15 March 2005

SR 520 Bridge Replacement and HOV Project Draft EIS

Appendix M

Noise

Discipline Report

Washington State Department of Transportation

SoundTransit

U.S. Department of Transportation Federal Highway Administration

SR 520 Bridge Replacement and HOV Project Draft EIS

Noise
Discipline Report

Prepared for

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Federal Highway Administration
Sound Transit

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March 15, 2005

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Acronyms and Abbreviations

ANSI	American National Standards Institute
dB	decibel
dBA	A-weighted decibel
EPA	U.S Environmental Protection Agency
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
Hz	hertz
L_{eq}	equivalent sound level
MOHAI	Museum of History and Industry
NAC	noise abatement criteria
NIST	National Institute of Standards and Testing
NOAA	National Oceanic and Atmospheric Administration
TNM	Traffic Noise Model
USDOT	U.S. Department of Transportation
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 sound is perceived as unpleasant, unwanted, or disturbingly loud, it is 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 (e.g., 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 the 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?

Today there are approximately 406 residences in the SR 520 project study area that meet or exceed the Washington State traffic noise abatement criteria (NAC) of 66 dBA L_{eq} (equivalent sound pressure level in A-weighted decibels; see the section *What is sound (noise)?* for an explanation of these terms). Of these 406 residences, slightly over 100 are exceeding the criteria because of noise sources other than SR 520. These locations have substantial noise from I-5 and other major and minor arterial roads, such as Harvard Avenue East, Roanoke Street, 10th Avenue East, Montlake Boulevard, and Lake Washington

Boulevard in Seattle, and Evergreen Point Road, 84th Avenue Northeast, 92nd Avenue Northeast, and Bellevue Way on the Eastside.

Under the No Build Alternative's Continued Operation Scenario, 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 humans. However, with this increase, noise levels would exceed the NAC at an additional 36 residences, bringing the total up to 442 from the current estimate of 406.

Under the No Build Alternative's Catastrophic Failure Scenario, overall noise levels would be reduced throughout the SR 520 corridor. In addition, the number of residences where noise levels meet or exceed the NAC would also be reduced. Future noise levels would be similar to those experienced during bridge maintenance closures.

Compared to today's and the projected 2030 No Build Alternative noise levels, the 4-Lane and 6-Lane Alternatives, which both include sound walls, would reduce the noise levels substantially throughout the SR 520 project corridor. The difference in overall noise levels between the 4-Lane and 6-Lane Alternatives is minor. The main difference would be a reduction in noise levels near bridges over SR 520 where the 6-Lane Alternative would have lids instead of sound walls. With the 4-Lane Alternative, some noise would travel around the sound walls at these locations. The total number of residences where noise levels would exceed the NAC would be 151 under the 4-Lane Alternative and 127 under the 6-Lane Alternative.

Number of Residences Where Noise Levels Exceed NAC

Existing	No Build	4-Lane	6-Lane
406	442	151	127

For residences in the Seattle study area, the 6-Lane Alternative noise levels would range from 52 to 78 dBA L_{eq}, which is the same as the 4-Lane Alternative; however, at several residences in the Portage Bay/Roanoke and North Capitol Hill neighborhoods where noise levels would exceed the NAC under the 4-Lane Alternative, noise levels under the 6-Lane Alternative would fall below the criteria.

In the Eastside study area, residential noise levels would be reduced by up to 13 dBA, and noise levels at almost all residences would be below the NAC. At the few residences where noise levels would be above the NAC, area topography and/or noise from SR 520 ramps or arterial roadways (such as Evergreen Point Road, 84th Avenue Northeast, 92nd Avenue Northeast, and Bellevue Way) are the primary reasons for noise levels that exceed the NAC.

Construction noise levels would be similar for both build alternatives. Major noise sources would include heavy construction equipment such as haul trucks, excavators, jackhammers, and, in Seattle and Lake Washington, pile driving. The major difference between construction of the two build alternatives would be in the length of time it takes to build the project.

What are the project alternatives?

The SR 520 Bridge Replacement and HOV Project area comprises neighborhoods in Seattle from I-5 to the Lake Washington shore, Lake Washington, and Eastside communities and neighborhoods from the Lake Washington shore to 124th Avenue Northeast just east of I-405. Exhibit 1 shows the general location of the project. Neighborhoods and communities in the project area are:

- Seattle neighborhoods—Portage Bay/Roanoke, North Capitol Hill, Montlake, University District, Laurelhurst, and Madison Park
- Eastside communities and neighborhoods—Medina, Hunts Point, Clyde Hill, Yarrow Point, Kirkland (the Lakeview neighborhood), and Bellevue (the North Bellevue, Bridle Trails, and Bel-Red/Northup neighborhoods).

The SR 520 Bridge Replacement and HOV Project Draft EIS evaluates the following three alternatives and one option:

- No Build Alternative
- 4-Lane Alternative
  - Option with pontoons without capacity to carry future high capacity transit
- 6-Lane Alternative

Each of these alternatives is described below. For more information, see the *Description of Alternatives and Construction Techniques Report* contained in Appendix A of this EIS.

Exhibit 1. Project Vicinity Map

What is the No Build Alternative?

All EISs provide an alternative to assess what would happen to the environment in the future if nothing were done to solve the project's identified problem. This alternative, called the No Build Alternative, means that the existing highway would remain the same as it is today (Exhibit 2). The No Build Alternative provides the basis for measuring and comparing the effects of all of the project's build alternatives.

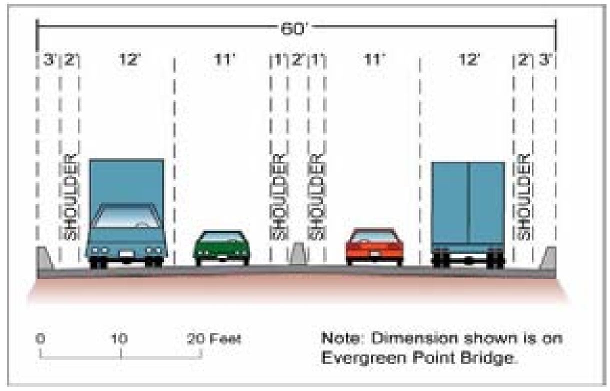


Exhibit 2. No Build Alternative

This project is unique because the existing SR 520 bridges may not remain intact through 2030, the project's design year. The fixed spans of the Portage Bay and Evergreen Point bridges are aging and are vulnerable to earthquakes; the floating portion of the Evergreen Point Bridge is vulnerable to wind and waves.

In 1999, the Washington State Department of Transportation (WSDOT) estimated the remaining service life of the Evergreen Point Bridge to be 20 to 25 years based on the existing structural integrity and the likelihood of severe windstorms. The floating portion of the Evergreen Point Bridge was originally designed for a sustained wind speed of 57.5 miles per hour (mph), and was rehabilitated in 1999 to withstand sustained winds of up to 77 mph. The current WSDOT design standard for bridges is to withstand a sustained wind speed of 92 mph. In order to bring the Evergreen Point Bridge up to current design standards to withstand at least 92 mph winds, the floating portion must be completely replaced.

The fixed structures of the Portage Bay and Evergreen Point bridges do not meet current seismic design standards because the bridge is supported on hollow-core piles. These hollow-core piles were not designed to withstand a large earthquake. They are difficult and cost prohibitive to retrofit to current seismic standards.

If nothing is done to replace the Portage Bay and Evergreen Point bridges, there is a high probability that both structures could fail and become unusable to the public before 2030. WSDOT cannot predict when or how these structures would fail, so it is difficult to determine the actual consequences of doing nothing. To illustrate what could happen, two scenarios representing the extremes of what is possible are evaluated as part of the No Build Alternative. These are the Continued Operation and Catastrophic Failure scenarios.

Under the Continued Operation Scenario, SR 520 would continue to operate as it does today as a 4-lane highway with nonstandard shoulders and without a bicycle/pedestrian path. No new facilities would be added and no existing facilities (including the unused R.H. Thompson Expressway Ramps near the Arboretum) would be removed. WSDOT would continue to maintain SR 520 as it does today. This scenario assumes the Portage Bay and Evergreen Point bridges would remain standing and functional through 2030. No catastrophic events (such as earthquakes or high winds) would be severe enough to cause major damage to the SR 520 bridges. This scenario is the baseline the EIS team used to compare the other alternatives.

In the Catastrophic Failure Scenario, both the Portage Bay and Evergreen Point bridges would be lost due to some type of catastrophic event. Although in a catastrophic event, one bridge might fail while the other stands, this Draft EIS assumes the worst-case scenario—that both bridges would fail. This scenario assumes that both bridges would be seriously damaged and would be unavailable for use by the public for an unspecified length of time.

What is the 4-Lane Alternative?

The 4-Lane Alternative would have four lanes (two general purpose lanes in each direction), the same number of lanes as today (Exhibit 3). SR 520 would be rebuilt from I-5 to Bellevue Way. Both the Portage Bay and Evergreen Point bridges would be replaced. The bridges over SR 520 would also be rebuilt. Roadway shoulders would meet current standards (4-foot inside shoulder and 10-foot outside shoulder). A

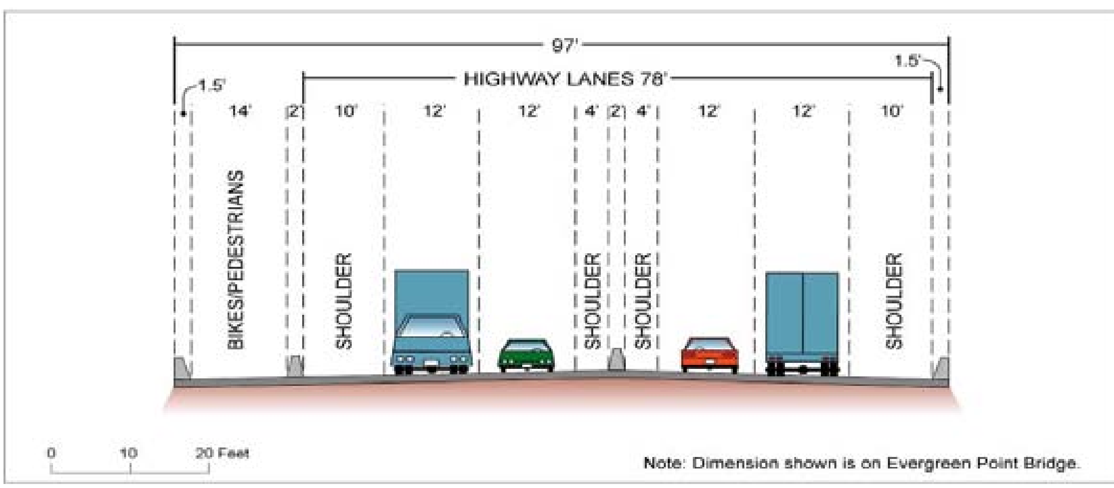


Exhibit 3. 4-Lane Alternative

14-foot-wide bicycle/pedestrian path would be built along the north side of SR 520 through Montlake, across the Evergreen Point Bridge, and along the south side of SR 520 through Medina, Hunts Point, Clyde Hill, and Yarrow Point to 96th Avenue Northeast, connecting to Northeast Points Drive. Sound walls would be built along much of SR 520 in Seattle and the Eastside. This alternative also includes stormwater treatment and electronic toll collection.

The floating bridge pontoons of the Evergreen Point Bridge would be sized to carry future high-capacity transit. An option with smaller pontoons that could not carry future high-capacity transit is also analyzed. The alternative does not include high-capacity transit.

A bridge operations facility would be built underground beneath the east roadway approach to the bridge as part of the new bridge abutment. A dock to moor two boats for maintenance of the Evergreen Point Bridge would be located under the bridge on the east shore of Lake Washington.

A flexible transportation plan would promote alternative modes of travel and increase the efficiency of the system. Programs include intelligent transportation and technology, traffic systems management, vanpools and transit, education and promotion, and land use as demand management.

What is the 6-Lane Alternative?

The 6-Lane Alternative would include six lanes (two outer general purpose lanes and one inside HOV lane in each direction; Exhibit 4). SR 520 would be rebuilt from I-5 to 108th Avenue Northeast in Bellevue, with an auxiliary lane added on SR 520 eastbound east of I-405 to 124th Avenue Northeast. Both the Portage Bay and Evergreen

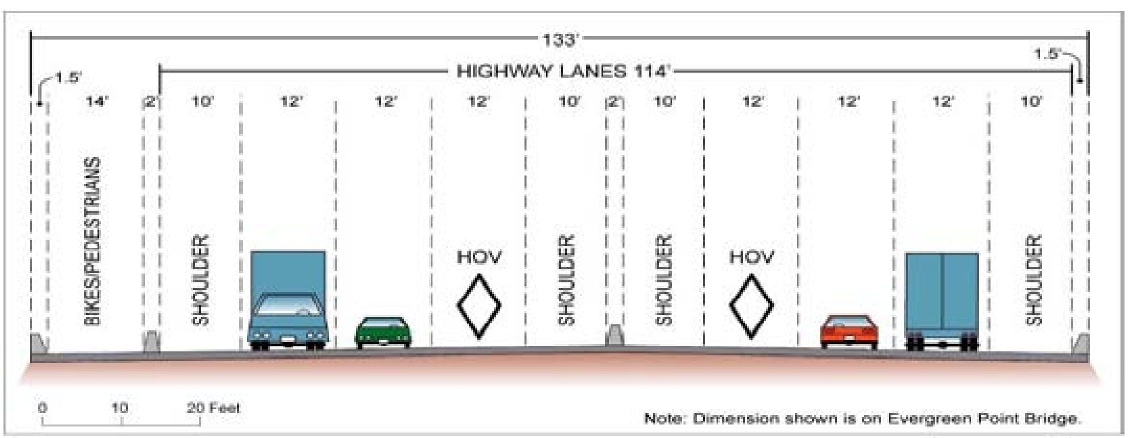


Exhibit 4. 6-Lane Alternative

Point bridges would be replaced. Bridges over SR 520 would also be rebuilt. Roadway shoulders would meet current standards (10-foot-wide inside shoulder and 10-foot-wide outside shoulder). A 14-foot-wide bicycle/pedestrian path would be built along the north side of SR 520 through Montlake, across the Evergreen Point Bridge, and along the south side of SR 520 through the Eastside to 96th Avenue Northeast, connecting to Northeast Points Drive. Sound walls would be built along much of SR 520 in Seattle and the Eastside. This alternative would also include stormwater treatment and electronic toll collection.

This alternative would also add five 500-foot-long landscaped lids to be built across SR 520 to help reconnect communities. These communities are Roanoke, North Capitol Hill, Portage Bay, Montlake, Medina, Hunts Point, Clyde Hill, and Yarrow Point. The lids are located at 10th Avenue East and Delmar Drive East, Montlake Boulevard, Evergreen Point Road, 84th Avenue Northeast, and 92nd Avenue Northeast.

The floating bridge pontoons of the Evergreen Point Bridge would be sized to carry future high-capacity transit. The alternative does not include high-capacity transit.

A bridge operations facility would be built underground beneath the east roadway approach to the bridge as part of the new bridge abutment. A dock to moor two boats and maintain the Evergreen Point Bridge would be located under the bridge on the east shore of Lake Washington.

A flexible transportation plan would promote alternative modes of travel and increase the efficiency of the system. Programs would include intelligent transportation and technology, traffic systems management, vanpools and transit, education and promotion, and land use as demand management.

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, 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 unpleasant, unwanted, or disturbingly loud, they are normally considered "noise."

How do we measure sound?

We measure sound both in terms of loudness and frequency. The unit used to measure the loudness of noise is called a decibel (dB). 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 we use to measure the frequency of noise is called 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 noise 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 decibel scale, provides an accurate "single number" measure of what the human ear can actually hear. When the A-weighted scale is used, the decibel levels are designated as dBA. This unit of measurement is used in this report.

Sounds expressed in terms of *dBA* provide a single number measure of a sound's **loudness** based on the ear's sensitivity to different **frequencies**.

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 noise levels is judged as a doubling of sound level, while a 10 dBA decrease in noise 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.

What are 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 winds 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. While noise levels in urban neighborhoods are louder than rural areas, they share the same pattern of lower noise levels at night than during the day. Quiet urban nighttime noise levels range from 40 to 50 dBA. Noise levels during the day in a noisy urban area are frequently as high as 70 to 80 dBA.

How do we take into account that 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 pressure level (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,

The $\mathbf{L_{eq}}$ is used to account for the variance in loudness over time. Transportation-related noise is most often described in terms of $\mathbf{L_{eq}}$.

let's assume 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}.

How does sound decrease as it travels from the source to the receiver?

Several factors determine how sound levels decrease, or attenuate, over a distance. There are two general rules of thumb that apply to noise sources, which can be categorized as either a *point* source (for example, a church bell) or 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 at 100 feet and to 54 at 200 feet.

Attenuation refers to the reduction in loudness of noise with greater distance between source and receiver.

Items considered in this traffic noise analysis that affect attenuation are:

- Buildings, walls, and topography that block the path between sound and receiver
- Dense foliage, loose soil, or grass that can reduce noise levels between the source and receiver
- Reflective surfaces such as water that can increase the transmission of noise levels to the receiver

A traffic noise analysis **does not consider** atmospheric conditions because they change frequently and are just as likely to decrease as increase noise levels.

The general rules of thumb for attenuation of point and line sources are 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; 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 dB 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 dB or less, which is the minimum change in noise levels that can be noticed by the human ear.

