TERMINAL 5 CARGO WHARF REHABILITATION, BERTH DEEPENING, AND IMPROVEMENTS

Final Environmental Impact Statement
Volume II

Port of Seattle
SEPA Lead Agency
Project Proponent

THE NORTHWEST SEAPORT ALLIANCE

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FINAL
ENVIRONMENTAL IMPACT STATEMENT

TERMINAL 5 CARGO WHARF REHABILITATION, BERTH DEEPENING, AND IMPROVEMENTS

PORT OF SEATTLE
SEATTLE, WASHINGTON

POS SEPA NO. 16-08

Prepared for the Review and Comments of Citizens,
Groups, and Governmental Agencies

In Compliance With
The State Environmental Policy Act of 1971 (Chapter 43.21C RCW)
and Port of Seattle SEPA Policies and Procedures

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Volume II

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Appendix A
Air Quality Technical Report

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TERMINAL 5 WHARF REHABILITATION, BERTH DEEPENING, AND IMPROVEMENTS PROJECT

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ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

AERMOD	Air quality dispersion modeling system used in this analysis. The AERMOD modeling system consists of two pre-processors and a dispersion model. The meteorological preprocessor (AERMET) provides meteorological information, and a terrain pre-processor (AERMAP) characterizes terrain, and generates receptor grids for the dispersion model (AERMOD).
Ambient air quality standard	Health-based standard representing a pollutant concentration in the ambient air usually over some averaging period like 1-hour, intended to protect the health and welfare of people with a margin of safety
Ambient air	the air in outdoor locations to which the public has access, e.g., outside the property boundary of the emissions source
ASIL	Acceptable Source Impact Level – a *screening* level (as opposed to a *standard*) used to evaluate the potential impact of **TAPs** based on the estimated risk of a lifetime of exposure
Attainment/Nonattainment	a determination and classification made by EPA indicating whether ambient air quality in an area complies with (i.e., attains) or fails to meet (i.e., nonattainment) the requirements of one or more **NAAQS**
Averaging time	a specific length of time (e.g., 1 hour, 24-hours, 1 year) over which measured or model-calculated concentrations of an air pollutant are averaged for comparison with the **NAAQS** based on the same averaging period. Note that some NAAQSs are also based on multi-year averages of certain percentiles of measured or calculated concentrations.
cf	cubic foot, a measure of volume
cfm	cubic feet per minute, a measure of air flow
CO	carbon monoxide, a criteria air pollutant
CO_2	carbon dioxide
CO_2e	Greenhouse gas equivalents (emissions of all GHGs expressed in terms of their "global warning potential")
Criteria air pollutant	an air pollutant specifically governed by the Federal Clean Air Act for which ambient air quality standards have been set. Criteria air pollutants include carbon monoxide, particulate matter, sulfur dioxide, nitrogen dioxide, ozone, and lead.
Dispersion model	A computerized calculation tool used to estimate pollutant concentrations in the ambient air based on numeric simulations that consider the locations and rates of pollutant emissions and the effects of meteorological conditions, usually over specific averaging times (e.g., 8-hours)
dwt	Deadweight tonnage is a measure of how much weight a ship is carrying or can safely carry. It is the sum of the weights of

	cargo, fuel, fresh water, ballast water, provisions, passengers, and crew. The term is often used to specify a ship's maximum permissible deadweight, and is expressed in long tons or metric tons (tonnes).
ECA	Environmental Control Area
Ecology	Washington State Department of Ecology
EPA	US Environmental Protection Agency
Fugitive dust	Potential air pollutant in the form of dust (or other pollutant) emitted from a non-point or non-mobile source such as dust from a road or from a storage pile caused by wind
GHG	Greenhouse gas (e.g., carbon dioxide or methane) that contributes to the process of a gradual warming of the atmosphere that can result in global climate change
Global warming potential	a measure of the potential of a gas to have an effect in the atmosphere that could lead to climate change based on the potential of the gas to cause global warming. This is a standard measure, typically based on a 100-year time horizon, used to compare each GHG with the global warming potential of carbon dioxide (CO_2), the most abundant GHG.
hp	horsepower
IMO	International Maritime Organization
Knot	a unit of speed equal to one nautical mile per hour, or approximately 1.151 mph
Long ton	also called imperial ton and equal to 2,240 pounds (1,016 kg)
Maintenance area	An area that was once designated as nonattainment that has since come into compliance with the ambient air quality standard but where air quality control measures may remain in effect (in perpetuity).
Meteorological data set	a compilation of meteorological data representing conditions over some period of time and including such things as wind speed and wind direction, and formatted as required by the dispersion model being used. This analysis used a meteorological data set covering 5 years.
Metric ton	1,000 kilograms (kg) = 2,204.6 pounds = tonne (see also short ton)
Micrometer/Micron	one millionth of a meter; typically used to distinguish particle size; typical human hair is 100 about microns in diameter
mmtpy	million metric tons per year
Modeling domain	the area included in the **dispersion-modeling** analysis, such as in this case, which used a larger than 10 kilometer by 10 kilometer domain. Modeling receptors are distributed

	within this domain, usually over a standard grid pattern with receptors every 100 to 500 meters.
Modeling receptor	a theoretical (i.e., often non-specific) location used in computer modeling at which air pollutant concentrations are calculated. Modeling may also use site-specific receptors representing individual locations.
MOVES	EPA's **Mo**bile **V**ehicle **E**mission **S**imulator
mtyp	metric tons per year
NAAQS	National Ambient Air Quality Standard
Nautical mile (nm)	The nautical mile is a unit of length that is about one minute of arc of latitude measured along any meridian, or about one minute of arc of longitude at the equator. By international agreement it is exactly 1,852 meters (approximately 6,076 feet).
NSPS	New Source Performance Standard; rules that pertain to air pollution emission sources subject to air quality permits and newly manufactured equipment
NO_2	nitrogen dioxide, a **criteria** air pollutant
Nonattainment area	An area delineated by regulatory agencies including US EPA and the Washington Department of Ecology in which an ambient air quality standards have been violated and where there is a program in place designed to reduce air pollution so that the standard attained.
NONROAD	EPA emissions model for off-road sources except locomotives and ocean-going vessels
NO_x	oxide of nitrogen, a general class of air pollutant without a specific air quality standard but used in monitoring air quality
PSCAA	Puget Sound Clean Air Agency; the designated local air quality control agency in the project area
OGV	Ocean-going Vessel
Particulate matter (PM)	air pollutant comprised of solid or liquid particles; PM is usually characterized based on the particle size. See also PM_{10} and $PM_{2.5}$.
PM_{10}	"Coarse" inhalable particulate matter with an aerodynamic size less than or equal to 10 micrometers (**microns**)
$PM_{2.5}$	"Fine" inhalable particulate matter with an aerodynamic size less than or equal to 2.5 micrometers (**microns**)
Point source	an emission source type defined in AERMOD. Point source emissions are released from a single location.
ppm	parts per million (a metric used in quantifying concentrations of air pollutants)
PSRC	Puget Sound Regional Council
Receptor	See modeling receptor.

Release height .... an AERMOD term defining the height above ground at which source emissions are released

RTG .... Rubber-tired gantry, a mobile unit to transport a container

Short ton .... 2,000 pounds (see also **metric ton** and long ton)

SO_2 .... Sulfur dioxide, a **criteria air pollutant**

Soiling .... A non-health-related effect of air pollution such as staining or deposition of a fine film typically on exterior surfaces

TAP .... Toxic air pollutant

TEU .... Twenty-foot equivalent. A unit of measurement of shipping containers. Containers are typically 20' or 40' long.

tonne.................................. **metric ton**

tpy .... tons per year, an estimate of annual emissions

$\mu g/m^3$ .... micrograms per cubic meter (a metric used in quantifying concentrations of air pollutants)

Volume source .... an emission source type defined in AERMOD. Volume sources emit diffuse air pollutants from a three-dimensional area. Line sources, such as emissions from transiting trains, can be simulated using multiple, adjacent volume sources.

SUMMARY

The Port of Seattle proposes to rehabilitate Terminal 5 to accommodate larger container ships and provide infrastructure improvements that could lead to improved cargo handling efficiency and capability. Two action alternatives are under consideration. Each would rehabilitate and strengthen the wharf as required for operation of larger heavier container cargo cranes, essential for serving large container cargo vessels. Upland improvements for Alternative 2 and 3 would enable higher container throughput than existing conditions with Alternative 3 capability being greater than the capability of Alternative 2.

This report provides technical details of the air quality impact and mitigation analysis conducted by Ramboll Environ US Corporation (Ramboll Environ) as part of the environmental review of the proposed project. The methods and findings of the analysis reported here were summarized in the environmental impact statement for this project.

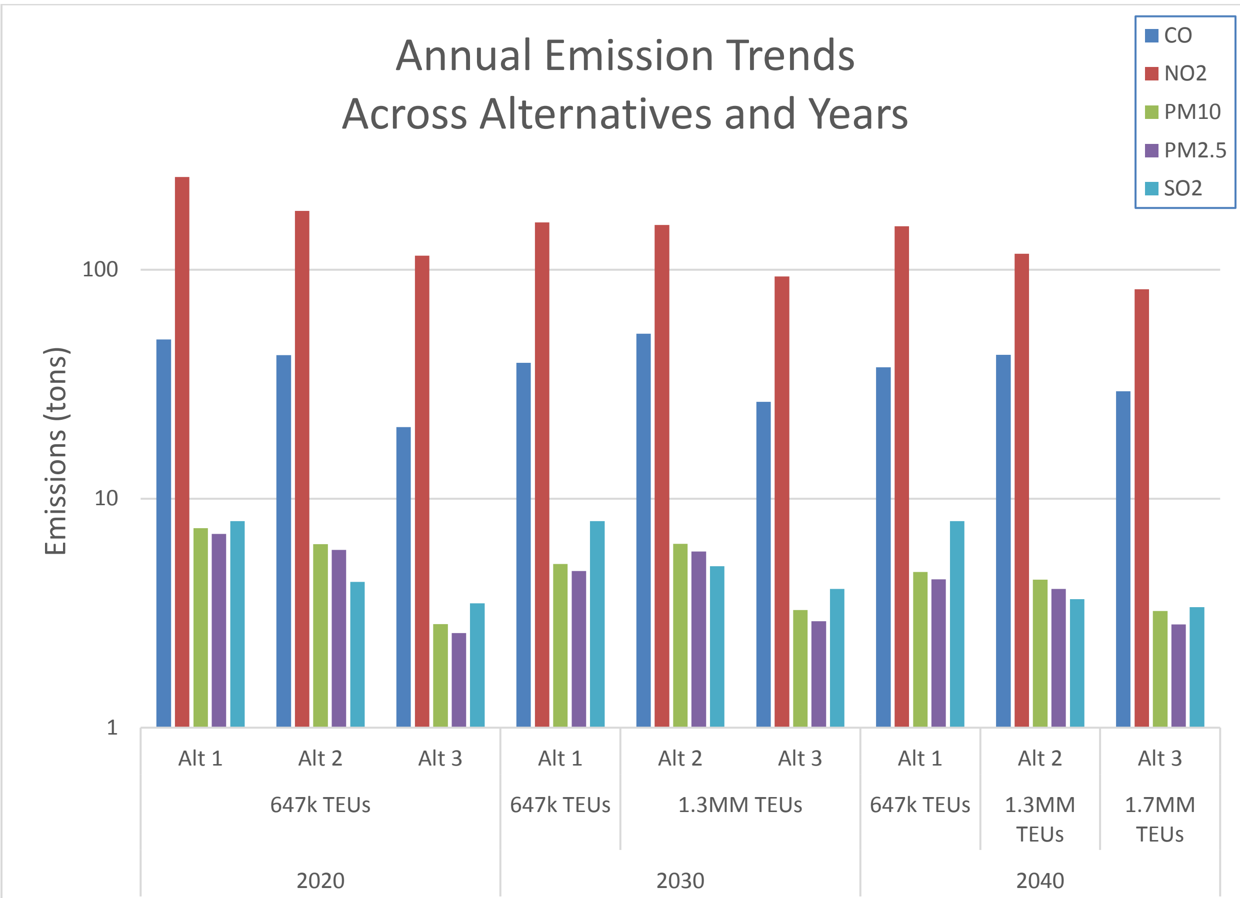
Engine emissions attributable to ocean-going vessels, tugs, locomotives serving intermodal rail operations at the site, on-site mobile cargo-handling equipment, and on-road trucks are calculated for a No Action Alternative in 2020, Alternative 2 in 2020 and 2030, and for Alternative 3 in 2020, 2030, and 2040. The years of analysis are associated with increasing throughput at the terminal and are limited in Alternatives 1 and 2 due to physical and economic constraints. Emissions are affected by three competing factors: 1) improvements in engine technology and related fuel policies; 2) the level of intermodal activity (i.e., the number of containers transloaded); and 3) the degree to which ships and cargo handling are electrified (greatest with Alternative 3). The trends in emissions for the three alternatives in years 2020, 2030, and 2040 are depicted in the **Summary Figure 1** and tabulated within the body of this technical report.

Terminal 5 emissions are evaluated using an EPA-approved air quality dispersion model and local meteorological data. Pollutant concentrations are predicted at locations throughout a ten by fifteen kilometer area centered on Terminal 5. Predicted pollutant concentrations, including conservative background concentrations, comply with the national and state ambient air quality standards established to protect human health and welfare.

For all site configurations and years, predicted concentrations of carbon monoxide, sulfur dioxide, nitrogen dioxide (NO_2), PM_{10} (coarse particulate matter), and $PM_{2.5}$ (fine particulate matter) from Terminal 5 operations, in addition to background concentrations, are below the ambient standards with no action and with the action alternatives.

Although there is no ambient standard for diesel particulate matter, it is a pollutant of concern. Assuming all particulate matter emissions from the terminal are diesel particulate matter, model-predicted concentrations from the project are between 15 and 18 percent of

the annual $PM_{2.5}$ standard for the 2020 No Action Alternative, the 2020 Alternative 2, and 2030 Alternative 2. Diesel particulate matter concentrations are approximately half of the No Action Alternative under Alternative 3, with steady improvement from 2020 through 2040. The maximum modeled concentrations occur immediately adjacent to the wharf in the west waterway. Modeled concentrations in the neighborhoods west and south of the terminal are far less than those in the waterway.



Summary Figure 1. Alternative and Analysis-Year Emissions

1. PROJECT DESCRIPTION

The Port of Seattle is the sponsor of the proposed "Terminal-5 Cargo Wharf Rehabilitation, Berth Deepening, and Improvements Project." The project is at the existing Terminal-5 (T-5) marine cargo facility, on the west margin of the West Waterway, in southwest Elliott Bay, Seattle, Washington. The project area, owned and available for use by the Port, includes the existing T-5 marine cargo facility that consists of approximately 197 acres for transshipment activity and approximately 2,900 linear feet of cargo wharf.

1.1 Projected Economic Limitations & Temporal Considerations

The proposed project would improve the container-handling efficiency of the existing terminal to accommodate the projected fleet mix of larger container vessels, up to 18,000 TEUs, that are anticipated to call T-5 through 2040. This report analyzes the air quality implications of the proposed project in 2020, 2030, and 2040. The DEIS analyses and evaluations for the proposed T-5 actions are based on completion of project actions in 2020, with cargo volumes increasing from approximately 650,000 TEUs to an upper capacity level of approximately 1,300,000 TEUs by 2030. For Alternative 2 that level would continue through the 2040 planning horizon unless modifications as proposed for Alternative 3 were constructed. Alternative 3 modifications would include the electrification of many of the cargo-handling operations that could provide an estimated throughput capacity 1,700,000 TEUs in 2040. The actual throughput levels and expected progressive timeline of expansion for the proposed Project may be extremely variable due to market conditions.

1.2 Alternatives Being Considered

1.2.1 Alternative 1 - No Action

The No-Action Alternative proposes that no physical improvements would be made to the existing 197-acres site. The No-Action Alternative provides a baseline case against which potential impacts of the proposal can be compared.

The No Action Alternative assumes that no improvements would be made to the existing 197-acre site other than minor alterations, routine maintenance and repair work, none of which would increase container cargo capacity. The T-5 shoreline and upland area would continue as a marine cargo transportation facility with vessel moorage, cargo wharf, cargo marshalling, and truck and rail cargo transshipment operations taking place. The terminal would continue to be capable of accommodating diverse marine cargo uses such as breakbulk or neo-bulk (goods that are loaded individually, and not in containers) and other water-dependent uses and activities intrinsic to marine transportation facilities.

Marine cargo operations would be similar to T-5 uses and activities during the past 15 years, making use of existing infrastructure designed and constructed to transship approximately 647,000 twenty-foot equivalent units (TEU) per year. The present T-5 marine cargo facility is the result of substantial expansion and improvements completed in 1999. The construction and operation of the present marine cargo facility was preceded by detailed environmental analyses and evaluations, including a combined federal, state, and local government Environmental Impact Statement (EIS), Southwest Harbor Cleanup and Redevelopment Project, and subsequent authorizations received from federal, state, and local regulators and government entities, including substantial shoreline development approval from the City of Seattle.

The No Action Alternative would preclude large post-Panamax vessels and expected larger capacity container ships from serving the site because they cannot be accommodated by the existing wharf or cranes.

1.2.2 Alternative 2 - Wharf Improvements, Berth Deepening and Increased Cargo Handling

Alternative 2 would consist of modification of existing container facilities, including cargo wharf rehabilitation, berth deepening, water and storm-water upgrades and electrical utility capacity improvements. Changes to existing T-5 facilities would increase container cargo transshipment capability at the site to allow throughput of up to approximately 1.3 million TEU annually.

These changes to allow T-5 to accommodate existing large Post-Panamax and larger New Post-Panamax container cargo vessels and transship increased cargo volumes are described in more detail below. Cargo pier improvements would include the following:

- Replacement of cargo pier crane rail beam
- Stabilization of existing armored slope beneath the cargo wharf
- Replacement of treated wood piling wharf fender system
- Deepening navigational access to existing berth area, increasing berth depths to approximately minus 55 feet MLLW
- Repair and maintenance of existing wharf piling
- Installation of upgraded utilities, including replacement primary substation equipment and replacement water service to the existing wharf structure.
- Potential remodel of existing buildings for labor, management, maintenance and terminal operations and installation of other small buildings as needed to service the site
- Possible installation of Rubber-Tired Gantry (RTG) crane concrete pads or runways to move and position containers in a container yard in a portion of the yard.
- Wharf and crane improvements would allow simultaneous loading and unloading of two 18,000 TEU vessels
- Installation of up 8 new electric Ship-to-Shore cranes.

- A provision for shore power for moored vessels.
- Cargo handling equipment predominately diesel powered similar to previous operations

Most relevant to this air quality technical analysis are Alternative 2 upland improvements to re-design and reorganize the container cargo marshalling yard area land-ward of the rehabilitated cargo wharf including changes in the distribution of grounded and wheeled container cargo and revised internal cargo handling circulation, and travel lanes.

1.2.3 Alternative 3 - Wharf Improvements, Berth Deepening, Increased Cargo Handling and Additional Upland Improvements

Alternative 3 consists of the same improvements listed for Alternative 2 with the addition of reorganized intermodal rail facilities, a reconfigured gate, and demolition of buildings. Alternative 3 improvements include:

- Substantial improvements to the upland cargo marshalling area to increase overall terminal throughput capacity to 1.7 million TEUs per year (by 2040) by increasing efficiency of cargo handling equipment that would largely be electric-powered.
- Wharf and crane improvements would allow simultaneous loading and unloading of two 18,000 TEU vessels.
- Installation of up 12 new electric Ship-to-Shore cranes.
- The container yard would be enlarged through relocation or demolition of the existing entrance gate, freight station, transit shed, maintenance and repair buildings, and operations buildings.
- The container yard capacity would be increased through use of grounded container storage served by RTG or RMG cranes.
- The truck gate would be relocated, and the existing intermodal rail yard would be reconfigured with additional rail lines and concrete or rail runways for RTG or RMG equipment.

1.2.4 Shorepower

Shorepower plug in capability for two berths will be provided as part of either Alternative 2 or Alternative 3 when the terminal renews operation. Shorepower reduces annual emissions for criteria pollutants, Greenhouse Gas Emissions, and has a secondary effect of reducing noise levels from vessels while at berth.

The air quality emissions analyses assumes 30 percent of at berth vessel power generation was offset by shorepower in 2020, 50 percent in 2030, and 70 percent in 2040 for the action alternatives. Estimates of the penetration rate of on-shore power (OPS) capable container cargo ships calling the Northwest Seaport Alliance (NWSA) terminals in 2015 (baseline), and a low and high range forecasts for shorepower adoption rates in 2020 and

2030 were derived from a study conducted by Starcrest Consulting. These forecast rates of penetration are consistent with the high end of the study's estimates particularly in later years. The penetration rates used in the EIS are conservatively optimistic in comparison to the estimates outlined in the study. For example, the study suggests in 2020 the OPS-capable fleet fraction will be between 33%-59% and in 2030 that fraction will be between 33%-74%. Furthermore, 32% of the current container fleet calling the Northwest Seaport Alliance terminals is OPS-capable

But, the percentage of vessels calling at Terminal 5 that will use shorepower at berth is encouraged by several developments and polices:

- Ships entering Puget Sound are required to burn fuel with a maximum sulfur content of 0.1 percent as of January 1, 2015. The higher cost of lower sulfur fuels vs electricity costs for shorepower may approach parity encouraging use of shorepower over diesel generation.
- The CARB (California Air Resources Board) requires ships in California to use shorepower or equivalent control techniques to reduce at berth emissions by 2020. The number of vessels modified to accept shorepower has increased since passage of the policy. Vessels that call at California ports often call at Pacific Northwest ports after calling at California, increasing the chance that a vessel is equipped to accept shorepower connections.
- Seattle City Light sells power at rates often less than that of other major shipping centers, making shorepower equal to or less expensive than using diesel generators.

In southern California, where regulations were promulgated due to poor air quality in the Los Angeles basin, an 80 percent plug-in rate is required by 2020. The Port and NWSA anticipated the need to provide shorepower as part of the Terminal 5 modernization project and directed planners to include a component of shorepower as part of operations, even though there are no regulatory mandates to do so. The estimated shorepower adoption rates increase over time is based on reasonable estimates of vessels with the capability to connect to shorepower and a competitive cost structure relative to use of diesel to power vessels at berth.

Although shorepower connection will be voluntary, the Port recognizes that additional incentives beyond low electric rates may further encourage shipping lines to send vessels equipped with shorepower capability to Terminal 5 in the future. Once a tenant is selected, the NWSA and Port will work with the company and shipping lines to design a program to incentivize shorepower utilization.

2. AFFECTED ENVIRONMENT

This section describes the air quality regulatory environment and existing air quality near T-5.

2.1 Regulatory Overview

2.1.1 Ambient Air Quality Standards and Attainment Status

Air quality is generally assessed in terms of whether concentrations of air pollutants are higher or lower than ambient air quality standards set to protect human health and welfare. Ambient air quality standards are set for "criteria" pollutants (e.g., CO, particulate matter [in two size ranges described later], nitrogen dioxide [NO_2], and SO_2). Three agencies have jurisdiction over the ambient air quality near T-5: the U.S. Environmental Protection Agency (USEPA), the Washington State Department of Ecology (Ecology), and the Puget Sound Clean Air Agency (PSCAA). These agencies establish regulations that govern the concentrations of pollutants in the outdoor air. Although their regulations are similar in stringency, each agency has established its own ambient air quality standards. Applicable local, state, and federal ambient air quality standards are displayed in **Table 1**. These standards have been set at levels that USEPA and Ecology have determined will protect human health with a margin of safety, including the health of sensitive individuals such as the elderly, the chronically ill, and the very young.

Ecology and PSCAA maintain a network of air quality monitoring stations throughout the Puget Sound area. In general, these stations are located where there may be air quality problems, and so are usually in or near urban areas or close to specific large air pollution sources. Other stations located in more remote areas provide indications of regional or background air pollution levels. Based on monitoring information for criteria air pollutants collected over a period of years, Ecology and EPA designate regions as being "attainment" or "nonattainment" areas for particular pollutants. Attainment status is, therefore, a measure of whether air quality in an area complies with the federal health-based ambient air quality standards for criteria pollutants. Once a nonattainment area achieves compliance with the National Ambient Air Quality Standards (NAAQSs), the area is considered an air quality "maintenance" area. The project study area is considered an air quality maintenance area for carbon monoxide (CO) and for fine particulate matter (PM_{10}). There have not been violations of the CO or the PM_{10} standards in the area in many years.

Table 1. Ambient Air Quality Standards for Criteria Pollutants

Pollutant	Terms of Compliance [a]	Concentration
Total Suspended Particulate (TSP)		
Annual Average (μg/m^3)	Geometric mean not to exceed	60 μg/m^3
24-Hour Average (μg/m^3) WA State only; no federal standard	Not to be exceeded more than once per year	150 μg/m^3
Inhalable Particulate Matter (PM_{10})		
Annual Average (μg/m^3)	Arithmetic mean; not to be exceeded	50 μg/m^3 [b]
24-Hour Average (μg/m^3)	The 3-year average of the 98th percentile of the daily concentrations must not exceed	150 μg/m^3
Fine Particulate Matter ($PM_{2.5}$)		
Annual Average (μg/m^3)	The 3-year annual average of daily concentrations must not exceed	12 μg/m^3
24-Hour Average (μg/m^3)	The 3-year average of the 98th percentile of daily concentrations must not exceed	35 μg/m^3
Sulfur Dioxide (SO_2) [(b)]		
Annual Average (ppm)	Annual arithmetic mean of 1-hour averages must not exceed	0.02 ppm [b]
24-Hour Average (ppm)	24-hour average must not exceed	0.10 ppm [b]
1-Hour Average (ppm)	1-hour average must not exceed	0.40 ppm [b]
1-Hour Average (ppm)	The 3-year average of the 99th percentile of daily max 1-hour conc. must not exceed	0.075 ppm
1-Hour Average (ppm)	No more than twice in 7 consecutive days may 1-hour average exceed	0.25 ppm [b]
Carbon Monoxide (CO)		
8-Hour Average (ppm)	The 8-hour average must not exceed more than once per year	9 ppm
1-Hour Average (ppm)	The 1-hour average must not exceed more than once per year	35 ppm
Ozone (O_3)		
8-Hour Average (ppm)	The 3-year average of the 4th highest daily maximum 8-hour average must not exceed	0.075 ppm
8-Hour Average (ppm) Revised 2015 [c]	The 3-year average of the 4th highest daily maximum 8-hour average must not exceed	0.070 ppm
Nitrogen Dioxide (NO_2)		
Annual Average (ppm)	The annual mean of 1-hour averages must not exceed	0.053 ppm
1-Hour Average (ppm)	3-year avg. of 98th percentile of daily max 1 hour averages must not exceed	0.1 ppm

Note: μg/m^3 = micrograms per cubic meter; ppm = parts per million; note that some standards also are sometimes expressed as parts per billion (ppb); standards for lead (Pb) not reported here

[a] All limits are federal and state air quality standards except as noted. All indicated limits represent "primary" air quality standards intended to protect human health.

[b] Washington State standards; Washington applies more stringent annual and 24-hour limits for SO_2 than in federal rules. There is also a federal 0.5 ppm 3-hour average "secondary" standard for SO_2 to protect welfare.

[c] The latest 8-hour ozone standard became effective 12/28/2015, but will not wholly replace the existing standard until the current standard is revoked, probably sometime in 2017.

2.1.2 Air Quality Conformity Review

Federal air quality "conformity" rules require review of some projects in areas that are designated as nonattainment or maintenance for one or more air pollutants. The Transportation conformity rules apply to large transportation projects and to components of other projects that would adversely affect operation of the regional transportation system. The General conformity rules apply to the portions of projects that are subject to permits or approvals by federal agencies. Each type of air quality conformity is discussed further below.

2.1.2.1 Transportation Conformity

Transportation projects in nonattainment and maintenance areas that affect the regional transportation system are subject to review under the federal and state air quality Transportation conformity rules. 40 CFR 93.123(a)(1) defines the projects requiring quantitative carbon monoxide (CO) hot-spot analysis and 40 CFR 93.123(b)(1) defines projects requiring quantitative fine particulate matter (PM) hot-spot modeling. Both sections require projects to be analyzed if they affect intersections that are Level-of-Service (LOS) D, E, or F or if the project will result in intersections with a LOS of D, E, or F. However, to trigger quantitative PM hot-spot modeling, a project must also include "a significant number of diesel vehicles." EPA guidance states that a facility servicing 125,000 average annual daily traffic (AADT) with 8% or more as diesel truck traffic would be considered significant (EPA 2015b).

Because the proposed project would potentially affect operation of several regionally significant arterial roads operating at LOS D or worse, it is subject to some level of review under the conformity rule. This rule is intended to prevent a project or action from causing a new air quality problem due to potential violations of an ambient air quality standard or the exacerbation of any existing problem by extending the time it takes to attain the standard. For this project, this means considering the emissions of both CO and PM (defined and discussed later) from off-site project-related traffic. This sort of review is typically accomplished using either screening or more sophisticated modeling tools, and for the T-5 project the transportation conformity review was conducted using an approved screening method to consider the potential for pollutant "hot spots."

2.1.2.2 General Conformity

Actions and plans in nonattainment and maintenance areas that require an approval or permit from a federal agency are subject to review under the General air quality conformity rule. This rule is intended to prevent a project or action from causing a new air quality problem due to potential violations of an ambient air quality standard or actions that might worsen any existing problem by extending the time it takes to attain the standard. Very importantly, the emissions subject to review under the general conformity rule must be subject to continuing control of the reviewing federal agency that issues the approval or permit. For the T-5 project, this means considering emissions of several air pollutants related to some parts of construction of the facility, while excluding both construction activities that are not subject to federal review and emissions from operation of the facility. The specific actions and pollutants considered are described in a later methods section.

2.2 Existing Air Quality Conditions

Existing sources of air pollution in the vicinity of the proposed project site include industry and transportation, including marine diesel-fueled vessels, both diesel and gas vehicles on the nearby roadways, and existing cargo-handling equipment. Criteria air pollutants of primary concern are NO_x and particulate matter (PM_{10} [coarse particulate matter of 10 microns in diameter or less] and $PM_{2.5}$ [fine particulate matter of 2.5 microns in diameter or less]). Other pollutants include ozone precursors (hydrocarbons and NO_x) and SO_2. Given the setting, industrial and transportation sources likely comprise the largest contributors to ambient pollutant concentrations in the vicinity of the project site. Wood smoke from residential wood combustion may also be a significant contributor to particulate matter concentrations in winter months.

Estimated existing concentrations of air pollutants in the general vicinity of the project site were developed based on monitored air data during 2012-2014 at the Beacon Hill and 10th and Weller monitoring sites and, as requested in the Draft EIS comments, during 2011-2013 at the Marginal Way Duwamish site for $PM_{2.5}$. Data from these monitors were used to estimate existing background concentrations for a variety of air pollutants. Modeled estimates of background provided by the Northwest International Air Quality Environmental Science and Technology Consortium[(1)] (NW AIRQUEST) were used if monitoring data were unavailable. Additionally, if the monitor data was less than that of the modeled estimates, the higher value was used to remain conservative. The exception to this rule was the background 1-hour NO_2 concentrations from Beacon Hill. These measurements provided background NO_2 variations by season and by hour of day. Applying background in this manner is consistent with EPA methodologies used for permitting purposes and accounts for the considerable variation in seasonal NO_2 concentrations. The background pollutant concentrations are included in the results tables in Chapter 4. Several pollutants of particular interest and their sources are described below.

[1] Northwest International Air Quality Environmental Science and Technology Consortium Overview (https:// www.lar.wsu.edu/nw-airquest/lookup_overview.html)

2.2.1 Inhalable Coarse and Fine Particulate Matter

Particulate matter air pollution is generated by industrial activities, fuel combustion sources like marine vessels, residential wood burning, locomotives, motor vehicle engines and tires, and other sources. Federal, state, and local regulations set limits for particulate concentrations in the air based on the size of the particles and the related potential threat to health. When first regulated, airborne particulate matter rules were based on concentrations of "total suspended particulate," which included all size fractions. As air sampling technology has improved and the importance of particle size and chemical composition to human health risk has become clearer, ambient standards have been revised to focus on the size fractions thought to be most dangerous to human health. Based on the most recent studies, USEPA has redefined the size fractions and set more stringent standards for particulate matter based on fine (i.e., $PM_{2.5}$) and coarse (i.e., PM_{10}) inhalable particulate matter to focus control efforts on the smaller size fractions.

There are currently health-based ambient air quality standards for PM_{10}, as well as for $PM_{2.5}$ (**Table 1**). $PM_{2.5}$ and even smaller (ultra-fine) particles are now thought to be the most harmful size fractions of airborne particulate matter.

With the revocation of the federal annual standard for PM_{10} in October 2006, the focus of ambient air monitoring and control efforts related to particle air pollution in the region has been almost entirely on $PM_{2.5}$. The model-calculated existing background $PM_{2.5}$ concentrations, shown in the results tables in Chapter 4, represent about half the daily and annual NAAQS. Particulate matter emissions attributable to T-5 were analyzed in detail as part of the air quality review documented here.

2.2.2 Ozone

Ozone is a highly reactive form of oxygen created by sunlight-activated chemical transformation of nitrogen oxides and volatile organic compounds (hydrocarbons) in the atmosphere. Ozone problems tend to be regional in nature because the atmospheric chemical reactions that produce ozone occur over a period of time, during which ozone precursors can be transported far from their sources. Transportation sources, including large marine vessels, locomotives, trucks, and general traffic are some of the sources that produce ozone precursors. Because ozone is not emitted directly, only very sophisticated air quality models are capable of assessing ozone formation in the atmosphere, and such models are typically used for regional assessments of air quality plans. Thus, ozone modeling is not typically performed for project-specific reviews, and ozone was not considered in this project-specific air quality analysis.

In October 2015, EPA adopted a more stringent primary NAAQS for ozone based on an 8-hour average concentration of 70 ppb that became effective December 28. The current standard of 75 ppb (**Table 1**) will remain in effect until it is revoked sometime in the next several years. The current standard and the new standard have no immediate implications for the proposed project.

2.2.3 Sulfur Dioxide

SO_2 is a colorless, corrosive gas produced by burning fuels containing sulfur like coal and oil, and by industrial facilities such as smelters, paper mills, power plants, and steel manufacturing plants. Except near large sources of SO_2, ambient SO_2 concentrations are typically well below federal standards.

The model-calculated existing background SO_2 concentrations shown in the results tables in Chapter 4 are about 6% and 7% of the daily and the annual NAAQSs, respectively.

Sources of SO_2 in the project vicinity include industry, vessels in transit and generating electrical power while moored (called hoteling), vehicles traveling on I-5 and other area roadways, and diesel locomotives. Potential SO_2 concentrations attributable to the proposed project were analyzed in detail as part of the air quality review documented in this report.

2.2.4 Carbon Monoxide

Carbon monoxide is the product of incomplete combustion. It is generated by transportation sources and other fuel-burning activities like residential space heating, especially heating with solid fuels like coal or wood. Carbon monoxide is usually the pollutant of greatest concern related to roadway transportation sources because it is the pollutant emitted in the greatest quantity for which short-term health standards exist. CO is a pollutant whose impact is usually localized, and CO concentrations typically diminish within a short distance of roads. The highest ambient concentrations of CO usually occur near congested roadways and intersections during wintertime periods of air stagnation.

Central Puget Sound was designated a CO nonattainment area in 1991. Because no monitoring stations have recorded violations of the standards in recent years, in 1997 EPA redesignated the Central Puget Sound region as attainment for CO. The region remains an air quality maintenance area for CO, but there have been no measured violations of the standards in many years, and the former CO problem is thought to have been resolved.

2.2.5 Nitrogen Oxides

Collectively, nitric oxide (NO) and nitrogen dioxide (NO_2) are commonly called oxides of nitrogen or NO_x. Other oxides of nitrogen, including nitrous acid and nitric acid are part of the nitrogen oxide family. Of this family of gasses, NO_2 is the only component for which ambient air quality standards have been established. An annual average standard for NO_2 that has been in effect for many years.

EPA adopted a new 1-hour standard for NO_2 that became effective in April 2010. NO_2 has not been measured in the project vicinity, though measurements have been taken at Beacon Hill. The 1-hour (by season and by hour of day) NO_2 background concentrations, described in section 2.2, and reported annual average concentrations presented in Table 1 indicate that background NO_2 concentrations are well below the current NAAQS. NO_2 concentrations attributable to sources associated with the proposed T-5 project are considered in detail in the air quality review documented in this report.

2.2.6 Toxic Air Pollutants

In addition to the criteria air pollutants for which health-protective air quality standards have been set, fuel combustion sources emit a number of known or suspected toxic air pollutants that may be directly harmful due to their chemistry and/or cause cancer or other detrimental effects to human health with long-term exposure. Although there are not any specific health-related air quality standards for such pollutants, Ecology and PSCAA have established screening levels for a variety of toxic air pollutants (TAPs) that can be used in assess predicted concentrations. One TAP, diesel engine exhaust particulate matter (DPM), was considered in this analysis because information regarding T-5 project-related emissions of this pollutant is expected to be of interest during the environmental review phase for this project.

A common method of assessing potential risk related to exposure to TAPs is to estimate the likelihood of increases in cancer due to a lifetime of exposure (usually assumed to be 70 years) to a given contaminant. Some screening levels for assessing such potential risk are based on an increased risk of one additional cancer among one million people. Ecology and PSCAA apply "Acceptable Source Impact Levels" (ASILs) during air quality permitting of proposed new or modified stationary emission sources. ASILs are applied based on the incremental changes in pollutant concentrations expected to occur due to proposed projects. The Washington State ASILs are not intended for use in evaluating emissions from mobile sources such as those associated with the T-5 project because such sources are not subject to air pollution permits. The ASILs nonetheless represent general benchmarks that can be used to assess potential risk related to exposure to TAPs.

As screening levels, ASILs and guidelines used to review predicted TAP concentrations are based on estimated health impact thresholds derived from scientific studies. Unlike the ambient air quality standards for criteria air pollutants which are adopted after rigorous review of the science involved, screening levels like ASILs are adopted based on much less thorough evaluations.

The ASIL referred to in this assessment is also fundamentally different than the ambient air quality standards (NAAQSs) adopted to protect human health and welfare with a margin of safety. The NAAQSs shown in Table 1 are designed to protect against known or suspected short-term acute and long-term chronic health effects due to exposure over certain periods of time. The NAAQSs are based on protecting even the most sensitive populations from exposure over periods ranging from 1 hour to 1 year. For example, SO_2 standards are based on 1-hour, 3 hour, 24-hour, and annual average concentrations, and the ambient standards for other criteria pollutants are similarly based on time-weighted average exposure limits.

In contrast, ASILs such as the one for DPM considered in this analysis are based on estimates of the risk of additional incidence of cancer in a population with continuous (i.e., 24 hours per day) exposure over 70 years. So instead of standards based on relatively well-defined dose-responses, the DPM screening levels are based on the estimated potential risk associated with long-term, constant exposure.

2.3 Meteorological Conditions and Climate

Air quality is substantially influenced by climate and meteorological conditions, so prevalent weather patterns are a major factor in both short and long-term air quality conditions. Regional geography affects climate in the T-5 study area. The combination of mountains and water create a regional meteorology unique to the Pacific Northwest. The climate in the proposed project study area is predominately temperate, characterized by wet, mild winters and dry, warm summers. The climate is influenced by the relative proximity of the Pacific Ocean and the Cascade Range of Washington.

Wind direction and wind speed are affected by geography so it is more difficult to represent predominant winds using more distant climatological data. Ramboll Environ created a 5-year meteorological data set for purposes of dispersion modeling using data from PSCAA's Duwamish monitoring site. These data captured all hourly combinations of meteorological conditions from 2010 through 2014 and provided the basis of the air quality modeling. These data are described more completely in section 3.2.1.7.

2.4 Greenhouse Gases and Global Climate Change

The phenomena of natural and human-caused effects on the atmosphere that cause changes in long-term meteorological patterns due to as climate change. Due to the importance of the greenhouse effect and related atmospheric warming to climate change, the gases that affect such warming are called GHGs. The GHGs of primary importance are CO_2, methane, and nitrous oxide. Because CO_2 is the most abundant of these gases, GHGs are usually quantified in terms of CO_2e, based on their relative longevity in the atmosphere and the related "global warming potential" of these constituents. CO_2 is not considered an air "pollutant" that causes direct health-related effects, so it is <u>not</u> subject to ambient air quality standards used to gauge pollutant concentrations in the air.

Fuel combustion used for transportation is a significant source of GHG emissions primarily through the burning of gasoline and diesel fuels. National estimates indicate the transportation sector (including on-road, construction, airplanes, and vessels) accounts for about 31 percent of total domestic CO_2e emissions from fossil fuels in 2014 (EPA 2016). In an interim tabulation of 2012 emissions within Washington, Ecology estimated transportation accounted for about 46 percent of statewide GHG emissions[2]; the higher percentage is due to lower GHG emissions from electrical generation because the state relies heavily on hydropower for electricity.

No specific federal, state, or local emission reduction requirements or targets are applicable to the proposed project, and there are no generally accepted emission level thresholds against which to assess potential localized or global consequences of GHG emissions. Ecology has issued internal guidance to assist its staff in determining which projects should be evaluated and how to evaluate GHG emissions under SEPA (Ecology 2011).

[2] http://www.ecy.wa.gov/climatechange/docs/2012GHGtable.pdf

3. ANALYTICAL METHODS

This chapter documents how Ramboll Environ conducted its analysis of the air quality implications of the project alternatives. Section 3.1 addresses emissions – the types and quantities of air pollutants created as engines in locomotives, trucks, cargo handling equipment, tugs and ships combust fuel. Emissions are typically measured in pounds per hour or tons per year. Evaluating facility-wide emissions over time can provide a general characterization of air quality effects, but emissions alone do not indicate whether a source has a significant impact on neighboring properties.

In order to determine and characterize air quality impacts, one must consider how the emissions from a source disperse in the atmosphere and affect off-site concentrations. Concentrations are commonly measured in micrograms (millions of a gram) per cubic meter of air (µg/m^3). It is standard industry practice to apply EPA-approved air quality computer models to calculate concentrations of air pollutants at off-site locations using the emissions information for the site and local meteorological conditions. Section 3.2 describes the computer model, the operating scenarios and meteorological inputs, and other modeling considerations. In Chapter 4, the results of the modeling (off-site concentrations of air pollutants) are identified and compared with national air quality standards to provide context for the impact assessment.

3.1 Emission Inventory Methods

The proposed modifications to T-5 would result in emissions from OGVs, harbor craft, locomotives, cargo-handling equipment, and on-road trucks. The emissions derived from these sources change in response to fleet turnover, engine deterioration rates, and regulatory triggers. These sources of emissions and their forecast changes in emissions were considered in the analysis and documented here.

3.1.1 Emission Factor Tools and Sources

The emissions estimates for project-related sources employed several standard computer tools as well as emission rate calculations using formulas published by the EPA, the California Air Resources Board, and topic-specific studies conducted by individual ports. Important assumptions employed in this portion of the assessment are summarized in **Table 2**.

3.1.2 Facility Operational Air Emissions

Ramboll Environ estimated combustion source emissions associated with full capacity operation of the terminal in 2020, 2030, and 2040 based on the maximum expected commodity throughput. The combustion source emissions assessment used detailed operational scenarios of peak hour, peak day, and annual levels of activities developed in discussions with the Port. Emission estimates considered the following sources:

- Vessels within the modeling domain that are in transit, maneuvering, and hoteling at berth;
- tugs assisting vessels during docking and undocking;
- empty and loaded trains traveling between East Marginal Way and the facility;
- a switch engine arranging train cars;
- cargo handling equipment, including yard tractors, top picks, RTGs, and RMGs; and
- on-road trucks traveling between East Marginal Way and the facility, queueing before the main gate, queueing at the main gate, and traveling on the facility.

Table 2 lists critical assumptions regarding terminal operations and basic dispersion modeling characteristics associated with project-related combustion sources.

Table 2. Tools, Sources, and Critical Assumptions

Equipment Type	Tool/Method Source and Critical Assumptions
Ocean-going Vessels & Tugs	**Emission Factors - OGV** • Emission factors based on 1,000 ppm (0.1%) S distillate fuel (in accordance with the 2015 IMO ECA requirements) [(a)] • Vessel average propulsion by TEU capacity [(b)] → 2,200 TEU: 19,391 kW → 5,500 TEU: 43,058 kW → 8,000 TEU: 65,833 kW → 14,000 TEU: 70,040 kW • Load factors were derived using the propeller law for propulsion engines. Conservatively assumed a 15 knot cruise speed outside of Elliott Bay and a 7 knot maneuvering speed inside the bay. • For hoteling, auxiliary power was calculated based on data collected during the Port of Los Angeles and Port of Long Beach vessel boarding study programs and reported in the Port of Los Angeles (PoLA) 2014 emission inventory. [(c)] → The PoLA 2014 maximum reported auxiliary power at berth (1,450 kW) for container ships was conservatively used for all vessel hoteling calculations. These reported power ratings describe engine load at berth and do not represent total available auxiliary engine power. • For cruise and maneuvering, auxiliary engine load factors and boiler loads were taken from EPA, 2009 [(d)]: → Auxiliary Cruising - 0.13 → Auxiliary Maneuvering - 0.48

Table 2. Tools, Sources, and Critical Assumptions

Equipment Type	Tool/Method Source and Critical Assumptions
	→ Boiler Maneuvering and Hoteling – 506 kW • Applied forecasted ECA-based NO_x adjustments from EPA, 2009 guidance. These adjustments account for IMO-imposed NOx control measures that reflect penetration of new, higher tier engines. • For 2020, 230 and 2040 respectively, shore power efficacy of 0%, 50%, and 70% was applied for Alternative 1, and 30%, 50%, and 70% efficacy was applied for the action alternatives as reported in Starcrest, 2016 [(d)] **Emission Factors – Tugs** • Propulsion assumed as two 1,540.1 kW Category 2 (conservative assumption) engines and two Category 1 auxiliary engines at 100.2 kW (EPA, 2009 [(d)] Table 3-10) • Propulsion and auxiliary engine loads taken from EPA, 2009 [(d)] (0.31 and 0.43 respectively) • Assumed Tier 2 propulsion and auxiliary engines for all years based on the Northwest Ports Clean Air Strategy goals for harbor craft by 2020, recent upgrade to Tier 3 for a tug serving the Port of Seattle, and on-going auxiliary engine replacement funded by the Clean Air Agency and the department of Ecology.[(n)] • PM emission factors corrected for ultra-low sulfur fuel content • Assume 2 tugs for each vessel **Operations** • Transit speed at 15 knots • Maneuvering Speed 7 knots • Vessels maneuver for approximately 40 minutes of activity within the model domain • Assumed 2 tugs for each vessel • Tugs escort inbound vessels starting from middle of Elliott Bay • Maneuvering occurs with tugs for approximately 20 minutes of activity to and from the dock • Time at berth (i.e., hoteling emissions) based on M&N estimates of berthing required for unloading • Considers two vessels hoteling simultaneously **Modeling** • Transiting vessels considered series of point sources • Annual modeling considered total annual emissions related to transiting, maneuvering, and hoteling vessels – distributed evenly in time and space, accounting for expected ship-to-shore power [(f)] • Short-term, 1-hour modeling initially included a single vessel and two tugs maneuvering to dock, and the vessel hoteling the remaining 20 minutes of the hour while a second vessel hotels for the entire hour [(g)]. However, analyses demonstrated that two

Table 2. Tools, Sources, and Critical Assumptions

Equipment Type	Tool/Method Source and Critical Assumptions
	hoteling vessels resulted in higher concentrations and thus this configuration was used for the model presented within this document. • Short-term, 24-hour modeling assumed two vessels trips, with tugs, and both vessels hoteling for the remaining period (g) • Conservatively, shore power was not considered for the 1-hour and 24-hour scenarios.
Locomotives	**<u>Emission Factors - Line-haul Locomotives</u>** • Conservatively assumed EPA-forecasted U.S. fleet average emission rates for class-I line-haul engines that reflect fuel quality requirements (m) • Per locomotive power assumed to be 4,300 HP • Assumed operations occur at idle (0.4% of rated power), notch 1 (5% of rated power), or notch 2 (11.4% of rated power) in and near the terminal • Conservatively assumed no AESS (automatic engine stop during idling) **<u>Emission Factors - Switch Locomotives</u>** • Conservatively assumed EPA-forecasted U.S. fleet average emission rates for switch engines that reflect fuel quality requirements (m) • Applied average time-in-notch weighted emission factors (d) • Assumed 3,000 HP per switch engine **<u>Operations</u>** • Arriving trains include 3 locomotives operating in notch 1 for an hour • Departing trains include 4 locomotives operating in notch 2 for about 30 minutes • Assumed a switch engine would operate for two hours per train, after the arriving train engines have split the cars and departed **<u>Modeling</u>** • Annual modeling based on total annual emissions evenly distributed in time and space across the entire year (f) • Annual modeling considered trains along all on-site rail routes and out to approximately East Marginal Way. • Short-term modeling considered reasonable worst-case conditions during periods up to 24-hours long (because this is the longest "short-term" ambient standard) (g)

Table 2. Tools, Sources, and Critical Assumptions

Equipment Type	Tool/Method Source and Critical Assumptions
	• Short-term, 1-hour modeling considered worst-case conditions by assuming departing train emissions on-site during any (and every) hour • Short-term, 24-hour modeling considered average daily train traffic, including arrivals, departures, and switch engine activity every day → Train movements were treated as a series of point sources onsite and offsite between the Facility and Marginal Way East
Trucks	**Emission Factors** • Modeled using USEPA's MOVES 2014a • Fleet data from Puget Sound Regional Council (PSRC) population and forecast using the PSRC approach of static relative fleet distributions [(i)] • High emitting older trucks not included in accordance with the Port's Clean Truck Program[(h)] to reduce truck emissions (2007 and newer model years by January 1, 2018) • Average daily emission rates calculated for the following conditions: → 35 mph off-site movement speed → 10 mph on-site movement speed → Daily average idle emission rate • Assumes short-haul combination trucks (MOVES Class 61) **Operations** • Operations considered for the main gate queue, pre-queue (assuming queueing for half the time at the main gate), on-site movements, and off-site movements extending to East Marginal Way • Modeling assumed peak daily truck traffic, and typical queue lengths based on traffic data provided by Heffron Transportation, Inc. **Modeling** • Modeled as series of point sources • Off-site truck traffic was considered in a separate analysis explained in Section 3.2.2
Cargo Handling Equipment	**Emission Factors** • Calculated emission rates (g/hp-hr) using USEPA's NONROAD model via MOVES2014a • Fleet turnover and deterioration rates estimated for 2020, 2030, and 2040

Table 2. Tools, Sources, and Critical Assumptions

Equipment Type	Tool/Method Source and Critical Assumptions
	• Equipment horsepower taken from the 2011 Puget Sound Emission Inventory except for RTGs • Communications with Total Terminals International indicated that the Port of Seattle RTGs have 535 HP engines [(j)] • Load factors for RTGs (20%) and Yard Tractors (39%) were taken from equipment-specific studies conducted by the Port of Los Angeles and the Port of Long Beach [(k)(l)] • The top pick load factor (59%) was taken from EPA, 2009 [(d)] • Equipment SCC values provided below: → Yard Tractors - SCC 2270003070 → Top Picks - SCC 2270003040 → RTGs - SCC 2270003050 **<u>Operations</u>** • Assumed activity and operations based on schedule provided by Moffatt & Nichol • The CHE schedule only considered operations during the 1st and 2nd shift and did not account for hoot shift activity (3am-8am) that may be required in irregular situations. **<u>Modeling</u>** • Under alternatives 1 and 2, the cargo handling equipment was assumed to operate throughout the site → Under alternative 3, cargo handling equipment emissions would occur in designated areas near the vessels and cranes or near the rail yard.

[(a)] The International Maritime Organization (IMO) has established a program to create and administer Emission Control Areas (ECA) intended to result in lower emissions within specially designated areas.

[(b)] Lloyd's Registry of Ships, Containership Records by TEU Capacity, Purchased and Accessed in 2012

[(c)] *2014 Port of Los Angeles Emission Inventory*, September 2015. https://www.portoflosangeles.org/pdf/2014_Air_Emissions_Inventory_Full_Report.pdf

[(d)] EPA, 2009. *Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories*. USEPA Office of Policy, Economics, and Innovation. April 2009

[(e)] *Forecasting the Penetration of On-Shore Power Supply (OPS) Capable Container Ships*, Memorandum from Starcrest Consulting to the Northwest Seaports Alliance, February 2016.

[(f)] "Annual" modeling refers to the process of assessing pollutant emissions and concentrations based on expected emissions over an entire year. Calculated concentrations are compared with ambient standards based on annual statistics and/or with annual average health risk estimate criteria.

[(g)] "Short-term" modeling refers to assessments considering emissions and concentrations to be compared with short-term ambient standards such as 1-hour and 24-hour averages.

Table 2. Tools, Sources, and Critical Assumptions

Equipment Type	Tool/Method Source and Critical Assumptions
[h] Port of Seattle's Clean Truck Program, Accessed February 2016, http://www.portseattle.org/Environmental/Air/Seaport-Air-Quality/Pages/Clean-Trucks.aspx [i] Personal Communication between Ramboll Environ and the Puget Sound Regional Council, Rebecca Frohning, February 8, 2016 [j] Personal Communication between Ramboll Environ, Moffatt & Nichol, and Total Terminals International, March 9, 2016 [k] 2008, POLA and POLB, *Yard Tractor Load Factor Study Addendum* [l] 2009, POLA and POLB, *Rubber Tired Gantry Crane Load Factor Study* [m] EPA, 2009a. *Emission Factors for Locomotives*, Office of Transportation and Air Quality, April 2009. [n] *Northwest Ports Clean Air Strategy: 2014 Implementation Report*, October 2015, https://www.portseattle.org/Environmental/Air/Seaport-Air-Quality/Documents/2014_nw_ports_clean_air_strat_report.pdf	

3.1.3 Greenhouse Gas Emissions

Ramboll Environ estimated short-term GHG emissions associated with construction and long-term emissions related to operation of the proposed facility based on the proposed configurations and combustion source activity. Those emissions estimates considered combustion source emissions directly related to the construction and operation of the facility (Scope 1), indirect emissions from purchased energy (Scope 2), and indirect emissions due to combustion sources associated with the operational activities of the facility (Scope 3). The estimates also included indirect emissions associated with product delivery by rail, along with emissions associated with transferring products via vessel (from the wharf out to the edge of the modeling domain). Emissions of CO2, N2O, and CH4 were calculated using the assumptions and models described in **Table 2**.

3.2 Dispersion Modeling

Ramboll Environ used air quality dispersion modeling simulations to estimate air pollutant concentrations due to emissions from on-site emission sources associated with selected alternatives and throughputs. This section discusses the methods used to develop these simulations for T-5.

3.2.1 Modeling Operations

The U.S. EPA has designated AERMOD as the preferred guideline air dispersion model for air dispersion modeling (EPA "Guideline on Air Quality Models," codified as Appendix W to 40 CFR Part 51) for complex source configurations and for sources subject to exhaust plume down-wash. AERMOD incorporates numerical plume rise algorithms (the PRIME algorithms) that implicitly include the downwash effects a structure may have on an exhaust plume rather than using the wind tunnel based empirical algorithms of ISCST3. The PRIME algorithm also treats the geometry of upwind and downwind structures and their relationship to the emission point.

3.2.1.1 Model Setup and Application

Ramboll Environ employed the most recent version of AERMOD (version 15181) with meteorological data from PSCAA's Duwamish monitoring station and regional upper air data from Quillayute, Washington. Missing surface data observations were substituted from the Boeing Field station. The meteorological data were processed with AERMET (version 15181) using the adjust U-star (ADJ_U*) option to account for over predictions due to low wind speeds under very stable conditions. The ADJ_U* option is listed in the draft of Appendix W to become a default option for this sort of modeling in the near future. The meteorological pre-processing also included an analysis of the physical characteristics of land use surrounding the terminal.

3.2.1.2 NO_2 Modeling – PVMRM

Ramboll Environ applied the Plume Volume Molar Ratio Method (PVMRM) within AERMOD to allow the model to consider factors that affect both NO_2 emission rates and resulting concentrations in the ambient air. This EPA-designated Tier 3 method is the most technically rigorous approach and was used instead of less detailed Tier 1 and Tier 2 methods. The PVMRM method accounts for both direct NO_2 emissions from stacks (e.g., locomotive exhausts) as well as atmospheric transformations that create NO_2 in the presence of estimated concentrations of ozone. Atmospheric formation of NO_2 from NO_x sources in the project study area is almost certainly limited due to the lack of ozone. For this portion of the analysis Ramboll Environ assumed 10% of exhaust emissions from mobile sources were NO_2 and up to 80% of NO_x could be converted to NO_2 in the atmosphere (Boulter, 2007).

Hourly ozone monitoring data were collected from the Beacon Hill ozone monitor (ID 53-033-0088) for the entire modeling period (2011-2014). Missing hourly ozone data were substituted using the 98th percentile of hourly concentrations (i.e., 44 ppb).

3.2.1.3 Elevation Data and Receptor Network

Dispersion modeling receptor elevations were estimated using digital elevation models developed by the United States Geological Survey (USGS) and available on the USGS National Map system. These data have a horizontal spatial resolution of approximately 10 meters (m). The base elevation and hill height scale for each receptor were determined using the EPA terrain processor AERMAP (version 11103). AERMAP generates a receptor output file that is read by AERMOD.

The dispersion modeling analyses used modeling receptors spaced 1000 meters apart covering the 10 kilometer (km) by 15 km simulation domain, with a 10-km by 10-km nested receptor grid at 500-m spacing, a 5-km by 5-km nested receptor grid at 200-m spacing, a 3 km by 3 km nested receptor grid at 50-m spacing, a 1.8 km by 1.8 km nested receptor grid at 25-m spacing, and fence line receptors with 10-m spacing. The modeling domain and receptor locations are depicted in attached Figure 1.

3.2.1.4 Operational Scenario Selection

Ramboll Environ developed six modeling scenarios for the terminal based on alternative throughputs and associated modeling years. The modeling analysis assumed full-capacity operation for all emission source activities. The selected modeling scenarios considered with air quality modeling are shown in **Table 3** with filled cells. Empty cells in this table were not considered with modeling because operations would not be possible due to physical and year-based economic limitations on the facility.

Table 3. Operational Scenarios Considered with Air Quality Modeling

Throughput	Year	Alt. 1	Alt. 2	Alt. 3
647K TEUs	2020	●	●	●
1.27MM TEUs	2030		●	●
1.7MM TEUs	2040			●

Modeling was not conducted for the 2030 and 2040 throughput scenarios for Alternative 1, or the 2040 throughput scenario for Alternative 2. Alternative 1, with no improvements, would not allow the port to expand throughput beyond 647,000 TEUs. Similarly, Alternative 2 could not support 1,700,000 TEU throughput without the cargo-handling equipment changes proposed in Alternative 3. Assessing emissions in future years without additional growth in throughput would result in lower emissions due to fleet turnover and regulatory changes. Accordingly, the scenarios not modeled would be expected to produce lower maximum concentrations than the modeled scenarios. The selected scenarios provided in **Table 3** are reflective of the most conservative configurations with the highest emissions and maximized throughput. See **Table 6** for total emissions (tons/year) expected for each alternative in each year.

3.2.1.5 Dispersion Modeling Source Parameters

The modeling scenarios considered and the emissions parameters for all the sources considered in the dispersion modeling assessment are presented in Attachment E.

3.2.1.6 Averaging Periods

Pollutant concentrations predicted by the model were averaged over annual and short-term (1, 3, 8, and 24-hour) periods, as appropriate for a given pollutant's ambient standards or screening level. The modeling assessments for the CO standards and the short-term SO_2, $PM_{2.5}$, and NO_2 standards were based on the peak-day modeling described above. The assessments for comparison with the ambient standards for PM_{10}, $PM_{2.5}$, and the annual SO_2 and NO_2 concentrations were all based on the annual operations modeling scenarios due to the statistical techniques required for assessing compliance.[3]

3.2.1.7 Meteorological Data

Ramboll Environ constructed a 5-year meteorological data set for use in the AERMOD dispersion model using surface and upper air data for the period of 2010 through 2014 after conducting a survey of available and complete meteorological data for use in the modeling simulations. For surface meteorological data, the closest and most representative PSCAA station was the Duwamish River Valley, in Washington. A wind rose presenting wind speed and wind direction data for the five year period is shown in Figure 2. The wind rose indicates that the winds are observed and modeled for all directions, but predominantly arrive from the south

Because winds from the south are most common, annual average pollutant concentrations are higher north of T5 (over Elliot Bay) than south of T5. However, winds from every wind direction occur some hours of the year, so all wind directions have the potential to affect short term (hourly or daily) pollutant concentrations. AERMOD evaluation calculates pollutant concentrations at each of the 7,000 receptor locations for each hour of the five year period. Consequently, the analysis addresses the full range of meteorological conditions that occur in the project vicinity.

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[3] For example, the $PM_{2.5}$ 24-hour standard is based on the 3-year average of the 98th percentile of daily concentrations, which eliminates one or more of the highest concentrations each year and requires averaging the results. These calculations can be completed with the AERMOD model based on the realistic annual operations scenario, and cannot be based on the worst-case day modeling process used to evaluate not-to-exceed short-term standards. Thus, the annual operations modeling scenario was used to consider $PM_{2.5}$ and PM_{10} which are subject to statistical ambient standards.

Upper air data from Quillayute, Washington were also used for the 5-year meteorology data set. The Quillayute upper air data were compiled from the National Oceanic and Atmospheric Administration (NOAA) Forecast Systems Laboratory Radiosonde Database.[(4)]

EPA guidance indicates that surface parameters (albedo, Bowen ratio, and surface roughness) surrounding the primary meteorological site should be used in AERMET to construct the meteorological profiles used by AERMOD. Seasonal surface parameters were determined for the Duwamish and Boeing Field meteorological site using the AERMET preprocessor, AERSURFACE (Version 13016).

3.2.2 Transportation Conformity "Hot-spot" Modeling

Ramboll Environ reviewed the traffic study performed by Heffron Transportation Group to determine the applicability of PM and CO hot-spot modeling. The specific models and analysis methods are described below.

3.2.2.1 PM Hot-spot Determination

PM hot-spot analyses are only required for projects of local air quality concern. These projects include highway and transit projects that involve significant levels of diesel vehicle traffic. EPA has indicated facilities serving greater than 125,000 annual average daily traffic (AADT) with 8% or more (i.e., 10,000 or more) of such AADT as diesel truck traffic would be considered a significant level of diesel vehicle traffic (EPA 2015b). Based on review of the traffic study, the maximum total average daily trips would occur in 2040 with the project. Under Alternative 3 in 2040, Terminal 5 is expected to serve 3,320 average daily truck trips and 4,660 design day truck trips. These volumes are well below the 10,000 average annual daily truck trips that would represent significant levels of diesel vehicle traffic. Therefore, a quantitative hot-spot analysis was not required for PM.

3.2.2.2 Intersection Screening

The traffic study considered seven project-affected intersections in the study area. Ramboll Environ screened these intersections for possible "hot-spot" modeling based on review of intersection LOS and delay (in average seconds per vehicle) in future years. The intersection, highlighted in **Table 4**, indicates SW Spokane St / West Marginal Way SW / Chelan Ave SW would be worse than any other intersection under every alternative based on LOS, delay, and traffic volumes (volumes not reported here). Since idling vehicle emissions represent the greatest source of traffic-related CO emissions, this five-way intersection was selected for quantitative CO "hot-spot" modeling based on the methods, described further, below.

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(4) http://esrl.noaa.gov/raobs/

Table 4. Intersection Level-of-Service (LOS) during PM Peak Hour

Intersection	2020		2030				2040			
	No Action		No Action		1.27 M TEU/Yr		No Action		1.7 M TEU/Yr	
	LOS	Delay (a)	LOS	Delay (a)	LOS	Delay (a)	LOS	Delay (a)	LOS	Delay (a)
SW Spokane St / Harbor Ave SW	C	22	D	36	D	40	D	50	D	43
SW Spokane St / West Marginal Way SW / Chelan Ave SW (b)	F	124	F	191	F	204	F	282	F	301
SW Spokane St / Terminal 5 Access	B	18	C	25	C	34	D	41	D	53
SW Spokane St / 11th Avenue SW	A	5	A	7	A	7	A	9	A	10
S Spokane St / East Marginal Way S	C	31	E	57	E	57	E	66	E	66
S Hanford St / East Marginal Way S	C	26	D	43	D	43	E	80	F	81
East Marginal Way NB Ramp / North Argo Access Road 3	B	13	B	15	B	15	B	19	B	19

Notes:
(a) Delay represents the average traffic delay at the intersection, in seconds per vehicle.
(b) The highlighted intersection represents the worst-performing project-affected intersection included in the traffic study.

Source of traffic data: Heffron Transportation Group 2016

The traffic volumes and total delays of the top three worst performing intersections are compared in **Table 5**. This table indicates SW Spokane St / West Marginal Way SW / Chelan Ave S has the most traffic and total delay of the worst-performing intersections. Based on the comparison of intersection volumes, delays, and LOS, the potential air quality impacts at any other intersection would likely be less than at this intersection. Therefore, this intersection was selected for evaluation using dispersion modeling for the alternatives considered in the traffic study.

Table 5. Intersection Traffic Volume and Total Delay Comparison

Intersection	2020		2030				2040			
	No Action		No Action		1.27 M TEU/Yr		No Action		1.7 M TEU/Yr	
	Vol.	Total Delay	Vol.	Total Delay	Vol.	Total Delay	Vol.	Total Delay	Vol.	Total Delay
SW Spokane St / West Marginal Way SW / Chelan Ave SW	2440	84	2830	150	2911	165	3290	258	3418	286
S Spokane St / East Marginal Way S	1435	12	1685	27	1693	27	1960	36	1965	36
S Hanford St / East Marginal Way S	1045	8	1220	15	1225	15	1435	32	1439	32

Notes:
Vol. represents the total intersection volume, in vehicles per hour.
Total Delay is calculated by multiplying intersection volume and average vehicle delay, expressed in hours.
The highlighted intersection represents the project-affected intersection with the greatest volume and total delay.
Source: Traffic volumes and average delays by Heffron Transportation Group, 2016

3.2.2.3 Emission Factor Model Setup and Application

Traffic-related air quality dispersion modeling requires vehicle emission factors for the years and region of interest. Under current air quality rules, the EPA motor vehicle emission simulator model, MOVES, is required to generate emission factors for this purpose. The Puget Sound Regional Council (PSRC), Ecology, and other agencies have developed standard inputs for use in MOVES modeling for analyses of various plans and projects. Vehicle emission factors are calculated in grams of pollutant per vehicle mile-of-travel based on a wide array of vehicle classes, basic emission rates, driving patterns, separation of start and running emissions, and fleet composition. Ramboll Environ employed the following assumptions in MOVES modeling:

- Methodology based on EPA guidance (EPA 2015a)
- King County meteorology and vehicle database files provided by PSRC (Rebecca Frohning, email February 8, 2016); files include vehicle age distribution, I&M coverage, fuel supply, and fuel formulation - all developed by Ecology for the 2014 emissions inventory
- Local traffic composition adjusted based on traffic volume data provided by Heffron Transportation Group
- MOVES operated in Inventory Mode/Project scale using road type "Urban Unrestricted" for summer and winter weekday, hour 5 p.m., for all fuel types and vehicle classifications

3.2.2.4 Hot-spot Dispersion Modeling

Ramboll Environ used the EPA CAL3QHC dispersion model (version 2.0, dated 04244) to calculate peak-hour CO concentrations near the single most project affected intersection. CAL3QHC is designed to calculate pollutant concentrations caused by transportation sources. It considers "free-flow" and "queue" emissions based on MOVES emission factors together with intersection geometry, wind direction, and other meteorological factors.

The following assumptions and parameters were used in the CAL3QHC modeling. These factors are consistent with the Washington State CO SIP, CO Maintenance Plan, and EPA guidance for dispersion modeling:

- Meteorological parameters included a 1,000-meters mixing height, low wind speed (1 m/s) and a neutral atmosphere (Class D)
- Modeling evaluated 72 wind directions (in 5 degree increments) to ensure worst-case conditions were considered for each receptor location
- A "background" 1-hour carbon monoxide concentration of 5 ppm was assumed to represent other sources in the project area
- The modeling configuration considered road links extending more than 1,000 feet from the single worst-operating intersection in the study area
- Both free-flow and queue links were configured approaching and departing the intersection
- Near-road receptors were placed along all roadways where sidewalks, bike paths, or other areas accessible by pedestrians exist. Receptors were located about 3, 25, 50, and 100 meters from cross streets, 3 meters from the nearest traffic lane, and 1.8 meters above ground (typical sidewalk locations at breathing height)
- Modeled calculated 1-hour CO concentrations were converted to represent 8-hour concentrations using a 0.7 "persistence factor" (i.e., the ratio of 8-hour to 1-hour CO concentrations) to represent variability in both traffic volumes and meteorological conditions.

4. AIR QUALITY ANALYSIS RESULTS

The air quality analysis results present the emissions modeling and dispersion modeling results for construction and operational scenarios. As indicated in the prior section, the mass of emissions expected to be produced by the on-site equipment for each scenario is reported. Then the results of dispersing these emissions for every hour of 5-years of meteorological data is reported as the maximum off-site concentrations.

4.1 Alternative 1

4.1.1 Construction

As described in section 1.2.1, Alternative 1 represents no change to the current facility or operating practices. Without wharf rehabilitation, berth deepening, or other improvements, no construction-related emissions would be produced.

4.1.2 Operation

4.1.2.1 Emissions

The emission factors of criteria air pollutants from full capacity operation of T-5 in 2020 are presented in **Attachment A** (**Table 19**). Source-specific annual emissions are provided in **Attachment B** (**Table 22**). The total estimated annual operational emissions for alternative 1 are presented in **Table 6**.

Table 6. Annual Alternative 1 Emissions (tpy)

Pollutant	Alt 1		
	2020	2030	2040
PM_{10}	7.4	5.2	4.8
$PM_{2.5}$	7.0	4.8	4.5
SO_2	8.0	8.0	8.0
CO	49.7	39.2	37.4
NO_2	254.5	161.1	154.6

Emissions are, in many cases, lower in successive years because engine emissions are generally decreasing over time, and vehicles are increasingly required to use ultra-low sulfur distillate fuel. The improving emission factors reflect regulatory requirements of engine manufacturers, regulations on in-use fuel for ocean-going vessels and harbor craft, and EPA-model predicted turnover of the cargo-handling equipment fleet for King County. The validity of emission improvements is proven by decades of success with federal mobile source emissions regulations improving urban air quality throughout the United States.

4.1.2.2 Off-Site Concentrations

With no physical changes to T-5, operations would be consistent with those that have occurred in the past. Potential emissions would be lower than in the past because engine emissions are generally decreasing over time with fleet turnover and because equipment are increasingly required to use ultra-low sulfur distillate fuel.

As noted above, Ramboll Environ calculated pollutant concentrations at more than 7,300 locations in the vicinity of T-5. Of all those receptors, the highest model-predicted concentrations of criteria air pollutants attributable to capacity operation of T-5 in 2020 – with existing ambient air quality concentrations added - are presented in **Table 7**. **Table 7** indicates that the maximum predicted concentrations of all pollutants comply with ambient air quality standards, which are designed to be protective of human health.

Table 7. Alternative 1 Modeling Results: Maximum Criteria Pollutant Concentrations (μg/m³)

Criteria Pollutant	Averaging Time	Background Conc. [(a)]	Project-Related Conc. [(b)(c)] 2020; 0.64M TEUs	Project Conc. with Background 2020; 0.64M TEUs	Ambient Standard [(d)]
CO	1-hour	3,779	64.0	3842.5	40,000
	8-hour	1,947	40.2	1986.7	10,000
NO_2	1-hour	Varies [(e)]	N/A	183.7	188
	Annual	26.3	41.1	67.4	100
$PM_{2.5}$	24-hour	24.3	2.9	27.2	35
	Annual	10.2	1.2	11.4	12
PM_{10}	24-hour	48	4.0	52.0	150
SO_2	1-hour	68.1	19.9	88.0	196
	3-hour	52.4	17.1	69.5	1,310
	24-hour	21.5	8.7	30.2	365 [(f)]
	Annual	3.7	1.3	5.0	52 [(f)]

[(a)] Background concentrations (expressed as μg/m³) based on the higher of nearby monitor design values (identified as complete by EPA) or values provided by Northwest Airquest 2009-2011 design values specific to the Terminal-5 location, except for 1-hr NO_2.

[(b)] Reported pollutant concentrations are those occurring at the maximum impact location for each pollutant. Concentrations at all other locations are less than those reported here.

[(c)] Except as noted below, all short-term concentrations are based on modeling that considered maximum hourly activity during every hour of the 5-year meteorological data set, which is not a possible actual level of activity. These results therefore represent intentionally conservative conditions. Note that consistent with USEPA guidance, the annual modeling results are based on 5-year averages from the 5-year meteorological data set instead of 3-year as per the NAAQSs.

[(d)] All ambient concentrations are expressed in terms of micrograms per cubic meter (μg/m³); importantly, other sources may report the ambient air quality standard concentrations in parts per million (ppm) or parts per billion (ppb).

[(e)] Hourly and seasonal variation were assessed at Beacon Hill and incorporated into the dispersion model. The use of this form of background concentrations is consistent with EPA guidance.

[(f)] Denote Washington State ambient air quality standard (only, i.e., no federal standard)

4.2 Alternative 2

4.2.1 Construction

The T-5 wharf rehabilitation, berth deepening, and other improvements would include grading, re-paving, utility trenching, demolition of portions of the wharf and other substantial infrastructure improvements. Such activities could result in temporary, localized increases in particulate concentrations due to emissions from construction-related sources. For example, dust from construction activities such as excavation, grading, sloping and filling would contribute to ambient concentrations of suspended particulate matter. Construction contractor(s) would be required to comply with PSCAA regulations requiring that reasonable precautions be taken to minimize dust emissions.

If demolition of any existing structures is required it might require the removal and disposal of building materials that could possibly contain asbestos. If this proves to be the case, demolition contractors would be required to comply with EPA and PSCAA regulations related to the safe removal and disposal of any asbestos-containing materials.

Construction would require the use of heavy trucks, excavators, graders, work vessels, pile drivers, and numerous types of smaller equipment such as generators, pumps, and compressors. Based on numerous previous analyses and evaluations, emissions from existing industrial and transportation sources around the project area would very likely outweigh any emissions resulting from construction equipment. Pollution control agencies are nonetheless now urging that emissions from diesel equipment be minimized to the extent practicable to reduce potential health risks. With appropriate controls, construction-related diesel emissions would not be likely to substantially affect air quality in the project vicinity. Recent construction specifications for Port-related projects include requirements such as; use of Tier 2 or better engines for off-road equipment; use of model year 2007 or newer engines for heavy duty vehicle; use of biofuel B20,and; idle reduction plan.

Although some construction phases would cause odors, particularly during paving operations using tar and asphalt, any odors related to construction would be short-term and located within commercial/industrial land uses where such odors would likely go unnoticed. Construction contractor(s) would be required to comply with PSCAA regulations that prohibit the emission of any air contaminant in sufficient quantities and of such characteristics and duration as is, or is likely to be, injurious to human health, plant or animal life, or property, or which unreasonably interferes with enjoyment of life and property.

Construction equipment and material hauling can affect traffic flow in a project area if construction vehicles travel during peak periods or other heavy-traffic hours of the day and pass through congested areas.

With implementation of the controls required for the various aspects of construction activities and consistent use of best management practices to minimize on-site emissions, construction of the proposed project would not be expected to significantly affect air quality.

4.2.2 Operation

4.2.2.1 Emissions

Emission factors of criteria air pollutants with full capacity Alternative 2 operation in 2020 and 2030 are presented in **Attachment A** (**Table 19** and **Table 20**), source-specific annual emissions are provided in **Attachment B** (**Table 23**), and alternative 2 emissions are reported in **Table 8**.

Table 8. Annual Alternative 2 Emissions (tpy)

Pollutant	Alt 2		
	2020	2030	2040
PM_{10}	6.3	6.4	4.4
$PM_{2.5}$	6.0	5.9	4.0
SO_2	4.3	5.1	3.6
CO	42.4	52.6	42.5
NO_2	180.9	156.7	117.6

Emission factors are, in many cases, lower in successive years because engine emissions are generally decreasing over time, vehicles are increasingly required to use ultra-low sulfur distillate fuel, and because of the use of shore power. The improving emission factors reflect regulatory requirements of engine manufacturers, regulations on in-use fuel for ocean-going vessels and harbor craft, and EPA-model predicted turnover of the cargo-handling equipment fleet for King County. The validity of emission improvements is proven by decades of success with federal mobile source emissions regulations improving urban air quality throughout the United States. Additionally, larger vessels expected to serve Seattle are newer, and more fuel efficient per unit of cargo. The number of vessels needed to transport cargo will decrease even if cargo throughput increases.

4.2.2.2 Off-Site Concentrations

The physical and operational changes associated with Alternative 2 would enable an increase in container throughput capacity. Model-predicted concentrations of criteria air pollutants attributable to capacity operation in 2020 and 2030 are presented in **Table 9**. As shown in **Table 9**, the maximum model-predicted concentrations of all pollutants comply with ambient air quality standards, which are designed to be protective of human health.

Emissions are expected to decrease or be unchanged in 2040 because no design or throughput change is expected.

Table 9. Alternative 2 Modeling Results: Maximum Criteria Pollutant Concentrations (µg/m^3)

Criteria Pollutant	Avg. Time	Back-ground Conc. [a]	Project-Related Conc. [b], [c]		Project Conc. with Background		Ambient Standard [d]
			2020; 0.64M TEU	2030; 1.27M TEU	2020; 0.64M TEU	2030; 1.27M TEU	
CO	1-hour	3,779	48.8	48.7	3827.3	3827.2	40,000
	8-hour	1,947	35.2	35.2	1981.7	1981.7	10,000
NO_2	1-hour	Varies [e]	N/A	N/A	179.6	163.3	188
	Annual	26.3	25.1	21.6	51.4	47.9	100
$PM_{2.5}$	24-hour	24.3	2.6	2.3	26.9	26.6	35
	Annual	10.2	1.1	0.9	11.3	11.1	12
PM_{10}	24-hour	48	3.0	2.8	51.0	50.8	150
SO_2	1-hour	68.1	13.1	13.2	81.2	81.3	196
	3-hour	52.4	11.5	11.6	63.9	64.0	1,310
	24-hour	21.5	5.8	5.9	27.3	27.4	365 [f]
	Annual	3.7	0.5	0.5	4.2	4.2	52 [f]

[a] Background concentrations (expressed as µg/m^3) based on the higher of nearby monitor design values (identified as complete by EPA) or values provided by Northwest Airquest 2009-2011 design values specific to the Terminal-5 location, except for 1-hr NO_2.

[b] Reported pollutant concentrations are those occurring at the maximum impact location for each pollutant. Concentrations at all other locations are less than those reported here.

[c] Except as noted below, all short-term concentrations are based on modeling that considered maximum hourly activity during every hour of the 5-year meteorological data set, which is not a possible actual level of activity. These results therefore represent intentionally conservative conditions. Consistent with USEPA guidance, the annual modeling results are based on 5-year averages from the 5-year meteorological data set instead of 3-year as per the NAAQSs.

[d] All ambient concentrations are expressed in terms of micrograms per cubic meter (µg/m^3); importantly, other sources may report the ambient air quality standard concentrations in parts per million (ppm) or parts per billion (ppb).

[e] Hourly and seasonal variation were assessed at Beacon Hill and incorporated into the dispersion model. The use of this form of background concentrations is consistent with EPA guidance.

[f] Denote Washington State ambient air quality standard (only, i.e., no federal standard)

4.3 Alternative 3

4.3.1 Construction

As described in section 1.2, Alternatives 2 and 3 have the same construction-related improvements, despite the distinct differences in operations. The construction-related emissions associated with Alternatives 2 and 3 are described in section 4.2.1.

4.3.2 Operation

4.3.2.1 Operational Emissions

Emission factors of criteria air pollutants with full capacity Alternative 3 operation in 2020, 2030, and 2040 are presented in **Attachment A** (**Table 19**, **Table 20**, and **Table 21**, respectively). Source-specific annual emissions are provided in **Attachment B** (**Table 24**) and total project emissions are reported in **Table 10**.

Table 10. Annual Alternative 3 Emissions (tpy)

Pollutant	Alt 3		
	2020	2030	2040
PM_{10}	2.8	3.3	3.2
$PM_{2.5}$	2.6	2.9	2.8
SO_2	3.5	4.0	3.4
CO	20.6	26.5	29.5
NO_2	115.1	93.3	82.2

Emission factors are, in many cases, lower in successive years because engine emissions are generally decreasing over time, vehicles are increasingly required to use ultra-low sulfur distillate fuel, and because of the use of a second truck gate and reservation system. The improving emission factors reflect regulatory requirements of engine manufacturers, regulations on in-use fuel for ocean-going vessels and harbor craft, and EPA-model predicted turnover of the cargo-handling equipment fleet for King County. The validity of emission improvements is proven by decades of success with federal mobile source emissions regulations improving urban air quality throughout the United States. Additionally, larger vessels expected to serve Seattle are newer, and more fuel efficient per unit of cargo. The number of vessels needed to transport cargo will decrease even if cargo throughput increases. Project-specific total emissions frequently decrease over time, despite the increased intermodal activity, due to the increased adoption of shore power and due to fleet turn-over. The trends in emissions across alternatives and throughputs are described in more detail in section 4.3.2.2.

4.3.2.2 Predicted Off-Site Concentrations

The physical and operational changes associated with Alternative 3 would enable an increase in container throughput capacity. The maximum model-predicted concentrations of criteria air pollutants attributable to capacity operation in 2020, 2030, and 2040 are presented in **Table 11**. As shown in **Table 11**, the maximum model-predicted concentrations of all pollutants comply with ambient air quality standards. Increased electrification and lower engine emissions offset the increase in container throughput capacity to result in lower future concentrations.

Table 11. Alternative 3 Modeling Results: Maximum Criteria Pollutant Concentrations (μg/m³)

Criteria Pollutant	Avg. Time	Back-ground Conc. [a]	Project-Related Conc. [b][c]			Project-Related Conc. w/ Background			Ambient Standard [d]
			2020; 0.64M TEU	2030; 1.27M TEU	2040; 1.70M TEU	2020; 0.64M TEU	2030; 1.27M TEU	2040; 1.70M TEU	
CO	1-hour	3,779	40.5	40.4	40.8	3819.0	3818.9	3819.3	40,000
	8-hour	1,947	26.4	26.2	26.9	1972.9	1972.7	1973.4	10,000
NO_2	1-hour	Varies [e]	148.3	139.5	139.1	148.3	139.5	139.1	188
	Annual	26.3	12.5	10.3	9.4	38.8	36.6	35.7	100
$PM_{2.5}$	24-hour	24.3	1.8	1.7	1.8	26.1	26.0	26.1	35
	Annual	10.2	0.3	0.3	0.2	10.5	10.5	10.4	12
PM_{10}	24-hour	48	2.5	2.4	2.4	50.5	50.4	50.4	150
SO_2	1-hour	68.1	13.1	13.1	13.1	81.2	81.2	81.2	196
	3-hour	52.4	11.4	11.4	11.5	63.8	63.8	63.9	1,310
	24-hour	21.5	5.8	5.8	5.8	27.3	27.3	27.3	365 [f]
	Annual	3.7	0.4	0.4	0.3	4.1	4.1	4.0	52 [f]

[a] Background concentrations (expressed as μg/m³) based on the higher of nearby monitor design values (identified as complete by EPA) or values provided by Northwest Airquest 2009-2011 design values specific to the Terminal-5 location, except for 1-hr NO_2.

[b] Reported pollutant concentrations are those occurring at the maximum impact location for each pollutant. Concentrations at all other locations are less than those reported here.

[c] Except as noted below, all short-term concentrations are based on modeling that considered maximum hourly activity during every hour of the 5-year meteorological data set, which is not a possible actual level of activity. These results therefore represent intentionally conservative conditions. Note that consistent with USEPA guidance, the annual modeling results are based on 5-year averages from the 5-year meteorological data set instead of 3-year as per the NAAQSs.

[d] All ambient concentrations are expressed in terms of micrograms per cubic meter (μg/m³); importantly, other sources may report the ambient air quality standard concentrations in parts per million (ppm) or parts per billion (ppb).

[e] Hourly and seasonal variation were assessed at Beacon Hill and incorporated into the dispersion model. The use of this form of background concentrations is consistent with EPA guidance.

[f] Denote Washington State ambient air quality standard (only, i.e., no federal standard)

4.4 Comparison of Alternatives Emissions

A comparison of the annual emission totals and how they change over time is presented in **Table 12**. The shaded columns in **Table 12** were not assessed using air quality dispersion modeling because they represent conditions with no operational or site configuration changes, and thus have either unchanged or decreasing emissions (e.g., Alternative 2 at 1.3MM TEU throughput in 2040 has lower emissions than Alternative 2 at 1.3MM TEU throughput in 2030). However, emissions for these scenarios are presented for comparison with those scenarios that were evaluated with modeling.

The shaded scenarios in Table 12 have estimated emissions equal to or less than with the same facility configurations in the decade prior because of equipment fleet turnover, changes to regulations, and increased utilization of shore power. For these reasons, there was no need to conduct modeling to conclude that emissions associated with the shaded scenarios would be expected to comply with the NAAQS because the prior decade scenario was in compliance.

As discussed in the introduction to Chapter 3, a facility-wide emissions summary can provide the "big picture" overview of the air quality effects of a project. While not providing the level of detail as the dispersion modeling analysis, **Table 12** indicates that concentrations generally decrease in the future even with the increased activity with Alternatives 2 and 3. There are competing factors that affect the facility-wide emissions:

- Emissions increase with higher activity levels associated with the development alternatives (more ground equipment moving more containers);
- Emissions decrease because the gradual retirement and replacement of locomotives, trucks, ground equipment, and ships substitutes cleaner, less pollutant equipment;
- Emissions decrease with the development alternatives as the percentage of ships using shorepower increases with time.
- Emissions decrease with redevelopment because fewer vessels would call due to increased vessel TEU capacity

The degree to which emissions rates decrease with fleet turnover is different for each pollutant and each type of equipment (trucks vs locomotives vs ships). Detailed information on emission factors applied in 2020, 2030, and 2040 are provided in Attachment A. The effect of increased use of shorepower is discussed below.

Table 12. Annual Project Emissions (tpy)

Pollutant	2020			2030			2040		
	647K TEUs			647K TEUs	1.3MM TEUs		647K TEUs	1.3MM TEUs	1.7MM TEUs
	Alt 1	Alt 2	Alt 3	Alt 1	Alt 2	Alt 3	Alt 1	Alt 2	Alt 3
CO	49.7	42.4	20.6	39.2	52.6	26.5	37.4	42.5	29.5
NO_2	254.5	180.9	115.1	161.1	156.7	93.3	154.6	117.6	82.2
$PM_{2.5}$	7.0	6.0	2.6	4.8	5.9	2.9	4.5	4.0	2.8
PM_{10}	7.4	6.3	2.8	5.2	6.4	3.3	4.8	4.4	3.2
SO_2	8.0	4.3	3.5	8.0	5.1	4.0	8.0	3.6	3.4

Note: The shaded cells indicate scenarios that were not considered with air quality modeling but that are expected to comply with the NAAQS because, for the same alternative, the emissions decreased from the prior decade and no operational or configuration changes occurred between the two decades.

Table 12 indicates all criteria pollutant emissions would decrease with modernization and upgrades of the Terminal 5 facility in 2020. This reduction is largely true for the other years, but exceptions exist between Alternative 1 and Alternative 2 in 2030 for PM and CO, and in 2040 for CO. These increases are attributable to the increased activities required to accommodate a 1.3MM TEU throughput with Alternative 2. Additionally, the larger potential vessel sizes expected with the action alternatives also contribute to these exceptions in the emission reduction trend.

For the scenarios that were considered with air quality modeling shown in Table 12 (i.e., the non-shaded cells), emission decreases between Alternatives 1 and 2 in 2020 are attributable to (1) fewer vessels calling on the Port due to increased vessel TEU capacity and (2) a projected 30 percent use rate of shore power (there is no shore power available for the no-build scenario).

The decreases in emissions from Alternative 2 to Alternative 3 in 2020 are largely due to the electrification of the majority of container-handling equipment activities. As Alternative 2 and Alternative 3 progress into years beyond 2020, their respective activity levels increase with throughput, but they benefit from increasingly greater use of shore power and vehicle fleet turnover, which result in reduced overall emissions, except for CO and SO_2. The estimates for CO and SO_2 increase with activity and do not have the same pronounced reductions in future years as the other pollutants. For Alternatives 2 and 3, the anticipated emissions reductions expected to result from use of shore power are shown in Table 13. The emissions reductions associate with shore power are higher with Alternative 2, 2040 than Alternative 3, 2040 because the numbers of hours spent at berth are higher in Alternative 2 (.e. less efficient movement of cargo).

Generally, over time, improving emission factors reflect regulatory requirements of engine manufacturers, regulations on in-use fuel for ocean-going vessels and harbor craft, EPA-model predicted turnover of the cargo-handling equipment fleet for King County, and increased utilization of shore power. The validity of expecting emission improvements is proven by decades of success with federal mobile source emissions regulations improving urban air quality throughout the United States.

Table 13. Reduction in Annual Emissions with Shore Power (tpy)

	Alternative 2			Alternative 3		
Pollutant	**2020**	**2030**	**2040**	**2020**	**2030**	**2040**
Shore Power Efficacy:	**30%**	**50%**	**70%**	**30%**	**50%**	**70%**
CO	3.9	9.3	13.0	3.1	7.8	12.3
NO_2	34.3	56.4	79.0	27.2	47.5	74.4
PM_{10}	0.6	1.5	2.1	0.5	1.3	2.0
$PM_{2.5}$	0.6	1.4	2.0	0.5	1.2	1.9
SO_2	1.5	3.5	5.0	1.2	3.0	4.7

4.5 Diesel Particulate Matter

Ramboll Environ evaluated potential off-site concentrations of diesel engine exhaust particulate matter (DPM) associated with project emission sources using $PM_{2.5}$ emissions as a surrogate for DPM emissions. Ramboll Environ used the AERMOD-predicted $PM_{2.5}$ concentrations across the entire modeling domain receptor grid to produce isopleths of estimated annual average DPM concentrations.

Predicted concentrations can be compared to a range of DPM unit risk factors to assess potential health implications. Ecology has adopted a DPM Acceptable Source Impact Level (ASIL) for use in the permit process for industrial facilities. However, the basis of Washington's ASIL value has recently been questioned by numerous studies. The inadequacies of the DPM ASIL are discussed at length in **Attachment C**.

The USEPA has not adopted a cancer risk factor for DPM because of uncertainties in the underlying health risk data. However, in 2002 the EPA suggested a range of values for assessing DPM risk: 1 x 10-5 – 1 x 10-3 μg/m^3. In practical terms, this means the increased risk of cancer after a 70-year exposure to 1 μg/m^3 DPM is between one in 100,000 and one in 1,000. **Figure 5** and **Figure 6** indicate predicted DPM concentrations in neighborhoods west and south of the site are about 0.1 μg/m³ with No Action (Alternative 1) and approximately 0.01 μg/m³ with Alternative 3 in 2040, a 10-fold improvement. The model-predicted concentrations of DPM associated with Alternative 2 were within the bounds of the DPM results identified for Alternatives 1 and 3. Further details on the health assessment are discussed in the proceeding section and provided in **Attachment C**.

4.6 Health Risk Characterization for DPM and $PM_{2.5}$

The Puget Sound Clean Air Agency (PSCAA) requested an evaluation of potential air quality health impacts associated with the modernization of Terminal 5. Specifically, PSCAA requested evaluation of potential cancer risks associated with exposure to DPM and non-cancer health risks associated with exposure to $PM_{2.5}$ attributable to Terminal 5 activities. As part of this effort, Ramboll Environ developed a white paper describing possible DPM cancer unit risk numbers and made a recommendation for a range of values to be applied in this evaluation. Based on PSCAA's recommendation, Ramboll Environ focused the impact assessment on residential areas nearest the terminal and on two communities south of Terminal 5, South Park and Georgetown, but assessed all communities adjacent to the Terminal. A detailed description of the methods and results is provided in **Attachment C**, a summary is presented here.

The health risk study was conducted in parallel with the DEIS technical report and was not updated to include the more realistic characterization of the vessels (vessel shape, stack height, stack location, etc.) that was included in the air quality impact assessment in the DEIS and this FEIS. Those unrefined parameters resulted in higher modeled concentrations and add to the conservatism of the health risk characterization.

To complete the health risk characterization, future DPM and $PM_{2.5}$ air concentrations attributable to Terminal 5 activities were modeled and incorporated into health risk models to estimate cancer risk and non-cancer health risks for relevant health endpoints. The relative impacts of each of 2 proposed alternatives were assessed by comparison with baseline (i.e., comparison with health impacts associated with the no-action alternative). Maximum and minimum model-predicted DPM and $PM_{2.5}$ concentrations scenarios were selected to bound the impacts from all alternatives and temporal configurations. Of the modeled scenarios, the lowest concentration was associated with Alternative 3, 2040 and highest was associated with Alternative 2, 2020.

Cancer risk was evaluated using annual average DPM concentrations; Non-cancer risks were evaluated using both annual and 24-hour maximum concentrations of $PM_{2.5}$, depending on the health outcome.

The following health endpoints were evaluated for short-term exposures to $PM_{2.5}$:

- Mortality
  - All-cause
  - Cardiovascular
  - Respiratory
- Morbidity:
  - Hospital admissions for cardiovascular effects
  - Hospital admissions for respiratory diseases
  - Hospital admissions for asthma

The following health endpoints were evaluated for long-term exposures to $PM_{2.5}$:

- Mortality
  - All-cause
  - Cardiovascular

The relationship between a specific concentration of DPM or $PM_{2.5}$ and a particular health outcome is called the concentration-response relationship. Epidemiology and toxicology studies are used to quantify these concentration-response relationships; resulting in numerical values that can be combined with measured or monitored air concentration to derive estimated health impacts. The white paper developed to support this risk characterization provides the rationale for the quantitative toxicity estimate for DPM, called a cancer unit risk factor. **Attachment C** also provides the statistics used to quantify the noncancer health outcomes associated with $PM_{2.5}$ exposures. For the noncancer health evaluation, baseline US Census population and Washington State Department of Health health incidence data also were utilized.

With respect to DPM and cancer risk, the use of a single, discrete value representing potential cancer potency of diesel exhaust attributes greater confidence to cancer risk estimates than is appropriate given the underlying shortcomings in the current quantitative assessment of diesel exhaust cancer risk. While it is apparent that the body of research as a whole supports a positive relationship between exposure to diesel exhaust (particularly from older diesel engines) and lung cancer, the numerical values that estimate potential cancer risk are hampered by a large range of uncertainty that is rarely communicated and considered in project planning and risk communication efforts. An analysis of this literature (see **Attachment C**) supports the use of a range of unit risk factors rather than selecting a single diesel exhaust risk estimate for appraising potential cancer risk. This selection allows a comparison of relative ranges in impacts of each alternative, without assigning a single "cancer risk" number which might overstate the certainties of the science. We therefore took this approach to assess cancer risk.

Compared to baseline, or Alternative 1, changes in air quality resulting from Alternatives 2 and 3 were small, and the resulting changes in health risks relative to baseline were correspondingly small. The maximum modeled air concentrations of DPM and $PM_{2.5}$ are associated with Alternative 2 (year 2020) and are similar to the no action, Alternative 1. Thus, there are no anticipated changes in health risk – both cancer risk and risk for a variety of relevant noncancer health outcomes – associated with the Project when considering the alternative and time-frame when air concentrations of DPM and $PM_{2.5}$ are expected to be greatest. While Alternative 3 (year 2040) is expected to result in improved air quality as compared to baseline, the corresponding observed improvement in the health outcomes is negligible. **Attachment C** provides a detailed discussion, numerical results, and figures for the DPM cancer risk characterization and for each noncancer health outcome identified for the evaluation of $PM_{2.5}$.

4.7 Greenhouse Gas Emissions

In order to evaluate the potential for climate change due to the Terminal 5 action alternatives, direct GHG emissions associated with implementation of the project were calculated based on fuel combustion related to construction of the facility, operation of the facility, indirect activities associated with project actions, and purchased electricity.

4.7.1 Construction-Related Greenhouse Gas Emissions

The construction-related GHG assessment was based on estimates of emissions from facility construction using expected construction equipment (specified by SCC code and horsepower) and the time all such equipment is expected to be active. Each phase of construction was considered separately and in detail. GHG emissions were tabulated based on emission rates estimated using the EPA NONROAD emissions model and the specific equipment population in King County, Washington. The emissions estimates considered both land-side and in-water equipment.

In total, the estimated lifespan emissions attributable to the project are about 12,000 $MTCO_2e$ over the three-season construction period. [5] A summary of the GHG emissions calculations is presented in **Table 14**. As shown, direct annual GHG emissions are less than 6,000 MTCO2e during each of the first two years of construction and even less in the final

[5] MTCO2e is defined as Metric Ton Carbon Dioxide Equivalent; equates to 2,204.62 pounds of CO2. This is a standard measure of amount of C02.

year. According to Ecology, no additional analysis is required of projects that are expected to produce an average of less than 10,000 metric tons per year, (Ecology 2011).

Table 14. Construction-Related GHG Emissions (tonnes)

Construction Phase	CO_2	N_2O	CH_4	CO_2e
Phase I (year 1)	1,679	11.90	26.78	5,896
Phase II (year 2)	1,529	10.83	24.38	5,367
Phase III (year 3)	206.7	1.46	3.29	725.1
Total	**3,415**	**24.20**	**54.45**	**11,987**

4.7.2 Operational Greenhouse Gas Emissions

Long term (operational) GHG emissions were estimated for on-site sources as well as limited off-site locomotive, vessel, and truck emissions (as described in **Section 3.1.2**). The operational GHG emissions were quantified within the immediate vicinity of T-5 and were based on project-specific operations. Statewide, off-site emissions from locomotives, vessels, and on-road trucks were not quantified because they are expected to improve under either action alternative. By leasing T-5, business entities would seek to improve their transportation efficiency and cut associated costs. The Terminal 5 action alternatives would enable larger vessels to serve Seattle and the surrounding region. These larger vessels are more fuel efficient and therefore produce less GHGs per unit of cargo. The improvement in transportation efficiency would be concurrent with improvements in environmental efficiency. **Table 15** identifies the total estimated annual T-5 GHG emissions.

Table 15. Operational Greenhouse Gas Emissions

Operational Emissions	Annual Emissions CO_2e - Metric Tons					
	Alt 1 647k TEUs 2020	**Alt 2 647k TEUs 2020**	**Alt 2 1.3MM TEUs 2030**	**Alt 3 647k TEUs 2020**	**Alt 3 1.3MM TEUs 2030**	**Alt 3 1.7MM TEUs 2040**
Direct Emissions						
On-Site Cargo-Handling & Trucks	36,176	33,419	82,229	10,754	20,742	27,578
Indirect Emissions						
Purchased Energy [a]	0	0	0	0	0	0
Employee Commute[b]	--	--	--	--	--	--
Rail Product Delivery [c]	2,914	2,914	5,733	2,888	5,733	7,620
On-road Truck Delivery [d]	2,164	2,164	2,108	2,164	2,108	1,746
Vessel Product Delivery [e]						
Transiting	13,884	9,076	16,625	9,076	16,625	16,144
Hoteling	53,669	31,639	26,872	25,503	22,121	15,271
Annual Facility-Related GHG Emissions	**108,808**	**79,211**	**133,568**	**50,385**	**67,329**	**68,359**

[a] Seattle City Light operates as a "Zero-net Carbon" entity. Their fuel mix is heavily dependent on hydroelectric power and other fuels that produce carbon are offset. Because of these offsets the purchased energy CO2e emissions are zero. (http://www.seattle.gov/light/enviro/)

[b] Employee data were not available at the time of this analysis.

[c] "Rail Product Delivery" refers to locomotive operations to and from East Marginal Way and operation on-site. Note that these projected emissions do not consider the GHG emission reductions that would result from the use of AESS to shut down unneeded locomotives because AESS is not used all the time (i.e., when temperature are less than about 40°F). Since temperatures exceed 40°F about 85% of the time, the locomotive AESS would reduce GHG to less than represented in this tabulation.

[d] "On-road Truck Delivery" refers to truck movements to and from East Marginal Way, but does not consider on-site truck queue idling or movements. On-site truck activity is captured as direct emissions.

[e] "Vessel Product Delivery" Transiting emissions represent engine and boiler combustion emissions associated with transiting activities during the arrival and departure of vessels and assist tugs. Hoteling emissions are vessel-related combustion emissions from the auxiliary engines and boilers while the vessels are docked at the wharf.

As mentioned in Section 2.4, no specific federal, state, or local emission reduction requirements or targets are applicable to the proposed project, and there are no generally accepted emission level thresholds against which to assess potential localized or global consequences of GHG emissions. The relatively small contribution from this Terminal facility would not result in significant impacts from GHGs. The project would reduce world-wide emissions of GHGs due to improved efficiencies in commodity deliveries compared with existing transport systems – and due to improving emission controls in future years.

4.8 Transportation Conformity Review

4.8.1 Emissions

The CAL3QHC dispersion model uses emission rates for "free-flow" and "queue" links. Free-flow links represent emissions from traffic traveling through the intersection and are expressed in terms of grams per vehicle mile. Queue links represent emissions from idling vehicles and are expressed in terms of grams per vehicle hour. These emission rates, which vary by speed traveled and model year, are presented in **Table 16**. The greater of the emission rates during the summer and winter months simulated with MOVES were modeled. Based on the traffic study, the total traffic volume at SW Spokane St / West Marginal Way SW / Chelan Ave SW would include less than 9% heavy vehicles under all alternatives. Therefore, the composite emission rates based on the King County fleet population were increased to 9% for each model year.

Table 16. Hot-Spot CO Emission Rates

Link Type	Speed	Model Year			Emission Unit
		2020	2030	2040	
Free-flow	35 mph	3.67	1.98	1.18	g/mi
	30 mph	4.03	2.12	1.24	g/mi
Queue	Idle	12.41	4.81	3.19	g/hr

Notes:
Emission rates based on King County 2014 fleet population, adjusted for the increase in heavy vehicles in the area.

4.8.2 CO Model Concentrations

The results of the CO "hot-spot" modeling, provided in **Table 17**, represent the maximum concentration among the receptors included in the CAL3QHC dispersion model. Based on projected future traffic conditions in 2020, 2030, and 2040, and assuming a background CO concentration of 5 ppm, model-calculated concentrations would be less than the ambient air quality standards for CO. The results of the "hot-spot" modeling indicate additional traffic due to Alternatives 2 and 3 would not noticeably increase concentrations compared to the Alternative 1 scenario during the PM peak period.

Table 17. Hot-Spot Model Results (ppm)

Intersection	Avg. Period	Ambient Standard [a]	Modeled Concentration [b]					
			Alt 1 (No Action)			Alt 2	Alt 3	Alt 3 Mit. [c]
			2020; 0.64M TEU	2030; 0.64M TEU	2040; 0.64M TEU	2030; 1.27M TEU	2040; 1.70M TEU	2040; 1.70M TEU
SW Spokane St / West Marginal Way SW / Chelan Ave SW	1 HR	35	5.7	5.5	5.2	5.5	5.2	5.2
	8 HR	9	5.5	5.4	5.1	5.4	5.1	5.1

Notes:
[a] Ambient concentrations are expressed in terms of parts per million (ppm)
[b] 1-HR and 8-HR modeled concentrations include 5 ppm CO background. 8-HR concentrations assume a 0.7 persistance factor
[c] Under the Alt 3 Mitigated scenario, the northwest leg of the intersection would be closed, removing access to the T5 terminal.

Due to the poor performance of this intersection, the traffic study assessed a mitigated Alternative 3 scenario. Under the mitigated Alternative 3 scenario, the northwest leg would be closed permanently, reducing delays from trains and trucks accessing Terminal 5 through this intersection. The results from this alternative also indicate there would be no change in the maximum local air quality because the intersection would continue to perform at LOS F due to local traffic conditions not related to Terminal 5.

Although project-related traffic delays almost double in 2040 over those in 2020, maximum predicted CO concentrations decrease in 2040 due to vehicle emissions reduction measures implemented by federal and state regulatory requirements in future years. Based on this finding, the proposed plan would not be expected to result in any significant air quality impacts due to its effect on the surface roadways in the area.

4.9 General Conformity Review

The proposed project would result in air pollutant emissions related to demolition of portions of the existing wharf structure, reconstruction of the wharf, and related activities to deepen the adjacent waterway and to stabilize the underwater slope abutting the wharf structure. Because the facility is located in air quality maintenance areas for PM_{10}, ozone, and carbon monoxide, and because portions of the facility construction are subject to approval by the U.S. Army Corps of Engineers, facility construction emissions are subject to consideration under the federal air quality General Conformity rules. Consequently, construction-related emissions were quantified as required under the General Conformity rules for comparison with the General Conformity *de minimis* levels. This tabulation is summarized in **Table 18**.

The General Conformity *de minimis* levels are based on annual tons of pollutant emissions, and because each construction phase of the project is more or less representative of a single year, the emissions associated with each construction phase may be compared with the *de minimis* levels. Although total construction-related emissions are not typically used in General Conformity assessments, the total project-related construction emissions are listed in **Table 18** to illustrate the relatively minor nature of this project. As shown, the estimates of project construction-related emissions are far less than the respective General Conformity *de minimis* levels, and as a result, these emissions would not be expected to significantly affect air quality.

Importantly, Alternative 1 does not require a General Conformity review because no in-water work, with federal oversight, will occur. The emissions and comparison against *de minimis* thresholds are relevant to Alternatives 2 and 3, which have identical construction emissions.

Table 18. Project Construction-Related Air Pollutant Emissions (tons)

Construction Phase	VOC	CO	NO_x	CO_2	SO_2	PM
Phase I	0.92	3.96	13.41	1,851	0.06	0.53
Phase II	0.82	3.58	11.82	1,685	0.06	0.47
Phase III	0.13	0.58	1.63	228	0.02	0.08
Total Construction-Related Emissions	**1.87**	**8.12**	**26.86**	**3,764**	**0.15**	**1.08**
General Conformity *De Minimis* Levels	**100**	**100**	**100**	**N/A**	**100**	**100**

Note that CO_2 emissions are not considered under General Conformity rules but are included here for completeness. Likewise, total construction emissions are not used for comparison with the annual-oriented *de minimis* levels, but are included for completeness.

VOC = volatile organic compound

5. TRACKING TERMINAL PROGRESS

Port and Terminal Operator will track T5 air quality performance after the Terminal renews operation to ensure air quality predictions as described in the EIS are consistent with operations over the twenty-year horizon of the project. Tracked data will supplement the Puget Sound Maritime Air Emission Inventory, the ongoing summary reporting of airshed wide air emissions related to Pacific Northwest port operations sponsored by the NWSA and part of the Northwest Ports Clean Air Summary. The Port will work with the Terminal Operator to identify the appropriate level of detail for publication of Terminal 5-specific data (as opposed to aggregate maritime-related information that is currently reported) without compromising proprietary information. T5 performance information reported on website annually will include:

- Cargo throughput in TEU or other unit
- Summary of CHE inventory e.g. how many units are alternatively fuels (propane, electric, CNG, hybrid) vs. diesel
- % of CHE meeting Tier 4 interim (T4i) emission stds or equivalent
- Summary/status of fuel efficiency planning for CHE and trucks calling at terminal
- Shorepower utilization rate (number and % of ships plugged in)
- AQ trends from representative local PSCAA air monitoring station

Every 5 years, emission inventory data specific to terminal will be extracted from Puget Sound Maritime Air Emission Inventory, the ongoing summary reporting of airshed wide air emissions related to Pacific Northwest port operations. The next emission data will be reported in 2022 for data collected in 2012.

6. MITIGATION

6.1 Construction

Although construction at the proposed terminal is not expected to significantly affect air quality, construction contractors will be required to comply with all relevant federal, state, and local air quality rules. In addition, implementation of best management practices will reduce emissions related to the construction phase of the project. Management practices for reducing the potential for air quality impacts during construction include measures for reducing both exhaust emissions and fugitive dust. The Washington Associated General Contractors brochure Guide to Handling Fugitive Dust from Construction Projects and PSCAA suggest a number of methods for controlling dust and reducing the potential exposure of people to emissions from diesel equipment. A list of the control measures that will be implemented during construction follows:

- Require Tier 2 or better engines for off-road equipment
- Require model year 2007 or newer engines for heavy duty vehicles (exempt trucks that are operated < 100 hours/yr on this job)
- Require use of biofuel B20, or offer contractor incentive for this fuel
- Require contractor to have idle reduction plan or ensure that project specs have a max idle time of 5 min
- Use only equipment and trucks that are maintained in optimal operational condition.
- Require all off-road equipment to have emission reduction equipment (e.g., require participation in Puget Sound Region Diesel Solutions, a program designed to reduce air pollution from diesel, by project sponsors and contractors).
- Use car-pooling or other trip-reduction strategies for construction workers.
- Spray exposed soil with water or other suppressant to reduce emissions of PM and deposition of particulate matter.
- Pave or use gravel on staging areas and roads that would be exposed for long periods.
- Cover all trucks transporting materials, wetting materials in trucks, or providing adequate freeboard (space from the top of the material to the top of the truck bed), to reduce PM emissions and deposition during transport.
- Provide wheel washers to remove particulate matter that would otherwise be carried off site by vehicles to decrease deposition of particulate matter on area roadways.
- Cover dirt, gravel, and debris piles as needed to reduce dust and wind-blown debris.
- Stage construction to minimize overall transportation system congestion and delays to reduce regional emissions of pollutants during construction.

6.2 Operations

The project, as proposed, includes a number of measures intended to reduce operational emissions, including GHG Emissions.

- Shorepower plug in capability for two berths will be provided as part of project when the terminal renews operation.
- The NWSA and Port will work with the Terminal Operator and shipping lines to design a program focused on attracting ships that are already carrying shipside onshore power equipment and encourage usage of electric shore power at berth to meet the 30% adoption goal that increase over time. The program will be in place beginning when the terminal restarts operations. The NWSA, Port and Terminal Operator will be responsible for tracking progress toward the modeled goals.
- Trucks entering container terminals will be required to meet model-year 2007 EPA emissions standards beginning in 2018 as part of the Northwest Ports Clean Air Strategy.
- Development of facility will utilize an electrical power supplier that obtains >90% of their power from non-fossil fuel sources reducing greenhouse gas emissions for terminal operations.
- Operational management plans to reduce truck queuing and wait times as outlined in proposed Queue Management Plan (see Traffic Technical Report) will reduce idling of diesel drayage vehicles. –
- Port and Terminal Operator will track T5 air quality performance after the Terminal renews operation to ensure air quality predictions as described in the EIS are consistent with operations. The tracking plan will be approved prior to occupancy.

7. REFERENCES

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8. SELECTED FIGURES

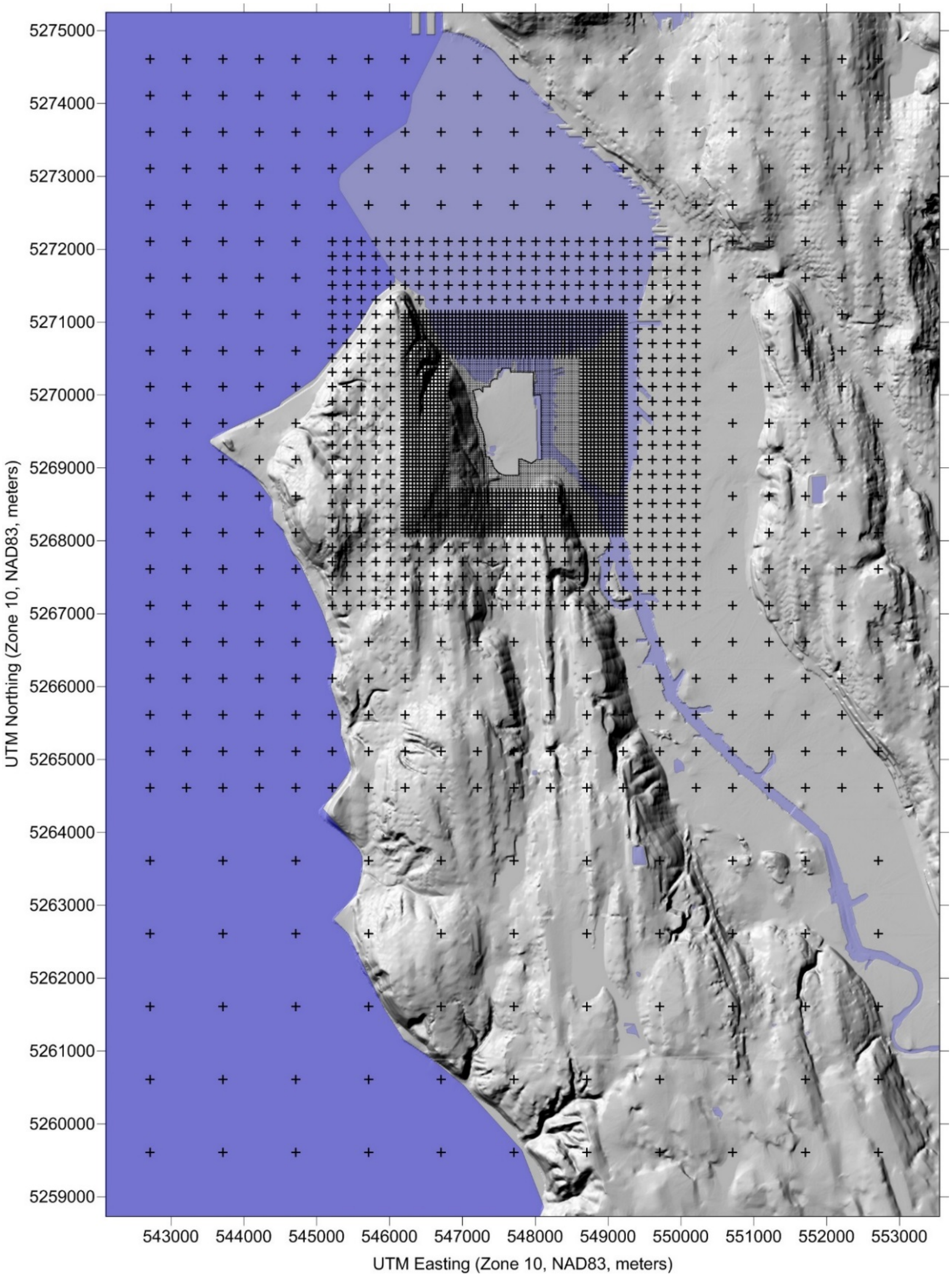


Figure 1. AERMOD Modeling Domain and Receptor Locations

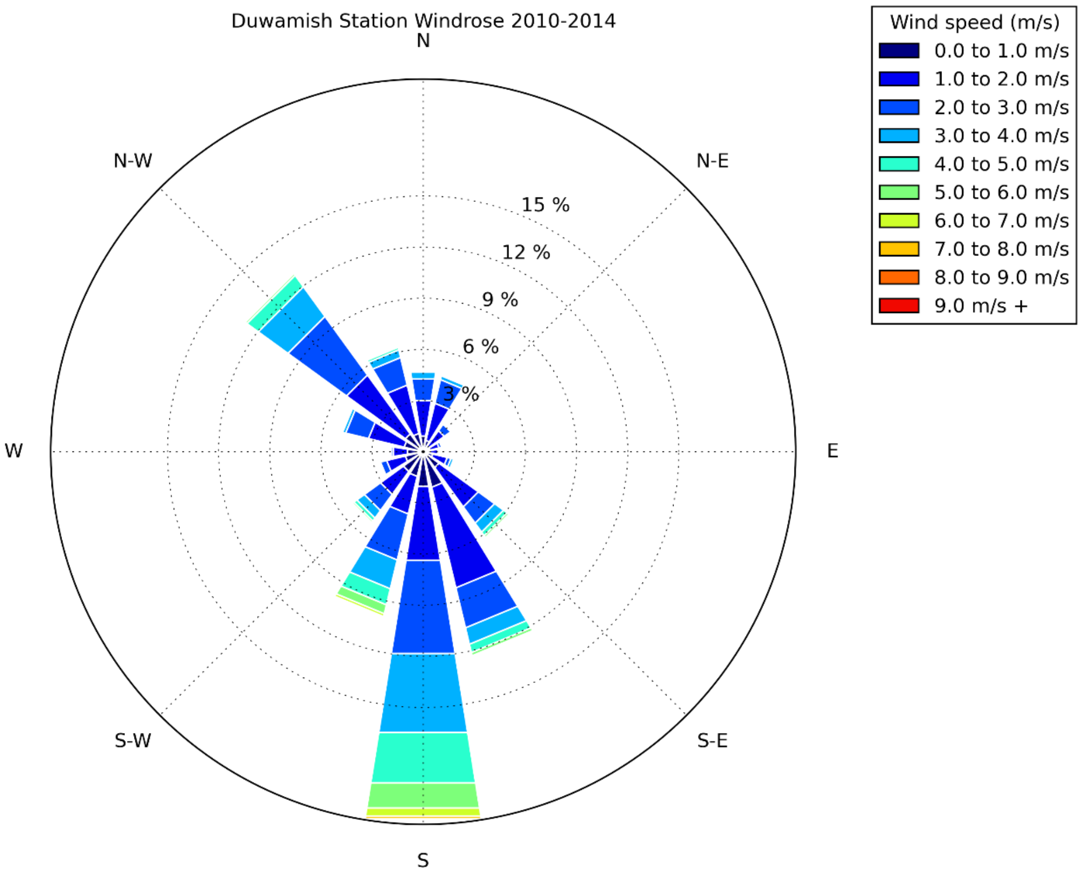
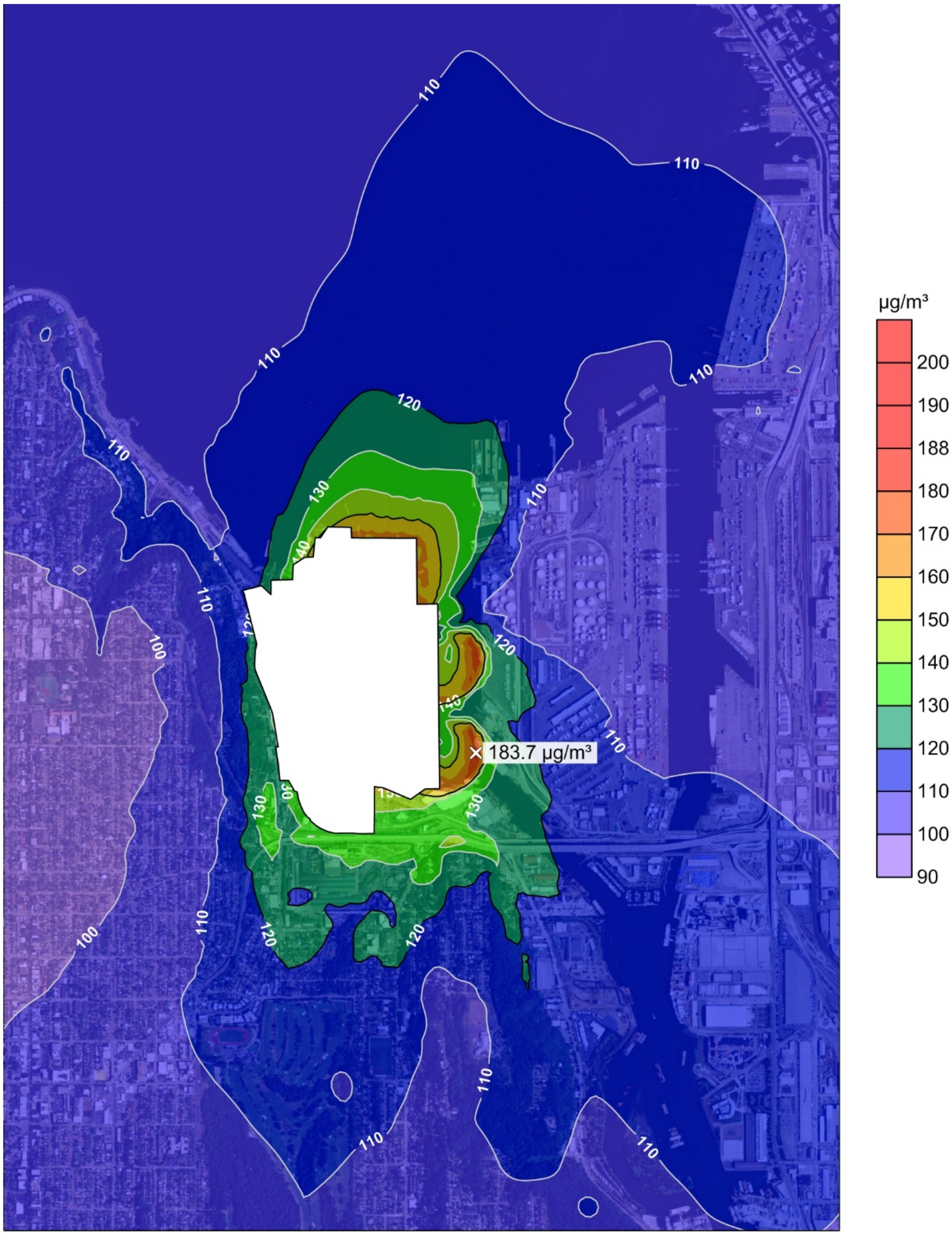


Figure 2. Windrose of Duwamish Meteorological Station (2010-2014)



Note: Model results include seasonal, hourly NO_2 background concentrations from 2012-2014 monitoring data.

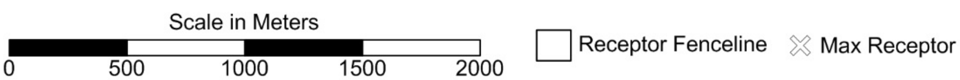


Figure 3. Alternative 1 (2020): Model-Calculated 1-Hour NO_2 Concentrations

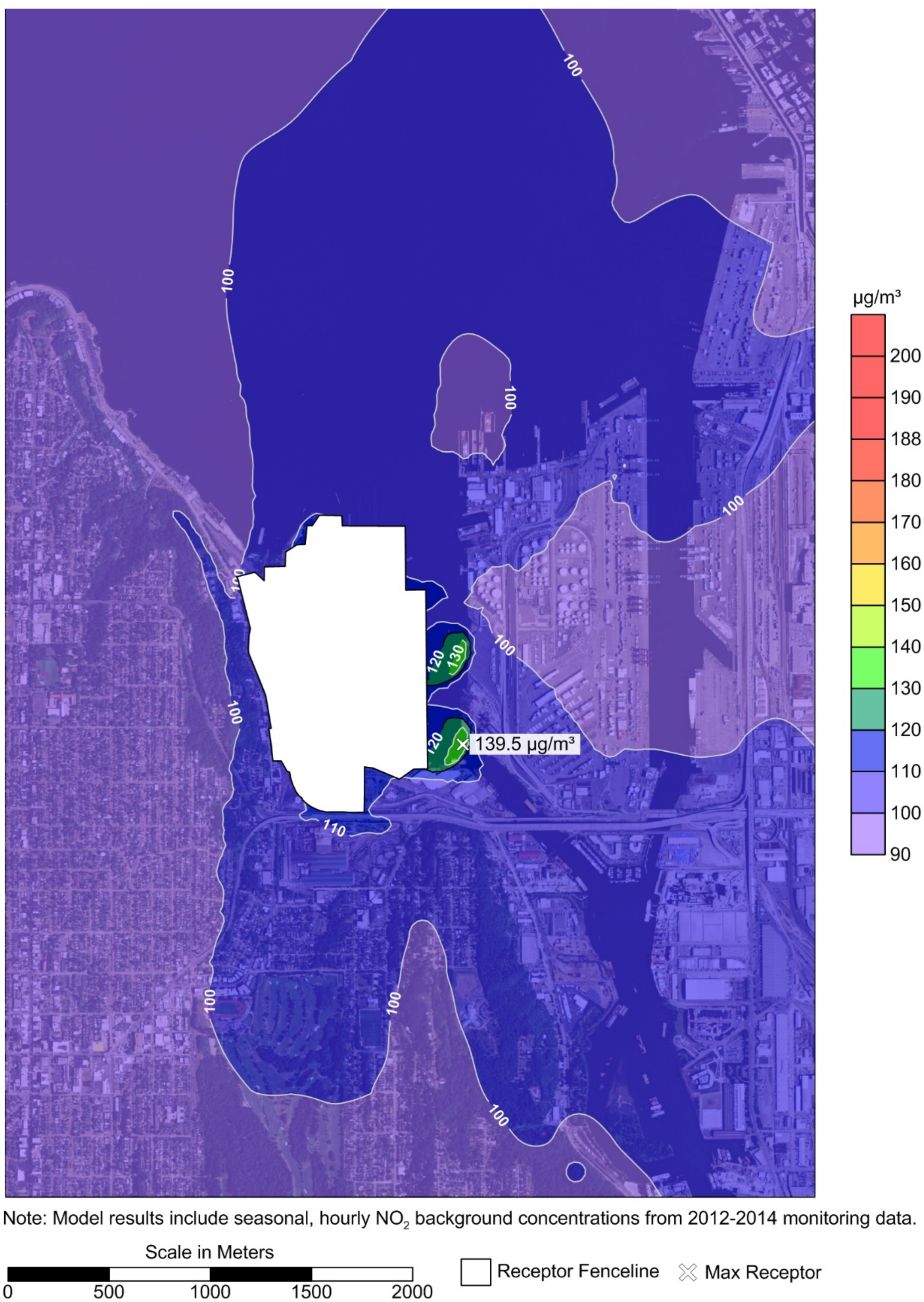


Figure 4. Alternative 3 (2030): Model-Calculated 1-Hour NO_2 Concentrations

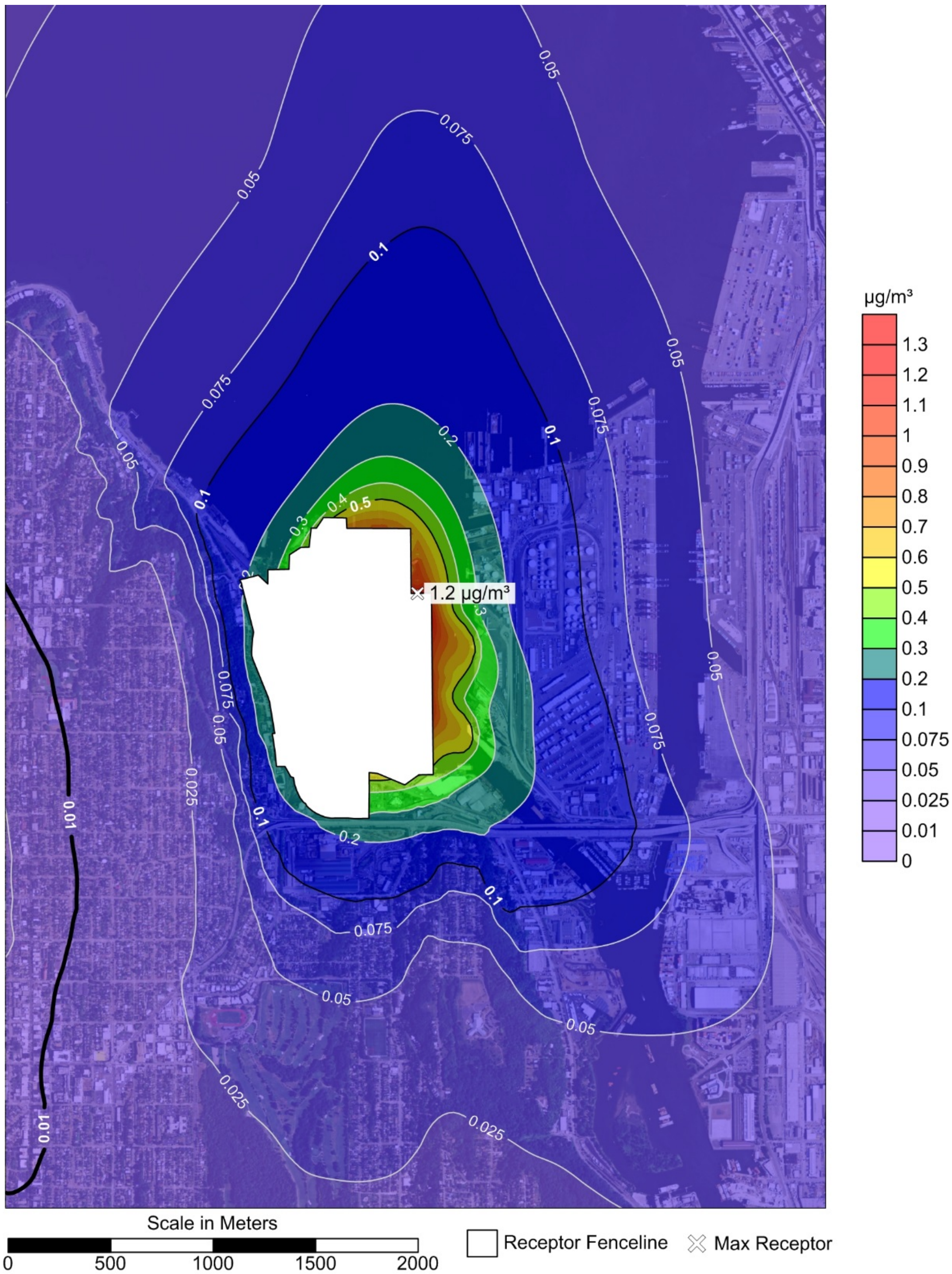


Figure 5. Alternative 1 (2020): Model-Calculated Diesel Particulate Concentrations Attributable to Terminal 5 Activities

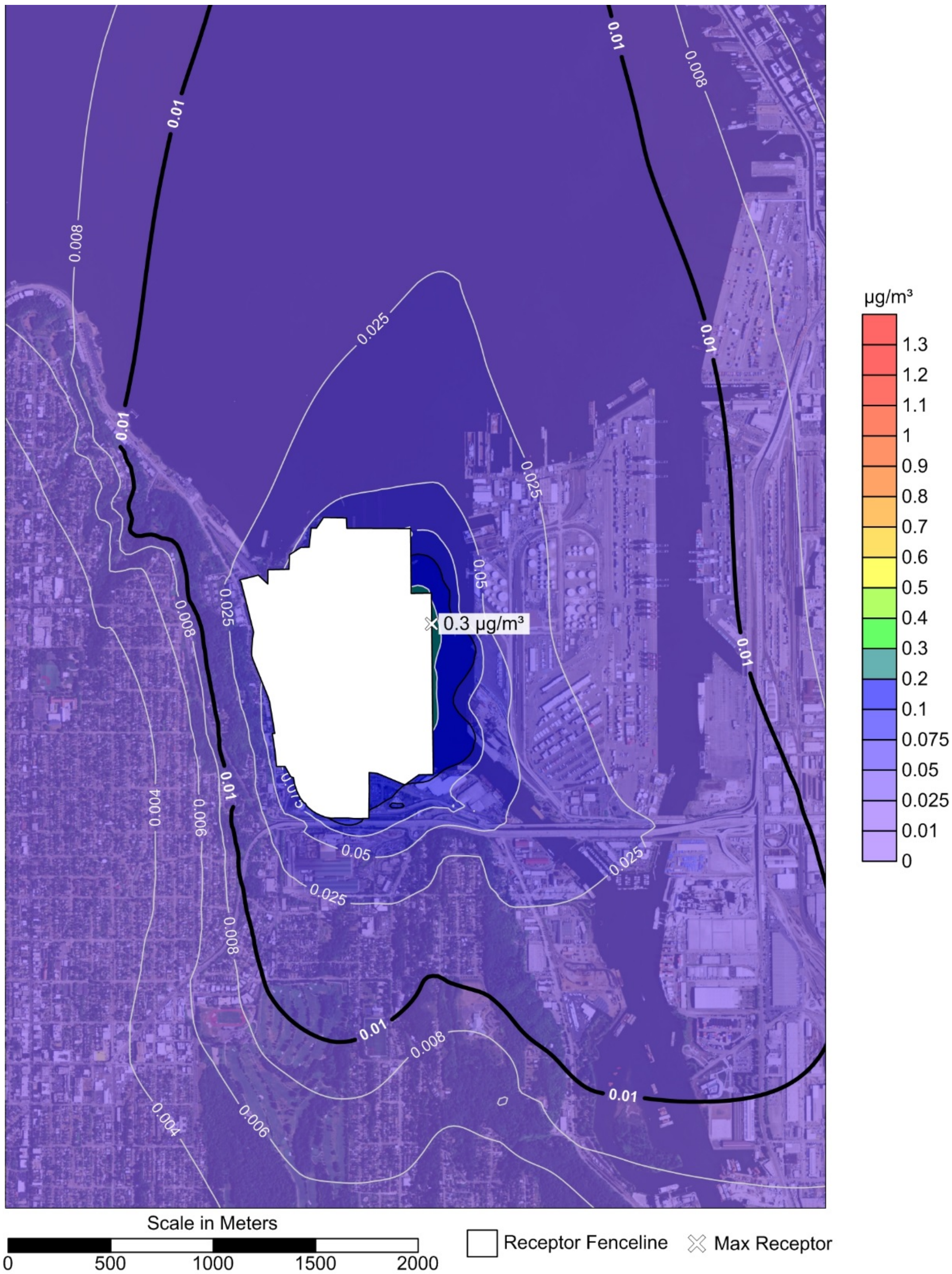


Figure 6. Alternative 3 (2030): Model-Calculated Diesel Particulate Concentrations Attributable to Terminal 5 Activities

ATTACHMENT A: EMISSION FACTORS

Table 19. 2020 Emission Factors

Locomotive Emission Factors (g/hp-hr)[a]					
Type	NO_x	PM_{10}	$PM_{2.5}$	**CO**	SO_2
Line-haul	4.8	0.11	0.11	1.3	0.017
Switcher	12.3	0.27	0.26	1.3	0.023
Vessel Emission Factors (g/kW-hr) [b]					
Engine Type	NO_x	PM_{10}	$PM_{2.5}$	**CO**	SO_2
Tug Mains	9.8	0.72	0.6984	5	1.3
Tug Aux	6.8	0.3	0.291	5	1.3
Vessel Mains	17	0.19	0.17	1.4	0.36
Vessel Aux	13.9	0.18	0.17	1.1	0.42
Vessel Boiler [c]	13.9	0.18	0.17	1.1	0.42
Cargo-Handling Emission Factors (g/hp-hr)[d]					
Equipment Type	NO_x	PM_{10}	$PM_{2.5}$	**CO**	SO_2
Top Picks	1.52	0.09	0.09	0.54	0.0030
RTGs	3.76	0.39	0.38	2.41	0.0038
Yard Tractors	0.53	0.02	0.02	0.21	0.0027
On-road Truck Emission Factors (g/hr)[e]					
Engine Mode	NO_x	PM_{10}	$PM_{2.5}$	**CO**	SO_2
Idle	29.88	0.44	0.43	6.82	0.17
10 mph	38.67	11.22	1.89	8.46	0.23
35 mph	69.67	8.44	2.00	14.30	0.50

[a] Future year emission rates provided within EPA, 2009

[b] Emissions factors for vessel engines varied by year using the forecasted adoption rates of ECA imposed restrictions for NO_x. These emission adjustments were applied to the uncontrolled emission rates provided here. Additionally, specific emission rates varied as a function of fuel quality.

[c] Boiler emission factors conservatively assumed to be equivalent to auxiliary emission factors.

[d] CHE emission factors taken from the NONROAD model component of the EPA MOVES2014a model

[e] On-road truck emission factors were estimated based on estimated fleet turnover, consistent with the projections of the Puget Sound Regional Council, and applied using the EPA MOVES2014 model.

Table 20. 2030 Emission Factors

Locomotive Emission Factors (g/hp-hr)[a]					
Type	NO_x	PM_{10}	$PM_{2.5}$	**CO**	SO_2
Line-haul	2.5	0.05	0.05	1.3	0.017
Switcher	7.8	0.16	0.16	1.3	0.023
Vessel Emission Factors (g/kW-hr) [b]					
Engine Type	NO_x	PM_{10}	$PM_{2.5}$	**CO**	SO_2
Tug Mains	9.8	0.72	0.6984	5	1.3
Tug Aux	6.8	0.3	0.291	5	1.3
Vessel Mains	17	0.19	0.17	1.4	0.36
Vessel Aux	13.9	0.18	0.17	1.1	0.42
Vessel Boiler [c]	13.9	0.18	0.17	1.1	0.42
Cargo-Handling Emission Factors (g/hp-hr)[d]					
Equipment Type	NO_x	PM_{10}	$PM_{2.5}$	**CO**	SO_2
Top Picks	0.54	0.02	0.02	0.18	0.0027
RTGs	1.80	0.15	0.15	1.10	0.0034
Yard Tractors	0.38	0.01	0.01	0.16	0.0026
On-road Truck Emission Factors (g/hr)[e]					
Engine Mode	NO_x	PM_{10}	$PM_{2.5}$	**CO**	SO_2
Idle	22.02	0.42	0.43	6.37	0.160
10 mph	28.61	11.17	1.86	7.89	0.226
35 mph	51.24	8.38	1.95	13.32	0.473

(a) Future year emission rates provided within EPA, 2009

(b) Emissions factors for vessel engines varied by year using the forecasted adoption rates of ECA imposed restrictions for NO_x. These emission adjustments were applied to the uncontrolled emission rates provided here. Additionally, specific emission rates varied as a function of fuel quality.

(c) Boiler emission factors conservatively assumed to be equivalent to auxiliary emission factors.

(d) CHE emission factors taken from the NONROAD model component of the EPA MOVES2014a model

(e) On-road truck emission factors were estimated based on estimated fleet turnover, consistent with the projections of the Puget Sound Regional Council, and applied using the EPA MOVES2014 model.

Table 21. 2040 Emission Factors

Locomotive Emission Factors (g/hp-hr)[a]					
Type	NO_x	PM_{10}	$PM_{2.5}$	**CO**	SO_2
Line-haul	1.3	0.02	0.02	1.3	0.017
Switcher	3.9	0.08	0.08	1.3	0.023
Vessel Emission Factors (g/kW-hr) [b]					
Engine Type	NO_x	PM_{10}	$PM_{2.5}$	**CO**	SO_2
Tug Mains	9.8	0.72	0.6984	5	1.3
Tug Aux	6.8	0.3	0.291	5	1.3
Vessel Mains	17	0.19	0.17	1.4	0.36
Vessel Aux	13.9	0.18	0.17	1.1	0.42
Vessel Boiler [c]	13.9	0.18	0.17	1.1	0.42
Cargo-Handling Emission Factors (g/hp-hr)[d]					
Equipment Type	NO_x	PM_{10}	$PM_{2.5}$	**CO**	SO_2
Top Picks	0.47	0.01	0.01	0.15	0.0026
RTGs	0.97	0.04	0.04	0.48	0.0032
Yard Tractors	0.38	0.01	0.01	0.16	0.0026
On-road Truck Emission Factors (g/hr)[e]					
Engine Mode	NO_x	PM_{10}	$PM_{2.5}$	**CO**	SO_2
Idle	20.95	0.42	0.43	6.31	0.159
10 mph	25.20	11.17	1.86	7.82	0.231
35 mph	48.73	8.37	1.95	13.19	0.469

[a] Future year emission rates provided within EPA, 2009

[b] Emissions factors for vessel engines varied by year using the forecasted adoption rates of ECA imposed restrictions for NO_x. These emission adjustments were applied to the uncontrolled emission rates provided here. Additionally, specific emission rates varied as a function of fuel quality.

[c] Boiler emission factors conservatively assumed to be equivalent to auxiliary emission factors.

[d] CHE emission factors taken from the NONROAD model component of the EPA MOVES2014a model

[e] On-road truck emission factors were estimated based on estimated fleet turnover, consistent with the projections of the Puget Sound Regional Council, and applied using the EPA MOVES2014 model.

ATTACHMENT B: EMISSION TOTALS BY SOURCE-TYPE

Table 22. Alternative 1 Total Annual Emissions

Criteria Air Pollutant	Operational Sources	Alt 1 Emissions (tpy)		
		2020; 647k TEU	2030; 647k TEU	2040; 647k TEU
Inhalable Coarse Particulate Matter (PM_{10})	Vessels in Transit	1.0	1.0	1.0
	Vessels Hoteling	3.0	3.0	3.0
	On-Site Trains	0.3	0.1	0.05
	Off-Site Trains	0.03	0.01	<0.01
	Trucks	0.1	0.1	0.1
	CHE	3.0	0.9	0.6
Inhalable Fine Particulate Matter ($PM_{2.5}$)	Vessels in Transit	1.0	1.0	1.0
	Vessels Hoteling	2.8	2.8	2.8
	On-Site Trains	0.2	0.1	0.05
	Off-Site Trains	0.03	0.01	<0.01
	Trucks	0.03	0.03	0.03
	CHE	2.9	0.9	0.6
Sulfur Dioxide (SO_2)	Vessels in Transit	0.8	0.8	0.8
	Vessels Hoteling	7.0	7.0	7.0
	On-Site Trains	0.03	0.03	0.03
	Off-Site Trains	<0.01	<0.01	<0.01
	Trucks	<0.01	<0.01	<0.01
	CHE	0.1	0.1	0.1
Carbon Monoxide (CO)	Vessels in Transit	8.3	8.3	8.3
	Vessels Hoteling	18.2	18.2	18.2
	On-Site Trains	2.4	2.4	2.4
	Off-Site Trains	0.4	0.4	0.4
	Trucks	0.4	0.4	0.3
	CHE	20.0	9.5	7.8
Nitrogen Dioxide (NO_2)	Vessels in Transit	32.2	18.9	18.9
	Vessels Hoteling	159.5	110.7	110.7
	On-Site Trains	11.2	6.3	3.3
	Off-Site Trains	1.4	0.7	0.4
	Trucks	1.7	1.2	1.2
	CHE	48.6	23.2	20.1

Assumes 100% of NO_x emissions are NO_2; Vessels in Transit include tug assists during maneuvering.; Train emissions without AESS produces conservative results; including AESS would reduce emissions.; On-Site Trains include arrivals, departures, and switch engine emissions while at the facility.; Off-Site Trains include emissions between Marginal Way East and the Facility.; CHE includes top picks, and yard hostlers.; Truck emissions include trucks idling in pre-queue, at the main gate, on-site movements, and off-site movements. Shaded scenarios were not used for air quality modeling (discussed in detail in the report).

Table 23. Alternative 2 Total Annual Emissions

Criteria Air Pollutant	Operational Sources	Alt 2 Emissions (tpy)		
		2020; 647k TEU	2030; 1.3MM TEU	2040; 1.3MM TEU
Inhalable Coarse Particulate Matter (PM_{10})	Vessels in Transit	0.9	1.9	1.9
	Vessels Hoteling	1.5	1.5	0.9
	On-Site Trains	0.3	0.2	0.1
	Off-Site Trains	0.03	0.03	0.01
	Trucks	0.1	0.2	0.2
	CHE	3.5	2.5	1.3
Inhalable Fine Particulate Matter ($PM_{2.5}$)	Vessels in Transit	0.8	1.7	1.7
	Vessels Hoteling	1.4	1.4	0.9
	On-Site Trains	0.2	0.2	0.1
	Off-Site Trains	0.03	0.03	0.01
	Trucks	0.03	0.05	0.05
	CHE	3.4	2.4	1.3
Sulfur Dioxide (SO_2)	Vessels in Transit	0.6	1.2	1.2
	Vessels Hoteling	3.5	3.5	2.1
	On-Site Trains	0.03	0.07	0.07
	Off-Site Trains	<0.01	<0.01	<0.01
	Trucks	<0.01	0.01	0.01
	CHE	0.2	0.2	0.2
Carbon Monoxide (CO)	Vessels in Transit	6.7	14.1	14.1
	Vessels Hoteling	9.2	9.3	5.6
	On-Site Trains	2.4	4.7	4.7
	Off-Site Trains	0.4	0.7	0.7
	Trucks	0.4	0.4	0.4
	CHE	23.4	23.3	16.9
Nitrogen Dioxide (NO_2)	Vessels in Transit	28.8	32.8	32.8
	Vessels Hoteling	80.0	56.4	33.8
	On-Site Trains	11.2	12.5	6.5
	Off-Site Trains	1.4	1.4	0.8
	Trucks	1.7	1.4	1.4
	CHE	57.9	52.2	42.4

Assumes 100% of NO_x emissions are NO_2; Vessels in Transit include tug assists during maneuvering.; Vessels Hoteling assume 30%, 50%, and 70% ship-to-shore power in 2020, 2030, and 2040 respectively.; Train emissions without AESS produces conservative results; including AESS would reduce emissions.; On-Site Trains include arrivals, departures, and switch engine emissions while at the facility.; Off-Site Trains include emissions between Marginal Way East and the Facility.; CHE includes top picks, and yard hostlers.; Truck emissions include trucks idling in pre-queue, at the main gate, on-site movements, and off-site movements. Shaded scenarios were not used for air quality modeling (discussed in detail in the report).

Table 24. Alternative 3 Total Annual Emissions

Criteria Air Pollutant	Operational Sources	Alt 3 Emissions (tpy)		
		2020; 647k TEU	2030; 1.3MM TEU	2040; 1.7MM TEU
Inhalable Coarse Particulate Matter (PM_{10})	Vessels in Transit	0.9	1.3	1.7
	Vessels Hoteling	1.2	1.3	0.9
	On-Site Trains	0.3	0.2	0.1
	Off-Site Trains	0.03	0.03	0.01
	Trucks	0.1	0.2	0.2
	CHE	0.3	0.2	0.3
Inhalable Fine Particulate Matter ($PM_{2.5}$)	Vessels in Transit	0.8	1.2	1.5
	Vessels Hoteling	1.1	1.2	0.8
	On-Site Trains	0.2	0.2	0.1
	Off-Site Trains	0.03	0.03	0.01
	Trucks	0.03	0.05	0.05
	CHE	0.3	0.2	0.3
Sulfur Dioxide (SO_2)	Vessels in Transit	0.6	0.9	1.2
	Vessels Hoteling	2.8	3.0	2.0
	On-Site Trains	0.03	0.07	0.09
	Off-Site Trains	<0.01	<0.01	0.01
	Trucks	<0.01	0.01	<0.01
	CHE	0.04	0.05	0.07
Carbon Monoxide (CO)	Vessels in Transit	6.7	9.7	12.7
	Vessels Hoteling	7.3	7.8	5.3
	On-Site Trains	2.4	4.7	6.3
	Off-Site Trains	0.4	0.7	1.0
	Trucks	0.4	0.4	0.3
	CHE	3.5	3.2	4.0
Nitrogen Dioxide (NO_2)	Vessels in Transit	28.8	22.9	29.9
	Vessels Hoteling	63.4	47.5	31.9
	On-Site Trains	11.1	12.5	8.6
	Off-Site Trains	1.3	1.4	1.0
	Trucks	1.7	1.4	1.2
	CHE	8.9	7.6	9.6

Assumes 100% of NO_x emissions are NO_2; Vessels in Transit include tug assists during maneuvering.; Vessels Hoteling assume 30%, 50%, and 70% ship-to-shore power in 2020, 2030, and 2040 respectively.; Train emissions without AESS produces conservative results; including AESS would reduce emissions.; On-Site Trains include arrivals, departures, and switch engine emissions while at the facility.; Off-Site Trains include emissions between Marginal Way East and the Facility.; CHE includes top picks, and yard hostlers.; Truck emissions include trucks idling in pre-queue, at the main gate, on-site movements, and off-site movements.

ATTACHMENT C: HEALTH RISK ASSESSMENT

Prepared for:
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On behalf of:
Port of Seattle
Seattle, Washington

Prepared by:
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Seattle, Washington

Project Number
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Date:
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TERMINAL 5 WHARF REHABILITATION, BERTH DEEPENING, AND IMPROVEMENTS PROJECT

HUMAN HEALTH RISK CHARACTERIZATION

RAMBOLL ENVIRON

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ACRONYMS AND ABBREVIATIONS

ACS	American Cancer Society
BenMAP	Benefits Mapping and Analysis Program
CHIA	Cumulative Health Impacts Analysis
CPS	Cancer Prevention Study
CPS-II	Cancer Prevention Study II
C-R	concentration-response
DEIS	T-5 Draft Environmental Impact Statement
DEMS	Diesel Exhaust in Miners Study
DPM	diesel particulate matter
EIS	Environmental Impact Statement
IARC	International Agency for Research on Cancer
ICD	International Classification of Diseases
IHD	Ischemic heart disease
NAAQS	National Ambient Air Quality Standards
OEHHA	Office of Environmental Health and Hazard Assessment
PAHs	polycyclic aromatic hydrocarbons
PM	particulate matter
PSCAA	Puget Sound Clean Air Agency
RTG	Rubber-Tired Gantry
SCAQMD	South Coast Air Quality Management District
T-5	Port of Seattle's Terminal 5
TEU	twenty-foot equivalent units
URF	unit risk factor
USEPA	United States Environmental Protection Agency

1. INTRODUCTION

1.1 Objective

The Port of Seattle ("the Port") is interested in understanding the potential air quality health implications associated with modernization of the Port's Terminal 5 (T-5) facility. Specifically, the Port requested a health risk characterization of project-related cancer risks associated with exposure to diesel particulate matter (DPM) and non-cancer health endpoints associated with exposure to fine particulate matter ($PM_{2.5}$). The risk characterization documented in this report focused on residences nearest the terminal and on the communities of South Park and Georgetown, which are considered "highly impacted" communities nearest the T-5 facility due to existing levels of air pollution. The analysis only considered the incremental health implications caused by the Port project and does not assess the overall health risk across the lower Duwamish.

1.2 Overview of Proposed Project

The Port is sponsoring the proposed "Terminal-5 Cargo Wharf Rehabilitation, Berth Deepening, and Improvements Project" (the project). The project site is the existing T-5 marine cargo facility, on the west margin of the West Waterway, in southwest Elliott Bay, Seattle, Washington. The project area, owned and available for use by the Port, includes the existing T-5 marine cargo facility that consists of approximately 197 upland and approximately 19 acres of cargo pier.

The proposed project would improve the container-handling efficiency of the existing terminal to accommodate the projected fleet mix of larger container vessels that are anticipated to call on T-5 through 2040. The project alternatives being considered include a baseline or "no action" (Alternative 1) and two action alternatives. Both Alternatives 2 and 3 would rehabilitate and strengthen the wharf and support structure for larger cranes. Upland improvements with Alternatives 2 and 3 would enable higher container throughput than existing/baseline conditions represented by Alternative 1, and Alternative 3 would allow greater throughput capacity than Alternative 2. Brief descriptions of each alternative are provided in Sections 1.2.1 to 1.2.3.

1.2.1 Alternative 1 – No Action

The No-Action Alternative generally establishes baseline conditions against which the development (action) alternatives can be evaluated. If the Port does not redevelop the site as proposed, the site would remain as is or may be redeveloped for a different use. With the No Action Alternative, future uses are unknown. The market and existing zoning would dictate how the sites are developed.

The No Action Alternative assumes that no improvements would be made to the existing 197-acre site other than minor alterations, routine maintenance and repair work, none of which would increase container cargo capacity. The T-5 shoreline and upland area would continue as a marine cargo transportation facility with vessel moorage, cargo wharf, cargo marshalling, and truck and rail cargo transshipment operations taking place. The terminal would continue to be capable of accommodating diverse marine cargo uses such as breakbulk or neo-bulk (goods that are loaded individually, and not in containers) and other water-dependent uses and activities intrinsic to marine transportation facilities.

Marine cargo operations would be similar to the uses and activities conducted at T-5 during the past 15 years, making use of existing infrastructure designed and constructed to transship approximately 650,000 twenty-foot equivalent units (TEU) per year. The present T-5 marine cargo facility is the result of substantial expansion and improvements completed in 1999. The construction and operation of the present marine cargo facility was preceded by detailed environmental analyses and evaluations, including a combined federal, state, and local government Environmental Impact Statement (EIS), Southwest Harbor Cleanup and Redevelopment Project, and subsequent authorizations received from federal, state, and local regulators and government entities, including substantial shoreline development approval from the City of Seattle.

The No Action Alternative would preclude super Post-Panamax vessels from utilizing the site because they cannot be accommodated by the existing wharf or cranes.

1.2.2 Alternative 2 - Wharf Improvements, Berth Deepening, and Increased Cargo Handling

Alternative 2 would consist of modification of existing container facilities, including cargo wharf rehabilitation, berth deepening, and water, storm-water and electrical utility capacity improvements. Changes to existing T-5 facilities would increase container cargo transshipment capacity at the site to allow up to approximately 1.3 million TEU annually. Alternative 2 includes the provision of shore power for vessels moored at the rehabilitated wharf.

These changes to allow T-5 to accommodate existing large Post-Panamax and larger New Post-Panamax container cargo vessels and transship increased cargo volumes are described in more detail below. Cargo pier improvements would include the following:

- Replacement of cargo pier crane rail beam
- Stabilization of existing armored slope beneath the cargo wharf
- Replacement of treated wood piling wharf fender system
- Deepening navigational access to existing berth area, increasing berth depths to approximately minus 55 feet MLLW
- Repair and maintenance of existing wharf piling
- Installation of upgraded utilities, including replacement primary substation equipment and replacement water service to the existing wharf structure.
- Potential remodel of existing buildings for labor, management, maintenance and terminal operations, and installation of other small buildings as needed to service the site
- Possible installation of Rubber-Tired Gantry (RTG) crane concrete pads or runways (Rubber-Tired Gantry – a traveling crane used to move and position containers in a container yard) and a steel framed 3 level high platform (reefer rack system) to access grounded and stacked 4-high refrigerated containers
  - Installation of up 12 new electric Ship-to-Shore cranes

The Alternative 2 components most relevant to the air quality technical analyses for this project are the upland improvements to redesign and reorganize the container cargo marshalling yard area (i.e., landward of the rehabilitated cargo wharf). These changes would relocate and alter the distribution systems for grounded and wheeled container cargo (e.g., changes in internal circulation and travel lanes).

1.2.3 Alternative 3 - Wharf Improvements, Berth Deepening, Increased Cargo Handling and Additional Upland Improvements

Alternative 3 consists of the same improvements listed for Alternative 2 with the addition of reorganized intermodal rail facilities, a reconfigured gate, and demolition of buildings. Alternative 3 also includes the provision of shore power for vessels moored at the rehabilitated wharf. Alternative 3 improvements include the following:

- Substantial improvements to the upland cargo marshalling area to increase overall terminal throughput capacity to 1.7 million TEUs per year (by 2040).
- Wharf and crane improvements would allow simultaneous loading and unloading of two 18,000 TEU vessels.
- The container yard would be enlarged through relocation or demolition of the existing entrance gate, freight station, transit shed, maintenance and repair buildings, and operations buildings.
- The container yard capacity would be increased through use of grounded container storage served by RTG or RMG cranes.
- The truck gate would be relocated, and the existing intermodal rail yard would be reconfigured with additional rail lines and concrete or rail runways for RTG or RMG equipment.

1.3 Report Outline

This report is organized as follows:

- Section 2 provides an overview of the project site setting, including a discussion of features at the project site relevant to the risk characterization.

The remainder of the report is then organized to reflect the basic steps of this health risk characterization, as follows:

- Section 3 presents the air modeling methodology
- Section 4 presents the hazard identification for $PM_{2.5}$
- Section 5 presents the hazard identification for diesel particulate matter (DPM)
- Section 6 presents the detailed health assessment for $PM_{2.5}$
- Section 7 presents the detailed health assessment for DPM
- Section 8 presents the conclusions and
- Section 9 presents references

Additional information regarding the $PM_{2.5}$ analysis is included in Appendix A, and a whitepaper supporting the DPM analysis is included in Appendix B.

2. SITE SETTING

This section presents an overview of the project Site Setting, including a discussion of features at the project site relevant to the human health risk characterization.

2.1 Location & Land Use

Terminal 5 is located approximately 1.5 miles southwest from the City of Seattle urban center. Terminal 5 is immediately bordered by existing industrial land, shoreline and aquatic area use designations. The nearest residential neighborhoods are West Seattle to the west and Delridge to the south, with the nearest residential location approximately 500 feet from the southwest corner of the Terminal property. The nearest major roadway is the West Seattle Bridge to the south and Alaskan Way Viaduct to the east (highway 99). Interstate 5 is approximately 2 miles east of the Terminal 5 property.

2.1.1 South Elliott Bay Setting

Terminal 5 is located on the west shoreline of the West Waterway in southwest Elliott Bay. The West and East Waterway comprise the principal deep draft cargo vessel navigational access threshold facilities in south Elliott Bay. The West and East Waterways, separated by Harbor Island, are located at the north, downstream, end of the Duwamish Waterway in the Duwamish River Valley. The West and East waterways and the Duwamish Waterway serve maritime navigational requirements throughout the south Elliott Bay and Duwamish industrial areas.

The shoreline and surrounding upland area extending from south Elliott Bay to the upstream portion of the Duwamish Waterway include marine industrial uses and marine industrial infrastructure and commercial uses, approximately 80 percent of industrially zoned area in the City of Seattle. The south Elliott Bay and Duwamish industrial areas are served by substantial rail road and highway infrastructure. Rail lines located east and west of the waterways provide direct access to the national rail network. Similarly, industrial area arterial traffic routes converge and connect with the interstate highway system through three principal west-to-east corridors and the primary north-south corridor.

The existing Terminal 5 marine cargo site is one of four deep draft container cargo facilities in Elliott Bay. Along with four other terminals providing cargo use areas, port-owned container cargo facilities include dedicated international containerized cargo shipping facilities and deep draft maritime vessel access.

2.1.2 Terminal 5 Facility—Location and Surrounding uses

Publicly-owned port property at the existing Terminal 5 marine cargo site was built and committed to the principal site use and marine cargo transshipment uses and activities. This property includes existing combined upland cargo marshalling/transfer areas, cargo wharves, and adjacent deep draft navigational access areas in the west margin of the West Waterway. Total publicly-owned property comprising the Terminal 5 facility in southwest Elliott Bay includes port-owned upland and aquatic areas and publicly-owned state property, upland, and aquatic areas available for use by the port through a harbor area management agreement with the Washington Department of Natural Resources.

In addition to the principal marine cargo use site, port-owned Terminal 5 facility includes property not directly associated with marine cargo terminal operation. These areas consist of industrial use and activity work areas, un-improved tenant use areas, and areas used for vehicle access/circulation. A portion of the Terminal 5 facility is committed to public shoreline access and landscaped open space and pedestrian/bicycle access areas.

The principal water-dependent marine industrial cargo portion of the Terminal 5 facility entails transshipment of containerized and break-bulk cargo, accomplished by means of a concrete wharf providing two vessel berths, located at the east margin of Terminal 5, in the west portion of the West Waterway. Six container cranes operate as mobile cargo handling equipment, installed on parallel wharf surface crane rails. Terminal 5 includes occupied marine industrial warehouse, maintenance, and administrative buildings, truck entrance canopy buildings, intermodal rail transshipment facilities, a container cargo marshalling and vessel loading/unloading area, and entrance, vehicle queuing lanes, and internal vehicle circulation routes.

The Terminal 5 facility, including the marine cargo site and adjacent facility area consist entirely of industrial uses and activities. The south margin of the Terminal 5 facility is bordered by private industrial upland and shoreline barge/warehouse/truck drayage uses and tug/barge terminal operations. The area south of Terminal 5 includes substantial arterial traffic infrastructure, primarily the Southwest Spokane Street corridor and the West Seattle expressway, and a large steel production/mill facility. The west margin of the Terminal 5 facility consists of arterial right-of-way present as Harbor Avenue Southwest, with area west of Harbor Avenue Southwest including industrial and commercially zoned property.

The existing Terminal 5 marine cargo use area was improved, most recently, in the period 1996 through 1999. Cargo facility improvements completed in 1999 included: (1) adding upland cargo marshalling area; (2) construction of intermodal cargo transfer rail lines; (3) construction of cargo wharf; (4) construction of a grade-separated vehicle/rail overpass entrance; and, (5) improvement of public shoreline access, landscaped buffer areas, pedestrian/bicycle pathways, and fish and wildlife habitat.

Environmental review for the 1999 Terminal 5 redevelopment project, referred to as the Southwest Harbor Cleanup and Redevelopment Project, included a joint U.S. Army Corps of Engineers, Ecology, and Port SEPA/NEPA analysis. Environmental analyses and evaluations assessing potential environmental effects due to the Terminal 5 redevelopment project were presented in the Southwest Harbor Cleanup and Redevelopment Project Final EIS published in November 1994. The draft and final EIS analyzed the potential effects due to the redevelopment and determined mitigation actions necessary for off-setting potential negative redevelopment project effects.

2.1.3 Existing Use and Purpose for Proposed Actions—Terminal 5 Marine Cargo Site

The proposed Terminal 5 rehabilitation actions are in response to industry changes, and the need to ensure that existing cargo facilities remain capable of serving industry needs. The inability of the Terminal 5 site to accommodate existing large capacity vessels and increased capacity cargo carriers currently being deployed in Pacific trade forecloses the capability of Terminal 5 to serve future marine cargo activity. Relocation of Terminal 5 container cargo shipping operations to other port-operated cargo shipping terminals in Elliott Bay provides the Port with an opportunity to rehabilitate elements of the Terminal 5 container cargo shipping infrastructure. Strengthening the existing Terminal 5 wharf and deepening navigational access is timely since the site is not committed to a long-term cargo use at present, allowing for efficient, cost-effective, comparatively un-impeded marine cargo site rehabilitation actions.

2.2 Demographics

This analysis evaluated impacts in the Duwamish River Valley, focusing on six residences bordering the facility to the west and south and on the zip codes falling within the air quality assessment study area. These zip codes include 98108, which encompasses the South Park and Georgetown neighborhoods, as well as the following:98101 (downtown), 98102 (Eastlake/Capitol Hill), 98104 (downtown), 98106 (Riverview/Delridge), 98109 (Queen Ann/Westlake/South Lake Union), 98112 (Madison Park/Montlake), 98116 (North Admiral/West Seattle), 98119 (Queen Ann), 98121 (Belltown), 98122 (Capitol Hill/Madrona), 98126 (Fauntleroy/Roxhill), 98134 (Industrial District), 98136 (Fauntleroy), and 98144 (Beacon Hill). Results specific to South Park and Georgetown (98108) are emphasized in this report because they are communities nearest the T-5 facility that the Puget Sound Clean Air Agency (PSCAA) has identified communities as being highly impacted by transportation, economic, or historic barriers to participation in clean air decisions and solutions.

South Park and Georgetown are low-income riverfront neighborhoods south of downtown Seattle, near the King County International Airport and approximately two miles south of T-5 along the Duwamish Waterway. According to the 2010 Census, households in South Park (census tract 112) and Georgetown (census tract 109) had a median income of $42,907 and $37,097, respectively, compared to a median income of $60,665 in the greater city of Seattle. Similarly, 9.9% and 11.4% of families in South Park and Georgetown, respectively, had incomes below the poverty line while in Seattle that percentage was 6.8% (USCB 2010a). South Park is additionally an ethnically-diverse neighborhood made up of 44.6% white residents, 15.8% Asian residents, 10.3% Black or African American residents, 1.9% American Indian and Alaska Native residents, 1.6% Native Hawaiian and Other Pacific Islander, and the remaining 25.8% "some other race" or two or more races. Thirty seven point three percent (37.3%) of the South Park population is Hispanic or Latino (UCSB 2010b).

2.3 Highly Impacted Communities

PSCAA identifies "highly impacted communities" as "*geographic locations characterized by degraded air quality, whose residents face economic or historic barriers to participation in clean air decisions and solutions*" (PSCAA 2015). PSCAA has established partnerships with South Park and Georgetown to improve their air quality through mitigation measures at the individual and residential level as well as via broader policy changes.

As outlined in the *Cumulative Health Impacts Analysis (CHIA) of the Duwamish River Valley* (Gould and Cummings 2013), South Park and Georgetown, and other residents living in zip code 98108, have higher heart disease death rates and a lower life expectancy than other communities in Seattle and greater King County. This analysis was conducted based on the 2010 Census data for these two neighborhoods. Due to poor health status in these communities relative to other Seattle communities and knowledge of air quality and other environmental impacts from many nearby sources, PSCAA requested that this health evaluation focus on these areas.

3. AIR MODELING METHODOLOGY AND RESULTS

3.1 Emission Inventory Methods

The proposed modifications to Terminal 5 would result in emissions from ocean-going vessels, harbor craft, locomotives, cargo-handling equipment, and on-road trucks. The emissions derived from these sources change in response to fleet turnover, engine deterioration rates, and regulatory triggers. These sources of emissions and their forecast changes in emissions were considered in the analysis, are documented here, and with more detail in the Terminal 5 Draft Environmental Impact Statement (DEIS).

3.1.1 Emission Factor Tools and Sources

The emissions estimates for project-related sources employed several standard computer tools as well as emission rate calculations using formulas published by the USEPA, the California Air Resources Board, and topic-specific studies conducted by individual ports. Important assumptions employed in this portion of the assessment are provided in the DEIS.

As a caveat, this study was conducted in parallel with the DEIS technical report, but contains assumptions which are more conservative than those in the DEIS. Notably, the vessel parameters used for the health study were based on conservative values and were not refined to reflect the vessels which are expected to call the Terminal. These assumptions result in higher modeled concentrations and add to the conservatism of the health risk characterization.

3.1.2 Facility Operational Criteria Pollutant Air Emissions

Combustion source emissions associated with operation of the terminal in 2020, 2030, and 2040 were estimated based on the maximum expected commodity throughput. The combustion source emissions assessment used detailed operational scenarios of peak hour, peak day, and annual levels of activities developed in discussions with the Port of Seattle. Emission estimates considered the following sources:

- Vessels in transit, maneuvering, and hoteling at berth.
- Tugs assisting vessels during docking and undocking.
- Empty and loaded trains traveling between East Marginal Way S and the facility.
- A switch engine arranging train cars.
- Cargo handling equipment, including yard tractors, top-picks, rubber-tired gantry cranes, and rail-mounted gantry cranes.
- On-road trucks traveling between East Marginal Way S and the facility, queueing before the main gate, queueing at the main gate, and traveling on the facility.

The DEIS details the critical assumptions regarding terminal operations and basic dispersion modeling parameters associated with project-related combustion sources.

3.2 Dispersion Modeling

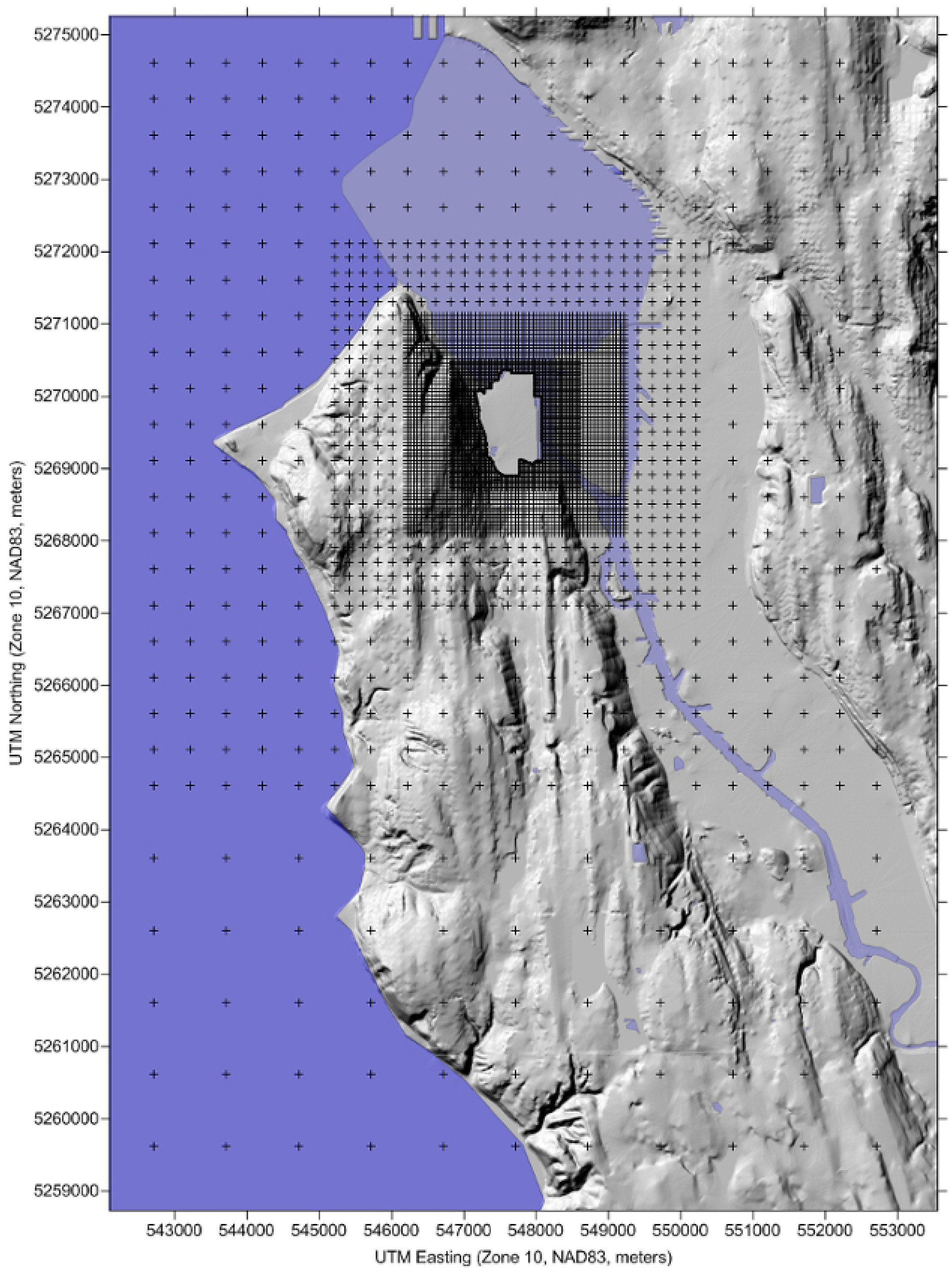
Air quality dispersion modeling simulations were used to estimate air pollutant concentrations due to emissions from on-site emission sources associated with selected alternatives and throughputs. This section discusses the methods used to develop these simulations for Terminal 5.

3.2.1 Modeling Operations

The USEPA has designated AERMOD as the preferred guideline air dispersion model for air dispersion modeling (USEPA "Guideline on Air Quality Models," codified as Appendix W to 40 CFR Part 51) for complex source configurations and for sources subject to exhaust plume down-wash. The most recent version of AERMOD (version 15181) was employed with meteorological data from PSCAA's Duwamish monitoring station and regional upper air data from Quillayute, Washington. Missing surface data observations were substituted from the Boeing Field station. The meteorological pre-processing also included an analysis of the physical characteristics of land use surrounding the terminal.

Dispersion modeling calculates pollutant concentrations at locations referred to as receptors. The Terminal 5 dispersion modeling analyses used receptors spaced 1000 meters apart covering the 10 kilometer (km) by 15 km simulation domain, with a 10 km by 10 km nested receptor grid at 500-m spacing, a 5 km by 5 km nested receptor grid at 200-meter (m) spacing, a 3 km by 3 km nested receptor grid at 50-m spacing, a 1.8 km by 1.8 km nested receptor grid at 25-m spacing, and fence line receptors with 10-m spacing. The modeling domain and receptor locations are depicted in **Figure 1**. Note that the dispersion modeling results discussed in Section 3.2.2.present the maximum concentrations of each pollutant from the more than 7,000 receptors displayed in **Figure 1**.

Figure 1: AERMOD Modeling Domain and Receptor Locations



RAMBOLL ENVIRON	AERMOD Modeling Domain and Receptor Locations	Figure 1

3.2.2 Operational Scenario Selection

Six modeling scenarios were developed for the terminal based on alternative throughputs and associated modeling years. The modeling analysis assumed peak-throughput operation for all emission source activities. The selected modeling scenarios considered with air quality modeling are shown in **Table 1** with filled cells. Empty cells in this table were not considered with modeling because operations would not be possible due to physical and year-based economic limitations of the facility.

Table 1: Operational Scenarios Considered with Air Quality Modeling

Throughput	Year	Alt. 1	Alt. 2	Alt. 3
647K TEUs	2020	●	●	●
1.27MM TEUs	2030		●	●
1.7MM TEUs	2040			●

Modeling was not conducted for the 2030 and 2040 throughput scenarios for Alternative 1, or the 2040 throughput scenario for Alternative 2. Alternative 1, with no improvements, would not allow the port to expand throughput beyond 647,000 twenty-foot equivalent units (TEUs). Similarly, Alternative 2 could not support 1,700,000 TEU throughput without the cargo-handling equipment changes proposed in Alternative 3. Assessing emissions in future years without additional growth in throughput would result in lower emissions due to fleet turnover and regulatory changes. In other words, the scenarios not modeled would be expected to produce lower maximum concentrations than the modeled scenarios. The selected scenarios provided in Table 1 are reflective of the most conservative configurations with the highest emissions and maximized throughput. Additional detail of the emissions for each scenario is provided in Section 3.2.3.

3.2.3 Operational Emissions

The total estimated annual operational emissions for three alternatives are presented in **Table 2**. Note that the shaded scenarios in **Table 2** were not considered with air quality dispersion modeling because they represent conditions with no operational or site configuration changes. Emissions for these scenarios are presented for comparison with those scenarios that were evaluated with modeling.

The shaded scenarios shown in **Table 2** have estimated emissions equal to or less than the same facility configurations in the decade prior (e.g., Alternative 2 at 1.3MM TEU throughput in 2040 has lower emissions than Alternative 2 at 1.3MM TEU throughput in 2030). These decreases are due to equipment fleet turnover. For these reasons, there was no need to conduct modeling to be able to conclude that emissions associated with the shaded scenarios would be expected to comply with the NAAQS if the prior decade scenario was in compliance.

Table 2: Annual Project Emissions (tons per year)

	2020			2030			2040		
	647K TEUs			647K TEUs	1.3MM TEUs		647K TEUs	1.3MM TEUs	1.7MM TEUs
Pollutant	Alt 1	Alt 2	Alt 3	Alt 1	Alt 2	Alt 3	Alt 1	Alt 2	Alt 3
CO	49.7	42.4	20.6	39.2	52.6	26.5	37.4	42.5	29.5
NO_2	254.5	180.9	115.1	161.1	156.7	93.3	154.6	117.6	82.2
$PM_{2.5}$	7.0	6.0	2.6	4.8	5.9	2.9	4.5	4.0	2.8
PM_{10}	7.4	6.3	2.8	5.2	6.4	3.3	4.8	4.4	3.2
SO_2	8.0	4.3	3.5	8.0	5.1	4.0	8.0	3.6	3.4

Note: The shaded cells indicate scenarios that were not considered with air quality modeling but that are expected to comply with the NAAQS because, for the same alternative, the emissions decreased from the prior decade and no operational or configuration changes occurred between the two decades.

3.2.3.1 Intra-year Comparisons

Table 2 indicates nearly all criteria pollutant emissions would decrease with modernization and upgrades of the Terminal 5 facility. The exception to the emission reduction trend is the expected change in emissions between Alternative 1 and Alternative 2 in 2030 for PM and CO, and in 2040 for CO. These increases are attributable to the increased activities required to accommodate a 1.3MM TEU throughput with Alternative 2. Additionally, the larger potential vessel sizes expected with the action alternatives also contribute to these exceptions in the emission reduction trend.

3.2.3.2 Modeled Scenarios

For the scenarios that were considered with air quality modeling shown in **Table 2** (i.e., the non-shaded cells), emission decreases between Alternatives 1 and 2 in 2020 are attributable to (1) fewer vessels calling on the Port due to increased vessel TEU capacity and (2) a projected 30 percent use rate of shore power (there is no shore power available for the no action alternative).

The decreases in emissions from Alternative 2 to Alternative 3 in 2020 are largely due to the electrification of the majority of container-handling equipment activities. As Alternative 2 and Alternative 3 progress into years beyond 2020, their respective activity levels increase with throughput, but they benefit from increasingly greater use of shore power and vehicle fleet turnover, which result in reduced overall emissions, except for CO and SO_2. The estimates for CO and SO_2 increase with activity and do not have the same pronounced reductions in future years as the other pollutants. For Alternatives 2 and 3, the anticipated emissions reductions expected to result from use of shore power are shown in **Table 3**. The emissions reductions due to use of shore power are higher with Alternative 2, 2040 than Alternative 3, 2040 because the expected numbers of hours spent at berth are higher in Alternative 2 due to more cargo handling equipment electrification, resulting in increased efficiency, but the total ship emissions are lower with Alternative 3.

Table 3: Reduction in Annual Emissions with Shore Power (tons per year)

Pollutant	Alternative 2			Alternative 3		
	2020	2030	2040	2020	2030	2040
Shore Power Efficacy:	30%	50%	70%	30%	50%	70%
CO	3.9	9.3	13.0	3.1	7.8	12.3
NO_2	34.3	56.4	79.0	27.2	47.5	74.4
PM_{10}	0.6	1.5	2.1	0.5	1.3	2.0
$PM_{2.5}$	0.6	1.4	2.0	0.5	1.2	1.9
SO_2	1.5	3.5	5.0	1.2	3.0	4.7

3.2.4 Model Results & NAAQS Compliance

The modeled results comply with the NAAQS for each alternative, temporal configuration, and criteria pollutant considered. The DEIS provides the dispersion modeling results for all pollutants in detail and contrasts the results against the NAAQS. A summary of the NAAQS-based results for $PM_{2.5}$ are provided in **Table 4**.

Table 4: Comparison of Model-Predicted $PM_{2.5}$ Concentrations to the NAAQS

Averaging Period	Background Concentration[(a)] (µg/m³)	Year @ Capacity (# TEUs)	Alternative	Model-Predicted $PM_{2.5}$ Concentrations[(b)(c)] (µg/m³)		Ambient Standard (µg/m³)
				Project-Specific	Project-Specific with Background	
24-Hour[(d)]	21	2020 @ 647k	Alt. 1	4.4	25.4	35
			Alt. 2	6.4	27.4	
			Alt. 3	5.9	26.9	
		2030 @ 1.3MM	Alt. 2	6.2	27.2	
			Alt. 3	5.8	26.8	
		2040 @ 1.7MM	Alt. 3	5.8	26.8	
Annual[(e)]	8.1	2020 @ 647k	Alt. 1	1.3	9.4	12
			Alt. 2	1.5	9.6	
			Alt. 3	0.7	8.8	
		2030 @ 1.3MM	Alt. 2	1.2	9.3	
			Alt. 3	0.7	8.8	
		2040 @ 1.7MM	Alt. 3	0.5	8.6	

(a) Background concentrations (expressed as micrograms per cubic meter [µg/m³]) based on the higher of nearby monitor design values (identified as valid by USEPA) or values provided by Northwest Airquest 2009–2011 design values specific to the Terminal 5 location.

(b) Reported concentrations are those occurring at the maximum impact location. Concentrations at all other locations are less than those reported here.

(c) Short-term concentrations are based on modeling that considered maximum hourly activity during every hour of the 5-year meteorological data set, which is not a possible actual level of activity. These results therefore represent intentionally conservative conditions. Note that consistent with USEPA guidance, the annual modeling results are based on 5-year averages from the 5-year meteorological data set instead of 3-year as per the NAAQS.

(d) The 24-hour project-specific concentrations represent the 5-year average of the 98th percentile 24-hour concentrations in accordance with the NAAQS standards.

(e) The annual project-specific concentrations represent the annual arithmetic mean averaged over 5-years in accordance with the NAAQS standards.

3.3 Health-Based Model Results

In an effort to provide the most conservative modeled concentrations for the health risk characterization, statistics other than those used for determining NAAQS compliance were applied. AERMOD produced model results for every receptor and every hour of the 5-year modeling period, allowing for numerous statistics to be considered. The short-term and long-term health assessments considered the extremes of the modeled-concentrations against a baseline (Alternative 1, 2020) to understand the extents of possible health endpoints associated with any alternative, year, and throughput. For both the short-term and long-term assessments, the modeled concentrations predicted for Alternative 2 in 2020 (modeled-concentration exceeding baseline) and Alternative 3, 2040 (lowest modeled-concentration and less than baseline) served as bounds for the health assessments.

3.3.1 24-Hour Model-predicted $PM_{2.5}$ Concentrations

In contrast to the NAAQS-form, which is the 5-year average of the 98th percentile values at each receptor, the health risk characterization is based on the average of the maximum daily $PM_{2.5}$ concentration in each of the five years. These results, calculated for each receptor, served as input to the non-cancer $PM_{2.5}$ assessment.

For the 24-hour assessment, the concentrations were further assessed to determine the maximum concentration observed in each of the zip codes adjacent to Terminal 5. A zip code level of analysis was required to pair with incidence data obtained from the Washington Department of Health. These health data were used to facilitate risk calculations. The model-predicted zip code concentrations of project-specific concentrations are provided in **Table 5**.

Table 5: 24-Hour Maximum $PM_{2.5}$ Concentrations by Zip Code

Zip Code	Modeled Maximum 24-Hour Concentrations[a] ($\mu g/m^3$)		
	Alt. 1, 2020	Alt. 2, 2020	Alt. 3, 2040
98106	1.40	1.45	0.65
98108	0.11	0.11	0.06
98126	2.71	2.46	1.62
98134	2.44	1.59	1.18

[a] Project-specific concentrations (i.e., do not include background). The health assessment only considers the difference between scenarios. Additionally, a background of 21 $\mu g/m^3$ (as reported elsewhere) would be used for either scenario being considered, thereby making it redundant.

3.3.2 Annual Model-predicted DPM Concentrations

Using annual emission rates, annual average PM concentrations were calculated at each receptor for each year. Of these 5 years of annual averages, the year corresponding to the maximum-modeled concentration was used as a conservative approximation of the long-term impacts. This is in contrast to the NAAQS-form which is the 5-year average of the annual average concentrations at each receptor. These long-term results were intended to serve as input to the DPM assessment.

For the DPM analysis, the modeled-concentrations were assessed for six of the residences nearest Terminal 5. The project-related DPM annual average modeled concentrations at selected residences for baseline and the bounding scenarios are provided in **Table 6**. Isopleths of concentrations for the DPM scenarios are provided in **Figure 8**, **Figure 9**, and **Figure 10**.

Table 6: Annual Average DPM Concentrations at Selected Locations

Residence ID	DPM Annual Average (µg/m³)		
	Alt. 1	Alt. 2	Alt. 3
	2020	2020	2040
Residence 1	0.18	0.21	0.04
Residence 2	0.20	0.24	0.04
Residence 3	0.23	0.27	0.04
Residence 4	0.23	0.28	0.04
Residence 5	0.17	0.20	0.02
Residence 6	0.13	0.13	0.02

4. HAZARD IDENTIFICATION FOR $PM_{2.5}$

This section presents the hazard identification for $PM_{2.5}$. A detailed assessment of health impacts associated with the T-5 modernization project is provided in Section 6.

4.1 Physical and Chemical Properties

Particulate matter (PM) is a complex mixture of solid and liquid particles that can vary greatly in size, composition, and concentration, depending on the sources generating the particles and other factors such as geographic location, season, and time. PM may originate from a variety of sources, including diesel exhaust, as well as exhaust from gasoline engines, combustion from other sources such as wood and coal, and windblown dust from agriculture and construction and motor vehicles. The major components of PM are metals, organic chemicals, biological material, ions, reactive gases, and a carbon core. PM are largely made up of a carbon core containing a variety of metals, secondary particles (formed through reactions with gases in the atmosphere and containing sulfates, nitrates, and secondary organic chemicals), and hydrocarbons.

The sizes of PM may range over a wide scale, usually classified based on their aerodynamic diameter. Common size descriptions used by regulatory agencies within the United States include PM_{10} and $PM_{2.5}$, which refer to particles with aerodynamic diameters smaller than 10 µm and 2.5 µm, respectively. Other particle sizes referenced in health effects studies include fine particles and ultrafine particles, which refer to particles with aerodynamic diameters smaller than 1-2.5 µm and 0.1 µm, respectively. Smaller particles tend to be present in greater numbers, with a greater total surface area than larger particles of the same mass. Scientists believe the toxic materials carried by smaller particles may be more likely to interact with cells in the lung than those carried by larger particles.

4.2 Health Effects Associated with $PM_{2.5}$

Particulate matter that is small enough to be inhaled and retained by the lungs is a public health concern. These respirable particles (PM_{10} and $PM_{2.5}$) can accumulate in the respiratory system or penetrate into the vascular system, potentially causing or aggravating diseases such as asthma, bronchitis, lung disease, and cardiovascular disease.

There is a large body of epidemiology and toxicology studies examining the relationship between exposure to PM and increased illness (morbidity) or increased death rates (mortality) in people. A number of these studies demonstrate that short-term exposure to elevated PM increases acute mortality in people with pre-existing cardiovascular disease or respiratory conditions, especially elderly people with such diseases. Other epidemiology studies suggest that exposure to elevated PM may affect pregnant women and their fetuses and infants, including effects such as increased incidence of low birth weight, premature infants, or increased risk of infant or child mortality. Studies exposing animals, bred to mimic certain human cardiac and pulmonary conditions, to air containing concentrated PM support the linkage between exposures to PM and disease.

In support of the National Ambient Air Quality Standards (NAAQS) for PM, the United States Environmental Protection Agency (USEPA) published an Integrated Science Assessment for Particulate Matter (USEPA 2009), describing the scientific body of literature supporting associations between exposure to PM and adverse health effects. The Integrated Science Assessment reflects "the latest scientific knowledge useful in indicating the kind and extent of identifiable effects on public health which may be expected from the presence of [a] pollutant in ambient air" and forms the scientific foundation for the review of the NAAQS standards. In addition, the South Coast Air Quality Management District (SCAQMD) published an appendix with summaries of health effects information for PM and additional references (SCAQMD 2013). The epidemiology literature supports an association between short-term exposures to elevated concentrations of PM_{10} and increases in mortality (USEPA 2009, SCAQMD 2013, and references within those documents). The epidemiology literature also supports an association between exposure to elevated concentrations of PM and increases in serious illnesses reflected by hospital admissions, emergency room visits, or physician office visits for respiratory and cardiovascular diseases. The associations for serious illness are stronger than the associations discussed above for mortality, and are associated with both PM_{10} and $PM_{2.5}$.

4.3 Health Endpoints Assessed for $PM_{2.5}$ Exposures

Among the specific health endpoints of concern for PM are respiratory disease and cardiovascular disease. Often, epidemiology studies examine total mortality to capture all possible causes of death, while other studies break down the analysis by disease. In addition to mortality, exposure to PM has been associated with respiratory and cardiovascular disease or symptoms (morbidity). These effects are often captured in examining symptoms or hospital visits. The scientific literature supporting the association between exposure to PM and these health outcomes has been extensively reviewed and summarized (USEPA 2009, SCAQMD 2013). Details about the studies used to assess these health endpoints are provided in Section 6.2.

Many of the individual constituents of $PM_{2.5}$ are classified as air toxics (by the USEPA) or toxic air contaminants (by the OEHHA). Some of these constituents have been shown to have mutagenic and carcinogenic properties (for example, benzene, formaldehyde, polycyclic aromatic hydrocarbons (PAHs; USEPA 2002). In addition to non-cancer effects, PM has been classified as a known human carcinogen by the International Agency for Research on Cancer (IARC 2015) and the association between exposure to both $PM_{2.5}$ and PM_{10} and lung cancer have been observed in the epidemiology literature (Hamra et al. 2014). For the purpose of this assessment, we consider the potential cancer effects of PM under DPM. Further discussion of the literature for DPM can be found in Appendix B. Both short-term and long-term exposures to $PM_{2.5}$ have been associated with increased risk of adverse health effects (summarized in USEPA 2009). We therefore considered potential health impacts related to both exposure durations. In choosing the appropriate non-cancer health endpoints to be used in the risk characterization, we considered:

- The overall weight-of-evidence from the collective body of epidemiology and toxicology scientific literature (summarized in the PM Integrated Science Assessment; USEPA, 2009);
- The public health significance of specific health endpoints within broader health effects categories;
- The availability of high quality epidemiology studies providing concentration-response (C-R) functions for specific health endpoints; and
- The availability of baseline incidence data for each health endpoint for the communities assessed in this study.

4.3.1 Health Endpoints Associated with Long-term Exposures to $PM_{2.5}$

Similarly, we considered the following health endpoints for long-term exposures to $PM_{2.5}$:

- Mortality
  - All-cause
  - Cardiovascular - Ischemic heart disease (IHD)-related
  - Cardiopulmonary-related [including acute bronchitis and asthma]).
  - Diabetes
  - Infant mortality
  - Lung cancer

We considered but excluded a number of health outcomes, as noted in **Table 7**. In some cases, there were poor population data that precluded the application of these data to the area of interest. In others, the health endpoint is better captured by a more clinically relevant outcome examined.

Table 7: Exclusion of Health Endpoints Associated with Long-term $PM_{2.5}$ Exposures

Health effect, condition	Reason for exclusion
Mortality from cardiopulmonary diseases	Too general a health outcome; includes two different mortality causes (cardiovascular and respiratory)
Mortality from ischemic heart disease	Already included in mortality from cardiovascular disease
Mortality from diabetes	Inconclusive evidence of an association
Mortality from hypertension	Inconclusive evidence of an association
Infant mortality (overall and cause-specific)	Not relevant to the project
Lung cancer	Separately considered in section examining cancer risk from DPM

Based on these considerations, we selected the following two health endpoints for evaluation of non-cancer health impacts of long-term exposures to $PM_{2.5}$:

- All-cause mortality; and
- Cardiovascular mortality.

4.3.2 Health Endpoints Associated with Short-term Exposures to $PM_{2.5}$

Based on the above considerations, we considered the following health endpoints for short-term exposures to $PM_{2.5}$:

- Mortality
  - All-cause
  - Cardiovascular
  - Respiratory
- Morbidity

- Cardiovascular effects (incidence of ischemic heart disease and cardiovascular-related hospital admissions)
- Respiratory effects (respiratory-related hospital admissions [including asthma and chronic pulmonary disease]; asthma-related emergency department visits; respiratory symptoms [including acute bronchitis and asthma]).

We considered but excluded a number of health outcomes for practical reasons, listed in **Table 8**. In some cases, there were poor population data that precluded the application of these data to the area of interest. In others, the health endpoint is better captured by a more clinically relevant outcome examined. **Table 8** presents our reasons for exclusions.

Table 8: Exclusion of Health Endpoints Associated with Short-term PM2.5 Exposures

Health effect, condition	Reason for exclusion
Incidence of ischemic heart disease	Included in the broader category of hospitalization for cardiovascular disease (a more clinically-relevant health outcome)
Incidence of chronic pulmonary disease	Included in the broader category of hospitalization for respiratory diseases (a more clinically- relevant clinically)
Emergency department visits for asthma	Included in hospital admissions for the same condition (more clinically-relevant); no baseline incidence data available
Prevalence of acute bronchitis and of lower respiratory symptoms	Poor population data; inconclusive evidence of an association
Prevalence of asthma-related and other respiratory conditions (cough, shortness of breath, wheezing, upper respiratory symptoms)	Poor population data; included in the broader category of hospitalization for asthma

Based on these considerations, we selected the following final list of health endpoints for evaluation of health impacts of short-term exposures to PM2.5:

- Mortality
  - All-cause;
  - Cardiovascular; and
  - Respiratory
- Morbidity
  - Hospital admissions for cardiovascular effects;
  - Hospital admissions for respiratory diseases; and
  - Hospital admissions for asthma.

5. HAZARD IDENTIFICATION FOR DPM

5.1 Physical and Chemical Properties

Diesel exhaust is a complex mixture of hundreds of constituents that exist either in the gas phase or in particle form, produced during the combustion of diesel fuel. Gaseous components of diesel exhaust include water vapor, carbon dioxide, carbon monoxide, oxygen, nitrogen, nitrogen compounds, sulfur compounds, and numerous low-molecular-weight volatile organic hydrocarbons, including aldehydes such as formaldehyde, and acetaldehyde, and acrolein, benzene, 1,3-butadiene, PAHs and nitro-PAHs.

DPM is a source-specific type of PM formed by various physical processes as diesel engine exhaust cools and dilutes. Diesel exhaust emissions vary significantly in chemical composition and particle sizes are dependent on engine types (heavy-duty, light-duty), engine operating conditions (idle, accelerate, decelerate), and fuel formulations (high/low sulfur fuel).

Like PM, DPM consist of a solid core consisting of elemental carbon, with other compounds such as organic compounds, sulfate, nitrate, metals, and other trace elements adsorbed to the surface. The particle phase includes $PM_{2.5}$, fine, and ultrafine particles. These size classes have a large surface area-to-volume ratio that makes them an efficient medium for adsorbing organics and allows them to penetrate deep into the lung (USEPA 2002).

