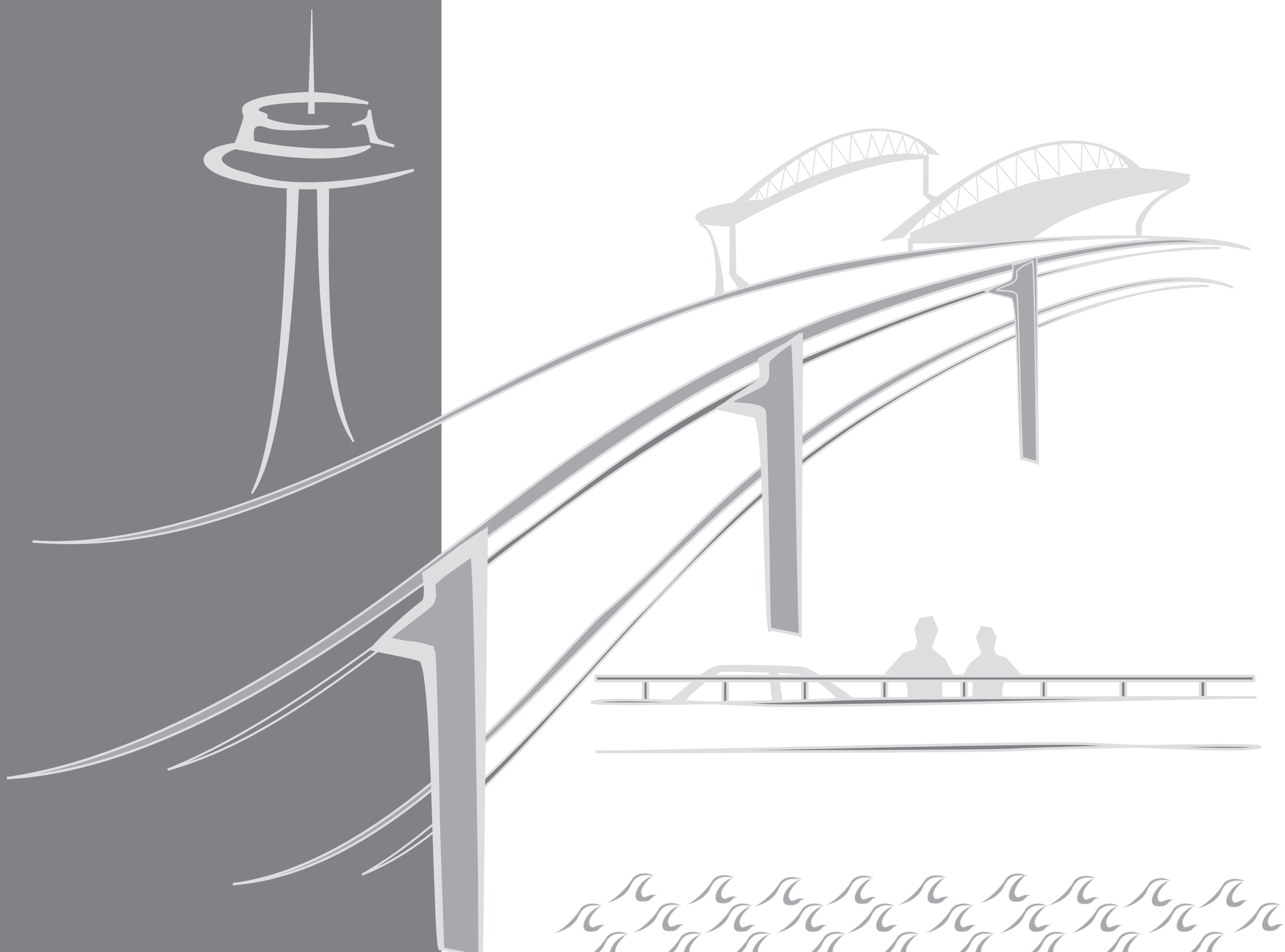
SR 99: ALASKAN WAY VIADUCT & SEAWALL REPLACEMENT PROJECT

Draft Environmental Impact Statement

Appendix Q
Air Quality Discipline Report



MARCH 2004

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U.S. Department of Transportation Federal Highway Administration

Washington State Department of Transportation

City of Seattle

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SR 99: Alaskan Way Viaduct & Seawall Replacement Project

Draft EIS
Air Quality Discipline Report

Agreement No. Y-7888

FHWA-WA-EIS-04-01-D

Submitted to:

Washington State Department of Transportation
Alaskan Way Viaduct and Seawall Replacement Project Office
999 Third Avenue, Suite 2424
Seattle, WA 98104

The SR 99: Alaskan Way Viaduct & Seawall Replacement Project is a joint effort between the Washington State Department of Transportation (WSDOT), the City of Seattle, and the Federal Highway Administration (FHWA). To conduct this project, WSDOT contracted with:

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In association with:

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TABLE OF CONTENTS

LIST OF EXHIBITS

ATTACHMENTS

ACRONYMS

$\mu g/m^3$	micrograms per cubic meter
AQI	Air Quality Index
AQMPs	Air Quality Maintenance Plans
AWV	Alaskan Way Viaduct
BMP	Best Management Practices
BPIP	Building Profile Input Program
BTUs	British Thermal Units
CO	carbon monoxide
CO_2	carbon dioxide
Ecology	Washington State Department of Ecology
EIS	Environmental Impact Statement
EPA	United States Environmental Protection Agency
FHWA	Federal Highway Administration
HAPs	Hazardous air pollutants
HC	hydrocarbons
I&M	inspection and maintenance
IARC	International Agency for Research on Cancer
LOS	level of service
MTP	Metropolitan Transportation Plan
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NO_2	nitrogen dioxide
NO_x	nitrogen oxides
PAHs	polynuclear aromatic hydrocarbons
PM	particulate matter
POM	polycyclic organic matter
ppm	parts per million
PSCAA	Puget Sound Clean Air Agency
PSRC	Puget Sound Regional Council
SIP	State Implementation Plan
SO_2	sulfur dioxide
SR	State Route
TIP	Transportation Improvement Program
TSP	total suspended particulates
VOCs	volatile organic compounds
WSDOT	Washington State Department of Transportation

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Chapter 1 EXECUTIVE SUMMARY

The proposed project is the replacement of the Alaskan Way Viaduct (AWV) and Seawall, which is part of State Route (SR) 99, a regionally important north–south highway located on the western edge of downtown Seattle.

Traffic conditions in the project area will be affected by changes in both the number of vehicles on local roadways and the speeds and levels of congestion of these vehicles on these roadways. Air quality, which is a general term used to describe pollutant levels in the atmosphere, can be affected by these changes. In addition, vehicular emissions released through the mechanical ventilation systems and exit portals of the Tunnel Alternatives could cause localized air quality impacts. The purpose of the air quality analysis is to identify the potential air quality effects associated with these changes.

Procedures established by the Puget Sound Regional Council (PSRC) and the United States Environmental Protection Agency (EPA) were used to estimate localized carbon monoxide (CO) concentrations. CO is the pollutant most associated with the localized effects of motor vehicle emissions. Concentrations of CO were estimated under peak traffic concentrations for study-area intersections and tunnels. The results were compared with the National Ambient Air Quality Standards (NAAQS) established by the EPA. For comparison to NAAQS time frames, worst-case 1-hour and 8-hour CO concentrations were estimated. Twenty-four hour and annual particulate matter (PM_{10}) concentrations also were modeled not to exceed NAAQS. The result of this analysis is that estimated future air pollution levels under the No Build and Build Alternatives are all below (within) the NAAQS.

Potential air quality impacts that may occur during the temporary construction phase of the project were also estimated. Analyses were conducted assuming that the Washington State Department of Transportation (WSDOT) best management practices (BMPs) for construction activities would be followed. Pollutants most associated with the localized effects of construction activities were considered—PM_{10} and nitrogen dioxide (NO_2). A qualitative review of construction emissions was completed. Prior to the Final EIS, a detailed estimate of construction pollutant emissions will be completed.

The results of the air quality analysis for the operational and construction phases of the project are summarized in Exhibit 1-1.

Exhibit 1-1. Summary of Air Quality Impacts and Mitigation

Alternative	Construction Impacts	Operation Impacts	Mitigation Measures
No Build	None	Eight-hour average CO concentrations predicted to range between 4.0 and 6.3 ppm. No exceedances of the NAAQS are predicted.	None required
Rebuild	Construction activities would release particulates, CO, and NO_x.	Eight-hour average CO concentrations predicted to range between 4.0 and 6.3 ppm. No exceedances of the NAAQS are predicted.	Develop construction pollutant control plan to control particulate emissions.
Aerial	Construction activities would release particulates, CO, and NO_x.	Eight-hour average CO concentrations predicted to range between 4.0 and 7.0 ppm. No exceedances of the NAAQS are predicted.	Develop construction pollutant control plan to control particulate emissions.
Tunnel	Construction activities would release particulates, CO, and NO_x.	Eight-hour average CO concentrations predicted to range between 4.8 and 6.9 ppm. No exceedances of the NAAQS are predicted.	Develop construction pollutant control plan to control particulate emissions.
Bypass Tunnel	Construction activities would release particulates, CO, and NO_x.	Eight-hour average CO concentrations predicted to range between 5.1 and 7.4 ppm. No exceedances of the NAAQS are predicted.	Develop construction pollutant control plan to control particulate emissions.
Surface	Construction activities would release particulates, CO, and NO_x.	Eight-hour average CO concentrations predicted to range between 4.6 and 7.4 ppm. No exceedances of the NAAQS are pr edicted.	Develop construction pollutant control plan to control particulate emissions.

ppm = parts per million
CO = carbon monoxide
NO_x = nitrogen oxides
NAAQS = National Ambient Air Quality Standards

Chapter 2 INTRODUCTION

The proposed Alaskan Way Viaduct and Seawall Replacement Project would, under most alternatives, replace an existing highway and provide similar capacity. With the exception of the Surface Alternative, which would reduce the capacity of the roadway network and increase local congestion, these alternatives should not substantially affect overall traffic volumes in the study area.

Air quality, which is a general term used to describe pollutant levels in the atmosphere, is affected by emissions generated by vehicular traffic. Potential air quality impacts of the project alternatives could result from changes in the location of where emissions are released to the atmosphere, including the impact of emissions released from alternate locations of the elevated viaduct, locations of tunnel portals and ventilation buildings, and the impact of traffic diversions that result from the relocations of entrance and exit ramps.

This study addresses air quality impacts associated with the operation of the proposed AWV project alternatives. The air quality studies performed include estimates of the following:

1. Pollutant levels near heavily traveled roadways and congested intersections that may be affected by the redesign or relocation of roadways.
2. Potential impacts associated with changes in traffic patterns on congested intersections of the local street network, including heavily traveled roadway sections and new or modified entrance/exit ramps.
3. Potential impacts associated with vehicular emissions that would be generated within the tunnel and released through the exhaust ducts of the tunnel's ventilation system under each of the proposed tunnel alternatives.
4. Potential impacts associated with vehicular emissions that would be generated within the tunnel and released through the tunnel's exit portals under each of the proposed tunnel alternatives.

In addition, changes in vehicular emissions generated in the study area under each of the proposed alternatives were estimated, and determinations were made as to whether these changes conform to the requirements of the State Implementation Plan (SIP). Potential impacts associated with the construction phase of the proposed alternatives were also considered.

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Chapter 3 BACKGROUND, STUDIES, AND COORDINATION

3.1 Air Quality Standards

Air quality in the project area is regulated by the U.S. Environmental Protection Agency (EPA), the Washington State Department of Ecology (Ecology), and the Puget Sound Clean Air Agency (PSCAA). Under the Clean Air Act, EPA has established the National Ambient Air Quality Standards (NAAQS), which specify maximum concentrations for carbon monoxide (CO), particulate matter less than 10 micrometers in size (PM_{10}), particulate matter less than 2.5 micrometers in size ($PM_{2.5}$), ozone, sulfur dioxide (SO_2), lead, and nitrogen dioxide (NO_2). The pollutants regulated by the NAAQS are referred to as criteria pollutants. The standards applicable to transportation projects are summarized in Exhibit 3-1. The 8-hour ozone and $PM_{2.5}$ standards are not yet being implemented by EPA.

Exhibit 3-1. Summary of Ambient Air Quality Standards

Pollutant	National Primary Standard	Washington State Standard	PSCAA Regional Standard
Carbon Monoxide (CO)			
One-Hour Average (not to be exceeded more than once per year)	35 ppm	35 ppm	35 ppm
Eight-Hour Average (not to be exceeded more than once per year)	9 ppm	9 ppm	9 ppm
PM_{10}			
Annual Arithmetic Mean	50 $\mu g/m^3$	50 $\mu g/m^3$	50 $\mu g/m^3$
24-Hour Average Concentration (99th percentile)	150 $\mu g/m^3$	150 $\mu g/m^3$	150 $\mu g/m^3$
$PM_{2.5}$			
Annual Arithmetic Mean	15 $\mu g/m^3$	N/A	N/A
24-Hour Average Concentration (98th percentile)	65 $\mu g/m^3$	N/A	N/A
Total Suspended Particulates (TSP)			
Annual Arithmetic Mean	N/A	60 $\mu g/m^3$	60 $\mu g/m^3$
24-Hour Average Concentration (not to be exceeded more than once per year)	N/A	150 $\mu g/m^3$	150 $\mu g/m^3$

Exhibit 3-1. Summary of Ambient Air Quality Standards (continued)

Pollutant	National Primary Standard	Washington State Standard	PSCAA Regional Standard
Ozone			
One-Hour Average (not to be exceeded more than once per year)	0.12 ppm	0.12 ppm	0.12 ppm
Eight-Hour Average (not to be exceeded more than once per year)	0.08 ppm	N/A	N/A
Sulfur Dioxide (SO_2)			
One-Hour Average (not to be exceeded more than twice in seven days)	N/A	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)			
Annual Arithmetic Mean	0.053 ppm	0.053 ppm	0.053 ppm
Lead			
24-Hour Average Concentration (never to be exceeded)	1.5 $\mu g/m^3$	1.5 $\mu g/m^3$	1.5 $\mu g/m^3$

Notes: ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
Sources: PSCAA Regulation 1 (1994); 40 CFR Part 50 (1997); WAC chapters 173-470, 173-474, 173-175 (1987).

A violation of the NAAQS may threaten federal funding of transportation projects, and proposed roadway projects requiring federal funding and/or approval must demonstrate compliance with EPA's Transportation Conformity Rule. Conformity is demonstrated by showing that the 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.

3.2 Pollutants of Concern

3.2.1 Carbon Monoxide

Carbon monoxide is a colorless, odorless, poisonous gas that reduces the blood's oxygen-carrying capability by bonding with hemoglobin and forming carboxyhemoglobin, which prevents oxygenation of the blood. Exposure to CO concentrations of 80 parts per million (ppm) over 8 hours results in a carboxyhemoglobin level of approximately 15 percent (Ehrlich et al. 1977).

The NAAQS for CO are protective; exposure to CO concentrations that meet the NAAQS will not result in elevated carboxyhemoglobin levels.

Acute health effects, such as headaches, slowed reflexes, weakened judgment, and impaired perception begins at about 3 percent carboxyhemoglobin (carbon monoxide bonding with 3 percent of the hemoglobin). Chronic effects include aggravation of pre-existing cardiovascular disease and increased heart disease risk in healthy individuals. At carboxyhemoglobin levels of approximately 30 percent, individuals become nauseous and collapse, and at very high levels (above 50 percent carboxyhemoglobin), individuals die. The major sources of CO are vehicular traffic, industry, wood stoves, and slash burns. In urban areas, motor vehicles are often the source of over 90 percent of the CO emissions that cause ambient levels to exceed the NAAQS (EPA 1992). Areas of high CO concentrations are usually localized, occur near congested roadways and intersections in fall and winter, and are associated with light winds and stable atmospheric conditions. Consequently, CO concentrations must be predicted on a localized, or microscale, basis. CO emissions are also modeled on a regional scale.

Stringent federal emission standards for new motor vehicles and the gradual replacement of older, more polluting vehicles have resulted in CO concentration decreases in most areas over the last 10 years.

3.2.2 Particulate Matter

Particulate matter is a broad class of air pollutants that exist as liquid droplets or solids, with a wide range of sizes and chemical composition. Particulate matter is emitted by a variety of sources, both natural and man-made. Natural sources include the condensed and reacted forms of natural organic vapors; salt particles resulting from the evaporation of sea spray; wind-borne pollen, fungi, molds, algae, yeasts, rusts, bacteria, and debris from live and decaying plant and animal life; particles eroded from beaches, desert, soil, and rock; particles from volcanic and geothermal eruptions; and forest fires. Major man-made sources of particulate matter include the combustion of fossil fuels in vehicles, power plants, and homes; chemical and manufacturing processes; all types of construction; agricultural activities; and wood-burning fireplaces. The broadest class of particulate matter is total suspended particulates (TSP), which includes all particulate matter within the air. Smaller particulates that are smaller than or equal to 10 microns in size (PM_{10}), which are a subset of TSP, are of particular health concern. The principal health effects of airborne particulate matter are on the respiratory system.

Changes to the operations of the roadway network in the study area may affect localized PM_{10} levels as a result of changes in tailpipe emissions (from both the diesel trucks and gasoline-fueled automobiles and vans) and the amount of dust that would be re-entrained into the air from the tires of vehicles traveling within the corridor. As such, PM_{10} concentrations must also be predicted on a localized, or microscale, basis. Total regional PM_{10} emissions are also modeled.

In 1997, the EPA promulgated proposed ambient air quality standards for fine particulate matter equal to or smaller than 2.5 microns in diameter ($PM_{2.5}$). The action was taken as part of EPA's mandate, as set forth in Section 109 of the Clean Air Act, to assess continually the latest scientific information in an effort to update and revise the standards to protect the public health and welfare. Prior to 1997, NAAQS had been established only for PM_{10}. The action taken by EPA in 1997 left the standards for PM_{10} substantially unchanged, but established proposed standards for $PM_{2.5}$. These standards were promulgated as a result of recent findings regarding the potential health effects of these smaller particles.

Fine particulate matter is mainly derived from combustion material that has volatilized and then condensed to form primary particulate matter (often after release from a stack or exhaust pipes) or from precursor gases reacting in the atmosphere to form secondary particulate matter. It is also derived from mechanical breakdown of coarse particulate matter such as pollen fragments. Man-made sources of fine particulate matter include combustion of fossil fuel (such as diesel fuel), chemical/industrial processing, and burning of vegetation. Major components of $PM_{2.5}$ include sulfate, ammonium nitrate, organic compounds, trace metals, elemental carbon, and water. The proposed ambient air quality standards for $PM_{2.5}$ are an annual average of 15 micrograms per cubic meter and a 24-hour limit of 65 micrograms per cubic meter.

Compliance with $PM_{2.5}$ standards, however, is not possible to predict at this time for the following reasons:

- **Lack of an Approved or Recommended Analytical Methodology** – The EPA has not as yet specified or recommended a methodology to estimate $PM_{2.5}$ levels. While PM_{10} and CO are primarily considered local pollutants, where compliance with the NAAQS is measured at microscale sites where elevated concentrations are usually found near congested intersections or heavily traveled roadways, $PM_{2.5}$ is considered a regional pollutant (created by the combustion of fossil fuels) where compliance is measured at neighborhood scale sites since ambient concentrations are more uniform throughout an urban area.

- **Lack of Background Levels** – Since the $PM_{2.5}$ standards regulate fine particulates for the first time, EPA has allowed 5 years to establish a nationwide monitoring network for $PM_{2.5}$. Three years of data collected using EPA-reference monitoring methods are required to establish a database of existing $PM_{2.5}$ levels for comparison to the NAAQS. These efforts have not as yet been completed.
- **Lack of Accepted Emission Factors** – Information regarding the exact contributions from different types of sources to ambient concentrations of $PM_{2.5}$ has not been developed. In addition to the uncertainties associated with estimating emissions from existing traffic on roadway networks, there is additional uncertainty when estimating a potential source's contribution of primary particulate matter to ambient $PM_{2.5}$ concentrations. This requires an estimate of a specific source's emission rates, which are composed of re-entrained dust and tailpipe releases from a vehicle mix that may be different from baseline traffic and may have different operating characteristics.
- **Suitability of Current Mobile Source Emission Factors** – The EPA Part 5 model is the current tool that is available to estimate particulate emissions from mobile sources. Part 5 was developed only to address PM_{10} emissions. There are several components of vehicular PM emissions—tailpipe exhaust, tire and brake wear, and re-entrained road dust. While Mobile 6.2 includes updated particulate emissions calculations for tailpipe and tire and break wear for both PM_{10} and $PM_{2.5}$, it neglects re-entrained dust. To date, applicability of the Part 5 and Mobile 6.2 models for $PM_{2.5}$ has not been demonstrated to be appropriate or accurate.

For these reasons, a detailed mobile source PM_{10} analysis but not a detailed $PM_{2.5}$ analysis was undertaken. EPA guidance for new source review, which deals with stationary sources, indicated that until a comprehensive $PM_{2.5}$ modeling system is approved, a PM_{10} analysis should be used as a surrogate for a $PM_{2.5}$ analysis in meeting Clean Air Act requirements, and that its "specific concern is the lack of necessary tools to calculate emissions of $PM_{2.5}$ and related precursors and project ambient air quality."

