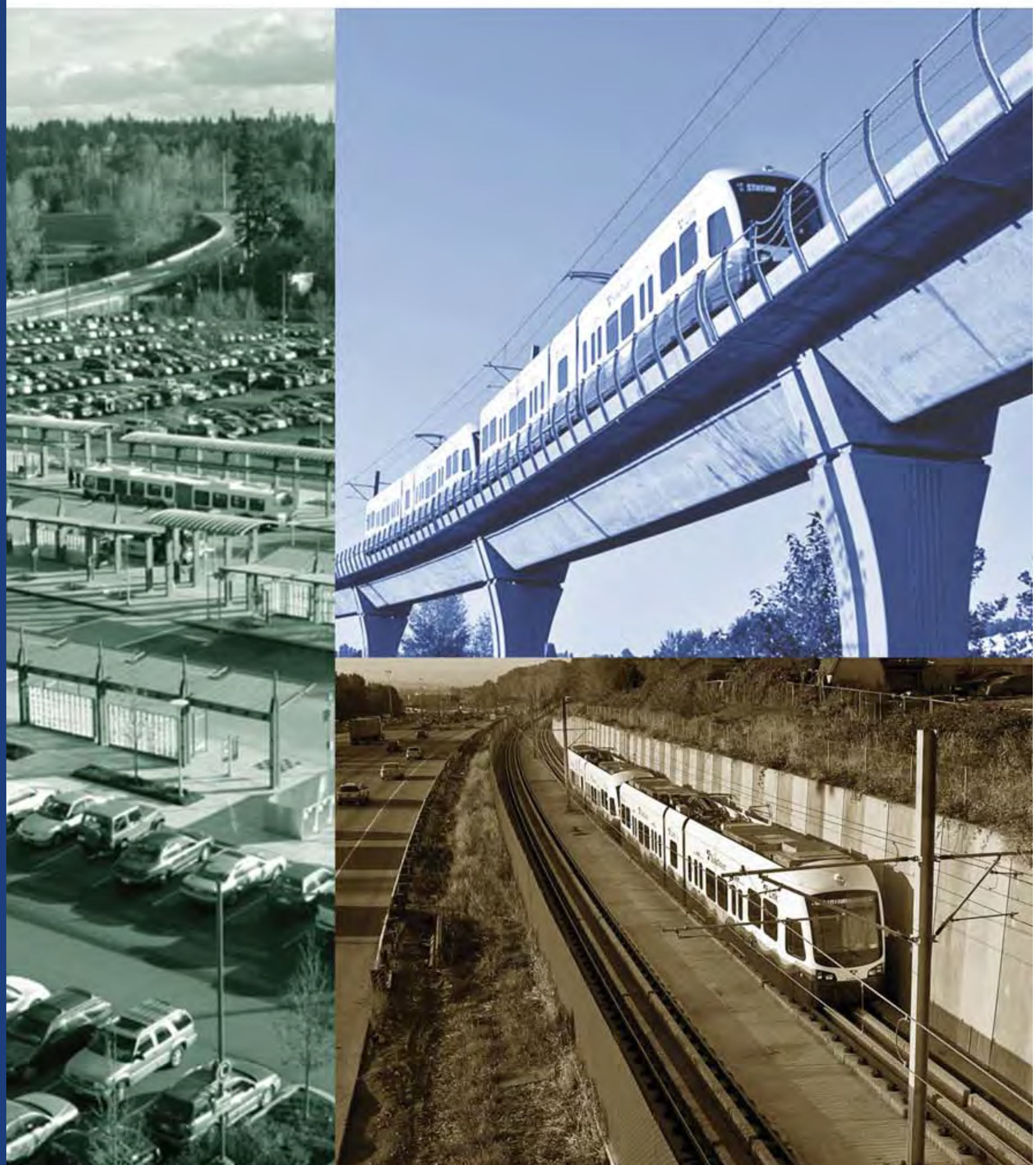
LYNNWOOD LINK EXTENSION

FINAL ENVIRONMENTAL IMPACT STATEMENT

Noise and Vibration Technical Report



SOUNDTRANSIT

U.S. Department of Transportation
Federal Transit Administration

APRIL 2015

SOUNDTRANSIT
RIDE THE WAVE

Lynnwood Link Extension

Technical Report
Noise and Vibration

401 South Jackson Street
Seattle, WA 98104-2826

April 2015

North Corridor
Transit Partners
PARAMETRIX + PARSONS BRINCKERHOFF

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Acronyms and Abbreviations

ANSI	American National Standards Institute
BVR	Building Vibration Response
CFR	Code of Federal Regulations
dB	decibel
dBA	unit of A-weighted sound level in decibels
DNR	Department of Natural Resources
EDNA	Environmental Designation for Noise Abatement
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
FAA	Federal Aviation Administration
FDL	Force Density Level
FHWA	Federal Highway Administration
FST	floating slab track
FTA	Federal Transit Administration
GIS	geographic information system
HUD	U.S. Department of Housing and Urban Development
HVAC	heating, ventilation, and air conditioning
Hz	Hertz
I-5	Interstate 5
Ldn	24-hour, time-averaged, A-weighted sound level (day-night)
Leq	equivalent continuous sound level
Lmax or Lm	maximum noise level
LSR	Line Source Response (equivalent to Line Source Transfer Mobility, TMline)
Lv	vibration velocity level
mph	miles per hour
NAC	Noise Abatement Criteria
NEPA	National Environmental Policy Act
NIST	National Institute of Standards and Technology
PPV	peak particle velocity

PSR	Point Source Response
rms	root mean square
SEPA	State Environmental Act
SFC	spring frog crossover
SMC	Seattle Municipal Code
Sound Transit	Central Puget Sound Regional Transit Authority
SR	State Route
ST2	Sound Transit 2
TDA	tire-derived aggregate
TNM	Traffic Noise Model
V	velocity
VdB	decibel unit for vibration level
VTA	Santa Clara Valley Transportation Authority
WAC	Washington Administrative Code
WSDOT	Washington State Department of Transportation

Part 1: Noise

1 INTRODUCTION AND SUMMARY

This technical report presents a noise impact study for the Lynnwood Link Extension being proposed by the Central Puget Sound Regional Transit Authority (Sound Transit). The objective of the study is to assess the potential noise impacts of the planned light rail transit project.

Section 1 of this report describes the background and results of the assessment. Section 2 discusses environmental noise basics, and Section 3 describes the existing noise conditions and measurement results. The criteria and methods used to assess noise impacts are presented in Sections 4 and 5, respectively. Future No Build noise conditions projections are described in Section 6. Section 7 summarizes the impact assessment, and Section 8 outlines potential mitigation measures. Attachment A includes noise monitoring details; Attachment B provides detailed noise impact assessment data; and Attachment C presents noise impact maps by affected alternative.

2 ENVIRONMENTAL NOISE BASICS

What humans perceive as sound is a series of continuous air pressure fluctuations superimposed on the atmospheric pressure that surrounds us. The amplitude of fluctuation is related to the energy carried in a sound wave; the greater the amplitude, the greater the energy, and the louder the sound. The full range of sound pressures encountered in the world is so great that it is more convenient to compress the range by using a logarithmic scale, resulting in the fundamental descriptor used in acoustics—the sound pressure level, which is measured in decibels (dB). When sounds are unpleasant, unwanted, or disturbingly loud, people tend to classify them as noise.

Another aspect of sound is the quality described as its pitch. The pitch of a sound is established by the frequency, which is a measure of how rapidly a sound wave fluctuates. The unit of measurement is cycles per second, called hertz (Hz). When a sound is analyzed, its energy content at individual frequencies is displayed over the frequency range of interest, usually the range of human audibility from 20 Hz to 20,000 Hz. This display is called a frequency spectrum.

Sound is measured using a sound-level meter with a microphone designed to respond accurately to all audible frequencies. However, the human hearing system does not respond equally to all frequencies. Low-frequency sounds below about 400 Hz are progressively and severely attenuated, as are high frequencies above 10,000 Hz. To approximate the way humans interpret sound, a filter circuit with frequency characteristics similar to the human hearing mechanism is built into sound-level meters. Measurements with this filter enacted are called A-weighted sound levels, expressed in A-weighted decibels (dBA). Community noise is usually characterized in terms of the A-weighted sound level. Figure 2-1 illustrates the A-weighted levels of common sounds.

The range of human hearing extends from about 0 dBA for young healthy ears (that have not been exposed to loud noise sources) to about 140 dBA. When sounds exceed 110 dBA, there is a potential for hearing damage, even with relatively short exposures. In quiet suburban areas far from major freeways, the noise levels during the late night hours will drop to about 30 dBA. Outdoor noise levels lower than this only occur in isolated areas where there is a minimum amount of natural noises, such as leaves blowing in the wind, crickets, or flowing water.

Another characteristic of environmental noise is that it is constantly changing. The noise level increase when a train passes is an example of a short-term change. The lower average noise levels occur during nighttime hours when activities are at a minimum; higher noise levels during daytime hours are caused by daily patterns of noise-level fluctuation. The instantaneous A-weighted sound level is insufficient to describe the overall acoustic “environment.” Thus, it is common practice to condense the fluctuating noise levels into a single number, called the “equivalent” sound level (Leq). Leq can be thought of as the steady sound level that represents the same sound energy as the varying sound levels over a specified time period (typically 1 hour or 24 hours). Often, the Leq values over a 24-hour period are used to calculate cumulative noise exposure in terms of the day-night equivalent sound level (Ldn, also abbreviated DNL), which is defined as the 24-hour Leq but with a 10-dB penalty added to each nighttime hourly Leq (with “nighttime” defined

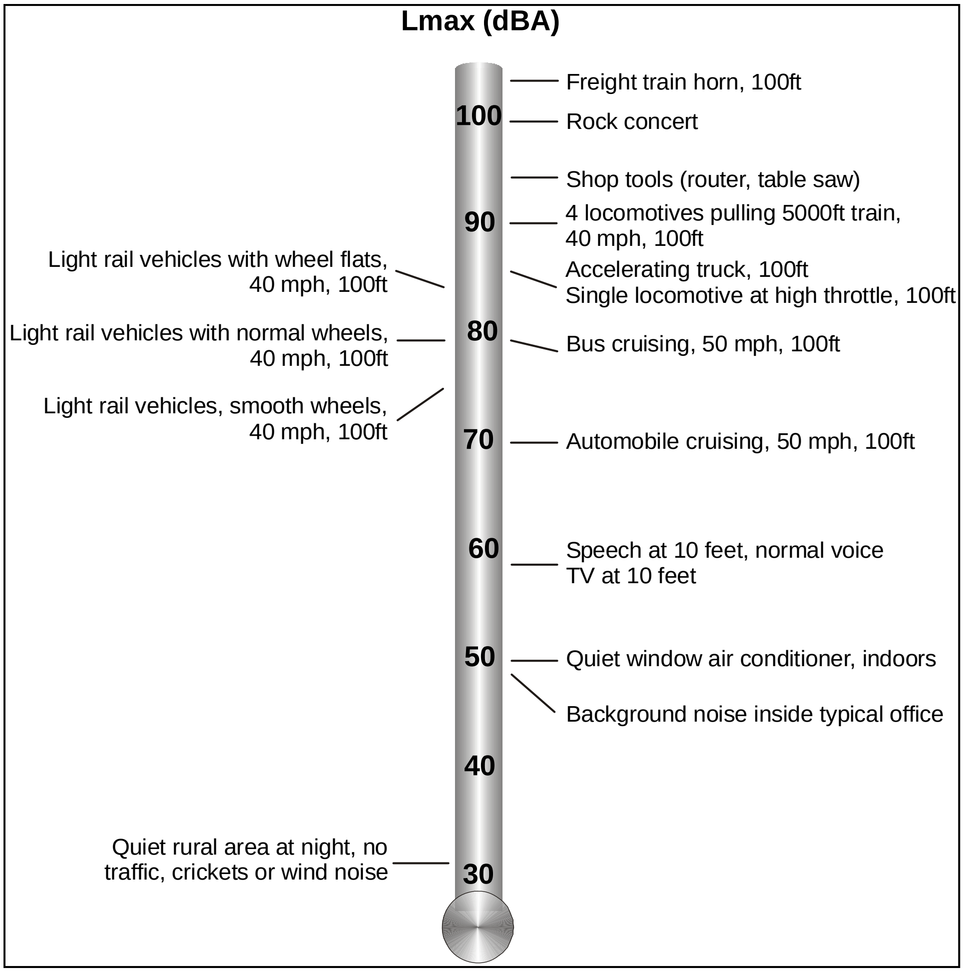


Figure 2-1. Comparison of Various Noise Levels

as the period from 10:00 pm to 7:00 am). The effect of this penalty is that any event during the nighttime is equivalent to 10 events during the daytime. This strongly weights Ldn toward nighttime noise to reflect most people being more easily annoyed by noise at night, when background noise is lower and most people are resting.

Environmental impact assessments for mass transit projects in the United States typically use Ldn to describe the community noise environment at residential locations. Studies of community response to a wide variety of noises indicate that Ldn is a good measure of the noise environment. Figure 2-2 defines typical community noise levels in terms of Ldn. Most urban and suburban neighborhoods are usually in the range of Ldn 50 dBA to 70 dBA. An Ldn of 70 dBA is a relatively noisy environment that might be found at buildings on a busy surface street, close to a freeway, or near a busy airport and would usually be considered unacceptable for residential land use without special measures taken to enhance outdoor-indoor sound insulation. Residential neighborhoods that are not near major sound sources are usually in the range of Ldn 55 dBA to 60 dBA. If there is a freeway or moderately busy arterial nearby, or any nighttime noise, Ldn is usually in the range of 60 to 65 dBA.

Ldn is the designated noise metric of choice for many federal agencies, including the U.S. Department of Housing and Urban Development (HUD), Federal Aviation Administration (FAA), Federal Transit Administration (FTA), and U.S. Environmental Protection Agency (EPA). Most federal and state agency criteria for noise impacts are based on some measurement of noise energy. For example, the FAA and HUD use Ldn, and the Federal Highway Administration (FHWA) uses peak hour Leq. The noise impact criteria applicable to residential areas, and included in the FTA *Transit Noise and Vibration Impact Assessment* (FTA 2006) (FTA guidance manual), use both Leq and Ldn to characterize community noise.

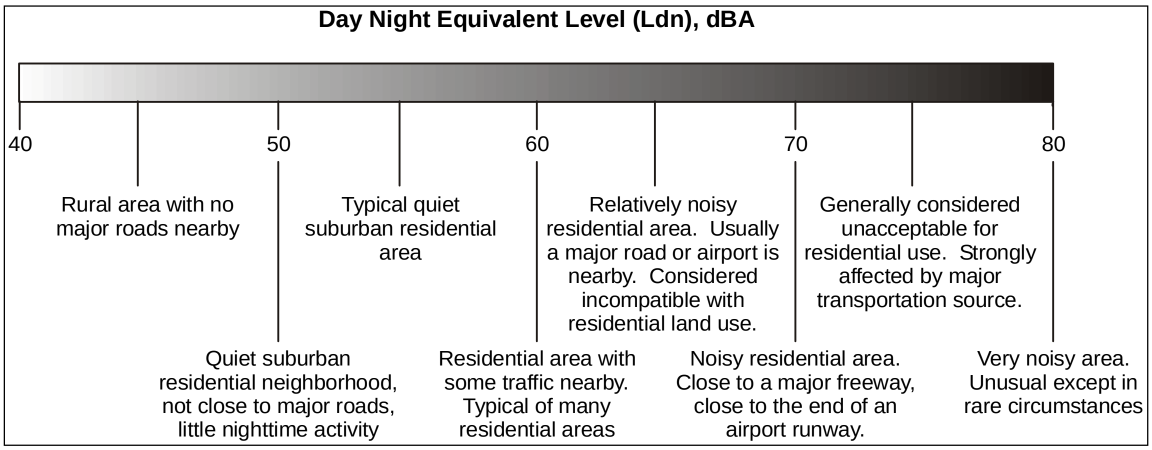


Figure 2-2. Examples of Typical Outdoor Noise Exposure

3 AFFECTED ENVIRONMENT

Sound Transit examined the project corridor to identify noise-sensitive locations and select locations where noise monitoring would be performed. The potential area of affect for the noise study was determined by modeling the worst-case operational noise levels and including all noise-sensitive properties within that area that have a potential for a noise impact. The following sections describe the land use along the project corridor, the existing noise-level measurements, and the current noise sources in the project corridor. Figures 3-1 and 3-2 show the different alternatives and noise monitoring locations.

3.1 Land Use

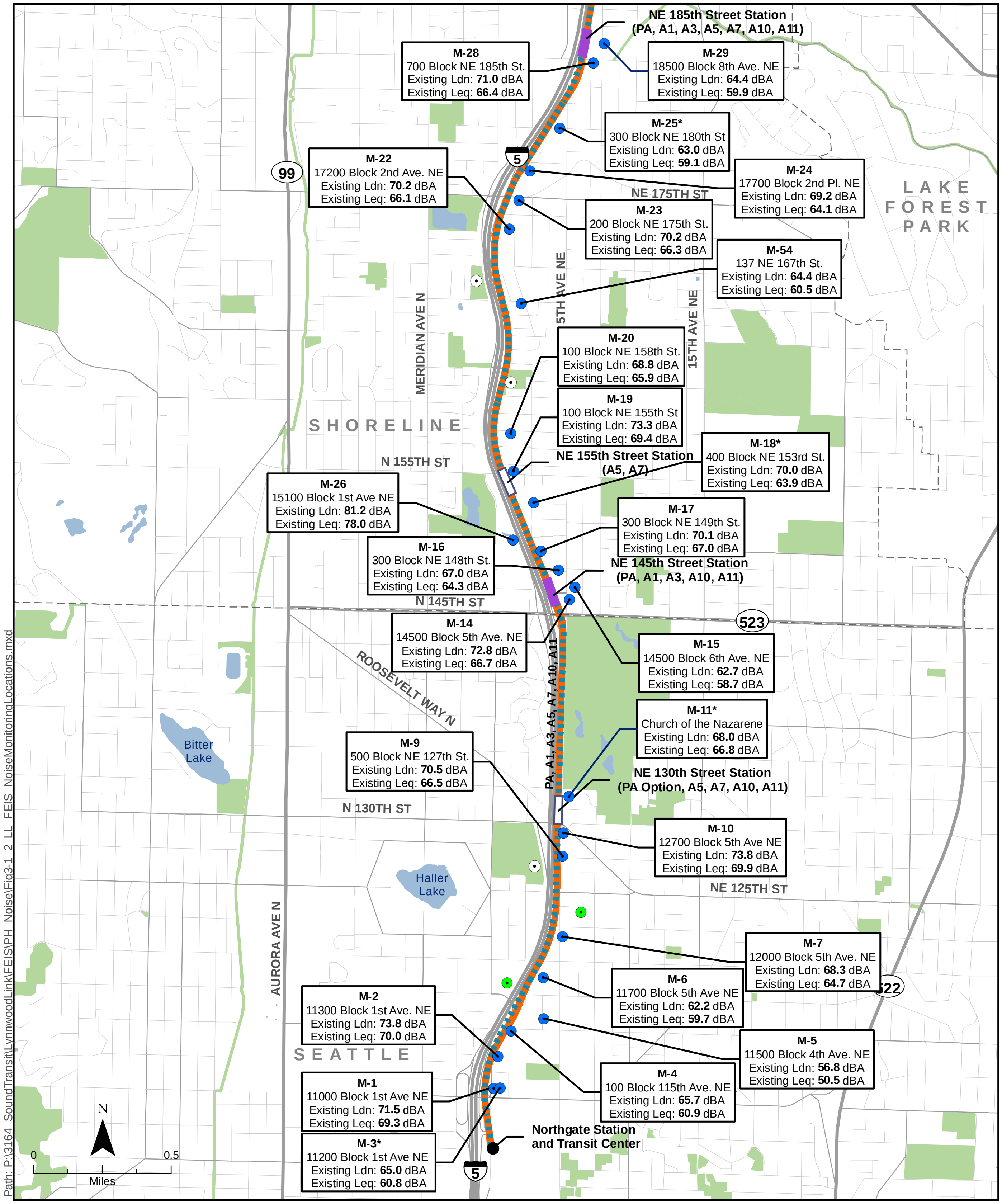
This section provides an overview of the land uses along the proposed corridor. Noise impacts under the FTA regulations are based on the land use type. Complete details on the regulatory categories are provided in Section 4, Noise Impact Criteria. Figures 3-3 and 3-4 show the land uses in the project vicinity.

3.1.1 Segment A

The Lynnwood Link Extension would begin at the northern end of the Northgate Link Extension, between Interstate 5 (I-5) and Northgate Mall. On the east side of I-5 south of Northgate Way, there are only commercial uses, including the shopping mall fronted by a parking lot. There is a freestanding restaurant in the northwest corner of the parking lot. North of Northgate Way is the Northgate Apartments complex (11200 1st Avenue NE), which consists of approximately 25 buildings. North of this complex is the Northgate West condominiums at 11300 1st Avenue NE. East of the condominiums are the Citigate apartments. All but one building in the Citigate complex is shielded from I-5 and the potential light rail alignment by the condominiums.

Continuing northward on the east side of I-5, single-family residences predominate beginning just south of NE 115th Street and going north past Roosevelt Way NE to 131st Place. North of the 1st Avenue NE overpass, land use is primarily single-family residential, with the Seattle Latvian Evangelical Lutheran Church located adjacent to I-5, just north of NE 117th Street. There is an existing traffic noise wall along this segment, beginning at the 1st Avenue NE overpass, and ending near the ramps from I-5 to NE 130th Street.

A string of properties beginning at the corner of 5th Avenue NE and NE 123rd Street and continuing northward consist of newly constructed multifamily units that would be acquired as part of the project. These properties are directly adjacent to the existing noise wall previously described. The Seattle Arabic Baptist Church is located at 13130 5th Avenue NE, just south of where the proposed light rail alignment would begin running alongside the Jackson Park Golf Course. The northern boundary of the golf course is NE 145th Street. On the west side of I-5 in this area, there are four non-residential noise-sensitive uses: the Northgate Elementary School at 11700 1st Avenue NE; the Korean Catholic Church, which is just west of Northgate Elementary School; Northacres



Data Sources: (King County, Snohomish County, WSDOT, Sound Transit)

Noise Monitor Locations

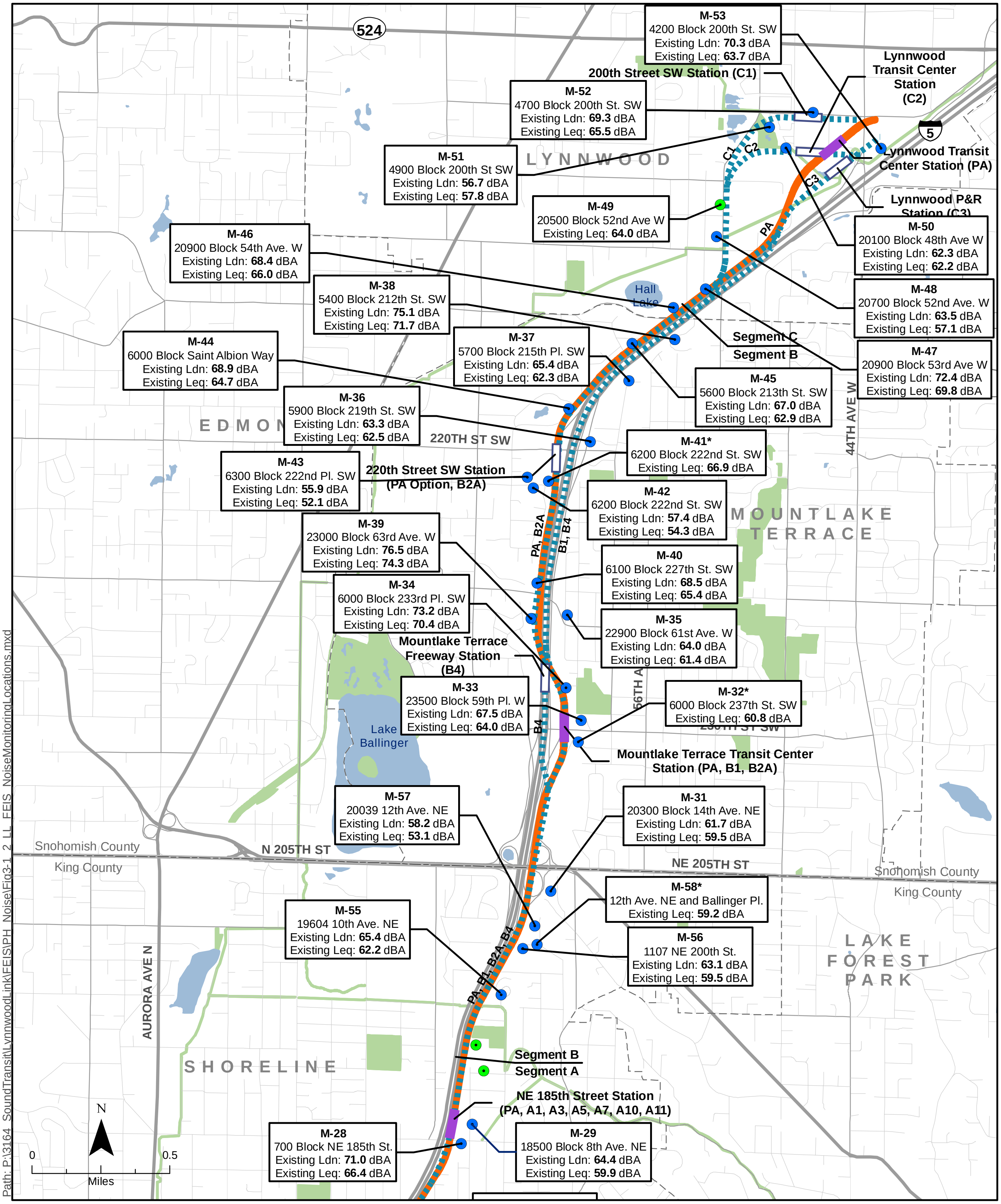
- FTA Land-use Category 2
- FTA Land-use Category 3
- General Ambient Noise Location

- Preferred Alternative (PA)
- Preferred Alternative Station Location
- Other Light Rail Alternatives
- Other Alternative Station Location
- Preferred Alternative and Other Alternatives

Notes: - Ldn values for residences and hotels only.
- Noise Monitor Locations displayed with an asterisk (M-32*) are short term monitoring sites.

Figure 3-1
Noise Monitor Locations
Segment A

Lynnwood Link Extension



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Data Sources: (King County, Snohomish County, WSDOT, Sound Transit)

Noise Monitor Locations

- FTA Land-use Category 2
- FTA Land-use Category 3
- General Ambient Noise Location

- Preferred Alternative (PA)
- Preferred Alternative Station Location
- Other Light Rail Alternatives
- Other Alternative Station Location
- Preferred Alternative and Other Alternatives

Notes: - Ldn values for residences and hotels only.
- Noise Monitor Locations displayed with an asterisk (M-32*) are short term monitoring sites.

Figure 3-2
Noise Monitor Locations
Segments B and C

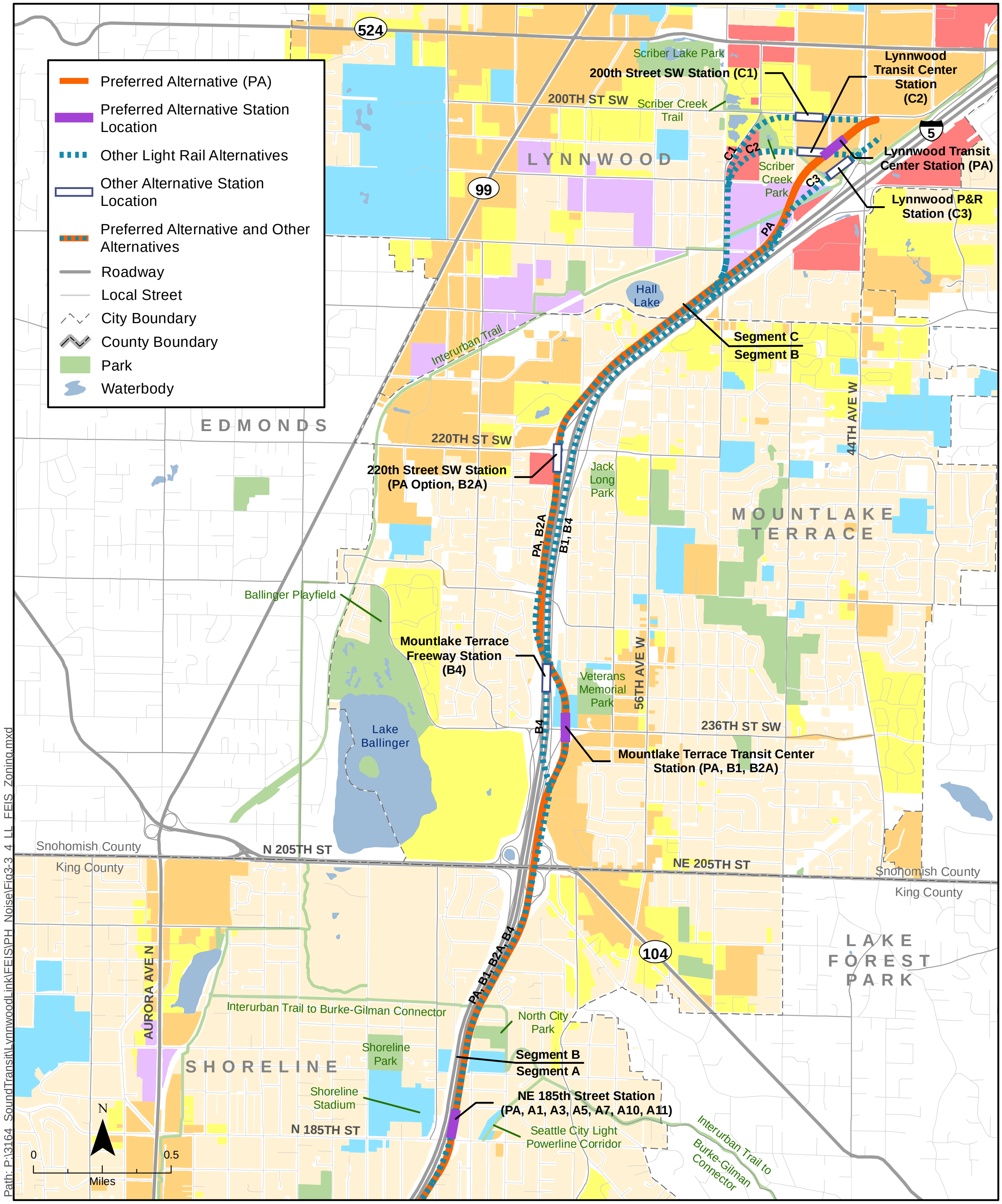
Lynnwood Link Extension

Data Sources: (King County, Snohomish County, WSDOT, Sound Transit)

Generalized Zoning

- Commercial
- Industrial/Warehouse
- Institutional/Public
- Single Family Residential
- Multi Family Residential
- Mixed Use (Residential/Commercial)

Figure 3-3
Generalized Zoning
Segment A



Data Sources: (King County, Snohomish County, WSDOT, Sound Transit)

Generalized Zoning

- Commercial
- Industrial/Warehouse
- Institutional/Public
- Single Family Residential
- Multi Family Residential
- Mixed Use (Residential/Commercial)

Figure 3-4
Generalized Zoning
Segment A

Park, which is immediately south of North 130th Street/Roosevelt Way NE; and the Lakeside Schools campus, which is southwest of the NE 145th Street/I-5 interchange.

On the east side of I-5, north of NE 145th Street and the existing park-and-ride lot, and south of NE 155th Street, there is another stretch of single-family homes. Also in this area is the Resurrection Fellowship Church of God at 225 NE 152nd Street. North of that church is a parcel of undeveloped land and the Shoreline Fire Department Station. On the west side of I-5, uses of note include three churches and Aegis Senior Living, an assisted living facility at 14900 1st Avenue NE.

Between NE 155th Street and NE 175th Street, on the east side of I-5, the project corridor is all residential except for Ridgecrest Park, which is between NE 161st and NE 163rd Streets, and a publicly-owned undeveloped parcel of land on the southeast corner of North 175th Street and the I-5 northbound off-ramp. On the west side of I-5, land uses include the St. Barnabas Anglican Church at 2340 N. 155th Street, an undeveloped parcel of land just north of the church, an expansive transit facility at North 165th Street, James Keough Park north of the transit facility, and the Ronald Bog, which borders NE 175th Street.

Between NE 175th Street and NE 185th Street, land use on the east side of I-5 is all single-family homes. On the west side of the freeway, an undeveloped parcel south of NE 185th Street that fronts I-5 is owned by the DNR (King County parcel number 6084100050). There is also an undeveloped parcel owned by the Shoreline Water District at the far northeastern point of Segment A (King County parcel number 6084100040).

Segment A extends to just south of NE 194th Street and North City Park on the east side of I-5. Between NE 185th Street and North City Park are residential land uses, with a strip of land to the east dedicated solely to power transmission lines (King County parcel number 0526049039). North of this residential area and south of North City Park is the North City Cooperative Preschool and an adjacent recreational field. On the west side of I-5, noise-sensitive land uses include a pocket of homes between I-5 and the Shoreline School District football field and the Evergreen Baptist Church.

3.1.2 Segment B

Segment B begins just south of NE 194th Street on the east side of I-5 near North City Park. In this area, there is a pocket of residential land uses adjacent to the I-5 pedestrian overpass. North of NE 195th Street and south of the I-5/(SR) 104 interchange is another area of predominantly single-family homes. Near SR 104, there are multifamily apartments and a four-unit condominium complex at 20101 14th Avenue NE. Other land uses in the area include a commercial storage facility and a 31-unit apartment complex at 20333 15th Avenue NE. North of the interchange but south of 236th Street SW commercial land uses predominate, including a strip mall, movie theatres, an office building, and the Studio 6 hotel. The former site of the Evergreen Elementary School abuts the proposed light rail route just south of 236th Street SW. Between the former school site and these commercial uses is a 4.87-acre piece of undeveloped land (Snohomish County parcel number 27043200401600). Facing the former school across I-5 is the Nile Shrine and Nile Golf Course and Country Club.

North of 236th Street SW/Lakeview Drive and on the east side of I-5 are the Mountlake Terrace Transit Center, Veterans Memorial Park, and residential uses north to 230th Street SW (228th Street SW on the west side of I-5). On the west side of I-5, there are only residences between 236th Street SW/Lakeview Drive and 228th Street SW (230th Street SW on the east side of I-5).

Residential land uses predominate in the project corridor on the east side of I-5 from 230th Street SW north to 220th Street SW. Near the I-5/220th Street SW interchange, second-line noise receivers would include Jack Long Park and a recreational field. At the interchange, homes abut the I-5 northbound on-ramp. Just north, at 21705 58th Avenue West, is a school affiliated with the City Church. Surrounding the school are several undeveloped parcels associated with the church and school (Snohomish County parcel numbers 00619900001401, 00619900001402, 00619900001102, and 00619900005300). Homes in this area only partially shield the school from I-5. After the bend in I-5 north of the school, the 106-unit Maple Glen apartment complex is at 5402 212th Street SW, and just south of that complex is a duplex at 5509 214th Place SW. East of the complex are numerous multifamily residences and a small store. Just north of the complex and north of 212th Street SW is a vacant, triangular-shaped property that was formerly a service station. Farther north of 212th Street SW are some single-family homes and another vacant piece of land.

On the west side of I-5 between 228th Street SW and 220th Street SW, land uses include some single-family homes relatively close to I-5. The 320-unit Lakeside Apartments complex is north of City Hall. There are two undeveloped parcels adjacent to I-5 as it begins to bend northeast (Snohomish County parcel numbers 00619900005000 and 00619900004800), and immediately northwest is a large recreational area at Hall Lake. Beyond this recreational area, land uses along the project corridor are residential northward to the northern end of Segment B, just past 212th Street SW.

3.1.3 Segment C

Segment C begins just north of 212th Street SW on the west side of I-5 or in between the northbound and southbound lanes of the freeway, depending on the alternative. Land use on the west side of I-5 is residential from 212th Street SW north to 52nd Avenue West. Northeast of 52nd Avenue West is one single-family residence (20909 52nd Avenue West), and then land uses transition to commercial. Near 50th Avenue West are a warehouse and distribution facility and the Interurban Trail. East of 52nd Avenue West are several vacant parcels, state and private office buildings, and Scriber Creek Park. Other land uses near the Segment C alternatives include single-family residences on the west side of 52nd Avenue West, the Park Five Apartments at 20104 48th Avenue West, the 76-unit Cedar Creek condominium complex at 4800-4920 200th Street SW, the Oxford Square Apartments at 4807 200th Street SW, the Cambridge Apartments at 4727 200th Street SW, the Marriott Courtyard Hotel at 4220 200th Street SW, and the La Quinta Motel at 4220 Alderwood Mall Boulevard.

3.2 Existing Noise Environment

Sound Transit characterized the existing noise environment through on-site inspections and on-site noise monitoring. Monitoring was performed at 59 locations, including 45 long-term (24-hour or greater) and 14 short-term (15-minute) sites. Long-term monitoring was performed at noise-sensitive locations representative of nearby properties. Short-term monitoring was also performed at other locations where long-term monitoring was not practical or where short-term data were used to supplement nearby long-term monitoring results. Sound Transit also performed short-term noise level readings and traffic counts at all of the long-term sites in preparation for the noise wall analysis that would be required for all relocated noise walls along the project corridor. Sound Transit selected monitoring sites based on land use, existing noise sources, light rail alternative proximity and profile type, and the site's ability to represent nearby noise-sensitive land uses.

All noise measurements were taken in accordance with the FTA guidance manual and the American National Standards Institute (ANSI) procedures for community noise measurements and guidelines provided in the FTA guidance manual. Measurement locations were at least 5 feet from any solid structure to prevent acoustical reflections and at a height of 5 feet off the ground as required by FTA and ANSI standards. The noise measurements and accompanying traffic counts were also taken in accordance with FHWA and Washington State Department of Transportation (WSDOT) standards to ensure their suitability for relevant analyses. The equipment used for noise monitoring included Bruel & Kjaer Type 2238 sound level meters. The meters were calibrated before and after measurement periods using a sound-level calibrator. Complete system calibration is performed on an annual basis by an accredited testing laboratory. The laboratory system calibration is traceable to the National Institute of Standards and Technology (NIST). The systems meet or exceed the requirements for an ANSI Type 1 noise measurement system.

For long-term monitoring locations, the Ldn was calculated using logarithmic energy averaging for the 24-hour data with a 10-dBA penalty for noise measured between 10:00 pm and 7:00 am. For short-term monitoring locations, the projected Ldn levels were calculated using formulas in the FTA guidance manual and comparing the levels with other nearby long-term noise monitoring sites.

The following sections describe the existing noise environment by project segments. Segments A and B have numerous existing noise walls along I-5 that might be affected by the proposed project. If it is necessary to remove an entire noise wall or a portion as part of the project, the noise wall would need to be replaced or relocated to a new location in order to maintain future noise levels that are equal to, or less than, the current noise levels.

3.2.1 Segment A

Segment A had 21 long-term and 11 short-term monitoring locations. Noise levels along the proposed light rail alternative route in Segment A are dominated by traffic noise from I-5 and major arterial roadways such as NE Northgate Way, 1st Avenue NE, 5th Avenue NE, NE 130th Street, NE 145th Street, NE 155th Street, and NE 185th Street.

The Ldn at first-line receivers near Segment A in the Northgate area ranged from 72 dBA to 74 dBA (sites M-1, M-2, M-9, M-10, and M-27). The high Ldn noise levels are primarily because of the constant traffic flow along I-5, in addition to noise on local major and minor arterials. Peak-hour noise levels measured at two schools, two churches, and other outdoor locations ranged from 69 dBA to 70 dBA Leq (sites M-8, M-11, M-12, M-13, M-21, M-27, and M-30).

Ldn noise levels at monitoring locations south of Jackson Park Golf Course along 5th Avenue NE ranged from 68 dBA to 74 dBA. Peak-hour noise levels measured at these same locations ranged from 65 dBA to 70 dBA Leq. In all cases, measured noise levels were higher at receivers closer to the I-5/NE 130th Street interchange.

In the residential neighborhood north of NE 145th Street between 5th Avenue NE and I-5, the measured Ldn ranged from 67 dBA to 70 dBA (sites M-16 and M-17). Peak-hour noise levels at these homes ranged from 64 dBA to 67 dBA Leq. As with other locations in Segment A, the major noise source is I-5 and major arterial roadways.

Near the proposed NE 155th Street Station, the measured Ldn was 73 dBA at site M-19 and the peak-hour noise level was 69 dBA Leq. Noise levels in that area are dominated by vehicles on I-5, and to a lesser extent, by local traffic on NE 155th Street and other arterial roadways.

At the NE 185th Street/I-5 overpass, represented by site M-28, the measured front-line Ldn was 71 dBA. At a second-line site (M-29), the Ldn was 64 dBA. Peak-hour noise levels at these two locations were 66 dBA and 60 dBA Leq, respectively. Noise levels here are dominated by I-5, with additional noise from arterial roadways. Noise levels at the entrance to the North City Cooperative Preschool were measured at 59 dBA Leq (M-30A), while to the north of the school, in the play area, noise levels are slightly higher, and were measured at 65 dBA Leq (see site M-30B in Segment B below).

Table 3-1 summarizes the noise monitoring effort for Segment A, which includes the monitoring location number, address, land use, and type of measurement. Although the monitoring site numbers may not be in order, the monitoring sites are presented beginning in the south end of the segment moving north. The peak-hour Leq is presented for all sites, but the 24-hour Ldn is presented for only FTA Category 2 land uses, such as residences and hotels. Although the monitoring data are presented to the tenth of a dBA, FTA recommends presenting the noise analysis data for impact analysis in whole numbers only.

3.2.2 Segment B

Segment B had 17 long-term and 4 short-term monitoring locations. Noise levels along the proposed light rail alternative route in Segment B are dominated by traffic noise from I-5 and major arterial roadways such as SR 104 and 220th Street SW.

South of Ballinger Way NE, and north of the North City Cooperative Preschool, noise levels ranged from 59 to 65 dBA Leq and 58 to 65 dBA Ldn (sites M-30B, M-55, M-56, M-57, and M-58). Behind the Mountlake Transit Center Station at site M-33, measured Ldn was 68 dBA and the peak-hour Leq was 64 dBA. Just north of the station on the bluff overlooking the transit center and I-5, the measured Ldn at site M-34 was 73 dBA and the peak-hour noise level was 70 dBA Leq. At site M-34, homes are not shielded from traffic noise on I-5, and they have a clear line-of-sight to the freeway. Likewise, at site M-39 on the west side of I-5, the Ldn was 77 dBA. For sites with some shielding from I-5, such as site M-35, the Ldn was reduced to 64 dBA.

Table 3-1. Segment A Noise Measurements

Monitoring Location[a]	Address	Land Use Type	Type of Measurement	Leq (Peak-hour Leq in dBA)	Ldn (24-hour Ldn in dBA)[b]
M-1	11012 1st Avenue NE (Northgate Apartments)	Multifamily	Long term	69.3	71.5
M-2	11300 1st Avenue NE (Northgate West Condominiums)	Multifamily	Long term	70.0	73.8
M-3	11200 1st Avenue NE (Northgate Apartments)	Multifamily	Short term	60.8	65.0
M-4	133 115th Avenue NE	Single family	Long term	60.9	65.7
M-5	11516 4th Avenue NE	Single family	Long term	50.5	56.8
M-6	11725 5th Avenue NE	Single family	Long term	59.7	62.2
M-7	12042 5th Avenue NE	Single family	Long term	64.7	68.3
M-8	12345 8th Avenue NE (Northgate Preschool and Child Care Center)	School	Short term	56.1	N/A[c]
M-9	502 NE 127th Street	Single family	Long term	66.5	70.5
M-10	12740 5th Avenue NE	Single family	Long term	69.9	73.8
M-11 #1	13130 5th Avenue NE (Church of the Nazarene and Parish Home)—Morning	Church and Single family	Short term	66.8	68.0
M-11 #2	13130 5th Avenue NE (Church of the Nazarene and Parish Home)—Afternoon	Church and Single family	Short term	66.7	68.0
M-12	11700 1st Avenue NE (St. Andrew Kim Korean Catholic Church)	Church	Short term	63.7	N/A[c]
M-13	12718 1st Avenue NE	Public	Short term	66.4	N/A[c]
M-14	14526 5th Avenue NE	Single family	Long term	66.7	72.8
M-15	14549 6th Avenue NE	Single family	Long term	58.7	62.7
M-16	348 NE 148th Street	Single family	Long term	64.3	67.0
M-17	314 NE 149th Street	Single family	Long term	67.0	70.1
M-18	405 NE 153rd Street	Single family	Short term	63.9	70.0
M-19	132 NE 155th Street	Single family	Long term	69.4	73.3
M-20	123 NE 158th Street	Single family	Long term	65.9	68.8
M-21	108 NE 161st Street	Public	Short-term	61.8	砨/A[c]
M-54	137 NE 167th Street	Single-Family	Long-term	60.5	64.4
M-22	17205 2nd Avenue NE	Single-family	Long-term	66.1	70.2
M-23	211 NE 175th Street	Single family	Long term	66.3	70.2
M-24	17748 2nd Place NE	Single family	Long term	64.1	69.2
M-25	350 NE 180th St	Single-family	Short-term	59.1	63.0
M-26	15100 1st Avenue NE (Aegis Senior Living)	Multifamily	Long term	78.0	81.2
M-27	2350 N 167th Street	Public	Short term	67.9	N/A[c]
M-28	721 NE 185th Street	Single family	Long term	66.4	71.0
M-29	18528 8th Avenue NE	Single family	Long term	59.9	64.4
M-30A	816 NE 190th Street (North City Cooperative Preschool)	School	Short term	59.4	N/A[c]

[a] Sites shown on Figures 3-1 and 3-2.

[b] Projected Ldn levels for short-term monitoring sites have been calculated using formulas and methods in the FTA *Transit Noise and Vibration Impact Assessment* (FTA 2006) and comparison with other nearby long-term noise monitoring sites.

[c] These sites were only measured for peak-hour Leq, and no Ldn measure is required because these sites do not represent residential uses.

dBA = decibel with A-weighting, FTA = Federal Transit Administration, Ldn = 24 hour, time-averaged, A-weighted sound level, Leq = equivalent continuous sound level, N/A = not applicable

Measured Ldn at homes west of the school building located at 6205 222nd Street SW (sites M-42 and M-43) ranged from 56 to 57 dBA. Peak hour Leq at these homes ranged from 52 to 54 dBA. Peak-hour Leq on the east side of the school building at site M-41, facing I-5, was 66.9 dBA.

Table 3-2 summarizes the noise monitoring effort for Segment B, which includes the monitoring location number, address, land use, and type of measurement, with the peak hour Leq for all sites and the 24-hour Ldn for FTA Category 2 land uses. Although the monitoring site numbers may not be in order, the monitoring sites are presented beginning in the south end of the segment and moving north.

Table 3-2. Segment B Noise Measurements

Monitoring Location[a]	Address	Land Use Type	Type of Measurement	Leq (Peak-hour Leq in dBA)	Ldn (24-hour Ldn in dBA)[b]
M-30B	816 NE 190th Street (North City Cooperative Preschool)	School	Short term	65.4	N/A[C]
M-55	19604 10th Avenue NE	Single family	Long term	62.2	65.4
M-56	1107 NE 200th Street	Single family	Long term	59.5	63.1
M-57	20039 12th Avenue NE	Single family	Long term	53.1	58.2
M-58	Corner of 12th Avenue NE and Ballinger Place NE	Right-of-way	Short term	59.2	N/A[C]
M-31	20313 14th Avenue NE	Single family	Long term	59.5	61.7
M-32	Grassy median across from 6002 and 5906 237th Street SW	Right-of-way	Short term	60.8	N/A[C]
M-33	23504 59th Place West	Single family	Long term	64.0	67.5
M-34	6005 233rd Place SW	Single family	Long term	70.4	73.2
M-35	22905 61st Avenue West	Single family	Long term	61.4	64.0
M-36	5905 219th Street SW	Single family	Long term	62.5	63.3
M-37	5709 215th Place SW	Single family	Long term	62.3	65.4
M-38	5402 212th Street SW	Multifamily	Long term	71.7	75.1
M-39	23005 63rd Avenue West	Single family	Long term	74.3	76.5
M-40	6103 227th Street SW	Single family	Long term	65.4	68.5
M-41	6205 222nd Street SW	School	Short term	66.9	N/A[C]
M-42	6206 222nd Street SW	Single family	Long term	54.3	57.4
M-43	6302 222nd Place SW	Single family	Long term	52.1	55.9
M-44	6102 Saint Albion Way	Multifamily	Long term	64.7	68.9
M-45	5632 213th Street SW	Single family	Long term	62.9	67.0
M-46	20908 54th Avenue West #1	Single family	Long term	66.0	68.4

[a] Sites shown on Figure 3-2.
[b] Projected Ldn levels for short-term monitoring sites have been calculated using formulas and methods in the FTA *Transit Noise and Vibration Impact Assessment* (FTA 2006) and comparison to other nearby long-term noise monitoring sites.
[c] These sites were only measured for peak hour Leq, and no Ldn measure is required because these sites do not represent residential uses.
dBA = decibel with A-weighting, FTA = Federal Transit Administration, Ldn = 24 hour, time-averaged, A-weighted sound level, Leq = equivalent continuous sound level, N/A = not applicable

3.2.3 Segment C

Segment C had seven long-term and no short-term monitoring locations. Noise levels along the proposed light rail alternative routes in Segment C are dominated by traffic noise from I-5 and major arterial roadways such as 52nd Avenue West and 200th Street SW.

The existing Ldn at homes west of 52nd Avenue West and adjacent to I-5 was characterized by site M-47, with a measured Ldn noise level of 72 dBA and a peak-hour Leq of 70 dBA. North along 52nd Avenue West, the measured Ldn at sites M-48 and M-49 ranged from 64 dBA to 65 dBA, and peak-hour Leq ranged from 57 dBA to 64 dBA. In this area, the major noise sources are traffic on 52nd Avenue West, 208th Street SW, and 208th Street SW, with background noise from I-5.

The results from monitoring locations near the Lynnwood Transit Center where noise measurements were taken vary depending on their proximity to major roadways. Major noise sources in this area include traffic on 200th Street SW, Cedar Valley Road, and, for sites near the existing transit center, 44th Avenue West. At the three multifamily buildings near and along 200th Street SW (site M-52), and at the Marriott Courtyard Hotel along I-5 (site M-53), the measured Ldn ranged from 69 dBA to 70 dBA. Peak-hour Leq at these locations ranged from 64 dBA to 66 dBA. Noise levels at the multifamily residences that abut Scriber Creek Park are quieter because these residences are shielded from traffic noise emanating from 200th Street SW, Cedar Valley Road, and the transit center. Measured Ldn at sites M-50 and M-51 ranged from 57 dBA to 62 dBA, and peak-hour Leq ranged from 58 dBA to 62 dBA.

Table 3-3 summarizes the noise monitoring for Segment C, which includes the monitoring location number, address, land use, and type of measurement, with the peak-hour Leq for all sites and the 24-hour Ldn for FTA Category 2 land uses.

Table 3-3. Segment C Noise Measurements

Monitoring Location[a]	Address	Land Use Type	Type of Measurement	Leq (Peak-hour Leq in dBA)	Ldn (24-hour Ldn in dBA)[b]
M-47	20929 53rd Avenue West	Single family	Long term	69.8	72.4
M-48	20706 52nd Avenue West	Single family	Long term	57.1	63.5
M-49	20526 52nd Avenue West (Cedar Valley Grange)	Public	Long term	64.0	N/A[C]
M-50	20128 48th Avenue West, Bldg. C, Apt. #30 (Park Five Apartments)	Multifamily	Long term	62.2	62.3
M-51	4900 200th Street SW, Bldg. C (Cedar Creek Condominiums)	Multifamily	Long term	57.8	56.7
M-52	4727 200th Street SW, Apt. A101 (Cambridge Apartments)	Multifamily	Long term	65.5	69.3
M-53	4220 200th Street SW (Courtyard Marriott)	Hotel	Long term	63.7	70.3

[a] Sites shown on Figure 3-2.

[b] Projected Ldn levels for short-term monitoring sites have been calculated using formulas and methods in the FTA *Transit Noise and Vibration Impact Assessment* (FTA 2006) and comparison with other nearby long-term noise monitoring sites.

c These sites were only measured for peak hour Leq, and no Ldn measure is required because these sites do not represent residential uses.

dBA = decibel with A-weighting, FTA = Federal Transit Administration, Ldn = 24 hour, time-averaged, A-weighted sound level, Leq = equivalent continuous sound level, N/A = not applicable

4 NOISE IMPACT CRITERIA

The operation of a light rail system can cause noise from transit operations (e.g., light rail operational noise, warning bells, maintenance facilities, ancillary facilities, and buses and park-and-ride lots at transit centers), changes in traffic resulting from a roadway being widened or realigned for the project, or changes in the noise path between existing noise sources and receivers, such as altering an existing noise wall; different criteria exist for each source of noise. This section summarizes what defines a noise impact, as applicable to the Lynnwood Link Extension.

4.1 Transit Noise Impact Criteria

Noise impacts for the proposed project are determined based on the criteria defined in the FTA guidance manual (FTA 2006). The FTA noise impact criteria are based on well-documented research on community reaction to noise and on change in noise exposure rated using a sliding scale. Although more transit noise is allowed in neighborhoods with high levels of existing noise, as existing noise levels increase, smaller increases in total noise exposure are allowed than in areas with lower existing noise levels. The FTA noise impact criteria group noise-sensitive land uses into the following three categories:

- Category 1: Tracts of land where quiet is an essential element in their intended purpose. This category includes lands set aside for serenity and quiet, land uses such as outdoor amphitheaters and concert pavilions, as well as National Historic Landmarks with significant outdoor use. Also included in this category are recording studios and concert halls.
- Category 2: Residences and buildings where people normally sleep. This category includes homes, hospitals, and hotels where a nighttime sensitivity to noise is assumed to be of utmost importance.
- Category 3: Institutional land uses with primarily daytime and evening use. This category includes schools, libraries, theaters, and churches where it is important to avoid interference with activities such as speech, meditation, and concentration on reading material. Places for meditation or study associated with cemeteries, monuments, museums, campgrounds, and recreational facilities are also considered to be in this category. Certain historical sites and parks are also included, but their sensitivity to noise must be related to their defining characteristics; generally, parks with active recreational facilities are not considered noise sensitive.

Ldn is used to characterize noise exposure for residential areas (Category 2). For other noise-sensitive land uses, such as outdoor amphitheaters and school buildings (Categories 1 and 3), the maximum 1-hour Leq during the facility's operating period is used.

The two levels of impact included in the FTA criteria (severe and moderate) are as follows:

- Severe Impact: Project-generated noise in the severe impact range can be expected to cause a large percentage of people to be highly annoyed by the new noise and represents the most compelling need for mitigation. Noise mitigation will normally be specified for severe impact areas unless there are truly extenuating circumstances that prevent mitigation.

- Moderate Impact: In this range of noise impact, the change in the cumulative noise level is noticeable to most people but may not be sufficient to cause strong, adverse reactions from the community. In this transitional area, other project-specific factors must be considered to determine the magnitude of the impact and the need for mitigation. These factors include the existing level, the projected level of increase over existing noise levels, the types and numbers of noise-sensitive land uses affected, the noise-sensitivity of the properties, the effectiveness of the mitigation measures, community views, and the cost of mitigating noise to more acceptable levels.

The FTA noise impact criteria are summarized in graphical form in Figure 4-1, which shows the existing noise exposure and the allowable noise exposure from the transit project that would cause either moderate or severe impact. The future noise exposure would be the combination of the existing noise exposure and the additional noise exposure caused by the light rail project. Figure 4-2 expresses the same criteria in terms of the increase in total or cumulative noise that can occur in the overall noise environment before an impact occurs.

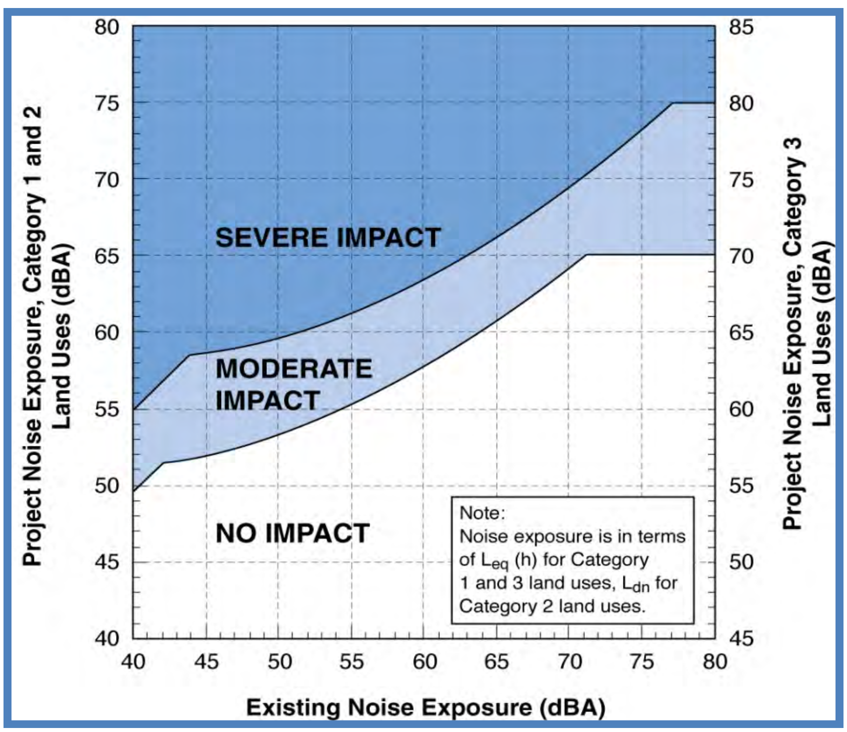


Figure 4-1. FTA Project Noise Impact Criteria

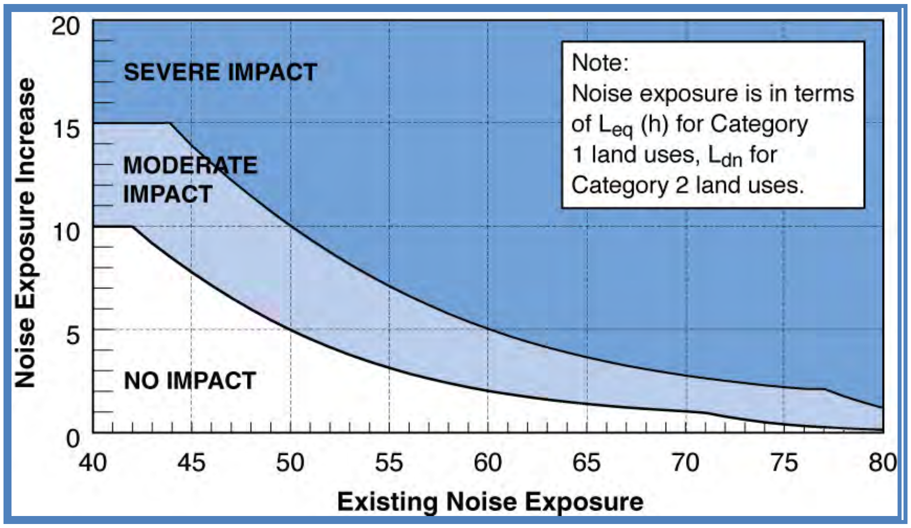


Figure 4.2. Increase in Cumulative Noise Exposure Allowed by FTA Criteria

The FTA guidance manual provides details on how parks are analyzed for noise in Chapter 3, Section 2, Application of Noise Impact Criteria, of the manual. FTA assumes that parks are a special case, and how they are used and where they are located should be considered when considering whether or not a particular park, or an area in a park, is considered noise-sensitive. Parks that are used for outdoor recreation are typically not considered noise-sensitive. This includes parks with baseball diamonds, soccer fields, basketball courts, football fields, and other active recreation areas.

Noise-sensitive parks are defined as those where quiet is an essential element in their intended purpose, or places where it is important to avoid interference with activities such as speech, meditation, and reading. The existing noise levels at a park can indicate the sensitivity of its use. All parks along the project corridor were evaluated for consideration under the FTA criteria, and based on the park locations and existing noise levels, none met the requirements for noise-sensitivity under the FTA Category 3 criteria.

4.2 Traffic Noise Impact Criteria

Consistent with the FTA guidance manual, Sound Transit used FHWA methodology and criteria to evaluate future project related traffic noise impacts. The criteria for highway noise impacts are taken from Title 23 of the Code of Federal Regulations (CFR) Part 772, Procedures for Abatement of Highway Traffic Noise and Construction Noise. Table 4-1 lists the traffic noise abatement criteria.

