Lake Oswego to Portland Transit Project

Environmental Noise and Vibration

November, 2010

TriMet and Metro

Richard Steffel & Kristen Wallace
ENVIRON International Corporation

The preparation of this report was financed in part by the U.S. Department of Transportation, Federal Transit Administration. The opinions, findings and conclusions expressed in this report are not necessarily those of the U.S. Department of Transportation, Federal Transit Administration.

This page intentionally blank.

TABLE OF CONTENTS **Page**

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

This report contains the detailed analysis and documentation that is the basis for Chapter 3, Section 3.10 on noise and vibration in the Lake Oswego to Portland Transit Project (LOPT) Draft Environmental Impact Statement (DEIS) published by the Federal Transit Administration in December 2010. This chapter of the report includes a summary of the project background, the Purpose and Need, the alternatives/options considered and the description of the alternatives analyzed.

1.1 Project Background

Transit improvements in the Lake Oswego to Portland corridor have been studied several times in recent history. In the 1970s and 80s, a light-rail alignment through Johns Landing was studied as part of the Westside Corridor Alternatives Analysis, and in the 1990s potential light-rail alignments through Johns Landing were studied as part of the South/North Corridor Study.

The Willamette Shore Line right-of-way was first established in 1885-1887 as the Portland and Willamette Valley Railroad, which began operation in July 1887. The Southern Pacific Railroad (SPRR) later purchased the railway in 1914. The railroad had a major impact on the development of southwest Portland. Initially, 14 trains operated between Portland and "Oswego" (as it then was known), and it became the main transportation link for developing residential communities along the route. The line was electrified in 1914 and passenger traffic hit its peak in 1920 with SPRR running 64 daily trains between Portland and Oswego. Passenger service ended on October 5, 1929, while freight service continued until 1983.

In August of 1984, the Interstate Commerce Commission granted SPRR permission to abandon the line. In 1988, the Willamette Shore Line Consortium (the Consortium) purchased the 6.3-mile-long line from SPRR for approximately $2 million. The Consortium, comprised of the City of Lake Oswego, City of Portland, Oregon Department of Transportation (ODOT), Clackamas County, Multnomah County, Metro, and TriMet, purchased the line to preserve it for future passenger rail transit use. TriMet holds title for the Consortium and the City of Lake Oswego provides maintenance services funded by the Consortium.

In 2005, with the endorsement of the Joint Policy Advisory Committee on Transportation (JPACT), the Metro Council directed staff to initiate the Lake Oswego to Portland Transit and Trail Alternatives Analysis. The alternatives analysis focused on improving the ability to serve travel demand in the corridor through improved transit service and development of a multi-use pathway.

1.2 Purpose and Need

The **Purpose** of the project is to optimize the regional transit system by improving transit within the Lake Oswego to Portland transit corridor, while being fiscally responsive and supporting regional and local land use goals. The project should maximize, to the extent possible, regional resources and economic development opportunities, and garner broad public support. The project should build on previous corridor transit studies, analyses, and conclusions and should be environmentally sensitive.

The **Need** for the project results from:

- Historic and projected increases in traffic congestion in the Lake Oswego to Portland corridor due to increases in regional and corridor population and employment;
- Lengthy and increasing transit travel times and deteriorating public transportation reliability in the corridor due to growing traffic congestion;
- Increasing operating expenses, combined with increasingly scarce operating resources and the demand for more efficient public transportation operations;
- Local and regional land use and development plans, goals, and objectives that target the corridor for residential, commercial, retail, and mixed-use development to help accommodate forecast regional population and employment growth, and previous corridor transit studies, analyses, and conclusions;
- The region's growing reliance on public transportation to meet future growth in travel demand in the corridor;
- The topographic, geographic, and built-environment constraints within the corridor that limit the ability of the region to expand the highway and arterial infrastructure in the corridor; and
- Limited options for transportation improvements in the corridor caused by the identification and protection of important natural, built, and socioeconomic environmental resources in the corridor.

1.3 Alternatives/Options Considered

Metro's 2004 Regional Transportation Plan (RTP) identified the need for a refinement plan for a high capacity transit option for the corridor, which included an analysis of several modal alternatives. Metro initiated the corridor refinement plan in July 2005 and issued the *Lake Oswego to Portland Transit and Trail Alternatives Analysis Evaluation Summary Public Review Draft* in June 2007.

On December 13, 2007, after reviewing and considering the alternatives analysis report, public comment, and recommendations from the Lake Oswego to Portland Transit and Trail Project Citizen Advisory Committee (CAC), the Lake Oswego to Portland Transit and Trail Project Management Group (PMG), Steering Committee, and partner jurisdictions and agencies, the Metro Council approved Resolution No. 07-3887A. The resolution adopted the *Lake Oswego to Portland Transit and Trail Alternatives Analysis: Alternatives to be Advanced into a Draft Environmental Impact Statement and Work Program Considerations* (December 13, 2007). (See Section 2.1 for additional detail on the process used to identify and narrow alternatives.) It also selected the No-Build, Enhanced Bus, and Streetcar alternatives to advance into the project's DEIS for further study, and directed staff to conduct a refinement study to identify design options in the Johns Landing Area and terminus options to advance into the project's DEIS. The resolution called for further refinement of the trail component to move forward as a separate process.

1.3.1 Alternatives Analysis

The project's Alternatives Analysis process developed a wide range of alternatives for evaluation and early screening, which included: a no-build alternative, widening of Highway 43, reversible lanes on Highway 43, river transit (three options), bus rapid transit (BRT) (three options), commuter rail, light rail, and streetcar (a wide range of alignment alternatives and terminus alternatives and options).

Through a screening process that assessed the ability of the alternatives to meet the project's Purpose and Need, the initial range of possible alternatives was narrowed. Appendix C of the DEIS provides a summary of the technical evaluation of the alternatives and options considered during the alternatives analysis phase.

The following alternatives were selected for further study through the alternatives analysis phase: 1) No-Build Alternative, 2) BRT Alternative, and 3) Streetcar Alternative. Following is a description of those alternatives as they were studied in the alternatives analysis (see the *Lake Oswego to Portland Transit and Trail Study Evaluation Summary Public Review Draft* for more information).

- **No-Build Alternative.** Similar to the project's current No-Build Alternative, as described in Section 1.4.1.

- **BRT Alternative.** This BRT Alternative would operate frequent bus service with Line 35 on Highway 43 between downtown Portland and downtown Lake Oswego, generally in mixed traffic, with bus station spacing that would be longer than TriMet typically provides for fixed-route bus service. Transit queue bypass lanes would be constructed at congested intersections, where feasible.

- **Streetcar Alternative.** The Streetcar Alternative would extend the existing Portland Streetcar line, which currently operates between NW 23rd Avenue and SW Lowell Street, to downtown Lake Oswego. Study of this alternative includes an evaluation of whether the Willamette Shore Line right-of-way would be used exclusively of whether it would be used in combination with SW Macadam Avenue or other adjacent roadways.

1.3.2 Scoping/Project Refinement Study

This section describes the alignment and terminus options developed, evaluated, and screened in 2009 as a part of the project's Scoping and Project Refinement Study phase. This phase focused on refinements in two areas: 1) alignment options for the Johns Landing area; and 2) terminus options in the Lake Oswego area. In summary, the project's Purpose Statement during the refinement phase was to:

- Optimize the regional transit system;
- Be fiscally responsive and maximize regional resources;
- Maximize the economic development potential of the project;
- Be sensitive to the built and social environments; and
- Be sensitive to the natural environment.

The options, evaluation measures, and results of the Johns Landing streetcar alignment refinement process and the Lake Oswego terminus refinement processes are summarized below.

A. Johns Landing Streetcar Alignment Refinement. For the refinement of streetcar design options within the Johns Landing area, the project used the following criteria: streetcar operations, streetcar performance, financial feasibility, traffic operations, accessibility and development potential, neighborhood sustainability, and adverse impacts to the natural environment. Measures for each of the criteria were developed and applied to each of the alignment options studied, which included:

- Hybrid 1: Macadam Avenue In-Street
- Hybrid 2: East Side Exclusive
- Hybrid 3: Macadam Avenue with New Northbound Lane
- Willamette Shore Line
- Full Macadam In-Street

B. Lake Oswego Terminus Option Refinement. For the refinement of terminus options in the Lake Oswego area, the project used the following criteria: expansion potential and regional context, streetcar operations, streetcar performance, financial feasibility, traffic operations, accessibility and development potential, and neighborhood sustainability. Measures for each of the criteria were developed and applied to each of the alignment options studied, which included: a) Safeway Terminus Option; b) Albertsons Terminus Option; and c) Trolley Terminus Option.

On June 1, 2009, in consultation with FTA and based on the findings of the analysis, public and agency comment and recommendations from the Lake Oswego to Portland Project Management Group, the Lake Oswego to Portland Transit Project Steering Committee selected the following options in the Johns Landing area to advance into the DEIS: Willamette Shore Line; Hybrid 1 – Macadam Avenue In Street (Boundary Street to Carolina Street); and Hybrid 3: Macadam Avenue with New Northbound Lane (Boundary Street to Carolina Street).

1.4 Description of Alternatives Analyzed in this Technical Report and the DEIS

This section summarizes the roadway and transit capital improvements and transit operating characteristics for the No-Build, Enhanced Bus, and Streetcar Alternatives. A more detailed description of the alternatives may be found in the *Lake Oswego to Portland Transit Project Detailed Definition of Alternatives Report* (Metro/TriMet: January 2010). Detailed drawings of the Streetcar Alternative, including the various design options, can be found in the *Streetcar Plan Set*, November 2009.

1.4.1 No-Build Alternative

This section describes the No-Build Alternative, which serves as a reference point to gauge the benefits, costs, and effects of the Enhanced Bus and Streetcar alternatives. In describing the No-Build Alternative, this section focuses on: 1) the alternative's roadway, bicycle and pedestrian, and transit capital improvements; and 2) the alternative's transit operating characteristics. This description of the No-Build Alternative is based on conditions in 2035, the project's environmental forecast year.

1.4.1.1 Capital Improvements

Following is a brief description of the roadway, bicycle and pedestrian, and transit capital improvements that would occur under the No-Build Alternative (see Table 1-1). Figure 1-1 illustrates the location of those improvements.

- **Roadway Capital Improvements**. The No-Build Alternative includes the existing roadway network in the corridor, with the addition of roadway capital improvements that are listed in the financially constrained road network of Metro's 2035 RTP.[1]Following is a list of the roadway projects that would occur within the corridor by 2035.

    - *Moody/Bond Avenue Couplet* (create couplet with two lanes northbound on SW Bond Avenue and two lanes southbound on SW Moody Avenue);
    - *South Portal* (Phases I and II to extend the SW Moody Avenue/SW Bond Avenue couplet to SW Hamilton Street and realign SW Hood Avenue to connect with SW Macadam Avenue at SW Hamilton Street);
    - *I-5 North Macadam* (construct improvements in the South Waterfront District to improve safety and access); and
    - *Macadam Intelligent Transportation Systems* (install system and devices in the SW Macadam Avenue corridor to improve traffic flow).

[1] Metro, 2035 Regional Transportation Plan, approved Dec. 13, 2007.

Table 1-1 Transit Capital Improvements for the No-Build, Enhanced Bus, and Streetcar Alternatives (2035)

Attribute	No-Build	Enhanced Bus	Streetcar
Streetcar[1]			
New Alignment Length	N/A	N/A	5.9 to 6.0
One-Way Track Miles			
Portland Streetcar System	15.7	15.7	26.2 to 27.0
Proposed Lake Oswego to Portland Project	0	0	10.5 to 11.3
Stations			
Portland Streetcar System	69	69	79
Proposed Lake Oswego to Portland Project	0	0	10[2]
Streetcars (in service/spares/total)			
Portland Streetcar System	17/5/22	17/5/22	27/6/33
Proposed Lake Oswego to Portland Project	N/A	N/A	10/1/11
Streetcar O&M Facility			
Number of Facilities[3]	1	1	2
Maintenance Capacity (number of Streetcars)	36	36	36
Storage Capacity (number of Streetcars)	25	25	33
Bus[4]			
Line 35 Bus Stops (Lake Oswego to SW Bancroft St.)	26	13	0
Buses (in service/spares)			
TriMet Systemwide	607/712	619/725	601/704
Difference from No-Build Alternative	N/A	13	- 8
Transit - Centers[5]	1	1	1
Park-and-Ride Facilities			
Joint Use Surface – Lots/Spaces	3/76	3/76	3/76
Surface – Lots/Spaces	0/0	0/0	1/100
Structured – Lots/Spaces	0/0	1/300	1/300

Note: LO = Lake Oswego; O&M = operating and maintenance.

1 Under the No-Build and Enhanced Bus alternatives, the Portland Streetcar System would include two streetcar lines: a) the existing Portland Streetcar Line, between NW 23rd Avenue and SW Bancroft Street; and b) the Portland Streetcar Loop, which is currently under construction and will be completed when the Milwaukie Light Rail and Streetcar Close the Loop project are constructed. The Streetcar Alternative would extend the existing Portland Streetcar line south, from SW Bancroft Street to Lake Oswego. The new alignment length is the length in miles from SW Bancroft to the Lake Oswego terminus station. One-way track miles are calculated by multiplying the mileage of double-tracked sections and adding that to the mileage of single-track sections. Alignment length and one-way track miles are presented as a range, because they would vary by design option. The number of streetcar stations, streetcars in service or as spares and the number and size of streetcar O&M facilities would not change by streetcar design option.

2 Two optional stations are also being considered for inclusion in the Streetcar Alternative (see Figure 1-5 and Figure 1-6): 1) the Pendleton Station under the Macadam In-Street and Macadam Additional Lane design options in the Johns Landing Segment; and the E Avenue Station in the Lake Oswego Segment.

3 There is an existing streetcar operations and maintenance (O&M) facility at NW 16th Avenue, between NW Marshall and NW Northrup streets; under the Streetcar Alternative, additional storage for eight vehicles would be provided along the streetcar alignment under the Marquam Bridge.

4 There would be no change in the number or size of bus O&M facilities under any of the alternatives or design options. Bus stops are those that would be served exclusively by Line 35 between Lake Oswego and SW Bancroft Street

5 Under the No-Build and Enhanced Bus alternative, the Lake Oswego Transit Center would remain at its current location (on 4th Street, between A and B avenues); under the Streetcar Alternative, the transit center would be moved to be adjacent to the Lake Oswego Terminus Station.

Source: TriMet, January 2010.

Table 1-2 Transit Operating Characteristics of No-Build, Enhanced Bus, and Streetcar Alternatives (2035)

Attribute	No-Build	Enhanced Bus	Streetcar
Streetcar[1]			
Weekday Vehicle Miles Traveled			
Systemwide	1,884	1,884	2,491 or 2,501
Difference from No-Build Alternative	N/A	0	607 or 617
Weekday Revenue Hours			
Systemwide	299	299	390
Difference from No-Build Alternative	N/A	0	91
Corridor Weekday Place Miles[2]	N/A	N/A	5,844 or 6,764
Corridor Round-Trip Time[3]	N/A	N/A	36 or 42 min.
Corridor Streetcar Headways[4]			
Lake Oswego to PSU	N/A	N/A	7.5/12 min.
Bus			
Weekday Vehicle Miles Traveled			
Systemwide	76,660	77,880	74,540
Difference from No-Build Alternative	N/A	1,220	-2,120
Weekday Revenue Hours			
Systemwide	5,320	5,410	5,150
Difference from No-Build Alternative	N/A	90	-170
Line 35 Weekday Place Miles[2]	37,000	57,840	0
Line 35 Headways[4]			
Lake Oswego to Downtown Portland	10/15 min.	5/15 min.	N/A
Oregon City to Lake Oswego	15/15 min.	15/15 min.	15/15 min.

Note: N/A = not applicable; LO = Lake Oswego; O&M = operating and maintenance; PSU = Portland State University.

[1] The operating characteristics of the Streetcar Alternative summarized in this table would not vary by design option, except when shown as a range and as noted for streetcar vehicle miles traveled, place miles, and round-trip time. The first number listed is under the Willamette Shore Line Design Option and the second number listed is under the Macadam design options (in the Johns Landing Segment).

[2] Place miles are a measure of the passenger carrying capacities of the alternatives, similar to airline seat miles. Place miles = transit vehicle capacity (seated and standing) of a vehicle type, multiplied by the number vehicle miles traveled for that vehicle type, summed across all vehicle types. The No-Build Alternative bus place miles are based on lines 35 and 36.

[3] Round-trip run time for the proposed streetcar line would include in-vehicle running time from SW Bancroft Street to the Lake Oswego Terminus Station and back to SW Bancroft Street; it does not include layover time at the terminus.

[4] Headways are the average time between transit vehicles per hour within the given time period that would pass by a given point in the same direction, which is inversely related to frequency (the average number of vehicles per hour in the given time period that would pass by a given point in the same direction). Weekday peak is generally defined as 7:00 to 9:00 a.m. and 4:00 to 6:00 p.m.; weekday off-peak is generally defined as 5:00 to 7:00 a.m., 9:00 a.m. to 4:00 p.m. and 6:00 p.m. to 1:00 a.m. There would be streetcar service every 12 minutes between SW Bancroft Street and the Pearl District (via PSU) under the No-Build and Enhanced Bus alternatives. The peak headways shown for the No-Build Alternative are the composite headways for lines 35 and 36.

Source: TriMet – January 2010.

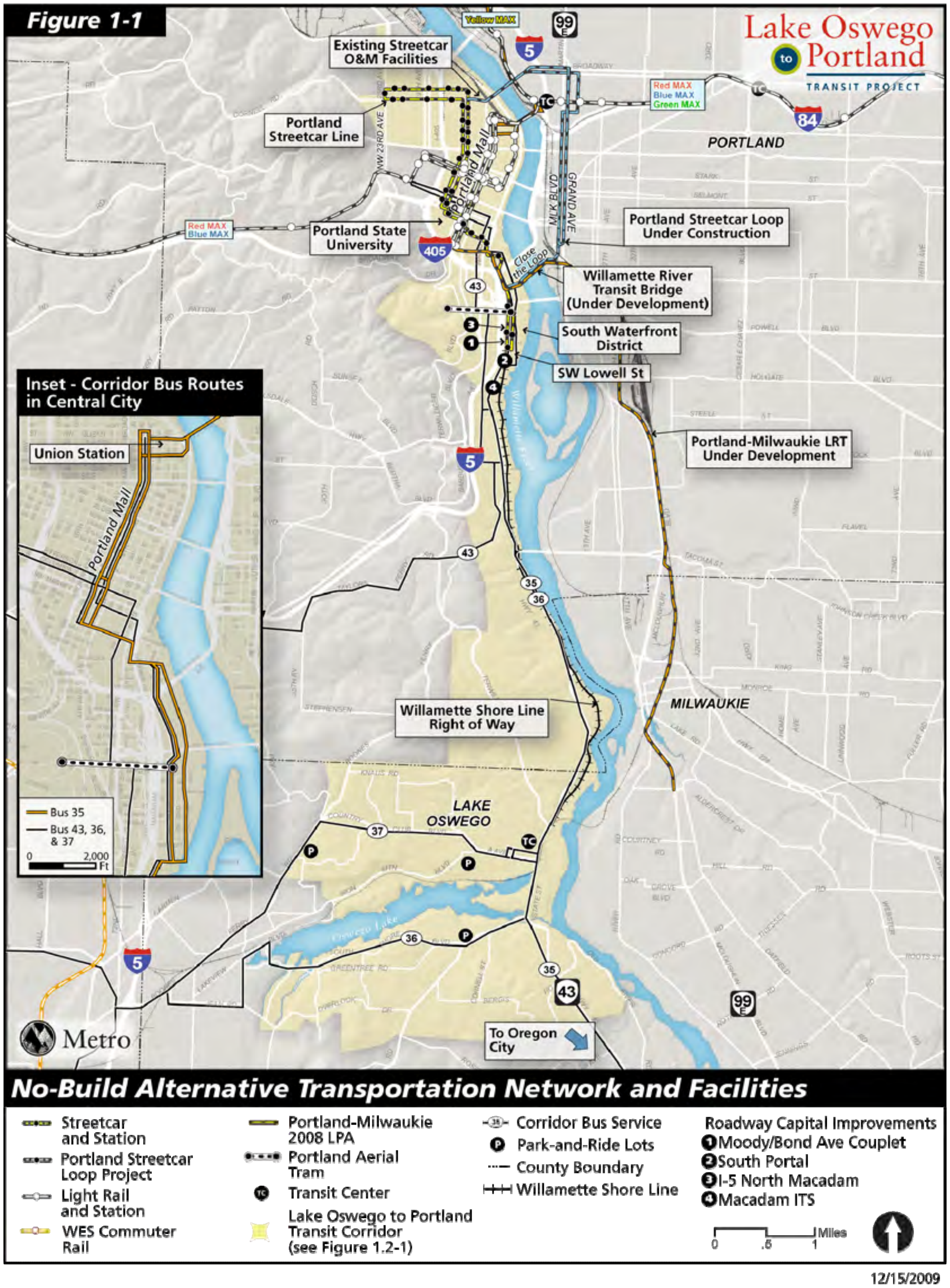

FIGURE 1-1 NO-BUILD ALTERNATIVE TRANSPORTATION NETWORK AND FACILITIES

- **Bicycle and Pedestrian Improvements**. The No-Build Alternative includes the existing bicycle and pedestrian network in the corridor, with the addition of bicycle and pedestrian capital improvements that are listed in the financially constrained road network of Metro's 2035 RTP. Following is a list of the bicycle and pedestrian projects that are proposed to occur within the corridor by 2035.
    - *Lake Oswego to Portland Trail* (extension of a multiuse path between Lake Oswego and Portland);
    - *I-5 at Gibbs Pedestrian/Bicycle Overcrossing* (construct a bicycle and pedestrian bridge over I-5 in the vicinity of SW Gibbs Street); and
    - *Tryon Creek Bridge* (construct a new pedestrian/bicycle bridge near the mouth of Tryon Creek).

- **Bus Capital Improvements.** There are currently two primary bus capital facilities in the corridor: *Lake Oswego Transit Center* (on 4th Street, between A and B avenues); and *Portland Mall* (bus and light rail lanes and shelters on NW/SW 5th and 6th avenues between NW Glisan Street and SW Jackson Street). These bus facilities would remain as-is under the No-Build Alternative. (The financially constrained transit project list of the RTP includes relocation of the Lake Oswego Transit Center to be adjacent to the Lake Oswego to Portland Streetcar alignment, which is also in the financially constrained project list. Neither would occur under the No-Build Alternative.) No additional bus capital improvements are planned for the corridor under the No-Build Alternative by 2035.

- **Light Rail Capital Improvements.** Under the No-Build Alternative, TriMet's existing Yellow Line light-rail service would continue to operate on the Portland Mall (with a station at PSU added), across the Steel Bridge and into North Portland. Yellow Line facilities and service would be extended north from the existing Expo Center Station, across the Columbia River into Vancouver, Washington, and south from the Portland Mall, generally via SW Lincoln Street, across the Willamette River to Milwaukie, Oregon. In addition, downtown Portland would be served by the following TriMet light-rail lines: Blue Line (Gresham to Hillsboro); Red Line (Beaverton to Portland International Airport); and Green Line (downtown Portland to Clackamas Town Center).

- **Excursion Trolley Capital Facilities.** Under the No-Build Alternative there would be no changes to the existing excursion trolley capital facilities that are located or operate within the corridor. Those excursion trolley capital facilities include approximately six miles of single-tracked Willamette Shore Line tracks and related facilities; stations at SW Bancroft and Moody streets and at N State Street at A Avenue; a trolley barn at approximately N State Street at A Avenue; and typically one vintage and/or other trolley vehicle propelled by externally attached diesel units.

- **Streetcar Improvements and Vehicles.** Under the No-Build Alternative, the existing Portland Streetcar Line would continue to operate between NW 23rd Avenue and SW Lowell Street. In addition, the No-Build Alternative includes the Eastside Streetcar Project (currently under construction), which would extend streetcar tracks and stations across the Broadway Bridge, serving NE and SE Portland on N and NE Broadway and NE and SE Martin Luther King

Boulevard and Grand Avenue to OMSI. With the Close the Loop Project, the Eastside Streetcar will be extended across the Willamette River, to complete the planned Streetcar Loop, via a new transit, bicycle, and pedestrian bridge to be constructed under the Milwaukie Light Rail Project, connecting to the Streetcar line in the South Waterfront District. Under the No-Build Alternative in 2035, there would be 22 streetcars in the transit system (including spares), an increase of 11 compared to existing conditions.

- **Park-and-Ride Facilities.** Under the No-Build Alternative, the park-and-ride facilities in the corridor would be those that currently exist: a shared-use 30-space park-and-ride lot at Christ Church (1060 SW Chandler Road); a shared-use 34-space park-and-ride lot at Lake Oswego United Methodist Church (1855 South Shore Boulevard); and a shared use 12-space park-and-ride lot at Hope Church (14790 SW Boones Ferry Road).

- **Operations and Maintenance Facilities.** Under the No-Build Alternative, there would be one operations and maintenance facility within the corridor, which would be the existing streetcar maintenance building and storage yard on NW 16th Avenue under I-405. With the Streetcar Loop and Close the Loop Projects, the storage yard could accommodate 25 streetcars and the maintenance facility would have the capacity to service 36 streetcars (an increase in capacity of 13 and 18 vehicles, compared to existing conditions, respectively).

1.4.1.2 Transit Operations

This section summarizes the transit operating characteristics that would occur under the No-Build Alternative, focusing on bus and streetcar operations (see Table 1-2). Figure 1-1 illustrates the transit network for the No-Build Alternative in the vicinity of the corridor.

- **Bus Operations.** Bus operations under the No-Build Alternative would be similar to TriMet's existing fixed-route bus network with the addition of improvements included in the 2035 RTP's 20-year financially constrained transportation system (see Figure 1-1). Transit service improvements within the No-Build Alternative would be limited to those that could be funded using existing and readily-foreseeable revenue sources. Systemwide, those bus operations improvements would include: 1) increases in TriMet bus route frequency to avoid peak overloads and/or maintain schedule reliability; 2) increases in run times to maintain schedule reliability; and 3) incremental increases in TriMet systemwide bus service hours consistent with available revenue sources and consistent with the 2035 RTP's 20-year financially-constrained transit network, resulting in annual increases in service hours of approximately 0.5 percent per year. Specifically, the No-Build Alternative would include the operation of the TriMet bus route Line 35 between downtown Portland and Lake Oswego (continuing south to Oregon City).

- **Streetcar Operating Characteristics**. Under the No-Build Alternative, the City of Portland, through an operating agreement with the Portland Streetcar, Inc. (PSI), would continue to operate the existing Portland Streetcar line between Northwest Portland and the South Waterfront District, via downtown Portland (see Figure 1-1). On average weekdays in 2035, the Streetcar line would operate every 12 minutes during the peak and off-peak periods. Further, the City of Portland would operate the Streetcar Loop Project, serving downtown Portland, the Pearl District, northeast and southeast Portland, OMSI and the South Waterfront District. Frequency on the line for an average weekday in 2035 would be every 12 minutes during the peak and off-peak periods.

1.4.2 Enhanced Bus Alternative

This section describes the roadway, bicycle and pedestrian, and transit capital improvements and transit operating characteristics under the Enhanced Bus Alternative, generally compared to the No-Build Alternative. The intent of the Enhanced Bus Alternative is to address the project's Purpose and Need without a major transit capital investment.

1.4.2.1 Capital Improvements

This section summarizes the transit, bicycle and pedestrian, and transit capital improvements that would occur under the Enhanced Bus Alternative, compared to the No-Build Alternative (see Table 1-1 and Figure 1-2).

- **Roadway Capital Improvements.** Except for the addition of a two-way roadway connection between the proposed 300-space park-and-ride lot and Foothills Road, there would be no change in roadway improvements under the Enhanced Bus Alternative, compared to the No-Build Alternative.

- **Bicycle and Pedestrian Improvements.** There would be no change in bicycle and pedestrian improvements under the Enhanced Bus Alternative, compared to the No-Build Alternative.

- **Bus Capital Improvements.** Under the Enhanced Bus Alternative, the 26 bus stops that would be served by Line 35 between downtown Lake Oswego and SW Bancroft under the No-Build Alternative would be consolidated into 13 bus stops, which would continue to be served by the Line 35 (the other 13 bus stops would be removed). The bus stops served by Line 35 between Lake Oswego and Oregon City would be unchanged under the Enhanced Bus Alternative, compared to the No-Build Alternative.

- **Light Rail Capital Improvements.** There would be no change in light rail capital improvements under the Enhanced Bus Alternative, compared to the No-Build Alternative.

- **Excursion Trolley Capital Improvements.** There would be no change in excursion trolley capital improvements under the Enhanced Bus Alternative, from the No-Build Alternative.

- **Streetcar Improvements and Vehicles.** There would be no change in streetcar improvements and vehicles under the Enhanced Bus Alternative, compared to the No-Build Alternative.

- **Park-and-Ride Facilities.** In addition to the park-and-ride facilities included under the No-Build Alternative, the Enhanced Bus Alternative would include a 300-space structured park-and-ride lot that would be located at Oswego Village Shopping Center on Highway 43 in downtown Lake Oswego. The park-and-ride lot would be served by Lines 35 and 36.

- **Operations and Maintenance Facilities.** There would be no changes to the region's operations and maintenance facilities under the Enhanced Bus Alternative, compared to the No-Build Alternative, except that the capacity of TriMet's bus operating and maintenance facilities under the No-Build Alternative (at either the Center or Powell facility) would be expanded proportionately to accommodate the additional 13 buses under the Enhanced Bus Alternative (see the *Detailed Definition of Alternatives Report* for additional information).

1.4.2.2 Transit Operations

This section summarizes the corridor's transit operations under the Enhanced Bus Alternative, focusing on bus and streetcar operations. Figure 1-2 illustrates the transit network for the Enhanced Bus Alternative in the vicinity of the corridor.

- **Bus Operations.** Except for changes to the routing, frequency, and number of stops of Line 35 and the elimination of Line 36 service between downtown Portland and downtown Lake Oswego, bus operations under the Enhanced Bus Alternative would be identical to the bus operations under the No-Build Alternative. Under the Enhanced Bus Alternative, Line 35's routing between Oregon City and Lake Oswego would remain unchanged relative to the No-Build Alternative. Further, between Lake Oswego and downtown Portland there would be two routing changes to Line 35, compared to the No-Build Alternative: 1) the bus would be rerouted to serve the new park-and-ride lot at the Oswego Village Shopping Center; and, 2) in downtown Portland, Line 35 would be rerouted to serve SW and NW 10th and 11th avenues, generally between SW Market and Clay streets and NW Lovejoy Street/Union Station to address the travel markets.

- **Streetcar Operating Characteristics.** Under the Enhanced Bus Alternative, there would be no change in streetcar operating characteristics, compared to the No-Build Alternative.

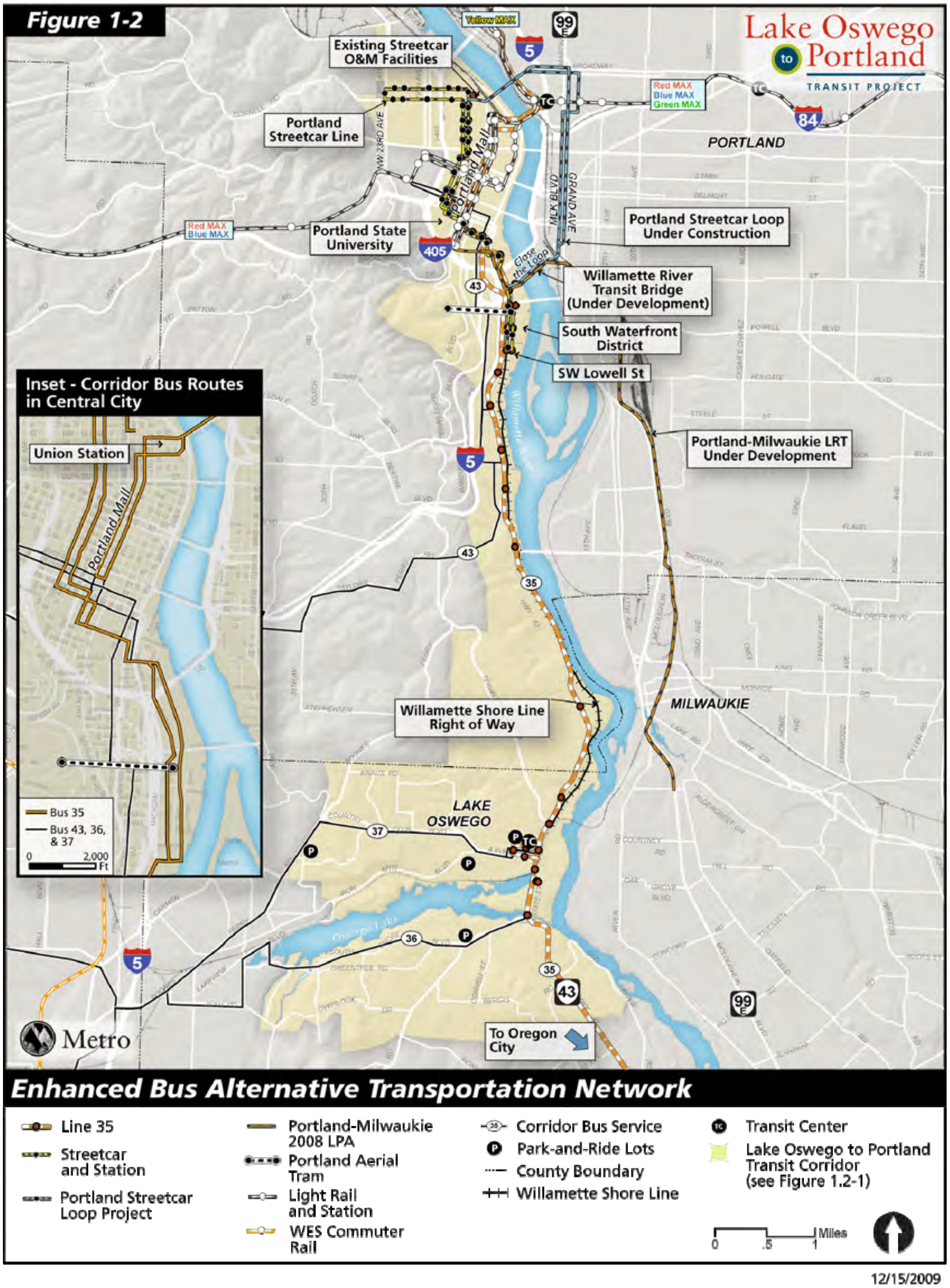

FIGURE 1-2 ENHANCED BUS ALTERNATIVE TRANSPORTATION NETWORK

1.4.3 Streetcar Alternative

This section describes the roadway, bicycle and pedestrian, and transit capital improvements and transit operating characteristics under the Streetcar Alternative, generally compared to the No-Build Alternative.

1.4.3.1 Capital Improvements

This section summarizes the transit, bicycle and pedestrian, and transit capital improvements that would occur under the Streetcar Alternative, generally compared to the No-Build Alternative (see Table 1-1 and Figure 1-3). This section provides a general description of the capital improvements that would occur under the Streetcar Alternative, independent of design option, and it highlights the differences between design options within four of the corridor's segments.