3.2.3 Ozone

Ozone (O_3), a highly toxic form of oxygen, is a major component of the complex chemical mixture that forms photochemical smog. Ozone is not produced directly, but formed by a series of reactions between sunlight, nitrogen oxides (NO_x), and hydrocarbons (HC) (Exhibit 3-2). It is primarily generated from the ozone precursors emitted by regional vehicular traffic and point-source and fugitive sources. Tropospheric (ground-level) ozone, which results from ground-level precursor emissions, is a health risk, but stratospheric (upper-atmosphere) ozone (produced through a different set of chemical reactions that only require oxygen and intense sunlight) protects people from harmful solar radiation. In the remainder of this report, the term ozone refers to tropospheric ozone.

$$\text{Hydrocarbon} + O_2 \rightarrow \text{Hydrocarbon (smaller)} + HO_2$$

$$HO_2 + NO \rightarrow OH + NO_2$$

$$NO_2 + \text{sunlight} \rightarrow O + NO$$

$$O + O_2 \rightarrow O_3 + \text{energy}$$

Exhibit 3-2. Generalized Ozone Formation Equations

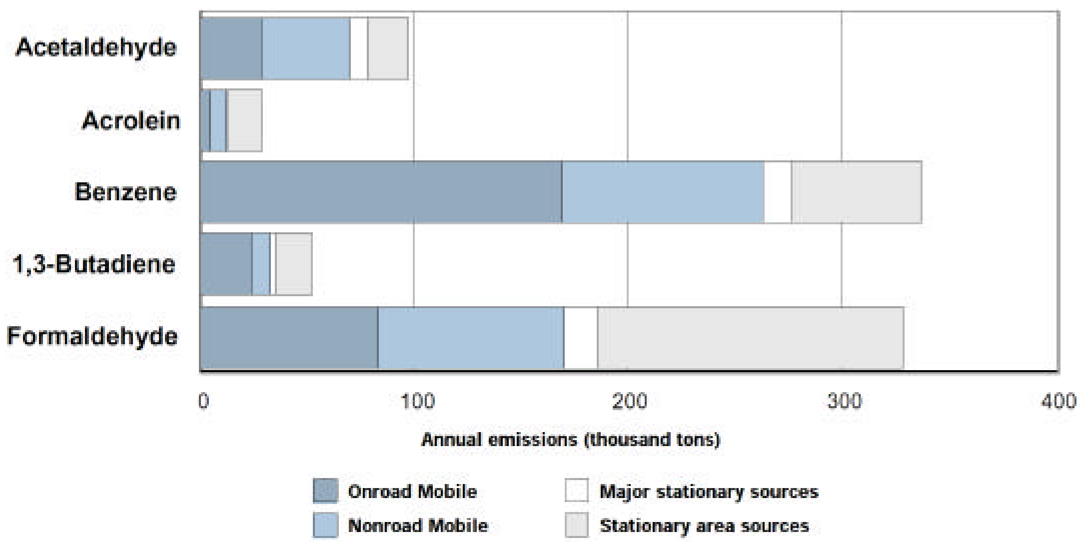
Ozone irritates the eyes and respiratory tract and increases the risk of respiratory and heart diseases. Ozone reduces the lung function of healthy people during exercise, can cause breathing difficulty in susceptible populations such as asthmatics and the elderly, and damages crops, trees, paint, fabric, and synthetic rubber products. The severity of health effects is both dose and exposure-duration related (National Research Council 1992). As with $PM_{2.5}$, the EPA has adopted a new 8-hour ozone standard (see Exhibit 3-1); however, the old 1-hour standard is still applicable for current nonattainment and maintenance areas. Regional ozone planning efforts by PSCAA consider both standards.

In the Puget Sound area, the highest ozone concentrations occur from mid-May until mid-September, when urban emissions are trapped by temperature inversions followed by intense sunlight and high temperatures. Maximum ozone levels generally occur between noon and early evening at locations several miles downwind from the sources, after NO_x and HC have had time to mix and react under sunlight. Light, northeasterly winds arising during these conditions result in high ozone concentrations near the Cascade foothills, to the south and southeast of major Puget Sound cities.

For these reasons, the effects of the proposed project on ozone levels are considered only on a regional, or mesoscale, basis. Ozone emissions are modeled regionally by PSRC to demonstrate regional transportation conformity to the Puget Sound air quality maintenance plan (AQMP) for ozone.

3.2.4 Hazardous Air Pollutants

Hazardous air pollutants (HAPs), also called air toxics, are pollutants known or suspected to cause cancer or other serious health or environmental effects. EPA's initial national-scale air toxics assessment effort focuses on 33 toxic air pollutants that are judged to present the greatest threat to public health in urban areas. Mobile sources emit 15 of these 33 HAPs. Five of these 15 are gaseous HAPs: acetaldehyde, acrolein, benzene, 1,3-butadiene, and formaldehyde (EPA 2001). Mobile sources contribute a substantial share of total nationwide emissions of each of these gaseous HAPs (Exhibit 3-3).



Source: EPA (2001).

Exhibit 3-3. Contribution of Mobile Sources to National HAPs Emissions

The remaining 10 HAPs emitted by mobile sources (from the list of 33) are trace metals and compounds associated primarily with the particulate phase: arsenic, beryllium, cadmium, chromium, dioxins/furans, lead, manganese, mercury, nickel, and polycyclic organic matter (POM). Mobile source emissions of metals and POM are small in comparison with stationary source emissions. In the case of POM, separate analyses were performed for total POM and for seven polynuclear aromatic hydrocarbons (PAHs) that have been named as animal carcinogens by the International Agency for Research on Cancer (IARC). Benzene and diesel particulate matter have been identified as the mobile source-related hazardous air pollutants that contribute the greatest risk in the Puget Sound region (PSCAA 2002).

Transportation-related hazardous air pollutant emissions are evaluated to determine whether the changes in local pollutant emissions resulting from the project alternatives would be significant.

3.2.5 Greenhouse Gases

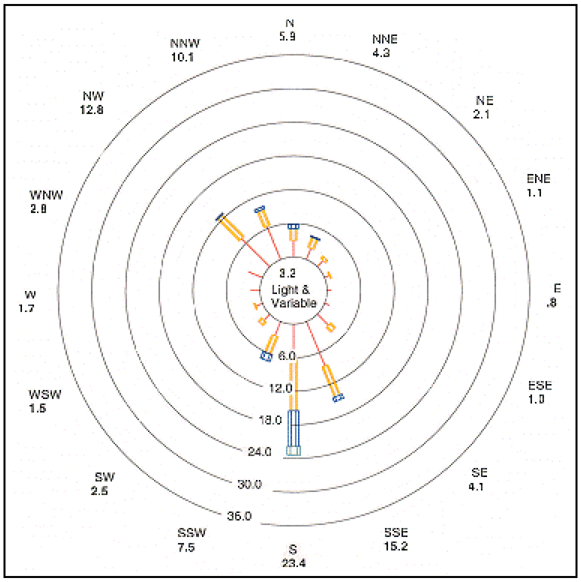
Motor vehicles also emit greenhouse gases, primarily carbon dioxide (CO_2). Greenhouse gases contribute to global warming and a change in the global climate caused by human activities that may result in increased drought, sea level rise, and other environmental changes (National Research Council 2001). The effect of the project alternatives on the generation of greenhouse gases is estimated on a regional basis.

3.3 Climate and Air Quality

Weather directly influences air quality. Important meteorological factors include wind speed and direction, atmospheric stability, temperature, sunlight intensity, and mixing depth. Typical wind patterns for the project area are shown in Exhibit 3-4. The length of the vectors on the wind rose show the percentage of time the wind blew from each direction of the compass. Wind speed is delineated by color and width of the brackets.

Temperature inversions, which are associated with higher air pollution concentrations, occur when warmer air overlies cooler air. During temperature inversions in late fall and winter, particulates and CO from wood stoves and vehicle sources can be trapped close to the ground, which can lead to violations of the NAAQS. Average monthly temperatures for Seattle-Tacoma Airport are shown in Exhibit 3-5. In the Puget Sound area, the highest ozone concentrations occur from mid-May until mid-September, when urban emissions are trapped by temperature inversions and followed by intense sunlight and high temperatures.

The National Weather Service currently issues an Air Stagnation Advisory when poor atmospheric dispersion conditions exist and are forecast to persist for 24 hours or more. Ecology issues a daily Air Quality Index (AQI). Using forecast meteorology and real-time pollutant monitoring, Ecology and PSCAA forecast the AQI to be one of six levels: good, moderate, unhealthy to sensitive populations, unhealthy, very unhealthy, and hazardous. Since adoption of the AQI in the Puget Sound region, there have been several instances of air quality in the moderate category. Between June 1999 and April 2003, air quality was declared "unhealthy for sensitive groups" in western Washington numerous times as a result of elevated $PM_{2.5}$ concentrations, most often in Tacoma. It was declared unhealthy in Tacoma once during that period, but never in Seattle.



Notes: Wind rose from PSCAA monitoring station at 4752 E. Marginal Way S., 1990 to 2001 data.

Exhibit 3-4. Duwamish Wind Rose

Month	Temperature (°F)	
	Minimum	Maximum
Jan	35.2	45.0
Feb	37.4	49.5
Mar	38.5	52.7
Apr	41.2	57.2
May	46.3	63.9
Jun	51.9	69.9
Jul	55.2	75.2
Aug	55.7	75.2
Sep	51.9	69.3
Oct	45.8	59.7
Nov	40.1	50.5
Dec	35.8	45.1

Source: Ecology (2003).

Exhibit 3-5. Seattle-Tacoma Airport Average Monthly Temperature Data

3.4 Project Coordination

Air quality analysis methods were developed for the Alaskan Way Viaduct and Seawall Replacement Project in coordination with WSDOT, the City of Seattle, Ecology, EPA, PSCAA, PSRC, and FHWA. During April of 2002, an air quality analysis protocol was distributed to these agencies for review and comment. On April 15, 2002 the approach was presented to these agencies for comment and discussion. A follow-up briefing was held for EPA on April 18. A revised protocol was distributed in April 2003 to address updates to emission files and changes in the alternatives. Input from these agencies was incorporated into the approach used in this study.

There was also a discussion during the spring of 2003 among the agencies on the most appropriate emissions model to use for this project, Mobile 5b or Mobile 6.2. On July 31, 2003 Mobile 6.2 was selected with input from WSDOT, PSRC, and Ecology. Mobile 6.2 input files were provided for the Puget Sound region by Ecology on August 5, 2003.

On July 23, 2003 an update was presented to WSDOT and City of Seattle staff. Air pollutant emission factors obtained from Mobile 6.2 were distributed to all agencies on August 11, 2003 for their information and review. Final traffic data became available in late August of 2003 and CO hot-spot screening results were distributed to all agencies on September 2, 2003.

Chapter 4 METHODOLOGY

4.1 Traffic Data

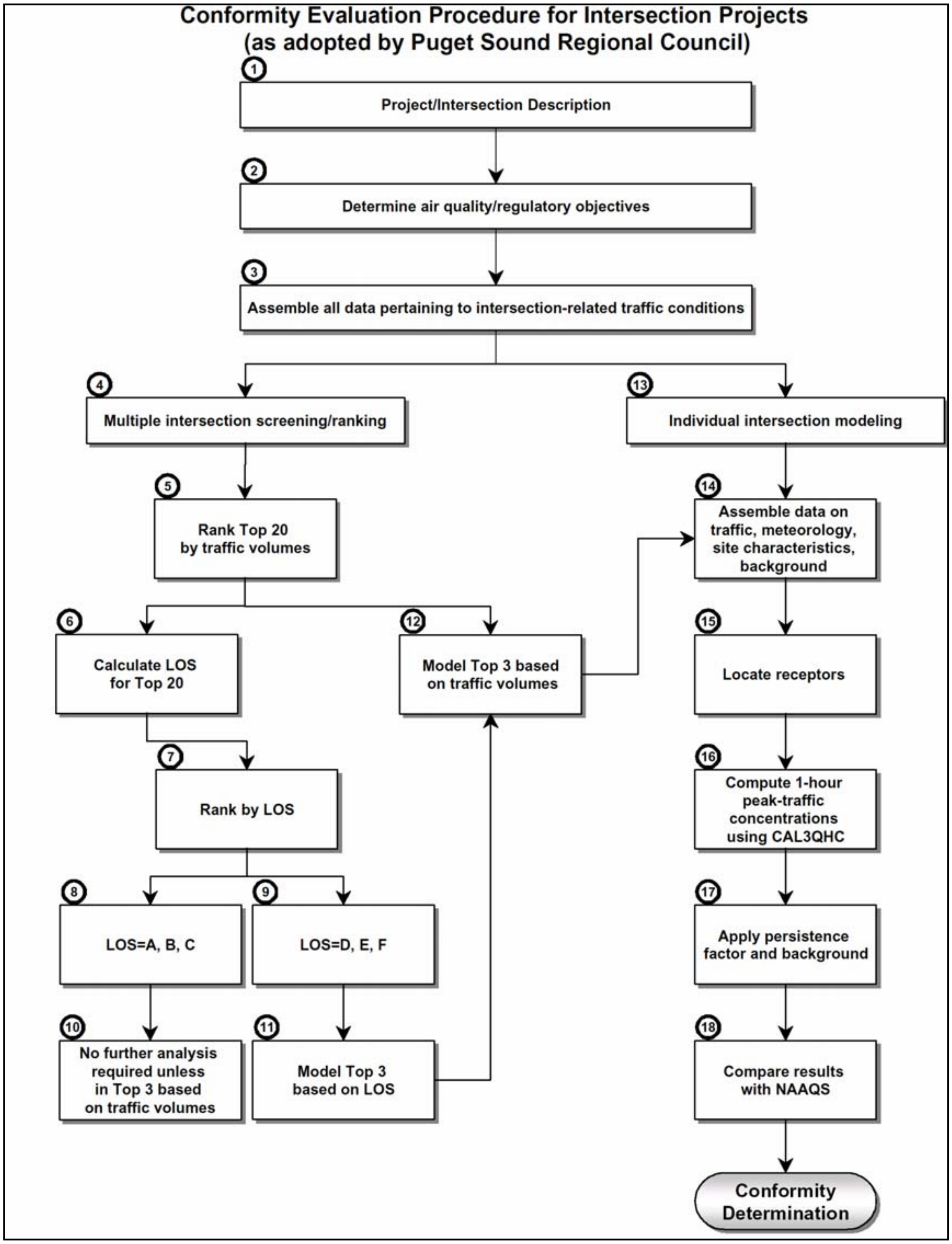
Detailed traffic analyses were completed for existing conditions and each of the alternatives for the year of opening (2016) and project design year (2030) to evaluate how the transportation system would function under each of these conditions. The transportation study area includes the portion of the City of Seattle where traffic patterns would most likely be affected by the various project alternatives. It encompasses the downtown core that is roughly defined by Elliott Bay on the west, Lake Union on the north, Interstate 5 (included in the study area) on the east, and S. Spokane Street (included in the study area) on the south. The results of the analysis are documented in Appendix C, Transportation Discipline Report. The evaluation of transportation air quality impacts was based on the data and findings of the transportation analysis.

4.2 Air Quality Analysis Locations

4.2.1 Analysis Sites Near Congested Intersections

Analysis sites 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 proposed project alternatives. In order to select sites for analysis, traffic volumes and the traffic levels of service for the year 2030 at the major signalized intersections that may be affected by proposed alternatives were evaluated with and without the project, and ranked as potential air quality analysis sites. Those sites where air quality levels were most likely to be significantly impacted by the project alternatives were selected for analysis following accepted PSRC procedures. Traffic analysis data for each alternative in 2030 was evaluated following steps 4 through 12 of the PSRC Conformity Evaluation Procedure for Intersection Projects (Exhibit 4-1).

Approximately 50 intersections under each alternative were ranked by volume to determine those locations most likely to have elevated pollutant levels. The top three intersections under each alternative were selected for intersection-level modeling. The twenty highest-volume intersections were further ranked by level of service (LOS) as measured by average vehicle delay. Average delay defines the LOS of an intersection as shown in Exhibit 4-2. The three intersections with the highest delay under each alternative



Source: FHWA (2001).

Exhibit 4-1. Puget Sound Regional Council Intersection-Level Conformity Procedure were also selected for detailed (intersection-level) analysis. Complete intersection ranking data is found in Attachment B. The results of this screening and selection process are presented in Exhibit 4-3. The intersections selected for intersection-level CO modeling are shown in Exhibit 4-4. Detailed traffic data for each of the modeled intersections are included in Attachment A. Further discussion of traffic operations is provided in Chapters 4 and 5 of Appendix C, Transportation Discipline Report.

Exhibit 4-2. Definition of Level of Service

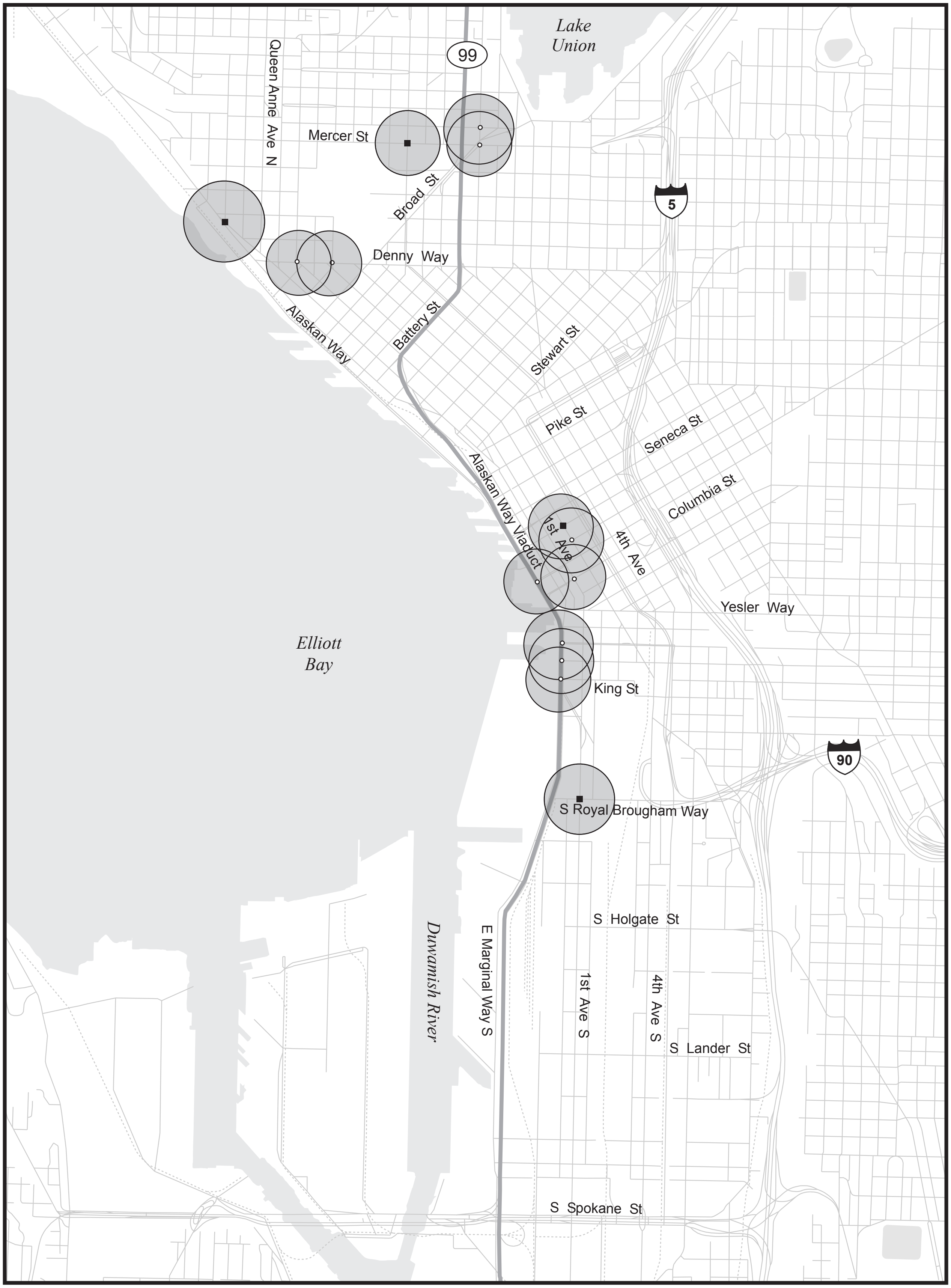
LOS	Stopped Delay Per Vehicle (Seconds)
A	< 5.0
B	5.1 to 15.0
C	15.1 to 25.0
D	25.1 to 40.0
E	40.1 to 60.0
F	> 60.0

Source: Table 9-1 Highway Capacity Manual (TRB 2000).

Exhibit 4-3. Intersection Screening Results

Intersection		Alternative					
Street	with Street	No Build	Rebuild	Aerial	Tunnel	Bypass Tunnel	Surface
1st Avenue	Columbia Street	D	D	D			
1st Avenue	Denny Way	V	V				D
1st Avenue	S. Royal Brougham Way	V	V		D		
2nd Avenue	Denny Way		D	D	D		
2nd Avenue	Madison Street	D					
2nd Avenue	Spring Street	D	D	D			
5th Avenue	Mercer Street			V	V	V	
Alaskan Way	Marion Street					D	
Alaskan Way	S. Jackson Street						V
Alaskan Way	S. King Street					D	V & D
Alaskan Way	S. Main Street						V
Dexter Avenue	Mercer Street			V	V	V & D	
Dexter Avenue	Roy Street				D		D
Elliott Avenue	Western (Denny)	V	V	V	V	V	

V = Intersection is one of highest three by volume under this alternative.
D = Intersection has one of three longest average delays of the twenty highest-volume intersections.



■ Intersection Modeled for CO and PM_{10} Impact

∘ Intersection Modeled for CO Impact

Area Included in Intersection Model

0 2,500
SCALE IN FEET

N

Exhibit 4-4
Intersections Modeled for Air Quality Impacts

The potential of the proposed project alternatives to create localized CO concentrations that would exceed the NAAQS at these locations were estimated.

The intersections modeled for PM_{10} were selected from those evaluated for CO to include the only intersection within the Duwamish PM_{10} maintenance area and three intersections identified as being most likely to exceed the NAAQS for PM_{10} in the future under any of the evaluated alternatives based on the modeled future CO concentrations at those locations.

4.2.2 Analysis Sites Near Tunnel Portals

Air quality levels near the exit portals of the renovated Battery Street Tunnel and the new Waterfront Tunnel under the Tunnel Alternative were estimated. Portal configurations under the Bypass Tunnel Alternative would be similar to those analyzed under the Tunnel Alternative, but traffic volumes would be lower; therefore, there would be a lower potential for adverse air quality impacts.

4.2.3 Analysis Sites Near Ventilation Buildings

Air quality levels were estimated at sensitive land use areas near where the ventilation buildings would be located under the new Waterfront Tunnel for the Tunnel Alternative. These buildings would be located near S. King Street, Yesler Way, Spring Street, and Pike Street. Configurations of the ventilation buildings under the Bypass Tunnel Alternative would be similar to those analyzed under the Tunnel Alternative, but traffic volumes would be lower; therefore, there would be a lower potential for adverse air quality impacts.

4.3 Receptor Locations

Specific locations where pollutant concentrations are predicted are called receptors. Mobile source modeling receptors are located where maximum concentrations would likely occur because of traffic congestion, and where the general public would have access (EPA 1992). For this analysis, mobile source receptors were located in areas accessible to the general public at mid-sidewalk distance from the edge of the travel lane and 6 feet (1.8 meters) off the ground. At each roadway intersection, individual receptors were located at the corners and along roadways that allow pedestrian access. Only the highest concentrations of CO at each intersection were reported for each modeled scenario.

Receptor locations were also considered near the tunnel exit portals and ventilation buildings. Receptors were placed along sidewalks accessible to the general public and buildings with windows or doorways that opened towards 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 employed:

- Locations near the portals that the public would have access to that are at least 10 feet (3 meters) from either side of the travel-way.
- Both ground-level and elevated receptors (i.e., operable windows, air intake ducts, etc.) on nearby buildings.

