3.11 Noise and Vibration

This section summarizes the guidelines and standards for evaluating noise and vibration impacts, existing noise levels, the long-term and temporary noise and vibration levels from the No-Build Alternative and the Modified Locally Preferred Alternative (LPA), and mitigation measures for noise and vibration impacts. The information presented in this section is based on the Noise and Vibration Technical Report. Section 3.16, Ecosystems, provides information about noise-related effects on fish and wildlife within the study area's environment.

How do decibels relate to sound levels?

The human ear generally cannot detect very slight changes in noise levels. The smallest change in noise level that a human ear can perceive is about 3 decibels, while increases of 5 decibels or more are clearly noticeable. For most people, a 10-decibel increase in noise levels is perceived as a doubling of sound level.

3.11.1 Changes or New Information Since 2013

The Columbia River Crossing (CRC) Selected Alternative identified in the 2011 Record of Decision (ROD), as revised by the 2012 and 2013 re-evaluations, is referred to as the CRC LPA. Over the past 10+ years since the CRC LPA was identified, the physical environment in the study area, community priorities, and regulations have changed, which necessitated design revisions and resulted in the IBR Modified LPA (see Section 2.5.2). Evaluation of potential impacts associated with noise and vibration has been updated in this Draft SEIS to include:

- Updated existing noise measurements for traffic noise modeling and transit noise assessment.
- Updated all peak-hour and peak-truck-hour traffic data for traffic noise assessment.
- Updated all transit operation assumptions for transit noise and vibration assessment.
- Updated the locations of sensitive noise receptors based on changes in land use.
- New FHWA, WSDOT, and ODOT traffic noise assessment guidance and FTA noise and vibration guidance.
- Developed new traffic noise model and transit noise and vibration assessment models.
- Changes to the project footprint, as necessitated by changed conditions, and in existing land uses resulting in changes to proximity to sensitive receptors.

Table 3.11-1 compares the impacts and benefits between the CRC LPA and the Modified LPA as a result of the changes listed above. Based on the analysis described in this section, the Modified LPA would have fewer residences, and other noise-sensitive land uses, that would have an increase in highway or transit noise levels or ground-borne vibrations that would meet FHWA's or FTA's threshold to be considered an impact. Key modifications that led to this decrease in highway noise, transit noise, and vibration impacts include reductions to the highway footprint at the I-5/SR 500/39th Street interchange and the realignment of light-rail from downtown Vancouver to along the I-5 corridor.

Table 3.11-1. Comparison of CRC LPA Effects and IBR Modified LPA Effects

Technical Considerations	CRC LPA Effects as Identified in the 2011 Final EIS (without Mitigation)	Modified LPA Effects as Identified in this Section (without Mitigation)	CRC LPA Effects as Identified in the 2011 Final EIS (with Mitigation)	Modified LPA Effects as Identified in this Section (with Mitigation)	Explanation of Differences
Number of receptors that exceed highway noise thresholds	325	198	110	121	Reduced highway footprint at the I-5/SR 500/39th St Interchange.
Number of receptors with moderate transit noise impact levels	31	12	0	0	Moved transit alignment from downtown Vancouver to along I-5.
Number of receptors with severe transit noise impact levels	0	0	0	0	No change.
Number of receptors with transit vibration impacts	15	13	0	13	Impacts associated with the Modified LPA are in proximity to the direct fixation trackway in downtown Vancouver.

3.11.2 Existing Conditions

Understanding Sound

How Sound Levels Are Measured

Two aspects of sound that partially determine its impacts are loudness and frequency. The loudness of sound is a result of its energy, which is measured in decibels (dB); an A-weighted decibel (dBA) measures noise as perceived by the human ear.

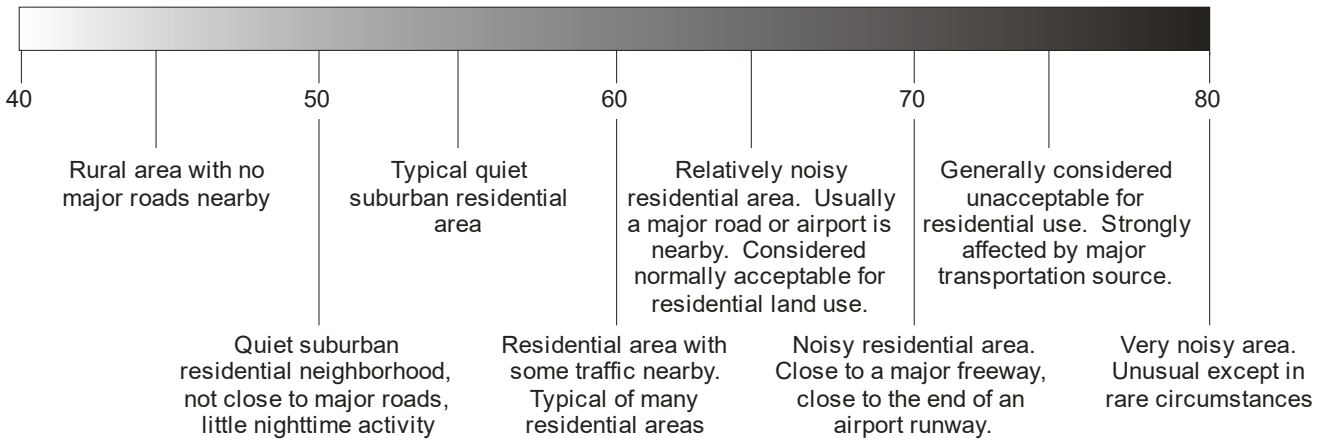
Most noise levels at a given location vary over time. To account for this variation, a commonly used noise measurement is the equivalent sound pressure level (L_{eq}). This noise analysis uses L_{eq} to describe traffic and transit noise at schools, libraries, and other noise-sensitive institutional uses. Consistent with FTA noise regulations, this analysis also gives more weight to noise that occurs at night (from 10:00 p.m. to 7 a.m.). This method produces the *day-night equivalent sound level*, which is abbreviated as L_{dn}.

The Noise and Vibration Technical Report (Chapter 2.4) provides detailed methods for sound level monitoring and noise model development.

Typical Noise Levels

Figure 3.11-1 shows typical community noise levels. Figure 3.11-2 shows how some common noise sources are perceived by the human ear.

Figure 3.11-1. Typical Community Noise Levels (in L_{dn})



Source: FTA 1995

L_{dn} = day-night equivalent sound level Noise Criteria and Analysis Methods

Highway Traffic Noise Criteria

Federal, state, and local governments regulate and provide guidance for acceptable noise and vibration levels to ensure the public's health and wellbeing. For highways and transit systems, FHWA, FTA, ODOT, and WSDOT have developed guidance for assessing noise and vibration impacts. This assessment also considers applicable regulations from the City of Portland and City of Vancouver.

Table 3.11-2 summarizes FHWA's traffic noise abatement criteria. ODOT is responsible for implementing the FHWA regulations in Oregon, and WSDOT administers the FHWA regulations in Washington. Under ODOT policy, a traffic noise impact occurs if predicted noise levels approach within 2 dBA or exceed the FHWA criteria; the criteria apply to the peak noise impact hour. Under WSDOT policy, a traffic noise impact occurs if predicted noise levels approach within 1 dBA of or exceed the FHWA criteria. Both agencies consider an increase of 10 dBA or more to be a substantial impact.

Figure 3.11-2. Typical Noise Source and Human Perception of Sound Levels

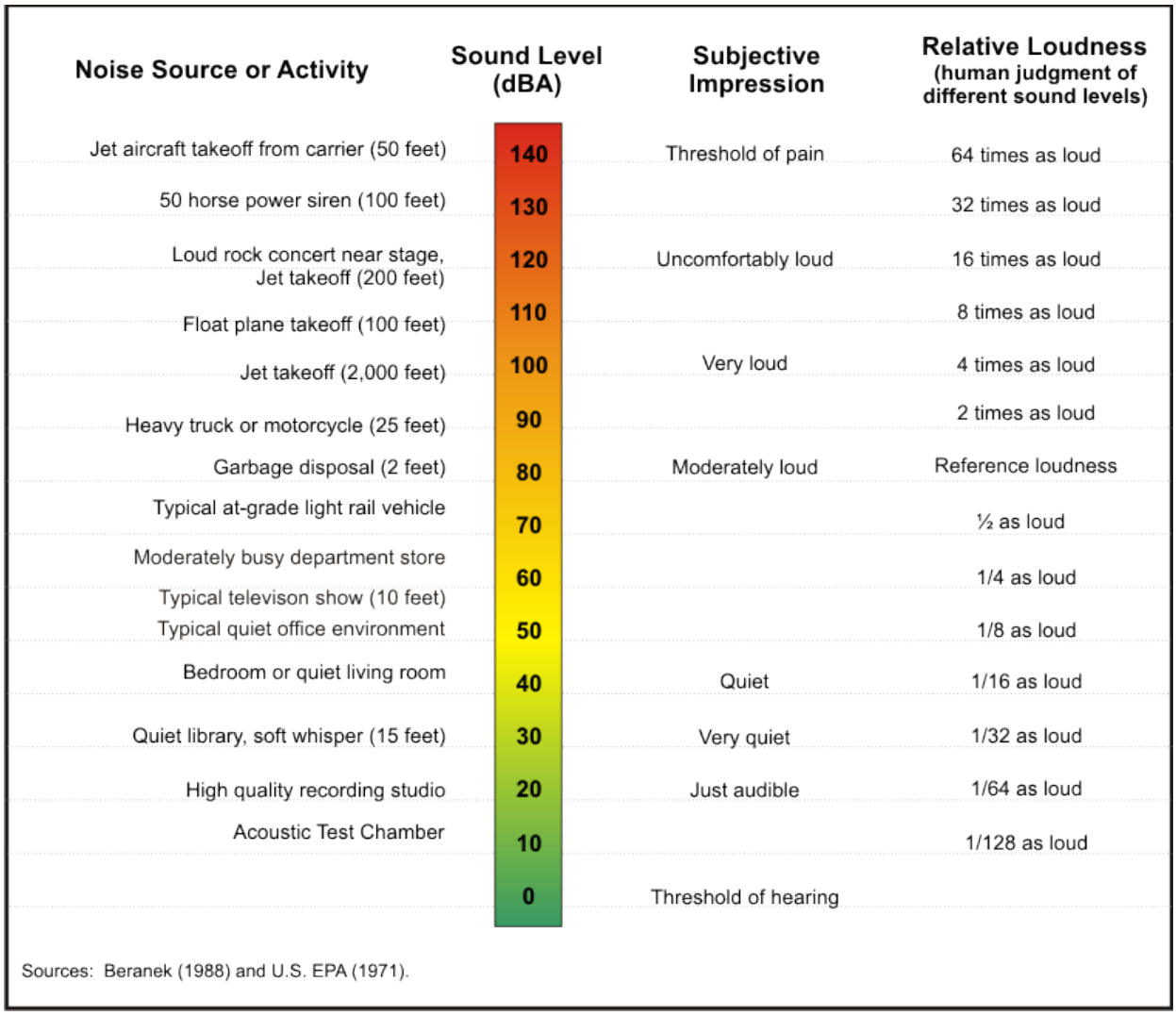


Table 3.11-2. FHWA Traffic Noise Abatement Criteria by Land Use Category

Activity Category	Hourly $L_{eq}(h)$ (dBA)	Description of Activity
A	57 (exterior)	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.
B	67 (exterior)	Residential (single and multifamily units).
C	67 (exterior)	Active sports areas, amphitheaters, auditoriums, campgrounds, cemeteries, day care centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playgrounds, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, recreation areas, Section 4(f) sites, schools, television studios, trails, and trail crossings.
D	52 (interior)	Auditoriums, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, schools, and television studios.

Activity Category	Hourly $L_{eq}(h)$ (dBA)	Description of Activity
E	72 (exterior)	Hotels, motels, offices, restaurants/bars, and other developed lands, properties or activities not included in A–D or F. Includes undeveloped land permitted for these activities.
F	N/A	Agriculture, airports, bus yards, emergency services, industrial logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, shipyards, utilities (water resources, water treatment, electrical), and warehousing
G	N/A	Undeveloped lands that are not permitted

Note: The noise abatement criteria for Categories B, C, and E also apply to undeveloped land with building permits.
Leq(h) = A-weighted (dBA) hourly equivalent steady state sound levels used for impact determination and are not design standards for abatement; N/A = not applicable

Construction Noise Criteria

In Washington, daytime construction noise is exempt from regulations in the Washington Administrative Code (WAC). Table 3.11-3 presents the WAC maximum allowable nighttime noise levels, above which the governing jurisdiction would require obtaining a noise variance. WAC noise control regulations apply to park-and-ride lots and transit stations (Table 3.11-3 and Table 3.11-4).

Table 3.11-3. Washington State Noise Control Regulation

Source of Noise	Receiver of Noise:[a] Residential	Receiver of Noise:[a] Commercial	Receiver of Noise:[a] Industrial
Residential	45	57	60
Commercial	47	60	65
Industrial	50	65	70

a Maximum allowable nighttime sound level in dBA. Sound level limits are based on measurements taken at the property lines of receiving properties.
dBA = A-weighted decibels

In addition to the noise standards listed in Table 3.11-3, there are exemptions for short-term noise exceedances, including those outlined in Table 3.11-4, based on the minutes per hour that the noise limit is exceeded.

Table 3.11-4. Washington State Exemptions for Short-Term Noise Exceedances

Statistical Descriptor [a]	Minutes Exceeded Per Hour	Adjustment to Maximum Sound Level
L_{25}	15 (25% of 1 hour)	+5 dBA
$L_{8.3}$	5 (8.3% of 1 hour)	+10 dBA
$L_{2.5}$	1.5 (2.5% of 1 hour)	+15 dBA

a L_{25}, $L_{8.3}$, and $L_{2.5}$ are the noise levels that are exceeded 25%, 8.3%, and 2.5% of the time (1 hour, in this case).
dBA = A-weighted decibels

Section 00292.32 of the ODOT Standard Specifications (Section 00292.32) includes construction noise abatement measures that apply to highway construction activities within Oregon. These abatement measures are considered mitigation and are discussed in Section 3.11.7.

Federal Transit Administration Noise Criteria

The FTA Transit Noise and Vibration Impact Assessment Manual provides FTA transit noise impact criteria applicable to noise generated by light-rail transit (FTA 2018). The FTA noise impact criteria identify the following noise-sensitive land use categories:

- **Category 1:** Buildings or parks where quiet is an essential element of their purpose.
- **Category 2:** Residences and buildings where people normally sleep. This includes residences, hospitals, and hotels where nighttime sensitivity is assumed to be of utmost importance.
- **Category 3:** Institutional land uses with primarily daytime and evening use. This category includes schools, libraries, churches, office buildings, and other commercial and industrial land uses.

Under these criteria, the degree to which transit operations are allowed to change the overall noise environment is reduced with increasing levels of existing noise. FTA's criteria include two impact levels, shown in Figure 3.11-3 and summarized below:

- **Severe Impact:** Project-generated noise in this range is likely to cause a high level of community annoyance. With severe impacts, alternative project alignments should be considered in an effort to avoid severe impacts.
- **Moderate Impact:** In this range, other project-specific factors must be considered to determine the magnitude of the impact and the need for mitigation. These other factors can include the predicted increase over existing noise levels, the types and number of noise-sensitive land uses affected, existing outdoor-indoor sound insulation, and the cost-effectiveness of mitigating noise to more acceptable levels.

No impact occurs when noise levels remain below the noise thresholds, which are dependent on land uses and existing noise levels.

Typically, state regulations are more stringent than FTA criteria, and in such cases, state regulations are used to estimate impacts from stationary noise sources. For example, the Oregon Department of Environmental Quality regulations were used to estimate impacts from the proposed expansion of the Ruby Junction Maintenance Facility and Hayden Island light-rail station (shown in Table 3.11-5). However, FTA criteria still apply and are used to determine noise impacts from stationary sources where there are no state or local noise regulations or where FTA criteria are more stringent.