Diesel exhaust composition has changed considerably over the years due to changes in the combustion process as well as filters and after-treatments technology. This "moving target" is especially important when comparing results of health studies that rest on health endpoints with long latency periods, such as those for lung cancer, as the epidemiology studies that these assessments are based on need to examine workers whose exposures started more than 20 years earlier. Starting in 1988 (trucks) and continuing in 1991 (trucks), 1994 (trucks), 1996 (buses), and 2007 (trucks), the USEPA has progressively tightened standards for particulate emissions from on-road heavy-duty diesel engines, resulting in the development of new technology diesel engines that emit lower amounts of particulate matter and other emitted pollutants (e.g., gases), and diesel exhaust with an inherently different composition. That is, these changes have not only resulted in the quantitative reduction in mass emitted by new technology diesel engines as compared to engines pre-regulation, but have also resulted in qualitative differences in the composition of what is emitted, both with respect to size and with respect to chemicals associated with the exhaust (Hesterberg et al. 2011). Thus, depending on the components of diesel exhaust that may be causally linked to the increased risk of lung cancer, simple dependence on particle mass (i.e., expressing cancer risk as "per $\mu g/m^3$") may not be an accurate metric of exposure, as the composition of the particles has changed dramatically.

5.2 Environmental Fate and Transport

DPM is directly emitted from combustion engines as a component of diesel engine exhaust. Like $PM_{2.5}$, DPM is removed from the atmosphere through both wet and dry deposition although less efficiently than larger particles, resulting in longer atmospheric residence times. Studies have shown that DPM can be dispersed widely after emission (USEPA 2002). In addition, diesel exhaust may "age" in the atmosphere, undergoing chemical and physical transformation and dispersion over a period of days. The physical and chemical transformation of diesel exhaust will vary depending on the environment. In an urban or industrial environment, there may be high concentrations of oxidizing and nitrating radicals present, which may affect chemical stability, and atmospheric residence time of the resulting "aged" particles.

5.3 Health Effects Associated with DPM

There is a large body of literature examining cancer risk specific to DPM. As early as the early 1990s, several epidemiology studies addressing the association between exposure to diesel DPM and lung cancer were available. These included a case-control and a retrospective cohort study of US railroad workers (Garshick et al. 1988) along with an associated industrial hygiene survey (Hammond et al. 1988; Woskie et al. 1988a, 1989); and a case-control study and exposure-response analysis of truckers (Steenland et al. 1990, 1992) along with an industrial hygiene study (Zaebst et al. 1991) and an exposure-response analysis (Steenland et al. 1998).

More recently several epidemiology studies have been published which examine occupational exposure among non-metal miners, railroad workers, and workers in the trucking industry. The Trucking Industry Particle Study (Garshick et al. 2012) reflects a large cohort in the US trucking industry of drivers and dockworkers with regular exposure to diesel exhaust. The Diesel Exhaust in Miners Study (DEMS) (Attfield et al., 2012; Silverman et al. 2012) included a cohort analysis and a nested case–control analysis that was adjusted for tobacco smoking. Both of these studies show positive trends in lung cancer risk with increasing exposure to diesel exhaust, using elemental carbon as a measure of diesel exposure.

In 2012, the World Health Organization International Agency for Research on Cancer (IARC) assembled an expert working group to evaluate the scientific literature and assess the carcinogenicity of diesel exhaust (along with gasoline engine exhausts, and some nitroarenes) (IARC 2014). Based on a number of occupational cohort studies, as well as supporting case-control studies, the expert group concluded that the epidemiological literature support a causal association between exposure to diesel engine exhaust and lung cancer in people. An increased risk for bladder cancer was also noted in some (but not all) available case–control studies. This finding was not observed in cohort studies. The expert group concluded that there was "sufficient evidence" in humans for the carcinogenicity of diesel-engine exhaust. Furthermore, their assessment of animal studies and other related studies supported this assessment, leading to an overall assessment of DPM as "carcinogenic to humans" (Group 1) (IARC 2014).

6. APPROACH FOR DETAILED $PM_{2.5}$ HEALTH ASSESSMENT

There is considerable overlap between the particles within the size range of $PM_{2.5}$ and the particles comprising DPM. In order to assess non-cancer and cancer risk associated with exposures to $PM_{2.5}$ and DPM, we have taken the approach of assessing non-cancer risk for $PM_{2.5}$, as the majority of the literature does not differentiate PM source when assessing health impacts based on population exposures. In addition to DPM, IARC has evaluated the carcinogenicity of PM as a component of outdoor air pollution (IARC 2015). The working group concluded that lung cancer is positively associated with indicators of air pollution in nearly all studies examined, and associations with PM are the most consistent component of air pollution. However, based on the specific assessment of the association between exposure to DPM and lung cancer (IARC 2014), we have chosen to assess cancer risk based on DPM (see Section 7).

6.1 Methods

Air quality impacts were assessed for baseline (no action) and two action alternatives as described in Section 3. The air quality impacts were then used together with concentration-response (C-R) functions (also called health impact functions), which relate a change in the concentration of a pollutant with a change in the incidence of a health endpoint. For this analysis, we evaluated the most relevant health endpoints, and selected the appropriate C-R functions to align with health statistics specific to the South Park and Georgetown neighborhoods. In the next section, we describe how methods from a USEPA model, the Benefits Mapping and Analysis Program (BenMAP), was applied to the evaluation of $PM_{2.5}$-associated non-cancer health impacts.

6.1.1 Exploring Use of BenMAP to Predict Non-Cancer Health Impacts

As requested by PSCAA, we initially explored using BenMAP to estimate non-cancer health impacts associated with exposures to $PM_{2.5}$. BenMAP is a computer program that uses C-R functions from studies in the published scientific literature to predict impacts of air pollution-related health effects. The USEPA originally developed the BenMAP program to derive health benefits and monetary values to inform policymakers by enabling the comparisons associated with national-scale air quality regulations (USEPA 2015). More recently, it has also been applied to local-scale analyses.

Local-scale BenMAP analyses use a recently-released version of the program, BenMAP CE, which still contains a number of program bugs. Although we attempted to use BenMAP CE, including working with USEPA staff to address the program issues, we eventually opted to instead use the underlying methodology and approach outside of BenMAP to estimate non-cancer health impacts for both short-term and long-term exposure to $PM_{2.5}$. Below, we describe the modeling system and how we applied the BenMAP methodology for our evaluation.

6.1.2 Overview of the BenMAP Methodology

BenMAP relies on air quality inputs to calculate the change in ambient air pollution associated with a change in emissions. These inputs are generally associated with at least two air quality modeling scenarios: a baseline scenario, and one or more alternative scenarios. For this assessment of two T-5 modernization project alternatives, we calculated the difference between baseline (Alternative 1) and each of two action alternatives (Alternatives 2 and 3).

BenMAP calculates risks for health impacts of exposure relying on published, previously observed associations between a change in air pollution concentration and health effects (for specific health endpoints), using C-R functions derived from epidemiology studies (USEPA 2015). The C-R functions are used together with baseline incidence of the specific health endpoints being evaluated and local population data to predict health effects from exposures. Health effects are typically calculated for a county or zip code and then summed to obtain regional- and national-scale estimates of health impact.

As discussed in Section 4.3, we selected several relevant health endpoints including premature all-cause mortality, cardiovascular mortality, and hospital admissions for respiratory and cardiovascular endpoints. These health effects were evaluated for the zip code-based locations in the vicinity of T-5, including those containing highly impacted communities (e.g., South Park and Georgetown).

6.1.3 Application of the BenMAP Methodology

Although we were unable to implement the BenMAP program itself, we were able to use similar input data to calculate potential health impacts from modeled $PM_{2.5}$ exposures resulting from the different project alternatives. This allowed comparison of the baseline (Alternative 1) with each of two action alternatives using the general PM/health risk model that serves as the basis of the BenMAP program. As described in more detail below, the algorithms within the BenMAP program take $PM_{2.5}$ air quality information for specific areas and combine these data with: (1) C-R functions derived from published epidemiology studies, (2) baseline health incidence data for the health endpoints of interest, and (3) population estimates. This information is used to estimate the annual incidence of various health effects associated with exposure to ambient $PM_{2.5}$ for different scenarios (*i.e.*, the Alternatives 2 and 3). We used the BenMAP algorithms described below in a spreadsheet to estimate the health risks.

Specifically, the elements of the impact assessment include:

- **Air quality information:** Excess $PM_{2.5}$ that would be generated for Alternative 1 (baseline), and Alternatives 2 and 3.
- **C-R function(s):** The C-R function is an estimate based on the association between the health endpoint and $PM_{2.5}$ concentrations (preferably derived for the location of interest though functions from other locations can be used, which introduces some uncertainty). C-R functions are available from epidemiology studies that assessed $PM_{2.5}$-related health effects for short- or long-term exposures.
- **Baseline health effects incidence rate and population**: The baseline incidence rate is an estimate of the number of cases of the health effect per year (usually per 100,000 general population) in the location of interest. The total baseline incidence per year is calculated by multiplying incidence by the corresponding population number.

The health impacts calculations are based on the epidemiology studies that primarily use exponential (or log-linear) C-R functions in which the natural logarithm of the health endpoint is a linear function of $PM_{2.5}$, as shown in equation 1.

$$y = Be^{\beta x} \quad (1)$$

where *y* is the health effects incidence, B is baseline health effects incidence, β is the coefficient based on the C-R function, and *x* is the concentration of $PM_{2.5}$.

The relationship between a specified ambient $PM_{2.5}$ concentration (for example, x_0) and the incidence of a given health endpoint associated with that concentration (denoted as y_0) is then:

$$y_o = Be^{\beta x o} \quad (2)$$

The log-linear form of a C-R function [equation (1)] was used in the $PM_{2.5}$ risk characterization. If x_0 denotes the baseline (upper) $PM_{2.5}$ concentration, and x_1 denotes the lower $PM_{2.5}$ concentration, and y_0 and y_1 denote the corresponding health effects incidences, then the following relationship is found between the change in *x*, $\Delta x = (x_0 - x_1)$, and the corresponding change in *y*, Δ*y*, from equation (1).

$$\Delta y = (y_0 - y_1) = y_0[1-e^{-\beta\Delta x}]*B*P \quad (3)$$

This health impact equation (3) is the key equation that combines air quality information (Δ*x)*, C-R function information (β), baseline health effects incidence (B), and population information (P) to estimate $PM_{2.5}$-associated health risks. This equation and the relevant data for each of the zip codes of interest were used to calculate the overall health risks.

6.2 Toxicity Assessment: C-R Functions

Chemicals are evaluated for their potential health effects in two broad categories: cancer and non-cancer. Estimating potential risk posed by exposure to carcinogens and non-carcinogens employs different methods, depending on the timeframe of exposures associated with health effects (acute, sub-chronic, chronic) and the presumption of a threshold or lack of threshold for effects. All chemicals are toxic at some concentration, but for some (particularly non-cancer endpoints) there is a concentration below which no toxicity is expected (a threshold). Unless there is strong mechanistic information to the contrary, most regulatory agencies consider that carcinogens pose some risk for cancer at all exposure levels (i.e., they assume there is no threshold for toxicity and that any concentration is associated with some amount of risk of developing cancer). For this risk characterization we also conservatively assumed that non-cancer risks were linear and that there is no threshold below which adverse effects would not be expected.

As outlined in Section 4.3, this analysis focuses on health endpoints associated both with short-term and long-term $PM_{2.5}$ exposures. Health endpoints associated with short-term $PM_{2.5}$ exposures included premature mortality (all-cause, cardiovascular, and respiratory) and hospital admissions (cardiovascular, all respiratory, and asthma). Health endpoints associated with long-term $PM_{2.5}$ exposures included mortality (all-cause, cardiovascular). The summary below describes the selected epidemiology studies that are the basis for the C-R functions used in the analysis.

These recent epidemiology studies were conducted in multiple cities. Multi-city studies offer several advantages over using single-city studies, including use of the same study design in each of the cities such that city-specific results are more readily comparable.

Multi-city studies also have more statistical power and provide effect estimates with relatively greater precision than single-city studies. Furthermore, in a multi-city study, the statistical power to detect an effect in any given city can be supplemented by drawing statistical power from data across all the cities included in the study (or in the region) to adjust city-specific estimates towards the mean across all cities (or region). This is useful where a city has relatively fewer data resulting in a larger uncertainty for that city's risk estimate.

Studies often report more than one value from which an estimated C-R function can be derived. The C-R functions are based on models that might include different sets of co-pollutants, different time-related lag structures, or different models to adjust for weather and temporal variables.

The selected studies and outcomes associated with long-term and short-term exposures to $PM_{2.5}$ are summarized in **Table 9**. Details related to the specific studies, including study limitations, follow.

Table 9: Selected Studies and Endpoints for Health Effects Associated with Long-term and Short-term Exposures to $PM_{2.5}$

Reference	Outcome	Study
Long-term Exposures		
Krewski et al. (2009)	All-cause Mortality	CPS-I, CPS-II
Pope et al. (2011)	Cardiovascular Mortality	CPS-II
Short-term Exposures		
Zanobetti and Schwartz (2009)	All-cause ; Cardiovascular, and Respiratory Mortality	202 counties
Bell et al. (2008)	Cardiovascular; Respiratory Hospital Admissions	202 counties
Sheppard et al. (2003)	Asthma Hospital Admissions	Seattle, WA

Notes:
CPS = cancer prevention study

6.2.1 Studies of Long-term $PM_{2.5}$ Exposures

The studies selected to evaluate health endpoints associated with long-term exposures are summarized in the following sections.

Krewski et al. (2009)

Estimates of risk of premature, all-cause mortality associated with long-term exposure to $PM_{2.5}$ are based on the study by Krewski et al. (2009). This study, which is an extension of the American Cancer Society (ACS) Cancer Prevention Study (CPS), an ongoing prospective cohort mortality study involving nearly 1.2 million adults (Pope et al. 2002), was used by USEPA in the PM risk assessment (USEPA 2010). The Krewski et al. (2009) study was selected because the extended air quality analysis incorporated data from 1989 to 2000, increasing the power of the study and because the study evaluated a range of model forms and effect estimates, including consideration of such factors as spatial autocorrelation in specifying response functions, consideration of a range of ecological variables (social, economic and demographic), and also was based on a large dataset with over 1.2 million individuals and 156 metropolitan statistical areas.

Krewski et al. (2009) considered mortality from all causes, as well as cardiopulmonary mortality, mortality from ischemic heart disease, and lung cancer mortality. The study presents a variety of results based on different methods or models. The authors did not endorse any particular result, noting that they had "refrained from expressing a preference among the results for their use in quantitative risk assessment," preferring to "explore several plausible statistical models that we have fit to the available data." However, the authors went on to state that "if forced to pick a single model for risk assessment applications in air quality management, our random effects model with ecological covariates might be selected" (Krewski et al. 2009). Based on the recommendations from the authors, we selected the results from the random-effects model with the coefficient and standard error are estimated from the relative risks (1.06) and 95 percent confidence intervals (95% CI: 1.04-1.08) for a 10 μg/m^3 increase in exposure to $PM_{2.5}$ for the years 1999-2000 (Krewski et al. 2009, Commentary Table 4). The results were adjusted for 44 individual-level covariates and seven ecologic covariates.

The study by Krewski et al. (2009) has several limitations, including key socioeconomic data (e.g., smoking history, education, diet) that were collected once in 1982, but were never updated. Thus, it is not possible to determine if the socioeconomic data changed over time and how these factors may impact the results. This is important because the authors report a significant education-gradient in PM mortality risk, with most of the risk in groups with low education (a surrogate for income and socioeconomic status) and much smaller risk in those with higher socioeconomic status. Also, the socioeconomic data for this study were collected using a self-administered questionnaire, which is often associated with under-reporting of important confounding factors such as smoking.

Another limitation to the Krewski et al. (2009) study is the use of a single pollutant model to estimate the mortality risks attributed to $PM_{2.5}$. Previous analysis of the ACS study (Krewski et al. 2000) showed that sulfur dioxide reduced the mortality risk attributed to fine PM to a statistically insignificant level. Use of single pollutant results may result in over-estimation of mortality attributed to PM, particularly at lower PM exposure concentrations.

Pope et al. (2011)

The Pope et al. (2011) study examines the relationship between chronic exposures to ambient $PM_{2.5}$ and cardiovascular and lung cancer mortality, with the objective of developing C-R functions that would be comparable, when also considering smoking and exposures to second-hand smoke. The estimated relative risks were based on data collected by the ACS as part of the Cancer Prevention Study II (CPS-II). As this study represents the most up to date analysis of cardiovascular mortality associations with $PM_{2.5}$ exposures, it was deemed to be the most relevant for use in our analysis for this endpoint.

The C-R function was derived from the relative risks reported for cardiovascular disease reported in Table 2 of Pope et al. (2011) and based on extended analyses of air pollution and mortality using the ACS CPS-II cohort (Pope et al. 2002) for a 10 μg/m^3 increment of $PM_{2.5}$. The study by Pope et al. (2011) suffers from the same limitations as the study by Krewski et al. (2009), discussed above.

6.2.2 Studies of Short-term $PM_{2.5}$ Exposures

Selected studies of short-term exposures associated with the selected health endpoints are summarized in the following sections.

6.2.2.1 Premature Mortality

Zanobetti and Schwartz (2009)

Zanobetti and Schwartz (2009) is a multi-city time-series study that examines the effect of short-term exposures to $PM_{2.5}$ on premature mortality on a national-scale. Mortality endpoints included all causes, cardiovascular disease, myocardial infarction, stroke, and respiratory mortality for the years 1999-2005. The authors used city- and season-specific Poisson regression in 112 U.S. cities to evaluate the association of exposures to mean (day of death and previous day) $PM_{2.5}$ with daily deaths. They then used a combined a random-effects approach with the city-specific estimates, in total, by season and by region to develop national estimates. The authors found statistically significant associations between short-term exposure to $PM_{2.5}$ and cardiovascular and respiratory mortality at lag 0-1. Although the overall effect estimates reported were positive, there was a large degree of variability between cities when examining city-specific effect estimates, which may be due to differences between cities and regional differences in $PM_{2.5}$ composition.

The study did not evaluate the effects of potential confounders, such as gaseous co-pollutants, on the $PM_{2.5}$ cardiovascular mortality risk estimates. Zanobetti and Schwartz (2009) used the same lag structure (i.e., an average of same-day and the previous day $PM_{2.5}$ concentrations) for all $PM_{2.5}$ models. However, the study did evaluate both single-pollutant and two-pollutant models (with coarse PM). We selected the single-pollutant model to be consistent with other studies for which only single-pollutant estimates were available. USEPA relied on this study when conducting their Quantitative Health Risk Assessment for Particulate Matter (USEPA 2010). At the request of USEPA, the authors produced Empirical Bayes "shrunken" city-specific estimates, adjusted towards the appropriate regional mean. In this analysis we used the city-specific estimates that were obtained for Tacoma, WA (USEPA 2010, Appendix C, Table C-1).

6.2.2.2 Hospitalization Admissions

Bell et al. (2008)

Bell et al. (2008) used log-linear models to evaluate the association between short-term exposure to $PM_{2.5}$ and hospital admissions for cardiovascular and respiratory illnesses among people 65 years of age and older, using a two-stage Bayesian hierarchical model, for each of 202 counties in the United States. The authors reported both annual and season-specific results, nationally and regionally (for four regions: Northeast, Southeast, Northwest, and Southwest), but did not provide city-specific estimates. The cardiovascular hospital admissions estimates were based on single-pollutant, 0-day lag models, whereas for respiratory hospital admissions, both single-pollutant 0-day models and single-pollutant two-day models were evaluated. We selected the regional (Northwest), annual C-R functions as the most appropriate value to use for the analysis. For respiratory hospital admissions, we chose the two-day lag models, based on a strongest association with PM exposure that may occur with longer lag periods for respiratory effects.

A limitation of this study includes the use of Medicare data collected for administrative purposes, which may result in some degree of misclassification of diagnoses and may vary geographically. An additional limitation is that the exposures were measured at the county level, using central monitors, so they are purely ecological. As with all ecological studies, individual data were not available, so it is not possible to associate person-specific exposures with specific individual outcomes. In addition, this study did not control for effects of other potentially confounding air pollutants.

Sheppard et al. (2003)

We selected the study by Sheppard (2003) because this study, although it is a single-city study, is specific to the location of interest (Seattle) and the particular endpoint of interest (asthma hospital admissions).

In the study by Sheppard et al. (2003), the authors assessed the relation between air pollution in Seattle and nonelderly (<65) hospital admissions for asthma from 1987 to 1994. They used a Poisson regression model with control for time trends, seasonal variations, and temperature-related weather to estimate effects air quality data for PM_{10}, $PM_{2.5}$, coarse $PM_{10-2.5}$, SO_2, ozone, and CO. Air concentrations of $PM_{2.5}$ were estimated from light scattering data, which makes these exposure estimates somewhat uncertain. The authors reported that asthma hospital admissions were associated with PM_{10}, $PM_{2.5}$, $PM_{10-2.5}$, CO, and ozone, and reported no association for SO_2. They also reported that PM and CO were jointly associated with asthma admissions. Although they reported that the best fitting co-pollutant models were found with PM and ozone, ozone was not considered because data were only available for the months of April through October. When considering other co-pollutants, the best fitting models included $PM_{2.5}$ and CO. Results for other co-pollutant models were not reported.

We selected the relative risk and 95 percent confidence interval for asthma hospital admissions (International Classification of Diseases (ICD) 9 code 493) for an 11.8 $\mu g/m^3$ increase in $PM_{2.5}$ based on the 1-day lag GAM stringent model (1.04, 95% CI: 1.01-1.06).

6.3 Baseline Health Effects Incidence Rate and Population Data

As described above, the C-R functions derived from the published epidemiology studies on health effects associated with exposures to $PM_{2.5}$ are log-linear in form, as represented by equation (1). Baseline incidence information, which is the number of cases per unit time (e.g., cases in a year) in a location before accounting for changes in air quality, is needed to estimate risks for each health endpoint. This baseline incidence is denoted as B_0 in equations 2 and 3.

Incidence rates are the occurrence of a disease over a specific period of time and are expressed as a value per population group (e.g., the number of cases in a county) or a value per number of people (e.g., the number of cases per 100,000 residents in a specific county). Incidence rates can be age- and sex-specific. Incidence rates vary across geographic areas due to differences in population characteristics, differences in health status, and other factors. We selected baseline incidence rates that matched the age-ranges for which the health effects estimates were calculated in the epidemiology literature as described in more detail below.

6.3.1 Mortality and Hospital Admissions

We obtained individual-level mortality and hospital admissions data for the year 2010, for 15 Seattle zip codes in the vicinity of T-5 from the Washington State Department of Health's Center for Health Statistics.[1] The data consisted of information for each individual, including underlying causes of death or hospital admission (i.e., ICD-9 or -10 codes). The detailed mortality data allowed the generation of cause-specific death counts at the zip code level for selected age groups. Similarly, cause-specific hospital admissions counts were used in the incidence calculations for this endpoint. Specifically, incidence (mortality or hospital admission) was calculated as the number of events that occurred within a zip code during 2010 divided by the population at risk in a particular zip code in 2010.

Mortality and hospital admission incidence was calculated based on ICD-9 or ICD-10 codes for outcomes of interest, matching the same ICD codes that were used in the underlying epidemiology study. Incidence was also calculated for specific population groups based on the population evaluated in the underlying epidemiology study. **Table 10** summarizes the outcomes, epidemiology studies, ICD codes, and age ranges that were extracted from the Center for Health Statistics files. Data were extracted by zip code, ICD-code, and age group using Statistical Analysis System software (by SAS Institute). The baseline incidence results for each zip code are presented in Appendix A.

Table 10: Summary of Baseline Health Endpoint Data from the Center for Health Statistics

Health Endpoint	Reference	ICD- 9 or 10 Code	Population Age (years)
All-cause mortality	Zanobetti and Schwartz (2009)	A00-R99	0 to 99
Cardiovascular mortality	Zanobetti and Schwartz (2009)	I01-I59	0 to 99
Respiratory mortality	Zanobetti and Schwartz (2009)	J00-J99	0 to 99
All-cause mortality	Krewski et al. (2009)	A00-R99	30 to 99
Cardiovascular mortality	Pope et al. (2011)	I01-I59	30 to 99
Cardiovascular hospital admissions	Bell et al. (2008)	426-449	65 to 99
Respiratory hospital admissions	Bell et al. (2008)	460-519	65 to 99
Asthma hospital admissions	Sheppard et al. (2003)	493	0 to 64

Notes:
ICD = International Classification of Diseases

6.3.2 Population Data

In addition to the health baseline incidence data, the corresponding population data were obtained in order to calculate the baseline incidence. The population data were obtained

[1] http://www.doh.wa.gov/AboutUs/ProgramsandServices/DiseaseControlandHealthStatistics/CenterforHealthStatistics

from the U.S. Census Bureau (http://www.census.gov/popest/counties/asrh/). These data are the population estimates of the resident populations by selected age groups and sex for the Seattle zip codes of interest. We used populations for the year 2010 to calculate incidence rates. The baseline incidence rates and relevant population numbers are shown in Appendix A.

6.4 Uncertainty and Variability

There are many sources of uncertainty and variability inherent in the inputs to the risk assessment that contribute to some degree of uncertainty in the results. Such uncertainties are related to: (a) the shape of the C-R function and any population threshold; (b) the use of appropriate statistical models in the underlying epidemiology study; (c) unaccounted confounding and modifying factors in the C-R relationships; (d) modeling daily $PM_{2.5}$ air quality impacts from the project; and (e) differences in the relative toxicity of the components within the mix of ambient $PM_{2.5}$.

Uncertainty is the lack of knowledge regarding the inputs to an analysis. When using statistical models there is often uncertainty in the actual values of the parameters of the model. There may also be uncertainty regarding the best model to use in the analysis to represent the relationships being modeled, i.e., the shape of C-R functions. In addition, there may be some uncertainty associated with other model inputs such as the $PM_{2.5}$ exposure estimates or baseline incidence rates.

In contrast, variability is the heterogeneity of a variable within or across populations. This heterogeneity can be due to populations in different regions that have different behaviors or activity patterns (e.g., air conditioning use, time spent indoors) that affect their PM exposures and thus the health response. Other factors include the composition of populations in different regions that could affect the population response to PM exposures, such as having a population that is older. The composition of PM that different populations are exposed to may differ as well, with some PM compositions having higher toxicity than others. Variability is inherent in any study and some studies have attempted to more fully characterize the variability in key factors in order to produce C-R functions that better reflect certain population or location characteristics.

6.5 Characterization of $PM_{2.5}$ Non-cancer Risks

Using the underlying BenMAP methodology, we calculated the health effects associated with short-term and long-term exposures to $PM_{2.5}$. Results for the zip code in which South Park and Georgetown are located (98108) are summarized in **Table 11**. Detailed calculations and specific results are provided in Appendix A for each zip code. Results are also depicted in **Figure 2** through **Figure 6**.

Health effects from short-term exposure to $PM_{2.5}$ included all-cause mortality, cardiovascular mortality, and respiratory mortality; however, due to very low baseline incidence numbers available only for a few zip codes we do not present results for respiratory mortality. In addition, we evaluated hospital admissions for cardiovascular, all-respiratory, and asthma associated with short-term exposures to $PM_{2.5}$. Health outcomes associated with long-term exposures to $PM_{2.5}$ included all-cause and cardiovascular mortality.

Results were calculated as the change in incidence of mortality or hospital admissions that would result from air quality changes between Alternative 1 (for year 2020) and Alternative 2 (for year 2020) and between Alternative 1 (for year 2020) and Alternative

3 (for year 2040). Alternative 2 modeled for the year 2020 represents the maximum impact between the two action alternatives. [2] For Alternative 2, for most zip codes, $PM_{2.5}$ concentrations are expected to increase relative to baseline conditions (i.e., Alternative 1, 2020).

In contrast, Alternative 3 modeled for the year 2040 represents the lowest impact between the two action alternatives. In **Table 11** and **Figure 2** through **Figure 6**, a positive change indicates an increased impact (due to increased particulate matter concentrations) and a negative change indicates a decreased impact (due to decreased $PM_{2.5}$ concentrations). That is, a positive number would indicate that there would be an increased risk of mortality (more deaths than expected) or increased risk of a hospital admission due to increased air pollution. In contrast, a negative number means an avoided death or hospital admissions (due to improved air quality).

Overall, the change in $PM_{2.5}$ concentration is very small with average area-wide reductions that range from < 0.01 to about 0.07 $\mu g/m^3$ for Alternative 2 compared with Alternative 1, and slightly higher reductions ranging from about 0.1 to 0.3 $\mu g/m^3$ for Alternative 3 compared with Alternative 1, across all zip codes. These small changes in $PM_{2.5}$ were associated with small average reductions in health effects incidence for most health endpoints, with the exception of asthma hospitalizations and mortality from long-term exposures for Alternative 2 relative to Alternative 1. For these endpoints, increases in incidence are negligible, with an average asthma hospitalization increase of 0.00007 persons and increase in mortality estimates of 0.0001 persons and lower.

This means that area-wide impacts are minimal. In some of the zip codes we observed increased impacts (positive increases) in both mortality and hospital admissions, particularly for Alternative 2 relative to Alternative 1. These increased health impacts are many times less than 1 increased death or hospital admissions, indicating negligible effects to the area. For some zip codes, results suggest that air quality improvements will result in avoided deaths or hospital admissions (a negative result), primarily for Alternative 3 compared with Alternative 1. These findings are also many times lower than one avoided death or hospital admissions, indicating minimal benefits.

For Georgetown and South Park, which are located in zip code 98108, we observed the smallest relative risks associated with Alternative 2 compared to Alternative 1 (**Figure 2** to **Figure 6**). For Alternative 3, these neighborhoods were generally associated with the smallest relative health benefits compared to Alternative 1. Considering the uncertainty in model estimates, it is likely that the estimates suggest little difference between Alternative 2 and Alternative 3 with respect to $PM_{2.5}$-related health impacts from Port renovation activities.

[2] As described in Section 3, the "maximum impact" scenario designation was based on the highest model-predicted $PM_{2.5}$ concentration (occurring on the facility's northeast fence line). The minimum impact designation was based on the lowest model-predicted $PM_{2.5}$ concentration.

Table 11: Summary of Health Impacts of Action Alternatives Compared to Baseline Conditions (Alternative 1) for Zip Code 98108 (South Park, Georgetown)

Outcome	Alternative 2 (2020) vs Alternative 1 (2020)		Alternative 3 (2040) vs Alternative 1 (2020)	
	Change in PM2.5 Concentration (µg/m³)	Change in Incidence	Change in PM2.5 Concentration (µg/m³)	Change in Incidence
Short-term P2.5 Exposures				
All-cause mortality	+0.0065	+0.00040	-0.045	-0.0027
Cardiovascular mortality	+0.0065	+0.00016	-0.045	-0.0011
Cardiovascular hospital admissions	+0.0065	+0.000019	-0.045	-0.00013
Asthma hospital admissions	+0.0065	+0.000087	-0.045	-0.00059
Respiratory hospital admissions	+0.0065	+0.000004	-0.045	-0.000025
Long-term PM2.5 Exposures				
All-cause mortality	-0.0035	-0.0016	-0.025	-0.011
Cardiovascular mortality	-0.0035	-0.00055	-0.025	-0.011

Notes:

"+" indicates an increase in modeled air concentrations or increase in health outcome incidence

"-" indicates a decrease in modeled air concentrations or decrease in health outcome incidence

For example, for Alternative 2 (2020), a slight increase in short-term PM2.5 concentrations results in a slight increased risk in all-cause mortality whereas for Alternative 3 (2040), a slight decrease in short-term PM2.5 concentrations results in a slight decrease or avoidance in all-cause mortality. In all cases, the increase or decrease in health incidence is orders of magnitude less than 1 death or hospital admission.

Figure 2: Short Term Exposures (Max 24-hr PM2.5): Mortality Net Change between Alternative 1, 2020 and Alternative 2, 2020

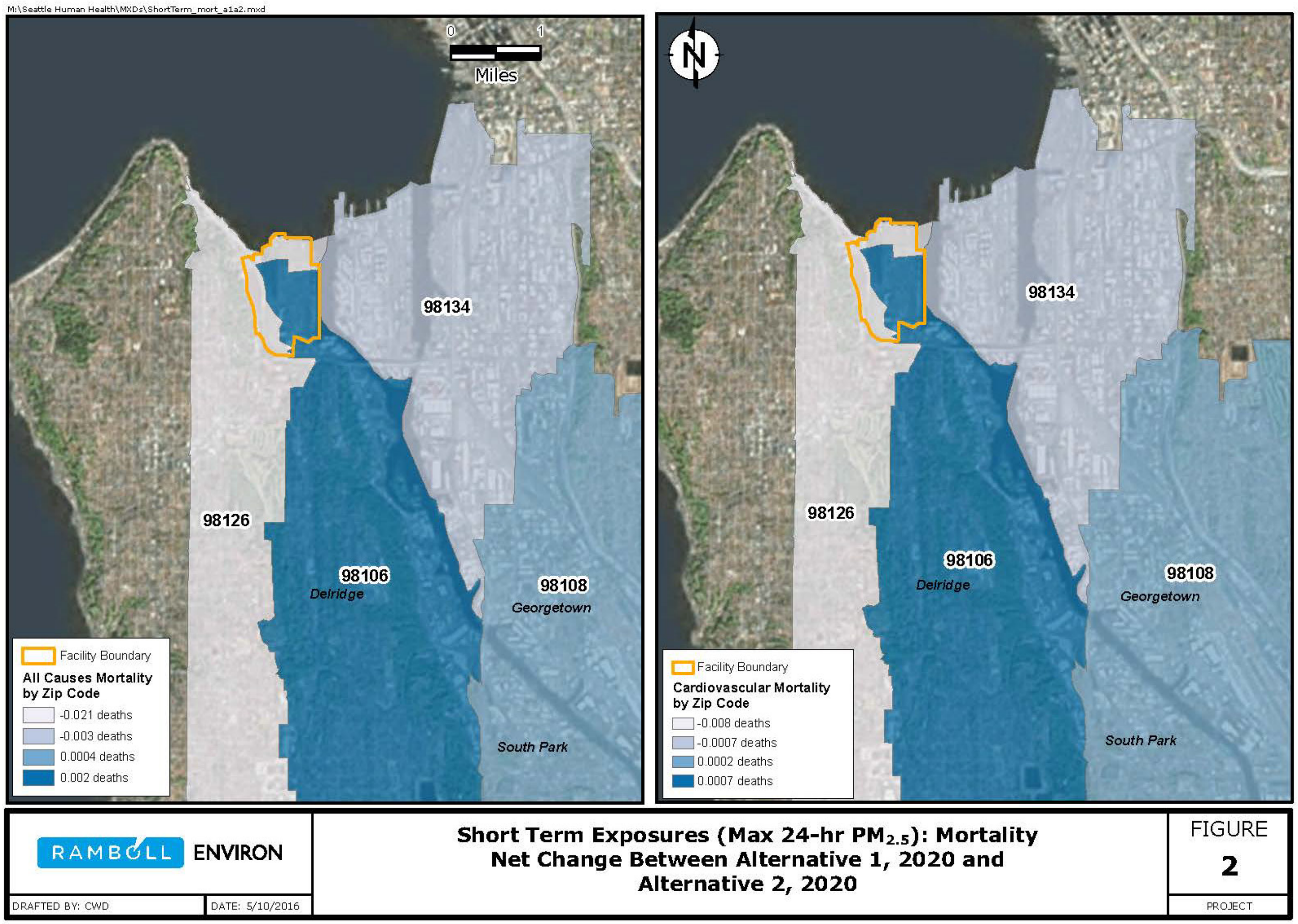


Figure 3: Short Term Exposures (Max 24-hr PM2.5): Mortality Net Change between Alternative 1, 2020 and Alternative 3, 2040

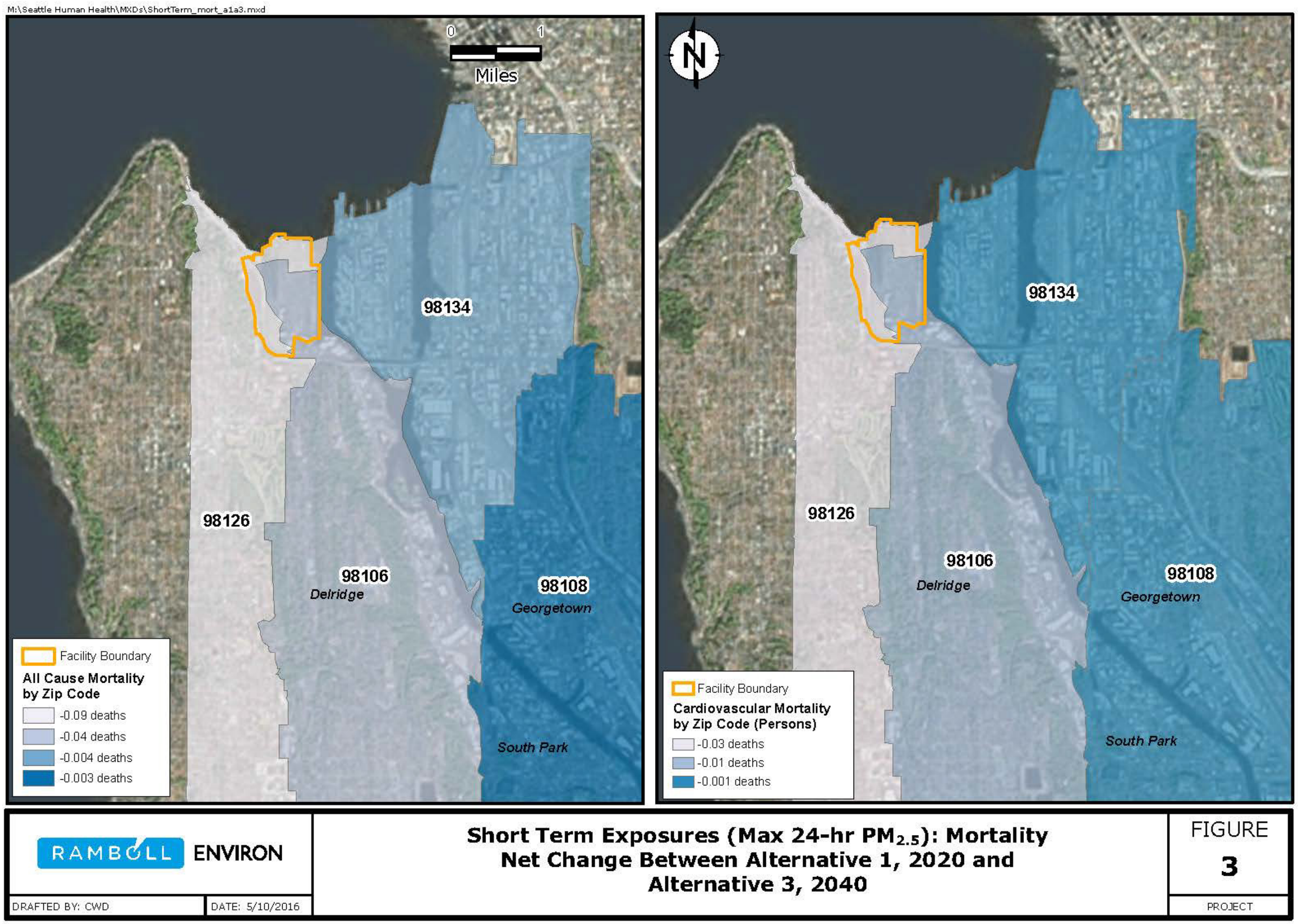
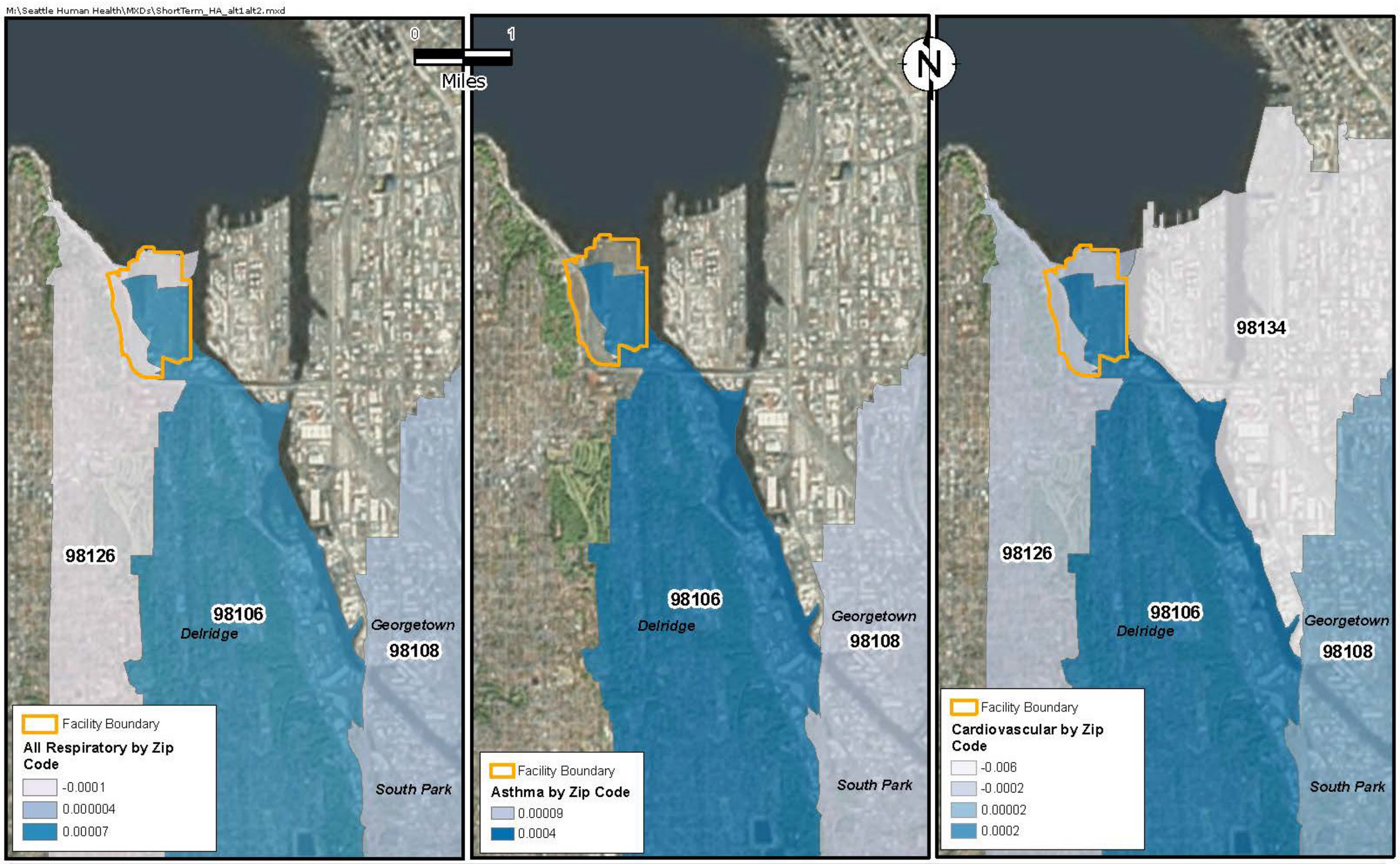


Figure 4: Short Term Exposures (Max 24-hr PM2.5): Hospital Admissions Net Change between Alternative 1, 2020 and Alternative 2, 2020



RAMBOLL ENVIRON	Short Term Exposures (Max 24-hr $PM_{2.5}$): Hospital Admissions Net Change Between Alternative 1, 2020 and Alternative 2, 2020	FIGURE 4
DRAFTED BY: CWD / DATE: 5/10/2016		PROJECT

Figure 5: Short Term Exposures (Max 24-hr PM2.5): Hospital Admissions Net Change between Alternative 1, 2020 and Alternative 3, 2040

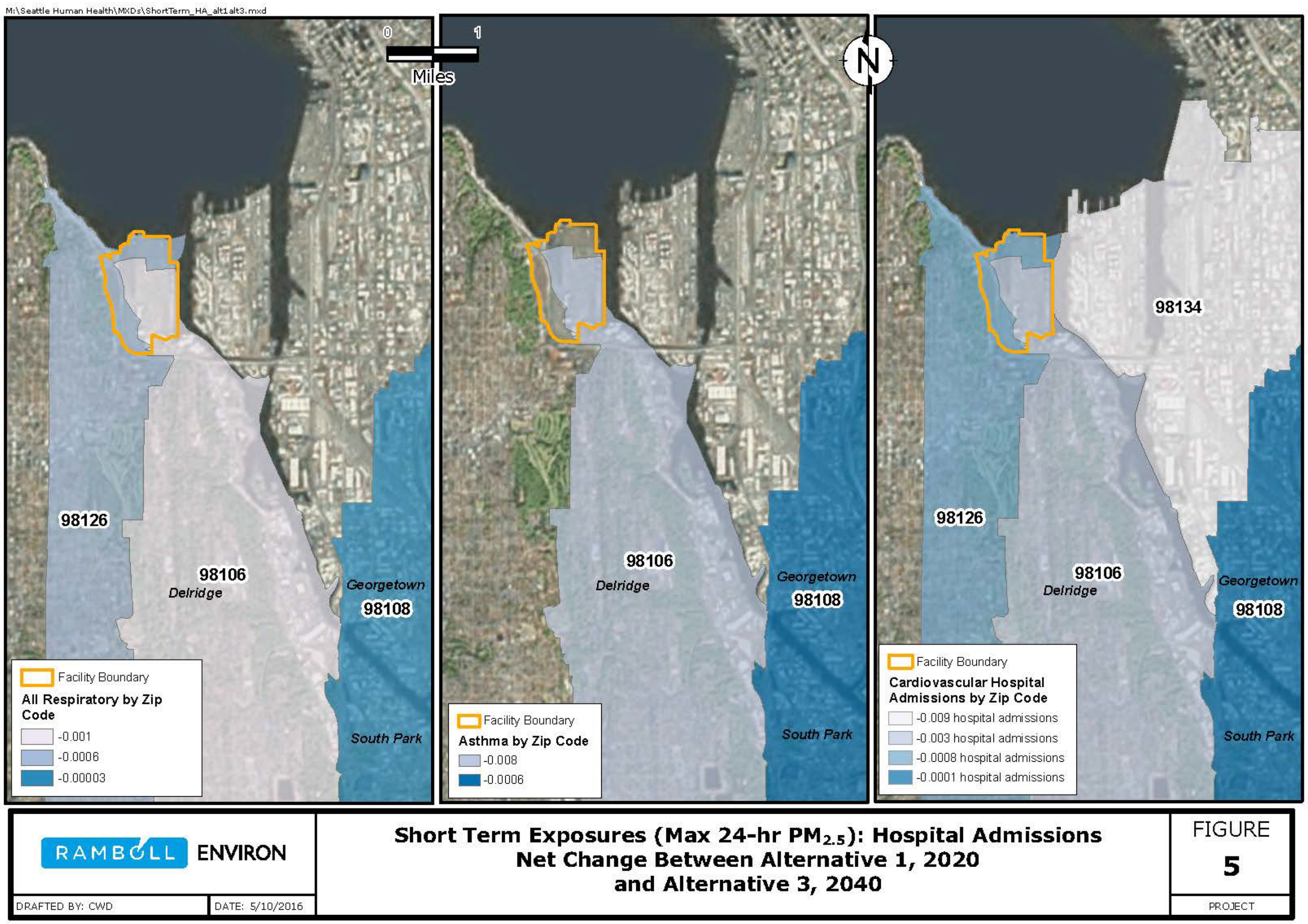


Figure 6: Long Term Exposure (Annual PM2.5): Mortality Net Change between Alternative 1, 2020 and Alternative 2, 2020

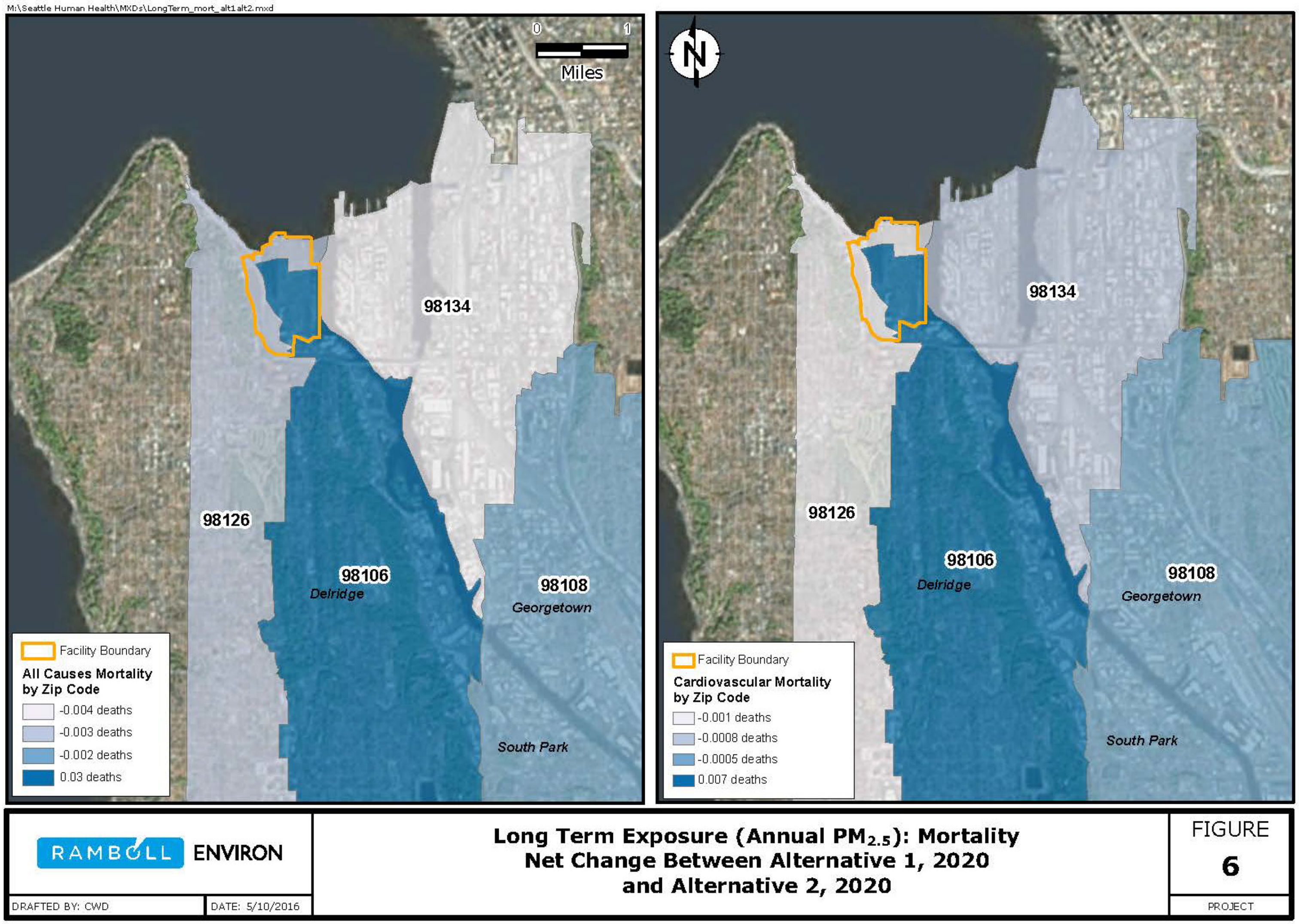
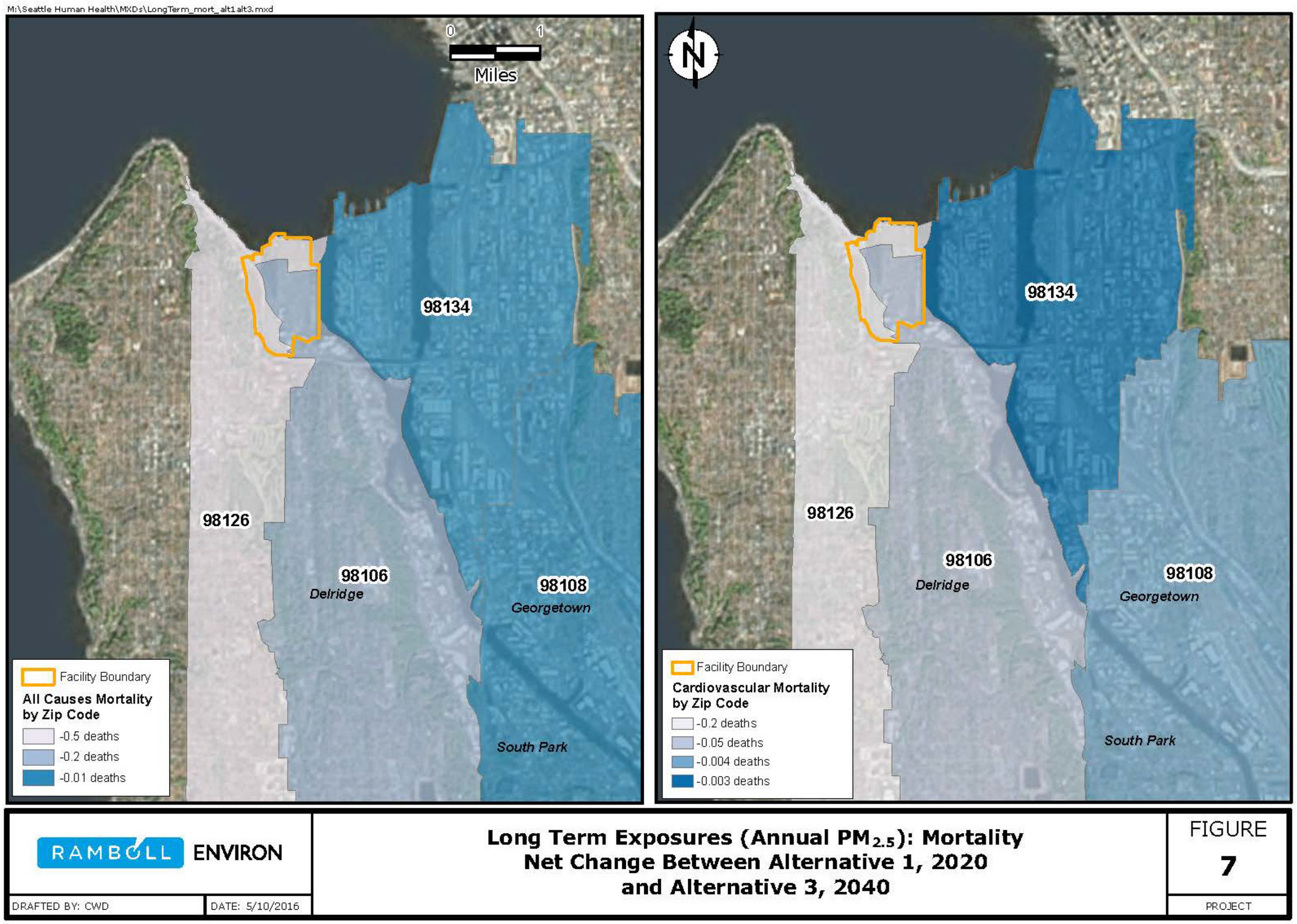


Figure 7: Long Term Exposures (Annual PM2.5): Mortality Net Change between Alternative 1, 2020 and Alternative 3, 2040



7. APPROACH FOR DETAILED DPM HEALTH ASSESSMENT

As described in Section 5.3, cancer risk is being evaluated based on DPM. Traditionally, cancer assessments are assumed to be without a threshold. Non-cancer health endpoints are being captured in the assessment of $PM_{2.5}$. Typically, a single cancer unit risk factor (URF), derived from one or more studies in the scientific literature, is applied to a monitored or modelled air concentration to estimate potential cancer risk that might result from a project. USEPA provides quantitative estimates of toxicity, such as cancer URFs, for a wide range of chemical constituents and in the cases where values from USEPA are not available, risk assessors look to other sources. A discussion of the URF(s) for DPM and value(s) applied in this study is provided in the next section.

7.1 Toxicity Assessment: Cancer

In the case of diesel engine exhaust, it has been problematic to derive a single cancer URF. The use of a single, discrete value representing potential cancer potency of diesel exhaust attributes greater confidence to cancer risk estimates than is appropriate given the underlying shortcomings in the quantitative assessment of diesel exhaust risk, as reflected by the current lack of a URF supported by the USEPA. Although California's Office of Environmental Health and Hazard Assessment (OEHHA) has proposed a URF for DPM, it is based on a study that has been judged by many as being inadequate for supporting quantitative risk assessments (see Appendix B).

There have been differing evaluations of the same body of literature in deriving a URF. In 2002, the USEPA concluded that "while the weight-of-evidence indicates that DE [DPM] has the potential to pose a lung cancer hazard to humans at anticipated levels of environmental exposure, as shown by occupational epidemiology studies, a confident dose-response relationship based on occupational exposure levels is currently lacking" (USEPA 2002). Due to the Agency's belief that available data were too uncertain to be used as the basis of a confident quantitative dose-response analysis, the USEPA did not develop a cancer URF for DPM. This conclusion was based, in part, on an in-depth evaluation by an expert panel (HEI 1999), which concluded that the studies to date had a number of limitations that precluded their use in quantitative health risk assessment. These limitations included (1) questions about the quality and specificity of the exposure assessments for diesel exhaust, (2) a lack of quantitative estimates of exposure to allow derivation of an exposure–response function, and (3) lack of adequate data to account quantitatively for individual worker exposures to other factors that might also be associated with lung cancer, such as smoking.

In contrast, OEHHA (1998) chose to use the US railroad workers to derive a cancer URF, in spite of the study limitations. OEHHA (1998) opted to retain their unit risk estimates for lung cancer on the then-available epidemiology studies, using the concentration-response information from two studies in US railroad workers (Garshick et al. 1987; Garshick et al. 1988). They considered a variety of exposure patterns based on average exposure concentration for the workers (as measured by Woskie et al. 1988) and the extent of change in exposures during the periods of 1959 to 1980. Using this approach, OEHHA derived a series of lifetime risk estimates ranging from 1.3×10^{-4} per µg/m^3 to 2.4×10^{-3} per µg/m^3, with a geometric mean risk of 6×10^{-4} per µg/m^3. For risk assessment purposes, OEHHA selected 3×10^{-4} per µg/m^3. OEHHA did not change this approach or update their findings following the HEI (1999) publication, or after the USEPA (2002) health assessment.

When fully considering the conclusions of multiple science review panels and risk assessment investigators, it is apparent that the current quantitative assessments for diesel exhaust are inadequate for deriving a single cancer potency number. While the body of research as a whole supports a positive relationship between exposure to diesel exhaust (particularly those with the composition of older diesel engines) and lung cancer, the numerical values that estimate potential cancer risk are hampered by a large range of uncertainty that is rarely communicated and considered in project planning and risk communication efforts. This dilemma can frustrate regulatory agencies, project proponents, and affected communities alike.

We therefore propose using a range of URFs, rather than selecting a single diesel exhaust risk estimate for appraising potential lung cancer risk. This approach allows project managers to compare relative ranges in impacts of each alternative, which can better support project planning and design decision-making. The range of cancer URFs selected is 10^{-3} to 10^{-5} per µg/m^3; the rationale for section of this range is provided in Appendix B.

7.2 Characterization of DPM Cancer Risks

For the purpose of examining cancer risk, we relied on Alternative 1 (No Action) for the year 2020, considered the baseline condition, and two action alternatives: Alternative 2 for the year 2020, which represents the highest impact alternative and time-frame, and Alternative 3 for the year 2040, which represents the least or lowest impact alternative and time-frame. The comparison between Alternatives 1 (2020) and 2 (2020) represents the difference between baseline conditions and a maximum impact, while the comparison between Alternatives 1 (2020) and 3 (2040) represents the difference between baseline and a minimum impact. This allows for consideration range of minimum and maximum impacts for each action alternative relative to baseline.

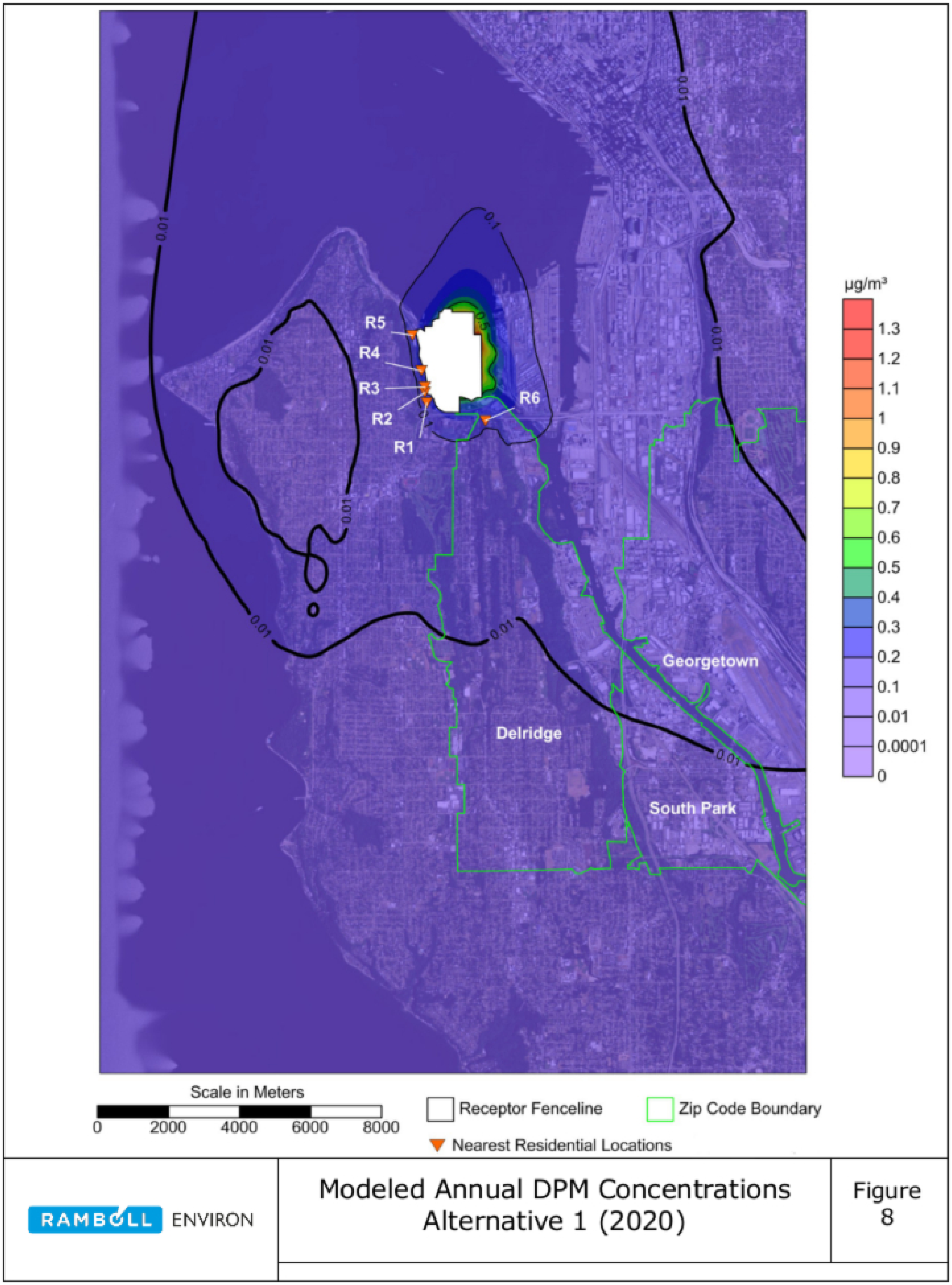
7.2.1 Alternative 1 / 2020

Results of the air quality dispersion modeling for DPM associated with Alternative 1, No Action, for the year 2020 are depicted in isopleths in Figure 8. Model-calculated DPM concentrations at each of six residential locations (representing the closest residents around the project site) range from 0.13 to 0.23 µg/m^3 (**Table 12**). Using the unit risk range of 10^{-3} to 10^{-5} per µg/m^3, these concentrations represent a baseline incremental cancer risk of between 1.3 and 2.3 per million individuals at the six residences nearest the facility. Predicted incremental cancer risks are lower for South Park and Georgetown, ranging from 0.30 to 30 per million individuals.

Table 12: Calculated Cancer Risks for Alternative 1 (No Action), Year 2020

Receptor Location	Projected DPM Concentration (µg/m³)	Range of Incremental Cancer Risks per Million Persons (using 10^{-3} to 10^{-5} per µg/m³ unit risk values)
Residence 1	0.18	1.8 to 180
Residence 2	0.20	2.0 to 200
Residence 3	0.23	2.3 to 230
Residence 4	0.23	2.3 to 230
Residence 5	0.17	1.7 to 170
Residence 6	0.13	1.3 to 130
South Park & Georgetown	0.030	0.30 to 30

Figure 8: Model-Calculated Annual DPM Concentrations Alternative 1 (2020)



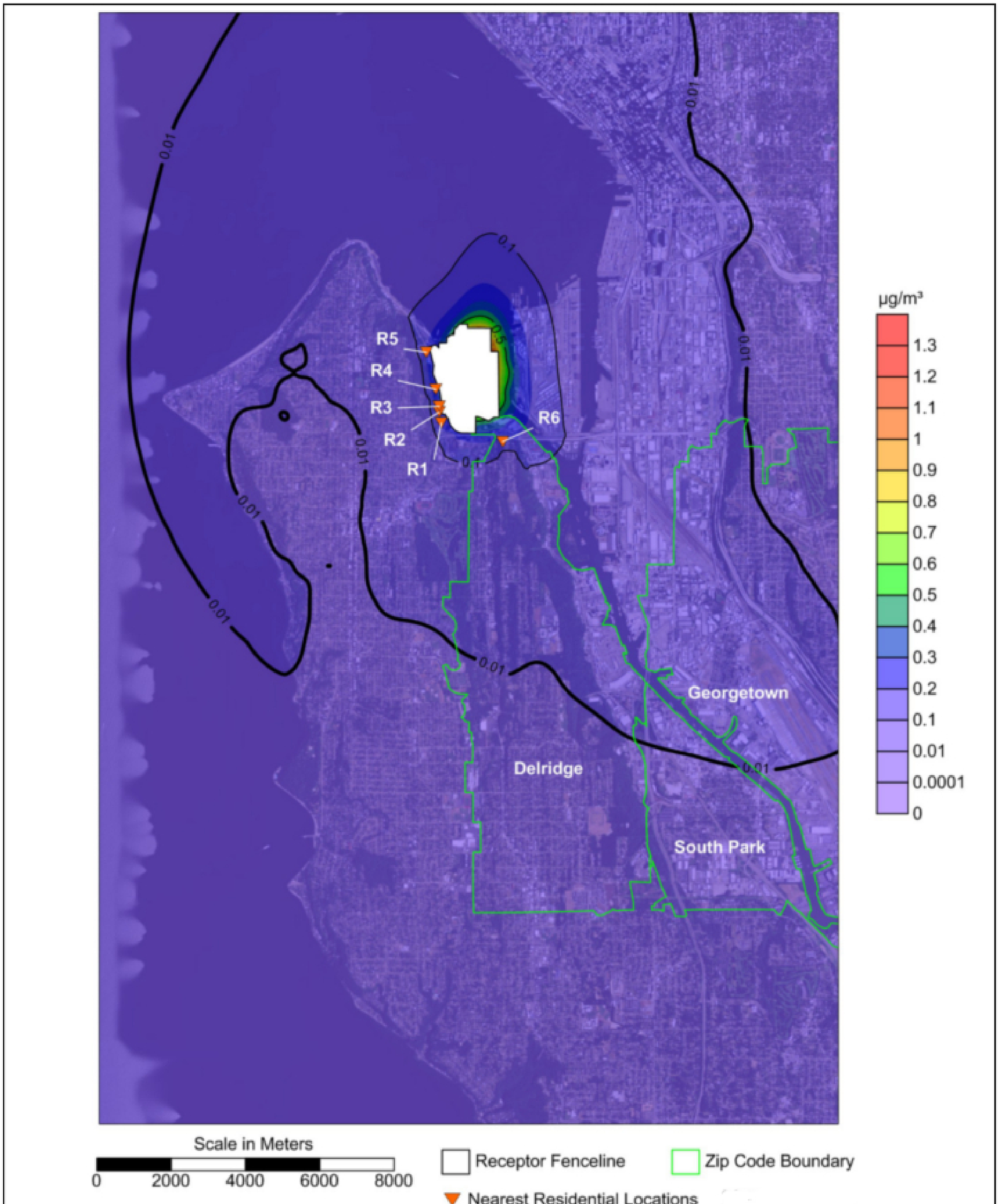
7.2.2 Alternative 2 / 2020

Air modeling results for Alternative 2 estimating concentrations of DPM for the year 2020 displayed as isopleths in Figure 9. This scenario represents the maximum potential impact of the project. The range of model-calculated DPM concentrations at each of six residential locations nearest the project site, range from 0.13 to 0.28 µg/m^3 (**Table 13**). Using the unit risk range of 10^{-3} to 10^{-5} per µg/m^3, these concentrations represent an incremental cancer risk with Alternative 2 of 1.3 and 280 per million individuals. Incremental cancer risks associated with DPM from the facility for Georgetown and South Park residents are lower, ranging from 0.27 to 27 per million individuals. These results, which represent the maximum potential impact from the proposed project, are statistically indistinguishable from the baseline Alternative 1.

Table 13: Calculated Cancer Risks for Alternative 2, Year 2020

Receptor Location	Projected DPM Concentration (µg/m^3)	Range of Incremental Cancer Risks per Million Persons (using 10^{-3} to 10^{-5} per µg/m^3 unit risk values)
Residence 1	0.21	2.1 to 210
Residence 2	0.24	2.4 to 240
Residence 3	0.27	2.7 to 270
Residence 4	0.28	2.8 to 280
Residence 5	0.20	2.0 to 200
Residence 6	0.13	1.3 to 130
South Park & Georgetown	0.027	0.27 to 27

Figure 9: Model-Calculated Annual DPM Concentrations Alternative 2 (2020)



Modeled Annual DPM Concentrations
Alternative 2 (2020)

Figure
9

7.2.3 Alternative 3 / 2040

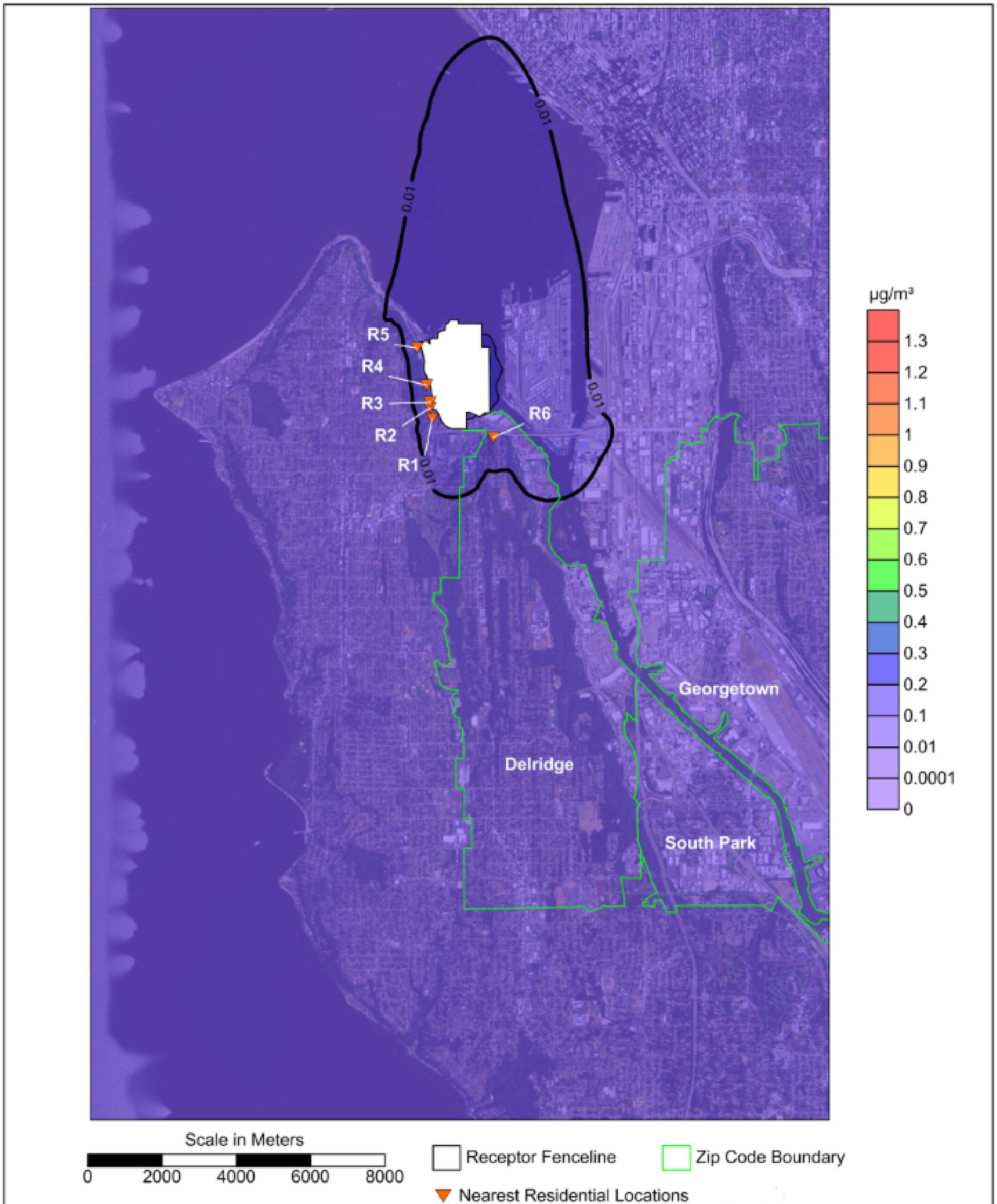
Results of the air modeling for Alternative 3 estimating concentrations of DPM for the year 2040 are depicted as isopleths in Figure 10. The range of modeled DPM concentrations at each of six residential locations nearest the project site range from 0.021 to 0.045 µg/m^3 (**Table 14**). This scenario represents the minimum potential impact of the project. Using the unit risk range of 10^{-3} to 10^{-5} per µg/m^3, these concentrations represent an incremental cancer risk with Alternative 3 of between 0.21 and 45 per million individuals. Predicted incremental cancer risks for Georgetown and South Park residents range from 0.054 to 5.4 per million individuals. These risks are nearly 6-fold less than with the baseline Alternative 1, as modeled for year 2020.

Table 14: Calculated Cancer Risks for Alternative 3, Year 2040

Receptor Location	Projected DPM Concentration (µg/m^3)	Range of Incremental Cancer Risks per Million Persons (using 10^{-3} to 10^{-5} per µg/m^3 unit risk values)
Residence 1	0.038	0.38 to 38
Residence 2	0.040	0.44 to 40
Residence 3	0.045	0.4 to 45
Residence 4	0.039	0.39 to 39
Residence 5	0.025	0.25 to 25
Residence 6	0.021	0.21 to 21
South Park & Georgetown	0.0054	0.054 to 5.4

Comparison of the action alternatives to the no action alternative demonstrates that predicted incremental cancer risks will not increase significantly as a result of the proposed project. For Alternative 2, incremental increases in predicted cancer risks are the same as or slightly greater than baseline cancer risks, whereas predicted incremental cancer risks for Alternative 3 are lower than baseline cancer risks. **Figure 11** depicts the relative differences in incremental cancer risk between the action alternatives and baseline, for the six selected residences near the facility and for South Park and Georgetown (zip code 98108).

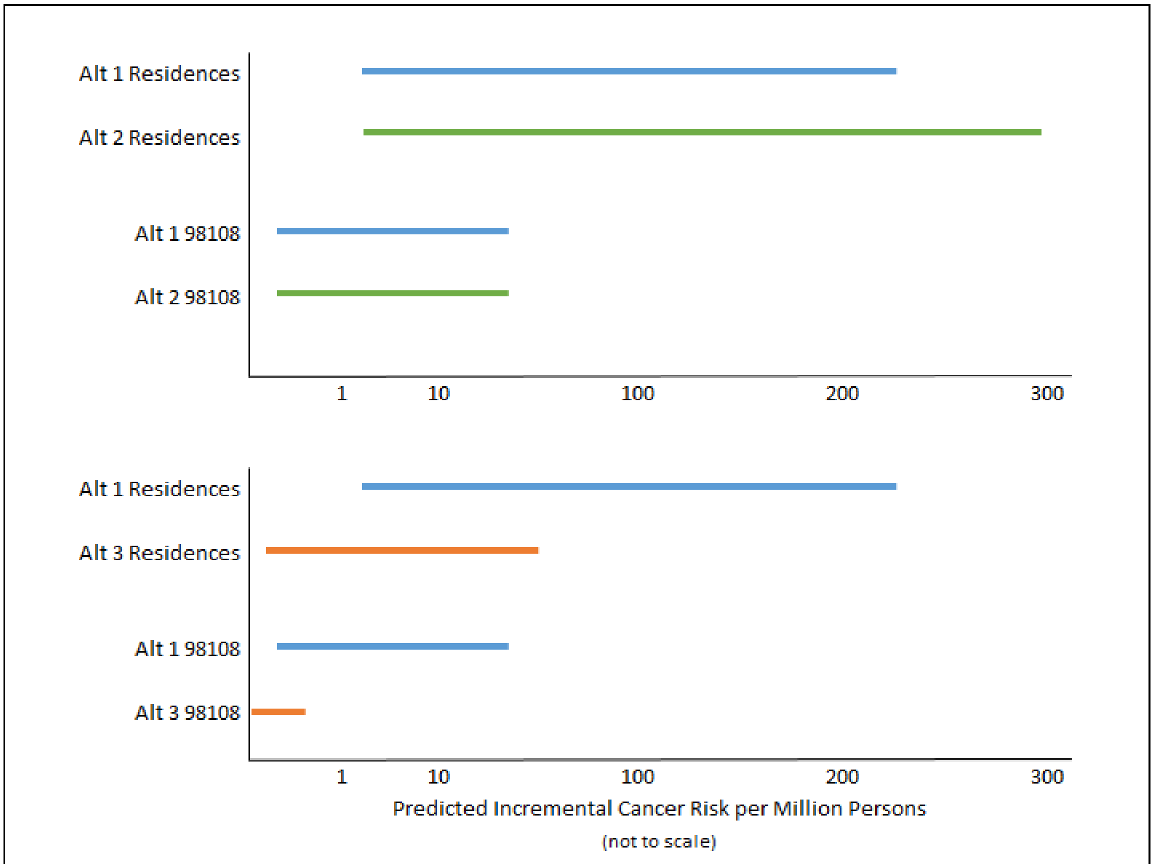
Figure 10: Model-Calculated Annual DPM Concentrations Alternative 3 (2040)



Modeled Annual DPM Concentrations
Alternative 3 (2040)

Figure 10

Figure 11: Comparison of Incremental Cancer Risk Ranges for Action and No Action Alternatives, for Residences 1 to 6 and Zip Code 98108 (South Park and Georgetown)



RAMBOLL ENVIRON	Comparison of Incremental Cancer Risk Ranges for Action and No Action Alternatives	Figure 11

8. CONCLUSIONS

Overall, changes in predicted $PM_{2.5}$ and DPM concentrations associated with Alternatives 2 and 3 result in negligible impacts (positive and negative) on health outcomes relative to baseline, or, the no action Alternative 1.

8.1 Non-cancer Risks from $PM_{2.5}$ Exposures

The estimated health impacts associated with the model-calculated changes in $PM_{2.5}$ concentrations resulting from Alternatives 2 and 3 are minimal. Both action alternatives result in average air quality improvements across all zip codes considered, but the changes are relatively small and likely within the uncertainty of modeling estimates. Alternative 3 is associated with larger air quality improvements and corresponding health benefits, but these benefits are very small – often several-fold less than one excess incidence depending on the health outcome. Given the uncertainties associated with this analysis together with the minimal health impacts estimated, these results indicate that even when considering the project scenario at the point of maximum air impacts (in this case, Alternative 2 for year 2020), the project would not result in significant non-cancer impacts from $PM_{2.5}$. These results extend to the two neighborhoods of concern, South Park and Georgetown.

8.2 Cancer Risks from DPM Exposures

Comparing risks among the three alternatives shows that there are very minor differences between the cancer risks associated with Alternative 2 (representing maximum potential impact) relative to the baseline, Alternative 1 (No Action) in the year 2020 for South Park and Georgetown. Implementation of Alternative 3 (representing minimum impact in 2040) is projected to decrease cancer risk from DPM compared to the baseline conditions, as modeled for 2020.

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APPENDIX A
SUPPORTING DOCUMENTATION FOR PM2.5 ANALYSIS

Table A-1: Data and Calculations of Mortality Associated with Short-term PM2.5 Exposures Resulting from Alternative 2 Compared with Alternative 1

Zip Code	Endpoint	Endpoint Group	City	State	Study	Age range	Population (2010)	Baseline Air Quality (Alt1) ug/m3	Control Air Quality Alternative 2 ug/m3	Change in Air Quality- ug/m3	Baseline Incidence	Total Baseline count	Health Effects function (Beta)	Change in Incidence of Mortality	Percentage of Total Incidence
98101	Mortality	Mortality, short-term, All Cause	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	10238	0.072	0.075	0.0037	0.0144	147	0.000495	**0.00027**	0.0002%
98102	Mortality	Mortality, short-term, All Cause	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	20756	0.043	0.046	0.0035	0.0024	50	0.000495	**0.00009**	0.0002%
98104	Mortality	Mortality, short-term, All Cause	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	13095	0.075	0.078	0.0027	0.0070	92	0.000495	**0.00012**	0.0001%
98106	Mortality	Mortality, short-term, All Cause	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	22873	1.402	1.447	0.0449	0.0044	100	0.000495	**0.00222**	0.0022%
98108	Mortality	Mortality, short-term, All Cause	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	22374	0.106	0.113	0.0065	0.0055	123	0.000495	**0.00040**	0.0003%
98109	Mortality	Mortality, short-term, All Cause	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	20715	0.086	0.090	0.0034	0.0052	107	0.000495	**0.00018**	0.0002%
98112	Mortality	Mortality, short-term, All Cause	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	21077	0.033	0.035	0.0020	0.0051	108	0.000495	**0.00011**	0.0001%
98116	Mortality	Mortality, short-term, All Cause	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	22241	0.201	0.217	0.0156	0.0076	170	0.000495	**0.00131**	0.0008%
98119	Mortality	Mortality, short-term, All Cause	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	21039	0.117	0.125	0.0071	0.0042	88	0.000495	**0.00031**	0.0003%
98121	Mortality	Mortality, short-term, All Cause	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	12628	0.112	0.116	0.0034	0.0035	44	0.000495	**0.00007**	0.0002%
98122	Mortality	Mortality, short-term, All Cause	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	31454	0.055	0.059	0.0042	0.0049	153	0.000495	**0.00032**	0.0002%
98126	Mortality	Mortality, short-term, All Cause	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	20698	2.714	2.464	-0.2507	0.0082	169	0.000495	**-0.02097**	-0.0124%
98134	Mortality	Mortality, short-term, All Cause	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	644	2.439	1.589	-0.8504	0.0093	6	0.000495	**-0.00253**	-0.0421%
98136	Mortality	Mortality, short-term, All Cause	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	14770	0.078	0.083	0.0051	0.0064	94	0.000495	**0.00024**	0.0003%
98144	Mortality	Mortality, short-term, All Cause	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	26881	0.054	0.058	0.0036	0.0069	186	0.000495	**0.00033**	0.0002%
98101	Mortality	Mortality, short-term, Cardiovascular	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	10238	0.072	0.075	0.0037	0.0042	43	0.000809	**0.00013**	0.0003%
98102	Mortality	Mortality, short-term, Cardiovascular	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	20756	0.043	0.046	0.0035	0.0005	10	0.000809	**0.00003**	0.0003%
98104	Mortality	Mortality, short-term, Cardiovascular	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	13095	0.075	0.078	0.0027	0.0021	27	0.000809	**0.00006**	0.0002%
98106	Mortality	Mortality, short-term, Cardiovascular	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	22873	1.402	1.447	0.0449	0.0009	20	0.000809	**0.00073**	0.0036%
98108	Mortality	Mortality, short-term, Cardiovascular	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	22374	0.106	0.113	0.0065	0.0014	31	0.000809	**0.00016**	0.0005%
98109	Mortality	Mortality, short-term, Cardiovascular	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	20715	0.086	0.090	0.0034	0.0016	34	0.000809	**0.00009**	0.0003%
98112	Mortality	Mortality, short-term, Cardiovascular	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	21077	0.033	0.035	0.0020	0.0009	18	0.000809	**0.00003**	0.0002%
98116	Mortality	Mortality, short-term, Cardiovascular	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	22241	0.201	0.217	0.0156	0.0021	46	0.000809	**0.00058**	0.0013%
98119	Mortality	Mortality, short-term, Cardiovascular	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	21039	0.117	0.125	0.0071	0.0012	26	0.000809	**0.00015**	0.0006%
98121	Mortality	Mortality, short-term, Cardiovascular	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	12628	0.112	0.116	0.0034	0.0012	15	0.000809	**0.00004**	0.0003%
98122	Mortality	Mortality, short-term, Cardiovascular	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	31454	0.055	0.059	0.0042	0.0013	42	0.000809	**0.00014**	0.0003%
98126	Mortality	Mortality, short-term, Cardiovascular	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	20698	2.714	2.464	-0.2507	0.0018	37	0.000809	**-0.00750**	-0.0203%
98134	Mortality	Mortality, short-term, Cardiovascular	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	644	2.439	1.589	-0.8504	0.0016	1	0.000809	**-0.00069**	-0.0688%
98136	Mortality	Mortality, short-term, Cardiovascular	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	14770	0.078	0.083	0.0051	0.0018	26	0.000809	**0.00011**	0.0004%
98144	Mortality	Mortality, short-term, Cardiovascular	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	26881	0.054	0.058	0.0036	0.0015	39	0.000809	**0.00011**	0.0003%

Table A-2: Data and Calculations of Mortality Associated with Short-term PM2.5 Exposures Resulting from Alternative 3 Compared with Alternative 1

Zip Code	Endpoint	Endpoint Group	City	State	Study	Age range	Population (2010)	Baseline Air Quality (Alt1) ug/m3	Control Air Quality Alternative 3 ug/m3	Change in Air Quality- ug/m3	Baseline Incidence	Total Baseline count	Health Effects function (Beta)	Change in Incidence of Mortality	Percentage of total incidence
98101	Mortality	Mortality, short-term, All Cause	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	10238	0.072	0.037	-0.035	0.0144	147	0.000495	**-0.0025**	-0.002%
98102	Mortality	Mortality, short-term, All Cause	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	20756	0.043	0.020	-0.022	0.0024	50	0.000495	**-0.0006**	-0.001%
98104	Mortality	Mortality, short-term, All Cause	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	13095	0.075	0.040	-0.035	0.0070	92	0.000495	**-0.0016**	-0.002%
98106	Mortality	Mortality, short-term, All Cause	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	22873	1.402	0.647	-0.755	0.0044	100	0.000495	**-0.0374**	-0.037%
98108	Mortality	Mortality, short-term, All Cause	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	22374	0.106	0.062	-0.045	0.0055	123	0.000495	**-0.0027**	-0.002%
98109	Mortality	Mortality, short-term, All Cause	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	20715	0.086	0.045	-0.041	0.0052	107	0.000495	**-0.0022**	-0.002%
98112	Mortality	Mortality, short-term, All Cause	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	21077	0.033	0.018	-0.016	0.0051	108	0.000495	**-0.0008**	-0.001%
98116	Mortality	Mortality, short-term, All Cause	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	22241	0.201	0.077	-0.124	0.0076	170	0.000495	**-0.0104**	-0.006%
98119	Mortality	Mortality, short-term, All Cause	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	21039	0.117	0.056	-0.062	0.0042	88	0.000495	**-0.0027**	-0.003%
98121	Mortality	Mortality, short-term, All Cause	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	12628	0.112	0.059	-0.053	0.0035	44	0.000495	**-0.0012**	-0.003%
98122	Mortality	Mortality, short-term, All Cause	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	31454	0.055	0.026	-0.029	0.0049	153	0.000495	**-0.0022**	-0.001%
98126	Mortality	Mortality, short-term, All Cause	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	20698	2.714	1.623	-1.091	0.0082	169	0.000495	**-0.0913**	-0.054%
98134	Mortality	Mortality, short-term, All Cause	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	644	2.439	1.182	-1.257	0.0093	6	0.000495	**-0.0037**	-0.062%
98136	Mortality	Mortality, short-term, All Cause	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	14770	0.078	0.034	-0.044	0.0064	94	0.000495	**-0.0021**	-0.002%
98144	Mortality	Mortality, short-term, All Cause	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	26881	0.054	0.029	-0.024	0.0069	186	0.000495	**-0.0023**	-0.001%
98101	Mortality	Mortality, short-term, Cardiovascular	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	10238	0.072	0.037	-0.035	0.0042	43	0.000809	**-0.0012**	-0.003%
98102	Mortality	Mortality, short-term, Cardiovascular	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	20756	0.043	0.020	-0.022	0.0005	10	0.000809	**-0.0002**	-0.002%
98104	Mortality	Mortality, short-term, Cardiovascular	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	13095	0.075	0.040	-0.035	0.0021	27	0.000809	**-0.0008**	-0.003%
98106	Mortality	Mortality, short-term, Cardiovascular	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	22873	1.402	0.647	-0.755	0.0009	20	0.000809	**-0.0122**	-0.061%
98108	Mortality	Mortality, short-term, Cardiovascular	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	22374	0.106	0.062	-0.045	0.0014	31	0.000809	**-0.0011**	-0.004%
98109	Mortality	Mortality, short-term, Cardiovascular	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	20715	0.086	0.045	-0.041	0.0016	34	0.000809	**-0.0011**	-0.003%
98112	Mortality	Mortality, short-term, Cardiovascular	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	21077	0.033	0.018	-0.016	0.0009	18	0.000809	**-0.0002**	-0.001%
98116	Mortality	Mortality, short-term, Cardiovascular	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	22241	0.201	0.077	-0.124	0.0021	46	0.000809	**-0.0046**	-0.010%
98119	Mortality	Mortality, short-term, Cardiovascular	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	21039	0.117	0.056	-0.062	0.0012	26	0.000809	**-0.0013**	-0.005%
98121	Mortality	Mortality, short-term, Cardiovascular	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	12628	0.112	0.059	-0.053	0.0012	15	0.000809	**-0.0006**	-0.004%
98122	Mortality	Mortality, short-term, Cardiovascular	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	31454	0.055	0.026	-0.029	0.0013	42	0.000809	**-0.0010**	-0.002%
98126	Mortality	Mortality, short-term, Cardiovascular	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	20698	2.714	1.623	-1.091	0.0018	37	0.000809	**-0.0327**	-0.088%
98134	Mortality	Mortality, short-term, Cardiovascular	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	644	2.439	1.182	-1.257	0.0016	1	0.000809	**-0.0010**	-0.102%
98136	Mortality	Mortality, short-term, Cardiovascular	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	14770	0.078	0.034	-0.044	0.0018	26	0.000809	**-0.0009**	-0.004%
98144	Mortality	Mortality, short-term, Cardiovascular	Seattle	WA	Zanobetti and Schwartz (2009)	0-99	26881	0.054	0.029	-0.024	0.0015	39	0.000809	**-0.0008**	-0.002%

Table A-3: Data and Calculations of Hospital Admissions Associated with Short-term PM2.5 Exposures Resulting from Alternative 2 Compared with Alternative 1

Zip Code	Endpoint	Endpoint Group	City	State	Study	Age range	Population (2010)	Baseline Air Quality (Alt1) ug/m3	Control Air Quality Alternative 3 ug/m3	Change in Air Quality- ug/m3	Baseline Incidence	Total Baseline count	Health Effects function (Beta)	Change in Incidence	Percentage of total incidence
98101	Hospital Admissions, Cardiovascular	HA, Cardiovascular	Seattle	WA	Bell et al. (2008)	65-99	1926	0.072	0.075	0.004	0.0031	6	0.00074	**0.000016**	0.0003%
98102	Hospital Admissions, Cardiovascular	HA, Cardiovascular	Seattle	WA	Bell et al. (2008)	65-99	2169	0.043	0.046	0.004	0.0023	5	0.00074	**0.000013**	0.0003%
98104	Hospital Admissions, Cardiovascular	HA, Cardiovascular	Seattle	WA	Bell et al. (2008)	65-99	1745	0.075	0.078	0.003	0.0017	3	0.00074	**0.000006**	0.0002%
98106	Hospital Admissions, Cardiovascular	HA, Cardiovascular	Seattle	WA	Bell et al. (2008)	65-99	2692	1.402	1.447	0.045	0.0019	5	0.00074	**0.000166**	0.0033%
98108	Hospital Admissions, Cardiovascular	HA, Cardiovascular	Seattle	WA	Bell et al. (2008)	65-99	2126	0.106	0.113	0.007	0.0019	4	0.00074	**0.000019**	0.0005%
98109	Hospital Admissions, Cardiovascular	HA, Cardiovascular	Seattle	WA	Bell et al. (2008)	65-99	2692	0.086	0.090	0.003	0.0011	3	0.00074	**0.000007**	0.0002%
98112	Hospital Admissions, Cardiovascular	HA, Cardiovascular	Seattle	WA	Bell et al. (2008)	65-99	3033	0.033	0.035	0.002	0.0023	7	0.00074	**0.000011**	0.0002%
98116	Hospital Admissions, Cardiovascular	HA, Cardiovascular	Seattle	WA	Bell et al. (2008)	65-99	1894	0.201	0.217	0.016	0.0021	4	0.00074	**0.000046**	0.0012%
98119	Hospital Admissions, Cardiovascular	HA, Cardiovascular	Seattle	WA	Bell et al. (2008)	65-99	1003	0.117	0.125	0.007	0.0030	3	0.00074	**0.000016**	0.0005%
98121	Hospital Admissions, Cardiovascular	HA, Cardiovascular	Seattle	WA	Bell et al. (2008)	65-99	2335	0.112	0.116	0.003	0.0034	8	0.00074	**0.000020**	0.0003%
98122	Hospital Admissions, Cardiovascular	HA, Cardiovascular	Seattle	WA	Bell et al. (2008)	65-99	2398	0.055	0.059	0.004	0.0038	9	0.00074	**0.000028**	0.0003%
98126	Hospital Admissions, Cardiovascular	HA, Cardiovascular	Seattle	WA	Bell et al. (2008)	65-99	46	2.714	2.464	-0.251	0.0217	1	0.00074	**-0.000186**	0.0186%
98134	Hospital Admissions, Cardiovascular	HA, Cardiovascular	Seattle	WA	Bell et al. (2008)	65-99	1992	2.439	1.589	-0.850	0.0050	10	0.00074	**-0.006295**	0.0629%
98136	Hospital Admissions, Cardiovascular	HA, Cardiovascular	Seattle	WA	Bell et al. (2008)	65-99	3456	0.078	0.083	0.005	0.0017	6	0.00074	**0.000023**	0.0004%
98101	Hospital Admissions, Respiratory	HA, Asthma	Seattle	WA	Sheppard (2003)	0-64	8312	0.072	0.075	0.004	0.0004	3	0.00332	**0.000037**	0.0012%
98104	Hospital Admissions, Respiratory	HA, Asthma	Seattle	WA	Sheppard (2003)	0-64	10926	0.075	0.078	0.003	0.0001	1	0.00332	**0.000009**	0.0009%
98106	Hospital Admissions, Respiratory	HA, Asthma	Seattle	WA	Sheppard (2003)	0-64	21128	1.402	1.447	0.045	0.0001	3	0.00332	**0.000447**	0.0149%
98108	Hospital Admissions, Respiratory	HA, Asthma	Seattle	WA	Sheppard (2003)	0-64	19682	0.106	0.113	0.007	0.0002	4	0.00332	**0.000087**	0.0022%
98112	Hospital Admissions, Respiratory	HA, Asthma	Seattle	WA	Sheppard (2003)	0-64	18385	0.033	0.035	0.002	0.0001	1	0.00332	**0.000007**	0.0007%
98116	Hospital Admissions, Respiratory	HA, Asthma	Seattle	WA	Sheppard (2003)	0-64	19208	0.201	0.217	0.016	0.0001	1	0.00332	**0.000052**	0.0052%
98119	Hospital Admissions, Respiratory	HA, Asthma	Seattle	WA	Sheppard (2003)	0-64	19145	0.117	0.125	0.007	0.0001	1	0.00332	**0.000023**	0.0023%
98121	Hospital Admissions, Respiratory	HA, Asthma	Seattle	WA	Sheppard (2003)	0-64	11625	0.112	0.116	0.003	0.0001	1	0.00332	**0.000011**	0.0011%
98122	Hospital Admissions, Respiratory	HA, Asthma	Seattle	WA	Sheppard (2003)	0-64	29119	0.055	0.059	0.004	0.0002	5	0.00332	**0.000070**	0.0014%
98136	Hospital Admissions, Respiratory	HA, Asthma	Seattle	WA	Sheppard (2003)	0-64	12778	0.078	0.083	0.005	0.0001	1	0.00332	**0.000017**	0.0017%
98144	Hospital Admissions, Respiratory	HA, Asthma	Seattle	WA	Sheppard (2003)	0-64	23425	0.054	0.058	0.004	0.0001	3	0.00332	**0.000036**	0.0012%
98101	Hospital Admissions, Respiratory	HA, All Respiratory	Seattle	WA	Bell et al. (2008)	65-99	1926	0.072	0.075	0.004	0.0016	3	0.00019	**0.000002**	0.0001%
98102	Hospital Admissions, Respiratory	HA, All Respiratory	Seattle	WA	Bell et al. (2008)	65-99	1455	0.043	0.046	0.004	0.0007	1	0.00019	**0.000001**	0.0001%
98104	Hospital Admissions, Respiratory	HA, All Respiratory	Seattle	WA	Bell et al. (2008)	65-99	2169	0.075	0.078	0.003	0.0014	3	0.00019	**0.000002**	0.0001%
98106	Hospital Admissions, Respiratory	HA, All Respiratory	Seattle	WA	Bell et al. (2008)	65-99	1745	1.402	1.447	0.045	0.0046	8	0.00019	**0.000068**	0.0009%
98108	Hospital Admissions, Respiratory	HA, All Respiratory	Seattle	WA	Bell et al. (2008)	65-99	2692	0.106	0.113	0.007	0.0011	3	0.00019	**0.000004**	0.0001%
98109	Hospital Admissions, Respiratory	HA, All Respiratory	Seattle	WA	Bell et al. (2008)	65-99	2126	0.086	0.090	0.003	0.0014	3	0.00019	**0.000002**	0.0001%
98112	Hospital Admissions, Respiratory	HA, All Respiratory	Seattle	WA	Bell et al. (2008)	65-99	2692	0.033	0.035	0.002	0.0011	3	0.00019	**0.000001**	0.0000%
98116	Hospital Admissions, Respiratory	HA, All Respiratory	Seattle	WA	Bell et al. (2008)	65-99	3033	0.201	0.217	0.016	0.0013	4	0.00019	**0.000012**	0.0003%
98119	Hospital Admissions, Respiratory	HA, All Respiratory	Seattle	WA	Bell et al. (2008)	65-99	1003	0.117	0.125	0.007	0.0010	1	0.00019	**0.000001**	0.0001%
98121	Hospital Admissions, Respiratory	HA, All Respiratory	Seattle	WA	Bell et al. (2008)	65-99	2335	0.112	0.116	0.003	0.0021	5	0.00019	**0.000003**	0.0001%
98122	Hospital Admissions, Respiratory	HA, All Respiratory	Seattle	WA	Bell et al. (2008)	65-99	2398	0.055	0.059	0.004	0.0013	3	0.00019	**0.000002**	0.0001%
98126	Hospital Admissions, Respiratory	HA, All Respiratory	Seattle	WA	Bell et al. (2008)	65-99	1992	2.714	2.464	-0.251	0.0015	3	0.00019	**-0.000143**	0.0048%
98136	Hospital Admissions, Respiratory	HA, All Respiratory	Seattle	WA	Bell et al. (2008)	65-99	3456	0.078	0.083	0.005	0.0006	2	0.00019	**0.000002**	0.0001%

A-4: Data and Calculations of Hospital Admissions Associated with Short-term PM2.5 Exposures Resulting from Alternative 3 Compared with Alternative 1

Zip Code	Endpoint	Endpoint Group	City	State	Study	Age range	Population (2010)	Baseline Air Quality (Alt1) ug/m3	Control Air Quality Alternative 3 ug/m3	Change in Air Quality- ug/m3	Baseline Incidence	Total Baseline count	Health Effects function (Beta)	Change in Incidence	Percentage of total incidence
98101	Hospital Admissions, Cardiovascular	HA, Cardiovascular	Seattle	WA	Bell et al. (2008)	65-99	1926	0.072	0.037	-0.035	0.0031	6	0.00074	**-0.000155**	0.0026%
98102	Hospital Admissions, Cardiovascular	HA, Cardiovascular	Seattle	WA	Bell et al. (2008)	65-99	2169	0.043	0.020	-0.022	0.0023	5	0.00074	**-0.000083**	0.0017%
98104	Hospital Admissions, Cardiovascular	HA, Cardiovascular	Seattle	WA	Bell et al. (2008)	65-99	1745	0.075	0.040	-0.035	0.0017	3	0.00074	**-0.000079**	0.0026%
98106	Hospital Admissions, Cardiovascular	HA, Cardiovascular	Seattle	WA	Bell et al. (2008)	65-99	2692	1.402	0.647	-0.755	0.0019	5	0.00074	**-0.002794**	0.0559%
98108	Hospital Admissions, Cardiovascular	HA, Cardiovascular	Seattle	WA	Bell et al. (2008)	65-99	2126	0.106	0.062	-0.045	0.0019	4	0.00074	**-0.000132**	0.0033%
98109	Hospital Admissions, Cardiovascular	HA, Cardiovascular	Seattle	WA	Bell et al. (2008)	65-99	2692	0.086	0.045	-0.041	0.0011	3	0.00074	**-0.000091**	0.0030%
98112	Hospital Admissions, Cardiovascular	HA, Cardiovascular	Seattle	WA	Bell et al. (2008)	65-99	3033	0.033	0.018	-0.016	0.0023	7	0.00074	**-0.000080**	0.0011%
98116	Hospital Admissions, Cardiovascular	HA, Cardiovascular	Seattle	WA	Bell et al. (2008)	65-99	1894	0.201	0.077	-0.124	0.0021	4	0.00074	**-0.000367**	0.0092%
98119	Hospital Admissions, Cardiovascular	HA, Cardiovascular	Seattle	WA	Bell et al. (2008)	65-99	1003	0.117	0.056	-0.062	0.0030	3	0.00074	**-0.000137**	0.0046%
98121	Hospital Admissions, Cardiovascular	HA, Cardiovascular	Seattle	WA	Bell et al. (2008)	65-99	2335	0.112	0.059	-0.053	0.0034	8	0.00074	**-0.000315**	0.0039%
98122	Hospital Admissions, Cardiovascular	HA, Cardiovascular	Seattle	WA	Bell et al. (2008)	65-99	2398	0.055	0.026	-0.029	0.0038	9	0.00074	**-0.000191**	0.0021%
98126	Hospital Admissions, Cardiovascular	HA, Cardiovascular	Seattle	WA	Bell et al. (2008)	65-99	46	2.714	1.623	-1.091	0.0217	1	0.00074	**-0.000808**	0.0808%
98134	Hospital Admissions, Cardiovascular	HA, Cardiovascular	Seattle	WA	Bell et al. (2008)	65-99	1992	2.439	1.182	-1.257	0.0050	10	0.00074	**-0.009307**	0.0931%
98136	Hospital Admissions, Cardiovascular	HA, Cardiovascular	Seattle	WA	Bell et al. (2008)	65-99	3456	0.078	0.034	-0.044	0.0017	6	0.00074	**-0.000196**	0.0033%
98101	Hospital Admissions, Respiratory	HA, Asthma	Seattle	WA	Sheppard (2003)	0-64	8312	0.072	0.037	-0.035	0.0004	3	0.00332	**-0.000384**	0.0116%
98104	Hospital Admissions, Respiratory	HA, Asthma	Seattle	WA	Sheppard (2003)	0-64	10926	0.075	0.040	-0.035	0.0001	1	0.00332	**-0.000127**	0.0116%
98106	Hospital Admissions, Respiratory	HA, Asthma	Seattle	WA	Sheppard (2003)	0-64	21128	1.402	0.647	-0.755	0.0001	2	0.00332	**-0.005303**	0.2510%
98108	Hospital Admissions, Respiratory	HA, Asthma	Seattle	WA	Sheppard (2003)	0-64	19682	0.106	0.062	-0.045	0.0002	4	0.00332	**-0.000588**	0.0149%
98112	Hospital Admissions, Respiratory	HA, Asthma	Seattle	WA	Sheppard (2003)	0-64	18385	0.033	0.018	-0.016	0.0001	2	0.00332	**-0.000098**	0.0053%
98116	Hospital Admissions, Respiratory	HA, Asthma	Seattle	WA	Sheppard (2003)	0-64	19208	0.201	0.077	-0.124	0.0001	2	0.00332	**-0.000791**	0.0412%
98119	Hospital Admissions, Respiratory	HA, Asthma	Seattle	WA	Sheppard (2003)	0-64	19145	0.117	0.056	-0.062	0.0001	2	0.00332	**-0.000394**	0.0206%
98121	Hospital Admissions, Respiratory	HA, Asthma	Seattle	WA	Sheppard (2003)	0-64	11625	0.112	0.059	-0.053	0.0001	1	0.00332	**-0.000205**	0.0176%
98122	Hospital Admissions, Respiratory	HA, Asthma	Seattle	WA	Sheppard (2003)	0-64	29119	0.055	0.026	-0.029	0.0002	6	0.00332	**-0.000561**	0.0096%
98136	Hospital Admissions, Respiratory	HA, Asthma	Seattle	WA	Sheppard (2003)	0-64	12778	0.078	0.034	-0.044	0.0001	1	0.00332	**-0.000187**	0.0146%
98144	Hospital Admissions, Respiratory	HA, Asthma	Seattle	WA	Sheppard (2003)	0-64	23425	0.054	0.029	-0.024	0.0001	2	0.00332	**-0.000187**	0.0080%
98101	Hospital Admissions, Respiratory	HA, All Respiratory	Seattle	WA	Bell et al. (2008)	65-99	1926	0.072	0.037	-0.035	0.0016	3	0.00019	**-0.000020**	0.0007%
98102	Hospital Admissions, Respiratory	HA, All Respiratory	Seattle	WA	Bell et al. (2008)	65-99	1455	0.043	0.020	-0.022	0.0007	1	0.00019	**-0.000004**	0.0004%
98104	Hospital Admissions, Respiratory	HA, All Respiratory	Seattle	WA	Bell et al. (2008)	65-99	2169	0.075	0.040	-0.035	0.0014	3	0.00019	**-0.000020**	0.0007%
98106	Hospital Admissions, Respiratory	HA, All Respiratory	Seattle	WA	Bell et al. (2008)	65-99	1745	1.402	0.647	-0.755	0.0046	8	0.00019	**-0.001152**	0.0143%
98108	Hospital Admissions, Respiratory	HA, All Respiratory	Seattle	WA	Bell et al. (2008)	65-99	2692	0.106	0.062	-0.045	0.0011	3	0.00019	**-0.000025**	0.0009%
98109	Hospital Admissions, Respiratory	HA, All Respiratory	Seattle	WA	Bell et al. (2008)	65-99	2126	0.086	0.045	-0.041	0.0014	3	0.00019	**-0.000023**	0.0008%
98112	Hospital Admissions, Respiratory	HA, All Respiratory	Seattle	WA	Bell et al. (2008)	65-99	2692	0.033	0.018	-0.016	0.0011	3	0.00019	**-0.000009**	0.0003%
98116	Hospital Admissions, Respiratory	HA, All Respiratory	Seattle	WA	Bell et al. (2008)	65-99	3033	0.201	0.077	-0.124	0.0013	4	0.00019	**-0.000093**	0.0024%
98119	Hospital Admissions, Respiratory	HA, All Respiratory	Seattle	WA	Bell et al. (2008)	65-99	1003	0.117	0.056	-0.062	0.0010	1	0.00019	**-0.000012**	0.0012%
98121	Hospital Admissions, Respiratory	HA, All Respiratory	Seattle	WA	Bell et al. (2008)	65-99	2335	0.112	0.059	-0.053	0.0021	5	0.00019	**-0.000049**	0.0010%
98122	Hospital Admissions, Respiratory	HA, All Respiratory	Seattle	WA	Bell et al. (2008)	65-99	2398	0.055	0.026	-0.029	0.0013	3	0.00019	**-0.000017**	0.0006%
98126	Hospital Admissions, Respiratory	HA, All Respiratory	Seattle	WA	Bell et al. (2008)	65-99	1992	2.714	1.623	-1.091	0.0015	3	0.00019	**-0.000622**	0.0207%
98136	Hospital Admissions, Respiratory	HA, All Respiratory	Seattle	WA	Bell et al. (2008)	65-99	3456	0.078	0.034	-0.044	0.0006	2	0.00019	**-0.000017**	0.0008%

Table A-5: Data and Calculations of Mortality Associated with Long-term PM2.5 Exposures Resulting from Alternative 2 Compared with Alternative 1

Zip code	Endpoint	Endpoint Group	City	State	Study	Age range	Population (2010)	Baseline Air Quality (Alt1) ug/m3	Control Air Quality Alternative 3 ug/m3	Change in Air Quality- ug/m3	Baseline Incidence	Total Baseline count	Health Effects function (Beta)	Change in Incidence of Mortality	Percentage of total incidence
98101	Mortality, long-term, All Cause	NA	Seattle	WA	Krewski	30-99	7472	0.027	0.027	-0.0005	0.0195	146	0.00379	**-0.000249**	0.0002%
98102	Mortality, long-term, All Cause	NA	Seattle	WA	Krewski	30-99	12549	0.010	0.010	-0.0006	0.0039	49	0.00379	**-0.000106**	0.0002%
98104	Mortality, long-term, All Cause	NA	Seattle	WA	Krewski	30-99	9022	0.029	0.029	-0.0007	0.0102	92	0.00379	**-0.000248**	0.0003%
98106	Mortality, long-term, All Cause	NA	Seattle	WA	Krewski	30-99	13502	0.609	0.684	0.0742	0.0070	94	0.00379	**0.026417**	0.0281%
98108	Mortality, long-term, All Cause	NA	Seattle	WA	Krewski	30-99	13639	0.031	0.027	-0.0035	0.0089	121	0.00379	**-0.001614**	0.0013%
98109	Mortality, long-term, All Cause	NA	Seattle	WA	Krewski	30-99	12839	0.029	0.026	-0.0035	0.0083	106	0.00379	**-0.001422**	0.0013%
98112	Mortality, long-term, All Cause	NA	Seattle	WA	Krewski	30-99	13896	0.007	0.006	-0.0009	0.0077	107	0.00379	**-0.000345**	0.0003%
98116	Mortality, long-term, All Cause	NA	Seattle	WA	Krewski	30-99	15867	0.047	0.052	0.0043	0.0107	169	0.00379	**0.002773**	0.0016%
98119	Mortality, long-term, All Cause	NA	Seattle	WA	Krewski	30-99	12317	0.037	0.033	-0.0037	0.0071	88	0.00379	**-0.001224**	0.0014%
98121	Mortality, long-term, All Cause	NA	Seattle	WA	Krewski	30-99	7973	0.037	0.031	-0.0063	0.0054	43	0.00379	**-0.001020**	0.0024%
98122	Mortality, long-term, All Cause	NA	Seattle	WA	Krewski	30-99	17408	0.011	0.010	-0.0008	0.0086	150	0.00379	**-0.000461**	0.0003%
98126	Mortality, long-term, All Cause	NA	Seattle	WA	Krewski	30-99	13503	1.127	1.122	-0.0053	0.0122	165	0.00379	**-0.003315**	0.0020%
98134	Mortality, long-term, All Cause	NA	Seattle	WA	Krewski	30-99	480	0.646	0.481	-0.1653	0.0125	6	0.00379	**-0.003760**	0.0627%
98136	Mortality, long-term, All Cause	NA	Seattle	WA	Krewski	30-99	10601	0.013	0.013	0.0001	0.0089	94	0.00379	**0.000043**	0.0000%
98144	Mortality, long-term, All Cause	NA	Seattle	WA	Krewski	30-99	17512	0.013	0.013	0.0000	0.0106	185	0.00379	**-0.000021**	0.0000%
98101	Mortality, long-term, Cardiovascular	NA	Seattle	WA	Pope	30-99	7472	0.027	0.027	-0.0005	0.0058	43	0.00502	**-0.000097**	0.0002%
98102	Mortality, long-term, Cardiovascular	NA	Seattle	WA	Pope	30-99	12549	0.010	0.010	-0.0006	0.0008	10	0.00502	**-0.000029**	0.0003%
98104	Mortality, long-term, Cardiovascular	NA	Seattle	WA	Pope	30-99	9022	0.029	0.029	-0.0007	0.0030	27	0.00502	**-0.000096**	0.0004%
98106	Mortality, long-term, Cardiovascular	NA	Seattle	WA	Pope	30-99	13502	0.609	0.684	0.0742	0.0015	20	0.00502	**0.007444**	0.0372%
98108	Mortality, long-term, Cardiovascular	NA	Seattle	WA	Pope	30-99	13639	0.031	0.027	-0.0035	0.0023	31	0.00502	**-0.000548**	0.0018%
98109	Mortality, long-term, Cardiovascular	NA	Seattle	WA	Pope	30-99	12839	0.029	0.026	-0.0035	0.0026	34	0.00502	**-0.000604**	0.0018%
98112	Mortality, long-term, Cardiovascular	NA	Seattle	WA	Pope	30-99	13896	0.007	0.006	-0.0009	0.0013	18	0.00502	**-0.000077**	0.0004%
98116	Mortality, long-term, Cardiovascular	NA	Seattle	WA	Pope	30-99	15867	0.047	0.052	0.0043	0.0029	46	0.00502	**0.001000**	0.0022%
98119	Mortality, long-term, Cardiovascular	NA	Seattle	WA	Pope	30-99	12317	0.037	0.033	-0.0037	0.0021	26	0.00502	**-0.000479**	0.0018%
98121	Mortality, long-term, Cardiovascular	NA	Seattle	WA	Pope	30-99	7973	0.037	0.031	-0.0063	0.0019	15	0.00502	**-0.000471**	0.0031%
98122	Mortality, long-term, Cardiovascular	NA	Seattle	WA	Pope	30-99	17408	0.011	0.010	-0.0008	0.0024	42	0.00502	**-0.000171**	0.0004%
98126	Mortality, long-term, Cardiovascular	NA	Seattle	WA	Pope	30-99	13503	1.127	1.122	-0.0053	0.0027	37	0.00502	**-0.000984**	0.0027%
98134	Mortality, long-term, Cardiovascular	NA	Seattle	WA	Pope	30-99	480	0.646	0.481	-0.1653	0.0021	1	0.00502	**-0.000830**	0.0830%
98136	Mortality, long-term, Cardiovascular	NA	Seattle	WA	Pope	30-99	10601	0.013	0.013	0.0001	0.0025	26	0.00502	**0.000016**	0.0001%
98144	Mortality, long-term, Cardiovascular	NA	Seattle	WA	Pope	30-99	17512	0.013	0.013	0.0000	0.0022	39	0.00502	**-0.000006**	0.0000%

Notes:

NA = not applicable

Table A-6: Data and Calculations of Mortality Associated with Long-term PM2.5 Exposures Resulting from Alternative 3 Compared with Alternative 1

Zip code	Endpoint	Endpoint Group	City	State	Study	Age range	Population (2010)	Baseline Air Quality (Alt1) ug/m3	Control Air Quality Alternative 3 ug/m3	Change in Air Quality- ug/m3	Baseline Incidence	Total Baseline count	Health Effects function (Beta)	Change in Incidence of Mortality	Percentage of total incidence
98101	Mortality, long-term, All Cause	NA	Seattle	WA	Krewski	30-99	7472	0.0270	0.0062	-0.021	0.0195	146	0.00379	**-0.0115**	0.008%
98102	Mortality, long-term, All Cause	NA	Seattle	WA	Krewski	30-99	12549	0.0101	0.0028	-0.007	0.0039	49	0.00379	**-0.0013**	0.003%
98104	Mortality, long-term, All Cause	NA	Seattle	WA	Krewski	30-99	9022	0.0293	0.0064	-0.023	0.0102	92	0.00379	**-0.0080**	0.009%
98106	Mortality, long-term, All Cause	NA	Seattle	WA	Krewski	30-99	13502	0.6095	0.1403	-0.469	0.0070	94	0.00379	**-0.1673**	0.178%
98108	Mortality, long-term, All Cause	NA	Seattle	WA	Krewski	30-99	13639	0.0305	0.0055	-0.025	0.0089	121	0.00379	**-0.0115**	0.009%
98109	Mortality, long-term, All Cause	NA	Seattle	WA	Krewski	30-99	12839	0.0295	0.0078	-0.022	0.0083	106	0.00379	**-0.0087**	0.008%
98112	Mortality, long-term, All Cause	NA	Seattle	WA	Krewski	30-99	13896	0.0068	0.0019	-0.005	0.0077	107	0.00379	**-0.0020**	0.002%
98116	Mortality, long-term, All Cause	NA	Seattle	WA	Krewski	30-99	15867	0.0472	0.0077	-0.039	0.0107	169	0.00379	**-0.0253**	0.015%
98119	Mortality, long-term, All Cause	NA	Seattle	WA	Krewski	30-99	12317	0.0366	0.0093	-0.027	0.0071	88	0.00379	**-0.0091**	0.010%
98121	Mortality, long-term, All Cause	NA	Seattle	WA	Krewski	30-99	7973	0.0374	0.0101	-0.027	0.0054	43	0.00379	**-0.0044**	0.010%
98122	Mortality, long-term, All Cause	NA	Seattle	WA	Krewski	30-99	17408	0.0110	0.0030	-0.008	0.0086	150	0.00379	**-0.0045**	0.003%
98126	Mortality, long-term, All Cause	NA	Seattle	WA	Krewski	30-99	13503	1.1273	0.2533	-0.874	0.0122	165	0.00379	**-0.5475**	0.332%
98134	Mortality, long-term, All Cause	NA	Seattle	WA	Krewski	30-99	480	0.6464	0.1049	-0.542	0.0125	6	0.00379	**-0.0123**	0.205%
98136	Mortality, long-term, All Cause	NA	Seattle	WA	Krewski	30-99	10601	0.0129	0.0031	-0.010	0.0089	94	0.00379	**-0.0035**	0.004%
98144	Mortality, long-term, All Cause	NA	Seattle	WA	Krewski	30-99	17512	0.0132	0.0029	-0.010	0.0106	185	0.00379	**-0.0072**	0.004%
98101	Mortality, long-term, Cardiovascular	NA	Seattle	WA	Pope	30-99	7472	0.0270	0.0062	-0.021	0.0058	43	0.00502	**-0.0045**	0.010%
98102	Mortality, long-term, Cardiovascular	NA	Seattle	WA	Pope	30-99	12,549	0.0101	0.0028	-0.007	0.0008	10	0.00502	**-0.0004**	0.004%
98104	Mortality, long-term, Cardiovascular	NA	Seattle	WA	Pope	30-99	9022	0.0293	0.0064	-0.023	0.0030	27	0.00502	**-0.0031**	0.011%
98106	Mortality, long-term, Cardiovascular	NA	Seattle	WA	Pope	30-99	13502	0.6095	0.1403	-0.469	0.0015	20	0.00502	**-0.0472**	0.236%
98108	Mortality, long-term, Cardiovascular	NA	Seattle	WA	Pope	30-99	13639	0.0305	0.0055	-0.025	0.0023	31	0.00502	**-0.0039**	0.013%
98109	Mortality, long-term, Cardiovascular	NA	Seattle	WA	Pope	30-99	12839	0.0295	0.0078	-0.022	0.0026	34	0.00502	**-0.0037**	0.011%
98112	Mortality, long-term, Cardiovascular	NA	Seattle	WA	Pope	30-99	13896	0.0068	0.0019	-0.005	0.0013	18	0.00502	**-0.0004**	0.002%
98116	Mortality, long-term, Cardiovascular	NA	Seattle	WA	Pope	30-99	15867	0.0472	0.0077	-0.039	0.0029	46	0.00502	**-0.0091**	0.020%
98119	Mortality, long-term, Cardiovascular	NA	Seattle	WA	Pope	30-99	12317	0.0366	0.0093	-0.027	0.0021	26	0.00502	**-0.0036**	0.014%
98121	Mortality, long-term, Cardiovascular	NA	Seattle	WA	Pope	30-99	7973	0.0374	0.0101	-0.027	0.0019	15	0.00502	**-0.0021**	0.014%
98122	Mortality, long-term, Cardiovascular	NA	Seattle	WA	Pope	30-99	17408	0.0110	0.0030	-0.008	0.0024	42	0.00502	**-0.0017**	0.004%
98126	Mortality, long-term, Cardiovascular	NA	Seattle	WA	Pope	30-99	13503	1.1273	0.2533	-0.874	0.0027	37	0.00502	**-0.1627**	0.440%
98134	Mortality, long-term, Cardiovascular	NA	Seattle	WA	Pope	30-99	480	0.6464	0.1049	-0.542	0.0021	1	0.00502	**-0.0027**	0.272%
98136	Mortality, long-term, Cardiovascular	NA	Seattle	WA	Pope	30-99	10601	0.0129	0.0031	-0.010	0.0025	26	0.00502	**-0.0013**	0.005%
98144	Mortality, long-term, Cardiovascular	NA	Seattle	WA	Pope	30-99	17512	0.0132	0.0029	-0.010	0.0022	39	0.00502	**-0.0020**	0.005%

Notes:
NA = not applicable

APPENDIX B
DIESEL PARTICULATE MATTER URF WHITEPAPER

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April 2016

WHITE PAPER ON DIESEL EXHAUST QUANTITATIVE HEALTH RISK ASSESSMENT VALUES FOR LUNG CANCER

RAMBOLL ENVIRON

EXECUTIVE SUMMARY

This paper is written for a technical audience interested in understanding the rationale and justification for use of a range in "unit risk factors" for estimating potential cancer risk from exposure to diesel exhaust rather than a single number (for example, that proposed by the California Office of Environmental Health Hazard Assessment [OEHHA]). The paper is not focused on a specific project but may be incorporated into project-specific risk assessments as supporting documentation for the selection of alternative unit risk factors.

Typically, a single unit risk factor, derived from one or more studies in the scientific literature, is applied to a monitored or modelled air concentration to estimate potential cancer risk that might result from the project. However, in the case of diesel engine exhaust, the use of a single, discrete value representing potential cancer potency of diesel exhaust attributes greater confidence to cancer risk estimates than is appropriate given the underlying shortcomings in the quantitative assessment of diesel exhaust risk. To adequately understand the limitations in current unit risk estimates for diesel engine exhaust, one must appreciate the historical process and causes for continued evaluation of the relationship between exposure to diesel engine exhaust and potential adverse health effects.

When fully considering the conclusions of multiple science review panels and risk assessment investigators, it is apparent that the current quantitative assessments for diesel exhaust are inadequate for deriving a single cancer potency number. While it is apparent that the body of research as a whole supports a positive relationship between exposure to diesel exhaust (particularly those with the composition of older diesel engines) and lung cancer, the numerical values that estimate potential cancer risk are hampered by a large range of uncertainty that is rarely communicated and considered in project planning and risk communication efforts. This dilemma can frustrate regulatory agencies, project proponents, and affected communities alike.

This document presents a summary of this dilemma and a proposal for addressing the inadequacies in unit risk estimates currently available. It consists of several sections that discuss the problem and offer a solution:

- Introduction to quantitative health risk assessment process;
- Overview of various Agency, Expert Panel, and Risk Assessment Investigator evaluations of the state-of-the-science related to the exposure-response relationship for diesel exhaust and cancer, along with a descriptions of key studies and their limitations;
- Description of the problems underlying the current quantitative estimates, along with a summary of different estimates for proposed unit risk factors;
- Proposal for estimating cancer risks associated with diesel exhaust until further assessment is complete

We conclude that, rather than selecting a single diesel exhaust risk estimate for appraising potential lung cancer risk, applying a range of unit risk factors allows project managers to compare relative ranges in impacts of each alternative, which can better support project planning and design decision-making. Given the uncertainties, we propose a range of numbers to be used to assess cancer risks, which range from 10^{-3} to 10^{-5} per µg/m^3, and propose to use these numbers to compare relative risks for different projects and exposure scenarios. Consideration of a plausible spectrum of risks for each proposed project alternative may provide greater insights into the relative differences in impacts between each alternative.

1. INTRODUCTION

Quantitative health risk assessments (HRAs) are based on combining exposure data with exposure-response information to quantitatively estimate potential risk. The National Research Council (1993) describes the risk assessment process as having four components: (1) a systematic review of evidence from epidemiology and other scientific disciplines concerning the association between environmental factors and human health (risk assessment hazard identification); (2) the understanding of the relationship between exposure and response (exposure-response assessment); (3) the compilation of exposure data (exposure assessment), and (4) estimation of the health impacts following exposure to risk factors (risk characterization). Each step is critical in deriving a useful estimate of risk.

This document summarizes existing information supporting steps 1 and 2 by examining the evidence and application of scientific information to understand quantitative health risks from exposure to diesel exhaust, specifically for cancer as a health endpoint. This information may then be carried forward to support the latter two steps in quantifying risks attributed to a specific source.

2. THE RISK ASSESSMENT PROCESS

2.1 Step 1: Diesel Exhaust Hazard Identification

Several authoritative bodies have examined the risk assessment hazard identification step of the HRA process, asking "*Is exposure to diesel exhaust associated with an increased risk of cancer (particularly lung cancer) at <u>some</u> level of exposure?*" A large body of more than 50 epidemiology studies of diesel exhaust-exposed occupational populations are available, including of miners (*e.g.*, non-metal and metal), bus drivers and bus garage workers, trucking industry workers, and railroad workers (Hesterberg et al., 2012; IARC, 2014). A number of critical reviews, epidemiology meta-analyses, and regulatory cancer hazard assessments have interpreted this body of diesel exhaust epidemiology studies as providing support for a causal relationship between diesel exhaust exposure and lung cancer risk (*e.g.*, Bhatia et al., 1998; HEI, 1995; Lipsett & Campleman, 1999; Lloyd & Cackette, 2001; Wichmann, 2007; IARC 2014; National Toxicology Program (NTP), 2011). In 2012, the International Agency for Research on Cancer (IARC) classified diesel exhaust as a Group 1 "known human carcinogen" based on "sufficient" human data from occupational studies of non-metal miners, railroad workers, and workers in the trucking industry (International Agency for Research on Cancer, 2014).

Due to the substantial uncertainties and limitations in the diesel exhaust epidemiology literature, other published evaluations of the diesel exhaust-lung cancer evidence have concluded that the epidemiology data are not sufficiently reliable to establish a causal association between exposure to diesel exhaust and lung cancer (Boffetta, 2012; Bunn et al., 2004; Gamble et al., 2012; Gamble, 2010; Hesterberg et al., 2006, 2012; Morgan et al., 1997; Muscat and Wynder, 1995; Stober and Abel, 1996). These analyses have highlighted inconsistencies in the epidemiology findings (*e.g.*, weak or a lack of statistically significant associations between diesel exhaust exposure and lung cancer and even negative dose-response trends in some studies), and a number of critical study limitations that include unreliable exposure assessments and often a general lack of quantitative data on workers' historical exposures to diesel exhaust, as well as inadequate control of confounding exposures, both from other air pollutants as well as for smoking (Hesterberg et al., 2012). While some of the more recently published diesel exhaust epidemiology studies (Attfield et al., 2012; Garshick et al., 2012; Silverman et al., 2012) have reported some of the strongest diesel-lung cancer associations, they remain affected by inconsistent exposure-response findings and possible effects of bias and exposure misclassification (Boffetta, 2012; Hesterberg et al., 2012; Moolgavkar et al., 2015). Nevertheless, the body of evidence suggests a need for assessing the potential cancer risk due exposures to diesel exhaust.

2.2 Step 2: Diesel Exhaust and Exposure-Response Assessment

A description of the forms exposure-response assessments may take is provided here for background in understanding the current body of scientific literature regarding diesel exhaust exposure-response research. Following this introduction are summaries of the critical diesel exhaust studies considered by regulatory bodies to date and a history of their consideration for use in quantifying the exposure-response relationship. An understanding of the basic study design and inherent limitations and uncertainties and regulatory review history is critical in applying quantitative unit risk estimates for diesel exhaust and interpreting cancer risk estimates in site-specific risk evaluations.

For the exposure-response assessment step of quantitative HRAs, the preferred basis for the exposure-response function are studies in human populations. When sufficient human data are not available, the exposure-response function is often based on experimental animal studies, but these are associated with additional uncertainties due to inter-species extrapolation. Studies in human populations may take the form of experimental exposure studies or observational (epidemiology) studies. Experimental studies are controlled studies in which the researcher controls the environment (such as the exposure), then observes what happens as a consequence of changing that environment. In an observational epidemiology study, the researcher studies the outcome, but the conditions cannot be controlled (*e.g.*, the exposures). Although experimental study designs are sometimes used to understand non-cancer endpoints in the drug development process (for example, clinical trials) or for substances that people are normally exposed to in the environment (controlled human exposure studies, or chamber studies) the more common approach to understanding toxicity to substances in humans is through epidemiology studies, where groups of people who are exposed to a chemical or substance in their environment are studied. These exposures may be due to exposure in a workplace environment, or to exposures in ambient air as people go about their lives. Various scientific procedures and tools have been devised to conduct such epidemiology studies.

There are several types of epidemiology studies, including cohort studies, case control studies, and cross-sectional studies. Some of these study designs are stronger than others. A cohort study (also sometimes called a longitudinal or prospective study) involves identifying groups of individuals with common exposures and then comparing subsequent rates of certain diseases in those groups with the rates of disease in similar groups with lower exposures. A case-control study (also sometimes called a retrospective study) identifies groups of people who have a certain disease and compares their exposure histories to similar groups of people who do not have the disease. A cross-sectional study examines the prevalence of a disease or health endpoint in one sample of people with a particular characteristic, and information about their health is then collected and interpreted in a systematic manner. This latter design is relatively weak for drawing conclusions about causation.

3. EVALUATIONS OF THE DIESEL EPIDEMIOLOGY LITERATURE

3.1 Evaluation of the Quality of the Science: The Health Effects Institute Diesel Epidemiology Expert Panel (1996 -1999)

While data from epidemiology studies have been useful in the hazard identification component associated with exposure to diesel exhaust, the usefulness of applying these data to develop reliable estimates of the magnitude of risk for lung cancer through quantitative HRAs has been questioned. In 1994, both the federal Environmental Protection Agency (US EPA) and the California Environmental Protection Agency, through their Office of Environmental Health Hazard Assessment (OEHHA), released draft cancer risk assessments for diesel exhaust through the inhalation pathway. Both agencies depended on the same set of scientific literature, but came to different conclusions. Although they considered the retrospective cohort study of US railroad workers (Garshick et al., 1988) and associated industrial hygiene survey (Hammond et al., 1988; Woskie et al., 1988a, 1988b) to derive an exposure-response function (Crump et al. 1991), the US EPA concluded that the data were too limited to support a quantitative HRA, and thus based their assessment on chronic animal studies. In contrast, OEHHA (Office of Environmental Health Hazard Assessment (OEHHA), 1998) chose to use the US railroad workers data, in spite of their limitations, as a basis of their quantitative HRA, as they viewed these data as more appropriate than using animal data.

In response to differences in addressing the exposure-response relationship, the Health Effects Institute (HEI) assembled a special panel, termed the Diesel Epidemiology Expert Panel, in the late 1990's. This Panel was charged with (1) reviewing the epidemiologic data that form the basis of the then-current quantitative HRAs for diesel exhaust, (2) identifying data gaps and sources of uncertainty, (3) making recommendations about the usefulness of extending or conducting further analyses of existing data sets, and (4) making recommendations for the design of new studies that would provide a stronger basis for risk assessment. In addition to the chair, the Panel was comprised of six senior scientists with expertise in epidemiology, biostatistics, exposure characterization, and exposure assessment. They focused on available epidemiology in railroad workers and teamsters, including the following studies and follow-up publications and research:

Railroad Worker Studies

- Case-control: Garshick et al. 1987
- Cohort: Garshick et al. (1988)
- Industrial hygiene: Hammond et al. (1988), and Woskie et al. (1988a, 1988b)
    - Exposure-response analyses: Crump et al. (1991); Crump (1999); Office of Environmental Health Hazard Assessment [OEHHA] (1998)

Teamster (Trucker) Studies

- Case-control: Steenland et al. (1992); Steenland et al. (1990)
- Industrial hygiene: Zaebst et al. (1991)
- Exposure-response analysis: Steenland et al. (1998)

The review performed by this Panel identified evidence for weak increases in lung cancer risk in exposed workers relative to unexposed workers. The Panel then examined whether the available epidemiology studies were of sufficient quality in terms of their design and performance to be useful for input for quantitative HRA, or if the limitations of the individual studies being considered rendered the study insufficient for this application. Their analysis also examined whether each study had a sufficient quality of retrospective data for estimating job-related work exposures. Such data are often difficult to acquire and investigators often need to make assumptions that cannot be validated in their attempts to reconstruct past exposures to diesel engine emissions. The Panel noted that many studies suffered from inadequate exposure assessment, incomplete adjustment for smoking, unmeasured confounding variables (*e.g.*, other job category differences), and latency periods being too short. While reasonable for the individual study, limitations that authors recognize and acknowledge are often ignored when risk assessors or other researchers apply the results of the studies in ways that go beyond the intent of the original investigators.

3.1.1 Garshick et al. (1987): US Railroad Worker Studies

The Garshick et al. (1987) case-control study, along with the Garshick et al. (1988) cohort study of US railroad workers have often been considered as a basis of estimating the risk of lung cancer in the general population. Garshick et al. (1987) examined Railroad Retirement Board registrants who died between March 1, 1981, and February 28, 1982. Among 650,000 active and retired male railroad workers born in or after 1900 who had at least 10 years of railroad employment, 15,059 deaths were reported to the Railroad Retirement Board. This study was actually designed primarily to investigate the relationship between smoking (*i.e.*, not occupations or environmental exposures) and lung cancer. This study evaluated exposure to diesel exhaust using job histories beginning in 1959 as well as the last job worked before retirement for workers who retired prior to 1959. Jobs were divided into "exposed" or "unexposed" categories, and cumulative diesel-years of exposure were estimated for each worker. For 39 job categories, an industrial hygienist (Woskie et al., 1988a, 1988b) helped define exposures. But workers whose jobs fell outside this group of 39 categories were assigned as either "exposed" or "unexposed" based on comparing their activities to the primary 39 job categories. The extent of contact with operating diesel equipment was also taken into consideration. The analysis in the Garshick et al. (1987) study found that, after adjusting for asbestos and smoking, the relative odds for continuous exposure to diesel exhaust were 1.39 (95% CI = 1.05, 1.83). Furthermore, among the younger workers with longer diesel exhaust exposure, the risk of lung cancer increased with duration of exposure after adjusting for asbestos and smoking.

Although this study was well-designed and conducted, it has several important limitations. The most important limitation was that occupations were not coded into exposures for different chemical and physical agents. This prevented calculating relative risks for diesel exposure. Instead, Interstate Commerce Commission (ICC) job classification were used as a surrogate for exposure, which may have led to misclassification of diesel exhaust exposure jobs with low intensity and intermittent exposure, such as railroad police and bus drivers, as unexposed. Use of a simple “exposed” and “unexposed” scheme for exposure also may have resulted in exposure misclassification. Another exposure limitation was that the year when workers were first exposed to diesel was unknown, as dieselization was being gradually introduced in the early 1950s. Finally, the relative risks decreases with duration of employment, so exposure-response functions cannot be derived. This weakens the study’s potential to provide a reliable quantitative estimate of risk from exposure to diesel exhaust.

3.1.2 Garshick et al. (1988): US Railroad Worker Study

The Garshick et al. (1988) cohort study of US railroad workers was one of only a few studies at the time that included industrial hygiene measurements of diesel exhaust. These measurements were correlated with job titles, and number of years of employment was used as a surrogate for exposure dose. The study found an elevated risk ratio (RR: 1.57 and 1.34); however, the youngest workers were found to have the highest risk of lung cancer, which is counter-intuitive. And this is not the only study showing a negative dose-response relationship. Re-analysis of the same data by OEHHA yielded a positive dose response relationship and reported a steadily increasing risk of lung cancer for exposed workers with increasing years of employment when examined by overall job category (*e.g.*, train workers compared to clerks). However, a subsequent analysis in the railroad workers (as presented by Dr. Garshick in a letter to US EPA in 1991[1]) did not confirm this result. Furthermore, additional analysis of the data using several metrics of cumulative diesel exhaust exposure indicated that the greater the exposure to diesel exhaust, the lower the risk of lung cancer (Crump et al. 1991; 1999).

When OEHHA altered the assumptions of the Crump exposure assessment, they found a positive association between exposure and risk for cumulative exposure. The OEHHA assumptions for diesel exposure were higher than the Crump (1991) or Garshick et al. (1988) assumptions, resulting in peak exposures that were twice as high as assumed in the exposure patterns by Garshick et al. (1988) and Crump et al. (1991). Crump (1999) has explained the OEHHA results as resting on the difference between train workers and clerks/signalmen; the HEI Panel agreed with this assessment. The HEI Panel concluded “These findings are not consistent with a steadily increasing association between cumulative diesel exposure and lung cancer risk.” They concluded “At present, the railroad worker cohort study (Garshick et al. 1988), though part of a larger body of hazard identification studies, has very limited utility for QRA of lifetime lung cancer risk from exposure to ambient levels of diesel exhaust…” and listed (1) limitations in the then-available exposure data; and (2) the dependence on comparing entire job classifications against each other (train workers with higher exposures as compared to clerks with lower exposures) as serious limitations to interpreting the data. The HEI Panel noted several possible explanations for the associations claimed by authors, including exposure misclassification, incomplete ascertainment of lung cancer deaths by job category, lack of information on other occupational exposures and air pollutants, a healthy worker effect, confounding by cigarette smoking, and analysis of relative risks rather than absolute risks.

[1] Cited in US EPA 2002 as “letter from Garshick, Harvard Medical School, to Chao Chen, U.S. EPA, dated August 15, 1991.”

3.1.3 Steenland et al. (1998): Truckers Study

Steenland et al. (1990) reported an increased risk of lung cancer mortality from a case-control study of truckers belonging to the Central States Teamsters Union, with increased risk associated with increasing years of employment. The investigator group then performed an exposure-response analysis for the study (Steenland et al., 1998). However, the HEI Panel had concerns about several of the assumptions used in the exposure-response analysis including the following: (1) 1990 emissions data were used to estimate past exposures to diesel exhaust, even though more recent data indicate there may have been higher emissions during that period (which might underestimate average exposures); (2) date assumed for dieselization in the trucking industry, which, if too early, may overestimate exposures; (3) assumptions using vehicle miles travelled as a surrogate for exposure to diesel exhaust for various job groups (may over- or underestimate exposures); (4) accounting for fleet turnover in the trucking industry; and (5) difficulties in distinguishing diesel exposure from trucks from background diesel exposures.

This study uses elemental carbon as a measure of diesel exhaust; however, there are also non-diesel sources of elemental carbon in ambient air, particularly in highway settings where gasoline vehicles can contribute. Although gasoline vehicles emit less elemental carbon per vehicle, there are many more gasoline-powered vehicles on the road than diesel, so the gasoline vehicles may have contributed to elemental carbon concentrations. Although the range of exposures in the Teamsters study is closer to the exposures anticipated for the general population than that of the railroad workers, the HEI Panel (and the authors themselves) were cautious about immediate application of the exposure-response function before further validation could be achieved because exposure estimates were based on broad assumptions rather than measurements of exposure.

Overall, the HEI Panel concluded that the studies they reviewed had a number of limitations that precluded their use in quantitative HRAs. These limitations included (1) questions about the quality and specificity of the exposure assessments for diesel exhaust, (2) a lack of quantitative estimates of exposure to allow derivation of an exposure–response function, and (3) lack of adequate data to account quantitatively for individual worker exposures to other factors that might also be associated with lung cancer, such as smoking.

3.2 The US Environmental Protection Agency Response (2002)

Following the HEI Panel's assessment, the US EPA concluded that diesel exhaust is likely to be carcinogenic to humans at environmental levels of exposure, but found that the data from health studies available at the time were not suitable for estimating cancer potency (U.S. Environmental Protection Agency [EPA], 2002). Among the occupational studies, the US EPA considered the US railroad worker studies (Garshick et al., 1987, 1988) and the Teamsters Union truck driver studies (Steenland et al., 1990, 1998) to have the best available exposure data for their possible use in establishing exposure-response relationships in support of a cancer unit risk. Given the equivocal evidence for the presence or absence of an exposure-response relationship for the study of railroad workers, and exposure uncertainties for the study of truck drivers, the US EPA concluded that even though the scientific evidence supported an association between exposure to diesel exhaust and lung cancer, available data were too uncertain to be used as the basis of a confident quantitative dose-response analysis and subsequent derivation of cancer unit risk for diesel exhaust.

Instead, the US EPA chose to take a set of exploratory approaches to estimate the possible magnitude of cancer risk. The first exploratory approach involved examining the differences between the exposure concentrations in occupational-exposed cohorts along with their cumulative life-time exposures, as compared to ambient environmental exposures that communities might experience, and infer risks based on how large a difference there was between the occupational and community exposure estimates. The second approach explored possible cancer risks from exposure to diesel exhaust in the general population in a more quantitative manner. This approach examined the risk observed in diesel exhaust-exposed workers, and then made assumptions as to how these risks could be extrapolated to environmental exposure conditions. This exploratory analysis concluded that environmental cancer risks from exposure to diesel exhaust were possibly in the range of 10^{-5} to almost 10^{-3}, while acknowledging numerous uncertainties and assumptions in reaching this conclusion.

3.3 The California OEHHA Response

In contrast to the US EPA, OEHHA (1998) opted to retain their unit risk estimates for lung cancer on the then-available epidemiology studies, using the concentration-response information from two studies in US railroad workers (Garshick et al. 1987; Garshick et al. 1988). They considered a variety of exposure patterns based on average exposure concentration for the workers (as measured by Woskie et al. 1988) and the extent of change in exposures during the periods of 1959 - 1980. Using this approach, OEHHA derived a series of lifetime risk estimates ranging from 1.3×10^{-4} per μg/m^3 to 2.4×10^{-3} per μg/m^3, with a geometric mean risk of 6×10^{-4} per μg/m^3. For risk assessment purposes, OEHHA selected[2] 3×10^{-4} per μg/m^3. OEHHA did not change this approach or update their findings following the HEI 1999 publication, or after the US EPA 2002 health assessment.

3.4 Evaluation of the Quality of the Science: The Health Effects Institute Diesel Epidemiology Expert Panel (2013-2015)

More recently, HEI assembled another expert panel to review new epidemiology studies of diesel exhaust and lung cancer, including key studies in the 2012 IARC evaluation of diesel exhaust (Health Effects Institute [HEI], 2015). This Panel focused on two studies, the Trucking Industry Particle Study (the Truckers study; Eric Garshick et al., 2012), and the Diesel Exhaust in Miners Study (DEMS) (Attfield et al., 2012; Silverman et al., 2012). As with the previous HEI Panel, this Panel's overall charge was to evaluate the data and results in these two large studies for their utility in quantitative characterization of the exposure–response relationship between diesel e xhaust and lung cancer. In this evaluation, the Panel found that both the Truckers and DEMS were well-designed, well-conducted studies that made considerable progress toward addressing a number of the serious limitations identified in previous studies of diesel exhaust and lung cancer. The studies included better metrics to specifically quantify diesel exposure, and used better models of historical exposures. Because of these stronger methods, the 2013-2015 HEI Panel concluded that the studies would be useful for quantitative estimates of historical exposures to diesel exhaust, and thus be appropriate for quantitative HRA.

The 2013-2015 HEI Panel also opined on whether findings of these occupational exposures were generalizable to estimate lung cancer risk in the general populations exposed to diesel exhaust at lower concentrations (*e.g.*, found in urban areas). They noted that there were broad and overlapping ranges of exposures to submicron and respirable elemental carbon in

[2] http://www.arb.ca.gov/toxics/dieseltac/de-fnds.htm

these studies, and that the lower end of these exposures was similar to the higher end of exposures in ambient air.

The decision about whether a given study or set of studies provide data of sufficient accuracy, precision, and relevance to be useful for quantitative HRAs is often a policy decision. However, the policy should rest upon basic principles of sound study design and analysis, while recognizing the strengths and weaknesses of each study. When applied to quantitative HRAs, the scientific evidence needs to be weighed against uncertainties and other factors to provide a useful tool. To date, because of the significant uncertainties in the diesel exhaust epidemiology literature, few regulatory agencies and authoritative bodies have made quantitative predictions of increased lung cancer risk as a function of diesel exposure.

3.5 Meta-Analyses of Diesel Epidemiology Studies and Associated Risk Estimates

One method of addressing this issue is to examine the more recent Truckers Study and DEMS – studies which have been deemed by the 2013-2015 HEI Panel to have sufficient quality to develop more robust unit risk values. The 2013-2015 HEI Panel stopped short of doing this, but noted that these studies were appropriate for use in a quantitative HRA. US EPA will likely be following this recommendation and developing such risk numbers in the future, but the timing is uncertain and until then there is a need for an alternative that is better justified by the science. In the meanwhile, it is possible to take a meta-analysis approach to develop risk numbers. Vermeulen et al. (2014) performed a meta-analysis of the risk of lung cancer from exposure to diesel exhaust using data from three case–control studies—two of workers in the trucking industry (Garshick et al., 2012; Steenland et al., 1998) and one from DEMS (Silverman et al., 2012). From these three studies, Vermeulen et al. (2014) generated an exposure–response curve based on a log-linear regression model using relative risk estimates. Individual relative risk estimates were plotted (with their 95% confidence interval bounds) along with a 95% confidence interval for the exposure-response curve based on the log-linear model. Figure 1 (from Vermeulen et al., 2014) plots the relative risks at different levels of cumulative exposure from each of the three studies, estimated at 5- or 15-year exposure lags (depending on the study).

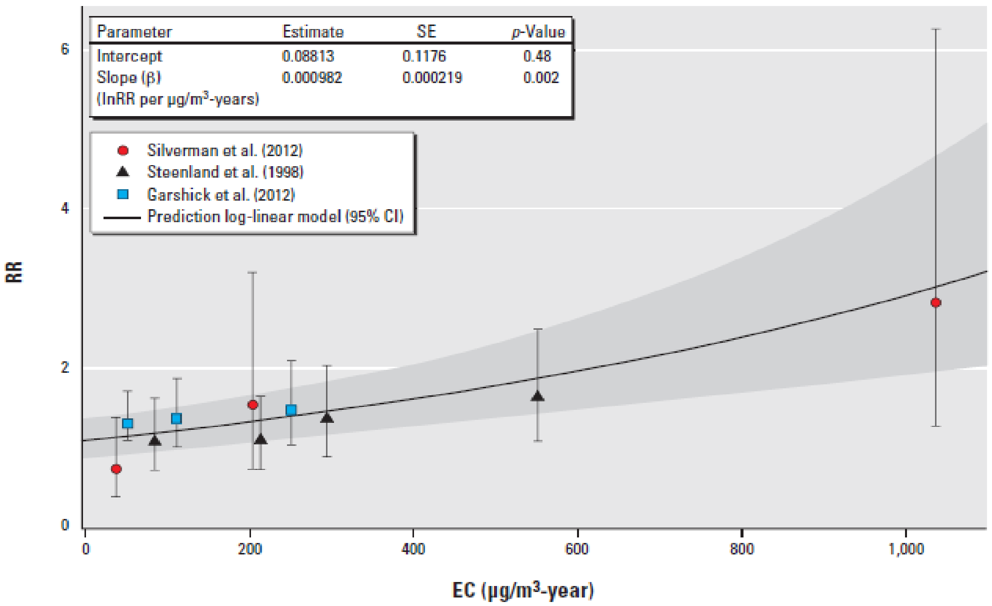

Figure 1. Predicted exposure–response curve based on a log-linear regression model using RR estimates from three cohort studies of DEE and lung cancer mortality. Individual RR estimates [based on HRs reported by Garshick et al. (2012) or ORs reported by Silverman et al. (2012) and Steenland et al. (1998)] are plotted with their 95% CI bounds indicated by the whiskers. The shaded area indicates the 95% CI estimated based on the log-linear model. The insert presents the estimates of the intercept and beta slope factor, the SE of these estimates, and the associated *p*-values.

Crump (2014) criticized the Vermeulen et al. (2014) meta-analysis for inappropriately mixing data from exposures with lags of 5 years and 15 years. Crump re-ran the analysis using several different assumption conditions, and, depending on the assumptions, got different results. Morfeld and Spallek (2015) performed a re-analysis of the same data using different modelling approaches. They reported that the data used by Vermeulen et al. (2014) led to the highest relative risk estimate across all sensitivity analyses performed, and cautioned against using the meta-analysis of Vermeulen et al. (2014) in risk assessments, especially at lower exposures.

4. THE DILEMMA AND A PATH FORWARD

At the time that OEEHA (1998) developed their inhalation lifetime unit risk value for diesel exhaust, several other authoritative groups had examined the same epidemiology evidence and judged it inadequate for derivation of a discrete, quantitative estimate of human risk (HEI 1999; US EPA 2002; Hesterberg et al., 2011; International Program for Chemical Safety (IPCS), 1996; see Table 1). OEEHA took the position that, in spite of the uncertainties, they would develop a unit risk value from this literature. Other organizations judged that the uncertainties were too great to take this step, and offered alternative numbers or ranges of numbers for this type of assessment. It is possible that the more recent literature evaluated by the HEI 2015 Panel will be of sufficient quality to develop more robust unit risk values, but no cancer risk estimates have been developed to date and some find that the available results are not sufficiently consistency and of sufficient quality to be used in a risk assessment (*e.g.*, Moolgavkar et al., 2015). Therefore, we face the dilemma of needing a risk-based number to evaluate health risks potentially resulting from proposed or existing projects despite a lack of faith in the numbers generated from the current body of literature.

The various meta-analyses of the same set of 3 studies show the uncertainty inherent in developing cancer risk estimates. It is important to keep this uncertainty in mind as risk numbers are developed. Table 1 presents the range of numbers from these meta-analyses, which vary considerably even though they are based on the same underlying studies. Table 1 also presents other cancer risk factors proposed by other Agencies and groups.

Table 1. Evaluation of studies for developing cancer risk estimates

Reference	Unit risks (per µg/m³)	Approach
Vermeulen et al. (2014)	1.7×10^{-3}	Meta-analysis of 3 studies: Silverman et al. (2012) Steenland et al. (1998) Garshick et al. (2012)
Crump (2014) letter to the editor	6.7×10^{-4} (n.s.)[(a)]	Reanalysis of the same 3 studies with consistent lag period
Vermeulen et al. (2014) response to letter to the editor	1.1×10^{-3}	Reanalysis of the same 3 studies with consistent lag period, using different methods
Morfeld and Spallek (2015)	Discussion of variables for deriving exposure-response relationship and proposal of a threshold for cancer risk	Reanalysis of the same 3 studies using different modelling approaches; other studies considered as well
US EPA (2002)	10^{-3}- 10^{-5}	Qualitative approaches to evaluate risk
OEHHA (1998)	3×10^{-4} [(b)]	Based on Garshick et al. (1998) study
WHO (1996)	3.4×10^{-5} [(c)]	Based on rat data, using modeling to extrapolate to human lungs
EPA (1994) *DRAFT*	1.6×10^{-5} - 7.5×10^{-5} [(d)]	Based on rat data and epidemiology data

(a) n.s.: not statistically significant

(b) Range of 1.3×10^{-4} – 2.4×10^{-3} with a geometric mean of 6×10^{-4}

(c) Range from 1.6×10^{-5} - 7.1×10^{-5} with a geometric mean of 3.4×10^{-5}

(d) Geometric mean of upper bound estimates 3.4×10^{-5}

Another important issue in extrapolating results from these older epidemiology studies (Garshick et al. 1987; Garshick et al. 1988) is that diesel exhaust in these epidemiology studies are based on diesel exhaust composition that is very different compared to more contemporary diesel exhaust. Due to the long latency period for lung cancer, epidemiology studies need to examine workers whose exposures started more than 20 years earlier. These particular studies are based on exposures from the 1950's and 1960's. However, starting in 1988 (trucks) and continuing in 1991 (trucks), 1994 (trucks), 1996 (buses), and 2007 (trucks), the US EPA has progressively tightened standards for particulate emissions from on-road heavy-duty diesel engines, resulting in the development of new technology diesel engines that emit lower amounts of particulate matter and other emitted pollutants (*e.g.*, gases), and diesel exhaust with an inherently different composition. That is, these changes have not only resulted in the quantitative reduction in mass emitted by new technology diesel engines as compared to engines pre-regulation, but have also resulted in qualitative differences in the composition of what is emitted, both with respect to size and with respect to chemicals associated with the exhaust (Hesterberg et al., 2011). Thus, depending on the components of diesel exhaust that may be causally linked to the increased risk of lung cancer, simple dependence on particle mass (*i.e.*, expressing cancer risk as "per µg/m^3") may not be an accurate metric of exposure, as the composition of the particles has changed dramatically.

To reflect these broad uncertainties and issues, we propose using a range of unit risk values to evaluate potential cancer risks: 10^{-3}- 10^{-5}. This range, which encompasses the various unit risk values presented in Table 1, better reflects the uncertainty of defining the exposure-response curve for assessing potential cancer risk from diesel exhaust, yet allows comparisons across different exposure scenarios.

5. SUMMARY

The OEEHA (1998) inhalation lifetime unit risk value for diesel exhaust is based on the study of Garshick et al. (1988), a study that has been judged by several authoritative bodies to be inadequate for use in developing a quantitative estimate of human risk for cancer (HEI 1999; US EPA 2002; WHO, 1996). Nevertheless, the absence of an alternative number has left agencies and others with a dilemma: either ignore the potential of diesel exhaust to result in elevated risk of lung cancer, or use a number derived from a study that cannot support such an application. More recently, a set of epidemiology studies in diesel miners (DEMS) and in truckers (Garshick et al., 2012) were published that were judged adequate for application in quantitative risk assessment. Although there have been some attempts to use these studies to develop quantitative estimates of cancer risk (Vermeulen et al. 2014; Crump 2014; Morfeld and Spallek, 2015), the numbers they generate can vary considerably. Given the uncertainties, we propose a range of numbers to be used to assess cancer risks, which range from 10^{-3} to 10^{-5} per µg/m^3, and propose to use these numbers to compare relative risks for different projects and exposure scenarios.

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ATTACHMENT D: ADDITIONAL MODELING FIGURES

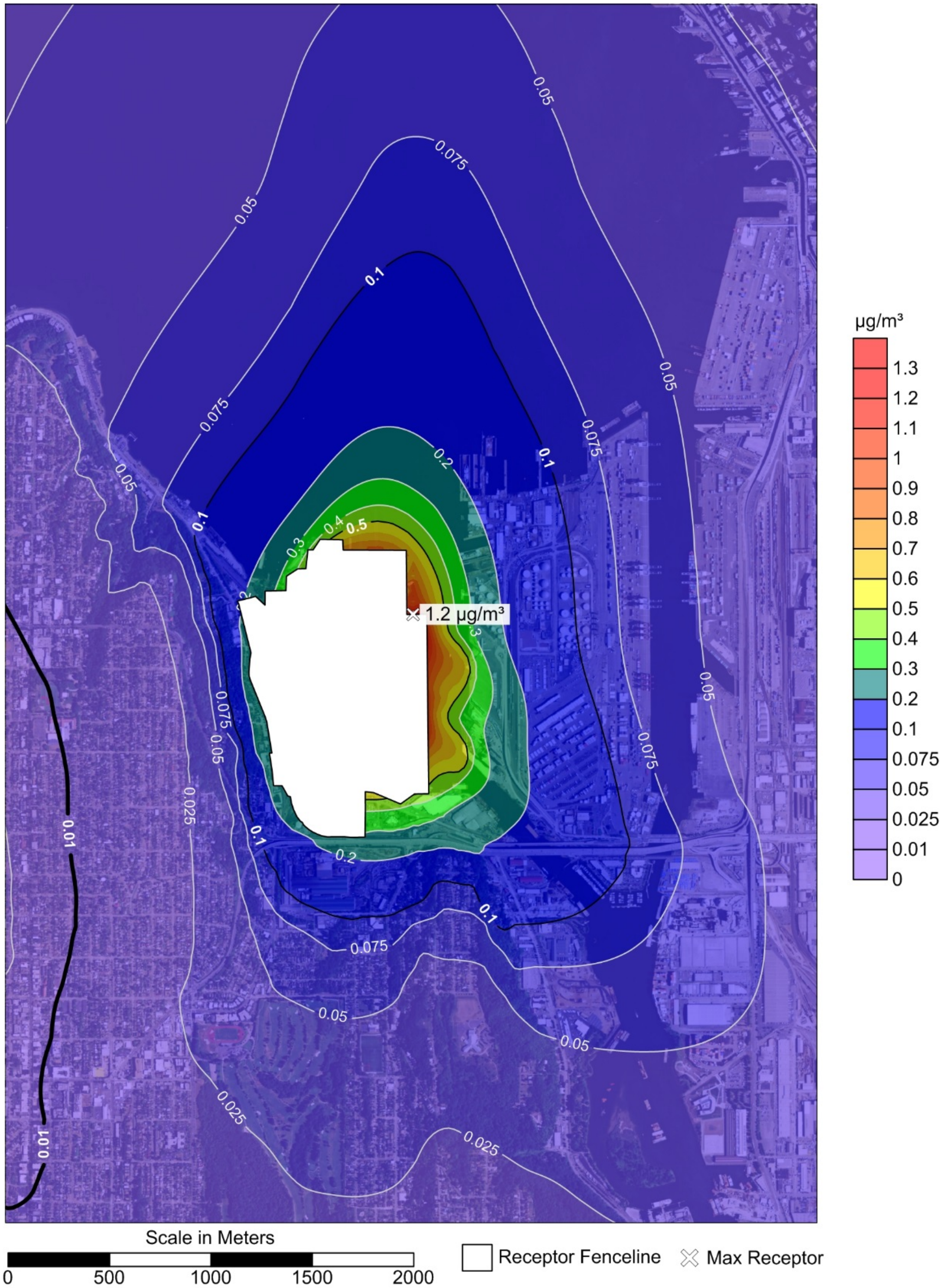


Figure 7. Alt 1, 2020 DPM Annual Model Results Attributable to Terminal 5 Activities

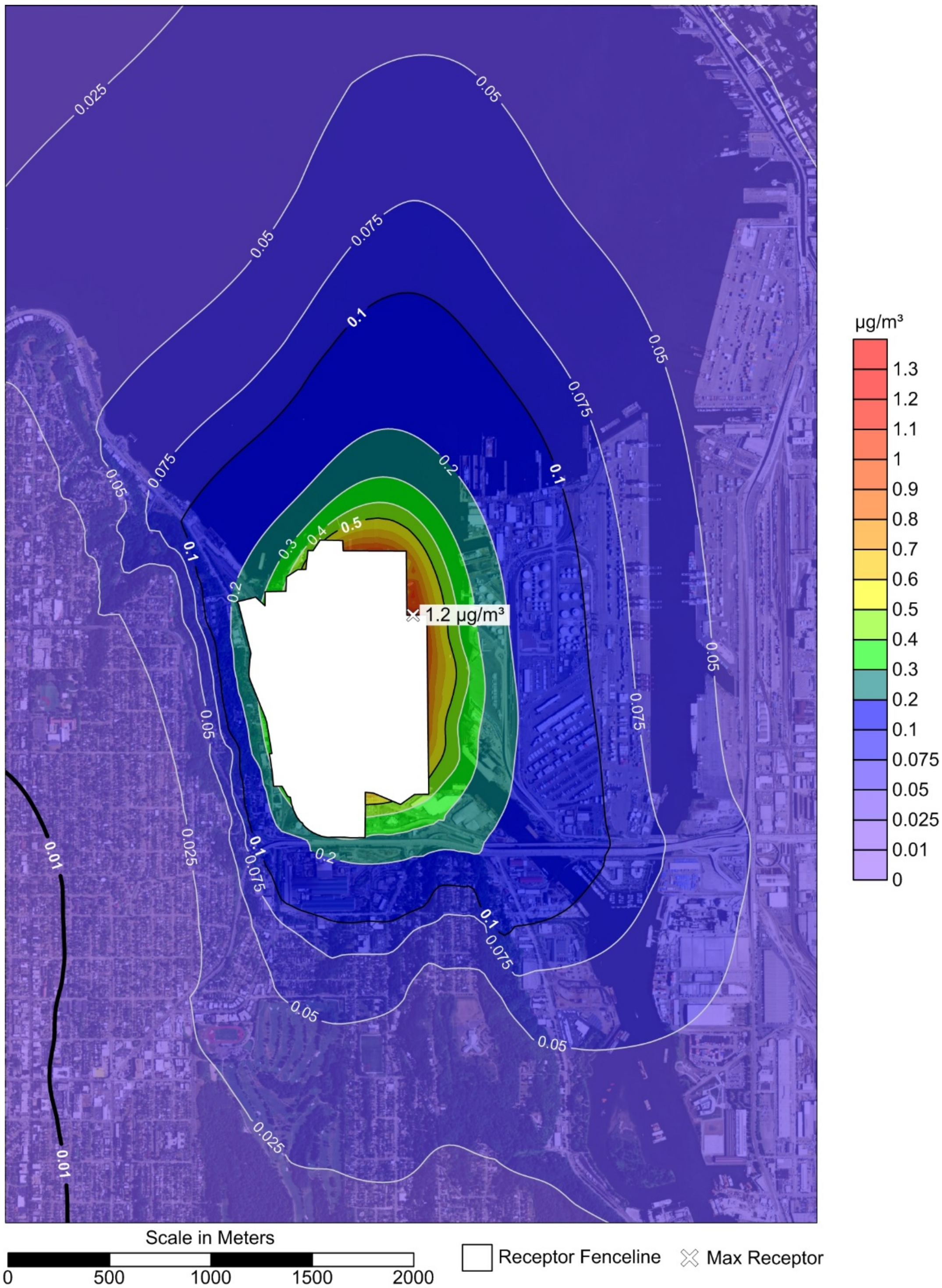


Figure 8. Alt 2, 2020 DPM Annual Model Results Attributable to Terminal 5 Activities

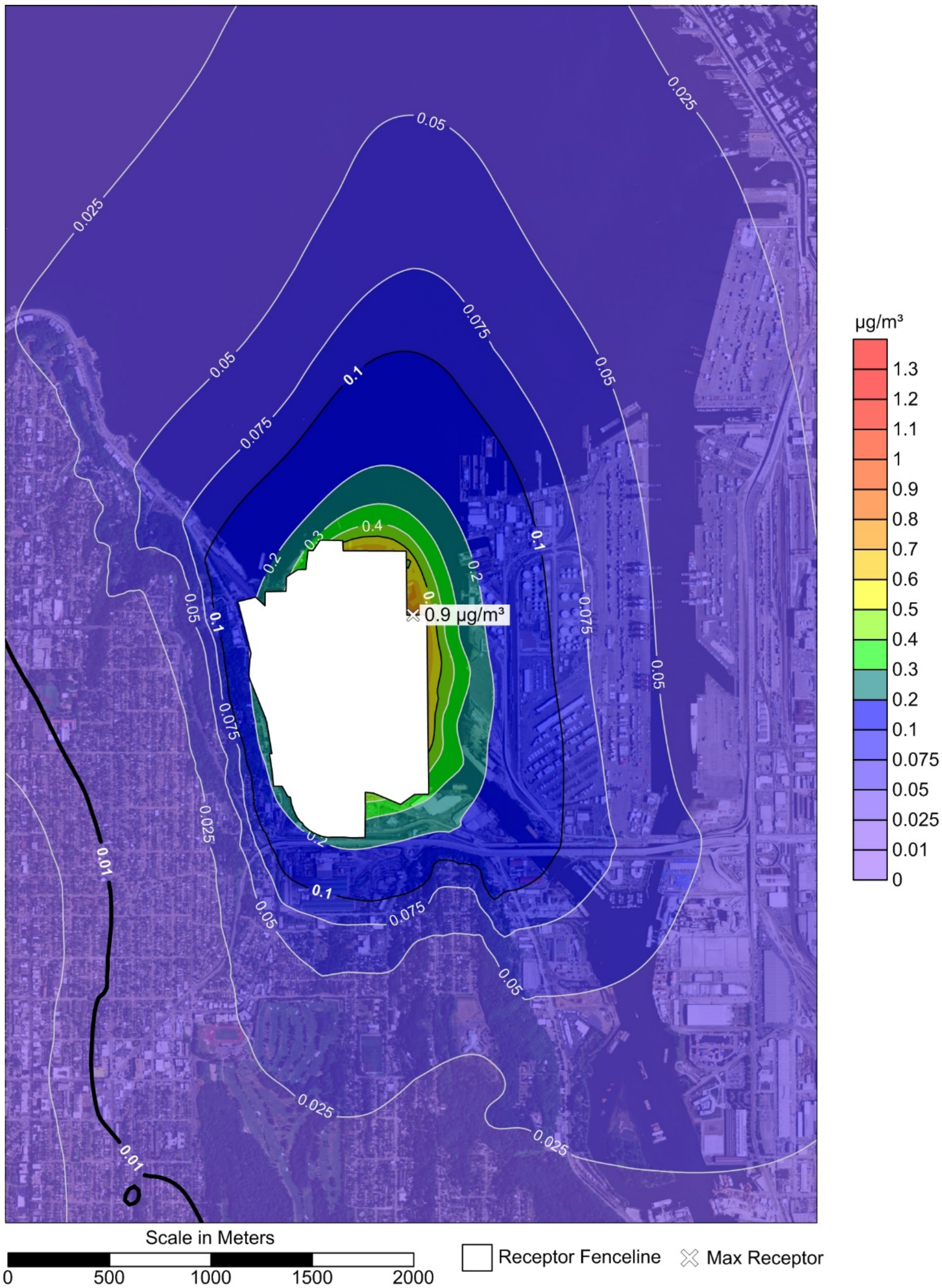


Figure 9. Alt 2, 2030 DPM Annual Model Results Attributable to Terminal 5 Activities

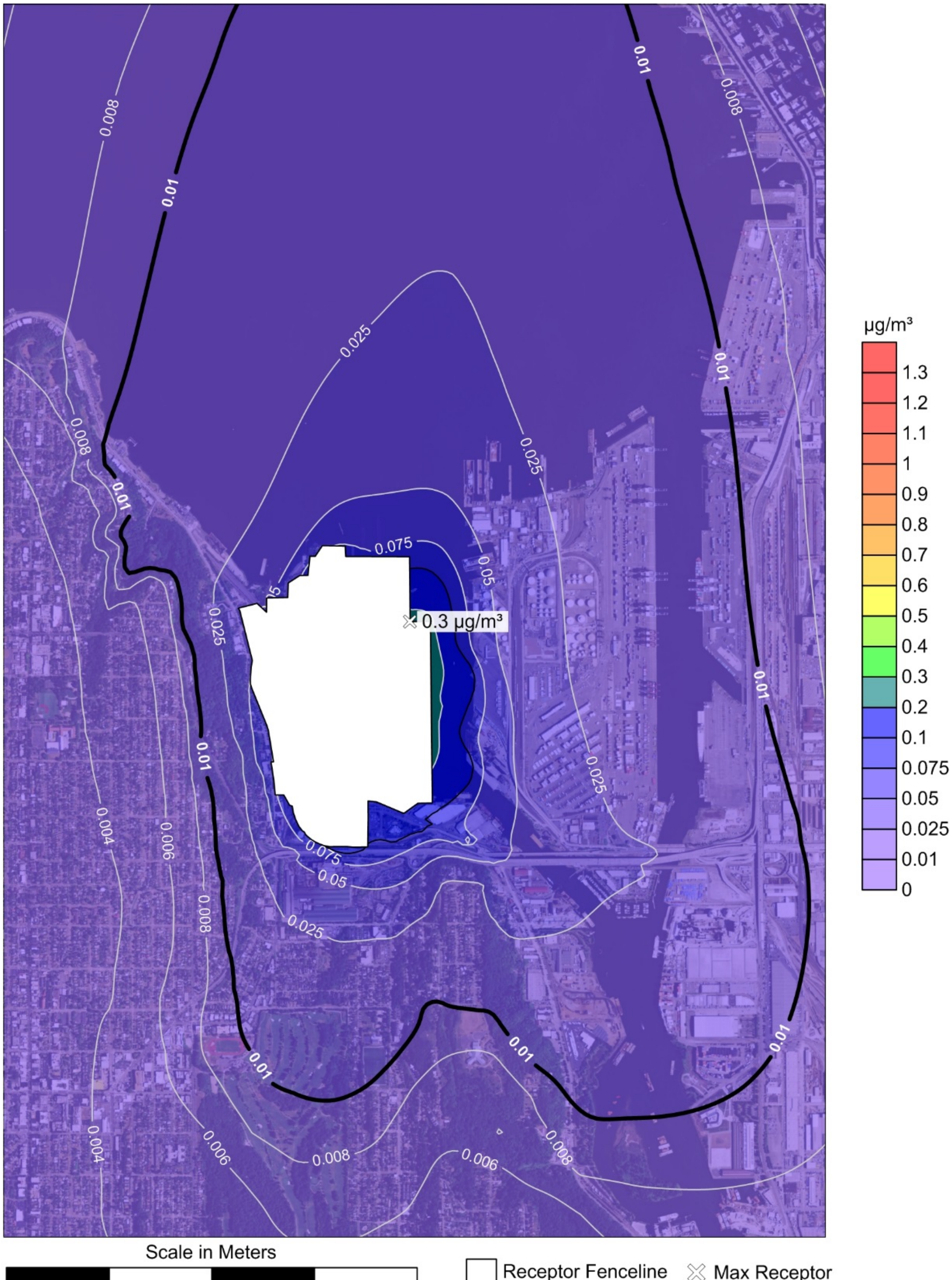


Figure 10. Alt 3, 2020 DPM Annual Model Results Attributable to Terminal 5 Activities

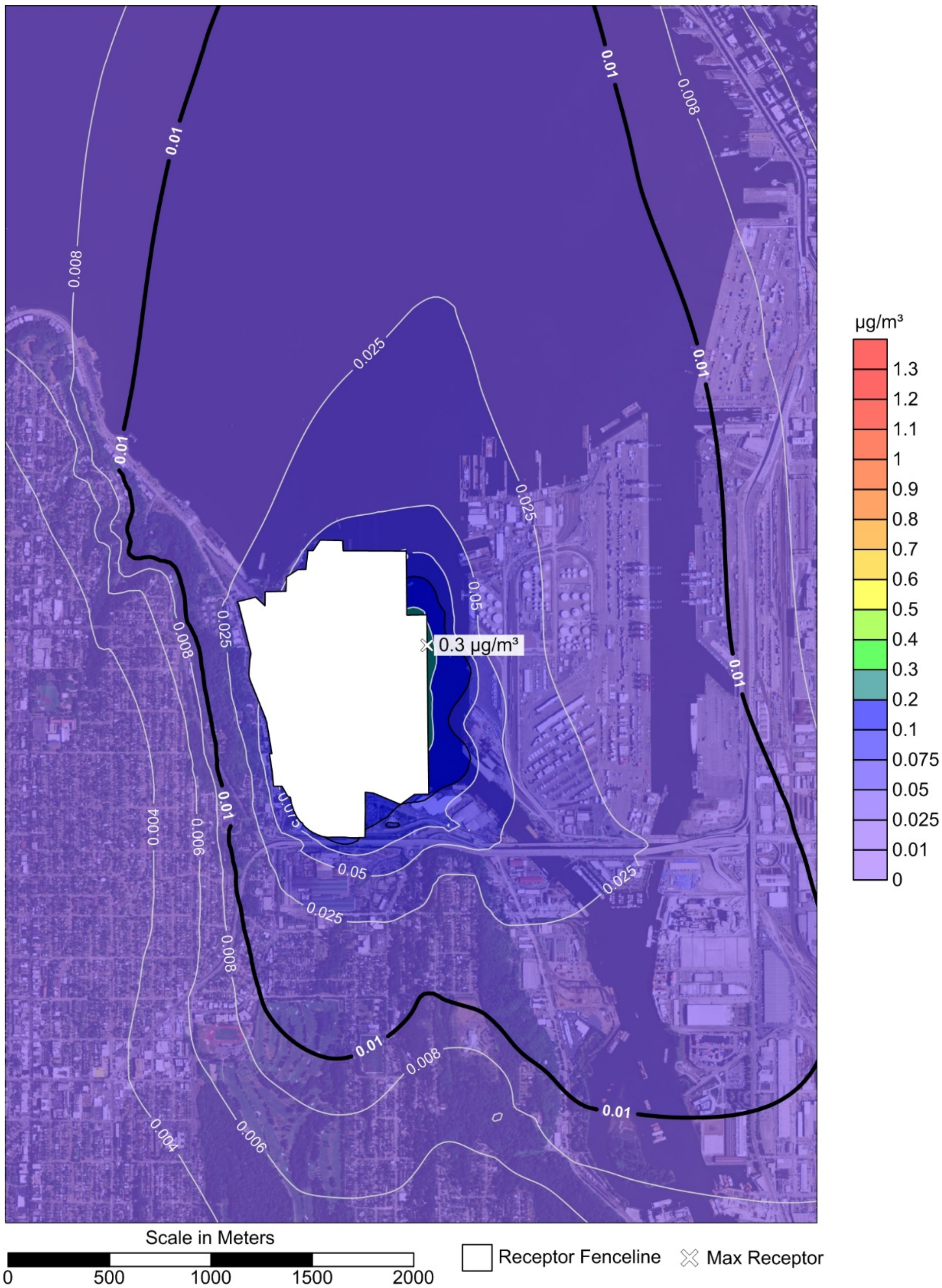


Figure 11. Alt 3, 2030 DPM Annual Model Results Attributable to Terminal 5 Activities

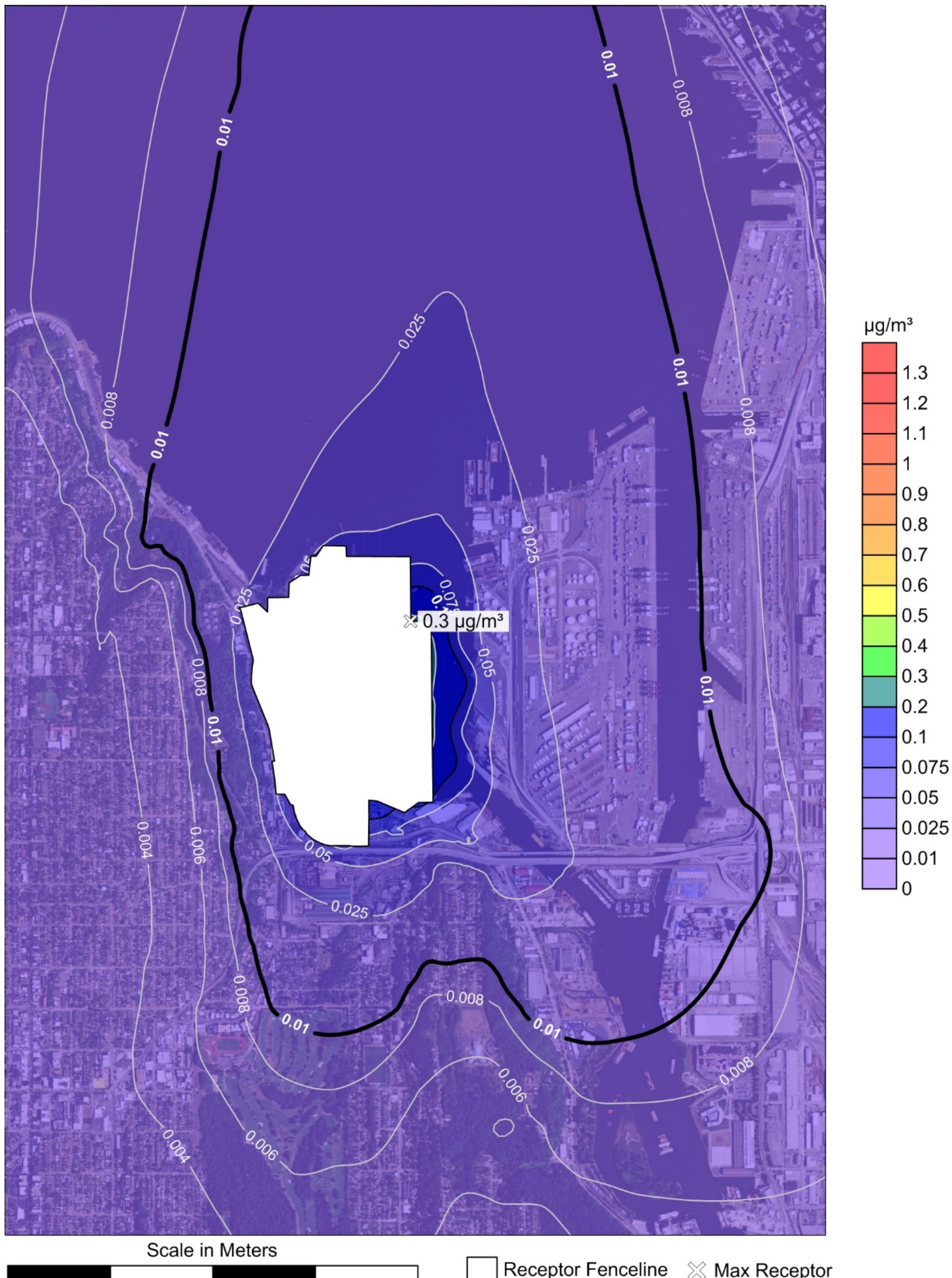


Figure 12. Alt 3, 2040 DPM Annual Model Results Attributable to Terminal 5 Activities

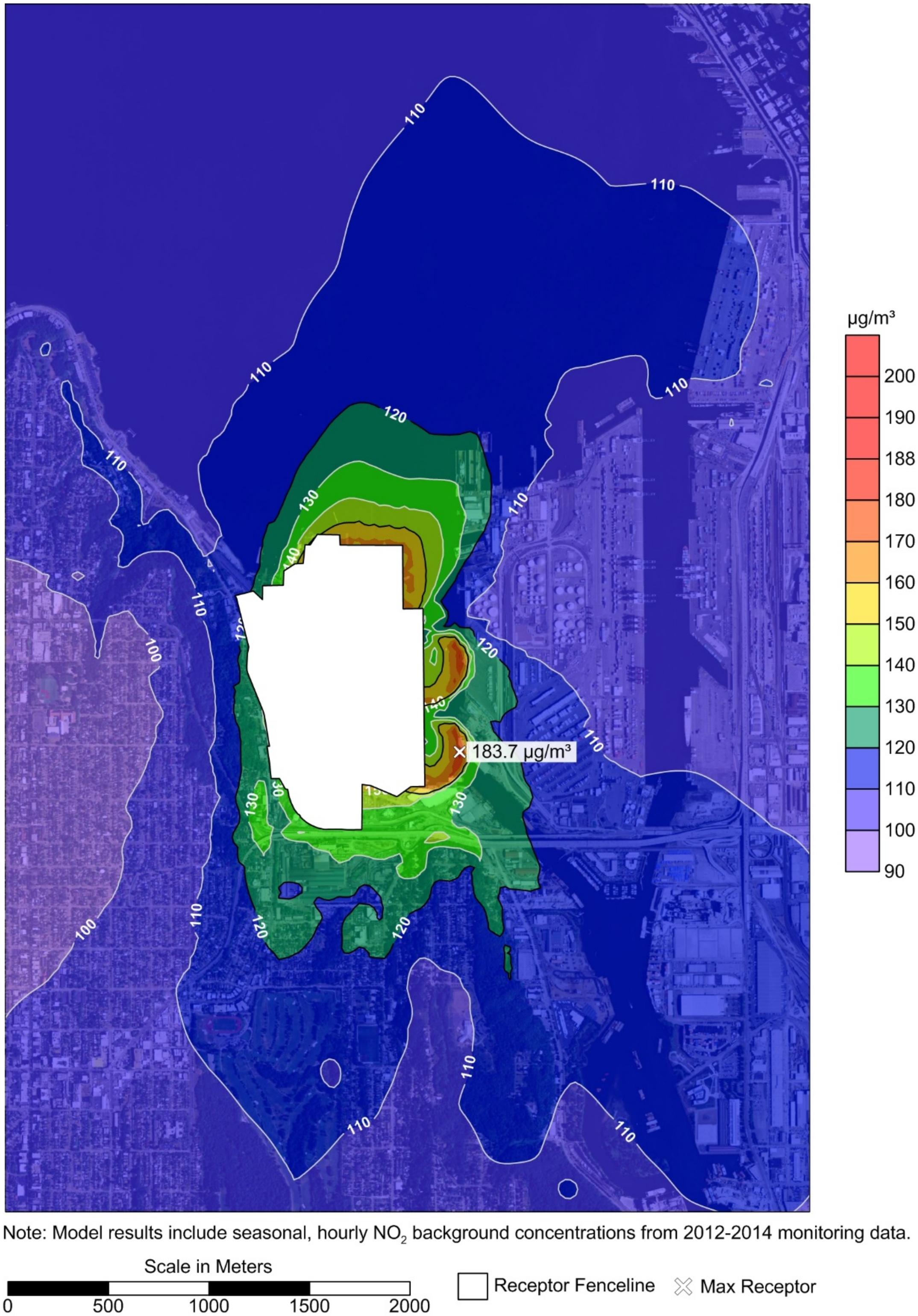


Figure 13. Alt 1, 2020 NO_2 1-hour Model Results

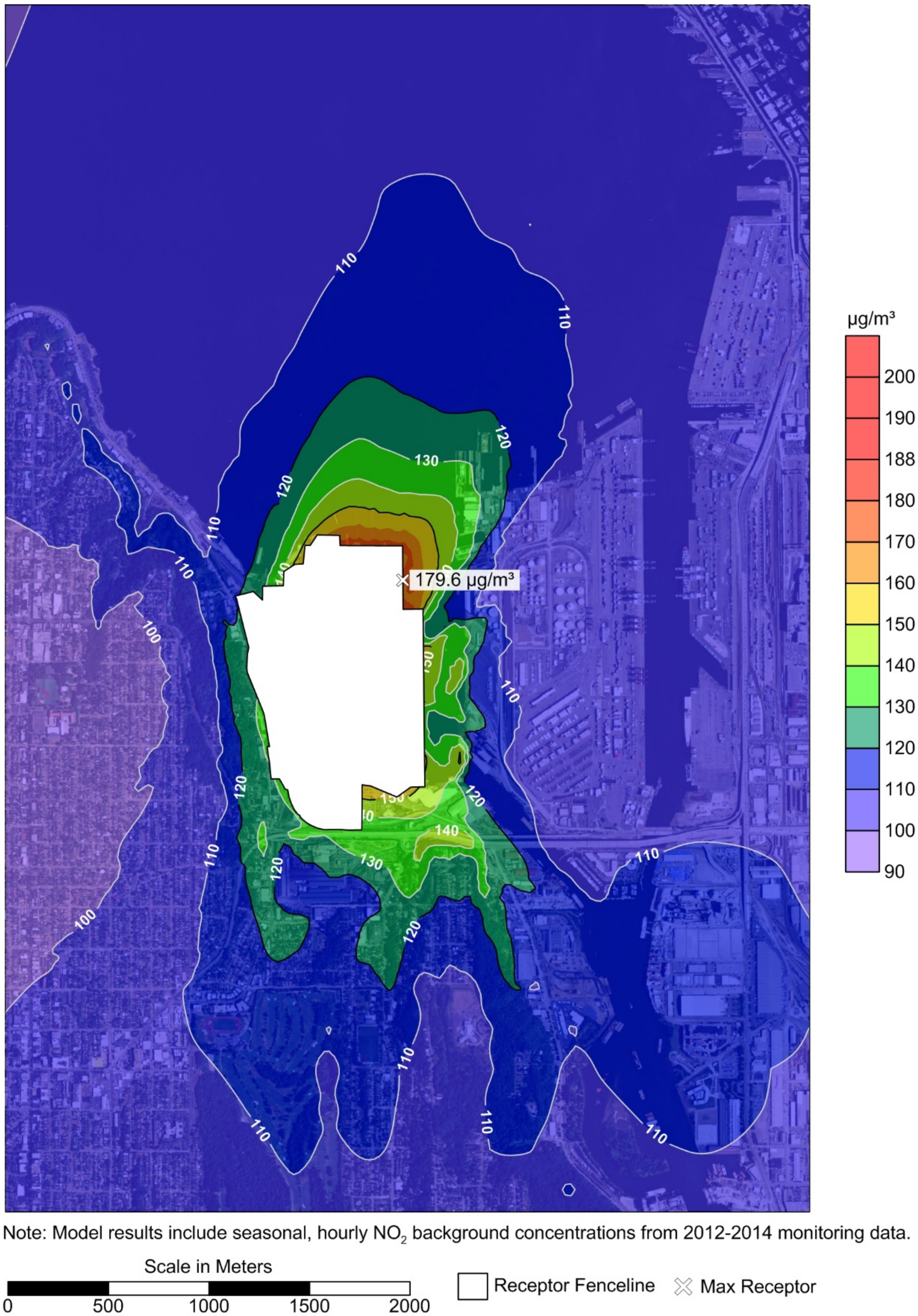
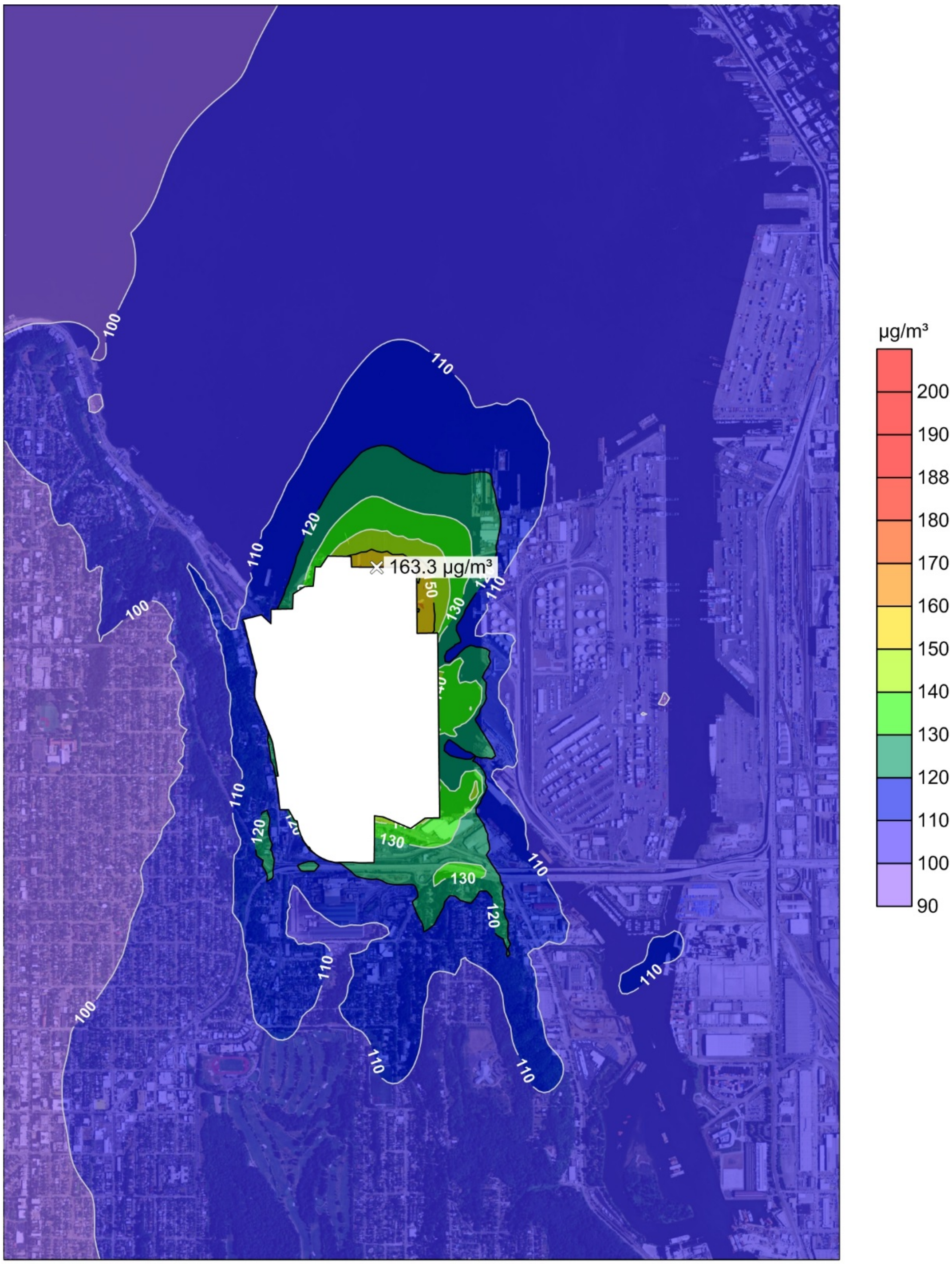


Figure 14. Alt 2, 2020 NO_2 1-hour Model Results



Note: Model results include seasonal, hourly NO_2 background concentrations from 2012-2014 monitoring data.

