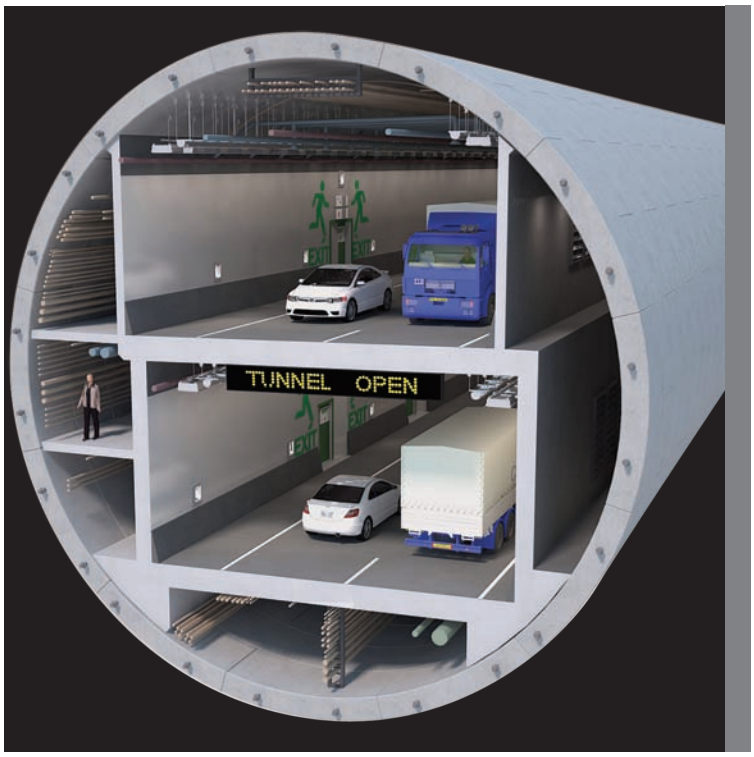
ALASKAN WAY VIADUCT REPLACEMENT PROJECT

2010 Supplemental Draft Environmental Impact Statement

APPENDIX M Air Discipline Report



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City of Seattle

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Alaskan Way Viaduct Replacement Project

Supplemental Draft EIS
Air Discipline Report

The Alaskan Way Viaduct Replacement Project is a joint effort between the Federal Highway Administration (FHWA), the Washington State Department of Transportation (WSDOT), and the City of Seattle. To conduct this project, WSDOT contracted with:

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ACRONYMS AND ABBREVIATIONS

$\mu g/m^3$	micrograms per cubic meter
AM	morning
CFR	Code of Federal Regulations
City	City of Seattle
CO	carbon monoxide
Ecology	Washington State Department of Ecology
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
EMIT	Easy Mobile Inventory Tool
FHWA	Federal Highway Administration
MSAT	mobile source air toxic
NAAQS	National Ambient Air Quality Standards
NATA	National Air Toxics Assessment
NEPA	National Environmental Policy Act
PAH	polycyclic aromatic hydrocarbon
PM	afternoon
$PM_{2.5}$	particulate matter with diameter of 2.5 micrometers or less
PM_{10}	particulate matter with diameter of 10 micrometers or less
ppm	parts per million
Program	Alaskan Way Viaduct and Seawall Replacement Program
project	Alaskan Way Viaduct Replacement Project
PSCAA	Puget Sound Clean Air Agency
PSRC	Puget Sound Regional Council
SR	State Route
VMT	vehicle miles of travel
VOC	volatile organic compound
WAC	Washington Administrative Code
WASIST	Washington State Intersection Screening Tool
WSDOT	Washington State Department of Transportation

Chapter 1 INTRODUCTION AND SUMMARY

1.1 Introduction

This discipline report evaluates the Bored Tunnel Alternative, the new alternative under consideration for replacing the Alaskan Way Viaduct. This report and the Alaskan Way Viaduct Replacement Project Supplemental Draft Environmental Impact Statement (EIS) that it supports are intended to provide new information and updated analyses to those presented in the March 2004 Alaskan Way Viaduct and Seawall Replacement Project Draft EIS and the July 2006 Alaskan Way Viaduct and Seawall Replacement Project Supplemental Draft EIS. The discipline reports present the detailed technical analyses of existing conditions and predicted effects of the Bored Tunnel Alternative. The results of these analyses are presented in the main volume of the Supplemental Draft EIS.

The Federal Highway Administration (FHWA) is the lead federal agency for this project, primarily responsible for compliance with the National Environmental Policy Act (NEPA) and other federal regulations, as well as distributing federal funding. As part of the NEPA process, FHWA is also responsible for selecting the preferred alternative. FHWA will base their decision on the information evaluated during the environmental review process, including information contained within the Supplemental Draft EIS and the subsequent Final EIS. FHWA can then issue their NEPA decision, called the Record of Decision (ROD).

The 2004 Draft EIS (WSDOT et al. 2004) evaluated five Build Alternatives and a No Build Alternative. In December 2004, the project proponents identified the 9cut-and-cover Tunnel Alternative as the preferred alternative and carried the Rebuild Alternative forward for analysis as well. The 2006 Supplemental Draft EIS (WSDOT et al. 2006) analyzed two alternatives—a refined cut-and-cover Tunnel Alternative and a modified rebuild alternative called the Elevated Structure Alternative. After continued public and agency debate, Governor Gregoire called for an advisory vote to be held in the city of Seattle. The March 2007 ballot included an elevated alternative and a surface-tunnel hybrid alternative. The citizens voted down both alternatives.

Following this election, the lead agencies committed to a collaborative process to find a solution to replace the viaduct along Seattle's central waterfront. This Partnership Process is described in Appendix S, the Project History Report. In January 2009, Governor Gregoire, King County Executive Sims, and Seattle Mayor Nickels announced that the agencies had reached a consensus and recommended replacing the aging viaduct with a bored tunnel.

The environmental review process for the Alaskan Way Viaduct Replacement Project (the project) builds on the five Build Alternatives evaluated in the 2004

Draft EIS and the two Build Alternatives evaluated in the 2006 Supplemental Draft EIS. It also incorporates the work done during the Partnership Process. The bored tunnel was not studied as part of the previous environmental review process, and so it becomes the eighth alternative to be evaluated in detail.

The Bored Tunnel Alternative analyzed in this discipline report and in the Supplemental Draft EIS has been evaluated both quantitatively and qualitatively. The Bored Tunnel Alternative includes replacing State Route (SR) 99 with a bored tunnel and associated improvements, such as relocating utilities located on or under the viaduct, removing the viaduct, decommissioning the Battery Street Tunnel, and making improvements to the surface streets in the tunnel's south and north portal areas.

Improvements at the south portal area include full northbound and southbound access to and from SR 99 between S. Royal Brougham Way and S. King Street. Alaskan Way S. would be reconfigured with three lanes in each direction. Two options are being considered for new cross streets that would intersect with Alaskan Way S.:

- New Dearborn Intersection – Alaskan Way S. would have one new intersection and cross street at S. Dearborn Street.
- New Dearborn and Charles Intersections – Alaskan Way S. would have two new intersections and cross streets at S. Charles Street and S. Dearborn Street.

Improvements at the north portal area would include restoring Aurora Avenue and providing full northbound and southbound access to and from SR 99 near Harrison and Republican Streets. Aurora Avenue would be restored to grade level between Denny Way and John Street, and John, Thomas, and Harrison Streets would be connected as cross streets. This rebuilt section of Aurora Avenue would connect to the new SR 99 alignment via the ramps at Harrison Street. Mercer Street would be widened for two-way operation from Fifth Avenue N. to Dexter Avenue N. Broad Street would be filled and closed between Ninth Avenue N. and Taylor Avenue N. Two options are being considered for Sixth Avenue N. and the southbound on-ramp:

- The Curved Sixth Avenue option proposes to build a new roadway that would extend Sixth Avenue N. in a curved formation between Harrison and Mercer Streets. The new roadway would have a signalized intersection at Republican Street.
- The Straight Sixth Avenue option proposes to build a new roadway that would extend Sixth Avenue N. from Harrison Street to Mercer Street in a typical grid formation. The new roadway would have signalized intersections at Republican and Mercer Streets.

For these project elements, the analyses of effects and benefits have been quantified with supporting studies, and the resulting data are found in the discipline reports (Appendices A through R). These analyses focus on assessing the Bored Tunnel Alternative's potential effects for both construction and operation, and consider appropriate mitigation measures that could be employed. The Viaduct Closed (No Build Alternative) is also analyzed.

The Alaskan Way Viaduct Replacement Project is one of several independent projects that improve safety and mobility along SR 99 and the Seattle waterfront from the South of Downtown (SODO) area to Seattle Center. Collectively, these individual projects are often referred to as the Alaskan Way Viaduct and Seawall Replacement Program (the Program). This Supplemental Draft EIS evaluates the cumulative effects of all projects in the Program; however, direct and indirect environmental effects of these independent projects will be considered separately in independent environmental documents. This collection of independent projects is categorized into four groups: roadway elements, non-roadway elements, projects under construction, and completed projects.

Roadway Elements

- Alaskan Way Surface Street Improvements
- Elliott/Western Connector
- Mercer West Project (Mercer Street improvements from Fifth Avenue N. to Elliott Avenue)

Non-Roadway Elements

- First Avenue Streetcar Evaluation
- Transit Enhancements
- Elliott Bay Seawall Project
- Alaskan Way Promenade/Public Space

Projects Under Construction

- S. Holgate Street to S. King Street Viaduct Replacement
- Transportation Improvements to Minimize Traffic Effects During Construction

Completed Projects

- SR 99 Yesler Way Vicinity Foundation Stabilization (Column Safety Repairs)
- S. Massachusetts Street to Railroad Way S. Electrical Line Relocation Project (Electrical Line Relocation Along the Viaduct's South End)

1.2 Summary

The purpose of this Air Discipline Report is to identify potential air quality effects associated with the project. The Alaskan Way Viaduct is part of SR 99, a regionally important north-south highway on the western edge of downtown Seattle.

Traffic in the project area would be affected by changes in the number of vehicles, travel speed, and the levels of congestion experienced on local roadways. Air quality, which is a general term used to describe pollutant levels in the atmosphere, can be affected by these changes.

The study area evaluated for air quality impacts includes areas likely to be affected by changes in pollutant levels as a result of changes in traffic conditions or emissions released from the tunnel ventilation systems under the Bored Tunnel Alternative.

The air quality analyses for this project followed current guidelines developed by the U.S. Environmental Protection Agency (EPA), FHWA, the Washington State Department of Transportation (WSDOT), the Washington State Department of Ecology (Ecology), and the Puget Sound Regional Council (PSRC).

EPA has identified several air pollutants as being of concern nationwide. These pollutants are known as *criteria pollutants*. The sources of these pollutants, their effects on human health and the nation's welfare, and their concentration in the atmosphere vary considerably. Under the Clean Air Act, EPA has established National Ambient Air Quality Standards (NAAQS), which specify maximum allowable concentrations for these criteria pollutants (EPA 2010a). Areas not in compliance with the NAAQS are deemed *nonattainment areas*. Areas that were once classified as nonattainment areas but have since demonstrated attainment with the NAAQS are classified as *maintenance areas*. The study area is located within a maintenance area for carbon monoxide (CO) and an attainment area for all of the other criteria pollutants.

In addition to the criteria pollutants for which there are NAAQS, EPA also regulates *air toxics*, which are pollutants known or suspected to cause cancer or other serious health effects. Most air toxics originate from human-made sources, including on-road mobile sources, non-road mobile sources (e.g., airplanes, construction equipment, marine vessels, and locomotives), area sources (e.g., dry cleaners), and stationary sources (e.g., factories and refineries). The Clean Air Act identified 188 air toxics. In 2001, EPA identified a list of 21 mobile source air toxics (MSAT) and highlighted six of these MSATs as priority MSATs (more recently updated to seven [FHWA 2009]). Since 2001, EPA has conducted an extensive review of the literature to produce a list of the compounds identified in the exhaust or evaporative emissions from on-road and non-road equipment, as

well as alternative fuels. This list currently includes approximately 1,000 compounds, many emitted in trace amounts. However, conformity requirements for MSAT emissions do not yet exist because EPA has not established ambient standards for MSAT concentrations.

Because the project area is located within a CO maintenance area, it must comply with the project-level and regional conformity criteria described in EPA's Transportation Conformity Rule (Code of Federal Regulations, Title 40, Part 93 [40 CFR 93]) and with Washington Administrative Code, Chapter 173-420 (WAC 173-420). Because this project would not cause or exacerbate an exceedance of the NAAQS or increase regional emissions, it would meet the project-level conformity requirements in accordance with 40 CFR 93.123.

The project is included in the Metropolitan Transportation Plan (PSRC 2001a) and the Transportation Improvement Program (WSDOT 2010b), as required to show that the project conforms with the Puget Sound region's Air Quality Maintenance Plans and would not cause or contribute to exceedances of the NAAQS at the regional level. The project meets all the requirements of 40 CFR 93 and WAC 173-420 and demonstrates regional conformity.

The Washington State Intersection Screening Tool (WASIST) was used to estimate CO concentrations at sensitive receptor sites near heavily congested intersections that are expected to be affected by the Viaduct Closed (No Build Alternative) and the Bored Tunnel Alternative. The analysis showed that the project would not cause or contribute to any new localized violations of the CO NAAQS, increase the frequency or severity of any existing violations of the NAAQS, or delay the timely attainment of the NAAQS.

In accordance with FHWA guidelines, the Easy Mobile Inventory Tool (EMIT) was used to calculate annual MSAT pollutant burdens (in tons per year) for the seven priority MSATs (see Section 3.4.6 for discussion). To assess potential project-related effects, existing MSAT pollutant concentrations were compared to future conditions under the Bored Tunnel Alternative. Future MSAT concentrations are predicted to be lower than the existing concentrations, even with the increase in vehicle miles of travel (VMT).

Because the regional MSAT emissions are not expected to increase and no exceedances of the NAAQS are expected, no significant adverse air quality effects are expected to result from the Bored Tunnel Alternative. Therefore, no operational mitigation measures would be required.

Air pollutant emissions that would result from construction activities associated with the Bored Tunnel Alternative were qualitatively assessed. A fugitive dust control plan would be developed to control dust during construction. The plan could include measures such as spraying exposed soil with water, covering truck loads and materials as needed, washing truck wheels before leaving the site, removing particulate matter from roads, routing and scheduling construction trucks to reduce delays, ensuring well-maintained equipment, and implementing other temporary mitigation measures as needed and considered appropriate.

