Lake Oswego to Portland Transit Project

Energy Technical Report

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TriMet and Metro

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ADT	Average Daily Traffic
AEO	Annual Energy Outlook
ARRA	American Recovery and Reinvestment Act
BPA	Bonneville Power Administration
Btu	British Thermal Units
CAC	Citizens Advisory Committee
Caltrans	California Department of Transportation
CF	Conversion Factor
DEIS	Draft Environmental Impact Statement
DEQ	Department of Environmental Quality
F	Fahrenheit
FCR	Fuel Consumption Rate
FHWA	Federal Highway Administration
ISTEA	Intermodal Surface Transportation Efficiency Act
kwh	kilowatt-hours
LOS	Level of Service
NEPA	National Environmental Policy Act
NPPC	Northwest Power Planning Council
Metro	Metro Regional Government
mpg	Miles per Gallon
mph	Miles per Hour
MPO	Metropolitan Planning Organization
OAR	Oregon Administrative Rules
ODOE	Oregon Department of Energy
ODOT	Oregon Department of Transportation
OHP	Oregon Highway Plan
OOE	Oregon Office of Energy
OTP	Oregon Transportation Plan
PNUCC	Pacific Northwest Utilities Conference Committee
PL	Public Law
PSI	Portland Streetcar, Inc.
RTO	Regional Travel Options
RTP	Regional Transportation Plan
SDEIS	Supplemental Draft Environmental Impact Statement
SEP	State Energy Program
TriMet	Tri-County Metropolitan Transportation District of Oregon
TDM	Transportation Demand Management
TPR	Transportation Planning Rule
TPS	Traction Power Substation
USC	United States Code
USDOE	United States Department of Energy
v/c	Volume to capacity ratio
Vac	Volts of alternating current
Vdc	Volts of direct current
VMT	Vehicle Miles Traveled
WSCC	Western Systems Coordinating Council

1. INTRODUCTION

This report contains the detailed analysis and documentation that is the basis for Chapter 3, Section 3.12 on energy in the Lake Oswego to Portland Transit Project (LOPT) Draft Environmental Impact Statement (DEIS) published by the Federal Transit Administration in September 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, 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) Bus Rapid Transit 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.

- **Bus Rapid Transit Alternative.** The Bus Rapid Transit 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 refinement study phase. In November 2010, Metro published the *Lake Oswego to Portland Transit Project Refinement Report*, which detailed the study's results and summarized public comment. 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. Table 1-1 provides a summary of the transit capital improvements associated with the three alternatives, and Table 1-2 summarizes the operating characteristics of the 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)

Capital Improvements	No-Build	Enhanced Bus	Streetcar[1]
New Streetcar Alignment Length[2]	N/A	N/A	5.9 to 6.0
One-Way Streetcar 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
Streetcar Stations			
Portland Streetcar System	69	69	79
Proposed Lake Oswego to Portland Project	0	0	10[3]
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 Operations and Maintenance (O&M) Facilities			
Number of Facilities[4]	1	1	2
Maintenance Capacity (number of Streetcars)	36	36	36
Storage Capacity (number of Streetcars)	25	25	33
Line 35 Bus Stops			
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] The transit capital improvements of the Streetcar Alternative summarized in this table would not vary by design option, except when shown as a range and as noted for new streetcar alignment length and one-way track miles. 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] 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. 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.

[3] 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.

[4] 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. 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 Streetcar and Bus Network Operating Characteristics of No-Build, Enhanced Bus, and Streetcar[1] Alternatives (2035)

Operating Characteristics by Vechicle Mode	No-Build	Enhanced Bus	Streetcar
Streetcar Network Operating Characteristics[1]			
Weekday Streetcar Vehicle Miles Traveled			
Systemwide	2,180	2,180	3,200 or 3,230
Difference from No-Build Alternative	N/A	0	1,020 or 1,050
Weekday Streetcar Revenue Hours			
Systemwide	267	267	326 or 332
Difference from No-Build Alternative	N/A	0	59 or 65
Corridor Weekday Streetcar Place Miles[2]	N/A	N/A	89,000 or 91,320
Corridor Streetcar Round-Trip Time[3]	N/A	N/A	37 or 44 minutes
Corridor Streetcar Headways[4]			
Lake Oswego to PSU	N/A	N/A	7.5 / 7.5 minutes
Bus Network Operating Characteristics			
Weekday Bus Miles Traveled			
Systemwide	76,560	77,560	75,520
Difference from No-Build Alternative	N/A	1,000	-1,040
Weekday Bus Revenue Hours			
Systemwide	5,300	5,400	5,210
Difference from No-Build Alternative	N/A	100	-90
Line 35 (bus) Weekday Place Miles[2]	37,000	57,840	0
Line 35 (bus) Headways[4]			
Lake Oswego to Downtown Portland	15 / 15 min.	6 / 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.

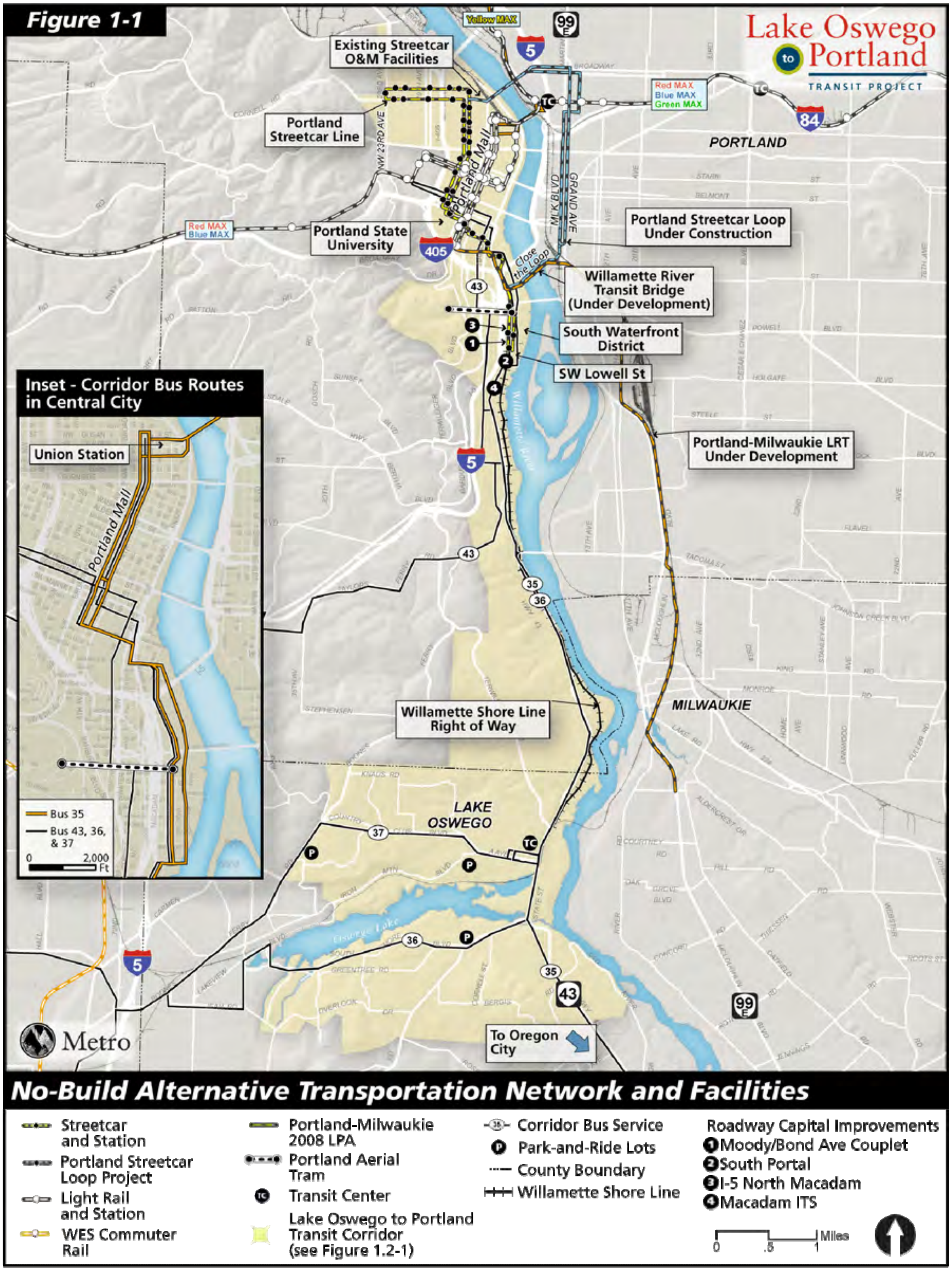

FIGURE 1-1 NO-BUILD ALTERNATIVE TRANSPORTATION NETWORK AND FACILITIES

- **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 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.

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 three of the corridor's segments.