Scale in Meters
0 500 1000 1500 2000

Receptor Fenceline   Max Receptor

Figure 15. Alt 2, 2030 NO_2 1-hour Model Results

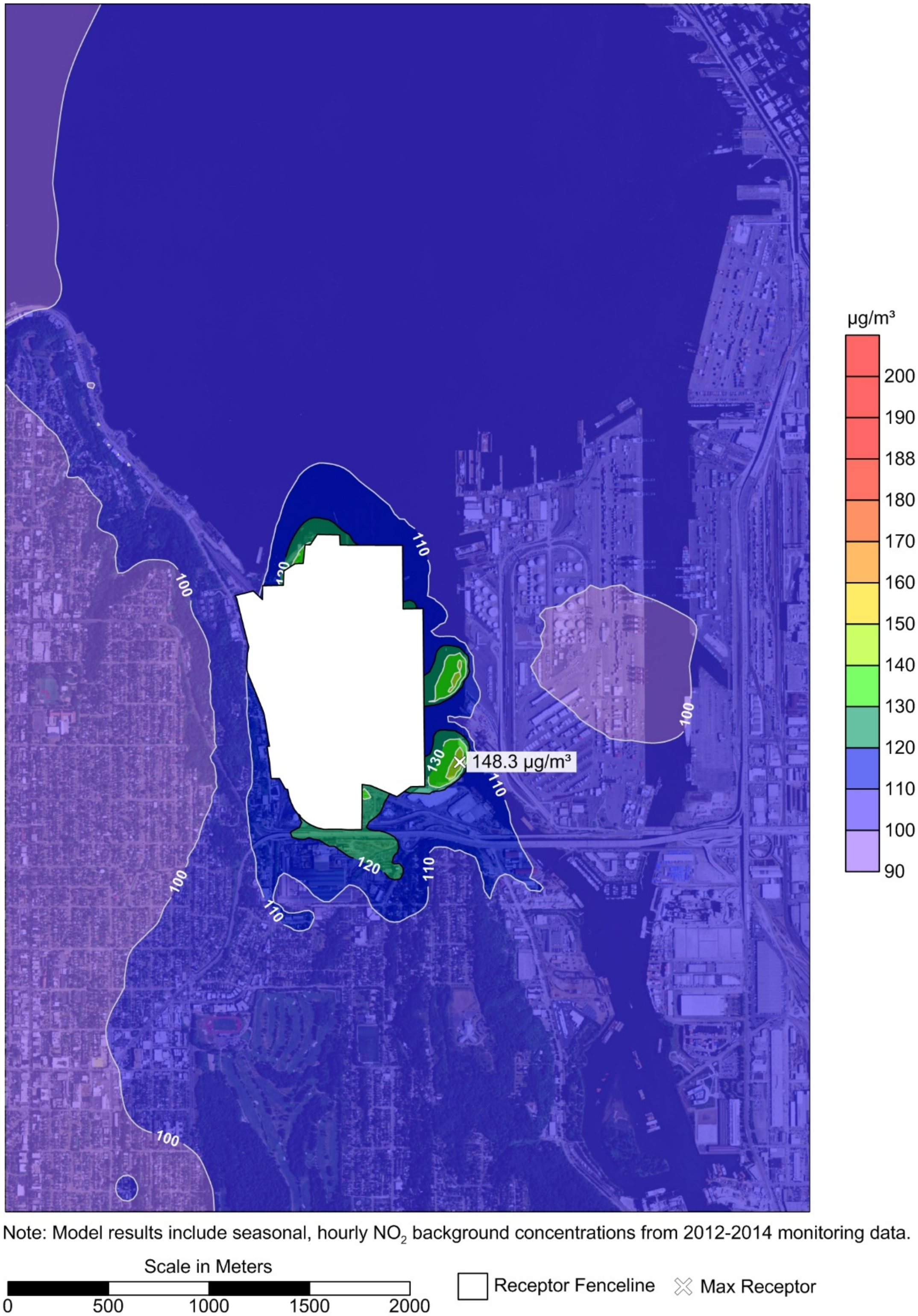
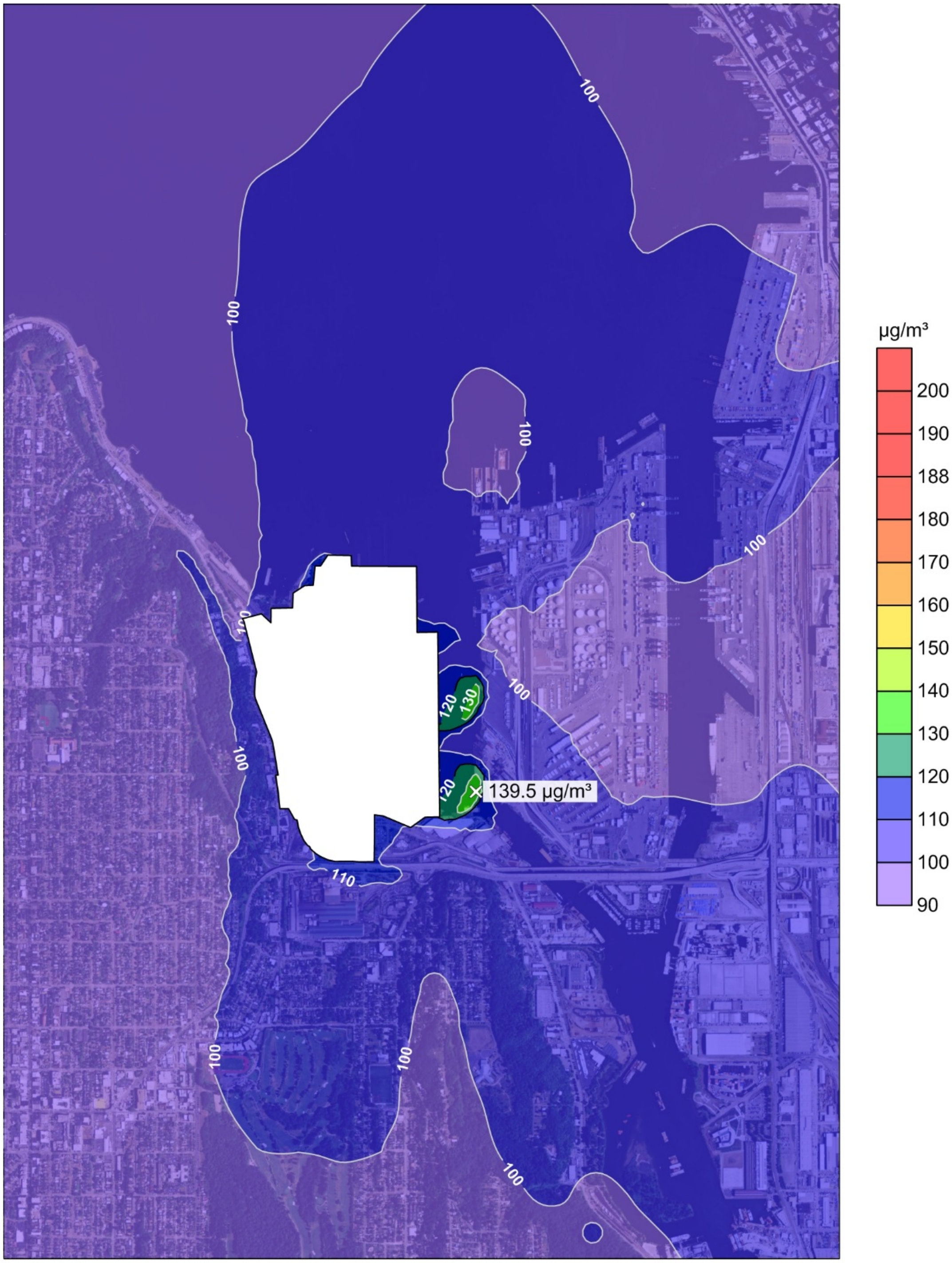


Figure 16. Alt 3, 2020 NO_2 1-hour Model Results



Note: Model results include seasonal, hourly NO_2 background concentrations from 2012-2014 monitoring data.

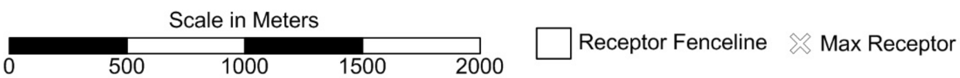
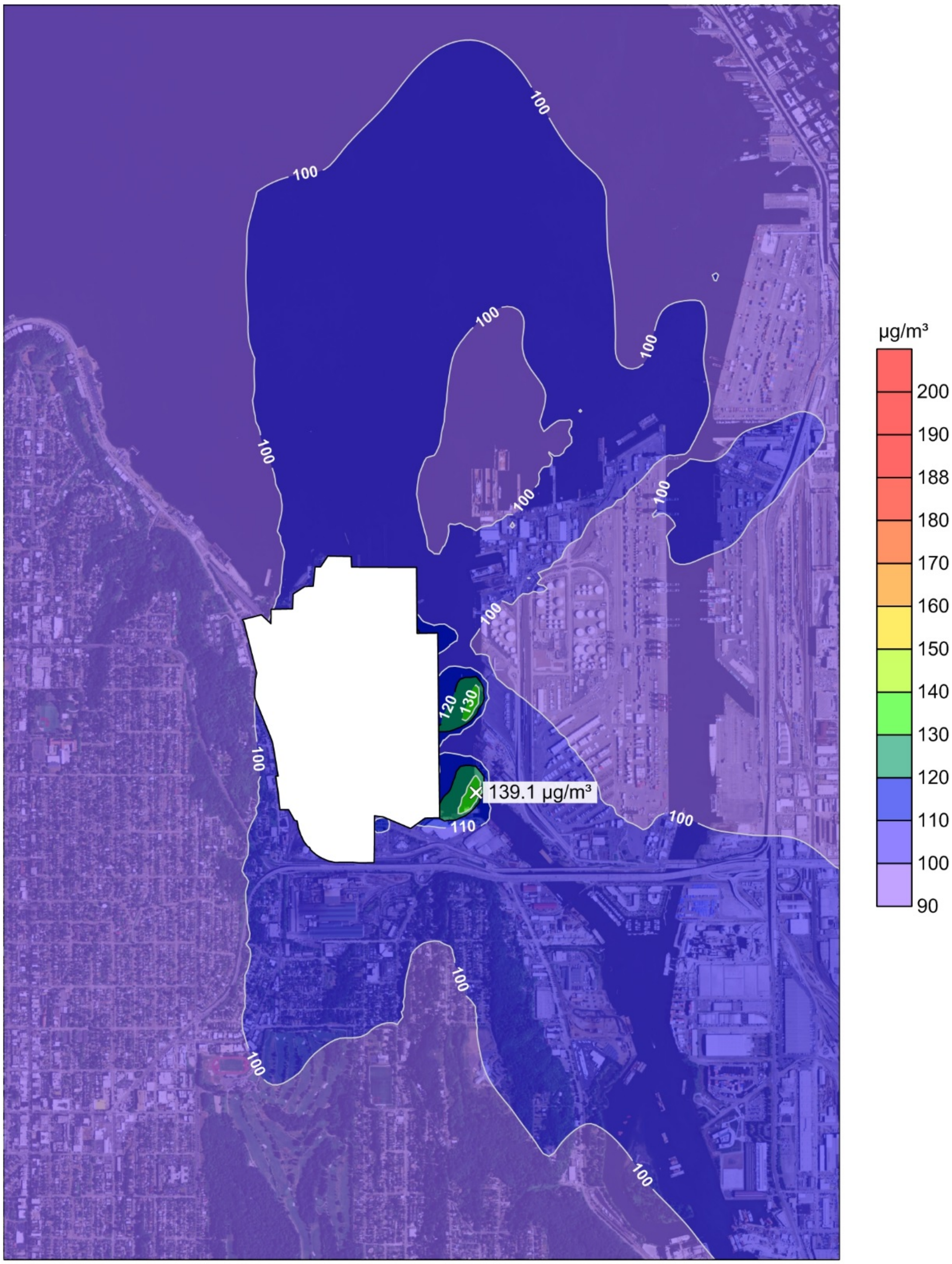


Figure 17. Alt 3, 2030 NO_2 1-hour Model Results



Note: Model results include seasonal, hourly NO_2 background concentrations from 2012-2014 monitoring data.

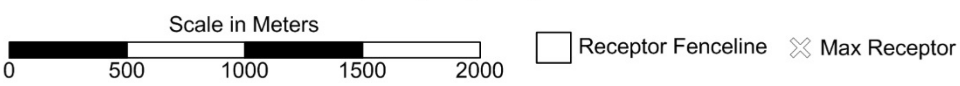


Figure 18. Alt 3, 2040 NO_2 1-hour Model Results

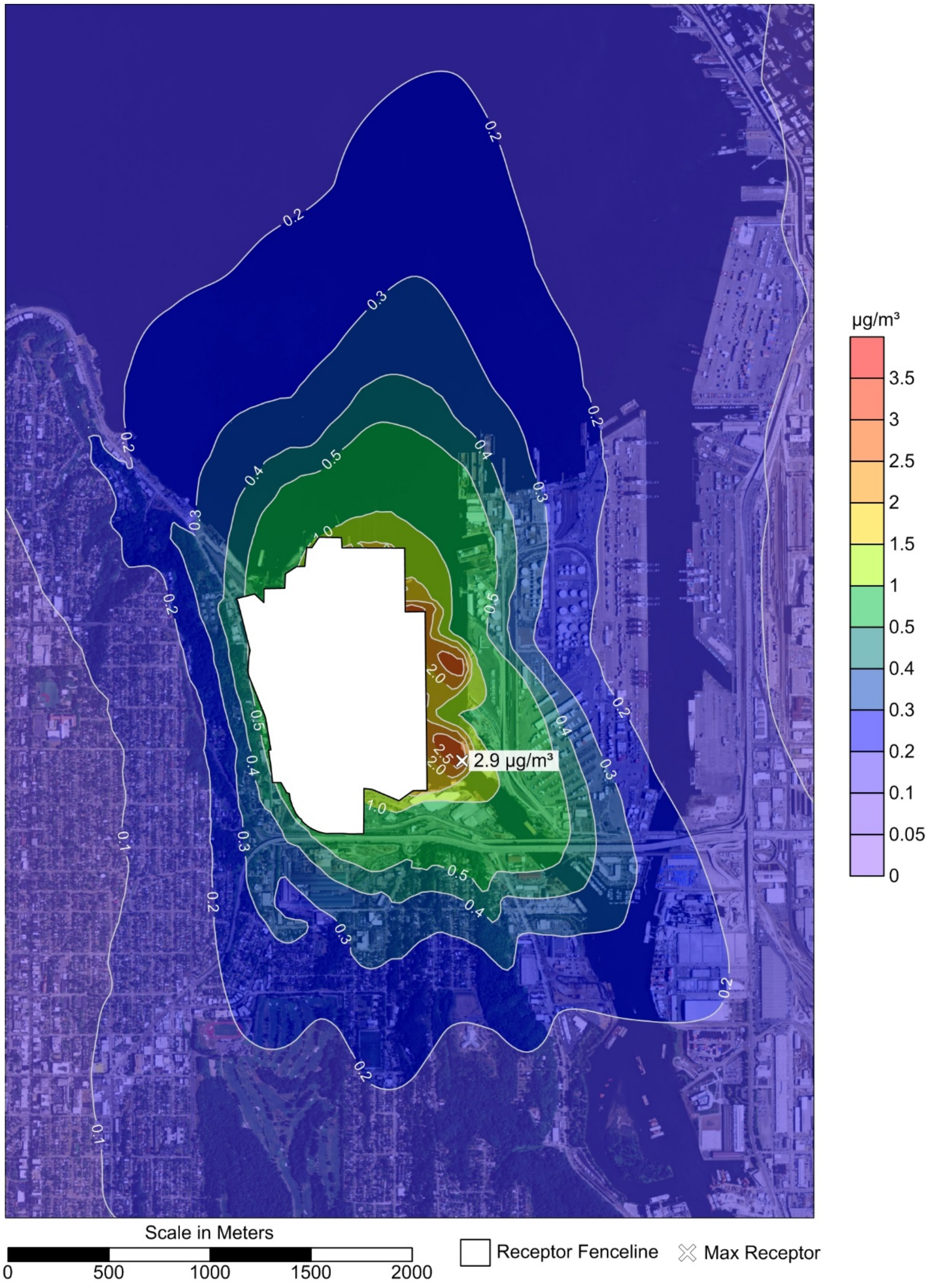


Figure 19. Alt 1, 2020 $PM_{2.5}$ 24-hour Model Results Attributable to Terminal 5 Activities

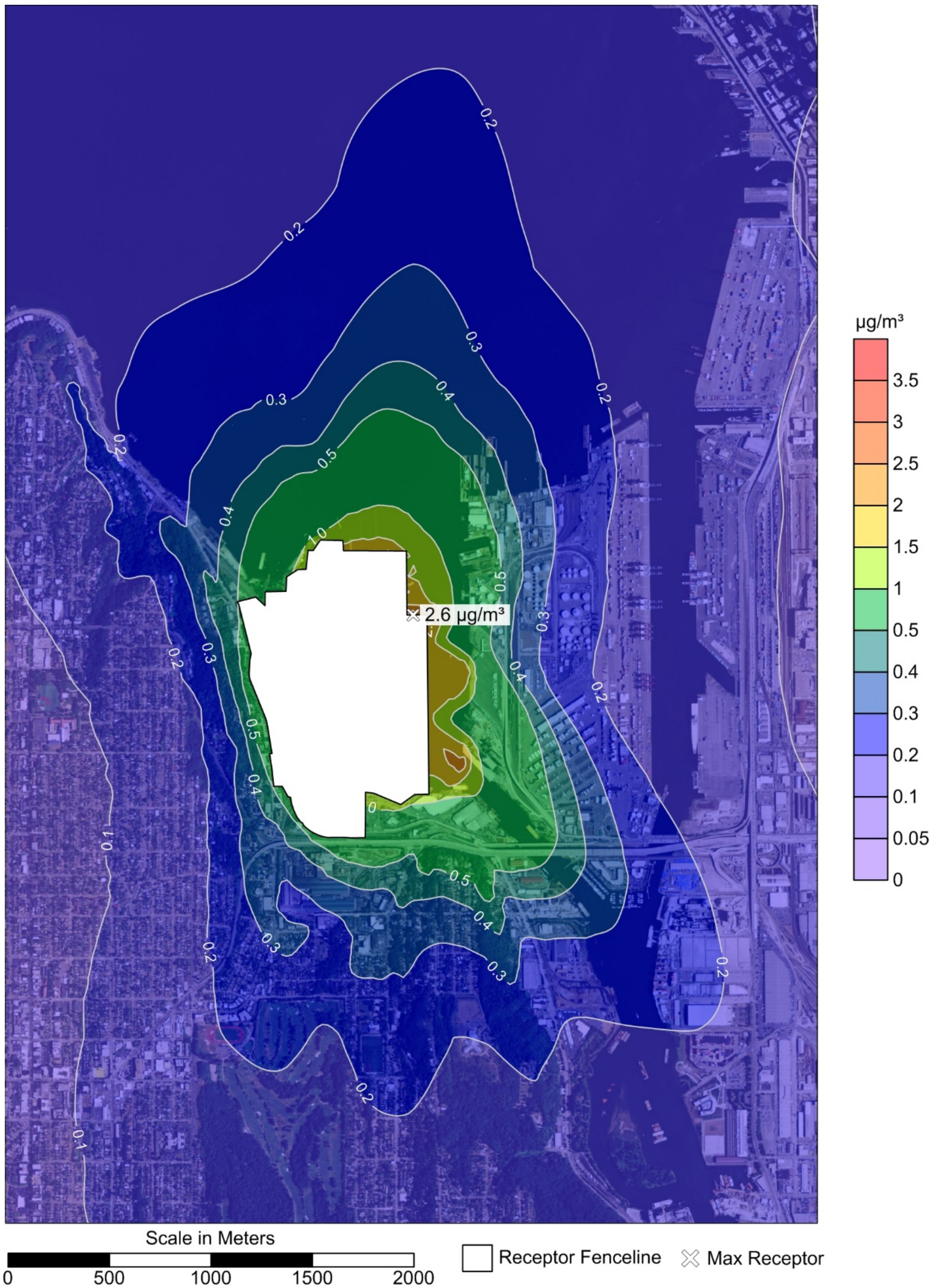


Figure 20. Alt 2, 2020 $PM_{2.5}$ 24-hour Model Results Attributable to Terminal 5 Activities

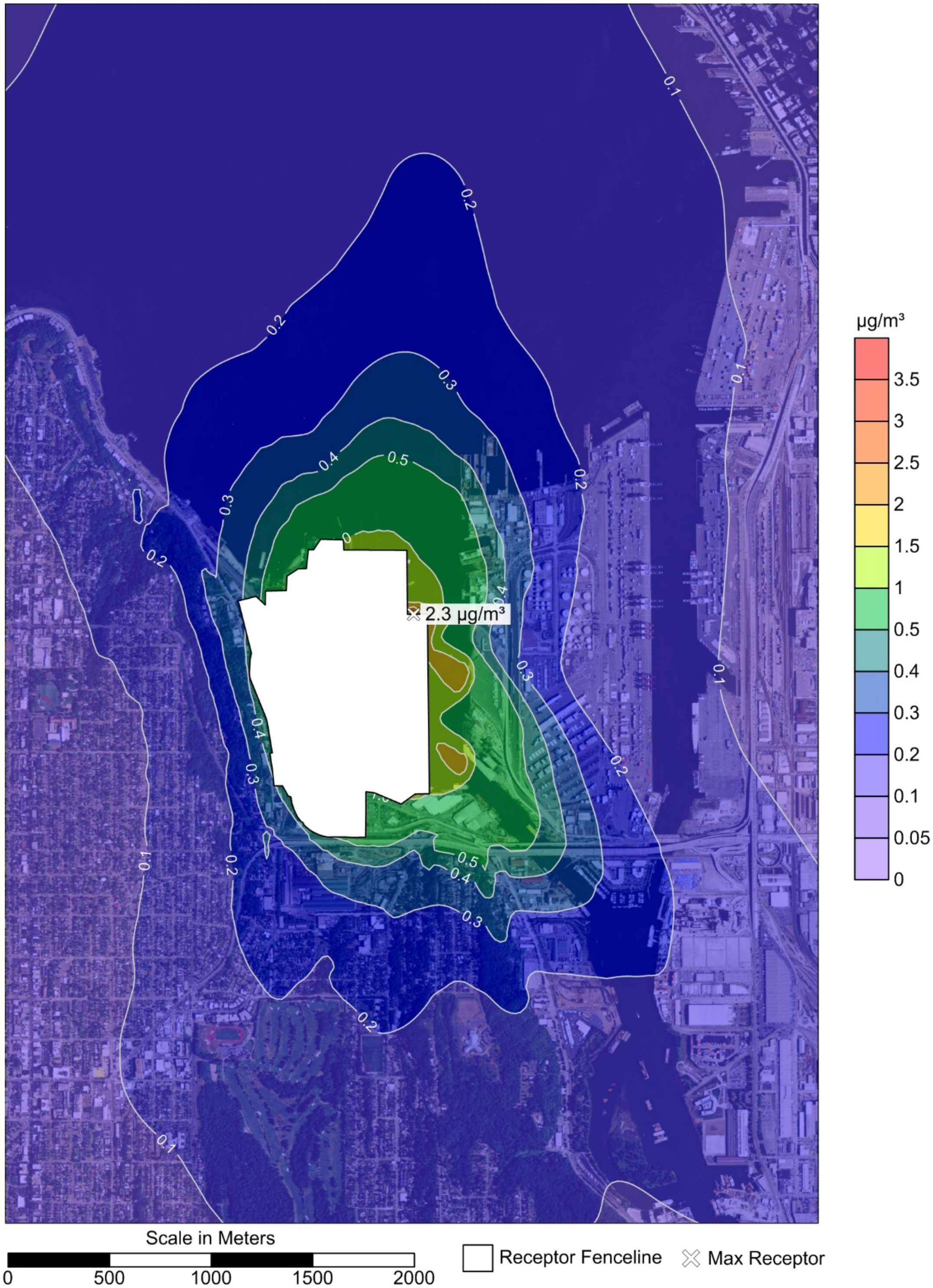


Figure 21. Alt 2, 2030 $PM_{2.5}$ 24-hour Model Results Attributable to Terminal 5 Activities

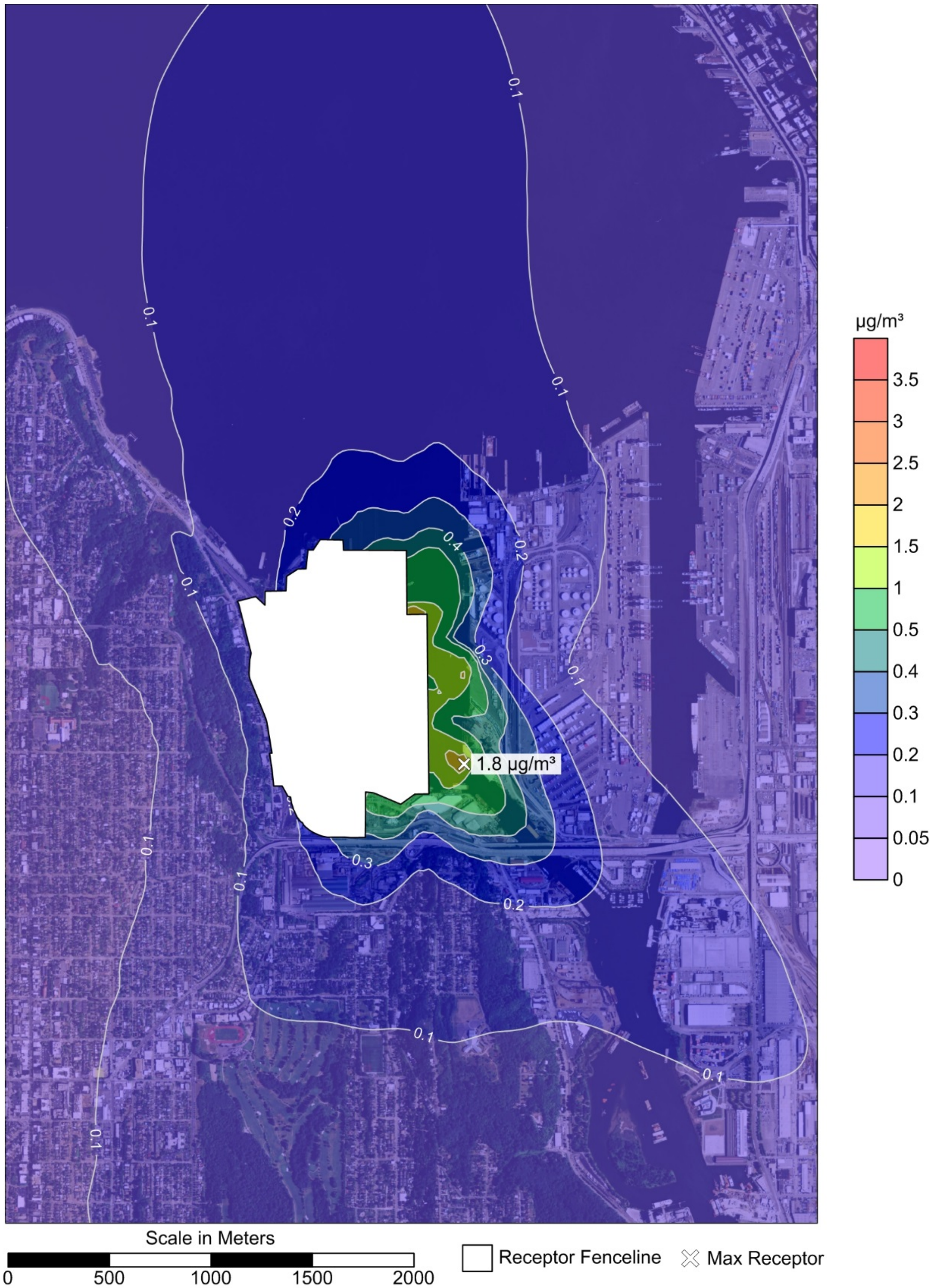


Figure 22. Alt 3, 2020 $PM_{2.5}$ 24-hour Model Results Attributable to Terminal 5 Activities

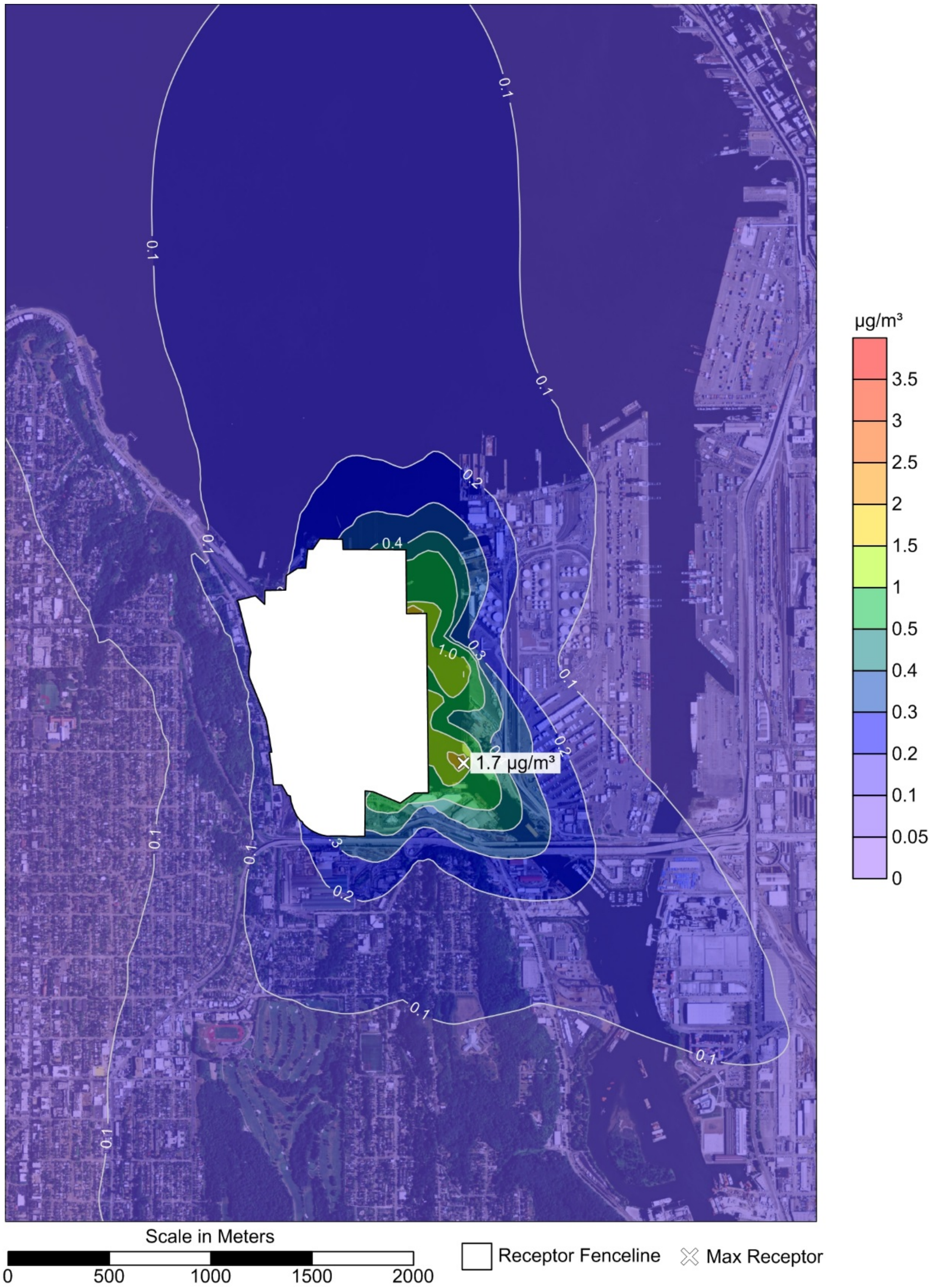


Figure 23. Alt 3, 2030 $PM_{2.5}$ 24-hour Model Results Attributable to Terminal 5 Activities

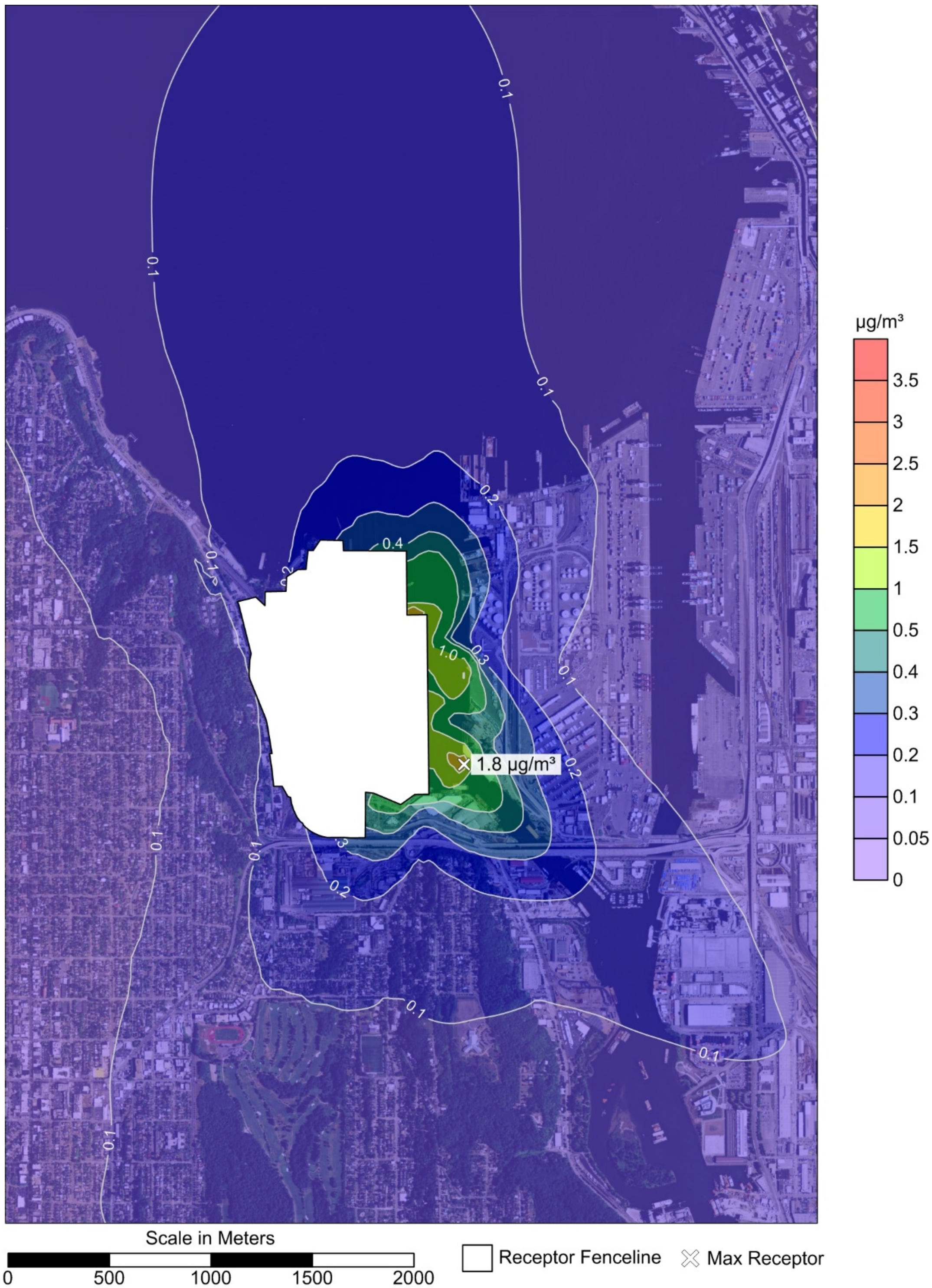


Figure 24. Alt 3, 2040 $PM_{2.5}$ 24-hour Model Results Attributable to Terminal 5 Activities

ATTACHMENT E: MODELING SOURCE PARAMETERS

Source Description	Number of Sources Modeled	Source Spacing (m)	Source Type	Height (m)	Temperature (K)	Velocity (m/s)	Diameter (m)	Sigma-Y (m)	Sigma-Z (m)	References
Hoteling Containership - Alternative 1	2		Point	47	618.15	25.8	0.5			(a)
Hoteling Containership - Alternative 2 & 3	2		Point	59	618.15	25.8	0.5			(a),(b)
Maneuvering Containership - Alternative 1	43		Point	47	573.15	25.8	1.9			(a)
Maneuvering Containership - Alternative 2 & 3	43		Point	59	573.15	25.8	1.9			(a),(b)
Tug Assist	19		Point	10	573.15	20	0.3			(a)
On-Site Locomotives	125		Point	4.52	459.66	3.5	0.3			(c)
Off-Site Locomotives	105	20	Point	4.52	459.66	3.5	0.3			(c)
Switch Locomotives	20		Point	4.52	459.66	3.5	0.3			(c)
Trucks - Gate Queue	43	14.63	Volume	2.55				6.80	2.37	(d)
Trucks - Pre-Queue	34	14.63	Volume	2.55				6.80	2.37	(d)
Trucks - Off-Site	124	14.63	Volume	2.55				6.80	2.37	(d)
Cargo Handling Equipment	24	130.00	Volume	2.55				60.47	2.37	(d)
Cargo Handling Equipment - Rail - Alternative 3	8	120.00	Volume	2.55				55.81	2.37	(d)
Cargo Handling Equipment - Ship-to-Shore - Alternative 3	13	30.48	Volume	2.55				14.18	2.37	(d)
Cargo Handling Equipment - Gate - Alternative 3	15	90.00	Volume	2.55				41.86	2.37	(d)

Reference Notes:
(a) Port of Los Angeles Baseline Air Emission Inventory - 2001
(b) Lloyd's Registry Database, Accessed 2012
(c) BNSF San Bernardino Rail Yard study & Southwest Research Institute's 2006 Aftertreatment Study
(d) EPA Haul Roads guidance, 2012

Appendix B
Noise Technical Report

Prepared for:

Moffatt & Nichol
Seattle, WA

On behalf of:

Port of Seattle
Seattle, WA

Prepared by:

Ramboll Environ US Corporation
Lynnwood, Washington

October 3, 2016

TERMINAL 5 WHARF REHABILITATION, BERTH DEEPENING, AND IMPROVEMENTS PROJECT

NOISE TECHNICAL REPORT

RAMBOLL ENVIRON

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ATTACHMENT

ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

Acoustically neutral	a description of equipment or material such as a wind screen used over a sound level meter microphone that, due to its composition, has little or no effect on the sound pressure levels reaching the microphone
CadnaA	Computer Aided Noise Abatement, a computer noise model used in this analysis
Cargo cranes	large cranes that transfer containers from ships to the shore, or vice versa; also referred to as ship-to-shore cranes or STS
CHE	cargo-handling equipment; a generic designation for equipment used to transfer cargo containers between ship, truck, and rail transportation modes. Refer to hoster/yard tractor, rail-mounted gantry (RMG), rubber-tired gantry (RTG), and top-pick (TP), below.
Day-night sound level (L_{dn})	A 24-hour sound level metric similar to a 24-hour Leq, except the L_{dn} includes an additional 10 dBA added to sound levels in each hour between 10 PM and 7 AM to account for increased sensitivity to noise during times when people are typically trying to sleep
dB	decibel, referring to a unit measured on the decibel scale used to quantify sound levels`
dBA	A-weighted decibel, a system for weighting measured sound levels to reflect the frequencies that people hear best
Distance attenuation	the rate at which sound levels decrease with increasing distance from a noise source based on the dissipation of sound energy as the sound wave expands in size (think of a balloon getting thinner as it becomes more inflated)
EPA	US Environmental Protection Agency
Equivalent sound level (L_{eq})	A sound level metric that is the level that if held constant over the same period of time would have the same sound energy as the actual, fluctuating sound (i.e., an energy-average sound level)
Federal preemption	A preemption of local requirements due to control by federal statute or policy; e.g., trains involved in interstate commerce are exempt from local noise rules by virtue of federal control of such sources
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
Hostler	A specialized off-road truck-tractor used to move cargo trailers or chassis loaded; hostlers are included in the general category of cargo-handling equipment (CHE); also referred to as yard tractor
ISO	International Organization for Standardization, which establishes standard methods and procedures for

accomplishing specific activities and calculations. The ISO has defined a number of standards related to the quantification of environmental noise.

L_{dn} .... Day-night sound level (see above)

L_{eq} .... Equivalent sound level (see above)

L_{max} .... Maximum sound level; highest sound level within a specified time interval; Fast Lmax is a 125 millisecond (1/8 second) sound level

L_n .... Statistical noise level, the level exceeded during n percent of the measurement period, where n is a number between 0 and 100 (for example, L50 is the level exceeded 50 percent of the time)

Maximum permissible level .... Term used in state and local noise rules in Washington State to define base sound levels specified in these regulations. Such base levels are often allowed to be exceeded for defined time periods. *Not* to be confused with Lmax or the actually allowed maximum sound level limit.

Model Receptor .... A theoretical location used in computer modeling at which the model calculates sound levels from a source or sources. Modeling receptors are usually placed at locations representing one or more potentially noise-sensitive uses.

NEPA .... National Environmental Policy Act

Noise criteria .... A set of definitions establishing the conditions under which a noise impact is determined to have occurred. The noise criteria applied in this assessment include those established by the FTA and adopted by the FRA.

Noise impact......................... A measured or model-calculated condition in which the absolute (i.e., total) sound level and/or a project-related sound level increase exceed a defined noise impact criterion.

Noise metric .... One of a number of measures used to quantify noise (e.g., L_{eq}, or Lmax)

RMG .... Rail mounted gantry – a crane mounted on fixed rails used to move and position containers within a specific area of a container marshalling yard or intermodal rail yard. The RMG container handling equipment proposed for the T-5 facility would be electrically powered.

RTG.................................... Rubber-tired gantry – a crane with wheels and rubber tires that can move about a container marshalling yard to move and position containers for transfer between ship, truck, and rail transport. The RTG container handling equipment proposed for the T-5 facility is anticipated to be diesel powered.

SEPA .... State Environmental Policy Act, a Washington State law

SLM.................................... Sound level measurement

Sound level .... Sound pressure level (see below)

Sound pressure level .... Ten times the base-10 logarithm of the square of the ratio of the mean square sound pressure, in a stated frequency band (often weighted), and the reference mean-square sound pressure of 20 μPa (micro pascals, a standard reference unit of pressure), which is approximately equal to the threshold of human hearing at 1 kilohertz. Sound pressure level is expressed in decibels.

TEU .... Twenty-foot equivalent unit, a standard measure of container capacity based on a 20-foot long container; for example, a 40-foot container equals two TEUs

TNM Model .... The FHWA's Traffic Noise Model, used for estimating sound levels of on-road vehicles.

TP .... Top-pick – a large lift-truck or forklift type vehicle that connects to the top corners of containers and is used to lift and transport containers for stacking and loading on truck trailer, container chassis, or rail cars. Top-picks are a type of container handling equipment.

Transporter .... Cargo handling equipment used to move containers from the ship-to-shore cranes to cargo marshalling and rail car loading areas. These could be hostlers, straddle carriers, or other forms of equipment. We expect they would use either diesel or diesel-hybrid power.

Type I meter .... A type of sound level meter defined by American National Standards Institute as being to measure sound pressure levels to an accuracy within 0.5 dBA

USACE .... United States Army Corps of Engineers

WAC .... Washington Administrative Code

Wayside Horn .... A warning horn installed at a road/rail intersection that focuses the warning sound at the oncoming traffic as a means to reduce the need for sound locomotive-mounted warning horns at specific intersections.

SUMMARY

The Port of Seattle proposes to rehabilitate Terminal 5 to accommodate larger container ships and improve cargo handling efficiency. Two action alternatives are under consideration. Each would rehabilitate and strengthen the existing cargo wharf for operation of large, heavier cargo cranes, but upland improvements with Alternative 3 would enable higher container throughput than the improvements proposed with Alternative 2.

This report provides technical details of the noise impact and mitigation analysis conducted by Ramboll Environ US Corporation (Ramboll Environ) as part of the environmental review of the proposed project. The methods and findings of the analysis reported here were summarized in the environmental impact statement for this project.

The noise analysis was based on modeling using the CadnaA model and considered the various alternative configurations of the Terminal 5 facility to evaluate compliance with applicable noise rules and to assess the potential for noise impacts from the proposed project. As an aid for analysis and evaluation of anticipated increases in marine cargo operations, operational scenarios and noise modeling included: Alternative 1 (No Action) in 2020; Alternative 2 in 2020 and 2030; and Alternative 3 in 2020, 2030, and 2040. The years of analysis are associated with increasing annual throughput at the terminal with 647,000 TEUs anticipated in 2020, 1.3 million TEUs anticipated by 2030, and 1.7 million TEUs anticipated by 2040.

The noise modeling used sound level data from representative equipment to characterize facility-related operational activities. Noise emissions attributable to on-site cargo-handling equipment, hoteling vessels, on-road trucks, and train-related sources were considered in the noise model. Noise data for representative sources were collected through direct measurements, provided by the equipment vendor or manufacturer, or were those incorporated into the CadnaA model FRA or TNM modules (for the train and on-road truck sources, respectively).

The noise modeling impact and mitigation analysis determined the following:

- With any of the alternatives in 2020, assuming an annual throughput of 647,000 TEUs, model-calculated sound levels comply with both Seattle's daytime and nighttime noise limits. With this level of throughput, the equipment demand calculations indicate that no nighttime gate operations would be necessary, and no nighttime intermodal yard operations would be necessary with Alternatives 1 or 2.
- By 2030, annual throughput is expected to increase to 1.3 million TEUs with either Alternative 2 or 3. With Alternative 2, this would entail nighttime intermodal yard operations but not nighttime gate operations. Alternative 3 would require both intermodal yard and gate operations at night. With either alternative, without use of

effective noise mitigation measures, model-calculated nighttime sound levels exceed the 50-dBA nighttime noise limit. With Alternative 2, the potential noise issue is primarily due to activities in the intermodal yard. With Alternative 3, the noise is primarily due to trucks operating in gate access areas of the terminal. Noise mitigation in the form of quieter equipment was found to reduce the facility operational sound levels somewhat, but model-calculated levels with the mitigation considered continue to exceed 50 dBA during nighttime operations. Daytime operations with both Alternative 2 and 3 in 2030 would comply with Seattle's daytime noise limit. Although model-calculated sound levels exceed the nighttime noise limit, no severe noise impacts due to project-related increases in community noise levels are expected using the FTA noise impact assessment criteria.

- By 2040, annual throughput with Alternative 3 is expected to increase to 1.7 million TEUs. With this throughput, model-calculated sound levels with Alternative 3 comply with the daytime limits but continue to exceed the 50-dBA nighttime noise limit. Noise modeling indicated quieter equipment could be used to reduce operational sound levels, but model-calculated levels even with mitigation continues to exceed 50 dBA. Although model-calculated sound levels exceed the nighttime noise limits, no severe noise impacts due to project-related increases in community noise levels are expected using the FTA noise impact assessment criteria.

1. PROJECT DESCRIPTION

The Port of Seattle is the sponsor of the proposed "T-5 Cargo Wharf Rehabilitation, Berth Deepening, and Improvements Project." The project site is located at the existing T-5 (T-5) marine cargo facility, on the west margin of the West Waterway, in southwest Elliott Bay, Seattle, Washington. The project area owned and available for use by the Port includes the existing T-5 marine cargo facility, approximately 197 total acres of existing upland and cargo pier marine cargo operational area (see **Figure 1**).

1.1 Projected Economic Limitations & Temporal Considerations

The proposed project would improve the container-handling efficiency of the existing terminal to accommodate the projected fleet mix of larger container vessels, up to 18,000 TEUs, that are anticipated to call at Terminal 5 through 2040. Assuming an initial container throughput level in 2020 of 650,000 TEU, the proposed project assumes a growth rate at approximately a 4% per annum rate, culminating at a potential throughput capacity of approximately 1,300,000 TEUs by 2030 and continuing at that level through the 20 year planning horizon of 2040. Additional modifications to the terminal would be required in order to exceed the 1,300,000 TEUs level. Such modifications would include the electrification and cargo-handling efficiencies that could provide a cargo handling capacity level of 1,700,000 TEUs in 2040. The actual throughput levels for the proposed project may be lower than the projected throughput at capacity as analyzed in this document due to market conditions.

1.2 Alternatives Being Considered

1.2.1 Alternative 1 - No Action

The No-Action Alternative generally establishes baseline conditions against which impacts of the development alternatives can be evaluated. With No Action, the subject site would involve no new building construction and would retain the existing uses on the site, unless and until some other redevelopment is proposed and approved.

If the Port does not rehabilitate the site as proposed, the site would remain as is or may be redeveloped for a different use. In the No Action Alternative, future uses are unknown. The market and existing zoning would dictate how the sites are developed.

The No Action Alternative assumes that no improvements would be made to the existing 197-acre site other than minor alterations, routine maintenance and repair work, none of which would increase container cargo capacity. The T-5 shoreline and upland area would continue as a marine cargo transportation facility with vessel moorage, cargo wharf, cargo marshalling, and truck and rail cargo transshipment operations taking place throughout the site. The terminal would continue to be capable of accommodating diverse marine cargo uses such as break-bulk or neo-bulk (goods that are loaded individually, and not in containers) and other water-dependent uses and activities intrinsic to marine transportation facilities.

Marine cargo operations would be similar to T-5 uses and activities during the past 15 years, making use of existing infrastructure designed and constructed to transship approximately 647,000 TEUs per year. Please note that the present T-5 marine cargo facility is the result of substantial expansion and improvements, completed in 1999. The construction and operation of the present marine cargo facility was preceded by detailed environmental analyses and evaluations, including a combined federal, state, and local government EIS, Southwest Harbor Cleanup and Redevelopment Project, and subsequent authorizations received from federal, state, and local regulators and government entities, including substantial shoreline development approval from the City of Seattle.

The No Action Alternative would preclude large post-Panamax and future larger capacity vessels from serving the site since they could not be accommodated by the existing wharf or cranes.

1.2.2 Alternative 2 - Wharf Improvements, Berth Deepening and Increased Cargo Handling

Alternative 2 would consist of modification of existing container facilities, including cargo wharf rehabilitation, berth deepening, and water, storm-water and electrical utility capacity improvements. Changes to existing T-5 facilities would increase container cargo trans-shipment capacity at the site to allow up to approximately 1.3 million TEU annually.

These changes to allow T-5 to accommodate existing large Post-Panamax and larger New Post-Panamax container cargo vessels and transship increased cargo volumes, are described in more detail below. Project elements included in Alternative 2 as essential cargo pier improvements include the following:

- Installation of replacement water-ward cargo pier crane rail beam, including demolition of water-ward portions of existing the wharf and installation of replacement structural concrete piling necessary for construction of a strengthened crane rail beam located below the water-ward margin of the existing 2,900 feet long cargo pier
- Installation of land-ward replacement crane rail beam, including new steel or concrete piling in upland area, immediately land-ward of the cargo pier, followed by construction of a new sub-grade crane rail beam
- Stabilization of existing armored slope beneath the cargo wharf, including installation of sub-tidal untreated wood piling in riprap slope and installation of a replacement steel sheet piling wall, approximately 3,100 linear feet, at the deep sub-tidal toe-of-slope, adjacent to the water-ward margin of the existing wharf

- Replacement of treated wood piling wharf fender system, including removal of creosote piling and timbers and installation of above-water inert vessel/wharf fender protection structures
- Deepening navigational access to existing berth area, consisting of excavation of approximately 29,800 cubic yards, in approximately 5.4 acres existing deep sub-tidal aquatic area, increasing berth depths to approximately minus 56 feet MLLW
- Repair and maintenance of existing wharf piling cap grid, including removal of spalled concrete and corroded steel and installation of replacement reinforcing steel and concrete grout, and
- Installation of upgraded utilities, including replacement primary substation equipment, with increased electrical power capacity, and installation of replacement water service to the existing wharf structure.

Specific Alternative 2 cargo pier and berth area rehabilitation and improvements include the following components:

- Site Preparation and Construction
  - Potential remodel of existing buildings for labor, management, maintenance and terminal operations and installation of other small buildings as needed to service the site
  - Possible installation of RTG concrete pads or runways (Rubber-Tired Gantry – a traveling crane used to move and position containers in a container yard) and a steel framed 3 level high platform (reefer rack system) to access grounded and stacked 4-high refrigerated containers
  - A wash system building for the cleaning of equipment and containers
  - Up 8 new Ship-to-Shore cranes would also be installed.
- In-Water and Over-Water Work
  - De-construction of a portion of the existing aged and deteriorating cargo wharf structure
  - Removal of approximately 87,000 square feet asphalt paving, exposing land-ward crane rail beam
  - Removal of existing container pier fender system and conflicting structural pile elements
- Rehabilitation of the existing wharf to strengthen the structural elements of the wharf to accommodate cargo crane equipment required to serve larger container cargo vessels. Elements of proposed wharf rehabilitation include the following:
  - Replacement rail crane rail beams
  - Replacement of the water-side crane rail beam, requiring concrete piling driven with an impact pile driver conducted from a barge or land-side crane
  - Replacement of the land-side crane rail beam, including installation of a total of 417, steel H-piling or 24 inch diameter concrete piling, driven with a land-based impact pile driver

    - Slope stabilization measures consisting of installation of up to 3,000 untreated wooden piling installed using impact and vibratory pile driving devices
- Replacement concrete deck structure, with the existing concrete wharf deck panels, pile caps and edge of wharf structures, removed to allow for replacement of the water-ward crane rail beam would be replaced with new concrete panels, within the existing wharf footprint. Approximately 20,000 cubic yards of concrete will be required to replace the deck.
- Repair and replacement of existing concrete piling caps beams
- Replacement fender system, with the existing treated wood piling and steel piling wharf fender system removed and replaced with an alternative panelized, above-water fender arrangement
- Dredging for berth deepening to allow vessel berths adjacent to the rehabilitated wharf by deeper draft, wider beam cargo vessels
- Water utility upgrades for potable service and fire protection, sanitary sewer, and storm water drainage
- Electrical upgrades to accommodate new distribution and increased loads, including replacement primary substation equipment sufficient to power modern container crane equipment and associated cargo operations
    - A new 26 MVA primary substation would be constructed to provide electrical power to the new cranes and associated terminal operations, such as cargo handling, marshalling, and refrigeration
    - Up to four new electrical distribution substations would be constructed, serving container cranes and dock power and lighting systems. A new underground electrical duct bank would be constructed, connecting distribution elements. Distribution vaults and trenches would be constructed, providing electrical power to container crane equipment. HVAC would be provided for electrical enclosures.
    - The conduit, wiring, and a connection system would be provided for a shorepower system for two berths. This would allow the terminal to be “plug-in ready” for those ships with have the capability and choose to use shorepower.
- Alternative 2 upland improvements to re-design and reorganize the container cargo marshalling yard area land-ward of the rehabilitated cargo wharf to relocate and change the distribution of grounded and wheeled container cargo, including changes in internal circulation, travel lanes, re-paving, re-striping, and changes in lighting and signage.

1.2.3 Alternative 3: Wharf Improvements, Berth Deepening, Increased Cargo Handling and Additional Upland Improvements

Alternative 3 consists of the same improvements listed for Alternative 2 with the addition of reorganized intermodal rail facilities, additional electrical improvements, reconfigured gate, and demolition of buildings.

- The same cargo wharf and vessel berth improvements identified in Alternative 2 would be combined with substantial improvements to the upland cargo marshalling area to increase overall terminal throughput capacity to 1.7 million TEUs per year (by 2040).
- Wharf and crane improvements would allow simultaneous loading and unloading of two 18,000 TEU vessels.
- The container yard would be enlarged through relocation or demolition of the existing entrance gate, freight station, transit shed, maintenance and repair buildings, and operations buildings.
- The container marshalling yard capacity would be increased through use of grounded container storage served by RTG or RMG cranes.
- To accommodate additional crane load and to power electrified cargo handling equipment, a new 50 MVA substation would be constructed to provide adequate electrical power.
- The truck gate would be relocated, and the existing intermodal rail yard would be reconfigured with additional rail lines and concrete or rail runways for RTG or RMG equipment.
- Site Preparation Work, Construction, In-water and Over-water work, Berth Deepening, Utilities, and Construction Laydown Area would be the same as Alternative 2.
- Increased throughput and upland improvements would be anticipated as follows:
    - The percentage of containers transported by rail is expected to increase to 75%. Of the containers transported by rail, two-thirds (or 50% of the intermodal total) are assumed to be handled at the on-dock intermodal yard and one-third (or 25% of the total) are assumed to be drayed to off-dock rail yards. The remaining 25% of the total cargo would be trucked to local and regional businesses.
    - The rail yard configuration would be changed to accommodate RMG loaders, which would increase the capacity of the yard. The size of the unit trains servicing the facility would remain 7,500 feet long.
    - The gate may require a second shift (6:00 P.M. to 3:00 A.M.) due to the change to gantry cranes within the container terminal yard. If a second gate shift is required, then it is likely that a reservation system for gate access would also be implemented to manage the tempo of trucks serving the terminal.

Figure 1. Project Location and Site

2. AFFECTED ENVIRONMENT

2.1 Noise Terminology and Descriptors

Noise is sometimes defined as unwanted sound; the terms noise and sound are used more or less synonymously in this report. The human ear responds to a very wide range of sound intensities. The decibel (dB) scale used to describe and quantify sound is a logarithmic scale that provides a convenient system for considering the large differences in audible sound intensities. On this scale, a 10-dB increase represents a perceived doubling of loudness to someone with normal hearing. Therefore, a 70-dB sound level will sound twice as loud as a 60-dB sound level.

People generally cannot detect sound level differences (increases or decreases) of 1 dB in a given noise environment. Although differences of 2 or 3 dB can be detected under ideal laboratory conditions, such changes are difficult to discern in an active outdoor noise environment. A 5-dB change in a given noise source would be likely to be perceived by most people under normal listening conditions.

When addressing the effects of noise on people, it is necessary to consider the "frequency response" of the human ear, or those sound frequencies that people hear most effectively. Sound-measuring instruments are therefore often programmed to "weight" sounds based on the frequency spectrum people hear. The frequency-weighting most often used to evaluate environmental noise is called A-weighting, and measurements using this system are reported in "A-weighted decibels" or dBA. All sound levels discussed in this evaluation are reported in A-weighted decibels.

As mentioned above, the decibel scale used to describe noise is logarithmic. On this scale, a doubling of sound-generating activity at a source (i.e., a doubling of the sound energy produced) causes a 3-dBA increase in average sound produced by that source, not a doubling of the loudness of the sound (which requires a 10-dBA increase). For example, if traffic along a road is causing a 60-dBA sound level at a nearby location, doubling the volume of traffic on this same road would cause the sound level at the same location to increase to 63 dBA. Such an increase might not be discernible in a complex acoustical environment.

Relatively long, multi-source "line" sources such as roads with steady traffic emit cylindrical sound waves. Due to the cylindrical spreading of these sound waves, sound levels from such sources decrease with each doubling of distance from the source at a rate of 3 dBA. Sound waves from discrete events or stationary "point" sources (such as a conveyor motor in a stationary location) spread as a sphere, and sound levels from such sources decrease 6 dBA per doubling of the distance from the source. Conversely, moving half the distance closer to a source increases sound levels by 3 dBA and 6 dBA for line and point sources, respectively.

For any noise source, a number of factors affect the efficiency of sound transmission traveling from the source, which in turn affects the potential noise impact at off-site locations. Important factors include distance from the source, frequency of the sound, absorbency and roughness of the intervening ground (or water) surface, the presence or absence of obstructions and their absorbency or reflectivity, and the duration of the sound. The degree of impact on humans also depends on existing sound levels, and who is listening. Typical sound levels of some familiar noise sources and activities are presented in **Table 1**.

Environmental noise is usually described in terms of certain "metrics" that allow comparison of sound levels at different locations or in different time periods. Federal regulatory agencies often use the equivalent sound level (L_{eq}) or the day-night sound level (L_{dn}) to characterize sound levels and to evaluate noise impacts. The L_{eq} is the level that if held constant over the same period of time would have the same sound energy as the actual, fluctuating sound. As such, the L_{eq} can be considered an energy-average sound level. Because the L_{eq} considers sound levels over time, this metric accounts for the number and levels of noise events during an interval (e.g., 1 hour) as well as the cumulative duration of these events. The L_{dn} is like a 24-hour L_{eq}, except that the calculation adds 10 dBA to the sound levels between 10 PM and 7 AM to account for possible sleep disturbance. The L_{dn} is used to describe the noise environment in areas where there is both nighttime and daytime use, such as residences.

Table 1. Sound Levels Produced by Common Noise Sources

<table>
<tr><th>Thresholds / Noise Sources</th><th>Sound Level (dBA)</th><th>Subjective Evaluations [a]</th><th>Possible Effects on Humans [a]</th></tr>
<tr><td>Human Threshold of Pain
Carrier jet takeoff at 50 feet</td><td>140</td><td rowspan="4">Deafening</td><td rowspan="7">Continuous exposure to levels above 70 can cause hearing loss in majority of population</td></tr>
<tr><td>Siren at 100 feet
Loud rock band</td><td>130</td></tr>
<tr><td>Jet takeoff at 200 feet
Auto horn at 3 feet</td><td>120</td></tr>
<tr><td>Chain saw
Noisy snowmobile</td><td>110</td></tr>
<tr><td>Lawn mower at 3 feet
Noisy motorcycle at 50 feet</td><td>100</td><td rowspan="2">Very Loud</td></tr>
<tr><td>Heavy truck at 50 feet</td><td>90</td></tr>
<tr><td>Pneumatic drill at 50 feet
Busy urban street, daytime</td><td>80</td><td rowspan="2">Loud</td></tr>
<tr><td>Normal automobile at 50 mph
Vacuum cleaner at 3 feet</td><td>70</td><td rowspan="2">Speech Interference</td></tr>
<tr><td>Air conditioning unit at 20 feet
Conversation at 3 feet</td><td>60</td><td rowspan="2">Moderate</td></tr>
<tr><td>Quiet residential area
Light auto traffic at 100 feet</td><td>50</td><td rowspan="2">Sleep Interference</td></tr>
<tr><td>Library
Quiet home</td><td>40</td><td rowspan="2">Faint</td></tr>
<tr><td>Soft whisper at 15 feet</td><td>30</td><td rowspan="4"></td></tr>
<tr><td>Slight rustling of leaves</td><td>20</td><td rowspan="3">Very Faint</td></tr>
<tr><td>Broadcasting Studio</td><td>10</td></tr>
<tr><td>Threshold of Human Hearing</td><td>0</td></tr>
<tr><td colspan="4">[a] Note that both the subjective evaluations and the physiological responses are continuums without true threshold boundaries. Consequently, there are overlaps among categories of response that depend on the sensitivity of the noise receivers.
Source: United States Environmental Protection Agency (EPA) 1974 and Others</td></tr>
</table>

2.2 Regulatory Limits and Guidelines

2.2.1 Local Noise Regulations and Zoning

The project site and the surrounding communities are located within the City of Seattle, Washington, and the noise limits included in the Seattle noise ordinance (Seattle Municipal Code Chapter – SMC 25.08) apply to noise related to this project. The SMC sets noise limits based on sound levels and durations of allowable daytime/nighttime operational noise (upper portion of **Table 2**) and daytime construction noise (lower portion of **Table 2**). These limits are based on the zoning of the source and receiving properties.

The project site is zoned for Industrial uses and potentially affected sensitive receivers in the project vicinity are residences on the hillsides west and south of the site. Because this project would involve construction-related activities only during daytime hours, only the daytime construction noise limits apply to the project.

As indicated in **Table 2**, the Seattle noise limits are based on hourly sound-energy average equivalent sound levels (L_{eq}s) in addition to not-to-be-exceeded L_{max} levels that vary by zoning of the noise source and receiving properties. The project site is zoned for Industrial uses and the nearby potentially affected sensitive receivers are in residentially zoned areas on the hillsides west and south of the site. As shown in the highlighted cell of **Table 2**, this establishes 1-hour L_{eq} sound level limits for operational noise of 60 dBA during the day and 50 dBA at night, along with hourly L_{max} limits of 75 dBA during the day and 65 dBA at night.

The Seattle noise code identifies a number of noise sources or activities that are exempt from the noise limits shown in **Table 2**. The following sources are among those specifically exempted:

- Sounds created by motor vehicles are exempt from the exterior sound level limits (**Table 2**), except that sounds created by any motor vehicle operated off highways shall be subject to the exterior sound level limits when the sounds are received within a residential district of the City (25.08.480), and
- Sounds created by warning devices or alarms (such as back-up alarms on vehicles) not operated continuously for more than 30 minutes per incident (25.08.530)

Sounds from the operation of railroads engaged in interstate commerce are exempt from local noise control rules by virtue of a federal preemption of this issue. [(1)]

[(1)] 42 U.S.C. §4901 et seq. (1972)

Table 2. Seattle Maximum Permissible Levels and Construction Noise Limits (dBA)

Zoning District of Noise Source [25.08.410 & 420 & 425]	Zoning District of Receiving Property		
	Residential Day / Night	Commercial	Industrial
Operational Noise Limits [a]			
Residential	55 / 45	57	60
Commercial	57 / 47	60	65
Industrial	60 / 50	65	70
Daytime Construction Noise Limits [b]			
On-site sources like dozers, loaders, power shovels, cranes, derricks, graders, off-highway trucks, ditchers, and pneumatic equip (maximum+25) [25.08.425 A.1]			
Residential	80	82	85
Commercial	82	85	90
Industrial	85	90	95
Impact types of equipment like pavement breakers, pile drivers, jackhammers, sand-blasting tools, or other impulse noise sources - may exceed maximum permissible limits between 8 a.m. and 5 p.m. weekdays and 9 a.m. and 5 p.m. weekends, but may not exceed the following limits [25.08.425 B]: L_{eq} (1 hr) 90 dBA L_{eq} (30 minutes) 93 dBA L_{eq} (15 minutes) 96 dBA L_{eq} (7.5 minutes) 99 dBA			

Note: The above sound level limits are based on the measurement interval equivalent sound level (L_{eq}) *and* a not-to-be-exceeded L_{max} level 15 dBA higher than the indicated limits. The construction noise limits are based on an hourly L_{eq}, unless noted otherwise for impact equipment.

[a] The operational noise limits for residential receivers are reduced by 10 dBA during nighttime hours (i.e., 10 PM to 7 AM weekdays, 10 PM to 9 AM weekends) and are displayed for daytime/nighttime hours.

[b] Construction noise limits apply at 50' or a real property line, whichever is greater. Construction noise is limited to the higher levels listed in the lower portion of the table during "daytime" hours only. For purposes of limiting construction noise received in certain zones, daytime hours are defined as 7 AM to 7 PM weekdays and 9 AM to 7 PM weekends for noise received in Lowrise, Midrise, Highrise, Residential-Commercial, or Neighborhood-Commercial zones. For construction projects in all other zones, and for public projects or locations where there are no residential uses within 100 feet, daytime construction hours are defined as 7 AM to 10 PM weekdays and 9 AM to 10 PM weekends.

Source: Seattle Municipal Code - 25.08 - Specific sections indicated.

2.2.2 Federal Transit/Federal Railway Administrations' Noise Impact Criteria

Although not applicable to any specific aspect of the proposed project, sound level impact criteria applied by two federal agencies can be used to provide benchmarks for comparison with off-site sound levels. These noise criteria are discussed below.

The Federal Transit Administration (FTA) has defined noise impact criteria for transit and rail projects in the FTA manual entitled *Transit Noise and Vibration Impact Assessment* (FTA 2006). These criteria apply to transit projects including commuter and light rail; fixed facilities such as transit stations, maintenance facilities, and park and ride lots; buses in bus-only highway lanes; ferry terminals; and motor vehicles in route to and from transit facilities.

The Federal Railroad Administration (FRA) applies the same noise impact assessment procedures and impact criteria employed by the FTA. [(2)] And although the FTA/FRA noise impact criteria are not directly applicable to on-site and near-site rail activities related to the proposed project, these criteria provide a useful and objective method for assessing potential noise impacts from increases in noise directly attributable to all sources associated with this project.

The FTA/FRA noise impact criteria apply a sliding scale of impact levels (or thresholds) for project-related noise based on the existing sound levels and the amount of noise a project would contribute (**Figure 2**). The criteria are based on the land use category of the receiving properties. For this project, the receiving properties of concern are residences (shown as Category 2 in **Figure 2**), and the FRA criteria use the day-night sound level (L_{dn}) noise descriptor to include consideration of the potential for sleep disturbance.

Based on the FRA impact criteria for increases in sound levels, receiving locations with low existing sound levels can be exposed to greater increases in overall noise, after the addition of project noise, before an impact occurs. Conversely, locations with higher existing sound levels can be exposed to smaller increases in overall noise before an impact occurs. For example, with existing sound levels of about 60 dBA, a project would have to increase hourly sound levels by more than 2 dBA to cause what FTA defines as a "moderate" impact, and increase hourly levels by more than 5 dBA to cause what FTA defines as a "severe" impact. At residential locations, for which the FTA impact criteria are based on the 24-hour day-night sound level metric (L_{dn}), with existing sound levels of about 60 dBA, a project

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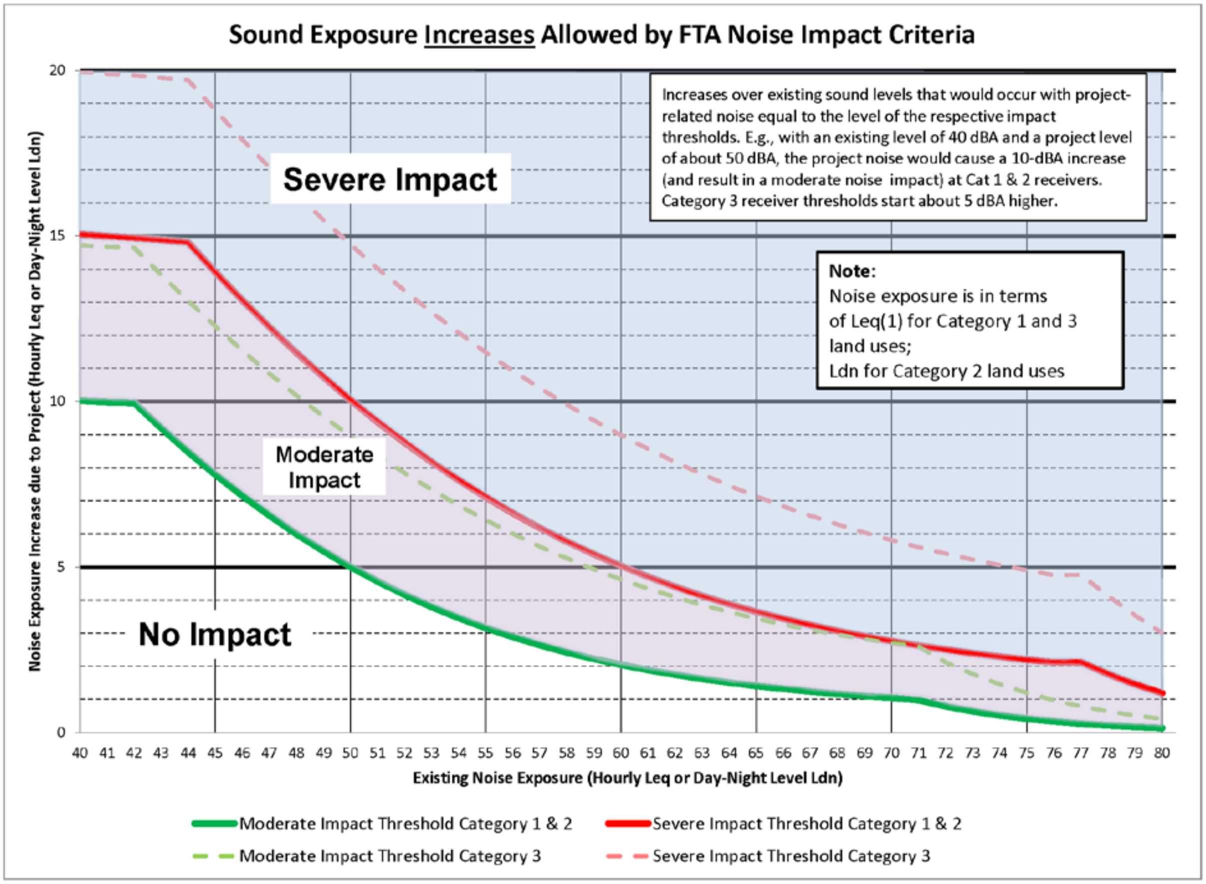
[(2)] The FRA uses identical calculation procedures as the FTA for conventional passenger rail lines, fixed rail facilities, and horn noise assessment. FRA uses slightly different methods, primarily in the form of modified source noise levels, for estimating noise from freight rail facilities.

would have to increase the Ldn by more than 2 dBA to cause what FTA calls a "moderate" impact, and increase Ldn levels by more than 5 dBA to cause a "severe" impact.



Source: Transit Noise and Vibration Impact Assessment
FTA, 2006, page 3-6 and Appendix A page A-5

Figure 2. FTA/FRA Noise Impact Criteria

In addition to considering the day-night sound levels, FTA also recommends identifying the maximum sound level (Lmax) from rail projects, particularly for those locations where the equipment and proximity to noise-sensitive uses indicate a potential for impacts. The Lmax is the maximum sound level that occurs during a given time interval, and this metric provides additional information with which to evaluate the potential effect of individual train events. FTA does *not* employ direct noise impact criteria based on applying Lmax levels.

2.3 Zoning and Land Uses

As indicated previously, the project site is zoned for Industrial uses and the nearby potentially affected sensitive receivers are in residentially zoned areas on the hillsides west and south of the site. Existing uses of the project site include operation of as a marine cargo terminal, while immediately surrounding uses include other heavy industrial uses to the east and west, along with commercial uses along surface streets to the south and west.

2.4 Existing Sound Levels

The existing acoustic environments at off-site locations near the project site are dominated by noise from a variety of existing industrial uses in the area and by roadway traffic noise from the West Seattle Freeway and from surface roads in the area. Ongoing train traffic serving existing industrial facilities in the area also contributes to the existing acoustic environment.

Sound levels in the residential areas to the south and west of the project site have been measured at a number of locations over the past 20+ years, beginning with noise analyses and evaluations conducted for environmental review of Terminal 5 redevelopment in 1994 and following completion of redevelopment in 1999. [(3)] Locations at which historical baseline (mid-to-late 1990s) and more recent sound level measurements have been taken are depicted in Attachment A.

New sound level data were not collected as part of the noise analysis for the study documented here because existing sound level data are sufficient to generally represent the acoustic environments at nearby locations. In addition, because of the current non-active state of the T-5 facility, sound level measurements at this time would tend to understate what have been the existing conditions in this area for at least the last 20 years (i.e., including some contribution from the previously ongoing industrial uses of the project site).

Historical measurements near the project site as part of previous studies indicate off-site sound levels rarely fall below 50 dBA and are more typically in the mid to upper 50s and the low to mid-60s dBA. More recent measurements indicate the sound sources and typical sound levels at the Hinds Street location and on 31st Avenue SW were similar to those documented in the baseline measurements. The measured sound levels are summarized in **Table 3**. Measurement details are provided in Attachment A.

[(3)] Port of Seattle, *Southwest Harbor Cleanup and Redevelopment Project - Draft Environmental Impact Statement*, January 1994.

Table 3. Range of Measured Sound Levels in Project Vicinity (dBA)

SLM Location	Date	Daytime L_{eq}s	Nighttime L_{eq}s	L_{dn}
Hinds St	2012-2016	62-63[(a)]	55-57[(b)]	64[(c)]
31st Ave SW	Mid 1990s	58-64	55-60	64
Fauntleroy Ave SW	Mid 1990s	53-61	52-56	60
City Light Condos	Mid 1990s	52-59	50-55	60
Pigeon Point	1993	70-72	61-72	74

(a) Measured between 7 AM and noon

(b) Measured between 11 PM and midnight

(c) Measured daytime sound levels at the Hinds Street location are similar to levels measured at 31st Ave SW, so the 31st Ave SW Ldn is used here to represent the Hinds St location.

3. ANALYTICAL METHODS

The noise impact and mitigation assessment conducted for this project was based on noise modeling using source-specific sound level data where possible to estimate cumulative levels of facility operational noise. Noise from on-site sources and activities was then considered in the noise modeling to estimate what levels of noise would be received at off-site locations.

The noise analysis of the action alternatives evaluated both *compliance* with the Seattle noise limits and the potential for noise *impacts* based on the project-related changes in the acoustic environment.

These specifics of the tools and methods used are described further below.

3.1 Noise Model

Ramboll Environ estimated noise generated by the facility as received at nearby residences using the Computer Aided Noise Abatement (CadnaA) noise model. CadnaA is a state-of-the-art software program that enables noise modeling of complex industrial sources using sound propagation factors as adopted by International Organization for Standardization (ISO) 9613. [(4)] Atmospheric absorption was estimated for conditions of 10°C and 70 percent relative humidity (i.e., conditions that favor propagation) and computed in accordance with ISO 9613-1. The modeling process included the following steps: (1) characterizing the noise sources, (2) creating 3-dimensional maps of the site and vicinity to enable the model to evaluate effects of distance and topography on noise attenuation, and (3) assigning the equipment sound levels to appropriate locations on the site. CadnaA then constructed topographic cross sections to calculate sound levels in the vicinity of the project site.

For the modeling effort, Ramboll Environ used numerous modeling "receptor" locations representing the residences nearest the project site. The modeling receptors considered in the noise modeling are depicted in **Figure 3**.

3.2 Facility Noise Sources

T-5 operations would involve a variety of types of equipment, some of which would produce noise and some of which would not be expected to generate much noise. The assumed equipment and the number of pieces involved with the alternative facility configurations are listed in **Table 4**.

[(4)] The ISO has established internationally recognized standard methods for calculating noise attenuation through the atmosphere.

Table 4. Assumed Operational Equipment

Scenario	Shift [a]	Facility Cargo Handling Equipment and Mobile Sources								
		Ships	STS Cranes	TPs	RTGs	RMGs	Transporters	Hostlers	Trucks	Trains
Alt1 – 647k TEU	1st Shift	2	6	22	3	0	0	67	166/hour	1.3/ day
	2nd Shift	2	6	9	0	0	0	42	0	
Alt2 – 647k TEU	1st Shift	2	8	25	3	0	0	71	166/hour	1.3/ day
	2nd Shift	2	8	12	0	0	0	56	0	
Alt2 - 1.3M TEU	1st Shift	2	8	36	13	0	0	92	327/hour	2.6/ day
	2nd Shift	2	8	29	0	0	0	92	0	
Alt3 – 647k TEU	1st Shift	2	8	0	0	38	32	13	167/hour	1.3/ day
	2nd Shift	2	8	0	0	26	32	13	0	
Alt3 – 1.3M TEU	1st Shift	2	10	0	0	45	40	13	213/hour	2.6/ day
	2nd Shift	2	10	0	0	45	40	13	115/hour	
Alt3 - 1.7M TEU	1st Shift	2	12	0	0	58	48	18	286/hour	3.5/ day
	2nd Shift	2	12	0	0	58	48	18	154/hour	

[a] First shift is between 8 AM and 5 PM. Second shift is between 6 PM and 3 AM.

Ramboll Environ used a variety of source sound level data to represent the facility equipment sources expected to be used on the project site. Where possible, the various noise sources were represented using data from direct sound level measurements of similar equipment.

Ships – Container ships usually leave a boiler and/or a ship's service diesel generator operating to supply shipboard power while at port. This power source may be audible at the pier apron, but it is not typically audible at a distance.(5) Ramboll Environ measured the sound level of a 10,000 TEU vessel while hoteling. A larger ship was not available for measurement, so the sound level of 14,000 TEU vessels were estimated by assuming they emitted 1.4 times the sound energy as a 10,000 TEU vessel. The sound level for a hoteling

(5) Anecdotal evidence indicates a few, discrete ships that have moored at T-5 have emitted low frequency sound that can be heard by some people on the hillside to the west. Such low frequency noise is less affected by obstructions and can travel longer distances than higher frequency sounds. There are no measurement data documenting the phenomenon of low frequency noise being received on the hillside, but we suspect such noise is generally restricted to older ships or ships where the boiler room and/or power generators are higher in the ship than is typical.

10,000 TEU ship was measured at 66 dBA at 100 feet, and a 14,000 TEU ship was estimated to be 68 dBA at 100 feet.

Ship-to-Shore Cranes – Ship-to-shore (STS) cranes are used to transfer containers on and off the ships. Such cranes are electrically powered, and other than emitting a whining sound from the motors and a clatter from cables and pulleys, these cranes are silent. STS crane noise is primarily directed downward and is not generally audible away from the crane. Ramboll Environ nevertheless measured the sound level of a new crane in operation. Scaled to a common reference distance of 100 feet, the electric crane generated a sound level of approximately 73 dBA when lifting a container (the loudest activity) and this noise is estimated to occur about 33% of the time.

Top-picks - A top-pick (TP) is similar to a large forklift except that it lifts containers from the top rather than underneath. The typical load/unload cycle begins when a hostler pulls a container on a truck chassis or specialized on-site container chassis to the stack for storage or the rail car for transport. A top-pick then lifts the container from the container chassis, the empty hostler drives out from under the container, and the top-pick places the container on the stack or rail car. Maximum sound levels from a top pick occur when the engine is operating at high rpm's, such as when it lifts a container.

It usually takes a top pick less than a minute to unload a container and stack it on a rail car or in the stack, and vice versa. Top-picks spend a considerable time either idling while waiting for an assignment or traveling to meet a truck. For purposes of this analysis, Ramboll Environ assumed that a top pick idles 25% of the time, travels around the yard 50% of the time, and is transferring a container on or off a truck 25% of the time. Based on a number of measurements of the Taylor "Big Red" top-picks operated at Terminal 5 previously and the typical operating scenario, the top-pick would generate an hourly Leq of 74 dBA at a distance of 100 feet. Measurements indicate the Fantuzzi and Mi-Jack top-picks operating at T-5 were slightly quieter, with a sound level of 72 dBA at a distance of 100 feet.

Rubber-Tired Gantry (RTG) Cranes - Rubber-tired gantry (RTG) cranes may be used to transfer containers between truck chassis and the stack. The RTGs would straddle the truck chassis and storage stack and move slowly back and forth the length of the stack transferring containers to and from the truck chassis. For this analysis, the RTGs were assumed to be powered by diesel engines. This analysis was based on manufacturer-provided sound level data for a Kalmar RTG. The specified sound level, scaled to a common reference distance of 100 feet, was 72 dBA.

Rail-Mounted Gantry Cranes (RMG) – With reconfiguration of the terminal under Alternative 3, containers could be transferred to and from the stacks and rail cars using rail-mounted gantry (RMG) cranes. The RMGs would be electric and would ride on steel wheels on fixed tracks. Noise from electrically-powered RMGs is typically due to the hoisting mechanical systems and movements on the rail. Ramboll Environ measured noise from RMGs at a different container terminal. The measured sound level during a container hoist was 63 dBA at 100 feet. The sound level during movement of the RMG over the rails was 60 dBA at 100 feet. For this analysis, Ramboll Environ estimated that the RMGs would be actively hoisting a container 20% of the time. The RMGs were estimated to be moving on the rails 33% of the time.

<u>Hostlers/Yard Tractors</u> – For the movement of containers on the terminal, containers are placed on a specialized wheeled container chassis, which is then hauled to the stacks or intermodal yard by a hostler (also called a yard tractor). A hostler is similar to a street-legal haul truck cab, but is restricted to terminal use. Sound level data for a hostler were captured at a container terminal for use in this analysis. A hostler passby was measured to be approximately 68 dBA at 100 feet.

<u>Transporters</u> – A transporter is any sort of container handling equipment (CHE) used to transport a container from one place to another. Transporters can be comprised of hostlers, straddle carriers, or other CHE capable of transferring containers or pulling containers on container chassis. Ramboll Environ measured a hybrid straddle carrier in operation at a different container terminal. The measured sound levels during idling, hoisting, and passby were 61, 66, and 62 dBA, respectively, at a distance of 100 feet.

<u>Truck Traffic</u> –Road trucks would continue to be used to carry containers to and from off-site destinations. Noise from road trucks was estimated using the FHWA Traffic Noise Model (TNM) module available in the CadnaA model.

<u>Refrigerated Containers (Reefers)</u> – Under any of the alternatives, reefers would be stored in stacks 3 to 4 containers high with their cooling units on. The measured sound level of a representative stack of reefers is 63 dBA at 100 feet.

<u>Train Arrivals and Departures</u> – With any of the proposed alternatives, trains approximately 7,500 feet in length would arrive at the terminal's working track, the locomotives would separate from the train, and a switch engine would break the train in pieces and move these to the intermodal yard for loading. Two locomotives on the front of the train would travel most of the way to the north end of the on-site tracks. A third locomotive at the rear of entering trains would not travel much further than the south entrance of the terminal. The noise analysis used the CadnaA FRA train noise module to estimate sound levels from a single train arriving at the terminal with two locomotives traveling to the north end of the site. The analysis also included the use of locomotive horns where the tracks cross right-of-way north of the West Marginal Way Southwest/Southwest Spokane Street intersection.

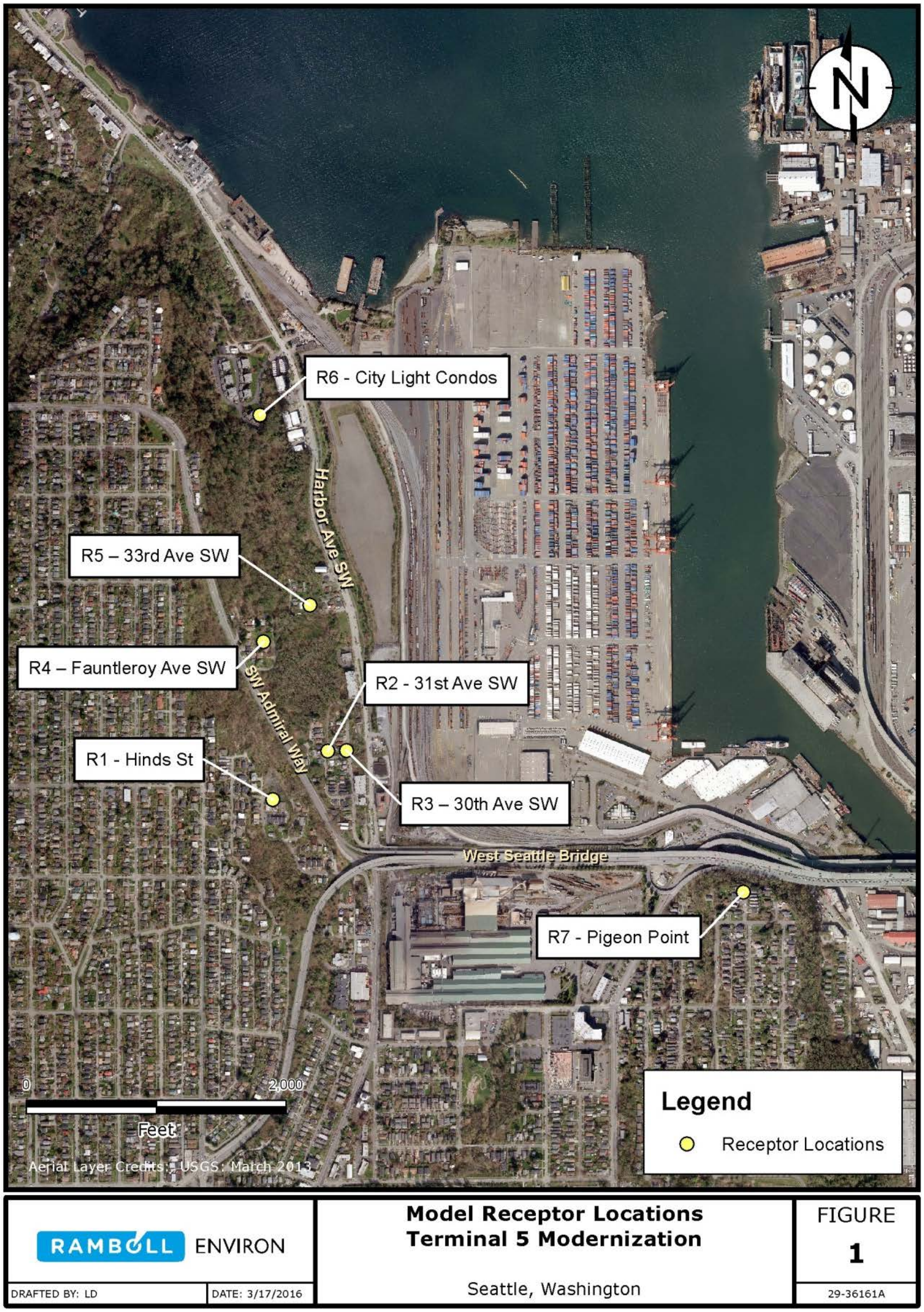


Figure 3. Noise Modeling Receptor Locations

4. POTENTIAL IMPACTS OF THE PROPOSED PROJECT

4.1 Alternative 1 – No Action - Impacts

4.1.1 Construction

The No Action Alternative would not require more than a nominal amount of construction and maintenance of existing facilities. No construction noise impacts would be expected.

4.1.2 Operation

Operation of the terminal under the No Action Alternative would continue in a similar fashion to the previous uses at the terminal. Under the old permit, the facility was allowed a throughput of up to 647k TEUs or equivalent, with requisite supporting vessels, CHEs, trains, and trucks.

Ramboll Environ assessed whether noise generated by on-site equipment and activities currently allowed under the existing permit would comply with the Seattle noise limits (**Table 2**, page 13). For this evaluation, Ramboll Environ used noise modeling assuming full operation of equipment to estimate resulting sound levels at receptors representing the residences nearest the project site. As identified in the equipment demand sheets for Alternative 1, the modeling considered ship-to-shore unloading and on-site operations in the stacks but excluded intermodal yard and gate operations during nighttime hours. (6) Results of the noise modeling, assuming the equipment usage identified in **Table 4** and the timing assumptions in the equipment demand sheet, are presented in **Table 5**.

As shown in **Table 5**, model-calculated operational sound levels associated with the Alternative 1 facility configuration received at residences nearest the on-site sources in the absence of noise mitigation measures comply with daytime and nighttime noise limits. This analysis assumed the intermodal yard and gate would only require a single, daytime shift.

In the past, occasional nighttime intermodal activity has occurred but typically at lower levels of activity than with full daytime operations. Measured levels of nighttime activity collected at the Hinds Street and 31st Avenue SW locations (**Figure 3**) during nighttime operations in the last several years have indicated that the facility was in compliance with the Seattle noise limits. It should be noted that background sound levels during these nighttime measurements were typically higher than sound levels from the facility, although some sources from the facility were sometimes audible.

(6) Moffatt and Nichol, Equipment Calculations, 647,000 TEU Scenario, 02/13/15

Table 5. Model-Calculated Sound Levels - Alternative 1 (dBA, Leq)

Receiver	Model-Calculated Sound Level
First Shift (8AM to 5PM), Noise Limit = 60 dBA	
R1 - Hinds St	56
R2 - 31st Ave SW	58
R3 – 30th Ave SW	59
R4 – Fauntleroy Ave SW	57
R5 – 33rd Ave SW	57
R6 - City Light Condos	57
R7 - Pigeon Point	55
Second Shift (6PM to 3AM), Most Stringent Noise Limit = 50 dBA	
R1 - Hinds St	47
R2 - 31st Ave SW	49
R3 – 30th Ave SW	49
R4 – Fauntleroy Ave SW	48
R5 – 33rd Ave SW	48
R6 - City Light Condos	48
R7 - Pigeon Point	48

4.2 Alternative 2 - Impacts

4.2.1 Construction

Construction activities associated with Alternative 2 were described in section 1.2. Noise from construction activities is subject to the Seattle noise limits (Table 2). Facility construction would be limited to daytime hours (7 AM to 10 PM weekdays and 9 AM to 10 PM weekends and holidays), and in general terms, the temporary nature of construction coupled with its restriction to daytime hours would reduce the potential for significant impacts from construction activities and equipment. More specifics are discussed below.

4.2.1.1 Typical Construction Activities

Table 6 shows the overall hourly noise levels (L_{eq}s) from various "typical" construction activities (upper portion of table) and the range of sound levels (i.e., minimum to maximum levels) emitted by individual pieces of equipment (lower portion of table). These levels give an idea of the relative sound levels that can be expected from different kinds of equipment. Existing residences south of the project site are more than 1,000 feet from the nearest proposed construction activities, and residences west of the site are more than 2,000 feet from the nearest proposed activities. In the absence of intervening terrain, structures, and/or dense vegetation, sounds from construction equipment and activities (usually point sources) decrease about 6 dBA for each doubling in distance from the source.

As shown in **Table 6**, the estimated hourly Leqs from even the nearest construction activities (more than 1,000 feet from the nearest residences) are mostly at or below the noise level limit of 60 dBA that would apply to long-term operational noise. Added to the fact that construction would be temporary and limited to daytime hours, there would be little if any potential for significant noise impacts from "typical" on-site construction activities.

Table 6. Noise Levels from Typical Construction Activities and Equipment (dBA)

Activity	**Range of Hourly Leqs**		
	At 1,000'	**At 2,000'**	**At 4,000'**
Clearing	57	51	51
Grading	50-62	43-56	37-50
Paving	47-62	40-56	34-50
Erection	47-58	40-52	34-46
Types of Equipment	**Range of Noise Levels**		
	At 1,000'	**At 2,000'**	**At 4,000'**
Bulldozer	51-70	45-64	39-58
Dump Truck	56-68	50-62	44-56
Scraper	54-67	48-61	42-55
Paver	60-62	54-56	48-50
Generators	45-56	39-50	33-44
Compressors	48-55	42-49	36-43
Source: EPA, 1971			

4.2.1.2 Pile Driving

The proposed project would require pile driving during rehabilitation of the wharf and stabilization of the slope. Pile driving would occur over 2,500 feet from the nearest residences west of the site and from 1,000 to 4,000 feet from the nearest residences south of the site. Ramboll Environ archived sound level measurement data of pile driving activities indicate that the hourly sound level (Leq) of pile driving at a distance of 100 feet is approximately 86 dBA. [7] The maximum sound level (L_{max}) of pile driving is estimated to be 104 dBA at a distance of 100 feet.

Ramboll Environ estimated pile driving sound levels at the residences nearest the site using the CadnaA noise model. The resulting sound levels were hourly L_{eq}s in the 40s to mid-50s dBA and L_{max}s in the mid-60s to mid-70s dBA at the nearest residences. Because of the large distances, estimated pile driving sound levels are greatly reduced at the nearest residences. As with "typical" construction, the model-calculated pile driving sound levels are generally below the limits the City of Seattle applies to long-term operational noise and well below the limits applied to impact (e.g., pile driving) sources. Therefore, no significant noise impacts would be expected during construction.

However, even with fairly low levels of pile driving noise, the unique nature of pile driving impact noise can result in the loudest sounds being audible at the residences nearest this activity. This noise could be perceived by some people as intrusive and possibly annoying, but the low overall levels would minimize the potential for impacts.

4.2.2 Alternative 2 Operational Noise

Under Alternative 2, operation of the terminal would be similar to the previous operation of the facility. The primary difference would be the accommodation of larger ships for loading and unloading, and densification of the operation by stacking more containers instead of placing containers on truck chassis.

At the projected facility opening in 2020, the terminal throughput would be expected to be approximately 647,000 TEUs. At this level of throughput, intermodal yard and gate operations are not expected to be necessary at night. [8]

With an expected annual growth rate of 4%, the terminal capacity under the Alternative 2 configuration would max out at 1.3 million TEUs in 2030. At this capacity, intermodal yard operations would be required at night to accommodate the throughput, but no nighttime gate operations would be expected.

4.2.2.1 Alternative 2 Compliance

Using the assumptions above and the equipment usage levels identified in **Table 4**, Ramboll Environ assessed whether noise generated by on-site equipment and activities would comply with the Seattle noise limits (**Table 2**, page 13). As discussed in Section 2.2 noise

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[7] Data from Ramboll Environ archive of pile driving measurements. The hourly L_{eq} included the placement and driving of two piles in a one-hour period.

[8] Moffatt and Nichol, Equipment Calculations, 647,000 TEU Scenario, 02/13/15

from trains is exempt from the limits and was not included in this portion of the analysis. Results of the compliance assessment are presented in **Table 7**.

As shown in **Table 7**, model-calculated sound levels with the equipment required to handle a throughput of 647,000 TEUs comply with both Seattle's 60-dBA daytime limit and 50-dBA nighttime noise limit at residences nearest the site.

With a capacity of 1.3 million TEUs, model-calculated sound levels continue to comply with the daytime noise limit of 60 dBA. However, at this throughput, nighttime intermodal yard operations will be required, and noise from CHE operating in the IY result in model-calculated sound levels exceeding the nighttime noise limit of 50 dBA.

Because model-calculated sound levels with a throughput of 1.3 million TEUs exceeded the nighttime noise limits, the analysis also considered the following potential noise mitigation measures:

- Use of top-picks with a sound level equivalent to a Fantuzzi model (i.e., 72 dBA at a distance of 100 feet) or quieter in lieu of louder top-picks (e.g., a Taylor "Big Red" top-pick emitting a 74 dBA sound level)

Although the mitigation reduced the sound levels somewhat (see the "With Mitigation" columns in **Table 7**), the model-calculated sound levels continue to exceed the Seattle noise limits.

Table 7. Model-Calculated Sound Levels - Alternative 2 (dBA, Leq)

Receiver	Model-Calculated Sound Level		
	647k TEU (~2020)	1.3M TEU (~2030)	
	No Mitigation	No Mitigation	With Mitigation
First Shift (8AM to 5PM), Noise Limit = 60 dBA			
R1 - Hinds St	55	57	56
R2 - 31st Ave SW	58	59	58
R3 – 30th Ave SW	59	60	59
R4 – Fauntleroy Ave SW	56	57	56
R5 – 33rd Ave SW	57	58	57
R6 - City Light Condos	56	57	56
R7 - Pigeon Point	54	56	55
Second Shift (6PM to 3AM), Most Stringent Noise Limit = 50 dBA			
R1 - Hinds St	48	55	52
R2 - 31st Ave SW	49	56	54
R3 – 30th Ave SW	50	57	55
R4 – Fauntleroy Ave SW	49	54	52
R5 – 33rd Ave SW	49	54	52
R6 - City Light Condos	49	56	53
R7 - Pigeon Point	48	52	51
Shaded cells identify model-calculated sound levels exceeding the applicable noise limit.			

4.2.2.2 Alternative 2 Noise Impact due to Sound Level Increases

In addition to considering the potential compliance of the facility with the Seattle noise limits, Ramboll Environ also assessed the potential for noise impacts due to sources directly attributable to the project (including trains arriving and locomotives departing from the site) increasing the sound levels in the vicinity of the site.

In the absence of applicable standards or criteria for assessing impacts due to sound level increases, Ramboll Environ applied the FTA/FRA review methodology and noise impact criteria based on the 24-hour day-night sound level (L_{dn}). (See discussion in section 2.2.2.)

As part of calculating the L_{dn}, Ramboll Environ assumed first shift equipment would operate between 8 AM and 5 PM and that second shift equipment would operate between 6 PM and 3 AM. In addition, the average 1.3 and 2.6 daily train arrivals and departures for throughputs of 647,000 TEUs and 1.3 million TEUs, respectively, were assumed to be split evenly over the first and second shifts.

The calculated cumulative sound levels, sound level increases, and determinations of the potential for noise impacts (under FTA criteria) are displayed in **Table 8**. As shown in **Table 8**, Alternative 2 would not result in noise impacts at the beginning when throughput is at or near 647,000 TEUs. By 2030, when the facility would be at or near its capacity of 1.3 million TEUs, all of the receptor locations could experience moderate noise impacts from the project, but none of the impacts would be classified as severe. With mitigation, the moderate noise impacts at two receptor locations would reduce to no impact.

It should be noted that the predicted increases over existing sound levels are based on a conservative representation of existing sound levels. Most of these sound levels are from measurements taken in 1993 or 1999. Invariably, the background sound levels have increased in the past 15-20 years with an increase in development and traffic in the area. In addition, the background levels used for this assessment do not include sounds from operation of the terminal between 1999 and 2014. Therefore, this can be considered a conservative assessment of impacts due to increases.

Regardless, even with model-calculated sound levels that exceed the noise limits and using conservative baseline sound levels, no severe noise impacts are anticipated, using the FTA noise impact criteria.

Table 8. Estimated Impacts due to Increases with Alternative 2 using FTA Impact Criteria (Ldn)

Model Receptor Locations	Existing Ldn	Increase for FTA Impact		Alt2 - 647k			Alt2 - 1.3M No Mitigation			Alt2 - 1.3M With Mitigation		
		Moderate	Severe	Project Ldn	Cumulative	Increase	Project Ldn	Cumulative	Increase	Project Ldn	Cumulative	Increase
R1 - Hinds St	64	1.5	3.9	55	65	0.5	60	65	1.4	58	65	1.0
R2 - 31st Ave SW	64	1.5	3.9	57	65	0.7	61	66	**1.9**	60	65	1.4
R3 – 30th Ave SW	64	1.5	3.9	57	65	0.9	62	66	**2.3**	61	66	**1.7**
R4 – Fauntleroy Ave SW	60	2.0	5.0	55	61	1.3	60	63	**2.8**	58	62	**2.1**
R5 – 33rd Ave SW	60	2.0	5.0	56	61	1.4	60	63	**2.8**	58	62	**2.1**
R6 - City Light Condos	60	2.0	5.0	55	61	1.3	60	63	**3.1**	58	62	**2.2**
R7 - Pigeon Point	74	0.5	2.3	63	74	0.3	66	75	**0.6**	66	75	**0.6**
Bold values identify potential moderate noise impacts as defined by FTA.												

4.3 Alternative 3

4.3.1 Construction

Construction activities associated with Alternative 3 were described in section 1.2. Construction activities required for modernization of the wharf to accommodate larger cranes would be similar to these activities with Alternative 2, and noise impacts from the associated pile driving would be the same under Alternative 3 as discussed previously for Alternative 2.

Upland "typical" construction activities would be more extensive under Alternative 3 than Alternative 2, but the worst-case upland activities would remain similar to those discussed in Section 4.2.1.1. Because construction would be limited to daytime hours, no significant noise impacts would be expected.

This configuration of the T-5 facility also would include modifications of the intermodal yard to allow the use of electric RMGs. This additional construction would be limited to daytime hours and also would not be expected to result in significant noise impacts.

4.3.2 Alternative 3 Operational Noise

Under Alternative 3, major upgrades to the facility would occur and much of the equipment would be electrically powered. The diesel TPs and RTGs would be replaced with electric RMGs, substantially reducing noise from CHE.

Even with major upgrades of the facility, the terminal throughput would still be expected to start at approximately 647,000 TEUs in 2020 due to market conditions. At this level of throughput, gate operations are not expected to be necessary at night. [9]

With an expected annual growth rate of 4%, the terminal throughput would increase to 1.3 million TEUs in 2030 and reach its capacity of 1.7 million TEUs in 2040. With both these more distant future year throughput scenarios, intermodal yard and gate operations would be required at night.

4.3.2.1 Alternative 3 Compliance

Using the assumptions above and the equipment usage levels identified in **Table 4**, Ramboll Environ assessed whether noise generated by on-site equipment and activities would comply with the Seattle noise limits (**Table 2**, page 13). As discussed in section 2.2.1, noise from trains is exempt from the limits and was not included in this portion of the analysis. Results of the compliance assessment are presented in **Table 9**.

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[9] Moffatt and Nichol, Equipment Calculations, 647,000 TEU Scenario, 02/13/15

As shown in Table 9, model-calculated sound levels with the equipment required to handle a throughput of 647,000 TEUs comply with both Seattle's 60-dBA daytime limit and 50-dBA nighttime noise limit at residences nearest the site.

With a throughput of 1.3 – 1.7 million TEUs, model-calculated sound levels continue to comply with the daytime noise limit of 60 dBA. However, nighttime gate operations would be required with these levels of throughput, and model-calculated sound levels exceed the nighttime noise limit of 50 dBA due primarily to truck noise.

Table 9. Model-Calculated Sound Levels - Alternative 3 (dBA, Leq)

Model Receptor Locations	647k TEU (~2020)	1.3M TEU (~2030)	1.7M TEU (~2040)
	No Mitigation	No Mitigation	No Mitigation
First Shift (8AM to 5PM), Noise Limit = 60 dBA			
R1 - Hinds St	53	54	56
R2 - 31st Ave SW	56	57	59
R3 – 30th Ave SW	56	57	60
R4 – Fauntleroy Ave SW	55	57	58
R5 – 33rd Ave SW	57	59	60
R6 - City Light Condos	54	56	58
R7 - Pigeon Point	52	52	56
Second Shift (6PM to 3AM), Most Stringent Noise Limit = 50 dBA			
R1 - Hinds St	47	52	54
R2 - 31st Ave SW	49	55	57
R3 – 30th Ave SW	49	55	58
R4 – Fauntleroy Ave SW	48	54	56
R5 – 33rd Ave SW	48	56	58
R6 - City Light Condos	49	54	56
R7 - Pigeon Point	49	51	55
Shaded cells identify model-calculated sound levels exceeding the applicable noise limit.			

Because model-calculated sound levels with a throughput of 1.3 – 1.7 million TEUs exceed the nighttime noise limits, the analysis also considered the following mitigation measures:

- Installing noise barriers to the height of the reefer stacks, on the west sides of the reefer support structures
- Constructing 20-foot high noise walls along the west side of the entrance and gate areas
- Constructing 20-foot high noise walls on the east sides of the proposed substation yards

These potential mitigation measurements were determined to be ineffective. Due to the physical configuration of the gate and on-site roads, it was not possible to substantially reduce on-site truck noise with noise walls. And because the nighttime noise levels are dominated by on-site trucks, using noise barriers to reduce reefer noise also resulted in minimal reduction in overall sound levels. In the absence of effective mitigation measures, the model-calculated sound levels continue to exceed the Seattle noise limits.

4.3.2.2 Alternative 3 Noise Impact due to Sound Level Increases

As done for Alternative 2, Ramboll Environ assessed the potential for noise impacts with Alternative 3 due to project-related sources increasing the sound levels in the vicinity of the site using FTA/FRA noise impact criteria based on the 24-hour day-night sound level (L_{dn}).

As part of calculating the L_{dn}, Ramboll Environ assumed first shift equipment would operate between 8 AM and 5 PM and that second shift equipment would operate between 6 PM and 3 AM. In addition, the average 1.3, 2.6, and 3.5 daily train arrivals and departures for throughputs of 647,000, 1.3 million, and 1.7 million TEUs, respectively, were assumed to be split evenly over the first and second shifts.

The calculated cumulative sound levels, sound level increases, and determinations of the potential for noise impacts (under FTA criteria) are displayed in **Table 10**. As shown in **Table 10**, Alternative 3 would not result in noise impacts at the beginning of its operation in 2020 when throughput is at or near 647,000 TEUs. By 2030, when the facility would be at or near its capacity of 1.3 million TEUs, many of the receptor locations would experience moderate impacts from the project, but none of the impacts would be classified as severe. With mitigation, the moderate noise impacts would be reduced. By 2040, when the facility would be at or near its capacity of 1.7 million TEUs, most of the receptor locations would experience moderate impacts from the project, but none of the impacts would be classified as severe. Mitigation reduces the levels nominally, but moderate noise impacts would still occur at the same receptor locations.

It should be noted, again, that the predicted increases over existing levels are based on conservative existing sound levels. Most of these levels are fairly old, taken in either 1993 or 1999, and they do not include sounds from the terminal that operated on the site until 2014. Therefore, this can be considered a conservative assessment of impacts due to increases.

Again, even with model-calculated sound levels that exceed the noise limits and using conservative baseline sound levels, no severe noise impacts are anticipated, using the FTA noise impact criteria.

Table 10. Estimated Impacts due to Increases with Alternative 3 using FTA Impact Criteria (Ldn)

MODEL RECEPTOR LOCATIONS	Existing Ldn	Increase for FTA Impact		647k TEU (~2020)			1.3M TEU (~2030)			1.7M TEU (~2040)		
		Moderate	Severe	Project Ldn	Cumulative	Increase	Project Ldn	Cumulative	Increase	Project Ldn	Cumulative	Increase
R1 - Hinds St	64	1.5	3.9	54	64	0.4	58	65	0.9	60	65	1.4
R2 - 31st Ave SW	64	1.5	3.9	56	65	0.6	60	66	1.5	62	66	2.2
R3 – 30th Ave SW	64	1.5	3.9	56	65	0.6	60	65	1.5	63	66	2.4
R4 – Fauntleroy Ave SW	60	2.0	5.0	55	61	1.1	59	63	2.7	61	64	3.6
R5 – 33rd Ave SW	60	2.0	5.0	56	61	1.3	61	64	3.5	63	64	4.5
R6 - City Light Condos	60	2.0	5.0	55	61	1.1	59	62	2.4	60	63	3.2
R7 - Pigeon Point	74	0.5	2.3	63	74	0.3	66	75	0.6	67	75	0.8

Shaded values identify potential moderate noise impacts under FTA criteria. No severe noise impacts were identified.

5. MITIGATION

5.1 Construction

5.1.1 General Construction Activities and Equipment

Typical construction activities will be limited to daytime hours (i.e., 7 AM to 10 PM weekdays, 9 AM to 10 PM weekends and holidays).

Some relatively simple and inexpensive practices can reduce the extent to which people are affected by construction noise. Examples include using properly sized and maintained mufflers, engine intake silencers, engine enclosures, and turning off idle equipment. Construction contracts can specify that mufflers be in good working order and that engine enclosures be used on equipment when the engine is the dominant source of noise.

Substituting hydraulic or electric models for impact tools such as jack hammers, rock drills, and pavement breakers could reduce construction and demolition noise. Electric pumps could be specified if pumps are required.

Although as safety warning devices (e.g., back-up alarms) are exempt from noise ordinances, these devices emit some of the most annoying sounds from a construction site. One potential mitigation measure would be to ensure that all equipment required to use backup alarms utilize ambient-sensing alarms that broadcast a warning sound loud enough to be heard over background noise but without having to use a preset, maximum volume. A better alternative would be to use broadband backup alarms instead of typical pure tone alarms. Such devices have been found to be very effective in reducing annoying noise from construction sites.

Although noise from impact pile driving may occasionally be annoying, model-calculated pile driving sound levels are well below the limits applied to impact (e.g., pile driving) sources. The use of impact equipment (e.g., pile drivers) will be limited to between the hours of 8 AM and 5 PM weekdays and between 9 AM and 5 PM weekends and holidays.

Details on how the Port will manage construction noise will be included in a construction noise management plan that will be developed prior to start of construction in consultation with Seattle Department of Construction & Inspections (DCI).

5.2 Operation

5.2.1 On-Site Terminal Source Mitigation

Although all of the alternatives considered indicate future compliance with Seattle's daytime noise limits, the model-calculated sound levels of the alternatives when throughput exceeds 1.3 million TEUS would not comply with the more stringent nighttime noise limit of 50 dBA.

The noise model used worst-case assumptions regarding peak operations equipment numbers, locations, and sound levels. The model lacks the actual operating parameters, equipment numbers, and specific equipment sound levels that will become available when a specific terminal manager develops its operational plan. However, the fact remains that under a variety of operational conditions with throughput beyond 1.3 million TEUs, nighttime noise from the terminal has the potential to exceed Seattle's nighttime noise limits.

For this assessment, a number of physical infrastructure improvements and equipment mitigation measures were considered as test compliance solutions. The mitigation measures considered, and the resulting likelihood of compliance with the daytime or nighttime noise limits are listed in Table 11.

Table 11. Mitigation Measures Considered

<table>
<tr><th>Scenario Considere</th><th>Mitigation Measures</th><th>Comply Daytime</th><th>Comply Nighttime?</th></tr>
<tr><td>Alt 1, 647k TEU</td><td>None</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Alt 2, 647k TEU</td><td>None</td><td>Yes</td><td>Yes</td></tr>
<tr><td rowspan="2">Alt 2, 1.3M TEU</td><td>Require the use of TPs that are at least 2-dBA quieter than the Taylor TPs used by the previous tenant (e.g., Fantuzzi TPs)</td><td rowspan="2">Yes</td><td rowspan="2">No</td></tr>
<tr><td>Construct 20-ft walls west of entrance and gate</td></tr>
<tr><td>Alt 3, 647k TEU</td><td>None</td><td>Yes</td><td>Yes</td></tr>
<tr><td rowspan="3">Alt 3, 1.3M TEU</td><td>Install noise barriers to the height of the reefer stacks, on the west sides of the reefer support structures</td><td rowspan="3">Yes</td><td rowspan="3">No</td></tr>
<tr><td>Construct 20-foot high noise walls along the west side of the entrance and gate areas</td></tr>
<tr><td>Construct 20-foot high noise walls on the east sides of the proposed substation yards</td></tr>
<tr><td rowspan="3">Alt 3, 1.7M TEU</td><td>Install noise barriers to the height of the reefer stacks, on the west sides of the reefer support structures</td><td rowspan="3">Yes</td><td rowspan="3">No</td></tr>
<tr><td>Construct 20-foot high noise walls along the west side of the entrance and gate areas</td></tr>
<tr><td>Construct 20-foot high noise walls on the east sides of the proposed substation yards</td></tr>
</table>

Although the mitigation elements reduced the sound levels somewhat, the model-calculated sound levels continue to exceed the Seattle nighttime noise limits. However, specific operational details and potential mitigation measures cannot be identified until a terminal operator is selected. These operational noise controls will be developed as part of an Operational Noise Management Plan in consultation with the City of Seattle Department of Construction and Inspections (DCI).

5.2.2 Operational Noise Management Plan

Noise modeling for the proposed Project included numerous assumptions regarding the potential modes of operations, equipment involved, locations of equipment being used, and amounts of cargo being handled. The noise modeling represents worst case, peak operations of the expected alternatives based on maximum throughputs of the alternatives. This analytical process is a reasonable way to estimate possible future activities in lieu of specific information that is not available at this time. Modeling based on these assumptions indicated a potential issue for compliance with the City of Seattle noise limits at some point in the future.

Because the noise modeling indicated a potential for the facility to exceed Seattle's nighttime noise limits under Alternatives 2 and 3, an Operational Noise Management Plan (ONMP) will be used to provide a compliance strategy for the facility. An ONMP can be used as an adaptive tool to identify reasonable and feasible best practices to ensure compliance with the noise limits. Advanced noise modeling and assessment, details regarding a noise monitoring program, and procedures for response to noise complaints will be developed as part of the ONMP in facilitated collaboration with all affected parties to ensure that noise levels will be in accordance with noise code and local approvals.

5.2.3 Annoyance Noise Control Measures Included in the Proposed Project

If the proposed project proceeds it would include several measures intended to reduce generation of what might be perceived as annoying noise by project related sources. These noise control measures that would be implemented as part of the proposed project include the following:

- Use of ambient-sensing, broadband back-up alarms on all mobile equipment instead of using standard pure tone alarms. This would remove one of the most potentially annoying noise sources from the facility.
- Addition of safety measures to the rail corridor between the bridge across the Duwamish and the terminal. Adding safety measures to the corridor, such as chain link fencing, crossing gates, and wayside horns at suitable at-grade crossings in all four quadrants of each driveway would substantially improve the safe operation of trains. As a result, the need to sound audible alarms should be reduced. These

measures could also be used by the City of Seattle as a basis to begin the process of requesting the corridor be converted into a railroad quiet zone.

- Reduction in noise from on-vessel power generators used for hoteling due to the provision of shore power for moored vessels. This change has the potential to reduce low frequency noise from moored vessels that has in the past been reported as intrusive by some residents on the hill west of the facility. In addition, if noise complaints are received related to a specific hoteling vessel, and if subsequent noise measurements indicate that the vessel is emitting excessive levels of low frequency noise (as determined by a methodology identified in consultation with the City of Seattle DCI as part of the Operational Noise Management Plan), then that specific vessel will be required to use shore power on any subsequent visits to Terminal 5, if possible.

These noise control measures have the potential to reduce or eliminate what have been identified as some of the most annoying facility related noise sources.

6. REFERENCES

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Moffatt and Nichol

Alt 1 Equipment Calculations, 647,000 TEU Scenario, 02/13/15

Alt 2 Equipment Calculations, 647,000 TEU Scenario, 02/13/15

Alt 2 Equipment Calculations, 127 M TEU Scenario, 12/22/15

Alt 3 Equipment Calculations, 647,000 TEU Scenario, 02/29/16

Alt 3 Equipment Calculations, 127 M TEU Scenario, 01/11/16

Alt 3 Equipment Calculations, 17 M TEU Scenario, 02/13/15

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1971. *Noise from Construction Equipment and Operations, Building Equipment, and Home Appliances*. NTID300.1

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ATTACHMENT A: HISTORICAL EXISTING SOUND LEVELS

The SLM locations depicted in **Figure A1** include four locations (in purple) used in collecting 24-hour baseline data in the late 1990s and two locations (in yellow) of more recent nighttime hour measurements taken to assess compliance of noise from intermodal yard activities with the Seattle noise limits.

The hourly sound measurements depicted in **Figure A2** were taken to establish baseline 1-hour sound levels in most hours of the day. These levels characterize the acoustic environment at four off-site residential locations prior to major operations at T-5.

An hour of 1-second sound level data for the Hinds and Vanek locations are depicted in **Figure A3** and **Figure A4**.

Figure A1. Historical Baseline and Recent Off-Site SLM Locations

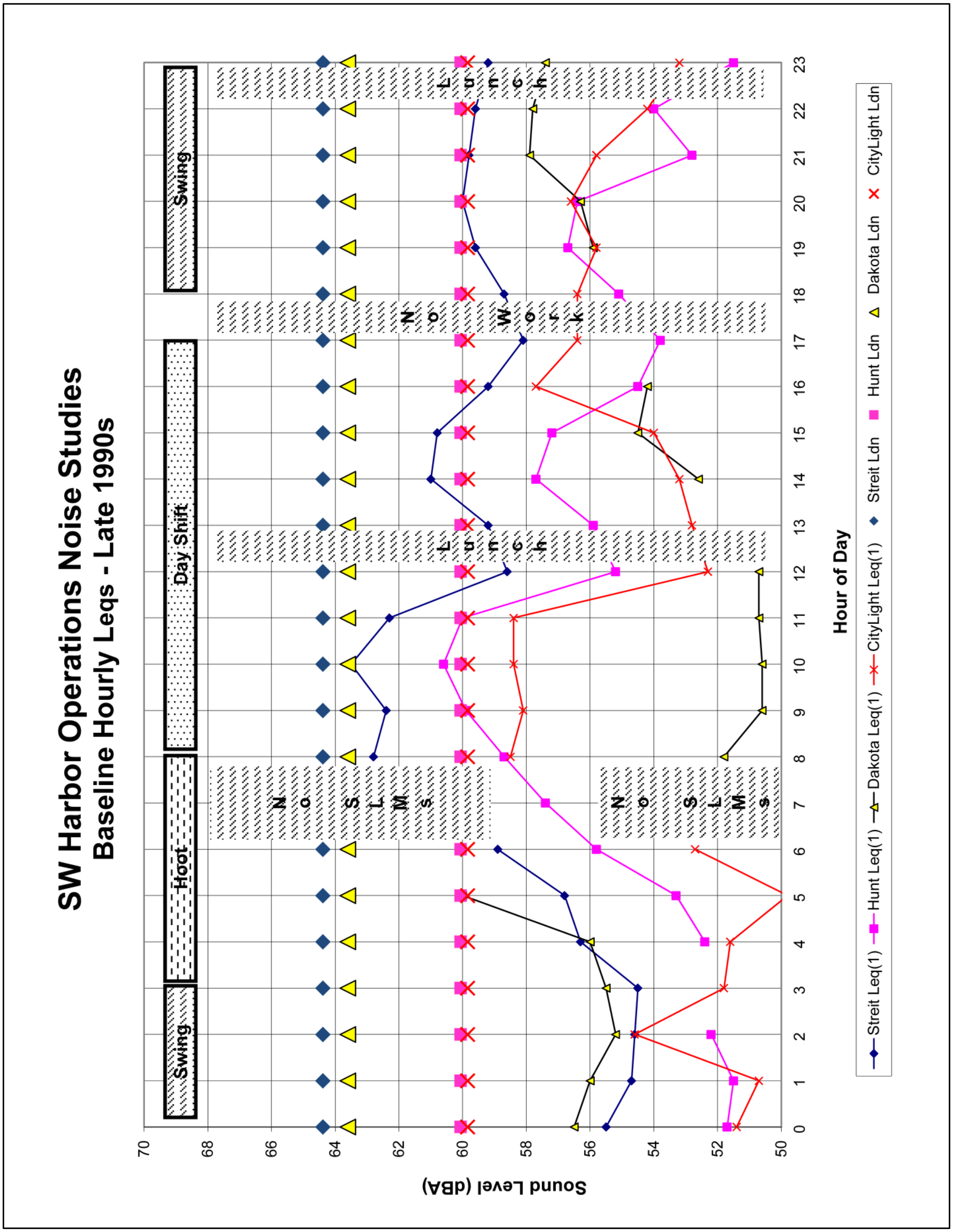

Figure A2. Historical Baseline Sound Levels near Project Site

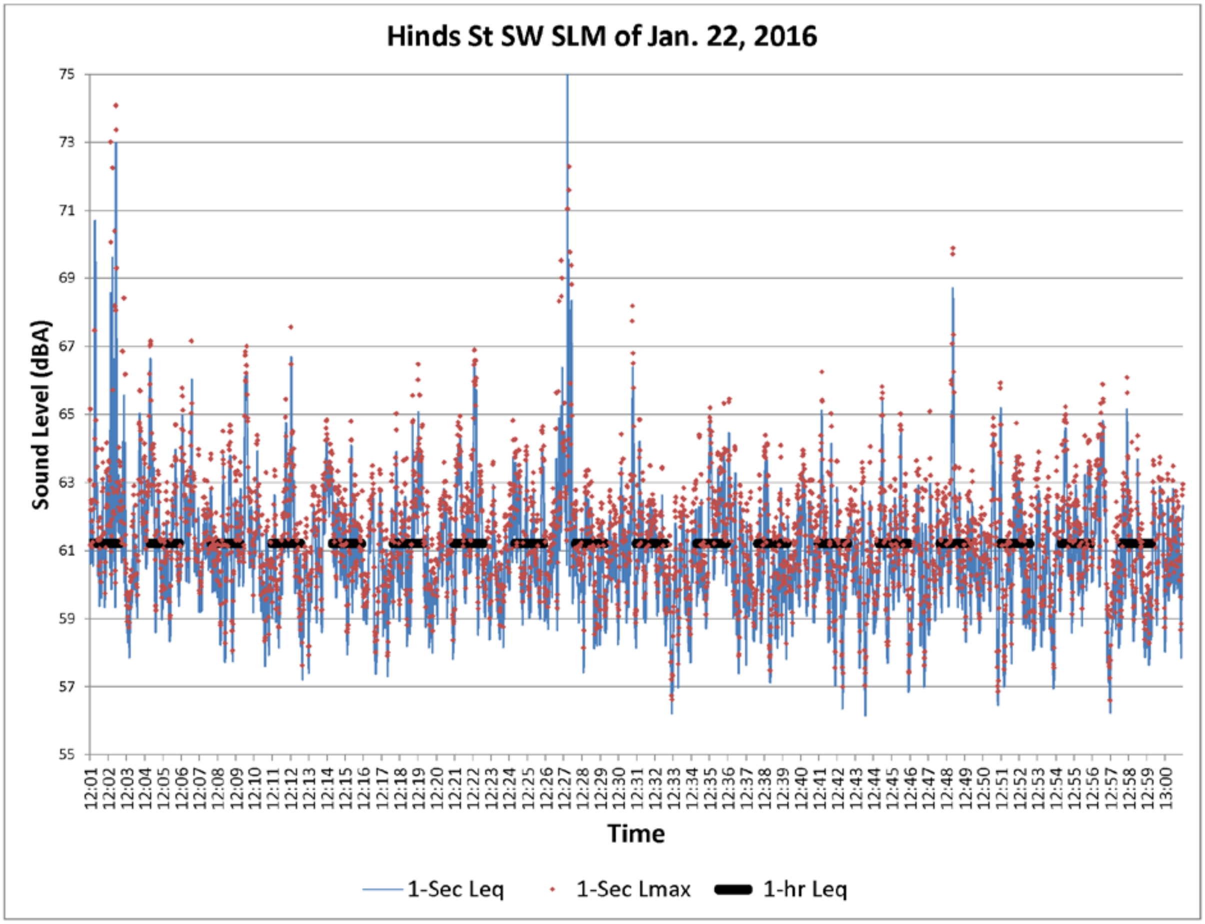

Figure A3. Midday Sound Levels at Hinds St. Location in January 2016

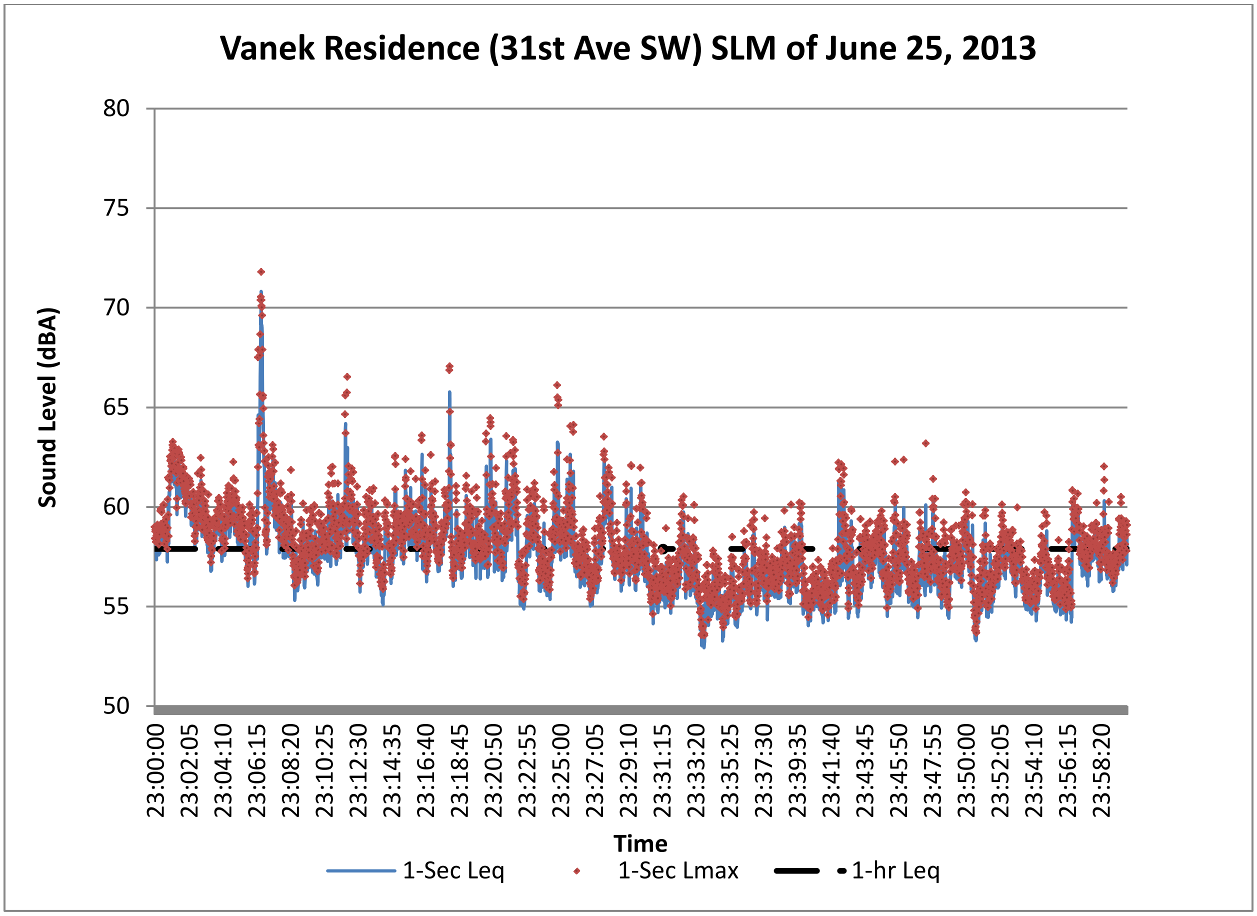

Figure A4. Nighttime Sound Levels at 31st Ave SW Location in June 2013

Appendix C
Transportation Technical Report

REVISED
TRANSPORTATION TECHNICAL REPORT FOR FINAL EIS

TERMINAL 5 IMPROVEMENT PROJECT

Prepared for:
Port of Seattle

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OCTOBER 6, 2016

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GLOSSARY OF TERMS and ACRONYMS

AWDT – Average weekday daily traffic.

Container – The box used to transport goods by several modes, including truck, rail, and ship. Containers come in a range of sizes from 20-feet long to 48-feet long. The most common containers are 40-feet long.

Container terminal – Major transportation transfer points where import containers are unloaded from ships and transferred to trucks or rail for inland delivery to either intermodal rail hubs or regional businesses. Export cargo also passes through terminals in the reverse direction, arriving by truck or rail and loaded onto ships.

DEIS – Draft Environmental Impact Statement.

Demurrage – Ancillary cost that represents liquidated damages for delays.

Dray – The movement of cargo by truck. In the Port of Seattle area, a “dray trip” generally refers to the short truck trip between a marine terminal and an intermodal rail terminal. Containers that are moved by truck to local or regional businesses are simply referred to as truck trips.

FGTS – Freight and goods transportation system designated by the Washington State Department of Transportation.

FEIS – Final Environmental Impact Statement.

Intermodal – A transfer of cargo from one mode to another. In the shipping business, an “intermodal container” generally refers to one that will be transported from or to a ship by rail. Terminal 5 has an on-dock intermodal rail yard that allows the direct transfer of containers between rail and ship using yard equipment. However, it is expected that some containers will be trucked (see definition for “dray”) between the marine terminal and the near-dock rail yards operated by the BNSF Railway and Union Pacific (UP) Railroad.

Near-Dock Intermodal Yard – These include the BNSF SIG/North SIG Yard and the UP Argo Yard.

NWSA – Northwest Seaport Alliance, the partnership entity comprised of the Port of Seattle and Port of Tacoma charged with operating cargo terminal facilities in Elliott Bay and Commencement Bay.

On-Dock Intermodal Yard – The rail yard at Terminal 5.

OCR – Optical character recognition. OCR portals are positions at terminal entry and exit points to automatically read identification numbers on trucks, chassis (the trailer on which the container is transported) and containers.

Panamax/Post-Panamax – Panamax-class ships are limited by the size of the original Panama Canal, and are capable of carrying 5,000 TEUs. The existing berth and cranes at Terminal 5 have a reach that can accommodate up to 6,000 TEU vessels. Vessels capable of carrying 10,000 to 18,000 TEU capacities have started to be used on routes to other West Coast terminals. These are often referred to as Post-Panamax, Super Panamax, and Ultra Panamax vessels depending on the size. Vessels of that size would call on several ports during a West Coast circuit, and typically discharge only a portion of their capacity at one port. With upgrades to the berth, cranes, and uplands, Terminal 5 would be able to support 18,000 TEU vessels.

RFID – Radio frequency identification. These devices are used to track truck and container movements through the terminal gates.

RMG – Rail-mounted gantry crane. The largest type of equipment used to lift and stack containers. They are guided by fixed rails, and although not as mobile as top-picks or RTGs, allow the yard to be more densely stacked, which increases capacity.

RTG – Rubber-tired gantry crane. Yard equipment used to lift and stack containers in the yard. Will typically span over trucks, railcars and container stacks.

SDOT – Seattle Department of Transportation.

Switch – Movement of train segments when building or decoupling a full train. For example, when decoupling a train, the full train will pull into a storage track and drop a segment of the train on those tracks, and then pull forward and back into another storage track and drop another segment, and so on until the entire train is decoupled from the engine. Train building reverses this process.

TEU – Twenty-foot Equivalent Unit. A unit of measure used in the shipping industry. A 40-foot container equals two TEUs. In recent years, Port of Seattle shipments have averaged 1.74 TEUs per container.

Throughput – Volume of container cargo that passes through a terminal, generally measured in TEUs per year.

Top Pick – Yard equipment that is used to lift containers off or onto a truck or rail car, and also used to stack containers in the yard.

TWIC - Transportation Worker Identification Credential, which is issued by the U.S. Department of Homeland Security, and is required to access Terminal 5.

WSDOT – Washington State Department of Transportation.

1. INTRODUCTION

The Port of Seattle (Port) is proposing improvements to Terminal 5 that would rehabilitate the pier and deepen the berth to enable larger ships to utilize the terminal, and increase the terminal's capacity with crane and upland improvements. This Transportation Technical Report was prepared to support the project's Final Environmental Impact Statement (FEIS). It evaluates the transportation effects of potential terminal improvements, and compares those to conditions that would occur if the existing terminal configuration and facilities were to remain. Terminal 5 is currently vacant while the Port seeks a new tenant; information provided in this report based upon observed conditions through 2013, the most recent year in which the terminal was fully occupied. Figure 1 shows the site location and project vicinity.

1.1. Project Alternatives

The following summarizes the project alternatives evaluated in this report. Full descriptions are provided in the FEIS.

1.1.1. Alternative 1 – No Action

The No Action Alternative assumes that no improvements would be made to the existing 197-acre site other than routine maintenance and repair work. The Terminal 5 upland and waterfront area would continue as a cargo terminal transportation facility with cargo marshalling (sorting), cargo storage, cargo trans-shipments, and vessel moorage. The capacity of the terminal would be defined by the numbers and sizes of vessels capable of being serviced by the height and reach capability of the existing six cranes at the terminal. It is assumed that the No Action Alternative would accommodate 647,000 TEUs per year, which is about 95% of the 684,000 TEUs per year established by the *Southwest Harbor Cleanup and Redevelopment Project Environmental Impact Statement*[1] for the original Terminal 5 improvements.

Under the No Action Alternative, container storage and handling are assumed to be similar to prior operations with 70% to 80% of the container yard being used to store containers directly on road chassis (wheeled operation), and empty and rail cargo being grounded storage (containers stacked on the pavement) served by top picks. The terminal would also be capable of accommodating other marine cargo uses such as breakbulk or neo-bulk (goods that are loaded individually, and not in containers) and other general marine uses. The No Action Alternative would preclude super post-Panamax vessels from utilizing the site since they could not be accommodated by the existing wharf or cranes.

1.1.2. Alternative 2 – Wharf Improvements, Increased Cargo Handling

Alternative 2 would rehabilitate the existing Terminal 5 container cargo pier and deepen the existing navigational vessel berth access; it would also make crane and upland improvements required for the terminal to accommodate loading and unloading of two large vessels, each with a capacity of up to 18,000 TEUs. The upland container yard storage area would be changed from a wheeled operation to a grounded operation, served by a mixture of RTGs and top-picks. No substantial changes are proposed to the upland buildings, intermodal rail facilities, or truck gates. With the Alternative 2 improvements, the terminal's throughput is estimated at 1.3 million TEUs per year.

[1] Port of Seattle. Draft EIS published January 1994; Final EIS published November 1994.

Figure 1. Vicinity Map

Source: Port of Seattle, August 2016.

1.1.3. Alternative 3 – Wharf Improvements plus Upland Improvements

Alternative 3 proposes the cargo wharf and vessel berth improvements identified in Alternative 2 combined with substantial improvements to the upland cargo marshalling area to increase overall terminal throughput to 1.7 million TEUs per year. The wharf and crane improvements would allow simultaneous loading and unloading of two 18,000 TEU vessels. The container yard would be enlarged through relocation or demolition of the freight station, transit shed, maintenance, repair buildings, and operations buildings. The truck gate would be relocated, and the existing intermodal rail yard would be reconfigured with additional rail lines and concrete or rail runways for RTG or RMG equipment. The container yard capacity would be increased through use of grounded container storage served by RTG or RMG cranes.

1.2. Transportation-related Container Terminal Operations

This section provides an overview of various elements of container terminal operations that may affect the transportation system. The effects on these elements with each of the three alternatives are also described.

1.2.1. Throughput and Vessel Calls

The Northwest Seaport Alliance (NWSA), the new partnership between the Port of Seattle and Port of Tacoma, anticipates that larger vessels will dominate future ship calls to the Pacific Northwest. Improvements at Terminal 5 are proposed to accommodate the larger ships. If the Alternative 2 or 3 improvements are not made (No Action Alternative), Terminal 5 would not be able to accommodate larger ships because of limitations in the crane height and overreach. With the ability to serve larger ships, the number of vessel calls per week is estimated to decrease from six per week under the No Action Alternative to four per week with Alternatives 2 or 3.

An analysis was performed by Moffatt & Nichol to determine the potential throughput that could be accommodated by the terminal given the potential berth capacity, container yard area, storage density, peaking factors associated with larger ships, and container dwell time in the terminal. Alternative 1 (No Action Alternative) assumes an annual throughput at Terminal 5 of 647,000 TEUs. Alternative 1 assumes that existing cranes would continue to be used, and that the vessel calls would be similar to what occurred previously when an average of six vessels per week called at the terminal. The vessels reflected a mix of sizes, and only a portion of the vessel capacity was unloaded from or loaded onto each ship.

With Alternatives 2 or 3, the improved pier and deeper berth would allow larger ships to call at Terminal 5. For Alternative 2, which would have modest upland improvements, the throughput is estimated at 1.3 million TEUs per year. For Alternative 3, which would have increased container yard and intermodal yard capacities, the throughput is estimated to be 1.7 million TEUs per year.

The range of volumes proposed in Alternatives 2 and 3 could be achieved with various vessel service call scenarios. For the purpose of this analysis, a total of four ships per week were assumed: two 18,000 TEU ships and two 8,000 TEU ships. Table 1 summarizes the vessel calls and throughput assumed for each alternative.

Table 1. Terminal Throughput and Vessel Call Scenarios

	Alternative 1 (No Action) No Improvements			Alternative 2 Wharf Improvements			Alternative 3 Wharf + Upland Improvements		
Weekly Service	Vessel Capacity (TEUs)	% Discharged & Loaded	Annual TEUs [a]	Vessel Capacity (TEUs)	% Discharged & Loaded	Annual TEUs	Vessel Capacity (TEUs)	% Discharged & Loaded	Annual TEUs
Service 1	5,500	30%	171,500	18,000	25%	468,000	18,000	30%	566,300
Service 2	5,500	30%	171,500	18,000	25%	468,000	18,000	30%	566,300
Service 3	2,200	33%	76,000	8,000	22%	182,000	8,000	34%	283,700
Service 4	2,200	33%	76,000	8,000	22%	182,000	8,000	34%	283,700
Service 5	2,200	33%	76,000			-			-
Service 6	2,200	33%	76,000			-			-
Annual TEU's			647,000			1,300,000			1,700,000

Source: Heffron Transportation and Moffat & Nichol, January 2016.
a. Annual TEUs = (cargo discharged + cargo loaded) x 52 weeks per year.
Each service reflects an individual ship call with one discharge operation and one loading operation.

The time that a ship spends in berth would vary based on size. The smaller ships anticipated for the No Action Alternative require about 16 to 20 hours at berth for loading and unloading. The larger ships anticipated for Alternatives 2 or 3 would require between 25 and 50 hours at berth.

1.2.2. Container Yard Operations

The container yard at a terminal functions as a surge pile—it provides space to quickly absorb containers unloaded from a ship before they are transported off terminal by rail or truck, and allows containers to be staged prior to ship loading. Both functions make the unloading and loading operations more efficient to reduce the time that a ship must stay at berth.

Terminal 5 has historically been a "wheeled operation," meaning that the majority of containers that enter or leave the terminal on truck are loaded directly from the ship to a chassis and then parked in a space on the terminal. This allows the truck driver to park or retrieve a container without the aid of a top-pick. With improvements and increased throughput, the container yard would be converted to a "grounded operation" in which containers are stored in stacks. Containers are unloaded from a ship to a specialized chassis, and then sorted into stacks. Containers are stacked according to destination. Some types of containers, such as refrigerated containers or hazardous materials would have separate areas.

The No Action Alternative assumes most loading, unloading, and stacking in the container yard would be performed by top-pick loaders, same as the existing condition. For Alternative 2, some RTGs would be used for loading trucks. For Alternative 3, it is expected that almost all loading functions in the container yard would be handled by RMG cranes in order to achieve the storage density required. RMGs have a fixed capacity, unlike top-picks where more equipment and staff can be added to increase capacity. As described later, the use of RMGs is likely to require that a second truck gate shift be added when 3,000 or more ship lifts per day are expected in order to meter the flow of truck loading and unloading to the capacity provided by the RMGs.

The crane and terminal crews often work two shifts when ships are in berth: the day shift, which typically occurs from 8:00 A.M. to 5:00 P.M., and the night shift, which typically occurs from 6:00 P.M. to 3:00 A.M. A "hoot shift" (typically from 3:00 to 7:00 A.M.) may be needed to unload or load a ship on rare occasions, which can occur if the ship is delayed by weather.

1.2.3. Rail and Intermodal Yard Operations

Terminal 5 has an on-dock intermodal rail yard that allows the direct transfer of containers between rail and ship within the terminal. This yard is primarily used to create or discharge unit trains where all containers have a common origin or destination. Intermodal containers with other origins or destinations are usually handled through one of the near-dock rail yards operated by the BNSF Railway and UP Railroad where a terminal's cargo is combined with cargo from other terminals to create either full unit trains or mixed-service trains that may drop or pick up segments at inland destinations. These containers are drayed (trucked) between Terminal 5 and the off-dock rail yards.

With the No Action Alternative, which would accommodate smaller ships, it is estimated that 55% of the terminal's throughput would be intermodal cargo. Just over half (30% out of 55%) is expected to be handled at the on-dock rail yard and the rest (25%) drayed to near-by off-dock rail yards. The remaining 45% of the total cargo would be trucked to local and regional businesses.

With increased throughput at Terminal 5, the percentage of containers transported by rail is expected to increase to 75%. This is because the regional market in the Pacific Northwest is not large enough to support higher demand for locally-trucked cargo. Of the containers transported by rail, two-thirds (or 50% of the intermodal total) are assumed to be handled at the on-dock intermodal yard and one-third (or 25% of the total) are assumed to be drayed to off-dock rail yards. The remaining 25% of the total cargo would be trucked to local and regional businesses. Table 2 presents the throughput and mode-of-travel assumptions for the three alternatives.

Table 2. Terminal 5 Throughput and Mode of Travel

Condition	Throughput	Moved through On-Dock I/M [a]	Drayed to/from Off-Dock I/M	Trucked to/from Local/Region
Alternative 1 – No Action				
Throughput (TEUs/Year)	647,000	194,100	161,800	291,100
Mode of Travel		30%	25%	45%
Alternative 2 – With Wharf Improvements				
Throughput (TEUs/Year)	1,300,000	650,000	325,000	325,000
Mode of Travel		50%	25%	25%
Alternative 3 – With Wharf and Upland Improvements				
Throughput (TEUs/Year)	1,700,000	850,000	425,000	425,000
Mode of Travel		50%	25%	25%

Source: Moffatt & Nichol, January 2016.

a. I/M = Intermodal containers moved between ship and rail.

For the No Action Alternative and Alternative 2, the existing rail yard configuration and operation are expected to continue, and containers would be carried by yard equipment between a container yard stack and the intermodal yard, and loaded (or unloaded) from the train using a top pick. Once the segment of railcars on the loading tracks is filled, it is moved to the storage tracks until enough are ready to create a single unit train destined for a common location. The segments are then switched and connected to form a full unit train, which is typically 7,500 feet long, but can range from 5,000 to 8,600 feet long including locomotives. For Alternative 3, the configuration would be changed to accommodate RMG loaders, which would increase the capacity of the yard. The size of the unit train would remain 7,500 feet long.

1.2.4. Truck Gate Operations

The truck gate is where security checks occur and transaction information is exchanged for containers that enter or leave the terminal by road. This includes the dray movements between Terminal 5 and the near-dock intermodal yards. Trucks are allowed to deliver or retrieve a container within a designated window related to a ship's schedule. Export containers are usually required to arrive at the terminal a minimum of one and maximum of five working days prior to ship arrival. A container that arrives late must wait until the next ship call. Containers that arrive too early or are not picked up within the allotted time are charged a demurrage fee for on-terminal storage.

Arriving trucks proceed through the security Transportation Worker Identification Credential (TWIC) check point, then through an OCR portal that processes some of the transaction information regarding the container and truck identification, before arriving in the main gate queue. Once the truck reaches the processing station at the main gate, its container information is verified and matched to a pre-loaded booking. The driver is given directions to proceed to the designated container stack to drop off or retrieve their container. If the driver has a dual transaction (both dropping off and receiving a container), they would then proceed to their second container stack to be loaded prior to exiting the terminal. When exiting the terminal, the truck passes through an OCR portal and radiation detection portal prior to the exit gate. At the exit processing station, transaction information is verified and the driver is cleared to leave the terminal. If additional screening is required by US Customs and Border Protection, drivers are directed to that area before leaving the terminal.

For the No Action Alternative and Alternative 2, the truck gate is assumed to operate only during the day shift (8:00 A.M. to 5:00 P.M.) up to six days per week. On high-volume days, the gate may need to open one hour earlier. For Alternative 3, the gate may require a second shift (6:00 P.M. to 3:00 A.M.) due to the change to RMGs within the container terminal yard. If a second gate shift is required, then it is likely that a reservation system for gate access would also be implemented to meter the flow of trucks onto the terminal and improve on-terminal operations. Further detail about gate operations is provided in Section 5.3.

1.3. Study Area

The transportation study area for this report includes the north end of the Duwamish Manufacturing and Industrial Area (MIC), extending from Terminal 5 to Interstate 5 and from S Atlantic Street (SR 519) to SR 509 south of the 1st Avenue S Bridge. Within that area, the primary travel corridors serving Terminal 5 are SW Spokane Street between Harbor Avenue SW and East Marginal Way S, and East Marginal Way S between S Hanford Street and the North Argo Access. These corridors cover the primary travel routes between Terminal 5 and the near-dock intermodal rail yards, and between the terminal and the Spokane Street Viaduct, which is the primary route to the interstate freeway system. The following intersections were evaluated for this report, which are shown later on Figure 3.

- SW Spokane Street/Harbor Avenue NW
- SW Spokane Street/West Marginal Way SW/Chelan Avenue SW
- SW Spokane Street/Terminal 5 Access
- SW Spokane Street/11th Avenue SW
- S Spokane Street/East Marginal Way S
- S Hanford Street/East Marginal Way S
- East Marginal Way S/North Argo Access Road

2. AFFECTED ENVIRONMENT

This section of the report discusses the existing transportation conditions in the project study area, including roadways, rail, transit and non-motorized traffic, operational characteristics of Port-generated and general background vehicle traffic, safety conditions, and parking characteristics.

2.1. Transportation Network

2.1.1. Existing Roadway Network

The near-site roadway network that serves Terminal 5 is shown on Figure 2. Terminal 5 has two vehicle access points. The primary (overpass) access is via the Terminal 5 Access Bridge that connects to SW Spokane Street just west of the Spokane Street Swing Bridge over the West Duwamish Waterway. This access bridge is grade-separated from the Terminal 5 lead railroad tracks. A secondary (surface) access is located at-grade via West Marginal Way SW and connects to the SW Spokane Street/West Marginal Way SW/Chelan Avenue SW intersection as its northern leg. This access points crosses the Terminal 5 lead railroad tracks at grade, which can be blocked for train movements. The surface route and overpass connect south of the Terminal 5 gate, and either route can be used to access the Terminal 5 office and businesses located southeast the terminal at privately-owned sites known as Terminals 7A, 7B, and 7C. In the past, at times of high truck activity for Terminal 5, trucks were discouraged (and even prohibited by the terminal operator) from short-cutting the queue line by using the surface access, and were directed to enter the terminal via the Terminal 5 Access Bridge. Trucks that exit the terminal could use either route.

Connections between the terminal and the regional highway network are provided by S/SW Spokane Street, West Marginal Way SW, East Marginal Way S, and the West Seattle Bridge/Spokane Street Via-duct. All of these roadways are part of WSDOT's *Freight and Goods Transportation System* (FGTS). The West Seattle Bridge, SR 99, East Marginal Way and West Marginal Way are classified as FGTS T-1 roadways, the highest classification, and SW Spokane Street is classified as a T-2 roadway. All of these connecting streets are also part of the City's new Heavy Haul Network that allows increased axle loads and gross tonnage for specially-permitted trucks. The Heavy Haul Networks and FGTS are described further in Sections 2.1.2 and 2.1.5, respectively.

S / SW Spokane Street is a surface arterial that connects from Harbor Avenue SW in West Seattle to Airport Way S near Interstate 5 (I-5). For most of its length, it is classified by the Seattle Department of Transportation (SDOT) as a Minor Arterial[2], except for the portion between East Marginal Way S and West Marginal Way SW (across Harbor Island), which is classified as a Collector Arterial. The arterial crosses the Duwamish West Waterway on a two-lane swing-bridge, which opens for marine vessel traffic. It then widens to five lanes (three westbound and two eastbound) as it crosses the fixed Duwamish East Waterway bridge. Two of the westbound lanes and one of the eastbound lanes provide exclusive access to Harbor Island. Just east of the East Waterway Bridge are ramps to and from the Spokane Street Viaduct, which can be used to access I-5.

[2] All City of Seattle street classifications are from the *Seattle Arterial Classifications Planning Map, December 11, 2003;* http://www.seattle.gov/transportation/streetclassmaps/planweb.pdf; accessed January 26, 2015.

Figure 2. Near-site Roadway Network

Source: Port of Seattle, August 2016.

West Marginal Way SW connects from SW Spokane Street to State Route 99 (SR 99) near the First Avenue S Bridge. It is classified as a Principal Arterial. Along much of its length, it is a five-lane roadway (two lanes in each direction plus a center two-way left turn lane). North of the intersection with SW Spokane Street, West Marginal Way SW crosses the lead railroad tracks that serve Terminal 5 at grade, and passes under the Terminal 5 Access Bridge. This street provides an at-grade connection to Terminal 5 and other local businesses that front the Duwamish River.

East Marginal Way S, between S Atlantic Street and Duwamish Avenue S, is a Minor Arterial that connects the downtown Seattle waterfront to SR 99 south of the Spokane Street Viaduct. This roadway provides access to BNSF Railway's Seattle International Gateway (SIG) Intermodal Yard via S Hanford Street, and also connects to I-5 and Interstate 90 (I-90) via S Atlantic Street. Just south of the intersection with S Spokane Street are two railroad crossings—one operated by the BNSF Railway and the other by the UP Railroad—that link the West Seattle and Harbor Island rail yards in to the mainline tracks and support yards. The Port recently completed the **East Marginal Way Grade-Separation Project** that vertically separates the roadway from the main railroad crossings. Trucks can access SR 99 just south of the grade-separated structure. This route also provides a connection to the North Argo Access, a Port-owned truck access roadway located along the south edge of the Argo Yard lead tracks (see description below).

West Seattle Freeway/Spokane Street Viaduct is an elevated Principal Arterial that connects West Seattle to State Route (SR) 99, I-5, and Beacon Hill to the east. Ramps connect this elevated roadway to surface Spokane Street at several locations, including ramps to and from SW Chelan Street just west of Terminal 5 and ramps to and from Harbor Island to the east. Ramps also provide an eastbound exit to 1st Avenue S and 4th Avenue S, and a westbound entry from 1st Avenue S.

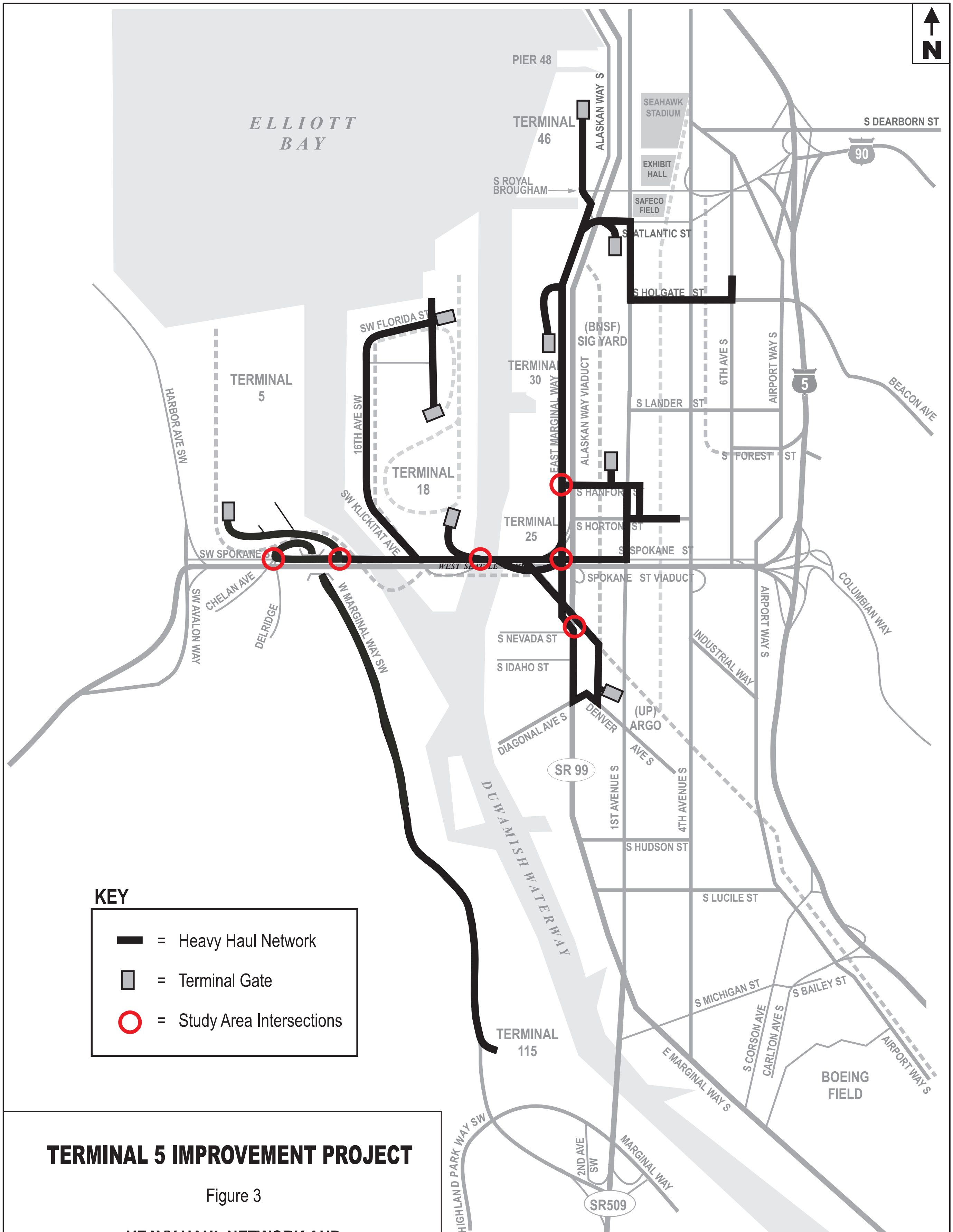
North Argo Access provides a one-way southbound truck connection between East Marginal Way S and the UP Argo Yard for intermodal transfers. The access route connects under SR 99 just south of the new East Marginal Way grade-separated structure. It was recently constructed to eliminate the need for trucks to weave across SR 99 in the southbound direction between the existing on-ramp and Diagonal Avenue S. Trucks returning to the container terminals exit the Argo Yard via Diagonal Avenue S and East Marginal Way S.

2.1.2. Heavy Haul Network

In October 2015, the City Council unanimously adopted legislation to create a Heavy Haul Network on a limited number of city streets to allow for the efficient drayage of sealed, ocean-going containers between the Port of Seattle and nearby intermodal facilities (Ordinance No. 124890). The new maximum allowable tandem drive axle weight of 43,000 pounds and maximum of gross vehicle weight of 98,000 pounds will be administered and enforced under a new permitting system. The adopted Heavy Haul Network, shown on Figure 3, includes the street system connecting Terminal 5 to the railyards; the upper level of the West Seattle Bridge and Spokane Street Viaduct are excluded from the Heavy Haul Network.[3]

Among the conditions of the permit is a requirement for twice-yearly inspections for permitted vehicles. In addition, the legislation establishes a new Commercial Vehicle Enforcement Officer (CVEO) position in SDOT devoted to enforcing truck-related rules and regulations in the Heavy Haul Network area.

[3] SDOT, *Summary – Adopted Heavy Haul Network Legislation*, October 27, 2015.



TERMINAL 5 IMPROVEMENT PROJECT

Figure 3

HEAVY HAUL NETWORK AND STUDY AREA INTERSECTIONS

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09.15.16

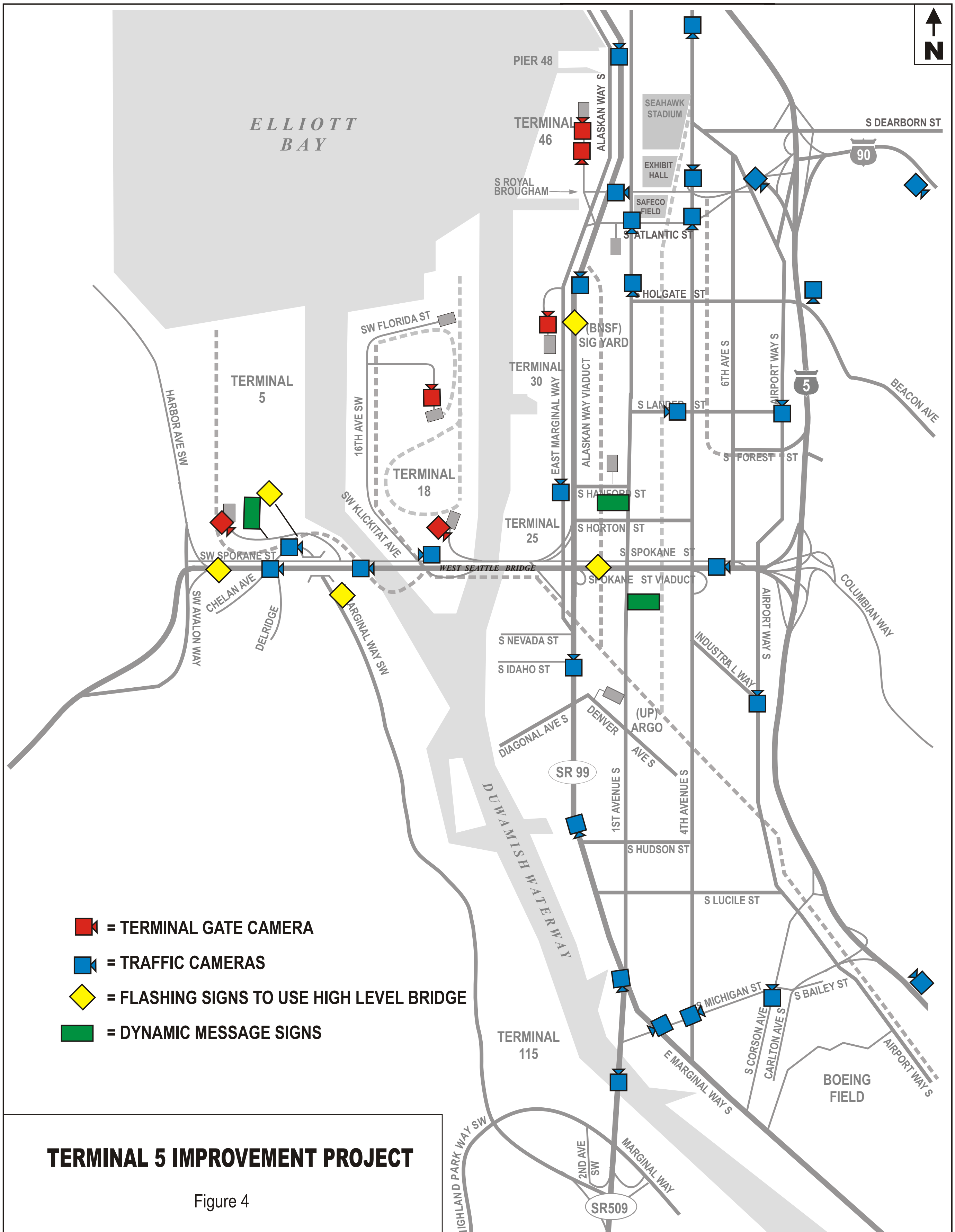
As part of the legislation, the Port and City have entered into a Memorandum of Understanding (MOU), detailing the Port's commitment to the program. It states that the Port will pay up to $250,000 to support the implementation and operation of the Heavy Haul program through at least the end of 2017. As a second component of the MOU, the Port has agreed to contribute between $10 million and $20 million over the next 20 years to pavement rehabilitation and restoration projects on heavy haul network roadways. Project-specific Port funding would be directly tied to the estimated cost of accelerated deterioration of pavement due to heavy vehicles on the roadway, in addition to the estimated additional layer of paving needed to support more frequent use by heavy vehicles.

Based on analysis, City and Port staff recommend that pavement investments be targeted to three principal corridors: 1) SW Spokane Street between Terminal 5 and East Marginal Way S, 2) East Marginal Way S between Terminal 46 and the North Access Road, and 3) S Hanford Street between East Marginal Way S and the BNSF SIG Yard.

2.1.3. Driver Information Infrastructure

SDOT, Port of Seattle and WSDOT jointly developed a good network of traffic cameras, dynamic message signs, and signs with flashing beacons to alert motorist about bridge openings in the Duwamish Industrial Area. There are City and State-owned cameras along most arterial routes and state highways in the neighborhood that can be viewed from various web sites. In addition, all of the Port of Seattle's terminal gates have cameras (some from multiple angles) that show the length of the gate queues. There are several flashing beacon signs that are triggered when the Spokane Street Swing Bridge opens for marine traffic to alert motorists to "Use High Bridge When Flashing." Finally, there are dynamic message signs along 1st Avenue S on which the message can be set at SDOT's Transportation Operations Center (TOC). The location of various driver information infrastructure is shown on Figure 4.

In addition to these efforts, the NWSA is in the process of deploying the data collection, sharing and communications infrastructure that will enable the NWSA's Operations Service Center to measure truck traffic congestion on, at and near container terminals and reduce it by providing real-time truck wait and queuing information to the trucking community. This will enable drivers to make informed routing decisions. The project is part of FHWA's *Freight Advanced Traveler Information System* (FRATIS) program and supported by an initial FRATIS grant. In addition, the NWSA has been awarded a federal grant through the federal Congestion Mitigation and Air Quality Improvement (CMAQ) Program to expand on an FHWA pilot-project current underway at the NWSA South Harbor (Tacoma terminals). Both applications are expected to reduce wait times at the terminal gates. This uses a new smartphone application—Dray Q—that provides terminal wait time information to a driver through mobile phones. An extension application, Dray Link, is also being offered that will provide a more robust set of logistics tools including providing drivers with the ability to manage pick-up and delivery information. Experience with pilot projects in locations such as the Ports of Los Angeles and Long Beach has shown that queuing and wait time reductions will result in reductions of diesel and greenhouse gas emissions.



TERMINAL 5 IMPROVEMENT PROJECT

Figure 4

EXISTING DRIVER
INFORMATION INFRASTRUCTURE

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2.1.4. Infrastructure Improvements since Construction of Terminal 5

Many infrastructure improvements were made when the current configuration of Terminal 5 was constructed in 1997. The major transportation-related improvements included:

- Constructing the Terminal 5 Access Bridge to grade-separate the terminal's vehicular traffic from its lead railroad tracks, and minimize truck queues on city streets;
- Rebuilding Harbor Avenue SW to include new curb, gutter, sidewalk and a landscape berm;
- Constructing the on-dock intermodal yard, storage tracks and lead railroad tracks;
- Installing a second lead track across Harbor Island to increase rail capacity; and
- Constructing a new emergency-access bridge between the south end of Harbor Island and the mainland that can be used if this area is blocked by a train.

Since Terminal 5 opened in 1997, both the Port and City of Seattle have made the following additional infrastructure improvements in the area.

- Rebuilding the Harbor Island roadway network as part of the Terminal 18 expansion in 1999, which relocated the lead railroad tracks to Harbor Island and Terminal 18 under the SW Spokane Street Bridge (these trains previously crossed Spokane Street at grade near 11th Avenue SW). The Terminal 18 project also reconfigured SW Spokane Street to create the frontage road system, which simplified the intersection at 11th Avenue SW.
- Constructing the East Marginal Way Grade Separation described previously, which allows Port trucks and other vehicular traffic to bypass train movements in the corridor.
- Widening the Spokane Street Viaduct, constructing a new eastbound off-ramp to 4th Avenue S, and rebuilding the westbound on and off-ramps at 1st Avenue S.
- Rebuilding surface Spokane Street under the viaduct. This project provided wider lanes, better U-turn facilities, new pavement, and improved traffic signal systems.
- Rebuilding the SW Spokane Street fixed bridge over the East Duwamish Waterway.
- Constructing the North Argo Access Road, which eliminated the need for trucks to weave across SR 99 in the southbound direction between the existing on-ramp at East Marginal Way and Diagonal Avenue S.

All of these improvements were constructed in part to accommodate future growth at the Port's container terminals, and were designed for large trucks.

2.1.5. Future Plans and Policies

The City's adopted modal transportation plans and programs were reviewed to identify goals, policies and planned future improvements to vehicular and non-motorized travel to and through the Terminal 5 study area.

Regional and State Freight Designations

The Port of Seattle marine facilities, including Terminal 5, are located within the Duwamish Manufacturing/Industrial Center (MIC), designated by the Puget Sound Regional Council (PSRC) as part of *VISION 2040*.[4] MICs are employment areas with intensive, concentrated manufacturing and industrial land uses that cannot be easily mixed with other activities. They are characterized as areas of large contiguous blocks served by the region's major transportation infrastructure, including roads, rail, and port facilities. The Duwamish MIC is one of the largest and most intensely developed industrial and manufacturing areas in the Pacific Northwest.[5] *Transportation 2040* is the region's long-range transportation plan that implements VISION 2040. Transportation 2040 presents the *Regional Freight Strategy*, which provides background on many of the bigger issues regarding the region's freight and goods movement and presents recommendations for a long-term regional freight strategy. Policies in the Regional Freight Strategy recognize that MICs are located to have ready access to transportation systems, to reduce the time and cost of transporting goods as well as pressure on the regional transportation system. Transportation policies identified in the City's *Comprehensive Plan*[6] for MICs in Seattle include maintaining land that is uniquely accessible to water, rail, and regional highways for continued industrial use, and promoting an intermodal freight transportation strategy that improves freight and goods movement within and between these modes.

WSDOT has established the Washington State *Freight and Goods Transportation System* (FGTS) to classify roadways, railways and waterways according to their annual freight tonnage. Each facility is categorized 1 through 5, with 1 reflected the highest annual freight tonnage and 5 reflecting the lowest. In the vicinity of Terminal 5, T-1 roadways (carrying more than 10 million tons of freight per year) include the West Seattle Bridge/Spokane Street Viaduct, SR 99, and West Marginal Way S. T-2 roadways (carrying 4 million to 10 million tons of freight per year) include 11th Avenue SW and 16th Avenue SW on Harbor Island and SW Spokane Street. The Puget Sound Marine Waterway has a W-1 classification (carrying more than 25 tons of freight per year), and the railroads serving the area are classified as R-1 (carrying more than 5 million tons per year). WSDOT has identified T-1 and T-2 roadways, as well as FGTS railroads and waterways, as freight economic corridors in Washington State.[7]

WSDOT is currently working to identify and designate Critical Urban and Rural Freight Corridors throughout the state. Although still in draft form, the designated corridors are expected to be submitted to the Federal Highway Administration (FHWA) by the end of 2016.[8] Criteria for Critical Urban Freight Corridors include high truck volume/tonnage, and close connectivity to the National Freight Highway Network, major freight intermodal facilities, and large industrial/warehouse centers. If approved, there will be a new Critical Urban Freight Corridor in the Duwamish that will include East Marginal Way S between Diagonal Avenue S and S Atlantic Street, as well as S Hanford Street between East Marginal Way S and 1st Avenue S. In the vicinity of the Terminal 5 site, SW Spokane Street (between Terminal 5 and I-5) is already designated as an Intermodal Connector, and is part of the Primary Highway Freight Network.[9]

4 Puget Sound Regional Council, VISION 2040, 2009.
5 Puget Sound Regional Council, Regional Centers Monitoring Report, 2013.
6 City of Seattle, Seattle's Comprehensive Plan: Toward a Sustainable Seattle, January 2005.
7 Washington State Department of Transportation, Washington State Freight and Goods Transportation System, 2015 Update, March 2016.
8 Washington State Department of Transportation, Designation of Critical Urban and Rural Freight Corridors, May 2016.
9 Washington State Department of Transportation, Draft Candidate Urban and Rural Freight Corridors Map, *http://wsdot.maps.arcgis.com/home/webmap/viewer.html?webmap=0fe90fe7cd324ed9a9a9586866aa9b04*, Accessed August 15, 2016.

Seattle Comprehensive Plan

Land use and transportation policies in the City of Seattle are guided by the *2005 Comprehensive Plan, Toward a Sustainable Seattle*. The Comprehensive Plan is currently undergoing a major update, which has been in process since 2012 and is planned to be completed in 2016. However, until the update is adopted, the City's adopted goals and policies remain those identified in the 2005 Comprehensive Plan. Freight goals identified in the Comprehensive Plan include preservation and improvement of mobility and access for the transport of goods and services (TG19) and maintenance of Seattle as the hub for regional goods movement and as a gateway to national and international suppliers and markets (TG20). The Terminal 5 project is consistent with these goals, and is particularly relevant to TG20, as the proposed improvements to accommodate larger ships have been identified to support changes to marine freight movement on a national and international scale. The Terminal 5 project is also consistent with adopted Comprehensive Plan freight transportation policies that support efficient and safe movement of goods by rail where appropriate (Policy T49) and encourage intermodal freight transportation improvements (Policy T50). Evaluation of the Terminal 5 project's potential impacts on all modes and integration of proposed improvements with non-freight improvements is consistent with Policy T48, which indicates that improvements supporting freight mobility on Major Truck streets may be integrated with improvements supporting other modes of travel.

The in-process update to the Comprehensive Plan includes policies that are consistent with the 2005 Plan but more detailed. It should be noted, however, that until the updated Comprehensive Plan is adopted by the City, policy updates are still draft and potentially subject to revision. The Transportation Elements of the Mayor's Draft Plan, which was issued in May 2016, maintains the goal (TG5) of improving mobility and access for the movement of goods and services to enhance and promote economic opportunity throughout the city. Transportation policies supporting this goal in the Mayor's Draft Plan relate to freight access and mobility in the Duwamish MIC. Key provisions of the draft Plan include:

- T4.6 – Improve mobility and access for freight in order to reduce truck idling, improve air quality, and minimize the impacts of truck parking and movement in residential areas.

- T 5.1 - Enhance Seattle's role as the hub for regional goods movement and as a gateway to national and international suppliers and markets.

- T5.2 - Develop a freight network in the Freight Master Plan that connects the city's manufacturing/industrial centers, enhances freight mobility and operational efficiencies, and promotes the city's economic health.

- T5.3 - Ensure that freight corridors are designed, maintained and operated to provide efficient movement of truck traffic.

- T5.6 - Work with freight stakeholders and the Port of Seattle and others to improve intermodal freight connections involving Port container terminals, rail yards, industrial areas, airports and regional highways.

- T5.7 – Support efficient and safe movement of goods by rail where appropriate, and promote efficient operation of freight rail lines and intermodal yards.

- T6.5 – Improve safety for all modes of transportation on streets heavily used by trucks.

The Container Port Element of the Comprehensive Plan recognizes the importance of the Port of Seattle as a vital economic development entity and cargo gateway. The Draft Container Port Element contains several goals and policies that support retention of this function; the updated Container Port polices reflect minimal changes to those in the current adopted plan. Key transportation provisions in the Container Port Element of the Mayor's Draft Plan include:

- CP1.6 - Monitor, maintain and improve key freight corridors, networks and intermodal connections that provide access to cargo-container facilities and the industrial areas around them to address bottlenecks and other access constraints.
- CP1.7 - Provide safe, reliable, efficient and direct access between Port marine facilities and the state highway or interstate system, and between Port terminals and railroad intermodal facilities, recognizing that Port operations must address other transportation needs, such as pedestrian safety.
- CP1.8 - Make operational, design, access and capital investments to accommodate trucks and railroad operations and preserve mobility of goods and services. Improvements may include improvement of pavement conditions, commute trip reduction strategies, roadway rechannelization to minimize modal conflicts, use of intelligent transportation systems, construction of critical facility links, and grade separation of modes, especially at heavily used railroad crossings.
- CP1.9 - Maintain a City classification for freight routes to indicate routes where freight will be the major priority. Street improvements that are consistent with freight mobility but also support other modes may be considered in these streets.
- CP1.10 - Continue joint City and Port efforts to implement relevant Port recommendations, such as recommendations contained in the Container Terminal Access Study.
- CP1.12 - Given the importance of cargo container terminal operations to the state and regional economies, develop partnerships within the City, the Port, the region and the State to advocate for project prioritization and timely funding to improve and maintain freight infrastructure, and explore funding partnerships.

Complete Streets Ordinance

In 2007, the Seattle City Council passed Ordinance 122386, known as the Complete Streets ordinance, which directs SDOT to design streets for pedestrians, bicyclists, transit riders, and persons of all abilities, while promoting safe operation for all users, including freight. Section 3 of the ordinance states, "*Because freight is important to the basic economy of the City and has unique right-of-way needs to support that role, freight will be the major priority on streets classified as Major Truck Streets. Complete Street improvements that are consistent with freight mobility but also support other modes may be considered on these streets.*"

The Complete Streets ordinance is the lens through which SDOT views all major maintenance and construction projects. The Complete Streets checklist is the tool SDOT uses to collect data and information about the status of the street and surroundings, as well as the details of the project, with a goal of identifying specific improvements that can be incorporated into the project to balance the needs of all users. Although Complete Streets evaluation is not a tool implemented at the development project level, it is important to note that it is a planning-level tool SDOT applies identify the appropriate transportation network and improvement priorities needed to accommodate all modes of travel, and it guides implementation of the modal plans and projects described in the following sections.

Seattle Freight Master Plan and Freight Access Project

The City of Seattle is developing a *Freight Master Plan* (FMP)[10] to address the unique characteristics, needs, and impacts of freight mobility. The public review draft of the FMP was issued in May 2016. The draft FMP designates a citywide freight network. In the Terminal 5 study area, it identifies SR 99 as a Limited Access Truck Street; S Spokane Street, West Marginal Way S, East Marginal Way, and the West Seattle Bridge as Major Truck Streets; Delridge Way SW as a Minor Truck Street; and the West Marginal Way access to Terminal 5 as a First/Last Mile Connector. The FMP outlines the critical role that freight movement has on meeting the City's goals for social equity, economic productivity, sustainability, and livable neighborhoods. It includes information about existing conditions, policies, future conditions assessment, identification of near- and long-term improvements, design guidelines, and the creation of an implementation strategy (recommended projects in the Terminal 5 study area are described below).[11] It is expected that the FMP will be adopted by the end of 2016.

The *Freight Access Project*[12], which was a joint effort between the City of Seattle and Port of Seattle, identifies truck-freight transportation investments needed over the next 20 years to support Seattle's industrial lands and keep freight traffic moving. The *Freight Access Project* identifies numerous projects to improve freight mobility, safety, and accessibility in the Duwamish MIC, which are also identified in the Draft FMP. In the vicinity of Terminal 5, recommended projects include heavy haul upgrades and other improvements to East Marginal Way (described in more detail in a section below) between the Port and rail yards, access improvements to the Main Seattle International Gateway (SIG) Yard via S Hanford Street, grade separation of S Lander Street over the BNSF railroad tracks, study of additional SODO railroad grade separations, and freight access and Intelligent Transportation System (ITS) improvements to S Spokane Street. The recommendations include the following projects in the Terminal 5 study area that would address capacity and access needs:

- **East Marginal Way Corridor (S Royal Brougham St to Idaho St.) –** This project would reconstruct a core freight route to heavy haul standards and offer safety and operational improvements for all modes.

- **East Marginal Way / S Hanford Street Intersection** - This project would upgrade the signal, lengthen the northbound right-turn lane, improve the railroad crossing pavement, and evaluate the need for railroad crossing gates at the Whatcom track crossings. The project also includes rebuilding the intersection and its approaches to Heavy Haul route requirements.

- **Hanford Street and Main SIG Access Improvements (East Marginal Way S to 1st Avenue S) -** This project evaluate the feasibility of installing a traffic signal at the Main SIG entrance. It would also rebuild the segment of Hanford Street between the E Marginal Way S and 1st Avenue S to Heavy Haul route standards, including new pavement at railroad crossings. It may include rail crossing gates or other devices, if needed.

- **South Spokane Street ITS Upgrades (Chelan Avenue to Airport Way South)** – Described in the following section.

10 Seattle Department of Transportation, Freight Master Plan, Public Review Draft, May 2016.
11 Seattle Department of Transportation website: http://www.seattle.gov/transportation/freight_fmp.htm, Accessed April 18, 2016.
12 Seattle Department of Transportation and Port of Seattle, Seattle Industrial Areas Freight Access Project, May 2015.

The *Freight Access Project* also recommends the following evaluation project:

- **Lower Spokane Street Freight Only Lanes Pilot Project (Harbor Island to Airport Way S) -** This pilot project would design, implement, and evaluate freight-only lanes on the corridor. It would modify roadway channelization for truck-only lanes, install signal and signage upgrades, and provide ITS equipment such as variable message signs and detection equipment. The project would evaluate time-of-day operations, while providing a contingency for allowing all traffic to use the lanes in the event of an incident on the upper bridge.

The Port would contribute to freight improvement projects identified in the FMP and FAP at locations affected by the Terminal 5 project.

West Seattle Bridge / Duwamish Waterway Corridor

SDOT prepared the *West Seattle Bridge / Duwamish Waterway Corridor Whitepaper and Priority Investment List*[13] in September 2015 at the request of Councilmember Tom Rasmussen and Mayor Ed Murray. This whitepaper compiled a list of investment strategies to address congestion in the corridor. Almost all of the project recommendations are part of prior studies and plans. Key high-priority projects related to the segments near Terminal 5 include the following:

- **South Spokane Street Intelligent Transportation System (ITS) Upgrades** – This project, which was part of SDOT's *2014 Next Generation ITS Implementation Plan*, would install ITS equipment along Lower Spokane Street corridor between Terminal 5 and Airport Way S to collect and display real-time travel time information to truck drivers and other motorists. Traffic signal system improvements at the intersection of Chelan Avenue could also be included in the project scope.

- **Bridge opening coordination –** SDOT will work with the Coast Guard and marine vessel operators to voluntarily avoid bridge openings if there is an incident that blocks traffic on the West Seattle High-Level Bridge or Spokane Street Viaduct. Bridge opening protocols are described later in Section 2.4.

- **Traffic management** – Several projects were listed to reduce delay related to openings of the Lower Spokane Street Swing Bridge, rail crossings, and truck queues at Terminals 5 and 18. Management measures could include advance notification, and coordination of systems to reduce delay after a bridge opening or train crossing.

In April 2016, SDOT prepared a written progress report to the City Council related to the implementation of these initiatives. SDOT's accomplishments in 2015 and 2016 include: [14]

- Painted eastbound red bus lane and increased police enforcement on the West Seattle Bridge.
- Coordinated with Coast Guard and marine vessel operators to obtain cooperation with voluntary avoidance of openings during road traffic peak periods.
- Revised mechanical opening sequence of the Swing Bridge to reduce the time it takes to open and close it.

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13 Seattle Department of Transportation, September 22, 2015.
14 SDOT, *West Seattle Bridge Corridor Improvements, Update on White Paper and Investment List Report*, April 15, 2016.

- Added enhanced markings of at-grade crossing of Alki Trail at five-way intersection (West Marginal Way SW/SW Spokane Street/Chelan Avenue SW).
- Revised RapidRide C Line Service.

Duwamish Freight Spot Improvement Program

SDOT prepared a summary report of spot improvements that it proposed for State of Washington's Freight Mobility Strategic Investment Board (FMSIB).[15] The list included pavement, turn radius, signal, and signage/wayfinding improvements. Near the Terminal 5 site it recommended:

- Railroad crossing reconstruction on SW Spokane Street at the 11th Avenue SW rail crossing and on East Marginal Way at the T-30 rail crossing.
- Pavement rehabilitation on S/SW Spokane Street.
- Port terminal wayfinding signs at various locations.

Multimodal Plans and Projects

Move Seattle,[16] approved by voters in November 2015, is a multimodal transportation package that integrates recommendations developed in the City's various modal plans, and includes a list of high-priority projects that are intended to be implemented within the next 10 years. Two high priority *Move Seattle* projects include elements also identified as part of the FMP and *Freight Access Project*: the South Lander Grade Separation and the East Marginal Way Corridor. The East Marginal Way Corridor Improvements Project seeks to implement the heavy haul and other freight improvement projects described above, while also providing facilities to improve safety and mobility for people who walk or bike through the corridor. The Delridge Complete Street Project, which seeks to streamline traffic operations and improve multimodal connections between transit, freight, pedestrians, and general-purpose vehicles, is also identified as a high priority *Move Seattle* project. Both the East Marginal Way and Delridge corridor projects recognize the Port as a critical freight generator in their respective study areas and include improvement of freight movement as part of their multimodal objectives. Terminal 5 is compatible with the freight objectives of these projects. However, these multimodal projects also seek to improve safety and mobility for other travelers in these corridors, including people who walk, bike, take transit, or drive personal vehicles. Any transportation improvements identified to support the Terminal 5 project should be compatible with the multimodal objectives of the East Marginal Way and Delridge Way corridor studies. Both corridor studies are currently underway so the timeline for project implementation is not yet known; however, it is possible that construction of the corridor projects could overlap with construction of Terminal 5 improvements, requiring construction coordination between the Port and the City.

The City's *Bicycle Master Plan (BMP)*[17] sets forth a vision that riding a bicycle be a comfortable and integral part of daily life in Seattle for people of all ages and abilities, and provides a blueprint to make it easier to decide to ride a bike. In the Terminal 5 vicinity, the BMP recommends an off-street trail connection between the West Seattle Bridge Trail and Duwamish River Trail. Non-motorized crossing of the SW Spokane Street/West Marginal Way SW/Chelan Avenue SW intersection—which connects the West Seattle Bridge Trail to the east and Alki Trail to the west—is identified as a "catalyst" project, defined as being located at a significant choke point that poses implementation challenges due to physical constraints. Further information about this project is presented in Section 2.8. The BMP also

[15] SDOT, *Duwamish Freight Spot Improvement Program, Proposed Projects for Partnership with Freight Mobility Strategic Investment Board,* September 2015.
[16] Seattle Department of Transportation, Move Seattle: 10-Year Strategic Vision for Transportation, Spring 2015.
[17] Seattle Department of Transportation, Bike Master Plan, April 2014.

recommends protected bike lanes along Delridge Way SW to the southwest of the project site, and along East Marginal Way S to the east of the site. None of the BMP-recommended projects located in the vicinity of Terminal 5 are included in the current BMP Implementation Plan;[18] however, bicycle facility recommendations are being developed as part of the *Move Seattle* Delridge Way and East Marginal Way multimodal corridor projects described above.

The City's *Pedestrian Master Plan (PMP)*[19] sets forth a mission to make Seattle the most walkable city in the nation. None of the PMP's Tier 1 (high priority) improvements are located near Terminal 5. However, pedestrian facility recommendations are being developed in the vicinity of the Terminal 5 site as part of the *Move Seattle* Delridge Way and East Marginal Way multimodal corridor projects described above.

The *Transit Master Plan (TMP[20])* defines the critical role that transit plays in meeting the City's goals related to sustainability, equity, economic productivity, and livability. Developed with feedback from King County Metro and Sound Transit, the *TMP* identifies the types of transit facilities, services, programs, and system features that will be required to meet Seattle's transit needs through 2030, based upon market analysis, review of future growth patterns, and evaluation of transit needs. In the vicinity of Terminal 5, the *TMP* identifies the West Seattle Bridge as part of Seattle's Frequent Transit Network (FTN), which is a vision for a network of transit corridors that connect the city's urban centers and villages with high-quality transit service within a short walk for most residents. It identifies the service level of the corridor connecting West Seattle and Downtown as "frequent" to "very frequent." It also identifies Delridge Way SW as a priority bus corridor; transit facility recommendations are being developed as part of the *Move Seattle* Delridge Way multimodal corridor project described above.

The *Sound Transit 3 (ST3)*[21] ballot measure that voters will consider in November 2016 will build upon the existing mass transit system of light rail, commuter rail and bus service to destinations throughout King, Snohomish and Pierce counties. The *ST3* package includes extension of light rail from Downtown to West Seattle, which is part of the City's FTN described above. If the ST3 package passes, this project would build light rail from the stadium district in downtown Seattle to the vicinity of Alaska Junction in West Seattle, with an alignment primarily on an elevated guideway and a new rail-only fixed span crossing the Duwamish River. The project would provide five new or expanded stations, including a new station on Delridge Way SW south of the Terminal 5 site. ST3 plans are conceptual at this time and exact locations of stations and support structures for the elevated line are not known. Nevertheless, the proposed light rail corridor and station are located to the south of the West Seattle Bridge, so they would not overlap with the Terminal 5 project footprint, which is located to the north of the West Seattle Bridge. However, the proposed Delridge station could be located within one-quarter mile of Terminal 5, which would greatly improve transit service for Port employees. Therefore, any transportation improvements proposed to support the Terminal 5 project should also be designed to accommodate pedestrian access between the site and Delridge Way SW. The proximity of the light rail extension and would also require coordination if construction activities for both the Terminal 5 and light rail projects were to overlap.

Capital Improvement Program

Every year during the annual budget process, the City adopts a six-year Capital Improvement Program (CIP) that outlines anticipated investments over that timeframe. While the CIP identifies near-term high priority projects, some may be fully funded while others are not. The *2016-2021 Proposed Capital Improvement Program*[22] includes transportation projects in the Terminal 5 vicinity. Funded pro-

18 Seattle Department of Transportation, Bike Master Plan, 2016-2020 Implementation Plan, March 2016.
19 Seattle Department of Transportation, Seattle Pedestrian Master Plan, September 2009.
20 Seattle Department of Transportation, Transit Master Plan, April 2012.
21 Sound Transit, Sound Transit 3, http://soundtransit3.org/, Accessed August 2016.
22 City of Seattle, 2016-2021 Proposed Capital Improvement Program, September 23, 2015.

jects include design of the Lander Street Grade Separation and the multi-modal corridor studies of East Marginal Way and Delridge Way SW; the City portion of the Heavy Haul Corridor Project on East Marginal Way is currently listed as an unfunded project in the CIP, but it indicates that this project will be implemented in partnership with the Port.

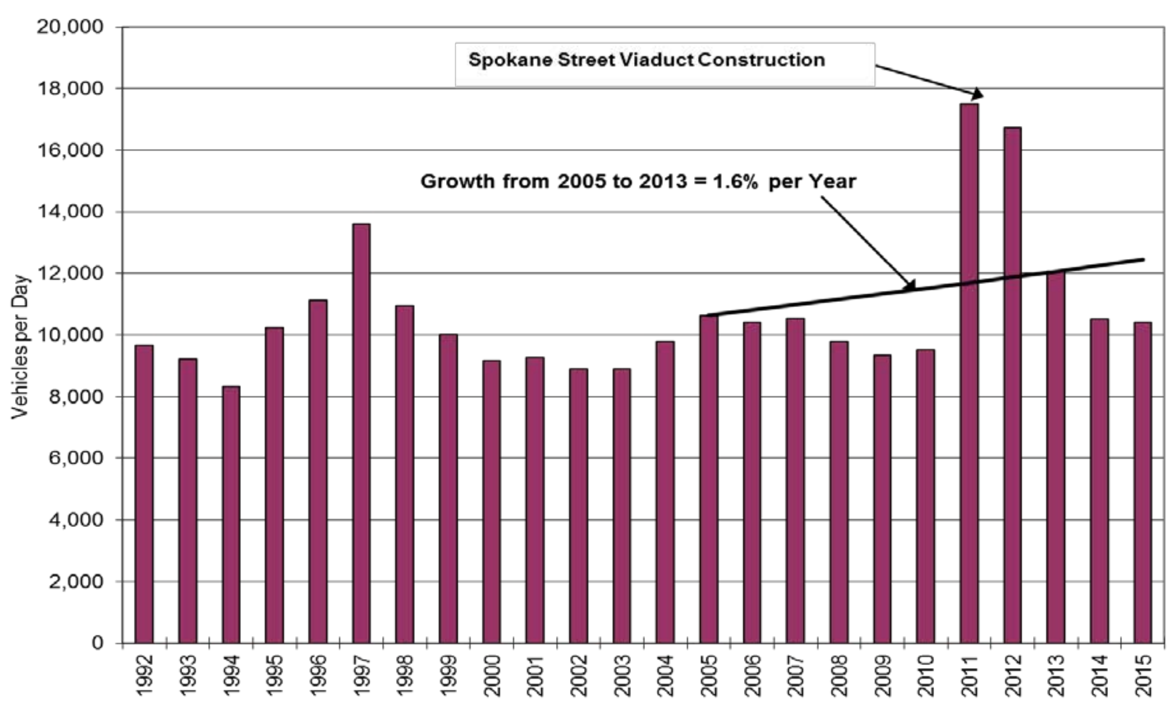
2.2. Traffic Volumes

2.2.1. Historic Traffic Volumes on SW Spokane Street

Traffic volumes along the Spokane Street corridor have fluctuated in the past decade. The City maintains a permanent traffic recording station on the Spokane Street Swing Bridge. Since 1992, traffic counts have been performed on the bridge for a seven-day period during every month of the year. These data were collected and compiled to show how traffic volumes have changed since 1992 and how the volumes vary from month to month.

Figure 5 shows the average weekday daily traffic (AWDT) volumes by year on the Spokane Street Swing Bridge. The peak volumes occurred in 2011 and 2012, coinciding with construction work that was occurring on the Spokane Street Viaduct and the Alaskan Way Viaduct. Additional traffic may have utilized surface routes that included Spokane Street to avoid construction-related congestion. The lowest volumes occurred in 2009 and 2010, coinciding with the economic recession. Year 2013 was the last full year with Terminal 5 operating as a container terminal, and existing conditions documented in this report reflect that year. Between 2005 (pre-recession) and 2013, and excluding the construction-related peaks in 2011 and 2012, traffic volumes grew at an average rate of about 1.6% per year.

Figure 5. Average Weekday Daily Traffic (AWDT) on Spokane Street – 1992 through 2015

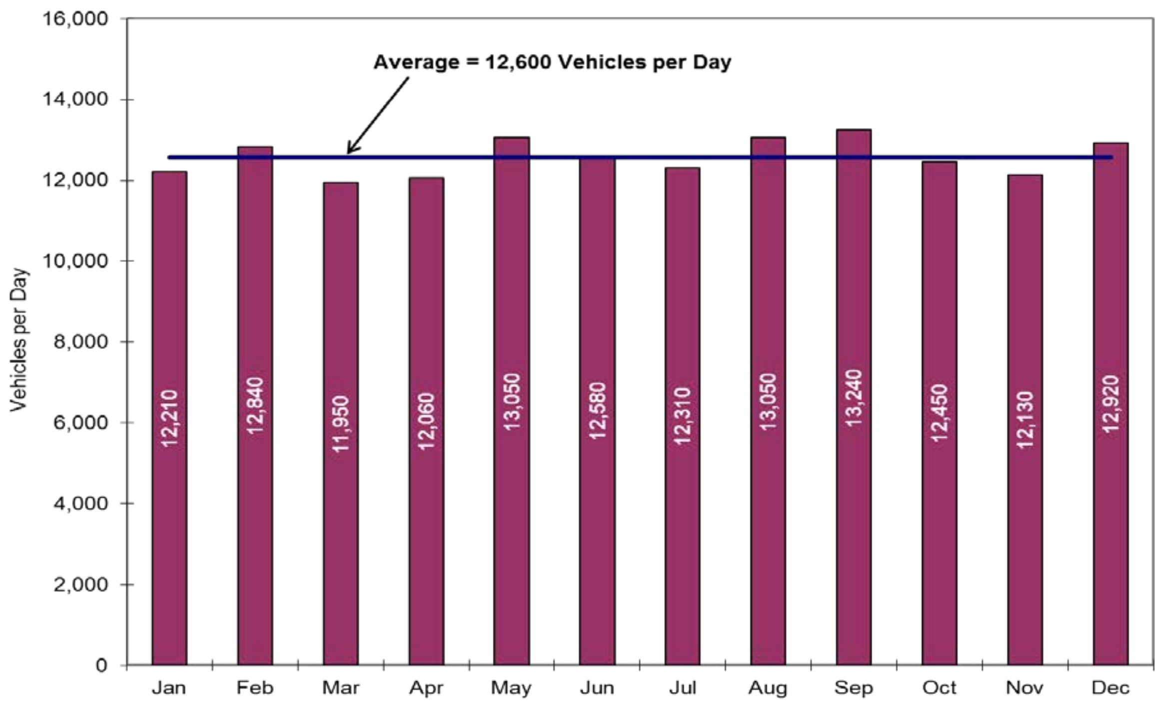


Source: Seattle Department of Transportation. Counts on Spokane Street at "Point A" which is the Lower Spokane Street (Swing) Bridge. Values reflect counts performed in the spring of each year (March or April).

Figure 6 shows the AWDT on the Spokane Street Swing Bridge for each month in 2013, which is the last full year with Terminal 5 operating as a container terminal. The annual average volume from 2013 was 12,600 vehicles per day with slightly more than half traveling the bridge in the eastbound direction. This unbalanced flow likely occurs as vehicles use the surface route in order to avoid eastbound congestion on the West Seattle Freeway and Spokane Street Viaduct approaching SR 99, 1st Avenue S, and I-5. As shown, average volumes vary only slightly from month to month.

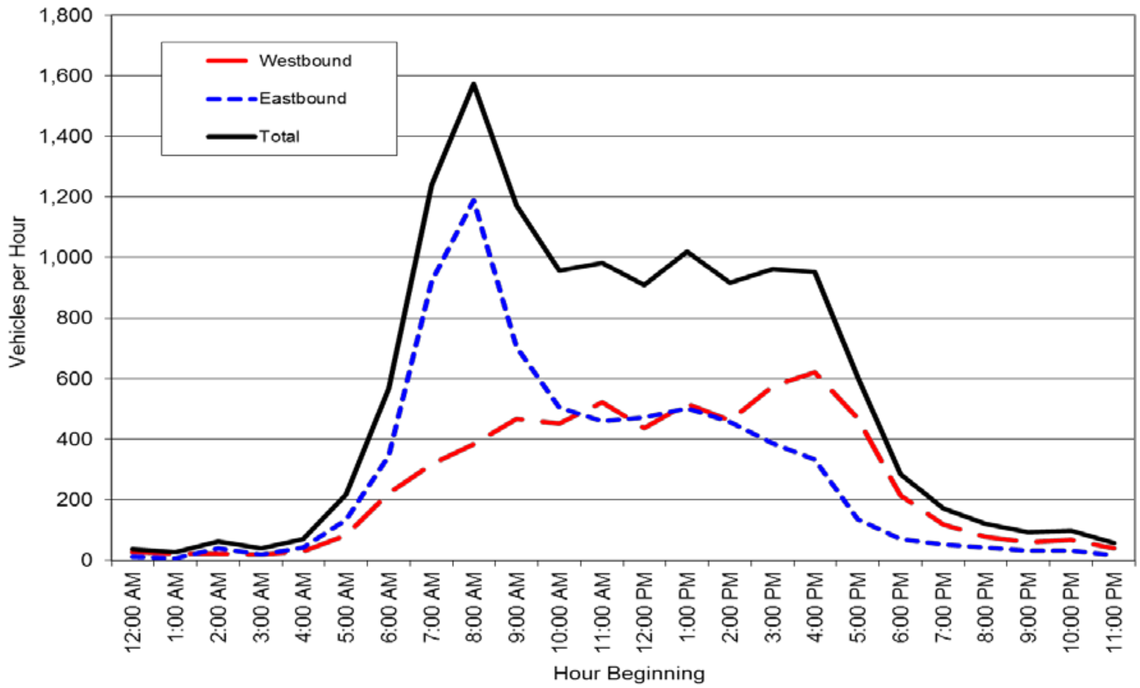
Hourly traffic volumes for June 2013, which Figure 6 shows most closely represents the average month, were plotted to show how traffic volumes fluctuate by time of day. Figure 7 shows that the highest volumes occur during the morning commuter peak hour, with the predominant flow in the eastbound direction. As previously discussed, Lower Spokane Street is often used as a bypass by commuters who look to avoid morning congestion on the West Seattle Freeway and Spokane Street Viaduct. Westbound flow across the Swing Bridge is highest during the commuter PM peak hour.

