SUPPLEMENTAL DRAFT ENVIRONMENTAL IMPACT STATEMENT
and SECTION 4(F) EVALUATION
SR 520 BRIDGE REPLACEMENT AND HOV PROGRAM

DECEMBER 2009

SR 520: I-5 to Medina Bridge Replacement and HOV Project

Noise Discipline Report

Washington State
Department of Transportation

U.S. Department of Transportation
Federal Highway
Administration

SR 520: I-5 to Medina Bridge Replacement and HOV Project

Noise Discipline Report

Prepared for

Washington State Department of Transportation
Federal Highway Administration

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December 2009

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Acronyms and Abbreviations

AB	Washington Park Arboretum modeled receiver designation
avg	average
BH	Floating Homes in Portage Bay modeled receiver designation
CAD	computer-aided design
CFR	Code of Federal Regulations
CH	North Capitol Hill modeled receiver designation
dB	decibel
dBA	A-weighted decibel
Delmar lid	10th Avenue East and Delmar Drive East
Draft EIS	SR 520 Bridge Replacement and HOV Project Draft Environmental Impact Statement
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ERP	Expert Review Panel
Evergreen Point lid	part of the Medina to SR 202: Eastside Transit and HOV Project
FHWA	Federal Highway Administration
ft	foot (feet)
FTA	Federal Transit Administration
HCT	high-capacity transit
HMA	hot mix asphalt
HOV	high occupancy vehicle
HR	Portage Bay/Roanoke modeled receiver designation
Hz	hertz

I-5	Interstate 5
I-5 to Medina project	SR 520: I-5 to Medina Bridge Replacement and HOV Project
in/sec	inches per second
KCC	King County Code
$L_{2.5}$	noise levels that are exceeded 2.5 percent of the time (for example, 1.5 minutes during a 1-hour measurement)
$L_{8.3}$	noise levels that are exceeded 8.3 percent of the time (for example, 5 minutes during a 1-hour measurement)
$L_{12.5}$	noise levels that are exceeded 12.5 percent of the time (for example, 7.5 minutes during a 1-hour measurement)
L_{25}	noise levels that are exceeded 25 percent of the time (for example, 15 minutes during a 1-hour measurement)
L_{50}	noise levels that are exceeded 50 percent of the time (for example, 30 minutes during a 1-hour measurement)
L_{eq}	equivalent sound level (that is, energy average noise level, in dBA, for a specific time period)
L_{eq} (24h)	equivalent sound level over a 24-hour period
L_{eq} (h)	equivalent sound level hourly
LH	Laurelhurst modeled receiver designation
L_{max}	average maximum noise emission
L_{xx}	sound level exceeded xx percent of the time
max	maximum
Medina to SR 202 project	SR 520: Medina to SR 202 Eastside Transit and HOV Project
min	minimum

MN	Montlake north of SR 520 modeled receiver designation
Montlake lid	Montlake vicinity
MP	Madison Park modeled receiver designation
mph	miles per hour
MS	Montlake south of SR 520 modeled receiver designation
N/A	not applicable
NAC	noise abatement criteria
NEPA	National Environmental Policy Act
NOAA	National Oceanic and Atmospheric Administration
NWFSC	Northwest Fisheries Science Center
OGFC	open-graded friction course
OSHA	Occupational Safety and Health Administration
Pacific Street lid	Montlake Boulevard NE and NE Pacific Street (Options K and L only)
PCC	Portland cement concrete
PN	Medina north of SR 520 modeled receiver designation
PS	Medina south of SR 520 modeled receiver designation
SDEIS	Supplemental Draft Environmental Impact Statement
SEPA	State Environmental Policy Act
SPUI	single point urban interchange
sq ft	square feet
sq m	square meters
SR	State Route
SR 520 Program	SR 520 Bridge Replacement and HOV Program
TNM	Traffic Noise Model

UBIT	under bridge inspection truck
USDOT	U.S. Department of Transportation
UW	University of Washington
WAC	Washington Administrative Code
WSDOT	Washington State Department of Transportation

Introduction

Why is noise considered in an EIS?

Sound is a fundamental component of daily life and the most universal method of communicating with other people. When sounds are perceived as desired, beneficial, or otherwise pleasing, they are typically considered as having a positive effect on daily life. When sounds are perceived as unpleasant, unwanted, or disturbingly loud, they are normally considered "noise."

Environmental noise may interfere with a broad range of human activities in a way that degrades public health and welfare. Examples include when noise adversely affects a person's hearing, mental state (for example, annoyance), or the ability to engage in important activities such as sleeping or communicating.

Understanding the adverse effects of traffic and construction noise is an integral part of this environmental impact statement (EIS). Federal, state, and local governments provide guidance on acceptable noise levels to ensure the public's health and well being, both now and in the future. Traffic and construction noise analyses are required by law for federally funded projects and by State of Washington policy for other funded projects that: 1) involve construction of a new highway, 2) substantially change the horizontal or vertical alignment, or 3) increase the number of through traffic lanes on an existing highway. State policy also requires review and consideration of noise abatement on projects that substantially alter the ground contours surrounding a state highway.

What are the key points of this report?

Currently, an estimated 288 residences of the 862 total residences identified in the Interstate 5 (I-5) to Medina: Bridge Replacement and HOV Project study area have noise levels that meet or exceed the Washington State traffic noise abatement criteria (NAC) of 67 A-weighted decibels (dBA) of equivalent sound level (L_{eq}) (WSDOT 2006a). Under the No Build Alternative, noise levels are projected to increase in 2030 by only 1 to 2 dBA L_{eq} in most locations, an amount that is not normally noticeable to most people with average hearing. However, with this increase, noise levels would exceed the NAC at an

additional 38 residences, bringing the total up to 327 from the current estimate of 288.

The recommended noise walls under the 6-Lane Alternative would lower the number of residences where noise levels would exceed the NAC. Under Option A, the number of residences exceeding the NAC would decrease to 94. The number of residences exceeding the NAC under Options K and L would decrease to 123 and 119, respectively.

I-5 to Medina Project Corridor Summary
(with Recommended Noise Walls)

Number of Residences Where Noise Levels Would Exceed NAC
(% of residences where noise levels would approach or exceed NAC based on the 862[a] total residences identified in the study area)

Current	No Build Alternative	6-Lane Alternative		
		Option A	Option K	Option L
288 (33.5%)	327 (37.9%)	94 (11.0%)	123 (14.4%)	119 (13.9%)

[a] For Options A and K the percentages of residences are based on a total of 858 residences and for Option L, a total of 855 residences.

Compared to current and projected 2030 No Build Alternative noise levels, the proposed 6-Lane Alternative (which includes noise walls and lids at several locations) would reduce the noise levels substantially throughout the I-5 to Medina project corridor. Noise-level reductions from the recommended 6-Lane Alternative noise walls would range from 7 to 17 dBA L_{eq} in those areas most benefited by the walls. Most of the remaining properties that would exceed the NAC would do so because of noise from I-5 or arterial roads, such as East Roanoke Street, 10th Avenue East, Lake Washington Boulevard, and Montlake Boulevard NE. The rest of the receivers that would exceed the NAC would do so because area topography limits the effectiveness of noise walls.

A project of this magnitude is likely to have noise and vibration effects over the length of the construction period. This report addresses the potential effects and provides a list of recommended noise mitigation measures that could be contained in the contract specifications. The construction noise and vibration mitigation that would be required to comply with all regulatory requirements would help keep the negative effects of construction to a minimum. The potential mitigation provided in the Ecosystems Discipline Report (WSDOT 2009a) for wildlife and habitat is incorporated by reference in this report as well. Nonetheless, it is likely there would be noise complaints during construction, and these would require handling on a case-by-case basis.

What is the I-5 to Medina: Bridge Replacement and HOV Project?

The I-5 to Medina: Bridge Replacement and High-Occupancy Vehicle (HOV) Project is part of the State Route (SR) 520 Bridge Replacement and HOV Program (SR 520 Program) (detailed in the text box below) and encompasses parts of three main geographic areas—Seattle, Lake Washington, and the Eastside. The project area includes the following:

- Seattle communities: Portage Bay/Roanoke, North Capitol Hill, Montlake, University District, Laurelhurst, and Madison Park
- Eastside communities: Medina, Hunts Point, Clyde Hill, and Yarrow Point
- The Lake Washington ecosystem and associated wetlands
- Usual and accustomed fishing areas of tribal nations that have historically used the area's aquatic resources and have treaty rights

The SR 520 Bridge Replacement and HOV Project Draft EIS, published in August 2006, evaluated a 4-Lane Alternative, a 6-Lane Alternative, and a No Build Alternative. Since the Draft EIS was published, circumstances surrounding the SR 520 corridor have changed in several ways. These changes have resulted in decisions to forward advance planning for potential catastrophic failure of the Evergreen Point Bridge, respond to increased demand for transit service on the Eastside,

What is the SR 520 Program?

The SR 520 Bridge Replacement and HOV Program will enhance safety by replacing the aging floating bridge and keep the region moving with vital transit and roadway improvements throughout the corridor. The 12.8-mile program area begins at I-5 in Seattle and extends to SR 202 in Redmond.

In 2006, WSDOT prepared a Draft EIS—published formally as the SR 520 Bridge Replacement and HOV Project—that addressed corridor construction from the I-5 interchange in Seattle to just west of I-405 in Bellevue. Growing transit demand on the Eastside and structure vulnerability in Seattle and Lake Washington, however, led WSDOT to identify new projects, each with a separate purpose and need, that would provide benefit even if the others were not built. These four independent projects were identified after the Draft EIS was published in 2006, and these now fall under the umbrella of the entire SR 520 Bridge Replacement and HOV Program:

- I-5 to Medina: Bridge Replacement and HOV Project replaces the SR 520 roadway, floating bridge approaches, and floating bridge between I-5 and the eastern shore of Lake Washington. This project spans 5.2 miles of the SR 520 corridor.
- Medina to SR 202: Eastside Transit and HOV Project completes and improves the transit and HOV system from Evergreen Point Road to the SR 202 interchange in Redmond. This project spans 8.6 miles of the SR 520 corridor.
- Pontoon Construction Project involves constructing the pontoons needed to restore the Evergreen Point Bridge in the event of a catastrophic failure and storing those pontoons until needed.
- Lake Washington Congestion Management Project, through a grant from the U.S. Department of Transportation, improves traffic using tolling, technology and traffic management, transit, and telecommuting.

and evaluate a new set of community-based designs for the Montlake area in Seattle.

To respond to these changes, the Washington State Department of Transportation (WSDOT) and the Federal Highway Administration (FHWA) initiated new projects to be evaluated in separate environmental documents. Improvements to the western portion of the SR 520 corridor—known as the I-5 to Medina: Bridge Replacement and HOV Project (the *I-5 to Medina project*)—are being evaluated in a Supplemental Draft EIS (SDEIS); this discipline report is a part of that SDEIS. Project limits for this project extend from I-5 in Seattle to 92nd Avenue NE in Yarrow Point, where it transitions into the Medina to SR 202: Eastside Transit and HOV Project (the *Medina to SR 202 project*). Exhibit 1 shows the project vicinity.

Exhibit 1. Project Vicinity Map

What are the project alternatives?

As noted above, the Draft EIS evaluated a 4-Lane Alternative, a 6-Lane Alternative (including three design options in Seattle), and a No Build Alternative. In 2006, following Draft EIS publication, Governor Gregoire identified the 6-Lane Alternative as the state's preference for the SR 520 corridor, but urged that the affected communities in Seattle develop a common vision for the western portion of the corridor. Accordingly, a mediation group convened at the direction of the state legislature to evaluate the corridor alignment for SR 520 through Seattle. The mediation group identified three 6-lane design options for SR 520 between I-5 and the floating span of the Evergreen Point Bridge; these options were documented in a Project Impact Plan (Parametrix 2008). The SDEIS evaluates the following:

- No Build Alternative
- 6-Lane Alternative
  - Option A
  - Option K
  - Option L

These alternatives and options are summarized below. The 4-Lane Alternative and the Draft EIS 6-lane design options have been eliminated from further consideration. More information on how the project has evolved since the Draft EIS was published in 2006, as well as

more detailed information on the design options, is provided in the Description of Alternatives Discipline Report (WSDOT 2009b).

What is the No Build Alternative?

Under the No Build Alternative, SR 520 would continue to operate between I-5 and Medina as it does today: as a 4-lane highway with nonstandard shoulders and without a bicycle/pedestrian path. (Exhibit 2 depicts a cross section of the No Build Alternative.) No new facilities would be added to SR 520 between I-5 and Medina, and none would be removed, including the unused R.H. Thomson Expressway ramps near the Washington Park Arboretum. WSDOT would continue to manage traffic using its existing transportation demand management and intelligent transportation system strategies.

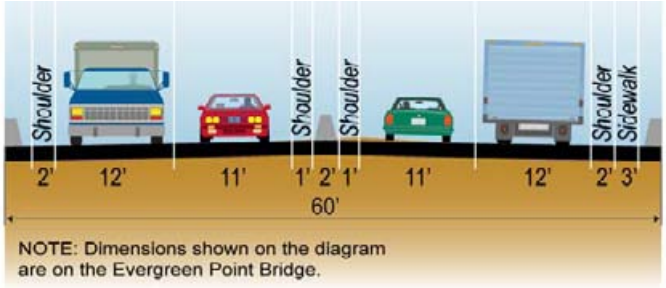


Exhibit 2. No Build Alternative Cross Section

The No Build Alternative assumes that the Portage Bay and Evergreen Point bridges would remain standing and functional through 2030 and that no catastrophic events, such as earthquakes or extreme storms, would cause major damage to the bridges. The No Build Alternative also assumes completion of the Medina to SR 202 project as well as other regionally planned and programmed transportation projects. The No Build Alternative provides a baseline against which project analysts can measure and compare the effects of each 6-Lane Alternative build option.

What is the 6-Lane Alternative?

The 6-Lane Alternative would complete the regional HOV connection (3+ HOV occupancy) across SR 520. This alternative would include six lanes (two 11-foot-wide outer general-purpose lanes and one 12-foot-wide inside HOV lane in each direction), with 4-foot-wide inside and 10-foot-wide outside shoulders (Exhibit 3). The proposed width of the roadway would be approximately 18 feet narrower than the one described in the Draft EIS, reflecting public comment from local communities and the City of Seattle.

SR 520 would be rebuilt from I-5 to Evergreen Point Road in Medina and restriped and reconfigured from Evergreen Point Road to 92nd Avenue NE in Yarrow Point. A 14-foot-wide bicycle/pedestrian path would be built along the north side of SR 520 through the Montlake

NOTE: Dimensions shown on the diagram are on the Evergreen Point Bridge.

Exhibit 3. 6-Lane Alternative Cross Section

area and across the Evergreen Point Bridge, connecting to the regional path on the Eastside. A bridge maintenance facility and dock would be built underneath the east approach to the Evergreen Point Bridge.

The sections below describe the 6-Lane Alternative and design options in each of the three geographical areas the project would encompass.

Seattle

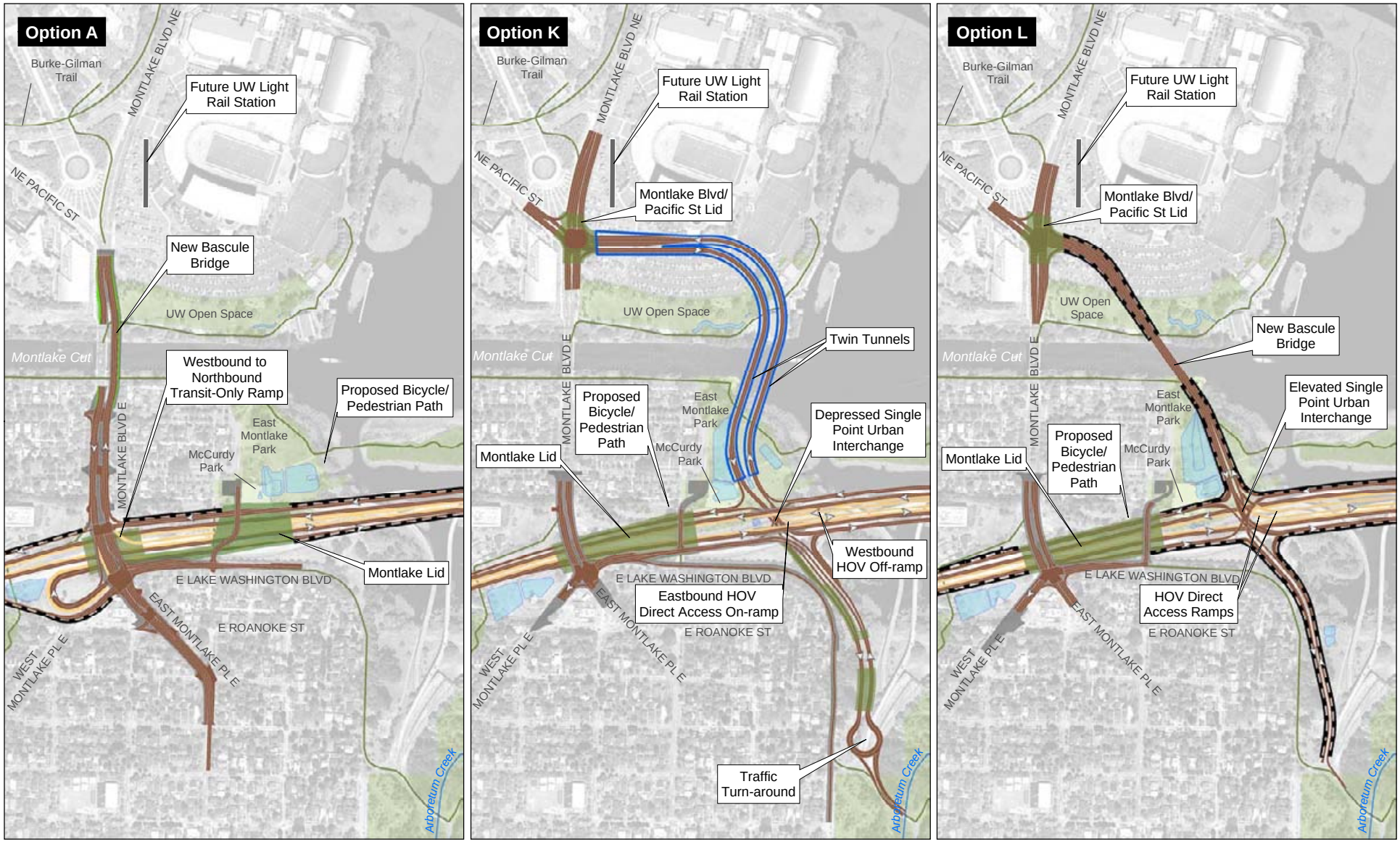
Elements Common to the 6-Lane Alternative Options

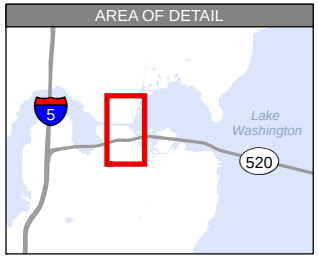
SR 520 would connect to I-5 in a configuration similar to the way it connects today. Improvements to the I-5/SR 520 interchange would include a new reversible HOV ramp connecting the new SR 520 HOV lanes to existing I-5 reversible express lanes. WSDOT would replace the Portage Bay Bridge and the Evergreen Point Bridge (including the west approach and floating span), as well as the existing local street bridges across SR 520. New stormwater facilities would be constructed for the project to provide stormwater retention and treatment. The project would include landscaped lids across SR 520 at I-5, 10th Avenue East and Delmar Drive East, and in the Montlake area to help reconnect the communities on either side of the roadway. The project would also remove the Montlake freeway transit station.

The most substantial differences among the three options are the interchange configurations in the Montlake and University of Washington areas. Exhibit 4 depicts these key differences in interchange configurations, and the following text describes elements unique to each option.

Option A

Option A would replace the Portage Bay Bridge with a new bridge that would include six lanes (four general-purpose lanes, two HOV lanes) plus a westbound auxiliary lane. WSDOT would replace the existing





- Potential Sound Wall
- Existing Regional Bicycle/Pedestrian Path
- Tunnel
- Lid or Landscape Feature
- Proposed Bicycle/Pedestrian Path
- Stormwater Facility
- General-Purpose Lane
- HOV, Direct Access, and/or Transit-Only Lane
- Future UW Light Rail Station
- Park

N

0 250 500 1,000 Feet

Source: King County (2006) Aerial Photo, King County (2005) GIS Data (Streams), City of Seattle (1994) GIS Data (Bike/Ped Trail), Seattle Bicycle Map (2008) GIS Data (Bike/Ped Trail) CH2M HILL (2008) GIS Data (Park). Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

Exhibit 4. **Options A, K, and L: Montlake and University of Washington Areas**

I-5 to Medina: Bridge Replacement and HOV Project

interchange at Montlake Boulevard East with a new, similarly configured interchange that would include a transit-only off-ramp from westbound SR 520 to northbound Montlake Boulevard. The Lake Washington Boulevard ramps and the median freeway transit stop near Montlake Boulevard East would be removed, and a new bascule bridge (i.e., drawbridge) would be added to Montlake Boulevard NE, parallel to the existing Montlake Bridge. SR 520 would maintain a low profile through the Washington Park Arboretum and flatten out east of Foster Island, before rising to the west transition span of the Evergreen Point Bridge. Citizen recommendations made during the mediation process defined this option to include sound walls and/or quieter pavement, subject to neighborhood approval and WSDOT's reasonability and feasibility determinations.

Suboptions for Option A would include adding an eastbound SR 520 on-ramp and a westbound SR 520 off-ramp to Lake Washington Boulevard, creating an intersection similar to the one that exists today but relocated northwest of its current location. The suboption would also include adding an eastbound direct access on-ramp for transit and HOV from Montlake Boulevard East, and providing a constant slope profile from 24th Avenue East to the west transition span.

Is it a highrise or a transition span?

A transition span is a bridge span that connects the fixed approach bridge to the floating portion of the bridge. The Evergreen Point Bridge has two transition spans, one at the west end of the floating bridge transitioning traffic on and off of the west approach, and one on the east end of the floating bridge transitioning traffic on and off of the east approach. These spans are often referred to as the "west highrise" (shown) and the "east highrise" during the daily traffic report, and the west highrise even has a traffic camera mounted on it.

Today's highrises have two characteristics—large overhead steel trusses and navigation channels below the spans where boat traffic can pass underneath the Evergreen Point Bridge. The new design for the floating bridge would not include overhead steel trusses on the transition spans, which would change the visual character of the highrise. For the SDEIS, highrise and transition span are often used interchangeably to refer to the area along the bridge where the east and west approach bridges transition to the floating bridge.

Option K

Option K would also replace the Portage Bay Bridge, but the new bridge would include four general-purpose lanes and two HOV lanes with no westbound auxiliary lane. In the Montlake area, Option K would remove the existing Montlake Boulevard East interchange and the Lake Washington Boulevard ramps and replace their functions with a depressed, single-point urban interchange (SPUI) at the Montlake shoreline. Two HOV direct-access ramps would serve the new interchange, and a tunnel under the Montlake Cut would move traffic from the new interchange north to

the intersection of Montlake Boulevard NE and NE Pacific Street. SR 520 would maintain a low profile through Union Bay, make landfall at Foster Island, and remain flat before rising to the west transition span of the Evergreen Point Bridge. A land bridge would be constructed over SR 520 at Foster Island. Citizen recommendations made during the mediation process defined this option to include only quieter pavement for noise abatement, rather than the sound walls that were included in the 2006 Draft EIS. However, because quieter pavement has not been demonstrated to meet all FHWA and WSDOT avoidance and minimization requirements in tests performed in Washington State, it cannot be considered as noise mitigation under WSDOT and FHWA criteria. As a result, sound walls could be included in Option K. The decision to build sound walls depends on neighborhood interest, the findings of the Noise Discipline Report (WSDOT 2009e), and WSDOT's reasonability and feasibility determinations.

A suboption for Option K would include constructing an eastbound off-ramp to Montlake Boulevard East configured for right turns only.

Option L

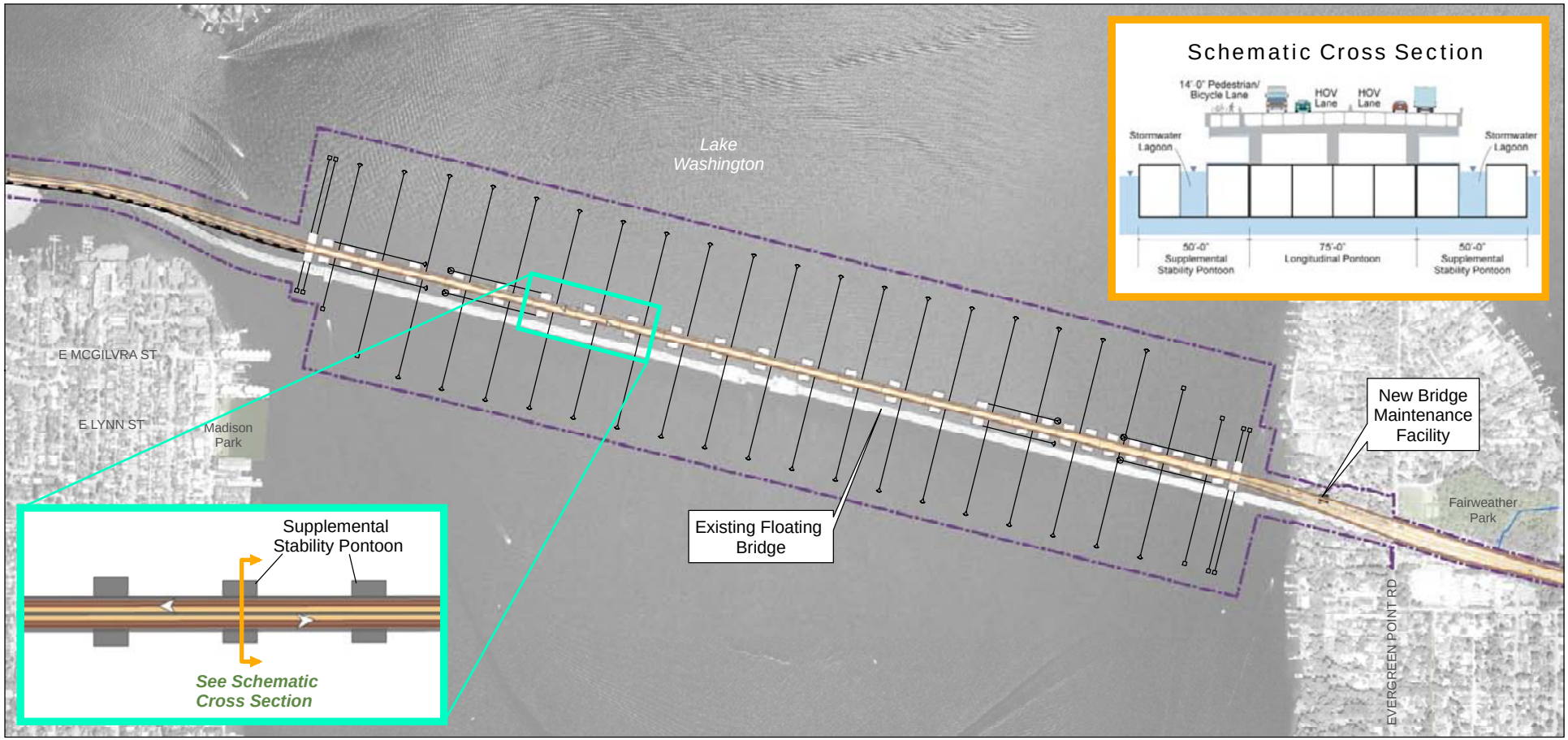
Under Option L, the Montlake Boulevard East interchange and the Lake Washington Boulevard ramps would be replaced with a new, elevated SPUI at the Montlake shoreline. A bascule bridge (drawbridge) would span the east end of the Montlake Cut, from the new interchange to the intersection of Montlake Boulevard NE and NE Pacific Street. This option would also include a ramp connection to Lake Washington Boulevard and two HOV direct-access ramps providing service to and from the new interchange. SR 520 would maintain a low, constant slope profile from 24th Avenue East to just west of the west transition span of the floating bridge. Noise mitigation identified for this option would include sound walls as defined in the Draft EIS.