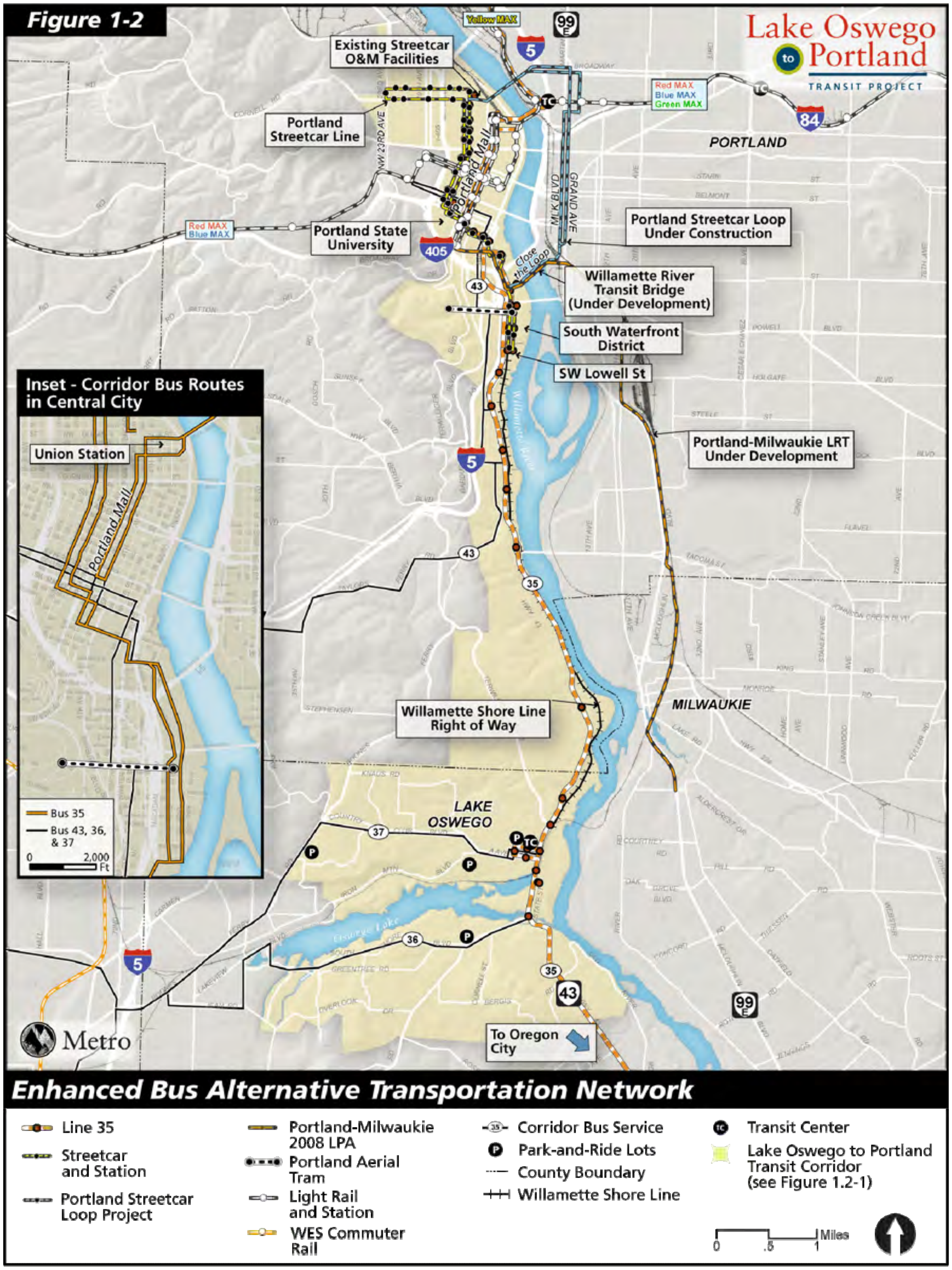

FIGURE 1-2 ENHANCED BUS ALTERNATIVE TRANSPORTATION NETWORK

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 three of the project's six segments. See Figure 1-4 for an illustration of the project segments and the design options under consideration.

- **Roadway Capital Improvements.** There would be no roadway improvements under the Streetcar Alternative in the following corridor segments: 1) Downtown Portland; and 2) South Waterfront. The roadway capital improvements that would occur under the other corridor segments are described below for those segments. 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, 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.

FIGURE 1-3 STREETCAR ALTERNATIVE TRANSPORTATION NETWORK

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

- **Interim 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 on the Willamette Shore Line alignment 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.

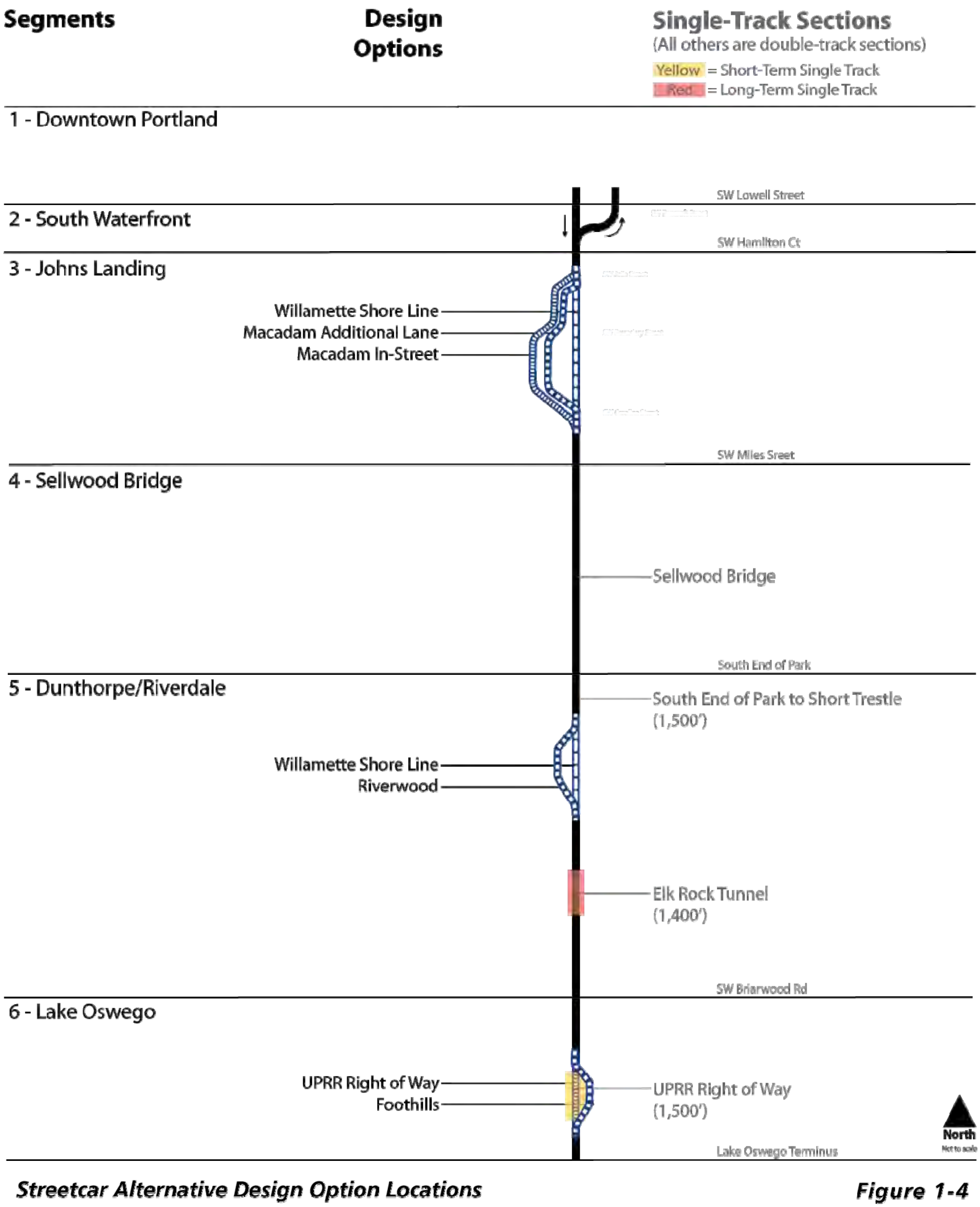

FIGURE 1-4 STREETCAR ALTERNATIVE DESIGN OPTION LOCATIONS

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.