A. Summary Description

Following is a general description of the roadway, bicycle and pedestrian, and transit improvements that would occur under the Streetcar Alternative. The next section provides a description of differences in capital improvements for design options that are under consideration in four of the project's six segments. See Figure 1-4 for an illustration of the project segments and the design options under consideration in four of those segments.

- **Roadway Capital Improvements.** Compared to the No-Build Alternative, there would be no roadway improvements under the Streetcar Alternative in the following corridor segments: 1) Downtown Portland; and 2) South Waterfront. Changes to traffic controls at signalized and non-signalized intersections would occur throughout the corridor to accommodate the safe and efficient operation of the streetcar and local traffic. The *Detailed Definition of Alternatives Report* and the *Streetcar Plan Set* provide additional details on changes to traffic operations at intersections under the Streetcar Alternative.

- **Bicycle and Pedestrian Improvements.** There would be no change in bicycle and pedestrian improvements under the Streetcar Alternative, compared to the No-Build Alternative, except as noted in the following segment-by-segment description.

- **Bus Capital Improvements.** Under the Streetcar Alternative, all 26 bus stops that would be served by Line 35 on Highway 43 between downtown Lake Oswego and the Sellwood Bridge and on SW Macadam Boulevard north of SW Corbett Street under the No-Build Alternative would be removed, because Line 35 service would be replaced in the corridor by streetcar service. The bus stops served by Line 35 between Lake Oswego and Oregon City would be unchanged under the Streetcar Alternative, compared to the No-Build Alternative. In addition, under the Streetcar Alternative,

FIGURE 1-3 STREETCAR ALTERNATIVE TRANSPORTATION NETWORK

the Lake Oswego Transit Center would be relocated to be adjacent to the Lake Oswego Terminus Station, from its existing location on 4th Street, between A and B avenues. The changes to the bus capital improvements under the Streetcar Alternative would not vary by any of the design options under consideration.

- **Light Rail Capital Improvements.** There would be no change in light rail capital improvements under the Streetcar Alternative, compared to the No-Build Alternative.

- **Excursion Trolley Capital Improvements.** Under the Streetcar Alternative, there would no longer be an operating and maintenance agreement between the City of Lake Oswego and the Willamette Shore Line Consortium that would allow for the operations of the excursion trolley between SW Bancroft Street and Lake Oswego. Further, the Oregon Electric Railway Historical Society would no longer operate the vintage excursion trolley under agreement with the City of Lake Oswego, as they currently do and as they would under the No-Build and Enhanced Bus Alternatives.

- **Streetcar Improvements and Vehicles.** The Streetcar Alternative would extend streetcar tracks and stations south from the existing Portland Streetcar line that operates between NW 23rd Avenue and SW Bancroft Street. Compared to existing conditions and the No-Build Alternative, the Streetcar Alternative would add approximately 5.9 to 6.0 one-way miles of new streetcar tracks and catenary (overhead electrical wiring and support) and ten new streetcar stations between SW Bancroft Street and Lake Oswego. Except when crossing over waterways, roadways, or freight rail lines or through an existing tunnel, the new streetcar line would generally be at the same grade as existing surface streets. Of the approximately six miles of new streetcar tracks, 5.3 miles would be double-tracked (i.e., two one-way tracks) and 0.7 miles would be single-tracked (i.e., inbound and outbound streetcars would operate on the same tracks; see Figure 1-4 for an illustration of the location of single and double-track segments). The new streetcar stations would be of a design similar to the existing streetcar stations in downtown Portland and the Pearl District.

- **Park-and-Ride Facilities.** In addition to the park-and-ride facilities included under the No-Build Alternative, the Streetcar Alternative would include: a) a 100-space surface park-and-ride lot served by the proposed streetcar line at the B Avenue Station; and b) a 300-space structured park-and-ride lot that would be served by the proposed streetcar line at the Lake Oswego Terminus Station. The size and location of these park-and-ride lots would not vary by any of the design options under consideration.

- **Operations and Maintenance Facilities.** With the Streetcar Alternative, a new storage facility that would accommodate eight streetcars would be located adjacent to the streetcar alignment under the Marquam Bridge. The size and location of the streetcar operating and maintenance facilities would not vary by any of the design options under consideration.

B. Segment-by-Segment Description and Design Option Differences
For the purposes of description and analysis, the Lake Oswego to Portland Corridor has been divided into six segments for the Streetcar Alternative – those segments and design options within three of the segments are illustrated schematically in Figure 1-4. Figure 1-3 illustrates the proposed roadway improvements, streetcar alignment, stations, and park-and-ride lots that would occur in the corridor under the Streetcar Alternative. Figures 1-5 and 1-6 provide more detailed illustrations of the streetcar design options currently under study.

1. Downtown Portland Segment. There would be no roadway or bicycle and pedestrian improvements within the Downtown Portland Segment under the Streetcar Alternative, compared to the No-Build Alternative. Under the Streetcar Alternative, a connection would be added between westbound streetcar tracks on SW Market Street to southbound tracks on W 10th Avenue, which would allow inbound streetcars from Lake Oswego to turn back toward Lake Oswego, providing increased operational flexibility. There are no streetcar alignment design options within this segment and there would be no new streetcar stations within this segment.

2. South Waterfront Segment. The South Waterfront Segment extends between SW Lowell Street to SW Hamilton Court. Streetcar tracks would be extended south of their existing southern terminus at SW Lowell Street, within the right-of-way of the planned Moody/Bond Couplet extension, to SW Hamilton Street. There would be two new streetcar stations within this segment (Bancroft and Hamilton stations).

3. Johns Landing Segment. The Johns Landing Segment extends between SW Hamilton Court to SW Miles Street. This segment includes three design options: Willamette Shore Line; Macadam In-Street; and Macadam Additional Lane. Under all options, the streetcar alignment would extend south from SW Hamilton to near SW Julia Street, generally within the existing Willamette Shore Line right-of-way. The three design options would include two new streetcar stations at varying locations, described below. To the south, all three options would share a common alignment between SW Carolina and SW Miles Street, generally via the existing Willamette Shore Line right-of-way, and they would share one common station at SW Nevada. Following is a description of how the design options would differ:

- **a.** ***The Willamette Shore Line Design Option*** would continue the extension of streetcar tracks south within the existing Willamette Shore Line right-of-way from SW Julia Street to SW Carolina Street (extending to SW Miles Street). There would be three new streetcar stations (Boundary, Nebraska, and Nevada stations).

- **b.** ***The Macadam In-Street Design Option*** would locate the new streetcar tracks generally within the existing outside lanes of SW Macadam Avenue, approximately between SW Boundary and Carolina streets. Between approximately SW Julia and Boundary streets, the streetcar alignment would be within the right-of-way of SW Landing Drive, which would be converted from a private to a public street. There would be three new streetcar stations (Boundary, Carolina, and Nevada stations). An optional station at Pendleton Street is also under consideration.

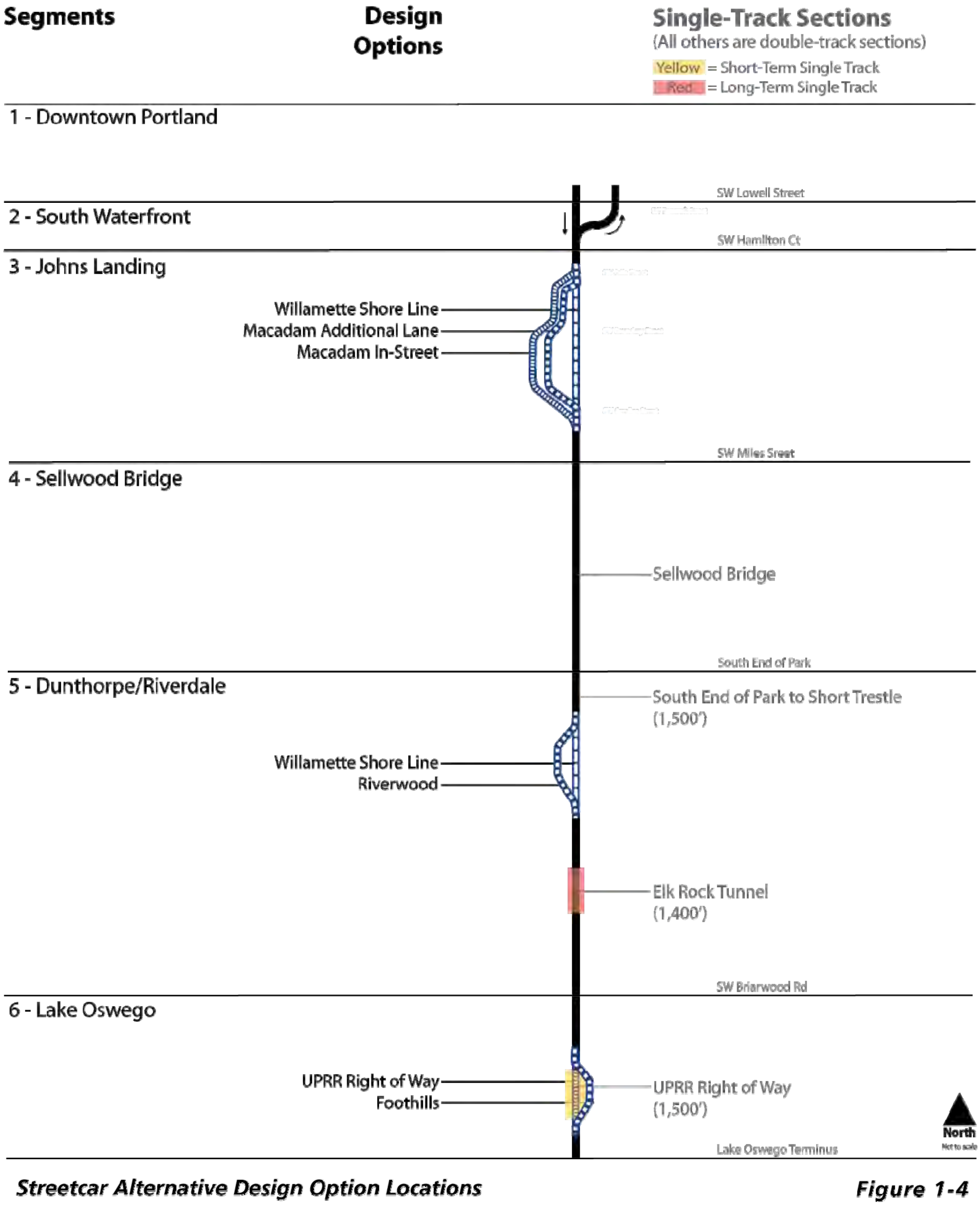

FIGURE 1-4 STREETCAR ALTERNATIVE DESIGN OPTION LOCATIONS

c. ***The Macadam Additional Lane Design Option*** would be similar to the Macadam In-Street Design Option, except that the new northbound streetcar tracks would be located within a new traffic lane just east of the existing general purpose lanes – streetcars would share the new lane with right-turning vehicles. Between approximately SW Julia and Boundary streets, the streetcar alignment would be within the right-of-way of SW Landing Drive, which would be converted from a private to a public street. There would be three new streetcar stations (Boundary, Carolina, and Nevada stations). An optional station at Pendleton Street is also under consideration.

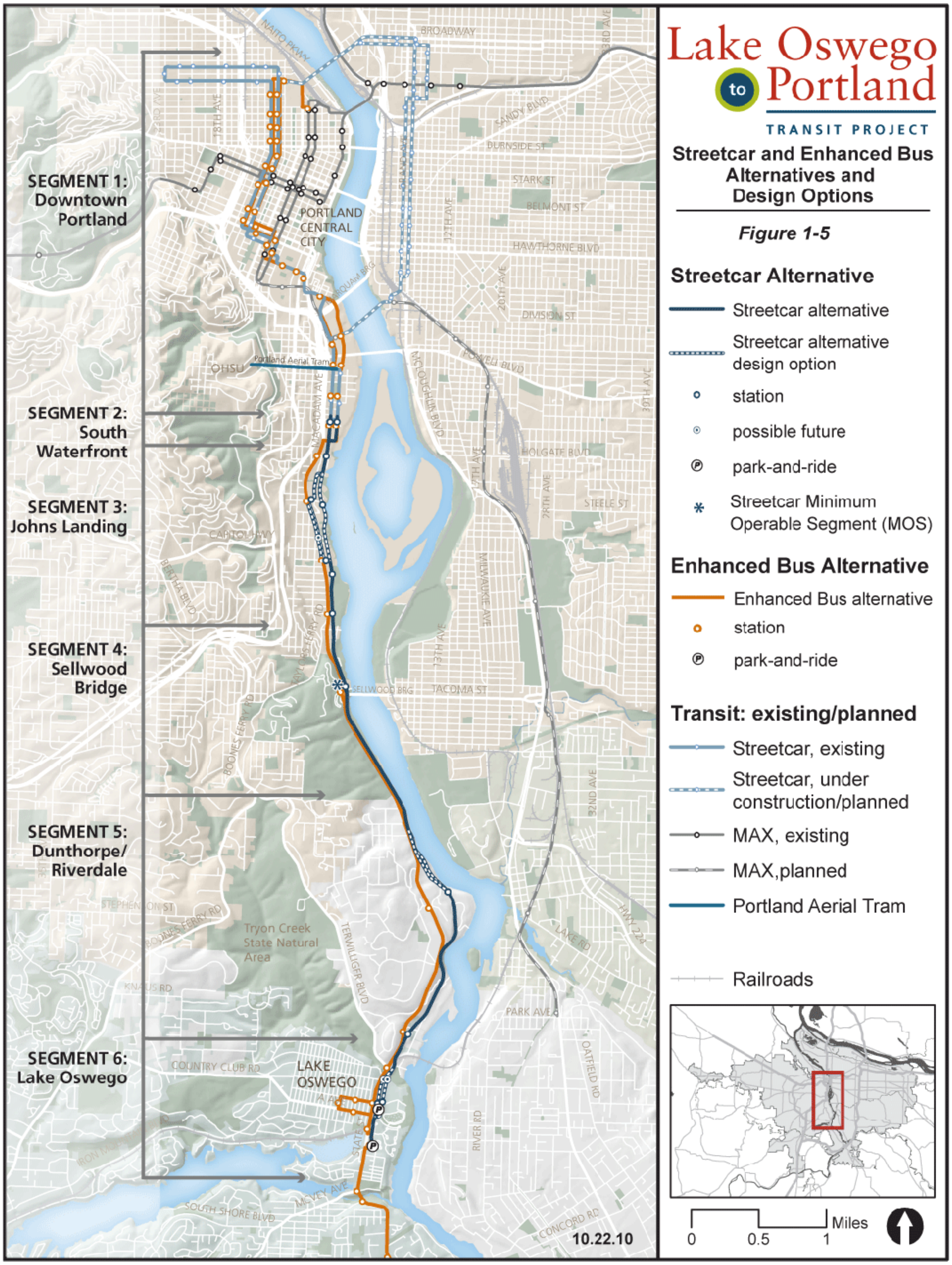

FIGURE 1-5 STREETCAR AND ENHANCED BUS ALTERNATIVES AND DESIGN OPTIONS

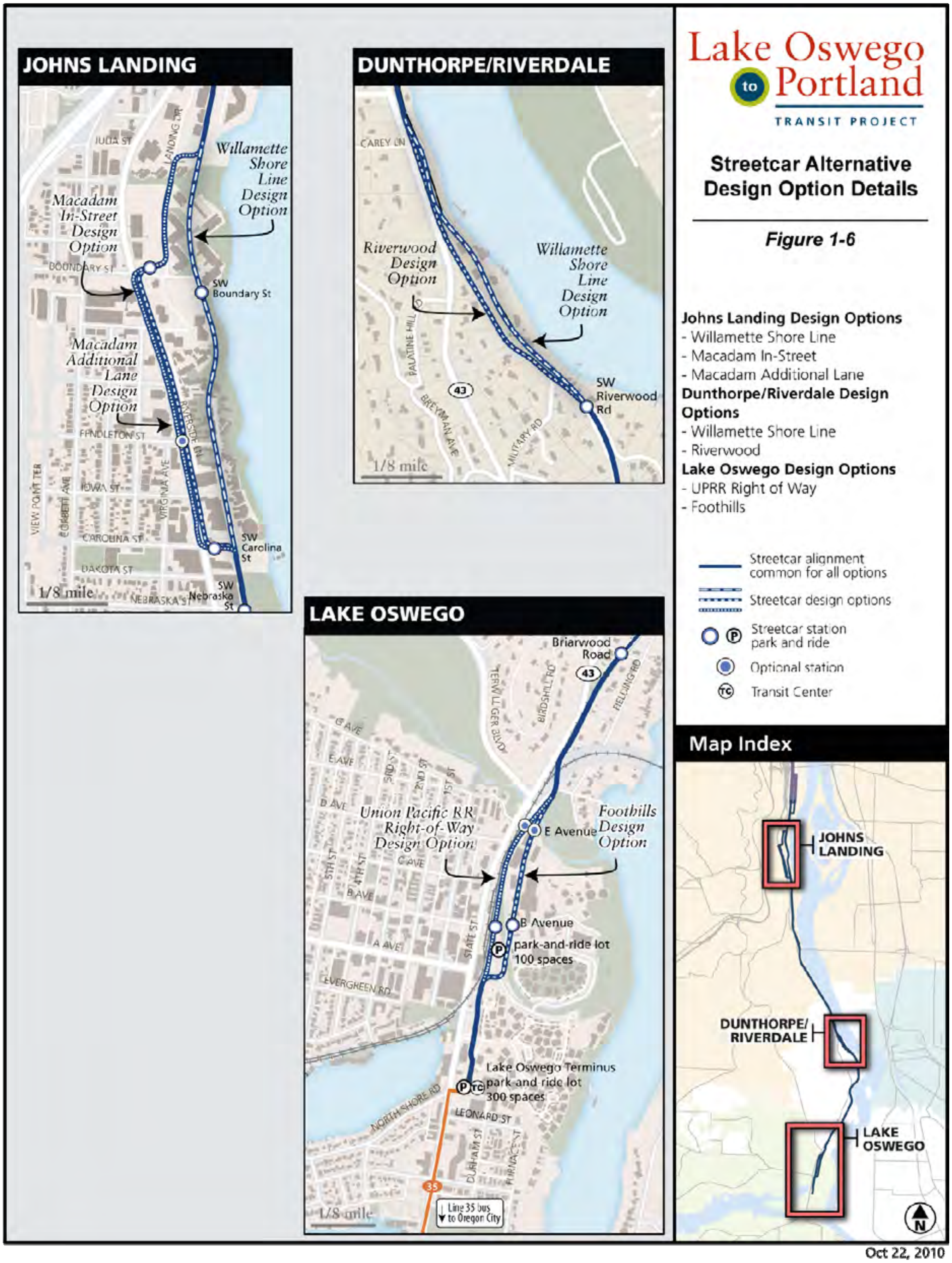

FIGURE 1-6 STREETCAR ALTERNATIVES DESIGN OPTIONS DETAILS

4. Sellwood Bridge Segment. The Sellwood Bridge Segment extends from SW Miles Street to the southern end of Powers Marine Park and it contains two design options. Following is a description of how the design options would differ.

a. ***The Willamette Shore Line Design Option*** would locate the new streetcar alignment in the existing Willamette Shore Line right-of-way in the vicinity of the existing Sellwood Bridge. This option could include single-track in the vicinity of Stephen's Creek and double-track elsewhere. This option could be constructed and used as an interim alignment if the new interchange for the Sellwood Bridge is not constructed before or concurrently with the Streetcar Alternative.

b. ***The New Interchange Design Option*** would provide for construction of the new double-tracked streetcar alignment in conjunction with the planned west interchange improvements for the Sellwood Bridge (the streetcar alignment would be located slightly east of the existing Willamette Shore Line right-of-way). The design and construction of the streetcar alignment under this design option would be coordinated with the design and construction of the new interchange for the Sellwood Bridge.

5. Dunthorpe/Riverdale Segment. The Dunthorpe/Riverdale Segment extends between the southern end of Powers Marine Park and SW Briarwood Road. There are two design options in this segment: Willamette Shore Line Design Option and Riverwood In-Street Design Option. Both options would share a common alignment within the Willamette Shore Line right-of-way, generally north of where SW Riverwood Road intersects with Highway 43 and generally south of the intersection of SW Military Road and SW Riverwood Road. One new streetcar station is proposed within this segment, generally common to both design options (Riverwood Station). Following is a description of how the design options would differ:

a. ***The Willamette Shore Line Design Option*** would generally locate the new streetcar alignment in the existing Willamette Shore Line right-of-way between the intersections of SW Riverwood Road and Highway 43 and SW Riverwood Road and SW Military Road.

b. ***The Riverwood Design Option*** would locate the new streetcar alignment generally adjacent to Highway 43, north of SW Riverwood Road, and within the right-of-way of SW Riverwood Road, generally between where it intersects with Highway 43 (that intersection would be closed) and where it intersects SW Military Road. Except for the closure of the Highway 43 and SW Riverwood Road intersection, SW Riverwood Road would remain open to traffic (with joint operation with streetcars).

6. Lake Oswego Segment. The Lake Oswego Segment extends between SW Briarwood Road and the Lake Oswego Terminus Station. There are two design options within this segment: the UPRR Right-of-Way (UPRR ROW) Design Option and the Foothills Design Option. Both options would generally be the same in two sections: 1) the new streetcar line alignment would extend south from SW Briarwood Road to where the alignment would cross under the existing UPRR tracks; and 2) the new streetcar alignment would be located within a new roadway that would extend south from SW A Avenue to the alignment's terminus near the intersection of N State Street and Northshore Road.

Both options would provide for a new bicycle and pedestrian connection under the existing UPRR tracks. There would be two stations within this segment, one that would be common to the two design options (Lake Oswego Terminus Station). An optional station at E Avenue is also under consideration.

This segment would include two park-and-ride lots, both of which would be generally common to the two design options. Following is a description of how the design options would differ:

a. ***The UPRR ROW Design Option*** would extend the streetcar alignment south, generally in the UPRR right-of-way, from its under crossing of the existing UPRR tracks to SW A Avenue. The B Avenue Station would be located on the west side of the 100-space surface park-and-ride lot.

b. ***The Foothills Design Option*** would extend the streetcar alignment south from its under crossing of the UPRR tracks to SW A Avenue generally within the right-of-way of a new general-purpose roadway (Foothills Road), which would be built as part of the Streetcar Alternative.

1.4.3.2 Transit Operations

This section describes transit operations under the Streetcar Alternative, generally compared to the No-Build Alternative (see Table 1-2). Figure 1-3 provides an illustration of the transit lines in the vicinity of the corridor under the Streetcar Alternative. There would be no difference in transit operations under any of the design options under consideration.

The Streetcar Alternative would extend the existing Portland Streetcar line from its current southern terminus at Lowell Street to the Lake Oswego Terminus Station in downtown Lake Oswego, expanding the streetcar length from 4 miles to 9.9 to 10 miles (depending on design option). The total round trip running time of the streetcar line between 23rd Avenue and downtown Lake Oswego (10 miles) in 2035 would be 105 or 112 minutes, excluding layover (based on the Willamette Shore Line and Macadam design options in the Johns Landing Segment, respectively). In comparison, under the No-Build Alternative the round trip running time for the streetcar line between 23rd Avenue and Lowell Street (4 miles) would be 68 minutes.

With the extension of streetcar service to Lake Oswego, Line 35 service between Lake Oswego and downtown Portland would be eliminated. The remainder of Line 35 between Oregon City and Lake Oswego would be combined with Line 78, in effect to create a new route between Oregon City and Beaverton. The new bus route and other TriMet transit routes serving downtown Lake Oswego would be rerouted to serve the relocated Lake Oswego Transit Center, which would be adjacent to Lake Oswego Terminus Station.

1.4.3.3 1.4.3.3 Construction Phasing Options

This section summarizes Streetcar Alternative construction phasing options currently under consideration – neither the No-Build Alternative nor the Enhanced Bus Alternative include construction phasing options. Currently, there are two types of construction phasing options or scenarios under consideration: 1) finance-related and 2) external project related. The Streetcar

Alternative evaluated in this Technical Report and the DEIS is as Full-Project Construction. Should the Streetcar Alternative with phasing be selected as the Locally Preferred Alternative, during preliminary engineering (PE) additional analysis of environmental impacts resulting from the interim project alignment (as opposed to Full-Project Construction) will be conducted and additional opportunity for public review and comment may be required.

A. Finance-Related Phasing Options
Following is a description of the two finance-related phasing options currently under consideration.

- **Full-Project Construction.** Under the first construction phasing option, the project would be constructed and opened in its entirety as described within Section 2.2.2.

- **Sellwood Bridge Minimum Operable Segment (MOS).** Under the Sellwood Bridge MOS phasing option, the Streetcar Alternative would be initially constructed between SW Lowell Street and the Sellwood Bridge, with a second construction phase between the Sellwood Bridge and the Lake Oswego Terminus Station occurring prior to 2035. Under this construction phasing option, there would be no additional park-and-ride facilities in the corridor, compared to existing conditions. Under this phasing option, Line 35 would operate between Oregon City and the Nevada Street Station; frequencies would be adjusted to meet demand. Service and bus stops served exclusively by Line 35 would be deleted between the Nevada Station and downtown Portland.

B. External Project Coordination Related Phasing Options
Following is a description of phasing options related to the coordination of the Streetcar Alternative, if it is selected as the LPA, and other external projects. These external project coordination related phasing options represent interim steps in the construction process that would be taken to implement the Streetcar Alternative.

- **South Waterfront Segment Phasing Options.** If the planned and programmed South Portal roadway improvements are not in place or would not be constructed concurrently with the Streetcar Alternative, there would be two options for proceeding with construction of the streetcar alignment in the segment: 1) a different streetcar alignment using the Willamette Shore Line right of way would be initially constructed within the South Waterfront Segment; or 2) the streetcar alignment and its required infrastructure improvements would be constructed consistent with the alignment under the Full-Project Construction phasing option, but other non-project roadway improvements would be constructed at a later date by others. If the Willamette Shore Line right of way were to be used, then, when the South Portal roadway improvements were made, the streetcar alignment would be reconstructed consistent. The transit operating characteristics of the Streetcar Alternative would not be affected by this phasing option.

- **Sellwood Bridge Segment Phasing Options**. The Sellwood Bridge Segment includes two phasing options for the Streetcar Alternative that reflect two potential phasing options or scenarios for construction of the project in relationship to construction of a proposed new interchange that is planned to occur with the Sellwood Bridge replacement project. If the new interchange is constructed prior to or concurrently with the Streetcar Alternative, the initial and long-term streetcar alignment would be based on the new interchange design. The new interchange design is the basis for the analysis in this technical report and the DEIS. If the proposed interchange is constructed after the Streetcar Alternative, then the initial streetcar alignment to be constructed would be in the Willamette Shore Line right of way. Subsequently, when the proposed interchange is constructed, the Sellwood Bridge replacement project would relocate the streetcar alignment with the new interchange design. Therefore, the long-term streetcar alignment would be the new interchange and the Willamette Shore Line phasing option would only be implemented as an interim alignment. Therefore, the two design options in this segment do not constitute a choice of alignments – instead they represent two construction phasing scenarios, dependent upon how external conditions transpire.

- The Foothills Design Option. The Foothills design option of the Streetcar Alternative is based on roadway improvements that would occur under the City of Lake Oswego's Foothills redevelopment project. If those roadway improvements are not constructed prior to or concurrently with construction of the streetcar alignment, then the Lake Oswego to Portland Transit Project would construct the streetcar alignment and required infrastructure improvements using the same alignment and the roadway improvements would be added at a later date by others.

2. EVALUATION METHODS

2.1 Environmental Noise Analysis Methods

2.1.1 Operational Noise

The environmental noise implications of operation of the proposed project were considered in accord with the noise impact criteria and procedures required by the FTA. FTA noise impact criteria are based on comparing expected project-related noise to existing sound levels. Therefore, any assessment of impact must first identify the existing sound levels at potentially affected locations. Potentially affected locations may be identified or eliminated using the first step of a 3-step process. The 3-step process includes (1) screening using standard distances, (2) a general noise assessment using a simple noise model produced by FTA, and (3) a detailed noise analysis. The level of analysis varied with location in the corridor, the project alternative being considered, and the relative proximity of any sensitive noise receptors. The various levels of analysis and how they were applied are described more completely below.

2.1.2 Construction Noise

Construction noise associated with the proposed project would be subject to applicable time of day restrictions and sound level limits in the various portions of the project area. Noise from temporary construction activities during daytime hours is typically exempt from specific noise limits. Therefore the potential for noise impacts from construction activities was assessed qualitatively based on typical noise levels from construction equipment and use of best management practices intended to limit both the production and the transmission of noise that could adversely affect nearby receivers.

2.1.2.1 Screening-Level Review

The first level of review was the application of the FTA screening process based on the distances between the noise source (i.e., streetcar, access road, or park-and-ride facility) and any potentially affected sensitive receiving locations.

The FTA screening distance for low and intermediate capacity transit sources with steel wheels is 125 feet if there are no intervening obstructions. In other words, sensitive receivers farther than 125 feet from the streetcar line would not be expected to be impacted by operational noise from the line and would not need to be considered further in the noise impact assessment. Similarly, the FTA screening distances for access roads and park-and-ride facilities are 100 feet and 225 feet (measured from the center of the park-and-ride), respectively, if there are no intervening obstructions.

The screening review for this project included use of detailed aerial photos of the project study area as well as extensive field observations to document the apparent uses of properties within about 200 feet of each project alternative and each design option of the streetcar alternative.

2.1.2.2 General Noise Assessment

Following a screening process to identify potentially affected receivers, the next typical step is to conduct a general noise review based on simple calculations that consider the noise source, its expected level of activity, and the intervening distances between the project source and the identified receiving locations. In this instance, however, this interim step was mostly skipped in favor proceeding directly to a detailed noise analysis as described in the next section.

2.1.2.3 Detailed Noise Assessment with CadnaA Noise Modeling

The final step in the analytical process was to conduct a detailed noise impact analysis as suggested in FTA guidance for those receivers within the screening distance for each project element. As part of the detailed noise assessment, existing sound levels at potentially affected locations were identified using numerous long-term (i.e., 24-hour) and short-term (i.e., 1-hour) sound level measurements. These were then used as the base against which the estimated project-related sound levels were compared in order to assess the potential for and degree of impact.

For this project, estimations of project-related noise were performed using the CadnaA noise model (version 4.0, DataKustik 2010). CadnaA is a computer model that can calculate cumulative sound levels from a variety of sound sources after considering the noise reductions or enhancements caused by distance, topography, ground surfaces, the presence of obstructions (e.g., noise barriers), atmospheric absorption, and meteorological conditions.

The modeling process includes use of source-specific sound level data and creation of a three-dimensional representation of the study area. Noise sources and receiving locations are placed appropriately within the modeling domain to enable the model to evaluate effects of distance and topography on noise attenuation. Based on this information, CadnaA then constructs topographic cross sections and calculates sound levels throughout the project vicinity.

For this project, ENVIRON characterized the streetcar noise source using the CadnaA source file for a Transit Vehicle/Commuter Rail Car. The reference sound level value called SEL_{ref} for this source, as specified in the FTA *Transit Noise and Vibration Impact Assessment Manual*, 2006, is 82 dBA. Based on the maximum noise level (L_{max}) specification for the new streetcar equipment that would be used on the LOPT line, the SEL_{ref} for the streetcar should be 80.3 dBA using the equation presented in Table E-1 of FTA 2006.[2] However, ENVIRON's review of CadnaA indicated that the model typically under-predicts sound levels of transit vehicles/rail cars at distances greater than 20 feet when compared to the values provided in the FTA *Noise Impact Assessment Spreadsheet*, 2007. Therefore, ENVIRON used the CadnaA source sound level with an SEL_{ref} 1.7 dBA greater than expected (i.e., 82 dBA instead of 80.3 dBA) to ensure that the model-calculated sound levels would be conservative (i.e., over-predicted) at any receptor location within 200 feet of the streetcar line. Receptors farther than 200 feet from the line are outside of the FTA screening distance and expected to have no potential for noise impact. This approach results in possible *overestimation* of the actual streetcar sound levels by between 0 and 2 dBA at all receptor locations of concern.

The streetcar bell noise source was characterized by noise measurements of streetcar bells being sounded on existing Portland streetcars. The streetcar bell sound level measurements were taken in 1/3 octave bands using a Larson Davis 2900 (Type I) real-time frequency analyzer. The sound levels in octave bands were then input into the CadnaA noise model as a separate noise source. The streetcar bells were assumed to be sounded at gated crossings of the streetcar line and upon leaving a station.

---

[2] LTK Engineering Services, 1998, Request for Proposals for Low Floor Streetcars for Central City Streetcar – Phase 1, Portland, Oregon, Book 3 Vehicle Technical Specification, Issued by Portland Streetcar, Inc, November 16, 1998

The noise modeling for the streetcar alternative considered the expected speeds along the project alignment based on speed profiles developed from modeling that assumed 6-minute headways (or 10 streetcar passbys per hour). Since the actual expected headways vary from 7.5 minutes during peak periods (or 8 streetcar passbys per hour in each direction) to 15 minutes during non-peak periods (or 4 streetcar passbys per hour in each direction), the noise modeling based on the higher travel speeds probably slightly *overstates* noise from the project's streetcar alternative.

The noise model computes noise levels from project-related sources at specific locations designated in the model as "receptors." Modeling receptors can represent one or more specific locations or residences of interest in the same vicinity. Due to the length of the study area, the various corridor alternatives and design options were considered in a series of smaller segments. The general modeling areas and the specific modeling receptor locations are shown in Figure 2-1through Figure 2-5.