4.4 Background Concentrations

This air quality analysis estimates impacts resulting from emissions released from motor vehicles (either directly or through ventilation buildings and tunnel portals). Air pollutant concentrations are predicted at nearby receptor locations. To estimate total pollutant concentrations at a prediction site (with and without a proposed project), background concentrations must be added to the predicted values to account for pollution entering the area from other sources upwind. Background concentrations therefore do not include impacts from the local emission sources analyzed. In estimating total pollutant levels for the purpose of comparing results with the applicable ambient air quality standards, it is necessary to add the background CO and PM_{10} levels to the impacts.

Existing year background levels were developed based on data collected at the Beacon Hill Reservoir monitoring station, which is located southwest of downtown Seattle. This is the only CO background monitoring station in the central Puget Sound region and is located to measure urban CO concentrations away from the influence of local traffic congestion. Because regional background CO levels are not influenced by local traffic conditions, the CO concentrations measured at this location are considered representative of background concentrations in the study area.

The second-highest monitored 1-hour CO concentration for 2000 to 2003 from the EPA AIRDATA database was 2.8 ppm; the second-highest 8-hour average was 2.2 ppm. These values were conservatively used as background concentrations for all CO modeling analyses (U.S. EPA AIRDATA Database, November 11, 2003).

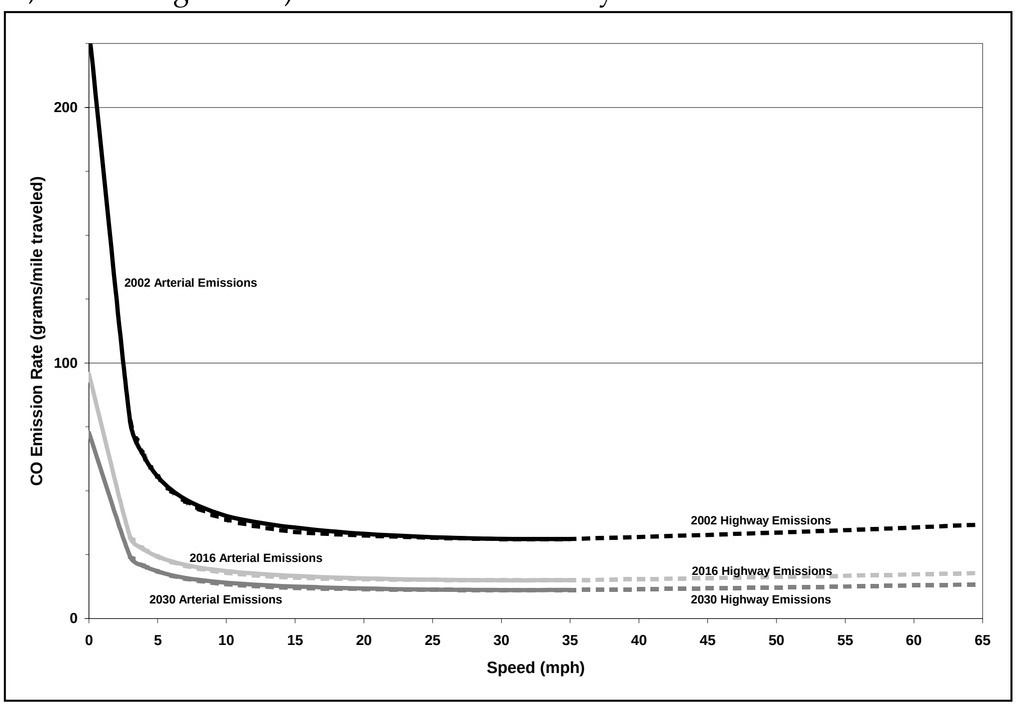
Future background CO levels are anticipated to be lower than the existing levels due to decreased emissions and controls over emissions in the future years that overpowers the effects of increases in traffic. In absence of future traffic predictions, 2016 and 2030 future background levels were conservatively assumed to be the same as the existing levels.

A 24-hour average PM_{10} background concentration of 67 $\mu g/m^3$ was estimated by averaging the 10 highest PM_{10} levels observed over the 1999-2001 period at the Duwamish monitor (at 4752 E. Marginal Way). The annual average PM_{10} concentrations measured at this location averaged 22 μg/m³ for the most recent three years (2001 through 2003). This site monitors the effects of nearby pollutant sources; therefore, it conservatively overestimates the background concentrations.

4.5 Vehicular 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. New technologies are also being implemented to reduce emissions in newer vehicles compared to prior models. 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 from an average vehicle in Seattle traveling on an arterial or highway for 2002, 2016, and 2030 are shown in Exhibit 4-5. Decreases over time occur as a result of the gradual replacement of older vehicles with newer, less-polluting vehicles. PM_{10} emission factors, however, are primarily dependent on average vehicular weights and the amount of dust (i.e., silt loading factors) on the affected roadways.



Source: MOBILE 6.2 with Ecology inputs for Seattle.

Exhibit 4-5. CO Emission Factors for Seattle Traffic

4.5.1 Microscale (Localized) Analysis

Air quality pollutant emission factors were estimated using EPA's MOBILE 6.2 emission factor program. The data inputs provided by Ecology are based on implementation of Washington State's enhanced inspection and maintenance (I&M) and anti-tampering programs, which require annual inspections of automobiles and light trucks to determine if CO and HC emissions from the vehicles' exhaust systems are below 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.

MOBILE 6.2 emission factors were developed for existing conditions (2002), the project's mid-construction year (2012), year of opening (2016), and design year (2030). Emission factors were developed for the appropriate conditions affecting worst-case concentrations of each pollutant—summertime conditions for CO and PM_{10} and wintertime for NO_x and HC. These factors supercede the Mobile 5b factors used in the conformity analysis of *Destination 2030*, the Metropolitan Transportation Plan (MTP) adopted in 2001, and were developed consistent with EPA guidance on Mobile 6.2 adoption. In addition to PM_{10} emissions released directly from vehicles, re-entrained road dust was estimated using the re-entrained dust emission factors from the Duwamish PM_{10} Air Quality Maintenance Plan (PSCAA, 1997a).

4.5.2 Mesoscale (Areawide) Analysis

An analysis was conducted to estimate the potential effects that the proposed project alternatives would have on the amount of mobile source-related air pollutants generated in the study area. The results of this analysis provide an indication of the relative effect of the proposed alternatives on air quality levels in the study area.

The analysis was performed for CO, HC, NO_X, and CO_2. The daily air pollutant emissions were estimated using the link-based volume and speed forecasts developed for Appendix C, Transportation Discipline Report. The traffic data used to develop these estimates, which are based on raw model forecasts (i.e., without link volume balancing or speed corrections), provide results that make a good comparison between existing conditions and the alternatives for the entire study area, but not a calibrated estimate of actual emissions.

Once a Preferred Alternative is selected, it will be submitted to PSRC for inclusion in regional modeling. The regional modeling results, including the Preferred Alternative, will demonstrate regional conformity of the Preferred Alternative to the air quality maintenance plans.

Criteria Pollutants

CO, HC, and NO_X emissions were calculated as part of the mesoscale analysis to provide an indication of the effects of the project alternatives throughout the downtown Seattle study area on those air pollutants regulated under the NAAQS.

Greenhouse Gases

Motor vehicles emit CO_2, a greenhouse gas that contributes to global warming. CO_2 emission rates, which are proportional to fuel consumption rates, were calculated as part of the mesoscale analysis to provide a comparison of the effects of the various alternatives on global warming potential. Energy consumption estimates from Appendix V, Energy Technical Memorandum were used to estimate the study area.

CO_2 is the primary greenhouse gas generated by the operation of motor vehicles. CO_2 emissions are proportional to fuel consumption. For every million British Thermal Units (BTUs) of energy consumed from gasoline, approximately 71 grams of CO_2 are emitted (USDOT 1998). Considering fuel economy, passenger cars emit on average 225 grams CO_2 per kilometer traveled (0.8 pounds per mile), and sport-utility vehicles and light trucks emit about 50 percent more CO_2 per mile because they are less efficient (EPA 1997).

Energy consumption estimates from Appendix V, Energy Technical Memorandum were used with a CO_2 emission coefficient of 71.2 grams CO_2 per million BTUs of fuel consumed to estimate the study area CO_2 emissions under each alternative.

4.6 Analysis Years

Pollutant estimates were made for four analysis years: existing conditions (2002), the project's mid-construction (2012), the project's opening year (2016), and its design year (2030). Future year analyses were conducted with and without the proposed roadway alternatives. The mid-construction year analysis will be completed for the Preferred Alternative as part of the construction period conformity determination.

4.7 Analysis Periods

4.7.1 Microscale Analysis

Afternoon peak-period traffic data were used to estimate maximum 1-hour and 8-hour CO concentrations. The afternoon peak is the highest traffic-volume period of the day in downtown Seattle. Peak-hour and average daily traffic volumes were used to estimate 24-hour average PM_{10} concentrations. The potential air quality impacts of emissions released from the tunnel portals and ventilation buildings were estimated using normal (i.e., not emergency or breakdown) operating conditions during these traffic periods. During a fire in the tunnel or other emergency condition, pollutant concentrations may exceed the NAAQS at nearby receptors, but are not expected to exceed acutely harmful levels during the time it would take to evacuate adjacent areas.

4.7.2 Mesoscale Analysis

Emission estimates were completed for a.m., p.m. peak, and off-peak periods using forecast vehicles miles traveled (VMT) and travel speed in the study area for the project's design year (2030). The link-based volume and speed forecasts developed for Appendix C, Transportation Discipline Report were used.

These estimates were developed with a traffic assignment model based on current and future population, employment, and travel and congestion information. The forecasting model was developed using the latest planning assumptions consistent with the current conforming Transportation Plan and Transportation Improvement Program (TIP) for the study area.

4.8 Dispersion Models

The mathematical expressions and formulations that compose the various air quality dispersion models attempt to describe an extremely complex physical phenomenon as closely as possible. However, because all models contain simplifications and approximations of actual conditions and interactions, the dispersion models themselves are designed to yield conservative results.

4.8.1 Mobile Source Models

Mobile source dispersion models are the basic analytical tools used to estimate pollutant concentrations expected under given conditions of traffic, roadway geometry, and meteorology.

CAL3QHC Version 2 is a line-source dispersion model that predicts pollutant concentrations, averaged over a 1-hour period, near congested intersections and heavily traveled roadways. CAL3QHC input variables include free flow and idle emission rates, roadway geometries, traffic volumes, site characteristics, background pollutant concentrations, signal timing, and meteorological conditions. CAL3QHC was used to predict concentrations at affected study-area intersections.

Different emission rates occur when vehicles are stopped (idling), accelerating, decelerating, and moving at different average speeds. CAL3QHC simplifies these different emission rates into the following two components:

- Emissions when vehicles are stopped (idling) during the red phase of a signalized intersection.
- Emissions when vehicles are in motion during the green phase of a signalized intersection.

Typical intersection geometry and receptor locations used in the CAL3QHC model are illustrated in Exhibit 4-6.

4.8.2 Stationary Source Models

Stationary source models are the basic analytical tools used to estimate contaminant concentrations resulting from one or more localized emission sources. Stationary source models are used in this analysis to estimate the effects of releases from ventilation buildings and tunnel exit portals on surrounding land uses. Three types of stationary sources are considered for this analysis: point sources, area sources, and volume sources.

- A point source refers to a condition where 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 ventilation buildings are considered as point sources.
- An area source refers to two-dimensional area from which pollutants are emitted, usually from or near ground level. Typical area sources are waste treatment lagoons and large open parking lots. The emissions released through jets of air created by the vehicles exiting the tunnel portals and ramps (before they reach street level) can be considered as either area or volume sources.
- A volume source refers to a three-dimensional source of pollutants such as a coal pile of a chemical processing plant. The emissions released through the jets of air created by the vehicles exiting the tunnel portals for the sections of roadway that are at-grade are considered as volume sources.

The EPA Industrial Source Complex Version 3 (ISC3) model was used to estimate pollutant concentrations near the tunnel's exit portals and ventilation buildings. The basis of the ISC3 model, which can be used to estimate the combined impacts from multiple emissions sources, is the straight-line, steady state Gaussian plume equation. The model is used to estimate impacts from simple point source emissions from stacks, emissions from stacks that experience the effects of aerodynamic downwash due to nearby buildings, isolated vents, multiple vents, storage piles, conveyor belts, and the like. The volume and area source options may also be used to simulate line sources.

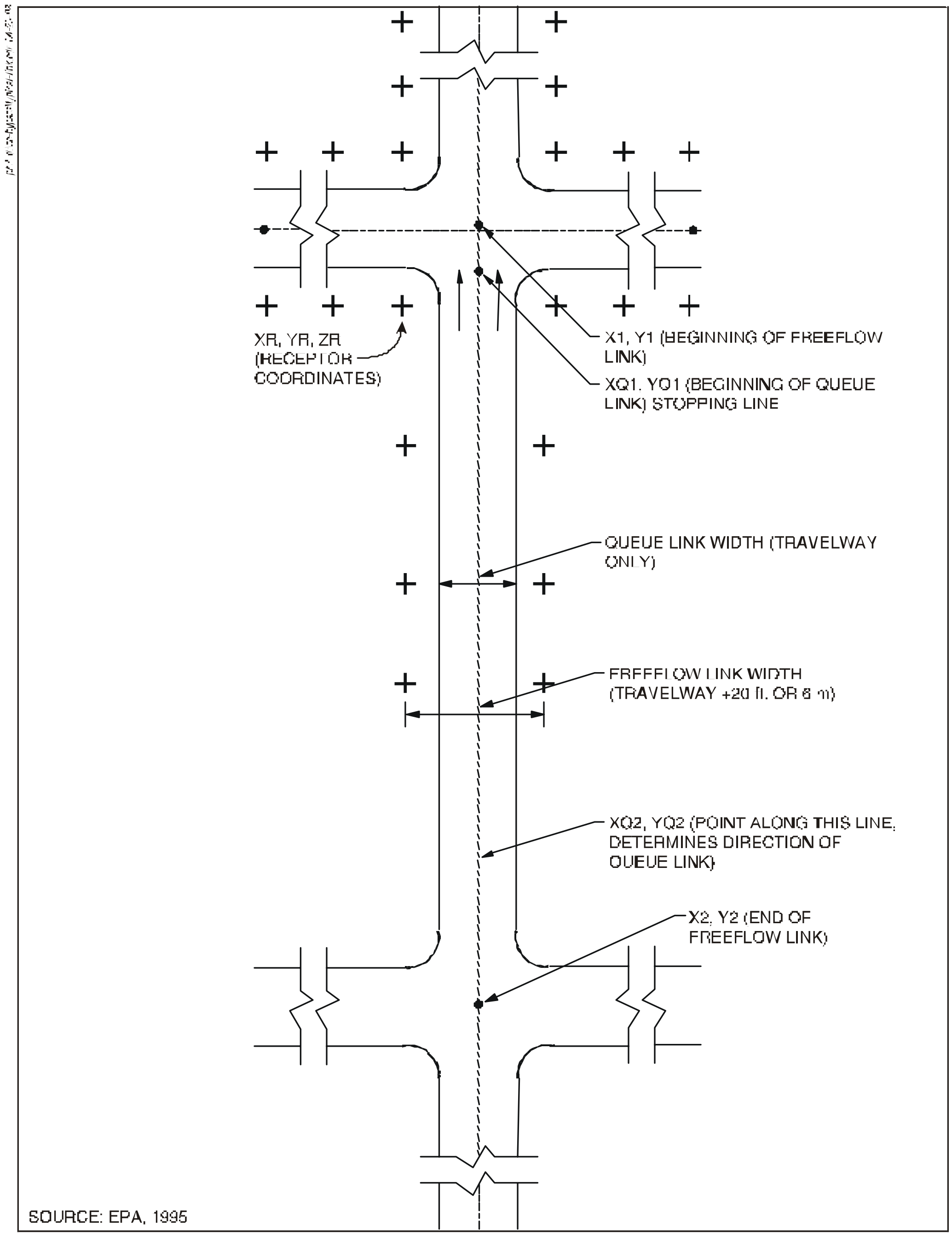


Exhibit 4-6. Typical CAL3QHC Intersection and Receptor Geometry

The ISC3 accepts actual hourly meteorological observations and is able to directly estimate concentrations over the short-term (e.g., 1-hour, 3-hour, 8-hour) and long-term (e.g., annual) time periods. Five years of upper atmospheric meteorological data (1997 to 2001) collected at Sea-Tac Airport were used in this analysis. Surface meteorologic data for the same period was taken from Boeing Field (1997–1998) and the Duwamish air monitoring site (1999–2001) because Boeing Field data did not meet EPA quality requirements. Urban algorithms were used for all analyses.

4.9 Mobile Source Persistence Factors

CAL3QHC directly estimates worst-case 1-hour CO concentrations, based on peak-hour traffic and stable meteorological conditions. These conditions do not usually persist for an 8-hour period, so the worst-case 8-hour CO concentrations are lower than the maximum 1-hour concentrations. Eight-hour average CO concentrations are calculated by multiplying maximum 1-hour concentrations by a persistence factor, which accounts for the time variance in traffic and meteorological conditions.

A CO persistence factor of 0.7 was developed per EPA guidelines using the 10 highest non-overlapping 8-hour CO concentrations recorded during the latest 9 years at the Fourth and Pike air quality monitor (Exhibit 4-7).

Exhibit 4-7. Calculation of 8-hour Persistence Factor

Date	Highest 8-Hour CO Concentrations in Past 3 Years*	Highest 1-Hour CO Concentration During 8-Hour Peak	Ratio of 8-Hour/ 1-Hour Values
September 8, 1999	16.1	6.0	0.37
December 7, 1997	6.8	5.8	0.85
September 25, 1997	7.0	4.4	0.63
December 4, 1997	5.8	4.0	0.69
November 10, 2001	5.0	4.0	0.80
October 23, 1999	5.5	3.9	0.71
November 21, 2000	4.7	3.9	0.83
December 3, 1997	5.1	3.9	0.76
December 5, 1997	4.7	3.8	0.81
November 14, 1997	5.8	3.8	0.66
Average Ratio			0.71

* Collected at the Fourth and Pike monitoring station.

4.10 Air Quality Modeling Methodology

4.10.1 Roadways and Intersections

A microscale modeling analysis was conducted that estimated CO and PM_{10} levels at sensitive receptor sites located near heavily congested intersections that are anticipated to be affected by the proposed project alternatives under existing, future No Build, and future Build Alternatives. For all mobile source analyses using CAL3QHC, a conservative worst-case set of meteorological conditions was used to estimate peak 1-hour concentrations (Exhibit 4-8).

Exhibit 4-8. Modeled Worst-Case Meteorological Conditions

Parameter	Value
Wind Speed	1 meter per second
Stability Class	E
Daily Temperature Range	34 to 50 degrees Fahrenheit (winter temperatures) 60 to 92 degrees Fahrenheit (summer temperatures)
Mixing Height	1,000 meters
Wind Angles	10 degree increments from 0 to 360
Surface Roughness	108 to 370 cm depending on adjacent land use

Free-flow traffic was modeled at the posted speed limit. Traffic volumes were obtained from the traffic analyses that were completed as part of Appendix C, Transportation Discipline Report. Traffic data used in intersection modeling are summarized in Appendix A.

So as not to double count queued vehicles at intersections downstream of an analysis site, CAL3QHC-estimated queues were truncated at the end of each roadway link that would overlap the next intersection.

4.10.2 Ventilation Buildings

The analysis of the exhaust stack emissions includes estimates of the direct plume impaction of these releases on nearby receptors (both ground level and elevated) and the downwash effects from the ventilation buildings themselves, as well as from nearby buildings, as applicable. CO concentrations were estimated.

4.10.3 Tunnel Exit Portals

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

Total pollutant levels estimated at each receptor location considered were assumed to consist of the following components:

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

The total pollutant levels estimated at the nearby receptors from all of these sources combined were compared with the appropriate air quality standards. The methodology used to estimate the potential impacts from each of the previously mentioned sources is discussed separately.

Releases From Tunnel Portals

The approach that was used for the analysis of tunnel portal releases 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 show that air emitted from a vehicular tunnel portal forms a plume that is both pushed out of the tunnel by vehicles prior to their exiting the tunnel (and, if applicable, mechanical ventilation systems) and dragged out of the portal by these same vehicles as they move downstream of the portal. Also, 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 there is no methodology currently available for mathematically estimating the configuration of the jet or its concentration gradients, there are several factors that were used to estimate its size and shape. These include the speed of the vehicles passing through the tunnel, atmospheric wind speed and direction, the topography of the area immediately surrounding the tunnel portal, the type of the 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 would be a wall between directional roadways), and 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 (either 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.

On the basis of wind tunnel studies conducted for similar tunnel portals, a scenario that divides the overall jet into separate finite regions, with each region having its own unique (and uniform) set of emission rates, was developed for each analysis. The portal jet properties that were assumed for estimating the impacts of the proposed project alternatives were based on the following assumptions:

- The number of lanes of traffic exiting each portal.
- Whether the entrance and exit portals are physically separated.
- For jets located in depressed sections of roadway downstream of the exit 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 an exit 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 vehicular speeds, portal release exit flow rates, and the geometrical alignment of the portal area.)
- For jets from the south portal of the Battery Street Tunnel and the north portal of the waterfront tunnel the roadway was elevated on structure downstream of the exit portals.
- 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 percent of total portal emissions in each section were based on the configuration of the exit portal and the downstream roadway.

Impacts were estimated using ISC3, with each jet section assumed to be a volume source.

Roadway Emissions

Emissions from the traffic immediately downstream of each portal were also modeled (using ISC3) as shallow volume sources with uniform emission rates that are located along the top of the depressed roadway section. The width of the area source was the width of the roadway. The length of the volume source was estimated based on the proposed configuration of the roadway. Hourly emission rates were used.

Local Traffic

Impacts from traffic emissions on local streets near the portals were estimated as line sources using ISC3. Peak-period hourly emission rates were used.

Total Concentrations Near Tunnel Portals

The total CO concentrations at each of the receptor locations were estimated by adding the sum of the impacts of each of these sources together (without regard to wind angles) with the appropriate background values. The maximum levels estimated at each receptor location near each portal were compared with the NAAQS.

4.10.4 Construction Phase Analysis

Construction impacts were evaluated qualitatively. As the project develops further, a detailed construction impact analysis will be developed that evaluates short- and long-duration emissions from expected construction activities. Expected construction phasing and equipment operations are not sufficiently defined to complete such a detailed analysis at this time.

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Chapter 5 AFFECTED ENVIRONMENT

5.1 Study Area Characteristics

The project 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 emission released from the tunnel ventilation systems under the various alternatives. Areas likely to be affected by increased emissions during construction were also considered. The study area encompasses the downtown core and is roughly defined by Elliott Bay on the west, Lake Union on the north, Interstate 5 (included in the study area) on the east, and S. Spokane Street (included in the study area) on the south. Land use in the area ranges from low-rise light industrial to high-rise office towers. A detailed description of the land use within the study area is provided in Appendix G, Land Use and Shorelines Technical Memorandum.