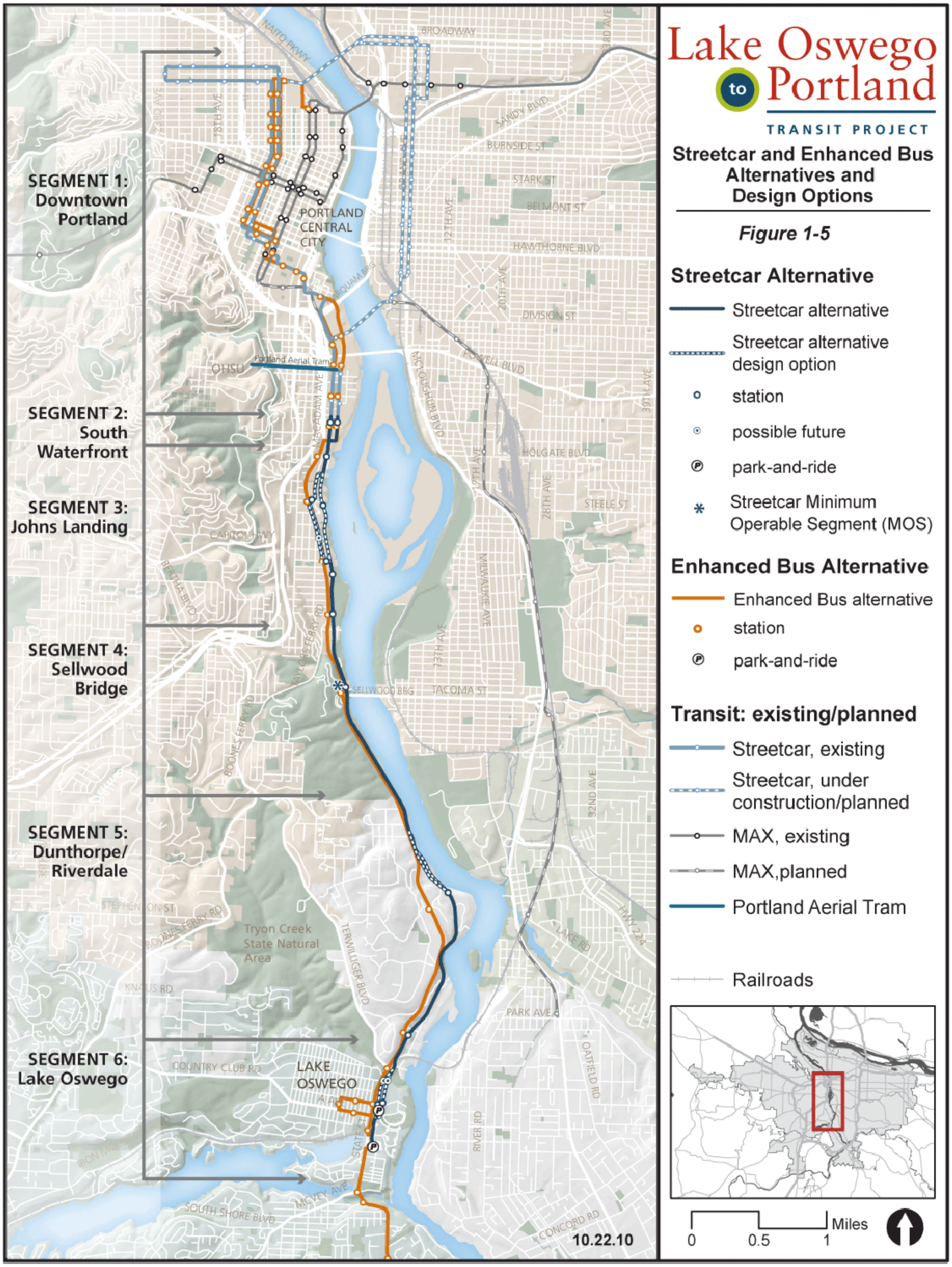

FIGURE 1-5 STREETCAR AND ENHANCED BUS ALTERNATIVES AND DESIGN OPTIONS

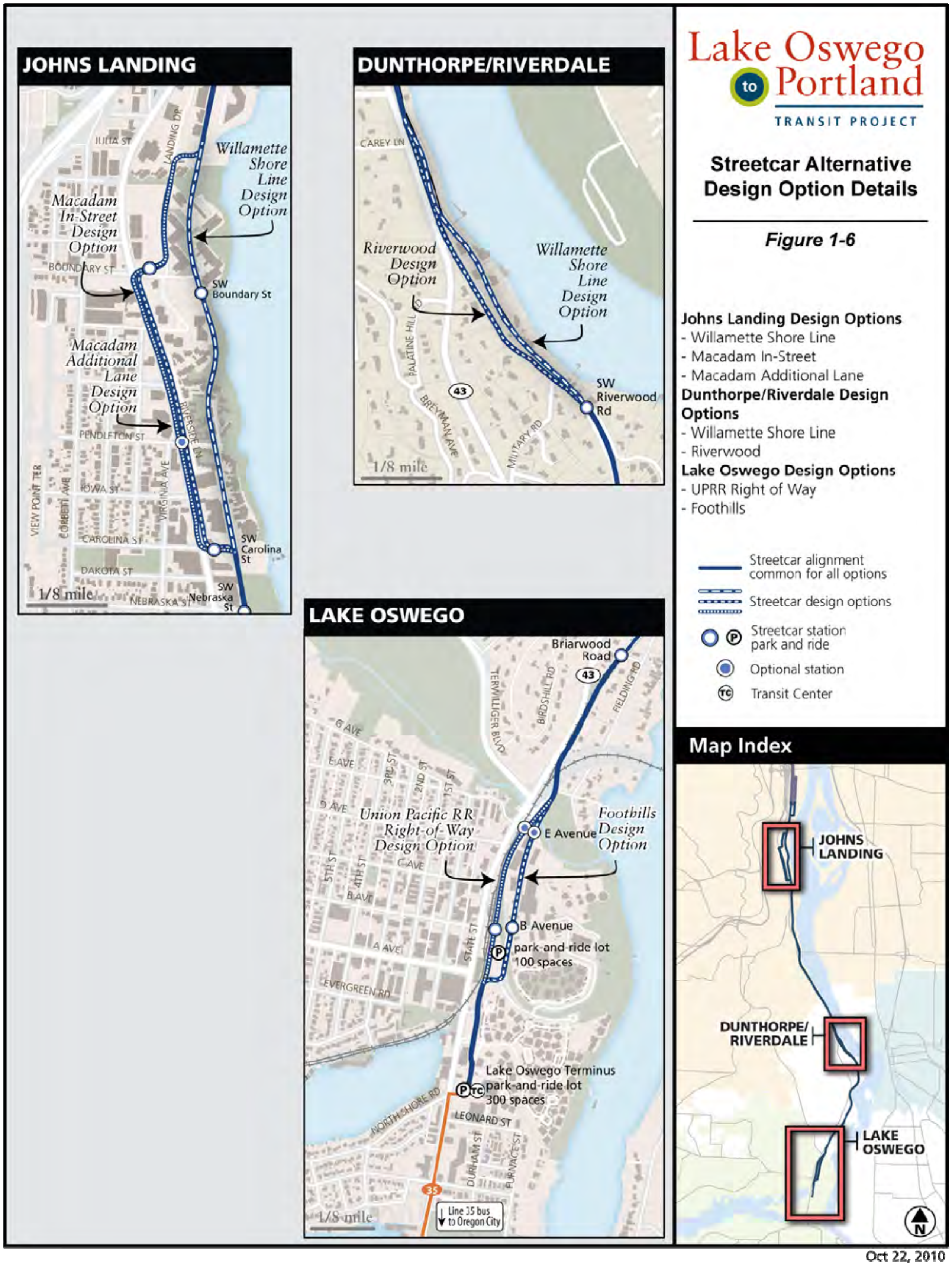

FIGURE 1-6 STREETCAR ALTERNATIVE DESIGN OPTION DETAILS

4. Sellwood Bridge Segment. The Sellwood Bridge Segment extends from Miles Street to the southern end of Powers Marine Park. Generally, the streetcar alignment would be located in the Willamette Shore Line right of way, except for the area between Stephens Creek and approximately 1,200 feet south of the Sellwood Bridge. In this area, the streetcar alignment would be constructed in conjunction with the planned west interchange improvements with the Sellwood Bridge (the streetcar 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. There would be one new streetcar station within this segment (Sellwood Bridge Station).

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 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 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 Introduction

The purpose of this Energy Technical Report is to provide quantitative and comparative analyses of the energy-related impacts in support of the Lake Oswego to Portland Transit Project (LOPT). The objective of performing an energy analysis is to compare, in general, the amount of energy that each alternative would require to construct and operate the facility. Energy use, supply sources, rates of energy use and demand forecasts in the greater Portland/Vancouver area are characterized for petroleum, electricity and natural gas. This report addresses long-term and short-term direct, indirect and cumulative impacts of the project alternatives. This report includes a comprehensive discussion on applicable regulations and related laws, coordination and consultations, technical methodology, the anticipated effects of the study alternatives and potential mitigation measures.

2.2 Applicable Regulations and Related Laws

No specific Federal, State of local energy regulatory standards apply to the project. However, several federal, state and local polices related to energy use have been considered as a means to evaluate energy efficiency and to incorporate energy saving procedures into transportation facilities and programs. Additionally, there are various laws, regulations and guidelines related to energy conservation, many of which specifically address transit as a means for reducing energy and fossil fuel use. The most significant are discussed in the following sections.

2.2.1 Federal

2.2.1.1 National Environmental Policy Act of 1969

The National Environmental Policy Act (NEPA) of 1969 was established to minimize or eliminate damage to the environment caused by actions funded or taken by the Federal government. NEPA establishes policy, sets goals and provides means for carrying out the policy. In order to comply with NEPA, an energy analysis is appropriate for some proposed transportation projects.

2.2.1.2 Federal Highway Administration Technical Advisory T6640.8

The Federal Highway Administration (FHWA) Technical Advisory T6640.8 dated February 24, 1982, states that Environmental Impact Statements "should discuss in general terms the energy requirements and conservation potential of various alternatives under consideration."

49 United States Code, Section 5309 is the federal legislation which governs capital investment grants (such as the LOPT Project) by FTA. It states that the "(d) (3) Evaluation of Project Justification. - In making the determinations under paragraph (2) (B) for a major capital investment grant, the Secretary shall analyze, evaluate, and consider....factors such as.... (v) energy consumption;..."

2.2.1.3 Energy Policy Act of 2005 Public Law 109-58.

The Energy Policy Act of 2005, Pubic Law (PL 109-58) includes transportation-related provisions which; reduce reliance on foreign energy sources (mainly petroleum), increase efficiency in motor vehicles, and increase use of recovered mineral content in construction of Federally funded projects involving procurement of cement or concrete.

2.2.1.4 Intermodal Surface Transportation Efficiency Act of 1991

The Intermodal Surface Transportation Efficiency Act (ISTEA) strengthens the metropolitan planning process by giving more emphasis to intermodal planning, coordination with land use planning and development, and consideration of economic, energy, environmental, and social effects.

2.2.1.5 U.S. Energy Policy Conservation Act

The U.S. Energy Policy Conservation Act focuses on energy conservation, reduced reliance on foreign energy sources (mainly petroleum), use of alternative fuels, and increased efficiency in energy use. The policies in Title 42 of the United States Code (USC) related to energy include:

- Providing for improved energy efficiency in motor vehicles (42 USC 6201);
- Increasing economic efficiency by meeting future needs for energy services at the lowest cost, by considering technologies that improve the efficiency of energy end use, while conserving energy supplies such as oil (42 USC 13401);
- Reducing the air, water, and other environmental effects (including emissions of greenhouse gases) related to energy production, distribution, transportation, and use by developing an environmentally sustainable energy system (42 USC 13401); and
- Reducing the demand for oil in the transportation sector for all motor vehicles (42 USC 13431).

2.2.1.6 Annual Energy Outlook 2009

The Annual Energy Outlook 2009 (AEO2009) presents projections and analysis of U.S. energy supply, demand, and prices through 2030. The projections are based on results from the Energy Information Administration's National Energy Modeling System. The AEO2009 includes the reference case, additional cases examining energy markets, and complete documentation.