- Topography includes existing hills, berms, and other ground surface features between the noise source and receiver location. As with structures, topography can potentially 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 towards a sensitive receiver location.

- Dense foliage can slightly reduce noise levels. As a general rule of thumb, if the foliage is sufficiently dense that you cannot see over it or through it, then it may be providing some additional noise level reduction from the source to the receiver. For example, the Federal Highway Administration (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 can loud noises affect my 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 5 shows some common noise sources and compares their relative loudness to that of an 80 dBA source, such as a garbage disposal or food blender.

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 ofpain	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 disposa(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 (1971).

Exhibit 5. Sound Levels and Relative Loudness of Typical Noise Sources

What project coordination was performed?

The noise discipline team worked directly with federal, state, and local agencies and community groups. The team coordinated with FHWA, WSDOT, Sound Transit, King County, Seattle, Medina, Hunts Point, Clyde Hill, Yarrow Point, Kirkland, and Bellevue. The team also attended several community meetings held throughout the project corridor and solicited and received valuable input during these meetings, which was used to select the noise monitoring and modeling locations.

Our team of noise analysts coordinated with Mia Waters, Jim Laughlin, and John Maas of WSDOT's Air Quality, Acoustics, and Energy Program for information related to the methods required for a noise study in the state of Washington. We 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 corridor to ensure that noise mitigation would be considered.

We 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 project area land use, including noise sensitive receivers such as residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals, auditoriums, and office space. The team 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 project corridor.
- Recreation and Section 4(f)/Section 6(f) resources – coordination with these discipline teams about potential noise effects on parks and historic properties.

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

There are several other projects currently under consideration in the greater Puget Sound area that may affect traffic volumes, and therefore noise levels, in the SR 520 corridor. However, these projects are taken into account in the transportation model and are therefore included in this noise analysis.

One planned project that will affect noise levels near the SR 520 corridor is the I-5 Roanoke Vicinity Noise Wall Project. This retrofit project is designed to reduce existing freeway noise from I-5. We coordinated with WSDOT and noise consultants at Parsons Brinkerhoff to obtain information about this noise wall project. The effects of the sound walls planned for construction under the I-5 Roanoke Vicinity Noise Wall Project are included in this noise analysis.

How is a noise study performed?

This section contains the primary steps that are taken to complete a traffic noise study in the state of Washington. Together, these steps also provide the outline for the rest of this Noise Discipline Report.

To further assist the reader in navigating through this report, the title of each section within this report that corresponds to each step below is given in the right hand margin. The 11 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 the project's potential effects?*

2. Establish the project area and perform field reconnaissance in order 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 to describe the overall traffic noise levels as well as identify other major noise sources in the project area.

➢ Step 3: *Where are the noise 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 collecting the field data?*

5. Perform onsite noise measurements to establish the existing noise environment. 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 noise levels today?*

6. Develop the input to the Traffic Noise Model (TNM) using the existing roadway alignments and the 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: *How do we verify the traffic noise model predictions?*

7. Model existing project corridor traffic noise levels using the peak-hour traffic volumes generated by the transportation discipline team and posted speed limits.

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

8. Model future project corridor traffic noise levels using the peak-hour traffic volumes generated by the transportation discipline team and posted speed limits. Future conditions include three possible alternatives: No Build Alternative, 4-Lane Alternative, and 6-Lane Alternative.

➢ Step 8: *What are the future peak traffic noise levels?*

9. Evaluate potential effects of construction-related noise for the 4-Lane and 6-Lane Alternatives. Calculate peak construction noise levels based on the equipment to be used, distance from the construction zones to receivers, and the duration and time of the construction.

➢ Step 9: *What construction noise can be expected?*

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

➢ Steps 10 and 11: *Where is traffic noise mitigation recommended?*

11. Re-model the build alternatives with noise mitigation measures and verify that the noise mitigation meets the WSDOT criteria for noise reduction effectiveness.

What criteria are used to evaluate the project's 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. Details on the FHWA criteria and how traffic studies are performed in Washington are given in the following sections.

Federal Highway Administration

FHWA traffic noise criteria defined in 23 CFR 772 are compared to the project 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 clarifies 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 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.

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, if the resulting noise level is greater than 50 dBA .

WSDOT also clarifies the meaning of "substantial increase" by considering 10 dBA to be a substantial increase if the resulting noise level is greater than 50 dBA.

Noise levels of 75 dBA L_{eq} and higher for outdoor activity areas and 60 dBA L_{eq} and higher for indoor areas are defined as "a severe exceedance of the NAC." A NAC exceedance is also considered severe if future design year noise levels are predicted to increase 15 dBA or higher over existing noise levels.

There are no criteria for undeveloped lands or construction noise.

This Noise Discipline Report uses the WSDOT NAC, which FHWA has approved for use on highway projects in the state of Washington.

Guiding Plans and Policies

The following plans and policies were reviewed as part of the noise impact criteria analysis.

- U.S. Department of Transportation (USDOT), 23 CFR 772, *Procedures for Abatement of Highway Traffic Noise and Construction Noise.*
- WSDOT, *Traffic Noise Analysis and Abatement, Policy and Procedures Manual*, November 1997.
- USDOT, *FHWA Highway Construction Noise: Measurement, Prediction and Mitigation*, 1997.
- USDOT, *FHWA Measurement of Highway-Related Noise*, 1996.
- USDOT, *FHWA Highway Traffic Noise Prediction Model,* TNM Version 2.5, 2004.
- Washington Administration Code (WAC), Chapter 173-60, Maximum Environmental Noise Levels.
- WSDOT *Environmental Procedures Manual*, Section 446, September 2003.
- Federal Transit Administration (FTA), *Transit Noise and Vibration Impact Assessment Manual*, 1995.

FHWA Traffic Noise Model

Traffic-noise levels are 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 volume generated by the transportation discipline team and posted speeds. In addition to the traffic data, noise-reducing effects of existing structures directly bordering the project roadway, roadway alignment and profiles, topography, ground cover, and foliage are included in the calculations where appropriate. Using the above information, the model predicts the hourly L_{eq} at selected receiver locations throughout the project corridor.

Affected Environment

What is the study area for the noise analysis?

As defined in the WSDOT Policy and Procedures Manual and in 23 CFR 772, the study area should include all lands within 500 feet of the project right-of-way. However, due to requests from the community, we expanded the study area to include Laurelhurst and other areas outside 500 feet. The general project area includes Seattle, Lake Washington, and the Eastside. A detailed reconnaissance of the project area was performed to identify all noise sensitive properties that are, or could be, directly affected by the SR 520 HOV and Bridge Replacement Project. All noise sensitive properties included in this analysis were located in Seattle and on the Eastside, as listed below.

- **Seattle**—Roanoke, Portage Bay, North Capitol Hill, Montlake, Madison Park, and Laurelhurst neighborhoods
- **Eastside**— Medina, Hunts Point, Clyde Hill, Yarrow Point, Kirkland, and Bellevue

What are the land uses in the study area?

This section is an overview of the land use in the 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.

Seattle

Seattle is primarily residential, with some schools, commercial uses, parklands, and undeveloped uses scattered along the corridor.

Land use in the Eastlake neighborhood includes residential, institutional, and commercial. Land use along the west side of I-5 is primarily single-family and multifamily residential, with an elementary school (The Option Program at Seward School [TOPS Seward School]) located along Boylston Avenue at Roanoke Street.

The Portage Bay/Roanoke neighborhood is primarily single-family residential, and includes a park and church. Closer to Portage Bay there are several multifamily land uses, along with some limited commercial uses such as restaurants and retail outlets. 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.

The Montlake neighborhood is mainly residential with some commercial uses such as retail and restaurants. This area also has parklands, a community center, playfields, the Museum of History and Industry (MOHAI), and the National Oceanic and Atmospheric Administration (NOAA) Northwest Fisheries Science Center building.

Foster Island is parkland with pedestrian trails. The Laurelhurst neighborhood north of SR 520 across Union Bay is entirely residential and faces the Evergreen Point Bridge.

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.

Eastside

Land use in the Eastside is mainly residential, with some parklands and trails and the Bellevue Christian School/Three Points Elementary (Bellevue Christian School). Land use between Lake Washington and 95th Avenue Northeast is mainly residential, with some parklands and trails and a nature preserve near 84th Avenue Northeast. There are some commercial and undeveloped lands along the project corridor, including a park-and-ride near Evergreen Point Road, a gas station on 84th Avenue Northeast, and coffee shop on Northeast 28th Avenue, all located on the south side of SR 520.

Land use between 95th Avenue Northeast and I-405 is primarily residential in the western section, changing to mixed residential-commercial use closer to I-405. Between Bellevue Way and 95th Avenue Northeast, land use is residential along the south side of SR 520. On the north side of SR 520, land use is residential, changing to commercial at Bellevue Way, with some trails and parklands and undeveloped lands. Between Bellevue Way and I-405, land use is primarily commercial, with some residential uses east of Bellevue Way on the south side of SR 520.

Land use east of I-405 consists of residential, commercial, light industrial, and undeveloped lands. On the north side of SR 520, land use is commercial near I-405, changing to residential where Northeast 24th Avenue and Northup Way intersect. Land use continues to be mainly residential along the north side of SR 520 to the 124th Avenue Northeast interchange, with some intermixed commercial uses and some undeveloped lands. The south side of SR 520 is primarily commercial from I-405 to 124th Avenue Northeast. No residential land uses were identified on the south side of SR 520 in this area.

For more information on current land uses in the study area, see Appendix K, *Land Use, Relocations, and Economics Discipline Report.*

What are the topographical characteristics of the project area?

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 project corridor.

Seattle

Seattle contains a large variety of topographical features that affect the transmission of noise. 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 sound walls are being 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 (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.

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 existing structures. Homes on the eastern end of the North Capitol Hill, where the hillside slopes down toward the Portage Bay Bridge, likely experience only 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.

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 of the proximity of many receiver locations to SR 520.

There are no substantial noise-reducing topographical features to 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. 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 section *How does sound reduce as it travels from the source to the receiver?*, water increases the transmission of noise levels to the receiver. The effects of water in increasing noise level transmission were included in the study.

Eastside

The Eastside is more level than Seattle and contains fewer topographical features that would affect the transmission of noise. In general, residents on the north side of SR 520 are below the highway grade, and residents on the south side of the highway are primarily above the highway grade. Residents west of Evergreen Point Road and along the east shoreline of Lake Washington have a direct line-of-sight to the SR 520 bridge structure, and therefore receive little or no acoustical shielding. The highway makes a transition to below grade for bridges at Evergreen Point Road, 84th Avenue Northeast, and 92nd Avenue Northeast. The highway transitions to an at-grade configuration between the bridges. For most locations, noise reduction from topographical features is minimal in this part of the project corridor.

Between I-405 and 124th Avenue Northeast, the north side of SR 520 is primarily above grade and most residential receivers in this area have a line-of-sight view of the project roadway. On the south side of the highway, the structures are below grade; however, there are no residential structures.

Where are the noise measurement locations?

The noise discipline team collected a variety of information to aid in the selection of noise measurement locations. Aerial mapping, survey data, CAD drawings, and information from the land use studies were studied, 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 general areas for noise monitoring were selected. More detailed information was then collected during onsite visits to the study area. The final selection of specific noise monitoring locations was made through a joint effort between the noise discipline team, WSDOT, Sound Transit, and the neighborhood communities and groups.

The noise discipline team measured noise levels at 98 locations in the project area. These included 14 long-term (24-hour or greater) and 84 short-term (15 to 30 minutes) monitoring locations. For the long-term monitoring locations, we provide an averaged peak-hour noise level in L_{eq} dBA. For short-term locations, 15 minutes is generally considered sufficient for obtaining an accurate L_{eq} on busy highways.

A summary of the number and type of measurement periods by neighborhood or area is provided in Exhibit 6. The Eastside project area communities are further divided for the analysis later in this report.

What equipment and methods were used for the noise measurements?

The equipment used for noise monitoring included Bruel & Kjaer Type 2238 Sound Level Meters equipped with statistical analysis, Bruel & Kjaer Type 2231 Sound Level Meters equipped with Bruel & Kjaer BZ-7101 Statistical Analysis Module, a Bruel & Kjaer Type 2236 Sound Level Meter, and a Larson Davis Type 710 Sound Level Meter. The

Exhibit 6. Noise Monitoring Locations by Neighborhood

Neighborhood or Area	Short-Term	Long-Term	Total
Seattle			
Portage Bay/Roanoke–North Capitol Hill	14	2	16
Montlake–Arboretum	12	4	16
Madison Park	4	1	5
Laurelhurst	1	1	2
Eastside			
East shore of Lake Washington to 84th Avenue Northeast	17	2	19
84th Avenue Northeast to I-405	32	2	32
East of I-405	4	2	8
Project Totals	**84**	**14**	**98**

meters were calibrated before and after the measurement periods using a Bruel & Kjaer Type 4231 Sound Level Calibrator. Each of the sound level meters receives a complete annual system calibration at a National Institute of Standards and Testing certified traceable calibration laboratory.

Typical outdoor systems used for long-term noise monitoring

Systems used for long-term unattended noise monitoring included Bruel & Kjaer Type 2238 Sound Level Meters equipped with statistical analysis and Bruel & Kjaer Type 2231 Sound Level Meters equipped with a Bruel & Kjaer BZ-7101 Statistical Analysis Module. These systems are in weatherproof cases and battery-operated. The systems store detailed noise levels on an hourly basis over the measurement period, which can range from several hours to several days.

All noise measurements conform to the guidelines and procedures provided by the American National Standards Institute for community noise measurements and the FHWA *Measurement of Highway-Related Noise* (USDOT 1996). Noise 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.

Stalker Radar Gun

A Stalker II radar gun was used to measure average travel speeds at several locations in the project corridor during the noise measurement periods. The radar gun is calibrated using a 60 mph tuning fork. Traffic counts were also taken at several of the monitoring locations simultaneously during the noise monitoring sessions. The measured speed data and traffic counts were used to help to establish an accurate noise prediction model for existing conditions.

Sound Level Meter

What are the measured noise levels?

The following sections provide the measured noise level results at each monitoring location.

Seattle

Exhibit 7 contains the noise level results for the Seattle monitoring locations. Measured levels in Seattle ranged from 48 to 76 dBA L_{eq}. Exhibit 8 shows the Seattle noise monitoring locations, land use, and measured noise levels. Descriptions of major noise sources along the corridor are given below.

Exhibit 7. Seattle Noise Monitoring Locations, Data, and Descriptions

Number[a]	Address (closest to monitoring location)	Type	Duration	Noise Level[b]
Portage Bay/Roanoke				
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
North Capitol Hill				
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
M16	16th Avenue East at East Calhoun	Short-Term	15 minutes	64
Montlake				
M17	1804 East Hamlin Street	Short-Term	15 minutes	63
M18	NOAA Building – North End	Long-Term	46 hours	67
M19	NOAA Building – South End by Docks	Short-Term	15 minutes	67
M20	1853 East Hamlin Street	Short-Term	15 minutes	63

Exhibit 7. Seattle Noise Monitoring Locations, Data, and Descriptions

Number[a]	Address (closest to monitoring location)	Type	Duration	Noise Level[b]
M21	Montlake Boulevard at East Hamlin Street	Short-Term	15 minutes	71
M22	2127 E 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
Arboretum				
M33	Foster Island Trail – near existing SR 520	Short-Term	15 minutes	69
Madison Park				
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
Laurelhurst				
M38	Trail to lake access at Northeast Belvoir Place	Short-Term	15 minutes	48
M39	3004 Webster Point Road Northeast	Long-Term	25 hours	57

[a] See Exhibit 8 for a map of the noise monitoring locations.

[b] Measured L_{eq} noise level in decibels with A-weighting (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.

Portage Bay/Roanoke Neighborhood

Monitoring locations M1 through M7 were used to characterize the existing noise environment in the Portage Bay area, bordered by Harvard Avenue East and Roanoke Street (see Exhibit 8). Noise levels in this area ranged from 57 to 76 dBA L_{eq}. The highest noise levels were measured near Harvard Avenue East at receivers near the Harvard/ Roanoke Street intersection. Noise levels measured at receivers with some shielding and farther away from Harvard Avenue ranged from 59 to 63 dBA L_{eq}.

Overall, the average measured noise level in this area was 62 dBA L_{eq}. Main noise sources included traffic on SR 520, I-5, Harvard Avenue, and East Roanoke.

North Capitol Hill

The North Capitol Hill neighborhood had one long-term and eight short-term monitoring locations, M8 through M16 (see Exhibit 8). Measured noise levels ranged from 56 to 72 dBA L_{eq}. Noise levels were highest along Harvard Avenue adjacent to I-5. Other areas with high noise 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 noise environment in the Montlake neighborhood (see Exhibit 8). Measured noise levels ranged from 57 to 73 dBA L_{eq}. The highest noise levels were measured along SR 520 near Montlake Boulevard, Lake Washington Boulevard, and at the SR 520 access ramps. The average noise level for all monitoring locations was 65 dBA L_{eq}. Major noise sources included SR 520 and associated on-ramps and off-ramps, Montlake Boulevard, and Lake Washington Boulevard.

Madison Park and Arboretum

Monitoring location M33 was used for the Arboretum, and M34 through M37 were used for the Madison Park neighborhood (see Exhibit 8). Measured noise levels near the trail on Foster Island were 69 dBA L_{eq}. Measured noise levels in the Madison Park neighborhood ranged from 58 to 66 dBA L_{eq}, with the highest noise levels at the Canterbury Apartments located near SR 520, represented by M36.