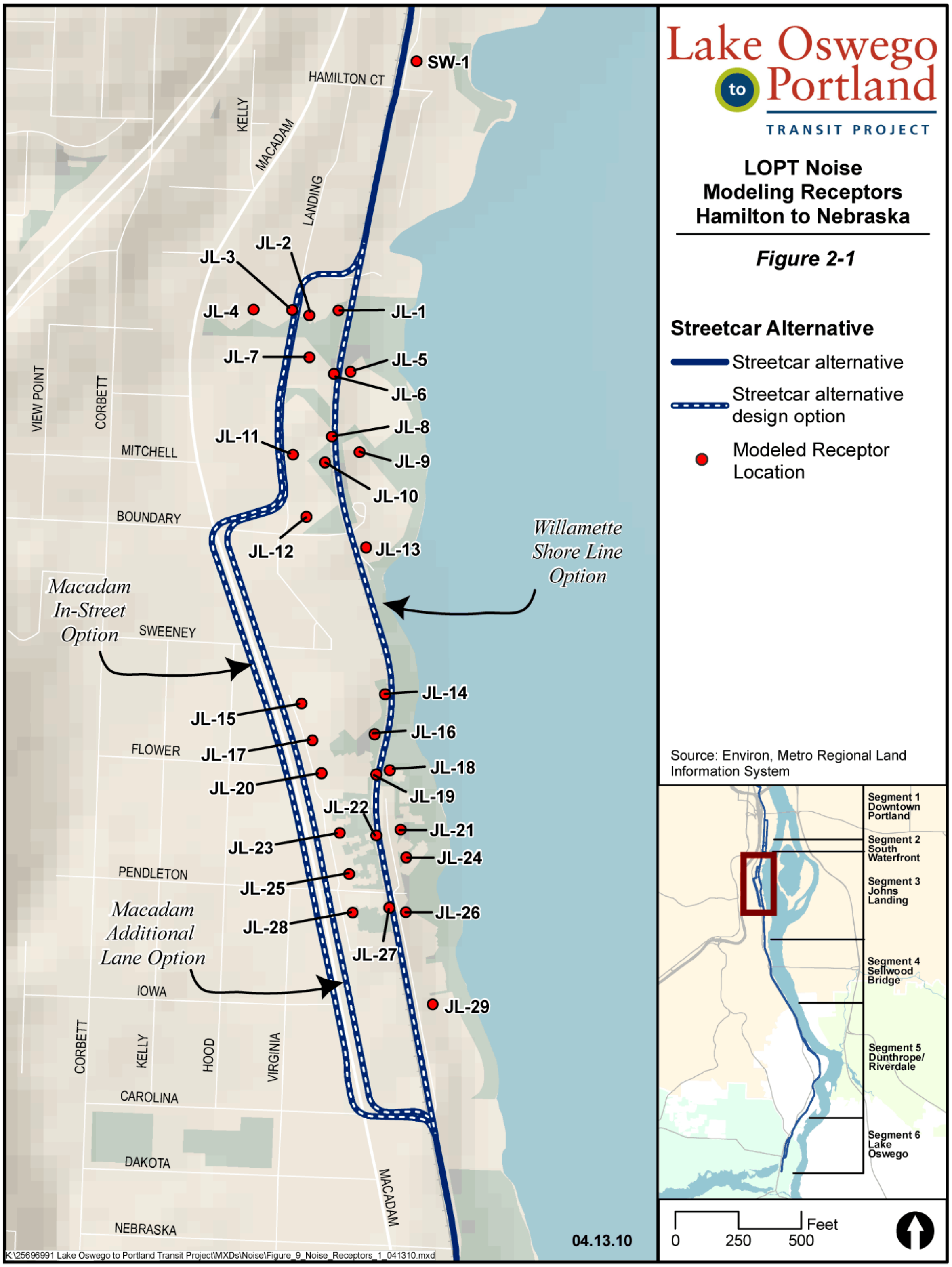

FIGURE 2-1. LOPT NOISE MODELING RECEPTORS – HAMILTON TO NEBRASKA

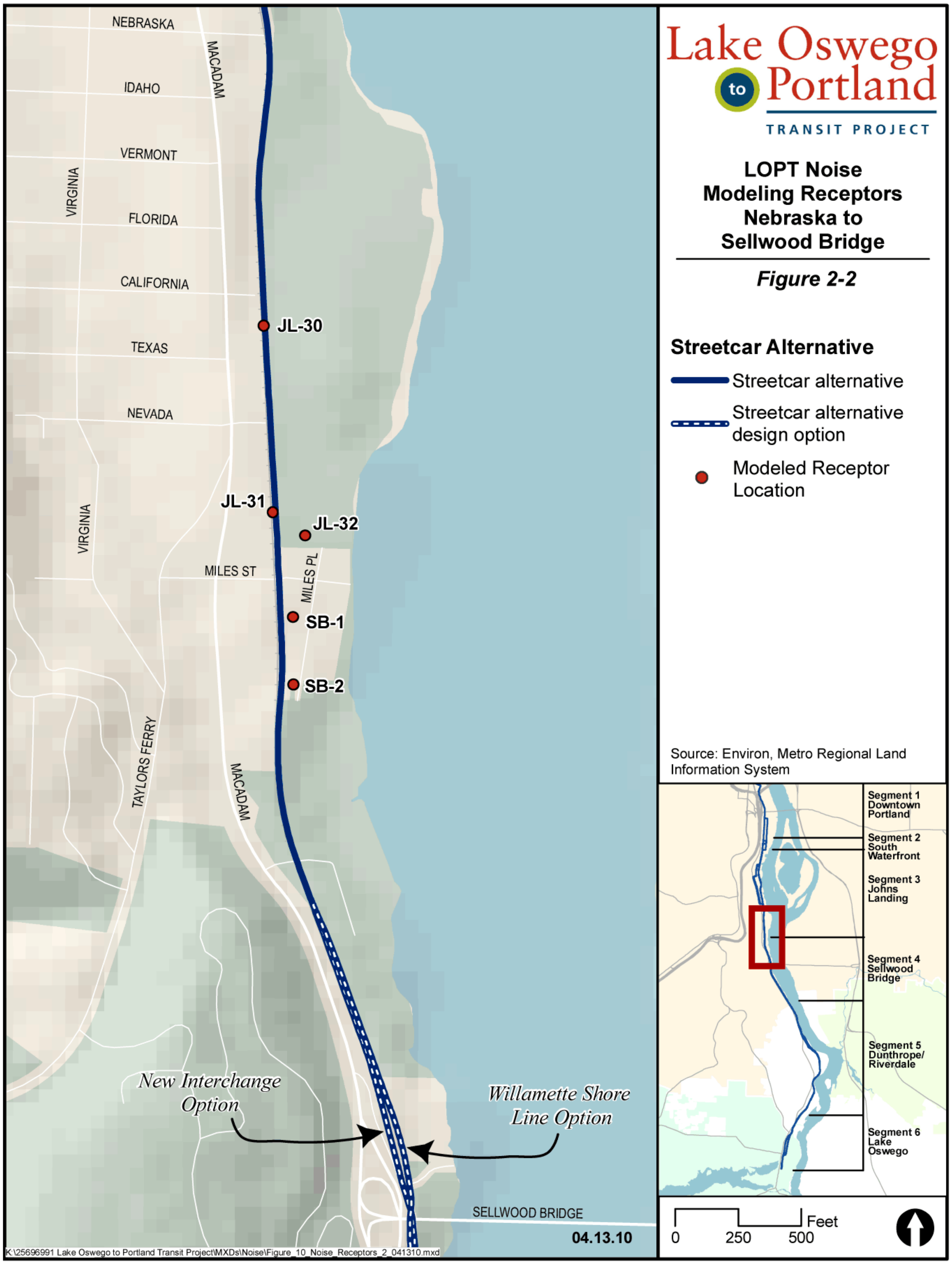

FIGURE 2-2. LOPT NOISE MODELING RECEPTORS – NEBRASKA TO SELLWOOD BRIDGE

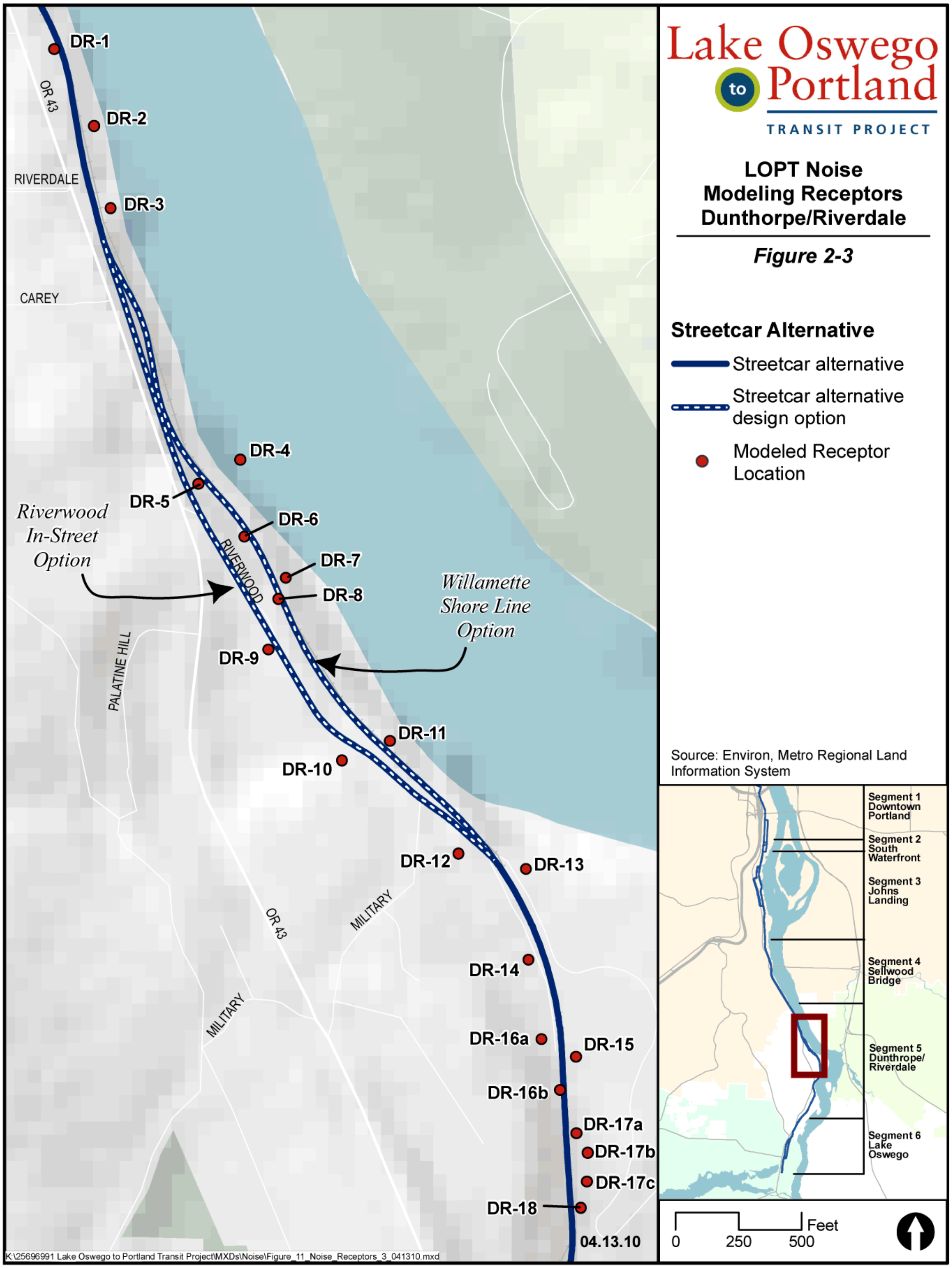

FIGURE 2-3. LOPT NOISE MODELING RECEPTORS – DUNTHORPE/RIVERDALE

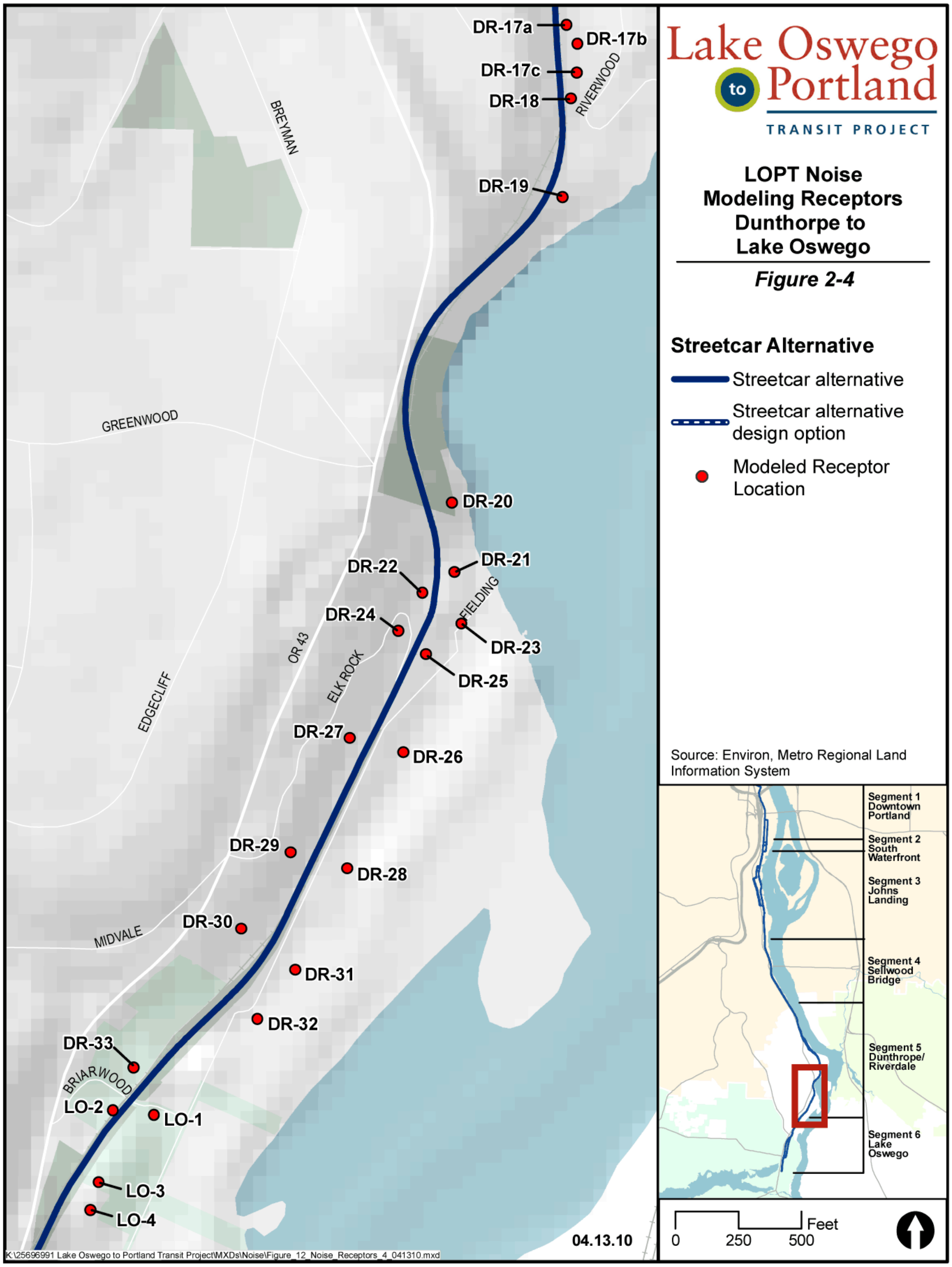

FIGURE 2-4. LOPT NOISE MODELING RECEPTORS – DUNTHORPE TO LAKE OSWEGO

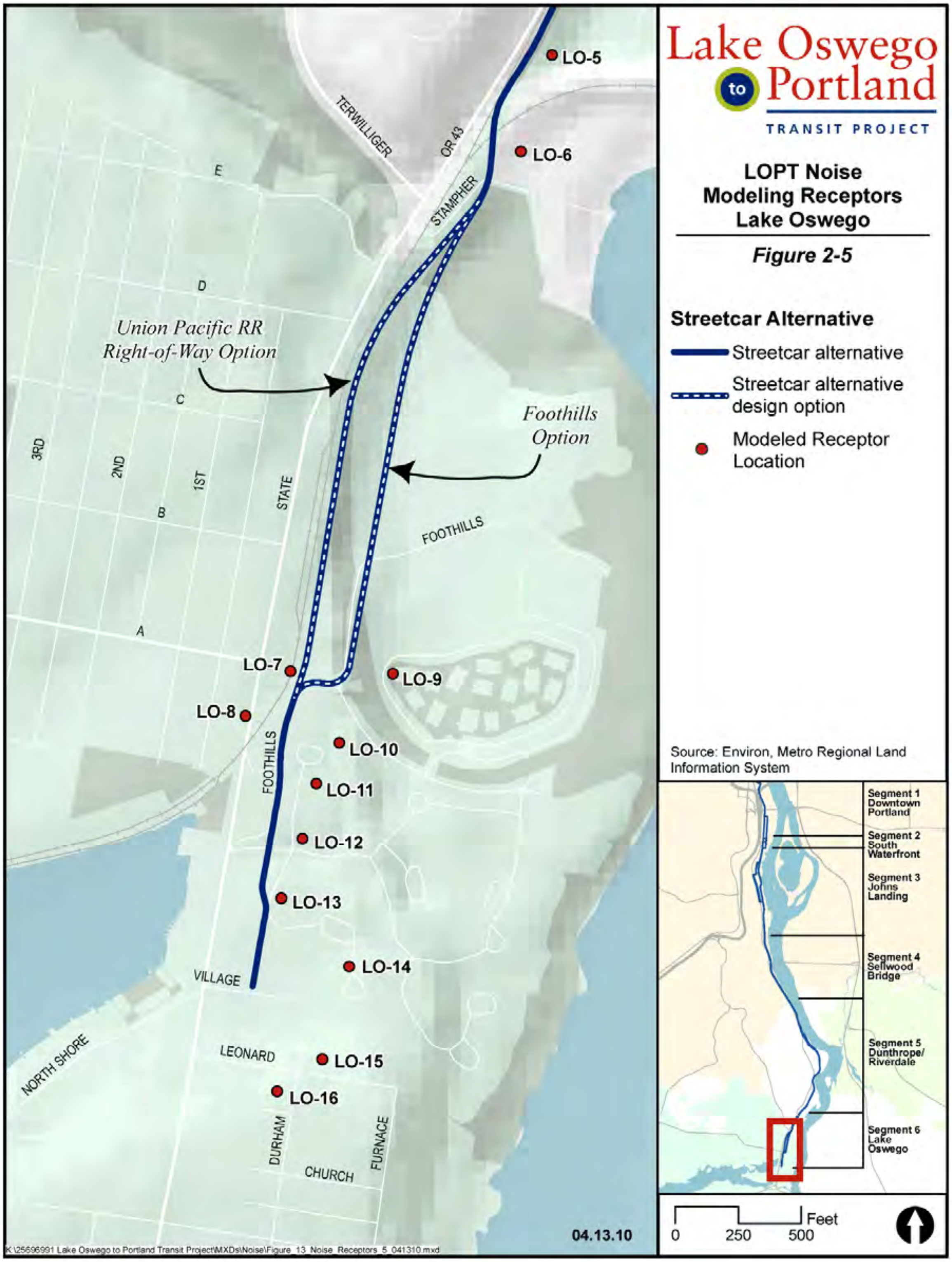

FIGURE 2-5. LOPT NOISE MODELING RECEPTORS – LAKE OSWEGO

2.2 Vibration Analysis Methods

2.2.1 Operational Vibration Impact Assessment Method

The potential ground-borne vibration implications of operation of the project were considered in accord with the procedures required by the FTA, and included a 2-step process based on screening using standard distances and a general vibration assessment for selected locations. Both steps were accomplished using a vibration-estimating spreadsheet tool developed for this project based on FTA equations and project-specific information. The level of analysis varied with location in the corridor, the project alternative and design option being considered, and the relative proximity of any sensitive noise receptors. The various levels of analysis and how they were applied are described more completely below.

2.2.2 Construction Vibration Impact Review

The assessment of potential vibration impacts from construction of the proposed facility applied methods specified in FTA noise and vibration manual 2006. This approach entails surveying locations and expected methods of construction to estimate likely intervening distances between vibration-causing construction activities and existing buildings. Levels of construction vibration are then estimated based on the expected construction activities/equipment and distance, assuming normal vibration transmission through the earth. The focus of this review was the potential for ground-borne vibration (GBV) to damage buildings, with this potential based on the vibration-sensitivity category of each building. The details of this review are discussed in Section 4.5.2 (page 48) and subsequent tables. The construction vibration assessment was conducted using a spreadsheet tool developed for this project.

2.2.2.1 Screening-Level Review

The screening process for assessing potential impacts from operational vibration was based on area visits, the apparent uses of each building, and the estimated distance between the potential streetcar line and the nearest portion of each building. The FTA vibration screening distances are presented in Table 2-1. Note that the LOPT project would create an "Intermediate Capacity Transit" facility as defined by FTA. If a building was within the screening distance, the analysis for that building moved on to the general vibration assessment described below.

Table 2-1. FTA Screening Distances for Vibration Assessment

	Critical Distance for Land Use Categories [1]		
Type of Transit Source	**Category 1**	**Category 2**	**Category 3**
Conventional Commuter Railroad	600	200	120
Rail Rapid Transit	600	200	120
Light Rail Transit	450	150	100
Intermediate Capacity Transit [2]	200	100	50
Bus Projects	100	50	--

[1] Distance from right-of-way or property line, based on land use categories defined in Table 4-5.
[2] The LOPT project falls into this FTA class of transit project
Source: FTA 2006, Table 9-2

2.2.2.2 General Vibration Assessment

The general vibration assessment was based on estimated levels of GBV from the streetcar operation derived from a curve of typical vibration velocity levels published in Figure 10-1 in FTA 2006. The curve from this reference document that was applied in the LOPT analysis was for Rapid Transit or Light Rail Vehicles traveling 50 mph, with vibration levels varying due to distance from this source. The FTA reference data can be adjusted to account for the following factors: (1) distance from the tracks, (2) speed of the streetcars, (3) the vehicle suspension system, (4) condition of the wheels and track, (5) track type and treatments, (6) ground type, (7) building construction material and method, and (8) receiver location within the potentially affected buildings. For LOPT operational vibration assessment, the vibration data presented in the FTA manual were approximated using a best-fit process to develop an equation representing variations in ground-borne vibration from the streetcar due to changes in operational speeds and distances. The other factors that can affect GBV levels were assumed to have no positive or negative effects on the creation or propagation of GBV.

To assess ground-borne noise (GBN), an additional adjustment is made to the estimated ground-borne vibration (GBV) level in VdB in order to estimate interior GBN levels in dBA. This adjustment is made based upon whether the vibration spectrum peak is expected to be around 30 Hz (low frequency) or around 60 Hz (high frequency). Because vibration from at-grade track is typically lower in frequency than vibration from subways, ENVIRON assumed the low frequency adjustment of 40 was appropriate (i.e., subtract 40 from the GBV vibration levels in VdB to estimate GBN levels in dBA). With frequent events, the subtraction of 40 dBA from the vibration impact criteria results in GBN levels at or lower than the impact criteria (see Table 4-5, page 48). This suggests that if GBV does not result in an impact, no impacts would be expected from GBN. Furthermore, GBN is typically more of a concern for trains in long tunnels or in underground transit systems such as subways, where little to no airborne noise reaches the receivers. [3] (Note that the Elk Rock Tunnel was specifically evaluated for GBV and would not result in either GBV or GBN impacts.) For these reasons, GBN issues were not specifically addressed in the LOPT analysis because no impacts would be expected.

3. CONTACTS, COORDINATION, AND CONSULTATION

ENVIRON worked closely with other members of the project team to coordinate efforts related to the noise and vibration analyses. These efforts are summarized below.

Sound Level Measurements

- Worked with TriMet and Metro to develop notification letter for use in contacting property owners
- After developing lists of desirable SLM locations, worked with public involvement coordinators to try to acquire permission to take long and short-term SLMs throughout the study area. In addition to TriMet and Metro, support was provided by Tom Markgraf of Markgraf & Associates and Kristin Hull of CH2M Hill.

[3] Utah Transit Authority (UTA), South Davis Transit Corridor Project Draft Environmental Study Report, February 2010, Page 3.7-3

Streetcar Operational Parameters

- Acquired noise level specifications from Erik Sitiko and Gary Cooper of Portland Streetcar
- Streetcar source noise measurements taken of random streetcars during operation to acquire passby noise and bells
- Trolley source noise measurements working in conjunction with Rod Cox, Willamette Shore Trolley
- Streetcar operational timing and speed profiles from John Cullerton of URS Corp

Other

- Site visit and facility tour of Oregon Public Broadcasting building and acquisition and review of as-built drawings to determine the location of vibration-sensitive uses within the facility
- Tour of existing trolley line along Willamette Shore Line with help of Rod Cox, Willamette Shore Trolley, and Thuy Tu of URS Corp

4. NOISE AND VIBRATION CHARACTERISTICS, DESCRIPTORS, AND CRITERIA

Noise and ground-borne vibration are caused by changes in sound pressure in the air and by physical oscillations in the ground. Describing and quantifying these sorts of energies and waves require use of fairly specialized vocabulary and descriptors (also called metrics). A general introduction to these terms and concepts follows.

4.1 Noise Characteristics and Terminology

Noise is generally defined as unwanted sound. This section makes no such distinction between the terms noise and sound, and these terms are used interchangeably. The human ear responds to a very wide range of sound intensities. The decibel (dB) scale used to describe sound is a logarithmic rating system capable of assessing large differences in audible sound intensities. This scale accounts for the human perception of a doubling of loudness as an increase of 10 dB. For example, a 70-dB sound level would sound about twice as loud as a 60-dB sound level.

People generally cannot detect sound level differences (increases or decreases) of 1 dB in a given noise source. Differences of 2 dB or 3 dB can be detected under ideal laboratory situations, although they are often difficult to discern in an active, outdoor noise environment. However, a 5-dB change in a given noise source or environment would likely be perceived by most people under normal listening conditions.

When assessing potential effects of noise on people, it is necessary to consider the range of frequencies that the human ear perceives the best. For example, human ears do not respond equally to all frequencies, so low frequency sounds below about 400 hertz (Hz) and high frequencies above 10,000 Hz are perceived much less well than the middle frequency ranges. Sound-measuring instruments are, therefore, designed to "weight" sounds based on the way people hear. The frequency weighting most often used to evaluate environmental noise is known as A-weighting, and measurements from instruments using this system are reported in A-weighted decibels or dBA. All sound levels discussed in this evaluation are reported in A-weighted decibels.

Because the dB scale used to describe noise is logarithmic, a doubling of sound energy from a noise source (e.g., twice as many vehicles on a road) produces a 3-dB increase in average sound produced by that source, *not* a doubling of the loudness of the sound (which requires a 10-dBA increase). For example, if traffic along a road is causing a 60-dBA sound level at some nearby location, doubling the traffic on this same road would cause the sound level at this same location to increase to 63 dBA. Such an increase might not be discernible in a complex acoustical environment.

Relatively long, multi-source "line" sources such as roads emit cylindrical sound waves. Due to the cylindrical spreading of these sound waves, sound levels from such sources decrease with each doubling of distance from the source at a rate of 3 dBA. Sound waves from discrete events or stationary "point" sources (such as a backhoe operating in a stationary location) spread as a sphere, and sound levels from such sources decrease 6 dBA per doubling of the distance from the source. Conversely, moving half the distance closer to a source increases sound levels by 3 dBA and 6 dBA for line and point sources, respectively.

Factors affecting the sound transmission from a given source, which in turn affects the potential for noise impacts, include distance from the source, frequency of the sound, absorbency and roughness of the intervening ground surface, the presence or absence of obstructions and their absorbency or reflectivity, and the duration of the sound. The degree of impact on humans also depends on existing sound levels at the receiving location and who is listening, and the perception of impact also may depend on any preconceived attitudes regarding the noise source. Typical sound levels of some familiar noise sources and activities are presented in Figure 4-1.

4.2 Sound Level Descriptors

4.2.1 Equivalent Sound Level, Leq

The Leq is a noise metric that represents the level of a constant sound that contains the same sound energy as the actual fluctuating sound over the same time period. As such, the Leq can be considered an energy-average sound level. But unlike arithmetic averages that tend to exclude values that are very high or very low compared with the average, the Leq emphasizes those sound levels that contain the most sound energy (i.e., are the loudest) and those that have the longest duration. Because the Leq considers sound levels over time, this metric accounts for the number, levels, and durations of noise events during a specific time interval (e.g., 1 hour). The Leq noise metric has been found to be highly correlated to community response to noise and is often the metric calculated by noise models used to assess potential adverse impacts and the need for mitigation.

Many federal regulatory agencies use the Leq or some other metric derived from this base metric to characterize sound levels and to evaluate noise impacts. For example, the noise impact criteria developed by the FTA apply the hourly Leq of the hour of greatest transit activity during hours of noise sensitivity to assess potential impacts at receivers involving primarily daytime use (i.e., where potential sleep disturbance is not an issue). Thus, the Leq is used to consider impacts at locations such as parks, schools, libraries, or churches. The FTA impact criteria are described more completely in a later section.

4.2.2 Day-Night Sound Level, Ldn

The day-night sound level (Ldn) is derived from the hourly Leqs across an entire day and is similar to 24-hour Leq, except that the calculation of this metric includes adding 10 dBA to sound levels between 10 p.m. and 7 a.m. In this way, the Ldn reflects the greater noise sensitivity of most people during the nighttime hours when typical background noise is lower and most people are sleeping. The Ldn is used to characterize the noise environment in situations or areas where there are both daytime and nighttime uses, such as residences, hospitals, and hotels.

Most urban and suburban neighborhoods typically have sound levels in the range of Ldn 50 to 70 dBA. An Ldn of 70 dBA is a noisy environment that might be found at buildings on busy surface streets, close to a freeway, or near a busy airport. These sorts of sound levels are usually considered unacceptable for residential land uses without special measures taken to enhance outdoor/indoor sound insulation. Residential neighborhoods that are not near major sound sources typically have levels in the range of Ldn 55 to 60 dBA. If there is a freeway or moderately busy arterial nearby (or any nighttime noise), Ldn is usually in the range of 60 to 65 dBA.

Most environmental impact assessments conducted in the United States use the Ldn to describe the community noise environment. Studies of community response to a wide variety of noises indicate that Ldn is a good measure of this aspect of the noise environment. Efforts to derive measures that are even better correlated to community response have not been successful, although there are still efforts in the acoustical community to develop improved measures. The noise impact criteria included in the May 2006 FTA *Transit Noise and Vibration Impact Assessment* manual use L_{dn} for assessing noise impacts to residential and other properties used for sleeping.

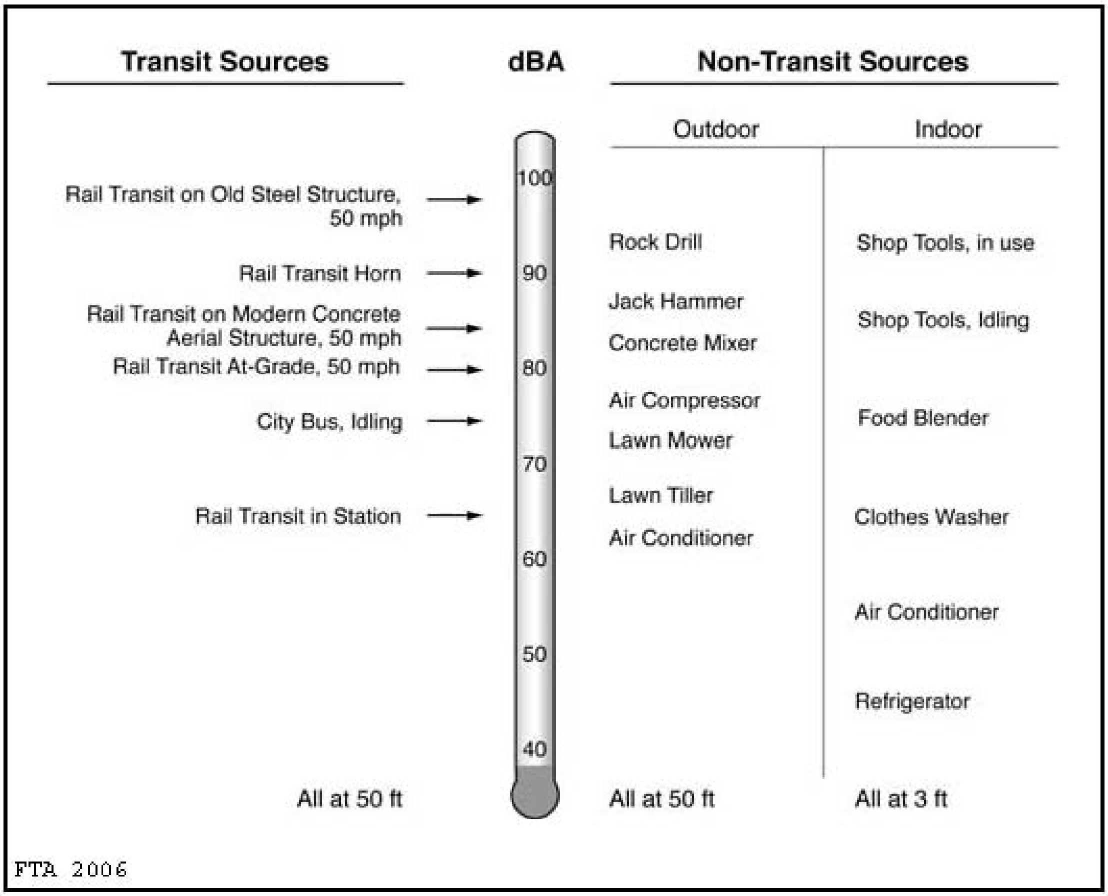

FIGURE 4-1. SOUND LEVELS PRODUCED BY COMMON NOISE SOURCES

4.2.3 Maximum Sound Level, L_{max}

The L_{max} is the maximum sound level that occurred during a specified period. This metric may be one of the descriptors used to characterize the sound level of an individual event such as an automobile or train passby. One thing missing from the L_{max} is any information about the duration or frequency of occurrence of such events. For example, a single dog bark could be somewhat annoying, but one such an event would hardly compare with a neighbor's dog barking all night. The maximum level of train noise, L_{max}, has been used in many environmental assessments of urban rail transit noise. This descriptor has the advantage of being independent of other community noise and the specific train schedule, and so may provide an indicator of the potential for annoyance from single loud events. An argument often advanced for use of L_{max} is that this metric, and not L_{eq}, reflects human response to occasional loud noises such as transit trains that pass by every 5 to 30 minutes or freight trains that may only occur a few times per day. Although there is some common sense logic in this argument, the available research on community response to environmental noise does not confirm the hypothesis. Although L_{max} may be useful for providing additional information regarding a single type of source, it fails to describe the effects of many sources with widely varying levels, some of which occur frequently, others infrequently. The FTA applies the L_{max} in a limited fashion and only in relation to mitigating interior sound levels in locations where noise impacts have been identified due to project-related exterior sound levels, but where there are either no outdoor use areas and/or no effective means to mitigate outdoor noise levels.[4]

4.2.4 Statistical Noise Level, Ln

The L_n is a statistical noise level descriptor, where the "n" is a percentage of the measurement time; usually one hour. For example, an hourly L_{50} of 60 dBA means that the sound level was at or above 60 dBA for 50 percent of that hour (or for 30 minutes). The FTA does not apply this noise metric, but some Oregon state agencies use various L_n values to determine compliance with their noise regulations.

4.3 Ground-Borne Vibration Terminology and Descriptors

Vibration is an oscillatory motion that can be measured and characterized by the frequency and amplitude of waves of motion. Ground-borne vibration (GBV) consists of oscillatory waves that propagate from a source through the ground to adjacent buildings. Vibration amplitude (i.e., the size of the wave of motion) can be measured as displacement, velocity, or acceleration. Displacement is a measure of the distance a point moves away from its resting position. Velocity represents the instantaneous speed and direction of the movement, and acceleration is the rate of change of the velocity. Although displacement is easier to understand than velocity or acceleration, this measure is rarely used for describing ground-borne vibration.

While it is conceivable that ground-borne vibration from rail rapid transit trains could cause building damage, the vibration from train movements is almost never of sufficient amplitude to cause even minor cosmetic damage to buildings. The real concern is that the vibration and radiated noise can be intrusive and annoying to building occupants. Any such building vibration caused by ground-borne vibration (GBV) could be perceived as either (1) motion of building surfaces such as rattling of windows, items on shelves or pictures hanging on walls, or (2) as a low-frequency rumbling noise, which is referred to as ground-borne noise. Some common levels of GVB are shown in **Figure 4-2**.