2.2.1.7 American Recovery and Reinvestment Act of 2009

American Recovery and Reinvestment Act (ARRA) of 2009 is the $787.2 billion economic stimulus package enacted by President Barack Obama and passed by Congress. More than $71 billion will be invested in green initiatives—from energy conservation and efficiency to mass transit to environmental cleanup. Transit related provisions include:

- Transit: Public transportation saves Americans time and money, saving as much as 4.2 billion gallons of gasoline and reducing carbon emissions by 37 million metric tons each year.
- New Construction: $1 billion for Capital Investment Grants for new commuter rail or other light rail systems to increase public use of mass transit and to speed projects already in construction. The Federal Transit Administration has $2.4 billion in pre-approved projects.
- Upgrades and Repair: $2 billion to modernize existing transit systems, including renovations to stations, security systems, computers, equipment, structures, signals, and communications. Funds will be distributed through the existing formula. The repair backlog is nearly $50 billion.
- Transit Capital Assistance: $6 billion to purchase buses and equipment needed to increase public transportation and improve intermodal and transit facilities. The Department of

- Maintenance and improvements: Transportation estimates a $3.2 billion maintenance backlog and $9.2 billion in needed improvements. The American Public Transportation Association identified 787 ready-to-go transit projects totaling $15.5 billion. Funds will be distributed through the existing formulas.
- Amtrak and Intercity Passenger Rail Construction Grants: $1.1 billion to improve the speed and capacity of intercity passenger rail service. The Department of Transportation's Inspector General estimates the North East Corridor alone has a backlog of over $10 billion.

2.2.1.8 State Energy Programs Goals

The State Energy Program (SEP) (10 CFR 420) goals are to help states:

- Increase energy efficiency to reduce energy costs;
- Reduce reliance on imported energy;
- Improve the reliability of electricity and fuel, and the delivery of energy services; and
- Reduce the impacts of energy production and use on the environment.

The ARRA of 2009 directs States to focus SEP funding on energy efficiency and renewable energy. ARRA calls for expanding existing programs approved by the state, directing funds to energy efficiency retrofits of buildings and supporting renewable energy projects (DE-FOA-0000052). The purpose of the SEP ARRA funds are to:

- Stimulate the creation or increase the retention of jobs;
- Save measurable energy (10 MMBtu per $1,000 invested);
- Increase energy generation from renewable resources; and
- Reduce greenhouse gas emissions.

2.2.2 State of Oregon

2.2.2.1 Oregon State Energy Plan, Biennial Energy Plan

The Oregon Department of Energy (ODOE) created a SEP for 2007-2009, which includes an energy action plan with recommendations and goals to help ensure that Oregon has an adequate supply of affordable and reliable energy. Goals related to transportation energy include the following:

- Reduce single-occupancy vehicle commuting;
- Implement Oregon’s Renewable Energy Action Plan (this plan includes long- and short-term goals for electricity generation and reduce consumption of transportation fuels); and
- Implement strategy for reducing greenhouse gases (this includes emissions from transportation sources).

2.2.2.2 Oregon Statewide Planning Goals

The Oregon Statewide Planning Goal 13 - Energy Conservation, Oregon Administration Rule (OAR 660-015-0000(13)) states that to conserve energy, land and uses developed on the land shall be managed and controlled so as to maximize the conservation of all forms of energy, based upon sound economic principles. Several energy related guidelines include:

- Priority consideration in land use planning should be given to methods of analysis and implementation measures that will assure achievement of maximum efficiency in energy utilization.

- Land use planning should, to the maximum extent possible, combine increasing density gradients along high capacity transportation corridors to achieve greater energy efficiency.
- Plans directed toward energy conservation within the planning area should consider as a major determinant to the existing and potential capacity of the renewable energy sources to yield useful energy output. Renewable energy sources include water, sunshine, wind, geothermal heat and municipal, forest and farm waste. Whenever possible, land conservation and development actions provided for under such plans should utilize renewable energy sources.

2.2.2.3 Transportation Planning Rule (OAR 660-12-035)

Section 35 of the State Transportation Planning Rule (TPR), (OAR 660-12-035) states that the following standards shall be used to evaluate and select transportation system alternatives: "The transportation system shall minimize adverse economic, social, environmental and energy consequences."

2.2.2.4 Oregon Transportation Plan

The Oregon Transportation Plan (OTP) gives direction to the coordination of transportation modes and states the desired characteristics of a transportation system. The OTP includes guidelines which operate in conjunction with the TPR. Goal 4 of the OTP, Sustainability, sets a policy framework that applies to all types of travel and transportation investments. The policies provide guidance on environmental quality, energy supply and creating communities that support the integration of land use and transportation including the key fundamentals of building street networks, connecting modes and utilizing land in efficient ways that reduce travel.

Policy 4.1 includes "environmental responsibility," as a characteristic for a transportation system. Policy 4.1 of the OTP states: To provide a transportation system that is environmentally responsible and encourages conservation and protection of natural resources.

2.2.2.5 Oregon Highway Plan

The Oregon Highway Plan (OHP) defines policies and investment strategies for Oregon's state highway system for the next 20 years and further refines the goals and policies of the OTP. Several of these relate to energy use and are similar to those found in the OTP. Travel demand management (TDM) measures have the goals of decreasing energy consumption, congestion, and vehicle miles traveled (VMT).

2.2.3 Local Jurisdictions

2.2.3.1 Metro

2.2.3.1.2 Regional Travel Options 2008-2013 Strategic Plan

The Regional Travel Options (RTO) Program carries out regional strategies to increase use of alternative travel options, reduce pollution and improve mobility. Regional travel options include all of the alternatives to driving alone – carpooling, vanpooling, riding transit, bicycling, walking and telecommuting. The program maximizes investments in the transportation system and relieves traffic congestion by managing travel demand, particularly during peak commute hours. Regional strategies offer low-cost solutions that:

- Address employer and commuter transportation needs;

- Save consumers money;
- Reduce vehicle emissions that contribute to air pollution and global warming;
- Encourage active travel modes that enhance public health and increase physical activity, and
- Increase public awareness of the personal and community benefits of travel options.

2.2.3.2 City of Portland

2.2.3.2.1 City of Portland Comprehensive Land Use Plan

The City of Portland Comprehensive Land Use Plan, Policy 7.6 relates to improving the energy efficiency for transportation. Among its objectives are to promote construction of a regional light rail transit system, reduce gas and diesel use by conventional buses, autos, and trucks by increasing fuel efficiency.

2.2.3.2 City of Portland: Energy Efficient Transportation Policy

The City of Portland shall provide opportunities for non-auto transportation including alternative fuels for vehicles, buses, light rail, bikeways, and walkways. The City shall also promote the reduction of gasoline and diesel use by conventional buses, autos and trucks by increasing fuel efficiency and promoting the use of alternative fuels. The action plans include the following energy related objectives:

Two-Year Action Plan:

- Support efforts to ensure the energy efficiency of the transit system, including good street maintenance and traffic light synchronization;
- Promote the construction of a regional light rail transit system; and
- Promote walking and bicycle commuting by identifying routes, encouraging spot hazard improvements on city streets, the provision of bicycle lockers at park-and-ride lots, and investigating bicycle commuter service centers and covered walkways/sidewalks.

Long-Term Plan:

- Match carpool riders and provide transit information to City employees. Promote public/private partnerships to increase employee rideshare, transit use, and flex-time;
- Investigate offering reduced cost bus passes to City employees and encourage similar action by the State, Multnomah County, and private employers;
- Support changes in Federal tax laws to increase deductions for employer paid transit; and
- Promote efficient transportation options for commuting between Northwest urban centers.

2.2.3.3 City of Lake Oswego

One of the City of Lake Oswego goals states that the “City shall conserve energy”. The policies related to transportation energy conservation include the following:

- Reduce the City’s overall energy consumption;
- Promote the use of renewable energy sources;
- Reduce energy consumption related to transportation by promoting a reduction in vehicle miles traveled through the use of alternative transportation;

- Require energy-efficient land use and circulation patterns through mixed use development, promoting high density developments near transit and major employment and shopping opportunities, and design of developments to encourage alternative transportation; and
- Promote energy efficiency through site planning for all types of development including residential subdivisions, multi-family, commercial and industrial projects.

Recommended Action Measures related to transportation energy conservation include the following:

- Establish an acceptable payback period for energy saving measures in municipally-owned buildings and facilities;
- Consider the energy consequences in decisions regarding the construction, delivery and siting of urban services;
- Coordinate with federal, state and regional agencies to promote energy conservation;
- Encourage concentrated developments of mixed uses in order to reduce auto trip length, encourage alternative transportation and to encourage the utilization of centralized heating systems;
- Work with TriMet to provide commuter information and education, more efficient transportation, better schedules, mini-buses, coordinate locations for shelters and planning for park and ride stations; and
- Encourage transportation fuel efficiency through traffic light synchronization.

2.2.3.4 Multnomah County

Multnomah County's *Policy 22: Energy Conservation* is to promote the conservation of energy and to use energy resources in a more efficient manner. In addition, it is the policy of Multnomah County to reduce dependency on non-renewable energy resources and to support greater utilization of renewable energy resources through:

- The development of energy-efficient land uses and practices;
- Increased density and intensity of development in urban areas, especially in proximity to transit corridors and employment, commercial and recreational centers; and
- An energy-efficient transportation system linked with increased mass transit, pedestrian and bicycle facilities.

2.2.3.5 Clackamas County

The goal of Clackamas County’s *Energy Sources and Conservation* is to: “Conserve energy and promote energy efficiency through source development, recycling, land use and circulation patterning, site planning, building design and public education.” The following items encourage energy-efficient land use and circulation patterns:

- Locate employment centers, shopping services, parks, recreational and cultural facilities, and medical/dental services near residential developments to minimize transportation, fully utilize urban services, and encourage neighborhood self-sufficiency.
- Provide for high density developments near transit and major employment/ shopping centers.
- Develop an overall circulation system for the County which promotes transportation alternatives (transit, carpooling, bicycling, and foot travel) and improves traffic flow on major arterials (synchronized signals, vacating nonessential cross streets, access controls).
- Design subdivisions, Planned Unit Developments, and multifamily, commercial and industrial developments to encourage the use of transit, bicycles, and pedestrian walkways.