Figure 3.11-3. Federal Transit Administration Transit Noise Impact Criteria

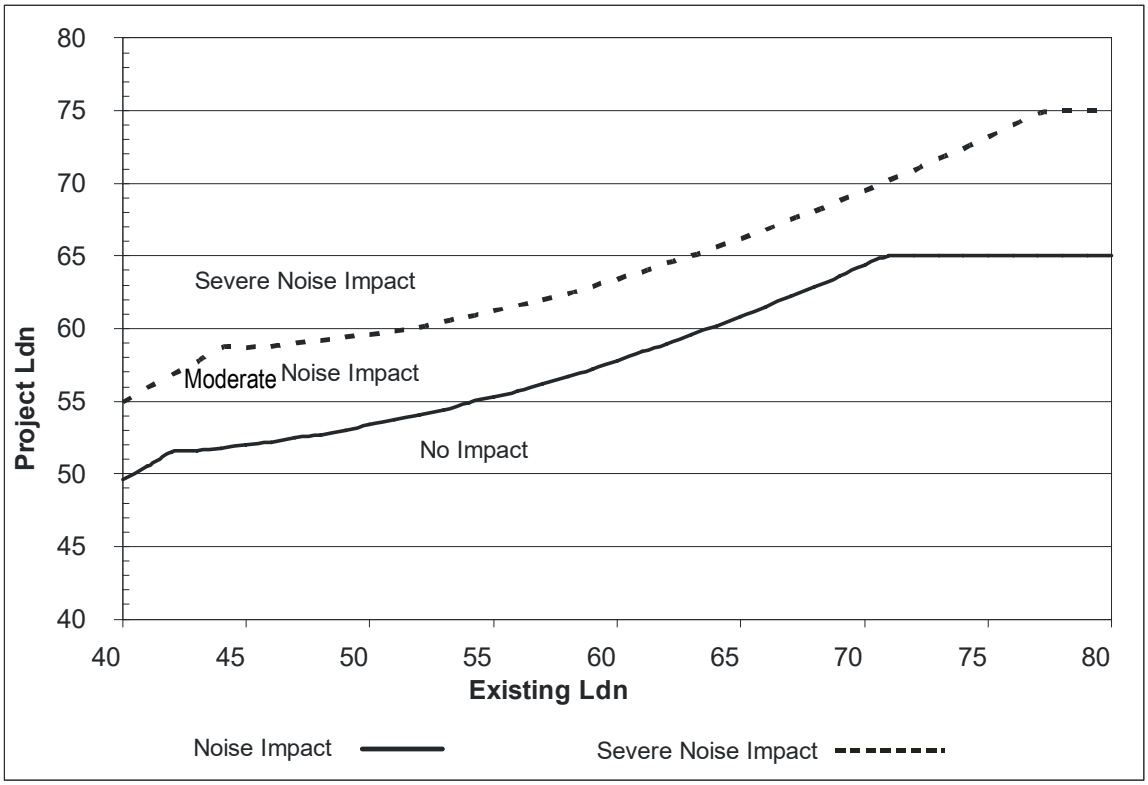


Table 3.11-5. Oregon Department of Environmental Quality Industrial and Commercial Noise Source Standards

Statistical Descriptor	Existing Noise Source (dBA): 7 a.m. to 10 p.m.	Existing Noise Source (dBA) 10 p.m. to 7 a.m.	New Noise Source (dBA): 7 a.m. to 10 p.m.	New Noise Source (dBA) 10 p.m. to 7 a.m.	New Source in Quiet Area (dBA) 7 a.m. to 10 p.m.	New Source in Quiet Area (dBA) 10 p.m. to 7 a.m.
L_1	75	60	75	60	60	55
L_{10}	60	55	60	55	55	50
L_{50}	55	50	55	50	50	45

Source: Oregon Administrative Rules 340-35-035, Tables 7, 8, and 9
a L_1, L_{10}, and L_{50} are the noise levels that are exceeded 1%, 10%, and 50% of the time (1 hour, in this case).
dBA = A-weighted decibels

City Noise Standards

In Portland, daytime construction noise up to 85 dBA is exempt, with additional exemptions for impact tools. From 7:00 p.m. to 7:00 a.m., and all day on Sundays, the City of Portland has restrictive noise regulations that apply to construction (City of Portland Municipal Code, Title 18, Noise Control). Under the noise control ordinance, virtually all major construction projects require a noise variance if work is planned during nighttime hours or on Sundays. Large projects typically require coordination with the City of Portland's Noise Review Board, which often imposes additional restrictions on construction.

The City of Vancouver has incorporated WAC noise regulations (Table 3.11-3 and Table 3.11-4) into the Vancouver Municipal Code (VMC). The City of Gresham has incorporated Oregon Department of Environmental Quality noise regulations (Table 3.11-5) into the Gresham Noise Control Code (Gresham Revised Code Article 7.20).

Understanding Vibration

How Vibration Levels Are Measured

Ground-borne vibration is a form of energy that travels from a source through the ground to another location. Two types of vibration were analyzed—vibration from the operation of the proposed light-rail extension and vibration from construction.

The severity of impact caused by vibration is related to its velocity and is discussed in terms of both inches per second and decibels, as appropriate. Velocity of vibration in decibels is noted as "VdB."

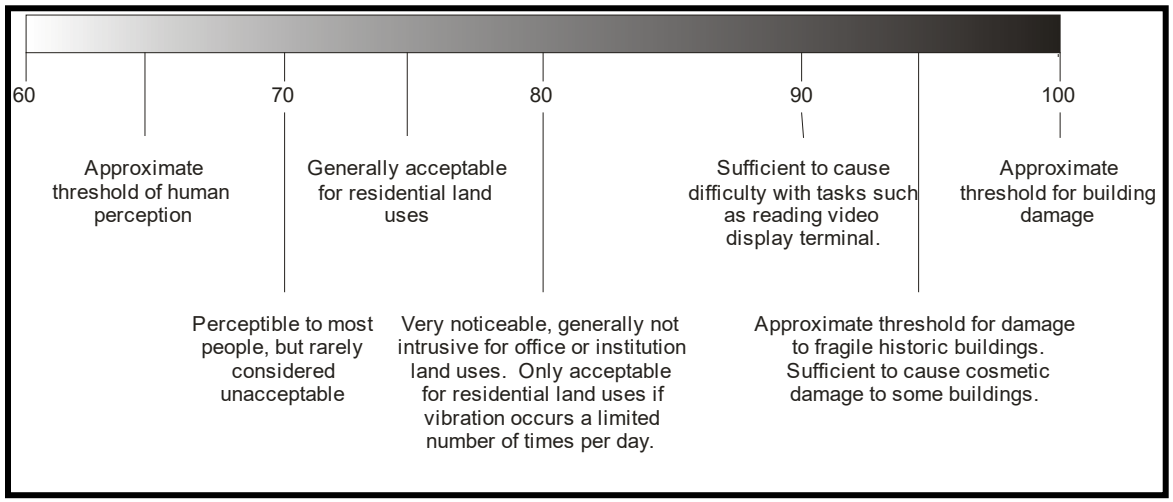
Ground-Borne Vibration vs. Ground-Borne Noise

The effects of ground-borne vibration include perceived movement of building floors, rattling of windows, or shaking of items on shelves. When ground-borne vibration creates a rumbling noise inside buildings, it is called ground-borne noise.

Typical Vibration Levels

Figure 3.11-4 gives a general idea of the effects of different levels of vibration on humans and buildings. Existing levels of building vibration from traffic and other local sources are usually in the range of 40 to 50 VdB, which is well below the range of human perception.

Figure 3.11-4. Human and Building Response to Ground-Borne Vibration Levels



Source: FTA 1995

Vibration Criteria and Analysis Methods

Vibration Criteria

FTA has developed impact criteria for acceptable levels of both ground-borne vibration and ground-borne noise that apply to light-rail transit.

Table 3.11-6 summarizes FTA's impact criteria for most buildings. Some buildings, such as concert halls, TV and recording studios, and theaters, can be very sensitive to ground-borne vibration and ground-borne noise but do not fit into the three categories shown in Table 3.11-6. Because of the sensitivity of these buildings, the

FTA has developed ground-borne vibration and ground-borne noise criteria for "special buildings," shown in Table 3.11-7.

Table 3.11-6. FTA Ground-Borne Vibration and Noise Impact Criteria

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

a "Frequent Events" is defined as more than 70 vibration events per day. Most rapid transit projects fall into this category.
b "Infrequent Events" is defined as fewer than 70 vibration events per day. This category includes most commuter-rail systems.
c This criterion limit is based on levels that are acceptable for most moderately sensitive equipment such as optical microscopes. Vibration-sensitive manufacturing or research equipment would require detailed evaluation to define the acceptable vibration levels. Ensuring lower vibration levels in a building often requires special design of the heating, ventilation, and air-conditioning system and stiffened floors.
d Vibration-sensitive equipment is generally not sensitive to ground-borne noise.
dBA = A-weighted decibels; N/A = not applicable; VdB = vibration in decibels

Table 3.11-7. Ground-Borne Vibration and Noise Impact Levels for Special Buildings

Type of Building or Room	Ground-Borne Vibration Impact Levels Frequent [a] Events	Ground-Borne Vibration Impact Levels: Occasional or Infrequent [b] Events	Ground-Borne Noise Impact Levels: Frequent [a] Events	Ground-Borne Vibration Impact Levels: Occasional or Infrequent [b] Events
Concert Halls	65 VdB	65 VdB	25 dBA	25 dBA
TV Studios	65 VdB	65 VdB	25 dBA	25 dBA
Recording Studios	65 VdB	65 VdB	25 dBA	25 dBA

Type of Building or Room	Ground-Borne Vibration Impact Levels Frequent [a] Events	Ground-Borne Vibration Impact Levels: Occasional or Infrequent [b] Events	Ground-Borne Noise Impact Levels: Frequent [a] Events	Ground-Borne Vibration Impact Levels: Occasional or Infrequent [b] Events
Auditoriums	72 VdB	80 VdB	30 dBA	38 dBA
Theaters	72 VdB	80 VdB	35 dBA	43 dBA

Note: If the building will rarely be occupied when the trains are operating, there is no need to consider impacts. As an example, consider locating a commuter-rail line next to a concert hall. If no commuter trains will operate after 7 p.m., the trains would rarely interfere with the use of the hall.

a "Frequent Events" is defined as more than 70 vibration events per day. Most rapid transit projects fall into this category.

b "Infrequent Events" is defined as fewer than 70 vibration events per day. This category includes most commuter-rail systems.

dBA = A-weighted decibels; VdB = vibration in decibels

City Vibration Standards

The City of Portland (Chapter 33.262, Off-Site Impacts) restricts continuous, frequent, or repetitive vibrations that exceed a 0.002 gravitational constant peak. Vibrations from temporary construction and vehicles that leave the site (such as trucks, trains, airplanes, and helicopters) are exempt. Vibrations lasting less than 5 minutes per day are also exempt. Vibrations from primarily on-site vehicles and equipment are not exempt.

The City of Gresham does not regulate vibration.

The City of Vancouver has incorporated vibration regulations into the VMC, including prohibiting off-site vibration impacts that are discernible without instruments at the property line. This prohibition would apply to all nighttime construction activities and the operation of light-rail stations and park-and-ride lots. Construction activity between the hours of 7 a.m. and 8 p.m. is exempt from these vibration regulations. The operations of public streets and sidewalks, rail maintenance yards, and essential public facilities, such as the interstate highway system, are exempt from these regulations 24 hours a day.

Existing Noise Levels in the Study Area

Traffic noise levels were modeled at 875 locations representing approximately 1,204 noise-sensitive land uses within the study area. For the light-rail transit analysis, noise levels were modeled at 16 locations representing 52 noise-sensitive land uses. Some of the modeling locations used for the traffic noise analysis were also used for the transit analysis. Each of these locations has one or more noise receptors that constitute sensitive land uses, such as a residence, historic buildings, hotel, motel, or park (see sidebar). Existing outdoor noise levels range from 49 to 75 dBA L_{eq}, with 24-hour L_{dn} noise levels ranging from 53 to 75 dBA.

Overall, noise levels in the study area are dominated by traffic on I-5. The year 2019 was used for existing conditions because it aligns with the traffic study completed for the IBR Program. Under existing conditions (2019), an estimated 160 noise-sensitive land uses approach or exceed the applicable traffic noise criteria in the study area. This includes single-family and multifamily residences, along with several hotels, parks, schools, and a cemetery. Of the existing noise-sensitive land uses that exceed applicable noise criteria levels, 50 are in Portland and 110 are in Vancouver. The Noise and Vibration Technical Report provides the existing modeled locations and noise levels for each subarea summarized below.

What are noise-sensitive receptors and residential equivalents?

A noise-sensitive receptor is a property where frequent exterior human use occurs and where a lower noise level would be beneficial. The nuisance level for traffic noise is perceived differently by people depending on the situation. For instance, roadway noise may not bother people walking to a commercial establishment but may disturb people at a backyard pool or while they are sleeping. Residential equivalency is a measurement of the amount of use at special sites such as schools, parks, churches, and hospitals.

Portland Existing Modeled Traffic Noise Levels

Current noise levels approach or exceed the ODOT Noise Abatement Approach Criteria (NAAC) at 50 locations adjacent to I-5, including approximately 19 floating homes, with noise levels of 65 to 69 dBA L_{eq}. Existing noise levels at multilevel apartment units located along N Marine Drive also approach or exceed the ODOT NAAC. These apartment units have private outdoor patios facing N Marine Drive, with noise levels ranging from 65 to 71 dBA L_{eq}.

Downtown Vancouver Existing Modeled Traffic Noise Levels

The analysis of noise levels in downtown Vancouver focuses on I-5, SR 14, and associated ramps. The traffic noise model also includes local streets that influence noise in the study area. Currently, 37 noise-sensitive sites approach or exceed the WSDOT noise abatement criteria (NAC), primarily due to I-5 traffic noise. Locations that would undergo noise impacts are mostly clustered at apartment buildings located just southwest of the I-5/E Mill Plain Boulevard interchange, C Street and E 7th Street, and a newly constructed building along Washington Street between West 4th and West 5th Streets.

Fort Vancouver Existing Modeled Traffic Noise Levels

At the Vancouver National Historic Reserve (VNHR), including the Fort Vancouver National Historic Site and nearby areas, noise levels currently range from 52 to 75 dBA L_{eq}, with the highest levels at unshielded areas along I-5 and SR 14. Currently, six modeled locations along the Fort Vancouver Park Trail and Confluence Land Bridge Trail within the Fort Vancouver Historic District, and three modeled locations along the Waterfront Renaissance Trail approach or exceed the WSDOT NAC.

Vancouver East Existing Modeled Traffic Noise Levels

East of I-5 and north of E Mill Plain Boulevard, noise levels currently range from 49 to 73 dBA L_{eq}, with the highest levels at residences not located behind existing noise walls north of E Fourth Plain Boulevard. Currently, 16 modeled locations at residences and one modeled location at Marshall Park approach or exceed the WSDOT NAC.

Vancouver West Existing Modeled Traffic Noise Levels

West of I-5 and north of E Mill Plain Boulevard, current noise levels range from 49 to 75 dBA L_{eq}, with the highest levels at residences located close to I-5 both north and south of E 39th Street. Currently, noise levels at 42 residences, Kiggins Bowl, Discovery Middle School, and two offices approach or exceed the WSDOT NAC.

Existing Noise Levels for Light-Rail Transit Analysis

Existing noise level data for the light-rail analysis were taken from on-site measurements and following methods in the FTA Transit Noise and Vibration Manual. Locations in the transit corridor that were used for the traffic noise analysis were also used for the light-rail analysis. The noise levels provided represent primarily residential uses, with some uses such as hotels that include overnight sleeping. Existing noise levels ranged from 69 to 77 L_{eq} and 77 to 83 L_{dn} in downtown Vancouver; from 58 to 73 L_{eq} and 66 to 81 L_{dn} at sites in north Portland; and from 69 to 71 L_{eq} and 67 to 70 L_{dn} in the area around the Ruby Junction Maintenance Facility.

3.11.3 Long-Term Effects

No-Build Alternative

Under existing conditions (2019), there are approximately 160 traffic noise impacts to noise-sensitive land uses; that number would rise to 215 under the No-Build Alternative (2045). Background traffic growth would cause an increase in traffic noise levels throughout the study area. Under the No-Build Alternative, routine maintenance of the existing noise walls in Vancouver would occur, but no new noise walls would be constructed. Under the No-Build Alternative), none of transit improvements associated with the IBR Program would occur, so there would be no new transit noise or vibration impacts from the Program.

This analysis does not address vibration levels associated with the No-Build Alternative because no new source of vibration is anticipated under the No-Build Alternative.

Portland Modeled Traffic Noise Levels

Forty-nine of the 50 receptors where existing noise levels approach or exceed the ODOT NAAC are predicted to continue to approach or exceed the ODOT traffic noise criteria under the No-Build Alternative (2045). In addition to these 49 receptors, it is predicted that traffic noise levels at 15 more locations near I-5 and N Marine Drive will approach or exceed the ODOT traffic noise criteria under the No-Build Alternative. Noise levels under the No-Build Alternative would range from 45 to 70 dBA L_{eq} with a 1 to 2 dBA increase over existing conditions at most locations due to an increase in traffic volumes.

Under the No-Build Alternative, noise levels at the estimated 19 floating homes that currently experience noise impacts, and an additional 10 floating homes, are predicted to approach or exceed the ODOT NAAC with noise levels of 65 to 69 dBA $L_{eq.}$ At most locations, noise levels would increase by 1 to 2 dBA due to an increase in traffic volumes in 2045. Most of the remaining traffic noise levels above the ODOT NAAC are located at the apartment complexes along N Marine Drive. Under the No-Build Alternative noise levels are predicted to exceed the ODOT NAAC at the same 30 apartments under the existing conditions and an additional four apartments within the Newport Apartment complex (Noise and Vibration Technical Report, Table 4-1), with

levels ranging from 49 to 70 dBA L_{eq}. Most locations are predicted to experience an increase of 1 to 2 dBA over existing noise levels. Traffic noise levels under the No-Build Alternative also approach or exceed the ODOT NAAC at one commercial property.

Downtown Vancouver Modeled Traffic Noise Levels

Under the No-Build Alternative, traffic noise levels in downtown Vancouver are predicted to approach or exceed the WSDOT traffic noise criteria at the same 37 multifamily residences and trail as under the existing conditions, and at five additional residential units and one additional trail use (see the Noise and Vibration Technical Report, Table 4-3). No-Build Alternative noise levels would range from 51 to 73 dBA L_{eq}. Compared to existing conditions, noise levels would increase 1 to 7 dBA, with most modeled locations showing an increase of 1 to 2 dBA. Increases in noise levels would result from an increase in traffic volumes from existing conditions to the year 2045. The highest predicted noise level under the No-Build Alternative would be 73 dBA L_{eq} at the apartments under construction at 400 Washington Street.