Figure 6. Average Weekday Traffic (AWDT) on Spokane Street Bridge by Month – 2013



Source: Seattle Department of Transportation. Counts on Spokane Street at "Point A" which is the Lower Spokane Street (Swing) Bridge. Values reflect counts performed one week each month in 2013.

Figure 7. Hourly Volumes on Spokane Street Bridge – Average Weekday in June 2013



Source: Seattle Department of Transportation. Counts on SW Spokane Street Bridge for one week in June 2013. Counts reflect the average of Tuesday, Wednesday and Thursday volumes.

2.2.2. Existing Intersection Traffic Volumes

Peak period intersection turning-movement counts (which show the volume for each movement at an intersection) were compiled from various sources for the AM and PM peak hours. As shown on Figure 4, peak traffic in the Spokane Street Bridge corridor occurs during the AM peak hour, which as described later in this report, is also when peak volumes generated by Terminal 5 are expected to occur. The PM peak hour condition was also evaluated since it is when reverse-direction traffic is highest, which can affect intersection operations. The traffic volume data were obtained for dates prior to June 2014 to reflect conditions when Terminal 5 was operational. Table 3 lists the intersections for which data were obtained. No recent turning movement counts were available for the SW Spokane Street/Terminal 5 Access Bridge or SW Spokane Street/11th Avenue SW intersections prior to the terminal closing. Therefore, traffic volumes for those intersections were derived based on counts at adjacent intersections, historic counts from SDOT's database for the Swing Bridge and Harbor Island roadways, and Terminal 5 gate volumes.

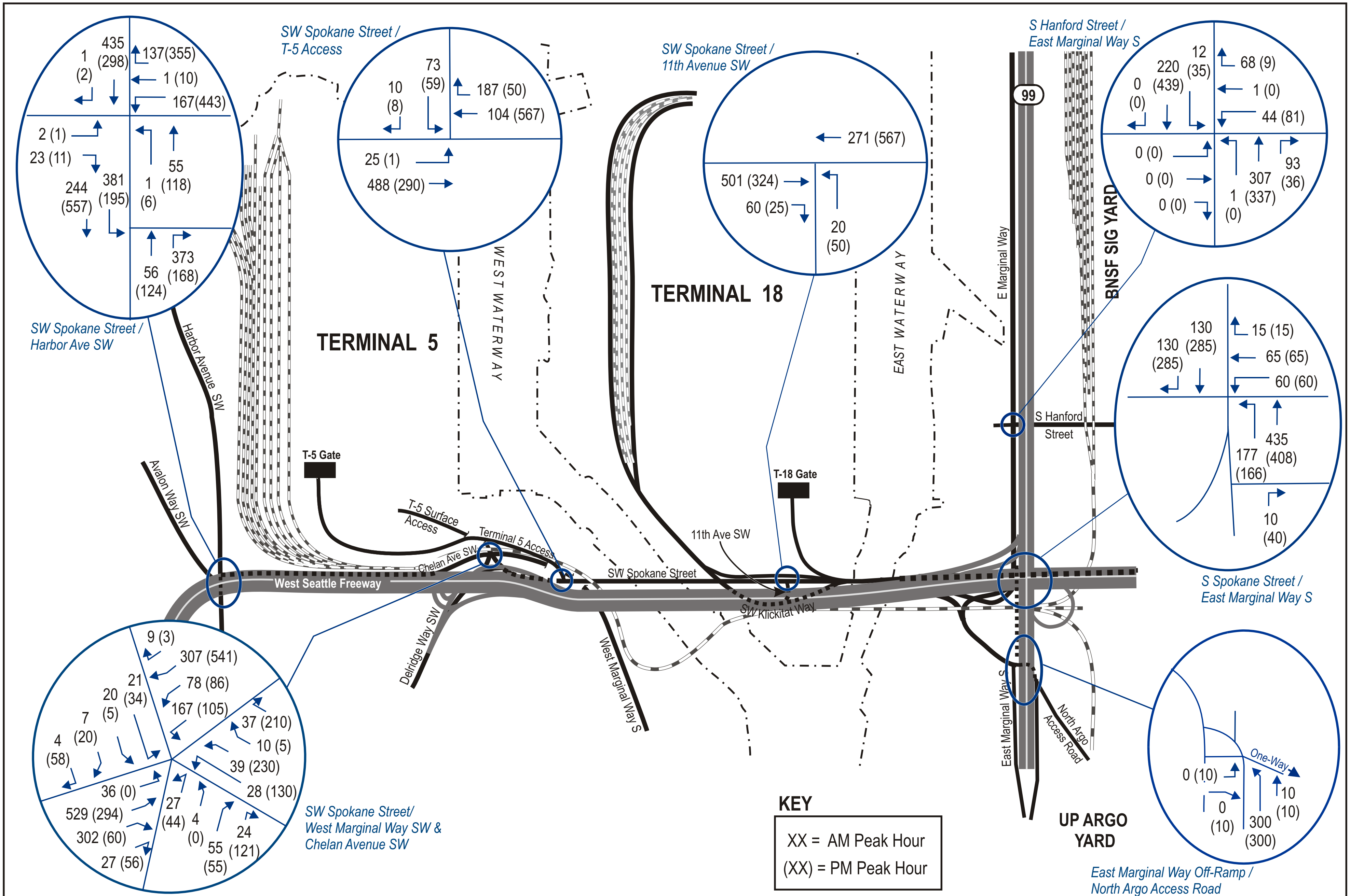
Table 3. Existing Intersection Traffic Counts

Intersection	Data source	Date of count(s)	Count Type [a]
SW Spokane Street/West Marginal Way SW/Chelan Ave SW	SDOT	April 2014	Intersection Count
SW Spokane St/ Harbor Avenue SW	SDOT	July 2013	Intersection Count
East Marginal Way S / SR 99 Ramps (at North Argo Access)	Heffron [b]	October 2012	Machine Counts
S Spokane Street/East Marginal Way S	SDOT	Dec 2009	Machine Counts
East Marginal Way S/S Hanford Street	SDOT	May 2013	Intersection Count

a. Intersection counts include volumes by turning movement and are usually performed using a camera; Machine counts are performed along roadway segments using pneumatic tubes and counting machine.

b. Counts commission by Heffron Transportation, Inc., and performed by All Traffic Data, Inc. on the new East Marginal Way Grade-Separated structure.

Intersection counts were adjusted to reflect the average month in 2013 based on data from the Spokane Street Swing Bridge described above. In addition, the volumes were increased to reflect the existing Design Day condition for Terminal 5, which is described in Section 2.2.4. Figure 8 shows the existing AM and PM peak hour traffic volumes for the study area intersections.



TERMINAL 5
Improvement Project

Figure 8
Existing (2013) Traffic Volumes
AM and PM Peak Hours

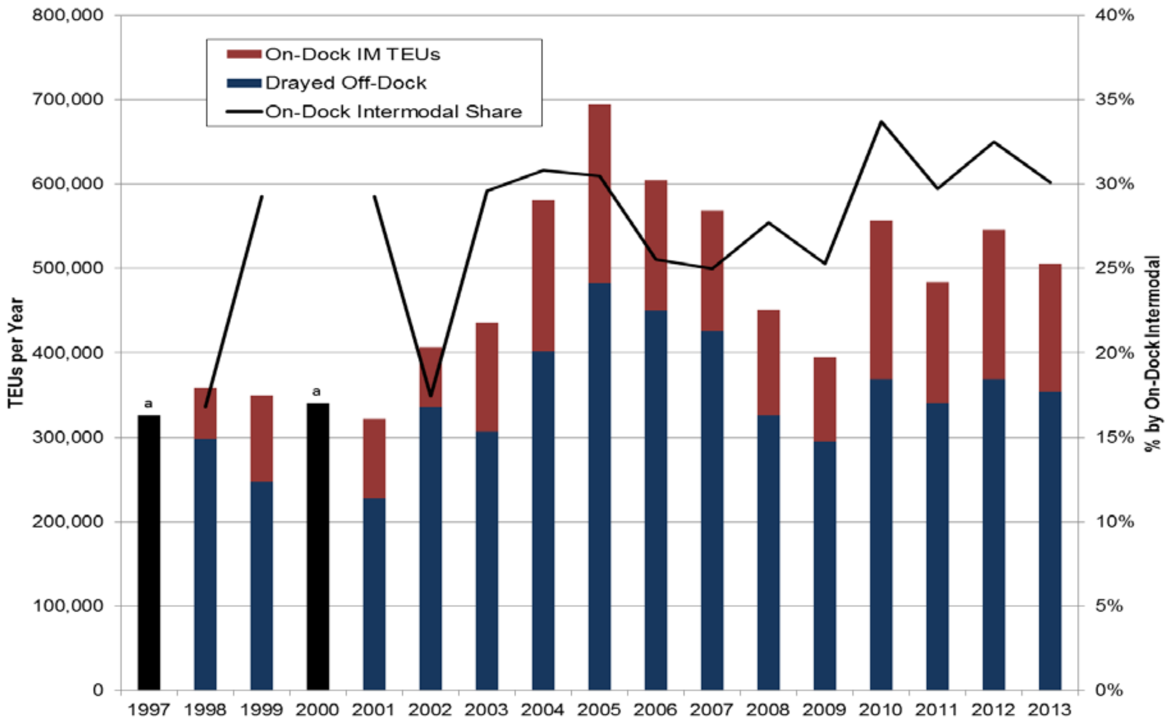
heffron transportation, inc.

09.15.16

2.2.3. Terminal 5 Throughput and On-Dock Intermodal Volumes

Since Terminal 5 reopened in its present configuration, the terminal throughput has averaged about 466,000 TEUs per year, with a peak throughput of about 695,000 TEUs in 2005 (a year that experienced increased traffic due to diversions from Southern California ports). The historic annual throughput and intermodal volumes are shown on Figure 9. In the past decade, the share of containers loaded directly to rail at Terminal 5's on-dock intermodal yard ranged from about 25% to 35%.

Figure 9. Annual Throughput and Intermodal Volumes at Terminal 5 – 1997 to 2013



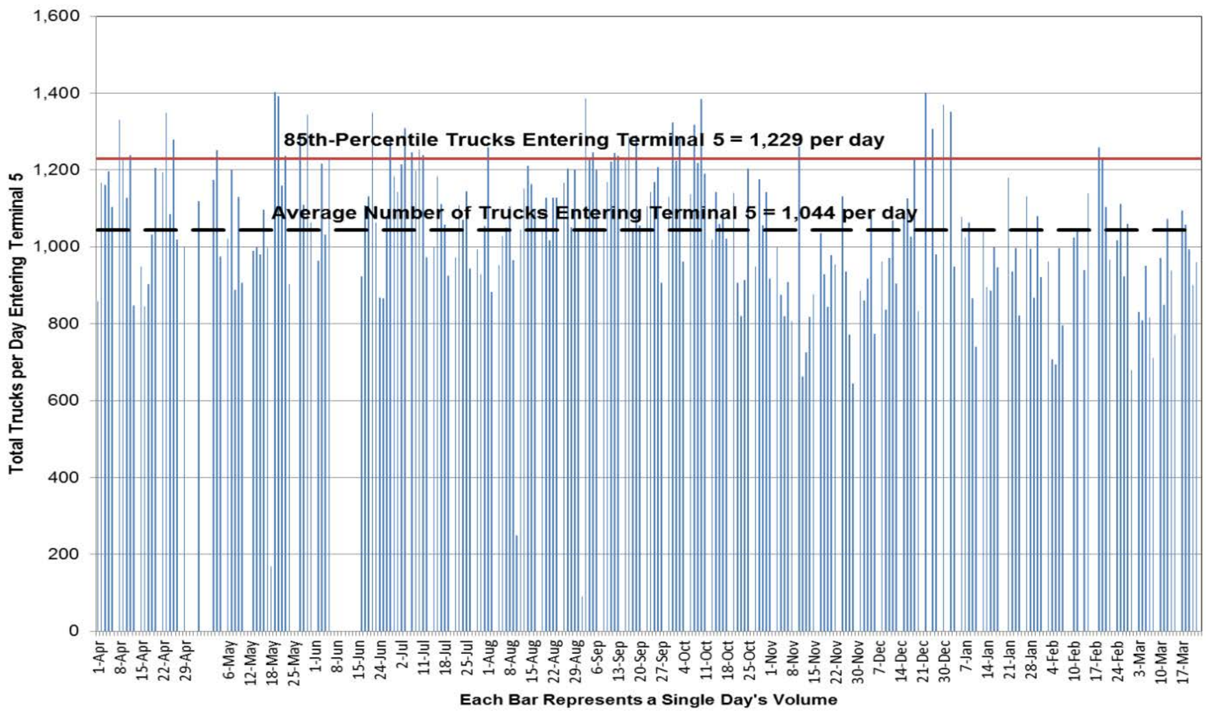
Source: Port of Seattle, 2015.

a. Data regarding intermodal traffic are not available.

2.2.4. Truck Volumes

RFID readers have been installed at all of the Port's container terminals and began recording trucks entering those terminals on April 1, 2013. Data for the nearly full-year period from April 1, 2013 through March 22, 2014 were compiled for Terminal 5. This period reflects full operation of the terminal before the former tenant moved to Terminal 18, and reflects all truck movements regardless of whether the truck carried an empty chassis or a container. Figure 10 presents the daily truck trips that entered Terminal 5 during this period. The figure shows that an average of 1,044 trucks per day entered Terminal 5, reflecting a total of 2,088 truck trips per day (one trip entering and one trip exiting the terminal). The 85th-percentile volume was approximately 1,230 entering trucks per day, or 2,460 total truck trips per day. On peak days, the volume approached 1,400 trucks entering the terminal each day (2,800 total truck trips). The 85th-percentile volumes were assumed to represent the Design Day condition for Terminal 5.

Figure 10. Trucks Entering Terminal 5 Each Day (April 1, 2013 thru March 22, 2014)



Source: RFID data from Port of Seattle for the period from April 1, 2013 through March 22, 2014. Data compiled by Heffron Transportation, Inc.

As described later in Section 4.1.4, an average of 12% of the daily truck trips occur during the commuter AM peak hour and 3% occur during the PM peak hour. The Design Day for existing conditions (in 2013) included 295 AM peak hour truck trips and 74 PM peak hour truck trips.

2.3. Level of Service

Level of service (LOS) is a qualitative measure used to characterize traffic operating conditions. Six letter designations, "A" through "F," are used to define level of service. LOS A is the best and represents good traffic operations with little or no delay to motorists. LOS F is the worst and indicates poor traffic operations with long delays. LOS D is acceptable to the City.

Level of service is defined in terms of delay. For signalized intersections, delay is dependent on a number of variables, including traffic volumes by turning movement, intersection lane geometry, percentage of heavy vehicles, signal timing, and signal phasing. Complete descriptions of level of service criteria are included in Appendix A.

Level of service for the study area intersections was determined using methodologies presented in the Highway Capacity Manual (HCM)[23] and calculated with the *Synchro 9.1* traffic operations analysis software. Existing intersection lane configurations and signal operations data, which were obtained from SDOT, were field verified. The model was also coded to account for the high volumes of trucks in the area with percentages that range up to 100% for some movements based on existing counts. Levels of service are reported using the *Synchro* module for signalized intersections and the *HCM 2010* module for the all-way stop intersection at East Marginal Way S/North Argo Access. Table 4 summarizes the existing levels of service for the study area intersections.

The analysis shows that almost all of the study area intersections now operate at LOS D or better. The exception is the five-legged intersection at SW Spokane Street/West Marginal Way SW/Chelan Avenue SW, which currently operates at LOS F during the PM peak hour. Operations at this intersection are affected by the need for each of the five streets that approach the intersection to be served with a separate signal phase. This level of service reflects typical operation without any pre-emption of signal phases due to train crossings of West Marginal Way SW just north of the intersection or openings of the Spokane Street Swing Bridge. Such pre-emptions exacerbate congestion at the intersection since some movements are not served to reduce potential vehicle-train conflicts at the crossing. Swing Bridge openings affect both the five-legged intersection and Terminal 5 Access Bridge operations due to vehicles that queue while waiting for vessels. Further information about the frequency and duration of Spokane Street Swing Bridge openings is provided in the next section.

23 HCM 2010, Transportation Research Board. 2010.

Table 4. Level of Service Summary - Existing (2013) Conditions

	AM Peak Hour		PM Peak Hour	
Signalized Intersections	LOS[1]	Delay[2]	LOS	Delay
SW Spokane St / Harbor Ave SW	C	24.7	C	20.4
SW Spokane St / West Marginal Way SW / Chelan Ave SW	D	51.0	F	80.1
SW Spokane St / Terminal 5 Access	A	9.8	B	13.4
SW Spokane St / 11th Avenue SW	A	2.0	A	4.1
S Spokane St / East Marginal Way S	B	15.9	B	25.2
S Hanford St / East Marginal Way S	B	17.7	C	21.5
East Marginal Way NB Ramp / North Argo Access Road [3]	B	11.1	B	11.9

Source: Synchro model developed by Concord Engineering and Heffron Transportation, Inc., January 2015. Levels of service for signalized intersections were calculated using the Synchro 9.1 methodology. The all-way stop intersection level of service was determined using the 2010 HCM methodology.

1. *Level of service.*
2. *Average seconds of delay per vehicle.*
3. *All-way stop controlled intersection*

2.4. Spokane Street Swing Bridge Operations

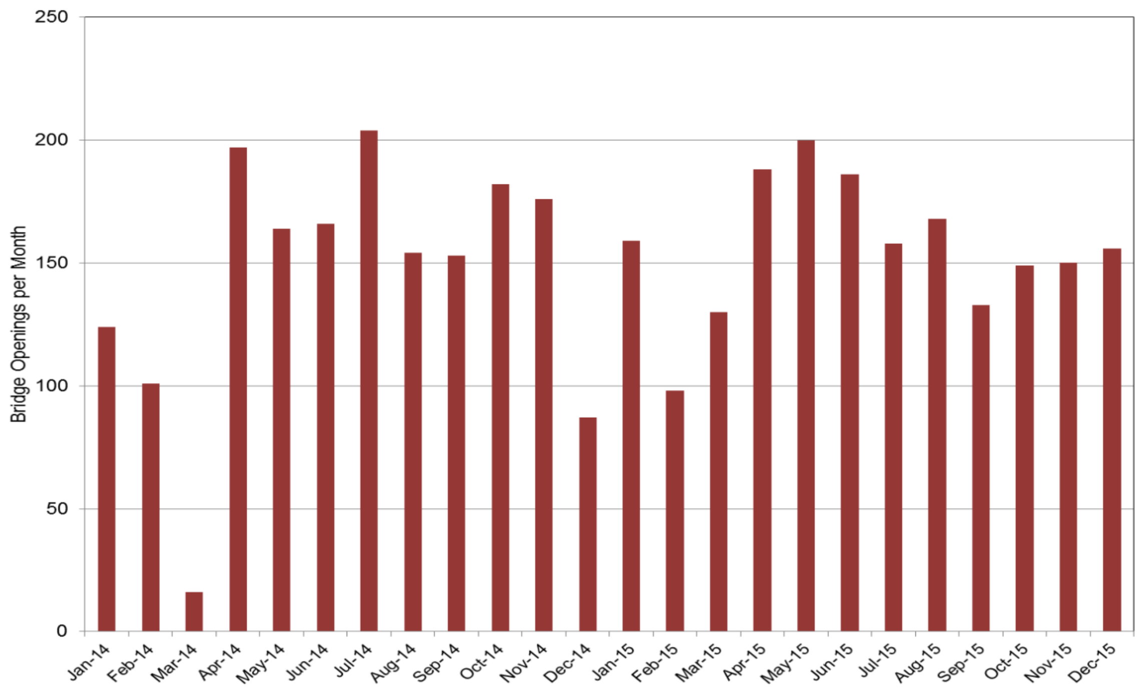
The Spokane Street Swing Bridge is located on lower SW Spokane Street and connects West Marginal Way and Terminal 5 to Harbor Island. This bridge pivots (“swings”) to open for marine traffic on the Duwamish River’s West Waterway. Many large commercial vessels and barges require the bridge to open when transiting to up-river industrial areas. Because the depth of the river is affected by tides, larger vessels must time their trips with accommodating tides. The Swing Bridge has no black-out periods that restrict marine traffic at certain hours of the day, and there is a parallel alternative route on the West Seattle Freeway that most traffic can use when the bridge is open. There are some static message signs with a flashing beacon that alert drivers to use alternative routes when the Swing Bridge is open (locations are shown on Figure 4).

Data related to the frequency and duration of bridge openings were obtained for a two-year period from January 1, 2014 through December 31, 2015. During this period, there were 3,599 bridge openings, an average of 150 per month. Openings tended to occur more frequently during the summer months, with a peak of about 200 openings per month, as shown on Figure 11.

The bridge data were also compiled to determine the duration for each bridge opening. As shown on Figure 12, the average opening was 11.8 minutes long, and the 85th-percentile was 14.0 minutes long. There were a handful of openings that lasted longer than 35 minutes, which included three openings that exceeded 100 minutes.

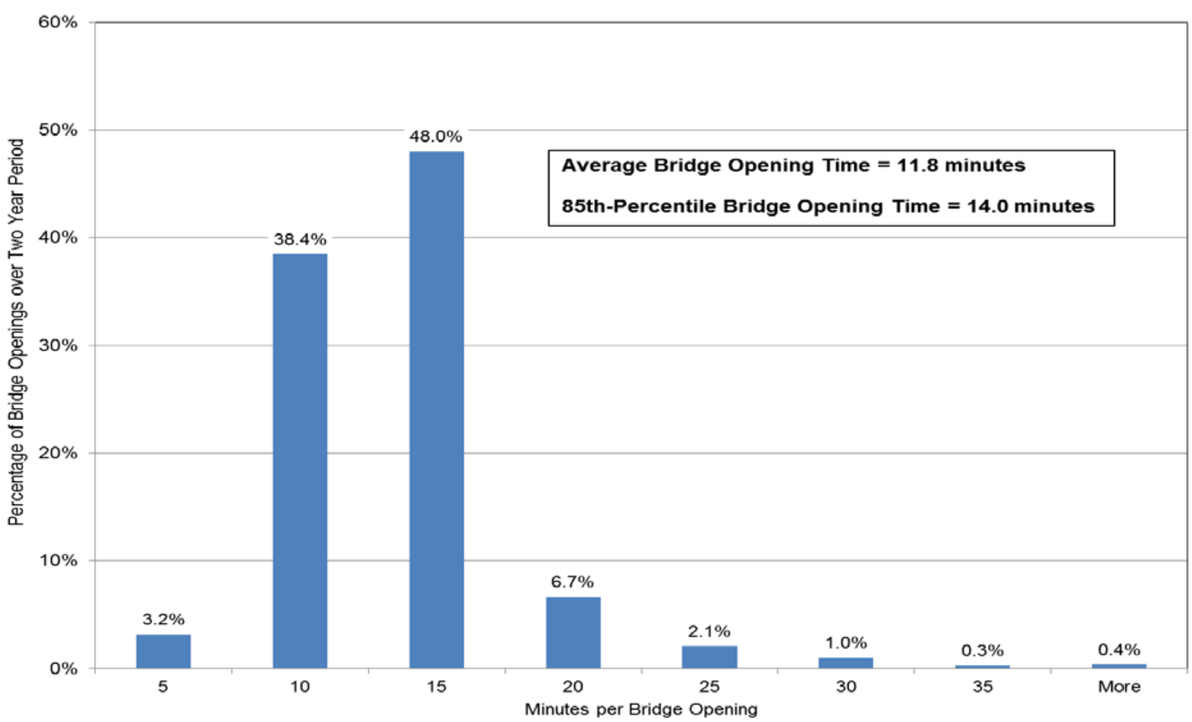
The time of day that openings occur was reviewed. The majority (64%) occurred during daytime business hours between 7:00 A.M. and 5:00 P.M.

Figure 11. Swing Bridge Openings per Month



Source: Seattle Department of Transportation, bridge tender data for period from January 1, 2014 through December 31, 2015.

Figure 12. Duration of Swing Bridge Openings



Source: Seattle Department of Transportation, bridge tender data for period from January 1, 2014 through December 31, 2015.

SDOT has evaluated the bridge opening protocols for the Swing Bridge. The *West Seattle Bridge / Duwamish Waterway Corridor Whitepaper and Priority Investment List*[24] included the following detail related to these protocols:

> *The Spokane St Swing Bridge crosses the West Duwamish Waterway. The waterway existed long before a bridge was installed. The U.S Coast Guard is charged with managing navigable waterways within the United States. Federal law CFR 33 Chapter 11, enacted in 1894, requires bridges to be permitted and, in general, not restrict navigation. The permit for the Swing Bridge requires that bridge openings must occur, without delay, when requested by a vessel captain. In the past, SDOT requested that the Coast Guard grant a deviation from this requirement and allow "closed periods" during peak commute times. Similar to the permit for the Lake Washington Ship Canal bridges, a closed period would restrict bridge openings and avoid vehicle delays during peak commute times. The Coast Guard has denied SDOT's request stating the significant hardship delaying vessel sailing would have on the waterway users. Waterway users argue that sailings are scheduled around tides and currents. A peak period delay of only a few hours could result in many hours of delay until sailing conditions are again favorable. The Coast Guard and federal courts have ruled that, although navigation may have a higher standing than vehicle travel, it is not absolute.*
>
> *SDOT requested that vessel openings be delayed during time of extreme congestion due to a blocking incident on the West Seattle High-Level Bridge. The Coast Guard has specifically ruled that "a bridge opening cannot be delayed due to an incident on a parallel route." They have agreed to broadcast a request that vessels "volunteer" delaying their sailing should SDOT report a blocking incident on the High-level Bridge.*

SDOT has proposed ITS improvements along SW Spokane Street to better coordinate signal operations with bridge openings and to alert users of potential bridge-opening delays. These were previously described in Section 2.1.5 above. In addition, SDOT recommended improvements to the Swing Bridge control system, which is the computer-based program that opens and closes the bridge. It may be possible to reduce the time that SW Spokane Street is closed to traffic by about 30 seconds for each bridge event by changing the electrical/mechanical functional time. In addition, SDOT has worked with the Coast Guard and marine vessel operators to voluntarily avoid bridge openings if there is an incident that blocks traffic on the West Seattle High-Level Bridge or Spokane Street Viaduct.

24 Seattle Department of Transportation, September 22, 2015.

2.5. Traffic Safety

Historical collision data were obtained from the City to determine if there are any unusual traffic safety conditions in the vicinity of Terminal 5. Signalized intersections with 10 or more collisions per year and unsignalized intersections with five or more collisions per year are typically considered high-collision locations by the City. Four years of data were obtained from the City, which includes the period from January 1, 2011 through December 31, 2014. Data specific to bicycle collisions along SW Spokane Street between East Marginal Way S and Terminal 5 were also requested. The reported collisions are summarized in Table 5.

During the four-year period, none of the intersections met the City's threshold for a high collision intersection, and there were no reported collisions involving trains. The highest number of collisions occurred at the S Spokane Street North Road/East Marginal Way S intersection. Of the 12 total collisions, one collision resulted in a fatality (discussed below) and five collisions resulted in six injuries. The second highest number of collisions occurred at the SW Spokane Street/Harbor Ave SW intersection. Two of the seven collisions resulted in a total of four injuries.

There were four recorded bicyclist collisions near the SW Spokane Street/11th Avenue SW intersection, which is where the West Seattle Trail crosses from the north side to the south side of SW Spokane Street. Two of the bicycle collisions occurred in 2011, one in 2012 and one in 2014. There was also one bicycle/bicycle collision on SW Spokane Street between SW Klickitat Way and 11th Avenue SW in 2013. None of the bicycle collisions resulted in a fatality.

There were two fatalities reported within the study area during the four-year analysis time period. One fatality occurred at the S Spokane Street /East Marginal Way S intersection in 2013 during daylight hours. This collision involved two vehicles caused by one vehicle changing lanes. The other fatality occurred at the intersection of S Hanford Street/East Marginal Way S. It involved a semi-truck and bicyclist and occurred in 2013 during daylight hours. After the bicyclist fatality, the City installed a flashing beacon north of S Horton Street to improve the visibility of pedestrians and bicyclists in the corridor. Future improvements are also proposed as part of the *Seattle Bicycle Master Plan*[25], recommends a protected bicycle lane along this segment of the corridor.

[25] Seattle Department of Transportation, *Bike Master Plan Implementation Plan 2015-2019*, October 17, 2014.

Table 5. Intersection Collision Summary

Intersection	Type of Collisions (Totals for 4 Years)							Severity [a]		Collisions by Year				Summary	
	Rear End	Side-Swp	Left Turn	Right Turn	Right Angle	Ped/ Bicycle	Other	# of Injuries	# of Fatalities	2011	2012	2013	2014	Total for 4 Years	Average per Year
S Spokane NR (north road) St / East Marginal Way S	2	2	0	1	3	0	4	6	1	3	5	1	3	12	3.0
SW Spokane St / Harbor Ave SW	1	2	0	2	1	0	1	4	0	1	2	1	3	7	1.8
S Spokane SR (south road) St / East Marginal Way S	1	3	0	0	1	0	1	0	0	3	3	0	0	6	1.5
SW Spokane St / 11th Ave SW	2	0	0	0	0	4	0	1	0	4	1	0	1	6	1.5
SW Spokane St / WSF off-ramp	0	2	0	0	0	0	2	6	0	0	0	4	0	4	1.0
SW Spokane St / West Marg Way SW / Chelan Ave SW	0	1	0	0	0	0	1	0	0	0	1	1	0	2	0.5
S Hanford St/East Marginal Wy S	1	0	0	0	0	1	0	0	1	1	0	1	0	2	0.5
SW Spokane St / T-5 Access	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
SW Spokane St / Klickitat Ave SW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
SW Spokane St / T-18 Access	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0

Source: City of Seattle, January 2015. Summarizes collision data for the four-year period from January 1, 2011 through December 31, 2014.
a. Injuries are not recorded for every collision in the report from the City.

2.6. Rail

Terminal 5 has an existing intermodal rail yard that has six 3,000-foot long loading tracks and about 40,000 linear feet of storage tracks. An intermodal unit train is typically made up of 24 to 28 double-stack rail cars, and each car can accommodate 10 intermodal boxes (containers). A full train's length, including locomotives, can range from 5,000 to 8,600 feet, and is typically 7,500 feet long. When a train arrives at the terminal, it is split into segments by switching each part into the loading tracks and/or storage tracks. The segments are reconnected, attached to locomotives, and undergo break tests before a full unit train leaves the terminal destined for the mainline. During both the arrival and departure switching maneuvers, the trains block the at-grade crossing of West Marginal Way SW just north of SW Spokane Street.

It is estimated that the existing intermodal rail yard has the capacity to handle about 530,000 TEUs per year, which averages to about 18 full unit trains per week. Historically, Terminal 5 generated about nine trains per week, about half of the yard's capacity. Further information about existing rail operations beyond the terminal is provided in the *T-5 Rail Infrastructure and Grade-Crossing Analysis* (Moffatt & Nichol, April 2016).

2.7. Transit

Two King County Metro routes provide bus transit service along SW Spokane Street adjacent to the site. Route 21 provides all-day service between Arbor Heights, West Seattle and Downtown Seattle. The buses operate from 4:45 A.M. to 1:00 A.M. at about 15-minute headways (time between consecutive buses) during most of its operating hours. Route 37 connects between Alaska Junction and Downtown Seattle via Alki Avenue SW, but only operates during the morning and afternoon peak periods. This route has four buses destined to downtown in the morning and four returning buses in the afternoon. Both routes have bus stops on SW Spokane Street just west of Chelan Avenue SW.

Sound Transit's ST3 package will be on the November 2016 ballot. If the ST3 package passes, this project would build light rail from the stadium district in downtown Seattle to the vicinity of Alaska Junction in West Seattle, with an alignment primarily on an elevated guideway and a new rail-only fixed span crossing the Duwamish River. The project would provide five new or expanded stations, including a new station on Delridge Way SW, south of the Terminal 5 site. Further information about the ST3 plans was provided in Section 2.1.5.

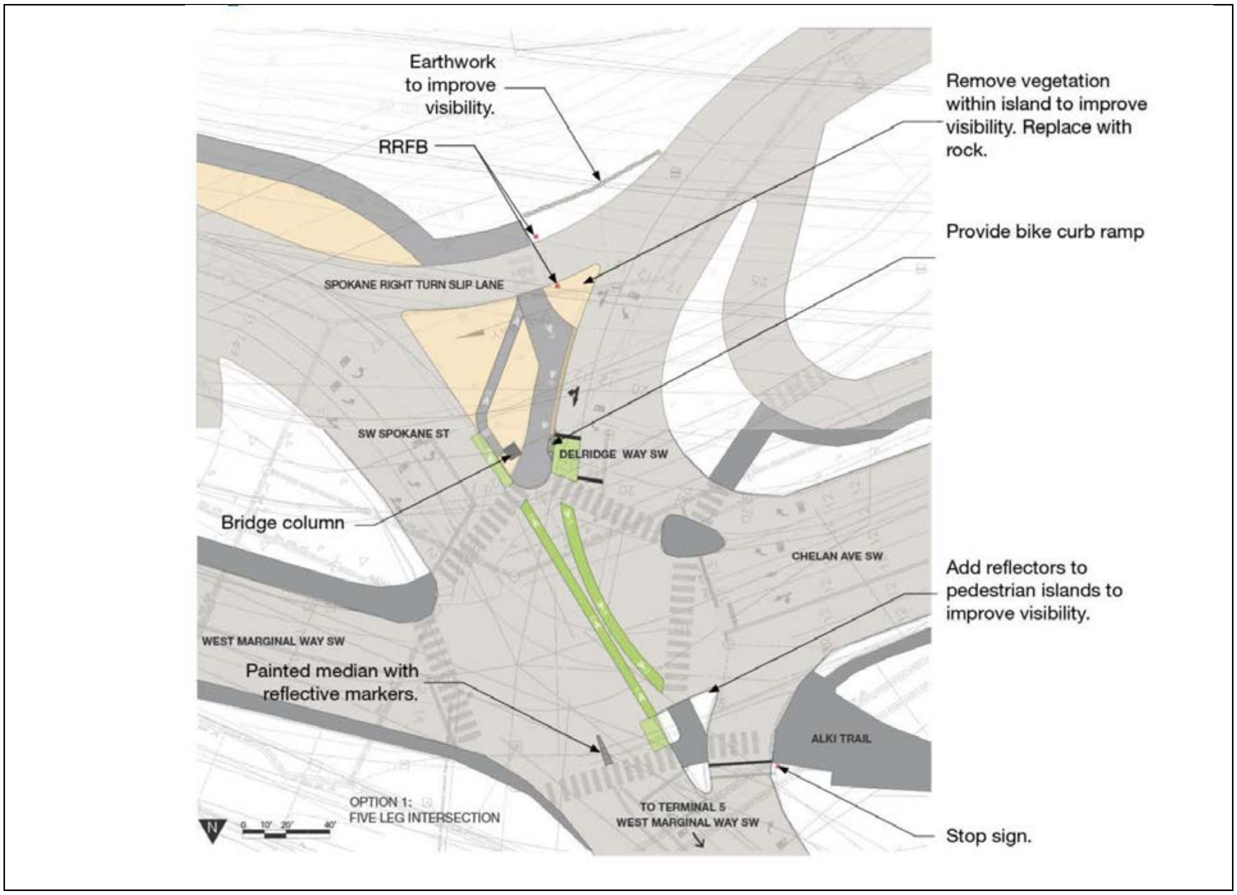
2.8. Non-Motorized Facilities

Most streets in the site vicinity have sidewalks on at least one side of the street. The Terminal 5 Access Bridge has no sidewalks, but does have shoulders (including a very wide shoulder on the west side of the structure) that could be used by pedestrians in an emergency. There is no sidewalk along the north/east side West Marginal Way SW south of Chelan Avenue SW due to the proximity of the railroad tracks along this corridor. There are wide gravel and dirt areas between the curb and railroad tracks that are used by pedestrians.

The West Seattle Trail crosses the Duwamish River on the south side of the Spokane Street Swing Bridge. The trail splits just west of the bridge with a trail continuing high on the slope under the West Seattle Freeway to the Delridge neighborhood, and a secondary connection descending to grade and along sidewalks at the SW Spokane Street/West Marginal Way SW/Chelan Avenue SW intersection. The bike path crosses the Duwamish West Waterway on the south side of the Swing Bridge, and crosses to the north side of SW Spokane Street at 11th Avenue SW, which provides a signalized crossing. The path crosses the Harbor Island Access Road (surface SW Spokane Street), 11th Avenue SW, and the Terminal 18 truck gate driveway at unsignalized crossings. Further east, the West Seattle Trail connects to East Marginal Way, which has a sidewalk on its west side and painted bicycle lanes on both sides.

In 2015, SDOT enhanced the existing surface bicycle travel routes through the intersection with green bike boxes and green bike lanes as shown on Figure 13. These "short-term" improvements are intended to be the first phase of bicycle improvements at the intersection.

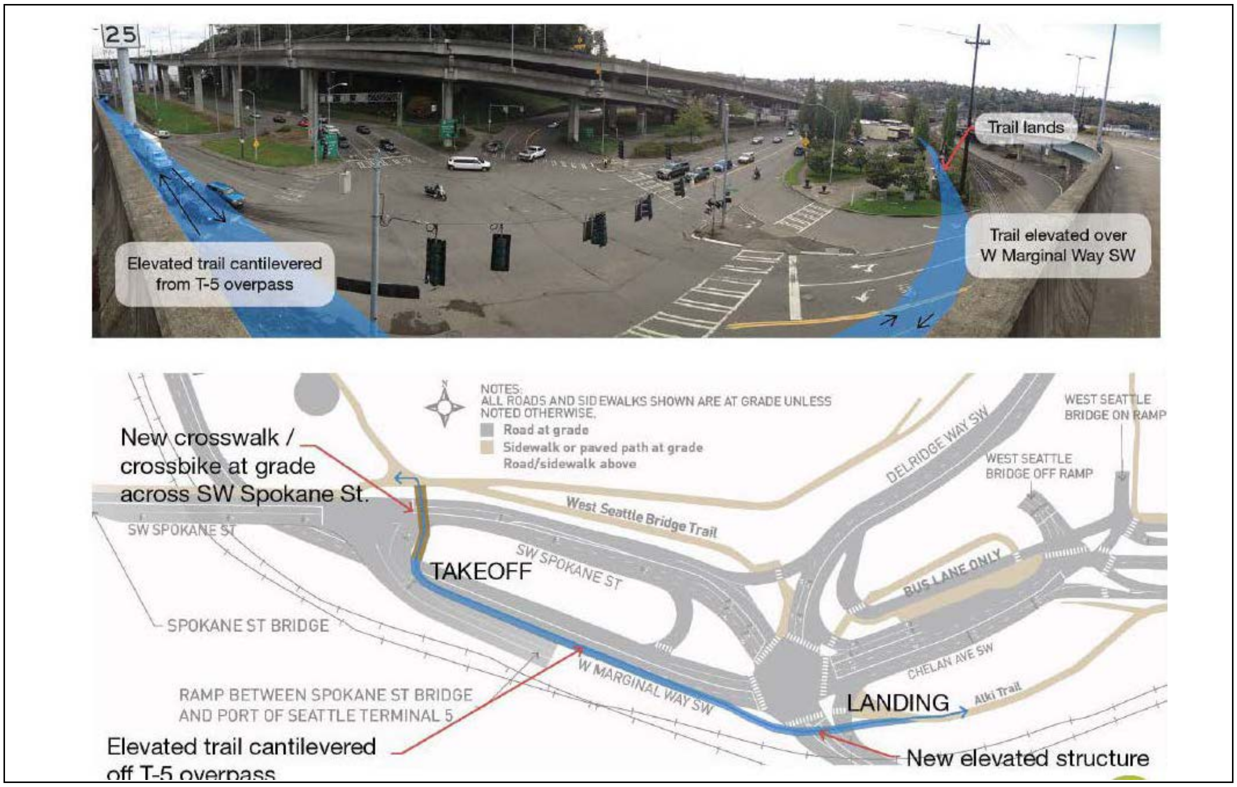
Figure 13. Short-Term Bicycle Improvements at Five-Legged Intersection



Source: SDOT, Presentation to the Seattle Bicycle Advisory Board, January 7, 2015. The green bicycle lanes were added to the intersection in 2015.

In the long-term, SDOT recommends a grade-separated structure for bicyclists (and pedestrians) that would connect from the existing Terminal 5 Access Bridge to SW Spokane Street west of Chelan Avenue SW. The potential new crosswalk on the west side of the SW Spokane St/T-5 Access would also be accompanied with bike and pedestrian signal heads and detection. That option is depicted in Figure 14. Additional structural analysis and design would be needed to determine if it is possible to cantilever the pedestrian/bicycle facility off of the existing T-5 Access Bridge. SDOT has also suggested a potential mid-term solution that would create a trail parallel to West Marginal Way SW and connect to the SW Spokane Street Bridge via streets located south of the bridge. SDOT will continue to evaluate the mid-term and long-term options, and no timetable for implementation has been proposed. SDOT has no plans or funding to implement mid- or long- term improvements at the intersection of Chelan Ave SW, W Marginal Way SW, SW Spokane St, and the Alki Trail.

Figure 14. Potential Long-Term Bicycle Improvements at Five-Legged Intersection



Source: SDOT, Presentation to the Seattle Bicycle Advisory Board, January 7, 2015.

2.9. Parking

Terminal 5 has about 540 parking spaces that are located in various lots around the terminal. The largest parking lots are located adjacent to the Administration Building (183 spaces), transit shed (143 spaces), and gate house (155 spaces). There are about 40 other spaces located near the maintenance facilities, intermodal yard, and security gate.

On-street parking is not allowed along most streets in the site vicinity. The exception is Harbor Avenue SW, but the parking is separated from the main areas of the terminal by the intermodal rail yard, a fence, and a landscaped berm.

In 2008, the City of Seattle and Port of Seattle convened the *South Harbor Truck Parking* workgroup in response to community concerns about heavy-duty trucks parking along residential streets in the Georgetown and South Park neighborhoods (truck parking is allowed on industrial streets). The work group recommended many measures to address truck parking.[26] The key elements that were implemented included:

- The Port of Seattle implemented a free truck parking lot for about 120 trucks (power only, no trailers) on the south end of T-25. That parking lot is still in operation.
- City and Port jointly developed outreach materials to inform truck drivers about parking regulations and show on a map where truck parking and overnight parking is prohibited.
- City installed additional signage where truck parking is prohibited (per SMC 11.72.070).
- City would increase enforcement of truck parking regulations.

The actions did help reduce truck parking impacts; however, ongoing education and enforcement may be needed.

[26] Port of Seattle, *South Harbor Truck Parking: Work Group Recommendations*, April 2009.

3. CONSTRUCTION-RELATED IMPACTS OF ACTION ALTERNATIVES

Alternatives 2 and 3 would generate temporary increases in vehicular, truck, train, and barge traffic associated with construction activities to rehabilitate the wharf, deepen the berth, and reconstruct upland facilities including the container yard, intermodal yard, and support facilities. The potential transportation-related elements of this work include:

- Transport of construction debris and dredge spoils away from the project site;
- Transport of construction materials and equipment to the site; and
- Travel and parking demand generated by construction workers.

In addition, the Action Alternatives would construct a new substation on the site, which would eliminate some existing parking. This section describes the transportation impacts associated with the construction elements of the Action Alternatives.

Details about how the Terminal 5 berth improvements would be constructed are presented in the *Biological Assessment Terminal 5 Cargo Wharf Rehabilitation and Berth Deepening*[27] report. The work is expected to be completed over two years, with in-water work limited to a period between mid-August and mid-February. The elements that could affect transportation would be demolition, transportation of piles and other materials, and dredging. Each of these is described below.

Wharf Demolition: The project would demolish older wharf and structural systems as needed. This includes removing piles, overwater structures, and asphalt paving. Materials removed during demolition are expected to be trucked off site. At the peak, demolition activities may generate up to ten double dump truck loads per hour, resulting in 20 truck trips per hour (10 trucks arriving and 10 trucks departing).

Transport of Piles: Upgrading the berth is expected to require about 4,400 piles, which includes a combination of H-piles, sheet piles, concrete piles, and pinch piles. Given the various installation methods, it is expected that six sheet or concrete piles could be installed per day, and 7 pinch piles could be installed per day. The piles would be delivered to the terminal on trucks, with up to two truck deliveries per day.

Dredging: Dredge spoils are expected to be loaded onto a barge, and disposed of according to strict requirements of the U.S. Environmental Protection Agency (EPA), Department of Natural Resources (DNR), and Washington Department of Ecology (DOE). Dredge sediments unsuitable for open water disposal would be barged to a contractor-provided upland offloading facility. Therefore, none of the dredged material is expected to generate truck traffic from Terminal 5.

Upland Improvements: Alternative 3 would include improvements to the upland areas and railyard to increase terminal storage and handling capacity. The container marshalling area would be enlarged by demolishing and/or relocating the existing entrance gate, freight station, transit shed, maintenance and repair facilities. The existing intermodal rail yard would be reconfigured with additional rail lines and concrete or rail runways for RTG or RMG equipment. These construction activities would generate truck and construction worker trips.

[27] Hart Crower, March 19, 2015.

The highest volume of trucks during uplands construction would occur during demolition. It is estimated that all of the demolition materials (e.g., pavement, structures) could generate 2,200 to 2,800 truckloads of material, and each load would generate two truck trips (one empty truck entering the site and one full truck leaving). If the material is stock-piled, then the number of trucks would be generated at the rate that they can be loaded, which with two loaders is estimated to be limited to about 20 loads per hour and 160 loads per day. This could generate up to 40 truck trips per hour and 320 truck trips per day. If the material is not stock-piled, trucks would be loaded at a slower rate that accounts for the time to remove materials and load them directly.

Concrete and pavement installation for the uplands is likely to occur in phases, with half of the pavement being completed during the non-in-water work months of one year, and half being completed in the next year. The total paved area is estimated to require 2,650 truckloads of surface course, concrete, and asphalt, which relates to 1,325 truckloads per year. Concrete and asphalt work would likely be done at different times, and each is estimated to generate a maximum of 10 truckloads per hour, and 80 truckloads per day.

Construction worker trips would vary by stage of work, and typically the peak construction worker load occurs during building construction when many different trades can be on the site simultaneously (e.g., carpenters, electricians, plumbers, etc.). These peak phases for construction workers would not overlap with the peak truck activity described above.

Substation: Alternatives 2 and 3 include upgrading the power supply to the terminal and constructing a new substation near the Administration Building, the footprint of which would eliminate 29 parking spaces.

For all stages of construction, the number of construction workers at the site would be less than the terminal employs when operational, and the number of truck trips generated would be less than the container terminal would generate. Therefore, the level of traffic and parking demand would also be less. The vicinity roadways and the on-site parking supply could accommodate traffic and parking demand generated by construction activities. No adverse impacts associated with construction traffic or parking are expected.

Prior to beginning construction work that could impact SDOT right-of-way; the contractor would be required to submit the following information to SDOT for review and approval of necessary permits:

- Haul Route Plan;
- Traffic control plan for work on or adjacent to an arterial street;

In addition, the Port and NWSA would commit to being part of SDOT's ongoing construction coordination program to ensure coordination of project timelines, construction sequencing, traffic control plans and construction staging.

4. TRAVEL DEMAND ESTIMATES FOR ALL PROJECT ALTERNATIVES

This section presents the travel demand estimates for all of the project alternatives, including the No Action Alternative. The historic travel demand for Terminal 5 was previously presented (see Section 2.2.3) to provide context and establish the Design Day trip generation for the existing condition. Information is then presented (Section 4.2) to estimate how those volumes would change with larger ship sizes and increased throughput. The travel routes and trip assignments are then presented (Section 4.3) to estimate each alternative's trips on study area roadways.

4.1. Parameters for Estimating Truck Trips

Over the past two decades, trucking logistics have improved with enhancements to fleet management systems and trip planning processes. One recent industry trend has seen shipping lines adding vessels to service routes while maintaining the same number of ports of call. This allows vessels to sail at reduced speeds, which saves significant costs by reducing fuel use. This also results in increased time in port, which spreads out discharge and load activities, and reduces the need to staff terminals during the more expensive hoot shifts.[28] These industry changes have affected truck traffic at the port by reducing seasonal and daily peaks in traffic. The following sections present the primary factors used to derive truck trip generation estimates for the increased capacity conditions that could occur at Terminal 5.

4.1.1. Average Container Size

The Port tracks throughput at each terminal by both the numbers of containers and TEUs, a twenty-foot equivalent unit, which is the standard unit of measure for the shipping industry. A 40-foot container is equivalent to 2.0 TEUs. In the past 10 years, the average number of TEUs per container for all Port terminals has been relatively steady at 1.74. Over 70% of containers are 40-foot or larger. This factor was used to convert TEU forecasts to containers for use in the truck trip forecasts.

4.1.2. Average Day and Design Day

RFID data described previously were compiled for all of the Port terminals. The number of days per year that truck gates were open at the Port's three largest terminals ranged from 245 days at Terminal 5 to 293 days at Terminal 18. The average was 260 days per year, which indicates that the terminal gates are open on some weekend days and some holidays. Many Saturdays experienced truck volumes that were close to the average day; Sunday volumes were the lowest of the week. It was assumed that the upgraded Terminal 5 would be open for 260 days per year to reflect an Average Day condition.

Traffic analysis is often performed for an 85th-percentile condition, which will be referred to as the Design Day. Based on RFID data for the entire port, the 85th-percentile volumes were 18% to 40% higher than the average day volumes through each terminal. The lowest peak condition occurred at Terminal 5, which had many smaller ship calls; the highest peak condition occurred at Terminal 18, which accommodated larger ships. To be conservative, and to account for the potential for larger ships at Terminal 5, the Design Day truck volumes were assumed to be 40% higher than an average day. As described later, the 40% increase accounts for the potential increase in truck activity associated with large ship loading and unloading events. Based on analysis of throughput at Terminal 18 during large-ship events, which is described in Section 4.1.5, this factor results in a conservatively high estimate of trips.

[28] Moffatt & Nichol, December 2014.

4.1.3. Truck Trips per Ship Lift

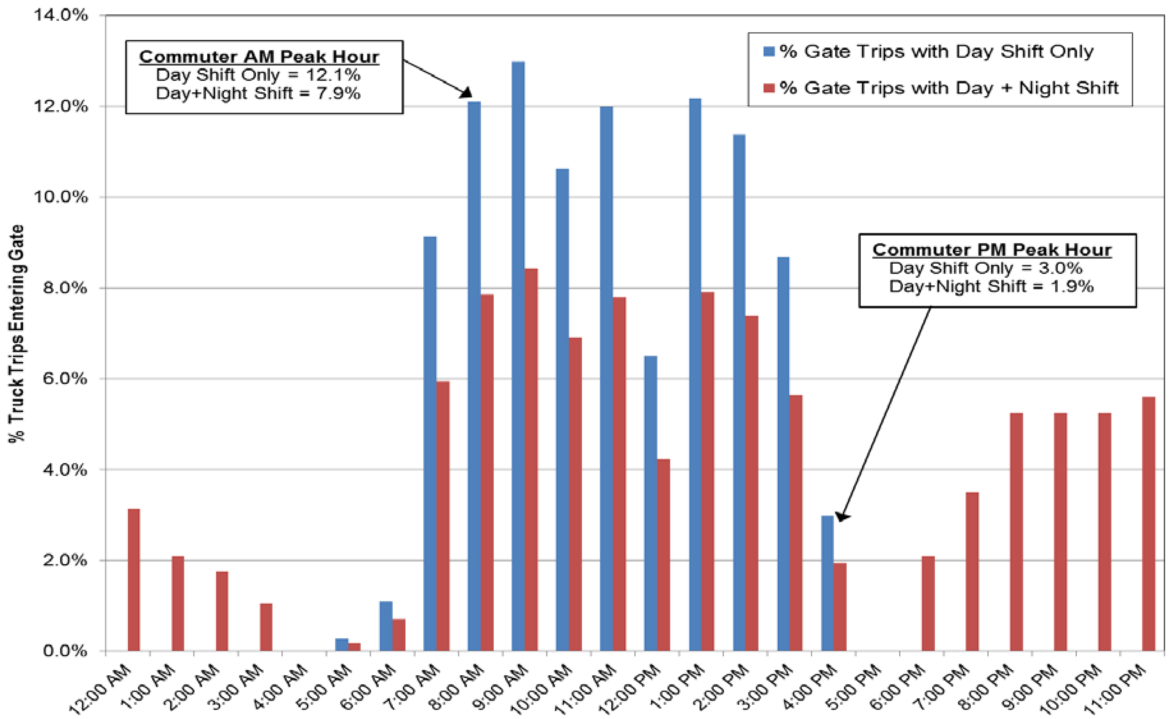
Two months of detailed RFID data and ship lift data for the Terminal 18 gate were compared to determine a truck trip factor per gate move. A ship lift is counted every time a container is either loaded or unloaded from a ship at the terminal. Overall, the terminal generated approximately 1.77 truck trips for every ship lift of a container not moved by on-dock rail. Trips are defined as one-way movements. Since the value is less than two, it means that some trucks drop off one container and pick up a second during the same trip through the terminal. This type of increased efficiency would likely be required for Terminal 5 to achieve the increased throughput target. The factor of 1.77 truck trips per ship lift was applied to all containers projected to enter or leave the terminal through the truck gate (excluding those moved through the terminal's on-dock rail yard).

4.1.4. Truck Trips by Time of Day

The port-wide RFID data for the period from April 1, 2013 through March 22, 2014 were compiled to determine the arrival patterns for trucks at all of the Port terminals. This average arrival pattern is presented in Figure 15. Based on these truck arrival data, peak hour traffic analysis assumed that 12% of each day's trips would occur during the AM peak hour of the nearby street system, which is the highest one-hour volume between 7:00 and 9:00 A.M. During the street system's PM peak hour (the highest one-hour volume between 4:00 and 6:00 P.M.), the terminal would generate 3% of the day's traffic. These data also show a lower arrival rate during the lunch hour, which reflects the anticipated change to a grounded container operation by which truck drivers cannot fetch or deliver their own load without longshore support. Under these conditions, the gates would likely close or operate at reduced capacity during the longshore lunch hour. It is noted that this pattern reflects a conservatively high condition where the terminal gates are open for the standard day shift from 8:00 A.M. to 5:00 P.M.. If gates are opened earlier or during lunch, a lower percentage of traffic would likely occur during the peak hours. The pattern with only a daytime shift was assumed for the No Action and Alternative 2 conditions.

For Alternative 3, capacity limitations of the RMGs within the terminal to load trucks would likely require that a second shift be added to the gate on peak days. Under this condition, a reservation system would also be implemented to spread truck traffic out over the course of the two shifts. The potential effect on traffic through the gate was estimated, assuming that 50% of the intermodal dray trips would be moved during the night shift, and that 25% of the local/regional trucks would be moved during the night shift. The potential effect on traffic through the gate is also shown on Figure 15. With a second shift, the percentage of daily trucks that would arrive during the AM peak hour would decrease from about 12% to 8%, and truck arrivals during the PM peak hour would decrease from 3% to 2%. The estimated daily and peak hour volumes for each alternative are presented later in this section.

Figure 15. Truck Arrivals at Port Terminals by Time of Day

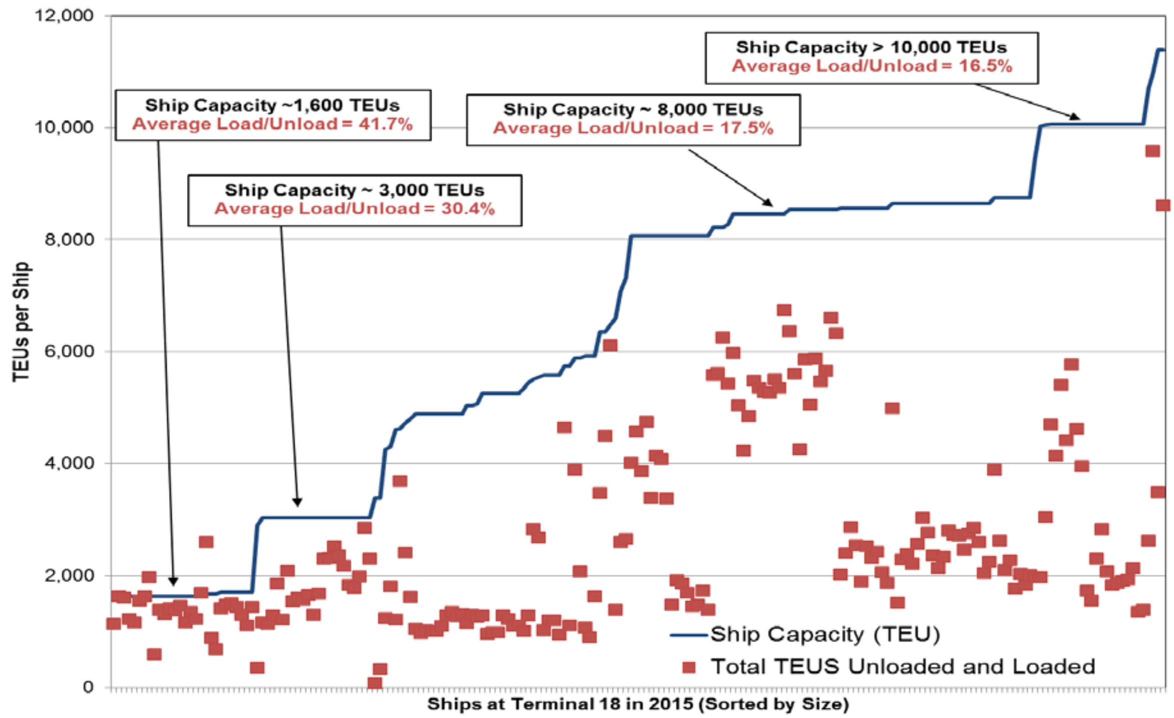


Source: RFID data from Port of Seattle for all terminals for the period from April 1, 2013 through March 22, 2014. Data compiled by Heffron Transportation, Inc.

4.1.5. Effect of Larger Vessels on Traffic Peaks

With the Alternative 2 or 3 improvements, larger vessels are expected to call at Terminal 5 than could be accommodated by the existing cranes. To better understand how larger ships could affect truck traffic entering and exiting the terminal, detailed analysis was performed for Terminal 18, which currently accommodates larger ships. For Seattle, which has a more limited local market for goods compared to other large ports such as Los Angeles or Long Beach, a larger ship does not necessarily relate to more containers per call. To illustrate this, 11 months of vessel calls were tracked for Terminal 18 and compared to the number of containers that were unloaded or loaded from each vessel. Figure 16 illustrates the relationship between vessel size and throughput. As shown, smaller ships have a higher percentage of cargo unloaded or loaded. The data reflected many calls of ships larger than 10,000 TEUs with fewer containers moved through the terminal than the containers moved for much smaller ships.

Figure 16. Vessel Size vs. Throughput at Terminal 18 – Year 2015



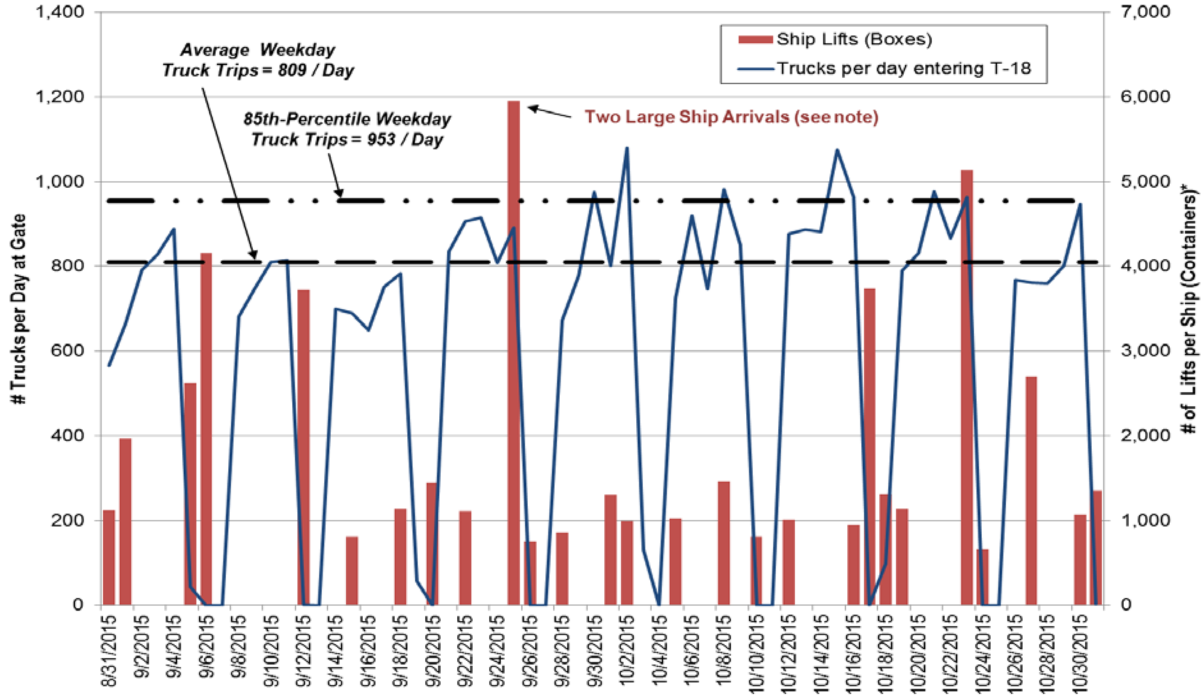
Source: Data from Port of Seattle, compiled by Heffron Transportation, Inc.,
Total TEUs loaded or unloaded per ship for the period from January 1, 2015 through November 30, 2015.

Ship activity at the various terminals usually follows a regular pattern, with weekly or biweekly service to and from various foreign ports. To understand how ship arrivals and the sizes of those ships could affect truck movements through the terminal gates, two months of ship lift and truck RFID data were reviewed for Terminal 18 (September and October 2015). Figure 17 shows the number of daily truck trips that entered Terminal 18 for each day of the period, overlaid with lifts from individual ships. Sundays are the days with no traffic through the gate. The ship lifts are shown for the day that the ship arrived, even though those lifts may have occurred over a number of days. This allows the truck gate effect to be related to the size and throughput for each ship.

The chart shows a relatively constant pulse of activity in each week, which typically included one large ship plus several smaller ones. The peak day for ship activity occurred on September 25, 2015 when two ships arrived at the terminal with respective capacities of 11,388 TEUs and 8,566 TEUs. A total of 5,956 containers (10,924 TEUs) were unloaded/loaded for these two ships, which is about 27% of the combined capacity. Truck volumes entering the terminal remained relatively constant, and while there was a slight increase in daily volumes about four days after the peak ship arrivals, it was not much higher than daily trips generated two weeks later when there were smaller ships at the terminal. On the average weekday during the two-month period, 809 trucks entered the terminal. This increased to 953 trucks per day on the 85th-percentile day (18% higher than average), and 1,081 trucks per day on the peak day (34% higher than average).

The Design Day for Terminal 5 assumes that truck volumes will be 40% higher than the average day. Based on the observations at Terminal 18, this factor reflects a conservatively high estimate of truck trips, and captures the potential increase in truck traffic associated with a larger ship or expedited load/unload event.

Figure 17. Trucks Entering Gate vs. Ship Lifts at Terminal 18



Source: Port of Seattle RFID Data at Terminal 18 inbound gate and ship lift data for Terminal 18. Notes: Two Ship Arrivals on 9/25/15 with capacity of 11,388 TEUs and 8,566 TEUs, respectively. A total of 5,956 boxes (10,924 TEUs) were unloaded/loaded for these two ships.
Red lines indicate the day that the ship arrived. Containers may have been loaded or unloaded over more than 1 day.

4.2. Future Throughput and Truck Volumes

Cranes at the current Terminal 5 facility are each capable of serving 6,000 TEU ships.. Shippers have been using larger and larger vessels to reduce costs. Vessels capable of carrying 10,000 to 18,000 TEU capacities are starting to be used on routes to other West Coast terminals. Vessels of that size would typically call on several ports during a West Coast circuit, discharging only a portion of their capacity at one port. Alternative 1, the No Action Alternative, assumes that Terminal 5 would resume operating as it had in the past with Panamax-class vessels. Alternatives 2 and 3 assume that vessels carrying up to 18,000 TEUs would call at Terminal 5, which would increase the throughput. The potential effects of these changes and the resulting truck and rail trip generation are described in the following sections.

4.2.1. Terminal Throughput and Vessel Calls

The estimated vessel call and discharge rates for Alternatives 1 through 3 were previously presented in Table 1 of this report.

Alternative 1 (No Action Alternative) assumes an annual throughput at Terminal 5 of 647,000 TEUs. Alternative 1 assumes that existing cranes would continue to be used, and that the vessel calls would be similar to what occurred previously when an average of six vessels per week called at the terminal. The vessels reflected a mix of sizes, and only a portion of the vessel capacity was unloaded from or loaded onto each ship.

With Alternatives 2 or 3, the improved pier and deeper berth would allow larger ships to call at Terminal 5. An analysis was performed by Moffatt & Nichol to determine the potential throughput that could be accommodated by the terminal given the potential berth capacity, container yard area, storage density, peaking factors associated with larger ships, and container dwell time in the terminal. For Alternative 2, which would have modest upland improvements, the throughput is estimated at 1.3 million TEUs per year. For Alternative 3, which would have increased container yard and intermodal yard capacities, the throughput is estimated to be 1.7 million TEUs per year.

4.2.2. Intermodal Share

The majority of containers that move through the Port are transported by rail between their landside connections and inland origins or destinations. At Terminal 5, most would be transferred to and from rail through the on-dock intermodal rail yard; some would be drayed to the off-dock rail yards. The percentages of containers via each mode of travel were previously presented in Table 2. For the No Action Alternative, an estimated 55% of the containers would be intermodal. With increased throughput at Terminal 5 with Alternatives 2 or 3, the percentage of containers transported by rail is expected to increase to 75%, with two-thirds (or 50% of the total throughput) assumed to be handled at the on-dock intermodal yard and one-third (or 25% of the total) assumed to be drayed to off-dock rail yards. The remaining 25% of the total cargo would be trucked to local and regional businesses.

4.2.3. Truck Trips

The factors described above were used to estimate truck trips for the increased throughput scenarios, which are presented in Table 6. As shown, with the increased throughput volumes, the upgraded Terminal 5 is expected to generate 3,560 to 4,660 truck trips on the Design Day for Alternatives 2 and 3, respectively. It is noted that truck trips are reported as one-way trips (e.g. 4,660 truck trips per day reflects 2,330 trucks entering the terminal and 2,330 trucks exiting the terminal). The table also shows the estimated net change in trips for the Action alternatives as compared to the No Action Alternative, projected at 1,080 additional Design Day truck trips for Alternative 2 and 2,180 additional Design Day truck trips for Alternative 3.

The table also summarizes projected peak hour trips. As previously described, Alternative 1 and 2 are assumed to operate with only a daytime shift at the truck gate. Alternative 3, however, would require a second gate shift on peak days. Therefore, Alternative 2 would have the highest peak hour truck trips, and is estimated to generate an additional 130 truck trips during the AM peak hour and 31 truck trips during the PM peak hour on the Design Day.

Table 6. Terminal 5 Truck Trip Generation Estimates – All Alternatives

Condition	Average Day Truck Trips			Design Day Truck Trips		
	Daily	AM Peak Hour	PM Peak Hour	Daily	AM Peak Hour	PM Peak Hour
Alternative 1 - No Action [a]						
Drayed to Off-Dock Rail Yard	630	76	19	890	107	27
Trucked to local/regional businesses	1,140	137	34	1,590	191	48
Total	1,770	213	53	2,480	298	75
Alternative 2 – 1.3 Million TEUs/Year [a]						
Drayed to Off-Dock Rail Yard	1,270	152	38	1,780	214	53
Trucked to local/regional businesses	1,270	152	38	1,780	214	53
Total	2,540	304	76	3,560	428	106
Alternative 3 – 1.7 Million TEUs/Year [b]						
Drayed to Off-Dock Rail Yard	1,660	133	33	2,330	186	47
Trucked to local/regional businesses	1,660	133	33	2,330	186	47
Total	3,320	266	66	4,660	372	94
Net Change in Trips for Alternative 2	770	91	23	1,080	130	31
Net Change in Trips for Alternative 3	1,550	53	13	2,180	74	19

Source: Derived by Heffron Transportation, Inc. January 2016.

a. *Terminal gate for Alternatives 1 and 2 assumed to be open during day shift only. With that condition, 12% of the daily trips would occur in the AM peak hour, and 3% would occur in the PM peak hour.*

b. *Terminal gate for Alternative 3 assumed to be open during both day and night shift. With that condition, 8% of the daily trips would occur in the AM peak hour and 2% would occur in the PM peak hour.*

4.2.4. Employee Trips

The numbers of employees needed to staff the terminal during various ship unload/load events was estimated for each alternative. When the terminal is operating at peak capacity, it is likely to have all cranes staffed. This in turn increases the yard equipment needed, as well as staffing at the terminal's on-dock intermodal yard and truck gates. The Average Day conditions assume that a single ship would call at the terminal; the Design Day assumes two ship calls. The following assumptions were made related to terminal staffing.

- **Crane/Yard Gangs –** Each crane is typically operated by a crew (referred to as a "gang") of 22 persons, which includes the crane personnel as well as ground crews to position containers inside the terminal. Terminal 5 currently has six cranes, which can be configured to service two smaller ships or one larger ship. With the Alternative 2 or 3 pier and berth improvements, the terminal could have up to 12 cranes operating for two large ships. When the terminal is operating at peak berth capacity, a second crane shift would be needed for all alternatives.

- **Gate Clerks and Supervisors –** The existing truck gate, which has 13 lanes (10 inbound and 3 outbound) would remain for the No Action Alternative and Alternative 2, and would be operated with remote clerks in a single office (also called "the kitchen"). When the terminal is operating at capacity, it is assumed to require 24 staff (clerks and supervisors). For Alternative 3, capacity limitations of the RMGs within the terminal to load and unload trucks would likely require that a second shift be added to the gate on peak days. Under this condition, a reservation system would also be implemented to spread truck traffic out over the course of the two shifts. The gate would require fewer staff for the day shift, but would add staff for a second gate shift.

- **Yard Staff –** Terminal 5's on-dock intermodal yard is assumed to operate during two shifts, and would be staffed by up to 30 people for the No Action Alternative and Alternative 2. Alternative 3 would increase the capacity of the yard, and yard staff could increase to 54 people for each of two shifts.

- **Mechanics/Service Personnel –** Staff needed to maintain yard equipment would increase with throughput and amount of equipment used. The highest staffing need would be for Alternative 2, which assumes use of top picks for many operations.

- **Management –** Five to eight managers are assumed to be on terminal for a day shift with one to two during a night shift.

Table 7 summarizes the assumed staffing needs for both the existing and improved conditions.

Table 7. Terminal 5 Employee Estimate – All Alternatives

Personnel	Throughput	Average Day (1 ship)		Design Day (2 ships)	
		Day Shift	Night Shift	Day Shift	Night Shift
Alternative 1 (No Action)	647,000 TEUs/year	4 cranes / 9 gate lanes		6 cranes / 13 gate lanes	
Crane/Yard Gangs		88	0	132	132
Gate Clerks & Supervisors		5	0	7	0
Rail Yard Staff		20	0	30	30
Management		5	0	5	1
Mechanics		16	0	16	8
Total		134	0	190	171
Alternative 2 (Wharf Improvements)	1.3M TEUs/year	6 cranes / 13 gate lanes		10 cranes/13 gate lanes	
Crane/Yard Gangs		132	0	220	220
Gate Clerks & Supervisors		24	0	24	0
Rail Yard Staff		30	0	30	30
Management		5	0	5	1
Mechanics		16	0	27	14
Total		207	0	306	265
Alternative 3 (Wharf + Uplands)	1.7 M TEUs/year	6 cranes / 13 gate lanes		12 cranes/13 gate lanes	
Crane/Yard Gangs		132	138	258	258
Gate Clerks & Supervisors		18	16	18	16
Rail Yard Staff		54	54	54	54
Management		8	2	8	2
Mechanics		26	13	23	13
Total		244	223	364	343

Source: Heffron Transportation and Moffatt & Nichol, January 2016.

Some of the employees who work the day shift could take transit, walk or bike to work. However, those options are limited by the fact that many employees are dispatched from the labor hall and do not arrive directly from home. In addition, transit may not be available to night shift employees since none of the bus routes that serve the near-site area operate after 2:00 A.M. when the night shift typically ends. Employee modes of travel were derived from 'Journey-to-Work' survey results from the year 2010 Census.[29] No data were reported for the Transportation Analysis Zone (TAZ) where Terminal 5 is located; therefore, data for the two TAZs just south of Terminal 5 (TAZs 176 and 179), which have industrial uses and similar transit service, were reviewed. The data showed that 96% of the employees commuted by personal vehicle (77% by single-occupant vehicle and 19% by carpool), 1% walked or biked to work, and 3% used transit. These results are similar to the year 2000 Census data reported for the census tract where Terminal 5 is located that also determined that 96% of the employee trips were made by personal vehicle. The modes of travel are reasonable given the limitations described above.

[29] Compiled by the Puget Sound Regional Council.

Trip generation rates used to estimate Terminal 5 employee trips assume that each employee travels to the site before the shift, leaves just after the shift, and that very few employees leave the site during the shift. Therefore, a daily trip generation rate of 2.10 trips per employee was used. For the morning and afternoon peak hours, a trip generation rate of 0.65 trips per employee was assumed, which reflects 65% of the employees entering or leaving the site during the peak hour. The employee trips were then adjusted to reflect the mode of travel characteristics described above in which 4% of the trips occur by non-vehicular modes, and the average vehicle carried 1.2 persons. The transit trip reduction was not applied to inbound trips during the PM peak hour since few transit routes are in service at 2:00 A.M. when the night shift ends. The employee trip generation for each alternative is summarized in Table 8.

Based on the estimated staffing levels, the highest number of employee trips would occur in the PM peak hour, when employees who work the day shift leave the terminal and those who work the night shift arrive at the terminal.

Table 8. Terminal 5 Employee Vehicle Trip Estimates – All Alternatives

	Daily [a]			AM Peak Hour			PM Peak Hour		
	In	Out	Total	In	Out	Total	In [b]	Out	Total
Average Day Condition									
No Action (Alternative 1)	113	113	226	70	0	70	0	70	70
Alternative 2	174	174	348	108	0	108	0	108	108
Alternative 3	392	392	784	127	0	127	121	127	248
Net Change - Alt 2	61	61	122	38	0	38	0	38	38
Net Change - Alt 3	279	279	558	57	0	57	121	57	178
Design Day Condition									
No Action (Alternative 1)	303	303	606	99	0	99	93	99	192
Alternative 2	480	480	960	159	0	159	144	159	303
Alternative 3	594	594	1,188	189	0	189	186	189	375
Net Change - Alt 2	177	177	354	60	0	60	51	60	111
Net Change - Alt 3	291	291	582	90	0	90	93	90	183

Source: Heffron Transportation, Inc., August 2016.

a. *Daily trips assume that each employee generated 2.10 trips per day, and that 65% of the employees commute during the peak one hour period in the morning and afternoon. Vehicle trips assume that 96% of the trips occur by vehicle with an average vehicle occupancy of 1.2 persons per vehicle.*

b. *Account for 2nd shift employees arriving during PM peak hour. All inbound trips during the PM peak hour are assumed to be by vehicle (single occupant and carpool) since most transit service does not operate at 2:00 A.M. when the night shift ends.*

The number of walk/bike and transit trips was also estimated based on the mode of travel experience for the site area. These are summarized in Table 9. At peak employment (Alternative 3 during a Design Day), the Terminal 5 project is expected to generate a net increase of 4 walk/bike trips per day (2 in and 2 out) and 10 transit trips per day (5 in and 5 out).

Table 9. Terminal 5 Employee Walk/Bike and Transit Trip Estimates – All Alternatives

	Daily Walk/Bike Trips [a]			Daily Transit Trips [b]		
	In	Out	Total	In	Out	Total
Average Day Condition						
No Action (Alternative 1)	1	1	2	4	4	8
Alternative 2	2	2	4	6	6	12
Alternative 3	2	2	4	7	7	14
Net Change - Alt 2	1	1	2	2	2	4
Net Change - Alt 3	1	1	2	3	3	6
Design Day Condition						
No Action (Alternative 1)	2	2	4	6	6	12
Alternative 2	3	3	6	9	9	18
Alternative 3	4	4	8	11	11	22
Net Change - Alt 2	1	1	2	3	3	6
Net Change - Alt 3	2	2	4	5	5	10

Source: Heffron Transportation, Inc., August 2016.
a. Based on 2010 Census results that 1% of employees in the site vicinity commute by walk or bike modes of travel.
b. Based on 2010 Census results that 3% of employees in the site vicinity commute by transit.

4.3. Trip Distribution Pattern and Trip Assignment

4.3.1. Truck Trips

The truck trip distribution pattern for Terminal 5 was based on detailed origin-destination studies performed in February 2014 to develop the *Container Terminal Area Traffic Analysis Tool.*[30] These studies used Bluetooth readers that were placed at the terminal entrances and along regional roadways to capture unique addresses emitted from vehicles containing Bluetooth-enabled devices. Data at points along major travel routes were then paired with the terminal data to derive an origin-destination pattern for each terminal at the Port. The data were further augmented with information from local warehouse and consolidation businesses to determine local truck trip patterns.

Data collected from the Bluetooth readers determined that nearly all Terminal 5 trucks (about 92%) arrived and departed the terminal via SW Spokane Street east of the terminal, crossing the Swing Bridge. About half of these trucks used the ramps to and from the Spokane Street Viaduct that connect to Harbor Island, east of the site. The rest stayed on surface streets to access the near-dock intermodal yards as well as local connections to SR 99 and I-90 (via East Marginal Way S and S Atlantic Street). None of the trucks arrived or departed using the West Seattle Freeway ramps that connect direct to Chelan Avenue SW west of the terminal.

With larger ships at Terminal 5, more trucks (25%) are expected to travel to and from the near-dock rail yards, resulting in more concentrated truck increases on surface SW Spokane Street and East Marginal Way between S Hanford Street and the Argo Yard. The new North Argo Access allows trucks destined to that railyard to avoid the merge across SR 99. The new access route passes under SR 99 just south of the

30 The Transpo Group, July 2015.

East Marginal Way grade-separated structure. Trucks returning from the Argo Yard use northbound East Marginal Way S north of Diagonal Avenue S. One change expected within the 10-year horizon is the extension of SR 509 from its current terminus near SeaTac Airport to I-5. In the future, this new highway connection is expected to attract more truck traffic to West Marginal Way SW and SR 509, reducing the number of trucks that may now use I-5 south of Spokane Street. That change is expected to result in decreased truck traffic on the Spokane Street Viaduct compared to existing conditions. Table 10 summarizes the truck trip pattern assumed for future conditions, which reflects the existing travel patterns for all of the Port's terminals and the planned changes to the roadway system described above.

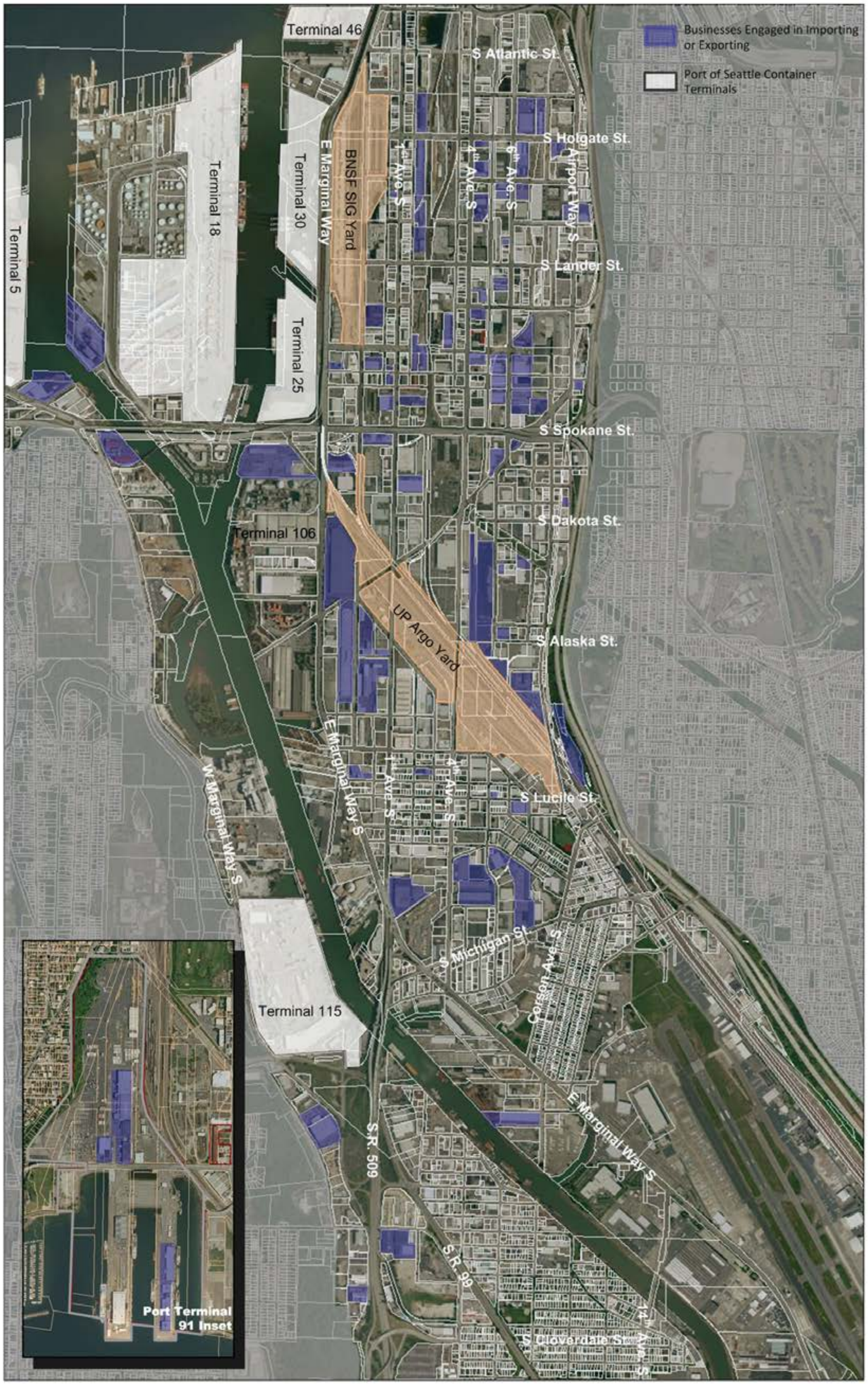
Table 10. Truck Trip Distribution Pattern for Terminal 5

	SIG Yard	Argo Yard	I-5 North	I-90 East	I-5 South	SR 99	SR 509	Local	Total
Existing	<1%	4%	15%	20%	29%	11%	9%	12%	100%
Future	15%	10%	7%	12%	18%	13%	13%	12%	100%

Source: *The Transpo Group, February 2014. Patterns derived from Bluetooth data at terminals and along primary travel routes.*
Note: *Existing conditions based on current travel patterns for Terminal 5; the future condition based on existing travel patterns for all of the Port's terminals.*

"Local" trips are those that travel between the terminal and local distribution and logistics facilities in the Duwamish neighborhood. Figure 18 shows the location of these businesses. Travel patterns would change by day depending on the customer and origin of the ship. The trip pattern assumed for the local trips was based on the port-wide average of local trips from all of the terminals.

Figure 18. Local Import/Export Businesses in Duwamish



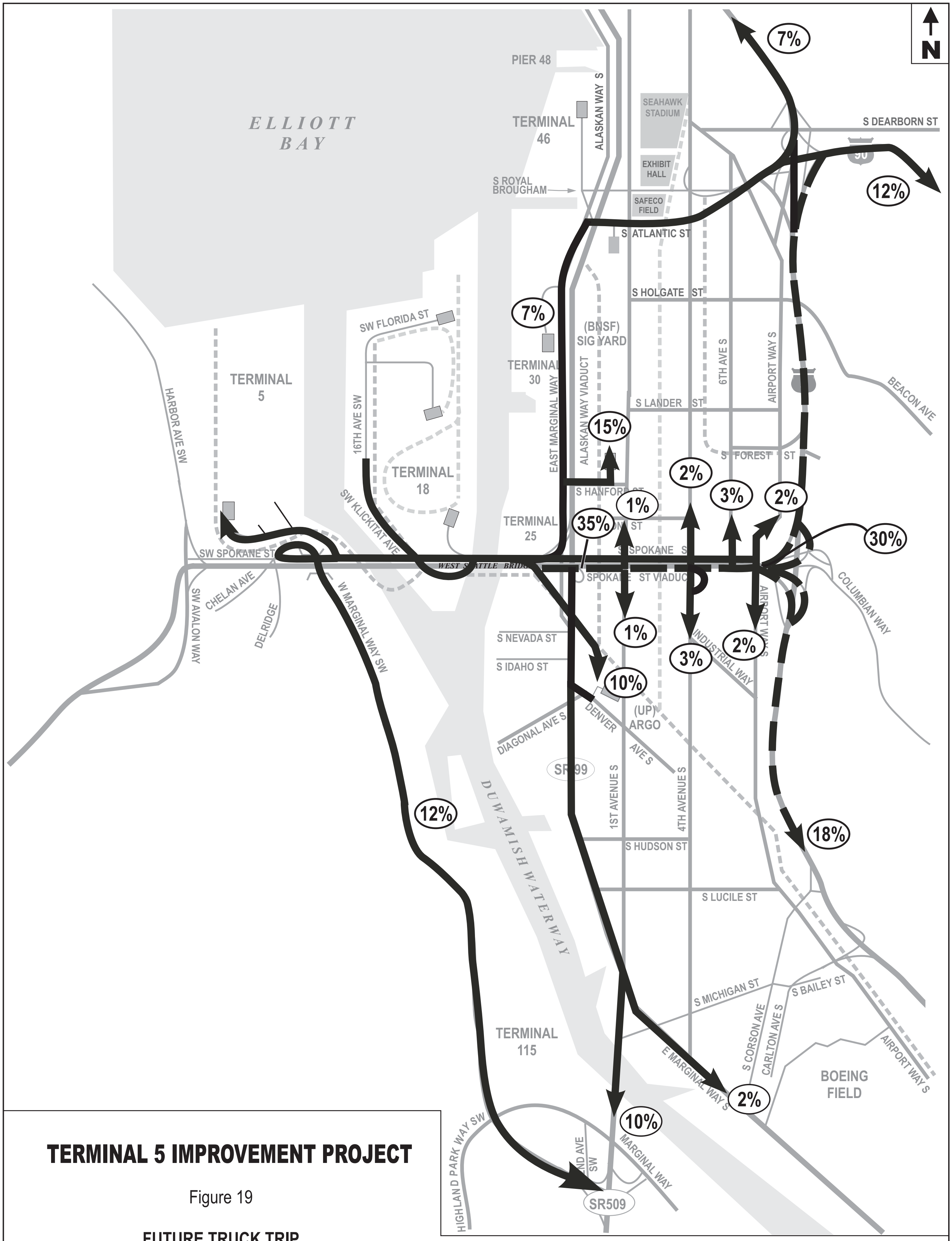
Source: Port of Seattle, August 2016.

Figure 19 shows the truck trip distribution pattern based on regional and local destinations. Figure 20 shows the truck trips for all three alternatives on the near site network. The net change in truck trips for Alternative 2, which has the highest number of peak hour truck trips, is shown on Figure 21.

4.3.2. Employee Trips

The travel pattern for employee trips was derived using information from the City of Seattle's Concurrency Director's Rule 5-2009.[31] The City's materials for this Directors Rule include a database that provides vehicle trip patterns for various types of land uses for each Transportation Analysis Zone (TAZ) in the city. The data were compiled to determine inbound and outbound patterns during the peak hours. Based on this information, about 70% of the employees are expected to use the West Seattle Freeway to access SR 99 North or I-5 (25% to SR 99 north of Spokane Street, 20% to I-5 north of downtown, 10% to I-90, 10% south on I-5, and 5% to Beacon Hill). About 17% are expected to use West Marginal Way SW to access SR 509 or SR 599 and destinations south of Seattle, while another 15% would use local streets (including Harbor Avenue SW and Delridge Way SW) to access West Seattle. Figure 22 shows the employee trips for the AM and PM peak hours.

[31] City of Seattle Department of Transportation, *Transportation Concurrency Project Review System, Director's Rule 5-2009*, Effective April 13, 2009.



TERMINAL 5 IMPROVEMENT PROJECT

Figure 19

FUTURE TRUCK TRIP DISTRIBUTION PATTERN

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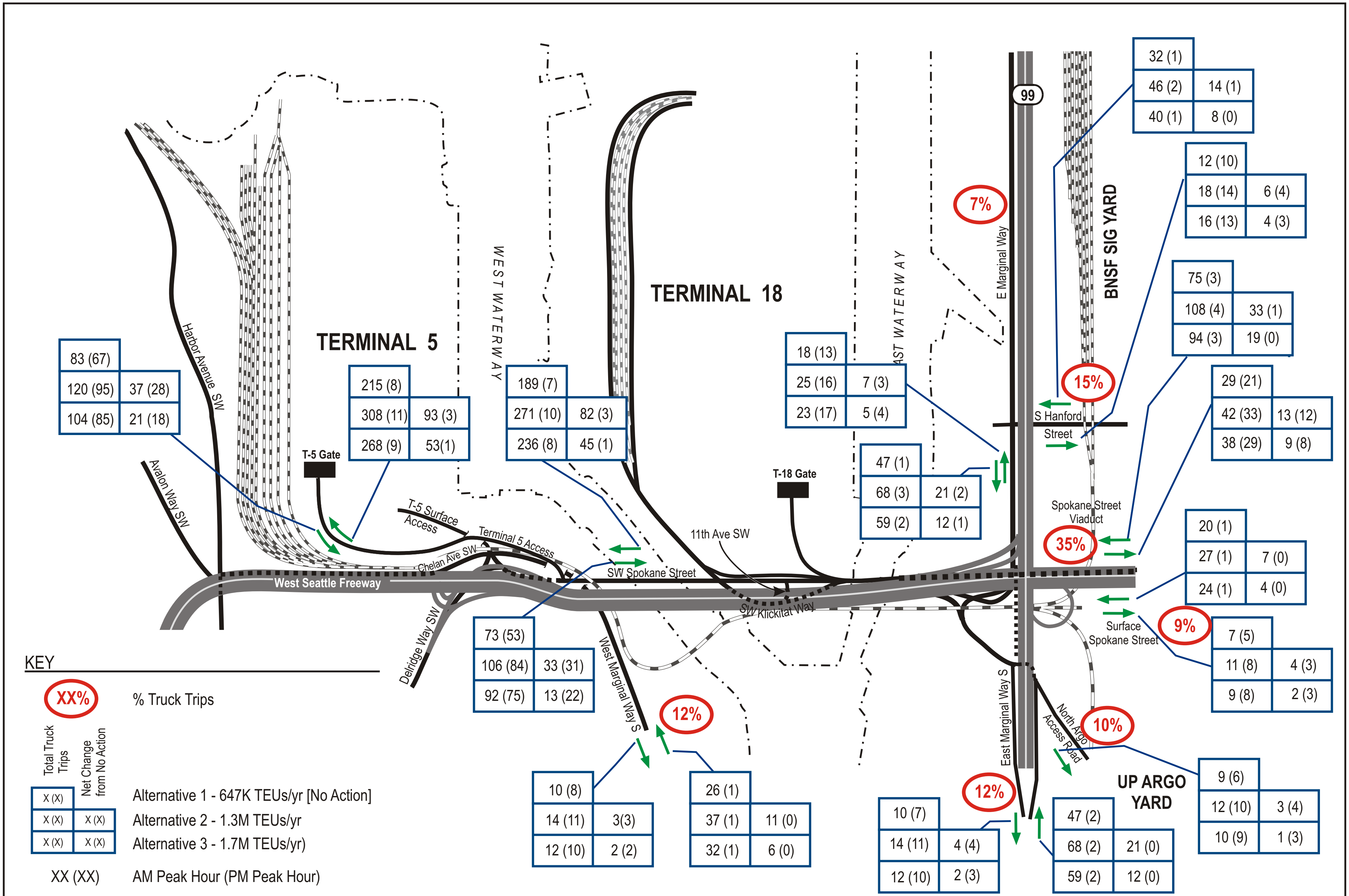

TERMINAL 5
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Figure 20
Terminal 5 Truck Trips (Design Day)
AM and PM Peak Hours

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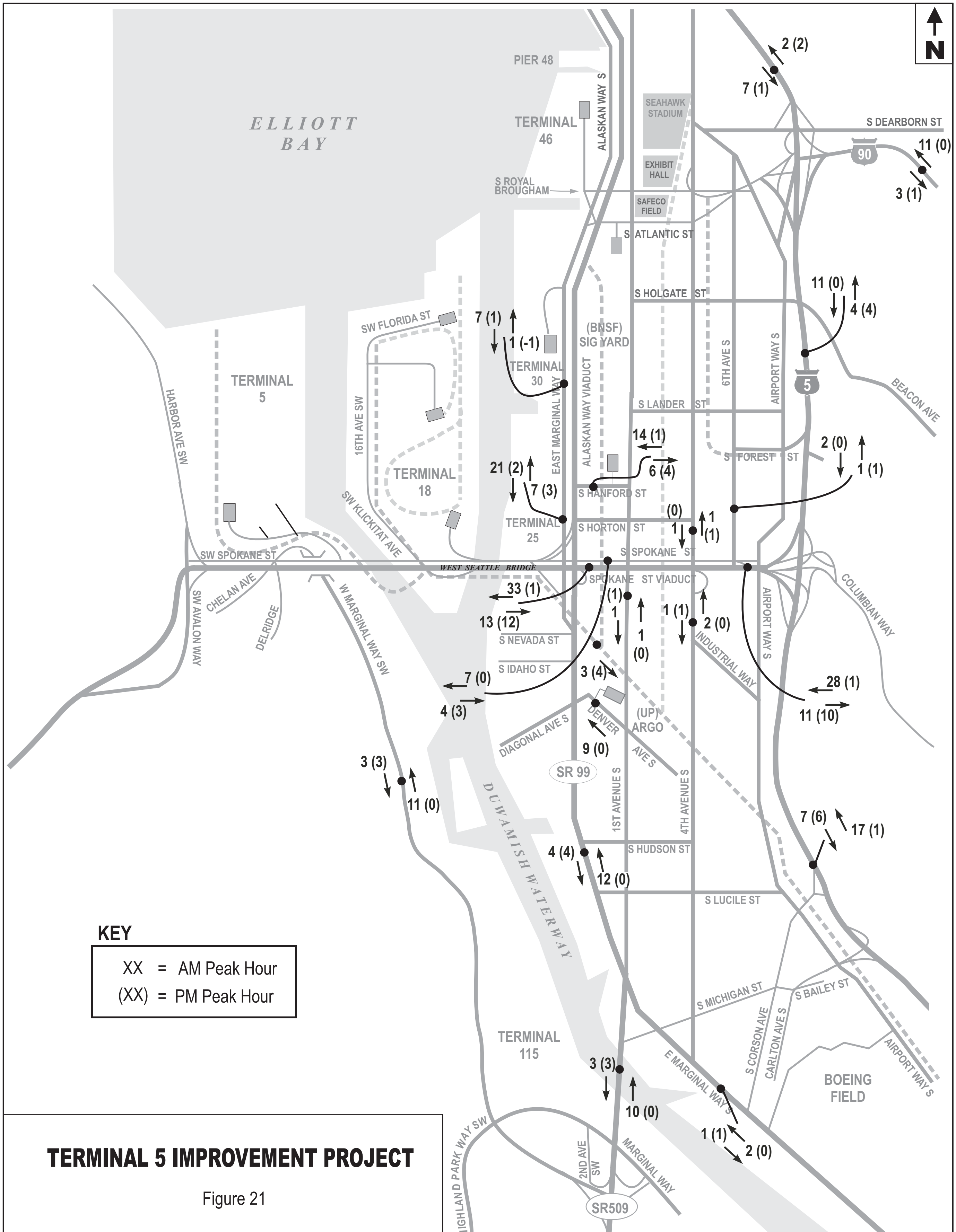

TERMINAL 5 IMPROVEMENT PROJECT

Figure 21

NET CHANGE IN TRUCK TRIPS
ALTERNATIVE 2 - DESIGN DAY

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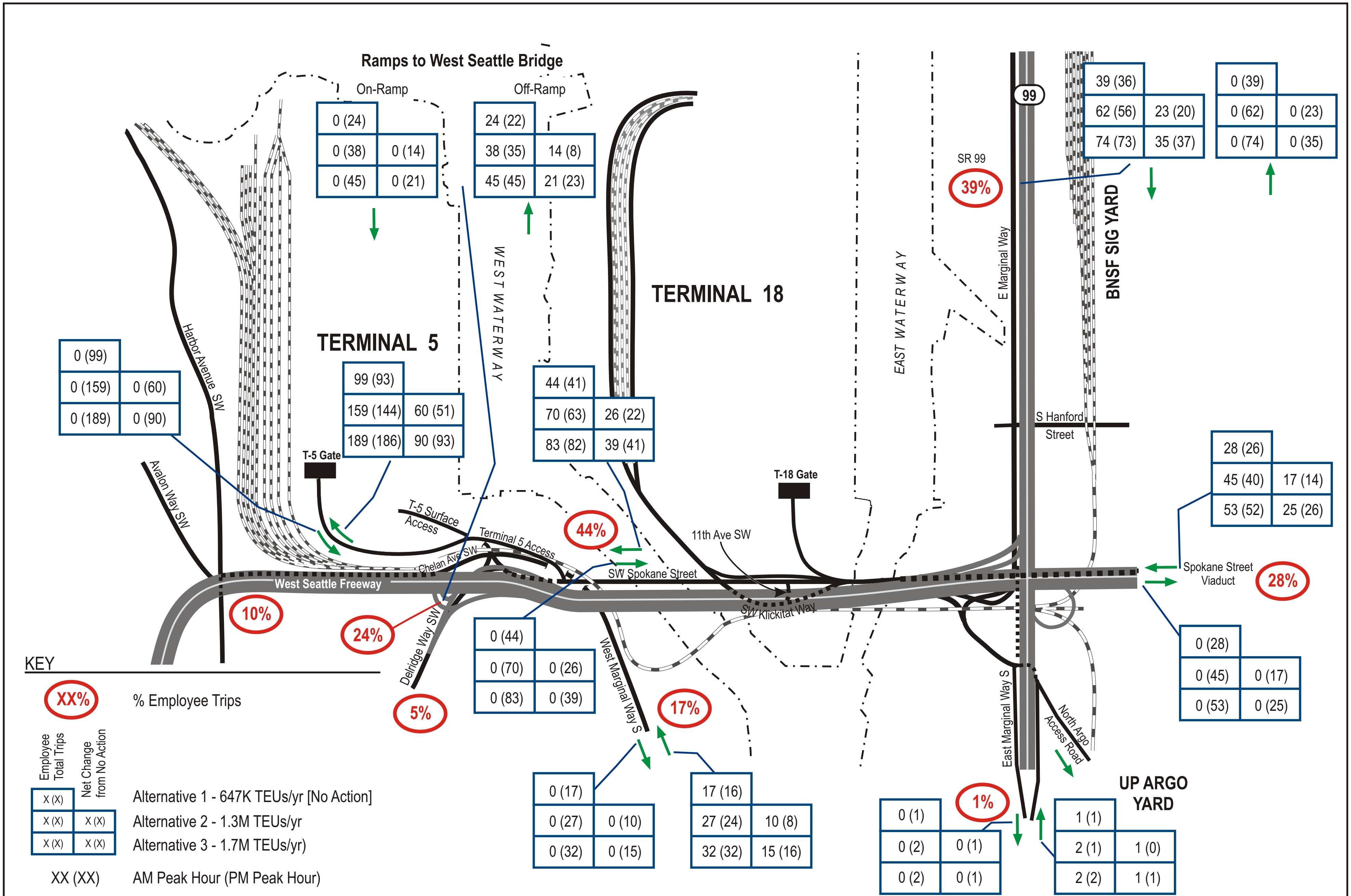

TERMINAL 5
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Figure 22
Terminal 5 Employee Trips (Design Day)
AM and PM Peak Hours

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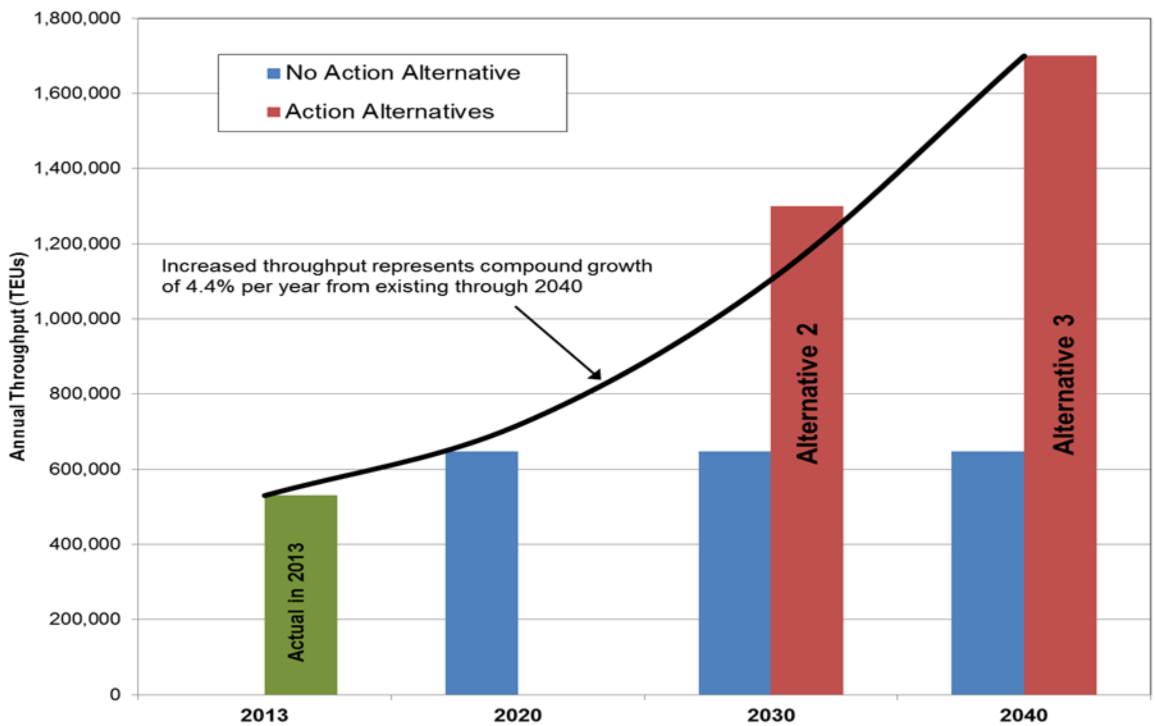
5. PROJECT IMPACTS

5.1. Future Traffic Volumes

Three future years—2020, 2030, and 2040—were evaluated to capture the potential growth in terminal throughput over time. The No Action volumes for Terminal 5 were evaluated for each of these horizon years to provide a basis for comparison. Under these conditions, container operations could continue with existing terminal infrastructure. Alternative 2 was evaluated for year 2030 conditions, and Alternative 3 was evaluated for year 2040 conditions. Figure 23 illustrates the analysis conditions evaluated for this report. It also shows the growth trend line between the actual conditions in 2013 and the Alternative 3 conditions in the year 2040. This shows that the compound growth would be 4.4% per year, a conservatively high assumption for container growth.

Figure 23. Analysis Conditions



Source: Heffron Transportation, Inc., January 2016.

Traffic volumes for the 2020, 2030, and 2040 No Action Alternative were derived by applying an annual growth rate of 1.6% per year to existing non-Terminal 5 traffic volumes. This is the historic growth rate for traffic on the Spokane Street Swing Bridge observed from 2005 through 2013, which accounts for the economic recovery since the 2008/2009 recession as well as increased traffic due to growth in West Seattle, and is similar to growth rates expected elsewhere in Seattle. This growth rate exceeds the growth rate predicted by the *Container Terminal Area Traffic Analysis Tool*[32], which used regional forecasts prepared by the Puget Sound Regional Council. The tool estimated a future growth rate for the Lower Spokane Street Swing Bridge of 0.3% per year.

[32] The Transpo Group, July 2015.

Traffic forecasts developed for the City's proposed *2035 Comprehensive Plan*[33] were reviewed for consistency with the background traffic growth assumptions described above. The Comprehensive Plan analysis forecasts 2035 traffic conditions with buildout of the City's preferred future land use plan, focusing on projected PM peak hour volume-to-capacity ratios (V/Cs) of vehicular traffic on arterials crossing screenlines defined throughout the City. The existing and projected future V/Cs across the screenlines closest to the Terminal 5 study area, as well as the resulting projected annual growth between them, is summarized as follows:

3.11 Duwamish River, West Seattle Freeway – S Spokane Street:
EB – 2013 V/C = 0.61; 2035 V/C = 0.69; annual growth = 0.6%
WB – 2013 V/C = 0.87; 2035 V/C = 1.15; annual growth = 1.3%

9.12 South of Spokane Street, East Marginal Way S – Airport Way S:
NB – 2013 V/C = 0.47; 2035 V/C = 0.60; annual growth = 1.1%
SB – 2013 V/C = 0.52; 2035 V/C = 0.70; annual growth = 1.4%

In addition, the Draft Comprehensive Plan analysis provides existing and projected future Average Weekday Daily Traffic (AWDT) vehicle volume forecasts for state highways throughout Seattle. The existing and projected volumes for the state highway nearest the Terminal 5 study area, as well as the resulting projected annual growth between them, is summarized as follows:

SR 99, East Marginal Way to West Seattle Bridge:
2013 AWDT = 43,000; 2035 AWDT = 61,300; annual growth = 1.6%

These Draft Comprehensive Plan projections indicate that the Terminal 5 background annual traffic growth assumption of 1.6% is conservatively higher than the projected annual growth on arterials crossing the screenlines nearest the study area, and is consistent with the projected annual growth on the state highway segment nearest the study area.

Existing non-terminal traffic was increased by 1.6% per year, and then Terminal 5 No Action truck and employee trips were added to the network. The No Action Traffic Volumes are shown on Figures 24 through 26 for the 2020, 2030, and 2040 conditions, respectively.

5.1.1. Future Traffic Volumes at Study Area Intersections

The net change in truck trips and employee trips generated by Alternatives 2 and 3 were added to the No Action Volumes to estimate the future Action Alternative volumes; Figure 27 shows for year 2030 with Alternative 2, and Figure 28 shows year 2040 with Alternative 3.

[33] Traffic forecasts developed for the *Mayor's Recommended Draft Plan, Transportation Appendix*, May 2016.

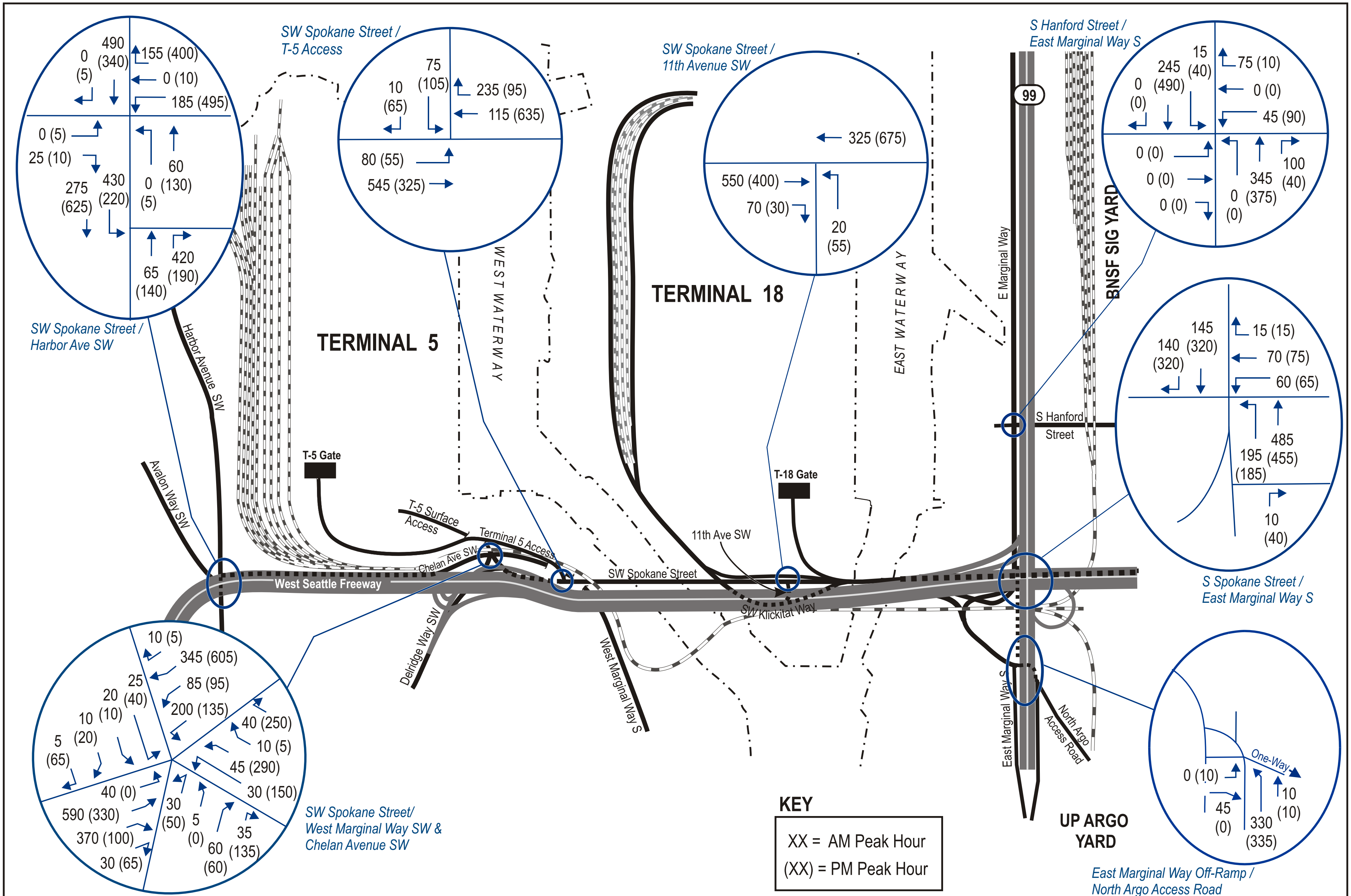


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Figure 24
Year 2020 No Action Traffic Volumes
AM and PM Peak Hours

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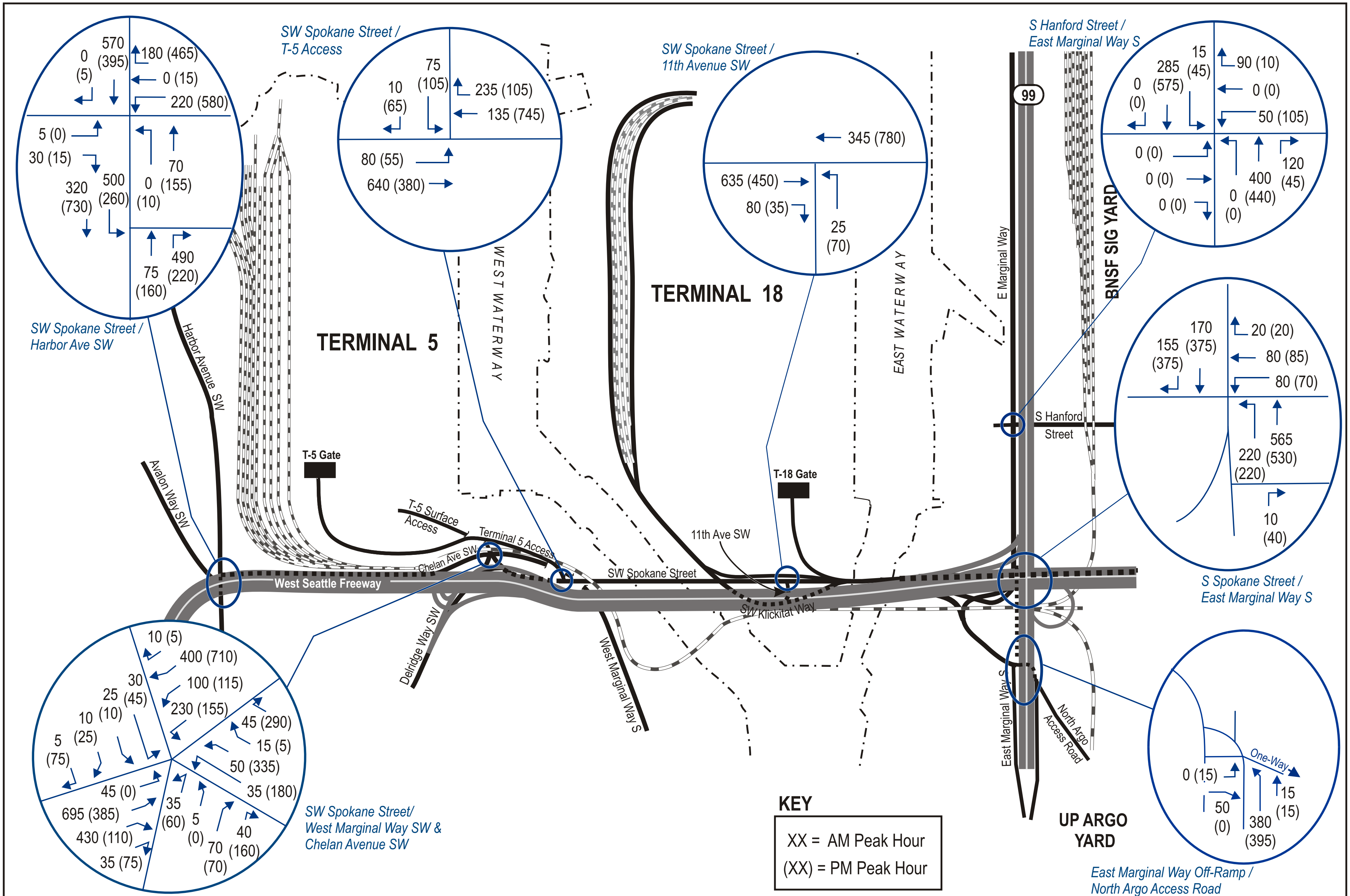

TERMINAL 5
Improvement Project

Figure 25
Year 2030 No Action Traffic Volumes
AM and PM Peak Hours

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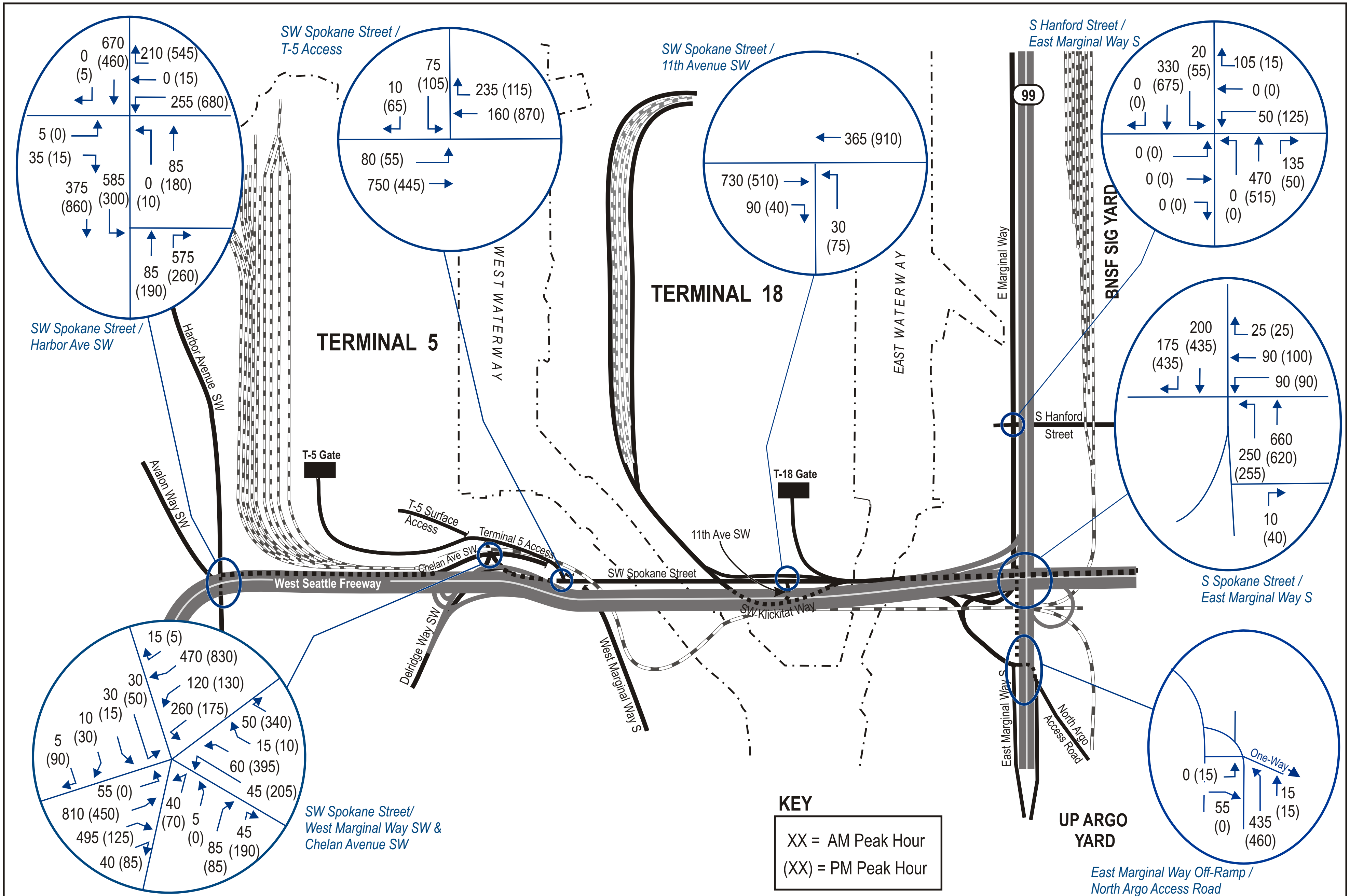

TERMINAL 5
Improvement Project

Figure 26
Year 2040 No Action Traffic Volumes
AM and PM Peak Hours

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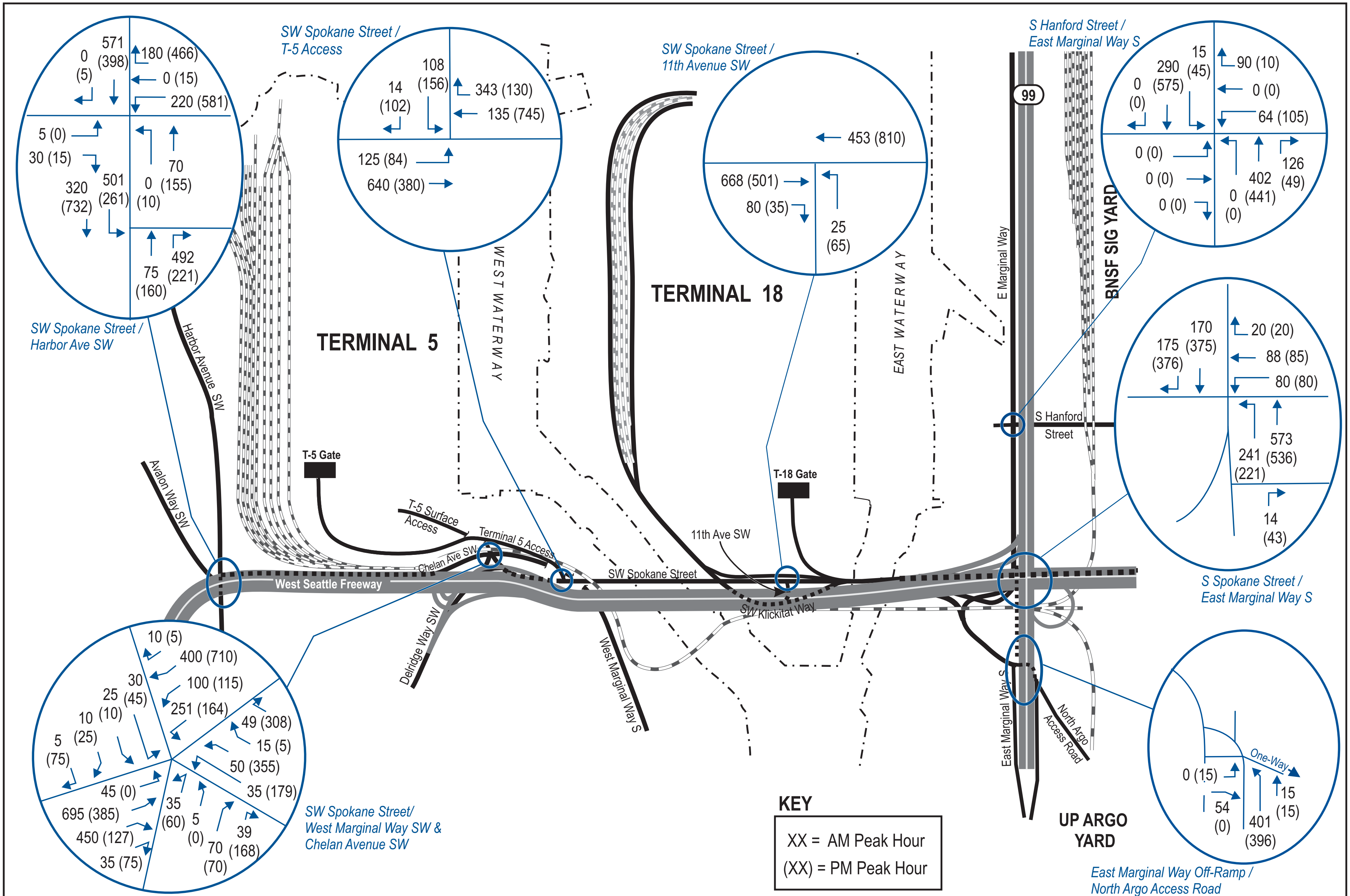

TERMINAL 5
Improvement Project

Figure 27
Year 2030 Traffic Volumes
with Terminal 5 Alternative 2 (1.3 M TEUs/Year)
AM and PM Peak Hours

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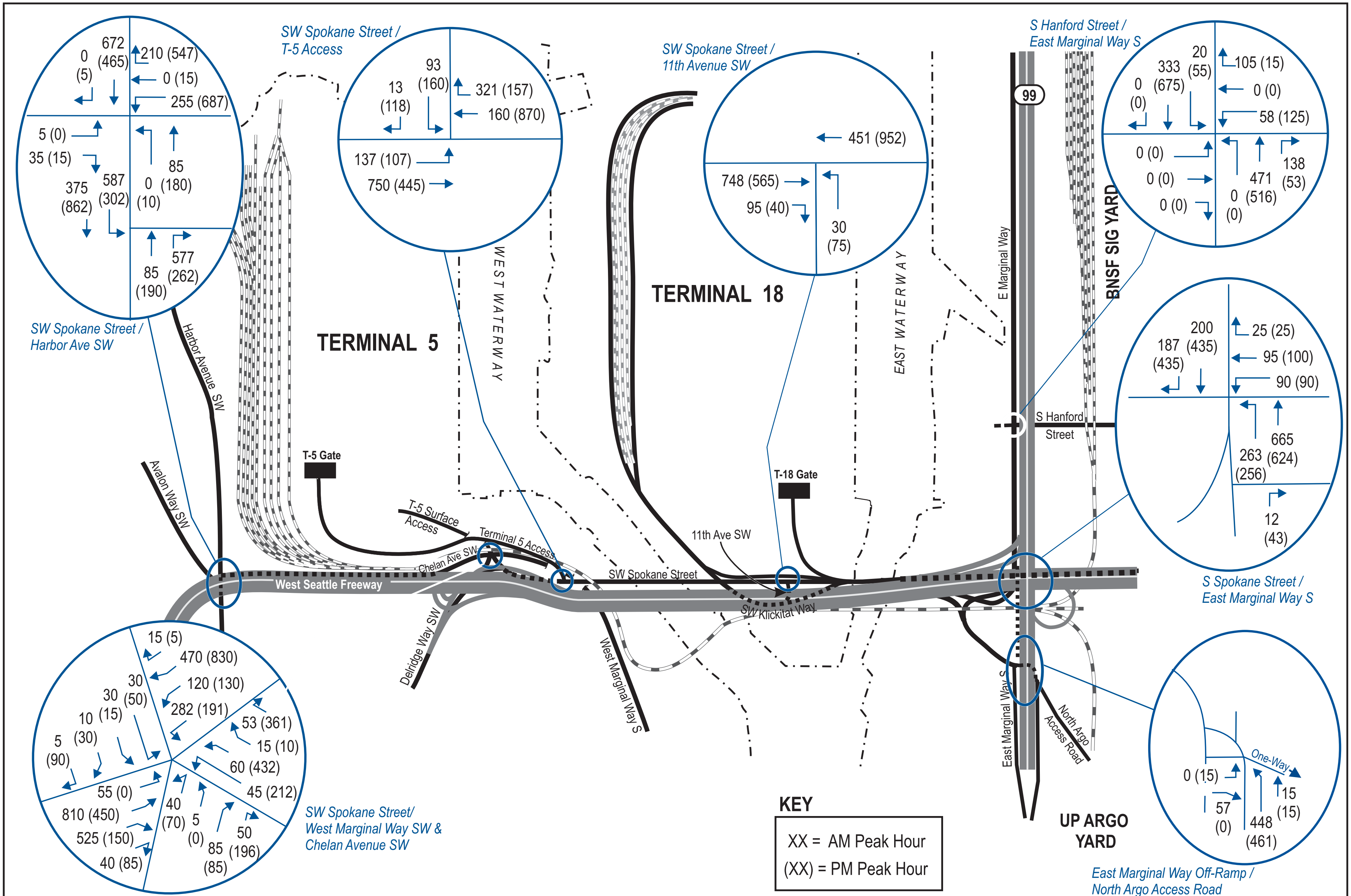

TERMINAL 5
Improvement Project

Figure 28
Year 2040 Traffic Volumes
with Terminal 5 Alternative 3 (1.7 M TEUs/Year)
AM and PM Peak Hours

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09.15.16

5.1.2. Traffic Volumes on State Highways

Traffic forecasts developed for the City's proposed *2035 Comprehensive Plan*[34] included forecasts for state highways in the area. These forecasts, which were built off of the PSRC's regional model included growth in Port of Seattle container terminal throughput to 3.5 million TEUs per year. Therefore, the forecasts did include Terminal 5 as part of the overall Port growth target. Forecasts for several state highways in the vicinity of Terminal 5 are summarized in Table 11. The net change in truck and employee trips generated by the terminal are then compared to the total volumes to show the magnitude of the project's impact. As shown, the project would represent a small percentage of the traffic on these routes. Alternative 2 would represent 0.03% to 0.11% of the year 2035 traffic, and Alternative 3 would represent between 0.07% and 0.29% of the 2035 traffic.

Table 11. Terminal 5 Traffic versus Future Traffic Volumes on State Highways

	Average Weekday Traffic [a]		Net Change in Terminal 5 Traffic [b]					
			Alternative 2			Alternative 3		
State Highway/Interstate	Year 2013	Year 2035	Truck Trips	Emp. Trips	T-5 % of 2035 Traffic	Truck Trips	Emp. Trips	T-5 % of 2035 Traffic
Interstate 5 North of West Seattle Freeway	235,700	266,500	30	160	0.07%	90	260	0.13%
Interstate 5 South of West Seattle Freeway	235,700	266,500	50	35	0.03%	130	60	0.07%
Interstate 90 across Lake Washington	142,800	185,100	30	35	0.04%	90	60	0.08%
SR 99 north of First Avenue S Bridge	43,000	61,300	20	0	0.03%	90	0	0.15%
SR 99 at Yesler Way	77,200	66,200	0	90	0.14%	0	150	0.23%
SR 509 at Cloverdale	38,900	51,800	25	30	0.11%	100	50	0.29%

a. *Traffic forecasts developed by Fehr & Peers, for the* Mayor's Recommended Draft 2035 Comprehensive Plan, Transportation Appendix, *May 2016.*

b. *Derived by Heffron Transportation, Inc. per methodology described in this report.*

5.2. Level of Service

Traffic operating conditions for the study area intersections were evaluated for each of the future year conditions described in the previous section. The analysis assumed that the existing intersection lane configurations would remain the same in the future; traffic signal timings were optimized since they are likely to be adjusted by the future 2030 and 2040 horizon years. In addition, truck percentages for each movement were adjusted to reflect changes in truck volumes relative to total volumes, which accounts for the changes in Terminal 5 truck trips. The methodology to determine intersection level of service was previously described in Section 2.3. Table 12 summarizes the projected future AM peak hour conditions for all alternatives, and Table 13 shows the projected future PM peak hour conditions.

The analysis indicated that the following three intersections along the Spokane Street corridor would operate at poor levels of service in the future:

[34] Traffic forecasts developed for the *Mayor's Recommended Draft Plan, Transportation Appendix*, May 2016.

SW Spokane Street/West Marginal Way/Chelan Avenue SW – This intersection is forecast to operate at LOS F for the 2020 No Action conditions during both the AM and PM peak hours. Conditions would get progressively worse in the subsequent decades due to background traffic growth in the corridor, with average PM peak hour vehicle delay of nearly 280 seconds per vehicle by 2040. Traffic generated by the Terminal 5 improvements is projected to add up to about 15 seconds of average delay per vehicle. As described later in the *Mitigation* section of this report, increased train traffic associated with the terminal could block the north leg of the five-legged intersection (the at-grade connection to Terminal 5) for much of the day, and at full operation, it is recommended that the north leg of the intersection be closed to vehicle traffic. Eliminating this leg of the intersection would dramatically improve traffic operations by eliminating one phase of the sequential-phase signal operation, and allowing some movements to operate concurrently. With closure of the north leg, it is estimated that in 2040 with Alternative 3, the intersection would operate at LOS E during the AM peak hour (68.5 seconds of delay per vehicle) and at LOS F in the PM peak hour, but with substantially reduced delay (97.3 seconds per vehicle) compared to the No Action Alternative. Closing the north leg of the intersection would also eliminate the at-grade railroad crossing and the signal pre-emption associated with train movements adjacent to the intersection. All traffic to and from Terminal 5, as well as local businesses at Terminal 7A, 7B, and 7C should be directed to use the Terminal 5 Access Bridge, which would operate at LOS C or better during the peak hours with this diverted traffic.

Until train movements across the surface access at West Marginal Way S warrant, other measures should be considered to improve operations. One alternative would be to convert the north leg of the five-legged intersection into a one-way northbound roadway and eliminate the ability to exit at this location. That would eliminate the signal phase associated with outbound movements and improve traffic operations at the intersection.

SW Spokane Street/Harbor Avenue SW – This intersection is forecast to operate at LOS F during the AM peak hour in 2040, without or with the proposed Terminal 5 project. This condition is related to the existing signal phasing that will not be able to accommodate growth in background traffic and the high volume of southbound left turns projected from Harbor Avenue SW onto the Spokane Street connector ramp. To mitigate this condition, it is recommended that the signal phasing be changed, which could improve operations to LOS E (63.1 seconds of delay) in 2040 with Alternative 3. Further detail about recommended signal improvements for the Spokane Street corridor are presented in the *Mitigation* section.

S Spokane Street/East Marginal Way S – This intersection is expected to operate at LOS E during the PM peak hour by 2030, and during both peak hours by 2040 without or with the proposed Terminal 5 project. The increase in traffic generated by Terminal 5 would add fewer than 2.0 seconds of delay to the intersection. Signal improvements described in the *Mitigation* section would include this intersection.

S Hanford Street/East Marginal Way S – This intersection would operate at LOS D or better until 2040, when it is forecast to operate at LOS F during the PM peak hour with Alternative 3. Although the project is expected to add little average delay to the intersection (less than 2 seconds per vehicle), operations could be improved by having all east-west pedestrian/bicycle movements served by a separate signal phase. Further detail about recommended signal improvements for the corridor are presented in the *Mitigation* section.

Table 12. Level of Service Summary - Future Conditions with All Alternatives – AM Peak Hour

Signalized Intersections	No Action Alternative		With T-5 Improvements	
	LOS[1]	Delay[2]	LOS	Delay
YEAR 2020	No Action (647,000 TEUs/Yr)			
SW Spokane St / Harbor Ave SW	D	44.9		
SW Spokane St / West Marginal Way SW / Chelan Ave SW	F	77.4		
SW Spokane St / Terminal 5 Access	B	10.6		
SW Spokane St / 11th Avenue SW	A	2.1		
S Spokane St / East Marginal Way S	B	17.2		
S Hanford St / East Marginal Way S	B	17.9		
East Marginal Way NB Ramp / North Argo Access Road [3]	B	12.0		
YEAR 2030	No Action (647,000 TEUs/Yr)		With 1.3 Million TEUs/Year	
SW Spokane St / Harbor Ave SW	E	58.3	E	58.8
SW Spokane St / West Marginal Way SW / Chelan Ave SW	F	129.3	F	142.2
SW Spokane St / Terminal 5 Access	B	12.7	B	14.7
SW Spokane St / 11th Avenue SW	A	2.3	A	2.7
S Spokane St / East Marginal Way S	C	22.3	C	26.7
S Hanford St / East Marginal Way S	B	19.3	C	20.7
East Marginal Way NB Ramp / North Argo Access Road [3]	B	13.4	B	14.6
YEAR 2040	No Action (647,000 TEUs/Yr)		With 1.7 Million TEUs/Year	
SW Spokane St / Harbor Ave SW	F	84.5	F	85.7
SW Spokane St / West Marginal Way SW / Chelan Ave SW	F	200.2	F	215.8
SW Spokane St / Terminal 5 Access	B	13.8	B	16.0
SW Spokane St / 11th Avenue SW	A	2.5	A	3.0
S Spokane St / East Marginal Way S	E	56.0	E	57.6
S Hanford St / East Marginal Way S	C	24.4	C	26.8
East Marginal Way NB Ramp / North Argo Access Road [3]	B	15.5	B	16.4

Source: Synchro model developed by Concord Engineering and Heffron Transportation, Inc., January 2016. Levels of service for signalized intersections were calculated using the Synchro 9.1 methodology. The all-way stop intersection level of service was determined using the 2010 HCM methodology.

1. *Level of service.*
2. *Average seconds of delay per vehicle.*
3. *All-way stop controlled intersection*

Table 13. Level of Service Summary - Future Conditions with All Alternatives – PM Peak Hour

Signalized Intersections	No Action Alternative LOS[1]	No Action Alternative Delay[2]	With T-5 Improvements LOS	With T-5 Improvements Delay
YEAR 2020	No Action (647,000 TEUs/Yr)			
SW Spokane St / Harbor Ave SW	C	21.5		
SW Spokane St / West Marginal Way SW / Chelan Ave SW	F	121.4		
SW Spokane St / Terminal 5 Access	B	17.5		
SW Spokane St / 11th Avenue SW	A	4.8		
S Spokane St / East Marginal Way S	C	26.2		
S Hanford St / East Marginal Way S	C	30.6		
East Marginal Way NB Ramp / North Argo Access Road [3]	B	12.9		
YEAR 2030	No Action (647,000 TEUs/Yr)		With 1.3 Million TEUs/Year	
SW Spokane St / Harbor Ave SW	D	34.6	D	38.3
SW Spokane St / West Marginal Way SW / Chelan Ave SW	F	188.3	F	199.0
SW Spokane St / Terminal 5 Access	C	24.3	C	32.3
SW Spokane St / 11th Avenue SW	A	6.5	A	7.2
S Spokane St / East Marginal Way S	E	56.8	E	57.0
S Hanford St / East Marginal Way S	D	42.6	D	42.6
East Marginal Way NB Ramp / North Argo Access Road [3]	B	15.1	B	15.2
YEAR 2040	No Action (647,000 TEUs/Yr)		With 1.7 Million TEUs/Year	
SW Spokane St / Harbor Ave SW	D	49.0	D	42.8
SW Spokane St / West Marginal Way SW / Chelan Ave SW	F	277.4	F	291.3
SW Spokane St / Terminal 5 Access	D	40.4	D	50.0
SW Spokane St / 11th Avenue SW	A	8.8	A	9.6
S Spokane St / East Marginal Way S	E	65.5	E	65.8
S Hanford St / East Marginal Way S	E	79.8	F	81.2
East Marginal Way NB Ramp / North Argo Access Road [3]	B	18.7	B	18.8

Source: Synchro model developed by Concord Engineering and Heffron Transportation, Inc., August 2016. Levels of service for signalized intersections were calculated using the Synchro 9.1 methodology. The all-way stop intersection level of service was determined using the 2010 HCM methodology.

1. *Level of service.*
2. *Average seconds of delay per vehicle.*
3. *All-way stop controlled intersection*

5.3. Gate Queue Analysis

This section details the methodology used to estimate queue lengths at the Terminal 5 inbound truck gate. This queuing analysis was performed to determine the number of gate lanes or service check points that may be required to accommodate the peak truck queue and prevent it from backing up to SW Spokane Street. There are two elements of the gate system that could cause truck queuing off of the terminal:

- **Pre-check** – This is where truck drivers must show security identification in order to access the terminal. The analysis was used to determine whether the existing single checkpoint would suffice or whether two check points would be needed under certain circumstances.

- **Main Gate –** Terminal 5's main gate operates with a "kitchen counter" system meaning that remote clerks can serve multiple lanes. There are 14 inbound truck lanes (13 queue lanes and one bypass lane) in advance of the gate, but trucks are usually only allowed to queue in lanes that correspond to an open gate. To be conservative, the analysis was performed assuming that only eight of the gate lanes and corresponding truck queue lanes would be used for the improved terminal. If needed, two additional inbound lanes could be opened to address queues.

5.3.1. Queue Model and Methodology

For queuing at the pre-check and main truck gate, a **M/M/s** model was applied. The M/M/s label refers to the key input elements of the queuing model. The first "M" is the symbol that defines an exponential distribution of inter-arrival times (times between each vehicle arrival at the transfer station) known as "Markovian." This distribution of arrivals is also described as a Poisson distribution. The second "M," also refers to an exponential distribution, but applies to service times in the queuing system. This assumption implies that the transaction times for each truck will vary and will also follow an exponential pattern. For example, many of the service times are expected to be less than the average, but will occasionally be much longer (e.g., a truck driver that cannot find or does not have the proper identification). It is important to note that the assumption that service times are exponentially distributed implies a somewhat large amount of variability and reflects a worst-case condition. Finally, the "s" label in the queuing model description refers to the number of service points. For the inbound flows at the pre-check gate, the model tested both a single and a double service point. For the main truck gate, the model tested queues assuming that 8 of the existing 13 service lanes would be used to process inbound truck movements.

Truck trips generated for each of the three alternatives, and previously described in Section 4 were used for this analysis. Inbound trips for each hour of the day were determined using the arrival rates shown on Figure 15. As previously described, a second gate shift is expected to be added for Alternative 3. However, for the purpose of understanding the resiliency of the gate, that alternative was evaluated for both a single shift and double shift condition.

5.3.2. Service Rates

Pre-Check Gate

Service rates for the pre-check gate were determined from observations at the Terminal 18 gate in 2012. The service rate was measured as the time between consecutive trucks arriving at the pre-check gate, with 66 arrivals observed during the morning peak period. The service times ranged from 6.4 seconds to 26.9 seconds with an average service time of 17.7 seconds.

If two pre-check lanes are provided, they could either be serviced by one or two security guards. It was assumed that if one guard has to serve both lanes, the service rate per truck would increase by about 5 seconds (to 22.7 seconds per truck) to account for additional time needed for the guard to move between the gate lanes. If a second guard is added, the average service time is assumed to remain at 17.7 seconds per truck per lane.

Main Gate

Service rates for the main gate were assumed to be 1.2 minutes (72 seconds) per truck. This rate is based on information provided by SSA Marine when Terminal 30 was being reactivated as a container terminal with a new truck gate.[35] The existing gate has 14 storage lanes; however, only 8 of those lanes were assumed to be used for inbound storage. Those 8 lanes have a capacity to hold 80 to 90 trucks. This configuration was assumed for the No Action and Alternative 2 conditions.

Alternative 3 would replace the existing gate. The proposed gate would have a similar capacity to the existing gate, with 80 to 90 trucks.

5.3.3. Queue Analysis Results

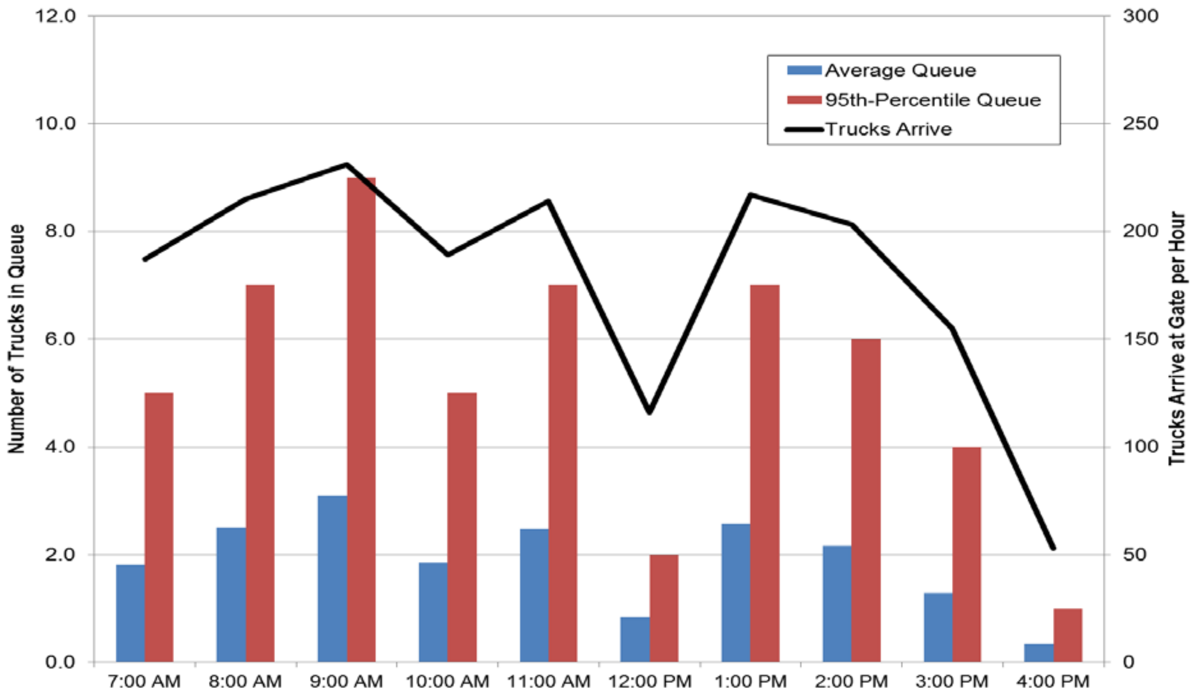
Pre-Check Gate

The analysis determined that the pre-check gate is the constraint in the system. Currently, the pre-check gate facility is located about 1,900 feet from SW Spokane Street. This distance is estimated to accommodate about 24 trucks, assuming an average of 80 feet per truck, which allows extra space given that this queue is continually moving. A single-lane gate with one security guard could accommodate hourly volumes up to about 180 trucks per hour before the truck queue would extend to SW Spokane Street. With two gate lanes for trucks, a single guard could accommodate hourly volumes up to about 280 trucks per hour. Beyond that volume, two security guards would be needed, one for each lane. To reduce the potential that queues would reach SW Spokane Street, it is recommended that Terminal 5 provide two pre-check gate lanes, and that the pre-check gate open at least 30 minutes before the main gate to accommodate early-arriving trucks. As noted below, the main gate would need to open one hour early on days when more than 1,500 truck arrivals are expected, in which case the pre-check gate hours would also need to open one-hour earlier than a typical day. The analysis also determined that the pre-check gate(s) would need to remain open for the entire workday (i.e., a security guard would staff the pre-check gate during morning, lunch, and afternoon breaks).

Queues by time of day for the Alternative 2 Design Day were determined using the queue model with two pre-check gates and a single security guard, shown on Figure 29. The average and 95th-percentile queues were evaluated, the latter is defined as the queue length that could be exceeded for 5% of the evaluated peak hour and is typically the basis used for facility design. Under this operating condition, the 95th-percentile queue length is estimated to be 9 trucks, and would occur during the 9:00 A.M. hour.

35 Heffron Transportation, Inc. *Transportation Technical Report for Terminal 30 Cargo Reactivation*, September 18, 2006.

Figure 29. Queues at Pre-Check Gate for Alternative 2 – Design Day



Source: Heffron Transportation, Inc., January 2016. Assumes two pre-check lanes with one security guard

Arrivals that exceed 330 trucks per hour could create queues that extend to Spokane Street. That relates to a daily volume of about 2,700 trucks entering the gate per day, which is 50% higher than Alternative 2 Design Day Volume. (It is noted that trucks entering the terminal are one-half of the total daily trips generated, which includes both entering and exiting trucks.) The pre-check gate should open one-hour earlier than normal on days when the entering truck volume is expected to exceed 1,500 trucks to reduce the potential for queues to extend onto SW Spokane Street.

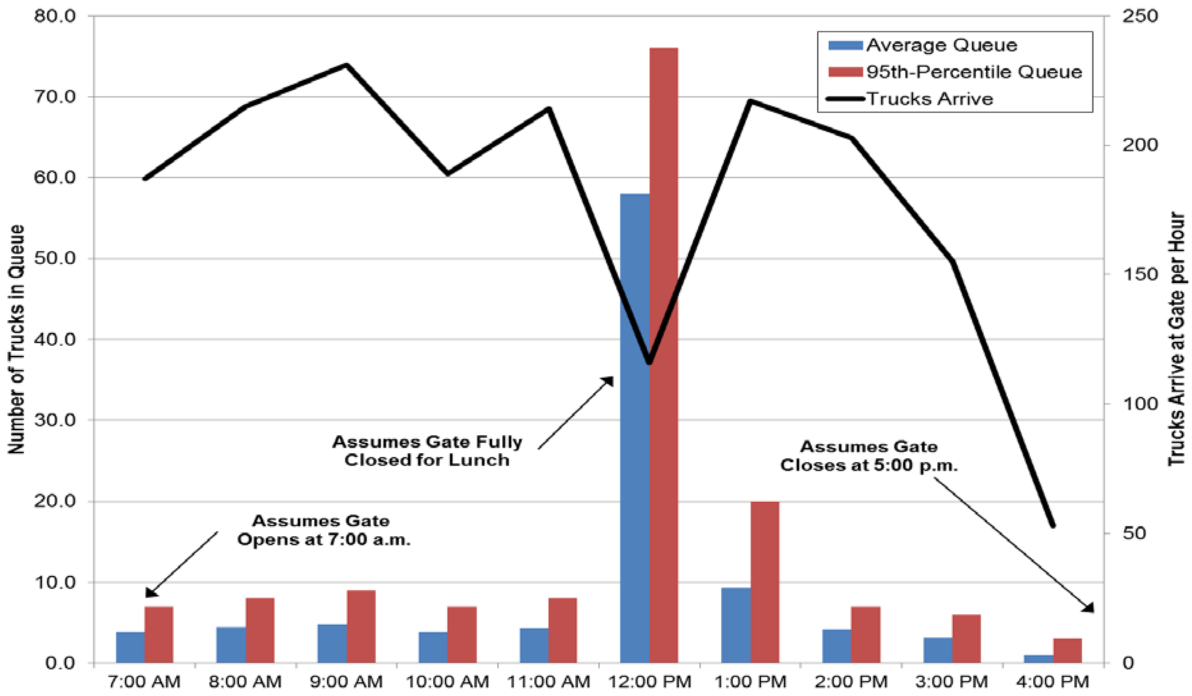
As previously described, if RMGs are installed within the terminal (Alternative 3), the number of trucks that can be served by the terminal's yard equipment would be constrained. Under that condition a second gate shift and a reservation system would be needed to meter the number of trucks that enter the terminal during each hour. Therefore, although the Design Day volumes would be higher for Alternative 3, hourly queues are expected to be lower.

Recommended physical features and operating protocols for the pre-check gate are described in the *Mitigation* section later in this report.

Main Gate

This analysis assumes that 8 of the existing 13 gate lanes would be used for inbound trucks, and would have a total queue capacity of 80 to 90 trucks. The analysis determined that the main gate would need to open one hour early (at 7:00 A.M.) when daily volumes are expected to exceed 1,500 trucks entering the terminal per day. The model also assumed that the gate would be closed during the one-hour lunch break. Figure 30 shows the Design Day queue by hour for Alternative 2 at the main gate. As shown, with the early gate hours, the main gate would accommodate the Alternative 2 Design Day volumes. The peak queue is expected to occur during the noon hour due to the lunch-time closure. However, the queued trucks would be accommodated by the available storage space and no overflow is expected.

Figure 30. Queues at Main Gate With Lunch Break



Source: Heffron Transportation, Inc., February 2015. Assumes 8 entry lanes and "kitchen counter" system. Gate would be closed during one-hour lunch break.

Incidents that Affect Gate Operations

It is recognized that incidents and labor conditions can affect gate operations and queuing conditions. In the past, computer malfunctions have occurred that either dramatically slow processing times or cease processing altogether. Labor issues have also affected gate processing. Protocols to manage the queue should be established if such conditions were to occur in the future. Operational protocols could include:

- Open up additional queuing space at the main terminal gate to process trucks through the pre-check lane.
- Notify truck drivers and dispatchers (using radio, cell phone and/or internet communications) to avoid Terminal 5 until the queue has cleared.
- Notify SDOT and WSDOT traffic operations personnel about closures, so that messages alerting drivers can be posted on select Dynamic Message signs along travel routes to the terminal.
- Pay the cost of locating a Police Officer at the intersection of SW Spokane Street and the Terminal 5 ramp to redirect truck traffic and prevent the queue from blocking through-traffic on SW Spokane Street.

It is recommended that the Port of Seattle and NWSA develop a Gate Queue Management Plan that defines the terminal operator's responsibilities related to gate infrastructure and operating protocols to prevent the truck queue from extending to SW Spokane Street. The Plan is presented in the *Mitigation* section later in this report.

5.4. Traffic Safety

Increased throughput at the terminal would add traffic to the surrounding street network, which could increase the potential for conflicts. Historic collision data for the study area do not indicate any unusual safety issues, and the data include truck traffic generated by the existing terminal along the same travel routes that will be used in the future. Therefore, the Terminal 5 improvements are not expected to adversely affect safety on the roadway network.

Increased throughput could increase the number of train crossings of West Marginal Way SW. The *Mitigation* measures section later in this report recommends that the north leg of the SW Spokane Street/West Marginal Way SW/Chelan Avenue SW intersection be closed to all but emergency vehicle traffic with Alternative 2 or 3. This would eliminate the potential conflict at this intersection.

5.5. Rail

The No Action Alternative is estimated to generate about 9 trains during a peak week; Alternative 2 is expected to generate up to 18 trains in a peak week, and Alternative 3 is expected to generate 24 trains in a peak week. Each train would typically be 7,500 feet in length, but could range up to 8,600 feet in length.

As described in the *Mitigation* section of this report, it is recommended that with Alternative 2 or 3 that surface West Marginal Way SW north of SW Spokane Street be closed to all traffic except emergency vehicles. With this change, any additional rail crossing delays created by the increased train activity at this location would be eliminated, and the traffic signal at the five-legged intersection of SW Spokane Street/ West Marginal Way SW/Chelan Avenue SW would no longer need to have a railroad pre-emption phase.

Three existing surface crossings of the Terminal 5 lead tracks, which are located off West Marginal Way SW southeast of the five-legged intersection would experience increased train blockages. This traffic could be accommodated by the Terminal 5 Access Bridge, which crosses over the rail tracks and provides access to Terminals 7A, 7B, and 7C. Measures to improve local business access are also suggested in the *Mitigation* section.

Further analysis of off-terminal rail impacts is described in the *T-5 Rail Infrastructure and Grade-Crossing Analysis* (Moffatt & Nichol, April 2016).

5.6. Transit

The proposed project is expected to generate about ten transit trips per day. As discussed in *Section 2.1.5. Future Plans and Policies,* Delridge Way SW has been designated as a high priority bus corridor (with improvements currently being studied as part of the Delridge Way Complete Streets Project) and Sound Transit's ST3 package includes extension of light rail between downtown Seattle and West Seattle, with a station proposed on Delridge Way SW to the south of the West Seattle Bridge. Implementation of these projects would improve transit service for Port employees. Measures to improve pedestrian access between the transit stops/station and Terminal 5 are described in the next section.

5.7. Non-Motorized Facilities

Terminal 5 would generate little, if any, pedestrian or bicycle traffic. As described in Section 4.2.4, at peak employment (Alternative 3 during a Design Day), the Terminal 5 project is expected to generate a net increase of 4 pedestrian/bicycle trips (2 in and 2 out) and 10 transit trips (5 in and 5 out) per day. Those who commute by transit would be pedestrian trips between transit stops and the terminal.

The Terminal 5 project would increase train activity across West Marginal Way SW north of SW Spokane Street. The amount of delay associated with each train crossing event would be the same for the No Action Alternative or Alternatives 2 or 3; however, the frequency of movements, and hence the chance for delay, would increase with the project. The delay would affect pedestrians and bicyclists travelling to or from Terminal 5 or businesses at Terminal 7 north of these tracks. As described in the *Mitigation* section of this report, at some point, the duration of total blockage time would likely warrant closing this surface crossing to all traffic except emergency vehicles. While this change would improve overall intersection operations, it would eliminate the pedestrian and bicycle access to Terminal 5. If and when that happens, an alternative pedestrian and bicycle access would need to be provided, which could be a bridge over the tracks, provision of a shuttle, or another measure. It is noted that on-terminal shuttles are typically provided to transport employees from the main office to their post on the terminal, and the route could be extended to pick up employees at off-site locations, including nearby transit stops or the future light rail station.

SDOT recently completed short-term bicycle improvements at and near the five-legged intersection of SW Spokane Street/West Marginal Way SW/Chelan Avenue SW, and is considering additional improvements. Closing West Marginal Way at the railroad crossing would improve conditions for the potential medium-term project with a surface bicycle trail along the east and north side of West Marginal Way SW. If the street crossing is closed, the potential at-grade trail would not need to cross vehicular movements, and bicyclists could flow freely across that leg of the intersection.

The City's potential long-term bicycle improvement proposes to cantilever a new bicycle facility off of the Terminal 5 Access Bridge. It would also add a new pedestrian/bicycle crosswalk on the west side of the SW Spokane Street/Terminal 5 Access intersection. This additional crosswalk would require a pedestrian crossing phase, but it could run concurrent with traffic from the Terminal 5 Access Bridge, and would not affect the overall intersection level of service even with the Terminal 5 improvements and closure of the West Marginal Way SW grade-crossing, which would add more traffic to the intersection. Additional structural analysis and design for the long-term bicycle improvement is necessary to determine the feasibility of cantilevering a bicycle/pedestrian path off the side of the existing Terminal 5 Access Bridge.

There is no "through" bicycle or pedestrian access allowed at Terminal 5. The proposed project is not expected to adversely affect the travel time or safety of pedestrians or bicycles who walk or ride near Terminal 5 since the Terminal 5 Access Bridge is located on the opposite side of the street from the bike trail/sidewalk across the SW Spokane Street Swing Bridge, and the new corner-to-corner bike crossing at the West Marginal Way SW/Chelan Avenue SW/Delridge Way/Spokane Street intersection does not cross concurrently with any of the major movements that serve the terminal's trucks or employees. To the east, the West Seattle Trail crosses SW Spokane Street at 11th Avenue SW, which provides a signalized crossing. While the project would increase truck and employee trips on SW Spokane Street, it would not affect the timing or operation of the bicycle crossing.

5.8. Parking

There are currently 481 parking spaces near the Terminal 5 Administration Building, which would remain for Alternative 1 (No Action). Parking would be reduced to 452 spaces with Alternative 2 due to construction of the substation, which would eliminate some parking near the Administration Building. Alternative 3 would reconfigure the yard, buildings, and parking lots. This alternative would have approximately 530 parking spaces.

The number of employees at the terminal on a peak day was detailed previously in Table 7. It is possible that some employees from the day shift would still be parked at the site when employee arrive for the night shift, and the peak parking demand for the terminal would occur during this overlap period. The parking supply described above reflects the potential worst-case condition assuming some overlap. Fewer parking spaces would be needed if the shifts are spread out enough to allow the day shift employees to leave the site before the night shift employees arrive. The parking supply will be refined once the terminal has a tenant and the actual shift times are known.

The proposed Terminal 5 project would increase the number of daily truck trips generated by the terminal, which could increase the number of trucks that serve the port and the potential truck parking demand. However, trucks that serve Terminal 5 also serve other terminals, including those in Tacoma, and are related to the peak loads of the cumulative NSWA terminals. Therefore, it is not possible to isolate the truck parking demand that would be associated with Terminal 5 alone. The Port of Seattle has partnered with the City of Seattle to reduce truck parking in Georgetown and South Park with measures describe previously in Section 0. The Port would continue to distribute outreach materials developed by the City of Seattle, including a map that indicates areas where truck parking and overnight parking is prohibited, to truck drivers who serve Terminal 5.

5.9. Transportation Concurrency

The City of Seattle developed a Transportation Concurrency policy as part of its *Comprehensive Plan* (City of Seattle, 1994). The Transportation Concurrency was updated with the *Transportation Concurrency Project Review System, Director's Rule 5-2009* (City of Seattle, Effective 4/13/09). Within the transportation concurrency policy, the City has adopted level-of-service standards for 30 screenlines, each of which encompasses one or more arterials in the City. Screenline analysis is a transportation-planning tool that groups key arterials of a transportation network together to measure the operating conditions of a corridor. For example, the Ship Canal functions as a screenline to measure north-south travel north of downtown Seattle. Up to four (4) of the City's screenlines that would be crossed by the greatest number of project trips are reviewed for concurrency.

The City has established a level of service (LOS) standard for each screenline, which is measured by the volume-to-capacity (v/c) ratio. A project would meet the concurrency standard if the v/c ratio with the addition of a proposed project's traffic is lower than or equal to the LOS standard for the screenline. However, if the new v/c ratio is greater than the LOS standard for the screenline, the proposed project would either fail concurrency or be allowed to propose alternative solutions.

Three screenlines were evaluated for this project:

1. Duwamish River between W Seattle Freeway and Spokane Street (Screenline 3.11),
2. South City limit from SR 99 to Airport Way S (Screenline 4.13), and
3. South of Spokane Street from East Marginal Way S to Airport Way S (Screenline 9.12).

The level of service standards and the volume-to-capacity (v/c) ratios are presented in Table 14.

Table 14. Concurrency Analysis for Terminal 5 Alternative 2

Screenline Number	Location	Direction	2008 Capacity	2008 Traffic Count [a]	Project Trips	Total Volume across screenline	With Project v/c ratio [b]	LOS Standard [c]
3.11	Duwamish River							
	W Seattle Freeway and	EB	4,950	3,281	57	3,338	0.67	1.20
	Spokane Street	WB	4,950	5,712	25	5,737	1.16	1.20
4.13	South City limit	NB	11,800	3,179	1	3,180	0.27	1.00
	SR 99 to Airport Way S	SB	11,800	3,788	2	3,790	0.32	1.00
9.12	South of Spokane St							
	E Marginal Way to	NB	9,600	5,138	0	5,138	0.54	1.00
	Airport Way S	SB	9,600	6,194	7	6,201	0.65	1.00

Source: City of Seattle DPD Director's Rule 5-2009, Approved 4/10/09. Attachment C.

a Data reflect most recent official measurement of screenline volumes and capacities from 2008. Reflect PM peak hour volumes.

b v/c = volume-to-capacity ratio. It equals the 2008 traffic count+ project trips, divided by the 2008 capacity.

c Level of service standard, reported as a v/c ratio, which was established by the City of Seattle Ordinance #117383.

The analysis shows that the v/c ratios for all screenlines would be less than the LOS standards; therefore, transportation concurrency would be met for the project. It should be noted, Screenline 3.11 in the westbound direction is approaching its LOS threshold standard. It is also noted that the City is in the process of updating its Concurrency process to account for multiple transportation modes.

6. MITIGATION

6.1. During Terminal Construction

No transportation or parking impacts are expected from construction of the Terminal 5 pier improvements or deepening the berth. The terminal would generate fewer truck and employee trips during the construction period than the No Action operations would generate.

Prior to beginning construction work that could impact SDOT right-of-way; the contractor would be required to submit the following information to SDOT for review and approval of necessary permits:

- Haul Route Plan; and
- Traffic Control Plan for work on or adjacent to an arterial street.

In addition, the Port and NWSA would commit to being part of SDOT's ongoing construction coordination program to ensure coordination of project timelines, construction sequencing, traffic control plans and construction staging with other projects with overlapping construction timelines. The Port would also be part of any coordination program established by Sound Transit if it proceeds with construction of the light rail line to West Seattle and a new station at Delridge.

6.2. Long-term Mitigation with Terminal 5 Improvements

The following describes measures recommended to mitigate the long-term transportation impacts of the proposed Terminal 5 Improvements. This includes both infrastructure improvements as well as operational protocols.

6.2.1. Off-site Intersection Improvements

Intersection of SW Spokane Street/West Marginal Way/Chelan Avenue SW. The analysis determined that increased vehicular traffic associated with either Alternative 2 or 3 would adversely affect operations at the five-legged intersection of SW Spokane Street/West Marginal Way SW/Chelan Avenue SW. In addition, increased train crossings of surface West Marginal Way SW, which is the north leg of this intersection, would exacerbate delay and congestion by increasing the number of signal preemptions of the intersection. Ultimately, when the terminal generates a high volume of trains (12 to 15 per week), it is recommended that the north leg of the intersection (West Marginal Way) be closed to all vehicular traffic except emergency vehicles. All traffic to and from Terminal 5, as well as local businesses at Terminal 7A, 7B, and 7C would then be directed to use the Terminal 5 Access Bridge, which has capacity to accommodate this diverted traffic.

In the interim, other measures should be considered to improve operations. One alternative would be to convert the north leg of the five-legged intersection into a one-way northbound roadway and eliminate the ability to exit at this location. That would eliminate the signal phase associated with outbound movements. Advance signage notifying drivers on northbound West Marginal Way to use left lane if the crossing is blocked by a train would be re-installed (see *Driver Information System Improvements* below). In addition, several measures are proposed to improve local access to businesses at Terminal 7 (see *Local Access Improvements* below). The Port should work with SDOT to determine the most desirable configuration for the five-way intersection and triggers for implementation.

Signal Upgrades on Spokane Street Corridor. With the closure of the north leg of the five-legged intersection (described above), the traffic signal operation and pre-emption protocols for that intersection would change. Railroad pre-emption would no longer be required when a train crosses the north leg of the intersection. Signal timing changes should also be made at the intersections of SW Spokane Street/Harbor Avenue SW and S Hanford Street/East Marginal Way to accommodate future background traffic growth. In addition, the manner in which signals operate following an opening of the lower Spokane Street Swing Bridge should be updated. Therefore, it is recommended that a comprehensive signal improvement project for the Spokane Street corridor be implemented as part of the Terminal 5 project that would reprogram signals along Spokane Street from Harbor Avenue SW to East Marginal Way S, and include the signal at East Marginal Way/S Hanford Street. This project should include upgrading the signal controller at the five-legged intersection and improving interconnection equipment, if needed. These upgrades are consistent with recommendations in the City's *Freight Access Project* and *Freight Master Plan* described previously in Section 2.1.5.

6.2.2. Driver Information System Improvements

The Port should improve systems that provide information to drivers. This includes:

- Replacing the Flashing Alert Sign located on northbound West Marginal Way that notifies motorists approaching Terminal 5 (and local businesses) that the railroad tracks are blocked by a train. This would allow them time to move from the right turn lane to the left turn lane so they can access the terminal and local businesses via the Terminal 5 Access Bridge. (It is noted that the foundation and conduit for the sign still exist, but the sign was damaged by a collision and removed.) The alert sign should be maintained until the surface access via W Marginal Way is closed to vehicular traffic.

- Connecting Terminal 5 to the NWSA's *Gate Wait Time Awareness System* or a similar system, which provides real-time information to truck drivers and dispatchers about the time it will take to get through a terminal gate and the terminal.

6.2.3. Local Business Access and Pedestrian Access

To improve access for local businesses at Terminal 7, the Port should:

- Reconfigure the Terminal 5 Access Bridge (if approved by SDOT and the Seattle Fire Department) to provide two inbound (westbound) lanes, with one of the lanes being signed for Terminal 5 only and the other being striped and signed for "Right Turn Only" onto 26th Avenue SW in order to provide a bypass lane for local businesses.

- Work with the Terminal 7 businesses to re-establish lane striping and No Parking signage to maintain the surface route that connects to West Marginal Way at the south end of Terminal 7 (near the West Seattle Bridge abutments).

- Work with the tenant to allow trucks from Terminal 7 to enter the Terminal 5 queue line from 26th Avenue SW. In the past, these locally-generated trucks were required to exit the terminal via the surface route and re-enter the queue line via the Terminal 5 Access Bridge.

If the surface access to Terminal 5 at West Marginal Way S is closed as described in Section 6.2.1, an alternative pedestrian and bicycle access should be provided, which could be a bridge over the tracks, provision of a shuttle, or other measure.

6.2.4. Gate Queue Management Plan

Increased truck traffic associated with Alternative 2 and 3 would require improvements and operational protocols at the truck gates. A *Gate Queue Management Plan* has been developed for Terminal 5, and is presented in Appendix B of this report. The plan identifies various elements that would be implemented to reduce the potential for truck queues to reach SW Spokane Street. It includes detail related to gate infrastructure, gate operations, incident management, monitoring, and remedies. The NWSA and Port of Seattle would make the terminal operator responsible for managing the queue.

Three key elements of the plan relate to the infrastructure that should be provided at the gate, the operating protocols that should then be implemented for various throughput conditions, and protocols if there is an incident or event that closes the gate or reduces its capacity. These are outlined below.

Gate Infrastructure

If the existing Terminal 5 Main Gate and queue storage capacity remains, then the following infrastructure will be provided at and approaching the Terminal 5 inbound gate prior to terminal occupancy and operation.

- Retain the Main Gate with at least eight (8) inbound truck lanes and storage for at least 80 trucks (total for all lanes).
- Reconfigure the Terminal 5 Access Bridge (if approved by SDOT and the Seattle Fire Department) to provide two inbound (westbound) lanes and one outbound (eastbound) lane. The southernmost inbound lane should be striped and signed for “Terminal 5 Access Only” and the northernmost inbound lane should be striped for “Right Turn Only” to provide for local access to local businesses and warehouses.
- Provide two inbound pre-check (TWIC security check) lanes entering Terminal 5 with a minimum storage length for two trucks each (150 feet) between the checkpoint and 26th Avenue SW (the road at the west end of the Terminal 5 Access Bridge).
- Provide a single security booth with foot access to each of the inbound pre-check lanes.
- Provide gate processing technologies, including equipment identification, to reduce gate transaction times. Equipment identification should occur at a location that does not affect the ability to queue at the main gate prior to opening.
- Terminal shall be connected to the NWSA’s Wait Time Awareness System or similar application that distributes information about gate and terminal wait times to truck drivers and dispatchers through a mobile phone application or web-based interface.
- Maintain and/or update the existing video equipment (or replacement technology) that provides real-time view of Terminal 5 queue lengths.

If the Terminal 5 Main Gate and Security Gate are relocated to extend the queue storage capacity, then the first four elements above may be altered or eliminated as requirements based on the capacity provided. The required features would be coordinated with SDOT and SDCI staff as part of the permit process for the new gate structures.

Gate Management Protocols

The terminal operator would operate the pre-check and main gate in a manner to prevent the truck queue from extending onto SW Spokane Street. The operation is expected to change daily based on the expected gate volume. The following lists a menu of potential operations that could be implemented to reduce the potential queue:

- Open the pre-check gate at least 30 minutes prior to main gate opening and allow trucks to queue at the main gate. On days when the daily throughput is expected to generate more than 1,500 inbound truck moves, the pre-check gate may need to be opened 1 hour prior to opening the main gate unless other flow management strategies are implemented.

- Keep the pre-check gate open and staffed during morning, lunch, and afternoon break periods.

- Provide a second security guard at the inbound pre-check lanes.

- Extend main gate hours for specific customers.

- Extend main gate hours for all movements.

Protocols during Gate Incidents/Events

It is recognized that incidents or events could occur that could reduce capacity of the gate or close it altogether. Under such conditions, the terminal operator would:

- Open up additional queuing space at the main terminal gate to process trucks through the pre-check lane.

- Notify truck drivers and dispatchers (using radio, cell phone and/or internet communications) to avoid Terminal 5 until the queue has cleared.

- Notify SDOT and WSDOT traffic operations personnel about closures, so that messages alerting drivers can be posted on select Dynamic Message signs along travel routes to the terminal.

- Pay the cost of locating a police officer at the intersection of SW Spokane Street and the Terminal 5 ramp to redirect truck traffic and prevent the queue from blocking through-traffic on SW Spokane Street.

In addition, the NWSA would monitor gate queue conditions and issue a bi-annual report. If queues do extend onto SW Spokane Street, the plan prescribes remedy and enforcement actions that could be taken against the terminal operator.

6.2.5. Truck Parking

The Port of Seattle and NWSA should continue to work with the City of Seattle to develop brochures and web-based information related to truck parking, and distribute the information to truck drivers who serve Terminal 5. The materials should include a map of the Sodo, Georgetown, South Park and Delridge neighborhoods, show where truck parking and overnight parking is prohibited, and provide information about off-street parking locations.

APPENDIX A

LEVEL OF SERVICE DEFINITIONS

Levels of service (LOS) are qualitative descriptions of traffic operating conditions. These levels of service are designated with letters ranging from LOS A, which is indicative of good operating conditions with little or no delay, to LOS F, which is indicative of stop-and-go conditions with frequent and lengthy delays. Levels of service for this analysis were developed using procedures presented in the *Highway Capacity Manual* (Transportation Research Board, 2010).

Level of service for signalized intersections is defined in terms of delay. Delay can be a cause of driver discomfort, frustration, inefficient fuel consumption, and lost travel time. Specifically, level of service criteria are stated in terms of the average delay per vehicle in seconds. Delay is a complex measure and is dependent on a number of variables including: the quality of progression, cycle length, green ratio, and a volume-to-capacity ratio for the lane group or approach in question. Table B-1 shows the level of service criteria for signalized intersections from the *Highway Capacity Manual*.

Table B-1. Level of Service Criteria

Level of Service	Average Delay Per Vehicle	General Description
A	Less than 10.0 Seconds	Free flow
B	10.1 to 20.0 seconds	Stable flow (slight delays)
C	20.1 to 35.0 seconds	Stable flow (acceptable delays)
D	35.1 to 55.0 seconds	Approaching unstable flow (tolerable delay—occasionally wait through more than one signal cycle before proceeding.
E	55.1 to 80.0 seconds	Unstable flow (approaching intolerable delay)
F	Greater than 80.0 seconds	Forced flow (jammed)

Source: Transportation Research Board, Highway Capacity Manual, 2010.

For unsignalized two-way-stop-controlled, all-way-stop-controlled, and roundabout intersections, level of service is based on the average delay per vehicle. The level of service for a two-way, stop-controlled intersection is determined by the computed or measured control delay and is defined for each minor movement. Delay is related to the availability of gaps in the main street's traffic flow, and the ability of a driver to enter or pass through those gaps. The delay at an all-way, stop-sign (AWSC) controlled intersection is based on saturation headways, departure headways, and service times. Delay at roundabouts is based on entry flow rates and flow rate capacity. Table B-2 shows the level of service criteria for unsignalized intersections from the *Highway Capacity Manual*.

Table B-2. Level of Service Criteria for Unsignalized Intersections

Level of Service	Average Delay (seconds per vehicle)
A	Less than 10.0
B	10.1 to 15.0
C	15.1 to 25.0
D	25.1 to 35.0
E	35.1 to 50.0
F	Greater than 50.0

Source: Transportation Research Board, Highway Capacity Manual, 2010.

APPENDIX B

GATE QUEUE MANAGEMENT PLAN

Terminal 5
Gate Queue Management Plan

A. Purpose

The Northwest Seaport Alliance (NWSA), the Port Development Authority responsible for managing marine cargo facilities within the Puget Sound gateway including the planned re-opening of Terminal 5 within the North Harbor (Seattle), will require that the Terminal Operator (lessee) for Terminal 5 implement measures to avoid, reduce, and manage queues at the inbound terminal gate. The intent of these measures is to prevent truck queues from extending onto SW Spokane Street.

B. Gate Infrastructure

If the existing Terminal 5 Main Gate and queue storage capacity remains, then the following infrastructure will be provided at and approaching the Terminal 5 inbound gate prior to terminal occupancy and operation.

1. Retain the Main Gate with at least eight (8) inbound truck lanes and storage for at least 80 trucks (total for all lanes).

2. Reconfigure the Terminal 5 Access Bridge (if approved by the Seattle Department of Transportation [SDOT] and the Seattle Fire Department) to provide two inbound (westbound) lanes and one outbound (eastbound) lane. The southernmost inbound lane should be striped and signed for "Terminal 5 Access Only" and the northernmost inbound lane should be striped for "Right Turn Only" to provide for local access to local businesses and warehouses.

3. Provide two inbound pre-check (Transportation Worker Identification Credential [TWIC] security check) lanes entering Terminal 5 with a minimum storage length for two trucks each (150 feet) between the checkpoint and 26th Avenue SW (the road at the west end of the Terminal 5 Access Bridge).

4. Provide a single security booth with foot access to each of the inbound pre-check lanes.

5. Provide gate processing technologies, including equipment identification, to reduce gate transaction times. Equipment identification should occur at a location that does not affect the ability to queue at the main gate prior to opening.

6. Terminal shall be connected to the NWSA's *Wait Time Awareness System* or similar application that distributes information about gate and terminal wait times to truck drivers and dispatchers through a mobile phone application or web-based interface.

7. Maintain and/or update the existing video equipment (or replacement technology) that provides real-time view of Terminal 5 queue lengths.

If the Terminal 5 Main Gate and Security Gate are relocated to extend the queue storage capacity, then Elements B1 through B4 above may be altered or eliminated as requirements based on the capacity provided. The required features would be coordinated with SDOT and SDCI staff as part of the permit process for the new gate structures.

C. Gate Management Protocols

The terminal operator shall operate the pre-check and main gate in a manner to prevent the truck queue from extending onto SW Spokane Street. The operation is expected to change daily based on the expected gate volume. The following lists a menu of potential operations that could be implemented to reduce the potential queue:

1. Open the pre-check gate at least 30 minutes prior to main gate opening and allow trucks to queue at the main gate. On days when the daily throughput is expected to generate more than 1,500 inbound truck moves, the pre-check gate may need to be opened 1 hour prior to opening the main gate unless other flow management strategies are implemented.

2. Keep the pre-check gate open and staffed during morning, lunch, and afternoon break periods.

3. Provide a second security guard at the inbound pre-check lanes.

4. Extend main gate hours for specific customers.

5. Extend main gate hours for all movements.

D. Protocols during Gate Incidents/Events

It is recognized that incidents or events could occur that could reduce capacity of the gate or close it altogether. Under such conditions, the terminal operator shall:

1. Open up additional queuing space at the main terminal gate to process trucks through the pre-check lane.

2. Notify truck drivers and dispatchers (using radio, cell phone and/or internet communications) to avoid Terminal 5 until the queue has cleared.

3. Notify SDOT and Washington State Department of Transportation (WSDOT) traffic operations personnel about closures, so that messages alerting drivers can be posted on select Dynamic Message signs along travel routes to the terminal.

4. Pay the cost of locating a police officer at the intersection of SW Spokane Street and the Terminal 5 ramp to redirect truck traffic and prevent the queue from blocking through-traffic on SW Spokane Street.

E. Monitoring

The NWSA shall perform bi-annual monitoring of the Terminal 5 gate volumes and queue conditions. The monitoring shall be performed in the 3rd Quarter (July 1 to September 30) and evaluate the following metrics:

1. Inbound truck volumes by day for at least a one-month period;
2. Hourly truck volumes for at least a one-week period;
3. Peak truck queues by time of day for at least a one-week period; and
4. Operational measures that were in effect during the queue survey period, including at a minimum operating hours for pre-check and main gate, number of security guards at the pre-check gate, number of clerks at the main gate, and description of gate processing technology used.

The information above will be compiled into a report that would be publically available.

F. Remedy and Enforcement

If the truck queue extends onto SW Spokane Street, which shall be defined as one truck that moves less than 30 feet in a five-minute period due to a truck blockage that emanates from the pre-check or the main gate, then the terminal operator shall implement additional measures to ameliorate the gate queue. These could include:

1. Implement truck flow management system to reduce the truck movements during the peak periods.
2. Pay the cost of locating traffic control personnel at the intersection of SW Spokane Street and the Terminal 5 ramp to redirect truck traffic and prevent the queue from blocking through traffic on SW Spokane Street.
3. Participate in a working group that includes representatives from the NWSA, Port of Seattle, and Seattle Department of Transportation to evaluate queue solutions.
4. Perform the monitoring prescribed in Section E up to three additional times in a two-year period.

If the queue length continues to extend onto SW Spokane Street, then the terminal operator would be responsible for any City enforcement action including civil penalties as provided by the SMC 23.90.018.

Appendix D
Stormwater Technical Memorandum

MEMORANDUM

Project No.: 140222-003

May 6, 2016

To:	Paul Meyer, Port of Seattle
cc:	Steven Gray, Moffatt & Nichol Pam Xander, Sound Earth Strategies, Inc.
From:	Tom Atkins, PE, LG Senior Associate Water Resources Engineer
Re:	**Stormwater Technical Memorandum for Terminal 5 EIS**

1 INTRODUCTION

This technical memorandum has been prepared to assess potential stormwater impacts associated with the proposed Terminal 5 Cargo Wharf Rehabilitation, Berth Deepening and Improvements Project (Project). The Port of Seattle (Port), as lead agency, has determined that the proposed Project is likely to have significant adverse impacts on the environment and is preparing an environmental impact statement (EIS) as required by the State Environmental Policy Act (SEPA) (RCW 43.21C).

The Project involves modifications to existing marine cargo facilities, including cargo wharf rehabilitation, berth deepening, electrical service capacity improvements, and upland improvements, with the potential for increased cargo volume. It would allow Terminal 5 (T5, Site) to accommodate existing large post-Panamax, new Panamax, and new super post-Panamax vessels. Project plans may also include a reconfigured marine cargo marshalling area, re-organized intermodal rail facilities, cargo area lighting modifications, pavement repair and maintenance, stormwater drainage improvements, maintenance and repair buildings improvements, and evaluation of entrance/exit gates and heavy vehicle access points.

The Project EIS addresses the probable impacts of three alternatives. The first alternative analyzed was the No-Action Alternative, which involves no facility improvements other than minor alterations, routine maintenance and repair work. The T5 upland and waterfront area would continue as a cargo terminal transportation facility with cargo marshalling, cargo storage, cargo trans-shipments, and vessel moorage at an annual cargo throughput of 647,000 twenty-foot equivalent units (TEUs) per year.

Alternative 2 consists of conducting modifications to existing container facilities, including cargo wharf rehabilitation, berth deepening, and water, stormwater and electrical service capacity improvements. Elements include demolition, rehabilitation of the existing wharf, slope stabilization measures, replacement of the concrete deck structure, repair and replacement of existing concrete piling caps beams, and replacement of the fender system. With the Alternative 2 improvements, the terminal's maximum throughput is estimated at 1.3 million (M) TEUs per year.

Alternative 3 proposes the cargo wharf and vessel berth improvements identified in Alternative 2 combined with substantial improvements to the upland cargo marshalling area to increase overall terminal throughput up to 1.7 million TEUs per year. It also includes the addition of reorganized intermodal rail facilities, reconfigured gate, shore power usage up to 80% by 2040 and demolition of buildings. The container yard would be enlarged through relocation or demolition of the existing entrance gate, freight station, transit shed, maintenance and repair buildings, and operations buildings. The container yard capacity would be increased through use of grounded container storage served by cranes. The truck gate would be relocated, and the existing intermodal rail yard would be reconfigured with additional rail lines and concrete or rail runways for equipment.

2 AFFECTED ENVIRONMENT

2.1 Project Location

The Project is located at the existing T5 marine cargo facility, located on the west margin of the West Waterway in Seattle, Washington (Range 3 East, Township 24 North, and Sections 12 and 13). T5 is bounded by the West Waterway channel on the east, the West Seattle Bridge on the south, Harbor Avenue SW on the west, and Elliott Bay on the north. The Project area includes the existing T5 marine cargo facility with approximately 197 acres of existing upland and approximately 19 acres of existing cargo pier and navigational access area in the west margin of the West Waterway adjacent to the terminal upland cargo marshalling area. Most of the Site is covered by pavement and buildings.

2.2 Local Hydrology

Seattle's climate is classified as oceanic or temperate marine, with cool, wet winters and warm, relatively dry summers. From 1981 to 2010, the average annual precipitation measured at Seattle–Tacoma International Airport was 37.49 inches. Annual precipitation has ranged from 23.78 inches in 1952 to 55.14 inches in 1950; for water year (October 1 – September 30) precipitation, the range was 23.16 inches in 1976–77 to 51.82 inches in 1996–97 (National Oceanic and Atmospheric Administration, 2016).

T5 is located at the mouth of Longfellow Creek, an urban stream that is piped under the industrial properties in its lowest reaches. Longfellow Creek drains approximately 3,000 acres of the Delridge valley in West Seattle and crosses the southeast corner of T5 before discharging to the West Waterway. The primary pipeline for Longfellow Creek has inadequate capacity to convey peak flows, so a secondary outlet named the Longfellow Creek Overflow Line (LFOL) was installed. The LFOL is located entirely underground. A weir installed in the creek well upstream of T5 diverts high flows into the LFOL. The LFOL traverses the western edge of T5 to discharge to Elliott Bay. Portions of T5 drain to Longfellow Creek and the LFOL, but the majority of T5 drains directly to the West Waterway through nine active stormwater outfalls.

T5 receives limited offsite stormwater run-on from the adjacent impervious pavement cap over the former West Seattle Landfill, which is now a holding yard and referred to as the CEM property (CEM). The offsite run-on from the CEM is addressed below as the "Offsite Tributary Basin."

In addition to the overflow stormwater from Longfellow Creek, the LFOL receives stormwater from several areas in the vicinity of the Site. These areas include portions of the upland Pacific Sound Resources (PSR) property, which is capped by asphalt, Florida Street, the north part of the CEM property, and from portions of Harbor Avenue.

2.3 T5 Stormwater Drainage Basins and Infrastructure

Stormwater drainage at T5 consists of 11 drainage basins. The location of the drainage basins and outfalls are shown in Figure 1, which also indicates stormwater structure types and stormwater pipe types. A summary of stormwater basin areas and their associated outfalls are shown in Table 1 below.

Table 1—Drainage Basin Areas by Outfall

Basin/Sub-Basin	Outfall	Area in Acres
Basin 1A	5802 (Longfellow Creek)	17.26
Basin 1B		7.81
Basin 1C		3.15
Basin 1D		2.51
Basin 2	5801	9.86
Basin 3	5799	4.82
Basin 4	5798	1.81
Basin 5	5796	15.33
Basin 6	5796	4.12
Basin 7	5266	6.71
Basin 8	5795	2.07
Basin 9A	5794	22.76
Basin 9B	5794	18.48
Basin 9C	5794	6.81
Basin 10A	9228	33.32
Basin 10B	9228	10.45
Basin 11	1415 (LFOL)	14.7
Offsite Tributary Basin	9228	18.4

The drainage system at T5 primarily consists of a network of catch basins and pipes. Extensive trench drains are installed in the Intermodal Yard. There are approximately 650 catch basins, 235 manholes, and 2.1 miles of trench drain at T5 connected and conveyed to the 11 outfalls by 16.5 miles of subsurface pipe. Six oil/water separators have been installed in areas of intense industrial activity, such as the fueling station and maintenance and repair building.

2.4 Stormwater Quality

Water quality at T5 has been monitored for multiple years under the Industrial Stormwater General Permit. Over the past several years, a variety of locations have been utilized for ISGP monitoring[1]. Most recently, monitoring during 2012 through early 2014 was conducted at locations in Basin 2 (designated sample point “C”), Basin 5 (designated sample point “B”), and Basin 9 (designated sample point “A”). A summary of stormwater monitoring results at T5 during the period 2012 through 2014 is provided in Table 2, and corresponding water quality graphs are provided in Figure 2 (total zinc), Figure 3 (total copper), and Figure 4 (turbidity). Monitoring locations are shown in Figure 5.

As shown in Table 2, from the first quarter of 2012 through the first quarter of 2014, total zinc concentrations ranged from 60 to 930 micrograms per liter (µg/L) with a median value of 310 µg/L, nearly three times the ISGP benchmark (117 µg/L). Total copper concentrations measured during the same period ranged from 6 to 77 µg/L, with a median value of 23 µg/L, nearly twice the ISGP benchmark (14 µg/L). Turbidity measured during the two-year period ranged from 7 to 270 nephelometric turbidity units (NTU) with a median value of 38 NTU, approximately 1.5 times the ISGP benchmark value (25 NTU).

2.5 Regulatory Requirements

The City of Seattle’s Stormwater Code (Stormwater Code) is contained in the Seattle Municipal Code (SMC), Chapters 22.800 – 22.808. The Stormwater Code contains regulatory requirements that provide for and promote the health, safety, and welfare of the general public. Specific technical requirements, criteria, guidelines, and additional information are provided in the five-volume City of Seattle Stormwater Manual (Stormwater Manual, City of Seattle, 2016). Volume 2 – Construction Stormwater Control provides guidance and requirements for Project construction.

The Federal Clean Water Act (FCWA, 1972, and later modifications, 1977, 1981, and 1987) establishes water quality goals for the navigable (i.e., surface) waters of the United States. These goals are achieved through the National Pollutant Discharge Elimination System (NPDES) permit program, which is administered by the U.S. Environmental Protection Agency (EPA). EPA has delegated to Ecology the responsibility to administer the NPDES permit program throughout Washington. Chapter 90.48 RCW defines Ecology's authority and obligations in administering the wastewater discharge permit program. The state administers the NPDES program by issuing separate individual NPDES permits and multiple statewide general permits.

Container terminals are required to obtain coverage under the NPDES Industrial Stormwater General Permit (ISGP) (Ecology, 2014a), which authorizes discharge of stormwater associated with industrial activity. T5 is covered under ISGP number WAR-000464. The ISGP provides guidance and requirements for Project operation.

[1] Since the outfalls at T5 are located under docks and are difficult to access, water quality monitoring at T5 has typically been conducted in manholes located upstream from the outfalls.

2.6 ISGP General Requirements

The ISGP authorizes stormwater discharges from certain industrial facilities as long as the discharges are consistent with the 13 special conditions and 25 general conditions of the permit. Ecology recently reissued the ISGP with an effective date of January 2, 2015 (Ecology, 2014a). The reissued permit expires on December 31, 2019.

Compliance is relatively complex, but generally involves the following key actions:

- Developing a Stormwater Pollution Prevention Plan (SWPPP) and implementing all mandatory operational source controls, structural source controls, and treatment best management practices (BMPs); a summary of mandatory ISGP BMPs is provided in Attachment A;
- Performing monthly inspections;
- Conducting quarterly water quality monitoring involving collection of stormwater samples from all outfalls (except "substantially identical" outfalls) and laboratory analysis for ISGP-specific benchmark parameters;
- Comparing analytical results to applicable ISGP numeric benchmarks and effluent limits;
- Performing escalating levels of corrective action based on benchmark exceedances; and
- Submitting quarterly Discharge Monitoring Reports (DMRs) and annual reports to Ecology.

A benchmark is a pollutant concentration used as a permit threshold, below which a pollutant is considered unlikely to cause a water quality violation, and above which it may. A benchmark exceedance is not a permit violation. When pollutant concentrations exceed benchmarks, escalating corrective action requirements take effect depending on how many quarterly benchmark exceedances occur within a calendar year for an applicable parameter. Benchmark values are not water quality standards and are not numeric effluent limitations; they are indicator values.

The ISGP also establishes effluent limits for certain industrial activities and for discharges to impaired waters. As opposed to a benchmark, the discharge of a pollutant at a level greater than an effluent limit is a violation of the conditions of the ISGP. In the event a numeric effluent limit is exceeded, ISGP Special Condition S9.E requires immediate action to minimize potential pollution or otherwise stop the noncompliance and correct the problem, immediate phone notification of the appropriate Ecology regional office of the failure to comply, and submittal of a detailed written report to Ecology within five days. Water quality parameters, associated benchmarks, and effluent limits relevant to T5 are listed in Table 3.

Table 3—ISGP Benchmark and Effluent Values Relevant to T5

Parameter	Units	Benchmark Value	Effluent Limit
Turbidity	NTU	25	--
pH	Standard Units	Between 5.0 and 9.0	--
Oil Sheen	Yes/No	No visible oil sheen	--
Copper, Total	µg/L	14	--
Zinc, Total	µg/L	117	--
TSS[a]	mg/L	--	30[a]
Fecal Coliform Bacteria	#Colonies/100mL	--	[b]

Notes
[a] The TSS effluent limit becomes effective January 1, 2017; however, TSS sampling and reporting is required effective January 2, 2015.
[b] Fecal coliform bacteria has a narrative effluent limit rather an a numeric effluent limit. The narrative effluent limit is met by performing required sampling and implementing mandatory BMPs targeted at reducing fecal coliform levels.

When benchmarks are exceeded, the ISGP requires tiered levels of Corrective Actions depending on the number of benchmark exceedances within a calendar year:

- **Level 1 – Operational Source Control BMPs** are required each time any applicable benchmark value is exceeded. Level 1 Corrective Actions include implementing additional operational source control BMPs such as employee training, prohibition of practices, and good housekeeping, maintenance and other managerial procedures and schedule of activities. The Level 1 implementation deadline is within 45 days following the end of the quarter the benchmark was exceeded.

- **Level 2 – Structural Source Control BMPs** are required when an applicable benchmark value (for a single parameter) is exceeded for any two quarters. Level 2 Corrective Actions include implementing additional structural source control BMPs such berms, roofs, grading or paving. The Level 2 implementation deadline is no later than August 31st of the following year.

- **Level 3 – Treatment BMPs** are required when an applicable benchmark value (for a single parameter) is exceeded for any three quarters. Level 3 Corrective Actions include treatment BMPs that are intended to remove pollutants from stormwater. Before installing treatment BMPs, an engineering report must be submitted to Ecology for review by May 15th of the following year, and the Level 3 implementation deadline is no later than September 30th of the following year. Additional information on Level 3 Corrective Action requirements is provided in Section 2.3

In addition to the standard ISGP benchmarks, two effluent limits apply to T5 based on its location. T5 discharges stormwater to the West Waterway of the Duwamish River, which is identified as an impaired water on the 2012 Washington State 303(d) list. Since T5 discharges to a 303(d) listed waterbody (Category 5), sampling for TSS and fecal coliform bacteria is included in Table 3.

2.7 T5 ISGP Status

The original ISGP at T5 was permit number SO3000464 issued on December 28, 1992 to American President Lines. The Port was a co-signer on this permit. On January 3, 1997, the permit was transferred to Eagle Marine Services as they became the new tenant at T5. During June 2000, Ecology determined that the Port could no longer be a co-signer on the permit and Eagle Marine Services became the sole permit holder. On January 1, 2010, the ISGP number changed to WAR-000464, which is the current permit number.