Chapter 2 BACKGROUND STUDIES AND COORDINATION

2.1 Air Quality Standards

EPA has identified several air pollutants as a concern nationwide. These pollutants, known as "criteria pollutants," are CO, particulate matter with a diameter of 10 micrometers or less (PM_{10}), particulate matter with a diameter of 2.5 micrometers or less ($PM_{2.5}$), ozone (O_3), sulfur dioxide (SO_2), lead (Pb), and nitrogen dioxide (NO_2). The sources of these pollutants, their effects on human health and the nation's welfare, and their concentration in the atmosphere vary considerably. Under the Clean Air Act, EPA has established NAAQS, which specify maximum allowable concentrations for these criteria pollutants (EPA 2010a). Washington State and the Puget Sound Clean Air Agency (PSCAA) have also adopted these standards. In addition, Washington State and PSCAA have a standard for total suspended particulates. Exhibit 2-1 summarizes the standards applicable to transportation projects.

A violation of the NAAQS may threaten federal funding of a transportation project, and proposed roadway projects requiring federal funding or approval must demonstrate compliance with EPA's Transportation Conformity Rule. Conformity is demonstrated by showing that a project would not cause or contribute to any new violation of any NAAQS, increase the frequency or severity of any existing NAAQS violations, or delay timely attainment of the NAAQS.

2.2 Air Pollutants for Analysis

Ambient concentrations of CO and ozone in and beyond the project area are predominantly influenced by emissions from motor vehicle activity. Nitrogen dioxide is emitted from motor vehicle activity and stationary sources (e.g., fossil fuel-fired power plants). Sulfur dioxide emissions are associated mainly with stationary sources. Emissions of particulate matter (PM_{10} and $PM_{2.5}$) are associated with stationary sources and diesel-fueled mobile sources (heavy trucks and buses). Lead emissions, which historically were principally influenced by motor vehicle activity, have been substantially reduced due to the elimination of lead from gasoline. The pollutants that are associated with motor vehicle activity are discussed in further detail in the following sections.

Exhibit 2-1. Summary of Ambient Air Quality Standards

Pollutant	National Primary Standard	Washington State Standard	PSCAA Regional Standard
Carbon Monoxide (CO)			
1-hour average (not to be exceeded more than once per year)	35 ppm	35 ppm	35 ppm
8-hour average (not to be exceeded more than once per year)	9 ppm	9 ppm	9 ppm
PM_{10}			
Annual arithmetic mean	NA	50 μg/m³	50 μg/m³
24-hour average concentration	150 μg/m³	150 μg/m³	150 μg/m³
$PM_{2.5}$			
Annual arithmetic mean	15 μg/m³	NA	NA
24-hour average concentration (98th percentile)	35 μg/m³	NA	NA
Total Suspended Particulates			
Annual arithmetic mean	NA	60 μg/m³	60 μg/m³
24-hour average concentration (not to be exceeded more than once per year)	NA	150 μg/m³	150 μg/m³
Ozone (O_3)			
8-hour average (3-year average of fourth highest daily maximum)	0.075 ppm	NA	NA
Sulfur Dioxide (SO_2)			
1-hour average (not to be exceeded more than twice in 7 days)	NA	0.25 ppm	0.25 ppm
24-hour average concentration (never to be exceeded)	0.14 ppm	0.1 ppm	0.1 ppm
Annual arithmetic mean	0.03 ppm	0.02 ppm	0.02 ppm
Nitrogen Dioxide (NO_2)			
1-hour average	0.1 ppm		
Annual arithmetic mean	0.053 ppm	0.053 ppm	0.053 ppm
Lead (Pb)			
Rolling 3-month average	0.15 μg/m³		
Quarterly average	1.5 μg/m³	1.5 μg/m³	1.5 μg/m³

Sources: EPA 2010a; PSCAA 1994; 40 CFR 50 (1997); WAC 173-470, 173-474, and 173-175 (1987).

Notes:

The 8-hour ozone standard of 0.075 ppm, which became effective in 2008, replaces (for the most part) the previous 1-hour standard of 0.08 ppm.

μg/m³ = micrograms per cubic meter

NA = not applicable

$PM_{2.5}$ = particulate matter with diameter less than or equal to 2.5 micrometers

PM_{10} = particulate matter with diameter less than or equal to 10 micrometers

ppm = parts per million

PSCCA = Puget Sound Clean Air Agency

2.2.1 Carbon Monoxide

CO is a colorless gas that interferes with the transfer of oxygen to the brain. CO is emitted almost exclusively from the incomplete combustion of fossil fuels. Prolonged exposure to high levels of CO can cause headaches, drowsiness, loss of equilibrium, or heart disease. CO concentrations can vary greatly over relatively short distances. Relatively high concentrations of CO are typically found near congested intersections, along heavily used roadways carrying slow-moving traffic, and in areas where atmospheric dispersion is inhibited by urban "street canyon" conditions. Consequently, CO concentrations are predicted on a localized, or microscale, basis.

2.2.2 Particulate Matter

Particulate pollution is composed of solid particles or liquid droplets that are small enough to remain suspended in the air. Of particular concern are those particles that are smaller than, or equal to, 10 micrometers (PM_{10}) and 2.5 micrometers ($PM_{2.5}$).

PM_{10} consists of very small liquid and solid particles floating in the air, which can include smoke, soot, dust, salts, acids, and metals. It also forms when gases emitted from motor vehicles or industrial sources undergo chemical reactions in the atmosphere. Major sources of PM_{10} include motor vehicles; wood-burning stoves and fireplaces; dust from construction, landfills, and agriculture; wildfires and brush/waste burning; industrial sources; windblown dust from open lands; and atmospheric chemical and photochemical reactions. Suspended particulates produce haze and reduce visibility. PM_{10} poses a greater health risk than larger particles. When inhaled, these particles can penetrate the human respiratory system's natural defenses and damage the respiratory tract. PM_{10} can increase the number and severity of asthma attacks, cause or aggravate bronchitis and other lung diseases, and reduce the body's ability to fight infections.

$PM_{2.5}$ results from fuel combustion (from motor vehicles, power generation, and industrial facilities), residential fireplaces, and wood stoves. In addition, $PM_{2.5}$ can be formed in the atmosphere from gases such as sulfur dioxide, nitrogen oxides, and volatile organic compounds (VOCs). The main health effects of airborne $PM_{2.5}$ are on the respiratory system. Like PM_{10}, $PM_{2.5}$ can penetrate the human respiratory system's natural defenses and damage the respiratory tract when inhaled. Whereas particles 2.5 to 10 micrometers in diameter tend to collect in the upper portion of the respiratory system, particles 2.5 micrometers or less in diameter are so tiny that they can penetrate deeper into the lungs and damage lung tissues. Because of the diesel truck emissions from fuel combustion that would be generated within the tunnel sections under the Bored Tunnel Alternative, $PM_{2.5}$

emissions released from the tunnel portals and tunnel operations buildings are considered on a localized level.

2.2.3 Ozone

Ozone (O_3) is a colorless toxic gas that enters the bloodstream and interferes with the transfer of oxygen, depriving sensitive tissues in the heart and brain of oxygen. Ozone also damages plants by inhibiting their growth. Although ozone is not directly emitted, it forms in the atmosphere through a chemical reaction between reactive organic gases and nitrogen oxides, which are emitted from industrial sources and automobiles. Substantial ozone formations generally require a stable atmosphere with strong sunlight.

The effects of this pollutant are normally examined on an areawide, or mesoscale, basis. However, as the effects of the project on regional traffic conditions would be minimal, a regional ozone analysis is not warranted.

2.2.4 Nitrogen Oxides

Nitrogen dioxide (NO_2) is a brownish gas that irritates the lungs. It can cause breathing difficulties at high concentrations. Like ozone, nitrogen dioxide is not directly emitted but is formed through a reaction between nitrous oxide (N_2O) and atmospheric oxygen. Nitrous oxide and nitrogen dioxide are collectively referred to as nitrogen oxides (NO_x) and are major contributors to ozone formation. Nitrogen dioxide also contributes to the formation of particulate matter. At atmospheric concentrations, nitrogen dioxide is only potentially irritating. High concentrations of nitrogen dioxide result in a brownish-red cast to the atmosphere and reduced visibility. There is some indication of a relationship between nitrogen dioxide and chronic pulmonary fibrosis. Some increase in bronchitis in children (2 and 3 years old) has also been observed at concentrations less than 0.3 parts per million (ppm).

Nitrogen oxide emissions for a transportation project are usually examined on a regional basis as a precursor of ozone, and, as discussed in Section 2.2.3, a regional ozone analysis is not warranted.

2.2.5 Lead

Lead (Pb) is a stable element that persists and accumulates in the environment and in animals, including humans. Its principal effects in humans are on the blood-forming, nervous, and renal systems. Lead levels in the urban environment from mobile sources, such as automobiles, have substantially decreased since the federally mandated switch to unleaded gasoline.

Lead concentrations have decreased considerably since the removal of lead from gasoline, and they are expected to decrease further. Therefore, an analysis of lead from mobile sources is not warranted.

2.2.6 Mobile Source Air Toxics

In addition to the criteria pollutants for which there are NAAQS, EPA also regulates air toxics. Toxic air pollutants are pollutants that are known or suspected to cause cancer or other serious health effects. Most air toxics originate from human-made sources, including vehicles, non-road mobile sources (e.g., airplanes), area sources (e.g., dry cleaners), and stationary sources (e.g., factories or refineries). The Clean Air Act identified 188 air toxics. In 2001, EPA provided a list of 21 MSATs and highlighted six of them as priority MSATs. Since 2001, EPA has conducted an extensive review of the literature to produce a list of compounds identified in the exhaust or evaporative emissions from on-road and non-road equipment, as well as alternative fuels. This list currently includes approximately 1,000 compounds, many emitted in trace amounts.

In February 2007, EPA finalized a rule to reduce hazardous air pollutants from mobile sources (Control of Hazardous Air Pollutants from Mobile Sources, Federal Register, Vol. 72, No. 37, page 8430, February 26, 2007). The rule limits the benzene content of gasoline and reduces the allowable toxic emissions from passenger vehicles and gas cans. EPA estimates that in 2030 this rule will reduce total MSAT emissions nationally by 330,000 tons and emissions of VOCs (precursors to ozone and $PM_{2.5}$) by over 1 million tons.

By 2010, EPA's existing programs will reduce MSAT emissions nationally by over 1 million tons from 1999 levels. In addition to controlling pollutants such as hydrocarbons, particulate matter, and nitrogen oxides, EPA's recent regulations controlling emissions from highway vehicles and non-road equipment will result in large reductions in air toxics. Furthermore, EPA is developing programs that would provide additional benefits from further controls for small non-road gasoline engines and diesel locomotive and marine engines. Finally, EPA has developed a variety of programs to reduce risk in communities, such as Clean School Bus USA, Voluntary Diesel Retrofit Program, Best Workplaces for Commuters, and National Clean Diesel Campaign.

MSATs, which are a subset of the 188 air toxics defined by the Clean Air Act, are compounds emitted from highway vehicles and non-road equipment. Some toxic compounds are present in fuel and are emitted to the air when the fuel evaporates or passes through the engine unburned. Other toxics are emitted from the incomplete combustion of fuels or as secondary combustion products. Metal air toxics also result from engine wear or from impurities in oil or gasoline. EPA has assessed this expansive list in its latest rule on the Control of Hazardous Air

Pollutants from Mobile Sources and identified a group of 93 compounds emitted from mobile sources that are listed in its Integrated Risk Information System (IRIS) (EPA 2010b). In addition, EPA identified seven compounds with significant contributions from mobile sources that are among the national and regional-scale cancer risk drivers from its 1999 National Air Toxics Assessment (NATA) (EPA 2006):

- **1,3-Butadiene** – characterized as carcinogenic to humans by inhalation.
- **Acrolein** – there is very little information about how long-term exposure to acrolein affects people's health. Its potential carcinogenicity cannot be determined because the existing data are inadequate for an assessment of human carcinogenic potential for either the oral or inhalation route of exposure. However, acrolein is extremely acrid and irritating to mucous membranes.
- **Benzene** – characterized as a known human carcinogen.
- **Diesel exhaust** – likely to be carcinogenic to humans by inhalation from environmental exposures. Diesel exhaust, as reviewed in the 1999 NATA, is the combination of diesel particulate matter and diesel exhaust organic gases. Diesel exhaust also produces chronic respiratory effects, possibly the primary noncancer hazard from MSATs. Prolonged exposures may impair pulmonary function and could produce symptoms, such as cough, phlegm, and chronic bronchitis. Exposure relationships have not been developed from these studies.
- **Formaldehyde** – a probable human carcinogen, based on limited evidence in humans and sufficient evidence in animals.
- **Naphthalene** – EPA has classified naphthalene as a Group C, possible human carcinogen. Acute exposure of humans to naphthalene by inhalation, ingestion, and dermal contact is associated with hemolytic anemia, damage to the liver, and neurological damage. Cataracts have also been reported in workers with acute exposures to naphthalene by inhalation and ingestion.
- **Polycyclic organic matter** – defines a broad class of compounds that includes the polycyclic aromatic hydrocarbons (PAHs), of which benzo(a)pyrene is a member. Cancer is the major concern from exposure to polycyclic organic matter. EPA has classified seven PAHs (benzo[a]pyrene, benz[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[k]fluoranthene, dibenz[a,h]anthracene, and indeno[1,2,3-cd]pyrene) as Group B2, probable human carcinogens.

While FHWA considers these the priority MSATs, the list is subject to change and may be adjusted in consideration of future EPA rules.

2.3 Climate and Air Quality

In accordance with WSDOT guidelines, greenhouse gas effects associated with the project are presented in Appendix R, Energy Discipline Report.

2.4 Project Coordination

Air quality methods and analysis were developed for the Program in coordination with WSDOT, the City of Seattle (City), King County, and FHWA. In April 2002, an approach for the air quality analysis was distributed to these agencies for review and comment. Input from these agencies was incorporated into the approach, and on March 5, 2009, an updated methodology was presented to WSDOT and City staff. Input from WSDOT and the City was incorporated into the approach used in this study.

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Chapter 3 METHODOLOGY

3.1 Study Area

Air quality effects were evaluated in areas likely to be affected by changes in pollutant levels due to changes in traffic conditions or emissions released from the tunnel ventilation systems. Areas likely to be affected by increased emissions during construction were also considered. The air quality effects were evaluated within the Center City area of Seattle, as well as on a regional scale. Exhibit 3-1 shows the Center City area. The regional scale includes all the vehicle movements occurring in King, Pierce, Snohomish, and Kitsap Counties.