Fort Vancouver Modeled Traffic Noise Levels

Noise levels at the VNHR under the No-Build Alternative are projected to range from 53 to 76 dBA L_{eq}, with the highest levels at unshielded areas along I-5 and SR 14. In general, noise levels are predicted to increase by 1 to 2 dBA over existing conditions within the VNHR due to an increase in traffic volumes. Currently, noise levels within the Fort Vancouver Historic District along the Fort Vancouver Trail and Confluence Land Bridge Trail, and along the Waterfront Renaissance Trail located outside the Fort Vancouver Historic District, approach or exceed the WSDOT NAC. Under the No-Build Alternative, the same sites would continue to approach or exceed the WSDOT NAC, with two additional trail use locations in the Fort Vancouver Historic District and one Historic District/office location exceeding the WSDOT NAC (see the Noise and Vibration Technical Report, Table 4-5).

North Vancouver, East of I-5 Modeled Traffic Noise Levels

Future noise levels under the No-Build Alternative at the modeling locations in this area of north Vancouver east of I-5 and north of E Mill Plain Boulevard ranged from 50 to 74 dBA L_{eq}, an increase of 1 to 3 dBA over existing noise levels. These increases are due to an increase in traffic volumes from existing conditions to the year 2045. Currently, 17 locations approach or exceed the WSDOT NAC. Under the No-Build Alternative, 30 locations approach or exceed the WSDOT NAC (Noise and Vibration Technical Report, Table 4-7). Noise levels do not approach or exceed the WSDOT NAC at the hospital, church, or cemeteries located in this subarea, but they do exceed the criteria at 25 residences and at athletic fields and other outdoor-use areas at Marshall Park.

North Vancouver, West of I-5 Modeled Traffic Noise Levels

Future No-Build Alternative noise levels at the modeling locations in this subarea north of Mill Plain Boulevard to Discovery Middle school range from 50 to 76 dBA L_{eq}, an increase of 1 to 3 dBA over existing noise levels. These increases are due to an increase in traffic volumes from existing conditions to the year 2045. Under the No-Build Alternative, the number of residences with noise levels that would approach or exceed the WSDOT NAC is predicted to increase from the current 47 locations to 65. The same locations predicted to reach the WSDOT NAC under existing conditions would also exceed the WSDOT NAC under the No-Build Alternative, along with 18 additional residences and two additional use areas at the Kiggins Bowl, one outdoor use at Discovery Middle School, and two offices (see the Noise and Vibration Technical Report, Table 4-9).

Modified LPA

Without mitigation, traffic noise impacts under the Modified LPA are expected to increase compared to existing conditions due to an increase in future traffic volumes and shift in roadway alignments. Compared to the No-Build Alternative, the Modified LPA without mitigation would be expected to have fewer traffic noise

impacts due to program acquisitions near the new Columbia River bridge alignment. Program acquisitions for the future Columbia River bridge alignment include houseboats located between Hayden Island and the Oregon mainland. Without mitigation, traffic noise impacts under the Modified LPA would occur at 198 residential equivalents. The Modified LPA, with mitigation, would replace existing noise walls in Vancouver with new noise walls as necessary for project construction. All existing noise walls that would be replaced in-kind (i.e., no changes to wall length or height) are evaluated as part of this analysis (see the Noise and Vibration Technical Report, Section 7).

Figure 3.11-5 through Figure 3.11-11 show the modeled noise impacts of the Modified LPA at locations within the study area. Potential changes in noise and vibration levels and effects for the design options were evaluated qualitatively by reviewing design changes in relation to the Modified LPA. Results from the noise analysis conducted for individual historic properties are discussed in Section 3.8, Cultural Resources.

Table 3.11-8 summarizes the major differences in impacts and benefits across the Modified LPA's bridge configurations, the one-auxiliary-lane and two-auxiliary-lane options, and the No-Build Alternative. The design options are discussed qualitatively for comparative purposes.

Table 3.11-8. Noise and Vibration Impacts and Benefits for the Modified LPA Bridge Configurations and Auxiliary Lane Options and No-Build Alternative

Modified LPA Bridge Configuration and Auxiliary Lane Design Option and No-Build Alternative	Noise and Vibration Impacts
Modified LPA with Double-Deck Fixed-Span Configuration and One Auxiliary Lane	• Without mitigation, the number of traffic noise impacts would be lower (198) in 2045 than under the No-Build Alternative due to the Program's acquisitions of houseboats located near the Columbia River bridge alignments. • With mitigation, existing noise walls in Vancouver would be replaced as necessary for project construction, which would reduce the number of traffic noise impacts to 121. • Transit vibration impacts would occur at 13 receptors in downtown Vancouver, including a 12-unit apartment complex located at E 7th Street and E C Street and a movie theater located at E 8th Street and E C Street.
Modified LPA with Single-Level Fixed-Span Configuration and One Auxiliary Lane	Similar noise and vibration impacts to the Modified LPA with the double-deck fixed-span bridge configuration, except: • Minor increases in highway noise (0 to 4 dBA at the closest noise-sensitive uses) and highway noise impacts east and west of the bridges as a result of the wider bridge spans (99 feet wider) and lower roadway deck (29 feet lower). • Users on the shared-use path across the Columbia River bridges would have less shielding and more exposure to noise from highway vehicles. • Transit vibration levels would increase for houseboats at Jantzen Beach and in downtown Vancouver due to the westward shift of the light-rail alignment from the increased width of the bridges over the Columbia River.
Modified LPA with Single-Level Movable-Span Configuration and One Auxiliary Lane	• Similar noise and vibration impacts to the single-level fixed-span configuration due to the similarity in noise source locations and distance to noise-sensitive receptors.

Modified LPA Bridge Configuration and Auxiliary Lane Design Option and No-Build Alternative	Noise and Vibration Impacts
Modified LPA with Double-Deck Fixed-Span Configuration and Two Auxiliary Lanes	Transit vibration impacts would be the same as for Modified LPA with one auxiliary lane. Traffic noise impacts before and after mitigation would be similar to the Modified LPA with one auxiliary lane, except: • Slight differences in noise levels (0 to 2 dBA at the noise-sensitive uses closest to the bridges: Sites PD-036, PD-037, DT-030 to DT-032, FV-048 to FV-052, and FV-071) are anticipated because the second auxiliary lane would bring traffic approximately 16 feet closer to noise-sensitive land uses located east and west of I-5.
No-Build Alternative	• 215 receptors would exceed highway noise thresholds. • No receptors would have moderate or severe transit noise impact levels. • No vibration impacts without the extension of light-rail.

dBA = A-weighted decibels; LPA = Locally Preferred Alternative

Figure 3.11-5. Modified LPA with Double-Deck Fixed-Span Configuration and One Auxiliary Lane – 2045 Traffic Noise Impacts – Portland Mainland

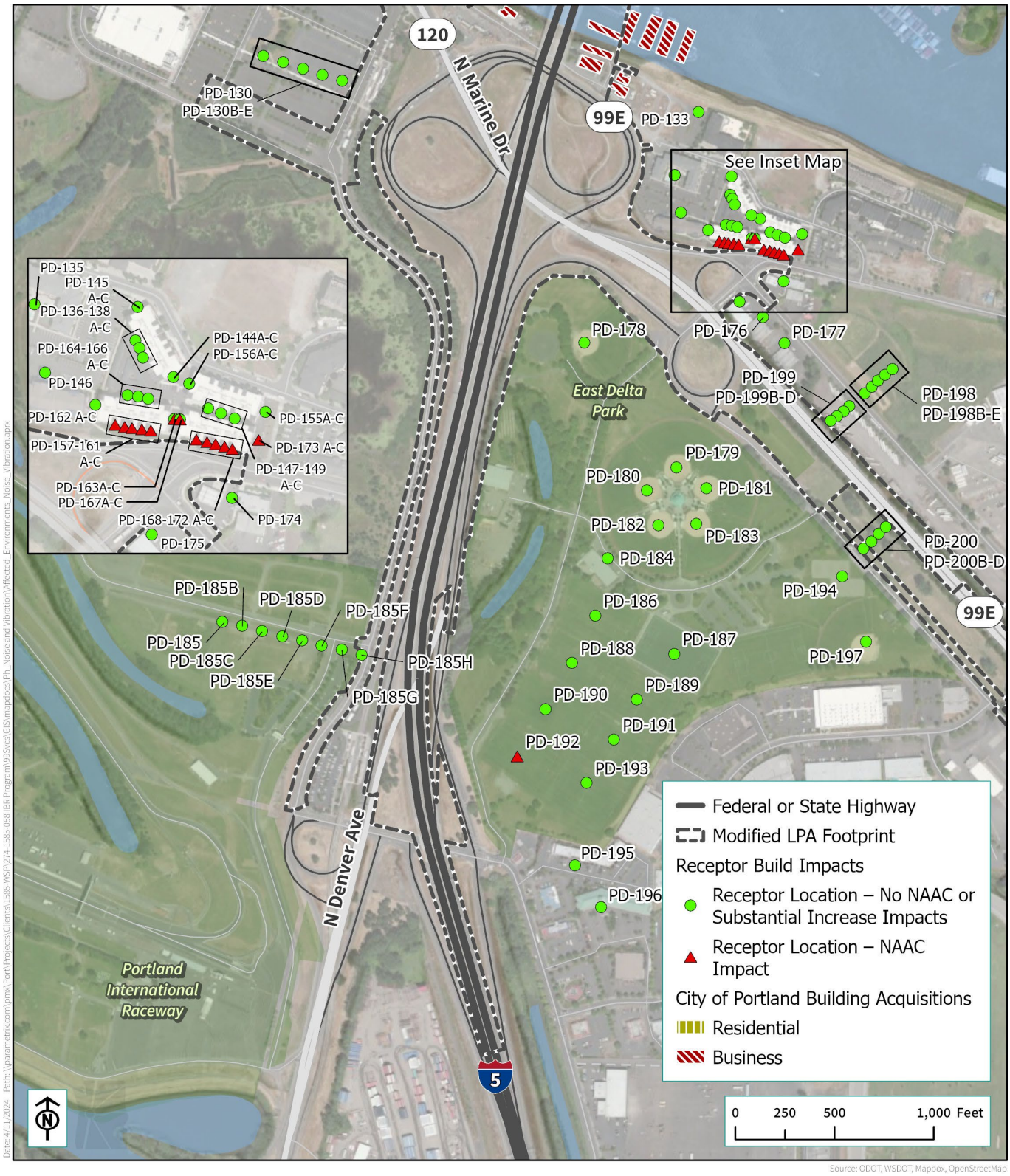


Figure 3.11-6. Modified LPA with Double-Deck Fixed-Span Configuration and One Auxiliary Lane – 2045 Traffic Noise Impacts – Portland/Hayden Island

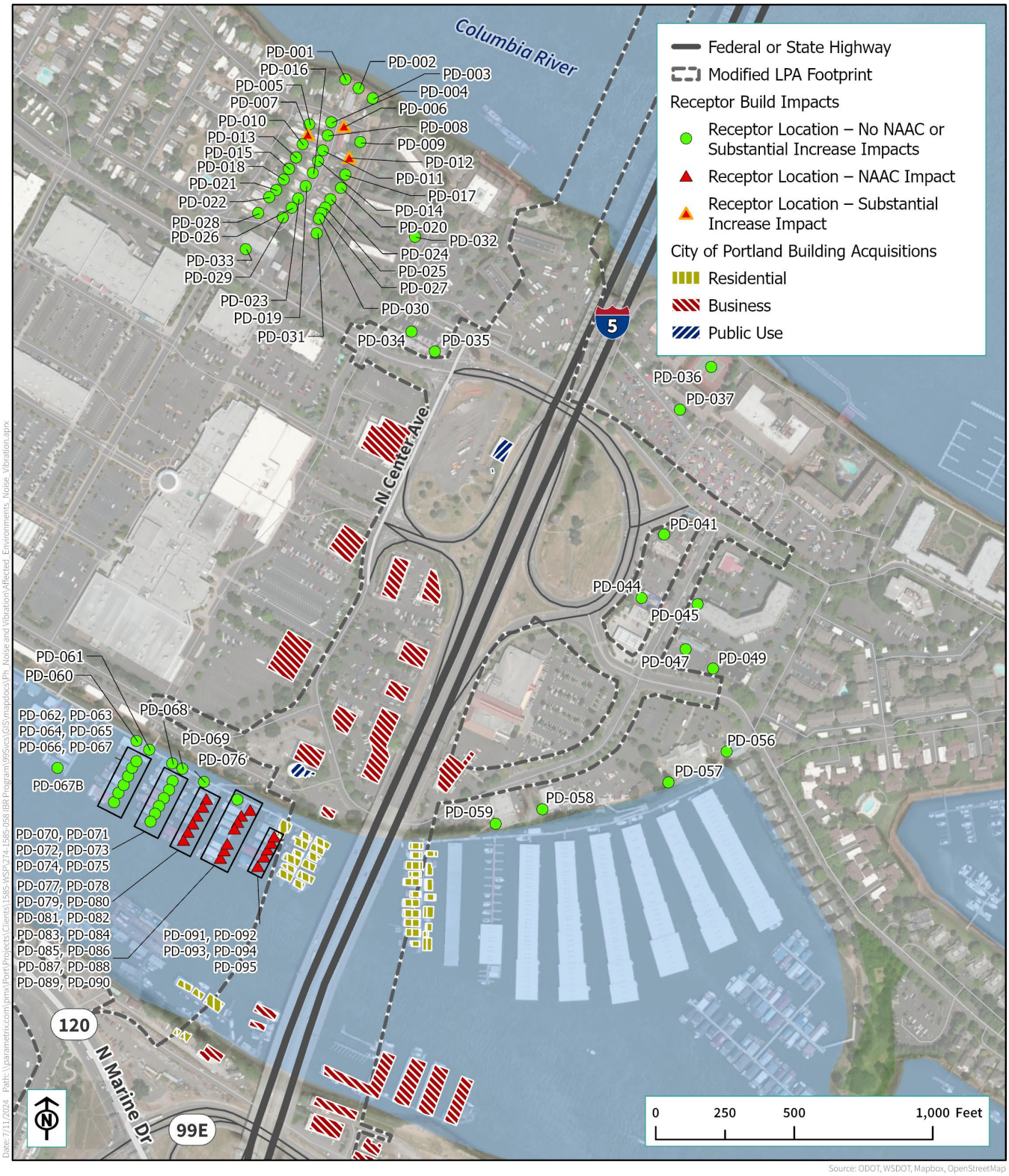


Figure 3.11-7. Modified LPA with Double-Deck Bridge Fixed-Span Configuration and One Auxiliary Lane – 2045 Traffic Noise Impacts – I-5/SR 14 Interchange

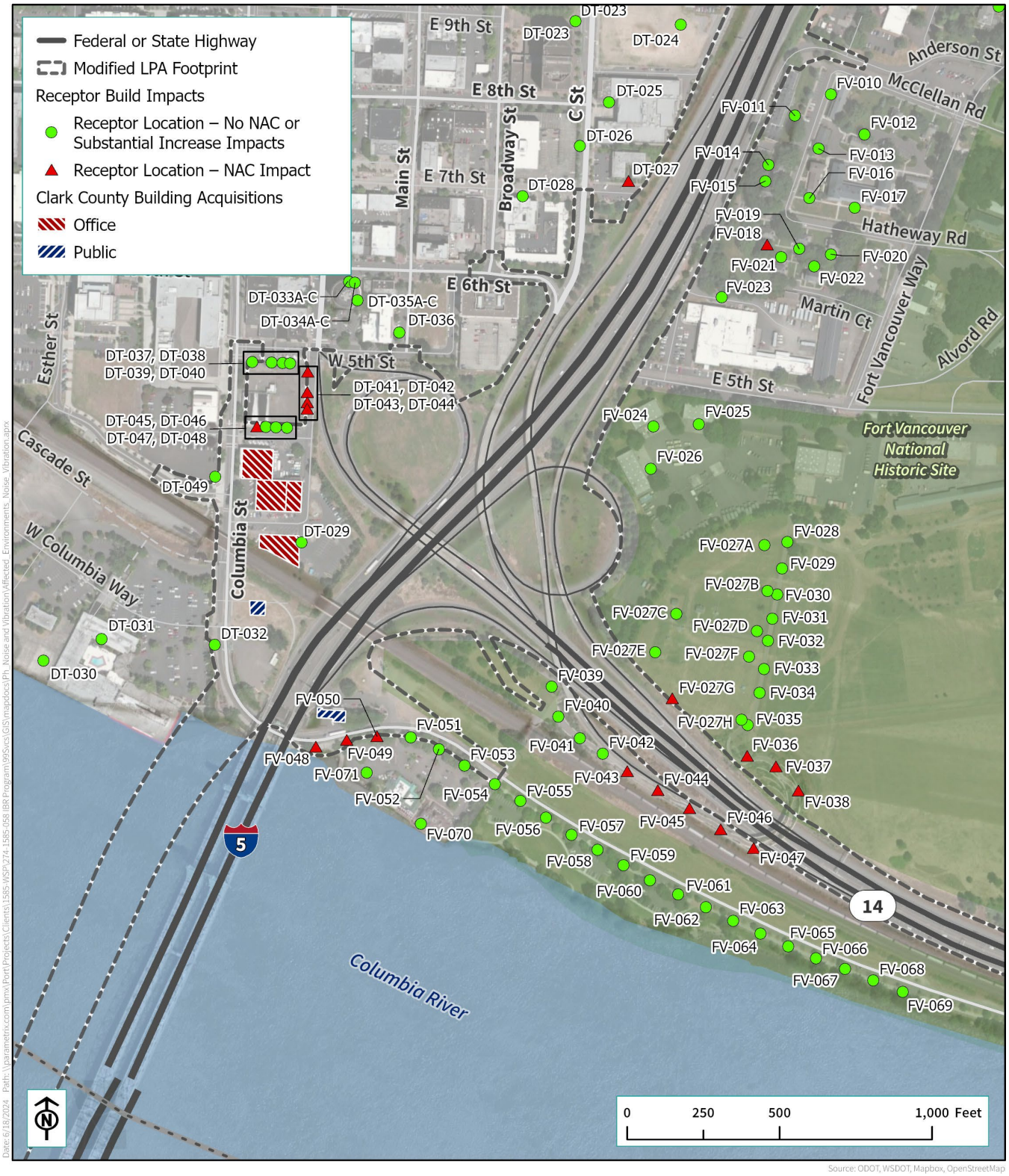


Figure 3.11-8. Modified LPA with Double-Deck Fixed-Span Configuration and One Auxiliary Lane – 2045 Traffic Noise Impacts – E 8th Street to McLoughlin Boulevard