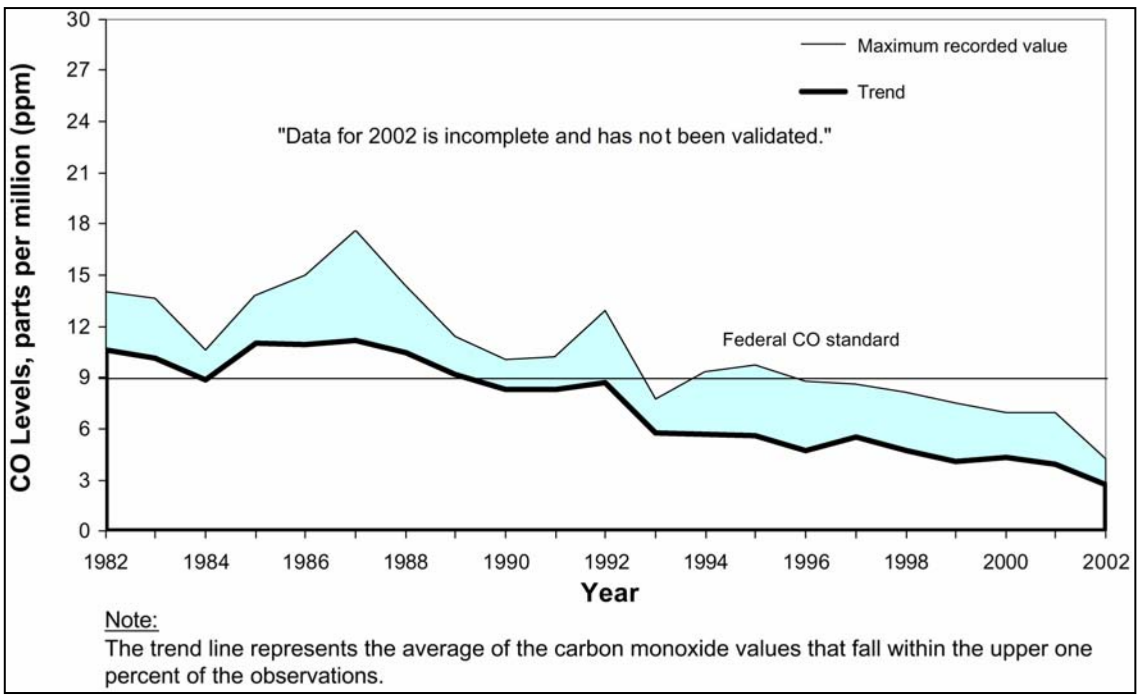
5.2 Regulatory Status of Study Area

The federal Clean Air Act defines nonattainment areas as geographic regions that have been designated as not meeting one or more of the NAAQS. Air quality maintenance areas are regions that have recently attained compliance with the NAAQS. The Alaskan Way Viaduct and Seawall Replacement Project study area lies within ozone and CO air quality maintenance areas, and the southern portion of the study area (south of S. Dearborn Street) lies within a PM_{10} maintenance area. In addition, air quality emissions in the Puget Sound region are currently being managed under the provisions of Air Quality Maintenance Plans (AQMPs) for ozone and CO. PSCAA and Ecology developed the current plans, and the EPA approved the CO and ozone plans in 1996 and the PM_{10} plan in 2000. Any regionally significant transportation project in the Puget Sound air quality maintenance areas must conform to the AQMPs.

5.3 Air Pollution Trends

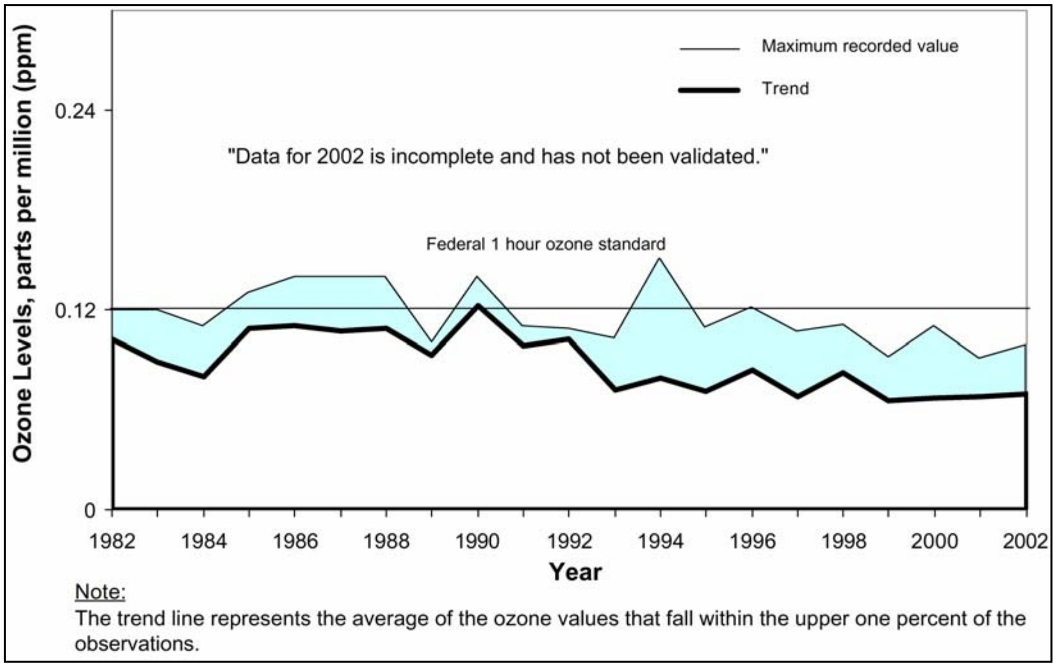
Nationwide, air pollutant emissions from motor vehicles have dropped considerably since 1970, even as vehicle travel has increased rapidly. In general, the air is noticeably cleaner than in 1970, and most criteria pollutant emissions from motor vehicles are less than they were in 1970. Total nationwide hydrocarbon emissions are down 38 percent, NO_x emissions have increased 15 percent, PM_{10} emissions are down 76 percent, and CO emissions are down 19 percent. These changes have occurred along with increasing population, economic growth, and vehicle travel (EPA 2002a). Still, challenges remain. Based on monitored data, approximately 46 million people in the U.S. reside in counties that did not meet the air quality standard for at least one NAAQS pollutant in 1996 (EPA 2002a).

Regional air pollutant trends have generally followed national patterns over the last 20 years. While the average weekday vehicle miles traveled in the central Puget Sound region has increased from 30 million miles in 1981 to 65 million in 1999 (PSRC 2000), pollutant emissions associated with transportation sources have decreased. Carbon monoxide 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 (Exhibit 5-1). Other transportation-related pollutants have followed similar but less pronounced trends (Exhibit 5-2).



Source: Ecology (2003c).

Exhibit 5-1. Puget Sound CO Trend



Source: Ecology (2003c).

Exhibit 5-2. Puget Sound Ozone Trend

The PSRC recently completed a regional emission analysis, which evaluated the air quality conditions in the area for *Destination 2030*, the current MTP for the central Puget Sound region through 2030. The recently completed emission analysis includes updates to reflect new EPA emission requirements, including the Tier II Gasoline/Sulfur Rule. The revised emission budget from the latest AQMP and the most recent emission trend modeling are shown in Exhibit 5-3.

Exhibit 5-3. Destination 2030 Air Pollutant Emission Projections (tons per day)

	PSRC Metropolitan Transportation Plan			
Pollutant	AQMP Budget	2010 Forecast	2020 Forecast	2030 Forecast
CO	1,497	860	719	735
VOCs	248	164	171	202
NO_x	263	206	199	217
PM_{10} (Duwamish sub-area)	0.4	0.3	0.2	0.3

Source: PSRC (2001).

Based on the *Destination 2030* analysis, none of the future transportation emissions scenarios is expected to exceed the AQMP transportation emission budgets. This means that the projected regional emission rates are anticipated to be lower than the rates necessary to maintain compliance with the NAAQS. The downward trend in CO is expected to continue for the Puget Sound region through 2020, but is expected to begin increasing again by 2030. For ozone, the future trend shows leveling off of emissions through 2020 and increasing emissions of ozone precursors by 2030. Hydrocarbon emissions [evaluated as volatile organic compounds (VOCs) in *Destination 2030*], which largely drive ozone formation in the central Puget Sound region, are projected to increase between 2010 and 2020 and continue to increase to 2030. However, HC emissions are expected to be below the emissions budget through 2030.

5.4 Monitored Air Quality Concentrations

The evaluation of existing air quality in the study area is largely based on ambient air quality data collected and published by Ecology and PSCAA, who have established air pollution monitoring stations throughout Washington State. In general, these stations are located where elevated air pollution levels have been identified. The air quality monitoring stations closest to the Alaskan Way Viaduct and Seawall Replacement Project for CO are located in downtown Seattle, approximately 0.5 kilometer (0.3 mile) east of the project area. No exceedance of the NAAQS for CO was recorded in Seattle between 1993 and 2002. The highest monitored values for 2000 through 2003 are shown in Exhibit 5-4. One exceedance of the 8-hour NAAQS for CO was recorded in 1995. Because of the local nature of CO impacts, concentrations measured at this location are not representative of the project site, which could have higher or lower concentrations because of different levels of traffic congestion and roadway configuration.

Ecology also monitors ozone, and the nearest monitoring station is at Lake Sammamish State Park, approximately 25 kilometers (15 miles) east of the project area. No exceedances of the NAAQS for ozone were observed at this location between 1994 and 1997. One exceedance in 1998 and three exceedances in 1999 were observed. There were no exceedances in 2000, 2001, or 2002. The highest monitored values for 2000 through 2003 are shown in Exhibit 5-4.

PSCAA operates particulate monitors for PM_{10} and $PM_{2.5}$ in the Duwamish industrial area. There have been no recorded exceedances of the NAAQS for either PM_{10} or $PM_{2.5}$ since PSCAA began monitoring for $PM_{2.5}$ in 1999. The highest monitored values for 2000 through 2003 are shown in Exhibit 5-4.

Exhibit 5-4. Highest Monitored Pollutant Concentrations From 2000 to 2003

Pollutant	Location	Year	Highest Value	Second Highest Value	NAAQS
CO (8-hour average)	Fourth and Pike	2000	5.5 ppm	5.2 ppm	
CO (8-hour average)	Fourth and Pike	2001	5 ppm	4.8 ppm	9 ppm
CO (8-hour average)	Fourth and Pike	2002	5.9 ppm	4.8 ppm	
CO (8-hour average)	Fourth and Pike	2003	4.5 ppm	3.9 ppm	
Ozone (1-hour average)	Lake Sammamish	2000	0.094 ppm	0.08 ppm	
Ozone (1-hour average)	Lake Sammamish	2001	0.079 ppm	0.069 ppm	0.12 ppm
Ozone (1-hour average)	Lake Sammamish	2002	0.08 ppm	0.071 ppm	
Ozone (1-hour average)	Lake Sammamish	2003	0.085 ppm	0.081 ppm	
Ozone (8-hour average)	Lake Sammamish	2000	0.073 ppm	0.067 ppm	
Ozone (8-hour average)	Lake Sammamish	2001	0.064 ppm	0.061 ppm	0.08 ppm
Ozone (8-hour average)	Lake Sammamish	2002	0.058 ppm	0.057 ppm	
Ozone (8-hour average)	Lake Sammamish	2003	0.071 ppm	0.067 ppm	
PM_{10} (24-hour average)	4752 E. Marginal Way	2000	73μg/m3	66μg/m3	
PM_{10} (24-hour average)	4752 E. Marginal Way	2001	73μg/m3	71μg/m3	150 μg/m3
PM_{10} (24-hour average)	4752 E. Marginal Way	2002	71μg/m3	57μg/m3	
PM_{10} (24-hour average)	4752 E. Marginal Way	2003	65μg/m3	52μg/m3	
$PM_{2.5}$ (24-hour average)	4752 E. Marginal Way	2000	47μg/m3	44μg/m3	
$PM_{2.5}$ (24-hour average)	4752 E. Marginal Way	2001	47μg/m3	43μg/m3	65 μg/m3
$PM_{2.5}$ (24-hour average)	4752 E. Marginal Way	2002	45μg/m3	44μg/m3	
$PM_{2.5}$ (24-hour average)	4752 E. Marginal Way	2003	37μg/m3	29μg/m3	

Source: U.S. EPA AIRDATA Database, November 11, 2003.

During 2000, the EPA, Ecology, and PSCAA conducted air quality monitoring in the Georgetown area (1 to 2 miles southeast of the Alaskan Way Viaduct study area) for 18 toxic air pollutants as part of a regional air toxics study. The monitoring results for the Georgetown site were similar to the other five sites monitored within the Seattle urban area (EPA 2000b; Ecology 2000). The cumulative cancer risk for monitored air toxics in Georgetown was 7.0 per hundred thousand individuals while the other sites ranged between 6.6 and 7.7 per hundred thousand. The monitored pollutant concentrations are partially the result of emissions from nearby industrial, airport, and roadway traffic sources. Approximately 60 percent of the air toxic risk estimated for Georgetown is from pollutants associated with transportation sources (traffic and aircraft). The greatest single air toxic risk was associated with diesel particulate emissions (PSCAA 2002). As a point of reference, EPA's National Air Toxics Assessment has found that the cumulative cancer risk is greater than 1 per hundred thousand for the entire U.S. population and exceeds 10 per hundred thousand for more than 20 million people (EPA 2002b).

5.5 Estimated Existing Air Pollutant Conditions

5.5.1 CO Concentrations Near Congested Intersections

Worst-case CO concentrations were estimated at 14 intersections (see Exhibit 4-4) to evaluate the potential for exceedances of the NAAQS for CO within the study area with existing traffic conditions. The modeled intersections include all of the intersections identified as being most likely to exceed the NAAQS for CO in the future under any of the evaluated alternatives. Consistent methodology and assumptions were used for modeling existing and future conditions; therefore, modeled CO concentrations for 2002 can be compared with those predicted for future years, to show the trend in air quality expected in the project area.

The maximum estimated 1-hour CO concentrations from vehicle emissions for existing conditions range between 8.8 and 16.8 ppm, and the maximum estimated 8-hour CO concentrations range between 6.4 and 12.0 ppm. Possible exceedances of the 8-hour average NAAQS for CO of 9 ppm were estimated at four intersections (Second Avenue with Madison, Second Avenue with Spring Street, Alaskan Way with Marion, and Elliott Avenue with Western Avenue) under existing conditions in 2002. The estimated exceedances of the 8-hour average NAAQS for CO under existing conditions reflect conservative modeling assumptions, including peak-period traffic conditions, worst-case meteorological conditions, high background CO concentrations, and atmospheric stability that may not persist in the study area; therefore, the exceedances may never actually occur (Exhibit 5-5).

5.5.2 PM_{10} Concentrations Near Congested Intersections

Worst-case PM_{10} concentrations were estimated at 4 intersections to evaluate the potential for exceedances of the NAAQS for PM_{10} within the study area with existing traffic conditions. The modeled intersections were selected from those evaluated for CO to include the only intersection within the Duwamish PM_{10} maintenance area and three intersections identified as being most likely to exceed the NAAQS for PM_{10} in the future under any of the evaluated alternatives.

Exhibit 5-5. Modeled Existing CO Concentrations

Intersection		Modeled 2002 CO Concentrations (ppm)	
Street	with Street	One-Hour Average	Eight-Hour Average
1st Avenue	Columbia Street	11.4	8.2
1st Avenue	Denny Way	11.4	8.2
1st Avenue	S. Royal Brougham Way	12.3	8.9
2nd Avenue	Denny Way	10.9	7.9
2nd Avenue	Madison Street	16.8	**12.0**
2nd Avenue	Spring Street	13.6	**9.8**
5th Avenue	Mercer Street	10.7	7.7
Alaskan Way	Marion Street	13.2	**9.5**
Alaskan Way	S. Jackson Street	8.8	6.4
Alaskan Way	S. King Street	9.2	6.7
Alaskan Way	S. Main Street	N/A	N/A
Dexter Avenue	Mercer Street	11.9	8.6
Dexter Avenue	Roy Street	9.2	6.7
Elliott Avenue	Western (Denny)	13.3	**9.6**

N/A = Not Applicable, intersection is not currently signalized.
Values in **bold** are estimated to exceed the NAAQS under worst-case traffic and meteorological conditions.
The 1-hour average NAAQS for CO is 35 ppm.
The 8-hour average NAAQS for CO is 9 ppm.

The maximum estimated existing 1-hour PM_{10} concentrations from vehicle emissions for existing conditions ranged between 21 and 53 $\mu g/m^3$ (Exhibit 5-6). The modeled values were for PM peak-hour traffic conditions; therefore, the 24-hour average concentration would be substantially less. A 24-hour average PM_{10} background concentration of 67 $\mu g/m^3$ was estimated by averaging the 10 highest PM_{10} levels observed over the 1999-2001 period at the Duwamish monitor (at 4752 E. Marginal Way). This site monitors the effects of nearby pollutant sources; therefore, it does not represent background concentrations. Adding the worst-case one-hour PM_{10} concentration to the second-highest twenty-four hour monitoring result defines an upper limit on PM_{10} concentrations near project area intersections of 120 $\mu g/m^3$, which is still below the twenty-four hour NAAQS of 150 $\mu g/m^3$.

Exhibit 5-6. Modeled Existing PM_{10} Concentrations

Intersection		Modeled 2002 PM_{10} Concentrations ($\mu g/m^3$)
Street	with Street	One-Hour Average
1st Avenue	S Royal Brougham Way	36
Elliott Avenue	Denny (Western)	53
5th Avenue	Mercer Street	29
2nd Avenue	Madison Street	21

The 24-hour Average Mean NAAQS for PM_{10} is 150 $\mu g/m^3$.

5.5.3 Mesoscale Emissions Analysis

Daily emissions of CO, NO_x, HC, and CO_2 generated by motor vehicles within the study area were estimated using the link-based volume and speed forecasts developed for Appendix C, Transportation Discipline Report. The traffic data used to develop this estimate consisted of raw model forecasts, without link volume balancing or speed corrections; therefore, the results provide a good comparison between existing conditions and the alternatives, but not a calibrated estimate of actual emissions (Exhibit 5-7).

Exhibit 5-7. Estimated Existing Study Area Pollutant Emission Rates

	Pollutant Emissions (Metric Tons per Day)			
	CO	NOx	HC	CO_2
2002 Existing Conditions	79	8.1	5.5	730

Chapter 6 IMPACTS AND ALTERNATIVES

6.1 No Build Alternative

6.1.1 CO Concentrations Near Congested Intersections

Predicted worst-case CO concentrations under the No Build Alternative in 2030 would be lower than those estimated under existing conditions because of reductions in vehicle emissions as newer vehicles replace older, more polluting vehicles. No exceedances of the 1-hour average NAAQS for CO of 35 ppm were predicted at any location under the No Build Alternative or any of the Build Alternatives in 2030 (Exhibit 6-1). Similarly, no exceedances of the 8-hour average NAAQS for CO of 9 ppm were predicted for 2030 (Exhibit 6-2). Worst-case 1-hour average CO concentrations were predicted to range between 5.3 and 8.6 ppm, while 8-hour average CO concentrations were predicted to range between 4.0 and 6.3 ppm.

Exhibit 6-1. Predicted 2030 1-Hour Average Intersection CO Concentrations

Intersection		Alternative					
Street	with Street	No Build	Rebuild	Aerial	Tunnel	Bypass Tunnel	Surface
1st Avenue	Columbia Street	7.9	7.9	7.9	7.1	7.3	10.2
1st Avenue	Denny Way	6.4	7.0	7.0	6.7	6.9	6.7
1st Avenue	S. Royal Brougham Way	8.6	8.5	8.9	9.5	8.3	8.6
2nd Avenue	Denny Way	6.2	6.6	6.6	6.5	6.5	6.2
2nd Avenue	Madison Street	7.1	7.0	6.8	7.5	7.3	7.1
2nd Avenue	Spring Street	6.5	6.9	6.9	7.3	7.7	7.0
5th Avenue	Mercer Street	6.1	6.2	9.6	8.7	10.2	9.9
Alaskan Way	Marion Street	6.2	5.3	6.2	8.4	7.0	9.1
Alaskan Way	S. Jackson Street	5.3	5.3	5.3	7.4	8.6	9.3
Alaskan Way	S. King Street	5.3	5.5	5.3	7.3	8.3	8.9
Alaskan Way	S. Main Street	N/A	6.0	N/A	7.3	8.1	10.2
Dexter Avenue	Mercer Street	6.8	6.8	8.4	8.5	8.5	7.8
Dexter Avenue	Roy Street	5.5	6.4	8.3	8.8	9.1	8.1
Elliott Avenue	Western (Denny)	8.1	8.6	8.8	8.4	8.3	8.8

N/A = Not Applicable, intersection is not signalized under this alternative.
The 1-hour average NAAQS for CO is 35 ppm.

Exhibit 6-2. Predicted 2030 8-Hour Average Intersection CO Concentrations

Intersection		Alternative					
Street	with Street	No Build	Rebuild	Aerial	Tunnel	Bypass Tunnel	Surface
1st Avenue	Columbia Street	5.8	5.8	5.8	5.2	5.4	7.4
1st Avenue	Denny Way	4.7	5.1	5.1	4.9	5.1	4.9
1st Avenue	S. Royal Brougham Way	6.3	6.2	6.5	6.9	6.1	6.3
2nd Avenue	Denny Way	4.6	4.9	4.9	4.8	4.8	4.6
2nd Avenue	Madison Street	5.2	5.1	5.0	5.5	5.4	5.2
2nd Avenue	Spring Street	4.8	5.1	5.1	5.4	5.6	5.1
5th Avenue	Mercer Street	4.5	4.6	7.0	6.3	7.4	7.2
Alaskan Way	Marion Street	4.6	4.0	4.6	6.1	5.1	6.6
Alaskan Way	S. Jackson Street	4.0	4.0	4.0	5.4	6.3	6.8
Alaskan Way	S. King Street	4.0	4.1	4.0	5.4	6.1	6.5
Alaskan Way	S. Main Street	N/A	4.4	N/A	5.4	5.9	7.4
Dexter Avenue	Mercer Street	5.0	5.0	6.1	6.2	6.2	5.7
Dexter Avenue	Roy Street	4.1	4.7	6.1	6.4	6.6	5.9
Elliott Avenue	Western (Denny)	5.9	6.3	6.4	6.1	6.1	6.4

N/A = Not Applicable, intersection is not signalized under this alternative.
The 8-hour average NAAQS for CO is 9 ppm.