3.2 Applicable Regulations and Guidelines

Air quality in the project area is regulated by EPA, Ecology, and PSCAA. The air quality analysis and preparation of this report followed guidance provided in Chapter 425 of WSDOT's *Environmental Procedures Manual* (WSDOT 2010a), as well as guidelines developed by EPA, FHWA, WSDOT, Ecology, and PSRC.

3.3 Data Needs and Sources

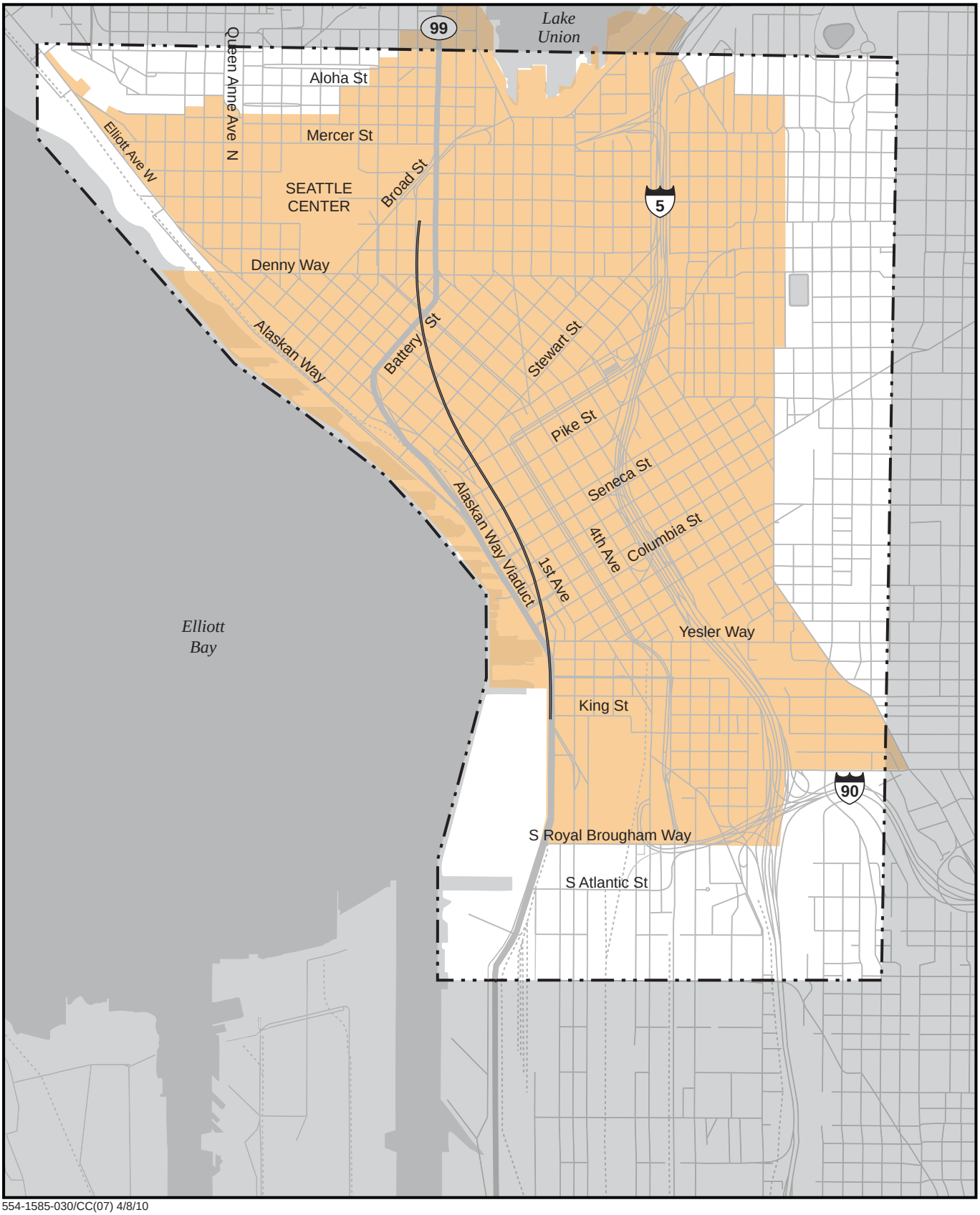
3.3.1 Traffic Data

The evaluation of air quality effects was based on the data and findings of the transportation analysis. The transportation study area includes the portion of Seattle in which traffic patterns would most likely be affected by the Bored Tunnel Alternative. Detailed traffic analyses were completed for existing (2005) conditions and for the year of opening (2015) and the project design year (2030) for the Bored Tunnel Alternative. The results of these analyses are documented in Appendix C, Transportation Discipline Report.

3.3.2 Background Concentrations

Microscale modeling analyses estimate concentrations of pollutants from motor vehicle emissions on the roadways adjacent to the receptor locations. To estimate total pollutant concentrations at a prediction site, background concentrations are added to account for pollution entering the area from other sources upwind.

WASIST, which was used in all the mobile source analyses, uses a conservative background concentration of 3 ppm for determining worst-case 1-hour and 8-hour CO concentrations at signalized intersections throughout Washington (WSDOT 2005).



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Study Area

Center City

Bored Tunnel

Exhibit 3-1
Center City

The CO and $PM_{2.5}$ background concentrations that were used in the more detailed analyses for the tunnel portals and tunnel operations buildings were estimated using monitoring data for the latest 3 years (2006–2008) at the Beacon Hill Reservoir station. Using the highest of the second-highest levels recorded in any of these years, the following background values were determined:

- CO: 2.3 ppm for 1-hour values and 1.5 ppm for 8-hour values.
- $PM_{2.5}$: 20.2 micrograms per cubic meter ($\mu g/m^3$) for 24-hour values and 7.5 $\mu g/m^3$ for annual values.

These values were added to the results of the modeling analyses to estimate total pollutant concentrations, which were then compared to the NAAQS.

3.3.3 Vehicle Emissions

Pollutant emissions from motor vehicles are affected by many factors, including travel speed; temperature; operating mode; and the age, type, and condition of the vehicle. Emission models calculate emission factors for average vehicles operating under specific parameters, such as speed, vehicle (which is a composite of automobiles, light trucks, heavy trucks, sport-utility vehicles [SUVs], etc.), age, and local emission control requirements.

Emission factors for CO and $PM_{2.5}$ for vehicles in Seattle traveling on an arterial or highway were estimated using the latest version of EPA's emission factor algorithm (MOBILE6.2.03). The data inputs provided by PSRC are based on implementation of Washington State's basic inspection and maintenance and antitampering programs, which require biannual inspections of automobiles and light trucks to determine whether emissions from the vehicles' exhaust systems are less than the strict emission standards. Vehicles failing the emissions test must undergo maintenance and pass a retest or receive a waiver to be registered in Washington State.

MOBILE6.2.03 emission factors were developed for the project's year of opening (2015) and its design year (2030). Emission factors were developed for wintertime conditions, which provide worst-case CO estimates. Emission factors generally decrease over time as a result of the gradual replacement of older vehicles with newer, less-polluting vehicles. All vehicles traveling on SR 99 (including those within tunnels) were assumed to be operating in the hot stabilized mode (i.e., after the engine has warmed up).

3.4 Analysis of Environmental Effects

3.4.1 Analysis Years

The following years were considered for analysis: existing (2005) conditions, the project's opening year (2015), and the project's design year (2030). The year 2012 was also analyzed as part of the construction period conformity determination.

Typically, the existing conditions year is established a few years back to be consistent with available data. The existing conditions estimates were derived from traffic counts by WSDOT and the City from 2004 through 2006. For modeling purposes and documentation of the affected environment, the project team used the year 2005 as the existing conditions year. Traffic volumes on SR 99 within the study area have generally remained stable in recent years, so these volume estimates may still be considered current. Some additional on-corridor traffic count data were collected in 2007 and 2008 by the City. These data were evaluated, and existing traffic volume estimates were updated as necessary to reflect changes, if any, evident in these latest counts. Appendix C, Transportation Discipline Report, provides more information on the determination of the 2005 traffic data.

3.4.2 Analysis Periods

For the local (microscale) analysis, traffic data for the afternoon (PM) peak period and morning (AM) peak period were used to estimate maximum 1-hour and 8-hour CO concentrations. The PM peak period is the period of the day with the highest traffic volume in downtown Seattle.

For the tunnel portal analysis, hourly emission rates were developed based on hour-by-hour traffic conditions over a 24-hour period. These emission rates were then used to estimate 1-hour and 8-hour CO concentrations and 24-hour and annual $PM_{2.5}$ concentrations associated with emissions generated within the tunnel and released through the exit portals.

3.4.3 Mobile Source Analysis Sites and Receptor Locations

Analysis sites typically include critical roadway links and heavily congested intersections, connecting bus routes, locations adjacent to sensitive land uses, and representative locations throughout the study area that may be affected by the project. To select sites for analysis, major signalized intersections that may be affected by the project were identified. These intersections were then evaluated for traffic volumes and levels of service under the Bored Tunnel Alternative for the design year 2030 and ranked according to the results. Sites at which air quality was most likely to be substantially affected by this alternative were selected for analysis in accordance with accepted WSDOT procedure.

The WASIST simulates physical conditions and predicts pollutant concentrations at specific receptor locations on sidewalks near intersections affected by roadway traffic. For this project, receptors were located at the four sidewalks of each intersection, at a distance of 10 feet from the edge of each travel lane.

The intersections were ranked and prioritized based on the total approach volume and intersection delay for the 2015 and 2030 Bored Tunnel Alternative conditions. The highest ranked intersections for each condition were selected for analysis. Based on this ranking, the following four intersections were analyzed:

- Mercer Street and Fairview Avenue N.
- Mercer Street and Westlake Avenue N.
- Mercer Street and Ninth Avenue N.
- Elliott Avenue W. and W. Mercer Place

Because these four intersections are located near the north end of the study area, an intersection near the south end of the study area (the intersection of First Avenue S. and S. Atlantic Street) was also analyzed as having the highest volumes and delays near the south portal. Exhibit 3-2 summarizes the data for these locations; Exhibit 3-3 shows the locations.

All of these intersections were considered for the analysis of existing (2005) conditions and future (2015 and 2030) conditions under the Bored Tunnel Alternative. While all of these intersections were evaluated under worst-case traffic conditions, which occur during the PM peak period, one intersection (Mercer Street and Fairview Avenue N.) was analyzed under both the AM and PM peaks because of high traffic volumes at this location during the AM peak period.

The worst-case CO concentrations estimated for the receptors at these locations were compared to the NAAQS to determine whether the Bored Tunnel Alternative would potentially result in concentrations greater than these standards.

3.4.4 Analysis Sites Near Tunnel Portals and Tunnel Operations Buildings

Air quality levels were estimated at sensitive land uses located near the tunnel portals and the north tunnel operations building. Receptors were placed along sidewalks at locations that are accessible to the general public and buildings with windows or doors that open toward the roadway. The exact number of receptors considered near each analysis site was determined based on the configuration and complexity of the site. The following types of receptor sites were used:

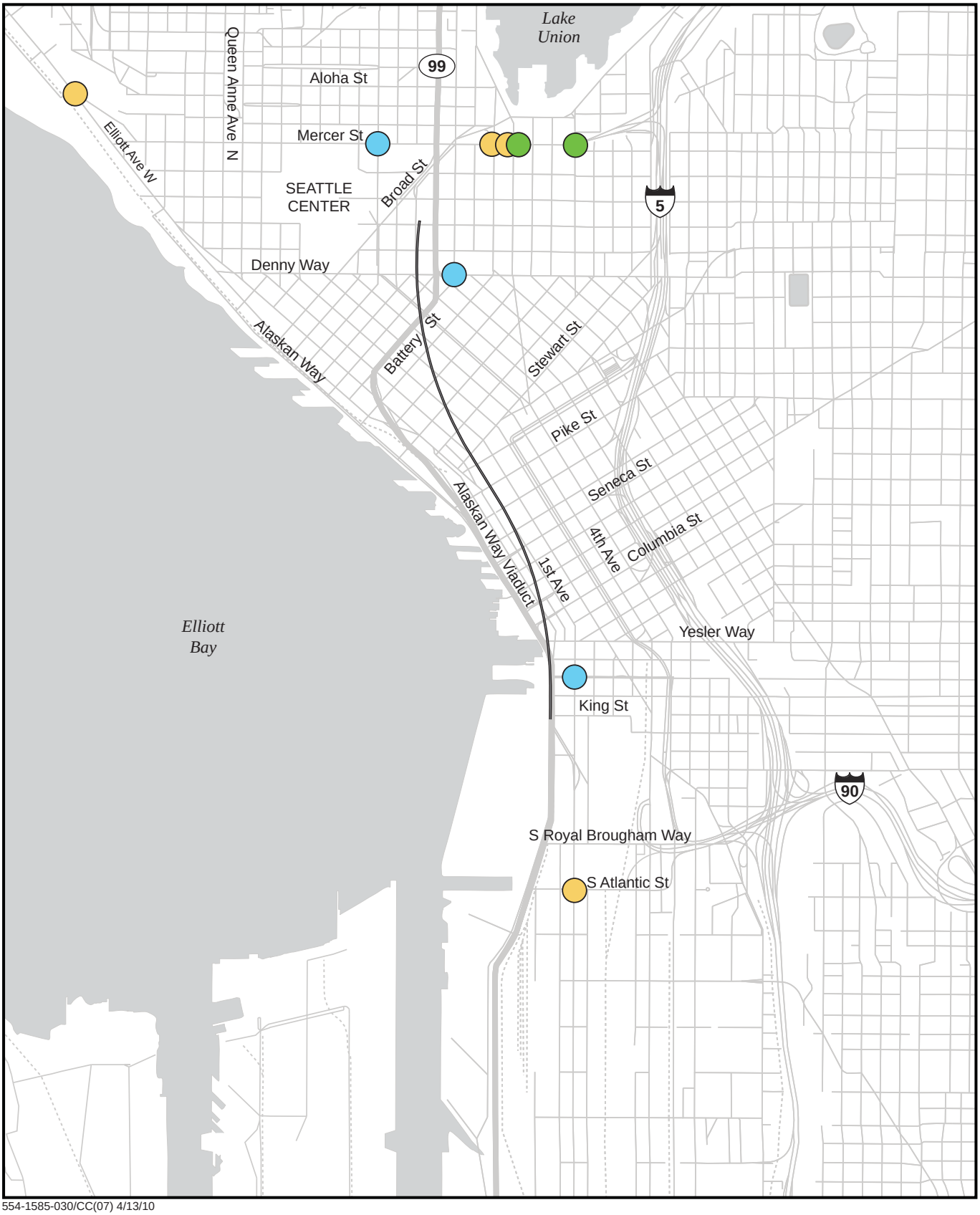
- Locations near the tunnel portals that would be accessible to the public and at least 10 feet from either side of the travelway.
- Both ground-level and elevated receptors (e.g., operable windows, air intake ducts) on nearby buildings.