2.3 Contacts, Coordination and Consultations

Coordination efforts and consultations among the project teams, as well as TriMet, Metro and various other federal, state and local agencies were established during the development of this Energy Technical Report. Information from a federal level primarily consisted of regulations, guidelines and fuel consumption rates data. Information from a state level primarily consisted of energy policy and guidelines. Consultations with local jurisdictional agencies provided energy and sustainability policies.

2.4 Data Collection

The base year traffic data and transportation operations energy consumption for the Portland Metropolitan Area was provided and documented in the *South Corridor Portland to Milwaukie Light Rail Project SDEIS - Energy Results Report (Metro and DEA, 2008).* The future year traffic volume data was obtained from the travel demand model, as provided by Metro regional model and reported in the *Lake Oswego to Portland Transit Project Transportation Technical Report (URS Corporation and DEA Inc.).*

The energy consumption of the proposed project alternatives was evaluated using the regional roadway data and corridor data from Metro for the base year (2005). The base year used for calibration of the regional travel forecast models is year 2005. For the purposes of the existing conditions assessment of local traffic in the DEIS, 2009 is considered the base year. The assessment of existing 2009 traffic conditions is based primarily on analysis of operations using traffic volumes collected in August, 2009. These are consistent with the adopted Regional Transportation Plan. Metro provided travel demand volumes for the following conditions using the Metro regional travel demand model (EMME):

The future year (2035) traffic volumes, similarly known as the planning horizon year, was derived using a methodology incorporating existing counts, base case travel demand model data (2005), and future travel demand model data (2035). The growth rate in volumes were determined between the two travel demand model years and applied to the existing volume counts for 2009.

The analysis and comparison of alternatives are conducted for the differences among the project alternatives and design options, as compared to the No-Build Alternative.

2.5 Affected Environment Profile

Transportation-related energy is primarily derived from petroleum-based fuel sources, with gasoline and diesel being the main fuel sources. Since energy generated from these resources generally accounts for over 95 percent of the total energy demand for the transportation sector, energy use generally refers to energy originating from crude oil products. Energy use focuses on fossil fuel, electricity, natural gases and the demand for these resources in the Pacific Northwest and the State of Oregon.

2.6 Impact Assessment Analysis Methods

The procedures and analyses are conducted in accordance with guidance provided by the FTA and uses FTA approved transportation energy analysis methods, created by California Department of Transportation (Caltrans).

Energy analysis addresses two components: long-term use (operational energy consumption) and short-term use (construction energy consumption). Long-term energy impacts refer to the fuel consumed by the operations of project alternatives, such as cars, buses and streetcar vehicles. Short-term energy impacts refer to the energy associated with the construction of the project alternatives. Both long-term and short-term energy consumption is measured in British Thermal Units (Btu)[2].

This section describes the analysis methods used to identify the effects on energy expenditure of the project alternatives and design options.

2.6.1 Direct Impacts

2.6.1.1 Long-Term (Operations Energy)

The operational energy evaluation involves an analysis of the energy consumed by the operations of vehicles for the No-Build Alternative and Streetcar Alternative. Also referred to as the long-term direct energy impact, the operations energy is the energy consumed by vehicles using a facility based on vehicular volumes, vehicle type, and average travel speeds. The project's long-term effects on energy supply and demand are related to the operations of the affected transportation facilities.

The long-term direct energy analysis was analyzed by applying the Urban Vehicle Miles Traveled (VMT) Fuel Consumption Method. The calculations procedure follows the guidelines outlined in the CALTRANS' Energy and Transportation Systems Manual (CALTRANS, 1983).

Traffic volumes used for the energy analysis include average daily trips (ADT) and VMT. Vehicle types are separated into eight categories including light-duty gasoline automobiles, light duty gasoline trucks, medium-duty gasoline trucks, heavy-duty gasoline trucks, light-duty diesel automobiles, light-duty diesel trucks, heavy-duty diesel vehicles (trucks and buses), and motorcycles. Each classification is associated with a unique fuel consumption rate; autos are assumed to use gasoline fuel and trucks are assumed to use diesel fuel.

The operations energy formula was applied to the VMT to produce the average daily and annual fuel consumption for each alternative. The calculation uses the number of vehicles, the types of vehicles, an estimated average vehicle speed and the length of roadway. The traffic volume and distance was multiplied by a fuel consumption factor specific to the year, and estimated speed for the roadway section.

[2] A British Thermal Unit (Btu) is the amount of heat required to raise the temperature of one pound of water one degree Fahrenheit (F) at or near 39.2 F degrees.

The aggregated fuel consumption was then converted to Btu, which was used to provide a common unit for the purposes of calculating and comparing the different forms of energy involved in the project. The following equation was applied to calculate the vehicle fuel energy:

Operations Energy Formula: E = V x L x FCR x CF

Where : E = Energy consumed (Btu);

- V = Number of vehicles (ADT);
- L = Length of roadway segment (miles);
- FCR = Fuel consumption rate (gal/mile) for average speed; and
- CF = Btu per gallon conversion factor based on fuel type (gasoline vs. diesel).

Operations energy determinations include the following assumptions for vehicles:

- One gallon of gasoline for light and medium automobile vehicles provides 125,000 Btu of energy; and
- One gallon of diesel for heavy trucks provides 139,000 Btu of energy.

Computations for determining energy use for Streetcars were determined by using the number of Streetcar vehicle miles traveled and current utility records for electrical use. The number of Streetcar vehicle miles traveled per year was multiplied by the average electrical energy consumption factor in kilowatt-hours (kwh) to obtain the total kwh per year of electrical use. This figure was multiplied by the Btu conversion factor to determine yearly energy consumption in Btu for the Streetcar Alternative. The following equation was applied to calculate the Streetcar energy:

(Streetcar miles/year x 8 kwh/car mile) x (3,412 Btu/kwh days per year) = 0.124 x 109 Btu/day

Streetcar miles were provided by Portland Streetcar, Inc. (PSI), TriMet and Metro and the energy consumption factors were provided by PSI and TriMet.

2.6.1.2 Short-Term (Construction Energy)

The construction energy evaluation involves analyzing the total energy required for the construction of the Enhanced Bus Alternative or the Streetcar Alternative. Also referred to as the short-term direct energy impact of the project, construction energy covers production and transport of materials, powering on-site equipment, worker transportation and factors including the materials used in construction. The project’s temporary effects on energy demand are exclusively associated with the construction of the project because no additional energy would be required after the construction is complete.

The short-term direct energy analysis was conducted using the Input-Output Approach for Urban Conventional Highway Construction developed by CALTRANS (1983). The estimated amount of energy consumed by the construction of the project was based on preliminary construction cost estimates. This approach estimates the construction energy requirements using energy factors that were developed for a variety of construction activities (e.g. construction of structures, site work, etc.). These energy factors relate project costs with the amount of energy required to manufacture, process, and place construction materials and structures.

The Input-Output Approach assigns an energy-to-dollar ratio to various roadway construction activities. The cost estimates for each type of facility are reduced to a base-year equivalent and then multiplied by the appropriate Btu per dollar ratio. Data necessary for this analysis included the type of facility proposed, i.e. streetcar; and the cost of each construction activity as determined for the base year. The following equation was applied to calculate the construction fuel energy:

Construction Energy Formula: E = C x DEF x DC

Where : E = Energy consumed (Btu);

- C = Cost of a particular construction activity (2010);
- DEF = Dollar-to-Energy Factor (Btu/1973$); and
- DC = Dollar Conversion, Price Escalation (1973$/2010$).

The analysis will be interpolated to relate the current year/planning horizon year (2010$/2035$).

2.6.2 Indirect Impacts

Indirect, or secondary, impacts are those impacts that may be caused by the project alternatives, which would be later in time or further removed due to distance. However, they may be considered in a reasonably foreseeable future.

2.6.3 Cumulative Impacts

Cumulative effects occur when a project's effects are combined with those from other past, present, and future projects. They can also result from individually small but collectively substantial actions that occur over a long period of time. The energy analysis relies on information generated from the forecasts of future traffic volumes and operations. The transportation model takes into account other planned and future projects and the effects of those projects on the various transportation modes, thus capturing cumulative effects.

2.7 Mitigation Measures

Some general measures can be implemented to reduce long-term and short-term energy use. The goal in most transportation projects is to reduce the operational energy consumed in the overall transportation system. If the energy analysis shows that the Enhanced Bus Alternative and the Streetcar Alternative would reduce energy consumption as compared to the No-Build Alternative, then mitigation measures would not be required. If energy consumption would not be reduced by one of the build alternatives, then decision-makers must factor this into their evaluation of whether to choose a build alternative and weigh other benefits against the increased use of energy in the transportation system. Other measures that reduce operational energy usage (reducing travel demand, improving operational efficiency, etc.) may also need to be considered.

Potential mitigation measures to reduce the energy consumed by the construction of the project would include conservation of construction materials and innovative energy-efficient practices during construction.

2.8 Documentation

This Energy Technical Report was prepared to document the results of the energy analysis. The report includes sections describing the affected environment, existing energy levels, and information on the projected energy needs of the study alternatives. Project-related construction energy needs is discussed. This technical report is summarized in Chapter 3, Section 3.12 of the DEIS.

3. CONTACTS, COORDINATION AND CONSULTATIONS

Coordination efforts and consultations among the project teams, as well as TriMet, Metro and various other federal, state and local agencies were established during the development of this Energy Technical Report. Data resources are included in the following sections.

3.1 Federal Agency Coordination

Information from a federal level primarily consisted of regulations, guidelines and fuel consumption rates data. Coordination and involvement at a Federal level consisted of the following administrations:

- United States Department of Energy (USDOE);
- Federal Highway Administration (FHWA); and
- Bonneville Power Administration (BPA).

3.2 State Agency Coordination

Information from a state level primarily consisted of energy policy and guidelines. Coordination and involvement at a State level consisted of the following departments:

- Oregon Department of Energy (ODOE);
- Department of Environmental Quality (DEQ); and
- Oregon Department of Transportation (ODOT).