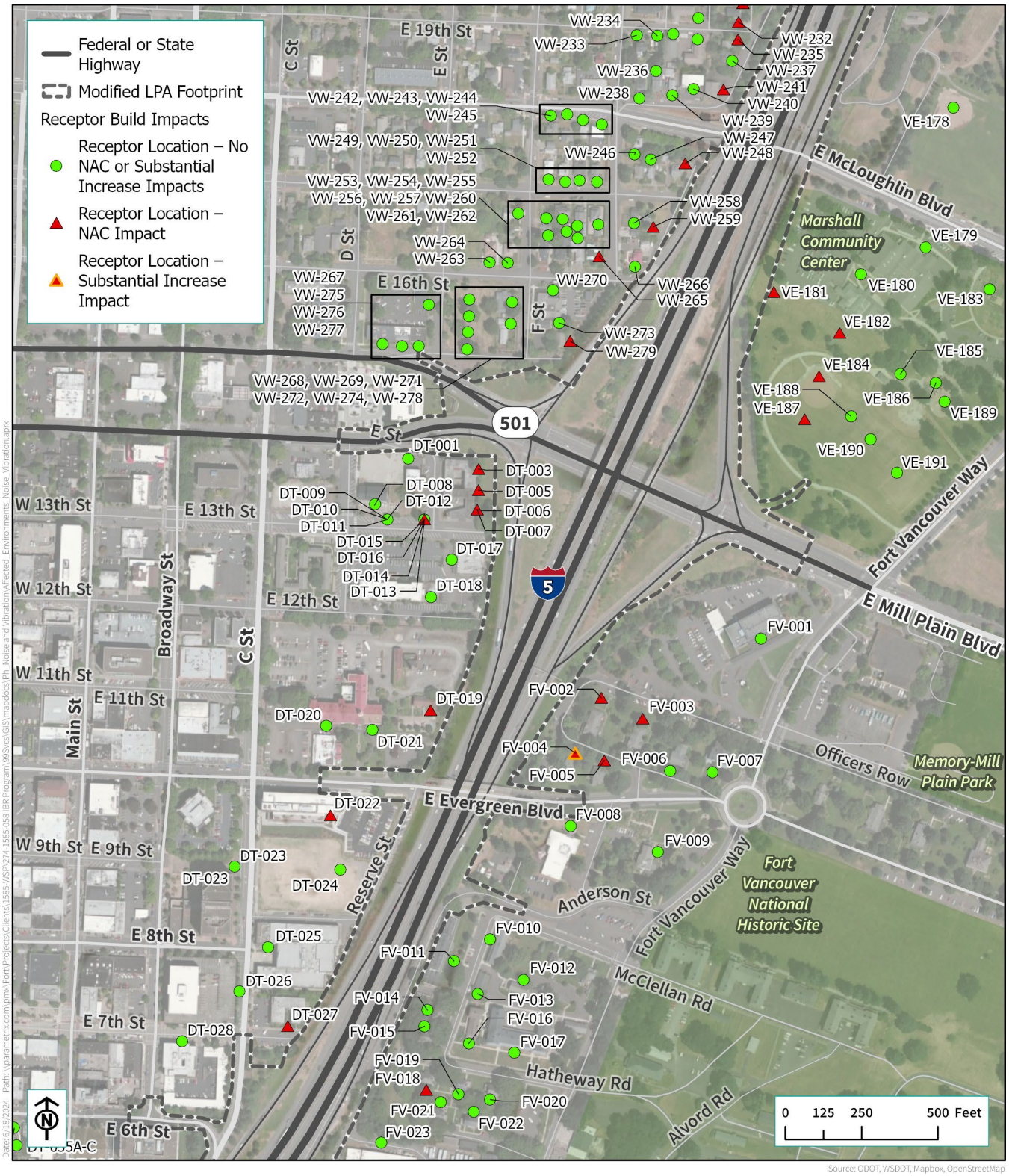


Figure 3.11-9. Modified LPA with Double-Deck Fixed-Span Configuration and One Auxiliary Lane – 2045 Traffic Noise Impacts – McLoughlin Boulevard to E 30th Street

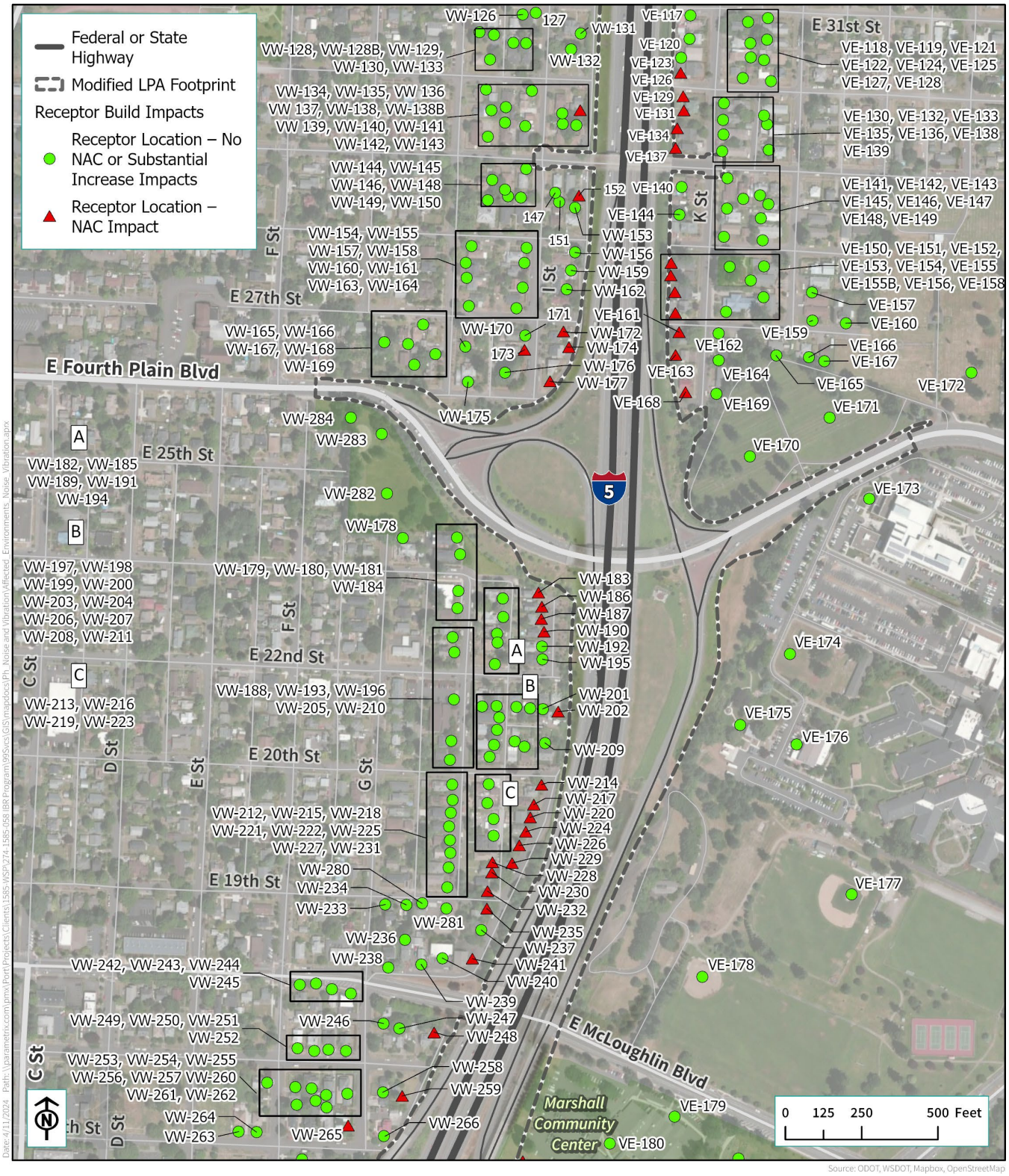


Figure 3.11-10. Modified LPA with Double-Deck Fixed-Span Configuration and One Auxiliary Lane – 2045 Traffic Noise Impacts – E 30th Street to E 39th Street

Figure 3.11-11. Modified LPA with Double-Deck Fixed-Span Configuration and One Auxiliary Lane – 2045 Traffic Noise Impacts – E 39th Street to Terminus

Portland/Hayden Island - Modified LPA Modeled Traffic Noise Levels

Under the Modified LPA with the double-deck fixed-span bridge configuration and one auxiliary lane, noise levels at modeled locations in Portland would range from 49 to 71 dBA L_{eq}. Most locations would experience an increase of 2 to 4 dBA over existing conditions, with increases of up to 11 dBA at one location, site PD-007, which represents one mobile home in the Jantzen Beach recreational vehicle (RV) park on Hayden Island. Noise levels would be 2 dBA above to 2 dBA below noise levels under the No-Build Alternative, at most locations.

The greatest increase in noise levels under the Modified LPA, with any of the design options, is predicted at the Jantzen Beach RV park, located at the north end of Hayden Island and west of I-5. Noise levels in this area are predicted to increase 4 to 11 dBA over existing conditions and 4 to 10 dBA above No-Build Alternative noise levels; this is because the Modified LPA, with any of the design options, would shift the alignment of I-5 closer to homes at the RV park. While noise levels would increase at all of the RV homes, as shown in Figure 3.11-6 the modeling showed that three of the RV homes may experience a substantial noise increase (defined as an increase of 10 dBA or greater). An existing block wall at the RV park and a nearby hotel building provides some shielding against noise, as modeled. Noise levels under the Modified LPA, with any of the design options would not approach or exceed ODOT's NAAC impact criteria at the RV park; however, the increase in noise levels would meet the threshold of 10 dBA over existing noise levels, making this a substantial increase.

Other areas that are predicted to undergo ODOT NAAC impacts include the floating homes in North Portland Harbor (sites PD-077 to PD-082, PD-084 to PD-095), the apartments located closest to N Marine Drive (PD-157 to PD-161A-C, PD-163A-C, PD-167A-C, PD-168A-C to PD-172A-C, and PD-172A-C), and one soccer field (PD-192) at Delta Park. In the area between Hayden Island and the Oregon mainline, the IBR Program would acquire 34 floating homes to allow for the new Columbia River bridge alignment. Due to this acquisition, the Modified LPA with the double-deck fixed-span bridge configuration and one auxiliary lane would result in fewer sites predicted to undergo an increase in noise than under the No-Build Alternative. Displaced homes are represented by modeled sites PD-096 to PD-127, and PD-129. As shown in Figure 3.11-6, the floating homes at the end of the dock (represented by modeled sites PD-076 and PD-083) experience additional noise shielding from the existing terrain and would not be subject to an NAAC impact. In addition to the floating home displacements, modeled sites PD-038, PD-039, PD-040, PD-042, PD-043, PD-046, PD-048, PD-050 to PD-055, PD-128, PD-131, and PD-132, which represent several commercial businesses and restaurants on N Center Avenue, would be displaced.

The Modified LPA with the double-deck fixed-span bridge configuration and one auxiliary lane would approach or exceed the ODOT NAAC at 62 locations. A substantial increase impact of 10 dBA over existing noise levels is predicted at three residences located at the Jantzen Beach RV park. Figure 3.11-5 and Figure 3.11-6 show the location of each traffic noise impact under the Modified LPA in Portland.

Downtown Vancouver - Modified LPA Modeled Traffic Noise Levels

In downtown Vancouver, traffic noise levels under the Modified LPA with the double-deck fixed-span bridge configuration and one auxiliary lane would approach or exceed the WSDOT NAC at the same 37 multifamily residences as existing conditions and at an additional four residences—one fewer than the No-Build Alternative. Traffic noise levels would approach or exceed the NAC at one office and one outdoor-use area at the Vancouver Community Library. Noise levels would range from 51 to 74 dBA L_{eq}, with noise levels within 1 dBA of existing conditions at most locations, and within a range of -1 to 6 dBA compared to existing noise levels where roadway alignment shifts closer to or further from noise receptor locations. At one undeveloped property along Columbia Street (DT-049), noise levels would be 12 dBA higher than existing conditions.

Noise levels resulting from the Modified LPA with the double-deck fixed-span bridge configuration and one auxiliary lane would be within 3 dBA of No-Build Alternative noise levels at most locations. Where roadways

would be closer to or further from noise receptor locations, the change in traffic noise levels would range from -8 to 8 dBA compared to the No-Build Alternative. The highest noise levels under Modified LPA with the double-deck fixed-span bridge configuration and one auxiliary lane would be 74 dBA L_{eq}, predicted to occur outside a building used as office and commercial space (DT-019) located north of E Evergreen Boulevard. In downtown Vancouver, no substantial noise level increases would occur. Figure 3.11-7 and Figure 3.11-8 show the location of each traffic noise impact under the Modified LPA with the double-deck fixed-span bridge configuration and one auxiliary lane in downtown Vancouver.

Compared to the Modified LPA with the double-deck fixed-span bridge configuration, one auxiliary lane and with the C Street ramps, the elimination of C Street ramps at the SR 14 interchange would result in a minor change in traffic noise levels below the common threshold of human hearing (0 to 2 dBA). This difference is due to the removal of these roadways, which would shift traffic to other roadways in the area. Compared to the Modified LPA with the double-deck fixed-span bridge configuration, one auxiliary lane, and centered I-5 mainline, the westward shift of the I-5 mainline would also shift traffic noise to the west but would result in a barely perceptible increase (2 to 3 dBA) in traffic noise levels west of I-5 near the southbound mainline and ramps. The I-5 mainline westward shift would require two additional acquisitions located east of C Street between E 7th Street and E 8th Street. One of these buildings houses commercial businesses, including a restaurant (DT-025), a theater, and a salon, and the other is an apartment building (DT-027). The design option of a centered I-5 mainline would result in traffic noise levels above the impact criteria at the apartment building, while the design option to shift the I-5 mainline west would acquire this noise-sensitive land use and thus exclude it from the total number of noise impacts.

Fort Vancouver - Modified LPA Modeled Traffic Noise Levels

The Modified LPA with the double-deck fixed-span bridge configuration and one auxiliary lane would result in the same WSDOT NAC exceedances as the No-Build Alternative at Fort Vancouver trails, one Fort Vancouver Historic Village site, and one of four offices. In the VNHR, noise levels would be above the WSDOT NAC at two residences and four total offices, with outdoor noise levels at one of the two offices predicted to experience a substantial increase of 10 dBA over existing conditions. Noise levels would range from 54 to 75 dBA L_{eq}, with a decrease of 2 dBA below existing conditions at Old Apple Tree Park and nearby trail and an increase of up to 10 dBA over existing conditions at one Fort Vancouver office, represented by site FV-004. Compared to the No-Build Alternative, traffic noise levels under the Modified LPA with the double-deck fixed-span bridge configuration and one auxiliary lane are expected to increase throughout much of the Fort Vancouver area, with an increase of 10 dBA at one site—site FV-004—and decrease by as much as 4 dBA at Old Apple Tree Park, represented by site FV-039. Figure 3.11-7 and Figure 3.11-8 show the location of each traffic noise impact in Fort Vancouver.

North Vancouver, East of I-5 - Modified LPA Modeled Traffic Noise Levels

In north Vancouver east of I-5, the Modified LPA with the double-deck fixed-span bridge configuration and one auxiliary lane would exceed the WSDOT NAC at 26 locations near the future I-5 alignment. The 26 locations include 26 of the 31 WSDOT NAC exceedances predicted under the No-Build Alternative (including 21 of the 25 exceedances at residences and five of the six outdoor-use locations at Marshall Park). No substantial increase impacts are predicted under the Modified LPA.

Noise levels would range from 49 to 73 dBA L_{eq} and would fall within 1 to 3 dBA of existing conditions at most locations. Compared to existing conditions, noise levels would range from a decrease of 5 dBA below existing conditions to an increase of 3 dBA above existing conditions. Compared to the No-Build Alternative, traffic noise levels are expected to be within 1 dBA throughout much of this subarea, with only slight increases of 0 to 2 dBA at most locations. Noise reductions of up to 6 dBA are predicted at outdoor-use areas south of the Department of Veterans Affairs (VA) Hospital from the shift in the northbound I-5 off-ramp to Fourth Plain

Boulevard. Figure 3.11-9, Figure 3.11-10, and Figure 3.11-11show the location of each traffic noise impact in north Vancouver east of I-5.

North Vancouver, West of I-5 - Modified LPA Modeled Traffic Noise Levels

In north Vancouver, west of I-5, noise levels under the Modified LPA with the double-deck fixed-span bridge configuration and one auxiliary lane would exceed the WSDOT NAC at 54 locations, which is seven more NAC impacts than existing conditions and 12 fewer NAC impacts than the No-Build Alternative. The 54 exceedance locations with the Modified LPA include the sites with an exceedance under existing conditions and the No-Build Alternative, which include residences, Kiggins Bowl, and one outdoor location at Discovery Middle School. No NAC impacts are predicted with the Modified LPA at the two offices that experience NAC impacts under existing conditions or under the No-Build Alternative.