Exhibit 3-2. Mobile Source Analysis Sites

Intersection	Year	Traffic Volume[1]	Delay (seconds)[1]	Peak Period (AM or PM)	Reasons for Selection
Mercer Street and Fairview Avenue N.	2015	8,015	162	PM	Volume
Mercer Street and Fairview Avenue N.	2015	6,240	57	AM	Volume
Mercer Street and Westlake Avenue N.	2015	6,300	220	PM	Volume and delay
Mercer Street and Ninth Avenue N.	2015	5,241	207	PM	Delay
Elliott Avenue W. and W. Mercer Place	2015	6,026	170	PM	Delay
First Avenue S. and S. Atlantic Street	2015	4,926	79	PM	(2)
Mercer Street and Fairview Avenue N.	2030	8,570	196	PM	Volume and delay
Mercer Street and Fairview Avenue N.	2030	6,955	66	AM	Volume
Mercer Street and Westlake Avenue N.	2030	6,757	534	PM	Volume and delay
Mercer Street and Ninth Avenue N.	2030	5,607	358	PM	Delay
Elliott Avenue W. and W. Mercer Place	2030	6,412	179	PM	(3)
First Avenue S. and S. Atlantic Street	2030	5,155	97	PM	(2)

Notes:

1. Volume and delay for the Bored Tunnel Alternative conditions.
2. Although volumes and delays estimated at this intersection are not high enough to require analysis, in accordance with WSDOT guidance, this intersection was included to represent conditions near the south portal.
3. Although volumes and delays estimated at this intersection for 2030 are not high enough to require analysis, in accordance with WSDOT guidance, this intersection was included because analyses were conducted at this intersection for 2015 conditions.



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Intersections Modeled for Existing Conditions, 2015, 2030 and Construction

Intersections Modeled for Existing Conditions, 2015 and 2030

Intersection Modeled for Construction Only

Bored Tunnel

Exhibit 3-3
CO Analysis Locations

3.4.5 Mobile Source Models

WASIST, which was used in all mobile source intersection analyses, is a screening model used for determining worst-case CO concentrations at signalized intersections throughout Washington. The results are based on the latest version of EPA's emission factor algorithm (MOBILE6.2.03) and EPA's CAL3QHC mobile source dispersions model. CO concentrations are estimated based on the intersection geometry, user inputs, and reasonable worst-case assumptions regarding meteorological and topographical factors. CO emission factors are determined for each approaching leg of traffic and for idling vehicles. All parameters used in WASIST and the model's output are provided in Attachment A.

WASIST uses readily available data in a user-friendly application to make a conservative estimate of project-related CO concentrations. This is done by using a combination of worst-case conditions that, when occurring simultaneously, produce the highest concentrations of CO. The purpose of the model is to allow the user to conservatively estimate the highest CO concentrations that would be found at an intersection without having to perform a more time-consuming detailed analysis. If the results from WASIST do not violate the NAAQS for CO, the effect from any other combination of conditions would also be less than the standards, and no further modeling is required.

3.4.6 Mobile Source Air Toxic Emissions Modeling Methodology

On February 3, 2006, FHWA released *Interim Guidance on Air Toxic Analysis in NEPA Documents*. This guidance was superseded on September 30, 2009, by FHWA's *Interim Guidance Update on Air Toxic Analysis in NEPA Documents* (FHWA 2009). The purpose of FHWA's guidance is to advise on when and how to analyze MSATs in the NEPA process for highways. This guidance is considered interim guidance because MSAT science is still evolving. As the science progresses, FHWA will update the guidance.

FHWA's interim guidance groups projects into three categories:

- Tier 1 – No analysis for projects with no potential for meaningful MSAT effects.
- Tier 2 – Qualitative analysis for projects with a low potential for MSAT effects.
- Tier 3 – Quantitative analysis to differentiate alternatives for projects with a higher potential for MSAT effects.

FHWA has developed this approach because currently available technical tools do not allow a prediction of the project-specific health effects that would result

from the potential emission changes associated with a project. These limitations include the following:

- Emissions – The EPA tools to estimate MSAT emissions from motor vehicles are not sensitive to key variables that determine emissions of MSATs in the context of a highway project.
- Dispersion – The tools to predict dispersion of MSATs into the environment are limited. The current dispersion models were developed to predict episodic concentrations of CO to determine compliance with the NAAQS. The performance of dispersion models is more accurate for predicting maximum concentrations than for predicting exposure patterns.
- Exposure levels and health effects – Even if emission levels and concentrations of MSATs could be accurately predicted, shortcomings in current techniques for exposure assessment and risk analysis preclude any meaningful conclusion about project-specific health effects. Exposure assessments are difficult because it is difficult to accurately calculate annual concentrations of MSATs near roadways, and to determine the portion of a year that people are actually exposed to those concentrations at a specific location.

Based on FHWA's recommended tiered approach, the project belongs in Tier 3 (i.e., projects with a high potential for MSAT effects). This category is appropriate because the Bored Tunnel Alternative has the potential to add capacity to urban roadways and the affected roadways are located near populated areas.

Following FHWA's recommendation, EMIT was used to calculate annual MSAT pollutant burdens in tons per year for the project. EMIT incorporates EPA's MOBILE6.2.03 emission factor model along with components for forecasting vehicle speeds under congested conditions and VMT as a function of area type and roadway functional class. EMIT focuses on the following pollutants because they were previously (before the February 2007 EPA Final Rule) classified as priority MSATs:

- 1,3-Butadiene
- Acetaldehyde
- Acrolein
- Benzene
- Diesel particulate matter/diesel exhaust organic gases
- Formaldehyde

Summer and winter parameters were used as input to the MOBILE6.2.03 portion of EMIT to obtain an accurate estimate of the annual pollutant burden. MOBILE6.2.03 input parameters recommended by PSRC, Ecology, and FHWA were used in EMIT, along with the traffic volumes, speeds, and travel

characteristics forecasted for the project. Attachment B provides all the parameters used in EMIT and the model's output.

3.4.7 Stationary Source Models

Stationary source models are the basic analytical tools used to estimate pollutant concentrations resulting from one or more localized emission sources. The EPA AERMOD model is a current recommended stationary model that was used to estimate pollutant concentrations near the tunnel portals and tunnel operations buildings. The basis of the AERMOD model, which can be used to estimate the combined effects from multiple emission sources, is the straight-line, steady-state Gaussian plume equation. The model is used to estimate effects from simple point-source emissions from stacks; emissions from stacks that are subjected to aerodynamic downwash due to nearby buildings; and emissions from isolated vents, multiple vents, storage piles, conveyor belts, and the like.

Two types of stationary sources were considered for this analysis: point sources and area sources.

- A point source refers to a condition in which emissions are released through a limited opening such as a stack or vent. The emissions released through the exhaust stacks located on the roofs of the tunnel operations buildings were considered as point sources.
- An area source refers to a two-dimensional area from which pollutants are emitted, usually from or near ground level. The emissions released through the tunnel portals and ramps (before they reach sensitive land uses) and downstream of the portal exits/entrances were considered as area sources.

AERMOD accepts hourly meteorological observations and is able to directly estimate concentrations over short-term (e.g., 1-hour, 3-hour, and 8-hour) and long-term (e.g., annual) periods. This analysis used 5 years of the atmospheric meteorological data (2002 to 2006) collected at Seattle-Tacoma International Airport. Surface characteristics and surface roughness factors were determined based on local land uses. Two sets of dispersion algorithms are included in AERMOD: one for urban areas and one for rural areas. The urban algorithms were used for all the project-related analyses.

3.5 Air Quality Modeling Methodology

3.5.1 Roadways and Intersections

A microscale modeling analysis was conducted using WASIST to estimate CO concentrations at sensitive receptor sites located near heavily congested

intersections that are expected to be affected under the Viaduct Closed (No Build Alternative) and the Bored Tunnel Alternative.

3.5.2 Tunnel Portals

The potential air quality effects of emissions released from the tunnel portals were estimated using normal (i.e., not emergency or breakdown) operating conditions during the PM peak period. During a fire in the tunnel or other emergency condition, pollutant concentrations may exceed the NAAQS at nearby receptors, but they are not expected to exceed acutely harmful concentrations during the time it would take to evacuate the adjacent areas.

CO and $PM_{2.5}$ concentrations were estimated at sensitive land uses located near the tunnel portals using a method specifically developed for this type of emissions source. The method is based on wind tunnel test data developed for several similar projects and procedures that were accepted by regulatory agencies in the United States and elsewhere. This analysis was conducted using data for emissions released through the tunnel portals, as supplied by the project's mechanical ventilation engineers.

Total pollutant concentrations estimated at each receptor location considered were assumed to be affected by the following components:

- Emissions exhausted out of the tunnel portals.
- Emissions from the vehicles traveling on roadways immediately downstream of the tunnel portals (including on- and off-ramps).
- Emissions (where applicable, depending on the portal and receptor locations and the critical wind angles) from traffic on adjacent surface roadways.
- Background levels appropriate for the area.

The total pollutant concentrations estimated at the nearby receptors from all of these sources combined were compared with the appropriate air quality standards. The methods used to estimate the potential effects from each of the previously mentioned sources are discussed separately in the following subsections. Attachment C provides the tunnel and ventilation modeling input and output tables.

Releases From Tunnel Portals

The approach that was used to analyze releases from the tunnel portals is based on the assumption that the jet of air exiting a tunnel portal maintains its integrity (i.e., maintains a uniform set of conditions from which pollutants disperse) for a finite distance along the roadway after exiting the portal. This assumption is based on observations made by researchers that indicate that air emitted from a tunnel portal forms a plume that is both pushed out of the tunnel by vehicles

before they exit the tunnel (and, if applicable, by mechanical ventilation systems) and dragged out of the portal by these same vehicles as they move downstream of the portal. In addition, the stream of moving cars exiting a tunnel portal creates a continuous source of momentum that maintains a jet of air with a finite length, width, and height, and the individual cars in the stream create a mechanical turbulence that mixes the air uniformly within this region.

Although no method is currently available for mathematically estimating the configuration of the jet or its concentration gradients, the following factors were used to estimate its size and shape:

- The speed of the vehicles passing through the tunnel.
- The atmospheric wind speed and direction.
- The topography of the area immediately surrounding the tunnel portal.
- The type of portal (i.e., whether it is one-way or two-way).
- The geometry of the portal (i.e., its height and physical configuration, and whether there is a wall between the directional roadways).
- The type of ventilation used in the tunnel (i.e., natural or mechanical and, if mechanical, either longitudinal or transverse).

In general, the greater the tunnel exhaust velocity (from a naturally or mechanically ventilated tunnel) and the lower the atmospheric wind speed in the direction opposite the traffic flow, the longer the length of the jet. In addition, the faster the speed of the vehicles exiting the portals, the higher the tunnel exhaust velocity.

Based on wind tunnel studies conducted for similar tunnel portals, a scenario that divides the overall jet into separate finite regions, each with its own unique (and uniform) set of emission rates, was developed for each analysis. The portal jet properties that were assumed for estimating the effects of the Bored Tunnel Alternative were based on the following factors:

- The number of lanes of traffic exiting each portal.
- Whether the entrance and exit roadways of the portal are physically separated.
- For jets located in depressed sections of roadway downstream of the tunnel portals, the emissions from these jets would disperse through the top portion of the exiting lanes of the depressed roadways. (Each of these jets was modeled as an area source that has the width of the exiting roadway. The relative height of receptor sites located at sidewalks immediately over a portal was raised above the area source to account for the vertical distances between these receptors and the height of the emission sources.

The length of each jet was estimated based on vehicle speeds, portal release exit flow rates, and the geometrical alignment of the portal area.)

- Based on a review of wind tunnel studies, it was assumed that the total emissions released through the tunnel portals would be dispersed into the atmosphere via three jet sections of equal length. The lengths of each jet section and the percentage of total portal emissions in each section were based on the configuration of the tunnel portal and the downstream roadway.

The effects were estimated using AERMOD, with each jet section assumed to be an area source.

Roadway Emissions From Downstream Traffic

Emissions from the traffic immediately downstream of each portal on the mainline and on the ramps were also modeled (using AERMOD) as area sources with emissions that would be released into the atmosphere along the top of the depressed roadway sections or above the at-grade section as appropriate. The width of the area source was the width of the roadway. The length of the area source was estimated based on the proposed configuration of the roadway. Hourly emission rates were developed based on hour-by-hour traffic conditions over a 24-hour period.

Total Concentrations Near Tunnel Portals

The total CO concentrations at each of the receptor locations were estimated by adding the effects of all of these sources to the appropriate background concentrations. The maximum CO concentrations estimated at each receptor location near each portal were compared with the NAAQS.

3.5.3 Tunnel Operations Buildings

Emissions captured by the tunnel ventilation system would be released through the exhaust located on the roof of the tunnel operations buildings. The effects of these emissions were modeled using the AERMOD point-source option. Exhaust points were located at the top of the ventilation stacks. Stack tip downwash and the downwash effect of the operations building were taken into account. Background concentrations and emissions from the tunnel portals and nearby roadways (where applicable) were added together to estimate the total pollutant concentrations at nearby sensitive receptors.

Two operations buildings would be constructed—one near each portal. Although two design options (are being considered for the north and south portal areas, the location of the tunnel operations buildings would be the same regardless of the design options selected.

3.6 Analysis of Construction Effects

Two analyses were conducted to evaluate the potential effects during project-related construction. One was a quantitative mobile source analysis to estimate potential effects associated with changes in traffic conditions during major construction (as a result of both changes in traffic patterns during major phases of construction and construction-related trucking activities on the local roadway network). The other was a qualitative analysis of potential effects associated with emissions from dust-generating activities, operation of heavy-duty diesel equipment, and trucking activities within major construction areas.

The mobile source analysis sites were chosen using the method described in Section 3.4.3. Major signalized intersections that may be affected by project construction were identified. These intersections were then evaluated for traffic volumes and levels of service under the Bored Tunnel Alternative with worst-case traffic conditions. The intersections were ranked according to the results of the evaluation. Those sites at which air quality was most likely to be substantially affected by the project were selected for analysis in accordance with accepted PSCAA procedures.

The intersections were ranked and prioritized based on the total approach volume and intersection delay for the worst-case construction conditions during the earliest affected year (2012) (Exhibit 3-4). The potential for localized CO concentrations in excess of the NAAQS at these locations was estimated.