3.3 Local and Regional Agency Coordination

Consultations with the following local jurisdictional agencies provided energy and sustainability policies:

- Northwest Power Planning Council (NPPC);
- Pacific Northwest Utilities Conference Committee (PNUCC);
- Tri-County Metropolitan Transportation District of Oregon (TriMet);
- Metro Regional Government (Metro);
- Portland Streetcar, Inc (PSI);
- City of Portland; and
- City of Lake Oswego.

Consultations with TriMet and Metro consisted of telephone conversations and email correspondence with the following individuals regarding travel demand traffic data, facilities and operations statistics, as well as methodologies for analysis.

- Mark Turpel, Metro, Principal Planner
- John Griffiths, TriMet, Rail Operations
- Eric Hesse, TriMet, Strategic Planning Analyst

Traffic analysis coordination with Metro was primarily conducted by Scott Harmon, PE of David Evans & Associates in preparation of the *Lake Oswego to Portland Transit Project Transportation Technical Report (URS Corporation and DEA Inc.).*

4. AFFECTED ENVIRONMENT

4.1 Affected Environment Profile

The affected environment section provides a discussion of general energy use including the type, source and utilization for applicable energy sources in the Pacific Northwest Region and State of Oregon. This section provides a brief and general description of the following items as follows:

- The existing use and demand for energy resources in the nation and region;
- The present energy use for transportation; and
- The available and forecasted supply and demand of energy.

Specifically, the discussion focuses on the energy use of petroleum fuel, electricity, and natural gas. Since gasoline and diesel are the primary fuel sources for the transportation sector, the discussion focuses on energy derived from petroleum-based fuel sources. Transportation energy use generally refers to energy originating from crude oil products, since energy derived from these sources generally accounts for over 95 percent of the total energy demand for the transportation sector.

4.1.1 Oregon Energy Supply and Demand

For energy generation, Oregon is part of the Pacific Northwest Regional Power system, as defined by the Pacific Northwest Electric Power Planning and Conservation Act. Along with Oregon; Washington, Idaho, western Montana, and portions of Nevada, Utah, and Wyoming; are within the Columbia River drainage basin that encompasses this power system. Utilities which encompass the Pacific Northwest regional power system are bonded by coordinated operation of the regional hydroelectric generation system (Oregon Office of Energy (OOE) 2000).

Oregon utilities are also a part of the Western Systems Coordinating Council (WSCC), which are interconnected with the transmission system that links utilities and power suppliers in all 11 western states and the western Canadian provinces of British Columbia and Alberta. Connection to this system allows participating utilities to purchase, sell and exchange power to optimize load and resource diversity amongst the participants.

4.1.2 Petroleum

Petroleum is the largest source of energy used in Oregon. Oregon imports 100 percent of its petroleum. Approximately 90 percent of Oregon's petroleum comes from refineries in the Puget Sound area in Washington through the Olympic Pipeline to Portland and then on to Eugene. The remaining ten percent comes from California and some amounts come from the northern Rockies states and are imported from Asia and Canada. Oil from California is transported by ship, truck and rail and oil from the Rockies states are transported from Salt Lake City through Chevron's pipeline. Imported oil arrives by ship, truck, and rail (OOE 2000).

Between 1990 and 1997, Oregon's petroleum consumption grew by about eight percent (Oregon Department of Energy (ODOE) 2000). In 2000, approximately 47 percent of Oregon's energy consumption came from petroleum. Since then, the demand for petroleum has decreased, but still accounts for the largest share of energy consumption at 35.7 percent, which is substantially less than the national average of 40.5 percent (United States Department of Energy ((USDOE 2004).

4.1.3 Hydropower

Hydroelectricity (Hydro) power is the primary source of Oregon's electrical power production, supplying approximately 60 percent of the electric supply in the Pacific Northwest (OOE 2000). Most of the Hydro power is tied to the Federal hydroelectric system, marketed and distributed by the Bonneville Power Administration (BPA), a Federal agency under the Department of Energy. BPA operates and maintains approximately 75 percent of the Pacific Northwest region's high-voltage transmission, and BPA facilities distribute approximately 45 percent of all the electric power used in the Northwest.

4.1.4 Natural Gas

The majority of natural gas consumed in Oregon comes from Western Canada. Additional natural gas used in Oregon is from the Rocky Mountain area, with a small amount coming from Oregon production fields. Gas flows into Oregon through two major pipelines; the Williams Northwest Pipeline brings natural gas produced in British Columbia, Canada and the Rocky Mountain states through Washington State, and the Pacific Gas, and Electric Gas Transmission Northwest pipeline transports gas produced in Alberta, Canada. The two major gas pipelines intersect near Stanfield, located in eastern Oregon (OOE).

4.1.5 Other Energy Supplies

Other energy sources include coal and renewable resources (Hydropower, wood and wood byproducts, solar, wind, geothermal and biomass). Coal is primarily used in Oregon for power generation, and coal use has remained relatively steady. Most of the electrical generation from coal is produced in Montana and Wyoming and some of this electricity may be purchased for use in Oregon. However, the Boardman Power Plant in Eastern Oregon is a 585-megawatt coal-fired electricity generating plant in northeastern Oregon.. Boardman provides about 15 percent of the power PGE delivers to its customers.

Renewable resources provide an increasing amount of energy, and Oregon uses more renewable energy than any other state. Hydropower and wood provide the majority of Oregon's energy supply, and Hydropower provides over half of the state's electricity. Wood supplies electricity for the lumber and paper industry.

Wind, geothermal, solar and biomass account for smaller portions of the Pacific Northwest's energy supply. Advancements in technology, volatility in the more traditional power supply markets and the decrease in the cost of generating power from renewable sources have made renewable energy and especially wind power a more integral component of the power supply for the region.

4.2 Existing Energy Consumption

The existing transportation energy consumption for the Portland Metropolitan Area includes energy used for motor vehicles, the TriMet light rail system, the Portland Streetcar System, TriMet buses, transit vehicle maintenance and the operation of maintenance facilities, and park-and-ride lots. Table 4-1 summarizes the daily energy consumption for these activities. Base year 2005 total daily transportation energy consumption in the Portland metropolitan area was estimated at 354 billion Btu per day, which was equivalent to 2,827,800 gallons of gasoline per day.

Table 4-1 Transportation Operations Energy Consumption in Portland Metropolitan Area
Base Year (2005)

Vehicle and Facility Operations	**Daily VMT**[1]	**Daily Fuel Consumption**[2] (Gallons)	**Daily Energy Consumption** (Billions of Btu*)
Motor Vehicle Operations Totals	41,611,800	2,528,800	322
Motor Vehicle Maintenance[3]		278,300	29
Total Motor Vehicle Energy Usage		2,807,100	351
Transit Bus Vehicles	85,900	13,600	1.891
Non-Fuel Source Transit System[4]	13,100		0.367
LRT Maintenance Facility Operation[5]			0.029
Bus Vehicle Maintenance[5]		7,100	0.147
Bus Maintenance Facility Operation[5]			0.147
Park and Ride Operation[5]			0.008
Total Transit Energy Usage		20,700	2.600
Combined Energy Usage		2,827,800	354

Source: South Corridor Portland to Milwaukie Light Rail Project SDEIS - Energy Results Report (Metro and DEA, 2008).
Note: * Btu = British Thermal Unit, Btu/gallon of gasoline = 125,000 (gross), Btu/gallon of diesel = 138,700 (gross)
[1] Vehicle Miles Traveled, Metro 2002
[2] Methodology derived from Caltrans 1997
[3] Methodology derived from Caltrans 1983
[4] Includes MAX, Portland Streetcar, and Tram; energy calculated as (8.2 kWH/car mile) x (13,127 car miles) x (3,412 Btu/kWH)
[5] TriMet 2007

5. ENVIRONMENTAL CONSEQUENCES

This section evaluates and assesses the effects of the project alternatives on the transportation-related energy consumption in the study corridor. The energy analysis focuses on the following components:

- Energy consumed during operation (direct, long-term impacts) and construction (direct, short-term) of the project alternatives;
- Indirect impacts and cumulative energy impacts; and
- Projected long-term and short-term energy savings for the transportation system with the operation and construction of the project alternative.

Variations associated with the Streetcar Alternative design and phasing options would result in only minor differences in energy use (less than 1 percent) on a system-wide level.
The following sections describe the project alternatives, data collection and analysis methodologies.

Project Alternatives

Chapter 1 of this report describes the project's background and provides a description of the alternatives analyzed. In summary, the project alternatives include the No-Build Alternative, the Enhanced Bus Alternative and the Streetcar Alternative. For the Streetcar Alternative, there are various design options in varying segments. Only one segment has design options with significant enough differences to evaluate the differences in energy consumption. The Johns Landing Segment includes three Streetcar design options: the Willamette Shore Line, Macadam In-Street and the Macadam Additional Lane Design Options. The analysis considers the differences in operation energy consumption between the Willamette Shore Line Design Option and the two Macadam Design Options. The differences between the Macadam In-Street and the Macadam Additional Lane design options are minimal; therefore no separate analysis was performed.

5.1 Direct Impacts

5.1.1 Long-Term Energy Impacts

Long-term, direct energy impacts refer to the fuel and electricity consumed by motor vehicles and transit for operations and maintenance of the project alternatives.

5.1.1.1 Fuel Consumption for the Project Alternatives

Summary of Daily Corridor Energy Consumption

Year 2035 total daily transportation energy consumption in the corridor for the No-Build Alternative is estimated at 1.817 billion Btu per day, which is equivalent to 14,533 gallons of gasoline per day. The Enhanced Bus Alternative is estimated at 1.825 billion Btu per day, which is equivalent to 14,593 gallons of gasoline per day. The Willamette Shore Line Streetcar Alternative is estimated at 1.772 billion Btu per day, which is equivalent to 14,176 gallons of gasoline per day. The Macadam In-Street or the Macadam Additional Lane Streetcar Design Option is estimated at 1.775 billion Btu per day, which is equivalent to 14,200 gallons of gasoline per day.

The daily corridor transportation operations fuel consumption for motor vehicle use and transit energy use in Year 2035 is summarized in Table 5-1.