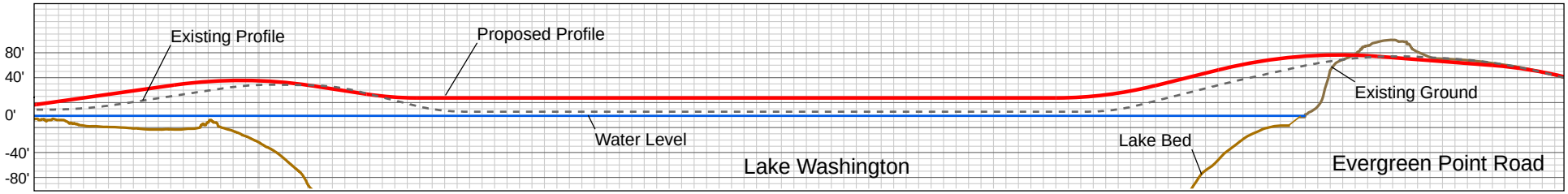
Suboptions for Option L would include adding a left-turn movement from Lake Washington Boulevard for direct access to SR 520 and adding capacity on northbound Montlake Boulevard NE to NE 45th Street.

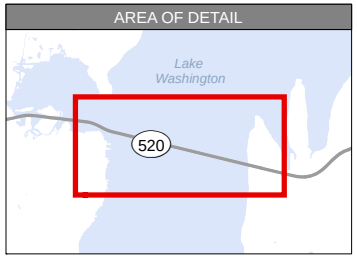
Lake Washington

Floating Bridge

The floating span would be located approximately 190 feet north of the existing bridge at the west end and 160 feet north at the east end (Exhibit 5). Rows of three 10-foot-tall concrete columns would support the roadway above the pontoons, and the new spans would be







- Anchor and Cable
- Pontoons
- Limits of Construction
- Proposed Bicycle/Pedestrian Path
- General-Purpose Lanes
- HOV, Direct Access, and/or Transit-Only Lane
- Park

Source: King County (2006) Aerial Photo, CH2M HILL (2008) GIS Data (Park). Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

N

0 250 500 1,000 Feet

Exhibit 5. **6-Lane Alternative at the Evergreen Point Bridge (Common to All Options)**

I-5 to Medina: Bridge Replacement and HOV Project

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approximately 22 feet higher than the existing bridge. A 14-foot-wide bicycle/pedestrian path would be located on the north side of the bridge.

The design for the new 6-lane floating bridge includes 21 longitudinal pontoons, two cross pontoons, and 54 supplemental stability pontoons. A single row of 75-foot-wide by 360-foot-long longitudinal pontoons would support the new floating bridge. One 240-foot-long by 75-foot-wide cross-pontoon at each end of the bridge would be set perpendicularly to the longitudinal pontoons. The longitudinal pontoons would be bolstered by the smaller supplemental stability pontoons on each side for stability and buoyancy. The longitudinal pontoons would not be sized to carry future high-capacity transit (HCT), but would be equipped with connections for additional supplemental stability pontoons to support HCT in the future. As with the existing floating bridge, the floating pontoons for the new bridge would be anchored to the lake bottom to hold the bridge in place.

Near the east approach bridge, the roadway would be widened to accommodate transit ramps to the Evergreen Point Road transit stop. Exhibit 5 shows the alignment of the floating bridge, the west and east approaches, and the connection to the east shore of Lake Washington.

Bridge Maintenance Facility

Routine access, maintenance, monitoring, inspections, and emergency response for the floating bridge would be based out of a new bridge maintenance facility located underneath SR 520 between the east shore of Lake Washington and Evergreen Point Road in Medina. This bridge maintenance facility would include a working dock, an approximately 7,200-square-foot maintenance building, and a parking area.

Eastside Transition Area

The I-5 to Medina project and the Medina to SR 202 project overlap between Evergreen Point Road and 92nd Avenue NE in Yarrow Point. Work planned as part of the I-5 to Medina project between Evergreen Point Road and 92nd Avenue NE would include moving the Evergreen Point Road transit stop west to the lid (part of the Medina to SR 202 project) at Evergreen Point Road, adding new lane and ramp striping from the Evergreen Point lid to 92nd Avenue NE, and moving and realigning traffic barriers as a result of the new lane striping. The restriping would transition the I-5 to Medina project improvements into the improvements to be completed as part of the Medina to SR 202 project.

Pontoon Construction and Transport

If the floating portion of the Evergreen Point Bridge does not fail before its planned replacement, WSDOT would use the pontoons constructed and stored as part of the Pontoon Construction Project in the I-5 to Medina project. Up to 11 longitudinal pontoons built and stored in Grays Harbor as part of the Pontoon Construction Project would be towed from a moorage location in Grays Harbor to Puget Sound for outfitting (see the sidebar to the right for an explanation of pontoon *outfitting*). All outfitted pontoons, as well as the remaining pontoons stored at Grays Harbor would be towed to Lake Washington for incorporation into the floating bridge. Towing would occur as weather permits during the months of March through October. Exhibit 6 illustrates the general towing route from Grays Harbor to Lake Washington, and identifies potential outfitting locations.

What is Outfitting?

Pontoon outfitting is a process by which the columns and elevated roadway of the bridge are built directly on the surface of the pontoon.

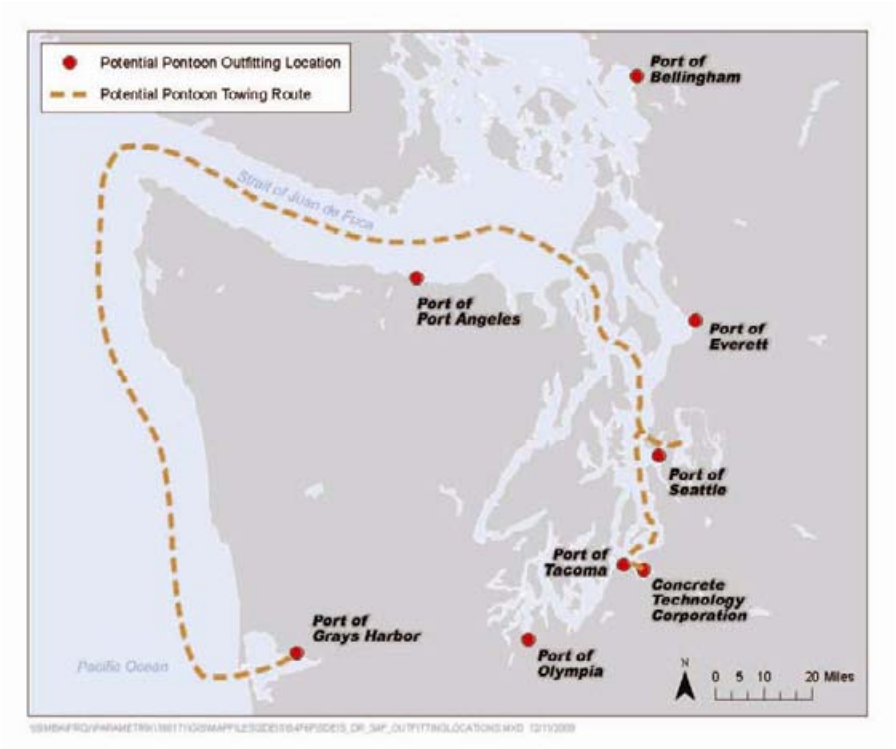


Exhibit 6. Possible Towing Route and Pontoon Outfitting Locations

The I-5 to Medina project would build an additional 44 pontoons needed to complete the new 6-lane floating bridge. The additional pontoons could be constructed at the existing Concrete Technology Corporation facility in Tacoma, and/or at a new facility in Grays Harbor that is also being developed as part of the Pontoon Construction Project. The new supplemental stability pontoons would be towed from

the construction location to Lake Washington for incorporation into the floating bridge. For additional information about pontoon construction, please see the Construction Techniques Discipline Report (WSDOT 2009c).

Would the project be built all at once or in phases?

Revenue sources for the I-5 to Medina project would include allocations from various state and federal sources and from future tolling, but there remains a gap between the estimated cost of the project and the revenue available to build it. Because of these funding limitations, there is a strong possibility that WSDOT would construct the project in phases over time.

If the project is phased, WSDOT would first complete one or more of those project components that are vulnerable to earthquakes and windstorms; these components include the following:

- The floating portion of the Evergreen Point Bridge, which is vulnerable to windstorms. This is the highest priority in the corridor because of the frequency of severe storms and the high associated risk of catastrophic failure.
- The Portage Bay Bridge, which is vulnerable to earthquakes. This is a slightly lower priority than the floating bridge because the frequency of severe earthquakes is significantly less than that of severe storms.
- The west approach of the Evergreen Point Bridge, which is vulnerable to earthquakes (see comments above for the Portage Bay Bridge).

Exhibit 7 shows the vulnerable portions of the project that would be prioritized, as well as the portions that would be constructed later. The vulnerable structures are collectively referred to in the SDEIS as the Phased Implementation scenario. It is important to note that, while the new bridge(s) might be the only part of the project in place for a certain period of time, WSDOT's intent is to build a complete project that meets all aspects of the purpose and need.

The Phased Implementation scenario would provide new structures to replace the vulnerable bridges in the SR 520 corridor, as well as limited transitional sections to connect the new bridges to existing facilities. This scenario would include stormwater facilities, noise mitigation, and

the regional bicycle/pedestrian path, but lids would be deferred until a subsequent phase. WSDOT would develop and implement all mitigation needed to satisfy regulatory requirements.

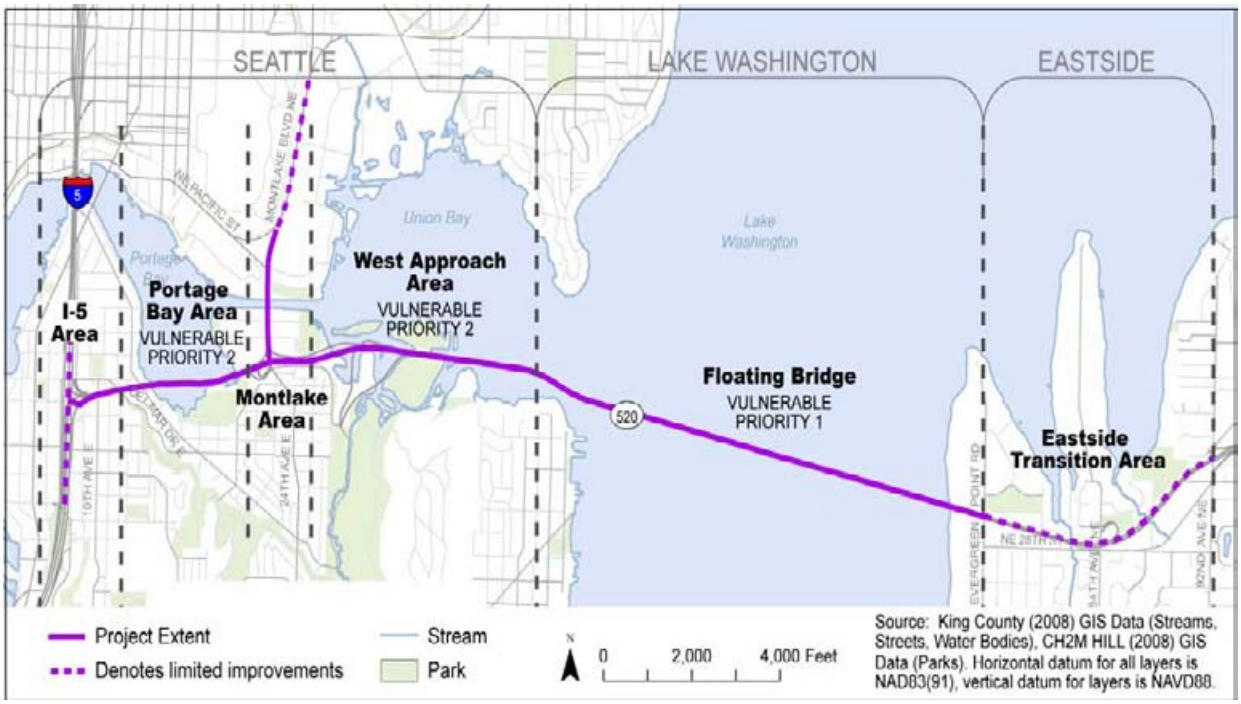


Exhibit 7. Geographic Areas along SR 520 and Project Phasing

To address the potential for phased project implementation, the SDEIS evaluates the Phased Implementation scenario separately as a subset of the "full build" analysis. The evaluation focuses on how the effects of phased implementation would differ from those of full build and on how constructing the project in phases might have different effects from constructing it all at one time. Impact calculations for the physical effects of phased implementation (for example, acres of wetlands and parks affected) are presented alongside those for full build where applicable.

Noise Analysis Overview

What is sound (noise)?

This section discusses how noise is evaluated—its definition, transmission characteristics, and measurement. This section also provides some typical noise levels for reference.

Sound is any change in air pressure that the human ear can detect, from barely perceptible sounds to sound levels that can cause hearing damage. These changes in air pressure are translated to sound in the human ear. The greater the change in air pressure, the louder the sound. For example, a quiet whisper in the library creates a relatively small change in the room air pressure, whereas air pressure changes are much greater in the front row of a rock concert.

In addition to the loudness of sound, *frequency* is a term also used to describe sound. The frequency of sound is determined by the number of recurring changes in air pressure per second. A sound that contains a relatively high number of pressure changes per second is generally referred to as a high frequency noise or "high-pitched." One common example of a high-frequency noise is a referee's whistle. A sound that has a low number of pressure changes per second is referred to as low frequency or low-pitched noise (for example, a bass drum).

A person's response to noise is subjective and can vary greatly from person to person. Some key factors that can influence an individual's response include the loudness, the frequency, the amount of background noise present, and the nature of the activity taking place that the noise affects. For example, boisterous children playing outside during the day, while there is background traffic noise, is generally less obtrusive than if the children were making the same amount of noise during the nighttime sleeping hours. When sounds are perceived as unpleasant, unwanted, or disturbingly loud, they are normally considered "noise."

How Sound is Measured

Sound is measured both in terms of loudness and frequency. The unit used to measure the loudness of sound is called a decibel (dB). In simple terms, the dB scale is a logarithmic conversion of air pressure level variations (measured in a unit called a Pascal) to a unit of measure

with a more convenient numbering system. A person with average hearing can detect a wide range of sound pressures, a ratio of over a million to one. A direct application of the Pascal linear scale using sound pressures would require the use of numbers typically ranging from about 10 micro-Pascals to 100,000,000 micro-Pascals. The dB scale simplifies the units of sound measurement to a manageable range of numbers and is also a more accurate representation of how the human ear reacts to variations in air pressure. A range from 0 to 120 dB is the typical range of hearing.

While the loudness of sound is an easy concept for most people, a sound's frequency is just as important in understanding how we hear sounds. Frequency is measured in terms of the number of changes in air pressure that occur per second. The unit used to measure the frequency of sound is called a hertz (Hz). While the human ear can detect a wide range of frequencies from 20 Hz to 20,000 Hz, it is most sensitive to sounds at the middle frequencies (500 to 4,000 Hz). The human ear is progressively less sensitive to sound at frequencies above and below this middle range. For example, a sound level of 60 dB at 250 Hz would be considerably less noticeable to a person than 60 dB at 1,000 Hz.

Of course, discussing sounds in terms of both loudness and frequency can become tedious and confusing. In order to simplify matters, an adjustment is made to the dB measurement scale that, in addition to loudness, accounts for the human ear's sensitivity to frequencies. The adjusted dB scale, referred to as the A-weighted dB scale, provides an accurate "single number" measure of what the human ear can actually hear. When the A-weighted dB scale is used, the dB levels are designated as dBA. This unit of measurement is used in this report.

For a sense of perspective, normal human conversation ranges between 44 and 65 dBA when people are about 3 to 6 feet apart. Very slight changes in noise levels, up or down, are generally not detectable by the human ear. The smallest change in noise level that a human ear can perceive is about 3 dBA, while increases of 5 dBA or more are clearly noticeable. For most people, a 10-dBA increase in sound levels is judged as a doubling of sound level, while a 10-dBA decrease in sound levels is perceived to be half as loud. For example, a person talking at 70 dBA is perceived as twice as loud as the same person talking at 60 dBA.

Because decibels are expressed on a logarithmic scale, they cannot be combined by simple addition. For example, if a single vehicle pass-by produces a sound level of 60 dB at 50 feet from a roadway, two

identical vehicle pass-bys would not produce a sound level of 120 dB. They would, in fact, produce a sound level of 63 dB. To combine decibels, they must first be converted to energy, then added or subtracted as appropriate, and converted back to decibels. When two decibel values differ by 10 dB or more, the combined sound level is simply equal to the higher value. That is, the sound level that is lower by more than 10 dB would not increase the sound level. Using the vehicle pass-by example, if two vehicles pass by at the same time, one of which produces 60 dB and another that only produces 50 dB, the sound level would be 60 dB. In this example, the louder vehicle can be considered as masking the quieter vehicle. Another practical example of this would be turning music up more than 10 dBA louder than the neighbor's barking dog so that the dog is no longer heard.

Typical Neighborhood Noise Levels

In most neighborhoods, nighttime noise levels are noticeably lower than daytime noise levels. In a quiet rural area at night, noise levels from crickets or wind rustling leaves on the trees can range between 32 and 35 dBA. As residents start their day and local traffic increases, the same rural area can have noise levels ranging from 50 to 60 dBA. Noise levels in urban neighborhoods are louder than rural areas. Noise levels during the day in a noisy urban area are frequently as high as 70 to 80 dBA. Nighttime noise levels in urban areas are generally much quieter than daytime noise levels and can range from 40 to 50 dBA.

How Noise Changes over Time

Noise levels from most sources tend to vary with time. For example, noise levels increase when a car approaches, then reach a maximum peak as it passes, and decrease as the car moves farther away. In this example, noise levels within a 1-minute timeframe may range from 45 dBA as the vehicle approaches, increase to 65 dBA as it passes by, and return to 45 dBA as it moves away. To account for the variance in loudness, over time, a common noise measurement is the equivalent sound level, or L_{eq}. The L_{eq} is defined as the energy average noise level, in dBA, for a specific time period (for example, 1 minute). Returning to the example of the passing car, assume that the energy average noise level was 60 dBA during the entire period of time the car could be heard as it passed by. In this example, the noise level would be stated as 60 dBA L_{eq}. The same approach is used to

> The equivalent sound level (L_{eq}) is used to account for the variance in loudness over time. Transportation-related noise is most often described in terms of L_{eq}.

determine the L_{eq} for other time periods such as hourly (L_{eq} [h]) or over a 24-hour period (L_{eq} [24h]).

Public response to sound depends greatly upon the range that the sound varies in a given environment. For example, people generally find a moderately high, constant sound level more tolerable than a quiet background level interrupted by high-level noise intrusions. In light of this subjective response, it is often useful to look at a statistical distribution of sound levels over a given time period. Such distributions identify the sound level exceeded and the percentage of time exceeded; therefore, they allow a more complete description of the range of sound levels during the given measurement period.

The State of Washington allows for an exceedance of the noise regulations based on the amount of time the noise source exceeds the criteria. The State of Washington noise regulations are applicable to the construction phases of transportation projects. The sound level descriptor L_{xx} is defined as the sound level exceeded xx percent of the time. To assist with compliance to the noise regulations, the statistical L_{xx} noise descriptor is very useful. For example, during a 1-hour measurement, an L_{25} of 75 dBA means the sound level was at or above 75 dBA for 15 minutes of that hour (25 percent of the time), which could be used to verify the 15-minute allowable exceedance criterion in the State's code. Similarly, two other statistical descriptors, the $L_{8.3}$ and $L_{2.5}$, can be used to verify the 5-minute and the 1.5-minute allowable exceedance criteria in the State's code.

How Noise Decreases over Distance

Several factors determine how sound levels decrease, or attenuate, over a distance. Two general categories apply to noise sources: 1) a *point* source (for example, a church bell) and 2) a *line* source (such as constant flowing traffic on a busy highway).

A single-point noise source will attenuate at a rate of 6 dB each time the distance from the source doubles. Thus, a point source that produces a noise level of 60 dB at a distance of 50 feet would attenuate to 54 dB at 100 feet and to 48 dB at 200 feet. A line source such as a highway, however, generally reduces at a rate of approximately 3 dB each time the distance doubles. Using the same example above, a line source measured at 60 dB at 50 feet would attenuate to 57 dB at 100 feet and to 54 dB at 200 feet.

Attenuation of point and line sources is influenced by the physical surroundings between the source and the receiver. For example, interactions of sound waves with the ground often result in slightly higher attenuation (called ground absorption effects) than the reduction factors given in the preceding paragraph. Other factors that affect the attenuation of sound with distance include existing structures, topography, dense foliage, ground cover, and atmospheric conditions (such as wind, temperature, and relative humidity. The potential effects these factors have on sound propagation are described below.

- **Existing structures** can substantially affect noise levels. Buildings or walls can reduce noise levels by physically blocking the path between the source and the receiver. Measurements have shown that a single-story house has the potential, through shielding, to reduce noise levels by as much as 10 dBA or greater. The actual noise reduction will depend greatly on the geometry of the noise source, receiver, and location of the structure. In cases where the source and the receiver are located on the same side of a structure, noise levels may be higher than expected due to the combination of sound transmitted directly from the source and sound reflected off the structure. Increases in noise caused by reflection are normally 3 dBA or less, which is the minimum change in noise levels that the human ear can notice.
- **Topography** includes existing hills, berms, and other ground surface features between the noise source and receiver location. As with structures, topography can reduce or increase sound, depending on the location or geometry of the surrounding terrain. Hills and berms that block the path between the noise source and receiver will reduce noise levels at the receiver location. In some locations, however, the topography can cause an overall increase in sound levels by either reflecting or channeling the noise toward a sensitive receiver location.
- **Dense foliage** can slightly reduce noise levels. Generally, if the foliage is sufficiently dense that one cannot see over it or through it, then it may provide some additional noise-level reduction from the source to the receiver. For example, the FHWA has stated that up to a 5-dBA reduction in traffic noise may result for locations that have at least 100 feet of dense evergreen foliage between the roadway and the receiver.

- **Ground cover** between the receiver and the noise source can also affect noise transmission. For example, sound travels across reflective surfaces (such as water or pavement) with minimal attenuation. On the other hand, sound will be more attenuated or absorbed as it travels across ground cover such as field grass, lawn, or even loose soil.
- **Atmospheric conditions** that can affect the transmission of noise include wind, temperature, humidity, and precipitation. Wind blowing in the direction from the source to the receiver can increase sound levels; conversely, wind can reduce noise levels when blowing in a direction from the receiver to the source. Noise levels can increase during a temperature inversion as the layer of warmer air atop the trapped layer of cooler air causes a deflection of skyward-bound sound waves back to the receivers at ground level. Other atmospheric conditions such as humidity and precipitation are rarely severe enough to noticeably affect the amount of noise attenuation. Because weather conditions change frequently, atmospheric conditions are not considered in traffic noise studies.

How Loud Noises Can Affect Hearing

Long-term, or continuous, exposure to very loud noises can damage the human ear. To protect against hearing loss in the workplace, the Washington State Department of Labor and Industries has established an 8-hour continuous exposure limit of 85 dBA (WAC 296-817-300). Noise levels exceeding 85 dBA over continuous periods can result in permanent hearing loss. Noise levels above 110 dBA become intolerable and then extremely painful.

Exhibit 8 shows some common noise sources or activities and compares their relative loudness to that of an 80-dBA source, such as a garbage disposal or food blender.

When a Traffic Noise Study is Required

FHWA and WSDOT require a noise analysis on all Type I projects. Type I projects involve 1) the construction of a new highway on a new alignment, 2) significant horizontal or vertical changes to the current highway alignment, or 3) increases to the number of through traffic lanes on an existing highway. Both agencies consider the proposed project a Type I project from I-5 to Medina (west of Evergreen Point Road) due to an increase in the number of through traffic lanes.

