Appendix D
RapidRide Roosevelt Noise and Vibration Technical Report

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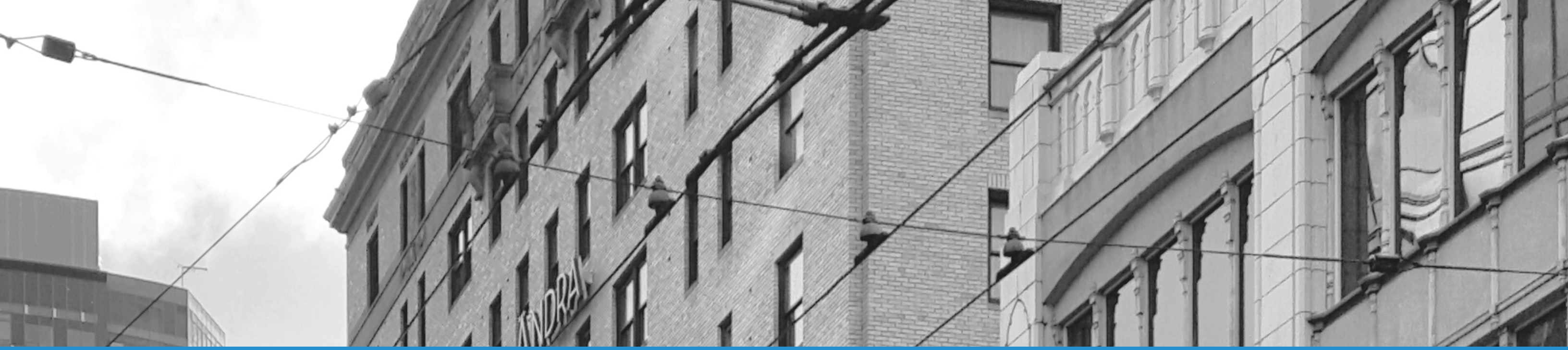

Seattle Department of Transportation and the Federal Transit Administration

RapidRide Roosevelt Project

NOISE & VIBRATION TECHNICAL REPORT

DECEMBER 2018

Federal Transit Administration

Seattle Department of Transportation

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ACRONYMS AND ABBREVIATIONS

ADA	Americans with Disabilities Act
A-weighted	A-weighting sound level network
BAT	business access and transit
dB	decibel
dBA	A-weighted decibel
FTA	Federal Transit Administration
FTA Manual	FTA Transit Noise and Vibration Impact Assessment (2006)
GIS	geographic information system
In/sec	inches per second
L_{dn}	day-night sound level
L_{eq}	equivalent sound level
L_{max}	maximum sound level
L_v	RMS vibration level
mph	miles per hour
OCS	overhead contact system
PPV	peak particle velocity
RMS	root mean square
SDOT	Seattle Department of Transportation
SEL	sound exposure level
SMC	Seattle Municipal Code
SPL	sound pressure level
TOL	transit-only lane
TPSS	traction power substation
UW	University of Washington
VdB	vibration velocity level

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1. INTRODUCTION AND SUMMARY

This technical report presents a noise and vibration study for the RapidRide Roosevelt project being proposed by the Seattle Department of Transportation (SDOT). The objective is to assess the potential noise and vibration impacts of the proposed project. The noise and vibration impact assessment for the RapidRide Roosevelt project is based upon guidance described in the Federal Transit Administration (FTA) *Transit Noise and Vibration Impact Assessment Manual* (FTA, 2006) and the memorandum, *Roosevelt RapidRide – Noise and Vibration Analysis Methodology,* developed by The Greenbusch Group (2017) and included in Appendix E. In 2018, FTA updated its manual. Updates were limited to source reference levels for new transit technologies, mitigation policies, and reformatting to improve the readability of the report. Electric bus source reference levels, which were used in this analysis, were not changed; therefore, the impact assessment including the methodology developed by the Greenbusch Group did not need to be updated based on the newest version of FTA's manual.

For the noise and vibration impact assessment, noise impact contours were identified that represent the area where noise and vibration impacts are projected to occur and if a noise- or vibration-sensitive receptor, or part of one, falls within the contour line. None of the noise-sensitive receptors identified in the corridor were located within the noise impact contour distances; therefore, there are no operational noise impacts anticipated. A vibration impact screening identified seven vibration-sensitive receptors (two condominium complexes, one recording studio, two University of Washington [UW] Medical Center buildings, and two commercial buildings). Further assessment, using receptor-specific adjustments (i.e., type of building foundation) as described in the FTA manual resulted in none of the seven vibration-sensitive receptors exceeding the FTA vibration impact criteria; therefore, no vibration impacts are anticipated. No mitigation is warranted given the absence of long-term impacts resulting from the operation of the project.

Construction activities would result in short-term increases in noise and vibration. Construction would occur over a 24-month period and would be phased so that any individual area would not be affected for the entire construction period. Noise from construction activities is predicted to exceed FTA and City of Seattle daytime construction noise criteria at residential receptors, but not at commercial receptors. With mitigation, construction activities are likely to satisfy City of Seattle and FTA criteria. A Construction Noise Control Plan will be developed and measures to mitigate construction noise could include:

- Use upgraded engine exhaust mufflers, engine shrouds, or sound enclosures on noisier equipment.
- Install portable sound barrier around noisier equipment.
- Use electric and hydraulic equipment in lieu of diesel or pneumatic equipment.
- Develop noise limits, address complaints, and monitor noise levels during construction.

If work occurs at night, a Noise Variance from the Seattle Department of Construction and Inspections will be required. Construction vibration has the potential to result in building damage and annoyance. Buildings, including historic buildings, are near construction activities but building damage, which would consist of cosmetic damage (i.e, cracked plaster), is not anticipated because the construction equipment to be used is not expected to produce high vibration levels. The exception is the paving on the corridor and the use of compaction methods that have the potential to produce high vibration levels. With the implementation of mitigation measures, impacts would be minimized or avoided. A Construction Vibration Control Plan will be developed and measures to mitigate construction vibration could include:

- Phase vibration-producing activities so they do not occur simultaneously.
- Schedule vibration-producing activities outside time periods to least annoy users most sensitive to vibration, as feasible. For example, execute vibration-producing work near residential buildings during daytime hours and commercial buildings during nighttime hours.
- Minimize the use of impact tools such as hoe rams and jackhammers; use lower-vibration equipment such as concrete saws for demolishing existing pavement.
- Use lower power settings on vibratory rollers or large static rollers, especially near buildings with plaster or within 26 feet of a structure.

1.1 Project Description

The RapidRide Roosevelt project would connect Downtown Seattle with the neighborhoods of Belltown, South Lake Union, Eastlake, University District, and Roosevelt. Compared to the existing conditions, the project would increase transit speed and reliability through enhanced signal systems and signal timing and roadway improvements. The project would increase passenger carrying capacity, serving high existing ridership and future population and employment growth. Service is targeted to begin in 2024.

The RapidRide Roosevelt project would run from 3rd Ave in Downtown Seattle to NE 65th St in the Roosevelt neighborhood (Figure 1-1 and Figure 1-2). No project improvements are proposed for the corridor south of the Virginia St and 3rd Ave intersection. The project would use the existing transit lanes on Stewart St between 9th Ave and 3rd Ave. Buses would travel along portions of S Main St, 2nd Ave S, and S Jackson St to transition from southbound to northbound service.

The RapidRide Roosevelt project would connect bicyclists with new transit service and enhance bicycle and pedestrian safety throughout the corridor. The project would add protected bike lanes along 11th Ave NE and 12 Ave NE and along Eastlake and Fairview Avenues. Pedestrian improvements would be added throughout the corridor.

The project includes the following elements:

1.1.1 Stations

26 new or upgraded RapidRide stations (13 for each direction of travel) from 3rd Ave in the south to NE 65th St in the north. Stations would be consistent with the existing RapidRide station standard, typically 80 feet long including a 12-foot-long shelter/transit canopy (see photo at right); longer stations would be provided where serving multiple routes. Each station would have a real-time arrival information system display, an off-board fare collection/card reader, a bench, pedestrian-level lighting, a trash receptacle, and RapidRide branding elements, including a signature signpost/blade marker, and a route information map. All stations would meet Americans with Disabilities Act (ADA) requirements. The RapidRide Roosevelt line will serve 9 existing stations along 3rd Ave in Downtown Seattle south of Stewart St.

Typical RapidRide Station

1.1.2 Operations

The buses for the project consist of all-electric trolley buses from the existing King County Metro Transit (KCM) fleet. No additional buses are needed as part of the project. The buses would be 60 feet long; articulated with front, middle, and back doors; and ADA-accessible from the front doors with a bridge plate.

The RapidRide Roosevelt route is expected to operate 24 hours per day. Buses would run at 7.5-minute headways or better during peak periods and at 10-minute headways during midday and until 10 PM on weekdays. Weekend headways would range from 10 to 15 minutes. Nighttime hourly service would be provided 7 days per week from 1 AM to 5 AM. Service will stop near the Roosevelt Link light rail station at 12th Ave NE and NE 65th St.

Establishing a network of 33 traffic signals with transit signal priority and queue jumps. The project would upgrade 29 intersections with transit signal priority and transit queue jumps allowing a leading signal interval would be provided at 4 intersections (Virginia St/Terry Ave, Fairview Ave N/Mercer St, Fairview Ave N/Valley St, and Fairview Ave N/Streetcar). The enhanced signal system would provide priority to transit and respond to corridor traffic congestion.

1.1.3 Roadway Improvements

1.1.3.1 Transit Lanes

2.3 miles of new transit-only lanes (TOLs) and business access and transit (BAT) lanes would be located along the corridor in the South Lake Union areas (Figure 1-2). TOLs would allow buses to operate in dedicated space and travel relatively unimpeded through congested areas. BAT lanes are curb lanes located along a route expressly reserved for buses along with business access and right turns.

1.1.3.2 Paving

In addition to the concrete paving associated with stations, the project would include mill and overlay asphalt paving along 11th Ave NE and 12th Ave NE from the University Bridge to NE 67th St (Figure 1-1). Mill and overlay asphalt paving, spot repairs, and full depth concrete paving are proposed on Eastlake Ave E between Fairview Ave and Harvard Ave E (Figures 1-1 and 1-2).[1]

1.1.4 Overhead Contact System and Traction Power Substation

1.1.4.1 Overhead Contact System

Buses would be powered by electricity provided by an overhead contact system (OCS). OCS includes both poles and wires. The OCS consists of a contact wire above the roadway that conveys electric power from the traction power substation (TPSS) to the buses.

New OCS poles and wire would be added north of the University Bridge, starting at Eastlake Ave E and NE 40th St, and along both 11th Ave NE and 12th Ave NE and Roosevelt Way NE (Figure 1-1). The OCS poles would be located within existing right-of-way (sidewalk) and would be spaced typically 100 feet apart. The OCS poles would be designed as consolidated traffic signal or lighting poles where possible. OCS poles and wire would extend to the northern bus layover.

1.1.4.2 Traction Power Substation

One new traction power substation or TPSS (source of electric power) in the northern portion of the project. Four TPSS sites are being considered (Figure 1-1) all within publicly owned property. The sites include existing SDOT transportation right-of-way at the intersection of NE Ravenna Blvd and 12th Ave NE, the parking lot at Seattle Public Schools Roosevelt High School, the Sound Transit Roosevelt Link Station, and Seattle Public Utilities property at the Green Lake Reservoir at NE 75th St and 12th Ave NE. Connection to the TPSS would use OCS poles or existing utility poles depending on option selected.

1.1.4.3 Communications Cabinet

One existing signals communications cabinet located at the southeast corner of NE 68th St and 15th Ave NE would be replaced with a larger cabinet (current cabinet is not large enough to accommodate the upgraded signals) (Figure 1-1). Fiber optic lines associated with the cabinet would use existing utility poles along NE 65th St and 15th Ave NE.

1.1.5 Bus Layovers

Bus layover areas where buses park while transitioning to service in a different direction would be provided at the southern and northern ends of the route. At the southern end, buses would use an existing layover area on S Main St (Figure 1-2). A new bus layover would be constructed at the northern end of the corridor. Three northern layover options are being evaluated (Figure 1-1):

- **Option 1.** Buses would continue along 12th Ave NE turning on NE 67th St with a layover area provided for up to four buses on NE 67th St between 12th Ave NE and Roosevelt Way NE.

[1] Milling and overlay consist of removal of the top 2 inches of asphalt and then overlay with 2 inches of new asphalt. Full depth concrete paving consists of removing and replacing the slab to the bottom of the concrete.

- **Option 2**. Buses would use NE 67th St to turn around as in Option 1; however, they would park on 12th Ave NE and Roosevelt Way NE. One or two buses would park on the east side of 12th Ave NE between NE 65th St and NE 67th St, and one to two buses would park on the west side of Roosevelt Way NE between NE 67th St and NE 66th St.
- **Option 3.** Buses would continue to travel north on 12th Ave NE but instead of turning around at NE 67th St, buses would turn around at NE 70th St. Up to four buses would lay over on 12th Ave NE between NE 65th St and NE 68th St.

1.1.6 Nonmotorized (Bicycle and Pedestrian) Improvements

The project would include protected bicycle lanes (PBLs) along 11th Ave NE, 12th Ave NE, Eastlake Ave E, and Fairview Ave N.

The project would include ADA-compliant curb ramps and ADA-compliant pedestrian push buttons and countdown pedestrian signal heads to control pedestrian traffic at intersections near proposed station locations.

The project would include intersection safety improvements for pedestrians accessing the stations, including sidewalk repairs and crosswalk striping.

1.1.7 Stormwater Improvements and Utility Relocations

The project would include installation of stormwater detention facilities consisting of detention pipe between 4 and 6 feet in diameter along 11th Ave NE, Eastlake Ave E (two locations), and Fairview Ave N. The project also includes the installation of water quality treatment units along Fairview Ave N. The project would also relocate, modify, or protect existing utilities that conflict with project elements.

1.1.8 Parking and Loading Zones

The project would remove up to 700 on-street parking and up to 94 vehicle loading zones along the corridor. The majority of the parking and loading zone removals occurs in the Eastlake and University District neighborhoods.

1.1.9 Construction

Project construction would require up to 24 months to complete and would be phased to minimize construction impacts along the alignment. Construction is planned to be limited to existing right-of-way but may require temporary construction easements on adjacent parcels.

Construction would affect on-street parking and require temporary closures of travel lanes. Temporary sidewalk closures with signage noting detour routes would be necessary when constructing around stations and installing utilities or OCS poles.

Staging area(s) for storage of equipment and materials would generally be within street rights-of-way. If necessary, staging areas outside the right-of-way would be established.

Figure 1-1 RapidRide Roosevelt Alignment – North

Figure 1-2 RapidRide Roosevelt Alignment - South

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2. NOISE AND VIBRATION BASICS AND CRITERIA

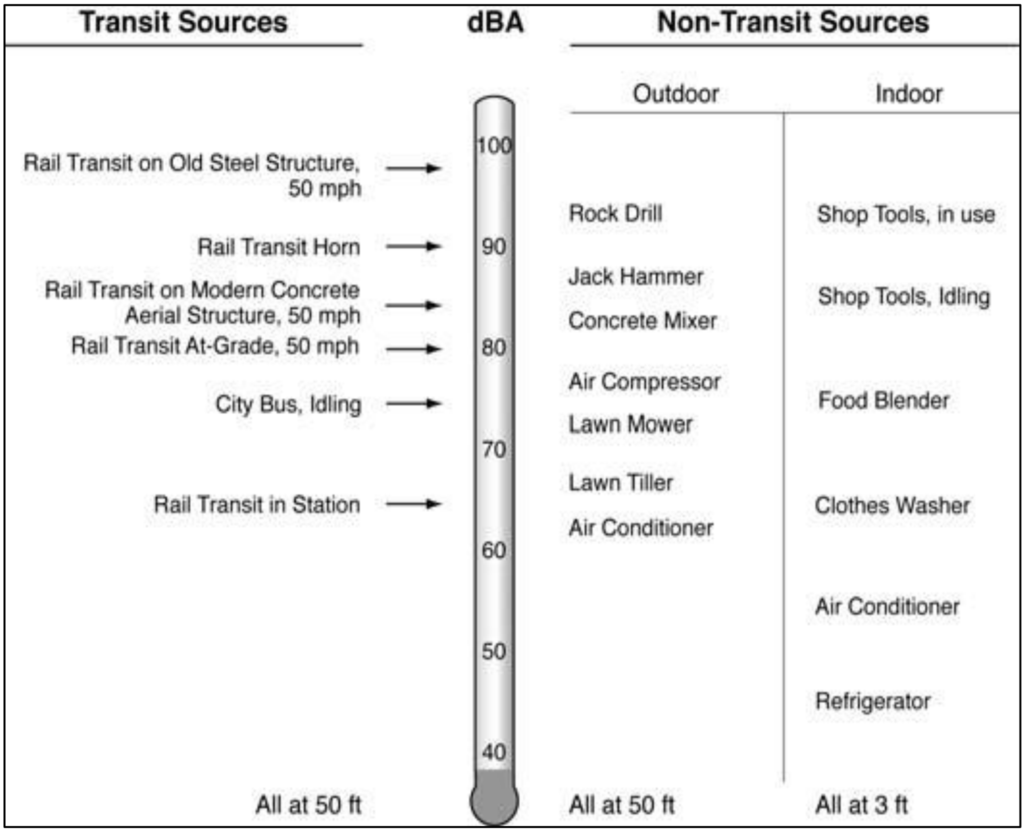
2.1 Noise

Noise is defined as unwanted sound, which is a subjective experience of exposure to different sound levels. The human ear processes small fluctuations in air pressure differently, depending on amplitude (loudness and softness), pitch (high and low frequency), and variability (how noise changes over time).

Noise is measured in terms of sound pressure level and is expressed in decibels (dB). The overall dB level does not address the varying human sensitivity to sound at different frequencies or overall loudness that might be experienced. The human ear has a unique response to sound pressure. It is less sensitive to sounds that fall outside the range of speech. Sound-level meters use a filtering system to approximate human perception of sound. Measurements made using this filtering system are referred to as “A weighted” and are called “dBA.” The FTA Manual provides sound levels from common sound sources. Figure 2-1 illustrates a summary of these sound levels.

Three common descriptors used for assessing environmental impacts include:

- **Equivalent Sound Level (L_{eq})** – The equivalent sound level is used to describe noise over a specified period of time, typically 1 hour, in terms of a single numerical value. The L_{eq} is the constant sound level that would contain the same acoustic energy as the varying sound level, during the same time period (i.e., the average noise exposure level for the given time period).
- **Day-Night Sound Level (L_{dn})** – The day-night average sound level is the energy average of the A-weighted sound levels occurring during a 24-hour period, accounting for the greater sensitivity of most people to nighttime noise by weighting (“penalizing”) nighttime noise levels by adding 10 dBA to noise between 10 PM and 7 AM.
- **Maximum Sound Level (L_{max})** – The L_{max} is the instantaneous maximum noise level measured during the measurement period of interest.



Source: FTA, 2006

Figure 2-1 Comparison of Various Sound Levels

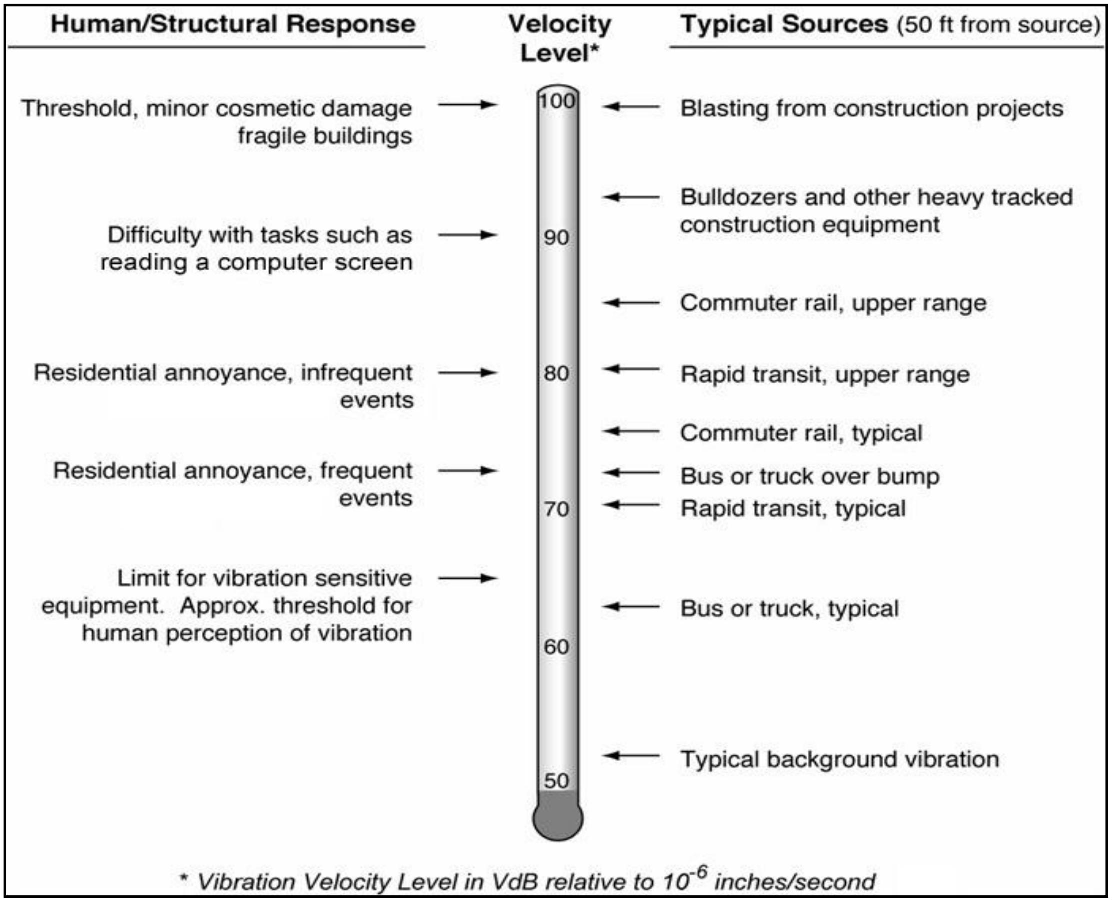
2.2 Vibration

Vibration is an oscillatory motion that can be measured in a variety of ways: displacement, velocity, or acceleration. Displacement is a measure of the distance that a point moves away from its resting position, velocity represents the instantaneous speed of the movement, and acceleration is the rate of change of the speed.