Eagle Marine Services was the ISGP holder until they terminated the lease and vacated T5, transferring the permit to the Port on September 26, 2014. Prior to leaving the Site, Eagle Marine Services had triggered an ISGP Level 3 Corrective Action (which requires installation of a stormwater treatment system) due to exceedances of ISGP benchmarks for zinc, copper, and turbidity. However, a stormwater treatment system was not installed prior to Eagle Marine Services' departure. According to Ecology's ISGP transfer letter (Moore, 2014), "the Port of Seattle (POS) is not required to implement the Level 3 Corrective Action originally triggered by former Permittee, Eagle Marine Services, LTD…" This relief is based on the following consideration, among others: "The POS plans to redevelop Terminal 5 into a deep water container terminal, with stormwater management addressed during the permitting, design and construction of the project."

2.8 ISGP Level 3 Corrective Action (Treatment) Requirements

When an applicable water quality benchmark value is exceeded for a single parameter for any three quarters during a calendar year, a Level 3 Corrective Action is required in accordance with ISGP Special Condition S8.D. Level 3 Corrective Action requirements are summarized below:

- Review the SWPPP and ensure that it fully complies with ISGP Special Condition S3.
- Make appropriate revisions to the SWPPP to include additional treatment BMPs with the goal of achieving the applicable benchmark value(s) in future discharges; the revised SWPPP needs to be signed and implemented according to ISGP Special Condition S3 and the and the Stormwater Management Manual for Western Washington (SWMMWW) (Ecology, 2014b).
- An engineering report must be submitted for Ecology review and approval prior to installing treatment BMPs that require the site-specific design or sizing of structures and equipment. The engineering report must address seven specific requirements identified in the ISGP and be prepared in accordance with Guidelines for the Preparation of Industrial Stormwater General Permit Engineering Reports (Ecology, 2013). The engineering report must include:
  - A brief summary of the treatment alternatives considered and why the proposed option was selected;
  - The basic design data and sizing calculations of the treatment units;
  - A description of the treatment process and operation;

  - The amount and kind of chemicals used in the treatment process, if any;

  - Results to be expected from the treatment process including the predicted stormwater discharge characteristics;

  - A statement, expressing sound engineering justification that the proposed treatment is reasonably expected to meet the permit benchmarks; and

  - Certification by a licensed professional engineer.

- The engineering report needs to be submitted to Ecology no later than the May 15th prior to the Level 3 Corrective Action deadline. An Operation and Maintenance Manual (O&M Manual) needs to be submitted to Ecology no later than 30 days after construction/installation is complete.

- The planned (or taken) Level 3 Corrective Action needs to be summarized in the annual report.

- If installation of necessary treatment BMPs are not feasible by the Level 3 Corrective Action deadline, Ecology may approve additional time by approving a Modification of Permit Coverage.

- If installation of treatment BMPs is not feasible or not necessary to prevent discharges that may cause or contribute to violation of a water quality standard, Ecology may waive the requirement for treatment BMPs by approving a Modification of Permit Coverage.

3 POTENTIAL IMPACTS

3.1 Construction (All Alternatives)

If not properly controlled through the use of BMPs, pollutants that might be expected in the discharge from the Site include sediment, pH, petroleum products, and other pollutants. Soil erosion or sheet erosion can cause turbid (muddy) stormwater when the sediment contacts rainwater; this is the most common and visible form of construction stormwater pollution. The resulting high turbidity can adversely impact receiving waters if not properly controlled using the BMPs. If not properly controlled, soil erosion and the resulting sedimentation produced by construction activities can impact the environment, damaging aquatic and recreational resources, as well as aesthetic qualities. Common examples of the impacts of erosion and sedimentation include the following:

- Silt fills culverts and storm drains, decreasing capacities and increasing flooding and maintenance frequency.

- Sediment causes obstructions to surface water bodies requiring dredging to restore navigability.

- Nutrient loading from phosphorus and nitrogen attached to soil particles and transported to surface water bodies can cause a change in the water pH, algal blooms, and oxygen depletion, leading to eutrophication and fish kills.
- Turbid water replaces aesthetically pleasing, clear, clean water in surface water.
- Eroded soil particles decrease the viability of macro-invertebrates and food-chain organisms, impair the feeding ability of aquatic animals, clog gill passages of fish, and reduce photosynthesis.
- Sediment-clogged gravel diminishes fish spawning and can smother eggs or young fry.

The sources of other commonly encountered construction stormwater pollutants include materials and chemicals used during day-to-day construction activities, such as concrete pouring, paving, truck and heavy equipment operation, and maintenance activities. Low and high acidity and petroleum products can adversely impact the receiving waters by introducing pollutants and reducing water quality.

3.2 Operation (All Alternatives)

If not properly controlled through the use of BMPs, operational stormwater impacts can include water-borne contaminants from a variety of activities including:

- Loading and unloading of bulk materials.
- Outdoor storage of materials or products.
- Spills, leaks or drips from engines, motors, hydraulic equipment, or other greasy equipment.
- Spills or leaks from drums or small containers containing chemicals or petroleum products such as fuels, oils or greases.
- Suspended solids including paint, metal, or wood particles generated during maintenance or repair.
- Metals from leaching galvanized materials, or particles containing metals generated during maintenance or repair.
- Tire particles and debris from operation of loading/unloading equipment.
- Sediment and suspended solids associated with runoff from unpaved areas or road grit tracked onto the site.
- On-site waste storage and management.

Potential operational stormwater pollutants include oil and grease (hydrocarbons) and heavy metals such as copper, lead, and zinc that can adversely impact receiving waters by introducing pollutants, reducing water quality, and adversely impacting aquatic life.

4 MITIGATION

The Stormwater Code and Stormwater Manual, ISGP, and SWMMWW provide guidance on the measures necessary to control the quantity and quality of stormwater produced by new development and redevelopment such that they comply with water quality standards and contribute to the protection of receiving waters. These are used to establish stormwater requirements, create construction and operation SWPPPs, design permanent stormwater control plans, and determine stormwater infrastructure. The method by which adverse impacts to stormwater quality and quantity is controlled is primarily through the application of BMPs. BMPs refer to schedules of activities, prohibitions of practices, maintenance procedures, and other physical, structural, treatment and/or managerial practices to prevent or reduce the pollution of waters.

4.1 Construction Impact Mitigation (All Alternatives)

Stormwater discharges from construction sites must not cause or contribute to violations of Washington State's surface water quality standards (Chapter 173-201A WAC), sediment management standards (Chapter 173-204 WAC), ground water quality standards (Chapter 173- 200 WAC), and human health based criteria in the National Toxics Rule (40 CFR Part 131.36). Before a construction site can discharge stormwater to waters of the State, all known, available, and reasonable methods of prevention, control, and treatment (AKART) must be applied. This includes preparing and implementing a Construction SWPPP, with appropriate BMPs installed and maintained in accordance with the SWPPP. Proper implementation and maintenance of appropriate BMPs is critical to adequately control any adverse water quality impacts from construction activity.

Volume 2 – Construction Stormwater Control of the Stormwater Manual (City of Seattle, 2016) applies to all construction projects in Seattle, defined in the Seattle Municipal Code (SMC), Chapter 22.801.170 as the addition or replacement of hard surface or the undertaking of land-disturbing activity. The construction stormwater BMPs and requirements in this volume have been integrated from many programs and regulations, including the provisions of the Federal Clean Water Act, Federal Coastal Zone Management Act, City of Seattle Phase I NPDES Municipal Stormwater Permit, Puget Sound Partnership Action Agenda, Ecology Construction Stormwater General Permit (CSWGP), and Stormwater Code.

Construction BMPs would be used to control and manage stormwater runoff during all project construction activities. Implementation would be in accordance with Port BMPs and the Stormwater Code requirements and would be consistent with the SWMMWW, including development of a Construction SWPPP and implementation of a Construction Stormwater and Erosion Control Plan. Implementation of these items and other additional requirements would result in the mitigation of any potential adverse impacts to construction stormwater runoff.

The Stormwater Manual requires 19 elements for construction site stormwater pollution prevention control:

1. Mark Clearing Limits and Environmentally Critical Areas
2. Retain Top Layer
3. Establish Construction Access
4. Protect Downstream Properties and Receiving Waters
5. Prevent Erosion and Sediment Transport from the Site
6. Prevent Erosion and Sediment Transport from the Site by Vehicles

7. Stabilize Soils
8. Protect Slopes
9. Protect Storm Drains
10. Stabilize Channels and Outlets
11. Control Pollutants
12. Control Dewatering
13. Maintain BMPs;
14. Inspect BMPs;
15. Execute Construction Stormwater and Erosion Control Plan;
16. Minimize Open Trenches;
17. Phase the Project;
18. Install Flow Control and Water Quality Facilities
19. Protect Stormwater BMPs.

A complete description of each element is provided in Volume 1, Chapter 2 of the Stormwater Manual, and associated stormwater pollution prevention control requirements are described in Volume 2 of the Stormwater Manual.

If needed, a CSWGP (Ecology, 2015) issued by Ecology would be obtained and implemented to minimize harm to surface waters from construction activities. Coverage under the CSWGP is generally required for any clearing, grading, or excavating if the project site discharges stormwater from the site into surface water of the State and disturbs one or more acres of land area. TESC plans would be implemented prior to construction. This would include strategies for meeting the SWPPP discharge monitoring and reporting requirements in the CSWGP. The project would need approval of TESC plans prior to starting construction. The measures would be modified and upgraded in response to different phases of construction and as a response to monitoring results. Cooperation with Ecology and local water quality jurisdictions would be essential during the subsequent design process. In addition, the construction contractor would be required to implement a SPCC plan and maintain spill control kits to be used in case of a material spill.

4.2 Operation Impact Mitigation

A future container terminal operator will need to continue coverage under and comply with the ISGP, as well as comply with the source control regulations of the Stormwater Code and Stormwater Manual. The ISGP authorizes stormwater discharges from T5 that are consistent with the 13 special conditions and 25 general conditions of the permit (Ecology, 2014a). Section 2.7 of this Technical Memorandum describes the general requirements of the ISGP and Section 2.8 describes the Level 3 Corrective Action (treatment) requirements. Compliance involves several key actions including developing a SWPPP and implementing mandatory operational source controls, structural source controls, and treatment BMP as summarized below.

Operational source controls are primarily common sense “good housekeeping” and preventive maintenance measures intended to lessen or eliminate the potential for stormwater contamination. Mandatory operational source controls required by the ISGP include:

- Good housekeeping practices, including quarterly vacuum sweeping
- Preventive maintenance measures

- Spill Prevention and Emergency Cleanup Plan (SPECP)
- Employee training
- Inspections and recordkeeping
- Illicit discharge prevention

Mandatory structural source controls required by the ISGP include:

- BMPs to minimize the exposure of manufacturing, processing, and material storage areas (including loading and unloading, storage, disposal, cleaning, maintenance, and fueling operations) to stormwater by either locating these industrial materials and activities inside or protecting them with storm resistant coverings.
- Use grading, berming, or curbing to prevent runoff of contaminated flows and divert run-on away from manufacturing, processing, and material storage areas.
- Perform all cleaning operations indoors, under cover, or in bermed areas that prevent stormwater runoff and run-on, and also that capture any overspray.
- Ensure that all washwater drains to a collection system that directs the wash water to further treatment or storage and not to the stormwater drainage system.

Water quality treatment BMPs include the use of facilities and/or equipment that remove pollutants from stormwater by filtration, biological uptake, absorption, adsorption, coagulation, flocculation, and/or gravity settling of particulate pollutants. The need for a facility to provide water quality treatment BMPs depends on the type and amount of pollutants contained in stormwater runoff, and the vulnerability of the receiving waters to the pollutants of concern. The mandatory ISGP treatment requirements include:

- Use treatment BMPs consistent with the applicable documents referenced in ISGP Special Condition S3.A.3
- Employ oil/water separators, booms, skimmers, or other methods to eliminate or minimize oil and grease contamination of stormwater discharges.
- Obtain Ecology approval before beginning construction/installation of all treatment BMPs that include the addition of chemicals to provide treatment.

A summary of mandatory ISGP BMPs is provided in Attachment A.

The Project does not include changes in the amount of upland impervious surface areas; therefore, stormwater runoff rates and volumes would be similar to the existing condition. The Project discharges stormwater to the West Waterway of Elliot Bay, which is a Designated Receiving Water as determined by the Director of Seattle Public Utilities and approved by Ecology as having sufficient capacity to receive drainage discharges (Volume 1, Chapter 2, Stormwater Manual). Since this is not a capacity-constrained system, flow control is not required.

In anticipation of T5 redevelopment, a stormwater management study was performed under the direction of the Port that developed and evaluated a range of stormwater management scenarios (Aspect Consulting, 2015). The stormwater management study considered and incorporated applicable information specific to container terminals contained in the Washington State Marine

Terminal All Known, Available, and Reasonable Methods of Prevention, Control, and Treatment (AKART) and ISGP Corrective Action Guidance Manual (Washington Public Ports Association [WPPA], 2014). The study summarized relevant stormwater management practices at similar Port of Seattle facilities, screened a suite of treatment technologies, evaluated hydrologic and hydraulic conditions at T5, and developed four scenarios for stormwater management, including three with various levels of treatment. Applicable results of the study are summarized below and applied to the three Project alternatives.

4.2.1 Potentially Applicable Treatment Technologies

The screening of feasible treatment technologies for T5 took into account the comprehensive treatment technology information provided in the WPPA AKART Manual, and factored in several items specific to T5 including operational, maintainability, and effectiveness considerations. Six potentially suitable treatment technologies were identified: the Jellyfish Filter, Media Cartridge Filter, Modular Wetlands, Aquip Filter, Up-Flo Filter, and Downspout Filter. A summary comparison of performance and cost for each treatment technology is presented in Table 4.

4.2.2 Hydrologic Analysis and Water Quality Treatment Rates

A hydrologic analysis of the drainage basins at T5 was performed to determine the required water quality treatment flow rates and peak flows for each basin. The basin were modeled using MGS Flood, a general, continuous, rainfall-runoff computer model used by the Washington State Department of Transportation specifically for stormwater facility design in Western Washington (MGS Software, 2009). The program uses the Hydrological Simulation Program-Fortran (HSPF) routine for computing runoff from rainfall. For simulating hydrology at T5, the extended precipitation time series for the City of Seattle was used including precipitation records compiled from multiple stations allowing for simulation of 158 years to represent a wide-range of climate conditions. The T5 basins were modeled with the assumption of 100 percent impervious surface for all basins.

The SWMMWW requires that water quality treatment facilities treat 91 percent of the average annual runoff volume. Modeled water quality treatment flow rates for each T5 basin are listed in Table 5, which also lists the modeled peak 2-year, 10-year, and 100-year storm flows.

4.2.3 Hydraulic Considerations

A key factor in selecting and applying a treatment technology is understanding its hydraulic characteristics and how it would potentially function with a given site's drainage system. Treatment systems using filtration technology require a pressure (or head) difference to push water through the filter media. Some systems require less head differential, and are therefore easier to incorporate into a storm drainage system driven by gravity. Others need a higher head differential and are typically used in pumping situations. The hydraulic requirements of the five screened treatment technologies applicable to treatment of large-scale basins (i.e., excluding the downspout filters) were evaluated including minimum operating head, required drop between inlet and outlet pipes, and ability to backwater to determine potential application at T5.

4.2.4 Level 3 Corrective Action Scenarios

The ISGP allows flexibility for permittees to tailor their Level 3 Corrective Actions to incorporate site-specific conditions and constraints. As such, there is a range of possible approaches that could be successful in meeting the ISGP requirement of providing treatment “with the goal of meeting benchmarks.” For T5, four possible approaches (Scenarios) were identified to meet ISGP requirements ranging from source controls only up to treatment for all areas of T5. The Scenarios were developed based on experiences at other Port terminals, hydrologic and hydraulic evaluations, screening of treatment technologies, and an assessment of areas most likely to generate high pollutant loadings. Highest priority basins were evaluated for stormwater treatment, the most relevant treatment technologies, and estimated cost for implementation. The four Scenarios evaluated were:

- **Scenario 1** – source controls only
- **Scenario 2** – source controls + focused treatment
- **Scenario 3** – source controls + 50% end of pipe treatment
- **Scenario 4** – source controls + site-wide treatment

Scenarios 2, 3, and 4 represent application of similar treatment technologies at varying scales across the Site, ranging from water quality treatment of 20 percent to 93 percent of the Site. A comparison of the areas of the Site that would receive treatment under each scenario is shown in Figure 6, and the Scenarios are summarized below.

Scenario 1 – Source Controls Only

This Scenario consists of aggressively implementing operational and structural source controls that go beyond the normal requirements of the ISGP. Scenario 1 assumes that required BMPs have been implemented and focuses solely on additional source controls (Figure 7). Additional BMPs were evaluated from the SWMMWW, WPPA AKART Study, approaches at other Port properties (particularly T18), and new approaches based on professional experience. The most promising BMPs were selected for inclusion in Scenario 1:

- Perform high-frequency vacuum sweeping
- Install wheel wash at main entrance
- Coat zinc sources (fences, light poles, siding, roofs, etc.)
- Use copper-free brake pads on terminal equipment
- Investigate tires for terminal equipment with lower zinc concentrations
- Repair pavement
- Install or maintain tide valves
- Routine cleaning of the drainage system

Scenario 2 – Source Controls + Focused Treatment

Scenario 2 is a combination of aggressive source controls and stormwater treatment in targeted areas. It includes the suite of source controls identified in Scenario 1, and adds stormwater treatment systems for areas of the Site expected to generate the highest pollutant concentrations, specifically high traffic areas and areas near vehicle and equipment maintenance buildings (Figure 8). The type of treatment selected would vary by location depending on the specific pollutants anticipated.

Treatment systems are envisioned for the following areas:

- Basin 1A and B - Main entrance, Container Freight Station (CFS) warehouse
- Basin 2 - Transit shed
- Maintenance and Repair (M&R) Building (part of Basin 10A)
- Intermodal Yard Shop (part of Basin 11)

Collectively these systems would treat approximately 20 percent of the Site.

<u>Scenario 3 – Source Controls + 50% End of Pipe Treatment</u>
Scenario 3 expands treatment to encompass approximately 50 percent of the Site, with the areas to be treated selected primarily based on anticipated pollutant loading, but also ease of treatment (Figure 9). Using these criteria the following basins would receive treatment:

- Basins 1A and 1B – Main Entrance, CFS Building and Fueling Station
- Basin 2 – Transit Shed
- Basins 10A and 10B – M&R Building, Hides Storage Area, IY, Container Storage and Reefer Wash
- Basin 11 – Intermodal Yard and Shop

This collection of locations includes the most intensive industrial activities and the majority of vehicle traffic, and Scenario 3 provides treatment for most areas of industrial activity draining to pipes owned by the City of Seattle.

<u>Scenario 4 – Source Controls + Site-Wide Treatment</u>
Under Scenario 4, treatment would be provided Site-wide by installing eight treatment systems and roof downspout filters on the south half of the Transit Shed (Figure 10). Several smaller basins, particularly those closer to the Duwamish River, would be combined through conveyance improvements to reduce the number of treatment systems. Scenario 4 would provide treatment for approximately 93 percent of the Site permitted under the ISGP, with the untreated portion consisting of most of the apron, furthest west rail track, the offsite portions of Basin 1D, and the administrative building and parking lot in Basin 1C. With treatment occurring Site-wide, it would be possible to implement a less aggressive set of source controls.

The four Scenarios were evaluated on a variety of metrics including effectiveness at meeting benchmarks, impacts to Site operations, estimated initial capital costs (including source control, treatment equipment, and associated infrastructure construction), and annual O&M costs. A summary of the evaluation is provided in Table 6.

4.2.5 Project Alternatives

All three Project alternatives have an operator returning to the Site and resuming container terminal operations. Relying on source control of pollutants alone will probably not represent a feasible solution for achieving long-term compliance with ISGP water quality benchmarks and some level of stormwater treatment will be required. It’s more likely that higher container throughput scenarios may require more aggressive treatment approaches.

Project design and operation should further evaluate and incorporate as appropriate the information provided in the T5 stormwater management study, with Scenario 2 considered as the starting basis for the No-Action Alternative and Alternative 2, and Scenario 3 considered as the starting basis for Alternative 3.

4.3 Significant Unavoidable Adverse Impacts (All Alternatives)

Implementation and compliance with the requirements specified in the Stormwater Code and Stormwater Manual, ISGP, and SWMMWW would result in the mitigation of any potentially significant adverse impacts to stormwater runoff. Therefore, no significant adverse impacts or cumulative impacts are anticipated.

5 REFERENCES

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6 LIMITATIONS

Work for this project was performed for the Port of Seattle and Moffatt & Nichol (Client), and this memorandum was prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. This memorandum does not represent a legal opinion. No other warranty, expressed or implied, is made.

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Attachments:

Table 2 – Stormwater Monitoring Results 2012-2014
Table 4 – Comparison of Treatment System Performance and Cost
Table 5 –T5 Water Quality Treatment Flow Rates and Peak Flow Rates by Drainage Basin
Table 6 – Summary of Scenario Evaluation
Figure 1– Stormwater Basins
Figure 2 – Water Quality - Zinc
Figure 3 – Water Quality - Copper
Figure 4 – Water Quality - Turbidity
Figure 5 – SWPPP Site Map
Figure 6 – Summary of Areas Treated by Scenario
Figure 7 – Scenario 1: Source Controls
Figure 8 – Scenario 2: Source Controls and Focused Treatment
Figure 9 – Scenario 3: Source Controls and 50% End of Pipe Treatment
Figure 10 – Scenario 4: Site Wide Treatment
Attachment A: ISGP Mandatory BMPs

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TABLES

Table 2 - Stormwater Monitoring Results 2012-2014

Project No. 140222 - Port of Seattle Terminal 5, Seattle, WA

Quarter	Sample Location	Turbidity (NTU)	Total Zinc (ug/L)	Dissolved Zinc (ug/L)	Total Copper (ug/L)	Dissolved Copper (ug/L)	Oil Sheen (yes/no)	pH	Fecal (# Colonies/100 mg/L)	Notes
Benchmark		25	117	-	14	-	No[1]	5 to 9	Narrative Criteria	
Jan-Mar 2012	A	**270**	**930**	*100*	**77**	*22*	-	6.79	-	
Jan-Mar 2012	B	**44**	**390**	*260*	**20**	*7*	-	6.65	-	
Jan-Mar 2012	C	**120**	**310**	*70*	**27**	*6*	-	6.7	-	
Apr-Jun 2012	A	**100**	**480**	*190*	**45**	*23*	-	6.89	-	
Apr-Jun 2012	B	20	**470**	*410*	**48**	*34*	-	6.76	-	
Apr-Jun 2012	C	**38**	**340**	*210*	**53**	*32*	-	6.74	-	
Jul-Sep 2012	A	21	**190**	*70*	**16**	*5*	-	6.3	-	
Jul-Sep 2012	B	15	**210**	*150*	14	*7*	-	6.34	-	
Jul-Sep 2012	C	**40**	**530**	*290*	**60**	*32*	-	6.49	-	
Oct - Dec 2012	A	**37**	**250**	*90*	13	*2*	-	6.37	-	
Oct - Dec 2012	B	11.7	**190**	*140*	6	*3*	-	5.94	-	
Oct - Dec 2012	C	**52**	**460**	*90*	**29**	*3*	-	5.93	-	
Jan-Mar 2013	A	**71**	**460**	*210*	**29**	*9*	No	6.72	720	
Jan-Mar 2013	B	13.7	**190**	*110*	8	*3*	No	5.96	21	
Jan-Mar 2013	C	**58**	**310**	*150*	**19**	*6*	No	6.51	20	
Apr-Jun 2013	A	7.8	**60**	*40*	9	*4*	No	7.24	1300	
Apr-Jun 2013	B	N/S	N/S	*N/S*	N/S	*N/S*	N/S	N/S	N/S	No sample collected - "B" inaccessible due to operations
Apr-Jun 2013	C	**50**	**290**	*170*	**33**	*19*	No	6.9	320	
Jul-Sep 2013	A	**40.6**	**250**	*90*	**23**	*12*	No	7.09	>20,000	
Jul-Sep 2013	B	7.37	**150**	*140*	7	*6*	No	7.01	1700	
Jul-Sep 2013	C	**35.5**	**320**	*180*	**33**	*23*	No	6.78	>20,000	
Oct - Dec 2013	A	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	No sample collected - no stormwater was discharged during normal working hours
Oct - Dec 2013	B	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	No sample collected - no stormwater was discharged during normal working hours
Oct - Dec 2013	C	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	No sample collected - no stormwater was discharged during normal working hours
Jan - Mar 2014	B	**37.5**	**450**	*170*	**30**	*11*	No	6.68	-	
Jan - Mar 2014	C	**55.35**	110	*70*	11	*5*	No	5.88	-	Turbidity averaged from two samples
Jan - Mar 2014	D	N/S	N/S	*N/S*	N/S	*N/S*	N/S	N/S	-	No sample collected - The configuration of the manhole does not allow sampling. The sampling plan will be revised to omit this location.
Jan - Mar 2014	E	*12*	*140*	*40*	*7*	*2 U*	-	*6.16*	90	

Notes:

[1] Under the 2010 ISGP, monitoring for Oil & Grease is performed by visual observation for oil sheen.

U = not detected at given detection limit

N/S = not sampled

Bold = exceeds benchmark

Italics = not a permit required analyte

Table 4 - Comparison of Treatment System Performance and Cost

Project No. 140222 - Port of Seattle Terminal 5, Seattle, WA

Treatment Technology	Overview	Treatment Performance in Percent Removal[3]				Treatment	Capital Cost Estimate in 2015 Dollars		
		Copper[4]	Zinc[4]	TSS	Turbidity	Confidence	1 CFS	3 CFS	6 CFS
Modular Wetlands (Bio Clean Environmental)	A biofiltration system that uses horizontal flow. Pre-treatment with proprietary BioMediaGREEN and treatment with WetlandMEDIA.GULD for enhanced treatment.[2]	50% (total)	66% (total)	85%	--	High	$ 160,000	$ 480,000	$ 960,000
Downspout Filter (Bio Clean Environmental)	A downspout filter with proprietary BioMediaGREEN.	78.22% (dissolved)	79.15% (dissolved)	85.35%	99.19%	High	$ 1,100	$ 3,000	$ 5,000
Upflow Filter (Hydro International)	A fluidized sand-bed filtration system. Filter modules contained in concrete vaults. CULD for basic treatment.[1]	38% (total)	42% (total)	86%	64%	Medium	$ 54,000	$ 162,000	$ 324,000
Media Cartridge Filter (Contech)	A rechargeable, media-filled cartridge system. Variety of proprietary media available. Maintenance hole, catch basin, and concrete vault options. CULD for enhanced treatment.[2]	39% (dissolved)	66% (dissolved)	88%	--	Low	Not estimated due to low treatment confidence		
Jellyfish Filter (Contech)	A membrane filtration system. Passive backflush. Not effective at removing dissolved metals. CULD for basic treatment.[1]	greater than 50% (total) (removal rate dependent on frequency of rinsing)	greater than 50% (total) (removal rate dependent on frequency of rinsing)	89%	--	Low	$ 56,400	$ 144,500	$ 290,300
Aquip Filter (StormwateRx)	A passive adsorptive media filtration system. Typically installed above ground with a pump station but can be installed below ground. CULD for enhanced treatment.[2]	77% (total)	92% (total)	84%	--	Medium	$ 285,000	$ 810,000	$ 1,575,000

Notes:

CFS = cubic feet per second; CULD - Conditional Use Level Designation from Ecology; GULD - General Use Level Designation from Ecology

1. Basic treatment focuses on removal of suspended solids with a goal of removing 80 percent of total suspended solids (TSS).
2. Enhanced treatment focuses on removal of total suspended solids and removal of dissolved metals.
3. Treatment performance for each technology are based on manufacturer's claims resulting from third-party testing and/or case studies.
4. Total metals includes suspended and dissolved metals. Suspended metals are removed as total suspended solids (TSS) and/or adsorption to filter material.

Table 5 – T5 Water Quality Treatment Flow Rates and Peak Flow Rates by Drainage Basin

Project No. 140222 - Port of Seattle Terminal 5, Seattle, WA

Water Quality Treatment Flow Rates

Name	On-line WQT Flowrate [cfs]	Off-line WQT Flowrate [cfs]
Basin 1A	2.60	1.49
Basin 1B	1.10	0.62
Basin 1C	0.44	0.25
Basin 1D	0.35	0.20
Basin 2	1.39	0.78
Basin 3	0.68	0.38
Basin 4	0.25	0.14
Basin 5	2.16	1.21
Basin 6	0.58	0.32
Basin 7	0.94	0.53
Basin 8	0.29	0.16
Basin 9A	3.22	1.80
Basin 9B	2.61	1.46
Basin 9C	0.96	0.54
Basin 10A	4.71	2.64
Basin 10B	1.47	0.83
Basin 11	2.08	1.16
Offsite Tributary Basin	2.60	1.46

Peak Flow Rates

Name	2-year [cfs]	10-year [cfs]	100-year [cfs]
Basin 1A	4.633	6.752	9.711
Basin 1B	2.659	4.497	6.232
Basin 1C	1.073	1.814	2.513
Basin 1D	0.855	1.445	2.003
Basin 2	3.357	5.677	7.868
Basin 3	1.641	2.775	3.846
Basin 4	0.616	1.042	1.444
Basin 5	5.222	8.826	12.232
Basin 6	1.403	2.372	3.287
Basin 7	2.285	3.863	5.354
Basin 8	0.705	1.192	1.652
Basin 9A	7.750	13.104	18.161
Basin 9B	6.292	10.640	14.746
Basin 9C	2.319	3.921	5.434
Basin 10A	1.389	2.345	3.307
Basin 10B	3.558	6.016	8.338
Basin 11	5.005	8.463	11.729
Offsite Tributary Basin	6.265	10.594	14.682

Notes:

Offsite Tributary Basin brings runoff from the paved CEM property, which is adjacent to T-5.
cfs = cubic feet per second.

Table 6 – Summary of Scenario Evaluation

Project No. 140222 - Port of Seattle Terminal 5, Seattle, WA

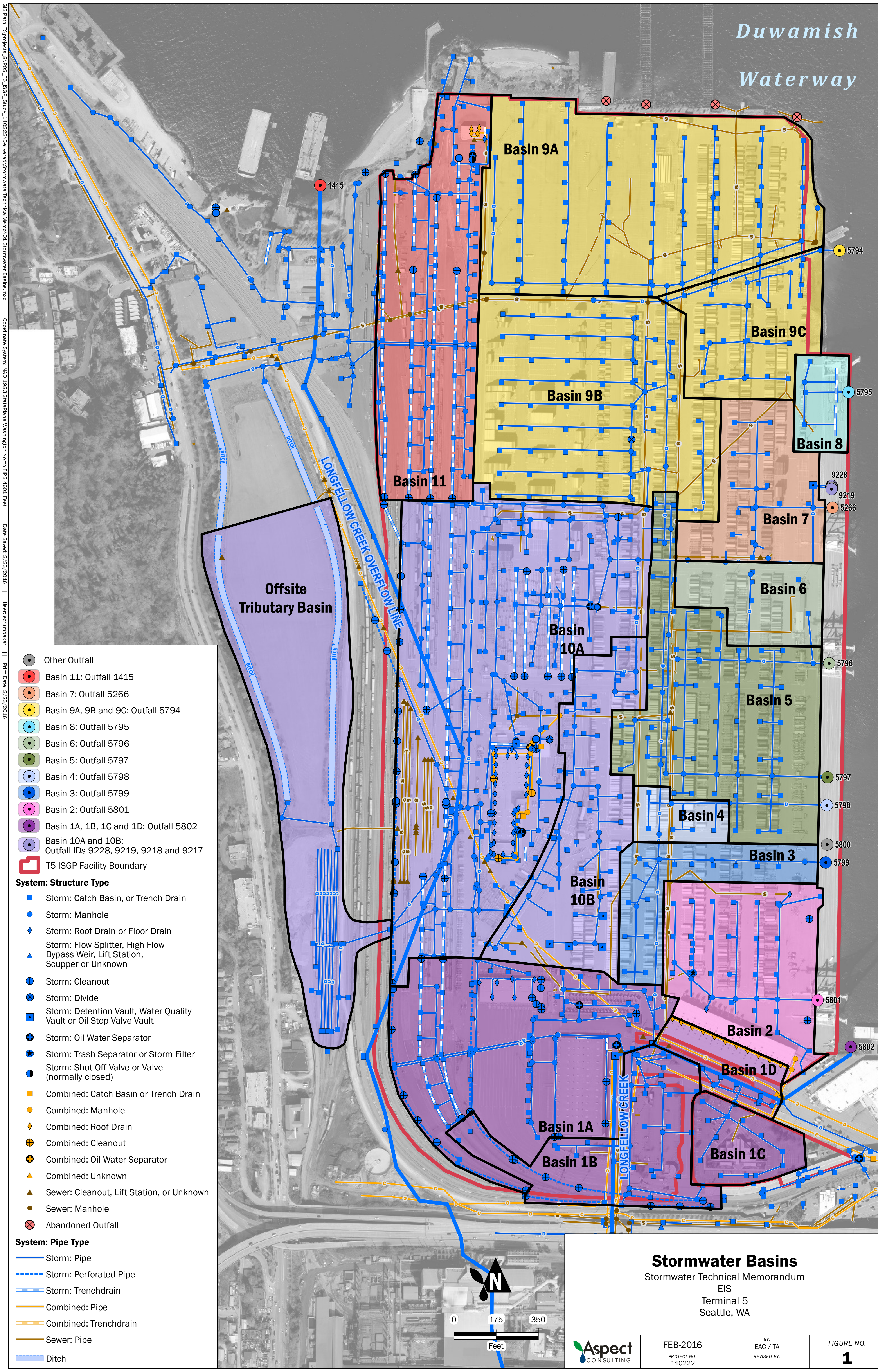
Category		Scenario 1 Source Controls Only	Scenario 2 Source Controls + Focused Treatment	Scenario 3 Source Controls + 50% Site Treatment	Scenario 4 Site-Wide Treatment
Scenario Overview	**Level of Source Controls**	High	High	High	Moderate
	Level of Treatment	None	Low	Moderate	High
	Percent of Site Treated	0%	20%	50%	93%
Effectiveness at Meeting Benchmarks		Very Low	Low/Moderate	Moderate/High	High
Impacts to Site Operations	**Overall Impact**	Moderate	Low	Moderate/High	Moderate
	Power Requirements	Low	Low	Low	Low
Estimated Costs	**Initial Capital[1]**	$2,500,000	$5,500,000	$7,500,000	$12,650,000
	Annual O&M	$650,000	$685,000	$740,000	$350,000

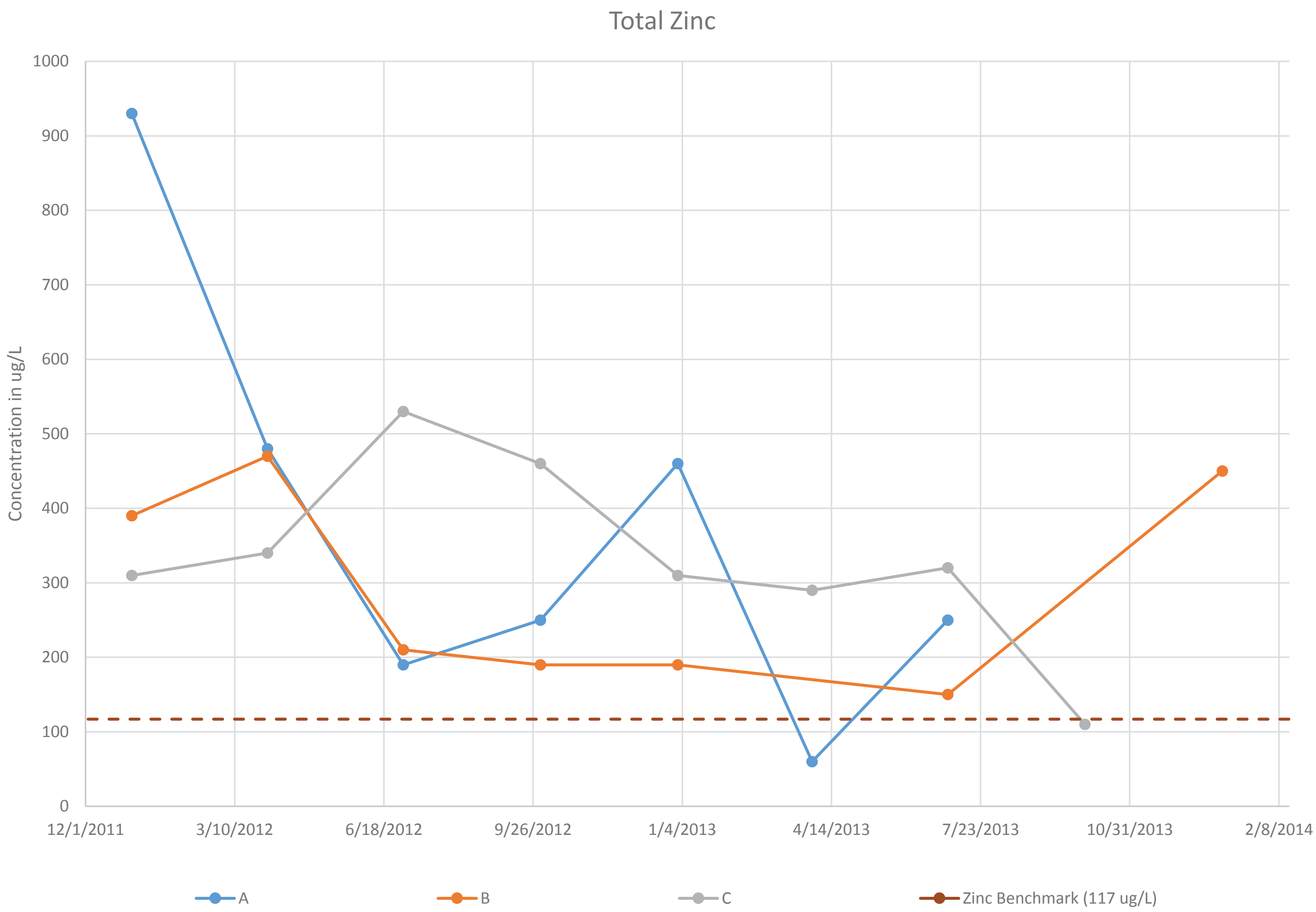
Notes:

N/A = not applicable

1 = Includes costs for source control BMPs, treatment equipment, and associated infrastructure construction.

FIGURES


Duwamish
Waterway
1415
5794
5795
9228
9219
5266
5796
5797
5798
5800
5799
5801
5802
Basin 9A
Basin 9B
Basin 9C
Basin 8
Basin 7
Basin 6
Basin 5
Basin 4
Basin 3
Basin 2
Basin 1D
Basin 1C
Basin 1A
Basin 1B
Basin 11
Basin 10A
Basin 10B
Offsite Tributary Basin
LONGFELLOW CREEK OVERFLOW LINE
LONGFELLOW CREEK
DITCH
Other Outfall
Basin 11: Outfall 1415
Basin 7: Outfall 5266
Basin 9A, 9B and 9C: Outfall 5794
Basin 8: Outfall 5795
Basin 6: Outfall 5796
Basin 5: Outfall 5797
Basin 4: Outfall 5798
Basin 3: Outfall 5799
Basin 2: Outfall 5801
Basin 1A, 1B, 1C and 1D: Outfall 5802
Basin 10A and 10B: Outfall IDs 9228, 9219, 9218 and 9217
T5 ISGP Facility Boundary
System: Structure Type
Storm: Catch Basin, or Trench Drain
Storm: Manhole
Storm: Roof Drain or Floor Drain
Storm: Flow Splitter, High Flow Bypass Weir, Lift Station, Scupper or Unknown
Storm: Cleanout
Storm: Divide
Storm: Detention Vault, Water Quality Vault or Oil Stop Valve Vault
Storm: Oil Water Separator
Storm: Trash Separator or Storm Filter
Storm: Shut Off Valve or Valve (normally closed)
Combined: Catch Basin or Trench Drain
Combined: Manhole
Combined: Roof Drain
Combined: Cleanout
Combined: Oil Water Separator
Combined: Unknown
Sewer: Cleanout, Lift Station, or Unknown
Sewer: Manhole
Abandoned Outfall
System: Pipe Type
Storm: Pipe
Storm: Perforated Pipe
Storm: Trenchdrain
Combined: Pipe
Combined: Trenchdrain
Sewer: Pipe
Ditch
N
0
175
350
Feet
Stormwater Basins
Stormwater Technical Memorandum
EIS
Terminal 5
Seattle, WA
Aspect CONSULTING
FEB-2016
PROJECT NO.
140222
BY:
EAC / TA
REVISED BY:
- - -
FIGURE NO.
1
Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet
Date Saved: 2/23/2016
Print Date: 2/23/2016



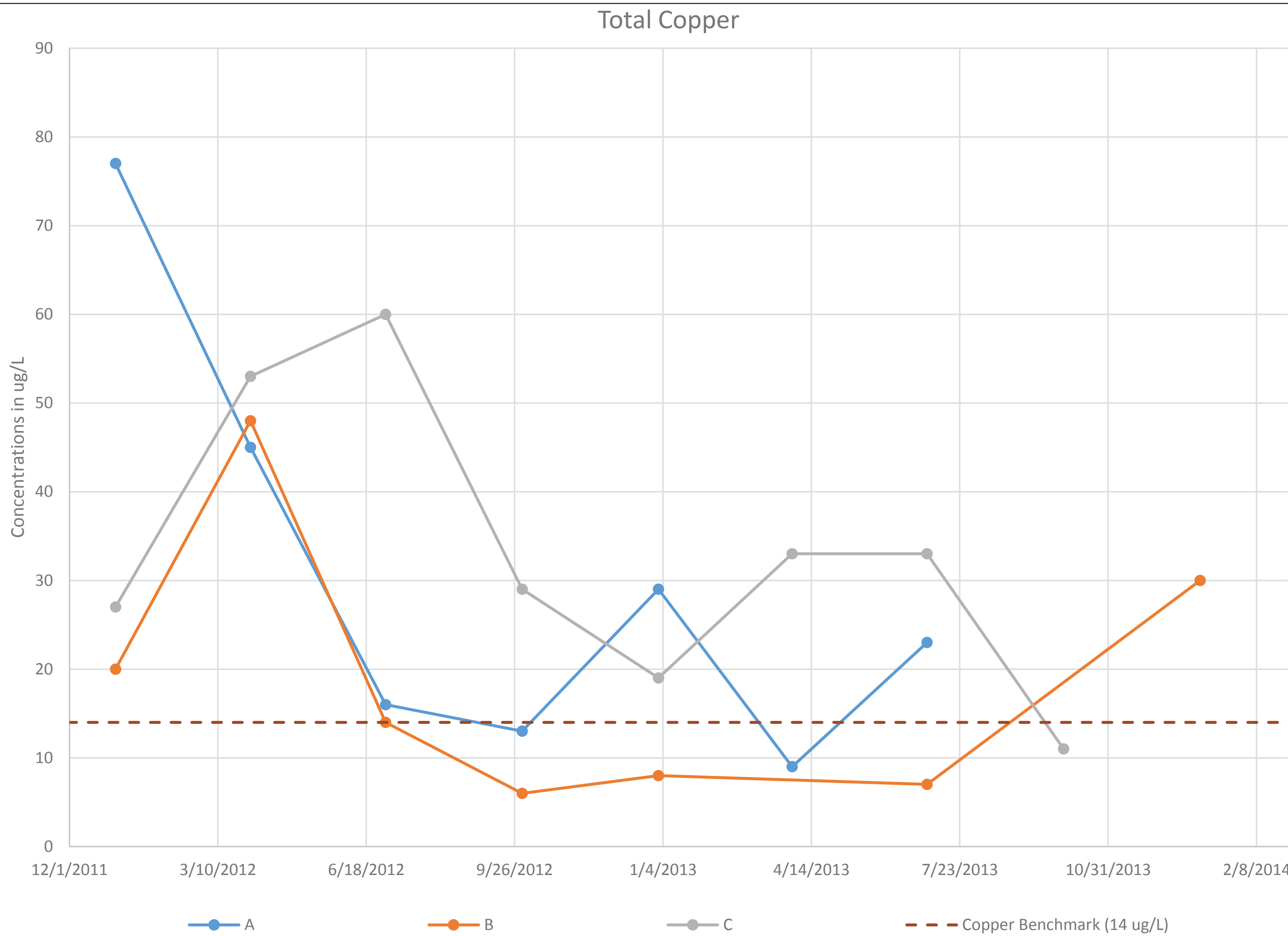
Note: Samples were taken quarterly and sampling dates are an estimate.

Water Quality - Zinc

Stormwater Technical Memorandum
EIS
Terminal 5
Seattle, WA

Aspect CONSULTING	FEB-2016	BY: TA / EAC	FIGURE NO.
	PROJECT NO. 140222	REVISED BY: - - -	2

GIS Path: T:\projects_8\POS_T5_ISGP_Study_140222\Delivered\StormwaterTechnicalMemo\02 Water Quality Zinc.mxd || Coordinate System: || Date Saved: 2/23/2016 || User: ecrumbaker || Print Date: 2/23/2016



Note: Samples were taken quarterly and sampling dates are an estimate.

Water Quality - Copper

Stormwater Technical Memorandum
EIS
Terminal 5
Seattle, WA

Aspect CONSULTING	FEB-2016	BY: EAC / TA	FIGURE NO. 3
	PROJECT NO. 140222	REVISED BY: - - -	

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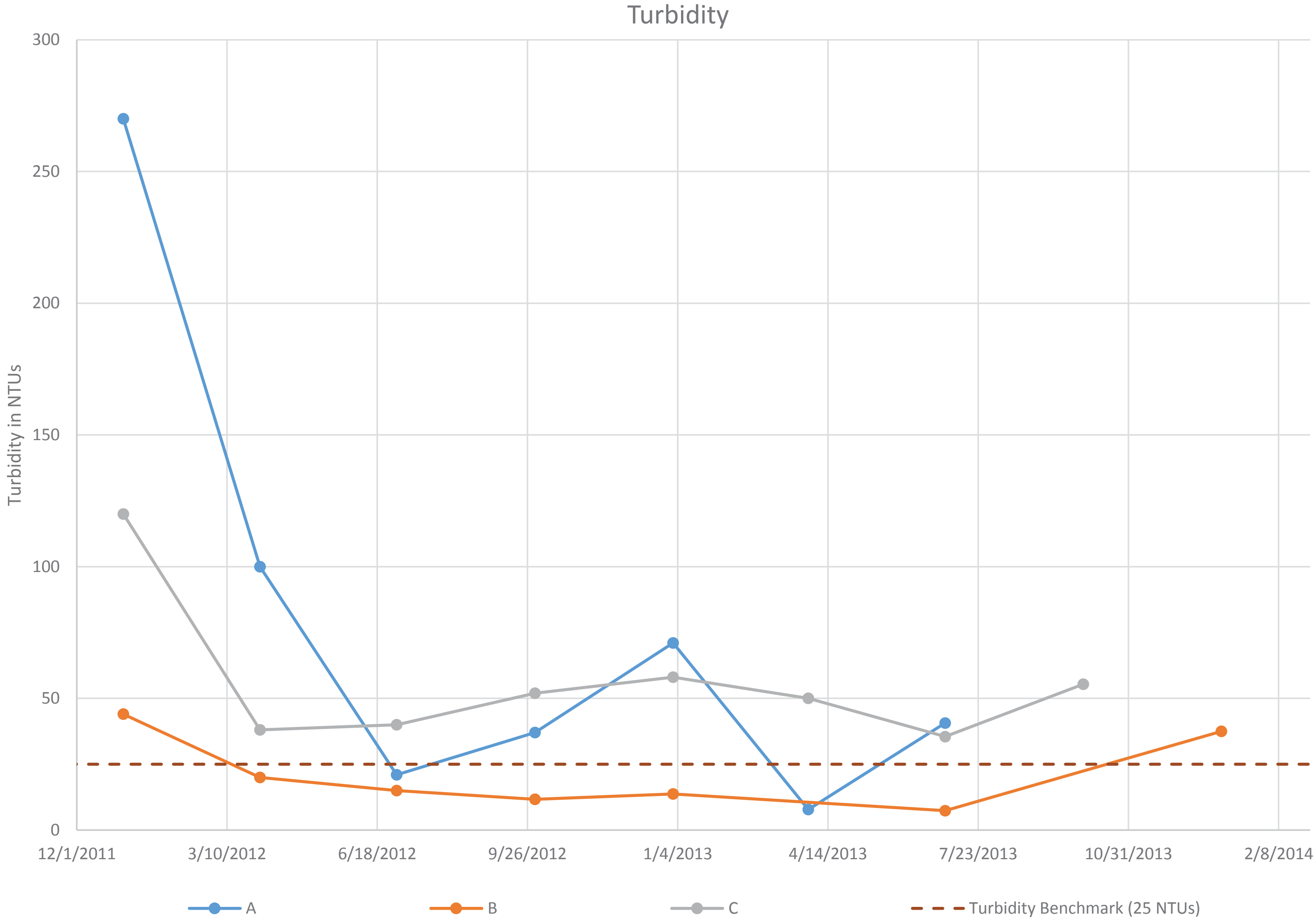

Note: Samples were taken quarterly and sampling dates are an estimate.

Water Quality - Turbidity

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Aspect CONSULTING	FEB-2016	BY: EAC / TA	FIGURE NO.
	PROJECT NO. 140222	REVISED BY: - - -	4

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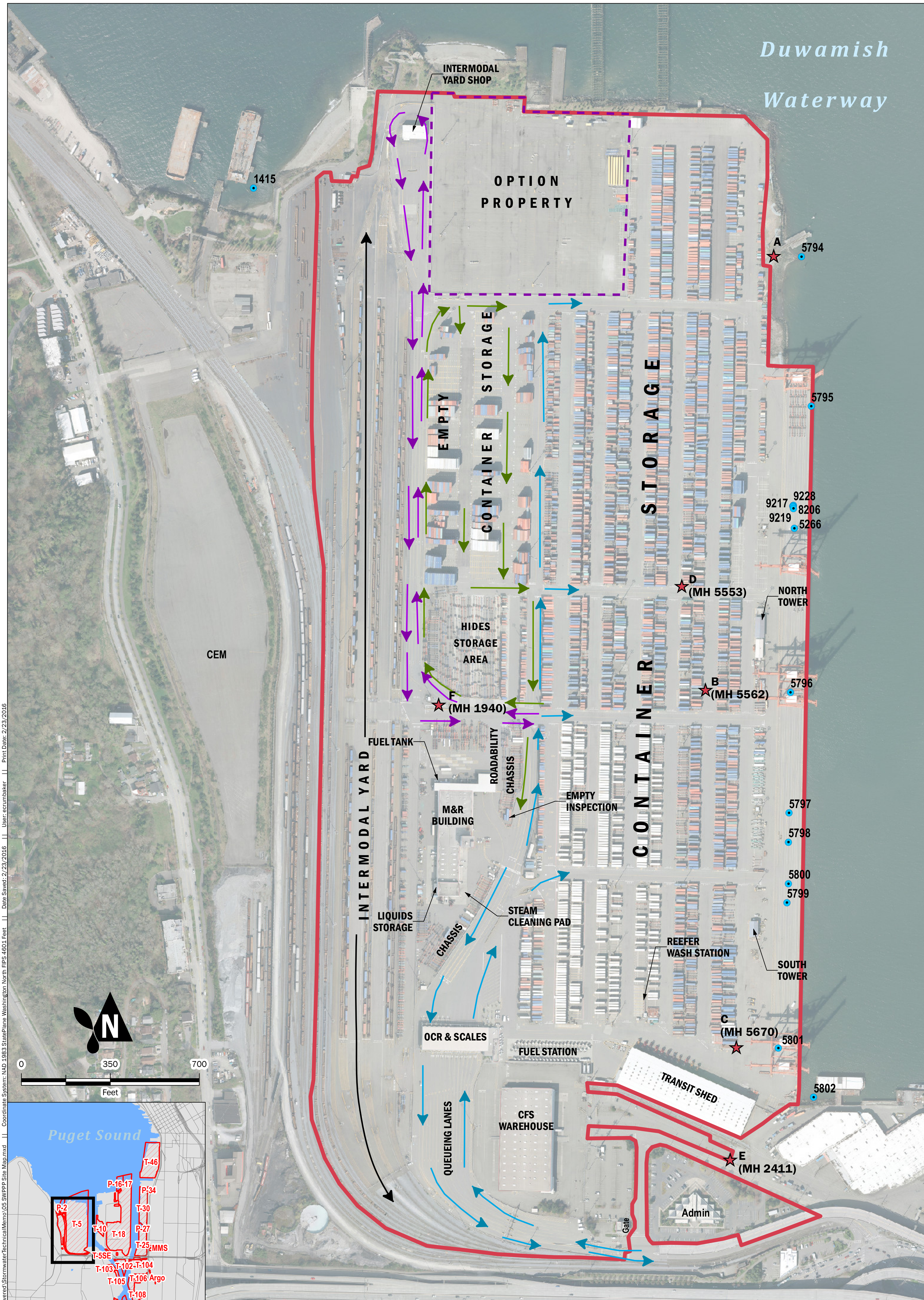

Sample Name C (MH 5670) (POS Manhole ID Number) Prior Sampling Location

Outfall

Local and Dray Traffic Pattern

Empty Traffic Pattern

Intermodal Traffic Pattern

Option Property

T5 ISGP Facility Boundary

SWPPP Site Map

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PROJECT NO. 140222	REVISED BY: TA	5	

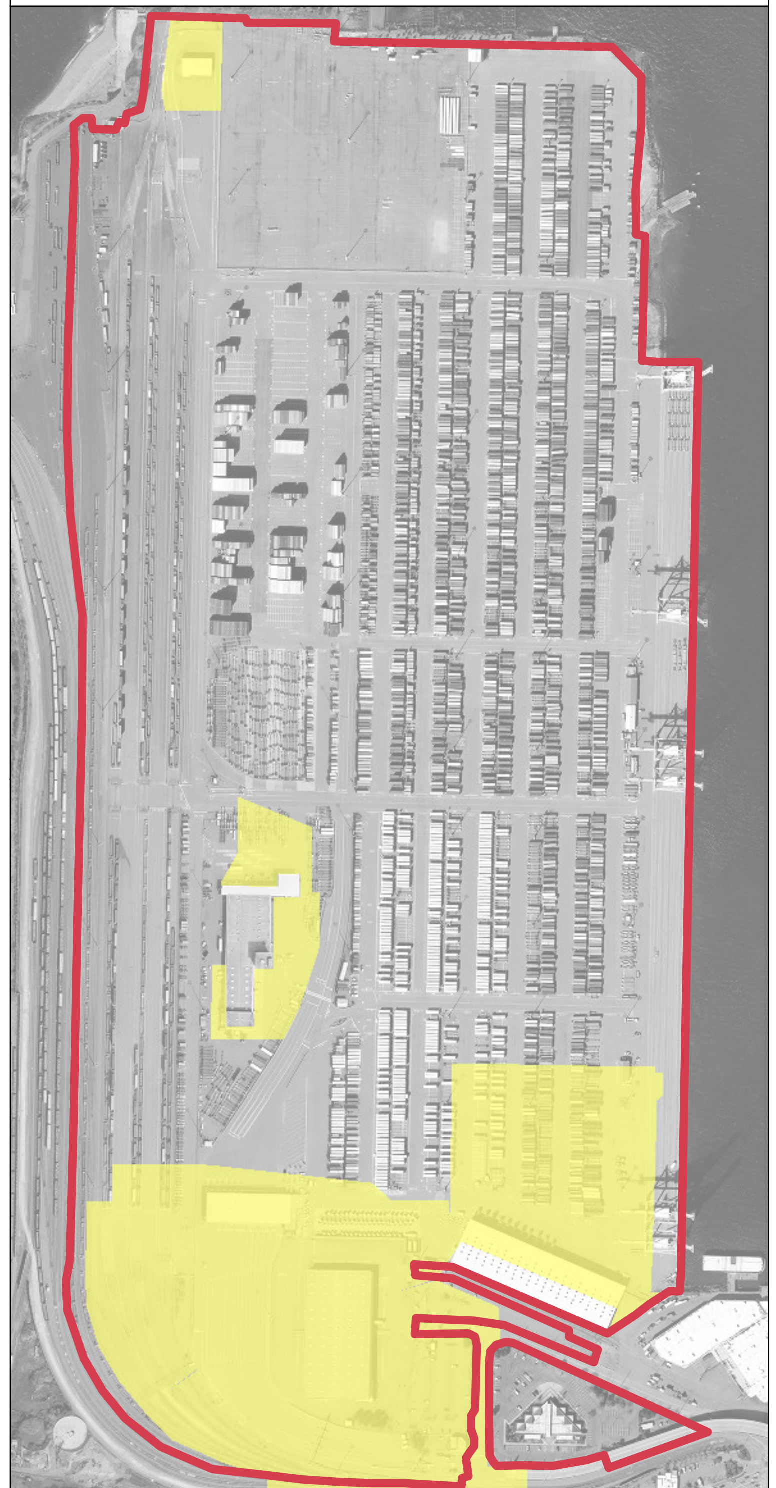
GIS Path: T:\projects_8\POS_T5_ISGP_Study_140222\Delivered\StormwaterTechnicalMemo\05 SWPPP Site Map.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 2/23/2016 || User: ecrumbaker || Print Date: 2/23/2016

Source of Aerial Image: Port of Seattle, 2012
Source of Impaired Waters and Sediment Sites: WA Department of Ecology 303(d) List, 2012

Scenario 1: Source Controls

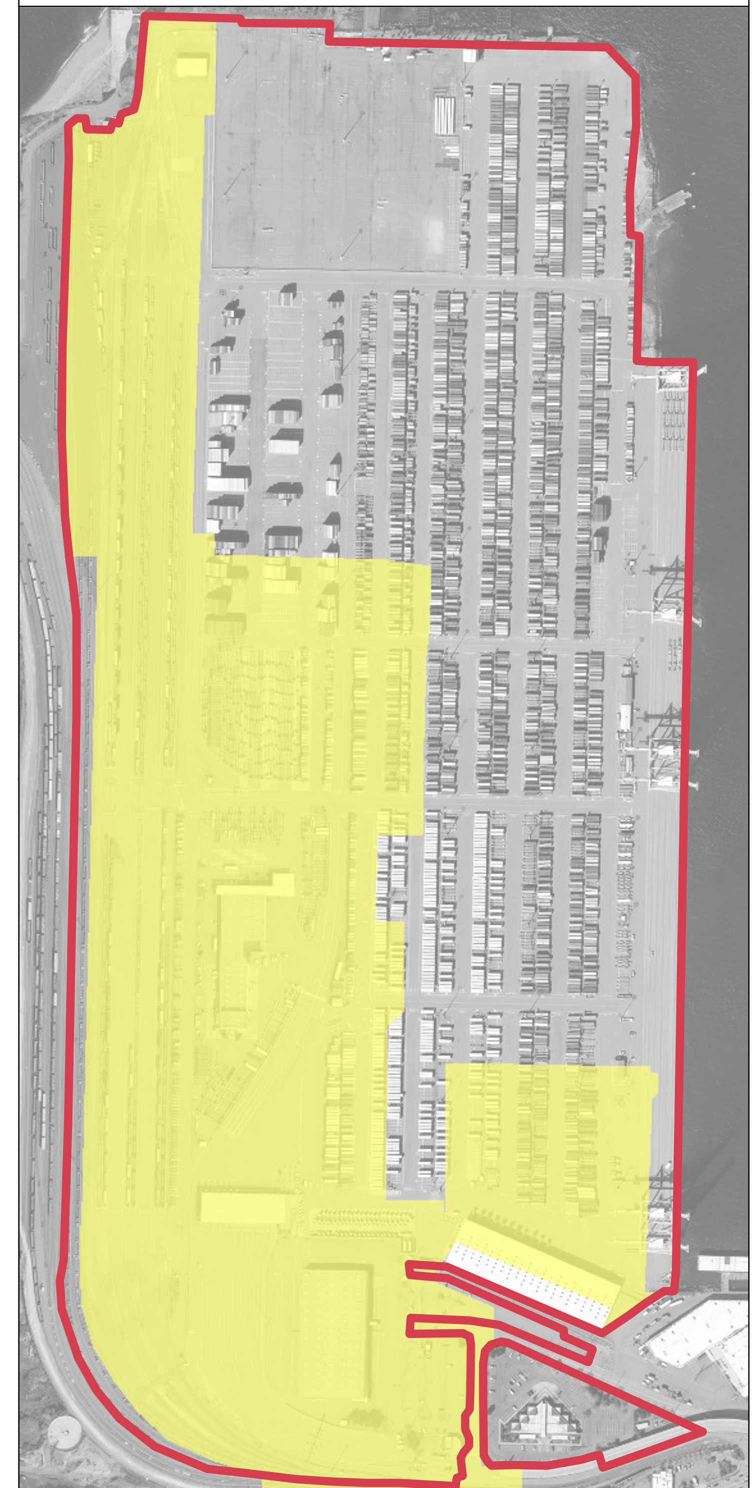
0 Acres Treated

Scenario 2: Source Controls and Focused Treatment



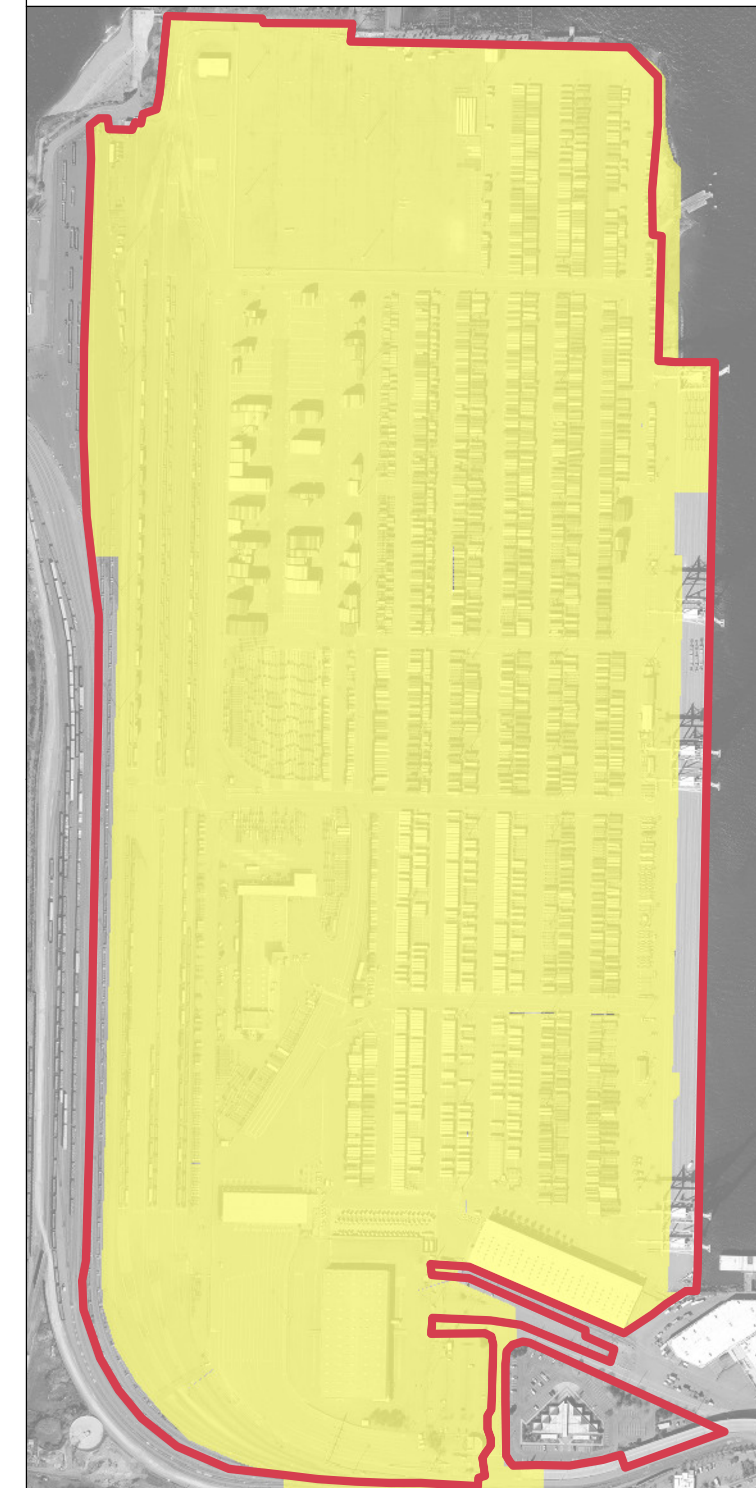
37.5 Acres Treated

Scenario 3: Source Controls and 50% End of Pipe Treatment



92 Acres Treated

Scenario 4: Site Wide Treatment



174 Acres Treated

T5 ISGP Facility Boundary

Area Receiving Treatment

N

0 600 1,200

Feet

Summary of Areas Treated By Scenario

Stormwater Technical Memorandum

EIS

Terminal 5

Seattle, WA

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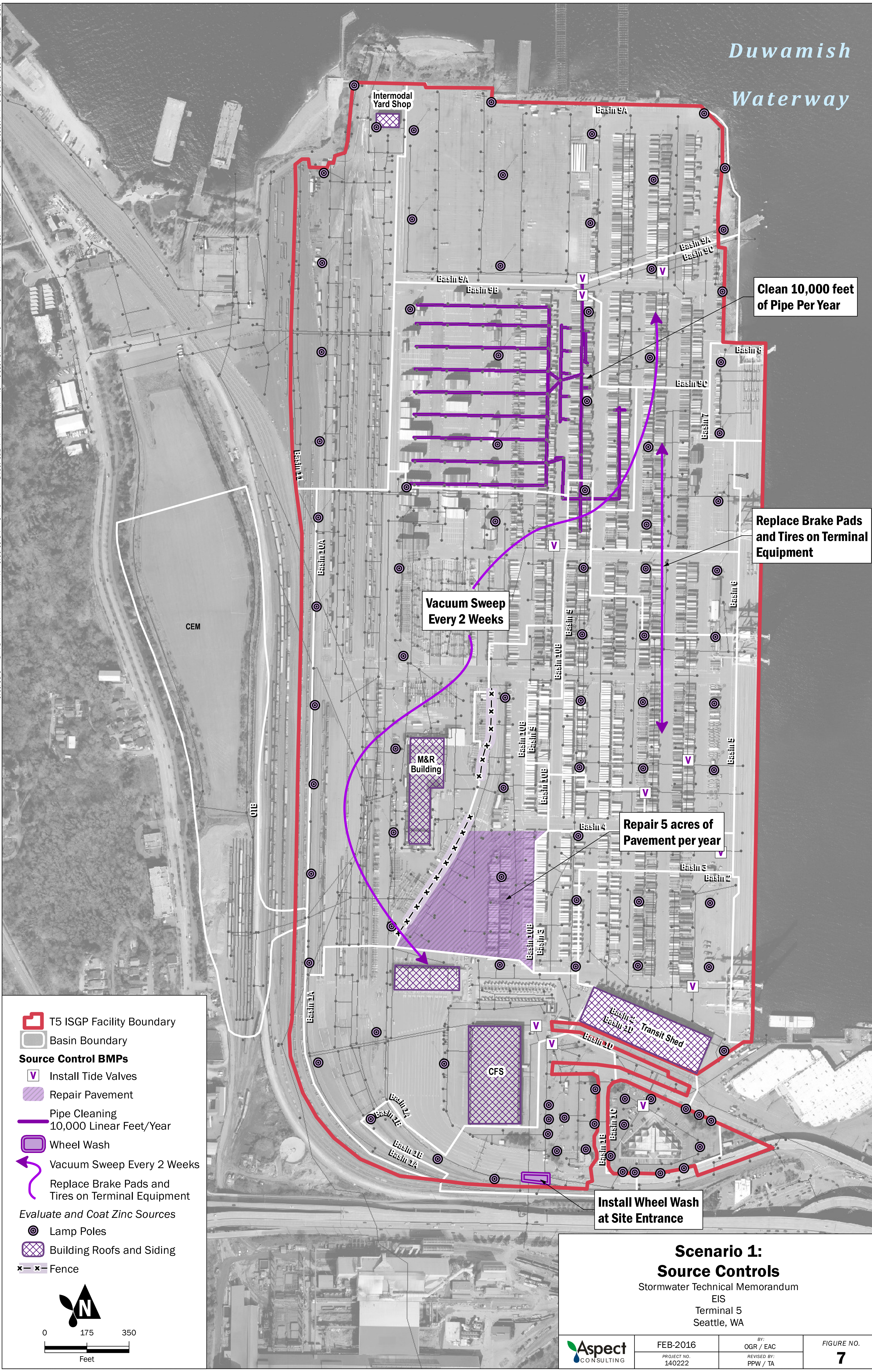
FIGURE NO. 6



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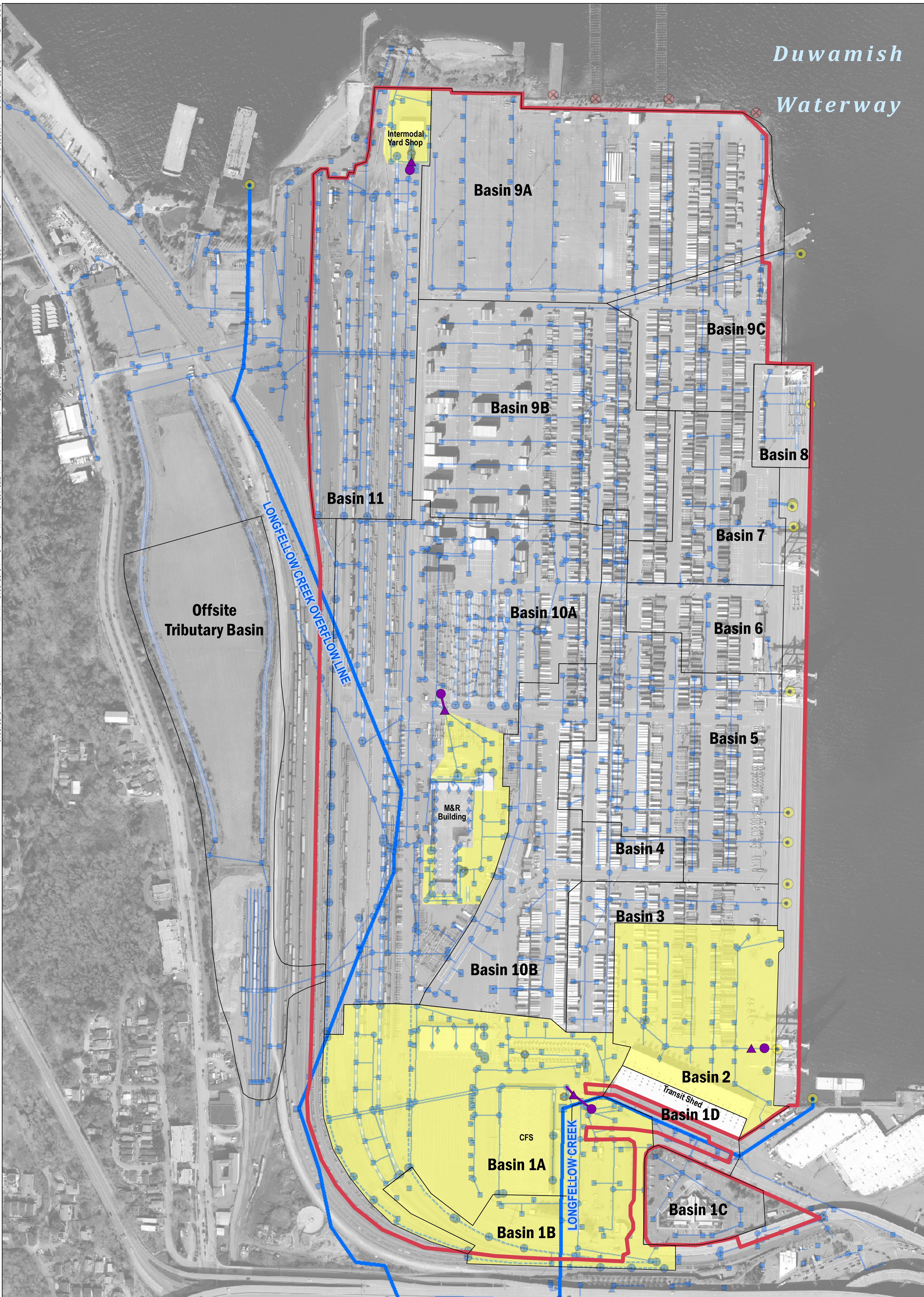

Treatment Improvement Included In Scenario:

- Treatment System (Below Ground)
- Pump Station
- Conveyance Improvement
- Area Receiving Treatment
- T5 ISGP Facility Boundary
- Basin Boundary

Scenario 2: Source Controls and Focused Treatment

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Terminal 5
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Scenario 3:
Source Controls and
50% End of Pipe Treatment

Industrial Stormwater Treatment Planning Study
Terminal 5
Seattle, WA

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PROJECT NO. 140222	REVISED BY: TA	

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ATTACHMENT A

ISGP Mandatory BMPs

ATTACHMENT A
ISGP Mandatory BMPs

The Industrial Stormwater General Permit (ISGP) requires implementation of mandatory Best Management Practices (BMPs) as applicable to a facility's industrial activities. Each BMP selected to eliminate or reduce the potential to contaminate stormwater and prevent violations of water quality standards must be described in the Stormwater Pollution Prevention Plan (SWPPP), and the SWPPP must explain in detail how and where the selected BMPs will be implemented. Individual BMPs may be omitted if site conditions render the BMP unnecessary, infeasible, or an alternative and equally effective BMP has been implemented, and any BMP omissions must be clearly justified in the SWPPP. The mandatory ISGP BMPs are listed below.

1.1 Operational Source Control BMPs

Operational source controls (Level 1) are primarily common sense "good housekeeping" and preventive maintenance measures intended to lessen or eliminate the potential for stormwater contamination. The ISGP requires that all industrial facility SWPPPs include mandatory operational source control BMPs, and that these BMPs must be implemented and followed.

1.1.1 Good Housekeeping

- Vacuum paved surfaces with a vacuum sweeper (or a sweeper with a vacuum attachment) to remove accumulated pollutants a minimum of once per quarter.
- Identify and control all on-site sources of dust to minimize stormwater contamination from the deposition of dust on areas exposed to precipitation.
- Inspect and maintain bag houses monthly to prevent the escape of dust from the system. Immediately remove any accumulated dust at the base of exterior bag houses.
- Keep all dumpsters under cover or fit with a lid that must remain closed when not in use.

1.1.2 Preventive Maintenance

- Clean catch basins when the depth of debris reaches 60 percent of the sump depth. In addition, accumulated debris must be at least 6 inches below the outlet pipe.
- Maintain ponds, tanks/vaults, catch basins, swales, filters, oil/water separators, drains, and other stormwater drainage/treatment facilities in accordance with the Maintenance Standards set forth in the *Stormwater Management Manual for Western Washington (SWMMWW)* (Washington State Department of Ecology (Ecology), 2012), other guidance documents or manuals approved in accordance with ISGP Special Condition S3.A.3.c., demonstrably equivalent BMPs per ISGP Special Condition S3.A.3.d., or an Operation and Maintenance (O&M) Manual submitted to Ecology in accordance with ISGP Special Condition S8.D.
- Inspect all equipment and vehicles during monthly facility inspections for leaking fluids such as oil, antifreeze, etc. Take leaking equipment and vehicles out of service or prevent leaks from spilling on the ground until repaired.

1.1.3 Spill Prevention and Emergency Cleanup Plan (SPECP)

- The SWPPP shall include a SPECP that includes BMPs to prevent spills that can contaminate stormwater. The SPECP shall specify BMPs for material handling procedures, storage requirements, cleanup equipment and procedures, and spill logs, as appropriate.
- Store all chemical liquids, fluids, and petroleum products, on an impervious surface that is surrounded with a containment berm or dike that is capable of containing 10 percent of the total enclosed tank volume or 110 percent of the volume contained in the largest tank, whichever is greater.
- Prevent precipitation from accumulating in containment areas with a roof or equivalent structure, or include a written plan on how it will manage and dispose of accumulated water if a containment area cover is not practical.
- Locate spill kits within 25 feet of all stationary fueling stations, fuel transfer stations, and mobile fueling units. At a minimum, spill kits shall include:

    - Oil absorbents capable of absorbing 15 gallons of fuel.
    - A storm drain plug or cover kit.
    - A non-water containment boom, a minimum of 10 feet in length with a 12-gallon absorbent capacity.
    - A non-metallic shovel.
    - Two 5-gallon buckets with lids.

- Do not lock shutoff fueling nozzles in the open position. Do not “top off” tanks being refueled.
- During fueling, block, plug, or cover storm drains that receive runoff from areas where fueling.
- Use drip pans or equivalent containment measures during all petroleum transfer operations.
- Locate materials, equipment, and activities so that leaks are contained in existing containment and diversion systems (confine the storage of leaky or leak-prone vehicles and equipment awaiting maintenance to protected areas).
- Use drip pans and absorbents under or around leaky vehicles and equipment, or store them indoors where feasible. Drain fluids from equipment and vehicles prior to on-site storage or disposal.
- Maintain a spill log that includes the following information for chemical and petroleum spills: date, time, amount, location, and reason for spill; date/time cleanup completed, notifications made, and staff involved.

1.1.4 Employee Training

- Employee SWPPP training will be conducted at least annually and the SWPPP training shall include:

    - An overview of what is in the SWPPP.

    - How employees make a difference in complying with the SWPPP and preventing contamination of stormwater.
    - Spill response procedures, good housekeeping, maintenance requirements, and material management practices.

- Training will be conducted by facility staff or a qualified consultant. Training may be conducted as a component of routine safety meetings, or in a separate meeting.
- A log will be kept of the SWPPP training dates and specific employees attending training.

1.1.5 Inspections and Recordkeeping

- Identify facility personnel who will inspect designated equipment and facility areas as required in ISGP Special Condition S7.
- Monthly inspections will be performed by a member of the Pollution Prevention Team.
- A visual inspection report or check list that includes all items required by ISGP Special Condition S7.C shall be used.
- Provide a tracking or follow-up procedure to ensure that a report is prepared and any appropriate action taken in response to visual inspections.
- Monthly inspections will be reviewed and certified by the Duly Authorized Representative or another signatory authority meeting the requirements of the ISGP.
- Include a certification of compliance with the SWPPP and permit for each inspection using the language in ISGP Special Condition S7.C.1.c.
- Records will be retained in the SWPPP for a period of at least 5 years as required by ISGP Special Condition S9.

1.1.6 Illicit Discharges

- The SWPPP shall include measures to identify and eliminate the discharge of process wastewater, domestic wastewater, noncontact cooling water, and other illicit discharges, to stormwater sewers, or to surface waters and groundwaters of the state; BMPs to identify and eliminate illicit discharges in Volume IV of the *SWMMWW* (Ecology, 2012).
- Water from washing vehicles or equipment, steam cleaning, and/or pressure washing is considered process wastewater. Process wastewater must not be allowed to commingle with stormwater or enter storm drains; and process wastewater must be collected in a tank for off-site disposal, or discharged to a sanitary sewer, with written approval from the local sewage authority.

1.2. Structural Source Control BMPs

Structural source control BMPs (Level 2) use constructed or mechanical features to prevent pollutants from entering stormwater.

- The SWPPP shall include BMPs to minimize the exposure of manufacturing, processing, and material storage areas (including loading and unloading, storage, disposal, cleaning, maintenance, and fueling operations) to rain, snow, snowmelt, and runoff by either locating these industrial materials and activities inside, or protecting them with storm resistant coverings.

- Use grading, berming, or curbing to prevent runoff of contaminated flows and divert run-on away from manufacturing, processing, and material storage areas (including loading and unloading, storage, disposal, cleaning, maintenance, and fueling operations).
- Perform all cleaning operations indoors, under cover, or in bermed areas that prevent stormwater runoff and run-on, and also that capture any overspray.
- Ensure that all washwater drains to a collection system that directs the wash water to further treatment or storage and not to the stormwater drainage system.

1.3. Treatment BMPs

Water quality treatment BMPs include the use of facilities and/or equipment that remove pollutants from stormwater by filtration, biological uptake, absorption, adsorption, coagulation, flocculation, and/or gravity settling of particulate pollutants. The need for a facility to provide water quality treatment BMPs depends on the type and amount of pollutants contained in stormwater runoff, and the vulnerability of the receiving waters to the pollutants of concern.

- Use treatment BMPs consistent with the applicable documents referenced in ISGP Special Condition S3.A.3.
- Employ oil/water separators, booms, skimmers, or other methods to eliminate or minimize oil and grease contamination of stormwater discharges.
- Obtain Ecology approval before beginning construction/installation of all treatment BMPs that include the addition of chemicals to provide treatment.

1.4. Stormwater Peak Runoff Rates and Volume Control BMPs

- Facilities with new development or redevelopment shall evaluate whether flow control BMPs are necessary to satisfy the State's all known, available, and reasonable methods of prevention, control, and treatment (AKART) requirements and prevent violations of water quality standards. If flow control BMPs are required, they shall be selected according to ISGP Special Condition S3.A.3.

1.5. Erosion and Sediment Control BMPs

- The SWPPP shall include BMPs necessary to prevent the erosion of soils and other earthen materials (crushed rock/gravel, etc.), control off-site sedimentation, and prevent violations of water quality standards.
- Sediment control BMPs such as detention or retention ponds or traps, vegetated filter strips, bioswales, or other permanent sediment control BMPs shall be implemented and maintained as needed to minimize sediment loads in stormwater discharges.
- Filtration BMPs to remove solids from catch basins, sumps, or other stormwater collection and conveyance system components (catch basin filter inserts, filter socks, modular canisters, sand filtration, centrifugal separators, etc.) shall be implemented and maintained, as needed.

1.6. Fecal Coliform Bacteria-Specific BMPs

T5 discharges stormwater to the West Waterway of the Duwamish River, which is identified as an impaired water on the 2012 Washington State 303(d) list. Since T5 discharges to a 303(d) listed waterbody (Category 5), sampling for fecal coliform bacteria is required. In addition, the following mandatory BMPs need to be incorporated into the SWPPP and implemented:

- Use all known, available, and reasonable methods to prevent rodents, birds, and other animals from feeding/nesting/roosting at the Terminal. The Terminal shall not violate any applicable federal, state, or local statues, ordinances, or regulations including the Migratory Bird Treaty Act.
- Perform at least one annual dry weather inspection of the stormwater system to identify and eliminate sanitary sewer cross connections.
- Install structural source control BMPs to address on-site activities and sources that could cause bacterial contamination (e.g., dumpsters, compost piles, food waste, and animal products).
- Implement operation source control BMPs to prevent bacterial contamination from any known source of fecal coliform bacteria (e.g., animal waste).
- Conduct additional bacteria-related sampling and/or BMPs, if ordered by Ecology on a case-by-case basis.

Appendix E
Biological Assessment

Biological Assessment

Terminal 5 Cargo Wharf Rehabilitation and Berth Deepening

Seattle, Washington

Prepared for

Port of Seattle

May 6, 2016

1909401-04

HARTCROWSER

www.hartcrowser.com

Biological Assessment

Terminal 5 Cargo Wharf Rehabilitation and Berth Deepening

Seattle, Washington

Prepared for

Port of Seattle

May 6, 2016

1909401-04

Prepared by

Hart Crowser, Inc.

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Associate Fisheries Biologist

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Edmonds, Washington 98020
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Contents

TABLES

FIGURES

SHEETS

APPENDIX A
Essential Fish Habitat Evaluation

Biological Assessment

Terminal 5 Cargo Wharf Rehabilitation and Berth Deepening

Seattle, Washington

1.0 INTRODUCTION

1.1 Project Proponent and Purpose

The Port of Seattle (Port) proposes to rehabilitate the wharf at Terminal 5 and deepen the adjoining berths in order to handle future growth in container operations.

1.2 Federal Nexus

This biological assessment (BA) has been prepared to aid the Port in assessing the potential effects of the proposed project on fish and wildlife species listed as threatened or endangered under the Endangered Species Act (ESA). Section 7 of the ESA requires that any action by a federal agency is “not likely to jeopardize the continued existence of any [listed] species or result in the destruction or adverse modification of habitat of such species….” Issuance of a Section 10/404 permit for terminal rehabilitation at Terminal 5 in Elliott Bay qualifies as such an action. Under ESA Section 7(c), the lead federal agency, in this case, the US Army Corps of Engineers (USACE), must prepare a BA of the potential influence of the action on listed species and their critical habitat. Depending on the conclusion, the USACE may be required to consult formally with NOAA Fisheries or US Fish and Wildlife Service (USFWS) regarding the project.

Because this work will occur in shoreline and aquatic areas along the west margin of the West Waterway in southwest Elliott Bay, the proposed project requires review to determine potential construction-related effects on fifteen aquatic-dependent species listed as threatened or endangered under ESA or their critical habitat. The ESA status of each of these species, as well as the effects determination of this BA are summarized in Table 1.

In addition, an evaluation of the effects of the proposed project on Essential Fish Habitat (EFH) has also been prepared, pursuant to the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) as amended by the 1996 Sustainable Fisheries Act (SFA). The effects of the proposed Project on EFH are addressed in Appendix A.

Table 1 – ESA-Listed Species Documented in Puget Sound

Species	Listing Status	ESA Agency	Effects Determination	Critical Habitat in Project Area	Critical Habitat Effects Determination
Puget Sound Chinook (*Oncorhynchus tshawytscha)*	Threatened	NOAA	LTAA	Designated	NLTAA
Coastal-Puget Sound Bull Trout (*Salvelinus confluentus*)	Threatened	USFWS	LTAA	Designated	NLTAA
Puget Sound Steelhead Trout (*O. mykiss*)	Threatened	NOAA	LTAA	Designated	NLTAA
Georgia Basin Bocaccio (*Sebastes paucispinis*)	Endangered	NOAA	NLTAA	No	--
Georgia Basin Yelloweye Rockfish (*S. ruberrimus*)	Threatened	NOAA	NLTAA	No	--
Georgia Basin Canary Rockfish (*S. pinniger*)	Threatened	NOAA	NLTAA	No	--
Green Sturgeon (*Acipenser medirostris*)	Threatened	NOAA	NE	No	--
Southern Pacific Eulachon *(Thaleichthys pacificus*)	Threatened	NOAA	NE	No	--
Marbled Murrelet *(Brachyramphus marmoratus)*	Threatened	USFWS	NLTAA	No	--
Southern Resident Killer Whale *(Orca orcinus)*	Endangered	NOAA	NLTAA	Designated	NLTAA
Humpback Whale *(Megaptera novaeangliae)*	Threatened	NOAA	NE	No	--
Leatherback Turtle *(Dermochelys coriacea)*	Threatened	NOAA	NE	No	--
Loggerhead Sea Turtle *(Caretta caretta)*	Threatened	NOAA	NE	No	--
Green Sea Turtle *(Chelonia mydas)*	Threatened	NOAA	NE	No	--
Olive Ridley Sea Turtle *(Lepidochelys olivacea)*	Threatened	NOAA	NE	No	--

Notes:
NE – No Affect
LTAA – Likely to Adversely Affect
NLTAA – Not Likely to Adversely Affect

2.0 PROJECT DESCRIPTION

2.1 Background

The Port of Seattle is proposing to rehabilitate the existing, approximately 50-year-old Terminal 5 container cargo wharf in order to meet the needs of present-day and emerging cargo handling equipment and container vessels. Container vessels currently being deployed between Asian trading partners and West Coast ports have significantly larger capacity than those envisioned twenty years ago when the project area was aggregated to form the Terminal as configured at the present. Newer vessels are about 28 feet wider and about 200 feet longer than vessels previously calling at Terminal 5. However, the duration of time that a vessel would be present at the berth for the same amount of throughput would decrease.

The proposed project includes actions necessary to strengthen portions of the existing wharf structure to receive larger, heavier container cranes necessary to reach up and over these newer vessels. In addition, the project includes dredging necessary to increase the operational depth of existing vessel berth area and vessel approach area in the west margin of the West Waterway to accommodate the larger vessels. Electrical system upgrades and water line replacements are also proposed along the wharf within the upland area dedicated for marine container cargo use. The proposed wharf strengthening, navigational access dredging, electrical service changes, and water line replacements are needed to ensure the continuing efficient use of Terminal 5 cargo handling infrastructure and prevent further decline in cargo transshipment capability at Terminal 5, compared with other port marine cargo facilities in south Elliott Bay.

2.2 Proposed Project and Construction Timing

2.2.1 Project Area

The project site is located at Terminal 5 on the west shore of the West Waterway, Seattle, Washington (Range 3 East, Township 24 North, and Sections 12 and 13). The project area coincides with the existing built wharf area that is approximately 2,900 linear feet by 100 feet wide and the adjoining berth area from the eastward edge of the dock eastward 175 feet. (Figure 1; Sheets 1 through 3).

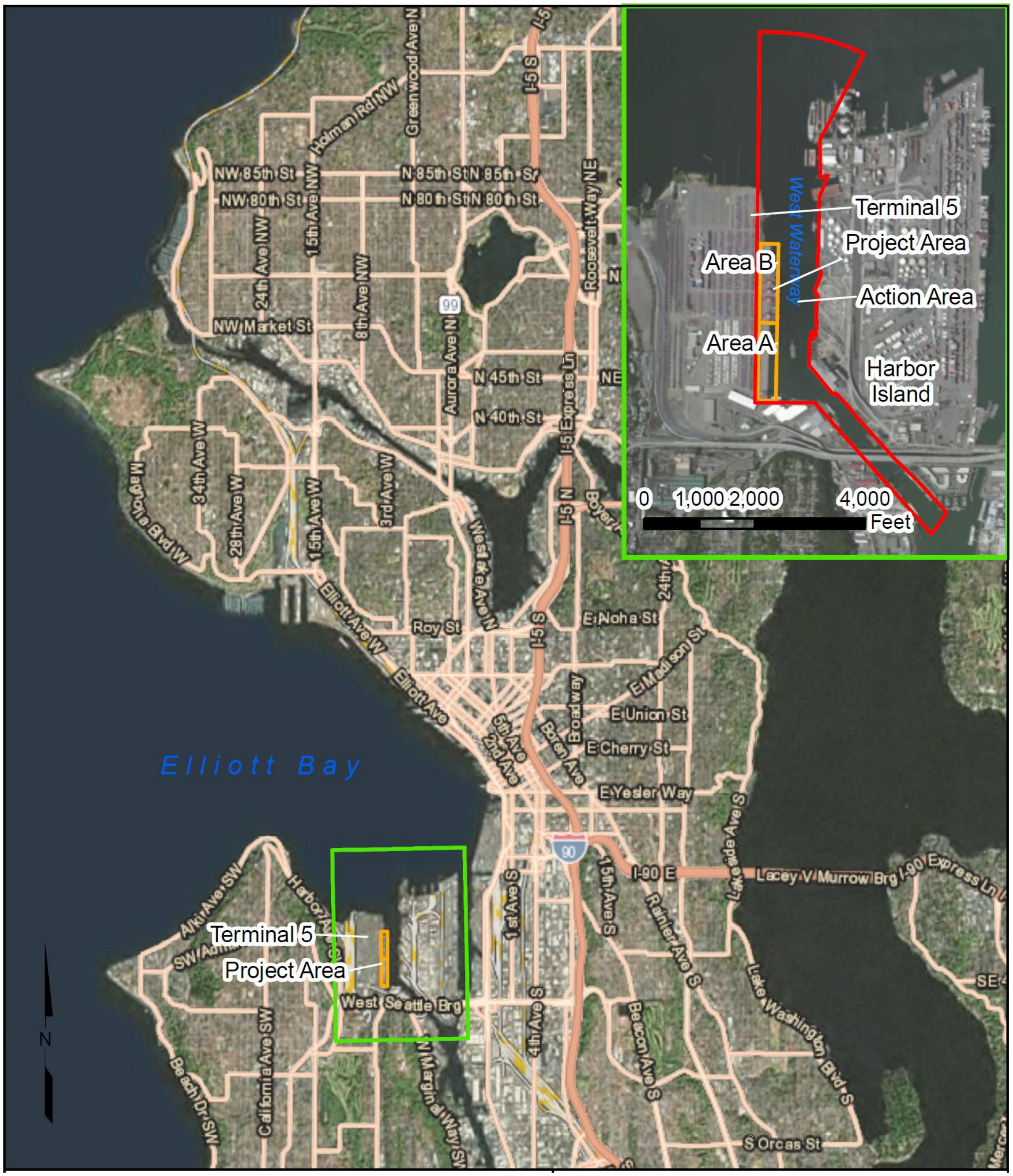

Figure 1 – Site Vicinity Map

2.2.2 Proposed Improvement

The Port of Seattle Terminal 5 Wharf Rehabilitation and Berth Deepening project (Project) consists of conducting upgrades and modifications to existing container facilities, including container cargo dock rehabilitation, berth deepening, and electrical upgrades necessary to accommodate increased capacity vessels access to the terminal. Construction drawings associated with the Project are presented in

Sheets 1 through 21, attached to the back of the document. The associated construction activities have the potential to effect ESA-listed species and their aquatic habitats. Project components include:

- The existing cargo wharf is 2,900 feet long. Strengthening actions apply to approximately 2,800 linear feet, while the toe-wall stabilization actions measure up to 3,100 linear feet. Wharf strengthening will include the following elements:
  - Demolish older wharf and structural systems as needed (Sheets 4 and 5).
    - Demolish asphalt paving for 31 feet x 2,800 feet to access area landside crane rail for strengthening.
    - Demolish cast-in-place concrete crane rail beams and pile caps (located above MHHW) and concrete deck slabs (located above MHHW) for 21 feet x 2,800 feet along dock face to waterside crane rail.
    - Remove fender system including extraction of timber fender piles and replace with a panelized fender system reducing overwater coverage by a net of 12,470 square feet at the face of the wharf.
    - Extract or cut off older, conflicting 16.5-inch structural piling below mudline.
  - Install new structural crane rail piles (Sheet 6).
    - Install 420 structural concrete piles (24-inch) and concrete pile cap beam within footprint of existing wharf structure to replace the waterside crane rail beam.
    - Install 420 structural steel pipe piles (24-inch) and concrete pile cap beam in existing upland area, land-ward of the cargo wharf bulkhead.
  - Install slope stabilization measures in the riprap armor slope beneath the existing container cargo wharf. Slope stabilization techniques will consist of installation of untreated wood piles penetrating the existing riprap armor slope (Sheet 7).
  - Install a toe-wall at the transition between the constructed riprap slope and the adjacent container vessel berth area to stabilize the existing slope beneath the container cargo wharf. Drive combination H-pile and sheet pile wall at the toe-of-slope for up to 3,100 feet (Sheet 7).
  - Install wharf rehabilitation elements (Sheet 8).
    - Replace the concrete deck structure within the existing wharf footprint.
    - Repair existing container wharf beams and deck panels.
    - Install panelized wharf fender system at 60-foot intervals.

- Deepen adjacent berth to -56 feet mean lower low water (MLLW; with allowances for over dredge depths; Sheets 10 through 14).
  - Slope stability structures are designed for a final depth of–56 feet MLLW (with allowances for over dredge depths).
- Electrical Improvements will include the following elements (Sheet 9):
  - Construct a new 26-MVA Primary Substation, to provide electrical power to the new cranes and associated terminal operations such as cargo handling, marshalling, and refrigeration.
  - Coordinate with Seattle City Light (SCL) to provide power to the new Primary Substation from both the SCL Delridge Substation and the SCL South Substation.

  - Construct up to four new electrical distribution substations feeding the new ship-to-shore cranes and dock power and lighting systems.
  - Construct a new underground electrical duct bank to connect distribution elements.
  - Construct distribution vaults and trenches to power trench.

- Water supply system upgrades will include the following elements:
  - Remove and replace existing dockside water distribution system.
  - Provide sectional valving in dockside water distribution system. Coordinate with existing looped water distribution system and existing fire hydrant layout.
  - Remove and replace existing ship's water supply assemblies. Coordinate assembly installation locations.
  - Update ship's water supply deduct meters to comply with City of Seattle standards.

2.3 Project Construction Details

Project components that may affect ESA-listed aquatic species include waterborne noise generated by impact and vibratory pile driving and potential water and sediment quality effects caused by dredging and geotechnical stabilization. Dredging will also alter existing aquatic habitats. Additional construction details of these activities are presented below.

2.3.1 Pile and Overwater Structure Removal

Approximately 665 existing piles will be removed from the project area subtidal zone by a barge or deck mounted crane—these include 491 timber, concrete, and steel piles extracted with a vibratory pile driver and 174 concrete and steel piles cutoff at the mudline (Sheets 15 through 17). Proposed work will occur over two inwater work windows with roughly half of the total proposed work element being completed in each year. Timber and concrete piles will be extracted from the substrate using a vibratory pile driver and crane hoist. Extracted piles will be stockpiled in an area with drainage control to prevent release of sediment-laden water to adjacent surface waters. If a pile breaks above the mudline during extraction, a chain will be used, if practical, to attempt to remove the broken pile. If unsuccessful, the pile will be cut off below the mudline. Most concrete structural piles will be cut off at the mudline with the above water section hoisted out of the water by crane. The concrete piles remaining below the mudline act as slope structural reinforcement in lieu of installing a new pinch pile.

Pile removal will clear a footprint of approximately 1,030 square feet of impediments, 311 square feet of which are creosote-treated fender piles in open areas of the West Waterway. The remaining piles to be removed are situated beneath Terminal 5. The existing creosote-treated wood pile and steel pile wharf fender system will be removed and replaced with an alternative panelized, above-water fender arrangement. The replacement fender elements will be spaced at approximately 60 feet intervals and do not include inwater elements.

In addition, the existing safety walkway along the entire (2,900 foot length) wharf between the bull rail and the existing fender system will be removed (Sheets 15 through 17). This represents an additional 8,500 square feet of overwater coverage removed from the wharf structure as part of this project.

To protect the surrounding marine area from impacts during removal, best management practices (BMPs) as described in Section 2.5 will be employed during extraction.

2.3.2 Pile Placement

Up to 3,000 pinch piles, 420 structural piles, and a 3,100 foot long combination sheet pile wall composed of 500 H-piles and 500 sheet piles are required to support the anticipated heavier loads on the rehabilitated dock needed for larger cranes and to stabilize the slope. The anticipated number of required piles and details of size, materials and construction methods for emplacement is presented in Table 2 and Sheets 18 through 20.

2.3.2.1 Structural Piles

Up to 420, 24-inch pre-stressed concrete octagonal piles will be driven into the subtidal zone (–35 to –40 feet MLLW) beneath the existing Terminal 5 Wharf to support the waterside crane rail beam. Concrete piles will be driven with an impact pile driver conducted from a barge crane (Sheets 18 and 19). Proposed work will occur over two inwater work windows with roughly half of the total proposed work element completed in each year. To protect the surrounding marine area from impacts during installation, best management practices will be employed during the installation of concrete piles.

A combination pile wall composed of a total of 500 steel H-piles and 500 steel sheet piles will be driven to establish a new toe wall approximately 3,100-foot in length at the bottom of the existing slope near the face of Terminal 5 (Sheets 18 and 19). The top elevation of the new toe wall will vary between –42 and –50 feet MLLW. Both the H-piles and sheet piles will be driven using a vibratory hammer primarily. However, if depth required for H-piles using vibratory hammer is not achieved, an impact hammer will be necessary to reach required toe elevation. Port engineers have estimated that on average, the last 10 feet of the H-piles may need to be driven with an impact hammer. Given the expected production rate and number of piles installed, approximately 900 extra blows per day via an impact hammer related to H-pile wall installation would be expected. Proposed work will occur over two inwater work windows with roughly half of the total proposed work element completed in each year. To protect the surrounding marine area from impacts during installation, BMPs as described in Section 2.5.1 will be employed during installation.

In upland areas west of the existing bulkhead, approximately 125 feet from the waterward face of the Terminal 5 wharf, a total of 420 24-inch diameter steel piles will also be driven with an impact pile driver along the length of the wharf.

Table 2 – Pile Driving Engineering Details

	Pile Wall	Waterside Piles	Pinch Piles
Type of Pile	18-in H-Piles 55-in Sheet Piles	24-inch Concrete	14-inch Wood (untreated)
Number of Piles	500 H-piles (250/season) 500 sheet piles (250/season)	420 (210/season)	3,000 (1,500/season)
Location of Piles	–45 feet MLLW	–30 feet MLLW	–11 to –37 feet MLLW
Installation Method	Vibratory and Impact Driver	Impact Pile Driver	Vibratory and Impact Driver
Installation Time/Pile	1 hr for H-Pile 0.75 hr for Sheet Pile	1.75 hr	0.8 hr
Blows/Pile	150	1,500	900
Piles/Day	6 Combo piles/day	6	7
Maximum Blows/Day	900	9,000	6,300

2.3.2.2 Slope Stabilization with Pinch Piles

The slope beneath the Terminal 5 wharf is steep—approximately 1.5 to 1.75 horizontal to 1 vertical grade (1.5 to 1.75H:1V). Geotechnical investigations have determined that portions of the slope beneath Terminal 5, constructed 3 to 4 decades ago, are in need of stabilization. Slope stabilization will be conducted by driving up to 3,000, 14-inch-diameter untreated wood piles into subtidal portions of the slope between elevations of about –11 feet and –37 feet MLLW (Table 2; Sheets 18 and 19). Piles will be driven both vertically along the base of the slope, and at an angle from the vertical, approximately 5 feet on-center for most of the length of the wharf between rows of existing structural piles. Piles will be driven to about 60 feet into the substrate and cut off at the substrate surface. Where possible, a vibratory driver will be used, however impact driving is expected to be necessary for most of the battered piles. Proposed work will occur over two inwater work windows with roughly half of the total proposed work element completed in each year. To protect the surrounding marine area from impacts during installation, BMPs as described in Section 2.5.1 will be employed.

2.3.3 Dredging

Approximately 235,384 square feet of area waterward of the edge of the dock at Terminal 5 will be dredged to a required depth of –56 feet MLLW plus an additional one foot of advanced maintenance dredge with a potential two foot over dredge depth. Existing depths in the proposed dredge prism are between –47 and –55 feet MLLW so proposed dredging will not convert intertidal or shallow water habitats to deep water habitats. The total volume of sediment to be removed from the project area is approximately 36,191 cubic yards (not including potential over dredge depth; Sheets 10 through 14).

The estimated number of working days for dredge activities will be 23 days at a removal rate of approximately 1,200 to 1,500 cubic yards per day. The Port typically dredges from December 1 to February 15 to accommodate the agency-approved work window and tribal fisheries in the area. The dredging event and the clean cover placement, if needed, are scheduled to occur separately in a third fish window (year) following construction of the rehabilitated dock and associated structural components.

2.3.4 Equipment

Dredging will be accomplished using mechanical dredging equipment. The description of mechanical dredging in this section is adapted from the USACE technical publication *Technical Guidelines for Environmental Dredging of Contaminated Sediments* (ERDC/EL TR-08-29; USACE 2008).

The basic components of a mechanical bucket dredge include the crane, dredge derrick barge, haul barge, anchor spuds, and bucket. There are two types of buckets common to this method: the clamshell digging bucket and the enclosed environmental bucket. The Port proposes to allow contractors to use either type of bucket, depending on the specific location conditions and sediment characteristics.

Once excavated from the bottom and lifted to the surface, dredged material will be placed into a haul barge.

2.3.5 Disposal

Disposal of all dredged sediments removed as part of the project will be conducted consistent with conditions and requirements stipulated by the Dredged Material Management Program (DMMP), Washington Department of Natural Resources (DNR), Washington Department of Ecology (Ecology), USACE, US Environmental Protection Agency (EPA), and other agencies with jurisdiction. Sediment sampling for DMMP characterization has recently been conducted; results indicate that all sediments within the proposed dredge prism are suitable for open-water disposal. Sediments will be placed by the dredge equipment into a bottom dump barge (or split hull barge) for transport and placement into the Elliott Bay Unconfined Open Water Disposal Site (Sheet 21).

2.4 Project Timing

2.4.1 Work Windows

Inwater project work is expected to begin in late summer 2017, soon after permits are received. Overwater and upland work will occur year-round until the completion of the Project. BMPs to control impacts to the marine environment will be implemented to minimize the potential effects on marine habitats or species and the aquatic environment (Section 2.5.1).

All inwater work will avoid the annual outmigration of juvenile salmonids. Based on guidance documents from the USACE and Washington Department of Fish and Wildlife (WDFW), the expected inwater work window is August 16 through February 15. The Port will comply with the work closures determined during Project review. Inwater work is expected to be completed in three consecutive, approved work windows, beginning in August 2017. Proposed dock reconstruction with associated in water structural upgrades and slope stability improvements will occur over two consecutive inwater work windows with roughly half of the total proposed work elements completed in each year. The dredging event is scheduled to occur separately in a third inwater work window following construction of the rehabilitated dock and associated structural components. The Port typically dredges from December 1 to February 15 to accommodate the agency-approved work window and reduce impacts to tribal fisheries in the area.

2.4.2 Description of Project Sequencing

2.4.2.1 Work Areas

To conduct inwater pile driving and pile removal activities, Terminal 5 will be divided into two areas—Area A and Area B—each encompassing approximately half of the terminal (Figure 1 and Sheet 3). Pile driving and removal activities will be conducted in Area A during the Year 1 agency-approved work window (August 16 to February 15) and in Area B during the Year 2 work window. Approximately half of the allotted number of piles will be installed (or removed) during each work window (Table 1). As reported, all dredging activities will take place during the Year 3 work window.

2.4.2.2 Pile Driving Schedule

To complete all pile driving within two agency-approved work windows, it is estimated that three pile-driving barges will work simultaneously in accordance to the rates shown in Table 3. Pile removal activities will be conducted at the start of the work window for up to 5 weeks. Only a vibratory hammer will be used for pile removal. Beginning in September and continuing into December, all three rigs will conduct pinch pile installation with both vibratory and impact driving rigs. Toe wall and concrete structural piles will be installed likely beginning in December and running through early-February. All structural piles will be driven with an impact hammer. For the toe wall, all H-piles and sheet piles will be initially driven with a vibratory hammer, but it is anticipated that the last 10 feet of some of the H-piles may need to be driven with an impact hammer to reach required depths (Table 2).

Each of the proposed inwater construction activities is estimated to start and end according to the following approximate schedule:

Pile Demolition:	Begin Aug 16th	End Sept 15th
Pinch Pile Installation:	Begin Sept 1st	End Jan 15th
Structural Concrete Pile Installation:	Begin Sept 15th to Dec 1st	End Jan 15th to Feb 1st
Toe Wall Installation:	Begin Nov 1st to Dec 15th	End Feb 15th

This estimated pile driving schedule was prepared to allow all pile driving rigs to operate simultaneously in either Area A (Year 1) or Area B (Year 2) while limiting the number of rigs conducting impact pile driving to two rigs at any one time. In addition, only one rig will impact steel piles while the second rig will impact wood or concrete piles. This schedule will reduce the potential for Level A injury as a result of impact pile driving (see Section 2.6). This pile driving schedule will also limit the total number of impact hammer blows to between 900 blows per day to a maximum of 12,600 blows per day. This maximum number of blows per day is only estimated to occur for a period of seven weeks annually (Table 4).

Table 3 – Estimated Pile Driving Schedule

<table>
<tr><th>Date</th><th>Timeline</th><th>Fish Window</th><th>Rig 1</th><th>Rig 2</th><th>Rig 3</th></tr>
<tr><td>8/15/2016</td><td>Week 1</td><td rowspan="26">(26 weeks)</td><td rowspan="4">Demolition/Pile Removal - Vibration (4 weeks)</td><td rowspan="3">Demolition/Pile Removal - Cut-off (3 weeks)</td><td rowspan="5">Demolition/Pile Removal - Cut-off (5 weeks)</td></tr>
<tr><td>8/22/2016</td><td>Week 2</td></tr>
<tr><td>8/29/2016</td><td>Week 3</td></tr>
<tr><td>9/5/2016</td><td>Week 4</td><td rowspan="13">Pinch Pile Impact (13 weeks)</td></tr>
<tr><td>9/12/2016</td><td>Week 5</td><td rowspan="13">Pinch Pile Vibration . (13 weeks)</td></tr>
<tr><td>9/19/2016</td><td>Week 6</td><td rowspan="16">Pinch Pile Vibration/Impact (16 weeks)</td></tr>
<tr><td>9/26/2016</td><td>Week 7</td></tr>
<tr><td>10/3/2016</td><td>Week 8</td></tr>
<tr><td>10/10/2016</td><td>Week 9</td></tr>
<tr><td>10/17/2016</td><td>Week 10</td></tr>
<tr><td>10/24/2016</td><td>Week 11</td></tr>
<tr><td>10/31/2016</td><td>Week 12</td></tr>
<tr><td>11/7/2016</td><td>Week 13</td></tr>
<tr><td>11/14/2016</td><td>Week 14</td></tr>
<tr><td>11/21/2016</td><td>Week 15</td></tr>
<tr><td>11/28/2016</td><td>Week 16</td></tr>
<tr><td>12/5/2016</td><td>Week 17</td><td rowspan="8">Structural Piles Impact (8 weeks)</td></tr>
<tr><td>12/12/2016</td><td>Week 18</td><td rowspan="9">Toe Wall Vibration/Impact (9 weeks)</td></tr>
<tr><td>12/19/2016</td><td>Week 19</td></tr>
<tr><td>12/26/2016</td><td>Week 20</td></tr>
<tr><td>1/2/2017</td><td>Week 21</td></tr>
<tr><td>1/9/2017</td><td>Week 22</td><td rowspan="5"></td></tr>
<tr><td>1/16/2017</td><td>Week 23</td></tr>
<tr><td>1/23/2017</td><td>Week 24</td></tr>
<tr><td>1/30/2017</td><td>Week 25</td><td rowspan="2"></td></tr>
<tr><td>2/6/2017</td><td>Week 26</td></tr>
</table>

Table 4 – Estimated Rig Schedule for Impact and Vibratory Pile Driving

Date	Timeline	Rig 1 Vibe (ft/day)	Rig 1 Impact (blows/day)	Rig 2 Vibe (ft/day)	Rig 2 Impact (blows/day)	Rig 3 Vibe (ft/day)	Rig 3 Impact (blows/day)	Total Vibe Rigs	Total Impact Rigs	Total Vibe/ Impact Rigs	Total Vibe (ft/day)	Total Impact (Blows/day)
8/15/2016	Week 1	330	0	0	0	0	0	1	0	1	330	0
8/22/2016	Week 2	330	0	0	0	0	0	1	0	1	330	0
8/29/2016	Week 3	330	0	0	0	0	0	1	0	1	330	0
9/5/2016	Week 4	330	0	0	6,300	0	0	1	1	2	330	6,300
9/12/2016	Week 5	420	0	0	6,300	0	0	1	1	2	420	6,300
9/19/2016	Week 6	420	0	0	6,300	0	6,300	1	2	3	420	12,600
9/26/2016	Week 7	420	0	0	6,300	0	6,300	1	2	3	420	12,600
10/3/2016	Week 8	420	0	0	6,300	0	6,300	1	2	3	420	12,600
10/10/2016	Week 9	420	0	0	6,300	0	6,300	1	2	3	420	12,600
10/17/2016	Week 10	420	0	0	6,300	0	6,300	1	2	3	420	12,600
10/24/2016	Week 11	420	0	0	6,300	0	6,300	1	2	3	420	12,600
10/31/2016	Week 12	420	0	0	6,300	0	6,300	1	2	3	420	12,600
11/7/2016	Week 13	420	0	0	6,300	0	6,300	1	2	3	420	12,600
11/14/2016	Week 14	420	0	0	6,300	420	0	2	1	3	840	6,300
11/21/2016	Week 15	420	0	0	6,300	420	0	2	1	3	840	6,300
11/28/2016	Week 16	420	0	0	6,300	420	0	2	1	3	840	6,300
12/5/2016	Week 17	420	0	0	9,000	420	0	2	1	3	840	9,000
12/12/2016	Week 18	660	900	0	9,000	420	0	2	2	3	1,080	9,900
12/19/2016	Week 19	660	900	0	9,000	420	0	2	2	3	1,080	9,900
12/26/2016	Week 20	660	900	0	9,000	420	0	2	2	3	1,080	9,900
1/2/2017	Week 21	660	900	0	9,000	420	0	2	2	3	1,080	9,900
1/9/2017	Week 22	660	900	0	9,000			1	2	2	660	9,900
1/16/2017	Week 23	660	900	0	9,000			1	2	2	660	9,900
1/23/2017	Week 24	660	900	0	9,000			1	2	2	660	9,900
1/30/2017	Week 25	660	900					1	1	1	660	900
2/6/2017	Week 26	660	900					1	1	1	660	900

Notes:
Assumes 5-day weeks with single shifts. If shift is limited by daylight concerns, work hours will be shifted to a weekend day.
Assumes 10 hour workday average (may be more limited in winter due to daylight needs.)

2.5 Best Management Practices and Conservation Measures

Conservation Measures and Best Management Practices (BMPs) will be employed during pile driving and dredging to avoid or minimize potential adverse impacts to the aquatic environment. Built into the design of the project is a substantial net reduction in overwater coverage and minimal increase in the pile footprint. Table 5 presents a summary of inwater and overwater structures removed and added to the project area. The following conservation measures and general BMPs will be implemented. Additionally, BMPs specific to dredging and pile driving are included in Sections 2.5.1 and 2.5.2 below.

- All inwater work will be limited to periods determined appropriate by participating state and federal agencies to avoid potential adverse effects on migratory fish.
- The project will be designed such that the wharf dimensions will not expand beyond the existing pier head line.
- The timber fender pile system and safety walkway along the entire length of the wharf will be removed and replaced with a panelized fender system. This will remove approximately 8,500 square feet of overwater coverage at the face of the wharf (Table 5).
- Approximately 227 creosote-treated fender piles will be removed from open areas of the West Waterway, occupying 311 square feet, thus, removing a potential source of contamination and impediments to juvenile salmon migration from the project area. An additional 381 concrete piles will also be extracted or cut off at the mudline from beneath the existing wharf. Total removal represents 1,030 square feet of piles (Table 5).
- New pile installation will add an additional 1,466 square feet of piles for a net increase of 436 square feet of piles; however, all new piles will be installed beneath the existing wharf (structural and pinch piles) or along the face near the mudline (sheet and H-piles) so new piles will not add impediments to juvenile salmon outmigration (Table 5).
- An Ecology-approved water quality monitoring plan has been developed and will be implemented during construction to verify compliance with water quality conditions of the Section 401 Water Quality Certificate, USACE Permit, and Hydraulic Project Approval.
- All equipment will be inspected daily to ensure that it is in proper working condition.
- The contractor will be responsible for the preparation and implementation of a Spill Prevention, Control, and Countermeasures (SPCC) Plan to be used for the duration of the project. The SPCC Plan will be submitted to the project engineer prior to the commencement of any construction activities. A copy of the plan with any updates will be maintained at the work site by the contractor. The contractor will also maintain at the job site the applicable equipment and materials designated in the SPCC Plan.

- Excess or waste materials, petroleum products, fresh cement, lime or concrete, chemicals, or other toxic or deleterious materials will not be allowed to enter the West Waterway.

Table 5 – Summary of Inwater and Overwater Structures Removed and Added

Structure	Number	Diameter (size)	Removal/ Installation Technique	Inwater Pile footprint (square feet)	Overwater coverage (square feet)
Structures Removed					
Timber fender piling	227	15-inch (average)	Vibratory extraction	311	
Timber/metal deck between fender and bull rail		2,900 lineal feet by	Above water demolition		8,500
Timber pinch Pile	57	15-inch (average)	Vibratory extraction	None, piles were driven to mudline	
Concrete Structural Pile	171	16.5-inch	Vibratory extraction	290	
Concrete Structural Pile	74	20-inch	Cutoff at mudline	162	
Steel Fender Piles	36	16.5-inch	Vibratory extraction	54	
Steel Structural Piles	100	18-inch	Cutoff at mudline	213	
Total Pile removal	**665**				
Total Inwater Footprint Removal				**1,030**	
Total Overwater Structure Removed					**8,500**
Structures Added					
Timber Pinch Piles	3,000	15-inch (average)	Vibratory and Impact	None, piles will be driven to mudline	
Composite Sheet Piles (H pile and sheet pile)	500 H- piles; 500 sheet piles	Each H-pile estimated at 0.3 square feet	Vibratory and Impact	146	
Concrete Structural Pile	420	24-inch	Impact	1,320	
Total Inwater footprint addition				**1,466**	
Net Changes					
Inwater Pile Footprint				**+436 sf**	
Overwater Structures					**-8,500 sf**

2.5.1 *Pile Driving and Pile Demolition*

The following BMPs will be employed to avoid and limit potential environmental impacts resulting from pile driving and pile removal activities.

- The project is designed to use concrete piles, untreated wood piles, H-piles, and sheet piles for all water-based activities, all of which produce substantially lower waterborne noise levels when struck than do steel pipe piles.

- All new inwater piles will be driven beneath the existing Terminal 5 Wharf within riprapped habitats or along the terminal face; natural light penetration in these areas is already severely limited.

- If fish are observed in distress or if a fish kill occurs, work will be stopped immediately. USACE, WDFW, and Ecology will be contacted and work will not resume until approval is given by these agencies.

- Pulled piles will be placed in a containment basin either on a barge or adjacent to the deck to capture any adhering sediment.

- A boom will be installed around the work area prior to removal of timber piles and related structures to contain and collect debris, which will be disposed of at an approved upland location.

- Operator will "wake up" the pile by vibrating to break the skin friction bond between pile and soil.

- Crane operator will minimize turbidity in the water column by removing released pile slowly.

2.5.2 Dredging

The following BMPs will be employed to avoid and limit potential environmental impacts of dredging activities:

- The Port will require the contractor to utilize real-time positioning control when implementing dredging operations.

- Based on the results of water quality monitoring, operational controls may be applied to dredging operations, as required to meet water quality standards, including:
  - Increasing cycle time: A longer cycle time reduces the velocity of the ascending bucket through the water column, which reduces potential to wash sediment from the bucket.
  - Elimination of multiple "bites": When the clamshell bucket hits the bottom, an impact wave of suspended sediment travels along the bottom away from the dredge bucket. When the clamshell bucket takes multiple bites, the bucket loses sediment as it is reopened for subsequent bites. Sediment is also released higher in the water column as the bucket is raised, opened, and lowered.
  - Prohibiting bottom stockpiling: Bottom stockpiling of the dredged sediment in silty sediment has a similar effect as multiple bite dredging; an increased volume of sediment is released into the water column from the operation.

2.6 Action Area

The action area, where direct or indirect effects of the proposed action may occur, encompasses the entire outer portion of West Waterway to account for temporary and localized turbidity affects from dredging activities and potential underwater sound effects (Figure 1). Also within this action area, waterborne injury and behavioral disturbance zones have been calculated to determine the potential effects of impact and vibratory pile driving on ESA-listed fish, marine mammals, and birds (Figures 2 and 3).

NOAA Fisheries has adopted the following Interim Criteria for injury and disturbance thresholds for fish (Stadler and Woodbury 2009):

- 206 decibels (dB) Peak re: 1 micropascal (µPa) for all fish;
- 187 dB accumulated sound exposure level (SEL; 1 micropascal squared seconds [µPa2 sec]) for fish greater than 2 grams; and
- 183 dB SEL re: 1 µPa2 sec for fish less than 2 grams.

In addition, NOAA Fisheries, under the Marine Mammal Protection Act, is in the process of developing noise guidelines for determining sound thresholds for the injury and disturbance of marine mammals. Present guidelines are as follows:

- 180 dB root mean square (rms) as the level at which cetaceans experience Level A injury for pulsed sound (impact pile driving);
- 190 dB rms as the level at which pinnipeds experience Level A injury for pulsed sound (impact pile driving);
- 160 dB rms as the level all marine mammals experience Level B (behavioral) harassment for pulsed sound (impact pile driving); and
- 120 dB rms as the level all marine mammals experience Level B harassment for continuous sound (vibratory pile driving).

The USFWS has also reported a waterborne injury threshold of 202 dB SEL for marbled murrelet. In addition, an in-air masking threshold of 29 dB Spectrum Level has also been established for the species. It is believed that these in-air noise levels may interfere with the murrelet ability to communicate with each other and decrease the efficiency of the bird's ability to feed on the water. For 24-inch diameter steel piles, the USFWS has determined that the in-air masking threshold is 42 meters from the driven pile.

The Washington (WSDOT) and California (Caltrans) Departments of Transportation have compiled waterborne acoustic monitoring data for various pile driving projects within their respective states (WSDOT unpublished; ICF Jones & Stokes and Illingworth and Rodkin 2009, updated in 2012). These data, in conjunction with the practical spreading loss model developed by NOAA Fisheries can be used to determine the distance from the driven pile at which the Interim Criteria are exceeded. Additional research conducted by the Port of Seattle has further refined this model to account for the relatively high ambient noise levels measured in Elliott Bay (Ewald and Sloan 2011). The resulting model is called the Port of Seattle Sound Evaluation (POSSE) model. The modeling approach and results from this research has been accepted by NOAA Fisheries and USFWS for Port of Seattle waters and was used in this BA. Underwater noise levels for the different pile types used for the project are presented in Table 6, along with the associated injury and disturbance zones. Bubble curtain use is not proposed for impact driving. Concrete and wood piles are not anticipated to generate exceptionally loud noise signatures and associated injury and disturbance zones are small (Table 6).

Injury and disturbance zones are plotted on Figures 2 and 3 which show the zones for Year 1 and Year 2 pile driving activities. Pile driving activities during Year 1 will occur along the south half of Terminal 5 (Area A; Figure 2), and during Year 2 along the north half of the terminal (Area B; Figure 3). The injury and disturbance zones are the distances from the driven pile where pile driving noise exceed criteria thresholds. Since pile driving of all inwater pile types (concrete structural, pinch piles, and toe wall) will occur for most of the entire length of Terminal 5, the injury and disturbance zones plotted on Figures 2 and 3 represent the farthest points away from the terminal that underwater sound thresholds are predicted to be exceeded. The actual exceedance zone depends upon where pile driving is occurring along the terminal.

All injury and disturbance zones largely fall within the West Waterway except for the marine mammal disturbance zone for continuous noise generated by the vibratory driving of sheet piles (Table 6; Figures 2 and 3). This zone extends for 1,000 meters beyond each driven sheet pile. During Year 1, most of this zone falls within the West Waterway (except when pile driving has reached the northern most portion of Area A). During Year 2, however, the zone will extend for up to 700 meters north of the West Waterway entrance when driving sheet piles at the northern portion of Area B (Figure 3). These areas encompass nearshore portions of Harbor Island. The disturbance zone extending beyond the West Waterway will be limited to a 9-week period during the Year 2 work window (Table 3).

The injury zones for ESA-listed fish are a maximum of 127 meters beyond the impact driven pile, which fall entirely within the West Waterway, extending about half way across (Figures 2 and 3). Impact pile driving is not expected to cause injury to pinnipeds and cetaceans; underwater noise generated by impact driving for all pile types is below the injury criteria (Table 6).

For marbled murrelet, the waterborne injury zone extends for a maximum of 15 meters beyond the driven pile (impact driven concrete piles; Table 6; Figures 2 and 3). For in-air masking, USFWS criteria typically applies only to steel piles, which will be driven in upland areas approximately 38 meters from the face of the wharf. In order to be exposed to in-air masking noise levels, the birds would have to occupy areas approximately 4 meters from the face of the wharf. In early coordination meetings and correspondence with the Services, the USFWS reported that in-air masking will not likely be an issue at Terminal 5 (Wright, L., personal communication, February 24, 2015).

Table 6 – Inwater Injury and Disturbance Zones from Proposed Impact and Vibratory Pile Driving at Terminal 5

		Underwater Noise			Impact Zones (distance from the pile in meters)							
Pile Type	Blows/Day (impact) Minutes/ Day (Vibratory)	Peak	rms	SEL	Peak Injury (206dB)	SEL Fish Injury (≥2g) (187dB)	SEL Fish Injury (<2g) (183dB)	SEL Marbled Murrelet (202dB)	Mar. Mam. Disturb. Impact (160dB)	Cetacean Injury (180dB)	Pinniped Injury (190dB)	Mar. Mam. Disturb. Vibe (130dB)
Impact Pile Driver												
H-Pile	900	195	180	170	<Thresh	69	127	7	215	<Thresh	<Thresh	NA
24-inch Concrete	9,000	188[1]	174[1]	165[1]	<Thresh	100	100	15	86	<Thresh	<Thresh	NA
14-inch Wood	6,300	180	170	160	<Thresh	46	46	5	46	<Thresh	<Thresh	NA
Vibratory Pile Driver												
H-Pile	360	165	150	150	NA	NA	NA	NA	NA	NA	NA	215
Sheet Pile	360	175	160	160	NA	NA	NA	NA	NA	NA	NA	1,000
14-inch wood	336	163	153	143	NA	NA	NA	NA	NA	NA	NA	341

[1] Hydroacoustic data collected at Terminal 5 during the Test Pile Program in January and February, 2016 (Robert Miner 2016). All other hydroacoustic data were obtained from ICF Jones and Stokes (2009; updated 2012) and Ewald and Sloan (2011).

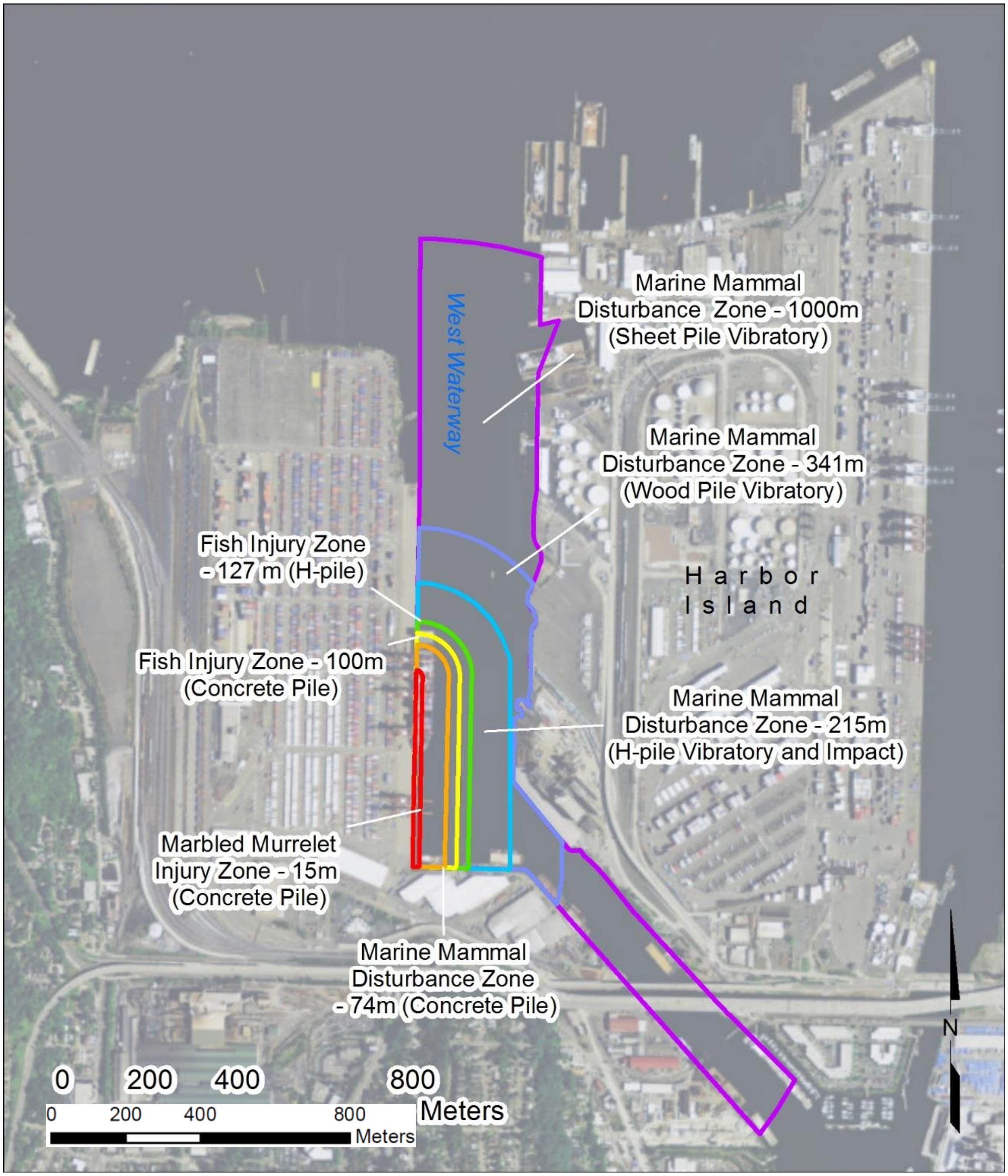

Figure 2 – Fish, Marine Mammal, and Bird Underwater Injury and Disturbance Zones in Area A

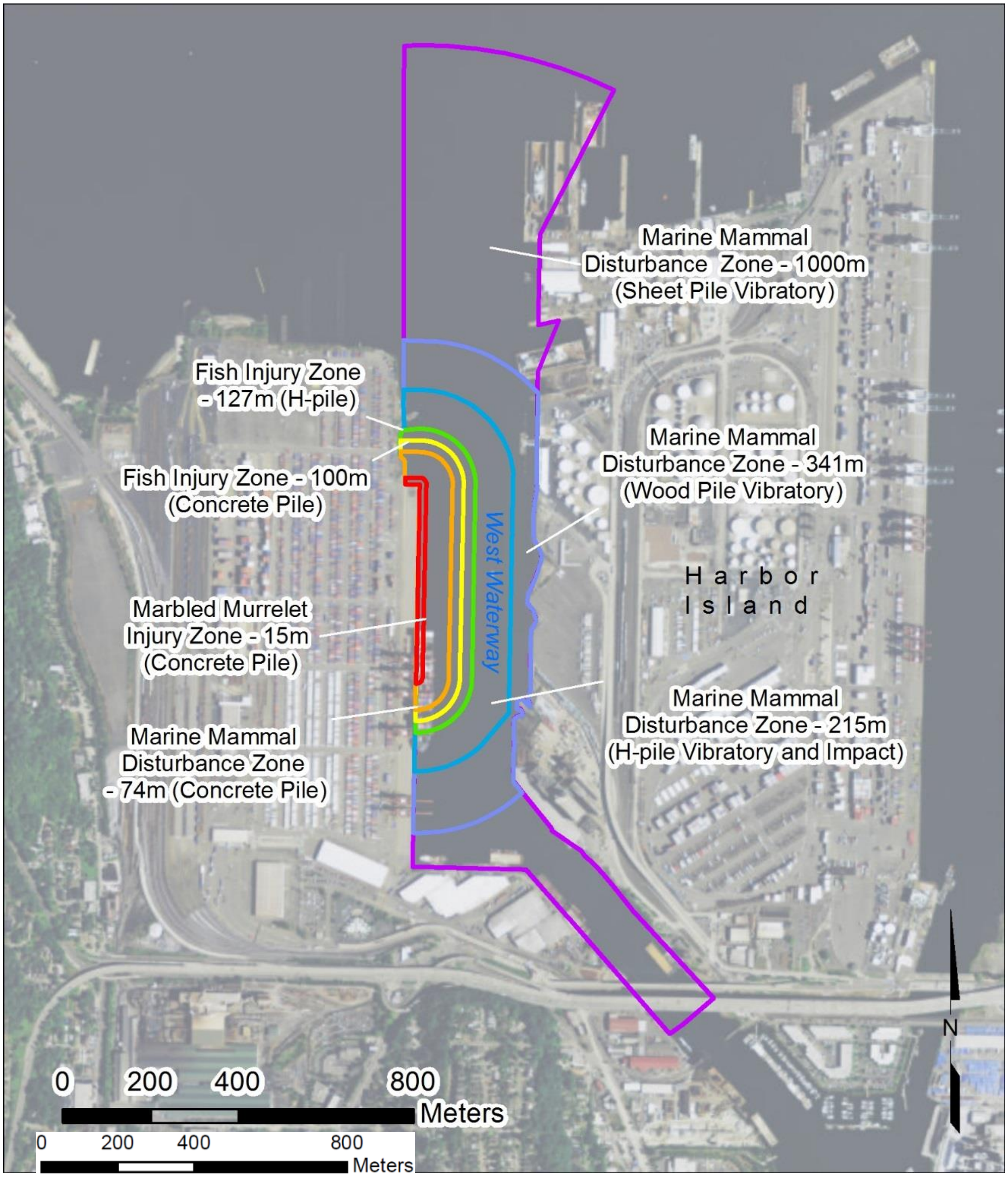

Figure 3 – Fish, Marine Mammal, and Bird Underwater injury and Disturbance Zones in Area B

3.0 ENVIRONMENTAL BASELINE CONDITIONS

3.1.1 Habitat Description

3.1.1.1 Overview

Habitats within the West Waterway and the Duwamish Estuary in general have been highly modified by over a century of urban and industrial development. Between the late 1800s and the mid-1900s, the Duwamish Estuary and Elliott Bay underwent massive modifications as the navigation channels and Harbor Island were constructed. The creation of the waterways involved dredging navigational channels, filling shallow habitat such as marshes and flats, and armoring of the shorelines with dikes, levees, bulkheads, and other structures. This development resulted in replacement of about 9.3 miles of meandering river with 5.3 miles of straightened channel. Nearly 100 percent of the shorelines of the estuary downstream of river mile (RM) 12 were modified by dikes, levees, or revetments, but efforts are well underway to restore significant reaches of these areas (King County 2001).

3.1.1.2 Terrestrial Habitat, Project area

Upland habitats within the Terminal 5 Project area are entirely paved with asphalt. No riparian vegetation or natural habitats are present. Therefore, upland habitats are not further discussed in this section. The overwater wharf structure is typically composed of pre-cast concrete decks and supported by cast-in-place concrete bents and pre-cast piles. The Terminal 5 wharf is pile supported with hundreds of piles extending from the upland to subtidal areas deeper than –45 feet MLLW.

3.1.1.3 Marine Habitat, Project Area

Aquatic portions of the project area are composed of intertidal and subtidal habitats extending to the edge of the proposed dredge prism, a maximum of 150 feet offshore of the face of the existing Terminal 5 wharf. The intertidal zone is composed of riprap at an approximate slope of 1.5H:1V entirely beneath the existing wharf. Subtidal habitat is also composed of riprap and continues at a similar slope to the current dredged depth which reaches approximately –53 feet MLLW. Very little light penetration occurs under the wharf within this portion of the intertidal and subtidal zones, so it is expected that primary and secondary production are low.

Offshore of the wharf, subtidal habitats are less steep and elevations range between –47 and –55 feet MLLW. Bathymetric data show that deeper portions below about –52 feet MLLW tend to be isolated pockets. Substrates are composed primarily of silty sands deposited from Duwamish/Green River basin. Salinities are estuarine to marine, generally ranging from 12 to 28 parts per thousand (ppt), depending upon freshwater inputs from the Duwamish River.

3.1.1.4 Terrestrial and Marine Habitat, Action Area

The action area is considered the lower portion of the West Waterway (Figure 1). The action area is primarily saltwater, but receives freshwater flows from the Duwamish River. Dredging and development since the early 1900s have substantially altered nearshore environments in the West Waterway. All of the original habitat in the action area has been either filled or dredged and is highly modified from original delta conditions. There are no remaining tidal marsh, mudflat, emergent vegetation, or riparian vegetation within the action area.

Existing shoreline conditions in the action area consist of overwater pile-supported wharves, fenders, riprap slopes, seawalls, and bulkheads associated with marine industrial and commercial use. Approximately 62 percent of the action area shoreline contains overwater wharves located above riprap slopes. The eastern shore of the West Waterway directly across from the project area contains an intertidal zone primarily composed of gravel sand habitats with more natural slopes over approximately 1,500 linear feet.

The riprap slopes, structural piling, subtidal and intertidal retaining walls, and fender systems provide substrate for algae and sessile invertebrates, though at substantially lower levels beneath Terminal 5 because of a lack of light penetration. Bottom sediments in the waterway, riprap on the slopes, and in the interstices of the riprap revetment provide habitat for benthic invertebrates. Some estuarine and marine fish and sub-tidal marine invertebrates inhabit and feed at deeper subtidal elevations within the action area. These are generally more mobile species, capable of avoidance behavior and therefore not subject to entrainment in large numbers during dredging operations.

No eelgrass or suitable habitats for eelgrass have been documented in the project and action areas.

3.1.2 Water and Sediment Quality Baseline

Terminal 5 is located on the west side of the West Waterway, which is included on the Washington Department of Ecology's 303 (d) Water Quality Assessment for the following Category 5 parameters: cadmium and mercury in sediment; PCBs in tissue samples; and dissolved oxygen and bacteria in the water column. Potential sources of heavy metals and PCBs in the waterway include upland stormwater, spills, and oily bilge discharge. The trend for water quality in the Terminal 5 action area is one of overall improvement.

Sediments within the proposed dredge footprint at Terminal 5 have been recently sampled and tested per the Washington DMMP to assess the materials' suitability for open-water disposal. Results show that the only exceedances of DMMP criteria were in two samples at surface dredged material management units (DMMUs; 0 to 2 feet) in Areas 2 and 4. These two samples slightly exceeded the dioxin criterion of 4 nanograms per kilogram (ng/kg; Puget Sound background). These sediments are still eligible for open water disposal since the volume weighted average of material to be dredged is less than 4.0 ng/kg. A final decision has been made to allow disposal of all sediments at an open water disposal site (DMMP 2015).

3.1.3 Fish and Wildlife

3.1.3.1 Fish

Eight species of anadromous salmonids use the Duwamish Estuary primarily as a migratory corridor: Chinook, coho, chum, pink, and sockeye salmon; steelhead trout, sea-run cutthroat trout, and bull trout. Of these species, Chinook and coho salmon and steelhead trout are common in the Duwamish basin, while pink and sockeye salmon, sea-run cutthroat trout, and bull trout are rare. Juvenile outmigration of salmonids may occur as early as February (Chinook and chum) with peak numbers migrating through the action area in April and May (Chinook, coho, steelhead); numbers decrease sharply by late-July. Adults migrate through the waterways for much of the year as early as April (summer run-steelhead), through the late summer months (fall Chinook salmon), fall (coho salmon), and winter (chum salmon and winter steelhead trout; King County 2001).

Non-anadromous fish species documented within the Duwamish are dominated by estuarine and marine species, with few freshwater species. In surveys conducted by Warner and Fritz (1995), shiner perch were the most abundant species collected in the estuary, but their presence is seasonal, appearing in early-May, peaking during the summer and declining by fall and nearly absent by November. Pacific staghorn sculpin, snake prickleback, starry flounder, and Pacific sand lance were also observed at abundances approaching those of juvenile salmonids during their outmigration. Upwards of 33 different species of fish have been documented in lower estuary, but the above four species, along with shiner perch and juvenile salmonids, comprised over 99 percent of fish collected in the estuary (Warner and Fritz 1995; Miller et al. 1977; Stober and Pierson 1984).

3.1.3.2 Wildlife

As reported, very little natural terrestrial habitat is present within the project area and few animal species outside of several passerine birds have been observed. European starling, song sparrow, house finch, house sparrow, American robin, and American crow were documented in the southwest portion of inner Elliott Bay (USACE 1994). Overwintering bald eagles may overfly the general area during the winter. Bald eagle presence and behavior was documented from four locations located immediately northwest of Terminal 5 within inner Elliott Bay. No nests are located within the West Waterway, but birds have been documented to perch on mature trees south of the Duwamish Head and perched on dolphins and moored barges in inner Elliott Bay (USACE 1994). The WDFW Priority Habitats and Species (PHS) database has documented bald eagle nests within the Duwamish Head green belt located approximately 1 mile west of the terminal. Documented seabird use includes alcids (pigeon guillemot and rhinoceros auklet) and several species of diving ducks (common loon, horned grebe, eared grebe, western grebe, surf scoter, and Barrow's goldeneye), cormorants, and gulls. Marbled murrelet have not been documented within the West Waterway. PHS has also documented California sea lions and harbor seals throughout the West and East Waterways (WDFW PHS 2014).

4.0 DESCRIPTIONS OF THE SPECIES AND HABITAT USE

4.1 Introduction

The ESA-listed species that may occur in the action area are Puget Sound Chinook salmon, Puget Sound steelhead trout, Coastal-Puget Sound bull trout, bocaccio, canary rockfish, yelloweye rockfish, green sturgeon, eulachon, humpback whale, southern resident killer whale, marbled murrelet, and four species of sea turtles (Table 1).

4.2 Chinook Salmon

4.2.1 Species Presence

Chinook salmon presence is documented, and juveniles and adults migrate through the action area (WDFW 2013). Chinook salmon in the action area would primarily be of Green River (Duwamish) stock, although fish from other stocks do use the same area (Nelson et al. 2004). Adult chinook could be present in the action area from mid-June through mid-October. Juvenile chinook arrive in the West Waterway/Elliott Bay as early as mid-February and may be present through June. Studies indicate that small numbers of juvenile Chinook salmon may be present in Elliott Bay as late as August or September and appear to be rearing in the marine nearshore. Most of these fish are usually larger subadults of approximately 120 to 150 mm.

For these reasons, it is expected that adult and juvenile Chinook salmon may be present in the action area as follows: adults are expected to occur in deep water areas in the vicinity of the action area in summer and fall during their upstream spawning migration, and juveniles may occur in the shallow nearshore during typical outmigration periods between February and August.

4.2.2 Chinook Salmon Critical Habitat

The Puget Sound evolutionarily significant unit (ESU) of Chinook salmon critical habitat is designated for areas containing the physical and biological habitat features, or primary constituent elements (PCEs), essential for the conservation of the species or that require special management considerations. PCEs include sites that are essential to supporting one or more life stages of the ESU and that contain physical or biological features essential to the conservation of the ESU. The PCEs applicable to this action area include the following criteria.

- Estuarine areas free of obstruction and excessive predation with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation.

- Nearshore marine areas free of obstruction with water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation; and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels.

In marine, estuarine, and nearshore areas like the action area, the inshore extent of critical habitat is defined by the line of extreme high water. The offshore extent of critical habitat for marine nearshore areas is to the depth of 30 meters (98 feet) relative to MLLW, an area that generally coincides with the maximum depth of the photic zone in Puget Sound. The action area lies within the nearshore marine areas critical habitat zone.

The condition of critical habitat PCEs in the action area for Chinook salmon is limited by several factors: developed shorelines, lack of complex habitat to provide forage and cover, and the presence of overwater structures. There will be no losses of critical habitat as part of this project and beneficial effects are anticipated.

4.3 Steelhead

4.3.1 Species Presence

Steelhead that would be present in the action area are winter and summer run steelhead from the Green River (Duwamish) stock (WDFW 2013). Run timing for adult Green River winter steelhead is generally from December through mid-March, with spawning from early March through mid-June (WDFW 2002). Run timing for Green River summer steelhead is generally from May through October with spawning from mid-January through mid-March. Juvenile steelhead would be expected to outmigrate between mid-March and early June. This species is not anticipated to be in the nearshore of the action area in large numbers because the majority of steelhead smolts migrate directly to the open ocean and do not rear extensively in the estuarine or coastal environments (Burgner et al. 1992).

For these reasons, it is expected that adult and juvenile steelhead may be present in the action area as follows: adults are expected to occur in the deep water areas in the vicinity of the West Waterway during the summer, fall, and winter of their upstream spawning migration, and juveniles may occur in the shallow nearshore during typical outmigration periods in the spring and early summer. The general steelhead life history and available research suggest that steelhead use of the action area is lowest in the winter. In addition, by the time juvenile steelhead reach marine waters, they would be much larger in size and would tend to move rapidly to offshore habitat.

4.3.2 Steelhead Critical Habitat

Critical habitat was designated for the Puget Sound Distinct Population Segment (DPS) for steelhead on February 24, 2016; the PCEs for steelhead are identical as those for the Puget Sound ESU of Chinook salmon and are presented in Section 4.2.2.

4.4 Bull Trout

4.4.1 Species Presence

Coastal-Puget Sound bull trout use of the Green/Duwamish River basin is very low. Adult bull trout do occur in the Green/Duwamish basin but very infrequently (Goetz et al. 2004), primarily using the area as foraging habitat. There is no indication that there is a spawning population of bull trout in the Green/Duwamish basin (USFWS 1998). Bull trout have been documented in Elliott Bay (Goetz et al. 2004), but are likely from nearby populations in the Stillaguamish River, Snohomish/Skykomish River, or Puyallup River. Based on the available information, it is expected that bull trout use of the action area is likely very low.

4.4.2 Bull Trout Critical Habitat

There are nine PCEs identified as essential for the conservation of bull trout and may require special management considerations or protection. Six of the nine PCEs are applicable to the action area, as follows:

- Migration habitats with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.
- An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.
- Complex river, stream, lake, reservoir, and marine shoreline aquatic environments, and processes that establish and maintain these aquatic environments, with features such as large wood, side channels, pools, undercut banks and unembedded substrates, to provide a variety of depths, gradients, velocities, and structure.
- Water temperatures ranging from 2 to 15° C (36 to 59° F), with adequate thermal refugia available for temperatures that exceed the upper end of this range. Specific temperatures within this range will depend on bull trout life-history stage and form; geography; elevation; diurnal and seasonal variation; shading, such as that provided by riparian habitat; streamflow; and local groundwater influence.
- Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.
- Sufficiently low levels of occurrence or nonnative predatory, interbreeding species that, if present, are adequately temporally and spatially isolated bull trout.

In marine nearshore areas like the action area, the inshore extent of critical habitat is mean higher high water (MHHW), including tidally influenced freshwater heads of estuaries. Adjacent shoreline riparian areas, bluffs, and uplands are not critical habitat. The offshore extent of critical habitat for marine nearshore areas is to the depth of 30 meters (98 feet) relative to MLLW, which is the average depth of the photic zone. This project falls within the geographical boundaries of Critical Habitat Unit 2 – Puget Sound (Marine).

The condition of critical habitat PCEs in the action area for bull trout is limited by several factors: developed shorelines, lack of complex habitat to provide forage and cover, and the presence of overwater structures. There will be no losses of critical habitat as part of this project and beneficial effects are anticipated.

4.5 Georgia Basin Rockfish

4.5.1 Bocaccio

In Puget Sound, most bocaccio are found south of the Tacoma Narrows and have always been rare in north Puget Sound (Drake et al. 2010). Adults tend to occur in waters that are between 160 and 820 feet in depth, but they may be found as deep as 1,560 feet (Love et al. 2002). Bocaccio juveniles prefer nearshore habitats characterized by rocky substrates and kelp or sandy bottoms with eelgrass (USACE 2012). Although bocaccio larvae may be found throughout the year throughout Puget Sound, they are widely dispersed with the surface water currents, making the concentration or potential presence of larvae in any particular location extremely small (NMFS 2011a, 2011b). Adult and juvenile bocaccio are very unlikely to be in the action area due the lack of deep water, suitable rocky substrate, and preferred aquatic vegetation (i.e., kelp and eelgrass).

4.5.2 Canary Rockfish

Canary rockfish were once common in the greater Puget Sound area (Holmberg et al. 1967), but are now rare. Adult canary rockfish most commonly inhabit waters 160 to 820 feet deep (Orr et al. 2000), but may be found up to 1,400 feet in depth (Boehlert 1980). Canary rockfish juveniles associate with shallow benthic substrates within tide pools and kelp beds (USACE 2012). Adult and juvenile canary rockfish are very unlikely to be in the action area due the lack of deep water, suitable rocky substrate, and preferred aquatic vegetation. Although canary rockfish larvae may be found throughout the year throughout Puget Sound, they are widely dispersed with the surface water currents, making the concentration or potential presence of larvae in any particular location extremely small (NMFS 2011a, 2011b). Adult and juvenile canary rockfish are very unlikely to be in the action area due the lack of deep water, suitable rocky substrate, and preferred aquatic vegetation (i.e., kelp and eelgrass).

4.5.3 Yelloweye Rockfish

Yelloweye rockfish are rare in central and south Puget Sound and little is known about their presence in the project and action areas, although adult yelloweye rockfish have been documented within Elliott Bay (Washington et al. 1978; Miller and Borton 1980; WDFW unpublished data; Dinnel et al. 1986). Adult yelloweye rockfish occur in waters 80 to 1,560 feet deep (Orr et al. 2000), but are most commonly found between 300 to 590 feet in depth (Love et al. 2002). Yelloweye rockfish are typically associated with high relief zones containing crevices and complex rock habitats (Love et al. 1991; Richards 1986). Yelloweye rockfish juveniles are typically associated with vertical walls at depths greater than 45 feet (USACE 2012). Although yelloweye rockfish larvae may be found throughout the year throughout Puget Sound, they are widely dispersed with the surface water currents, making the concentration or potential presence of larvae in any particular location extremely small (NMFS 2011a and 2011b). Adult and juvenile yelloweye rockfish are very unlikely to be in the action area due the lack of deep water, suitable rocky substrate, and preferred aquatic vegetation (i.e., kelp and eelgrass).

4.5.4 Georgia Basin Rockfish Critical Habitat

Critical habitat has been proposed in Puget Sound for Georgia Basin rockfish species on August 6, 2013, but do not include the inner Waterways of the Duwamish River where the project site is located.

4.6 Southern DPS Green Sturgeon

4.6.1 Species Presence

Green sturgeon are principally found in the Columbia River basin within the state of Washington, spawning within the river and spending the majority of their life cycles within shallow coastal areas of Washington, Oregon, and California. Tagging studies indicate a substantial use of estuaries along the Washington and Oregon coasts, with some use of the Strait of Juan de Fuca. The species has been occasionally documented in Puget Sound (WDFW 2002).

Green sturgeon are anadromous, thought to spawn every three to five years in large coastal streams such as the Columbia River (Tracy 1990). Their spawning period is March to July, with a peak in mid-April to mid-June. Sturgeon disperse widely in the ocean after their outmigration from freshwater spending the great majority of the time in the ocean, but large concentrations of immature fish use the Columbia River estuary, Willapa Bay, and Grays Harbor. Very little information on the use of Puget Sound is available and no such aggregations have been reported. Adult and juvenile green sturgeon have not been documented in the Green/Duwamish basin and are very unlikely to occur in the action area.

4.6.2 Green Sturgeon Critical Habitat

There is no green sturgeon critical habitat in the action area.

4.7 Southern DPS Eulachon

4.7.1 Species Presence

Eulachon are anadromous, spawning in freshwater and spending their juvenile and adult lives in marine waters. Eulachon are an ecologically important forage fish species, providing a food source for a wide variety of organisms such as birds, marine mammals, and fish, in both marine and freshwater ecosystems (WDFW 2001).

Although eulachon range from northern California to western Alaska, the southern distinct population segment (DPS) of eulachon consists of populations spawning in rivers south of the Nass River in British Columbia, Canada, to and including the Mad River in California. The major production areas include the Columbia and Fraser rivers, and may have historically included the Klamath River. The primary factor responsible for the decline of the southern DPS is climate change and its effects on ocean conditions and freshwater hydrology and other environmental factors. Directed commercial fishing for eulachon is identified as a low to moderate threat, whereas bycatch in other commercial fisheries (e.g., shrimp) is thought to be a moderate threat to the species. Dams and water diversions are also considered moderate threats (WDFW 2001).

The species is not known to spawn in Puget Sound streams and has been found infrequently in the Sound. The Fraser River is a key production area for eulachon that inhabit Puget Sound (WDFW 2001).

Adult and juvenile eulachon have not been documented in the Green/Duwamish basin and are very unlikely to occur in the action area.

4.7.2 Eulachon Critical Habitat

There is no eulachon critical habitat in the action area.

4.8 Southern Resident Killer Whale

4.8.1 Species Presence

The southern resident killer whale listing is specific to the DPS consisting of three resident whale pods (J, K, and L pods) with ranges in Puget Sound, the Strait of Georgia and the Strait of Juan de Fuca. The K and L pods are occasionally sighted in Puget Sound during winter (Hart Crowser 2012). These pods have been observed near Elliott Bay but typically remain outside of the Bay itself. Therefore, it is unlikely that southern resident killer whales would be found in the action area within West Waterway.

4.8.2 Killer Whale Critical Habitat

Designated critical habitat of southern resident Puget Sound DPS killer whale includes the summer core area in Haro Strait and waters around the San Juan Islands, Puget Sound, and the Strait of Juan de Fuca, which comprise approximately 2,560 square miles of marine habitat.

Critical habitat is designated for areas containing the physical and biological habitat features, or PCEs, essential for the conservation of the species or that require special management considerations. PCEs include sites that are essential to supporting one or more life stages of the DPS and that contain physical or biological features essential to the conservation of the DPS. Specific sites and features designated for southern resident killer whale DPS include the following:

- Water quality to support growth and development;
- Prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth; and
- Passage conditions to allow for migration, resting, and foraging.

The action area lies within the Puget Sound area of killer whale critical habitat and provides all three of the above PCEs.

4.9 Humpback Whale

4.9.1 Species Presence

Humpback whales are commonly found in the North Pacific Ocean, inhabiting coastal waters typically within about 50 nautical miles from shore (Evans 1987; Calambokidis and Steiger 1995). The coastal waters that attract the whales represent areas of high productivity in plankton and forage fish that are important food sources for these animals (Evans 1987). They are dependent on these abundant food resources because of their size and metabolic needs for reproduction, nursing, and sustenance during times of the year when food resources are less abundant (i.e., wintering grounds) (Evans 1987).

Humpback whales use coastal habitats because of their productivity. They are not expected to be routinely present in Puget Sound because of the lack of appropriate habitat and food availability for these large mammals. This expectation is based on limited data, because most studies of these animals are focused on the areas the whales frequent, not areas where they are rarely if ever seen. The Cascadia Research Institute conducts studies on marine mammals in Puget Sound and throughout the North Pacific Ocean. They reported two humpback whales in central and southern Puget Sound in 1988 (Calambokidis and Steiger 1995), and one humpback in the Strait of Juan de Fuca in June of 1999 (Cascadia Research Institute, personal communication). No humpback whales were recorded as incidental sightings in Puget Sound during other marine mammal surveys (Calambokidis et al. 1994, 1997, and 2002; Calambokidis and Quan 1997; Calambokidis 1996). Puget Sound is not considered a part of the natural habitat of humpback whales and hence their occurrence in the area is expected to be extremely rare.

4.9.2 Humpback Whale Critical Habitat

There is no humpback whale critical habitat in the action area.

4.10 Sea Turtles

4.10.1 Species Presence

The leatherback, loggerhead, green, and Olive Ridley sea turtles are highly pelagic species, generally approaching shores only during the reproductive season (NMFS 1999). The leatherback turtle is most adapted to temperate climates because of its ability to thermo-regulate; thus it is one of the most widely distributed of all turtles. Their breeding grounds are located in the tropical and subtropical latitudes, although they are regularly seen in more temperate areas (NMFS and USFWS 1998). The leatherback turtle is the most likely species to wander into Puget Sound, but the Washington region is not considered a part of its natural habitat and, hence, occurrence in this region is considered extremely rare.

4.10.2 Sea Turtle Critical Habitat

There is no sea turtle critical habitat in the action area.

4.11 Marbled Murrelet

4.11.1 Species Presence

The occurrence of marbled murrelets in the project and action areas is expected to be rare. Marbled murrelets feed in marine water but nest in old growth forests. There is no appropriate nesting habitat in or near the action area. WDFW Priority Habitats and Species maps indicate no marbled murrelet observations or nest sites near the action area (WDFW 2013). Murrelets could be present in the action area (i.e., marine water), but due to the high level of human activity and industrialization, it is unlikely they are present at any time of the year.

4.11.2 Marbled Murrelet Critical Habitat

There is no marbled murrelet critical habitat in the action area.

5.0 EFFECTS OF THE PROJECT

5.1 Introduction

The effects of the proposed Terminal 5 wharf rehabilitation and berth deepening project on ESA-listed fish, southern resident killer whale, and marbled murrelet, and their habitats are described in this section. The discussion encompasses how activities associated with wharf rehabilitation will contribute to improvement, maintenance, or degradation of habitats used by listed species. Potential disturbances caused by project activities, along with measurable indicators of habitat health are evaluated.

Presented below is a discussion of short-term and long-term direct and indirect effects of project activities in the project and action areas, as well as the net effects of those activities. Net effect is considered to be the overall effect on the species and habitat in the long term. For example, a short-term adverse condition (e.g., turbidity resulting from pile removal) may be necessary to achieve a long-term improvement in habitat quality; in such a case, the *net* effect is positive and would contribute toward improvement of the migratory corridor of listed juvenile salmon. Moreover, if short-term adverse conditions occur when few or no listed species are present, and if those conditions are no longer present when listed species return to the area, then those conditions do not constitute adverse modification of habitat quality.

As stated in Section 4, humpback whales and the listed sea turtles are unlikely to be present in the action area at any time, and are not expected to be present when project construction is occurring. No direct, indirect, or cumulative impacts of the project are expected to affect humpback whales, or the listed sea turtles; therefore, the effects analysis below does not address these species further.

5.2 Effects Analysis

5.2.1 Construction Disturbances

5.2.1.1 Short-Term Effects on ESA-Listed Fish

Direct Effects. Increased noise from pile driving and construction may result in avoidance of the project area by ESA-listed salmonids and other fish species during Terminal 5 construction activities. Of these activities, pile driving is expected to result in the greatest waterborne noise levels. The waterborne sound pressure levels (SPL) released by impact pile driving have been shown to cause injuries to fish in the immediate vicinity of such activities, with possible behavior-altering sound levels emanating for hundreds of meters. There is little evidence to indicate that vibratory driving has adverse effects to fish. Proposed impact pile driving at Terminal 5 will include concrete piles, H-piles, and wooden pinch piles; these activities will release waterborne SPLs.

WSDOT and Caltrans have compiled acoustic monitoring data for various pile driving projects within their respective states (WSDOT unpublished; ICF Jones & Stokes and Illingworth and Rodkin 2009, updated in 2012). Upon review of these datasets, sound pressure levels (SPLs) for the impact and vibratory driving of various piles were determined and presented in Table 6. Comparing these data with the Interim Criteria and using the Port's POSSE model indicates that the proposed impact driving of concrete piles, pinch piles, and steel H-piles will not exceed the criteria for peak sound pressures. However, underwater sounds may create accumulated SELs that would exceed present thresholds for injury to fish within 100 meters of concrete piles, 46 meters from wooden pinch piles, and 127 meters from steel H-piles (Table 6; Figures 2 and 3). The largest of these injury zones extends approximately halfway across the West Waterway, potentially exposing fish to levels of noise that may cause injury. However, fish also have available aquatic habitat to avoid the injury zone and outmigrating fish will have passage through the waterway without being exposed to these levels of noise.

Other studies have been conducted in the Puget Sound basin examining the direct effects of pile driving on juvenile salmonids. Near the Ballard Locks, Ruggerone et al. (2008) exposed juvenile coho salmon in live cages to over 1,600 strikes with an impact hammer of fourteen 20-inch diameter hollow steel pipe piles. Live cages were placed from 1.8 to 6.7 meters from the pile being driven. Measured sound pressures experienced were up to 208 dB peak, and 194 dB rms. SEL reached 179 dB and cumulative SEL was approximately 207 dB over the 4.3-hour exposure period. No mortality and no visible sublethal effects were observed in fish held up to 19 days after the exposure. Necropsies found no gross external or internal injuries associated with pile driving. Exposed fish fed normally and only a minor startle response was seen in some fish upon initiation of driving a given pile.

In Alaska, similar results were found exposing juvenile coho salmon to the impact and vibratory driving of steel sheet piles. At the Port of Anchorage, within Knik Arm, Hart Crowser (2009) conducted 13 live cage exposures of fish to sound pressure levels of up to 195 dB peak and of 171 dB rms. Tests exposed fish to between 354 and 2,781 impact pile strikes per test and vibratory driving for 30 to 51 minutes per test. No mortalities were observed. Post exposure observations, startle tests, and feeding responses showed no behavioral abnormalities over a 48 hour period. Necropsies found no gross or internal injuries associated with pile driving.

Feist et al. (1996) investigated the effects of impact driving of concrete piles on juvenile pink (*Onchorynchus gorbuscha*) and chum salmon (*O. keta*) behavior and distribution in Everett Harbor, Washington. The authors reported that there may be changes in general behavior and school size, and that fish appeared to be driven toward the acoustically isolated side of the site during impact pile driving. However, the abundance of fish schools did not change significantly with or without pile driving, and schools were often observed around the barge-mounted pile driving rigs. No impacts on feeding were reported. The study concluded that any effects of impact driving of concrete piles on juvenile salmonid fitness would be very difficult to measure quantitatively.

To further minimize the potential affects of pile driving on listed salmonid species within the project area, all inwater activities, including pile driving, will occur during agency-approved work windows (August 16 through February 15), when few juvenile salmonids are expected to occur in the nearshore.

Rockfish species are sensitive to sudden noises, though data on the potential impacts to noise are limited. Pearson et al. (1992) found that rockfish exposed to air gun sounds showed startle and alarm responses. The threshold for behavioral responses was observed between 161 and 205 dB. Skalski et al. (1992) found that catch per unit effort in hook-and-line fisheries declined by an average of 52 percent when geophysical survey air guns were shot near aggregations of rockfish. These limited studies indicate that rockfish respond to loud and sudden noises, but it is not known if permanent effects occur. In addition, underwater noise generated that exceed injury thresholds for fish will be limited to areas within the West Waterway. No eelgrass and very little marine macrovegetation is present within the waterway to provide habitat for juvenile rockfish and very little natural structure is present for adults.

In order to complete pile driving within two annual work windows, the Port plans to use up to three pile driving rigs at the same time. The potential impacts to ESA-listed fish of using multiple rigs will be reduced by limiting the number of rigs conducting impact pile driving to two at any one time, with only one rig impacting steel piles at any given time. This will limit the number of impact blows to between 900 and 12,600 blows per day, the latter of which will only occur for 7 weeks each year. Very little research has been conducted on the effects of multiple pile driving rigs on waterborne sound generation or the potential effects to fish or wildlife. However, limited work suggests that inwater noise is not additive or only additive over a small area of overlap (Laughlin, J. personal communication). Depending upon the distance between the two rigs conducting impact pile driving, it can be expected that the area of exposure may increase laterally along the waterway, increasing the potential to expose fish to levels of noise that may cause injury. The intensity of that exposure is not expected to increase substantially.

No noise-related adverse effects on ESA-listed salmonids are anticipated from other construction activities in the project area given that underwater dredging noise is expected to be well below effects thresholds (Hart Crowser 2010) and most other construction noises will be airborne. Other direct impacts could come from debris or chemicals entering the waterway. Care will be taken to ensure that no construction debris enters the waterway. No fresh concrete will be exposed to nearshore waters in the project area.

In summary, the following conclusions can be drawn from the above analyses and studies:

- The impact driving of concrete, wooden pinch, and steel H-piles beneath the existing wharf will not exceed peak SPLs for injury to fish;
- The more conservative accumulated sound criteria may be exceeded within the West Waterway. Since potentially injurious noise levels will not cross the entire waterway, fish that are present will have avenues to escape the noise and the migratory corridor will not be completely blocked, allowing fish passage through the waterway;

- It is not likely that significant rockfish habitat or use occurs in the waterway; and
- Adherence to approved work windows will minimize the number of ESA-listed juvenile salmonids present during active pile driving operations.

These conclusions indicate that the impact pile driving of piles beneath the existing Terminal 5 wharf, may result in low, but potentially significant effects on the limited number of ESA-listed juvenile salmonids that may occupy the action area during the inwater work window. The lack of suitable habitat for either juvenile or adult rockfish will result in discountable effects to these species. The action area is not within the range of habitats occupied by eulachon or green sturgeon; effects to these species will be insignificant.

Indirect Effects. No short-term indirect effects from construction activities are expected.

5.2.1.2 Short-Term Effects on Marbled Murrelet

Direct Effects of Underwater Noise. Proposed impact pile driving may exceed underwater SPLs considered injurious to diving marbled murrelet (202 dB SEL) for short distances beyond the pile. Using the Practical Spreading Loss Model provided by the USFWS, existing pile driving acoustic data, and the estimated number of pile strikes, the distance between pile driving activities and injury thresholds were calculated to occur between 5 and 15 meters from impact driven piles (Table 6). In addition, the concrete piles that create the largest potential injury zone will be driven approximately 7 meters beneath the wharf (landward of the wharf face), resulting in a threshold exceedance within about 8 meters beyond the face of the wharf. Marbled murrelet typically loaf and feed in quiet offshore areas of Puget Sound. It is unlikely that they would occupy areas of the West Waterway, much less feed and dive within 8 meters of the face of Terminal 5 during a major construction project.

Up to three rigs per day may engage in pile driving and may disturb marbled murrelets, if present, with their combined noise or physical presence. The potential for these effects will be minimized by conducting impact pile driving on only two rigs and impact driving of steel piles on only one rig at a time (H-piles). Steel H-piles will also be vibrated to the required depth and impacted for only those piles where depth has not been reached. All other impact pile driving will occur with concrete and wood piles, which generate considerably lower underwater sound signatures (Table 6). The USFWS does not consider vibratory driving to be injurious to marbled murrelet.

To further minimize the potential effects of pile driving on marbled murrelet, a USFWS-approved marbled murrelet monitoring plan will be implemented during all impact pile driving activities. If required by USFWS, a murrelet observer will be placed on all rigs (up to two per day) that will conduct impact pile driving on the same day and monitor the 15 meter monitoring zone around each pile (8 meter net given the position of the piles beneath the wharf).

Direct Effects of In-Air Noise. The USFWS has recently determined that impact pile driving, usually of large diameter steel piles, may cause the in-air masking of murrelet calls which the birds use to locate one another. Masking of these calls may disrupt the cooperative feeding efforts of birds reducing their feeding efficiency. No in-air-related adverse effects are anticipated from the upland impact pile driving of 24-inch steel piles. According to the USFWS, the in-air masking zone for 24-inch diameter steel piles is 42 meters from the driven pile, but all upland pile driving will occur 38 meters (125 feet) landward from the face of the wharf. Birds would have to occupy areas within 4 meters of the face of the wharf in order to be exposed to in-air masking. It is highly unlikely that marbled murrelets will occupy areas this close to the wharf.

Other airborne noises associated with construction are much lower than those for pile driving, so would not cause in-air masking.

Other direct impacts could come from debris or chemicals entering the waterway. Care will be taken to ensure that no construction debris enters the waterway. No fresh concrete will be exposed to nearshore waters in the project area.

In summary, these analyses show relatively small underwater injury zones generated by proposed impact pile driving. It is unlikely that marbled murrelets will occupy these injury zones since they are so close to the face of an active port terminal. An agency-approved seabird monitoring program will also be implemented to stop pile driving if marbled murrelet do happen to approach these injury zones. Therefore, the impact pile driving of piles beneath the Terminal 5 wharf, with a monitoring program in place, will result in discountable effects on marbled murrelet. The in-air masking zone is even smaller (4 meters from the face of the wharf) and it is highly unlikely that murrelets will enter this zone. Therefore the impact pile driving of upland piles, with a monitoring program in place, will result in insignificant effects on marbled murrelet.

Indirect Effects. No short-term indirect effects for construction activities are expected.

5.2.1.3 Short-Term Effects on Southern Resident Killer Whale

Direct Effects. Proposed pile driving may create SPLs that exceed the injury or behavioral disturbance thresholds for marine mammals. Existing acoustic data for the impact driving of concrete, wood, and steel H-piles and vibratory driving of wood, H-piles and sheet piles were used to determine potential Level A injury and Level B disturbance zones for southern resident killer whale. Using the POSSE model, the behavioral disturbance threshold would occur from 46 to 215 meters from impact driving and 215 to 1,000 meters from vibratory pile driving. Except for the vibratory driving of steel sheet piles, these distances are entirely within the West Waterway (Figures 2 and 3; Table 6). No southern resident killer whales have been documented within the waterway; therefore, it is highly unlikely that the species would be exposed to waterborne noises that exceed the thresholds for disturbance for most pile driving. The Level A injury criteria are not expected to be exceeded with impact pile driving (Table 6).

The vibratory pile driving of steel sheet piles may generate underwater noise that exceeds the measured background level of 130 dB rms, which by protocol, is used as the marine mammal disturbance threshold for continuous noise. This exceedance can extend up to 700 meters into inner portions of Elliott Bay (Figure 3). This extension of the behavioral effects threshold is within 300 meters of existing industrial and commercial piers on Harbor Island; it is unlikely that orca will occupy areas this close to active port operations. In addition, this extension of the disturbance zone into Elliott

Bay would only occur during the Year 2 work window when pile driving is proposed in Area B, the northern half of Terminal 5. During Year 1 work in Area A, the maximum extension into Elliott Bay would be about 250 meters when pile driving occurs on the northern most portion of Area A (Figure 2). Vibratory driving of sheet piles will only occur over approximately 9 weeks during the pile driving season.

To minimize the potential for disturbance impacts on orca from sheet pile installation (and all pile driving), a NOAA Fisheries-approved marine mammal monitoring program will be implemented during all periods of impact and vibratory pile driving. Monitoring can occur directly from Terminal 5, even during the installation of sheet piles during Year 2 when the disturbance zone extends beyond the West Waterway. The maximum extent of the disturbance zone is near the end of the existing wharves on the northwest portion of Harbor Island (Figure 3). If these areas cannot be easily observed from Terminal 5, then an additional observer can be placed on Harbor Island.

The use of multiple rigs during pile driving operations is not expected to have significant effects on southern resident killer whales. Even with the use of multiple rigs, all disturbance zones, except for the vibratory pile driving of sheet piles are within the West Waterway where whales have not been documented. When the zone extends beyond the waterway, it is still within the influence of substantial industrial and commercial port operations on Harbor Island.

No noise-related adverse effects are anticipated from other construction activities in the project area given that underwater dredging noise is expected to be well below effects thresholds (Hart Crowser 2010) and that most other construction noises will be airborne. Other direct impacts could come from debris or chemicals entering the waterway. Care will be taken to ensure that no construction debris enters the waterway. No fresh concrete will be exposed to nearshore waters in the project area.

With the implementation of an approved marine mammal monitoring program during all pile driving periods, it is concluded that pile driving will result in discountable effects on southern resident killer whales.

Indirect Effects. No short-term indirect effects from construction activities are expected. Indirect effects to orca in the form of reduced feeding opportunities are not likely to occur because pile driving and other construction activities have the potential to adversely affect only a few juvenile salmon remaining in the waterway from late-summer through winter (adult salmon are a primary prey of orca).

5.2.1.4 Long-Term Effects on ESA-Listed Species

Long-term effects to southern resident killer whales in the form of vessel disturbance and strikes would likely be insignificant to positive. Upgrades to Terminal 5 would result in a capacity for larger ships to utilize the terminal and a decrease in vessel trips from about 6 per week to 4 per week. This represents a 20 percent reduction in vessel calls at Terminal 5 (Moffatt and Nichol 2015). Vessel traffic presents a minor risk of serious injury or mortality from ships striking southern resident killer whales. The National Marine Fisheries Service (NMFS) reports that direct vessel strikes are rare, but do occur and can result in injury (NMFS 2005). Cargo vessel trips at Terminal 5 would transit two of the three specific areas designated as southern resident killer whale critical habitat: Area 2, Puget Sound, and Area 3, Strait of Juan de Fuca. According to the Biological Report associated with the southern resident killer whale designated critical habitat listing (NMFS 2006), they are most common in Area 1, Core Summer Areas (waters surrounding the San Juan Islands). Approximately 85 percent of all southern resident killer whale sightings in US waters occur in Area 1 (NMFS 2006). Since cargo vessel traffic will transit Areas 2 and 3, in which far fewer sightings have been reported, the increased risk of vessel strike is considered discountable. The anticipated lower number of vessels that will use the port after proposed improvements will further lower this risk.

Pile driving and other construction related noise will result in no long-term effects on ESA-listed fish and marbled murrelet.

The environmental impacts on aquatic species of the long term switch to larger, higher capacity vessels at the Terminal 5 berth is not likely to significantly increase, particularly on migrating juvenile salmonids. The presence of any vessel at the berth would be expected to disrupt migration due to the physical presence of the vessel since juvenile salmonids are unlikely to travel at depth below the vessel's hull. Their migration may be delayed as they mill back and forth to seek passage routes around the vessel. Juvenile salmonids are unlikely to travel underneath the terminal pier immediately adjacent to the west side of berthed ships, and would seek passage in open, lighted waters along the opposite side of the ship toward the middle of the channel. Alternatively, juvenile salmon may travel along the east side of the West Waterway, opposite Terminal 5, where shorelines have more natural low gradient slopes and pocket beaches have been restored, providing more shallow-water habitat and feeding opportunities.

The additional area covered by the larger vessels that could berth at Terminal 5 would not lead to further disruption of migration compared with smaller vessels because fish already have to find a way around the vessels that currently berth at the terminal. The proposed vessel width of 168 feet would cover 19.2 percent of the width of the West Waterway, leaving more than 80 percent open for unimpeded travel. Given the presence of shallow water pocket beaches on the east side of the West Waterway, it is expected that juvenile salmon would prefer this area and avoid the Terminal 5 berth area. The Port also expects that due to the larger-sized vessels, 20 percent fewer of them would be coming into the berth. This reduction in the number of vessel calls would improve overall migratory habitat over existing conditions.

5.2.1.5 Net Effects on ESA-Listed Species

Pile driving and construction activities will result in a brief period of increased noise, possibly causing salmonids and other species to avoid the project area during the construction period. Small numbers of ESA-listed juvenile salmonids may be exposed to noise levels that have the potential to cause injury to fish. This possible impact is only temporary and would not persist beyond the construction period. Conservation measures such as the use of concrete piles will reduce noise below peak sound effects and limit effects that may occur from accumulated sound to within 127 meters of the terminal face. All pile driving will also occur during approved work windows when few juvenile salmon will be present within the West Waterway.

Vessel traffic resulting from Terminal 5 rehabilitation will be lower and shipping traffic will not traverse areas commonly used by southern resident killer whales; hence, effects will be insignificant to positive. Effects on outmigration of juvenile salmonids from larger vessels at berth will not differ significantly than effects of smaller vessels now in use in Puget Sound.

5.2.2 Water Quality Disturbance

5.2.2.1 Short-Term Effects on ESA-Listed Species

Direct Effects. Dredging, and to a lesser extent, pile driving may produce localized impacts to water quality in the form of elevated turbidity plumes that would last from a few minutes to a several hours. Elevated turbidity plumes from dredging are likely to occur in the immediate vicinity of Terminal 5 and may extend throughout the outer portions of the West Waterway. Generalized turbidity effects on fish depend on the amount and timing of exposure (NMFS 2004). Because fish present in the action area have evolved in Pacific Northwest systems that periodically experience short-term pulses of high suspended sediment, they are adapted to such exposures. Increases in turbidity that result from dredging activities are typically of much less magnitude than increases caused by natural storm events (Nightingale and Simenstad 2001).

Juvenile salmon have been shown to avoid areas of unacceptably high turbidities (Servizi 1988), although they may seek out areas of moderate turbidity (10 to 80 nephelometric turbidity units [NTU]), presumably as cover against predation (Cyrus and Blaber 1987a and 1987b). Feeding efficiency of juveniles is impaired by turbidities in excess of 70 NTU, well below sublethal stress levels (Bisson and Bilby 1982). Reduced preference by adult salmon homing to spawning areas has been demonstrated where turbidities exceed 30 NTU (20 milligrams per liter [mg/L]) suspended sediments; Sigler 1990). However, Chinook salmon exposed to 650 mg/L of suspended volcanic ash were still able to find their natal water (Whitman et al. 1982).

Temporary turbidity effects on listed juvenile salmonids will be highly unlikely and discountable because work will occur during the approved inwater work window for the area when juvenile salmonids are not expected to be present. Adult salmonids could be present year-round in low numbers; however, the extent of turbidity will not be expected to reach levels higher than natural storm events and can thus be labeled as insignificant. Adult and juvenile rockfish are not expected in the action area, and effects will be discountable.

During dredging, suspension of anoxic sediment may result in reduced dissolved oxygen (DO) in the water column as the sediments oxidize, but any reduction in DO above background is expected to be limited in extent and temporary in nature. Based on a review of four studies on the effects of dredging on DO levels, LaSalle (1988) showed little or no measurable reduction in DO around dredging operations. In addition, impacts to listed fish due to any potential DO depletion around dredging activities is expected to be minimal for several reasons (LaSalle 1988; Simenstad 1988):

- The levels of suspended material generated by dredging operations are relatively low;
- There are counterbalancing factors in the area, such as tidal or current flushing;
- DO depletion typically occurs low in the water column; and

- High-sediment biological oxygen demand created by suspended sediment in the water column is not common.

Based on this information, dredging or sand layer placement (if needed) is not expected to result in a change in sediment oxygen demand (and resulting DO reduction) during transport through the water column. There may be minor resuspension at the point of impact of the placed materials; however, this condition is expected to be temporary and localized, and the activity will be monitored by water quality testing. Based on the above information, DO is not expected to drop to a level that will be significant to fish that may occur in the area.

There is a chance that other short-term water quality effects could occur related to fuel or contaminant spills; however, BMPs will be in place to minimize the potential for these to occur and to minimize the effect to listed salmonids if they do occur. These effects are therefore expected to be insignificant.

No direct effects to marbled murrelet or southern resident killer whales are expected from the short-term, localized water quality impacts that may occur within the action area.

Indirect Effects. Given the short-term and highly localized nature of turbidity, no indirect effects on ESA-listed fish, bird, or marine mammal species are anticipated.

5.2.2.2 Long-Term Effects on ESA-Listed Species

Long-term direct or indirect effects on water quality are expected to be positive. Although sediment testing has shown generally low values of contamination, dredging activities will remove low levels of potentially contaminated sediments from the project area and the West Waterway. Direct effects on benthic and other sessile sediment dwelling organisms will be discussed in Section 5.2.4.

Long-term direct effects from stormwater discharges are expected to be insignificant. The entire project site as well as the adjoining upland acreage devoted to cargo movement and storage is paved with concrete or asphalt. The proposed project would not alter or affect drainage patterns in the vicinity of the site. The existing stormwater collection and conveyance system is designed and maintained to minimize discharge of stormwater pollutants generated from impervious surface runoff in accordance with best management practices and regulatory criteria. Final development of the proposed project would utilize existing stormwater collection, conveyance, treatment, and discharge infrastructure as much as practicable, although some temporary rerouting and installation of temporary conveyance systems might be needed during construction activities. New treatment facilities are planned for the area surrounding the new electrical substation as required.

5.2.2.3 Net Effects

Short-term effects resulting from increased turbidity and sediment resuspension may be expected during pile-driving and dredging activities, but are expected to be minor and temporary, with no long-term effects. Therefore, the net effects of pile driving and other construction activities will be to maintain water quality in the project and action areas.

5.2.3 Sediment Quality Disturbance

5.2.3.1 Short-Term Effects on ESA-Listed Species

Direct Effects. Physical resuspension of the sediments during dredging will occur during the dredging component of the project. The resuspension of contaminated sediments have the potential to release these contaminants into the water column and cause acute or chronic toxicological effects on ESA-listed species that may be present during dredge activities.

Sediments within the proposed dredge footprint at Terminal 5 have been sampled and tested per the Washington DMMP protocols to assess the materials' suitability for open-water disposal. Sediment borings were collected at eight locations within the proposed dredge footprint, at 4 or 5 depths at each location, and analyzed for metals, tributyltin (TBT), and organic pollutants. Preliminary results show that the only exceedances of DMMP criteria were in two samples at surface DMMUs (0 to 2 feet) in Areas 2 and 4. These two samples slightly exceeded the dioxin criterion of 4 ng/kg (Puget Sound background). These sediments are still eligible for open water disposal since the volume weighted average of material to be dredged is less than 4.0 ng/kg. The DMMP has made this determination and provided approval for open water offshore disposal of dredged sediments. Potential effects of sediment resuspension to ESA-listed fish, marbled murrelet, or marine mammals from resuspended sediments will be discountable.

Indirect Effects. Indirect effects on ESA-listed fish are expected to be insignificant or positive. The removal of any residual sediment contamination present will provide improved sediment habitats for the recolonization of the benthic community. Since all dredging will occur in waters between –47 and –52 feet MLLW, there will be no conversion of shallow water habitat to deep water habitat.

5.2.3.2 Long-Term Effects on ESA-Listed Species

Long-term direct and indirect effects are expected to be positive since dredging will remove potentially contaminated surface sediments from the area. Contaminated sediments, if present, will be disposed of at agency-approved upland facilities.

5.2.3.3 Net Effects

Effects on sediment quality will be positive with the removal of any contaminated sediment that may be present. Toxicological effects associated with contaminated sediment resuspension will be low because of the low concentrations present, the temporary nature of resuspension, the small area that resuspension will occur, and work window restrictions during periods when few listed salmonids will be present.

5.2.4 Habitat and Biota Disturbance

5.2.4.1 Short-Term Effects on ESA-Listed Species

Direct Effects. Dredging will remove benthic organisms over approximately 235,384 square feet of deep subtidal habitat adjacent to Terminal 5. However, the existing substrate has been dredged previously, exists in deep-water locations, and is below the depth that juvenile salmonids would be expected to be feeding. Adult salmonids are not expected to feed on benthic prey. Forage fish would not be expected to spawn in or near the action area, because suitable substrates are lacking and eelgrass is not present. Adult rockfish are not expected to be present in the area, and juvenile rockfish would likely be feeding in shallower waters associated with marine macrovegetation. Thus, while disturbances to benthic habitat will occur as a result of project activities, due to existing habitat conditions and feeding habits it is expected that impacts to fish via disturbance of the epibenthic prey community will be insignificant.

Perturbation of the benthic community will likely be short-term in duration because the community is expected to recover rapidly after dredging, based on the results of studies in other areas (McCauley et al. 1977; Swartz et al. 1980; Albright and Borithilette 1981; Romberg et al. 1995; Wilson and Romberg 1996). For example, Romberg et al. (1995), studying a subtidal sand cap placed to isolate contaminated sediments in Elliott Bay, identified 139 species of invertebrates five months after placement of the cap. The benthic community reached its peak population and biomass approximately 2 1/2 years after placement of the cap, then decreased, while the number of species increased to 200 as long-lived species recruited to the population (Wilson and Romberg 1996).

Dredging is not expected to entrain or kill fish. Pressure waves created as the bucket descends will forewarn fish present within the area and may allow individuals time to avoid these mechanisms. In addition, during dredging the clamshell jaws will be open during descent, which should reduce the likelihood of entrapping or containing fish (NMFS 2003). The USACE conducted extensive sampling within the Columbia River in 1985 through 1988 (Larson and Moehl 1990), and no juvenile salmon were entrained. McGraw and Armstrong (1990) examined fish entrainment rates outside of peak migration times in Grays Harbor from 1978 to 1989 and found that one juvenile salmon was entrained.

For these reasons, it is anticipated that both the impacts to the prey community as a result of the proposed action and any subsequent effects on ESA-listed fish will be insignificant.

Indirect Effects. Indirect short-term effects, such as a reduction of prey species to ESA-listed salmonids are expected to be insignificant since recovery of the benthic community is expected to occur quickly. Short-term effects on the benthic community will also occur in waters deeper than –47 feet MLLW, which is deeper than juvenile salmonids feed while in the nearshore.

5.2.4.2 Long-Term Effects on ESA-Listed Species

Direct Effects. Long-term direct effects are expected to be insignificant or positive because of the proposed net reduction of overwater structure. The Project proposes to remove approximately 8,500 square feet of overwater structure at the face of the terminal with the removal of the deck between the fender and bull rail (Table 5).

In addition, the removal of 227 creosote-treated wood fender piles waterward of Terminal 5 will result in an improvement of approximately 311 square feet of subtidal habitat by eliminating a potential contaminant source and removing impediments within the migratory corridor of juvenile salmon (Table 5).

The pile driving of over 2,000 piles per year has the potential to eliminate benthic habitat or increase impediments to the juvenile salmon migratory corridor. These effects will be minimized given that all concrete and pinch piles will be driven beneath the existing wharf where little light penetration occurs. The scientific literature has consistently shown that juvenile salmon migrating along shorelines avoid areas of intense shading caused by overwater structures (Nightingale and Simenstad 2001), so it is highly unlikely that outmigrating juveniles will travel beneath the wharf. The 1,500 pinch piles per year will also be driven to the substrate surface, which is composed of riprap. These piles will add to the available hard substrate habitat. H- and sheet piles will be driven to near the substrate surface in deep waters between –42 and –50 feet MLLW where listed juvenile salmonids are not likely to feed.

Removal of sediments from water depths greater than –47 feet MLLW will have insignificant effects to ESA-listed juvenile salmon, since this is much deeper than juvenile salmon feed in the nearshore. Removal of surface sediments will also remove a potential source of sediment contamination from the waterway. New piles will be colonized by assemblages and species similar to those lost during removal of old piles.

Indirect Effects. No adverse long-term indirect effects on habitat are expected from the proposed project activities in the action and project areas. Post-construction operational effects will be insignificant. Larger cargo vessels will be able to moor along Terminal 5, but the frequency of vessel calls is expected to decrease by 20 percent because fewer vessels will be needed to fill the cargo capacity of the terminal. The fewer vessel calls may also decrease any avoidance of the area by juvenile salmonids during the outmigratory period. The new proposed dredge depths will accommodate the larger draft vessels; increases in bottom habitat perturbations from vessel movements are not expected.

5.2.4.3 Net Effects

Net effects on biota and listed salmonid habitats from project actions are expected to be insignificant or positive. The loss of the benthic community as the result of dredging will be temporary; multiple studies of dredged areas show a relatively rapid recolonization of the community from adjacent areas. Terminal improvements will both remove creosote-treated piles and decrease the overwater footprint at the face of the wharf. Dredging will also remove a potential source of sediment contamination from the area. Post-construction operations will have insignificant effects due largely to the lower number of vessel calls to the terminal.

5.3 Net Effects of Action

The net effect of the proposed actions in the project area will be to maintain or improve overall habitat quality for listed salmonids, rockfish, marbled murrelet, and southern resident killer whale relative to current conditions. Short-term localized water quality degradation during construction will not impact habitat for juvenile salmonids because of the short-term nature of the effects on water quality and because of seasonal work restrictions; thus, current water quality conditions will be maintained in the long term. Pile-driving will be short-term and exceedances of waterborne noise criteria will be limited to the West Waterway and the northwest nearshore of Harbor Island where most listed species are rare or unlikely to occur. Though short-term and outside of the outmigratory period, a small number of juvenile salmon may be exposed to waterborne noise levels that exceed injury criteria. Conservation measures in the form of work window restrictions and marine mammal and seabird monitoring programs will minimize potential adverse effects.

The effects of multiple rigs will be minimized since impact pile driving of steel piles will be limited to one rig per day. Proposed monitoring will also monitor for murrelets at all impact pile driving rigs operating during a single day. Acoustic modeling and the development of all injury and disturbance zones has accounted for multiple rig pile driving operations by modeling the maximum number of blows that may occur on any given day.

In the long-term, the reduction of total overwater coverage will improve habitat conditions within the West Waterway. The removal of creosote-treated piles and any residual sediment contamination from dredging will also improve long-term water quality conditions within the waterway.

Long-term operational effects on southern resident killer whale will be insignificant since total traffic will decrease and will not traverse areas most heavily used by southern residents in Puget Sound.

5.4 Interdependent and Interrelated Actions

There are no interdependent or interrelated actions that will affect the species of concern or associated critical habitats. Dredging activities associated with Terminal 5 will likely precede the Seattle Harbor Navigation Improvement project, a federal channel deepening project proposed by the USACE. All dredging activities proposed at Terminal 5 will coordinate with this larger federal project.

5.5 Cumulative Effects on Habitat

From an ESA perspective, the analysis of cumulative effects considers future non-federal actions (i.e., non-federal projects that do not require federal permits) that may affect habitats and listed species in the action areas. Any future project that entails inwater work would require a federal permit and appropriate ESA review.

The action area is located in heavily modified and heavily utilized areas, where significant alteration to salmonid and other marine habitats has occurred. This Project will not contribute significantly to cumulative adverse effects on marine habitat. Dredging, removal of existing fender piles, and reduction in overwater coverage will likely improve habitats by removing contaminated sediments and creosote-treated piles.

6.0 CRITICAL HABITAT EVALUATION

As described in Section 4, critical habitat has been designated for Puget Sound Chinook salmon, Puget Sound steelhead trout, Coastal-Puget Sound bull trout, and southern resident killer whale. Designated critical habitat within the action area for these animals contain one to several PCEs and potential effects are summarized in Tables 7, 8, and 9 for Chinook salmon/steelhead trout, bull trout, and killer whale, respectively.

Table 7 – Potential Effects on Critical Habitat PCEs for Chinook Salmon/Steelhead

Habitat	PCE	Effect from Proposed Action
Estuarine and Nearshore Marine Areas	Free of obstruction	Passage will be impeded in the action area during inwater work; project effects are likely to delay migration periodically for a period of hours, but will be limited to the duration of inwater work during dredging and pile driving which will all occur during the inwater work window when salmonids are not expected to be present. Pile placement will cause additional obstruction in the project area, but all new piles will be installed beneath or at the face of the existing Terminal 5 Wharf within existing riprap substrates and where little light penetration occurs. It is not likely juvenile Chinook salmon or steelhead will use this portion of critical habitat. In the long-term, numerous creosote-treated piles will be removed from critical habitat and the terminal overwater footprint will decrease by approximately 8,500 square feet at the face of the wharf. Potential effects caused by the use of multiple pile driving rigs on fish passage will be minimal, based on their temporary presence within critical habitat during periods when outmigration is low. Underwater sound modeling to determine injury zones that may be avoided within critical habitat were conducted using the maximum number of impact pile driving blows per day.
	Water quality and salinity	Short-term effects on water quality will occur related to dredging and pile driving, but turbidity is expected to be limited, short-term, and localized and is not expected to result in any long-term effects. Resuspension of sediments and contaminants may occur during inwater work, but Chinook salmon and steelhead would not be expected to be present; additionally, if present, they would not be expected to experience substantial effects, because the duration of exposure to potentially resuspended chemicals will not be long in duration. It is unlikely that dredging would result in water column contaminant concentrations that would pose a risk to listed fish species. Dredged Material Management Office (DMMO) sediment chemistry results indicate that all sediments are suitable for open water disposal. Water quality monitoring will occur concurrent with dredging in accordance with the 401 Water Quality Certification issued for the project. Inwater work for the project will comply with the timing restrictions specified in the inwater work window when Chinook salmon and steelhead are not expected to be present. No effects are expected on salinity.
	Water quantity	No effect are expected on water quantity.
	Natural cover[1]	Natural cover is absent in the action area; there will be no effect on the availability of natural cover. Dredging will result no loss of shallow water habitat.
	Juvenile and adult forage	Dredging will temporarily disturb existing benthic organisms and habitat. However, due to existing habitat conditions and feeding habits, it is expected that impacts to critical habitat via disturbance of the epibenthic prey community will be insignificant. All dredge disturbance will occur in deep water where very few juvenile salmon are expected to feed. There is no forage fish spawning in the action area, and they are not expected in high numbers.

[1] Large wood, side channels, pools, undercut banks, and unembedded substrates.

Table 8 – Potential Effects on Critical Habitat PCEs for Bull Trout

Habitat	PCE	Effect from Proposed Action
Migration habitats and Marine Shoreline Environments	Physical, biological, or water quality and foraging, and habitat barriers	Short-term effects on water quality will occur related to dredging but turbidity is expected to be limited, short-term, and localized and is not expected to result in any long-term effects. Resuspension of sediments and contaminants may occur during inwater work, when bull trout are not expected to be present; additionally, if present, they would not be expected to experience substantial effects because the duration of exposure to potentially resuspended chemicals will not be long in duration, and it is unlikely that dredging would result in water column contaminant concentrations that would pose a risk to listed fish species. DMMO sediment chemistry results indicate that all sediments are suitable for open water disposal. Water quality monitoring will occur concurrent with dredging in accordance with the 401 Water Quality Certification issued for the project. Inwater work for the project will comply with the timing restrictions specified in the inwater work window when bull trout are not expected to be present. Dredging will temporarily remove existing benthic organisms and habitat. However, due to existing habitat conditions and feeding habits, it is expected that impacts to fish via disturbance of the epibenthic prey community will be insignificant. Recolonization by benthic organisms will occur quickly. There is no forage fish spawning in the action area, and they are not expected in high numbers. Dredging will result in no loss of shallow water habitat. No activities will result in any increase in surface water temperatures. The increase in the number of piles will not cause any impediments to foraging and migratory movements because most piles will be driven beneath the Terminal 5 wharf where little light penetration occurs. H- and sheet piles driven near the face of the wharf will be driven to near the existing bottom; no aquatic habitats will be cut off or lost. Pile driving may cause temporary avoidance of critical habitats during impact pile driving events, but these activities will be conducted during approved work windows when few bull trout are expected to be present. Potential effects caused by the use of multiple pile driving rigs on fish passage will be minimal based on their temporary presence within critical habitat during periods when presence is low. Underwater sound modeling to determine injury zones within critical habitat were conducted using the maximum number of impact pile driving blows per day. In the long-term, numerous creosote-treated piles will be removed from critical habitat and the terminal overwater footprint will decrease by approximately 12,000 square feet at the face of the wharf.
	Habitat features[1] and non-native species	These features are absent in the action area; no effect will occur. No non-native competing species are present within the project and action areas.