Noise Source or Activity	Sound Level (dBA)	Subjective Impression	Relative Loudness (human judgment of different sound levels)
Jet aircraft takeoff from carrier (50 feet)	140	Threshold of pain	64 times as loud
50-horsepower siren (100 feet)	130		32 times as loud
Loud rock concert near stage Jet takeoff (200 feet)	120	Uncomfortably loud	16 times as loud
Float plane takeoff (100 feet)	110		8 times as loud
Jet takeoff (2,000 feet)	100	Very loud	4 times as loud
Heavy truck or motorcycle (25 feet)	90		2 times as loud
Garbage disposal (2 feet) **Pneumatic drill (50 feet)**	80	**Moderately loud**	**Reference loudness**
Vacuum cleaner (10 feet) Passenger car at 65 mph (25 feet)	70		1/2 as loud
Typical office environment	60		1/4 as loud
Light auto traffic (100 feet)	50	Quiet	1/8 as loud
Bedroom or quiet living room Bird calls	40		1/16 as loud
Quiet library, soft whisper (15 feet)	30	Very quiet	
High quality recording studio	20		
Acoustic test chamber	10	Just audible	
	0	Threshold of hearing	

Sources: Beranek (1988) and U.S. EPA (1974).

Exhibit 8. Sound Levels and Relative Loudness of Typical Noise Sources

How is a noise study performed?

This section describes the primary steps that are taken to complete a traffic noise study in Washington. Together, these steps also provide an outline for the rest of this discipline report.

To further assist the reader in navigating through this report, the title of each section within this report that corresponds to each of the following steps is given in the right-hand margin. The 12 primary steps to a noise study include:

1. Review all applicable federal, state, and local criteria for traffic noise analyses. These criteria provide approved methods, including the proper traffic noise model and noise abatement criteria for evaluating the project's potential effects.

➢ Step 1: *What criteria are used to evaluate potential effects?*

2. Establish the study area and perform field reconnaissance to identify noise-sensitive land uses (for example, parks) and local topography that affects the transmission of noise.

➢ Step 2: *What is the study area for the noise analysis?*

3. Select noise measurement locations that will best characterize the existing noise environment. Strategically selected noise monitoring locations help identify the overall traffic noise levels as well as identify other major noise sources in the study area.

➢ Step 3: *Where are the sound measurement locations?*

4. Select the proper noise measurement equipment and adhere to methods that will meet or exceed the federal, state, or local measurement standards. In addition to noise monitoring, select proper equipment to collect traffic speed and volume data.

➢ Step 4: *What equipment and methods were used for the sound measurements?*

5. Perform onsite noise measurements to validate the Traffic Noise Model (TNM). Collect traffic volume and speed data and make note of all existing topography that affects the transmission of noise.

➢ Step 5: *What are the measured sound levels?*

6. Develop the input to the TNM using the existing roadway alignments and counted traffic flow. Input the noise monitoring data to verify (or validate) that the TNM accurately predicts traffic noise levels at all monitoring locations.

➢ Step 6: *Verification of Traffic Noise Model Predictions*

7. Model existing I-5 to Medina project corridor traffic noise levels using the peak-hour traffic volumes generated by the transportation discipline analysts and posted speed limits.

➢ Step 7: *What are the existing peak-hour traffic noise levels?*

8. Evaluate potential effects of construction-related noise for the 6-Lane Alternative. Calculate peak construction noise levels based on the equipment to be used, the distance from the construction zones to receivers, and the duration and time of the construction.

➢ Step 8: *How would construction of the project affect noise levels?*

9. Model future I-5 to Medina project corridor traffic noise levels using the peak-hour traffic volumes generated by the transportation discipline analysts and posted speed limits. Future 2030 conditions include the 6-Lane Alternative and the No Build Alternative.

➢ Step 9: *How would operation of the project affect noise levels?*

10. Compare the modeled noise-level results to the project traffic noise criteria to determine where noise mitigation could be considered.

➢ Step 10: *What has been done to avoid or minimize negative effects from noise?*

11. Re-model the 6-Lane Alternative with options with noise mitigation measures and verify that the noise mitigation is both reasonable and feasible.

➢ Step 11: *What has been done to avoid or minimize negative effects from noise?*

12. Identify what noise mitigation measures are recommended for traffic noise effects.

➢ Step 12: *What has been done to avoid or minimize negative effects from noise? What noise walls are recommended for the 6-Lane Alternative? and What other types of traffic noise mitigation is WSDOT currently considering?*

What criteria are used to evaluate potential effects?

FHWA has published traffic noise criteria that determine when noise mitigation must be considered for a federally funded highway project. The wording of the FHWA criteria leaves some room for interpretation by the state that is conducting the study. The following sections provide details on the FHWA and WSDOT criteria, guiding plans, and policies.

Federal Highway Administration

FHWA traffic noise criteria defined in 23 CFR 772 are compared to the study area traffic-noise levels. The criteria applicable for residences, churches, schools, recreational uses, and similar areas are an exterior hourly L_{eq} that approaches or exceeds 67 dBA. The criteria applicable for other developed lands (such as commercial and industrial uses) are an exterior L_{eq} that approaches or exceeds 72 dBA. FHWA also requires noise abatement to be considered if future noise levels are projected to result in a "substantial increase" over existing noise levels.

Washington State Department of Transportation

WSDOT's NAC further clarify the FHWA traffic noise criteria. WSDOT clarifies the meaning of "approaches" by requiring noise abatement to be considered when predicted project-related noise levels approach the FHWA criteria level within 1 dBA. Therefore, noise abatement must be considered for residential land use with projected noise levels of 66 dBA L_{eq} or higher, and for commercial land uses with noise levels of 71 dBA L_{eq} or higher. Exhibit 9 provides WSDOT's Noise Abatement Table, which identifies noise levels in L_{eq}

> FHWA's use of the terms **approaches** and **substantial increase** leaves room for interpretation by the State of Washington.
>
> WSDOT defines **approaches** as within 1 dBA of the FHWA criteria and **substantial increase** as 10 dBA.

that are considered an impact on various land use activity categories. If a noise impact is identified as part of this Type I project, further analysis of potential noise mitigation shall be studied following procedures outlined in WSDOT's Traffic Noise Analysis and Abatement Policy and Procedures (WSDOT 2006a).

Exhibit 9. WSDOT Noise Abatement Criteria (NAC) Table

Activity Category	L_{eq} (h) (dBA)	Description of Activity
A	57 (exterior)	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.
B	67 (exterior)	Picnic areas, recreation areas, playgrounds, active sports areas, parks residences, motels, hotels, schools, churches, libraries, and hospitals.[a,b]
C	72 (exterior)	Developed lands, properties or activities not included in Categories A or B above.
D	–	Undeveloped lands.
E	52 (interior)	Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals, and auditoriums.[c]

[a] Bicycle and pedestrian facilities that serve a transportation purpose and qualify as a transportation facility shall not be evaluated for noise impacts or mitigation.

[b] Activity category B also includes campgrounds, RV parks, and cemeteries.

[c] Interior noise mitigation will only be considered for public institutions such as schools, hospitals, and libraries and analysis of exterior sound mitigation is determined to be unreasonable or infeasible.

Source: USDOT (1982); endnote source WSDOT (2006a).

WSDOT also clarifies the meaning of "substantial increase" by considering 10 dBA to be a substantial increase.

Noise levels of 80 dBA L_{eq} and higher for outdoor activity areas are defined as "a severe exceedance of the NAC." An NAC exceedance is also considered severe if future design-year noise levels are predicted to increase by 30 dBA or higher over existing noise levels.

There are no criteria for undeveloped lands or construction noise.

This discipline report uses the WSDOT NAC, which FHWA has approved for use on highway projects in Washington.

Guiding Plans and Policies

The noise discipline analysts reviewed the following plans and policies as part of the noise effects criteria analysis:

- Federal Transit Administration (FTA), Transit Noise and Vibration Impact Assessment Manual, 1995
- King County Code (KCC), Chapter 12.88, Environmental Sound Levels as amended by Ordinance 14114, 2001
- Medina Municipal Code, Title 8 Health and Safety, Chapter 8.06 Noise, 2001
- Seattle Municipal Code, Chapter 25.08, Noise Control, 2009
- U.S. Department of Transportation (USDOT), 23 CFR 772, Procedures for Abatement of Highway Traffic Noise and Construction Noise, 1996
- USDOT, FHWA Measurement of Highway-Related Noise, 1996
- USDOT, FHWA Highway Construction Noise: Measurement, Prediction and Mitigation, 1997
- USDOT, FHWA Traffic Noise Model, Version 2.5, 2004
- WAC Chapter 173-60, Maximum Environmental Noise Levels, 1994
- WSDOT, Environmental Procedures Manual, Highway Traffic Noise Analysis and Abatement, Section 446, October 2008
- WSDOT, Traffic Noise Analysis and Abatement Policy and Procedures, March 17, 2006

Affected Environment

What is the study area for the noise analysis?

The FHWA noise standard, which is documented in 23 CFR 772, requires the identification of all existing activities, developed lands, and undeveloped lands for which development is planned, designed, and programmed that noise from the project might affect. As defined in the WSDOT's Traffic Noise Analysis and Abatement Policy and Procedures (WSDOT 2006a), the noise study area that may be affected by noise from the project includes all lands within 500 feet of the project.

The noise discipline analysts performed a detailed reconnaissance of the project vicinity to identify all noise-sensitive properties within 500 feet of the I-5 to Medina project. The study area includes both sides of SR 520; the Seattle neighborhoods of Portage Bay, Roanoke, North Capitol Hill, Montlake, University of Washington, Washington Park Arboretum, Madison Park, Laurelhurst, and Medina. The analysts used physical features such as terrain and ground cover, along with any potential features that could be altered during construction, in the analysis.

It is possible that some roadways farther than 500 feet from the I-5 to Medina project could experience increases in traffic volumes and noise under the proposed action. Under WSDOT policy, any additional roadways that are modified as part of the project are subject to the same level of noise analysis as SR 520. For those roadways where no modifications are proposed, no noise abatement analysis was performed.

At the request of concerned citizens, some areas outside the normal 500-foot range are included in this analysis. These areas include seven locations in the Laurelhurst neighborhood. These same locations were also analyzed in previous environmental noise studies for the SR 520 corridor. This noise report addresses areas from I-5 to the west side of Evergreen Point Road. Areas east of Evergreen Point Road are addressed in the Medina to SR 202 project.

What project coordination was performed?

The noise discipline analysts worked directly with federal, state, and local agencies and with community groups to ensure the study area was adequately defined and all noise-sensitive properties were identified. The analysts coordinated with FHWA, WSDOT, Sound Transit, King County, the City of Seattle, the City of Medina, the Town of Hunts Point, the City of Clyde Hill, the Town of Yarrow Point, the City of Kirkland, and the City of Bellevue. The analysts also attended several community meetings held throughout the I-5 to Medina project corridor. The analysts solicited and received valuable input during these meetings, which was used to select the noise monitoring and modeling locations.

The noise analysts coordinated with WSDOT's Air Quality, Acoustics, and Energy Program for information related to the methods required for a noise study in Washington. The noise analysts worked with WSDOT personnel, project team members, and the general public to identify all noise-sensitive land uses and to determine an acceptable method of analyzing the many parks and trails in the I-5 to Medina project corridor to ensure that noise mitigation would be considered. For a more detailed explanation of the methodology developed for this project see the "What equipment and methods were used for the sound measurements?" section.

The analysts also coordinated with project team leads to obtain the following information:

- **Project design drawings**—details on the project alignment and profiles.
- **Relocations**—information about displacement of public facilities, residents, or commercial uses.
- **Land use**—details on existing study area land use, including noise-sensitive receivers such as residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals, auditoriums, and office space. The analysts also conducted research to identify where any substantial change in land use might be expected.

- **Transportation**—details on traffic data, including volumes, speeds, and vehicle types for all major roadways within the I-5 to Medina project corridor.
- **Recreation, Section 4(f) of the USDOT Act of 1966, and Section 6(f) of the Land and Water Conservation Fund Act of 1965 resources**—coordination with these discipline analysts about potential noise effects on parks and historic properties.

What other local projects may affect the results of this study?

Several other projects are currently under consideration in the greater Puget Sound area that might affect traffic volumes and, therefore, noise levels in the I-5 to Medina project corridor. Because the transportation model takes them into account, these projects are, therefore, included in this noise analysis.

What are the existing sound characteristics of the study area?

This section provides an overview of the characteristics and land use in the I-5 to Medina project corridor as it relates to the noise analysis. Land use is an important factor because it determines what criteria level is used for noise abatement. For noise studies, the actual use of the property determines the abatement criteria, not the land use zone. For example, a residential land use in a commercial or industrial zone is analyzed using the residential NAC, not the less stringent commercial or industrial criteria.

Land Use

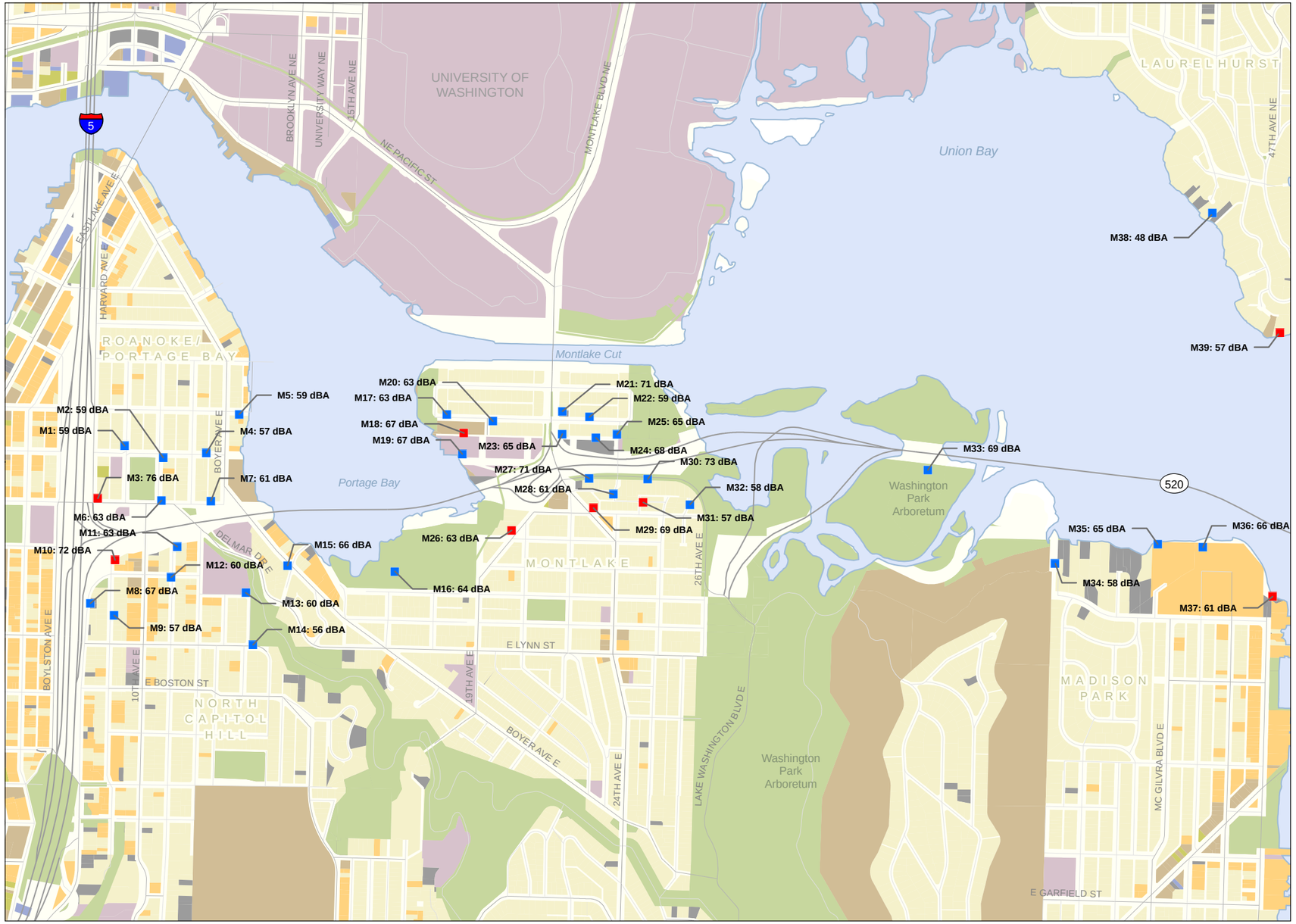
Exhibit 10 shows the land use in the I-5 to Medina project corridor. Land use in the I-5 to Medina project corridor is primarily residential, with some schools, commercial uses, parklands, and undeveloped use scattered along the I-5 to Medina project corridor.

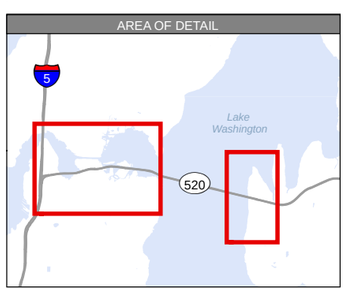
- **Portage Bay/Roanoke.** The Portage Bay/Roanoke neighborhood is primarily single-family residential, and includes a park and a church. Closer to Portage Bay, there are several multifamily land uses, along with some limited commercial uses such as restaurants and retail outlets. Several house boats are in the Portage Bay waterfront area along Boyer Avenue East.

- **North Capitol Hill.** The North Capitol Hill area includes residential and some light commercial uses such as retail and restaurants. Seattle Preparatory School and several parkland areas are also in this area.
- **Montlake.** The Montlake neighborhood is mainly residential with some commercial uses, such as retail stores and restaurants. This area also has parklands, a community center, playfields, the Museum of History and Industry, and the National Oceanic and Atmospheric Administration (NOAA) Northwest Fisheries Science Center (NWFSC) building.
- **Foster Island.** Foster Island is parkland with pedestrian trails.
- **Laurelhurst.** The Laurelhurst neighborhood north of SR 520 across Union Bay is entirely residential and faces the Evergreen Point Bridge.
- **Madison Park.** Madison Park is primarily residential, with a large multifamily complex located along the shore of Lake Washington facing SR 520. There are also several condominiums and single-family residential uses in the area. Commercial uses such as shopping and restaurants are located farther from the lakeshore.
- **Lake Washington.** There are no permanent noise-sensitive land uses in Lake Washington.
- **Medina.** The Medina neighborhood is entirely residential.

As noted previously, the study area should include all lands within 500 feet of the project. At the request of community leaders, some locations considered in this analysis are greater than 500 feet from the project, as WSDOT typically defines the study area. The analysts performed a detailed reconnaissance of the study area to identify all noise-sensitive properties that are, or could be, directly affected by the I-5 to Medina project. All noise-sensitive properties included in this analysis are located on the north and south sides of the I-5 to Medina project corridor, as listed below.

- **Portage Bay/ Roanoke.** North of SR 520 from I-5 to Portage Bay
- **North Capitol Hill.** South of SR 520 from I-5 to Boyer Avenue East
- **Montlake North.** North of SR 520 between Portage Bay and East Montlake Park





Sound Monitoring Location

- Long-term Measurement
- Short-term Measurement

Monitoring Site Identifier — **M1: 59 dBA**

Measured sound level

Existing Land Use

- Single Family
- Multifamily
- Park/Open Space
- Civic and Quasi-Public
- Commercial
- Industrial
- Parking
- Vacant
- Unknown

N

0 500 1,000 2,000 Feet

Source: King County (2008) GIS Data (Parcel), King County (2005) GIS Data (Streets), King County (2007) GIS Data (Water Bodies). Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

Exhibit 10. **Land Use and Monitoring Locations in Project Study Area**

I-5 to Medina: Bridge Replacement and HOV Project

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- **Montlake South.** South of SR 520 between Boyer Avenue East and Lake Washington Boulevard East
- **University of Washington/Husky Stadium.** North of SR 520 within University of Washington Campus
- **Arboretum.** North and South of SR 520 within Washington Park Arboretum
- **Madison Park.** South of SR 520 between Washington Park Arboretum and Lake Washington
- **Laurelhurst.** North of SR 520 within the Webster Point neighborhood along Washington Park Arboretum
- **Medina North.** North of SR 520 between east bridge approach and Evergreen Point Road
- **Medina South.** South of SR 520 between east bridge approach and Evergreen Point Road

Exhibit 11 shows these 10 general neighborhood areas, which are used to organize the large amount of data that was generated in this analysis. For more information on current land uses in the study area, see the Land Use, Economics, and Relocations Discipline Report (WSDOT 2009d).

Topography

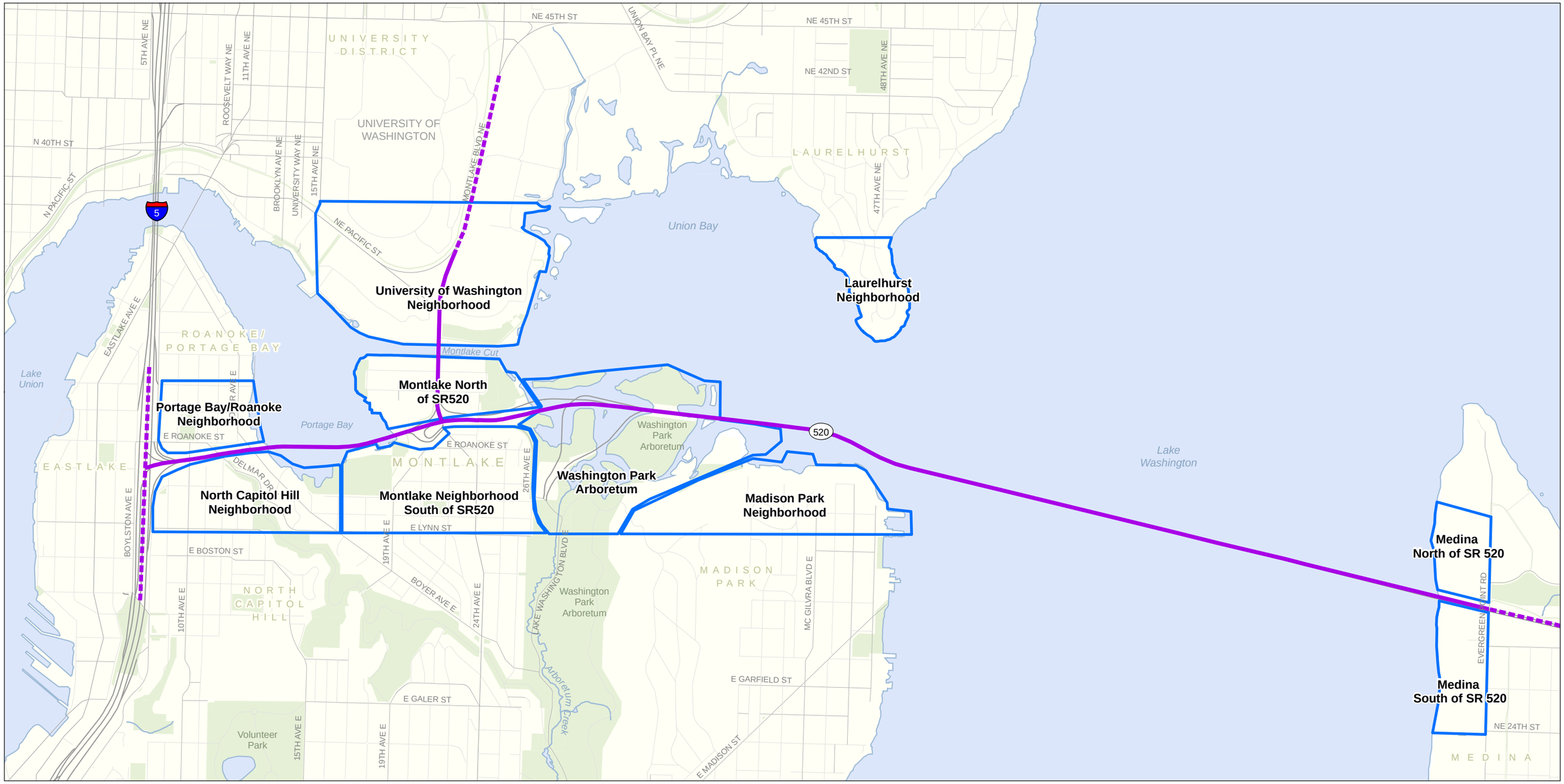
As described previously, the transmission of sound over distance can vary greatly depending on the topographical characteristics between the noise source and receiver. This section provides an overview of the topographical conditions as they relate to the transmission of noise in the I-5 to Medina project corridor.

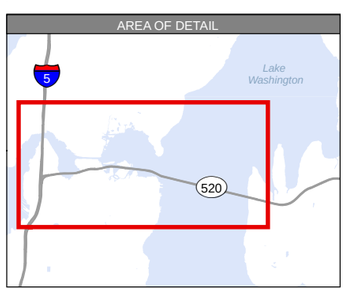
Seattle contains a large variety of topographical features that affect the transmission of noise.

- **Portage Bay/Roanoke.** Near the I-5/SR 520 interchange, both SR 520 and I-5 are depressed when compared to the residential structures in the Portage Bay/Roanoke neighborhood. A new set of noise walls was constructed along the west side of I-5 and along Harvard Avenue on the east side of I-5. The hillside along the north side of SR 520, east of the I-5 interchange, also provides some noise reduction for the Portage Bay/Roanoke neighborhood.

In the eastern end of the Portage Bay/Roanoke area, the ground slopes down to the waterfront area along Boyer Avenue East. Because SR 520 is on a structure near this area (the Portage Bay Bridge), the highway is on the same grade or above the grade of many homes along Boyer Avenue East and nearby areas. Traffic on the Portage Bay Bridge can be heard at greater distances because the residents have a direct line-of-sight view of the SR 520 structure and have no shielding from existing buildings or other topography.

- **North Capitol Hill.** The North Capitol Hill neighborhood is also located above the existing grade of SR 520 in this area. Most receivers in the central and western section of North Capitol Hill have some shielding from SR 520, either from the existing hillside or from other structures. Homes on the eastern end of North Capitol Hill, where the hillside slopes down toward the Portage Bay Bridge, likely experience minimal noise reduction from topographical shielding. Many residents along 13th Avenue East, Boyer Avenue East, and Delmar Drive East have a line-of-sight view of the Portage Bay Bridge and, therefore, have little or no topographical shielding from traffic noise on the bridge.
- **Montlake.** Through Montlake, the roadway is at or near the grade of the surrounding residential areas. SR 520 is depressed at the Montlake Boulevard bridge over SR 520; however, noise reduction from the highway depression is minimal because the gradual ground slope allows noise to travel up the hillside with little reduction and because many receiver locations are close to SR 520.
- **Arboretum, Madison Park, and Laurelhurst.** No substantial noise-reducing topographical features buffer noise from the bridge over Foster Island and north of the Madison Park neighborhood. The Laurelhurst neighborhood is located across Union Bay to the north of the west approach to the Evergreen Point Bridge. The existing highway is approximately 1,500 feet from Webster Point, and residents in this area have a direct line-of-sight to SR 520.
- **Lake Washington.** There are no permanent, noise-sensitive receivers or topographical features, except water, to affect the transmission of noise across Lake Washington. As discussed in the "How Noise Decreases over Distance" section, water acts as an acoustically hard surface and provides less attenuation from





Noise Analysis Area
Construction Extent
Limited Improvement
Park

N

0 500 1,000 2,000 Feet

Source: King County (2005) GIS Data (Streams and Streets), King County (2007) GIS Data (Water Bodies), CH2M HILL (2008) GIS Data (Park). Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

Exhibit 11. **Neighborhood Designations Used in Analysis**

I-5 to Medina: Bridge Replacement and HOV Project

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absorption than softer ground types like field grass. The effects of increased sound propagation over water were included in the study.