6.1.2 PM_{10} Concentrations Near Congested Intersections

Predicted worst-case PM_{10} concentrations under the No Build Alternative in 2030 would be higher than those estimated under existing conditions because of increased traffic volume. Worst-case 1-hour average PM_{10} concentrations for the No Build Alternative were predicted to range between 29 and 61 $\mu g/m^3$(Exhibit 6-3). The modeled values were for PM peak-hour traffic conditions; therefore, the 24-hour average concentration would be substantially less. Adding the estimated background PM_{10} concentration defines an upper limit on PM_{10} concentrations near project area intersections of 128 $\mu g/m^3$, which is still below the twenty-four hour NAAQS of 150 $\mu g/m^3$. No exceedances of the 24-hour average NAAQS for PM_{10} of 150 $\mu g/m^3$ are expected at any location under the No Build Alternative or any of the Build Alternatives in 2030.

Exhibit 6-3. Predicted 2030 1-Hour Average Intersection PM_{10} Concentrations

Intersection		Alternative					
Street	with Street	No Build	Rebuild	Aerial	Tunnel	Bypass Tunnel	Surface
1st Avenue	S Royal Brougham Way	48	41	37	38	37	40
Elliott Avenue	Denny (Western)	61	58	61	61	53	58
5th Avenue	Mercer Street	34	35	50	50	52	50
2nd Avenue	Madison Street	29	23	23	24	24	27

The 24-hour Average Mean NAAQS for PM_{10} is 150 µg/m^3.

6.1.3 Mesoscale Emissions Analysis

Daily pollutant emission rates generated in the study area in 2030 were estimated using the same methodology as was used to estimate existing emission rates. Comparison between existing study area emissions and the various alternatives in 2030 demonstrates the trend towards cleaner operating vehicles for CO, NO_x, and HC in 2030 (Exhibit 6-4). Average daily traffic would increase somewhat in the downtown Seattle core between 2002 and 2030, but the small increase in traffic would be more than offset by projected reductions in emissions per mile traveled. Differences between the No Build and Build Alternatives are small.

Emissions of CO_2 would increase (Exhibit 6-4) proportional to the projected increase in vehicle miles traveled between 2002 and 2030 because little change in vehicle fuel economy is projected over this time period (USDOE 2002).

Exhibit 6-4. Estimated Study Area Pollutant Emission Rates

Alternative	Modeled Pollutant Emissions (Metric Tons per Day)			
	CO	NO_x	HC	CO_2
2002 Existing Conditions	79	8.1	5.5	730
2030 No Build	34	0.9	1.1	880
2030 Rebuild	36	1.0	1.1	870
2030 Aerial	36	1.0	1.1	870
2030 Tunnel	35	1.0	1.1	870
2030 Bypass Tunnel	35	1.0	1.1	870
2030 Surface	34	0.9	1.1	860

6.2 Rebuild Alternative

6.2.1 CO Concentrations Near Congested Intersections

Predicted worst-case CO concentrations under the Rebuild Alternative would be similar to the No Build Alternative at most locations in 2030. No exceedances of either the 1-hour average NAAQS of 35 ppm or the 8-hour average NAAQS of 9 ppm were predicted at any location. Under the Rebuild Alternative, worst-case 1-hour average CO concentrations were predicted to range between 5.3 and 8.6 ppm, while 8-hour average CO concentrations were predicted to range between 4.0 and 6.3 ppm (see Exhibits 6-1 and 6-2).

Broad Street Underpass not Constructed

In the event that the Broad Street underpass is not constructed, traffic to and from Magnolia and the Ballard Bridge would continue to be routed primarily along Elliott and Western Avenues via reconstructed ramps south of the Battery Street Tunnel. Compared to the analyzed alternative, this option could shift some traffic off of the Alaskan Way surface street onto the rebuilt viaduct south of the Battery Street Tunnel and onto Elliott and Western Avenues through Belltown. This option would have a small effect on several of the modeled intersections, and it is not anticipated to have a substantial effect on air quality. If selected, it would require detailed analysis prior to completion of the National Environmental Policy Act (NEPA) documentation.

6.2.2 PM_{10} Concentrations Near Congested Intersections

Predicted worst-case PM_{10} concentrations under the Rebuild Alternative in 2030 would be similar than those estimated under the No Build Alternative. Worst-case 1-hour average PM_{10} concentrations for the Rebuild Alternative were predicted to range between 29 and 58 $\mu g/m^3$ (Exhibit 6-3). The modeled values were for PM peak-hour traffic conditions; therefore, the 24-hour average concentration would be substantially less. Adding the estimated background PM_{10} concentration defines an upper limit on PM_{10} concentrations near project area intersections of 125 $\mu g/m^3$, which is still below the twenty-four hour NAAQS of 150 $\mu g/m^3$. No exceedances of the 24-hour average NAAQS for PM_{10} of 150 $\mu g/m^3$ are expected at any location under any of the Alternatives in 2030.

6.2.3 Mesoscale Emissions Analysis

Differences between study area emissions of criteria pollutants under the Rebuild and No Build Alternatives would be small (see Exhibit 6-4). Emissions of CO_2 would be slightly less under the Rebuild Alternative than the No Build Alternative.

6.3 Aerial Alternative

6.3.1 CO Concentrations Near Congested Intersections

Predicted worst-case CO concentrations under the Aerial Alternative in 2030 would be similar to the No Build Alternative at most locations. No exceedances of either the 1-hour or 8-hour NAAQS were predicted. Under the Aerial Alternative, worst-case 1-hour average CO concentrations were predicted to range between 5.3 and 9.6 ppm, while 8-hour average CO concentrations were predicted to range between 4.0 and 7.0 ppm (see Exhibits 6-1 and 6-2).

Broad Street Underpass not Constructed

In the event that the Broad Street underpass is not constructed, traffic to and from Magnolia and the Ballard Bridge would continue to be routed primarily along Elliott and Western Avenues via reconstructed ramps south of the Battery Street Tunnel. Compared to the analyzed alternative, this option could shift a small volume of traffic off of the Alaskan Way surface street onto the rebuilt viaduct south of the Battery Street Tunnel and onto Elliott and Western Avenues through Belltown. This option would have a small effect on several of the modeled intersections, and it is not anticipated to have a substantial effect on air quality. If it is selected, it would require detailed analysis prior to completion of the NEPA documentation.

Option: Lowered Aurora/SR 99

The option to lower Aurora Avenue north of the Battery Street Tunnel would not have a substantial effect on signalized intersections, and it is not anticipated to have a substantial effect on air quality. If it is selected, it would require detailed analysis prior to completion of the NEPA documentation.

6.3.2 PM_{10} Concentrations Near Congested Intersections

Predicted worst-case PM_{10} concentrations under the Aerial Alternative in 2030 would be similar than those estimated under the No Build Alternative. Worst-case 1-hour average PM_{10} concentrations for the Aerial Alternative were predicted to range between 29 and 61 $\mu g/m^3$ (Exhibit 6-3). The modeled values were for PM peak-hour traffic conditions; therefore, the 24-hour average concentration would be substantially less. Adding the estimated background PM_{10} concentration defines an upper limit on PM_{10} concentrations near project area intersections of 128 $\mu g/m^3$, which is still below the twenty-four hour NAAQS of 150 $\mu g/m^3$. No exceedances of the 24-hour average NAAQS for PM_{10} of 150 $\mu g/m^3$ are expected at any location under any of the Alternatives in 2030.

6.3.3 Mesoscale Emissions Analysis

Differences between study area emissions of criteria pollutants under the Aerial Alternative and other alternatives would be small (see Exhibit 6-4). Emissions of CO_2 would be slightly less under the Aerial Alternative than under the No Build Alternative.

6.4 Tunnel Alternative

6.4.1 CO Concentrations Near Congested Intersections

Predicted worst-case CO concentrations under the Tunnel Alternative in 2030 would be similar to the other alternatives at most locations. No exceedances of the 1-hour or the 8-hour NAAQS were predicted at any location. Under the Tunnel Alternative, worst-case 1-hour average CO concentrations were predicted to range between 6.5 and 9.5 ppm, while 8-hour average CO concentrations were predicted to range between 4.8 and 6.9 ppm (see Exhibits 6-1 and 6-2).

Option: Side-by-Side Aerial

Construction of the roadway south of S. King Street as either an at-grade or aerial structure would not change the intersection-level air quality analysis.

Broad Street Underpass not Constructed

In the event that the Broad Street underpass is not constructed, traffic to and from Magnolia and the Ballard Bridge would continue to be routed primarily along Elliott and Western Avenues via reconstructed ramps south of the Battery Street Tunnel. Compared to the analyzed alternative, this option could shift a small volume of traffic off of the Alaskan Way surface street onto the rebuilt viaduct south of the Battery Street Tunnel and onto Elliott and Western Avenues through Belltown. This option would have a small effect on several of the modeled intersections, and it is not anticipated to have a substantial effect on air quality. If it is selected, it would require detailed analysis prior to completion of the NEPA documentation.

6.4.2 PM_{10} Concentrations Near Congested Intersections

Predicted worst-case PM_{10} concentrations under the Tunnel Alternative in 2030 would be similar than those estimated under the No Build Alternative. Worst-case 1-hour average PM_{10} concentrations for the Tunnel Alternative were predicted to range between 29 and 61 $\mu g/m^3$ (Exhibit 6-3). The modeled values were for PM peak-hour traffic conditions; therefore, the 24-hour average concentration would be substantially less. Adding the estimated background PM_{10} concentration defines an upper limit on PM_{10} concentrations near project area intersections of 128 $\mu g/m^3$, which is still below the twenty-four hour NAAQS of 150 μg/m^3.   No exceedances of the 24-hour average NAAQS for PM_{10} of 150 μg/m^3 are expected at any location under any of the Alternatives in 2030.

6.4.3 Mesoscale Emissions Analysis

Differences between study area emissions of criteria pollutants under the Tunnel Alternative and other alternatives would be small (see Exhibit 6-4). Emissions of CO_2 would be slightly less under the Tunnel Alternative than under the No Build Alternative.

6.4.4 Tunnel Ventilation Building Analysis

Four ventilation buildings are associated with this alternative. They would be located near S. King Street, Yesler Way, Spring Street, and Pike Street. For the purpose of conservatively estimating the potential impacts associated with emissions released through these buildings, a reasonable worst-case 1-hour operating scenario was selected for analysis. This scenario assumes peak-period normal (i.e., not breakdown or emergency) traffic conditions in the tunnel.

The emission rates estimated for each of the pollutants released from each of the ventilation buildings under this scenario, which are shown in Exhibit 6-5, were estimated by the project's ventilation engineers using procedures described in the September 23, 2003 Ventilation System Overview Memorandum and subsequently amended calculations.

Exhibit 6-5. Ventilation Building Emission Rates

Ventilation Building	Peak-Hour CO Emission Rates (grams CO /second)
S. King Street	2.0
Yesler Way	2.4
Spring Street	2.6
Pike Street	2.9

The following assumptions were used in the analysis of the emissions released through ventilation building stacks:

- The dimensions of each ventilation building are 50 feet by 50 feet, and 30 feet tall (Exhibit 6-6).
- The stack discharge points above the buildings were evaluated at various heights to determine the lowest height that would not result in

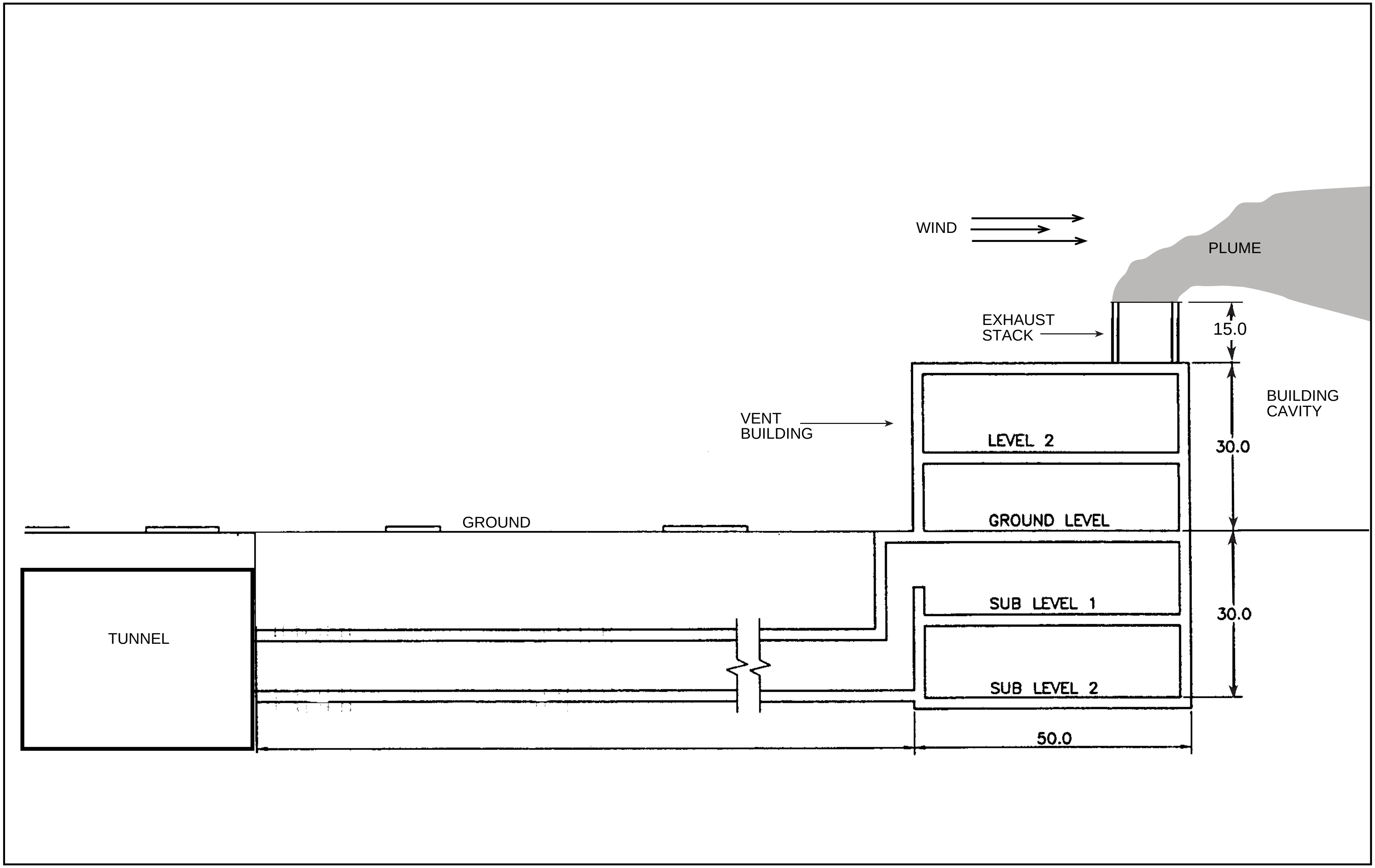
an exceedance of an NAAQS. In all cases, final minimum stack heights are 12 feet above the ventilation building.

- Two stacks are considered for each ventilation building.
- The exit velocity is 1,100 feet per minute.

Receptor locations (i.e., locations where air quality impacts were estimated) were selected at breathing heights (i.e., 1.8 meters above the ground) at multiple locations surrounding each of the ventilation buildings and at the windows of nearby residential and commercial buildings at varying heights. Exhibits 6-6 through 6-8 show the locations of the receptors considered for each ventilation building.

Three types of analyses were performed for each analysis, as follows:

- **Direct Plume Impact Analysis.** This analysis assumes that the direction and dispersion of the exhaust plume from the ventilation stacks would not be influenced by the irregular wind patterns that may form around the release points by the building and stack configuration under certain wind speeds. It also assumes that the plume would rise and disperse in the atmosphere under each of the meteorological conditions encountered during the analysis year, and the estimated



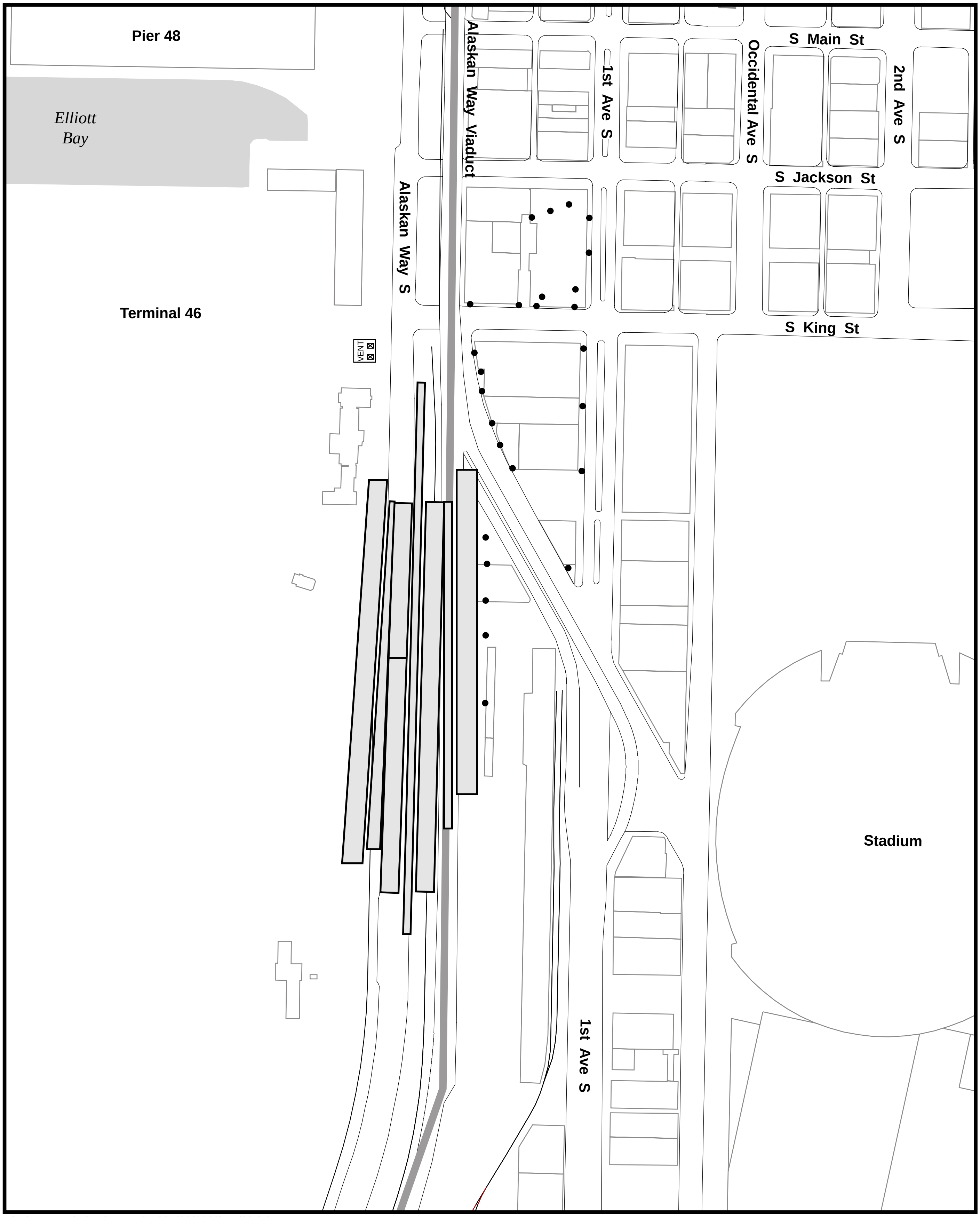
Alaska Way Viaduct/554-1585-025/06(0620) 121/03 (K)

0 300
SCALE IN FEET

N

• Receptor
⊠ Source

Exhibit 6-6
Typical Vent Building Configuration



Alaska Way Viaduct/554-1585-025/06(0620) 11/03 (K)

● Receptor

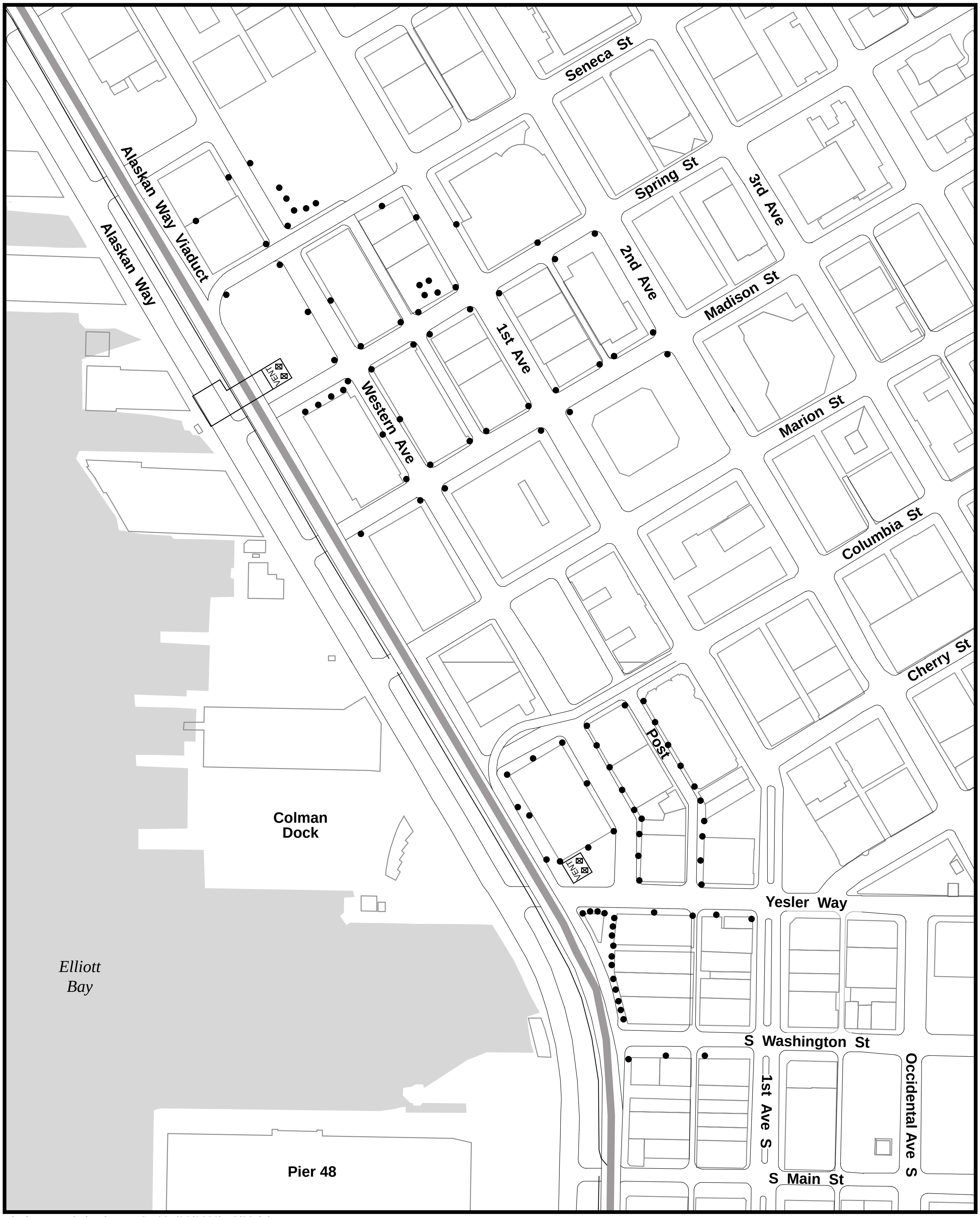
⊠ Vent Source

Tunnel Plume and Traffic Sources at Portal

0 300
SCALE IN FEET

N

Exhibit 6-7
Receptor and Source Locations Waterfront Tunnel South Portal and King Street Vent Building