[1] Large wood, side channels, pools, undercut banks, and unembedded substrates.

Table 9 – Potential Effects on Critical Habitat PCEs for Southern Resident Killer Whale

Habitat	PCE	Effect from Proposed Action
Marine Environment	Water quality and foraging	Short-term effects on water quality will occur related to dredging but turbidity is expected to be limited, short-term, and localized to the West Waterway and is not expected to result in any long-term effects. Killer whales have not been documented within the waterways of the Duwamish River. Temporary waterborne noise associated with pile driving would be limited to the West Waterway and the nearshore along the northwest portion of Harbor Island. Resuspension of sediments and contaminants may occur during inwater work, but killer whales and their prey would not be expected to be present; additionally, if present, they would not be expected to experience significant effects because the duration of exposure to potentially resuspended chemicals will not be long in duration, and it is unlikely that dredging would result in water column contaminant concentrations that would pose a risk to killer whales or their prey. Water quality monitoring will occur concurrent with dredging in accordance with the 401 Water Quality Certification issued for the project. Inwater work for the project will comply with the timing restrictions specified in the inwater work window when salmonids are not expected to be present. Pile driving activities are not expected to interfere with foraging opportunities since waterborne noise will be confined to the West Waterway and innermost portions of Elliott Bay near Harbor Island.
	Prey Species	Dredging will temporarily disturb existing habitat for Chinook salmon, killer whales' favored prey source. However, due to existing habitat conditions and feeding habits, it is expected that impacts to killer whale prey items (salmon) via disturbance of the epibenthic prey community will be insignificant. There is no forage fish spawning in the action area, and they are not expected in high numbers.
	Passage conditions	All potential effects (turbidity, sediment resuspension, and noise) will be short-term and occur within the West Waterway where killer whales are not likely to reside or traverse. Operationally, fewer cargo vessels will call at Terminal 5, further minimizing potential effects of vessel interactions in Puget Sound.

7.0 EFFECTS DETERMINATIONS

The effects determination is the conclusion of the analysis of potential direct or indirect effects of the proposed activity on listed species and critical habitat. Regulatory guidance from the Final Section 7 Consultation Handbook (USFWS and NMFS 1998) was used to make the effects determination for the proposed activity as described below.

The range of conclusions that could result from the effects analysis for the effects determination includes:

- **No effect** – the appropriate conclusion when the action agency determines its proposed action will not affect listed species or critical habitat.

- **May affect, is not likely to adversely affect** – the appropriate conclusion when effects on listed species are expected to be discountable, insignificant, or completely beneficial. Beneficial effects are contemporaneous positive effects without any adverse effects on the species. Insignificant effects relate to the size of the impact and should never reach the scale where take occurs. Discountable effects are those extremely unlikely to occur. Based on best judgment, a person would not: (1) be able to meaningfully measure, detect, or evaluate insignificant effects; or (2) expect discountable effects to occur.

- **May affect, is likely to adversely affect** – the appropriate conclusion if any adverse effect to listed species may occur as a direct or indirect result of the proposed action or its interrelated or interdependent actions, and the effect is not discountable, insignificant, or beneficial (see definition of "may affect, is not likely to adversely affect").

A key factor in making an effect determination and distinguishing between a significant and insignificant effect is determining if the effect would be significant enough to cause a take. "Take," as defined by the ESA, includes such activities that harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct [ESA §3(19)]. "Harm" is further defined to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing behavioral patterns such as breeding, feeding, or sheltering. "Harass" is further defined as actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns that include, but are not limited to, breeding, feeding, or sheltering (50 CFR §17.3).

7.1 Fish

7.1.1 Effects Determinations of Species

7.1.1.1 ESA-listed Salmonids

Based on the guidance and definitions provided above and the previously discussed project effects, this project **may affect, and is likely to adversely affect Puget Sound Chinook salmon, Puget Sound steelhead, and Coastal-Puget Sound bull trout.** Justification for this determination is provided below.

Inwater work will occur during the inwater work window when listed salmonids are not expected to be present in large numbers, but a few rearing juvenile and subadult fish may be present.

Therefore, the project **may affect, and is likely to adversely affect listed fish species**, because:

- Waterborne sound levels are predicted to exceed criteria for injury to fish. This will be limited to an area 127 meters from the edge of the wharf during agency-approved work windows when few juvenile salmonids will be migrating. This injury zone will also allow any fish to avoid the area of pile driving and will not block the migratory corridor through the West Waterway. However, the few ESA listed salmonids within the injury zone will be exposed to potentially injurious levels of waterborne noise. These effects are therefore considered low, but significant.

- Substrate disturbance of benthic and epibenthic prey items will occur during dredging. However, this effect will be short-term and temporary, and no long-term modifications of salmonid prey species habitats are expected. These effects are therefore considered insignificant.

- Short-term and localized impacts on water quality could result in the form of short-term changes in water column turbidity and resuspended contaminants for fish and fish prey, and there is minimal risk of acute contaminant exposure to fish that may be in the area. Direct fish mortality or stress from suspended sediment is not expected to occur, and water quality effects are not expected to be at a level that would affect the abundance of water column prey items. These effects are thus determined to be insignificant.

- Beneficial effects include removal of creosote-treated piles and decreasing the overwater footprint at the face of the wharf by over 8,500 square feet.

7.1.1.2 ESA-Listed Rockfish

Based on the guidance and definitions provided above and the previously discussed project effects, this project **may affect, but is not likely to adversely affect bocaccio, canary rockfish, and yelloweye rockfish.** Justification for this determination is provided below.

The project **may affect, but is not likely to adversely affect** bocaccio, canary rockfish, and yelloweye rockfish because these species are highly unlikely to be present within the action area:

- The habitats within the West Waterway are not suitable for adult bocaccio, canary rockfish, and yelloweye rockfish because of the much deeper habitats that adult fish typically occupy and the lack of preferred natural structure and high relief bottom habitats.

- The habitats within the West Waterway are not suitable for juvenile bocaccio, canary rockfish, and yelloweye rockfish because of the lack of shallow water eelgrass and other marine macrovegetation habitats used by juveniles to rear and forage.

7.1.1.3 Other ESA-listed Fish Species

Based on the guidance and definitions provided above and the previously discussed project effects, this project will have **no effect** on green sturgeon and eulachon. Both of these species are rare in the action area and Puget Sound, which is not considered within the natural range of the two species.

7.1.2 Effects Determinations of Critical Habitats

Based on the guidance and definitions provided above and the previously discussed project effects, this project **may affect, but is not likely to adversely affect, designated critical habitat for Puget Sound Chinook salmon, Puget Sound steelhead trout, and Coastal-Puget Sound bull trout.** Justification for these determinations and conclusions is provided below.

The project **may affect, but is not likely to adversely affect** designated critical habitat because:

- Substrate disturbance effects on prey species will be insignificant, because the existing substrate has been dredged previously, exists in deep water locations, and is below the depth that juvenile salmonids would be expected to be feeding. Adult salmonids are not expected to feed upon epibenthic prey. Forage fish, a known prey of adult salmon, would not be expected to spawn in or near the action area because suitable substrates are lacking and marine macrovegetation is not present.

- Impacts to water column habitat are expected to be temporary and localized, and no long-term water quality effects are expected. Water quality effects are not expected to be at a level that would affect the abundance of water column prey items; therefore, these effects are considered insignificant.

- There will be no effect on water quantity or flows.

- There will be no effect on availability of natural cover.

- Fish passage effects, if any, would be limited to the duration of inwater work during, which will occur during the inwater work window when salmonids are not expected to be present. These effects are thus discountable.

- BMPs will be in place to minimize the potential for spills to occur and to minimize the effect if they do occur. These effects are therefore expected to be insignificant.

Information presented above shows that critical habitat will not be permanently degraded. The effects of this action will lower the value of water quality and passage in the action area temporarily, but will not affect the conservation value of the action area over the long term for the ESUs and DPSs with critical habitat considered here. Actions will also have positive benefits in the long-term due to pile removal, decreasing the overwater footprint of the wharf, and the removal of degraded sediments.

7.2 Southern Resident Killer Whale

7.2.1 Effects Determination of Species

Based on the guidance and definitions provided above and the previously discussed project effects, this project **may affect, but is not likely to adversely affect, southern resident killer whale.**

This project **may affect, but is not likely to adversely affect** killer whale, because:

- Waterborne sound levels that exceed disturbance criteria will only occur within the West Waterway and the nearshore of Harbor Island where it is highly unlikely that killer whales will be present. These effects are therefore considered discountable.

- The number of vessels that will operate as a result of proposed project improvements will decrease and will not transit areas where the great majority of whales reside in Puget Sound; therefore these effects are expected to be discountable.

- The likelihood is extremely low that killer whales could occur in the action area during dredging and be temporarily displaced or subject to temporary water quality effects. Therefore, these effects are considered discountable.

- Construction of the project will not affect adult Chinook salmon (primary killer whale prey). Though a small number of juvenile salmon may be in the project area and temporarily exposed to injurious levels of waterborne noise (outside of the outmigratory season), these effects will not impact the total population of adult salmon available to killer whales.

- BMPs will be in place to minimize the potential for spills to occur and to minimize the effect if they do occur. These effects are therefore expected to be insignificant.

7.2.2 Effect Determination for Critical Habitat

Based on the guidance and definitions provided above and the previously discussed project effects, this project **may affect, but is not likely to adversely affect, killer whale critical habitat** because:

- Inwater work will be restricted to the work window when few salmon (primary killer whale prey) are present.

- Impacts to water column habitat (i.e., water quality) are expected to be temporary and localized, and no long-term water quality effects are expected. These effects are therefore considered insignificant.

- Passage limitations are unlikely because all potential effects would be short-term and limited to the West Waterway and innermost Elliott Bay where killer whales are unlikely to reside or traverse.

- BMPs and conservation measures will be in place to minimize the potential for spills and negative effects if they do occur. These effects are therefore expected to be insignificant.

7.3 Marbled Murrelet

Based on guidance and definitions provided above and the previously discussed project effects this project **may affect, but is not likely to adversely affect** marbled murrelet.

The project **may affect but is not likely to adversely affect** marbled murrelet because:

- The likelihood is low that marbled murrelets would occur within the industrial area of the West Waterway action area.

- Waterborne sound at levels predicted to exceed criteria for injury would occur only within 8 meters of the existing Terminal 5 wharf. With an approved marbled murrelet monitoring program in place, these effects will be discountable.

7.4 Other Species

Based on the guidance and definitions provided above and the previously discussed project effects, this project will have **no effect** on humpback whale and the four species of listed sea turtles. All of these species are rare in the action area and Puget Sound is not considered within the natural range of the species.

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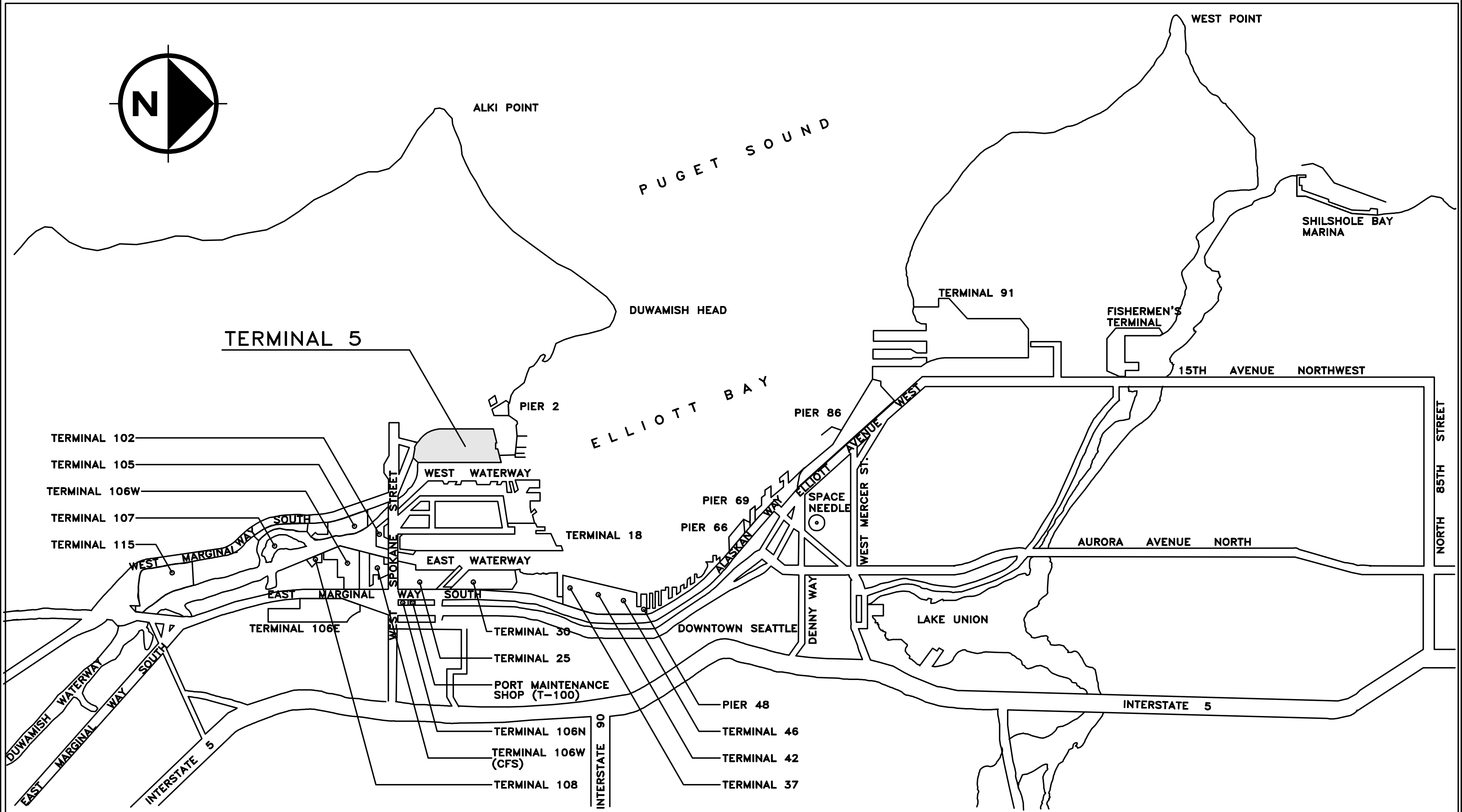
SHEETS



VICINITY MAP – NO SCALE

TERMINAL 5 CARGO WHARF REHABILITATION AND BERTH DEEPENING

PURPOSE: STRENGTHEN CRANE RAIL; SLOPE STABILIZATION AND TOE WALL; BERTH DEEPENING

DATUM: MLLW = 0.0 FEET

ADJACENT PROPERTY OWNERS:
1. CITY OF SEATTLE
2. BNSF
3. WA DNR
4. RICHTER, EDDIE M
5. GENERAL STEEL SERVICES OF WASHINGTON LLC

Port of Seattle
P.O. BOX 1209
SEATTLE, WA 98111

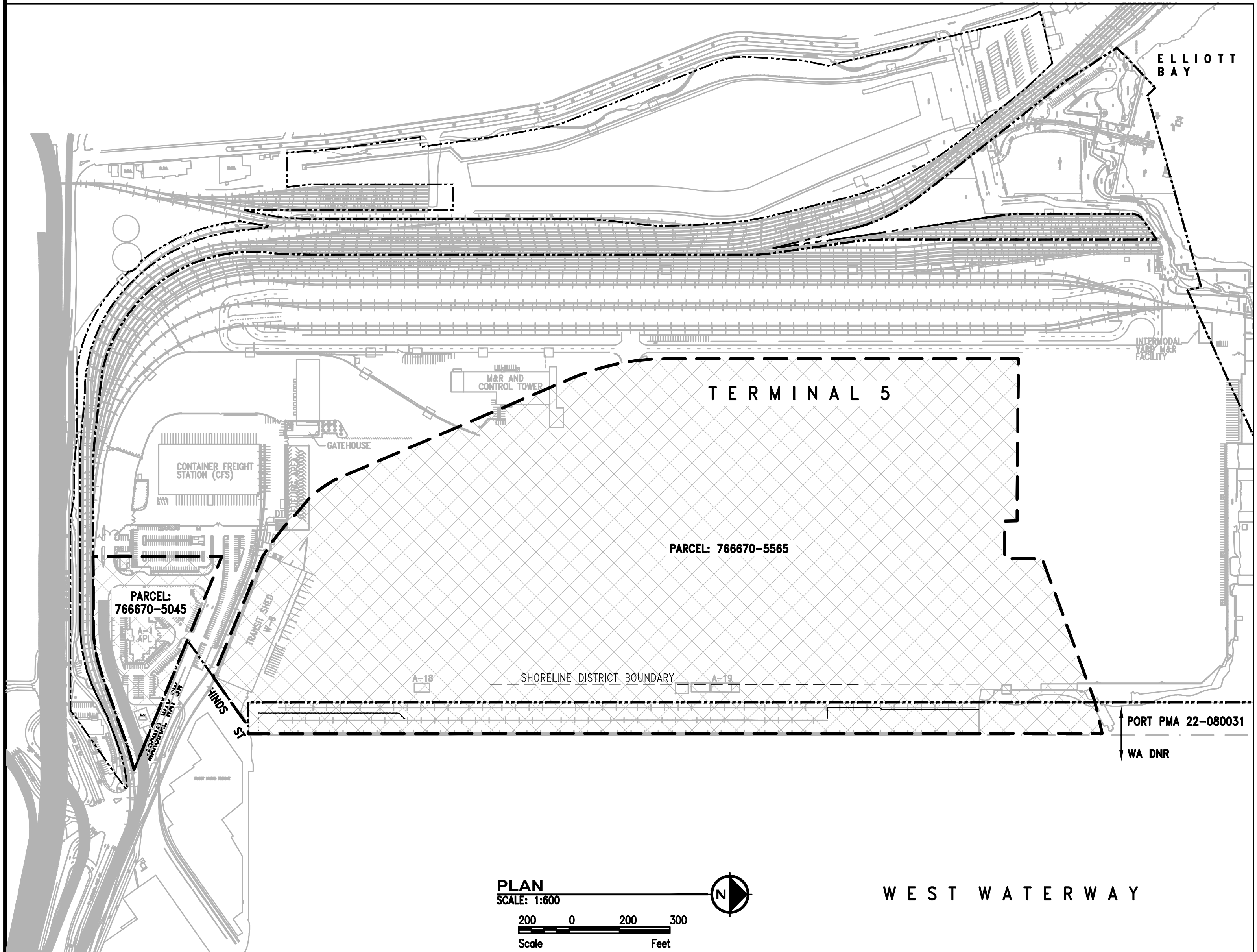
LATITUDE:	47.3433 N
LONGITUDE:	122.2144 W
MEAN HIGHER HIGH WATER:	11.36'
MEAN LOWER LOW WATER:	0.00'

CITY OF: SEATTLE COUNTY OF: KING STATE OF: WASHINGTON

APPLICATION BY: PORT OF SEATTLE
P.O. BOX 1209
SEATTLE, WA 98111

SHEET TITLE: VICINITY MAP
SHEET 01 of 21

DATE: MARCH 2015



PRIMARY WORK PARCELS INFORMATION

PARCEL: 766670-5565
OWNER: PORT OF SEATTLE
ADDRESS: 2701 26TH AVE SW 98106
LEGAL: SEATTLE TIDE LDS EXT #1 BLK 427 & LOTS 4-16 BLK 428 & LOTS 1-7 BLK 429 & BLKS 432 & 433 & POR OF LOTS 1 & 2 & 40-48 BLK 434 OF SD PLAT AND BLKS 428A & 432A & 433A OF SEATTLE TIDE LANDS HALLERS SUPL PLAT- TGW PCL ADJ LY WITHIN WEST WATERWAY & W OF LN PLW & 125 FT E OF E LN SD BLKS 427 428 & 429 - 428A TGW PORS VACATED STS ADJ - TGW E 1/2 OF 28TH AVE SW ADJ & POR OF E 34 FT OF W 50 FT OF VAC 28TH AVE SW LY BTWN S MGN OF UNVACATED SW FLORDIA ST & N OF ELY PROD OF N LN OF LOT 36 BLK 440 SEATTLE TIDE LAND TGW POR VAC 28TH AVE SW & VAC SW HANDFORD ST LY ELY & NLY OF PCL A SEATTLE LBA# 3011466 REC #20101028900005 & W OF W MARGINAL WAY SW

PARCEL: 766670-5045
OWNER: PORT OF SEATTLE
ADDRESS: 3443 WEST MARGINAL WAY SW 98106
LEGAL: SEATTLE TIDE LD EXT #1 PCL D SEATTLE LBA #3011161 REC# 20101021900005 SD LBA DAF- ALL SD BLK 426 LESS POR LY WLY OF ALLEY PER AF #1178522

LEGEND:

PORT OF SEATTLE BOUNDARY
OUTER HARBOR LINE
PRIMARY WORK PARCELS

TERMINAL 5 CARGO WHARF REHABILITATION AND BERTH DEEPENING

PURPOSE: STRENGTHEN CRANE RAIL; SLOPE STABILIZATION AND TOE WALL; BERTH DEEPENING

DATUM: MLLW = 0.0 FEET

ADJACENT PROPERTY OWNERS:
1. CITY OF SEATTLE
2. BNSF
3. WA DNR
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5. GENERAL STEEL SERVICES OF WASHINGTON LLC

Port of Seattle
P.O. BOX 1209
SEATTLE, WA 98111

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MEAN LOWER LOW WATER:	0.00'

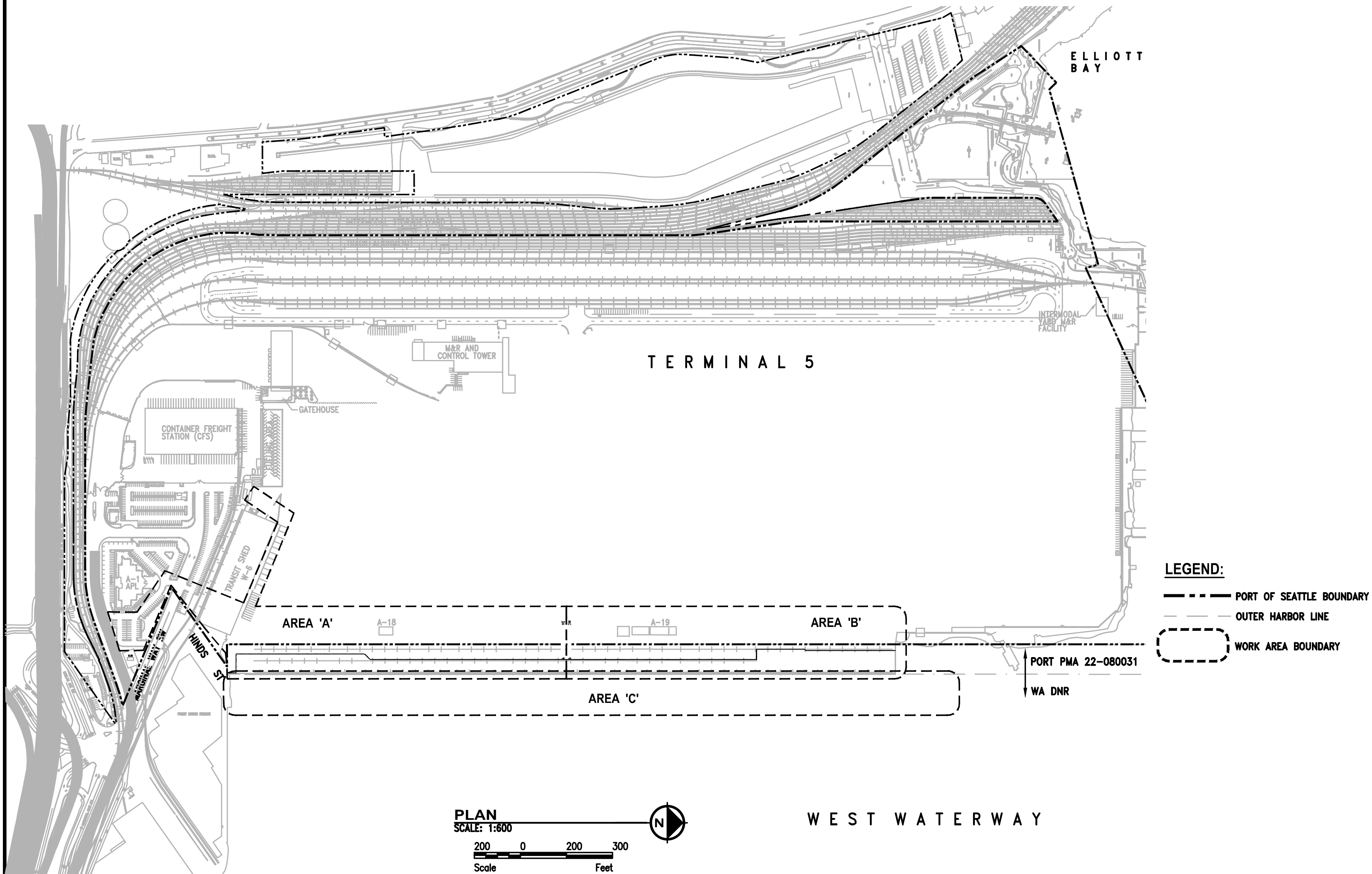
CITY OF: SEATTLE COUNTY OF: KING STATE OF: WASHINGTON

APPLICATION BY: PORT OF SEATTLE
P.O. BOX 1209
SEATTLE, WA 98111

SHEET TITLE: EXISTING CONDITIONS SITE PLAN

SHEET 02 of 21

DATE: MARCH 2015



TERMINAL 5 CARGO WHARF REHABILITATION AND BERTH DEEPENING

PURPOSE: STRENGTHEN CRANE RAIL; SLOPE STABILIZATION AND TOE WALL; BERTH DEEPENING

DATUM: MLLW = 0.0 FEET

ADJACENT PROPERTY OWNERS:
1. CITY OF SEATTLE
2. BNSF
3. WA DNR
4. RICHTER, EDDIE M
5. GENERAL STEEL SERVICES OF WASHINGTON LLC

Port of Seattle
P.O. BOX 1209
SEATTLE, WA 98111

LATITUDE:	47.3433 N
LONGITUDE:	122.2144 W
MEAN HIGHER HIGH WATER:	11.36'
MEAN LOWER LOW WATER:	0.00'

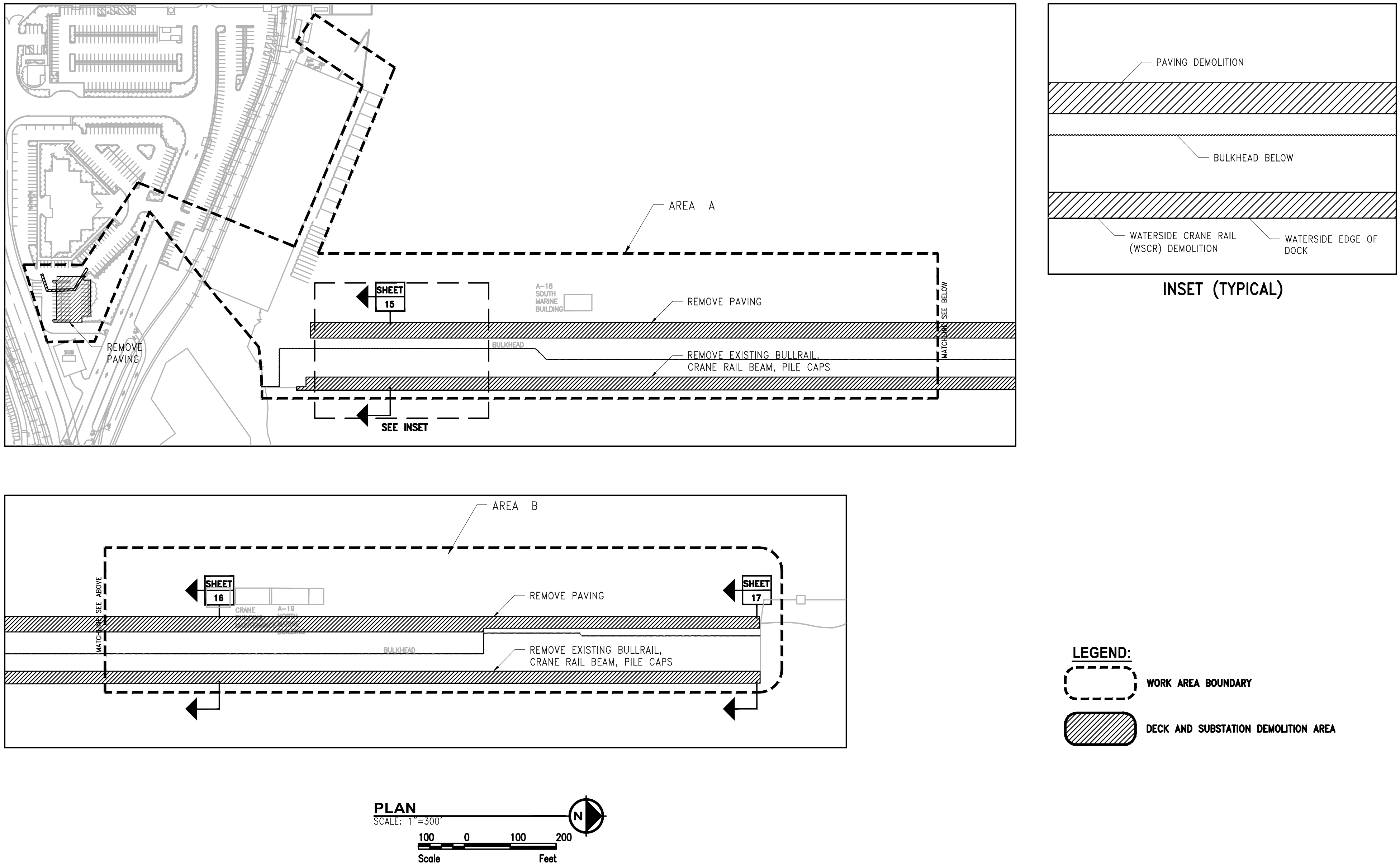
CITY OF: SEATTLE COUNTY OF: KING STATE OF: WASHINGTON

APPLICATION BY: PORT OF SEATTLE
P.O. BOX 1209
SEATTLE, WA 98111

SHEET TITLE: WORK AREAS SITE PLAN

SHEET 03 of 21

DATE: MARCH 2015



TERMINAL 5 CARGO WHARF REHABILITATION AND BERTH DEEPENING

PURPOSE: STRENGTHEN CRANE RAIL; SLOPE STABILIZATION AND TOE WALL; BERTH DEEPENING

DATUM: MLLW = 0.0 FEET

ADJACENT PROPERTY OWNERS:
① CITY OF SEATTLE
② BNSF
③ WA DNR
④ RICHTER, EDDIE M
⑤ GENERAL STEEL SERVICES OF WASHINGTON LLC

Port of Seattle
P.O. BOX 1209
SEATTLE, WA 98111

LATITUDE:	47.3433 N
LONGITUDE:	122.2144 W
MEAN HIGHER HIGH WATER:	11.36'
MEAN LOWER LOW WATER:	0.00'

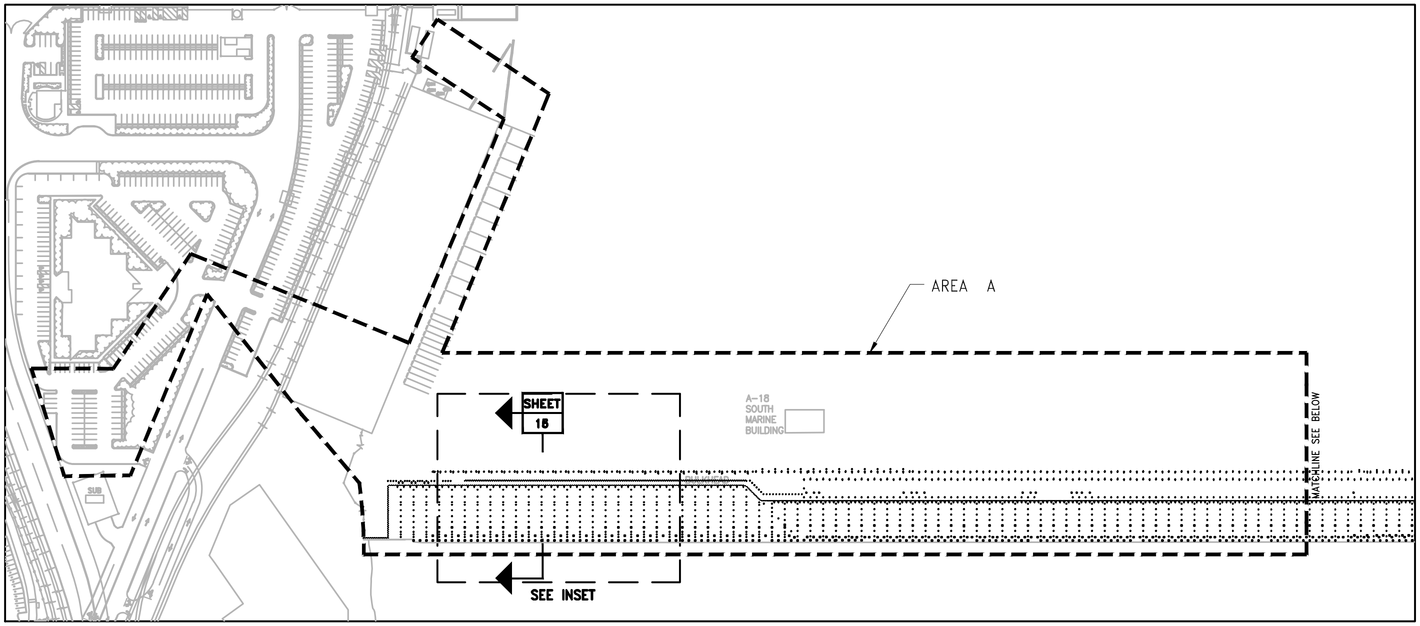
CITY OF: SEATTLE COUNTY OF: KING STATE OF: WASHINGTON

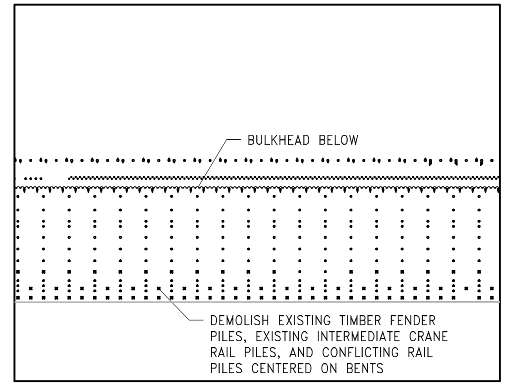
APPLICATION BY: PORT OF SEATTLE
P.O. BOX 1209
SEATTLE, WA 98111

SHEET TITLE: DECK AND SUBSTATION DEMOLITION

SHEET 04 of 21

DATE: MARCH 2015





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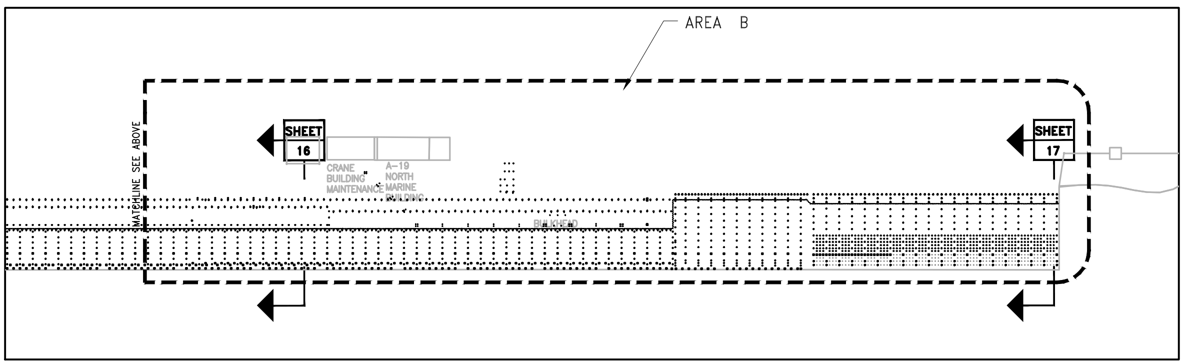


LEGEND:

WORK AREA BOUNDARY

EXISTING STRUCTURAL/TIMBER/PINCH PILE

PILES TO BE REMOVED

PLAN

SCALE: 1"=300'

100 0 100 200

Scale Feet

TERMINAL 5 CARGO WHARF REHABILITATION AND BERTH DEEPENING

PURPOSE: STRENGTHEN CRANE RAIL; SLOPE STABILIZATION AND TOE WALL; BERTH DEEPENING

DATUM: MLLW = 0.0 FEET

ADJACENT PROPERTY OWNERS:

1. CITY OF SEATTLE
2. BNSF
3. WA DNR
4. RICHTER, EDDIE M
5. GENERAL STEEL SERVICES OF WASHINGTON LLC

Port of Seattle
P.O. BOX 1209
SEATTLE, WA 98111

LATITUDE:	47.3433 N
LONGITUDE:	122.2144 W
MEAN HIGHER HIGH WATER:	11.36'
MEAN LOWER LOW WATER:	0.00'

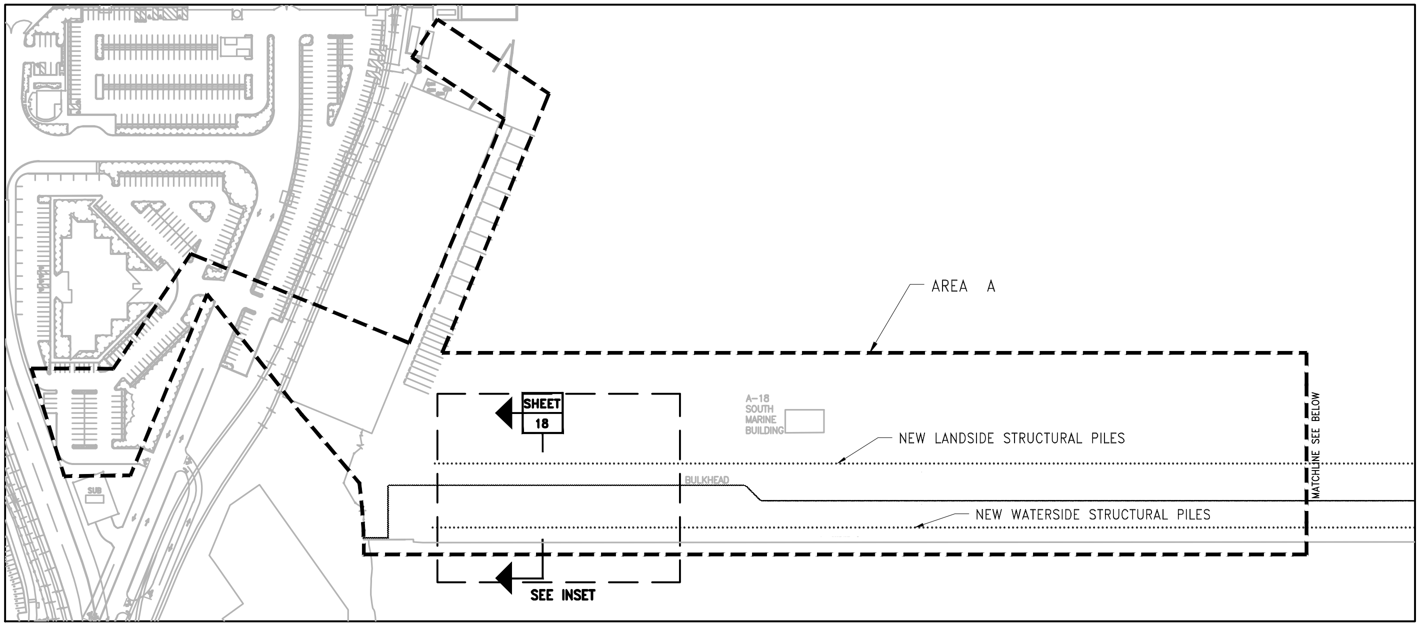
CITY OF: SEATTLE COUNTY OF: KING STATE OF: WASHINGTON

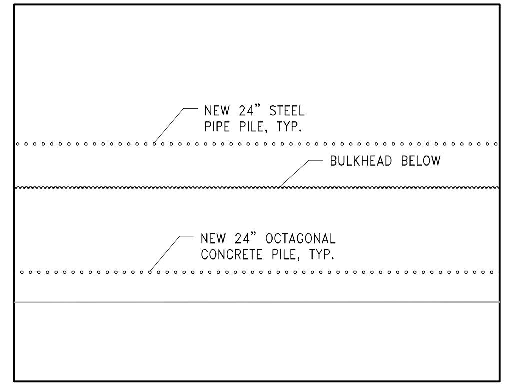
APPLICATION BY: PORT OF SEATTLE
P.O. BOX 1209
SEATTLE, WA 98111

SHEET TITLE: PILE DEMOLITION

SHEET 05 of 21

DATE: MARCH 2015





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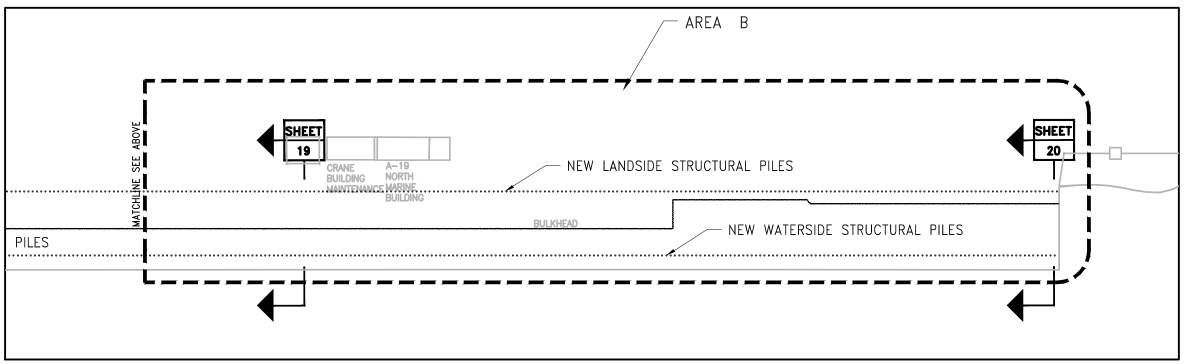


LEGEND:

WORK AREA BOUNDARY

NEW STRUCTURAL PILES

PLAN
SCALE: 1"=300'

100 0 100 200
Scale Feet

N

TERMINAL 5 CARGO WHARF REHABILITATION AND BERTH DEEPENING

PURPOSE: STRENGTHEN CRANE RAIL; SLOPE STABILIZATION AND TOE WALL; BERTH DEEPENING

DATUM: MLLW = 0.0 FEET

ADJACENT PROPERTY OWNERS:
1. CITY OF SEATTLE
2. BNSF
3. WA DNR
4. RICHTER, EDDIE M
5. GENERAL STEEL SERVICES OF WASHINGTON LLC

Port of Seattle
P.O. BOX 1209
SEATTLE, WA 98111

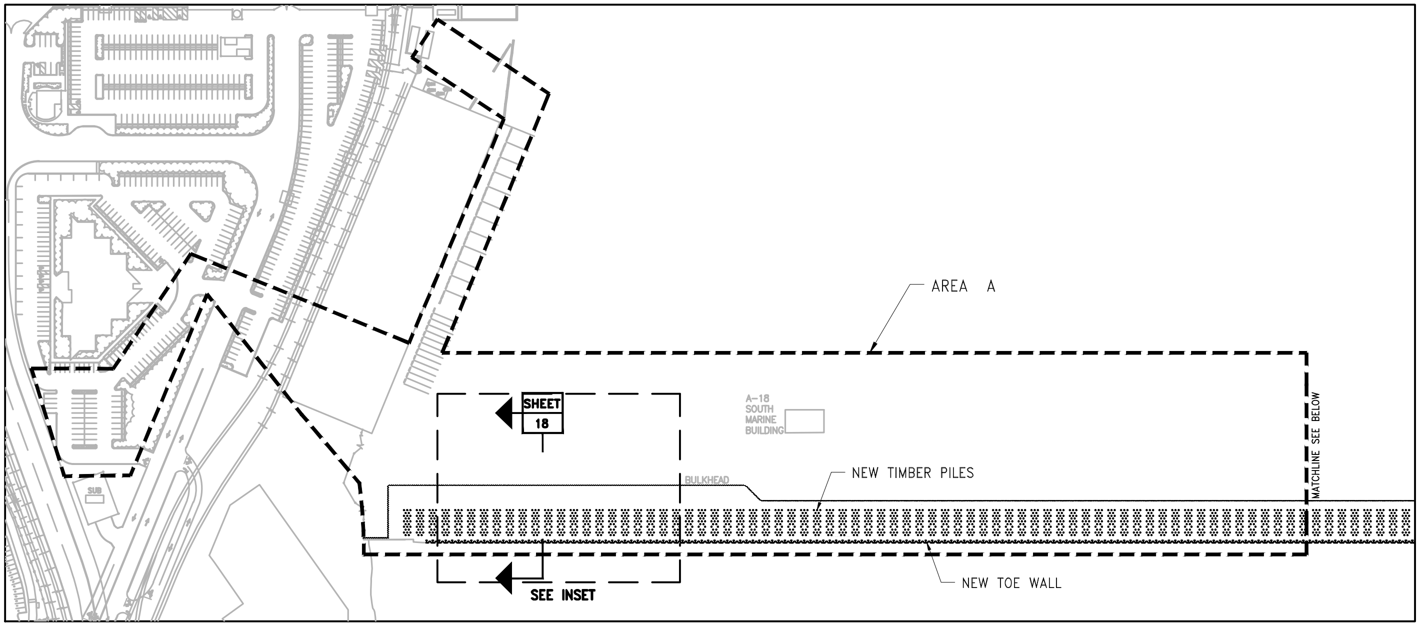
LATITUDE:	47.3433 N
LONGITUDE:	122.2144 W
MEAN HIGHER HIGH WATER:	11.36'
MEAN LOWER LOW WATER:	0.00'

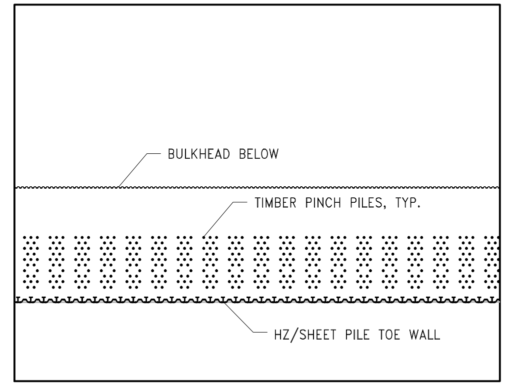
CITY OF: SEATTLE COUNTY OF: KING STATE OF: WASHINGTON

APPLICATION BY: PORT OF SEATTLE
P.O. BOX 1209
SEATTLE, WA 98111

SHEET TITLE: NEW STRUCTURAL PILES
SHEET 06 of 21

DATE: MARCH 2015





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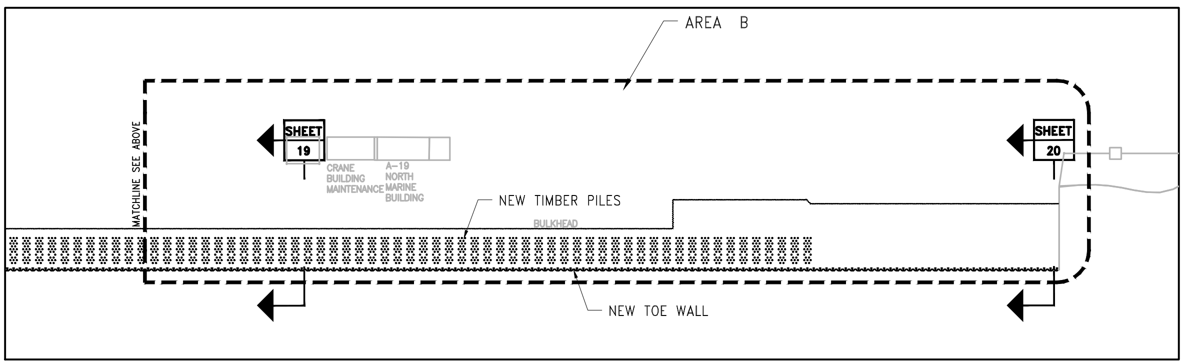
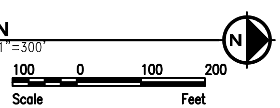


LEGEND:

- WORK AREA BOUNDARY
- NEW TOE WALL, HZ & SHEET PILES
- NEW PINCH PILES



PLAN
SCALE: 1"=300'

TERMINAL 5 CARGO WHARF REHABILITATION AND BERTH DEEPENING

PURPOSE: STRENGTHEN CRANE RAIL; SLOPE STABILIZATION AND TOE WALL; BERTH DEEPENING

DATUM: MLLW = 0.0 FEET

ADJACENT PROPERTY OWNERS:
(1) CITY OF SEATTLE
(2) BNSF
(3) WA DNR
(4) RICHTER, EDDIE M
(5) GENERAL STEEL SERVICES OF WASHINGTON LLC

Port of Seattle
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SEATTLE, WA 98111

LATITUDE:	47.3433 N
LONGITUDE:	122.2144 W
MEAN HIGHER HIGH WATER:	11.36'
MEAN LOWER LOW WATER:	0.00'

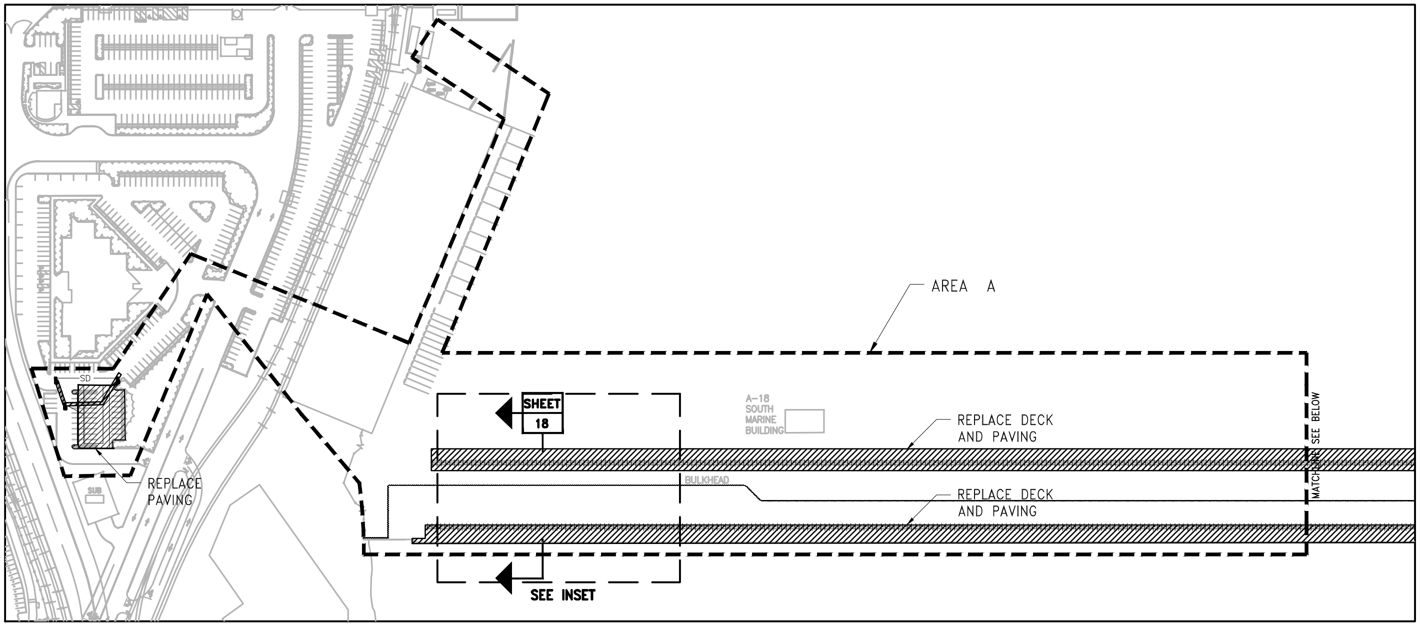
CITY OF: SEATTLE COUNTY OF: KING STATE OF: WASHINGTON

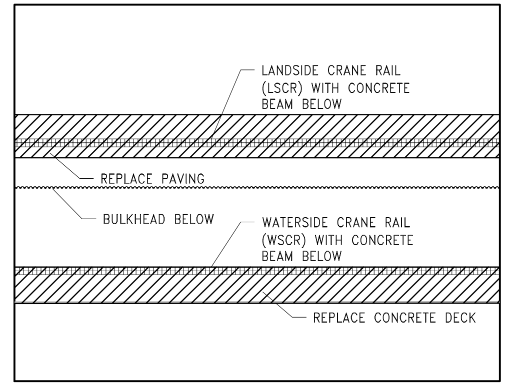
APPLICATION BY: PORT OF SEATTLE
P.O. BOX 1209
SEATTLE, WA 98111

SHEET TITLE: NEW PINCH PILES AND TOE WALL

SHEET 07 of 21

DATE: MARCH 2015





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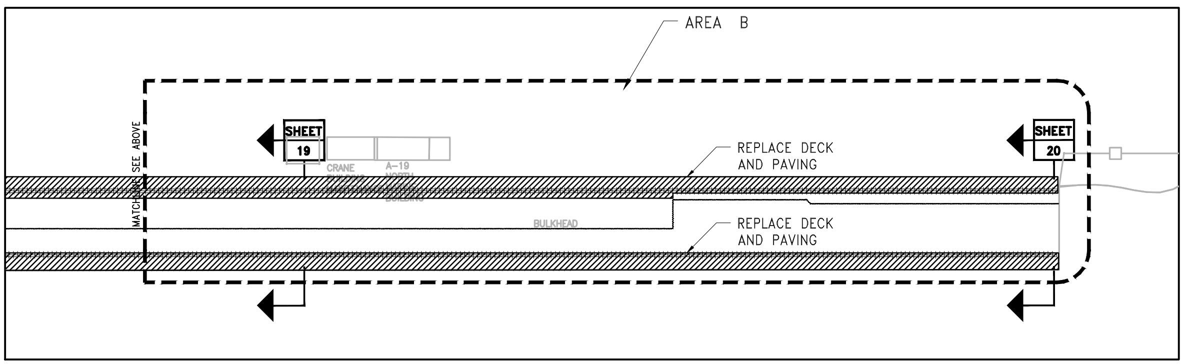


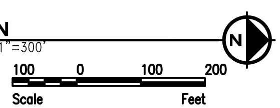
LEGEND:

WORK AREA BOUNDARY

NEW CRANE RAIL

PLAN

SCALE: 1"=300'



TERMINAL 5 CARGO WHARF REHABILITATION AND BERTH DEEPENING

PURPOSE: STRENGTHEN CRANE RAIL; SLOPE STABILIZATION AND TOE WALL; BERTH DEEPENING

DATUM: MLLW = 0.0 FEET

ADJACENT PROPERTY OWNERS:
1. CITY OF SEATTLE
2. BNSF
3. WA DNR
4. RICHTER, EDDIE M
5. GENERAL STEEL SERVICES OF WASHINGTON LLC

Port of Seattle
P.O. BOX 1209
SEATTLE, WA 98111

LATITUDE:	47.3433 N
LONGITUDE:	122.2144 W
MEAN HIGHER HIGH WATER:	11.36'
MEAN LOWER LOW WATER:	0.00'

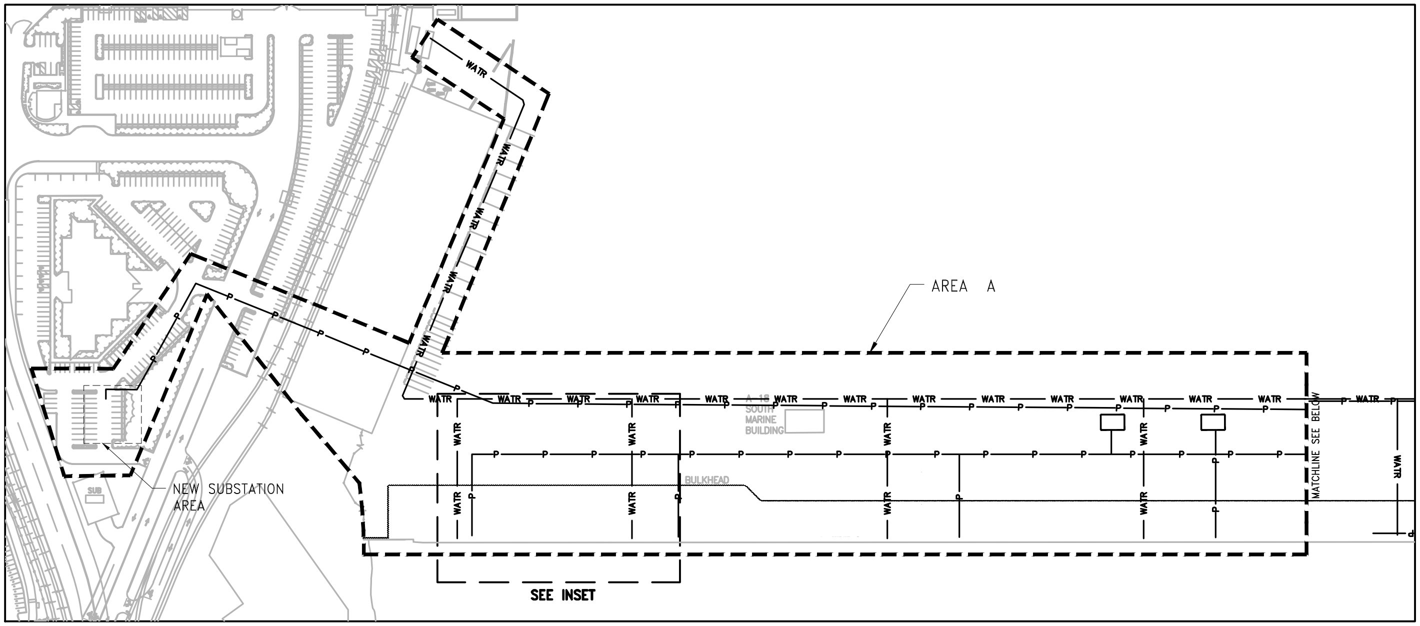
CITY OF: SEATTLE COUNTY OF: KING STATE OF: WASHINGTON

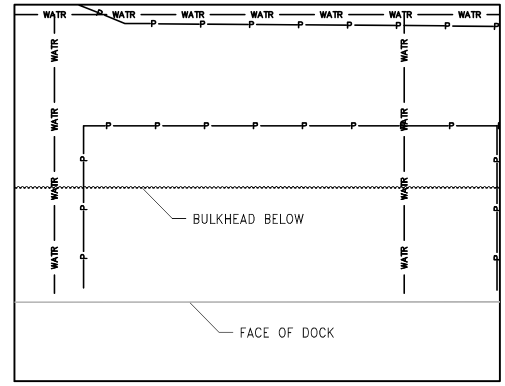
APPLICATION BY: PORT OF SEATTLE
P.O. BOX 1209
SEATTLE, WA 98111

SHEET TITLE: NEW DECK/CRANE RAIL

SHEET 08 of 21

DATE: MARCH 2015





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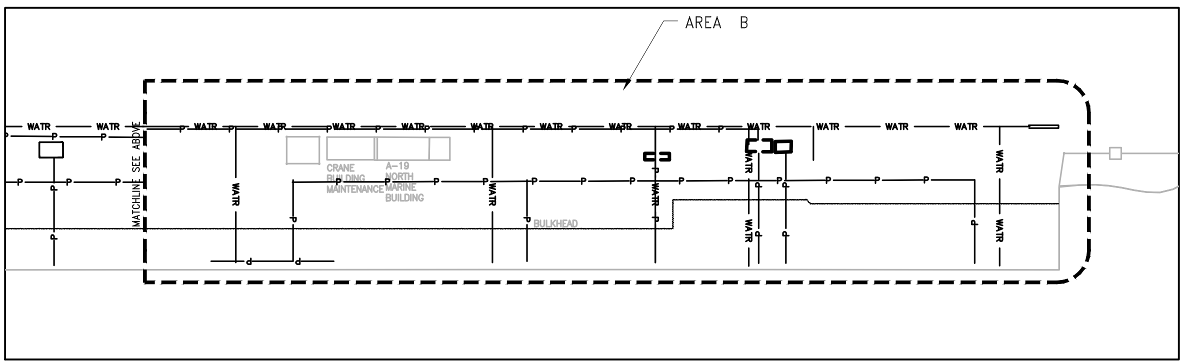

LEGEND:

- WORK AREA BOUNDARY
- WATR — PROPOSED WATER LINE
- P — PROPOSED POWER LINE

PLAN
SCALE: 1"=300'

100 0 100 200
Scale Feet

N

TERMINAL 5 CARGO WHARF REHABILITATION AND BERTH DEEPENING

PURPOSE: STRENGTHEN CRANE RAIL; SLOPE STABILIZATION AND TOE WALL; BERTH DEEPENING

DATUM: MLLW = 0.0 FEET

ADJACENT PROPERTY OWNERS:
(1) CITY OF SEATTLE
(2) BNSF
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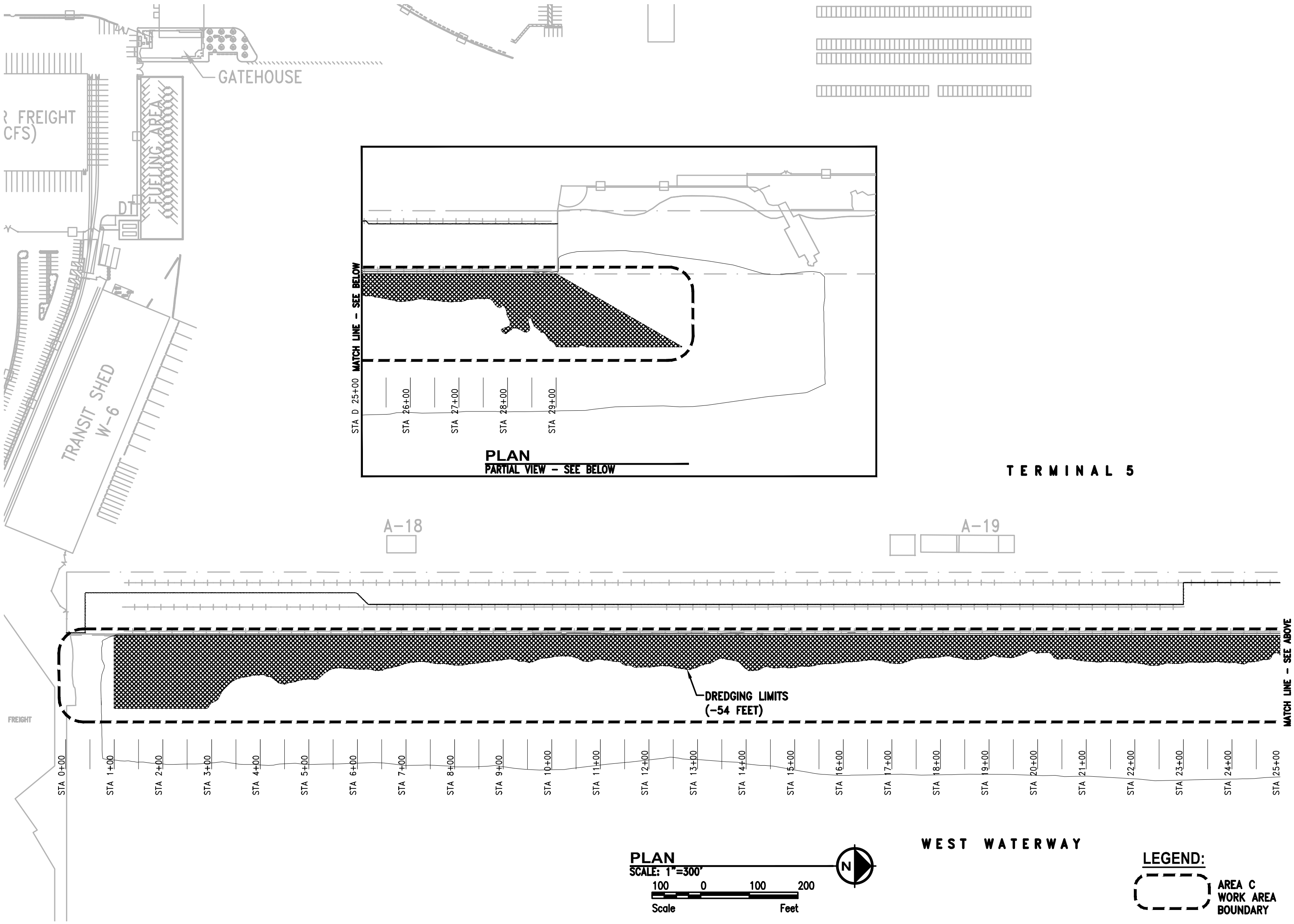
MEAN HIGHER HIGH WATER: 11.36'
MEAN LOWER LOW WATER: 0.00'

CITY OF: SEATTLE COUNTY OF: KING STATE OF: WASHINGTON

APPLICATION BY: PORT OF SEATTLE
P.O. BOX 1209
SEATTLE, WA 98111

SHEET TITLE: NEW UTILITIES
SHEET 09 of 21

DATE: MARCH 2015



NOTES:

1) -53 FEET REQUIRED DEPTH
2) -1 ADVANCED MAINTENANCE
3) UP TO -2 FOR OVERDEPTH
4) UP TO 234,460 SQ FT
5) UP TO 29,800 CU YDS

TERMINAL 5 CARGO WHARF REHABILITATION AND BERTH DEEPENING

PURPOSE: STRENGTHEN CRANE RAIL; SLOPE STABILIZATION AND TOE WALL; BERTH DEEPENING

DATUM: MLLW = 0.0 FEET

ADJACENT PROPERTY OWNERS:
1. CITY OF SEATTLE
2. BNSF
3. WA DNR
4. RICHTER, EDDIE M
5. GENERAL STEEL SERVICES OF WASHINGTON LLC

Port of Seattle
P.O. BOX 1209
SEATTLE, WA 98111

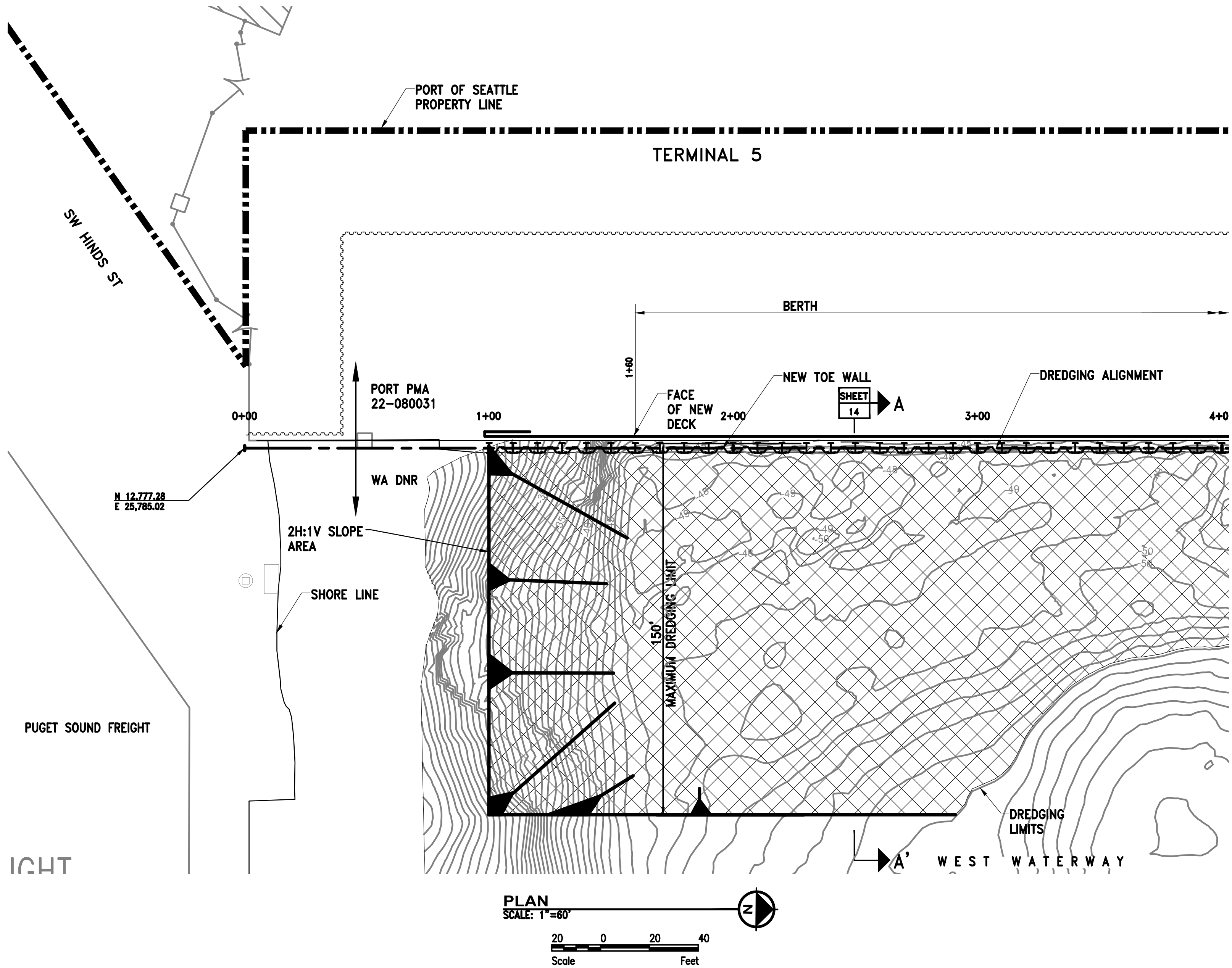
LATITUDE:	47.3433 N
LONGITUDE:	122.2144 W
MEAN HIGHER HIGH WATER:	11.36'
MEAN LOWER LOW WATER:	0.00'

CITY OF: SEATTLE COUNTY OF: KING STATE OF: WASHINGTON

APPLICATION BY: PORT OF SEATTLE
P.O. BOX 1209
SEATTLE, WA 98111

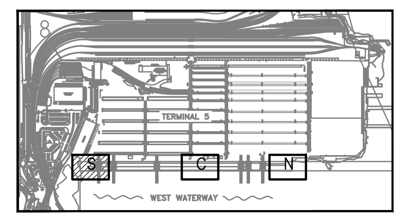
SHEET TITLE: DREDGING PLAN
SHEET 10 of 21

DATE: MARCH 2015



LEGEND:

REQUIRED DREDGING TO –54 FEET MLLW. (–53 FEET DESIGN PLUS 1 FOOT ADVANCE MAINTENANCE)



KEY PLAN
N.T.S.

TERMINAL 5 CARGO WHARF REHABILITATION AND BERTH DEEPENING

PURPOSE: STRENGTHEN CRANE RAIL; SLOPE STABILIZATION AND TOE WALL; BERTH DEEPENING

DATUM: MLLW = 0.0 FEET

ADJACENT PROPERTY OWNERS:
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④ RICHTER, EDDIE M
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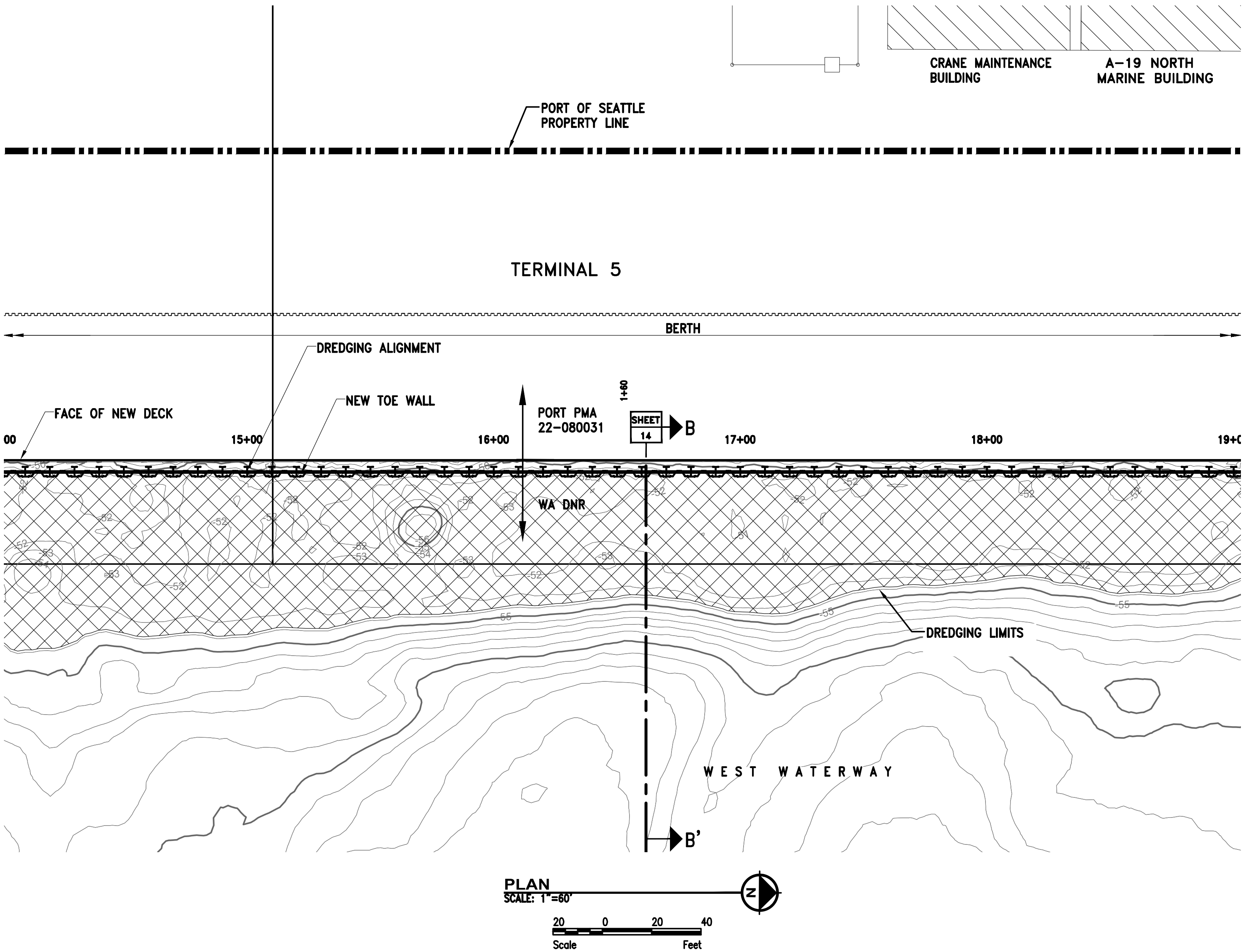
CITY OF: SEATTLE COUNTY OF: KING STATE OF: WASHINGTON

APPLICATION BY: PORT OF SEATTLE
P.O. BOX 1209
SEATTLE, WA 98111

SHEET TITLE: DREDGING PLAN DETAILS TYPICAL SOUTH AREA

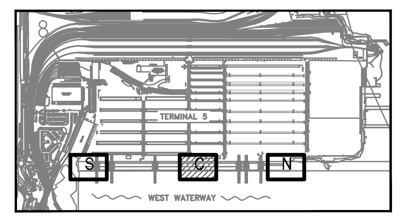
SHEET 11 of 21

DATE: MARCH 2015



LEGEND:

REQUIRED DREDGING TO -54 FEET MLLW. (-53 FEET DESIGN PLUS 1 FOOT ADVANCE MAINTENANCE)



KEY PLAN
N.T.S.

TERMINAL 5 CARGO WHARF REHABILITATION AND BERTH DEEPENING

PURPOSE: STRENGTHEN CRANE RAIL; SLOPE STABILIZATION AND TOE WALL; BERTH DEEPENING

DATUM: MLLW = 0.0 FEET

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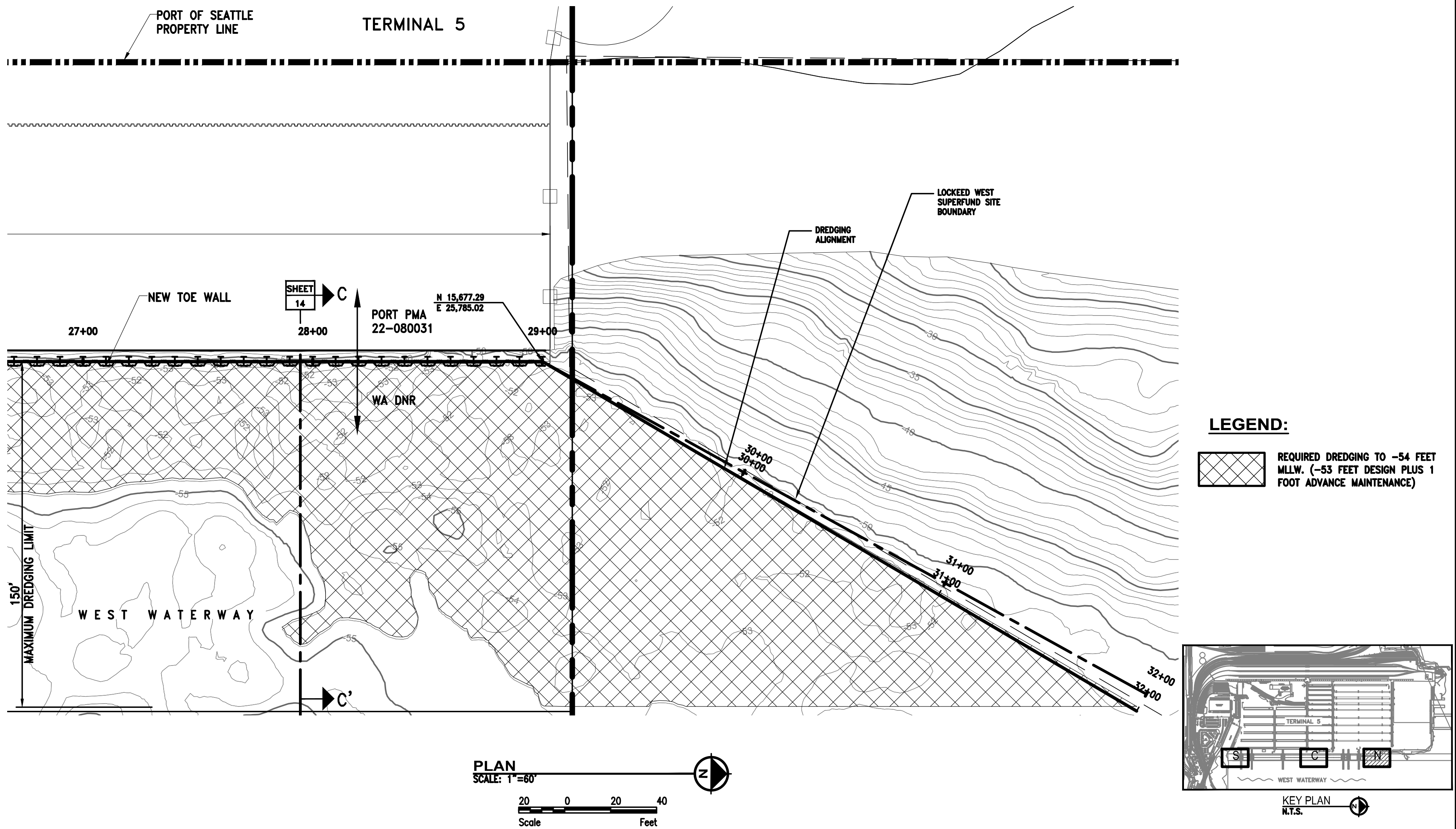
CITY OF: SEATTLE COUNTY OF: KING STATE OF: WASHINGTON

APPLICATION BY: PORT OF SEATTLE
P.O. BOX 1209
SEATTLE, WA 98111

SHEET TITLE: DREDGING PLAN DETAILS TYPICAL CENTRAL AREA

SHEET 12 of 21

DATE: MARCH 2015



TERMINAL 5 CARGO WHARF REHABILITATION AND BERTH DEEPENING

PURPOSE: STRENGTHEN CRANE RAIL; SLOPE STABILIZATION AND TOE WALL; BERTH DEEPENING

DATUM: MLLW = 0.0 FEET

ADJACENT PROPERTY OWNERS:
(1) CITY OF SEATTLE
(2) BNSF
(3) WA DNR
(4) RICHTER, EDDIE M
(5) GENERAL STEEL SERVICES OF WASHINGTON LLC

Port of Seattle
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SEATTLE, WA 98111

LATITUDE:	47.3433 N
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MEAN LOWER LOW WATER:	0.00'

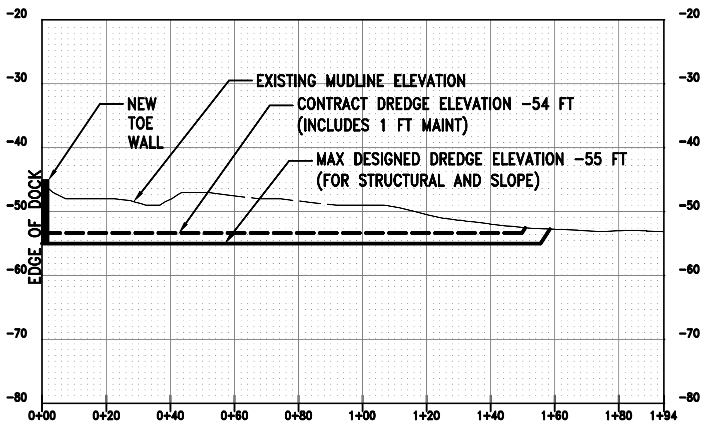
CITY OF: SEATTLE COUNTY OF: KING STATE OF: WASHINGTON

APPLICATION BY: PORT OF SEATTLE
P.O. BOX 1209
SEATTLE, WA 98111

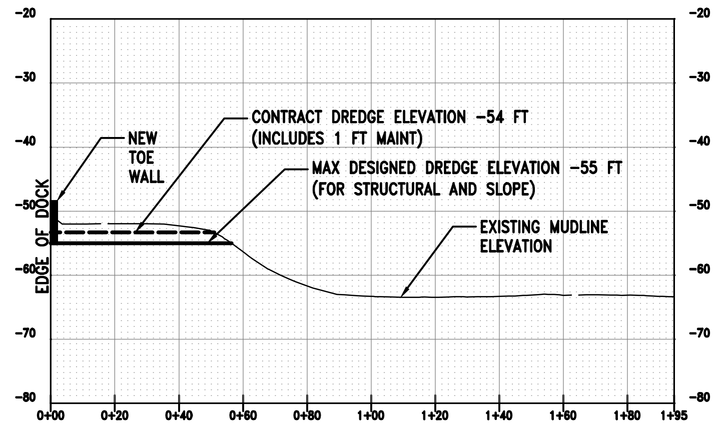
SHEET TITLE: DREDGING PLAN DETAILS TYPICAL NORTH AREA

SHEET 13 of 21

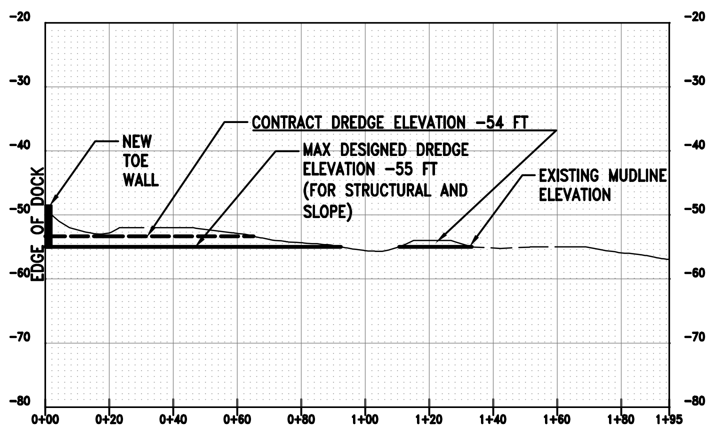
DATE: MARCH 2015



SECTION A–A SHEET11
VERTICAL SCALE: 1"=30'
HORIZONTAL SCALE: 1"=60'



SECTION B–B SHEET12
VERTICAL SCALE: 1"=30'
HORIZONTAL SCALE: 1"=60'



SECTION C–C SHEET13
VERTICAL SCALE: 1"=20'
HORIZONTAL SCALE: 1"=40'

TERMINAL 5 CARGO WHARF REHABILITATION AND BERTH DEEPENING

PURPOSE: STRENGTHEN CRANE RAIL; SLOPE STABILIZATION AND TOE WALL; BERTH DEEPENING

DATUM: MLLW = 0.0 FEET

ADJACENT PROPERTY OWNERS:
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② BNSF ④ RICHTER, EDDIE M

Port of Seattle
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SEATTLE, WA 98111

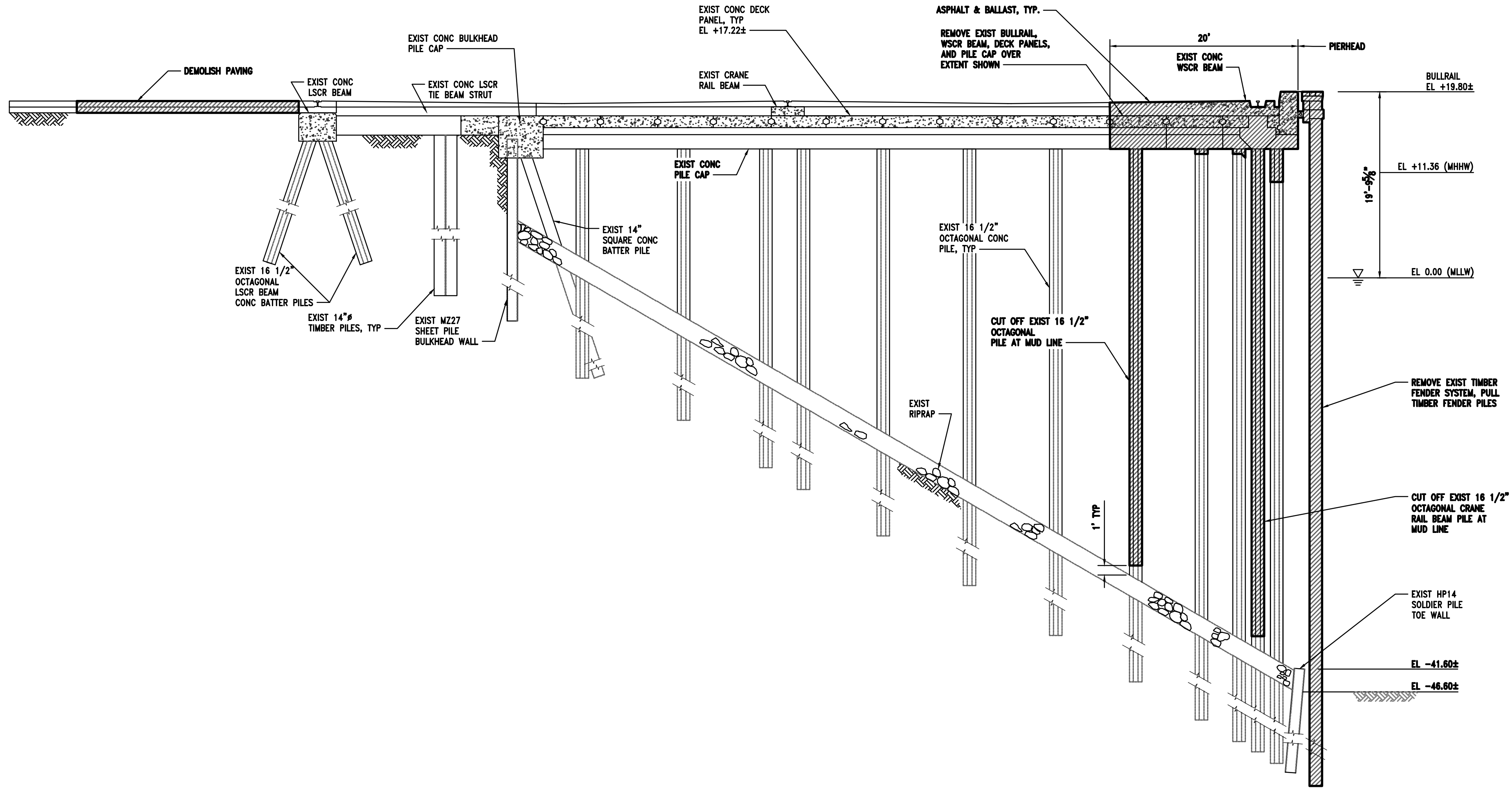
LATITUDE:	47.3433 N
LONGITUDE:	122.2144 W
MEAN HIGHER HIGH WATER:	11.36'
MEAN LOWER LOW WATER:	0.00'

CITY OF: SEATTLE COUNTY OF: KING STATE OF: WASHINGTON

APPLICATION BY: PORT OF SEATTLE
P.O. BOX 1209
SEATTLE, WA 98111

SHEET TITLE: DREDGING CROSS SECTIONS
SHEET 14 of 21

DATE: MARCH 2015



LEGEND:

DEMOLITION AREA

SECTION
BENT 20S
SCALE: 1/16" = 1'-0"

SHEET	SHEET
4	5

6 0 6 12 18 24 30
Scale Feet

TERMINAL 5 CARGO WHARF REHABILITATION AND BERTH DEEPENING

PURPOSE: STRENGTHEN CRANE RAIL; SLOPE STABILIZATION AND TOE WALL; BERTH DEEPENING

DATUM: MLLW = 0.0 FEET

ADJACENT PROPERTY OWNERS:
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SEATTLE, WA 98111

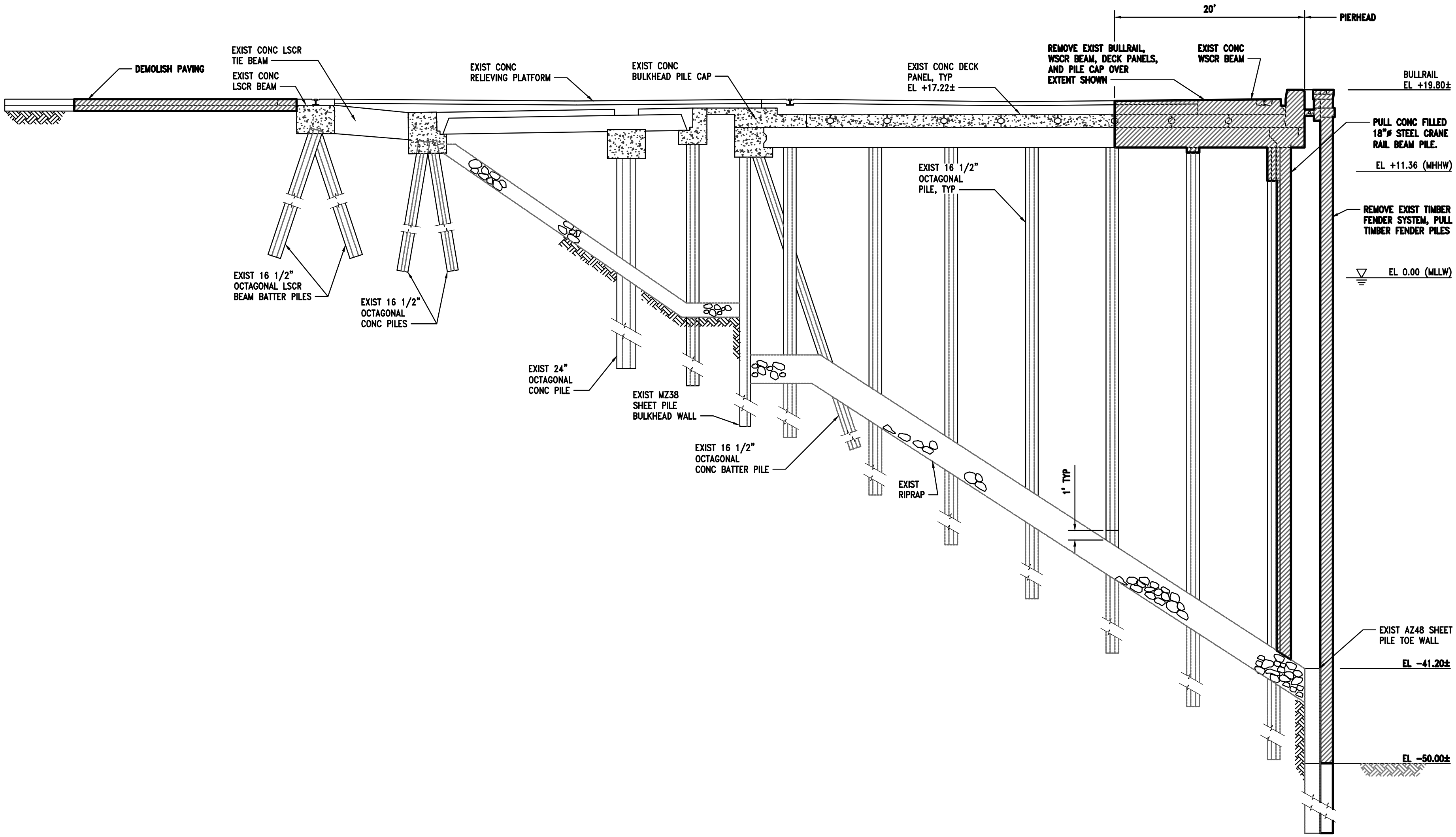
LATITUDE: 47.3433 N
LONGITUDE: 122.2144 W
MEAN HIGHER HIGH WATER: 11.36'
MEAN LOWER LOW WATER: 0.00'

CITY OF: SEATTLE COUNTY OF: KING STATE OF: WASHINGTON

APPLICATION BY: PORT OF SEATTLE
P.O. BOX 1209
SEATTLE, WA 98111

SHEET TITLE: DEMOLITION CROSS SECTION A
SHEET 15 of 21

DATE: MARCH 2015



LEGEND:

DEMOLITION AREA

SECTION
BENT 45
SCALE: 1/16" = 1'-0"

SHEET	SHEET
4	5

6 0 6 12 18 24 30
Scale Feet

TERMINAL 5 CARGO WHARF REHABILITATION AND BERTH DEEPENING

PURPOSE: STRENGTHEN CRANE RAIL; SLOPE STABILIZATION AND TOE WALL; BERTH DEEPENING

DATUM: MLLW = 0.0 FEET

ADJACENT PROPERTY OWNERS:
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MEAN HIGHER HIGH WATER: 11.36'
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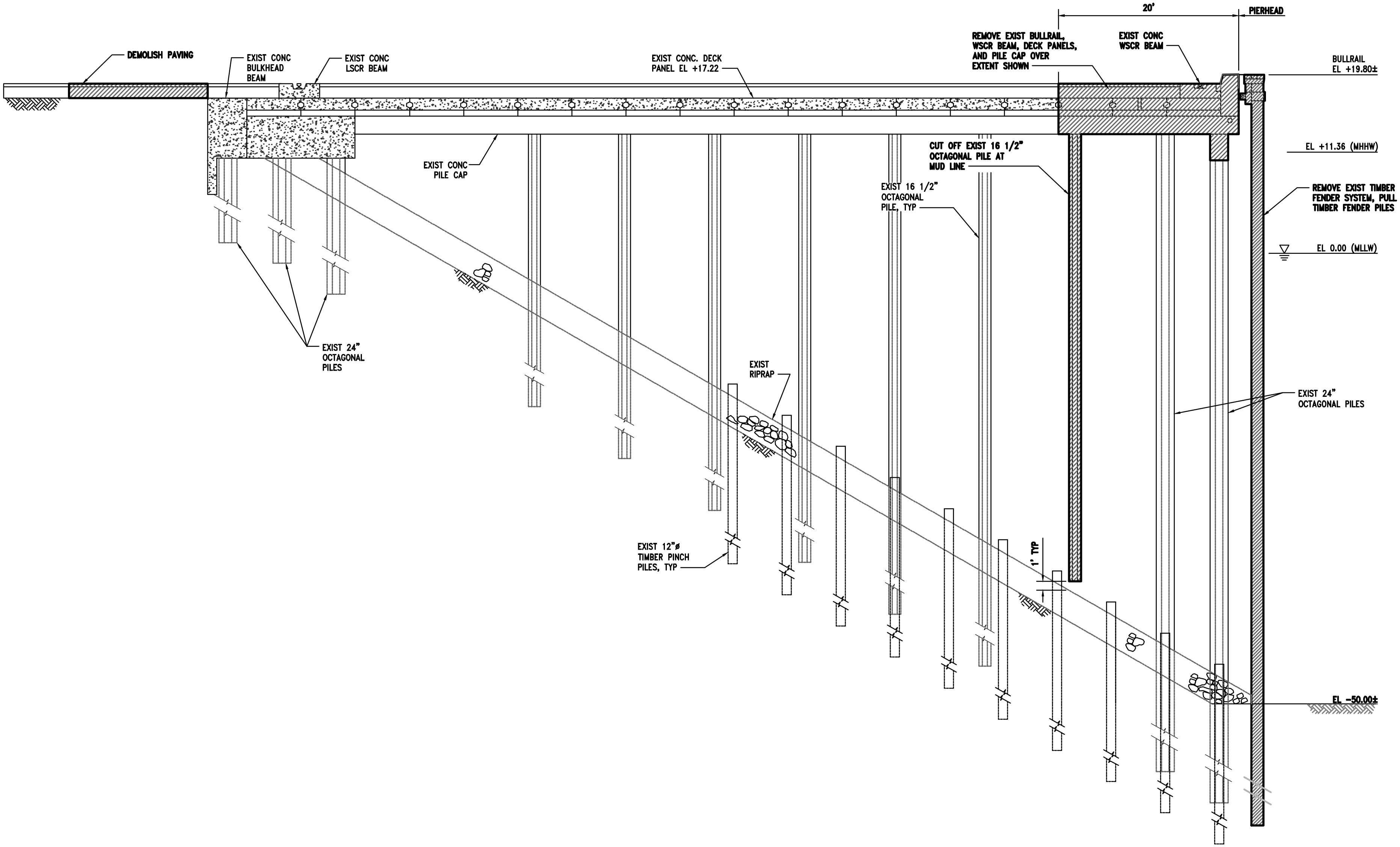
CITY OF: SEATTLE COUNTY OF: KING STATE OF: WASHINGTON

APPLICATION BY: PORT OF SEATTLE
P.O. BOX 1209
SEATTLE, WA 98111

SHEET TITLE: DEMOLITION CROSS SECTION B
SHEET 16 of 21

DATE: MARCH 2015



LEGEND:

DEMOLITION AREA

SECTION
BENT 100
SCALE: 1/16" = 1'-0"

SHEET	SHEET
4	5

6 0 6 12 18 24 30
Scale Feet

TERMINAL 5 CARGO WHARF REHABILITATION AND BERTH DEEPENING

PURPOSE: STRENGTHEN CRANE RAIL; SLOPE STABILIZATION AND TOE WALL; BERTH DEEPENING

DATUM: MLLW = 0.0 FEET

ADJACENT PROPERTY OWNERS:
① CITY OF SEATTLE ③ WA DNR ⑤ GENERAL STEEL SERVICES OF WASHINGTON LLC
② BNSF ④ RICHTER, EDDIE M

Port of Seattle
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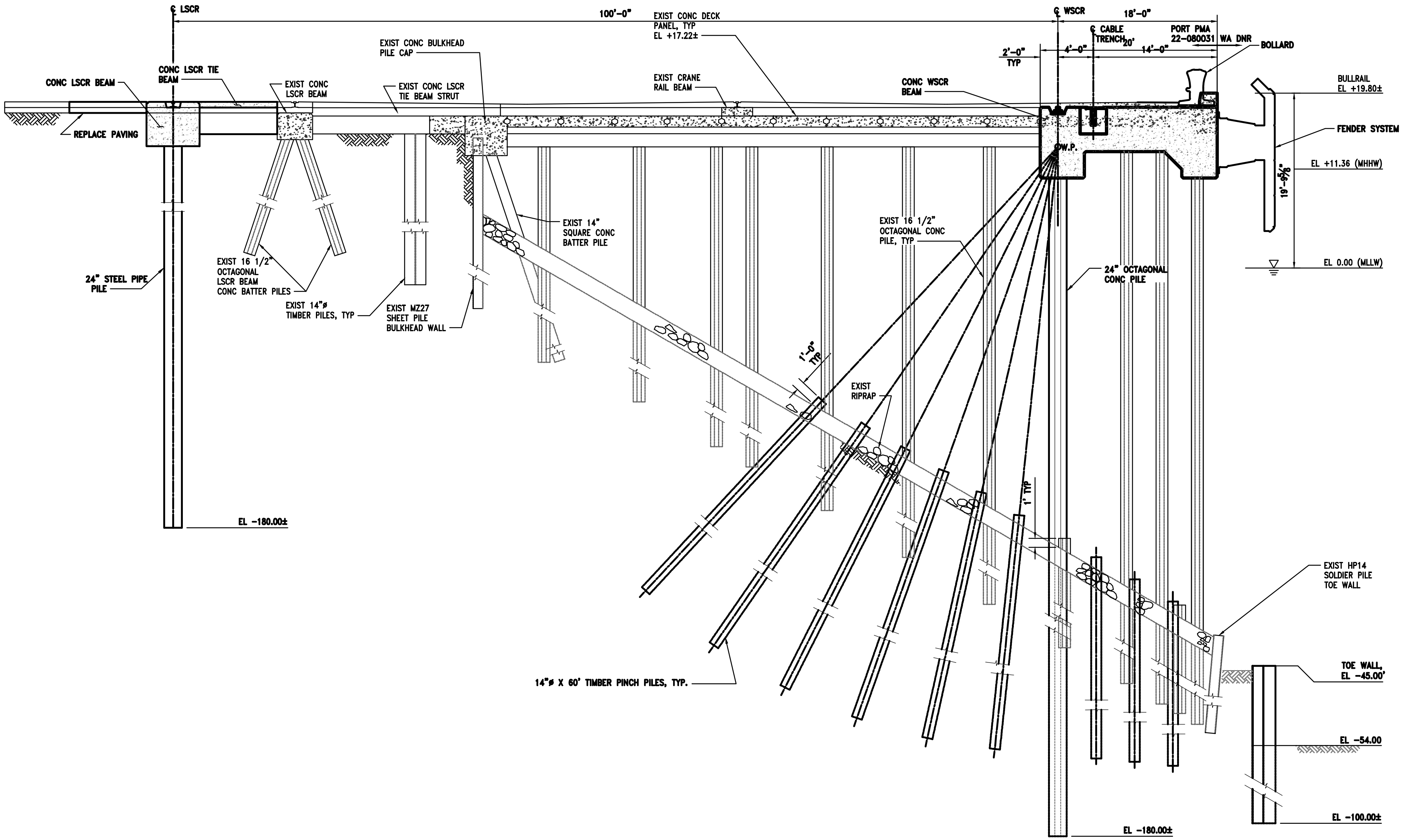
SEATTLE, WA 98111

LATITUDE: 47.3433 N
LONGITUDE: 122.2144 W
MEAN HIGHER HIGH WATER: 11.36'
MEAN LOWER LOW WATER: 0.00'

CITY OF: SEATTLE COUNTY OF: KING STATE OF: WASHINGTON

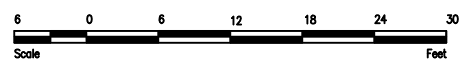
APPLICATION BY: PORT OF SEATTLE
P.O. BOX 1209
SEATTLE, WA 98111

SHEET TITLE: DEMOLITION CROSS SECTION C
SHEET 17 of 21
DATE: MARCH 2015



SECTION
BENT 20S
SCALE: 1/16" = 1'-0"

SHEET	SHEET	SHEET
6	7	8



TERMINAL 5 CARGO WHARF REHABILITATION AND BERTH DEEPENING

PURPOSE: STRENGTHEN CRANE RAIL; SLOPE STABILIZATION AND TOE WALL; BERTH DEEPENING

DATUM: MLLW = 0.0 FEET

ADJACENT PROPERTY OWNERS:
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SEATTLE, WA 98111

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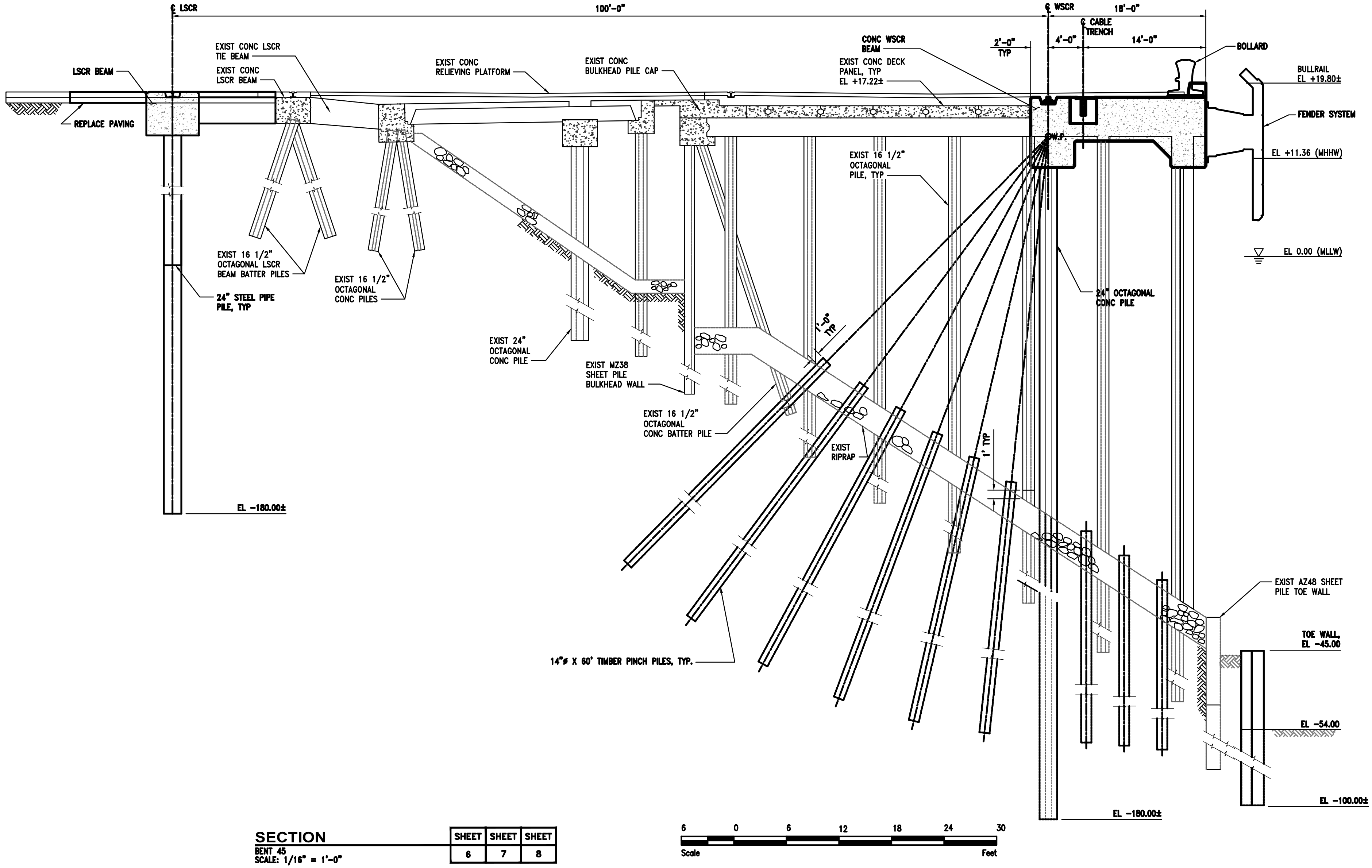
LONGITUDE:	122.2144 W
MEAN HIGHER HIGH WATER:	11.36'
MEAN LOWER LOW WATER:	0.00'

CITY OF: SEATTLE COUNTY OF: KING STATE OF: WASHINGTON

APPLICATION BY: PORT OF SEATTLE
P.O. BOX 1209
SEATTLE, WA 98111

SHEET TITLE: NEW CROSS SECTION A
SHEET 18 of 21

DATE: MARCH 2015



TERMINAL 5 CARGO WHARF REHABILITATION AND BERTH DEEPENING

PURPOSE: STRENGTHEN CRANE RAIL; SLOPE STABILIZATION AND TOE WALL; BERTH DEEPENING

DATUM: MLLW = 0.0 FEET

ADJACENT PROPERTY OWNERS:
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LATITUDE: 47.3433 N
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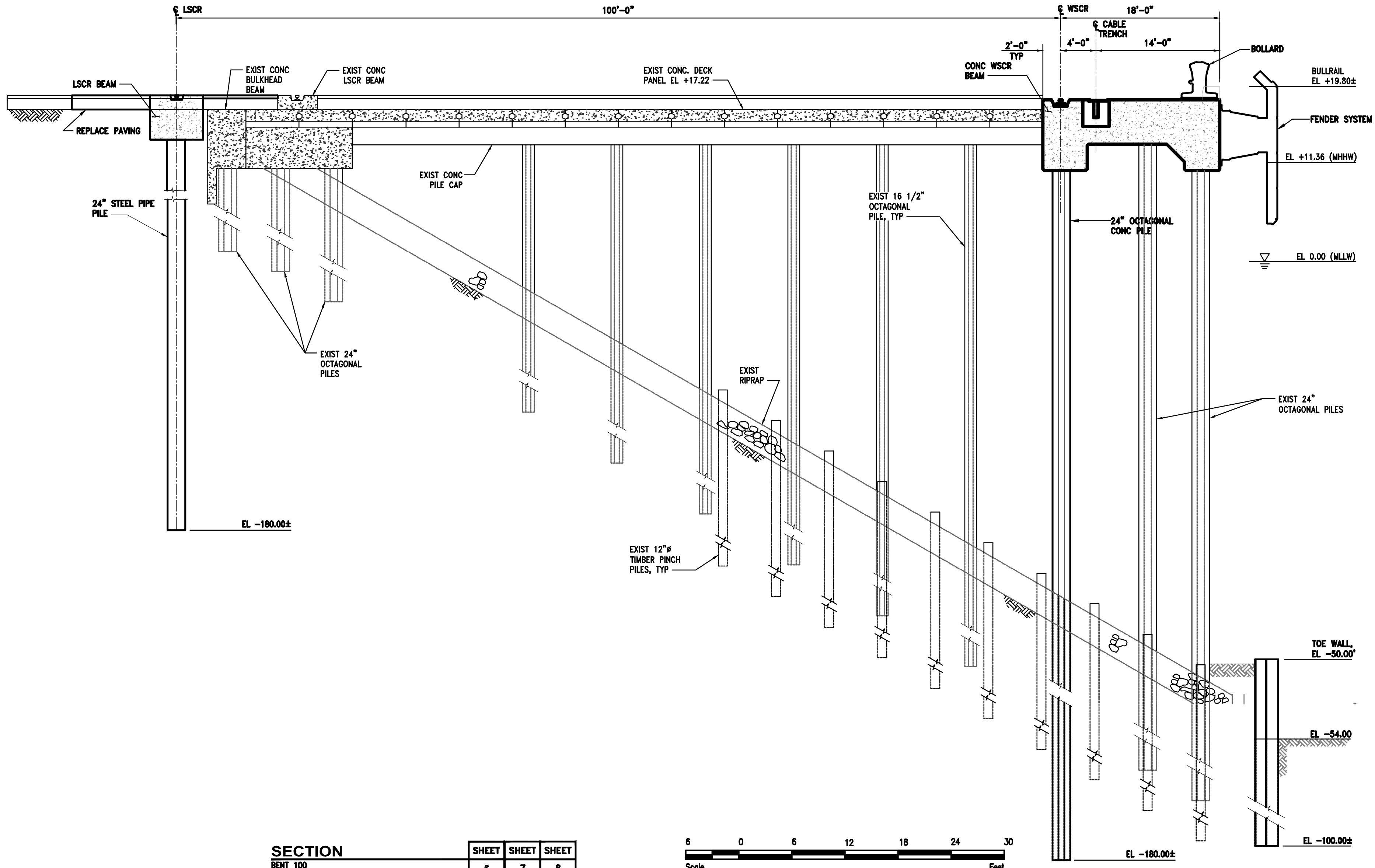
CITY OF: SEATTLE COUNTY OF: KING STATE OF: WASHINGTON

APPLICATION BY: PORT OF SEATTLE
P.O. BOX 1209
SEATTLE, WA 98111

SHEET TITLE: NEW CROSS SECTION B
SHEET 19 of 21

DATE: MARCH 2015



SECTION
BENT 100
SCALE: 1/16"=1'-0"

SHEET	SHEET	SHEET
6	7	8

TERMINAL 5 CARGO WHARF REHABILITATION AND BERTH DEEPENING

PURPOSE: STRENGTHEN CRANE RAIL; SLOPE STABILIZATION AND TOE WALL; BERTH DEEPENING

DATUM: MLLW = 0.0 FEET

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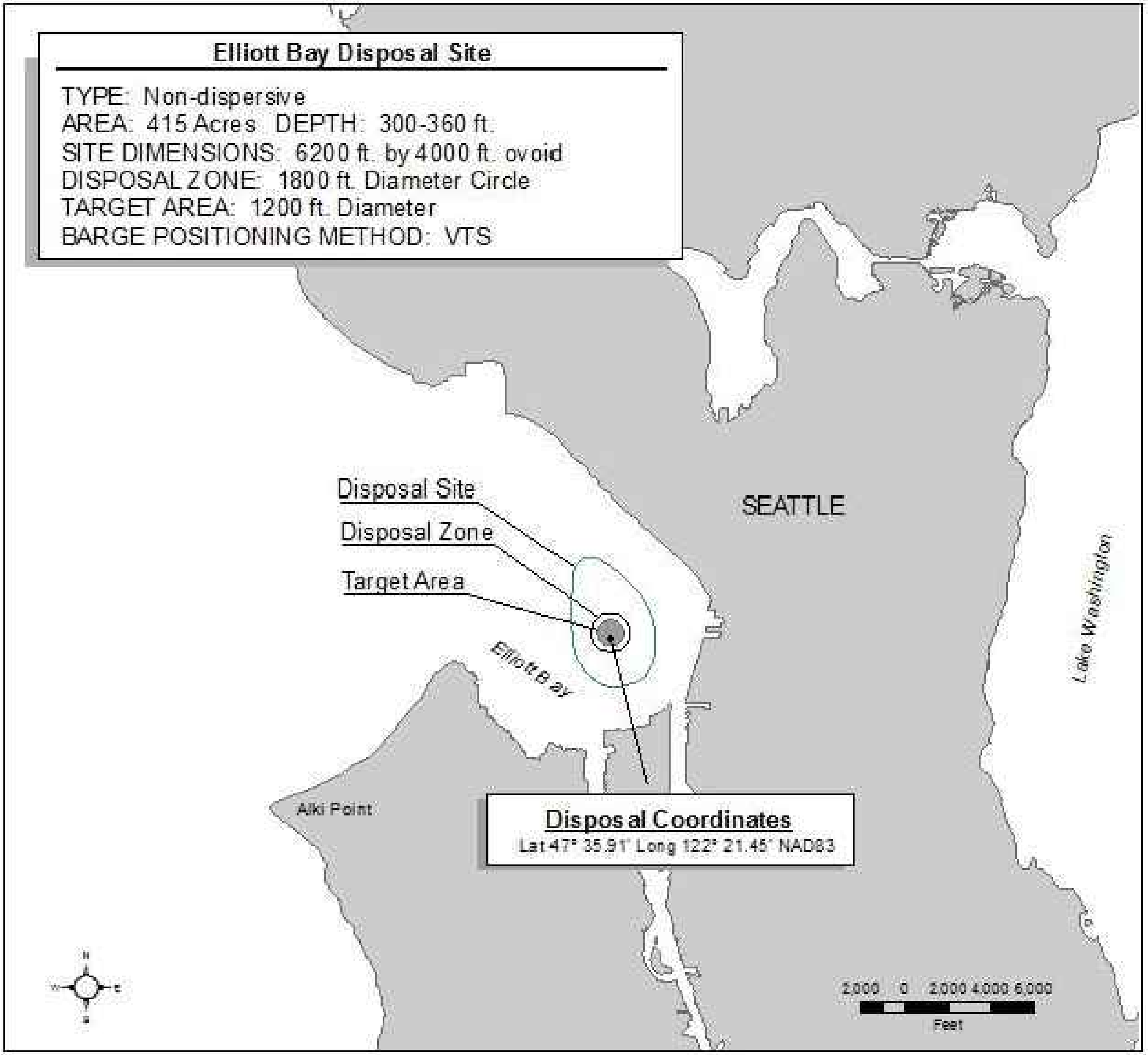
CITY OF: SEATTLE COUNTY OF: KING STATE OF: WASHINGTON

APPLICATION BY: PORT OF SEATTLE
P.O. BOX 1209
SEATTLE, WA 98111

SHEET TITLE: NEW CROSS SECTION C
SHEET 20 of 21

DATE: MARCH 2015



TERMINAL 5 CARGO WHARF REHABILITATION AND BERTH DEEPENING

PURPOSE: STRENGTHEN CRANE RAIL; SLOPE STABILIZATION AND TOE WALL; BERTH DEEPENING

DATUM: MLLW = 0.0 FEET

ADJACENT PROPERTY OWNERS:
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CITY OF: SEATTLE COUNTY OF: KING STATE OF: WASHINGTON

APPLICATION BY: PORT OF SEATTLE
P.O. BOX 1209
SEATTLE, WA 98111

SHEET TITLE: ELLIOTT BAY IN-WATER DISPOSAL SITE

SHEET 21 of 21

DATE: MARCH 2015

APPENDIX A
Essential Fish Habitat Evaluation

APPENDIX A
ESSENTIAL FISH HABITAT ASSESSMENT

Action Agency

US Army Corps of Engineers, Seattle District.

Project Name

Terminal 5 Cargo Wharf Rehabilitation and Berth Deepening.

Project Location

The proposed project area is located in Seattle, King County, Washington (Township 24 North, Range 3 East, Sections 12 and 13) on the west shore of the West Waterway, inner Elliott Bay (Figure 1).

Essential Fish Habitat Background

The 1996 amendments to the Magnuson-Stevens Fishery Conservation and Management Act set forth the essential fish habitat (EFH) provision to identify and protect important habitats of federally managed marine and anadromous fish species. Federal agencies, such as the USACE, which fund, permit, or undertake activities that may adversely affect EFH, are required to consult with NOAA Fisheries regarding the potential effects of their actions on EFH, and respond in writing to NOAA Fisheries' recommendations.

Essential fish habitat is defined as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. "Waters" include aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include aquatic areas historically used by fish where appropriate. "Substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities (NMFS 1999).

Identification of EFH

Estuaries of Washington, including Puget Sound and the Pacific Ocean off the mouth of these estuaries, are designated as EFH for various ground fish, coastal pelagic species, and several of the Pacific salmon. (NMFS 1998; PFMC 1998a, 1998b, 1999). EFH and life history stages for ground fish, pelagic, and salmonid species commonly found in Puget Sound are listed in Table A-1 (NMFS 1998). The marine extent of ground fish and coastal pelagic EFH includes those waters from the nearshore and tidal submerged environment within Washington, Oregon, and California state territorial waters out to the exclusive economic zone (370.4 km [231.5 miles]) offshore between Canada and the Mexican border. The EFH designation for the Pacific salmon fishery includes all those streams, lakes, ponds, wetlands, and other water bodies currently or historically accessible to salmon in Washington, Oregon, Idaho, and California, except above the impassible barriers identified by PFMC. In estuarine and marine areas, designated EFH for salmon extends from nearshore and tidal submerged environments within state territorial waters out to the full extent of the exclusive economic zone offshore of Washington, Oregon, and California north of Point Conception (PFMC 1999).

Table A-1 – Species of Fish with Designated EFH that may be present in the Action Area

EFH Species	Life History Stages				
Ground fish	**Eggs**	**Larvae**	**Juvenile**	**Adult**	**Spawning**
Spiny dogfish, *Squalus acanthias*			◊	◊	
Spotted ratfish, *Hydrolagus colliei*			◊	◊	
Lingcod, *Ophiodon elongatus*		◊			
Cabezon, *Scorpaenichthys marmoratus*		◊			
Kelp greenling, *Hexagrammos decagrammus*		◊			
Pacific cod, *Gadus macrocephalus*		◊			
Pacific hake, *Merluccius productus*			◊	◊	
Sablefish, *Anoplopoma fimbria*		◊	◊	◊	◊
Brown rockfish, *S. auriculatus*		◊		◊	
China rockfish, *S. nebulosus*		◊		◊	
Copper rockfish, *S. caurinus*		◊		◊	
Quillback rockfish, *S. maliger*		◊		◊	
Thornyheads, *Sebastolobus* spp.		◊		◊	
Other rockfishes		◊		◊	
Pacific sanddab, *Citharichthys sordidus*		◊	◊	◊	
Dover sole, *Microstomus pacificus*	◊		◊	◊	
English sole, *Pleuronectes vetulus*	◊	◊	◊	◊	◊
Flathead sole, *Hippoglossoides elassodon*		◊	◊	◊	◊
Petrale sole, *Eopsetta jordani*	◊	◊	◊	◊	
Rex sole, *Errex zachirus*	◊	◊	◊	◊	
Rock sole, *Pleuronectes bilineata*	◊	◊	◊	◊	◊
Sand sole, *Psettichthys melanostictus*	◊	◊	◊	◊	
Starry flounder, *Platichthys stellatus*	◊	◊	◊	◊	◊
Coastal Pelagic Species					
Northern anchovy, *Engraulis mordax*			?	◊	
Pacific sardine, *Sardinops sagax*			?	◊	
Chub mackerel, *Scomber japonicus*			?	◊	
Market squid, *Loligo opalescens*			◊	◊	◊
Pacific Salmon Species					
Chinook salmon, *Oncorhynchus tshawytscha*			◊	◊	
Coho salmon, *O. kisutch*			◊	◊	
Puget Sound pink salmon, *O. gorbuscha*			◊	◊	

Project Description

Background

The Port of Seattle is proposing to rehabilitate the existing, approximately 50-year-old Terminal 5 container cargo wharf in order to meet the needs of present-day and emerging cargo handling equipment and container vessels. Container vessels currently being deployed between Asian trading partners and West Coast ports have significantly larger capacity than those envisioned twenty years ago when the project area was aggregated to form the Terminal as configured at the present. Newer vessels are about 28 feet wider and about 200 feet longer than vessels previously calling at Terminal 5. However, the duration of time that a vessel would be present at the berth for the same amount of throughput would decrease.

The proposed project includes actions necessary to strengthen portions of the existing wharf structure to receive larger, heavier container cranes necessary to reach up and over these newer vessels. In addition, the project includes dredging necessary to increase the operational depth of existing vessel berth area and vessel approach area in the west margin of the West Waterway to accommodate the larger vessels. Electrical system upgrades and water line replacements are also proposed along the wharf within the upland area dedicated for marine container cargo use. The proposed wharf strengthening, navigational access dredging, electrical service changes, and water line replacements are needed to ensure the continuing efficient use of Terminal 5 cargo handling infrastructure and prevent further decline in cargo transshipment capability at Terminal 5, compared with other port marine cargo facilities in south Elliott Bay.

Project Description

The Port of Seattle Terminal 5 Wharf Rehabilitation and Berth Deepening project (Project) consists of conducting upgrades and modifications to existing container facilities, including container cargo dock rehabilitation, berth deepening, and electrical upgrades. The addition of numerous piles to strengthen existing crane facilities, installation of toe-wall slope stabilization in subtidal areas, and dredging of the length of the terminal to allow larger vessel access are the construction activities that have the potential to effect ESA-listed species and their aquatic habitats. Project components include:

- The existing cargo wharf is 2,900 feet long. Strengthening actions apply to approximately 2,800 linear feet, while the toe-wall stabilization actions measure up to 3,100 linear feet. Wharf strengthening will include the following elements:
  - Demolish older wharf and structural systems as needed.
    - Demolish asphalt paving for 31 feet x 2,800 feet to access area landside crane rail for strengthening.
    - Demolish cast-in-place concrete crane rail beams and pile caps (located above mean higher high water [MHHW]) and concrete deck slabs (located above MHHW) for 21 feet x 2,800 feet along dock face to waterside crane rail.

    - Remove fender system including extraction of timber fender piles and replace with a panelized fender system reducing overwater coverage by a net of 12,000 square feet at the face of the wharf.
    - Extract or cut off older, conflicting 16.5-inch structural piling below mudline.
  - Install new structural crane rail piling.
    - Install 420 structural concrete piles (24-inch) and concrete pile cap beam within footprint of existing wharf structure to replace the waterside crane rail beam.
    - Install 420 structural steel pipe piles (24-inch) and concrete pile cap beam in existing upland area, land-ward of the cargo wharf bulkhead.
  - Install slope stabilization measures in the riprap armor slope beneath the existing container cargo wharf. Slope stabilization techniques will consist of installation of untreated wood piles penetrating the existing riprap armor slope.
  - Install a toe-wall at the transition between the constructed riprap slope and the adjacent container vessel berth area to stabilize the existing slope beneath the container cargo wharf. Drive combination H-pile and sheet pile wall at the toe-of-slope for up to 3,100 feet.
  - Install wharf rehabilitation elements.
    - Replace the concrete deck structure within the existing wharf footprint.
    - Repair existing container wharf beams and deck panels.
    - Install panelized wharf fender system at 60-foot intervals.

- Deepen adjacent berth to -56 feet MLLW (with allowances for over dredge depths).
  - Slope stability structures are designed for a final depth of up to –56 feet MLLW (with allowances for over dredge depths).

- Electrical Improvements will include the following elements:
  - Construct a new 26-MVA Primary Substation, to provide electrical power to the new cranes and associated terminal operations such as cargo handling, marshalling, and refrigeration.
  - Coordinate with Seattle City Light (SCL) to provide power to the new Primary Substation from both the SCL Delridge Substation and the SCL South Substation.
  - Construct up to four new electrical distribution substations feeding the new ship-to-shore cranes and dock power and lighting systems.
  - Construct a new underground electrical duct bank to connect distribution elements.
  - Construct distribution vaults and trenches to power trench.

- Water supply system upgrades will include the following elements:
  - Remove and replace existing dockside water distribution system.
  - Provide sectional valving in dockside water distribution system. Coordinate with existing looped water distribution system and existing fire hydrant layout.
  - Remove and replace existing ship's water supply assemblies. Coordinate assembly installation locations.
  - Update ship's water supply deduct meters to comply with City of Seattle standards.

Project components that may affect designated EFH are the installation of piles, and water and sediment quality effects caused by dredging. All pile installation will occur beneath the existing wharf or along the face of the wharf over two work window seasons; see Table 2 in the Biological Assessment (BA) for details (Hart Crowser 2015). Dredging will also alter existing aquatic habitats, but all will occur in deep waters below -47 feet MLLW. Dredging will occur during a third work season. With the removal of existing fender and fender piles, other piles, and decking, the existing Terminal 5 Wharf footprint will decrease by a net of approximately 11,000 square feet. Additional project details are presented in Section 2 of the BA (see Table 5 in the BA).

Impact Avoidance and Minimization Measures

Conservation Measures and Best Management Practices (BMPs) will be employed during pile driving and dredging to avoid or minimize potential adverse impacts to the aquatic environment. The following conservation measures and general BMPs will be implemented.

Conservation Measures and Best Management Practices (BMPs) will be employed during pile driving and dredging to avoid or minimize potential adverse impacts to the aquatic environment. The following conservation measures and general BMPs will be implemented. Additionally, BMPs specific to dredging and pile driving are included below.

- All inwater work will be limited to periods determined appropriate by participating state and federal agencies to avoid potential adverse effects on migratory fish.

- The project will be designed such that the wharf dimensions will not expand beyond the existing pier head line.

- Approximately 227 creosote-treated fender piles will be removed from open areas of the West Waterway, occupying 311 square feet, thus, removing a potential source of contamination and impediments to juvenile salmon migration from the project area. An additional 381 concrete piles will also be extracted or cut off at the mudline from beneath the existing wharf. Total removal represents 1,030 square feet of piles (Table 5 of the Biological Assessment).

- Replacement of the timber fender pile system along the length of Terminal 5 with a panelized fender system will remove approximately 8,500 square feet of overwater coverage at the face of the wharf. The Project however, does add 500 new H-piles and 420 new concrete structural piles. There is a net reduction of overwater and inwater coverage by over 8,000 square feet by the removal of the existing fender pile system and removal of conflicting piles. A summary of structures removed and structures added is presented in Table 5 of the Biological Assessment.

- A water quality monitoring plan will be implemented during construction to verify compliance with water quality conditions of the Section 401 Water Quality Certificate, USACE Permit, and Hydraulic Project Approval.

- All equipment will be inspected daily to ensure that it is in proper working condition.

- The contractor will be responsible for the preparation and implementation of a Spill Prevention, Control, and Countermeasures (SPCC) Plan to be used for the duration of the project. The SPCC Plan will be submitted to the project engineer prior to the commencement of any construction activities. A copy of the plan with any updates will be maintained at the work site by the contractor. The contractor will also maintain at the job site the applicable equipment and materials designated in the SPCC Plan.

- Excess or waste materials, petroleum products, fresh cement, lime or concrete, chemicals, or other toxic or deleterious materials will not be allowed to enter the West Waterway.

Pile Driving and Pile Demolition

The following BMPs will be employed to avoid and limit potential environmental impacts resulting from pile driving and pile removal activities.

- The project is designed to use concrete piles, untreated wood piles, H-piles, and sheet piles for all water-based activities, all of which produce substantially lower waterborne noise levels when struck than do steel pipe piles.

- All new inwater piles will be driven beneath the existing Terminal 5 Wharf within riprapped habitats or along the terminal face; natural light penetration in these areas is already severely limited.

- If fish are observed in distress or if a fish kill occurs, work will be stopped immediately. USACE, WDFW, and Ecology will be contacted and work will not resume until approval is given by these agencies.

- Pulled piles will be placed in a containment basin either on a barge or adjacent to the deck to capture any adhering sediment.

- A boom will be installed around the work area prior to removal of timber piles and related structures to contain and collect debris, which will be disposed of at an approved upland location.

- Operator will “wake up” the pile by vibrating to break the skin friction bond between pile and soil.

- Crane operator will minimize turbidity in the water column by removing released pile slowly.

Dredging and Placement

The following BMPs will be employed to avoid and limit potential environmental impacts of dredging:

- The Port will require the contractor to utilize real-time positioning control when implementing dredging operations.

- Based on the results of water quality monitoring, operational controls may be applied to dredging operations, as required to meet water quality standards, including:

- Increasing cycle time: A longer cycle time reduces the velocity of the ascending bucket through the water column, which reduces potential to wash sediment from the bucket.
- Elimination of multiple “bites”: When the clamshell bucket hits the bottom, an impact wave of suspended sediment travels along the bottom away from the dredge bucket. When the clamshell bucket takes multiple bites, the bucket loses sediment as it is reopened for subsequent bites. Sediment is also released higher in the water column as the bucket is raised, opened, and lowered.
- Prohibiting bottom stockpiling: Bottom stockpiling of the dredged sediment in silty sediment has a similar effect as multiple bite dredging; an increased volume of sediment is released into the water column from the operation.

Potential Adverse Effects of Proposed Project

Adverse Effects on EFH for Ground fish

Pile Driving and Removal

Pile removal and driving will result in highly localized and temporary increases in turbidity; there will be no long-term effects on turbidity in the project or action areas. Most pile driving will also occur in areas that are riprapped, beneath the existing wharf, steep sloped (1.5 to 1.75H: 1V), and in an area with little light penetration. Very little displacement of benthic resources will occur in these marginal habitats. The proposed new toe wall will also be driven at the face of the existing wharf and driven to near the existing mudline, so little bottom habitat will not be modified. Ground fishes, such as several EFH flatfish species may be temporarily displaced by toe wall installation or other pile driving actions, but long-term habitats will be maintained or improved. The removal of existing pile fenders, and replacement with a fender system that does not use inwater components will reduce the overwater footprint of the wharf by a net of over 8,000 square feet. Removal of over 300 creosote-treated fender piles will eliminate a potential source of contamination from designated EFH.

There is the potential for unintentional release of debris or contaminants from wharf improvements activities and spills from construction equipment that could lead to adverse impacts to water column EFH. These potential effects will be minimized or eliminated by the proposed BMPs that will be implemented, as summarized above.

Dredging

Dredging activities will result in localized increases in turbidity that will not persist beyond the dredging season during Year 3 of in work activities. Dredging may displace bottom dwelling ground fishes from the dredge footprint, but this will be temporary. No conversion of valuable shallow water habitat to deep water habitat will occur since all dredging will occur at depths of -47 feet MLLW or deeper. Preliminary sediment chemistry results indicate that all dredge materials will be suitable for open-water disposal so resuspended sediments pose minimal risk of contamination or toxicity to EFH habitats or species.

It is expected that most all benthic invertebrates within the proposed dredge prism will be eliminated by dredging, removing a potential prey source for ground fishes. However, multiple studies in Puget Sound indicate that this will be temporary and the recolonization of the benthic community will be rapid (see section 5.2.4.1 in the BA).

Adverse Effects on EFH for Salmonids and Coastal Pelagic Species

Pile Driving and Removal

Pile driving will have minimal effects on the designated EFH of juvenile salmonids and coastal pelagic species. Pile driving activities may cause the avoidance of EFH during pile driving activities, but this will be limited to the pile driving period over two seasons. All pile driving work will also occur outside of the juvenile salmonid outmigratory window when few juvenile salmon are expected to be present in the project and action areas. The installation of piles will not eliminate substantial estuarine rearing or migration habitats since all pile driving will be conducted beneath the existing wharf where little light penetration occurs, or at the face of the wharf. Juvenile salmon are not expected to migrate beneath the wharf and though they may be found at the face, toe wall installation at this location will drive piles to near the existing mudline in waters greater than -40 feet MLLW. This is deeper than juvenile salmon typically feed. No open, unshaded shallow water habitats will be affected by pile driving. The removal of fender piles at the face of the wharf and associated decking will remove creosote-treated piles and remove a net of over 8,000 square feet of overwater structure from face of the wharf; therefore improving open water EFH for salmonids and coastal pelagic species.

There is the potential for unintentional release of debris or contaminants from wharf improvements activities and spills from construction equipment that could lead to adverse impacts to water column EFH. These potential effects will be minimized or eliminated by the proposed BMPs that will be implemented, as summarized above.

Dredging

Dredging activities will result in localized increases in turbidity that will not persist beyond the dredging season during Year 3 of inwater work activities. All dredging will also take place during agency-approved work windows when few juvenile salmon are expected to be present and potentially displaced from EFH.

It is expected that most all epibenthic invertebrates that form the base of juvenile salmon prey resources will be eliminated by dredging. However, the dredge prism will be deeper than -40 feet MLLW, which is deeper than juvenile salmon typically feed. Multiple studies in Puget Sound also indicate that this will be temporary and the recolonization of the community will be rapid (see section 5.2.4.1 in the Biological Assessment). No loss or conversion of shallow water habitat to deep water habitat will result from dredging activities. Preliminary sediment chemistry results indicate that all dredge materials will be suitable for open-water disposal so resuspended sediments pose minimal risk of contamination or toxicity to EFH habitats or species.

Conclusions and Determinations of Effects

The project actions described above and in the BA have the potential to adversely affect the EFH of federally managed species, but these effects are expected to be localized, temporary, and minimal. Pile driving activities will be conducted outside of the salmonid migratory period. Removal of creosote-treated piles in reduction in the overwater footprint will result in positive long-term effects. Care will be taken, and BMPs will be in place, to ensure that minimal construction debris or chemical spills enters the waterway. No fresh concrete will be exposed to waters.

Ground fish EFH

The impact of reduced food resources form dredging activities is expected to be short-term and minimal as epibenthic and benthic assemblages will quickly recolonize new substrates. Most all pile driving will occur in extremely marginal habitats characterized by high slopes, riprap, and little light penetration where few ground fish species will inhabitat. The removal of creosote-treated piles and reduction in the overwater footprint at the face of the wharf will improve EFH for ground fish. Overall, based on the temporary impacts of the project, the project **will not adversely affect ground fish EFH**.

Salmonids EFH

The effects of the removal of prey resources resulting from dredging will have minimal effects to salmonid EFH, since these areas are deeper than juvenile salmonids are likely to feed. No loss or conversion of shallow water habitat to deep water habitat will occur as a result of dredging. Removal of creosote-treated piles and overwater coverage at the face of the existing wharf will improve open water EFH for juvenile salmon. Overall, based on the temporary impacts of the project, and overall improvements of open water areas, the project **will not adversely affect salmonid EFH.**

Coastal Pelagic EFH

Spills from construction equipment could temporarily adversely affect the water column EFH for pelagic species, but conservation measures and BMPs will in place to avoid or minimize these impacts. Resuspension of sediments will have minimal effects since little contamination has been detected during recent sediment testing and turbidity effects will be short-term. Removal of creosote-treated piles and reducing overwater coverage at the face of the wharf will improve open water pelagic areas. Overall, based on the temporary impacts of the project, and overall improvements of open water areas, the project **will not adversely affect ground fish EFH**

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Appendix F
Railway Infrastructure and Train Volume Analysis

Memorandum

To:	Steven Gray, Moffatt & Nichol (M&N)
From:	James Todd (M&N)
Date:	April 22, 2016
Subject:	Terminal 5 Railway Infrastructure and Train Volume Analysis
Project:	Terminal 5 Cargo Wharf Rehabilitation, Berth Deepening and Improvements

1.0 INTRODUCTION

Moffatt & Nichol (M&N) has been retained by the Port of Seattle (Port) to provide design support services, including support for the State Environmental Policy Act (SEPA) review for the Terminal 5 (T5) Cargo Wharf Rehabilitation, Berth Deepening and Improvements Project (the Project). Part of this effort includes assessing the potential for project-related short-term and long-term effects relating to existing rail infrastructure.

This memorandum describes existing rail infrastructure and volume of train traffic in the study area, applicable regulations and management, and what potential changes in rail infrastructure and train volumes could occur. Measures to avoid, minimize, or compensate for potential adverse effects are identified and include two operational measures:

- Alternative 2 requires the use of additional storage tracks in the West Seattle Yard (WSY). This will allow the staging of additional loaded cuts[1] for removal from the Terminal.
- Alternative 3 requires additional shifts to support Terminal operations as well as the transfer of additional staging to the WSY. The addition of the on terminal air system will require qualified technicians on terminal to perform brake tests for staged cuts of cars. The closure of the T5 and Terminal 7 (T7) driveways will be required due to the impacts of switching movements.

Mitigation measures are not required or proposed for construction for any of the alternatives.

2.0 STUDY AREA

The study area for rail infrastructure is bounded to the east by the BNSF north/south mainline tracks on the east side of 2nd Ave S and UPRR Argo Yard. To the west, the study area terminates at the BNSF West Seattle Yard and the West Marginal Branch along the west side of the Duwamish waterway (Figure 6).

[1] A cut is a term for two or more cars that remain coupled together.

Figure 1: Port of Seattle Terminal 5

Source: Google Earth

2.1 Existing Rail Infrastructure

Two Class 1 railroads serve the Puget Sound region: the BNSF Railway (formerly Burlington Northern and Santa Fe Railroad) and the Union Pacific Railroad (UPRR). The BNSF and UPRR are the successor railroads to the first railroads to reach Seattle. The transcontinental Northern Pacific Railway line connected to Seattle shortly after 1883. In 1893, the Great Northern Railway reached Seattle. Over the course of the 20th century, these two railways became components of the BNSF and UPRR[2]. Between them, these two railways provide three main connections between Seattle and the rest of North America (Figures 2 and 3). These rail connections were a cornerstone of the development of international trade at the Port of Seattle.

The UPRR mainline terminates at Argo Yard in the southeast portion of the Duwamish industrial area. The yard is made up of multiple storage and loading tracks. Trackage rights allow for UPRR operations over BNSF owned track connecting to the Port's T5 and Terminal 18 (T18). Previously, UPRR provided shipping service to T5 over the BNSF track, but switching and spotting the trains between the terminal and Argo was performed by BNSF. From Argo Yard, the UPRR railway extends south on single track to Tacoma. South of Tacoma, UPRR operates through trackage rights on BNSF track to Vancouver, WA. South of the Columbia River, the UPRR can continue south or turn east on its own trackage. The south main connects with markets through California and the rest of the south central US. Running east from Portland, the UPRR serves the central plains to connect with major Midwestern markets[3].

The BNSF mainline runs north/south from California, through Seattle and terminates at Vancouver, BC. Through California, the BNSF connects with southern and plains areas of the US. From Seattle, three main east-west routes converge at Spokane, WA, and continue on to the mid-west. The three eastbound routes from the Seattle area are: Seattle-Vancouver-Kennewick-Spokane (Columbia River route), Seattle-Auburn-Kennewick-Spokane (Stampede Pass route), or Seattle-Everett-Spokane (Stevens Pass route) (Figure 4). Depending on rail traffic volumes, expedited traffic normally travels the Stevens Pass route, while bulk cargo uses the Columbia River route (Figure 5). The Stampede Pass route reopened in 1996, but sees only light traffic and the tunnel at the pass is too small to pass double stack container trains[4].

In the Seattle Industrial District, the north-south BNSF track connects to the north end of Argo Yard at the Coach wye[5]. The west leg of the wye skirts the north end of Argo Yard and turns north into the Seattle International Gateway (SIG) Intermodal Facility. The SIG has multiple storage and loading tracks that serve off-terminal containerized train traffic from the Port and other local customers. The SIG terminates at its north end with a dead end tail track on the west side of Alaskan Way (Figure 6).

The West Seattle Lead (WSL, also referred to as the Spokane Street Lead by the Federal Railroad Administration [FRA]) originates at a wye on the BNSF line north of Argo and south of SIG. The track crosses and then interchanges with UPRR track running north-south between the UPRR Argo and Whatcom Yards. The WSL continues west and is joined by a single track from the north end of Argo Yard. The two tracks continue across the southern end of Harbor Island with three leads north onto the island and then continues as a single track across the lift-bridge on the Duwamish River West Waterway. Just west of the lift bridge, the track is joined by the West Marginal Branch (WMB) from along the west side of the West Waterway. The WMB runs north south originating at the Port's Terminal 115 and terminating at the junction with the WSL. From the junction with the WMB, the two tracks continue north and west to T5, the BNSF West Seattle Yard (WSY) and the Nucor Steel Plant. The single track WMB to the south serves multiple industries along the western waterfront of the Duwamish River.

2 http://www.seattle.gov/cityarchives/seattle-facts/brief-history-of-seattle
3 http://www.up.com/aboutup/reference/maps/system_map/index.htm
4 http://www.bnsf.com/customers/where-can-i-ship/
5 "Wye" refers to a triangular junction where three legs of rail intersect. Two legs are normally the main tangent through track with two switches leading to the third diverging leg

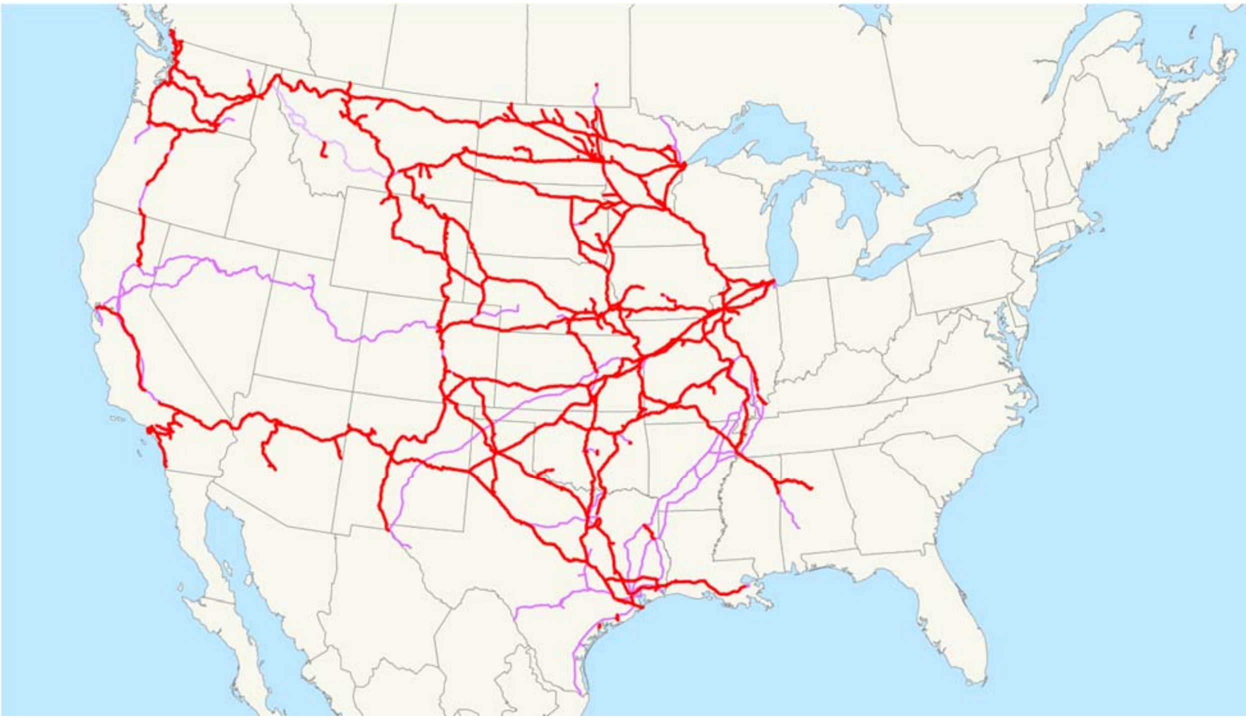

Figure 2 – BNSF National Network

Source: Wiki 2016

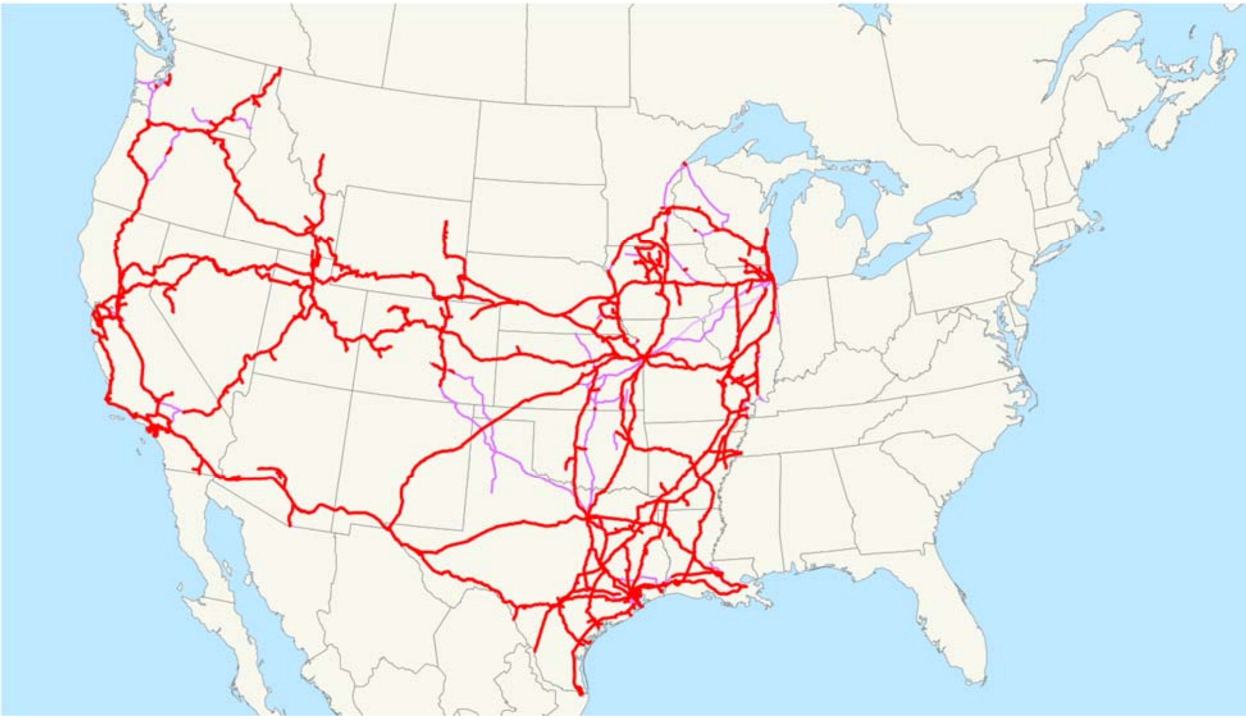

Figure 3 – UPRR National Network

Source: Wiki 2016

Figure 4 – Washington State Railways

Source: WSDOT 2013 Washington State Rail System

Figure 5 – Puget Sound Railways

Source: WSDOT 2013 Washington State Rail System

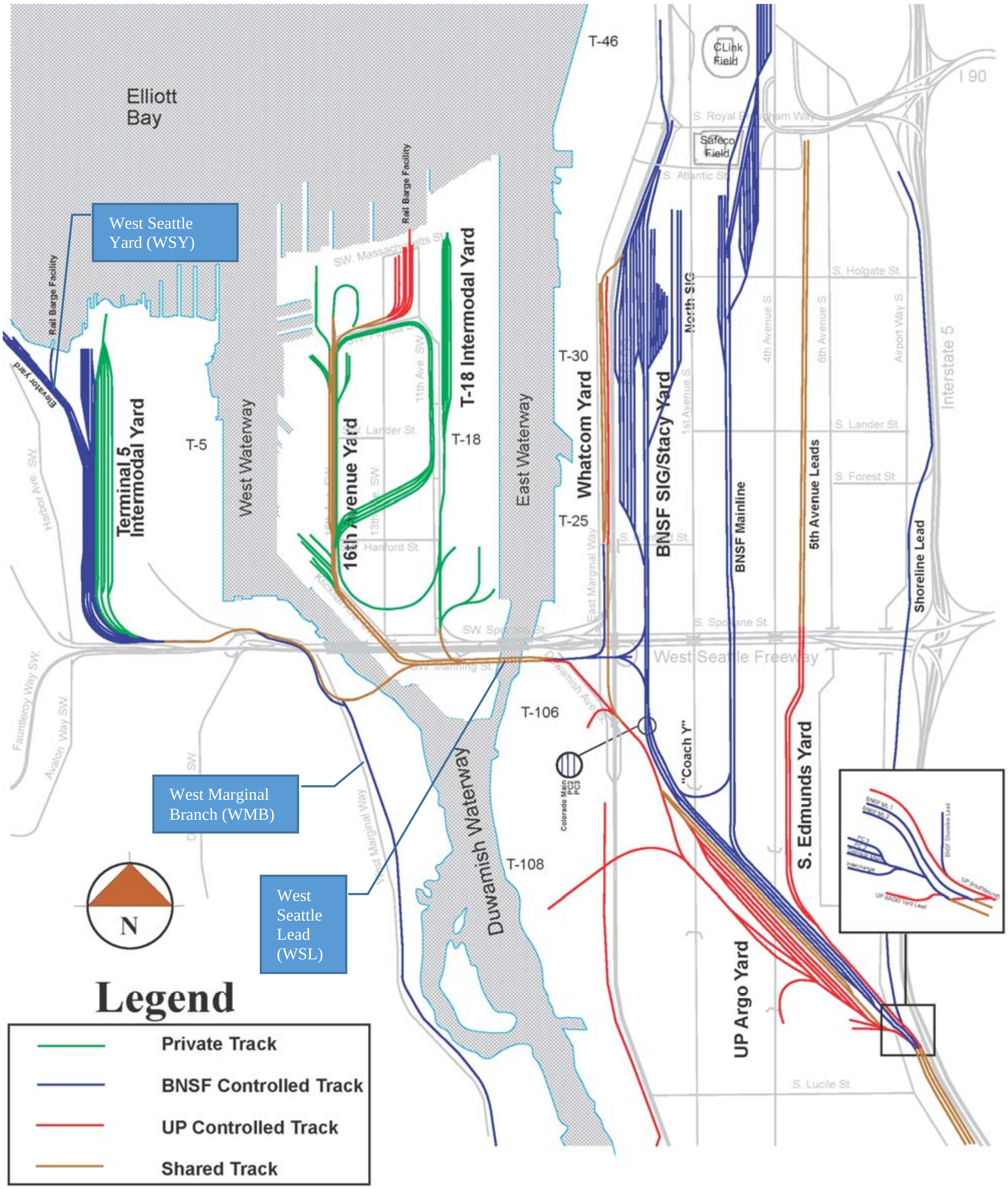

Figure 6 – Seattle Harbor Rail Network

2.2 Existing Freight Rail Traffic Volumes

The train counts in Table 1 represent traffic volumes on major segments of railway serving the Seattle area[6]. The current network is sufficient for existing freight rail volumes as indicated by the Daily Track Capacity in excess of the current Daily Train Volumes. Future demand will exceed track capacity through Stevens Pass and along the Columbia River Gorge.

Table 1: Freight Rail Traffic Volumes

Segment	Daily Track Capacity	Daily Train Volume (2010)
Seattle to Auburn	115 (BNSF) 48 (UPRR)	41 (BNSF) 10 (UPRR)
Seattle to Everett	81	33
Stampede Pass	39	6
Stevens Pass	28	16
Columbia River Gorge	40	28

The freight volumes forecasted by the Washington State Rail Plan anticipated increases in containerized, bulk and other commodities shipped throughout the State of Washington. The Plan also recognized that improvements to rail infrastructure are at the discretion and plans of the private railroads. Freight volumes can vary from year to year with commodity prices, demand and other factors. The current available capacity on each corridor is more than adequate to accommodate the peak 8 trains per day (4 each way) anticipated by the highest volume alternative (Alternative 3). Therefore no impact is anticipated to the rail network by the Project.

2.3 West Waterway Lift Bridge

The lift bridge over the West Waterway of the Duwamish River was originally constructed in 1928. The bridge is a single leaf bascule type with a single rail line. The bridge was improved coincident with the T5 redevelopment project completed in 1999. The improvements included renovations that support frequent and continuing intermodal train traffic. The bridge is normally kept open (raised) and lowered when needed for train movements. The bridge is owned and operated by BNSF.

2.4 Existing Infrastructure Constraints

The existing rail network between T5 and the UPRR/BNSF mainlines has several choke points. These existing nodes will constrict rail traffic in any of the proposed alternatives.

- The lift bridge over the West Waterway is a single track structure built in 1928. While fully operational at this time, increases in rail traffic will substantially increase the frequency of lifts.
- Rail traffic from Argo Yard must cross both WSL tracks to enter Harbor Island
- BNSF trains must cross a sharp reverse curve to enter the WSL from the south

[6] Washington State Rail Plan, March 2014

- WSL trains departing to the north on BNSF must travel the reverse curve followed by back to back cross overs before entering the Coach wye.
- Trains must be broken into multiple cuts to spot in the Terminal. This requires off site power which can delay the moves as switching locomotives transit from the Industrial District to the Terminal. This can result in extended at grade street closures during switching.
- There is no on terminal air[7]. This lengthens the amount of time that a locomotive must idle to perform brake checks when picking up a cut of cars.

2.5 Existing System Improvements

Several improvements have been made to the roadway/railroad infrastructure in the project area since the original Terminal 5 EIS was prepared (1994).

- The Harbor Island roadway network was rebuilt as part of the Terminal 18 expansion in 1999. That project relocated the lead railroad tracks to Harbor Island and T18 under the SW Spokane Street Bridge (these trains previously crossed Spokane Street at grade near 11th Avenue SW). The T18 project also reconfigured SW Spokane Street to create the frontage road system, which simplified the intersection at 11th Avenue SW.
- In 2012 the Port and its partners completed the East Marginal Way grade separation project on Duwamish Avenue South. The overpass improves road and rail access to Port terminals, BNSF and UPRR intermodal rail yards and regional manufacturing and distribution facilities. It also benefits motorists and industrial vehicle traffic moving to and from West Seattle. The road now rises over railroad tracks which connect rail mainline with the on-dock rail at the port’s T5 and T18. The grade separation is expected to reduce railroad crossing vehicle delay, which was estimated at more than 270 hours daily in 2010[8].

3.0 RAILROAD OPERATIONS

Once reactivated, the tenant at T5 will have the option to select either BNSF or UPRR as their freight rail handler. While BNSF owns the track crossing the West Waterway, the UPRR has shared trackage rights leading to the Terminal. The prior tenant of T5 selected UPRR. In that scenario, UPRR landed the trains at T5 in two cuts onto the terminal storage tracks. BNSF was responsible for any switching or further building of the trains. UPRR then pulled the loaded trains from the storage tracks and out of Seattle to the South.

Rail operations at T5 are similar regardless of the carrier chosen by a tenant. UPRR and BNSF will use similar circulation and processes for trains serving the Terminal. Rail operations outside of the Terminal, mainly east of Harbor Island, do vary between the two carriers. Trains moved to the BNSF mainline must travel through difficult geometry at the east end of the WSL, but have additional options for leaving the Seattle area. UPRR has a more direct route from the Terminal, but their options for reaching inland markets are limited to the mainline south to Portland. Ultimately, it will be the decision of the tenant to negotiate rates and services with the rail carriers. The discussion below summarizes operations in the near Terminal area for both carriers.

[7] On terminal air allows connection of cars to a site wide compressed air system that replicates the air supplied by a locomotive. This would allow brake testing of the cars prior to the arrival of the locomotives

[8] https://www.portseattle.org/Supporting-Our-Community/Regional-Transportation/Pages/East-Marginal-Way-Grade-Separation.aspx

3.1 Train Operating Speeds

Train speeds in the study area are limited to 20 mph. However, switching movements are typically conducted at 5 mph and most freight trains in the area do not operate above 10 mph. Sharp curves, multiple crossings and crossovers, as well as the draw bridge over the Duwamish, all contribute to lower speeds. Limited accelerations of freight trains further reduce operating speeds. Amtrak passenger trains are the exception to this tendency. Amtrak operates north south on the BNSF main tracks. The passenger trains are lighter and their terminus is further north of the study area at King Station. This allows Amtrak trains to operate closer to the 20 mph speed limit on the BNSF mainline in the eastern limits of the study area.

Except for local movements to and from the Amtrak Yard near South Holgate Street, no passenger trains operate on tracks off the BNSF mainline in the study area.

3.2 BNSF Operations

This section describes BNSF operations between T5 and their north south mainline. Full trains are typically 7,500 feet (ft) long with locomotives (7,200 ft without power). The full train may be received in the storage tracks adjacent to the WSY in two cuts.

Inbound trains are brought through Seattle to the Coach Wye. The train travels through the wye and double crossovers onto the northbound track towards SIG. The trains then diverge west onto the WSL. This is a potentially problematic geometry (curve-crossover-crossover-curve-curve) with reversing lateral movements. The train travels across the southern end of Harbor Island, across the lift-bridge, and then past the switch to the Terminal working tracks and onto the storage tracks adjacent to the WSY. Because the storage tracks are not long enough to store a full train, the train cuts off approximately 4,500 ft on the storage track and the locomotive runs around to pull the rest of the train into the storage tracks.

There are many variables that can impact the amount of time that it takes to deliver a full train to the Terminal including throttle behavior, bridge operations and track availability at the WSY. However, the time span for arriving trains can be approximated as shown in Table 2.

Table 2: Train Arrival Sequencing

Sequence	Duration (minutes)
Full length train arrives, pull first cut past yard switch	14
Cut off trailing length	10
Pull leading cut clear of yard switch	-
Cut off locomotive	10
Run around to trailing cut	9
Connect to trailing cut	10
Pull trailing cut into storage	14
Total Duration	**67**

The times in Table 2 represent the dwell time once a train has crossed the Western Waterway. The trailing cut of cars will clear the bridge and allow raising the span during delivery operations.

Departing trains will be staged on the storage tracks in similar sized segments. The returning locomotive will attach to the shorter segment, pull through the terminal switch towards the lift bridge and then reverse to connect to the longer segment. Full brake tests are performed as the two segments of the train are connected. The sequence of steps taken for departing trains is approximated in Table 3.

Table 3: Train Departure Sequencing

Sequence	Duration (minutes)
Pull leading cut out past yard switch	14
Push back through yard switch to second cut	-
Connect trailing cut	10
Pull out trailing cut	14
Total Duration	**34**

Note that in the approximation of both the arriving and departing sequences the brake testing time is omitted. See section 3.2 for discussion of brake test classification and durations.

Between the delivery/return of full trains, smaller cuts of cars are shifted to and from the storage tracks into the Terminal working tracks. Typically three cuts of train segments are moved from the storage yard to the working tracks. These intermediate moves would require movement of sole locomotives to the Terminal for pulling and shifting cuts of cars from one track to the other. These moves are inefficient and can be minimized with careful management of on Terminal circulation and staging.

3.3 UPRR Operations

UPRR operations to T5 are similar to BNSF's except that all trains depart south through Argo Yard. This is a more direct departure that does not require the movement through the Coach and WSL wyes.

3.4 Near Dock Rail Operations

Near dock rail refers to the movement of containers by truck to railyards for loading onto trains. These movements serve two purposes: allows the inclusion of containers in mixed commodity trains to destinations that do not require full trains, and allows movement of containers to other carriers beyond the primary one serving the terminal. These movements do not require movement of trains to and from the Terminal, but the volume of near dock traffic must be accommodated in railyards in the Seattle area.

3.5 On Terminal Rail Operations

There will be intermittent movements of cars between the working tracks in the intermodal yard (IY) and the storage yard. These movements will consist of partial cuts of cars, typically around 1,200 or 1,500 ft long, and will be conducted by switching engines. The switch engines will attach to the south end of the cuts, pull the cars out past the first yard switch and then push the cars up in to the storage yard. The switch engines would typically bring cars back into the IY on the return trip.

Note that the partial cuts can vary depending on container handling in the IY. Inefficient staging and coordination in the yard could result in more frequent movements of smaller cuts of cars between the IY and the storage yard.

3.6 Brake Testing

Brake tests are a critical component of railroad safety. The testing is mandated by the FRA[9] at five levels depending on the make-up and operation of a train.

Train brakes use air pressure generated either off train by a compressed air system (at terminals) or by the attached locomotive. The compressed air charges reservoirs on each car that then actuate the brakes. The trains are connected in sequence to form a single pressurized line. When pressure in the line drops (as when the engineer moves the locomotive into braking), the reservoirs discharge into the individual car brakes to slow the train. Leaks along the line can cause the brakes to accidentally engage. Leaks when the train is built can result in low reservoir pressure which undermines the braking capacity of the train. And, over time, wear on the individual cars can lead to failures of the individual cars' brakes.

The different levels of brake tests mandated by the FRA were established to identify failures in the brake lines. The classes range from the most involved (Class I) to the least (Transfer) [10]. Three of these tests are applicable to terminal operations: Class I, Class III and Transfer.

A Class I brake test will be required for most trains operating at T5 due to several conditions:

- Location where train originates operating in excess of 20 miles – trains departing T5 and traveling outside the Seattle area will exceed the 20 mile threshold
- Location where train consist[11] is changed – with limited exceptions, this applies to locations where trains are separated or cut into segments or assembled as long inter-modal trains
- Location where a train is off air for more than four hours – cars that are disconnected from a locomotive lose air and must be rechecked when reconnected to a locomotive

A Class III brake test must be performed in initial terminals whenever a locomotive is changed, a car or block of cars are removed (but the consist otherwise remains intact). This test will be applicable when cuts of cars are added or removed or when locomotives need to be changed out from an existing train.

Transfer brake tests will be required for trains that will travel less than 20 miles. This situation will arise if a partial consist is loaded and then moved off terminal for inclusion in other complete trains at SIG or Argo.

Part 232 of 49 CFR outlines 19 tasks that are required in various classes of brake test. The tasks are generally summarized as follows:

- Class I Brake Test – this test consists of three main steps: connect and pressurize the train; check pressure drop and airflow at the end of the train away from the locomotive or air source; walk the length of both sides of the train checking for kinks in the hoses, for engagement and release of the brakes and for piston travel in each brake; and provide documentation of the completed brake test to the engineer.

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[9] Brake tests per 49 CFR 232.607 - Inspection and testing requirements.

[10] See extended text of CFR Part 232 for locations and conditions outside of terminals that require further brake testing. Off terminal brake checks are considered outside the limits of this project.

[11] A consist is a group of cars making up the train, or more commonly a group of locomotives connected together.

- Class III Brake Test – this test omits the check for release and piston travel, but keeps the other tasks from a Class I test. This test still requires an inspector walk both side of the train, but they are only checking for engagement and attachment.
- Transfer Brake Test – this is the simplest test. It requires a pressure check and a check that the brakes engage. Similar to the other classes, this test requires a walkdown of both sides of the train.

The exact times that each test requires can vary greatly depending on lighting, weather, and inspector's experience level. The simplest approximation is to take the length of the train, and assumed walking speed and an allowance of time per car for inspection depending on the class of test performed Table 4).

Table 4: Brake Check Times by Class

Brake Test Class	Length of Train[12]	No. of Cars / Connections	Walking Time (2 mph)	Inspection Time	Total Brake Test Time
Class I	7,200 ft	94	81 minutes	94 minutes	3 hours
Class II				47 minutes	2 hours
Transfer Test				0 minutes	1.5 hours

The above tests are critical to ensuring safe operation of trains throughout the railroad networks. These are tests that are meticulously followed by all responsible railroad operators.

3.7 Railroad Locomotives

Current railroad operations are conducted primarily with six and four-axle diesel locomotives. The larger six axle locomotives are used for mainline and full train movements. The smaller four-axle locomotives are often used for shorter distances and lighter trains.

All locomotives in use in the Seattle area have diesel engines that drive generators feeding electric powered axles. Most of the locomotives in use have been upgraded to meet Tier 1, 2 or 3 air emissions targets as mandated by the Environmental Protection Agency (EPA)[13]. With limited exceptions, all locomotives constructed after 2015 are required to meet Tier 4 emissions standards[14]. The EPA tiered emissions requirements are applied by year of manufacture. All rebuilt locomotives are required to meet the emissions standards in effect at the time of their refurbishment (currently tier 4). Most locomotives are rebuilt on roughly 15 year intervals[15].

There are also strong economic incentives for more efficient locomotives and more efficient operations. Both Class I Railroads have expanding programs including cylinder deactivation, alternative fuels and alternative drive systems[16]. These programs are not mandated, but they are pursued for both economic and stewardship principles.

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12 Typical trains are 7,200 ft long without power

13 40 CFR part 1033 - Emission Standards and Certification Requirements, 40 CFR part 1068 - General Compliance Provisions, and CFR 1033.601 for instructions on applying the compliance provisions to locomotives. All available at http://www3.epa. gov/otaq/locomotives.htm

14 Discussion of EPA tiered regulations at https://www.dieselnet.com/standards/us/loco.php. Some of the excepted locomotives include historic steam-powered locomotives, all-electric locomotives, and some existing locomotives owned by small businesses.

15 EPA "Control of Emissions from Idling Locomotive" available at http://www3.epa.gov/otaq/locomotives.htm

16 http://www.bnsf.com/communities/bnsfandtheenvironment and https://www.up.com/aboutup/environment/

Rail road operators have the responsibility to determine where, and in what use, newer locomotives are deployed within their system. However, over time, the tier 4 compliant locomotives and switch engines will enter use in the Seattle operations of both railroads.

3.8 Rail-Street Crossings

The study area is located in a densely developed industrial district in south Elliot Bay, the Duwamish Industrial Area. Rail lines in this area cross multiple arterial surface streets and pass numerous commercial and industrial access points. There are also multiple private driveway crossings of the railways. All of these crossings expose trains to the danger of collision with vehicles that fail to yield right of way or have otherwise blocked the crossing. Trespassing is also a serious problem in any urban setting. There are opportunities for individuals to trespass on railroad right of way and be struck by trains.

The FRA retains accident data for all crossings in the US. For the 20 year period from 1995-2015, there were 29 accidents including 2 injuries involving freight trains in the study area[17]. There were no fatalities due to impacts with freight trains in the last 20 years. Table 5 summarizes the last 20 years of accident data for the study area:

Table 5: Accidents at Rail-Street Crossings Impacted by Terminal Rail Operations

Crossing No.	Name	No.	Injuries	Fatalities	Crossing Warning, Protection
933592P	Private - Yard	1	0	0	Stop signs
927504N	Private	1	0	0	Private crossing signs, crossbucks
096445R	E Marginal Way	13	2	0	Signs, signals, crossbucks
096442V	Spokane St.	1	0	0	Signs, signals, crossbucks, mast mounted lights
809548P	Colorado St.	2	0	0	Signs, signals, crossbucks
096202N	Chelan Ave. SW	2	0	0	Signs, signals, crossbucks, mast mounted lights
Total		***20***	***2***	***0***	

Note that of the 13 accidents at East Marginal Way, 12 occurred prior to the construction of the East Marginal Way Grade Separation. Since the construction of the overpass, there has only been one accident at the crossing.

Safety is a primary railroad concern in controlling train speeds. Switching at all yards is accomplished at speeds under five mph. Transfer movements on the BN from SIG/Stacy to the Ballmer Yard may reach 10 mph. Train crossings of surface streets result in street closures of 1 to 17 minutes in duration. Table 6 shows estimated street closure times in minutes associated with three train lengths.

Street closures by trains create traffic delays only to the extent that street traffic exists. Total traffic delays during a train crossing average half of the total street closure time. For example, in the affected line of delayed vehicles, the first car experiences full delay and the last car experiences zero.

[17] Data gathered from FRA accident reports at http://safetydata.fra.dot.gov. Crossing analysis omits locations beyond T5 rail traffic and also omits accidents involving Amtrak and Sounder trains.

Table 6. Train Crossing Delays (minutes)[18]

Train Speed	Full Train[19]	Half Train	Quarter Train
5 mph	17.4	9.2	5.1
10 mph	9.2	5.1	3.0
20 mph	5.1	3.0	2.0

3.9 CAPACITY

Previous Terminal 5 operations included up to two inter-modal trains in and out of the Terminal per day or 14 trains per week. Past operations also included switching moves between the Terminal 5 inter-modal rail facility and adjacent inter-modal storage tracks.

Prior operations at Terminal 5 relied on a 1:1 ratio of working to storage tracks at the Terminal. The balance of storage and working tracks is critical to the efficient conduct of on dock rail operations at container terminals. Deficient storage capacity requires additional moves on working tracks such as staging and swapping empty and loaded cuts of cars. During these moves on working tracks, loading and picking work must stop in the vicinity of the track where cars are being moved. Minimizing the number of times cars are moved to/from working tracks helps reduce interruptions to the marshaling operations.

4.0 PROJECT DESCRIPTION

In response to industry changes in marine cargo shipping practices, the Port is evaluating improvements to ensure that T5 will be capable of meeting industry needs. Three alternatives are being considered as part of the Project EIS and are described in brief detail below. Alternative 1, the No Action Alternative, provides a baseline of conditions for comparison when discussing the action alternatives.

The overall volume of train born traffic increases incrementally from each alternative to the next. However, the proportional share and distribution of rail traffic is the same for all three alternatives. It is forecast that 75% of the terminal container traffic will be carried by direct rail. That share is further divided such that 25% of the terminal traffic will be handled by near dock rail and 50% loaded to on dock rail. On dock rail includes use of the existing six track T5 inter-modal rail transshipment facility and use of the adjacent existing five track inter-modal storage yard. Near dock rail is loaded to truck chassis and then drayed to either the SIG (BNSF) or Argo (UPRR) for loading and incorporation into mixed use trains. These divisions are summarized in Table 7.

[18] Closure times include 30 seconds closure before the arrival and 30 seconds after the passing of the train for the crossing to clear and gate arms to rise. Closures may be shorter at ungated/un-signaled crossings depending on driver behavior and failure to observe driving regulations.

[19] Typical trains are 7,500 ft long with locomotives

Table 7: Rail Container Distribution

Mode	Percentage Share of Terminal Throughput
On Dock Rail	50%
Near Dock Rail	25%
Total Rail Share	**75%**
Truck Share	**25%**

Three alternatives are proposed for freight operations at Terminal 5:

4.1 *Alternative 1 or No Action Alternative.*

The No Action Alternative assumes that no improvements would be made to the existing site other than minor alterations, routine maintenance and repair work, none of which would impact throughput capacity.

In this alternative, on dock rail throughput will generate up to 9 full outbound trains per week during peak operations. Near dock rail will generate an additional average 5 trains per week during peak operations.[20,21]

The reactivation of the terminal to the previous throughput does not require modification to the existing track.

4.2 *Alternative 2:* Wharf improvements, increased cargo-handling efficiency and volume.

Alternative 2 would rehabilitate the existing T5 container cargo pier and deepen the existing navigational vessel berth access. Upland improvements could also be constructed to support the above wharf upgrades.

With improvements to the terminal, T5 could generate up to 18 full on dock trains each way per week and an additional 9 near dock trains per week during peak operation.

No terminal rail modifications are required, but this alternative will require the expansion of storage into the WSY beyond the previously utilized storage tracks.

4.3 *Alternative 3:* Wharf improvements, relocate buildings, and densify rail yard, optimized cargo-handling efficiency and volume.

Alternative 3 would reconfigure and expand the on terminal storage track to accommodate further increases in cargo volume.

The reconfigured track and shifted operation would support up to 24 full on dock trains each way per week and an additional 12 near dock trains per week during peak operation.

This alternative would require the transition of additional train building operations to the WSY as well as the installation of on terminal air at the receiving and departing tracks to allow for more rapid turnaround of outbound trains. This alternative will require the addition of third shift train moves only during peak operations.

[20] M&N conceptual design and model

[21] Alternative 1 represents no modification to the existing infrastructure of T5, but does represent a shift in inter-modal split from previous terminal operations. Previous operations did not reach the volume of rail traffic that is forecast in the reactivation. The historical 45% percentage share of truck volume is forecast to drop to 25%.

The distribution and share of containerized traffic is discussed above. The estimated terminal generated train traffic for the three alternatives are summarized in Table 8.

Table 8: Peak Weekly Terminal 5 Train Volume

Mode	No. of Trains per Week (each way)		
	Alternative 1	Alternative 2	Alternative 3
On Dock Rail	9	18	24
Near Dock Rail	5	9	12
Total Trains	**14**	**27**	**36**

4.3.1 On Terminal Air

On terminal air is required to support the number trains forecast as part of Alternative 3. The availability of on terminal compressed air can potentially decrease the amount of time that locomotives are on site and idling to provide air pressure during a brake test. While the necessity of the tests is unquestionable, it is worth noting that any class of brake test requires a substantial amount of time.

At terminals without a separate compressed air supply, arriving locomotives must attach to a cut of cars and then idle while the brake test is performed. In each brake test class, a person or persons must walk the entire length of both sides of the train. Depending on the class of test being performed, there are multiple features of each car that must be inspected. All this is performed while the locomotive engine is idling on site.

At terminals with a separate compressed air supply, the bulk of a Class I or Class II brake test can be performed prior to the arrival of the locomotive. The train is built and the brake system pressurized using the terminal air. The consist is inspected to the required class of test prior to the arrival of the locomotive. When the locomotive arrives, a valve in the lead car is closed to isolate the pressurized brake system and the terminal air is disconnected. The locomotive is connected and the end of train pressure and flow are checked. After this one Transfer test, the train may depart. In this operation the majority of the test is performed prior to the arrival of the locomotive and reduces idle times at the terminal.

The use of on terminal air to reduce turnaround times does require coordination between the terminal and railroad operators to ensure that the test is completed prior to the arrival of the locomotive. This also requires that a Qualified Mechanical Inspector (QMI) be on site to perform all tasks as part of Class I tests. Class III and Transfer tests may be performed by a Qualified Person (QP) or QMI. These persons are designated by the railroad as having demonstrated knowledge and ability to inspect the railroad cars.

5.0 RAIL AGENCIES REGULATIONS AND MANAGEMENT

This section describes the agencies, laws and regulations in place that helped to identify potential impacts to rail infrastructure and train traffic.

5.1 Laws and Regulations

Laws and regulations for determining potential impacts on rail traffic are summarized in Table 9. More information about laws and regulations is provided in Chapter 4, Environmental Health and Safety**.** The agencies and roles relative to the legislation are described in the following section.

Table 9: Laws and Regulations

Laws and Regulations	Description
Federal	
Interstate Commerce Commission Termination Act (49 U.S.C. 101)	Re-establishes the Surface Transportation Board and upholds the common carrier obligations of railroads; requires railroads to provide service upon reasonable request.
Federal Railroad Administration Regulations (49 CFR 200–299)	Establishes railroad regulations, including safety requirements related to track, operations, and cars.
State	
Title 81, Transportation – Railroads, Crossings (RCW 81.53)	Establishes requirements and process for railroad construction and extensions that would cross any existing railroad or highway at grade. Includes approval from the commission.
WSDOT Local Agency Guidelines M 36-63.28, June 2015, Chapter 32, Railroad/Highway Crossing Program	Focuses on adding protection that improves safety and efficiency of railroad/highway crossings. Provides a process for investigating alternatives for improving grade-crossing safety. Alternatives include closure, consolidation, and installation of warning devices
WSDOT Design Manual M 22.01.10, July 2013, Chapter 1350, Railroad Grade Crossings	Provides specific guidance for the design of at-grade railroad crossings.
Rail Companies - Operation (WAC 480-62)	Establishes operating procedures for railroad companies operating in Washington State. Includes general and procedural rules, safety rules, reporting requirement rules, and the establishment and distribution of a grade-crossing protective fund.

U.S.C. = United States Code, CFR = Code of Federal Regulations, RCW = Revised Code of Washington

5.2 Federal Rail Agencies

The Federal government controls interstate commerce to the exclusion of State and Local entities. Interstate rail system and railroad operators are primarily overseen by two federal agencies: the Federal Railroad Administration (FRA) as part of the US Department of Transportation, and the Surface Transportation Board (STB) as successor to the Interstate Commerce Commission (ICC). The Federal Transit Administration (FTA) has oversite of passenger transit systems that do not connect to the national freight rail network. Therefore, the FTA does not have jurisdictional oversite in this project.

In addition to the primary oversite of the FRA and STB, other Federal agencies have jurisdictional oversite of portions of railroads' operations as well as direct involvement with corollary State and Local agencies. These Federal roles are summarized in Table 10.

Table 10: Federal Agencies

Agency	Scope of Activity	Authorities/Responsibilities
Federal Railroad Administration (FRA)	Train/Track Safety	• Develops and enforces basic operating rules for train safety, tank car safety, railroad industrial hygiene, rail equipment safety, and grade crossing safety and trespass prevention. • Oversees employee hours of service regulations and signal and train control regulations. • Inspects and audits railroad track. • Tracks rail movement of spent nuclear fuel and radioactive waste. • Manages the Rail Safety Improvement Act of 2008 (RSIA).
	Rail Funding/ Financing	• Oversees Railroad Rehabilitation and Improvement Financing program (RRIF). • Manages American Recovery and Reinvestment Act (ARRA) as it relates to freight railroads. • Administers rail grants through various programs.
	Guidance	• Provides guidance and analysis of rail services. • Produces the National Rail Plan, outlining national priorities for freight and passenger rail networks, incorporating input from state rail plans.
Surface Transportation Board (STB)	Administrative Authority	• Settles railroad rate and service disputes. • Reviews proposed railroad mergers, acquisitions, abandonments and new line construction.
Pipeline and Hazardous Material Safety Administration (PHMSA)	Hazardous Materials Safety	• Regulates and enacts rules that ensure safe movement of hazardous materials. • Tracks data on hazardous materials. • Permits, inspects and enforces safety of hazardous materials.
Department of Homeland Security (DHS)	Security	• Establishes requirements for national rail security strategy and risk assessment. • Tracks hazmat shipments. • Creates railroad requirements for developing institutional risk assessments. • Conducts programs for rail security training. • Conducts rail security research and development (R&D).
DHS: U.S. Coast Guard	Construction Permitting and Funding	• Manages permitting for structures crossing navigable waterways. • Administers Truman-Hobbs Act, which funds bridge projects over navigable waterways.
Environmental Protection Agency (EPA)	Environmental Regulation	• Regulates and establishes locomotive emission standards. • Enforces the National Environmental Policy Act (NEPA) that requires environmental review for proposed rail projects.
U.S. Army Corps of Engineers	Construction Permitting	• Manages permitting for construction on waterways and wetlands.

Source: Washington State Rail Plan, Integrated Freight and Passenger Rail Plan 2013-2035

5.3 State and Regional Agencies

Non-Federal oversight of freight rail is limited by the federal preemption for interstate commerce. Outside of economic and safety oversight, nonfederal agencies are engaged in many other aspects of the rail industry, particularly in the realm of planning, coordination, investment, and, to some degree, safety. The key nonfederal agencies involved in these topics are described in Table 11.

Table 11: State and Local Agencies

Agency	Scope of Activity	Authorities/Responsibilities
Washington State Department of Transportation (WSDOT)	Rail Funding/ Financing	• Manage and direct the state's rail programs (both freight and passenger; and both capital and operating). • Oversees the state's freight grants and loans programs, and developing the State Rail Plan. • Prepare and administer the State Rail Plan. • Develop the State Freight Mobility Plan in cooperation with the Freight Mobility Strategic Investment Board (FMSIB).
Freight Mobility Strategic Investment Board (FMSIB)	Rail Planning and Financing	• Designate strategic freight corridors with WSDOT research. • Develop criteria for projects. • Administer project grants.
Washington State Utilities and Transportation Commission (UTC)	Train/Track Safety	• Monitor railroad operations, crossing signals and track. • Inspect crossings and evaluate company-filed petitions for crossing changes and close clearances. • Regulate movement of hazardous materials. • Provide education and outreach as part of the Operation Lifesaver program. • Investigate accidents and complaints from the public.
City of Seattle Department of Transportation (SDOT)	Rail Planning	• Prepare and administer the SDOT Freight Mobility Plan. • Maintain and improve roadway approaches to at-grade crossings.

Source: Washington State Rail Plan, Integrated Freight and Passenger Rail Plan 2013-2035

5.4 Other Organizations

Non-governmental organizations that weigh significantly in the railroad industry are listed in Table 12. While these two do not have specific statutory authority, their standards and guidelines are enforceable as cited by multiple railroads, agencies and organizations.

Table 12: Other Organizations

Organization	Scope of Activity	Authorities/Responsibilities
American Railway Engineering and Maintenance-of-Way Association (AREMA)	Rail design, safety, operation and maintenance	• Develop and advance the technical and practical knowledge and recommended practices for the design, construction and maintenance of railway infrastructure • By citation, complete standards for construction of track, roadway, structures and other ancillary railway improvements
Association of American Railroads (AAR)	Rail Planning and Financing	• Advance public policy that supports the interests of the freight rail industry • Establish safety, security, and operating standards • Prepares comprehensive statistical records • Support research, development and testing through the Transportation Technology Center Inc. (TTCI), Railinc, and the Railroad Research Foundation.

6.0 POTENTIAL IMPACTS TO RAIL INFRASTRUCTURE AND RAIL TRAFFIC

6.1 Construction

Construction at Terminal 5 will incur minimal impacts to the railroad infrastructure. The track reconfiguration in Alternative 3 would require slight modifications to the track interchange at the south end of the terminal. This connecting track work will be performed during scheduled windows.

6.2 Operations

6.2.1 Alternative 1 or No Action Alternative

There would be no impact to capacity or operations under Alterative 1. This alternative represents the resumption of terminal operations that are nearly identical to the prior function of the Terminal.

6.2.2 Alternative 2: Wharf improvements, increased cargo-handling efficiency and volume

There would be no impact to the capacity or operations under Alternative 2. The additional utilization of storage track in the WSY will support the programmed rail traffic volume over the existing system.

6.2.3 Alternative 3: Wharf improvements, relocate buildings, and densify rail yard, optimized cargo-handling efficiency and volume.

There would be impacts to the capacity and operations under Alternative 3. Additional train building operations will have to be transferred to the WSY. The storage tracks will have to be upgraded with on terminal air. Additional shifts will be necessary to allow movement of trains from the Terminal to the WSY without interruptions to the on terminal loading.

6.3 Potential Mitigation Measures for Impacts to Rail Infrastructure and Rail Traffic

6.3.1 During Construction

No mitigation measures are required during construction of the three alternatives.

6.3.2 Operations

Alternative 1 requires no operational mitigation.

Alternative 2 requires the use of additional storage tracks in the WSY. This will allow the staging of additional loaded cuts for removal from the terminal.

Alternative 3 requires additional shifts to support terminal operations as well as the transfer of additional staging to the WSY. The addition of the on terminal air system will require qualified technicians on terminal to perform brake tests for staged cuts of cars.

6.4 Significant Unavoidable Adverse Impacts

No significant impacts to rail infrastructure and train traffic would be anticipated from any of the Alternatives.

7.0 POTENTIAL MITIGATION MEASURES FOR IMPACTS TO NOISE, AIR QUALITY AND VEHICULAR TRAFFIC

The following potential mitigation measures are provided for information and are not required mitigation for impacts to Rail Infrastructure and Capacity. These measures may or may not be deemed necessary mitigation for other impacts in the project area.

7.1 Near Terminal Driveway Impacts

Increasing rail volumes moving to and from Terminal 5 will result in additional closure times of near terminal driveways and at grade crossings (Figure 7). The additional closures do not require mitigation for impacts to rail infrastructure and capacity. However, the driveways may have to be closed due to impacts to truck and vehicular traffic in the alternatives.

Arriving and departing trains have an additional impact on near terminal crossings beyond the simple transit time for a train to move through the crossing. These impacts are compounded by the switching movements between the Intermodal Yard of the Terminal and the adjacent storage yard. The arrival-departure of full 7,500 ft trains will impact all five of the crossings west of the West Waterway, but the switching movements will only impact the two western crossings: the T5 and T7 entrances.

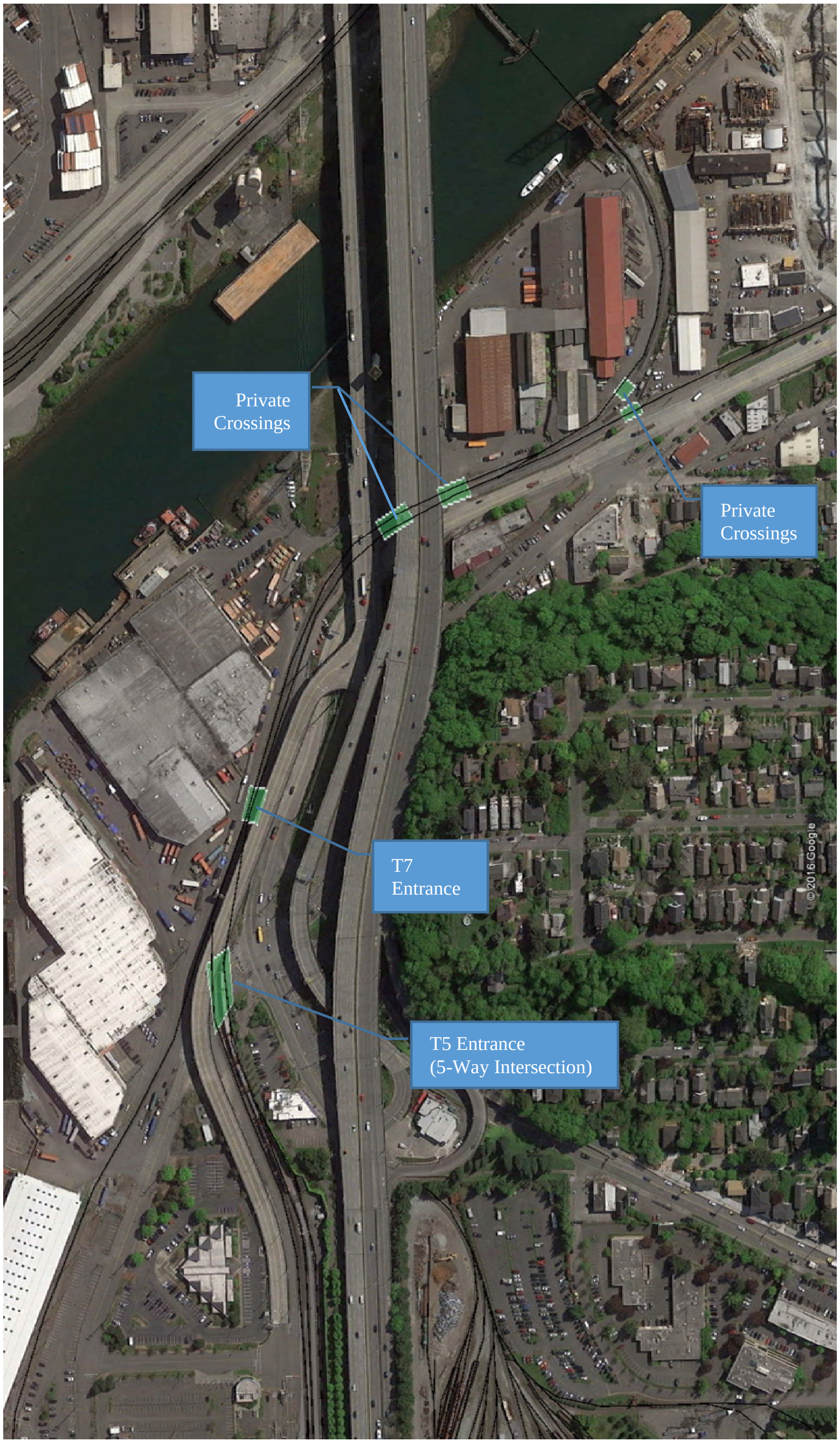


Figure 7 – Near Terminal Crossings

Source: Google Earth

Once across the West Waterway Bridge, arriving trains must stop and split out cuts of cars for staging on the Terminal storage tracks. Similarly, departing trains must be assembled and brake tests performed which can impact the crossings. These times are broken down in Section 3.2 above. At the proposed level of operations at T5, the delays at the five near terminal crossings can be considered cumulative during peak 24 hr periods as summarized in Table 13:

Table 13. Near Terminal Crossing Impacts – Train Arrival/Departure

Activity	Alternative 1	Alternative 2	Alternative 3
Trains/Week	9	18	24
Trains/Day	2	3	4
Inbound Closures (67 min/train)	134 min	201 min	268 min
Outbound Closures (34 min/train)	68 min	102 min	136 min
Total Closure Time per Day	202 min (3 hr 22 min)	303 min (5 hr 3 min)	404 min (6 hr 44 min)

In addition to the arrival/departure of complete trains, there are intervening switching movements between the IY and storage tracks that cause additional closures of the two crossings nearest the Terminal: the T5 and T7 drive entrances. Cuts of either 1,200 ft or 1,500 ft are moved between the two yards. Generally it takes at minimum three – 1,500 ft and 2 – 1,200 ft cuts to make a complete trains. The closure impacts due to switching movements are summarized in Table 14.

Table 14. Near Terminal Crossing Impacts – Switching

Activity	Alternative 1	Alternative 2	Alternative 3
Trains/Week	9	18	24
Trains/Day	2	3	4
Closure for 1,500 Ft Switches/day (3 per train, 17 min per switch)	102 min	153 min	205 min
Closure for 1,200 Ft Switches/day (2 per train, 14 min per switch)	55 min	82 min	109 min
Total Closure Time per Day	623 min (10 hr 23 min)	934 min (15 hr 34 min)	1,246 min (20 hr 46 min)

Note that the switching impacts only occur at the T5 and T7 gates. Furthermore, the full closure times only occur at the T5 gate. The T7 gate is further east and only experiences approximately 1/3 the time of closure as the cuts pull out and reverse direction to move through the yard switch.

The *Transportation Technical Report for the Terminal 5 Improvement Project*[22] has recommended that the surface access to Terminal 5 be closed to improve operations at the five-legged intersection at SW Spokane Street/West Marginal Way SW/SW Chelan Avenue. The surface access is the north leg of this

[22] Heffron Transportation, Inc.

intersection. Closing this access allows the intersection to operate with more conventional signal phasing, and would eliminate the railroad pre-emption phase that goes into effect whenever a train crosses that leg. Given the potential increase in rail closure times of that intersection with Alternative 2 or 3, the north leg would effectively be blocked for much of the day. The vehicular traffic analysis determined that the overpass which connects from SW Spokane Street to Terminal 5 as well as the private properties north of the tracks (Terminals 7A, 7B and 7C) has adequate capacity to accommodate all of the truck traffic generated by the terminal and those businesses.

7.2 Railway Safety

The increase in the number of trains crossing the West Waterway will increase the opportunities for vehicles and pedestrians to interfere with the safe operation of the railway. The existing crossings near the Terminal are provided with minimal crossing protection measures. Firgure 7 shows the locations of the near Terminal crossigns west of the West Waterway.

Only the driveway to Terminal 5 has lighted signals (flashers) at the crossing. The other driveways only have signs indicating the potential passage of trains. Furthermore, the corridor is open to sidewalks and adjacent parking. There are abundant opportunities for pedestrians and vehicles to impinge on the railway and expose themselves to serious injury, damage and even death.