- **Medina.** The Medina neighborhood is relatively level. The residents on the north side of SR 520 are either at or slightly above the highway grade, and residents on the south side of SR 520 are either at or slightly below the highway grade.

Why are the sound measurements conducted?

Sound level measurements are recorded only to validate the TNM (see the "Verification of Traffic Noise Model Predictions" section). The sound level measurements are not used to establish the existing sound levels in the study area. Once the model is validated with the sound measurement data, the existing sound levels are established by modeling peak-hour traffic volumes (see the "What are the existing peak-hour traffic noise levels?" section).

Where are the sound measurement locations?

The noise discipline analysts collected a variety of information to help select sound measurement locations. The analysts studied aerial mapping, survey data, computer-aided design (CAD) drawings, and information from the land use analysis, with special attention given to residential areas and the location of SR 520 and other major connector and arterial roads. Based on that research, the analysts selected the general areas for sound monitoring. They then collected more detailed information during onsite visits to the study area. The final selection of specific sound monitoring locations was made through a joint effort between the noise discipline analysts, WSDOT, Sound Transit, and the neighborhood communities and groups.

The noise discipline analysts measured sound levels at 48 locations in the study area. These included 8 long-term (24 hours or greater) and 40 short-term (15 to 30 minutes) monitoring locations. For the long-term monitoring locations, the analysts have provided an averaged peak-hour sound level in L_{eq} dBA. For short-term locations, 15 minutes is generally considered sufficient for obtaining an accurate L_{eq} on busy highways.

Exhibit 12 summarizes the number and type of measurement periods by neighborhood or area. For the purposes of presenting the sound measurement results, the data are consolidated into five major areas as shown in Exhibit 12. The five major areas in Exhibit 12 represent a consolidated list of the 10 neighborhood communities that are used later in this report.

Exhibit 12. Sound Monitoring Locations by Neighborhood

Neighborhood or Area	Short-Term	Long-Term	Total
Portage Bay/Roanoke–North Capitol Hill	14	2	16
Montlake	12	4	16
University of Washington/Arboretum	1	0	1
Madison Park-Laurelhurst	4	2	6
Medina	9	0	9
Project Totals	**40**	**8**	**48**

What equipment and methods were used for the sound measurements?

Traffic noise levels were calculated using the latest FHWA-approved noise model, Traffic Noise Model (TNM), Version 2.5, which was released in April 2004. Input to the model includes traffic volumes generated by the transportation discipline analysts and posted speeds. In addition to the traffic data, sound-reducing effects of existing structures directly bordering the I-5 to Medina project roadway, roadway alignment and profiles, topography, ground cover, and foliage are included in the calculations, where appropriate. Using the information described above, the model predicts the hourly L_{eq} at selected receiver locations throughout the I-5 to Medina project corridor.

Typical Outdoor Systems Used for Long-Term Noise Monitoring

Short-term sound monitoring (15 minutes or more) was performed using time-integrating Type 1 sound level meters equipped with statistical analysis. The meters were calibrated before and after the measurement periods. Each of the sound level meters receives a complete annual system calibration at a National Institute of Standards and Testing-certified traceable calibration laboratory.

Long-term, unattended sound monitoring (24 hours or longer) was performed using time-integrating Type 1 sound level meters equipped with statistical analysis. The meters were calibrated before and after the measurement periods. These systems are in weatherproof cases and battery-operated. The systems store detailed sound levels on an hourly basis over the measurement period, which can range from several hours to several days.

All sound measurements conformed to the guidelines and procedures provided by the American National Standards Institute for community noise measurements, the FHWA Measurement of Highway-Related Noise (USDOT 1996b), and the WSDOT Traffic Noise Analysis and Abatement Policies and Procedures (WSDOT 2006a). Sound measurement locations were at least 5 feet from any solid structure to prevent acoustical reflections. The microphones were on tripods or poles 5 feet off the ground elevation.

A vehicle speed radar gun was used to measure average travel speeds at several locations in the I-5 to Medina project corridor during the sound measurement periods. The radar gun was calibrated using a 60-miles-per-hour (mph) tuning fork. Typical speeds between 2:00 p.m. and 4:00 p.m., which are the peak-hour traffic noise periods based on long-term noise monitoring data, ranged from 50 to 60 mph, with an average of 55 mph. The analysts used the measured speed data to help establish an accurate sound prediction model for existing conditions.

Speed Radar Gun

What are the measured sound levels?

The following sections provide the measured sound level results for the study area, with specific measurements at each monitoring location.

The noise discipline analysts took 40 short-term and 8 long-term sound level measurements between I-5 and Evergreen Point Road. Overall, sound levels between I-5 and Evergreen Point Road ranged from 48 to 76 dBA L_{eq}.

The aerial map in Exhibit 10 shows the sound monitoring locations, land use, and measured sound levels.

Exhibit 13, which presents the sound monitoring data in tabular form, includes the location number, address (closest to the monitoring location), type of measurement (short- or long-term), the measurement duration, and the measured sound level.

Exhibit 13. Project Sound Monitoring Locations, Data, and Descriptions

Number[a]	Address (closest to monitoring location)	Type	Duration	Sound Level[b]
Portage Bay/Roanoke and North Capitol Hill				
M1	2718 Broadway East	Short-Term	15 minutes	59
M2	2636 East 10th	Short-Term	15 minutes	59
M3	2600 Harvard	Long-Term	118 hours[c]	76
M4	1108 Edgar East	Short-Term	15 minutes	57
M5	1208 East Hamlin Street	Short-Term	15 minutes	59
M6	Roanoke at East 10th	Short-Term	15 minutes	63
M7	Boyer Avenue East at Roanoke	Short-Term	15 minutes	61
M8	2348 Harvard Avenue East	Short-Term	15 minutes	67
M9	2320 Broadway Avenue East	Short-Term	15 minutes	57
M10	2412 Broadway Avenue East	Long-Term	42 hours	72
M11	2422 Federal Avenue East	Short-Term	15 minutes	63
M12	East Miller at Federal Avenue East	Short-Term	15 minutes	60
M13	Seattle Preparatory School East Miller at 13th Avenue East	Short-Term	15 minutes	60
M14	East Lynn at 13th Avenue East	Short-Term	15 minutes	56
M15	2525 Boyer Avenue East	Short-Term	15 minutes	66
Montlake				
M16	16th Avenue East at East Calhoun	Short-Term	15 minutes	64
M17	1804 East Hamlin Street	Short-Term	15 minutes	63
M18	NOAA NWFSC Building—North End	Long-Term	46 hours	67
M19	NOAA NWFSC Building—South End by Docks	Short-Term	15 minutes	67
M20	1853 East Hamlin Street	Short-Term	15 minutes	63
M21	Montlake Boulevard at East Hamlin Street	Short-Term	15 minutes	71
M22	2127 East Hamlin Street	Short-Term	15 minutes	59
M23	2734 Montlake Boulevard (frontage road)	Short-Term	15 minutes	65
M24	2147 East Hamlin Street	Short-Term	15 minutes	68
M25	2151 East Hamlin Street	Long-Term	32 hours	65
M26	2553 Montlake Place	Long-Term	46 hours	63
M27	2215 East Lake Washington Boulevard	Short-Term	15 minutes	71
M28	29th Avenue at East North Street	Short-Term	15 minutes	61
M29	2600 Montlake Boulevard	Long-Term	46 hours	69
M30	2415 Lake Washington Boulevard	Short-Term	15 minutes	73
M31	2422 Glenwilde Place East	Short-Term	15 minutes	57
M32	2611 East Royal Court East	Short-Term	15 minutes	58

Exhibit 13. Project Sound Monitoring Locations, Data, and Descriptions

Number[a]	Address (closest to monitoring location)	Type	Duration	Sound Level[b]
University of Washington and Arboretum				
M33	Foster Island Trail—near existing SR 520	Short-Term	15 minutes	69
Madison Park and Laurelhurst				
M34	3702 East McGilvra	Short-Term	15 minutes	58
M35	Canterbury Condominiums near waterfront	Short-Term	15 minutes	65
M36	2510/2511 42nd Avenue East	Short-Term	15 minutes	66
M37	2414 43rd Avenue East (near condo entrance)	Long-Term	25 hours	61
M38	Trail to lake access at NE Belvoir Place	Short-Term	15 minutes	48
M39	3004 Webster Point Road NE	Long-Term	25 hours	57
Medina				
M40	West of 3211, 100 feet from water	Short-Term	15 minutes	60
M41	7525 NE 28th Place	Short-Term	15 minutes	59
M42	2849—dead-end road near Lake Washington	Short-Term	15 minutes	62
M43	2879 west of Evergreen Point Road	Short-Term	15 minutes	70
M44	2853 NE 28th Place	Short-Term	15 minutes	64
M45	201 feet west of Evergreen Point Road	Short-Term	15 minutes	61
M46	3219–3233 Evergreen Point Road	Short-Term	15 minutes	63
M47	2841 NE 28th Place	Short-Term	15 minutes	72
M48	2665 Evergreen Point Road	Short-Term	15 minutes	53

[a] See Exhibit 10 for a map of the sound monitoring locations.

[b] Measured L_{eq} sound level in dBA.

[c] Site M3 was monitored over a 118-hour period that included a weekend; however, only the 70 hours of weekday data were used for this analysis.

Sound Levels Measured in the Neighborhoods

Major sound sources along the I-5 to Medina project corridor are described in the following sections.

Portage Bay/Roanoke–North Capitol Hill

Monitoring locations M1 through M7 were used to characterize the existing sound environment in the Portage Bay area, bordered by Harvard Avenue East and Roanoke Street. Sound levels in this area ranged from 57 to 76 dBA L_{eq}. The highest sound levels were measured near Harvard Avenue East at receivers near the Harvard Avenue/ Roanoke Street intersection. Sound levels measured at receivers with some shielding and farther away from Harvard Avenue ranged from

57 to 63 dBA L_{eq}. Main noise sources included traffic on SR 520, I-5, Harvard Avenue, and East Roanoke Street.

The existing sound environment in the North Capitol Hill neighborhood is characterized by monitoring locations M8 through M15. Measured sound levels ranged from 56 to 72 dBA L_{eq}. Sound levels were highest along Harvard Avenue adjacent to I-5. Other areas with high sound levels included locations along 10th Avenue East due to the high volume of traffic using this arterial and along Boyer Avenue East. Main noise sources included traffic on I-5, SR 520, and 10th Avenue East.

Montlake

Locations M17 through M32 were used to characterize the existing sound environment in the Montlake neighborhood. Measured sound levels ranged from 57 to 73 dBA L_{eq}. The highest sound levels were measured along SR 520 near Montlake Boulevard, along Lake Washington Boulevard, and at the SR 520 access ramps. Major noise sources included SR 520 and associated on-ramps and off-ramps, Montlake Boulevard, and Lake Washington Boulevard.

University of Washington and Arboretum

Monitoring location M33 was used for the Arboretum. The measured sound level near the trail on Foster Island was 69 dBA L_{eq}.

Madison Park and Laurelhurst

Monitoring locations M34 through M37 were used for the Madison Park neighborhood. Measured sound levels in the Madison Park neighborhood ranged from 58 to 66 dBA L_{eq}, with the highest sound levels at the Canterbury Apartments located near SR 520, represented by M36.

Sound levels at the two monitoring locations in the Laurelhurst neighborhood (M38 and M39) were 48 to 57 dBA L_{eq}, respectively.

Medina

There are nine short-term sound monitoring locations between Lake Washington and Evergreen Point Road (locations M40 through M48). Measured sound levels ranged from 53 to 72 dBA L_{eq}. The primary noise source is traffic on SR 520, with additional noise from Evergreen Point Road.

Study Area Noise Modeling

In addition to sites where sound was measured (designated M1 through M48), sound levels were modeled at 211 locations in the I-5 to Medina project corridor. Modeling was performed to determine what locations in the study area exceeded the NAC. Therefore, peak-hour traffic noise levels were calculated for existing conditions using current traffic volumes and for the future No Build Alternative and the 6-Lane Alternative with the Seattle design options using predicted 2030 traffic volumes, with and without noise mitigation measures.

The noise receiver locations were carefully selected to ensure that all potentially affected areas were studied. The noise discipline analysts selected the 211 receivers in the study area based on aerial mapping and onsite visits. The 211 receivers represent approximately 862 residences within the study area.

To help reduce the large volume of data, the analysts selected TNM number designations that would correspond to the 10 neighborhood areas (see "Land Use" under the "What are the existing sound characteristics of the study area?" section). Exhibit 11 shows how the neighborhoods were grouped into receiver designation areas.

The analysts numbered noise modeling locations in each neighborhood for easy and consistent identification. For example, HR-4 is a modeling receiver number in the Portage Bay/Roanoke neighborhood. As shown later in this report, all modeling receivers with an "HR" designation represent the modeled receivers used in the Portage Bay/Roanoke neighborhood. The analysts assigned similar modeling receiver designations (BH, CH, MN, MS, UW, AB, MP, LH, PN, and PS) for the other areas within the study area. The floating homes in Portage Bay represented by "BH" are grouped with the "HR" Portage Bay/Roanoke receivers in the data presented throughout the rest of this report.

Modeled Receiver Designations

HR—Portage Bay/Roanoke
BH—Floating Homes in Portage Bay
CH—North Capitol Hill
MN—Montlake north of SR 520
MS—Montlake south of SR 520
UW—University of Washington
AB—Washington Park Arboretum
MP—Madison Park
LH—Laurelhurst
PN—Medina north of SR 520
PS—Medina south of SR 520

Verification of Traffic Noise Model Predictions

Prior to using the TNM to predict noise levels in the I-5 to Medina project corridor, the noise discipline analysts verified that the model was computing accurate noise levels. This is called model validation.

The analysts used existing roadway alignments and the traffic counts and speed data observed during their monitoring sessions as input into the TNM. Major topographical features that affect the transmission of

noise (for example, hills or high retaining walls) were also used as input.

Next, the analysts ran the TNM and compared the modeled noise levels with the measured noise levels. If the modeled and measured results agreed within ±2 dBA, the model was considered accurate and met WSDOT requirements. A 2-dBA tolerance was used because a person with average hearing would need at least a 3-dBA change in noise level to notice a difference in overall loudness.

For locations where the modeled results differed by more than ±2 dBA from the measured results, the analysts considered several corrective options:

- Identify and add missing terrain, trees, or ground zones to make sure that the model accurately represented the existing conditions in the area
- Apply a correction factor in the TNM to manually adjust the noise levels to within the ±2-dBA tolerance (this is used only in rare cases where reflections or other acoustical anomalies exist)
- Identify and document the reason for the discrepancy (for example, non-traffic-related noise sources such as construction noise that occurred during the measurement period, thus causing the measured level to be higher than the calculated noise levels)

The analysts considered taking additional noise measurements. However, they rejected that option because the I-5 to Medina project corridor is currently being used to test several pavement types to determine if pavement could be used to help reduce traffic noise. The FHWA noise program policy related to tire/pavement noise (Highway Traffic Noise Analysis and Abatement Policy and Guidance [USDOT 1995], page 31), reads as follows:

> "Pavement is sometimes mentioned as a factor in traffic noise. While it is true that noise levels do vary with changes in pavements and tires, it is not clear that these variations are substantial when compared to the noise from exhausts and engines, especially when there are a large number of trucks on the highway. Additional research is needed to determine to what extent different types of pavements and tires contribute to traffic noise.

> "It is very difficult to forecast pavement surface condition into the future. Unless definite knowledge is available on the pavement type and condition and its noise generating characteristics, no adjustments should be made for pavement type in the prediction of highway traffic noise levels. Studies have shown open-graded asphalt pavement can initially produce a benefit of 2–4 dBA reduction in noise levels. However, within a short time period (approximately 6-12 months), any noise reduction benefit is lost when the voids fill up and the aggregate becomes polished. The use of specific pavement types or surface textures must not be considered as a noise abatement measure."

Sound measurements along the corridor performed after the pavement was installed have varied substantially. Therefore, additional sound measurements were not taken due to the likelihood that lower sound level readings would be recorded and erroneously skew this analysis, which is focused on long-term (20-year) results.

The analysts compared the measured with the modeled sound levels at all locations in the I-5 to Medina project corridor. With a few exceptions, all locations were within the ±2-dBA validation requirement. The few exceptions were due to other non-traffic-related sound sources. Because observed traffic volumes and speeds were used for the model validation, modeled values may differ from the typical current peak-hour noise modeling values described later in this report. Results of the model validation are discussed below.

Sound levels were measured at 48 locations between I-5 and Evergreen Point Road. Of the 48 monitoring locations, 47 were selected for model verification. One location, M46, was not included because it is too far from SR 520 where sound from local roadways or other activities is the dominant source. All but one of the 47 selected monitoring locations (see discussion for M47 below) meet the WSDOT ±2 dBA validation criteria. Exhibit 14 summarizes the validation process by analysis area for the study area. The selected I-5 to Medina project receiver validations are discussed in the following sections. Details on model validation for each of the seven analysis areas are provided in Attachments 1A through 1H and discussed below.

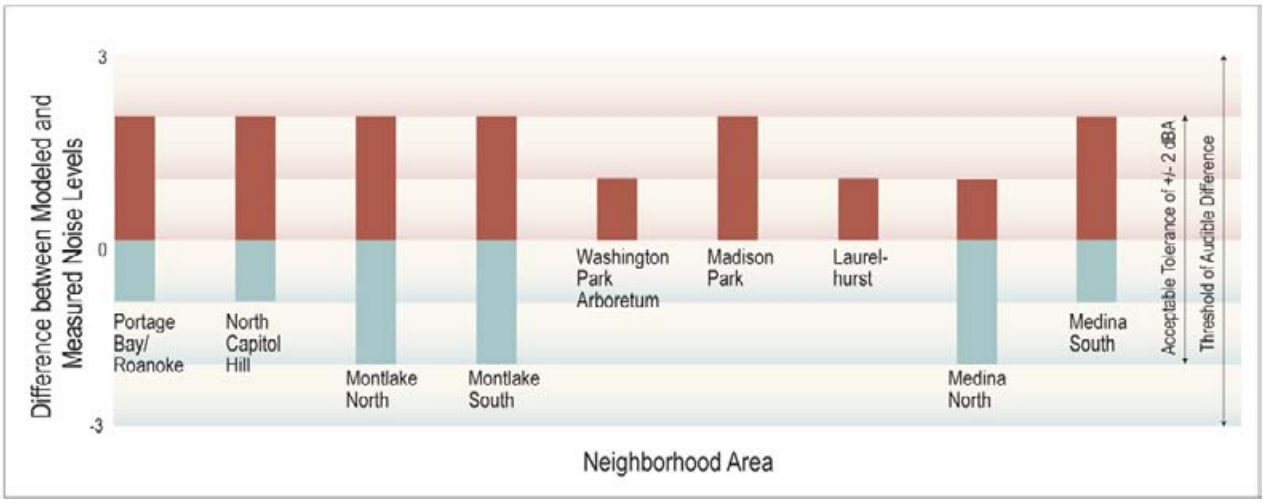


Exhibit 14. Overall Model Validation Summary for the Project Study Area

Portage Bay/Roanoke

In the Portage Bay/Roanoke area, the analysts monitored sound levels at seven different locations. All seven locations were validated, with maximum sound level variances between -1 and +2 dBA when compared to the measured sound levels. Attachment 1A provides a comparison between the measured and modeled sound levels in the Portage Bay/Roanoke neighborhood.

North Capitol Hill

The analysts monitored eight locations in the North Capitol Hill area. All eight locations were validated with the modeled sound levels within a range of -1 and +2 dBA. Attachment 1B provides the validation data for the North Capitol Hill area.

Montlake

The analysts split the Montlake neighborhood into two areas—north of SR 520 and south of SR 520. All 17 sound monitoring locations in both areas were validated, with modeled sound levels varying by ±2 dBA when compared to the measured levels. Attachments 1C and 1D present the validation results for the north and south Montlake areas, respectively.

Washington Park Arboretum

There was one sound monitoring location for the Washington Park Arboretum. The measured sound level was 69 dBA, and the modeled sound level was 70 dBA. The sound level variance of 1 dBA is within

the validation requirements. Attachment 1E provides the validation data for the Arboretum.

Madison Park

The Madison Park neighborhood had four sound monitoring locations. All four were validated, with modeled sound level ranging from 1 to 2 dBA higher than those that were measured. Attachment 1F provides the complete sound model validation results for the Madison Park neighborhood.

Laurelhurst

Two sound monitoring locations were selected in the Laurelhurst neighborhood. Both locations were validated, with the modeled sound levels 1 dBA higher than the measured sound levels. Attachment 1G presents the validation results for the Laurelhurst neighborhood.

Medina

Of the nine sound monitoring locations in the Medina neighborhood (M40 through M48), eight were selected for noise model validation. M46 was not selected for model validation because it is too far from SR 520. Seven of the eight locations validated the modeling results, with the modeled sound levels varying by ±2 dBA when compared to the measured levels. One location (M47) did not validate due to influences by local non-traffic-related noise sources that the model does not account for. Attachment 1H presents the validation results for the Medina neighborhood.

What are the existing peak-hour traffic noise levels?

After the TNM is verified to accurately predict traffic sound levels, the next step in a traffic noise study is to model the existing peak-hour traffic noise levels. Existing peak-hour traffic noise levels (using posted speeds) represent the worst-case noise levels that can be expected under the current roadway alignment and traffic flow conditions. Existing peak-hour traffic noise levels were modeled using posted speeds and 2004 peak-hour traffic volumes generated by the transportation discipline analysts.

Existing peak-hour traffic noise levels were modeled with 211 receivers located throughout the study area. The analysts carefully selected the

receiver locations to ensure that all potentially affected areas would be studied.

The following sections provide detailed results for the I-5 to Medina project corridor noise analysis. Exhibits 27 through 32, which show the sound modeling locations and levels, are provided in the "Potential Effects of the Project Alternatives on Neighborhoods in the Study Area" section.

Existing peak-hour traffic noise levels were modeled for 211 receiver locations, representing 862 residences within the I-5 to Medina project corridor. Noise levels at 75 receivers (representing 288 residences) approach or exceed the WSDOT NAC of 67 dBA L_{eq}.

Portage Bay/Roanoke

Existing peak-hour traffic noise levels were modeled for 26 receiver locations (representing 83 residences) in the Portage Bay/Roanoke neighborhood. Noise levels at residential receiver locations in this area ranged from 56 to 77 dBA L_{eq}, with the highest noise levels at receivers along Harvard Avenue East and East Roanoke Street (HR-1). The results for receivers HR-1 through HR-23 and BH-1 through BH-3 are presented in the "Potential Effects of the Project Alternatives on Neighborhoods in the Study Area" section. Noise levels at 9 receivers (representing 24 residences) currently exceed the NAC in this area.

North Capitol Hill

The analysts modeled existing peak-hour traffic noise levels for 32 receiver locations (representing 219 residences) in North Capitol Hill. The high receiver-to-residence ratio in this neighborhood is due to a large number of apartments. Current noise levels in this area were modeled between 60 and 73 dBA L_{eq}. The results for receivers CH-1 through CH-32 are presented in the "Potential Effects of the Project Alternatives on Neighborhoods in the Study Area" section. Noise levels at 11 receivers (representing 99 residences) in this portion of the study area currently exceed the NAC.

Montlake (North and South of SR 520)

Current peak-hour traffic noise levels were modeled for 35 receiver locations (representing 106 residences) in the Montlake neighborhood north of SR 520. Existing peak-hour noise levels at residential land uses in this area ranged from 59 to 72 dBA L_{eq}, with the highest noise levels near Montlake Boulevard East. The results for receivers MN-1 through

MN-35 are included in the "Potential Effects of the Project Alternatives on Neighborhoods in the Study Area" section. Noise levels at 14 receivers (representing 37 residences) in this area currently exceed the NAC.

Current peak-hour traffic noise levels in the Montlake neighborhood south of SR 520 were modeled for 33 receiver locations (representing 142 residences). Existing peak-hour noise levels at residential land uses in this area ranged from 56 to 74 dBA L_{eq}, with the highest noise levels along Montlake Place and Lake Washington Boulevard East. The results for receivers MS-1 through MS-33 are included in the "Potential Effects of the Project Alternatives on Neighborhoods in the Study Area" section. Noise levels at 12 receivers (representing 63 residences) in this area currently exceed the NAC.

Collectively, noise levels at 26 receivers (representing 100 residences) in the north and south portions of the Montlake neighborhood currently exceed the NAC.

University of Washington/Husky Stadium

Existing peak-hour traffic noise levels were modeled for 16 receivers (representing 83 residential equivalents) within the University of Washington campus (UW-1 through UW-16).

- UW-1 and UW-2 represent noise on the Burke Gilman Trail and green space near Montlake Boulevard East
- UW-3, UW-4, and UW-15 represent other outdoor use areas
- UW-5 through UW-10 represent areas in and around the Husky Stadium
- UW-11 and UW-12 represent outdoor areas near the entrances to the Clarence S. "Hec" Edmundson Pavilion athletic building
- UW-13 and UW-14 represent the University Hospital
- UW-16 is located outside classrooms

Existing peak-hour noise levels at these receivers ranged from 52 to 66 dBA L_{eq}. The results for receivers UW-1 through UW-16 are included in the "Potential Effects of the Project Alternatives on Neighborhoods in the Study Area" section. Existing peak-hour traffic noise levels exceed the NAC at one receiver (representing 2.2 residential equivalents) in this area.