Noise levels at this location would range from 49 to 76 dBA L_{eq}. Increases in noise levels over existing conditions would range from 2 to 12 dBA at residences between E 33rd Street and E 39th Street, where the I-5 southbound on-ramps would be shifted west (closer to residences). In this area, seven single-family homes would be displaced between E 35th Street and E 37th Street. Displaced residences are represented by modeled sites VW-056, VW-059, VW-062, VW-065, VW-068, VW-071, and VW-077. In this area, the Modified LPA with the double-deck fixed-span bridge configuration and one auxiliary lane would result in fewer sites predicted to experience increases in noise than the No-Build Alternative due to the seven displaced residences.

A 2 to 4 dBA increase in noise levels over existing conditions is predicted at most locations in this area. Compared to the No-Build Alternative, noise levels would be within 1 dBA at most locations and would have similar increases of up to 10 dBA at residences near the ramp improvements between E 33rd Street and E 39th Street. Six residences located between E 33rd Street and E 35th Street are predicted to undergo substantial noise impacts. The six residences are represented by five modeled sites: VW-080, VW-082, VW-084, VW-094, and VW-098. Figure 3.11-9, Figure 3.11-10, and Figure 3.11-11 show the location of each traffic noise impact in north Vancouver west of I-5.

Portland Light-Rail Noise

The only noise-sensitive land use between the existing light-rail alignment at the Expo Center and the Portland and Oregon boundary is several rows of floating homes in North Portland Harbor. The Modified LPA, with any of the design options, would require relocation of the first row of homes and one home on the second dock; therefore, those homes were not analyzed for noise impacts. Light-rail noise was analyzed at the nearest remaining homes based on the distance between the proposed tracks and the homes. In all, 36 homes on the west side of the proposed North Portland Harbor and Columbia River bridges were evaluated for light-rail noise. The existing L_{dn} for the homes was extrapolated from measured data and on-site inspections.

The analysis predicted noise levels below the FTA noise impact criteria under the Modified LPA, including at the nearest remaining floating homes in North Portland Harbor. At all other noise-sensitive properties in the Portland portion of the project area, noise from light-rail operations would be well below the traffic noise levels, including the manufactured home residential area along the Columbia River. The cumulative effects at receptor LRT-3 would be less than 1 dB because the train noise would be more than 10 dB lower than the existing ambient levels. Results at the floating homes in North Portland Harbor are shown in Table 3.11-9 under site LRT-3.

Portland Transit Station Noise

The analysis reviewed the noise-sensitive receptors located nearest to the station improvements under the Modified LPA, following the FTA's guidance for noise-screening distances. These included the Hayden Island Station, Expo Center Station, and Expo Center Overnight Station. The nearest noise-sensitive receptors were

located beyond the FTA noise-screening distance at each of the Portland Transit Stations. Therefore, no noise impacts are predicted at these locations.

Ruby Junction Maintenance Facility

The planned expansion of the Ruby Junction Maintenance Facility is 350 feet from the nearest homes on SE 202nd Avenue, which is located within the FTA noise-screening distance. Modeled noise levels at the nearest home that would result from overall maintenance yard improvements are predicted to be below the FTA moderate and severe impact criteria. Results are shown in Table 3.11-9 under site "OMF-1."

The other noise-sensitive land uses located closest to improvements at Ruby Junction Maintenance Facility are single-family residences at SE 196th Avenue and residences at the Mobile Park Plaza at 19776 SE Stark Street. Both noise-sensitive use areas were reviewed with the FTA noise-screening distances and are located beyond the screening distance from the planned improvements. Therefore, no noise impacts are predicted at either location.

Downtown Vancouver - Modified LPA Modeled Transit Noise and Vibration Effects

Downtown Vancouver Light-Rail Noise

The Modified LPA would have moderate noise impacts at one location between the southern Columbia River bridge landing and W 6th Street—modeled site LRT-1 (the Normandy Apartments located at 316 E 7th Street). These impacts would result from special track work (i.e. turnouts, crossovers, switches). Noise levels with light-rail operations at this location are predicted to be 67 dBA L_{dn}. The criterion for moderate impacts at site LRT-1 is 66 dBA L_{dn}. Therefore, moderate noise impacts are predicted at this location.

Downtown Vancouver Transit Station Noise

The FTA noise-screening distances were used to review the nearest noise-sensitive receptors to station improvements included in the Modified LPA: Evergreen Station, and Waterfront Station. These receptors were located beyond the FTA noise-screening distance at each of the Vancouver Transit Stations; therefore, no noise impacts are predicted.

Downtown Vancouver Park-and-Ride Noise

Two planned park-and-ride facilities with multiple options in downtown Vancouver were reviewed against the FTA noise-screening distances. Park-and-ride lots 1a and 1c, located near the planned Waterfront Station, and park-and-ride lot 2a, located near the planned Evergreen Station, were located beyond FTA noise-screening distances. Therefore, no noise impacts are predicted.

Downtown Vancouver park-and-ride lot 1b, at W 4th Street and Columbia Street, is located within the FTA noise-screening distance from the new apartments under construction at 400 Washington Street (shown as "PNR-1" on Table 3.11-9). Modeled noise levels that would result from park-and-ride lot 1b are predicted to be below the FTA moderate and severe impact criteria. Therefore, no noise impacts are predicted at 400 Washington Street. The park-and-ride lot 2b at C Street and E 7th Street is located within the FTA noise-screening distance from the Normandy Apartments located at 316 E 7th Street and the Econo Lodge located at 601 Broadway Street. Modeled noise levels that would result from park-and-ride lot 2a are predicted to be below the FTA moderate and severe impact criteria; therefore, no noise impacts are predicted at either location. Results are shown in Table 3.11-9.

Downtown Vancouver Total Transit Noise

Total transit noise was evaluated to identify any additional impact locations that weren't identified when evaluating individual noise sources. Impacts and calculated noise levels presented in Table 3.11-9 include

noise from all Modified LPA transit improvements. Calculated noise levels are unchanged from individual noise levels due to the distance from stationary noise sources from sites located near the light-rail alignment. However, all noise levels are influenced by highway noise, which is included in the evaluation of mitigation measures presented in Section 3.11.6.

Downtown Vancouver Combined Highway and Transit Noise

LRT-1 is the one location where highway noise and transit noise impacts result from the Modified LPA. Since traffic noise approaches the transit noise of 69 dBA the noise level from both sources could be 1 to 2 dB higher during the peak traffic hour of the day at this location. See Section 7.8.1 of the Noise and Vibration Technical Report for additional information.

Portland Light-Rail Vibration

Sites sensitive to vibration were reviewed, along with the location of transit improvements, to identify potential vibration impacts. In this area, the proposed extension of light-rail is on a structure in most areas and is not near vibration-sensitive buildings. The one area that includes sites sensitive to vibration near transit improvements is the area of floating homes located near the proposed light-rail bridge from the Portland mainland to Hayden Island. Because these homes are located on water, minimal transmission of vibration is expected, and no impacts are predicted. The other transit facilities included in the Modified LPA located in and around Portland are Hayden Island Station, Expo Center Station, Expo Center Overnight Station, and the Ruby Junction Maintenance Facility, located in Gresham. As no vibration-sensitive sites are located in close proximity to these sites, no impacts are predicted. Therefore, no transit-related vibration impacts are predicted in the Portland area.

Downtown Vancouver Light-Rail Vibration

Vibration levels at the Normandy Apartments located at 316 E 7th Street (LRV-1) and the mixed-use building at 801 C Street that includes the Regal City Center Cinema (LRV-2) are predicted to exceed the FTA vibration criteria due to the close proximity of special trackwork to each building. Maximum vibration levels at these sites could reach 77 to 81 VdB as shown in Table 3.11-10. The ground-borne vibration levels are due to the special trackwork near the receptors and not the vibration generated by the train passbys. Vibration levels at the Econo Lodge hotel at 601 Broadway (LRV-4) are predicted to be below the FTA vibration impact criteria. Figure 3.11-12, at the end of this section, provides an aerial view of this area and identifies the grouping of the homes and location of the proposed light-rail alignment. The Modified LPA with the I-5 mainline westward shift design option would result in higher vibration levels in downtown Vancouver due to the westward shift of the light-rail alignment; however, no additional vibration impacts are anticipated due to the distance to sensitive receptors.

Table 3.11-9. Modified LPA L_{eq} and L_{dn} for Transit Operations

Receptor [a]	Area Description [b]	Land Use	Number of Units [c]	Existing Noise [d] (dBA)	Modified LPA Primary Transit Noise Source	Modified LPA Noise Contribution [e] (dBA)	FTA Impact Criteria: Moderate (dBA)	FTA Impact Criteria: Severe (dBA)	Units with Moderate Impacts:	Units with Severe Impacts:
LRT-1	E 7th Street/E C Street	SF	12	83	Light-Rail	67	66	76	12	–
LRT-2	E 6th Street/ E C Street	Hotel	0	80	Light-Rail	65	66	76	–	–
LRT-3	Jantzen Beach Houseboats	SF	5	77	Light-Rail	65	66	76	–	–
OMF-1	SE 202nd Avenue (Gresham)	SF	3	61	Ruby Junction Maintenance Facility	56	59	64	–	–
PNR-1 [f]	400 Washington Street	MF	200	68	Park-and-Ride Lot 1b	63	64	74	–	–

a Receptors with impacts shown on Figure 3.11-21.
b General description of the area of analysis.
c Number of individual apartments or homes affected.
d Existing noise levels in L_{dn} for category 2 land use, or L_{eq} for category 1 or 3 land uses.
e Noise from operation of the Modified LPA transit source only. This is the noise level used to determine impacts with the FTA criteria. Levels in **bold** exceed FTA criteria.
f Site PNR-1 used to assess contribution of park-and-ride noise at sites at other nearby sites located similar distance to planned Park-and-Ride lots 1c and 2b. Park and Rides were evaluated using FTA methods. Noise-sensitive land uses were also included in the traffic noise modeling analysis.
Key: dBA = A-weighted decibels; FTA = Federal Transit Administration; L_{dn} = day-night equivalent sound level; L_{eq} = equivalent sound level; LPA = Locally Preferred Alternative; MF = multifamily; SF = single family; "-" = no impact

Table 3.11-10. Projected Transit Vibration Effects under the Modified LPA

Receptor [a]	Area Description [b]	Land Use	FTA Vibration Criteria [c] (VdB)	Vibration Level [d] (VdB)	Meets Criteria [e]	Number of Impacts [f]
LRV-1	E 7th Street/E C Street	MF	72	77	Y	12
LRV-2	E 8th Street/E C Street	Movie Theater	75	81	Y	1 - Movie Theater
LRV-3	Hayden Island Floating Homes	SF	72	See note [g]	See note [g]	See note [g]
LRV-4	Econo Lodge, 601 Broadway	Hotel	72	70	N	-

a Receptors with impacts shown on Figure 3.11-12. Figure 3.11-21
b General description of the area of analysis.
c FTA vibration impact criteria.
d Predicted vibration level.
e Amount the predicted level exceeds the criteria.
f Number of individual structures affected.
g Because these SF residences are on water, minimal transmission of ground vibration occurs.
FTA = Federal Transit Administration; MF = multifamily; SF = single family; VdB = vibration decibels; "-" = no impact

No transit-related vibration impacts are predicted in the Portland area. In Vancouver, vibration impacts would affect 12 multifamily residences at the Normandy Apartments at 316 E 7th Street (LRV-1) and a multi-use building at 801 C Street that includes a cinema and commercial businesses (LRV-2) shown in Figure 3.11-12.

3.11.4 Temporary Effects

No-Build Alternative

Under the No-Build Alternative, there would be no construction of replacement bridges, no removal of existing bridge, and none of the other proposed roadway, transit, or stormwater improvements associated under the Modified LPA. Because no program improvements are included in the No-Build Alternative, short-term effects would be limited to noise-sensitive land uses near ongoing maintenance activities.

Modified LPA

Construction Activities

Construction of the new Columbia River bridges, removal of the existing Interstate Bridge, and improvements to interchanges, local roads, and various transit facilities would require equipment and machinery common to roadway, transit, bridge, and structural projects. Table 3.11-11 provides a list of the typical types of equipment used for this kind of construction, the corresponding activities, and the maximum noise levels as measured at 50 feet from the noise source under normal use.

Figure 3.11-12. Downtown Vancouver Transit Noise and Vibration Analysis and Impacts

Table 3.11-11. Typical Construction Equipment, Use, and Reference Maximum Noise Level

Equipment	Typical Expected Project Use [a]	L_{max} [b]	Source [c]
Air Compressors	Used for pneumatic tools and general maintenance - all phases	70–76	a, b, c
Backhoe	General construction and yard work	78–82	b, c
Backhoe	General construction and yard work	78–82	b, c
Concrete Pump	Pumping concrete	78–82	b, c
Concrete Saws	Concrete removal, utilities access	75–80	b, c
Crane	Materials handling, removal, and replacement	78–84	b, c
Excavator	General construction and materials handling	82–88	b, c
Forklifts	Staging area work and hauling materials	72	a, b, c
Haul Trucks	Materials handling, general hauling	86	b, c
Jackhammers	Pavement removal	74–82	b, c
Loader	General construction and materials handling	86	b, c
Pavers	Roadway paving	88	b

Equipment	Typical Expected Project Use [a]	L_{max} [b]	Source [c]
Pile Drivers	Support for structure and hillside	99–105	b, c
Power Plants	General construction use, nighttime work	72	b, c
Pumps	General construction use, water removal	62	b, c
Pneumatic Tools	Miscellaneous construction work	78–86	c
Service Trucks	Repair and maintenance of equipment	72	b, c
Tractor Trailers	Material removal and delivery	86	c
Utility Trucks	General project work	72	b
Vibratory equipment	Shore up hillside to prevent slides and soil compacting	82–88	b, c
Welders	General project work	76	b, c

Sources: FTA 1995, 2018

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

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

c Sources of noise levels presented:

Portland, Oregon Area Projects: Light-rail, I-5 Preservation, and Hawthorne Bridge construction projects and other measured data.

U.S. Department of Transportation construction noise documentation and other construction noise sources.

Construction Noise

The Modified LPA would be completed in the following four typical construction phases.

Preparation

Major noise-producing equipment used during the preparation stage could include concrete pumps, cranes, excavators, haul trucks, loaders, and tractor trailers. During this phase, maximum noise levels could reach 82 to 94 dBA at the nearest residences (50 to 100 feet) for normal construction activities.

Other major noise sources that may be required include the use of vibratory and impact equipment to install piles or sheet piles. Other equipment expected during this phase includes backhoes, air compressors, forklifts, pumps, power plants, service trucks, and utility trucks.

Construction

Construction impacts would persist at the construction site, and temporary noise impacts would occur at various times throughout construction and demolition over approximately a 9- to 15-year construction period. The loudest noise sources during construction of the new bridges would be pile drivers, cement mixers, concrete pumps, pavers, haul trucks, and tractor trailers. Drilled shafts would be used to reduce the number of piles driven. The cement mixers and concrete pumps would be required for construction of the superstructure. Maximum noise levels would range from 82 to 94 dBA at the closest receiver locations.

Approximately 3,311 temporary piles would be installed and removed during the multiyear construction of the Columbia River and North Portland Harbor bridges. These piles would be staged throughout the in-water construction and demolition periods. Between 100 and 400 temporary piles could be in the water at a given time.

An average of six temporary, load-bearing piles could be installed per day using one or two impact drivers. Some amount of impact pile driving in the Columbia River or North Portland Harbor would occur on approximately 735 days spread over the estimated six in-water work windows that would be required for the construction of the Columbia River bridges.

Three hundred impact strikes could be required to finish driving or proofing a given pile. This number of strikes would require approximately 30 to 45 minutes of impact hammer activity. Between two and three piles per day could be installed or proofed with an impact hammer, with an estimated total maximum number of 900 impact strikes per day if a single impact pile driver is in operation, or up to 1,800 impact strikes per day if two pile-driving rigs are operated concurrently. Actual pile production rates vary, and a typical day would likely have fewer strikes.

A bubble curtain or similarly effective noise attenuation device would be implemented during all impact pile driving, and a hydroacoustic monitoring plan would be implemented during impact pile driving to confirm the level of attenuation provided. This monitoring program would require unattenuated pile strikes in order to confirm the amount of attenuation provided by the system. Up to 75 unattenuated strikes could be required to accomplish this testing. Testing would occur up to approximately 40 days total over the course of construction. On each day of testing, unattenuated pile strikes would occur over a period of less than 10 minutes.

During construction, up to two impact pile drivers could operate simultaneously near one another. In addition, the contractor could elect to have both a vibratory and impact pile-driving rig in operation simultaneously. Operation of two pile-driving rigs simultaneously is not expected to produce greater decibel levels. Pile strikes from both drivers would need to be synchronous (within 0.0 and approximately 0.1 seconds apart) to produce higher noise levels than a single pile driver operating alone. Because this level of synchronicity is highly unlikely, the analysis assumes that pile drivers would not generate noise levels greater than that of a single pile driver. Refer to Section 3.16, Ecosystems, for additional information regarding construction noise impacts to underwater species.

The Modified LPA with any of the design options would result in temporary impacts to noise levels associated with construction of the Columbia River bridges and associated roadway and interchange improvements. The extent and nature of these impacts would be minimized and avoided to the extent possible through the implementation of best management practices (BMPs), such as implementing a bubble curtain (or similarly effective noise attenuation device) during all in-water impact pile driving.