Exhibit 3-4. Mobile Source Analysis Sites for Construction

Intersection	Traffic Volume[1]	Delay (seconds)[1]	Peak Period (AM or PM)	Reasons for Selection
Mercer Street and Fairview Avenue N.	8,160	232	PM	Volume and delay
Mercer Street and Westlake Avenue N.	6,347	73	PM	Volume
Mercer Street and Fairview Avenue N.	6,264	45	AM	Volume
Mercer Street and Fifth Avenue N.	4,530	562	PM	Delay
S. Main Street and First Avenue S.	1,826	381	PM	Delay

Notes:

1. Volume and delay for the worst-case construction conditions.

Chapter 4 AFFECTED ENVIRONMENT

4.1 Study Area Characteristics

The study area for the air quality analysis is located in downtown Seattle. This is a dense urban area, and land use in the area ranges from industrial and commercial to residential buildings.

4.2 Regulatory Status of Study Area

Air quality in the study area is regulated by EPA, Ecology, and PSCAA. Section 107 of the 1977 Clean Air Act Amendments requires EPA to publish a list of all geographic areas in compliance with the NAAQS, as well as those not attaining the NAAQS. Areas not in compliance with the NAAQS are deemed nonattainment areas. Areas that were once classified as nonattainment but have since demonstrated attainment are classified as maintenance areas. The designation of an area is based on the data collected by the state monitoring network on a pollutant-by-pollutant basis.

The project area is located entirely within a CO maintenance area and a former 1-hour ozone maintenance area, as shown on Exhibit 4-1. This area was designated as a nonattainment area for CO and classified as moderate upon enactment of the Clean Air Act Amendments of 1990. On August 23, 1999, the state submitted a CO maintenance plan, which was approved by EPA on March 13, 2001. The plan relies on control of residential wood smoke, fugitive dust, industrial emissions, open burning, and diesel exhaust. Because this maintenance area would be affected by the project, the project must demonstrate compliance with the Transportation Conformity Rule (40 CFR 93).

4.3 Air Pollution Trends

Regional air pollutant trends have generally followed national patterns over the last 20 years. While the average weekday VMT in the central Puget Sound region has increased from 30 million in 1981 to 65 million in 1999 (PSRC 2000), pollutant emissions associated with transportation sources have decreased. CO is the criteria pollutant most closely tied to transportation, with over 90 percent of the CO emissions in the Puget Sound urban areas coming from transportation sources (PSCAA 2002). Regionally, the maximum measured CO concentrations have decreased considerably over the past 20 years. Other transportation-related pollutants have followed similar but less pronounced trends.

Exhibit 4-1. CO and PM_{10} Maintenance Areas

Central Puget Sound Region Designated Maintenance Areas

4.4 Monitored Air Quality Concentrations

Air quality data were compiled using Ecology and EPA AirData (EPA 2009b) databases for 2008, the latest calendar year for which these data are available. Since EPA is focused on the fine particulate ($PM_{2.5}$) pollution, PM_{10} monitors have largely been discontinued, and representative data for PM_{10} for the area date back to 2006. The highest recorded ambient air quality levels from representative sites that were monitored for these data and are located within or near the study area are shown in Exhibit 4-2. The monitored concentrations for the criteria pollutants do not exceed national and state ambient air quality standards in the study area.

Exhibit 4-2. Monitored Ambient Air Quality Levels (2008)

Pollutant	Location (County)[1]	Averaging Time	Concentration	NAAQS
Carbon monoxide	Beacon Hill Reservoir (King)	8 hours	0.9 ppm	9 ppm
		1 hour	1.4 ppm	35 ppm
Nitrogen dioxide	Casino Drive, Anacortes, (Skagit)[2]	Annual	0.011 ppm	0.053 ppm
Ozone	Beacon Hill Reservoir (King)	8 hours	0.052 ppm	0.075 ppm
Sulfur dioxide	Beacon Hill Reservoir (King)	Annual	0.001 ppm	0.03 ppm
		24 hours	0.011 ppm	0.14 ppm
		3 hours	0.030 ppm	0.5 ppm
$PM_{2.5}$	Beacon Hill Reservoir (King)	Annual	7.25 μg/m^3	15 μg/m^3
		24 hours	20.5 μg/m^3	35 μg/m^3
PM_{10}	E. Marginal Way S. (King)	24 hours	51 μg/m^3	150 μg/m^3

Source: EPA 2009b.

Notes: Values shown correspond to NAAQS time periods.
μg/m^3 = micrograms per cubic meter
NAAQS = National Ambient Air Quality Standards
$PM_{2.5}$ = particulate matter with diameter less than or equal to 2.5 micrometers
PM_{10} = particulate matter with diameter less than or equal to 10 micrometers
ppm = parts per million
1. If data are available from more than one monitoring station in a county, the highest value is provided.
2. Although this monitor is located outside of the study area, data collected at this monitor are provided because it is the only nitrogen dioxide monitor in the state with available EPA data.

4.4 Estimated Existing Air Pollutant Conditions

4.4.1 Mobile Source Analysis

Exhibit 4-3 shows the results of the screening-level mobile source analysis that was conducted using WASIST. The values provided are the highest 1- and 8-hour

CO concentrations predicted at any of the receptor sites near the selected intersections under existing conditions. The estimated CO concentrations are all less than the 1-hour NAAQS of 35 ppm and equal to or less than the 8-hour NAAQS of 9 ppm.

Exhibit 4-3. Existing Conditions Maximum Predicted CO Concentrations

Intersection	Peak Period (AM or PM)	Existing Conditions	
		1-hour Concentration (ppm)	8-hour Concentration (ppm)
Mercer Street and Fairview Avenue N.	AM	10.4	8.2
Mercer Street and Fairview Avenue N.	PM	11.6	9.0
Mercer Street and Westlake Avenue N.	PM	10.1	8.0
Mercer Street and Ninth Avenue N.	PM	8.5	6.8
Elliott Avenue W. and W. Mercer Place	PM	8.8	7.1
First Avenue S. and S. Atlantic Street	PM	8.3	6.7

Notes:

All values include a conservative background concentration of 3 ppm.
The 1-hour NAAQS for CO is 35 ppm; the 8-hour NAAQS for CO is 9 ppm.
CO = carbon monoxide
NAAQS = National Ambient Air Quality Standards
ppm = parts per million

WASIST uses readily available data in a user-friendly application to make a conservative estimate of project-related CO concentrations using a combination of reasonable worst-case conditions that, when occurring simultaneously, produce high CO concentrations. The purpose of the model is to allow the user to conservatively estimate the highest CO concentrations that would be found at an intersection without having to perform a more time-consuming detailed analysis. Existing conditions are estimated for a comparison to the future No Build and Build conditions and do not need to demonstrate conformity with the NAAQS for CO; therefore, no further refined modeling is required.

Chapter 5 OPERATIONAL EFFECTS, MITIGATION, AND BENEFITS

5.1 Operational Effects of the Viaduct Closed (No Build Alternative)

Federal and Washington State environmental regulations require agencies to evaluate a No Build Alternative to provide baseline information about existing conditions in the project area. For this project, the No Build Alternative is not a viable alternative since the existing viaduct is vulnerable to earthquakes and structural failure due to ongoing deterioration. Multiple studies of the viaduct's current structural conditions, including its foundations in liquefiable soils have determined that retrofitting or rebuilding the existing viaduct is not a reasonable alternative. At some point, the roadway will need to be closed.

The Viaduct Closed (No Build Alternative) describes what would happen if the Bored Tunnel Alternative or another build alternative is not implemented. If the existing viaduct is not replaced, it will be closed, but it is unknown when that would happen. However, it is highly unlikely that the existing structure could still be in use in 2030. Therefore, the Viaduct Closed (No Build Alternative) describes the consequences of suddenly losing the function of SR 99 along the central waterfront based on the two scenarios described below. All vehicles that would have used SR 99 would either navigate the Seattle surface streets to their final destination or take S. Royal Brougham Way to I-5 and continue north. The consequences would be short-term, lasting until transportation and other agencies could develop and implement a new, permanent solution. The planning and development of the new solution would have its own environmental review.

5.1.1 Scenario 1: Sudden Unplanned Loss of the Viaduct

Under this scenario, there would be a sudden, unplanned closure of SR 99 between S. King Street and Denny Way due to some structural deficiency, weakness, or smaller earthquake event. Under this scenario, SR 99 would be closed for an unknown period until a viaduct replacement could be built. Severe travel delays would be experienced, and utilities on the viaduct would likely be damaged and require repair. Due to increased congestion and decreased travel speeds, fuel usage would likely increase, resulting in an overall increase in air pollutants compared to the existing conditions.

5.1.2 Scenario 2: Catastrophic and Complete Collapse of the Viaduct

This scenario considers the effects of a catastrophic failure and collapse of the viaduct. Under this scenario, a seismic event of similar or greater magnitude than the 2001 Nisqually earthquake could trigger failure of portions of the viaduct. This scenario would have the greatest effect on people and the environment.

Failure of the viaduct could cause injuries and death to people traveling on or near the structure at the time of the seismic event. Travel delays would be severe. The environmental effects and length of time it would take to repair the SR 99 corridor are unknown, but the effects would be severe. Due to increased congestion and decreased travel speeds, fuel usage would likely increase, resulting in an overall increase in air pollutants compared to the existing conditions.

5.2 Operational Effects of the Bored Tunnel Alternative

5.2.1 Mobile Source Analysis

The results of the screening-level mobile source analysis that was conducted using WASIST (Exhibit 5-1) represent the worst-case scenario that would occur in the project area (see Section 3.4.3). The values provided are the highest 1-hour and 8-hour CO concentrations predicted at any of the receptor sites near the selected intersections for conditions in the year of opening (2015) and the design year (2030). The estimated maximum CO concentrations for the Bored Tunnel Alternative are all less than the 1-hour and 8-hour NAAQS of 35 and 9 ppm, respectively. Therefore, a more in-depth mobile source air quality analysis is not required.

Exhibit 5-1. Opening and Design Year Maximum Predicted CO Concentrations for the Bored Tunnel Alternative

Intersection	Peak Period (AM or PM)	CO Concentrations (ppm)			
		2015		2030	
		1-hour	8-hour	1-hour	8-hour
Mercer Street and Fairview Avenue	AM	8.7	7.0	8.0	6.5
Mercer Street and Fairview Avenue	PM	10.8	8.5	9.4	7.5
Mercer Street and Westlake Avenue	PM	9.4	7.5	8.2	6.6
Mercer Street and Ninth Avenue	PM	8.4	6.8	7.6	6.2
Elliott Avenue W. and W. Mercer Place	PM	8.3	6.7	7.3	6.0
First Avenue S. and S. Atlantic Street	PM	8.2	6.2	8.6	6.9

Notes:

All values include a background concentration of 3 ppm.
The 1-hour NAAQS is 35 ppm; the 8-hour NAAQS is 9 ppm.
CO = carbon monoxide
NAAQS = National Ambient Air Quality Standards
ppm = parts per million

5.2.2 Tunnel Portal and Tunnel Operations Building Analysis

Exhibit 5-2 shows the results of the analysis for the tunnel portals and tunnel operations buildings that was conducted using the AERMOD model. The values provided are the highest 1-hour and 8-hour concentrations of CO and the annual and 24-hour concentrations of $PM_{2.5}$ predicted at any of the receptor sites located near the tunnel portals and the tunnel operations buildings under 2015 and 2030 conditions. The estimated CO and $PM_{2.5}$ concentrations are all less than the NAAQS.

Exhibit 5-2. Maximum Predicted CO and $PM_{2.5}$ Concentrations Near the Tunnel Portals for the Bored Tunnel Alternative

Portal and Option	CO Concentrations[1] (ppm)				$PM_{2.5}$ Concentrations[2] (µg/m³)			
	2015		2030		2015		2030	
	1-hour	8-hour	1-hour	8-hour	24-hour	Annual	24-hour	Annual
South portal (New Dearborn Intersection option)	12.1	4.1	9.9	3.5	22.6	8.1	22.5	8.1
South portal (New Dearborn and Charles Intersections option)	12.3	4.3	10.0	3.7	22.6	8.1	22.6	8.1
North portal (either option)	12.0	4.7	10.0	4.1	24.2	8.4	23.9	8.2

Notes:

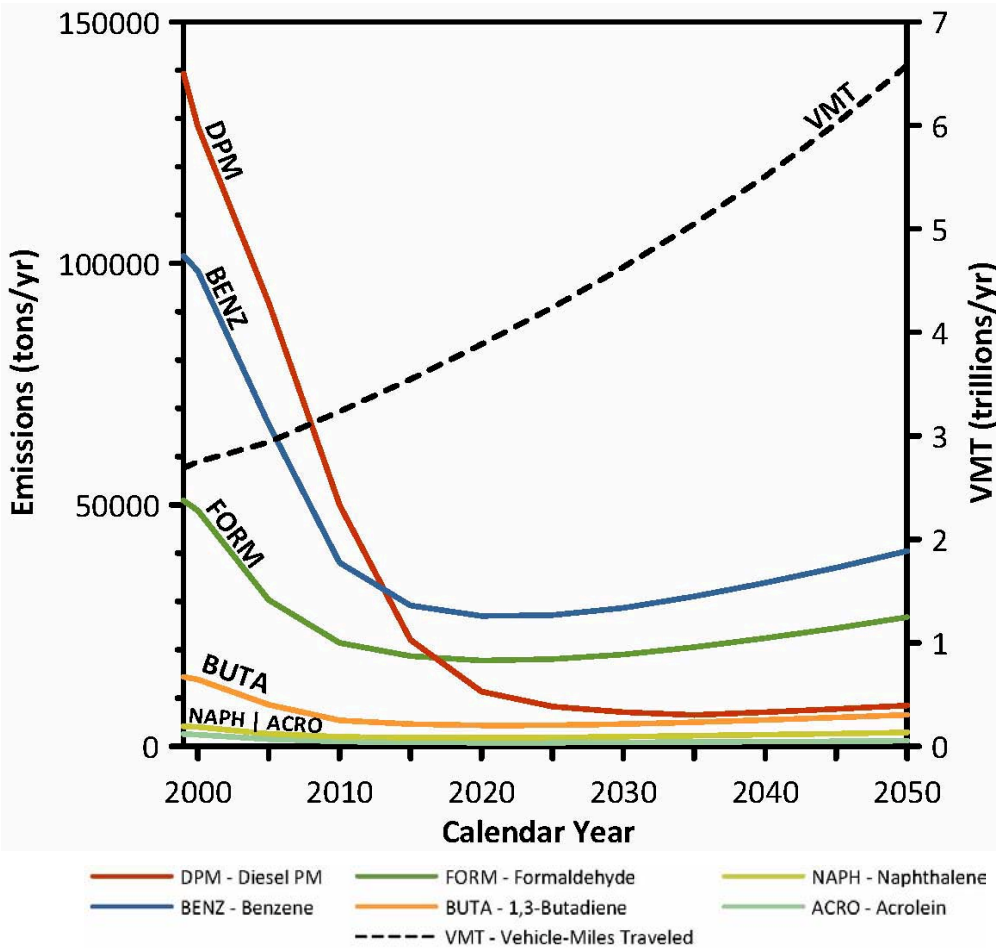
CO = carbon monoxide
µg/m³ = micrograms per cubic meter
$PM_{2.5}$ = particulate matter with diameter less than or equal to 2.5 micrometers
ppm = parts per million

1. For CO, the 1-hour concentrations include a background concentration of 2.3 ppm; the 8-hour concentrations include a background concentration of 1.5 ppm. The 1-hour NAAQS is 35 ppm; the 8-hour NAAQS is 9 ppm.
2. For $PM_{2.5}$, the annual concentrations include a background concentration of 7.5 µg/m³; the 24-hour concentrations include a background concentration of 20.2 µg/m³. The annual NAAQS is 15µg/m³; the 24-hour NAAQS is 35µg/m³.