Laurelhurst

Noise levels at the two noise monitoring locations in the Laurelhurst neighborhood, M38 and M39 (see Exhibit 8), ranged from 48 to 57 dBA L_{eq}.

Lake Washington

No monitoring locations were selected in Lake Washington.

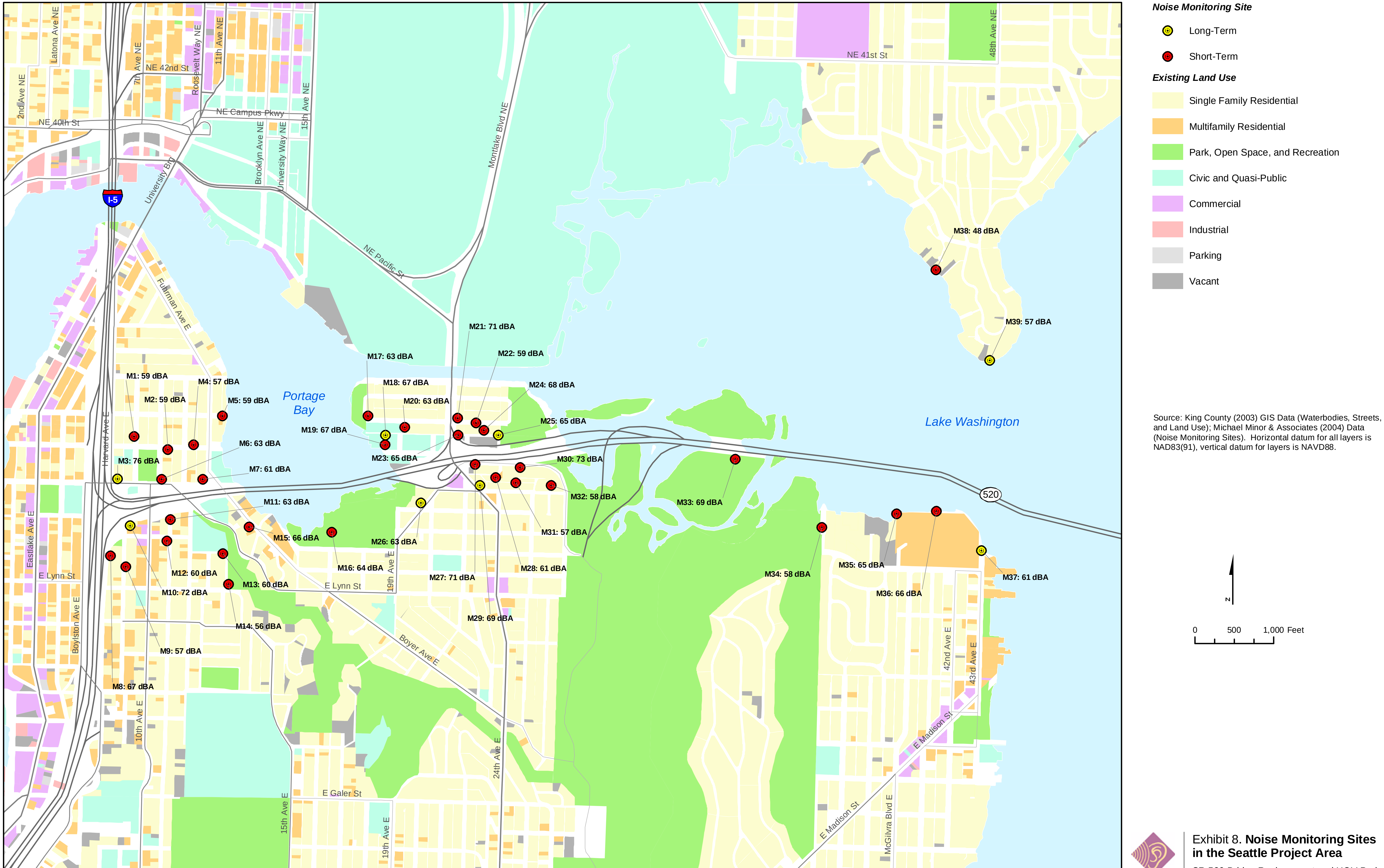


Exhibit 8. **Noise Monitoring Sites in the Seattle Project Area**

SR 520 Bridge Replacement and HOV Project

Eastside

The noise discipline team took 49 short-term and 4 long-term noise level measurements between Lake Washington and I-405, with an additional 4 short-term and 2 long-term noise level measurements east of I-405 to 124th Avenue Northeast. Overall, noise levels between Lake Washington and I-405 ranged from 48 to 72 dBA L_{eq}. East of I-405, noise levels ranged from 54 to 74 dBA L_{eq}. Exhibit 9 presents the measured noise levels for the Eastside. Exhibit 10 shows the Eastside noise monitoring locations, land use, and measured noise levels. Descriptions of major noise sources along the project corridor are in the following sections.

Medina and Hunts Point (from Lake Washington to 84th Avenue Northeast)

There are 17 short-term and 2 long-term noise monitoring locations from Lake Washington east to 84th Avenue Northeast (M40 through M58 shown in Exhibit 9). Measured noise levels ranged from 48 to 72 dBA L_{eq}, with an overall average noise level of approximately 62 dBA.

The primary noise source was traffic on SR 520, with additional noise from arterial roads, including Evergreen Point Road and 84th Avenue Northeast.

Hunts Point, Clyde Hill, Yarrow Point, and Kirkland

Between 84th Avenue Northeast and 95th Avenue Northeast, there are 25 short-term and 2 long-term noise monitoring locations (M59 through M85 shown in Exhibit 9). Measured noise levels ranged from 48 to 72 dBA L_{eq}. The highest noise levels were recorded on the south side of SR 520 because of the area topography. Major noise sources included traffic on SR 520 and access ramps, 84th Avenue Northeast, Northeast 28th, Points Drive Northeast, and 92nd Avenue Northeast.

Bellevue

Noise levels at the seven short-term noise monitoring locations between 95th Avenue Northeast and I-405 (M86 through M92 shown in Exhibit 9) ranged from 57 to 69 dBA L_{eq}. Similar to other areas along the SR 520 corridor, the highest noise levels were measured near the highway and major arterial roadways such as Bellevue Way. Major noise sources included traffic on SR 520 and Bellevue Way.

Exhibit 9. Eastside Monitoring Locations Data, and Descriptions

Number[a]	Address (closest to monitoring location)	Type	Duration	Noise Level[b]
Medina and Hunts Point				
M40	West of 3211, 100 feet from water	Short-Term	15 minutes	60
M41	7525 Northeast 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	Short-Term	15 minutes	70
M44	2853 Northeast 28th Place	Short-Term	15 minutes	64
M45	201 feet west of Evergreen Point	Short-Term	15 minutes	61
M46	3219–3233 Evergreen Point Road	Short-Term	15 minutes	63
M47	2841 Northeast 28th Place	Short-Term	15 minutes	72
M48	2665 Evergreen Point Road	Short-Term	15 minutes	53
M49	Playfield near tennis courts	Short-Term	15 minutes	67
M50	Bellevue Christian School	Short-Term	15 minutes	66
M51	2619 78th Avenue Northeast – near Northeast 28th	Short-Term	15 minutes	48
M52	3010 80th Avenue Northeast	Short-Term	15 minutes	58
M53	7979 Northeast 28th	Short-Term	15 minutes	63
M54	3003 Fairweather Lane - near foot trail	Short-Term	15 minutes	62
M55	8049 Northeast 28th Avenue	Long-Term	24 hours	67
M56	2831 Hunts Point Road	Short-Term	15 minutes	59
M57	8305 Hunts Point Circle (Northeast 30th Avenue)	Long-Term	25 hours	65
M58	Intersection of 84th Avenue Northeast and Northeast 28th Street, next to the off-ramp	Short-Term	15 minutes	67
Hunts Point, Clyde Hill, Yarrow Point, and Kirkland				
M59	Fairweather Nature Preserve Entrance	Short-Term	15 minutes	59
M60	8500 Northeast 28th Avenue – next door in field	Short-Term	15 minutes	67
M61	8510 85th Avenue Northeast	Short-Term	15 minutes	48
M62	8472 Hunts Point Road	Short-Term	15 minutes	63
M63	8580 Hunts Point Road	Short-Term	15 minutes	51
M64	8581 Hunts Point Road	Short-Term	15 minutes	55
M65	8531 Hunts Point Road	Long-Term	25 hours	64
M66	2827 88th Avenue Northeast	Long-Term	24 hours	72
M67	Intersection of Northeast 28th Avenue Northeast and 88th Avenue Northeast	Short-Term	15 minutes	63
M68	9010 Points Drive	Short-Term	15 minutes	60
M69	8829-8832 25th Street	Short-Term	15 minutes	61
M70	9106 – on street north of Northeast 32nd Street	Short-Term	15 minutes	66
M71	9043 Northeast 33rd – behind wall	Short-Term	15 minutes	62
M72	9114 Northeast 32nd – closer to SR 520	Short-Term	15 minutes	61

Exhibit 9. Eastside Monitoring Locations Data, and Descriptions

Number[a]	Address (closest to monitoring location)	Type	Duration	Noise Level[b]
M73	Intersection of Points Drive and 92nd Avenue Northeast	Short-Term	15 minutes	62
M74	9030 Northeast 34th Street	Short-Term	15 minutes	53
M75	9052 Northeast 33rd Street	Short-Term	15 minutes	60
M76	3233 92nd Avenue Northeast	Short-Term	15 minutes	65
M77	3223 93rd Place Northeast	Short-Term	15 minutes	64
M78	3216 93rd Place Northeast	Short-Term	15 minutes	57
M79	Intersection of 36th Avenue Northeast and 92nd Avenue Northeast	Short-Term	15 minutes	61
M80	9243 Points Drive	Short-Term	15 minutes	64
M81	2710 95th Avenue	Short-Term	15 minutes	61
M82	9636–9645 Northeast 30th Street	Short-Term	15 minutes	60
M83	Dead-end on Northeast 37th - east of 92nd Avenue Northeast	Short-Term	15 minutes	55
M84	9417 Points Drive	Short-Term	15 minutes	61
M85	8411 Northeast 32nd Street	Short-Term	15 minutes	52
Bellevue				
M86	9650 98th Avenue Northeast – off Northeast 34th Place	Short-Term	15 minutes	69
M87	9660 Northeast 34th Place	Short-Term	15 minutes	62
M88	10015 off Points Drive and 100th Lane Northeast	Short-Term	15 minutes	59
M89	9836 Northeast 34th Place	Short-Term	15 minutes	68
M90	Intersection of 101st Way and Northeast 35th Court	Short-Term	15 minutes	57
M91	3240 103rd Place	Short-Term	15 minutes	68
M92	10514 Northeast 32nd	Short-Term	15 minutes	62
East of I-405 (Bellevue)				
M93	12100 Boulders at Pikes	Long-Term	24 hours	68
M94	12238 Boulders at Pikes	Short-Term	15 minutes	54
M95	2403 124th Place Northeast	Short-Term	15 minutes	70
M96	12505 Cherry Crest Vista	Short-Term	15 minutes	74
M97	2303 126th Avenue Northeast	Short-Term	15 minutes	60
M98	2511 127th Avenue Northeast	Long-Term	24 hours	70

[a] See Exhibit 10 for a map of the noise monitoring locations.
[b] Measured L_{eq} noise level in decibels with A-weighting (dBA).

Neighborhoods East of I-405

Monitoring locations M93 to M98 were used to quantify noise levels between I-405 and 124th Avenue Northeast (see Exhibit 9). The six locations included two long-term monitoring sites at M93 and M98. Measured noise levels ranged from 54 to 74 dBA L_{eq}. The highest noise levels were measured at locations on the bluff between Northup Way and 130th Avenue Northeast, with a direct line-of-sight view to SR 520. Major noise sources included traffic on SR 520 and local arterial roads such as Northeast 24th, 140th Avenue Northeast, and 148th Avenue Northeast.

Project Area Noise Modeling

In addition to sites where noise was measured (designated M1 through M98), noise levels were modeled at 361 locations in the project corridor. Modeling is performed to determine what locations in the study area exceed the NAC. Therefore, peak-hour traffic noise levels must be calculated for existing conditions and the No Build, 4-Lane, and 6-Lane Alternatives, 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 team selected 162 receiver locations in Seattle and 199 receivers on the Eastside based on aerial mapping and onsite visits. The 361 receivers represent approximately 1,281 residences within the project study area, 678 in Seattle and 603 on the Eastside.

To help reduce the large volume of data, we selected TNM modeling number designations that would correspond to general neighborhood areas. We divided the project study area into 12 neighborhoods—7 in Seattle and 5 on the Eastside. Exhibit 11 shows how the neighborhoods are grouped into receiver designation areas.

For each neighborhood, we numbered noise modeling locations for easy and consistent identification in Exhibits 23 through 34 later in this report and in Attachments 1 and 2. For example, HR-1 is a modeling receiver number in the Portage Bay/Roanoke neighborhood. As shown later in this report, HR-1 through HR-23 represent the 69 modeled receivers used in the Portage Bay/Roanoke neighborhood. We assigned similar modeling receiver

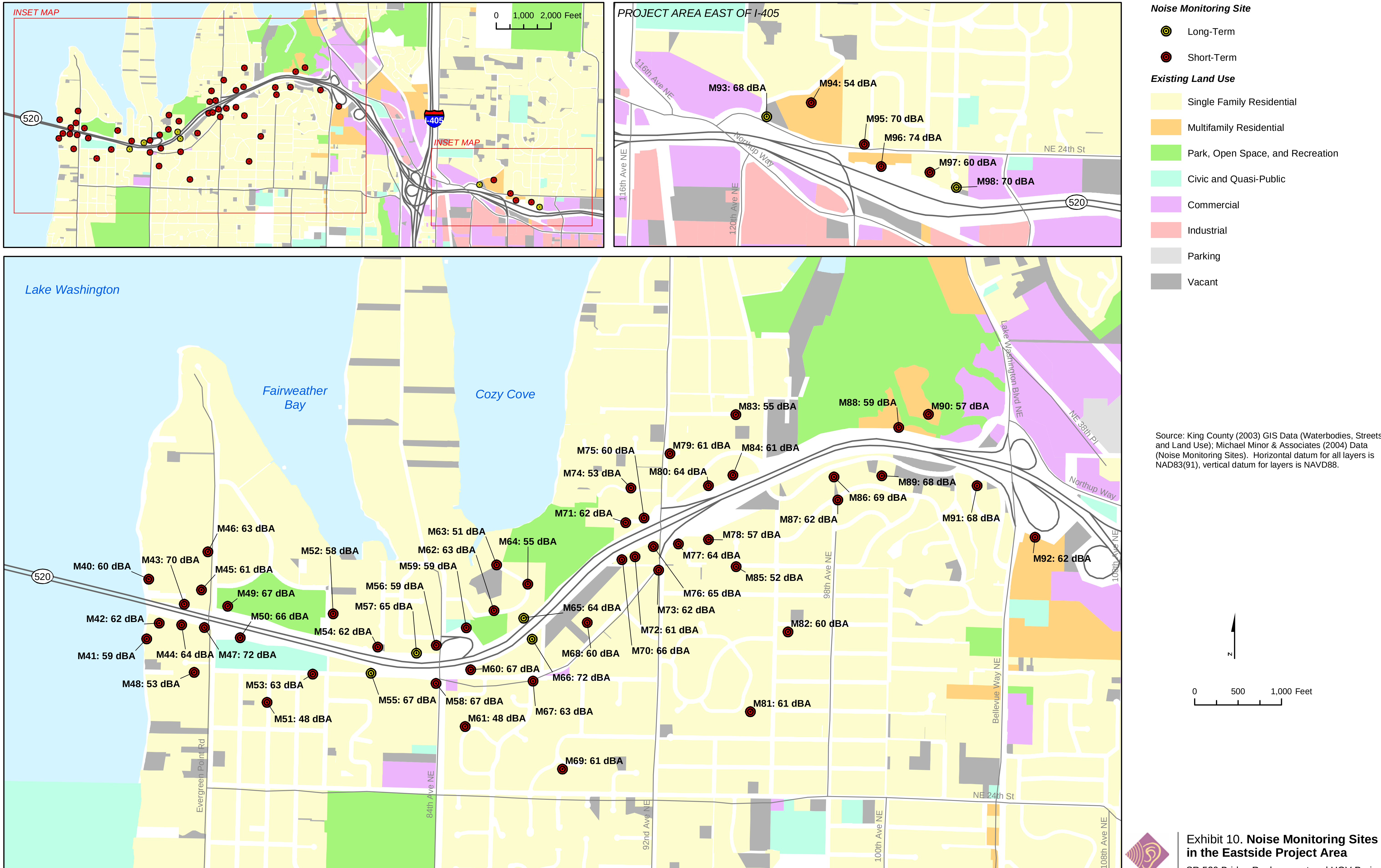
Modeled Receiver Designations

Seattle Project Area

HR	Portage Bay/Roanoke
CH	North Capitol Hill
MN	Montlake north of SR 520
MS	Montlake south of SR 520
AB	Washington Park Arboretum
MP	Madison Park
LH	Laurelhurst

Eastside Project Area

PN	Medina and Hunts Point north of SR 520
PS	Medina and Hunts Point south of SR 520
PK	Hunts Point, Clyde Hill, Yarrow Point, and Kirkland north of SR 520
PB	Hunts Point, Clyde Hill, Yarrow Point, and Bellevue south of SR 520
E405	Bellevue east of I-405



Source: King County (2003) GIS Data (Waterbodies, Streets, and Land Use); Michael Minor & Associates (2004) Data (Noise Monitoring Sites). Horizontal datum for all layers is NAD83(91), vertical datum for layers is NAVD88.