Miscellaneous Activities

General construction activities would occur after completion of the heavy construction and would include installation of bridge railings, signage, lighting, roadway striping, and others. As shown in Table 3.11-12, many of these activities are expected to produce noise levels above 80 dBA at 50 feet for extended periods of time.

Demolition

Demolition of the existing structures would require heavy equipment such as concrete saws, cranes, excavators, hoe-rams, haul trucks, jackhammers, loaders, and tractor trailers. Maximum noise levels could reach 82 to 93 dBA at the nearest receptors.

Table 3.11-12 provides the noise levels for each of the four typical construction phases as measured at 50 feet from the construction activity. The noise levels shown in Table 3.11-12 are the typical maximums and would only occur periodically during the heaviest periods of construction. Actual hourly noise levels could be substantially lower than those stated, depending on the level of activity at that time and the distance from the work site to the noise-sensitive properties.

Table 3.11-12. Noise Levels for Typical Construction Scenarios at 50 Feet from Work Site

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

Note: Combined worst-case noise levels for all equipment 50 feet from work site.
a Operational conditions under which the noise levels are projected.
b Normal equipment in operation under the given scenario.
c L_{max} (dBA) is an average maximum noise emission for the construction equipment under the given scenario.
d L_{eq} (dBA) is an energy average noise emission level for construction equipment operating under the given scenario. For this type of equipment, the L_{eq} is approximately equal to the L_{50} (that is, noise level that is exceeded 50 percent of the time).
dBA = A-weighted decibels

The construction noise study assumed worst-case noise levels during each of the four general construction phases for periods of maximum construction activity. Actual noise levels experienced during construction would generally be lower than those described below. The information in Table 3.11-12 was used to predict construction noise levels for several distances from the project work area. Figure 3.11-13 is a graph of the construction noise level versus distance for the phases of project construction listed in Table 3.11-12.

Construction Vibration

Major vibration-producing activities would occur primarily during preparation for the new bridges and demolition of the existing bridge. Activities that have the potential to produce high levels of vibration would include pile driving, vibratory shoring, soil compacting, and some hauling and demolition activities. Vibration effects from pile driving or vibratory sheet installations could occur within 50 to 100 feet of sensitive receivers. It is unlikely that vibration levels would exceed 0.5 inches per second (approximate threshold for building damage) at distances greater than 100 feet from the construction sites. Although analysis indicates that buildings in the study area would not experience adverse vibration-related impacts from construction, owners of two historic structures (Barracks Post Hospital and Clark County Museum) have expressed concerns. See Section 3.8, Historic and Archaeological Resources, for further discussion of efforts to measure, monitor, and, if necessary, mitigate vibration impacts to these historic structures.

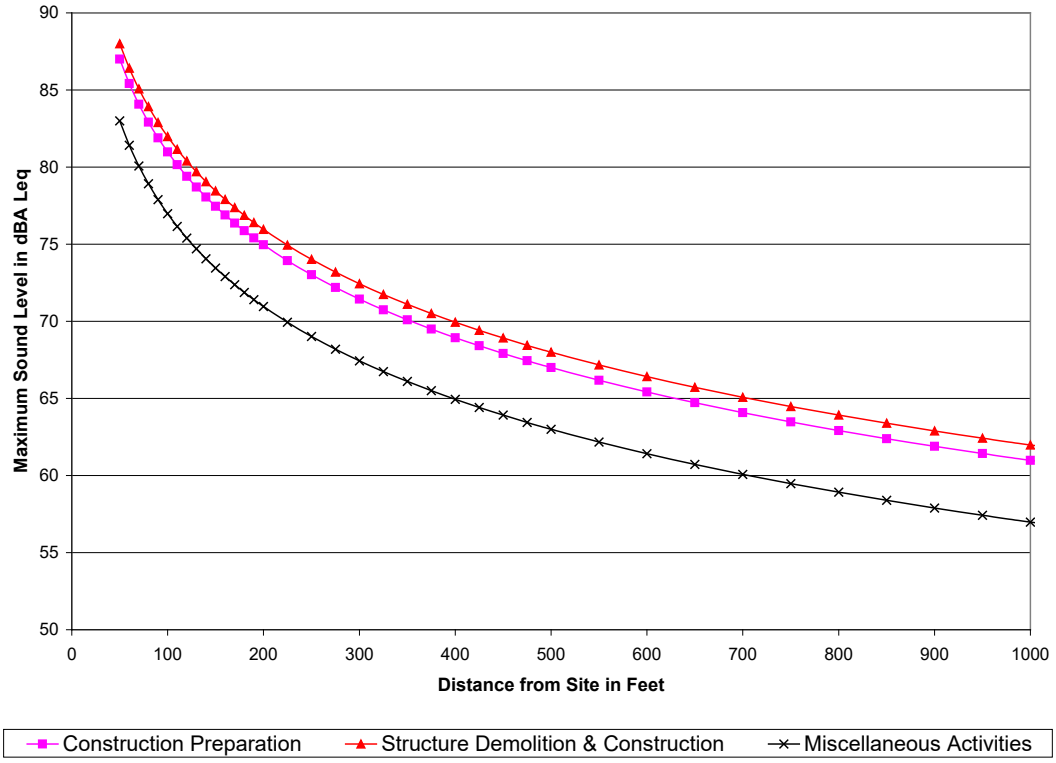
The mitigation measures intended to protect marine life from pile-driving hydroacoustic impacts, as described in Section 3.16, Ecosystems, would also reduce the potential for noise and vibration impacts to nearby noise-sensitive land uses.

3.11.5 Indirect Effects

An indirect effect of the Modified LPA on population and employment distribution and land use patterns is the promotion of more transit-oriented development around the new transit stations and support of minor

redistribution in future population and employment growth from outlying areas to the I-5 corridor, consistent with local land use plans. This increase in density and activity would likely result in further minor increases in ambient noise and vibration in the study area, and additional residents, including sensitive receptors, would be exposed to the urban noise levels in the study area. Because this new residential and commercial development is expected to occur in areas that already experience a fairly high level of background noise and vibration, and because new residents moving into that sound environment would do so by choice, indirect noise and vibration effects are anticipated to be minor.

Figure 3.11-13. Noise Level vs. Distance for Typical Construction Phases



Source: Noise and Vibration Technical Report

3.11.6 Potential Avoidance, Minimization, and Mitigation Measures

Long-Term Effects

Highway Traffic Noise Mitigation

Mitigation related to highway traffic noise, including mitigation (abatement) measures that meet ODOT's and WSDOT's feasibility and reasonableness criteria, may be recommended for inclusion in the Modified LPA. Feasibility primarily deals with engineering considerations such as whether substantial noise level reductions can be achieved or whether there would be a negative effect on property access resulting from the placement of noise walls (WSDOT 2020). Reasonableness comprises three factors: (1) if abatement is cost-effective; (2) if abatement can achieve the design goal; (3) and if the abatement is desired by benefiting receptors (WSDOT 2020). The complete evaluation of potential traffic noise abatement measures can be found in Section 7 of the Noise and Vibration Technical Report, including discussion of isolated noise receptors where mitigation would not be reasonable.

Under ODOT and WSDOT policies, the following noise abatement measures must be considered:

- Traffic management measures (for example, traffic control devices and signing for prohibition of certain vehicle types, time-use restrictions for certain vehicle types, modified speed limits, and exclusive land designations).
- Highway design measures (for example, alteration of horizontal/vertical alignments).
- Acquisition of property rights (either in fee or lesser interest) for construction of noise barriers.
- Acquisition of real property or interests therein (predominantly unimproved property) to serve as a buffer zone to preempt development that would be adversely affected by traffic noise.
- Sound insulation of all Activity Category D land uses, including public use or nonprofit institutional structures.
- Construction of sound barriers (including landscaping for aesthetic purposes), whether within or outside the highway right of way. Interstate construction funds may not participate in landscaping. The use of landscaping for noise abatement requires a minimum of 65 feet of densely planted, mature vegetation to provide a noticeable noise abatement up to 6 dB (NCHRP 2021).

Noise mitigation was evaluated at all locations where traffic noise impacts were predicted. Noise walls were evaluated to mitigate noise impacts at 16 locations in Washington and three in Oregon. Fourteen of the 16 noise walls in Washington (Noise Walls 1 through 9 and Noise Walls 11, 11A, 12, 14, and 15) were found to meet WSDOT criteria for the placement of a feasible noise wall. However, only 10 locations—Noise Walls 1 through 8, Noise Wall 11A, and Noise Wall 12—met WSDOT criteria for the placement of both a feasible and reasonable noise barrier. Included in the 10 recommended noise walls, Noise Walls 2 through 8 would replace existing noise walls.

Two of the three noise walls evaluated in Oregon (Noise Walls 16 and 17) did not meet ODOT criteria for the placement of a feasible noise wall. The third noise wall evaluated in Oregon (Noise Wall 18) met ODOT criteria for the placement of both a feasible and reasonable noise barrier.

Noise mitigation results would be the same for the Modified LPA with all bridge configurations, one or two auxiliary lanes, and the SR 14 Interchange without C Street ramps. The only difference in highway traffic noise mitigation between the Modified LPA design options is that under the I-5 mainline shifted west design option, Noise Wall 12 would not be recommended because the noise-affected property would be acquired.

The 11 feasible and reasonable noise walls are listed below and described in Section 7.2.1.1 of the Noise and Vibration Technical Report. The general location of each feasible and reasonable noise wall is described below and shown on Figure 3.11-14 to Figure 3.11-20. Table 3.11-13 summarizes each noise wall evaluation.

- Noise Wall 1: west side of I-5 from the southbound on-ramp from Main Street to E 39th Street.
- Noise Wall 2: west side of I-5 between E 39th Street and E 33rd Street.
- Noise Wall 3: east side of I-5 between E 33rd Street and SR 500.
- Noise Wall 4: west side of I-5 between E 33rd Street and E 29th Street.
- Noise Wall 5: east side of I-5 between E 33rd Street and E 29th Street.
- Noise Wall 6: west side of I-5 between E 29th Street and E 26th Street/E Fourth Plain Boulevard.
- Noise Wall 7: east side of I-5 between E 29th Street and E Fourth Plain Boulevard.
- Noise Wall 8: west side of I-5 between E 4th Plain Boulevard and E McLoughlin Boulevard.
- Noise Wall 11A: east side of I-5 between E Evergreen Boulevard and Officers Row.
- Noise Wall 12: west side of I-5 between E 7th Street and E 8th Street.
- Noise Wall 18: north side of N Marine Drive and east of I-5.

Table 3.11-13. Noise Wall Analysis Summary

Wall	No. of Impacts [a]	Length (feet)	Height (feet)	No. of Impacts Benefited [b]	Feasible?	Achieves Design Goal?	Total Benefits [c]	Planning Level Cost [d]	Cost Allowance / Cost per Benefited Receiver [e]	Cost Reasonable? [e]	Wall Recommended?
1	10	898	12	7	Yes	Yes	15	$555,530	$664,736	Yes	Yes
2	10	1,727	8	10	Yes	Yes	15	$712,631	$717,379	Yes	Yes
3	3	1,845	14	3	Yes	Yes	40	$1,333,086	$1,455,607	Yes	Yes
4	1	970	10	10	Yes	Yes	18	$500,617	$794,174	Yes	Yes
5	17	986	10	17	Yes	Yes	18	$509,391	$1,053,875	Yes	Yes
6	10	986	10	8	Yes	Yes	11	$508,875	$579,889	Yes	Yes
7	10	1,104	10	10	Yes	Yes	10	$570,291	$708,706	Yes	Yes
8	21	1,496	16	15	Yes	Yes	38	$1,235,337	$1,723,771	Yes	Yes
9	4	898	18	4	Yes	Yes	8	$834,224	$327,620	No	No
10	6	1,089	16	0	No	No	0	N/A	N/A	No	No
11	11	1,172	18	4	Yes	Yes	6	$1,088,765	$269,404	No	No
11A	4	464	6	3	Yes	Yes	3	$143,682	$150,495	Yes	Yes
12	6	540	10 to 12	6	Yes	Yes	6	$316,782	$322,044	Yes	Yes
13	24	497	12	4	No	No	12	N/A	N/A	No	No
14	4	1,132	8 to 20	4	Yes	Yes	8	$1,062,702	$352,185	No	No
15	8	1,041	14	3	Yes	Yes	3	$719,185	$150,494	No	No
16	3	3,114	24	0	No	N/A	0	N/A	N/A	No	No

Wall	No. of Impacts [a]	Length (feet)	Height (feet)	No. of Impacts Benefited [b]	Feasible?	Achieves Design Goal?	Total Benefits [c]	Planning Level Cost [d]	Cost Allowance / Cost per Benefited Receiver [e]	Cost Reasonable? [e]	Wall Recommended?
17	18	1,828	24	0	No	N/A	0	N/A	N/A	No	No
18	12	1,029	12 to 16	12	Yes	Yes	28	$436,770	$15,599	Yes	Yes

Note: N/A = not applicable for walls that do not meet feasibility. Details of all wall evaluations are presented in the Noise and Vibration Technical Report.

a Impacts based on WSDOT NAC, ODOT NAAC, and Substantial Increase thresholds with 2045 Modified LPA.

b Impacts benefited based on reduction from 2045 Modified LPA with existing noise walls in place.

c Total benefits based on reduction from 2045 Modified LPA without existing noise in place.

d Planning level cost calculated from WSDOT's planning level cost of $51.61 per square foot and ODOT's planning level cost of $30 per square foot for wall heights up to 16 feet and $37.50 per square feet for wall heights from 17 to 25 feet.

e WSDOT Cost allowance and ODOT wall cost per benefited receiver.

f Cost reasonableness based on WSDOT Noise Policy Reasonableness guidelines and ODOT's Noise Manual Cost Effectiveness Criteria.

LPA = Locally Preferred Alternative; NAAC = Noise Abatement Approach Criteria; NAC = Noise Abatement Criteria; ODOT = Oregon Department of Transportation; WSDOT = Washington State Department of Transportation

Statement of Likelihood

Based on the findings of this analysis, ODOT and WSDOT will further evaluate traffic noise abatement measures in the form of noise walls during the final design of the Modified LPA. The 11 noise wall locations (10 in Washington and 1 in Oregon) determined to be feasible and reasonable (Noise Walls 1, 2, 3, 4, 5, 6, 7, 8, 11A, 12, and 18) will be re-assessed in detail during final design.

The 11 noise walls would mitigate impacts at 76 residences or residential equivalent receiver locations and would benefit an additional 125 residences or residential equivalents. The combined preliminary cost for the 11 recommended noise walls totals approximately $6,823,000. If conditions change substantially during final design of the Modified LPA, the mitigation measure may no longer be feasible and reasonable and, therefore, would not be constructed as part of the Program. A final decision will be made upon the completion of the final design, a cost-estimating process, and the public involvement process, which includes balloting of benefitted receptors.

The IBR Program Team will also continue to evaluate installation of a tall safety barrier or sound barrier along the elevated light-rail transit structure between E 6th Street and E 8th Street in downtown Vancouver to mitigate transit noise impacts at site LRT-1. LRT-1 represents the Normandy Apartments at 316 E 7th Street in downtown Vancouver. A 3- to 4-foot acoustically absorbent wall or 6-foot reflective wall would be effective at reducing transit noise levels at this location by 7 to 10 dBA.

As described in Section 7.8.1 of the Noise and Vibration Technical Report, there is one location (the Normandy Apartments at 316 E 7th Street in downtown Vancouver) where the Modified LPA would have highway noise impacts and transit noise impacts. Additional information is presented in Section 7.8.1 of the Noise and Vibration Technical Report to support the recommendation to include both the highway traffic noise barrier (Noise Wall 12) and a sound barrier along the elevated structure (at site LRT-1).

Light-Rail Noise and Vibration Mitigation

Light-Rail Noise Mitigation

Table 3.11-14 summarizes the single transit noise impact location, mitigation measures, and future light-rail noise levels after mitigation. Aerial photos of the analysis areas and mitigation are shown in Figure 3.11-21.

Portland Light-Rail Noise Mitigation

No transit noise impacts are predicted in Portland; therefore, no mitigation is needed.

Vancouver Light-Rail Noise Mitigation

- Install tall safety barriers or sound barriers along the elevated structure to mitigate the noise impacts at site LRT-1, which represents the Normandy Apartments located at E 7th Street and E C Street in downtown Vancouver. A 3- to 4-foot acoustically absorbent wall or 6-foot reflective wall would reduce noise levels at this location by 7 to 10 dBA.
- Equip all light-rail track curves with a radius of less than 300 feet with wayside lubricators. After construction of the alignment, during the initial testing, if additional curves are identified with wheel squeal, install wayside track lubricators, as necessary.