5.2.3 Mobile Source Air Toxic Emissions Analysis

Future emissions likely would be lower than current levels as result of the EPA's national control programs that are projected to reduce MSAT emissions by 72 percent from 1999 to 2050 even if VMT increases by 145 percent, as shown on Exhibit 5-3. Similarly, as shown in Exhibit 5-4, MSATs in the study area are predicted to dramatically decrease in the future compared to existing conditions, even though the VMT on SR 99 is predicted to increase by 17.6 percent. Local trends differ slightly from national trends due to fleet mix and turnover, VMT growth rates, and local control measures.

Exhibit 5-3. National MSAT Emission Trends for Vehicles Operating on Roadways (1999–2050), Using EPA's MOBILE6.2 Model



Source: EPA 2009. MOBILE6.2 Model run 20.

Notes:

Annual emissions of polycyclic organic matter are projected to be 561 tons/year for 1999, decreasing to 373 tons/year for 2050.

Trends for specific locations may differ, depending on locally derived information representing vehicle miles of travel, vehicle speeds, vehicle mix, fuels, emission control programs, meteorology, and other factors.

Exhibit 5-4. Predicted MSAT Concentrations – Existing Conditions Versus 2030 Bored Tunnel Alternative

Condition	Vehicle Miles of Travel	Change in Vehicle Miles of Travel From Existing Conditions (%)	MSAT (tons/year)						Change From Existing Conditions (%)					
			Acetaldehyde	Acrolein	Benzene	1,3-Butadiene	DPM	Formaldehyde	Acetaldehyde	Acrolein	Benzene	1,3-Butadiene	DPM	Formaldehyde
Existing conditions	2,115,390	NA	4.44	0.685	53.6	4.7	23.1	11.9	NA	NA	NA	NA	NA	NA
2030 Bored Tunnel Alternative	2,487,985	17.6%	2.04	0.279	23.5	1.73	1.4	5.24	-54%	-59%	-56%	-63%	-94%	-56%

Notes:

DPM = diesel particulate matter
MSAT = mobile source air toxic
NA = not applicable

The project area is in a highly developed urban area with numerous sensitive land uses. Although the Bored Tunnel Alternative would result in local increases in MSAT concentrations relative to those resulting from the Viaduct Closed (No Build Alternative), future MSAT concentrations are predicted to be lower than the existing concentrations, even with increased VMT. In addition, while there would be localized increases in some areas (e.g., near the tunnel portals), there would be a corresponding decrease in other areas (e.g., areas that are near the tunnel but away from the portals).

5.3 Operational Mitigation

Regional MSAT emissions are expected to substantially decrease from existing conditions, and no exceedances of the NAAQS are expected under the Bored Tunnel Alternative. Because no substantial adverse air quality effects are expected, no mitigation measures would be necessary.

5.4 Operational Benefits

As noted above, all air quality standards would be met with the Bored Tunnel Alternative. However, while there might be local changes in pollutant levels between the Bored Tunnel Alternative and the Viaduct Closed (No Build Alternative) (e.g., levels would be lower along the tunnel sections but higher near the tunnel portals with the Bored Tunnel Alternative), there would be no significant operational benefits specific to the regional amounts of air pollutants emitted into the atmosphere for the Bored Tunnel Alternative relative to the Viaduct Closed (No Build Alternative).

Chapter 6 CONSTRUCTION EFFECTS AND MITIGATION

6.1 Construction Effects

Air quality effects from construction of the Bored Tunnel Alternative would occur primarily as a result of emissions from heavy-duty construction equipment (such as bulldozers, backhoes, and cranes), diesel-fueled mobile sources (such as trucks, brooms, and sweepers), diesel- and gasoline-fueled generators, and on- and off-site project-related vehicles (such as service trucks and pickups).

Fugitive PM_{10} emissions are associated with demolition, land clearing, ground excavation, grading, cut-and-fill operations, and structure erection. PM_{10} emissions would vary from day to day, depending on the level of activity, specific operations, and weather conditions. Emission rates would depend on the soil moisture, silt content of soil, wind speed, and amount and type of operating equipment associated with project construction. Larger dust particles would settle near the source, and fine particles would be dispersed over greater distances from the construction site.

Fugitive PM_{10} emissions from construction activities could be noticeable, if uncontrolled. Mud and particulates from trucks may also be of concern if construction trucks are routed through streets near sensitive land uses (e.g., residences, schools, parks). The project will create a fugitive dust control plan. The plan will implement WSDOT's Memorandum of Understanding with PSCAA to comply with PSCAA regulations that require dust control during construction and to prevent deposition of mud on paved streets (PSCAA 1994, Article 9). Measures to reduce the deposition of mud and emissions of particulates are listed in Section 6.2, Construction Mitigation.

In addition to PM_{10} emissions, heavy trucks and construction equipment powered by gasoline and diesel engines would generate $PM_{2.5}$, CO, and nitrogen oxides in exhaust emissions. If construction traffic and lane closures increase congestion and reduce the speed of other vehicles in the area, emissions from traffic would increase temporarily while those vehicles are delayed. These emissions would be temporary, and the effects of these emissions would generally be limited to the immediate area in which the congestion occurs.

Some construction phases (particularly those involving paving operations using asphalt) would result in short-term odors, which might be detectable to some people near the site and would be diluted as distance from the site increases.

Because the total construction period is longer than 60 months, a mobile source analysis has been conducted to determine whether the Bored Tunnel Alternative conforms with CO standards near the congested intersections that would be most

affected by construction-related vehicles during the worst-case long-term construction period. Appendix C, Transportation Discipline Report provides more information on the construction period.

Exhibit 6-1 shows the results of the screening-level mobile source analysis that was conducted using WASIST. The values provided are the maximum 1-hour and 8-hour CO concentrations predicted at any of the receptor sites near the selected intersections during the worst-case construction year without the incorporation of any mitigation measures. The estimated CO concentrations are all less than the 1-hour and 8-hour NAAQS of 35 and 9 ppm, respectively. The results of this analysis indicate that a more in-depth mobile source air quality analysis is not required.

Exhibit 6-1. Maximum Predicted 1-Hour and 8-Hour CO Concentrations Under Construction With No Mitigation

Intersection	Peak Period (AM or PM)	1-hour Concentration (ppm)	8-hour Concentration (ppm)
Mercer Street and Fairview Avenue N.	PM	11.1	8.7
Mercer Street and Westlake Avenue N.	PM	8.5	6.8
Mercer Street and Fairview Avenue N.	AM	8.9	7.1
Mercer Street and Fifth Avenue N.	PM	9.7	7.7
S. Main Street and First Avenue S.	PM	5.7	4.9

Notes:

All values include a conservative background concentration of 3 ppm.
The 1-hour NAAQS is 35 ppm; the 8-hour NAAQS is 9 ppm.
CO = carbon monoxide
ppm = parts per million

6.1.1 South Portal

Construction of the south portal would include ground replacement, construction of the south access point and tunnel operations building, and the south end surface improvements. The major activities would include earth excavation and grading, handling and transport of excavated material and debris, operation of heavy-duty diesel- and gasoline-powered equipment, and trucking activities.

6.1.2 Bored Tunnel

Construction of the bored tunnel would include construction of a power substation for the tunnel boring machine, construction of a slurry treatment plant (if needed), operation of the tunnel boring machine and construction of the tunnel structure, and operation of an intelligent transportation system. The major activities would include earth excavation and grading, handling and transport of

excavated material and debris, operation of heavy-duty diesel- and gasoline-powered equipment, and trucking activities.

6.1.3 North Portal

Construction of the north portal would include utility relocation, construction of the north access point and tunnel operations building, and the north end surface improvements. The major activities would include earth excavation and grading, handling and transport of excavated material and debris, operation of heavy-duty diesel- and gasoline-powered equipment, and trucking activities.

6.1.4 Viaduct Removal

The viaduct removal would include utility relocations, demolition of the viaduct, and removal of spoils. The major activities would include earth excavation and grading, handling and transport of excavated material and debris, operation of heavy-duty diesel- and gasoline-powered equipment, and trucking activities.

6.1.5 Battery Street Tunnel Decommissioning

One likely option for decommissioning the Battery Street Tunnel is to fill the void space with suitable material (potentially recycling the concrete rubble from the demolition of the viaduct structure), close all of the street access vents, and block off the portals at both ends of the tunnel. The major activities would include handling and transport of excavated material and debris, operation of heavy-duty diesel- and gasoline-powered equipment, and trucking activities.

6.2 Construction Mitigation

PSCAA would regulate particulate emissions (in the form of fugitive dust) during construction activities. WSDOT would take reasonable precautions to prevent these emissions from becoming airborne and would have to maintain and operate the source to minimize emissions.

A Memorandum of Understanding between WSDOT and PSCAA is in place to help eliminate, confine, or reduce construction-related emissions for WSDOT projects. WSDOT will create a plan for controlling fugitive dust during construction. This fugitive dust control plan would reduce air pollutant emissions near the construction site, including near residences located along Battery Street adjacent to the open grates.

The project's traffic management plan includes detours and strategic construction planning (like weekend work, parking restrictions, and signal timing enhancements) to continue moving traffic through the area and reduce backups for the traveling public to the extent possible. Construction areas, staging areas (see Appendix B, Alternatives Description and Construction Methods Discipline

Report), and material transfer sites would be set up in a way that reduces standing wait times for equipment, engine idling, and the need to block the movement of other activities on the site. These strategies would reduce fuel consumption by reducing wait times and ensuring that construction equipment operates efficiently. Due to space constraints at the work site and the benefit of additional emissions reductions, ridesharing and other commute trip reduction efforts may be promoted for employees working on the project.

In addition to the strategies detailed above, other possible measures for reducing air pollutant emissions near construction areas include the following (Associated General Contractors of Washington 1997):

- Spray exposed soil with water or other dust palliatives to reduce emissions of PM_{10} and deposition of particulate matter.
- Cover all trucks transporting materials, wet materials in trucks, or provide adequate freeboard (space from the top of the material to the top of the truck) to reduce particulate emissions during transportation.
- Remove particulate matter deposited on paved public roads to reduce mud and resultant windblown dust on area roadways.
- Require appropriate emission-control devices (e.g., a diesel oxygen catalyst, diesel particulate filters, and particulate traps) on large pieces of diesel-fueled equipment to reduce CO, nitrogen oxide, and particulate emissions in vehicle exhaust.
- Enclose conveyor system that would transport dirt from the tunnel excavation sites to the waterfront.
- Use electrical equipment as feasible.
- Use relatively new, well-maintained equipment to reduce CO and nitrogen oxide emissions.
- When feasible and where practicable, route construction trucks away from residential and business areas to minimize annoyance from dust.
- Require the use of low or ultra-low sulfur fuels in construction equipment to allow the use of effective particulate-emission control devices on diesel vehicles.
- Coordinate construction activities between WSDOT and the Seattle Department of Transportation with respect to other projects in the area to reduce the cumulative effects of concurrent construction projects.

Chapter 7 CUMULATIVE EFFECTS

Cumulative effects are effects on the environment that result from the incremental impact of the proposed action when added to other past, present, and reasonably foreseeable future actions. The focus of the cumulative effects analysis is the combined effects of the Bored Tunnel Alternative, the other Program elements, and other past, present, and reasonably foreseeable future projects that could contribute to effects on air quality in the study area.

This chapter discusses the following topics:

- Past and recent trends that have influenced current air quality and predictions of future air quality resulting from these trends
- Effects of the roadway elements of the Program
- Effects of the non-roadway elements of the Program
- Cumulative effects of the Bored Tunnel Alternative when combined with the effects of the other Program elements
- Cumulative effects of the Bored Tunnel Alternative when combined with the effects of the other Program elements and the effects of other past, present, and reasonably foreseeable future projects

A more detailed analysis of the cumulative effects analysis is provided in Attachment D. It describes the specific geographic area evaluated for cumulative effects and the period considered, and provides a list of past, present, and foreseeable future actions included in the analysis. It also describes the stepwise process used to identify and evaluate cumulative effects.

A more detailed description of the other Program elements included in the cumulative effects analysis is provided in Appendix B, Alternatives Description and Construction Methods Discipline Report.

7.1 Current Air Quality Trends

The past 100 years of urban development and growth in the greater Seattle region has contributed to the existing air quality condition, which results in part from the generation of pollutants of concern such as particulate matter, carbon dioxide, ozone, nitrogen dioxide, lead, and sulfur dioxide. PSRC's *Transportation 2040 Draft EIS* includes an analysis of air quality levels for these pollutants of concern over time, which concluded that the trend for the level of the six criteria air pollutants has been generally decreasing, with substantial decreases in pollutants such as CO (PSRC 2009). The reduction in CO is largely due to the replacement of older vehicles that cause more pollution with newer vehicles that meet federal emissions standards. Other measures including traffic control,

inspection/maintenance, and oxygenated fuel have contributed to declining CO emissions. Even though population and miles travelled have increased, concentrations of the criteria pollutants have declined below federal standards. Emissions of air toxics such as benzene have also been declining, but they still pose a health risk and EPA considers the region to have a high potential for risk of cancer from air toxics.