Moving vehicles including buses can result in ground-borne vibration that might be felt on or extend to adjacent properties. Ground-borne vibration has the potential to result in perceptible building vibration that occupants feel, the rattling of items on shelves and rattling of windows and doors, and damage to building structures.

Vibrations above certain levels can damage buildings, disrupt sensitive operations, and be felt by humans. The response of buildings, equipment, and humans to vibration is most commonly described as velocity. Vibration velocity level (VdB) is used to evaluate the effects of vibration on humans and equipment. Damage to buildings is assessed using peak particle velocity (PPV). The FTA Manual provides vibration levels from common sources. These vibration levels and the response are illustrated in Figure 2-2. The threshold of human perception to vibration is approximately 65 VdB, and annoyance does not usually occur unless the vibration exceeds 70 VdB.

Ground-borne noise is the noise radiated from the motion of room surfaces due to the rumble of moving vehicles.



Source: FTA, 2006

Figure 2-2 Typical Ground-borne Vibration Levels and Human/Building Response

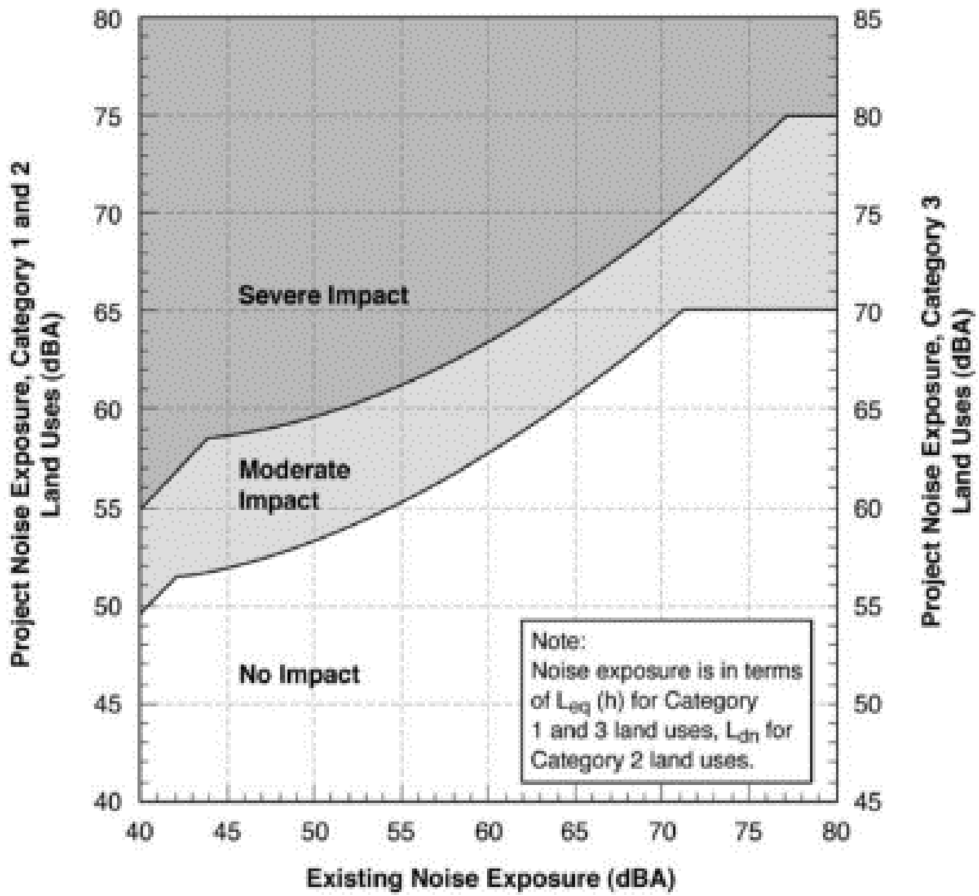
2.3 Noise Impact Criteria

2.3.1 Transit Noise Impact Criteria

Noise impacts for the RapidRide Roosevelt project were determined based on criteria defined in the FTA Manual. FTA defines two levels of noise impacts moderate and severe:

- Moderate Impact - a change in the cumulative noise level that would be noticeable to most people, but may not be sufficient to cause strong, adverse reactions from the community.
- Severe Impact – project-generated noise in the severe impact range that would highly annoy a substantial percentage of people and would most likely require mitigation.

The FTA noise impact criteria are summarized in graphical form in Figure 2-3.



Source: FTA, 2006

Figure 2-3 FTA Noise Impact Criteria

Noise impact criteria are applied to sensitive land uses or receptors as defined by FTA (Table 2-1). Potential noise impacts are determined by comparing the noise generated from the proposed project operations to the existing noise conditions where the project would operate.

Table 2-1 FTA Noise-Sensitive Receptor Categories

NOISE CATEGORY	DESCRIPTION
Category 1 (High Sensitivity)	Places with the highest sensitivity to airborne noise from transit sources. Examples include concert halls, recording studios, outdoor concert pavilions and National Historic Landmarks where outdoor interpretation routinely takes place.
Category 2 (Residential)	Places where people normally sleep. Examples include apartments and condominiums, single-family homes, hotels, apartments, and shelters.
Category 3 (Daytime Use)	Places with sensitive receptors used during daytime and evening hours. Examples include schools, libraries, places of worship, theaters, and museums.

Source: FTA, 2006 (Table 3-2)

2.3.2 Construction Noise Criteria

2.3.2.1 FTA Criteria

Noise analysis for projects funded by FTA must be performed in accordance with the FTA Manual. The FTA Manual defers to noise levels set by local jurisdictions for determining noise impacts from construction. However, the FTA Manual does give "reasonable criteria for assessment" to help predict "adverse community reaction" (Table 2-2).

Table 2-2 FTA Construction Noise Impact Criteria

LAND USE	DAYTIME (dBA)	NIGHTTIME (dBA)
Residential	90	80
Commercial	100	100
Industrial	100	100

Source: FTA, 2006 (Section 12.1.3)

2.3.2.2 City of Seattle Regulations

The City of Seattle Municipal Code (SMC) defines sound level limits for construction sites under SMC 25.08, Noise Control. The criteria are defined by the district the sound originates within and the district the sound is received in. SMC 25.08.100 defines districts as land use zones including Residential, Commercial, and Industrial. For purposes of the Noise Control Code, the following zones are defined in the Seattle Land Use Code, Title 23:

- Residential District: Residential and NC1 zones
- Commercial District: NC2, NC3, SM, C1, C2, DOC1, DOC2, DRC, DMC, PSM, IDM, DH1, DH2, PMM, and IB zones
- Industrial District: IG1, IG2, and IC zones

A summary of City of Seattle sound level limits by district for construction is shown in Table 2-3.

Table 2-3 City of Seattle Hourly Sound Level Limits for Construction Sites

DISTRICT OF SOUND SOURCE	DISTRICT OF RECEIVING PROPERTY		
	RESIDENTIAL L_{eq}/L_{max} (dBA)	COMMERCIAL L_{eq}/L_{max} (dBA)	INDUSTRIAL L_{eq}/L_{max} (dBA)
DAYTIME			
Residential	80 / 95	82 / 97	85 / 100
Commercial	82 / 97	85 / 100	90 / 105
Industrial	85 / 100	90 / 105	95 / 110
NIGHTTIME			
Residential	45 / 60	57 / 72	60 / 75
Commercial	47 / 62	60 / 75	65 / 80
Industrial	50 / 65	65 / 80	70 / 85

Source: Seattle Municipal Code 25.08.410 and 25.08.425

Daytime limits are enforced between 7 AM and 10 PM on weekdays and 9 AM and 10 PM on weekends and legal holidays. Nighttime hours are enforced at all other times. These limits also apply inside commercial buildings when all windows and doors are closed. Additionally, nighttime sound level limits are subject to modifications delineated in SMC 25.08.420, depending on the classification of receiving properties and the type of sound generated. The modifications to the exterior sound-level limits include the following reductions:

- 5 dBA for sources that carry a pure tone component
- 5 dBA for impulsive sources not measured with an impulse sound level meter

These modifications are additive and independent of one another.

The predominant districts throughout the project corridor are commercial and residential. Residential districts have an hourly L_{eq} limit of 80 dBA during the day and 45 dBA at night. Commercial districts have an hourly L_{eq} limit of 85 dBA during the day and 60 dBA at night.

2.4 Vibration Impact Criteria

2.4.1 Transit Vibration Criteria

Similar to noise impact criteria, the FTA Manual identifies sensitive vibration land uses or receptors (Table 2-4).

Table 2-4 Vibration-Sensitive Receptor Categories

VIBRATION CATEGORY	DESCRIPTION
Category 1 (High Sensitivity)	Place with high sensitivity to ground-borne noise and vibration from transit sources. Examples include concert halls, research facilities, and medical facilities with vibration-sensitive equipment.
Category 2 (Residential)	Places where people normally sleep. Examples include apartments and condominiums, single-family homes, hotels, apartments, and shelters.
Category 3 (Daytime Use)	Places with sensitive uses during daytime and evening hours. Examples include schools, libraries, places of worship, and commercial buildings with a high percentage of office space and minimal retail.

Source: FTA, 2006 (Section 8.1.1)

Criteria established in the FTA Manual are used to determine the likelihood of operational vibration impacts on vibration-sensitive receptors based on land use (receptor category) and to impact thresholds for ground-borne vibration. Thresholds are also based on the frequency of events. Ground-borne vibration criteria for frequent events can be found in Table 2-5.

Table 2-5 Operational Vibration Impact Criteria – Frequent Events

LAND USE CATEGORY	GROUND-BORNE VIBRATION (VdB)
Category 1 (high sensitivity)	65
Concert Halls	65
TV Studios	65
Recording Studios	65
Auditoriums	72
Theaters	72
Category 2 (residential)	72
Category 3 (daytime use)	75

Source: FTA, 2006 (Table 8-1)

2.4.1 Construction Vibration Criteria

The FTA Manual divides assessment of vibration levels associated with construction activities into two categories: building damage and occupant annoyance. Building damage criteria uses the PPV metric and annoyance uses VdB, which is also used for the operational vibration impact assessment.

2.4.1.1 Building Damage

Assessment criteria depends on the type of building construction, as indicated in Table 2-6. Lighter-weight timber buildings are associated with lower building damage thresholds than those built with heavier steel and concrete. The City of Seattle has not codified regulatory criteria for vibration.

Table 2-6 Construction Vibration Criteria – Building Damage

BUILDING CATEGORY	PPV (IN/SEC)
I. Reinforced concrete, steel, or timber (no plaster)	0.50
II. Engineered concrete and masonry (no plaster)	0.30
III. Non-engineered timber and masonry	0.20
IV. Buildings extremely susceptible to vibration damage	0.12

Source: FTA Manual, Table 12-3

2.4.1.2 Annoyance

Similar to operational vibration, criteria established in the FTA Manual are used to identify receptors that may experience annoyance due to vibration from construction. Assessment criteria for annoyance depend on receptor land use, with the same receptor classifications and criteria as operational vibration, shown in Table 2-5.

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3. METHODOLOGY

3.1 Study Area

The study area includes the project corridor from Stewart St and extending to the north to NE 70th St as well as a screening distance which extends outward from the northbound and southbound bus route centerlines to adjacent parcels (Figure 3-1). While buses would travel along 3rd Ave, this is an existing transit route. There are no planned project improvements and bus frequencies would not change during peak periods or late evening hours. There is a small change in frequencies (two buses per hour) during midday and weekends but changes to the existing noise and vibration conditions along the 3rd Ave corridor are not expected as a result; therefore, it was excluded from the study area.

The screening distance used to define the study area was meant to be sufficiently large to encompass all noise and vibration sensitive receptors with a potential for noise impact. Based on Noise Screening Procedure in the FTA Manual and the FTA *Noise Impact Assessment Spreadsheet* (HMMH, 2007), the noise impact screening distance extends 18 feet from either side of noise sources within the project corridor. FTA's General Vibration Screening suggests a vibration study area of 100 feet from vibration sources within the project corridor (FTA, 2006). Therefore, a combined study area for the noise and vibration analysis extends 100 feet in both directions from the proposed RapidRide Roosevelt centerline (refer to the inset map on Figure 3-1 for details).

3.2 Existing Noise Conditions

Measurements were conducted in the study area to establish existing noise conditions and to determine impact assessment criteria for operational noise. Measurement locations were chosen to acoustically represent an area along the project corridor. Measured and assumed (unmeasured) sound levels are considered to be the same within a few blocks in either direction of the measurement location because of the consistent nature of traffic noise.

Noise measurements were conducted for 24 continuous hours between 12 PM Monday and 12 PM Friday on the dates shown in Table 3-1. Measurement equipment consisted of a microphone housed in an environmental shroud and placed on a tripod or utility pole mount, depending on measurement location. The microphone was connected to a sound-level meter in a small Pelican Case that was chained to a nearby structure. Measured sound levels and measurement locations are summarized in Table 3-1 and Figure 3-2. Refer to Appendix B, Noise and Vibration Measurements, for additional information.

Table 3-1 Noise Measurement Locations

MEASUREMENT LOCATION[a]	NEAREST ADDRESS	DATE	PEAK OPERATIONAL HOUR L_{eq}[b] (dBA)	24-HOUR L_{dn} (dBA)[c]
N-1	6126 12th Ave NE	1/22-23/2018	63	66
N-2	4131 11th Ave NE	1/22-23/2018	69	72
N-3	2851 Eastlake Ave E	1/16-17/2018	64	67
N-4	1925 Eastlake Ave E	1/18-19/2018	71	74
N-5	2020 Terry Ave	1/22-23/2018	62	68

[a] Locations shown on Figure 3-2.

[b] 7 AM to 7 PM

[c] Sound levels increased by 10 dB between 10 PM and 7 AM

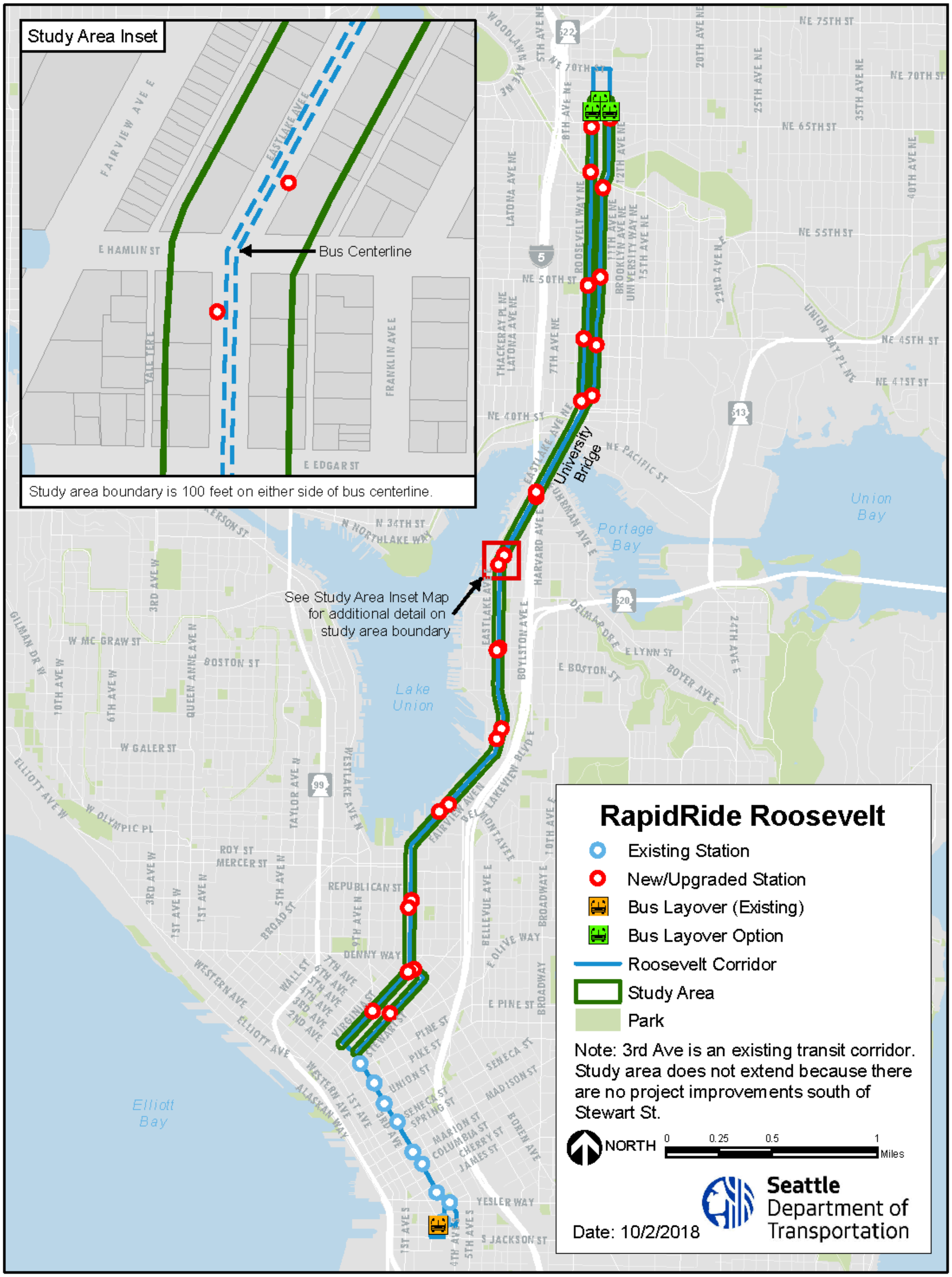

Figure 3-1 Study Area

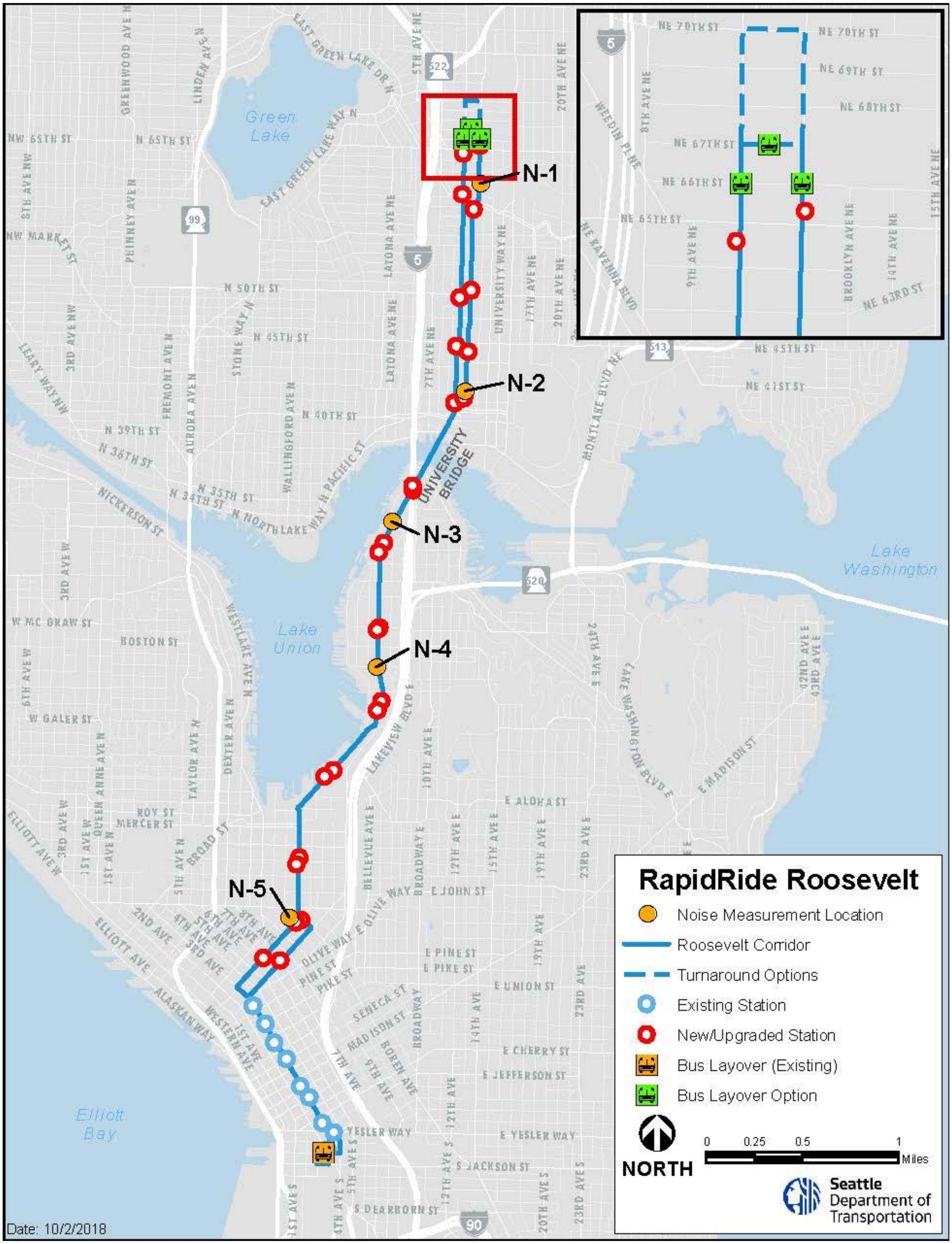

Figure 3-2 Noise Measurement Locations

3.3 Operational Noise

Procedures for evaluating noise impacts at this stage of project development are defined in the FTA Manual, Chapter 5, General Noise Assessment, and the October 31, 2017, methodology memorandum (The Greenbusch Group, 2017; see Appendix E). The General Noise Assessment can be summarized in four main steps:

1. Determine project characteristics, such as transit type, hours of operation, and traffic volumes and speed.
2. Identify project location characteristics, such as existing sound levels.
3. Use the characteristics from Steps 1 and 2, and the FTA *Noise Impact Assessment Spreadsheet* (HMMH, 2007) to calculate noise impact contour distances.
4. Identify potential noise impacts using the contour distances.

Noise impact distances are based on vehicle type, operating conditions, and existing sound levels (i.e., travel speed and number of buses per hour). Input parameters used in this assessment are shown in Table 3-2.