Under the FHWA criteria, projects that include construction of new highways, reconstruction of existing highways that includes significantly changing either the horizontal or vertical profile, or an increase in the number of through-traffic lanes require a traffic noise analysis. A significant change in the horizontal or vertical profile occurs when the change is likely to result in increased noise levels on developed lands that are perceptible to an average person, typically defined as a 3-dBA increase. The FHWA criteria are provided because they will be used in the analysis for any potential traffic noise impacts related to new or modified roadways that meet the above requirements, the relocation of existing noise walls, modification of existing physical shielding, and removal of existing shielding structures.

4.2.1 FHWA and WSDOT Traffic Noise Criteria

Under the FHWA criteria, a noise impact occurs if projected noise levels approach or exceed the FHWA levels listed in Table 4-1 or substantially exceed existing noise levels. Each state defines its own quantitative levels considered to approach or substantially exceed existing noise levels. WSDOT is responsible for implementing the FHWA regulations in Washington. Under WSDOT policy, a traffic noise impact occurs if projected noise levels are within 1 dBA of the FHWA criteria; therefore, a residential impact occurs at 66 dBA Leq and many commercial impacts occur at 71 dBA Leq. WSDOT also considers a 10-dBA increase in noise a substantial increase impact, regardless of the existing noise level. Potential noise from park-and-ride lots was assessed using the local noise criteria, which is discussed later in Section 4.3.1.

Table 4-1. Noise Abatement Criteria (NAC) by Land Use Category

Activity Category	Activity Criteria in hourly Leq (dBA)		Evaluation Location	Activity Description
	FHWA NAC	WSDOT NAC		
A	57	56	Exterior	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose
B[1]	67	66	Exterior	Residential (single-family and multifamily units)
C[a]	67	66	Exterior	Active sport areas, amphitheaters, auditoriums, campgrounds, cemeteries, daycare centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playgrounds, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, recreation areas, Section 4(f) sites, schools , television studios, trails, and trail crossings
D	52	51	Interior	Auditoriums, daycare centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, schools, and television studios

Table 4-1. Noise Abatement Criteria (NAC) by Land Use Category

Activity Category	Activity Criteria in hourly Leq (dBA) FHWA NAC	WSDOT NAC	Evaluation Location	Activity Description
E[a]	72	71	Exterior	Hotels, motels, offices, restaurants/bars, and other developed lands, properties, or activities not included in A–D or F
F	--	--	--	Agriculture, airports, bus yards, emergency services, industrial, logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, shipyards, utilities (water resources, water treatment, electrical), and warehousing
G	--	--	--	Undeveloped lands that are not permitted

Notes:
[a] Includes undeveloped lands permitted for this activity category.
dBA = decibel with A-weighting, FHWA = Federal Highway Administration, Leq = equivalent continuous sound level, WSDOT = Washington State Department of Transportation

4.3 State Regulations and Local Noise Ordinances

Project operation and construction would take place in Seattle and Shoreline in King County, and in Mountlake Terrace and Lynnwood in Snohomish County. Therefore, four different noise ordinances would be applicable to the operation of ancillary facilities, such as park-and-ride lots, and traction-power substations, as well as to project-related construction activities.

In Chapter 173-60 of the Washington Administrative Code (WAC), the Department of Ecology has adopted Maximum Environmental Noise Levels for residential, commercial, industrial, and construction areas. However, WAC 173-60-110 states that:

> *"The department conceives the function of noise abatement and control to be primarily the role of local government and intends actively to encourage local government to adopt measures for noise abatement and control. Wherever such measures are made effective and are being actively enforced, the department does not intend to engage directly in enforcement activities."*

Each of the four cities has adopted measures for noise abatement and control. Seattle and Lynnwood have adopted ordinances that are based upon WAC 173-60, while Shoreline and Mountlake Terrace have taken different approaches as discussed in sections 4.2.5 and 4.2.6. The provisions of WAC 173-60 are summarized below.

4.3.1 Washington Administrative Code

WAC Chapter 173-60 (Maximum Environmental Noise Levels) defines three classes of property usage, called Environmental Designation for Noise Abatement (EDNA), and states maximum allowable noise levels for each, as shown in Table 4-2. For example, the noise caused by a commercial property must be less than 57 dBA at the closest residential property line. From 10:00 pm to 7:00 am, the allowable maximum sound levels shown in Table 4-2 are reduced by 10 dBA in

Class A EDNAs (residential zones). The WAC contains short-term exemptions to the property line noise standards in Table 4-2 based on the minutes per hour that the noise limit is exceeded. These exceedances are outlined in Table 4-3.

Table 4-2. Washington State Noise Control Regulation

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

[a] Between 10 pm and 7 am, the levels given above are reduced by 10 dBA in Class A EDNAs.
dBA = decibel with A-weighting

Table 4-3. Washington State Exemptions for Short-Term Noise Exceedances

Minutes Per Hour	Adjustment to Maximum Sound Level
15	+5 dBA
5	+10 dBA
1.5	+15 dBA

dBA = decibel with A-weighting

WAC Construction Noise Criteria

Sounds received in Class A EDNAs that originate from construction sites are exempt from the limits of the WAC regulations during normal daytime hours (7:00 am to 10:00 pm). If construction is performed during the nighttime, the contractor must still meet the WAC noise-level requirements for sounds received in Class A EDNAs, as presented in Table 4-2, or get a noise variance from the governing jurisdiction.

The WAC also contains a set of construction-specific allowable noise-level limits. These construction noise regulations are organized by type of noise and, among other things, include haul trucks and back-up safety alarm criteria.

Haul Truck Noise Criteria

Maximum permissible sound levels for haul trucks on public roadways are limited to 86 dBA for speeds of 35 miles per hour (mph) or less, and 90 dBA for speeds over 35 mph when measured at 50 feet (Chapter 173-62, WAC). For trucks operating within staging areas, the general construction equipment noise criteria would be used to determine compliance during nighttime hours in Class A EDNAs.

Noise Related to Back-up Alarms

Sounds created by back-up alarms are essentially prohibited by the WAC during nighttime hours (10:00 pm and 7:00 am) in Class A EDNAs, when other forms of back-up safety measures would need to be used. These could include the use of smart back-up alarms, which automatically adjust the alarm level based on the background level, or switching off back-up alarms and replacing them with spotters.

4.3.2 City of Seattle

The City of Seattle has maximum permissible environmental noise level requirements that are similar to those contained in the WAC (Seattle Municipal Code [SMC] Chapter 25.08; SMC Section 25.08.410). However, while the WAC does not define a noise descriptor to be used for purposes of applying the limits shown in Table 4-2, the City of Seattle explicitly mandates that the Leq descriptor be used. In addition, during a measurement interval, maximum noise levels (Lmax) may exceed the Leq exterior sound level limits shown in Table 4-2 above by no more than 15 dBA (SMC Section 25.08.410(B)).

The SMC also imposes the following three limitations on the maximum permissible sound level limits, which are more restrictive than the WAC:

- The Seattle ordinance extends the 10 dBA reduction in maximum nighttime noise levels to 9:00 am on weekends and legal holidays, while under the WAC the reduction stops at 7:00 am.
- For any source of sound (other than an electrical substation) that has a pure tone component, the exterior sound level limits established under SMC Section 25.08.410 are reduced by 5 dBA.
- For any source of sound that is impulsive and not measured with an impulse sound level meter, the exterior sound level limits established under SMC Section 25.08.410 are reduced by 5 dBA.

Construction Noise Criteria

The WAC exempts construction noise from maximum permissible noise levels except during nighttime hours in residential zones, but the Seattle code provides upper limits on construction noise at all times. Under SMC Section 25.08.425, the sound level limits established by SMC Section 25.08.410 may be exceeded for non-impact construction equipment used on public projects, such as the Lynnwood Link Extension, between 7:00 am and 10:00 pm on weekdays, and between 9:00 am and 10:00 pm on weekends and legal holidays, by no more than the following:

- **25 dBA** for equipment on construction sites, including, but not limited to, crawlers, tractors, dozers, rotary drills and augers, loaders, power shovels, cranes, derricks, graders, off-highway trucks, ditchers, trenchers, compactors, compressors, and pneumatic-powered equipment.
- **20 dBA** for portable-powered equipment used in temporary locations in support of construction activities or used in the maintenance of public facilities, including, but not limited to, chainsaws, log chippers, lawn and garden maintenance equipment, and hand-powered tools.

- **15 dBA** for powered equipment used in temporary or periodic maintenance or repair of the grounds and appurtenances of residential property, including, but not limited to, lawnmowers, powered hand tools, snow-removal equipment, and composters.

For impact types of equipment, including, but not limited to, pavement breakers, pile-drivers, jackhammers, sandblasting tools, or other types of equipment that create impulse sound or impact sound, the sound level limits established by SMC Section 25.08.425 may be exceeded in any 1-hour period between 8:00 am and 5:00 pm on weekdays and 9:00 am and 5:00 pm on weekends and legal holidays, but in no event may the sound level for impact types of equipment exceed the following:

- Leq 90 dBA continuously
- Leq 93 dBA for 30 minutes
- Leq 96 dBA for 15 minutes
- Leq 99 dBA for 7.5 minutes

Sound levels in excess of Leq 99 dBA are prohibited unless authorized by variance, and impact equipment that produces sound levels less than 90 dBA must comply with the non-impact equipment construction sound level requirements between 7:00 am 8:00 am and again between 5:00 pm and 10:00 pm on weekdays and between 9:00 am and 10:00 pm on weekends and legal holidays.

The sound levels for all types of construction equipment are measured at the property line of the receiver or at a distance of 50 feet from the equipment making the sound, whichever is greater. Furthermore, any type of equipment that exceeds the sound level limits in SMC Section 25.08.410, when measured from the interior of buildings within a commercial district, is prohibited between 8:00 am and 5:00 pm.

Haul Truck Noise Criteria

Sounds created by motor vehicles on public roadways, including haul trucks, are exempt from Seattle's previously described maximum permissible environmental noise levels, and instead, maximum permissible sound levels for haul trucks on public roadways are simply limited to 95 dBA (SMC Section 25.08.430 et seq.). However, the previously described maximum permissible environmental noise level requirements do apply to vehicles operating off highways, such as trucks at staging areas, when the sounds are received within a residential district.

Noise Related to Back-Up Alarms

Sounds created by warning devices or alarms not operated continuously for more than 30 minutes per incident are exempt from the City of Seattle noise control requirements (SMC Section 25.08.530). For nighttime construction activity, the noise from the alarms would be addressed in permit conditions.

4.3.3 City of Shoreline

The City of Shoreline regulates noise pursuant to Chapter 9.05 of its Code, Public Disturbance Noise. A public disturbance noise is one that unreasonably disturbs or interferes with the peace and comfort of owners or possessors of real property. The City of Shoreline does not have any maximum permissible environmental noise level requirements that are similar to those contained in the WAC (as outlined in Section 4.2.3 of this report) or otherwise. Therefore, Sound Transit has chosen to use the WAC regulations for ancillary equipment and park-and-ride facilities.

Construction Noise Criteria

Sounds originating from construction sites including, but not limited to, sounds from construction equipment, power tools, and hammering, between 10:00 pm and 7:00 am on weekdays and 10:00 pm and 9:00 am on weekends, may constitute "public disturbance noise" depending on the location of the construction site and the receiving property (Shoreline Municipal Code Section 9.05.010(C)(8)). Noise from construction activities is, therefore, generally permitted on weekdays between 7:00 am and 10:00 pm and on weekends between 9:00 am and 10:00 pm. In addition, construction activities in the city's right-of-way that have been conditioned by the city to minimize the impact on adjacent property owners are exempt from regulation as public disturbance noise, while the creation within a residential district of frequent, repetitive or continuous sounds in connection with the operation of any motor vehicle may be a public disturbance noise.

The City of Shoreline does not have any laws or regulations that address noise variances.

4.3.4 City of Mountlake Terrace

The City of Mountlake Terrace primarily regulates noise pursuant to Chapter 8.20 of its Municipal Code, Regulation of Noise and Sound. That chapter prohibits "unreasonable noise that disturbs another" and therefore constitutes a public nuisance. (Mountlake Terrace Municipal Code Section 8.20.010(A)). The City of Mountlake Terrace does not have any maximum permissible environmental noise level requirements that are similar to those contained in the WAC (as outlined in Section 4.3.1 of this report) or otherwise. Therefore, Sound Transit has chosen to use the WAC regulations for ancillary equipment and park-and-ride facilities.

Construction Noise Criteria

Sounds created by blasting and sounds originating from construction sites as a result of construction activity are considered a nuisance when performed between 10:00 pm and 7:00 am (Mountlake Terrace Municipal Code Section 8.20.010(D)(2) and (D)(3)). Hence, sounds from construction activities are exempt every day of the week between 7:00 am and 10:00 pm. In addition, "loud and frequent, repetitive or intermittently continuous sounds made in connection with the starting, operation, repair, rebuilding or testing of any motor vehicle" are considered a nuisance.

Mountlake Terrace also regulates Essential Public Facilities pursuant to Chapter 18.15 of the City's Municipal Code, and one of the purposes of this chapter is to ensure that such facilities are subject to reasonable conditions for noise. (Mountlake Terrace Municipal Code Section 18.15.010).

The City of Mountlake Terrace does not have any laws or regulations that address construction noise variances.

4.3.5 City of Lynnwood

The City of Lynnwood primarily regulates noise pursuant to Chapter 10.12 of its Code, Noise, which states maximum permissible environmental noise level requirements that are similar to those contained in the WAC (Lynnwood Municipal Code Section 10.12.500). These requirements are outlined in Section 4.3.1 of this report. In addition, Lynnwood Municipal Code Section 17.05.070, Environmental Health, authorizes a responsible official to "require applicants for city permits to provide documentation by a qualified consultant that the project will not exceed noise standards or violate nuisance regulations pertaining to noise, and provide recommendations from such a consultant as to how noise can be minimized. The responsible official is authorized to condition or deny projects which would violate state and local standards. "

Sounds that are exempt at all times from the maximum permissible sound levels include "Sounds created by warning devices not operating continuously for more than 5 minutes, or bells, chimes, and carillons (Lynnwood Municipal Code Section 10.12.500(F)(4)).

Construction Noise Criteria

Sounds originating from construction sites as a result of construction activity are exempt on every day of the week from the City of Lynnwood environmental noise level requirements at all times in Class B and C EDNAs and between 7:00 am and 10:00 pm in Class A EDNAs (Lynnwood Municipal Code Section 10.12.500(E)).

In addition, section 10.12.500(G) states "Nothing in these exemptions is intended to preclude the community development director from requiring installation of the best available noise abatement technology consistent with economic feasibility."

The City of Lynnwood does not have any laws or regulations that address construction noise variances.

5 NOISE IMPACT ANALYSIS METHODS

This section summarizes the models used to predict future noise levels for potential sources of community impact related to the Lynnwood Link Extension. These sources include light rail operation, changes in traffic noise altered by the project, and construction activities.

5.1 Operational Measures

This section describes the assessment approach for noise related to operating the light rail system. This includes noise from light rail operations, traffic noise (where applicable), ancillary facilities, and wheel squeal. Sound Transit employs several operational measures to maintain low noise and vibration levels for its light rail trains. Table 5-1 lists operational and maintenance measures that Sound Transit performs on a regular basis and the benefit that each measure provides.

Table 5-1. Systemwide Light Rail Operational and Maintenance Measures

Operational Measure	System Benefit
Rail grinding, maintenance, and replacement	As rails wear, both noise and vibration levels from light rail operations can increase. By grinding or replacing worn rails or correcting improper track alignment, noise and vibration levels will remain at the projected levels.
Wheel truing and replacement	Wheel truing is a method of grinding down flat spots (commonly called wheel flats) on the vehicle wheels. Flat spots occur primarily because of hard braking. When flat spots occur, they can cause increases in both the noise and vibration levels produced by the light rail vehicles.
Vehicle maintenance	Vehicle maintenance includes performing scheduled and general maintenance on items such as air conditioning units, bearings, wheel skirts, and other mechanical units on the light rail vehicles. Keeping the mechanical systems on the light rail vehicles in top condition will also help to maintain the projected levels of noise and vibration.
Operator training	Operators will be trained to operate light rail vehicles at the speeds given in the operation plan that was used for the analysis and to avoid “hard-braking,” which can cause wheel flats and may also damage the track. Furthermore, by training operators to identify potential wheel flats and other mechanical problems with the light rail trains, proper maintenance can be performed in a timely manner.

5.2 Reference Light Rail Noise Levels

Sound Transit modeled noise from light rail operations using the methods described in the FTA guidance manual. Input to the model included measured reference noise levels for the new light rail vehicles that are currently being used on the Central Link light rail system. Reference measurements for light rail operations were taken along the ballast and tie segment of the initial segment in south Seattle in March 2010. The measured reference noise levels are 79 dBA Lmax for a single-car train traveling at 40 mph at a distance of 50 feet.

5.3 Alignment and Special Trackwork

A plan and profile of the proposed light rail alignment, including the locations of special trackwork, such as crossovers, and typical speeds, were obtained from project design engineers. The design information included the elevation of the trackway, type of track (ballast and tie, embedded, aerial, and direct fixation), and the location and design of the station alternatives. The current design calls for ballast and tie, aerial, and direct fixation types of trackway.

Track crossovers are mechanical devices that enable light rail cars to be guided from one track to another at a junction point. Crossovers have a gap in the rails that is necessary for the flange of the light rail wheels to pass through at the location where the two tracks cross. As a wheel passes through the gap there is increased noise and vibration levels. According to the FTA guidance manual and measurements of the Central Link light rail system, standard frogs, which are crossover components, can increase noise levels by as much as 8 to 10 dBA.

Spring switch and movable point frogs solve the added noise and vibration problems by closing the gap on the rails. Flange-bearing frogs, another mitigation option, transfer the vehicle load from the wheel tread to the wheel flange and raise the light rail car up and over the gap, reducing noise and vibration levels. Each of these types of frogs produce notably lower noise levels than standard frogs. Depending on the type of crossover and angle between the crossover and mainline track, special frogs, like those described, can reduce noise levels between 4 and 8 dBA compared to a standard frog. The type of frogs used for the Lynnwood Link Extension would depend on the track type, crossover location, and proximity of noise-sensitive properties.

5.4 Light Rail Warning Bells

Sound Transit measured and validated train-mounted bells on light rail cars in October 2009, with several supplemental measurements over the last 2 years. Consistent with Sound Transit operating rules, this analysis assumes that train-mounted bells would be sounded twice as a train enters a station, and twice when the train leaves the station. The bells produce a maximum noise level of 80 dBA Lmax at 50 feet between 6:00 am and 10:00 pm and are reduced to 72 dBA Lmax between 10:00 pm and 6:00 am.

5.5 Operational Plan

The Sound Transit operations schedule includes all other planned light rail expansions between now and 2030. The operations plan for this analysis is taken from the Sound Transit 2 (ST2) Plan, which assumes service to Lynnwood as well as the East Link Extension would be complete and running. Under this worst-case future operational plan, all light rail trains would operate with four passenger cars during all hours of operation.

The operating plan used in the analysis was taken from the highest potential service for the 2030 ridership model, which uses the following train lengths and headways:

- Peak (6:00 am to 8:30 am and 3:00 pm to 6:30 pm): 4-minute headways, four-car trains
- Midday and early evening (8:30 am to 3:00 pm and 6:30 pm to 10:00 pm): 5-minute headways, four-car trains
- Early morning and late evening (5:00 am to 6:00 am and 10:00 pm to 1:00 am): 7.5-minute headways, four-car trains

5.6 Wheel Squeal and Wheel-Flanging Noise

Wheel squeal is caused by the oscillation of the wheel against the rail on curved sections of the track. Sound Transit measured wheel squeal noise levels at several different locations along the Central Link corridor and used these measurements as reference data. Based on these measurements, curves with radii of less than 600 feet can produce maximum wheel squeal noise levels of 80 dBA to 90 dBA at 50 feet.

Research into methods of reducing wheel squeal noise, including using lubricants that are not oil based (such as water) and friction modifiers, has found such methods effectively reduce or eliminate wheel squeal. The lubricants can be applied by personnel working trackside or by an automated applicator. It is a general policy of Sound Transit to install lubricators or prepare for lubrication on any curves near noise-sensitive properties with a radius of less than 1,000 feet. If, after system operation begins, wheel squeal is identified, it is possible to add lubricators in a reasonable amount of time.

Sound Transit examined the project corridor for curves with radii of 600 feet or less and identified no such curves. There are curves in Segment C with radii of 800 feet. Under Alternatives C1 and C2 with Option 1, the curve from the I-5 median to 52nd Avenue West has a radius of 800 feet. Also, under Alternatives C1 and C2 with both design options, the curve from Cedar Valley Road to the transit station also has a radius of 800 feet. Sound Transit would prepare the light rail tracks along these curves to accept automated lubricators in case wheel squeal is noted during the initial system testing.

5.7 Light Rail Noise Projections

Noise impacts that would result from the Lynnwood Link Extension were determined through the following approach:

1. Sound Transit performed a land use survey of potential noise-sensitive receptors near the proposed light rail alignments. This process involved site visits and use of area land-use maps and information from other project team members.
2. Sound Transit conducted long-term (multi-day) and short-term (15- to 30-minute) noise monitoring to establish existing noise levels for the potentially affected area. Ambient noise monitoring was taken at 55 locations along the corridor. The criteria for monitoring location selection included land use, existing ambient noise, number of sensitive receivers in the area,

and level of expected impact. Traffic counts were also taken at several sites that will be used for future traffic noise modeling as part of noise wall relocation.

3. Field noise measurements were used to develop a set of existing ambient sound levels for the noise-sensitive receptors.
4. Existing ambient sound levels were used to determine the noise impact criteria. The FTA criteria for noise impact are based on the existing noise level and land use.
5. Projections of light rail noise levels were made based on track type, train speed, number of passenger cars, and distance of receiver from tracks, with adjustments for shielding and ground attenuation. Adjustments based on track type, noise walls, elevated acoustical walls, and retained cut situations are shown in Table 5-2. Sound attenuation related to physical shielding from the elevated structure and other existing and planned structures were included in the analysis using acoustical formulas from the FTA Manual. Noise related to warning bells at stations and special trackwork was also included in the analysis. Measured noise reductions taken in Tukwila, Washington, as part of Sound Transit's commitment to maintain a quiet system, were used in this analysis.
6. Sound Transit evaluated projections regarding impact thresholds to determine if a receiver would be affected by light rail operations.
7. Where noise impacts were identified, mitigation was considered. Mitigation recommendations followed the Sound Transit Noise Mitigation Policy and, as such, these recommendations were considered reasonable and feasible.

Table 5-2. Light Rail Track-Type and Shielding Adjustments

Track Type	Adjustment in Decibels (dBA)
At-grade ballast and tie-track (ballast exposed)	0
Elevated structure	+4
Embedded track or other trackway without any ballast overlay	+3
Retained cut with at least 4 to 6 feet below grade, with correction for deep cuts calculated with FTA. formulas	-5
Crossover, standard type	+10
Crossover, with special trackwork (movable point or spring rail type crossovers)	+2
Acoustical noise walls on structure between 4 and 6 feet above the top of rail with some going as high as 8 feet. Walls on structure over 8 feet are not normally used because of wind loading and safety concerns. If walls over 8 feet are required, the additional wind load would need to be considered in the design of the structure.	Typical noise reduction of 8 to 15 decibels or more, as predicted using FTA formulas and verified with measured data during normal operations along the Tukwila segment
Relocated noise wall at-grade with an expected height of at least 6 feet above the grade of the trackway. An at-grade noise wall can go as high as 20 feet or more when used to replace an existing traffic noise wall in addition to mitigating noise from the light rail operation. An at-grade wall for light rail only mitigation typically ranges from 4 to 8 feet.	Typical noise reduction of 8 to 12 decibels or more, as predicted using FTA formulas and verified with measured data during normal operations along the Tukwila segment

5.8 Park-and-Ride Noise Projections

Sound Transit calculated operational noise levels from buses and vehicles that would use the light rail park-and-ride facilities by using the methods outlined in the FTA guidance manual (FTA 2006). Future bus and passenger traffic volumes for the park-and-ride facilities are based on the predicted maximum number of parking spots, peak-hour bus service, and hourly bus service throughout the day, evening, and at night. Sound Transit used future park-and-ride operations to determine the noise levels at the residential areas near the proposed facilities.

As previously stated in Section 4.3, ancillary facilities must not only meet the FTA criteria for noise but also meet the applicable state, county, or city criteria. The Cities of Seattle and Lynnwood each have a local noise control ordinance. The Cities of Shoreline and Mountlake Terrace do not have an applicable noise ordinance, and therefore, as a matter of policy, Sound Transit has chosen to use the WAC regulations for ancillary equipment and park-and-ride facilities.

Sound Transit's noise analysis team calculated operational noise levels for the park-and-ride facilities at the nearest representative receivers' property line. Sound Transit projected the 24-hour Ldn and the peak hour Leq using the methods described in the FTA guidance manual (2006). The noise analysts obtained future hourly bus volumes and park-and-ride lot access times from Sound Transit. The daily Ldn noise levels were compared to the FTA noise regulations provided in Section 4.1.

The proposed park-and-ride facility sites are considered commercial uses, and most of the receiving sites near the proposed park-and-ride facilities are residential. As shown in Table 4-2, the maximum allowable noise level from a commercial property to the nearest residential use is 57 dBA at the property line. The noise impact analysis was performed for all passenger vehicles and buses only while they are on park-and-ride facility property using the worst case hourly Leq. Buses on public roadways, or at existing bus stops on public roadways, are exempt under local noise control ordinances. .

Table 5-3 summarizes the total number of parking spots for the transit centers and Table 5-4 summarizes the number of buses expected at each of the transit stations based on the time of day. The reference noise levels for park-and-ride operations for the peak-hour noise analysis and the 24-hour Ldn are provided in Table 5-5. Reference noise levels are provided for the parking lots and bus operations while at the park-and-ride.

Table 5-3. Passenger Vehicle Parking Spaces and Type

Station	Option	Parking Spaces[a]	Notes
NE 130th Street	Preferred Alternative and Option 1	100	Surface Lot (leased)
NE 130th Street	Option 2	100	Surface Lot
NE 145th Street	All NE 145th Street	500	Parking Garage
NE 155th Street	All NE 155th Street	500	Parking Garage
NE 185th Street	Preferred Alternative, Preferred Alternative with Shoreline Stadium Garage Option, and Options 1 and 2	500	Parking Garage
NE 185th Street	Option 3	360	Surface Lots
Mountlake Terrace Transit Center or Freeway Station	All Options	880	Parking Garage and Surface Lots
220th Street SW Station	All Options	200	Parking Garage and Surface Lots
Lynnwood Transit Center	All Options	1,900	Parking Garage and Surface Lots

[a] Parking spaces based on current design drawings

Table 5-4. Bus Trips by Park-and-Ride Option and Time of Day[a]

Station	Morning Peak 6:00 am to 7:00 am	Daytime Peak 5:00 pm to 6:00 pm	Daytime Trips 7:00 am to 10:00 pm	Nighttime Trips 10:00 pm to 7:00 am
NE 130th Street	8	8	120	16
NE 145th Street	24	24	360	48
NE 155th Street	24	24	360	48
NE 185th Street	44	44	620	84
Mountlake Terrace Transit Center or Freeway Station	44	44	532	84
220th Street SW Station	4	6	25	3
Lynnwood Transit Center	112	96	972	176

a. Estimated maximum number of buses accessing each of the park-and-ride options.

Table 5-5. Reference Park-and-Ride Facility Noise Levels at 50 Feet

		Peak Hour Leq (dBA)[a]		24-hour Ldn (dBA)[b]	
Station	Park-and-Ride Option	Buses 6:00–7:00 am	Vehicles 6:00–7:00 am	Ldn Buses	Ldn Vehicles
NE 130th Street	All options	N/A[c]	43	49	40
NE 145th Street	All options	N/A[c]	50	54	47
NE 155th Street	All options	N/A[c]	50	54	47
NE 185th Street	Option 1, 2	55	50	56	47

Table 5-5. Reference Park-and-Ride Facility Noise Levels at 50 Feet

Station	Park-and-Ride Option	Peak Hour Leq (dBA)[a]		24-hour Ldn (dBA)[b]	
		Buses 6:00–7:00 am	Vehicles 6:00–7:00 am	Ldn Buses	Ldn Vehicles
NE 185th Street	Option 3	55	48	56	45
Mountlake Terrace Transit Center or Freeway Station	All Mountlake Terrace options	55	52	56	49
220th Street SW Station	All options	45	46	56	49
Lynnwood Transit Center	Preferred Alternative	59	61	70	67
Lynnwood Transit Center	200th Street SW (Alternative C1)	59	56	70	52
Lynnwood Transit Center	Lynnwood Transit Center (Alternative C2)	59	64	70	70
Lynnwood Transit Center	Lynnwood Park-and-Ride Option 1 (Alternative C3)	59	61	70	68
Lynnwood Transit Center	Lynnwood Park-and-Ride Option 2 (Alternative C3)	59	60	70	66

[a] Worst-case hourly Leq. For buses, the noise level was projected using the maximum number of buses at the park-and-ride in a single hour; for vehicles, the noise levels were projected assuming all parking spots would be occupied in a single hour.

[b] 24-hour Ldn projections that are based on the number of buses and vehicles predicted to access the park-and-ride throughout the daytime and nighttime hours.

[c] All bus traffic for this station option is on existing public roadways, at or near existing bus stops, and is therefore exempt from the local noise ordinances.

N/A = not applicable

5.9 Traffic Noise Analysis

As discussed in Section 4.2, Traffic Noise Impact Criteria, a traffic noise study would be required for any roadway modifications that increase capacity or modify the alignment and that increase the traffic noise by 3 dB or more. A traffic study is also required for the removal or replacement of any existing noise walls or other structural shielding. This project has several locations along I-5 where roadways are modified and/or noise walls or other noise reducing structural shielding are being removed or modified. Section 5.9.1 describes the methods for the traffic noise analysis for five locations along I-5 where noise walls are being relocated as part of this project. Section 5.9.2 describes the traffic noise analysis near the Lynnwood Transit Center, where several roadways are being modified to better serve the transit center operations.

5.9.1 Shielding and Structural Replacement

Because the Lynnwood Link Extension may need to remove several noise walls and shielding structures along I-5, the project would be responsible for replacing these noise walls and structural shielding with new noise walls. The Draft EIS noted that noise walls would need to be replaced or relocated, but it did not identify the specific locations where removal of noise walls or shielding or roadway realignment would necessitate a traffic noise study to determine the locations and specifications of new noise walls within the project corridor. Since the publication of the Draft EIS, details of the Preferred Alternative alignment were used to review potential sites that would require a traffic noise study because of alternations caused by the project. While the alignment likely will continue to be revised as the design progresses, the general information used for this review is not expected to change substantially. Therefore, a traffic noise study was performed in five areas where existing traffic noise walls and/or structural shielding would be removed and/or replaced and roadways realigned as a result of the project. Details of the study areas are outlined below.

1. Replacement Traffic Noise Wall #1: Between NE 115th Street and NE 130th Street (approximate station numbers 30+00 to 76+00)—replacement of an existing noise wall, removal of shielding structures, and the realignment of 5th Avenue NE and the NE 130th Street off-ramps
2. Replacement Traffic Noise Wall #2: Between 5th Avenue NE to I-5 northbound just north of NE 145th Street (approximate station numbers 122+00 to 138+00)—relocation of an existing on-ramp and noise wall and removal of shielding for station construction and track installation
3. Replacement Traffic Noise Wall #3: Between NE 161st Street and NE 175th Street (approximate station numbers 161+00 to 200+00)—removal and replacement of an existing noise wall and earth berm from the Ridgecrest Park to NE 175th Street and the realignment of 1st Street NE along with the removal of several homes between NE 170th Street and NE 175th Street
4. Replacement Traffic Noise Wall #4: Between NE 180th Street and NE 185th Street (approximate station numbers 215+00 to 229+00)—replacement of an existing noise wall, removal of shielding, and realignment of NE 5th Avenue
5. Replacement Traffic Noise Wall #5: NE 185th Street Station area (approximate station numbers 230+00 to 243+00)—removal of approximately 16 homes, and replacement of a noise wall

The traffic noise modeling analysis for the Lynnwood Link Extension consisted of the following steps:

1. Traffic noise levels were predicted using FHWA's Traffic Noise Model (TNM®) software.
2. Each traffic noise model was validated using measured noise levels and actual traffic counts taken during the measuring periods at various locations along the project corridor.
3. Once each traffic noise model was validated, it was used to model existing and Future No Build conditions in each study area at receivers selected to be representative of homes throughout the study area. Existing traffic volumes and vehicle percentages provided by the project traffic engineers were used for this purpose. Future No Build traffic data was estimated based on existing travel patterns and connections combined with Future Build traffic projections.
4. Future Build conditions for each study area were also modeled in TNM using future year 2035 build traffic volumes and vehicle percentages provided by project traffic engineers. Any existing traffic noise walls not affected by the project were included in a model if the

walls affected the traffic noise analysis in the area being studied. Where applicable and constructible, replacement noise walls will be located on top of any cut and fill walls that will be constructed as part of the project. In such cases, the combined structure (cut and fill wall and noise wall) was analyzed against the design criteria because the cut and fill walls may also assist in the abatement of traffic noise.

5. The possibility of a replacement traffic noise wall also mitigating light rail noise from the project was also considered in designing each traffic noise wall, but the new wall was still required to meet the design criteria specific to traffic noise.

In the traffic noise analysis of replacement walls, the design criteria specified that the walls must be able to abate I-5 traffic noise in the specific study area, using the future (year 2035) traffic volumes at the posted speed limit, to the extent that when the proposed project becomes operational there would be, whenever feasible:

1. No new traffic noise impacts, and
2. No increase in the severity of any existing traffic noise impacts that would occur if the project were not built.

For example, the new noise walls were designed to ensure that there are no additional residences in the replacement noise wall study areas with I-5 traffic noise levels above the WSDOT Noise Abatement Criteria of 66 dBA as a result of the project, and that any residences in those same study areas that would experience traffic noise impacts (noise level above 66 dBA Leq) without the project would not have increased traffic noise levels as a result of the project. The analysis compared the existing and future 2035 traffic noise levels that would be experienced with the existing noise walls and highway configuration to the future (year 2035) roadway build conditions and the replacement walls. Noise levels for receivers behind the noise walls were evaluated based on the above criteria and the noise walls were optimized to meet these requirements. Noise wall optimization included adjusting the heights of individual noise wall panels to achieve the necessary noise reduction while maintaining a cost-effective form of noise abatement.

It is anticipated that final noise wall heights or even their placement may be reconsidered during final design when the light rail alignments and roadway configurations are further developed. However, this current traffic noise analysis provides sufficient data to allow the likely placement and scale of the new noise walls for this environmental impact statement (EIS) and other preliminary engineering efforts. Proposed noise walls will be located beyond the 84-foot WSDOT compatibility line whenever possible and, when feasible, will be installed between the light rail corridor and the private properties to mitigate noise from light rail operations as well as traffic noise. Any noise walls that cannot be constructed outside the 84-foot WSDOT compatibility line will require additional consultation between Sound Transit and WSDOT.

5.9.2 Traffic Noise Modeling

Since the publication of the Draft EIS, new details regarding the design of the Lynnwood Park-and-Ride Station were used to determine that a traffic noise analysis using the methods set forth in the

FTA manual would be necessary for the area surrounding the Lynnwood Park-and-Ride Station. As part of the project, several area roadways would be altered under the Preferred Alternative to include the following changes:

1. Addition of a northbound right turning lane at 48th Avenue W where it intersects with 200th Street SW;
2. Addition of an eastbound through lane on 200th Street SW between 48th Avenue W and 46th Avenue W;
3. Restricting traffic on 46th Avenue W to only high occupancy vehicles (HOV) so that the HOV designation includes the northern portion of that roadway between 200th Street SW and I-5 that is not already designated as HOV-only;
4. Extension westward of the eastbound right turn lane between 46th Avenue W and 44th Avenue W; and
5. Addition of a northbound left turning lane at 44th Avenue W where it intersects with 200th Street SW.

The study area included three apartment complexes, a condominium complex, and two motels. The two motels are the Marriott Courtyard Hotel at 4220 200th Street SW and the La Quinta Motel at 4220 Alderwood Mall Boulevard, both of which are located in a triangular area bounded by I-5, 44th Avenue W, and Alderwood Mall Boulevard. The three apartment complexes are the Park Five Apartments at 20104 48th Avenue West, the Oxford Square Apartments at 4807 200th Street SW, and the Cambridge Apartments at 4727 200th Street SW. The Cedar Creek condominium complex located at 4800-4920 200th Street SW was also included in the analysis.

In general, the traffic noise modeling analysis methodology for the Lynnwood Park-and-Ride Station area consisted of the same steps used for the replacement noise walls, as outlined in Section 5.9. However, FHWA and WSDOT Traffic Noise Criteria were used for the analysis.

6 FUTURE NO BUILD CONDITIONS

If the proposed project is not built, traffic on I-5 and ancillary roadways will increase. For roadways such as I-5, an increase in traffic volume of 1 to 2 percent per year is typical. Hence, in 35 years the daily traffic volume on I-5 will increase and cause a corresponding increase in traffic noise. Because I-5 is already at or near capacity during peak periods, the maximum-hour Leq(h) will not increase substantially unless the capacity is increased. In the future, one or more of the following cases might occur:

- Traffic would extend to off-peak hours, resulting in more hours of the day with high-traffic noise levels.
- Increased congestion, resulting in reduced speeds and lower noise levels during peak hours; the loudest hours would then occur during off-peak periods.
- Roadway capacity would increase to accommodate traffic demand, which would qualify as an FHWA and WSDOT Type 1 project and be evaluated individually for noise impact.

A doubling of traffic volumes, although unlikely, could cause an increase in current traffic noise levels of approximately 3 dBA if all other conditions remain the same. An increase in the traffic noise levels of 3 dBA is normally perceptible to most people. This projected increase in noise levels caused by an increase in I-5 traffic assumes a roadway-carrying capacity that can support such a volume in a manner that still allows for the free flow of traffic. Traffic that is at a standstill or traveling significantly less than the posted speeds produce even less noise. A general rule is a reduction of approximately 3 dBA for each reduction of 10 mph until the speeds slow to 25 to 30 mph, when motor noise, acceleration, and other traffic-related noise sources keep traffic noise fairly constant.

While traffic on I-5 is the dominant source of noise for many receivers in the project corridor, many receivers are also affected by noise from traffic on ancillary roadways. The projected annual volume increases on these roadways could be greater than 1 to 2 percent. Therefore, future noise levels at some homes might increase by more than 3 dBA over what they are now. Changes in ancillary roadway alignments and traffic control measures could also affect future noise levels at some homes. Roadway projects that would have a significant effect on traffic noise levels would require their own individual analysis under the National Environmental Policy Act (NEPA) or State Environmental Policy Act (SEPA), depending on the funding source.

7 FUTURE BUILD CONDITIONS

Sound Transit performed a detailed noise impact assessment based on the criteria discussed in Section 4 and on the methods and projections described in Section 5 of this report. For areas with noise impacts, noise mitigation measures are provided in Section 8. Detailed sheets, including complete tabulated data of the project parcel identification, existing noise levels, project noise levels, criteria, and other information, are provided in Attachment B.

7.1 Considerations of Traffic Noise, Existing Noise Barriers, and Removal of Shielding

Because the light rail alignment is proposed directly adjacent to I-5 (along either the west or east sides) between existing residential and commercial land uses, several existing noise walls constructed for traffic noise abatement would need to be relocated. Any existing noise walls that would be relocated would be required to meet FHWA and WSDOT requirements and achieve equal or better noise reduction. In addition, in some locations (currently estimated to be approximately 1,000 linear feet), the modification of the existing terrain or the removal of existing structures for some of the alternatives could result in the removal of shielding that could cause an increase in traffic noise levels at some residences. For these areas, replacement noise walls will be necessary based on the traffic noise modeling results discussed in Section 7.4 of this report. In the area around the Lynnwood Park-and-Ride Station, new traffic noise walls will be necessary based on the traffic noise modeling results, also discussed in Sections 7.4 and 8.8 of this report. In all cases, any property noted as a full displacement as part of construction for a specific alternative was not included in that alternative's noise analysis.

7.2 Transit Noise Impact Analysis

Sound Transit based the evaluation of the potential environmental noise impacts on the changes in the environmental noise level that would be caused by each project alternative and the number of dwelling units potentially affected by project noise. The transit noise methodology, as discussed in Section 5 of this report, is consistent with the FTA guidance manual (FTA 2006). Also, as defined in Sections 5.3 and 5.4, special trackwork, including crossovers, along with light-rail-mounted bells used at stations, are included in the analysis. Sound Transit also applied the FTA noise assessment methodology to evaluating the park-and-ride facilities and transit centers.

Since the Draft EIS, the operational schedule assumption has changed slightly, with four-car trains replacing two-car trains between 6:30 pm and 1:00 am. In addition, the noise study was further refined with updated design drawings and more detailed information on the replacement noise walls, structure configurations, and other revisions and updates. The noise analysts used this information to reevaluate noise levels and impacts for each potential alternative and design option. The most notable change in the modeling results is an overall increase in the total number of noise impacts under all Segment A alternatives, Alternative B2A in Segment B, and Alternative C3 Option 2 (west side of I-5) in Segment C.

In addition to the increase in the total number of impacts, there is also an increase in the number of moderate impacts under all alternatives, with a slight reduction in the number of severe impacts under all alternatives except Alternative C3 Option 2. The reduction in the number of severe impacts is directly related to the increase in moderate impacts. Refinement of the analysis reflects that some of the receivers located near the elevated structures are shielded from the far track noise by the base of the structure, thereby reducing the number of severe impacts and increasing the number of moderate impacts. Additional increases in the number of moderate impacts are caused by the four-car trains during evening and nighttime hours.

Because of the large number of properties analyzed for noise impacts, this report only provides a summary of the impacts. Attachment B provides complete tabulated data, including the project parcel identification, existing noise levels, project noise levels, criteria, and other information. Attachment C contains detailed maps showing all parcels analyzed, noise impacts, severity of impacts, and potential mitigation measures.

7.2.1 Segment A

Table 7-1 provides a summary of the moderate and severe impacts for each of the proposed Segment A alternatives, beginning with the Preferred Alternative. As Table 7-1 shows, the elevated alternatives (A3, A7 and A11) would have more impacts than the at-grade alternatives (Preferred Alternative and A1, A5, and A10). This is partly a result of the relocated noise walls for the at-grade alternatives, which would also reduce the noise from light rail operations. Details on noise impacts under the Segment A alternatives are provided in the following sections.

Table 7-1. Summary of Potential Transit Noise Impacts in Segment A

Alternative	Station Option	Moderate Light Rail Impacts	Severe Light Rail Impacts	Total Impacts
Preferred Alternative	NE 145th Street Elevated Station NE 185th Street At-Grade Station	181	112	293
Alternative A1	NE 145th Street Option 1 NE 185th Street Option 1	190	29	219
Alternative A3	NE 145th Street Option 2 NE 185th Street Option 2	269	198	467
Alternative A5	NE 130th Street Option 1 NE 155th Street Station NE 185th Street Option 3	181	105	286
Alternative A7	NE 130th Street Option 2 NE 155th Street Station NE 185th Street Option 2	296	183	479
Alternative A10	NE 130th Street Option 1 NE 145th Street Option 1 NE 185th Street Option 3	161	110	271
Alternative A11	NE 130th Street Option 2 NE 145th Street Option 2 NE 185th Street Option 2	272	195	467

Note: Also, see Section 7.3 for park-and-ride noise impacts.

Preferred Alternative Segment A

Under the Preferred Alternative, there would be 181 moderate and 112 severe noise impacts. No noise impacts were identified at any other institutional uses, such as schools and libraries, or any hospitals or other noise-sensitive medical uses. Included in this analysis is approximately 11,900 feet of relocated traffic noise walls as well as the noise-reducing effects of these new noise walls.

Between Northgate Way and NE 115th Street, several multifamily complexes, including the Citigate Apartments, would experience noise impacts. There are 68 severe noise impacts predicted at the three different complexes in this area. North of 115th Street to NE 130th Street, noise impacts are predicted at all front-line residences with 21 impacts in the severe category. A severe noise impact was also predicted at the Seattle Latvian Evangelical Lutheran Church.

The light rail alignment and reconfigured off-ramps from I-5 at NE 130th Street would require the construction of 4,599 feet of noise wall from NE 115th Street to the NE 130th Street overpass to replace the existing noise wall. Details of the proposed new noise walls and the accompanying traffic and light rail noise reductions are provided in the noise mitigation section. These new walls would be designed to replace the highway noise walls as well as mitigate noise from the light rail system.

North of NE 130th Street, no transit noise impacts are predicted because the light rail alignment is below grade near the only residences in this area and the North Seattle Church of the Nazarene. North of this church, the alignment is elevated along the Jackson Park Golf Course, which is not noise-sensitive, before entering the NE 145th Street Station; no noise impacts are predicted.

North of NE 145th Street and south of NE 158th Street, 850 feet of noise walls would be installed to replace an existing noise wall that would be displaced by the Preferred Alternative. Severe impacts in this area would occur along the elevated guideways between NE 151st Street and NE 158th Street. All other impacts between NE 145th Street and south of NE 158th Street would be in the moderate category. These impacts include the effects of a crossover at NE 151st Street. Because trains would be required to slow as they enter and exit the platforms at the NE 145th Street Station, the project noise levels and impacts are reduced in this area.

Between NE 158th Street and NE 175th Street, there would be five noise impacts, including one in the FTA severe category. The low number of impacts reflects the installation of approximately 3,800 feet of new replacement noise walls, with the light rail on the I-5 side of the wall, and approximately 2,500 feet where the light rail is shielded from the residences by being in a retained cut.

North of NE 175th Street and extending to the connection with Segment B, there would be 13 moderate impacts and 8 severe impacts. Two noise walls, with a total length of approximately 2,700 feet, would be relocated through this area, which would reduce the potential noise impact from light rail operations. As with the previous section of Segment A, all severe impacts, except one at NE 189th Street, would be along the elevated guideway sections.

Alternative A1: At-grade/Elevated with NE 145th Street and NE 185th Street Stations

Under Alternative A1, there would be 190 moderate impacts and 29 severe impacts. All noise impacts under Alternative A1 would be at single-family and multifamily residences. No noise impacts were identified at any institutional uses, such as schools, churches, or any hospitals or other noise-sensitive medical uses. As part of the project, approximately 7,900 feet of existing noise walls would be relocated in Segment A under Alternative A1, and, whenever possible, these relocated noise walls would also be used to reduce noise from light rail operations.

Noise impacts are predicted at 147 multifamily units in two different complexes just north of Northgate Way along 1st Avenue NE. These impacts include 8 severe impacts that would result from the added noise associated with an elevated profile and proximity to the multifamily units. There would also be one impact at a single-family residence that meets the FTA moderate impact criteria between NE 115th Street and NE 131st Place, near the south end of the Jackson Park Golf Course. The low number of noise impacts north of NE 115th Street would partly be a result of relocating 1,500 feet of existing noise walls, and placing the light rail alignment west of the noise walls along the east side of I-5.

Between NE 131st Place and NE 145th Street, land use consists of the Jackson Park Golf Course, which is not noise-sensitive. North of NE 145th Street and south of NE 158th Street, the relocation of an additional 1,200 feet of noise walls would minimize the noise impacts, with 26 moderate and 12 severe impacts identified. The severe impacts would be spread out along elevated guideway sections of the corridor. Because of the proposed station at NE 145th Street, trains would be required to slow as they enter and exit the platforms; therefore, project noise levels and impacts would be reduced in this area.

Between NE 158th Street and NE 175th Street, there would be 7 moderate noise impacts. The 7 impacts were determined assuming the relocation of approximately 3,400 feet of noise walls on the east side of I-5, with the light rail alignment placed on the I-5 side of the noise wall.

North of NE 175th Street to the connection with Segment B, there would be 17 moderate impacts and 9 severe impacts. Approximately 1,800 feet of noise wall would be relocated through this area, reducing the potential noise impact from light rail operations. As with the previous section of Segment A, most severe impacts would be along the elevated guideway sections.

Alternative A3: Mostly Elevated with NE 145th and NE 185th Street Stations

Under Alternative A3, there would be 269 moderate impacts and 198 severe impacts. The noise impacts would be at single-family and multifamily residences, the North City Cooperative Preschool on NE 190th Street, and the Seattle Latvian Evangelical Lutheran Church. No noise impacts were identified at any other institutional uses, such as schools, or at any hospitals or other noise-sensitive medical uses. As part of the project, approximately 2,100 feet of existing noise walls would be relocated in Segment A due to the elevated guideway; however, the relocated noise walls would not be effective at reducing noise from light rail operations at most locations because of the track elevation. As a result of the unshielded aerial guideway, before considering mitigation, there would be substantially more noise impacts from Alternative A3 than from Alternative A1.

Noise impacts are predicted at 171 multifamily units in three different complexes just north of Northgate Way along 1st Avenue NE. These impacts include 64 severe impacts that would result from the added noise associated with an elevated profile. There would also be 120 noise impacts between NE 115th Street and NE 131st Place, near the south end of the Jackson Park Golf Course. These 120 noise impacts would include severe impacts at 49 single-family residences, one duplex, and the Seattle Latvian Evangelical Lutheran Church. All severe impacts would be caused, in part, by the added noise from an elevated guideway and low existing noise levels because of shielding from I-5 by the existing noise wall.

Between NE 131st Place and NE 145th Street, land use consists of the Jackson Park Golf Course, which is not noise-sensitive. North of NE 145th Street and south of NE 158th Street, 57 noise impacts were identified, including 29 moderate and 27 severe impacts. All of the severe impacts would be along the elevated guideway.

Between NE 158th Street and NE 175th Street, there would be 12 noise impacts, including 4 in the FTA severe category. The 8 impacts were determined assuming the relocation of approximately 2,100 feet of noise walls on the east side of I-5, with the light rail alignment placed on the I-5 side of the noise wall.

North of NE 175th Street to the connection with Segment B, there would be 107 noise impacts, including 57 moderate impacts and 50 severe impacts. As with the previous Segment A area discussed, the severe impacts would be related to the added noise from the elevated guideway and lack of shielding from relocated noise walls.

Alternative A5: At-grade/Elevated with NE 130th, NE 155th, and NE 185th Street Stations

Under Alternative A5, there would be 181 moderate impacts and 105 severe impacts. Noise impacts would include single-family and multifamily residences. No noise impacts were identified at any institutional uses, such as schools, or at any hospitals or other noise-sensitive medical uses. As part of the project, approximately 8,200 feet of existing noise walls would be relocated in Segment A under Alternative A5, and, whenever possible, these relocated noise walls would also be used to reduce noise from light rail operations.

Sound Transit predicts noise impacts at 173 multifamily units in three different complexes just north of Northgate Way along 1st Avenue NE. These 173 impacts include 72 severe impacts that would be caused by the added noise associated with an elevated light rail profile. There would also be 19 single-family residences that meet the impact criteria between NE 115th Street and NE 131st Place, near the south end of the Jackson Park Golf Course. These 19 impacts would include 10 severe impacts (8 at single-family residences and one duplex) and 16 moderate noise impacts. The severe impacts would be a result of the elevated guideway. Compared with Alternative A1, there would be a greater number of severe impacts in this area because the guideway would be closer to the multifamily units near Northgate Way. Under Alternative A1, the alignment would remain on the west side of 1st Avenue NE, while under Alternative A5, the alignment would be along the east side of 1st Avenue NE, resulting in a notably higher number of impacts. The station at NE 130th Street would not cause any noise impacts.

Between NE 131st Place and NE 145th Street, land use consists of the Jackson Park Golf Course, which is not noise-sensitive. North of NE 145th Street and south of NE 158th Street, 47 moderate and 11 severe impacts were identified, even with the relocation of an additional 1,100 feet of noise walls, because of the elevated guideway. One of the moderate impacts would be at the Fire Station on NE 155th Street, with the other 57 at single-family residences. Most severe impacts would be along elevated guideway sections at single-family residences. Alternative A5 would result in fewer impacts near NE 155th Street than with Alternative A1 because of a reduced speed to serve the station and displacement of several residences north of NE 155th Street that otherwise would experience noise impacts.

Between NE 158th and NE 175th Streets, there would be 7 noise impacts, including 1 in the FTA severe category. The 7 noise impacts were determined assuming the relocation of approximately 3,400 feet of noise walls, with the light rail alignment placed on the I-5 side of the noise wall.

North of NE 175th Street to the connection with Segment B, there would be 18 moderate impacts and 11 severe impacts. Approximately 1,800 feet of noise wall would be relocated through this area, reducing the potential noise impact from light rail operations.

Alternative A7: Mostly Elevated with NE 130th, NE 155th, and NE 185th Street Stations

Under Alternative A7, there would be 296 moderate impacts and 183 severe impacts. Without mitigation, Alternative 7 would have the most noise impacts of any of the Segment A alternatives. The higher number of impacts would be caused, in part, by the higher noise levels associated with the elevated guideway structure. Noise impacts under Alternative A7 would affect single-family and multifamily residences as well as one church. No noise impacts were identified at any other institutional uses, such as schools, or at any hospitals or other noise-sensitive medical uses. As part of the project, approximately 2,100 feet of existing noise walls would be relocated in Segment A; however, because the guideway would be elevated, the relocated noise walls would not be effective at reducing noise from light rail operations at most locations. Under Alternative A7, noise impacts from the Northgate Transit Center to NE 115th Street would be the same as predicted for Alternative A3, with 107 moderate and 64 severe impacts predicted at the multifamily units in three different complexes just north of Northgate Way along 1st Avenue NE.

From NE 115th Street to the south end of the Jackson Park Golf Course, 71 moderate and 49 severe impacts were identified, including severe impacts at a multifamily duplex and a severe impact at the Seattle Latvian Evangelical Lutheran Church. All severe impacts would occur adjacent to the elevated guideway. There would be no impacts at the golf course.

North of NE 145th Street and south of NE 158th Street, 69 noise impacts were identified, including 53 moderate and 16 severe impacts. All impacts in this area would be on single-family residences, and the severe impacts would primarily be along elevated sections of the guideway.

Between NE 158th Street and NE 175th Street, noise impacts under Alternative A7 would be the same as under Alternative A3, with 12 noise impacts, including 4 in the FTA severe category. The 12 impacts were determined assuming the relocation of approximately 2,100 feet of noise walls on the east side of I-5, with the light rail alignment placed on the I-5 side of the noise wall.

North of NE 175th Street to the connection with Segment B, Alternative A7 noise impacts would be the same as under Alternative A3, with 107 noise impacts predicted, including 57 moderate impacts and 50 severe impacts.

Alternative A10: At-grade/Elevated with NE 130th, NE 145th, and NE 185th Stations

Under Alternative A10, there would be 161 moderate impacts and 110 severe impacts. Noise impacts would include single-family and multifamily residences; no noise impacts were identified at any institutional uses, such as schools and churches, or at any hospitals or other noise-sensitive medical use locations. As part of the project, approximately 8,100 feet of existing noise walls would be relocated in Segment A under Alternative 10 and, whenever possible, these relocated noise walls would also be used to reduce noise from light rail operations.

Noise impacts would occur at 173 multifamily units in three different complexes just north of Northgate Way along 1st Avenue NE. These 173 impacts include 72 severe impacts that would be caused by the added noise associated with an elevated profile. There would also be 18 single-family residences that meet the impact criteria between NE 115th Street and NE 131st Place, near the south end of the Jackson Park Golf Course. These 18 impacts would include 7 severe impacts (5 at single-family residences and 1 at a duplex) and 11 moderate noise impacts. The severe impacts would be a result of the elevated guideway. Compared with Alternative A1, there would be a greater number of severe impacts in this area under Alternative A10 because the guideway would be closer to the multifamily units near Northgate Way. Under Alternative A1, the alignment would remain on the west side of 1st Avenue NE, while under Alternative A10 (and A5), the alignment would be along the east side of 1st Avenue NE, resulting in a notably higher number of impacts. There would be no noise impacts from just north of NE 126th Street northward to NE 145th Street. The station at NE 130th Street would not cause any noise impacts. Between NE 131st Place and NE 145th Street, land use consists of the Jackson Park Golf Course, which is not noise-sensitive.

Under Alternative A10, there would be 39 noise impacts north of NE 145th Street to NE 158th Street, with 13 of these being severe impacts. All impacts in this section of Segment A would be on single-family residences.

Between NE 158th and NE 175th Streets, there would be 8 noise impacts, including 1 in the FTA severe category. The 8 impacts reflect the relocation of approximately 3,400 feet of noise walls, with the light rail alignment placed on the I-5 side of the noise wall.

North of NE 175th Street to the connection with Segment B, there would be 16 moderate impacts and 17 severe impacts. Approximately 1,800 to 1,900 feet of noise wall would be relocated through this area, reducing the potential noise impact from light rail operations.

Alternative A11: Mostly Elevated with NE 130th, NE 145th, and NE 185th Street Stations

Under Alternative A11, there would be 272 moderate impacts and 195 severe impacts, the second most of the 7 Segment A alternatives. All noise impacts under Alternative A11 would be at single-family and multifamily residences, along with an impact at the Seattle Latvian Evangelical Lutheran Church and at the North City Cooperative Preschool on NE 190th Street. No noise impacts were identified at any other institutional uses, hospitals, or other noise-sensitive medical uses. As part of the project, approximately 3,400 feet of existing noise walls would be relocated in Segment A because of the elevated guideway. The relocated noise walls would not be effective at reducing noise from light rail operations at most locations because the track would be elevated.

From the Northgate Transit Center north to NE 131st Street, noise impacts under Alternative A11 would be the same as described under Alternative A7, with 107 moderate impacts and 64 severe impacts. From NE 145th Street to NE 175th Street, noise impacts would be the same as Alternative A3, with 37 moderate impacts and 32 severe impacts. North of NE 175th Street to Segment B, noise impacts would also be the same as predicted under Alternative A3, with 57 moderate and 50 severe impacts.

7.2.2 Segment B

Table 7-2 provides a summary of the moderate and severe transit noise impacts for the Segment B alternatives. As Table 7-2 shows, the Preferred Alternative would have more impacts than the other Segment B alternatives. This is partly related to Alternatives B1 and B4 being placed in the center of I-5 for much of this segment; in addition, an increased distance from the residences to the guideway also would reduce noise levels from light rail operations. Alternative B2A differs from the Preferred Alternative with the addition of the 220th Street Station, which would result in a reduced speed for station access, and reduce the noise level near the station and the total number of noise impacts by two. The connection modification to Segments A and C, where the track elevations would be different, depending on the connection, would not change the number or severity of impacts or cause any additional noise impacts. Details on noise impacts under the Segment B alternatives are provided in the following sections.

Table 7-2. Summary of Potential Transit Noise Impacts for Segment B

Alternative	Station Option	Moderate Light Rail Impacts	Severe Light Rail Impacts	Total Impacts
Preferred Alternative	Preferred Stations (no station at 220th Street SW)	148	65	213
Preferred Alternative Option	Mountlake Terrace Transit Center Station 220th Street Station South Option	133	65	198
Alternative B1	Mountlake Terrace Transit Center Station	89	29	118
Alternative B2A	Mountlake Terrace Transit Center Station 220th Street Station North Option	138	50	188
Alternative B4	Mountlake Terrace Freeway Station	73	33	106

Note: Also see Section 7.3 for park-and-ride noise impacts.

Preferred Alternative Segment B

Under the Preferred Alternative, there would be 148 moderate impacts and 65 severe impacts in Segment B. All noise impacts under the Preferred Alternative would be at single-family and multifamily residences; no noise impacts were identified at any institutional uses, such as schools, or at any hospitals or other noise-sensitive medical use locations. There would be no relocated noise walls under the Preferred Alternative in Segment B.

Between the north end of Segment A, near NE 190th Street, to just south of 236th Street SW near the Mountlake Transit Center, Sound Transit predicted noise impacts at 86 single-family and multifamily residences on the east side of I-5. This includes 52 moderate noise impacts and 34 impacts in the FTA severe category. Noise levels along the west side of I-5 in this area ranged from 58 to 62 dBA Ldn; no noise impacts were projected.

North of the Mountlake Terrace Transit Center Station and south of 230th Street SW, on the east side of I-5, where the alignment transitions to the center of I-5, there would be an additional 12 moderate and 2 severe noise impacts on the east side of I-5 near 232nd Street SW. On the west side of I-5, north of Lakeview Drive and south of 228th Street SW, there would be an additional 13 moderate noise impacts located along 63rd Avenue and 63rd Place, adjacent to I-5.

Once the light rail alignment is along the west side of I-5, north of 228th Street SW, and south of 220th Street SW, there are 2 moderate noise impacts predicted on the east side of I-5 near the ramps to 220th Street SW. On the west side of I-5 in this same area, there are 12 additional moderate noise impacts, all located to the north of 224th Street SW.