Table 5-1 Summary of Daily Corridor Transportation Operations Energy Consumption Future Year 2035, Lake Oswego to Portland Transit Project Alternatives

Vehicle and Facility Operations[3]			Streetcar Alternative[3] (Billions of Btu)	
	No-Build Alternative (Billions of Btu[1])	**Enhanced Bus Alternative** (Billions of Btu)	**with Willamette Shore Line Design Option**	**with Macadam In-Street/ Macadam Additional Lane Design Options**
Motor Vehicle Operations Totals	1.36200	1.35700	1.34300	1.34600
Motor Vehicle Maintenance	0.16100	0.16100	0.15900	0.15900
Total Motor Vehicle Energy Usage[4]	1.52300	1.51800	1.50200	1.50500
Transit Bus Vehicles	0.07100	0.08400	0.05100	0.05100
Non-Fuel Source Transit System	0.00000	0.00000	0.00012	0.00012
Total Transit Energy Usage	0.07100	0.08400	0.05112	0.05112
Bus Vehicle Maintenance	0.00600	0.00700	0.00400	0.00400
Bus Maintenance Facility Operation	0.05500	0.05500	0.05500	0.05500
LRT Maintenance Facility Operation	0.00100	0.00100	0.00100	0.00100
Total Transit Maintenance Energy Usage[4]	0.06200	0.06300	0.06000	0.06000
Heavy Duty Vehicle Maintenance	0.08800	0.08750	0.08670	0.08690
Light Duty Vehicle Maintenance	0.07290	0.07270	0.07200	0.07220
Total Vehicle Maintenance Energy Use[4]	0.16090	0.16020	0.15870	0.15910
Combined Energy Usage (Billions of Btu per day)	**1.817**	**1.825**	**1.772**	**1.775**
Combined Energy Usage (Gallons of Gasoline per day)	**14,533**	**14,593**	**14,176**	**14,200**

Sources: URS Corporation 2010, Metro 2010, TriMet 2010, Caltrans 1983

[1] Btu = British Thermal Unit, Btu/gallon of gasoline = 125,000 (gross), Btu/gallon of diesel = 138,700 (gross)

[2] The data for the Streetcar Alternative includes the full Streetcar Project from the South Waterfront to Lake Oswego. Only the Johns Landing Segment Design Options would result in significant energy consumption differences, which are shown above.

[3] There are no energy contributions from operations of Commuter Rail Vehicles, Commuter Rail Maintenance and Park-and-Ride Operations.

[4] The Total Motor Vehicle Energy usage does not include auto repair shop operational energy use.
The Total Transit Maintenance Energy usage includes Bus and Light Rail Vehicle Maintenance and Maintenance Facility Operations.
The Total Vehicle Maintenance Energy usage includes Heavy Duty and Light Duty Vehicle Maintenance

Summary of Annual Corridor Energy Consumption

Future Year 2035 total annual corridor transportation energy consumption in the corridor for the No-Build Alternative is estimated at 593.47 billions of Btu per year, which is equivalent to 4,747,700 gallons of gasoline per year. The Enhanced Bus Alternative is estimated at 591.78 billions of Btu per year, which is equivalent to 4,734,200 gallons of gasoline per day. The Willamette Shore Line Streetcar Alternative is estimated at 585.17 billions of Btu per year, which is equivalent to 4,681,400 gallons of gasoline per year. The Macadam In-Street or the Macadam Additional Lane Streetcar design option is estimated at 586.23 billions of Btu per year, which is equivalent to 4,689,800 gallons of gasoline per year.

Table 5-2 summarizes the combined annual energy use for operations of the alternatives.

Table 5-2 Summary of Annual[1] Corridor Energy Consumption by Project Alternative Future Year 2035

Alternative	Motor Vehicle[3] Annual Energy Use	Bus Annual Energy Use	Rail Annual Energy Use	Total Annual Operations Energy	Total Fuel Consumption (gal/year)	Annual Operational Energy Savings[4]
		(Billions of Btu[2])			(gal/year)	(Billions of Btu)
No-Build Alternative	548.37	44.76	0.34	593.47	4,747,700	--
Enhanced Bus Alternative	542.08	49.36	0.34	591.78	4,734,200	1.69
Streetcar Alternative [5]:						
Willamette Shore Line design option	547.45	37.34	0.38	585.17	4,681,400	8.29
Macadam In-Street design option	548.45	37.34	0.38	586.23	4,689,800	7.24
Macadam Additional Lane design option	548.45	37.34	0.38	586.23	4,689,800	7.24

Sources: URS Corporation 2010, Metro 2010, TriMet 2010
Notes: DO = Design Option
[1] Assumes an annualization factor of 340 days per year.
[2] Btu = British Thermal Unit. One gallon of gasoline = 125,000 Btu. One gallon of diesel = 138,700 Btu.
[3] Not including buses.
[4] As compared to No-Build Alternative.
[5] The data for the Streetcar Alternative includes the full Streetcar Project from the South Waterfront to Lake Oswego. Only the Johns Landing Segment Design Options would result in significant energy consumption differences, which are shown above.

Comparison of Corridor Energy Consumption by Alternative

The energy analysis and comparison of alternatives are conducted for the differences among the project alternatives, as compared to the No-Build Alternative. The operations energy consumption for the Enhanced Bus Alternative would increase 0.008 billion Btu per day, as compared to the No-Build Alternative. This is equivalent to a daily increase in expenditure of 60 gallons of gasoline and would require approximately 0.42 percent more operations energy than the No-Build Alternative.

The operations energy consumption for the Willamette Shore Line Streetcar Alternative would decrease 0.045 billion Btu per day, as compared to the No-Build Alternative. This is equivalent to a daily decrease in expenditure of 360 gallons of gasoline and would require approximately 2.46 percent less operations energy than the No-Build Alternative.

The operations energy consumption for the Macadam In-Street or the Macadam Additional Lane Streetcar Alternative would decrease 0.042 billion Btu per day, as compared to the No-Build Alternative. This is equivalent to a daily decrease in expenditure of 335 gallons of gasoline and would require approximately 2.29 percent less operations energy than the No-Build Alternative.

Besides the Willamette Shore Line Streetcar Alternative and the Macadam In-Street or the Macadam Additional Lane Streetcar, there are no length differences between the design options, therefore, no operational energy consumption difference. The energy differences between the design options are negligible; therefore, no separate comparison analysis of energy consumption between the design options was conducted.Table 5-3 compares the daily and annual corridor energy operations consumption by alternatives and design options, with respect to the No-Build Alternative for future year 2035.

Table 5-3 Total and Comparison of Corridor Operations Energy Consumption for the Lake Oswego to Portland Corridor Future Year 2035

	Daily			Annual[2]		
Project Alternatives and Design Options	**Vehicle Miles Traveled** (Daily VMT)	**Energy Consumption**[1] (Billions of Btu/day)	**Fuel Consumption** (gal/day)	**Vehicle Miles Traveled** (Annual VMT)	**Energy Consumption**[1] (Billions of Btu/year)	**Fuel Consumption** (gal/year)
No-Build Alternative	220,100	1.817	14,500	79,151,600	595	4,747,700
Enhanced Bus Alternative	219,600	1.825	14,600	78,756,600	595	4,734,200
Streetcar Alternative[3]						
Willamette Shore Line design opion	215,900	1.772	14,200	77,979,600	585	4,681,400
Macadam In-Street design option	216,400	1.775	14,200	78,144,100	590	4,689,800
Macadam Additional Lane design option	216,400	1.775	14,200	78,144,100	590	4,689,800
Percent Change in Energy Consumption as Compared to the No-Build Alternative[4]						
Enhanced Bus Alternative	- 0.23%	0.42%	0.42%	- 0.50%	0.28%	0.28%
Streetcar Alternative[3]						
Willamette Shore Line design option	- 1.88%	- 2.46%	- 2.46%	- 1.48%	1.40%	1.40%
Macadam In-Street design option	- 1.67%	- 2.29%	- 2.29%	- 1.27%	1.22%	1.22%
Macadam Additional Lane design option	- 1.67%	- 2.29%	- 2.29%	- 1.27%	1.22%	1.22%
Net Difference In 2035 Energy Consumption as Compared to the No-Build Alternative[5]						
Enhanced Bus Alternative	- 500	0.008	60	- 395,000	- 2	- 13,500
Streetcar Alternative[3]						
Willamette Shore Line design option	- 4,200	- 0.045	- 360	- 1,172,000	- 8	- 66,400
Macadam In-Street design option	- 3,700	- 0.042	- 335	- 1,007,600	- 7	- 58,000
Macadam Additional Lane design option	- 3,700	- 0.042	- 335	- 1,007,600	- 7	- 59,000

Sources: URS Corporation 2010, Metro 2010, DEA, Inc. 2010
Lake Oswego to Portland Transit Project Transportation Technical Report (DEA Inc. and Metro/TriMet, March 2010)
Btu = British Thermal Unit
VMT = Vehicle Miles Traveled
[1] Energy Consumption, Auto: Btu/gallon of gasoline = 125,000, Trucks: Btu/gallon of diesel = 139,000
[2] Annual energy consumptions are estimates only and do not accurately account for variations in seasonal energy use
[3] Streetcar Alternatives calculations reflect the whole alignment with the design options in the Johns Landing segment.
[4] Percentages computed from unrounded numbers. Differences computed from unrounded numbers and rounded.
[5] These figures do not include maintenance and maintenance facility energy use

Summary of Daily Regional Energy Consumption

Future Year 2035 total daily regional transportation energy consumption in the corridor for the No-Build Alternative is estimated at 593.24 billions of Btu per day, which is equivalent to 4,746,021 gallons of gasoline per day. The Enhanced Bus Alternative is estimated at 593.08 billions of Btu per day, which is equivalent to 4,744,740 gallons of gasoline per day. The Willamette Shore Line

Streetcar Alternative is estimated at 592.68 billions of Btu per day, which is equivalent to 4,741,519 gallons of gasoline per day. The Macadam In-Street or the Macadam Additional Lane Streetcar design options are estimated at 592.58 billions of Btu per day, which is equivalent to 4,740,753 gallons of gasoline per day.