Because it takes time for the human body to perceive and respond to vibration signals, vibration amplitudes are usually characterized using "smoothed" amplitudes based on the root mean square (RMS) of data points along the wave of motion. RMS vibration velocity is considered the best available measure of potential human annoyance from ground-borne vibration. FTA methodology for assessing potential impacts from vibration from transit facility operations considers vibration amplitude reported as RMS velocity, converted to vibration decibel levels (VdB).

Characterizing vibration in terms of RMS velocity in VdB to consider potential annoyance contrasts with describing vibration using peak-particle velocity (PPV). Most vibration measurements are taken to monitor the potential for building damage (i.e., not annoyance) from construction activities, and

[4] Federal Transit Administration (FTA), 2007, Email correspondence from Dave Leighow, Director of Planning & Program Development, FTA – Region 10, to Steve Kennedy, Sound Transit, October 31, 2007

such measurements are usually expressed in terms of PPV. The PPV represents the maximum instantaneous peak in the velocity of an object's vibratory motion about the equilibrium position. PPV is used to define thresholds of potential building damage from vibration because this metric is thought to more directly correlate with peak stresses in building components than RMS vibration.

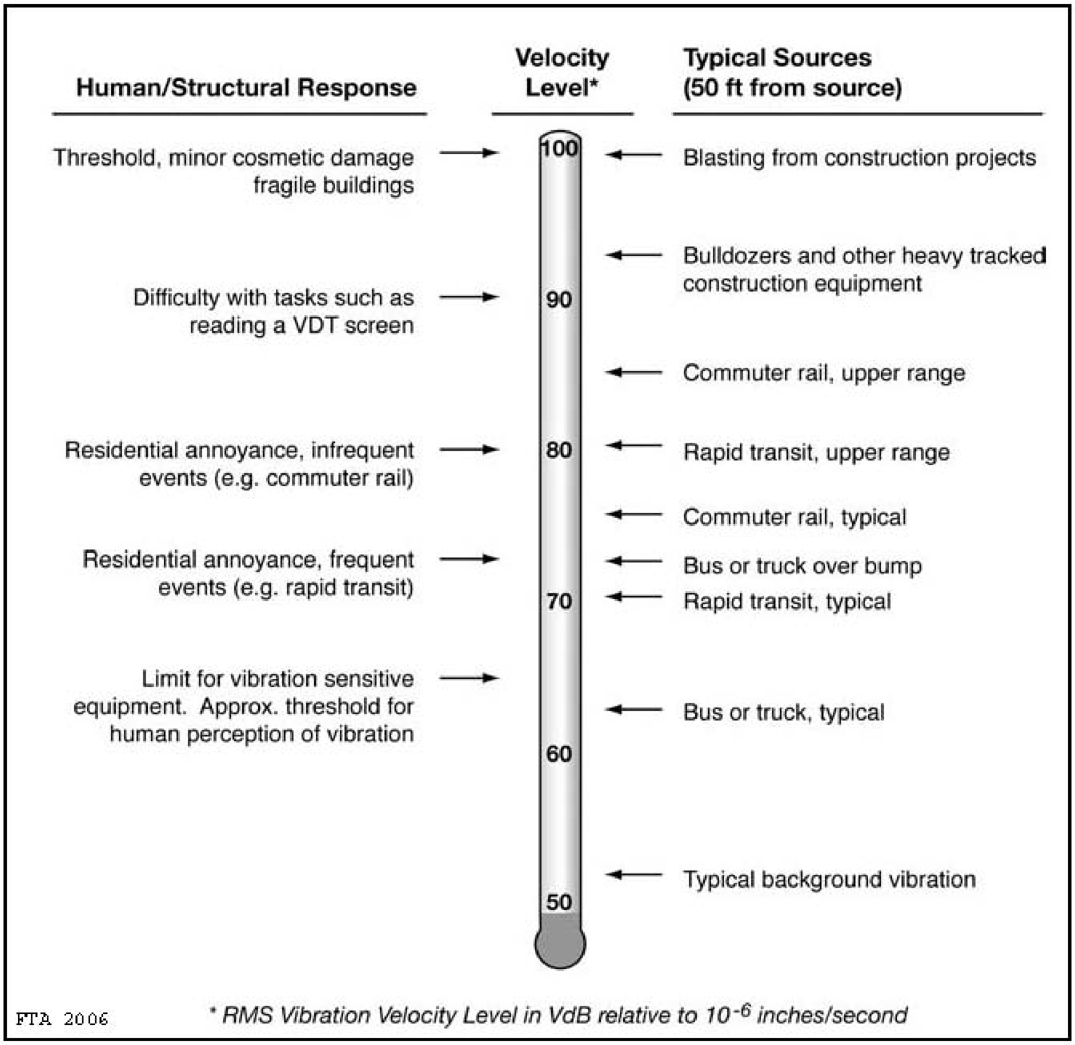

FIGURE 4-2. TYPICAL LEVELS OF GROUND-BORNE VIBRATION

4.4 Noise Limits and Criteria (Related Laws and Regulations)

The noise assessment for the proposed project will consider these issues in accord with the impact criteria described in this section. Other potentially applicable noise limits are also discussed.

4.4.1 Federal Transit Administration (FTA) Noise Impact Criteria

As previously mentioned, the FTA describes its noise impact criteria for transit projects in the manual entitled *Transit Noise and Vibration Impact Assessment* (FTA 2006). These criteria apply to rail projects; stationary facilities like transit stations, maintenance facilities, and park and ride lots, and to buses traveling on local roads and highways or in bus-only highway lanes.

The FTA noise impact criteria apply a sliding scale of impact levels of project-related noise based on comparison with, and related effect on the existing sound levels. These criteria are based on applying one of two metrics commonly used to quantify sound levels – the hourly equivalent sound level (L_{eq}) and the day-night sound level (L_{dn}), both described above. The FTA applies the L_{max} metric only in certain instances where noise mitigation may be required to reduce interior sound levels.

FTA noise impact criteria use the hourly L_{eq} of the hour of heaviest transit activity during hours of noise sensitivity to assess potential impacts at receivers involving primarily daytime use (i.e., where potential sleep disturbance is not an issue). Thus, the L_{eq} is used to consider impacts at locations such as parks, schools, libraries, offices, and churches. The L_{dn}, which factors in nighttime noise levels, is used to describe the noise environment in areas where there is both nighttime and daytime use, such as residences, hospitals, and hotels. FTA land use categories are described in Table 4-1 and transit noise impact criteria are shown in Figure 4-3.

Table 4-1. FTA Land Use Categories and Metrics for Transit Noise Impact Criteria

Land Use Category	Noise Metric (dBA)	Description of Land Use Category
1	Outdoor $L_{eq(1)}$ [1]	Tracts of land where quiet is an essential element in their intended purpose. This category includes lands set aside for serenity and quiet, and such land uses as outdoor amphitheaters and concert pavilions, as well as National Historic Landmarks with significant outdoor use.
2	Outdoor Ldn	Residences and buildings where people normally sleep. This category includes homes, hospitals, and hotels, where a nighttime sensitivity to noise is assumed to be of utmost importance.
3	Outdoor $L_{eq(1)}$ [1]	Institutional land uses with primarily daytime and evening use. This category includes schools, libraries, and churches, where it is important to avoid interference with such activities as speech, meditation, and concentration on reading material. Buildings with interior spaces where quiet is important, such as medical offices, conference rooms, recording studios, and concert halls fall into this category, as do places for meditation or study associated with cemeteries, monuments, and museums. Certain historical sites, parks, and recreational facilities are also included.

[1] Equivalent sound level of the noisiest hour of transit-related activity during period of noise sensitivity.
Source: U.S. Federal Transit Administration's *Transit Noise and Vibration Impact Assessment Manual*, May 2006. FTA-VA-90-1003-06.

FTA noise impact criteria are based on comparing expected project-related noise to existing sound levels (see Figure 4-3). Under these criteria, receiving locations with low existing sound levels can be exposed to greater increases in overall noise due to the addition of project noise before an impact occurs. Conversely, locations with higher existing sound levels can be exposed to smaller increases in overall noise before an impact occurs. For example, residential locations with an existing sound level of L_{dn} 40 dBA would not be considered severely impacted unless a project would cause a 15-dBA increase in noise, while residential locations with an L_{dn} 60 dBA baseline noise level would be considered severely impacted by less than a 5-dBA increase.

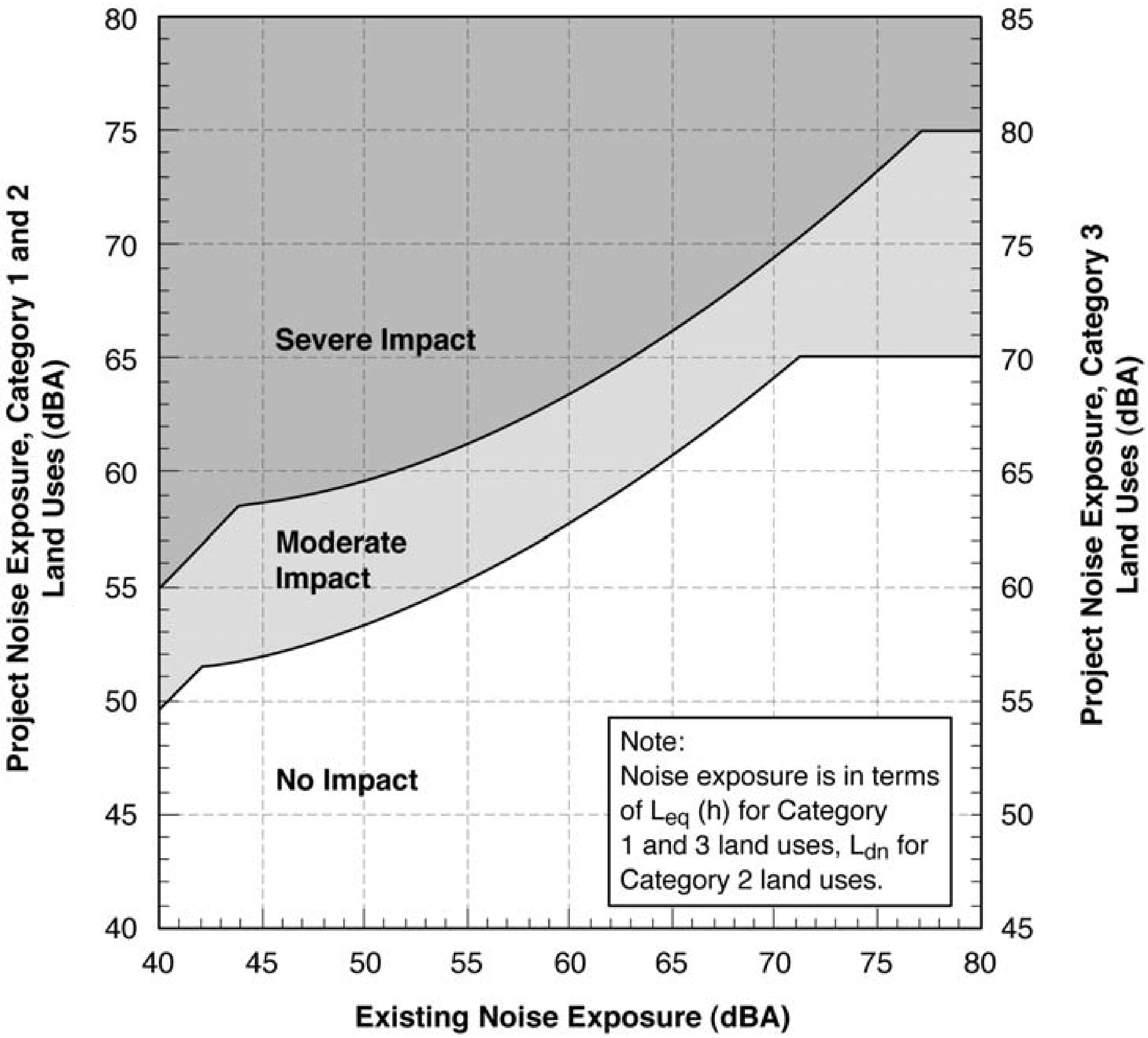

FIGURE 4-3. FTA NOISE IMPACT CRITERIA

For residential land uses, the FTA noise impact criteria are to be applied to exterior locations only, such as patios, decks, pools, and play areas. When there are no such exterior uses near a sensitive receiver, the impact criteria are applied near building doors and windows. FTA guidance assumes a typical building will provide an outdoor-to-indoor noise reduction of about 25 dBA, which can in some instances result in interior sound levels that do not warrant additional noise mitigation even if impact-level noises are likely outside the building.

FTA noise impact criteria allow for special consideration of the noise-sensitive nature of some historically significant sites. Historically significant sites with (1) residential uses, (2) with considerable outdoor use required for site interpretation (e.g., some parks), or (3) where quiet indoor levels are important to the operation of the site are treated as noise-sensitive receivers and evaluated using FTA criteria. Where historically significant sites are used for commercial or industrial purposes, despite being listed in the national or local historic registry, such sites are not considered noise-sensitive uses, and FTA does not identify or consider impact noise levels for such receivers.

4.4.2 FHWA/ODOT Noise Impact Criteria

The Federal Highway Administration (FHWA) has adopted noise standards that apply to traffic noise associated with its projects. These criteria are intended for analyzing effects related to new, expanded, or substantially modified roads controlled by state or federal agencies. Oregon State Department of Transportation (ODOT) policy clarifies that a substantially modified road would include one where a significant change in the horizontal or vertical alignment could lead to a perceptible increase in noise (i.e., at least a 2 to 3 dBA increase). For alternatives or projects that affect traffic volumes on state or federal roadways but do not otherwise result in substantial modifications to the roadway, the FHWA traffic noise criteria and the Oregon state implementation of these rules through state policies are used to provide readers a perspective on the noise levels and the potential for noise impacts related to traffic sources.

The FHWA defines a traffic noise impact as a predicted traffic noise level (peak hourly Leq) approaching or exceeding the noise abatement criteria (i.e., 67 dBA at exterior locations associated with residential uses or 72 dBA for exterior use areas associated with other types of developed lands that are not particularly sensitive to noise), or when the predicted traffic noise levels substantially exceed the existing noise levels. FHWA leaves the definition of "approach" to the states. ODOT defines "approaching" the FHWA limits as sound levels within 2 dBA of the criterion level. ODOT defines "substantially exceeding" existing noise levels as an increase greater than 10 dBA. The FHWA and ODOT noise impact criteria are summarized in Table 4-2.

Table 4-2. FHWA Roadway Noise Abatement Criteria (dBA)

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

Source: Federal noise rules in 23 CFR 772

4.4.3 State Noise Control Regulations and Ordinances

The State of Oregon has noise control ordinances that may pertain to certain aspects of the project. The ordinances regulate noise from commercial and industrial land uses near noise sensitive receivers. The Oregon DEQ noise limits for new and existing industrial and commercial noise sources would be applicable to the maintenance base, park and ride, and any other project-related ancillary facilities in areas where no local noise criteria exist. The applicable noise limits are shown in Table 4-3.

Other than these provisions pertaining to noise from ancillary facilities, operational noise from the streetcar would be exempt from noise limits along the corridor by virtue of being a public transport facility. Construction noise is exempt from the State noise limits without regard to timing.

Table 4-3. Oregon Industrial and Commercial Noise Source Standards

Statistical Level	Allowable Statistical Noise Levels in Any One Hour	
	7 a.m. - 10 p.m.	10 p.m. - 7 a.m.
L_{50}	55	50
L_{10}	60	55
L_{1}	75	60

The L_{50}, L_{10}, and L_{1} statistical noise descriptors are the sound levels exceeded 50%, 10%, and 1% of the time, respectively.
Source: OAR 340-35-035

4.4.4 Local Noise Control Regulations and Ordinances

The streetcar line could potentially affect communities in unincorporated Multnomah or Clackamas Counties, the City of Portland, and/or the City of Lake Oswego. The applicable noise regulations in each jurisdiction are discussed below.

4.4.4.1 Multnomah County

Multnomah County has no specific regulations regarding noise. The applicable noise limits for activities or facilities in unincorporated Multnomah County would, therefore, be those established by the State of Oregon or the City of Portland, the latter of whom may have jurisdiction by virtue of the City's enforcement of the zoning code in this area.

4.4.4.2 Clackamas County

Chapter 6.05 of the Clackamas County Code establishes limits on noise levels of 60 dBA between 7 a.m. and 10 p.m. and 50 dBA between 10 p.m. and 7 a.m. Noise from construction-related activities is exempt from these limits between 6 a.m. and 10 p.m.

4.4.4.3 City of Portland Noise Regulations

Title 18 of the Portland Municipal Code establishes noise control regulations for sources in the City of Portland. The permissible sound levels, by land use, are shown in Table 4-4. The City of Portland exempts noise from operation of vehicles traveling on public roads and thoroughfares from environmental noise limits, and instead applies the operational noise limits included in OAR 340-35-030 Table 3. Although a streetcar is not specifically included in the types of vehicles mentioned in the rule, this exemption was assumed to apply to operation of the streetcar line. Note that the noise limit included in the specification for the streetcar equipment that would be used on the project alignment is 75 dBA at 33 feet, which is 12 dBA less than the comparable truck/bus noise limit identified in OAR 340-35-030. Between 7 a.m. and 6 p.m. Monday through Saturday, the permissible sound level for construction activities is 85 dBA at 50 feet. This standard does not apply to trucks, pile drivers, pavement breakers, scrapers, concrete saws, and rock drills. Exempt sounds include sounds made by warning devices operated continuously for 3 minutes or less.

Table 4-4. City of Portland Permissible Sound Level (dBA)

	Zone Categories of Receiver			
Zone Categories of Source	Residential	Open Space	Commercial	Industrial
Residential	55	55	60	65
Open Space	55	55	60	65
Commercial	60	60	70	70
Industrial	65	65	70	75

Note: Limits above apply between 7 a.m. and 10 p.m., and in other hours are minus 5 dBA
Source: PMC 18.10.010

4.4.4.4 City of Lake Oswego

The City of Lake Oswego City Code, Section 34.10.537-539 identifies noise disturbances and prohibited noises. Construction-related noise is allowed between 7 a.m. and 6 p.m. Monday through Friday (or Monday through Saturday in other than residential zones); between 8 a.m. and 6 p.m. on Saturdays in residential zones, and between 10 a.m. and 6 p.m. on Sundays and holidays.

4.5 FTA Vibration Impact Criteria

The vibration assessment for the proposed project will consider these issues in accord with the impact criteria described in this section.

4.5.1 Impact Criteria Applied to Operation

The FTA characterizes the potential for impacts from ground-borne vibration (GBV) and ground-borne noise (GBN) based on three categories of land uses with varying sensitivity to interference or annoyance from vibration. FTA further delineates the potential for such impacts based on how often GBV or GBN events would be expected to occur. The FTA impact criteria for GBV and GBN are summarized in Table 4-5. These criteria are considered in relation to potentially sensitive receiving locations within the FTA impact screening distances.

Note that the FTA vibration impact criteria do not use a scale that includes "moderate" and "severe" impacts as are applied to noise (e.g., Figure 4-3). Instead, the criteria are used to determine the presence or absence of vibration-related impacts, and any such identified impacts are intended to be considered for possible mitigation.

Table 4-5. FTA Ground-Borne Vibration and Ground-Borne Noise Impact Criteria

Land Use Category	Ground-Borne Vibration Impact Levels (VdB re 1 micro-inch/sec)			Ground-Borne Noise Impact Levels (dB re 20 micro Pascals)		
	Frequent Events [1]	Occasional Events [2]	Infrequent Events [3]	Frequent Events [1]	Occasional Events [2]	Infrequent Events [3]
Category 1 [4] Buildings where vibration would interfere with sensitive interior operations (e.g., sensitive equipment)	65 VdB [5]	65 VdB [5]	65 VdB [5]	25 dBA [6]	25 dBA [6]	25 dBA [6]
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 (e.g., quiet offices)	75 VdB	78 VdB	83 VdB	40 dBA	43 dBA	48 dBA

1 "Frequent Events" are more than 70 vibration events of the same source per day. Most rapid transit projects fall into this category, and the LOPT project is in this category.
2 "Occasional Events" are between 30 and 70 vibration events of the same source per day. Most commuter trunk lines are in this category.
3 "Infrequent Events" are fewer than 30 vibration events of the same kind per day. Most commuter rail branch lines are in this category.
4 Although not specifically identified as "Category 1" uses, concert halls, TV studios, and recording studios have the same ground-borne vibration and ground-borne noise level criteria as Category 1 uses.
5 This criterion limit is based on levels that are acceptable for most moderately sensitive equipment such as optical microscopes. Vibration-sensitive manufacturing or research will require detailed evaluation to define the acceptable vibration levels. Ensuring lower vibration levels in a building often requires special design of the HVAC systems and stiffened floors.
6 Vibration-sensitive equipment is generally not sensitive to ground-borne noise, so these criteria do *not* apply to the Category 1 uses. Instead, specified ground-borne noise levels apply to concert halls and TV and recording studios.
Source: FTA 2006

4.5.2 Vibration Damage Criteria Applied to Construction

In contrast with the FTA vibration impact criteria for transit facility operations that are based on the potential for GBV to annoy people or to interfere with the operation of sensitive equipment, FTA vibration impact criteria for construction are based on the potential for the vibration to result in physical damage to buildings. In this instance, the criteria are based on potential vibration levels from a variety of construction equipment in conjunction with classes of buildings and their potential to be adversely affected by GBV. In this instance, the criteria are based on potential vibration levels from a variety of construction equipment (Table 4-6) in conjunction with classes of buildings and their potential to be adversely affected by GBV (Table 4-7).

Table 4-6. Vibration Source Levels for Construction Equipment

Equipment		PPV at 25 ft (in/sec)
Pile Driver (Impact)	Upper Range	1.515
	Typical	0.644
Pile Driver (Sonic)	Upper Range	0.734
	Typical	0.170
Vibratory Roller		0.210
Hoe Ram		0.089
Large Bulldozer		0.089
Caisson drilling		0.089
Loaded trucks		0.076
Jackhammer		0.035
Small bulldozer		0.003

Source: FTA 2006

Table 4-7. FTA Construction Vibration Damage Criteria

Building Category and Description	PPV (in/sec)
I. Reinforced-concrete, steel, or timber (no plaster)	0.5
II. Engineered concrete and masonry (no plaster)	0.3
III. Non-engineered timber and masonry buildings	0.2
IV. Buildings extremely susceptible to vibration damage	0.12

Source: FTA 2006

5. AFFECTED ENVIRONMENT

This section describes existing environmental noise conditions within the project study area and provides a tabulation of the vibration sensitivity survey of the area.

5.1 Existing Acoustic Environment

The existing acoustic environments at selected locations throughout the project area were documented using a series of long-term (about 24-hours) and short-term (about 1 hour) sound level measurements. These measurements were taken at representative locations such that measured levels indicate typical existing acoustic conditions in the vicinity of each measurement. Each long-term sound level measurement (SLM) was mostly unobserved except during set up and demobilization of the equipment, except that some long-term SLMs were visited one or more additional times during the measurement period to document contributing noise sources. Existing conditions and contributing noise sources were noted during each visit.

Measured existing sound levels are summarized in Table 5-1, which includes data from both the long-term (24-hour) and short-term (1-hour) SLMs. The hourly L_{eq}s at long-term SLM locations are presented as ranges during daytime and nighttime hours, while short-term SLM data are presented as a single hourly L_{eq}. The 24-hour L_{dn} levels are presented for the long-term SLMs only. Finally, note that the SLMs are labeled by the project subarea in which they are located (e.g., SW = South Waterfront), are designated "S" to indicate they represent an SLM, and numbered sequentially from north to south. The sound level measurement locations are depicted in Figure 5-1 through Figure 5-5 following the table. More complete sound level measurement data are included in Appendix A of this report.

Table 5-1. Measured Existing Sound Levels (dBA)

Area Name/ SLM ID	Address	Date	Start Time	Duration	Interval L_{eq} or Range	Daily L_{dn}
South Waterfront						
SW-S1	0455 Hamilton Court	09/23/2009	1100	24 Hrs	Day: 60-65 Night: 58-63	67
Johns Landing						
JL-S1	4990 SW Landing Drive	11/02/2009	1600	24 Hrs	Day: 53-61 Night: 47-58	60
JL-S2	4980 SW Landing Drive	11/03/2009	1400	1 Hr	57	
JL-S3	Landing Condos	11/03/2009	1500	1 Hr	62	
JL-S4	Willamette Shores Condos	11/02/2009	1600	24 Hrs	Day: 51-57 Night: 45-53	57
JL-S5	5640 SW Riverside Lane	11/03/2009	1200	1 Hr	67	
JL-S6	6932 SW Macadam Avenue	08/20/2009	1600	1 Hr	65	
Sellwood Bridge						
SB-S1	0752 SW Miles Street	08/20/2009	1600	1 Hr	55	
SB-S2	Mile Post 3 OR 43	08/21/2009	900	1 Hr	64	
Dunthorpe/Riverdale						
DR-S1	10110 OR 43	08/21/2009	1200	1 Hr	60	
DR-S2	10400 SW Riverside Dr (OR-43)	08/20/2009	1200	24 Hrs	Day: 56-59 Night: 43-57	57
DR-S3	10808 SW Riverwood Road (Down)	09/23/2009	900	1 Hr	52	
DR-S4	10808 SW Riverwood Road (Up)	09/23/2009	1200	1 Hr	59	

Table 5-1. Measured Existing Sound Levels (dBA)

Area Name/ SLM ID	Address	Date	Start Time	Duration	Interval L_{eq} or Range	Daily L_{dn}
DR-S4	10808 SW Riverwood Road	11/05/2009	900	1 Hr	61	
DR-S5	11000 SW Riverwood Road	09/24/2009	1200	24 Hrs	Day: 50-59 Night: 46-54	58
DR-S5	11000 SW Riverwood Road	11/05/2009	900	1 Hr	55	
DR-S6	11075 SW Riverwood Road	11/04/2009	1300	1 Hr	58	
DR-S6	11075 SW Riverwood Road	11/04/2009	1400	1 Hr	56	
DR-S7	11150 SW Riverwood Road	08/18/2009	1500	1 Hr	50	
DR-S8	11175 SW Riverwood Road	11/03/2009	1700	24 Hrs	Day: 50-57 Night: 43-54	57
DR-S9	11322 SW Riverwood Road	08/18/2009	1500	24 Hrs	Day: 49-56 Night: 44-55	56
DR-S10	2484 SW Military Road	11/04/2009	1300	1 Hr	60	
DR-S10	2484 SW Military Road	11/04/2009	1400	1 Hr	51	
DR-S11	11385 SW Riverwood Road	08/19/2009	1600	1 Hr	52	
DR-S12	11623 SW Riverwood Road	08/19/2009	1200	24 Hrs	Day: 42-55 Night: 39-48	52
DR-S13	11395 SW Riverwood Road	08/19/2009	1600	1 Hr	Equipment Malfunction	
DR-S14	11821 SW Riverwood Road	09/24/2009	1100	48 Hr	Day: 43-54 Night: 34-57	55
DR-S15	On ROW Just North of tunnel	09/23/2009	1500	1 Hr	46	
DR-S16	12700 SW Fielding Road	08/19/2009	1100	24 Hrs	Day: 43-53 Night: 42-47	52
DR-S17	12525 Elk Rock Road	08/20/2009	900	1 Hr	45.1	
DR-S18	12716 Elk Rock Road	08/19/2009	900	24 Hrs	Day: 49-60 Night: 42-51	55
DR-S19	12850 SW Fielding Road	08/20/2009	900	1 Hr	52	
DR-S20	13060 Elk Rock Road	08/18/2009	1200	1 Hr	53	
DR-S21	13200 SW Fielding Road	08/18/2009	1000	24 Hrs	Day: 45-51 Night: 38-46	51
Lake Oswego						
LO-S1	Adjacent to S Briarwood Road	09/24/2009	1400	1 Hr	53	
LO-S2	26 S Briarwood Road	09/24/2009	1100	24 Hrs	Day: 52-58 Night: 40-56	58
LO-S3	13581 SW Fielding Road	08/18/2009	1200	1 Hr	55	
LO-S4	13711 SW Fielding Road	08/18/2009	1000	24 Hrs	Day: 57-61 Night: 47-59	61
LO-S5	Vacant Lot	11/03/2009	1800	24 Hrs	Day: 50-57 Night: 41-59	59
LO-S6	5062 Foothills Drive	11/03/2009	1100	24 Hrs	Day: 52-77 Night: 41-57	67
LO-S7	5013 Waterfront Apartments	11/04/2009	800	1 Hr	57	
LO-S8	5001 Waterfront Apartments	11/03/2009	1100	24 Hrs	Day: 56-70 Night: 39-59	61
LO-S9	121 Leonard Street	11/04/2009	1000	1 Hr	54	

Note that the SLM locations are labeled by the project subarea in which they occur and are numbered sequentially from north to south and not based on the actual measurement sequence.
Source: ENVIRON International Corporation, 2010