Exhibit 10. **Noise Monitoring Sites in the Eastside Project Area**

SR 520 Bridge Replacement and HOV Project

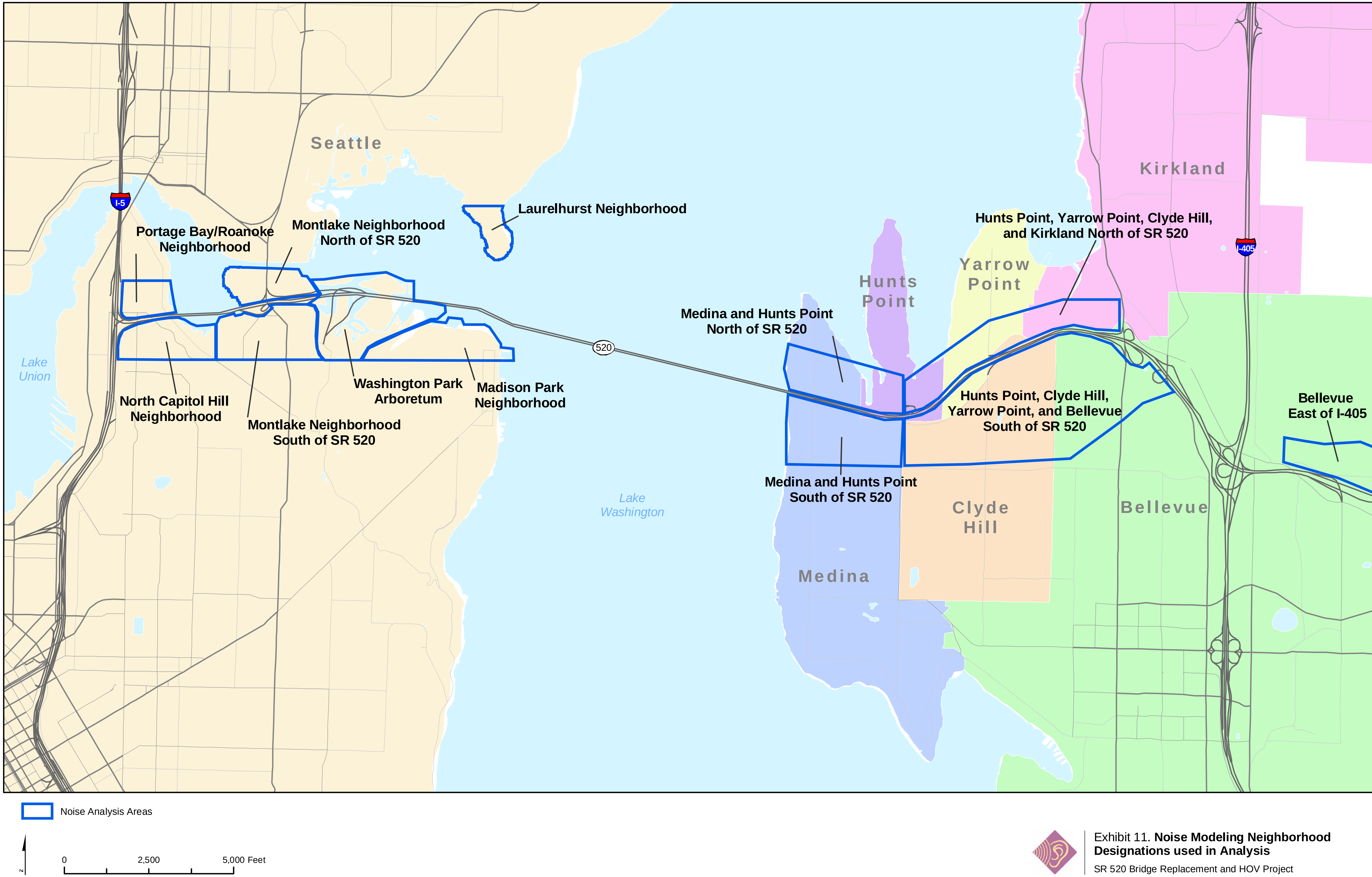


Exhibit 11. **Noise Modeling Neighborhood Designations used in Analysis**

SR 520 Bridge Replacement and HOV Project

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designations for the other 11 neighborhoods in the Seattle and Eastside project area. This numbering convention was developed to help readers navigate through the large amount of data required for this project.

How do we verify traffic noise model predictions?

Prior to using the Traffic Noise Model (TNM) to predict noise levels in the project corridor, the noise discipline team first verified that the model was computing accurate noise levels. This is called model validation.

We used the existing roadway alignments and the traffic counts and speeds data observed during our 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, we 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, several corrective options were considered:

- Identify and add missing terrain, trees, or ground zones to make sure that the model accurately represents 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), or
- Identify and document the reason for the discrepancy (for example, nontraffic 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).

For this project, we compared the measured with the modeled noise levels at all locations in the corridor and, with a few exceptions, all locations were within the ±2 dBA validation requirement. The few exceptions were due to other nontraffic-related noise sources. Results of the model validation are discussed below.

Because observed traffic volumes and speeds were used for the model validation, modeled values may differ from the typical peak-hour, existing-conditions noise modeling found later in this report.

Seattle

We monitored noise at 39 locations in Seattle. All 39 locations were validated with the measured versus modeled noise levels varying by +2 dBA or less. Exhibit 12 summarizes the variance between the measured and modeled noise levels. Details on noise model validation for each of the seven analysis areas are provided in Attachments 1A through 1G and are discussed below.

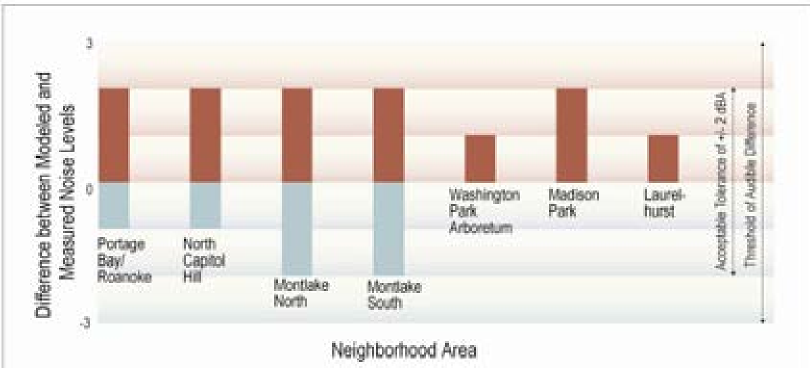


Exhibit 12. **Overall Noise Model Validation Summary for Seattle Project Area**

Portage Bay/Roanoke

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

North Capitol Hill

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

Montlake

For this analysis, we split the Montlake neighborhood into two areas—north of SR 520 and south of SR 520. All noise monitoring locations in both areas were validated, with modeled noise levels varying by +2 dBA when compared to the measured levels. Attachments 1C and 1D present the validation results for the north and south areas, respectively.

Washington Park Arboretum

There was one noise monitoring location for the Arboretum. The measured noise level was 69 dBA, and the modeled noise level was 70 dBA. The noise level variance of 1 dBA is within the validation requirements.

Madison Park

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

Laurelhurst

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

Eastside

Noise levels were measured at 53 locations between Lake Washington and I-405. An additional six noise monitoring locations were added east of I-405 to review noise levels under the 6-Lane Alternative. Of the 59 monitoring locations, 46 were selected for noise model verification. The other 13 monitoring locations were not included because they are in areas where noise from local roadways or other activities were the dominant noise sources. Most of the 46 selected monitoring locations on the Eastside were validated with the noise modeling results. Five locations did not meet the validation level of ±2 dBA. The remaining 41 noise monitoring locations meet the WSDOT ±2 dBA validation criteria. Exhibit 13 summarizes the validation process by analysis area for the Eastside study area. All Eastside validations are discussed below. The locations that were not validated are not included in the graph but are identified and explained in the discussions below.

Medina and Hunts Point North of SR 520

Nine noise monitoring locations were in Medina and Hunts Point west of 84th Avenue Northeast and north of SR 520. One location (PN-9/M45) was too far from SR 520 to receive a reliable validation. In addition, receiver location PN-29/M56 had a modeled noise level that was 4 dBA higher than the measured level. During the noise monitoring period, SR 520 and the on-ramp to SR 520 westbound were gridlocked, which resulted in lower than normal noise levels. For most vehicles, the higher the operating speed, the higher the noise levels.

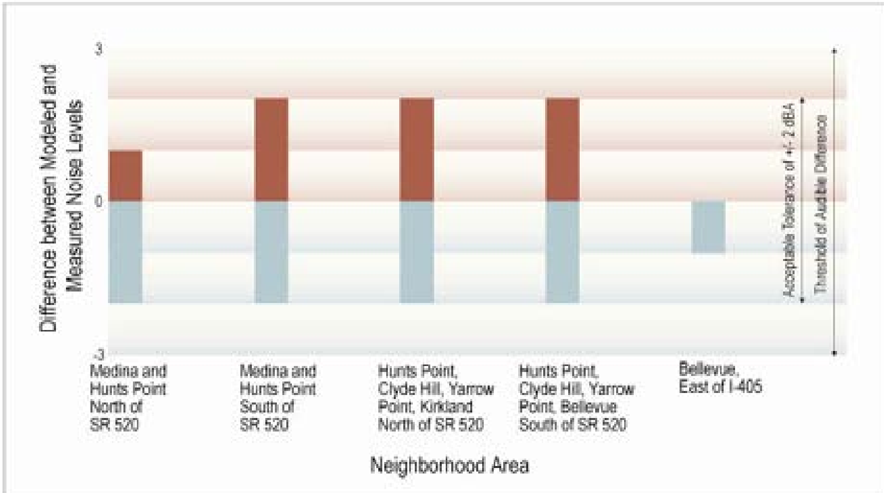


Exhibit 13. Overall Noise Model Validation Summary for the Eastside Study Area

Under a gridlocked condition, the slow-moving vehicles produce lower noise levels. All other modeling locations validated within +1 to -2 dBA of the measured noise levels. A detailed comparison of the monitoring and modeling results for this area are provided in Attachment 2A.

Medina and Hunts Point South of SR 520

There were 10 noise monitoring locations in Medina and Hunts Point west of 84th Avenue Northeast and south of SR 520. One location (PS-29/M51) was too far from SR 520 for a reliable validation. The measurement taken at receiver location PS-5/M47 was higher than modeled because of the addition of nontraffic-related sources. Receiver location PS-13/M58 had a modeled noise level that was 3 dBA higher than the measured level. During the noise reading, traffic flow on SR 520 and the on-ramp to SR 520 eastbound was in a stop-and-go condition, which resulted in lower than normal noise levels. All other modeling locations validated within ±2 dBA of the measured noise levels. The detailed comparison of the monitoring and modeling results for this area are provided in Attachment 2B.

Hunts Point, Clyde Hill, Yarrow Point, and Kirkland North of SR 520

We selected 14 noise monitoring locations in Hunts Point, Clyde Hill, Yarrow Point, and Kirkland north of the SR 520 corridor. One location (PK-35/M83) was too far from SR 520 to provide a reliable validation. In addition, receiver location PK-4/M62 had a high measurement during the noise reading due to local noise effects that were the result of activities in Fairweather Park and some local construction, not traffic on SR 520. All other modeling locations validated within ±2 dBA of the measured noise levels. The detailed comparison of the monitoring and modeling results for this area are provided in Attachment 2C.

Hunts Point, Clyde Hill, Yarrow Point, and Bellevue South of SR 520

We selected 20 noise monitoring locations in Hunts Point, Clyde Hill, Yarrow Point, and Bellevue south of SR 520 for this analysis. Within this area, four locations (PB-52/M61, PB-62/M81, PB-63/M69, and PB-64/M82) were all too far from SR 520 to provide for a reliable validation. All other modeling locations validated within ±2 dBA of the measured noise levels. A detailed comparison of the monitoring and modeling results for this area are provided in Attachment 2D.

Bellevue East of I-405

Six noise monitoring locations were in the project area east of I-405. In this area, three locations (E405-5/M97, E405-7/M95, and E405-9/M94) were too far from SR 520 to provide for a reliable validation. In addition, receiver location E405-3/M96 was not validated due to local access traffic noise that was not the result of SR 520 highway traffic. All other modeling locations validated within -1 dBA of the measured noise levels. A detailed comparison of the monitoring and modeling results in this area are provided in Attachment 2E.

What are the existing peak-hour traffic noise levels?

After the TNM is verified, 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 are modeled using 2004 peak-hour traffic volumes generated by the transportation discipline team and posted speeds.

Exhibit 11 shows how the neighborhoods are grouped into receiver designation areas within the project corridor. The receiver designations (for example, HR for Portage Bay/Roanoke) are used throughout Attachments 1 and 2 to help readers navigate through the large amount of data.

Existing peak-hour traffic noise levels were modeled for a total of 361 receivers throughout the study area. The receiver locations were carefully selected to ensure that all potentially affected areas would be studied. We selected the 361 receivers to represent approximately 1,281 residences within the study area.

The following sections provide detailed results for the Seattle and the Eastside. Maps showing the noise modeling locations are provided later in this report under *Potential Effects of the Project*. Tabular data and detailed aerial photos with modeling locations are provided in Attachments 1 and 2.

Seattle

Existing peak-hour traffic noise levels were modeled for 162 receiver locations, representing 678 residences in Seattle. Of the 162 receivers modeled, noise levels at 63 receivers (representing 271 residences) exceed the WSDOT NAC of 66 dBA L_{eq}.

Portage Bay/Roanoke

Existing peak-hour traffic noise levels were modeled for 23 receiver locations, representing 69 residences in the Portage Bay/Roanoke neighborhood. Noise levels ranged from 56 to 77 dBA L_{eq}, with the highest noise levels at receivers along Harvard Avenue East and East Roanoke Street. The nine receivers (24 residences) where noise levels currently exceed the NAC are presented in *How would the project affect noise levels in the Seattle project area?* later in this report and in Attachment 1A.

North Capitol Hill

Existing peak-hour traffic noise levels were modeled for 32 receiver locations (representing 219 residences) in the North Capitol Hill neighborhood. The high receiver to residence ratio in this neighborhood is due to a large number of apartments in this area. Noise levels ranged from 60 to 73 dBA L_{eq}. The results for North Capitol Hill receivers CH-1 through CH-32 are presented in *How would the project affect noise levels in the Seattle project area?* later in this report and in Attachment 1B. Noise levels at 11 receivers (99 residences) are currently exceeding the NAC.

Montlake North of SR 520

In the Montlake neighborhood north of SR 520, existing peak-hour traffic noise levels were modeled for 24 receiver locations, representing 60 residences. Existing modeled noise levels ranged from 60 to 75 dBA L_{eq}, with the highest noise levels near Montlake Boulevard East. The section titled *How would the project affect noise levels in the Seattle project area?* and Attachment 1C present the results for MN-1 through MN-24. Noise levels at 12 receivers (24 residences) currently exceed the NAC.

Montlake South of SR 520

In the Montlake neighborhood south of SR 520, existing peak-hour traffic noise levels were modeled for 33 receiver locations, representing 114 residences. Existing modeled noise levels ranged from 56 to 74 dBA L_{eq}, with the highest noise levels along East Montlake Place and Lake Washington Boulevard East. The section titled *How would the project affect noise levels in the Seattle project area?* and Attachment 1D present the results for MS-1 through MS-33. Noise levels at 12 receivers (35 residences) in this neighborhood currently exceed the NAC.

Washington Park Arboretum

Existing peak-hour traffic noise levels were modeled for 20 receiver locations in the Arboretum. Receivers were spaced throughout the park to estimate how far away from SR 520 that noise levels exceed the NAC. Areas in the Arboretum that are within 450 feet of the SR 520 alignment currently exceed the residential NAC of 66 dBA L_{eq}. Overall, the modeled noise levels for the 20 receptor locations in the Arboretum ranged from 56 to 80 dBA L_{eq}. Receivers AB-1 through AB-12 and AB-15 represent the areas where noise levels exceed the NAC. Receiver locations and the results of the noise modeling in this area are presented in the section *How would the project affect noise levels in the Seattle project area?* later in this report and in Attachment 1E.

Madison Park

Existing peak-hour traffic noise levels were modeled for 23 receiver locations (representing 201 residences) in the Madison Park neighborhood. Noise levels in this neighborhood ranged from 57 to 69 dBA L_{eq}. The results for Madison Park receivers MP-1 through MP-25 are presented in the section *How would the project affect noise levels in the Seattle project area?* later in this report and in Attachment 1F. Noise levels at six waterfront receivers (representing 89 residences) in Madison Park currently exceed the NAC.