Alternatively, ozone and fine particulates continue to be of some concern, given the tougher federal standard for ozone and the relatively flat rate of change over time for fine particulates. There is currently no federal standard for greenhouse gases, although these emissions have been increasing over time largely due to CO from transportation sources, buildings and factories, and the generation of electricity (PSCAA 2004). Since Washington passed several pieces of legislation related to reducing greenhouse gas emissions, greenhouse gases are expected to decrease over time.

A variety of federal, state, and regional agencies oversee and cooperate on regional air quality issues, including the EPA Office of Air Quality Planning Standards, Ecology, PSRC, and PSCAA. These agencies have established compatible air quality management goals. Local agencies have also established air quality statues, which further the goals of controlling and reducing air emissions. Air quality in the region is predicted to continue to improve as vehicles, industries, and consumer products become less polluting and air quality regulations are fully implemented (EPA 2008).

7.2 Effects From Other Roadway Elements of the Program

7.2.1 Operational Effects

Other roadway elements of the Program include the Alaskan Way Surface Street Improvements from S. King Street to Pike Street, the Elliott/Western Connector from Pike Street to Battery Street, and the Mercer West Project (Mercer Street improvements from Fifth Avenue N. to Elliott Avenue). Together, these elements would decrease congestion and increase travel speeds, causing a decrease in fuel usage and resulting in an overall decrease in pollutant emissions compared to existing conditions or the Bored Tunnel Alternative without these other Program elements.

7.2.2 Construction Effects

Construction of these other roadway elements would result in a temporary increase in pollutant emissions from construction equipment and construction activities. Lane closures or detours could temporarily increase congestion and decrease travel speeds, resulting in an overall increase in pollutant emissions during construction.

7.3 Effects From Non-Roadway Elements of the Program

7.3.1 Elliott Bay Seawall Project

Construction of the seawall replacement would result in a temporary increase in pollutant emissions from construction equipment and construction activities. The operation and maintenance of the facility would not affect air quality.

7.3.2 Alaskan Way Promenade/Public Space

The effects of the Alaskan Way Promenade/Public Space would be similar to those described for the seawall in Section 7.3.1.

7.3.3 First Avenue Streetcar Evaluation

Operation of the First Avenue streetcar would not substantially affect congestion or travel speeds; therefore, it would have little effect on concentrations of air pollutants compared to existing conditions.

Construction of these improvements would result in a temporary increase in pollutant emissions from construction equipment and construction activities. Lane closures or detours could temporarily increase congestion and decrease travel speeds, resulting in an overall increase in pollutant emissions during construction.

7.3.4 Transit Enhancements

Due to decreased traffic congestion (resulting from increased transit use) and increased travel speeds, as well as the use of more fuel-efficient vehicles, fuel usage would decrease, resulting in an overall decrease in air pollutants compared to the existing conditions.

7.4 Cumulative Effects of the Project and Other Program Elements

The cumulative operational effects of the Bored Tunnel Alternative and other Program elements would include a decrease in congestion and increase in travel speeds; therefore, fuel usage would decrease, resulting in an overall decrease in air pollutants compared to the existing conditions.

Construction of the various elements of the Program would result in a temporary increase in pollutant emissions from construction equipment and construction activities. Lane closures or detours could temporarily increase congestion and decrease travel speeds, resulting in an overall increase in pollutant emissions during construction.

7.5 Cumulative Effects of the Project, Other Program Elements, and Other Actions

This section describes the cumulative effects of the Bored Tunnel Alternative and the other Program elements, combined with those of other past, present, and reasonably foreseeable future projects. Other key development projects located within the study area include the following:

- Alaskan Way Viaduct and Seawall Replacement Moving Forward projects
- Sound Transit University Link Light Rail Project
- Sound Transit North Link Light Rail
- Sound Transit East Link Light Rail
- Sound Transit Phases 1 and 2
- S. Spokane Street Viaduct Widening
- SR 519 Intermodal Access Project, Phase 2
- SR 520 Bridge Replacement and HOV Program
- I-5 Improvements
- Washington State Ferries Seattle Terminal Improvements

The Bored Tunnel Alternative in combination with the other Program elements and these other key projects is not expected to result in or exacerbate a violation of an air quality standard. This is because the issue of concern for this alternative is its effect on local air quality (primarily near the tunnel portals), and these other projects should not measurably affect air quality at these locations.

Construction of these improvements would result in a temporary increase in pollutant emissions from construction equipment and construction activities, as well as increased congestion and decreased speeds due to lane closures and detours. Once the improvements are completed, the transportation system would be more efficient, congestion would decrease, travel speeds would increase, and fuel usage would decrease, resulting in an overall decrease in air pollutants compared to the existing conditions.

Chapter 8 REGULATORY COMPLIANCE

8.1 Compliance With NAAQS

Maximum predicted 1-hour and 8-hour CO concentrations for the 2015 year of opening, the 2030 design year, and the 2012 construction year are provided in Exhibits 5-1, 5-2, and 6-1, respectively. The values presented are the highest values obtained at each of the analysis sites using methods presented in this report. Exhibit 5-2 shows the maximum predicted $PM_{2.5}$ concentrations (24-hour and annual) for the years 2015 and 2030 under the Bored Tunnel Alternative. Estimated pollutant concentrations at all the analysis sites are less than the NAAQS. No significant adverse air quality effects are expected to result from the Bored Tunnel Alternative.

8.2 Conformity

The study area for the project is within a CO maintenance area. Projects located in maintenance areas must comply with the project-level and regional conformity criteria described in EPA's Transportation Conformity Rule (40 CFR 93) and with WAC 173-420. Because this project would not cause or exacerbate an exceedance of the NAAQS or increase regional emissions, it would meet the project-level conformity requirements in accordance with 40 CFR 93.123.

The project is included in the Metropolitan Transportation Plan (PSRC 2001a) and the Transportation Improvement Program (WSDOT 2010b), as required to show that it conforms with the Puget Sound region's Air Quality Maintenance Plans and would not cause or contribute to exceedances of the NAAQS at the regional level. The project meets all the requirements of 40 CFR 93 and WAC 173-420 and demonstrates regional conformity.

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Chapter 9 REFERENCES

Associated General Contractors of Washington. 1997. Guide to Handling Fugitive Dust From Construction Projects. Seattle, Washington.

EPA. 2006. 1999 National Air Toxics Assessment. Released February 2006, last updated Friday, June 26, 2009. Available at: http://www.epa.gov/ttn/atw/nata1999/. Accessed March 2010.

EPA. 2008. National Air Quality Status and Trends Through 2007. EPA-454/R-08-006. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Air Quality Assessment Division, Research Triangle Park, North Carolina. November 2008.

EPA. 2009a. 2002 National Air Toxics Assessment. Last updated August 18, 2009. Available at: http://www.epa.gov/nata2002/. Accessed March 2010.

EPA. 2009b. Ambient Monitored Data. AirData. Last updated July 1, 2009. Available at: http://www.epa.gov/air/data/geosel.html. Accessed March 2010.

EPA. 2010a. National Ambient Air Quality Standards. Last updated February 10, 2010. Available at: http://www.epa.gov/air/criteria.html. Accessed March 2010.

EPA. 2010b. Integrated Risk Information System. Last updated August 13, 2010. Available at: http://www.epa.gov/ncea/iris/index.html. Accessed August 2010.

FHWA (Federal Highway Administration). 2009. Interim Guidance Update on Air Toxic Analysis in NEPA Documents. September 30, 2009.

PSCAA (Puget Sound Clean Air Agency, Formerly Puget Sound Air Pollution Control Agency). 1994. Regulation 1 of the Puget Sound Air Pollution Control Agency. Seattle, Washington.

PSCAA. 2002. Draft Puget Sound Air Toxics Evaluation. Seattle, Washington.

PSCAA. 2004. Roadmap for Climate Protection: Reducing Greenhouse Gas Emissions in Puget Sound. The Puget Sound Clean Air Agency, Climate Protection Advisory Committee.

PSRC (Puget Sound Regional Council). 2000. Puget Sound Trends: Growth in Traffic and Vehicle Miles Traveled.

PSRC. 2001a. Destination 2030 Metropolitan Transportation Plan for the Central Puget Sound Region.

PSRC. 2009. Transportation 2040 Draft Environmental Impact Statement. Available at: http://www.psrc.org/projects/tip/currentip/index.htm. Accessed July 6, 2010.

WSDOT (Washington State Department of Transportation). 2005. Washington State Intersection Screening Tool (WASIST). Seattle, Washington.

WSDOT. 2010a. Environmental Procedures Manual. M 31-11.07. Washington State Department of Transportation, Environmental and Engineering Programs, Environmental Services Office, Olympia, Washington. February 2010.

WSDOT. 2010b. Washington State Statewide Transportation Implementation Plan 2009 to 2012. Available at: http://www.wsdot.wa.gov/localprograms /ProgramMgmt/STIP.htm. Accessed May 2010.

WSDOT, City of Seattle, and U.S. Department of Transportation, Federal Highway Administration. 2004. SR 99: Alaskan Way Viaduct & Seawall Replacement Project Draft Environmental Impact Statement. Washington State Department of Transportation, Urban Corridors Office, Seattle, Washington.

WSDOT, City of Seattle, and U.S. Department of Transportation, Federal Highway Administration. 2006. SR 99: Alaskan Way Viaduct & Seawall Replacement Project Supplemental Draft Environmental Impact Statement and Section 4(f) Evaluation. Washington State Department of Transportation, Urban Corridors Office, Seattle, Washington.

ATTACHMENT A

WASIST Input and Output Tables

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Attachment A provides the WASIST Input and Output Tables used for the analysis discussed in the body of the discipline report. This attachment is too large (either in length or file size) to include in the document, but is available upon request.

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ATTACHMENT B

EMIT Input and Output Tables

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Attachment B provides the EMIT Input and Output Tables used for the analysis discussed in the body of the discipline report. This attachment is too large (either in length or file size) to include in the document, but is available upon request.

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ATTACHMENT C

Tunnel and Ventilation Modeling Input and Output Tables

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Attachment C provides the Tunnel and Ventilation Modeling Input and Output Tables used for the analysis discussed in the body of the discipline report. This attachment is too large (either in length or file size) to include in the document, but is available upon request.

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ATTACHMENT D

Cumulative Effects Analysis

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CUMULATIVE EFFECTS ANALYSIS

This cumulative effects analysis follows *Guidance on Preparing Cumulative Impact Analyses*, published by Washington State Department of Transportation (WSDOT) in February 2008. The guidance document was developed jointly by WSDOT, Federal Highway Administration (FHWA) – Washington Division, and U.S. Environmental Protection Agency – Region 10. The guidance can be used for FHWA's National Environmental Policy Act (NEPA) compliance (Code of Federal Regulations, Title 23, Part 771 [23 CFR 771]) and fulfillment of Washington State Environmental Policy Act (SEPA) requirements for evaluation of cumulative effects (Washington Administrative Code, Chapter 197-11-792).

The approach provided in the WSDOT guidance calls for early consideration of cumulative impacts while direct and indirect effects are being identified, preferably as part of the scoping process. For analysis, the guidance recommends the use of environmental documents such as discipline reports, as well as other relevant information such as local comprehensive plans, zoning, recent building permits, and interviews with local government. The guidance also advocates a partnership approach among agencies that includes early collaboration and integrated planning activities.

The guidance established eight steps to serve as guidelines for identifying and assessing cumulative impacts. These eight steps have been used in the following cumulative effects evaluation for the Bored Tunnel Alternative of the Alaskan Way Viaduct Replacement Project (the project). A matrix that identifies projects with the potential for cumulative effects with this project and an assessment of likely contributions to cumulative effects is also included.

Step 1. Identify the resource that may have cumulative impacts to consider in the analysis

Air quality.

Step 2. Define the study area and timeframe for the affected resource

Air quality effects were evaluated in areas likely to be affected by changes in pollutant levels due to changes in traffic conditions or emissions released from the tunnel ventilation systems. Areas likely to be affected by increased emissions during construction were also considered. The air quality effects were evaluated within the Center City area of Seattle, as well as on a regional scale. Exhibit 3-1 of the Air Discipline Report shows the Center City area. The regional scale includes all the movements occurring in King, Pierce, Snohomish, and Kitsap Counties.

The timeframe for historic air quality effects has an assumed start date of 1850, which coincides with the beginning of significant European settlement in the Puget Sound region. The period from 1850 to 1970 saw rapid deforestation, increases in emissions from wood burning and industrial activity, and the rise of the automobile society with accompanying air pollution. Since the 1970s, regulations have been implemented for controlling air pollutants, vehicle and industrial emissions have been reduced, and there is a new urgency in reducing greenhouse gases and their effects on climate.

The existing condition for the affected environment discussion is 2010, just before project-related construction would begin. The timeframe for construction-related (temporary) impacts is the approximately 66-month (5.5-year) construction duration for the Bored Tunnel Alternative (2011 through 2017). The timeframe for operational impacts is from the year of opening (2017) to the design year (2030) of the project.

Step 3. Describe the current health and historical context for each affected resource

Historically, emissions to air have increased over time due to urban and industrial development, population growth, and the increased use of automobiles. Air emissions in the past often increased to the point where human health was threatened. The passing of the Clean Air Act of 1977 and implementation of federal air quality standards, as well as other measures such as cleaner fuel-burning vehicles, has resulted in nationwide reductions of what the U.S. Environmental Protection Agency (EPA) identifies as pollutants of concern. These pollutants are known as "criteria pollutants." The sources of these pollutants, their effects on human health and the nation's welfare, and their concentration in the atmosphere vary considerably. Under the Clean Air Act, EPA has established National Ambient Air Quality Standards (NAAQS), which specify maximum allowable concentrations for these criteria pollutants. Areas not in compliance with NAAQS are deemed nonattainment areas. Areas that were once classified as nonattainment but have since demonstrated attainment are classified as maintenance areas.

The project area is entirely located within a carbon monoxide (CO) maintenance area, as shown in Exhibit 4-1 of the Air Discipline Report. This area was designated as nonattainment for CO and classified as moderate upon enactment of the Clean Air Act Amendments of 1990. The state submitted a CO maintenance plan on August 23, 1999, which was approved by EPA on March 13, 2001. The plan relies on control of residential wood smoke, fugitive dust, industrial emissions, open burning, and diesel exhaust. Because the CO maintenance area would be affected by the Bored Tunnel Alternative, compliance with the Transportation Conformity Rule (40 CFR 93) must be demonstrated.

Regional air pollutant trends have generally followed national patterns over the last 20 years. While the average weekday vehicle miles of travel (VMT) in the central Puget Sound region increased from 30 million miles in 1981 to 65 million miles in 1999 (PSRC 2000), pollutant emissions associated with transportation sources have decreased. CO is the criteria pollutant most closely tied to transportation, with over 90 percent of the CO emissions in the Puget Sound urban areas coming from transportation sources. Regionally, the maximum measured CO concentrations have decreased considerably over the past 20 years. Other transportation-related pollutants have followed similar but less pronounced trends.