Table 3-2 Sound Emission Input Parameters

DESCRIPTION	VALUE
Reference SEL at 50 feet (Electric Bus)	80 dBA
Travel speed[a]	25 mph
Average hourly volume of traffic	4.5 buses per hour
Average daytime hourly volume of traffic	5.6 buses per hour
Average nighttime hourly volume of traffic	2.6 buses per hour
L_{dn} (Category 2)[b]	66 dBA
$L_{eq(h)}$ (Category 1 and 3)[c]	62 dBA

[a] Speed limit used as analysis speed
[b] Lowest measured L_{dn} was used to calculate impact distance.
[c] Lowest measured $L_{eq(h)}$ was used to calculate impact distance.

Table 3-3 identifies noise impact criteria at each noise monitoring location, based on the existing noise measurement data summarized in Section 3.2. The moderate and severe impact criteria sound levels are used to predict impacts from operational noise. These impact criteria sound levels are not compared with existing sound levels to determine impacts.

Table 3-3 Operational Noise Impact Criteria, based on Existing Conditions

MEASUREMENT LOCATION	EXISTING L_{eq} (dBA)	EXISTING L_{dn} (dBA)	MODERATE IMPACT CATEGORIES 1/2/3[a, b] (dBA)	SEVERE IMPACT CATEGORIES 1/2/3[a, b] (dBA)
N-1	63	66	60 / 62 / 65	65 / 67 / 70
N-2	69	72	64 / 66 / 69	69 / 71 / 74
N-3	64	67	61 / 63 / 66	65 / 67 / 70
N-4	71	74	66 / 66 / 71	70 / 72 / 75
N-5	62	68	59 / 63 / 64	64 / 68 / 69

[a] Impact occurs once predicted level exceeds value.
[b] Values calculated from measured existing sound levels and Figure 3-2.

3.4 Existing Vibration Conditions

Vibration in the study area is associated with vehicles (i.e., buses, freight, and passenger vehicles) on the adjacent roadways and other sources include construction activities along the corridor for new developments.

One ambient vibration measurement was conducted for the analysis due to the proximity to two Category 1 receptors (Figure 3-3) which include the UW Medical Buildings, 4225 Roosevelt Way NE and 4245 Roosevelt Way NE. Measured vibration levels are summarized in Table 3-4; additional measurement details are in Appendix B, Noise and Vibration Measurements.

Table 3-4 Existing Vibration Measurement Summary

MEASUREMENT LOCATION	NEAREST ADDRESS	DATE	DURATION	VdB	PPV (in/sec)
V-1	4245 Roosevelt Way NE	1/26/2018	1-hour	43	0.0065

Ground-borne vibration impacts from operation of the RapidRide Roosevelt fleet are not anticipated because buses have rubber tires and suspension systems, which provide vibration isolation (FTA, 2006). This was confirmed by screening calculations that followed methodologies in Chapter 10 of the FTA Manual. Therefore, ground-borne noise was not included in this analysis.

3.5 Vibration Propagation Testing

Vibration propagation testing was conducted to determine if an "efficient propagation in soil" condition (as defined by FTA), as part of the General Vibration Assessment should be applied within the study area. The test is performed to determine if vibration propagates more efficiently and farther than the FTA Manual assumes. A single test location was chosen based on methodology outlined in the October 31, 2017, methodology memorandum (The Greenbusch Group, 2017; see Appendix E).

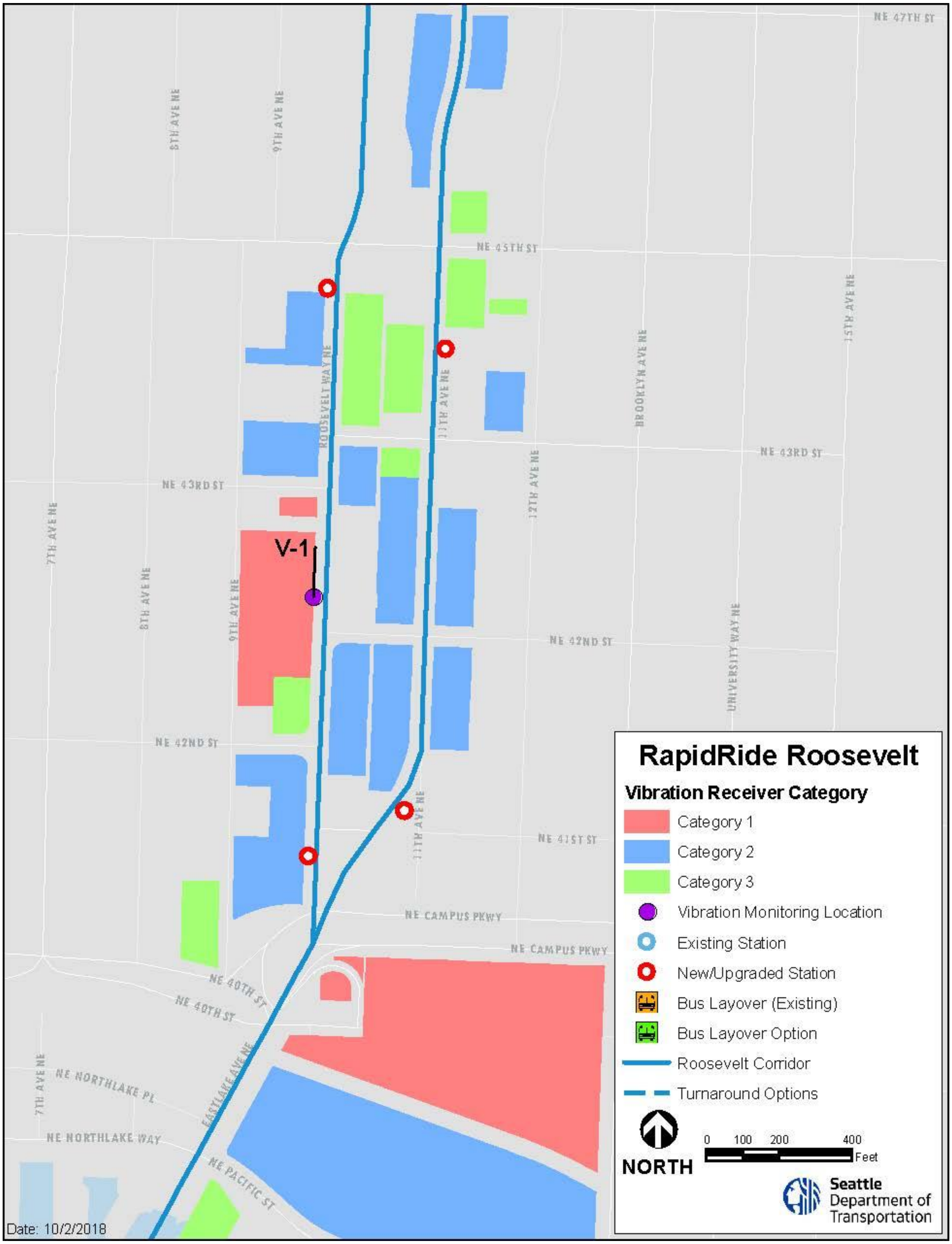

Figure 3-3 Existing Vibration Measurement Location

The vibration propagation test took place on NE Pacific St near the University Bridge (Figure 3-4). The site was selected for the vibration propagation test due to the representative soil conditions, space to conduct the test, and proximity of nearby vibration-sensitive receptors including the University of Washington Applied Physics Lab, University of Washington Roosevelt Medical Buildings, and Jack Straw recording studio. The vibration propagation test setup included six vibration sensors, six-channel recorder, and a 16-pound sledge hammer. The vibration sensors were placed in a line, at distances of 5, 10, 20, 30, 40, and 50 feet from the sledge hammer impact location to capture vibration from the sledge hammer.

Test results show propagation characteristics similar to the FTA surface vibration curve, which supports the use of the FTA methodologies without "efficient propagation in soil." Soil boring sample logs made available through the Washington Geological Survey Database (Washington State Department of Natural Resources, 2018) within the study area were also examined and did not reveal soil conditions commonly associated with "efficient propagation in soil" as defined by the FTA. Based on these findings, the typical vibration models included in the FTA Manual are appropriate for the RapidRide Roosevelt project. Refer to Appendix B, Noise and Vibration Measurements, for information on the vibration propagation testing and Appendix C, Soil Boring Logs, for a summary of the analyzed boring logs.

3.6 Operational Vibration

Procedures for evaluating vibration impacts are outlined in Chapter 10, General Vibration Assessment, of the FTA Manual and the October 31, 2017, methodology memorandum (The Greenbusch Group, 2017; see Appendix E). In accordance with these procedures, vibration emissions from bus operations were assessed to predict vibration impacts. The General Vibration Assessment occurred in two main steps: estimating vibration levels emitted by the project at vibration-sensitive receptors within the study area to identify impacts, and then refining the predicted vibration levels at impacted vibration-sensitive receptors and comparing again with impact criteria to determine whether there are impacts remaining. If there are impacts identified after these adjustments, then mitigation measures may be proposed.

Because of the large number of vibration-sensitive receptors in the study area, predicting vibration impacts from operations was completed in two steps. The first step of the analysis used a conservative approach to identify potential vibration impacts by excluding receptor specific characteristics. The second step of the analysis further examined the identified potential vibration impacts by examining receptor specific characteristics. These receptor-specific characteristics consist of building foundation type, resonances, and sensitive receiver location (floor). Each characteristic has an associated vibration level adjustment that modifies the predicted vibration level. Once these adjustments are included the adjusted predicted vibration level is compared with the impact criteria in Table 2-5 to determine if the receptor is impacted.

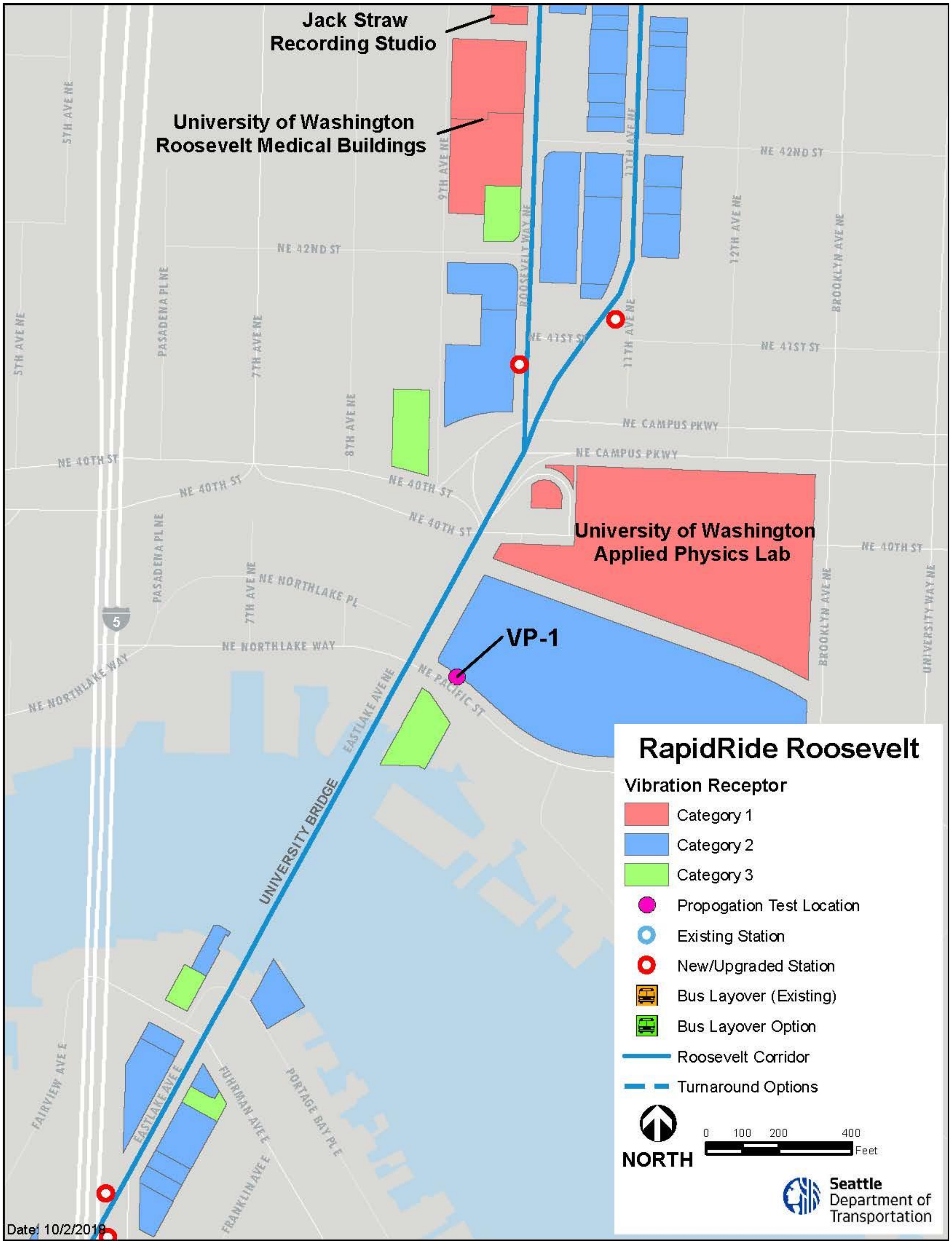

Figure 3-4 Vibration Propagation Testing Location

Vibration emissions are based on vehicle type, operating conditions, and road conditions. Input parameters are shown in Table 3-5.

Table 3-5 Vibration Emission Input Parameters

DESCRIPTION	VALUE
Reference vibration at 50 feet (30 mph)	64 VdB
Bus speed	25 mph
Uneven Road Surface?	No
Efficient Propagation in Soil?	No

Source: FTA Manual, Table 10-1

3.7 Construction

The General Assessment of construction noise outlined in Chapter 12 of the FTA Manual provides methodologies to estimate construction noise levels. These methodologies include analyzing sound levels from the two loudest pieces of equipment per construction phase operating continuously for 1 hour. The predicted sound level is then compared to FTA and local criteria. Due to limited information related to equipment and phasing at this early stage of design, the General Assessment methodologies are intended to yield conservative results. For construction, exterior sound-level limits are measured at the property line or at a distance of 50 feet, whichever is greater during the day, and at the property line at night. Both daytime and nighttime sound-level limits under city regulations (SMC 25.08) for construction near commercial and residential zoned areas are more stringent than FTA criteria. Sound emissions in excess of the SMC require a noise variance from the City of Seattle.

4. AFFECTED ENVIRONMENT

4.1 Noise-Sensitive Receptors

The land uses along the project corridor are mostly commercial and residential. In the southern portion of the project corridor within Downtown Seattle there are also higher densities of office related land uses. Much of the residential development along the corridor includes commercial uses on the ground floor and multifamily residencies above. There are single-family residences adjacent to the project corridor, with the majority located between NE 50th St and NE 64th St on both 11th Ave NE and 12th Ave NE and Roosevelt Way NE. Figure 4-1 shows an overview of zoning based upon City of Seattle zoning codes for the parcels along the project corridor based on the three districts identified in Section 2.3.1.2.

Noise-sensitive receptors are areas, sites, or properties that could be affected by project noise. Receptors within the study area were categorized by noise sensitivity based on FTA categories, King County records, City of Seattle zoning, and field assessment. Most receptors with industrial and commercial uses are not considered noise-sensitive, and therefore those properties are not included in the noise analysis. However, exceptions are made for some noise-sensitive commercial uses, such as sound and motion picture recording studios. A summary of the type of noise-sensitive receptors in the study area is shown in Table 4-1. Figures 4-2 through 4-4 show the locations of noise-sensitive receptors in the study area. Most of the noise-sensitive receptors are Category 2. Refer to Appendix A, Noise and Vibration Sensitive Receptors, for information on the noise-sensitive receptors in the study area.