Laurelhurst

Existing peak-hour traffic noise levels were modeled for 7 receiver locations (representing 15 residences) in the Laurelhurst neighborhood. Noise levels ranged from 51 to 61 dBA L_{eq}. The results for receivers LH-1 through LH-7 are presented in the section *How would the project affect noise levels in the Seattle project area?* later in this report and in Attachment 1G. Currently, SR 520 traffic noise levels do not exceed the NAC at any residences in the Laurelhurst neighborhood.

Eastside

Existing peak-hour traffic noise levels were modeled for 199 receiver locations, representing 603 residences on the Eastside. Noise levels at 57 receivers (representing 135 residences) exceed the WSDOT NAC of 66 dBA L_{eq}.

Medina and Hunts Point North of SR 520

Existing peak-hour traffic noise levels were modeled for 43 receiver locations, representing 118 residences in Medina and Hunts Point west of 84th Avenue Northeast and north of SR 520. Noise levels at residential receiver locations in this area ranged from 52 to 75 dBA L_{eq}. The results for receivers PN-1 through PN-43 are presented in the section *How would the project affect noise levels in the Eastside project area?* later in this report and in Attachment 2A. Noise levels at 14 receivers (29 residences) currently exceed the NAC in this area.

Medina and Hunts Point South of SR 520

Existing peak-hour traffic noise levels were modeled for 33 receiver locations (representing 109 residences) in Medina and Hunts Point west of 84th Avenue Northeast and south of SR 520. Existing noise levels in this area were modeled between 56 and 73 dBA L_{eq}. The results for receivers PS-1 through PS-33 are presented in the section *How would the project affect noise levels in the Eastside project area?* later in this report and in Attachment 2B. Noise levels at 15 receivers (37 residences) in this portion of the Eastside project area currently exceed the NAC.

Hunts Point, Clyde Hill, Yarrow Point, and Kirkland North of SR 520

Existing peak-hour traffic noise levels were modeled for 50 receiver locations (representing 116 residences) in the Hunts Point, Clyde Hill, Yarrow Point, and Kirkland areas east of 84th Avenue Northeast and north of SR 520. Current noise levels at residential land uses in this area ranged from 49 to 70 dBA L_{eq}. The results for receivers PK-1 through PK-50 are included in the section *How would the project affect noise levels in the Eastside project area?* and in Attachment 2C. Noise levels at 7 receivers (16 residences) in this portion of the Eastside project area currently exceed the NAC.

Hunts Point, Clyde Hill, Yarrow Point, and Bellevue South of SR 520

Existing peak-hour traffic noise levels were modeled for 64 receiver locations (representing 243 residences) in Hunts Point, Clyde Hill, Yarrow Point, and Bellevue east of 84th Avenue Northeast and south of

SR 520. Existing noise level in this area ranged from 48 to 73 dBA L_{eq}. The results for receivers PB-1 through PB-64 are included in the section *How would the project affect noise levels in the Eastside project area?* and in Attachment 2D. Noise levels at 17 receivers (47 residences) in this area currently exceed the NAC.

Bellevue East of I-405

Existing peak-hour traffic noise levels were modeled for 9 receiver locations (representing 17 residences) in the study area east of I-405. The results for receivers E405-1 through E405-9 are included in the section *How would the project affect noise levels in the Eastside project area?* and in Attachment 2E. Noise levels at four receivers (six residences) in this area currently exceed the NAC. Overall noise levels in this part of the study area ranged from 59 to 69 dBA L_{eq}.

Reducing Project Noise Levels

Early in the development of this project, WSDOT committed to installing sound walls wherever they were needed to reduce the noise levels caused by the proposed project to below the NAC. These sound walls are included as part of the project design; in other words, they are integral to and inseparable from the project, not just mitigation added to the project. In addition, several other design elements also help reduce noise levels caused by the current roadway. The sound walls and how they work are described below. Other noise-reducing features are discussed in the *Mitigation* section. For more detailed information about how sound walls and other noise abatement measures work, see the *Noise Mitigation and Design Options Report* (April 2001) on the project Web site.

What are sound walls and how do they work?

The noise discipline team determined the height and location of the sound walls by modeling sound walls at various locations and heights. To be effective, sound walls need to be constructed to a height higher than required to break the line-of-sight between the highway and the receiver. Sound walls also need to be long enough to prevent flanking of noise around the ends of the walls. Openings in sound walls (for example, at driveways, bridges, and side streets) allow noise to travel through the openings, usually making the noise level reduction less than 3 dBA for receivers near the openings.

Other design considerations that can effect the overall effectiveness of sound walls include horizontal placement, the general topography between the receivers and the roadway, and the elevation relationship (e.g., relative height differences) between the receiver, noise barrier, and roadway. In general, sound walls are most effective if they are placed as close as possible to either the noise source or the receiver locations. In addition, if sensitive receivers are located above the roadway grade, the overall effectiveness of the noise barrier can be considerably reduced unless it is placed at the same elevation as the receiver. Finally, sound walls have the greatest noise-reducing effect on receivers located close to the roadway.

As shown in Exhibit 14, sound walls reduce traffic noise either by directly absorbing it, reflecting it back across the highway, or dispersing or diffracting it upward. Reflected noise is the noise that moves back toward the traffic after hitting the noise barrier. Some noise will be diffracted over the barrier, while a small amount of noise will either be transmitted through, or absorbed by, the barrier.

The *bright zone* is the area above the barrier with a direct line-of-sight to the noise source. The bright zone contains noise directly transmitted from the noise source. The other two zones are the "transmission zone" and the "shadow zone." The transmission zone contains some noise that is directly transmitted by the noise source along with some noise that is diffracted over the wall. The shadow zone is primarily all diffracted noise.

Two additional factors to consider when determining a barrier's height are design feasibility and construction costs. There is a point of diminishing returns, where the additional height of a barrier is vastly more expensive to construct while providing very little additional noise reduction.

Other factors, such as construction considerations and safety and potential barrier reflections, are also considered when determining if a noise barrier is feasible. If these criteria are met, and the walls proposed also meet the WSDOT cost-effectiveness criteria explained below, the walls are normally recommended for construction with the project.

WSDOT Noise Barrier Feasibility and Cost Criteria

WSDOT requires that every reasonable effort should be made to attain a 10 dBA (or greater) noise reduction at the first row of receivers (e.g.,

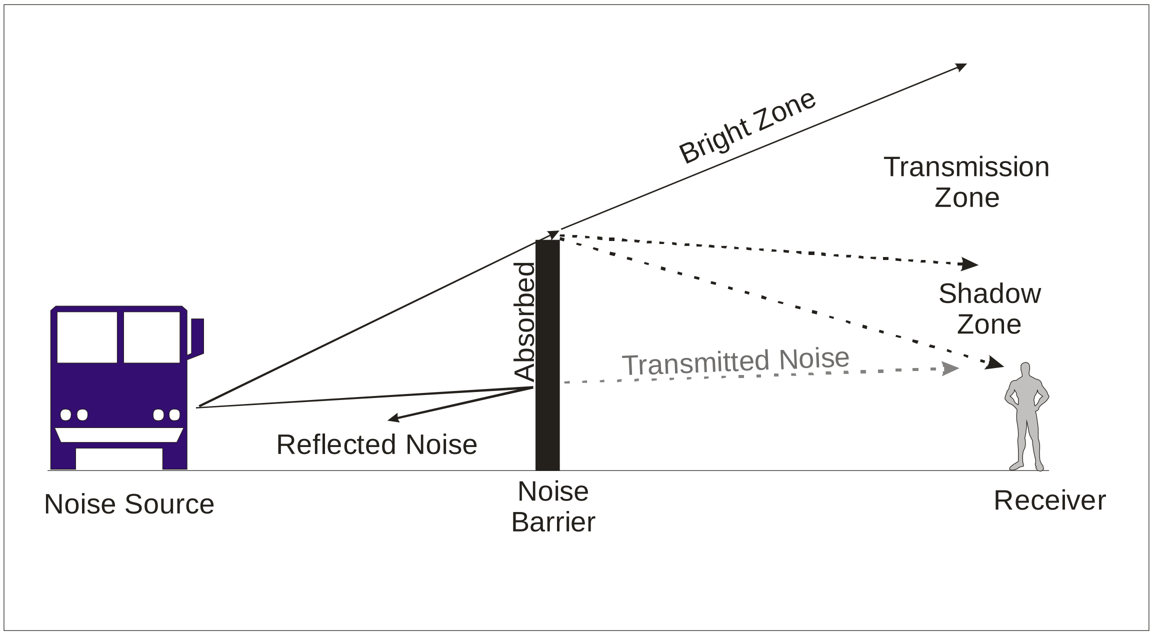


Exhibit 14. Barrier Absorption, Transmission, Reflection, and Diffraction
(Source: Adapted from *FHWA Highway Noise Barrier Design Handbook* [USDOT 2000])

front-line receivers). For a noise barrier to be considered a feasible form of mitigation by WSDOT, the majority of the first row ground floor receivers must achieve a 5 dBA noise reduction and at least one receiver must have a 7 dBA reduction. For most projects, noise barrier construction is considered feasible if a 7 dBA noise reduction can be achieved for ground floor residences. There is no mitigation for upper floors, such as second floors of single-family residences.

WSDOT has established cost-effectiveness criteria to ensure that if a noise barrier is recommended, the cost of the noise barrier is consistent with the level of reduction and is not excessive.

When the construction of a noise barrier has been determined feasible, WSDOT will determine whether its construction is reasonable by thoroughly considering a wide range of criteria, as stated below. It is important to note that sound walls would only be constructed if WSDOT determines the barriers are reasonable. This decision is normally the responsibility of WSDOT and FHWA, with concurrence from design personnel. Reasonableness is based on the following factors:

- Noise levels in the design year approach or exceed the NAC or substantially exceed existing noise levels.

- A majority of the first row of receivers obtain a minimum 5 dBA reduction, and at least one receiver has a minimum 7 dBA reduction.
- The noise mitigation cost per residence (or residential equivalent) does not exceed the amounts indicated in Exhibit 15. This amount is determined by counting all residences (including owner-occupied, rental units, mobile homes, and residential equivalents as defined by WSDOT) that receive at least a 3 dBA noise reduction from the noise barrier, and then dividing that number into the total cost of the noise abatement measure. Please note, each unit in a multifamily building is counted as a separate residence. In addition, areas such as parks and schools are counted based on the WSDOT residential equivalent calculations. The criteria used for the residential equivalency for this analysis were determined using a draft method provided by WSDOT. Exhibit 15 shows that as the predicted future noise-level increases, it is considered reasonable to implement more costly measures as necessary, to mitigate traffic noise.

Exhibit 15. Cost Allowance for Impacts Caused by Total Traffic-Noise Levels

Design Year Traffic Noise Level	Allowed Cost per Household[a]	Equivalent Wall Surface Area per Household
66 dBA	$22,600	700 sq. feet (65.0 sq. meters)
67 dBA	$24,900	770 sq. feet (71.5 sq. meters)
68 dBA	$27,000	836 sq. feet (77.7 sq. meters)
69 dBA	$29,200	904 sq. feet (84.0 sq. meters)
70 dBA	$31,400	972 sq. feet (90.3 sq. meters)
71 dBA	$33,600	1,040 sq. feet (96.6 sq. meters)
72 dBA	$35,800	1,108 sq. feet (103.0 sq. meters)
73 dBA	$38,000	1,176 sq. feet (109.2 sq. meters)
74 dBA	$40,200	1,244 sq. feet (115.6 sq. meters)

[a] Costs shown are for 2004-2005 and are reevaluated each year using current construction costs. Based on $32.31 per square foot construction cost.

How did we determine sound wall locations and heights?

The following section provides the details on the proposed sound walls, including graphic illustrations of typical situations for receivers located at-grade, below-grade, and above-grade and how the sound walls' overall noise reduction characteristics are affected by area topography.

We have also included detailed drawings that show an aerial view of the project corridor and locations of the sound walls.

Residents in the SR 520 project corridor are either at-grade with SR 520, below the grade of SR 520, or above the grade of SR 520. The heights of sound walls are greatly influenced by this geometry.

Sound Walls for At-Grade Receivers

For receivers located at a similar grade to the project corridor, such as near the Montlake Playfield and at locations south of SR 520 just east of the 84th Avenue Northeast exit, sound walls would be a very effective mitigation method. The sound walls would be placed close to the roadway within the project corridor and have little room for horizontal movement because of limited right-of-way. Sound wall heights for locations such as these would be 10 to 14 feet high. Walls of this height are normal for major highways with light to moderate levels of heavy truck traffic (such as SR 520) where receivers are at approximately the same grade as the roadway. Exhibit 16 shows a typical schematic of sound wall placement and relative effectiveness for receivers located at grade for different distances from the project roadway.

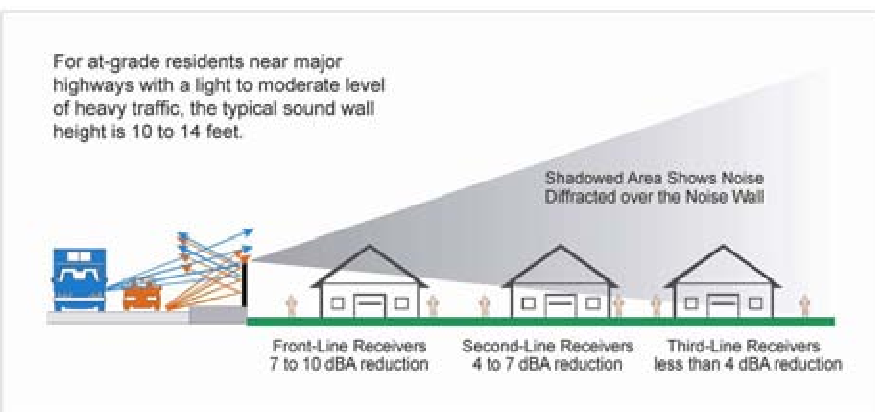


Exhibit 16. Typical Sound Wall Effectiveness with At-Grade Receiver

Sound Walls with Below-Grade Receivers

For locations where the receivers are located below the highway elevation (such as the north side of SR 520 just east of the 84th Avenue Northeast bridge over SR 520), the overall effectiveness of a sound wall is normally increased. Because the receivers are located below the elevation of the highway, less of the noise diffracted over the top of the sound wall reaches the receivers. In most cases, the wall height would be lower and still provide the same level of noise reduction, as shown for receivers located at the same level as the roadway. Typical noise barrier heights for below-grade receivers are 2 to 4 feet less than for at-grade receivers. The actual height of the wall would again depend on wall placement, distance to the receiver, and vehicle mix. Exhibit 17 provides a typical schematic of wall heights and relative effectiveness for receivers located below the road grade.

Sound Wall with Above-Grade Receivers

For locations where receivers are elevated above the roadway (such as North Capitol Hill and Clyde Hill), sound walls are normally less effective at reducing transportation noise because the receivers are closer to noise that is diffracted over the top of the sound wall. Increasing the height of the sound wall can, in some circumstances,

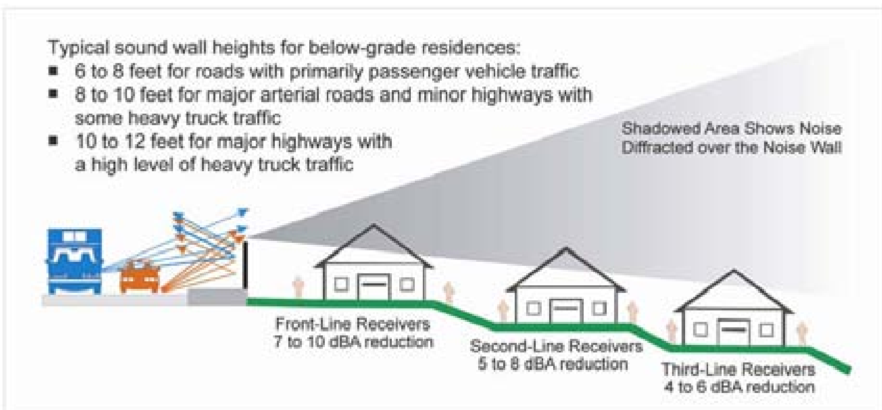


Exhibit 17. Typical Sound Wall Effectiveness with Below-Grade Receiver

result in noise reductions of the same magnitude that would be achieved for at-grade receivers. The overall effectiveness would depend on the level of elevation over the roadway, vehicle mixture, wall placement, and other geometric considerations. Again, because of the limited right-of-way in the project corridor, changing the horizontal placement of the sound wall was, in most cases, not an option; therefore, sound walls of 18 to 20 feet and higher are being considered in certain sections of the corridor. Exhibit 18 shows a typical schematic of wall heights and relative effectiveness for receivers located above the road grade.

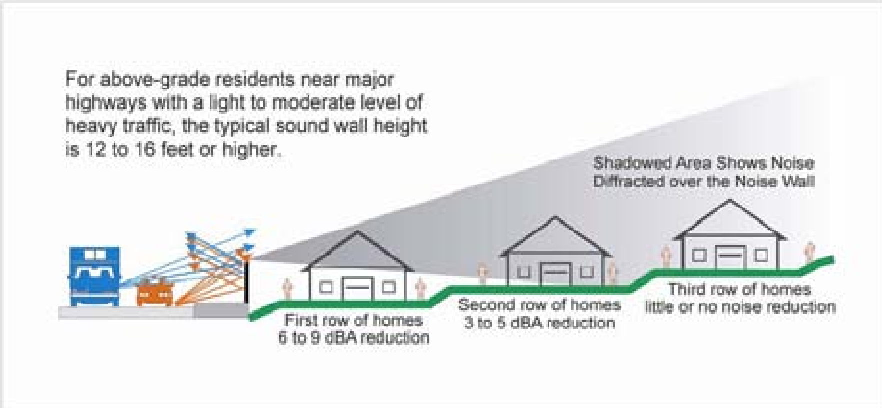


Exhibit 18. Typical Sound Wall Effectiveness with Above-Grade Receiver

What sound walls are included with the 4-Lane Alternative?