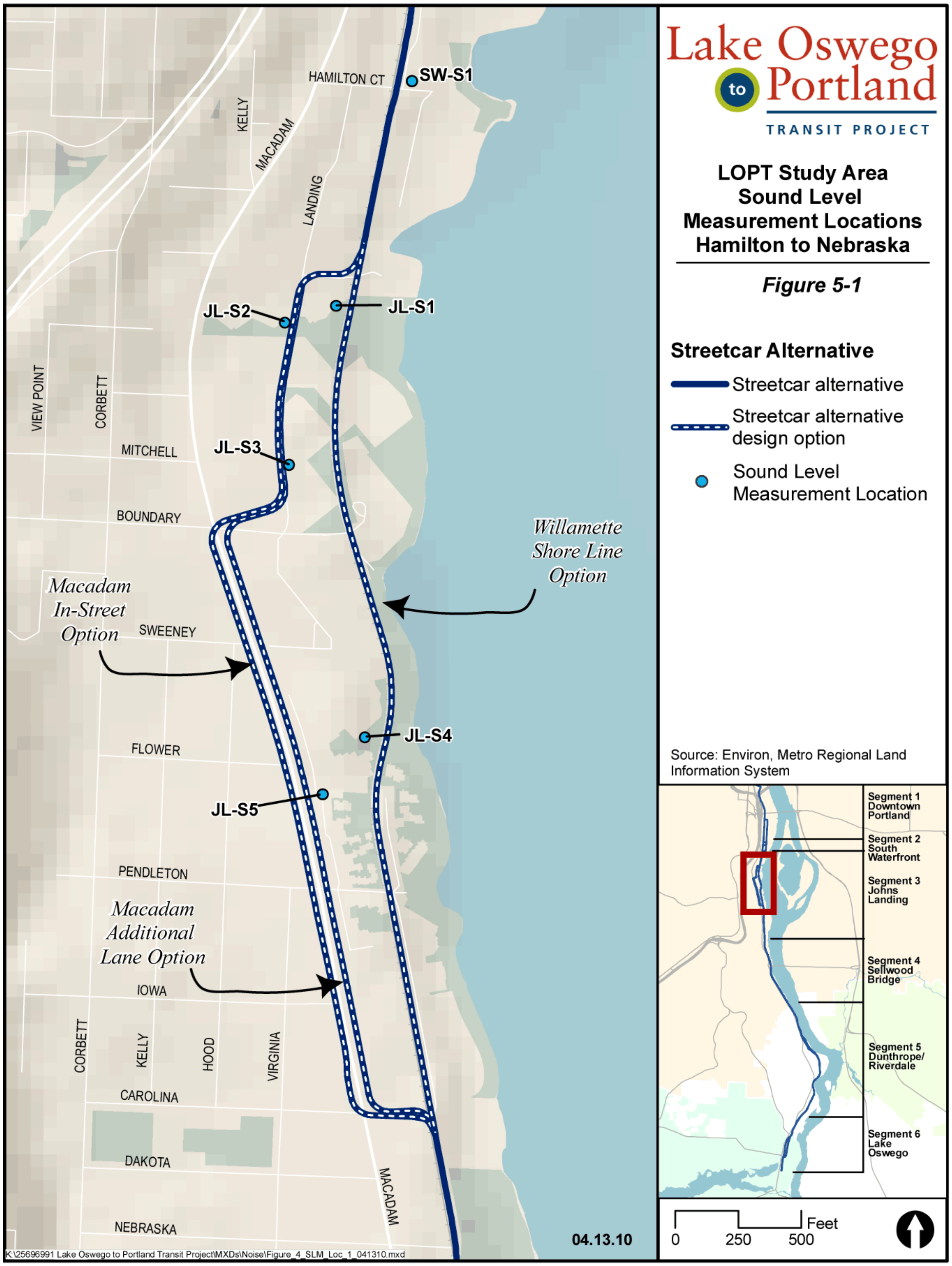

FIGURE 5-1. LOPT STUDY AREA SLM LOCATIONS - HAMILTON TO NEBRASKA

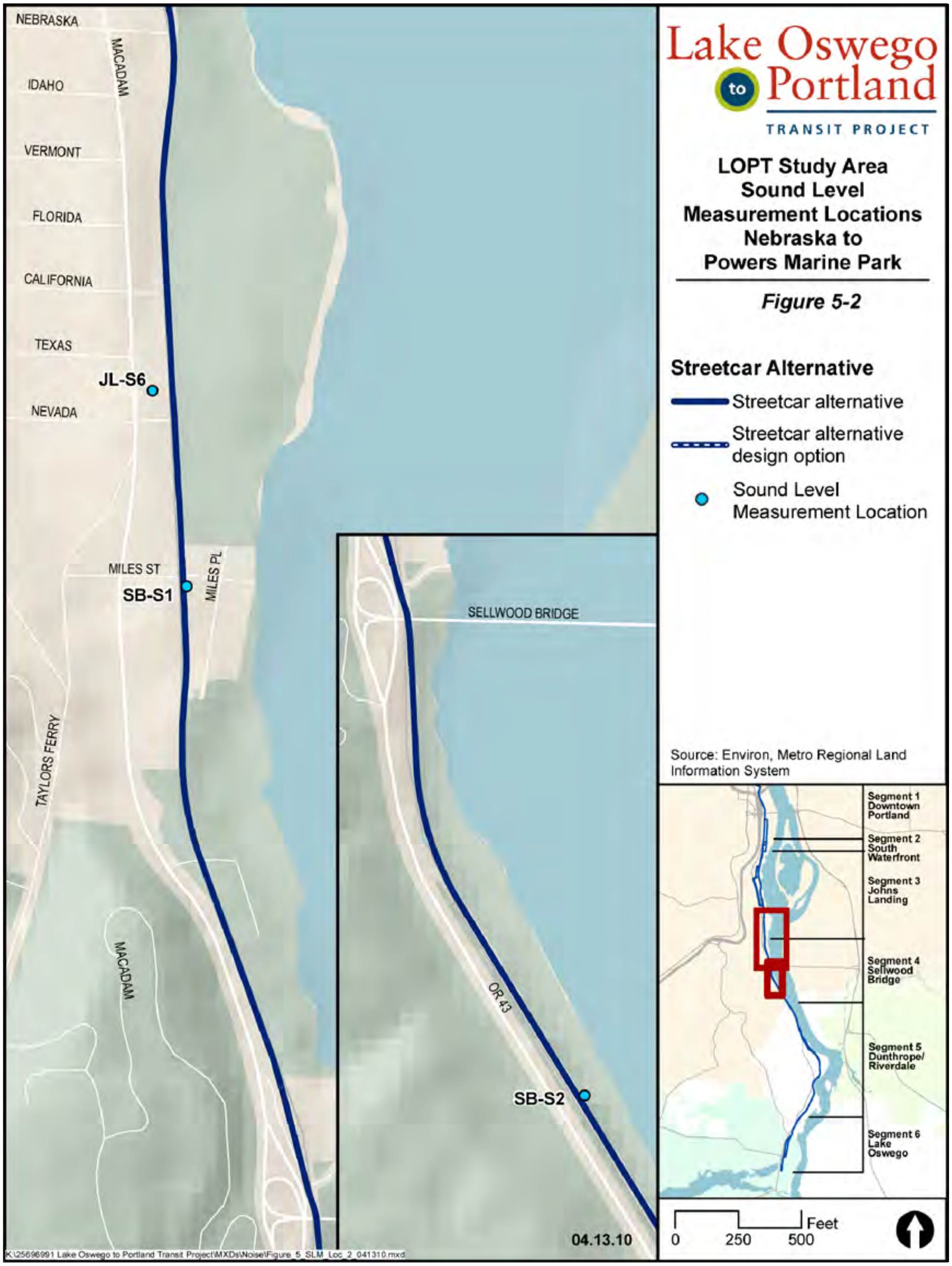

FIGURE 5-2. LOPT STUDY AREA SLM LOCATIONS - NEBRASKA TO POWERS MARINE PARK

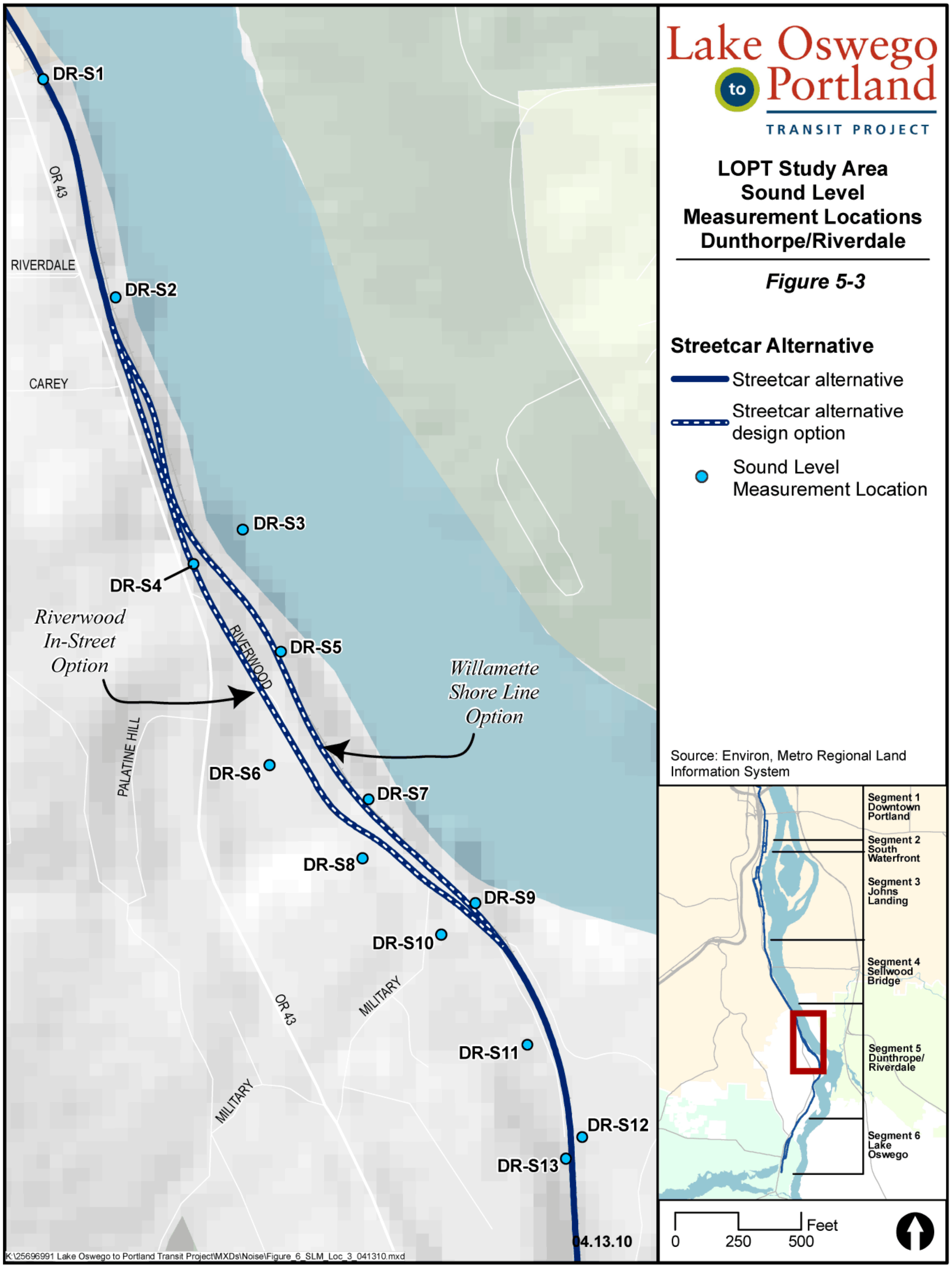

FIGURE 5-3. LOPT STUDY AREA SLM LOCATIONS - DUNTHORPE/RIVERDALE

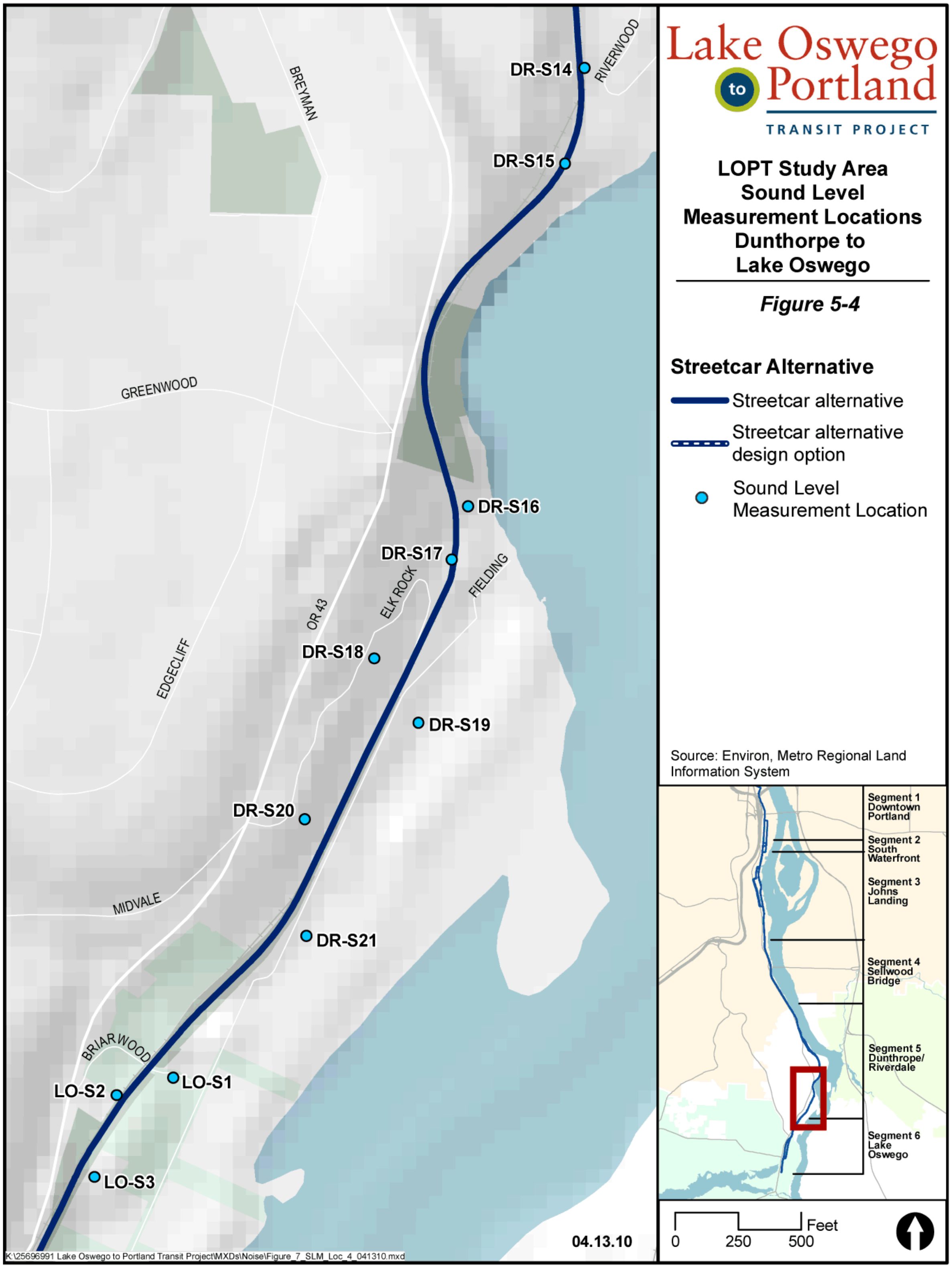

FIGURE 5-4. LOPT STUDY AREA SLM LOCATIONS - DUNTHORPE TO LAKE OSWEGO

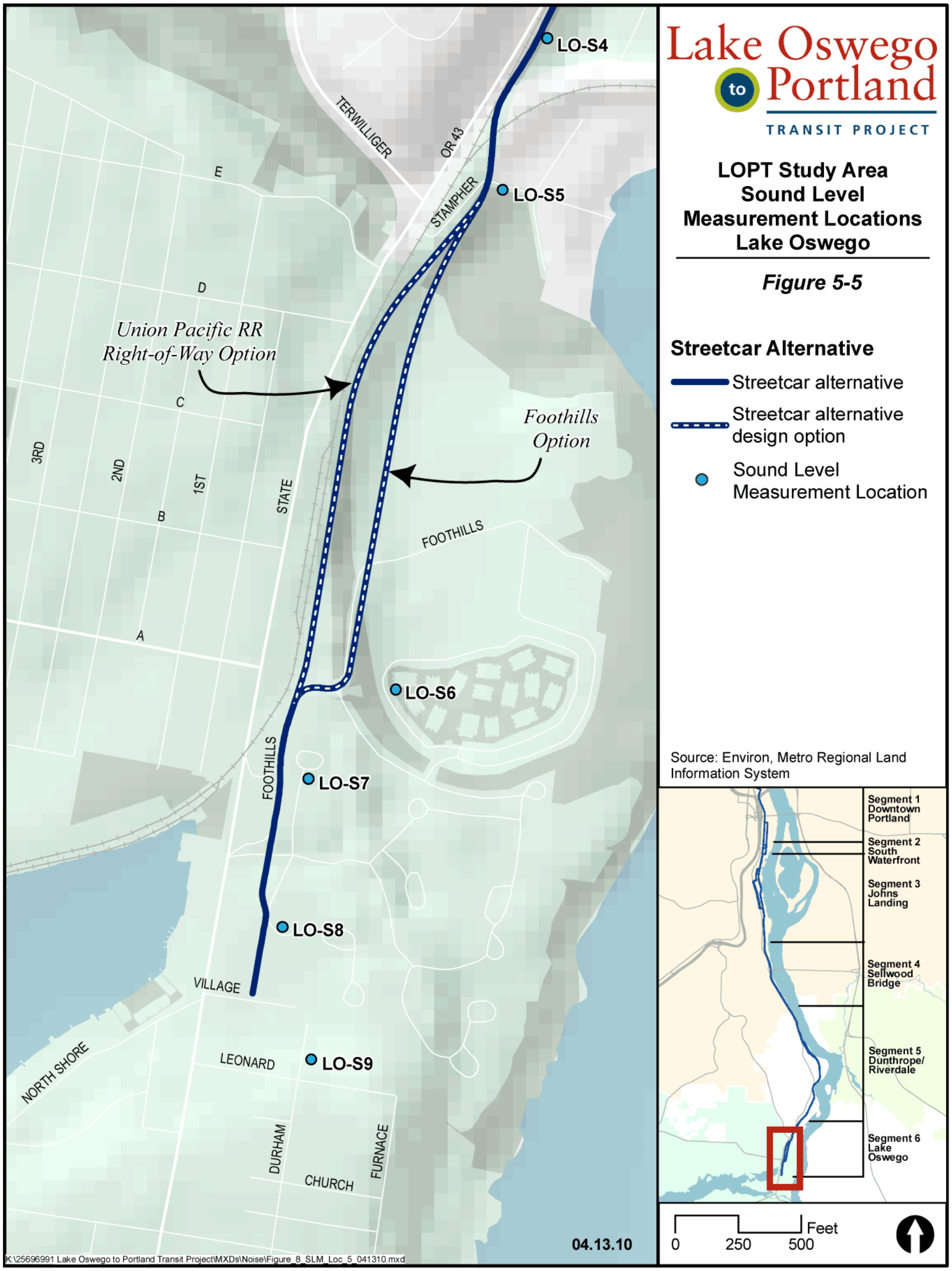

FIGURE 5-5. LOPT STUDY AREA SLM LOCATIONS - LAKE OSWEGO

Existing Vibration Environment

The review of existing vibration conditions in the project study area was based on a survey of existing homes and other buildings and a determination of their distance from the alternative alignments and the various design options of those alternatives. This survey was conducted during three separate site visits to the project study area and included field notes differentiated by study area section and alternative/design option. The results of the vibration receiver survey are summarized in Table 5-2**.**

Table 5-2. Existing Vibration Receptor Survey Summary

	Buildings Within Operational Screening Distance [1]		
Project Study Areas	**Category 1**	**Category 2**	**Category 3**
South Waterfront	0	1	7
Johns Landing	1	10	16
Sellwood Bridge	0	8	1
Dunthorpe Riverdale	0	44	0
Lake Oswego	0	12	3
All	1	75	27

[1] Refer to Table 4-5 for information regarding the land use categories designations.
Source: ENVIRON International Corporation, 2010

As shown, there is only one vibration sensitive (Category 1) use in the project study area (i.e., the Oregon Public Broadcasting building), while there are 75 residential uses (Category 2) and 27 office or commercial uses (Category 3) within the screening distances of the streetcar corridor. These locations were considered further in a general vibration analysis conducted in accord with FTA methods described in a later section.

6. ENVIRONMENTAL CONSEQUENCES

6.1 Environmental Noise

6.1.1 Direct Effects

6.1.1.1 No Build Alternative

With the no build alternative, none of the proposed project's "action" alternatives would be pursued. Thus, there would be no direct noise impacts from this alternative.

The existing excursion trolley service on the Willamette Shore Line tracks that operates seasonally and by special arrangement by the Oregon Electric Railway Historical Society (OERHS) could continue with this alternative. This would maintain existing occasional noise from this operation including both a diesel engine generator and crossing whistles/bells.

6.1.1.2 Enhanced Bus Alternative

With the enhanced bus alternative, the existing transit system would be augmented with additional bus routes and additional numbers of buses along existing routes. But because the numbers of new buses would be very small relative to numbers of existing vehicles using established roadways, any changes in the noise environment due to these additional vehicles would be minimal. This conclusion is discussed more completely below.

Operation

This alternative would cause small increases in the numbers of buses traveling on existing roadways in the project study area, which would cause slight, if any, increases in overall sound levels. For example, during the morning peak commute period the six additional buses would represent less than 0.01% of the total hourly traffic along OR-43, which would result in little or no change in noise from this roadway. For this reason, the Enhanced Bus Alternative would result in no noise impacts due to increased traffic along this roadway.

Operation of the new roadway from the park-and-ride facility to Foothills Road and the park-and-ride itself would create a new noise source in the commercial area that would replace existing traffic and parking lot sources. Both the parking structure and the access roadway would be outside the 225 foot screening distance FTA applies to park-and-ride lots to assess the potential for noise impacts. Thus, no noise impacts would be expected from the operation of these facilities.

The Enhanced Bus Alternative would result in additional bus traffic traveling on a state highway but would not result in new, expanded, or substantially modified roads controlled by state or federal agencies. Therefore, the FHWA/ODOT noise impact criteria do not specifically apply to this project.

The existing excursion trolley service using the Willamette Shore Line tracks that operates seasonally and by special arrangement by the OERHS could continue with the Enhanced Bus alternative. This would maintain existing occasional noise from this operation including both a diesel engine generator and crossing whistles/bells.

6.1.1.3 Streetcar Alternative

The streetcar alternative of this project includes several design options in portions of the project area as well as a portion that would be the same regardless of the design options in other areas. The potential construction and operational noise impacts are discussed below based on both the project subarea and the design option involved. For clarity, each subarea and design option (if any) is included in the section header.

Construction

During construction there would be temporary increases in sound levels near the active areas of construction and near any materials staging areas due to the use of heavy equipment. In some areas construction activities would occur within close proximity to buildings, some immediately adjacent to the Willamette Shore Line right-of-way, including residences and numerous commercial structures along Highway 43. Construction noise received at both commercial and residential uses adjacent to the alignment could be perceived as intrusive. However, construction in any one area is expected to be of limited duration and any such intrusive noise would be temporary.

Potential construction and operational noise impacts are discussed in detail in the sections that follow.

Construction – SW Waterfront and Johns Landing – Willamette Shore Line (WSL) Design Option

Construction of the streetcar alternative in the SW Waterfront and Johns Landing area with the WSL design option would involve following the existing rail line alignment and the removal and replacement of existing tracks. This process would include as much work as possible from within the existing right of way. Construction of the new facility components would require site preparation, excavation, fill and compaction, and placement of new ties and rails. These processes would require use of heavy equipment such as loaders, dozers, and cranes. Final placement of the rails would require use of a ballast tamping machine to compact the ballast and align the rails. All this large equipment is diesel powered and so represents relatively loud sound sources. But construction of most components of the streetcar line can be accomplished within a matter of weeks, so while construction noise could be intrusive at nearby uses, it would not last long. Due to the short-term nature of construction activities, with adherence to timing restrictions and application of reasonable measures to minimize noise production and transmission from the active construction areas, significant noise impacts can be avoided. Expected construction noise control measures are discussed in the mitigation portion of this section.

Construction –Johns Landing – Macadam In-Street Design Option

Construction of the streetcar alternative in the Johns Landing area with the Macadam In-Street design option would involve following the existing rail line alignment for a portion of the alignment, then shift to SW Landing Drive generally between SW Julia Street and SW Boundary Street. At SW Boundary Street the streetcar would transition to SW Macadam Avenue, and then this road for about 1,500 feet before transitioning back to the existing alignment at SW Carolina Street. With the in-street option the portion of the alignment along SW Macadam Avenue would include a southbound rail line within the westernmost lane and a northbound rail line within the easternmost lane of the street, all within the existing SW Macadam Avenue right of way. Construction within these areas would be similar to normal street repair work and because it would be short term, would be unlikely to result in significant noise impacts.

Construction –Johns Landing – Macadam Additional Lane Design Option

Construction of the streetcar alternative in the Johns Landing area with the Macadam Additional Lane design option would be similar to the in-street option except for the construction of a new lane along the eastern side of the roadway to accommodate the streetcar while still allowing for two northbound traffic lanes. This would require construction to occur slightly closer to existing residential uses east of the road, and thus somewhat increase construction noise from this design option. Nonetheless, because construction noise would be short term, it would be unlikely to result in significant noise impacts.

Construction – Sellwood Bridge

Construction of the streetcar alternative in the Sellwood Bridge area would involve following near the existing rail line alignment and the removal and replacement of existing tracks. This process would include as much work as possible from within the existing right of way. Construction of the new facility components would involve the same activities and equipment as described previously. Construction impacts would be the same for the Willamette Shore Line phasing option.

Streetcar in this area would involve repair of the Staff Jennings Trestle just north of the Sellwood Bridge. This construction activity would involve some form of pile driving to provide structural support to the ends of the trestle. Impact pile driving can be quite loud, while vibratory (also called "sonic") pile driving is less loud or less intrusive because the primary noise source is a large engine but there is no noise associated with impact driving because the pile is gripped firmly and vibrated into place. Piles driven using vibratory installation also may require a small amount of impact driving to test the bearing load of the pile. Thus, the entire process of installing each pile requires more set up time than with impact driving. But noise from impact pile installation is often one of the most intrusive noises associated with construction sites.

Construction – Dunthorpe/Riverdale – Willamette Shore Line (WSL) Option

Construction of the streetcar alternative WSL design option in the Dunthorpe/Riverdale subarea would involve repair of existing trestles along with the removal of existing rails, ties, and ballast materials, followed by excavation, grading, compaction, ballast placement, rail installation, and final rail truing and spacing. These processes would require use of heavy equipment such as loaders, dozers, and cranes, and final placement of the rails would require use of a ballast tamping machine to compact the ballast and align the rails. All this large equipment is diesel powered and so represents relatively loud sound sources. But construction of most components of the streetcar line can be accomplished within a matter of weeks, so while construction noise could be intrusive at nearby uses, it would not last long. Due to the short-term nature of construction activities, with adherence to timing restrictions and application of reasonable measures to minimize noise production and transmission from the active construction areas, significant noise impacts can be avoided. Expected construction noise control measures are discussed in the mitigation portion of this section.

Construction of the WSL design option in this area would involve repair of both the short and the long trestles. This construction activity would involve some form of pile driving to provide structural support to the trestles. Impact pile driving can be quite loud, and while vibratory pile driving is somewhat less loud, it may take longer to accomplish.

Construction – Dunthorpe/Riverdale – Riverwood Design Option

Construction of the Riverwood In-Street design option in the Dunthorpe/Riverdale subarea would require the same construction processes described for the WSL option in this area, but instead of repair of two trestles would instead include construction of a new trestle structure to provide a transition from the existing rail alignment up the grade to the new design option alignment along SW Riverwood Road. This would relocate the pile driving from the existing trestles area to provide for a new trestle structure for the transitional alignment to SW Riverwood Road. While the amount and duration of construction in this area would be about the same as for the WSL Option, the Riverwood In-Street Option would require more excavation using heavy equipment and haul truck in the vicinity of the intersection with Highway 43 than the WSL Option.

Construction -- Lake Oswego – UPRR Design Option

Construction of the UPRR ROW design option in Lake Oswego would involve excavation of an underpass for the streetcar line under the existing UPRR line, creation of a new rail line south to the project terminus, construction of a new roadway from Foothills Road southward through the Oswego Village Shopping Center, and construction of a new 300-space park-and-ride garage at the shopping center. These construction processes would require use of heavy equipment such as loaders, dozers, trucks, cranes, and concrete delivery and pumping trucks. All this large equipment is diesel powered and so represents relatively loud sound sources, and nearby receivers could be adversely affected, if only for short-term periods by such noise.

Construction -- Lake Oswego – Foothills Design Option

Construction of the Foothills design option in Lake Oswego would involve the same construction activities in about the same locations as described for the UPRR ROW design option above. Related construction noise effects would be similar, and nearby receivers could be adversely affected for short-term periods.

Operations

This section discusses the results of the analysis of potential noise impacts associated with operation of the proposed streetcar facility. A general visual overview of locations potentially impacted by noise from operation of the streetcar is provided in Figure 6-1.

Operation – SW Waterfront and Johns Landing – Willamette Shore Line (WSL) Design Option

Operation of the streetcar along the WSL alignment in the SW Waterfront and Johns Landing areas would result in moderate noise impacts at one model receptor location (JL-22) representing approximately eight residential units in this area that are within tens of feet of the existing rail line (see Table 6-1 for model results and Figure 2-1, page 30 and Figure 2-2 for receptor locations). The potentially affected residential uses are approximately at grade with the rail line, and there are stair steps and nearby walkways indicating the rail line is subject to pedestrian traffic within this residential area.

Table 6-1. SW Waterfront and Johns Landing Noise Impact Modeling Summary

				LOPT Streetcar Alternative Design Options					
				WSL		Macadam In Street		Macadam Additional Lane	
Rec#	# Res [1]	SLM [2]	Exist Ldn	Project Ldn	Impact?	Project Ldn	Impact?	Project Ldn	Impact?
SW-1	hotel	SW-S1	67	50	--		--		--
JL-1	multiple	JL-S1	60	48	--		--		--
JL-2	multiple	JL-S1	60	27	--		--		--
JL-3	multiple	JL-S2	59 [3]	33	--		--		--
JL-4	multiple	JL-S2	59 [3]	30	--		--		--
JL-5	multiple	JL-S1	60	49	--		--		--
JL-6	multiple	JL-S1	60	53	--		--		--
JL-7	multiple	JL-S1	60	33	--		--		--
JL-8	multiple	JL-S3	62 [3]	56	--		--		--
JL-9	multiple	JL-S4	57	44	--		--		--
JL-10	multiple	JL-S3	62 [3]	48	--		--		--
JL-11	multiple	JL-S3	62 [3]	26	--		--		--
JL-12	multiple	JL-S3	62 [3]	30	--		--		--
JL-13	multiple	JL-S4	57	49	--		--		--
JL-14	multiple	JL-S4	57	51	--		--		--
JL-15	multiple	JL-S5	67 [3]	28	--		--		--
JL-16	multiple	JL-S4	57	47	--		--		--
JL-17	multiple	JL-S5	67 [3]	29	--		--		--
JL-18	multiple	JL-S4	57	52	--		--		--
JL-19	multiple	JL-S4	57	56	--		--		--
JL-20	multiple	JL-S5	67 [3]	31	--		--		--
JL-21	multiple	JL-S4	57	44	--		--		--
JL-22	8	JL-S4	57	57	Moderate		--		--
JL-23	multiple	JL-S5	67 [3]	27	--		--		--
JL-24	multiple	JL-S4	57	44	--		--		--
JL-25	multiple	JL-S5	67 [3]	28	--		--		--
JL-26	multiple	JL-S4	57	50	--		--		--
JL-27	multiple	JL-S4	57	57	--		--		--
JL-28	multiple	JL-S5	67 [3]	31	--		--		--
JL-29	multiple	JL-S4	57	41	--		--		--
JL-30	OPB	JL-S6	65 [4]	63 [4]	--	63 [4]	--	63 [4]	--
JL-31	OPB	SB-S1	55 [4]	59 [4]	--	59 [4]	--	59 [4]	--
JL-32	2	SB-S1	59 [3]	47	--	47	--	47	--

1 Some receptor locations may represent more than one residence. Because most of the residences in the John's Landing area are condominiums, each receptor location may represent numerous individual residences, and the number of residences was quantified only for those receptors identified to receive potential noise impacts from the proposal.
2 The SLM locations are identified in Table 5-1 and displayed in Figure 5-1 and Figure 5-2.
3 The existing Ldn was estimated based on the difference between the hourly sound level measured to represent this location and a nearby, simultaneous long-term measured sound level. Appendix A contains both the short-term and long-term measurement data and indicates which short-term measurement locations were assigned to which representative long-term location.
4 The reported existing and projected future project-related sound levels for these receptor locations are based on the morning peak hour Leq and not the Ldn because these are commercial establishments and thus not places where people sleep.
Source: ENVIRON International Corporation, 2010

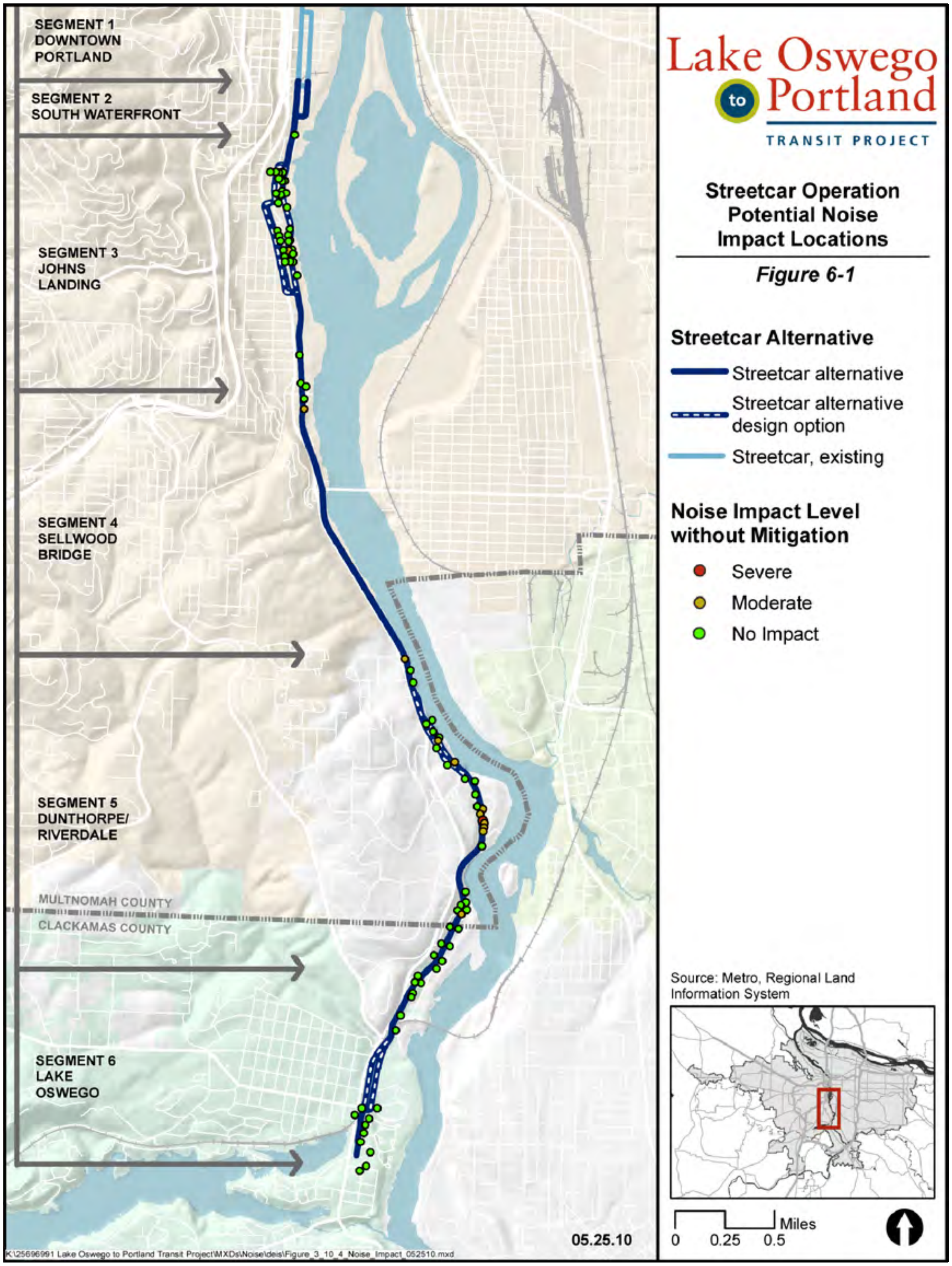

FIGURE 6-1. STREETCAR OPERATION POTENTIAL NOISE IMPACT LOCATIONS

Operation –Johns Landing – Macadam In-Street Design Option

The streetcar line through the Johns Landing area on the Macadam In-Street design option would be nearer to a few residential uses in this area but farther from most compared with the WSL alignment. Modeling indicated no locations would be impacted by operational noise based on consideration of both existing sound levels and the increase that would result from streetcar operation (Table 6-1).

Operation –Johns Landing – Macadam Additional Lane Design Option

The streetcar line through the Johns Landing area with the Macadam Additional Lane design option would be nearer to a few residential uses in this area but farther from most compared with the WSL alignment. Modeling indicated no locations would be impacted by operational noise based on consideration of both existing sound levels and the increase that would result from streetcar operation (Table 6-1).

The Macadam Additional Lane design option of the Streetcar Alternative would result in the addition of a restricted travel lane (for streetcar use and for traffic turning right) on approximately 1,500 feet of Macadam Avenue, a state-controlled roadway. Therefore, FHWA/ODOT noise impact assessment procedures must be considered. However, this lane would not result in additional overall traffic volumes on Macadam Avenue, would not represent an additional through lane, and would not be expected to result in a 2-3 dBA increase in noise on such a busy road. Therefore, it would not be designated a "substantial realignment" according to ODOT criteria.[5] Furthermore, the addition of a streetcar in the lane would be quieter than a heavy truck, would be less frequent than trucks, and would result in virtually no increase in overall traffic noise. Therefore, the following statements pertain to this project:

> In accordance with the provisions of 23 CFR 772 (h) (which defines a Type I project), the additional lane design option of the streetcar alternative of the proposed LOPT project would not add a through lane of traffic, would not construct a new roadway on a new alignment, would not result in an acoustically significant shift in the roadway alignment, nor bring about a new traffic noise impact. Therefore, an ODOT level traffic noise study is not required for this portion of the LOPT project (ODOT Noise Manual, March 2009, page 2).

Operation – Sellwood Bridge

Operation of the streetcar through the Sellwood Bridge area would result in moderate noise impacts at one model receptor representing 2 residences in the area (see Table 6-2 for model results and Figure 2-2, page 31 for receptor locations). The Willamette Shore Line phasing option would have the same potential impact.

[5] Oregon Department of Transportation, *Noise Manual*, March 2009

Table 6-2. Sellwood Bridge Streetcar Alternative Noise Impact Modeling Summary

Rec#	# Res [1]	SLM [2]	Exist L_{dn}	Project Ldn	Impact?
SB-1	4	SB-S1	59 [3]	58	--
SB-2	2	SB-S1	59 [3]	59	Moderate

1 Some receptor locations may represent more than one residence.
2 The SLM locations are identified in Table 5-1 and displayed in Figure 5-2.
3 The existing L_{dn} was estimated based on the difference between the hourly sound level measured to represent this location and a nearby, simultaneous long-term measured sound level. Appendix A contains both the short-term and long-term measurement data and indicates which short-term measurement locations were assigned to which representative long-term location.

Source: ENVIRON International Corporation, 2010

Operation – Dunthorpe/Riverdale – Willamette Shore Line (WSL) Design Option

Noise modeling indicates operation of the streetcar along the WSL alignment through the Dunthorpe/Riverdale area would result in moderate to severe noise impacts at numerous model receptors locations representing most homes very near and with direct line of sight exposure to the rail line. (See

Table 6-3. Dunthorpe Riverdale Noise Impact Modeling Summary

for the model results and Figure 2-3 and Figure 2-4 for receptor locations.) This assessment was based on measurements of existing sound levels in the area – in the absence of a working rail line – which has not been the historical reality of this area due to the long use of the existing rail corridor for freight and commuter rail. Nonetheless, the relatively quiet existing acoustic environment and the addition of a new streetcar noise source combine to result in estimates of moderate to severe noise impacts under FTA criteria.

Modeling indicates that of the approximately 65 homes near the streetcar line in the area, about 14 would be subject to moderate noise impacts under FTA policy. One receptor location (DR-17a) representing one residence would be subject to severe noise impacts due to streetcar operation in this area. The potentially affected homes are almost all immediately adjacent to the existing rail line, and those closest and potentially most affected are within 20 feet and sometimes less of the rail right-of-way. In some instances the walls of buildings abut the location of an edge of ROW fence line, and some buildings even appear to encroach into the ROW. This proximity and the relative quiet of the existing environment (in the absence of regular train operations along the existing line) couple to result in projected moderate to potentially severe noise impacts due to the increased noise that would be generated by the streetcar. In the case of the potential severe impact, without effective mitigation, operation of the streetcar would result in a substantial increase in overall day-night sound levels over existing levels.