North of 220th Street SW, on the east side of I-5, 10 moderate noise impacts are predicted just north of 220th Street SW, west of 58th Avenue West. On the west side of I-5, north of 220th Street SW, there would be 40 impacts at the Lakeside Apartment complex, including 24 moderate and 16 severe. North of the apartment complex, north to the connection to Segment C, there would be an additional 23 moderate and 13 severe noise impacts at single-family residences along 214th Street SW, 213th Street SW, and 212th Street SW.

Preferred Alternative with 220th Street Station South Option

Under the Preferred Alternative with the 220th Street Station South Option, there would be 133 moderate and 65 severe noise impacts, which is 15 fewer moderate impacts than the Preferred Alternative. The only difference between the Preferred Alternative and the Preferred Alternative with the 220th Street Station South Option is the elimination of 2 moderate noise impacts on the east side of I-5 near the 220th Street SW off-ramps, and 13 noise impacts located to the west of the station resulting in part from slower speeds at the station platform. All other noise impacts would be the same as the Preferred Alternative.

Alternative B1: East Side to Mountlake Terrace Transit Center to Median

Under Alternative B1, there would be 89 moderate impacts and 29 severe impacts. All noise impacts under Alternative B1 would be at single-family and multifamily residences; no noise impacts were identified at any institutional uses, such as schools, or at any hospitals or other noise-sensitive medical use locations. Under Alternative B1, there would be no relocated noise walls.

Between the north end of Segment A, near NE 190th Street, to SR 104 (Ballinger Way – NE 205th Street), Sound Transit predicted noise impacts at 67 single-family and multifamily residences on the east side of I-5, including 39 moderate and 28 in the FTA severe category. Between SR 104 and 236th Street SW near the Mountlake Transit Center, an additional 14 moderate impacts were identified, with no severe impacts in this area due to the added distance between the residences and the light rail alignment. North of the Mountlake Terrace Transit Center Station, as the alignment transitions to the center of I-5 (236th Street to 230th Street), there would be an additional 20 moderate and 1 severe noise impact on the east side of I-5. On the west side of I-5, 12 moderate noise impacts were projected along 63rd Avenue and 63rd Place, adjacent to I-5.

When the light rail alignment is in the center of I-5, there would be no noise impacts along the east side of I-5 because the retained cut wall on the east side of the alignment would provide shielding. On the west side of I-5, moderate impacts were identified at 2 residences near 220th Street SW, with 2 more on 213th Street SW.

Alternative B2A: East Side to Mountlake Terrace Transit Center to West Side

Under Alternative B2A, there would be 138 moderate impacts and 50 severe impacts. All identified noise impacts under Alternative B2A would be at single-family and multifamily residences. Sound Transit predicted no other noise-sensitive uses with noise impacts. Under Alternative B2A, there would be approximately 900 feet of noise walls that would be relocated.

Between the northern end of Segment A, near NE 190th Street, north SR 104 (Ballinger Way – NE 205th Street), noise impacts under Alternative B2A would be the same as under Alternative B1, with 39 moderate and 28 severe impacts. As with other elevated guideway sections, the added noise from the elevated guideway would be the main reason for the severe impacts. Between SR 104 and 236th Street SW near the Mountlake Transit Center, an additional 8 moderate and 1 severe noise impacts were identified. Between 236th Street SW and 230th Street SW, north of the Mountlake Terrace

Transit Center Station, 21 single-family residences on the east side of I-5 would experience impacts, including 1 impact considered severe under FTA regulations. On the east side of I-5 between 230th Street SW and 220th Street SW, there would be no noise impacts because the alignment has transitioned to the west side of the highway.

On the west side of I-5, from the start of Segment B to SR 104, there would be no noise impacts. North of SR 104, to 228th Street SW, 10 moderate noise impacts were identified. All 10 noise impacts are at single-family residences along 63rd Avenue and 63rd Place SW. Once the alignment transitions to the west side of I-5 and is placed into a retained cut, Sound Transit predicted 32 single-family noise impacts between 228th Street SW and 220th Street SW on the west side of I-5. The 32 predicted noise impacts between 228th Street SW and 220th Street SW include 23 moderate and 9 severe impacts, including 6 severe impacts related to noise from the transit bells.

North of 220th Street SW, there would be 48 noise impacts on single-family and multifamily residences. These 48 impacts would include severe noise impacts at 7 single-family residences. The severe impacts would be caused, in part, by speed and proximity to the residences, along with some sections of the elevated guideway.

Alternative B4: East Side to Mountlake Terrace Freeway Station to Median

Under Alternative B4, there would be 73 moderate impacts and 33 severe impacts. All noise impacts under Alternative B4 would be at single-family and multifamily residences. Sound Transit did not identify noise impacts at any schools, parks, churches, or medical facilities. Under Alternative B4, no noise wall relocations are planned.

Between the connection to Segment B and Ballinger Way NE, there would be 38 moderate and 28 severe noise impacts on single-family residences along the east side of the alignment. The severe impacts would be located at single-family and multifamily units in the vicinity of Forest Park Drive NE, south of Ballinger Way NE (also known as SR 104).

North of Ballinger Way NE, the light rail alignment transitions to the center of I-5, and there would be 8 moderate and 4 severe impacts along 237th Street SW. Sound Transit predicted 12 additional moderate and 1 severe noise impacts at single-family residences overlooking I-5 on, and near, 61st Avenue West, on the east side of I-5. In the same general area, but on the west side of I-5, there would be an additional 13 moderate noise impacts at single-family residences along 63rd Avenue West and the general vicinity. There would be 2 additional moderate noise impacts at the end point of the existing noise walls at 227th Street SW and at 222nd Street SW.

7.2.3 Segment C

Table 7-3 provides a summary of the moderate and severe impacts predicted for each of the Segment C alternatives. As Table 7-3 shows, the alternatives using 52nd Avenue West (i.e., both options under each of Alternatives C1 and C2) would have more impacts than the alternatives that remain along I-5 (Preferred Alternative, Alternative C3 Option 1 [from I-5 median] and Alternative C3 Option 2 [from west side of I-5]). This difference in impacts is related to the single-family and multifamily residences that would be affected for the 200th Street SW Station option and, to a lesser extent, the transit center station option. Also, the primary difference between Option 1 and Option 2 connections is whether or not the light rail alignment would be in the middle of I-5 (Option 1) or west of I-5 (Option 2). The middle of I-5 options could only connect to Segment B Alternatives B1 and B4, while the west of I-5 options would connect to Segment B Preferred Alternative and Alternative B2A. The Preferred Alternative would connect between Segments B and C on the west side of I-5. No noise walls would be relocated as part of the project under any of the Segment C alternatives. Details on noise impacts under the Segment C alternatives are provided in the following sections.

Table 7-3. Summary of Potential Transit Noise Impacts for Segment C

Alternative	Station Option	Moderate Light Rail Impacts	Severe Light Rail Impacts	Total Impacts
Preferred Alternative West Side	Lynnwood Park-and-Ride Station	26	8	34
Alternative C1, Option 1	200th Street SW Station	159	24	183
Alternative C1, Option 2	200th Street SW Station	152	23	175
Alternative C2, Option 1	Lynnwood Transit Center	52	41	93
Alternative C2, Option 2	Lynnwood Transit Center	49	41	90
Alternative C3, Option 1	Park-and-Ride Option 1 Park-and-Ride Option 2	16	1	17
Alternative C3, Option 2	Park-and-Ride Option 1 Park-and-Ride Option 2	13	8	21

Note: Also see Section 7.3 for park-and-ride noise impacts.

Preferred Alternative Segment C

Under the Preferred Alternative, along the west side of I-5, there would be 26 moderate and 8 severe noise impacts. The 26 moderate noise impacts include single-family and multifamily residences located west of 52nd Avenue West. The 8 severe noise impacts are all located in this general area, which are the residences located closest to the elevated guideway along 52nd Avenue West, 53rd Avenue West, and 54th Avenue West. Noise levels on the east side of I-5 are all below the FTA criteria; no noise impacts were projected.

Alternative C1: 52nd Avenue West to 200th Street SW, with Option 1

Sound Transit identified that Alternative C1 with Option 1 would have 183 noise impacts (159 moderate and 24 severe). The noise impacts would include 1 severe impact at the quiet use area of Scriber Creek Park.

Noise impacts include 21 moderate noise impacts between Segment B and the alignment crossing over 206th Street and an additional 138 moderate impacts between 206th Street SW and the Lynnwood Transit Center. One hundred and ten of these moderate impacts occur between 201st Place SW and the transit center. These include 12 moderate impacts at the Park Five Apartments; 54 moderate noise impacts at the Oxford Square Apartments; and 44 moderate noise impacts at the

Cambridge Apartments. All of the severe impacts occur at noise sensitive receivers along 52nd Avenue West.

Alternative C1: 52nd Avenue West to 200th Street SW, with Option 2

Alternative C1 with Option 2 would have 230 noise impacts (152 moderate and 23 severe). Beginning at the connection to Segment B to the crossing at 208th Street SW, Sound Transit identified 10 moderate and 3 severe noise impacts. These would include noise impacts on 1 multifamily residential unit, 8 single-family residences (moderate), and 3 single-family residences (severe). All of these impacts would be along 52nd Avenue West, east of 208th Street SW. There would be an additional 51 noise impacts between 208th Street SW and 201st Place SW. This total includes 32 moderate impacts and 51 severe noise impacts. As with Option 1, the majority of impacts would be at the three multifamily complexes near the 200th Street SW Station.

Alternative C2: 52nd Avenue West to Lynnwood Transit Center, with Option 1

Alternative C2 with Option 1 would result in 93 noise impacts (52 moderate and 41 severe). There would be 28 noise impacts, including 14 moderate and 4 severe, along the connection from Segment B to 206th Street SW. There would be 38 moderate and 37 severe noise impacts from 206th Street SW to the Lynnwood Transit Center Station, including 1 severe impact at the quiet use area of Scriber Creek Park, 24 severe impacts at the Park Five Apartments and 18 moderate impacts at the Cedar Creek Condominiums.

Alternative C2: 52nd Avenue West to Lynnwood Transit Center, with Option 2

Alternative C2 with Option 2 would have 90 noise impacts (49 moderate and 41 severe). There would be several noise impacts along the elevated guideway from I-5 to the intersection of 52nd Avenue West and 208th Street SW. There would be 75 noise impacts, including 38 moderate and 37 severe impacts from 208th Street SW to the Lynnwood Transit Center Station. The noise impacts would include 1 severe impact at the quiet use area of Scriber Creek Park and the same 24 severe impacts at the Park Five Apartments and 18 moderate impacts at the Cedar Creek Condominiums that are identified under Option 1.

Alternative C3: Along I-5 to Lynnwood Park-and-Ride, with Option 1

Alternative C3 with Option 1 would result in 17 noise impacts (16 moderate and 1 severe). Of these 17 noise impacts, 5 moderate and 1 severe noise impacts would occur at single-family homes and an apartment near I-5 along 52nd Avenue West and 53rd Avenue West. An additional 11 moderate noise impacts were identified on the east side of I-5. The number of impacts under this alternative option would be lower than Alternatives C1 and C2 because the light rail alignment would run in the I-5 median through areas with residences.

Alternative C3: Along I-5 to Lynnwood Park-and-Ride, with Option 2

Alternative C3 with Option 2 would result in 21 noise impacts (13 moderate and 8 severe). All impacts would occur at single-family homes near I-5 along 52nd Avenue West and 53rd Avenue West. The lower number of noise impacts under this alternative and option, when compared with the other Segment C alternatives, is due to the light rail alignment remaining alongside I-5 and only affecting residences near the connection to Segment B, as well as to the reduced approach speeds at the 52nd Avenue West curve near I-5.

7.3 Park-and-Ride Facilities Impact Analysis

This section provides the results of the noise analysis for the proposed park-and-ride facilities. The analysis methods and reference values used for this analysis are provided in Section 5.8. The combination of park-and-ride facilities is based on alternative selection.

7.3.1 Segment A

The park-and-ride locations, options, impacts, and their associated light rail alternatives in Segment A are provided in Table 7-4, followed by a discussion of each station option.

Table 7-4. Summary of Park-and-Ride Facility Impacts by Alternatives and Options

Alternative	NE 130th Street Station	NE 145th Street Station	NE 155th Street Station	NE 185th Street Station
Preferred Alternative	N/A	No impacts	N/A	Preferred (13 impacts)
Preferred Alternative Optional	Optional Station (No impacts)	No impacts	N/A	Shoreline Stadium Parking Lot (16 impacts)
Alternative A1	N/A	Option 1 (2 impacts)	N/A	Option 1 (13 impacts)
Alternative A3	N/A	Option 2 (No impacts)	N/A	Option 2 (9 impacts)
Alternative A5	Option 1 (No impacts)	N/A	(5 impacts)	Option 3 (12 impacts)
Alternative A7	Option 2 (No impacts)	N/A	(5 impacts)	Option 2 (9 impacts)
Alternative A10	Option 1 (No impacts)	Option 1 (No impacts)	N/A	Option 3 (12 impacts)
Alternative A11	Option 2 (No impacts)	Option 2 (No impacts)	N/A	Option 2 (9 impacts)

N/A = not applicable

Preferred Alternative with NE 130th Street Station or Future Station Option

Under the Preferred Alternative with the NE 130th Street Station Option, there is a potential for a leased, 100 space, surface parking lot on private property owned by the nearby church. All bus activity and kiss-and-ride activity would occur on public right-of-way along 5th Avenue NE. As a result, no impacts would be created by the surface parking lot due to the low number of parking spaces and lack of long-term bus layovers. The analysis results are provided in Table 7-5.

Table 7-5. Summary of Preferred Alternative NE 130th Street Station Noise Analysis

Representative Address[a]	Location of Homes Represented[b]	Seattle Code Analysis Leq[c]	Ldn[d]	FTA Analysis Existing Ldn[e]	FTA Criteria[f]	Impact Type and Criteria Exceeded[g]
13041 Roosevelt Way	5 SFR west of I-5	32	29	72	66	None
502 NE 130th Street	2 SFR at Roosevelt Way	34	31	74	66	None
12740 5th Avenue NE	2 SFR south of 30th Street	32	29	74	66	None
510 131st Place NE	3 SFR south of church lot	39	36	72	66	None
13130 5th Avenue NE	Church residence	37	35	67	63	None
13085 8th Court NE	2 SFR east of church parking lot	36	33	66	62	None

a. Address of representative parcel used in modeling.
b. Number and type of land use: SFR = single-family residence
c. Peak-hour Leq for analysis, typically between 6:00 am and 7:00 am (> 47 dBA nighttime).
d. 24-hour Ldn noise from park-and-ride, includes vehicles in parking areas and buses on park-and-ride property.
e. Existing Ldn from Section 3.2.
f. FTA criteria for 24-hour Ldn for category 2 land uses.
g. Number and type of noise impact from park-and-ride alternative.

Preferred Alternative NE 145th Station

Under the Preferred Alternative with the NE 145th Street Station or Future Station options, no noise impacts were predicted. The analysis results are provided in Table 7-6.

Table 7-6. Summary of Preferred Alternative NE 145th Street Station Noise Analysis

Representative Address[a]	Location of Homes Represented[b]	WAC Analysis Leq[c]	Ldn[d]	FTA Analysis Existing Ldn[e]	FTA Criteria[f]	Impact Type and Criteria Exceeded[g]
501 NE 145th Street	1 SFR on NE 145th Street	40	37	74	66	None
14512 5th Avenue NE	2 SFR on 5th Avenue NE	41	38	74	66	None
14526 5th Avenue NE	4 SFR on 5th Avenue NE	42	39	73	66	None
14556 5th Avenue NE	3 SFR on 5th Avenue NE	43	40	73	66	None
14570 5th Avenue NE	3 SFR on 5th Avenue NE	42	39	73	66	None
345 NE 148th Street	3 SFR on NE 148th Street	42	39	73	66	None

a. Address of representative parcel used in modeling.
b. Number and type of land use: SFR = single-family residence.
c. Peak-hour Leq for analysis, typically between 6:00 am and 7:00 am (> 47 dBA nighttime).
d. 24-hour Ldn noise from park-and-ride, includes vehicles in parking areas and buses on park-and-ride property.
e. Existing Ldn from Section 3.2.
f. FTA criteria for 24-hour Ldn for category 2 land uses.
g. Number and type of noise impact from park-and-ride alternative.

Preferred Alternative NE 185th Station

Under the Preferred Alternative, 13 impacts would be caused by station operations. Of the 13 impacts, 11 would occur at single-family residences along 8th Avenue NE, and 2 would occur on 185th Avenue near 8th Avenue NE. The impacts are related to noise from buses operating on the station turnout and general park-and-ride traffic during early morning hours. Table 7-7 provides the analysis results.

Table 7-7. Summary of Preferred Alternative NE 185th Street Station Noise Analysis[a]

Representative Address[b]	Location of Homes Represented[c]	WAC Analysis	FTA Analysis			Impact Type and Criteria Exceeded[h]
		Leq[d]	Ldn[e]	Existing Ldn[f]	FTA Criteria[g]	
18504 8th Avenue NE	1 SF on 8th Avenue NE	49	50	63	60	1 SFR with WAC noise impact
18510 8th Avenue NE	1 SFR on 8th Avenue NE	49	50	63	60	1 SFR with WAC noise impact
18516/18522 8th Avenue NE	2 SFR on 8th Avenue NE	49	50	63	60	2 SFR with WAC noise impact
18528/18534 8th Avenue NE	2 SFR on 8th Avenue NE	48	50	63	60	2 SFR with WAC noise impact
18540/18554 8th Avenue NE	2 SFR on 8th Avenue NE	48	49	63	60	2 SFR with WAC noise impact
18547 8th Avenue NE	1 SFR on 8th Avenue NE	52	53	63	60	1 SFR with WAC noise impact
18553 8th Avenue NE	1 SFR on 8th Avenue NE	50	51	71	66	1 SFR with WAC noise impact
18559 8th Avenue NE	1 SFR on 8th Avenue NE	49	50	72	66	1 SFR with WAC noise impact
721/731 NE 185th Street	2 SFR on NE 185th Street	51	52	73	66	2 SFR with WAC noise impact
351 NE 185th Street	1 SFR on NE 185th Street	46	47	74	66	None
341 NE 185th Street	1 SFR on NE 185th Street	47	47	75	66	None
335 NE 185th Street	1 SFR on NE 185th Street	47	47	76	66	None

a. Includes impacts from buses at the station drop-off and layover area.
b. Address of representative parcel used in modeling.
c. Number and type of land use: SFR = single-family residence.
d. Peak-hour Leq for analysis, typically between 6:00 am and 7:00 am (> 47 dBA nighttime).
e. 24-hour Ldn noise from park-and-ride, includes vehicles in parking areas and buses on park-and-ride property.
f. Existing Ldn from Section 3.2.
g. FTA criteria for 24-hour Ldn for category 2 land uses.
h. Number and type of noise impact from park-and-ride alternative.
Note: Values in red meet or exceed the project noise impact criteria.

Preferred Alternative NE 185th Station with Shoreline Stadium Garage Option

Under the Preferred Alternative with the Shoreline Stadium Garage Option, the main parking garage would be relocated along NE 185th Street at the existing surface lot. The relocated parking garage results in three additional noise impacts over those predicted under the Preferred Alternative with the NE 185th Street Station Option. The three new noise impacts are all along the south side of

NE 185th Street, near I-5. The other 13 noise impacts identified under the Preferred Alternative with the NE 185th Street Station Option also have impacts under this alternative. Table 7-8 provides the results of the noise analysis for this station option.

Table 7-8. Summary of Preferred Alternative with NE 185th Station Shoreline Stadium Garage Option Noise Analysis[a]

Representative Address[b]	Location of Homes Represented[c]	WAC Analysis	FTA Analysis			Impact Type and Criteria Exceeded[h]
		Leq[d]	Ldn[e]	Existing Ldn[f]	FTA Criteria[g]	
18504 8th Avenue NE	1 SFR on 8th Avenue NE	49	50	63	60	1 SFR with WAC noise impact
18510 8th Avenue NE	1 SFR on 8th Avenue NE	49	50	63	60	1 SFR with WAC noise impact
18516/18522 8th Avenue NE	2 SFR on 8th Avenue NE	49	50	63	60	2 SFR with WAC noise impact
18528/18534 8th Avenue NE	2 SFR on 8th Avenue NE	48	50	63	60	2 SFR with WAC impact
18540/18554 8th Avenue NE	2 SFR on 8th Avenue NE	48	49	63	60	2 SFR with WA noise impact
18547 8th Avenue NE	1 SFR on 8th Avenue NE	52	53	63	60	1 SFR with WAC noise impact
18553 8th Avenue NE	1 SFR on 8th Avenue NE	50	51	71	66	1 SFR with WAC noise impact
18559 8th Avenue NE	1 SFR on 8th Avenue NE	49	50	72	66	1 SFR with WAC noise impact
721/731 NE 185th Street	2 SFR on NE 185th Street	51	52	73	66	2 SFR with WAC noise impact
351 NE 185th Street	1 SFR on NE 185th Street	49	49	74	66	1 SFR with WAC noise impact
341 NE 185th Street	1 SFR on NE 185th Street	49	49	75	66	1 SFR with WAC noise impact
335 NE 185th Street	1 SFR on NE 185th Street	49	48	76	66	1 SFR with WAC noise impact

a. Includes impacts from buses at the station drop-off and layover area.
b. Address of representative parcel used in modeling.
c. Number and type of land use: SFR = single-family residence.
d. Peak-hour Leq for analysis, typically between 6:00 am and 7:00 am (> 47 dBA nighttime).
e. 24-hour Ldn noise from park-and-ride, includes vehicles in parking areas and buses on park-and-ride property.
f. Existing Ldn from Section 3.2.
g. FTA criteria for 24-hour Ldn for category 2 land uses.
h. Number and type of noise impact from park-and-ride alternative.
Note: Values in red meet or exceed the project noise impact criteria.

NE 130th Street Station Option 1

Under Alternatives A5 and A10 with the NE 130th Street Station Option 1, no park-and-ride impacts are predicted. The analysis results are provided in Table 7-9.

Table 7-9. Summary of NE 130th Street Station Option 1 Park-and-Ride Noise Analysis

Representative Address[a]	Location of Homes Represented[b]	Seattle Code Analysis	FTA Analysis			Impact Type and Criteria Exceeded[g]
		Leq[c]	Ldn[d]	Existing Ldn[e]	FTA Criteria[f]	
13041 Roosevelt Way	5 SFR west of I-5	32	29	72	66	None
502 NE 130th Street	2 SFR at Roosevelt Way	34	31	74	66	None
12740 5th Avenue NE	2 SFR south of 30th Street	32	29	74	66	None
510 131st Place NE	3 SFR south of church lot	39	36	72	66	None
13130 5th Avenue NE	Church residence	37	35	67	63	None
13085 8th Court NE	2 SFR east of church parking	36	33	66	62	None

a. Address of representative parcel used in modeling.
b. Number and type of land use: SFR = single-family residence.
c. Peak-hour Leq for analysis, typically between 6:00 am and 7:00 am (> 47 dBA nighttime).
d. 24-hour Ldn noise from park-and-ride, includes vehicles in parking areas and buses on park-and-ride property.
e. Existing Ldn from Section 3.2.
f. FTA criteria for 24-hour Ldn for category 2 land uses.
g. Number and type of noise impact from park-and-ride alternative.

NE 130th Street Station Option 2

Under Alternatives A7 and A11 with the NE 130th Street Station Option 2, there would be no noise impacts from park-and-ride operations. The analysis results are provided in Table 7-10.

Table 7-10. Summary of NE 130th Street Station Option 2 Park-and-Ride Noise Analysis

Representative Address[a]	Location of Homes Represented[b]	Seattle Code Analysis	FTA Analysis			Impact Type and Criteria Exceeded[g]
		Leq[c]	Ldn[d]	Existing Ldn[e]	FTA Criteria[f]	
13041 Roosevelt Way	5 SFR west of I-5	31	28	72	66	None
502 NE 130th Street	2 SFR at Roosevelt Way	31	28	74	66	None
12740 5th Avenue NE	2 SFR south of 30th Street	30	27	74	66	None
510 131st Place NE	3 SFR south of church lot	33	30	72	66	None
13130 5th Avenue NE	Church residence	33	30	67	63	None
13085 8th Court NE	2 SFR east of church parking	33	30	66	62	None

a. Address of representative parcel used in modeling.
b. Number and type of land use: SFR = single-family residence.
c. Peak-hour Leq for analysis, typically between 6:00 am and 7:00 am (> 47 dBA nighttime).
d. 24-hour Ldn noise from park-and-ride, includes vehicles in parking areas and buses on park-and-ride property.
e. Existing Ldn from Section 3.2.
f. FTA criteria for 24-hour Ldn for category 2 land uses.
g. Number and type of noise impact from park-and-ride alternative.

NE 145th Street Station Option 1

Under Alternatives A1 and A10 with the NE 145th Street Station Option 1, there would be two noise impacts from park-and-ride operations. Both impacts are at single-family residences on NE 148th Street. These results are provided in Table 7-11.

Table 7-11. Summary of NE 145th Street Station Option 1 Park-and-Ride Noise Analysis

Representative Address[a]	Homes Represented Location[b]	WAC Analysis	FTA Analysis			Impact Type and Criteria Exceeded[g]
		Leq[c]	Ldn[d]	Existing Ldn[e]	FTA Criteria[f]	
501 NE 145th Street	1 SFR on NE 145th Street	39	36	74	66	None
14512 5th Avenue NE	2 SFR on 5th Avenue NE	39	37	74	66	None
14526 5th Avenue NE	4 SFR on 5th Avenue NE	40	37	73	66	None
14556 5th Avenue NE	3 SFR on 5th Avenue NE	43	40	73	66	None
14570 5th Avenue NE	3 SFR on 5th Avenue NE	42	39	73	66	None
358 NE 148th Street	2 SFR on NE 148th Street	**48**	45	73	66	2 SFR with WAC noise impact
336 NE 148th Street	4 SFR on NE 148th Street	47	44	72	66	None

a. Address of representative parcel used in modeling.
b. Number and type of land use: SFR = single-family residence.
c. Peak-hour Leq for analysis, typically between 6:00 am and 7:00 am (> 47 dBA nighttime).
d. 24-hour Ldn noise from park-and-ride, includes vehicles in parking areas and buses on park-and-ride property.
e. Existing Ldn from Section 3.2.
f. FTA criteria for 24-hour Ldn for category 2 land uses.
g. Number and type of noise impact from park-and-ride alternative.

NE 145th Street Station Option 2

Under Alternatives A3 and A11 with the NE 145th Street Station Option 2, there would be no noise impacts from park-and-ride operations. The results are provided in Table 7-12.

Table 7-12. Summary of NE 145th Street Station Option 2 Park-and-Ride Noise Analysis

Representative Address[a]	Homes Represented Location[b]	WAC Analysis	FTA Analysis			Impact Type and Criteria Exceeded[g]
		Leq[c]	Ldn[d]	Existing Ldn[e]	FTA Criteria[f]	
501 NE 145th Street	1 SFR on NE 145th Street	40	37	74	66	None
14512 5th Avenue NE	2 SFR on 5th Avenue NE	41	38	74	66	None
14526 5th Avenue NE	4 SFR on 5th Avenue NE	42	39	73	66	None
14556 5th Avenue NE	3 SFR on 5th Avenue NE	43	40	73	66	None
14570 5th Avenue NE	3 SFR on 5th Avenue NE	42	39	73	66	None
345 NE 148th Street	3 SFR on NE 148th Street	42	39	73	66	None

a. Address of representative parcel used in modeling.
b. Number and type of land use: SFR = single-family residence.
c. Peak-hour Leq for analysis, typically between 6:00 am and 7:00 am (> 47 dBA nighttime).
d. 24-hour Ldn noise from park-and-ride, includes vehicles in parking areas and buses on park-and-ride property.
e. Existing Ldn from Section 3.2.
f. FTA criteria for 24-hour Ldn for category 2 land uses.
g. Number and type of noise impact from park-and-ride alternative.

NE 155th Street Station Option 1

Under Alternatives A5 and A7 with the NE 155th Street Station, there would be noise impacts at two residences directly east of the parking garage, two residences south of the parking garage, and also at the fire station to the west of the parking garage. These noise impacts are predicted to occur during the early morning hour of 6:00 am to 7:00 am and are related to vehicles accessing the parking garage. The analysis assumes that all 500 parking spaces would be filled between 6:00 am and 7:00 am; therefore, this can be considered a worst-case noise scenario. These noise level projections will be reviewed when more detailed information on the garage design is available. The updated analysis will include any shielding from the garage structure that would be predicted to reduce noise levels. However, for this analysis, the worst-case unshielded noise levels are presented for the most recent garage design. The analysis results are provided in Table 7-13.

Table 7-13. Summary of NE 155th Street Station Park-and-Ride Noise Analysis

Representative Address[a]	Location of Homes Represented[b]	WAC Analysis	FTA Analysis			Impact Type and Criteria Exceeded[g]
		Leq[c]	Ldn[d]	Existing Ldn[e]	FTA Criteria[f]	
110 NE 155th Street	2 SFR on NE 155th Street	42	39	71	66	None
132 NE 155th Street	3 SFR on NE 155th/156th Streets	45	42	71	66	None
151 NE 156th Street	3 SFR on NE 156th Street	47	44	71	66	None
303 NE 155th Street and 15455 4th Avenue NE	2 SFR on NE 155th Street and 4th Avenue NE	51	48	68	63	2 SFR with WAC noise impact
15451 4th Avenue NE and 15240 3rd Avenue NE	2 SFR on 3rd Avenue NE and 4th Avenue NE	51	48	71	66	2 SFR with WAC noise impact
145 NE 155th Street	Fire Department	51	48	71	66	Fire Department with WAC noise impact

a. Address of representative parcel used in modeling.
b. Number and type of land use: SFR = single-family residence.
c. Peak-hour Leq for analysis, typically between 6:00 am and 7:00 am (> 47 dBA nighttime).
d. 24-hour Ldn noise from park-and-ride, includes vehicles in parking areas and buses on park-and-ride property.
e. Existing Ldn from Section 3.2.
f. FTA criteria for 24-hour Ldn for category 2 land uses.
g. Number and type of noise impact from park-and-ride alternative.

NE 185th Street Station Option 1

Under Alternative A1 with the NE 185th Street Station Option 1, Sound Transit identified 13 single-family residences that would experience noise impacts related to vehicles accessing the park-and-ride and buses accessing the station drop-off and layover area off 8th Avenue NE, and continuing along the new bus-only route to the elevated station. The noise impacts occur during the morning hours between 6:00 am and 7:00 am, when the noise code is more stringent. The analysis results are provided in Table 7-14.

Table 7-14. Summary of NE 185th Street Station Option 1 Park-and-Ride Noise Analysis[a]

Representative Address[b]	Homes Represented Location[c]	WAC Analysis	FTA Analysis			Impact Type and Criteria Exceeded[h]
		Leq[d]	Ldn[e]	Existing Ldn[f]	FTA Criteria[g]	
18523 8th Avenue NE	4 SFR on 8th Avenue NE	**49**	51	65	61	4 SFR with WAC noise impact
18529 8th Avenue NE	1 SFR on 8th Avenue NE	**50**	52	63	60	1 SFR with WAC noise impact
18533 8th Avenue NE	1 SFR on 8th Avenue NE	**52**	54	63	60	1 SFR with WAC noise impact
18547 8th Avenue NE	1 SFR on 8th Avenue NE	**52**	53	63	60	1 SFR with WAC noise impact
18534 8th Avenue NE	3 SFR on 8th Avenue NE	**51**	53	63	60	3 SFR with WAC noise impact
18528 8th Avenue NE	1 SFR on 8th Avenue NE	**50**	51	63	60	1 SFR with WAC noise impact
18522 8th Avenue NE	1 SFR on 8th Avenue NE	**48**	50	63	60	1 SFR with WAC noise impact
18516 8th Avenue NE	1 SFR on 8th Avenue NE	**48**	49	63	60	1 SFR with WAC noise impact
721 NE 185th Street	2 SFR on NE 185th Street	47	49	71	66	None
18556 5th Avenue NE	1 SFR on 5th Avenue NE	42	39	63	60	None
338 NE 185th Street	1 SFR on NE 185th Street	42	39	64	61	None
330 NE 185th Street	1 SFR on NE 185th Street	42	39	63	60	None

a. Includes impacts from buses at the station drop-off and layover area.
b. Address of representative parcel used in modeling.
c. Number and type of land use: SFR = single-family residence.
d. Peak-hour Leq for analysis, typically between 6:00 am and 7:00 am (> 47 dBA nighttime).
e. 24-hour Ldn noise from park-and-ride, includes vehicles in parking areas and buses on park-and-ride property.
f. Existing Ldn from Section 3.2.
g. FTA criteria for 24-hour Ldn for category 2 land uses.
h. Number and type of noise impact from park-and-ride alternative.

Note: Values in red meet or exceed the project noise impact criteria.

NE 185th Street Station Option 2

Under Alternatives A3, A7, and A11 with the NE 185th Street Station Option 2, Sound Transit identified nine single-family residences that would experience noise impacts related to the cars and buses accessing the park-and-ride facility. All of the nine residences are predicted to exceed the nighttime criteria between 6:00 am and 7:00 am with peak hour noise levels exceeding the allowable maximum level of 47 dBA Leq. The analysis results are provided in Table 7-15.

Table 7-15. Summary of NE 185th Street Station Option 2 Park-and-Ride Noise Analysis

Representative Address[a]	Homes Represented Location[b]	WAC Analysis	FTA Analysis			Impact Type and Criteria Exceeded[g]
		Leq[c]	Ldn[d]	Existing Ldn[e]	FTA Criteria[f]	
18516 8th Avenue NE	1 SFR on 8th Avenue NE	**49**	49	63	60	1 SFR with WAC noise impact
18522 8th Avenue NE	1 SFR on 8th Avenue NE	**49**	50	63	60	1 SFR with WAC noise impact
18528 8th Avenue NE	1 SFR on 8th Avenue NE	**50**	51	63	60	1 SFR with WAC noise impact
18534 8th Avenue NE	1 SFR on 8th Avenue NE	**51**	52	63	60	1 SFR with WAC noise impact
18540/18554 8th Avenue NE	2 SFR on 8th Avenue NE	**52**	53	63	60	2 SFR with WAC noise impact
18547 8th Avenue NE	1 SFR on 8th Avenue NE	**53**	54	63	60	1 SFR with WAC noise impact
721/731 NE 185th Street	2 SFR on NE 185th Street	**49**	49	71	66	2 SFR with WAC noise impact

a. Address of representative parcel used in modeling.
b. Number and type of land use: SFR = single-family residence.
c. Peak-hour Leq for analysis, typically between 6:00 am and 7:00 am (> 47 dBA nighttime).
d. 24-hour Ldn noise from park-and-ride, includes vehicles in parking areas and buses on park-and-ride property.
e. Existing Ldn from Section 3.2.
f. FTA criteria for 24-hour Ldn for category 2 land uses.
g. Number and type of noise impact from park-and-ride alternative.

NE 185th Street Station Option 3

Under Alternatives A5 and A10 with the NE 185th Street Station Option 3, Sound Transit identified 12 single-family residences that would experience noise impacts related to traffic and buses accessing the park-and-ride on 8th Avenue NE. The twelve residences are predicted to exceed the nighttime criteria between the hours of 6:00 am and 7:00 am. The analysis results are provided in Table 7-16.

Table 7-16. Summary of NE 185th Street Station Option 3 Park-and-Ride Noise Analysis

Representative Address[a]	Homes Represented Location[b]	WAC Analysis	FTA Analysis			Impact Type and Criteria Exceeded[h]
		Leq[d]	Ldn[e]	Existing Ldn[f]	FTA Criteria[g]	
18504 8th Avenue NE	1 SFR on 8th Avenue NE	**52**	53	74	66	1 SFR with WAC noise impact
18510 8th Avenue NE	1 SFR on 8th Avenue NE	**52**	53	68	63	1 SFR with WAC noise impact
18516 8th Avenue NE	1 SFR on 8th Avenue NE	**51**	52	65	61	1 SFR with WAC noise impact
18342 8th Avenue NE	1 SFR on 8th Avenue NE	**48**	50	68	63	1 SFR with WAC noise impact
731 NE 185th Street	2 SFR on NE185th Street	**48**	49	70	65	2 SFR with WAC noise impact

Table 7-16. Summary of NE 185th Street Station Option 3 Park-and-Ride Noise Analysis

Representative Address[a]	Homes Represented Location[b]	WAC Analysis	FTA Analysis			Impact Type and Criteria Exceeded[h]
		Leq[d]	Ldn[e]	Existing Ldn[f]	FTA Criteria[g]	
18522 8th Avenue NE	1 SFR on 8th Avenue NE	**50**	51	63	60	1 SFR with WAC noise impact
18528 8th Avenue NE	1 SFR on 8th Avenue NE	**51**	52	63	60	1 SFR with WAC noise impact
18534 8th Avenue NE	1 SFR on 8th Avenue NE	**52**	53	63	60	1 SFR with WAC noise impact
18540/18554 8th Avenue NE	2 SFR on 8th Avenue NE	**52**	53	63	60	2 SFR with WAC noise impact
18547 8th Avenue NE	1 SFR on 8th Avenue NE	**52**	53	63	60	1 SFR with WAC noise impact
814 NE 185th Street	1 SFR on 8th Avenue NE	39	36	68	63	None
18525 10th Avenue NE	1 SFR on 10th Avenue NE	40	37	66	62	None

a. Address of representative parcel used in modeling.
b. Number and type of land use: SFR = single-family residence.
c. Peak-hour Leq for analysis, typically between 6:00 am and 7:00 am (> 47 dBA nighttime).
d. 24-hour Ldn noise from park-and-ride, includes vehicles in parking areas and buses on park-and-ride property.
e. Existing Ldn from Section 3.2.
f. FTA criteria for 24-hour Ldn for category 2 land uses.
g. Number and type of noise impact from park-and-ride alternative.

7.3.2 Segment B

The park-and-ride locations, options, impacts and their associated light rail alternatives in Segment B are provided in Table 7-17 followed by a discussion of each of the station options.

Table 7-17. Summary of Park-and-Ride Facility Impacts by Alternatives and Options

Alternative	Mountlake Terrace Station	220th Street Station
Preferred Alternative	Preferred Alternative (4 Impacts)	Preferred Alternative (None) 220th Street Station South Option (None)
Alternative B1	Transit Center (4 Impacts)	N/A
Alternative B2A	Transit Center (4 Impacts)	None
Alternative B4	Freeway Station (4 Impacts)	N/A

N/A = not applicable

a. Includes impacts from buses at the station drop-off and layover area.

Preferred Alternative Mountlake Terrace Transit Center Park-and-Ride

Under the Preferred Alternative with the Mountlake Terrace Transit Center Station Option, Sound Transit identified four single-family residences would experience noise impacts related to the noise from buses leaving the park-and-ride along the eastern layover route and general park-and-ride traffic. Table 7-18 provides a summary of the noise analysis for the Mountlake Terrace Transit Center Park-and-Ride under the Preferred Alternative.

Table 7-18. Summary of Preferred Alternative Mountlake Terrace Transit Center Park-and-Ride Noise Analysis

Representative Address[a]	Location of Homes Represented[b]	WAC Analysis	FTA Analysis			Impact Type and Criteria Exceeded[g]
		Leq[c]	Ldn[d]	Existing Ldn[e]	FTA Criteria[f]	
6002 233rd Place SW	2 SFR on 233rd Place SW	46	45	72	66	None
23504 59th Place SW	4 SFR on 59th Place SW	**51**	52	68	63	4 SFR with WAC noise impact
5906 236th Street SW	1 SFR on 236th Street SW	47	47	62	59	None

a. Address of representative parcel used in modeling.
b. Number and type of land use: SFR = single-family residence.
c. Peak-hour Leq for analysis, typically between 6:00 and 7:00 am (> 47 dBA nighttime).
d. 24-hour Ldn noise from park-and-ride, includes vehicles in parking areas and buses on park-and-ride property.
e. Existing Ldn from Section 3.2.
f. FTA criteria for 24-hour Ldn for category 2 land uses.
g. Number and type of noise impact from park-and-ride alternative.

Preferred Alternative 220th Street Station South Option

Under the Preferred Alternative with the 220th Street Station South Option, there are no additional noise impacts related to station operation. The results of the analysis are provided in Table 7-19.

Table 7-19. Summary Preferred Alternative 220th Street Station South Option Noise Analysis

Representative Address[a]	Location of Homes Represented[b]	WAC Analysis	FTA Analysis			Impact Type and Criteria Exceeded[g]
		Leq[c]	Ldn[d]	Existing Ldn[e]	FTA Criteria[f]	
6305 220th Place SW	1 SFR on 220th Place SW	41	38	72	66	None
6303 220th Place SW	1 SFR on 220th Place SW	41	39	73	66	None
6302 220th Place SW	1 SFR on 220th Place SW	41	38	74	66	None
6304 220th Place SW	1 SFR on 220th Place SW	40	37	75	66	None
6305 221st Place SW	1 SFR on 220th Place SW	39	37	76	66	None
6303 221st Place SW	1 SFR on 220th Place SW	39	37	77	66	None
6302 221st Place SW	1 SFR on 220th Place SW	39	36	78	66	None
6303 222nd Street SW	1 SFR on 220th Place SW	38	35	79	66	None

a. Address of representative parcel used in modeling.
b. Number and type of land use: SFR = single-family residence.
c. Peak-hour Leq for analysis, typically between 6:00 and 7:00 am (> 47 dBA nighttime).
d. 24-hour Ldn noise from park-and-ride, includes vehicles in parking areas and buses on park-and-ride property.
e. Existing Ldn from Section 3.2.
f. FTA criteria for 24-hour Ldn for category 2 land uses.
g. Number and type of noise impact from park-and-ride alternative.

Mountlake Terrace Transit Center

Under Alternatives B1 and B2A with the Mountlake Terrace Transit Center Station Option, Sound Transit identified four single-family residences that would experience noise impacts during the early morning hours of 6:00 am to 7:00 am. The analysis results are provided in Table 7-20.

Table 7-20. Summary of Mountlake Terrace Transit Center Park-and-Ride Noise Analysis

Representative Address[a]	Location of Homes Represented[b]	WAC Analysis	FTA Analysis			Impact Type and Criteria Exceeded[g]
		Leq[c]	Ldn[d]	Existing Ldn[e]	FTA Criteria[f]	
6002 233rd Place SW	2 SFR on 233rd Place SW	46	45	72	66	None
23504 59th Place SW	4 SFR on 59th Place SW	**51**	52	68	63	4 SFR with WAC noise impact
5906 236th Street SW	1 SFR on 236th Street SW	47	47	62	59	None

a. Address of representative parcel used in modeling.
b. Number and type of land use: SFR = single-family residence.
c. Peak-hour Leq for analysis, typically between 6:00 and 7:00 am (> 47 dBA nighttime).
d. 24-hour Ldn noise from park-and-ride, includes vehicles in parking areas and buses on park-and-ride property.
e. Existing Ldn from Section 3.2.
f. FTA criteria for 24-hour Ldn for category 2 land uses.
g. Number and type of noise impact from park-and-ride alternative.

Mountlake Terrace Freeway Station

Under Alternative B4 with the Mountlake Terrace Freeway Station Option, park-and-ride noise impacts would be the same as with the Mountlake Terrace Transit Center Station Option. The analysis results are provided in Table 7-21.

Table 7-21. Summary of Alternative B4 Mountlake Terrace Freeway Station Park-and-Ride Noise Analysis

Representative Address[a]	Location of Homes Represented[b]	WAC Analysis	FTA Analysis			Impact Type and Criteria Exceeded[g]
		Leq[c]	Ldn[d]	Existing Ldn[e]	FTA Criteria[f]	
6002 233rd Place SW	2 SFR on 233rd Place SW	46	45	72	66	None
23504 59th Place SW	4 SFR on 59th Place SW	**51**	52	68	63	4 SFR with WAC noise impact
5906 236th Street SW	1 SFR on 236th Street SW	47	47	62	59	None

a. Address of representative parcel used in modeling.
b. Number and type of land use: SFR = single-family residence.
c. Peak-hour Leq for analysis, typically between 6:00 and 7:00 am (> 47 dBA nighttime).
d. 24-hour Ldn noise from park-and-ride, includes vehicles in parking areas and buses on park-and-ride property.
e. Existing Ldn from Section 3.2.
f. FTA criteria for 24-hour Ldn for category 2 land uses.
g. Number and type of noise impact from park-and-ride alternative.

220th Street Station

Under Alternative B2A with the 220th Street Station, there would be no noise impacts from station operation. The analysis results are provided in Table 7-22.

Table 7-22. Summary of Alternative B2A 220th Street Station Park-and-Ride Noise Analysis

Representative Address[a]	Location of Homes Represented[b]	WAC Analysis	FTA Analysis			Impact Type and Criteria Exceeded[g]
		Leq[c]	Ldn[d]	Existing Ldn[e]	FTA Criteria[f]	
6305 220th Place SW	1 SFR on 220th Place SW	41	38	72	66	None
6303 220th Place SW	1 SFR on 220th Place SW	41	39	73	66	None
6302 220th Place SW	1 SFR on 220th Place SW	41	38	74	66	None
6304 220th Place SW	1 SFR on 220th Place SW	40	37	75	66	None
6305 221st Place SW	1 SFR on 220th Place SW	39	37	76	66	None
6303 221st Place SW	1 SFR on 220th Place SW	39	37	77	66	None
6302 221st Place SW	1 SFR on 220th Place SW	39	36	78	66	None
6303 222nd Street SW	1 SFR on 220th Place SW	38	35	79	66	None

a. Address of representative parcel used in modeling.
b. Number and type of land use: SFR = single-family residence.
c. Peak-hour Leq for analysis, typically between 6:00 and 7:00 am (> 47 dBA nighttime).
d. 24-hour Ldn noise from park-and-ride, includes vehicles in parking areas and buses on park-and-ride property.
e. Existing Ldn from Section 3.2.
f. FTA criteria for 24-hour Ldn for category 2 land uses.
g. Number and type of noise impact from park-and-ride alternative.

7.3.3 Segment C

The park-and-ride locations, options, impacts and their associated light rail alternatives in Segment C are provided in Table 7-23. Discussion for each of the station options follows the table.

Table 7-23. Summary of Park-and-Ride Facility Impacts by Alternatives and Options

Alternative	Lynnwood Transit Center
Preferred Alternative	Lynnwood Transit Center (58 Impacts)
Alternative C1	200th Street SW Station Option (51 Impacts)
Alternative C2	Lynnwood Transit Center Option (58 Impacts)
Alternative C3	Park-and-Ride Option 1 (58 Impacts)
Alternative C3	Park-and-Ride Option 2 (12 Impacts)

Preferred Alternative with Lynnwood Transit Center

Under the Preferred Alternative with the Lynnwood Transit Center, Sound Transit identified several multifamily buildings near the proposed facility that would experience noise impacts. Based on building plans from the complexes, 58 units were identified that would have noise impacts, including 28 units at the Park Five Apartments and 30 units at the Cedar Creek Condominiums. All impacts would be related to noise from buses accessing the reconfigured bus facility. The analysis results are provided in Table 7-24.

In addition to the station related impacts described above, new details regarding planned roadway improvements that are part of the Preferred Alternative with the Lynnwood Transit Center were made available. Because of these planned improvements, which meet the requirements for a traffic noise analysis using the methods set forth in the FTA manual, a separate traffic noise impact analysis was performed. The results of that traffic noise analysis are discussed in detail in Section7.4.3, New Traffic Noise Walls.

Table 7-24. Preferred Alternative: Lynnwood Transit Center Station Park-and-Ride Noise Analysis

Representative Address[a]	Location of Homes Represented[b]	Lynnwood Code Analysis	FTA Analysis			Impact Type and Criteria Exceeded[g]
		Leq[c]	Ldn[d]	Existing Ldn[e]	FTA Criteria[f]	
20104 48th Avenue West (Park Five Bldg. A)	24 MFR on 48th Avenue West	**50**	61	66	62	24 MFR with noise impact
20104 48th Avenue West (Park Five Bldg. C)	4 MFR on 48th Avenue West	**50**	**61**	62	59	4 MFR with noise impact
4800 200th Street (Cedar Creek Bldg. D)	12 MFR on 200th Street SW	**49**	60	66	62	12 MFR with impact
4800 200th Street (Cedar Creek Bldg. E)	6 MFR on 200th Street SW	**49**	60	67	63	6 MFR with noise impact
4800 200th Street (Cedar Creek Bldg. E)	12 MFR on 200th Street SW	**49**	59	67	63	12 MFR with noise impact
4807 200th Street SW (Oxford Square SE corner on 200th Street SW)	10 MFR on 200th Street SW	45	55	69	64	No Impacts
4727 200th Street SW (Cambridge Apartments SW corner on 200th Street SW)	14 MFR on 200th Street SW	44	54	69	64	No Impacts
4727 200th Street SW (Cambridge Apartments on 200th Street SW)	14 MFR on 200th Street SW	45	55	69	64	No Impacts
4727 200th Street SW (Cambridge Apartments SE corner on 200th Street SW)	13 MFR on 200th Street SW	44	54	69	64	No Impacts

a. Address of representative parcel used in modeling.
b. Number and type of land use: MFR = multi-family residence.
c. Peak-hour Leq for analysis, typically between 6:00 and 7:00 am (> 47 dBA nighttime).
d. 24-hour Ldn noise from park-and-ride, includes vehicles in parking areas and buses on park-and-ride property.
e. Existing Ldn from Section 3.2.
f. FTA criteria for 24-hour Ldn for category 2 land uses.
g. Number and type of noise impact from park-and-ride alternative.

Alternative C1: 200th Street SW Station

Under the 200th Street SW Station Park-and-Ride Option, Sound Transit identified several multifamily buildings near the proposed facility that would experience noise impacts. Based on building plans from the complexes, 51 units were identified that would have noise impacts, including 14 units at the Park Five Apartments, 10 units at the Oxford Square Apartments, and 27 units at the Cambridge Apartments. All impacts would be related to noise from buses accessing the reconfigured bus facility and, to a lesser extent, from passenger vehicles accessing the parking areas off 48th Avenue West. The analysis results are provided in Table 7-25.

Table 7-25. Alternative C1: 200th Street SW Station Park-and-Ride Noise Analysis

Representative Address[a]	Location of Homes Represented[b]	Lynnwood Code Analysis	FTA Analysis			Impact Type and Criteria Exceeded[g]
		Leq[c]	Ldn[d]	Existing Ldn[e]	FTA Criteria[f]	
20104 48th Avenue West (Park Five Bldg. A)	24 MFR on 48th Avenue West	**53**	51	66	62	14 MFR with noise impact
20104 48th Avenue West (Park Five Bldg. C)	4 MFR on 48th Avenue West	45	43	62	59	No Impacts
4807 200th Street SW (Oxford Square SE corner on 200th Street SW)	10 MFR on 200th Street SW	**52**	50	69	64	10 MFR with impact
4727 200th Street SW (Cambridge Apartments SW corner on 200th Street SW)	14 MFR on 200th Street SW	45	43	69	64	No Impacts
4727 200th Street SW (Cambridge Apartments on 200th Street SW)	14 MFR on 200th Street SW	**52**	50	69	64	14 MFR with noise impact
4727 200th Street SW (Cambridge Apartments SE corner on 200th Street SW)	13 MFR on 200th Street SW	**52**	50	69	64	13 MFR with noise impact

h. Address of representative parcel used in modeling.
i. Number and type of land use: MFR = multi-family residence.
j. Peak-hour Leq for analysis, typically between 6:00 and 7:00 am (> 47 dBA nighttime).
k. 24-hour Ldn noise from park-and-ride, includes vehicles in parking areas and buses on park-and-ride property.
l. Existing Ldn from Section 3.2.
m. FTA criteria for 24-hour Ldn for category 2 land uses.
n. Number and type of noise impact from park-and-ride alternative.

Alternative C2: Lynnwood Transit Center

Under the Lynnwood Transit Center Station configuration with Alternative C2, the noise impacts would be the same as given above under the Preferred Alternative with the Lynnwood Transit Center. All impacts would be related to noise from buses accessing the reconfigured bus facility. The analysis results are provided in Table 7-26.

Table 7-26. Alternative C2: Lynnwood Transit Center Station Park-and-Ride Noise Analysis

Representative Address[a]	Location of Homes Represented[b]	Lynnwood Code Analysis	FTA Analysis			Impact Type and Criteria Exceeded[g]
		Leq[c]	Ldn[d]	Existing Ldn[e]	FTA Criteria[f]	
20104 48th Avenue West (Park Five Bldg. A)	24 MFR on 48th Avenue West	**50**	61	66	62	24 MFR with noise impact
20104 48th Avenue West (Park Five Bldg. C)	4 MFR on 48th Avenue West	**50**	**61**	62	59	4 MFR with noise impact
4800 200th Street (Cedar Creek Bldg. D)	12 MFR on 200th Street SW	**49**	59	66	62	12 MFR with impact
4800 200th Street (Cedar Creek Bldg. E)	6 MFR on 200th Street SW	**49**	60	67	63	6 MFR with noise impact
4800 200th Street (Cedar Creek Bldg. E)	12 MFR on 200th Street SW	49	59	67	63	12 MFR with noise impact
4807 200th Street SW (Oxford Square SE corner on 200th Street SW)	10 MFR on 200th Street SW	45	55	69	64	No Impacts
4727 200th Street SW (Cambridge Apartments SW corner on 200th Street SW)	14 MFR on 200th Street SW	44	54	69	64	No Impacts
4727 200th Street SW (Cambridge Apartments on 200th Street SW)	14 MFR on 200th Street SW	44	55	69	64	No Impacts
4727 200th Street SW (Cambridge Apartments SE corner on 200th Street SW)	13 MFR on 200th Street SW	44	54	69	64	No Impacts

a. Address of representative parcel used in modeling.
b. Number and type of land use: MFR = multi-family residence.
c. Peak-hour Leq for analysis, typically between 6:00 and 7:00 am (> 47 dBA nighttime).
d. 24-hour Ldn noise from park-and-ride, includes vehicles in parking areas and buses on park-and-ride property.
e. Existing Ldn from Section 3.2.
f. FTA criteria for 24-hour Ldn for category 2 land uses.
g. Number and type of noise impact from park-and-ride alternative.

Alternative C3: Lynnwood Park-and-Ride Station

With Alternative C3, there would be two options for developing the station and park-and-ride garage. Under Option 1, there would be 58 noise impacts. These impacts would be the same as given above under the Preferred Alternative with the Lynnwood Transit Center, and all of them would be due to noise from buses accessing the facility. Under Option 2, there would be 12 noise impacts. All of these impacts would occur at building C of the Park Five Apartments, which is closest to the bus bays. All of these impacts would occur at night. The analysis results are provided in Tables 7-27 and 7-28.

Table 7-27. Alternative C3: Lynnwood Park-and-Ride Station Option 1 Noise Analysis

Representative Address[a]	Location of Homes Represented[b]	WAC Analysis Leq[c]	FTA Analysis Ldn[d]	FTA Analysis Existing Ldn[e]	FTA Analysis FTA Criteria[f]	Impact Type and Criteria Exceeded[g]
20104 48th Avenue West (Park Five Bldg. A)	24 MFR on 48th Avenue West	**51**	61	66	62	24 MFR with noise impact
20104 48th Avenue West (Park Five Bldg. C)	4 MFR on 48th Avenue West	**51**	**61**	62	59	4 MFR with noise impact
4800 200th Street (Cedar Creek Bldg. D)	12 MFR on 200th Street SW	**50**	60	66	62	12 MFR with impact
4800 200th Street (Cedar Creek Bldg. E)	6 MFR on 200th Street SW	**50**	60	67	63	6 MFR with noise impact
4800 200th Street (Cedar Creek Bldg. E)	12 MFR on 200th Street SW	49	59	67	63	12 MFR with noise impact
4807 200th Street SW (Oxford Square SE corner on 200th Street SW)	10 MFR on 200th Street SW	45	55	69	64	No Impacts
4727 200th Street SW (Cambridge Apartments SW corner on 200th Street SW)	14 MFR on 200th Street SW	44	54	69	64	No Impacts
4727 200th Street SW (Cambridge Apartments on 200th Street SW)	14 MFR on 200th Street SW	45	55	69	64	No Impacts
4727 200th Street SW (Cambridge Apartments SE corner on 200th Street SW)	13 MFR on 200th Street SW	44	54	69	64	No Impacts

a. Address of representative parcel used in modeling.
b. Number and type of land use: MFR = multi-family residence.
c. Peak-hour Leq for analysis, typically between 6:00 and 7:00 am (> 47 dBA nighttime).
d. 24-hour Ldn noise from park-and-ride, includes vehicles in parking areas and buses on park-and-ride property.
e. Existing Ldn from Section 3.2.
f. FTA criteria for 24-hour Ldn for category 2 land uses.
g. Number and type of noise impact from park-and-ride alternative. .

Table 7-28. Alternative C3: Lynnwood Park-and-Ride Station Option 2 Noise Analysis

Representative Address[a]	Location of Homes Represented[b]	WAC Analysis Leq[c]	FTA Analysis Ldn[d]	FTA Analysis Existing Ldn[e]	FTA Analysis FTA Criteria[f]	Impact Type and Criteria Exceeded[g]
20104 48th Avenue West (Park Five Bldg. A)	4 MFR on 48th Avenue West	46	56	66	62	No Impacts
20104 48th Avenue West (Park Five Bldg. C)	12 MFR on 48th Avenue West	**47**	57	62	59	12 MFR with noise impact
4800 200th Street (Cedar Creek Bldg. D)	12 MFR on 200th Street SW	45	56	66	62	No Impacts
4800 200th Street (Cedar Creek Bldg. E)	6 MFR on 200th Street SW	46	56	67	63	No Impacts
4800 200th Street (Cedar Creek Bldg. E)	12 MFR on 200th Street SW	45	55	67	63	No Impacts
4807 200th Street SW	10 MFR on 200th	42	52	69	64	No Impacts

Table 7-28. Alternative C3: Lynnwood Park-and-Ride Station Option 2 Noise Analysis

Representative Address[a]	Location of Homes Represented[b]	WAC Analysis	FTA Analysis			Impact Type and Criteria Exceeded[g]
		Leq[c]	Ldn[d]	Existing Ldn[e]	FTA Criteria[f]	
(Oxford Square SE corner on 200th Street SW)	Street SW					
4727 200th Street SW (Cambridge Apartments SW corner on 200th Street SW)	14 MFR on 200th Street SW	40	51	69	64	No Impacts
4727 200th Street SW (Cambridge Apartments on 200th Street SW)	14 MFR on 200th Street SW	41	51	69	64	No Impacts
4727 200th Street SW (Cambridge Apartments SE corner on 200th Street SW)	13 MFR on 200th Street SW	41	52	69	64	No Impacts

a Address of representative parcel used in modeling.
b Number and type of land use: MFR = multi-family residence.
c Peak-hour Leq for analysis, typically between 6:00 and 7:00 am (> 47 dBA nighttime).
d 24-hour Ldn noise from park-and-ride, includes vehicles in parking areas and buses on park-and-ride property.
e Existing Ldn from Section 3.2.
f FTA criteria for 24-hour Ldn for category 2 land uses.
g Number and type of noise impact from park-and-ride alternative.

7.4 Traffic Noise Modeling

As described in Section 5.9, a traffic noise analysis was performed in six areas where the project could change the traffic noise environment through the relocation of existing traffic noise walls or other structural shielding, or by project related roadway modifications.

This section provides the noise model validation and the results of the existing conditions traffic noise with any existing noise walls and shielding in place as it is today. As discussed in Section 8.7, noise modeling was performed for replacement noise walls under the Preferred Alternative to better provide the public with an understanding of the length and height of the new replacement noise walls, their locations with respect to nearby receivers, and any changes to noise levels from traffic on I-5 based on the year 2035 traffic projections. The model validation for the I-5 area is provided in Section 7.4.1, and the existing I-5 traffic noise levels are provided in Section 7.4.2.

Traffic noise modeling was also performed to determine if there are any new noise impacts in the vicinity of the Lynnwood Transit Center resulting from the proposed roadway modifications in that area. Model validation for this area is also provided in Section 7.4.1, with the existing traffic noise modeling results are provided in Section 7.4.3.

7.4.1 Traffic Noise Model Validation

Prior to performing the traffic noise analysis, the traffic noise levels were modeled to test the agreement of calculated and measured noise levels. This step is required to verify that the noise levels projected are accurate and capture the acoustical characteristics of the study area. This task is performed for each monitoring site by entering the traffic count and speed data taken during the on-site noise monitoring and verifying that the noise model produces the same noise level (within +/- 2 dBA) measured at that site. A variance between the measured and modeled noise levels of +/- 2 dBA or less is considered acceptable because the average person needs a 3-dBA change in traffic noise levels to clearly discern a change in the noise levels. This step ensures that the modeled noise levels are correct and that noise modeling for all noise-sensitive properties can proceed. The 11 monitoring sites and their calculated measured noise levels are compared in Table 7-29.

