the implementation years for relevant California or USEPA emission standards and fuel sulfur limits. A simple linear replacement rate over the nominal lifetime of the equipment item is assumed in the model calculations. Equipment entries are assigned nominal

lifetimes of 10, 15, 20, 25, or 30 years. Users can modify the equipment lifetimes in the database if desired.

In addition to equipment engine emissions, CNSTEMIS calculates emissions from several other construction-related sources:

- Fugitive dust emissions from general construction and demolition site disturbance;
- Fugitive dust from mechanical or explosive building demolition;
- Fugitive dust from construction blasting;
- Volatile organic compound emissions from the curing of asphalt pavement;
- Volatile organic compound emissions from paints and surface coatings; and
- PM_{10} aerosol emissions from spray painting activities.

In addition to accounting for active dust control program effects, the CNSTEMIS model allows emission calculations for fugitive dust from site disturbance to account for the seasonal frequency of precipitation events, frozen ground conditions, and snow cover. Fugitive dust emission estimates also can be adjusted to reflect the seasonal effects of persistently high soil moisture conditions from shallow perched water tables, seeps, or other natural factors. Natural dust control factors are applied to the residual fugitive dust generated after accounting for active dust control program effects.

The fugitive dust database sheet in the model provides a range of default fugitive dust generation rates for construction activity and building demolition, information on the PM_{10} and $PM_{2.5}$ content of soils according to soil texture class, information on water application rates for fugitive dust control, a calculator to estimate the required number of water trucks, and a calculator to estimate fugitive PM_{10} and $PM_{2.5}$ emissions from construction blasting. The fugitive volatile organic compound (VOC) database sheet includes a database of 49 categories of paints and coatings; a database of federal, state, and California air pollution control district limits for the VOC content of architectural coatings; and a calculator to generate project-specific fugitive VOC emission rates for up to four categories of coatings (e.g., exterior paints, interior paints, roof coatings, and floor coatings). The VOC emission rates account for the number and thickness of applied paint coats, which can include up to three coating types (for example, primers, main coats, and top coats) in each coating category. Internal calculations convert the coating thickness to a coating coverage value (square feet per gallon), which can be compared to a table of default coverage values for various types of coatings.

A building construction data worksheet allows users to calculate the square footage of exterior and interior wall areas, floor areas, ceiling areas, and roof areas for each building or group of buildings in a project. Building component square footage values account for building footprint area, building height, number of stories, and building shape (length to width ratio). Building component square footage data is useful for estimating the quantity of paint or architectural coatings required for individual buildings in a project. The building construction data worksheet also provides a convenient location to compute the acreage of project-related roadways, parking lots, or other features, or to develop a time schedule of project phases. The demolition debris sheet in CNSTEMIS allows users to estimate demolition debris volumes, tonnages, and debris haul truck loads when independent estimates are not available.

Additional database sheets in the model provide information on typical material densities and typical heavy equipment work rates. A detailed unit conversion factor database sheet and a particle size unit conversion sheet also are included in the model.

The summary sheet in the CNSTEMIS model provides a comprehensive data summary for each phase of construction activity: disturbed acreages; total equipment item numbers; total equipment use hours; total equipment fuel use; off-site truck trips; construction worker commute trips; assumptions used for fugitive emissions calculations; and annual, quarterly, and daily summaries of criteria pollutant emissions, diesel particulate matter emissions, and GHG emissions. The summary sheet allows users to account for ridesharing programs (both carpooling and shuttle bus programs) in the calculation of worker commute trips. Ridesharing program participation rates, average carpool occupancy, and average shuttle bus occupancy can be varied by construction activity phase.

The summary sheet also provides a detailed tabulation of equipment items by activity phase, including the assumed horsepower, load factor, operating time factor, number of items, active hours per day, hourly fuel use rate, criteria pollutant emission rates, and GHG pollutant emission rates for each item type. A construction phase overlap calculator in the summary sheet identifies the extent of overlap among work phases by calendar quarter, allowing calculation of maximum day and maximum calendar quarter emissions. The construction phase overlap calculator allows the user to specify the number of work days by calendar quarter (with allowances for major holidays; the average default values are 64 days for a five-day work week schedule, 77 days for a six-day work week schedule, and 89 days for a seven-day work week schedule.

The $PM_{2.5}$ emission estimates provided by the CNSTEMIS model are extrapolated from the PM_{10} emission estimates using separate $PM_{2.5}$ fractions for engine exhaust, fugitive dust, and spray painting, with the option of setting $PM_{2.5}$ fractions separately for each of these categories by construction phase. Default $PM_{2.5}$ fractions for engine exhaust and spray painting are based on the California Air Resources Board CEIDARS (California Emission Inventory Data and Reporting System) database. The default fugitive dust $PM_{2.5}$ fraction can be based on soil texture class using the fugitive dust database sheet in the model, or a more generic fraction from the CEIDARS database can be used. Users can substitute alternative $PM_{2.5}$ fractions for any of the default values.

A data entry notes sheet in the CNSTEMIS workbook provides users with detailed instructions and cell-by-cell discussions of data entry areas in the key worksheets of the model. Supplemental instructions and notes are provided in the individual worksheets throughout the workbook.

APPENDIX C.
AVAILABILITY OF CONSTRUCTION EMISSIONS ANALYSIS MODELING FILES[5]

October 2012

The CNSTEMIS spreadsheet model files are too large for convenient hard copy printing. The 68 individual files used for analysis of Alternatives A and C and Alternative B are available in electronic form upon request.

The MOBILE6.2 model output files and associated spreadsheet summaries also are too large for convenient hard copy printing. These files are available in electronic form upon request.

[5] These results were based on initial conservative construction durations. Recently, possible shorter construction durations have been identified. However, the shorter construction durations will not have an appreciable effect on emissions or air quality.