Table 6-3. Dunthorpe Riverdale Noise Impact Modeling Summary

Rec#	# Res [1]	SLM [2]	Exist Ldn	LOPT Streetcar Alternative Design Options			
				WSL		Riverwood	
				Project Ldn	Impact?	Project Ldn	Impact?
DR-1	4	DR-S1	58 [3]	58	Moderate	58	Moderate
DR-2	4	DR-S2	57	56	--	56	--
DR-3	1	DR-S2	57	48	--	49	--
DR-4	1	DR-S3	59 [3]	44	--	43	--
DR-5	1	DR-S4	65 [3]	55	--	Displaced	--
DR-6	1	DR-S5	58	56		36	--
DR-7	2	DR-S5	58	55		39	--
DR-8	1	DR-S5	58	59	Moderate	41	--
DR-9	1	DR-S6	61 [3]	45	--	53	--
DR-10	2	DR-S8	57	42	--	48	--
DR-11	2	DR-S7	56 [3]	61	Moderate	39	--
DR-12	1	DR-S10	56 [3]	47	--	46	--
DR-13	2	DR-S9	56	54		52	--
DR-14	3	DR-S12	52	53		53	--
DR-15	1	DR-S12	52	60	Moderate	60	Moderate
DR-16a	1	DR-S12	52	52	--	52	--
DR-16b	1	DR-S12	52	59	Moderate	59	Moderate
DR-17a	1	DR-S12	52	64	Severe	64	Severe
DR-17b	1	DR-S12	52	55	Moderate	55	Moderate
DR-17c	1	DR-S12	52	56	Moderate	56	Moderate
DR-18	2	DR-S12	52	60	Moderate	60	Moderate
DR-19	1	DR-S12	52	54	--	54	--
DR-20	1	DR-S12	52	44.8	--	44.8	--
DR-21	1	DR-S16	52	53	--	53	--
DR-22	1	DR-S17	54 [3]	54	--	54	--
DR-23	2	DR-S16	52	50	--	50	--
DR-24	1	DR-S18	55	50	--	50	--
DR-25	1	DR-S18	55	59	Moderate	59	Moderate
DR-26	3	DR-S19	56 [3]	51	--	51	--
DR-27	2	DR-S18	55	52	--	52	--
DR-28	5	DR-S21	51	51	--	51	--
DR-29	2	DR-S20	56 [3]	49	--	49	--
DR-30	2	DR-S20	56 [3]	48	--	48	--
DR-31	3	DR-S21	51	50	--	50	--
DR-32	4	DR-S21	51	49	--	49	--
DR-33	2	LO-S2	58	53	--	53	--

1 Some receptor locations may represent more than one residence.
2 The SLM locations are identified in Table 5-1 and displayed **in** Figure 5-3 **and** Figure 5-4. The measured sound levels at some SLM locations were affected by extraneous construction noise and would have resulted in an overestimation of the existing sound levels. Because this may have resulted in an underestimation of potential noise impacts, unadulterated (and lower) measured sound levels from the next most-representative SLM location were used for these locations.
3 The existing Ldn was estimated based on the difference between the hourly sound level measured to represent this location and a nearby, simultaneous long-term measured sound level. Appendix A contains both the short-term and long-term measurement data and indicates which short-term measurement locations were assigned to which representative long-term location.

Source: ENVIRON International Corporation, 2010

Operation – Dunthorpe/Riverdale – Riverwood Design Option

As shown in

Table 6-3. Dunthorpe Riverdale Noise Impact Modeling Summary

, operation of the streetcar along this design option alignment would result in noise impacts similar to those expected with the WSL design option in this same area. A few moderate noise impacts would be avoided in the area with the shifted location of the rail line, but all other moderate and severe impacts would remain the same. Modeling indicates a total of about 11 residences would be moderately impacted under FTA criteria by facility operational noise, and the same receptor location (DR-17a) representing one residence would be subject to a severe noise impact from streetcar operation.

Operation – Lake Oswego – UPRR Design Option

As indicated in Table 6-4, operation of the streetcar through the Lake Oswego area is projected to result in no moderate or severe noise impacts.

The streetcar alternative in Lake Oswego includes operation of a park-and-ride facility and access road to the park-and-ride. Because both the parking structure and the access roadway would be outside the 225 foot screening distance from the center of park-and-ride lots that FTA applies to assess the potential for noise impacts, no noise impacts would be expected from the operation of these facilities.

Operation – Lake Oswego – Foothills Design Option

Operation of the streetcar along this design option alignment would result in similar results to operation of the UPRR design option, and no noise impacts are projected. Similarly, as discussed above for the UPRR design option, no impacts would be expected from operation of the new park-and-ride facility and access road.

Table 6-4. Lake Oswego Noise Impact Modeling Summary

				LOPT Streetcar Alternative Design Options			
				Foothills		UPRR ROW	
Rec#	# Res [1]	SLM [2]	Exist L_{dn}	Project L_{dn}	Impact?	Project L_{dn}	Impact?
LO-1	2	LO-S1	56 [3]	51	--	51	--
LO-2	3	LO-S2	58	56	--	56	--
LO-3	2	LO-S3	65 [3]	51	--	51	--
LO-4	2	LO-S3	65 [3]	48	--	48	--
LO-5	2	LO-S4	61	51	--	51	--
LO-6	2	LO-S5	59	45	--	45	--
LO-7	Commercial	LO-S7	56 [3]	47	--	46	--
LO-8	Commercial	LO-S7	56 [3]	44	--	38	--
LO-9	4	LO-S6	67	37	--	34	--
LO-10	2	LO-S7	67 [3]	32	--	25	--
LO-11	2	LO-S7	67 [3]	38	--	34	--
LO-12	2	LO-S7	67 [3]	46	--	40	--
LO-13	2	LO-S8	61	54	--	50	--
LO-14	14	LO-S9	63 [3]	30	--	27	--
LO-15	2	LO-S9	63 [3]	29	--	24	--
LO-16	2	LO-S9	63 [3]	29	--	24	--

1 Some receptor locations may represent more than one residence.
2 The SLM locations are identified in **Table 5-1** and displayed in **Figure 5-4** and **Figure 5-5**.
3 The existing L_{dn} was estimated based on the difference between the hourly sound level measured to represent this location and a nearby, simultaneous long-term measured sound level. Appendix A contains both the short-term and long-term measurement data and indicates which short-term measurement locations were assigned to which representative long-term location.

Source: ENVIRON International Corporation, 2010

6.1.2 Indirect and Cumulative Effects

The noise impact assessment for this project focused on the environmental noise implications of the project alternatives and the design options of the streetcar alternative. The elements considered represent the primary noise sources associated with the proposed project. There also is likely to be slow to moderate new development and some redevelopment in the Portland Central City, in the South Water front area, in the Johns Landing/North Macadam area, and in the Lake Oswego Town Center. In the Lake Oswego Town Center area, the foothills area is likely to expand, and include a new street plan and some new development. This eventual growth and changes would lead to new but minor noise sources in the project study area.

6.2 Vibration

6.2.1 Direct Effects

6.2.1.1 No Build Alternative

With the no build alternative, none of the proposed project's "action" alternatives would be pursued. Thus, there would be no direct vibration impacts from this alternative.

The existing excursion trolley service on the Willamette Shore Line tracks that operates seasonally and by special arrangement by the OERHS could continue with this alternative. This would maintain existing occasional vibration from this operation.

6.2.1.2 Enhanced Bus Alternative

With the Enhanced Bus Alternative, the existing transit system would be augmented with additional bus service and additional numbers of buses along the existing route. But because the numbers of new buses would be small relative to numbers of existing vehicles using established roadways, any changes in the vibration effects from affected roadways due to these additional vehicles would be minimal. This conclusion is discussed more completely below.

Construction

Components of this alternative requiring new construction include a 300-space park-and-ride garage at the Oswego Village Shopping Center and a new roadway north to Foothills Road. Construction of these components would require demolition of existing structures, site preparation and excavation, and construction of the new facilities. These activities would result in short-term increases in construction vibration near active construction areas. All of the buildings nearest this area are relatively new and so were constructed in accord with modern building standards. So even though some of these buildings would within 50 feet of the construction zone for the parking structure, the potential for vibration-related impacts is low unless pile driving would be required or if it would be necessary to use large equipment in close proximity to off-site buildings. Should these activities be required, care will need to be taken to reduce the potential for GBV-related impacts. Any such impacts would be temporary.

Operation

New operational vibration sources (i.e., added buses) associated with this alternative would be similar to existing heavy-duty vehicles using area roadways, and the few additional vehicles would have minimal potential for increasing vibration from these sources. For this reason, the Enhanced Bus Alternative would not be expected to result in any operational vibration impacts due to increased traffic along this roadway.

Similarly, operation of the new roadway from the park-and-ride facility to Foothills Road and the park-and-ride itself would be similar to existing vehicles using this area and would not be expected to result in vibration impacts off site.

The existing excursion trolley service using the Willamette Shore Line tracks that operates seasonally and by special arrangement by the OERHS could continue with this alternative. This would maintain existing occasional vibration from this operation.

6.2.1.3 Streetcar Alternative

Construction

Construction of the streetcar alternative would be as described above for noise (for example, see discussion on page 59 and subsequent pages). Construction equipment can result in ground-borne vibration (GBV), and the potential levels of vibration were assessed as described in section 2.2.2.

As shown in Table 6-5**,** depending on the types of construction equipment and the category of buildings, potential "minimum safe" recommended distances for construction-related vibration damage range from 140 feet for the worst-case impact pile driving affecting a Category IV building (i.e., a building extremely susceptible to vibration damage) to less than 5 feet for small bulldozers affecting Category I buildings (i.e., the least vibration sensitive).

Table 6-5. "Minimum Safe" Recommended Distances from Construction Equipment to Reduce Potential for GBV Damage (ft)

	Building Categories and (FTA Guideline Damage Thresholds)			
Equipment	**Category I (0.5 PPV)**	**Category II (0.3 PPV)**	**Category III (0.2 PPV)**	**Category IV (0.12 PPV)**
Pile Driver (Impact) Upper Range	55	75	100	140
PD (sonic) upper	35	50	60	85
Pile Driver (Impact) Typical Range	30	45	55	80
Vibratory Roller	15	20	30	40
Clam shovel drop	15	20	30	40
Pile Driver (Sonic) Typical Range	15	20	25	35
Hoe Ram	10	15	15	25
Large bulldozer	10	15	15	25
Caisson drilling	10	15	15	25
Loaded trucks	10	15	15	20
Jackhammer	5	10	10	15
Hydromill in rock	5	5	5	10
Hydromill in soil	5	5	5	5
Small bulldozer	5	5	5	5

Distance estimates have been rounded **up** to the nearest multiple of 5 feet.
Refer to Table 4-7 (page 49) for additional information on building categories.
Source: ENVIRON International Corporation, 2010 based on FTA data and calculation techniques.

The review of potential vibration impacts associated with construction of the project was based on consideration of examples of large equipment listed in Table 6-5 that would be expected to be used and vibration level estimates assuming such equipment could be working in the portion of the defined construction work area nearest each potential receptor. This worst-case assumption provides a conservative estimate of possible vibration effects from construction activities and primarily serves to indicate those areas where particular care would need to be taken during project construction to avoid such impacts. This assessment indicated that use of any large construction equipment (e.g., a large vibratory roller used for compacting earth, or a large bull dozer used for moving and/or compacting earth) would have the potential to create sufficient GBV to damage nearby buildings.

The potential GBV impacts of construction of the streetcar alternative and its various design options are summarized in Table 6-6. For clarity, each subarea and design option (if any) is included in the section header. The potential construction vibration impacts are based on the number of potentially affected buildings (all assumed to be Category II for this assessment) and discussed by subarea and design option below the table.

Table 6-6. Streetcar Alternative Construction Vibration Impact Summary

Study Subarea and Design Options[1]	Example Construction Equipment and Number of Potentially Affected Buildings: Vibratory Roller	Large Bulldozer	Loaded Trucks
South Waterfront	9	8	7
Johns Landing Design Options			
Willamette Shore Line	12	11	11
Macadam In Street	21	20	17
Macadam Additional Lane	21	20	19
Sellwood Bridge Design Options[2]	12	11	10
Dunthorpe/Riverdale Design Options			
Willamette Shore Line	30	27	25
Riverwood In-Street	33	31	28
Lake Oswego			
UPRR Right-of-Way	15	11	11
Foothills	13	10	10

Note: The number of potentially affected buildings is based on the assumption that all are Category II buildings (see Table 4-7).
[1] Vibration impacts were not assessed in the Downtown segment 1 because no major new facilities would be constructed in this area.
Source: ENVIRON International Corporation, 2010
[2] Construction vibration impacts in this table reflect the Sellwood Bridge new interchange alignment. Vibration impacts for the Willamette Shore Line Phasing Option in Segment 4 – Sellwood Bridge would be the same as it would be with the Sellwood Bridge new interchange alignment.

Construction – SW Waterfront. Construction through the SW Waterfront area along the WSL design option alignment has the potential to occur near a number of buildings close to the existing rail line right of way, and thus could result in construction-related vibration impacts unless care is taken to limit or avoid use of vibration-producing equipment near these buildings. Vibration level calculations indicated that there are about 7 to 9 buildings along the WSL alignment in this area that could be subjected to potential construction-related GBV impacts depending on the types of equipment used.

Construction – Johns Landing – WSL Option. Construction through the Johns Landing area along the WSL design option alignment has the potential to occur near a number of buildings close to the existing rail line ROW, and thus could result in construction-related vibration impacts unless care is taken to limit or avoid use of vibration-producing equipment near these buildings. Vibration level calculations indicated that there are about 11 to 12 buildings along the WSL alignment in this area that could be subjected to potential construction-related GBV impacts.

Construction – Johns Landing – Macadam In-Street Option. Construction through the Johns Landing area along the Macadam In-Street design option alignment has the potential to involve construction equipment use near a number of buildings close to the proposed alignment. Thus, construction activities could result in vibration impacts unless care is taken to limit or avoid use of vibration-producing equipment near these buildings. Vibration level calculations indicated that there are about 17 to 21 buildings along the Macadam In-Street alignment in this area that could be subjected to potential construction-related GBV impacts.

Construction – Johns Landing – Macadam Additional Lane Option. Potential construction-related vibration impacts with the Macadam Additional Lane design option would be about the same as described for the Macadam In-Street design option. This design option would require working slightly closer to existing buildings along SW Macadam Avenue, slightly increasing the potential for construction-related GBV impacts.

Construction – Sellwood Bridge. Construction of the streetcar alternative in the Sellwood Bridge area has the potential to affect about 10 to 12 buildings due to use of typical heavy construction equipment. Care would need to be taken within areas close to existing buildings. Refer to Table 6-5 for information regarding critical distances associated with large construction equipment.

Streetcar in this area would involve repair of the Staff Jennings Trestle just north of the Sellwood Bridge. This construction activity would involve some form of pile driving to provide structural support to the ends of the trestle. The high end of the range of methods of impact pile driving (i.e., using the largest "hammers") creates the most GBV of any construction activity, while "sonic" pile driving and even more typical impact driving produce less GBV (as suggested by respective "minimum" distances in Table 6-5, page 72). Thus, the potential GBV from pile driving deserves special attention during the consideration of possible effects on nearby structures. An evaluation based on the closest portion of the expected pile-driving area near the ends of the trestle indicated the Staff Jennings Boating Center building at 8240 SW Macadam Avenue could be near enough to the pile driving (i.e., within 75 feet) for the trestle repair to be of concern if either high impact or sonic pile driving is used. But GBV from typical impact driving would likely be less than the damage threshold level for Category II buildings.

Construction – Dunthorpe/Riverdale – WSL Option. Construction through the Dunthorpe/Riverdale area with the WSL design option has the potential to involve the use of large construction equipment near a number of buildings close to or even abutting the proposed alignment. Such activity could result in construction-related vibration impacts unless care is taken to limit or avoid use of vibration-producing equipment near these buildings. Vibration level calculations indicated that there are about 26 to 31 buildings along the Riverwood In-Street alignment in this area that could be subjected to potential construction-related GBV impacts.

Construction of the WSL design option in this area would additionally involve repair of both the short and the long trestles. This construction activity would involve some form of pile driving to provide structural support to the trestles. An evaluation based on the closest portion of the expected pile-driving area near the ends of the trestle indicated the houses at 10808 and 10900 SW Riverwood Road both could be within 50 feet of the area where pile driving would occur. At this distance, high impact, sonic, or even more typical (i.e., lower vibration) impact pile driving could result in GBV in excess of the threshold level for Category II buildings.

Construction – Dunthorpe/Riverdale – Riverwood In-Street Option. Construction through the Dunthorpe/Riverdale area with the Riverwood In-Street design option also would have the potential to involve the use of large construction equipment near a number of buildings close to the proposed alignment. Construction activity could result in vibration impacts unless care is taken to limit or avoid use of vibration-producing equipment near these buildings. Vibration level calculations indicated that there are about 29 to 34 buildings along the WSL alignment in this area that could be subjected to potential construction-related GBV impacts.

Construction of the Riverwood In-Street design option would require the same construction processes described for the WSL option in this area, but instead of repair of two trestles would instead include construction of a new trestle structure to provide a transition from the existing rail alignment up the grade to the new design option alignment along SW Riverwood Road. This would relocate the pile driving to provide for a new trestle structure for the transitional alignment to SW Riverwood Road. While the amount and duration of construction in this area would be about the same as for the WSL Option, the Riverwood In-Street Option would require more excavation using heavy equipment and haul truck in the vicinity of the intersection with Highway 43 than the WSL Option.

Construction – Lake Oswego – UPRR ROW Option. Construction-related vibration associated with the UPRR design option in Lake Oswego would have the potential to adversely affect from 11 to 15 homes near the streetcar rail alignment.

The replacement of the Briarwood Road overcrossing trestle could require some form of pile driving to create the structure of the ends of the trestle. The house at 26 S Briarwood Road would be within about 60 feet of the potential area of pile driving, and thus could be adversely affected by GBV related to use of high-impact pile driving but would be beyond the critical distance for sonic pile driving.

The replacement of the Tryon Creek trestle in this area could require some form of pile driving to create the structure of the ends of the trestle. The northernmost building in the Self Storage facility would be within 25 feet of the potential area of pile driving, and thus could be adversely affected by GBV related to use of any kind of standard pile driving.

Construction -- Lake Oswego – Foothills Option. Construction-related vibration associated with the Foothills design option in Lake Oswego would have the potential to adversely affect from 10 to 13 homes near the streetcar rail alignment.

Potential effects of pile driving related to replacement of the Briarwood Road overcrossing trestle would be the same as with the UPRR design option.

The replacement of the Tryon Creek trestle in this area could require some form of pile driving to create the structure of the ends of the trestle. The northernmost building in the Self Storage facility would be displaced by the design option and so would no longer be threatened by potential damage stemming from GBV.

Operation

The survey of potentially affected receivers based on FTA screening distance from the streetcar line in all the study areas and all design options revealed a number of buildings within the screening distances for the three use categories. A general assessment of vibration impacts was conducted for these buildings.

The overall operational vibration impact assessment results are summarized in Table 6-7**.** Locations of buildings potentially affected by operational vibration are displayed in Figure 6-2. It is again worth noting that the FTA vibration impact criteria do not use a scale that includes "moderate" and "severe" impacts as are applied to noise. Instead, the criteria are used to determine the presence or absence of vibration-related impacts, and any such identified impacts are intended to be considered for possible mitigation.

Table 6-7. Streetcar Alternative Operational Vibration Impacts By Segment Design Options

Segment/Design Option	Number of Affected Buildings
1 – Downtown Portland [1]	0
2 – South Waterfront	0
3 – Johns Landing	
Willamette Shore Line	3
Macadam In-Street	5
Macadam Additional Lane	5
4 – Sellwood Bridge[2]	4
5 – Dunthorpe/Riverdale	
Willamette Shore Line	19
Riverwood In-Street	16
6 – Lake Oswego	
UPRR ROW	0
Foothills Realignment	0

Note: All data are based on operations during an average weekday in 2035.
1 Vibration impacts were not assessed in the Downtown segment 1 because no new facilities would be constructed in this area.
2 Vibration impacts in this table reflect the Sellwood Bridge new interchange alignment. Vibration impacts for the Willamette Shore Line Phasing Option in Segment 4 – Sellwood Bridge would be the same (4 affected buildings) as it would be with the Sellwood Bridge new interchange alignment.
Source: ENVIRON International Corporation, 2010

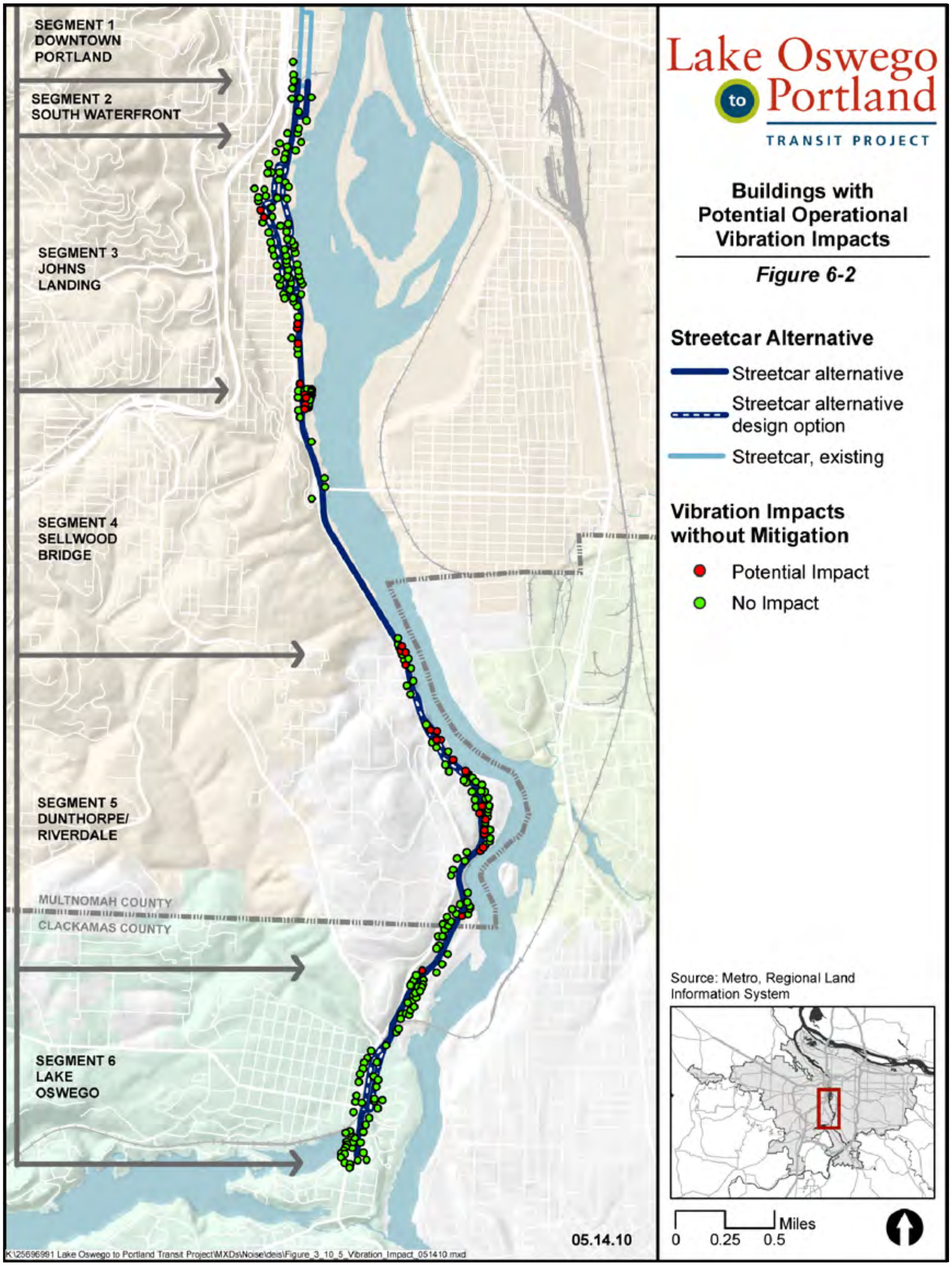

FIGURE 6-2. BUILDINGS WITH POTENTIAL OPERATIONAL VIBRATION IMPACTS

Operation – SW Waterfront and Johns Landing – WSL Option. Operation of the streetcar along the WSL alignment in the SW Waterfront and Johns Landing areas could result in vibration impacts at 3 buildings in this area that are very near the existing rail line and/or are particularly sensitive (see Figure 6-2 for approximate building locations). The buildings include two office buildings (FTA Category 3) approximately 10 feet from the center of the nearest rail line and the Oregon Public Broadcasting (OPB) building (FTA Category 1), approximately 23 feet from the line. Although there are numerous residences and other commercial buildings very near the alignment, particularly in the John's Landing area, the speed through much of the area is slow (i.e., 15 mph), which would prevent vibration impacts. The impacts identified occurred at the south end of the John's Landing area where higher speeds (over 30 mph) are expected.

Operation –Johns Landing – Macadam In-Street Option. The alignment with the Macadam In-Street Option affects the same buildings as the WSL Option and an additional 2 buildings on the west side of Macadam Avenue, for a total of 5 buildings potentially affected by streetcar vibrations. Along Macadam Avenue, the alignment of the southbound streetcar line is near enough to some buildings and the speeds are high enough (i.e., 30 mph) to potentially cause vibration impacts (see Figure 6-2 for approximate building locations).

Operation –Johns Landing – Macadam Additional Lane Option. The Macadam Additional Lane Option has a similar alignment to the Macadam In-Street Option for the southbound rail line and would affect the same buildings along Macadam Avenue on the west side of the street. The northbound rail line with the Macadam Additional Lane Option is further east than the In-Street Option and nearer to buildings located east of Macadam Avenue. However, the northbound rail line remains far enough away from the nearest buildings east of the roadway that it is not expected to cause vibration impacts to these buildings. Therefore, the vibration impacts identified for the Macadam Additional Lane Option are the same as identified with the Macadam In-Street Option (i.e., 5 affected buildings).

Operation – Sellwood Bridge. The streetcar is generally expected to operate at 35 to 40 mph in the Sellwood section of the project, except at locations very near a station. However, there are not many residences or buildings near the streetcar line in this section. Most of the nearest buildings are at the north end of the section, in the vicinity of Miles Street. Operation of the streetcar through the Sellwood Bridge area would result in vibration impacts at 4 residences in the north end of the Sellwood section. This is true for the Willamette Shore Line phasing options as well. See Figure 6-2 for approximate impact locations.

Operation – Dunthorpe/Riverdale – WSL Option. There are numerous residences in the Dunthorpe/Riverdale section that are very near the streetcar alignment. Speeds throughout the area vary markedly, particularly in the vicinity of stations. Lower speeds (25 to 30 mph) in some of the areas serve to reduce the potential for vibration impacts at several residences. Overall, vibration level calculations indicate operation of the streetcar along the WSL alignment through the Dunthorpe/ Riverdale area would result in vibration impacts at 19 residential buildings. See Figure 6-2 for approximate impact locations.

One residence, located directly over the Elk Rock tunnel (and streetcar alignment), is approximately 190 feet above the grade of the track and is beyond the screening distance for potential vibration impacts.

Operation – Dunthorpe/Riverdale – Riverwood In-Street Option. The track alignment with the Riverwood Option is similar to the WSL Option except it moves the alignment slightly further from several residences, resulting in 16 residential buildings potentially affected by vibration.

Operation – Lake Oswego – UPRR ROW Option. Operation of the streetcar through the Lake Oswego area is projected to result in no vibration impacts. This is primarily due to lower operating speeds (i.e., 30 mph or less) throughout much of this section. So, although there are a few residential buildings within 50 feet of the streetcar alignment, none are expected to be exposed to streetcar-related vibration impacts.

Operation – Lake Oswego – Foothills Option. As with the UPRR ROW Option, the speeds with the Foothills Option are generally 30 mph or less, and no vibration impacts are identified in this section.

6.2.2 Indirect and Cumulative Effects

The vibration impact assessment for this project focused on the implications of the project alternatives and the design options of the streetcar alternative. The elements considered represent the primary vibration sources associated with the proposed project. There also is likely to be slow to moderate new development and some redevelopment in the Portland Central City, in the South Water front area, in the Johns Landing/North Macadam area, and in the Lake Oswego Town Center. In the Lake Oswego Town Center area, the foothills area is likely to expand, and include a new street plan and some new development. This eventual growth and changes would lead to temporary vibration sources during construction of such development, but any new operational sources of vibration are likely to be minor

7. POTENTIAL MITIGATION MEASURES

This section discussed potential mitigation measures for construction and operational noise and vibration.

7.1 Environmental Noise

7.1.1 Construction

Noise from construction of any elements of the project alternatives or the various design options would be unlikely to result in significant noise impacts. Such noise may nonetheless be intrusive at nearby locations and especially at homes. For that reason it is worth discussing the relatively simple, common sense means through which such intrusive noise can be minimized.

Some relatively simple and inexpensive practices can reduce the extent to which people are affected by construction noise and ensure that construction noise levels. Examples include using properly sized and maintained mufflers, engine intake silencers, engine enclosures, and turning off idle equipment. Construction contracts could specify that equipment mufflers be in good working order and that engine enclosures be used on equipment when the engine is the dominant source of noise.

Stationary equipment could be placed as far away from sensitive receiving locations as possible. Where this is infeasible, or where noise levels are nonetheless still loud at nearby receivers, temporary, portable noise barriers could be placed around the equipment with the opening directed away from the sensitive receiving property. These measures are especially effective for engines used in pumps, compressors, welding machines, and similar equipment that operate continuously and contribute to high, steady background noise levels. Such measures can typically provide about a 10-dBA reduction in equivalent sound levels from shielded equipment.

Substituting hydraulic or electric models for impact tools such as jack hammers, rock drills and pavement breakers could reduce construction and demolition noise. Electric pumps could be specified if pumps are required.

Although as safety warning devices sounds from back-up alarms are exempt from noise ordinances, these devices emit some of the most annoying sounds from construction and large equipment operations site. One means to reduce potential annoyance from this sort of noise would be to require all equipment to use ambient-sensing alarms that broadcast a warning sound loud enough to be heard over background noise, without having to use a preset, maximum volume. An even better alternative would be to use ambient-sensing alarms that generate broadband warning sounds instead of typical pure tone alarms. Broadband devices have been found to be very effective in reducing annoying noise from construction sites. Requiring operators to lift rather than drag materials wherever feasible can also minimize noise from material handling.

Construction staging areas expected to be in use for more than a few weeks should be located and, to the extent practicable, laid out to situate the most frequent or loud activities as far as possible from sensitive receivers, particularly residences. Likewise, in areas where construction would occur within about 200 feet of existing uses (such as residences and noise-sensitive businesses), effective noise control measures (possibly outlined in a construction noise management plan) should be employed to minimize the potential for noise impacts. In addition to placing noise-producing equipment as far as possible from homes and businesses, such control could include using quiet equipment and temporary noise barriers to shield sensitive uses, and orienting the work areas to minimize noise transmission to sensitive off-site locations. Although the overall construction sound levels will vary with the type of equipment used, common sense placement to maximize distance attenuation should be applied. Additionally, effort could be made to plan the construction schedule to the extent feasible with nearby sensitive receivers to avoid the loudest activities during the most sensitive time periods.

7.1.2 Operation

The analysis of noise from streetcar operation indicated several locations could be moderately impacted and that one could be severely impacted. Thus consideration of mitigation measures is warranted. FTA policy regarding possible mitigation focuses first on locations that would potentially be subjected to severe noise impacts in the absence of mitigation. The possibilities for mitigating moderate noise impacts also need to be considered to assess the magnitude of the impact (i.e., within the range FTA considers "moderate"), the noise control options, and the cost of such mitigation. The decision whether to include noise mitigation in a project is made by FTA in consultation with the project sponsor after public review of the environmental document. If mitigation measures are deemed necessary to satisfy the statutory requirements, such measures will be incorporated into the project.

Mitigation of streetcar operational noise would require less noisy equipment or noise barriers to shield nearby homes from the rail line. The specification for the streetcar equipment noise is already established at a level almost 10-dBA lower than the noise limit that usually applies to large vehicles. So noise barriers are likely to be found to be a better option for providing noise reduction in most locations.

To be effective noise barriers would need to be placed so as to break the line of sight between the streetcar noise source (i.e., the wheels/track) and the locations to be shielded, and the barriers would have to be sufficiently tall and long to increase the sound transmission path from the source to the receiving locations. This requirement substantially reduces the effectiveness of barriers in locations where either views or access may be an issue. Barriers would need to be solid from the ground to full height, remain solid in perpetuity, and provide sufficient mass to prevent "through-barrier" transmission. Thus masonry walls are usually the most cost-effective means for reducing noise from such sources.

A preliminary review indicates the severe noise impact to one residence in the Dunthorpe/ Riverdale Segment projected to result from the Streetcar Alternative could be mitigated with a noise wall situated between the residence and the streetcar tracks. Based on preliminary calculations, one noise wall 3 feet tall and 200 feet long east of the tracks could reduce the severe noise impact expected without mitigation to a moderate impact (based on FTA impact criteria). The approximate noise barrier location based on a preliminary modeling review is illustrated in Figure 7-1.