Figure 3.11-14. Modified LPA with Double-Deck Fixed-Span Configuration and One Auxiliary Lane – 2045 Evaluated Noise Walls – Portland Mainland

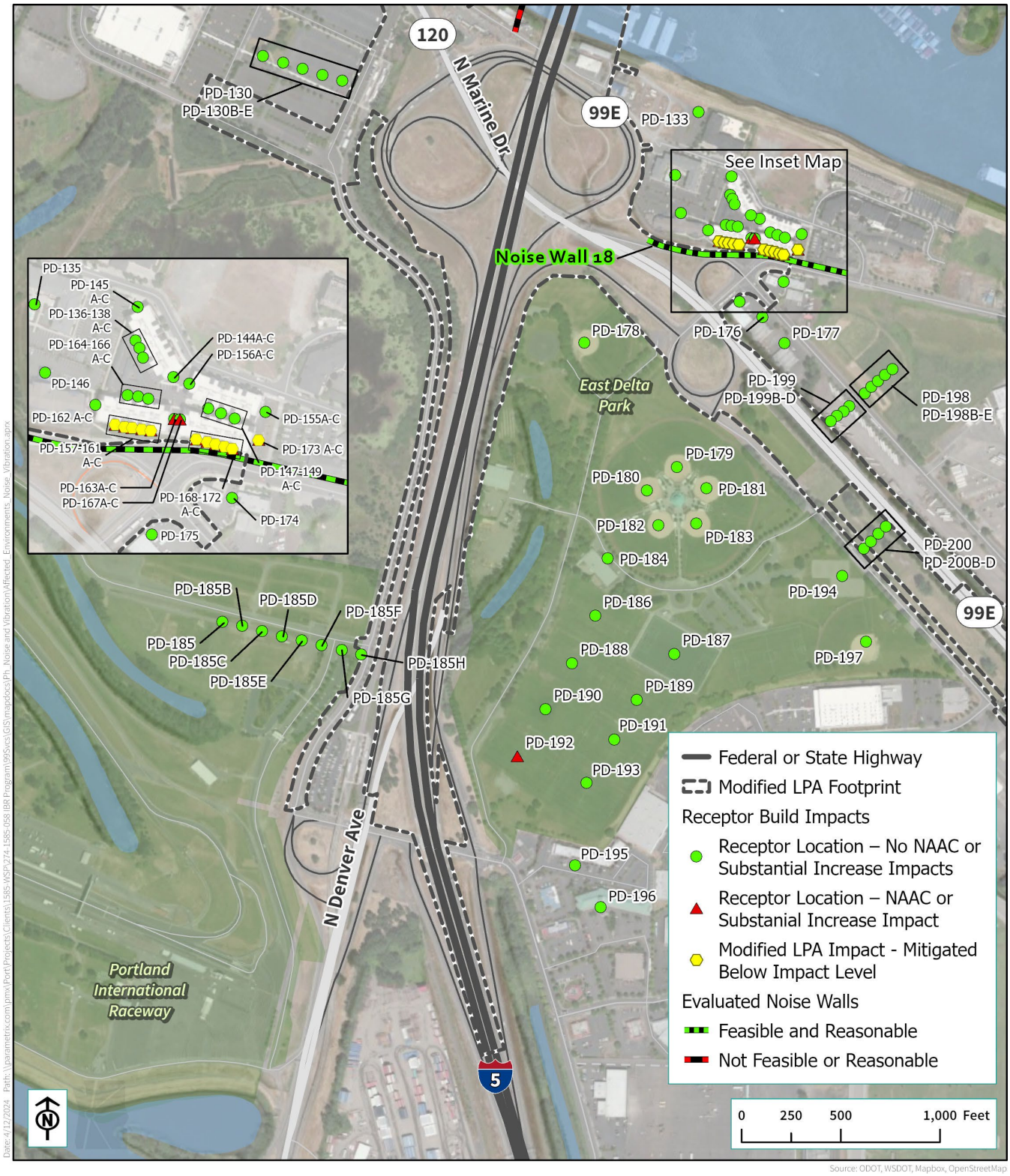


Figure 3.11-15. Modified LPA with Double-Deck Fixed-Span Configuration and One Auxiliary Lane – 2045 Evaluated Noise Walls – Portland/Hayden Island

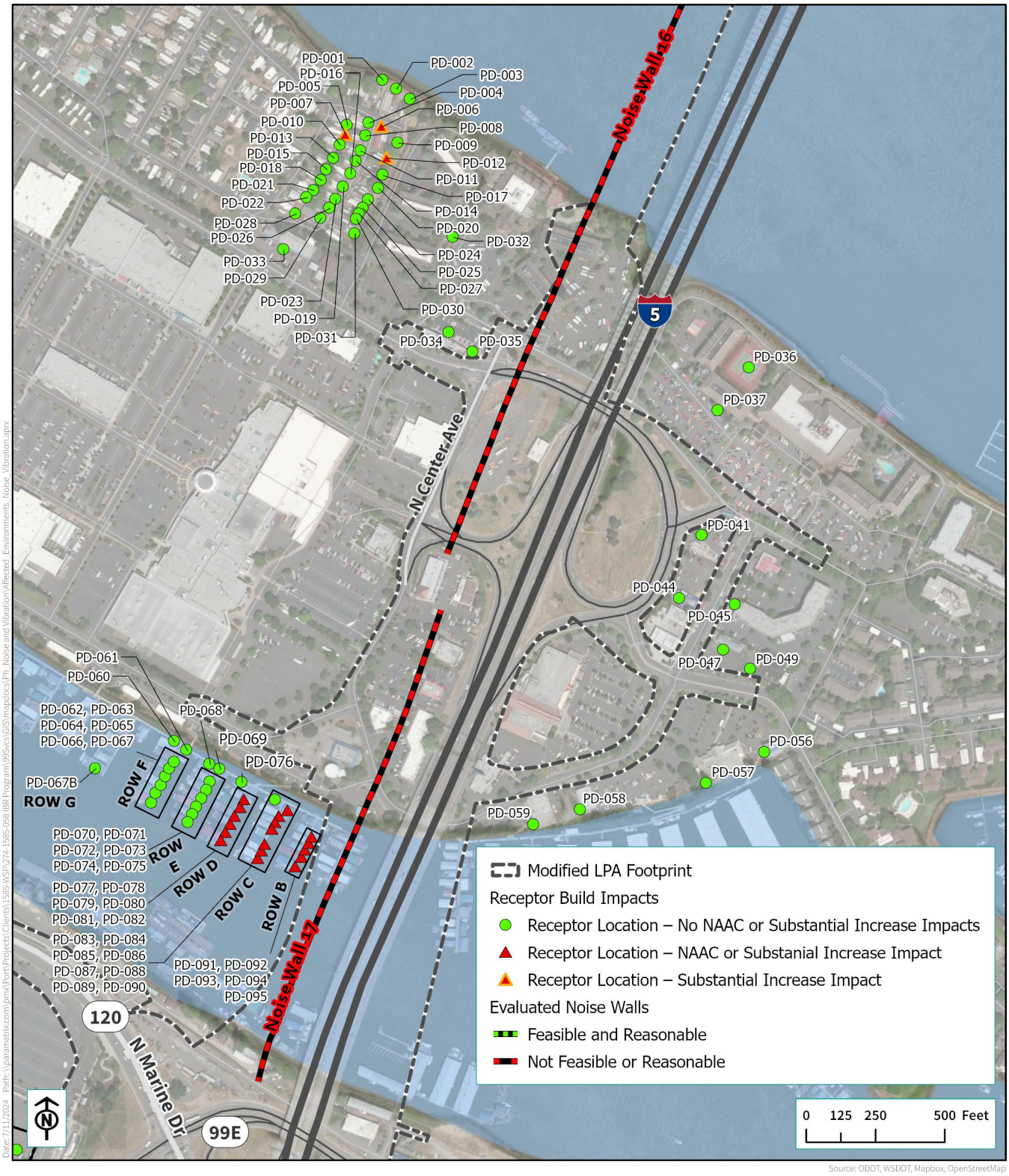


Figure 3.11-16. Modified LPA with Double-Deck Fixed-Span Configuration and One Auxiliary Lane – 2045 Evaluated Noise Walls – I-5 / SR 14 Interchange

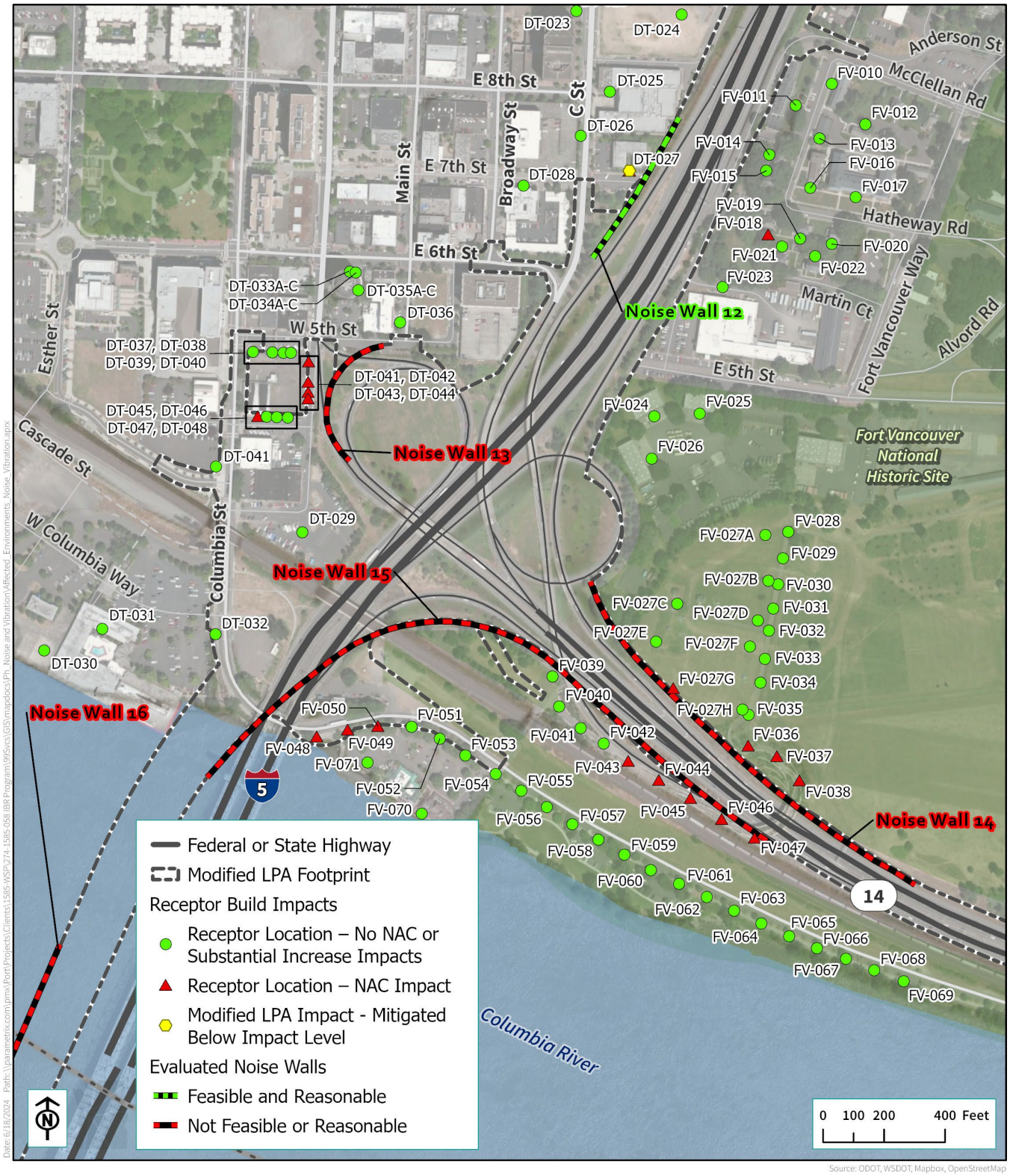


Figure 3.11-17. Modified LPA with Double-Deck Fixed-Span Configuration and One Auxiliary Lane – 2045 Evaluated Noise Walls – E 8th Street to McLoughlin Boulevard

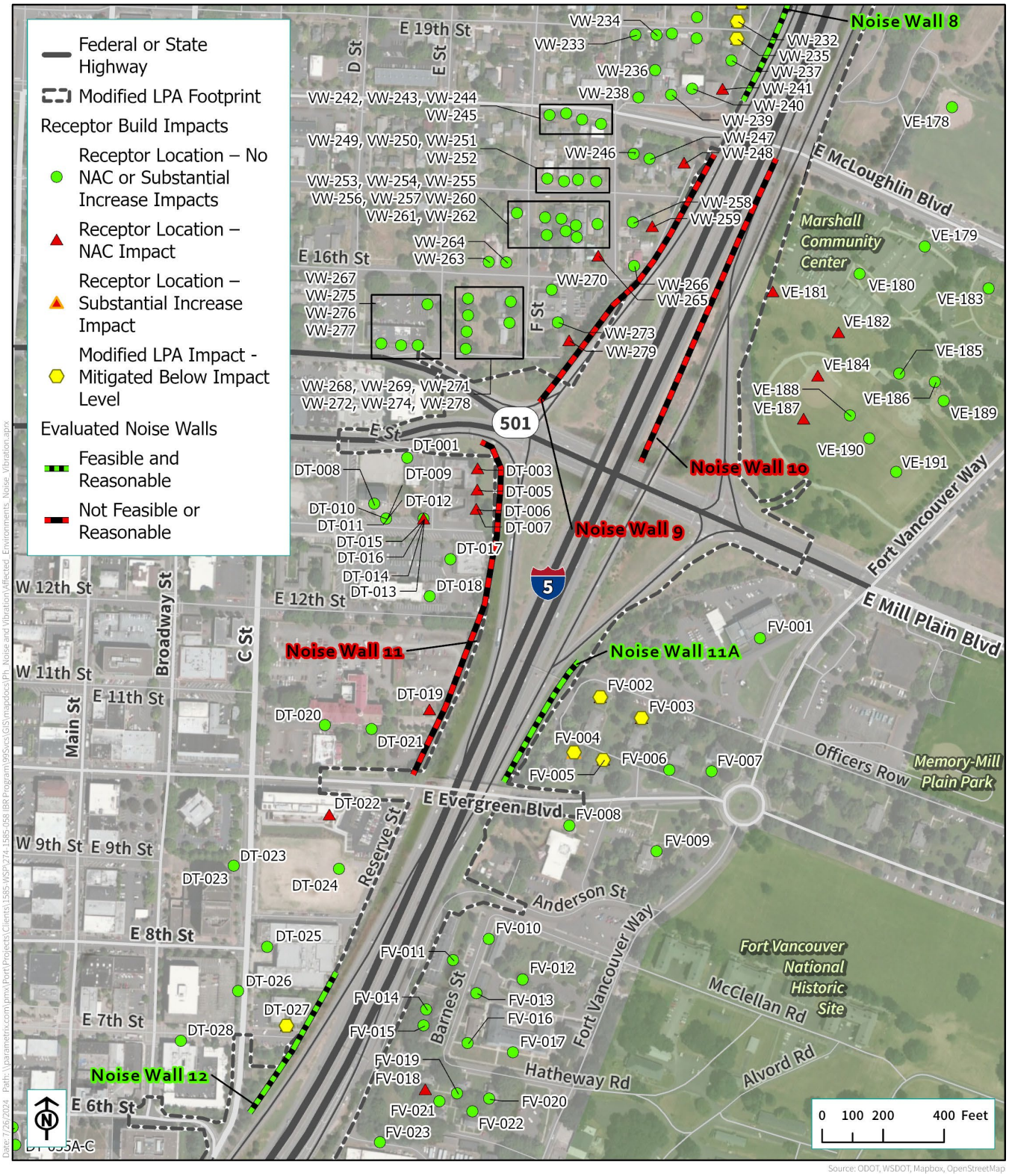


Figure 3.11-18. Modified LPA with Double-Deck Fixed-Span Configuration and One Auxiliary Lane – 2045 Evaluated Noise Walls – McLoughlin Boulevard to E 30th Street

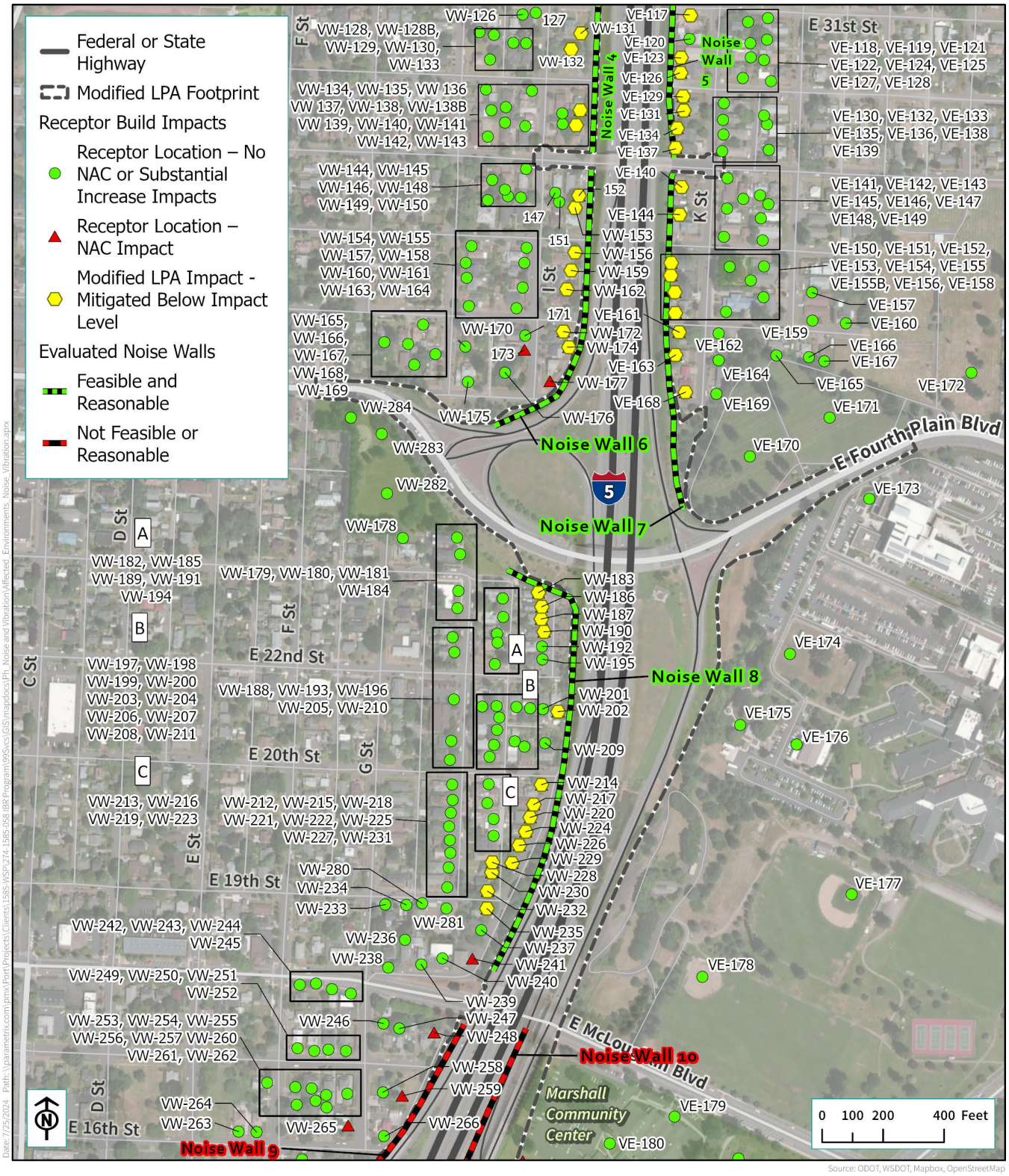


Figure 3.11-19. Modified LPA with Double-Deck Bridge Fixed-Span Configuration and One Auxiliary Lane – 2045 Evaluated Noise Walls – E 30th Street to E 39th Street