Table 4-1 Noise-Sensitive Receptor Summary

RECEPTOR CATEGORY	NUMBER
Category 1	2
Category 2	348
Category 3	12

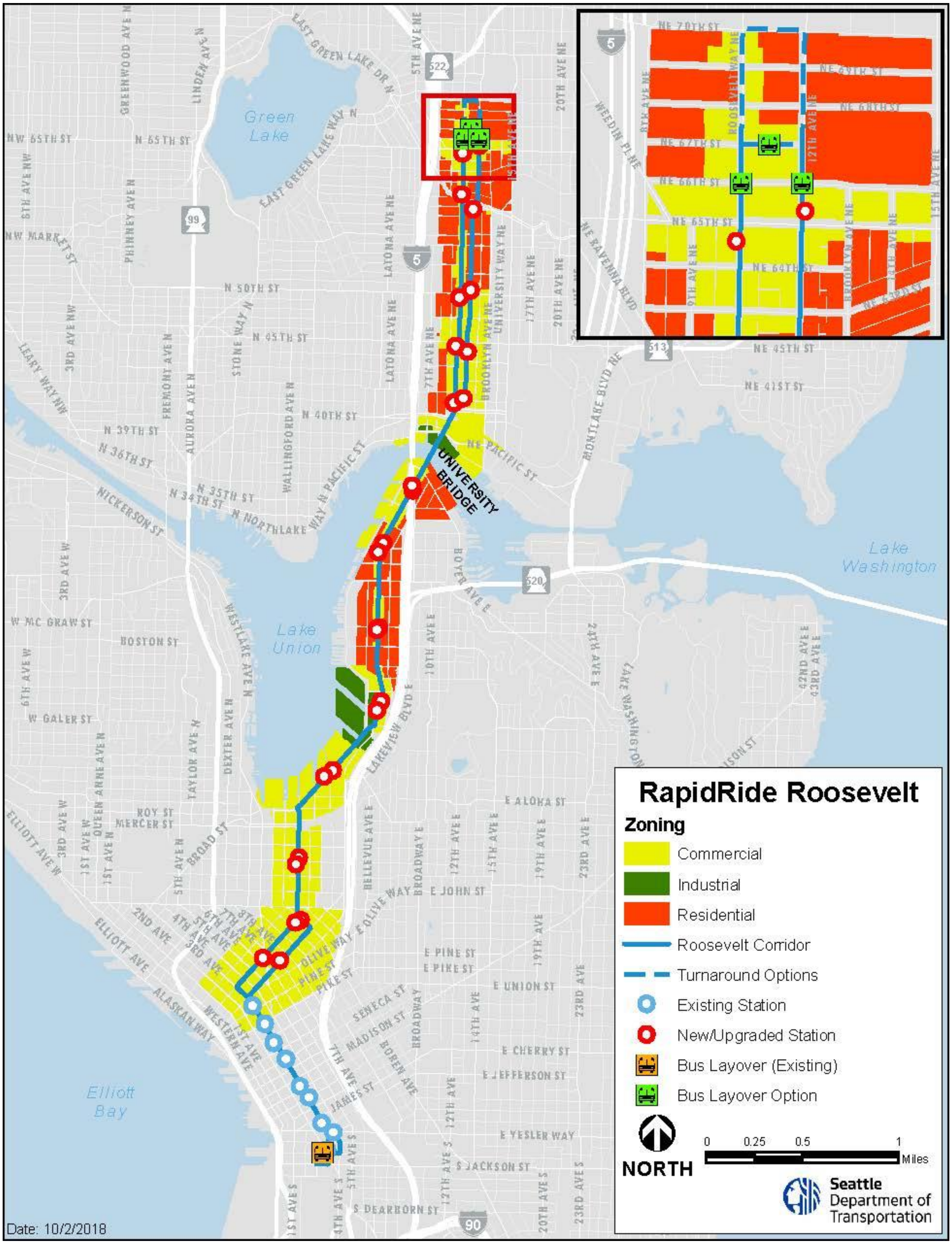

Figure 4-1 **Zoning**

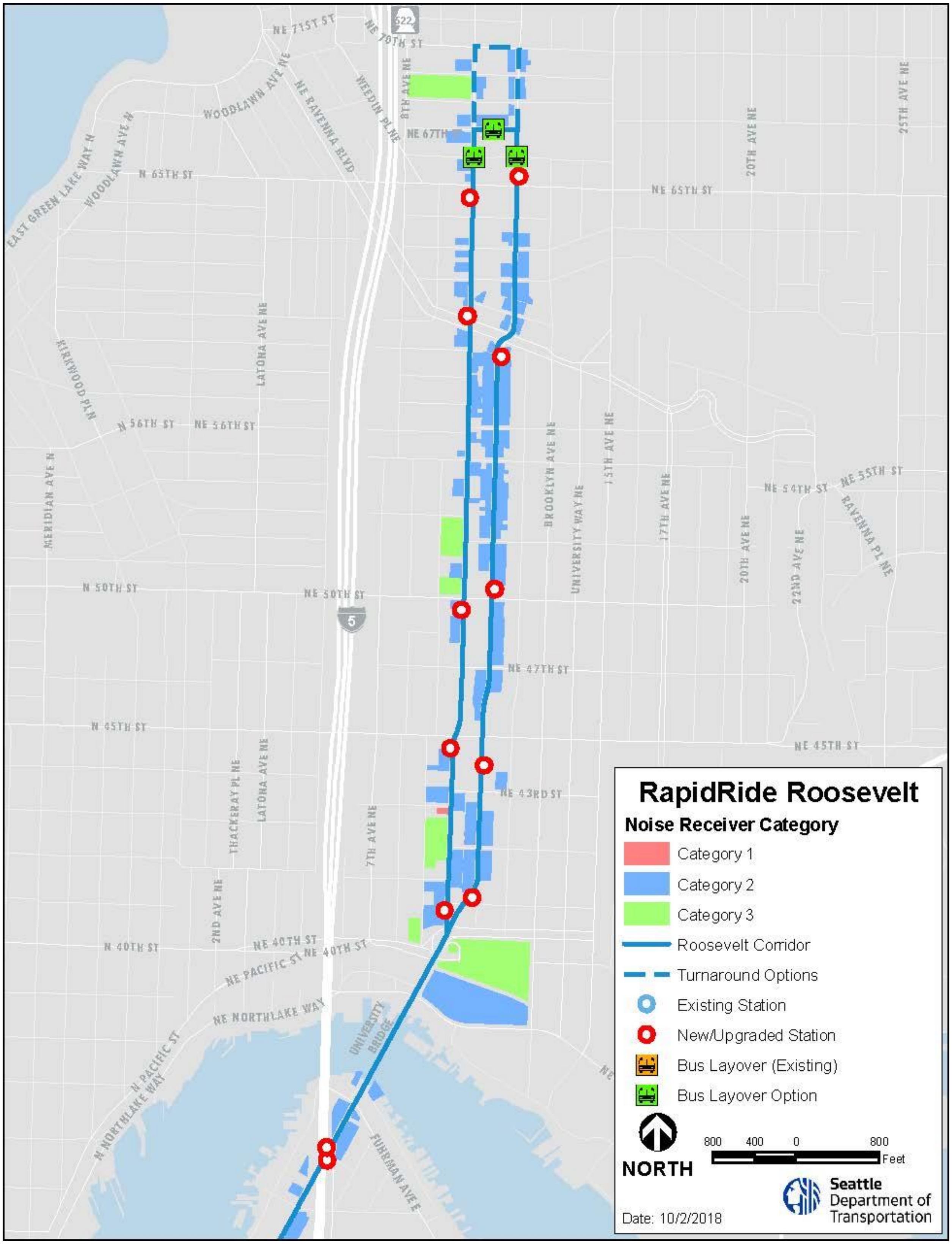

Figure 4-2 Noise-Sensitive Receptors - Roosevelt and University District

Figure 4-3 Noise-Sensitive Receptors – Eastlake

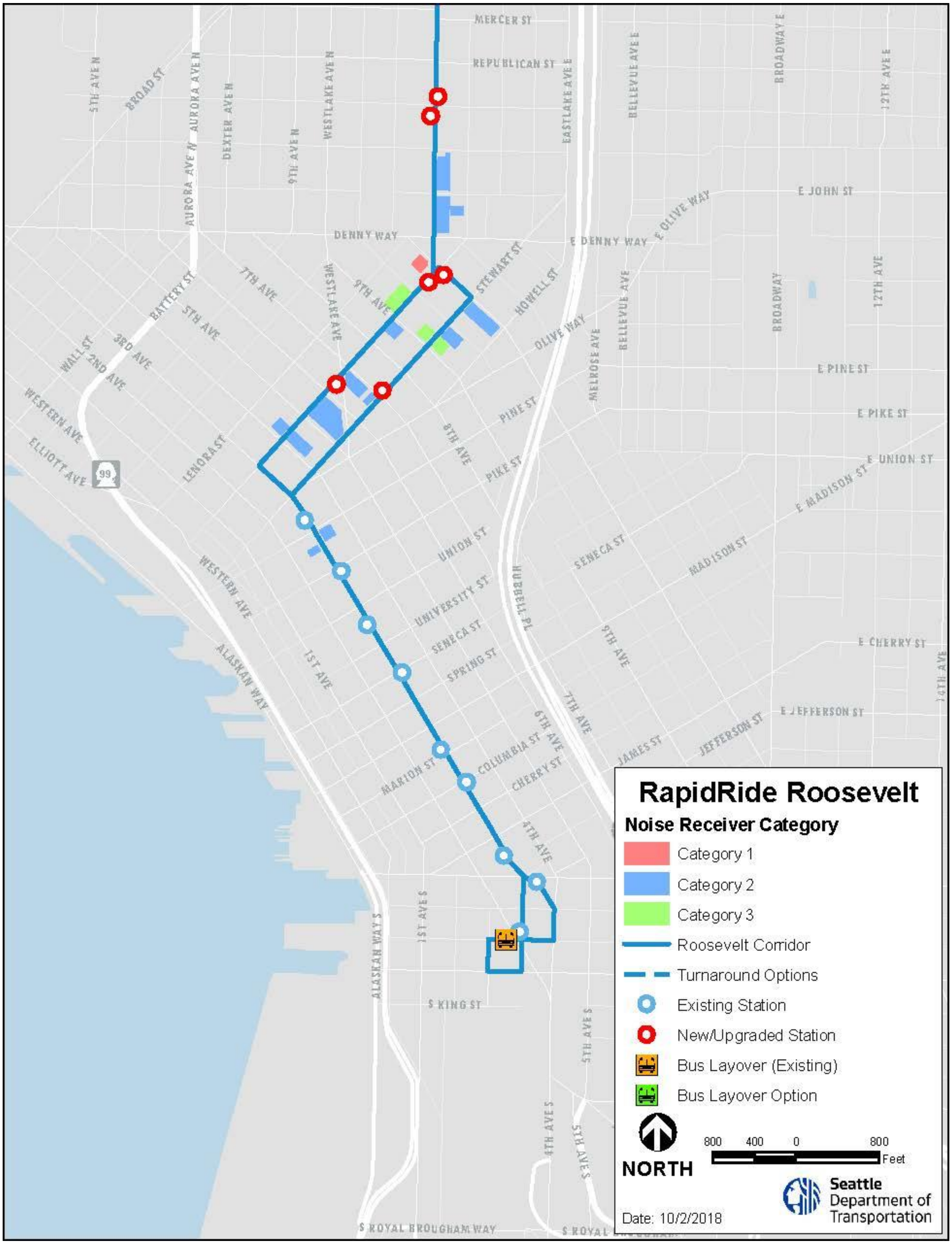

Figure 4-4 Noise-Sensitive Receptors – South Lake Union and Downtown

4.2 Vibration-Sensitive Receptors

A summary of vibration-sensitive receptors is shown in Table 4-2. Figures 4-5 to 4-7 show the locations of vibration-sensitive receptors in the study area. The majority of the vibration-sensitive receptors are Category 2. Refer to Appendix A, Noise and Vibration Sensitive Receptors, for information on the vibration-sensitive receptors in the study area.

Table 4-2 Vibration-Sensitive Receptor Summary

RECEPTOR CATEGORY	NUMBER
Category 1	7
Category 2	348
Category 3	91

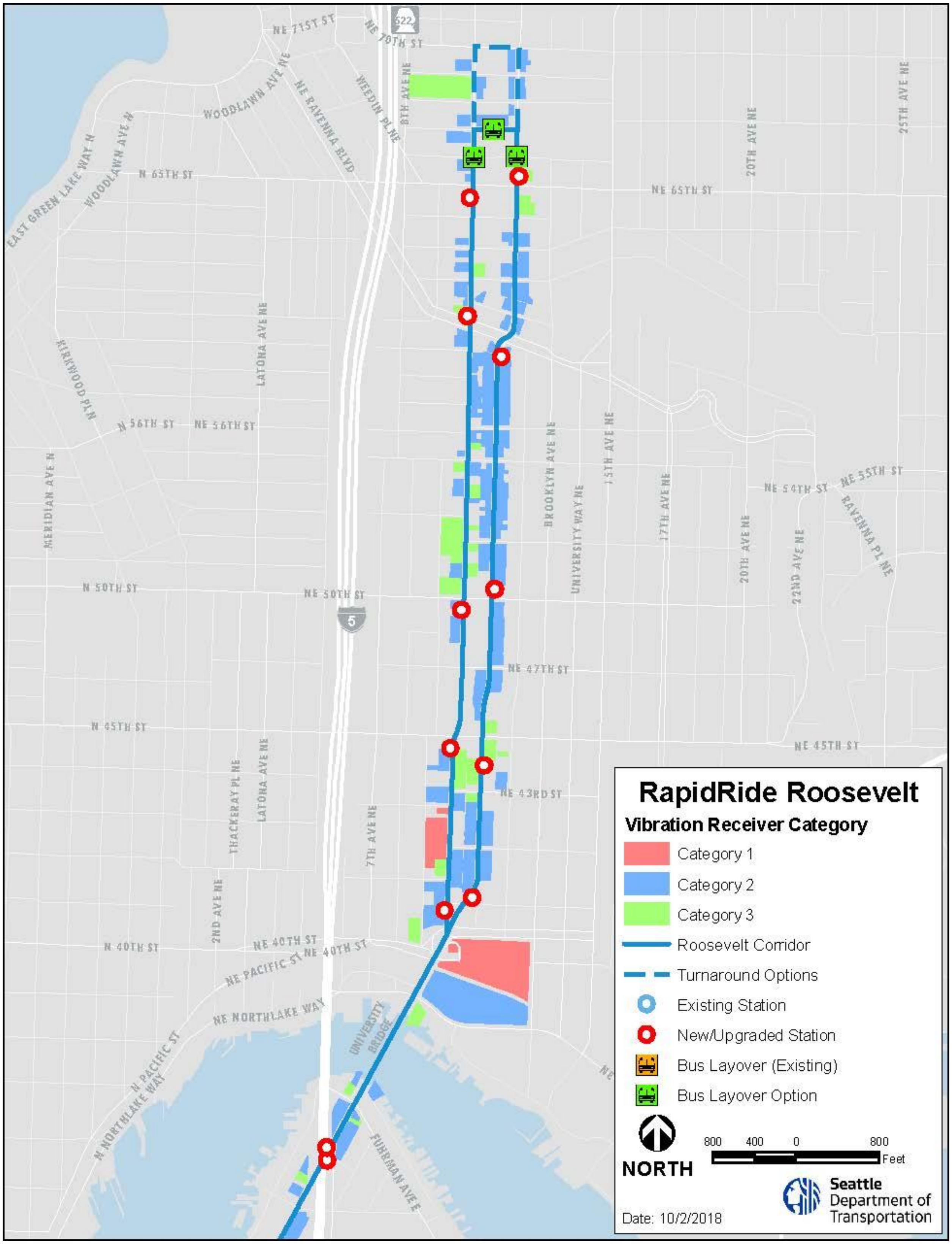

Figure 4-5 **Vibration-Sensitive Receptors - Roosevelt and University District**

Figure 4-6 **Vibration-Sensitive Receptors – Eastlake**

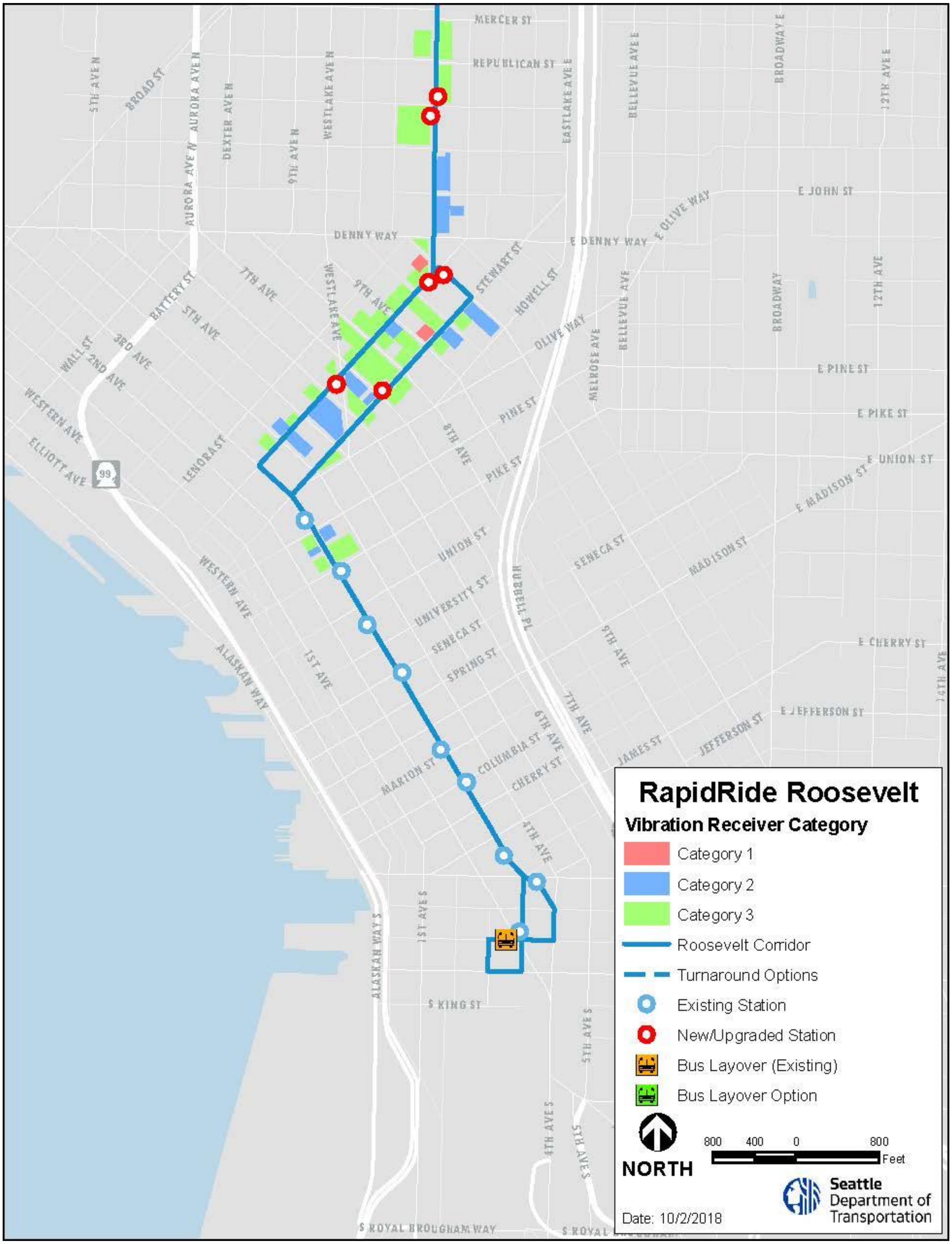

Figure 4-7 Vibration-Sensitive Receptors – South Lake Union and Downtown

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5. IMPACT ASSESSMENT

5.1 Operational Noise

Operational noise impacts were predicted by comparing the distance between noise-sensitive receptors and the RapidRide Roosevelt centerline with the noise impact contour distances calculated with the FTA Noise Impact Assessment Spreadsheet. These noise impact contour distances are shown in Table 5-1, as measured from the RapidRide Roosevelt centerline. Refer to Appendix D, FTA Noise Impact Spreadsheets, for information.

Table 5-1 Noise Impact Contour Distances

RECEPTOR CATEGORY	MODERATE (feet)	SEVERE (feet)
Category 1 (High Sensitivity)	5[b]	2[b]
Category 2 (Residential)	6[a]	3[a]
Category 3 (Daytime Use)	2[b]	1[b]

[a] Lowest measured L_{dn} was used to calculate impact distance.

[b] Lowest measured $L_{eq(h)}$ was used to calculate impact distance.

Comparison of the distance between receptors and the RapidRide Roosevelt centerline with the calculated impact distances was done utilizing Geographic Information System (GIS) software. Using the calculated noise impact contour distances, impact contours, extending from the RapidRide Roosevelt centerline were created in the GIS software. These contours spatially represent an area, extending from the RapidRide Roosevelt centerline where noise impacts occur. If a noise sensitive receptor overlapped or fell within its respective impact contour, the receptor was considered to be impacted. For example, using Table 5-1, if a Category 2 receptor was within 3 feet of the RapidRide Roosevelt centerline, it would be categorized as a Severe Impact. Each receptor along the project corridor was analyzed by this method. It was found that no noise-sensitive receptors illustrated in Figures 4-2 to 4-4 fell within their respective noise impact contour distance therefore no operational noise impacts are anticipated.

5.2 Operational Vibration

Using the input parameters in Table 3-5 potential vibration impact contour distances were calculated based on vibration criteria in Table 2-5. These potential vibration impact contour distances are presented in Table 5-2 and are used to identify potential vibration impacts from transit operations.

Table 5-2 Potential Vibration Impact Contour Distance

VIBRATION CATEGORY	POTENTIAL IMPACT DISTANCE (feet)
Category 1 (High Sensitivity)	32
Concert Halls	32
TV Studios	32
Recording Studios	32
Auditoriums	14
Theaters	14
Category 2 (Residential)	14
Category 3 (Daytime Use)	10

Similar to the operational noise impact analysis, potential operational vibration impacts were identified by comparing the distance between vibration-sensitive receptors and the RapidRide Roosevelt centerline with the potential vibration impact contour distances in Table 5-2. With the use of GIS software, impact contours were created extending from the RapidRide Roosevelt centerline. Potential vibration impacts were identified where vibration sensitive receptors are located within their respective vibration impact contour. Based on the analysis, there are seven locations with potential vibration impacts listed in Table 5-3 and shown in Figures 5-1 to 5-3.

Table 5-3 Receptors with Potential Vibration Impacts

VIBRATION RECEPTOR	KING COUNTY PARCEL	ADDRESS	DESCRIPTION	VIBRATION CATEGORY
VR-1	0660001215	1900 9th Ave	Life Sciences Children’s	1
VR-2	4088802925	1241 Eastlake Ave E	Zymogenetics	1
VR-3	1145000200	4225 Roosevelt Way NE	UW Medical Center	1
VR-4	1145000310	4245 Roosevelt Way NE	UW Medical Center	1
VR-5	1145000165	4261 Roosevelt Way NE	Jack Straw Recording Studio	1
VR-6	2208500000	2225 Eastlake Ave E	Eastlake Garden Court Condominiums	2
VR-7	5175100000	3242 Eastlake Ave E	Martello Condominiums	2

Figure 5-1 Potentially Impacted Vibration-Sensitive Receptors – Roosevelt and University District

Figure 5-2 Potentially Impacted Vibration-Sensitive Receptors – Eastlake

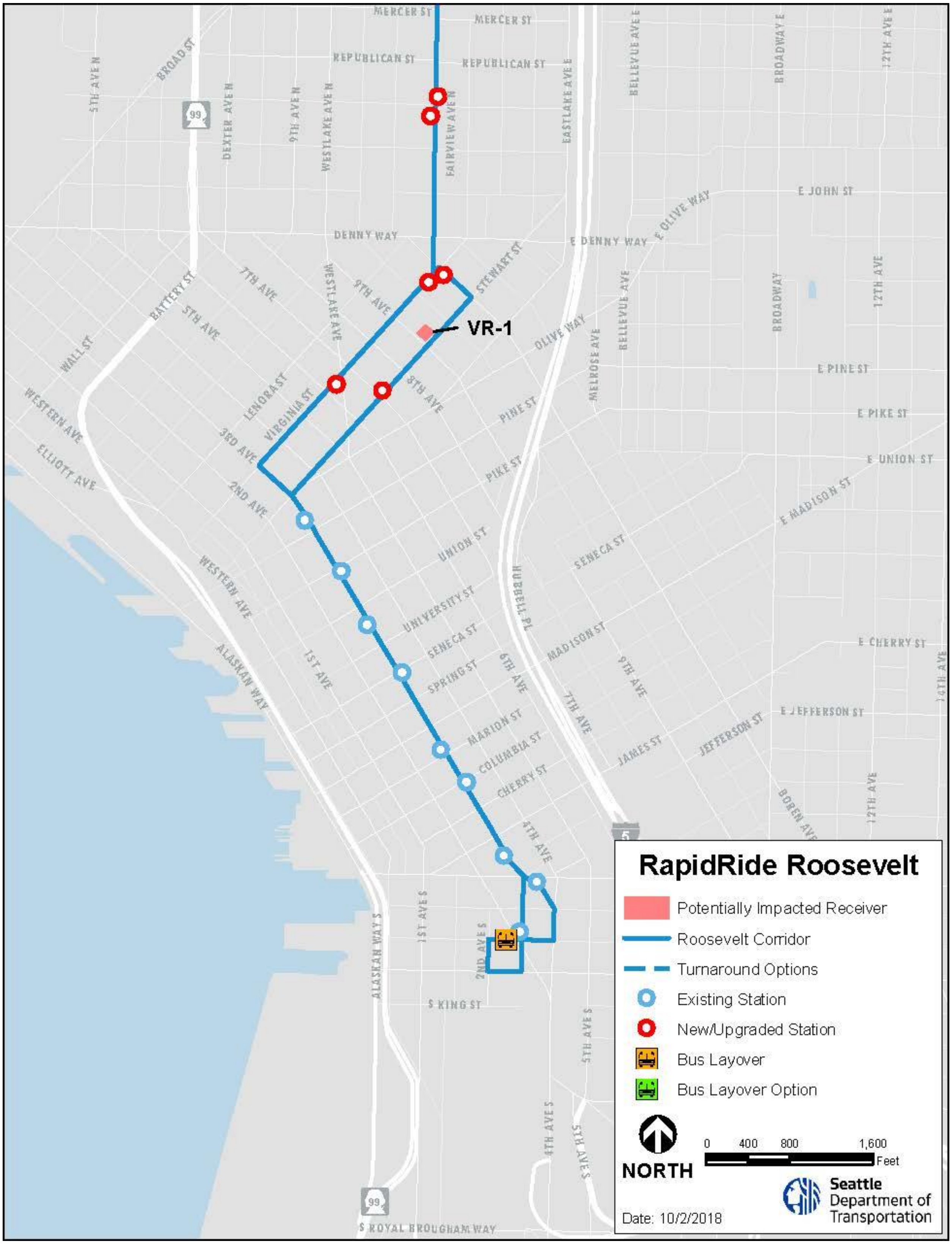

Figure 5-3 **Potentially Impacted Vibration-Sensitive Receptors – South Lake Union and Downtown**

Additional investigation of potential vibration impacts to sensitive receptors was performed following FTA Manual (Table 10-1). These adjustments are shown in Table 5-4 and account for decreases in vibration levels due to losses through a structure. This is between the ground, building foundations, and floors. There are also amplifications (increases) of vibration levels that occur within structures that must be accounted for, such as resonance of walls, floors, and ceilings.

Table 5-4 Vibration Receptor Adjustments

DESCRIPTION	VALUE
Ground to Building Foundation Coupling (Wood Framed Houses)	-5 dB
Ground to Building Foundation Coupling (1- to 2-story Masonry)	-7 dB
Ground to Building Foundation Coupling (3- to 4-story Masonry)	-10 dB
Ground to Building Foundation Coupling (Large Masonry on Piles)	-10 dB
Ground to Building Foundation Coupling (Large Masonry on Spread Footings)	-13 dB
Foundation in Rock	0 dB
Floor-to-Floor Attenuation (1 to 5 Floors Above Grade)	-2 dB / floor
Floor-to-Floor Attenuation (5 to 10 Floors Above Grade)	-1 dB / floor
Floor/Wall/Ceiling Resonances	+6 dB

Source: FTA Manual, Table 10-1

These adjustments were applied to the vibration levels calculated for potentially impacted sensitive receptors. The adjusted vibration levels were then compared to FTA vibration criteria to identify vibration impacts (Table 2-5). By applying these adjustments to the potentially impacted receptors, it was found that none of these receptors have predicted vibration levels that exceed the vibration impact criteria in Table 2-5 and therefore no impacts are anticipated. Receptor specific adjustments made to the potentially impacted receptors are shown in Table 5-5.