Under the 4-Lane Alternative, sound walls would be built along both sides of SR 520 for most of the project corridor. Exhibits 19 and 20 show the locations and heights of the proposed sound walls for Seattle and the Eastside, respectively. The heights given on the exhibits are for the height of the wall above the grade of the highway, and do not include any retaining walls that could be included during final design. If a retaining wall is added during final design, the sound wall could be placed on top of the retaining wall, thereby making the height requirement of the sound wall lower. For example, if a 20-foot-high sound wall is shown, and a 10-foot-high retaining is required in that same location, the height of the sound wall would be reduced to 10 feet (10 feet retaining + 10 feet sound wall = 20 feet effective wall height) to achieve the same level of noise reduction. The one exception to this is the Montlake area, where the proposed 8-foot-high sound wall is assumed to be 8 feet from the grade of Lake Washington Boulevard (above the depressed highway's retaining wall).

Seattle

At the western end of the Seattle project area, sound walls would start in the Portage Bay/Roanoke neighborhood on the north side of SR 520, just past the 10th Avenue East bridge and continue for 1,200 feet, ending just past Boyer Avenue East. A second 1,100-foot-long sound wall is proposed on the north side of SR 520 near the Seattle Yacht Club and NOAA Northwest Fisheries Science Center and would continue east to Montlake Boulevard. This wall would begin on the west with a height of 10 feet and decrease to 6 feet near Montlake Boulevard.

Another sound wall would continue along the north side of SR 520 from Montlake Boulevard through the Arboretum. This wall would range in height from 10 to 16 feet near Montlake, decrease to 8 feet across Foster Island, and end at the east end of the island.

A sound wall would also be built on the south side of SR 520 near the North Capitol Hill neighborhood and run continuously from the 10th Avenue East bridge to Montlake Boulevard. This wall would reach a maximum height of 22 feet near Delmar Drive East and reduce to 10 feet from just east of Delmar Drive East all the way to its endpoint near Montlake Boulevard.

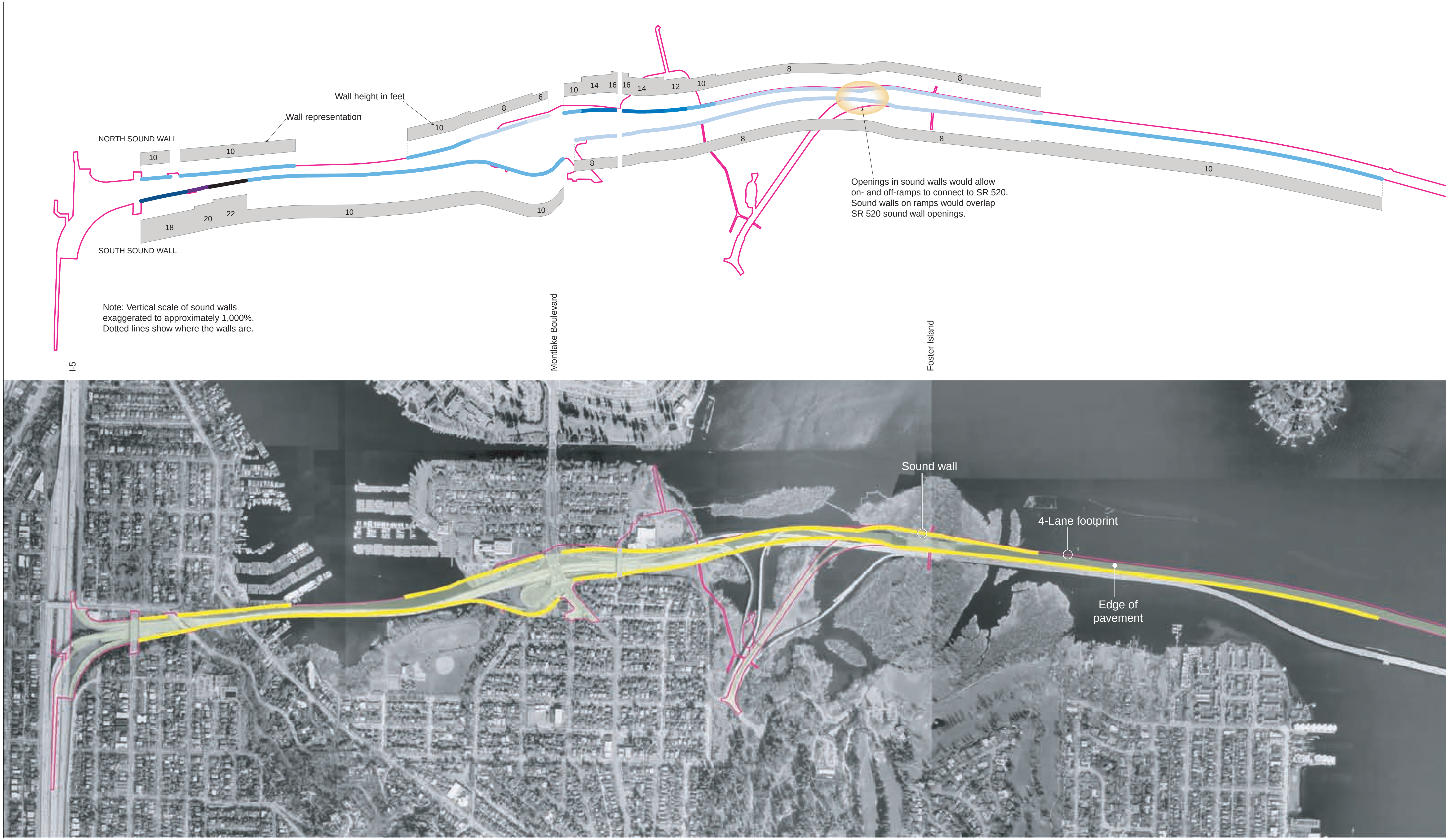
The south sound wall would continue from the east side of Montlake Boulevard and continue past Madison Park. The wall height would vary from 8 feet near Montlake Boulevard to 10 feet adjacent to Madison Park.

The sound walls in Seattle would cover 29,606 linear feet, with heights ranging from 6 to 22 feet above the local area elevation. The tallest walls would be along the steep cut of North Capitol Hill and may be constructed on top of retaining walls, which would reduce the actual wall height. The estimated cost of the sound walls (using the recommended WSDOT cost of $32.31 per square foot) would be $9,087,321. With a projected 313 residences and residential equivalents achieving a 5 dBA or greater noise reduction, the cost per receiver was calculated at $29,033, which is within the recommended costs given in Exhibit 15 for highways with future noise levels projected at 68 to 69 dBA.

Eastside

Sound walls are proposed for the Eastside from just west of the eastern shoreline of Lake Washington to just west of Bellevue Way. The sound walls would be virtually continuous through the entire area except for breaks at Evergreen Point Road, 84th Avenue Northeast, and 92nd Avenue Northeast. Wall heights on the north side of the highway would vary from 8 feet on the structure to 20 feet near Evergreen Point Road. The sound wall height would decrease to 10 to 14 feet near 80th Avenue Northeast and increase back up to 20 feet at 84th Avenue Northeast.

Sound walls on the Eastside would total 21,575 feet in length, with heights ranging from 8 to 20 feet above the local area elevation. The cost of the sound walls using the recommended WSDOT cost of $32.31 per



N

0 500 1,000 Feet

4-Lane footprint
Sound wall location
Edge of pavement

Exhibit 19. **Sound Wall Locations and Heights for the 4-Lane Alternative, Seattle**

SR 520 Bridge Replacement and HOV Project

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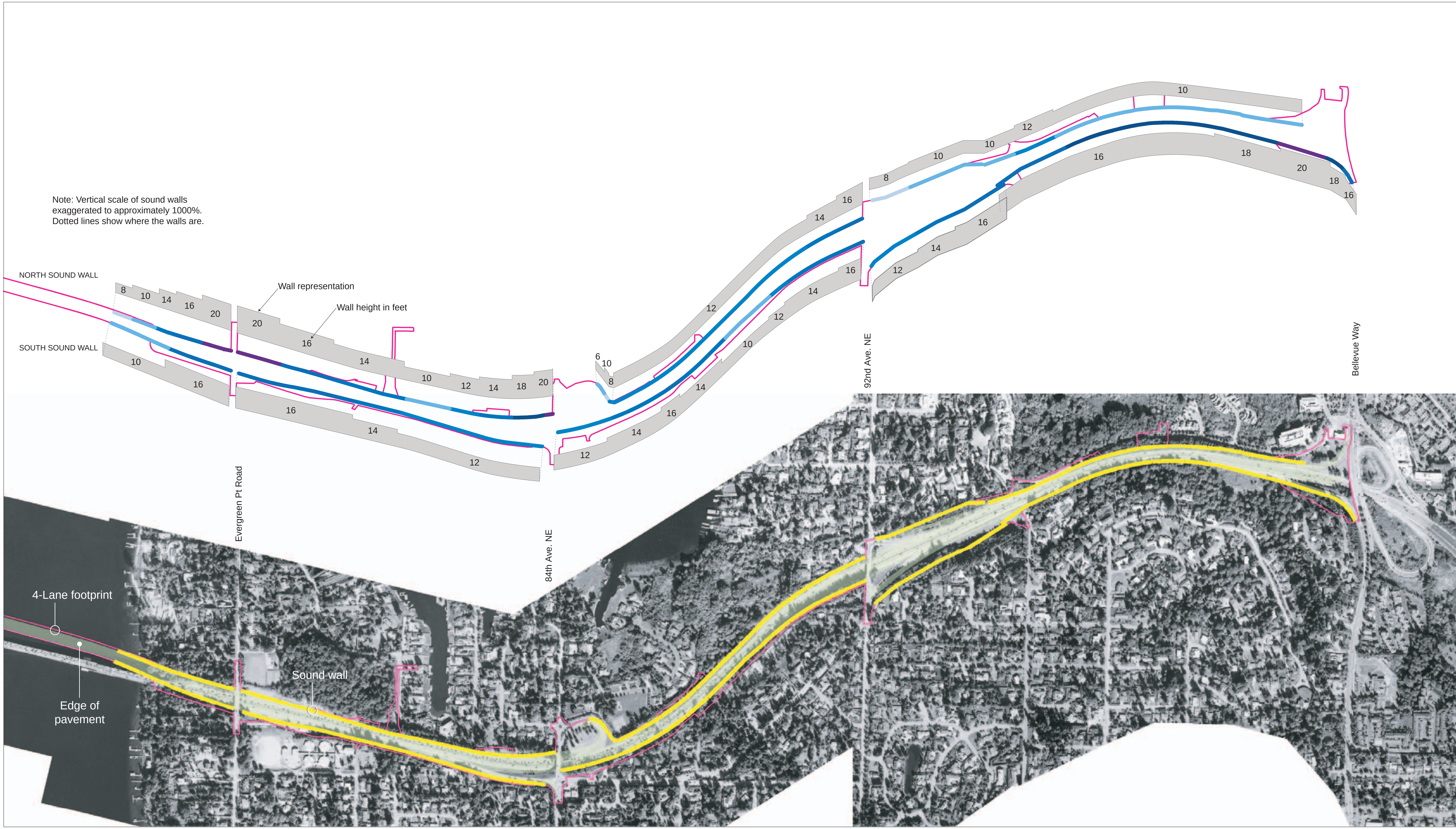

0 500 1,000 Feet

- 4-Lane footprint
- Sound wall location
- Edge of pavement

Exhibit 20. **Sound Wall Locations and Heights for the 4-Lane Alternative, Eastside**

SR 520 Bridge Replacement and HOV Project

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A sound wall would also be built on the south side of SR 520, beginning at the east end of the 10th and Delmar lid and running continuously to the Montlake Boulevard eastbound off-ramp. This south wall would reach a maximum height of 14 feet near the 10th and Delmar lid, lowering to 10 feet from just east of Delmar Drive East all the way to its end point near Montlake Boulevard. This wall would be shorter than the wall under the 4-Lane Alternative because of the 10th and Delmar lid.

The south sound wall would continue east from the east side of the Montlake lid past Madison Park. The wall height would be 8 feet near Montlake Boulevard and through the Arboretum, then increase to 10 feet adjacent to Madison Park.

The sound walls in Seattle would cover 26,583 linear feet, with heights ranging from 8 to 18 feet above the local area elevation. The total length is less than the 4-Lane Alternative because of the lids at 10th and Delmar and Montlake. The estimated cost of the sound walls under the 6-Lane Alternative (using the recommended WSDOT cost of $32.31 per square foot) would be $7,981,215. With a projected 320 residences and residential equivalents achieving a 5 dBA or greater noise reduction, the cost per receiver would be $24,941, which is within the recommended noise cost criteria.

Eastside

Under the 6-Lane Alternative, sound walls are proposed for the Eastside from just west of the eastern shoreline of Lake Washington to just west of Bellevue Way. The sound walls would be continuous throughout the entire area except for breaks at Evergreen Point Road, 84th Avenue Northeast, and 92nd Avenue Northeast, where the sound walls would be integrated with the lids. Wall heights would vary from 8 feet to 20 feet throughout the corridor. The taller walls are necessary in areas where residents are located uphill from the project corridor.

The Eastside sound walls would total 19,418 feet in length, with heights ranging from 8 to 20 feet above the local area elevation. The cost of the sound walls (using the recommended WSDOT cost of $32.31 per square foot) would be $8,798,324. Based on an estimated 289 residences and residential equivalents with noise level reductions of 5 dBA or greater, the cost per residence would be $30,444, which is within the WSDOT cost criteria. The number of benefited receivers is lower under the 6-Lane Alternative than with the 4-Lane due to noise reduction by the lids.

square foot would be $9,679,696. Based on an estimated 351 residences and residential equivalents with noise level reductions of 5 dBA or greater, the cost-per-residence would be $27,577, which is within the WSDOT cost criteria for highways with future noise levels projected at 68 to 69 dBA.

What sound walls are included with the 6-Lane Alternative?

The proposed sound walls under the 6-Lane Alternative would be very similar to those for the 4-Lane Alternative and run along both sides of SR 520 for most of the project corridor. Major differences would occur near the lids, and in some locations the wall heights would differ because of roadway geometry. Exhibits 21 and 22 show the locations and heights of the proposed sound walls in Seattle and on the Eastside, respectively.

As with the 4-Lane Alternative sound walls, the heights given on the exhibits are for the height of the wall above the grade of the highway and do not include any retaining walls that may be included during final design. The one exception to this is in the Montlake area, where the 8-foot-high sound wall between Lake Washington Boulevard and SR 520 assumes that the 8-foot-high sound wall is above the retaining wall for the depressed highway. Brief discussions on the walls heights and lengths are provided below.

Seattle

Under the 6-Lane Alternative, the sound walls in Seattle on the north side of SR 520 would begin in the Portage Bay/Roanoke neighborhood and connect to the 10th and Delmar lid at both the west and east ends, then end just past the Boyer Avenue East in the same location as the 4-Lane Alternative. A second 1,100-foot-long sound wall would start on the north side of SR 520 near the Seattle Yacht Club and continue east to the Montlake lid. This wall would be 10 feet high on the west end, increase to 12 feet high, and then decrease in height to 8 feet near the Montlake lid.

A sound wall would continue east along the north side of SR 520 and along the westbound off-ramp through the Arboretum. This wall would range in height from 10 to 18 feet near Montlake, decrease to 8 feet across Foster Island, and end at the east side of the island in the same location as the 4-Lane sound wall.