Washington Park Arboretum

In the Washington Park Arboretum, the analysts modeled existing peak-hour traffic noise levels for 20 receiver locations, designated AB-1 through AB-20. Of these, 10 receivers (AB-1 through AB-3 and AB-14 through AB-20) represented 54 residential equivalents and the remaining 10 (AB-4 through AB-13) were used only to determine the distance from SR 520 to where the traffic noise levels would approach or exceed the NAC of 67 dBA L_{eq}. The results for receivers AB-1 through AB-20 and an additional explanation about how the receivers in the Arboretum were used to evaluate this large open space are included in the "Potential Effects of the Project Alternatives on Neighborhoods in the Study Area" section.

Areas in the Arboretum that are within 450 feet of the SR 520 edge-of-roadway currently approach or exceed the residential NAC of 67 dBA L_{eq}. Overall, the modeled noise levels for the 20 receivers in the Arboretum ranged from 56 to 80 dBA L_{eq}. Currently, 22 residential equivalents approach or exceed the NAC.

Madison Park and Laurelhurst

Existing peak-hour traffic noise levels were modeled for 23 receiver locations (representing 99 residences) in the Madison Park neighborhood. Existing peak-hour noise levels at residential land uses in this area ranged from 57 to 69 dBA L_{eq}. The results for receivers MP-1 through MP-23 are included in the "Potential Effects of the Project Alternatives on Neighborhoods in the Study Area" section. Noise levels at 6 receivers (representing 16 residences) in this area currently exceed the NAC.

Current peak-hour traffic noise levels were modeled for 7 receiver locations (representing 15 residences) in the Laurelhurst neighborhood. Existing peak-hour noise levels at residential land uses in this area ranged from 51 to 61 dBA L_{eq}. The results for receivers LH-1 through LH-7 are included in the "Potential Effects of the Project Alternatives on Neighborhoods in the Study Area" section. SR 520 traffic noise levels in this area currently do not exceed the NAC.

Medina

Existing peak-hour traffic noise levels were modeled for 19 receiver locations (representing 61 residences) in the Medina neighborhood. Existing peak-hour noise levels at residential land uses in this area

ranged from 57 to 75 dBA L_{eq}. The results for the Medina receivers are included in the "Potential Effects of the Project Alternatives on Neighborhoods in the Study Area" section. Noise levels at 9 receivers (representing 26 residences) in this area currently exceed the NAC.

Potential Effects of the Project

What methods were used to evaluate the potential effects?

The noise discipline analysts modeled future traffic noise levels using the peak-hour traffic volumes for the design year (2030) and the posted speed limits in the I-5 to Medina project corridor. Traffic noise levels increase with increasing traffic speeds. Because the actual travel speeds are projected to be lower than the posted speed limit (55 mph on SR 520), noise-level projections in this report are considered conservative. Due to this conservative modeling approach, the traffic noise levels presented in this report are likely 1 to 3 dBA higher than what actual noise levels would be in the I-5 to Medina project corridor under the forecasted traffic volumes. Future noise levels were projected for the No Build Alternative and the 6-Lane Alternative with Options A, K, and L.

The five proposed landscaped lids (see sidebar) are treated as part of the base highway design in much the same way as other highway design features (such as the proposed depressed SPUI at the Montlake shoreline and the tunnel under the Montlake Cut with Option K). Therefore, the noise-reducing effects of the proposed lids were included in the future noise-level modeling but are not evaluated under the WSDOT traffic noise mitigation cost-effectiveness criteria. The lid and station platforms would have acoustical treatments that would provide the additional benefit of noise reduction for transit patrons.

Five Landscaped Lids Evaluated for the Project

- I-5/East Roanoke Street
- 10th Avenue East and Delmar Drive East (Delmar lid)
- Montlake vicinity (design and location vary by option) (Montlake lid)
- Montlake Boulevard NE and NE Pacific Street (Options K and L only) (Pacific Street lid)
- Foster Island (land bridge) (Option K only)

The TNM results are presented for each study area neighborhood group within the I-5 to Medina project corridor. The analysts used the existing alignment of SR 520 to model the No Build Alternative. The proposed 6-Lane Alternative alignment, major local arterial roads, and all SR 520 ramps were included in the noise model at the posted speed limits.

Public parks (for example, Washington Park Arboretum) and other outside activity areas (such as the Montlake Playfield) were also included in the modeling analysis. Because these types of facilities

generally have a greater number of receivers than if simply counted as a residence, WSDOT has developed a method of assigning a "residential equivalents" value to noise-sensitive areas such as parks. Based on WSDOT's Environmental Procedures Manual (WSDOT 2008), residential-equivalent values were calculated for the Arboretum, Montlake Playfield, West Montlake Park, NOAA NWFSC outside use area, McCurdy Park, East Montlake Park, the Broadmoor Golf Club, and the University of Washington. Attachment 2 includes the calculations for residential equivalents for these facilities.

For the No Build Alternative, the noise discipline analysts calculated future noise levels using the TNM and compared those results to the 2004 existing noise levels presented in the "What are the existing peak-hour traffic noise levels?" section. Comparing 2004 existing conditions to the 2030 No Build Alternative shows what changes in noise levels could be expected assuming nothing is done to alter SR 520 in the next 20 years.

How would construction of the project affect noise levels?

The noise discipline analysts predicted construction noise levels using the methods described in FHWA Highway Construction Noise: Measurement, Prediction and Mitigation (USDOT 1997). In addition to these FHWA methods, the analysts relied on their experience and work on major construction projects to assist in providing the most accurate information available. Information provided includes descriptions of the types of construction activities required for this type of project, noise levels associated with specific construction equipment, and overall construction-related noise and vibration projections.

Front End Loader

This section discusses the regulations and criteria governing construction noise, the methods of calculating construction noise levels, and the estimated worst-case noise levels for project construction. This section also provides an introduction to construction-related vibration and information on how vibration from construction projects affects humans and structures.

Construction activities could also affect wildlife and habitat, including fish and aquatic habitat. See the Ecosystems Discipline Report (WSDOT 2009a) for more details on the potential effects to wildlife and habitat.

Construction Noise Regulations

Project construction would take place within King County and the communities of Seattle and Medina. Most cities in Washington rely on WAC, Chapter 173-60, "Maximum Environmental Noise Levels," for their noise ordinances. The WAC would apply to this project.

Seattle has adopted noise regulations that apply to construction activities as codified in the Seattle Municipal Code, Chapter 25.08 Noise Control.

The City of Medina has adopted regulations that limits construction and development activity as codified in the Medina Municipal Code, Chapter 8.06, Noise, and more specifically, Chapter 8.06.030, Limitations on construction and development activity. The Medina Municipal Code has adopted portions of the King County Code by reference (KCC Chapters 12.86 through 12.100).

Because these regulations are subject to change, the most current versions must be used at the time construction commences within each community. The project contractor would be required to adhere to the construction noise regulations and obtain any site-specific requests for variances or other construction-related noise issues associated with the proposed project.

The following sections describe, in general, the construction noise regulations that apply to this project at the time this report was prepared. Each applicable code should be reviewed prior to the start of construction to assure that all requirements are met.

Washington Administrative Code (WAC)

Daytime construction noise is exempt from regulations in the WAC. Therefore, within the WAC noise ordinance, project construction could be performed during the normal daytime hours of 7:00 a.m. to 10:00 p.m. If construction were to be performed during nighttime hours, the contractor would be required either to meet the noise-level requirements presented in Exhibit 15 or to obtain a noise variance from the governing jurisdiction.

In addition to the property-line noise standards listed in Exhibit 15, there are exemptions for short-term noise exceedances, including those outlined in Exhibit 16, that are based on the minutes per hour that the noise limit is exceeded. This exhibit also provides the corresponding statistical descriptors for each range of exceedances.

Exhibit 15. Washington State Noise Control Regulation

Source of Noise	Receiver of Noise (Maximum Allowable Sound Level in dBA[a])		
	Residential	Commercial	Industrial
Residential	55	57	60
Commercial	57	60	65
Industrial	60	65	70

[a] Between 10:00 p.m. and 7:00 a.m., the levels given above are reduced by 10 dBA for residential receiving property.

Exhibit 16. Washington State – Exemptions for Short-Term Noise Exceedances

Statistical Descriptor[a]	Minutes Per Hour	Adjustment to Maximum Sound Level
L_{25}	15 (25% of one hour)	+5 dBA
$L_{8.3}$	5 (8.3% of one hour)	+10 dBA
$L_{2.5}$	1.5 (2.5% of one hour)	+15 dBA

[a] L_{25}, $L_{8.3}$ and $L_{2.5}$ are the noise levels that are exceeded 25 percent, 8.3 percent, and 2.5 percent of the time (one hour, in this case).

Seattle Municipal Code

The City of Seattle has developed a set of construction-specific allowable noise-level limits that would apply to construction of the I-5 to Medina project within the Seattle City limits. Unlike the WAC, the Seattle Municipal Code does not exempt daytime construction activities from regulation. Although, the City of Seattle has not generally enforced its regulations on daytime construction activities for highway projects, the contractor should discuss its plans with the City of Seattle and obtain variances as needed. Exhibit 17 includes the maximum permissible sound levels depending on the district designations of the sound source and receiving properties.

The City of Seattle noise-level limits listed in Exhibit 17 are reduced or increased as follows:

1) Between 10:00 p.m. and 7:00 a.m. during weekdays, and between 10:00 p.m. and 9:00 a.m. on weekends, the levels are reduced by 10 dBA for residential receiving property.

2) For any source of sound that is periodic, has a pure tone component, or is not measured with an impulse sound level meter, the levels are reduced by 5 dBA. Electrical substations are exempt from this penalty.

3) For any source of sound that is of short duration, the levels are increased as shown in Exhibit 18.

Exhibit 17. City of Seattle – Maximum Permissible Sound Levels

District of Sound Source	District of Receiving Property within the City of Seattle (dBA[a])		
	Residential (dBA)	Commercial (dBA)	Industrial (dBA)
Rural	52	55	57
Residential	55	57	60
Commercial	57	60	65
Industrial	60	65	70

[a] Applies to daytime hours of 7:00 a.m. to 10:00 p.m.

Exhibit 18. City of Seattle – Exemptions for Short-Term Noise Exceedances

Statistical Descriptor[a]	Minutes Per Hour	Adjustment to Maximum Sound Level
L_{25}	15 (25% of one hour)	+5 dBA
$L_{8.3}$	5 (8.3% of one hour)	+10 dBA
$L_{2.5}$	1.5 (2.5% of one hour)	+15 dBA

[a] L_{25}, $L_{8.3}$ and $L_{2.5}$ are the noise levels that are exceeded 25 percent, 8.3 percent, and 2.5 percent of the time (one hour, in this case).

At the time this report was written, the short-term allowable exceedances in Exhibit 18 are the same as those provided in the WAC (see Exhibit 16).

The Seattle Municipal Code, Chapter 25.08.425, applies directly to construction and equipment operations. For the purposes of enforcement, the maximum permissible sound levels listed in Exhibit 17, and the time-restrictive limits in Exhibit 18, are to be measured from the real property of another person or at a distance of 50 feet from the equipment, whichever is greater.

The levels in Exhibit 17 may be exceeded between 7:00 a.m. and 10:00 p.m. on weekdays and between 9:00 a.m. and 10:00 p.m. on weekends by no more than the amounts shown in Exhibit 19.

Exhibit 19. City of Seattle – Allowable Exceedances for Construction and Equipment Operations

Allowable Exceedance	Equipment Covered
25 dBA	Equipment on construction sites, including but not limited to crawlers, tractors, dozers, rotary drill and augers, loaders, power shovels, cranes, derricks, graders, off-highway trucks, ditchers, trenchers, compactors, compressors, and pneumatic-powered equipment
20 dBA	Portable powered equipment used for temporary locations in support of construction activities or used in the maintenance of public facilities, including but not limited to chainsaws, log chippers, lawn and garden equipment, and powered hand tools
15 dBA	Powered equipment used in temporary repair or periodic maintenance of the grounds and appurtenances of residential property, including but not limited to lawnmowers, powered hand tools, snow removal equipment, and composters.

Sounds created by impact types of construction equipment (including but not limited to pavement breakers, pile drivers, jackhammers, sandblasting tools, or other types of equipment or devices that create impulse noise or impact noise or are used as impact equipment) as measured at the property line or 50 feet from the equipment, whichever is greater, may exceed the noise-level limits given in Exhibit 17 in any 1-hour period between 8:00 a.m. and 5:00 p.m. on weekdays and 9:00 a.m. and 5:00 p.m. on weekends by no more than the maximum noise levels shown in Exhibit 20.

Construction activities that exceed the maximum permissible sound levels in Exhibit 17, when measured from the interior of buildings within a commercial district, are prohibited between 8:00 a.m. and 5:00 p.m. For the purposes of this limitation for commercial receiving property, interior sound levels shall be measured only after every reasonable effort, including but not limited to closing windows and doors, is taken to reduce the effect of exterior construction noise.

Medina Municipal Code

The City of Medina has adopted the noise control provisions of the King County Code (KCC Chapters 12.86 through 12.100) governing excessive noise and noise control. In addition, City of Medina

Exhibit 20. City of Seattle – Maximum Noise Levels for Impact Types of Construction Equipment

Statistical Descriptor[a]	Noise Level (in dBA L_{eq})	Time Duration Exceedance Prohibited
L_{eq}	90	Continuously
L_{50}	93	30 minutes
L_{25}	96	15 minutes
$L_{12.5}$	99	7.5 minutes[b]

[a] L_{eq}, L_{50}, L_{25}, and $L_{12.5}$ are the equivalent sound level and the noise levels that are exceeded 50 percent, 25 percent, and 12.5 percent of the time.

[b] Provided that sounds levels in excess of 99 dBA are prohibited unless authorized by variance obtained from the Administrator; and provided further that sources producing sound levels less than 90 dBA shall comply with the provisions (A) and (B) as follows:

(A) The standard of measurement shall be a 1 hour L_{eq}. L_{eq} may be measured for times not less than 1 minute to project hourly L_{eq}. Reference to 1 hour is for measurement purposes only and shall be construed as limiting construction to a 1-hour period.

(B) These provisions shall be reviewed periodically by the City to assure that the sound level limits are technically feasible.

Municipal Code Chapter 8.06.030, Limitation on construction and development activity, provides specific regulations relating to construction. KCC Chapter 12.88.040 contains specific regulations for construction and equipment operation. At the time this report was written, the KCC construction regulations were the same as those provided under the Seattle Municipal Code (see Exhibits 17 through 20). For this reason, the KCC is not reprinted here.

The portion of the Medina Municipal Code that relates to construction activity states that:

- It is a violation of this chapter to engage in any commercial construction and development activity or to operate any heavy equipment before 7:00 a.m. and after 7:00 p.m. Monday through Friday and before 8:00 a.m. and after 5:00 p.m. on Saturday. No construction and development activity or use of heavy equipment may occur on Sundays or holidays that are holidays observed by the city.
- The city manager or designee may grant written permission to engage in a construction and development activity or to operate heavy equipment after the hours of 7:00 p.m. and before 7:00 a.m. on Monday through Friday and after the hours of 5:00 p.m. and before 8:00 a.m. on Saturday, on Sundays or holidays that are observed by the city if this will not unreasonably interfere with any residential use.

Haul Truck Criteria

The KCC (and the Medina Code by reference to the KCC) establishes maximum permissible sound levels for haul trucks that could be used for the project. Haul trucks are limited to 86 dBA for speeds of 35 mph or less, and 90 dBA for speeds over 35 mph, when measured at 50 feet.

Alarm Criteria

The WAC exempts sounds created by warning devices not operating continuously for more than 5 minutes. This exemption does not apply during nighttime hours (10:00 p.m. to 7:00 a.m.) for residential receiving property.

The City of Seattle now requires the use of broadband alarm systems or both back-up spotters and broadband alarms on nighttime constructions sites.

The KCC (and the Medina Code by reference to the KCC) exempt sounds at all times created by warning devices not operated continuously for more than 30 minutes per incident.

Construction Vibration Prediction Methods and Effect Guidelines

There are no specific regulations or criteria applicable to vibration related to construction activities. However, State Environmental Policy Act (SEPA) and National Environmental Policy Act (NEPA) guidelines allow federal, state, and local agencies the authority to determine acceptable levels of construction vibration using guidelines, research, and professional standards. King County, the City of Seattle, and the City of Medina have not adopted vibration guidelines that would apply to this project. For this project, WSDOT would rely on the USDOT guidelines for acceptable vibration levels from construction activities. The guidelines, based on information given in Exhibit 21, recommend that the maximum peak-particle-velocity levels remain below 1.27 inches per second at structures nearest the construction site. Vibration levels above 1.27 inches per second have the potential to cause architectural damage to normal dwelling-houses with plastered ceilings and walls. USDOT also states that vibration levels above 0.64 inch per second can be annoying to people and disrupt normal working or living environments (USDOT 1978).

Peak particle velocity is the maximum vibration velocity of an object during a specific period of measurement.

Exhibit 21. Peak Particle Velocity Guidelines

Vibration Velocity (in/sec)	Effects on Humans	Effects on Buildings
0 to 0.001	Imperceptible to people—no intrusion	Vibrations unlikely to cause damage of any type
0.04 to 0.08	Threshold of perception—possibility of intrusion	Vibrations unlikely to cause damage of any type
0.15	Vibrations perceptible	Recommended upper level of the vibration to which ruins and ancient monuments should be subjected
0.64	Level at which continuous vibrations begin to annoy people	Virtually no risk of "architectural" damage to normal buildings
1.27	Vibrations annoying to people in buildings (this agrees with the levels established for people standing on bridges and subjected to relatively short periods of vibrations)	Threshold at which there is a risk of "architectural" damage to normal dwelling-houses with plastered ceilings and walls
2.54 to 3.81	Vibrations considered unpleasant by people subjected to continuous vibrations and unacceptable to some people walking on bridges	Vibrations at a greater level than normally expected from traffic, but would cause "architectural" damage and possible minor structural damage

in/sec = inches per second

Source: USDOT (1978).

Based on the information presented in Exhibit 21, the noise discipline analysts recommend that vibration monitoring be considered as a possible course of action during construction activities that might produce vibration levels near the USDOT maximum recommended vibration level of 1.27 inches per second. This would include pile driving, vibratory sheet installation, soil compacting, and other construction activities that have the potential to cause high levels of vibration when the activity is within 50 to 75 feet of a vibration-sensitive property.

Noise Levels that Could be Expected during Construction

The analysts considered temporary noise effects that construction could cause in the study area; effects that would end when project construction was completed.

Typical construction equipment used for many roadway and structural activities would be required to complete the I-5 to Medina project. Exhibit 22 lists equipment typically used for constructing this type of project, the activities they would be used for, and the corresponding maximum noise levels under normal use measured at 50 feet.

Exhibit 22. Construction Equipment List, Use, and Reference Maximum Noise Levels

Equipment	Typical Expected Project Use[a]	L_{max}[b] (dBA)	Source[c]
Air Compressor	Used for pneumatic tools and general maintenance—all phases	70–76	1, 2, 3
Backhoe	General construction and yard work	78–82	2, 3
Concrete Pump	Pumping concrete	78–82	2, 3
Concrete Saw	Concrete removal, utilities access	75–80	2, 3
Crane	Materials handling, removal, and replacement	78–84	2, 3
Excavator	General construction and materials handling	82–88	2, 3
Forklift	Staging area work and hauling materials	72	1, 2, 3
Haul Truck	Materials handling, general hauling	86	2, 3
Jackhammer	Pavement removal	74–82	2, 3
Loader	General construction and materials handling	86	2, 3
Paver	Roadway paving	88	2
Pile Driver	To supply support for structure and hillside	99–105	2, 3
Power Plant	General construction use, nighttime work	72	2, 3
Pump	General construction use, water removal	62	2, 3
Pneumatic Tools	Miscellaneous construction work	78–86	3
Service Truck	Repair and maintenance of equipment	72	2, 3
Tractor Trailer	Material removal and delivery	86	3
Utility Truck	General project work	72	2
Vibratory Equipment	To shore up a hillside to prevent slides and soil compacting	82–88	2, 3
Welder	General project work	76	2, 3

[a] Typical maximum noise level under normal operation as measured at 50 feet from the noise source.

[b] Maximum noise level as measured at a distance of 50 feet under normal operation.

[c] Sources of noise levels presented:

1 Portland, Oregon, light rail, I-5 preservation, and Hawthorne Bridge construction projects
2 Measured data from other projects in the Portland, Oregon, area
3 USDOT or other construction noise source

Project Construction Phases and Noise Levels

Four general construction phases would be required to complete the I-5 to Medina project. Typical construction phases for the project would include the following:

- Preparing for construction of new structures
- Constructing new structures and paving roadways

- Conducting miscellaneous activities, including striping, lighting, and providing signs
- Demolishing existing structures

To provide the public with a general understanding of how loud construction might be, the analysts performed a study that assumed worst-case noise levels based on the four expected construction phases plus construction pile-driving activities. The noise levels presented in this report are for periods of maximum construction activity. The actual noise levels experienced during construction would generally be lower than those described in this report.

Using the information provided in Exhibit 22, the analysts projected typical construction noise levels for several distances from the I-5 to Medina project work area. Exhibit 23 identifies the overall noise levels for each of the four typical construction phases as measured at 50 feet from the construction activity.

Following Exhibit 23, each of the four defined construction phases is discussed, including the assumptions about the equipment that would be used in each of the phases. Pile driving and construction vibration effects are discussed separately.

Preparing for Construction of New Structures

Major noise-producing equipment used during the preparation stage could include concrete pumps, cranes, excavators, haul trucks, loaders, and tractor trailers. Maximum noise levels could reach 82 to 86 dBA at the nearest residences (50 to 100 feet) for normal construction activities during this phase. Other less noticeable noise-producing equipment expected during the preparation phase includes backhoes, air compressors, forklifts, water pumps, power plants, service trucks, and utility trucks.

Constructing New Structures and Paving Roadways

The loudest noise sources during new bridge construction would include cement mixers, concrete pumps, pavers, haul trucks, and tractor trailers. The cement mixers and concrete pumps would be required to construct the superstructure and substructure. The pavers and haul trucks would be used to provide the final surface on the roadway and to construct the transitions from the at-grade roadway to the new structures. Maximum noise levels would range from 82 to 94 dBA at the closest receiver locations.

Exhibit 23. Noise Levels for Typical Construction Phases at 50 Feet from Work Site

Scenario[a]	Equipment[b]	L_{max}[c] (dBA)	L_{eq}[d] (dBA)
Preparing for construction of new structures	Air compressor, backhoe, concrete pump, crane, excavator, forklift, haul truck, loader, water pump, power plant, service truck, tractor trailer, utility truck, and vibratory equipment	94	87
Constructing new structures and paving roadways	Air compressor, backhoe, cement mixer, concrete pump, crane, forklift, haul truck, loader, paver, pump, power plant, service truck, tractor trailer, utility truck, vibratory equipment, and welder	94	88
Conducting miscellaneous activities, including striping, lighting, and providing signs	Air compressor, backhoe, crane, forklift, haul truck, loader, pump, service truck, tractor trailer, utility truck, and welder	91	83
Demolishing existing structures	Air compressor, backhoe, concrete saw, crane, excavator, forklift, haul truck, jackhammer, loader, power plant, pneumatic tools, water pump, service truck, and utility truck	93	88

[a] Operational conditions under which the noise levels are projected.

[b] Normal equipment in operation under the given scenario.

[c] L_{max} (dBA) is an average maximum noise emission for the construction equipment under the given scenario.

[d] L_{eq} (dBA) is an energy average noise emission level for construction equipment operating under the given scenario. For this type of equipment, the L_{eq} is approximately equal to the L_{50} (that is, noise levels that are exceeded 50 percent of the time).

Note: Combined worst-case noise levels for all equipment at a distance of 50 feet from work site.

Conducting Miscellaneous Activities

Following heavy construction, general construction activities such as installing bridge railings, providing signage, striping roadways, and conducting other general activities would occur. These less intensive activities would not be expected to produce noise levels above 80 dBA at 50 feet except during rare occasions, and then for only short periods. In general, the miscellaneous activities are expected to produce noise levels that would be less than the short-term noise-exceedance limits set forth in the WAC, the Seattle Municipal Code, and the Medina Municipal Code.

Demolishing Existing Structures

Demolition of the existing structures would require heavy equipment such as concrete saws, cranes, excavators, backhoes, haul trucks, jackhammers, loaders, and tractor trailers. Maximum noise levels could reach 82 to 92 dBA at the nearest residences.

The construction noise analysis assumed that there would be construction staging areas along the proposed bridges during demolition and construction activities. The typical maximum noise levels listed in Exhibit 23 would occur only periodically during the

heaviest periods of construction. Actual hourly noise levels could be substantially lower than those stated, depending on the level of activity at that time.

Exhibit 24 translates the noise levels in Exhibit 23 into a graph showing maximum noise levels for each construction phase at various distances from the construction site. This graph can be used to approximate construction noise levels at noise-sensitive properties at various distances from construction activity.

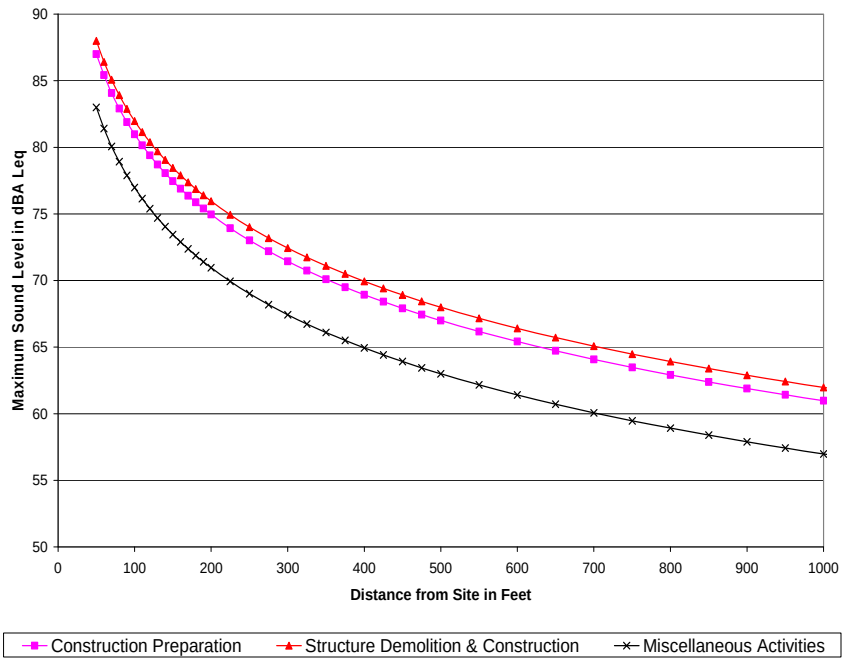


Exhibit 24. Hourly Maximum Construction Noise for Different Distances from Construction Site

Pile Driving

Vibratory and impact equipment (such as pile driving and vibratory sheet installations) is another major noise source that might be required during construction preparation. These activities would supply support for temporary bridges and the new structure and would shore up hillsides to stop slides before retaining walls were installed.