Alaska Way Viaduct/554-1585-025/06(0620) 12/03 (K)

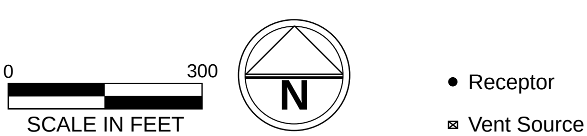
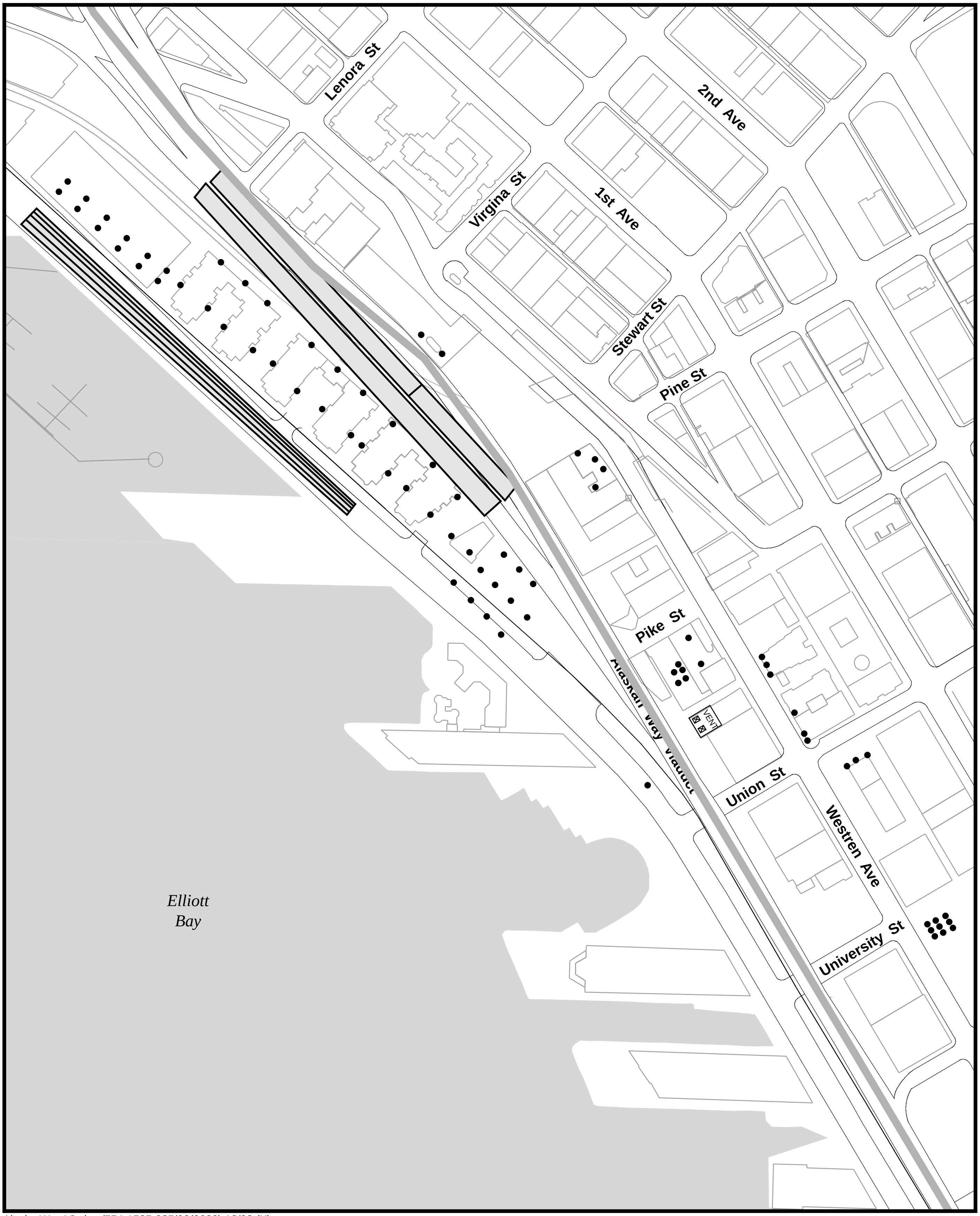


Exhibit 6-8
Receptor and Source Locations
Yesler Way and Spring Street
Vent Buildings



Alaska Way Viaduct/554-1585-025/06(0620) 12/03 (K)

● Receptor

⊠ Vent Source

Tunnel Plumes and Traffic Sources at Portal

0 300
SCALE IN FEET

N

Exhibit 6-9
Receptor and Source Locations Waterfront Tunnel North Portal and Pike Street Vent Building

pollutant concentration at each of the receptor locations is calculated. While this calculation is made for every hour of the year, only the highest values estimated at each of the receptors are reported.

- **Wake Region Analysis.** This analysis takes into account the effects of nearby buildings that interfere with the wind flow and cause aerodynamic wake effects. The Building Profile Input Program (BPIP, a part of the ISC3 model) was used to determine which of the structures surrounding the ventilation stack affect the plume.
- **Cavity Analysis.** A cavity impact analysis was performed to determine whether the stack effluents would be recirculated in cavity zones immediately downwind of the ventilation buildings.

The results of the analysis, which are summarized in Exhibit 6-10, are that NAAQS would not be exceeded at any of the receptors considered near any of the tunnel exhaust stacks.

Exhibit 6-10. Maximum CO Concentrations Estimated at Sensitive Receptors Located Near Each Ventilation Building

Ventilation Building	8-Hour CO (Initial Stack Height) (ppm)	8-Hour CO (12 ft Above the Roof) (ppm)
S. King Street	2.3	2.3
Yesler Way	2.3	3.8
Spring Street	2.4	5.1
Pike Street	2.5	4.0

Note: The concentrations presented in this table include the sum of the highest predicted impact from each ventilation building and the background concentration.
The 8-hour average NAAQS for CO is 9 ppm.

6.4.5 Tunnel Portal Analysis

Two tunnels are associated with this alternative. The following exit portals were considered:

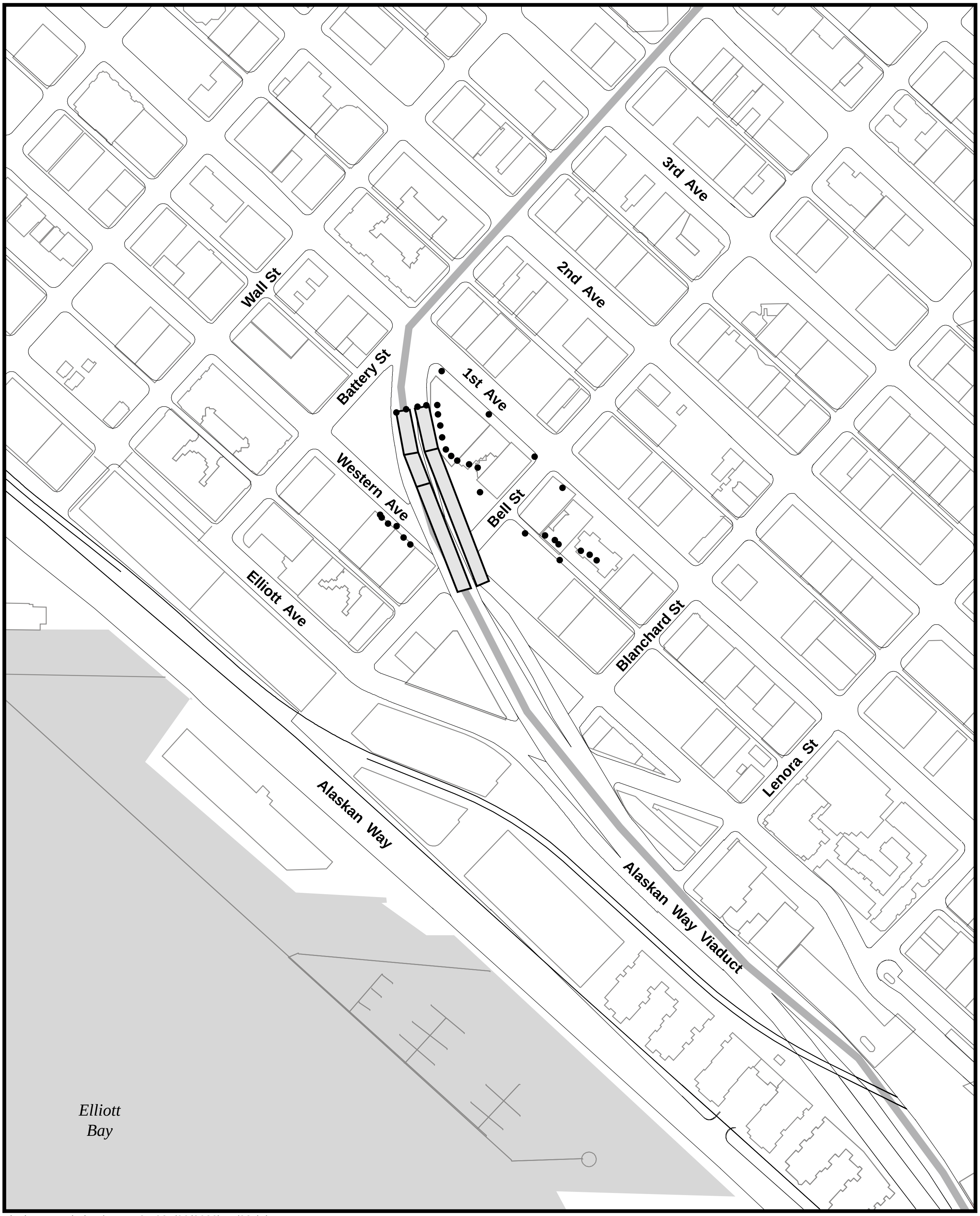
- The Waterfront Tunnel south portal at S. King Street – one exit portal.
- The Waterfront Tunnel north portal at Stewart Street – one exit portal along main line and one off-ramp along the waterfront.
- The Battery Street Tunnel south portal at First Avenue – one exit portal.
- The Battery Street Tunnel north portal at Aurora Avenue – one exit portal.

Hour-by-hour emission rates from the tunnel ventilation system's exhaust stacks were estimated over a 24-hour period based on hourly estimated traffic volumes and corresponding travel speeds in the tunnels, and the anticipated operation of the fan system during each hour.

The emission rates estimated for each of the pollutants released from each of the portals under this scenario for each hour are shown in Exhibit 6-11. The traffic volumes and speeds within the tunnel for each hour are also provided. Also provided are a schematic of each portal showing the local roadways near each portal that were considered for analysis (Exhibits 6-6, 6-8, 6-11, and 6-12).

Exhibit 6-11. Tunnel Portal CO Emission Rates

Hour	Waterfront Tunnel South Portal (grams CO/sec)	Waterfront Tunnel North Waterfront Ramp (grams CO/sec)	Waterfront Tunnel North Portal (grams CO/sec)	Battery Street Tunnel South Portal (grams CO/sec)	Battery Street Tunnel North Portal (grams CO/sec)
0:00	0.3	0.4	0.8	0.2	0.4
1:00	0.5	0.1	0.2	0.2	0.2
2:00	0.5	0.2	0.3	0.2	0.2
3:00	0.5	0.2	0.3	0.2	0.2
4:00	1.2	0.3	0.6	0.4	0.3
5:00	3.7	0.9	1.9	1.3	0.9
6:00	11.8	3.2	6.4	3.9	3.2
7:00	10.0	2.9	5.9	5.3	4.7
8:00	9.7	3.2	6.5	4.9	4.7
9:00	7.8	2.9	5.8	3.9	4.2
10:00	5.7	1.9	3.9	2.8	2.8
11:00	6.3	1.8	3.6	3.1	2.6
12:00	6.9	1.7	3.4	3.4	2.5
13:00	7.7	1.7	3.4	3.5	2.5
14:00	8.7	2.1	4.2	4.3	3.1
15:00	9.0	2.9	5.9	4.6	4.2
16:00	9.2	3.6	7.3	4.8	5.4
17:00	9.1	3.6	7.3	4.8	5.4
18:00	8.7	2.8	5.6	4.6	4.1
19:00	9.6	1.9	3.9	2.8	1.8
20:00	5.6	1.3	2.7	1.7	1.3
21:00	5.6	1.0	2.1	1.8	1.0
22:00	3.6	0.9	1.8	1.2	0.8
23:00	2.0	0.6	1.2	0.6	0.6



Alaska Way Viaduct/554-1585-025/06(0620) 11/03 (K)

- Receptor
- Tunnel Plume and Traffic Sources at Portal

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SCALE IN FEET

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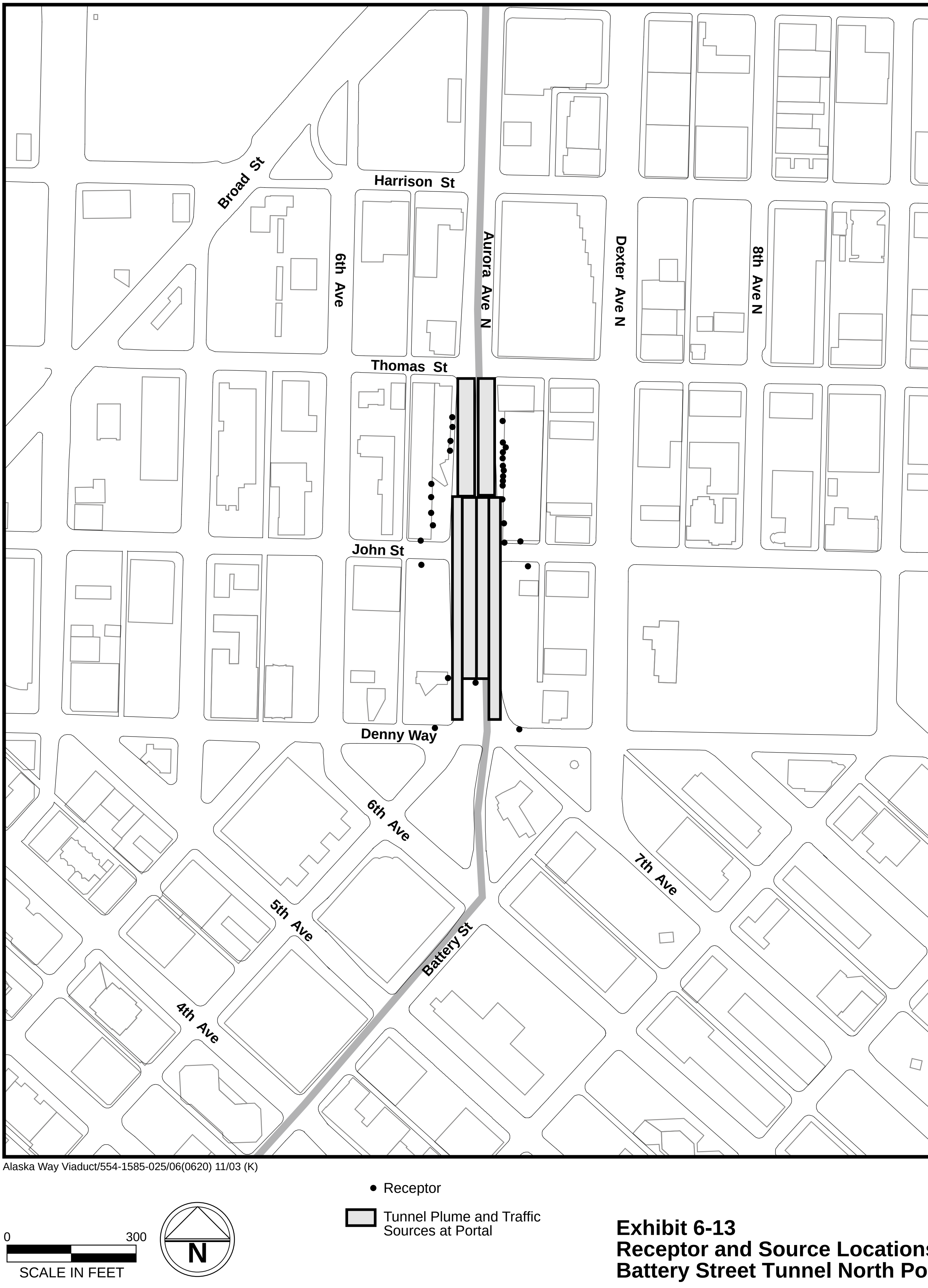
Exhibit 6-12
Receptor and Source Locations
Battery Street Tunnel South Portal



Alaska Way Viaduct/554-1585-025/06(0620) 11/03 (K)

Exhibit 6-13
Receptor and Source Locations
Battery Street Tunnel North Portal

Receptor locations (i.e., locations where air quality impacts were estimated) were selected at breathing heights (i.e., 1.8 meters above the ground) at multiple locations surrounding each exit portal (see Exhibits 6-6, 6-8, 6-11, and 6-12).

The results of the analysis, which are summarized in Exhibit 6-14, are that NAAQS would not be exceeded near any of the tunnel exhaust stacks.

Exhibit 6-14. Maximum CO Concentrations Estimated at Sensitive Land Uses Located Near Each Tunnel Portal

Tunnel Portal	8-Hour CO (ppm)
Waterfront Tunnel south	7.3
Waterfront Tunnel north off-ramp portal	8.8
Waterfront Tunnel north mainline portal	8.8
Battery Street Tunnel south	8.7
Battery Street Tunnel north	8.5

Note: The concentrations presented in this table include the sum of the highest predicted impacts and the background concentrations.
The 8-hour average NAAQS for CO is 9 ppm.

6.4.6 Tunnel PM_{10} Analysis

Worst-case PM_{10} concentrations were estimated at two tunnel portals and two vent buildings to evaluate the potential for exceedances of the NAAQS for PM_{10} within the study area with existing traffic conditions. The modeled locations include the only portal within the Duwamish PM_{10} maintenance area, the vent building nearest to the maintenance area and the other locations identified as being most likely to exceed the NAAQS for PM_{10} in the future under the Tunnel or Bypass Tunnel Alternatives.

A 24-hour average PM_{10} background concentration of 67 $\mu g/m^3$ was estimated by averaging the 10 highest PM_{10} levels observed over the 1999-2001 period at the Duwamish monitor (at 4752 E. Marginal Way). The annual average PM_{10} concentrations measured at this location averaged 22 $\mu g/m^3$ for the most recent three years (2001 through 2003). This site monitors the effects of nearby pollutant sources; therefore, it overestimates background concentrations.

The estimated background concentrations were added to the predicted emissions from the tunnel portals and vent stacks (Exhibit 6-15). All estimated concentrations were below the twenty-four hour NAAQS of 150 $\mu g/m^3$ and the annual average hour NAAQS of 50 $\mu g/m^3$.

Exhibit 6-15. Maximum PM_{10} Concentrations Estimated at Sensitive Land Uses Located Near Tunnel Ventilation Buildings and Portals

Location	24-Hour Average PM_{10} (µg/m³)	Annual Average PM_{10} (µg/m³)
Waterfront Tunnel south	91	26
S. King Street Vent Building	68	22
Spring Street Vent Building	77	23
Waterfront Tunnel north mainline portal	96	28

Note: The concentrations presented in this table include the sum of the highest predicted impacts and the background concentrations.
The 24-hour Average Mean NAAQS for PM_{10} is 150 µg/m³. The Annual Average Mean NAAQS for PM_{10} is 50 µg/m³.

6.5 Bypass Tunnel Alternative

6.5.1 CO Concentrations Near Congested Intersections

Predicted worst-case CO concentrations under the Bypass Tunnel Alternative in 2030 would be similar to the other alternatives at most locations. No exceedances of either the 1-hour or 8-hour NAAQS were predicted at any location. Under the Bypass Tunnel Alternative, worst-case 1-hour average CO concentrations were predicted to range between 6.5 and 10.2 ppm, while 8-hour average CO concentrations were predicted to range between 4.8 and 7.4 ppm (see Exhibits 6-1 and 6-2).

Broad Street Underpass not Constructed

In the event that the Broad Street underpass is not constructed, ramps would need to be constructed from Alaskan Way north of the central waterfront tunnel to Elliott and/or Western Avenues to replace the existing connections to the Alaskan Way Viaduct in that area. This option would shift a small volume of traffic off of the Alaskan Way surface street onto the rebuilt viaduct south of the Battery Street Tunnel and onto Elliott and Western Avenues through Belltown. This option would have a small effect on several of the modeled intersections, and it is not anticipated to have a substantial effect on air quality. If it is selected, it would require detailed analysis prior to completion of the NEPA documentation.

6.5.2 PM_{10} Concentrations Near Congested Intersections

Predicted worst-case PM_{10} concentrations under the Bypass Tunnel Alternative in 2030 would be similar than those estimated under the No Build Alternative. Worst-case 1-hour average PM_{10} concentrations for the Bypass Tunnel Alternative were predicted to range between 29 and 53 µg/m³ (Exhibit

6-3). The modeled values were for PM peak-hour traffic conditions; therefore, the 24-hour average concentration would be substantially less. Adding the estimated background PM_{10} concentration defines an upper limit on PM_{10} concentrations near project area intersections of 120 $\mu g/m^3$, which is still below the twenty-four hour NAAQS of 150 $\mu g/m^3$. No exceedances of the 24-hour average NAAQS for PM_{10} of 150 $\mu g/m^3$ are expected at any location under any of the Alternatives in 2030.

6.5.3 Mesoscale Emissions Analysis

Differences between study area emissions of criteria pollutants under the Bypass Tunnel Alternative and other alternatives would be small (see Exhibit 6-4). Emissions of CO_2 would be slightly less under the Bypass Tunnel Alternative than under the No Build Alternative.

6.5.4 Tunnel Analysis

Air pollutant emissions from the tunnel portals and vent buildings under the Bypass Tunnel Alternative would be similar to or less than for the Tunnel Alternative because there would be fewer automobiles using the waterfront tunnel under the Bypass Tunnel Alternative and a similar number using the Battery Street Tunnel.