There are two measures that can help increase safety on the rail corridor: crossing safety equipment and fencing the rail corridor.

The addition of gates and flashing signals would help reduce opportunities for vehicles to collide with trains. Due to the varied approaches and striping at driveway entrances, quad gates might be necessary to prevent runaround movements.

Fencing the rail corridor would help reduce two current conflicts: trespassing and parking. The open corridor provides multiple locations where parked vehicles and equipment can intrude on the railway operating envelope. Pedestrians have no barriers to trespassing between the sidewalks and track. Chain link fencing would help to seal off the railway and reduce such conflicts.

7.3 Quiet Zones

If noise from increased rail operations is deemed adverse, a new quiet zone could be implemented to mitigate for this impact. Quiet zones are not required as mitigation for impacts to rail infrastructure and capacity under any of the alternatives.

Quiet zones are sections of track where trains are, in certain conditions, prohibited from sounding horns. Trains use horns in a number of circumstances and are considered a vital element of the safe operation of trains. The horn is typically sounded in switching operations when the train begins to move. The horn is sounded continuously when persons or vehicles are sighted in the way of the train. Horns are also sounded at the approach to all at grade crossings with roadways. Quiet zones are implemented in segments of track to reduce the use of the horns in the last situation, at approaches to roadways. The trains will still sound their horns for trespassing pedestrians and blocking vehicles, even in quiet zones.

The FRA provides guidance on the establishment of quiet zones. The steps in part include[23]:

1. Identify the crossings in the intended quiet zone. The new quiet zone must be at least ½ mile in length along the railroad tracks.

[23] Part III of FRA “Guidance on the Quiet Zone Creation Process”

2. A new quiet zone must have, at a minimum, flashing lights and gates in place at each public crossing. These must be equipped with constant warning time devices where reasonably practical, and power out indicators.
3. Private crossings that allow access to the public or provide access to active industrial or commercial sites, must conduct a diagnostic team review of those crossings. The recommendations of the team's review must be implemented.
4. Using the FRA's Quiet Zone Calculator, compare the Quiet Zone Risk Index (QZRI) to the Nationwide Significant Risk Threshold (NSRT). If the QZRI is less than or equal to the NSRT, the Quiet Zone may be designated through public authority[24].

The steps described above involve qualifying a quiet zone without implementing any Supplementary Safety Measures (SSMs) or Alternative Safety Measures (ASMs). If the calculator indicates that the proposed quiet zone will not qualify, necessary measures must be implemented. Public Authority Designation requires the implementation of SSMs, grade separations, crossing closures, or wayside horns.

If every public crossing in the proposed Quiet Zone is equipped with one or more SSMs and the QZRI falls below the Risk Index with Horns (RIWH), the Quiet Zone may then be designated through public authority.

To meet the minimum ½ mile length, the quiet zone could be developed between the T5 entrance at the five-way intersection and the lift-bridge over the West Waterway. The zone would exclude the track south along the WMB. The quiet zone would include the one public crossing at the entrance to T5 and 4 private crossings: the entrance to Terminal 7, access to the parcel between the high and low bridges, entrance to the north side of Riverside Mill, and the double crossing on the south side of the Mill (Figure 7). The public crossing to T5 has flashers. The private crossings only have signs. Also, most of the length of the track in this area is unfenced and allows unimpeded access to pedestrians trespassing on the railroad right of way.

Subject to a detailed technical assessment, the implementation of a quiet zone in this area would, at a minimum, require substantial upgrades at all five crossings (crossings arms, flashing lights and associated track circuitry). The quiet zone would also require securing the right of way with chain link fence to reduce the ease of trespassing on the right of way. These measures would mitigate for the loss of protection afforded by the audible warnings of an approaching train. In principle, the mitigating measures for a quiet zone outweigh the loss of the train horns and result in a net increase in crossing protection. In the case of the near terminal driveways, the installation of physical barriers to trespassing pedestrians and impinging vehicles would provide a substantial net improvement in safety.

It is standard practice for the crossing authority to maintain the added crossing equipment not the railroad. Agreements would have to be introduced for SDOT to maintain the crossing protection equipment.

The costs and footprint required to upgrade additional crossings east of the West Waterway makes an eastward extended quiet zone infeasible. There is not enough space available to install the gates and other equipment necessary to upgrade all of the crossings on Harbor Island.

7.4 On Terminal Air

As discussed in Section 6, the addition of an on terminal air system will result in substantial reductions in idle times for locomotives assembling departing trains. The air system is necessary to mitigate for impacts to Rail infrastructure in Alternative 3, but might be warranted in other alternatives as a mitigation to air quality impacts. See EIS section on air quality impacts for discussion of potential mitigation measures.

[24] Quiet Zones established by comparison to the NSRT are subject to annual FRA review (rule section 222.51).

Appendix G
Vessel Traffic and Navigation

Memorandum

To:	Steven Gray, Moffatt & Nichol (M&N)
From:	Margaret Schwertner, Emy Carpenter, and Kyle Landon (M&N)
Date:	April 20, 2016
Subject:	Terminal 5 Vessel Traffic and Navigation
Project:	Terminal 5 Cargo Wharf Rehabilitation, Berth Deepening and Improvements

1.0 INTRODUCTION

Moffatt & Nichol (M&N) has been retained by the Port of Seattle (Port) to provide design support services, including support for the State Environmental Policy Act (SEPA) review for the Terminal 5 (T5) Cargo Wharf Rehabilitation, Berth Deepening and Improvements Project (the Project). Part of this effort includes assessing the potential for project-related short-term and long-term effects relating to existing vessel traffic and navigation.

This memorandum describes existing vessel traffic and navigation in the study area, vessel traffic management, and what potential changes in vessel traffic or navigation could occur. Measures to avoid, minimize, or compensate for potential adverse effects are identified and include:

- Current regulations (e.g. requirement for a licensed Pilot on board large commercial vessels) and communications with the VTS and other vessels will continue and minimize risks of traffic collisions, delays, or accidents.
- Communication between the Port and Muckleshoot and Suquamish Indian Tribes, with the objective of avoiding and minimizing potential disruption to Treaty fishing activities. This includes scheduling of construction activities (to avoid specific fishing periods and controlling the location and timing of construction activities) and the advance sharing of vessel arrivals and departures during fishing periods to avoid and minimize potential net and vessel conflicts.

Information is provided in a format that can be incorporated into the Project's in-development Environmental Impact Statement (EIS) as a separate chapter or as part of other existing EIS sections.

2.0 STUDY AREA

The study area for vessel traffic and navigation includes the southern edge of Elliott Bay into the Duwamish River West Waterway and the existing T5 wharf (Figure 1).

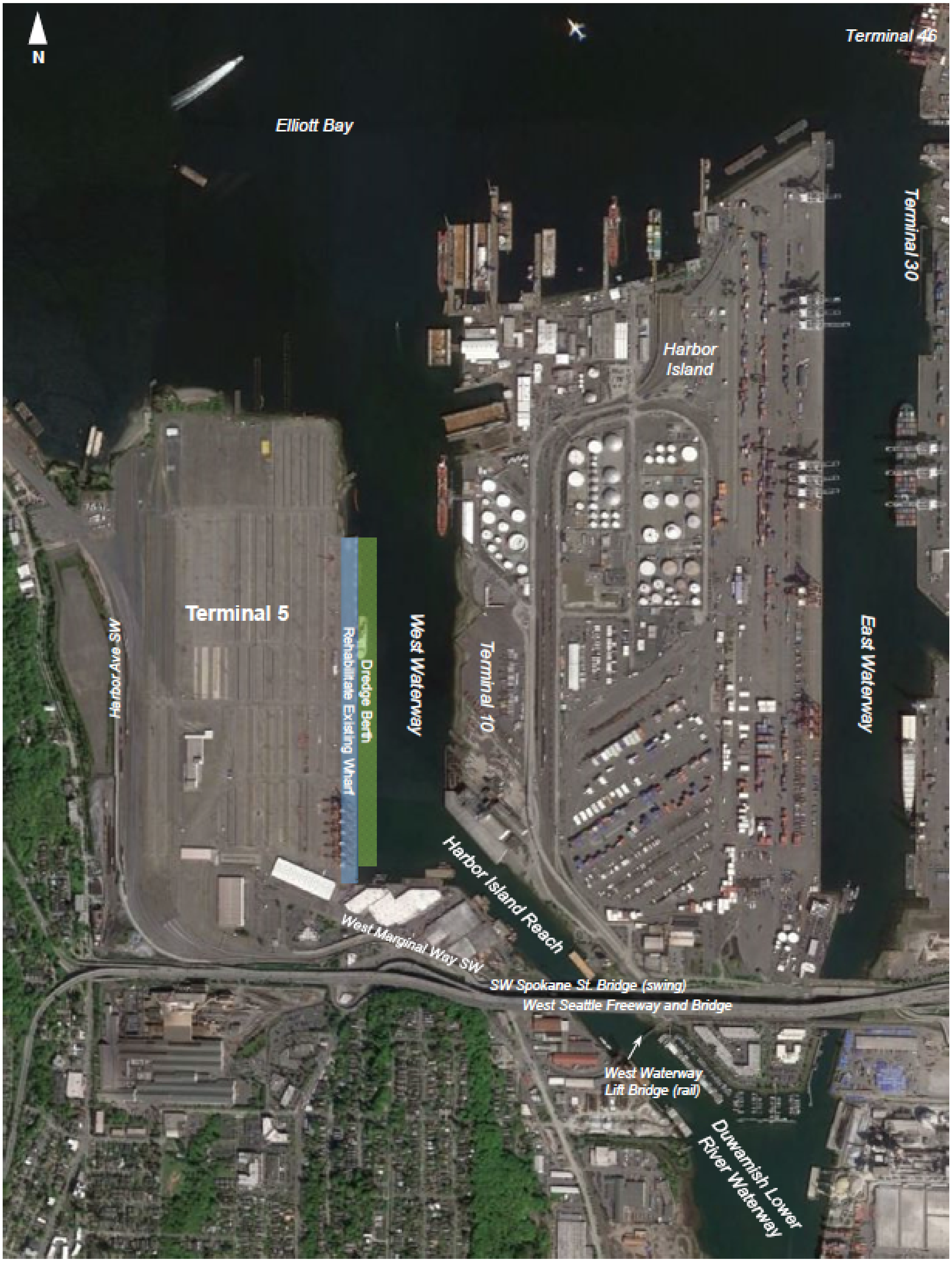


Figure 1: Port of Seattle Terminal 5 on the Duwamish River

3.0 EXISTING CONDITIONS WEST WATERWAY DUWAMISH RIVER

The existing Duwamish River Waterway is an artificially deepened and straightened industrial waterway that supports a number of water-dependent industries and facilities. Deep draft navigational access into the Duwamish River is through the West and East Waterways, both of which are located on either side of Harbor Island (Figure 1).

The U.S. Army Corps of Engineers (USACE) manages the federally authorized channels within the Duwamish River for vessel navigation. Authorized depths of the northern end of the Duwamish River into Elliott Bay are shown in Figure 2. Specific USACE authorizations related to the West Waterway are listed in Table 1.

The Duwamish River West Waterway extends south from pierhead line Elliott Bay for 5,200 feet (USACE and POS 2014). The waterway is 750 feet wide and authorized to -34 feet Mean Lower Low Water (MLLW), although existing depths range up to -56 feet MLLW (USACE and POS 2014). The West Waterway accesses the narrower 200-foot wide Lower Duwamish Waterway at river mile (RM) 0.

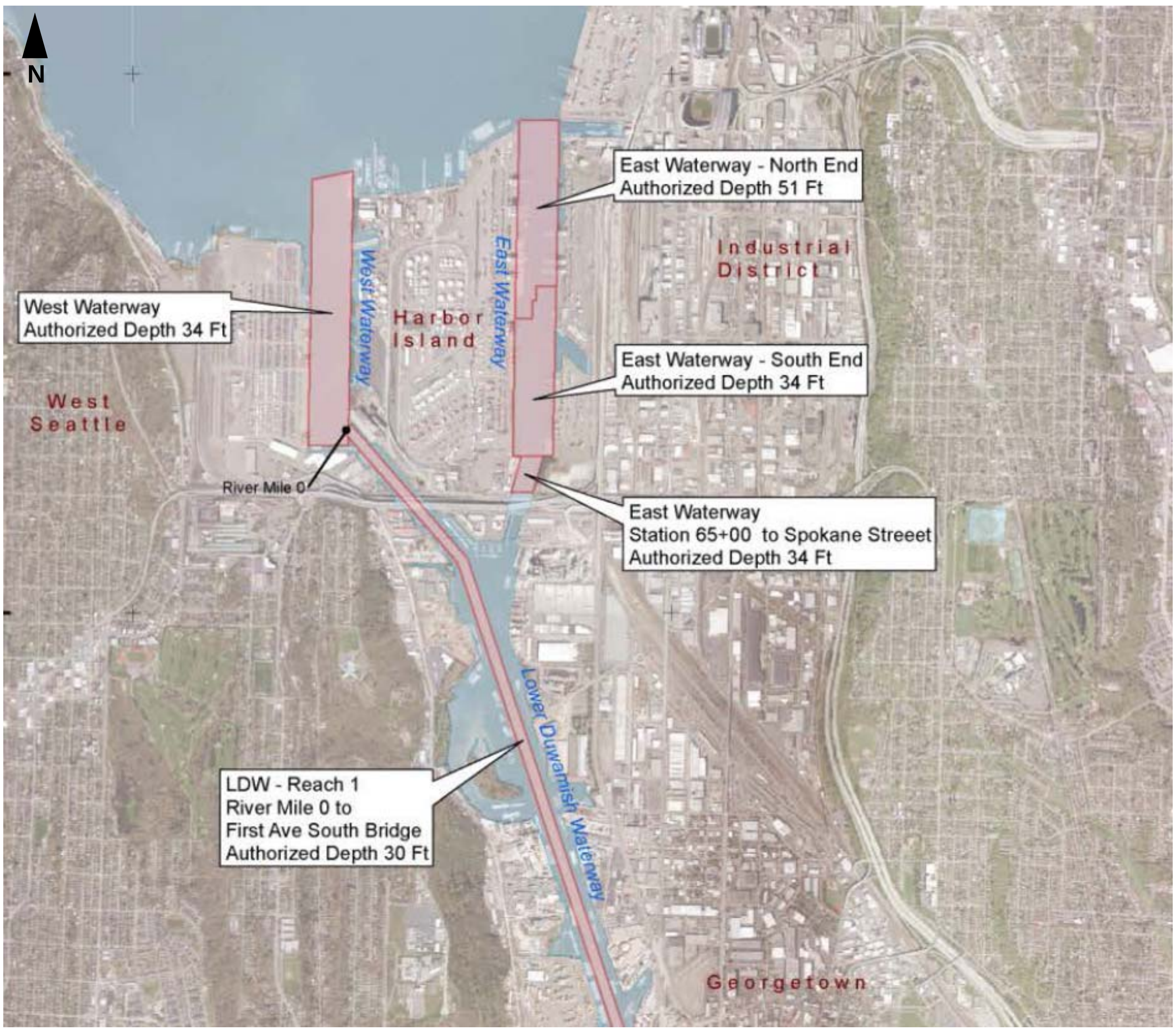


Figure 2: Port of Seattle Terminal 5 on the Duwamish River

Table 1: West Waterway Authorizing Language (USACE and POS 2014)

Document	Date	Citation	Authorization Language
Senate Doc 313 15 Dec	15 Dec 1918	S.D. 313, 65th Cong. 3d Sess.	…the United States take over and assume the maintenance of these portions of the East and West Waterways for distances of 6,500 feet and 5,200 feet, respectively, from the pierhead line at Elliott Bay… maintaining the East and West Waterways to a depth of 34 feet…
River and Harbor Act (RHA) 1919	2 Mar 1919	40 Stat. 1285	Construction, completion, repair, and preservation of the works hereinafter named:… maintenance of East and West Waterways, Seattle Harbor, in accordance with the report in Senate Document numbered 313, Sixty-fifth Congress, third Session…
RHA 1935	30 Aug 1935	74 Pub. L. 409	That the following works of improvement of rivers, harbors, and other waterways are hereby adopted and authorized, to be prosecuted under the direction of the Secretary of War and supervision of the Chief of Engineers, in accordance with the plans… designated and subject to the conditions set forth in…; *Seattle Harbor, Washington; House Document Numbered 211, Seventy-second Congress…*
Water Resources development Act (WRDA) 1986	17 Nov 1986	99 Pub. L. 662	Sec. 202 GENERAL CARGO AND SHALLOW HARBOR PROJECTS (a) AUTHORIZATION FOR CONSTRUCTION - The following projects for harbors are authorized… subject to the conditions recommended in the respective reports designated in this subsection, except as otherwise provided in this subsection: EAST, WEST, AND DUWAMISH WATERWAYS, WA…

The Southwest Spokane Street Swing Bridge crosses the Duwamish River at mile 0.2 with 44 feet of vertical clearance at MHHW (55 feet at center) and 250 feet of horizontal clearance (NOAA 2015). A second fixed bridge, the West Seattle Bridge is located just above the swing bridge and has a vertical clearance of 140 feet and a horizontal clearance of 150 feet. A third rail bridge, the Bascule Bridge, is located just south of the West Seattle Bridge and has a vertical clearance of 7 feet and a horizontal clearance of 150 feet (NOAA 2015).

3.1 Navigation Improvements – West Waterway

In 1955, the Port purchased property on the west side of the West Waterway from the Ames Shipping Company. Ames Shipping had operated a shipyard at the site between 1916 and 1920, and then a breakbulk cargo terminal between 1920 and 1955. Upon purchase, the site included piling supported piers, warehouses, cargo marshaling areas, and moorage depth to between -25 feet MLLW and -40 feet MLLW. Immediately after purchasing the property, the Port set to work replacing docks, stabilizing slopes, and deepening berths. Between 1961 and 1964, the port dredged the berths to a uniform depth of -40 feet MLLW.

In the early 1990’s, as part of the Southwest Harbor Redevelopment Project, the Port added several parcels to the Terminal 5 facility, including the former Lockheed Shipyard 2 and PSR/Wykoff properties. The new, larger facility was to be built out to support deeper draft vessels, and the Port dredged the berths to their present depths at that time (-45 feet MLLW at Station 1+50 to 9+00 and -50 feet MLLW at Station 9+00 to 29+50). An EIS was completed to assess the environmental impacts of the expanded facility, including its deeper berths.

Subsequent to the Southwest Harbor Redevelopment Project, the Port completed several dredging projects to maintain the current -45 feet MLLW to -50 feet MLLW depth configuration originally approved in the 1990s.

High spots and narrow areas at the entrance to the West Waterway (Figure 3) cause consistent delays for ships (USACE and POS 2014). In addition, the current bathymetry has only a narrow “key way” at all times. Tide restrictions, light loading and other operational inefficiencies created by inadequate channel depth limit the Port’s competitiveness with other West Coast ports.

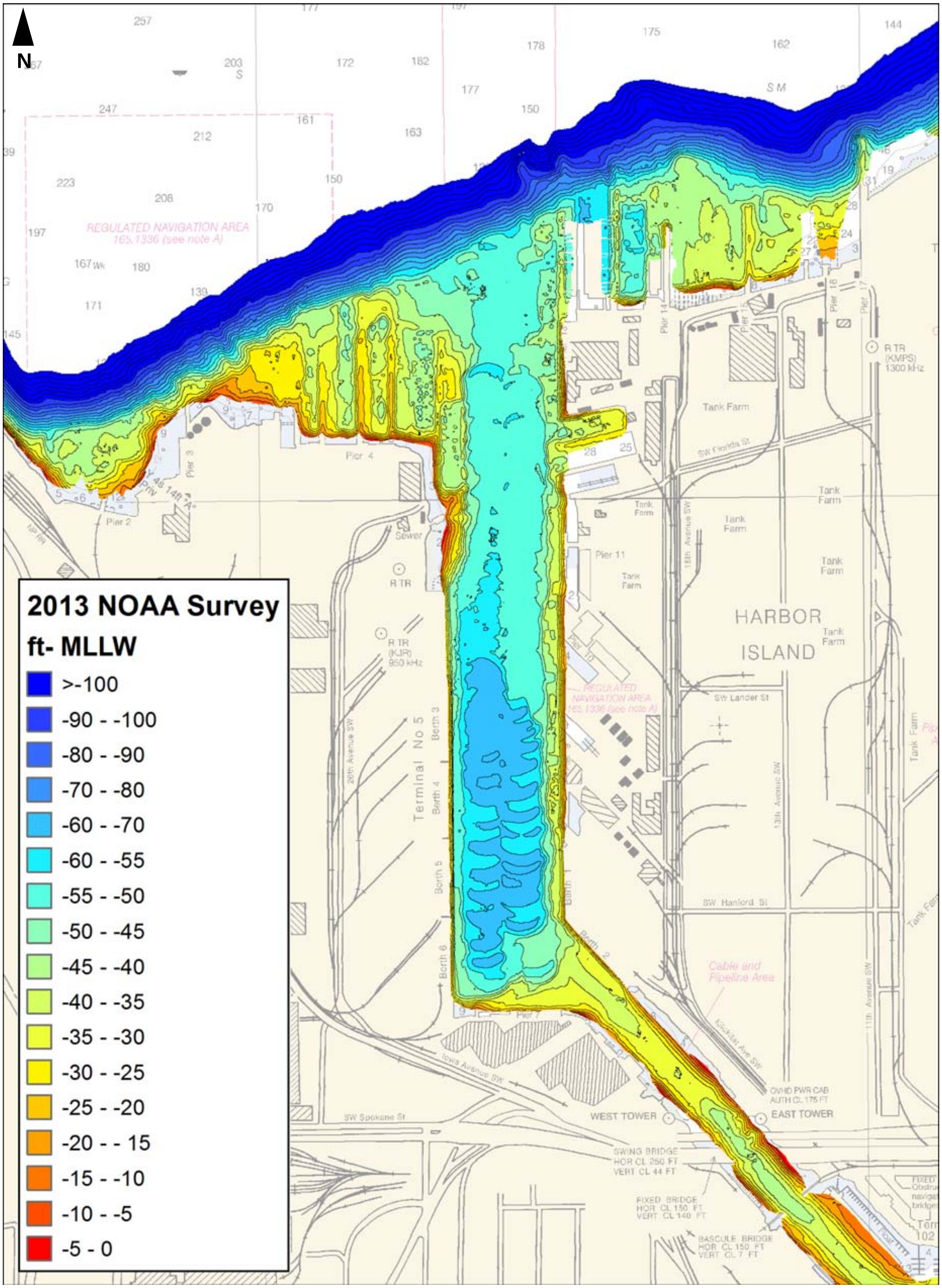


Figure 3: NOAA 2013 Bathymetry of the Duwamish River – West Waterway

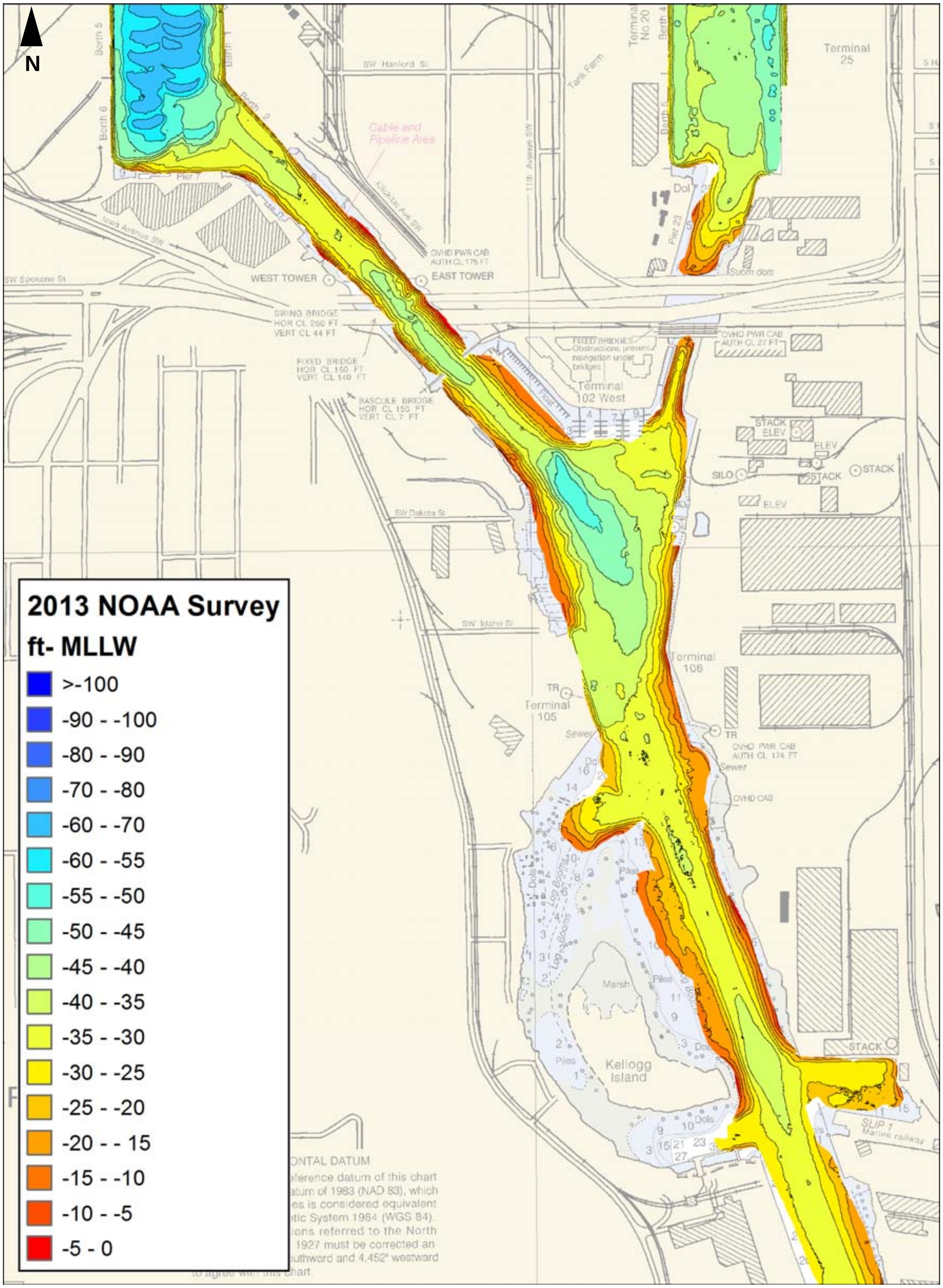


Figure 4: NOAA 2013 Bathymetry of the Duwamish River – West Waterway to Lower Duwamish Waterway

3.2 Existing Vessel Traffic – West Waterway

Only the West Waterway provides access from Puget Sound up the Duwamish Waterway to RM 5.1 near the south end of King County International Airport (Boeing Field). The East Waterway provides access to Terminals 18, 25, and 30 and is limited by low clearance, non-opening highway and railroad bridges at its upstream end (USACE and POS 2014).

Existing vessel traffic into the West Waterway includes commercial vessels navigating to/from Port and private terminals up the Duwamish River and recreational and Tribal fishing vessels. Several wharves near the waterway entrance, receive deep-draft vessels, including T5, (Vigor Shipyard, BP/ARCO, Pacific Terminals, and Sea-Pac Transport Services/Island Tug and Barge Seattle).

Characterization of this existing traffic scheme was completed by M&N with historical shipborne Automatic Identification Systems (AIS) collected over the past two years (August 2013 to April 2015). The data was first compiled to complete a Passing Ship Analysis Report (M&N 2015a), which reveals the characterization of the existing navigation patterns around T5. Figure 2 presents a visual representation of all large vessel traffic (length overall greater than 100 meters or 330 feet) occurring while a ship is berthed at T5. Query extents were limited to a 1-km (3280-foot) radius around the terminal. More recent AIS data, collected for the period of January 2014 through January 2015 shows the different sizes of vessels that use the West Waterway (Figures 3 through 5). These three figure includes all vessels regardless of where they are in the channel (i.e., they may or may not pass all the way through to the swing bridge). It should be noted that AIS tracking beacons are located on ships only, not on barges that may be towed by tugs within the waterway. Figures 6 and 7 identify only large vessels (have a Length Overall [LOA] greater than 100 m). Figures 6 and 7 only include ships passing through the waterway. Ships that enter the north side but do not reach the swinging bridge are excluded from the counts.

To further understand existing vessel use of the West Waterway, the data showing the number of times that the SW Spokane Bridge was opened was obtained for a two-year period from January 1, 2014 through December 31, 2015 (SDOT 2016). During this period, there were 3,065[1] bridge openings (allowing for the passage of taller vessels), an average of 116 per month and about five per day. Openings peaked at about 160 openings per month (Figure 8). These numbers are used to determine the number and frequency of larger vessels that use the Duwamish River and pass by T5. They do not account for vessels that stop prior to the swing bridge or for smaller vessels that do not require the swing bridge to be opened (recreational power boats, small sailboats). Most of the vessels identified were cargo vessels supported by one to two tugboats (tugs) (Table 1).

[1] Openings conducted for testing, training, or maintenance were removed from the raw data.

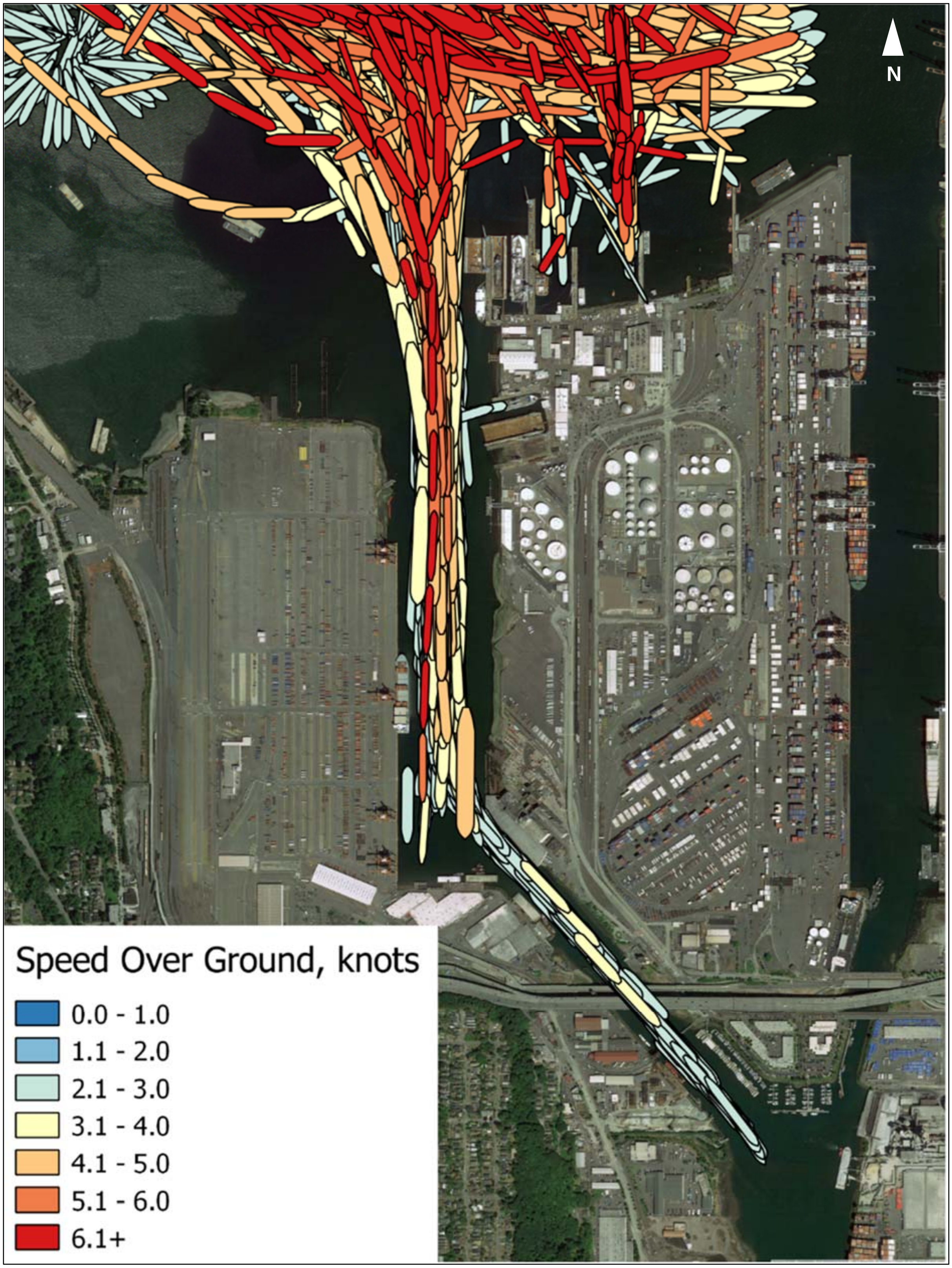


Figure 2: Vessel Use in the Duwamish River West Waterway

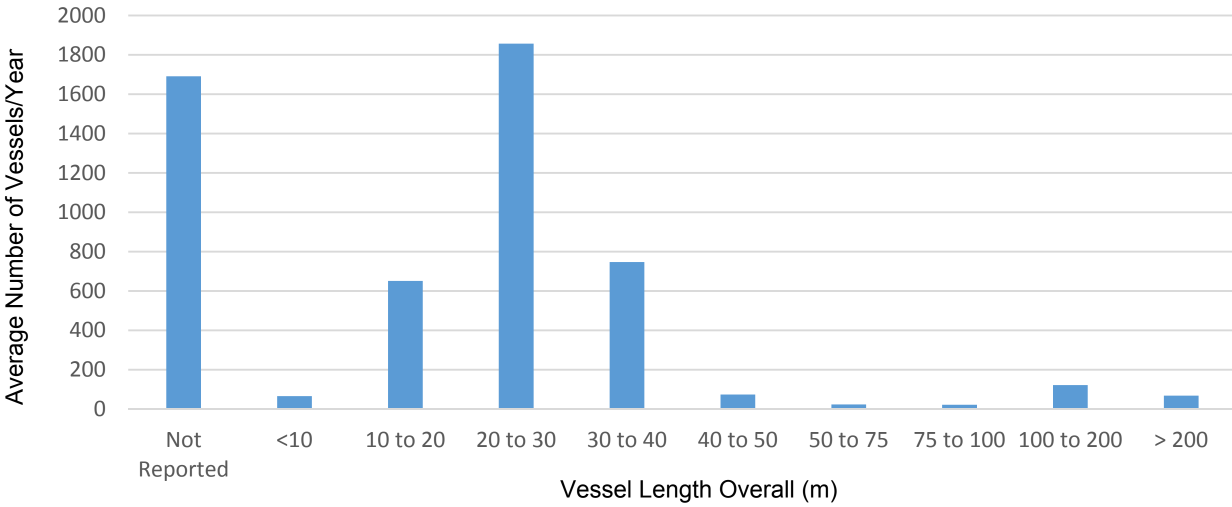


Figure 3: Total Vessel Use in the Duwamish River West Waterway by Size

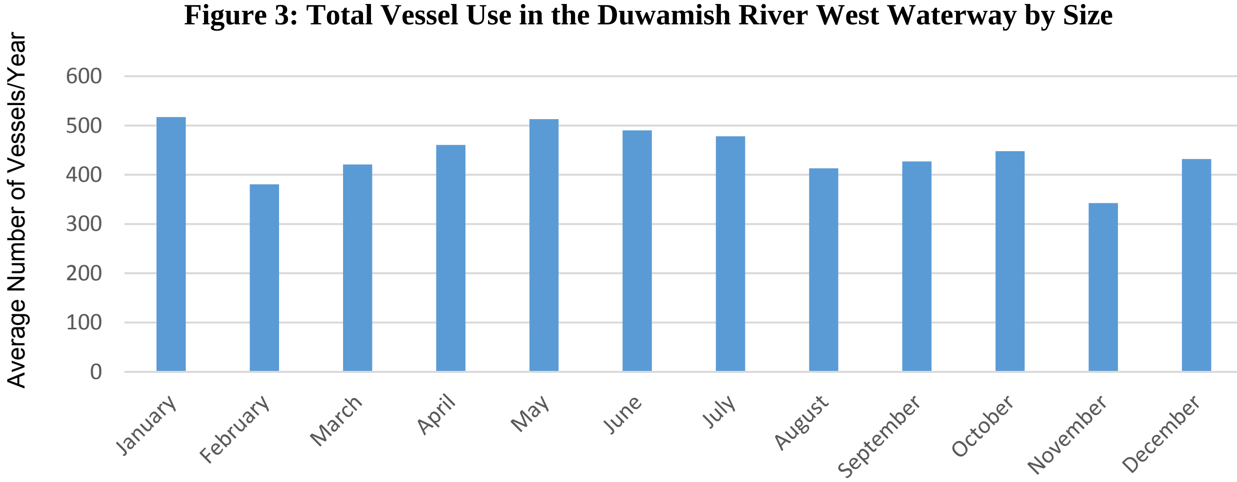


Figure 4: Total Vessel Use in the Duwamish River West Waterway by Month

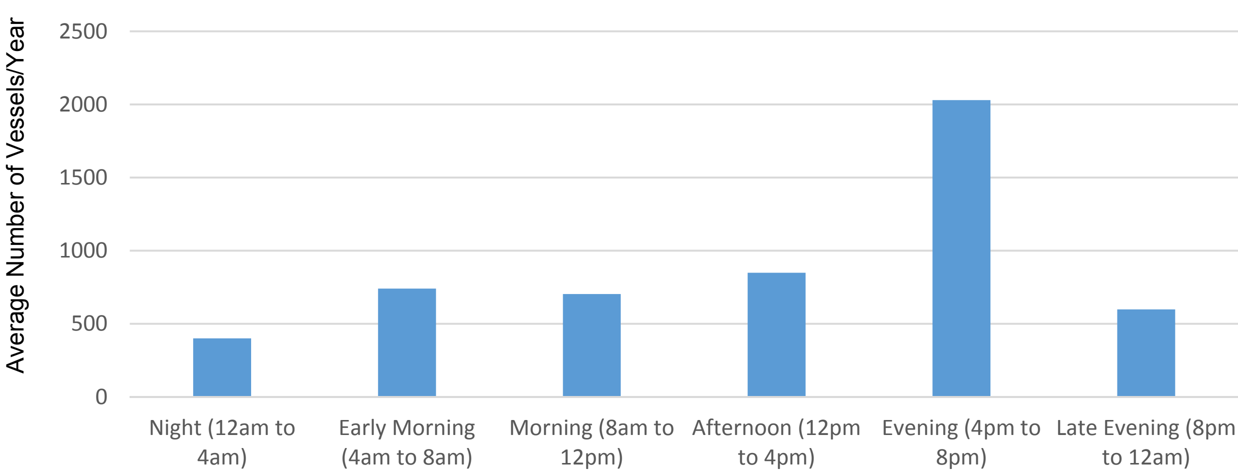


Figure 5: Total Vessel Use in the Duwamish River West Waterway by Time of Day

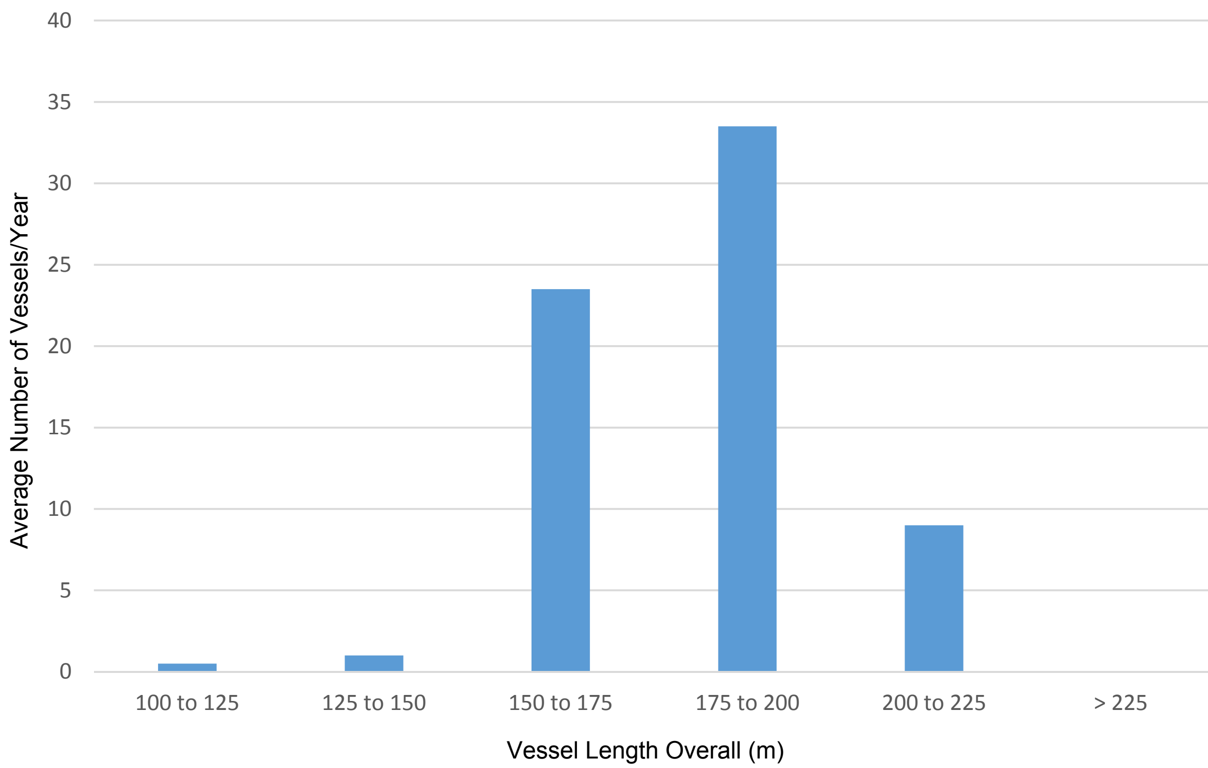


Figure 6: Total Large Vessel Use in the Duwamish River West Waterway by Size

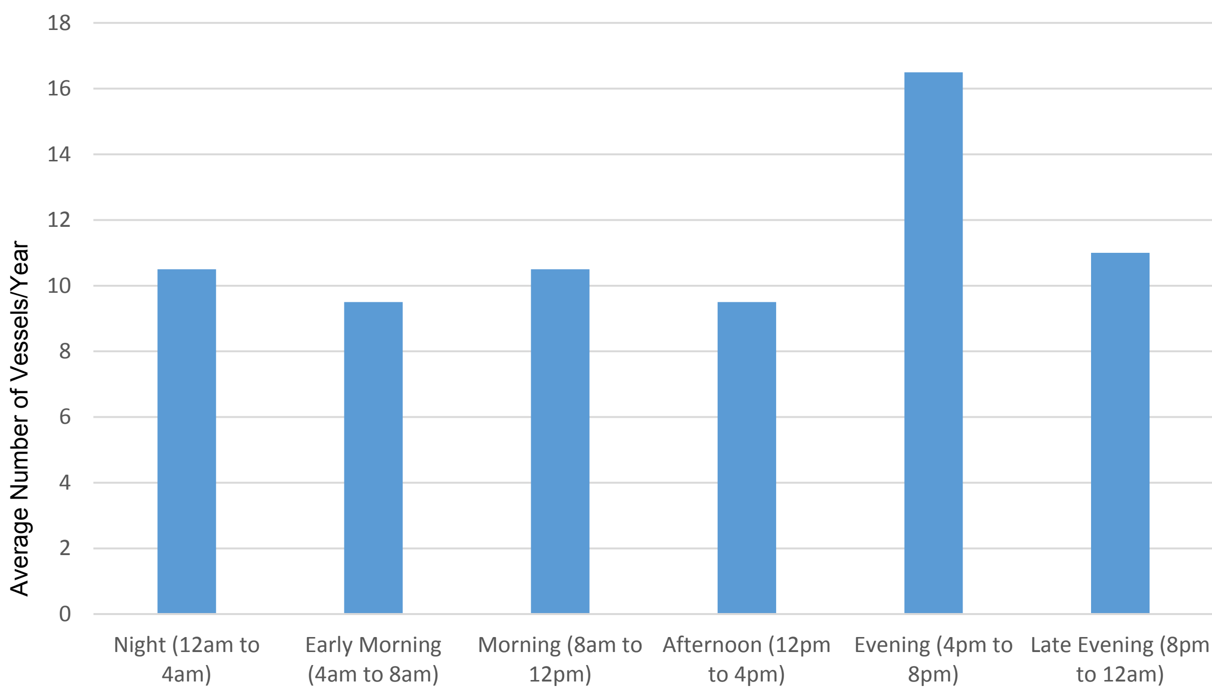


Figure 7: Total Large Vessel Use in the Duwamish River West Waterway by Time of Day

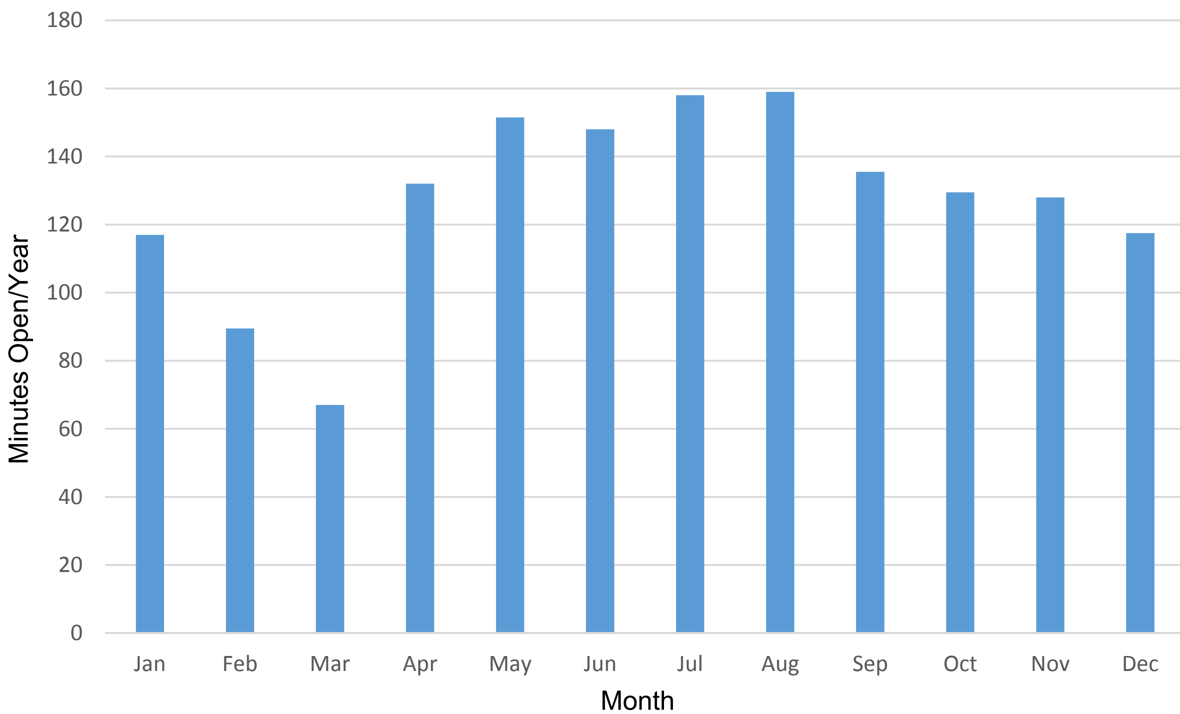


Figure 8: Total Duration/Year SW Spokane Swing Bridge Was Open, 2014 and 2015 (SDOT 2016)

Table 1: Example of SW Spokane Bridge Data (SDOT 2016)

Date & Time	Minutes Open	Vessel in Tow	No. of Support Tugs	Vessel Tons
01/02/2014 06:25	12	TAKU PROVIDER	T,T	143,92
01/02/2014 07:38	16	NANA PROVIDER	T,T	143,92
01/02/2014 20:58	13	CRANE BARGE	T	150
01/02/2014 23:03	13	DB Tacoma	T	150
01/03/2014 16:10	13	ANCHORAGE TRADER	TT	143, 92
01/03/2014 16:50	12	TAKU PROVIDER	TT	92, 143

3.3 Existing Terminal 5 Facility

T5 is located on the west side of the Duwamish River West Waterway and includes the existing marine cargo facility, approximately 197 acres of existing upland, 7.3 acres of existing cargo wharf (the wharf being 2900 feet long), and approximately 200 feet of subtidal aquatic area managed as a berth area for commercial cargo vessels adjacent to the terminal wharf (Figure 9).

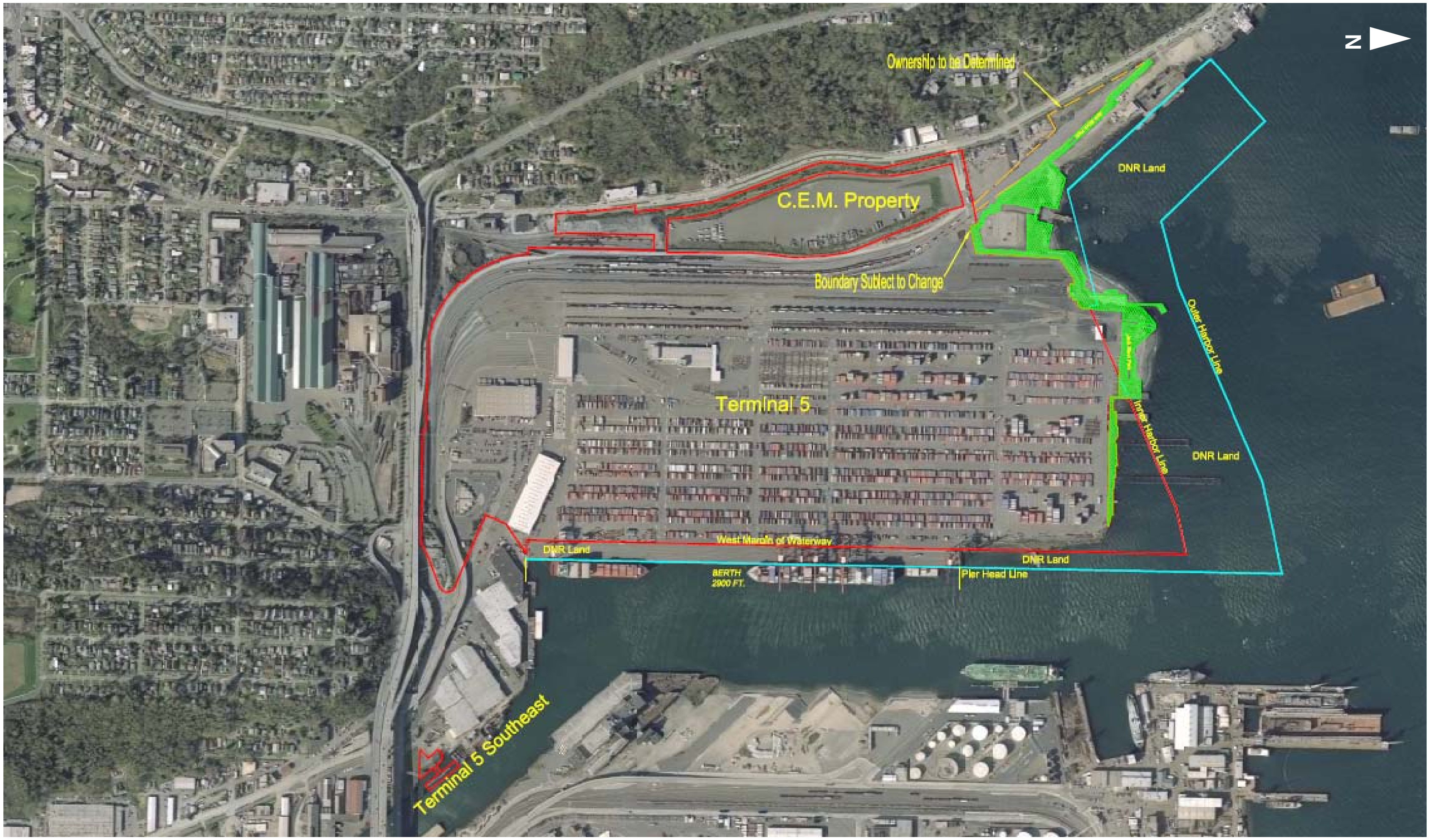


Figure 9: Terminal 5 – Aquatic Property Boundaries

The T5 berths were last deepened in the late-1990s by stabilizing the slope toe with soldier piles and constructing a steel sheet pile toe wall. Soldier piles were installed at the wharf face between Bents 27S and 13.5, and a steel sheet pile toe wall, approximately 10-feet tall, was installed at the wharf face between Bents 14.5 and 85. The existing berth depth south of Bent 14.5 is -45 feet MLLW, and the existing berth depth north of Bent 14.5 is -50 feet MLLW. The top of the existing toe wall is generally at -41.5 feet MLLW (Figure 10).

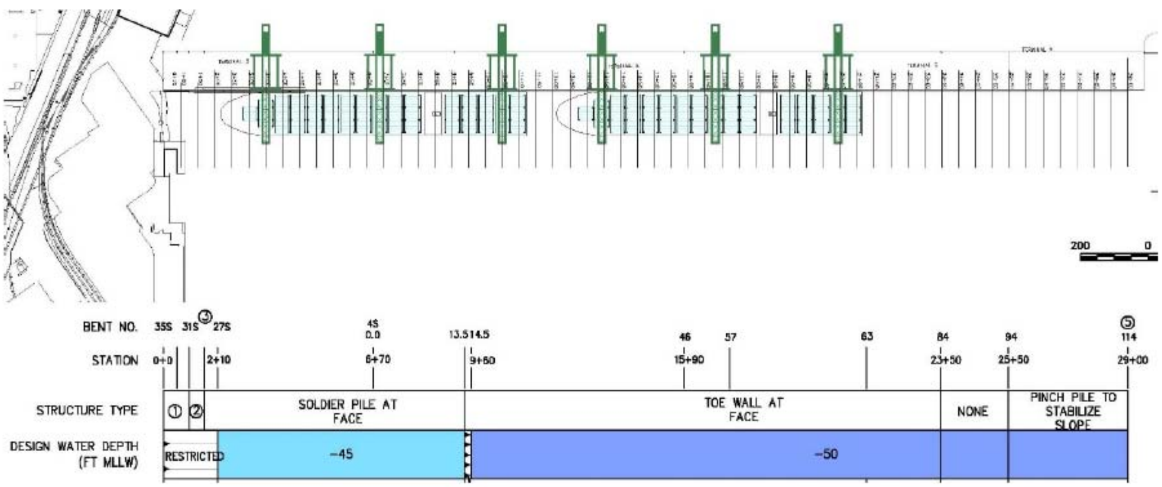


Figure 10: Terminal 5 Berth Deepening Improvements in 1990s

Container cargo vessel forecast changes in the container cargo industry have occurred subsequently, resulting in shippers using larger vessels to reduce operating costs. Vessels capable of carrying 10,000 to 14,000 TEU capacities are starting to be used on routes to other West Coast cargo terminals, with 18,000 TEU capacity vessels also emerging. These larger vessels would typically call on a number of ports during one trip, discharging only a portion of their capacity at any one port.

3.4 Existing Vessel Traffic to Terminal 5

Until recently, T5 received up to 195 to 235 container vessel calls per year between 2010 and 2013, about one call every two days or about 18 per month (Figure 11). The average hours at berth ranged from an average of 128 to 153 hours per week between 2010 and 2013 (Figure 12). The Port is planning to lease T5 to a new tenant. Vessel traffic will commence again and anticipated vessel calls are further detailed for each of three alternatives in Section 5.

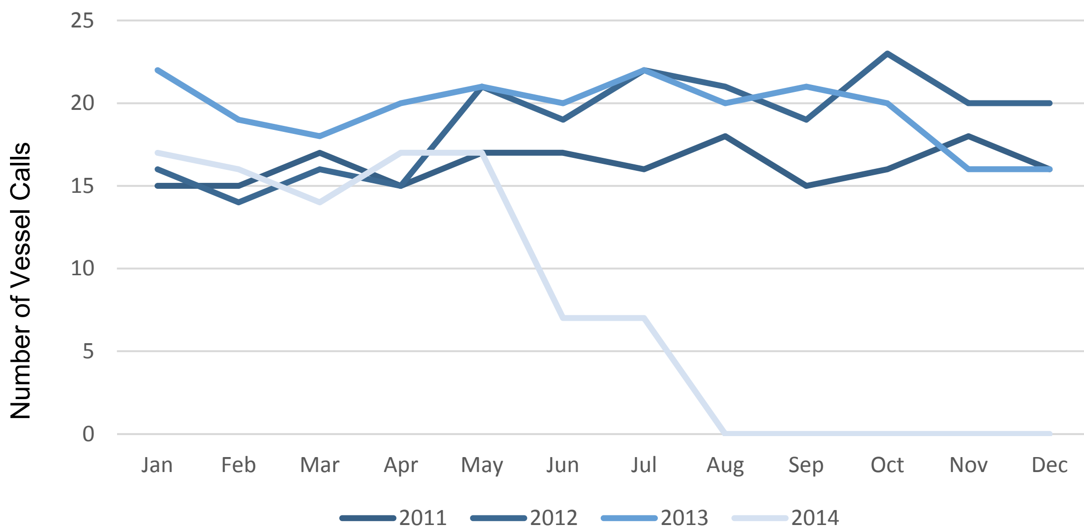


Figure 11: Existing Vessel Calls at Terminal 5 – 2011 through 2015 (POS 2016)

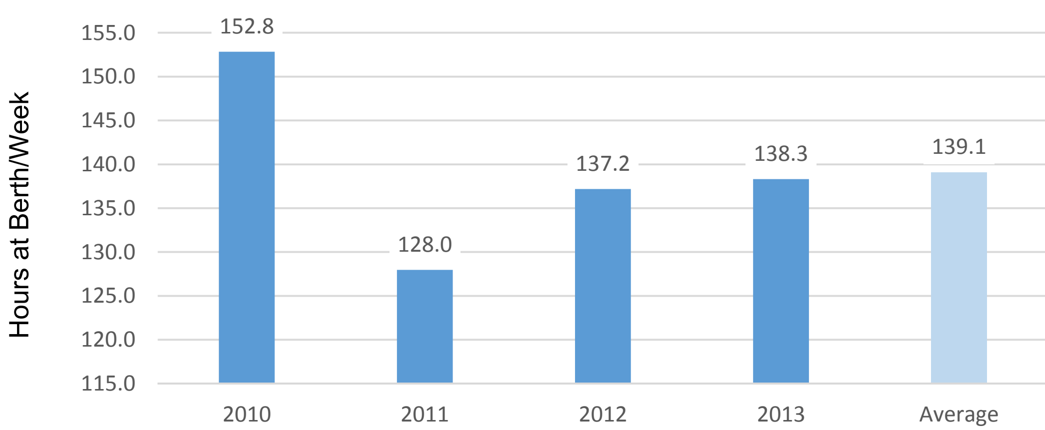


Figure 12: Existing Vessel Calls at Terminal 5 – 2010 through 2013 (POS 2016)

4.0 PROJECT DESCRIPTION

In response to industry changes in marine cargo shipping practices, the Port is evaluating upgrades to ensure that Terminal 5 will be capable of meeting industry needs. Three alternatives are being considered as part of the Project EIS and are described in brief detail below. Alternative 1, the No Action Alternative, provides a baseline of conditions for comparison when discussing the action alternatives.

- ***Alternative 1 or No Action Alternative.***

  The No Action Alternative assumes that no improvements would be made to the existing site. It is anticipated that repair, remodeling, maintenance, or minor alterations would take place, including facilities and equipment, however, no material expansion in use or change in marine cargo capability or capacity would result.

This alternative assumes that T5 would continue to be capable of accommodating four to six vessel calls per week, serving vessels similar to the most recent marine cargo operations at the site, container ships with capacities of 4,500 to 5,000 TEUs. Annual throughput is estimated at up to 647,000 TEUs and berth utilization would be approximately 35 percent (the percentage of time a ship occupies each berth). Ships are anticipated to require between 22 to 30 hours at berth for loading and unloading activities, with approximately 148 total berth hours per week.

- ***Alternative 2: Wharf improvements, increased cargo-handling efficiency and volume.***

  Alternative 2 would rehabilitate the existing T5 container cargo pier and deepen the existing navigational vessel berth access. In-water and over-water work includes strengthening the existing 2,900 linear feet existing cargo pier in order to receive larger, heavier container cranes capable of serving larger, higher and wider, cargo vessels. Approximately 234,460 square feet of area adjacent to T5 would be dredged to a required depth of -56 feet MLLW with a maximum over-dredge depth to -58 feet MLLW. Upland improvements could also be constructed to support the above wharf upgrades.

  With improvements to the berth depth, wharf and cranes, T5 could accommodate up to two 18,000 TEU ships simultaneously. A lower percentage of cargo would be unloaded/loaded for larger ships than for smaller ships. This operational scenario anticipates that each week T5 will have 4 vessel calls, two 14,000 TEU ships and two 8,000 TEU ships. Annual throughput is estimated at up to 1.3 million TEUs and berth utilization will be on the order of 57 percent. Ships are anticipated to require between 25 to 50 hours at berth for loading and unloading activities, with approximately 150 total berth hours per week.

- ***Alternative 3: Wharf improvements, relocate buildings, densify rail yard, optimized cargo-handling efficiency and volume.***

  In-water and over-water construction including berth deepening, and upland construction activities would be the same as described for Alternative 2. However, increased throughput and upland improvements are anticipated (wharf and crane improvements would allow simultaneous loading and unloading of the two 18,000 TEU vessels). This operational scenario anticipates that each week T5 will have four vessel calls, two 14,000 TEU ships and two 8,000 TEU ships. The vessel call scenario generates annual throughput of up to 1.7 million TEUs and a berth utilization on order of 59 percent. Ships are anticipated to require between 22 to 30 hours at berth for loading and unloading activities, with approximately 142 total berth hours per week.

Both Alternatives 2 and 3 will deepen the berths to -54 feet MLLW by installing an additional toe wall outboard of the existing toe wall, installing pinch piling to increase slope stability, increasing the crane rail capacity, and replacing the fender system. The top of the toe wall is proposed to be -45 feet MLLW between Bents 32S and 14 and -50 feet MLLW between Bents 14 and 114. The proposed toe wall will be approximately 9-feet-tall south of Bent 14 and 4-feet-tall north of Bent 14.

The Port’s draft Terminal 5 Berth Modernization – Basis of Design dated January 23, 2015 (Port 2015) specifies the toe wall to be designed to a dredge depth of -58 feet MLLW. This increased dredge depth will allow for potential future berth deepening.

5.0 VESSEL NAVIGATION MANAGEMENT

This section describes the laws and regulations in place that helped to identify potential impacts to vessel traffic and navigation.

5.1 Laws and Regulations

The U.S. Coast Guard (USCG) and the Puget Sound Harbor Safety Committee have developed a Harbor Safety Plan that formally establishes a set of Standards of Care for the Puget Sound area, which supplement existing federal, state, and local laws (Table 2). The applicable federal, state and local laws are listed here to aid in better understanding vessel traffic and navigation within the Duwamish River and determining potential impacts on existing uses. For example:

- Each commercial vessel arriving in Elliott Bay from the Strait of Juan de Fuca is under the direction of a Puget Sound Pilot, with tug aid to the final berth. Ships discharge and load cargo and are then piloted with tug assist off berth though Elliott Bay and out to the open ocean. Pilotage for Puget Sound is regulated under the Federal Pilotage Requirements (46 CFR 15.610 and 15.812). Even light tugs (tugs without a tow) must be under the direction and control of either a first class pilot or a deck officer with authority to “act as pilot” when underway in designated pilotage waters. This mandated expertise minimizes the risk for collision in busy or narrow waterways.
- The USCG Vessel Traffic Service (VTS) regulates vessel traffic and safety in Puget Sound by monitoring and directing vessel movements to maintain appropriate navigation corridors and vessel transit separation, with the coincident benefit of minimizing shipping interruptions and delays. VTS encompasses a wide range of capabilities to prevent vessel collisions and support harbor approach and inland waterway navigation. They are also designed to expedite ship movements, increase transportation system efficiency, and improve all-weather operating capability. Transiting vessels make position reports to the VTS center, located at Pier 36, and are, in turn, provided with accurate, complete, and timely navigational safety information. The addition of a network of radars, AIS, and close circuit television cameras and computer-assisted tracking, similar to that used in air traffic control, results in VTS being an important element of marine traffic management, thereby decreasing vessel congestion, critical encounter situations, and the probability of a marine casualty resulting in environmental damage.
- A “Notice to Mariners” and “Local Notice to Mariners” are both means used to report current or future information and navigation changes that could affect existing vessels and waterways (Navigation and Navigable Waters, 33 CFR 72.01). These notices are published weekly and incorporate upcoming marine events (regattas), new chart information, danger areas or obstructions, weather warnings, and pending marine construction projects.
- Vessel speed within the Duwamish River is limited to 7-knots throughout the river. Most larger vessels within the narrow West Waterway travel at lower speeds ranging from 2.5 to about 3.5 knots, the highest speeds of 4 to 5 knots observed for outbound commercial vessels (M&N 2015a).

Table 2: Laws and Regulations for Vessel Traffic

Laws and Regulations	Description
Federal	
Ports and Waterways Safety Act of 1972 (31 U.S.C. 1221 et seq.)	Authorizes USCG to provide for navigation and vessel safety; protect the marine environment; and protect life, property, and structures in, on, or adjacent to U.S. navigable waters.
Port and Tanker Safety Act of 1978 (33 U.S.C. 1221 et seq.)	Grants USCG authority to supervise and control all types of vessels, foreign and domestic, operating in U.S. navigable waters.
Navigation and Navigable Waters, Subchapter E: Inland Navigation Rules (33 CFR 83 – 90)	Applies to all vessels on the inland waters of the U.S. Complements the International Regulations for Preventing Collisions at Sea 1972, applicable in International Waters.
Federal Pilotage Requirements (46 CFR 15.610 and 15.812)	Identifies the type of vessels that require a federally licensed master or mate and federal pilotage requirements for U.S.-inspected vessels on coastwise voyages[1].
State	
Washington State Pilotage Act (RCW 88.16)	Identifies requirements for compulsory pilotage provisions in certain waters of the state, including Puget Sound.
Local	
Puget Sound Harbor Safety Committee and the Puget Sound Harbor Safety Plan	In partnership with the USCG, established a set of Standards of Care for the Puget Sound area, which supplement existing federal, state, and local laws.

U.S.C. = United States Code, CFR = Code of Federal Regulations, RCW = Revised Code of Washington

[1] A coastwise voyage by sea is a voyage in which a U.S.-flagged vessel proceeds from one port or place in the U.S. to another port or place in the U.S. while engaged in trade (46 CFR 46.05-15).

6.0 POTENTIAL IMPACTS TO VESSEL TRAFFIC AND NAVIGATION

Impacts to existing vessel traffic and navigation may include:

- Short-term (temporary) impacts from construction activities, include changes in vessel traffic within the waterway due to project demolition, dredging, and wharf construction. Specifically, vessels may be used to transport project debris, dredged material, equipment, and materials to and from the Project site.
- Long-term (operational) impacts from changes in vessel traffic and modifications to existing navigation channels and access could result in:
  - Conflicts with other large commercial vessels, including bulk carriers and barge/tug traffic, commercial and Tribal fishing vessels, and recreational vessels.
  - Changes to navigation, specifically to channel capacity. The ease and ability of vessels to pass T5 when a large vessel is in berth may be altered, impacting existing waterway access and navigability of the West Waterway.

To better quantify the above potential impacts to existing vessel traffic, the short-term and long-term changes in vessel traffic were summarized in Table 3.

Table 3: Potential Vessel Use at T5 for Three Project Alternatives

Vessel Use	Alternative 1	Alternative 2	Alternative 3
Construction			
Max. No. of Vessels at site any one time.	No change in existing vessel traffic	3 derricks 3 supply barges/scows 2 support tugs	3 derricks 3 supply barges/scows 2 support tugs
Operations			
Max TEU/Vessel	5,500	18,000	18,000
Vessel Length Overall	294 m (965 feet)	399 m (1,309 ft)	399 m (1,309 ft)
Vessel Beam[1]	46 m (150 feet)	59 m (194 ft)	59 m (194 ft)
Maximum Possible Calls	6/week	4/week	4/week
Maximum Berth Utilization	35%	57%	59%
Time at Berth/Vessel	22 to 30 hrs	25 to 50 hrs	25 to 46 hrs
Average Total Time for all vessels at Berth/Week	148 hrs	150 hrs	142 hours

[1] A vessel's width is referred to as its beam.

6.1 Alternative 1

The No Action Alternative is not anticipated to result in significant impacts to existing vessel traffic or navigation. Strengthening and improving the existing Terminal 5 cargo pier will not take place and vessel use at the existing site is anticipated to return to conditions typical of previous operations, including up to six vessel calls per week.

6.2 Alternatives 2 and 3

6.2.1 Construction

Construction for Alternatives 2 and 3 would require vessel support for in-water work (dredging, pile driving) or equipment and material transport (dredged sediment, piles, demolition and construction debris). Demolition, transportation of piles and other material used to strengthen the berth, and dredging would require derrick barges, along with support barges and tugs. Table 1 summarizes the potential maximum number of vessels that could be located at T5 at any one time during in-water work.

The Project is expected to begin following receipt of City of Seattle, Washington State and federal authorizations, with completion within three years following commencement. In-water work is restricted between February 16 and August 15 and is anticipated to take two or three in-water work seasons to complete. In-water construction activities may be coincident, with wharf strengthening and slope stability actions taking place simultaneously, while berth deepening dredging is anticipated to be implemented during final phases of in-water construction, following substantial completion of wharf strengthening and slope stability improvements.

At most, eight vessels are anticipated to be working off the T5 wharf within the West Waterway at any one time during construction, 3 of them derricks each with a support barge. The 3 derricks would most likely be 100 feet by 300 feet in size and positioned directly next to a scow or supply barge of similar dimensions. This total width (from herein referred to as the vessel beam) of about 200 feet for the side-to-side arrangement of construction vessels is similar to the beam of the anticipated 18,000 TEU ship (194 feet), discussed further in Section 5.2.3.

Construction vessels may also be stationed perpendicular to the wharf or east of the berth being dredged. In both cases, the beam of these vessels could extend up to 400 feet into the waterway from the wharf. This will not impede smaller vessels, which can maneuver around the barges. Additionally, the Navigation and Navigable Waters, Subchapter E: Inland Navigation Rules aligns with the 1972 International Regulations for Prevention of Collisions at Sea. Vessels with more maneuverability are required to "give way" to those more restricted in their ability to move within a navigation channel. It is general practice for construction vessels to yield to larger cargo vessels within working port areas.

6.2.2 Berth Modifications

While the new sheet pile wall will be constructed waterward of the pierhead line, wall improvements proposed for Alternatives 2 and 3 will ensure slope stability remains comparable to existing conditions. Even though vessels may be berthed closer to the wall under Alternatives 2 and 3, slope stability, and therefore channel navigability, remains unchanged (M&N 2015b).

6.2.3 Traffic

For both Alternatives 2 and 3, the number of vessel calls is anticipated to decrease to about 4 calls per week from 6 calls per week for the No Action Alternative. This reduction in vessels is a reduction of 20%.

Berth utilization (the percentage of time a ship is occupying each berth) will increase from about 35% (Alternative 1) to 57 to 59% (Alternatives 2 and 3 respectively). The impacts of this change can be viewed in Figure 5 which compares the three alternatives. Fewer vessels will occupy T5 in Alternatives 2 and 3 but they will use more of the berth. The average overall hours that berth at T5 for one week will remain relatively constant (148 hours/week for Alternative 1, 150 hours/week for Alternative 2, 142 hours/week for Alternative 3). Alternative 3 results in a slight decrease in vessel hours at berth/week. In past years at T5, vessel hours at berth has ranged from as low as 128 hours/week to 153 hours/week (Figure 13). All alternatives remain well within this variability, although both Alternatives 2 and 3 result in higher berth utilization (57 percent and 59 percent respectively).

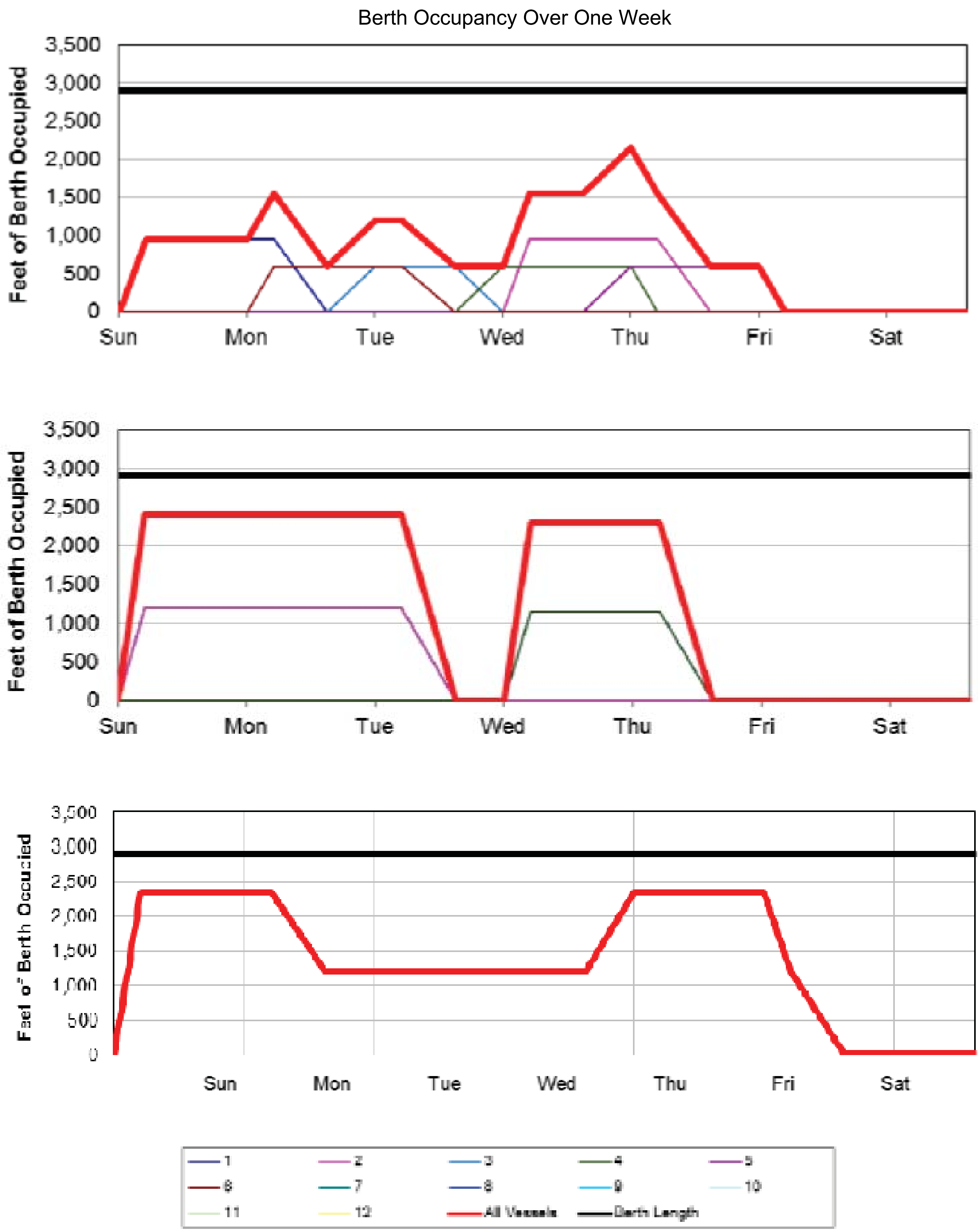


Figure 13: Alternative Comparison of Berth Utilization

6.2.4 Channel Navigation

The existing Duwamish River West Waterway is 750 feet wide. The largest proposed vessel that could call at T5 under Alternatives 2 and 3 would need to accommodate 18,000 TEU. As shown in Table 3, this vessel is assumed to be similar to vessels referred to as Ultra Post-Panamax or New Post-Panamax, with approximately 1,250 to 1,300 feet Length Overall (LOA) and a beam of about 160 to 200 feet. Two vessel passing scenarios were considered:

1. ***Scenario 1:*** In this scenario, an 18,000 TEU vessel with a beam of 200 feet is in berth at T5 and is being passed by the largest anticipated vessel that could move past T5 into the Lower Duwamish Waterway[2], at low speed (about 3 knots), typical of vessels using the West Waterway, with a beam of about 90 feet and a draft of 30 feet.
2. ***Scenario 2:*** In this scenario, an 18,000 TEU vessel with a beam of 200 feet is in berth at T5 and is being passed by another 18,000 TEU vessel, which is also preparing to berth at T5. The passing vessel is also traveling at low speed (less than 3 knots) as it prepares to berth. Both 18,000 TEU vessels have drafts of 50 feet, requiring about 2 feet of depth clearance.

Table 4 summarizes the types and sizes of the vessels used to determine the remaining channel width with an 18,000 TEU vessel in berth at T5.

Table 4: Vessel Dimensions Used for Channel Width Evaluation

Vessel Characteristics	Vessel in Berth	Passing Vessel Scenario 1	Passing Vessel Scenario 2
Vessel Type[1]	Ultra Post-Panamax, New Post-Panamax	Handymax	Ultra Post-Panamax, New Post-Panamax
Vessel Length Overall[2]	Approximately 300-400 m (1,250-1300 feet)	Approximately190 m (623 feet)	Approximately 300-400 m (1,250-1300 feet)
Vessel Beam[2]	Approximately 48-60 m (160-200 feet)	Approximately 27 m (90 feet)	Approximately 48-60 m (160-200 feet)
Vessel Draft	50 feet	30 feet	50 feet

[1] Largest cargo vessels typically serving Duwamish Waterway industrial and commercial facilities.

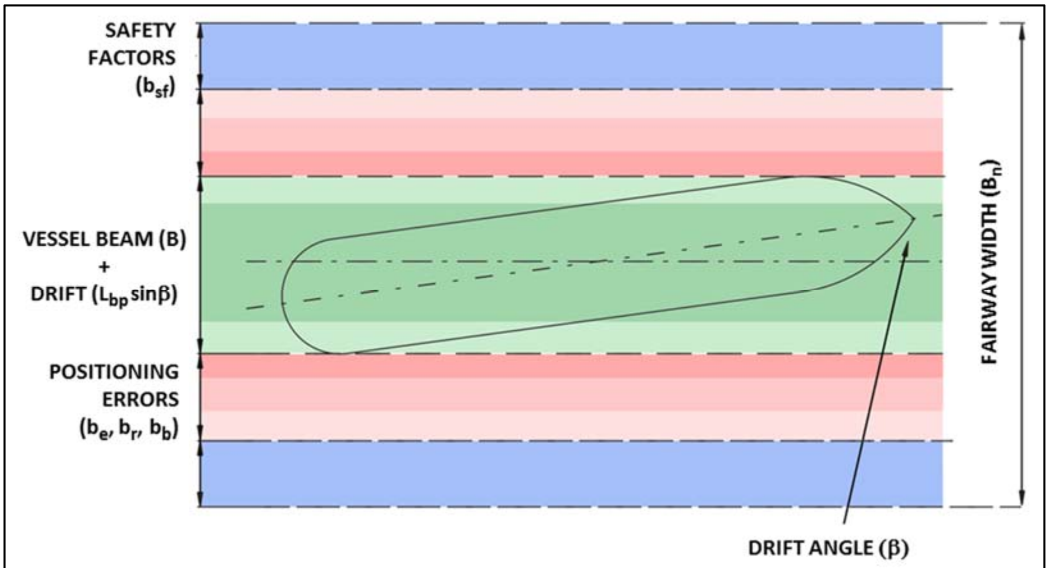
[2] Passing vessel LOA and beam values derived from 1982 ACOE, East, West, and Duwamish Waterways, Navigation Improvements Study, Appendix C.

In both scenarios, M&N used a number of different methods to determine if there was available channel width and space between vessels to pass the berthed 18,000 TEU vessel in berth. These methods were for straight, single-lane ship traffic and included:

1. ***Desktop USACE Evaluation Method.*** The USACE method (EM 1110-2-1613) takes into account five variables: current speed, navigation aid quality, channel section type, channel variability, and ship beam.
2. ***Desktop PIANC Evaluation Method.*** The PIANC method (Report No 121 – 2014) is more complex, taking into account additional factors such as wind, waves, current direction, and ship maneuverability.

[2] The Duwamish Waterway has an authorized bottom width of 150 to 200 feet as it extends from the West Waterway to the Lower Duwamish Waterway. The Bascule Bridge has a horizontal clearance of 150 feet. Both limit the width of vessels that can pass T5 when an 18,000 TEU vessel is in berth.

3. ***Desktop Evaluation for Channel Width, referred to as the Spanish ROM Method.*** This method is the most complex. The Spanish Recommendations for Maritime Works (in Spanish: Recomendaciones para Obras Marítimas [ROM]) method (Puertos del Estado 2007) is an empirically based, spreadsheet-level approach for determining a channel width. It is one of the major references used in the Permanent International Association of Navigation Congresses (PIANC) guidelines for approach channel design (PIANC 2014). In addition to the previously mentioned variables for the USACE and PIANC methods, the ROM method also estimates a tug correction, ship drift angle, and incorporates additional ship dimension into the environmental factor (Figure 14).



The equation for nominal width of a single-lane fairway (B_n) is:

$$B_n = B + L_{bp} \sin\beta + 2(b_e + b_b) + 2b_r + b_{sf}$$

Where:

- B is the beam of the vessel.
- L_{bp} **sin** β represents the additional width due to the drift or crab angle. The crab angle is primarily created by currents and winds, and is countered by tugs. It is a function of vessel parameters, vessel speed, current speed and direction, and wind speed and direction.
- The crab angle increases (as expected) with increasing relative currents and wind speeds, and is greater for cross currents and cross winds.
- b_e and b_b represent uncertainties in vessel position.
  - b_e is additional width associated with the type of positioning (e.g., visual positioning) and whether an experienced pilot is guiding the vessel.
  - b_b represents errors or uncertainties associated with navigation aids (e.g., errors in range marker position). These errors are both independent of vessel characteristics; the 2*(b_e + b_b) term ranges from 30 to 120 feet.
- b_r is an additional width proportional to the beam of the vessel and represents positioning errors due to the limited responsiveness of the vessel. This width also incorporates risk elements (economic repercussions and potential for loss of life associated with any incidents).
- b_{sf} represents a safety factor proportional to the vessel beam, providing a margin of safety while accounting for bank conditions; i.e., a higher factor of safety is required for rocky banks than for gentle, sandy shoals. The safety margin term (2*br+b_{sf}) ranges from 144 to 269 feet.

Figure 14: Width Elements for Straight Channel: Spanish ROM Method

All three methods are more commonly used to design approach channels (vessels transiting a channel at speeds greater than four knots). The three methods all follow the same general approach of applying design factors which are then summed and multiplied by the vessel's beam. All three methods also require input of channel width and depths.

While the West Waterway is a 750 foot-wide channel, shoaling and side slopes reduce the usable channel width and depth, as do any channel "high spots" from sediment caps. Bathymetry was used to account for these above factors, and determined that the usable channel width, that which reached a 32-foot depth for Scenario 1, was 700 feet (Figure 16). This assumes a 50-foot allowance from either edge of the channel. For Scenario 2, the existing usable channel width is observed to be as narrow as 390 feet in some areas (Figure 16). Dredging may be required if additional channel width is desirable. At this time, a 650-foot wide usable channel width is assumed.

For both Scenarios, the PIANC and USACE methods reflect similar minimum fairway widths as the ROM Method (Table 5). Using a 2B Rule of Thumb (PIANC 2011), the minimum separation distance required for both scenarios was calculated:

- Scenario 1 is 54 m (178 feet), as shown using the ROM, PIANC and USACE methods. Even with this narrower channel, an 80- to 90-foot wide (beam) vessel could still pass a 200-foot wide container cargo vessel moored at T5 (the largest vessel proposed to visit T5 under Alternatives 2 and 3) with appropriate separation of between the two vessels and given 650 feet of usable channel width (accounting for side slopes and narrower regions of the channel). With a vessel of 90 feet in width and a separation distance of 180 feet (rounded), 380 feet remains for maneuverability.
- Scenario 2 does not accommodate a 2B Rule of Thumb using the ROM, PIANC and USACE methods. However, these methods are more appropriate for vessels passing open channels at speed (greater than 3 knots). Scenario 2 is more of a berthing activity, rather than a passing activity. For very slow vessels the required separation distance decreases. Therefore a fourth Desktop Evaluation for Channel Beam was also used.

Table 5: Channel Width Evaluations

<table>
<tr><th>Evaluation Method</th><th>Minimum Vessel Fairway Width Calculated1</th><th>Berthed Vessel Beam</th><th>Usable Channel Width</th><th>Min Separation Distance Required (2B Rule of Thumb)</th><th>Remaining Separation Distance</th></tr>
<tr><td>Scenario 1
ROM</td><td>85 m
(279 ft)</td><td rowspan="6">59 m
(194 ft)</td><td rowspan="3">198 m
(700 ft)</td><td rowspan="6">54 m
(178 ft)</td><td>54 m
(178 ft)</td></tr>
<tr><td>PIANC</td><td>82 m
(269 ft)</td><td>57 m
(187 ft)</td></tr>
<tr><td>USACE</td><td>70 m
(228 ft)</td><td>70 m
(228 ft)</td></tr>
<tr><td>Scenario 2
ROM</td><td>161 m
(527 ft)</td><td rowspan="3">198 m
(650 ft)</td><td>-22 m
(-71 ft)</td></tr>
<tr><td>PIANC</td><td>177 m
(582 ft)</td><td>-38 m
(-126 ft)</td></tr>
<tr><td>USACE</td><td>151 m
(495 ft)</td><td>-12 m
(-39 ft)</td></tr>
</table>

4. **Desktop Navy/ROM Evaluation Method.** Both the US Navy DOD and ROM address separation distance while berthing in more or less a similar fashion as a multiplier of the beam plus an allowance for tug maneuvering. The method allows a beam width on either side of the maneuvering vessel.

For Scenario 2, a beam of 59 meters (194 ft), the recommended slip beam would be about 261 m (856 ft). This allows a maneuvering lane of 3B (plus length of tug) plus the beam of the ship at berth (4B plus length of tug). If available width is less, then vessel simulations are used to prove the concept, incorporating other factors such as current, wind, etc. Often times a much lower multiplier provides adequate access. Recent work by M&N at a port on the west coast showed that a straight 3B multiplier was adequate. Additional studies, completed prior to construction, may demonstrate that the available 3.35B at T5 (Figure 15) is adequate for two berthing 18,000 TEU vessels. Additional studies may also clarify if further dredging is desirable.

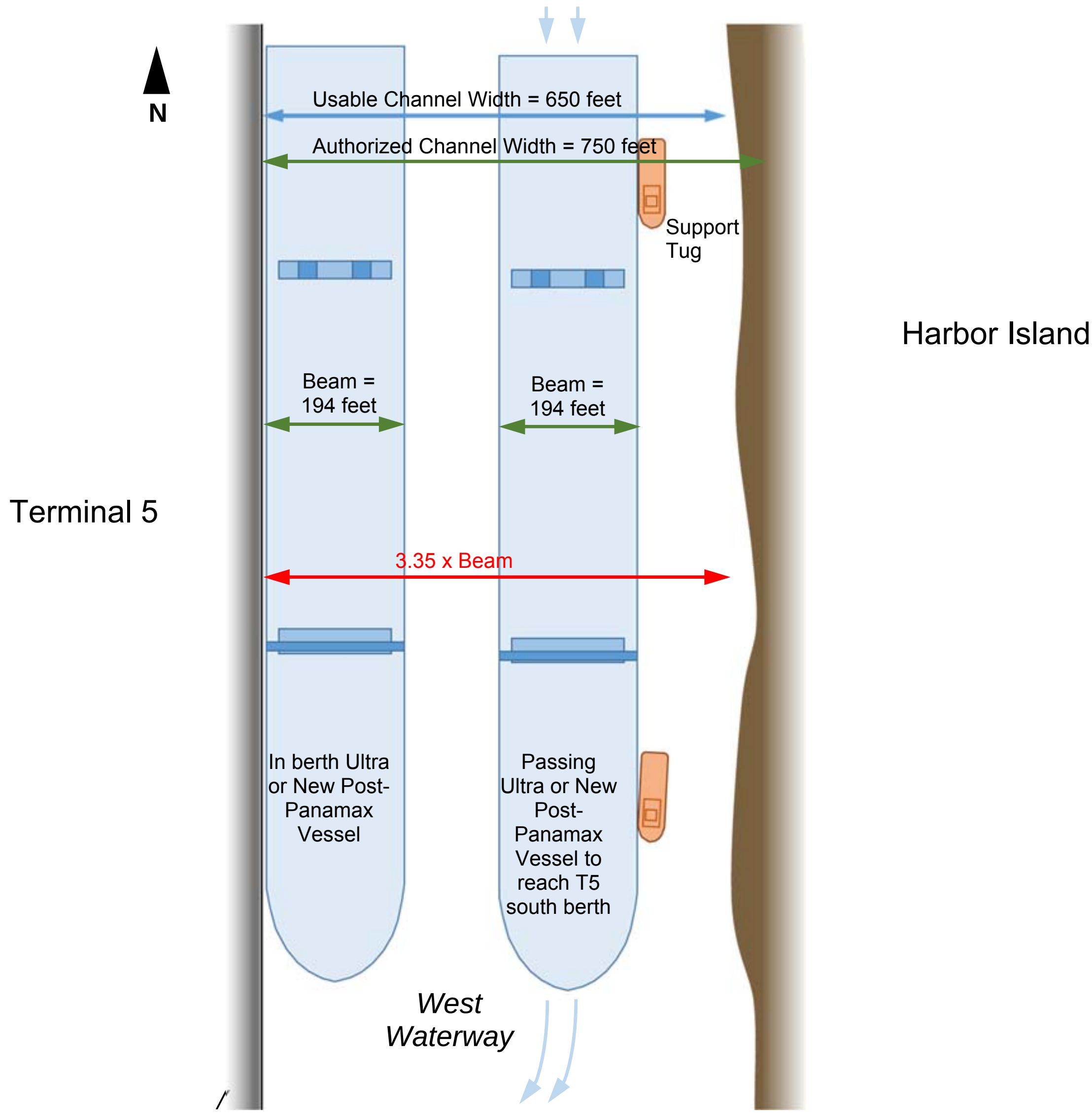


Figure 15: Scenario 2 Berthing Separation Distance Using Navy/ROM Evaluation Method

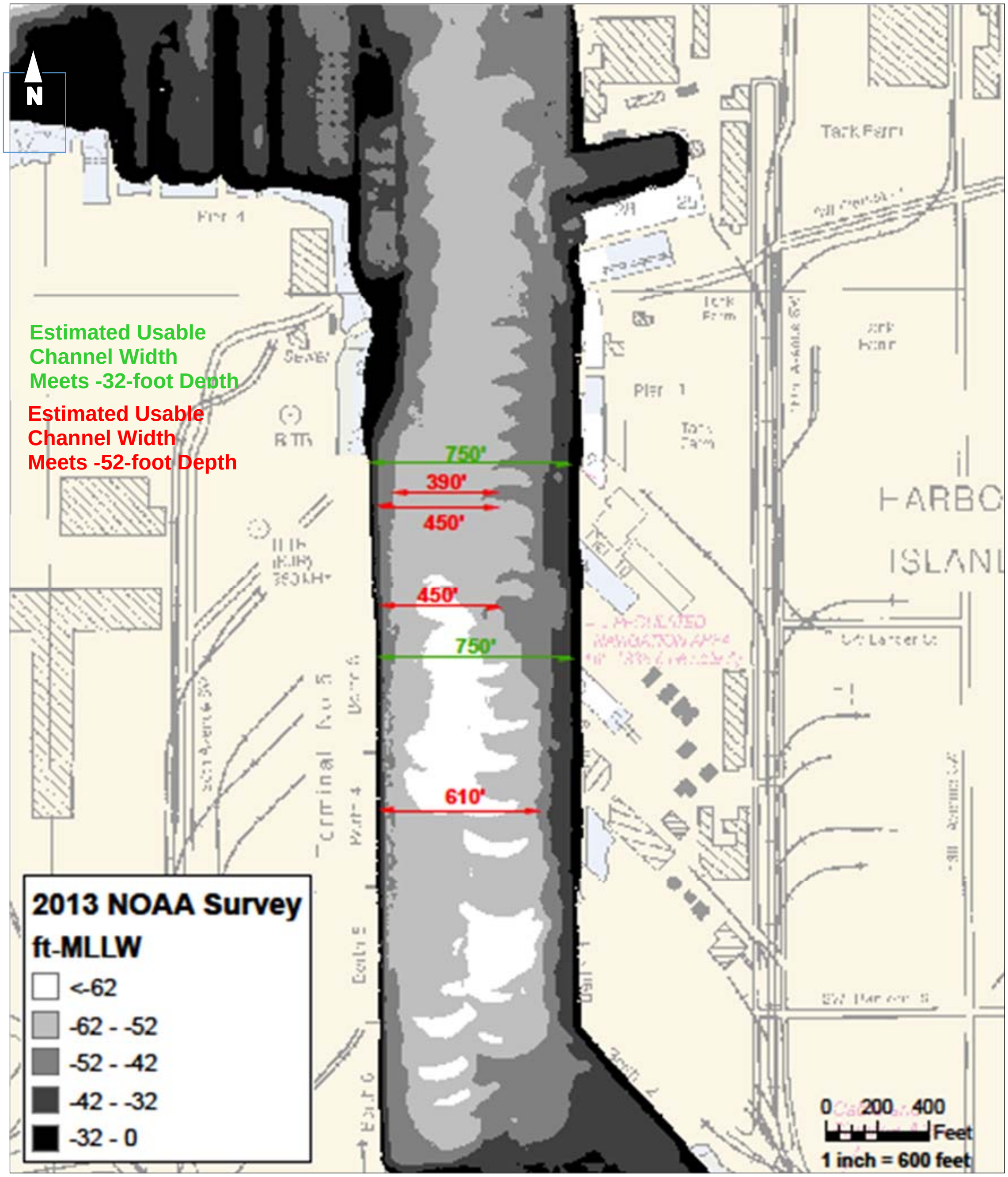


Figure 16: Location Used in Channel Width Analysis (NOAA 2013)

6.3 Potential Mitigation Measures

6.3.1 During Construction

Vessel traffic and navigation impacts during construction will be temporary. Minor delays could occur during dredging or wharf construction. However, the current communication practices used within Puget Sound, and the applicable maritime regulations and guidelines, described in Section 4.1, minimize delay and collision risks. Additionally, all Port in-water construction activities are coordinated with the Muckleshoot and Suquamish Indian Tribes, with the objective of avoiding and minimizing potential disruption to Treaty fishing activities. This includes scheduling of construction activities to avoid specific fishing periods and controlling the location and timing of construction activities. Therefore, adverse impacts to existing vessel traffic and navigation are not anticipated and mitigation measures are not proposed.

6.3.2 Traffic and Navigation

The number of vessels that could call at T5 under either Alternative 2 or 3 decreases compared to the No Action Alternative. These fewer vessels will be larger (specifically wider), however, adequate channel width for passing remains for vessels of about 90-feet in beam. For vessels with a beam of 200 feet, additional maneuvering analysis is recommended and additional channel dredging may be required. Similar to existing conditions, commercial, Tribal, and recreational vessels will be able to pass and continue transiting the West Waterway.

Current regulations (e.g. requirement for a licensed Pilot on board large commercial vessels) and communications with the VTS and other vessels will continue and minimize risks of traffic collisions, delays, or accidents. Additionally, the Port works with the Muckleshoot and Suquamish Indian Tribes on Port operations, to ensure that vessel arrivals and departures during fishing periods are known in advance to avoid and minimize potential net and vessel conflicts. Therefore, adverse impacts to existing vessel traffic and navigation are not anticipated and mitigation measures are not proposed.

6.4 Significant Unavoidable Adverse Impacts

No significant impacts to vessel traffic and navigation would be anticipated from any of the Alternatives.

7.0 REFERENCES

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Appendix H
Water Quality Monitoring Plan

Water Quality Monitoring Plan

Terminal 5 Cargo Wharf Rehabilitation and Berth Deepening

Seattle, Washington

Prepared for

Port of Seattle

May 12, 2016
19094-01-04

HARTCROWSER

HARTCROWSER

Water Quality Monitoring Plan

Terminal 5 Cargo Wharf Rehabilitation and Berth Deepening

Seattle, Washington

Prepared for

Port of Seattle

May 6, 2016
19094-01-04

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Contents

ACRONYMS AND ABBREVIATIONS

ACZA	ammoniacal copper zinc arsenate
BMP	best management practices
DGPS	differential global positioning system
DMMP	Dredged Material Management Program
DNR	Washington State Department of Natural Resources
Ecology	Washington State Department of Ecology
EPA	US Environmental Protection Agency
MLLW	mean lower low water
NTU	nephelometric turbidity unit
USACE	US Army Corps of Engineers
WAC	Washington Administrative Code
WQC	water quality criteria
WQMP	Water Quality Monitoring Plan

Water Quality Monitoring Plan

Terminal 5 Cargo Wharf Rehabilitation and Berth Deepening

Seattle, Washington

1.0 INTRODUCTION AND BACKGROUND

This document presents the Water Quality Monitoring Plan (WQMP) for in-water construction associated with the Terminal 5 Cargo Wharf Rehabilitation and Berth Deepening project located at the Port of Seattle Terminal 5 (Figure 1).

The project site is located at Terminal 5 on the west shore of the West Waterway, Seattle, Washington (Range 3 East, Township 24 North, and Sections 12 and 13). The WQMP has been prepared to ensure compliance with Section 401 of the Clean Water Act, the project 401 Water Quality Certification from the Washington State Department of Ecology (Ecology), and Washington State Water Quality Standards Chapter 173-201A of the Washington Administrative Code (WAC).

The Port of Seattle is proposing to rehabilitate the existing, approximately 50-year-old Terminal 5 container cargo wharf in order to meet the needs of present-day and emerging cargo handling equipment and container vessels. Container vessels currently being deployed between Asian trading partners and West Coast ports have significantly larger capacity than those envisioned 20 years ago when the project area was aggregated to form the Terminal as configured at the present. Newer vessels are about 28 feet wider and about 200 feet longer than vessels previously calling at Terminal 5. However, the duration of time that a vessel would be present at the berth for the same amount of throughput would decrease.

The proposed project includes actions necessary to strengthen portions of the existing wharf structure to receive larger, heavier container cranes necessary to reach up and over these newer vessels. In addition, the project includes dredging necessary to increase the operational depth of existing vessel berth area and vessel approach area in the west margin of the West Waterway to accommodate the larger vessels. Electrical system upgrades and water line replacements are also proposed along the wharf within the upland area dedicated for marine container cargo use. The proposed wharf strengthening, navigational access dredging, electrical service changes, and water line replacements are needed to ensure the continuing efficient use of Terminal 5 cargo handling infrastructure and prevent further decline in cargo transshipment capability at Terminal 5, compared with other port marine cargo facilities in south Elliott Bay.

1.1 Project Description

There are three construction elements (Pile and Overwater Structure Removal, Pile Placement, and Dredging) that have the potential to affect water quality in the project area. Each has at least some level of water quality monitoring that is required, and each is discussed in this WQMP relative to water quality potential impacts, monitoring, and best management practices (BMPs).

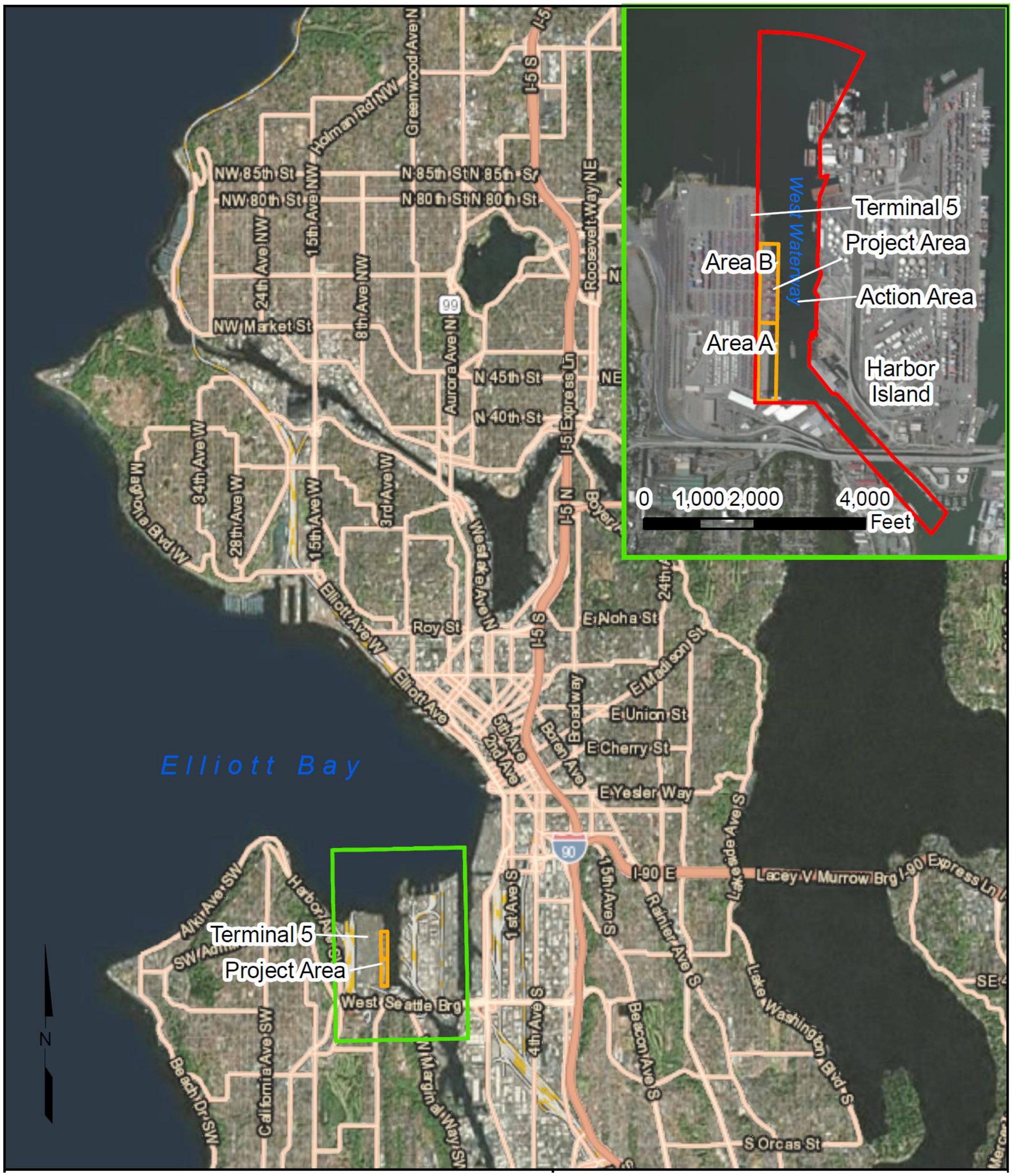

Figure 1 – Site vicinity map

1.1.1 Pile and Overwater Structure Removal

Approximately 665 existing piles will be removed from the project area subtidal zone by a barge or deck mounted crane: extract 227 fender piles (14- to 16-inch diameter, creosote- or ACZA-treated timber piles), 57 timber pinch piles (14- to 16-inch diameter, creosote-treated timber piles), 72 structural piles (16.5-inch concrete piles obstructing installation of larger-diameter structural piles), and 36 fender piles (16-inch diameter steel); and cut off of 173 concrete structural piles (16.5- to 20-inch concrete piles from existing crane rail) and 100 steel structural piles (18-inch-diameter steel). Proposed work will occur over two in-water work windows with roughly half of the total proposed work element being completed in each year. Timber, steel, and concrete piles will be extracted from the substrate using a vibratory pile driver and crane hoist. Extracted piles will be stockpiled in an area with drainage control to prevent release of sediment-laden water to adjacent surface waters. If a pile breaks above the mudline during extraction, a chain will be used, if practical, to attempt to remove the broken pile. If unsuccessful, the pile will be cut off at the mudline. Most concrete structural piles will be cut off at the mudline with the above water section hoisted out of the water by crane. The concrete piles remaining below the mudline act as slope structural reinforcement in lieu of installing a new pinch pile.

Pile removal will clear a footprint of approximately 1,030 square feet of impediments, 311 square feet of which are creosote- or ACZA-treated fender piles in open areas of the West Waterway. The remaining piles to be removed are situated beneath Terminal 5. The existing creosote- and ACZA-treated wood pile and steel pile wharf fender system will be removed and replaced with an alternative panelized, above-water fender arrangement. The replacement fender elements will be spaced at approximately 60-foot intervals and do not include in-water elements.

In addition, the existing safety walkway along the entire (2,900-foot length) wharf between the bull rail and the existing fender system will be removed. This represents an additional 8,500 square feet of overwater coverage removed from the wharf structure as part of this project.

To protect the surrounding marine area from impacts during removal and as required by the 401, 404, and other permits, best management practices (BMPs) as described in Section 2.1 will be employed during extraction.

1.1.2 Pile Placement

Up to 3,000 pinch piles, 420 structural piles, and a 3,100-foot-long combination sheet pile wall composed of 500 H-piles and 500 sheet piles are required to support the anticipated heavier loads on the rehabilitated dock needed for larger cranes and to stabilize the slope.

1.1.2.1 Structural Piles

Up to 420 pre-stressed, 24-inch concrete octagonal piles will be driven into the subtidal zone (-35 to -40 feet mean lower low water [MLLW]) beneath the existing Terminal 5 Wharf to support the waterside crane rail beam. Concrete piles will be driven with an impact pile driver conducted from a barge crane. Proposed work will occur over two in-water work windows with roughly half of the total proposed work element completed in each year. To protect the surrounding marine area from impacts during installation, best management practices will be employed during the installation of concrete piles.

A combination pile wall composed of a total of 500 steel H-piles and 500 steel sheet piles will be driven to establish a new toe wall approximately 3,100 feet long at the bottom of the existing slope near the face of Terminal 5. The top elevation of the new toe wall will vary between -42 and -50 feet MLLW. Both the H-piles and sheet piles will be driven using a vibratory hammer primarily. However, if the depth required for H-piles using vibratory hammer is not achieved, an impact hammer will be necessary to reach required toe elevation. Port engineers have estimated that, on average, the last 10 feet of the H-piles may need to be driven with an impact hammer. Given the expected production rate and number of piles installed, approximately 900 extra blows per day via an impact hammer related to H-pile wall installation would be expected. Proposed work will occur over two in-water work windows with roughly half of the total proposed work element completed in each year. To protect the surrounding marine area from impacts during installation and as required by regulatory approvals, BMPs as described in Section 2.1 will be employed during installation.

In upland areas west of the existing bulkhead, approximately 125 feet from the waterward face of the Terminal 5 wharf, a total of 420 24-inch-diameter steel piles will also be driven with an impact pile driver along the length of the wharf.

1.1.2.2 Slope Stabilization with Pinch Piles

The slope beneath the Terminal 5 wharf is steep—approximately 1 horizontal to 1.5 vertical grade (1H:1.5V). Geotechnical investigations have determined that portions of the slope beneath Terminal 5, constructed 30 to 40 years ago, would need to be stabilized after removal of the existing piles and prior to toewall installation and berth deepening. Slope stabilization will be conducted by driving up to 3,000, 14-inch-diameter untreated wood piles into subtidal portions of the slope between elevations of about -11 feet and -37 feet MLLW. Piles will be driven both vertically along the base of the slope and at an angle from the vertical, approximately 5 feet on-center for most of the length of the wharf between rows of existing structural piles. Piles will be driven about 60 feet into the substrate and cut off at the substrate surface. Where possible, a vibratory driver will be used; however, impact driving is expected to be necessary for most of the battered piles. Proposed work will occur over two in-water work windows with roughly half of the total proposed work element completed in each year. BMPs will be employed as described in Section 2.1 to protect the surrounding marine area from impacts during installation and to meet regulatory approvals.

1.1.3 Dredging

Approximately 234,460 square feet of area waterward of the edge of the dock at Terminal 5 will be dredged to a required depth of -56 feet MLLW plus an additional one foot of advanced maintenance dredge with a potential two foot over dredge depth. Existing depths in the proposed dredge prism are between -47 and -55 feet MLLW, so proposed dredging will not convert intertidal or shallow water habitats to deep water habitats. The total volume of sediment to be removed from the project area is approximately 36,200 cubic yards (cy) (not including potential over dredge depth).

The estimated number of working days for dredging activities will be 23 days at a removal rate of approximately 1,200 to 1,500 cy per day. The Port typically dredges from December 1 to February 15 to accommodate the agency-approved work window and to avoid impacting treaty-fishing activities. The dredging event is scheduled to occur separately in a third fish window (year) following construction of the rehabilitated dock and associated structural components. If necessary, an extension of the 2015 suitability determination will be requested from the Dredged Material Management Program (DMMP), or additional sediment sampling will be completed in accordance with regulatory requirements.

The 2015 DMMP suitability determination found that the sediment that would be exposed by dredging did not exceed any DMMP screening levels, and was not considered to be degraded relative to the currently exposed sediment surface. The DMMP agencies concluded that the project was in compliance with the State of Washington antidegradation policy. Unless conditions change, there is no plan to place sand cover following the dredging activities.

1.1.3.1 Equipment

Dredging will be accomplished using mechanical dredging equipment. The description of mechanical dredging in this section is adapted from the US Army Corp of Engineers (USACE) technical publication Technical Guidelines for Environmental Dredging of Contaminated Sediments (ERDC/EL TR-08-29; USACE 2008).

The basic components of a mechanical bucket dredge include the crane, dredge derrick barge, haul barge, anchor spuds, and bucket. There are two types of buckets common to this method: the clamshell digging bucket and the enclosed environmental bucket. The Port proposes to allow contractors to use either type of bucket, depending on the specific location conditions and sediment characteristics.

Once excavated from the bottom and lifted to the surface, dredged material will be placed into a haul barge.

1.1.3.2 Disposal

Disposal of all dredged sediments removed as part of the project will be conducted consistently with conditions and requirements stipulated by the DMMP, Washington State Department of Natural Resources (DNR), Washington State Department of Ecology (Ecology), USACE, US Environmental Protection Agency (EPA), and other agencies with jurisdiction. Sediment sampling for DMMP characterization was conducted in 2014, and results indicate that all of the sediments are suitable for open-water disposal. The sediments will be placed by the dredge equipment into a bottom dump barge (or split hull barge) for transport and placement into the Elliott Bay Unconfined Open Water Disposal Site. The barge will be fitted with a screen to remove debris. The debris will be transported and disposed of appropriately at an upland disposal site.

2.0 BEST MANAGEMENT PRACTICES AND CONSERVATION MEASURES

2.1 Pile Driving and Pile Demolition

General BMPs for pile driving and pile removal are described in Attachment B of the Section 401 Water Quality Certification No. 13195 issued for this project. The BMPs referenced in that document will be used as applicable to the project and equipment specifics. The following BMPs will be employed to avoid and limit potential environmental impacts resulting from pile driving and pile removal activities.

- Pulled piles will be placed in a containment basin either on a barge or adjacent to the deck to capture any adhering sediment. These basins will fully contain the sediments and associated water.
- A boom will be installed around the work area prior to removal of timber piles and related structures to contain and collect debris, which will be disposed of at an approved upland location.
- Operator will “wake up” the pile by vibrating to break the skin friction bond between pile and soil.
- Crane operator will minimize turbidity in the water column by removing the released pile slowly.
- Creosote-treated wood pilings will be disposed of at an approved upland location. Any sediments, construction debris/residue and plastic sheeting from the containment basin will be removed and disposed of in accordance with applicable federal and state regulations.

2.2 Dredging

The following BMPs will be employed to avoid and limit potential environmental impacts of dredging activities:

- The Port will require the contractor to utilize real-time positioning control when implementing dredging operations.
- The Port will require the contractor to not take multiple “bites” of the sediment.
- The Port will require the contractor to not stockpile sediment on the bottom.
- The Port will require the contractor to not overfill the scow to the point where dredge material overtops the sidewalls.
- The Port will require the contractor to use caution when placing the material from the dredge bucket into the scow to limit splashing and prevent spillage.

3.0 WATER QUALITY MONITORING PLAN

3.1 Monitoring Program Objectives

This WQMP describes the monitoring activities associated with construction activities at Terminal 5. The WQMP is designed to gather information to assess potential impacts on water quality during the execution of this work. The objectives of the monitoring program are to:

- Assess potential impacts on water quality caused by dredging and pile removal/installation;
- Help the contractor ensure compliance with water quality criteria (WQC);
- Provide information to evaluate the effectiveness of operational controls to achieve compliance with WQC during dredging and pile removal/installation; and
- Document the monitoring activities and sampling results in a final report.

This WQMP also provides additional information, including:

- Field procedures and a schedule for implementing the WQMP;
- Responses to address contingency measures that might be used if WQC are exceeded; and
- Requirements for the timing and reporting of monitoring program results.

3.2 Water Quality Monitoring

Construction activities will be monitored to determine if the work significantly affects surface water quality. For in-water work, monitoring will occur at specific locations within the compliance zone to evaluate compliance with WQC in Elliott Bay. Applicable WQC from WAC 173-201A-210 for marine surface waters are shown in the table below.

Table 1 – WAC Water Quality Criteria for Marine Surface Waters

Parameter	Criteria
Turbidity (1-day maximum)	5 NTU over background when background is 50 NTU or less; or A 10% increase in turbidity when background turbidity is more than 50 NTU

Notes:
NTU – nephelometric turbidity unit

The point of compliance where the WQC must be met for water column monitoring during in-water work is a maximum distance of 150 feet from the point of disturbance or work activity that may create turbidity.

3.3 Monitoring Schedule

Monitoring will be conducted during the first week of the pile driving/removal activities using continuous monitoring turbidity loggers to demonstrate that there are no issues. If there are no issues during the first week, the monitoring will be discontinued. Monitoring will be conducted during the entire dredge season with continuous monitoring turbidity loggers.

Continuous monitoring and logging of turbidity in the water column will be conducted using subsurface turbidity sensors with cellular telemetry attached to anchored monitoring buoys (e.g. YSI EX02 Multi-Parameter Sonde attached to a NexSens CB-50 or CB-150 Data Buoy). The monitoring system will be designed with two turbidity sensors—one located 3 feet below the water surface and one 3 feet above the bottom. The bottom monitoring sensor may be adjusted slightly upwards to account for sediment consolidation at the anchor location. The turbidity sensors and data buoys can be either battery operated (CB-50) or solar powered (CB-150) and are very visible when deployed. The turbidity instrument will be equipped with built-in Bluetooth® wireless technology for calibrating, communicating, and downloading data. The monitoring system also includes a web datacenter for project and data management. This datacenter provides 24/7 instant access to the environmental data and allows for quick viewing of the most recent site data. The data can be accessed from any computer through the web datacenter. If appropriate, alarms and alerts can be set to notify project personnel via email or text message when turbidity levels exceed desired thresholds. The turbidity monitoring systems can be leased or purchased for use on this project.

The advantage to using an automated system is that it is not necessary to have someone physically on site to conduct monitoring. Instantaneous readings also allow for quick shutdown during exceedances, if necessary. The automated system can be set up to send alerts to the Port's environmental compliance manager, who will coordinate with the Port engineer on site and the dredge operator to adjust dredging activities if there are exceedances. In addition, the sensor array allows for monitoring turbidity over a depth profile without having to physically adjust the depth of the sensors, providing more accurate data within the compliance zone.

3.4 Monitoring Locations

Representative in-water monitoring locations are shown on Figure 2. Following discussions with Ecology, a monitoring zone consisting of two "boxes" of approximately 200 × 1,500 feet will be created along the length of the pier, one to the north and one to the south. This "box" approach was approved by Ecology for use with this project because 1) the Port will be using continuous monitoring technology, 2) the material being dredged is suitable for in-water disposal, and 3) the Port has previously monitored dredging in this area using a standard monitoring approach (including early warning locations) without exceedances.

Two water quality compliance stations will be located 150 feet to the east along each box edge. As work is being conducted in a tidally influenced area, two reference background sampling locations will be established to the north and south, approximately 600 feet outside of the in-water work area of influence (Figure 2).

Additional monitoring may be conducted in or near the project at the discretion of the Port or their designee directing the field effort. The intent is to adapt monitoring to field conditions and address concerns about dredging and pile removal/installation, or conditions that may affect water quality near the dredging activities. Details about the type and frequency of additional monitoring and the location and rationale for performing it will be documented in the field logbook.

Monitoring depth at the sample and background locations will be determined based on the water depth at the location. In water deeper than 12 feet, vertical monitoring points will be set at 3 feet below the water surface and 3 feet above the bottom. However, the bottom sensor may be adjusted slightly upwards to account for sediment consolidation at the anchor location. If water is shallower than 12 feet, one vertical monitoring point will be set in the middle of the water column.

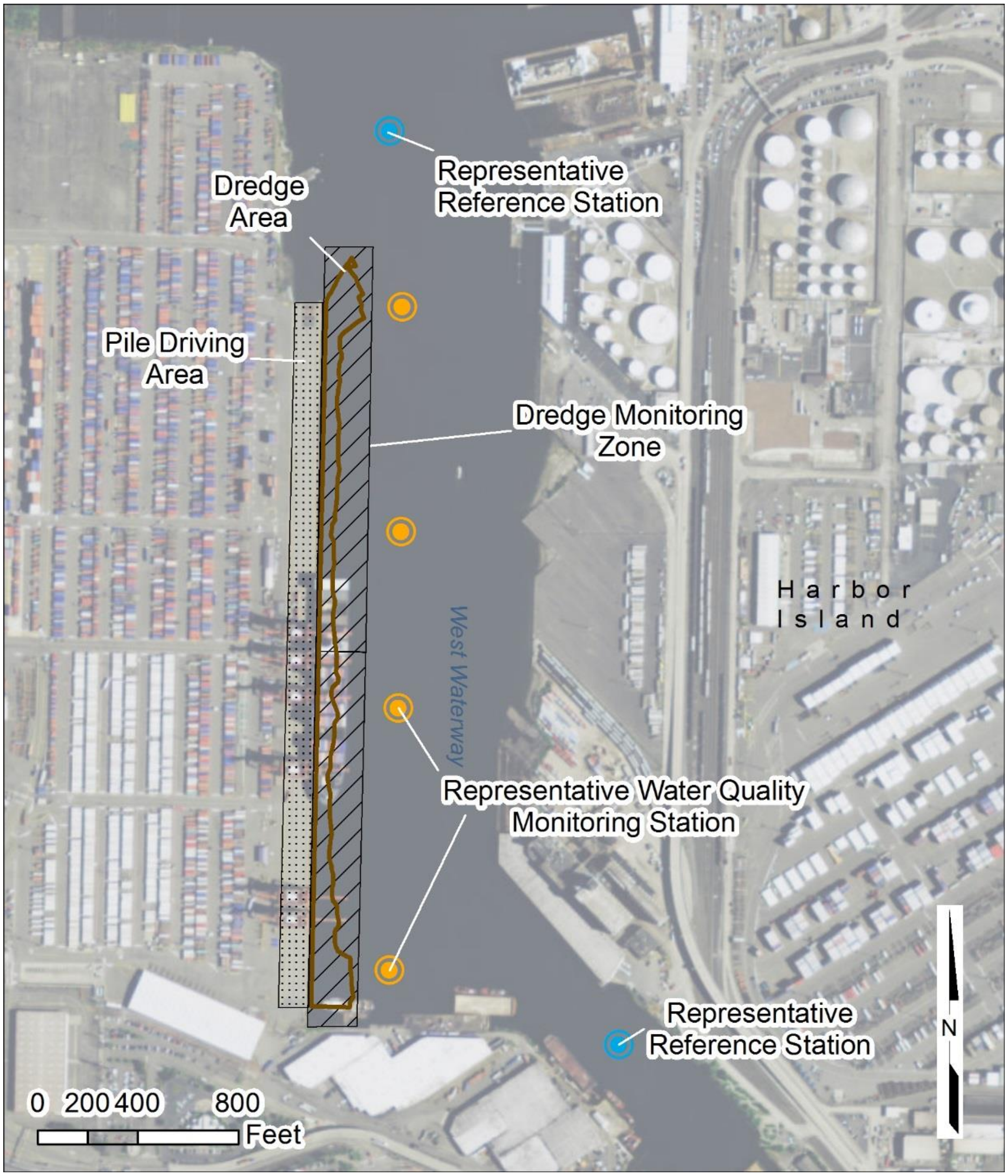

Figure 2 – Water quality monitoring locations

3.5 Water Quality Criteria Measurement and Equipment

3.5.1 Turbidity Measurement Methodology

WQC will be continuously measured in the water column using subsurface turbidity sensors attached to anchored monitoring buoys at the monitoring locations. As described above, the sensors will be installed at depths based on the water column height at the monitoring location. Cellular telemetry will be used to monitor the sensors remotely. Webcams may be installed to monitor ship traffic as a check on potential compliance exceedances.

Monitoring buoy turbidity measurements will be continuously logged and recorded to determine whether there is an exceedance when compared with corresponding data from the background locations. Collection of water samples for off-site laboratory analysis of turbidity will not be required. The data loggers will be set so that there is no depth or time averaging of the turbidity measurements.

3.5.2 Monitoring Location Measurement and Documentation

Distances from the monitoring zone boxes to monitoring buoy locations will be verified through differential global positioning system (DGPS) readings or by an accurate ranging device, such as a laser rangefinder. If DGPS methods are used, one reading will be needed at the pier, and then a second reading will be needed at the proposed monitoring location. Actual DGPS coordinates, times, and depths of all monitoring locations will be recorded. DGPS accuracy will be ±6 feet.

When in-water work is completed within a compliance monitoring zone “box,” the two monitoring buoys would be moved to the other “box” and set up 150 feet from the new box edge. The reference background sampling locations will not be shifted.

3.5.3 Monitoring Equipment Calibration and Handling

Turbidity monitoring equipment will be calibrated before use for the monitoring program. If the instrument manual calls for more frequent calibration for the types of measurements being made and the conditions, the calibration frequency will conform to the specifications in the manual.

Calibration information will be recorded and calibration records maintained. The monitoring sensors will be allowed to equilibrate before logging measurements. Monitoring equipment will be handled according to manufacturer’s recommendations. Unusual or questionable readings will be noted and addressed appropriately.

3.5.4 Documentation

The turbidity measurements from the monitoring equipment will be continuously logged and recorded. When pertinent, additional information regarding monitoring buoy locations, weather conditions, visual observations at the monitoring locations and vicinity of construction activities, and the presence or movement of watercraft (generally, all information that might be pertinent to water quality) will be recorded on a field data sheet and saved in the field notebook. If necessary, a standard site map showing the general work area will be used for noting monitoring locations and sketching any features or conditions that might influence water quality near the monitoring locations.

The following quality control data will be collected and recorded:

- Names and affiliations of technical and support staff;
- Buoy locations and times for all measurements and samples;
- Depth measurements; and
- Calibration data for field probes.

Field equipment will be calibrated following the methods and frequencies specified by the equipment manufacturer.

4.0 RESPONSE TO EXCEEDANCES OF WATER QUALITY CRITERIA

The Port of Seattle's environmental compliance manager or designee will monitor the turbidity data for WQC exceedances. The continuous turbidity monitoring system can be set up to send email notifications when there are WQC exceedances. When there are exceedances, the Port of Seattle's environmental compliance manager or designee will take steps to confirm the exceedance and then take appropriate corrective actions. The following information will be collected:

- A description of the nature and cause of noncompliance, including the quantity and quality of any unauthorized discharges and the measurement of confirmed exceedances;

- The period of noncompliance, including exact dates, duration, times, and the anticipated time when compliance will be reestablished; and

- The steps taken, or to be taken, to reduce, eliminate, and prevent recurrence of the noncompliance.

The Port of Seattle or its designee will require contractors to take all appropriate corrective actions if WQC exceedances are confirmed. Corrective actions may include implementation of additional best management practices (BMPs) or modification of work methods and operations. For in-water operations, corrective actions may include the following:

- Confirming that the monitoring equipment is working properly, and performing cleaning and recalibration as necessary;

- If webcams are installed, reviewing the information to determine if WQC exceedances are caused by ship traffic;

- Increasing dredging cycle time (a longer cycle time reduces the velocity of the ascending/descending bucket through the water column, which reduces potential to wash sediment from the bucket and suspend sediment as the bucket contacts the sediment surface);
- Increasing wooden pile removal cycle time;
- Checking for conformance with BMPs for dredging (no bottom stockpiling, no multiple bites, no dragging the dredge bucket, proper performance of the dredge equipment, etc.), and BMPs for pile removal; and
- Checking for and removing debris that may be interfering with in-water operations.

In addition, work will cease upon any discharge of oil, fuel, or chemicals into state waters or onto land with the potential to enter state waters. All oil spills will be immediately reported to Ecology's 24-Hour Spill Response Team at (800) 258-5990 and reported within 24 hours to Ecology's 401/coastal zone management federal project manager.

5.0 REPORTING

The Port of Seattle's environmental compliance manager or designee will provide weekly reports and notifications in the case of WQC exceedances. As turbidity monitoring will be continuous, the data collected will be downloaded and saved electronically. At the end of the project, the monitoring data will be saved to a CD-ROM.

5.1 Water Quality Criteria Exceedance Notifications

If WQC exceedances occur, the Port of Seattle's environmental compliance manager or designee will notify Ecology's 401/coastal zone management federal project manager within 24 hours.

5.2 Weekly Water Quality Reports

The weekly water quality reports will include:

- The names of the personnel conducting the monitoring;
- The date, weather conditions, and project activities being conducted during the monitoring period;
- Data summary tables with comparisons to the water quality criteria;
- A discussion of elevated turbidity results that were not confirmed;
- A discussion of any exceedances;
- A summary of any corrective actions taken; and
- A discussion of any deviations from the WQM plan.

The final weekly summary report for the project will include a summary of all the data and exceedances for the project.

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Appendix I
Sea Level Rise Considerations

Memorandum

To: Steven Gray, Moffatt & Nichol (M&N)
From: Aaron Patterson (M&N)
Date: April 20, 2016
Subject: Terminal 5 Sea Level Rise Considerations
Project: Terminal 5 Cargo Wharf Rehabilitation, Berth Deepening and Improvements

1.0 INTRODUCTION

Moffatt & Nichol (M&N) has been retained by the Port of Seattle (Port) to provide design support services, including support for the State Environmental Policy Act (SEPA) review for the Terminal 5 (T5) Cargo Wharf Rehabilitation, Berth Deepening and Improvements Project (the Project). Part of this effort includes assessing the potential for project-related short-term and long-term impacts due to rising sea levels in the Puget Sound.

This memorandum describes existing sea levels in the study area, observed sea level rise during the 20th Century, projected sea level rise during the 21st Century, and what potential changes to the Project alternatives might occur. Measures to avoid, minimize, or compensate for potential adverse effects are identified. Information is provided in a format that can be incorporated into the Project's in-development Environmental Impact Statement (EIS) as a separate chapter or as part of other existing EIS sections.

2.0 STUDY AREA

The study area for sea level rise includes the southern edge of Elliott Bay into the Duwamish River West Waterway and the existing T5 wharf (Figure 1).

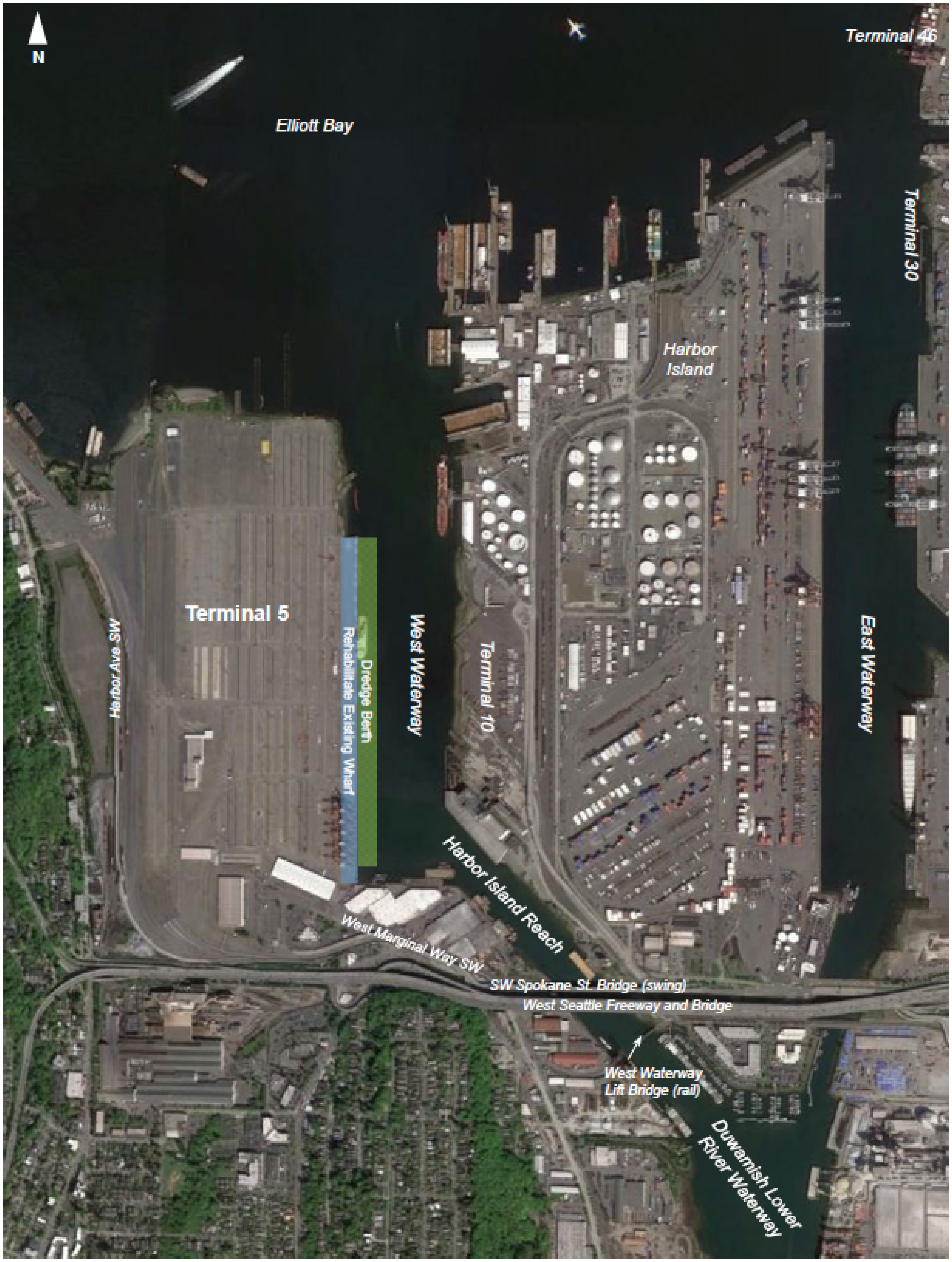

Figure 1: Port of Seattle Terminal 5 on the Duwamish River

2.1 Existing Terminal 5 Facility

T5 is located on the west side of the Duwamish River West Waterway and includes the existing marine cargo facility, approximately 197 acres of existing upland, and 19 acres of existing cargo pier, and berth in the west margin of the waterway, adjacent to the terminal upland cargo marshalling area. The existing T5 wharf is approximately 2,900 feet long. The existing top of wharf elevation is approximately 18.60 feet Mean Lower Low Water (MLLW).

2.1.1 Existing Sea Levels

Existing tidal datums for the Project are provided in the following table, relative to MLLW and based on the 1983 – 2001 epoch (NOAA/NOS 2012). NOAA Station 9447130 is located near Coleman Dock in downtown Seattle.

Table 2-1. Tidal datum and vertical datum relationships in feet relative to MLLW at NOAA Station 9447130, Seattle, WA

Datum	Elevation (feet, MLLW)
Extreme High Water	14.48
Mean Higher High Water	11.36
Mean High Water	10.49
Mean Low Water	2.83
Mean Lower Low Water	0.00
Extreme Low Water	-5.04

3.0 SEA LEVEL RISE

Sea level rise is the relative increase in mean sea level, primarily caused by two processes: additional water in the ocean from glacial and land-based ice sheet melt, and thermal expansion of ocean waters due to warmer sea temperatures (Adelsman and Ekrem 2012). Sea level rise is a global occurrence, however, observed sea level rise varies by location due to changes in land elevation and wind.

3.1.1 Observed Sea Level Rise

On a global scale, oceans have risen approximately eight inches from 1900 to 2009. In Washington, sea level rise has varied due to variations in land elevation changes. Subduction of the Juan de Fuca plate has resulted in the Olympic Peninsula rising approximately 0.08 inches a year, while the Puget Sound has subsided at an equal rate (Adelsman and Ekrem 2012). Sea level rise in Seattle, as measured by the Seattle tide gauge, has risen by 8.6 inches over the same time span.

3.1.2 Projected Sea Level Rise

Climate projections for the Pacific Northwest (PNW) are available from the Climate Impacts Group at the University of Washington (Mauger et al. 2015). The climate projections indicate that the Puget Sound is likely to experience the following effects over the next 50 to 100 years:

- Increased temperature leading to more frequent extreme heat events, worsened air quality, and glacial melting.
- Sea-level rise, coastal erosion, and salt water intrusion.
- Changes in the volume and timing of precipitation resulting in reduced snow pack, increased erosion, and more frequent and severe flooding.
- Ecological effects of a changing climate including the spread of disease, altered plant and animal habitats, and negative impacts on human health and well-being.

Sea levels are projected to rise over the coming century, with a wide range of possible future amounts, depending on the rate of global greenhouse gas (GHG) emissions. Globally, sea level is projected to increase by 11 to 38 inches between 2000 and 2100, depending on the amount of GHG emission. Between 2000 and 2100, relative sea level in Seattle is projected to rise between 4 and 56 inches. The Climate Impact Group has provided a middle estimate of sea level rise for the latitude of Seattle of +24 inches by 2100, relative to 2000 (Mauger et al. 2015).

The Port of Seattle is developing a draft climate change adaptation plan to address projected rates of sea level rise at Port facilities. The draft adaptation plan notes that the longest design life that the Port assigns to an asset is 50 years and the most likely amount of sea level rise that an asset will experience over the next 50 years is about nine inches (Port of Seattle 2015).

4.0 PROJECT DESCRIPTION

Three alternatives are being considered as part of the Project EIS and are described in brief detail below. Alternative 1, the No Action Alternative, provides a baseline of conditions for comparison when discussing the action alternatives.

- ***Alternative 1 or No Action Alternative.***

  The No Action Alternative assumes that no improvements will be made to the existing site other than minor alterations, routine maintenance and repair work. No changes to the cargo pier, existing berth or wharf, potable water lines, sewer, or site elevations and grades are proposed. Stormwater treatment facilities will be installed to aid the facility in achieving Department of Ecology Industrial Stormwater Permit compliance.

- ***Alternative 2: Wharf improvements, increased cargo-handling efficiency and volume.***

  Alternative 2 proposes to rehabilitate the existing T5 container cargo pier to support larger container cranes. The rehabilitation includes upgrades to the existing apron area and crane rails to support the large container cranes. Upgrades to the apron will not include changes to apron or upland surface elevations. Slope stabilization measures under the wharf will be implemented with apron upgrades, to maintain the existing slope stability.

  The extent of utilities work, other than associated with electrical is limited. Stormwater treatment facilities will be installed to aid the facility in achieving Department of Ecology Industrial Stormwater Permit compliance. Minimal excavation is proposed for trenching of utilities and site preparation work and the new crane beam.

- ***Alternative 3: Wharf improvements, relocate buildings, densify rail yard, optimized cargo-handling efficiency and volume.***

  In-water and over-water construction including berth deepening, and upland construction activities will be the same as described for Alternative 2, including upgrades to the apron and slope stabilization measures, to maintain the existing slope stability.

The majority of the stormwater collection system will be reconfigured to accommodate the new terminal stacking system. Existing outfalls will be maintained where possible. A stormwater management plan and potential treatment facilities will be installed to aid the facility in achieving Department of Ecology Industrial Stormwater Permit compliance.

Excavation will be required for trenching of utilities and site preparation work and the new crane beams. Utility excavations are expected to be up to 10 feet below ground surface, and dewatering may be required to accommodate construction.

5.0 POTENTIAL IMPACTS TO THE PROJECT

Inundation from rising sea levels could challenge the capacity of storm drains and treatment facilities. Rising sea levels could inundate or disrupt numerous nearshore facilities due to flooding caused by the increased elevation of receiving water bodies. Drainage facilities may need to be enlarged to provide storage for additional stormwater volumes that may result from water backing up due to sea level rise.

Sea-level rise impacts could potentially include changes to shoreline slope stability due to changes in tidal flux and wave action and higher frequency of flooding; higher ground water elevations which may affect pavement and foundation performance, settlement, subsurface utilities and berthing functionality.

The SEPA Implementation Working Group (IWG) has developed recommendations to ensure that consideration of climate change is included in SEPA review (IWG 2008). Analysis of the environmental impacts of a given proposal and its vulnerability to climate change effects, including sea level rise, is required.

The Port of Seattle's DRAFT Climate Change Adaption Plan (Port of Seattle 2015) also addresses anticipated climate change vulnerabilities of Port and adjacent facilities and how major capital projects should be designed to account for resiliency, including sea level rise. The Port focuses on adaptation measures that would be required prior to 2065 and combines it with their overall philosophy of adaptive management and business planning. Typical adaptation measures prescribed by the Port include improvements to terminal stormwater conveyance, treatment, and drainage systems along with necessary modifications to power supply.

5.1 Alternative 1

Increased sea levels could result in changes in tidal flux and wave action along the wharf. The existing rock-stabilized slope extends the length of the wharf from the existing bulkhead wall to below the intertidal zone. Increases in tidal flux and wave action may result in additional erosion and shoreline degradation in areas where the riprap may not be sufficiently sized. Slope stability improvements are not proposed under Alternative 1.

Higher groundwater elevations may coincide with higher sea levels affecting T5 pavement subgrades, building and structure foundations, and settlement. Compromised pavement subgrades, foundations, and settlement may lead to reductions in terminal operations and increased levels of maintenance and repair.

Increasing the elevation of a water body that receives runoff from a stormwater system can affect the hydraulic performance of the stormwater system. If the elevation of a receiving water body is increased, water may begin to encroach up the end of the pipe, reducing the overall system capacity. With a reduced capacity, existing systems may become inundated and not be able to convey the design flows for that system, which leads to localized upland flooding during periods of higher tidal cycles and large storm events. This could occur at T5 under the No Action Alternative. Localized flooding could then adversely impact terminal operations.

5.2 Alternative 2

Slope stability improvements are not proposed in Alternative 2. Increased wave action due to increased sea levels may result in shoreline degradation in areas where the existing riprap, under the wharf or along the north shoreline of the site, may not be sufficiently sized.

Similar to Alternative 1, higher groundwater elevations may compromise pavement subgrades, foundations, and settlement, which may lead to reductions in terminal operation efficiencies and increased maintenance and repair efforts.

Inundation of existing subsurface utilities may occur under Alternative 2 and could lead to localized upland flooding during periods of higher tidal cycles. Stormwater treatment facilities constructed under Alternative 2 would be installed at elevations that accommodate the existing elevations of the stormwater system and may not account for increased water levels in the receiving water body.

5.3 Alternative 3

Similar to Alternatives 1 and 2, slope stability improvements are not proposed in Alternative 3. Increased wave action due to increased sea levels may result in shoreline degradation in areas where the existing riprap may not be sufficiently sized.

The majority of the stormwater collection system will be reconfigured to accommodate the new terminal stacking system. As part of the reconfiguration, existing outfalls will be maintained where possible and the conveyance system elevations may be adjusted, where upland elevations allow. Raising the conveyance system elevations could minimize potential flooding due to projected increases in sea level.

5.4 Potential Mitigation Measures

It is important to note that the project is proposed on an existing site, with existing rail, vehicle, and vessel access and support infrastructure already in place. Continued use of and connectivity to existing infrastructure are critical design considerations. The proposed opportunities for Alternatives 2 and 3 present ideas that could be implemented now as a part of this project, or at a later date in an adaptive management strategy to minimize sea level rise risks and maintain terminal efficient operations:

- Replacement of the fender system could incorporate design to account for some sea level rise. The existing fender system could be replaced with a panelized fender system that could accommodate vessels berthing during higher tidal elevations and increased sea levels.
- The installation of backflow prevention devices (flap gates) could prevent saltwater from backing up into the enclosed drainage system of T5.
- The installation of larger diameter storm system piping, modification of existing outfalls, and/or installation of new outfalls could provide additional system capacity and prevent overtopping during high tidal events.
- The majority of the pavement in the container yard will be removed and replaced as part of Alternative 3. The subgrade of the replaced pavement could be designed to accommodate increased groundwater elevations.

Compared to the Alternative 1 and Alternative 2, Alternative 3 will most likely provide the most opportunities to accommodate sea level rise in design.

5.5 Significant Unavoidable Adverse Impacts

Under all alternatives the existing elevation of the wharf deck will not be increased. As sea levels rise, increased tidal flux and wave action will result in waves overtopping the wharf during storm events at higher tide cycles. Although rebuilding of the outer wharf deck under Alternative 2 and Alternative 3 would allow for the elevation of the outer portion to be raised to account for higher tidal elevations, the inner portion of the terminal would remain at the existing elevation and would result in grade changes that are not suitable for containerized port facilities.

6.0 REFERENCES

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Appendix J
95% Geotechnical Engineering Design Study

95% Geotechnical Engineering Design Study

Terminal 5 Deepening and Crane Rail Upgrade

Seattle, Washington

Prepared for

Port of Seattle

June 14, 2016
19094-01

HARTCROWSER

95% Geotechnical Engineering Design Study

Terminal 5 Deepening and Crane Rail Upgrade

Seattle, WA

Prepared

Port of Seattle

June 14, 2016

19094-01

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FIGURES (Continued)

95% Geotechnical Engineering Design Study

Terminal 5 Deepening and Crane Rail Upgrade

Seattle, Washington

EXECUTIVE SUMMARY

We completed 12 new soil borings to support the geotechnical engineering design of the Terminal 5 Deepening and Crane Rail Upgrade project. Using the results of these borings and soil laboratory tests on selected samples, we developed representative soil profiles for geotechnical engineering analysis and design for this project. We provide recommendations for seismic, substation building, and pile design in this study. Our limit equilibrium slope stability analyses show that the proposed dredged slope configurations factors of safety can meet or exceed the current factors of safety with the addition of a king-pile toe wall supplemented with pinch piles on the lower portion of the under-pier slope. This design satisfies the Port's memorandum of understanding with the city that the seismic slope stability will not be diminished following the terminal improvements. In addition, we performed dynamic deformation-based analyses using PLAXIS that show reduced slope movement following the improvements. We believe the project is feasible from a geotechnical perspective.

INTRODUCTION

This 95% geotechnical engineering study report presents the results of our geotechnical investigation and our recommendations for the Terminal 5 Deepening and Crane Rail Upgrade Project at the Port of Seattle.

The project's significant geotechnical design elements include new crane rail piles, dredging at the toe of the slope, a new submerged king-pile toe wall near the waterside edge of the terminal, slope-stabilizing pinch piles, and a substation building. The king-pile toe wall will increase the design berth depths by 8 to 13 feet over existing conditions, to elevation −58 feet (ft) Mean Lower Low Water (MLLW). The −58-ft MLLW depth is based on a design dredge depth of −55 feet and up to 3 feet of maintenance dredging and overdredging (cumulative). Terminal 5 has already been deepened in most of the project area from the design elevation of −40 feet MLLW. We found that maintaining seismic stability of the slope and toe wall is possible, but will require a new, larger-capacity king-pile toe wall and structural reinforcement (pinch piles) over a portion of the slope area where berth deepening is planned.

We have organized this report into several sections. The first two pages describe the purpose and scope of our work and our understanding of the project. The main body of the report presents the subsurface conditions, seismic considerations, and our geotechnical engineering conclusions and recommendations.

Tables and figures are included within the text if space permits; larger tables and figures follow the text. Attachment 1, a Tsunami Hazard Map for Seattle, follows the tables and figures. Field data are presented in Appendix A and geotechnical laboratory test program results are presented in Appendix

B. Appendix C presents relevant exploration logs from earlier geotechnical studies at the site. Appendix D includes results of our slope stability analyses.

PURPOSE, SCOPE, AND USE OF THIS REPORT

The purpose of our work is to provide the Port of Seattle with subsurface information and interpretation and geotechnical engineering design recommendations. Our work supports the Port's design and cost estimate for deepening the berth and upgrading the crane rail at Terminal 5.

Our scope of work for this project included:

- Assessing subsurface conditions using explorations, laboratory tests, and historical geotechnical reports and explorations;
- Performing geotechnical design and analysis;
- Providing geotechnical engineering recommendations; and
- Producing a geotechnical engineering design report.

This report addresses each of our scope items. We prepared this report for the exclusive use of the Port of Seattle, Moffatt & Nichol Engineers, and their design and construction consultants for specific application to the Terminal 5 Dock Upgrade Project and site location. Within the limitations of scope, schedule, and budget, we completed the work according to generally accepted geotechnical practices in the same or similar localities, related to the nature of the work accomplished, at the time the services were accomplished. We make no warranty, expressed or implied.

PROJECT UNDERSTANDING

The project site is located along the west shore of the West Waterway at the mouth of the Duwamish River at the Port of Seattle (Figure 1).

Figure 1. Vicinity Map

The site is occupied by a pile-supported wharf structure and a paved shipping container storage area constructed and improved over many decades. The paved upland area of the site is generally level, with a surface elevation of approximately 20 feet MLLW. (Unless stated otherwise, elevations in this study correspond to the vertical datum MLLW.) The ground under the wharf slopes down from the upland area to the bottom of the waterway at approximately elevation −40 feet. This under-pier slope is inclined at approximately 1.5 to 1.75 horizontal to 1 vertical. The southern end of the project area has already been deepened from −40 to −45 feet with closely spaced H-piles supporting the cut. The middle of the site has already been deepened from −40 to −50 feet with a cantilevered AZ-48 sheet pile toe wall. The northern end of the site has not been deepened and was designed to −50 feet at the toe of the slope with timber pinch piles already installed along the slope.

The Port of Seattle is updating Terminal 5 to service container ships as large as the Maersk EEE that entered service in July 2013, which has a capacity of 18,000 twenty-foot-equivalent units (TEU). To support this type of vessel the Port wants to deepen up to 2,900 linear feet of Terminal 5 to design elevation −55 feet (including 1 foot of maintenance dredge and 2 feet of overdredge results in a new toe of slope up to −58 feet). In addition, larger and heavier cranes are required, which will produce crane loads of approximately 85 kips per foot on each rail. Our study limits extend from Station 2+00 to 29+00 (Bent 25s to 114). To facilitate additional berth deepening, a new, stronger, king-pile toe wall will be required with supplemental structural reinforcement (pinch piles) required along some or all of the stations.

SUBSURFACE CONDITIONS

Our understanding of the subsurface conditions at Terminal 5 is based on numerous existing soil explorations, the materials encountered in 12 new mud rotary borings, laboratory testing of soil samples, shear wave testing (Attachment 2), and our experience in the area. Figure 2 shows the location of the existing and new soil explorations. Figures 3a and 3b illustrate the interpreted subsurface conditions along the wharf. Details of the conditions observed at the new boring locations are shown on the logs included in Appendix A and should be referred to for specific information.

Subsurface soil conditions are based on explorations accomplished at discrete locations at the site. Soil properties inferred from the field and laboratory tests formed the basis for developing our geotechnical recommendations contained in this report. The nature and extent of variations between the explorations may not become evident until construction. If variations appear, it may be necessary to reevaluate the recommendations in this report.

Soil Conditions

The soil conditions can be generalized as follows:

- A surficial veneer of riprap of varying size and depth was on the under-pier slopes. A layer of asphalt over gravel and sand fill was encountered in the upland areas.

- Very loose to dense Sand to very silty Sand with layers of Silt and Clay was observed throughout the site. For our analyses this is referred to as engineering soil unit (ESU) 1.

- Very soft Silt and Clay layers were observed, typically located just above the bearing layer. This layer is referred to as ESU 2.

- Very dense glacially overridden soils were observed at depth in the new and the historical explorations. This bearing layer is at elevation −120 to −90 feet at the south end of Terminal 5 and gradually deepens to elevation −135 feet in the borings at the north end of the terminal. Our most southern upland boring (HC-5) encountered this layer at approximately elevation –90 feet. Very dense till and till-like materials are referred to as ESU 3, while glacially overridden silts and clays are labeled ESU 4.

Groundwater

Groundwater at the site is influenced by tidal fluctuations in Elliott Bay. We did not observe the groundwater table in the upland soil borings because of the drilling method that was used. Tidal influence is typically limited to a short distance behind the top of the slope. Typical groundwater levels in the backland throughout Terminal 5 are at around elevation 9 to 10 feet.

SEISMIC CONSIDERATIONS

The site is in a seismically active area. In this section, we describe the seismic setting at the project site, identify the seismic basis of design, provide our recommended preliminary design response spectra, and discuss the seismic hazards at the site.

Seismic Setting

The seismicity of Western Washington is dominated by the Cascadia Subduction Zone, in which the offshore Juan de Fuca Plate is subducting beneath the continental North American Plate (Figure 4). Three types of earthquakes are associated with subduction zones: intraslab subduction, interface subduction, and crustal earthquakes.

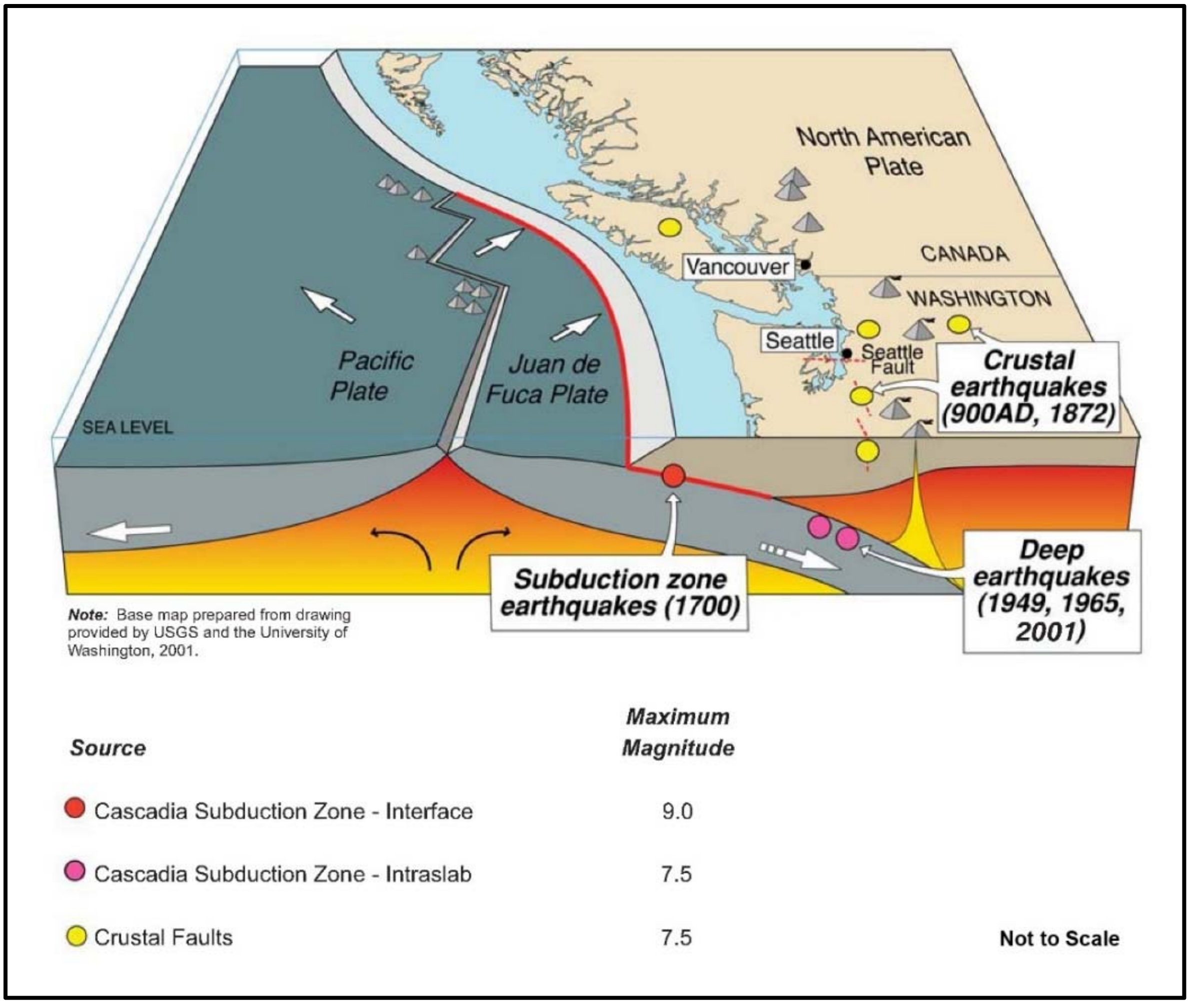

Figure 4. Cascadia Subduction Zone Earthquake Sources

Subduction Zone Sources. The offshore Juan de Fuca Plate is subducting below the North American Plate. This causes two distinct types of events. Large-magnitude interface earthquakes occur at shallow depths near the Washington coast at the interface between the two plates (e.g., the 1700 earthquake, which had a magnitude of approximately 9). A deeper zone of seismicity is associated with bending of the Juan de Fuca Plate below the Puget Sound Region that produces intraslab earthquakes at depths of 40 to 70 kilometers (e.g., the 1949, 1965, and 2001 earthquakes). Figure 4 depicts the Cascadia Subduction Zone and the various types of earthquakes it can produce.

Crustal Sources. Recent fault trenching and seismic records in the Puget Sound area indicate a distinct shallow zone of crustal seismicity, the Seattle Fault, which may have surficial expressions and can extend 25 to 30 kilometers deep. The project site is within the Seattle Fault Zone, with the northern splay of the Seattle Fault mapped through the southern end of Terminal 5 (Figure 5).

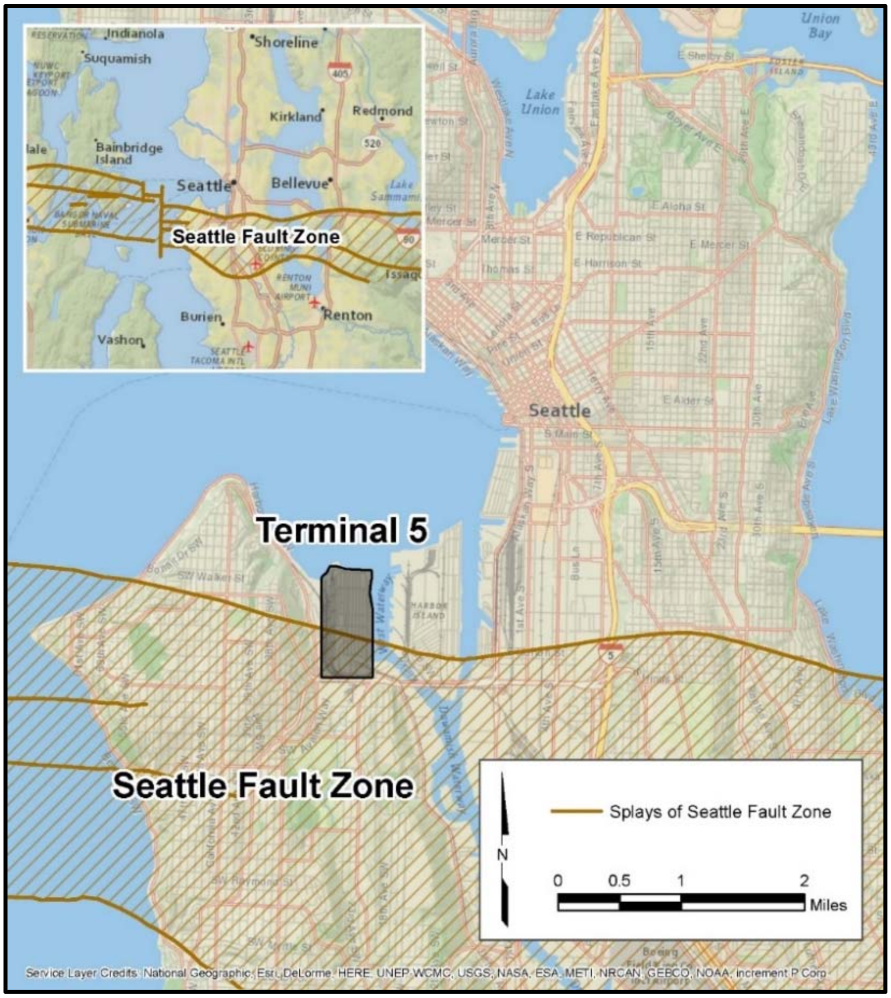

Figure 5. Site Proximity to the Seattle Fault Zone

Seismic Basis of Design

We developed design response spectra at the ground surface using code-based methods. We have referred to ASCE 61-14 Seismic Design of Piers and Wharves for this design as appropriate.

The seismic basis of design for this project is different than for a new construction project. The Port of Seattle and City of Seattle have entered into an agreement of understanding that states that the Port may redevelop existing facilities to current codes for static conditions, but the agreement requires not making the seismic hazard worse than it was before the improvements. Therefore, we evaluated the seismic hazard at the typical hazard levels, with our seismic analyses primarily comparative rather than absolute.

We considered four seismic hazard levels in our analysis (OLE, CLE, DE, and MCE, defined below). The basis of design for the 2012 International Building Code (IBC) is two-thirds of the hazard associated with the Risk-Targeted Maximum Considered Earthquake (MCE_R). The IBC event is referred to as the Design Event (DE). The ASCE Piers and Wharves standard requires the consideration of two additional seismic events: the Operating Level Event (OLE) and the Contingency Level Event (CLE). The OLE has a

50 percent probability of exceedance in 50 years, which corresponds with a return period of 72 years. The CLE has a 10 percent probability of exceedance in 50 years, which corresponds with a return period of 475 years. Slope performance was evaluated for the OLE, CLE, and DE. Liquefaction hazard was evaluated for the OLE, CLE, DE, and Maximum Considered Earthquake (MCE). The MCE has a 2 percent probability of exceedance in 50 years, which corresponds with a return period of 2,475 years.

Design Response Spectra and PGA

We determined the site class in accordance with 2012 IBC based on Standard Penetration Test (SPT) data collected from our explorations at the project site. The site contains liquefiable soil corresponding to a classification of Site Class F. The code requires a site-specific analysis for Site Class F, if the period of the structure is greater than 0.5 seconds. Because this structure will have a period greater than 0.5 seconds, we typically recommend that a site-specific analysis be performed as part of final design. As the seismic structural design for this project is comparison-based, and we understand a site-response analysis is not needed, the project team decided a site-specific response analysis was unnecessary. For miscellaneous design, and for buildings with a period less than 0.5 seconds, we used the site class definition without considering liquefaction-susceptibility, which corresponds to Site Class E.

We obtained the seismic hazard parameters from the United States Geologic Survey 2008 National Seismic Hazard Maps (USGS 2008) for the site location at latitude 47.577 and longitude −122.362. Code-based design response spectra and seismic design parameters for the MCE_R, DE, OLE, and CLE are provided on Figure 6. The recommended peak ground acceleration (PGA) values for the MCE_R, OLE, and the CLE hazards are also shown on the bottom left of Figure 6. Table 1 includes spectral accelerations at periods of 0.2 and 1 seconds (S_s and S_1 respectively) for all three hazard levels. These spectral accelerations, along with the site classification, may be used to develop a code-based response spectrum.

Table 1 – S_s and S_1 Values for MCE_R, OLE, and CLE

Hazard Level	Rock S_s in g	Rock S_1 in g
OLE	0.239	0.070
CLE	0.691	0.228
MCE_R	1.456	0.564

Liquefaction Potential

Liquefaction is a phenomenon caused by a rapid increase in pore water pressure that reduces the effective stress between soil particles, resulting in the sudden loss of shear strength in the soil. Granular soils that rely on interparticle friction for strength are susceptible to liquefaction until the excess pore pressures can dissipate. Sand boils and flows observed at the ground surface after an earthquake are the result of excess pore pressures dissipating upward, carrying soil particles with the draining water. In general, loose, saturated sandy soils with low silt and clay contents are the most susceptible to liquefaction. Silty soils with low plasticity are moderately susceptible to liquefaction under relatively higher levels of ground shaking. For any soil type, the soil must be saturated for liquefaction to occur.

We used empirical methods to estimate liquefaction potential based on the standard penetration test (SPT) data obtained at the site. Procedures after Idriss and Boulanger (2008) were used for the SPT data. For the OLE and MCE hazard levels we used earthquake magnitudes of 6.53 and 6.8 and peak ground surface horizontal acceleration (PGA) of 0.26 and 0.545 g in our analysis, respectively. According to our analysis, the site is very susceptible to liquefaction in soil units below the water table down to glacial soils. The potential for liquefaction in the alluvial soils is relatively consistent across the site. The results of our analyses are presented on Figures 7 through 18 for each of our new borings. Occasional interbedded layers of non-liquefiable soil may be present throughout the profile; however, the vast majority of submerged soils within 80 feet of the ground surface are susceptible to liquefaction in the MCE event.

Site-specific dynamic laboratory testing resistance to liquefaction have been completed. Results of these tests are included in Appendix B. Sandy soils tests likely had the liquefaction resistance reduced during the process of sampling. When completed on sandy soils, the tests were generally completed to verify that they did not have a higher liquefaction resistance than empirical methods estimated.

Post-Liquefaction Vertical Settlement

Post-liquefaction settlement results from densification and redistribution of liquefiable soils following an earthquake. The ground surface settlement is not typically uniform across the area, and can result in significant differential settlement.

We estimated liquefaction-induced ground surface settlement using the Idriss and Boulanger (2008) method based on SPT data. The results of our analysis indicate that liquefaction-induced settlement will be slightly greater at the south end of the terminal in upland crane rail areas. MCE settlement is predicted to range up to 38 inches and 49 inches at the north and south ends of the terminal, respectively. Assuming a stable slope, the pile-supported crane rail structure is not expected to settle more than a couple of inches. Although, many of the wharf piles could see more settlement because they do not all extend to the bearing layer. This could lead to significant differential settlement within the wharf structure and between the structure and surrounding ground surface.

Ground Motions

We selected and scaled a single ground motion for two hazard levels for input to our finite element analysis using PLAXIS. We used response spectra based on the deaggregated hazard from the USGS (2008) probabilistic seismic hazard analysis for the 72-year and 2,475-year return periods with a corresponding shear wave velocity of 2,500 feet per second. These response spectra correspond to the OLE and the MCE hazards, respectively. The MCE hazard was then scaled by two-thirds to obtain the design-level event. We selected and scaled multiple ground motions to obtain a single motion that was a close match to the target response spectra.

For the OLE and MCE hazards, we selected intraslab subduction record and a crustal record, respectively. These earthquake mechanisms were chosen based on the deaggregated data from USGS. The data show that approximately 50 percent of OLE hazard corresponds with an intraplate subduction event and that nearly 50 percent of the MCE hazard corresponds with a Seattle Fault type of event (crustal fault). The OLE was chosen out of a suite of 30 intraslab ground motions and the MCE from a suite of over 100 crustal motions. These suites of motions are part of a Hart Crowser database. The selection was based on the smallest least squares error in combination with a modest scaling factor.

For the OLE hazard, we chose a ground motion from the 1965 Puget Sound earthquake, and for the design level earthquake (2/3 MCE) we selected one from the 1999 Chi-Chi earthquake. The target and ground motion response spectra for the selected ground motions are presented on Figure 19. The spectral accelerations in this figure are lower than the code-based spectra on Figure 6 for equivalent hazard levels. This is because the Figure 6 spectra are developed to represent soil conditions at the base of the PLAXIS model, which is equivalent to the Site Class B/C boundary.

Fault Surface Rupture

As mentioned previously, the southern end of Terminal 5 is within the northern portion of the Seattle Fault Zone (Figure 5). Therefore, there is potential for surface rupture at the site in the case of a Seattle Fault event. Even if there is not surface rupture due to the deep, loose-to-soft soil, it is possible for significant differential movement of piles embedded in the dense bearing layer. Design for this type of rupture is cost-prohibitive and difficult due to uncertainty about where fault rupture could occur. Fortunately, because of the relatively long return periods of the Seattle Fault, the uncertainty about where fault rupture could occur within the Seattle Fault Zone, and the low potential for fault surface rupture during the design life of the structure, the overall hazard associated with fault surface rupture is low.

Tsunami Hazard

The tsunami hazard within Puget Sound is controlled by crustal faults. According to the Elliott Bay Area Tsunami Hazard Map prepared by the Washington State Department of Natural Resources (2003), a tsunami originating from a Seattle Fault earthquake is predicted to cause widespread inundation ranging from 0.5 to 2 meters deep across the project site. In addition, inundation could be 2 to 5 meters in localized areas. The Tsunami Hazard Map is included as Attachment 1. Because of the relatively long return period of the Seattle Fault, the tsunami hazard during the design life of the structure is also low, but is larger than the potential for fault surface rupture.

GEOTECHNICAL ENGINEERING CONCLUSIONS AND RECOMMENDATIONS

This section of the report presents our conclusions and recommendations for the geotechnical aspects of design and construction on the project site. We have developed our recommendations based on our current understanding of the project and the subsurface conditions encountered by our explorations. If the nature or location of the development is different than we have assumed, we should be notified so we can change or confirm our recommendations.

Slope Stability

The focus of the geotechnical engineering assessment of the berth deepening to elevation −58 feet was two-fold: (1) to assess the static condition to determine if the project meets the local standard of practice for slope stability, and (2) to assess the seismic condition to determine how the post-deepening conditions compare to the existing conditions. The goal of the seismic condition analyses are to show that the deepening can be performed with no reduction in seismic stability.

Under static conditions, it appears that the wharf is and has been stable, as evidenced by its past and current use. The driving factor in many designs in the Puget Sound region is seismic stability. Therefore, the analysis focused primarily on the seismic stability of the wharf's under-pier slope. However, the seismic performance of the wharf's structure and crane was not studied (i.e., the weight and inertial loads were not included in our analysis). Structural and inertial loads are typically not included in a geotechnical seismic analysis.

In our analysis, pile lengths of existing piles were determined from historical pile driving records, if available. If no records were available for a given section, plan pile depths were used.

Pinch piles were modeled in our slope stability analysis to improve stability, primarily in seismic conditions. The pinch piles improve stability of the slope through structural reinforcement, and are not considered a ground improvement method, and were not modeled as such in our analysis. However, densification of the surrounding soil after driving the pinch piles is likely.

Limit Equilibrium Slope Stability Analysis

Slope stability was modeled for pre-dredging slope conditions using SLOPE/W and the geometry shown on Figures 20 through 27 for Sections B-B' through E-E'. Sections F-F' and G-G' have not been analyzed for this report as the analysis was completed as part of our preliminary report, and the sections are well bounded by the four in this report. For stability of slopes between the cross sections presented, interpolation of the factors of safety is adequate. Soil properties used in the SLOPE/W analysis are presented in Table 2. Internal angles of friction for the soft and stiff clay layers were based on Atterberg limit lab test results (see Appendix B). The effective stress friction angle generally increases with lower values of plasticity index. For soils classified as ESU 2, the plasticity index was determined to be 18. This value corresponds to an internal angle of friction of approximately 25 to 35 degrees. ESU 4 was determined to have a lower plasticity index (tested at 1, 9, and 13), which would correspond to an internal angle of friction of 27 to 45 degrees (Casey and Germain 2013, Sorensen and Okkels 2013).

Table 2 - SLOPE/W soil properties

Soil Name	Soil Description	Unit Weight (pcf)	Internal Angle of Friction (degrees)	Cohesion (psf)	Liquefied Tau/Sigma Ratio
ESU 1	Loose to medium dense sand and silt	125	36	--	0.2
ESU 2	Soft to stiff clay and silt	105	27	--	--
ESU 3	Glacial Till	135	45	--	--
ESU 4	Glacially overridden soils	125	39	--	--
Rip Rap	Rip Rap	130	45	--	--

The analyses indicated that under pre-dredging conditions, the slope had a factor of safety under static loading which indicates a stable slope, as shown in Table 3.

Table 3 - Static Slope Stability Safety Factors

		Current Condition		Proposed Condition	
Cross Section	Station Number	Global Slope Stability	Shallow Slope Stability	Global Slope Stability	Shallow Slope Stability
B-B'	**2+00**	2.3	1.7	2.7	1.8
C-C'	**8+00**	2.5	1.7	3.4	1.8
D-D'	**12+00**	3.1	1.8	8.0	2.1
E-E'	**27+00**	1.6	1.6	1.9	1.7

This factor of safety applies to potential failure surfaces that are 5 to 10 feet deep or more. There may be lower factors of safety (0.9 to 1.0) for shallow, surficial "raveling" types of soil movement, although in reality this is partially mitigated by the presence of riprap protection on the slope surface, which was not explicitly modeled in our analysis. Reinforcing elements were modeled as a shear strength based on an estimated hinge length and the moment capacity of each structural element as provided by the Port of Seattle. Details of the slope stability analysis are provided in Appendix D. The use of structural reinforcements, especially discontinuous reinforcements like piles in 2D limit equilibrium slope stability analyses is crude and does not consider bending moments, pile stiffness, or slope failure between piles. That being said, it is a commonly used approach to provide a reasonable estimate of the stability of a slope. We performed a finite element analysis, discussed in detail later, to leverage an approach which better models soil-structure interaction. A combination of these shear elements and a new berth elevation of up to −58 feet defines our proposed condition.

A design-level seismic event was modeled with SLOPE/W using both a pseudostatic method and a residual strength (post-earthquake) method. Under pseudostatic conditions, a horizontal force equal to one-half of the peak seismic acceleration was applied to all soil units. This analysis is intended to indicate the level of stability before the point at which a significant degree of liquefaction occurs. The use of one-half of the peak acceleration is an attempt to represent the “time averaged” degree of horizontal acceleration. Under these conditions, the factor of safety for the existing slope dropped to safety factors less than 1 for some of the modeled conditions, as shown in Table 4, indicating that a significant or observable level of slope movement is likely to occur. We believe the Proposed Condition safety factors can be increased with the introduction of ground improvement or structural reinforcement methods to meet or exceed the Current Condition safety factors.

Table 4 - Pseudostatic Slope Stability Safety Factors

Cross Section	Current Condition				Proposed Condition			
	Global Slope Stability		Shallow Slope Stability		Global Slope Stability		Shallow Slope Stability	
	OLE	CLE/DE	OLE	CLE/DE	OLE	CLE/DE	OLE	CLE/DE
B-B’	1.4	1.2	1.1	0.9	1.7	1.4	1.1	0.9
C-C’	1.4	1.2	1.0	0.9	1.8	1.6	1.1	0.9
D-D’	1.8	1.5	1.0	0.9	2.5	1.9	1.2	1.0
E-E’	0.9	0.8	0.9	0.8	1.0	8.2	1.0	0.9

The residual strength method is based on the assumption that liquefaction results in a loss of soil strength. Given the density of these soils and our estimate of the extent of the liquefiable zones, we analyzed the effects of liquefaction by reducing the liquefiable soil layers to a shear strength ratio of 0.2. Our analyses assumed the alluvium is fully liquefied following the design earthquake event. Similar to the pseudostatic model, the residual strength approach also yielded factors of safety less than 1, shown in Table 5. Again, we believe the Proposed Condition safety factors can be increased with the introduction of structural reinforcement methods to meet or exceed the Current Condition safety factors.

Table 5 - Residual Slope Stability Safety Factors

Cross Section	Current Condition		Proposed Condition	
	Global Slope Stability	Shallow Slope Stability	Global Slope Stability	Shallow Slope Stability
B-B’	0.7	0.7	1.1	0.8
C-C’	0.8	0.7	1.2	0.8
D-D’	0.5	0.5	0.8	0.6
E-E’	0.6	0.6	0.7	0.7

Therefore, it appears that prior to dredging, the existing wharf structure at the location analyzed was stable under static conditions. In a design-level seismic event, however, the wharf structure will have relatively low stability and, thus, a potential for significant deflections.

Stability of South End Section

We analyzed the stability of the South End Section running perpendicular to the previously analyzed cross sections. We understand the area at the toe of the slope will be dredged to an elevation of approximately −55 ft, from the existing mudline of approximately −48 ft. We also understand that part of the existing slope will be cut back to 2H:1V. This proposed cut is steeper than the existing mudline slope. The proposed changes to the mudline in this area will cause the slope to be less stable, and therefore we analyzed several slope stabilization methods. We believe the best method to maintain the current factor of safety against slope failure is a toe wall.

Of most concern with the proposed dredging is a building located at the top of the slope. We understand that this building does not belong to the Port of Seattle and people may frequent this area. In order to account for this, our analysis included a 250 psf surcharge for the building and the failure surface was forced to a location such that the building would be affected by a slope failure. Table 6 below is a summary of the factors of safety for this slope. The factors of safety presented are for both the As-Is and Proposed conditions. The shear strength of the toe wall was input such that the proposed condition factor of safety was at least equal to the current condition. The necessary shear force to maintain the factor of safety was 10 kips. The toe wall design should account for this shear force. For the psuedostatic case, only the DE case was analyzed.

Table 6 – South End Slope Stability Factors of Safety

Analysis	Global Slope Stability	Slope Stability for Building
Static	1.8	1.8
Pseudostatic	0.9	0.9
Liquefied	0.6	0.6

Deformation-Based Slope Stability Analysis Using PLAXIS

PLAXIS provides a more meaningful evaluation of stability for both structurally stabilized slopes and seismic loading conditions of slopes than the traditional limit-equilibrium approaches as a deformation-based analysis. We analyzed Cross Sections A-A’ and E-E’ under the DE and OLE. Initially, for each earthquake, we ran an analysis that assumes the soil liquefaction is decoupled from shaking (i.e., it will occur at the end of the earthquake event). For each analysis, we input the deconvoluted incident wave ground motion from SHAKE into the base of the PLAXIS model using a compliant base, which allows the wave energy to exit the bottom of the model. This is a realistic representation of the base conditions for these profiles.

For the decoupled analyses, we modeled the soils using the HSsmall soil model in PLAXIS, which provides reasonable hysteretic damping and an adjustable shear modulus degradation curve based on the Hardin-Drnevich relationship (PLAXIS 2014). For the liquefiable analyses, we used the UBCSAND model as modified by PLAXIS with site-specific laboratory based parameters and standard relationships correlated to the SPT (Beaty and Byrne 2011; Galavi, Petalas, and Brinkgreve 2013). We have used elasto-plastic structural elements with the moment capacity provided by the Port of Seattle to provide a consistent comparison between the proposed conditions. Piles were modeled using the embedded pile row element in PLAXIS, which attempts to model the three-dimensional nature of piles in two dimensions, with the peak lateral spring forces defined by LPILE. Existing structural elements which are intersected by the battered pinch piles in the cross section view are not modeled. These elements do not change from the current condition to proposed design, and thus should not significantly alter the comparative results. For each analysis condition, we provide a solution that maintains or improves the approximate level of slope stiffness that is currently in place. The expected trends of increasing deformation with level of shaking and with the onset of liquefaction were observed. Each of these was relative and consistent for each condition, meaning that if the proposed condition was stiffer under the DE than the current condition, it was also stiffer for the OLE as well.

PLAXIS Analyses and Results

Section B-B' currently has H-piles supporting a 5-foot cut spaced at approximately 4 or 5 feet on center. Current berthing elevation at this location is −45 MLLW. As previously discussed, the proposed dredging increases the design depth of the berth to elevation −55 with an allowance of 3 feet for dredging and overdredging.

Section E-E' is currently sloped down to elevation −50 MLLW. The proposed berthing elevation is −55 with allowances for dredging and overdredging at this location, as well.

In order to provide comparable stiffness to the current condition, we have analyzed a HZ1180M D-26 with AZ 26-700 king-pile toe wall with structural properties provided by the Port of Seattle, which we converted to the units used in PLAXIS. The structural properties for this system were an EA of 87E6 pounds per lineal foot, an EI of 1.68E9 square foot pound per lineal foot, and a plastic moment of 1.904E6 foot pound per lineal foot. The HP14x73 was modeled with a modulus of elasticity of 4.18E9 psf, an area of 0.148 square feet, and a moment of inertia of 0.035 ft^4 at a spacing of 5.5 feet. We have conservatively modeled the king-pile toe wall at an elevation of −90 feet, with the wall HZ piles extending to bearing. Existing pile properties for concrete piles are provided in Attachment 3. All structural systems were modeled with a target 5% Rayleigh damping between 1 and 4 hertz.

The pinch piles specified are 60 foot long, 14 inch diameter timber piles with a 1 inch taper every 10 feet. The lateral springs for the piles were modeled with the taper taken into consideration in LPILE. The structural properties in the PLAXIS model are based on a 1 foot diameter pile, as the majority of the deformation within the model is shallow, and the piles are not controlled by bending. The piles were modeled with a moment capacity of 10.58E3 foot pounds. Spacing was based on the current design drawings of 6.7 and 10 feet on average.

The king-pile toe wall configuration provides a similar response as the current condition while also providing a continuous wall to retain the soils, rather than the discrete H-pile system.

As explored in our preliminary report, the proposed king-pile system alone results in greater up-slope deformation than the current condition. We previously considered two improved ground situations to reduce the king-pile system displacement.

The first of these alternatives is a generic, 10-foot-wide jetted grouted system placed immediately behind the king-pile toe wall. The wall could also be constructed using a compaction grouted system spaced 4 to 6 feet on center with equivalent composite material strength. Compaction grouting would likely result in less grout spoils while also densifying/strengthening the soil around it.

The grouted section was modeled with a bottom elevation of −100 feet MLLW and up to our estimated bottom of rip-rap. The grouted section dimensions should be refined as part of final design. The grouted improvement zone was modeled with a Mohr Coulomb soil model with a stiffness of 62E6 psf, shear strength of 55E3 psf (382 psi), and an allowable tension of 500 psf. The grouted section condition shows more deformation under the OLE than the current condition but less deformation under the DE. This can largely be attributed to the simplicity of the Mohr Coulomb model and its inability to model shear modulus degradation. We anticipate stone columns to perform similarly, with little mitigation of upslope movements.

A “pinch-pile” alternative was considered, which consists of driving timber piles into the lower third of the slope at approximately 5 feet on-center. The pinch piles were modeled with the embedded pile row element with a modulus of elasticity of 216E6 psf and a diameter of 0.75 feet. Pinch piles were modelled vertically along approximately the lower third of the slope, installation would likely be in a radial manner along the same portion of the slope. We do not expect this to significantly alter the performance of the piles. The decreases in the up-slope from deformation associated with the alternatives are shown in Table 5.

During design, discussions with ground improvement contractors resulted in the preferred ground improvement method of compaction grouting based on constructability and performance requirements. As access to the slope is limited by the removal of approximately 20 feet of pier, the pinch pile approach is the most flexible to address construction and design modifications as needed. In addition to flexibility, the pinch piles provide the best coverage of the slope for improvement as observed in the upslope conditions in Table 7. Table 7 was based on a larger number of pinch piles than the current design, but provides a good comparison for the effects of various design approaches. The use of pinch piles provides a consistent design with the northern 400 hundred feet of pier, as that was originally designed with timber pinch piles for slope stability.

We recommend the new king-pile toe wall be installed with the pinch pile structural reinforcement to achieve equivalent or better seismic performance than the existing condition. We expect each of these methods to improve the safety factors of the Proposed Condition reported in Tables 3 through 5.

Table 7 – Alternative Study Results for Maximum Deformations in Feet at Station 16+50

Stabilization Approach	Upslope		Top-of-Wall	
	OLE	DE	OLE	DE
Current Condition	0.6	8	0.4	3
King-Pile Toe Wall Only	0.9	10	0.4	3

Grouted Section Addition	0.7	7	0.2	2
Pinch-Pile Addition	0.2	6	0.1	2

Our analyses of the proposed design and pinch pile layout at Sections B-B' and E-E' are tabulated in Table 8. This table shows compatible performance of the design at northernmost and southernmost sections analyzed. Due to the uncertainty in soil parameters, three dimensional effects, and the unaccounted for potential soil improvement, Table 8 reports the results to the nearest quarter foot. Figures 28 and 29 show the response of the slope to loading under the DE condition without liquefaction considered for the sections analyzed. There is a section south of Section B-B' which does not currently have a toe wall, this section was addressed previously in the SLOPE/W section.

Table 8 – PLAXIS Analysis Results

Condition and Location	Upslope		Top-of-Wall	
	OLE	DE	OLE	DE
Current Condition Section B-B'	1.5	2	0.25	1.5
Proposed Condition Section B-B'	0.5	2	0.25	1.5
Current Condition Section E-E'	0.5	1.5	0	1
Proposed Condition Section E-E'	0.5	1.5	0.25	1

During the design a few material types were proposed for the pinch piles. These material types were steel, concrete, and timber. Based on our analysis, and the current pile spacing, timber is the preferred method of improvement as it is inexpensive compared to the other material types and the pinch piles are currently constrained mostly by the pile spring capacity and not the structural capacity of the pile. The full displacement properties of a timber pile provide the added benefit of soil improvement surrounding the piles, which non-displacement steel sections would not.

Based on recent experience, we recommend a pilot pile program to confirm the drivability of the timber piles with a vibratory hammer, and if not, monitor the performance of a small impact hammer. This program could be used to verify that the timber piles can be installed through the riprap key and at the specified pile spacing.

Lateral Earth Pressures for King-Pile Toe Wall Design

We understand that a king-pile wall will be constructed at the toe of the under-pier slope to support a vertical cut up to 18-feet at the base of the under-pier slope from the southern end of the site to Station 23+00. From Station 23+00 to 29+00 the wharf has been designed to elevation -50 feet. For this 600 feet we expect that a heavy-duty sheet pile (e.g., AZ-48 or AZ-50) will be installed at the toe of the slope. Between Stations 23+00 and 25+00 pinch piles will likely need to be installed. Between Stations 25+00 and 29+00 pinch piles were installed as part of the original construction in 1998. Design for and sizing of the sheet pile wall between Station 23+00 and 29+00 will be part of final design.

The lateral pressures acting against a wall depend primarily on:

- Fill material type and degree of compaction immediately adjacent to the wall;
- Surcharges and sloping ground conditions at or behind the wall;
- Flexibility of the wall and the degree of lateral movement the wall undergoes;
- Drainage and presence of water; and
- Seismic loading considerations.

Lateral loading on the bulkhead can be expected from the soil for both static and seismic loads.

Static Loading. We expect that active (yielding wall) conditions will develop behind the king-pile wall. When loaded laterally, the top of a yielding wall will move at least 0.1 percent of its exposed height. Allowable lateral pressures on the bulkhead can be estimated using Figure 30.

The equivalent fluid weight does not include any surface or surcharge load conditions. Any vertical loads that are behind and adjacent to the bulkhead will impose additional lateral loads on the bulkhead. Lateral loads should be incorporated into the bulkhead design on a case-by-case basis. Furthermore, we recommend that the passive resistance in the upper 2 feet be neglected to account for soil disturbance or erosion.

Seismic Loading. Lateral loads due to seismic pressure can be computed by applying a rectangular pressure distribution over the height of the bulkhead. We used the force required to stabilize the slope above the dredge elevation in a slope-stability model to develop the seismic lateral earth pressures that should be added to the active pressures provided on Figures 30. This method involved placing a point load in our SLOPE/W model at a point 2/3 of the toe wall height from the top of the toe wall (where an equivalent load would act on a wall), instead of placing a toe wall reinforcement. The point load was then increased or decreased on a trial and error basis until a factor of safety of 1 was obtained. This load is the force required to stabilize the slope above the dredge elevation. This approach addresses concerns of Monobe-Okabe performing poorly for backslopes near the friction angle of the soils. The post-seismic condition can be addressed by increasing the active pressure equivalent unit weight of ESU 1 to 46 pounds per cubic foot (pcf), and reducing the passive pressure equivalent fluid unit weight to 50 pcf. This increase is based on a full liquefied alluvial section, which is consistent with our slope-stability results.

Vertical Pile Capacity

Vertical compressive loads can be resisted by friction along the pile sides and by end bearing at the tip. Because of the high pile load requirements, it is important that piles be embedded sufficiently in the bearing layer. Because the bearing layer is variable, required pile lengths can only be approximated based on field boring logs at discrete locations. Actual pile lengths will depend upon driving resistance and other factors, and may need to be adjusted in the field. Piles should have an excess length, such that they can be driven to additional depths for adequate embedment into the bearing layer if necessary. The capacity recommendations provided with this report consider the results of the test pile program, the results of which are summarize in Attachment 5.

Based on the soil conditions at the project site, our review of the test pile program results, we determined pile capacities based on effective stress analysis methods. We used Unipile to model the vertical capacity at each of our borings (HC-1 through 12). For each soil profile, multiple pile sizes were considered; steel pipe piles were used for the landside profiles and concrete piles were used for the offshore profiles. We used a compressive factor of safety of 2.0 for static and 1.0 for post-liquefied conditions. Under uplift condition we used a factor of safety of 3.0 for static and 1.0 for post-liquefied uplift conditions. A factor of safety of one considering structural and downdrag loading is consistent with ASCE 61-14. These factors of safety must be verified in the field by a load test as defined by the IBC, which allows PDA/CAPWAP to be the load test method.

Downdrag results from settlement within the liquefiable layer and all the soil layers above it. Soils above and within the liquefiable layer settle relative to the pile and cause downward forces on the pile. The post-liquefaction plots neglect compressive soil resistance above the base of the liquefied layer. Downdrag loads are accounted for in the allowable compressive resistance plots on Figures 31 to 54. The compressive capacity under downdrag loading due to liquefaction generally appears to control the design.

The load-displacement response of piles is highly dependent on the nonlinear shaft and tip load-deformation response. Springs developed for this are described as t-z and q-z springs for the pile shaft and tip, respectively. To provide the Port with flexibility in their design, we recommend the following equations for t-z and q-z response, using the unit resistances from Figures 55 to 78 for the input of individual springs for various pile depths. The response of the t-z and q-z springs for any given deformation are defined in the equations below. Note that the equations are multiplied by 2 to account for the factor of safety applied to the allowable unit resistances given in the figures. For t-z springs we recommend:

$$r = 2 * q_a\left(1 - e^{-25*\delta}\right)$$

Where:

r = resistance at δ

q_a = allowable resistance

δ = deformation (inches).

This formulation of t-z springs should reach 90% of their peak at about 0.1 inches, and 99% at 0.2 inches.

For q-z springs we recommend:

$$r\% = 2 * \frac{\delta}{.0083 * \delta + B * (.00002778)}$$

Where:

r = percent resistance of allowable load at δ (allowable)

δ = deformation (units of choice)

B = pile diameter (same units as deformation).

Each of these equations converts the allowable compressive loads with a factor of safety of 2 into a nominal load for serviceability and deformation analyses. This is the reason that the q-z plot results in resistances near 200% of the allowable load at deformations approximately equal to B/100. Under typical working stress loads, the tip resistance is approximately linear. The above equations were derived based on our specific analysis for this project and root equations presented in Fellenius 2014.

Landside Crane Rail: Steel Pipe Piles

We understand that 24- to 30-inch-diameter open ended steel pipe piles are being considered for the landside crane rail support. Pile capacities of the two upland soil profiles were analyzed and the results of the allowable vertical capacities are presented on Figures 31 through 54. The estimated pile soil resistance at various depths is provided on these figures for compressive (left graph) and uplift (right graph) loading conditions. The static condition includes pile side friction from the ground surface down to the pile tip.

The downdrag loads due to the non-liquefied (static side friction) soil above liquefied zones and liquefied (residual strength side friction) soil are provided as a note on each figure. Downdrag loads represent an additional downward structural load for these structures that is accounted for in our pile resistance plots.

Waterside Crane Rail: Concrete Piles

We understand that existing 16.5-inch octagonal and new 24-inch octagonal concrete piles may be used on the waterside. Pile capacities of the waterside soil profiles were analyzed and the results of the allowable vertical capacities are presented on Figures 31 through 54. The 24-inch octagonal pile is assumed to be a closed-ended pile. The estimated pile soil resistance at various depths is provided on these figures for compressive (left graph) and uplift (right graph) loading conditions. The static condition includes pile side friction from the ground surface down to the pile tip.

The downdrag loads due to the non-liquefied (static side friction) soil above liquefied zones and liquefied (residual strength side friction) soil are provided as notes on each pile capacity figure. Downdrag loads represent an additional downward structural load for the above structures that is accounted for in our pile resistance plots.

Lateral Pile Fixity

We analyzed the lateral pile fixity depth using method presented by Davisson and presented in the AASHTO Bridge Design Specifications. Our estimates for pile fixity, as defined as 1.8T herein, are shown in Table 9. These sections presented are the piles sizes requested by the Port. We assumed a loose, submerged soil profile with a rate of increase of the soil modulus of 0.208 ksi/ft.

Table 9 – Approximate Depths to Lateral Fixity for Crane Rail Piles

24-inch 8 ksi	24-inch 6 ksi	16.5-inch 8 ksi	16.5-inch 6 ksi
13 feet	13 feet	10 feet	9 feet

Upland Crane Rail Piles Near Outfalls

We understand that a number of outfalls exist at depth (approximately 20 to 40 feet below grade) near the northern extent of the project. There is concern about damaging the outfalls from pile driving. Based on past experience driving piles, we do not expect any outfall damage for piles located more than 50 feet from the outfalls. However, with piles spaced 6.67 to 8 feet on center, many piles will be located very close to the outfalls. We recommend that a survey of the outfalls be performed to identify their location and condition. Means to reduce potentially damaging vibrations at the outfall locations include:

- Replacing driven pipe piles with drilled shafts; and
- Predrilling steel pile locations to a depth well below the outfall.

The best approach for this project should be determined by the Port considering the condition of the outfalls, impact of a damage or collapsed outfall, cost of replacement, and cost of protection. Depending on the selected approach, a vibration monitoring program could be performed to evaluate the level of ground surface vibrations that are caused by both impact and vibratory pile installation. This monitoring could be used to select the preferred distance between pile driving and outfall locations.

Light Pole Foundation

We understand that HLT-11-WH-AB light poles will be used. These will have a drilled shaft foundation, which must have a diameter of at least 4 feet to fit the anchorage. Based on the WSDOT Geotechnical Design Manual, an allowable lateral bearing pressure of 1500 psf may be used. For a 4-foot diameter drilled shaft foundation, an allowable axial capacity of 5.7 kips and 12.3 kips may be used for 10 and 15-foot-deep foundations, respectively.

Substation Design Recommendations

A new substation building will be located on the landside portion of the terminal as part of the project. The substation building is approximately 30 feet by 75 feet above a below-grade unoccupied vault that is approximately 30 feet by 90 feet and 10 feet deep. The substation building will be founded entirely on the vault.

Lateral Pressure on Permanent Subgrade Walls

Subgrade walls backfilled on one side (i.e., the outside) will be used for the vault. For compacted structural fill above the water table use an active and at-rest lateral earth pressures using an equivalent fluid unit weight for the soil equal to 35 and 55 pcf, respectively. Use an allowable passive equivalent fluid unit weight for this material of 270 pcf, which includes a factor of safety of 1.5. These values are based on a drained condition behind the walls so there is no buildup of hydrostatic pressure.

In addition to the active soil pressures we recommend applying a horizontal traffic and material surcharge be applied. This surcharge may be calculated as 0.3 times the vertical surcharge load (e.g., for a vertical surcharge of 250 psf the horizontal surcharge pressure on the wall is 75 psf).

Below the water table, the active and at-rest pressure equivalent fluid weights are 18 and 29 pcf, respectively. Similarly, the equivalent fluid unit weight for passive resistance reduces to 135 pcf. Hydrostatic pressure should be applied to the wall when submerged.

The use of active pressure is appropriate if the subgrade wall is allowed to yield a minimum of 0.001 times the height of the wall. For a non-yielding wall, at-rest conditions should be used. We expect that the vault walls will be non-yielding. Lateral loads applied to the wall caused by external vertical loads applied to the surrounding soils can be determined using Figure 79.

Vault Foundation

Where finish floor elevations are above or only slightly below the design high groundwater elevation, slab-on-grade floor slabs may be used. We provide recommendations for both slab-on-grade floor slabs, and structural slabs, and the base of the vault.

The floor slab of vault base could be constructed as a slab-on-grade above a drainage layer and the specified improved ground. Do not found near-grade floor slabs on existing fill or loose soil, unless they are free of organic material and can be compacted to a dense, non-yielding condition as determined by probing or proof rolling the subgrade. Overexcavate at least 12 inches of unsuitable fill (if encountered) and replace it with structural fill compacted to a firm non-yielding condition below the vault slab.