Pile driving can produce maximum short-term noise levels of 99 to 105 dBA at 50 feet. Actual levels can vary, depending on the distance and topographical conditions between the pile-driving location and the receiver location. The noise-level limits for pile driving (see Exhibit 20) can vary depending on the frequency of pile driving and the number of pile drivers operating at one time in any one area. Exhibit 25 provides a

graph of a maximum pile-driving noise level based on 105 dBA at 50 feet for distances up to 1,000 feet.

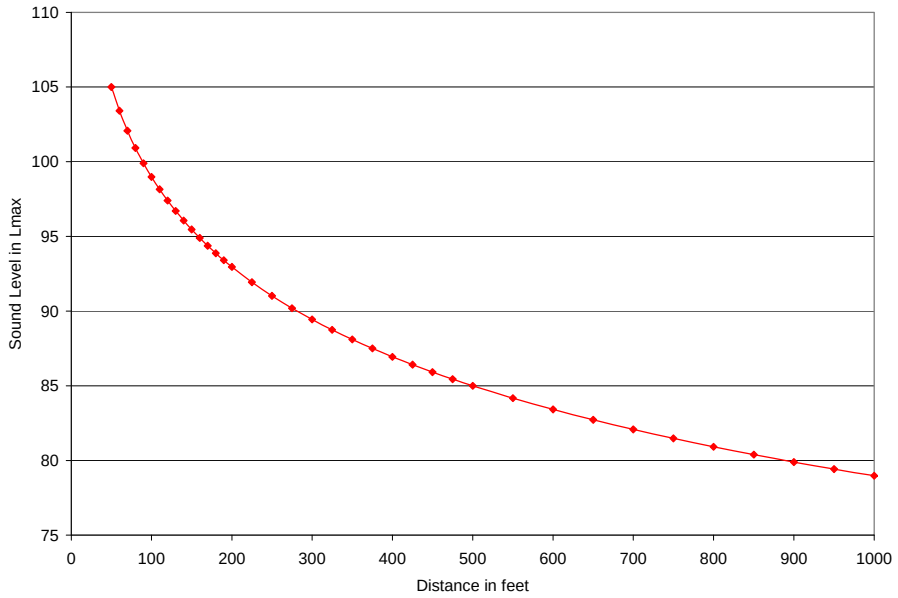
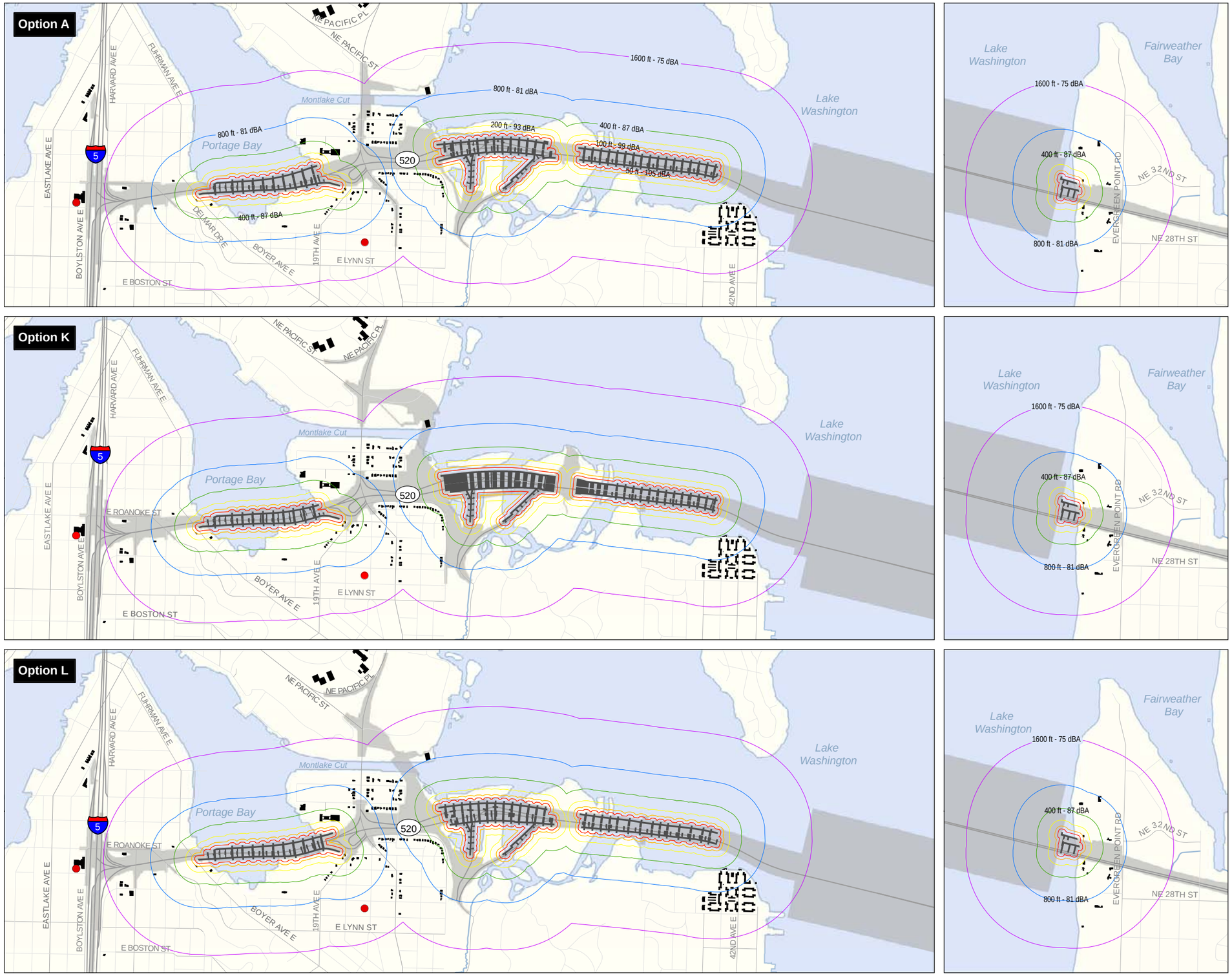
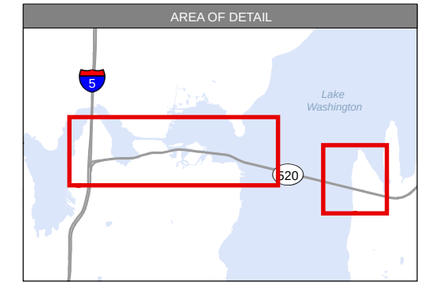


Exhibit 25. Typical Maximum Pile-Driving Noise Levels Assuming 105 dBA at 50 Feet

Exhibit 26 shows contoured views of the potential pile-driving noise that could occur with each of the design options. The noise-level contours are based on a maximum of 105 dBA at 50 feet and assume a drop-off rate of 6 dBA per doubling of distance out to 1,000 feet. The contours shown in Exhibit 26 should serve as conservative estimates because they ignore excess attenuation resulting from ground and atmospheric absorption.

Noise and associated construction activity can disturb wildlife by causing stress and altering behavior patterns and, therefore, interfering with activities such as reproduction and feeding. The degree of disturbance would depend on the noise level, timing, and duration of construction activities, as well as the sensitivity of the individual animals. In general, most wildlife species found in areas adjacent to the I-5 to Medina project site are adapted to urban conditions and highway noise. However, loud construction activities could displace some animals or discourage them from using adjacent habitats. In extreme cases, birds could abandon their nests in response to noise disturbance. See the Ecosystems Discipline Report (WSDOT 2009a) for more details on the potential effects of construction noise on wildlife and habitat, including fish and aquatic habitat.





- Public School
- Historic Building
- Construction Work Bridge
- Limits of Construction

Pile Driving Noise Level

- 50-feet (noise level of 105 dBA)
- 100-feet (noise level of 99 dBA)
- 200-feet (noise level of 93 dBA)
- 400-feet (noise level of 87 dBA)
- 800-feet (noise level of 81 dBA)
- 1600-feet (noise level of 75 dBA)

N

0 500 1,000 2,000 Feet

Note: Contours based on the general rule that noise levels from a point source like pile driving drop off (attenuate) at a rate of 6 dBA per doubling of distance. The contours represent a conservative estimate that ignores excess attenuation resulting from ground and atmospheric absorption.

See Exhibit 20. City of Seattle - Maximum Noise Levels for impact Types of Construction Equipment for noise level limits of pile driving or other impact types of construction equipment.

Source: King County (2008) GIS Data (Streets, Water Bodies), Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

Exhibit 26. **Potential Pile Driving Noise in the Study Area**

I-5 to Medina: Bridge Replacement and HOV Project

Construction Vibration Effects

Vibration associated with general construction can affect surrounding receivers. Major vibration-producing activities would occur primarily during demolition and preparation for the new bridges. Activities that have the potential to produce a high level of vibration include pile driving, vibratory shoring, soil compacting, and some hauling and demolition. Vibration effects from pile driving or vibratory sheet installations could occur within 50 to 100 feet of sensitive receivers. It is unlikely that vibration levels would exceed 0.5 inch per second at distances greater than 100 feet from the construction sites. (See Exhibit 21 for peak particle velocity guidelines.)

How would operation of the project affect noise levels?

This section discusses the overall effects of the No Build Alternative and operation of the 6-Lane Alternative in the study area, including discussions of the effects on individual communities and neighborhoods.

No Build Alternative

Under the No Build Alternative, peak-hour traffic flow conditions on project roadways represent the worst-case noise levels because the modeling assumed a posted speed of 55 mph (higher traffic speeds generate higher noise levels). The modeling results are presented for each neighborhood within the study area. The analysts paid particular attention to any increase in noise levels above existing peak-hour traffic conditions that would cause noise levels at additional residences to exceed the NAC.

The No Build Alternative peak-hour traffic noise levels were modeled for the same 211 receiver locations in the study area as the existing peak-hour traffic conditions. Noise levels would be expected to increase slightly over current levels because of growth in traffic volumes on SR 520 and other roadways within the study area. Of the 211 modeled receivers, 86 (representing 327 residences) would have noise levels that approach or exceed the NAC of 67 dBA L_{eq}. Currently, 75 receivers (representing 288 residences) exceed the NAC. Under the No Build Alternative, an additional 39 residences would exceed the NAC.

6-Lane Alternative

The 6-Lane Alternative peak-hour traffic noise levels represent the worst-case traffic noise levels that could be expected with 2030 traffic flow conditions. This section compares the 6-Lane Alternative peak-hour traffic noise levels with those that could be expected under the No Build Alternative.

Of the 211 receiver locations modeled for the existing and No Build Alternative peak-hour traffic noise conditions, 3 receivers (representing 4 residences) would be displaced with Options A and K. With Option L, 4 receivers (representing 7 residences) would be displaced by the project. These displaced receivers are discussed in more detail in the following sections.

The I-5 to Medina project peak-hour traffic noise levels were modeled for the remaining 208 receiver locations for Options A and K and for 207 receiver locations under Option L. With Options A and K, the 208 receivers represented 858 residences and residential equivalents throughout the study area. With Option L, project peak-hour traffic noise levels were modeled for 207 receiver locations (representing 855 residences). Compared to the No Build Alternative, the 6-Lane Alternative would lower the number of residences where noise levels would exceed the NAC due to the noise-reducing elements of the proposed design, which include lids, depressed roadway sections, and roadway realignments.

With Option A, the number of residences exceeding the NAC would decrease to 249 compared to 327 under the No Build Alternative. Under Options K and L, the number of residences that would exceed the NAC would decrease to 256 and 235, respectively. The modifications in the horizontal and vertical alignments of the project roadways, construction of new retaining walls, and the addition of lids and landscape features over the highway at I-5/East Roanoke Street, 10th Avenue East/Delmar Drive East (Delmar lid), Montlake vicinity (Montlake lid), and Montlake

I-5 to Medina Project Corridor Summary
(without Noise Mitigation)

Number of Residences Where Noise Levels Would Approach or Exceed NAC
(% of residences where noise levels would approach or exceed NAC based on the 862[a] total residences identified in the study area)

Current	No Build Alternative	6-Lane Alternative		
		Option A	Option K	Option L
288 (33.5%)	327 (37.9%)	249 (29.0%)	256 (29.8%)	235 (27.5%)

[a] For Options A and K, the percentages of residences are based on a total of 858 residences and, for Option L, a total of 855 residences.

Boulevard NE/NE Pacific Street (Pacific Street lid) would be the primary reasons for the reduction in noise levels.

The Foster Island land bridge, if constructed, could reduce noise levels in the Arboretum by up to 3 dBA, but only in those areas within about 100 feet of the proposed land bridge.

Exhibits 27 through 32 show the receiver locations and modeled sound levels. For each receiver, the existing, 2030 No Build Alternative, and 2030 6-Lane Alternative peak-hour noise levels are shown. Sound levels under the 2030 6-Lane Alternative are shown for both "with" and "without" the recommended noise walls. The "What noise walls are recommended for the 6-Lane Alternative?" section provides a detailed discussion of the recommended noise walls.

Exhibits 33 through 35 present the results of the traffic noise analysis in terms of relative noise-level changes that could be expected for each neighborhood. For the purposes of describing the noise-level changes, the 2030 6-Lane Alternative peak-hour traffic noise levels are compared to the existing and 2030 No Build Alternative peak-hour traffic noise levels.

The exhibits show the noise modeling sites, note which receivers exceed the NAC, and provide a symbol indicating whether a person with average hearing would notice an increase, decrease, or no change in traffic noise. Noise levels would be reduced by 3 dBA L_{eq} or more at locations where there would be a noticeable decrease in noise levels. Conversely, noise levels would increase by 3 dBA L_{eq} or more at receivers where there would be a noticeable increase in traffic noise. Noise levels at locations shown as having no noticeable change would remain within 2 dBA L_{eq} of current levels.

Potential Effects of the Project Alternatives on Neighborhoods in the Study Area

This section describes the relative audible differences for each neighborhood in the study area. The focus is on where traffic noise levels would approach or exceed the NAC and on the noise-level differences between existing conditions and the 2030 No Build Alternative and the 2030 6-Lane Alternative.

Portage Bay/Roanoke

The noise discipline analysts modeled peak-hour traffic noise levels for 26 receiver locations (representing 83 residences) in the Portage Bay and

Roanoke areas. Currently, 24 residences exceed the NAC. Compared with existing conditions, noise levels in this portion of the study area would increase by 1 dBA L_{eq} under the No Build Alternative. However, no additional residences would exceed the NAC.

Portage Bay/Roanoke without Noise Mitigation Number of Residences Where Noise Levels Would Exceed NAC				
		6-Lane Alternative		
Current	No Build Alternative	Option A	Option K	Option L
24	24	26	27	27

Under the 6-Lane Alternative with Option A, 9 receivers—HR-1 through HR-3, HR-5 through HR-8, HR-10, HR-14 and HR-15 (representing 26 residences)—would have noise levels that exceed the NAC in this area. These 26 residences would exceed the NAC due to their proximity to unmitigated traffic noise from I-5 and East Roanoke Street. One receiver in this neighborhood, HR-6 (representing 1 residence), would be displaced with the three design options.

Under the 6-Lane Alternative with Options K and L, the same receivers as noted in Option A plus HR-9 would have noise levels that would exceed the NAC. Under Options K and L, HR-9 would be 2 dBA higher than under Option A. Under Options K and L, 27 residences would exceed the NAC. Under all options, HR-6 (one residence) would be displaced.

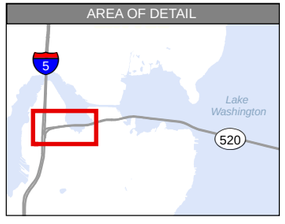
The views in Exhibits 33 through 35 show how current noise levels would change under the No Build Alternative and the 6-Lane Alternative with Options A, K, and L without noise walls. The exhibits include all modeled locations and show where traffic noise levels are projected to exceed the NAC and where noise levels are projected to increase, remain the same, or decrease.

Exhibit 36 provides tabulated TNM results that compare the 6-Lane Alternative with Options A, K, and L 2030 peak-hour traffic noise levels to 2030 No Build Alternative and current peak-hour traffic noise levels for Portage Bay/Roanoke.

North Capitol Hill

The noise discipline analysts modeled peak-hour traffic noise levels for 32 receiver locations (representing 219 residences) in North Capitol Hill. Currently, 99 residences exceed the NAC. Under the No Build Alternative, noise levels at receiver CH-5 and CH-12 (representing 10 additional residences) would exceed the NAC, increasing the total to 109 residences.

AREA OF DETAIL



*Note: This location displaced by the Options A, K, and L; no noise data modeled.

Modeling Location

Monitor and Modeling Location

CH-22
Ex NB A K L
64 65 63 63 63
- - 55 56 56

- Modeling number
- Alternatives (Existing, 2030 No Build, 2030 Options A, K, and L)
- Equivalent sound level (L_{eq}) in A-weighted decibels (dBA) without wall
- Equivalent sound level (L_{eq}) in A-weighted decibels (dBA) with recommended wall

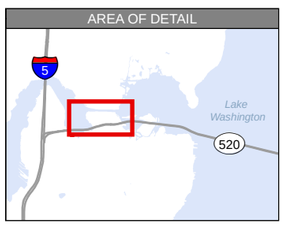
N

0 100 200 400 600 Feet

Source: King County (2006) aerial photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

Exhibit 27. **Sound Modeling Locations and Levels in Portage Bay, Roanoke, and North Capitol Hill Neighborhoods**

I-5 to Medina: Bridge Replacement and HOV Project



*Note: This location displaced by the Options A, K, and L; no noise data modeled.

Receiver MN-30 would be displaced with Option L of the 6-Lane Alternative.

Modeling Location

Monitor and Modeling Location

MN-9 Ex NB A K L 64 65 63 65 64 - - 56 63 63

- Modeling number
- Alternatives (Existing, 2030 No Build, 2030 Options A, K, and L)
- Equivalent sound level (L_{eq}) in A-weighted decibels (dBA) without wall
- Equivalent sound level (L_{eq}) in A-weighted decibels (dBA) with recommended wall

N

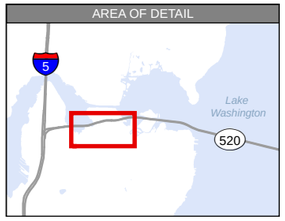
0 100 200 400 600 Feet

Source: King County (2006) aerial photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

Exhibit 28. **Sound Modeling Locations and Levels in Montlake North**

I-5 to Medina: Bridge Replacement and HOV Project

AREA OF DETAIL



Modeling Location

Monitor and Modeling Location

MS-5
Ex NB A K L
70 71 69 71 71
- - 69 71 71

Modeling number

Alternatives (Existing, 2030 No Build, 2030 Options A, K, and L)

Equivalent sound level (L_{eq}) in A-weighted decibels (dBA) without wall

Equivalent sound level (L_{eq}) in A-weighted decibels (dBA) with recommended wall

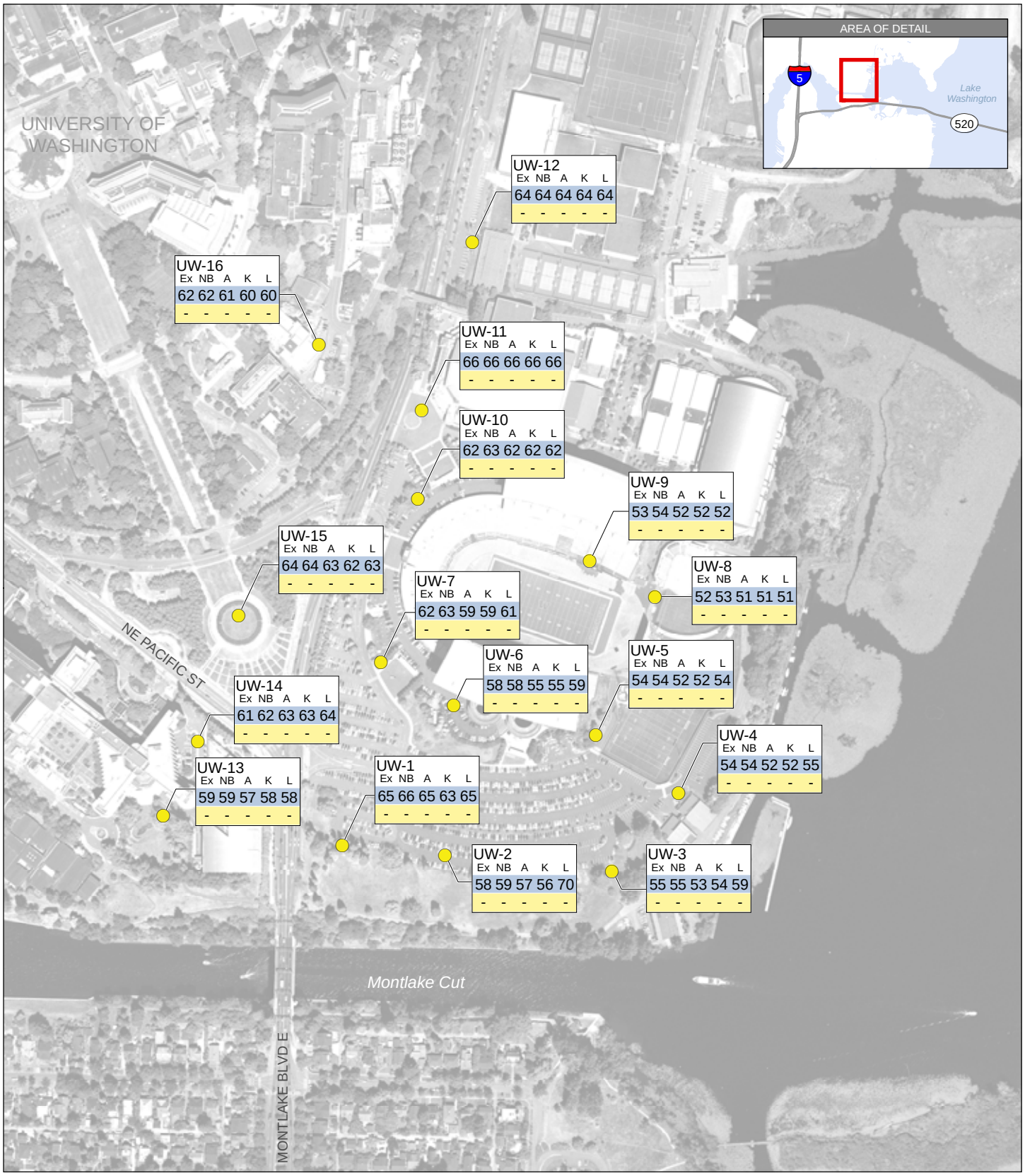
N

0 100 200 400 600 Feet

Source: King County (2006) aerial photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

Exhibit 29. **Sound Modeling Locations and Levels in Montlake South**

I-5 to Medina: Bridge Replacement and HOV Project



Modeling Location

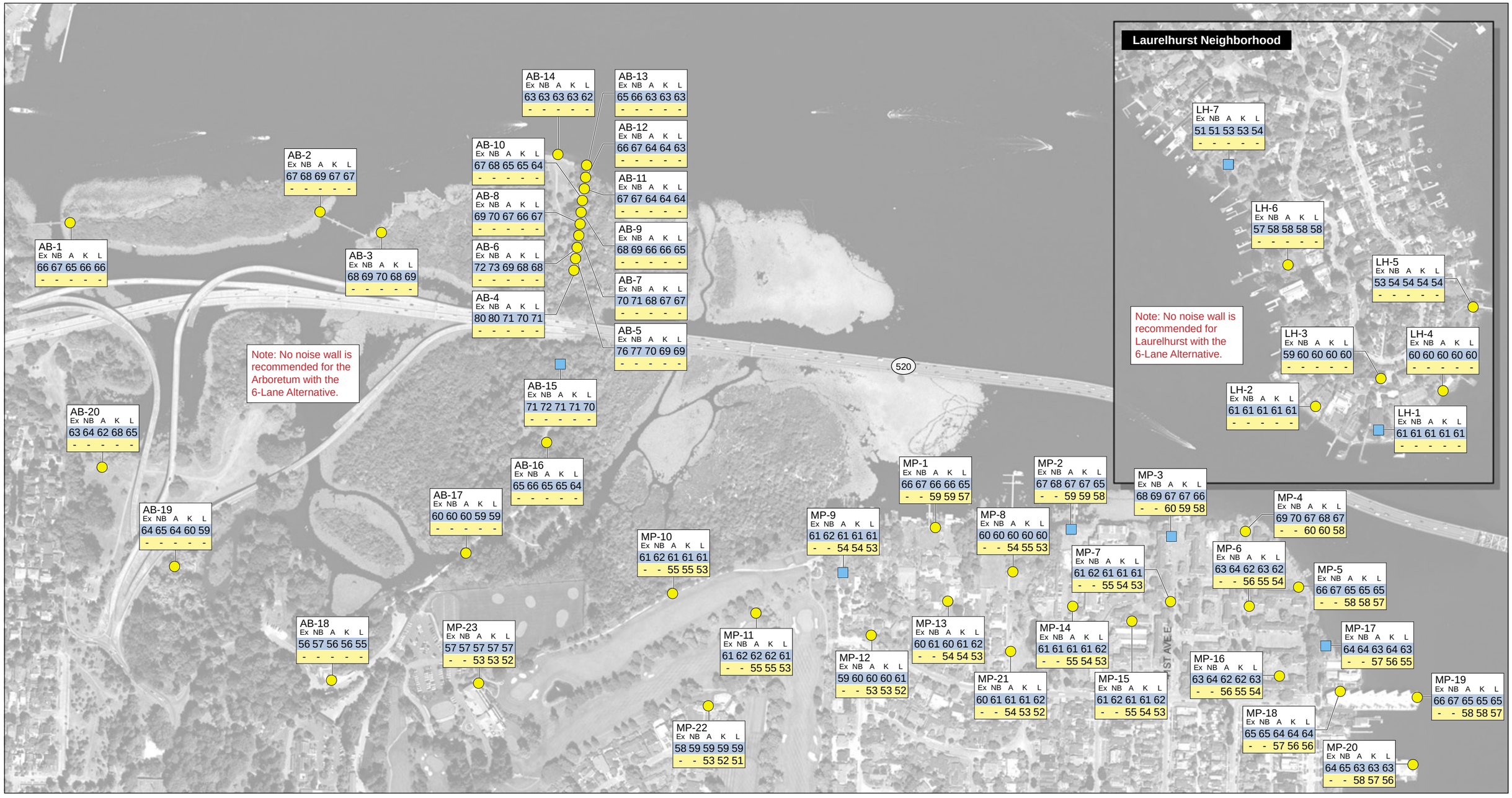
UW-5
Ex NB A K L
54 54 52 52 54
- - - - -

- Modeling number
- Alternatives (Existing, 2030 No Build, 2030 Options A, K, and L)
- Equivalent sound level (L_{eq}) in A-weighted decibels (dBA) without wall
- Note: No noise wall is recommended for the University of Washington with the 6-Lane Alternative.