Table 5-5 Adjusted Levels for Receptors with Potential Impacts

VIBRATION RECEPTOR	ADJUSTMENTS	PREDICTED VIBRATION LEVEL PRE-ADJUSTMENT	PREDICTED VIBRATION LEVEL POST-ADJUSTMENT	PREDICTED IMPACT? (CRITERIA)
VR-1	• Coupling to Foundation (-10 dB) 3- to 4-story Masonry • Resonances (+6 dB)	67 VdB	63 VdB	None (65 VdB)
VR-2	• Coupling to Foundation (-10 dB) Large Masonry on Pile • Floor-to-Floor Attenuation (-4 dB) • Resonances (+6 dB)	71 VdB	63 VdB	None (65 VdB)
VR-3	• Coupling to Foundation (-10 dB) 3- to 4-story Masonry • Resonances (+6 dB)	66 VdB	62 VdB	None (65 VdB)

Table 5-5 Adjusted Levels for Receptors with Potential Impacts

VIBRATION RECEPTOR	ADJUSTMENTS	PREDICTED VIBRATION LEVEL PRE-ADJUSTMENT	PREDICTED VIBRATION LEVEL POST-ADJUSTMENT	PREDICTED IMPACT? (CRITERIA)
VR-4	• Coupling to Foundation (-10 dB) 3- to 4-story Masonry • Resonances (+6 dB)	66 VdB	62 VdB	None (65 VdB)
VR-5	• Coupling to Foundation (-10 dB) 3- to 4-story Masonry • Resonances (+6 dB)	65 VdB	61 VdB	None (65 VdB)
VR-6	• Coupling to Foundation (-10 dB) 3- to 4-story Masonry • Resonances (+6 dB)	73 VdB	69 VdB	None (72 VdB)
VR-7	• Coupling to Foundation (-5 dB) Wood Framed • Floor-to-Floor Attenuation (-2 dB) • Resonances (+6 dB)	72 VdB	71 VdB	None (72 VdB)

5.3 Construction Noise

The project is expected to include the following construction activities: shallow excavation (up to 5 feet) for stations and utility relocation, installation of OCS poles (approximately 15 feet), and roadwork including mill and overlay along 11th Ave NE and 12th Ave NE from the University Bridge to NE 67th St and paving on Eastlake Ave E between Fairview Ave and Harvard Ave E. Table 5-6 shows anticipated loudest sound levels from these construction activities.

Table 5-6 General Assessment of Construction Noise (dBA)

EQUIPMENT	REFERENCE SOUND LEVEL AT 50 FEET	USAGE FACTOR	ADJUSTED SOUND LEVEL AT 50 FEET
STATION AND OCS POLE INSTALLATION			
Concrete Mixer	85	1[a]	85
Truck	88	1[a]	88
		Total[b]	90
ROADWAY			
Paver	89	1[a]	89
Scraper	89	1[a]	89
		Total[b]	92

Source: FTA Manual, Section 12.1.1 and Table 12-1

[a] General Assessment assumes equipment runs continuously, which is a usage factor of 1.

[b] Adjusted sound levels are based on a logarithmic sum. The logarithmic sum is used with decibels and the sound levels are not added together.

5.3.1 FTA Criteria

Construction activities at the stations and for OCS installation is not anticipated to exceed daytime FTA construction impact criteria but would exceed nighttime FTA criteria at residential receptors (Table 5-7). Roadway construction would exceed daytime and nighttime FTA criteria at residential receptors but not at commercial receptors (Table 5-7).

Table 5-7 Construction Noise Impacts (dBA)

PREDICTED SOUND LEVEL AT 50 FEET	FTA RESIDENTIAL CRITERIA (DAY/NIGHT)[a]	FTA COMMERCIAL CRITERIA	SMC RESIDENTIAL SOUND-LEVEL LIMIT	SMC COMMERCIAL SOUND-LEVEL LIMIT	PREDICTED IMPACTS
STATION AND OCS POLE INSTALLATION					
90	90 / 80	100	82 / 47	85 / 60	Yes
ROADWAY					
92	90 / 80	100	82 / 47	85 / 60	Yes

[a] FTA nighttime criteria is 10 dB less than the daytime criteria.

5.3.2 City of Seattle Criteria

The predicted sound levels are expected to exceed City of Seattle daytime and nighttime sound-level limits for construction based on Table 2-3. However, the FTA General Assessment for Construction Noise used to determine the predicted impacts in Table 5-7 is generally conservative. With mitigation, construction activities are likely to satisfy SMC daytime sound level limits and thereby satisfy FTA criteria. If SMC sound level limits are not satisfied, it will be necessary to obtain a noise variance (SMC 25.08.655). If nighttime work is anticipated, a noise variance will also need to be obtained from the City of Seattle. When construction activities occur 50 or more feet from buildings, sound-level limits inside buildings located on commercial zoned properties are typically satisfied. However, when work occurs closer, noise control measures may be required to satisfy interior sound-level limits.

5.4 Construction Vibration

The FTA Manual defines reference vibration levels for construction equipment that may cause high vibration levels. Table 5-8 provides a summary of vibration levels for equipment anticipated to be used during construction based on the construction activities anticipated for the project.

Table 5-8 Construction Vibration Levels at 25 feet

EQUIPMENT	PPV (IN/SEC)	L_v
Vibratory Roller	0.210	94
Large Bulldozer	0.089	87
Loaded Truck	0.076	86
Jackhammer	0.035	79

Source: FTA Manual, Table 12-2

5.4.1 Building Damage

Overall, building damage is not anticipated through the corridor, because the construction equipment used is not expected to produce high vibration levels. However, paving between the University Bridge and NE 67th St along 11th Ave NE and 12th Ave NE, and on Eastlake Ave E between Fairview Ave and Harvard Ave E has the potential to cause cosmetic building damage (i.e., cracked plaster) to 130 buildings, which includes historic buildings. Distances where predicted vibration levels equal the building damage impact criteria are listed in Table 5-9. Appendix A identifies the 130 buildings and most of these are located on 11th Ave NE and consist of single family residences.

The potential impacts are the result of the compaction methods associated with paving, which have the potential to produce high vibration levels. Vibratory compaction within 26 feet of a structure has the potential to cause cosmetic building damage because of large vibratory rollers used during paving. These impacts would be minimized or avoided through the implementation of mitigation measures identified in Section 6.3, Construction Vibration Mitigation.

Table 5-9 Construction Vibration Building Damage Impact Distance

EQUIPMENT	BUILDING CATEGORY[a] (FEET)			
	I	II	III	IV
Vibratory Roller	14	20	26	36
Large Bulldozer	8	11	15	20
Loaded Truck	7	10	13	18
Jackhammer	4	6	8	11

[a] Building Category defined in Table 2-6

5.4.2 Annoyance

Construction would occur for up to 24 months and would be phased such that any individual area would not be affected for the entire construction period. Vibration velocity levels were calculated using methodologies outlined in Section 12.2.1 of the FTA Manual to determine impact screening for building annoyance. Based on the results of the analysis (Table 5-10) nearly all receptors between the University Bridge and NE 67th St along 11th Ave NE and 12th Ave NE, and on Eastlake Ave E between Fairview Ave and Harvard Ave E, may experience annoyance due to vibration from compaction during paving. Additionally, receptors near OCS pole and station locations are predicted to experience annoyance due to vibration during certain construction activities including jack hammering and concrete sawing.

Table 5-10 Construction Vibration Annoyance Impact Distances

EQUIPMENT	RECEPTOR CATEGORY (FEET)		
	1	2	3
Vibratory Roller	232	135	107
Large Bulldozer	135	79	63
Loaded Truck	125	73	58
Jackhammer	73	43	34

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6. MITIGATION

6.1 Operational Noise and Vibration

There would be no noise or vibration impacts during operation of the RapidRide Roosevelt project; therefore, no mitigation is required.

6.2 Construction Noise Mitigation

By meeting City of Seattle noise regulations in SMC 25.08, FTA criteria would also be satisfied. It is recommended that the contractor prepare a Construction Noise Control Plan to assess potential noise control strategies based on actual means and methods. Such measures could include the following:

- Maintain 1-foot-thick layer of muck or dirt in the bottom of haul truck beds.
- Use only ambient-sensing broadband back-up alarms and minimize backing.
- Limit engine idling to 5 minutes or less.
- Use radios for long-range communication; only use raised voices and public address systems in an emergency.
- Use upgraded engine exhaust mufflers, engine shrouds, or sound enclosures on noisier equipment.
- Install portable sound barrier around noisier equipment.
- Use electric and hydraulic equipment in lieu of diesel or pneumatic equipment.
- Develop noise limits, address complaints, and monitor noise levels during construction.

If required, nighttime noise will require a Noise Variance from the Seattle Department of Construction and Inspections.

6.3 Construction Vibration Mitigation

To minimize annoyance from construction vibration, the contractor will prepare a Construction Vibration Control Plan to assess potential vibration control strategies based on actual means and methods. Such measures could include the following:

- Phase vibration-producing activities so they do not occur simultaneously.
- Schedule vibration-producing activities outside time periods to least annoy users most sensitive to vibration, as feasible. For example, execute vibration-producing work near residential buildings during daytime hours and commercial buildings during nighttime hours.
- Minimize the use of impact tools such as hoe rams and jackhammers; use lower-vibration equipment such as concrete saws for demolishing existing pavement.

- Use lower power settings on vibratory rollers or large static rollers, especially near buildings with plaster or within 26 feet of a structure.
- Establish vibration limits, implement a vibration monitoring program, and address vibration-related complaints during construction.
- Implement vibration monitoring at buildings with masonry or high susceptibility to damage (identified in Appendix A) from vibration based on the criteria identified in Table 5-9.

7. REFERENCES

Federal Transit Administration (FTA). 2006. *Transit Noise and Vibration Impact Assessment*. May.

Federal Transit Administration (FTA). 2018. *Noise and Vibration Impact Assessment Guidance Manual.* September.

HMMH. 2007. *Federal Transit Administration Noise Impact Assessment Spreadsheet.* July 2007.

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Washington State Department of Natural Resources. *Subsurface Geology Information System:* https://geologyportal.dnr.wa.gov/#subsurface. Accessed January 2018.

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Appendix A
Noise and Vibration Sensitive Receptors

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Table A-1 Receptor Inventory

King County Parcel Number	Address	Noise Category	Vibration Category
069000045	***5514 11TH AVE NE***	***2***	***2***
0659000255	-	-	3
0659000265	1835 8TH AVE	-	3
0659000350	601 STEWART ST	-	3
0659000355	1825 7TH AVE	-	-
0659000380	500 OLIVE WAY	-	-
0659000381	1801 WESTLAKE AVE	-	-
0659000385	414 OLIVE WAY	-	3
0659000400	410 STEWART ST	-	-
0659000430	1927 5TH AVE	-	-
0659000475	1900 5TH AVE	2	2
0659000555	600 STEWART ST	-	3
0659000600	1950 6TH AVE	-	-
0659000610	1942 WESTLAKE AVE	2	2
0659000640	620 STEWART ST	2	2
0659000645	722 STEWART ST	-	-
0659000650	1906 7TH AVE	-	3
0659000675	711 VIRGINIA ST	-	3
0659000685	1921 8TH AVE	-	3
0659000710	700 VIRGINIA ST	-	3
0659000750	2001 8TH AVE	-	3
0660001530	1001 VIRGINIA ST	-	-
0659000775	2000 6TH AVE	-	-
0659000880	2001 WESTLAKE AVE	-	3
0659000890	2000 5TH AVE	-	-
0659000950	2001 6TH AVE	-	3
0659001020	2005 5TH AVE	-	3
0660000560	810 VIRGINIA ST	-	3
0660000625	800 STEWART ST	-	3
0660000650	801 VIRGINIA ST	-	3
0660000708	808 HOWELL ST	-	-
0660001170	1823 TERRY AVE	2	2
0660001215	1900 9TH AVE	3	1
0660001240	1932 9TH AVE	-	-
0660001255	1915 TERRY AVE	-	3
0660001280	2000 9TH AVE	3	3
0660001365	914 VIRGINIA ST	3	3
0660001370	922 VIRGINIA ST	3	3
0660001445	1000 VIRGINIA ST	-	3
0660001490	2015 BOREN AVE	1	1
0660001505	1020 VIRGINIA ST	-	3
0660001510	1024 STEWART ST	-	-
0660001512	1906 TERRY AVE	-	-
1142000450	1120 NE 43RD ST	2	2

Note: Bold and italic receptors indicate potential for building damage due to construction vibration.

Table A-1 Receptor Inventory

King County Parcel Number	Address	Noise Category	Vibration Category
0660001605	1005 STEWART ST	-	3
0660002155	1900 BOREN AVE	-	-
0660002170	1916 BOREN AVE	-	-
0660002190	1930 BOREN AVE	-	-
0660002230	1100 VIRGINIA ST	-	-
0660002245	2022 BOREN AVE	-	3
0825049005	***5513 11TH AVE NE***	***2***	***2***
0825049026	5500 ROOSEVELT WAY NE	-	-
0825049028	5508 ROOSEVELT WAY NE	-	3
0825049029	5512 ROOSEVELT WAY NE	-	3
0825049041	5009 ROOSEVELT WAY NE	3	3
0825049050	4508 ROOSEVELT WAY NE	-	-
0825049062	916 NE RAVENNA BLVD	-	3
0825049066	4518 ROOSEVELT WAY NE	-	-
0825049072	***5507 11TH AVE NE***	***2***	***2***
0825049074	***1102 NE 55TH ST***	***2***	***2***
0825049093	***5501 11TH AVE NE***	***2***	***2***
1142000400	1121 NE 45TH ST	-	-
1142000415	4333 12TH AVE NE	-	3
1142000425	***4317 12TH AVE NE***	***-***	***-***
1142000445	4311 12TH AVE NE	2	2
1142000860	***4214 11TH AVE NE***	***2***	***2***
1142000500	***1107 NE 45TH ST***	***-***	***3***
1142000525	1013 NE 45TH ST	-	-
1142000530	***4311 11TH AVE NE***	***-***	***3***
1142000550	4300 ROOSEVELT WAY NE	-	3
1142000575	***4307 11TH AVE NE***	***-***	***3***
1142000580	1023 NE 43RD ST	-	-
1142000630	4336 ROOSEVELT WAY NE	-	-
1142000645	***4241 11TH AVE NE***	***-***	***3***
1142000655	***4237 11TH AVE NE***	***2***	***2***
1142000660	4235 11TH AVE NE	2	2
1142000665	4229 11TH AVE NE	2	2
1142000670	***4225 11TH AVE NE***	***2***	***2***
1142000690	4211 11TH AVE NE	2	2
1142000695	4207 11TH AVE NE	2	2
1142000700	1012 NE 42ND ST	2	2
1142000710	4212 ROOSEVELT WAY NE	-	-
1142000725	4212 ROOSEVELT WAY NE	-	-
1142000735	-	-	-
1142000740	-	-	-
1142000745	-	-	-
1142000755	4242 ROOSEVELT WAY NE	2	2
1145000165	4261 ROOSEVELT WAY NE	1	1

Note: Bold and italic receptors indicate potential for building damage due to construction vibration.

Table A-1 Receptor Inventory

King County Parcel Number	Address	Noise Category	Vibration Category
1142000875	***4226 11TH AVE NE***	***2***	***2***
1142000880	4230 11TH AVE NE	2	2
1142000885	4232 11TH AVE NE	-	-
1142000890	***4236 11TH AVE NE***	***-***	***-***
1142000900	-	-	-
1142001680	1100 NE CAMPUS PKWY	-	-
1142001725	***4120 11TH AVE NE***	***2***	***2***
1142001740	4134 11TH AVE NE	2	2
1142001760	4144 11TH AVE NE	2	2
1142001770	***4145 11TH AVE NE***	***2***	***2***
1142001780	4131 11TH AVE NE	2	2
1142001810	4111 11TH AVE NE	2	2
1142001815	-	-	-
1142001825	4100 ROOSEVELT WAY NE	-	-
1142001835	4110 ROOSEVELT WAY NE	-	-
1142001871	4140 ROOSEVELT WAY NE	2	2
1142001950	1010 NE COWLITZ RD	3	1
1142002970	1112 NE PACIFIC ST	2	2
1145000005	4359 ROOSEVELT WAY NE	-	-
1145000050	-	-	-
1145000070	4305 ROOSEVELT WAY NE	2	2
1797500485	6202 12TH AVE NE	2	2
1145000166		-	-
1145000200	4225 ROOSEVELT WAY NE	3	1
1145000231	4201 ROOSEVELT WAY NE	-	3
1145000310	4245 ROOSEVELT WAY NE	3	1
1145000325	4115 ROOSEVELT WAY NE	2	2
1145000365	4041 ROOSEVELT WAY NE	2	2
1419730000	2220 EASTLAKE AVE E	2	2
1604500000	2000 FOURTH AVE	2	2
1659500040	5517 ROOSEVELT WAY NE	-	-
1659500045	5503 ROOSEVELT WAY NE	2	2
1659500050	5507 ROOSEVELT WAY NE	-	-
1725049001	-	-	-
172504UNKN	-	-	-
1766000000	819 VIRGINIA ST	2	2
1797500410	***6102 12TH AVE NE***	***2***	***2***
1797500411	***6106 12TH AVE NE***	***2***	***2***
1797500420	6114 12TH AVE NE	2	2
1797500421	6112 12TH AVE NE	2	2
1797500425	6118 12TH AVE NE	2	2
1797500435	6120 12TH AVE NE	2	2
1797500440	***6126 12TH AVE NE***	***2***	***2***
1797500870	***6211 12TH AVE NE***	***2***	***2***

Note: Bold and italic receptors indicate potential for building damage due to construction vibration.

Table A-1 Receptor Inventory

King County Parcel Number	Address	Noise Category	Vibration Category
1797500490	***6204 12TH AVE NE***	***2***	***2***
1797500495	6210 12TH AVE NE	2	2
1797500500	***6212 12TH AVE NE***	***2***	***2***
1797500505	***6218 12TH AVE NE***	***2***	***2***
1797500510	***6222 12TH AVE NE***	***2***	***2***
1797500555	***6302 12TH AVE NE***	***2***	***2***
1797500560	***6306 12TH AVE NE***	***2***	***2***
1797500565	6310 12TH AVE NE	2	2
1797500580	-	-	-
1797500625	***1200 NE 64TH ST***	***-***	***3***
1797500646	***1201 NE 65TH ST***	***-***	***-***
1797500715	***1027 NE 65TH ST***	***-***	***-***
1797500755	-	-	-
1797500770	***6309 12TH AVE NE***	***2***	***2***
1797500775	***6307 12TH AVE NE***	***2***	***2***
1797500778	1036 NE 63RD ST	2	2
1797500805	6300 ROOSEVELT WAY NE	-	-
1797500810	6304 ROOSEVELT WAY NE	-	-
1797500815	6308 ROOSEVELT WAY NE	-	-
1797500830	6322 ROOSEVELT WAY NE	-	-
1797500855	1023 NE 63RD ST	-	-
1797501116		2	2
1797500875	***6207 12TH AVE NE***	***2***	***2***
1797500880	***1032 NE 62ND ST***	***2***	***2***
1797500905	6206 ROOSEVELT WAY NE	-	3
1797500925	6220 ROOSEVELT WAY NE	-	-
1797500955	1029 NE 62ND ST	2	2
1797500960	6121 12TH AVE NE	2	2
1797500965	6117 12TH AVE NE	2	2
1797500975	***6101 12TH AVE NE***	***2***	***2***
1797500976	***6107 12TH AVE NE***	***2***	***2***
1797501010	1004 NE 61ST ST	2	2
1797501015	6100 ROOSEVELT WAY NE	-	-
1797501055	1021 NE RAVENNA BLVD	2	2
1797501075	5908 ROOSEVELT WAY NE	-	-
1797501080	5828 ROOSEVELT WAY NE	-	-
1797501085	5818 ROOSEVELT WAY NE	2	2
1797501090	5814 ROOSEVELT WAY NE	2	2
1797501095	5810 ROOSEVELT WAY NE	2	2
1797501100	5806 B ROOSEVELT WAY NE	2	2
1797501101	5806 A ROOSEVELT WAY NE	2	2
1797501104	5802 ROOSEVELT WAY NE	2	2
1797501115	5720 ROOSEVELT WAY NE	2	2
1797501235	***5632 11TH AVE NE***	***2***	***2***

Note: Bold and italic receptors indicate potential for building damage due to construction vibration.

Table A-1 Receptor Inventory

King County Parcel Number	Address	Noise Category	Vibration Category
1797501117	5724 ROOSEVELT WAY NE	2	2
1797501119	5716 ROOSEVELT WAY NE	2	2
1797501120	-	2	2
1797501125	5712 ROOSEVELT WAY NE	2	2
1797501130	5635 11TH AVE NE	2	2
1797501135	5637 11TH AVE NE	2	2
1797501140	5641 11TH AVE NE	2	2
1797501145	5645 11TH AVE NE	2	2
1797501146	5649 11TH AVE NE	2	2
1797501155	5653 11TH AVE NE	2	2
1797501160	5657 11TH AVE NE	2	2
1797501165	5663 11TH AVE NE	2	2
1797501170	5665 11TH AVE NE	2	2
1797501190	1107 NE RAVENNA BLVD	2	2
1797501200	***5660 11TH AVE NE***	***2***	***2***
1797501205	***5656 11TH AVE NE***	***2***	***2***
1797501210	***5654 11TH AVE NE***	***2***	***2***
1797501215	***5650 11TH AVE NE***	***2***	***2***
1797501220	***5646 11TH AVE NE***	***2***	***2***
1797501225	5642 11TH AVE NE	2	2
1797501230	***5638 11TH AVE NE***	***2***	***2***
1959700105	2624 EASTLAKE AVE E	2	2
1798000005	***1205 NE 61ST ST***	***2***	***2***
1798000075	***5902 12TH AVE NE***	***2***	***2***
1798000080	6000 ROOSEVELT WAY NE	-	-
1798000121	***1028 NE RAVENNA BLVD***	***2***	***2***
1798000125	***1035 NE 61ST ST***	***2***	***2***
1928300940	5901 ROOSEVELT WAY NE	2	2
1928301020	5821 ROOSEVELT WAY NE	-	-
1928301075	5809 ROOSEVELT WAY NE	-	-
1928301085	5615 ROOSEVELT WAY NE	-	-
1959700007	-	2	2
1959700008	-	2	2
1959700010	2516 EASTLAKE AVE E	-	-
1959700015	2501 EASTLAKE AVE E	-	-
1959700023	2517 EASTLAKE AVE E	-	3
1959700040	***2523 EASTLAKE AVE E***	***2***	***2***
1959700050	***112 1/2 E ROANOKE ST***	***2***	***2***
1959700070	***2621 EASTLAKE AVE E***	***-***	***-***
1959700075	***2633 EASTLAKE AVE E***	***-***	***3***
1959700090	207 E EDGAR ST	-	3
1959700095	2632 EASTLAKE AVE E	2	2
1959700100	2626 EASTLAKE AVE E	2	2
1959702620	2900 EASTLAKE AVE E	-	3

Note: Bold and italic receptors indicate potential for building damage due to construction vibration.