Step 4. Identify the direct and indirect impacts that may contribute to a cumulative impact

Other projects were qualitatively assessed to consider whether their construction would contribute to traffic congestion, which would result in additional cumulative pollutant emissions. Construction of other projects could result in a temporary increase in pollutant

emissions from construction equipment and construction activities. Lane closures or detours could temporarily increase congestion and decrease travel speeds, resulting in an overall increase in pollutant emissions during construction. These direct and indirect impacts may contribute to a cumulative impact on air quality.

Operational benefits and effects of other projects were qualitatively assessed on how they would affect traffic congestion and travel speeds, which would then affect fuel usage and cumulative pollutant emissions. Operation of other projects could result in a decrease or increase in traffic congestion and travel speeds, which could cause a change in fuel usage, resulting in an overall increase or decrease in pollutant emissions compared to conditions without these projects. These direct and indirect impacts may contribute to a cumulative impact.

Step 5. Identify other historic, current, or reasonably foreseeable actions that may affect resources

The project team considered 39 projects (shown in the matrix at the end of this attachment) for potential activities that could have a cumulative effect on air quality in Seattle. Of those 39 projects, the 19 projects in the following list could have temporary adverse effects on air quality during construction. Operation of the following projects would not adversely affect air quality and would generally provide a minor decrease in air pollutant concentrations.

- **A.1.** Alaskan Way Surface Street Improvements – S. King Street to Pike Street
- **A.2.** Elliott/Western Connector – Pike Street to Battery Street
- **A.3.** Mercer West Project – Mercer Street becomes two-way from Fifth Avenue N. to Elliott Avenue, and Roy Street becomes two-way from Aurora Avenue to Queen Anne Avenue N.
- **B.1.** Elliott Bay Seawall Project
- **B.2.** Alaskan Way Promenade/Public Space
- **B.3.** Transit Enhancements
- **B.4.** First Avenue Streetcar Evaluation
- **E.1.** Gull Industries on First Avenue S.
- **E.2.** North Parking Lot Development at Qwest Field
- **E.3.** Seattle Center Master Plan (EIS) (Century 21 Master Plan)
- **E.4.** Bill and Melinda Gates Foundation Campus Master Plan
- **E.5.** South Lake Union Redevelopment
- **E.6.** U.S. Coast Guard Integrated Support Command
- **E.7.** Seattle Aquarium and Waterfront Park
- **E.8.** Seattle Combined Sewer System Upgrades
- **F.1.** Bridging the Gap Projects

- **F.2.** S. Spokane Street Viaduct Widening
- **F.3.** SR 99/East Marginal Way Grade Separation
- **F.4.** Mercer East Project from Dexter Avenue N. to I-5

Step 6. Assess potential cumulative impacts to the resource; determine the magnitude and significance

Construction effects of the projects would include the following temporary effects:

- Simultaneous construction activity occurring in the same areas as the Bored Tunnel Alternative. A minor decrease in air quality would be experienced through added traffic congestion and vehicle idling.

Simultaneous construction activity is anticipated during much of the time the Bored Tunnel Alternative is under construction. Temporary traffic detours would further affect traffic that cannot use the new SR 99 bored tunnel and would be reliant upon the surface street network along the waterfront and through downtown. These impacts would be highly localized and would not likely affect most of Seattle or the Puget Sound region. Refer to Appendix C, Transportation Discipline Report, for construction traffic management and mitigation information.

Improvements to the roadway network in the study area as a result of completion of roadway projects are expected to have a net beneficial cumulative effect on transportation-related measures of effectiveness in the study area. These improvements to the roadway network should result in a net positive effect on the air quality in the study area.

Step 7. Report the results

The cumulative effects would be localized, occurring in the immediate vicinity of construction activities; there would be no significant cumulative effects on the larger area that includes nearby projects (see the Project-Specific Cumulative Effects Matrix). Improvements to the roadway network resulting from the Bored Tunnel Alternative and other nearby projects would have a net positive effect on air quality the region.

Step 8. Assess and discuss potential mitigation issues for all adverse impacts

Mitigation for the localized effects in the area of immediate impact around the projects during construction would be similar to the measures discussed for the Bored Tunnel Alternative during construction (see Section 6.2 of the Air Discipline Report). No mitigation is proposed for cumulative effects on air quality.

The following matrix identifies project-specific potential cumulative effects.

PROJECT-SPECIFIC CUMULATIVE EFFECTS MATRIX

PROJECT	POTENTIAL CUMULATIVE EFFECTS
A. Roadway Elements	
A1. Alaskan Way Surface Street Improvements – S. King Street to Pike Street	Construction of these improvements would result in a minor adverse cumulative effect on air quality through increased pollutant emissions from simultaneous construction and added traffic congestion. During operation, a minor beneficial cumulative effect on air quality would be experienced through decreases in traffic congestion and fuel usage resulting in an overall decrease in pollutant emissions as compared to the existing conditions.
A2. Elliott/Western Connector – Pike Street to Battery Street	Construction of these improvements would result in a minor adverse cumulative effect on air quality through increased pollutant emissions from simultaneous construction and added traffic congestion. During operation, a minor beneficial cumulative effect on air quality would be experienced through decreases in traffic congestion and fuel usage resulting in an overall decrease in pollutant emissions as compared to the existing conditions.
A3. Mercer West Project – Mercer Street becomes two-way from Fifth Avenue N. to Elliott Avenue and Roy Street becomes two-way from Aurora Avenue to Queen Anne Avenue N.	Construction of these improvements would result in a minor adverse cumulative effect on air quality through increased pollutant emissions from simultaneous construction and added traffic congestion. During operation, a minor beneficial cumulative effect on air quality would be experienced through decreases in traffic congestion and fuel usage resulting in an overall decrease in pollutant emissions as compared to the existing conditions.
B. Non-Roadway Elements	
B1. Elliott Bay Seawall Project	Construction of these improvements would result in a minor adverse cumulative effect on air quality through increased pollutant emissions from simultaneous construction and added traffic congestion. The operation and maintenance of the facility would not affect air quality.
B2. Alaskan Way Promenade/Public Space	Construction of these improvements would result in a minor adverse cumulative effect on air quality through increased pollutant emissions from simultaneous construction and added traffic congestion. The operation and maintenance of the facility would not affect air quality.
B3. Transit Enhancements – 1) Delridge RapidRide 2) Additional service hours on West Seattle and Ballard RapidRide lines 3) Peak hour express routes added to South Lake Union and Uptown 4) Local bus changes to several West Seattle and northwest Seattle routes 5)Transit priority on S. Main and/or S. Washington Streets between Alaskan Way and Third Avenue 6) Simplification of the electric trolley system	During operation, a minor beneficial cumulative effect on air quality would be experienced due to the decrease in traffic congestion and increase in travel speeds, which would decrease fuel usage, resulting in an overall decrease in air pollutants as compared to the existing conditions.

PROJECT-SPECIFIC CUMULATIVE EFFECTS MATRIX (CONTINUED)

PROJECT	POTENTIAL CUMULATIVE EFFECTS
B4. First Avenue Streetcar Evaluation	Construction of these improvements would result in a minor adverse cumulative effect on air quality through increased pollutant emissions from simultaneous construction and added traffic congestion. The operation and maintenance of the facility would not affect air quality.
C. Projects Under Construction	
C1. S. Holgate Street to S. King Street Viaduct Replacement Project	Construction of these improvements would result in a minor adverse cumulative effect on air quality through increased pollutant emissions from simultaneous construction and added traffic congestion. Operational effects were included in the 2015 and 2030 Bored Tunnel Alternative air quality analysis.
C2. Transportation Improvements to Minimize Traffic Effects During Construction	No cumulative effects on air quality are anticipated during construction or operation. Construction will be completed before bored tunnel construction begins. Operational effects were included in the 2015 and 2030 Bored Tunnel Alternative air quality analysis.
D. Completed Projects	
D1. SR 99 Yesler Way Vicinity Foundation Stabilization (Column Safety Repairs)	No cumulative effects on air quality are anticipated during construction or operation. Construction has already been completed. Operational effects were included in the 2015 and 2030 Bored Tunnel Alternative air quality analysis.
D2. S. Massachusetts Street to Railroad Way S. Electrical Line Relocation Project (Electrical Line Relocation Along the Viaduct's South End)	No cumulative effects on air quality are anticipated during construction or operation. Construction is already complete. Operational effects were included in the 2015 and 2030 Bored Tunnel Alternative air quality analysis.
E. Seattle Planned Urban Development	
E1. Gull Industries on First Avenue S.	Possible minor cumulative effects on air quality during construction. No cumulative effects on air quality are expected during operation.
E2. North Parking Lot Development at Qwest Field	Possible minor cumulative effects on air quality during construction. No cumulative effects on air quality are expected during operation.
E3. Seattle Center Master Plan (EIS) (Century 21 Master Plan)	Possible minor cumulative effects on air quality during construction. No cumulative effects on air quality are expected during operation.
E4. Bill and Melinda Gates Foundation Campus Master Plan	Possible minor cumulative effects on air quality during construction. No cumulative effects on air quality are expected during operation.
E5. South Lake Union Redevelopment	Possible minor cumulative effects on air quality during construction. No cumulative effects on air quality are expected during operation.
E6. U.S. Coast Guard Integrated Support Command	Possible minor cumulative effects on air quality during construction. No cumulative effects on air quality are expected during operation.
E7. Seattle Aquarium and Waterfront Park	Possible minor cumulative effects on air quality during construction. No cumulative effects on air quality are expected during operation.
E8. Seattle Combined Sewer System Upgrades	Possible minor cumulative effects on air quality during construction. No cumulative effects to air quality are expected during operation.

PROJECT-SPECIFIC CUMULATIVE EFFECTS MATRIX (CONTINUED)

PROJECT	POTENTIAL CUMULATIVE EFFECTS
F. Local Roadway Improvements	
F1. Bridging the Gap Projects	Possible minor cumulative effects on air quality during construction. No cumulative effects on air quality are expected during operation because operational effects of the improvements were included in the 2030 Bored Tunnel Alternative air quality analysis.
F2. S. Spokane Street Viaduct Widening	Possible minor cumulative effects on air quality during construction. No cumulative effects on air quality are expected during operation because operational effects of the improvements were included in the 2030 Bored Tunnel Alternative air quality analysis.
F3. SR 99/East Marginal Way Grade Separation	Possible minor cumulative effects on air quality during construction. No cumulative effects on air quality are expected during operation because operational effects of the improvements were included in the 2030 Bored Tunnel Alternative air quality analysis.
F4. Mercer East Project from Dexter Avenue N. to I-5	Possible minor cumulative effects on air quality during construction. No cumulative effects on air quality are expected during operation because operational effects of the improvements were included in the 2030 Bored Tunnel Alternative air quality analysis.
G. Regional Roadway Improvements	
G1. I-5 Improvements	No cumulative effects on air quality are anticipated during construction or operation. Construction will occur before or after bored tunnel construction. Operational effects were included in the 2015 and 2030 Bored Tunnel Alternative air quality analysis.
G2. SR 520 Bridge Replacement and HOV Program	No cumulative effects on air quality are anticipated during construction or operation. Operational effects were included in the 2015 and 2030 Bored Tunnel Alternative air quality analysis.
G3. I-405 Corridor Program	No cumulative effects on air quality are anticipated during construction or operation. Operational effects were included in the 2015 and 2030 Bored Tunnel Alternative air quality analysis.
G4. I-90 Two-Way Transit and HOV Operations, Stages 1 and 2	No cumulative effects on air quality are anticipated during construction or operation. Operational effects were included in the 2015 and 2030 Bored Tunnel Alternative air quality analysis.
H. Transit Improvements	
H1. First Hill Streetcar	No cumulative effects on air quality are anticipated during construction or operation. Operational effects were included in the 2015 and 2030 Bored Tunnel Alternative air quality analysis.
H2. Sound Transit University Link Light Rail Project	No cumulative effects on air quality are anticipated during construction or operation. Operational effects were included in the 2015 and 2030 Bored Tunnel Alternative air quality analysis.
H3. RapidRide	No cumulative effects on air quality are anticipated during construction or operation. Operational effects were included in the 2015 and 2030 Bored Tunnel Alternative air quality analysis.

PROJECT-SPECIFIC CUMULATIVE EFFECTS MATRIX (CONTINUED)

PROJECT	POTENTIAL CUMULATIVE EFFECTS
H4. Sound Transit North Link Light Rail	No cumulative effects on air quality are anticipated during construction or operation. Operational effects were included in the 2015 and 2030 Bored Tunnel Alternative air quality analysis.
H5. Sound Transit East Link Light Rail	No cumulative effects on air quality are anticipated during construction or operation. Operational effects were included in the 2030 Bored Tunnel Alternative air quality analysis.
H6. Washington State Ferries Seattle Terminal Improvements	No cumulative effects on air quality are expected during construction because these improvements will already have been completed before construction of the Bored Tunnel Alternative begins. No cumulative effects will result from operation because these improvements will not increase capacity.
I. Transportation Network Assumptions	
I1. HOV Definition Changes to 3+ Throughout the Puget Sound Region	No cumulative effects on air quality are anticipated during construction or operation. Operational effects were included in the 2015 and 2030 Bored Tunnel Alternative air quality analysis.
I2. Sound Transit Phases 1 and 2	No cumulative effects on air quality are anticipated during construction or operation. Operational effects were included in the 2015 and 2030 Bored Tunnel Alternative air quality analysis.
I3. Other Transit Improvements	No cumulative effects on air quality are anticipated during construction or operation. Operational effects were included in the 2015 and 2030 Bored Tunnel Alternative air quality analysis.
J. Completed but Relevant Projects	
J1. Sound Transit Central Link Light Rail (including the Sea-Tac Airport extension)	No cumulative effects on air quality are anticipated during construction or operation. Construction of this project has already been completed. Operational effects were included in the 2015 and 2030 Bored Tunnel Alternative air quality analysis.
J2. South Lake Union Streetcar	No cumulative effects on air quality are anticipated during construction or operation. Construction of this project has already been completed. Operational effects were included in the 2015 and 2030 Bored Tunnel Alternative air quality analysis.
J3. SR 519 Intermodal Access Project, Phase 2	No cumulative effects on air quality are anticipated during construction which has been completed. Operational effects were included in the 2015 and 2030 Bored Tunnel Alternative air quality analysis.