6.6 Surface Alternative

6.6.1 CO Concentrations Near Congested Intersections

Predicted worst-case CO concentrations under the Surface Alternative in 2030 would be similar to the other alternatives at most locations. No exceedances of the 1-hour or 8-hour NAAQS were predicted at any location. Under the Surface Alternative, worst-case 1-hour average CO concentrations were predicted to range between 6.2 and 10.2 ppm, while 8-hour average CO concentrations were predicted to range between 4.6 and 7.4 ppm (see Exhibits 6-1 and 6-2).

Option: SR 99 At-Grade With SR 519 Interchange At-Grade

Construction of the roadway south of S. King Street as either an at-grade or aerial structure would not change the intersection-level air quality analysis.

Broad Street Underpass not Constructed

In the event that the Broad Street underpass is not constructed, ramps would need to be constructed from Alaskan Way north of the central waterfront tunnel to Elliott and/or Western Avenues to replace the existing connections to the Alaskan Way Viaduct in that area. This option would shift a small volume of traffic off of the Alaskan Way surface street onto the rebuilt viaduct south of the Battery Street Tunnel and onto Elliott and Western Avenues through Belltown. This option would have a small effect on several of the modeled intersections, and it is not anticipated to have a substantial effect on air quality. If it is selected, it would require detailed analysis prior to completion of the NEPA documentation.

Option: Existing SR 99 With Added Signals at Roy, Republican, and Harrison Streets

Reconnecting the roadway grid at grade with Aurora Avenue and including a signal at Mercer Street would lower peak-period speeds and greatly increase congestion on Aurora Avenue. This option would likely cause an exceedance of the NAAQS at the signalized intersection, resulting in a significant adverse effect on air quality. If this option is selected, it would require detailed analysis prior to completion of the NEPA documentation. Should modeled CO concentrations exceed the NAAQS after all reasonable and prudent mitigation measures have been evaluated, the option would be precluded from construction.

6.6.2 PM_{10} Concentrations Near Congested Intersections

Predicted worst-case PM_{10} concentrations under the Surface Alternative in 2030 would be similar than those estimated under the No Build Alternative. Worst-case 1-hour average PM_{10} concentrations for the Surface Alternative were predicted to range between 29 and 61 $\mu g/m^3$ (Exhibit 6-3). The modeled values were for PM peak-hour traffic conditions; therefore, the 24-hour average concentration would be substantially less. Adding the estimated background PM_{10} concentration defines an upper limit on PM_{10} concentrations near project area intersections of 125 $\mu g/m^3$, which is still below the twenty-four hour NAAQS of 150 $\mu g/m^3$. No exceedances of the 24-hour average NAAQS for PM_{10} of 150 $\mu g/m^3$ are expected at any location under any of the Alternatives in 2030.

6.6.3 Mesoscale Emissions Analysis

Differences between study area emissions of criteria pollutants under the Surface Alternative and other alternatives would be small (see Exhibit 6-4). Emissions of CO_2 would be slightly less under the Surface Alternative than under the No Build Alternative.

Differences between the alternatives are small, with the fewest total emissions in the study area under the Surface Alternative because the reduced capacity under that alternative would restrict the volume of traffic that would be served.

6.7 Project Benefits

Air quality for all alternatives would improve compared to existing conditions because of decreases in vehicular emissions through baseline transportation improvements independent of this project, emission reductions as a result of the Puget Sound area inspection and maintenance (I&M) program, stricter vehicle emission standards for new cars, and gradual replacement of older, more polluting vehicles with newer, cleaner cars. Of all the Build Alternatives, the Surface Alternative would have the smallest benefit.

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Chapter 7 CONSTRUCTION PHASE IMPACTS

7.1 Introduction

Air quality impacts related to the construction phase of the project 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 gas-fueled generators, and on- and off-site project-generated vehicles (such as service trucks and pickups). Since large-scale construction activities may occur near sensitive land uses, an analysis will be conducted to evaluate the potential impacts of these activities.

This technical study includes a general evaluation of construction-related air pollutant emissions. Because the construction phase of the Alaskan Way Viaduct and Seawall Replacement Project is anticipated to last longer than 5 years, conformity to the NAAQS must be demonstrated during the construction phase. Subsequent to selection of a Preferred Alternative, a detailed analysis of construction emissions and construction period traffic emissions shall be completed. This analysis will provide a detailed assessment of construction-phase air quality impacts than can be provided with current information on construction phasing and techniques. The analysis also will be used to demonstrate whether conformity requirements would be met during construction of the project.

7.2 Emission Sources

The following types of construction operations were considered:

- Material storage, handling, and processing.
- Loading and unloading (stockpile to trucks).
- Demolition and dumping.
- Earth excavation and movement.
- Grading, scraping, dozing, and removal activities.
- Hauling of materials.
- Wind erosion of exposed surfaces.
- Transport materials on paved and unpaved roads.

7.3 Construction Phase Air Quality

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 soil moisture, silt content of soil, wind speed, and the amount and type of operating equipment. Larger dust particles would settle near the source, and fine particles would be dispersed over greater distances from the construction site.

The quantity of particulate emissions would be proportional to the area of the construction operations and the level of activity. Based on field measurements of suspended dust emissions from construction projects, an approximate emission factor for construction operations would be 1.2 tons per acre of construction per month of activity (EPA 1995). Emissions would be reduced if less site area was disturbed or mitigation was performed.

Numerous residences and businesses are within 100 feet of major construction areas. At that distance, fugitive PM_{10} emissions from construction activities would be noticeable, if uncontrolled. Mud and particulates from trucks would also be noticeable if construction trucks would be routed through residential neighborhoods. Mitigation measures would be necessary to comply with the PSCAA regulations that require dust control during construction and prevent the deposition of mud on paved streets (PSCAA Regulation 1, Article 9). Measures to reduce the deposition of mud and emissions of particulates are identified in Chapter 9, Mitigation.

In addition to particulate emissions, heavy trucks and construction equipment powered by gasoline and diesel engines would generate small particulates, CO, and NO_x in exhaust emissions. If construction traffic and lane closures were to 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 limited to the immediate area surrounding the construction site.

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

7.3.1 No Build Alternative

Under the No Build Alternative, air pollutant emissions would be limited to those associated with ongoing maintenance activities to the existing viaduct. Should the existing viaduct be damaged and need to be closed, there would be air pollutant emissions created by activities to close or remove the structure.

7.3.2 Rebuild Alternative

The Rebuild Alternative is anticipated to be constructed in four general stages: Site Preparation, Construction of Seawall, Rebuild of Alaskan Way, and Project Closeout. The construction would take approximately 7.5 years.

The Site Preparation stage is anticipated to require approximately 18 months. Most construction activities during the first stage would be of limited duration in any single location. Air pollutant emissions would result from excavation and paving activities as utilities and rail lines are relocated and access roads and staging areas are constructed.

Construction of the seawall is anticipated to require approximately 24 months. During that period, several work crews would be rebuilding the existing seawall progressively along the waterfront. Construction activities would be occurring at several locations along the waterfront at any point in time during this stage. Seawall construction would require stabilization of existing soils, likely by jet grouting. Drilled shaft piles would be placed where needed, and a new face would be attached. Other activities during the second stage would include limited roadway reconstruction or retrofit.

Stage three would include rebuilding most of the existing viaduct over an approximately 54-month period. At times, traffic would be detoured in various locations along the project corridor. Rebuilding the viaduct would include various activities that would be occurring in localized work areas that would move over the period of reconstruction. Activities would include placement of new piles and footings, replacement of structural supports, and replacement of the roadway decks. Pollutant emissions would result largely from demolition activities and material transport. Other activities, including excavation, pavement breaking, and concrete pumping, would generate air pollution during this phase.

The fourth stage would require approximately 8 months and would include various activities to finalize construction, replace the waterfront trolley tracks, and complete street restoration. Most construction activities during the fourth stage would be of limited duration (a few days) in any single location.

7.3.3 Aerial Alternative

Construction activities for the Aerial Alternative would be similar to the Rebuild Alternative. It is anticipated to be constructed in five general stages: Site Preparation, Construction of Seawall, Southbound Battery Street Tunnel and Broad Street Detour, Removal and Construction of the Aerial Viaduct, and Project Closeout. The construction would take approximately 11 years.

The first two construction stages would be similar in activities and duration to the Rebuild Alternative. The seawall construction stage would take approximately 36 months because it would also include the construction of temporary aerial structures above a portion of the seawall.

Stage three would take approximately 30 months and would include removal and replacement of the viaduct north of Pike Street, improvements to the southbound Battery Street Tunnel, and configuration of local streets to accommodate detour traffic. During this period, construction activities similar to those described for stage three of the Rebuild Alternative construction would occur between Pike Street and the Battery Street Tunnel. Demolition of the existing viaduct would include saw cutting and removal by crane, pulverizing, shearing, jack hammering, and drilling. Pollutant emissions would result largely from demolition activities and material transport.

Stage four would include removal and replacement of the viaduct south of Pike Street over an approximately 48-month period. It would also include improvements to the northbound Battery Street Tunnel and configuration of local streets to accommodate detour traffic. During this period, construction activities would be similar to those during stage three, but would largely occur south of Pike Street. Improvements to the Battery Street Tunnel would include lengthening the tunnel slightly and installing emergency ventilation equipment.

Stage five would require approximately 15 months. In addition to the pollutant emissions from activities described for stage four of the Rebuild Alternative, temporary aerial structures along the waterfront would need to be removed under the Aerial Alternative.

7.3.4 Tunnel Alternative

The Tunnel Alternative is anticipated to be constructed in five general stages: Site Preparation, Construction of Seawall and Southbound Tunnel, Southbound Aerial and Battery Street Tunnel Construction, Removal of Viaduct and Northbound Tunnel, Aerial and Battery Street Tunnel Construction, and Project Closeout. The construction would take approximately 9 years. The first construction stage would be similar in activities and duration to the Rebuild and Aerial Alternatives.

The second stage would take approximately 24 months and would include construction of a secant pile wall to replace the existing seawall between approximately S. King and Pike Streets. In the vicinity of the Colman Dock Ferry Terminal, the pile wall would extend into Elliott Bay. The secant pile wall would be constructed of a series of large-diameter drilled shafts placed adjacent to each other.

An excavation support wall would then be constructed to form the center wall of the final tunnel. The construction would utilize excavation and concrete pumping equipment. Finally, the area between the two walls would be excavated and the roadway and roof slab constructed. These earthmoving activities have a large potential for generating PM_{10} emissions if not properly managed. At any one time during this stage, these various activities would be occurring in limited areas along the waterfront south of approximately Pike Street.

The third stage would be similar to stage three under the Aerial Alternative and would take approximately 36 months. In addition to the activities north of Pike Street described under the Aerial Alternative, final utility relocations would be occurring along the corridor, which would be of limited duration in any single location.

Stage four would include removal of the viaduct south of Pike Street and excavation and construction of the northbound half of the waterfront tunnel over an approximately 36-month period. Demolition of the existing viaduct would include saw cutting and removal by crane, pulverizing, shearing, jack hammering, and drilling. Construction of the southbound tunnel would include construction of the eastern excavation support wall, excavation of the final northbound section, and roadway and roof slab placement. Battery Street Tunnel improvements would be similar to the Aerial Alternative.

Stage five would require approximately 13 months and would generate air pollutant emissions similar to stage four of the Rebuild Alternative.

7.3.5 Bypass Tunnel Alternative

The Bypass Tunnel Alternative is anticipated to be constructed in five general stages: Site Preparation, Construction of Seawall and Tunnel, Southbound Aerial and Battery Street Tunnel Construction, Removal of Viaduct and Northbound Aerial and Battery Street Tunnel Construction, and Project Closeout. The construction would take approximately 8.5 years.

The first two construction stages would be similar in activities and duration to the Tunnel Alternative. The third stage would be similar to stage three under the Aerial Alternative and would take approximately 30 months.

Stage four would include removal of the viaduct south of Pike Street and rehabilitation of the northbound Battery Street Tunnel over an approximately 30-month period. Demolition of the existing viaduct would include saw cutting and removal by crane, pulverizing, shearing, jack hammering, and drilling. Pollutant emissions would result largely from demolition activities and material transport. Battery Street Tunnel improvements would be similar to the Aerial and Tunnel Alternatives.

Stage five would require approximately 18 months and would generate air pollutant emissions similar to stage five of the Tunnel Alternative.

7.3.6 Surface Alternative

The Surface Alternative is anticipated to be constructed in five general stages: Site Preparation, Construction of Seawall, Southbound Aerial and Battery Street Tunnel Construction, Removal of Viaduct and Northbound Aerial and Battery Street Tunnel Construction, and Project Closeout. The construction would take approximately 8 years. The first construction stage would be similar in activities and duration to the other Build Alternatives.

Stage two, construction of the seawall, is anticipated to require approximately 30 months and would include similar activities to the second stage of the Rebuild Alternative. The third stage would be similar to stage three under the Aerial and Bypass Tunnel Alternatives and would take approximately 30 months. The fourth stage would be similar in activity and duration to stage four of the Bypass Tunnel Alternative. Stage five would require approximately 8 months and would be similar to stage four of the Rebuild Alternative.

Chapter 8 SECONDARY AND CUMULATIVE IMPACTS

Secondary impacts are reasonably foreseeable effects of an action that occur later in time or are further removed in distance from the direct effects of the project. Generally, these effects are induced by the initial action. Secondary impacts are expected to be limited and unlikely because none of the alternatives increase capacity and connections compared to the existing configuration.

Cumulative impacts are additive effects of the project with other reasonably foreseeable developments or actions in the future. The air quality analysis for the Alaskan Way Viaduct and Seawall Replacement Project considers the long-term cumulative effects of air pollutant emissions from all traffic forecast to operate within the downtown Seattle core. The addition of background concentrations in the analysis accounts for the cumulative effect of pollutant sources not specifically included in this air quality evaluation.

During the construction phase, several other projects are expected to be under construction in the downtown Seattle area, including Central Link Light Rail, Mercer Street Corridor, Seattle Monorail Project, and several other smaller or less well defined projects. If construction detours and material haul routes are not well coordinated, the projects could have an adverse cumulative effect on traffic congestion and associated air pollutant emissions. If other construction projects are within the immediate vicinity (less than approximately 1,000 feet) of the Alaskan Way Viaduct and Seawall Replacement Project construction areas, the cumulative concentration of dust and other construction emissions could increase in the vicinity of those activities.

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Chapter 9 MITIGATION

9.1 Operation

Because long-term emissions associated with replacement of the Alaskan Way Viaduct and Seawall are expected to be within SIP emission budgets and no exceedances of the NAAQS are anticipated, no significant adverse air quality impacts are expected to result from the alternative and no mitigation measures would be required.

Any transportation demand control measures that reduce traffic volumes within the study area would reduce traffic-related air pollutant emissions.

9.2 Construction

The PSCAA regulates particulate emissions (in the form of fugitive dust during construction activities). The operator of a source of fugitive dust shall take reasonable precautions to prevent fugitive dust from becoming airborne and shall maintain and operate the source to minimize emissions. Construction impacts could be reduced by incorporating mitigation measures per the Associated General Contractor of Washington Guidelines into the construction specifications for the project. After selection of the Preferred Alternative, a detailed construction air quality impact assessment will be developed to specify what mitigation methods could be required for this project. Possible mitigation measures to control PM_{10}, deposition of particulate matter, and emissions of CO and NO_x during construction are listed below (Associated General Contractors of Washington 1997).

- Development of a detailed construction air pollutant emission control plan, possibly supported by particulate monitoring, could substantially reduce construction-phase pollutant emissions by specifying project-specific techniques to be abided by the contractor.
- Spraying exposed soil with water or other dust palliatives would reduce emissions of PM_{10} and deposition of particulate matter.
- Covering all trucks transporting materials, wetting materials in trucks, or providing adequate freeboard (space from the top of the material to the top of the truck) would reduce PM_{10} and deposition of particulates during transportation.
- Providing wheel washers to remove particulate matter that vehicles would otherwise carry offsite would decrease deposition of particulate matter on area roadways.
- Removing particulate matter deposited on paved, public roads would reduce mud and resultant windblown dust on area roadways.

- Routing and scheduling construction trucks to reduce delays to traffic during peak travel times would reduce secondary air quality impacts caused by a reduction in traffic speeds while waiting for construction trucks.
- Maintaining as many traffic lanes as possible on I-5 during peak travel times would reduce air quality impacts caused by increased congestion.
- Placing quarry spall aprons where trucks enter public roads would reduce mud track-out.
- Graveling or paving haul roads would reduce particulate emissions.
- Requiring appropriate emission-control devices (catalytic converters or particulate traps) on all construction equipment powered by gasoline or diesel fuel would reduce CO, NO_x, and particulate emissions in vehicular exhaust.
- Using relatively new, well-maintained equipment would reduce CO and NO_x emissions.
- Planting vegetative cover on graded areas that would be left vacant for more than one season would reduce windblown particulates in the area.
- Routing construction trucks away from residential and business areas would minimize annoyance from dust.
- Delivery and removal of materials by barge would reduce traffic congestion and localized pollution from construction trucks.
- Routing and scheduling construction trucks so as to reduce delays to traffic during peak travel times would reduce secondary air quality impacts caused by a reduction in traffic speeds while waiting for construction trucks.
- Requiring the use of low or ultra-low sulfur fuels in construction equipment would reduce sulfur emissions. It would also allow for the use of effective particulate-emission control devices on diesel vehicles.
- Coordination by lead agencies of construction activities for other projects, including the monorail and central link light rail, to reduce the cumulative effects of concurrent construction projects.

Chapter 10 REGULATORY COMPLIANCE

10.1 Compliance With NAAQS

Maximum predicted 1-hour and 8-hour CO concentrations under the various alternatives for 2030 are shown in Exhibits 6-1 and 6-2. The values presented are the highest values obtained at each of the analysis sites using methodology presented in this report. Estimated pollutant concentrations at all analysis sites are below the NAAQS. No significant adverse air quality impacts are anticipated for the modeled alternatives.

10.2 Conformity

Current air quality modeling does not include the year of opening or evaluation of the construction phase. The MTP and TIP do not yet include a proposed alternative. Prior to the Final EIS, year of opening and construction phase hot-spot analyses will be completed. The Preferred Alternative, once selected, will be submitted for inclusion in the MTP and TIP. Once that analysis is complete, a conformity determination will be made for the SR 99 Alaskan Way Viaduct and Seawall Replacement Project.

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ATTACHMENT A

Analysis Data

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Traffic data used for Air Quality analysis is summarized in the Transportation Discipline Report (Appendix C), and fully documented in the AWV Project Data Documentation Reports (Parsons Brinckerhoff 2003).

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ATTACHMENT B

Air Quality Intersection Screening

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Table B-1. Intersection Screening Results with 2030 PM Peak Traffic Data

Intersection		Alternative					
Street	**with Street**	**No Build**	**Rebuild**	**Aerial**	**Tunnel**	**Bypass**	**Surface**
1st Avenue	Columbia Street	**D**	**D**	**D**			
1st Avenue	Denny Way	**V**	**V**				**D**
1st Avenue	S Royal Brougham Way	**V**	**V**		**D**		
2nd Avenue	Denny Way		**D**	**D**	**D**		
2nd Avenue	Madison Street	**D**					
2nd Avenue	Spring Street	**D**	**D**	**D**			
5th Avenue	Mercer Street			**V**	**V**	**V**	
Alaskan Way	Marion Street					**D**	
Alaskan Way	S Jackson Street						**V**
Alaskan Way	S King					**D**	**V & D**
Alaskan Way	S Main Street						**V**
Dexter Avenue	Mercer Street			**V**	**V**	**V & D**	
Dexter Avenue	Roy Street				**D**		**D**
Elliott Avenue	Denny (Western)	**V**	**V**	**V**	**V**	**V**	

V = Intersection is one of highest three by volume under this alternative.

D = Intersection has one of three longest average delays of the twenty highest volume intersections.

Table B-2. No Build Alternative Ranking by Volume

Vol Rank	Street	with Street	Volume (vehicles per hour)	Delay
1	Elliott Avenue	Western Avenue	5509	91
2	1st Avenue	S Royal Brougham Way	4985	123
3	1st Avenue	Denny Way	4555	51
4	Broad Street	Denny Way	4261	26
5	2nd Avenue	Denny Way	4043	108
6	1st Avenue	S Atlantic Street	3995	132
7	Dexter Avenue	Mercer Street	3825	50
8	Aurora NB	Denny Way	3575	46
9	Dexter Avenue	Denny Way	3484	20
10	2nd Avenue	Madison Street	3309	225
11	5th Avenue	Mercer Street	3256	16
12	1st Avenue	Columbia Street	2841	151
13	5th Avenue	Broad Street	2776	25
14	2nd Avenue	Columbia Street	2715	66
15	Alaskan Way	S Main Street	2430	11
16	2nd Avenue	Spring Street	2415	185
17	5th Avenue	Denny Way	2396	19
18	Western Avenue	Battery Street	2391	11
19	1st Avenue	Seneca Street	2385	23
20	Aurora SB	Denny Way	2340	23
21	Alaskan Way	Yesler Way	2339	127
22	Alaskan Way	S King	2335	11
23	Alaskan Way	S Jackson Street	2308	2
24	2nd Avenue	Marion Street	2270	117
25	Elliott Avenue	Broad Street	2099	32
26	1st Avenue	S Jackson Street	2035	70
27	1st Avenue	Madison Street	1950	51
28	1st Avenue	Marion Street	1930	57
29	1st Avenue	Spring Street	1918	48
30	Dexter Avenue	Roy Street	1861	6
31	Alaskan Way Ext	Elliott Avenue	1840	8
32	Alaskan Way	Marion Street	1761	171
33	2nd Avenue	Battery Street	1570	8
34	1st Avenue	S Main Street	1551	70
35	5th Avenue	Roy Street	1540	19
36	Alaskan Way	S Royal Brougham Way	1374	23
37	Alaskan Way	Madison Street	1290	31
38	Alaskan Way	Columbia Street	1285	18
39	Alaskan Way	Spring Street	1270	9
40	Dexter Avenue	Harrison Street	1254	7
41	Alaskan Way	S Atlantic Street	1227	15
42	Alaskan Way	Seneca Street	1200	1
43	Alaskan Way	Broad Street	1175	7
44	Western Avenue	Madison Street	1170	13
45	Dexter Avenue	Thomas Street	1166	5
46	Western Avenue	Spring Street	1165	9
47	Western Avenue	Marion Street	1020	13
48	Western Avenue	Seneca Street	1009	4

Results of ranking by volume for all intersections under this alternative
Shaded intersections were selected under this ranking.