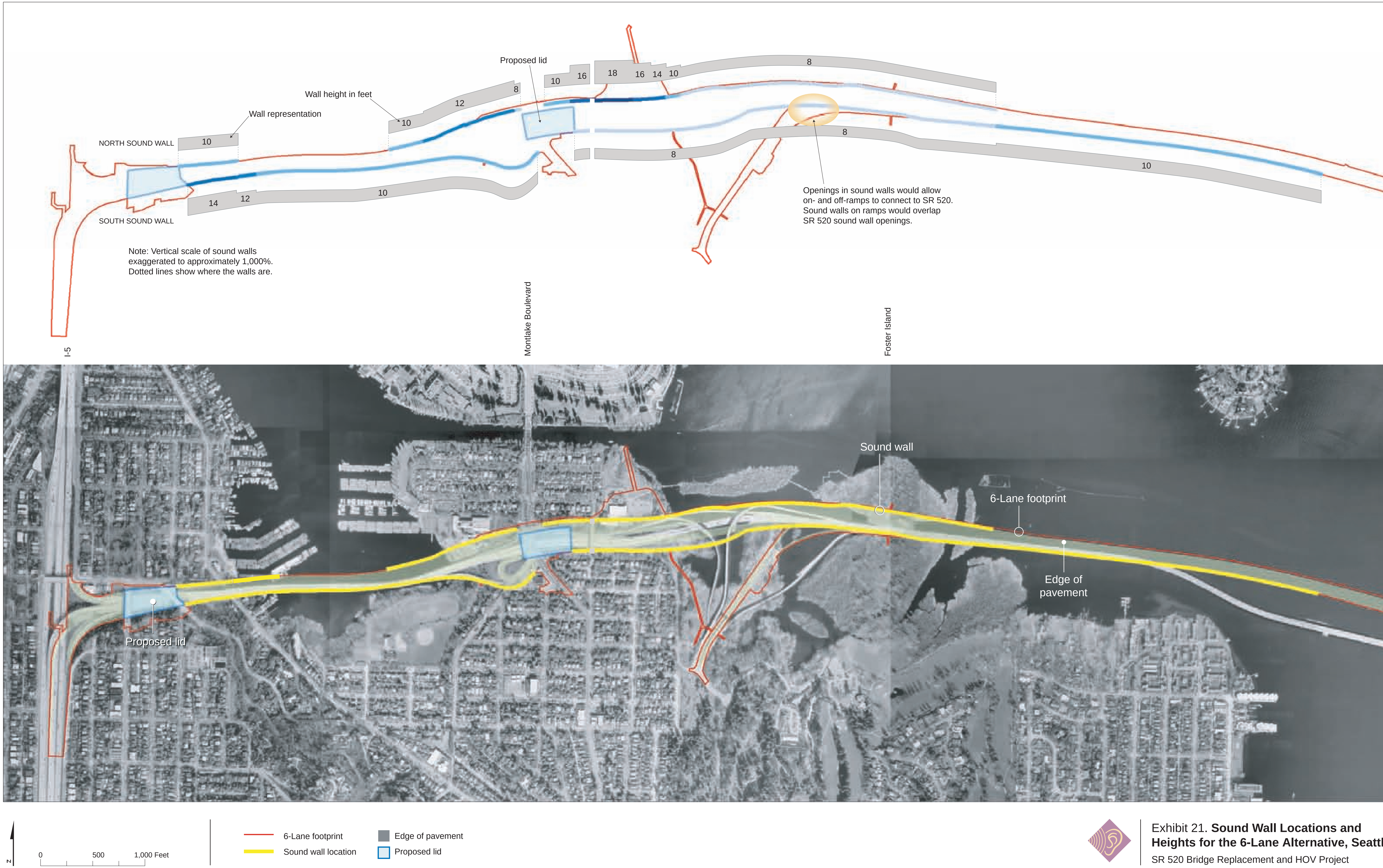

Exhibit 21. **Sound Wall Locations and Heights for the 6-Lane Alternative, Seattle**

SR 520 Bridge Replacement and HOV Project

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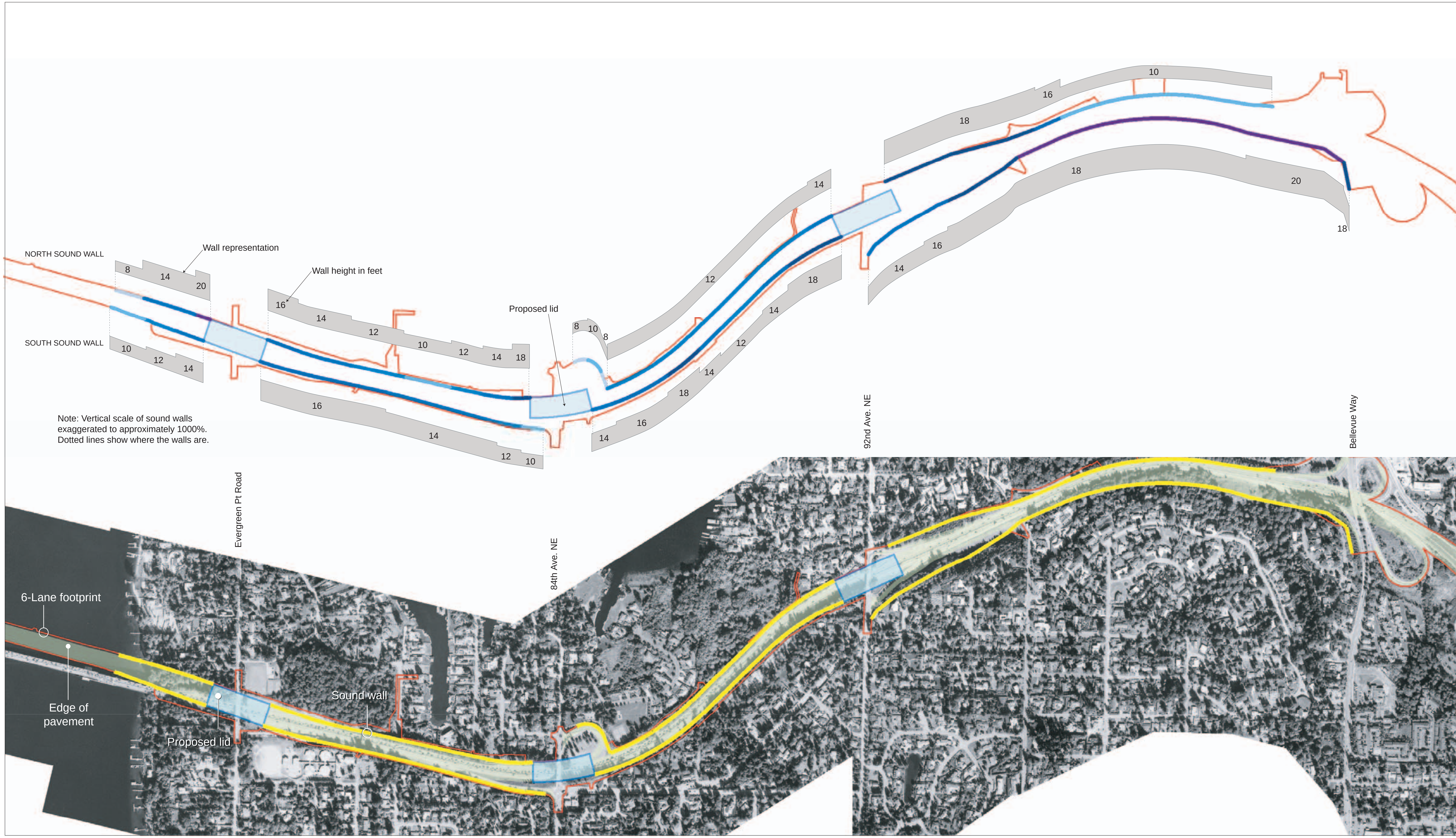

N
0 500 1,000 Feet

6-Lane footprint
Sound wall location
Edge of pavement
Proposed lid

Exhibit 22. **Sound Wall Locations and Heights for the 6-Lane Alternative, Eastside**

SR 520 Bridge Replacement and HOV Project

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Potential Effects of the Project

The noise discipline team modeled future traffic noise levels using the peak-hour traffic volumes for the design year 2030 and the posted speed limits in the project corridor. Because the actual travel speeds are projected to be lower than the posted speed limit, noise level projections are considered conservative and are likely 1 to 3 dBA or more higher than actual noise levels would be in the corridor under the forecasted traffic volumes. Future conditions noise levels were projected for the No Build Alternative, the 4-Lane Alternative, and the 6-Lane Alternative.

Sound walls are included as part of the project in both the 4-Lane Alternative and 6-Lane Alternative and have been included in the TNM modeling. The sound walls were designed to meet the following project objectives:

- Reduce overall noise levels in the surrounding communities.
- Reduce future noise levels at all residences to below the WSDOT NAC of 66 dBA L_{eq}.
- Wherever possible, reduce noise levels at front-line residences adjacent to SR 520 by 7 to 10 dBA L_{eq}.

For an understanding of how effective the sound walls would be in reducing future noise levels, the exhibits in Attachments 1 and 2 show future noise levels for each alternative as well as noise levels without sound walls. These attachments provide detailed exhibits for all noise modeling locations used in this analysis.

The modeling results are presented for each project area neighborhood group in Seattle and on the Eastside. Particular attention is paid to whether the sound walls would lower noise levels to below the NAC for the design year 2030.

To conservatively predict future noise level conditions for all of the project alternatives, we used design year 2030 traffic volumes for each alternative and the posted speed limits (55 mph on the SR 520 mainline). We used the existing alignment of SR 520 to model the No Build Alternative, and the 4-Lane and 6-Lane Alternative alignments to model the build alternatives. Major local arterial roads and all SR 520 ramps were included in the noise model and also modeled at the posted speed limits.

The noise discipline team considered two scenarios under the No Build Alternative: the Catastrophic Failure Scenario and the Continued Operation Scenario. For the Catastrophic Failure Scenario, we evaluated future noise conditions in a qualitative manner, relying on minimum measured noise levels during nighttime hours to describe this scenario. For the Continued Operation Scenario, we calculated future noise levels using the TNM model and compared those results to the 2004 existing levels presented in the *Affected Environment* section of this report. 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 25 years.

We also compared the 4-Lane Alternative and 6-Lane Alternative to show how the noise levels would vary in the future if the project were built. To make it easier to understand how noise levels would change under the different project alternatives, we have included maps for each analysis area (Exhibits 23 through 29 for Seattle and Exhibits 30 through 34 for the Eastside).

As described earlier in this report, it takes an approximately 3 dBA change in noise for an average person to notice a difference in sound levels. Using this number as a baseline for noticeable change, Exhibits 23 through 34 show what noise level change would occur at each receiver location under the project alternatives compared to existing noise levels. The exhibits show the location of all noise modeling sites, identify which receivers exceed the NAC, and provide a symbol indicating whether an average person 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.

The 4-Lane Alternative and 6-Lane Alternative noise levels were compared to existing conditions and the No Build Alternative. Results of these comparisons are provided in table format in Attachments 1 and 2.

How would the project affect noise levels in the Seattle project area?

This section discusses the overall effects of the No Build, 4-Lane, and 6-Lane Alternatives on the Seattle project area, followed by discussions about the individual neighborhoods.

Summary of Effects in the Seattle Project Area

No Build Alternative

Under the Catastrophic Failure Scenario, noise levels in the Seattle project area would change along the SR 520 corridor. Most traffic in this area crosses Lake Washington. Loss of the Portage Bay Bridge or the Evergreen Point Bridge would divert traffic to alternate routes. This could result in a substantial drop in overall noise in much of the project corridor, with the potential for increases in noise along alternative routes such as I-90. In general, noise levels in many areas would be similar to those experienced during occasional Evergreen Point Bridge closures.

Receivers in the Portage Bay/Roanoke and North Capitol Hill neighborhoods would experience a negligible reduction in noise levels because of continued traffic on I-5, Harvard Avenue East, and 10th Avenue East. Loss of the bridges would reduce noise levels from SR 520 in the Montlake neighborhood, but because of traffic on Montlake and Lake Washington Boulevards, the overall noise reduction in the Montlake neighborhood would only occur at locations farther away from the major arterial roads. Noise levels in the Arboretum and Madison Park could decrease by 10 dBA or more.

To predict future No Build Alternative noise levels under the Continued Operation Scenario, the noise discipline team modeled the peak-hour traffic noise levels in 2030 for the same 162 receiver locations in Seattle that were used to determine existing peak-hour traffic conditions. Future noise levels would increase slightly (1 dBA or less) compared to existing levels because of growth in traffic volumes on SR 520 and other roadways within the study area. Of the 162 modeled receivers, noise levels at 70 receivers, representing 288 residences, would exceed the NAC of 66 dBA L_{eq} under the No Build Alternative. Compared to existing conditions, this would be an increase of 17 residences with noise levels exceeding the NAC.

Number of Residences Where Noise Levels Exceed the NAC in the Seattle Project Area

Existing	No Build	4-Lane	6-Lane
271	288	127	109

4-Lane and 6-Lane Alternatives

The noise discipline team modeled the 4-Lane Alternative and 6-Lane Alternative for peak-hour traffic noise levels in 2030 at the same 162 Seattle receiver locations that were used to determine existing peak-hour traffic conditions. As noted previously in the *What are the existing peak-hour traffic noise levels?* section, existing peak-hour traffic conditions produce noise levels that exceed the NAC at 63 receivers, representing 271 residences. Overall, the 4-Lane Alternative would lower the number of residences where noise levels exceed the NAC to 127. The 6-Lane Alternative would lower the number of residences where noise levels exceed the NAC to 109. Residences where noise levels would continue to exceed the NAC would not be further benefited by a sound wall constructed near the roadway because of topographical constraints or because the major noise source at these residences is I-5, Montlake Boulevard, Lake Washington Boulevard, or another major arterial road—not SR 520.

Aerial photos showing the modeling locations and the modeled noise levels for the Seattle project area are provided in Attachment 1, along with a set of tables that provide a complete comparison of the alternatives at each modeling location.

Effects of the Project on Neighborhoods in the Seattle Project Area

The following sections describe and compare year 2030 traffic to the existing conditions for each neighborhood in the Seattle project area for the No Build, 4-Lane, and 6-Lane Alternatives. Exhibits 23 through 29 show the noise level changes between the alternatives when compared to the existing conditions and also show locations that exceed the NAC. Each of the seven Seattle areas are discussed below.

Portage Bay/Roanoke

The noise discipline team modeled peak-hour traffic noise levels for 23 receiver locations (representing 69 residences) in the Portage Bay/Roanoke neighborhood (see Exhibit 23). A slight increase in traffic noise levels (1 dBA or less) is expected in the Portage Bay/Roanoke neighborhood under the No Build Alternative. However, no additional residences are expected to have noise levels exceeding the NAC. The number of residences exceeding the NAC would remain at 24.

Under the 4-Lane Alternative, the number of residences with noise levels exceeding the NAC would decrease from the current and future

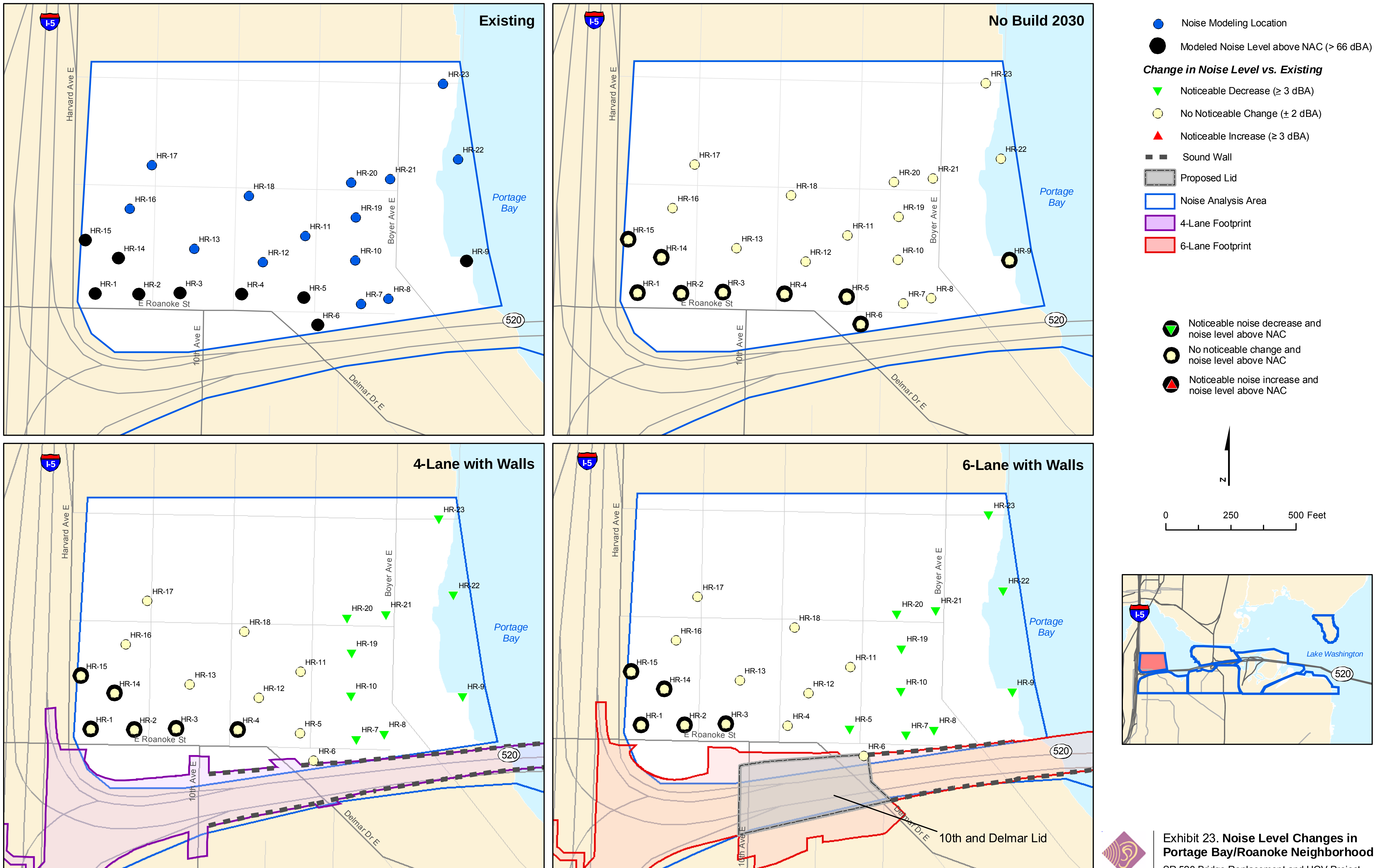


Exhibit 23. **Noise Level Changes in Portage Bay/Roanoke Neighborhood**

SR 520 Bridge Replacement and HOV Project

No Build count of 24 to 19. Under the 6-Lane Alternative, NAC exceedances would be reduced even further to 16. The greater noise level reduction under the 6-Lane Alternative would be due to the addition of the 10th and Delmar lid.