Table A-1 Receptor Inventory

King County Parcel Number	Address	Noise Category	Vibration Category
1959700115	2608 EASTLAKE AVE E	2	2
1959700120	2600 EASTLAKE AVE E	2	2
1959701170	***2722 EASTLAKE AVE E***	***-***	***-***
1959701180	-	-	-
1959701185	2718 EASTLAKE AVE E	2	2
1959701195	***2704 EASTLAKE AVE E***	***2***	***2***
1959701250	-	-	-
1959701260	2713 EASTLAKE AVE E	-	3
1959701265	2717 EASTLAKE AVE E	-	3
1959701270	2727 EASTLAKE AVE E	2	2
1959701285	2815 EASTLAKE AVE E	-	3
1959701300	2825 EASTLAKE AVE E	-	3
1959701320	2833 EASTLAKE AVE E	2	2
1959701325	2835 EASTLAKE AVE E	2	2
1959701330	2851 EASTLAKE AVE E	2	2
1959701355	***2852 EASTLAKE AVE E***	***2***	***2***
1959701365	2840 EASTLAKE AVE E	2	2
1959701376	2828 EASTLAKE AVE E	2	2
1959701390	2822 EASTLAKE AVE E	2	2
1959701395	2820 EASTLAKE AVE E	2	2
1977200980	1601 THIRD AVE	-	-
1977201070	1907 THIRD AVE	-	-
1959702695	-	-	-
1959702705	-	-	-
1959702715	2921 EASTLAKE AVE E	-	-
1959702735	2947 EASTLAKE AVE E	-	-
1959702740	***3101 EASTLAKE AVE E***	***-***	***-***
1959702745	***3107 EASTLAKE AVE E***	***2***	***2***
1959702760	***3119 EASTLAKE AVE E***	***-***	***-***
1959702765	3125 EASTLAKE AVE E	2	2
1959702770	3123 EASTLAKE AVE E	-	3
1959702820	-	-	-
1959702937	3120 HARVARD AVE E	-	-
1959703000	3272 FUHRMAN AVE E	-	-
1959703120	3240 EASTLAKE AVE E	-	3
1959703130	3230 EASTLAKE AVE E	2	2
1959703145	3218 EASTLAKE AVE E	2	2
1959703150	-	2	2
1959703155	3206 HARVARD AVE E	2	2
1959703260	3245 EASTLAKE AVE E	2	2
1959703265	3302 FUHRMAN AVE E	-	3
1970200044	3304 FUHRMAN AVE E	2	2
1984200035	700 FAIRVIEW AVE N	-	-
1984200065	800 FAIRVIEW AVE N	2	2

Note: Bold and italic receptors indicate potential for building damage due to construction vibration.

Table A-1 Receptor Inventory

King County Parcel Number	Address	Noise Category	Vibration Category
1977201245	316 VIRGINIA ST	-	3
1977201255	300 VIRGINIA ST	-	-
1977201260	301 VIRGINIA ST	-	-
1977201280	1916 THIRD AVE	-	-
1977201295	1908 THIRD AVE	-	-
1977201315	1904 THIRD AVE	-	-
1983200425	1114 VALLEY ST	-	-
1983200450	809 FAIRVIEW PL N	-	-
1983200475	-	-	-
1983200480	-	-	-
1983200485	-	-	-
1983200495	-	-	-
1983200535	529 FAIRVIEW AVE N	-	-
1983200540	527 FAIRVIEW AVE N	-	-
1983200545	509 FAIRVIEW AVE N	-	3
1983200560	501 FAIRVIEW AVE N	-	3
1983200605	429 FAIRVIEW AVE N	-	-
2163900955	1165 EASTLAKE AVE E	-	-
2208000000	2017 EASTLAKE AVE E	2	2
2208500000	***2225 EASTLAKE AVE E***	***2***	***2***
2208800000	2245 EASTLAKE AVE E	2	2
2285050000	818 STEWART ST	-	3
1984200105	1000 FAIRVIEW AVE N	-	-
1984200135	900 FAIRVIEW AVE N	-	3
1984200160	-	-	3
1984200455	1100 FAIRVIEW AVE N	-	3
1986200525	1120 JOHN ST	-	-
2025049036	1925 EASTLAKE AVE E	2	2
2025049037	1901 EASTLAKE AVE E	2	2
2025049038	-	2	2
2025049039	-	2	2
2025049124	1917 EASTLAKE AVE E	2	2
2025049131	1916 EASTLAKE AVE E	-	3
2107700162	1500 EASTLAKE AVE E	-	3
2107700190	***1536 EASTLAKE AVE E***	***-***	***3***
2107700195	1540 EASTLAKE AVE E	2	2
2107700210	1551 EASTLAKE AVE E	-	3
2107700260	1500 FAIRVIEW AVE E	-	-
2154600000	2044 EASTLAKE AVE E	2	2
2748000000	911 STEWART ST	3	3
2862100550	5301 ROOSEVELT WAY NE	-	-
2862100560	5315 ROOSEVELT WAY NE	-	-
2862100570	5317 ROOSEVELT WAY NE	2	2
2862100575	5321 ROOSEVELT WAY NE	2	2

Note: Bold and italic receptors indicate potential for building damage due to construction vibration.

Table A-1 Receptor Inventory

King County Parcel Number	Address	Noise Category	Vibration Category
2289900000	***4204 11TH AVE NE***	***2***	***2***
2366500000	1520 EASTLAKE AVE E	2	2
2382000000	1920 FOURTH AVE	2	2
2467400005	234 FAIRVIEW AVE N	-	-
2467400006	230 FAIRVIEW AVE N	2	2
2467400015	222 FAIRVIEW AVE N	2	2
2467400065	318 FAIRVIEW AVE N	-	-
2467400073	-	-	-
2467400080	312 FAIRVIEW AVE N	-	-
2467400085	306 FAIRVIEW AVE N	-	-
2467400090	300 FAIRVIEW AVE N	-	-
2467400120	400 FAIRVIEW AVE N	-	3
2468400005	-	2	2
2468400025	116 FAIRVIEW AVE N	2	2
2693100068	107 FAIRVIEW AVE N	-	-
2902200142	2028 A EASTLAKE AVE E	2	2
2902200145	2020 EASTLAKE AVE E	2	2
2902200161	2002 EASTLAKE AVE E	2	2
2902200165	***2001 EASTLAKE AVE E***	***2***	***2***
2902200170	***2007 EASTLAKE AVE E***	***2***	***2***
2902200181	2023 EASTLAKE AVE E	2	2

King County Parcel Number	Address	Noise Category	Vibration Category
2862100580	5325 ROOSEVELT WAY NE	2	2
2862100585	5329 ROOSEVELT WAY NE	2	2
2862100590	5333 ROOSEVELT WAY NE	-	-
2862100600	5339 ROOSEVELT WAY NE	-	3
2862100610	5040 9TH AVE NE	3	3
2862100695	5029 ROOSEVELT WAY NE	-	3
2869600080	219 E GALER ST	-	3
2869600135	-	-	-
2902200129	2042 C EASTLAKE AVE E	2	2
2902200130	2042 B EASTLAKE AVE E	2	2
2902200131	2042 A EASTLAKE AVE E	2	2
2902200133	2038 EASTLAKE AVE E	2	2
2902200135	2034 C EASTLAKE AVE E	2	2
2902200136	2034 B EASTLAKE AVE E	2	2
2902200137	2034 A EASTLAKE AVE E	2	2
2902200141	2028 B EASTLAKE AVE E	2	2
2902200955	-	-	-
2902200965	2334 EASTLAKE AVE E	-	-
2902200970	2324 EASTLAKE AVE E	-	3
2902200975	***2312 EASTLAKE AVE E***	***-***	***3***
2902200980	2300 EASTLAKE AVE E	-	2
2902200990	***2301 EASTLAKE AVE E***	***-***	***-***

Note: Bold and italic receptors indicate potential for building damage due to construction vibration.

Table A-1 Receptor Inventory

King County Parcel Number	Address	Noise Category	Vibration Category
2902200185	***2027 EASTLAKE AVE E***	***2***	***2***
2902200186	2031 EASTLAKE AVE E	2	2
2902200205	***2045 EASTLAKE AVE E***	***-***	***-***
2902200490	2203 EASTLAKE AVE E	-	-
2902200496	2209 EASTLAKE AVE E	2	2
2902200500	***2215 EASTLAKE AVE E***	***2***	***2***
2902200520	***2237 EASTLAKE AVE E***	***-***	***-***
2902200610	2240 EASTLAKE AVE E	-	-
2902200620	2234 EASTLAKE AVE E	2	2
2902200625	2228 EASTLAKE AVE E	2	2
2902200630	2222 EASTLAKE AVE E	-	-
2902200640	2206 EASTLAKE AVE E	2	2
2902200645	200 E BOSTON ST	-	3
2902200925	2366 EASTLAKE AVE E	-	-
2902200941	2352 EASTLAKE AVE E	-	-
2902200950	2344 EASTLAKE AVE E	-	-
3383900125	1823 EASTLAKE AVE E	2	2
3383900145	-	-	-
3383900175	1605 EASTLAKE AVE E	-	-
3383900176	***1601 EASTLAKE AVE E***	***-***	***-***
3383900230	1616 EASTLAKE AVE E	-	3
3383900232	1600 EASTLAKE AVE E	-	-

King County Parcel Number	Address	Noise Category	Vibration Category
2902200995	***2307 EASTLAKE AVE E***	***2***	***2***
2902201000	***2323 EASTLAKE AVE E***	***-***	***-***
2902201015	2331 EASTLAKE AVE E	-	3
2902201020	2341 EASTLAKE AVE E	-	3
2902201025	-	-	3
2902201030	2345 EASTLAKE AVE E	-	3
2902201035	***2355 EASTLAKE AVE E***	***2***	***2***
2902201036	***2365 EASTLAKE AVE E***	***2***	***2***
2902201045	2371 EASTLAKE AVE E	-	-
2902201050	2379 EASTLAKE AVE E	-	-
292504PUBL		-	-
3110730000	2611 EASTLAKE AVE E	2	2
3374400000	1821 BOREN AVE	2	2
3383900065	1820 EASTLAKE AVE E	-	3
3383900095	1800 EASTLAKE AVE E	2	2
3383900110	***1816 EASTLAKE AVE E***	***2***	***2***
3589500227	5524 ROOSEVELT WAY NE	2	2
3589500228	5522 ROOSEVELT WAY NE	2	2
3589500229	5520 ROOSEVELT WAY NE	2	2
3589500230	5518 ROOSEVELT WAY NE	2	2
3589500240	5516 ROOSEVELT WAY NE	2	2
3589500245	5603 11TH AVE NE	2	2

Note: Bold and italic receptors indicate potential for building damage due to construction vibration.

Table A-1 Receptor Inventory

King County Parcel Number	Address	Noise Category	Vibration Category	King County Parcel Number	Address	Noise Category	Vibration Category
3589500135	***5630 11TH AVE NE***	***2***	***2***	***3589500250***	***5605 11TH AVE NE***	***2***	***2***
3589500140	5626 11TH AVE NE	2	2	***3589500255***	***5611 11TH AVE NE***	***2***	***2***
3589500145	5622 11TH AVE NE	2	2	***3589500260***	***5615 11TH AVE NE***	***2***	***2***
3589500150	5616 11TH AVE NE	2	2	***3589500270***	***5619 11TH AVE NE***	***2***	***2***
3589500160	***5612 11TH AVE NE***	***2***	***2***	***3589500275***	***5621 11TH AVE NE***	***2***	***2***
3589500165	***5610 11TH AVE NE***	***2***	***2***	***3589500280***	***5625 11TH AVE NE***	***2***	***2***
3589500170	***5608 11TH AVE NE***	***2***	***2***	3589500285	5629 11TH AVE NE	2	2
3589500175	5606 11TH AVE NE	2	2	3589500290	5708 ROOSEVELT WAY NE	2	2
3589500180	5600 11TH AVE NE	2	2	3589500295	5626 ROOSEVELT WAY NE	2	2
3589500200	***5524 11TH AVE NE***	***2***	***2***	3589500314	5620 ROOSEVELT WAY NE	2	2
3589500205	***5520 11TH AVE NE***	***2***	***2***	3589500315	5618 ROOSEVELT WAY NE	2	2
3589500210	***5516 11TH AVE NE***	***2***	***2***	3589500316	5616 ROOSEVELT WAY NE	2	2
3589500215	***5517 11TH AVE NE***	***2***	***2***	3589500320	5612 B ROOSEVELT WAY NE	2	2
3589500220	5523 11TH AVE NE	2	2	3589500321	5612 A ROOSEVELT WAY NE	2	2
3589500225	***5525 11TH AVE NE***	***2***	***2***	3589500330	5610 ROOSEVELT WAY NE	2	2
3589500226	5518 ROOSEVELT WAY NE	2	2	3589500335	5600 ROOSEVELT WAY NE	-	-
3658700005	6515 12TH AVE NE	-	-	3658700655	1205 NE 70TH ST	2	2
3658700006	6511 12TH AVE NE	-	-	3658700660	6908 12TH AVE NE	2	2
3658700045	6516 ROOSEVELT WAY NE	-	-	3658700670	6902 12TH AVE NE	2	2
3658700046	6512 ROOSEVELT WAY NE	-	-	3658700750	1201 NE 69TH ST	2	2
3658700065	6500 ROOSEVELT WAY NE	-	-	3658700760	1202 NE 68TH ST	2	2
3658700115	1032 NE 65TH ST	-	-	3658700820	-	-	-

Note: Bold and italic receptors indicate potential for building damage due to construction vibration.

Table A-1 Receptor Inventory

King County Parcel Number	Address	Noise Category	Vibration Category
3658700135	6612 ROOSEVELT WAY NE	-	-
3658700245	6717 12TH AVE NE	2	2
3658700295	6718 ROOSEVELT WAY NE	-	-
3658700305	6700 ROOSEVELT WAY NE	2	2
3658700355	-	-	-
3658700360	-	-	-
3658700365	6825 12TH AVE NE	2	2
3658700410	6814 ROOSEVELT WAY NE	2	2
3658700420	-	2	2
3658700475	1032 NE 68TH ST	2	2
3658700485	6915 12TH AVE NE	2	2
3658700486	6911 12TH AVE NE	2	2
3658700540	6920 ROOSEVELT WAY NE	-	-
3658700555	6910 ROOSEVELT WAY NE	-	-
3658700605	6903 12TH AVE NE	2	2
3658700615	6907 12TH AVE NE	2	2
4088802668	-	-	3
4088802755	1515 FAIRVIEW AVE E	-	-
4088802810	-	-	-
4088802875	-	-	-
4088802890	1171 FAIRVIEW AVE N	-	-
4088802896	1141 FAIRVIEW AVE N	-	-
3658700915	-	-	-
3658700971	1200 NE 65TH ST	-	3
3658700995	6516 12TH AVE NE	-	-
3658701000	6512 12TH AVE NE	-	-
3920030010	6011 ROOSEVELT WAY NE	2	2
3920030020	6013 ROOSEVELT WAY NE	2	2
3920030100	6029 ROOSEVELT WAY NE	2	2
3956660000	4343 ROOSEVELT WAY NE	2	2
4079000000	2012 EASTLAKE AVE E	2	2
4086300150	-	-	-
4088000000	1151 FAIRVIEW AVE N	-	-
4088801095	1001 NE BOAT ST	-	-
4088801100	909 NE BOAT ST	-	3
4088801195	705 NE NORTHLAKE WAY	-	-
4088801438	3254 PORTAGE BAY PL E	2	2
4088802667	199 E BLAINE ST	-	3
5335200040	4737 ROOSEVELT WAY NE	2	2
5335200060	4731 ROOSEVELT WAY NE	2	2
5335200070	4729 ROOSEVELT WAY NE	2	2
5335200080	4725 ROOSEVELT WAY NE	2	2
5335200090	4723 ROOSEVELT WAY NE	2	2
5335200115	4709 ROOSEVELT WAY NE	-	-

Note: Bold and italic receptors indicate potential for building damage due to construction vibration.

Table A-1 Receptor Inventory

King County Parcel Number	Address	Noise Category	Vibration Category
4088802925	1241 EASTLAKE AVE E	-	1
4088802955	1150 FAIRVIEW AVE N	2	2
4088802995	1111 FAIRVIEW AVE N	-	-
4088803010	1001 FAIRVIEW AVE N	-	-
4088803011	-	-	-
4088803045	901 FAIRVIEW AVE N	-	
408880UNKN	-	-	-
4089300065	-	-	-
4090300000	2219 EASTLAKE AVE E	2	2
4092301675	4001 9TH AVE NE	3	3
4092302265	814 NE NORTHLAKE PL	-	-
4092302290	805 NE NORTHLAKE PL	-	-
5175100000	3242 EASTLAKE AVE E	2	2
5335200005	911 NE 50TH ST	2	2
5335200020	4749 ROOSEVELT WAY NE	-	-
5335200030	4747 ROOSEVELT WAY NE	-	-
6746700610	5238 11TH AVE NE	2	2
6746700615	5236 11TH AVE NE	2	2
6746700620	***5232 11TH AVE NE***	***2***	***2***
6746700625	***5230 11TH AVE NE***	***2***	***2***
6746700630	5228 11TH AVE NE	2	2
6746700635	***5226 11TH AVE NE***	***2***	***2***
5335200125	4701 ROOSEVELT WAY NE	-	-
5335200281	4545 ROOSEVELT WAY NE	-	-
5335200380	4501 ROOSEVELT WAY NE	-	-
5479800040	5609 ROOSEVELT WAY NE	-	-
5676500005	5715 ROOSEVELT WAY NE	-	-
5676500045	5701 ROOSEVELT WAY NE	-	-
6385300000	217 PINE ST	-	3
6746700566	***1103 NE 55TH ST***	***2***	***2***
6746700570	***5262 11TH AVE NE***	***2***	***2***
6746700575	***5258 11TH AVE NE***	***2***	***2***
6746700579	5256 B 11TH AVE NE	2	2
6746700580	5256 A 11TH AVE NE	2	2
6746700590	5252 11TH AVE NE	2	2
6746700595	5248 11TH AVE NE	2	2
6746700600	5244 11TH AVE NE	2	2
6746700605	5242 11TH AVE NE	2	2
6746700890	***5012 11TH AVE NE***	***2***	***2***
6746700895	5008 B 11TH AVE NE	2	2
6746700896	5008 A 11TH AVE NE	2	2
6746700905	5004 11TH AVE NE	2	2
6746700906	5002 11TH AVE NE	2	2
6746700907	5000 11TH AVE NE	2	2

Note: Bold and italic receptors indicate potential for building damage due to construction vibration.

Table A-1 Receptor Inventory

King County Parcel Number	Address	Noise Category	Vibration Category
6746700640	***5220 11TH AVE NE***	***2***	***2***
6746700648	5216 B 11TH AVE NE	2	2
6746700649	5216 A 11TH AVE NE	2	2
6746700655	***5210 11TH AVE NE***	***2***	***2***
6746700663	5206 B 11TH AVE NE	2	2
6746700664	5206 A 11TH AVE NE	2	2
6746700668	5200 B 11TH AVE NE	2	2
6746700669	5200 A 11TH AVE NE	2	2
6746700825	***5046 11TH AVE NE***	***2***	***2***
6746700835	***5042 11TH AVE NE***	***2***	***2***
6746700840	***5038 11TH AVE NE***	***2***	***2***
6746700850	***5032 11TH AVE NE***	***2***	***2***
6746700855	***5028 11TH AVE NE***	***2***	***2***
6746700865	5026 11TH AVE NE	2	2
6746700870	***5020 11TH AVE NE***	***2***	***2***
6746700880	5018 11TH AVE NE	2	2
6746701515	***4741 11TH AVE NE***	***-***	***-***
6746701535	-	-	-
6746701565	4750 ROOSEVELT WAY NE	-	-
6746701575	4740 ROOSEVELT WAY NE	-	-
6746701635	4700 ROOSEVELT WAY NE	-	-
6746701655	1050 NE 50TH ST	-	-
6746701020	4746 11TH AVE NE	2	2
6746701045	4738 11TH AVE NE	2	2
6746701055	4726 11TH AVE NE	2	2
6746701065	4724 11TH AVE NE	2	2
6746701067	-	2	2
6746701070	***4718 11TH AVE NE***	***2***	***2***
6746701090	***4716 11TH AVE NE***	***2***	***2***
6746701100	***4710 11TH AVE NE***	***2***	***2***
6746701106	1100 NE 47TH ST	2	2
6746701240	4550 11TH AVE NE	2	2
6746701265	-	-	-
6746701275	***4534 11TH AVE NE***	***-***	***-***
6746701320	***4557 11TH AVE NE***	***2***	***2***
6746701380	4554 ROOSEVELT WAY NE	-	-
6746701390	4542 ROOSEVELT WAY NE	-	-
6746701440	***4701 11TH AVE NE***	***-***	***-***
6746701850	***5205 11TH AVE NE***	***2***	***2***
6746701860	***5211 11TH AVE NE***	***2***	***2***
6746701870	***5213 11TH AVE NE***	***2***	***2***
6746701875	***5215 11TH AVE NE***	***2***	***2***
6746701880	***5221 11TH AVE NE***	***2***	***2***
6746701883	5225 B 11TH AVE NE	2	2

Note: Bold and italic receptors indicate potential for building damage due to construction vibration.