Table B-3. No Build Alternative Ranking by Delay

Delay Rank	Street	with Street	Volume	Delay
1	2nd Avenue	Madison Street	3309	225
2	2nd Avenue	Spring Street	2415	185
3	1st Avenue	Columbia Street	2841	151
4	1st Avenue	S Atlantic Street	3995	132
5	1st Avenue	S Royal Brougham Way	4985	123
6	2nd Avenue	Denny Way	4043	108
7	Elliott Avenue	Western Avenue	5509	91
8	2nd Avenue	Columbia Street	2715	66
9	1st Avenue	Denny Way	4555	51
10	Dexter Avenue	Mercer Street	3825	50
11	Aurora NB	Denny Way	3575	46
12	Broad Street	Denny Way	4261	26
13	5th Avenue	Broad Street	2776	25
14	1st Avenue	Seneca Street	2385	23
15	Aurora SB	Denny Way	2340	23
16	Dexter Avenue	Denny Way	3484	20
17	5th Avenue	Denny Way	2396	19
18	5th Avenue	Mercer Street	3256	16
19	Alaskan Way	S Main Street	2430	11
20	Western Avenue	Battery Street	2391	11

Results of ranking by delay for the 20 highest volume intersections under this alternative
Shaded intersections were selected under this ranking.

Table B-4. Rebuild Alternative Ranking by Volume

Vol Rank	Street	with Street	Volume (vehicles per hour)	Delay
1	Elliott Avenue	Denny (Western)	5690	80
2	1st Avenue	Denny Way	4555	33
3	1st Avenue	S Royal Brougham Way	4250	60
4	Broad Street	Denny Way	4241	28
5	Aurora NB	Denny Way	4080	86
6	2nd Avenue	Denny Way	4045	102
7	1st Avenue	S Atlantic Street	3960	76
8	Alaskan Way (CD NB)	S Royal Brougham Way	3925	39
9	Dexter Avenue	Mercer Street	3875	51
10	Dexter Avenue	Denny Way	3726	28
11	5th Avenue	Mercer Street	3331	17
12	1st Avenue	Columbia Street	2815	141
13	5th Avenue	Broad Street	2801	25
14	2nd Avenue	Columbia Street	2715	42
15	Aurora SB	Denny Way	2570	37
16	5th Avenue	Denny Way	2489	16
17	Alaskan Way (CD NB)	S Atlantic Street	2470	14
18	2nd Avenue	Spring Street	2415	138
19	Alaskan Way	Yesler Way	2344	10
20	1st Avenue	Seneca Street	2335	20
21	2nd Avenue	Madison Street	2310	103
22	Alaskan Way	S Main Street	2305	12
23	2nd Avenue	Marion Street	2270	99
24	Alaskan Way	S Jackson Street	2210	2
25	Western Avenue	Battery Street	2160	10
26	1st Avenue	S Jackson Street	2135	54
27	Elliott Avenue	Broad Street	2080	22
28	Alaskan Way (CD SB)	S Royal Brougham Way	2055	14
29	Alaskan Way	S King	1990	41
30	1st Avenue	Madison Street	1925	39
31	1st Avenue	Spring Street	1870	25
32	Dexter Avenue	Roy Street	1861	6
33	Alaskan Way Ext	Elliott Avenue	1860	8
34	1st Avenue	Marion Street	1855	33
35	Alaskan Way CD SB	S Atlantic Street	1850	5
36	2nd Avenue	Battery Street	1720	17
37	1st Avenue	S Main Street	1690	108
38	5th Avenue	Roy Street	1615	25
39	Alaskan Way	Marion Street	1535	46
40	Dexter Avenue	Harrison Street	1279	7
41	Western Avenue	Madison Street	1270	11
42	Alaskan Way	Madison Street	1215	31
43	Alaskan Way	Columbia Street	1210	9
44	Dexter Avenue	Thomas Street	1190	5
45	Alaskan Way	Spring Street	1170	6
46	Western Avenue	Spring Street	1165	8
47	Alaskan Way	Broad Street	1145	9
48	Alaskan Way	Seneca Street	1090	1
49	Western Avenue	Marion Street	1020	7
50	Western Avenue	Seneca Street	1010	3

Results of ranking by volume for all intersections under this alternative
Shaded intersections were selected under this ranking.

Table B-5. Rebuild Alternative Ranking by Delay

Delay Rank	Street	with Street	Volume	Delay
1	1st Avenue	Columbia Street	2815	141
2	2nd Avenue	Spring Street	2415	138
3	2nd Avenue	Denny Way	4045	102
4	Aurora NB	Denny Way	4080	86
5	Elliott Avenue	Denny (Western)	5690	80
6	1st Avenue	S Atlantic Street	3960	76
7	1st Avenue	S Royal Brougham Way	4250	60
8	Dexter Avenue	Mercer Street	3875	51
9	2nd Avenue	Columbia Street	2715	42
10	Alaskan Way (CD NB)	S Royal Brougham Way	3925	39
11	Aurora SB	Denny Way	2570	37
12	1st Avenue	Denny Way	4555	33
13	Broad Street	Denny Way	4241	28
14	Dexter Avenue	Denny Way	3726	28
15	5th Avenue	Broad Street	2801	25
16	1st Avenue	Seneca Street	2335	20
17	5th Avenue	Mercer Street	3331	17
18	5th Avenue	Denny Way	2489	16
19	Alaskan Way (CD NB)	S Atlantic Street	2470	14
20	Alaskan Way	Yesler Way	2344	10

Results of ranking by delay for the 20 highest volume intersections under this alternative
Shaded intersections were selected under this ranking.

Table B-6. Aerial Alternative Ranking by Volume

Vol Rank	Street	with Street	Volume (vehicles per hour)	Delay
1	Dexter Avenue	Mercer Street	5695	61
2	Elliott Avenue	Western Avenue	5605	84
3	5th Avenue	Mercer Street	4735	57
4	1st Avenue	S Royal Brougham Way	4315	98
5	1st Avenue	Denny Way	4291	51
6	1st Avenue	S Atlantic Street	4011	109
7	2nd Avenue	Denny Way	3944	132
8	Aurora NB	Denny Way	3911	78
9	Broad Street	Denny Way	3910	22
10	Dexter Avenue	Denny Way	3611	21
11	Dexter Avenue	Roy Street	3600	122
12	2nd Avenue	Columbia Street	2715	61
13	1st Avenue	Columbia Street	2691	145
14	5th Avenue	Thomas Street	2570	14
15	5th Avenue	Broad Street	2560	17
16	Aurora SB	Denny Way	2440	30
17	2nd Avenue	Spring Street	2415	166
18	Alaskan Way	S Main Street	2405	15
19	2nd Avenue	Marion Street	2320	132
20	Alaskan Way	S Jackson Street	2309	9
21	Alaskan Way	S Royal Brougham Way	2309	19
22	2nd Avenue	Madison Street	2309	121
23	Alaskan Way	Yesler Way	2264	115
24	1st Avenue	Seneca Street	2185	22
25	1st Avenue	S Jackson Street	2160	53
26	5th Avenue	Roy Street	2120	56
27	Elliott Avenue	Broad Street	2109	38
28	5th Avenue	Denny Way	2087	17
29	Western Avenue	Battery Street	2060	0
30	Dexter Avenue	Harrison Street	1889	16
31	Dexter Avenue	Thomas Street	1864	10
32	Alaskan Way Ext	Elliott Avenue	1860	14
33	2nd Avenue	Battery Street	1810	12
34	1st Avenue	Marion Street	1781	43
35	1st Avenue	Madison Street	1750	36
36	1st Avenue	Spring Street	1734	34
37	1st Avenue	S Main Street	1691	132
38	Alaskan Way	Marion Street	1659	90
39	Alaskan Way	S Atlantic Street	1635	17
40	Alaskan Way	Broad Street	1380	12
41	Western Avenue	Madison Street	1221	10
42	Western Avenue	Spring Street	1215	8
43	Alaskan Way	Madison Street	1190	13
44	Alaskan Way	Columbia Street	1185	10
45	Alaskan Way	Spring Street	1169	8
46	Alaskan Way	Seneca Street	1101	1
47	Western Avenue	Marion Street	1070	12
48	Western Avenue	Seneca Street	1059	4

Results of ranking by volume for all intersections under this alternative
Shaded intersections were selected under this ranking.

Table B-7. Aerial Alternative Ranking by Delay

Delay Rank	Street	with Street	Volume	Delay
1	2nd Avenue	Spring Street	2415	166
2	1st Avenue	Columbia Street	2691	145
3	2nd Avenue	Denny Way	3944	132
4	2nd Avenue	Marion Street	2320	132
5	Dexter Avenue	Roy Street	3600	122
6	1st Avenue	S Atlantic Street	4011	109
7	1st Avenue	S Royal Brougham Way	4315	98
8	Elliott Avenue	Western Avenue	5605	84
9	Aurora NB	Denny Way	3911	78
10	Dexter Avenue	Mercer Street	5695	61
11	2nd Avenue	Columbia Street	2715	61
12	5th Avenue	Mercer Street	4735	57
13	1st Avenue	Denny Way	4291	51
14	Aurora SB	Denny Way	2440	30
15	Broad Street	Denny Way	3910	22
16	Dexter Avenue	Denny Way	3611	21
17	5th Avenue	Broad Street	2560	17
18	Alaskan Way	S Main Street	2405	15
19	5th Avenue	Thomas Street	2570	14
20	Alaskan Way	S Jackson Street	2309	9

Results of ranking by delay for the 20 highest volume intersections under this alternative
Shaded intersections were selected under this ranking.

Table B-8. Tunnel Alternative Ranking by Volume

Vol Rank	Street	with Street	Volume (vehicles per hour)	Delay
1	Dexter Avenue	Mercer Street	5821	66
2	Elliott Avenue	Denny (Western)	5490	90
3	5th Avenue	Mercer Street	4785	62
4	1st Avenue	S Royal Brougham Way	4084	108
5	1st Avenue	Denny Way	4070	25
6	Aurora NB	Denny Way	3915	86
7	Broad Street	Denny Way	3860	18
8	2nd Avenue	Denny Way	3844	129
9	1st Avenue	S Atlantic Street	3796	77
10	Dexter Avenue	Roy Street	3762	112
11	Dexter Avenue	Denny Way	3546	34
12	Alaskan Way (CD NB)	S Royal Brougham Way	3526	33
13	Alaskan Way	S King	3434	107
14	Alaskan Way	S Jackson Street	2880	8
15	Alaskan Way	S Main Street	2856	17
16	Alaskan Way	Broad Street	2753	48
17	Alaskan Way Ext	Elliott Avenue	2681	119
18	Aurora SB	Denny Way	2650	33
19	5th Avenue	Thomas Street	2574	14
20	5th Avenue	Broad Street	2560	18
21	Alaskan Way	Marion Street	2499	155
22	Alaskan Way	Yesler Way	2455	63
23	Alaskan Way	Columbia Street	2455	47
24	2nd Avenue	Spring Street	2394	114
25	2nd Avenue	Marion Street	2369	133
26	2nd Avenue	Madison Street	2310	126
27	1st Avenue	S Jackson Street	2235	48
28	2nd Avenue	Columbia Street	2215	17
29	5th Avenue	Roy Street	2180	40
30	Alaskan Way	Madison Street	2160	51
31	5th Avenue	Denny Way	2144	14
32	Alaskan Way (CD NB)	S Atlantic Street	2140	12
33	1st Avenue	Madison Street	2001	88
34	1st Avenue	Spring Street	1969	41
35	Dexter Avenue	Harrison Street	1954	12
36	Elliott Avenue	Broad Street	1908	19
37	1st Avenue	Columbia Street	1845	29
38	Alaskan Way (CD SB)	S Royal Brougham Way	1845	11
39	2nd Avenue	Battery Street	1840	10
40	Dexter Avenue	Thomas Street	1790	9
41	1st Avenue	Marion Street	1780	51
42	1st Avenue	Seneca Street	1755	12
43	1st Avenue	S Main Street	1745	162
44	Alaskan Way CD SB	S Atlantic Street	1656	8
45	Alaskan Way	Spring Street	1591	2
46	Alaskan Way	Seneca Street	1560	10
47	Western Avenue	Madison Street	1435	18
48	Western Avenue	Marion Street	1115	11
49	Western Avenue	Spring Street	995	11
50	Western Avenue	Seneca Street	889	3
51	Western Avenue	Battery Street	845	0

Results of ranking by volume for all intersections under this alternative
Shaded intersections were selected under this ranking.

Table B-9. Tunnel Alternative Ranking by Delay

Delay Rank	Street	with Street	Volume	Delay
1	2nd Avenue	Denny Way	3844	129
2	Dexter Avenue	Roy Street	3762	112
3	1st Avenue	S Royal Brougham Way	4084	108
4	Alaskan Way Ext	Elliott Avenue	2681	107
5	Alaskan Way	S King	3434	107
6	Elliott Avenue	Denny (Western)	5490	90
7	Aurora NB	Denny Way	3915	86
8	1st Avenue	S Atlantic Street	3796	77
9	Dexter Avenue	Mercer Street	5821	66
10	5th Avenue	Mercer Street	4785	62
11	Alaskan Way	Broad Street	2753	48
12	Dexter Avenue	Denny Way	3546	34
13	Alaskan Way (CD NB)	S Royal Brougham Way	3526	33
14	Aurora SB	Denny Way	2650	33
15	1st Avenue	Denny Way	4070	25
16	Broad Street	Denny Way	3860	18
17	Alaskan Way	S Main Street	2856	17
18	5th Avenue	Thomas Street	2574	14
19	Alaskan Way	S Jackson Street	2880	8
20	Western Avenue	Battery Street	2391	11

Results of ranking by delay for the 20 highest volume intersections under this alternative
Shaded intersections were selected under this ranking.

Table B-10. Bypass Tunnel Alternative Ranking by Volume

Vol Rank	Street	with Street	Volume (vehicles per hour)	Delay
1	Dexter Avenue	Mercer Street	6046	87
2	Elliott Avenue	Denny (Western)	5195	47
3	5th Avenue	Mercer Street	4885	65
4	Alaskan Way	S King	4730	100
5	1st Avenue	Denny Way	4266	22
6	1st Avenue	S Royal Brougham Way	4245	78
7	Broad Street	Denny Way	4090	26
8	Alaskan Way	S Jackson Street	4075	2
9	Alaskan Way	S Main Street	4070	4
10	Aurora NB	Denny Way	3911	81
11	1st Avenue	S Atlantic Street	3890	59
12	Dexter Avenue	Roy Street	3787	87
13	Dexter Avenue	Denny Way	3786	40
14	2nd Avenue	Denny Way	3770	71
15	Alaskan Way	Marion Street	3570	138
16	Alaskan Way	Yesler Way	3460	51
17	Alaskan Way	Columbia Street	3450	37
18	Alaskan Way	Madison Street	3310	73
19	Alaskan Way (CD NB)	S Royal Brougham Way	3245	14
20	Alaskan Way	Seneca Street	2960	6
21	Alaskan Way	Spring Street	2940	6
22	Aurora SB	Denny Way	2730	40
23	5th Avenue	Thomas Street	2644	16
24	5th Avenue	Broad Street	2610	19
25	2nd Avenue	Madison Street	2450	123
26	2nd Avenue	Marion Street	2450	127
27	2nd Avenue	Spring Street	2410	150
28	2nd Avenue	Columbia Street	2365	13
29	1st Avenue	S Jackson Street	2260	32
30	Alaskan Way Ext	Elliott Avenue	2260	21
31	5th Avenue	Roy Street	2231	63
32	Alaskan Way	Broad Street	2225	14
33	Dexter Avenue	Harrison Street	2211	15
34	5th Avenue	Denny Way	2185	11
35	1st Avenue	Madison Street	2155	65
36	1st Avenue	Spring Street	2115	37
37	Alaskan Way (CD NB)	S Atlantic Street	2065	12
38	Dexter Avenue	Thomas Street	1990	10
39	1st Avenue	Marion Street	1974	52
40	2nd Avenue	Battery Street	1970	19
41	1st Avenue	Seneca Street	1910	45
42	Alaskan Way (CD SB)	S Royal Brougham Way	1805	19
43	1st Avenue	Columbia Street	1795	38
44	1st Avenue	S Main Street	1700	99
45	Alaskan Way CD SB	S Atlantic Street	1665	5
46	Elliott Avenue	Broad Street	1645	11
47	Western Avenue	Madison Street	1245	12
48	Western Avenue	Spring Street	1030	9
49	Western Avenue	Marion Street	1015	18
50	Western Avenue	Seneca Street	940	2
51	Western Avenue	Battery Street	895	0

Results of ranking by volume for all intersections under this alternative
Shaded intersections were selected under this ranking.

Table B-11. Bypass Tunnel Alternative Ranking by Delay

Delay Rank	Street	with Street	Volume	Delay
1	Alaskan Way	Marion Street	3570	138
2	Alaskan Way	S King	4730	100
3	Dexter Avenue	Mercer Street	6046	87
4	Dexter Avenue	Roy Street	3787	87
5	Aurora NB	Denny Way	3911	81
6	1st Avenue	S Royal Brougham Way	4245	78
7	Alaskan Way	Madison Street	3310	73
8	2nd Avenue	Denny Way	3770	71
9	5th Avenue	Mercer Street	4885	65
10	1st Avenue	S Atlantic Street	3890	59
11	Alaskan Way	Yesler Way	3460	51
12	Elliott Avenue	Denny (Western)	5195	47
13	Dexter Avenue	Denny Way	3786	40
14	Alaskan Way	Columbia Street	3450	37
15	Broad Street	Denny Way	4090	26
16	1st Avenue	Denny Way	4266	22
17	Alaskan Way (CD NB)	S Royal Brougham Way	3245	14
18	Alaskan Way	Seneca Street	2960	6
19	Alaskan Way	S Main Street	4070	4
20	Alaskan Way	S Jackson Street	4075	2

Results of ranking by delay for the 20 highest volume intersections under this alternative
Shaded intersections were selected under this ranking.

Table B-12. Surface Alternative Ranking by Volume

Vol Rank	Street	with Street	Volume (vehicles per hour)	Delay
1	Alaskan Way	S King	7891	158
2	Alaskan Way	S Jackson Street	7375	24
3	Alaskan Way	S Main Street	7170	7
4	Alaskan Way	Columbia Street	6670	96
5	Alaskan Way	Yesler Way	6650	99
6	Alaskan Way	Madison Street	6501	116
7	Alaskan Way	Marion Street	6480	86
8	Alaskan Way	Seneca Street	6090	68
9	Alaskan Way	Spring Street	6030	13
10	Dexter Avenue	Mercer Street	5485	29
11	Elliott Avenue	Denny (Western)	5380	60
12	5th Avenue	Mercer Street	4805	77
13	Broad Street	Denny Way	4490	19
14	1st Avenue	Denny Way	4442	125
15	1st Avenue	S Royal Brougham Way	4300	88
16	Aurora NB	Denny Way	4160	99
17	Dexter Avenue	Denny Way	4061	63
18	1st Avenue	S Atlantic Street	4049	77
19	2nd Avenue	Denny Way	4043	107
20	Dexter Avenue	Roy Street	3850	136
21	5th Avenue	Thomas Street	3025	20
22	5th Avenue	Broad Street	3010	28
23	1st Avenue	Columbia Street	2915	221
24	2nd Avenue	Columbia Street	2820	187
25	2nd Avenue	Spring Street	2805	225
26	Alaskan Way Ext	Elliott Avenue	2800	12
27	2nd Avenue	Marion Street	2800	156
28	1st Avenue	S Jackson Street	2779	32
29	2nd Avenue	Madison Street	2729	171
30	1st Avenue	Marion Street	2690	128
31	1st Avenue	Seneca Street	2680	35
32	1st Avenue	Madison Street	2666	63
33	1st Avenue	Spring Street	2645	85
34	Aurora SB	Denny Way	2465	34
35	1st Avenue	S Main Street	2350	19
36	5th Avenue	Denny Way	2295	18
37	5th Avenue	Roy Street	2240	25
38	Dexter Avenue	Thomas Street	2180	15
39	Alaskan Way (CD NB)	S Atlantic Street	2170	13
40	Alaskan Way (CD NB)	S Royal Brougham Way	2035	9
41	Dexter Avenue	Harrison Street	2000	13
42	2nd Avenue	Battery Street	1970	14
43	Elliott Avenue	Broad Street	1875	25
44	Alaskan Way	Broad Street	1819	9
45	Alaskan Way CD SB	S Atlantic Street	1791	12
46	Western Avenue	Battery Street	1466	0
47	Alaskan Way (CD SB)	S Royal Brougham Way	1319	9
48	Western Avenue	Marion Street	1180	11
49	Western Avenue	Madison Street	1175	8
50	Western Avenue	Seneca Street	950	11
51	Western Avenue	Spring Street	910	38

Results of ranking by volume for all intersections under this alternative
Shaded intersections were selected under this ranking.

Table B-13. Surface Alternative Ranking by Delay

Delay Rank	Street	with Street	Volume	Delay
1	Alaskan Way	S King	7891	158
2	Dexter Avenue	Roy Street	3850	136
3	1st Avenue	Denny Way	4442	125
4	Alaskan Way	Madison Street	6501	116
5	2nd Avenue	Denny Way	4043	107
6	Alaskan Way	Yesler Way	6650	99
7	Aurora NB	Denny Way	4160	99
8	Alaskan Way	Columbia Street	6670	96
9	1st Avenue	S Royal Brougham Way	4300	88
10	Alaskan Way	Marion Street	6480	86
11	5th Avenue	Mercer Street	4805	77
12	1st Avenue	S Atlantic Street	4049	77
13	Alaskan Way	Seneca Street	6090	68
14	Dexter Avenue	Denny Way	4061	63
15	Elliott Avenue	Denny (Western)	5380	60
16	Dexter Avenue	Mercer Street	5485	29
17	Alaskan Way	S Jackson Street	7375	24
18	Broad Street	Denny Way	4490	19
19	Alaskan Way	Spring Street	6030	13
20	Alaskan Way	S Main Street	7170	7

Results of ranking by delay for the 20 highest volume intersections under this alternative
Shaded intersections were selected under this ranking.

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ATTACHMENT C

Air Quality Modeling Files

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The detailed modeling files are several hundred pages in length and available upon request.

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ATTACHMENT D

List of Preparers

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LIST OF PREPARERS

Name/Title Participation	Education	Professional Discipline	Experience
Helen Ginzburg Tunnel Air Quality Modeling	M.S.	Meteorology and Mathematical Modeling	24 years
Ginette Lalonde Air Quality Analysis	B.S.C.E.	Civil Engineering	5 years
Joel Soden Technical direction and quality control	B. Ch.E., M.C.E., M.S	Air Quality	32 years
Lawrence Spurgeon Air Quality Study Lead	M.S.E.	Environmental Engineering	10 years

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