Source: King County (2006) aerial photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

Exhibit 30. **Sound Modeling Locations and Levels in the University of Washington**

I-5 to Medina: Bridge Replacement and HOV Project



Source: King County (2006) aerial photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

Modeling Location

Monitor and Modeling Location

MP-22
Ex NB A K L
58 59 59 59 59
- - 53 52 51

- Modeling number
- Alternatives (Existing, 2030 No Build, 2030 Options A, K, and L)
- Equivalent sound level (L_{eq}) in A-weighted decibels (dBA) without wall
- Equivalent sound level (L_{eq}) in A-weighted decibels (dBA) with recommended wall

N

0 100 200 400 600 Feet

Exhibit 31. **Sound Modeling Locations and Levels in the Washington Park Arboretum, Madison Park, and Laurelhurst Neighborhoods**

I-5 to Medina: Bridge Replacement and HOV Project

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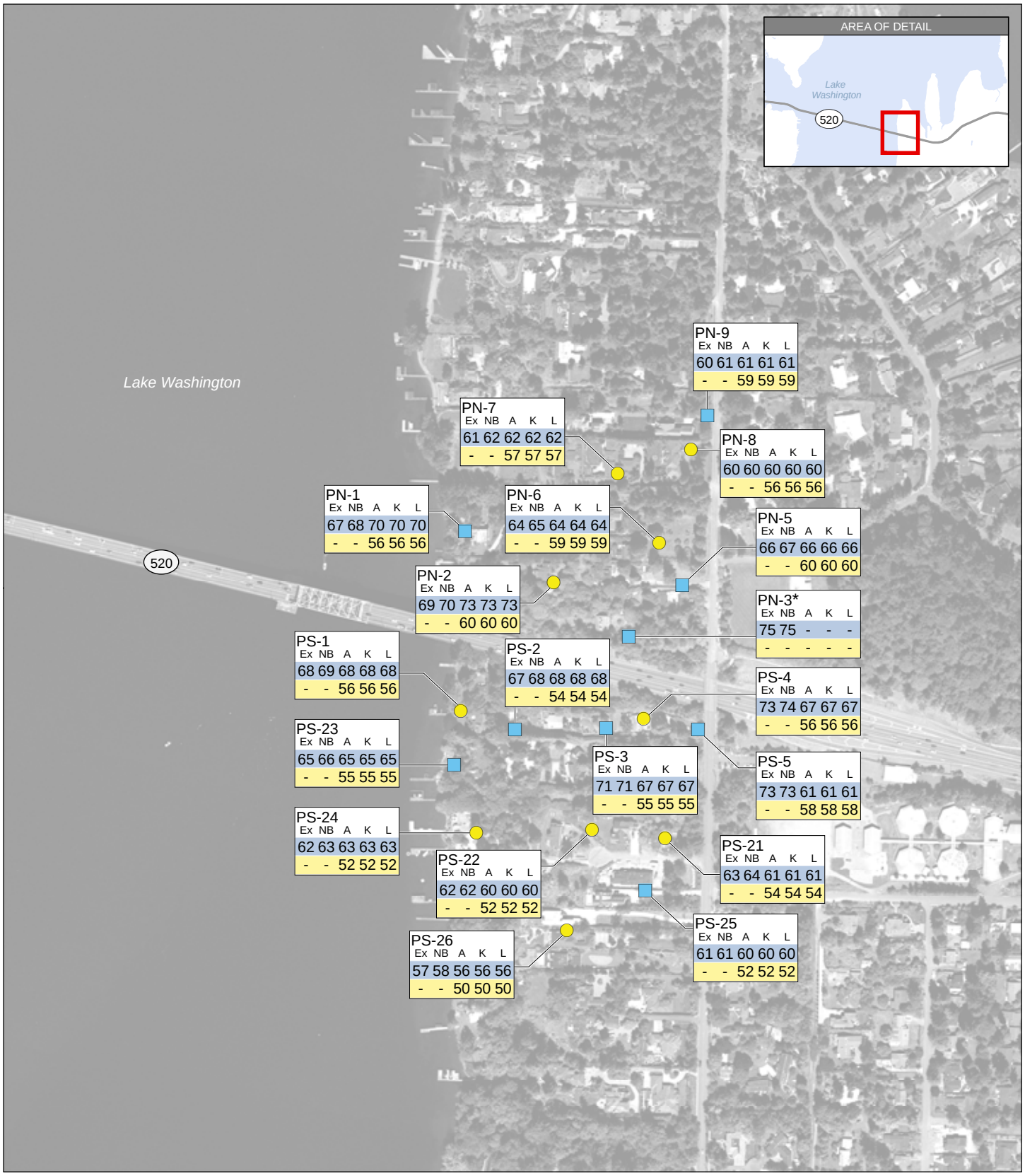


*Note: This location displaced by the Options A, K, and L; no noise data modeled.

PS-22
Ex NB A K L
62 62 60 60 60
- - 52 52 52

- Modeling number
- Alternatives (Existing, 2030 No Build, 2030 Options A, K, and L)
- Equivalent sound level (L_{eq}) in A-weighted decibels (dBA) without wall
- Equivalent sound level (L_{eq}) in A-weighted decibels (dBA) with recommended wall

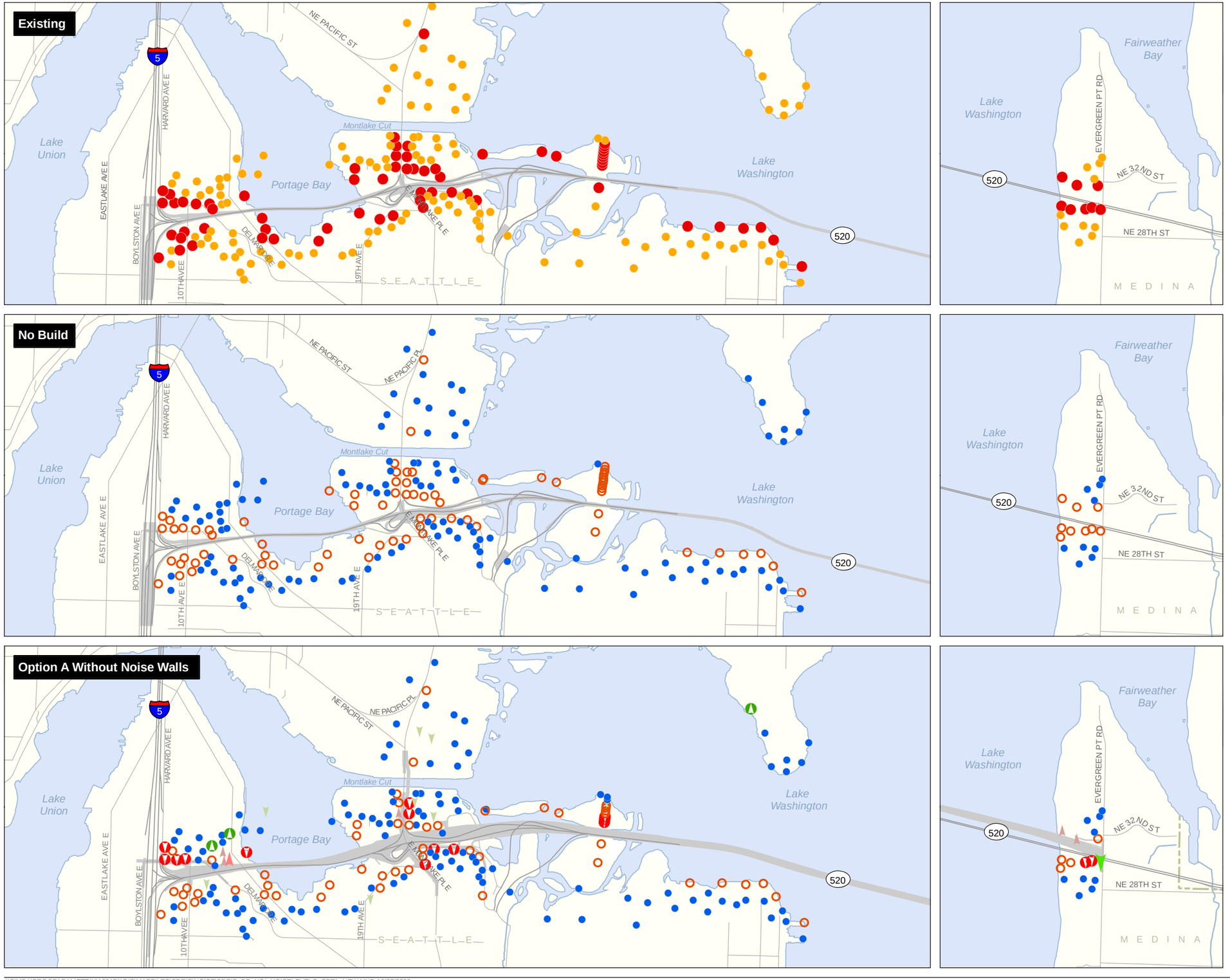
Modeling Location

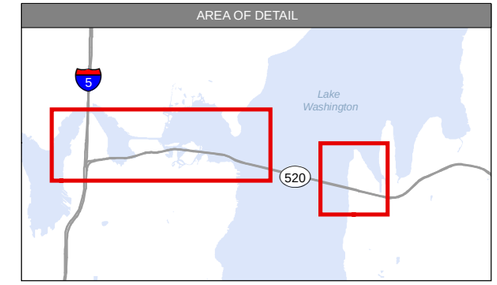
Monitor and Modeling Location

Source: King County (2006) aerial photo. Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

Exhibit 32. **Sound Modeling Locations and Levels in the Medina North and South Neighborhoods**

I-5 to Medina: Bridge Replacement and HOV Project





Existing Sound Level

- 0 - 65 (dBA)
- 66 - 80 (dBA) Noise level above noise abatement criteria

Change in Sound Level (2030)

- < -13 (dBA)
- -10 to -13 (dBA)
- -7 to -9 (dBA)
- -3 to -6 (dBA)
- Noticeable increase and noise level below noise abatement criteria
- No noticeable change and noise level below noise abatement criteria
- Noticeable decrease and noise level above noise abatement criteria
- No noticeable change and noise level above noise abatement criteria
- 3 to 6 (dBA)
- 7 to 9 (dBA)
- 10 to 13 (dBA) Substantial noise increase
- > 13 (dBA) Substantial noise increase
- Pavement

N

0 500 1,000 2,000 Feet

Sources: King County (2005) GIS Data (Streets), King County (2007) GIS Data (Water Bodies). Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

Exhibit 33. **Sound Level Changes in the Study Area with Option A**

I-5 to Medina: Bridge Replacement and HOV Project

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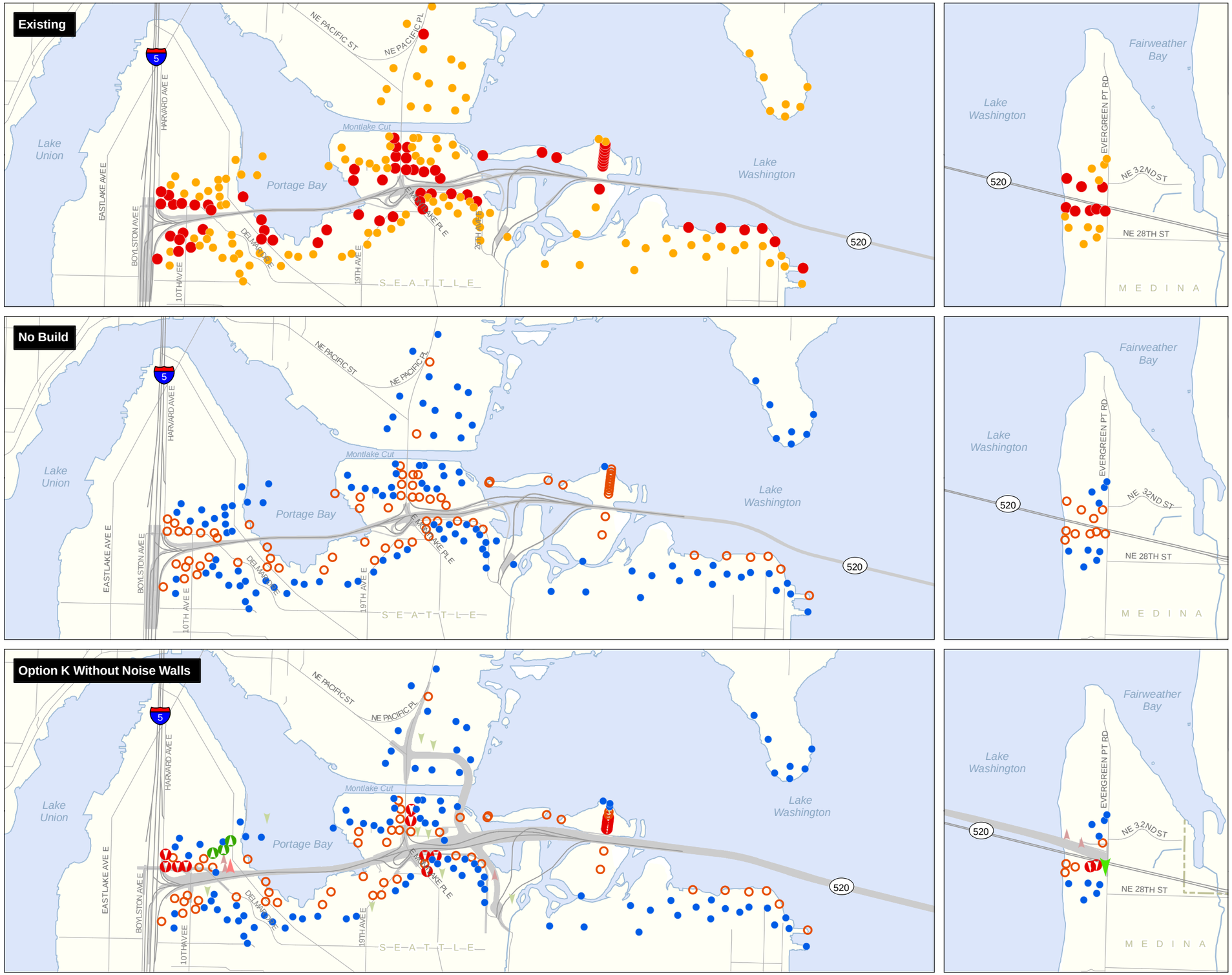
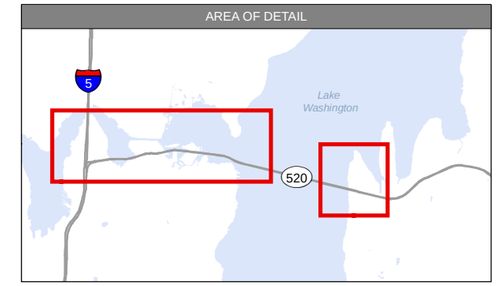




Existing Sound Level

- 0 - 65 (dBA)
- 66 - 80 (dBA) Noise level above noise abatement criteria

Change in Sound Level (2030)

- < -13 (dBA)
- -10 to -13 (dBA)
- -7 to -9 (dBA)
- -3 to -6 (dBA)
- Noticeable increase and sound level below noise abatement criteria
- No noticeable change and sound level below noise abatement criteria
- Noticeable decrease and noise level above noise abatement criteria
- No noticeable change and noise level above noise abatement criteria
- 3 to 6 (dBA)
- 7 to 9 (dBA)
- 10 to 13 (dBA) Substantial noise increase
- > 13 (dBA) Substantial noise increase
- Pavement

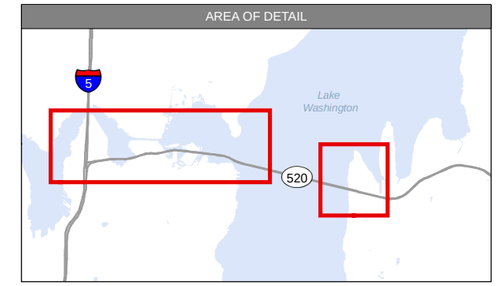
N

0 500 1,000 2,000 Feet

Sources: King County (2005) GIS Data (Streets), King County (2007) GIS Data (Water Bodies). Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

Exhibit 34. **Sound Level Changes in the Study Area with Option K**

I-5 to Medina: Bridge Replacement and HOV Project



Existing Sound Level

- 0 - 65 (dBA)
- 66 - 80 (dBA) Noise level above noise abatement criteria

Change in Sound Level (2030)

- < -13 (dBA)
- -10 to -13 (dBA)
- -7 to -9 (dBA)
- -3 to -6 (dBA)
- Noticeable increase and sound level below noise abatement criteria
- No noticeable change and sound level below noise abatement criteria
- Noticeable decrease and noise level above noise abatement criteria
- No noticeable change and noise level above noise abatement criteria
- 3 to 6 (dBA)
- 7 to 9 (dBA)
- 10 to 13 (dBA) Substantial noise increase
- > 13 (dBA) Substantial noise increase
- Pavement

N

0 500 1,000 2,000 Feet

Sources: King County (2005) GIS Data (Streets), King County (2007) GIS Data (Water Bodies). Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

Exhibit 35. **Sound Level Changes in the Study Area with Option L**

I-5 to Medina: Bridge Replacement and HOV Project

Exhibit 36. 6-Lane Alternative with Options A, K, and L 2030 Peak-Hour Traffic Noise Levels for Portage Bay/Roanoke

Receiver Number	Residential Structures	NAC	Current[a,b]	No Build Alternative[a,b]	6-Lane Alternative[a,b]		
					Option A	Option K	Option L
HR-1	4	67	**77**	**78**	**73**	**73**	**73**
HR-2	4	67	**75**	**76**	**72**	**72**	**72**
HR-3	2	67	**72**	**73**	**68**	**68**	**68**
HR-4	3	67	**66**	**67**	64	65	65
HR-5	3	67	**67**	**68**	**68**	**69**	**69**
HR-6	1	67	**75**	**76**	–[c]	–[c]	–[c]
HR-7	2	67	64	65	**70**	**70**	**70**
HR-8	1	67	62	63	**69**	**69**	**69**
HR-9	1	67	**68**	**68**	65	**67**	**67**
HR-10	4	67	63	64	**67**	**67**	**67**
HR-11	4	67	56	57	63	63	63
HR-12	4	67	63	64	64	65	65
HR-13	5	67	64	65	63	64	64
HR-14	3	67	**67**	**68**	**66**	**66**	**66**
HR-15	3	67	**74**	**75**	**67**	**67**	**68**
HR-16	1	67	64	65	64	64	64
HR-17	3	67	63	64	64	64	64
HR-18	4	67	61	62	62	62	62
HR-19	4	67	61	62	63	64	63
HR-20	4	67	60	61	62	62	61
HR-21	3	67	58	58	61	62	62
HR-22	5	67	63	64	61	62	62
HR-23	6	67	61	62	59	59	59
BH-1	3	67	63	64	61	62	62
BH-2	3	67	64	65	62	63	62
BH-3	3	67	62	63	59	59	59

[a] All noise levels in the exhibit are L_{eq} in dBA.

[b] Bold numbers throughout the exhibit indicate noise levels that approach within 1 dBA or exceed the NAC of 67 dBA L_{eq}.

[c] This receiver would be displaced by the 6-Lane Alternative under all three options.

In general, fewer receivers would exceed the NAC under Options A, K, and L compared to the existing peak-hour and No Build Alternative noise levels due to noise-reducing effects of the 10th Avenue East and Delmar Drive East lid.

Under the 6-Lane Alternative with Option A, receivers CH-1, CH-2, CH-6 through CH-9, CH-13, CH-16, and CH-28 (representing 89 residences) would exceed the NAC. These 89 residences are a subset

of those residences estimated to exceed the NAC under the existing peak-hour and No Build Alternative noise-level conditions.

Under the 6-Lane Alternative with Option K, the same number of residences (89) would exceed the NAC. The specific receivers that would exceed the NAC differ slightly under Option K compared to Option A. With Option K, CH-9 (representing 8 residences) would have noise levels 1 dBA less than under Option A, resulting in noise levels at CH-9 that would be below the NAC. However, CH-12 (representing 8 residences) would be 1 dBA higher than under Option A, resulting in noise levels at CH-12 that would exceed the NAC.

North Capitol Hill without Noise Mitigation

Number of Residences Where Noise Levels Would Exceed NAC

Current	No Build Alternative	6-Lane Alternative		
		Option A	Option K	Option L
99	109	89	89	83

Under the 6-Lane Alternative with Option L, 83 residences would exceed the NAC (6 residences less than under Options A and K). With Option L, CH-5 (representing 2 residences) would be 1 dBA higher than with Options A and K, resulting in noise levels at CH-5 that would exceed the NAC. The noise levels at CH-12 (representing 8 residences) would be 1 dBA less than with Option A, resulting in noise levels that would be less than the NAC.

Exhibit 37 provides tabulated TNM results that compare the 6-Lane Alternative with Options A, K, and L 2030 peak-hour traffic noise levels to 2030 No Build Alternative and current peak-hour traffic noise levels for North Capitol Hill.

Montlake North of SR 520

The noise discipline analysts modeled peak-hour traffic noise levels for 35 receiver locations (representing 106 residences) in Montlake north of SR 520. Currently, noise levels at 37 residences exceed the NAC. Under the No Build Alternative, noise levels at receiver MN-12, M-27, and M-29 (representing 10 additional residences) would exceed the NAC, bringing the number of residences that would exceed the NAC to 47.

In general, under the 6-Lane Alternative with Options A, K, and L, noise levels at the 47 residences that would exceed the NAC under the No Build Alternative would decrease due to the highway lids and shifts in project roadway alignments.

Exhibit 37. 6-Lane Alternative with Options A, K, and L 2030 Peak-Hour Traffic Noise Levels for North Capitol Hill

Receiver Number	Residential Structures	NAC	Current[a,b]	No Build Alternative[a,b]	6-Lane Alternative[a,b]		
					Option A	Option K	Option L
CH-1	3	67	**73**	**73**	**71**	**71**	**72**
CH-2	2	67	**71**	**72**	**71**	**71**	**71**
CH-3	4	67	**66**	**67**	62	63	62
CH-4	4	67	64	65	63	64	64
CH-5	2	67	65	**66**	65	65	**66**
CH-6	18	67	**70**	**71**	**69**	**69**	**69**
CH-7	4	67	**68**	**69**	**67**	**67**	**67**
CH-8	24	67	**67**	**67**	**66**	**66**	**66**
CH-9	8	67	**67**	**67**	**66**	65	65
CH-10	1	67	64	65	64	64	64
CH-11	3	67	63	64	62	62	62
CH-12	8	67	65	**66**	65	**66**	65
CH-13	6	67	**69**	**69**	**68**	**68**	**69**
CH-14	5	67	65	65	63	64	64
CH-15	6	67	**66**	**66**	65	65	65
CH-16	20	67	**66**	**67**	**67**	**67**	**67**
CH-17	6	67	63	64	63	63	63
CH-18	4	67	62	63	62	62	62
CH-19	2	67	63	64	62	62	62
CH-20	4	67	63	64	63	62	62
CH-21	14	67	64	65	63	63	63
CH-22	16	67	64	65	63	63	63
CH-23	8	67	64	65	63	63	63
CH-24	14	67	62	63	61	61	61
CH-25	6	67	63	63	62	62	62
CH-26	7	67	62	63	62	61	62
CH-27	6	67	62	62	61	61	61
CH-28	4	67	**69**	**69**	**71**	**70**	**70**
CH-29	3	67	61	62	61	61	61
CH-30	5	67	61	61	60	60	60
CH-31	1	67	60	61	59	59	59
CH-32	1	67	61	62	61	61	61

[a] All noise levels in the exhibit are L_{eq} in dBA.

[b] Bold numbers throughout the exhibit indicate noise levels that approach within 1 dBA or exceed the NAC of 67 dBA L_{eq}.

With Option A, noise levels at 27 residences represented by receivers MN-1, MN-4, MN-5, MN-7, MN-8, MN-17, MN-18, MN-23, MN-26, and MN-34 would have noise levels that would exceed the NAC. These 27 residences are a subset of those residences estimated to exceed the NAC

under the existing peak-hour and No Build Alternative noise-level conditions.

With Option K, the specific list of receivers that would have noise levels that would exceed the NAC would vary slightly from Option A. With Option K, noise levels at MN-5 (representing 3 residences) would not exceed the NAC, but noise levels at MN-2 would exceed the NAC. MN-2 represents 3.3 residential equivalents. After rounding to the nearest full residential equivalent, Option K would have one more residential equivalent (a total of 28) with noise levels that would exceed the NAC. With Options A and K, receiver MN-3 (representing no residential equivalents) would be displaced.

Montlake North of SR 520 without Noise Mitigation

Number of Residences Where Noise Levels Would Exceed NAC

Current	No Build Alternative	6-Lane Alternative		
		Option A	Option K	Option L
37	47	27	28	28

With Option L, the specific list of receivers that would have noise levels that would exceed the NAC would vary slightly from Options A and K. With Option L, noise levels at MN-4 would not exceed the NAC, but noise levels at MN-29 (representing 3.3 residential equivalents) would exceed the NAC. With Option L, 28 residential equivalents would have noise levels that would exceed the NAC. Also, with this option, receivers MN-3 and MN-30 (representing 3 residences) would be displaced.