Table A-1 **Receptor Inventory**

King County Parcel Number	Address	Noise Category	Vibration Category
6746701675	-	-	-
6746701685	-	-	-
6746701695	-	-	-
6746701705	***5029 11TH AVE NE***	***2***	***2***
6746701715	5031 11TH AVE NE	2	2
6746701720	5035 11TH AVE NE	2	2
6746701730	***5039 11TH AVE NE***	***2***	***2***
6746701740	***5043 11TH AVE NE***	***2***	***2***
6746701745	5045 11TH AVE NE	2	2
6746701750	5048 ROOSEVELT WAY NE	-	3
6746701765	5036 ROOSEVELT WAY NE	-	-
6746701775	5030 ROOSEVELT WAY NE	-	-
6746701795	5020 ROOSEVELT WAY NE	-	3
6746701805	5014 ROOSEVELT WAY NE	-	-
6746701815	1000 NE 50TH ST	-	-
6746701845	***5203 11TH AVE NE***	***2***	***2***
6746701990	5342 ROOSEVELT WAY NE	2	2
6746701995	5340 ROOSEVELT WAY NE	2	2
6746702000	5336 ROOSEVELT WAY NE	2	2
6746702005	5330 ROOSEVELT WAY NE	-	-
6746702015	5326 ROOSEVELT WAY NE	-	-
6746702020	5322 ROOSEVELT WAY NE	-	3
6746701884	5225 A 11TH AVE NE	2	2
6746701895	***5229 11TH AVE NE***	***2***	***2***
6746701901	5231 11TH AVE NE	2	2
6746701903	5235 B 11TH AVE NE	2	2
6746701904	5235 A 11TH AVE NE	2	2
6746701915	***5241 11TH AVE NE***	***2***	***2***
6746701925	5243 11TH AVE NE	2	2
6746701930	***5245 11TH AVE NE***	***2***	***2***
6746701935	***5249 11TH AVE NE***	***2***	***2***
6746701940	***5251 11TH AVE NE***	***2***	***2***
6746701945	***5255 11TH AVE NE***	***2***	***2***
6746701950	***5259 11TH AVE NE***	***2***	***2***
6746701955	***5261 11TH AVE NE***	***2***	***2***
6746701960	5263 11TH AVE NE	2	2
6746701966	***5267 11TH AVE NE***	***2***	***2***
6746701985	5344 ROOSEVELT WAY NE	2	2
7733600095	***4526 11TH AVE NE***	***-***	***-***
7733600155	1000 NE 45TH ST	-	-
7863500020	530 FAIRVIEW AVE N	-	3
7863500040	500 FAIRVIEW AVE N	-	3
8634230000	300 PINE ST	-	-
8647700000	1812 BOREN AVE	-	-

Note: Bold and italic receptors indicate potential for building damage due to construction vibration.

Table A-1 Receptor Inventory

King County Parcel Number	Address	Noise Category	Vibration Category
6746702030	5320 ROOSEVELT WAY NE	-	3
6746702040	5312 ROOSEVELT WAY NE	-	3
6746702050	5310 ROOSEVELT WAY NE	2	2
6746702060	5306 ROOSEVELT WAY NE	-	-
6746702070	5300 ROOSEVELT WAY NE	-	-
6746702080	5222 ROOSEVELT WAY NE	-	-
6746702095	5220 ROOSEVELT WAY NE	-	-
6746702110	5210 ROOSEVELT WAY NE	-	3
6746702120	5200 ROOSEVELT WAY NE	-	-
7326250000	1550 EASTLAKE AVE E	2	2
7409000000	5624 ROOSEVELT WAY NE	2	2
7459970000	2960 EASTLAKE AVE E	2	2
7733600055	1100 NE 45TH ST	-	3
7733600075	-	-	-
7733600080	-	-	-
7733600090	-	-	-
9221400495	6205 ROOSEVELT WAY NE	2	2
9221400505	6201 ROOSEVELT WAY NE	-	-
9221400825	6113 ROOSEVELT WAY NE	2	2
9221400835	6107 ROOSEVELT WAY NE	2	2
9221400845	6105 ROOSEVELT WAY NE	2	2
9528102180	6911 ROOSEVELT WAY NE	-	-

King County Parcel Number	Address	Noise Category	Vibration Category
8669900000	2920 EASTLAKE AVE E	2	2
8692000000	300 BOREN AVE N	-	3
8724000000	2035 EASTLAKE AVE E	2	2
8814800000	5019 ROOSEVELT WAY NE	2	2
9221400005	6415 ROOSEVELT WAY NE	-	-
9221400020	6413 ROOSEVELT WAY NE	-	-
9221400025	6411 ROOSEVELT WAY NE	-	-
9221400035	6401 ROOSEVELT WAY NE	-	-
9221400375	6319 ROOSEVELT WAY NE	-	-
9221400385	6317 ROOSEVELT WAY NE	-	-
9221400400	6311 ROOSEVELT WAY NE	-	
9221400405	6307 ROOSEVELT WAY NE	-	-
9221400410	6301 ROOSEVELT WAY NE	2	2
9221400465	917 NE 63RD ST	2	2
9221400475	6215 ROOSEVELT WAY NE	-	-
9221400485	6211 ROOSEVELT WAY NE	2	2
9528102345	6801 ROOSEVELT WAY NE	3	3
9528102740	6717 ROOSEVELT WAY NE	-	-
9528102750	858 NE 67TH ST	2	2
9528102785	6619 ROOSEVELT WAY NE	2	2
9528102820	6615 ROOSEVELT WAY NE	-	-
9528103115	845 NE 66TH ST	2	2

Note: Bold and italic receptors indicate potential for building damage due to construction vibration.

Table A-1 Receptor Inventory

King County Parcel Number	Address	Noise Category	Vibration Category
9528102185	844 NE 69TH ST	2	2
9528102186	6909 ROOSEVELT WAY NE	2	2
9528103125	6501 ROOSEVELT WAY NE	2	2
9528103127	6509 ROOSEVELT WAY NE	-	-

Note: Bold and italic receptors indicate potential for building damage due to construction vibration.

Appendix B
Noise and Vibration Measurements

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NOISE MEASUREMENTS

N-1 6126 12th Ave NE

Photo A-1 6126 12th Ave NE

Table A-2 N-1 Noise Measurement Equipment

EQUIPMENT	MANUFACTURER	MODEL	SERIAL NO.	CALIBRATION DATE
6126 12TH AVE NE				
Sound Level Meter	Rion	NL-52	821097	12/19/17
Microphone	Rion	UC-59	4064	12/18/17
Preamplifier	Rion	NH-25	21138	12/19/17
Calibrator	Larson Davis	CAL200	9253	12/18/17

Table A-3 N-1 Measurement Results

DATE	START OF HOUR	L_{eq} (dBA)
6126 12TH AVE NE		
1/22/2018	1 PM	66
1/22/2018	2 PM	66
1/22/2018	3 PM	67
1/22/2018	4 PM	68
1/22/2018	5 PM	67
1/22/2018	6 PM	65
1/22/2018	7 PM	64
1/22/2018	8 PM	63
1/22/2018	9 PM	63
1/22/2018	10 PM	60
1/22/2018	11 PM	58
1/23/2018	12 AM	57
1/23/2018	1 AM	54
1/23/2018	2 AM	53
1/23/2018	3 AM	52
1/23/2018	4 AM	50
1/23/2018	5 AM	58
1/23/2018	6 AM	61
1/23/2018	7 AM	63
1/23/2018	8 AM	66
1/23/2018	9 AM	65
1/23/2018	10 AM	66
1/23/2018	11 AM	66
1/23/2018	12 PM	66

N-2 4131 11th Ave NE

Photo A-2 4131 11th Ave NE

Table A-4 N-2 Noise Measurement Equipment

EQUIPMENT	MANUFACTURER	MODEL	SERIAL NO.	CALIBRATION DATE
4131 11TH AVE NE				
Sound Level Meter	Svantek	971	51818	10/24/17
Microphone	ACO Pacific	7052E	62522	10/24/17
Preamplifier	Svantek	SV18	49561	10/24/17
Calibrator	Larson Davis	CAL200	9253	12/18/17

Table A-5 N-2 Measurement Results

DATE	START OF HOUR	L_{eq} (dBA)
4131 11TH AVE NE		
1/22/2018	12 PM	72
1/22/2018	1 PM	71
1/22/2018	2 PM	70
1/22/2018	3 PM	72
1/22/2018	4 PM	72
1/22/2018	5 PM	71
1/22/2018	6 PM	70
1/22/2018	7 PM	70
1/22/2018	8 PM	68
1/22/2018	9 PM	68
1/22/2018	10 PM	68
1/22/2018	11 PM	62
1/23/2018	12 AM	62
1/23/2018	1 AM	60
1/23/2018	2 AM	61
1/23/2018	3 AM	53
1/23/2018	4 AM	59
1/23/2018	5 AM	63
1/23/2018	6 AM	69
1/23/2018	7 AM	69
1/23/2018	8 AM	72
1/23/2018	9 AM	71
1/23/2018	10 AM	71
1/23/2018	11 AM	72

N-3 2851 Eastlake Ave NE

Photo A-3 2851 Eastlake Ave NE

Table A-6 N-3 Noise Measurement Equipment

EQUIPMENT	MANUFACTURER	MODEL	SERIAL NO.	CALIBRATION DATE
2851 EASTLAKE AVE NE				
Sound Level Meter	Svantek	971	51818	10/24/17
Microphone	ACO Pacific	7052E	62522	10/24/17
Preamplifier	Svantek	SV18	49561	10/24/17
Calibrator	Larson Davis	CAL200	9253	12/18/17

Table A-7 N-3 Measurement Results

DATE	START OF HOUR	L_{eq} (dBA)
2851 EASTLAKE AVE NE		
1/16/2018	1 PM	65
1/16/2018	2 PM	65
1/16/2018	3 PM	66
1/16/2018	4 PM	65
1/16/2018	5 PM	66
1/16/2018	6 PM	65
1/16/2018	7 PM	64
1/16/2018	8 PM	64
1/16/2018	9 PM	64
1/16/2018	10 PM	61
1/16/2018	11 PM	57
1/17/2018	12 AM	58
1/17/2018	1 AM	55
1/17/2018	2 AM	54
1/17/2018	3 AM	53
1/17/2018	4 AM	58
1/17/2018	5 AM	62
1/17/2018	6 AM	64
1/17/2018	7 AM	67
1/17/2018	8 AM	67
1/17/2018	9 AM	65
1/17/2018	10 AM	64
1/17/2018	11 AM	65
1/17/2018	12 PM	65

N-4 1925 Eastlake Ave E

Photo A-4 1925 Eastlake Ave E

Table A-8 N-4 Noise Measurement Equipment

EQUIPMENT	MANUFACTURER	MODEL	SERIAL NO.	CALIBRATION DATE
1925 EASTLAKE AVE E				
Sound Level Meter	Svantek	971	51818	10/24/17
Microphone	ACO Pacific	7052E	62522	10/24/17
Preamplifier	Svantek	SV18	49561	10/24/17
Calibrator	Larson Davis	CAL200	9253	12/18/17

Table A-9 N-4 Measurement Results

DATE	START OF HOUR	L_{eq} (dBA)
1925 EASTLAKE AVE E		
1/18/2018	11 AM	71
1/18/2018	12 PM	71
1/18/2018	1 PM	71
1/18/2018	2 PM	72
1/18/2018	3 PM	73
1/18/2018	4 PM	73
1/18/2018	5 PM	72
1/18/2018	6 PM	72
1/18/2018	7 PM	71
1/18/2018	8 PM	70
1/18/2018	9 PM	69
1/18/2018	10 PM	68
1/18/2018	11 PM	67
1/19/2018	12 AM	64
1/19/2018	1 AM	61
1/19/2018	2 AM	60
1/19/2018	3 AM	62
1/19/2018	4 AM	65
1/19/2018	5 AM	69
1/19/2018	6 AM	71
1/19/2018	7 AM	75
1/19/2018	8 AM	72
1/19/2018	9 AM	72
1/19/2018	10 AM	72

N-5 2020 Terry Ave

Photo A-5 2020 Terry Ave

Table A-10 N-5 Noise Measurement Equipment

EQUIPMENT	MANUFACTURER	MODEL	SERIAL NO.	CALIBRATION DATE
2020 TERRY AVE				
Sound Level Meter	Svantek	958	59108	10/17/17
Microphone	Microtech	MK255	12529	10/16/17
Preamplifier	Svantek	SV12L	57961	10/17/17
Calibrator	Brüel & Kjaer	4231	3001160	1/30/17

Table A-11 N-5 Measurement Results

DATE	START OF HOUR	L_{eq} (dBA)
2020 TERRY AVE		
1/22/2018	1 PM	65
1/22/2018	2 PM	65
1/22/2018	3 PM	65
1/22/2018	4 PM	67
1/22/2018	5 PM	63
1/22/2018	6 PM	62
1/22/2018	7 PM	62
1/22/2018	8 PM	63
1/22/2018	9 PM	62
1/22/2018	10 PM	61
1/22/2018	11 PM	59
1/23/2018	12 AM	59
1/23/2018	1 AM	57
1/23/2018	2 AM	61
1/23/2018	3 AM	57
1/23/2018	4 AM	60
1/23/2018	5 AM	62
1/23/2018	6 AM	63
1/23/2018	7 AM	64
1/23/2018	8 AM	64
1/23/2018	9 AM	65
1/23/2018	10 AM	64
1/23/2018	11 AM	65
1/23/2018	12 PM	67

VIBRATION AND PROPAGATION MEASUREMENTS

V-1 University of Washington Roosevelt Buildings

Photo A-6 University of Washington Roosevelt Buildings

Table A-12 V-1 Vibration Measurement Equipment

EQUIPMENT	MANUFACTURER	MODEL	SERIAL NO.
UNIVERSITY OF WASHINGTON ROOSEVELT BUILDINGS			
Vibration Level Meter	Brüel & Kjaer	2270	59108
Geophone	R.T. Clark	HP206-4.5-375V	V400011760

Table A-13 V-1 Measurement Results

DATE	TIME	L_v (VdB)	PPV (IN/SEC)
UNIVERSITY OF WASHINGTON ROOSEVELT BUILDINGS			
1/26/2018	9:30 AM – 10: 30 AM	43	0.0065

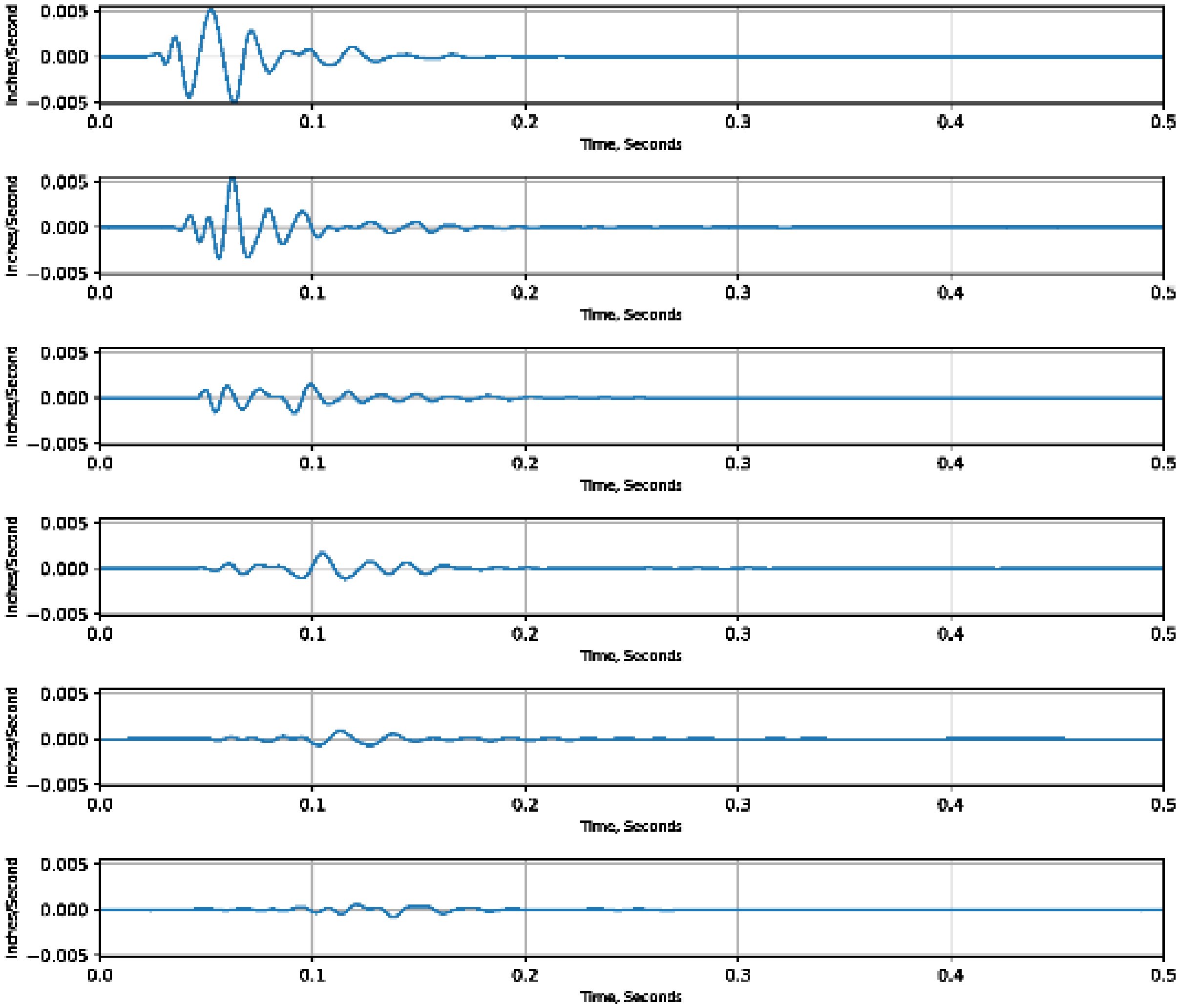
VP-1 Vibration Propagation Test

Photo A-7 Vibration Propagation Test

Table A-14 VP-1 Vibration Propagation Measurement Equipment

EQUIPMENT	MANUFACTURER	MODEL	SERIAL NO.
UNIVERSITY OF WASHINGTON ROOSEVELT BUILDINGS			
Audio Recorder	Tascam	680 MKII	80239
Vibration Transducer	R.T. Clark	HP206-4.5-375V	V400011706
Vibration Transducer	R.T. Clark	HP206-4.5-375V	V400011760
Vibration Transducer	R.T. Clark	HP206-4.5-375V	V400011730
Vibration Transducer	PCB	TLD333B50	58930
Vibration Transducer	PCB	TLD333B50	58929
Vibration Transducer	PCB	TLD333B50	58926
Signal Conditioner	PCB	482A16	2987

Figure A-1 VP-1 Measurement Results



Appendix C
Soil Boring Logs

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Table C-1 Soil Boring Logs

BOREHOLE ID	BOREHOLE NAME	LOCATION	SOIL DESCRIPTION
8235	TB-67	3rd and Cherry	Concrete, silty sand, clay, silty clay, silt, sand
8230	TB-13	3rd and Madison	Fill, silty sand, silty clay, clayey sand, sandy clay, sandy silt
8219	TB-84 (MW-4)	3rd and Pine	Clayey sand, silty sand, sandy silt, clayey silt
5323	B-3	8th and Stewart	Silty sand, sandy silt, sandy clay, silty clay, clay, sand
58029	EB-4	Terry and Virginia	Sandy silt, silty sand, silt, sand
68200	B-5	Fairview and Thomas	Concrete, sand, sandy silt, silty sand
11297	BB-18	Valley and Fairview	Clay, sand, silty sand, sandy silt
11413	HC-8	Fairview (near Zymogenetics)	Concrete, silty sand
45892	HC-3	Eastlake and Blaine	Concrete, gravel, sandy silt, gravelly sand, sand
9926	B-4	Eastlake and Louisa	Concrete, silty sand, sand
70312	B-102	Eastlake and Allison	Silty clay
62505	B-3	Eastlake and Fuhrman	Concrete, silty sand
61202	B-102	Eastlake and Pacific	Silty sand, sand
29208	B-1	Eastlake and Lincoln Way	Sandy silt, silty sand, sand
13037	BH-1	Roosevelt and 42nd St	Silty sand, sandy silt, sand
17157	BH-3	11th and 45th	Concrete, sandy silt, debris, silty sand, clay
46385	B-3	Roosevelt and 52nd	Sandy silt, silty sand
41720	NB-216	11th and Ravenna	Silty sand, sand, sandy silt, silt, sand, silt
41703	NB-111	66th and 12th Ave	Concrete, silty sand, sand, silt, sandy silt, silty clay, silty sand, gravelly sand, gravelly silt, sand

Source: Washington State Department of Natural Resources, Washington Geological Survey Database, 2018

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Appendix D
FTA Noise Impact Spreadsheets

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Federal Transit Administration
Noise Impact Assessment Spreadsheet

version: 7/3/2007

Project:	FTA Example 6-1, Part 1

Receiver Parameters	
Receiver:	Category 1 (High Sensitivity)
Land Use Category:	1. Outdoor Quiet
Existing Noise (Measured or Generic Value):	62 dBA

Noise Source Parameters	
Number of Noise Sources:	1

Noise Source Parameters		Source 1
	Source Type:	Highway/Transit
	Specific Source:	Buses (electric)
Noisiest hr of Activity During Sensitive hrs		
	Speed (mph)	25
	Number of Events/hr	8
Distance	Distance from Source to Receiver (ft)	0
	Number of Intervening Rows of Buildings	0
Adjustments	Noise Barrier?	No

Project Results Summary

Existing Leqh:	62 dBA
Total Project Leqh:	#NUM!
Total Noise Exposure:	#NUM!
Increase:	#NUM!
Impact?:	#NUM!

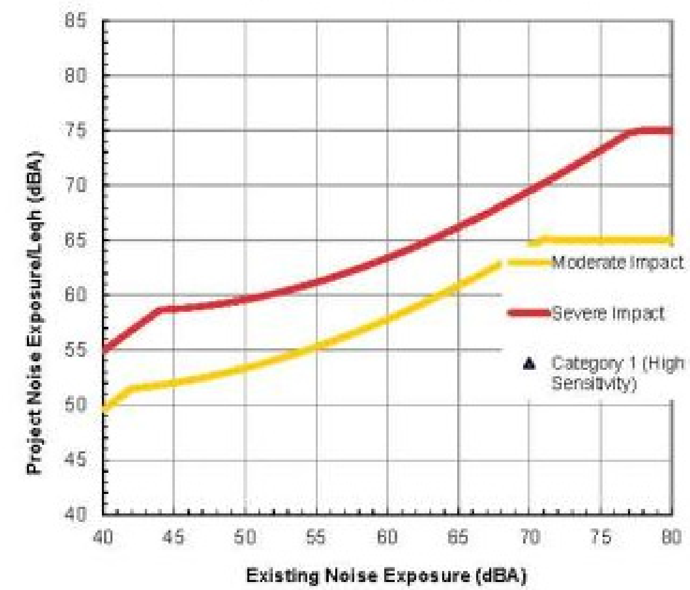
Distance to Impact Contours

Dist to Mod. Impact Contour (Source 1):	5 ft
Dist to Sev. Impact Contour (Source 1):	2 ft

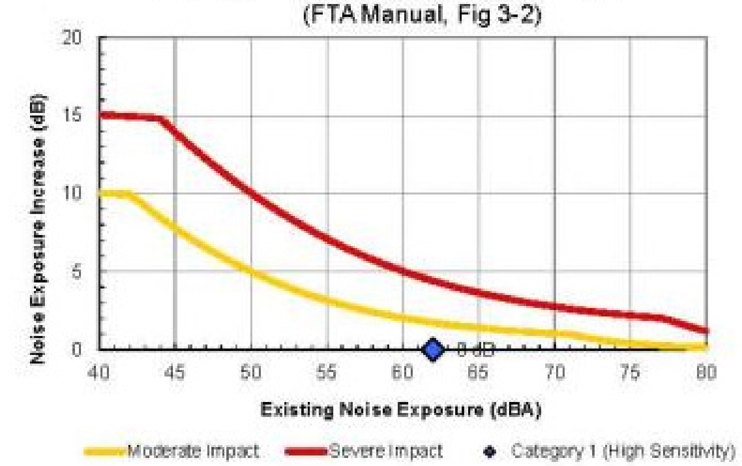
Source 1 Results

Leqh:	#NUM!