Under both build alternatives, several residential locations north of East Roanoke and east of 10th Avenue East would experience noise levels that are noticeably lower than today's noise levels, with noise reductions of 3 to 13 dBA. The remaining residences that would continue to exceed the NAC experience traffic noise from I-5, Harvard Avenue East, East Roanoke, and 10th Avenue East or are too high in elevation for sound walls to provide effective noise reduction. Overall, maximum noise levels under the different alternatives in the Portage Bay/Roanoke neighborhood would not change more than 1 dBA L_{eq} because of the dominant noise from I-5, Harvard Avenue East, and East Roanoke Street.

Exhibit 23 provides four maps of this neighborhood that show existing noise levels, with the future noise levels projected under the No Build and build alternatives. These maps also show which locations are projected to exceed the NAC and where noise levels are projected to increase, remain the same, or decrease under each of the alternatives when compared to existing noise levels. Attachment 1A presents complete tabulated results and compares the project alternatives to existing peak-hour traffic noise levels.

North Capitol Hill

The noise discipline team modeled peak-hour traffic noise levels for 32 receiver locations (representing 219 residences) in the North Capitol Hill neighborhood. Currently, 99 residences exceed the NAC. Compared to existing conditions, noise levels under the No Build Alternative would exceed the NAC at an additional two receivers (representing 10 residences), bringing the total number of residences exceeding the NAC to 109. Slight increases in noise of less than 3 dBA L_{eq} can be expected throughout North Capitol Hill as traffic on SR 520, I-5, 10th Avenue East, and other roadways increase over time.

Compared to existing conditions, with noise levels at 99 residences exceeding the NAC, the 4-Lane Alternative would reduce the number of residences where noise levels exceed the NAC to 60 and the 6-Lane Alternative would reduce this number to 49. Under both the 4-Lane and 6-Lane Alternatives, noise levels would be reduced substantially for most receivers east of Delmar Avenue East. The remaining residences where noise levels would exceed the NAC would do so primarily because of noise from I-5 and 10th Avenue East. Noise reductions of up to 12 dBA from the existing conditions are expected at many receivers that currently exceed the NAC.

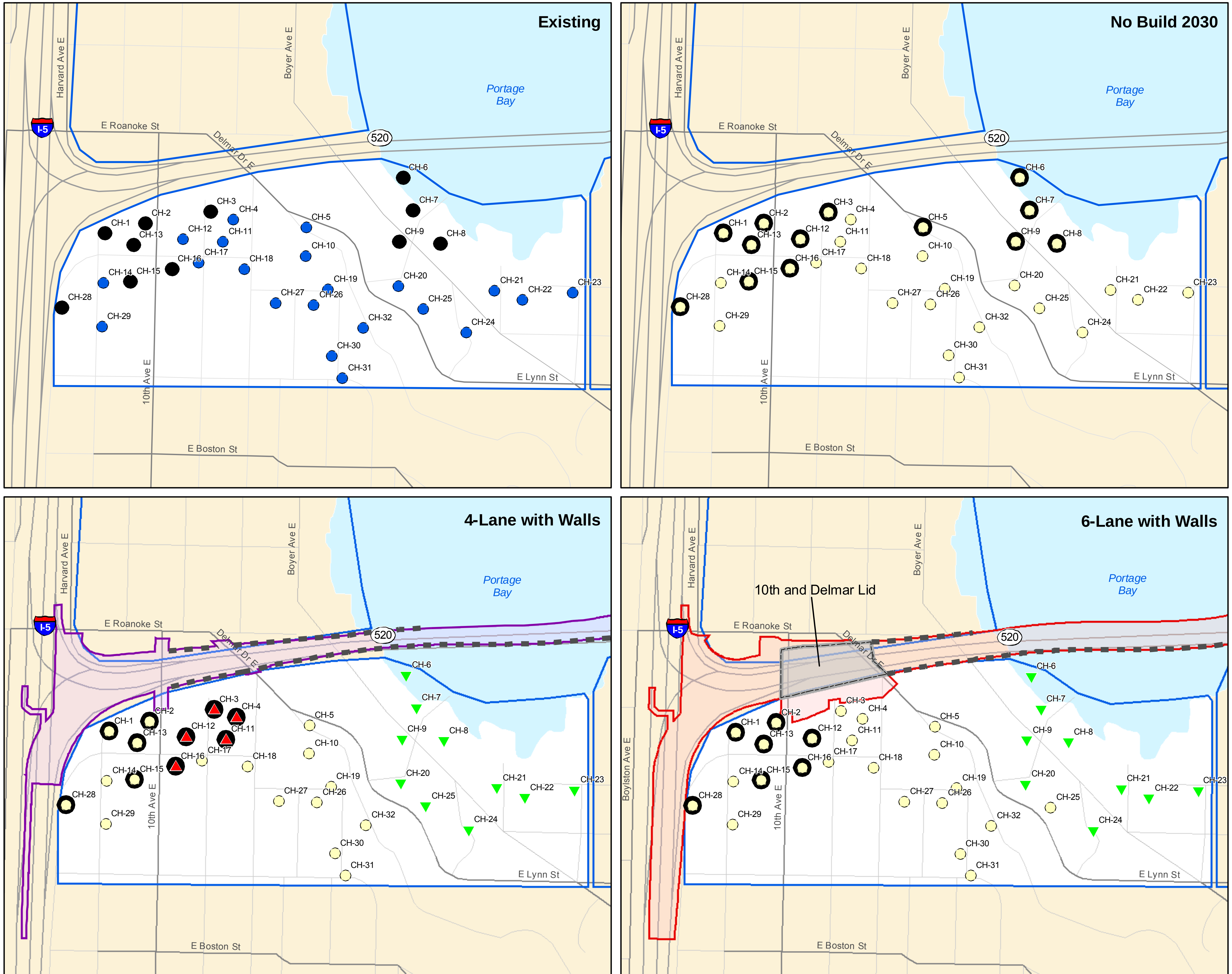
The 10th and Delmar lid would reduce noise levels at many residences east of 10th Avenue East under the 6-Lane Alternative. The steep hillside cut near Delmar Drive East would make sound walls under the 4-Lane Alternative less effective at reducing noise from SR 520 than this lid under the 6-Lane Alternative. Noise levels at receivers CH-3, CH-4, CH-11, CH-12, and CH-16 would exceed the NAC under the 4-Lane Alternative because of noise from SR 520 and traffic noise from 10th Avenue East.

Exhibit 24 shows the receiver locations used for modeling the North Capitol Hill neighborhood and identifies the locations that could exceed the NAC. The maps on Exhibit 24 also show how noise levels in the Capitol Hill area would change under the No Build, 4-Lane, and 6-Lane Alternatives compared to existing noise levels. Attachment 1B contains tables and graphics that show, in detail, the results for North Capitol Hill receivers and compares the project alternatives to existing peak-hour traffic noise levels.

Montlake North of SR 520

The noise discipline team modeled peak-hour traffic noise levels for 24 receiver locations, representing 60 residences, in the Montlake neighborhood north of SR 520. Compared to existing conditions, noise levels under the No Build Alternative would exceed the NAC at only one additional receiver at the west end of the neighborhood near West Montlake Park and the Seattle Yacht Club, where there are no permanent residences. The number of residences exceeding the NAC under the No Build Alternative would therefore be the same as today.

Compared to existing conditions and the No Build Alternative, both the 4-Lane Alternative and 6-Lane Alternative would reduce the number of residences where noise levels exceed the NAC from 24 to 16. All 16 residences that would continue to exceed the NAC are located along Montlake Boulevard East; Montlake Boulevard is the primary noise source during the peak-traffic hour. Virtually all other residences in this area would have reduced noise levels under both the 4-Lane Alternative and 6-Lane Alternative. Overall noise reductions of up to 12 dBA L_{eq} were calculated for the 4-Lane Alternative, and the 6-Lane Alternative would have noise levels reductions of up to 10 dBA L_{eq}.



Noise Modeling Location

Modeled Noise Level above NAC (> 66 dBA)

Change in Noise Level vs. Existing

Noticeable Decrease (≥ 3 dBA)

No Noticeable Change (± 2 dBA)

Noticeable Increase (≥ 3 dBA)

Sound Wall

Proposed Lid

Noise Analysis Area

4-Lane Footprint

6-Lane Footprint

Noticeable noise decrease and noise level above NAC

No noticeable change and noise level above NAC

Noticeable noise increase and noise level above NAC

N

0 250 500 1,000 Feet

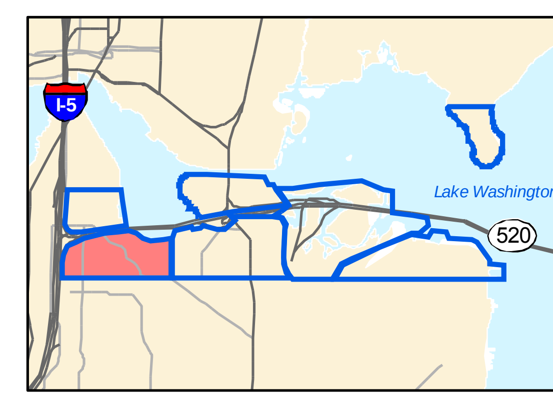


Exhibit 24. **Noise Level Changes in North Capital Hill Neighborhood**

SR 520 Bridge Replacement and HOV Project

Exhibit 25 shows locations of the receivers used for the noise modeling and a noise level comparison of existing conditions with the No Build, 4-Lane, and 6-Lane Alternatives. Attachment 1C lists the results for the Montlake receivers north of SR 520 and compares the project alternatives to existing peak-hour traffic noise levels.

Montlake South of SR 520

The noise discipline team modeled peak-hour traffic noise levels for 33 receiver locations, representing 114 residences, in the Montlake neighborhood south of SR 520. Currently, noise levels at 35 residences exceed the NAC. Compared to existing conditions, noise levels at two additional receivers (seven residences) would exceed the NAC, bringing the total number of residences where noise levels would be exceeded to 42 under the No Build Alternative.

Compared to existing conditions, the number of residences in this neighborhood where noise levels exceed the NAC would decrease to 32 under the 4-Lane Alternative and 28 under the 6-Lane Alternative. The receivers that would still be above the NAC are along East Montlake Place East and East Lake Washington Boulevard. These two major arterial roads are prime contributors to the overall noise environment and are the main reasons that noise levels at some residences would still exceed the NAC. For receivers located west of East Montlake Place East (receivers MS-22 through MS-28), noise levels would be reduced by 4 to 11 dBA L_{eq} under the 4-Lane Alternative and by 5 to 12 dBA L_{eq} under the 6-Lane Alternative. Receivers located on the east side of East Montlake Place East that are near major arterials (MS-10 through MS-16) would have future noise levels of 59 to 62 dBA L_{eq} under either the 4-Lane of the 6-Lane Alternative.

Exhibit 26 shows the noise level comparison between the existing conditions, No Build Alternative, 4-Lane Alternative, and 6-Lane Alternative. This exhibit also shows the locations of noise modeling receivers and identifies locations that exceed the NAC. Attachment 1D compares the project alternatives to existing peak-hour traffic noise levels for the Montlake neighborhood receivers south of SR 520.

Washington Park Arboretum

The noise discipline team modeled peak-hour traffic noise levels for the 20 receiver locations in the Arboretum. As previously discussed in *What are the existing peak-hour traffic noise levels?*, the modeling receivers locations were spaced throughout the Arboretum and along the Loop Trail to estimate where noise levels exceed the NAC.

Noise levels under the No Build Alternative would exceed the NAC at distances up to 500 feet from SR 520. This would be an increase of 50 feet beyond the existing NAC exceedance point, which is approximately 450 feet from SR 520.

Compared to existing conditions, both the 4-Lane Alternative and 6-Lane Alternative would lower noise levels at all receivers in the Arboretum to below the NAC. Noise levels are projected to decrease by 3 to 18 dBA throughout the park for both the 4-Lane Alternative and the 6-Lane Alternative.

Exhibit 27 shows a separate map for each alternative so readers can easily compare existing noise levels with the future noise levels in the Arboretum under the No Build, 4-Lane, and 6-Lane Alternatives. Attachment 1E shows the results of noise modeling for the Arboretum.

Madison Park

The noise discipline team modeled peak-hour traffic noise levels for 23 receiver locations (representing 201 residences) in the Madison Park neighborhood. Under the No Build Alternative, noise levels would exceed the NAC at the same 89 residences that exceed the NAC today.

Compared to existing conditions, no residences in Madison Park would have noise levels exceeding the NAC under the 4-Lane and 6-Lane Alternative. The sound walls on the Evergreen Point Bridge would reduce noise throughout this neighborhood to below the NAC. Future 4-Lane Alternative noise levels would be 2 to 6 dBA L_{eq} lower than today's noise levels. Under the 6-Lane Alternative, noise levels would be 3 to 8 dBA L_{eq} lower than today. Under the 4-Lane and 6-Lane Alternatives, noise levels would be lower than today's noise levels at virtually all residences.

Exhibit 28 shows a separate map for each alternative so readers can easily compare existing noise levels with the future noise levels in Madison Park under the No Build, 4-Lane, and 6-Lane Alternatives. This exhibit shows what locations exceed the NAC under existing conditions and the No Build Alternative. Attachment 1F contains the results for the Madison Park receivers and compares the project alternatives to existing peak-hour traffic noise levels.

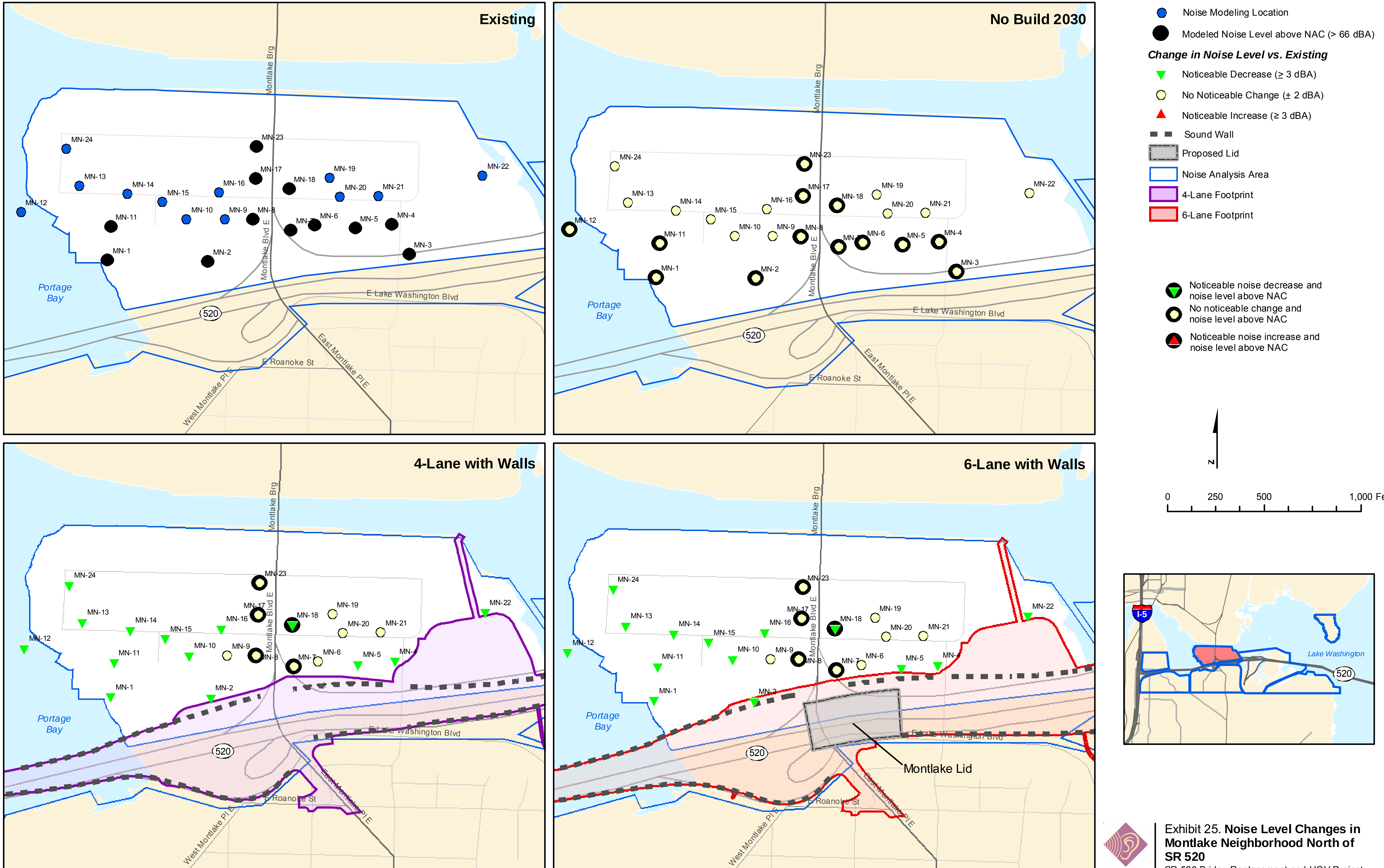


Exhibit 25. **Noise Level Changes in Montlake Neighborhood North of SR 520**

SR 520 Bridge Replacement and HOV Project