In addition to the structural fill, all slabs should be underlain directly by a drainage layer at least 6 inches thick. This layer should consist of clean, well graded coarse sand and gravel with a fines content (soil finer than the No. 200 sieve based on the minus 3/4-inch fraction of the material) of less than 3 percent by weight. -This layer serves as a capillary break and drainage layer and is intended to reduce the potential buildup of hydrostatic pressure beneath the slab and to provide permanent control of groundwater beneath the floor slab and behind the perimeter walls, (see Section 6.7). For slab-on-grade floors, we recommend:

- Compact the drainage layer to the criteria of structural fill described in our Earthwork Recommendations.
- Use an allowable bearing pressure of 1,000 pounds per square foot (psf) with an estimated settlement of up to an inch;

- Use a modulus of subgrade reaction of 25 pounds per cubic inch (pci) for design of the vault floor slabs on compacted structural fill.

- Determine sliding friction between the slab and subgrade using an allowable coefficient of friction of 0.30.

- Submit any soil that is to be considered as capillary break or drainage material to Hart Crowser for gradational analysis.

- Note that if the bottom of the excavation is soft, wet, and disturbed, the contractor should be prepared to place a temporary working surface. This surface cannot count as part of the 6-inch drainage layer.

Drainage Recommendations

Groundwater is typically near elevation 10 feet MLLW at Terminal 5. Based on these groundwater levels, our recommendations for drainage are as follows. If the base of the vault is below the groundwater table, waterproofing should be applied up to at least one foot above the water table.

Foundation Drainage

For permanent drainage around the structure foundations, we recommend that a capillary break layer of at least 6 inches of free-draining material be placed below slabs-on-grade, vault foundations, and shallow footings. This 6-inch-thick layer should be composed of import material.

Backfilled Walls

Walls with soil backfilled on one side will require drainage, or must be designed to withstand full hydrostatic pressure. We recommend the following:

- Backfill with a minimum thickness of 18 inches of well-graded, free-draining sand (less than 3 percent fines based on the minus 3/4-inch fraction) or sand and gravel.

- Install drains behind any backfilled subgrade walls. Drains with cleanouts should incorporate a minimum 4-inch-diameter perforated pipe surrounded by at least 6 inches of well-graded, free-draining sand (less than 3 percent fines based on minus 3/4 inch fraction), or sand and gravel. The drains should be sloped to carry the water to a sump or other suitable discharge.

- The backfill should be continuous and envelop the drainage behind the wall.

Site Drainage

Final grades should be sloped to carry surface water runoff away from structures to prevent water from infiltrating near the foundation walls. Roof drainage and new surface water drainage should not be tied into the subdrain system and should not discharge onto the site.

Earthwork Recommendations

Site Preparation and Grading

We recommend all site grading, paving, and any utility trenching be conducted during relatively dry weather conditions.

It may be necessary to relocate or abandon some utilities. Excavation of these utility lines will probably occur through fill. Abandoned underground utilities should be removed or completely grouted. Ends of remaining abandoned utility lines should be sealed to prevent piping of soil or water into the pipe. Soft or loose backfill should be removed, and excavations should be backfilled with structural fill. Coordination with the utility agency is generally required.

Structural Fill

Backfill placed within the building area or below paved areas should be considered structural fill. We make the following recommendations for structural fill:

- For imported soil to be used as structural fill, use a clean, well-graded sand or sand and gravel with less than 5 percent by weight passing the No. 200 mesh sieve (based on the minus 3/4-inch fraction). Compaction of soil containing more than about 5 percent fines may be difficult if the material is wet or becomes wet during rainy weather.

- Place and compact all structural fill in lifts with a loose thickness no greater than 10 inches. For hand-operated "jumping jack" compactors, loose lifts should not exceed 6 inches. For small vibrating plate/sled compactors, loose lifts should not exceed 3 inches.

- Compact all structural fill to at least 95 percent of the modified Proctor maximum dry density (as determined by ASTM D 1557 test procedure).

- Control the moisture content of the fill to within 2 percent of the optimum moisture. Optimum moisture is the moisture content corresponding to the maximum Proctor dry density.

- In wet subgrade areas, clean material with a gravel content of at least 30 to 35 percent may be necessary. Gravel is material coarser than a US No. 4 sieve.

- Before filling begins, provide samples of the structural and drainage fill for laboratory testing. Laboratory testing will include a Proctor test and gradation for structural fill and a gradation for drainage fill. Field testing with a nuclear density gauge uses the maximum dry density determined from a Proctor test so it is important to complete the laboratory testing as soon as possible in order to not delay backfilling.

Use of On-Site Soil as Structural Fill

Our explorations indicated that the near-surface site soil includes silty sand, silt, and clay; we do not recommend using these soils for structural fill. The sands may be used but are likely to contain more than 5 percent fines and will be moisture-sensitive and could be difficult to compact in wet weather.

Temporary Cuts

Because of the variables involved, actual slope grades required for stability in temporary cut areas can only be estimated before construction. We recommend that stability of the temporary slopes used for construction be the sole responsibility of the contractor, since the contractor is in control of the construction operation and is continuously at the site to observe the nature and condition of the subsurface. Excavations should be made in accordance with all local, state, and federal safety requirements.

For planning purposes, the soils across the site are likely OSHA Soil Classification Type C; however, the soil classification must be reevaluated at the time of construction.

The stability and safety of open trenches and cut slopes depend on a number of factors, including:

- Type and density of the soil;
- Presence and amount of any seepage;
- Depth of cut;
- Proximity of the cut to any surcharge loads near the top of the cut, such as stockpiled material, traffic loads, structures, etc.;
- Duration of the open excavation; and
- Care and methods used by the contractor.

Based on these factors, we recommend:

- Using plastic sheeting to protect slopes from erosion; and
- Limiting the duration of open excavations as much as possible.

RECOMMENDED ADDITIONAL GEOTECHNICAL SERVICES

This report will be superseded with a 100% report at a later date which will include the final numerical modelling results.

Recommendations discussed in this report should be reviewed and modified as needed during the final design stages of the project. We also recommend that geotechnical construction observation be incorporated into the construction plans. The following sections present our recommended post-report geotechnical engineering services specific to this project.

Post-Report Design Services

We recommend that Hart Crowser be afforded the opportunity to review geotechnical aspects of the final design plans and specifications to confirm that our recommendations were properly understood and implemented in the design. We will be available to discuss these issues with the design team as the design develops and as needed. Specifically, we recommend the following additional design services:

- Provide geotechnical engineering support to the civil/structural engineer during preparation of project plans and specifications; and
- Prepare geotechnical review letters and response to geotechnical plan review comments from the City of Seattle Department of Planning and Development (DPD).

Construction Observation Services

Because the future performance and integrity of the structural elements of the project will depend largely on proper pile installation, site preparation, drainage, fill placement, and construction procedures, monitoring and testing by experienced geotechnical personnel should be considered an integral part of the construction process.

The purpose of our observations is to verify compliance with design concepts and recommendations, and to allow design changes or evaluation of appropriate construction methods in the event that subsurface conditions differ from those anticipated prior to the start of construction. Consequently, we recommend that Hart Crowser be retained to provide the following construction support services:

- Review geotechnically related construction submittals from the contractor to verify compliance with the construction plans and the recommendations of this report.
- Attend a pre-construction conference with the contractor and DPD to discuss important geotechnically related construction issues.
- Observe the installation of new piles to confirm conformance with the geotechnical design recommendations and the construction plans.
- Observe installation of ground improvement elements (i.e., pinch piles).
- Observe all exposed footing, slab-on-grade, and pavement subgrades after completion of stripping and overexcavation to confirm that suitable soil conditions have been reached and to determine appropriate subgrade compaction methods.
- Observe the installation of all perimeter drains, wall drains, and capillary break layers to verify their conformance with the construction plans.

- Monitor the placement and test the compaction of all structural fill soil to verify confirm conformance with the construction specifications.
- Monitor and test utility trench backfill.
- Provide assistance with any other geotechnical considerations that may arise during the course of construction.

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There are 1052 pages of Figures, Attachments, and Appendices removed from this document for brevity.

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Appendix K
Southwest Harbor Terminal 5
Groundwater Quality Monitoring Evaluation Report

Southwest Harbor Terminal 5
Groundwater Quality Monitoring
Evaluation Report
Seattle, Washington

Prepared for
Port of Seattle

July 8, 2014
_17627-00_

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Southwest Harbor Terminal 5
Groundwater Quality Monitoring Evaluation Report
Seattle, Washington

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LIST OF ACRONYMS

BEHP	Bis(2-ethylhexyl) phthalate
bgs	below ground surface
BNSF	Burlington Northern Santa Fe Railway
CEE's	chlorinated ethanes and ethenes
DCE	dichloroethene
Ecology	Washington State Department of Ecology
EPA	Environmental Protection Agency
GQMER	Groundwater Quality Monitoring Evaluation Report
GWCMP	Groundwater Confirmation Monitoring Program
IDW	Investigation-derived waste
PCE	Tetrachloroethene
Port	Port of Seattle
RA	Remediation Area
SWHP	Southwest Harbor Project
SSI	Seattle Steel Incorporated
TCE	trichloroethene

SOUTHWEST HARBOR TERMINAL 5
GROUNDWATER QUALITY MONITORING EVALUATION REPORT
SEATTLE, WASHINGTON

1.0 INTRODUCTION

This Groundwater Quality Monitoring Evaluation Report (GQMER) presents the results from four semiannual (twice yearly) groundwater monitoring events for the Phase II Southwest Harbor Project (SWHP) Groundwater Confirmation Monitoring Program (GWCMP) located at the Southwest Harbor Terminal 5 (Site) in Seattle, Washington (Figure 1). The purpose of the GWCMP is to confirm that soil remedial actions conducted under the individual SWHP Cleanup Action Plans are protective of surface water quality for the Site as a whole.

Phase I of the GWCMP focused on characterizing the post-remediation groundwater flow system at the Site in 2006. The resulting Hydrologic Characterization Report (Aspect 2007a) presented a detailed characterization of the post-remediation groundwater flow system, and concluded that Fill Aquifer flow conditions at the Site had equilibrated sufficiently to proceed with Phase II of the GWCMP.

This report summarizes the sampling activities and laboratory results for the four sampling events, completed by Aspect Consulting in October 2008, March/April 2009, and September 2009 and by Hart Crowser in June 2010. Sampling was performed in accordance with the Ecology-approved Water Quality Monitoring Plan (Aspect 2007 b).

Our work was completed in general accordance with our executed contract dated April 29, 2010, authorized by Mr. Brian Knight with the Port of Seattle.

2.0 BACKGROUND

The SWHP is located along the base of the West Seattle highlands at the confluence of the West Waterway of the Duwamish River (West Waterway) and Elliott Bay. The Site location is shown on Figure 1. The SWHP comprises approximately 185 areas of land generally bordered by Harbor Avenue and non-Port industrial and commercial properties on the west, SW Spokane Street and non-Port commercial properties on the south, Elliott Bay and Florida Street on the north, and the original Terminal 5 on the east. Most of the SWHP overlies former tideflats that have been filled and used for various industrial purposes, including but not limited to railroad yards, wood treatment facilities, steel scrap storage, and a municipal and wood waste landfill.

The SWHP was divided into five Remediation Areas (RAs). Figure 2 shows the SWHP area and the boundaries of each RA. To facilitate Port plans for redevelopment, the individual RAs were remediated in the mid- to late-1990s. RA-1, RA-2, RA-3 and RA-5 were redeveloped under oversight by Ecology, while RA-4 was addressed under agreement with EPA. The locations and histories of the individual RAs and specific remedial actions completed at each RA are summarized below.

2.1 Remediation Area (RA) Descriptions

2.1.1 Spokane Street Properties (RA-1)

RA-1 consists of two disconnected land parcels (Figure 2). The narrow northern strip of land in RA-1 is the site of the former Buckley Yard, a rail car staging area that dates from the 1920s. The portion of RA-1 south of the former Buckley Yard is referred to as the Spokane Street Properties, which was historically occupied by an aluminum foundry, a chemical distribution warehouse, automotive repair areas, a fuel oil distribution facility and retail food stores. Soil contamination associated with the Spokane Street Properties was remediated between 1994 and 1998. Low-level soil contamination associated with the Buckley Yard was left in place. Asphalt and concrete covers were placed over the Buckley Yard, except in the northern portion of the area east of RA-3, where 24 inches of ballast cover was placed under the railroad tracks. Presently, RA-1 is occupied by Burlington Northern Santa Fe (BNSF) rail spurs, the main access road into the intermodal yard facility, and office buildings.

2.1.2 Former Salmon Bay Steel Property (RA-2)

RA-2 is the former Salmon Bay Steel property, located north of Spokane Street (Figure 2), and was used to store slag and scrap for the steel mill south of Spokane Street from the early 1900s until the 1970s. The area also included two large warehouses, a scale, and railroad spurs. Beginning in the late 1800s, the tideflats on the property were gradually filled with dredge sediment, slag, and steel mill debris. This fill material is predominantly slag, and reaches depths of 25 feet in places. Between 1996 and 1998, a cleanup measure was implemented that involved covering a quarter of the RA with a gravel ballast cap and the remainder of the RA with an impermeable asphalt pavement cap. Prior to this effort, the contaminated soil from areas where the gravel ballast cover was to be placed was moved to areas where asphalt cover would be placed. Presently, the western portion of RA-2 is occupied by the BNSF Rail Yard, and the eastern portion is occupied by the main entrance and south end of the intermodal yard.

2.1.3 Former West Seattle Landfill and Purdy Scrap/Former Seattle Steel Inc. Property (RA-3)

RA-3 was the location of both the West Seattle Landfill and the former Seattle Steel Incorporated (SSI) property (Figure 2), a scrap metal processing company. The West Seattle Landfill occupied 30 acres (approximately three-quarters of this RA) and was in operation from 1939 to 1966. The former landfill was almost entirely covered with slag, construction debris, steel mill debris, and an un-engineered soil cover. In the spring of 1995, near-surface refuse from the eastern portion of the landfill was relocated to a consolidation landfill area on the western portion of the RA. An interim cover consisting of processed solid landfill material was placed over the property. Since this time, an engineered cover consisting of clean fill and a low-permeability geomembrane has been placed over the former landfill, and an asphalt cover has been placed over the former SSI property south of the landfill. The Port operates a landfill gas collection and treatment system in the former landfill area. Presently, the asphalt-paved area on the consolidated landfill portion of RA-3 is used for tenant-lease activities including truck and vehicle parking, container chassis storage, and temporary construction laydown and component assembly for Sound Transit's light rail project.

2.1.4 Pacific Sound Resources Superfund Site (RA-4)

RA-4, a former wood treating facility referred to as the Pacific Sound Resources Superfund site, is being addressed separately under the Superfund process by EPA (Figure 2). Monitoring of groundwater downgradient of RA-4, for the purpose of verifying RA-4 cleanup action protection, is not included in the scope of the GWCMP. However, the portion of RA-4 south of Florida Street is being considered under this GWCMP in order to evaluate groundwater flow from RA-4 into the adjacent remediation areas.

Until 1994, when remediation activity began, the north portion of RA-4 (north of the Florida Street alignment) was occupied by wood treating operations, and the south portion was the location of a kiln building, laboratory area, sawmill, office building and storage areas for treated and untreated stock (Retec 1994). Remediation involved limited removal of contaminated soils and the placement of a specially-designed, low-permeability asphalt concrete cap over the entire RA. Woodwaste from an area at the west side of the RA was recycled off site and the resulting excavation pit was backfilled with fill. A geotextile identifier layer was installed throughout the RA between clean import fill and underlying contaminated soils. In addition, a groundwater containment slurry wall was built in the northern portion of the property to reduce tidal influence on groundwater in the RA interior and limit migration of contaminants into Puget Sound. RA-4 is presently occupied by the northern end of the Terminal 5 intermodal yard, the BNSF Storage Track Yard, and the Jack Block Public Shoreline Access and Park area.

2.1.5 Former Lockheed Shipyard 2 (RA-5)

RA-5 was originally a tideflat zone that has since been filled with dredge sediment, slag, and construction debris. The western portion of the remediation area (Figure 2), filled prior to 1936, was the site of Nettleton Lumber until the late 1960s. The eastern portion of the RA was filled in the late 1950s, becoming the location of Lockheed Shipyard 2, which operated from 1956 to 1987 as a ship maintenance and refitting yard. In 1994, the area used for shipbuilding operations underwent excavation and treatment of contaminated soils. Pursuant to this cleanup effort, the shipyard-era storm drain system was removed or abandoned, and the associated contaminated storm drain sediments were disposed of. In addition, an asphalt concrete cap was placed over the entire site and a new stormwater drainage system was installed. Presently, RA-5 is used by the intermodal yard tenant for parking and interim container storage.

2.2 Monitoring Locations

The study area addressed in the GWCMP encompasses most of the SWHP Site, including the former Buckley Yard and Spokane Street Properties (RA-1), former Salmon Bay Steel Property (RA-2), former West Seattle Landfill and SSI property (RA-3), and the former Lockheed Shipyard 2 (RA-5). Phase II of the GWCMP involves sampling of Fill and Estuarine Aquifer monitoring wells within and/or downgradient of these RAs.

Figure 2 presents the locations of 11 Fill Aquifer and 3 Estuarine Aquifer monitoring wells that are currently sampled as part of the Phase II monitoring network. These wells are used to monitor groundwater quality within and/or downgradient of the target RAs, as follows:

- Wells CMP-17 and MW-125 monitor Fill Aquifer groundwater quality downgradient of the former Spokane Street Properties (RA-1).

- Well CMP-3 monitors Fill Aquifer groundwater quality downgradient of RA-2 and the extreme southern portion of the former Buckley Yard (RA-1).

- Well CMP-4, located within the former Buckley Yard (RA-1), monitors Fill Aquifer groundwater quality within this RA, and immediately downgradient of the central portion of RA-3.

- Well MW-308N monitors Fill Aquifer groundwater quality downgradient of the northern portions of the former Buckley Yard (RA-1) and RA-3.

- Well MW-308S monitors Estuarine Aquifer groundwater quality downgradient of the northern portions of the former Buckley Yard (RA-1) and RA-3.

- Well CMP-15 monitors Fill Aquifer groundwater quality on flow paths that transect the central and/or northern portions of the former Buckley Yard (RA-1) and RA-3, the southern portion of RA-4, and the western portion of RA-5.

- Well MW-36 monitors Estuarine Aquifer groundwater quality on flow paths that transect the central and/or northern portions of the former Buckley Yard (RA-1) and RA-3, the southern portion of RA-4, and the western portion of RA-5.

- Well MW-26R monitors Fill Aquifer groundwater quality on flow paths that transect the central portions of the former Buckley Yard (RA-1) and RA-3, the southern portion of RA-4, and the eastern portion of RA-5.

- Well MW-44 monitors Estuarine Aquifer groundwater quality on flow paths that transect the central portions of the former Buckley Yard (RA-1) and RA-3, the southern portion of RA-4, and the eastern portion of RA-5.

Four Phase II GWCMP wells were sampled to monitor background water quality upgradient of the target RAs, as follows:

- Background wells FM-105 and CMP-1 are located on the southern borders of RA-1 and RA-2, respectively. These wells monitor the quality of groundwater that flows beneath the Nucor Steel facility and SW Spokane Street, and enters the SWHP from the south.

- Background well CMP-2 monitors groundwater quality entering the SWHP from commercial/industrial areas located immediately southwest of RA-2.

- Background well CMP-5, located immediately upgradient of RA-3, monitors groundwater quality along the flow path of recharge from the adjacent West Seattle highlands.

The Phase II GWCMP monitoring network comprises monitoring wells sited for the Phase I groundwater flow characterization. It is possible that one or more of the monitoring wells may not prove to be optimal for Phase II water quality monitoring. The first four rounds of groundwater monitoring during the Phase II GCWMP have been completed and are summarized within this groundwater quality monitoring evaluation report. A summary of the recommendations for the replacement or addition of wells to better meet the goals of the Phase II program are detailed in Section 6.0.

2.3 Monitoring Schedule

In accordance with the Groundwater Conceptual Letter, Phase II groundwater sampling was performed semiannually (twice yearly) (Port of Seattle 1999). Aspect Consulting completed two low-level groundwater sampling events in October 2008 and September 2009 and one high-level groundwater sampling event in March/April 2009. Hart Crowser completed the second high-level groundwater sampling event in June 2010.

Figure 2 shows the spatial distribution of monitoring wells that are currently sampled as part of the Phase II monitoring network.

3.0 SCOPE OF WORK

The purpose of the Phase II Southwest Harbor Project (SWHP) Groundwater Confirmation Monitoring Program (GWCMP) is to confirm that soil remedial actions conducted under the individual SWHP Cleanup Action Plans are protective of surface water quality for the Site as a whole.

The groundwater monitoring tasks included in Phase II are described below.

- Measure depth to water in sampled monitoring wells to determine groundwater elevation contours during the high-level groundwater sampling event (Table 1).

- Sample 14 monitoring wells in the existing monitoring well network using low-flow sampling methods.

- Monitor field parameters (dissolved oxygen, pH, temperature, specific conductivity, and turbidity) using a flow-through cell during purging and sampling.

- Collect and submit one grab groundwater sample for chemical analysis, using low-flow sampling, from each monitoring well location.

4.0 GROUNDWATER ELEVATIONS

4.1 Site Hydrogeology

The Site is underlain by two aquifers, a shallow Fill Aquifer and a deeper Estuarine Aquifer. Eleven wells are completed in the Fill Aquifer and three wells are completed in the Estuarine Aquifer. The Fill Aquifer consists of groundwater in various fill materials between 20 to 40 feet below ground surface (bgs). Sandy Silt to silty fine Sand tideflat deposits, typically 1 to 10 feet in thickness, occur between the Fill and Estuarine Aquifer zones over most of the Site with the exception of the easternmost portion near the West Waterway, and in isolated areas near the former axis of Longfellow Creek along the eastern edge of RA-3. Where present, this low-permeability unit results in locally confined conditions in the Estuarine Aquifer zone. The Estuarine Aquifer is underlain by a lower permeability unit that occurs at depths ranging from 30 to 50 feet bgs. The Fill Aquifer/Estuarine Aquifer system is bounded to the north by Elliott Bay and to the east by the West Waterway. The aquifers thin to the south and west and terminate to the west against the West Seattle bluff, encountering deposits of the low-permeability Lawton Clay unit.

4.2 Groundwater Elevations

The depth to water was measured in all the monitoring wells during the June 2 through June 4, 2010, groundwater sampling event. Monitoring well groundwater elevation data for all four groundwater sampling events (low and high levels) are summarized and presented in Table 1. Since groundwater at the Site is tidally influenced and water levels were measured over a 3-day period, meaningful groundwater contours could not be plotted. Post-redevelopment and tidally corrected groundwater elevation contours based on a 72-hour mean during dry and wet season in the Fill and Estuarine Aquifers are provided in Figures 3 through 6 (Aspect 2007a).

4.2.1 Fill Aquifer

The groundwater elevations during the June 2010 measurements for shallow monitoring wells in the Fill Aquifer ranged from 8.67 to 15.09 feet bgs. Groundwater elevations in all monitoring wells increased by 0.29 to 1.85 feet relative to the September 2009 monitoring event. Based on the Aspect Consulting Hydrologic Characterization Report (2007a), groundwater flows in the Fill Aquifer monitoring wells were generally toward the east-northeast of the West Seattle uplands, beneath RA-3, and then diverged toward the nearest water body, West Waterway or Elliott Bay, within the main Terminal 5 area. The most recent groundwater elevation contours based on a 72-hour mean during dry and wet seasons in the Fill Aquifer are provided in Figure 3 and 4, respectively. In general, Fill Aquifer groundwater flows measured during the June 2010 sampling event showed a similar trend to what was observed during the long-term study conducted by Aspect Consulting.

4.2.2 Estuarine Aquifer

The groundwater elevations in the deep monitoring wells completed in the Estuarine Aquifer ranged from 8.29 to 9.44 feet bgs. Groundwater elevations in monitoring wells MW-308A(S) and MW-36 were 0.27 to 0.38 feet lower than nearby shallow monitoring wells screened in the Fill Aquifer, indicating that a downward gradient exists between the Fill Aquifer and the Estuarine Aquifer. A downward gradient was not observed at the shallow and deep monitoring well cluster, MW-26R and MW-44. This is likely due the absence of a low-permeability confining unit on the easternmost portion of the Site near the West Waterway. However, based on the Aspect Consulting Hydrologic Characterization Report (2007a), groundwater flows in the Estuarine Aquifer monitoring wells were generally from the southwest toward the northeast, with discharge to Elliott Bay and the West Waterway. The most recent groundwater elevation contours based on a 72-hour mean during dry and wet season in the Estuarine Aquifer are provided in Figure 5 and 6, respectively. During the June 2010 sampling event, only three deep monitoring wells (MW-308S, MW-36, and MW-44) were measured, providing inadequate data for field verification of groundwater flows observed during the long-term study conducted by Aspect Consulting.

5.0 GROUNDWATER SAMPLING AND ANALYTICAL RESULTS

5.1 Surface Water Quality Screening Criteria

As noted in the Groundwater Conceptual Letter (Port of Seattle 1999), the remediation activities completed at each of the RAs are believed to be protective of groundwater quality whose highest beneficial use is discharge to surface water. Since surface water is the assumed final receptor of groundwater, surface water quality screening criteria were included in this report for preliminary comparison purposes only.

Potential surface water quality screening criteria for each analyte are summarized in Table 2. Note that the most stringent surface water criterion for arsenic is 0.14 ug/L. However, since Ecology has established the natural background concentration of arsenic in groundwater at 5 ug/L (MTCA Method A), arsenic concentrations were screened against the established background concentration of 5 ug/L. It should also be noted that surface water quality criteria are based on dissolved metals concentrations. Since the work plan for the SWHP GWCMP specified analysis of total metals, depending upon turbidity and suspended solids concentrations, reported groundwater metal concentrations may have an artificially high bias relative to the dissolved metals criteria they are being screened against.

5.2 Groundwater Concentrations Protective of Surface Water

As part of this Groundwater Quality Monitoring Evaluation Report, a memorandum was developed to identify the appropriate groundwater chemical concentrations that are protective of surface water, against which the GWCMP data should be compared (Appendix A).

The protectiveness of current groundwater chemical concentrations was assessed by modeling natural attenuation of chemical constituents within the groundwater aquifer to determine if chemicals detected in groundwater are naturally attenuated to concentrations below surface water quality criteria prior to discharge to Puget Sound marine water.

Fate and transport modeling using BIOSCREEN was conducted to predict contaminant concentrations at the shoreline. The natural attenuation processes simulated in the modeling include dispersion and sorption. Biodegradation and tidal mixing processes were not included in the model.

The model results show that even under the conservative conditions, predicted concentrations of most constituents of potential concern (COPCs), including bis(2-ethylhexyl)phthalate, PAHs and PCBs detected in groundwater will not exceed the screening level concentrations at the shoreline within 100 years. For organic compounds, groundwater concentrations as high as the solubility limit would not result in an exceedance of surface water quality criteria at the shoreline.

Tidal dilution factors ranging from 4 to 10,000 have been reported from groundwater modeling at the Terminal 5 and adjacent sites (Aspect 2007; Retec 1998). Use of the lowest tidal dilution estimate of four would further reduce the calculated chemical concentrations at the shoreline after 100 years by an additional factor of four. Incorporation of chemical degradation rates would result in even lower chemical concentrations at the groundwater to surface water interface.

5.3 Monitoring Well Groundwater Sampling and Analysis

Groundwater samples were collected from the 11 shallow Fill Aquifer monitoring wells (CMP-1, CMP-2, CMP-3, CMP-4, CMP-5, CMP-15, CMP-17, MW-26R, MW-125, MW-308N, and FM-105) and the deep Estuarine Aquifer monitoring wells (MW-36, MW-44, and MW-308S) to evaluate water quality in the Fill and Estuarine Aquifers.

All groundwater samples were submitted for chemical analysis of:

- cPAHs by EPA Method 8270C-SIM;
- PCBs by EPA Method 8082;
- TPH-Dx by NWTPH-Dx with silica gel cleanup; and
- Bis(2-ethylhexyl) phthalate (BEHP) by EPA Method 8270C.

Additionally, selected groundwater samples were submitted for chemical analysis of:

- VOCs, chlorinated ethanes and ethenes (CEE's) by EPA Method 8260B for monitoring wells FM-105, MW-125, and CMP-17;
- Total metals by EPA Method 6010B/6020 for antimony, arsenic, chromium, copper, lead, and nickel for monitoring wells CMP-15, MW-26R, MW-36, and MW-44; and
- Total metals by EPA Method 6010B/6020 for arsenic and lead for monitoring wells CMP-1, CMP-2, CMP-3, CMP-4, CMP-5, CMP-17, MW-125, MW-308N, MW-308S, and FM-105.

Details of the low-flow sampling procedures are presented in Appendix A. The monitoring well boring logs for the Phase II GWCMP monitoring network are presented in Appendix B. Field water quality parameters including pH, temperature, conductivity, dissolved oxygen, and turbidity were monitored during groundwater sampling of the Fill and Estuarine Aquifer monitoring wells. Field water quality monitoring results are provided on the groundwater sampling forms presented in Appendix C. The review of chemical data quality and laboratory certificates is included in Appendix D.

Tables 3 through 6 present the tabulated field monitoring and analytical results for the RA-1 and RA-3, RA-2, and RA-5, respectively, for the four groundwater monitoring events (October 2008, March/April 2009, September 2009, and

June 2010). Groundwater quality data are organized by RA, background/ confirmation monitoring location, aquifer designation, and sampling date.

5.3.1 Spokane Street Properties (RA-1)

Groundwater samples were collected from within the Fill Aquifer from one upgradient background monitoring well (FM-105) and two confirmation monitoring wells (MW-125 and CMP-17) to evaluate water quality within RA-1. Groundwater monitoring and analytical results for the Phase II GWCMP are summarized in Table 3. Additional information or clarification for selected analytes and monitoring wells is provided below.

Total arsenic was detected in all background and confirmation monitoring wells. Concentrations were comparable in the background monitoring well, FM-105, and the confirmation monitoring well, MW-125. Concentrations in confirmation monitoring well, CMP-17, were somewhat higher and may be indicative of the more reducing conditions (lower dissolved oxygen) in CMP-17.

Bis(2-ethylhexyl) phthalate (BEHP) was detected in the duplicate groundwater sample but not the primary groundwater sample collected from background monitoring well, FM-105, in March 2009. BEHP was not detected in groundwater samples from the two downgradient confirmation monitoring wells, MW-125 and CMP-17.

Tetrachloroethene (PCE) and its degradation products, trichloroethene (TCE) and dichloroethene (DCE) were detected in the upgradient background monitoring well FM-105 and confirmation monitoring wells, MW-125 and CMP-17 indicating that contamination is from an off-site source not associated with the RA-1 area. Concentrations of the more mobile degradation compounds TCE and DCE are slightly higher in downgradient confirmation monitoring well CMP-17 than in background well MW-125.

5.3.2 Former Salmon Bay Steel Property (RA-2)

Groundwater samples were collected from within the Fill Aquifer from two upgradient background monitoring wells (CMP-1 and CMP-2) and one confirmation monitoring well (CMP-3) to evaluate water quality within RA-2. Groundwater monitoring and analytical results for the Phase II GWCMP are summarized in Table 4. Additional information or clarification for selected analytes and monitoring wells is provided below.

Total arsenic concentrations ranged from 2.6 to 3.1 ug/L in background monitoring well CMP-1, from 20.8 to 23.2 ug/L in background monitoring well

CMP-2, and from 6.6 to 11.6 ug/L in confirmation monitoring well CMP-3 indicating that contamination is from an off-site source not associated with the RA-2 area.

Total lead concentrations ranged from 1 to 15 ug/L in background monitoring well CMP-2 and from non-detected to 4 ug/L in confirmation monitoring well CMP-3 indicating that contamination is from an off-site source not associated with the RA-2 area.

5.3.3 Former West Seattle Landfill and Purdy Scrap/Former Seattle Steel Inc. Property (RA-3), Former Buckley Yard (RA-1)

Groundwater samples were collected from within the Fill Aquifer from one upgradient background monitoring well (CMP-5) and two confirmation monitoring wells (CMP-4 and MW-308N) within RA-3 and RA-1, and one monitoring well (MW-308S) within the Estuarine Aquifer to evaluate water quality within RA-3 and RA-1. Groundwater monitoring and analytical results for the Phase II GWCMP are summarized in Table 5. Additional information or clarification for selected analytes and monitoring wells is provided below.

BEHP was detected in background well CMP-5 and confirmation monitoring well CMP-4. Background concentrations were higher than the confirmation well concentrations suggesting that contamination is from an off-site source.

5.3.4 Former Lockheed Shipyard 2 (RA-5)

Groundwater samples were collected from within the Fill Aquifer from one upgradient background monitoring well (CMP-5) and two confirmation monitoring wells (CMP-15 and MW-26R) and two monitoring wells (MW-36 and MW-44) within the Estuarine Aquifer to evaluate water quality within RA-5. Groundwater monitoring and analytical results for the Phase II GWCMP are summarized in Table 6. Additional information or clarification for selected analytes and monitoring wells is provided below.

Diesel- and motor oil-range petroleum hydrocarbons were not detected with the exception of Estuarine Aquifer well MW-44, which had a concentration of 530 ug/L. This single result may be questionable. Monitoring well MW-44 is located in a container storage area with heavy truck traffic and, therefore, is susceptible to small oil drips on the pavement. In addition, the flush-mount well monument was full of water, presumably runoff from the pavement, which had to be removed before the well could be sampled.

Concentrations of BEHP detected in background well CMP-5 were higher than the confirmation and Estuarine Aquifer well concentrations suggesting that contamination is from an off-site source not associated with RA-5.

6.0 FUTURE ESTUARINE WELL GROUNDWATER MONITORING PROGRAM

As noted in the Ecology-approved Water Quality Monitoring Plan (Aspect 2008), the remediation activities completed at each of the RAs are believed to be protective of groundwater quality whose highest beneficial use is discharge to surface water. As such, the Phase II GWCMP is not expected to continue indefinitely. Groundwater monitoring will continue for one additional year (one high water and one low water event) after the submittal of this Groundwater Quality Monitoring Evaluation Report. Groundwater monitoring may be continued after that time in select monitoring wells for select analytes, if Ecology and the Port are in mutual agreement that additional groundwater monitoring is warranted to meet the GWCMP program's objectives. Once the goal of demonstrating that surface water protection is met, groundwater monitoring will be discontinued.

In addition, as specified in the Ecology-approved work plan and in accordance with the Groundwater Conceptual Letter (Port of Seattle 1999):

> "Assessment of whether modifications to the monitoring network are warranted will occur on an ongoing basis as the program progresses. The Port will evaluate the initial findings after completion of the first year of groundwater monitoring, and may propose modifications to the monitoring network at that time. Water quality in the monitored Estuarine Aquifer wells will be evaluated after 1 year of monitoring. If no inorganic or organic constituents are detected in the Estuarine Aquifer wells above background levels during the first year, these wells will be dropped from the program and the assessment of the Estuarine Aquifer will be considered complete."

The Port has continued monitoring estuarine wells for an additional year beyond the time required by the work plan. The following changes to groundwater monitoring for Estuarine Aquifer wells will be implemented based on the fact that the analytes have not been detected in estuarine wells during four rounds of semiannual groundwater monitoring conducted over a 2-year period, between October 2008 and June 2010 or chemical concentrations in estuarine wells are less than background levels.

Estuarine Well MW-308S

- TPH monitoring in Estuarine Aquifer well MW-308S will be discontinued since TPH has not been detected in this monitoring well.

- Lead monitoring in Estuarine Aquifer well MW-308S will be discontinued since lead has not been detected in this monitoring well.

- cPAH monitoring in Estuarine Aquifer well MW-308S will be discontinued since cPAHs have not been detected in this monitoring well.

- PCB monitoring in Estuarine Aquifer well MW-308S will be discontinued since PCBs have not been detected in this monitoring well.

Estuarine Well MW-36

- TPH monitoring in Estuarine Aquifer well MW-36 will be discontinued since TPH has not been detected in this monitoring well.

- Antimony, chromium, copper, and lead monitoring in Estuarine Aquifer well MW-36 will be discontinued since these analytes have not been detected in this monitoring well.

- cPAH monitoring in Estuarine Aquifer well MW-36 will be discontinued since cPAHs have not been detected in this monitoring well.

- PCB monitoring in Estuarine Aquifer well MW-36 will be discontinued since PCBs have not been detected in this monitoring well.

Estuarine Well MW-44

- PCB monitoring in Estuarine Aquifer well MW-44 will be discontinued since PCBs have not been detected in this monitoring well.

- Estuarine Aquifer well, MW44, which had a questionable detection of TPH will be redeveloped prior to the next round of groundwater sampling to determine if TPH is actually present in the groundwater or if it was an artifact resulting from surface water leaking into the monitoring well casing. If TPH is not detected during the next monitoring event (October 2010), TPH monitoring will be discontinued.

7.0 CONCLUSIONS

Groundwater concentrations at Terminal 5 are protective of surface water for all chemicals included in the long-term groundwater monitoring program. For semivolatile organic compounds, natural attenuation modeling demonstrates that groundwater concentrations at the shoreline would be non-detect even after 100 years. Incorporation of chemical degradation rates and tidal mixing factors would further decrease groundwater chemical concentrations and would also result in non-detect concentrations for volatile organic compounds and metals near the shore.

In accordance with the Ecology-approved work plan and the Groundwater Conceptual Letter groundwater monitoring will be discontinued in estuarine wells for chemicals that have not been detected during the past two years.

8.0 LIMITATIONS

Work for this project was performed, and this report prepared, in accordance with generally accepted professional practices for the nature and conditions of the work completed in the same or similar localities, at the time the work was performed. It is intended for the exclusive use of Port of Seattle for specific application to the referenced property. This report is not meant to represent a legal opinion. No other warranty, express or implied, is made.

9.0 REFERENCES

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Table 1 - Summary of Monitoring Well Groundwater Elevation Data

Well Name	TOC Elevation in Feet (1)	Date	DTW in Feet	Groundwater Elevation in Feet
Fill Aquifer				
CMP-1	22.71	10/13/2008	12.92	9.79
		3/31/2009	12.21	10.50
		9/4/2009	13.10	9.61
		6/4/2010	11.83	10.88
CMP-2	22.67	10/13/2008	12.92	9.75
		3/31/2009	12.92	9.75
		9/2/2009	13.60	9.07
		6/4/2010	11.75	10.92
CMP-3	17.40	10/14/2008	8.40	9.00
		4/1/2009	7.90	9.50
		9/3/2009	8.45	8.95
		6/2/2010	7.60	9.80
CMP-4	19.92	10/14/2008	11.04	8.88
		4/2/2009	10.34	9.58
		9/3/2009	11.01	8.91
		6/2/2010	10.17	9.75
CMP-5	23.80	10/13/2008	10.09	13.71
		4/1/2009	8.48	15.32
		9/2/2009	10.12	13.68
		6/3/2010	8.71	15.09
CMP-15	18.42	10/14/2008	10.38	8.04
		4/2/2009	9.91	8.51
		9/3/2009	10.14	8.28
		6/3/2010	9.75	8.67
CMP-17	18.43	10/13/2008	9.47	8.96
		3/31/2009	9.05	9.38
		9/2/2009	9.50	8.93
		6/4/2010	8.81	9.62
MW-26R	18.27	10/14/2008	9.91	8.36
		4/1/2009	9.66	8.61
		9/3/2009	9.69	8.58
		6/4/2010	9.40	8.87
MW-125	15.90	10/13/2008	6.88	9.02
		3/31/2009	6.40	9.50
		9/2/2009	7.01	8.89
		6/3/2010	6.25	9.65
MW-308A(N)	14.86	10/13/2008	6.53	8.33
		4/2/2009	5.86	9.00
		9/4/2009	6.50	8.36
		6/3/2010	5.73	9.13
FM-105	20.80	10/13/2008	11.20	9.60
		3/31/2009	10.76	10.04
		9/2/2009	11.36	9.44
		6/3/2010	10.70	10.10

Table 1 - Summary of Monitoring Well Groundwater Elevation Data

Well Name	TOC Elevation in Feet (1)	Date	DTW in Feet	Groundwater Elevation in Feet
Estuarine Aquifer				
MW-36	17.60	10/14/2008	10.00	7.60
		4/2/2009	9.06	8.54
		9/3/2009	9.72	7.88
		6/2/2010	9.31	8.29
MW-44	18.38	10/14/2008	10.90	7.48
		4/1/2009	8.94	9.44
		9/3/2009	11.46	6.92
		6/2/2010	8.94	9.44
MW-308B(S)	14.42	10/13/2008	6.30	8.12
		4/1/2009	5.74	8.68
		9/4/2009	6.17	8.25
		6/3/2010	5.56	8.86

Notes:
TOC - Top of Casing.
DTW - Depth to Water.
Vertical datum is in Feet MLLW.
(1) Based on a professional survey completed by Aspect Consulting, LLC (December 21, 2009).

Table 2 - Surface Water Quality Screening Criteria. Screening Levels for Groundwater Based on Marine Surface Water Criteria

Port of Seattle Terminal 5 Southwest Harbor

Analyte	Surface Water ARAR - Aquatic Life - Marine/Acute - Ch. 173-201A WAC (µg/L)	Surface Water ARAR - Aquatic Life Marine/Acute - Clean Water Act §304 (µg/L)	Surface Water ARAR - Aquatic Life - Marine/Acute - National Toxics Rule, 40 CFR 131 (µg/L)	Surface Water ARAR - Aquatic Life - Marine/Chronic - Ch. 173-201A WAC (µg/L)	Surface Water ARAR - Aquatic Life - Marine/Chronic - Clean Water Act §304 (µg/L)	Surface Water ARAR - Aquatic Life - Marine/Chronic - National Toxics Rule, 40 CFR 131 (µg/L)	Surface Water ARAR - Human Health – Marine – Clean Water Act §304 (µg/L)	Surface Water ARAR - Human Health – Marine – National Toxics Rule, 40 CFR 131 (µg/L)	Surface Water, Method B, Carcinogen, Standard Formula Value (µg/L)	Surface Water, Method B, Non-Carcinogen, Standard Formula Value (µg/L)	Screening Level [2, 3] (µg/L)
Metals (4)											
Antimony	--	--	--	--	--	--	640	4300	--	1000	**640**
Arsenic, inorganic	69	69	69	36	36	36	0.14	0.14	0.098	18	**0.14 (5 - MTCA A GW)**
Chromium (VI)	1100	50	1100	50	1100	50	--	--	--	490	**50**
Copper	4.8	4.8	2.4	3.1	3.1	2.4	--	--	--	2,700	**2.4**
Lead	210	210	210	8.1	8.1	8.1	--	--	--	--	**8.1**
Nickel soluble salts	74	74	74	8.2	8.2	8.2	4,600	4,600	--	1,100	**8.2**
Polychlorinated Biphenyls (PCBs)											
Aroclor 1016	--	--	--	--	--	0.03	--	--	--	0.0058	**0.0058**
Aroclor 1221	--	--	--	--	--	--	--	--	--	--	--
Aroclor 1232	--	--	--	--	--	--	--	--	--	--	--
Aroclor 1242	--	--	--	--	--	--	--	--	--	--	--
Aroclor 1248	--	--	--	--	--	--	--	--	--	--	--
Aroclor 1254	--	--	--	--	--	0.03	--	--	--	0.0017	**0.0017**
Aroclor 1260	--	--	--	--	--	0.03	--	--	--	--	**0.03**
Aroclor 1262	--	--	--	--	--	--	--	--	--	--	--
Aroclor 1268	--	--	--	--	--	--	--	--	--	--	--
Polychlorinated biphenyls	10	--	--	0.03	0.03	0.03	0.000064	0.00017	0.00011	--	**0.000064**
Total Petroleum Hydrocarbons											
TPH, diesel range	--	--	--	--	--	--	--	--	--	--	**500 [5]**
TPH, heavy oils	--	--	--	--	--	--	--	--	--	--	**500 [5]**
Chlorinated Volatile Organic Compounds (VOCs)											
1,1,1,2-Tetrachloroethane	--	--	--	--	--	--	--	--	--	--	**--**
1,1,1-Trichloroethane	--	--	--	--	--	--	--	--	--	930,000	**420,000**
1,1,2,2-Tetrachloroethane	--	--	--	--	--	--	4	11	6.5	--	4
1,1,2-Trichloroethane	--	--	--	--	--	--	16	42	25	2,300	16
1,1-Dichloroethane	--	--	--	--	--	--	--	--	--	--	**--**
1,1-Dichloroethene	--	--	--	--	--	--	7100	3.2	--	23,000	**3.2**
1,2-Dichloroethane	--	--	--	--	--	--	37	99	59	43,000	**37**
Chloroethane	--	--	--	--	--	--	--	--	--	--	--
cis-1,2-Dichloroethene	--	--	--	--	--	--	--	--	--	--	**--**
Tetrachloroethene	--	--	--	--	--	--	3.3	8.9	0.39	840	**0.39**
trans-1,2-Dichloroethene	--	--	--	--	--	--	10,000	--	--	33,000	**10,000**
Trichloroetlene	--	--	--	--	--	--	30	81	6.7	71	**6.7**
Vinyl chloride	--	--	--	--	--	--	2.4	530	3.7	6,600	**2.4**
Semivolatile Organic Compounds (SVOCs)											
bis(2-Ethylhexyl) phthalate	--	--	--	--	--	--	2.2	5.9	3.6	400	**2.2**
Carcinogenic Polycyclic Aromatic Hydrocarbons (cPAHs)											
Benzo[a]anthracene	--	--	--	--	--	--	0.018	0.031	--	--	**0.018**
Benzo[a]pyrene	--	--	--	--	--	--	0.018	0.031	0.03	--	**0.018**
Benzo[b]fluoranthene	--	--	--	--	--	--	0.018	0.031	--	--	**0.018**
Benzo[k]fluoranthene	--	--	--	--	--	--	0.018	0.031	--	--	**0.018**
Chrysene	--	--	--	--	--	--	0.018	0.031	--	--	**0.018**
Dibenzo[a,h]anthracene	--	--	--	--	--	--	0.018	0.031	--	--	**0.018**
Indeno[1,2,3-cd]pyrene	--	--	--	--	--	--	0.018	0.031	--	--	**0.018**

Notes
1. -- = Not established.
2. Screening levels may be adjusted depending on lab PQLs.
3. Screening levels may be adjusted based on background data results
4. Surface water quality criteria screening levels are based on dissolved metal concentrations.
5. Screening levels based on MTCA Method A Cleanup levels for groundwater.

Abbreviations
µg/L = micrograms per liter.
ARAR = applicable or relevant and appropriate requirements
CFR = code of federal regulations
WAC = Washington Administrative Code

Table 3 - RA-1 Groundwater Monitoring and Analytical Results

POS Terminal 5 Southwest Harbor
Phase II GWCMP SWHP

	Remediation Area 1 (former Spokane Street Properties)														
	Background							Confirmation Monitoring							
	Fill Aquifer														
Sample Name	FM105-081013	FM105-081013D	FM105-090331	FM105-090331D	FM105-090902	FM105-090902D	FM105	MW125-081013	MW125-090331	MW125-090902	MW125	CMP17-081013	CMP17-090331	CMP17-090902	CMP17
Sampling Date	10/13/08	10/13/08	3/31/09	3/31/09	9/2/09	9/2/09	6/3/10	10/13/08	3/31/09	9/2/09	6/3/10	10/13/08	3/31/09	9/2/09	6/4/10
Groundwater Level Measurements															
Reference Elevation in feet MLLW	20.80		20.80		20.80		20.80	15.90	15.90	15.90	15.90	18.43	18.43	18.43	18.43
Depth To Water in feet	11.20		10.76		11.36		10.70	6.88	6.40	7.01	6.25	9.47	9.05	9.50	8.81
Water Level Elevation in feet MLLW	9.60		10.04		9.44		10.10	9.02	9.50	8.89	9.65	8.96	9.38	8.93	9.62
Water Quality Field Parameters															
Temperature in degrees Celsius	14.8		11.5		14.5		12.1	18.6	11.4	19.3	15.1	17.6	12.3	17.5	13.8
pH	7.03		6.26		5.95		6.45	6.61	6.18	5.94	6.42	6.61	6.05	5.83	6.19
Conductivity in µS/cm	440		476		518		399	412	589	475	387	569	678	597	483
Dissolved Oxygen in mg/L	0.37		0.96		0.58		0.97	0.52	1.74	0.83	2.47	0.1	0.39	0.32	0.02
Turbidity in NTUs	2.1		0.53		3.64		0	0.9	0.74	2.34	0	1.74	2	4.87	135
Total Petroleum Hydrocarbons by Method NWTPH-Dx															
Diesel Range in µg/L	250 U	250 U	250 U	250 U	250 U	250 U	100 U	250 U	250 U	250 U	100 U	250 U	250 U	250 U	100 U
Motor Oil Range in µg/L	500 U	500 U	500 U	500 U	500 U	500 U	200 U	500 U	500 U	500 U	200 U	500 U	500 U	500 U	200 U
Total Metals by EPA Method 200.8															
Total arsenic, inorganic in µg/L	**0.4**	**0.4**	**0.5**	**0.5**	**0.5**	**0.5**	2 U	**0.4**	**0.4**	**0.6**	2 U	**2.6**	**2.6**	**2.9**	**8.1**
Total lead in µg/L	1 U	1 U	1 U	1 U	1 U	1 U	*10 U*	1 U	1 U	1 U	*10 U*	1 U	1 U	1 U	1 U
Carcinogenic Polycyclic Aromatic Hydrocarbons (cPAHs) by Method 8270D-SIM															
Benz(a)anthracene in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	**0.097**	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Benzo(a)pyrene in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	**0.140**	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Benzo(b)fluoranthene in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	**0.100**	**0.011**	0.010 U	0.010 U	0.010 U	0.010 U
Benzo(k)fluoranthene in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	**0.120**	**0.011**	0.010 U	0.010 U	0.010 U	0.010 U
Chrysene in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	**0.084**	**0.011**	0.010 U	0.010 U	0.010 U	0.010 U
Dibenzo(a,h)anthracene in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	**0.028**	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Indeno(1,2,3-cd)pyrene in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	**0.051**	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Semi-Volatile Organics by EPA Method 8270D															
bis(2-ethylhexyl) phthalate in µg/L	1.0 U	1.0 U	1.0 UJ	5.8 J	1.0 U	1.0 U	**1.4**	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
Polychlorinated Biphenyls (PCBs) by EPA Method 8082															
Aroclor 1016 in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Aroclor 1221 in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Aroclor 1232 in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Aroclor 1242 in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Aroclor 1248 in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Aroclor 1254 in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Aroclor 1260 in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Total PCBs in µg/L	*0.010 U*	*0.010 U*	*0.010 U*	*0.010 U*	*0.010 U*	*0.010 U*	*0.010 U*	*0.010 U*	*0.010 U*	*0.010 U*	*0.010 U*	*0.010 U*	*0.010 U*	*0.010 U*	*0.010 U*
Volatile Organic Compounds by EPA Method 8260B															
tetrachloroethane;1,1,1,2- in µg/L	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
tetrachloroethane;1,1,2,2- in µg/L	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
trichloroethane;1,1,1- in µg/L	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	**0.2**	0.2 U	0.2 U	**0.2**	0.2 U	0.2 U	0.2 U	0.2 U
trichloroethane;1,1,2- in µg/L	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
dichloroethane;1,1- in µg/L	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	**0.4**	**0.2**	**0.3**	**0.3**	0.2 U	0.2 U	0.2 U	0.2 U
dichloroethane;1,2- in µg/L	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
ethyl chloride in µg/L	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
tetrachloroethene in µg/L	**6.1**	**6.2**	**3.4**	**3.7**	**5.2**	**5**	**5.7**	**6.7**	**4.1**	**5.1**	**5.4**	**0.3**	**0.2**	**0.3**	0.2 U
trichloroethene in µg/L	**0.9**	**0.9**	**0.6**	**0.6**	**0.6**	**0.5**	**0.8**	**2.8**	**1.0**	**1.8**	**1.4**	0.2 U	0.2 U	0.2 U	0.2 U
dichloroethene;1,1- in µg/L	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
dichloroethene;1,2-,cis in µg/L	**0.7**	**0.7**	**0.4**	**0.5**	**0.2**	**0.2**	**2.5**	**2.1**	**0.4**	**1**	**1.5**	0.2 U	0.2 U	0.2 U	0.2 U
dichloroethene;1,2-,trans in µg/L	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
vinyl chloride in µg/L	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U

U - Analyte was not detected at or above the reported result.
J - The analyte was detected above the reported quantitation limit, and the reported concentrations was an estimated value.
UJ - The analyte was analyzed for, and the associated quantitation limit was an estimated value.
Detected concentrations are bolded.

Table 4 - RA-2 Groundwater Monitoring and Analytical Results
POS Terminal 5 Southwest Harbor
Phase II GWCMP SWHP

	Remediation Area 2 (former Salmon Bay Steel Property)											
	Background								Confirmation Monitoring			
	Fill Aquifer											
Sample Name	CMP1-081013	CMP1-090331	CMP1-090904	CMP1	CMP2-081013	CMP2-090331	CMP2-090902	CMP2	CMP3-081014	CMP3-090401	CMP3-090903	CMP3
Sampling Date	10/13/08	3/31/09	9/4/09	6/4/10	10/13/08	3/31/09	9/2/09	6/4/10	10/14/08	4/1/09	9/3/09	6/2/10
Groundwater Level Measurements												
Reference Elevation in feet MLLW	22.71	22.71	22.71	22.71	22.67	22.67	22.67	22.67	17.40	17.40	17.40	17.40
Depth To Water in feet	12.92	12.21	13.10	11.83	12.92	12.92	13.60	11.75	8.40	7.90	8.45	7.60
Water Level Elevation in feet MLLW	9.79	10.50	9.61	10.88	9.75	9.75	9.07	10.92	9.00	9.50	8.95	9.80
Water Quality Field Parameters												
Temperature in degrees Celsius	14.4	12.7	13.1	13.1	16.9	14.96	16.2	14.1	19.5	12.9	19.8	15.5
pH	6.9	6.23	6.36	6.61	9.38	9.08	8.42	9.01	10.96	8.68	10.01	9.55
Conductivity in µS/cm	563	506	511	482	1272	1402	1669	920	613	726	703	403
Dissolved Oxygen in mg/L	0.3	0.19	0.55	0.2	0.09	0.26	0.24	0.12	0.19	0.26	0.4	0.08
Turbidity in NTUs	1.76	1.17	0.78	38	0.86	1.58	1.31	4	1.09	1.8	5.3	4
Total Petroleum Hydrocarbons												
Diesel Range in µg/L	250 U	250 U	250 U	100 U	250 U	250 U	250 U	100 U	250 U	250 U	250 U	100 U
Motor Oil Range in µg/L	500 U	500 U	500 U	200 U	500 U	500 U	500 U	200 U	500 U	500 U	500 U	200 U
Total Metals by EPA Method 200.8												
Total arsenic, inorganic in µg/L	**2.8**	**2.7**	**3.1**	**2.6**	**22.7**	**23.2**	**20.8**	**23**	**11.6**	**6.6**	**8.3**	**7.4**
Total lead in µg/L	1 U	1 U	1 U	1 U	**15**	**1**	1 U	**2**	1 U	**4**	1 U	1 U
Carcinogenic Polycyclic Aromatic Hydrocarbons (cPAHs) by Method 8270D-SIM												
Benz(a)anthracene in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	**0.010**	0.010 U	0.010 U	0.010 U
Benzo(a)pyrene in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	**0.011**	0.010 U	0.010 U
Benzo(b)fluoranthene in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	**0.019**	0.010 U	0.010 U
Benzo(k)fluoranthene in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	**0.011**	0.010 U	0.010 U
Chrysene in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	**0.013**	**0.015**	**0.010**	0.010 U
Dibenzo(a,h)anthracene in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Indeno(1,2,3-cd)pyrene in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Semi-Volatile Organics by EPA Method 8270D												
bis(2-ethylhexyl) phthalate in µg/L	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
Polychlorinated Biphenyls (PCBs) by EPA Method 8082												
Aroclor 1016 in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.100 U	0.100 U
Aroclor 1221 in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.100 U	0.100 U
Aroclor 1232 in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.015 Y	0.010 U	0.010 U	0.010 U	0.010 U	0.100 U	0.100 U
Aroclor 1242 in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.012 Y	0.010 U	0.010 U	0.010 U	0.200 Y	0.400 Y	0.100 U	0.100 U
Aroclor 1248 in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	**0.015**	**0.020**	0.010 U	0.010 U	**1.2** PJ	**2.5**
Aroclor 1254 in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	**0.016**	0.010 U	0.150 Y	0.400 Y	1.000 Y	**1.5**
Aroclor 1260 in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.015 Y	0.010 U	0.100 U	0.100 U
Total PCBs in µg/L	*0.010 U*	*0.010 U*	*0.010 U*	*0.010 U*	*0.012 Y*	*0.015 Y*	**0.031**	**0.02**	*0.200 Y*	*0.400 Y*	**1.2** PJ	**4**

Notes

U - Analyte was not detected at or above the reported result.

Y - The analyte is not detected at or above the reported concentration. The reporting limit is raised due to chromatographic interference. The Y flag is equivalent to the U flag with a raised reporting limit.

P - The analyte was detected on both chromatographic columns but the quantified values differ by >=40% RPD with no obvious chromatographic interference.

J - The analyte was detected above the reported quantitation limit, and the reported concentrations was an estimated value.

Detected concentrations are bolded.

Table 5 - RA-3 and RA-1 Groundwater Monitoring and Analytical Results

POS Terminal 5 Southwest Harbor
Phase II GWCMP SWHP

	Remediation Area 3 (former West Seattle Landfill and SSI Property), Remediation Area 1 (Former Buckley Yard)															
	Background				Confirmation Monitoring											
					Fill Aquifer								Estuarine Aquifer			
Sample Name	CMP5-081013	CMP5-090401	CMP5-090902	CMP5	CMP4-081014	CMP4-090402	CMP4-090903	CMP4	MW308N-081013	MW308N-090402	MW308N-090904	MW308N	MW308S-081013	MW308S-090401	MW308S-090904	MW308S
Sampling Date	10/13/08	4/1/09	9/2/09	6/3/10	10/14/08	4/2/09	9/3/09	6/2/10	10/13/08	4/2/09	9/4/09	6/3/10	10/13/08	4/1/09	9/4/09	6/3/10
Groundwater Level Measurements																
Reference Elevation in feet MLLW	23.80	23.80	23.80	23.80	19.92	19.92	19.92	19.92	14.86	14.86	14.86	14.86	14.42	14.42	14.42	14.42
Depth To Water in feet	10.09	8.48	10.12	8.71	11.04	10.34	11.01	10.17	6.53	5.86	6.50	5.73	6.30	5.74	6.17	5.56
Water Level Elevation in feet MLLW	13.71	15.32	13.68	15.09	8.88	9.58	8.91	9.75	8.33	9.00	8.36	9.13	8.12	8.68	8.25	8.86
Water Quality Field Parameters																
Temperature in degrees Celsius	16	11.2	16.8	13.4	17.1	12.6	17	14.2	16.8	12.3	16.3	13.8	15	12.9	14.5	13.7
pH	6.73	6.05	6.05	6.4	7.7	6.14	8.13	6.47	7.59	6.45	6.55	7.08	8.11	7.13	7.08	7.79
Conductivity in µS/cm	358	480	509	228	440	619	771	472	1586	1712	2509	959	15230	1565	1541	13000
Dissolved Oxygen in mg/L	0.07	0.32	0.44	0.15	0.25	0.74	0.19	0.73	0.02	0.05	0.23	0.03	0.03	0.08	0.11	0.03
Turbidity in NTUs	0.81	4.11	6.98	0	0.98	0.83	2.75	23	12.7	8.62	11.2	0	2.13	1.1	1.51	0
Total Petroleum Hydrocarbons																
Diesel Range in µg/L	250 U	250 U	250 U	100 U	250 U	250 U	250 U	100 U	250 U	250 U	250 U	100 U	250 U	250 U	250 U	100 U
Motor Oil Range in µg/L	500 U	500 U	500 U	200 U	500 U	500 U	500 U	200 U	500 U	500 U	500 U	200 U	500 U	500 U	500 U	200 U
Total Metals by EPA Method 200.8																
Total arsenic, inorganic in µg/L	**14.2**	**1.9**	**12.9**	**3.6**	**2.8**	**1.1**	**3.8**	**1.4**	**25.4**	**16.8**	**15.3**	**16.2**	**8**	**3**	**3**	2 U
Total lead in µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	**1**	1 U	1 U	1 U	1 U	5 U	5 U	5 U	5 U
Carcinogenic Polycyclic Aromatic Hydrocarbons (cPAHs) by Method 8270D-SIM																
Benz(a)anthracene in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Benzo(a)pyrene in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Benzo(b)fluoranthene in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Benzo(k)fluoranthene in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Chrysene in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Dibenzo(a,h)anthracene in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Indeno(1,2,3-cd)pyrene in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Semi-Volatile Organics by EPA Method 8270D																
bis(2-ethylhexyl) phthalate in µg/L	1.0 U	**23**	1 U	1.0 U	1.0 U	1.0 U	1 U	**2.4**	1.0 U	**1.1**	1.0 U	1.0 U	**1.5**	**5**	1.0 U	1.0 U
Polychlorinated Biphenyls (PCBs) by EPA Method 8082																
Aroclor 1016 in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Aroclor 1221 in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Aroclor 1232 in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.015 Y	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Aroclor 1242 in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	**0.013**	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	**0.010**	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Aroclor 1248 in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	**0.017**	**0.025**	**0.014**	0.010 U	0.010 U	**0.020**	0.010 U	0.010 U	0.010 U	0.010 U
Aroclor 1254 in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	**0.02**	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Aroclor 1260 in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Total PCBs in µg/L	*0.010 U*	*0.010 U*	*0.010 U*	*0.010 U*	**0.013**	*0.010 U*	**0.017**	**0.045**	**0.014**	*0.015 Y*	**0.01**	**0.02**	*0.010 U*	*0.010 U*	*0.010 U*	*0.010 U*

Notes
U - Analyte was not detected at or above the reported result.
Y - The analyte is not detected at or above the reported concentration. The reporting limit is raised due to chromatographic interference. The Y flag is equivalent to the U flag with a raised reporting limit.
Detected concentrations are bolded.

Table 6 - RA-5 Groundwater Monitoring and Analytical Results

POS Terminal 5 Southwest Harbor
Phase II GWCMP SWHP

	Remediation Area 5 (former Lockheed Shipyard 2)															
	Background				Confirmation Monitoring											
	Fill Aquifer															
Sample Name	CMP5-081013	CMP5-090401	CMP5-090902	CMP5	CMP15-081014	CMP15-090402	CMP15-090903	CMP15	MW26R-081014	MW26R-081014D	MW26R-090401	MW26R-090401D	MW26R-090903	MW26R-090903D	MW26R	MW26RD
Sampling Date	10/13/08	4/1/09	9/2/09	6/3/10	10/14/08	4/2/09	9/3/09	6/3/10	10/14/08	10/14/08	4/1/09	4/1/09	9/3/09	9/3/09	6/4/10	6/4/10
Groundwater Level Measurements																
Reference Elevation in feet MLLW	23.80	23.80	23.80	23.80	18.42	18.42	18.42	18.42	18.27		18.27		18.27		18.27	
Depth To Water in feet	10.09	8.48	10.12	8.71	10.38	9.91	10.14	9.75	9.91		9.66		9.69		9.40	
Water Level Elevation in feet MLLW	13.71	15.32	13.68	15.09	8.04	8.51	8.28	8.67	8.36		8.61		8.58		8.87	
Water Quality Field Parameters																
Temperature in degrees Celsius	16	11.2	16.8	13.4	17.7	13.2	15.9	14.2	16.9		12.3		15.4		14.2	
pH	6.73	6.05	6.05	6.4	6.88	6.69	6.39	6.64	7.29		6.43		7.14		6.86	
Conductivity in µS/cm	358	480	509	228	2336	7059	3547	6920	10190		1198		1043		9600	
Dissolved Oxygen in mg/L	0.07	0.32	0.44	0.15	0.008	0.1	0.36	0.05	0.11		0.22		0.15		0.05	
Turbidity in NTUs	0.81	4.11	6.98	0	1.12	0.73	1.78	0	0.94		0.93		1.91		11	
Total Petroleum Hydrocarbons																
Diesel Range in µg/L	250 U	250 U	250 U	250 U	250 U	250 U	250 U	100 U	250 U	250 U	250 U	250 U	250 U	250 U	100 U	100 U
Motor Oil Range in µg/L	500 U	500 U	500 U	500 U	500 U	500 U	500 U	200 U	500 U	500 U	500 U	500 U	500 U	500 U	200 U	200 U
Total Metals by EPA Method 200.8																
Total antimony in µg/L	**14.2**	**1.9**	**12.9**	**3.6**	0.2 U	0.5 U	0.2 U	0.2 U	0.2 U	0.2 U	1 U	1 U	1 U	1 U	1 U	1 U
Total arsenic, inorganic in µg/L					**1**	**1**	**0.9**	0.5 U	2 U	**3**	2 U	2 U	2 U	2 U	2 U	2 U
Total chromium (total) in µg/L					1 U	1 U	2 U	0.5 U	2 U	**3**	**3**	**3**	**3**	**3**	**3**	**4**
Total copper in µg/L					**0.8**	1 U	0.5 U	**0.7**	2 U	2 U	2 U	2 U	**3**	**3**	2 U	**3**
Total lead in µg/L	1 U	1 U	1 U	1 U	1 U	2 U	1 U	1 U	1 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Total nickel soluble salts in µg/L					**1**	**4**	**2**	**5.6**	**6**	**7**	**6**	**7**	**7**	**6**	**6**	**6**
Carcinogenic Polycyclic Aromatic Hydrocarbons (cPAHs) by Method 8270D-SIM																
Benz(a)anthracene in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	**0.025**	**0.024**	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Benzo(a)pyrene in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	**0.011**	0.010 U	0.010 U	0.010 U	0.010 U
Benzo(b)fluoranthene in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	**0.018**	0.010 U	0.010 U	0.010 U	0.010 U
Benzo(k)fluoranthene in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	**0.016**	0.010 U	0.010 U	0.010 U	0.010 U
Chrysene in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	**0.027**	**0.026**	**0.011**	**0.022**	**0.013**	**0.013**	**0.014**	**0.014**
Dibenzo(a,h)anthracene in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Indeno(1,2,3-cd)pyrene in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Semi-Volatile Organics by EPA Method 8270D																
bis(2-ethylhexyl) phthalate in µg/L	1.0 U	**23**	1.0 U	1.0 U	1.0 U	1 U	**1.6**	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
Polychlorinated Biphenyls (PCBs) by EPA Method 8082																
Aroclor 1016 in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Aroclor 1221 in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Aroclor 1232 in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Aroclor 1242 in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Aroclor 1248 in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Aroclor 1254 in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.018 Y	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Aroclor 1260 in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Total PCBs in µg/L	*0.010 U*	*0.010 U*	*0.010 U*	*0.010 U*	*0.010 U*	*0.010 U*	*0.010 U*	*0.010 U*	*0.010 U*	*0.010 U*	*0.010 U*	*0.010 U*	*0.010 U*	*0.010 U*	*0.010 U*	*0.010 U*

U - Analyte was not detected at or above the reported result.

Y - The analyte is not detected at or above the reported concentration. The reporting limit is raised due to chromatographic interference. The Y flag is equivalent to the U flag with a raised reporting limit.

NA = Not available.

Detected concentrations are bolded.

Table 6 - RA-5 Groundwater Monitoring and Analytical Results

POS Terminal 5 Southwest Harbor
Phase II GWCMP SWHP

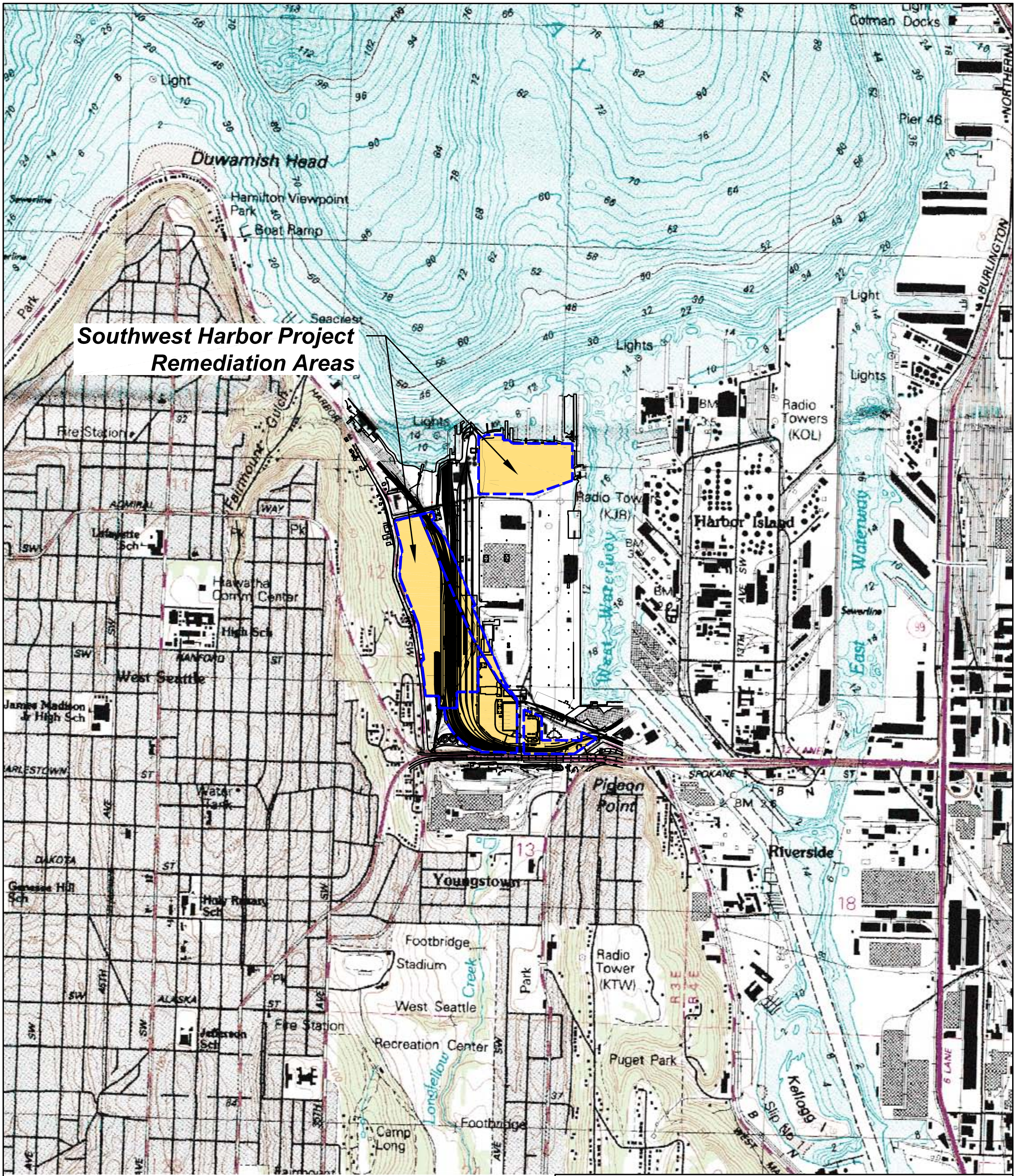
	Remediation Area 5 (former Lockheed Shipyard 2)							
	Confirmation Monitoring							
	Estuarine Aquifer							
Sample Name	MW36-081014	MW36-090402	MW36-090903	MW36	MW44-081014	MW44-090401	MW44-090903	MW44
Sampling Date	10/14/08	4/2/09	9/3/09	6/2/10	10/14/08	4/1/09	9/3/09	6/2/10
Groundwater Level Measurements								
Reference Elevation in feet MLLW	17.60	17.60	17.60	17.60	18.38	18.38	18.38	18.38
Depth To Water in feet	10.00	9.06	9.72	9.31	10.90	8.94	11.46	8.94
Water Level Elevation in feet MLLW	7.60	8.54	7.88	8.29	7.48	9.44	6.92	9.44
Water Quality Field Parameters								
Temperature in degrees Celsius	14.6	12.4	13.9	14.7	15.3	11.5	14	14.9
pH	7.47	6.48	8.78	7.43	7.23	6.42	5.84	5.94
Conductivity in µS/cm	36200	3734	3812	40000	41	46	37	11
Dissolved Oxygen in mg/L	0.06	0.11	0.13	0.08	1.59	7.25	3.84	6.88
Turbidity in NTUs	1.02	0.84	1.83	5	3.21	7.33	3.26	NA
Total Petroleum Hydrocarbons								
Diesel Range in µg/L	250 U	250 U	250 U	100 U	250 U	250 U	250 U	100 U
Motor Oil Range in µg/L	500 U	500 U	500 U	200 U	500 U	500 U	500 U	**530**
Total Metals by EPA Method 200.8								
Total antimony in µg/L	5 U	2 U	2 U	2 U	0.2 U	**0.6**	**0.3**	**0.4**
Total arsenic, inorganic in µg/L	**6**	**7**	**6**	5 U	**0.5**	**0.8**	**0.3**	**0.8**
Total chromium (total) in µg/L	10 U	5 U	5 U	5 U	1 U	**11**	**3.4**	**7.8**
Total copper in µg/L	*10 U*	*5 U*	*5 U*	5 U	**7**	**18**	**6.4**	**15.5**
Total lead in µg/L	*20 U*	*10 U*	*10 U*	10 U	**4**	**33**	**4**	**21**
Total nickel soluble salts in µg/L	*10 U*	**9**	**12**	**12**	**2**	**4.3**	**1.4**	**3.8**
Carcinogenic Polycyclic Aromatic Hydrocarbons (cPAHs) by Method 8270D-SIM								
Benz(a)anthracene in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	**0.059**	0.010 U	**0.033**
Benzo(a)pyrene in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	**0.11**	0.010 U	**0.054**
Benzo(b)fluoranthene in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	**0.27**	**0.010**	**0.079**
Benzo(k)fluoranthene in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	**0.14**	0.010 U	**0.079**
Chrysene in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	**0.19**	0.010 U	**0.13**
Dibenzo(a,h)anthracene in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	**0.035**	0.010 U	**0.023**
Indeno(1,2,3-cd)pyrene in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	**0.11**	0.010 U	**0.063**
Semi-Volatile Organics by EPA Method 8270D								
bis(2-ethylhexyl) phthalate in µg/L	1.0 U	1.0 U	1.0 U	**1.5**	**1.0**	**2.2**	1.0 U	**2.4**
Polychlorinated Biphenyls (PCBs) by EPA Method 8082								
Aroclor 1016 in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Aroclor 1221 in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Aroclor 1232 in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.015 Y	0.010 U	0.010 U
Aroclor 1242 in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Aroclor 1248 in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Aroclor 1254 in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Aroclor 1260 in µg/L	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Total PCBs in µg/L	*0.010 U*	*0.010 U*	*0.010 U*	*0.010 U*	*0.010 U*	*0.010 U*	*0.010 U*	*0.010 U*

U - Analyte was not detected at or above the reported result.

Y - The analyte is not detected at or above the reported concentration. The reporting limit is raised due to chromatographic interference. The Y flag is equivalent to the U flag with a raised reporting limit.

NA = Not available.

Detected concentrations are bolded.



Source: Base map prepared from USGS Topographic 7.5-Minute Series Map, Seattle South Quadrangle. Linework from drawing "990106-01.dwg," produced by Aspect Consulting.

N

0 2000 4000

Scale in Feet

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Seattle, Washington

Vicinity Map

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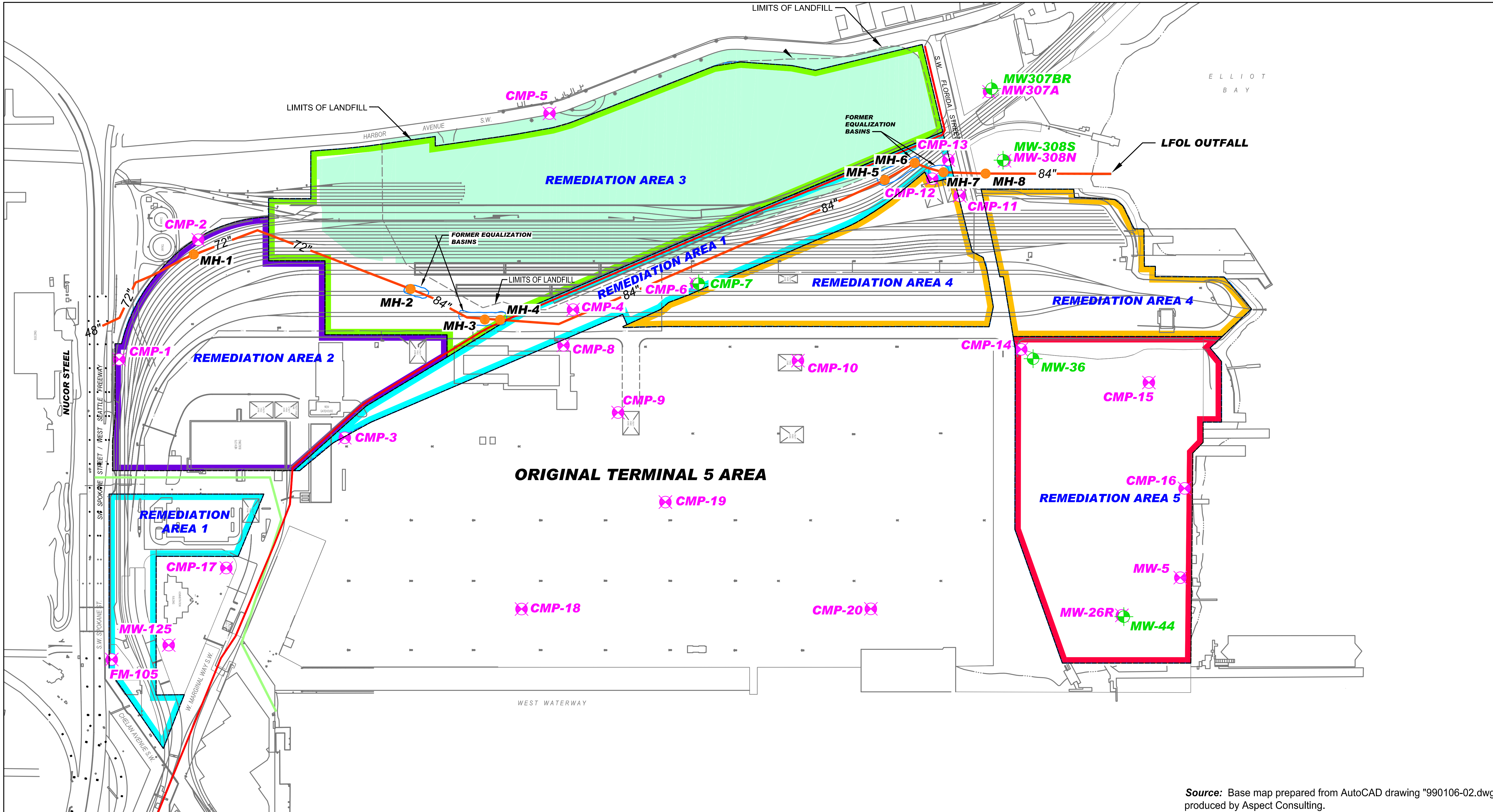
HARTCROWSER

Figure

1

EAL 08/17/10 1762700-001.dwg



Source: Base map prepared from AutoCAD drawing "990106-02.dwg," produced by Aspect Consulting.

CMP-1	Fill Aquifer Well
MW-36	Estuarine Aquifer Well
	Longfellow Creek Main Line
72"	Longfellow Creek Overflow Line (LFOL) w/ Pipe Diameter
MH-1	Existing LFOL Manhole
	Remediation Area 1 Boundary
	Remediation Area 2 Boundary
	Remediation Area 3 Boundary
	Remediation Area 4 Boundary
	Remediation Area 5 Boundary
	Landfill Cap (geomembrane)

N

0 400 800

Scale in Feet

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Seattle, Washington

Site Plan

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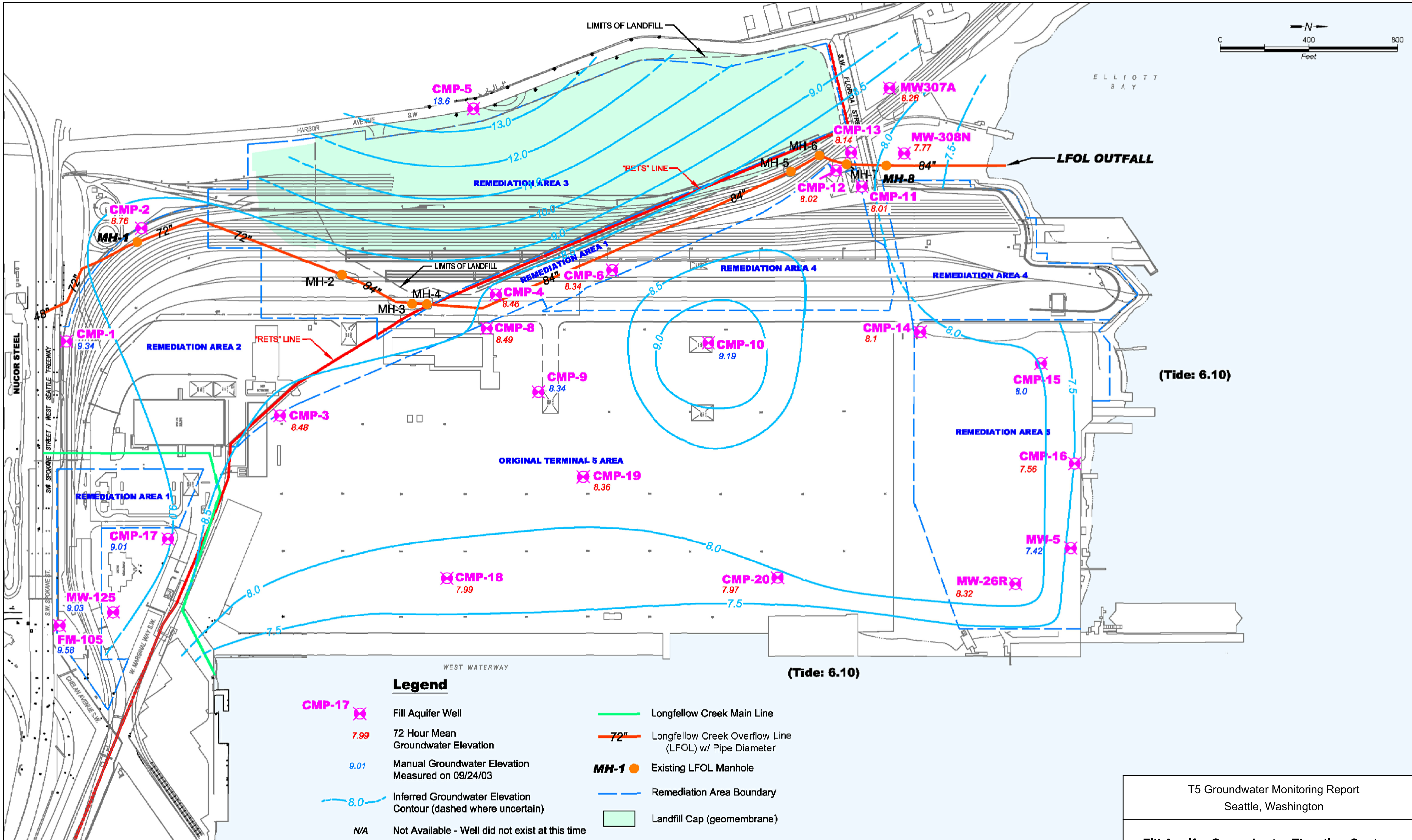
Figure **2**

EAL 08/17/10 1762700-002.dwg



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Fill Aquifer Groundwater Elevation Contours
72 Hour Mean 09-24-03

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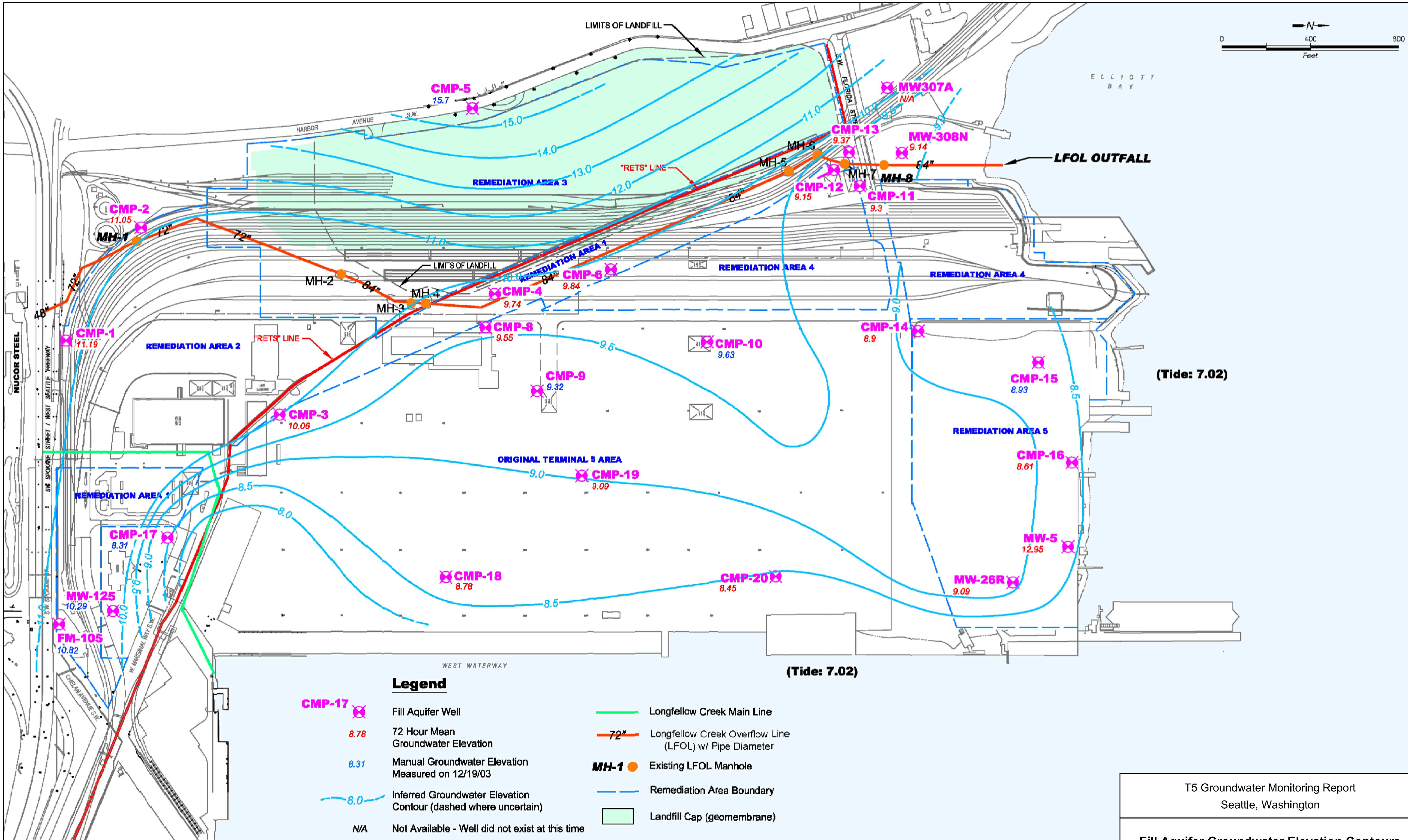
Figure
3

Source: Aspect Consulting, LLC, 2007a. Southwest Harbor Project, Phase I Groundwater Confirmation Monitoring Program, Hydrologic Characterization Report, Bainbridge Island, Washington. January 18, 2007.

EAL 09/22/10 1762700-006.dwg



T5 Groundwater Monitoring Report
Seattle, Washington

Fill Aquifer Groundwater Elevation Contours
72 Hour Mean 12-19-03

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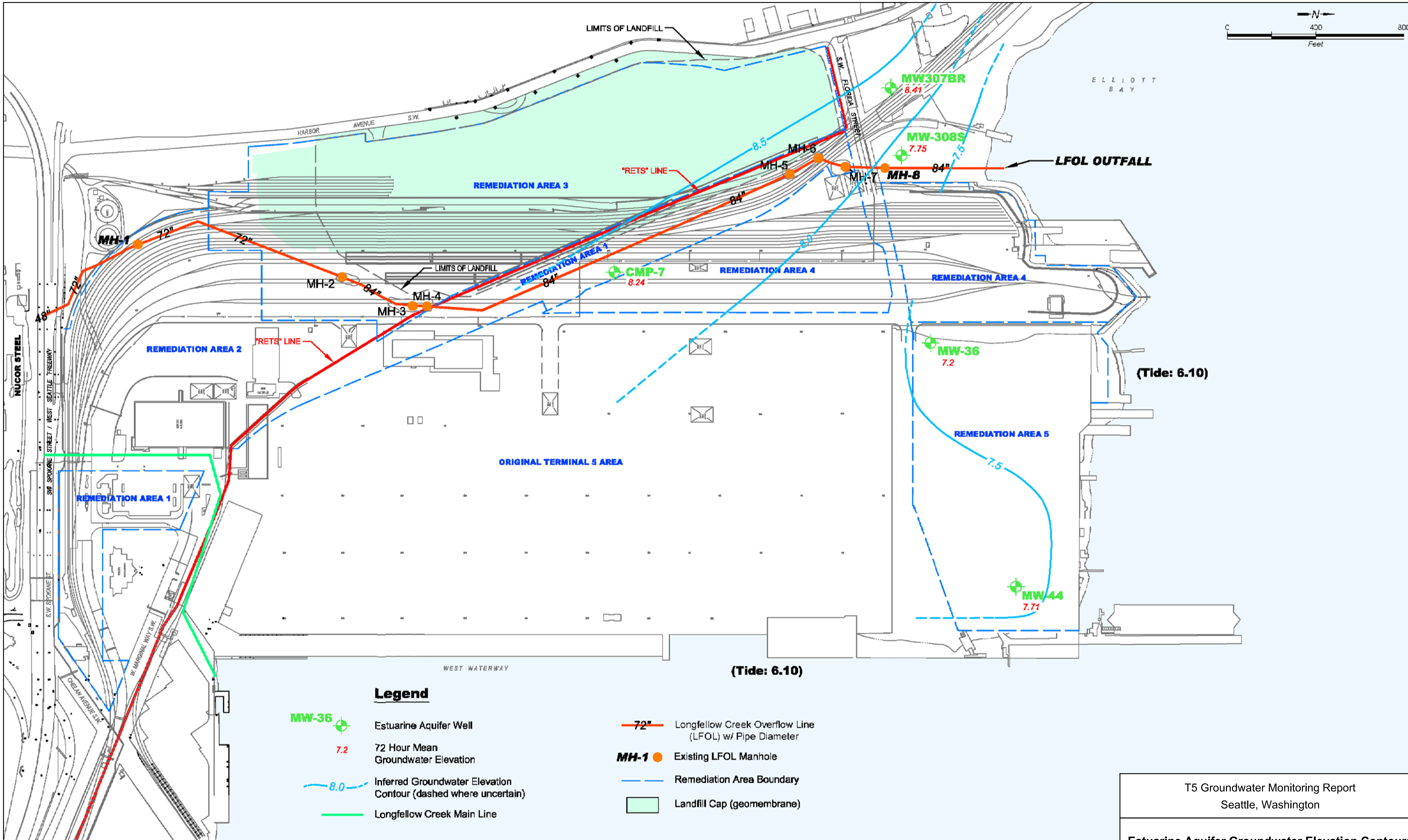
HARTCROWSER

Figure
4

Source: Aspect Consulting, LLC, 2007a. Southwest Harbor Project, Phase I Groundwater Confirmation Monitoring Program, Hydrologic Characterization Report, Bainbridge Island, Washington. January 18, 2007.

EAL 09/22/10 1762700-007.dwg



Source: Aspect Consulting, LLC, 2007a. Southwest Harbor Project, Phase I Groundwater Confirmation Monitoring Program, Hydrologic Characterization Report, Bainbridge Island, Washington. January 18, 2007.

T5 Groundwater Monitoring Report
Seattle, Washington

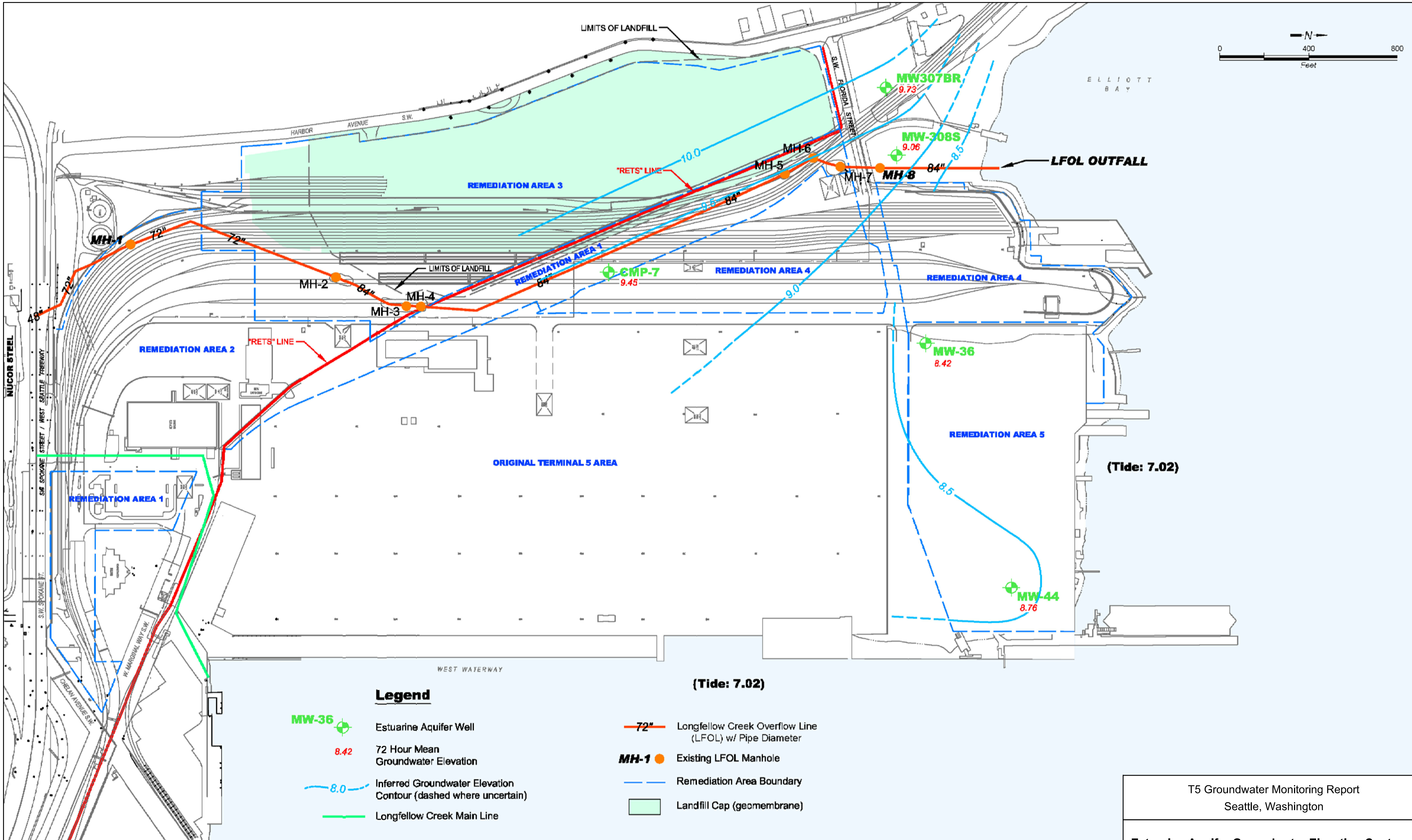
Estuarine Aquifer Groundwater Elevation Contours
72 Hour Mean 09-24-03

17627-00 9/10

HARTCROWSER

Figure **5**

EAL 09/22/10 1762700-008.dwg



T5 Groundwater Monitoring Report
Seattle, Washington

Estuarine Aquifer Groundwater Elevation Contours
72 Hour Mean 12-19-03

17627-00 9/10

HARTCROWSER

Figure **6**

Source: Aspect Consulting, LLC, 2007a. Southwest Harbor Project, Phase I Groundwater Confirmation Monitoring Program, Hydrologic Characterization Report, Bainbridge Island, Washington. January 18, 2007.

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APPENDIX A
EVALUATION OF GROUNDWATER CHEMICAL CONCENTRATIONS PROTECTIVE OF SURFACE WATER

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EVALUATION OF GROUNDWATER CHEMICAL CONCENTRATIONS PROTECTIVE OF SURFACE WATER

This Appendix presents our evaluation to determine groundwater chemical concentrations that would be protective of surface water for the Phase II Southwest Harbor Project (SWHP) located at the Southwest Harbor Terminal 5 (Terminal 5) in Seattle, Washington. The protectiveness of current groundwater chemical concentrations was assessed by modeling natural attenuation of chemical constituents. The purpose of modeling natural attenuation is to supplement the Groundwater Confirmation Monitoring Program and to determine if chemicals detected in groundwater are naturally attenuated to concentrations below surface water quality criteria prior to discharge to Puget Sound marine water.

GROUNDWATER CHEMICAL CONDITIONS

Groundwater quality data was obtained from four rounds of groundwater data collected from 14 wells between 2008 and 2010 as part of the confirmational groundwater monitoring program. Monitoring well locations for the program are presented on Figure 1 and are summarized below:

- Four background monitoring wells are screened in the Fill Aquifer (FM-105, CMP-1, CMP-2, and CMP-5);

- Seven downgradient monitoring wells are screened in the Fill Aquifer (CMP-3, CMP-4, CMP-15, CM-17, MW-26R and MW-125, and MW-308N); and

- Three downgradient monitoring wells are screened in the Estuarine Aquifer (MW-36, MW-44, and MW-308S).

Identification of Constituents of Potential Concern

A compilation of Terminal 5 groundwater quality data was reviewed to identify constituents of potential concern (COPCs). COPCs for groundwater were identified using a three-step procedure summarized below:

- Step 1 - Screening levels were developed for chemicals analyzed as part of the Terminal 5 Long-Term Monitoring Program. Screening levels for individual chemicals were defined as the most conservative of the marine surface water quality criteria taken from Washington State Department of Ecology's Cleanup Levels and Risk Calculation (CLARC) database. Groundwater quality criteria were not evaluated since the highest beneficial use for groundwater at the site is discharge to surface water. The screening levels were intended to identify COPCs and should not be considered cleanup levels or standards. The screening levels for Terminal 5 are presented in Table 1.

- Step 2 - Terminal 5 groundwater quality data collected as part of the groundwater confirmation monitoring program were reviewed to identify the chemicals detected in groundwater samples. Table 2 presents a general statistical summary of groundwater analytes and results from the Terminal 5 groundwater confirmation monitoring program compared to potentially applicable surface water quality criteria.

- Step 3 - Groundwater quality data was compared to the screening levels. A well-by-well comparison of groundwater concentrations with the screening criteria is presented in Table 3.

Groundwater Screening Process

Validated groundwater sample analytical results were compared to the most conservative surface water quality criteria to identify COPCs in groundwater at Terminal 5. Migration of upland groundwater has been identified as a potential pathway for dissolved chemicals to reach surface water. Surface water quality criteria used to screen the Terminal 5 groundwater chemical concentrations include:

- Water Quality Standards for Surface Waters of the State of Washington (Chapter 173-201A WAC);

- Clean Water Act 304 for Human Health and Chronic Aquatic Life;

- National Toxics Rule (40 CFR Part 131) for Human Health and Chronic Aquatic Life; and

- MTCA Method B carcinogen and non-carcinogen cleanup levels for surface water (WAC 173-340-730).

The published marine surface water criteria used to establish the surface water screening levels are presented in Table 1. The most conservative of these criteria for each constituent were established as the preliminary screening levels for groundwater modeling.

Groundwater Screening Results

Tables 2 and 3 present a summary of the results of groundwater comparing concentrations against the screening levels for COPCs at Terminal 5. Relatively few of the detected constituents exceed the screening levels. The analytes with one or more detections in monitoring wells, which exceed the screening levels include:

- Heavy oil-range petroleum hydrocarbons;
- Polychlorinated biphenyls (PCBs);
- Metals (arsenic, copper, lead, and nickel);
- Carcinogenic polycyclic aromatic hydrocarbons (cPAHs);
- Bis(2-ethylhexyl) phthalate; and
- Tetrachlorethene (PCE).

Natural Attenuation of Dissolved Groundwater Chemicals

Natural attenuation refers to the reliance on natural processes to achieve site-specific cleanup goals (EPA, 1997). Natural attenuation occurs using the physical, chemical, and biological processes inherent within the aquifer that act to reduce the mass, toxicity, mobility, volume or concentration of contaminants in soil or groundwater. These processes can include biodegradation, dispersion, dilution, sorption, transformation, stabilization, and volatilization of the unwanted contaminants.

Biodegradation is degradation of chemicals by microbes within the soil matrix. The rate of and extent of microbial degradation of chemicals are complex and regulated by the chemical properties of the contaminant, soil and groundwater chemistry, and the microbial population present. Degradation rates are typically measured in terms of half-life. The half-life is the amount of time needed for one-half of the original contaminant mass to be degraded. The half life of the COPCs are presented in Table 4.

Dispersion refers to the process whereby a plume will spread out in a longitudinal direction (along the direction of groundwater flow), transversely (perpendicular to groundwater flow), and vertically downwards due to mechanical mixing in the aquifer and chemical diffusion. Dispersion is usually estimated rather than measured, given the impracticability of measuring dispersion in the field. Dispersion is usually estimated based on the length of the plume or distance to the measurement point. Researchers indicate that dispersion values can range over two to three orders of magnitude for a given value of plume length or distance to a measurement point (Gelhar et al., 1992).

Tidal dilution is mixing of chemicals in groundwater that occurs as the result of changes in gradient during tidal changes. Groundwater will mix with tidal inflows during rising tides. The outflow during a falling tide consists of a mixture of tidal inflow and groundwater. The amount of tidal dilution is a function of the relative range in tidal stage and the aquifer properties. Tidal dilution factors ranging from 4 to 10,000 have been reported from groundwater modeling at Terminal 5 and adjacent sites (Aspect 2007; S. S. Papadopulos & Associates 1997).

Most organic chemicals are removed from solution by sorption onto soil particles. Sorption of dissolved contamination onto the aquifer matrix results in slowing or retardation of the contaminant relative to advective groundwater flow velocity and a reduction in dissolved contaminant concentrations. Sorption is generally represented in fate and transport models using a retardation factor. The retardation factor is the rate at which dissolved contaminants moving through an aquifer are reduced by sorption of contaminants to the solid aquifer matrix. The degree of retardation depends on both aquifer and constituent properties. The retardation factor is the ratio of the groundwater seepage velocity to the rate that organic chemicals migrate in the groundwater. A retardation value of two indicates that if the groundwater seepage velocity is 100 feet/year, then the organic chemicals migrate at approximately 50 feet/yr.

FATE AND TRANSPORT MODELING

A fate and transport model was implemented to evaluate the potential for existing upland groundwater to exceed the screening criteria at the point of compliance (surface water). The selected fate and transport model, BIOSCREEN (EPA 1996), is based on the Domenico analytical solution (Domenico 1987), and was used to estimate the natural attenuation of COPCs between downgradient monitoring wells and the surface water/sediment interface. BIOSCREEN uses the following assumptions:

- Uniform and constant aquifer properties;
- One-dimensional groundwater flow;
- First-order decay, degradation, or transformation of contaminants; and
- Constant source area and concentrations.

The model predicts maximum groundwater concentrations in the centerline of the groundwater chemical plume to the receptor (Elliott Bay and Duwamish Waterway). The model was evaluated using the following conditions:

- Steady-state conditions without biodegradation;
- Assumed dispersion in the longitudinal, transverse, and vertical directions,
- Equilibrium partitioning and adsorption of COPCs to the aquifer soil matrix; and
- The minimum distance from the monitoring well to the surface water was used for the distance to the receptor.

Model Input Parameters

Model input parameters are summarized in Table 4.

Arsenic attenuation was not modeled since it is ubiquitous throughout the region. Background monitoring wells have arsenic concentrations ranging from 0.4 to 23.2 micrograms per liter (ug/L) and the downgradient wells have arsenic concentrations ranging from 0.3 to 25.4 ug/L.

The model represents the contaminant source as a vertical plane, perpendicular to groundwater flow, releasing dissolved constituents into groundwater passing through this plane. The source is assumed to have existed for a period of 100 years, with source zone concentrations set to equal measured chemical concentrations in the groundwater wells. Concentrations used for modeling were conservatively set to equal the maximum measured concentration at each well location.

The groundwater flow and velocity are defined by the hydraulic conductivity, hydraulic gradient, and porosity. Hydrogeologic and aquifer characteristics were obtained from the fate and transport analysis in the Upland Remedial Investigation and Feasibility Study report (RETEC 1997) and Marine Sediments

Remedial Investigation and Marine Sediments Feasibility Study (Weston 1998a and 1998b, respectively).

Biodegradation was not used in modeling. For references purposes, biodegradation half life values presented in Table 4 were taken from Howard, 1991.

The soil bulk density, in kg/L, of the aquifer matrix is related to porosity and pure solids density. Although this value can be measured in the lab, in most cases estimated values are used. A default value of 1.7 kg/L was used.

Fraction organic carbon (foc) is the fraction of the aquifer soil matrix comprised of natural organic carbon. More natural organic carbon typically means higher adsorption of organic constituents on the aquifer matrix. Typical values of foc are 0.002 to 0.02. A value of 0.01 was used for this study as this is a representative value for site soil based on RETEC (1997) and WESTON (1998a and 1998b). Other chemical properties (e.g., organic carbon partition coefficient) were obtained through Ecology's CLARC database.

The model was used to predict the chemical concentration at the receptor which was considered to be at the groundwater/surface water interface. The distance to the receptor was measured on the site map from the well to the closest shoreline following the groundwater flow path based on the groundwater contour maps provided in Aspect (2007). A simulation time of 100 years was considered a sufficient amount of time for the COPCs to potentially reach the surface water.

Two modeling runs were performed using: (1) a maximum concentration of the COPCs for each well from groundwater quality database (Hart Crowser 2010) as a baseline case; and (2) solubility concentrations for the COPCs for each well (solubility case). The solubility case is considered to be the worst-case scenario assuming that NAPL phase was present. There is no evidence that NAPL phase is present at Terminal 5.

Modeling Results

The model results are summarized in Table 5. The model results predict that for the baseline case using the maximum chemical concentrations detected in each well, the COPC concentrations will not reach marine surface water after 100 years except for tetrachloroethene (PCE) from MW-125 and copper from MW-26R and MW-44.

The model predicts the PCE from MW-125 will reach the shoreline at a concentration in the Fill Aquifer of 1.9 ug/L (0.0019 mg/L), which is slightly above the screening criteria of 0.39 ug/L (0.00039 mg/L). If PCE degradation is incorporated into the model, concentrations at the shoreline after 100 years would be non-detect.

The model also predicts that copper from MW-26R and MW-44 will reach the shoreline at concentrations less than 0.1 ug/L (0.0001 mg/L), which is below the screening criteria of 2.4 ug/L (0.0024 mg/L).

For organic compounds, using the solubility limit as a worst-case scenario, the model results predict the COPC concentrations will be non-detect at the surface water after 100 years, except for PCE. Given that the aqueous solubility of PCE is relatively high (200 mg/L), the predicted concentration using the solubility limit model is well above surface water criteria. This scenario assumes that PCE in the form of dense non-aqueous phase liquid (DNAPL) is present. However, the relatively low dissolved PCE concentrations observed in both upgradient and site wells do not indicate the presence of DNAPL at Terminal 5 making the solubility scenario unrealistic. If PCE degradation is incorporated into the model, concentrations at the shoreline after 100 years would be non-detect.

Solubility values for metals were not provided in the CLARC database; therefore, the metals were not modeled for the solubility case.

Tidal Mixing

Tidal mixing, while not incorporated into the model, would further reduce chemical concentrations in groundwater prior to discharge to surface water. As discussed earlier, groundwater will mix with tidal inflows during rising tides. The outflow during a falling tide consists of a mixture of tidal inflow and groundwater. The amount of tidal mixing is a function of the relative range in tidal stage and the aquifer properties. Tidal dilution factors ranging from 4 to 10,000 have been reported from groundwater modeling at the Terminal 5 and adjacent sites (Aspect 2007; S. S. Papadopulos & Associates 1997). Use of the lowest tidal dilution estimate of four would further reduce the calculated chemical concentrations at the shoreline after 100 years by an additional factor of four times less than concentrations presented in Table 5.

SUMMARY AND CONCLUSIONS

- An evaluation was completed to determine if chemicals detected in groundwater at Terminal 5 are naturally attenuated to concentrations below marine surface water quality criteria prior to discharge to Puget Sound.

- Screening criteria based on marine surface water criteria were developed to compare against the groundwater quality data collected from Terminal 5. The screening criteria are presented in Table 1. The statistical summary of groundwater quality database and a comparison with the screening criteria are presented in Tables 2 and 3.

- Fate and transport modeling using BIOSCREEN was conducted to predict contaminant concentrations at the shoreline. The natural attenuation processes simulated in the modeling include dispersion and sorption. Processes not modeled included biodegradation and tidal mixing.

- The model results show that even under conservative conditions, predicted concentrations of most COPCs, including bis(2-ethylhexyl)phthalate, PAHs and PCBs detected in groundwater will not exceed the screening level concentrations at the shoreline within 100 years. For organic compounds, concentrations as high as the solubility limit would not result in an exceedance of surface water quality criteria at the shoreline.

- The model results show that even under the conservative conditions, predicted concentrations of copper and lead detected in groundwater will not exceed the screening level concentrations at the shoreline within 100 years. If tidal mixing is incorporated into the model, copper and lead concentrations four times higher than the maximum detected concentrations will not exceed the screening level concentrations at the shoreline within 100 years.

- PCE in monitoring well MW-125 is calculated to exceed surface water quality criteria within 100 years based on retardation modeling. If degradation half-life and tidal mixing are incorporated into the model, PCE concentrations will be non-detect at the shoreline after 100 years. Furthermore, the source of PCE is from off-site of Terminal 5. PCE is present in off-site, upgradient monitoring well FM-105 at concentrations comparable to those found in MW-125.

- Although not simulated during modeling, tidal mixing and biodegradation are important natural attenuation processes that would further reduce groundwater chemical concentrations at Terminal 5.

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There are 182 pages of Attachments and Appendices removed from this document for brevity.

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Appendix L
Shoreline Master Program Development Standards Compliance

SHORELINE MASTER PROGRAM DEVELOPMENT STANDARDS COMPLIANCE
TERMINAL 5 CARGO WHARF REHABILITATION AND BERTH DEEPENING (DPD PROJECT NO. 3019071)

Prepared for

Port of Seattle
2811 Alaskan Way
Seattle, Washington 98121

Prepared by

Anchor QEA, LLC
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December 2015

SHORELINE MASTER PROGRAM DEVELOPMENT STANDARDS COMPLIANCE

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December 2015

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List of Attachments

LIST OF ACRONYMS AND ABBREVIATIONS

1H:1.5V	1 horizontal to 1.5 vertical slope
ACZA	ammoniacal copper zinc arsenate
BMP	best management practice
cfs	cubic feet per second
City	City of Seattle
cm/s	centimeter per second
cy	cubic yard
DMMP	Dredged Materials Management Program
DNR	Department of Natural Resources
DPD	Department of Planning and Development
Ecology	Washington State Department of Ecology
EFH	Essential Fish Habitat
ESA	Endangered Species Act
GPS	Global Positioning System
LDW	Lower Duwamish Waterway
MHHW	mean higher high water
MLLW	mean lower low water
OHWM	ordinary high water mark
Port	Port of Seattle
Project	Terminal 5 Cargo Wharf Rehabilitation and Berth Deepening Project
SCL	Seattle City Light
SEPA	State Environmental Policy Act
SMC	Seattle Municipal Code
SMP	Shoreline Master Program
SPCC	Spill Prevention, Control, and Countermeasure
UI	Urban Industrial
USACE	U.S. Army Corps of Engineers

1 INTRODUCTION

The purpose of this report is to provide supplemental information as requested by the City of Seattle (City) Department of Planning and Development (DPD) for the Port of Seattle (Port) Terminal 5 Cargo Wharf Rehabilitation and Berth Deepening Project (Project; DPD Project No. 3019071). This report is intended to demonstrate Project compliance with the Shoreline Master Program (SMP) development standards and standards for the Urban Industrial (UI) shoreline environment in which the Project is located.

The following includes a Project description of the proposed activities occurring within the UI shoreline environment. Section 2 includes a description of property use and existing conditions. Per DPD Correction Notice No. 1, dated October 2, 2015, the following sections describe how the Project complies with the following Seattle Municipal Code (SMC) standards:

- **Section 3:** SMC 23.60A.152 – General development
- **Section 4:** SMC 23.60A.154 – Standards for archaeological and historic resources
- **Section 5:** SMC 23.60A.182 – Standards for dredging
- **Section 6:** SMC 23.60A 185 – Standards for grading, landfill and slope stabilization
- **Section 7:** SMC 23.60A.217 – Standards for utility lines
- **Section 8:** SMC 23.60A.158 – Standards for mitigation sequencing

Attachment 1 includes a comprehensive Plan Set. Attachment 2 includes the Dredged Materials Management Program (DMMP) April 21, 2015, Suitability Determination. Attachments 3 and 4 include the Biological Assessment and State Environmental Policy Act (SEPA) Checklist that were prepared in support of the Project and are referenced throughout this report.

1.1 Project Description

The Project consists of conducting modifications to existing container facilities, including cargo wharf rehabilitation, berth deepening, electrical service capacity improvements, and minor stormwater and water supply improvements (see Plan Set in Attachment 1). Upland improvements would occur on land owned by the Port. The proposed wharf and berth improvements would occur entirely within the existing built wharf area that is approximately 2,900 linear feet long by 100 feet wide, and the adjoining berth comprising the area from the eastward edge of the dock waterward 175 feet. The wharf and berth improvements are located within a publicly owned aquatic area controlled by the Department of Natural Resources (DNR) in southwest Elliott Bay. The Project activities occurring in the aquatic area immediately adjacent to the Terminal 5 cargo pier would be administered under Port Management Agreement No. 22-080031 and other authorizations as needed in coordination with DNR.

1.1.1 Demolition

The Project consists of demolishing a portion of the existing aged and deteriorating cargo wharf structure including the following: removing approximately 59,000 square feet of horizontal concrete container crane rail beams and cargo pier deck panels at the waterward margin of the wharf; removing approximately 87,000 square feet of asphalt paving, exposing the landward crane rail beam; removing the existing container wharf fender system and conflicting structural pile elements including extracting approximately 290 timber and steel fender piles, 38 timber pinch piles, and approximately 345 16.5-inch-diameter concrete structural piles.

1.1.2 Rehabilitation of the Existing Wharf

The existing 2,900-linear-foot cargo wharf would be rehabilitated to strengthen the structural elements of the wharf to accommodate cargo crane equipment required to serve super Post-Panamax container vessels. The elements of the proposed wharf rehabilitation are as follows.

1.1.2.1 Replacement Crane Rail Beams

Two stronger crane rail beams would replace the existing crane rail beams at the Terminal 5 wharf, including a replacement waterward crane rail beam supported by an increased-diameter structural concrete piling that would be installed within the footprint perimeter of the existing cargo wharf. A second replacement crane rail beam would be installed landward of the existing wharf. It should be noted that this landward crane rail beam is located in an existing upland area and does not include in-water construction. Replacing the waterward crane rail beam includes installing approximately

420 24-inch-diameter, pre-stressed concrete, octagonal piles driven into the subtidal aquatic area (-35 to -40 feet mean lower low water [MLLW]) beneath the existing Terminal 5 wharf. Concrete piles would be driven with an impact pile driver from a barge or landward crane. The new piling would support the new waterside crane rail beam. Replacing the landward crane rail beam includes installing approximately 420 24-inch-diameter steel pipe piles that would be driven as far as possible with a land-based vibratory driver, and then finished and proofed with an impact pile driver to support a sufficiently strong upland crane rail beam.

1.1.2.2 Slope Stabilization Measures

The slope beneath the Terminal 5 Wharf is steep—approximately a 1 horizontal to 1.5 vertical slope (1H:1.5V). Geotechnical investigations show that the lower portions of the slope beneath the existing terminal wharf require structural stabilization measures coincident with strengthening the cargo wharf and deepening the adjacent vessel berths. Slope stabilization techniques include installing up to 3,000, 10- to 14-inch-diameter untreated wooden piles, each approximately 60 feet long. These piles would penetrate the existing riprap slope, underlying select fill material, and native sediment layers. The timber piling would be installed using impact and vibratory pile drivers and would be installed flush with the ground to match the existing riprap elevation.

In addition, a short toe wall would be installed at the transition between the constructed riprap slope beneath the existing cargo wharf and the adjacent container vessel berth area to stabilize the bottom margin of the riprap-armored slope. Approximately 3,100 linear feet of combined steel sheet piling and "HZ" steel piling would be installed at the toe-of-slope. The top elevation of the new toe wall would vary between -42 and -50 feet MLLW. The toe wall steel sheet and HZ piling would be installed using a vibratory pile driver. Limited impact pile driving may be required to complete portions of toe wall piling if soil conditions impede vibratory pile driving.

1.1.2.3 Replacement Concrete Deck Structure

Existing concrete wharf deck panels, pile caps, and edge-of-wharf structures would be removed, allowing for replacement. The waterward crane rail beam area would be replaced with new concrete pile caps and panels within the existing wharf footprint. Approximately 20,000 cubic yards (cy) of concrete would be required to replace the deck and pile caps.

1.1.2.4 Repair and Replacement of Existing Concrete Piling Caps Beams

The existing wharf includes pile cap beams oriented east to west between the wharf crane rail beams that connect the above-water portions of structural piling and form a grid to support the wharf deck panel surface. Due to the age of the wharf, numerous sections of the cast-in-place pile cap beams have deteriorated and corroded. The Project includes repairing and maintaining failing pile cap beam sections, including removing spalled concrete and corroded reinforcing steel and installing replacement reinforcing steel and concrete grout. All pile cap beam repair and maintenance activities would take place in above-water portions of the underside of the existing wharf structure (i.e., no in-water work would occur).

1.1.2.5 Replacement Fender System

The existing treated wood piling and steel piling wharf fender system, totaling approximately 290 to 300 piles, would be removed and replaced with an alternative, panelized, above-water fender arrangement. The replacement fender elements would be spaced at approximately 60-foot intervals and no in-water work would occur. Up to 110 cy of clean sand fill would be applied as a protective layer in the subtidal aquatic area affected by removing treated wood fender piling. Forty-one 18-inch-diameter steel piles would be installed by vibratory pile driving methods in the middle of the berth at the end of the first in-water work season. The piling would be temporarily installed to allow barge and vessel moorage for the duration of the Project. A temporary fender piling would be removed prior to a new tenant occupying the facility.

1.1.3 Berth Deepening

Existing depths in the proposed dredge prism are between -47 and -55 feet MLLW. The Project includes deepening the Terminal 5 berth to a required depth of -55 feet MLLW to accommodate deeper draft cargo vessels. Dredging would also include allowance for 1-foot advanced maintenance dredging and up to 2 feet of overdredge allowance, for a maximum dredge depth of up to -58 feet MLLW and a total volume of approximately 51,000 cy. The area of disturbance is 290,000 square feet or approximately 6.6 acres. The overdredge allowance includes incidental excursions in isolated spots where the contractor might exceed allowable overdredge elevations due to unanticipated site and sea state conditions (e.g., unanticipated obstructions, high wind and/or wave condition, or survey inaccuracy). The effect of these incidental excursions on the overall dredge volumes and area are anticipated to be negligible. Proposed dredging for this Project is comparable to other berth deepening and terminal modernization projects, including the recent Georgia-Pacific Tacoma Marine Terminal Upgrade Project at the Port of Tacoma, which consists of increasing depths at its maintained berth by up to 13 feet (from -31 to -44 feet MLLW) by removing approximately 28,000 cy to accommodate larger vessels.

Disposal of dredged sediments would be consistent with the requirements of the DMMP, DNR, Washington State Department of Ecology (Ecology), U.S. Army Corps of Engineers (USACE), U.S. Environmental Protection Agency, and other agencies with jurisdiction. Based on the results of the previously described testing, the DMMP agencies concluded that all of the proposed dredged material is suitable for open-water disposal at the Elliott Bay non-dispersive disposal site (see DMMP Suitability Determination in Attachment 2).

1.1.4 Upgrade Electrical, Water, and Stormwater Systems

The Project includes maintaining or upgrading the electrical, water, and stormwater systems to accommodate the rehabilitated cargo wharf and to support ongoing operations. The work includes the following:

- Electrical supply and distribution would be upgraded for increased loads. Replacement primary substation equipment would be installed to provide electrical power sufficient for modern container crane equipment and associated cargo operations. A new 26 Megavolt-Ampere Primary Substation would be constructed to provide electrical power to the new cranes and associated terminal operations which may include cargo handling, marshalling, and refrigeration. Coordination with Seattle City Light (SCL) would provide power to the new Primary Substation from both the SCL Delridge Substation and the SCL South Substation.
- Up to four new electrical distribution substations would be constructed, serving container cranes and dock power and lighting systems. A new underground electrical duct bank would be constructed, connecting distribution elements. Distribution

vaults and trenches would be constructed, providing electrical power to container crane equipment. Heating and ventilation, as necessary, would be provided for electrical enclosures.

- The existing dockside water distribution system would be removed and replaced. A sectional distribution system would be provided and integrated with the existing looped water distribution system and existing fire hydrant layouts. Existing vessel water supply assemblies would be removed and replaced including water use metering code requirements.
- Stormwater treatment and improvements would be installed, as needed, to support operation of the new cargo wharf facility.
- Other utilities would be upgraded as needed to accommodate the Project.

2 PROPERTY USE AND EXISTING CONDITIONS

Existing shoreline conditions consist of previously developed industrial areas and include over-water, pile-supported wharves, fenders, riprap slopes, seawalls, and bulkheads associated with marine industrial and commercial use. The majority of the shoreline in the vicinity of the Project area contains over-water wharves located above riprap slopes. Dredging and development since the early 1900s substantially altered nearshore environments in the Duwamish West Waterway. Upland areas are entirely paved with asphalt. All of the original habitat in the Project area has been either filled or dredged and is highly modified from its original delta condition. There is no remaining tidal marsh, mudflat, emergent vegetation, or riparian vegetation in or adjacent to the Project area.

The Project is located at the Port's Terminal 5, which is currently used as a heavy industrial marine cargo terminal. The terminal includes 2,900 linear feet of wharf structure and adjacent deep draft vessel berth areas along the West Waterway. The wharf currently supports container cranes, cargo marshalling areas, and intermodal rail/ship cargo transfer facilities. The entire Project area is built out and committed to water-dependent, marine industrial use. The principal water-dependent industrial use at the Project area consists of transshipment of container and bulk cargo.

The Project area contains numerous accessory cargo use and maintenance and repair structures, totaling over 231,000 square feet, and currently provides 585 parking spaces. The cargo pier consists of a concrete deck approximately 110 feet in width that is supported by a structural concrete piling arranged in bents that were installed perpendicular to the shoreline, with approximately 20 feet separating each concrete structural piling bent. Each bent consists of 11 to 13, 18-inch-diameter, octagonal concrete structural piles. The concrete structural piles are placed in a riprap embankment that, constructed at an approximately 1.5H:1V slope, extends from approximately -50 feet MLLW at the waterward margin of the container pier (the vessel berth area) to a top of slope elevation of approximately +11 feet MLLW. The west margin (upland edge) of the under-pier area consists of a vertical steel and concrete bulkhead with a toe elevation of approximately +11 feet MLLW.

The waterward margin of the cargo pier at Terminal 5 includes a fender system that serves as a compression buffer to protect vessels moored at the Project area and prevent damage to the concrete pier structure. The Terminal 5 fender system includes the following three fender arrangements:

1. Approximately 75% of the Terminal 5 container pier (approximately 2,300 linear feet comprising the center portion of the pier) is fitted with ammoniacal copper zinc arsenate (ACZA) fender piles spaced approximately 10 feet apart. The ACZA fender piles are supplemented with unit fenders at intervals of 100 feet. The unit fenders consist of cylindrical rubber bladders approximately 12 feet long and 3 feet in diameter.
2. Approximately 450 linear feet at the north end of the container pier is protected by steel pipe piles and rubber unit fenders. The steel pipe piles are approximately 18 inches in diameter and spaced approximately 20 feet apart. The steel fender piles are coated with ultra-high-molecular-weight polyethylene plastic for protection from abrasion. The unit fenders in this area of the dock are larger, approximately 12 feet long and 6 feet in diameter, and are spaced approximately 80 feet apart.
3. The south 200 linear feet of the cargo pier is protected with creosote fender piles spaced 10 feet apart.

2.1 Habitat Conditions

Aquatic areas at Terminal 5 are composed of intertidal and subtidal habitats. The seabed in the intertidal zone is composed of a 1.5H:1V riprap slope located entirely beneath the existing wharf. Subtidal seabed habitat is also composed of riprap and continues at a similar slope to approximately -50 feet MLLW, which is coincident with the edge of wharf and the beginning of the berth. The riprap slopes, structural piling, subtidal and intertidal retaining walls, and fender systems provide substrate for algae and sessile invertebrates. The riprap on the slopes, and the interstices of the riprap revetment also provide habitat for algae (e.g., sea lettuce [*Ulva lactuca*] and rockweed [*Fucus gardneri*]) and sessile invertebrates (e.g., anemones [*Metridium* spp.] and barnacles [*Balanus glandula*]). At -50 feet MLLW, the slope ends are replaced by gently sloping (less than 3 degrees of slope) bottom sediments in the waterway, Some estuarine and marine fish and subtidal marine invertebrates inhabit and feed at deeper subtidal elevations within the Project area. Very little light penetration occurs under the wharf within this portion of the intertidal and subtidal zones, so primary and secondary production is low.

Offshore of the wharf in the berth area, subtidal habitats are less steep and elevations range between -47 and -55 feet MLLW. Bathymetric data show that subtidal areas below about -52 feet MLLW tend to be isolated pockets. The berth area transitions from a steep slope underneath the wharf to a generally flatter berth that grades into the navigation channel. Elevations in the center of the channel range from approximately -60 to -70 feet MLLW in the channel centerline. Substrates in both the berth area and navigation channel are composed primarily of silty sands deposited from the Duwamish River/Green River basin.

The West Waterway is one of two channels that connect the Lower Duwamish Waterway (LDW) to Elliott Bay; the East Waterway is the other. Both of these channels are active port facilities, are actively dredged to maintain navigable depths for ongoing operations, and are significantly deeper than the natural depth of this system (prior to development) and the current depth of the LDW just upstream of the Project area. Both the West Waterway and the East Waterway are part of the same salt wedge estuary, which is characterized by a wedge of saline water underlying a thinner surface layer of freshwater. The upstream limit of the salt wedge in the LDW system is located approximately 2 miles upstream of its mouth (QEA 2008). Salinities are estuarine to marine, generally ranging from 12 to 28 parts per thousand, depending upon freshwater inputs from the Duwamish River.

Currents in the West Waterway are not specifically known; however, extensive modeling has been conducted in the East Waterway, which has a similar geometry and hydrodynamic regime. Currents in the East Waterway are generally low; smaller than 20 centimeters per second (cm/s) near the bed. Surface currents are dependent on inflow from the Green River, and in the East Waterway these can range from 10 cm/s for a mean annual flow (1,300 cubic feet per second [cfs]) to 30 cm/s for a 100-year flow (12,000 cfs; Anchor QEA 2012a).

3 SMC 23.60A.152 – GENERAL DEVELOPMENT

A. **All shoreline developments, shoreline modifications, and uses shall be located, designed, constructed and managed to achieve no net loss of ecological functions. No net loss of ecological functions shall be achieved by applying the standards set out in this Chapter 23.60A, including applying mitigation sequencing pursuant to Section 23.60A.158.**

The Project is designed, and would be constructed and managed, to achieve no net loss of ecological functions. Conservation measures and best management practices (BMPs) are proposed during construction and operation of the Project to avoid and minimize potential impacts to the shoreline and marine environment. No net loss or conversion of marine habitats would occur, and adverse effects would be limited to temporary and localized impacts occurring well outside of the juvenile salmon outmigration season. Therefore, no mitigation measures are proposed.

B. **All shoreline development, shoreline modifications, and uses shall be located, designed, constructed, and managed to avoid, or if that is infeasible, to minimize to the maximum extent feasible, adverse impacts or interference with beneficial natural shoreline processes such as water circulation, littoral drift, sand movement, or erosion.**

The Project includes deepening the Terminal 5 berth from existing depths of -47 to -55 feet MLLW to a depth of -55 feet MLLW (with a maximum overdredge depth to -58 feet MLLW) within an area of approximately 6.6 acres. Berth deepening would not significantly alter depths in the waterway compared to existing conditions and is not expected to have significant impact to hydrodynamics or sediment transport in the West Waterway or adjacent waterbodies; this includes impacts to wind, waves, ship wakes, near-bed current velocities, salinity and salinity intrusion, or sediment deposition. Wind, waves, and ship wakes are a function of wind speeds and vessel operations, respectively, and the width and length of the West Waterway. The Project would not alter the shape of the basin within the tidal range (between MLLW and mean higher high water [MHHW]); therefore no changes to wind waves or wakes are expected from the Project.

Near-bed current velocities in the West Waterway, similar to the East Waterway, are controlled by the salt wedge behavior of the system and the tidal range and tidal prism (volume of water between MLLW and MHHW) within the West Waterway. Existing near-bed current velocities in the West Waterway are expected to be low based on the salt wedge behavior of the system and data collection and modeling conducted for the East Waterway (Anchor QEA and Coast and Harbor Engineering 2012), which is expected to have similar hydrodynamics. The Project would not impact the tidal range or tidal prism within the West Waterway, nor would it impact the salt wedge behavior of the system, because the proposed deepening occurs well below the extent of the low end of the tidal range (lowest tides are approximately -3 feet MLLW based on the National Oceanic and Atmospheric Administration Tide Station No. 9447130, Seattle). Therefore, post-Project current velocities are also expected to be similar to existing velocities (e.g., small) with little change from pre-Project conditions.

The West Waterway is within the salt wedge of the LDW estuary; higher salinity water is always present below the surface with a thin layer of fresh water on top. The salt wedge currently extends approximately 2 miles upstream of the West Waterway into the LDW, which has a much higher bed elevation than the West Waterway at present (i.e., the West Waterway is approximately two times as deep as the LDW). Deepening the Terminal 5 berth is not expected to impact the extent of saltwater intrusion (extent of salt wedge) upstream. This is because saltwater intrusion in this system is controlled by the tidal prism in the West Waterway and the bed elevation in the LDW—neither of which would be impacted by the proposed deepening.

The tidal prism would not be impacted by the proposed deepening because the proposed work would occur well below the expected lowest tides in the West Waterway, as discussed above. The distribution of salinity in the West Waterway is expected to be similar in post-Project conditions. Near-bed salinities (at the deeper depth) are expected to have the same salinity range as current near-bed salinities due to the salt wedge behavior of the West Waterway, which retains higher salinity water (from Elliott Bay) in the lower portion of the water column during all tides. This salt wedge behavior was documented in the adjacent East Waterway through both empirical data collection and numerical modeling (Anchor QEA and Coast and Harbor Engineering 2012). The West Waterway is expected to have similar hydrodynamics as the East Waterway since they have similar basin shape and depths and are part of the same larger estuarine system.

Overall, there may be minor short-term effects on littoral drift, waves, and current patterns in the vicinity of the Project area due to the presence of construction support vessels in the waterway during construction and related construction activities (e.g., propwash). Any long-term effects on littoral drift, waves, and current patterns in the vicinity of the Project would be negligible. The targeted deepening of the West Waterway is not expected to have long-term effects on shoreline littoral drift, wind, waves, or currents in the vicinity of the Project since the deepening is focused in deeper water areas.

C. **All shoreline developments, shoreline modifications, and uses shall be located, designed, constructed, and managed to prevent the need for shoreline defense and stabilization measures and flood protection works such as bulkheads, other bank stabilization, fills, levees, dikes, groins, jetties, dredging, or substantial site regrades to the extent feasible except as allowed in Section 23.60A.188.**

All shoreline developments would occur entirely within an existing shoreline environment that is already heavily modified and armored to protect shorelines from erosion within a working waterfront with substantial commercial vessel traffic and to stabilize large industrial wharf structures. The engineered slope beneath the wharf structure is currently protected by large riprap and a sheetpile structure at the toe of the existing slope to protect the stability of the entire slope structure and to prevent erosion at toe of slope. The Project does not change the riprap slope, but does include installing a new combination toe wall structure, composed of H-pile and sheet piling, 3 to 6 feet east of the existing toe wall to prevent sloughing of the bank slope and to protect the integrity of adjacent infrastructure by providing lateral support for the toe of the slope. New riprap armoring is limited to the replacement of existing armoring disturbed by construction.

D. **All new shoreline development and uses shall be sited and designed to avoid or, if that is infeasible, to minimize to the maximum extent feasible the need for new and maintenance dredging.**

The Project area is currently used as a heavy industrial marine cargo terminal. All shoreline developments and uses associated with the Project are sited within the existing maintained berth area and are designed to be consistent with the existing uses in the vicinity of the Project area, thereby minimizing—to the maximum extent feasible—the need for new and maintenance dredging.

E. **All shoreline developments, shoreline modifications, and uses shall be located, designed, constructed, and managed in a manner that minimizes adverse impacts to surrounding land and water uses in the Shoreline District and is compatible with the affected area in the Shoreline District.**

The Project would result in continued use of the property as a heavy industrial marine cargo terminal, which is compatible with current and projected land uses and plans.

F. **All shoreline developments, shoreline modifications, and uses shall be located, constructed, operated, and managed to protect public health and safety.**

The Project includes modifications to existing container facilities, including cargo wharf rehabilitation, berth deepening, and electrical service capacity improvements. These modifications would be constructed, operated, and managed to protect public health and safety through the implementation of BMPs and the safe operation of the completed Project.

G. **Disturbance areas and land clearing shall be limited to the minimum necessary for development. Any surface disturbed or cleared of vegetation and not to be used for development shall be planted with native vegetation, except that pre-disturbance landscaped areas containing non-native vegetation located outside the shoreline setback may be re-landscaped using non-native, noninvasive vegetation pursuant to Section 23.60A.190.**

The Project is located within the footprint of currently maintained and developed infrastructure and paved areas, and would not disturb or clear any native vegetation for wharf rehabilitations or dredging. Because no disturbance or clearing would occur, no landscaping is included as part of the Project.

H. All shoreline developments, shoreline modifications, and uses shall use best management practices pursuant to DR 16-2009, Construction Stormwater Control Technical Requirements, to control impacts during construction.

Stormwater control BMPs would be employed during construction to avoid or minimize potential stormwater impacts to adjacent surface waters pursuant to DR 16-2009. This includes implementing dust control measures as needed during construction to prevent fugitive dust from entering the waterway. Other conservation measures and BMPs would be implemented to avoid or minimize potential impacts to the shoreline environment during construction and operation as described in the Biological Assessment in Attachment 3 and the SEPA Checklist in Attachment 4.

I. All shoreline developments, shoreline modifications, and uses shall be located, designed, constructed, operated and managed to protect the quality and quantity of surface and ground water on and adjacent to the development lot by using best management practices as follows:

1. **Keep all material on the property appropriately stored, and maintain all structures, machinery, and materials on the property to prevent the entry of debris and waste materials into any water body.**
2. **Pave and/or berm drum storage areas, and control fugitive dust to prevent contamination of land or water.**
3. **Minimize the impervious surface on the site, and use permeable surfacing where practicable, except where other required state or federal permits prohibit such actions.**
4. **Use other control measures as appropriate, including but not limited to bioretention, rainwater harvesting, downspout dispersion, filters, catch basins, and planted buffers.**

Conservation measures and BMPs would be employed to protect the quality and quantity of surface water and groundwater on and adjacent to the Project as described in the Biological Assessment in Attachment 3 and SEPA Checklist in Attachment 4. BMPs would include proper storage of materials to prevent debris and waste materials from entering the waterway and controlling fugitive dust, as necessary. Permeable surfacing is not practicable, and therefore not proposed, for the Project. Stormwater treatment and improvements would be installed, as required under City Stormwater Code, to support operation of the new cargo wharf facility. The facility currently operates, and would continue to operate, under the conditions of the National Pollutant Discharge Elimination System Industrial General Stormwater Permit.

J. **All in-water and over-water structures shall be designed, located, constructed, and managed to avoid adverse impacts to aquatic habitat, such as increased salmonid predator habitat and adverse impacts due to shading, to the maximum extent feasible and to limit construction to the times of the year when construction will have the least impact on migrating salmonids as set by WDFW and the U.S. Army Corps of Engineers.**

The Project is designed, and would be constructed and managed, to achieve no net loss of ecological functions. Adverse impacts of shading would be improved due to an overall reduction in over-water cover by 12,470 square feet. There would be a minor increase of the in-water footprint of 306 square feet, however 146 square feet of the in-water footprint is attributed to composite sheet piles along the new toe wall at a depth that would not directly affect surface-oriented fish, such as migrating juvenile salmon. In-water barriers to migration would be reduced as there would be 249 fewer structural piles extending into the water (see Table 5 in the Biological Assessment, Attachment 3). All new structures would be within the existing covered footprint of the wharf—an area with lower productivity and fish abundance due to lack of existing light penetration.

No known marine vegetation, including eelgrass (*Zostera* spp.), exists in the vicinity of Terminal 5; thus, no impacts to vegetation are anticipated to result from the completed Project. Conservation measures and BMPs would also be implemented during construction to avoid or minimize potential impacts to Endangered Species Act (ESA)-listed species and habitats as described in the Biological Assessment in Attachment 3. Pollution control and response BMPs would be in place to avoid or minimize potential pollution resulting from vessel traffic and other uses (including maintenance of facilities and ancillary recreation uses). This includes implementation of a Spill Prevention, Control, and Countermeasure

(SPCC) Plan during construction to prevent and, if necessary, respond to any leaks or spills resulting from Project activities.

The West Waterway of the Duwamish River estuary is a migration corridor for salmonids. All in-water activities, including pile driving, would occur during agency-approved work windows (August 16 through February 15), when few juvenile salmonids are expected to occur in the nearshore. Adult salmonids migrate through the area throughout much of the year; however, they are highly mobile and regularly exhibit avoidance behavior. While some prey species for migrating and foraging juvenile salmonids such as zooplankton, larval fish, and sand lance (*Ammodytidae* sp.) may be temporarily affected by dredging, these organisms are abundant and widely distributed throughout Elliott Bay and adjacent estuaries, and would be redistributed to the affected areas by tidal circulation. Dredging would occur at depths greater than -40 MLLW, which is deeper than juvenile salmon typically feed, and benthic communities are known to recolonize disturbed areas over several months (NMFS 2015). There would be no loss of habitat for salmon because habitat in the Project area is limited by existing development and over-water cover (see Section 5, response to SMC 23.60A.182.D, discussing federally listed species, critical habitat, and Essential Fish Habitat [EFH]).

Upwards of 33 different marine and freshwater fish species have been documented in the Duwamish estuary, however 99% of the fish community is made up of shiner perch (*Cymatogaster aggregate*), Pacific staghorn sculpin (*Leptocottus armatus*), snake prickleback (*Lumpenus sagitta*), starry flounder (*Platichthys stallatus*), Pacific sandlance (*Ammodytes hexapterus*), and juvenile salmonids. These marine species are abundant and mobile. Shiner perch and salmon are migratory and peak abundance occurs in spring, summer, and early fall, outside of the regulatory in-water work window. The marine species present in the Project area are able to avoid entrainment during dredging and are expected to recolonize the area after dredging and construction activities subside.

Seabirds documented in the area include alcids (pigeon guillemot [*Cepphus columba*] and rhinoceros auklet [*Cerorhinca monocerata*]), several species of diving ducks, cormorants, and gulls. Bald eagles (*Haliaeetus leucocephalus*) roost within 1 mile of the Project and are known to perch on dolphins or moored barges in inner Elliott Bay. Harbor seals

(*Phoca vitulina*) and California sea lions (*Zalophus californianus*) have been documented throughout the East and West waterways.

Over-water cover and in-water structures could harbor salmon predators, either by creating cover for predators in the water or perch points for piscivorous birds. Juvenile salmon are surface-oriented, and in Elliott Bay and the LDW, juvenile salmon tend to orient with the shallow nearshore or the edges of structures rather than travel in open water. Juvenile salmon also avoid travelling under piers, likely due to a natural avoidance of shading cast by over-water piers (Munsch et al. 2014). Juvenile salmon tend to mill along the edges of in-water structures that impede their natural migration routes in nearshore areas, causing concentrations of juvenile salmon to aggregate at focal points around structures (Anchor QEA 2012b). There is some uncertainty around whether predatory fish occupy areas under piers or shallow waters in order to “ambush” juvenile salmon in Elliott Bay (Anchor QEA 2012b). In the West Waterway, juvenile salmon would be expected to migrate in the upper water column along the edge of the over-water covered area, avoiding the covered shallow areas.

For the Project, the area of over-water cover would decrease, the area available for perching of avian predators is not expected to change, and there is no change in in-water structure configuration that would introduce a significant change in existing focal points to concentrate migrating juveniles. In water, the number of piles supporting the structure would decrease, the new toe wall would be installed deeper than the typical swimming depth of juvenile salmon, and areas of riprapped slope that could be considered refuge for predatory fish would not change. The 3,000 slope stabilization piles would be installed flush with the ground, so the slope stabilization piles would provide habitat features comparable to the existing riprap bank and result in a negligible change from existing conditions. The change in conditions presents no net loss of ecological function from predation of juvenile salmon.

Habitat for benthic invertebrates, including crab and shellfish, is provided in the bottom sediments in the West Waterway, riprap on the slopes, and in the interstices of the riprap revetment. Sessile invertebrates colonize on riprap slopes, structural piling, subtidal and intertidal retaining walls, and fender systems, though at substantially lower levels beneath Terminal 5 because of a lack of light penetration as described in the Biological Assessment in

Attachment 3. Potential impacts to sessile species would occur over a small area relative to the area of the West Waterway and Elliott Bay, such that any impacts would be expected to be insignificant and not impact a species' population.

Some estuarine and marine fish and subtidal marine invertebrates inhabit and feed in sandy substrate at deeper subtidal elevations within the Project area. These are generally more mobile species capable of avoidance behavior (e.g., starry flounder and other flatfishes, staghorn sculpin, Dungeness crab [*Metacarcinus magister*], red rock crab [*Cancer productus*]) and are therefore not subject to entrainment in large numbers during dredging operations.

K. Durable, non-toxic components are the first priority for in-water and over-water structures and shall be used unless it is unreasonable. Treated wood and other material shall be the least toxic according to industry standards. Treated wood used shall be applied and used in accordance with the American Wood Preserver Association (AWPA) standards for aquatic use. Wood treated with pentachlorophenol, creosote, chromate copper arsenate (CCA), or comparably toxic compounds is prohibited for decking or piling.

Only durable, non-toxic components would be used for the Project. Slope stabilization techniques would include installing untreated wooden piling into the existing bank slope underneath the wharf. No treated wood, including wood treated with pentachlorophenol, creosote, chromate copper arsenate, or comparably toxic compounds, would be used.

L. Creosote piles

1. **Creosote treated piles may be repaired if:**
    a. **the piling is under a structure that is not being replaced; or**
    b. **fewer than 50 percent of the existing piles are in need of repair under a structure that is being replaced.**
2. **"Sleeving" shall be the repair method used unless another method provides better protection of ecological functions.**
3. **Creosote treated piles in need of repair must be replaced if under a structure that is being replaced and 50 percent or more of the number of piles are proposed to be repaired, if reasonable.**

Not applicable. No creosote piles would be reused or repaired as part of the Project.

M. Replaced covered moorage and new and replaced boat sheds shall be designed to provide the maximum ambient light to reach the water.

Not applicable. No moorage or boat sheds are included in the Project.

N. Light transmitting features are required to be installed for all new and replaced piers and floats, over-water boat repair facilities and similar structures to the maximum extent feasible. When determining feasibility of light transmitting features for nonresidential piers and floats see subsection 23.60A.187.E.6.

It is infeasible to install light transmitting features as part of the Project due to structural and use requirements of the pier and the potential for discharges that might pollute the water. The replaced over-water concrete decking would support modern container crane equipment and associated cargo operations, which would carry average loads greater than 30 pounds per square foot. Light transmitting features are not required for these types of overwater structures per the requirements for nonresidential piers and floats in SMC 23.60A.187.E.6.

O. Tires are prohibited as part of above or below water structures or where tires could potentially come in contact with the water (e.g., floatation, fenders, hinges). During maintenance of structures using tires, existing tires shall be removed or replaced with nontoxic material.

Not applicable. No tires would be used as part of above- or below-water structures, or where tires could potentially come in contact with the water. Additionally, any existing tires discovered during demolition would be removed and disposed of at an approved upland facility.

P. All foam material, whether used for floatation or for any other purpose, shall be encapsulated within a shell that prevents breakup or loss of the foam material into the water and that is not readily subject to damage by ultraviolet radiation or abrasion.

During maintenance of structures using foam, existing un-encapsulated foam material shall be removed or replaced with material meeting the standards of this subsection 23.60A.152.P.

Not applicable. No exposed foam material would be used or maintained as part of the Project.

Q. Artificial night lighting shall first be avoided. If that is infeasible, lighting should minimize night light impacts on the aquatic environment by focusing the light on the pier surface, using shades that minimize illumination of the surrounding environment and using lights that minimize penetration into the water, to the maximum extent feasible, considering the activities that occur at the site at night.

Lighting associated with the Project would focus light on the pier surface, thereby minimizing light impacts to the shoreline and marine environment at night. Shades that minimize illumination of the surrounding environment and lights that minimize penetration into the water would be used to the maximum extent feasible.

R. The release of oil, chemicals, solid waste, untreated effluents, or other hazardous materials onto or into the water is prohibited. Best management practices shall be employed for the safe handling of these materials to prevent them from entering the water. Equipment for the transportation, storage, handling or application of such materials shall be maintained in a safe and leak-proof condition. If there is evidence of leakage, the further use of such equipment shall be suspended until the cause has been completely corrected. Best management practices shall be employed for prompt and effective clean-up of any spills that occur. A spill prevention and response plan to meet the above requirements may be required by the Director prior to issuance of a permit unless the Director has determined that it is reasonable to provide the plan prior to commencement of construction.

It is unlikely that waste materials would enter groundwater or surface water from construction equipment at the Project area, although there is a chance that a minor oil or fuel spill could occur during construction and enter surface water. The contractor would be required to implement measures outlined in the SPCC Plan to prevent and, if necessary, respond to any leaks or spills throughout construction. As described previously, conservation measures and BMPs are also proposed to avoid and minimize potential adverse impacts to the shoreline and marine environments.

S. Facilities, equipment and established procedures for the containment, recovery and mitigation of spilled petroleum products shall be provided at recreational marinas, commercial marinas, vessel repair facilities, marine service stations and any use regularly servicing vessels that have petroleum product capacities of 10,500 gallons or more. A third party may provide the containment and clean-up of spills if a containment boom, capable of containing a spill from the largest vessel, is available on site and personnel are trained to deploy containment booms around vessels moored at the site.

Terminal 5 regularly services vessels that have petroleum product capacities of 10,500 gallons or more. Facilities, equipment, and established procedures for the containment, recovery, and mitigation of spilled petroleum products that are currently in place would continue to be provided at Terminal 5. Personnel at Terminal 5 are trained to deploy containment booms around vessels moored at the Project area to adequately respond to spills that may occur at the property.

T. Construction and repair work shall use best management practices to prevent the entry of debris and other waste materials into any water body. No over-water or in-water application of paint, preservative treatment, or other chemical compounds is permitted, except in accordance with best management practices. Any cleaning, sanding, cutting of treated wood, or resurfacing operation occurring over-water or in-water shall employ tarpaulins securely affixed above the water line to prevent material from entering the water. Prior to removing the tarpaulins, the accumulated contents shall be removed by vacuuming or an equivalent method that prevents material from entering the water.

BMPs would be employed to prevent the entry of debris and other waste materials into any waterbody. The contractor would be required to retrieve any floating debris generated during construction using a skiff and a net. Debris would be disposed of at an approved upland facility. Demolition and construction materials would not be stored where high tides, wave action, or upland runoff could cause materials to enter surface water. Additionally, the contractor would be required to implement measures outlined in the SPCC Plan to prevent and, if necessary, respond to any leaks or spills.

U. **Construction staging areas shall be as far from the OHW mark as reasonable. For projects involving concrete, a concrete truck chute cleanout area shall be established to contain wet concrete. All inlets and catch basins shall be protected from fresh concrete, paving, paint stripping and other high-risk pollution generating activities during construction.**

The Project involves in-water work that includes removing and installing timber and steel piles, installing a toe wall, and dredging. All work above the ordinary high water mark (OHWM) would meet these standards. Construction staging areas would be located above the OHWM as reasonable. Spill prevention BMPs would be implemented to protect from any fresh concrete, paving, paint stripping, and other high-risk, pollution-generating activities during construction. The contractor would be required to follow an approved SPCC Plan, including maintaining spill response materials at Terminal 5.

V. **If at any time project-related activities cause a fish kill, the permittee shall stop all work relating to the fish kill and immediately notify the Department of Planning and Development, WDFW, and Ecology.**

If any fish kills occur during Project activities, the contractor would immediately stop work and notify DPD, the Washington Department of Fish and Wildlife, and Ecology.

W. **Navigation channels shall be kept free of hazardous or obstructing development or uses.**

The overall Project is intended to improve navigation in the vicinity of Terminal 5 by allowing safe, unobstructed passage of larger commercial marine vessels currently being deployed on Pacific trade routes. The Project would occur within a similar footprint to the existing wharf and would not obstruct adjacent navigational channels. The proposed toe wall, although placed in front of the existing toe wall towards the berth, would occupy the space that wooden fender piles currently occupy. The new compression panel fenders installed on the bull rail above the water would hold the vessel sufficiently waterward of the new toe wall to prevent potential impacts from ongoing use of the berth.

X. **On waterfront lots uses that are not water-dependent shall be designed and located on the shoreline to encourage efficient use of the shoreline and to allow for water-dependent uses. Design considerations may include additional setbacks from all or a portion of the water's edge, joint use of piers and wharves with water-related or water-dependent uses, development of the lot with a mixture of water-related and water-dependent uses, or other means of ensuring continued efficient use of the shoreline by water-dependent uses.**

Not applicable. The Project is a water-dependent use.

Y. **All open areas used for boat storage are required to be screened with natural existing vegetated buffers or planted landscaped areas except for lots with a dry land lot depth of less than 35 feet and areas within the UG, UI and UM Environments. Screening shall include a 5 foot wide landscaping strip with native evergreen plantings at least 3 feet tall. The screening shall be located outside any required sight triangle. The requirement for screening may be waived or modified by the Director to address traffic safety.**

Not applicable. The Project does not include boat storage facilities.

4 SMC 23.60A.154 – STANDARDS FOR ARCHAEOLOGICAL AND HISTORIC RESOURCES

A. Developments, shoreline modifications, and uses on any site having historic, cultural, scientific, or educational value, as defined by the Washington State Department of Archaeology and Historic Preservation and local tribes, shall reasonably avoid disruption of the historic, cultural, scientific, or educational resource.

There are no recorded sites with historic, cultural, scientific, or educational value at or near the Project area. The nearest sites, 45KI039 and 45KI432, are 0.4 and 0.5 mile away, respectively, and are situated on different landforms (DAHP 2015). Terminal 5 is located in an area that was significantly modified during the dredging of the East and West waterways and construction of Harbor Island in the early 1900s (the island was completed in 1909). Exhibit A includes a Duwamish River 1901 pre-dredging map with a Terminal 5 overlay.

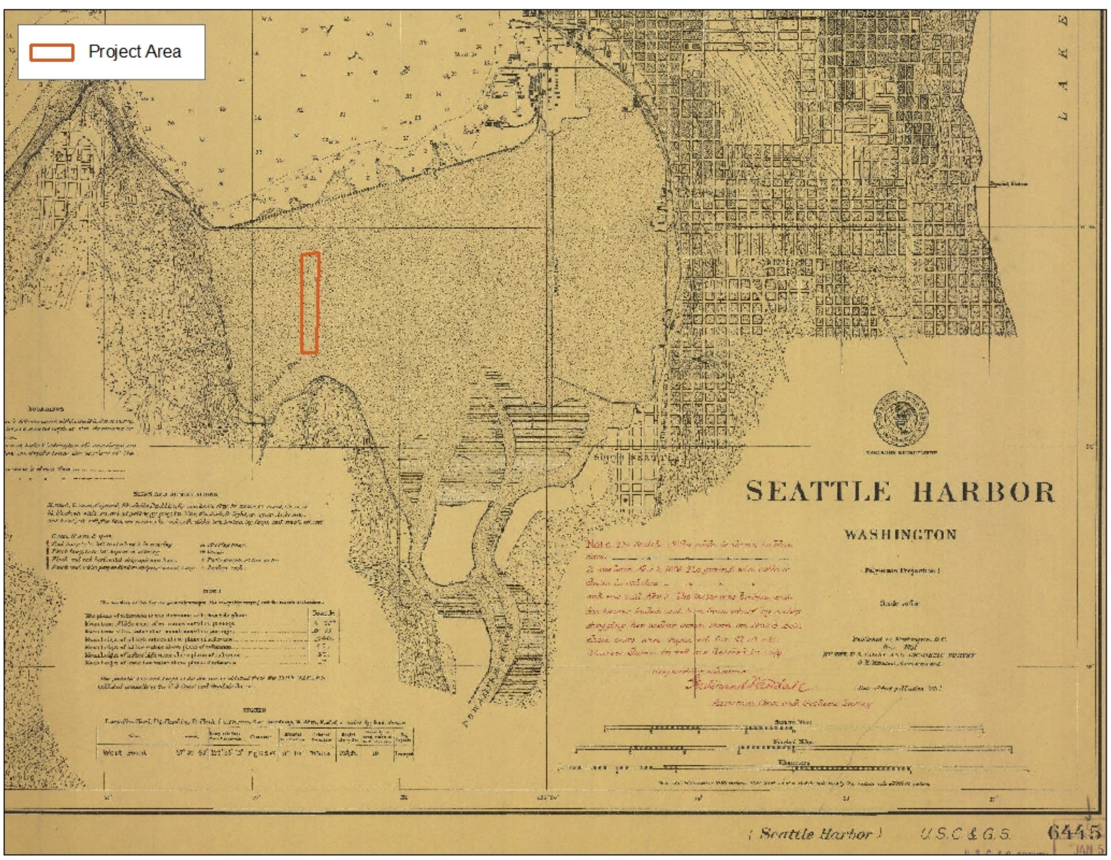

Exhibit A – Duwamish River Delta 1901 Pre-dredging Map Terminal 5 Overlay

As shown in the exhibit, Terminal 5 was previously located in the intertidal portion of the Duwamish River estuary. Prior to about 2,200 years ago, when the Duwamish River delta aggraded to its historic pre-modification maximum, it would have been a deep bay. The Project includes deepening a previously maintained berth area occurring in potentially native sediments. There is little to no potential for unrecorded cultural resources in the Project area.

B. Applications in areas documented by the Washington State Department of Archaeology and Historic Preservation to contain archaeological resources shall include a preliminary cultural resource evaluation or site inspection, and a written report prepared by a qualified professional archaeologist in compliance with Section 106 of the National Historic Preservation Act or State Executive Order 05-05, approved by the City, prior to the issuance of a permit. In addition, the archaeologist also shall provide copies of the draft report to affected tribes and the Washington State Department of Archaeology and Historic Preservation. After consultation with these tribes and agencies, the archaeologist shall provide a final report that includes any recommendations from affected tribes and the Washington State Department of Archaeology and Historic Preservation on avoidance or mitigation of the proposed project's impacts. The Director shall condition project approval based on the final report from the archaeologist to avoid, minimize, and mitigate impacts to the site consistent with federal and state law.

No archaeological resources are documented in the vicinity of the Project area, and none are likely, as described previously.

C. If any archaeological resources are uncovered during the proposed work, work shall be stopped immediately, and the applicant shall notify the City, affected tribes, and the Washington State Department of Archeology and Historic Preservation. The applicant shall submit a site inspection and evaluation report by a qualified professional archaeologist, approved by the City, that identifies all possible valuable archaeological data and makes recommendations on how to handle the data properly. When the report is prepared, the applicant shall notify affected tribes and the

Washington State Department of Archaeology and Historic Preservation and provide them with copies of the report.

No archaeological resources are documented in the vicinity of the Project area, and none are likely, as described above; therefore, a site inspection and evaluation report has not been prepared for the Project. If any archaeological resources are uncovered during the proposed work, work would be stopped immediately and the City, affected tribes, and Department of Archaeology and Historic Preservation would be notified.

D. **If identified historical or archaeological resources are present, site planning and access to such areas shall be designed and managed to give protection to the resource and surrounding environment, and any permit issued shall be revised.**

No historical or archaeological resources are documented to exist within the Project area as described previously.

E. **In the event that unforeseen factors constituting an emergency as defined in RCW 90.58.030 necessitate rapid action to retrieve or preserve artifacts or data, the project may be exempted from the requirement to obtain a shoreline substantial development permit. The City shall notify Ecology, the State Attorney General's Office, affected tribes and the State Department of Archaeology and Historic Preservation of the exemption in a timely manner.**

In the event that unforeseen factors constituting an emergency necessitate rapid action to retrieve or preserve artifacts or data, the Port would request a shoreline substantial development permit exemption from the City.

5 SMC 23.60A.182 – STANDARDS FOR DREDGING

A. **In shoreline environments where dredging is allowed, allowed as a special use or allowed as a shoreline conditional use it shall comply with the standards in Section 3.60A.172 and in this Section 23.60A.182. Disposal of dredged material is regulated in Section 23.60A.184, Standards for fill.**

The Project includes deepening the Terminal 5 berth to -55 feet MLLW, with a maximum overdredge depth to -58 feet MLLW, within the maintained Terminal 5 berth area. Dredging is a permitted use within the UI shoreline environment per SMC 23.60A.172(5)(b), which allows "dredging for the purpose of establishing, expanding, relocating or reconfiguring navigation channels, basins, berthing areas, and dry docks is allowed if the applicant demonstrates dredging is necessary for assuring safe and efficient accommodation of existing navigational uses or safe berthing or operation of water dependent equipment such as dry docks."

Sediments in the proposed dredge prism are suitable for DMMP open-water disposal and are proposed for discharge at the Elliott Bay Unconfined Open Water Disposal Site (see DMMP Suitability Determination in Attachment 2). The Elliott Bay Unconfined Open Water Disposal Site is located outside of the shoreline environment, however the material would meet all applicable provisions of standards for fill in SMC 23.60A.184. BMPs would be employed during dredging to avoid or minimize potential adverse impacts to the aquatic environment, including adherence to a project-specific water quality monitoring plan to verify compliance with water quality conditions of the Section 401 Water Quality Certificate, USACE permit, and Hydraulic Project Approval as issued for the Project.

B. **Dredging for the primary purpose of obtaining fill material is prohibited except if it complies with Section 23.60A.172.**

The Project does not include dredging for the primary purpose of obtaining fill material, and the dredged material would not be used as fill.

C. New development shall be sited and designed to avoid or, if that is not feasible, to minimize to the maximum extent feasible the need for new and maintenance dredging.

The Project area is currently used as a heavy industrial marine cargo terminal. All shoreline developments and uses associated with the Project are sited within the existing maintained berth area and are designed to be consistent with existing uses in, and in the vicinity of, the Project area, thereby minimizing, to the maximum extent feasible, the need for new and maintenance dredging.

D. Dredging shall be timed to be consistent with the state and federal regulatory agencies standards for state aquatic priority species and aquatic species protected under the Endangered Species Act.

All in-water maintenance activities would be limited to in-water work windows determined by state and federal agencies to avoid potential adverse effects on aquatic species. Additionally, the Project would adhere to the provisions put forth by the U.S. Fish and Wildlife Service and National Marine Fisheries Service as part of the ESA consultation, which would be part of the USACE permit.

The ESA-listed species that may occur in the Project area and adjacent Elliott Bay include Chinook salmon (*Oncorhynchus tshawytscha*), steelhead trout (*O. mykiss*), bull trout (*Salvelinus confluentus*), bocaccio (*Sebastes paucispinis*), canary rockfish (*Sebastes pinniger*), yelloweye rockfish (*Sebastes ruberrimus*), green sturgeon (*Acipenser medirostris*), eulachon (*Thaleichthys pacificus*), humpback whale (*Megaptera novaeangliae*), southern resident killer whale (*Orcinus orca*), marbled murrelet (*Brachyramphus marmoratus*), and leatherback sea turtle (*Dermochelys coriacea*). Green sturgeon, eulachon, humpback whales, and sea turtles are extremely rare or undocumented in the Puget Sound. Marbled murrelet depend on old growth forest to nest and, due to the high level of human activity and industrialization in the Project area, it is unlikely they are present in the Project area at any time of the year. Although bocaccio, canary rockfish, and yelloweye rockfish larvae may be found throughout the year in Puget Sound, they are widely dispersed with the surface water currents, making the concentration or potential presence of larvae in any particular location extremely small

(NMFS 2011a and 2011b). Adult and juvenile bocaccio, canary rockfish, and yelloweye rockfish are very unlikely to be in the Project area due the lack of deep water, suitable rocky substrate, and preferred aquatic vegetation (i.e., kelp [*Phaeophyceae* spp.] and eelgrass). Leatherback sea turtles and other sea turtle species primarily occur in outer coastal areas and are extremely rare in Puget Sound (NOAA 2012).

Critical habitat is designated in the Project area for Chinook salmon and bull trout, and is proposed for steelhead trout; however, the condition of these critical habitats is limited by several factors as follows: developed shorelines, lack of complex habitat to provide forage and cover, and the presence of overwater structures. Critical habitat has been proposed in Puget Sound for Georgia Basin rockfish species (*Sebastes* spp.) on August 6, 2013, but does not include the inner waterways of the LDW where the Project is located. There would be no losses of critical habitat as part of this Project and beneficial effects are anticipated due to the reduction in covered area. The West Waterway is also a designated critical habitat for southern resident killer whale. However, when killer whale pods are present near Elliott Bay, they typically remain outside of the bay itself. It is unlikely that southern resident killer whales would be found in the Project area within the West Waterway.

Estuaries of Washington, including Puget Sound are designated as EFH for various ground fish, coastal pelagic species, and several of the Pacific salmon (NMFS 1998; PFMC 1998, 1999). Conservation measures and BMPs would be employed during pile driving and dredging to avoid or minimize potential adverse impacts to the shoreline and marine environment as described in the Biological Assessment in Attachment 3. This includes adhering to a project-specific water quality monitoring plan to verify compliance with water quality conditions of the Section 401 Water Quality Certificate, USACE permit, and Hydraulic Project Approval as issued for the Project. Implementation of a project-specific SPCC Plan during construction would also prevent and, if necessary, respond to any leaks or spills resulting from Project activities.

E. **Dredging operations shall be designed, located, constructed, and managed to minimize impacts to stability of slopes on and off the site.**

Dredging operations would be designed, located, constructed, and managed to avoid or minimize impacts to slope stability on and off the Project area. Slope stabilization measures, including installing a toe wall, would be implemented prior to dredging operations to support the adjacent bank slope and wharf infrastructure. BMPs and engineering controls would be employed during dredging operations to avoid or minimize erosion or potential impacts to slope stability.

F. Dredging in harbors, bays or other such basins shall prevent internal deeper pockets that create unflushed aquatic areas.

Controls would be in place during dredging operations, including tracking of dredge depths via Global Positioning System (GPS) software and surveying, to prevent the creation of holes or any perturbations that may result in the creation of internal deeper pockets that result in unflushed aquatic areas.

G. Temporary stockpiling of dredged material in or under water is prohibited.

The Project does not include any temporary stockpiling of dredged material in or under water. Dredged material would be disposed of at the Elliott Bay Unconfined Open Water Disposal Site.

H. Dredging of material that does not meet the federal Environmental Protection Agency and Ecology criteria for open-water disposal is allowed if the applicant demonstrates that:

1. **The dredging would not cause long-term adverse impacts to water sediment quality, aquatic life or human health in adjacent areas; and**
2. **The dredged material will be disposed of at a dry land or contained submerged disposal site that has been approved by the federal Environmental Protection Agency and/or the Dredge Material Management Program (DMMP), or any successor agency or at a site meeting the standards of subsection 23.60A.184.E.**

Sediments in the proposed dredge prism are suitable for DMMP open-water disposal and are proposed for discharge at the Elliott Bay Unconfined Open Water Disposal Site (see DMMP

Suitability Determination in Attachment 2). The Elliott Bay Unconfined Open Water Disposal Site is located outside of the shoreline environment and is therefore not subject to the provisions of SMC 23.60A.184(E).

I. Incidental dredged material resulting from the installation of a utility line or intake or outfall may remain under water if the applicant demonstrates that:

1. **It can be placed without long-term adverse impacts to water quality, sediment quality, aquatic life or human health; and**
2. **The adverse environmental impacts of removing the material and relocating it to an open-water disposal site are greater than the adverse impacts of leaving the material at the original site.**

Not applicable. No underwater utilities are proposed; therefore, the Project would not include discharging incidental dredged material resulting from utility installation.

J. In applying mitigation sequencing pursuant to Section 23.60A.158, potential adverse impacts to be addressed include, but are not limited to: turbidity; release of nutrients, heavy metals, sulfides, organic materials or toxic substances; dissolved oxygen depletion; disruption of food chains; loss of benthic productivity; disturbance of fish runs and important biological communities; and loss or modification of shallow water habitat.

The Project includes deepening the Terminal 5 berth to -55 feet MLLW, with a maximum overdredge depth to -58 feet MLLW, within the maintained Terminal 5 berth area. The Project is designed to avoid or minimize impacts of dredging by limiting dredging activities to those that are necessary to provide safe access for vessels at the terminal, and through using the appropriate technology and affirmative steps to avoid or minimize impacts, including tracking of dredge depths via GPS software and surveying.

During dredging activities, the Port would adhere to the conditions outlined in local, state, and federal permits and approvals obtained for the Project. Conservation measures and BMPs would be implemented during the maintenance activities to avoid or minimize potential impacts to the shoreline environment. Based on the results of the previously described testing, the DMMP agencies concluded that all of the proposed dredged material is suitable for open-water disposal at the Elliott Bay non-dispersive disposal site (see DMMP Suitability Determination in Attachment 2). Turbidity and dissolved oxygen levels would be controlled and monitored during dredging operations through adhering to a project-specific water quality monitoring plan to verify compliance with water quality conditions of the Section 401 Water Quality Certificate, USACE permit, and Hydraulic Project Approval as issued for the Project. Implementation of a project-specific SPCC Plan during construction would prevent and, if necessary, respond to any leaks or spills resulting from Project activities. BMPs would also be employed during upland construction, and stormwater control measures would be in place during and after construction to ensure long-term stormwater control to prevent impacts to the adjacent berth area.

Dredging would not cause long-term adverse impacts to water sediment quality, aquatic life, or human health in adjacent areas. No marine vegetation exists in the dredge footprint and any disturbance to food chains due to the removal of benthic invertebrates in the dredge area would be temporary as benthic invertebrate communities recover quickly. The disturbance of anadromous salmon runs would be avoided by working outside of peak juvenile migration windows. Natural cover is absent in the action area and there would therefore be no effect on the availability of natural cover. Dredging would not result in a loss of shallow water habitat as all dredging is proposed in deep water habitats. Dredging in deep water habitats would occur within the same deepwater habitat zone as under current conditions and would not result in a loss of deepwater habitat. No net loss or conversion of existing marine habitats, including shallow water habitats, would occur, and adverse effects from dredging would be limited to temporary and localized impacts occurring well outside of the juvenile salmon outmigration season.

6 SMC 23.60A 185 – STANDARDS FOR GRADING, LANDFILL AND SLOPE STABILIZATION

A. **In shoreline environments where grading, landfill or on land slope stabilization are allowed, allowed as special uses or allowed as shoreline conditional uses they shall comply with the standards in Section 23.60A.172 and in this Section 23.60A.185.**

The proposed activities are an allowed use in the UI shoreline environment and would comply with the applicable standards for shoreline modifications pursuant to SMC 23.60A.172 and the standards in this section, SMC 23.60A.185.

B. **Grading or landfill that necessitates the installation of a taller bulkhead or additional slope stabilization measures is prohibited unless necessary for the operation of a water-dependent use.**

The Project would install a new toe wall and slope stabilization piles as part of a slope stabilization system necessary to support heavier cranes required to reach up and over larger vessels being deployed to Pacific maritime trade routes. Dredging to -55 feet MLLW plus overdredge and advance maintenance is also proposed to provide safe navigation and berthing access to the rehabilitated wharf for larger vessels and to reduce the need for future maintenance activities. These actions are required for continued operation of Terminal 5 as a strategic terminal over the long term to accommodate larger vessels.

C. **Grading, landfill and alteration of natural drainage features and landforms is limited to the minimum necessary for development. Surface drainage systems or substantial earth modifications shall be professionally designed to prevent maintenance problems or adverse impacts on shoreline features.**

The proposed activities would occur entirely within the footprint of the maintained Terminal 5 berth and associated existing infrastructure. As described above, dredging and development since the early 1900s substantially altered nearshore environments in the West Waterway. Upland areas are entirely paved with asphalt. All of the original habitat in the Project area has been either filled or dredged and is highly modified from its original delta condition. There is no remaining tidal marsh, mudflat, emergent vegetation, or riparian vegetation in or adjacent to the Project area.

Within the Terminal 5 berth area, the Port is proposing the minimum necessary dredging to accommodate vessel traffic, consistent with the Project purpose and need. The depths chosen for the Project are intended to accommodate vessels accessing the berth over the next 20 years. Much of the Terminal 5 berth is already at depth (-55 feet MLLW), so dredging would not significantly alter the waterway from existing conditions. Dredging to -55 feet MLLW plus overdredge and advance maintenance is also proposed to provide safe navigation and berthing access to the rehabilitated wharf for larger vessels and reduce the need for future maintenance activities.

As described above, the dredge design is not anticipated to impact river hydrodynamics or change river hydrology (e.g., the salt wedge). During dredging operations, BMPs would control impacts to water quality. Conservation measures and BMPs would be implemented during the maintenance activities to avoid or minimize potential impacts to the shoreline environment. Based on the results of the previously described testing, the DMMP agencies concluded that all of the proposed dredged material is suitable for open-water disposal at the Elliott Bay non-dispersive disposal site (see DMMP Suitability Determination in Attachment 2). Turbidity and dissolved oxygen levels would be controlled and monitored during dredging operations through adhering to a project-specific water quality monitoring plan to verify compliance with water quality conditions of the Section 401 Water Quality Certificate, USACE permit, and Hydraulic Project Approval as issued for the Project. Implementation of a project-specific SPCC Plan during construction would prevent and, if necessary, respond to any leaks or spills resulting from Project activities. BMPs would also be employed during upland construction, and stormwater control measures would be in place during and after construction to ensure long-term stormwater control to prevent impacts to the adjacent berth area.

The Project has been professionally designed by geotechnical and structural engineers to prevent maintenance problems and avoid or minimize potential impacts to shoreline features to the extent feasible. The design incorporates safety standards that would be approved in advance of the Project by DPD and in conjunction with the City Building Code and associated review for wharf rehabilitation activities to prevent future maintenance issues to the extent practicable.

D. Landfill shall not be placed in the critical root zone of any trees over 6 inches DBH, and grading, landfill and slope stabilization work shall not result in the compaction of soils in the critical root zone of any trees over 6 inches DBH.

Not applicable. No grading is proposed within the critical root zone of any trees.

E. Spray-on concrete and similar material is prohibited as a slope stabilization method.

Spray-on concrete and similar material would not be used as a slope stabilization method.

F. Slope stabilization on a waterfront lot with the intent to stabilize the shoreline is shoreline stabilization and is regulated pursuant to Section 23.60A.188 and not this Section 23.60A.185.

Not applicable. According to SMC 23.60A.936, shoreline stabilization includes "techniques to protect against erosion." The shorelands, meaning "those lands extending landward for 200 feet…from the ordinary high water mark or mean higher high water" per SMC 23.60A.936, are currently protected against erosion by existing wharf infrastructure and riprap along the bank slope. No shoreline stabilization measures with the intent to stabilize the shoreline 200 feet landward from OHWM or MHHW are proposed as part of this Project.

7 SMC 23.60A.217 – STANDARDS FOR UTILITY LINES

A. **In shoreline environments where utility lines, including intakes and outfalls, are allowed or allowed as a special use or a shoreline conditional use they shall comply with the standards in the applicable shoreline environment and in this Section 23.60A.217.**

No in-water utilities are proposed as part of the Project. The proposed electrical, water, and stormwater utility upgrades require a shoreline location to operate and are therefore allowed in the UI shoreline environment pursuant to SMC 23.60A.482.J. The utility upgrades would comply with the standards in the UI shoreline environment and standards for utility lines in SMC 23.60A.217 as described herein.

B. **All new utility lines shall be located or constructed in the following order to the extent feasible; when determining that no feasible alternative location exists in these areas, the criteria in Section 23.60A.066 shall be used:**
   1. **Outside the Shoreline District;**
   2. **Within existing utility corridors or in public rights-of-way, including attaching to existing bridges;**
   3. **In locations that minimize adverse impacts within the Shoreline District; and**
   4. **Under water, subject to the provisions in subsection 23.60A.217.D, using methods that minimize impacts and assist in future repair and replacement, such as boring and sleeving, and constructed to prevent the pipe from leaking.**

No in-water utilities are proposed as part of the Project. The proposed electrical, water, and stormwater upgrades would be installed in locations that minimize adverse impacts within the UI shoreline environment by installing them above water, within the footprint of the wharf and existing infrastructure.

C. **New utility lines in areas where no such lines exist or the substantial expansion of existing utility lines shall be located as follows:**
   1. **Underground to the extent reasonable or under water, except for lines carrying 115 kilovolts or more and for temporary relocation;**

2. **Overhead in the UI Environment and lines carrying 115 volts or more, except for temporary lines pursuant to subsection 23.60A.217.C.3, if the location and design minimizes visibility of the overhead utilities and preserves views of the water; or**
3. **Overhead installation of utility lines is allowed temporarily for a period of one year or less.**

The proposed electrical, water, and stormwater upgrades would be installed generally within the footprint of existing utilities and infrastructure and would not result in the substantial expansion of existing utility lines.

D. **Pipelines, except gravity sewers and storm drains and underwater pipelines, carrying materials intrinsically harmful or potentially injurious to aquatic life and/or water quality shall have shutoff facilities and use other appropriate best management practices to prevent and contain such materials from entering the water or the ground.**

None of the proposed utilities lines would carry materials intrinsically harmful or potentially injurious to aquatic life or water quality. Therefore, no new shutoff facilities or other BMPs are proposed.

E. **Underwater pipelines, except gravity sewers and storm drains, carrying materials intrinsically harmful or potentially injurious to aquatic life and/or water quality shall have shutoff facilities at each end of the underwater segments.**

No underwater pipelines are included as part of the Project.

F. **All disturbed areas shall be restored to pre-project configuration and shall be planted in compliance with Section 23.60A.190.**

The proposed electrical, water, and stormwater upgrades would occur within the footprint of the existing development. No vegetation disturbance and no increase in impervious surface would result from utility installation; therefore, no planting is proposed.

8 SMC 23.60A.158 – STANDARDS FOR MITIGATION SEQUENCING

A. Regulations set out in this Chapter 23.60A are minimum requirements that shall be supplemented by mitigation sequencing in this Section 23.60A.158 when needed to achieve no net loss of ecological functions. Mitigation under this Section 23.60A.158 is not intended to duplicate mitigation for the same ecological function that is required under other City regulations or under state and federal permits: coordination among local, state and federal regulatory agencies and Indian Tribes, as applicable, shall occur when determining required mitigation for shoreline substantial development permits.

Mitigation is not proposed for the Project because associated impacts are primarily temporary and construction-related as described in the following sections. Proposed dredging would not convert any existing intertidal or shallow water habitats to deepwater habitats. The dredge depths involved would have discountable direct effects to juvenile salmon, which tend to be surface-oriented. Insignificant effects relate to the size of the impact and should never reach the scale where harm to species would occur. While juvenile Chinook and chum salmon are expected to use nearshore and estuarine areas extensively during their first year at sea, these fish tend to orient with shallow, sloped beaches where available (Simenstad et al. 1982; Simenstad and Cordell 2000).

Where shallow, nearshore areas are covered by piers, juvenile salmon tend to migrate around the edges of structures rather than travelling under piers (likely due to a natural avoidance of shading cast by over-water piers), yet remain in the upper part of the water column (Toft et al. 2007; Munsch et al. 2014). Thus, it is expected that juvenile salmonids are unlikely to travel underneath the terminal pier immediately adjacent to the west side of berthed ships, and would seek passage in open, lighted waters along the opposite side of the ship and toward the middle of the channel. Alternatively, juvenile salmon may travel along the east side of the West Waterway, opposite Terminal 5, where shorelines are more shallowly sloped and pocket beaches have been restored, providing more shallow water habitat and the associated feeding opportunities juvenile salmon require.

Dredging would remove most of the benthic community from the dredge footprint, however multiple studies in other areas indicate that recolonization of the area by benthic organisms would quickly occur (McCauley et al. 1977; Swartz et al. 1980; Albright and Borithilette 1981; Romberg et al. 1995; Wilson and Romberg 1996). With the residual removal of any contaminated sediments, it is expected that post-dredge benthic habitats would be improved over existing conditions. It can be expected that the degree of recolonization by the benthic community would be near that found in clean sediments at associated depths within Puget Sound (Hart Crowser 2015).

To further offset adverse effects of the Project, a substantial net reduction in overwater structure has been built into the design of proposed improvements at Terminal 5. A 4.3-foot-wide safety walkway along the face of the entire wharf (2,900-foot length) between the bull rail and the existing fender system, along with the associated fender piling, would be removed, reducing the overwater footprint by approximately 12,470 square feet. Modifications to the over-water area of the wharf would reduce the amount of over-water cover and physical barriers to juvenile salmon migration. The proposed toe wall to strengthen the slope under the wharf has been located at depths below the typical migratory pathways of juvenile salmon. Over-water cover modifications may provide habitat for salmon predators; however, the area available to such predators would decrease with proposed modifications to the wharf.

As described above, deepening the Terminal 5 berth is not expected to have significant impact to hydrodynamics or sediment transport in the West Waterway or adjacent waterbodies; this includes impacts to wind, waves, ship wakes, near-bed current velocities, salinity and salinity intrusion, or sediment deposition.

Conservation measures and BMPs for dredging, pile removal, and pile installation activities (as described in the Biological Assessment in Attachment 3 and SEPA Checklist in Attachment 4) would minimize the temporary adverse effects of the construction activities within the Project area. Contaminant removal—including treated piles, surface sediments, and reduction of over-water cover—would improve aquatic habitats within the West Waterway, offsetting the minimal changes associated with the Project. No net loss or conversion of marine habitat zones would occur, and adverse effects would be limited to temporary and localized impacts occurring outside of the juvenile salmon outmigration season. For these reasons, the Port does not propose additional mitigation actions for the Project.

B. Mitigation sequencing

1. **The mitigation sequence below shall be undertaken in the following priority:**
    a. **Step A. Avoiding the impact altogether by not taking a certain action or parts of an action;**
    b. **Step B. Minimizing impacts by limiting the degree or magnitude of the action and its implementation by using appropriate technology or by taking affirmative steps to avoid or reduce impacts;**
    c. **Step C. Rectifying the impact by repairing, rehabilitating, or restoring the affected environment;**
    d. **Step D. Reducing or eliminating the impact over time by preservation and maintenance operations;**
    e. **Step E. Compensating for the impact by replacing, enhancing, or providing substitute resources or environments; and**
    f. **Step F. Monitoring the impact and the compensation projects and taking appropriate corrective measures.**
2. **Lower priority measures shall be applied only if the higher priority measure is infeasible or inapplicable.**

As described previously, conservation measures and BMPs are proposed to avoid and minimize potential adverse impacts to the shoreline and marine environments; therefore, no mitigation measures are proposed.

C. Each development, shoreline modification, or use comprising the mitigation proposed to meet the requirements of subsections 23.60A.158.B.1.b through 23.60A.158.B.1.f (Steps B through F) shall comply with the standards for the shoreline environment where the mitigation action will occur and with all applicable regulations.

As described above, conservation measures and BMPs are proposed to avoid and minimize potential adverse impacts to the shoreline environment; therefore, no mitigation measures are proposed.

D. Mitigation and Monitoring Plan

1. **As part of any application for approval of development, shoreline modification, or use that requires mitigation under subsections 23.60A.158.B.1.b through 23.60A.158.B.1.f (Steps B through F), the applicant shall submit a mitigation and monitoring plan that meets the standards set out in this subsection 23.60A.158.D unless the applicant demonstrates based on competent scientific evidence that no net loss of ecological function will occur as the result of the development, shoreline modification or use, its construction, or its management.**
2. **The required level of detail in the mitigation and monitoring plans and the length of time required for monitoring shall be determined by the Director after considering the location, size and type of the proposed shoreline development, modification and/or use and the type of mitigation proposed.**
3. **The mitigation and monitoring plan shall include the following information:**
   a. **An inventory of the existing ecological functions where the impact will occur;**
   b. **An analysis of the project's impacts on the existing ecological functions necessary to support existing shoreline resources;**
   c. **Management recommendations received from federal, state, or local agencies that have been developed for the protection of ecological function including protection of avian, terrestrial, wetlands or aquatic species and habitat on the site and their applicability to the proposal;**
   d. **Proposed management practices that will protect ecological function both during construction and during the management of the site;**
   e. **Measures to avoid and minimize impacts to preserve ecological functions and existing habitats;**
   f. **Proposed measures that will compensate for the impacts of the project remaining after applying avoidance and minimization measures, to ensure no net loss of shoreline ecological functions;**
   g. **Vegetation species, planting and soil specifications and a minimum of 5 years of monitoring for plans that include vegetation planting;**

h. Identify success criteria and the evaluation of mitigation effectiveness to ensure no net loss of ecological functions;

i. Contingency actions to be taken if the mitigation fails to meet established success criteria; contingency actions should include additional monitoring if the mitigation fails;

j. Performance bonds not to exceed a term of five years may be required to ensure compliance with the conditions except for public agencies; and

k. Any additional information as determined by the Director that is necessary to determine the impacts of a proposal and mitigation of the impacts.

4. If off-site mitigation is proposed by the applicant, the applicant shall provide proof of the off-site owner's consent; any restrictions, conditions, or easements that are tied to the parcel through off-site mitigation shall be set out in both the permit and in a covenant and recorded.

5. Where practicable, replacement mitigation shall be required to be completed prior to impact and, at a minimum, prior to occupancy.

A mitigation plan has not been prepared because the impacts of the Project are primarily temporary and construction-related. As described previously, conservation measures and BMPs are proposed to avoid and minimize potential adverse impacts to the shoreline environment; therefore, no mitigation measures are proposed.

E. Bonds. Except for projects undertaken by public entities, the applicant shall provide performance and maintenance bonds, as applicable, or other security to the City to assure that work is completed, monitored, and maintained.

Not applicable. No mitigation measures requiring bonding are proposed pursuant to SMC 23.60A.158.

F. The monitoring plan approved by the Director shall be part of the permit or approval issued by the City.

Not applicable. No mitigation measures or associated monitoring plans are proposed pursuant to SMC 23.60A.158.

G. If SEPA or mitigation requirements of this Chapter 23.60A requires providing habitat units, the provisions of Sections 23.60A.027 and 23.60A.028 apply.

Not applicable. Habitat units are not required by SEPA or SMP, SMC 23.60A; therefore, no mitigation measures are proposed.

9 REFERENCES

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Appendix M
Operational Noise Management Plan - Outline

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October 1, 2016

OPERATIONAL NOISE MANAGEMENT PLAN - OUTLINE

PORT OF SEATTLE – TERMINAL 5

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TABLES

1. BACKGROUND

1.1 Introduction

The Port of Seattle's Terminal 5 Cargo Wharf Rehabilitation, Berth Deepening, and Improvements Project is being proposed to accommodate larger vessels. These improvements will serve increased throughput capacity as operations expand to meet expected growth at the terminal, which will require more cranes and vessels, increased cargo-handling equipment (CHE), and increased numbers of trains and trucks moving through the Facility. These changes in operations could result in increased noise levels and noise impacts from Terminal 5 operations when compared to recent historical levels.

The analyses of noise impacts in the EIS considered several alternatives, with potential throughput up to 1.7 million TEUs, but the Port has since committed to a maximum throughput of 1.3 million TEUs. Based on the analyses, evaluations, and mitigation actions included in the FEIS, the Port will continue to seek project authorizations from city, state, federal, and Treaty tribe entities as required for rehabilitating Terminal 5 wharf, berth, and cargo facilities, providing project infrastructure improvements, and managing the impacts from operations resulting from that establishing container cargo capability up to 1.3 million TEUs.

Because the improved terminal and resulting changes in noise could create the potential for facility noise to exceed the Seattle night-time noise limits, a noise management plan was identified as the most effective solution to provide a compliance strategy for the facility. An Operational Noise Management Plan (ONMP) is an adaptive tool to identify reasonable and feasible best practices to meet noise levels.

1.2 Existing Environment

The land surrounding Terminal 5 is primarily used for industrial and commercial purposes however, sensitive receivers potentially impacted by noise associated from Terminal 5 operations include residences on the hillsides west and south of and overlooking the site.

1.3 Seattle Noise Limits

Terminal 5 and the surrounding communities are located within the City of Seattle, and the noise limits included in the Seattle noise ordinance (Seattle Municipal Code Chapter – SMC 25.08) apply to noise related to this project. The SMC sets noise limits based on sound levels and durations of allowable daytime/nighttime operational noise (**Table 1**). These limits are based on the zoning of the source and receiving properties.

As indicated in **Table 1**, the Seattle noise limits are based on hourly sound-energy average equivalent sound levels (L_{eq}s) in addition to not-to-be-exceeded L_{max} levels that vary by zoning of the noise source and receiving properties. The project site is zoned for Industrial uses and the nearby potentially affected sensitive receivers are in residentially zoned areas on the hillsides west and south of the site. As shown in the highlighted cell of **Table 1**, this establishes 1-hour L_{eq} sound level limits for operational noise of 60 dBA during the day and 50 dBA at night. In addition, there are hourly L_{max} limits of 75 dBA during the day and 65 dBA at night.

The Seattle noise code identifies a number of noise sources or activities that are exempt from the noise limits shown in **Table 1**. The following sources are among those exempted:

- Sounds created by motor vehicles are exempt from the sound level limits, except that sounds created by any motor vehicle operated off highways (e.g., on the Terminal) shall be subject to the sound level limits when the sounds are received within a residential district of the City (25.08.480), and
- Sounds created by warning devices or alarms not operated continuously for more than 30 minutes per incident (25.08.530)
- Sounds from the operation of railroads engaged in interstate commerce are exempt from local noise control rules by virtue of a federal preemption of this issue.

Table 1. Seattle Noise Limits (dBA)

Zoning District of Noise Source	Zoning District of Receiving Property		
	Residential Day / Night [a]	Commercial	Industrial
Residential	55 / 45	57	60
Commercial	57 / 47	60	65
Industrial	60 / 50	65	70

Note: The above sound level limits are based on the equivalent sound level (L_{eq}) *and* a not-to-be-exceeded L_{max} level 15 dBA higher than the indicated limits.

[a] The operational noise limits for residential receivers are reduced by 10 dBA during nighttime hours (i.e., 10 PM to 7 AM weekdays, 10 PM to 9 AM weekends and legal holidays) and are displayed for daytime/nighttime hours.

Source: Seattle Municipal Code - 25.08

2. OPERATIONAL NOISE MANAGEMENT PLAN

2.1 Operational Noise Management Plan Objective

The objective of the ONMP is to:

- Advise a future terminal operator and its contractors along with the Port of Seattle and its management by the NWSA of their responsibilities in managing noise on site;
- Facilitate compliance with City of Seattle noise code;
- Facilitate compliance with any authorizations or conditions with regard to noise management;
- Provide methods to identify and document potential noise issues and to allow development of appropriate mitigation measures and procedures to ensure that the relevant noise regulations and requirements are addressed.

2.2 Operational Noise Management Plan and Responsibility

The NWSA and the Port of Seattle will be responsible for compliance with all project authorization for construction and long-term container cargo operations. Notice of permit authorization and conditions of operation will be identified in all lease and site use agreements with a selected marine terminal operator. Comprehensive compliance with city, state, federal, and Treaty tribe conditional approvals will be shared with selected marine terminal operator at Terminal 5.

2.3 Operational Noise Management Plan Elements

The ONMP provides management and performance requirements related to operational noise at the Terminal. The ONMP includes the following elements:

- Applicable noise limits
- Noise monitoring plan
- Noise complaint response system
- Description of potential sources of noise and potential control measures, and
- Reporting requirements.

The details of the means and methods to meet the management and performance requirements of the elements listed above will be determined in discussions with the City of Seattle when a marine terminal operator is selected. The Plan will be activated and ready for implementation prior to occupancy of the terminal by the selected tenant.

2.4 Activities or Sources not Covered by the ONMP

Unless noted otherwise, the ONMP does not cover the following:

- Vessel movements
- Activities outside the Terminal 5 lease area
- Activities beyond the reasonable control or responsibility of the Port or its terminal operator
- Sources exempt from the Seattle noise limits, unless otherwise specified (e.g., backup/motion alarms)

3. POTENTIAL NOISE SOURCES AND CONTROLS

An equipment noise inventory will be provided.

This section will be updated once a terminal operator is selected and specific information relating to equipment and operations is identified.

4. MANAGEMENT STRATEGIES

Details of overall management methods and procedures that will be implemented to control noise from the Facility will be provided. The terminal operator will identify both proactive and reactive management processes to of noise issues.

4.1 Proactive Noise Management

Proactive noise management will be conducted with annual noise monitoring and maintenance of an equipment noise inventory. If monitored operational noise levels are demonstrated to exceed the Seattle noise limits, then investigation and implementation of control strategies would occur. Similarly, development, maintenance, and review of an equipment noise inventory can be used to identify potential noise issues, leading to proactive management of the issue.

4.2 Reactive Noise Management

Reactive management would be in response to noise complaints received by the terminal operator.

This section will be updated once a terminal operator is selected and specific information relating to equipment and operations is identified.

5. NOISE MONITORING PROGRAM

The noise monitoring program involves several elements, including identification of existing background sound levels, annual noise monitoring of Terminal 5 operations, potential supplementary noise monitoring conducted to assess the efficacy of noise mitigation measures or in response to noise complaints, and the establishment and upkeep of an equipment noise inventory.[1]

Details of the noise monitoring program will be developed in consultation with the City of Seattle once a terminal operator is selected and specific information relating to equipment and operations is identified. The following outline shows specific elements expected to be provided in more detail in the final ONMP.

5.1 Identification of Background Sound Levels

5.1.1 Background Measurement Locations

5.1.2 Measurement Details

5.2 Annual Operational Noise Compliance Monitoring

5.2.1 Measurement Locations

5.2.2 Sound Level Measurement Equipment

5.2.3 Duration and Timing

5.2.4 Reporting

5.3 Equipment Noise Inventory

5.3.1 Timing

5.3.2 Instrumentation and Basic Measurement Procedures

This section will be updated once a terminal operator is selected and specific information relating to equipment and operations is identified.

[1] All noise monitoring tasks will be conducted by an established acoustical consultant who has appropriate experience conducting sound level measurements.

6. NOISE COMPLAINT PROCESS

A key component of the ONMP includes implementation of a noise complaint hotline or process.

Details of the noise complaint process will be developed in consultation with the City of Seattle once a terminal operator has been found and specific information relating to equipment and operations is identified. The following outline shows specific elements expected to be provided in more detail in the final ONMP.

6.1 Noise Complaint Channels

6.2 Responding to Noise Complaints

This section will be updated once a terminal operator is selected and specific information relating to equipment and operations is identified.

7. DOCUMENTATION AND RECORD KEEPING

7.1 Internal Report Obligations

Records relating to noise measurements, noise environment, and community interactions will be retained for a period of time.

Details will be developed when a terminal operator is selected.

7.2 External Report Obligations

Reports of measurements, noise environment, and community interactions will be retained and made available to the community and to the City of Seattle noise department.

Reporting Details of will be developed when a terminal operator is selected.