Exhibit 38 provides tabulated TNM results that compare the 6-Lane Alternative with Options A, K, and L 2030 peak-hour traffic noise levels to 2030 No Build Alternative and current peak-hour traffic noise levels for Montlake north of SR 520.

Montlake South of SR 520

The noise discipline analysts modeled peak-hour traffic noise levels for 33 receiver locations (representing 142 residences) in Montlake south of SR 520. Currently, 63 residences exceed the NAC. Under the No Build Alternative, noise levels at an additional 2 receivers (representing 7 residences) would exceed the NAC, bringing the total number of residences that would exceed the NAC to 70.

Under the 6-Lane Alternative with Options A, K, and L, the 63 residences that currently exceed the NAC would be reduced to 57, 52, and 45, respectively, due to the noise-reducing effects of the proposed highway lids and depressed roadway sections.

Exhibit 38. 6-Lane Alternative with Options A, K, and L 2030 Peak-Hour Traffic Noise Levels for Montlake North of SR 520

Receiver Number	Residential Structures	NAC	Current[a,b]	No Build Alternative[a,b]	6-Lane Alternative[a,b]		
					Option A	Option K	Option L
MN-1	3.3[c]	67	**69**	**69**	**67**	**67**	**67**
MN-2	3.3[c]	67	**66**	**67**	64	**68**	**67**
MN-3	0	–[d]	75[d]	75[d]	–[d]	–[d]	–[d]
MN-4	2	67	**67**	**68**	**67**	**66**	65
MN-5	3	67	**67**	**68**	**66**	62	61
MN-6	3	67	**66**	**66**	64	62	62
MN-7	2	67	**69**	**70**	**69**	**67**	**67**
MN-8	3	67	**68**	**68**	**70**	**69**	**69**
MN-9	3	67	64	65	63	65	64
MN-10	4	67	64	65	63	64	63
MN-11	3.3[c]	67	**66**	**67**	65	65	65
MN-12	3.3[c]	67	65	**66**	64	64	64
MN-13	4	67	64	65	63	63	63
MN-14	3	67	64	65	63	63	63
MN-15	4	67	64	64	62	63	63
MN-16	4	67	63	64	62	64	63
MN-17	4	67	**68**	**68**	**71**	**70**	**70**
MN-18	3	67	**72**	**72**	**68**	**69**	**68**
MN-19	5	67	62	62	60	62	61
MN-20	3	67	60	61	59	61	58
MN-21	3	67	61	61	58	61	58
MN-22	3.3[c]	67	63	64	61	65	58
MN-23	4	67	**68**	**68**	**70**	**70**	**69**
MN-24	3	67	62	63	62	62	62
MN-25	2	67	63	64	62	64	63
MN-26	2	67	**72**	**72**	**68**	**68**	**67**
MN-27	3	67	65	**66**	62	63	62
MN-28	6	67	60	61	58	60	59
MN-29	3.3[c]	67	65	**66**	64	65	**66**
MN-30	3.3[c]	67	60	60	58	60	–[e]
MN-31	4	67	59	59	57	59	60
MN-32	2	67	62	62	60	61	59
MN-33	1	67	64	65	63	62	61
MN-34	1	67	**66**	**67**	**66**	**66**	65
MN-35	2	67	63	63	62	63	63

Exhibit 38. 6-Lane Alternative with Options A, K, and L 2030 Peak-Hour Traffic Noise Levels for Montlake North of SR 520

[a] All noise levels in the exhibit are L_{eq} in dBA.

[b] Bold numbers throughout the exhibit indicate noise levels that approach within 1 dBA or exceed the NAC of 67 dBA L_{eq}.

[c] Includes residential equivalents for outside activity areas represented by this receiver. These areas include the Arboretum, Montlake Playfield, West Montlake Park, NOAA NWFSC outside use area, McCurdy Park, East Montlake Park, and the Broadmoor Golf Club. The residential equivalents calculation is displayed to the tenths of a decimal.

[d] This receiver (MN-3) is near the existing SR 520 alignment and was used only to aid in model verification. Because it is not a location representing a noise-sensitive property, the NAC does not apply. Under the 6-Lane Alternative with all design options, MN-3 would be displaced with the new project alignment and is not carried through the rest of this report.

[e] This receiver (outdoor use area) is displaced by the elevated SPUI with Option L.

With Option A, noise levels at 57 residences represented by receivers MS-1 through MS-5, MS-10, and MS-17 through MS-22 would have noise levels that would exceed the NAC.

Compared to Option A, Option K would have 5 fewer residences with noise levels that would exceed the NAC. The noise-reducing effects of the depressed SPUI would lower noise levels at MS-10, MS-18, and MS-19 to below the NAC. Under Option K, receivers MS-27 and MS-28 would have slightly higher noise levels that would exceed the NAC.

Montlake South of SR 520 without Noise Mitigation

Number of Residences Where Noise Levels Would Exceed NAC

Current	No Build Alternative	6-Lane Alternative		
		Option A	Option K	Option L
63	70	57	52	45

Under Option L, the same residences that would have noise levels exceeding the NAC with Option K (with the exception of the 7 residences represented by MS-27 and M-28) would have noise levels that would exceed the NAC.

Exhibit 39 provides tabulated TNM results that compare the 6-Lane Alternative with Options A, K, and L 2030 peak-hour traffic noise levels to 2030 No Build Alternative and current peak-hour traffic noise levels for Montlake south of SR 520.

University of Washington

The noise discipline analysts modeled peak-hour traffic noise levels for 16 receiver locations (representing 83 residential equivalents) within the University of Washington campus. Currently, one receiver, UW-11 (south entrance to the Edmundson Pavilion athletic building near Husky Stadium) representing 2.2 residential equivalents, exceeds the NAC. Under the No Build Alternative, noise levels at an additional

Exhibit 39. 6-Lane Alternative with Options A, K, and L 2030 Peak-Hour Traffic Noise Levels for Montlake South of SR 520

Receiver Number	Residential Structures	NAC	Current[a,b]	No Build Alternative[a,b]	6-Lane Alternative[a,b]		
					Option A	Option K	Option L
MS-1	4	67	**74**	**75**	**72**	**68**	**71**
MS-2	4	67	**74**	**74**	**70**	**70**	**70**
MS-3	6	67	**74**	**74**	**70**	**72**	**71**
MS-4	3	67	**72**	**73**	**70**	**72**	**71**
MS-5	5	67	**70**	**71**	**69**	**71**	**71**
MS-6	4	67	59	59	60	60	61
MS-7	4	67	59	60	61	61	61
MS-8	3	67	61	62	62	63	62
MS-9	2	67	62	63	63	63	63
MS-10	4	67	**67**	**67**	**66**	65	65
MS-11	2	67	60	60	60	59	59
MS-12	4	67	56	57	57	56	56
MS-13	4	67	58	58	59	59	59
MS-14	4	67	60	61	61	62	62
MS-15	6	67	56	56	56	54	55
MS-16	4	67	62	62	61	58	58
MS-17	2	67	**73**	**73**	**69**	**69**	**69**
MS-18	4	67	65	**66**	**67**	63	63
MS-19	4	67	**66**	**66**	**66**	65	64
MS-20	3	67	**66**	**66**	**67**	**67**	**67**
MS-21	9.2[c]	67	**70**	**71**	**68**	**69**	**69**
MS-22	9.2[c]	67	**69**	**70**	**67**	**67**	**67**
MS-23	9.2[c]	67	**66**	**67**	65	65	65
MS-24	2	67	63	64	62	62	62
MS-25	2	67	63	64	62	62	62
MS-26	4	67	63	64	57	57	56
MS-27	3	67	65	**66**	64	**66**	65
MS-28	4	67	64	65	65	**66**	65
MS-29	4	67	63	64	62	62	62
MS-30	4	67	64	64	64	62	62
MS-31	6	67	58	58	59	59	60
MS-32	4	67	61	61	62	63	63
MS-33	5	67	64	65	65	64	65

[a] All noise levels in the exhibit are L_{eq} in dBA.

[b] Bold numbers throughout the exhibit indicate noise levels that approach within 1 dBA or exceed the NAC of 67 dBA L_{eq}.

[c] Includes residential equivalents for outside activity areas represented by this receiver. These areas include the Arboretum, Montlake Playfield, West Montlake Park, NOAA NWFSC outside use area, McCurdy Park, East Montlake Park, and the Broadmoor Golf Club. The residential equivalents calculation is displayed to the tenths of a decimal.

receiver, UW-1 (Burke-Gilman Trail and green space near Montlake Boulevard East), would approach the NAC.

Under the 6-Lane Alternative with Options A, K, and L, the area outside the Edmundson Pavilion athletic building entrance (UW-11) would continue to exceed the NAC. Compared to the No Build Alternative, Options A, K, and L noise levels are predicted to decrease slightly along the Burke-Gilman trail and near Lake Washington (UW-1) due to reduced traffic on the Montlake Bridge. UW-1 would not exceed the NAC under any of the design options.

University of Washington without Noise Mitigation

Number of Residences Where Noise Levels Would Exceed NAC

Current	No Build Alternative	6-Lane Alternative		
		Option A	Option K	Option L
2	4	2	2	4

With Option L, noise levels are expected to increase by 11 dBA at UW-2 compared to the No Build Alternative. The noise-level increase at UW-2 would be due to the introduction of traffic on the proposed elevated SPUI interchange. (UW-2 represents the Burke-Gilman Trail and green space near Montlake Boulevard East .) Compared to existing peak-hour noise levels, noise levels would increase by 12 dBA L_{eq} at UW-2 (representing 2.2 residential equivalents). WSDOT considers a 10-dBA (or more) increase in noise as substantial. Therefore, UW-2 would also exceed the NAC substantial increase criterion.

Exhibit 40 provides tabulated TNM results that compare the 6-Lane Alternative with Options A, K, and L 2030 peak-hour traffic noise levels to 2030 No Build Alternative and current peak-hour traffic noise levels for the University of Washington.

Washington Park Arboretum

The noise discipline analysts modeled peak-hour traffic noise levels for 20 receiver locations in the Washington Park Arboretum. AB-1 through AB-3 and AB-14 through AB-20 (represented 54 residential equivalents). AB-4 through AB-13, which did not represent residential equivalents, were used only to determine the distance from SR 520 to where the traffic noise levels would approach or exceed the NAC of 67 dBA L_{eq}. Exhibit 31 shows these 10 receivers as a line of modeling points that are evenly spaced 50 feet apart.

Currently, 22 residential equivalents approach or exceed the NAC. Under the No Build Alternative, noise levels at an additional 5.4 residential equivalents would exceed the NAC, bringing the total number of residences that would exceed the NAC to 27.

Exhibit 40. 6-Lane Alternative with Options A, K, and L 2030 Peak-Hour Traffic Noise Levels for the University of Washington

Receiver Number	Residential Structures	NAC	Current[a,b]	No Build Alternative[a,b]	6-Lane Alternative[a,b]		
					Option A	Option K	Option L
UW-1	2.2[c]	67	65	**66**	65	63	65
UW-2	2.2[c]	67	58	59	57	56	**70**
UW-3	2.2[c]	67	55	55	53	54	59
UW-4	2.2[c]	67	54	54	52	52	55
UW-5	11.2[c]	67	54	54	52	52	54
UW-6	3.3[c]	67	58	58	55	55	59
UW-7	5.6[c]	67	62	63	59	59	61
UW-8	5.6[c]	67	52	53	51	51	51
UW-9	22.3[c]	67	53	54	52	52	52
UW-10	5.6[c]	67	62	63	62	62	62
UW-11	2.2[c]	67	**66**	**66**	**66**	**66**	**66**
UW-12	2.2[c]	67	64	64	64	64	64
UW-13	5.4[c]	67	59	59	57	58	58
UW-14	2.7[c]	67	61	62	63	63	64
UW-15	2.2[c]	67	64	64	63	62	63
UW-16	5.6[c]	67	62	62	61	60	60

[a] All noise levels in the exhibit are L_{eq} in dBA.

[b] Bold numbers throughout the exhibit indicate noise levels that approach within 1 dBA or exceed the NAC of 67 dBA L_{eq}.

[c] Includes residential equivalents for outside activity areas represented by this receiver. These exterior areas include open space within the University of Washington campus, inside and around the Husky Stadium, outside the University Hospital, and areas outside classrooms. The residential equivalents calculation is displayed to the tenths of a decimal.

Compared to the No Build Alternative, noise levels within the Washington Park Arboretum would decrease due to the proposed highway lids and/or depressed roadway sections under the 6-Lane Alternative with Options A, K, and L. All residential equivalents that would have noise levels exceeding the NAC with the design options are a subset of those residences estimated to exceed the NAC under the existing and No Build Alternative peak-hour traffic noise-level conditions.

With Option A, noise levels at 16 residential equivalents (represented by receivers AB-2, AB-3, and AB-15) would have noise levels that would exceed the NAC.

With Option K, 27 residential equivalents would have noise levels that would exceed the NAC. Additional receivers AB-1 and AB-20

Washington Park Arboretum without Noise Mitigation

Number of Residences Where Noise Levels would Exceed NAC

Existing	No Build Alternative	6-Lane Alternative		
		Option A	Option K	Option L
22	27	16	27	22

would have slightly higher noise levels under Option K due to the proposed SR 520 westbound off-ramps to the SPUI and the alignment of Lake Washington Boulevard.

With Option L, 22 residential equivalents (represented by AB-1 through AB-3 and AB-15) would have noise levels that would exceed the NAC.

To document the noise-reduction benefits with the Foster Island land bridge design option, the analysts ran a second model for the Arboretum area receivers with this lid feature under the Option K alignment. The amount of noise reduction expected would be directly related to how close the receiver was to the land bridge. The receiver nearest the land bridge (AB-15) would receive an approximate 3-dBA-reduction benefit. Arboretum receivers farther from the land bridge would receive reductions of 1 dBA or less. Overall, the Foster Island land bridge would lower noise levels by a perceptible level only at the nearest receivers. Under Option K with the land bridge, 17 residential equivalents would exceed the NAC. Although not modeled, it is expected that the Foster Island land bridge would obtain the same slight noise-reduction benefit with Options A or L.

Exhibit 41 provides tabulated TNM results that compare the 6-Lane Alternative with Options A, K, and L 2030 peak-hour traffic noise levels to 2030 No Build Alternative and current peak-hour traffic noise levels for the Washington Park Arboretum.

Madison Park

The noise discipline analysts modeled peak-hour traffic noise levels for 23 receiver locations (representing 99 residences) in Madison Park. Currently, 16 residences exceed the NAC. The same 16 residences would continue to exceed the NAC under the No Build Alternative.

Under the 6-Lane Alternative with Options A and K, the 16 residences that currently exceed the NAC would decrease to 10 residences (represented by MP-1 through MP-4) because of the highway lids and altered roadway alignments. With Option L, 5 residences (represented by MP-3 and MP-4) would exceed the NAC. Noise levels at MP-1 and MP-2 would be 1 to 2 dBA less than with Options A or K. This slight reduction with Option L would be sufficient to lower noise levels at these 5 residences to less than the NAC.

Madison Park without Noise Mitigation

Number of Residences Where Noise Levels Would Exceed NAC

Current	No Build Alternative	6-Lane Alternative		
		Option A	Option K	Option L
16	16	10	10	5

Exhibit 41. 6-Lane Alternative with Options A, K, and L 2030 Peak-Hour Traffic Noise Levels for the Washington Park Arboretum

Receiver Number	Residential Structures	NAC	Current[a,b]	No Build Alternative[a,b]	6-Lane Alternative[a,b]		
					Option A	Option K	Option L
AB-1	5.4[c]	67	**66**	**67**	65	**66**	**66**
AB-2	5.4[c]	67	**67**	**68**	**69**	**67**	**67**
AB-3	5.4[c]	67	**68**	**69**	**70**	**68**	**69**
AB-4	0[d]	67	**80**	**80**	**71**	**70**	**71**
AB-5	0[d]	67	**76**	**77**	**70**	**69**	**69**
AB-6	0[d]	67	**72**	**73**	**69**	**68**	**68**
AB-7	0[d]	67	**70**	**71**	**68**	**67**	**67**
AB-8	0[d]	67	**69**	**70**	**67**	**66**	**67**
AB-9	0[d]	67	**68**	**69**	**66**	**66**	65
AB-10	0[d]	67	**67**	**68**	65	65	64
AB-11	0[d]	67	**67**	**67**	64	64	64
AB-12	0[d]	67	**66**	**67**	64	64	63
AB-13	0[d]	67	65	**66**	63	63	63
AB-14	5.4[c]	67	63	63	63	63	62
AB-15	5.4[c]	67	**71**	**72**	**71**	**71**	**70**
AB-16	5.4[c]	67	65	**66**	65	65	64
AB-17	5.4[c]	67	60	60	60	59	59
AB-18	5.4[c]	67	56	57	56	56	55
AB-19	5.4[c]	67	64	65	64	60	59
AB-20	5.4[c]	67	63	64	62	**68**	65

[a] All noise levels in the exhibit are L_{eq} in dBA.

[b] Bold numbers throughout the exhibit indicate noise levels that approach within 1 dBA or exceed the NAC of 67 dBA L_{eq}.

[c] Includes residential equivalents for outside activity areas represented by this receiver. These areas include the Arboretum, Montlake Playfield, West Montlake Park, NOAA NWFSC outside use area, McCurdy Park, East Montlake Park, and the Broadmoor Golf Club. The residential equivalents calculation is displayed to the tenths of a decimal.

[d] This receiver was used only to validate the noise model and to determine the distance from SR 520 to where the NAC of 67 dBA L_{eq} would be approached or exceeded.

To document the noise-reduction benefits with the Foster Island land bridge design option, a second model was run with this lid feature under the Option K alignment. Because of the distance between the proposed location of the land bridge and the Madison Park receivers, the noise-level reduction would be less than 1 dBA. This slight reduction would not be noticeable to the residents from the locations identified by MP-1 through MP-23. The number of Madison Park receivers where noise levels would exceed the NAC would not change with the Foster Island land bridge. This statement would hold true for Options A and L, if the land bridge were considered under these two design options.

Exhibit 42 provides tabulated TNM results that compare the 6-Lane Alternative with Options A, K, and L 2030 peak-hour traffic noise levels to 2030 No Build Alternative and current peak-hour traffic noise levels for Madison Park.

Exhibit 42. 6-Lane Alternative with Options A, K, and L 2030 Peak-Hour Traffic Noise Levels for Madison Park

Receiver Number	Residential Structures	NAC	Current[a,b]	No Build Alternative[a,b]	6-Lane Alternative[a,b]		
					Option A	Option K	Option L
MP-1	3	67	**66**	**67**	**66**	**66**	65
MP-2	2	67	**67**	**68**	**67**	**67**	65
MP-3	2	67	**68**	**69**	**67**	**67**	**66**
MP-4	3	67	**69**	**70**	**67**	**68**	**67**
MP-5	3	67	**66**	**67**	65	65	65
MP-6	2	67	63	64	62	63	62
MP-7	3	67	61	62	61	61	61
MP-8	3	67	60	60	60	60	60
MP-9	4	67	61	62	61	61	61
MP-10	16.7[c]	67	61	62	61	61	61
MP-11	16.7[c]	67	61	62	62	62	61
MP-12	4	67	59	60	60	60	61
MP-13	3	67	60	61	60	61	62
MP-14	4	67	61	61	61	61	62
MP-15	4	67	61	62	61	61	62
MP-16	4	67	63	64	62	62	63
MP-17	3	67	64	64	63	64	63
MP-18	5	67	65	65	64	64	64
MP-19	3	67	**66**	**67**	65	65	65
MP-20	3	67	64	65	63	63	63
MP-21	1	67	60	61	61	61	62
MP-22	4	67	58	59	59	59	59
MP-23	3	67	57	57	57	57	57

[a] All noise levels in the exhibit are L_{eq} in dBA.

[b] Bold numbers throughout the exhibit indicate noise levels that approach within 1 dBA or exceed the NAC of 67 dBA L_{eq}.

[c] Includes residential equivalents for outside activity areas represented by this receiver. These areas include the Arboretum, Montlake Playfield, West Montlake Park, NOAA NWFSC outside use area, McCurdy Park, East Montlake Park, and the Broadmoor Golf Club. The residential equivalents calculation is displayed to the tenths of a decimal.

Laurelhurst

The noise discipline analysts modeled peak-hour traffic noise levels for 7 receiver locations (representing 15 residences) in Laurelhurst. Currently, no residences exceed the NAC. Similarly, No Build Alternative noise levels would not exceed the NAC at any receiver location in Laurelhurst.

Laurelhurst without Noise Mitigation Number of Residences Where Noise Levels Would Exceed NAC				
		6-Lane Alternative		
Current	No Build Alternative	Option A	Option K	Option L
0	0	0	0	0

Under the 6-Lane Alternative with Options A, K, and L, even though noise levels in Laurelhurst would increase by 1 to 3 dBA compared to the No Build Alternative, noise levels at all the receivers would remain below the NAC.

Exhibit 43 provides tabulated TNM results that compare the 6-Lane Alternative with Options A, K, and L 2030 peak-hour traffic noise levels to 2030 No Build Alternative and current peak-hour traffic noise levels for the Laurelhurst neighborhood nearest the project.

Exhibit 43. 6-Lane Alternative with Options A, K, and L 2030 Peak-Hour Traffic Noise Levels for Laurelhurst

Receiver Number	Residential Structures	NAC	Current[a,b]	No Build Alternative[a,b]	6-Lane Alternative[a,b]		
					Option A	Option K	Option L
LH-1	2	67	61	61	61	61	61
LH-2	2	67	61	61	61	61	61
LH-3	2	67	59	60	60	60	60
LH-4	2	67	60	60	60	60	60
LH-5	2	67	53	54	54	54	54
LH-6	3	67	57	58	58	58	58
LH-7	2	67	51	51	53	53	54

[a] All noise levels in the exhibit are L_{eq} in dBA.
[b] Bold numbers throughout the exhibit indicate noise levels that approach within 1 dBA or exceed the NAC of 67 dBA L_{eq}.

Medina North of SR 520

The noise discipline analysts modeled peak-hour traffic noise levels for 8 receiver locations (representing 27 residences) in Medina north of SR 520. Currently, 12 residences (represented by PN-1, PN-2, PN-3, and PN-5) exceed the NAC. Under the No Build Alternative, noise levels would increase by 1 dBA compared to the current conditions.

Medina North of SR 520 without Noise Mitigation Number of Residences Where Noise Levels Would Exceed NAC				
		6-Lane Alternative		
Current	No Build Alternative	Option A	Option K	Option L
12	12	9	9	9

The same 12 residences currently exceeding the NAC would continue to exceed the NAC under the No Build Alternative.

Under the 6-Lane Alternative with Options A, K, and L, 9 of the residences that currently exceed the NAC would continue to exceed the NAC. The reduction of the number of residences that would exceed the NAC with each of the three design options would be due to the displacement of the three residences represented by PN-3.

Exhibit 44 provides tabulated TNM results that compare the 6-Lane Alternative with Options A, K, and L 2030 peak-hour traffic noise levels to 2030 No Build Alternative and current peak-hour traffic noise levels for Medina north of SR 520. There are no differences among the three design options.

Exhibit 44. 6-Lane Alternative with Options A, K, and L 2030 Peak-Hour Traffic Noise Levels for Medina North of SR 520

Receiver Number	Residential Structures	NAC	Current[a,b]	No Build Alternative[a,b]	6-Lane Alternative[a,b]		
					Option A	Option K	Option L
PN-1	3	67	**67**	**68**	**70**	**70**	**70**
PN-2	3	67	**69**	**70**	**73**	**73**	**73**
PN-3	3	67	**75**	**75**	–[c]	–[c]	–[c]
PN-5	3	67	**66**	**67**	**66**	**66**	**66**
PN-6	2	67	64	65	64	64	64
PN-7	6	67	61	62	62	62	62
PN-8	4	67	60	60	60	60	60
PN-9	3	67	60	61	61	61	61

[a] All noise levels in the exhibit are L_{eq} in dBA.

[b] Bold numbers throughout the exhibit indicate noise levels that approach within 1 dBA or exceed the NAC of 67 dBA L_{eq}.

[c] This receiver would be displaced by the 6-Lane Alternative under all three options.

Medina South of SR 520

The noise discipline analysts modeled peak-hour traffic noise levels for 11 receiver locations (representing 34 residences) in Medina south of SR 520. Currently, 14 residences exceed the NAC. Under the No Build Alternative, noise levels at 1 additional receiver (representing 4 residences) would exceed the NAC, bringing the total number of residences that would exceed the NAC to 18.

Medina South of SR 520 without Noise Mitigation

Number of Residences Where Noise Levels Would Exceed NAC

Current	No Build Alternative	6-Lane Alternative		
		Option A	Option K	Option L
14	18	12	12	12

Under the 6-Lane Alternative with Options A, K, and L, the 14 residences that currently exceed the NAC would decrease to 12 residences (represented by PS-1 through PS-4) due to the noise-reduction effects of the Evergreen Point lid.

Exhibit 45 provides tabulated TNM results that compare the 6-Lane Alternative with Options A, K, and L 2030 peak-hour traffic noise levels to 2030 No Build Alternative and current peak-hour traffic noise levels for Medina south of SR 520. There are no differences among the three design options.

Exhibit 45. 6-Lane Alternative with Options A, K, and L 2030 Peak-Hour Traffic Noise Levels for Medina South of SR 520

Receiver Number	Residential Structures	NAC	Current[a,b]	No Build Alternative[a,b]	6-Lane Alternative[a,b]		
					Option A	Option K	Option L
PS-1	3	67	**68**	**69**	**68**	**68**	**68**
PS-2	3	67	**67**	**68**	**68**	**68**	**68**
PS-3	2	67	**71**	**71**	**67**	**67**	**67**
PS-4	4	67	**73**	**74**	**67**	**67**	**67**
PS-5	2	67	**73**	**73**	61	61	61
PS-21	2	67	63	64	61	61	61
PS-22	3	67	62	62	60	60	60
PS-23	4	67	65	**66**	65	65	65
PS-24	4	67	62	63	63	63	63
PS-25	3	67	61	61	60	60	60
PS-26	4	67	57	58	56	56	56

[a] All noise levels in the exhibit are L_{eq} in dBA.

[b] Bold numbers throughout the exhibit indicate noise levels that approach within 1 dBA or exceed the NAC of 67 dBA L_{eq}.