Table 7-29. Measured Versus Modeled Noise Levels

Receiver[a]	Measured (dBA Leq)[b]	Modeled (dBA Leq)[c]	Difference (in dBA)[d]
M-6	59.7	58.5	1.2
M-7	64.7	63.1	1.6
M-9	66.5	66	0.5
M-16	64.3	63.4	0.9
M-17	66	64.1	1.9
M-18	63.9	63.8	0.1
M-22	66.1	68.1	-2
M-24	64.1	62.8	1.3
M-25	59.1	58.9	0.2
M-29	59.9	61	-1.1
M-30A	59.4	60.2	-0.8
M-51	57.8	56	1.8
M-52	65.5	66.9	-1.9
M-53	63.7	65.7	-2.0

a Receivers used in the modeling are shown on Figures 3-1 and 3-2 in Section 3.
b These are the noise levels measured at the receiver locations; traffic counts were taken during the noise measurements.
c Modeled noise levels using the FHWA TNM with the traffic counts to predict traffic noise levels.
d Change in noise levels between the measured and modeled noise levels.

7.4.2 Existing Noise Levels for Replacement Noise Walls

This section describes the existing conditions for the five areas along I-5 where existing noise walls and structural shielding may be removed and replaced as part of the project. For the analysis, modeling was performed at representative receivers to determine existing noise levels and anticipated future traffic noise levels in the year 2035 with and without construction of the project. The future noise levels were modeled with new or replacement noise walls. The replacement noise walls were designed to meet the design criteria so that when the proposed project becomes operational there will be, whenever feasible:

1. No new traffic noise impacts, and
2. No increase in the severity of any existing traffic noise impacts.

The new traffic noise walls, which are only found in the area around the Lynnwood Park-and-Ride Station, were designed to meet FHWA and WSDOT Traffic Noise Criteria.

The subsections below discuss the traffic noise modeling results at the representative receivers in each of the five modeled areas for the weekday PM peak hour existing conditions. The five modeling areas are shown in Figures 8-1 through 8-5 in Section 8, Potential Noise Mitigation Measures. These figures also provide the locations of the proposed replacement noise walls and Section 8.7 provides approximate height for each wall. A discussion of traffic noise analysis issues specific to each area is included.

Existing Traffic Noise Wall #1—NE 115th Street to NE 130th Street

Modeling was performed for 27 receiver locations selected to be representative of homes in the area, as well as the Seattle Latvian Evangelical Lutheran Church (receiver R-8). Table 7-30 provides a summary of the existing modeled traffic noise levels for these 27 receivers. Modeled traffic noise levels under existing conditions range from 56 to 72 dBA Leq. There are 4 receiver locations with traffic noise levels that meet or exceed the WSDOT NAC under the existing conditions. At present, there is a noise wall shielding receivers in the area from I-5 traffic noise. That wall runs from just south of NE 117th Street to the intersection of the off-ramp and 5th Avenue NE and ranges in height from approximately 4.5 to 16.5 feet tall.

Table 7-30. Traffic Noise Wall #1: Existing Modeled Traffic Noise Levels

	Leq (dBA)		
Receiver[a]	Criteria[b]	Existing[c]	Meets or Exceeds WSDOT Criteria[d]
M-4	66	63	No
R-1	66	59	No
R-2	66	64	No
R-3	66	65	No
R-4	66	60	No
R-5	66	61	No
R-6	66	61	No
R-7	66	58	No
R-8 (Latvian Church)	66	63	No
M-6	66	60	No
R-9	66	61	No
R-10	66	62	No
R-11	66	63	No
R-12	66	64	No
M-7	66	**66**	Yes
R-13	66	64	No
M-8	66	56	No
R-14	66	61	No
R-15	66	65	No
R-16	66	61	No
R-17	66	65	No
R-18	66	**66**	Yes
M-9	66	**68**	Yes
R-19	66	62	No

Table 7-30. Traffic Noise Wall #1: Existing Modeled Traffic Noise Levels

Receiver[a]	Leq (dBA) Criteria[b]	Leq (dBA) Existing[c]	Meets or Exceeds WSDOT Criteria[d]
R-20	66	62	No
R-21	66	65	No
M-10	66	72	Yes

[a] Receivers shown on Figures 8-1 in Section 8.
[b] WSDOT traffic noise impact criteria.
[c] Peak hour modeled noise levels; noise levels that are equal to, or greater than, the WSDOT traffic noise abatement criteria are shown in red.
[d] Indicates whether the receiver currently meets, or exceeds, the WSDOT noise abatement criteria.

Existing Traffic Noise Wall #2—NE 145th Street

Modeling was performed for 13 receiver locations selected to be representative of homes in the area, as well as the True Jesus Church (receiver R-9). Table 7-31 provides a summary of the existing modeled traffic noise levels for these 13 receivers. Modeled traffic noise levels under existing conditions range from 64 to 67 dBA Leq. There is 1 receiver location (the True Jesus Church represented by receiver R-9) with traffic noise levels that meet or exceed the WSDOT NAC under the existing conditions. At present, there is a noise wall shielding receivers in the area from I-5 traffic noise. That wall runs from the NE 145th Street on-ramp to just north of the True Jesus Church and ranges in height from approximately 5 to 16 feet tall.

Table 7-31. Traffic Noise Wall #2: Existing Modeled Traffic Noise Levels

Receiver[a]	Leq (dBA) Criteria[b]	Leq (dBA) Existing[c]	Meets or Exceeds WSDOT Criteria[d]
R-1	66	64	No
R-2	66	65	No
R-3	66	64	No
R-4	66	64	No
M-16	66	64	No
M-17	66	65	No
R-5	66	64	No
R-6	66	64	No
R-7	66	64	No
R-8	66	65	No
R-9	66	67	Yes
R-10	66	65	No
M-18	66	65	No

[a] Receivers shown on Figures 8-6 in Section 8.
[b] WSDOT traffic noise impact criteria.
[c] Peak hour modeled noise levels; noise levels that are equal to, or greater than, the WSDOT traffic noise abatement criteria are shown in red.
[d] Indicates whether the receiver currently meets, or exceeds, the WSDOT noise abatement criteria.

Existing Traffic Noise Wall #3—Ridgecrest Park to NE 175th Street

Modeling was performed for 19 receiver locations selected to be representative of homes in the area, as well as Ridgecrest Park (receiver M-21). Under FHWA and WSDOT NAC, parks are evaluated for traffic noise impacts under the same impact criteria as residences. Table 7-32 provides a summary of the existing modeled traffic noise levels for these 19 receivers. Modeled traffic noise levels under existing conditions range from 60 to 72 dBA Leq. There are 10 receiver locations with traffic noise levels that meet or exceed the WSDOT NAC under the existing conditions. At present, there are 2 noise walls shielding receivers in the area from I-5 traffic noise. The first wall runs from just north of Ridgecrest Park all the way up to NE 175th Street and ranges in height from approximately 5 to 11 feet tall. The second wall is 6.5 feet in height and is located between the NE 175th Street off-ramp and I-5.

In the section of this area located south of Ridgecrest Park, the project plans include the removal of physical shielding along with a slight roadway realignment along 1st Avenue NE between NE 158th Street and NE 161st Street. A review of this area's topographical conditions revealed that the second-line homes are at a substantially higher elevation than the front-line homes, and that the front-line homes are not providing any measureable noise reduction for the second-line homes. Hence, the removal of any front-line shielding in this area will have no impact on noise levels at the second-line homes. Consequently, a detailed traffic noise analysis was not conducted for this specific area located south of Ridgecrest Park.

Table 7-32. Traffic Noise Wall #3: Existing Modeled Traffic Noise Levels

Receiver[a]	Leq (dBA)		Meets or Exceeds WSDOT Criteria[d]
	Criteria[b]	Existing[c]	
M-21	66	64	No
R-1	66	**70**	Yes
R-2	66	**68**	Yes
R-3	66	**68**	Yes
R-4	66	**66**	Yes
R-5	66	**67**	Yes
R-6	66	64	No
R-7	66	65	No
R-8	66	**72**	Yes
R-9	66	64	No
R-10	66	64	No
R-11	66	60	No
R-12	66	60	No
R-13	66	65	No
R-14	66	62	No
R-15	66	**66**	Yes
M-22	66	**68**	Yes
R-16	66	**68**	Yes
R-17	66	**68**	Yes

[a] Receivers shown on Figures 8-3 in Section 8.
[b] WSDOT traffic noise impact criteria.
[c] Peak hour modeled noise levels; noise levels that are equal to, or greater than, the WSDOT traffic noise abatement criteria are shown in red.
[d] Indicates whether the receiver currently meets, or exceeds, the WSDOT noise abatement criteria.

Existing Traffic Noise Wall #4—NE 180th Street to NE 185th Street

Modeling was performed for 14 receiver locations selected to be representative of homes in the area. Table 7-33 provides a summary of the existing modeled traffic noise levels for these 14 receivers. Modeled traffic noise levels under existing conditions range from 58 to 65 dBA Leq. There are no receiver locations with traffic noise levels that meet or exceed the WSDOT NAC under the existing conditions. At present, there is a noise wall shielding receivers in the area from I-5 traffic noise. That wall runs from approximately NE 178th Street to approximately NE 184th Street and ranges in height from approximately 9 to 14 feet tall.

Table 7-33. Traffic Noise Wall #4: Existing Modeled Traffic Noise Levels

	Leq (dBA)		
Receiver[a]	**Criteria[b]**	**Existing[c]**	**Meets or Exceeds WSDOT Criteria[d]**
R-6	66	61	No
M-25	66	60	No
R-7	66	63	No
R-8	66	65	No
R-9	66	63	No
R-10	66	59	No
R-11	66	58	No
R-12	66	59	No
R-13	66	58	No
R-14	66	58	No
R-15	66	59	No
R-16	66	61	No
R-17	66	62	No
M-28	66	65	No

[a] Receivers shown on Figures 8-4 in Section 8.
[b] WSDOT traffic noise impact criteria.
[c] Peak hour modeled noise levels.
[d] Indicates whether the receiver currently meets, or exceeds, the WSDOT noise abatement criteria.

Existing Traffic Noise Wall #5—NE 185th Street to NE 191st Street

Modeling was performed for 9 receiver locations selected to be representative of homes in the area, as well as the Shoreline Cooperative Preschool (receiver M-30A). Table 7-34 provides a summary of the existing modeled traffic noise levels for these 9 receivers. Modeled traffic noise levels under existing conditions range from 60 to 73 dBA Leq. There are 2 receiver locations situated between the Shoreline Cooperative Preschool and I-5 that have traffic noise levels that meet or exceed the WSDOT NAC under the existing conditions. At present, there is a noise wall shielding receivers in the area from I-5 traffic noise. That wall runs from approximately NE 178th Street to approximately NE 190th Street and ranges in height from approximately 5 to 15 feet tall.

Table 7-34. Traffic Noise Wall #5: Existing Modeled Traffic Noise Levels

Receiver[a]	Leq (dBA)		Meets or Exceeds WSDOT Criteria[d]
	Criteria[b]	Existing[c]	
R-1	66	64	No
R-2	66	65	No
R-3	66	**67**	Yes
R-4	66	**73**	Yes
M-30A	66	60	No
R-5	66	63	No
R-6	66	62	No
M-29	66	61	No
R-7	66	65	No

[a] Receivers shown on Figures 8-5 in Section 8.
[b] WSDOT traffic noise impact criteria.
[c] Peak hour modeled noise levels; noise levels that are equal to, or greater than, the WSDOT traffic noise abatement criteria are shown in red.
[d] Indicates whether the receiver currently meets, or exceeds, the WSDOT noise abatement criteria.

7.4.3 New Traffic Noise Walls—Lynnwood Park-and-Ride Station

Modeling was performed for 111 receiver locations selected to be representative of 215 condominiums and apartment homes, as well as two hotels, surrounding the Lynnwood Park-and-Ride Station. Receivers R-1 through R-7 are for the Park Five Apartments, receivers R-8 through R-16 are for the Oxford Square Apartments, receivers R-17 through R-24B are for the Cambridge Apartments, and receivers R-27 through R-45 are for the Cedar Creek Condominiums. Finally receivers R-25 and R-26 are for the Courtyard Hotel and La Quinta Inn, respectively. Table 7-35 provides a summary of the existing modeled traffic noise levels for these 111 receivers. Modeled traffic noise levels under existing conditions range from 46 to 67 dBA Leq. There are 8 receiver locations with traffic noise levels that meet or exceed the WSDOT NAC under the existing conditions.

Table 7-35. Lynnwood Park-and-Ride Station: Existing Modeled Traffic Noise Levels

Receiver[a]	Leq (dBA) Criteria[b]	Leq (dBA) Existing[c]	Meets or Exceeds WSDOT Criteria[d]
R-1 (Lower)	66	56	No
R-1 (Upper)	66	58	No
R-2 (Lower)	66	56	No
R-2 (Upper)	66	58	No
R-3/M-50 (Lower)	66	55	No
R-3 (Upper)	66	57	No
R-4 (Lower)	66	54	No
R-4 (Upper)	66	57	No
R-5 (Lower)	66	58	No
R-5 (Upper)	66	60	No
R-6 (Lower)	66	56	No
R-6 (Upper)	66	59	No
R-7 (Lower)	66	55	No
R-7 (Upper)	66	58	No
R-8 (Lower)	66	59	No
R-8 (Upper)	66	62	No
R-9 (Lower)	66	50	No
R-9 (Upper)	66	54	No
R-10 (Lower)	66	50	No
R-10 (Upper)	66	52	No
R-11 (Lower)	66	59	No
R-11 (Upper)	66	61	No
R-12 (Lower)	66	55	No
R-12 (Upper)	66	58	No
R-13 (Lower)	66	55	No
R-13 (Upper)	66	58	No
R-14 (Lower)	66	59	No
R-14 (Upper)	66	61	No
R-15 (Lower)	66	53	No
R-15 (Upper)	66	55	No
R-16 (Lower)	66	61	No
R-16 (Upper)	66	62	No
R-17 (Lower)	66	**66**	Yes
R-17 (Upper)	66	**67**	Yes
R-18 (Lower)	66	61	No
R-18 (Upper)	66	63	No
R-19 (Lower)	66	60	No
R-19 (Upper)	66	61	No
R-20 (Lower)	66	65	No
R-20 (Upper)	66	65	No
R-21 (Lower)	66	64	No
R-21 (Upper)	66	65	No
R-22A/M-52 (Lower)	66	65	No
R-22A (Upper)	66	**66**	Yes
R-22B (Lower)	66	65	No
R-22B (Upper)	66	**66**	Yes
R-23 (Lower)	66	59	No
R-23 (Upper)	66	62	No
R-24A (Lower)	66	**67**	Yes
R-24A (Upper)	66	**67**	Yes
R-24B (Lower)	66	**66**	Yes

Table 7-35. Lynnwood Park-and-Ride Station: Existing Modeled Traffic Noise Levels

R-24B (Upper)	66	**66**	Yes
R-25 - Courtyard Hotel	71	64	No
R-26 - La Quinta Inn	71	63	No
R-27 (Lower)	66	63	No
R-27 (Middle)	66	65	No
R-27 (Upper)	66	65	No
R-28 (Lower)	66	61	No
R-28 (Middle)	66	63	No
R-28 (Upper)	66	63	No
R-29 (Lower)	66	54	No
R-29 (Middle)	66	57	No
R-29 (Upper)	66	57	No
R-30/M-51 (Lower)	66	55	No
R-30 (Middle)	66	58	No
R-30 (Upper)	66	58	No
R-31 (Lower)	66	54	No
R-31 (Middle)	66	58	No
R-31 (Upper)	66	58	No
R-32 (Lower)	66	60	No
R-32 (Middle)	66	63	No
R-32 (Upper)	66	63	No
R-33 (Lower) - Pool Room	66	56	No
R-33 (Middle)	66	60	No
R-33 (Upper)	66	60	No
R-34 (Lower)	66	53	No
R-34 (Middle)	66	57	No
R-34 (Upper)	66	57	No
R-35 (Lower)	66	53	No
R-35 (Middle)	66	56	No
R-35 (Upper)	66	57	No
R-36 (Lower)	66	61	No
R-36 (Middle)	66	63	No
R-36 (Upper)	66	63	No
R-37 (Lower)	66	57	No
R-37 (Middle)	66	60	No
R-37 (Upper)	66	60	No
R-38 (Lower)	66	54	No
R-38 (Middle)	66	58	No
R-38 (Upper)	66	58	No
R-39 (Lower)	66	53	No
R-39 (Middle)	66	57	No
R-39 (Upper)	66	57	No
R-40 (Lower)	66	57	No
R-40 (Middle)	66	60	No
R-40 (Upper)	66	60	No
R-41 (Lower)	66	56	No
R-41 (Middle)	66	58	No
R-41 (Upper)	66	58	No
R-42 (Lower)	66	56	No
R-42 (Middle)	66	58	No
R-42 (Upper)	66	59	No
R-43 (Lower)	66	56	No
R-43 (Middle)	66	58	No

Table 7-35. Lynnwood Park-and-Ride Station: Existing Modeled Traffic Noise Levels

R-43 (Upper)	66	58	No
R-44 (Lower)	66	54	No
R-44 (Middle)	66	58	No
R-44 (Upper)	66	58	No
R-45 (Lower)	66	54	No
R-45 (Middle)	66	57	No
R-45 (Upper)	66	58	No

[a] Receivers shown on Figures 8-6 in Section 8.8.
[b] WSDOT traffic noise impact criteria.
[c] Peak hour modeled noise levels; noise levels that are equal to, or greater than, the WSDOT traffic noise abatement criteria are shown in red.
[d] Indicates whether the receiver currently meets, or exceeds, the WSDOT noise abatement criteria.

7.5 Construction Noise Impact Analysis

The construction noise analysis considers the temporary noise impacts that construction would cause in the project vicinity. These impacts would end when project construction is completed.

Noise related to construction would result from the operation of heavy equipment needed to construct various project components, including bridges, retaining walls, roads, park-and-ride facilities, and stations. The contractor would be required to adhere to local ordinances regulating noise, as discussed in Section 4.3. Construction activities outside normal weekday daytime hours would require a noise variance from the City or County where the work is being performed if regulatory noise levels are exceeded.

Equipment required to complete the Lynnwood Link Extension would include construction equipment typically used for transportation construction projects. Table 7-36 lists the typical equipment used for this type of project, the activities they would be used for, and the corresponding maximum noise levels that would be produced when measured at 50 feet from the sources under normal use.

Table 7-36. Construction Equipment and Reference Noise Levels

Equipment	Expected Project Use	Lmax[a, b] (dBA)
Air compressors	Pneumatic tools and general maintenance (all phases)	70 to 76
Backhoe	General construction and yard work	78 to 82
Concrete pump	Pumping concrete	78 to 82
Concrete saws	Concrete removal and utilities access	75 to 80
Crane	Materials handling: removal and replacement	78 to 84
Excavator	General construction and materials handling	82 to 88
Forklifts	Staging area work and hauling materials	72
Haul trucks	Materials handling: general hauling	86
Jackhammers	Pavement removal	74 to 82
Loader	General construction and materials handling	86
Pavers	Roadway paving	88
Pile-drivers	Support for structure and hillside	99 to 105
Power plants	General construction use: nighttime work	72

Table 7-36. Construction Equipment and Reference Noise Levels

Equipment	Expected Project Use	Lmax[a, b] (dBA)
Pumps	General construction use: water removal	62
Pneumatic tools	Miscellaneous construction work	78 to 86
Tractor trailers	Material removal and delivery	86
Utility trucks	General project work	72
Vibratory equipment	Shoring up hillside to prevent slides and soil compacting	82 to 88
Welders	General project work	76

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

[b] Noise levels presented are based on measured data from the Portland Light Rail and I-5 Preservation and Hawthorne Bridge construction projects and other measured data, as well as U.S. Department of Transportation construction noise documentation and other construction noise sources.

dBA = decibel with A-weighting, Lmax = maximum noise level

7.5.1 Construction Noise

Several construction phases would be required to complete the Lynnwood Link Extension. The FHWA Construction Noise Model (2006) was used to provide an estimate of the project construction noise levels, as well as to predict the maximum noise levels for several different construction phases. The analysis assumes the worst-case average and maximum noise levels based on three major types of construction described below and shown in Table 7-37. The actual noise levels experienced during construction would generally be lower than those described in Table 7-36 because these are the maximum noise levels for each activity. The noise levels presented here are for short periods of maximum construction activity and would occur for a limited period of time.

Table 7-37. Noise Levels for Typical Construction Phases[a]

Scenario[b]	Equipment[c]	Lmax[d]	Leq[e]
Demolition, site preparation, and utilities relocation	Air compressors, backhoes, concrete pumps, cranes, excavators, forklifts, haul trucks, loaders, pumps, power plants, service trucks, tractor trailers, utility trucks, and vibratory equipment	88	87
Structures construction, track installation, and paving activities	Air compressors, backhoes, cement mixers, concrete pumps, cranes, forklifts, haul trucks, loaders, pavers, pumps, power plants, service trucks, tractor trailers, utility trucks, vibratory equipment, and welders	88	88
Miscellaneous activities	Air compressors, backhoes, cranes, forklifts, haul trucks, loaders, pumps, service trucks, tractor trailers, utility trucks, and welders	86	83

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

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

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

[d] Lmax (dBA) is the highest maximum noise level for the construction equipment listed under the given scenario.

[e] Leq (dBA) is a 1-hour energy average noise emission for construction equipment operating under the given scenario.

7.5.2 Demolition, Site Preparation, and Utilities Relocation

Major noise-producing equipment in use during the preparation stage of light rail construction could include saw cutters, concrete pumps, cranes, excavators, haul trucks, loaders, tractor-trailers, and vibratory equipment. Maximum noise levels could reach 82 dBA to 94 dBA at the nearest residences (i.e., within 50 to 100 feet) for normal construction activities during this phase. Other less-notable noise-producing equipment expected during this phase would include backhoes, air compressors, forklifts, pumps, power plants, service trucks, and utility trucks.

7.5.3 Structures Construction, Track Installation, and Paving Activities

The loudest noise sources in use during construction of elevated structures would include cement mixers, concrete pumps, cranes, pavers, haul trucks, and tractor-trailers. The cement mixers, cranes, and concrete pumps would be required for construction of the light rail superstructure. The pavers and haul trucks would be used to provide the final surface on the trackway, roadways, and ramps modified during other phases of construction. Maximum noise levels would range from 82 dBA to 94 dBA at the closest receiver locations.

7.5.4 Miscellaneous Activities

Following heavy construction, general construction would still be required such as installation of bridge railing, signage, roadway striping, and communication and power systems, as well as other miscellaneous activities. These less intensive activities are not expected to produce noise levels above 80 dBA at 50 feet except during rare occasions, and even then only for short periods of time when maximum noise levels could reach 91 dBA Lmax at 50 feet. Using the information in Table 7-36, typical construction noise levels were projected for several distances from the project work area. Figure 7-1 is a graph of general construction noise level versus distance for phases of construction.

7.5.5 Pile-Driving

Pile-driving would likely be required to support permanent structures such as piers for elevated structures and retaining tunnel walls. Pile-driving can produce maximum short-term noise levels of 99 dBA to 105 dBA at 50 feet. Actual levels can vary and would depend on the distance and topographical conditions between the pile-driving location and the receiver location. Figure 7-2 is a graph of maximum pile-driving noise levels versus distance.

7.5.6 Nighttime Construction Activities

Some construction activities might be required during nighttime hours because of the nature of the construction, to avoid daytime traffic impacts, or to accommodate adjacent land uses. In order to perform construction at night, a noise variance from the local governing agency would be required. If nighttime construction is deemed necessary, Sound Transit would work with each governing agency to obtain any necessary noise variance specific to project construction.

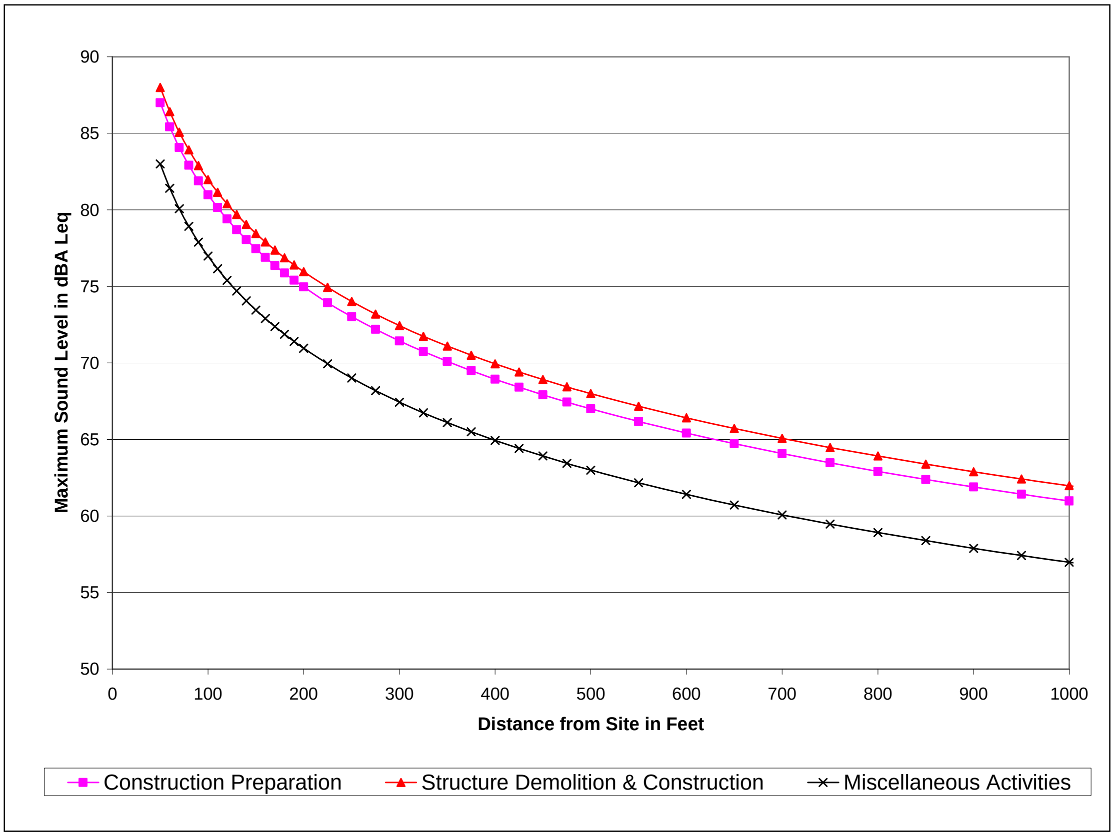


Figure 7-1. Maximum Noise Level versus Distance for Typical Construction Phases

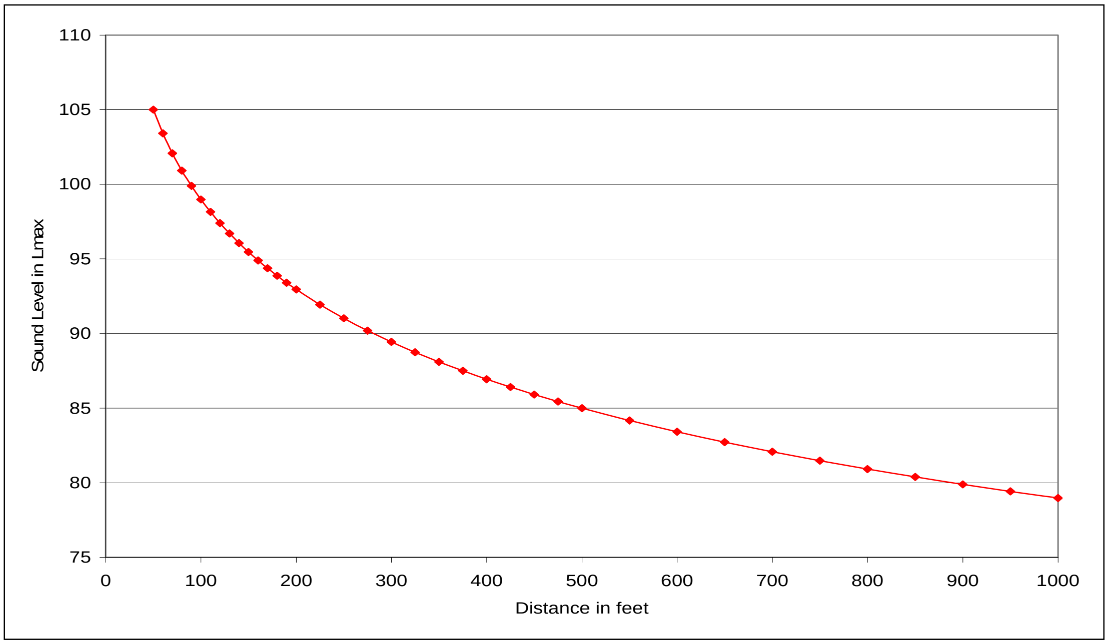


Figure 7-2. Pile-Driving Noise Level versus Distance

7.5.7 Segment A

There are a large number of single-family and multifamily residences along the Segment A alternative alignments. Under all of the Segment A alternatives, noise levels at adjacent residences would have short periods of time with maximum noise levels exceeding 80 dBA Lmax. Major construction noise would occur during demolition of existing structures; relocation of noise walls and utilities; installation of retaining walls (where required); repaving of local access and arterial roadways; and construction of the at-grade, retained cut-and-fill and elevated guideway structures. Pile-driving and sheet-pile installation might also be required. Pile-driving could produce noise levels of 105 dBA Lmax at 50 feet. Although there would be periods of relatively loud construction, noise levels would decrease as tasks are completed and construction activities move to other areas.

Near Northgate, the major noise generator for all light rail alternatives would be construction of the elevated structures connecting the Northgate Station to the guideway along 1st Avenue NE and crossing over Northgate Way. North of Northgate Way, major construction activities could include installation of the elevated guideway under all light rail alternatives and reconstruction of 1st Avenue NE and the North 117th Street overpass under Alternative A1. Several noise walls would also be relocated during the initial phase of the project. Every attempt would be made to replace the noise walls early in the construction process, if possible, which would allow the walls to also assist with mitigating construction noise. Without the noise walls, there would be short periods of time with maximum noise levels exceeding 80 dBA Lmax; when the walls are replaced, the maximum levels should be 10 dBA to 12 dBA lower than without the walls in place.

Under Alternatives A5, A7, A10, and A11, construction of the NE 130th Street Station would result in additional short-term construction activities in the vicinity of 5th Avenue NE and NE 130th Street. Because this station would not include any parking structures, the main construction activities would be restricted to the west side of 5th Avenue NE for station platforms and associated facilities, including a parking lot under the NE 130th Street Station Option 2. Maximum noise levels during periods of heavy construction would reach up to 75 dBA Lmax, with typical noise levels ranging from 65 dBA to 75 dBA during periods of active construction.

North of NE 130th Street and south of the NE 145th Station options in Segment A, the land use consists mainly of recreational uses that are not noise-sensitive under the FTA regulations. Although construction noise is expected to have some effect on noise levels at the golf course, the added distance and 5th Avenue NE buffer would help to reduce the overall noise effects in this area. With the buffer zone, noise levels should remain below 70 dBA to 75 dBA Lmax in this area.

Noise levels related to the construction of the NE 145th Street Station would be similar under Alternatives A1, A3, A10, and A11. For residences located near the proposed station, short-term maximum noise levels of 70 dBA to 80 dBA could be expected, with typical construction-related noise levels of 65 dBA to 75 dBA.

Several additional noise walls would be relocated under all Segment A alternatives north of the NE 145th Street Station. The noise walls would also be used to provide noise mitigation for light rail operations as well as traffic noise; therefore, these proposed walls might be slightly higher than the existing noise walls. Sound Transit would attempt to relocate the noise walls early in the construction process to assist with construction noise mitigation. During the short periods when the walls would be removed, construction and traffic noise would likely meet or exceed 80 dBA at homes closest to the construction sites.

The NE 155th Street Station under Alternatives A5 and A7 would include the construction of a multistory parking facility. Because of the light rail station and parking structure, noise levels in the vicinity of this station would be elevated longer under Alternatives A7 and A10 than under Alternatives A1, A3, A10, and A11, which would not include the NE 155th Street Station.

North of NE 155th Street to the north end of Segment A, just past NE 185th Street, construction noise and activities would be similar to those described for the southern part of Segment A, with short periods of time with maximum noise levels exceeding 80 dBA Lmax. In addition, several existing noise walls in this area would also be relocated as part of the project.

Construction noise related to the NE 185th Street Station would vary by design option. Under Alternative A1 with the NE 185th Street Station Option 1, the parking structure would be on the west side of I-5, and the overpass would be improved for better pedestrian access. Therefore, Option 1 is the only option with which construction noise could affect residences on both sides of I-5. Construction of the parking area along the west side of I-5 would elevate noise levels at residences north of the station along 5th Avenue NE and south of the parking area along NE 185th Street.

Under Alternatives A3, A7, and A11, the NE 185th Street Station Option 2 would include a three-story parking facility constructed between the station and 8th Avenue NE. Both Alternatives A5 and A10 would include the NE 185th Street Station Option 3, which would have a surface parking lot between the station and 8th Avenue NE, with an option for additional parking farther east. Although both of these station design options would be located entirely on the east side of I-5, construction of the parking garage under Option 2 would be expected to elevate noise levels slightly higher and longer than under Option 3 because of the added construction effort and time required to build the parking structure. Construction of the elevated structures, parking garages, and other major project-related construction activities could result in noise levels of 83 to 87 dBA Leq during periods of heavy construction.

7.5.8 Segment B

Major construction activities in Segment B would include relocating utilities; installing retaining walls (where required); repaving local access and arterial roadways; and constructing the at-grade, retained cut-and-fill, and elevated guideway structures. Pile-driving and sheet-pile installation might also be required; pile-driving could produce Lmax noise levels of 105 dBA at 50 feet. Beginning just north of the NE 185th Street Station options, all four Segment B alternative alignments would be along the east side of I-5, and, as with other segments, would require relocating several noise walls. Construction-related noise levels would be highest during the relocation of the walls and installation of the elevated and retained cut-and-fill guideways. During these periods of heavy construction, noise levels would likely exceed 80 dBA Lmax at most front-line residences. When the noise wall relocation is completed, construction noise levels would be reduced because the noise walls would provide shielding from many construction activities.

North of Ballinger Way (SR 104), all four of the Segment B alternatives would be elevated to the Mountlake Terrace Transit Center Station except for Alternative B4, which would move to the I-5 median and return to at-grade near the 236th Street SW overpass. Under all Segment B alternatives, several homes along 60th Avenue NW would experience elevated noise levels from project construction because they would have a direct line-of-sight to the construction areas north of Gateway Place. Because these residences are located approximately 500 feet from most of the construction activities, Sound Transit expects that noise levels during construction would remain below 70 dBA Lmax.

North of the Mountlake Terrace Transit Center Station, Alternatives B1 and B4 would remain in the I-5 median; therefore, most construction would be performed in the center of the freeway, using the express lanes and shoulders. The added buffer of 250 feet to 400 feet and existing noise walls (depending on location) could help to reduce maximum noise levels by 5 dBA to 10 dBA or more.

7.5.9 Segment C

Major construction noise would occur during the demolition of existing structures; relocation of utilities; repaving of local access and arterial roadways; and construction of the at-grade, retained cut-and-fill, and elevated guideway structures. In Segment C, a limited number of residential land uses would be affected by the construction noise. Noise would increase at the homes located in the residential area west of 52nd Avenue West, north of I-5, and south of the Interurban Trail. Under Alternatives C1 and C2, the area of affected homes would continue north along 52nd Avenue West. Businesses along 52nd Avenue West would also be affected. Conversely, under Alternative C3, only the aforementioned residential area and a few businesses would be affected along 52nd Avenue West near the connection between Segments B and C alternatives. Under Alternative C1, numerous apartment and condominium homes along 200th Street SW, which are 70 feet to 100 feet from the project work site, would also experience increased noise levels because of construction activities. Sound Transit projects that maximum noise levels would reach up to 80 dBA Lmax, with typical noise levels ranging from 72 dBA to 80 dBA during periods of active construction.

8 POTENTIAL NOISE MITIGATION MEASURES

For locations where Sound Transit has identified potential noise impacts, mitigation measures would be considered and reviewed using Sound Transit's Noise Mitigation Policy (Sound Transit 2004). Under this policy, mitigation measures would be considered for all noise impacts.

Sound Transit's practice is to mitigate both moderate and severe impacts beginning with source treatment, followed by treatments in the noise path (Sound Transit Light Rail Noise Mitigation Policy, Motion No. M2004-08). If source and path treatments are not sufficient to mitigate the impact, Sound Transit will evaluate and implement sound insulation at affected properties where the existing building does not already achieve sufficient exterior-to-interior reduction of noise levels. The following sections provide an introduction to the mitigation strategies normally used for light rail projects. Following this introduction are the mitigation strategies and measures proposed for the Lynnwood Link Extension.

During final design, all impacts and mitigation measures will be reviewed for verification. If it is discovered that the mitigation can be achieved by less costly means or if detailed analysis shows no impact, the mitigation measure may be eliminated.

8.1 Source Noise Mitigation

One of the most effective forms of noise mitigation is to reduce noise at the source. One form of source noise reduction is using vehicles with low noise levels during operation. Sound Transit has purchased state-of-the-art rail cars equipped with noise-reducing wheel skirts covering the wheel-rail interface. Several additional operational measures can also be used to reduce noise levels at the source. Table 5-1 in Section 5 lists operational and maintenance measures that Sound Transit performs on a regular basis and the benefits that these measures provide.

Source treatments that Sound Transit is currently using to minimize noise impacts include requiring wheel skirts, maintaining smooth tracks, performing vehicle maintenance and wheel truing, and conducting operator training.

8.2 Path Noise Mitigation

The next type of mitigation considered would be applied between the noise source and receiver. Typical noise path mitigation includes noise walls, earth berms, and buffer zones. Constructing noise walls between the light rail tracks and the affected receivers would reduce noise levels by physically blocking the transmission of noise generated by light rail. Barriers can be constructed as walls or earth berms, which require more right-of-way than walls and are usually constructed with a 3-to-1 slope gradient. For the Lynnwood Link Extension, berms would not be feasible because of topographical conditions and limited right-of-way. Noise walls should be high enough to break the line-of-sight between the noise source and the receiver. The typical height for at-grade noise walls is 6 feet to 8 feet and 4 feet to 6 feet when on elevated structures. Noise walls must also be long enough to prevent flanking of noise around the ends of the walls. Openings in noise walls for driveway connections or intersecting streets greatly reduce the effectiveness of these walls.

Buffer zones are undeveloped open spaces between the noise source and receiver. Buffer zones are created when an agency purchases land or development rights in addition to the normal right-of-way to ensure that future dwellings cannot be constructed close to the noise source. However, because the Lynnwood Link Extension would be in an urban setting where land is at a premium, creating buffer zones is not a feasible form of noise mitigation because it would require substantially more project-related displacements.

8.3 Receiver Noise Mitigation

For situations where noise path mitigation would be either unfeasible or ineffective, Sound Transit would consider building sound insulation. Sound insulation programs are developed to reduce the interior noise levels in sleeping and living quarters in residential properties or in noise-sensitive areas such as schools and other institutional uses to within the guidelines set by HUD. Under these guidelines, interior noise levels for residential properties should not exceed 45 dBA Ldn, and a form of fresh air exchange must be maintained. The air exchange can be achieved by opening a window or using a ventilation system. Sound insulation is typically only used on older dwellings with single-paned windows, or in buildings with double-paned windows that are ineffective because of leakage. Sound insulation would not reduce exterior noise levels.

8.4 Crossover Mitigation

When a light rail train travels over a crossover, there is a loud clicking noise as the steel wheels go over the gap between the tracks. This can increase noise levels from the train by as much as 10 dBA compared with a smooth track with no gaps. Mitigation for noise impacts from crossover tracks can include relocating the crossover away from noise-sensitive properties, or the use of special trackwork, such as special "frogs" that include gap-closing mechanisms, or using movable point frogs. A frog in this context is a rail-crossing structure at track crossovers that allows the train to cross over to another track or continue moving on the same track. A gap is provided on top of the frog so that vehicle wheels can pass regardless of which track is in use. With standard rigid frogs, noise and vibration occurs when the wheels pass over the gap, but a movable-point frog eliminates the gap and one end of the frog moves in the direction of train travel. Other similar options for reducing noise from crossovers include spring-rail or flange-bearing frogs. Relocation of crossovers to more than 500 feet from noise-sensitive sites also would eliminate the noise impact from the crossovers.

8.5 Transit Noise Mitigation Analysis

This section generally describes the potential noise mitigation measures that would be used for the light rail alternatives. The mitigation design is based on the current alignments and are implemented to meet the requirements of the FTA and the Sound Transit Noise Mitigation Policy (Sound Transit 2004). However, if during final design Sound Transit determines that the relevant noise criterion could be achieved by a less costly means, or that the noise impact at that location would not occur even without mitigation (for example, a revised alignment), then the mitigation measure might be eliminated or modified as needed. Conversely, if any additional noise impacts were identified during final design, then Sound Transit would provide mitigation that is consistent with the Sound Transit Noise Mitigation Policy (Sound Transit 2004).

Noise walls would be the primary form of noise mitigation for transit noise impacts. Attachment B provides complete details on mitigation, including projected noise levels with the proposed noise mitigation measures for each receiver. Table 8-1 summarizes specific mitigation measures for each alternative. Attachment F provides maps of the locations where at-grade and elevated noise walls are anticipated to mitigate the noise impacts for each alternative. Noise walls to reduce transit noise impacts would include short walls, like those used in Tukwila as part of Central Link, which are directly attached to the sides of the elevated guideway. These walls are acoustically absorbent and very effective at reducing noise; typical noise reductions are in the range of 10 dBA to 15 dBA, depending on the topographical conditions between the receiver and the guideway. Additional at-grade noise walls and walls along retained fills and cuts also would be used, depending on the track type. Because the majority of noise from light rail operations comes from the wheel-rail interface, even relatively short walls can reduce noise levels by 7 dBA to 10 dBA, depending on topographical conditions and distance. On elevated guideways short barriers can provide an even greater noise reduction.

Table 8-1. Summary of Potential Noise Impacts and Mitigation Measures

Alternative	Relocation of Noise Walls Required for Project Construction[a]	Light Rail Impacts		Proposed Noise Mitigation Measures for Impacts (Excluding New and Relocated Traffic Noise Walls)	Locations Considered for Sound Insulation
		Moderate[b]	Severe[c]		
Segment A Alternatives					
Preferred Alternative	Approximately 12,250 feet of relocated noise walls, 2,500 feet at-grade, 9,400 feet on retaining walls, and 350 feet along elevated structures sta 35-50: 1,500 feet sta 44-74: 3,100 feet sta 123-131: 1,150 feet (including 300 feet along ramp) sta 162-200: 3,800 feet sta 216-225: 950 feet sta 230-238: 800 feet sta 237-247: 950 feet	181	112	Approximately 9,700 feet of additional noise walls, 300 feet at-grade, 5,900 feet on retaining walls, and 3,500 feet along elevated structures	8
A1	sta 38–53: 1,500 feet sta 114–126: 1,200 feet sta 155–189: 3,400 feet sta 197–215: 1,800 feet	190	29	Approximately 11,200 feet of additional noise walls, 2,700 feet at-grade, 4,700 feet on retaining walls, and 3,800 feet along elevated structures	0

Table 8-1. Summary of Potential Noise Impacts and Mitigation Measures

Alternative	Relocation of Noise Walls Required for Project Construction[a]	Light Rail Impacts		Proposed Noise Mitigation Measures for Impacts (Excluding New and Relocated Traffic Noise Walls)	Locations Considered for Sound Insulation
		Moderate[b]	Severe[c]		
A3	sta 155-176: 2,100 feet	269	198	Approximately 17,300 feet of additional noise walls, 500 feet at-grade, 1,600 feet on retaining walls, and 15,200 feet along elevated structures	27
A5	sta 30–52: 2,200 feet sta 115–126: 1,100 feet sta 155–189: 3,400 feet sta 197–202: 500 feet sta 206–216: 1,000 feet	181	105	Approximately 11,000 feet of additional noise walls, 2,600 feet at-grade, 4,500 feet on retaining walls, and 3,900 feet along elevated structures	8
A7	sta 155–176: 2,100 feet	296	183	Approximately 17,400 feet of additional noise walls, 400 feet at-grade, 2,200 feet on retaining walls, and 14,800 feet along elevated structures	29
A10	sta 30–31: 100 feet sta 38–53: 1,500 feet sta 114–126: 1,200 feet sta 155–189: 3,400 feet sta 197–216: 1,900 feet	161	110	Approximately 11,500 feet of additional noise walls, 2,300 feet at-grade, on 5,100 feet on retaining walls, and 4,100 feet along elevated structures	3
A11	sta 155–189: 3,400 feet	272	195	Approximately 17,100 feet of additional noise walls, 300 feet at-grade, 1,600 feet on retaining walls, and 15,200 feet along elevated structures	28
Segment B Alternatives					
Preferred Alternative	None	148	65	Approximately 16,975 feet of additional noise walls, 1,100 feet at-grade, 4,550 feet on retaining walls, and 11,325 feet along elevated structures	9
Preferred Alternative – 220th Street Station Option	None	133	65	Approximately 16,975 feet of additional noise walls, 1,100 feet at-grade, 4,550 feet on retaining walls, and 11,325 feet along elevated structures	9
B1	None	89	29	Approximately 20,800 feet of additional noise walls, 14,600 feet at-grade or on retaining walls and 6,200 feet along elevated structures	0
B2A	None	138	50	Approximately 15,000 feet of additional noise walls, 5,600 feet at-grade or on retaining walls and 9,400 feet along elevated structures	3
B4	None	73	33	Approximately 20,000 feet of additional noise walls, 14,500 feet at-grade or on retaining walls and 5,500 feet along elevated structures	0

Table 8-1. Summary of Potential Noise Impacts and Mitigation Measures

Alternative	Relocation of Noise Walls Required for Project Construction[a]	Light Rail Impacts		Proposed Noise Mitigation Measures for Impacts (Excluding New and Relocated Traffic Noise Walls)	Locations Considered for Sound Insulation
		Moderate[b]	Severe[c]		
Segment C Alternatives					
Preferred Alternative	None	26	8	Approximately 3,960 feet of additional noise walls along elevated structures	0
C1, Option 1	None	159	24	Approximately 7,200 feet of additional noise walls along elevated structures	0
C1, Option 2	None	152	23	Approximately 7,200 feet of additional noise walls along elevated structures	0
C2, Option 1	None	52	41	Approximately 6,600 feet of additional noise walls along elevated structures	0
C2, Option 2	None	49	41	Approximately 6,600 feet of additional noise walls along elevated structures	0
C3, Option 1	None	16	1	Approximately 1,700 feet of additional noise walls, 700 feet on retained fill and 1,000 feet along elevated structures	0
C3, Option 2	None	13	8	Approximately 1,700 feet of additional noise walls, 700 feet on retained fill and 1,000 feet along elevated structures	0

[a] This column shows the location of the start and end points (sta) for relocated noise walls along the light rail route and the corresponding length (feet) of relocated noise walls. The "sta" references the designated station numbering, or location along the alignment, on the project design drawings, and each consecutive sta marker on the design drawings indicates a distance of 100 feet. For example, from sta 38 to 53 there are 15 sta on the design drawings, which multiplied by 100 for each sta equals a distance of 1,500 feet.

[b] Moderate impact: In this range of noise impact; the change in the cumulative noise level is noticeable to most people but might not be sufficient to cause strong, adverse reactions from the community.

[c] Severe impact: Project-generated noise in the severe impact range can be expected to cause a substantial percentage of people to be highly annoyed by the new noise and represents the most compelling need for mitigation.

In addition to noise walls for transit noise mitigation, the project would replace several highway noise walls that currently reduce traffic noise levels. The analysis for the replacement walls is separate from the transit mitigation analysis and these evaluations are presented in Section 8.7. The noise walls specified for the Preferred Alternative in Table 8-1 include the proposed replacement traffic noise walls but not the new traffic noise walls in the Lynnwood Park-and-Ride Station area.

All of the transit and traffic noise wall heights and locations specified in this report are approximations based on current alignment, topographical and other data. During final design, Sound Transit will update all of this data, and as a result, those heights and locations could change. Based on the current noise analysis, all noise impacts for the Preferred Alternative, except for 17 single-family and multifamily residences, would be fully mitigated by noise walls. Additional noise analysis will be performed during final design for the remaining 17 noise impacts to determine the best form of mitigation to complete the project's mitigation package. Options that could be used to mitigate the remaining 17 impacts could include special noise walls or sound insulation. The number of remaining impacts after including noise barriers would vary for the other alternatives.

8.5.1 Segment A

Noise mitigation in Segment A would be achieved with noise walls. The walls are located on retaining walls, at-grade, and along the sides of elevated structures.

Preferred Alternative Segment A

Under the Preferred Alternative, there are 21,957 feet of new and replacement noise walls that are used to mitigate light rail noise, and in some cases traffic noise. The effect of these walls on traffic noise is presented in Section 8.7. The walls range in height from a typical light rail elevated structure noise wall at 4 feet tall to a 16- to 20-foot-tall noise wall that reduces traffic noise and mitigates light rail noise. Table 8-2 provides a summary of the noise walls, including replacement traffic noise walls, proposed for the Preferred Alternative. With the proposed noise walls, and the relocation/replacement of existing traffic noise walls, Sound Transit would mitigate all predicted noise impacts resulting from the Preferred Alternative, with the exception of 8 residences, including 1 duplex and 6 single-family residences (Table 8-2). Any remaining homes with light rail noise impacts will be reevaluated during final design to verify the impacts and apply sound insulation if necessary.

There are several areas along the corridor where the existing traffic noise walls do not reduce traffic noise levels to below the NAC. In those areas, the relocated walls at their current height may also not reduce the traffic noise to below the NAC but still meet the criteria of producing no new traffic noise impacts or increasing the severity of any existing traffic noise impacts. In these areas, increasing the height of the wall may be considered and will be reviewed with WSDOT during final design.

Table 8-2. Summary of Potential Noise Mitigation Measures for Preferred Alternative

Wall Type[a]	Start Station[b]	End Station[b]	Length (linear feet)	Height (feet)
LR Wall on Structure	17	22	500	4
LR Wall on Structure	22	26	400	6
LR Wall on Structure	26	29.5	350	8
LR Wall on Fill Wall	29.5	32	250	8
LR Wall on Fill Wall	32	35	300	12
LR and TR Wall on Fill Wall	35	38	300	12
LR and TR Wall At-Grade	38	39	100	14
LR and TR Wall At-Grade	39	39.75	75	16
LR and TR Wall on Cut Wall	39.75	40	25	12
LR and TR Wall on Cut Wall	40	41	100	8
LR and TR Wall on Cut Wall	41	42	100	6
LR and TR Wall on Cut Wall	42	43	100	9
LR and TR Wall on Cut Wall	43	44	100	12
LR and TR Wall on Cut Wall	44	44.5	50	16
TR and LR Wall on Fill Wall	44.5	50	550	10
LR Wall on Fill Wall	50	55	500	8
LR Wall At-Grade	55	58	300	8
LR Wall on Cut Wall	58	59	100	4
LR Wall on Cut Wall	59	60	100	4
LR Wall on Cut Wall	60	61	100	2
LR Wall on Cut Wall	61	62	100	2

Table 8-2. Summary of Potential Noise Mitigation Measures for Preferred Alternative

Wall Type[a]	Start Station[b]	End Station[b]	Length (linear feet)	Height (feet)
TR Wall on Fill Wall	44	47	300	14
TR Wall on Fill Wall	47	49	200	16
TR Wall on Fill Wall	49	50	100	18
TR Wall on Fill Wall	50	56	600	22
TR Wall on Fill Wall	56	58	200	24
TR Wall on Fill Wall	58	59	100	24
TR Wall on Fill Wall	59	61	200	22
TR Wall on Fill Wall	61	62	100	20
TR Wall on Fill Wall	62	66	400	18
TR Wall At-Grade	2010.75	2011.75	100	16
TR Wall At-Grade	2011.75	2011.95	20	18
TR Wall At-Grade	2011.95	2012.75	80	20
TR Wall on Cut Wall	67.64	72	499	20
TR Wall on Cut Wall	72	74	200	18
TR Wall At-Grade	--	--	50	8
TR Wall At-Grade	--	--	50	10
TR Wall At-Grade	--	--	50	10
TR Wall At-Grade	--	--	50	10
TR Wall At-Grade	--	--	22	12
TR Wall At-Grade	--	--	30	12
TR Wall At-Grade	--	--	60	12
LR Wall on Structure	110	125	1,500	4
LR and TR Wall At-Grade (Alignment is on Structure)	123.2	123.5	60	38.37
LR and TR Wall At-Grade (Alignment is on Structure)	123.5	123.94	57	36.75
LR and TR Wall At-Grade (Alignment is on Structure)	123.94	124.67	73	35.2
LR and TR Wall At-Grade (Alignment is on Structure)	124.67	124.67	12	36.18
LR and TR Wall At-Grade (Alignment is on Structure)	124.67	126	133	36.18
LR and TR Wall At-Grade (Alignment is on Structure)	126	127	100	36.12
LR and TR Wall At-Grade (Alignment is on Structure)	127	128	100	13.07
LR and TR Wall At-Grade (Alignment is on Structure)	128	128.45	44	33.62
LR and TR Wall At-Grade (Alignment is on Structure)	128.45	128.78	50	33.16
LR and TR Wall At-Grade (Alignment is on Structure)	128.78	129.37	59	34.75
LR and TR Wall At-Grade (Alignment is on Structure)	129.37	130	63	33.81
LR and TR Wall At-Grade (Alignment is on Structure)	130	13.2	20	33.02
TR Wall At-Grade	130.2	131	80	20
LR Wall on Fill Wall	130.5	144	1,350	6
LR Wall on Structure	144	146	200	8
LR Wall on Fill Wall	146	162	1,600	8

Table 8-2. Summary of Potential Noise Mitigation Measures for Preferred Alternative

Wall Type[a]	Start Station[b]	End Station[b]	Length (linear feet)	Height (feet)
LR and TR Wall on Fill Wall	162	163	100	8
LR and TR Wall on Cut Wall	163	165	200	10
LR and TR Wall on Cut Wall	165	169	400	12
LR and TR Wall on Cut Wall	169	173	400	14
LR and TR Wall on Cut Wall	173	174	100	16
LR and TR Wall on Cut Wall	174	176	200	18
LR and TR Wall on Cut Wall	176	178	200	20
LR and TR Wall on Cut Wall	178	179	100	18
LR and TR Wall on Cut Wall	179	185	600	14
LR and TR Wall on Cut Wall	185	192	700	12
LR and TR Wall on Fill Wall	192	196.25	425	12
LR and TR Wall on Structure	196.25	200	375	8
LR Wall on Structure	200	205	500	8
LR Wall on Fill Wall	205	210	500	8
LR Wall on Cut Wall	210	216	600	8
TR and LR Wall on Cut Wall	216	217	100	10
TR and LR Wall on Cut Wall	217	218	100	12
TR and LR Wall on Cut Wall	218	219	100	14
TR and LR Wall on Cut Wall	219	220	100	16
TR and LR Wall on Cut Wall	220	221	100	16
TR and LR Wall on Cut Wall	221	222	100	18
TR and LR Wall on Cut Wall	222	223	100	18
TR and LR Wall on Cut Wall	223	223.5	50	18
TR and LR Wall on Cut Wall	223.5	224	50	16
TR and LR Wall on Cut Wall	224	224.5	50	12
TR and LR Wall on Cut Wall	224.5	225	50	10
TR and LR Wall on Cut Wall	225	225.45	45	8
TR Wall on Cut Wall	230	238	800	18
LR Wall on Cut Wall	233	237.33	433	6
LR and TR Wall At-Grade	237.33	238	67	14
LR and TR Wall At-Grade	238	239	100	16
LR and TR Wall At-Grade	239	242	300	18
LR and TR Wall At-Grade	242	244	200	20
LR and TR Wall At-Grade	244	245	100	18
LR and TR Wall At-Grade	245	246	100	16
LR and TR Wall At-Grade	246	247	100	14
Total linear feet of noise wall			**21,957**	

[a] "TR" stands for a replacement traffic noise wall that will mitigate traffic noise impacts caused by the project and, in some cases, light rail noise. "LR" stands for a wall that is intended to mitigate light rail noise only. All replacement traffic noise walls are included in this table.

[b] Station refers to locations on the project design drawings that indicate each 100-foot section of the proposed light rail route.

Alternative A1: At-grade/Elevated with NE 145th Street and NE 185th Street Stations

Table 8-3 summarizes the potential mitigation noise walls in Segment A for Alternative A1. The proposed noise mitigation would include approximately 11,200 linear feet of noise wall. The majority of noise walls on elevated structures would be 4 feet to 6 feet tall, while noise walls on retaining walls and in cut-and-fill sections would range from 4 feet to 8 feet tall. With the proposed noise walls (Table 8-3) and the relocation of existing noise walls, Sound Transit would mitigate all predicted noise impacts resulting from Alternative A1. In some areas, proposed replacement traffic noise walls might not fully mitigate all noise impacts from the project; these walls could be increased in height, if possible, or sound insulation might be applied to provide additional noise mitigation, where required.

Table 8-3. Summary of Potential Noise Mitigation Measures for Alternative A1

Wall Type[a]	Start Station[b]	End Station[b]	Length (linear feet)	Height (feet)
Wall on Structure	11	20	900	4
Wall on Retaining Wall	20	26	600	6
Wall At-Grade	36	37	100	4
Wall on Retaining Wall	37	45	800	4
Wall At-Grade	45	53	800	4
Wall on Structure	107	122	1,500	4 to 6
Wall on Retaining Wall	122	133	1,100	4 to 6
Wall on Structure	133	141	800	4 to 6
Wall on Retaining Wall	141	151	1,000	4 to 6
Wall At-Grade	151	156	500	4 to 6
Wall on Structure	190	196	600	4 to 6
Wall on Retaining Wall	196	199	300	4 to 6
Wall At-Grade	199	206	700	4 to 8
Wall on Retaining Wall	206	212	600	4 to 8
Wall on Retaining Wall	228	231	300	4
Wall At-Grade	231	237	600	4
Total linear feet of noise wall			**11,200**	

[a] Replacement traffic noise walls that do not also mitigate light rail noise are not included in this summary, but they would be included in the project, as necessary, to mitigate traffic noise impacts caused by this alternative.

[b] Station refers to locations on the project design drawings that indicate each 100-foot section of the proposed light rail route.

Alternative A3: Mostly Elevated with NE 145th and NE 185th Street Stations

Table 8-4 summarizes the potential mitigation noise walls in Segment A for Alternative A3. The proposed noise mitigation would include approximately 17,300 linear feet of noise wall, with Sound Transit installing most of the walls along the elevated guideway structures. All noise walls would be 4 feet to 6 feet tall. The proposed noise walls (Table 8-4) and the relocation of existing noise walls would together mitigate most predicted noise impacts. Currently, 10 single-family homes and a duplex immediately adjacent to the proposed light rail alignment on the east side of I-5 between NE Northgate Way and NE 125th Street NE and 15 single-family homes immediately adjacent to the alignment on the east side of I-5 between NE 175th Street and NE 200th Street NE might need sound insulation.

Table 8-4. Summary of Potential Noise Mitigation Measures for Alternative A3

Wall Type[a]	Start Station[b]	End Station[b]	Length (linear feet)	Height (feet)
Wall on Structure	11	87	7,600	4 to 6
Wall on Structure	108	126	1,800	4 to 6
Wall on Retaining Wall	126	131	500	4 to 6
Wall on Structure	131	141	1,000	4 to 6
Wall on Retaining Wall	141	149	800	4 to 6
Wall At-Grade	149	154	500	4 to 6
Wall on Retaining Wall	154	157	300	4
Wall on Structure	185	233	4,800	4 to 6
Total linear feet of noise wall			**17,300**	

[a] Replacement traffic noise walls that do not also mitigate light rail noise are not included in this summary, but they would be included in the project, as necessary, to mitigate traffic noise impacts caused by this alternative.

[b] Station refers to locations on the project design drawings that indicate each 100-foot section of the proposed light rail route.

Alternative A5: At-grade/Elevated with NE 130th, NE 155th, and NE 185th Street Stations

Table 8-5 summarizes the potential mitigation noise walls in Segment A for Alternative A5. The proposed noise mitigation would include approximately 11,000 linear feet of noise wall, with Sound Transit installing most of the walls along the elevated guideway structures and on retaining walls. The majority of noise walls on elevated structures would be 4 feet to 6 feet tall, while noise walls on retaining walls and at-grade would range from 4 feet to 8 feet tall. With the proposed noise walls, (Table 8-5) and the relocation of existing noise walls, Sound Transit would mitigate most predicted noise impacts. Currently, six single-family homes and a duplex immediately adjacent to the proposed light rail alignment on the east side of I-5 may need sound insulation.