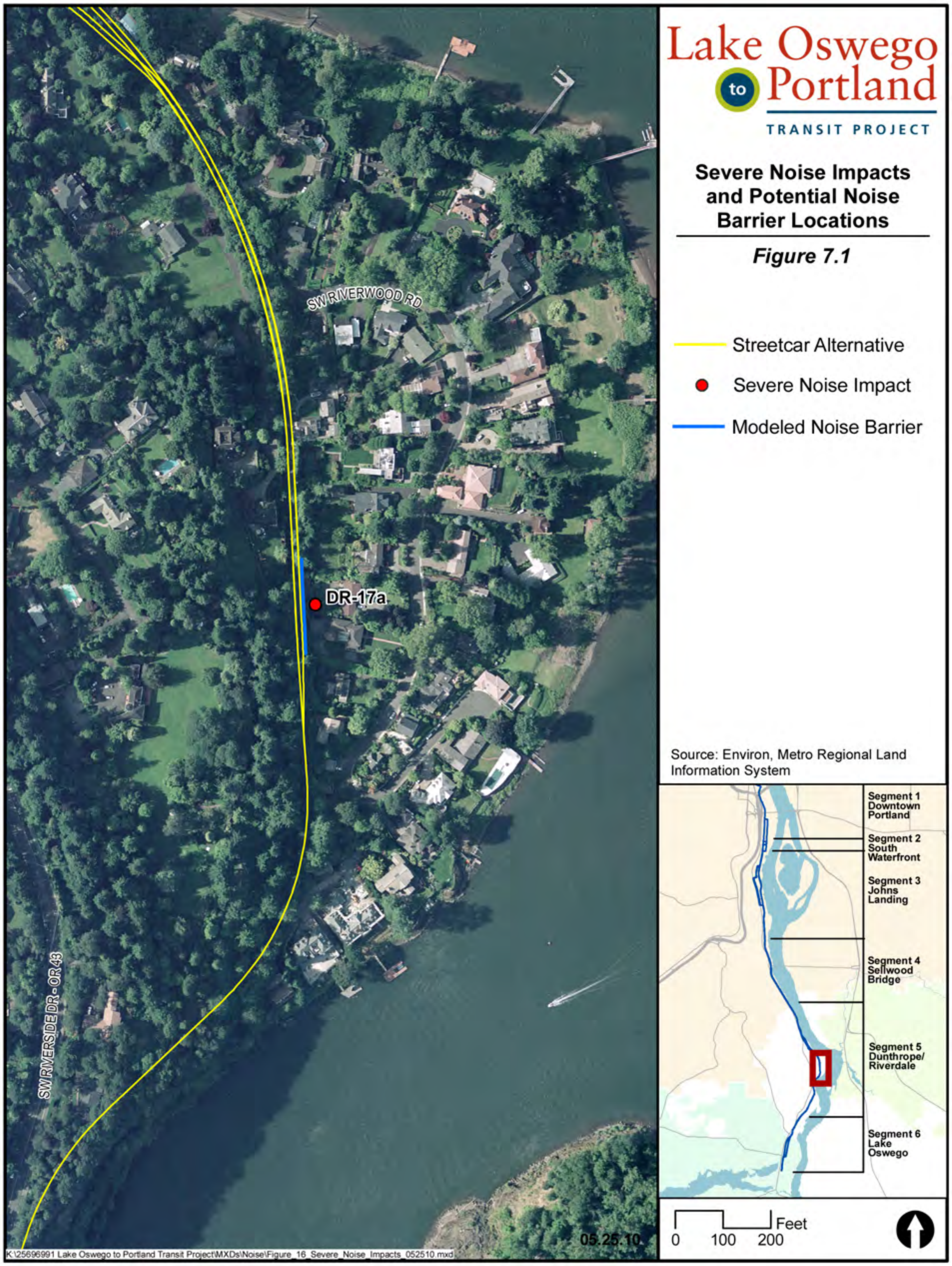

FIGURE 7-1. SEVERE NOISE IMPACTS AND POTENTIAL NOISE BARRIER LOCATIONS

The moderate noise impacts projected to occur in three of the six project segments also could potentially be mitigated using noise walls between buildings and the streetcar tracks. The effects of the potential mitigation measures on moderate impacts have not been calculated, and noise walls may not be feasible and/or cost-effective in all locations (e.g., where gaps in the walls would be required to retain vehicular and/or pedestrian access and in any locations where there is insufficient room to accommodate such barriers).

If the streetcar alternative is selected as the locally preferred alternative, the size, design, and location of noise walls and/or other mitigation measures that would be constructed with the project, would be determined during the project's Preliminary Engineering Phase and before publication of the project's Final EIS. Those decisions would be based on several factors, such as FTA criteria for mitigation measures, costs compared to effectiveness, and any secondary impacts associated with the potential mitigation measures (e.g., visual or access impacts that could result from noise walls).

7.2 Vibration

7.2.1 Construction

The potential for impacts from GBV related to construction equipment and activities could be most effectively controlled by avoiding use of problematic equipment within defined critical distances for such equipment (Table 6-5, page 72).

Where avoidance is impractical or impossible, using equipment that generates less GBV instead of more standard equipment also would reduce the potential for impacts. If neither option is feasible, potentially affected buildings should be examined for pre-construction conditions and possibly monitored during nearby construction activities.

7.2.2 Operation

The only mitigation necessary to avoid vibration impacts associated with operation of the streetcar alternative would be in the form of ballast mats under the rail line. With the use of ballast mats or similarly effective vibration-reducing technology in locations where the rail would be very near one or more potentially affected buildings, all the potential operational vibration impacts could be avoided. Thus, no additional mitigation measures were considered. The preliminarily identified locations at which ballast mats or some equally effective vibration-reducing technologies would be employed are identified in Figure 7-2 through Figure 7-5.

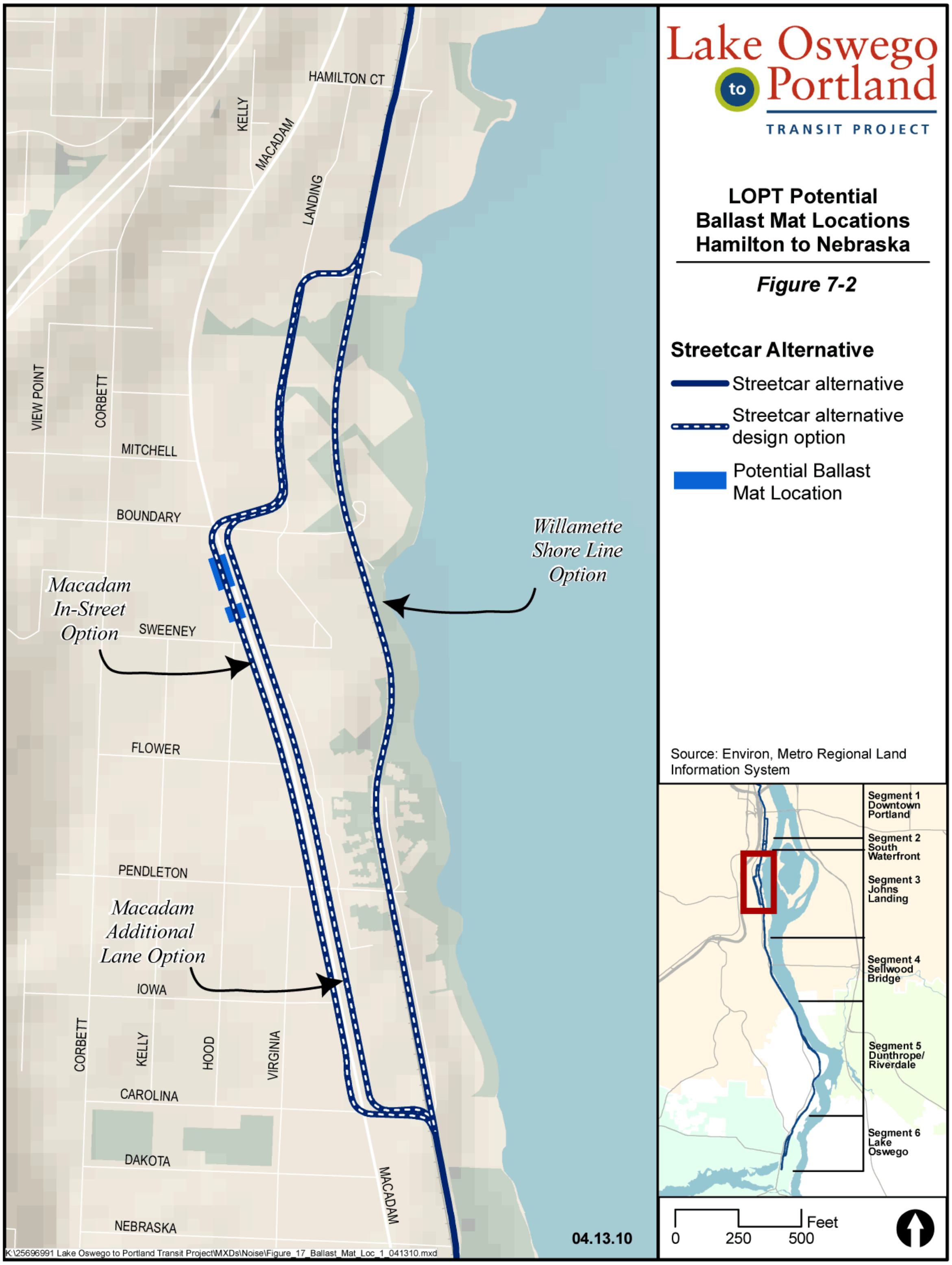

FIGURE 7-2. LOPT POTENTIAL BALLAST MAT LOCATIONS – HAMILTON TO NEBRASKA

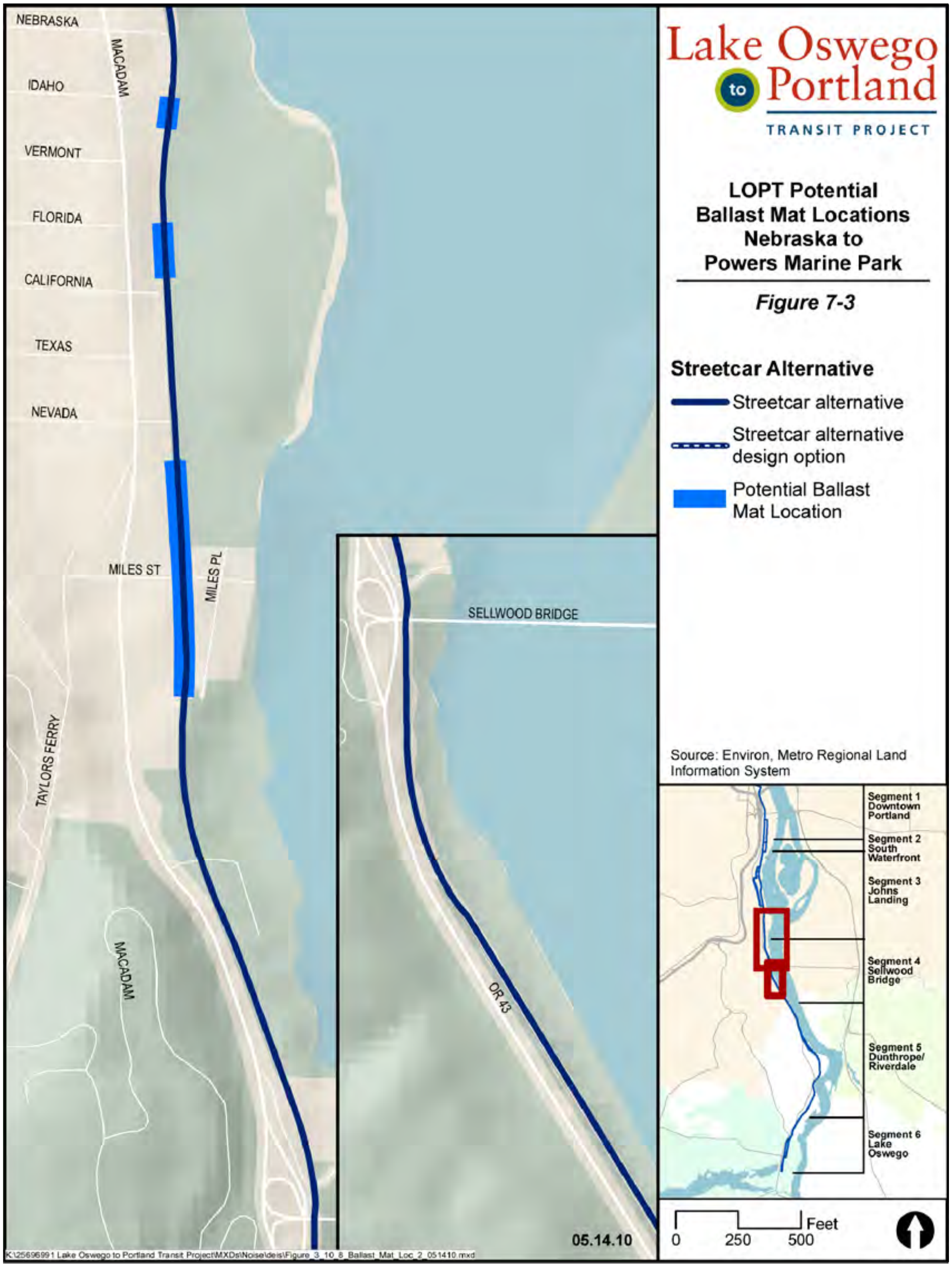

FIGURE 7-3. LOPT POTENTIAL BALLAST MAT LOCATIONS – NEBRASKA TO POWERS MARINE PARK

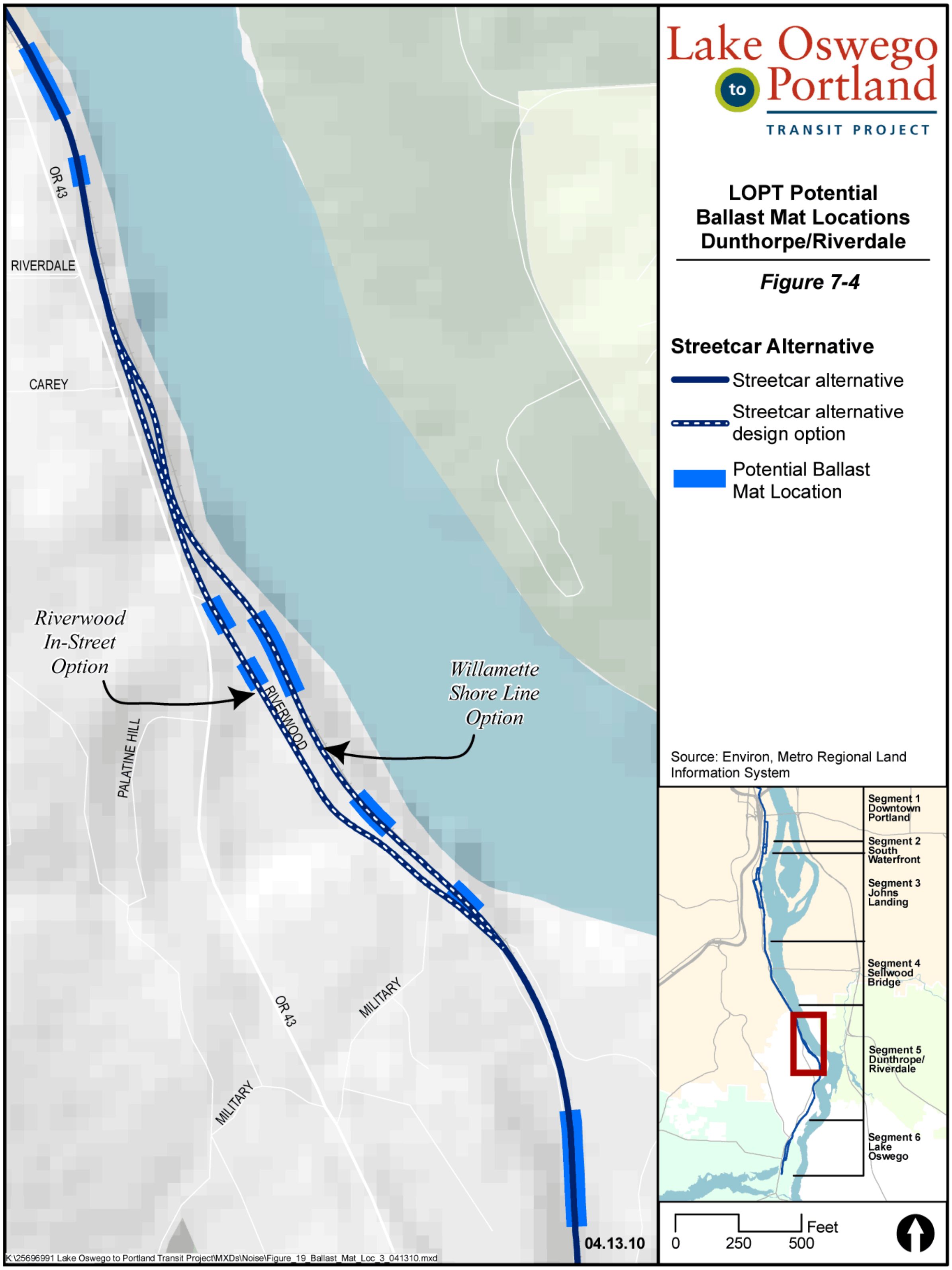

FIGURE 7-4. LOPT POTENTIAL BALLAST MAT LOCATIONS – DUNTHORPE/RIVERDALE

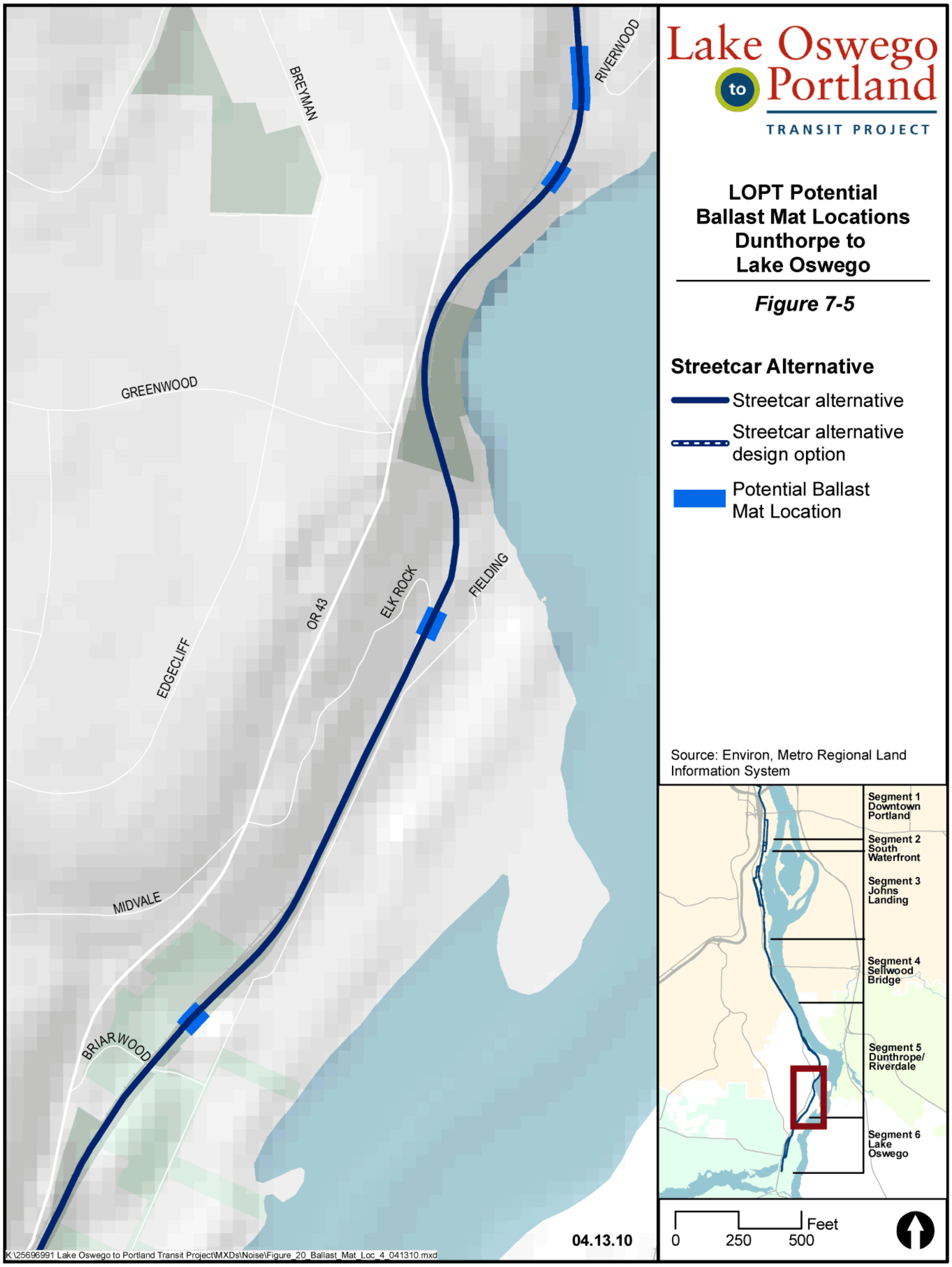

FIGURE 7-5. LOPT POTENTIAL BALLAST MAT LOCATIONS – DUNTHORPE TO LAKE OSWEGO

8. REFERENCES CITED

Federal Transit Administration (FTA).

2006. *Transit Noise and Vibration Impact Assessment*. FTA-VA-90-1003-06. May 2006

2007. *Noise Impact Assessment Spreadsheet*. Copyright 2007 HMMH Inc. Version 7/3/2007.

2007. Email correspondence from Dave Leighow, Director of Planning & Program Development, FTA – Region 10, to Steve Kennedy, Sound Transit (Puget Sound Regional Transit Authority). October 31, 2007.

LTK Engineering Services. 1998. Request for Proposals for Low Floor Streetcars for Central City Streetcar – Phase 1, Portland, Oregon. Book 3, Vehicle Technical Specification. Issued by Portland Streetcar, Inc. November 16, 1998.

Oregon Department of Transportation. *Noise Manual*. March 2009.

Utah Transit Authority (UTA). *South Davis Transit Corridor Project Draft Environmental Study Report.* February 2010.

9. LIST OF PREPARERS

ENVIRON International Corporation
19020 33rd Avenue W, Suite 310
Lynnwood, WA 98036
(425) 412-1800

Richard Steffel
Principal Consultant
M.S. Environmental Studies, University of Montana (Air Quality/Energy Conservation), 1981
B.A. Anthropology, Georgia State University (Ecological Anthropology), 1975

Kristen L. Wallace
Senior Manager
M.S. Aerospace Engineering, University of Cincinnati, 1992
B.A. Mathematics and History, College of Idaho, 1988

Kurt Richman
Associate
B.S. Environmental Science, Oregon State University, 2006

Kris Hansen
Senior Science Advisor
Hazardous Waste Site Operations, 40-hour Course, OSHA 29 CFR 1910.120

Appendix A: Long-Term Sound Level Measurement Data

SW-S1: 0455 Hamilton Court (Avalon Hotel)								
Date	Time	L_{eq}	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}
23-Sep-09	11:00:00	60.4	76.6	57.2	64.7	61.6	59.8	58.8
23-Sep-09	12:00:00	62.2	72.7	58.7	65.3	63	62.1	61
23-Sep-09	13:00:00	61.1	76.3	57.4	66.1	62.5	60.6	59.2
23-Sep-09	14:00:00	61.1	81.9	58	65.9	62.3	60.5	59.2
23-Sep-09	15:00:00	61.1	77.1	57.9	66.9	62.1	60.5	59.3
23-Sep-09	16:00:00	61	75.8	58.3	65.7	62.1	60.6	59.4
23-Sep-09	17:00:00	63.2	76.9	58.6	68.7	64.8	62.5	60.4
23-Sep-09	18:00:00	63.3	70.2	60.2	65.9	64.5	63.2	62.1
23-Sep-09	19:00:00	62.5	70.6	59.7	65.5	63.7	62.4	61.2
23-Sep-09	20:00:00	62.8	69.3	60	65.5	63.9	62.6	61.5
23-Sep-09	21:00:00	62.7	71.5	59.4	65.8	63.9	62.5	61.2
23-Sep-09	22:00:00	60.8	74	57.2	63.9	62.1	60.5	59.1
23-Sep-09	23:00:00	59.7	65	56.2	62.4	60.9	59.6	58.3
24-Sep-09	0:00:00	58.6	63.6	55	61	59.8	58.5	57.1
24-Sep-09	1:00:00	58.3	67.9	55.1	60.7	59.5	58.3	57
24-Sep-09	2:00:00	58.3	73.4	54.2	61.9	59.5	57.9	56.2
24-Sep-09	3:00:00	59.6	87.2	54.6	66.9	60	58	56.1
24-Sep-09	4:00:00	59.7	71.2	55.2	63.4	60.9	59.3	57.8
24-Sep-09	5:00:00	61.4	69.6	56.7	64.5	62.9	61.3	59.4
24-Sep-09	6:00:00	63.4	75.5	59.1	67.8	64.7	63.1	61.5
24-Sep-09	7:00:00	65	75.9	60.5	73.5	65.7	63.8	62.4
24-Sep-09	8:00:00	62.7	74.8	58.6	68	63.9	62.2	60.7
24-Sep-09	9:00:00	61.6	87.7	58.2	68.6	62.2	60.6	59.3
24-Sep-09	10:00:00	61.7	81.2	58.1	68.4	63.2	60.7	59.3
24-Sep-09	11:00:00	63.5	82	59.9	66.6	64.7	63.1	62
24-Sep-09	12:00:00	63.4	74.4	60.4	66.7	64.6	63.1	62.1
24-Sep-09	13:00:00	63.3	77.5	59.7	68.7	64.6	62.8	61.4
Ldn: 67.1								

JL-S1: 4990 Heron Pointe SW Landing Drive (Heron Pointe Condominiums)								
Date	Time	L_{eq}	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}
2-Nov-09	16:00:00	55.5	72.1	51.5	58	56.8	55.4	53.9
2-Nov-09	17:00:00	56	66.9	53.3	60.3	56.9	55.6	54.5
2-Nov-09	18:00:00	56.1	67	52.9	59	57.5	55.9	54.6
2-Nov-09	19:00:00	55.6	73.2	52	60.1	56.6	55	53.8
2-Nov-09	20:00:00	53.3	67.8	50.2	59.9	54	52.6	51.5
2-Nov-09	21:00:00	52.6	56.7	48.7	54.9	54	52.6	50.5
2-Nov-09	22:00:00	52.5	68.9	48.6	59.7	53.5	51.7	50.3
2-Nov-09	23:00:00	49.1	68.8	44.2	56.7	50.1	48.2	46.4
3-Nov-09	0:00:00	49.3	66.6	43.4	55.9	51.9	47.8	46
3-Nov-09	1:00:00	46.8	58.2	41.2	52.7	48.9	45.8	44.1
3-Nov-09	2:00:00	49.1	59.3	42.3	54.3	51.4	48.3	45.7
3-Nov-09	3:00:00	48.2	59.2	42.7	52.8	50.3	47.6	45.2
3-Nov-09	4:00:00	50.8	57.8	44.1	54.9	52.8	50.4	48.1
3-Nov-09	5:00:00	53.8	61.5	46.1	57.9	55.9	53.4	50.6
3-Nov-09	6:00:00	57.5	64.6	52.4	61.5	59.5	57.2	55.1
3-Nov-09	7:00:00	59.6	72.5	55.8	63.9	61.5	59.1	57.3
3-Nov-09	8:00:00	59.9	69.4	55.6	63.8	61.7	59.6	57.8
3-Nov-09	9:00:00	60.1	77.1	55.8	64	61.9	59.7	57.6
3-Nov-09	10:00:00	60.8	74.8	56.2	66	62.1	60.3	58.6
3-Nov-09	11:00:00	59.5	75.5	55.6	63	61	59	57.3
3-Nov-09	12:00:00	59.9	73.5	56.2	63.7	61.3	59.6	58.1
3-Nov-09	13:00:00	59.6	76.6	55.9	62.9	61	59.2	57.7
3-Nov-09	14:00:00	59	65.9	54.8	62.3	60.7	58.8	56.8
3-Nov-09	15:00:00	59.4	71.3	55.7	62.8	60.7	59.1	57.8
Ldn: 60.2								

JL-S2: 4980 Heron Pointe SW Landing Drive (Simultaneous with JL-S1)								
Date	Time	L_{eq}	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}
3-Nov-09	14:00:00	57.4	76.6	52.4	66.5	58.2	55.5	54.1
JL-S3: Landing Condominiums (Simultaneous with JL-S1)								
3-Nov-09	15:00:00	61.6	80.4	55	70.6	63.7	58.8	57.2

JL-S4: Willamette Shores Condominiums								
Date	Time	L_{eq}	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}
2-Nov-09	16:00:00	53.1	60.7	48.9	57.5	54.9	52.6	50.6
2-Nov-09	17:00:00	54.1	64.8	49.5	60.4	55	53.5	52.1
2-Nov-09	18:00:00	53.8	65.5	51	57.7	54.9	53.6	52.4
2-Nov-09	19:00:00	53	71.5	49.8	59.2	53.8	52.4	51.2
2-Nov-09	20:00:00	52.4	69.1	48.4	61.6	52.6	51	49.9
2-Nov-09	21:00:00	50.8	62	47.5	53.7	52	50.7	49.2
2-Nov-09	22:00:00	51.5	71.3	45	61.9	51.9	49.1	47.4
2-Nov-09	23:00:00	48.5	70.9	43.4	57.3	48.5	46.7	45.3
3-Nov-09	0:00:00	48	69.7	43	54.5	48.2	46.2	44.7
3-Nov-09	1:00:00	45.6	61.7	40.4	50.1	46.9	45	43.2
3-Nov-09	2:00:00	45	61.6	39.8	49.3	46.4	44.5	42.7
3-Nov-09	3:00:00	45.5	55.1	41.8	50.5	47	45	43.5
3-Nov-09	4:00:00	46.3	57.3	42.3	50	47.8	45.9	44.2
3-Nov-09	5:00:00	49.1	65.5	44	53.5	50.8	48.7	46.4
3-Nov-09	6:00:00	53	63.4	48.1	55.9	54.5	53.1	50.5
3-Nov-09	7:00:00	54.2	60.9	51.3	57.4	55.3	54	53
3-Nov-09	8:00:00	56.2	75.3	51.9	63	55.9	54.5	53.4
3-Nov-09	9:00:00	55.1	65.3	52.3	58.8	56.4	54.9	53.6
3-Nov-09	10:00:00	56.5	75.2	52.3	67.6	56.5	54.8	53.6
3-Nov-09	11:00:00	55.8	71.9	52.5	59.6	56.8	55.3	54.1
3-Nov-09	12:00:00	56.7	78.1	52.9	63.7	57.2	55.7	54.5
3-Nov-09	13:00:00	55.8	66.8	52.4	59.2	56.9	55.5	54.3
3-Nov-09	14:00:00	55.2	62	52.6	57.6	56.3	55.1	54
3-Nov-09	15:00:00	55.5	68.5	51.9	59.7	56.7	55.1	54
Ldn: 56.8								
JL-S5: 5640 SW Riverside Lane (Simultaneous with JL-S4)								
Date	Time	L_{eq}	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}
3-Nov-09	12:00:00	66.6	81.7	59.2	72.4	69.1	65.7	62.2

JL-S6: 6932 SW Macadam Avenue								
Date	Time	L_{eq}	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}
20-Aug-09	16:00:00	65.3	79.6	51.7	72	68.9	63.6	57.1
SB-S1: 0752 SW Miles Street (Simultaneous with JL-S4)								
20-Aug-09	16:00:00	55.4	74.4	50.1	63.4	57	53.7	52.1

DR-S2: 10400 SW Riverside Road								
Date	Time	L_{eq}	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}
20-Aug-09	12:00:00	56.4	72.8	38.6	62.7	59	55.6	50.1
20-Aug-09	13:00:00	57.2	78	40.8	65.2	59.3	55.4	50.1
20-Aug-09	14:00:00	58.1	72.7	41.9	66.1	61	56.4	51.6
20-Aug-09	15:00:00	57.6	71	44.8	65.3	60.1	56.4	52
20-Aug-09	16:00:00	58.4	71.2	45.3	65	60.9	57.5	53.3
20-Aug-09	17:00:00	59	76.5	45.6	66.8	61.2	57.7	53.5
20-Aug-09	18:00:00	59.4	78.9	45.9	67.8	60.8	57.4	52.6
20-Aug-09	19:00:00	59	84	42.9	67.8	60	55.6	50.1
20-Aug-09	20:00:00	55.7	79.8	43.5	62.7	57.5	53.6	47.9
20-Aug-09	21:00:00	55.7	91.3	41	59.9	56.6	52.4	46.1
20-Aug-09	22:00:00	52.7	75.1	40.3	59.5	55.8	50.4	43.4
20-Aug-09	23:00:00	49.8	79.2	38.8	58	53.7	45.2	41.3
21-Aug-09	0:00:00	47.3	64.1	36.2	56.8	51.2	42.3	38.9
21-Aug-09	1:00:00	45.7	64.8	36.2	56.2	49.6	39.9	38
21-Aug-09	2:00:00	45	66.3	35.2	57	46	38.8	37.2
21-Aug-09	3:00:00	43.1	63.4	32.9	55.2	44.6	37.2	35.3
21-Aug-09	4:00:00	46.7	64.3	32.9	58.1	51	37.7	35.2
21-Aug-09	5:00:00	51.8	72.9	34.4	59.7	55.5	46.5	39.8
21-Aug-09	6:00:00	56.6	73.9	38.3	66.7	58.9	54.1	45.5
21-Aug-09	7:00:00	56.8	87.9	42.3	62	59.1	56	49.9
21-Aug-09	8:00:00	57.4	73.5	41.4	65.8	59.1	56.4	51
21-Aug-09	9:00:00	59	87.7	40.4	63.2	58.7	55.5	49.7
21-Aug-09	10:00:00	56.7	83.7	40.2	63.6	58.6	55	48.5
21-Aug-09	11:00:00	56.4	76.7	42.2	62.8	58.8	55.4	49.1
Ldn: 56.8								
DR-S1: 10110 OR 43 (Simultaneous with DR-S2)								
Date	Time	L_{eq}	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}
21-Aug-09	9:00:00	60.3	86.2	42.5	60.4	60.1	57.1	51.4
SB-S2: Mile Post 3 OR 43 (Simultaneous with DR-S2)								
21-Aug-09	9:00:00	64	86.3	44.8	66.4	66	61.9	54.3

DR-S5: Between 10960 and 10940 Riverwood Road in ROW								
Date	Time	L_{eq}	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}
22-Sep-09	12:00:00	53.4	73.7	46.1	64.7	54	50.5	48.6
22-Sep-09	13:00:00	52.2	70.8	47.1	58.9	54.1	51	49.2
22-Sep-09	14:00:00	53	71.8	46.9	59.7	55	51.9	49.9
22-Sep-09	15:00:00	55.1	76.7	46.5	64.5	58.1	51.4	49.3
22-Sep-09	16:00:00	52.6	65.8	46.7	58.7	54.8	51.6	49.7
22-Sep-09	17:00:00	54.7	78.9	47.6	61.8	55.5	52.1	50.3
22-Sep-09	18:00:00	55.6	84.8	46.7	62.7	55.5	51.5	49.2
22-Sep-09	19:00:00	54.4	81.1	45	64	54.2	49.4	47.2
22-Sep-09	20:00:00	58.2	90.5	44.5	61.2	51.7	48.1	46.4
22-Sep-09	21:00:00	49.9	70.3	44.5	58.6	50.6	48.2	46.5
22-Sep-09	22:00:00	50.1	69.8	43.8	59.7	50.8	47.6	45.7
22-Sep-09	23:00:00	49.5	73.7	42.5	60.5	48	45.7	44.2
23-Sep-09	0:00:00	45.7	61.8	41.7	50.3	47.4	45.2	43.5
23-Sep-09	1:00:00	50.1	75.9	41.7	58.9	48.2	44.9	43.2
23-Sep-09	2:00:00	48	70.4	42.4	57.1	48.6	45.1	43.6
23-Sep-09	3:00:00	50.7	72.8	42.4	59.7	51.2	46.7	44.3
23-Sep-09	4:00:00	50.3	75.6	43.1	59.9	50.9	48.1	45.9
23-Sep-09	5:00:00	50.9	63.7	46.2	55.9	52.6	50.4	48.4
23-Sep-09	6:00:00	54.4	74.7	48.4	62.5	54.9	53.1	51.3
23-Sep-09	7:00:00	55.3	73.1	50.4	62.6	57.1	54	52.5
23-Sep-09	8:00:00	52.5	66.6	47.9	58.5	54.3	51.7	50.1
23-Sep-09	9:00:00	56.2	84.7	45.9	66.7	56.6	51.4	49.1
23-Sep-09	10:00:00	55.3	83.4	44.5	66.9	54.7	49.7	47.1
23-Sep-09	11:00:00	55.7	72.7	42.9	65.2	61	48.6	45.8
23-Sep-09	12:00:00	58.9	76.8	40.8	73.3	60.7	48.1	44.4
23-Sep-09	13:00:00	53.3	71.5	42.5	65.2	55.5	49.4	46.3
23-Sep-09	14:00:00	53.4	80.7	43.2	58.8	55.7	52.6	47
Ldn: 58.0								