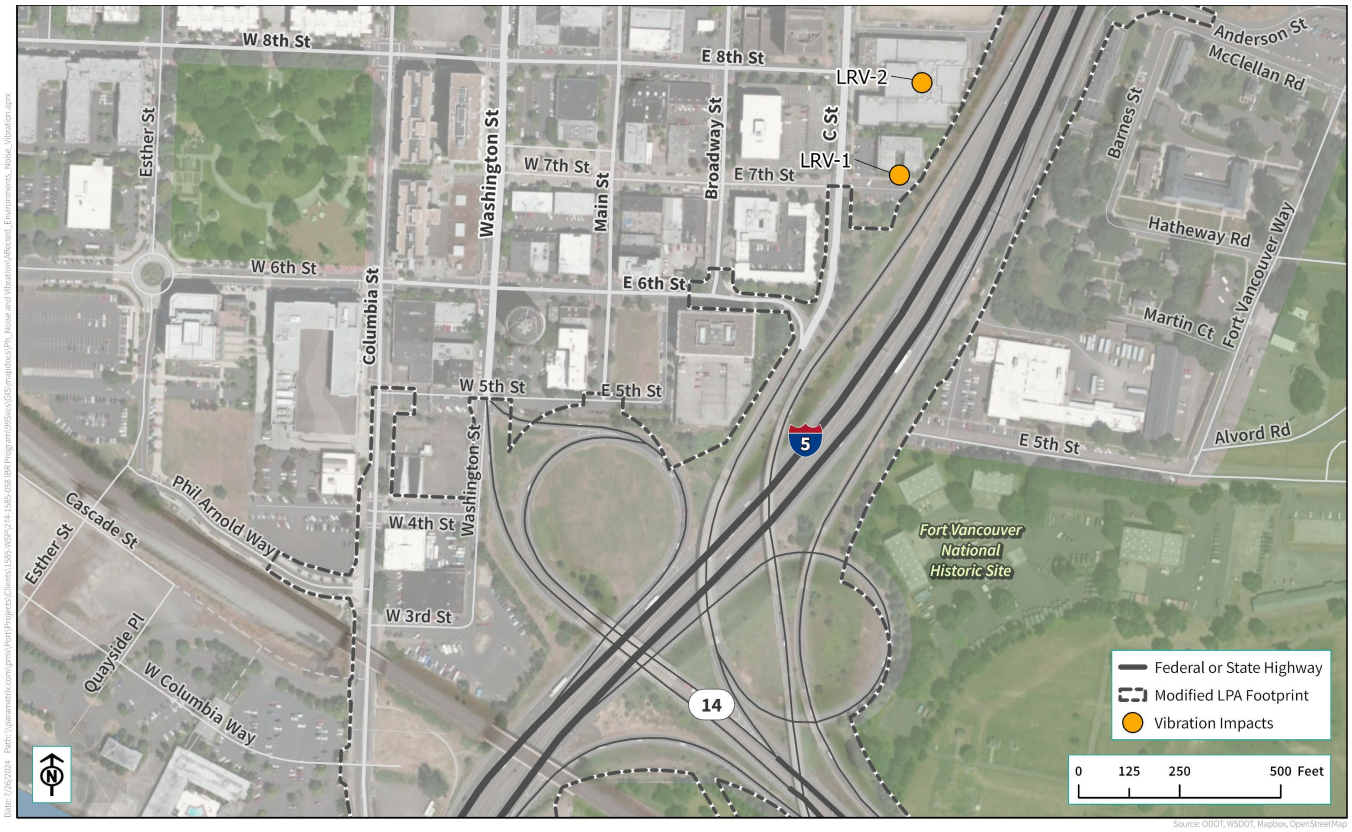
Figure 3.11-20. Modified LPA with Double-Deck Bridge Fixed-Span Configuration and One Auxiliary Lane – 2045 Evaluated Noise Walls – E 39th Street to Northern Terminus

Table 3.11-14. Noise Mitigation Analysis

Receptor [a]	Area Description [b]	Land Use	Number of Units [c]	Existing Noise [d] (dBA)	Light-Rail Noise [e] (dBA)	Project Noise with Mitigation [f] (dBA)	FTA Moderate Impact Criteria [g] (dBA, L_{dn})	Impacts [h]	Mitigation [i]	Residual Impacts [j]
LRT-1	E 7th Street/E C Street	SF	12	83	69	64	66	12	Wall	0

a Receivers shown on Figure 3.11-21.
b General description of the area of analysis.
c Number of individual apartments or homes affected.
d Existing noise levels in L_{dn} for category 2 land use, or L_{eq} for category 1 or 3 land uses (see Table 3.11-6 for categories).
e Noise from operation of the light-rail only. This is the noise level used to determine impacts under the FTA criteria.
f Exterior noise level with mitigation.
g FTA impact criteria.
h Number of units adversely affected by project noise.
i Mitigation measures.
dBA = A-weighted decibel; FTA = Federal Transit Administration; SF = single family

Figure 3.11-21. Light-Rail Noise and Vibration Impacts Post-Mitigation



Light-Rail Vibration Mitigation

Portland Vibration Mitigation

No vibration impacts are predicted in Portland; therefore, no mitigation is needed.

Vancouver Vibration Mitigation

- Use resilient rail fasteners to mitigate vibration impacts along direct fixation track way. Resilient rail fasteners typically reduce vibration levels by 5 VdB, which would not reduce all the predicted vibration levels below the FTA 72 VdB criteria for residential land uses. Receivers LRV-1 and LRV-2, with predicted levels of 77 VdB and 81 VdB, respectively, would be the only locations where there is still a potential for vibration impact following mitigation.
- Perform additional testing to ensure that the vibration levels at LRV-1 and LRV-2 would be below the 72 VdB criteria (Figure 3.11-9).

Table 3.11-15 summarizes the vibration levels with and without mitigation. Figure 3.11-21 shows the vibration impacts and proposed mitigation in downtown Vancouver.

Table 3.11-15. Modified LPA Vibration Mitigation Analysis

Location	Receptor	Area Description [b]	Land Use	FTA Vibration Criteria [c] (VdB)	Vibration Level [d] (VdB)	Vibration Level with Mitigation [e] (VdB)	Number of Potential Impacts with Mitigation [f]
Vancouver	LRV-1	E 7th Street/E C Street	MF	72	77	72	12
	LRV-2	E 8th Street/E C Street	Theater	72	81	76	1 - Theater

a Receptors shown on Figure 3.11-21.
b General description of the area of analysis.
c FTA vibration impact criteria.
d Predicted vibration level.
e Predicted vibration level with mitigation.
f Number of individual structures affected.
FTA = Federal Transit Administration; MF = multifamily; SF = single family; VdB = vibration decibels

Table 3.11-16 summarizes the long-term noise and vibration impacts that would result from the Modified LPA with the double-deck bridge configuration and one auxiliary lane. The Noise and Vibration Technical Report documents that, aside from the differences discussed above for the I-5 mainline westward shift design option, noise levels would be similar for the other design options. Table 3.11-8 summarizes the major differences in impacts and benefits across the Modified LPA's bridge configurations, the one-auxiliary-lane and two-auxiliary-lane options, and the No-Build Alternative. As detailed in Table 3.11-8, the difference in noise levels between design options result from the distance between the nearest noise-sensitive land uses and the design options, minimal change in traffic noise shielding from roadway alignments to noise-sensitive land uses, and no large change in peak hour traffic between design options.

Table 3.11-16. Comparison of Effects of the Modified LPA with the Double-Deck Bridge Configuration and One Auxiliary Lane without and with Mitigation

Technical Considerations	Modified LPA without Mitigation	Modified LPA with Mitigation
Number of receptors that exceed highway noise thresholds	198	121
Number of receptors with moderate transit noise impact levels	12	0
Number of receptors with severe transit noise impact levels	0	0
Number of receptors with transit vibration impacts	13	13

Noise/Vibration Mitigation Summary

Table 3.11-17 summarizes IBR Program mitigation related to noise and vibration during operation and construction.

Table 3.11-17. Noise/Vibration Mitigation Summary

IBR Program Area	Noise/Vibration Mitigation during IBR Program Operation	Noise/Vibration Mitigation during IBR Program Construction
Portland Mainland	Highway: Noise Wall 18 Light-Rail: Equip all light-rail track curves with a radius of less than 300 feet with wayside lubricators. After construction of the alignment, during the initial testing, if additional curves are identified with wheel squeal, install wayside track lubricators, as necessary.	• Comply with ODOT construction noise abatement measures (§ 00290.32 Noise Control) at the time of construction. • If a specific noise impact complaint occurs during the construction of the Modified LPA, implement noise mitigation measures outlined in this section as directed by the engineer. • In addition to § 00290.32, ODOT would also implement additional noise abatement methods, including: • Limit activities that produce the highest noise levels (such as hauling, loading spoils, jack hammering, and using other demolition equipment) from 7:00 a.m. to 7:00 p.m. Maximum noise levels associated with pile driving could reach 105 dBA at distances of 50 feet. Mitigation of the noise associated with pile driving would, when possible, include drilled shafts or auguring rather than driving piles (however, using an auger is not likely to be feasible or practical for all locations) or limiting the times the activity could take place. Other less effective methods of reducing noise from pile driving include coating the piles, using pile pads, or using piston mufflers. In the event that pile driving exceeds the limits set forth in Table 3.11-4, a noise variance would be requested from the local jurisdiction. • Keep a construction log for each of the construction staging areas. The log would contain general construction information such as the time an activity took place, type of equipment used, and other information that might help with potential noise effects. • Establish a complaint hotline to investigate noise complaints and compare them to the construction

IBR Program Area	Noise/Vibration Mitigation during IBR Program Operation	Noise/Vibration Mitigation during IBR Program Construction
		logs. A construction monitoring and complaint program would help to ensure that all equipment meets state, local, and any manufacturer's specifications for noise emissions. Equipment not meeting the standards would be removed from service until proper repairs were made and the equipment retested for compliance. This procedure would apply to all haul trucks, loaders, excavators, and other equipment that would be used extensively at the construction sites and that would contribute to potential noise effects. • Use equipment complying with pertinent equipment noise standards of the EPA. • Monitor all activities that might produce vibration levels at or above 0.5 inches per second if structures are near the construction activity, in compliance with WSDOT and ODOT requirements. This would include pile driving, vibratory sheet installation, soil compacting, and other construction activities with the potential to cause high levels of vibration. • For historic built properties within 500 feet of construction, monitor construction activities where construction-related vibration would exceed 0.2 inches per second for transient vibrations and 0.1 inches per second for continuous vibrations.
Portland/Hayden Island	Highway: None. Light-Rail: Equip all light-rail track curves with a radius of less than 300 feet with wayside lubricators. After construction of the alignment, during the initial testing, if additional curves are identified with wheel squeal, install wayside track lubricators, as necessary.	Same as Portland Mainland.
I-5/SR 14 Interchange	Highway: Noise Wall 11A, Noise Wall 12	Same as Portland Mainland with the following clarification for WSDOT:

IBR Program Area	Noise/Vibration Mitigation during IBR Program Operation	Noise/Vibration Mitigation during IBR Program Construction
	Light-Rail: Install tall traffic safety barriers or sound barriers along the elevated structure to mitigate the noise impacts at site LRT-1, which represents the Normandy Apartments. A 3- to 4-foot acoustical absorbent wall or 6-foot reflective wall would be effective at reducing noise levels at this location by 7 to 10 dBA. Equip all light-rail track curves with a radius of less than 300 feet with wayside lubricators. After construction of the alignment, during the initial testing, if additional curves are identified with wheel squeal, install wayside track lubricators, as necessary. Use resilient rail fasteners to mitigate for vibration impacts located along direct fixation track way. Resilient rail fasteners typically reduce vibration levels by 5 VdB, which would bring all the predicted vibration levels to, or below, the FTA 72 VdB criteria for residential land uses. Receivers LRV-1 and LRV-2, with predicted levels of 77 VdB and 81 VdB, respectively, would be the only locations where there is still a potential for vibration impact. Perform additional testing to ensure that the vibration levels at LRV-1 and LRV-2 would be below the 72 VdB criteria	Although WSDOT does not have noise control provisions, WSDOT would voluntarily comply with ODOT Standard Specification for Construction, § 00290.32 Noise Control (2015) for work completed in Washington.
E 8th Street to McLoughlin Boulevard	Highway: None Light-Rail: Equip all light-rail track curves with a radius of less than 300 feet with wayside lubricators. After construction of the alignment, during the initial testing, if additional curves are identified with wheel squeal, install wayside track lubricators, as necessary.	Same as I-5/SR 14 Interchange.
McLoughlin Boulevard to E 30th Street	Highway: Noise Wall 6, Noise Wall 7, Noise Wall 8 Light-Rail: None.	Same as I-5/SR 14 Interchange.
E 30th Street to E 39th Street	Highway: Noise Wall 2, Noise Wall 3, Noise Wall 4, Noise Wall 5 Light-Rail: None.	Same as I-5/SR 14 Interchange.

IBR Program Area	Noise/Vibration Mitigation during IBR Program Operation	Noise/Vibration Mitigation during IBR Program Construction
E 39th Street to Terminus	Highway: Noise Wall 1 Light-Rail: None.	Same as I-5/SR 14 Interchange.

Notes:
A final decision will be made upon the completion of the final design, a cost-estimating process, and the public involvement process. Additional vibration mitigation measures intended to protect marine life are described in Section 3.16, Ecosystems. Additional mitigation measures related to built historic resources are described in Section 3.8, Cultural Resources.

Temporary Effects

Construction noise and vibration BMPs applicable to the Modified LPA with any design option are discussed below.

Construction Noise

Regulatory Requirements

- Comply with ODOT construction noise abatement measures (§ 00290.32 Noise Control) at the time of construction.
- If a specific noise impact complaint occurs during the construction of the Modified LPA, implement noise mitigation measures outlined in this section as directed by the engineer.

Although WSDOT does not have noise control provisions, WSDOT would voluntarily comply with § 00290.32 for work completed in Washington.

Program-Specific Mitigation

In addition to § 00290.32, ODOT and WSDOT would also implement additional noise abatement methods, including:

- Limit activities that produce the highest noise levels (such as hauling, loading spoils, jack hammering, and using other demolition equipment) to 7:00 a.m. to 7:00 p.m. Maximum noise levels associated with pile driving could reach 105 dBA at distances of 50 feet. Mitigation of the noise associated with pile driving would, when possible, include drilled shafts or auguring rather than driving piles (however, using an auger is not likely to be feasible or practical for all locations) or limiting the times the activity could take place. Other less effective methods of reducing noise from pile driving include coating the piles, using pile pads, or using piston mufflers. In the event that pile driving exceeds the limits set forth in Table 3.11-4, a noise variance would be requested from the local jurisdiction.
- Keep a construction log for each of the construction staging areas. The log would contain general construction information such as the time an activity took place, type of equipment used, and other information that might help with potential noise effects.
- Establish a complaint hotline to investigate noise complaints and compare them to the construction logs. A construction monitoring and complaint program would help to ensure that all equipment meets state, local, and any manufacturer's specifications for noise emissions. Equipment not meeting the standards would be removed from service until proper repairs were made and the equipment retested for compliance. This procedure would apply to all haul trucks, loaders, excavators, and other equipment that would be used extensively at the construction sites and that would contribute to potential noise effects.
- Use equipment complying with pertinent equipment noise standards of the U.S. Environmental Protection Agency.

Construction Vibration

Regulatory Requirements

- Monitor all activities that might produce vibration levels at or above 0.5 inches per second if structures are near the construction activity, in compliance with WSDOT and ODOT requirements. This would include pile driving, vibratory sheet installation, soil compacting, and other construction activities with the potential to cause high levels of vibration.
- For historic built properties within 500 feet of construction, monitor construction activities where construction-related vibration would exceed 0.2 inches per second for transient vibrations and 0.1 inches per second for continuous vibrations.

Additional vibration mitigation measures intended to protect marine life are described in Section 3.16, Ecosystems. Additional mitigation measures related to built historic resources are described in Section 3.8, Cultural Resources.

Program-Specific Mitigation

No program-specific mitigation measures are proposed for vibration levels during construction.