Table 8-5. Summary of Potential Noise Mitigation Measures for Alternative A5

Wall Type[a]	Start Station[b]	End Station[b]	Length (linear feet)	Height (feet)
Wall on Structure	11	23	1,200	4 to 6
Wall on Retaining Wall	23	26	300	8
Wall At-Grade	26	33	700	8
Wall on Retaining Wall	33	44	1,100	4
Wall At-Grade	44	45	100	4
Wall on Structure	107	115	800	4 to 6
Wall on Retaining Wall	115	124	900	4 to 6
Wall on Structure	124	134	1,000	4
Wall on Structure	138	141	300	4
Wall on Retaining Wall	141	151	1,000	4 to 6
Wall At-Grade	151	156	500	4 to 6
Wall on Structure	190	196	600	4 to 6
Wall on Retaining Wall	196	199	300	4 to 6
Wall At-Grade	199	204	500	4 to 8
Wall on Retaining Wall	204	209	500	4
Wall At-Grade	223	224	100	4

Table 8-5. Summary of Potential Noise Mitigation Measures for Alternative A5

Wall on Retaining Wall	224	226	200	4
Wall At-Grade	226	230	400	4 to 6
Wall on Retaining Wall	230	231	100	4
Wall At-Grade	231	234	300	4 to 6
Wall on Retaining Wall	234	235	100	4
Total linear feet of noise wall			**11,000**	

[a] Replacement traffic noise walls that do not also mitigate light rail noise are not included in this summary, but they would be included in the project, as necessary, to mitigate traffic noise impacts caused by this alternative.

[b] Station refers to locations on the project design drawings that indicate each 100-foot section of the proposed light rail route.

Alternative A7: Mostly Elevated with NE 130th, NE 155th, and NE 185th Street Stations

Table 8-6 summarizes the potential mitigation noise walls in Segment A for Alternative A7. The proposed noise mitigation would include approximately 17,400 linear feet of noise wall, with Sound Transit installing most of the walls along the elevated guideway structures. The majority of noise walls on elevated structures would be 4 feet to 6 feet tall, while noise walls on retaining walls and at-grade would range from 4 feet to 8 feet tall. With the proposed walls (Table 8-6) and the relocation of existing noise walls, South Transit would mitigate most predicted noise impacts. Currently, 29 residences on the east side of I-5 may need sound insulation. Ten of these residences are 8 single-family residences and a duplex immediately adjacent to the proposed light rail alignment between NE Northgate Way and NE 120th Street NE. Four of these residences are located on the east side of I-5 between NE 120th Street and NE 152nd Street. The remaining 15 of these residences are single-family homes immediately adjacent to the alignment between NE 178th Street and NE 190th Street NE.

Table 8-6. Summary of Potential Noise Mitigation Measures for Alternative A7

Wall Type[a]	Start Station[b]	End Station[b]	Length (linear feet)	Height (feet)
Wall on Structure	11	87	7,600	4 to 6
Wall on Structure	107	114	700	4
Wall on Retaining Wall	114	125	1,100	4 to 8
Wall on Structure	125	140	1,500	4 to 6
Wall on Retaining Wall	140	150	1,000	4 to 6
Wall At-Grade	150	154	400	4 to 6
Wall on Retaining Wall	155	156	100	4
Wall on Structure	185	235	5,000	4 to 6
Total linear feet of noise wall			**17,400**	

[a] Replacement traffic noise walls that do not also mitigate light rail noise are not included in this summary, but they would be included in the project, as necessary, to mitigate traffic noise impacts caused by this alternative.

[b] Station refers to locations on the project design drawings that indicate each 100-foot section of the proposed light rail route.

Alternative A10: At-grade/Elevated with NE 130th, NE 145th, and NE 185th Street Stations

Table 8-7 summarizes the potential mitigation noise walls in Segment A for Alternative A10. The proposed noise mitigation would include approximately 11,500 linear feet of noise wall, with Sound Transit installing most of the walls along the elevated guideway structures and retaining walls. The majority of noise walls on elevated structures would be 4 feet to 6 feet tall, while noise walls on retaining walls and at-grade would range from 4 feet to 8 feet tall. The proposed walls (see Table 8-7) together with the relocation of existing noise walls would mitigate most predicted noise impacts. Currently, three single-family homes immediately adjacent to the proposed light rail alignment on the east side of I-5 may need sound insulation. Two of these homes are located between NE 115th Street and NE 117th Street NE, and one is just north of NE 175th Street.

Table 8-7. Summary of Potential Noise Mitigation Measures for Alternative A10

Wall Type[a]	Start Station[b]	End Station[b]	Length (linear feet)	Height (feet)
Wall on Structure	11	23	1,200	4 to 6
Wall on Retaining Wall	23	27	400	8
Wall At-Grade	27	34	700	8
Wall on Retaining Wall	34	44	1,000	4
Wall At-Grade	44	45	100	4
Wall on Structure	107	122	1,500	4 to 6
Wall on Retaining Wall	122	133	1,100	4 to 6
Wall on Structure	133	141	800	6 to 8
Wall on Retaining Wall	141	156	1,500	6 to 8
Wall on Structure	190	196	600	6
Wall on Retaining Wall	196	199	300	8
Wall At-Grade	199	206	700	8
Wall on Retaining Wall	206	210	400	8
Wall At-Grade	223	224	100	4
Wall on Retaining Wall	224	226	200	4
Wall At-Grade	226	230	400	4 to 6
Wall on Retaining Wall	230	231	100	4 to 6
Wall At-Grade	231	234	300	4 to 6
Wall on Retaining Wall	234	235	100	4 to 6
Total linear feet of noise wall			**11,500**	

[a] Replacement traffic noise walls that do not also mitigate light rail noise are not included in this summary, but they would be included in the project, as necessary, to mitigate traffic noise impacts caused by this alternative.

[b] Station refers to locations on the project design drawings that indicate each 100-foot section of the proposed light rail route.

Alternative A11: Mostly Elevated with NE 130th, NE 145th, and NE 185th Street Stations

Table 8-8 summarizes the potential mitigation noise walls in Segment A for Alternative A11. The proposed noise mitigation would include approximately 17,100 linear feet of noise wall, with Sound Transit installing most of the walls along the elevated guideway structures. All noise walls would be 4 feet to 6 feet tall. The proposed walls (Table 8-8) together with the relocation of existing noise walls would mitigate most predicted noise impacts. Currently, 10 single-family homes and a duplex immediately adjacent to the proposed light rail alignment on the east side of I-5 between NE 115th Street and NE 123rd Street NE, a single family residence on NE 158th Street, and 15 single-family homes immediately adjacent to the alignment on the east side of I-5 between NE 178th Street and NE 190th Street NE may need sound insulation.

Table 8-8. Summary of Potential Noise Mitigation Measures for Alternative A11

Wall Type[a]	Start Station[b]	End Station[b]	Length (linear feet)	Height (feet)
Wall on Structure	11	87	7,600	4 to 6
Wall on Structure	108	126	1800	4 to 6
Wall on Retaining Wall	126	131	500	4 to 6
Wall on Structure	131	141	1000	4 to 6
Wall on Retaining Wall	141	151	1000	4 to 6
Wall At-Grade	151	154	300	4 to 6
Wall on Retaining Wall	154	155	100	4
Wall on Structure	185	233	4,800	4 to 6
Total linear feet of noise wall			**17,100**	

[a] Replacement traffic noise walls that do not also mitigate light rail noise are not included in this summary, but they would be included in the project, as necessary, to mitigate traffic noise impacts caused by this alternative.

[b] Station refers to locations on the project design drawings that indicate each 100-foot section of the proposed light rail route.

8.5.2 Segment B

The primary noise mitigation measure in Segment B would be the use of noise walls, including short, acoustical absorbent walls directly attached to the sides of the elevated guideway. Sound Transit would also use additional at-grade noise walls and walls along retained fills and cuts, depending on the track type. In Segment B there are several locations where the receivers would be substantially above the grade of the alignment and, therefore, noise walls might not be as effective as when the light rail profile is at the same or higher elevation as the receivers. For those sites, building sound insulation might be the only form of noise mitigation available.

Preferred Alternative Segment B

Under the Preferred Alternative, there are 16,975 feet of new noise walls proposed. The walls are located on retaining walls, at-grade, and along the sides of elevated structures and range in height from 4 to 8 feet tall. With the additional noise walls, all predicted noise impacts resulting from the Preferred Alternative would be mitigated, with the exception of 9 single-family residences. The remaining homes with light rail noise impacts will be reevaluated during final design to verify the impacts and apply sound insulation if necessary.. Table 8-9 provides the location and heights of the noise walls. At the time of this report, there were no replacement traffic noise walls under the Preferred Alternative.

Table 8-9. Summary of Potential Noise Mitigation Measures for Preferred Alternative

Wall Type[a]	Start Station[b]	End Station[b]	Length (linear feet)	Height (feet)
East Side of Alignment				
LR Wall on Cut Wall	247	264	1,700	6
LR Wall on Cut Wall	264	265	100	8
LR Wall on Cut Wall	265	266.2	120	6
LR Wall on Structure	266.2	276	980	6
LR Wall on Structure	276	283	700	4
LR Wall on Structure	289	310	2,100	4
LR Wall on Structure	400	402.25	225	8
LR Wall on Cut Wall	402.25	406.7	445	8
LR Wall on Structure	442	465.8	2,380	4
LR Wall on Fill Wall	465.8	475	920	4
West Side of Alignment				
LR Wall on Cut Wall	402.25	406.7	445	4
LR Wall on Structure	406.7	411	430	4
LR Wall on Structure	411	423	1,200	8
LR Wall on Structure	442	452	1,000	6
LR Wall on Structure	452	465.8	1,380	4
LR Wall on Fill Wall	465.8	467	120	6
LR Wall on Fill Wall	467	469	200	8
LR Wall on Fill Wall	469	471	200	6
LR Wall on Fill Wall	471	473	200	4
LR Wall on Cut Wall	473	474	100	4
LR and TR Wall At-Grade	474	485	1,100	--
Total linear feet of noise wall and traffic safety barrier			**16,975**	

[a] "LR" stands for a wall that is intended to mitigate light rail noise only. There are no replacement traffic noise walls in Segment B.

[b] Station refers to locations on the project design drawings that indicate each 100-foot section of the proposed light rail route.

Preferred Alternative Segment B with 220th Street Station South Option

Mitigation for the Preferred Alternative with the 220th Street Station South Option is the same as provided for the Preferred Alternative.

Alternative B1: East side to Mountlake Terrace Transit Center to Median

Table 8-10 summarizes the potential mitigation noise walls in Segment B with Alternative B1. The proposed noise mitigation would include approximately 20,800 linear feet of noise wall, with 12,900 feet of wall on the east side and 7,900 feet of wall on the west side of the alignment. All noise walls would be 4 feet to 8 feet tall, and slightly taller walls could be used if they were found to be effective at mitigating receiver locations higher than the light rail alignment. In addition, where the alignment is in the I-5 median, the walls would be maintained continuously as an approximately 3- to 4-foot-tall safety barrier. This would be required regardless of the noise impacts, except along the portion of the alignment where the light rail would be in a retained cut below the grade of the northbound lanes, where a safety barrier already exists. Sound Transit would mitigate all predicted noise impacts by installing the proposed noise walls (Table 8-10).

Table 8-10. Summary of Potential Noise Mitigation Measures for Alternative B1

Wall Type	Start Station[a]	End Station[a]	Length (linear feet)	Height (feet)
East Side of Alignment				
Wall on Retaining Wall	305	321	1,600	4 to 6
Wall on Structure	321	338	1,700	4
Wall on Structure	352	364	1,200	4
Wall on Structure	370	388	1,800	4 to 6
Wall At-Grade or Wall on Retaining Wall (includes traffic safety barrier)	388	454	6,600	4 to 6
West Side of Alignment				
Wall on Structure	378	388	1,000	6
Wall on Retaining Wall (includes traffic safety barrier)	388	392	400	8
Wall At-Grade (includes traffic safety barrier)	392	451	5,900	4 to 6
Wall on Retaining Wall	451	452	100	8
Wall on Structure	452	457 (merge with wall in Segment C, which begins at station 500)	500	6
Total linear feet of noise wall and traffic safety barrier			**20,800**	

[a] Station refers to locations on the project design drawings that indicate each 100-foot section of the proposed light rail route.

Alternative B2A: East Side to Mountlake Terrace Transit Center to West Side

Table 8-11 summarizes the potential mitigation noise walls in Segment B with Alternative B2A. The proposed noise mitigation would include approximately 15,000 linear feet of noise wall, with 6,700 feet of wall on the east side and 8,300 feet of wall on the west side of the alignment. All noise walls would be 4 feet to 6 feet tall, and slightly taller walls could be used if they were found to be effective at mitigating receiver locations at a higher elevation than the light rail alignment. With the proposed noise walls (Table 8-11), relocating several noise walls, and adding building sound insulation where required, Sound Transit would mitigate all predicted noise impacts. Currently, one single-family home along the east side of I-5 near 12th Avenue NE might need sound insulation. In addition, two homes immediately south of the 212th Street SW that have severe noise impacts might also need sound insulation.

Table 8-11. Summary of Potential Noise Mitigation Measures for Alternative B2A

Wall Type	Start Station[a]	End Station[a]	Length (linear feet)	Height (feet)
East Side of Alignment				
Wall on Structure	321	338	1,700	4
Wall on Structure	353	365	1,200	4
Wall on Structure	369	388	1,900	4 to 6
Wall near Track	400	419	1,900	4

Table 8-11. Summary of Potential Noise Mitigation Measures for Alternative B2A

Wall Type	Start Station[a]	End Station[a]	Length (linear feet)	Height (feet)
West Side of Alignment				
Wall on Structure	377	385	800	4 to 6
Wall on Retaining Wall	385	400	1,500	4 to 6
Wall on Structure	400	438	3,800	4
Wall on Fill/Structure	438	460 (merge with wall in Segment C, which begins at station 500)	2,200	4 to 6
Total linear feet of noise wall			**15,000**	

[a] Station refers to locations on the project design drawings that indicate each 100-foot section of the proposed light rail route.

Alternative B4: East Side to Mountlake Terrace Freeway Station to Median

Table 8-12 summarizes the potential noise walls that Sound Transit would use to mitigate noise in Segment B for Alternative B4. The proposed noise mitigation would include approximately 20,000 linear feet of noise wall, with 12,100 feet of wall on the east side and 7,900 feet of wall on the west side of the alignment. All noise walls would be 4 feet to 8 feet tall, and slightly taller walls could be used if they were found to be effective at mitigating receiver locations at a higher elevation than the light rail alignment. In addition, where the light rail alignment is in the I-5 median, the walls would be maintained continuously as a safety barrier approximately 3 feet to 4 feet tall. This would be required regardless of the noise impacts, except along the portion of the alignment where the light rail would be in a retained cut below the grade of the northbound lanes, and where a safety barrier already exists. With the proposed noise walls (Table 8-12), Sound Transit would mitigate all predicted noise impacts.

Table 8-12. Summary of Potential Noise Mitigation Measures for Alternative B4

Wall Type	Start Station[a]	End Station[a]	Length (linear feet)	Height (feet)
East Side of Alignment				
Wall on Retaining Wall	305	321	1,600	4 to 6
Wall on Structure	321	338	1,700	4
Wall on Structure	352	365	1,300	4
Wall on Structure (includes traffic safety barrier)	378	388	1,000	4 to 6
Wall At-Grade or Wall on Retaining Wall (includes traffic safety barrier)	388	453	6,500	4 to 6

Table 8-12. Summary of Potential Noise Mitigation Measures for Alternative B4

Wall Type	Start Station[a]	End Station[a]	Length (linear feet)	Height (feet)
West Side of Alignment				
Wall on Structure (includes traffic safety barrier)	378	388	1,000	6
Wall on Retaining Wall (includes traffic safety barrier)	388	392	400	8
Wall At-Grade (includes traffic safety barrier)	392	451	5,900	4 to 6
Wall on Retaining Wall (includes traffic safety barrier)	451	452	100	8
Wall on Structure (includes traffic safety barrier)	452	457 (merge with wall in Segment C, which begins at station 500)	500	4 to 6
Total linear feet of noise wall and traffic safety barrier			**20,000**	

[a] Station refers to locations on the project design drawings that indicate each 100-foot section of the proposed light rail route.

8.5.3 Segment C

The light rail alignment in Segment C would be mainly elevated in areas with noise impacts; therefore, noise walls on the elevated guideway structure would be the primary noise mitigation. Additional at-grade noise walls and walls along retained fills and cuts would also be used for the light rail alignments along I-5. New traffic noise walls would also be required under the Preferred Alternative in the area around the Lynnwood Park-and-Ride Station. These noise walls are not included in the discussions that follow but are explained in detail in Section 8.8 of this report.

Preferred Alternative Segment C

Under the Preferred Alternative in Segment C, there are 3,225 feet of noise walls proposed along the west side of the elevated structure and 735 feet along the east side of the elevated structure. With the proposed noise walls, all noise impacts would be mitigated. The noise wall location and heights are provided in Table 8-13.

Table 8-13. Summary of Potential Noise Mitigation Measures for Preferred Alternative

Wall Type[a]	Start Station[b]	End Station[b]	Length (linear feet)	Height (feet)
LR Wall on Structure	491 (continued from Segment B)	498	700	4
LR Wall on Structure	498	502	400	6
LR Wall on Structure	502	507.5	550	4
LR Wall on Structure	515	530.75	1,575	4
LR Wall on Structure	534.5	541.85	735	4
Total linear feet of noise wall			**3,960**	

[a] "LR" stands for a wall that is intended to mitigate light rail noise only. There are no replacement traffic noise walls in Segment C. New traffic noise walls are explained in detail in Section 8.8 of this report.

[b] Station refers to locations on the project design drawings that indicate each 100-foot section of the proposed light rail route.

Alternative C1: 52nd Avenue West to 200th Street SW, with Option 1

Table 8-14 summarizes the potential noise walls for noise mitigation in Segment C for Alternative C1 with Option 1. The proposed noise mitigation would include approximately 7,200 linear feet of noise wall, with 2,900 feet of wall on the east side and 4,300 feet of wall on the west side of the light rail alignment. All noise walls would be 4 feet to 6 feet tall, and slightly taller walls could be used if they were found to be effective at mitigating elevated receiver locations. With the proposed noise walls (Table 8-14), Sound Transit would mitigate all predicted noise impacts.

Table 8-14. Summary of Potential Noise Mitigation Measures for Alternative C1 with Option 1

Wall Type	Start Station[a]	End Station[a]	Length (linear feet)	Height (feet)
East Side of Alignment				
Wall on Structure	508	512	400	4
Wall on Structure	540	560	2,500	4 to 6
West Side of Alignment				
Wall on Structure	500 (continued from Segment B)	535	3,500	4
Wall on Structure	535	548	800	4 to 6
Total linear feet of noise wall			**7,200**	

[a] Station refers to locations on the project design drawings that indicate each 100-foot section of the proposed light rail route.

Alternative C1: 52nd Avenue West to 200th Street SW, with Option 2

Noise mitigation under Alternative C1 with Option 2 would be the same as described above for Alternative C1 with Option 1.

Alternative C2: 52nd Avenue West to Lynnwood Transit Center, with Option 1

Table 8-15 summarizes the potential noise walls to mitigate noise in Segment C for Alternative C2 with Option 1. The proposed noise mitigation would include approximately 6,600 linear feet of noise wall, with 2,200 feet of wall on the east side and 4,400 feet of wall on the west side of the light rail alignment. All noise walls would be 4 feet to 6 feet tall, and slightly taller walls could be used if they were found to be effective at mitigating elevated receiver locations. With the proposed noise walls (see Table 8-15), Sound Transit would mitigate all predicted noise impacts.

Table 8-15. Summary of Potential Noise Mitigation Measures for Alternative C2 with Option 1

Wall Type	Start Station[a]	End Station[a]	Length (linear feet)	Height (feet)
East Side of Alignment				
Wall on Structure	508	512	400	4
Wall on Structure	535	553	1,800	4 to 6
West Side of Alignment				
Wall on Structure	500 (continued from Segment B)	535	3,500	4
Wall on Structure	535	544	900	4
Total linear feet of noise wall			**6,600**	

[a] Station refers to locations on the project design drawings that indicate each 100-foot section of the proposed light rail route.

Alternative C2: 52nd Avenue West to Lynnwood Transit Center, with Option 2

Noise mitigation under Alternative C2 with Option 2 would be the same as described for Alternative C2 with Option 1.

Alternative C3: Along I-5 to Lynnwood Park-and-Ride, with Option 1

Table 8-16 summarizes the potential noise walls to mitigate noise in Segment C for Alternative C3 with Option 1. The proposed noise mitigation would include approximately 1,700 linear feet of noise wall. All noise walls would be 4 feet tall. With the proposed walls (Table 8-16), Sound Transit would mitigate all predicted noise impacts.

Table 8-16. Summary of Potential Noise Mitigation Measures for Alternative C3 with Option 1

Wall Type	Start Station[a]	End Station[a]	Length (linear feet)	Height (feet)
Wall on Retaining Wall	500 (continued from Segment B)	507	700	4
Wall on Structure	507	517	1,000	4
Total linear feet of noise wall			**1,700**	

[a] Station refers to locations on the project design drawings that indicate each 100-foot section of the proposed light rail route.

Alternative C3: Along I-5 to Lynnwood Park-and-Ride, with Option 2

Noise mitigation under Alternative C3 with Option 2 would be the same as discussed for Alternative C3 with Option 1.

8.6 Park-and-Ride Facility Noise Mitigation

This section provides specific noise mitigation for impacts associated with the park-and-ride facilities based on the most current conceptual drawings for the facilities. Those impacts are summarized in Tables 7-4, 7-17 and 7-23. These mitigation measures would be in addition to those for the light rail operations and are not included in Table 8-1. The approximate length and heights of the walls are provided in the following sections.

8.6.1 Segment A

Preferred Alternative with NE 130th Station Option

With the NE 130th Street Station Option under the Preferred Alternative, there would be no park-and-ride noise impacts; therefore, no noise mitigation is proposed.

Preferred Alternative with NE 145th Station

With the NE 145th Street Station under the Preferred Alternative, there would be no park-and-ride noise impacts; therefore, no noise mitigation is proposed.

Preferred Alternative with NE 185th Station

With the NE 185th Street Station under the Preferred Alternative, there would be 13 park-and-ride noise impacts. Most of the noise impacts are related to the noise from buses operating on the station turnout during early morning hours in addition to traffic accessing the station. The noise mitigation would include a noise wall along the east side of the bus access area for approximately 530 feet long and 10 to 12 feet tall. The noise wall would reduce noise from bus operations by up to 10 dBA. There is a potential for sound insulation or a taller noise wall at one residence located at the north end of the station area. Further investigation will be performed during final design.

Preferred Alternative with NE 185th Station with Shoreline Stadium Garage Option

With the NE 185th Street Station with the Shoreline Stadium Garage Option under the Preferred Alternative, there would be 16 park-and-ride noise impacts. Noise mitigation is the same as proposed for the Preferred Alternative with the NE 185th Street Station with the exception of the three impacts located along NE 185th Street near I-5. These three impacts, which do not occur under the Preferred Alternative with the NE 185th Street Station, would be mitigated with station design, such as taller walls along the parking garage, or residential sound insulation.

NE 130th Street Station Option 1

Under Alternatives A5 and A10 with the NE 130th Street Station Option 1, there would be no park-and-ride noise impacts; therefore, no noise mitigation is proposed.

NE 130th Street Station Option 2

Under Alternatives A7 and A11 with the NE 130th Street Station Option 2, there would be no noise impacts; therefore, no noise mitigation is proposed.

NE 145th Street Station Option 1

Under Alternatives A1 and A10 with the NE 145th Street Station Option 1, there would be 2 park-and-ride noise impacts. Noise mitigation for the parking structure could include modifications to the structure to shield the nearby residences from traffic noise.

NE 145th Street Station Option 2

Under Alternatives A3 and A11 with the NE 145th Street Station Option 2, there would be no park-and-ride noise impacts; therefore, no noise mitigation is proposed.

NE 155th Street Station Option 1

Under Alternatives A5 and A7 with the NE 155th Street Station, there would be park-and-ride noise impacts at five properties directly adjacent to the parking garage during the early morning hours of 6:00 am to 7:00 am under the assumption that all 500 parking spaces would be filled in 1 hour by 7:00 am. The analysis assumes no additional shielding from the parking structure. Noise mitigation for the parking structure could include modifications to the structure to shield the nearby residences and Fire Department from traffic noise emitted from the structure or by providing sound insulation as needed to the five impacted structures.

NE 185th Street Station Option 1

Under Alternative A1 with the NE 185th Street Station Option 1, Sound Transit identified 13 single-family residences that would experience park-and-ride noise impacts from buses accessing the station drop-off and layover area off 8th Avenue NE, and continuing along the new bus-only route to the elevated station. All impacts would be related to the noise from buses entering and leaving the drop-off and layover area near residences on 8th Avenue NE and near residences on NE 185th Street. Up to six of the affected residences would be mitigated with a noise wall along the northern and western property lines of the affected residences. These homes are located on 8th Avenue NE directly adjacent to the bus travel routes through the station drop-off and layover area. All other impacts would be mitigated with sound insulation. With the proposed noise mitigation measures, all noise impacts would be mitigated.

NE 185th Street Station Option 2

Under Alternatives A3, A7, and A11 with the NE 185th Street Station Option 2, Sound Transit identified nine single-family residences that would experience park-and-ride noise impacts from the buses accessing the park-and-ride. All noise impacts would be related to noise from buses entering the park-and-ride near residences on 8th Avenue NE and leaving the park-and-ride near residences on NE 185th Street. There are no feasible noise walls that could be used to provide noise mitigation; therefore, all nine single-family residences would be mitigated with sound insulation.

NE 185th Street Station Option 3

Under Alternatives A5 and A10 with the NE 185th Street Station Option 3, Sound Transit identified 12 single-family residences that would experience park-and-ride noise impacts from buses accessing the park-and-ride on 8th Avenue NE. The noise impacts would be related to noise from buses entering and leaving the park-and-ride near residences on 8th Avenue NE. The majority of the impacts would be mitigated with sound insulation. Two affected residences could be mitigated with a noise wall between 8th Avenue NE and the power substation. With the proposed mitigation, all noise impacts would be mitigated.

8.6.2 Segment B

Preferred Alternative with Mountlake Terrace Station

With the Mountlake Terrace Transit Center Station Option under the Preferred Alternative, Sound Transit identified four single-family residences that would have park-and-ride noise impacts. Mitigation for these impacts would include a noise wall on top of the eastern retaining wall between the park-and-ride facility and the residences. The wall would be effective at mitigating all noise impacts under this station option.

Preferred Alternative with 220th Street Station South Option

With the 220th Street Station South Option under the Preferred Alternative, there would be no park-and-ride noise impacts; therefore, no noise mitigation is proposed.

Mountlake Terrace Transit Center

With the Mountlake Terrace Transit Center Station Option under Alternatives B1 and B2A, Sound Transit identified four single-family residences that would have park-and-ride noise impacts. Mitigation for these impacts would include a noise wall on top of the eastern retaining wall between the park-and-ride facility and the residences. The wall would be effective at mitigating all noise impacts under this station option.

Mountlake Terrace Freeway Station

With the Mountlake Terrace Freeway Station Option under Alternative B4, the park-and-ride noise impacts and mitigation would be the same as described above under the Mountlake Terrace Transit Center Station option. With the proposed mitigation, all noise impacts would be mitigated.

220th Street SW Station

With the 220th Street Station North Option under Alternative B2A, there would be no noise impacts from vehicles accessing the park-and-ride lot; therefore, no noise mitigation is proposed.

8.6.3 Segment C

Preferred Alternative with Lynnwood Transit Center Station

With the Lynnwood Transit Center Station Option under the Preferred Alternative, Sound Transit identified park-and-ride noise impacts at 58 multifamily units near the proposed park-and-ride. All impacts would be related to noise from buses accessing the reconfigured bus facility. Because of the elevation of the multifamily units, all noise impacts would be mitigated with sound insulation.

200th Street SW

With the 200th Street SW Park-and-Ride Station Option under Alternative C1, Sound Transit identified park-and-ride noise impacts at 51 multifamily units near the proposed park-and-ride. All impacts would be related to noise from buses accessing the reconfigured bus facility and, to a lesser extent, from vehicles accessing the parking areas off 48th Avenue West. Because of the elevation of the multifamily units, all noise impacts would be mitigated with sound insulation.

Lynnwood Transit Center

With the Lynnwood Transit Center Station Option under Alternative C2, noise impacts from the transit center would be the same as given above under the Preferred Alternative with the Lynnwood Transit Center. Because of the elevation of the multifamily units, all noise impacts would be mitigated with sound insulation.

Lynnwood Park-and-Ride Station Option 1

With the Lynnwood Park-and-Ride Station Option 1 under Alternative C3, 58 noise impacts were identified. Because of the elevation of the multifamily units, all noise impacts would be mitigated with sound insulation.

Lynnwood Park-and-Ride Station Option 2

With the Lynnwood Park-and-Ride Station Option 2 12 noise impacts were identified. All impacts would be related to noise from buses accessing the reconfigured bus facility at night. Because of the elevation of the multifamily units, all noise impacts would be mitigated with sound insulation..

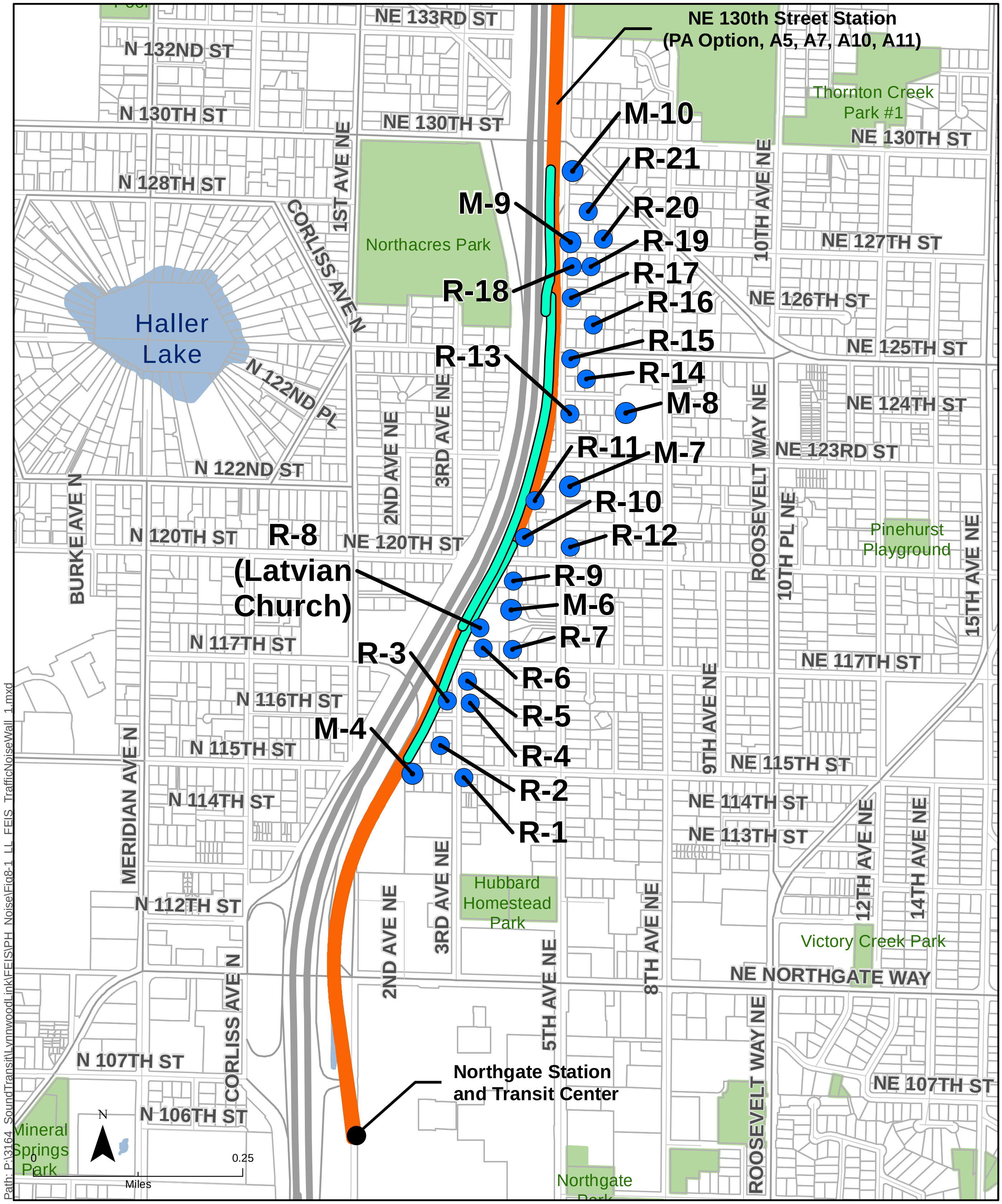
8.7 Traffic Noise Wall Replacements

This section describes the replacement traffic noise walls for the five areas modeled under the existing conditions and in the year 2035 with and without construction of the project (see Section 7.4, Traffic Noise Levels). Maps showing the location of the receivers used in the noise modeling and the locations and heights of each of the proposed replacement noise walls are provided on Figures 8-1 through 8-5. Some of these relocated walls would also reduce transit noise experienced in the neighborhoods behind the walls. The analysis of the transit noise benefits of the walls are included in Section 8.5.

This section provides the traffic noise modeling results at the representative receivers for the weekday PM peak hour under the Preferred Alternative, using year 2035 predicted traffic volumes, compared to the existing condition and the future No Build conditions for the year 2035. The modeling results are compared with the replacement wall design criteria (see Section 5.9). It is important to note that the Future No-Build conditions are the future noise levels (predicted for the year 2035) without the project, while the existing conditions are modeled results using the current (2013) traffic volumes. Therefore, the comparison of Future Build to No Build conditions provides an assessment of the direct impacts of the project, while the comparison to existing conditions provides an assessment of cumulative impacts of the project and increased traffic in the corridor. A discussion of traffic noise analysis issues specific to each area is included when applicable.

8.7.1 Replacement Traffic Noise Wall #1—NE 115th Street to NE 130th Street

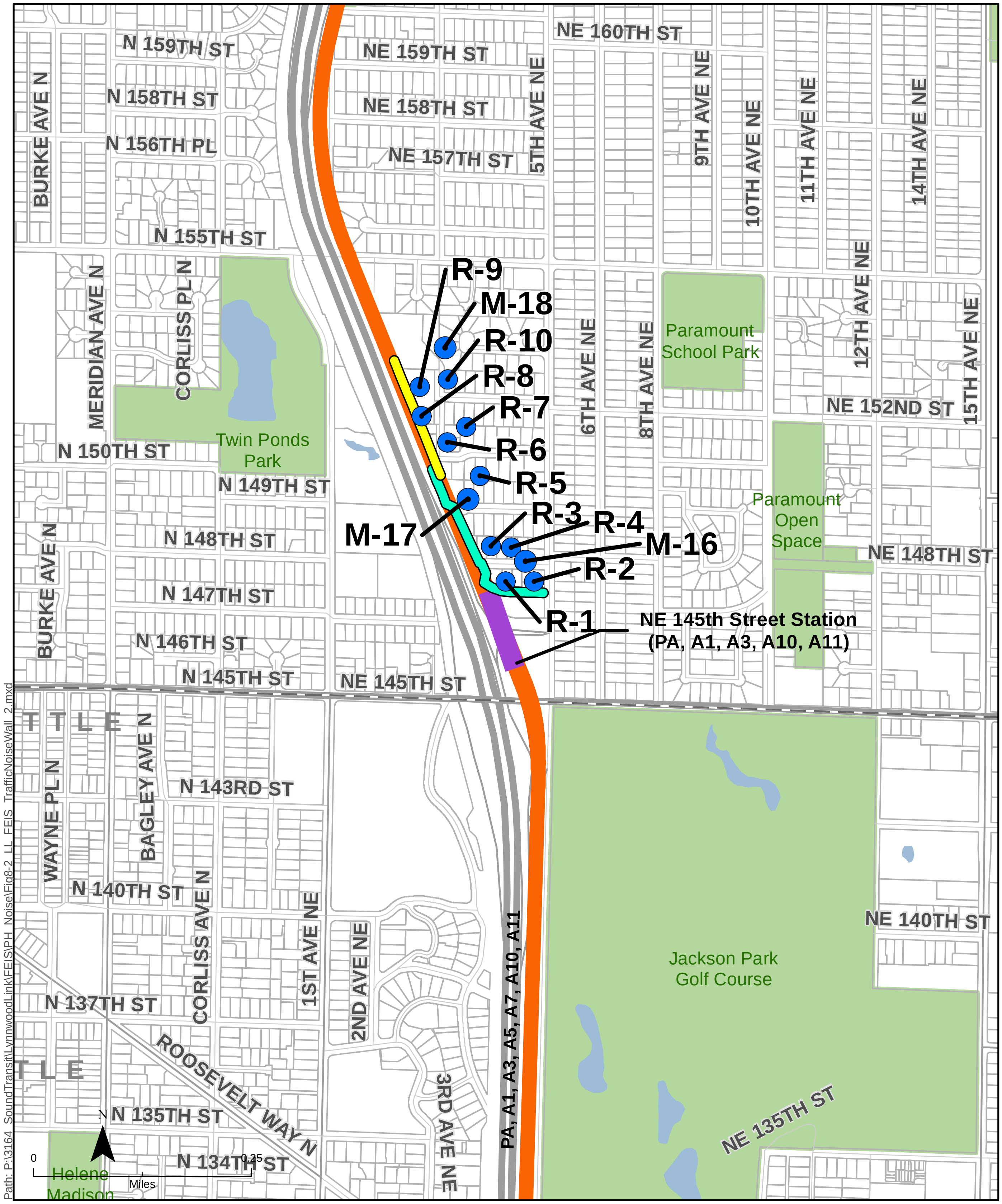
Replacement Traffic Noise Wall #1 is a system of three separate but overlapping walls. The first wall begins south of NE 115th Street at approximately station number 35 and extends north along the east side of the light rail alignment to station number 50. The first wall is approximately 1,500 feet in length and has heights of 6 feet to 16 feet along the light rail alignment. The second wall begins at station number 44 and extends north along the west side of the light rail alignment (and east of the I-5 northbound off-ramp) to station number 66. The second wall is approximately 2,184 feet in length and has heights of 14 feet to 24 feet. The third wall begins at approximately ramp station number 2011 of the I-5 northbound off-ramp at NE 130th Street and extends north along the west side of the off-ramp to approximately ramp station number 2013, at which point it



Data Sources: (King County, Snohomish County, WSDOT, Sound Transit)

- Receiver Location
- Replacement Traffic Noise Wall
- Preferred Alternative (PA)
- Preferred Alternative Station Location

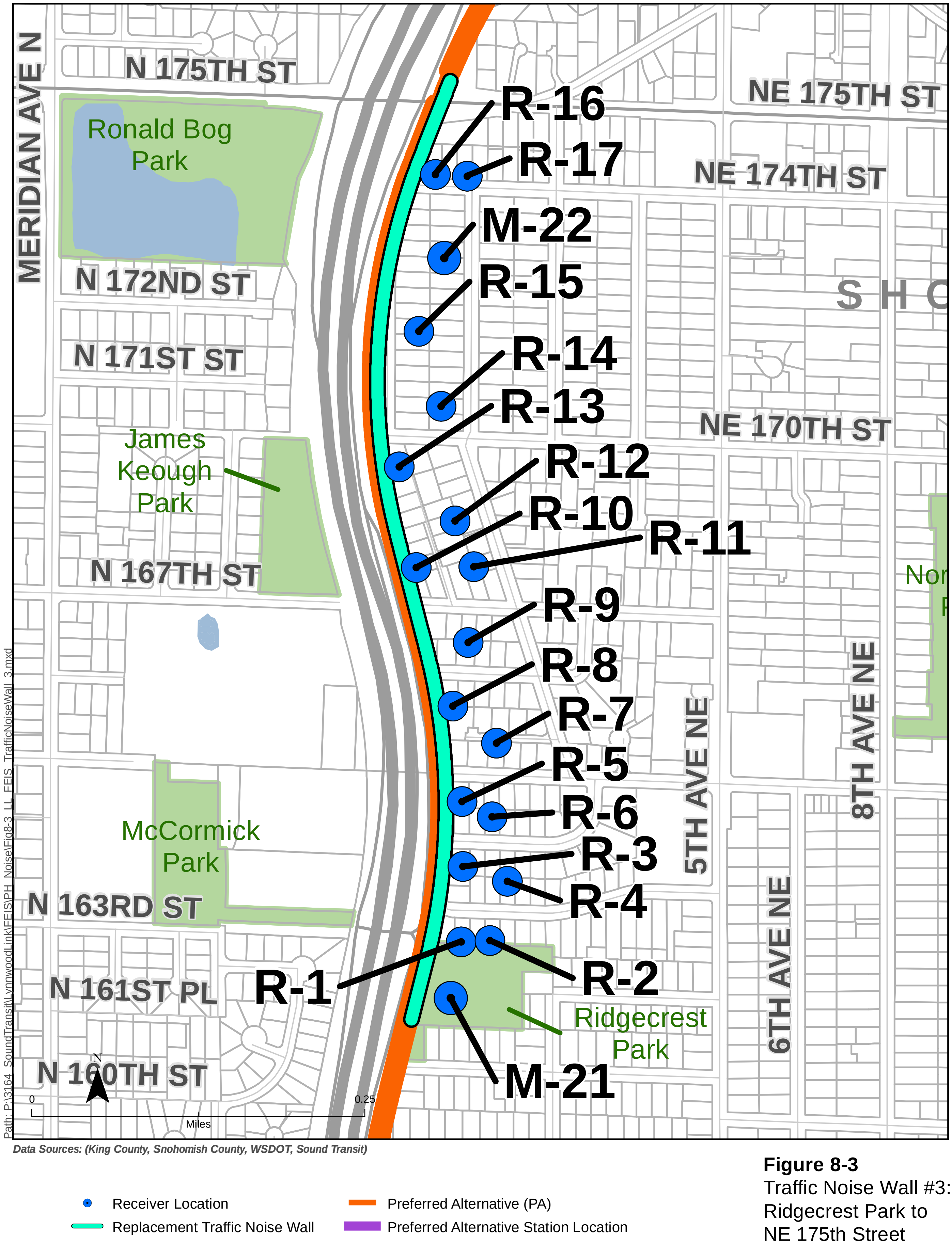
Figure 8-1
Traffic Noise Wall #1:
NE 115th Street to
NE 130th Street



Data Sources: (King County, Snohomish County, WSDOT, Sound Transit)

- Receiver Location
- Replacement Traffic Noise Wall
- Retaining Wall
- Preferred Alternative (PA)
- Preferred Alternative Station Location

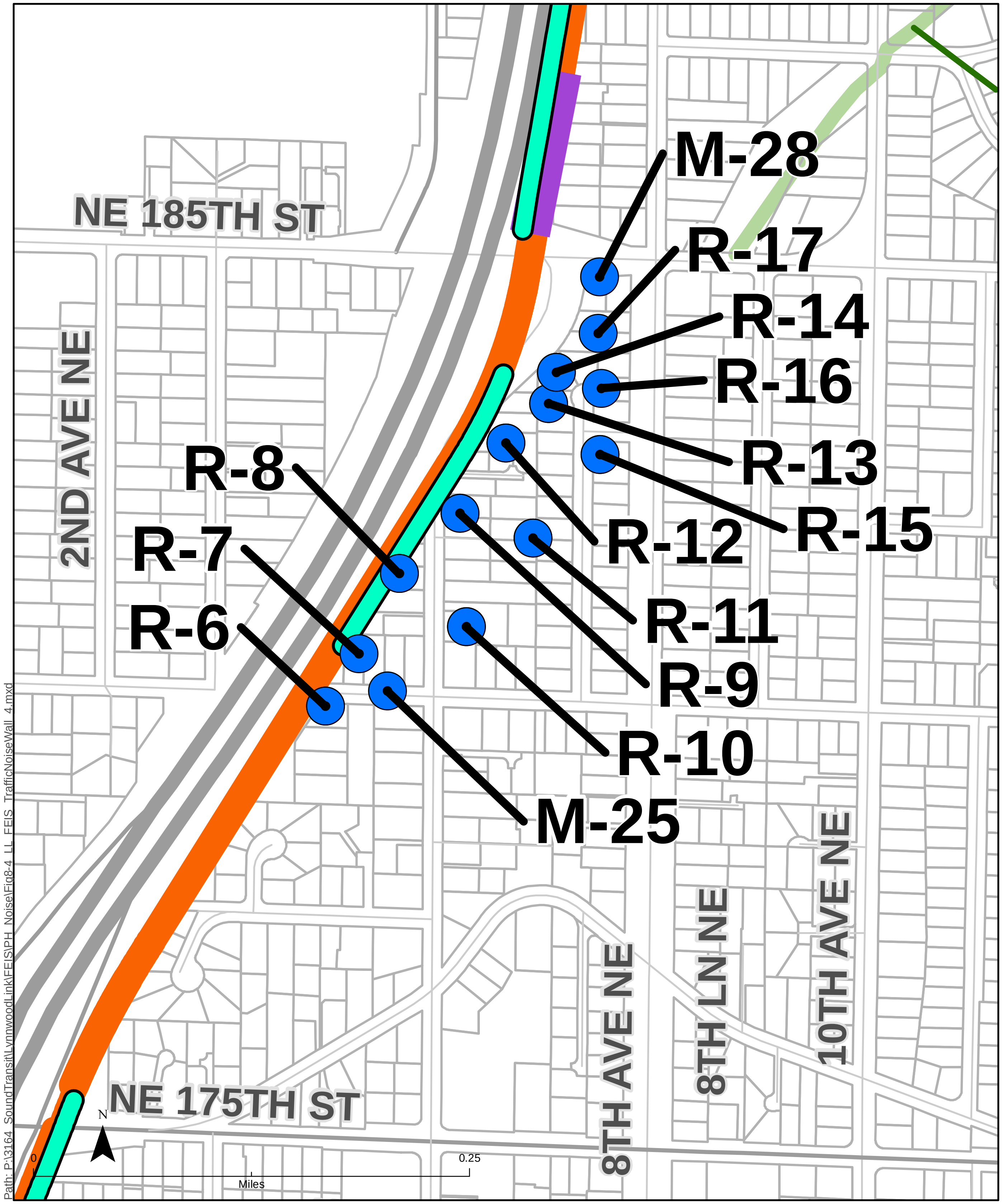
Figure 8-2
Traffic Noise Wall #2:
NE 145th Street



Data Sources: (King County, Snohomish County, WSDOT, Sound Transit)

Figure 8-3
Traffic Noise Wall #3: Ridgecrest Park to NE 175th Street

Lynnwood Link Extension

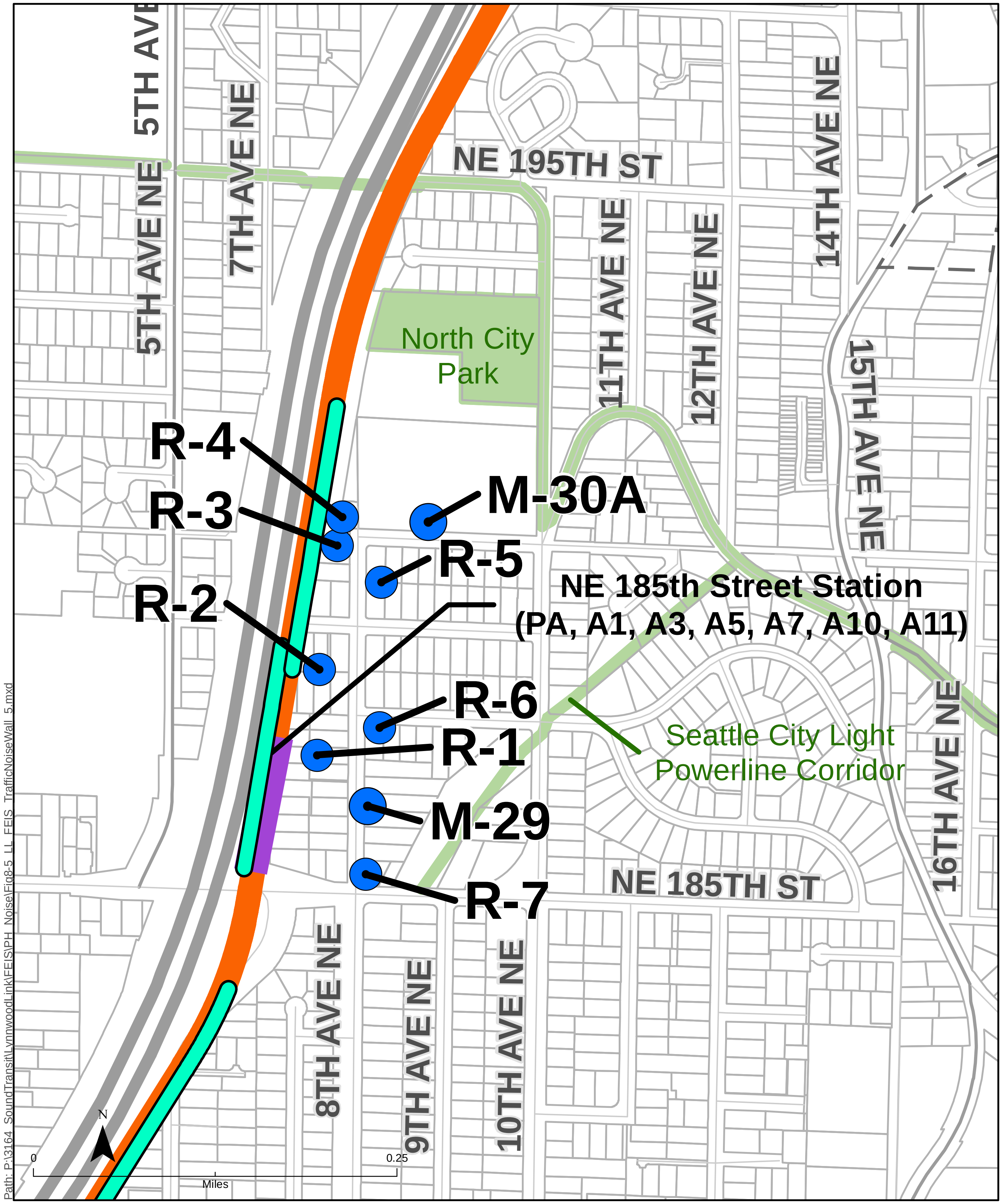


Data Sources: (King County, Snohomish County, WSDOT, Sound Transit)

Receiver Location
Replacement Traffic Noise Wall
Preferred Alternative (PA)
Preferred Alternative Station Location

Figure 8-4
Traffic Noise Wall #4:
NE 180th Street to
NE 185th Street

Lynnwood Link Extension



Data Sources: (King County, Snohomish County, WSDOT, Sound Transit)

Receiver Location
Replacement Traffic Noise Wall
Preferred Alternative (PA)
Preferred Alternative Station Location

Figure 8-5
Traffic Noise Wall #5:
NE 185th Street to
NE 191st Street

Lynnwood Link Extension

continues along the west side of the light rail alignment to station number 74 of the alignment. The third wall is approximately 900 feet in length and has heights of 16 feet to 20 feet.

Replacement Traffic Noise Wall #1 is effective at meeting the traffic noise design criteria at all of the modeled receiver locations in the area. Under the Preferred Alternative, the severity of the impact at receiver M-7 (see Table 8-17) is expected to increase by 1 dBA compared to existing conditions, but would be less than the level under the No Build conditions. An increase of 1 dBA in traffic noise is not perceptible to the average human ear. I-5 is shielded by the noise wall at receiver M-7; however, the increase in future noise levels would result from increased traffic volumes and noise on 5th Avenue NE, which cannot be reduced with a noise wall. Additional modeling with and without traffic on I-5 would be needed to ascertain the exact contribution of each noise source.

Table 8-17. Traffic Noise Wall #1: Build Modeled Traffic Noise Levels

Receiver[a]	Leq (dBA)				Causes New Impact or Increases Severity of Impact[d]
	Criteria[b]	Existing	No Build[c]	Build[c]	
M-4	66	63	64	61	No
R-1	66	59	60	59	No
R-2	66	64	63	61	No
R-3	66	65	**66**	64	No
R-4	66	60	61	60	No
R-5	66	61	62	61	No
R-6	66	61	61	60	No
R-7	66	58	59	58	No
R-8 (Latvian Church)	66	63	63	61	No
M-6	66	60	60	60	No
R-9	66	61	61	61	No
R-10	66	62	63	62	No
R-11	66	63	63	62	No
R-12	66	64	65	65	No
M-7	66	**66**	**67**	**67**	No
R-13	66	64	65	64	No
M-8	66	56	57	56	No
R-14	66	61	61	59	No
R-15	66	65	65	64	No
R-16	66	61	62	60	No
R-17	66	65	**66**	64	No
R-18	66	**66**	**67**	65	No
M-9	66	**68**	**68**	**66**	No
R-19	66	62	63	60	No
R-20	66	62	62	60	No
R-21	66	65	**66**	62	No
M-10	66	**72**	**72**	**68**	No

[a] Receivers shown on Figure 8-1.

[b] WSDOT traffic noise impact criteria.

[c] Peak hour modeled noise levels for the year 2035; noise levels that equal or exceed the WSDOT traffic noise abatement criteria are shown in red.

[d] Indicates whether the Preferred Alternative is predicted to cause a new impact or increase the severity of any future No Build impact at the receiver.

8.7.2 Replacement Traffic Noise Wall #2—NE 145th Street

Replacement Traffic Noise Wall #2 begins north of NE 145th Street, close to 5th Avenue NE, at approximately station number 123 and extends from east to west along the north side of the I-5 on-ramp until it meets the guideway structure. At that point, it turns north and runs along the east side of the light rail until approximately station number 128+50. It then travels under the elevated guideway and runs along the west side of the light rail until station number 131. Noise Wall #2 is approximately 850 feet in length and has heights of approximately 33 feet to 38 feet.

The proposed light rail alignment is on an elevated structure in the area where Replacement Traffic Noise Wall #2 is located. As a result, Noise Wall #2 extends from the ground up to, and is integrated with, the transit noise wall in order to prevent traffic noise from reflecting off of the bottom of the elevated structure. This area is the only replacement noise wall location where the light rail alignment will be on an elevated structure.

Replacement Traffic Noise Wall #2 is effective at maintaining or reducing the traffic noise levels at all of the modeled receiver locations in the area by up to 5 dBA (Table 8-18). In addition, Noise Wall #2 meets the replacement wall design criteria at all receiver locations.

Table 8-18. Traffic Noise Wall #2: Build Modeled Traffic Noise Levels

	L_{eq}(dBA)				
Receiver[a]	**Criteria[b]**	**Existing**	**No Build[c]**	**Build[c]**	**Causes New Impact or Increases Severity of Impact[d]**
R-1	66	64	64	60	No
R-2	66	65	65	63	No
R-3	66	64	65	59	No
R-4	66	64	64	61	No
M-16	66	64	64	62	No
M-17	66	65	65	61	No
R-5	66	64	64	60	No
R-6	66	64	64	61	No
R-7	66	64	64	62	No
R-8	66	65	65	62	No
R-9	66	**67**	**67**	65	No
R-10	66	65	65	64	No
M-18	66	65	65	65	No

a Receivers shown on Figure 8-2.
b WSDOT traffic noise impact criteria.
c Peak hour modeled noise levels for the year 2035; noise levels that are equal to, or greater than, the WSDOT traffic noise abatement criteria are shown in red.
d Indicates whether the Preferred Alternative is predicted to cause a new impact or increase the severity of any future No Build impact at the receiver.

8.7.3 Replacement Traffic Noise Wall #3—Ridgecrest Park to NE 175th Street

Replacement Traffic Noise Wall #3 begins south of NE Ridgecrest Park at approximately station number 162 and extends north along the east side of the light rail alignment to station number 198. Noise Wall #3 is approximately 3,800 feet in length and has heights of 8 feet to 20 feet along the light rail alignment.

Replacement Traffic Noise Wall #3 is effective at maintaining or reducing by up to 4 dBA the existing traffic noise levels at all of the modeled receiver locations in the area (Table 8-19). In addition, Noise Wall #3 meets the replacement wall design criteria at all receiver locations. While the proposed replacement wall would be more effective at reducing traffic noise levels than the existing wall and meet all replacement criteria, Noise Wall #3 would still leave existing traffic noise impacts at seven of the representative receiver locations; however, they would be less severe than under No Build conditions.

Table 8-19. Traffic Noise Wall #3: Build Modeled Traffic Noise Levels

Receiver[a]	Leq(dBA)				Causes New Impact or Increases Severity of Impact[d]
	Criteria[b]	Existing	No Build[c]	Build[c]	
M-21	66	64	65	60	No
R-1	66	**70**	**71**	**69**	No
R-2	66	**68**	**69**	**67**	No
R-3	66	**68**	**68**	**67**	No
R-4	66	**66**	**66**	65	No
R-5	66	**67**	**67**	**66**	No
R-6	66	64	64	63	No
R-7	66	65	65	63	No
R-8	66	**72**	**72**	**68**	No
R-9	66	64	64	64	No
R-10	66	64	64	62	No
R-11	66	60	60	60	No
R-12	66	60	60	60	No
R-13	66	65	65	63	No
R-14	66	62	62	61	No
R-15	66	**66**	**66**	64	No
M-22	66	**68**	**68**	65	No
R-16	66	**68**	**69**	**67**	No
R-17	66	**68**	**68**	**67**	No

[a] Receivers shown on Figure 8-3.
[b] WSDOT traffic noise impact criteria.
[c] Peak hour modeled noise levels for the year 2035; noise levels that are equal to, or greater than, the WSDOT traffic noise abatement criteria are shown in red.
[d] Indicates whether the Preferred Alternative is predicted to cause a new impact or increase the severity of any future No Build impact at the receiver.

8.7.4 Replacement Traffic Noise Wall #4—NE 180th Street to NE 185th Street

Replacement Traffic Noise Wall #4 begins at approximately station number 215 and extends north along the east side of the light rail alignment to approximately station number 226. Noise Wall #4 is approximately 1,092 feet in length and has heights of 8 feet to 18 feet along the light rail alignment. The existing traffic noise wall just to the south of Noise Wall #4 will not be affected by the project.

Replacement Traffic Noise Wall #4 is effective at maintaining or reducing the traffic noise levels at 3 of the 14 modeled receiver locations in the area (Table 8-20). Traffic noise levels at the other 11 locations are expected to increase by up to 3 dBA. However, Noise Wall #4 meets the replacement wall design criteria at all receiver locations other than M-28. Under the Preferred Alternative, the severity of the impact at receiver M-28 is expected to increase by 2 dBA. An increase of 3 dBA in traffic noise is barely perceptible to the average human ear. This increase is likely unrelated to traffic noise emanating from I-5, which is shielded by the noise wall, and is more likely caused by increased traffic volumes on NE 185th Street, which would experience increased traffic volumes to and from the NE 185th Street station. Additional modeling with and without traffic on I-5 would be needed to ascertain the exact contribution of each noise source. In addition, increasing the height of the wall could decrease traffic noise levels at some or all of the 11 receiver locations where those noise levels are expected to increase.

Table 8-20. Traffic Noise Wall #4: Build Modeled Traffic Noise Levels

Receiver[a]	L_{eq}(dBA)				Causes New Impact or Increases Severity of Impact[d]
	Criteria[b]	Existing	No Build[c]	Build[c]	
R-6	66	61	61	62	No
M-25	66	60	60	60	No
R-7	66	63	63	63	No
R-8	66	65	65	64	No
R-9	66	63	63	64	No
R-10	66	59	59	60	No
R-11	66	58	58	59	No
R-12	66	59	60	61	No
R-13	66	58	58	61	No
R-14	66	58	58	59	No
R-15	66	59	59	62	No
R-16	66	61	61	62	No
R-17	66	62	62	64	No
M-28	66	65	65	**67**	Yes

[a] Receivers shown on Figure 8-4.
[b] WSDOT traffic noise impact criteria
[c] Peak hour modeled noise levels for the year 2035; noise levels that are equal to, or greater than, the WSDOT traffic noise abatement criteria are shown in red.
[d] Indicates whether the Preferred Alternative is predicted to cause a new impact or increase the severity of any future No Build impact at the receiver.

8.7.5 Replacement Traffic Noise Wall #5—NE 185th Street to NE 191st Street

Replacement Traffic Noise Wall #5 is a system of two separate but overlapping walls. The first wall begins north of NE 185th Street at approximately station number 230 and extends north along the west side of the light rail alignment to approximately station number 236. The first wall is approximately 592 feet in length and has a uniform height of 18 feet tall along the light rail alignment. The second wall begins at approximately station number 236 and also extends north along the west side of the light rail alignment to station number 247. The second wall is approximately 1,100 feet in length and has heights of 14 feet to 20 feet.