Noise Impact Criteria
(FTA Manual, Fig 3-1)



Increase in Cumulative Noise Levels Allowed
(FTA Manual, Fig 3-2)



Category 1 – High Sensitivity

Federal Transit Administration
Noise Impact Assessment Spreadsheet

version: 7/3/2007

Project:	FTA Example 6-1, Part 1

Receiver Parameters	
Receiver:	Category 2 (Residential)
Land Use Category:	2. Residential
Existing Noise (Measured or Generic Value):	66 dBA

Noise Source Parameters	
Number of Noise Sources:	1

Noise Source Parameters		Source 1
	Source Type:	Highway/Transit
	Specific Source:	Buses (electric)
Daytime hrs		
	Speed (mph)	25
	Avg. Number of Events/hr	6
Nighttime hrs		
	Speed (mph)	25
	Avg. Number of Events/hr	3
Distance	Distance from Source to Receiver (ft)	0
	Number of Intervening Rows of Buildings	0
Adjustments	Noise Barrier?	No

Project Results Summary

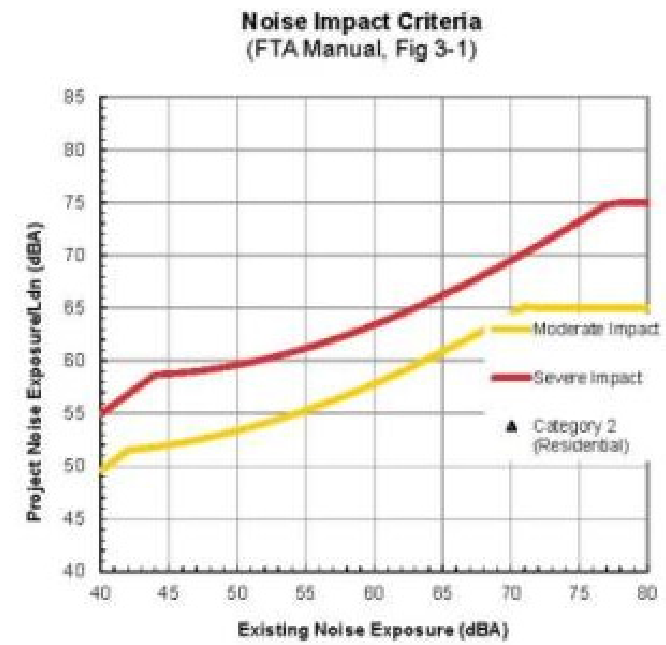
Existing Ldn:	66 dBA
Total Project Ldn:	#NUM!
Total Noise Exposure:	#NUM!
Increase:	#NUM!
Impact?:	#NUM!

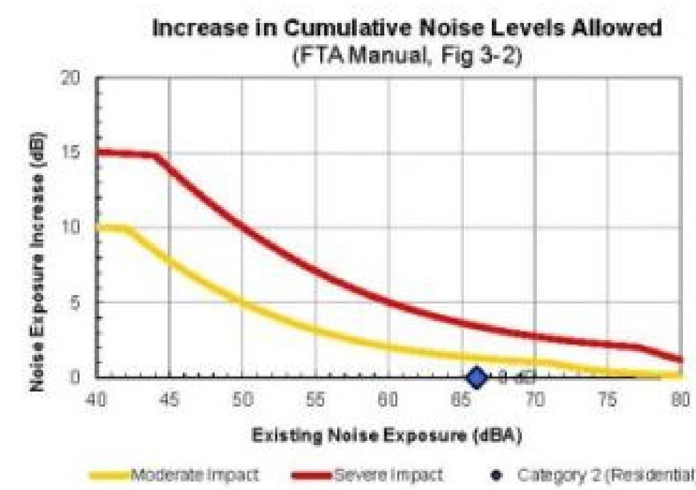
Distance to Impact Contours

Dist to Mod. Impact Contour (Source 1):	6 ft
Dist to Sev. Impact Contour (Source 1):	3 ft

Source 1 Results

Leq(day):	#NUM!
Leq(night):	#NUM!
Ldn:	#NUM!





Category 2 – Residential

Federal Transit Administration
Noise Impact Assessment Spreadsheet

version: 7/3/2007

Project:	FTA Example 6-1, Part 1

Receiver Parameters

Receiver:	Category 3 (Daytime Use)
Land Use Category:	3. Institutional
Existing Noise (Measured or Generic Value):	62 dBA

Noise Source Parameters

Number of Noise Sources:	1

Noise Source Parameters		Source 1
	Source Type:	Highway/Transit
	Specific Source:	Buses (electric)
Noisiest hr of Activity During Sensitive hrs	Speed (mph)	25
	Number of Events/hr	6
Distance	Distance from Source to Receiver (ft)	0
	Number of Intervening Rows of Buildings	0
Adjustments	Noise Barrier?	No

Project Results Summary

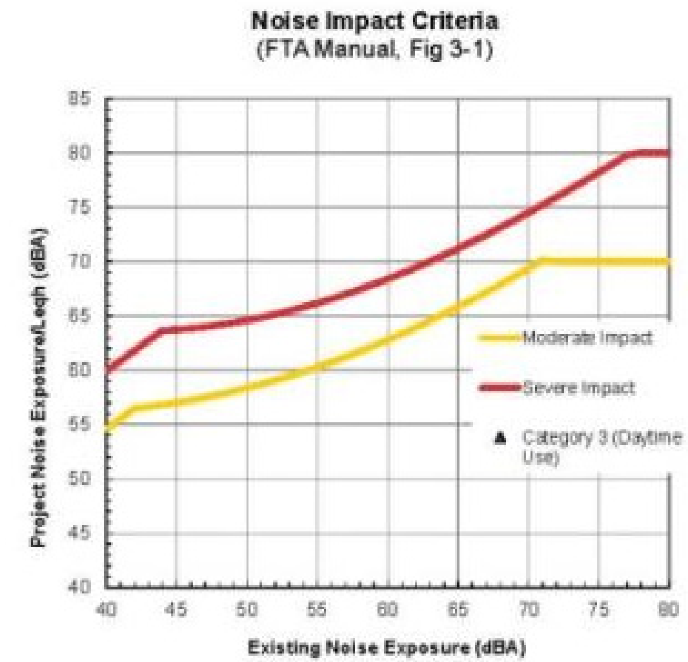
Existing Leqh:	62 dBA
Total Project Leqh:	#NUM!
Total Noise Exposure:	#NUM!
Increase:	#NUM!
Impact?:	#NUM!

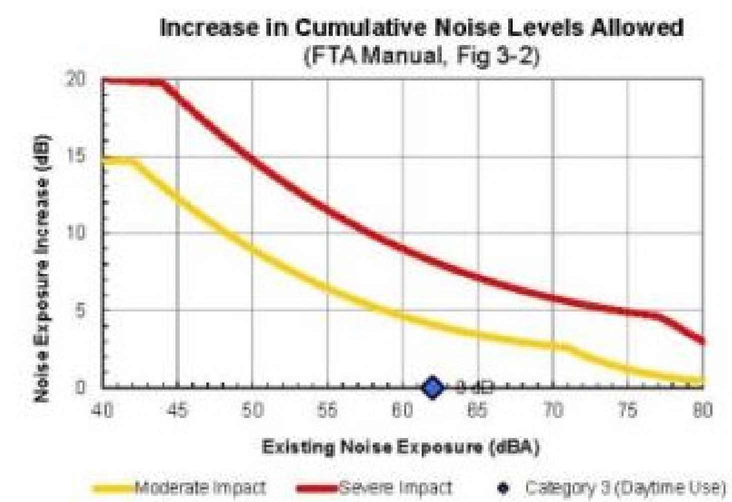
Distance to Impact Contours

Dist to Mod. Impact Contour (Source 1):	2 ft
Dist to Sev. Impact Contour (Source 1):	1 ft

Source 1 Results

Leqh:	#NUM!





Category 3 – Daytime Use

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Appendix E
RapidRide Roosevelt Noise and Vibration Analysis Methodology

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RapidRide Roosevelt Project – Noise and Vibration Analysis Methodology

PREPARED FOR:	Seattle Department of Transportation
COPY TO:	CH2M
PREPARED BY:	The Greenbusch Group
DATE:	March 19, 2018

Background

The RapidRide Roosevelt Project will provide a high-quality bus rapid transit service connecting Downtown Seattle with the neighborhoods of Belltown, South Lake Union, Eastlake, the University District, and Roosevelt. It will increase transit speed, reliability, and passenger carrying capacity, serving high existing ridership in this corridor and future population and employment growth. Service is proposed to begin in 2024.

Study Area

The study area for the noise and vibration analysis includes noise and vibration receptors along the RapidRide Roosevelt corridor from Stewart St and extending to the north to NE 67th St and near potential bus layover areas, extending outward to the farthest impact screening distance. Because 3rd Avenue is an existing transit corridor and noise levels would not be affected by a new bus route, noise and vibration analysis for both operation and construction will not be performed. Figure 1 illustrates the RapidRide Roosevelt corridor.

Methodology

OVERVIEW

With the addition of a bus travel lane where existing curb parking exists, an operational noise and vibration analysis is to be conducted as a part of the National Environmental Policy Act (NEPA) process. This noise and vibration analysis will be conducted in accordance with the General Methodology described in the 2006 Federal Transit Administration (FTA) Transit Noise and Vibration Impact Assessment manual,[1] summarized as follows:

- Noise
  - Inventory noise-sensitive receptors along the project alignment.
  - Utilize FTA Noise Impact Assessment spreadsheet to determine noise impact contour distances based on operations, existing sound levels, and receptor category.

[1] https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/FTA_Noise_and_Vibration_Manual.pdf

  - Utilize ArcGIS to overlay noise impact contour distances over adjacent receptors along the alignment to identify potential noise impacts.
- Vibration
  - Inventory vibration-sensitive receptors along the project alignment.
  - Establish ground surface vibration curve based on generalized rubber-tired vehicle curve and relevant adjustment factors.
    - Perform desk review of historical geological borings to determine likelihood of efficient propagation in soil or rock layers.
  - Determine vibration impact distances based on ground vibration surface curve and operations.
  - Inventory potential vibration impacts based on receptor sensitivity and location along the alignment.
  - Verify potential impacts based on receptor conditions (foundation type, first floor with sensitive use, etc.).
  - Identify potential mitigation measures.
  - Inventory potential residual impacts.

EXISTING NOISE AND VIBRATION

Measurements will be conducted in accordance with FTA guidelines to characterize existing noise levels at a minimum of five but no more than eight locations throughout the project corridor. The following procedures will be followed:

- Conduct measurements between noon Monday and noon Friday.
- At residential locations, measure sound levels for 24 hours.
- If measurements are warranted at non-residential locations, measure sound levels for one hour during the period of day when project operations are expected to be the highest.

Measurements of existing vibration levels will also be conducted at one location, near a representative vibration-sensitive receptor.

CONSTRUCTION NOISE AND VIBRATION

Construction noise and vibration will also be conducted in accordance with the General Methodology described in the 2006 FTA Transit Noise and Vibration Impact Assessment manual. Predicted noise levels will also be compared to noise limits in Seattle Municipal Code Chapter 25.08.

Vibration impacts will evaluate potential cosmetic damage and occupant annoyance at representative vibration-sensitive receptors along the project alignment.

Figure 1. RapidRide Roosevelt Alignment

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Appendix E
Visual Simulations

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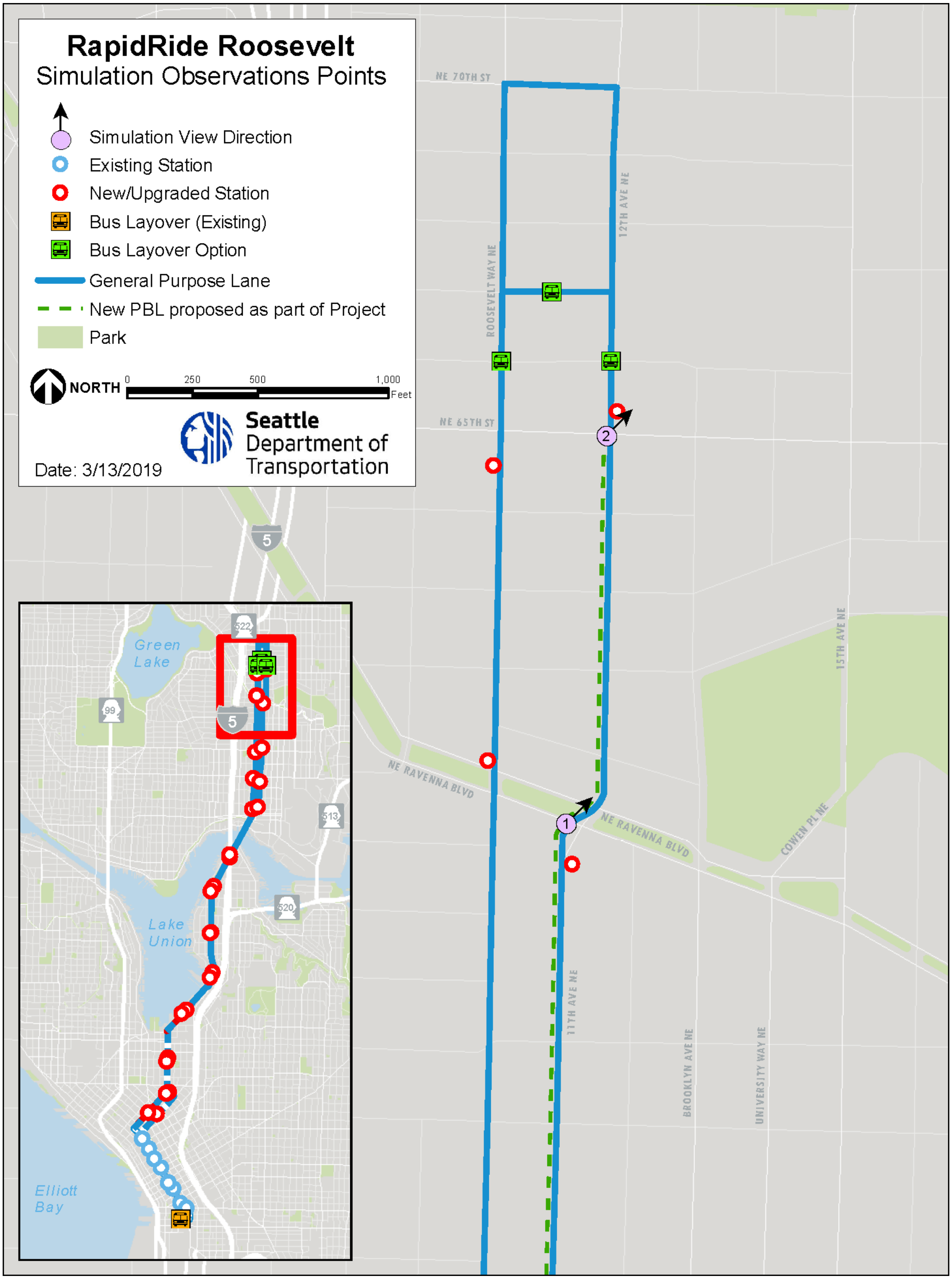
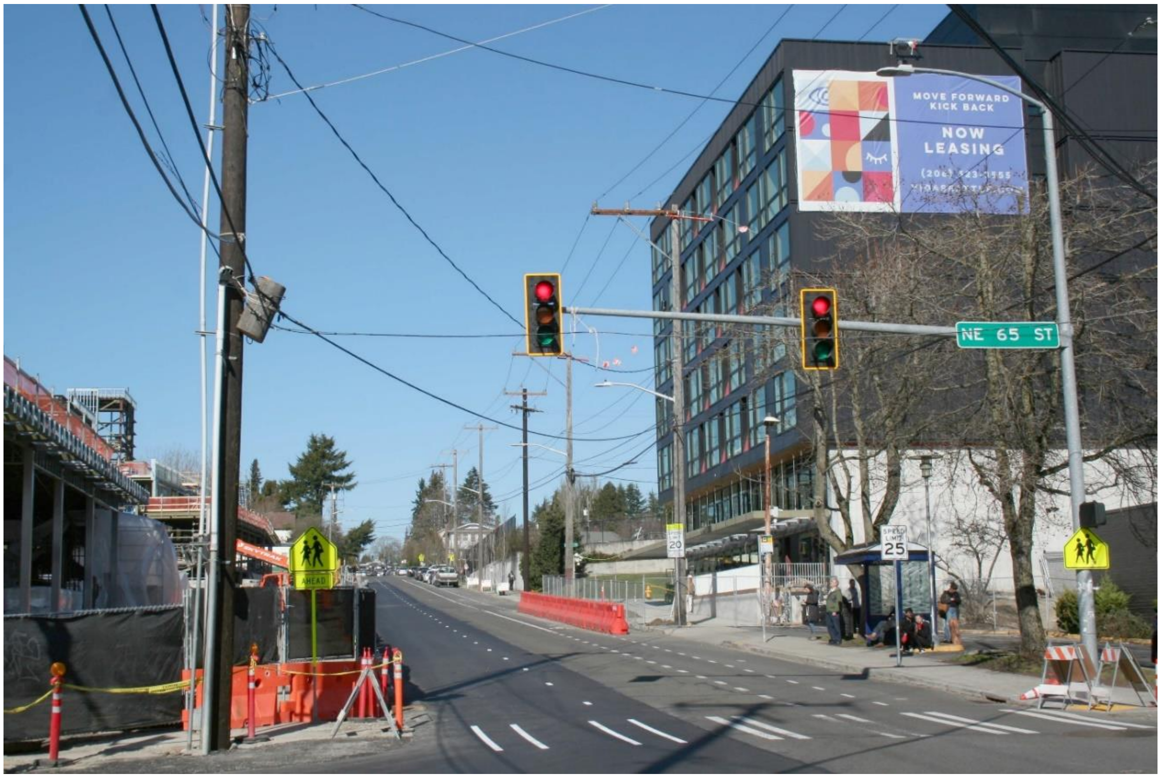


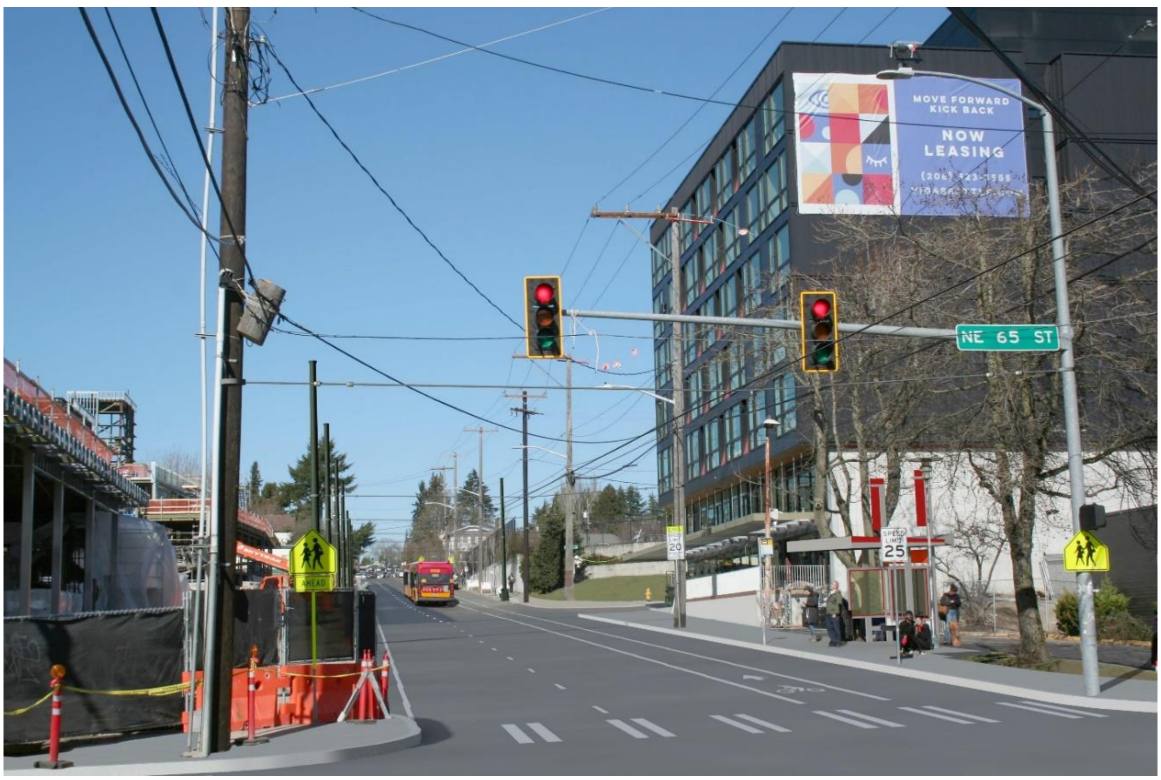
Figure E-1 Visual Simulation Key Observation Points (KOP)

Existing Condition – looking north up 12th Ave NE at Ravenna Blvd (KOP 1)

Simulation of RapidRide Roosevelt improvements looking up 12th Ave NE at Ravenna Blvd.



Existing Condition – Looking north up 12th Ave NE by NE 65th St (KOP 2)



Simulation of RapidRide Roosevelt improvements looking north up 12th Ave NE by NE 65th St (KOP 2)

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