DR-S3: 10808 Riverwood Road, Down at Water (Simultaneous with DR-S5)								
Date	Time	L_{eq}	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}
23-Sep-09	9:00:00	52.4	66.3	46.5	57	53.9	52	49.8
DR-S4: 10808 Riverwood Road, Up at House (Simultaneous with DR-S5)								
23-Sep-09	12:00:00	59.4	70.3	40.3	65.1	62.6	58.4	51.4

DR-S8: 11175 SW Riverwood Road								
Date	Time	L_{eq}	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}
3-Nov-09	17:00	54.8	66.1	51.3	60.8	56.3	54.1	53
3-Nov-09	18:00	53.4	67.1	48.9	59.8	54.9	52.7	51.1
3-Nov-09	19:00	52.5	72.7	46.3	58.6	53.3	50.5	48.5
3-Nov-09	20:00	50.3	65.3	46.2	58.9	51.4	49.3	47.8
3-Nov-09	21:00	52.9	75.5	45.8	64	53.5	49.7	48.1
3-Nov-09	22:00	51.1	73.2	43.4	62.6	51	47.7	45.8
3-Nov-09	23:00	49.2	69.4	42.1	60.4	49	46.1	44.3
4-Nov-09	0:00	48.4	73.8	40.5	56.9	48	44.9	43
4-Nov-09	1:00	47.4	70.3	39	55.9	47.8	43.5	41.4
4-Nov-09	2:00	45.8	69.6	38.8	52.8	46.7	42.7	40.8
4-Nov-09	3:00	43.1	55.1	37.8	48.5	44.9	42.4	40.4
4-Nov-09	4:00	47.6	67.2	39.6	55.7	48.9	45.1	42.1
4-Nov-09	5:00	52	70	43.2	61.8	53.1	50.3	47.2
4-Nov-09	6:00	54.1	66.7	47.2	61.5	55.8	53.4	50.7
4-Nov-09	7:00	55.1	70.7	50.9	62	56	54.2	52.8
4-Nov-09	8:00	54.6	69.6	50.5	62.7	55.7	53.3	52
4-Nov-09	9:00	52.5	68.7	48.4	59	53.8	51.7	50.3
4-Nov-09	10:00	54.3	70.3	48.9	60.8	56.9	52.7	50.9
4-Nov-09	11:00	57.2	82.8	50.1	63	58.7	55.5	53.2
4-Nov-09	12:00	54.6	67.4	48.3	61.3	57.3	53	50.7
4-Nov-09	13:00	56.3	84.2	47.8	63.5	55.5	52.6	50.4
4-Nov-09	14:00	52.2	71.2	47.9	59.1	53.7	51.1	49.5
4-Nov-09	15:00	54.3	72.4	48.7	62.6	55.6	52.5	50.9
4-Nov-09	16:00	53	67.8	49.1	58.7	54.3	52.4	51
4-Nov-09	17:00	53.1	65.1	49.6	59.2	54.1	52.6	51.3
Ldn: 57.2								
DR-S10: 2484 Military Road (Simultaneous with DR-S8)								
Date	Time	L_{eq}	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}
4-Nov-09	13:00	60	84	46.9	69.6	63	53.9	49.1
4-Nov-09	14:00	51.1	66.7	46.6	58.8	52.3	49.8	48.4
DR-S6: 11075 SW Riverwood Road (Simultaneous with DR-S8)								
4-Nov-09	13:00	58.2	87.6	47.9	66.1	55.9	53.2	51.1
4-Nov-09	14:00	55.6	73.4	47.5	62.6	58.6	54	50.6

DR-S9: 11322 SW Riverwood Road								
Date	Time	L_{eq}	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}
18-Aug-09	15:00:00	50.4	72.2	42.8	58.4	53.4	48.5	45.3
18-Aug-09	16:00:00	51.5	75.8	43.6	59.1	54.3	49.1	45.8
18-Aug-09	17:00:00	52.2	71.6	42.7	61.4	55.2	49.6	45.7
18-Aug-09	18:00:00	53.7	73.9	42.3	63	56.8	50.7	46.4
18-Aug-09	19:00:00	55.8	74.5	43.9	66	58.5	52.5	47.7
18-Aug-09	20:00:00	56.4	78.9	43.4	67.8	58.8	50.5	45.9
18-Aug-09	21:00:00	50.1	71.8	42	61.8	49.7	45.8	43.6
18-Aug-09	22:00:00	46.4	69	39.3	55.3	47.7	43.6	41.5
18-Aug-09	23:00:00	44.4	58.7	39.4	52.3	45.8	43.2	41.3
19-Aug-09	0:00:00	43.9	54.9	39.4	49.3	45.8	43.3	41.4
19-Aug-09	1:00:00	44	55.9	39.6	48.5	45.8	43.4	41.5
19-Aug-09	2:00:00	48.3	72.1	38.3	60.3	46.6	43.5	40.8
19-Aug-09	3:00:00	43.9	62.9	38.4	47.6	45.6	43.2	40.8
19-Aug-09	4:00:00	49.3	75.6	40.2	56	48.7	44.4	42.1
19-Aug-09	5:00:00	48.6	64.5	42.3	52.4	50.4	48.3	45.8
19-Aug-09	6:00:00	54.7	77	45.6	63.6	55.6	52	49.2
19-Aug-09	7:00:00	54.8	87.3	45.8	61.3	55.6	51	48.5
19-Aug-09	8:00:00	49.3	70	44.2	56.7	50.5	47.7	46.1
19-Aug-09	9:00:00	48.6	73	44.2	54.3	50.1	47.6	46.1
19-Aug-09	10:00:00	50.7	78.3	42.7	61.5	52.3	47.5	45.2
19-Aug-09	11:00:00	51.3	68.3	42.1	58.7	54.7	48.5	44.4
19-Aug-09	12:00:00	52.1	65.8	42.5	60.9	55	49.9	46.1
19-Aug-09	13:00:00	50.4	67.2	39.6	60.4	52.9	47.7	43.5
19-Aug-09	14:00:00	51.7	71.7	39.7	62.5	53.8	47.7	43.8
Ldn: 55.9								

DR-S7: 11150 SW Riverwood Road (Simultaneous with DR-S9)								
Date	Time	L_{eq}	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}
18-Aug-09	15:00:00	50.1	62.7	42.8	56.9	52.5	48.9	46.4

DR-S12: 11623 SW Riverwood Road								
Date	Time	L_{eq}	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}
19-Aug-09	12:00:00	43.3	64.6	36.7	52.8	44.5	40.9	39
19-Aug-09	13:00:00	46.2	70	35.5	56.2	45.4	39.8	37.6
19-Aug-09	14:00:00	42.7	66	36.6	52.1	43.7	39.9	38.4
19-Aug-09	15:00:00	41.6	57.6	36	50.2	43.4	39.8	38.1
19-Aug-09	16:00:00	55	82.1	34.9	56.6	42.7	39.9	38.1
19-Aug-09	17:00:00	45.4	66.9	35.5	55.9	46.6	41.9	39.9
19-Aug-09	18:00:00	48.9	66.5	39.8	61.1	49.7	45.2	42.6
19-Aug-09	19:00:00	47.2	63	42.1	54.8	48.9	46	44.3
19-Aug-09	20:00:00	48.7	74.2	41.6	58.4	47.8	45.4	43.7
19-Aug-09	21:00:00	48.1	67	42.7	57.3	48.6	46.2	44.8
19-Aug-09	22:00:00	45.9	61.7	41	49.1	47.4	45.6	44
19-Aug-09	23:00:00	48.2	75.1	41	56.9	49	44.3	42.8
20-Aug-09	0:00:00	47.5	72.9	38.6	58.3	48.1	42.9	41.1
20-Aug-09	1:00:00	41.7	57.1	37.9	45.2	43	41.3	39.9
20-Aug-09	2:00:00	44.6	68.9	37	54.5	44.6	40.6	39
20-Aug-09	3:00:00	41.2	64.6	33.6	52.1	40.3	38.5	36.9
20-Aug-09	4:00:00	44.3	70.5	33	56.8	40.6	37.3	35.2
20-Aug-09	5:00:00	39.1	56.8	33.4	45.6	41	37.6	35.6
20-Aug-09	6:00:00	42.6	63.9	34.8	54	44.1	39	37.1
20-Aug-09	7:00:00	44.9	63.5	35.3	56.2	46.6	40.5	37.9
20-Aug-09	8:00:00	47	73.5	36.1	53.9	44.6	41.2	39.1
20-Aug-09	9:00:00	44	63.2	36.4	54.7	45.9	40.7	38.7
20-Aug-09	10:00:00	43.9	61.4	35.6	53.4	47.7	39.8	37.7
20-Aug-09	11:00:00	42.9	63	35.2	54	43.2	39.4	37.1
Ldn: 51.7								

DR-S11: 11385 SW Riverwood Road (Simultaneous with DR-S12)								
Date	Time	L_{eq}	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}
19-Aug-09	16:00	52	76.9	34.9	54	43.2	39.3	37.3

DR-S14: 11821 SW Riverwood Road								
Date	Time	L_{eq}	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}
22-Sep-09	11:00:00	53.1	80.4	39.6	62.6	50.8	48	44.5
22-Sep-09	12:00:00	51.1	82.7	40.1	56.7	48.3	44.9	42.9
22-Sep-09	13:00:00	55.1	68.5	40.4	63	57.8	54.5	43.8
22-Sep-09	14:00:00	59.3	74.6	48.8	63.9	61.9	57.6	52.7
22-Sep-09	15:00:00	56.3	64.7	43.4	60.7	58.8	56.3	48
22-Sep-09	16:00:00	53.3	81.5	40.1	60.5	54.2	45.6	42.7
22-Sep-09	17:00:00	49.7	65.5	41.3	58.8	53.8	45.4	43.2
22-Sep-09	18:00:00	49.4	80	39.6	58	46.6	42.9	41.3
22-Sep-09	19:00:00	50	82.5	39	53.8	46.2	42.5	40.6
22-Sep-09	20:00:00	56.3	88.9	39.5	59.1	45.9	42.6	41.1
22-Sep-09	21:00:00	46.1	70	38.1	58.1	44.6	41.7	40.3
22-Sep-09	22:00:00	45.9	72.1	37.4	58.1	44.2	40	39
22-Sep-09	23:00:00	48.5	73	37.6	61.5	42.2	40	39
23-Sep-09	0:00:00	39.9	52.3	36.7	44.3	41.2	39.4	38.1
23-Sep-09	1:00:00	45.2	71.2	35.3	52.1	42	38.4	37.1
23-Sep-09	2:00:00	42.8	69.5	34.6	49.8	42	37.9	36.4
23-Sep-09	3:00:00	44.4	71.9	34.9	53.3	42.3	38.9	37.1
23-Sep-09	4:00:00	48	73.9	35.9	60.5	45	41.3	38.5
23-Sep-09	5:00:00	44.2	60.7	38.7	52.2	44.9	43.2	41.4
23-Sep-09	6:00:00	49.8	74	41.2	61.4	48.2	45	43.3
23-Sep-09	7:00:00	51.2	75	43.6	61.3	51.7	47	45.4
23-Sep-09	8:00:00	47.1	73.3	42	53.5	49.3	45.7	43.6
23-Sep-09	9:00:00	48.2	67.2	41	57.3	52.3	44	42.4
23-Sep-09	10:00:00	51.3	65.4	39.9	57.8	54.5	50.3	42.4
23-Sep-09	11:00:00	48.5	69.8	33.4	55.4	52.4	41.3	36.4
23-Sep-09	12:00:00	42.5	62.6	31.8	54.8	43.6	37.1	34.1
23-Sep-09	13:00:00	46.7	69.1	31.9	56	48.7	42.9	37.1
23-Sep-09	14:00:00	50.2	68.6	31.1	62.3	52	42.9	34.7
23-Sep-09	15:00:00	45.7	65.6	32.5	56.7	48.8	40	35
23-Sep-09	16:00:00	49.5	75.1	32.9	60.2	49.5	43.7	37.7
23-Sep-09	17:00:00	53.2	83.8	36.1	57.8	46.9	41.6	39
23-Sep-09	18:00:00	44.6	67.3	36.7	55.8	45.6	41.1	39
23-Sep-09	19:00:00	43.6	60.6	37.3	54.3	44.6	41.3	39.3
23-Sep-09	20:00:00	43.3	55.6	38.4	49.4	45.3	42.3	40.7
23-Sep-09	21:00:00	53.8	85.8	37	53.6	42.5	40.7	39.2
23-Sep-09	22:00:00	56.5	100.6	34.6	45.8	40.6	38.8	37.7
23-Sep-09	23:00:00	39.7	59.9	34.2	49.4	40.3	37.2	35.6
24-Sep-09	0:00:00	39.5	68.1	32.2	49.3	38.8	35.7	34.1
24-Sep-09	1:00:00	39.9	65.7	30.7	51	39.3	34.7	32.8
24-Sep-09	2:00:00	34.3	39.9	31.3	37	35.7	34.2	33

DR-S14: 11821 SW Riverwood Road								
24-Sep-09	3:00:00	34.8	46.5	31	38.9	36.3	34.4	32.9
24-Sep-09	4:00:00	37.1	47.8	32.7	41.8	38.6	36.7	34.8
24-Sep-09	5:00:00	44.5	69.8	35.5	53.7	41.7	40	38.3
24-Sep-09	6:00:00	41.8	61.8	37.3	49.9	42.8	40.7	39.4
24-Sep-09	7:00:00	45.2	61.6	38.4	53.7	48.7	41.8	40.1
24-Sep-09	8:00:00	53.2	82.7	32.8	61	52	40.9	39.3
24-Sep-09	9:00:00	47.2	65.1	36.6	58.3	51	40.8	39.1
24-Sep-09	10:00:00	49.6	83.4	35.6	54.2	48.6	40.4	38.2
24-Sep-09	11:00:00	51	83.8	35.3	55.8	46.6	39.3	37.4
Ldn: 54.5								

DR-S15: On ROW Just North of Tunnel (Simultaneous with DR-S15)								
Date	Time	L_{eq}	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}
23-Sep-09	15:00:00	45.8	62.9	34.8	55.2	49.4	41.9	38.9

DR-S16: 12700 SW Fielding Road								
Date	Time	L_{eq}	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}
19-Aug-09	11:00:00	46.5	65.1	37.6	56.5	48.8	42.7	40.3
19-Aug-09	12:00:00	47.2	64	35.9	57.5	49.7	44.1	41
19-Aug-09	13:00:00	47.4	65	35.2	57	50	44.4	39.8
19-Aug-09	14:00:00	48.1	70.9	35.6	56.6	49.5	44.2	39.8
19-Aug-09	15:00:00	47.5	68.9	35.1	58	49.7	43.3	39.6
19-Aug-09	16:00:00	53.3	83.1	35.3	57.3	51.4	45.2	40.8
19-Aug-09	17:00:00	50.3	73.1	37.7	61.8	51.2	44.9	41.5
19-Aug-09	18:00:00	52.9	70.3	42.2	63.8	55.2	49.3	45.7
19-Aug-09	19:00:00	51.7	74.4	43.5	61	53.1	48.5	45.7
19-Aug-09	20:00:00	48.6	68	41.4	59	49.8	45.7	43.7
19-Aug-09	21:00:00	46.7	59.2	43.3	52.9	48	45.8	44.6
19-Aug-09	22:00:00	45.4	62.7	42.4	48.3	46.3	45	44
19-Aug-09	23:00:00	45.4	58.9	42.3	50.9	46.6	44.7	43.5
20-Aug-09	0:00:00	45.1	62.2	40.9	52.1	46.4	43.9	42.2
20-Aug-09	1:00:00	42.9	57.6	40.5	45	44.4	42.8	41.3
20-Aug-09	2:00:00	42.6	57.6	40.3	47.6	43.3	41.9	41.1
20-Aug-09	3:00:00	42.5	60.6	40.3	48.8	42.7	41.6	41.1
20-Aug-09	4:00:00	44.8	70.8	39.3	54.9	42.9	40.9	39.8
20-Aug-09	5:00:00	42.2	72.9	39.2	48.8	42.9	40.9	39.9
20-Aug-09	6:00:00	47.3	62.9	38.4	57.4	50.9	43.2	41.1
20-Aug-09	7:00:00	47	66.6	36.5	56.6	50	43.7	40.6
20-Aug-09	8:00:00	45.7	75.1	37	54.9	45.1	42	40.1
20-Aug-09	9:00:00	43.3	64.2	36.4	51.8	45.1	41.5	39.3
20-Aug-09	10:00:00	49.8	65.7	37.4	58.6	53.6	45.8	40.7
Ldn: 52.0								

DR-S17: 12525 Elk Rock Road (Simultaneous with DR-S16)								
Date	Time	L_{eq}	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}
20-Aug-09	9:00 AM	45.1	63.7	36.2	53.3	47.8	43.4	39.3

DR-S18: 12716 SW Elk Rock Road								
Date	Time	L_{eq}	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}
19-Aug-09	11:00:00	50.9	68.4	40.2	58.1	53.2	49.8	46
19-Aug-09	12:00:00	51.3	66.3	39.5	58.8	53.6	50.2	46.2
19-Aug-09	13:00:00	51.5	66.3	40.5	58.6	54	50.1	46.4
19-Aug-09	14:00:00	50.6	66.4	39.5	58.7	52.5	49.7	46.1
19-Aug-09	15:00:00	50.9	68.4	40.8	57.6	52.9	50.1	46.3
19-Aug-09	16:00:00	53.1	76.3	41.6	57.9	53.4	50.6	47.6
19-Aug-09	17:00:00	52.2	66.3	41.8	60.2	54	51.2	48.2
19-Aug-09	18:00:00	52.8	69.3	41.8	62.1	54.3	51.4	47.9
19-Aug-09	19:00:00	51.6	67.5	41.7	59.9	53.6	50.2	46.8
19-Aug-09	20:00:00	50	66.8	39.1	57.5	51.9	48.7	44.4
19-Aug-09	21:00:00	49.3	63.5	42.2	54.5	51.5	48.6	44.9
19-Aug-09	22:00:00	46.9	59.5	40.6	52.1	49.7	45.9	42.7
19-Aug-09	23:00:00	46.1	61.9	39.9	52.5	49	44.5	41.5
20-Aug-09	0:00:00	45.3	60.2	39.1	53.8	48.8	41.9	40.3
20-Aug-09	1:00:00	42	57.8	38.3	49	44.3	40.7	39.5
20-Aug-09	2:00:00	43.1	62.1	37.3	53.2	44.6	40.4	39.1
20-Aug-09	3:00:00	41.7	60.6	35.5	52	42.8	39.1	37.6
20-Aug-09	4:00:00	45	69.8	34.4	57.1	45.7	37.7	35.7
20-Aug-09	5:00:00	48.4	59.1	35	56.4	54.8	43.8	37.8
20-Aug-09	6:00:00	50.5	70.5	36.4	58.6	53	48.5	41.6
20-Aug-09	7:00:00	52	70.1	39.6	59.6	53.9	51	47.4
20-Aug-09	8:00:00	51.2	70.1	40.7	56.7	52.9	50.2	47
20-Aug-09	9:00:00	50.1	61.6	39.1	55.5	52.4	49.6	46
20-Aug-09	10:00:00	60.1	77.2	40.3	69.4	64.8	52.4	47.8
Ldn: 54.5								

DR-S19: 12850 SW Fielding Road (Simultaneous with DR-S18)								
Date	Time	L_{eq}	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}
20-Aug-09	9:00 AM	51.6	68.2	40.5	63.1	53.6	45.5	43.1

DR-S21: 13200 SW Fielding Road								
Date	Time	L_{eq}	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}
18-Aug-09	10:00:00	47	74.3	34.3	58.8	48.2	42.5	39.4
18-Aug-09	11:00:00	45.1	64.5	34.2	54.8	46.7	42	39
18-Aug-09	12:00:00	48.2	74.8	35.2	59.9	48.9	43.5	40.6
18-Aug-09	13:00:00	50.8	68.7	36.7	58.8	55.4	45.4	42.3
18-Aug-09	14:00:00	47.2	67.8	39.5	58.7	47.6	43.8	42
18-Aug-09	15:00:00	46.4	66	38.8	57.9	47	43.7	41.8
18-Aug-09	16:00:00	48.5	70	38.2	59.4	49.4	44.5	42.2
18-Aug-09	17:00:00	47.3	65.3	36.7	58.7	48.4	43.7	41.4
18-Aug-09	18:00:00	46.3	70.4	38.1	56.7	47.5	43.5	41.1
18-Aug-09	19:00:00	46.4	66	38.9	57.1	48	43.7	41.3
18-Aug-09	20:00:00	47.2	70.8	39.1	57.5	47.3	43.9	41.7
18-Aug-09	21:00:00	47	69.9	41.2	57.9	46.6	44.6	43.2
18-Aug-09	22:00:00	44.8	61.5	40.2	52.2	45.5	43.6	42.3
18-Aug-09	23:00:00	44.5	61.6	38.4	52.1	45.8	42.9	41.3
19-Aug-09	0:00:00	42.4	59.8	37.8	46.2	43.1	41.8	40.4
19-Aug-09	1:00:00	41.3	46.5	37.2	43.8	42.6	41.2	39.8
19-Aug-09	2:00:00	45.4	71	34.1	56.9	44.3	40.5	37.7
19-Aug-09	3:00:00	38.3	50.3	34.6	41.8	39.7	38.1	36.6
19-Aug-09	4:00:00	38.8	54.8	34.3	44.7	40.2	37.9	36.3
19-Aug-09	5:00:00	42.7	61	34.8	51.8	44	41.6	37.6
19-Aug-09	6:00:00	46	65.6	39.8	54.7	47.2	44.3	41.9
19-Aug-09	7:00:00	48.4	69.5	39.3	59.5	48.5	45.1	43.3
19-Aug-09	8:00:00	47.3	65.8	38.9	59	48.3	44	41.7
19-Aug-09	9:00:00	48.2	80.4	37.7	56.9	47.8	43.6	41.6
Ldn: 50.7								

DR-S20: 13060 Elk Rock Road (Simultaneous with DR-S21)								
Date	Time	L_{eq}	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}
18-Aug-09	12:00	53	69.1	40.3	58.8	55.3	52.2	47.8

LO-S2: 26 Briarwood Road								
Date	Time	L_{eq}	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}
22-Sep-09	11:00:00	55.6	85.6	43	60.6	58.1	54.2	48
22-Sep-09	12:00:00	56.2	86.2	42.3	61.1	58	53.7	47.9
22-Sep-09	13:00:00	54.8	69.6	42	60.8	57.6	54.1	48.4
22-Sep-09	14:00:00	54.8	71.1	41.6	60.6	57.5	54	48.6
22-Sep-09	15:00:00	54.9	64.8	43.3	59.9	57.8	54.4	48.6
22-Sep-09	16:00:00	55.8	66.4	42.3	60.6	58.3	55.5	50.4
22-Sep-09	17:00:00	56.6	64.7	44.4	60.8	58.9	56.4	52
22-Sep-09	18:00:00	55.9	80	42	60.8	58.2	54.6	48.6
22-Sep-09	19:00:00	54.5	88.1	39.1	59.4	56.6	52.2	46.1
22-Sep-09	20:00:00	55.2	84.2	39.2	58.6	55.7	51	45
22-Sep-09	21:00:00	51.7	61.6	39.7	58.3	55.4	49.7	43.2
22-Sep-09	22:00:00	50.1	63.8	38.4	57.7	54.3	46.9	40.8
22-Sep-09	23:00:00	47.9	69	36.1	57	52	42.6	38.7
23-Sep-09	0:00:00	45.1	62.8	32.8	56.1	49.3	37.2	34.7
23-Sep-09	1:00:00	43.3	64	32.9	54.7	45.8	36.2	34.4
23-Sep-09	2:00:00	39.8	56.5	32.4	51.5	41.6	35.2	33.8
23-Sep-09	3:00:00	43.5	64.7	32.5	54.9	45.4	36.9	34.5
23-Sep-09	4:00:00	49.4	70.9	33.9	59.6	52.3	41.3	36.4
23-Sep-09	5:00:00	50.9	65.5	35.5	59.7	55.2	46.3	39.2
23-Sep-09	6:00:00	55.8	68.4	40.6	62.6	59.1	54.6	46.7
23-Sep-09	7:00:00	57.8	66.6	43.5	62.9	60.6	57.3	51.5
23-Sep-09	8:00:00	57.2	75.6	44.9	62.3	59.9	56.5	51.5
23-Sep-09	9:00:00	56.2	78.6	43.9	61.9	58.8	55	49.6
23-Sep-09	10:00:00	56	84.1	37.7	60.9	57.8	53.6	46.7
Ldn: 57.7								

LO-S1: Adjacent to S Briarwood Road (Simultaneous with LO-S2)								
Date	Time	L_{eq}	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}
22-Sep-09	14:00:00	52.6	73.8	40.9	64.1	53	48.9	45.7

LO-S4: 13711 SW Fielding Road								
Date	Time	L_{eq}	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}
18-Aug-09	10:00:00	59.7	81	42.3	67.4	62.5	58.1	50.6
18-Aug-09	11:00:00	59.2	77.2	39.7	66.7	62.2	57.7	49.9
18-Aug-09	12:00:00	59.1	75.9	41.3	66.4	62	57.8	51.1
18-Aug-09	13:00:00	59.9	79.2	45.2	68.9	62.3	58	52.1
18-Aug-09	14:00:00	59	76.2	46.8	66.9	61.8	57.4	52.2
18-Aug-09	15:00:00	59.1	71.4	46.6	65.9	61.9	58.1	53.2
18-Aug-09	16:00:00	60.3	78.8	49.2	66	62.6	59.4	55.8
18-Aug-09	17:00:00	60.4	75.1	49.1	65.2	62.8	59.9	56.4
18-Aug-09	18:00:00	59.7	73.7	47.9	64.9	62.5	58.9	53.8
18-Aug-09	19:00:00	58.1	71.5	47.5	64.1	61.1	56.9	52.2
18-Aug-09	20:00:00	57.8	73.1	49.3	64.2	60.6	56.4	52.3
18-Aug-09	21:00:00	57.1	75.7	47.7	62.7	59.9	55.8	51.5
18-Aug-09	22:00:00	55.2	69.2	46.5	61.9	58.7	53.1	49.4
18-Aug-09	23:00:00	54.6	70	39	63.8	58.1	51.7	43.8
19-Aug-09	0:00:00	49.7	71.1	37.1	59.9	53.8	43	39.4
19-Aug-09	1:00:00	47	70	36.4	57.3	49.4	39.9	38.3
19-Aug-09	2:00:00	49.1	77.4	34.8	62.3	49.5	39.5	37
19-Aug-09	3:00:00	48	72.4	33.4	59.4	49.6	37.6	35.7
19-Aug-09	4:00:00	50	66.1	33.4	60.9	54.3	40.5	35.4
19-Aug-09	5:00:00	54.3	70.1	33.7	63.3	58.5	49.9	38.6
19-Aug-09	6:00:00	58.6	76.2	39.3	65.5	62.2	56.6	48.7
19-Aug-09	7:00:00	60.7	70.4	43.1	65.8	63.5	60.1	55
19-Aug-09	8:00:00	60.2	76.5	44.6	65.8	62.9	59.4	53.8
19-Aug-09	9:00:00	59.5	76	43.1	67.3	62.3	58.1	52
Ldn: 61.4								

LO-S3: 13581 SW Fielding Road (Simultaneous with LO-S4)								
Date	Time	L_{eq}	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}
18-Aug-09	12:00	55.4	76.8	38.7	61.9	57.9	54.5	49.1

LO-S5: Vacant Lot across road from 13885 SW Stampher								
Date	Time	L_{eq}	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}
3-Nov-09	18:00	52.4	68.9	45.2	56.7	54	51.8	49.3
3-Nov-09	19:00	50.2	65.3	43.8	56	52.2	49.3	46.6
3-Nov-09	20:00	51	72.8	42.8	57.9	51.7	48.7	46
3-Nov-09	21:00	50	66.6	44	56.2	51.9	49	46.4
3-Nov-09	22:00	47.5	67.9	40.8	53.4	49.8	46.4	43.3
3-Nov-09	23:00	54	80.5	40	65.3	49.1	44.8	42.2
4-Nov-09	0:00	44.1	63.5	39.4	50.5	46.2	42.8	40.9
4-Nov-09	1:00	42.1	58.3	36.6	49.7	44.9	40.2	38.2
4-Nov-09	2:00	40.7	55.6	36.5	48.6	42.4	39.2	37.8
4-Nov-09	3:00	42.7	69.7	36.6	50.6	43.9	38.9	37.5
4-Nov-09	4:00	45.2	68.1	37.8	52.6	47.4	42.5	39.7
4-Nov-09	5:00	59.4	91.7	39.8	68.5	52.5	47.5	42.8
4-Nov-09	6:00	52.8	74.3	45	57.9	55.1	51.9	48.7
4-Nov-09	7:00	56.6	77.4	48.8	67.1	56.8	54.9	52.8
4-Nov-09	8:00	54.8	74.3	49	62.3	56	53.9	51.7
4-Nov-09	9:00	55.7	78	48.2	62.3	57.6	53.9	51.2
4-Nov-09	10:00	55.5	74.6	46.9	63.4	58.5	53	49.8
4-Nov-09	11:00	56.9	83.3	47	65	57.2	53.6	50.8
4-Nov-09	12:00	52.1	76.6	45.4	59.5	53.4	50.9	48.2
4-Nov-09	13:00	53	75.6	44.7	61.6	53.7	50.8	48.3
4-Nov-09	14:00	52.5	72.8	43.9	61.2	53.8	50.8	47.9
4-Nov-09	15:00	52.2	68.2	45.7	57.6	53.8	51.7	49.2
4-Nov-09	16:00	52.9	68.4	46	57.6	54.5	52.5	50.1
4-Nov-09	17:00	53.6	70.4	47.7	59.2	54.8	53	51.1
Ldn: 58.8								

LO-S6: 5062 Foothills Drive								
Date	Time	L_{eq}	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}
3-Nov-09	11:00	59.9	88.2	47.7	69.8	61.4	56.8	54
3-Nov-09	12:00	57.6	83.6	46.7	67.7	58.6	54.9	51.7
3-Nov-09	13:00	77.1	97	48.3	87.7	81	58.1	54
3-Nov-09	14:00	76.5	92.5	49.6	86.7	81	69.3	54.9
3-Nov-09	15:00	57.3	78.8	48.3	65.3	58.9	55.9	53.2
3-Nov-09	16:00	56.1	72.6	48.1	63.8	57.9	55	51.8
3-Nov-09	17:00	57.5	78.7	47.5	68.1	58.2	54.9	51.6
3-Nov-09	18:00	55.3	77.2	46.4	62.6	57	53.9	50.3
3-Nov-09	19:00	52.9	67.4	44.4	59.2	55.4	51.8	48.2
3-Nov-09	20:00	55.5	81.5	43.8	62.6	55.2	51.2	47.5
3-Nov-09	21:00	52.4	72.6	42.7	59.2	54.9	50.8	46.9
3-Nov-09	22:00	51.6	74.7	39.4	60.8	53.2	47	42.6
3-Nov-09	23:00	56.8	84.4	37.2	60.4	51.7	44.2	39.7
4-Nov-09	0:00	45.4	70.9	36.9	54.8	46.9	40.9	38.8
4-Nov-09	1:00	40.9	65.6	35.6	50.4	42.3	38.4	37.2
4-Nov-09	2:00	42.7	63.2	35.2	52.2	45.8	37.9	36.4
4-Nov-09	3:00	41.9	62.2	35.6	51.3	44.1	39	37.1
4-Nov-09	4:00	45.6	65.4	36.1	55.7	47.8	41.6	38.8
4-Nov-09	5:00	56.6	81.9	39	66.8	54.4	47.5	42.7
4-Nov-09	6:00	54.1	67.2	44	60.2	56.8	53.1	48.7
4-Nov-09	7:00	55.9	70.9	46.3	62	58	55.1	51.7
4-Nov-09	8:00	56.6	73.8	47.3	63.9	59.1	55.4	52.1
4-Nov-09	9:00	57.2	77.9	47.1	65.1	58.2	55.1	51.7
4-Nov-09	10:00	57.7	81.6	48.6	66.4	58.6	55.4	52.2
Ldn: 66.9								

LO-S7: 5013 Waterfront Apartments (Simultaneous with LO-S6)								
Date	Time	L_{eq}	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}
4-Nov-09	8:00	56.9	70.7	49.3	62.5	58.9	56.3	53.5
LO-S9: 121 Leonard Street (Simultaneous with LO-S6)								
4-Nov-09	10:00	53.9	81.9	48.7	62.3	55.4	51.6	50.2

LO-S8: 5001 Waterfront Apartments								
Date	Time	L_{eq}	L_{max}	L_{min}	L_1	L_{10}	L_{50}	L_{90}
3-Nov-09	11:00	53	81.8	44.6	62.8	52.2	48.4	46.8
3-Nov-09	12:00	58.7	90	43.7	70.8	56.5	48.3	45.8
3-Nov-09	13:00	51.5	73.2	44.5	59.3	53.1	49.7	47.2
3-Nov-09	14:00	50.6	64.6	45.2	58.5	52.6	49	47.1
3-Nov-09	15:00	50.4	65.8	45.3	58.2	52.7	48.9	47.2
3-Nov-09	16:00	52.1	75.7	45.2	58.8	52.5	49.2	47.4
3-Nov-09	17:00	51.4	72.2	45.1	61.7	51.6	49.5	47.5
3-Nov-09	18:00	50.5	75.7	43.1	57.2	50.6	48	45.4
3-Nov-09	19:00	46.9	67.4	41.8	53.3	48.3	45.7	43.9
3-Nov-09	20:00	46.9	66	41	55.6	48	45.4	43.1
3-Nov-09	21:00	46.2	62	40.5	53.8	47.7	44.9	43.1
3-Nov-09	22:00	42.6	58.2	37.9	48.6	44.2	41.8	40.1
3-Nov-09	23:00	48.7	74.5	37.4	60	44.1	41	39.1
4-Nov-09	0:00	40.5	56.6	36.7	45.8	42.2	39.8	38.2
4-Nov-09	1:00	38.8	62.7	34.9	44.8	41.1	37.5	36.3
4-Nov-09	2:00	38.8	57.8	34.7	46.4	39.8	37.3	36.2
4-Nov-09	3:00	38.7	61.7	34.2	47.1	39.8	37.3	35.9
4-Nov-09	4:00	40.4	60.5	36.3	47.7	41.6	39.5	38
4-Nov-09	5:00	59.4	89	38.3	65.4	47.8	44	40.9
4-Nov-09	6:00	49.2	67.1	42.6	56.6	51.4	47.7	45.3
4-Nov-09	7:00	51.9	70.1	46	58.2	53.4	50.9	49.1
4-Nov-09	8:00	52.7	82.4	45.3	61.8	52.8	49.2	47.2
4-Nov-09	9:00	69.8	94.3	44.8	79.6	76.3	51.8	47.1
4-Nov-09	10:00	66.1	93.5	45	79.2	64.2	50.6	47.2
Ldn: 60.5								