Replacement Traffic Noise Wall #5 is effective at meeting the traffic noise design criteria at all but one of the modeled receiver locations in the area (receiver R-7, see Table 8-21). Under the Preferred Alternative, the severity of the impact at receiver R-7 is expected to increase by 2 dBA. An increase of 3 dBA in traffic noise is barely perceptible to the average human ear. This increase is likely unrelated to traffic noise emanating from I-5, which is being shielded by the noise wall, and is more likely caused by increased traffic volumes on NE 185th Street and 8th Avenue NE, streets that would experience increased traffic volumes to and from the NE 185th Street station. Additional modeling with and without traffic on I-5 would be needed to ascertain the exact contribution of each noise source.

Table 8-21. Traffic Noise Wall #5: Build Modeled Traffic Noise Levels

	L_{eq}(dBA)				Causes New Impact or Increases Severity of Existing Impact[d]
Receiver[a]	**Criteria[b]**	**Existing**	**No Build[c]**	**Build[c]**	
R-1	66	64	64	62	No
R-2	66	65	65	63	No
R-3	66	67	67	63	No
R-4	66	73	73	64	No
M-30A	66	60	60	60	No
R-5	66	63	63	60	No
R-6	66	62	62	61	No
M-29	66	61	62	64	No
R-7	66	65	65	67	Yes

a Receivers shown on Figure 8-5.
b WSDOT traffic noise impact criteria.
c Peak hour modeled noise levels for the year 2035; noise levels that are equal to, or greater than, the WSDOT traffic noise abatement criteria are shown in red.
d Indicates whether the Preferred Alternative is predicted to cause a new impact or increase the severity of any future No Build impact at the receiver.

8.8 Roadway Improvement Traffic Noise Analysis

This section describes the traffic noise impact and mitigation analysis for the Lynnwood Park-and-Ride Station area modeled under the existing conditions and in the year 2035 with and without construction of the project (see Section 7.4, Traffic Noise Levels). The Preferred Alternative includes roadway changes to improve access to the Lynnwood Transit Center that would cause traffic noise impacts at 23 residential units. Sound Transit would mitigate noise impacts with the proposed noise walls shownin Figure 8-6, or through sound insulation. Although noise walls would effectively mitigate most of the impacts, they may not be practical along this urban corridor. Sound Transit will work with the City of Lynnwood on mitigation design.

This section provides the traffic noise modeling results at the representative receivers for the weekday PM peak hour under the Preferred Alternative, using year 2035 predicted traffic volumes, compared to the existing condition and the future No Build conditions for the year 2035. The modeling results are compared with the wall design criteria (see Section 5.9.2). It is important to note that the Future No-Build conditions are the future noise levels (predicted for the year 2035) without the project, while the existing conditions are modeled results using the current (2013) traffic volumes. Therefore, the comparison of Future Build to No Build conditions provides an assessment of the direct impacts of the project, while the comparison to existing conditions provides an assessment of cumulative impacts of the project and increased traffic in the corridor. A discussion of traffic noise analysis issues specific to each area is included when applicable.

Table 8-22 summarizes the existing conditions, No Build, and Future Build noise levels at each of the modeled receivers. Receivers R-1 through R-7 are for the Park Five Apartments, receivers R-8 through R-16 are for the Oxford Square Apartments, receivers R-17 through R-24B are for the Cambridge Apartments, and receivers R-27 through R-45 are for the Cedar Creek Condominiums. Finally receivers R-25 and R-26 are for the Courtyard Hotel and La Quinta Inn, respectively. Future Build traffic noise impacts (e.g., noise levels at or above 66 dBA Leq) were identified at the Cambridge Apartment complex and the Cedar Creek Condominiums. Hence, noise mitigation measures were only analyzed for those two locations. Neither the Park Five nor the Oxford Square Apartment complex is predicted to have any traffic noise impacts under the Preferred Alternative. The Park Five Apartments are located south of the Cedar Creek Condominiums and are well shielded from traffic noise by those buildings. The Oxford Square Apartments, although located directly on 200th SW, are set back from the roadway, and all exterior uses at this facility are shielded and have noise levels that are below the WSDOT NAC. The traffic noise mitigation analysis and recommendations follow the table.

Table 8-22. Lynnwood Park-and-Ride Station: Modeled Traffic Noise Levels

Receiver[a]	Leq(dBA) Criteria[b]	Existing	No Build[c]	Build[c]	Build Condition Meets or Exceeds WSDOT Criteria[d]
R-1 (Lower)	66	56	56	58	No
R-1 (Upper)	66	58	58	60	No
R-2 (Lower)	66	56	55	57	No
R-2 (Upper)	66	58	58	59	No
R-3/M-50 (Lower)	66	55	55	56	No
R-3 (Upper)	66	57	57	59	No
R-4 (Lower)	66	54	55	55	No
R-4 (Upper)	66	57	57	58	No
R-5 (Lower)	66	58	58	61	No
R-5 (Upper)	66	60	60	63	No
R-6 (Lower)	66	56	57	59	No
R-6 (Upper)	66	59	59	61	No
R-7 (Lower)	66	55	56	57	No
R-7 (Upper)	66	58	59	60	No
R-8 (Lower)	66	59	61	62	No
R-8 (Upper)	66	62	64	64	No
R-9 (Lower)	66	50	52	53	No
R-9 (Upper)	66	54	56	57	No
R-10 (Lower)	66	50	52	53	No
R-10 (Upper)	66	52	54	55	No
R-11 (Lower)	66	59	61	61	No
R-11 (Upper)	66	61	63	63	No
R-12 (Lower)	66	55	57	57	No
R-12 (Upper)	66	58	60	61	No
R-13 (Lower)	66	55	57	58	No
R-13 (Upper)	66	58	61	61	No
R-14 (Lower)	66	59	61	61	No
R-14 (Upper)	66	61	64	63	No
R-15 (Lower)	66	53	56	56	No
R-15 (Upper)	66	55	58	58	No
R-16 (Lower)	66	61	62	63	No
R-16 (Upper)	66	62	64	65	No
R-17 (Lower)	66	**66**	**70**	**71**	Yes
R-17 (Upper)	66	**67**	**70**	**71**	Yes
R-18 (Lower)	66	61	65	**66**	Yes
R-18 (Upper)	66	63	**66**	**67**	Yes
R-19 (Lower)	66	60	64	65	No
R-19 (Upper)	66	61	64	65	No
R-20 (Lower)	66	65	**67**	**68**	Yes
R-20 (Upper)	66	65	**68**	**69**	Yes
R-21 (Lower)	66	64	**66**	**67**	Yes

Table 8-22. Lynnwood Park-and-Ride Station: Modeled Traffic Noise Levels

Receiver[a]	Leq(dBA)				Build Condition Meets or Exceeds WSDOT Criteria[d]
	Criteria[b]	Existing	No Build[c]	Build[c]	
R-21 (Upper)	66	65	**67**	**67**	Yes
R-22A/M-52 (Lower)	66	65	**67**	**68**	Yes
R-22A (Upper)	66	**66**	**68**	**68**	Yes
R-22B (Lower)	66	65	**67**	**68**	Yes
R-22B (Upper)	66	**66**	**68**	**68**	Yes
R-23 (Lower)	66	59	61	62	No
R-23 (Upper)	66	62	64	65	No
R-24A (Lower)	66	**67**	**69**	**69**	Yes
R-24A (Upper)	66	**67**	**69**	**69**	Yes
R-24B (Lower)	66	**66**	**68**	**68**	Yes
R-24B (Upper)	66	**66**	**68**	**68**	Yes
R-25 - Courtyard Hotel	71	64	64	64	No
R-26 - La Quinta Inn	71	63	64	64	No
R-27 (Lower)	66	63	**66**	**66**	Yes
R-27 (Middle)	66	65	**67**	**67**	Yes
R-27 (Upper)	66	65	**67**	**67**	Yes
R-28 (Lower)	66	61	63	63	No
R-28 (Middle)	66	63	65	65	No
R-28 (Upper)	66	63	65	65	No
R-29 (Lower)	66	54	54	55	No
R-29 (Middle)	66	57	57	58	No
R-29 (Upper)	66	57	57	58	No
R-30/M-51 (Lower)	66	55	55	56	No
R-30 (Middle)	66	58	58	59	No
R-30 (Upper)	66	58	58	59	No
R-31 (Lower)	66	54	56	56	No
R-31 (Middle)	66	58	60	60	No
R-31 (Upper)	66	58	60	60	No
R-32 (Lower)	66	60	63	64	No
R-32 (Middle)	66	63	**66**	**66**	Yes
R-32 (Upper)	66	63	**66**	**66**	Yes
R-33 (Lower) - Pool Room	66	56	59	59	No
R-33 (Middle)	66	60	63	63	No
R-33 (Upper)	66	60	63	63	No
R-34 (Lower)	66	53	54	55	No
R-34 (Middle)	66	57	58	59	No
R-34 (Upper)	66	57	58	59	No
R-35 (Lower)	66	53	53	54	No
R-35 (Middle)	66	56	57	58	No
R-35 (Upper)	66	57	57	58	No

Table 8-22. Lynnwood Park-and-Ride Station: Modeled Traffic Noise Levels

Receiver[a]	Leq(dBA)				Build Condition Meets or Exceeds WSDOT Criteria[d]
	Criteria[b]	Existing	No Build[c]	Build[c]	
R-36 (Lower)	66	61	64	64	No
R-36 (Middle)	66	63	**66**	**67**	Yes
R-36 (Upper)	66	63	**66**	**67**	Yes
R-37 (Lower)	66	57	60	60	No
R-37 (Middle)	66	60	63	63	No
R-37 (Upper)	66	60	63	63	No
R-38 (Lower)	66	54	57	57	No
R-38 (Middle)	66	58	61	61	No
R-38 (Upper)	66	58	61	61	No
R-39 (Lower)	66	53	55	56	No
R-39 (Middle)	66	57	59	60	No
R-39 (Upper)	66	57	60	60	No
R-40 (Lower)	66	57	56	59	No
R-40 (Middle)	66	60	60	63	No
R-40 (Upper)	66	60	60	63	No
R-41 (Lower)	66	56	55	57	No
R-41 (Middle)	66	58	58	60	No
R-41 (Upper)	66	58	58	60	No
R-42 (Lower)	66	56	56	58	No
R-42 (Middle)	66	58	59	61	No
R-42 (Upper)	66	59	59	61	No
R-43 (Lower)	66	56	56	57	No
R-43 (Middle)	66	58	58	60	No
R-43 (Upper)	66	58	59	60	No
R-44 (Lower)	66	54	55	57	No
R-44 (Middle)	66	58	58	60	No
R-44 (Upper)	66	58	59	60	No
R-45 (Lower)	66	54	55	56	No
R-45 (Middle)	66	57	58	59	No
R-45 (Upper)	66	58	59	60	No

[a] Receivers shown on Figure 8-6.
[b] WSDOT traffic noise impact criteria.
[c] Peak hour modeled noise levels for the year 2035; noise levels that are equal to, or greater than, the WSDOT traffic noise abatement criteria are shown in red.
[d] Indicates whether the Preferred Alternative is predicted to cause a traffic noise impact at the receiver.

8.8.1 Traffic Noise Mitigation for Cambridge Apartments—Lynnwood Park-and-Ride Station

There are six separate traffic noise walls for the Cambridge Apartments that act as a system. The first wall begins approximately 100 feet north of the northeast corner of the intersection of 48th Avenue W and 200th Street SW and extends south along the east side of 48th Avenue W to the corner, at which point it continues east along the north side 200th Street SW for approximately 150 feet until it reaches the walkway that provides pedestrian access from the sidewalk to the apartment homes. The second wall extends eastward from that same walkway to the main driveway entrance to the apartment complex about half-way down the block. Together, the first two walls are approximately 350 feet in length and ranges in height from 11 to 14 feet tall.

The remaining four walls start at the eastern edge of the driveway entrance to the complex and extend east along the north side of 200th Street SW to the northwest corner of where it intersects with 46th Avenue W. These four walls act as one contiguous wall, but they too have walkway openings that separate them to provide pedestrian access from the sidewalk to the apartment homes. Collectively, the these four walls are approximately 312 feet in length and ranges in height from 14 to 16 feet tall.

The Cambridge Apartment noise walls are effective at meeting the traffic noise design criteria and eliminate most of the traffic noise impacts at the impacted receiver locations (see Table 8-23). Traffic noise impacts would remain after inclusion of the proposed mitigation into the Preferred Alternative wherever an apartment home has a direct line of sight through the walls due to walkway openings (e.g., the homes represented by receiver R-24A). Because of the urban nature of the corridor and remaining impacts, sound insulation would be considered. With the proposed mitigation measures and/or sound insulation, all traffic noise impacts will be mitigated. Table 8-23 summarizes the performance of the evaluated noise walls working together as a system.

Table 8-23. Noise Wall Mitigation Performance Summary

Receiver[1]	No. of Uses[2]	Land Use[3]	Build Noise Level[4] *(No wall)*	Build Noise Level[5] *(With wall)*
R-17 (Lower)	2	Res	**71**	58
R-17 (Upper)	2	Res	**71**	64
R-18 (Lower)	2	Res	**66**	61
R-18 (Upper)	2	Res	**67**	63
R-19 (Lower)	2	Res	65	64
R-19 (Upper)	2	Res	65	64
R-20 (Lower)	4	Res	**68**	58
R-20 (Upper)	4	Res	**69**	62
R-21 (Lower)	4	Res	**67**	61
R-21 (Upper)	4	Res	**67**	63
R-22A/M-52 (Lower)	3	Res	**68**	64
R-22A (Upper)	3	Res	**68**	65
R-22B (Lower)	3	Res	**68**	60
R-22B (Upper)	3	Res	**68**	62
R-23 (Lower)	2	Res	62	58
R-23 (Upper)	2	Res	65	61

Table 8-23. Noise Wall Mitigation Performance Summary

Receiver[1]	No. of Uses[2]	Land Use[3]	Build Noise Level[4] *(No wall)*	Build Noise Level[5] *(With wall)*
R-24A (Lower)	3	Res	**69**	**66**
R-24A (Upper)	3	Res	**69**	**67**
R-24B (Lower)	4	Res	**68**	61
R-24B (Upper)	4	Res	**68**	64

Notes:

1. Receivers shown in Figure 8.6
2. Number of residential, commercial, or other uses represented by each receiver
3. Land use: Res = Residential
4. Future Build noise levels with no abatement. Impacts in **Bold-Red** typeface
5. Future Build noise levels with noise wall as described and remaining impacts in **Bold-Red** typeface

8.8.2 Traffic Noise Mitigation at Cedar Creek Condominiums—Lynnwood Park-and-Ride Station

There are two separate traffic noise walls for the Cedar Creek Condominiums that act as a system. The first wall begins on the east side of Cedar Valley Road and extends north to the southeast corner of the intersection of 50th Avenue W and 200th Street SW. The wall then turns to the east and extends almost to the western edge of the main entrance to the complex. The first wall is approximately 250 feet in length and ranges in height of from 10 to 12 feet. The second wall begins at about the midpoint of the block located on the south side of 200th Street SW between 50th Avenue W and 48th Avenue W and extends east to 48th Avenue W, where it wraps around the corner to the south. The second wall is approximately 350 feet in length and also ranges in height of from 10 to 12 feet.

The Cedar Creek Condominiums noise walls are effective at meeting the traffic noise design criteria and eliminate the traffic noise impacts at all of the impacted receiver locations. Given the urban nature of the corridor, sound insulation would be considered wherever impacts remain. With the proposed mitigation measures and/or sound insulation, all traffic noise impacts will be mitigated. Table 8-24 summarizes the performance of the evaluated noise walls working together as a system.

Table 8-24. Noise Wall Mitigation Performance Summary

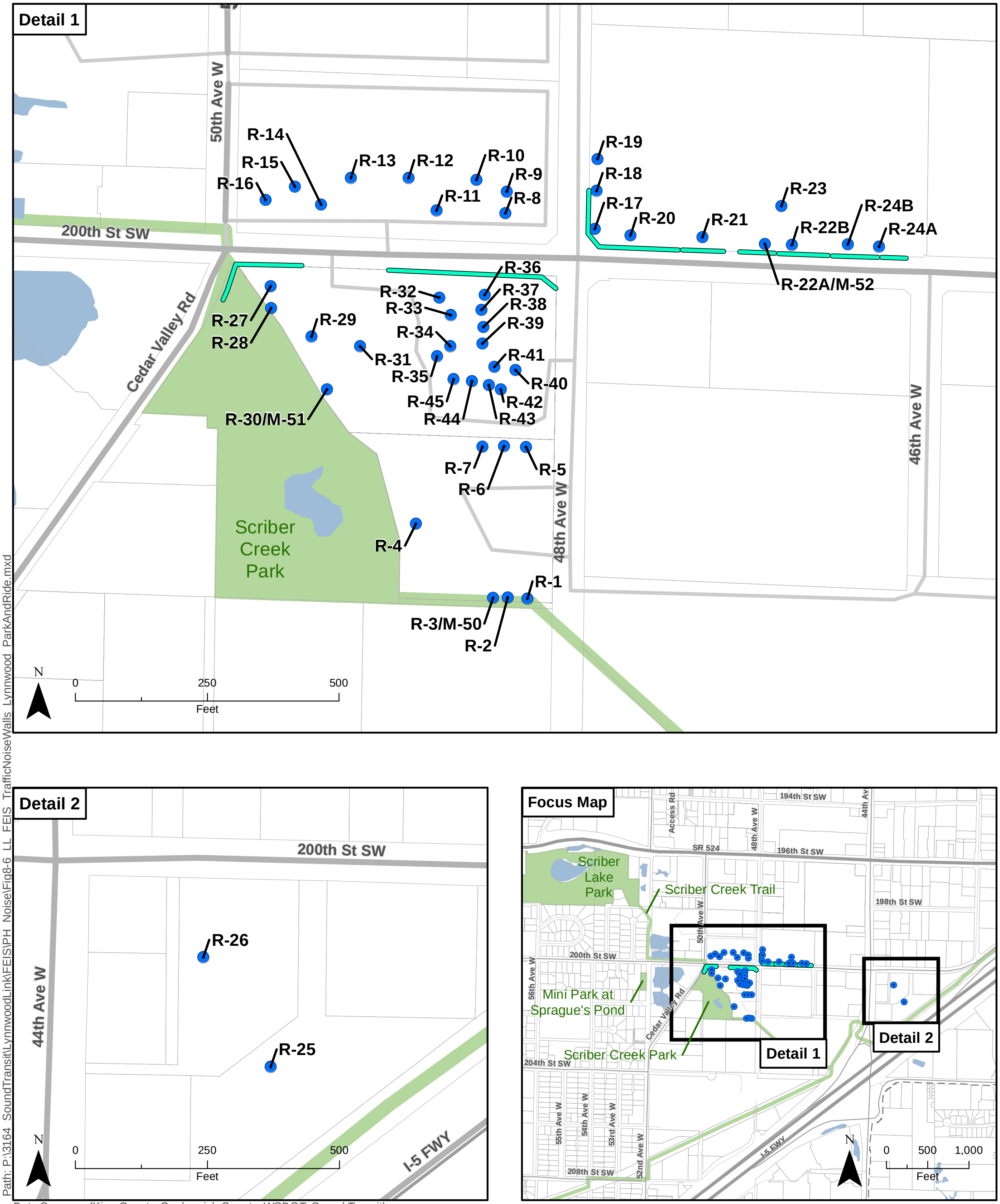
Receiver[1]	No. of Uses[2]	Land Use[3]	Build Noise Level[4] *(No wall)*	Build Noise Level[5] *(With wall)*
R-27 (Lower)	1	Res	**66**	59
R-27 (Middle)	1	Res	**67**	61
R-27 (Upper)	1	Res	**67**	62
R-28 (Lower)	1	Res	63	58
R-28 (Middle)	1	Res	65	60
R-28 (Upper)	1	Res	65	60
R-29 (Lower)	4	Res	55	54
R-29 (Middle)	4	Res	58	57
R-29 (Upper)	4	Res	58	57
R-30/M-51 (Lower)	4	Res	56	55
R-30 (Middle)	4	Res	59	58
R-30 (Upper)	4	Res	59	58
R-31 (Lower)	2	Res	56	55

Table 8-24. Noise Wall Mitigation Performance Summary

Receiver[1]	No. of Uses[2]	Land Use[3]	Build Noise Level[4] *(No wall)*	Build Noise Level[5] *(With wall)*
R-31 (Middle)	2	Res	60	59
R-31 (Upper)	1	Res	60	59
R-32 (Lower)	1	Res	64	58
R-32 (Middle)	1	Res	**66**	61
R-32 (Upper)	1	Res	**66**	62
R-33 (Lower) – Pool Room	0	Res	59	54
R-33 (Middle)	1	Res	63	57
R-33 (Upper)	1	Res	63	58
R-34 (Lower)	1	Res	55	53
R-34 (Middle)	1	Res	59	56
R-34 (Upper)	1	Res	59	57
R-35 (Lower)	1	Res	54	54
R-35 (Middle)	1	Res	58	57
R-35 (Upper)	1	Res	58	57
R-36 (Lower)	1	Res	64	57
R-36 (Middle)	1	Res	**67**	62
R-36 (Upper)	1	Res	**67**	62
R-37 (Lower)	1	Res	60	54
R-37 (Middle)	1	Res	63	58
R-37 (Upper)	1	Res	63	59
R-38 (Lower)	1	Res	57	52
R-38 (Middle)	1	Res	61	54
R-38 (Upper)	1	Res	61	55
R-39 (Lower)	1	Res	56	52
R-39 (Middle)	1	Res	60	54
R-39 (Upper)	1	Res	60	54
R-40 (Lower)	1	Res	59	59
R-40 (Middle)	1	Res	63	63
R-40 (Upper)	1	Res	63	63
R-41 (Lower)	1	Res	57	57
R-41 (Middle)	1	Res	60	59
R-41 (Upper)	1	Res	60	60
R-42 (Lower)	1	Res	58	57
R-42 (Middle)	1	Res	61	61
R-42 (Upper)	1	Res	61	61
R-43 (Lower)	1	Res	57	56
R-43 (Middle)	1	Res	60	59
R-43 (Upper)	1	Res	60	59
R-44 (Lower)	1	Res	57	56
R-44 (Middle)	1	Res	60	58
R-44 (Upper)	1	Res	60	59
R-45 (Lower)	1	Res	56	55
R-45 (Middle)	1	Res	59	58
R-45 (Upper)	1	Res	60	59

Notes:

1. Receivers shown in Figure 8.6
2. Number of residential uses represented by each receiver
3. Land use: Res = Residential
4. Future Build noise levels with no abatement. Impacts in **Bold-Red** typeface
5. Future Build noise levels with noise wall as described and remaining impacts in **Bold-Red** typeface



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Data Sources: (King County, Snohomish County, WSDOT, Sound Transit)

Receiver Location   New Traffic Noise Wall

Note:
All receiver locations other than R-26 and R-27 have multi-floor receivers for modeling purposes at the outdoor uses of the apartment building location depicted.

Figure 8-6
Traffic Noise Walls:
Lynnwood Park-and-Ride Station

8.9 Construction Noise Mitigation Analysis

Construction noise and vibration impacts can be reduced with operational methods and scheduling, equipment choice, and acoustical treatments. In locations where existing noise walls will require relocation, the relocation would be completed as early in the construction process as practical so that the relocated walls would reduce noise from the ongoing construction activities. When required, Sound Transit or its contractor would seek the appropriate noise variance from the local jurisdiction. Noise control mitigation to meet local regulatory requirements, noise ordinances, and permit or variance conditions would be required. These measures could include the following actions:

- Install construction site noise barrier or wall by noise-sensitive receivers where appropriate.
- Use smart backup alarms during nighttime work that automatically adjust, or lower the alarm level or tone based on the background noise level, or switch off back-up alarms and replace with spotters.
- Use low-noise emission equipment.
- Implement noise-deadening measures for truck loading and operations.
- Monitor and maintain equipment to meet noise limits.
- Use lined or covered storage bins, conveyors, and chutes with sound-deadening material.
- Use acoustic enclosures, shields, or shrouds for equipment and facilities.
- Install high-grade engine exhaust silencers and engine-casing sound insulation.
- Prohibit aboveground jack hammering and impact pile driving during nighttime hours.
- Minimize the use of generators or use whisper quiet generators to power equipment.
- Limit use of public address systems.
- Use movable noise barriers at the source of the construction activity where practical.
- Limit or avoid certain noisy activities during nighttime hours.

9 REFERENCES AND SUPPORTING DOCUMENTS

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Part 2: Vibration

1 INTRODUCTION AND SUMMARY

1.1 Introduction

This technical report presents a vibration impact assessment for the Lynnwood Link Extension. Section 1 of this report summarizes the results of the vibration assessment. Section 2 discusses the fundamentals of environmental vibration and Section 3 describes the criteria used to assess potential vibration impacts. Section 4 presents the methodology used to predict vibration impacts. Section 5 summarizes the impact assessment and Section 6 outlines potential impact mitigation measures. In addition, Attachment D lists the projected vibration levels and potential vibration impacts by alternative and Attachment E provides detailed vibration measurement data.

1.2 Summary of Vibration Impact Assessment

Based on criteria from the Federal Transit Administration (FTA), the Lynnwood Link Extension would cause 8 to 32 potential vibration impacts without mitigation, depending upon the alignment alternative, at the locations listed in Table 1-1. These potential impacts would be related to annoyance impacts but not to building damage impacts. There will be no impacts related to building damage from future train operations. Section 5.1 includes detailed information regarding the potential vibration impacts from future train operations, and Section 6.1 discusses proposed mitigation measures for those potential impacts.

Most of the potential vibration impacts due to future train operations are limited to track segments with at-grade track and most of those impacts can be mitigated with tire-derived aggregate (TDA) as an underlayment beneath the sub-ballast layer of the track. Other mitigation approaches were considered. Of the mitigation approaches currently available, a floating slab track (FST) is the only option other than TDA that would remove all potential vibration impacts from at-grade track. However, FST costs as much as ten times more than TDA and, therefore, it would be considered for mitigation only if TDA would not fully mitigate an impact. Wayside noise from an FST track would be higher relative to noise from a ballast-and-tie track because noise would reflect from the concrete slab, whereas ballast effectively absorbs sound energy produced by wheel/rail interaction and under-car equipment. Higher levels of noise adjacent to FST were accounted for in the noise analysis, where FST is considered for vibration mitigation.

Some vibration impacts are predicted to occur next to the elevated structure but most of those impacts can be mitigated through the use of high compliance rail fasteners. Wayside noise might be higher adjacent to rail with high compliance fasteners relative to standard rail fasteners because the rail tends to vibrate more on the softer fasteners, generating more sound. This increase in sound can be offset by noise walls integrated with the elevated structure and is included in the noise analysis.

Some vibration impacts can be mitigated by incorporating special provisions in the design of track crossovers to avoid increased levels of ground vibration that are associated with typical crossover design, relative to track that is away from crossovers. For example, the use of spring or movable point frogs reduces impact energy at crossovers.

Table 1-1 lists the total length of vibration mitigation recommended for each alternative. Vibration impacts and mitigation options will be reviewed during final design to confirm that appropriate measures are included in the design.

Potential vibration impacts resulting from project construction are summarized in Section 5.2. The potential for cosmetic damage to nearby structures would be evaluated if vibratory pile-driving methods are to be used within 80 feet of any receptor or vibratory soil compactor within 40 feet. This task should include documenting the condition of buildings before construction and monitoring vibration during construction. No structural damage will occur to any building adjacent to project construction as long as the vibration does not exceed the threshold levels for causing cosmetic damage.

Potential vibration impacts related to annoyance during construction are projected for sensitive receptors near the stations and are discussed in Section 5.2. Approaches for mitigating potential vibration impacts resulting from construction are discussed in detail in Section 6.2.

Table 1-1. Summary of Potential Vibration Impacts and Mitigation

Alternative	Number of Potential Vibration Impacts	Number of Potential Vibration Impacts After Mitigation	Total Mitigation Length (feet)
Preferred Alternative (Segment A)	27	0	4,280[a,b]
A1: At-grade/Elevated with NE 145th and NE 185th Street Stations	9	0	1,725
A3: Mostly Elevated with NE 145th and NE 185th Street Stations	8	0	1,060[c]
A5: At-grade/Elevated with NE 130th, NE 155th, and NE 185th Street Stations	16	0	2,800
A7: Mostly Elevated with NE 130th, NE 155th, and NE 185th Street Stations	9	0	1,410[c]
A10: At-grade/Elevated with NE 130th, NE 145th, and NE 185th Street Stations	14	0	2,450
A11: Mostly Elevated with NE 130th, NE 145th, and NE 185th Street Stations	8	0	1,060[c]
Preferred Alternative (Segment B)	3	0	460[a,b]
Alternatives B1, B2A, and B4	0	0	0
Preferred Alternative (Segment C)	0	0	0
C1M: 52nd Avenue West to 200th Street SW, Option 1 within I-5 Median	2	0	450
C1W: 52nd Avenue West to 200th Street SW, Option 2 West of I-5	1	0	250
C2M: 52nd Avenue West to Lynnwood Transit Center, Option 1 within I-5 Median	2	0	450
C2W: 52nd Avenue West to Lynnwood Transit Center, Option 2 within I-5 Median	1	0	250
C3M and C3W: Along I-5 to Lynnwood Park-and-Ride Station	0	0	0

[a] Recommended mitigation includes using spring or movable point frogs and Tire Derived Aggregate underlayment at the crossover.
[b] Spring or movable point frogs recommended for crossovers at: Civil Station 130+50 – 132+80, 258+70 – 260+40, and 476+50 – 478 + 90 (three total, included as 230 feet each in Total Mitigation Length).
[c] Spring or movable point frogs recommended for crossovers at: Civil Station 200+25 – 203+50 and 204+75 – 208+00 (two total, as 230 feet each included in Total Mitigation Length).
Note: C1M = Alternative C1 Option 1: From I-5 median; C1W = Alternative C1 Option 2: From west side of I-5; C2M = Alternative C2 Option 1: From I-5 median; C2M = Alternative C2 Option 2: From west side of I-5

2 ENVIRONMENTAL VIBRATION BASICS

Groundborne vibration is the oscillatory motion of the ground in relation to a static equilibrium position, which can be described in terms of displacement, velocity, or acceleration. Displacement refers to the distance an object moves away from its equilibrium position. Velocity refers to the rate of change in displacement with respect to time or the speed of this motion. Acceleration refers to the time rate of change in the velocity of the object. At any given frequency of oscillation, vibration displacement, velocity, and acceleration are related. However, the relationship between these descriptors can vary greatly in different situations, depending on the frequency content of the vibration energy. The overall vibration is the total unfiltered vibration over the entire spectrum.

The response of humans, buildings, and equipment to vibration is usually described in terms of velocity or acceleration. Because human sensitivity to vibration typically corresponds to a constant level of vibration velocity amplitude as a function of frequency within the frequency range that is of most concern for environmental vibration produced by rail transit systems (i.e., roughly 8 to 100 Hertz [Hz]), vibration velocity is used in this analysis as the primary measure to evaluate the impacts of vibration.

Several different measures are used to quantify vibration velocity amplitude. One of the most common is the peak particle velocity (PPV), defined as the maximum instantaneous positive or negative peak of the vibration velocity. PPV is used to characterize the threshold of cosmetic damage to building components. The root mean square (rms) velocity is used for evaluating human response. The rms amplitude is defined as the square root of the average of the squared amplitude of the signal over a time interval, typically 1 second. In this report, the averaging time is the train passby duration, usually 4 to 8 seconds. The difference is generally small, but longer averaging times produce less statistical fluctuation when measured.

The vibration velocity is represented by its level in decibels. The decibel scale compresses the range of numbers required to describe vibration. In this report, the vibration is expressed in terms of velocity level in decibels relative to 1 micro-inch per second, defined as follows:

$$L_v = 20\log_{10}(v/v_{ref}), \text{ VdB} \quad \text{(Equation 2-1)}$$

where:

v = rms velocity, inches/second
v_{ref} = 1×10^{-6} inches/second = 1 micro-inch/second

Figure 2-1 illustrates typical ground vibration velocity levels for common sources and associated human and structural responses. As shown, the range extends from approximately 50 VdB to 100 VdB (i.e., from imperceptible background vibration to the threshold of building cosmetic damage). Although the threshold of human perception to vibration is approximately 65 VdB, annoyance does not usually occur unless the rms vibration velocity level exceeds at least 72 VdB.

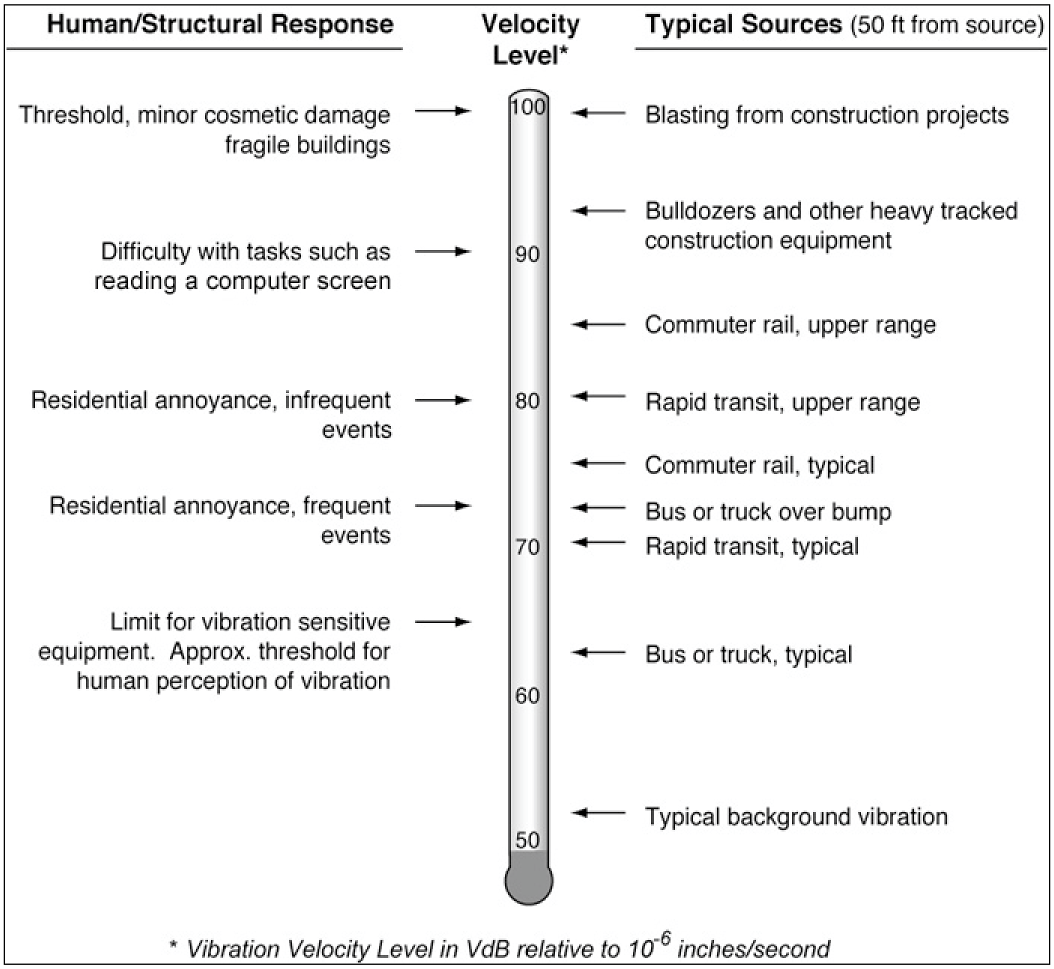


Figure 2-1. Typical Ground Vibration Levels and Human/Structural Response

When vibration propagates from transit vehicles to nearby buildings, the floors and walls of the building structure respond to the motion and resonate at natural frequencies. The vibration of the walls and floors may cause perceptible vibration, rattling of items such as windows or dishes on shelves, or a rumbling noise. The rumble is the noise radiated from the motion of the room surfaces and is called "groundborne noise." The potential annoyance of groundborne noise is described here in terms of the A-weighted sound level or dBA, averaged over the duration of the train passage.

3 VIBRATION IMPACT CRITERIA

This section briefly defines the criteria for vibration or groundborne noise impacts that might be produced by a transit system; these impacts are then evaluated as they apply to the Lynnwood Link Extension. The criteria for preventing building damage from construction-generated vibration are also discussed.

3.1 Transit Vibration and Groundborne Noise Criteria

3.1.1 Vibration Impact Criteria

The FTA vibration impact criteria are based on land use and train passage frequency. These criteria generally apply to floors of structures. Table 3-1 lists the criteria for a general assessment of most land uses. The FTA vibration criteria apply primarily to residential floors (including hotels and other places where people sleep) and to institutional land uses. Commercial land uses are only considered when they contain vibration-sensitive uses, such as medical offices or sensitive manufacturing equipment. The criteria applied to these locations depend on the sensitivity of the use. Some buildings, such as concert halls, recording studios, and theaters, can be particularly sensitive to vibration but do not fit into any of the three categories listed in Table 3-1. These buildings usually warrant special attention during the impact assessment. Table 3-2 provides the criteria for acceptable levels of groundborne floor vibration for special buildings.

If a general assessment of vibration impacts indicates that the project would exceed the criteria in Table 3-1, then a detailed analysis considering the frequency spectra of the vibration is used to provide more information about the effects of the project. In many cases, it is desirable to conduct a detailed analysis without first conducting a general assessment, as was done for the Lynnwood Link Extension.

Table 3-3 provides vibration criteria for the detailed vibration analyses that were used for the Lynnwood Link Extension. The criteria in Table 3-3 apply to the 1/3-octave-band vibration velocity levels over the frequency range 6.3 to 80 Hz. These detailed criteria are also used to assess vibration impacts at highly sensitive locations. However, no such highly sensitive locations have been identified along the project corridor. These criteria are also shown graphically in Figure 3-1.

During the public comment period for the Draft EIS, a concern was raised regarding a commercial property at 20815 52nd Avenue West in Lynnwood. One of the occupants uses lasers to etch plaques for trophies while another occupant conducts automobile restoration that includes antique automobile phonographs. Both occupants were concerned that vibration from construction and train operations would have an adverse impact upon their businesses. Referring to Table 3-3, a maximum 1/3 octave band level of 72 VdB was used as the criterion for estimating the vibration impact at the property.

3.1.2 Groundborne Noise Impact Criteria

Tables 3-1 and 3-2 include separate FTA criteria for groundborne noise—the “rumble” that can be radiated by the groundborne vibration of room surfaces in buildings. Because airborne noise often masks groundborne noise for aboveground (i.e., at-grade or elevated) transit systems, groundborne noise criteria are commonly applied only to subway operations where airborne noise is not a factor. For above-grade transit systems, groundborne noise criteria are applied only to special types of buildings that have sensitive interior spaces that are well insulated from exterior noise and that are used for noise-sensitive activities, such as sound recording or concert production. There are no special uses that fall into these categories within the project corridor because the entire project is above ground; therefore, a groundborne noise analysis has not been included in this assessment.

Table 3-1. Groundborne Vibration and Noise Impact Criteria for General Assessment

	Groundborne Vibration Impact Levels (VdB re: 1 micro-inch/second)			Groundborne Noise Impact Levels (dB re: 20 micro-Pascals)		
Land Use Category	**Frequent Events[a]**	**Occasional Events[b]**	**Infrequent Events[c]**	**Frequent Events[a]**	**Occasional Events[b]**	**Infrequent Events[c]**
Category 1: Buildings where low ambient vibration is essential for interior operations	65 VdB[d]	65 VdB[d]	65 VdB[d]	N/A[e]	N/A[e]	N/A[e]
Category 2: Residences and buildings where people normally sleep	72 VdB	75 VdB	80 VdB	35 dBA	38 dBA	43 dBA
Category 3: Institutional land uses with primarily daytime use	75 VdB	78 VdB	83 VdB	40 dBA	43 dBA	48 dBA

[a] "Frequent Events" are defined as more than 70 vibration events of the same source per day; most rapid transit projects fall into this category.

[b] "Occasional Events" are defined as between 30 and 70 vibration events of the same source per day; most commuter trunk lines have this many operations.

[c] "Infrequent Events" are defined as fewer than 30 vibration events of the same kind per day; this category includes most commuter rail branch lines.

[d] This criterion limit is based on levels that are acceptable for most moderately sensitive equipment, such as optical microscopes. Vibration-sensitive manufacturing or research requires detailed evaluation to define the acceptable vibration levels. Ensuring lower vibration levels in a building often requires special design of the heating, ventilation, and air conditioning (HVAC) systems and stiffened floors.

[e] Not applicable. Vibration-sensitive equipment is generally not sensitive to groundborne noise.

Table 3-2. Groundborne Vibration and Noise Impact Criteria for Special Buildings

	Groundborne Vibration Impact Levels (VdB re: 1 micro-inch/sec)		Groundborne Noise Impact Levels (dB re: 20 micro Pascals)	
Type of Building or Room[a]	**Frequent Events[b]**	**Occasional or Infrequent Events[c]**	**Frequent Events[b]**	**Occasional or Infrequent Events[c]**
Concert Halls	65 VdB	65 VdB	25 dBA	25 dBA
Television Studios	65 VdB	65 VdB	25 dBA	25 dBA
Recording Studios	65 VdB	65 VdB	25 dBA	25 dBA
Auditoriums	72 VdB	80 VdB	30 dBA	38 dBA
Theaters	72 VdB	80 VdB	35 dBA	43 dBA

[a] If the building will rarely be occupied when trains are operating, then there is no need to consider impact. As an example, consider locating a commuter rail line next to a concert hall; if no commuter trains will operate after 7 pm, then trains should rarely interfere with the use of the hall.

[b] "Frequent Events" are defined as more than 70 vibration events per day; most transit projects fall into this category.

[c] "Occasional or Infrequent Events" are defined as fewer than 70 vibration events per day; this category includes most commuter rail systems.

Table 3-3. Vibration Criteria for Detailed Analysis

Criterion Curve	Maximum L_v (VdB)[a]	Description of Use
Workshop	90	Distinctly detectable vibration; appropriate to workshops and non-sensitive areas
Office	84	Detectable vibration; appropriate to offices and non-sensitive areas
Residential day	78	Barely detectable vibration; adequate for computer equipment and low-power optical microscopes (up to 20X)
Residential night, operating rooms, and sensitive hospital equipment	72	Vibration not detectable, but groundborne noise might be audible inside quiet rooms; suitable for medium-power optical microscopes (100X) and other equipment of low sensitivity
VC-A	66	Adequate for medium- to high-power optical microscopes (400X), microbalances, optical balances, and similar specialized equipment
VC-B	60	Adequate for high-power optical microscopes (1,000X) and inspection and lithography equipment up to 3 micron-line widths
VC-C	54	Appropriate for most lithography and inspection equipment to 1 micron detail size
VC-D	48	Suitable in most instances for the most demanding equipment, including electron microscopes operating to the limits of their capability
VC-E	42	The most demanding criterion for extremely vibration-sensitive equipment

[a] As measured in 1/3-octave bands of frequency over the frequency range 8 to 80 Hz.

L_v = vibration velocity level; VC = vibration criteria

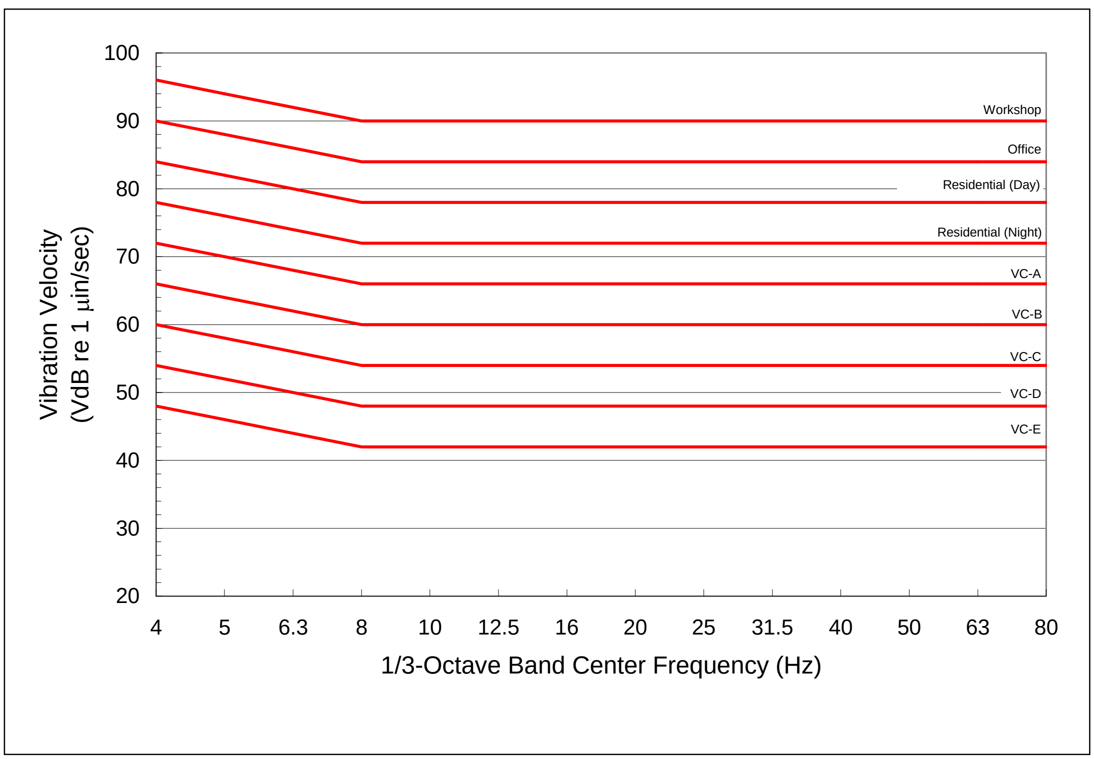


Figure 3-1. Vibration Criteria for Highly Sensitive Locations

3.2 Construction Vibration Criteria

Construction vibration from activities such as blasting and pile-driving, unlike vibration from train operations, has the potential to damage structures at very short distances. Because of this factor, the construction vibration discussion includes both damage criteria and annoyance impact criteria.

Table 3-4 presents threshold cracking criteria for visible cracking in building surfaces for a range of building types, in terms of the PPV. The approximate corresponding rms vibration velocity level is also included in Table 3-4. The majority of the residential receptors in the vicinity of the project guideway will fall into the Category III structure. Vibration that does not exceed threshold cracking criteria for cosmetic damage will not cause structural damage. Thus, threshold cracking criteria are used as the main building damage criteria.

Table 3-4. Cosmetic Structural Damage Criteria

Building Category	PPV (in/sec)	Approximate L_V[a]
I. Reinforced concrete, steel, or timber (no plaster)	0.50	102
II. Engineered concrete and masonry (no plaster)	0.30	98
III. Non-engineered timber and masonry buildings	0.20	94
IV. Buildings extremely susceptible to vibration damage	0.12	90

[a] Root mean square velocity level in decibels (VdB) re 1 micro-inch/second

Structural damage, as opposed to cosmetic or threshold cracking, would be accompanied by permanent settlement, opened cracks in foundations and walls, misalignment or rocking of doors and windows, and the like. The probability of this being caused by construction vibration is negligible if ground vibration is limited to less than threshold cracking criteria. Structural damage is usually caused by natural building settlement, dewatering, surcharging, land slippage or creep, or pest damage, rather than by vibration.

When vibration and associated groundborne noise are assessed for annoyance due to specific construction activities, the transit vibration impact criteria determine the potential for impact (Table 3-1). Potential impact for threshold cracking damage is considered for all construction activities whereas potential impact for annoyance is considered only for long-term activities.

4 PREDICTION METHODOLOGY

This section summarizes the models, methods, and assumptions used to predict future noise and vibration velocity levels for potential sources of community impacts related to the Lynnwood Link Extension. These sources include light rail operation and construction activities. The light rail vehicle wheels and track are assumed to be maintained in good condition with regular wheel truing and rail grinding, in accordance with the Central Puget Sound Regional Transit Authority (Sound Transit) maintenance procedures.

4.1 Light Rail Vibration Projections

The vibration analysis for the Lynnwood Link Extension Environmental Impact Statement (EIS) follows the approach described in the FTA guidance manual, *Transit Noise and Vibration Impact Assessment*, Chapter 11, Detailed Vibration Analysis (FTA 2006). The 1/3 octave band floor vibration velocity levels (L_v) at each vibration-sensitive receptor were estimated from the 1/3 octave dynamic forces generated by the transit vehicle (Force Density Level [FDL]), the 1/3 octave line-source transfer mobility from the tracks to the receptor (Line Source Response [LSR]), and the 1/3 octave vibration response of the building (Building Vibration Response [BVR]). The BVR accounts for attenuation due to soil/foundation interaction and for amplification due to floor resonance. Additional adjustments were made to account for increased vibration due to special track work such as crossovers and any vibration impact mitigation incorporated into the track design. The above components were used to calculate the 1/3-octave vibration velocity level as follows:

$$L_v \text{ (VdB)} = \text{FDL} + \text{LSR} + \text{BVR} + \text{Adjustment} \qquad \text{(Equation 4-1)}$$

where: L_v = vibration velocity level due to trains (VdB re: 1 micro-inch/second)

FDL = train force density level (L_f) (dB re: 1 lb/ft$^{1/2}$)

LSR = soil line source response (TM_{line}) (dB re: (1 micro-inch/s)/(lb/ft$^{1/2}$))

BVR = building vibration response (C_{build}) (dB)

Adjustment = adjustment to account for crossovers and/or mitigation (dB)

Each of the above factors for the Lynnwood Link Extension is described in the following sections.

In the project area, special purpose receptors with sensitive interior spaces that were well insulated from exterior noise were not found; moreover, the entire project would be above ground. Therefore, projections of groundborne noise were not included in this study.

The estimates presented in this analysis do not contain conservative elements, added "safety factors," or adjustments for uncertainty. They are the best estimates or median expected levels based on the best available information, and are compared directly with the “detailed” assessment criteria shown in Figure 3-1.

4.1.1 Force Density Level

The FDLs for all at-grade ballast-and-tie segments were based on measurements taken by ATS Consulting (ATS Consulting 2013). The data represent the most recent FDLs developed to date for Sound Transit at-grade ballast-and-tie track, and are the only FDL data at Sound Transit for multiple car trains on ballast-and-tie track. Figure 4-1 indicates the FDL spectra that were used for trains traveling at speeds from 25 to 55 miles per hour (mph), in 5-mph increments, on ballast-and-tie track. The FDL values plotted in Figure 4-1 are listed in Table 4-1. The FDLs reported by ATS Consulting were obtained at speeds up to 40 mph. The FDLs at higher speeds were obtained by adding differences between FDLs measured for higher speeds on a direct fixation track in a cut section along Macadam Road, north of the South 144th Street Bridge over I-5, and adding these differences to the 40-mph FDL for the ballast-and-tie track.

The FDLs for elevated structures were based on measurements at three locations. Wilson, Ihrig & Associates took measurements next to the elevated guideway leading into the west portal of the Beacon Hill tunnel (at Airport Way) in October 2011 and May 2012, and ATS Consulting took measurements at two locations next to the Tukwila elevated guideway in January and October 2011. These measurements were taken during revenue service, so the FDL for the elevated structure was determined at only one nominal speed at each location—35 mph west of the Beacon Hill tunnel, and an estimated speed of 55 mph at the two locations in Tukwila. In the model, the Wilson, Ihrig & Associates data were adjusted to a speed of 55 mph using the relationship between speed and force density that had been measured while running the trains at different speeds along the ballast-and-tie track in separate scenarios for two transit operators—for Sound Transit near the SODO Station in Seattle, and for the Santa Clara Valley Transportation Authority (VTA). Next, the energy average was taken of the speed-adjusted Airport Way FDL and the two FDLs measured in Tukwila to develop an FDL at 55 mph for use in the Lynnwood Link Extension vibration analysis. Finally, the differences due to speed that were observed in the previous measurements for Sound Transit and VTA were applied to the energy-averaged FDL to obtain an elevated structure FDL at different speeds. Figure 4-2 and Table 4-2 indicate the FDLs for trains traveling at speeds from 25 to 55 mph, in 5-mph increments, on elevated structures. The FDL applies to a line of vibration forces acting on the ground near the elevated structures and includes the effect of the soil/structure interaction at the foundations of the guideway columns.

Table 4-1. Sound Transit Force Density Levels (dB re: 1 lb/ft$^{1/2}$) on At-Grade Ballast-and-Tie Track

	1/3-Octave Band Center Frequency (Hz)																	
Speed	**3.15**	**4**	**5**	**6.3**	**8**	**10**	**12.5**	**16**	**20**	**25**	**31.5**	**40**	**50**	**63**	**80**	**100**	**125**	**160**
25 mph	25	20	21	23	23	29	24	19	21	18	18	15	21	24	25	21	20	15
30 mph	25	21	18	24	26	26	25	23	23	19	18	18	23	26	26	23	20	17
35 mph	28	24	24	25	30	28	25	25	25	21	18	19	22	28	27	23	21	17
40 mph	32	26	28	27	33	32	30	26	27	23	20	20	24	30	28	24	21	18
45 mph	31	25	23	26	35	37	35	27	28	24	22	20	26	31	28	24	21	18
50 mph	26	22	28	27	38	36	36	28	27	26	21	21	26	32	30	25	22	20
55 mph	24	29	31	27	39	36	37	29	25	27	21	23	25	32	31	26	23	22

Table 4-2. Sound Transit Force Density Levels (dB re: 1 lb/ft$^{1/2}$) on Elevated Structures

	1/3-Octave Band Center Frequency (Hz)																	
Speed	**3.15**	**4**	**5**	**6.3**	**8**	**10**	**12.5**	**16**	**20**	**25**	**31.5**	**40**	**50**	**63**	**80**	**100**	**125**	**160**
25 mph	10	12	23	31	18	23	23	27	15	9	10	15	22	20	22	21	18	22
30 mph	10	17	26	33	20	22	22	25	23	9	9	13	22	19	20	21	18	22
35 mph	13	16	26	35	26	26	22	28	21	17	10	15	22	20	21	21	19	21
40 mph	14	18	24	34	28	31	24	27	20	16	12	15	24	21	21	21	19	21
45 mph	19	24	27	37	31	35	29	27	22	16	17	17	24	20	21	21	20	24
50 mph	14	21	18	30	34	33	33	32	21	17	18	20	22	21	20	20	19	19
55 mph	13	28	25	24	29	34	31	31	18	14	11	22	24	24	24	23	21	22

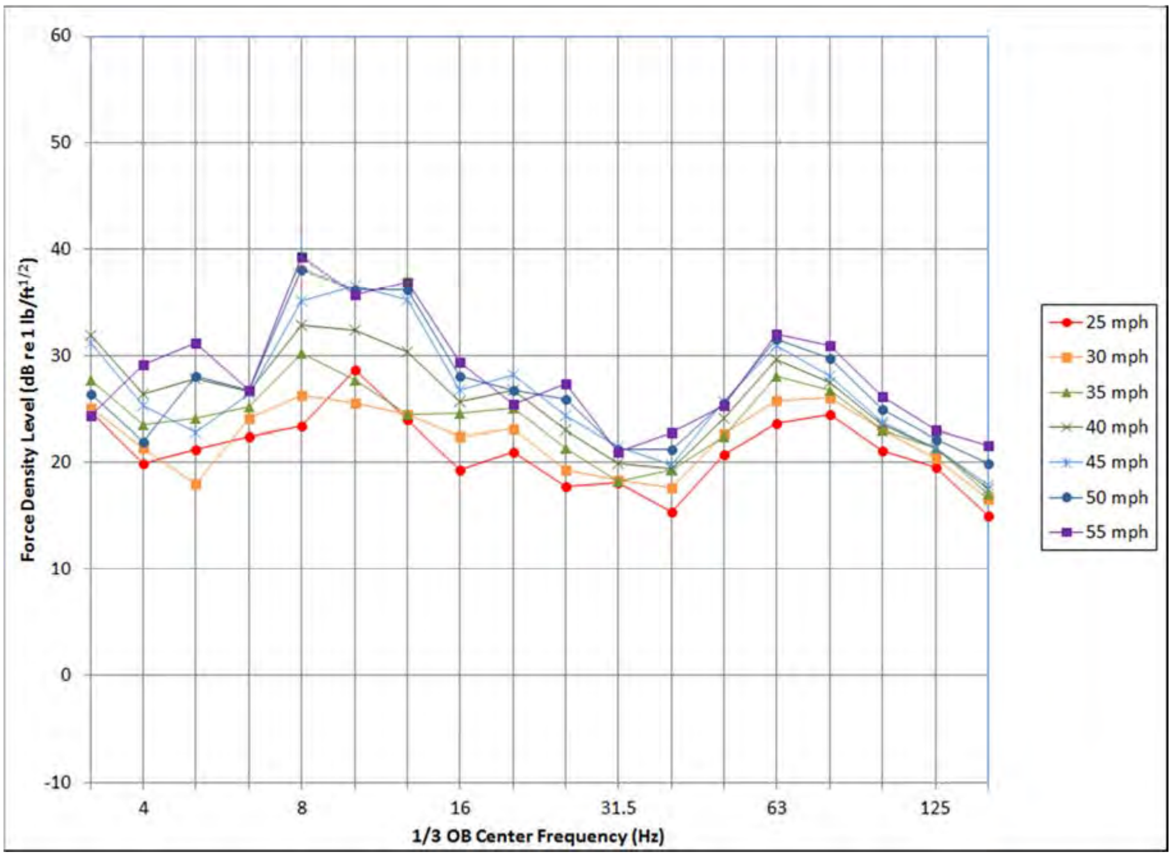


Figure 4-1. Sound Transit Force Density Levels on Ballast-and-Tie Track

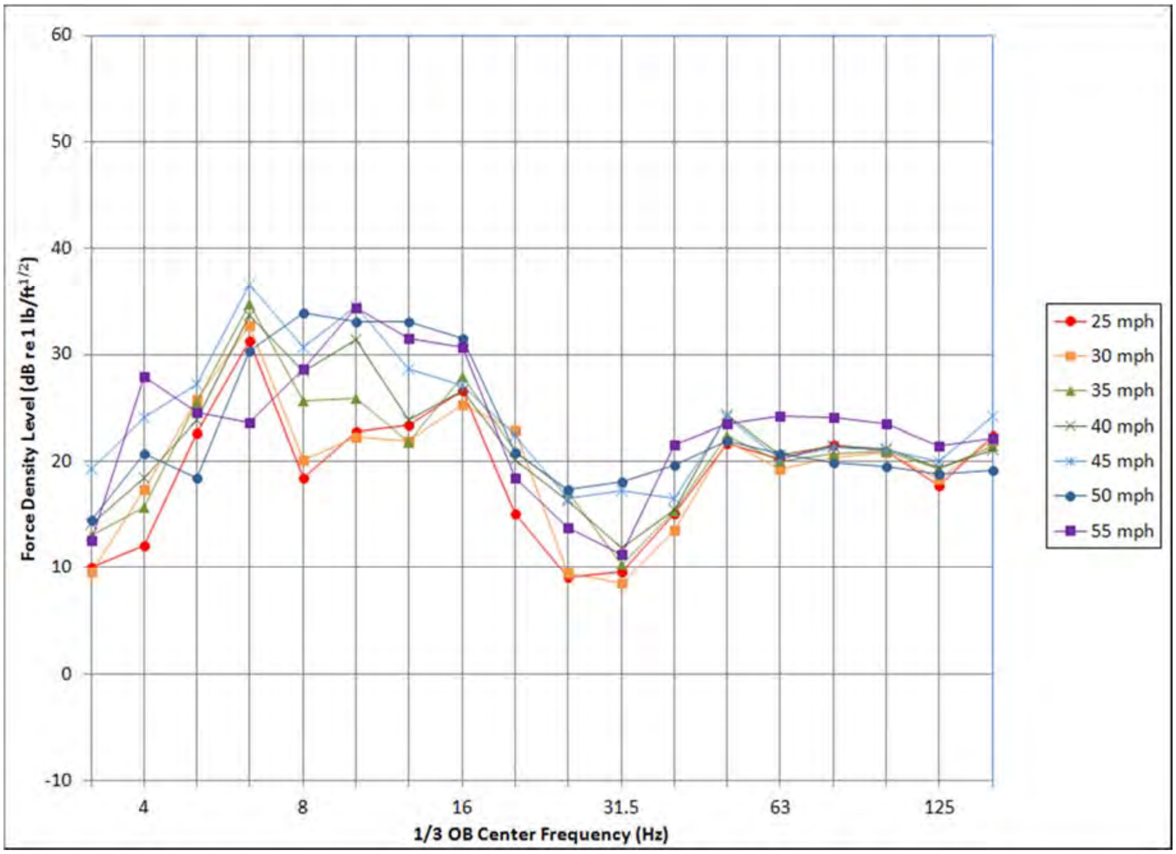


Figure 4-2. Sound Transit Force Density Levels on Elevated Structures

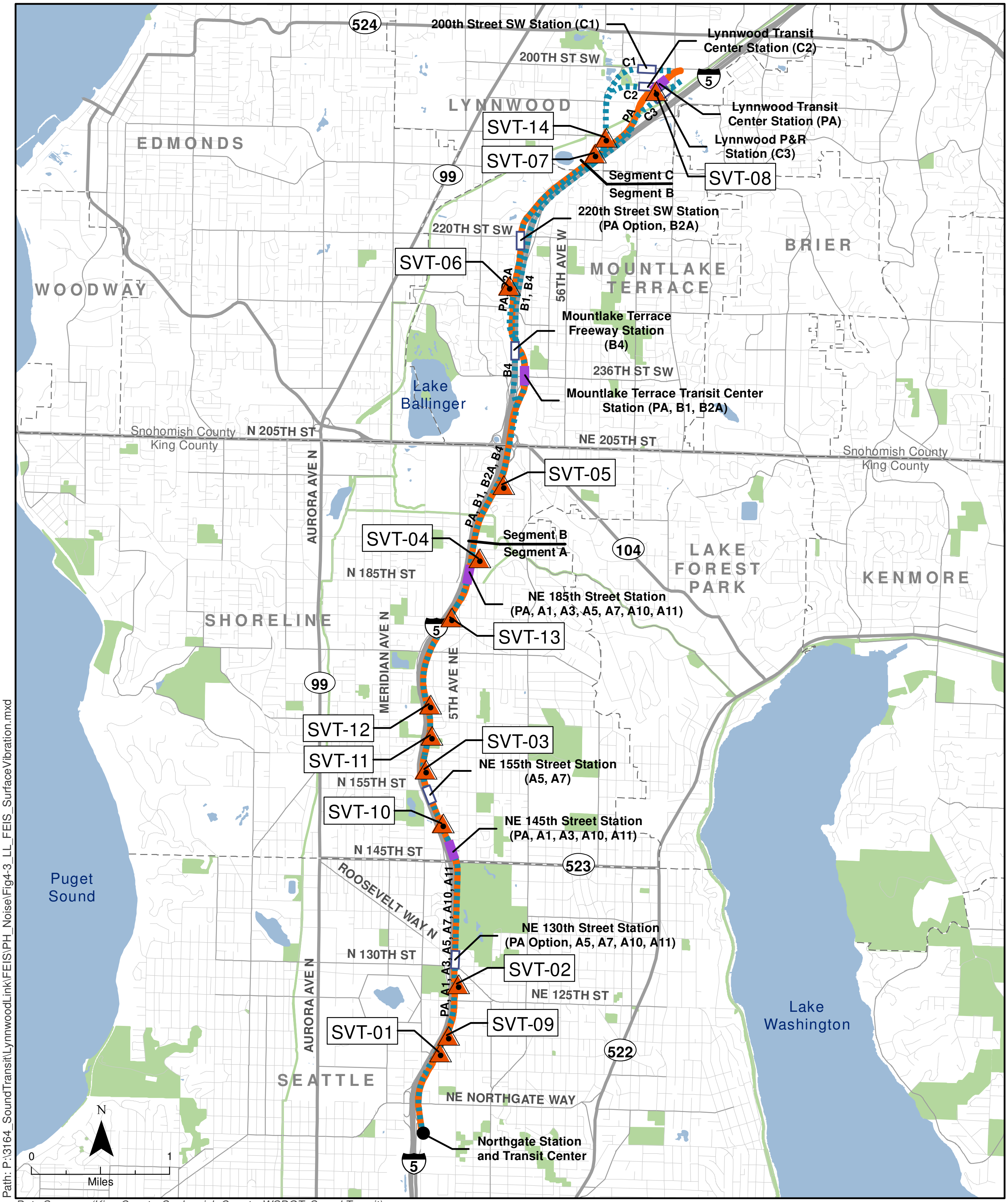
4.1.2 Line Source Response

The LSR represents the response of the ground to vertical forces incoherently distributed over the length of the train (i.e., the force at one location is unrelated to the force at another location). To develop the LSR, the vibration propagation characteristics of the soil are determined by producing an impulsive force on or below the ground surface and measuring the vibration response in each 1/3-octave band (typically from 4 to 160 Hz) at geophones located over a range of distances. The transfer mobilities between each impact and geophone location are calculated from the measured data. The Point Source Response (PSR) is the level in dB of the transfer mobility magnitude. The LSR is calculated by integrating the square of the 1/3-octave transfer mobility at specific distances over the length of the train.

Vibration from elevated structures propagates outward from the foundations of the guideway columns, which act roughly like point sources within the ground. At the time of the vibration analysis, the proposed locations of the guideway columns were not known. Therefore, the LSRs developed for the analysis of the at-grade segments of track were combined with the FDLs developed for elevated structures (see Section 4.1.1) to estimate vibration impacts at locations along the proposed elevated guideway alignment. The FDL was based on vibration measurements taken near the columns of existing guideways. Thus, the projected vibration levels for elevated structures represent the worst-case condition for receptors close to the columns. The vibration at receptors located farther away from the columns should be lower than projected.

The LSRs were measured at fourteen sites near the proposed alignment. Test sites were based on a review of aerial photographs, geological information available online from the Washington State Geological Survey, and supplemented by a visual land-use survey. The 14 test sites, designated as SVT-01 through SVT-14, were selected to represent a range of soil conditions in areas along the project corridor near sensitive land uses. The test sites were located in the municipalities of Seattle, Shoreline, Mountlake Terrace, and Lynnwood. The locations of these test sites are shown in Figure 4-3 and are described below.

- **Site SVT-01:** This site was located at the intersection of 3rd Avenue NE and NE 117th Street in Seattle. The measurement at this location characterizes the vibration propagation in the south portion of Segment A.
- **Site SVT-02:** This site was located at the intersection of 5th Avenue NE and NE 127th Street in Seattle. The measurement at this location characterizes the vibration propagation in the south portion of Segment A, south of the Jackson Park Golf Course.
- **Site SVT-03:** This site was located at the intersection of 1st Avenue NE and NE 158th Street in Shoreline. The measurement at this location characterizes the vibration propagation in the middle portion of Segment A, north of the Jackson Park Golf Course.
- **Site SVT-04:** This site was located at the intersection of 8th Avenue NE and NE 189th Street in Shoreline. The measurement at this location characterizes the vibration propagation in the north portion of Segment A.
- **Site SVT-05:** This site was located at the end of NE 200th Street in Shoreline, immediately east of the I-5 corridor. The measurement at this location characterizes the vibration propagation in the south portion of Segment B.
- **Site SVT-06:** This site was located at the intersection of 226th Street SW and 62nd Avenue West in Mountlake Terrace. The measurement at this location characterizes the vibration propagation in the middle portion of Segment B.
- **Site SVT-07:** This site was located in the cul-de-sac at the south end of 53rd Avenue West in Lynnwood, north and west of the Interstate 5 (I-5) corridor. The measurement at this location characterizes the vibration propagation in the north portion of Segment B and the southern half of Segment C.
- **Site SVT-08:** This site was located in the Lynnwood Park-and-Ride parking lot in Lynnwood. The measurement at this location characterizes the vibration propagation in the north half of Segment C.
- **Site SVT-09:** This site was located at the end of NE 120th Street in Seattle, immediately east of the I-5 corridor. The measurement at this location characterizes the vibration propagation in the south portion of Segment A where potential vibration impact was indicated during the initial vibration study for the Draft EIS.



Data Sources: (King County, Snohomish County, WSDOT, Sound Transit)

Preferred Alternative (PA)
Preferred Alternative Station Location
Other Light Rail Alternatives
Other Alternative Station Location
Preferred Alternative and Other Alternatives
Surface Vibration Test Location
Roadway
Local Street
City Boundary
County Boundary
Park
Waterbody

Figure 4-3
Surface Vibration Test Locations

Lynnwood Link Extension

- **Site SVT-10:** This site was located at the intersection of 3rd Avenue NE and NE 151st Street in Shoreline. The measurement at this location characterizes the vibration propagation in the middle portion of Segment A where potential vibration impact was indicated during the initial vibration study for the Draft EIS.
- **Site SVT-11:** This site was located at the end of NE 163rd Street in Shoreline, immediately east of the I-5 corridor. The measurement at this location characterizes the vibration propagation in the middle portion of Segment A where potential vibration impact was indicated during the initial vibration study for the Draft EIS.
- **Site SVT-12:** This site was located at the end of NE 167th Street in Shoreline, immediately east of the I-5 corridor. The measurement at this location characterizes the vibration propagation in the middle portion of Segment A where potential vibration impact was indicated during the initial vibration study for the Draft EIS.
- **Site SVT-13:** This site was located at the end of NE 180th Street in Shoreline, immediately east of the I-5 corridor. The measurement at this location characterizes the vibration propagation in the north portion of Segment A where potential vibration impact was indicated during the initial vibration study for the Draft EIS.
- **Site SVT-14:** This site was located at 20825 52nd Avenue West in Lynnwood. The measurement at this location characterizes the vibration propagation at a potentially vibration-sensitive commercial property in the north portion of Segment C that was identified during the public comment period for the Draft EIS.

The vibration propagation test procedure and transducer layout are shown schematically in Figure 4-4. As shown in the cross-section view at the top of Figure 4-4, a 42-pound mass is dropped from a height of 4 feet onto a load cell placed against the ground to generate a dynamic impact force. The measurement equipment includes a load cell to measure the force produced by the weight, high-sensitivity geophones, amplifiers, and a multi-channel digital data recorder. Geophones produce an analog electrical signal that is proportional to the vertical vibration velocity of the ground surface to which they are attached. The geophones are located on paved surfaces, concrete curbs, or on aluminum stakes driven into soil, adhered with wax. Where space permitted, impact forces were generated along a line parallel with and adjacent to the rail alignment, at multiple points typically spaced 25 feet apart. Ten geophones were placed in a line perpendicular to the impact locations at distances of 15 to 400 feet from the impact locations. For locations at the ends of streets, impact forces were at three points at 0 and 25 feet offset to each side of the geophone line. For each impact location, a minimum of 30 impacts were used. Analog data were digitally recorded continuously for each set of impacts.

Data were analyzed with digital signal processing software to calculate the auto- and cross-spectral components from which the transfer mobility and coherence between each impact and geophone location were computed as functions of frequency. Coherence is a measure of the signal-to-noise ratio of the test as a function of frequency. The basic analysis steps taken are as follows:

- Linear averages of auto- and cross-spectral components were computed for each source-receiver location.

- Transfer mobilities and coherence functions for each source-receiver pair were computed from the auto- and cross-spectral components.
- The narrowband squared transfer mobility magnitudes were averaged over each 1/3-octave band and the result was expressed as the PSR in decibels.
- The PSR levels were plotted with respect to the logarithm of distance from the impacts and a polynomial curve was fitted to the data by the method of least squares for each 1/3-octave band using the following formula to obtain the PSR as a function of distance:

$$PSR = A_0 + A_1 \bullet \log_{10}(D) + A_2 \bullet \log_{10}^2(D) + A_3 \bullet \log_{10}^3(D) \qquad \text{(Equation 4-2)}$$

where:

PSR is the Point Source Response in dB; A_0, A_1, A_2 and A_3 are the regression coefficients; and D is the distance (feet) between the source and the receiver.

- The LSR at each test site was calculated by integrating the 1/3-octave PSR energy at specific distances over the length of a four-car train (380 feet) using the regression coefficients determined above.
- Propagation test and analysis procedures are described in more detail in the FTA guidance manual *Transit Noise and Vibration Impact Assessment*.

Detailed vibration propagation data for the project are included in Attachment E of this report.

For all test sites with the exception of SVT-05, SVT-07, and SVT-10, there was no observable correlation between the LSR and the geological properties of the soil at those sites. Therefore, a general LSR was developed by energy-averaging the computed LSRs from each of the remaining sites (SVT-01 through SVT-04, SVT-06, SVT-08, SVT-09, and SVT-11 through SVT-14) at multiple distances up to 400 feet, then applying a polynomial curve fit to the data. The resulting general LSR is plotted at several distances in Figure 4-5 while the regression coefficients are listed in Table 4-3. The general LSR was applied along the length of the alignment except where noted below.

The LSRs calculated at SVT-05, SVT-07, and SVT-10 were notably different from those obtained at the other sites. A review of the geological data in the vicinities indicated a relatively deep top layer of soft soil (based on standard penetration test results) that was likely to have contributed to the observed differences. The LSRs calculated from the data at the above three test sites were applied for receivers in the vicinity of each site. The extents along the alignment where the LSR data were used were determined from available geological information obtained from the Washington State Geological Survey Web site. The LSR was calculated by integrating the PSR energy at specific distances over the length of a four-car train (380 feet) using the regression coefficients determined as described above. The PSR regression coefficients used to calculate the LSRs at SVT-05, SVT-07, and SVT-10 are provided in Attachment E with the vibration data from all the test sites.

Site-specific LSRs were used, where available, at every location indicated to have potential vibration impact. The PSR regression coefficients used to calculate each site-specific LSR are provided in Attachment E with the vibration data from all the test sites. Table 4-4 indicates the extents along the alignment where each LSR (site-specific or general) was used in the vibration analysis.

Table 4-3. Regression Coefficients for the General LSR Applied Along the Length of the Alignment Except Where Noted

	1/3-Octave Band Center Frequency (Hz)																	
Coefficient	**3.15**	**4**	**5**	**6.3**	**8**	**10**	**12.5**	**16**	**20**	**25**	**31.5**	**40**	**50**	**63**	**80**	**100**	**125**	**160**
A_0	44.5	-8.0	-7.0	7.5	10.0	22.9	18.8	32.3	50.2	52.7	118.2	89.9	51.7	15.4	57.5	86.4	47.6	-76.6
A_1	-49.7	39.6	41.4	15.6	17.0	0.8	13.9	-6.5	-27.7	-24.0	-116.2	-50.6	11.5	77.9	6.2	-49.4	18.0	230.3
A_2	25.4	-25.2	-27.1	-11.3	-12.6	-2.4	-9.6	4.8	17.5	16.3	61.9	21.2	-10.5	-52.2	-17.1	13.9	-24.8	-142.4
A_3	-4.4	4.9	5.3	2.1	2.4	0.4	1.5	-1.8	-4.7	-4.9	-12.7	-5.2	-0.4	7.7	2.2	-3.4	3.7	24.9

$LSR = A_0 + A_1 \cdot \log_{10}(D) + A_2 \cdot \log_{10}^2(D) + A_3 \cdot \log_{10}^3(D)$

Table 4-4. Extents[a] Where Each Line Source Response (LSR) Was Used in the Vibration Analysis

Starting Station[b]	Ending Station[b]	LSR
27+00	34+60	General
36+20	43+30	SVT-01
43+60	54+70	SVT-09
55+00	121+90	General
122+30	137+00	SVT-10
138+00	144+00	General
144+30	150+00	SVT-03
150+60	162+10	General
162+20	169+00	SVT-11
170+50	185+80	SVT-12
186+10	207+50	General
208+20	220+00	SVT-13
220+50	229+20	General
230+10	246+60	SVT-04
251+50	266+10	General
268+40	277+40	SVT-05
279+50	423+80	General
424+00	428+60	SVT-06
429+40	483+30	General
483+40	495+60	SVT-07
496+00	499+80	General
500+20	501+90	SVT-14
205+10	541+80	General

[a]Extents shown only where there are vibration-sensitive receptors.
[b]Preferred Alternative stationing

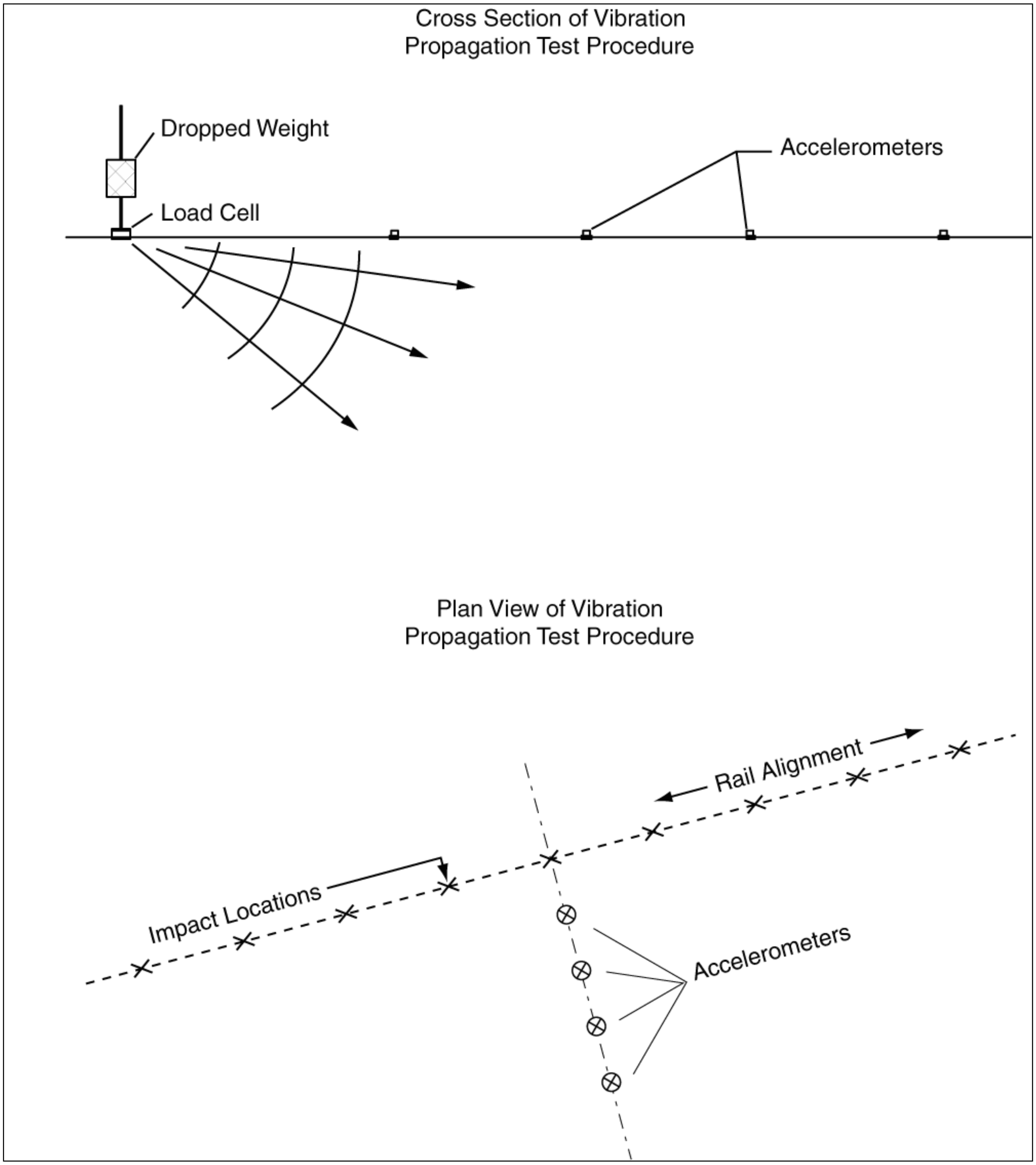


Figure 4-4. Surface Vibration Propagation Test Procedure

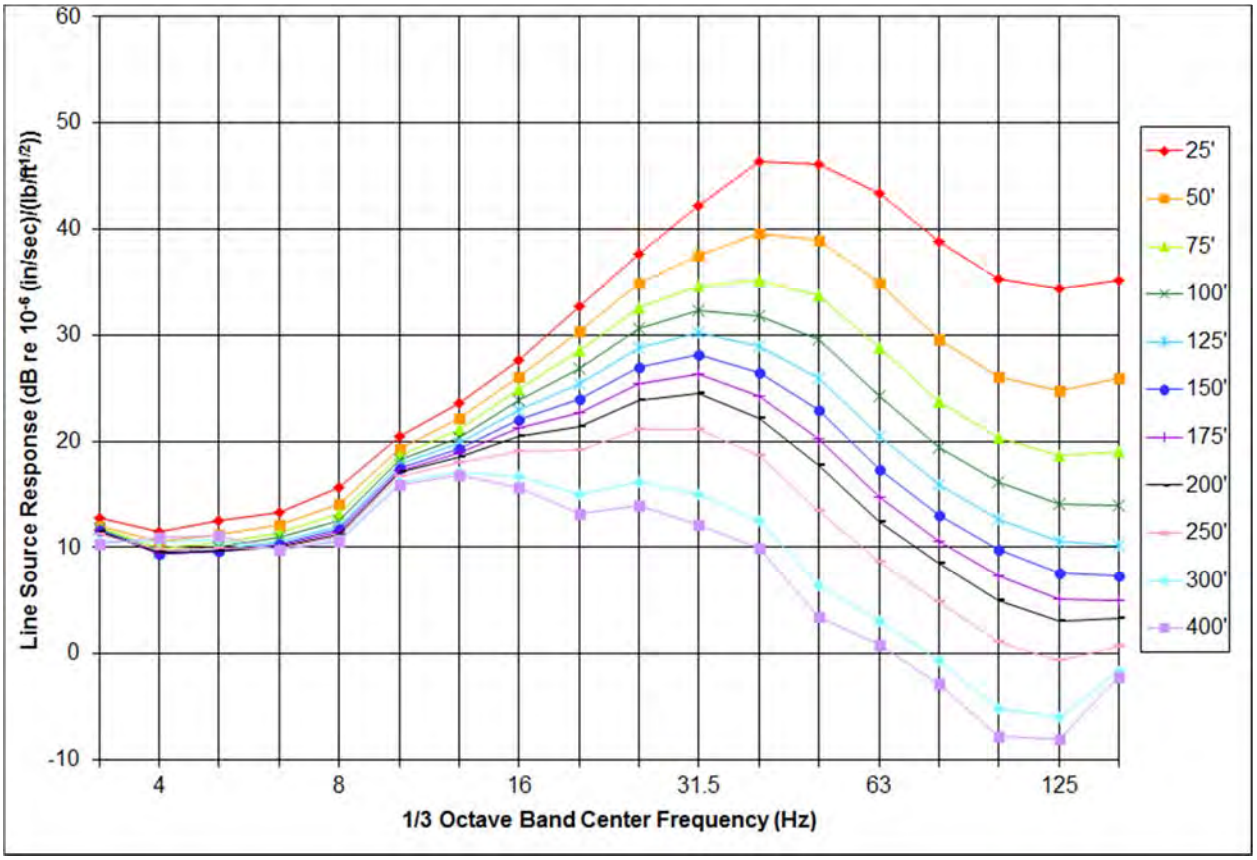


Figure 4-5. General Line Source Transfer Mobilities Based on SVT-01 through SVT-04, SVT-06, SVT-08, SVT-09, and SVT-11 through SVT-14

4.1.3 Building Vibration Response

The mechanical responses of various parts of building structures either reduce or increase the interior vibration levels. Composite building vibration responses were derived to represent the response of the foundation to incident ground vibration, floor-to-floor attenuation, and resonance amplification of floors. These building vibration responses are added to the predicted ground surface vibration levels to arrive at the final predicted indoor floor vibration levels.

Vibration is reduced as it travels from the soil into the building because of the mass of the building and foundation. These combined effects are referred to as the “foundation coupling loss.” The FTA guidance manual provides foundation coupling losses for a variety of buildings. Because the majority of sensitive land uses along the project corridor are single-family residential structures, the predictions herein are for the first floor only. No floor-to-floor attenuation has been included to predict floor vibration at upper floors. The FTA manual states that the floor resonance amplification varies greatly; therefore, the manual suggests adding +6 dB to floor vibration velocity levels in the frequency range of the fundamental resonance in the floor—from 15 to 20 Hz for wood-frame residential structures and 20 to 30 Hz for a reinforced-concrete slab floor in modern buildings (Chapter 11: Detailed Vibration Analysis, page 11-11). The combined frequency range for both types of buildings includes the 1/3-octave bands from 16 to 31.5 Hz. For the Lynnwood Link

Extension vibration analysis, this adjustment was extended to all bands above 31.5 Hz and an adjustment was also added at frequencies below 16Hz. Table 4-5 lists these adjustments.

The foundation coupling losses, floor attenuation, and floor resonance amplification were combined to obtain the BVR in decibels. The BVRs for basic types of buildings are identical to those used previously for Sound Transit's University Link Extension and Northgate Link Extension, and are listed in Table 4-6. The BVR assigned to each type of building was based on observation of the buildings along the alignment.

Table 4-5. Adjustment for Floor Resonance Amplification (dB)

	1/3-Octave Band Center Frequency (Hz)														
	6.3	8	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160
Adjustment	2	3	4	5	6	6	6	6	6	6	6	6	6	6	6

Table 4-6. Building Vibration Response (dB) (Including Adjustment for Floor Resonance Amplification)

	1/3-Octave Band Center Frequency (Hz)														
Structure	**6.3**	**8**	**10**	**12.5**	**16**	**20**	**25**	**31.5**	**40**	**50**	**63**	**80**	**100**	**125**	**160**
Single Family	2	2	2	2	2	1	1	1	1	1	1	1	1	1	2
1-2 Story Residential	2	1	-1	-1	-1	-2	-2	-2	-3	-3	-3	-3	-2	-2	-1
2-4 Story Masonry on Spread Footings	-1	-2	-3	-4	-4	-5	-6	-7	-8	-8	-8	-6	-6	-5	-4
Large Masonry on Pile Foundation	-2	-2	-1	0	0	-1	-2	-3	-3	-4	-5	-6	-7	-8	-8
Large Masonry on Spread Footings	-6	-7	-6	-6	-6	-7	-8	-8	-8	-8	-8	-8	-8	-7	-6
Slab on Grade Floor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

4.1.4 Additional Adjustments

Wheel impacts at crossovers increase vibration relative to a tangent track. The vibration generated by special track work tends to propagate as from a point source. Therefore, the adjustment depends strongly upon the proximity of the receptor to the crossover. To account for the increased vibration from crossovers, the following adjustment was applied:

$$+11 \text{ dB for } D < 20 \text{ ft} \qquad \text{(Equation 4-3)}$$

$$11 + 20\log_{10}(20/D) \text{ dB for } 20 \text{ ft} \leq D \leq 70 \text{ ft}$$

$$0 \text{ dB for } D > 70 \text{ ft}$$

where:

D equals the distance between the receiver and the closest extent of any crossover.

The above adjustment is based upon ground vibration measurements conducted adjacent to crossovers on other transit systems and is identical to the adjustment that was applied to the University Link Extension and Northgate Link Extension.

4.2 Construction Vibration Projections

Construction vibration, similar to noise, is highly dependent on the specific equipment and methods employed. Construction vibration can cause a variety of potential effects, including interference with vibration-sensitive equipment, low rumbling or groundborne noise, vibrations perceptible to humans at moderate levels, and cosmetic damage to buildings at the highest levels considered here. Because construction is a short-term, temporary impact, construction vibration was assessed at locations where prolonged annoyance or building cosmetic damage might occur; namely, at the receptors within the vicinity of the stations planned for the project.

Most construction processes do not generate high enough vibration levels to approach the threshold for cracking damage; moreover, structural damage is highly unlikely for construction vibration. Cosmetic damage from construction vibration is generally limited to pile-driving and vibratory rolling—the only two activities with PPV levels at 25 feet that are higher than the threshold for cracking damage. Because of this reason, care should be taken to limit these activities near structures as much as practicable.

The methodology for assessing construction vibration annoyance includes measuring maximum rms overall vibration levels with an integration time of 1 second for each source at a distance of 25 feet. A summary of expected upper-range vibration levels at a reference distance of 25 feet from the vibration source is presented in Table 4-7 (from FTA). For reference, the distance from the vibration source necessary to achieve vibration levels of 72 VdB or below is given in the last column. This level corresponds to the vibration annoyance criteria for frequent events at residential receptors (Table 3-1).

Using the available reference vibration levels at 25 feet, the following general prediction model (from the FTA guidance manual) gives the vibration level as a function of distance:

$$L_v(\text{distance}) = L_v(25\text{ feet}) - 30*\log(\text{distance}/25\text{ feet}) \quad \text{(Equation 4-4)}$$

Table 4-7. Summary of Construction Equipment Vibration

Equipment	PPV at 25 feet (inches/second)	Approx. L_V[a] at 25-foot VdB	Minimum Distance between Equipment and Receptor to Avoid Annoyance Impact (feet)
Vibratory pile or casing	0.734	105	315
Oscillatory pile casing	0.089	87	80
Vibratory soil compactor	0.210	94	120
Auger drilling	0.016	72	25
Hoe ram	0.089	87	80
Excavator/grader/bulldozer	0.089	87	80
Loaded trucks	0.076	86	75

[a] Root mean square velocity level in decibels (VdB) re: 1 micro-inch/second, determined with an integration time of 1 second.

5 VIBRATION IMPACT ASSESSMENT

The detailed vibration impact assessment is based on the criteria discussed in Section 4 and on the projections described in this section. The assessment results are described below.

5.1 Light Rail Vibration Impact Assessment

The vibration impact assessment is based on the FDL as a function of train speed and the LSR as a function of distance from the receivers to the tracks. The locations of sensitive receptors and the distances from the receivers to the tracks were based on geographic information system (GIS) data available in the online document-sharing database for the project. Plan and profile information for all alternatives, except the Preferred Alternative, were based on the conceptual design drawings (dated 13 July 2012) in the Draft EIS. Plan and profile information for the Preferred Alternative were based on the Draft Preliminary Plans for the Final EIS evaluation dated April 2014.

Operating speeds used for the analysis were obtained from the Draft EIS conceptual plans for the Lynnwood Link Extension, dated June 8, 2012. In accordance with Sound Transit's *Link Design Criteria Manual* (May 2011), the maximum design speed for Link light rail corridors is 55 mph, and the maximum acceleration and deceleration rate is 3 mph per second. Using this rate, the design speed may be achieved in less than 20 seconds over a distance of less than 600 feet. As a result, and accounting for 380-foot platforms, the operating speed beyond 200 feet from stations was evaluated at 55 mph, except where limited by track geometry, as listed in Table 5-1. Within 200 feet of stations, a conservative average speed of 45 mph was used. A four-car consist was modeled as described in the operating plan in Part 1: Noise Section 5.5 of this report.

Table 5-1. Areas with Limited Operating Speed

Applicable Alternatives	Begin Track Station	End Track Station	Speed
Preferred	113+00	115+00	40 mph
Preferred	118+00	122+00	40 mph
Preferred	223+00	226+00	45 mph
Preferred	230+00	234+90	40 mph
Preferred	306+00	308+00	35 mph
Preferred	310+00	313+90	40 mph
Preferred	402+00	406+00	40 mph
Preferred	413+00	416+00	40 mph
Preferred	443+00	445+00	45 mph
Preferred	455+00	458+00	35 mph
Preferred	522+00	525+00	45 mph
Preferred	530+00	533+80	40 mph
Preferred	540+00	541+85	25 mph
A1, A3, A10	100+00	117+00	45 mph
A5, A10	212+00	218+00	45 mph

Table 5-1. Areas with Limited Operating Speed

Applicable Alternatives	Begin Track Station	End Track Station	Speed
B4	352+00	357+00	40 mph
B4	357+00	367+00	35 mph
B1	360+00	364+00	35 mph
B1	370+00	375+00	35 mph
B1	378+00	384+00	45 mph
B2A	348+00	356+00	45 mph
B2A	360+00	365+00	35 mph
B2A	371+00	376+00	35 mph
B2A	380+00	391+00	45 mph
B2A	407+00	411+00	45 mph
B2A	421+00	428+00	45 mph
B2A	438+00	444+00	45 mph
C1, C2	502+00	513+00	45 mph
C3	516+00	521+00	40 mph
C3	525+00	530+00	40 mph
C1	526+00	534+00	45 mph
C2	526+00	538+00	35 mph
C1	537+00	546+00	35 mph

Attachment D includes tables that list the vibration-sensitive receptor locations, receiver type, FTA criteria, distance to the nearest track, and the projected maximum 1/3-octave-band vibration velocity levels for each segment, including all alternatives. Receptors with potential vibration impacts are highlighted in the tables.

As discussed in Section 3.1.2, groundborne noise criteria are only applied to buildings that have sensitive interior spaces that are well insulated from exterior noise when assessing potential groundborne noise impacts from at-grade track or elevated guideway. No such buildings exist along the project alignment; therefore, no groundborne noise impacts are reported in this study.

Tables 5-2 through 5-13 summarize the potential vibration impacts, including locations and number of potential impacts at each receptor, for each project segment plus the Preferred Alternative. The number of potential impacts at multifamily receptors, if any, is estimated by assuming that the total number of residential units is divided evenly between buildings. The potential impacts reported in this section do not include potential mitigation measures. Mitigation for potential impacts is discussed in Section 6.1.

5.1.1 Segment A: Seattle to Shoreline

The following sections discuss the potential vibration impacts for each of the Segment A alternatives.

Preferred Alternative

Table 5-2 summarizes the potential vibration impacts for the Preferred Alternative in Segment A. Potential vibration impacts include 25 single-family homes and one duplex distributed along the alignment.

Table 5-2. Preferred Alternative Segment A Potential Vibration Impacts

Station No.	Address	Distance to Near Track (feet)	Speed (mph)	Maximum 1/3-Octave Vibration Level (VdB)	1/3-Octave Band (Hz)	Vibration Impact Criterion	No. of Potential Impacts
36+20	136 NE 115TH ST, Seattle	30	55	76	63	72	1
36+40	147 NE 116TH ST, Seattle	24	55	79	63	72	2
43+30	11710 3rd Avenue NE, Seattle	20	55	81	63	72	1
50+60	338 NE 120th Street, Seattle	37	55	73	63	72	1
52+40	12027 5th Avenue NE, Seattle	32	55	74	63	72	1
53+50	12045 5th Avenue NE, Seattle	24	55	77	63	72	1
54+30	12049 5th Avenue NE, Seattle	32	55	74	63	72	1
130+20	301 NE 151st Street, Shoreline	29	55	79	25	72	1
146+50	106 NE 155th Street, Shoreline	23	55	72	63	72	1
172+30	126 NE 165th Street, Shoreline	43	55	72	25	72	1
173+20	124 NE 165th Place, Shoreline	41	55	72	25	72	1
174+60	119 NE 166th Street, Shoreline	41	55	72	25	72	1
182+90	16735 2nd Avenue NE, Shoreline	45	55	72	25	72	1
183+00	16741 2nd Avenue NE, Shoreline	43	55	72	25	72	1
185+30	119 NE 170th Street, Shoreline	45	55	72	25	72	1
203+20	17737 2nd Place NE, Shoreline	22	55	72	50	72	1
209+00	17809 3rd Avenue NE, Shoreline	34	55	75	63	72	1
210+00	17821 3rd Avenue NE, Shoreline	23	55	79	63	72	1
213+40	331 NE 180th Street, Shoreline	28	55	77	63	72	1
216+30	338 NE 180th Street, Shoreline	40	55	73	63	72	1
217+30	18019 5th Avenue NE, Shoreline	25	55	78	63	72	1

Table 5-2. Preferred Alternative Segment A Potential Vibration Impacts

Station No.	Address	Distance to Near Track (feet)	Speed (mph)	Maximum 1/3-Octave Vibration Level (VdB)	1/3-Octave Band (Hz)	Vibration Impact Criterion	No. of Potential Impacts
218+40	18027 5th Avenue NE, Shoreline	45	55	72	63	72	1
218+90	18031 5th Avenue NE, Shoreline	20	55	80	63	72	1
238+70	715 NE 189th Street, Shoreline	30	55	73	63	72	1
239+20	718 NE 189th Street, Shoreline	17	55	78	63	72	1
240+60	18915 8th Avenue NE, Shoreline	24	55	75	63	72	1
						Total	**27**

Note: Vibration levels are measured in VdB referenced to 1 micro-inch per second.

Alternative A1: At-grade/Elevated with NE 145th and NE 185th Street Stations

Table 5-3 summarizes the potential vibration impacts for Alternative A1. Potential vibration impacts include nine single-family homes distributed along the alignment.

Table 5-3. Alternative A1 Potential Vibration Impacts

Station No.	Address	Distance to Near Track (feet)	Speed (mph)	Maximum 1/3-Octave Vibration Level (VdB)	1/3-Octave Band (Hz)	Vibration Impact Criterion	No. of Potential Impacts
38+25	327 NE 120th Street, Seattle	34	55	74	63	72	1
155+50	121 NE 163rd Street, Shoreline	27	55	79	63	72	1
169+50	114 NE 167th Street, Shoreline	26	55	74	50	72	1
198+75	17815 3rd Avenue NE, Shoreline	22	55	79	63	72	1
199+75	17821 3rd Avenue NE, Shoreline	28	55	77	63	72	1
203+25	331 NE 180th Street, Shoreline	34	55	80	63	72	1
206+25	18019 5th Avenue NE, Shoreline	32	55	75	63	72	1
209+50	18031 5th Avenue NE, Shoreline	28	55	77	63	72	1
231+00	18921 8th Avenue NE, Shoreline	27	55	74	63	72	1
						Total	**9**

Note: Vibration levels are measured in VdB referenced to 1 micro-inch per second.

Alternative A3: Mostly Elevated with NE 145th and NE 185th Street Stations

Table 5-4 summarizes the potential vibration impacts for Alternative A3. Potential vibration impacts include eight single-family homes along the alignment.

Table 5-4. Alternative A3 Potential Vibration Impacts

Station No.	Address	Distance to Near Track (feet)	Speed (mph)	Maximum 1/3-Octave Vibration Level (VdB)	1/3-Octave Band (Hz)	Vibration Impact Criterion	No. of Potential Impacts
33+00	11710 3rd Avenue NE, Seattle	21	55	73	63	72	1
114+75	324 NE 148th Street, Shoreline	24	45	72	16	72	1
155+50	121 NE 163rd Street, Shoreline	27	55	79	63	72	1
169+50	114 NE 167th Street, Shoreline	26	55	74	50	72	1
198+75	17815 3rd Avenue NE, Shoreline	22	55	72	50	72	1
199+50	17821 3rd Avenue NE, Shoreline	28	55	75	50	72	1
203+00	331 NE 180th Street, Shoreline	34	55	73	50	72	1
206+00	18019 5th Avenue NE, Shoreline	32	55	75	50	72	1
						Total	**8**

Note: Vibration levels are measured in VdB referenced to 1 micro-inch per second.

Alternative A5: At-grade/Elevated with NE 130th, NE 155th, and NE 185th Street Stations

Table 5-5 summarizes the potential vibration impacts for Alternative A5. Potential vibration impacts include 14 single-family homes and one duplex distributed along the alignment.

Table 5-5. Alternative A5 Potential Vibration Impacts

Station No.	Address	Distance to Near Track (feet)	Speed (mph)	Maximum 1/3-Octave Vibration Level (VdB)	1/3-Octave Band (Hz)	Vibration Impact Criterion	No. of Potential Impacts
26+00	136 NE 115th Street, Seattle	30	55	76	63	72	1
26+25	147 NE 116th Street, Seattle	24	55	79	63	72	2
33+00	11708 3rd Avenue NE, Seattle	37	55	73	63	72	1
38+25	327 NE 120th Street, Seattle	34	55	74	63	72	1
114+75	324 NE 148th Street, Shoreline	44	55	72	25	72	1

Table 5-5. Alternative A5 Potential Vibration Impacts

Station No.	Address	Distance to Near Track (feet)	Speed (mph)	Maximum 1/3-Octave Vibration Level (VdB)	1/3-Octave Band (Hz)	Vibration Impact Criterion	No. of Potential Impacts
116+25	309 NE 149th Street, Shoreline	32	55	75	25	72	1
155+50	121 NE 163rd Street, Shoreline	27	55	79	63	72	1
169+50	114 NE 167th Street, Shoreline	26	55	74	50	72	1
198+75	17815 3rd Avenue NE, Shoreline	22	55	79	63	72	1
199+75	17821 3rd Avenue NE, Shoreline	28	55	77	63	72	1
203+25	331 NE 180th Street, Shoreline	34	55	80	63	72	1
206+00	18019 5th Avenue NE, Shoreline	32	55	75	63	72	1
209+25	18031 5th Avenue NE, Shoreline	28	55	77	63	72	1
228+75	718 NE 189th Street, Shoreline	20	55	77	63	72	1
230+25	18915 8th Avenue NE, Shoreline	23	55	75	63	72	1
						Total	**16**

Note: Vibration levels are measured in VdB referenced to 1 micro-inch per second.

Alternative A7: Mostly Elevated with NE 130th, NE 155th, and NE 185th Street Stations

Table 5-6 summarizes the potential vibration impacts for Alternative A7. Potential vibration impacts include nine single-family homes distributed along the alignment.

Table 5-6. Alternative A7 Potential Vibration Impacts

Station No.	Address	Distance to Near Track (feet)	Speed (mph)	Maximum 1/3-Octave Vibration Level (VdB)	1/3-Octave Band (Hz)	Vibration Impact Criterion	No. of Potential Impacts
33+00	11710 3rd Avenue NE, Seattle	21	55	73	63	72	1
114+75	324 NE 148th Street, Shoreline	44	55	72	25	72	1
116+25	309 NE 149th Street, Shoreline	32	55	75	25	72	1
155+50	121 NE 163rd Street, Shoreline	27	55	79	63	72	1
169+50	114 NE 167th Street, Shoreline	26	55	74	50	72	1
198+75	17815 3rd Avenue NE, Shoreline	22	55	72	50	72	1
199+50	17821 3rd Avenue NE, Shoreline	28	55	75	50	72	1

Table 5-6. Alternative A7 Potential Vibration Impacts

Station No.	Address	Distance to Near Track (feet)	Speed (mph)	Maximum 1/3-Octave Vibration Level (VdB)	1/3-Octave Band (Hz)	Vibration Impact Criterion	No. of Potential Impacts
203+00	331 NE 180th Street, Shoreline	34	55	73	50	72	1
206+00	18019 5th Avenue NE, Shoreline	32	55	75	50	72	1
						Total	**9**

Note: Vibration levels are measured in VdB referenced to 1 micro-inch per second.

Alternative A10: At-grade/Elevated with NE 130th, NE 145th, and NE 185th Street Stations

Table 5-7 summarizes the potential vibration impacts for Alternative A10. Potential vibration impacts include 12 single-family homes and one duplex distributed along the alignment.

Table 5-7. Alternative A10 Potential Vibration Impacts

Station No.	Address	Distance to Near Track (feet)	Speed (mph)	Maximum 1/3-Octave Vibration Level (VdB)	1/3-Octave Band (Hz)	Vibration Impact Criterion	No. of Potential Impacts
26+00	136 NE 115th Street, Seattle	30	55	76	63	72	1
26+25	147 NE 116th Street, Seattle	24	55	79	63	72	2
33+00	11708 3rd Avenue NE, Seattle	37	55	73	63	72	1
38+25	327 NE 120th Street, Seattle	34	55	74	63	72	1
155+50	121 NE 163rd Street, Shoreline	27	55	79	63	72	1
169+50	114 NE 167th Street, Shoreline	26	55	74	50	72	1
198+75	17815 3rd Avenue NE, Shoreline	22	55	79	63	72	1
199+75	17821 3rd Avenue NE, Shoreline	28	55	77	63	72	1
203+25	331 NE 180th Street, Shoreline	34	55	80	63	72	1
206+00	18019 5th Avenue NE, Shoreline	32	55	75	63	72	1
209+25	18031 5th Avenue NE, Shoreline	28	55	77	63	72	1
228+75	718 NE 189th Street, Shoreline	20	55	77	63	72	1
230+25	18915 8th Avenue NE, Shoreline	23	55	75	63	72	1
						Total	**14**

Note: Vibration levels are measured in VdB referenced to 1 micro-inch per second.

Alternative A11: Mostly Elevated with NE 130th, NE 145th, and NE 185th Street Stations

Table 5-8 summarizes the potential vibration impacts for Alternative A11. Potential vibration impacts include eight single-family homes distributed along the alignment.

Table 5-8. Alternative A11 Potential Vibration Impacts

Station No.	Address	Distance to Near Track (feet)	Speed (mph)	Maximum 1/3-Octave Vibration Level (VdB)	1/3-Octave Band (Hz)	Vibration Impact Criterion	No. of Potential Impacts
33+00	11710 3rd Avenue NE, Seattle	21	55	73	63	72	1
114+75	324 NE 148th Street, Shoreline	24	45	72	16	72	1
155+50	121 NE 163rd Street, Shoreline	27	55	79	63	72	1
169+50	114 NE 167th Street, Shoreline	26	55	74	50	72	1
198+75	17815 3rd Avenue NE, Shoreline	22	55	72	50	72	1
199+50	17821 3rd Avenue NE, Shoreline	28	55	75	50	72	1
203+00	331 NE 180th Street, Shoreline	34	55	73	50	72	1
206+00	18019 5th Avenue NE, Shoreline	32	55	75	50	72	1
						Total	**8**

Note: Vibration levels are measured in VdB referenced to 1 micro-inch per second.

5.1.2 Segment B: Shoreline to Mountlake Terrace

No potential vibration impacts are projected along any of the alternatives or options for Segment B except where indicated in the Preferred Alternative.

Preferred Alternative

Table 5-9 summarizes the potential vibration impacts for the Preferred Alternative in Segment B. Potential vibration impacts include three single-family homes in Segment B.

Table 5-9. Preferred Alternative Segment B Potential Vibration Impacts

Station No.	Address	Distance to Near Track (feet)	Speed (mph)	Maximum 1/3-Octave Vibration Level (VdB)	1/3-Octave Band (Hz)	Vibration Impact Criterion	No. of Potential Impacts
259+30	19705 10th Avenue NE, Shoreline	40	55	76	63	72	1
259+80	19715 10th Avenue NE, Shoreline	45	55	72	63	72	1
478+80	5632 213th Street SW, Mountlake Terrace	48	55	72	63	72	1
						Total	**3**

Note: Vibration levels are measured in VdB referenced to 1 micro-inch per second.

5.1.3 Segment C: Mountlake Terrace to Lynnwood

Preferred Alternative

There are no potential vibration impacts for the Preferred Alternative in Segment C.

Alternative C1: 52nd Avenue West to 200th Street SW, Option 1 within I-5 Median

Table 5-10 summarizes the potential vibration impacts for Alternative C1 Option 1 (within the I-5 median). Potential vibration impacts include one single-family home and one commercial property identified to be potentially sensitive to vibration.

Table 5-10. Alternative C1 Option 1 Potential Vibration Impacts

Station No.	Address	Distance to Near Track (feet)	Speed (mph)	Maximum 1/3-Octave Vibration Level (VdB)	1/3-Octave Band (Hz)	Vibration Impact Criterion	No. of Potential Impacts
510+00	20909 52nd Avenue West, Lynnwood	25	55	75	50	72	1
513+00	20815 52nd Avenue West, Lynnwood	17	55	82	40	72	1
						Total	**2**

Note: Vibration levels are measured in VdB referenced to 1 micro-inch per second.

Alternative C1: 52nd Avenue West to 200th Street SW, Option 2 West of I-5

Table 5-11 summarizes the potential vibration impacts for Alternative C1 Option 2 (west of I-5). Only one potential vibration impact is projected at a commercial property identified to be potentially sensitive to vibration.

Table 5-11. Alternative C1 Option 2 Potential Vibration Impacts

Station No.	Address	Distance to Near Track (feet)	Speed (mph)	Maximum 1/3-Octave Vibration Level (VdB)	1/3-Octave Band (Hz)	Vibration Impact Criterion	No. of Potential Impacts
513+00	20815 52nd Avenue West, Lynnwood	17	55	82	40	72	1
						Total	**1**

Note: Vibration levels are measured in VdB referenced to 1 micro-inch per second.

Alternative C2: 52nd Avenue West to Lynnwood Transit Center, Option 1 within I-5 Median

Table 5-12 summarizes the potential vibration impacts for Alternative C2 Option 1 (within the I-5 median). Potential vibration impacts include one single-family home and one commercial property identified to be potentially sensitive to vibration.

Table 5-12. Alternative C2 Option 1 Potential Vibration Impacts

Station No.	Address	Distance to Near Track (feet)	Speed (mph)	Maximum 1/3-Octave Vibration Level (VdB)	1/3-Octave Band (Hz)	Vibration Impact Criterion	No. of Potential Impacts
510+00	20909 52nd Avenue West, Lynnwood	25	55	75	50	72	1
513+00	20815 52nd Avenue West, Lynnwood	17	55	82	40	72	1
						Total	**2**

Note: Vibration levels are measured in VdB referenced to 1 micro-inch per second.

Alternative C2: 52nd Avenue West to 200th Street SW, Option 2 West of I-5

Table 5-13 summarizes the potential vibration impacts for Alternative C2 Option 2 (west of I-5). Only one potential vibration impact is projected at a commercial property identified to be potentially sensitive to vibration.

Table 5-13. Alternative C2 Option 2 Potential Vibration Impacts

Station No.	Address	Distance to Near Track (feet)	Speed (mph)	Maximum 1/3-Octave Vibration Level (VdB)	1/3-Octave Band (Hz)	Vibration Impact Criterion	No. of Potential Impacts
513+00	20815 52nd Avenue West, Lynnwood	17	55	82	40	72	1
						Total	**1**

Note: Vibration levels are measured in VdB referenced to 1 micro-inch per second.

Alternative C3: Along I-5 to Lynnwood Park-and-Ride, Option 1 within I-5 Median

No potential vibration impacts are projected along Alternative C3 Option 1 (within the I-5 median).

Alternative C3: Along I-5 to Lynnwood Park-and-Ride, Option 2 West of I-5

No potential vibration impacts are projected along Alternative C3 Option 2 (west of I-5).

5.2 Construction Vibration Impact Assessment

Building damage is the primary concern related to construction vibration. Annoyance is typically a concern only where there is prolonged exposure to construction vibration that would occur during construction of the stations. The following sections discuss potential vibration impacts relative to building damage during construction of the guideway and potential vibration impacts relative to both building damage and annoyance during construction of the stations.

The construction assessment assumes that impact pile-driving will not be used in any construction related to the project. Alternative pile-driving techniques, such as vibratory pile-driving or augered piles, have been considered in this assessment as substitutes for impact pile-driving.

5.2.1 Guideway Construction

Two construction sources that have the potential to cause cosmetic damage to receptors along the alignment during construction of the guideway are vibratory soil compactors and vibratory pile drivers. Vibratory soil compactors might be used during construction of the at-grade segments of the guideway. Vibratory sheet pile-driving might be required during construction of the retained cut segments, for excavation, and/or for retaining wall foundations.

The design of the foundations for the elevated guideway columns may include large-diameter concrete piles. A common method is to force a large-diameter cylindrical steel casing into the ground to the required depth, excavate the contents of the casing, insert a rebar cage, and then pour concrete into the void. As the concrete is poured in, the casing is extracted for reuse. The casing would be driven into the ground using a vibratory hammer (with a variable frequency drive) that can produce substantial ground vibration. Constant frequency vibratory pile drivers produce substantially less vibration than vibratory hammers that sweep upwards through the resonance frequency of the pile casing, hammer, and soil. An oscillatory method whereby the temporary casing is rotated back and forth in torsion generates measurably less vibration. The vibration caused by the oscillatory method is similar to other non-pile-driving construction activities, and would not represent a substantial source of vibration. These pile-casing installation techniques may be used for localized foundations such as guideway columns or for large secant-piled walls.

The potential for cosmetic damage to nearby structures should be closely evaluated if vibratory pile-driving methods are to be used within 80 feet of any receptor, or if a vibratory soil compactor is to be used within 40 feet of any sensitive receptor. This task should include documenting the condition of buildings prior to construction and monitoring vibration during construction.

No structural damage would occur to any building as long as the vibration does not exceed the threshold cracking criteria, which is the vibration velocity magnitude at which minor cosmetic cracking might occur (Dowding 1996).

5.2.2 Station Construction

In general, station construction receptors would include primarily single-family residences, a church, a firehouse, and apartment complexes (multifamily residences) adjacent to the Lynnwood Transit Center and Park-and-Ride. All of the stations would be in proximity to I-5.

Station Construction Equipment

The precise means and methods of station construction are not yet known. General construction activities applicable to this project that can produce ground vibration are discussed below.

Demolition of existing structures: Some of the station options would require the demolition (or relocation) of existing buildings, sidewalks, curbs, or other structures. In general, this type of activity would involve the use of hoe rams to break up concrete and large bulldozers for moving materials around the site.

Site excavation and grading: At the station locations and adjacent parking garages as well as surface parking areas, various degrees of excavation and grading of the sites would be required. Large vibratory soil compactors may be used to pack down the soil after grading.

Foundations and shoring: Elevated station-platform supporting columns, multi-level parking structures, and retaining walls could require deep pile foundations. Piles could be driven or drilled into the ground using a number of methods.

A common method is to force a large-diameter cylindrical-steel casing into the ground to the required depth, excavate the contents of the casing, insert a rebar cage, and then pour concrete into the void. As the concrete is poured in, the casing is extracted for reuse. The casing can be driven into the ground using a vibratory hammer (with a variable frequency drive) that can produce substantial ground vibration. Constant frequency vibratory pile drivers produce substantially less vibration than vibratory hammers. An oscillatory method whereby the temporary casing is rotated back and forth generates measurably less vibration. These pile-casing techniques may be used for localized foundations such as guideway columns or for large secant-pile walls.

For smaller diameter piles and shallower foundations, pile shafts would typically be drilled with an auger. This would also apply to temporary shoring methods such as soldier pile walls.

Materials transport: For all phases of construction at all of the station sites, haul trucks would transport materials from the construction sites and bring in new materials, especially concrete.

Station Construction Vibration Impact Assessment Results

The analysis outlined herein assumes that impact pile-driving would not be used in the station construction. Alternative pile-driving techniques, such as vibratory pile-driving or augered piles, have been considered in the vibration assessment.

Cosmetic Damage Assessment

Based on the available station plans, vibration levels sufficient to cause cosmetic damage to adjacent buildings would not occur, or can be avoided. The potential for cosmetic damage to nearby structures should be more closely evaluated if vibratory pile-driving methods are used within 80 feet of the receptor or if vibratory soil compactors are used within 40 feet of the receptor. This task could include documenting the condition of buildings prior to construction and monitoring vibration during construction.

Vibration Annoyance Assessment

Construction will continue at the station sites for longer periods than at locations along the guideway. Therefore, nearby residents could be annoyed by vibration. Based on the approximate distances between receptors and the construction site and the distances indicated in the last column of Table 4-6, a summary of potentially affected receptors is presented in Table 5-14. This assessment is based on the assumption that pile foundations would be used only at the station platforms and multi-level parking garages, and that vibratory soil compactors might be used anywhere on the site. All receptors on the perimeter of the construction sites are assumed to be exposed to construction-related truck traffic regardless of other construction activity.

Potentially affected receptors with respect to vibration annoyance include primarily single-family residences, some apartment complexes, a church, and a fire station. The majority of pile-driving and other construction-related vibration would occur during daytime periods when most people are least sensitive to vibration.

Table 5-14. Summary of Potential Annoyance Impacts from Station Construction Vibration

	Potential Construction Vibration Annoyance Impacts		
Station	**Vibratory Pile Methods**	**Vibratory Soil Compactor, Non-Vibratory Pile**	**No Vibratory Methods**
NE 130th Street, Option 1	25 SFRs, 1 church	12 SFRs, 1 church	7 SFRs, 1 church
NE 130th Street, Option 2	12 SFRs, 1 church	6 SFRs	6 SFRs
NE 130th Street, Preferred Alternative Option Segment A	25 SFRs, 1 church	12 SFRs, 1 church	7 SFRs, 1 church
NE 145th Street, Option 1	43 SFRs	20 SFRs	20 SFRs
NE 145th Street, Option 2	46 SFRs	23 SFRs	23 SFRs
NE 145th Street, Preferred Alternative	46 SFRs	23 SFRs	23 SFRs
NE 155th Street	40 SFRs, fire station	10 SFRs, fire station	4 SFRs, fire station
NE 185th Street, Option 1	21 SFRs	12 SFRs	12 SFRs
NE 185th Street, Option 2	14 SFRs	11 SFRs	11 SFRs
NE 185th Street, Option 3	18 SFRs	14 SFRs	14 SFRs
NE 185th Street, Preferred Alternative	16 SFRs	7 SFRs	7 SFRs
NE 185th Street, Preferred Alternative Option Segment A	35 SFRs	7 SFRs	7 SFRs
Mountlake Terrace, Transit	0	0	0

Table 5-14. Summary of Potential Annoyance Impacts from Station Construction Vibration

Station	Potential Construction Vibration Annoyance Impacts		
	Vibratory Pile Methods	Vibratory Soil Compactor, Non-Vibratory Pile	No Vibratory Methods
Center Option			
Mountlake Terrace, Freeway Option	3 SFRs	3 SFRs	3 SFRs
Mountlake Terrace Transit Center, Preferred Alternative	0	0	0
Mountlake Terrace Transit Center, Preferred Alternative Option Segment B	8 SFRs	0	0
220th Street SW	Melody Hill School, Mountlake Terrace City Hall, 1 office building, 1 apartment complex (Lakeside Apartments)	Mountlake Terrace City Hall	Mountlake Terrace City Hall
220th Street SW Station – South, Preferred Alternative Option Segment B	3 SFRs	0	0
Lynnwood, 200th Street SW	3 Apartment Complexes	3 Apartment Complexes	3 Apartment Complexes
Lynnwood Transit Center	1 Apartment Building	0	0
Lynnwood Park-and-Ride, Option 1	1 Apartment Building	0	0
Lynnwood Park-and-Ride, Option 2	1 Apartment Building	0	0
Lynnwood Transit Center, Alternative – Preferred Alternative (C3 Modified)	2 Commercial Strip Malls 1 Commercial Bldg. (VCA) 4 Apartment Buildings 4 Office Buildings	4 Apartment Buildings 4 Office Buildings 1 Commercial Strip Mall	4 Apartment Buildings 4 Office Buildings 1 Commercial Strip Mall

SFR = Single-Family Residence

6 MITIGATION OF POTENTIAL VIBRATION IMPACTS

6.1 Potential Vibration Mitigation Measures

Several mitigation measures were considered during the analysis for mitigating potential vibration impacts.

The vibration analysis indicated that most potential vibration impacts next to an at-grade ballast-and-tie track could be mitigated with TDA as an underlayment beneath the sub-ballast layer of the track. TDA is inexpensive compared to other mitigation measures and has been installed beneath light rail tracks for systems in San Jose, California and Denver, Colorado. To date, there has been no indication of decreased effectiveness of the TDA nor an increase in maintenance costs attributed to the TDA at those light rail systems (Wilson, Ihrig & Associates, Inc. 2009). Vibration impacts and mitigation options will be reviewed during final design to confirm that appropriate measures are included in the design.

TDA is proposed for mitigating potential ground vibration impacts at the ballast-and-tie track if used for the project. A typical TDA installation consists of a compacted underlayment, 12 inches deep, of nominally 3-inch tire shreds or chips wrapped with geotextile filter fabric, covered with 12 inches of sub-ballast, and 12 inches of ballast above that to the base of the ties. A cross-sectional drawing of a typical TDA installation is provided in Figure 6-1. TDA can only be used on ballast-and-tie tracks. Tests indicate that the vibration-attenuation properties of this treatment are between that of ballast mats and FST. The adjustments applied in the vibration analysis to account for adding TDA under the tracks were empirically based and are listed in Table 6-1.

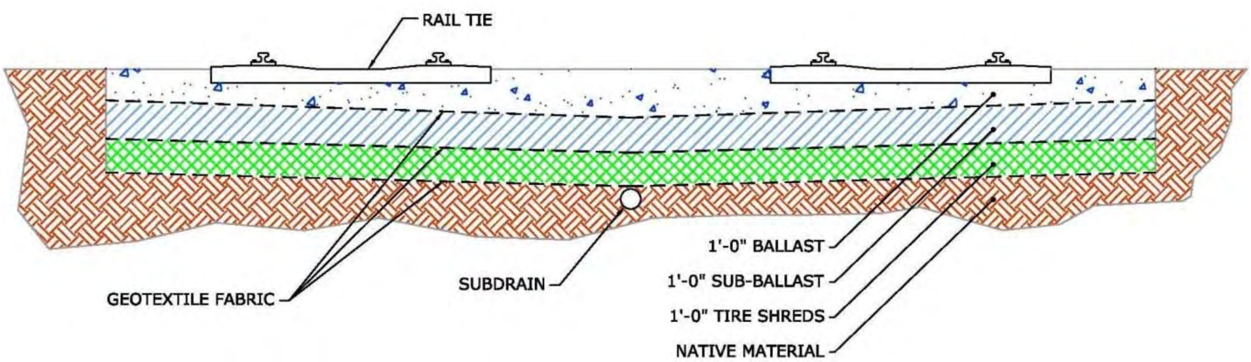


Figure 6-1. Typical Installation of Tire-Derived Aggregate (TDA) for Transit Vibration Mitigation

FST was considered for the at-grade ballast-and-tie segments wherever TDA would not sufficiently mitigate the vibration impacts. With an FST system, the rails would be fixed to either a continuous or segmented concrete slab that would be resiliently supported either by natural rubber pads or steel springs. Such systems have been used on transit systems globally to reduce vibration from running trains. A key feature in the design of an FST system is the natural or resonance frequency of the slab considered as a single-degree-of-freedom oscillator, or spring-mass system. Vibration transmitted to the soil would be reduced at frequencies above the natural frequency, whereas there would be a slight amplification at frequencies near or at the natural frequency and no reduction below the natural frequency. The range of natural frequency for typical FST systems is 8 to 16 Hz. The effects of FST with different natural frequencies were assessed, where needed, and it was concluded that an FST with a maximum natural frequency of 8 Hz would be required to mitigate vibration impacts. An FST with a lower natural frequency may be desired to reduce possible dynamic interaction between the FST and the primary suspension of the light rail vehicles. The adjustments applied in the vibration analysis to account for replacing the ballast-and-tie track with FST were empirically based and are listed in Table 6-1.

Table 6-1. Adjustment (Insertion Gain, dB) for Vibration Mitigation

	1/3-Octave-Band Center Frequency (Hz)														
Mitigation	**6.3**	**8**	**10**	**12.5**	**16**	**20**	**25**	**31.5**	**40**	**50**	**63**	**80**	**100**	**125**	**160**
Tire-Derived Aggregate	0	0	0	0	-2	-5	-6	-7	-8	-12	-14	-14	-13	-11	-10
Floating Slab Track	0	2	0	-3	-5	-9	-12	-13	-14	-16	-18	-19	-19	-18	-18
High Compliance Fasteners	0	0	0	0	1	2	-1	-2	-3	-5	-6	-7	-7	-7	-5

Wayside noise along the FST would be higher relative to noise at the ballast-and-tie track due to the lack of acoustical absorption normally associated with ballast-and-tie tracks. Such increases in noise adjacent to the FST were accounted for in the noise analysis. Alternatives A5 and A7 would require FST at one residence, 309 NE 149th Street, which would be less than 50 feet from the tracks and require a greater reduction in vibration than could be provided with TDA.

High compliance rail fasteners were considered for mitigating potential vibration impacts along elevated structures compared to standard fasteners used on concrete structures. The adjustments applied in the vibration analysis to account for replacing standard rail fasteners on elevated structures with high compliance fasteners were empirically based and are listed in Table 6-1. There is a risk that wayside noise may be higher with high compliance fasteners relative to noise with standard rail fasteners because the rail tends to vibrate more on the softer fasteners generating more sound. This increase in sound may be offset by noise walls on the elevated guideway.

As discussed in Section 4.1.4, increased levels of vibration are generated by wheel impacts at typical crossovers. Impacts are often generated as the wheels cross the gap in what is referred to as the frog, i.e. where the rails of the main and diverging tracks cross. A spring or movable point frog is a device that provides a continuous surface for the wheels to travel upon along the main track, thereby avoiding wheel impacts during normal operations. Impacts while switching from one track to the other are not considered significant as the trains would be operating at a much slower speed than normal operations and would rarely occur. Figures 6-2(a) and 6-2(b) are photographs of a typical frog and a spring frog, respectively. The use of spring frogs (as well as movable point frogs) was considered wherever impacts were projected adjacent to a crossover and the projected vibration levels with spring or movable point frogs were calculated as if no crossover was present.

(a) (b)

Figure 6-2. Crossover frogs: (a) solid (typical), (b) spring (photographs: voestapline Nortrack)

The effects of installing ballast mat under at-grade track were assessed and it was concluded that a ballast mat would not provide enough vibration reduction to mitigate the potential vibration impacts. Soil modification beneath the tracks depends upon the relative stiffness of the modified and unmodified soils and may not provide sufficient vibration reduction.

Based on the vibration projections conducted for this study, all but a few potential vibration impacts could be mitigated by one of the approaches described above or by other approaches with identical or better vibration reduction performance. Table 6-2 outlines and Figures 6-3 and 6-4 show the projected extents along the alignment where mitigation for potential vibration impacts is recommended.

A total of three properties have potential vibration impacts that would not be completely mitigated with standard mitigation approaches. These potentially remaining vibration impacts are discussed below. Although this study shows these impacts as remaining after mitigation, this does not mean that they could not be mitigated; instead, they would need to be addressed individually during design.

The single-family residence at 301 NE 151st Street in Shoreline has a potentially remaining impact for the Preferred Alternative. This property is immediately past the north end of the proposed elevated guideway where the alignment has transitioned to a filled wall. There is also a double crossover planned for the Preferred Alternative at this location. Under the assumptions used for the study, the maximum predicted 1/3-octave-band vibration level is 79 VdB at 25 Hz without mitigation and 72 VdB at 12.5 Hz with TDA and spring or movable pointfrogs installed in the crossover, which equals the criteria. A more thorough investigation of the possible vibration and mitigation approach at this property can be conducted during final design to avoid vibration impacts. Should that analysis indicate a remaining impact at this property it could be avoided with FST combined with spring or movable point frogs at the crossover.

The single-family residence at 324 NE 148th Street in Shoreline has a potentially remaining impact for Alternatives A3 and A11, which are on an elevated guideway at this location. The projected vibration is highest within the 16 Hz 1/3 octave band. High compliance fasteners that are currently available are ineffective at reducing vibration at that frequency or lower. However, the projected maximum

1/3-octave-band vibration level is 72 VdB without mitigation, which equals the FTA vibration criteria. Modifying the structural design of the guideway and/or locating the support columns away from this property can be considered during final design in order to avoid vibration impacts.

The commercial property at 20815 52nd Avenue West in Lynnwood has a potentially remaining impact for Alternatives C1 Option 1 (within I-5 median), C1 Option 2 (west of I-5), C2 Option 1 (within I-5 median), and C2 Option 2 (west of I-5). These alternatives are on an elevated structure at 17 feet from the building. The projected vibration is 82 VdB within the 40 Hz 1/3 octave band, without mitigation. With high compliance rail fasteners, the projected maximum 1/3-octave-band vibration level is 79 VdB at 40 Hz, compared to an impact criterion of 72 VdB. Locating the support columns away from this property or incorporating features in the structural design of the guideway to reduce vibration transmitted to the ground can be considered in order to avoid vibration impacts. It may be possible to reduce the vibration through pier foundation design and/or soil modification, taking advantage of differences with the foundation at the elevated structure west of Beacon Hill, upon which the FDL for the elevated structure is based. Alternately, it may be possible to incorporate resilient supports at the tops of the piers, under the guideway, which would reduce the vibration transmitted to the piers. The above approaches to reduce vibration can be considered during final design in order to avoid vibration impacts.

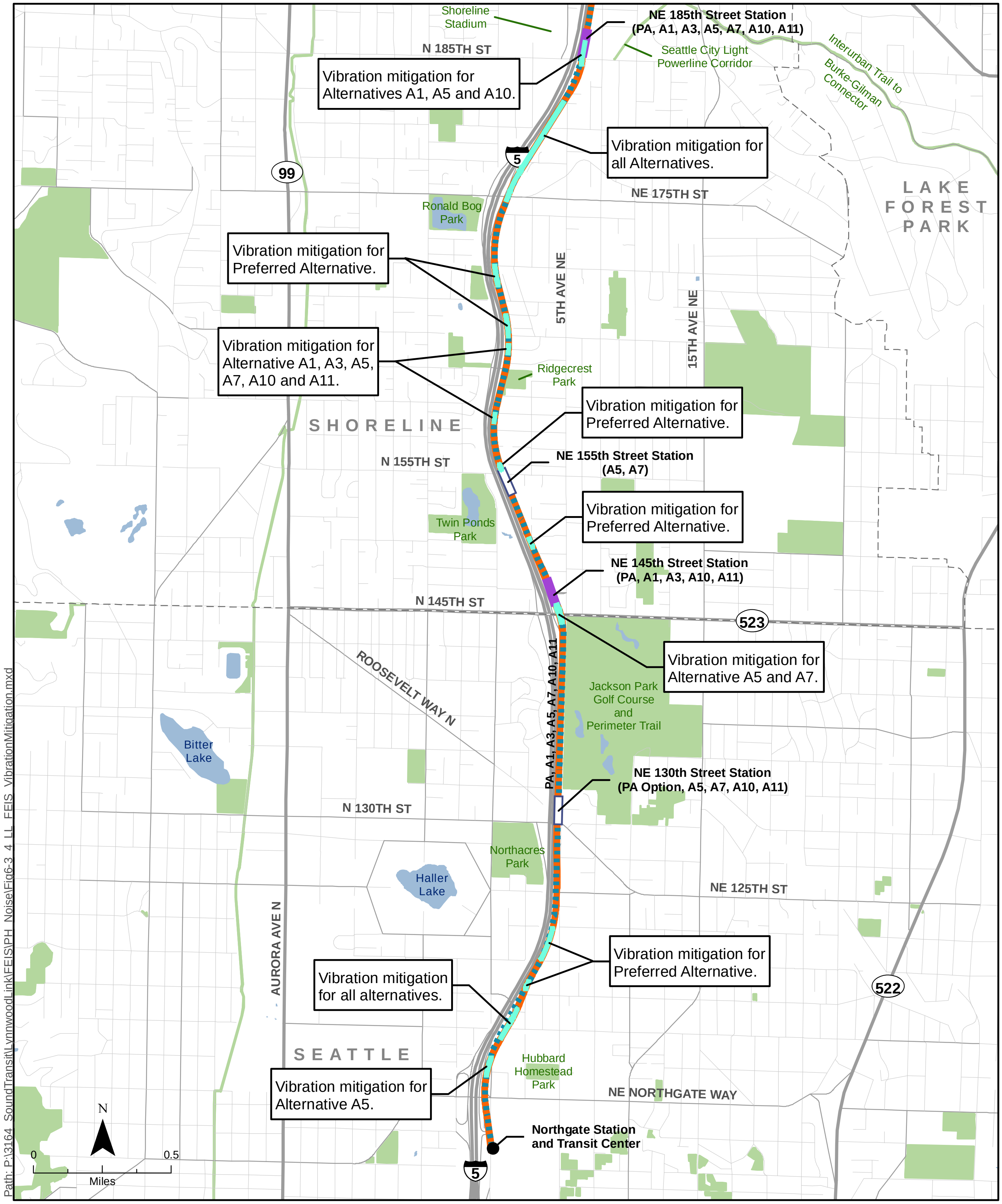
Table 6-2. Recommended Locations for Vibration Mitigation

Alternative	Mitigation Extents (Station Numbers)	Mitigation Type	Total Mitigation Length (feet)
Preferred Alternative (Segment A)	34+50 – 38+00 42+75 – 44+25 49+25 – 55+50 129+75 – 131+50 145+75 – 146+75 171+75 – 175+75 181+75 – 185+50 207+75 – 220+00 237+00 – 241+75 202+75 – 204+50 130+50 – 132+80	TDA TDA TDA TDA TDA TDA TDA TDA TDA HCF SFC/MPF+TDA	3,875 TDA 175 HCF 230 SFC/MPF+TDA
A1: At-grade/Elevated with NE 145th and NE 185th Street Stations	37+25 – 38+50 155+00 – 156+50 168+50 – 170+00 198+50 – 210+00 231+00 – 232+50	TDA TDA TDA TDA TDA	1,725 TDA
A3: Mostly Elevated with NE 145th and NE 185th Street Stations	155+00 – 156+50 168+50 – 170+00 32+75 – 34+25 198+50 – 200+00 200+25 – 203+50 204+75 – 208+00	TDA TDA HCF HCF SFC/MPF SFC/MPF	300 TDA 300 HCF 460 SFC/MPF

Table 6-2. Recommended Locations for Vibration Mitigation

Alternative	Mitigation Extents (Station Numbers)	Mitigation Type	Total Mitigation Length (feet)
A5: At-grade/Elevated with NE 130th, NE 155th, and NE 185th Street Stations	24+50 – 28+00 32+25 – 34+00 37+25 – 38+50 114+25 – 116+25 155+00 – 156+50 168+50 – 170+00 198+50 – 210+00 228+25 – 231+75 126+00 – 127+50	TDA TDA TDA TDA TDA TDA TDA TDA FST	2,650 TDA 150 FST
A7: Mostly Elevated with NE 130th, NE 155th, and NE 185th Street Stations	114+25 – 116+25 155+00 – 156+50 168+50 – 170+00 126+00 – 127+50 32+75 – 34+25 198+50 – 200+00 200+25 – 203+50 204+75 – 208+00	TDA TDA TDA FST HCF HCF SFC/MPF SFC/MPF	500 TDA 150 FST 300 HCF 460 SFC/MPF
A10: At-grade/Elevated with NE 130th, NE 145th, and NE 185th Street Stations	24+50 – 28+00 32+25 – 34+00 37+25 – 38+50 155+00 – 156+50 168+50 – 170+00 198+50 – 210+00 228+25 – 231+75	TDA TDA TDA TDA TDA TDA TDA	2,450 TDA
A11: Mostly Elevated with NE 130th, NE 145th, and NE 185th Street Stations	155+00 – 156+50 168+50 – 170+00 32+75 – 34+25 198+50 – 200+00 200+25 – 203+50 204+75 – 208+00	TDA TDA HCF HCF SFC/MPF SFC/MPF	300 TDA 300 HCF 460 SFC/MPF
Preferred Alternative (Segment B)	258+70 – 260+40 476+50 – 478+90	SFC/MPF+TDA SFC/MPF+TDA	460 SFC/MPF+TDA
C1: 52nd Avenue West to 200th Street SW, Option 1 within I-5 Median	509+50 – 514+00	HCF	450 HCF
C1: 52nd Avenue West to 200th Street SW, Option 2 West of I-5	511+50 – 514+00	HCF	250 HCF
C2: 52nd Avenue West to Lynnwood Transit Center, Option 1 within I-5 Median	509+50 – 514+00	HCF	450 HCF
C2: 52nd Avenue West to Lynnwood Transit Center, Option 2 within I-5 Median	511+50 – 514+00	HCF	250 HCF

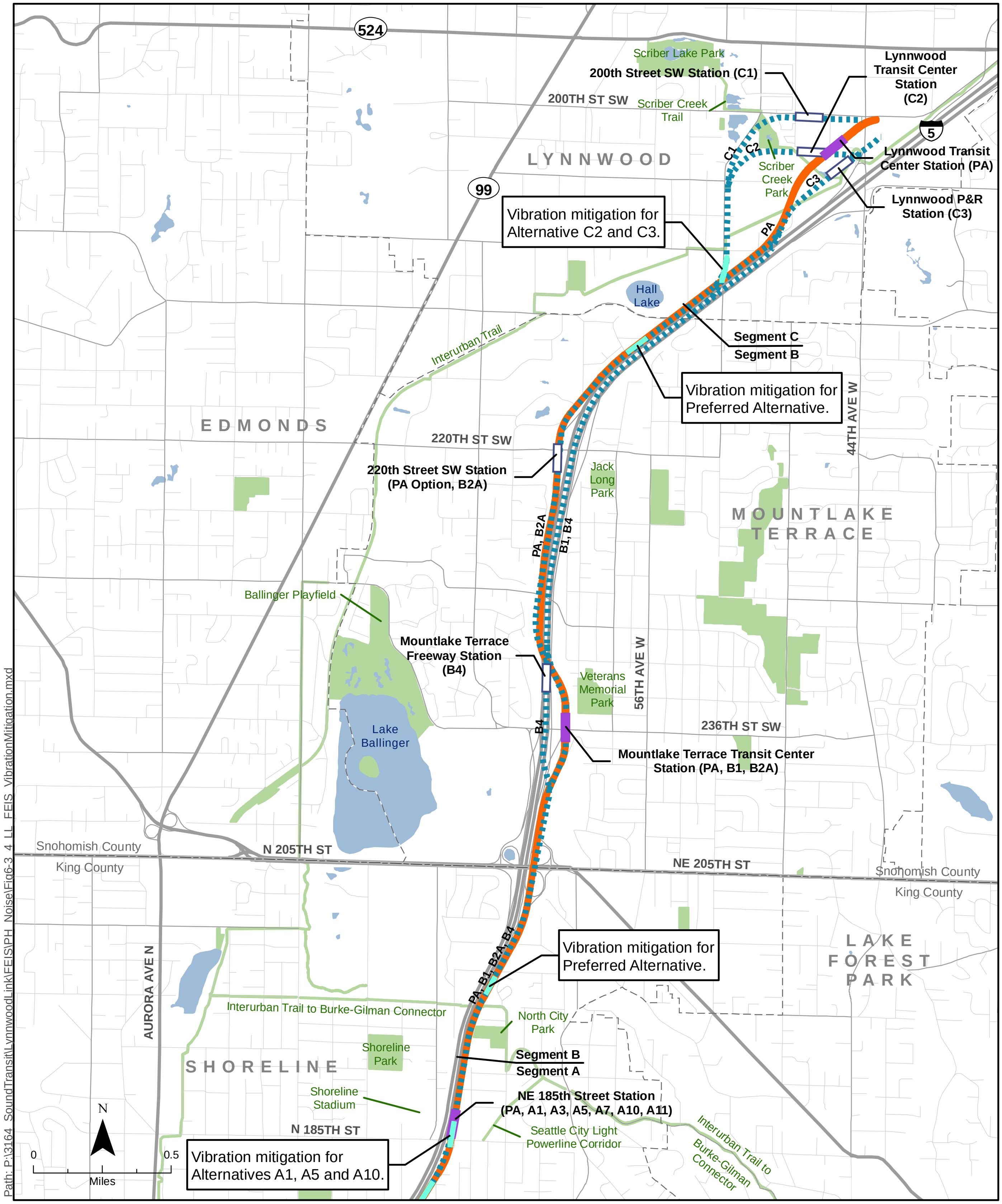
TDA = Tire-Derived Aggregate
FST = Floating Slab Track
HCF = High Compliance Rail Fastener
SFC/MPF = Spring or Movable Point Frog Crossover



Data Sources: (King County, Snohomish County, WSDOT, Sound Transit)

- Preferred Alternative (PA)
- Preferred Alternative Station Location
- Other Light Rail Alternatives
- Other Alternative Station Location
- Preferred Alternative and Other Alternatives
- Vibration Mitigation Area

Figure 6-3
Recommended Locations for Vibration Mitigation
Segment A



Data Sources: (King County, Snohomish County, WSDOT, Sound Transit)

- Preferred Alternative (PA)
- Preferred Alternative Station Location
- Other Light Rail Alternatives
- Other Alternative Station Location
- Preferred Alternative and Other Alternatives
- Vibration Mitigation Area

Figure 6-4
Recommended Locations for Vibration Mitigation Segments B and C

Lynnwood Link Extension

6.2 Construction Vibration Mitigation Control Provisions

Several measures can be implemented to control vibration during construction. The measures require consideration of construction equipment location relative to receptors, as well as construction processes. The basic approach is outlined in the FTA guidance manual. Vibration mitigation measures may include the following:

Project Scheduling:

- Avoid nighttime activities involving major vibration sources. People are generally less aware of vibration during waking hours than when lying in bed. Excessive vibration can disturb sleep.

Alternative Construction Methods:

- Demolish existing structures that are near vibration-sensitive receptors with methods that do not cause impact forces against the buildings or near them. For example, concrete structures can be saw-cut into small sections and loaded onto trucks, rather than breaking large sections and dropping them to the ground.
- Minimize use of vibratory soil compactors or compactors near vibration-sensitive receptors.
- Avoid using variable-frequency vibratory hammers in dense residential areas, such as around the NE 130th, NE 145th, NE 155th, and NE 185th Street Stations.
- Use of oscillatory pile-casing techniques where appropriate. Oscillatory pile-driving generates significantly lower vibration than impact pile-driving.
- Avoid conventional vibratory hammers. Conventional vibratory hammers that operate from zero to maximum frequency may cause objectionable vibration and risk cosmetic damage as the hammer sweeps through resonance. An alternative to conventional vibratory pile drivers is a resonance-free vibrator or variable eccentric moment vibrator.

7 REFERENCES

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FTA (Federal Transit Administration). 2006. *Transit Noise and Vibration Impact Assessment*. Report FTA-VA-90-1003-06. May 2006.

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ATS Consulting. 2013. *Vibration Measurements of Existing Sound Transit Train*. Memorandum. July 2013.

Wilson, Ihrig & Associates, Inc. 2009. *Evaluation of Tire Derived Aggregate as Installed Beneath Ballast and Tie Light Rail Track – Results of 2009 Field Tests*. Report submitted to Dana N. Humphrey, Ph.D., P.E., Consulting Engineer. June 2009.

ATTACHMENT A

Noise Monitoring Details

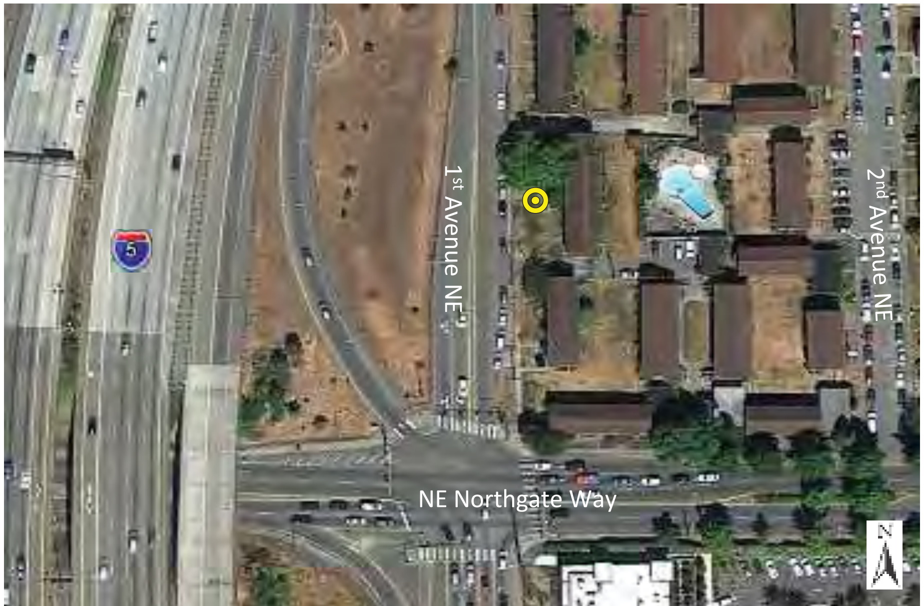

Photo 1: Aerial View

Photo 2: Looking north

Photo 3: Looking southwest toward Northgate Way & Interstate 5

Photo 4: Looking northwest toward Interstate 5

Monitoring Location M-1
11012 1st Avenue NE – Northgate Apartments
Seattle, Washington

Michael Minor & Associates
Sound.Vibration.Air
Portland, Oregon

Figure 1
Noise Monitoring Locations
Northgate to Lynwood Corridor

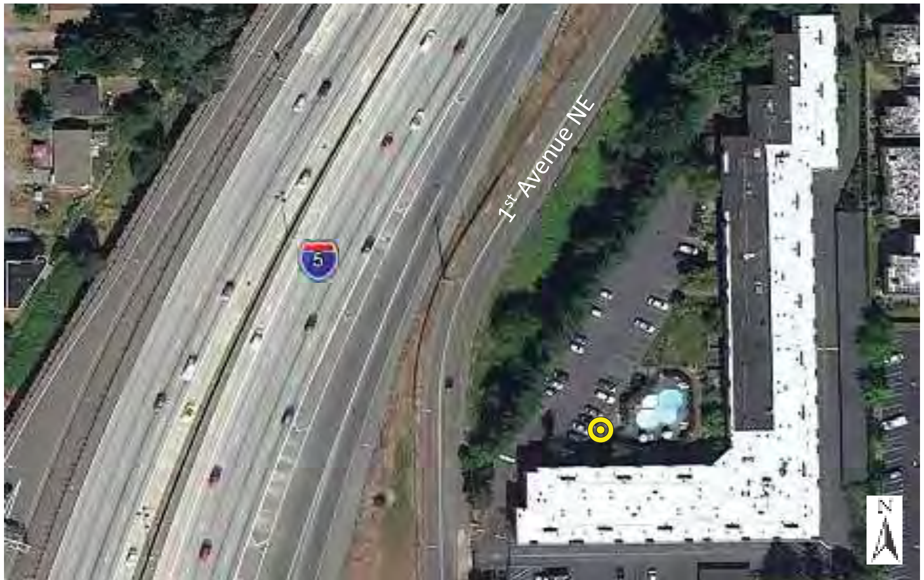

Photo 1: Aerial View

Photo 2: Looking east

Photo 3: Looking west toward Interstate 5

Photo 4: Looking north

Monitoring Location M-2
11300 1st Avenue NE – Northgate West Condos
Seattle, Washington

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Sound.Vibration.Air
Portland, Oregon

Figure 2
Noise Monitoring Locations
Northgate to Lynwood Corridor

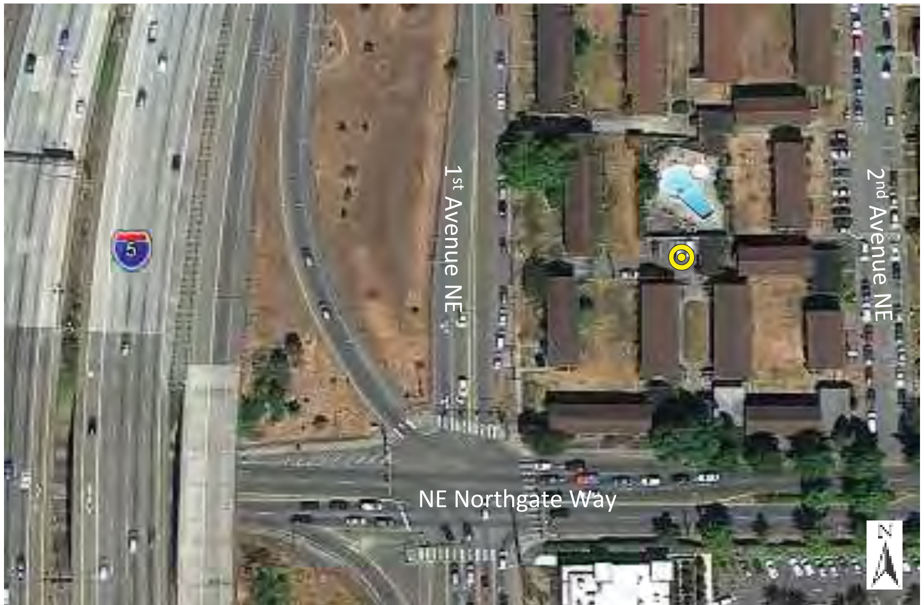

Photo 1: Aerial View

Photo 2: Looking west toward Interstate 5

Photo 3: Looking south

Photo 4: Looking east

Monitoring Location M-3
11012 1st Avenue NE – Northgate Apartments
Seattle, Washington

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Portland, Oregon

Figure 3
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking north

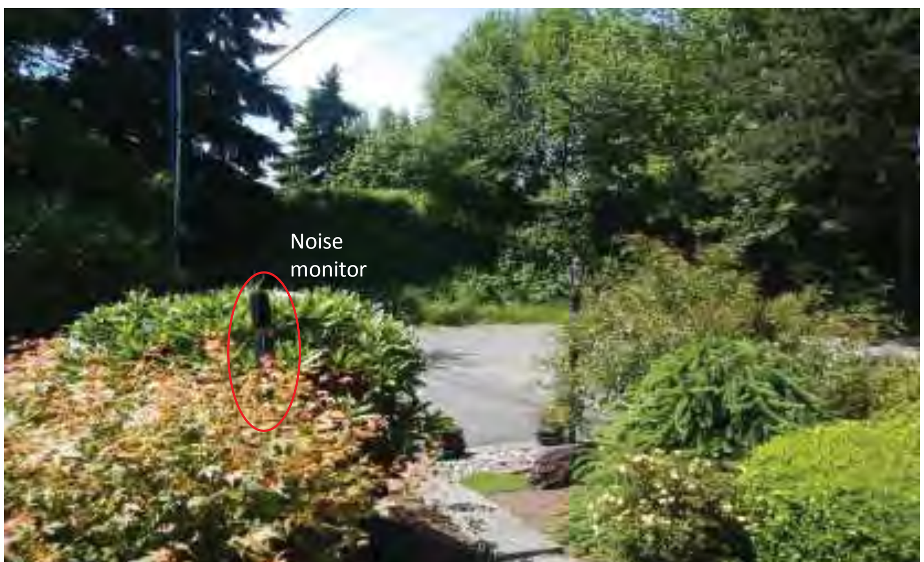

Photo 3: Looking west

Photo 4: Looking east

Monitoring Location M-4
133 NE 115th Street
Seattle, Washington

Michael Minor & Associates
Sound.Vibration.Air
Portland, Oregon

Figure 4
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking south

Photo 3: Looking north

Photo 4: Looking west

Monitoring Location M-5
11516 4th Avenue NE
Seattle, Washington

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Sound.Vibration.Air
Portland, Oregon

Figure 5
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking east

Photo 3: Looking west

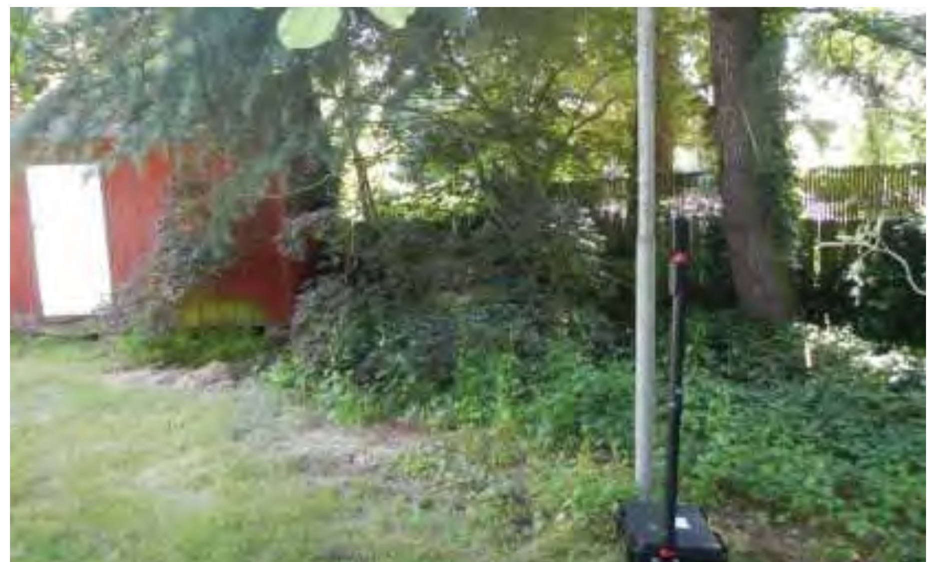

Photo 4: Looking south

Monitoring Location M-6
11725 5th Avenue NE
Seattle, Washington

Michael Minor & Associates
Sound.Vibration.Air
Portland, Oregon

Figure 6
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking west

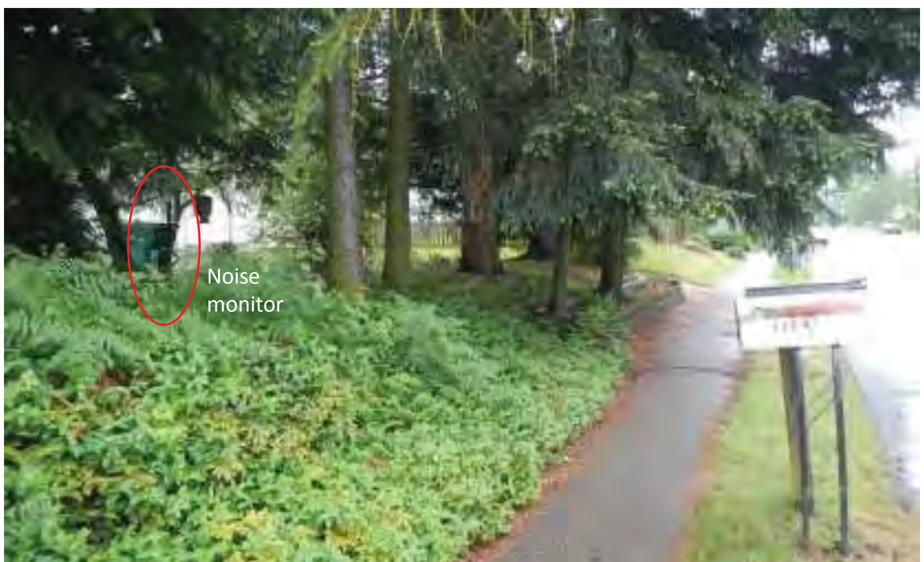

Photo 3: Looking south

Photo 4: Looking north

Monitoring Location M-7
12042 5th Avenue NE
Seattle, Washington

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Portland, Oregon

Figure 7
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking east

Photo 3: Looking west

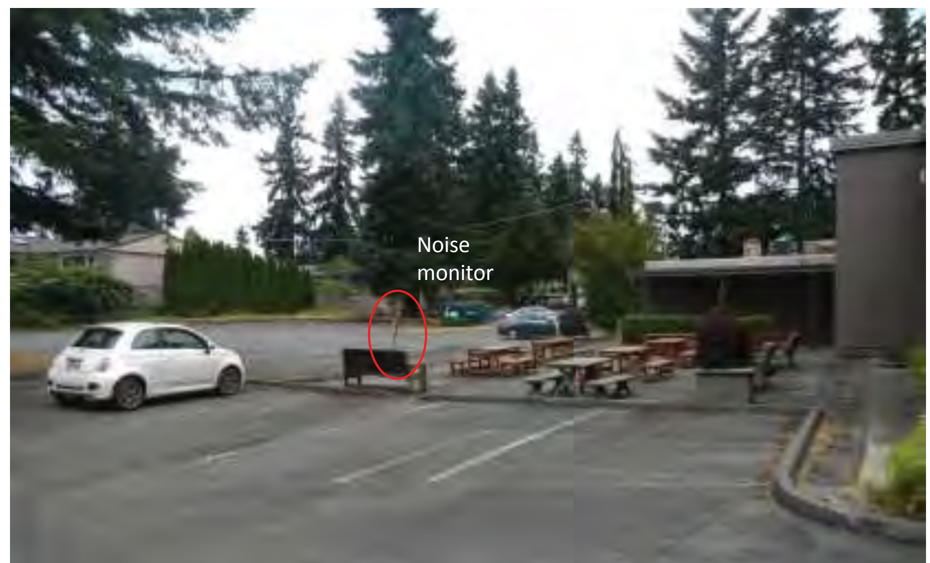

Photo 4: Looking northwest

Monitoring Location M-8
12345 8th Avenue NE – Northgate Preschool
Seattle, Washington

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Portland, Oregon

Figure 8
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking northeast

Photo 3: Looking south

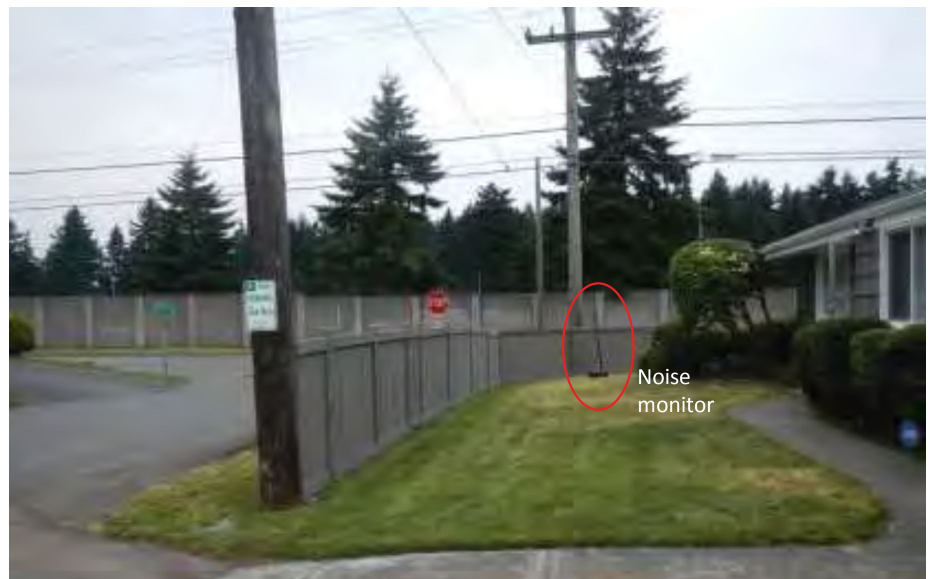

Photo 4: Looking west

Monitoring Location M-9
502 NE 127th Street
Seattle, Washington

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Portland, Oregon

Figure 9
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking west

Photo 3: Looking south

Photo 4: Looking north

Monitoring Location M-10
12740 5th Avenue NE
Seattle, Washington

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Portland, Oregon

Figure 10
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking south

Photo 3: Looking north

Photo 4: Looking south from 5th Avenue NE entrance

Monitoring Location M-11
13130 5th Avenue NE – Church of the Nazarene
Seattle, Washington

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Portland, Oregon

Figure 11
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking east

Photo 3: Looking west

Photo 4: Looking south

Monitoring Location M-12
11700 1st Ave NE – Korean Catholic Church
Seattle, Washington

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Portland, Oregon

Figure 12
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking southeast

Photo 3: Looking northeast

Photo 4: Looking northwest

Monitoring Location M-13
12718 1^{st} Avenue NE – North Acres Park
Seattle, Washington

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Sound.Vibration.Air
Portland, Oregon

Figure 13
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

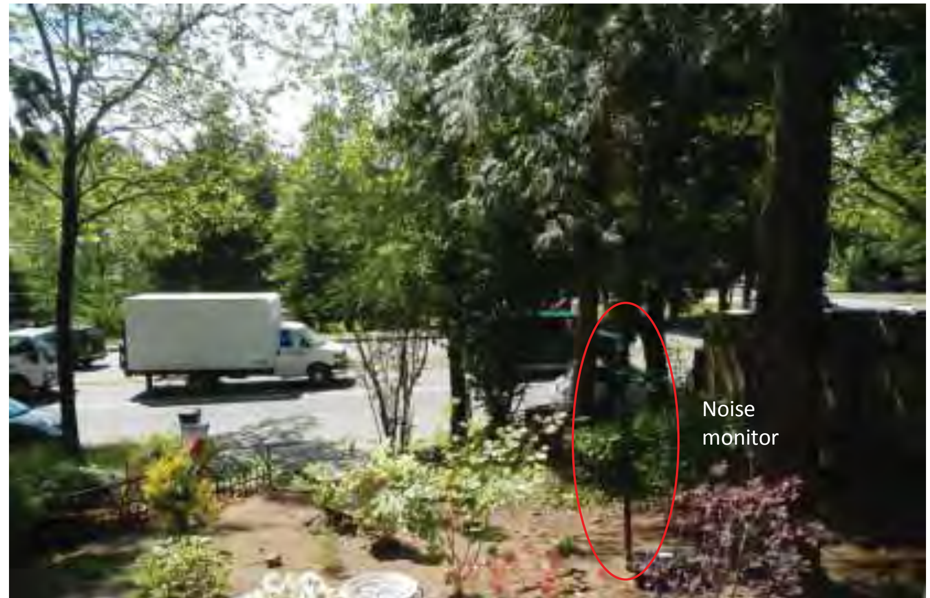

Photo 2: Looking west

Photo 3: Looking south

Photo 4: Looking east

Monitoring Location M-14
14526 5th Avenue NE
Seattle, Washington

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Portland, Oregon

Figure 14
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking northwest

Photo 3: Looking east

Photo 4: Looking southwest

Monitoring Location M-15
14549 6th Avenue NE
Seattle, Washington

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Portland, Oregon

Figure 15
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking north

Photo 3: Looking southeast

Photo 4: Looking west

Monitoring Location M-16
348 NE 148th Street
Seattle, Washington

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Portland, Oregon

Figure 16
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking southwest

Photo 3: Looking

Photo 4: Looking east

Monitoring Location M-17
314 NE 149th Street
Seattle, Washington

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Portland, Oregon

Figure 17
Noise Monitoring Locations
Northgate to Lynwood Corridor

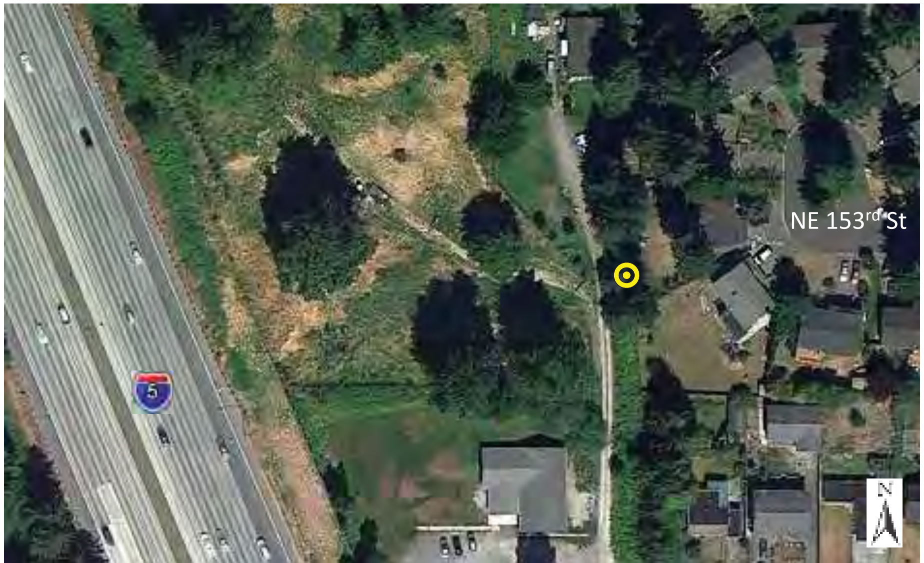

Photo 1: Aerial View

Photo 2: Looking

Photo 3: Looking

Photo 4: Looking west

Monitoring Location M-18
405 NE 153rd Street
Seattle, Washington

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Portland, Oregon

Figure 18
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking

Photo 3: Looking

Photo 4: Looking

Monitoring Location M-19
132 NE 155th Street
Seattle, Washington

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Portland, Oregon

Figure 19
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking southeast

Photo 3: Looking west

Photo 4: Looking west

Monitoring Location M-20
123 NE 158th Street
Seattle, Washington

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Figure 20
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking west

Photo 3: Looking

Photo 4: Looking

Photo 1: Aerial View

Photo 2: Looking east

Photo 3: Looking south

Photo 4: Looking west

Monitoring Location M-22
17205 2nd Avenue NE
Seattle, Washington

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Figure 22
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking northwest from alley

Photo 3: Looking east

Photo 4: Looking northeast from alley

Photo 1: Aerial View

Photo 2: Looking

Photo 3: Looking

Photo 4: Looking

Monitoring Location M-24
17748 2nd Place NE
Seattle, Washington

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Portland, Oregon

Figure 24
Noise Monitoring Locations
Northgate to Lynwood Corridor

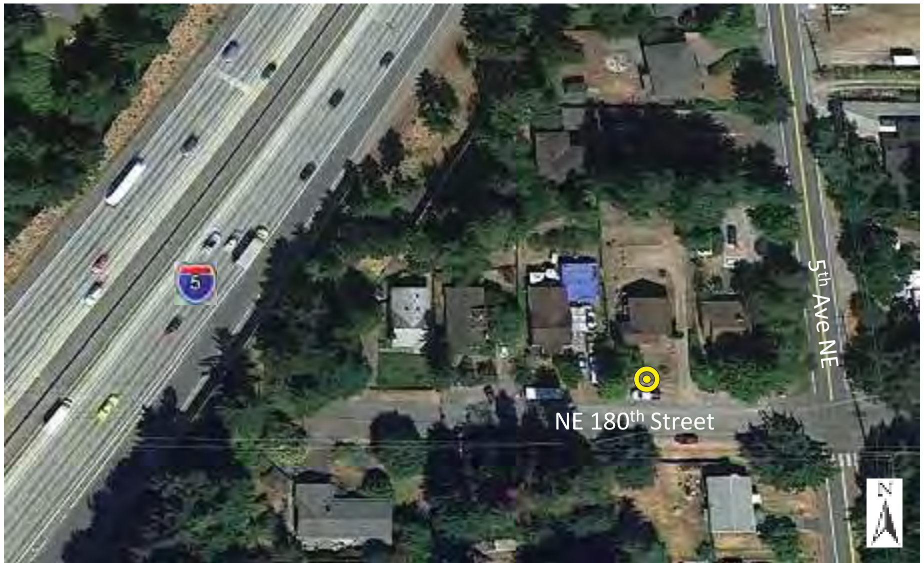

Photo 1: Aerial View

Photo 2: Looking south

Photo 3: Looking southeast toward 5th Avenue NE

Photo 4: Looking west toward Interstate 5

Photo 1: Aerial View

Photo 2: Looking south

Photo 3: Looking north

Photo 4: Looking west

Photo 1: Aerial View

Photo 2: Looking east

Photo 3: Looking northwest from Interstate 5

Photo 4: Looking south

Monitoring Location M-27
2350 N 167th Street – James Keough Park
Seattle, Washington

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Portland, Oregon

Figure 27
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking southwest at residence

Photo 3: Looking east at NE 185th Street

Photo 4: Looking west at NE 185th Street

Monitoring Location M-28
721 NE 185th Street
Seattle, Washington

Figure 28
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking east

Photo 3: Looking south

Photo 4: Looking north

Monitoring Location M-29
18528 8th Avenue NE
Seattle, Washington

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Figure 29
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking north

Photo 3: Looking west

Photo 4: Looking south

Monitoring Location M-30 (from entry)
816 NE 190th St – North City Cooperative Preschool
Seattle, Washington

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Portland, Oregon

Figure 30
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View


Photo 2: Looking west

Photo 3: Looking south

Photo 4: Looking north

Monitoring Location M-30 (from field)
816 NE 190th St – North City Cooperative Preschool
Seattle, Washington

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Portland, Oregon

Figure 31
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking east

Photo 3: Looking southeast

Photo 4: Looking west

Monitoring Location M-31
20313 14th Avenue NE
Seattle, Washington

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Figure 32
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking south

Photo 3: Looking east

Photo 4: Looking west

Monitoring Location M-32
237th Street SW (at northernmost curve)
Seattle, Washington

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Figure 33
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Western view of Transit Center

Photo 3: Looking west

Photo 4: Looking east

Monitoring Location M-33
23504 59th Place W
Seattle, Washington

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Portland, Oregon

Figure 34
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View


Photo 2: Looking west from noise monitor position

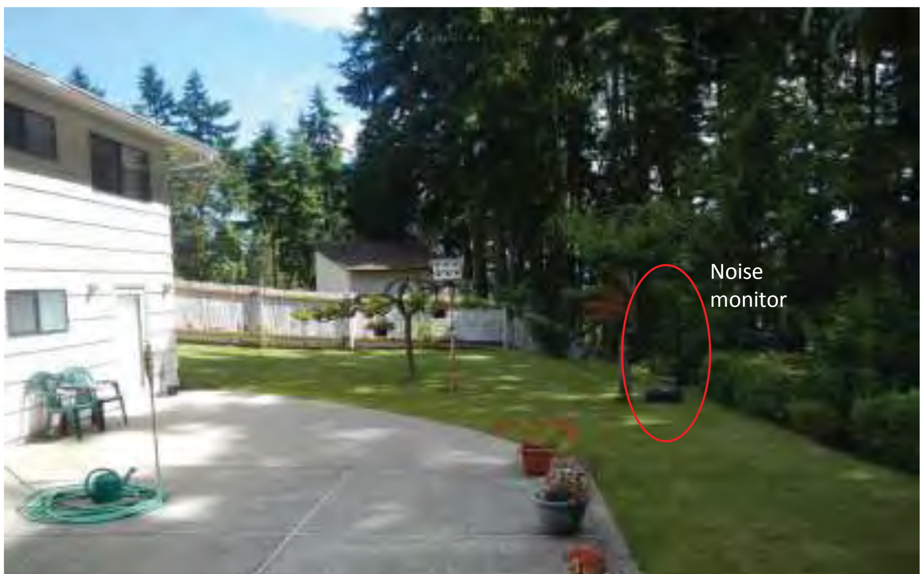

Photo 3: Looking south


Photo 4: Looking southwest from cul de sac

Monitoring Location M-34
6005 233rd Place SW
Seattle, Washington

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Portland, Oregon

Figure 35
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking east

Photo 3: Looking south

Photo 4: Looking north

Monitoring Location M-35
22905 61st Avenue W
Seattle, Washington

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Figure 36
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking north

Photo 3: Looking west

Photo 4: Looking east

Photo 1: Aerial View

Photo 2: Looking northeast

Photo 3: Looking southwest

Photo 4: Looking east

Monitoring Location M-37
5709 215th Place SW
Mountlake Terrace, Washington

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Portland, Oregon

Figure 38
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking south


Photo 3: Looking north


Photo 4: Looking west

Monitoring Location M-38
5402 212th St SW – Maple Glen Apartments
Lynnwood, Washington

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Figure 39
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Street view looking east

Photo 3: Looking southeast

Photo 4: Looking north

Monitoring Location M-39
23005 63rd Avenue W
Mountlake Terrace, Washington

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Portland, Oregon

Figure 40
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking north

Photo 3: Looking west

Photo 4: Looking east

Monitoring Location M-40
6103 227th Street SW
Mountlake Terrace, Washington

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Portland, Oregon

Figure 41
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking north

Photo 3: Looking east

Photo 4: Looking south

Monitoring Location M-41
6205 222nd Street SW – Mountlake Terrace Preschool
Mountlake Terrace, Washington

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Portland, Oregon

Figure 42
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking south

Photo 3: Looking northeast

Photo 4: Looking east

Monitoring Location M-42
6206 222nd Street SW
Mountlake Terrace, Washington

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Portland, Oregon

Figure 43
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking east

Photo 3: Looking west

Photo 4: Looking south

Monitoring Location M-43
6302 221st Place SW
Mountlake Terrace, Washington

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Portland, Oregon

Figure 44
Noise Monitoring Locations
Northgate to Lynwood Corridor

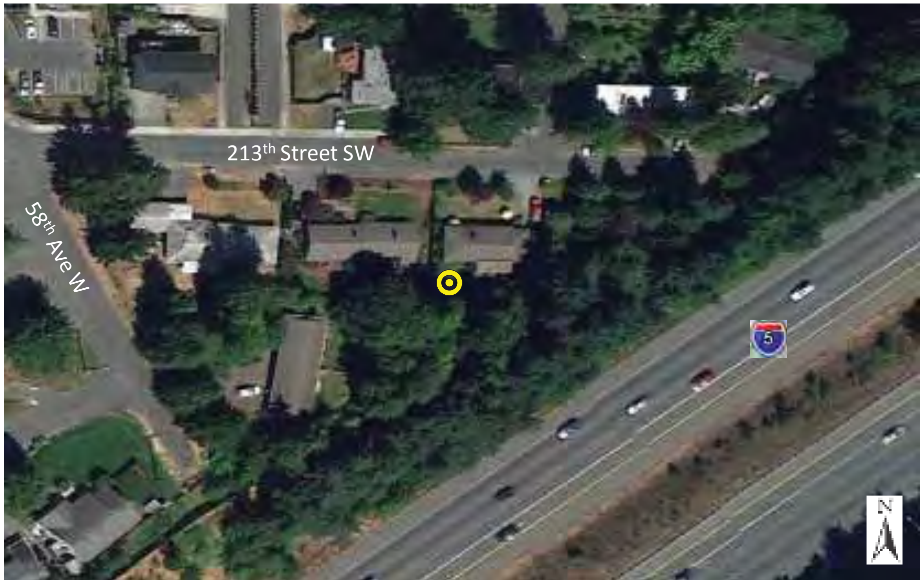

Photo 1: Aerial View

Photo 2: Looking

Photo 3: Looking

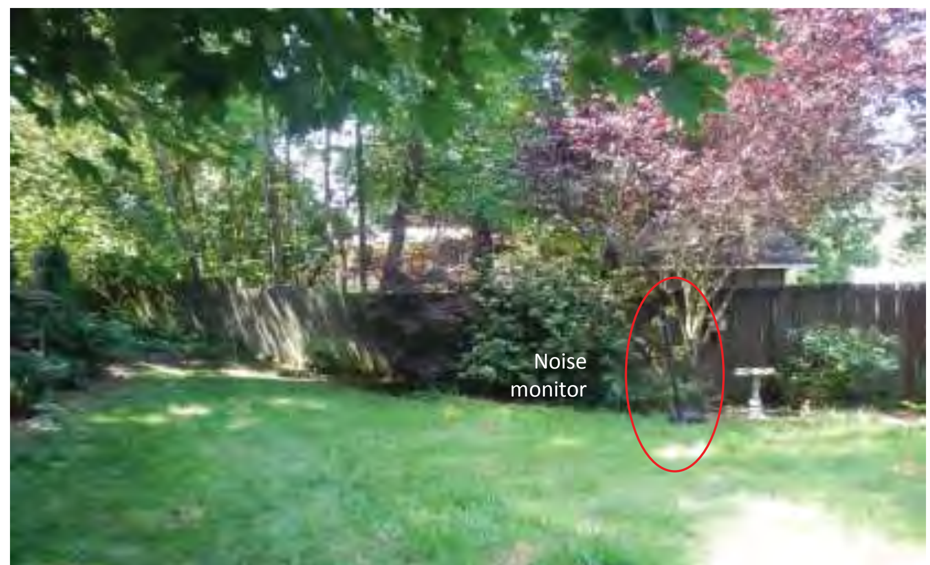

Photo 4: Looking

Monitoring Location M-45
5632 213th Street SW
Mountlake Terrace, Washington

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Portland, Oregon

Figure 45
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking south

Photo 3: Looking north


Photo 4: Looking east

Monitoring Location M-46
Green space east of Hall Lake at 212th Street SW
Lynnwood, Washington

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Portland, Oregon

Figure 46
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking

Photo 3: Looking

Photo 4: Looking

Monitoring Location M-47
20929 53rd Avenue W
Lynnwood, Washington

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Portland, Oregon

Figure 47
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking southeast

Photo 3: Looking north

Photo 4: Looking south

Monitoring Location M-48
20706 52nd Avenue W
Lynnwood, Washington

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Portland, Oregon

Figure 48
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking southwest

Photo 3: Looking south

Photo 4: Looking north

Monitoring Location M-49
20526 52nd Avenue W – Cedar Valley Grange
Lynnwood, Washington

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Portland, Oregon

Figure 49
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking northwest toward Lynnwood Transit Center

Photo 3: Looking east

Photo 4: Looking west

Monitoring Location M-50
20128 48th Avenue W C-30 – Park Five Apartments
Lynnwood, Washington

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Portland, Oregon

Figure 50
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking north

Photo 3: Looking south

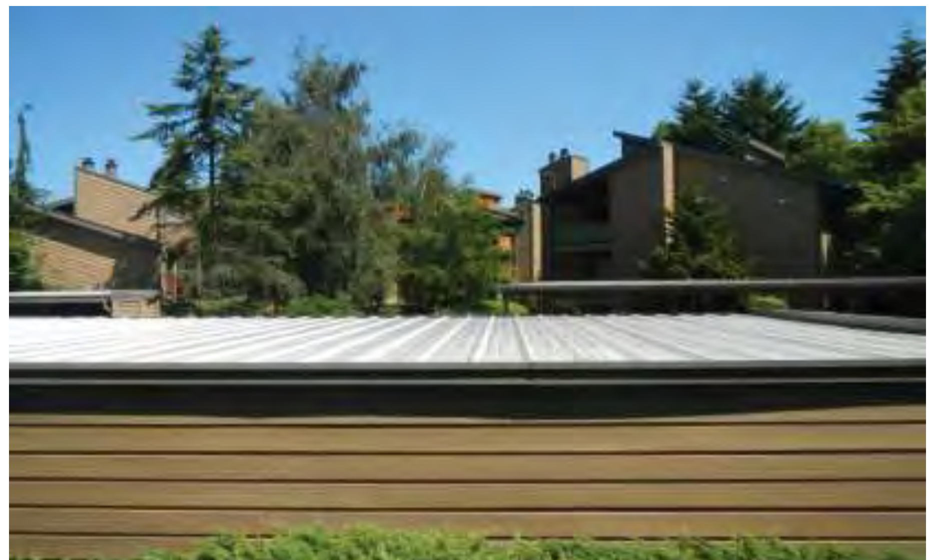

Photo 4: Looking east

Monitoring Location M-51
4900 200th St SW Bldg. C – Cedar Creek Condos
Lynnwood, Washington

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Portland, Oregon

Figure 51
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking south

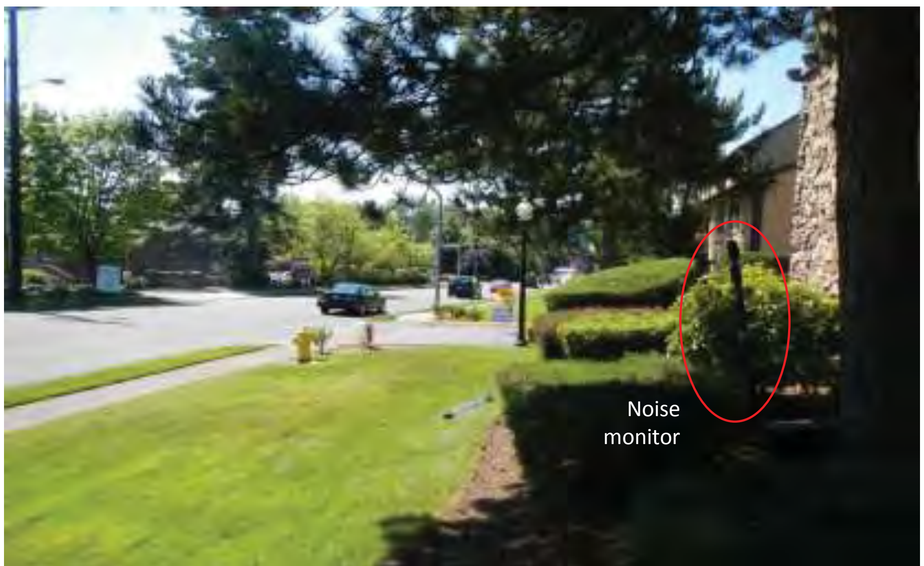

Photo 3: Looking west

Photo 4: Looking east

Monitoring Location M-52
4727 200th St SW #101A – Cambridge Apartments
Lynnwood, Washington

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Portland, Oregon

Figure 52
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking south

Photo 3: Looking east

Photo 4: Looking north

Monitoring Location M-53
4220 Alderwood Mall Blvd – Courtyard Marriott
Lynnwood, Washington

Michael Minor & Associates
Sound.Vibration.Air
Portland, Oregon

Figure 53
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking east

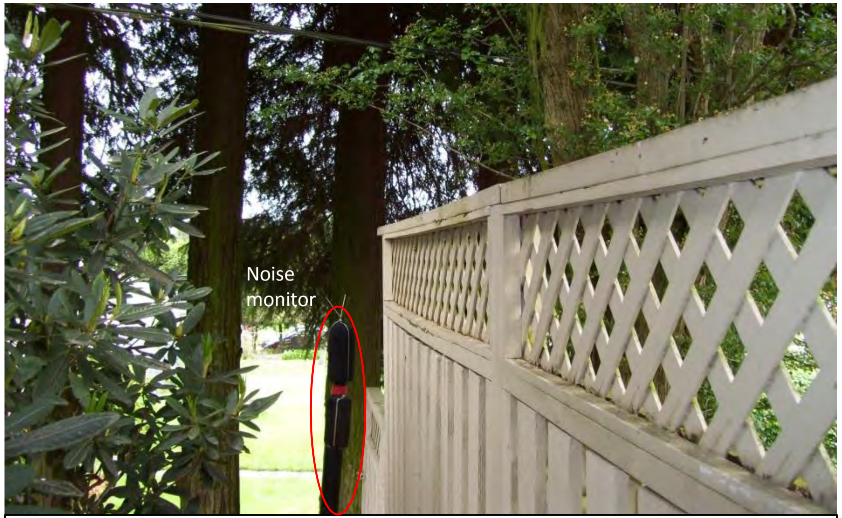

Photo 3: Looking west

Photo 4: Looking north

Monitoring Location M-54
137 NE 167th St.
Shoreline, Washington

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Portland, Oregon

Figure 54
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking east

Photo 3: Looking southwest

Photo 4: Looking north

Monitoring Location M-55
19604 10th Ave.
Shoreline, Washington

Michael Minor & Associates
Sound.Vibration.Air
Portland, Oregon

Figure 55
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking southwest

Photo 3: Looking south

Photo 4: Looking north

Monitoring Location M-56
1107 NE 200th St.
Shoreline, Washington

Michael Minor & Associates
Sound.Vibration.Air
Portland, Oregon

Figure 56
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking north

Photo 3: Looking west

Photo 4: Looking east

Monitoring Location M-57
20039 12th Ave.
Shoreline, Washington

Michael Minor & Associates
Sound.Vibration.Air
Portland, Oregon

Figure 57
Noise Monitoring Locations
Northgate to Lynwood Corridor

Photo 1: Aerial View

Photo 2: Looking west

Photo 3: Looking north

Photo 4: Looking east

Monitoring Location M-58
2005 12th Ave.
Shoreline, Washington

Michael Minor & Associates
Sound.Vibration.Air
Portland, Oregon

Figure 58
Noise Monitoring Locations
Northgate to Lynwood Corridor