The daily regional transportation operations fuel consumption for motor vehicle use and transit energy use for Future Year 2035 is summarized in Table 5-4.

Table 5-4 Summary of Daily Regional Operations Energy Consumption Future Year 2035, Lake Oswego to Portland Transit Project Alternatives

			Streetcar Alternative [4] (Billions of Btu)	
Vehicle and Facility Operations[3]	**No-Build Alternative** (Billions of Btu[1])	**Enhanced Bus Alternative** (Billions of Btu)	**with Willamette Shore Line Design Option**	**with Macadam In-Street/ Macadam Additional Lane Design Options**
Motor Vehicle Operations Totals	488.2464	487.9291	487.7201	487.7402
Motor Vehicle Maintenance	57.7153	57.9028	57.7291	57.6113
Total Motor Vehicle Energy Usage[4]	545.9617	545.8319	545.4492	545.3515
Transit Bus Vehicles	2.7780	2.7762	2.7750	2.7751
Non-Fuel Source Transit System	0.3070	0.3070	0.3071	0.3071
Total Transit Energy Usage	3.0850	3.0832	3.0821	3.0822
Bus Vehicle Maintenance	0.2163	0.2161	0.2160	0.2161
Bus Maintenance Facility Operation	0.1470	0.1470	0.1470	0.1470
LRT Maintenance Facility Operation	0.0370	0.0370	0.0370	0.0370
Total Transit Maintenance Energy Usage[4]	0.4003	0.4001	0.4000	0.4001
Light Duty Vehicle Maintenance	25.0745	25.0582	25.0475	25.0485
Medium Duty Vehicle Maintenance	8.2308	8.2255	8.2220	8.2223
Heavy Duty Vehicle Maintenance	10.4894	10.4826	10.4781	10.4785
Total Vehicle Maintenance Energy Use[4]	43.7947	47.7663	43.7475	43.7493
Park and Ride Operation	0.0110	0.0110	0.0110	0.0110
Combined Energy Usage (Billions of Btu per day)	**593.24**	**593.08**	**592.68**	**592.58**
Combined Energy Usage (Gallons of Gasoline per day)	**4,746,021**	**4,744,740**	**4,741,519**	**4,740,753**

Sources: URS Corporation 2010, Metro 2010, TriMet 2010, Caltrans 1983

[1] Btu = British Thermal Unit, Btu/gallon of gasoline = 125,000 (gross), Btu/gallon of diesel = 138,700 (gross)

[2] The data for the Streetcar Alternative includes the full Streetcar Project from the South Waterfront to Lake Oswego. Only the Johns Landing Segment Design Options would result in significant energy consumption differences, which are shown above.

[3] There are no energy contributions from operations of Commuter Rail Vehicles, Commuter Rail Maintenance and Park-and-Ride Operations.

[4] The Total Motor Vehicle Energy usage does not include auto repair shop operational energy use.
The Total Transit Maintenance Energy usage includes Bus and Light Rail Vehicle Maintenance and Maintenance Facility Operations.
The Total Vehicle Maintenance Energy usage includes Heavy Duty and Light Duty Vehicle Maintenance

Summary of Annual Regional Energy Consumption

Future Year 2035 total annual regional transportation energy consumption in the corridor for the No-Build Alternative is estimated at 200,761 billions of Btu per year. The Enhanced Bus Alternative is estimated at 200,708 billions of Btu per year. The Willamette Shore Line Streetcar Alternative is estimated at 200,571 billions of Btu per year. The Macadam In-Street or the Macadam Additional Lane Streetcar design option is estimated at 200,538 billions of Btu per year.

Table 5-5 summarizes the combined annual energy use for operations of the alternatives in the region.

Table 5-5 Summary of Annual[1] Regional Energy Consumption by Project Alternative Future Year 2035

Alternative	Motor Vehicle Annual Energy Use[3]	Bus Annual Energy Use	Rail Annual Energy Use	Total Annual Operations Energy	Total Fuel Consumption	Annual Operational Energy Savings [4]
		(Billions of Btu[2])			(gal/year)	(Billions of Btu[2])
No-Build Alternative	199,573	1,068	121	200,761	1.606 Billion	0
Enhanced Bus Alternative	199,519	1,067	121	200,708	1.606 Billion	54
Streetcar Alternative [5]:						
Willamette Shore Line design option	199,383	1,067	121	200,571	1.605 Billion	190
Macadam In-Street design option	199,351	1,067	121	200,538	1.604 Billion	223
Macadam Additional Lane design option	199,351	1,067	121	200,538	1.604 Billion	223

Sources: URS Corporation 2010, Metro 2010, TriMet 2010
Notes: DO = Design Option
[1] Assumes an annualization factor of 340 days per year.
[2] Btu = British Thermal Unit. One gallon of gasoline = 125,000 Btu. One gallon of diesel = 138,700 Btu.
[3] Not including buses.
[4] As compared to No-Build Alternative.
[5] The data for the Streetcar Alternative includes the full Streetcar Project from the South Waterfront to Lake Oswego. Only the Johns Landing Segment Design Options would result in significant energy consumption differences, which are shown above.

Comparison of Regional Energy Consumption by Alternative

The energy analysis and comparison of alternatives for the region were conducted for the differences among the project alternatives and design options, as compared to the No-Build Alternative. The operations energy consumption for the Enhanced Bus Alternative would decrease 0.160 billions of Btu per day, as compared to the No-Build Alternative. This is equivalent to a daily decrease in expenditure of 1,282 gallons of gasoline and would require approximately 0.03 percent less operations energy than the No-Build Alternative.

The operations energy consumption for the Willamette Shore Line Streetcar Alternative would decrease 0.658 billions of Btu per day, as compared to the No-Build Alternative. This is equivalent to a daily decrease in expenditure of 5,268 gallons of gasoline and would require approximately 0.11 percent less operations energy than the No-Build Alternative.

The operations energy consumption for the Macadam In-Street Streetcar Alternative would decrease 0.563 billions of Btu per day, as compared to the No-Build Alternative. This is equivalent to a daily decrease in expenditure of 4,502 gallons of gasoline and would require approximately 0.11 percent less operations energy than the No-Build Alternative.

The operations energy consumption for the Macadam Additional Lane Streetcar Alternative would decrease 0.658 billions of Btu per day, as compared to the No-Build Alternative. This is equivalent to a daily decrease in expenditure of 5,268 gallons of gasoline and would require approximately 0.11 percent less operations energy than the No-Build Alternative.

Besides the Willamette Shore Line Streetcar Alternative and the Macadam In-Street or the Macadam Additional Lane Streetcar, there are no length differences between the design options, therefore, no operational energy consumption difference. The energy differences between the design options are negligible; therefore, no separate comparison analysis of energy consumption between the design options was conducted.

Table 5-6 compares the daily and annual regional energy operations consumption by alternatives and design options, with respect to the No-Build Alternative for future year 2035.

Table 5-6 Total and Comparison of Regional Operations Energy Consumption for the Lake Oswego to Portland Corridor Future Year 2035

	Daily			Annual[2]		
Project Alternatives and Design Options	**Vehicle Miles Traveled** (Daily VMT)	**Energy Consumption**[1] (Billions of Btu/day)	**Fuel Consumption** (gal/day)	**Vehicle Miles Traveled** (Annual VMT)	**Energy Consumption**[1] (Billions of Btu/year)	**Fuel Consumption** (gal/year)
No-Build Alternative	63,090,900	593	4,746,021	21.45 Billion	200,761	1.606 Billion
Enhanced Bus Alternative	63,049,900	593	4,744,740	21.44 Billion	200,708	1.606 Billion
Streetcar Alternative[3]						
Willamette Shore Line design option	63,022,900	593	4,741,519	21.43 Billion	200,571	1.605 Billion
Macadam In-Street design option	63,025,500	593	4,740,753	21.43 Billion	200,538	1.604 Billion
Macadam Additional Lane design option	63,025,500	593	4,740,753	21.43 Billion	200,538	1.604 Billion
Percent Change in Energy Consumption as Compared to the No-Build Alternative[4]						
Enhanced Bus Alternative	- 0.06%	- 0.03%	- 0.03%	- 0.06%	- 0.03%	- 0.03%
Streetcar Alternative[3]						
Willamette Shore Line design option	- 0.10%	- 0.11%	- 0.11%	- 0.10%	- 0.09%	- 0.09%
Macadam In-Street design option	- 0.11%	- 0.09%	- 0.09%	- 0.11%	- 0.11%	- 0.11%
Macadam Additional Lane design option	- 0.10%	- 0.11%	- 0.11%	- 0.10%	- 0.11%	- 0.11%
Net Difference In 2035 Energy Consumption as Compared to the No-Build Alternative[5]						
Enhanced Bus Alternative	- 41,000	- 0.160	- 1,282	- 13,940,000	- 54	- 430,823
Streetcar Alternative[3]						
Willamette Shore Line design option	- 65,400	- 0.658	-5,268	- 22,236,000	- 190	- 1,522,525
Macadam In-Street design option	- 68,000	- 0.563	- 4,502	- 23,120,000	- 223	- 1,783,273
Macadam Additional Lane design option	- 65,400	- 0.658	- 5,268	- 22,236,000	- 223	- 1,783,273

Sources: URS Corporation 2010, Metro 2010, DEA, Inc. 2010
Lake Oswego to Portland Transit Project Transportation Technical Report (DEA Inc. and Metro/TriMet, March 2010)
Btu = British Thermal Unit
VMT = Vehicle Miles Traveled
[1] Energy Consumption, Auto: Btu/gallon of gasoline = 125,000, Trucks: Btu/gallon of diesel = 139,000
[2] Annual energy consumptions are estimates only and do not accurately account for variations in seasonal energy use
[3] Streetcar Alternatives calculations reflect the whole alignment with the design options in the Johns Landing segment.
[4] Percentages computed from unrounded numbers. Differences computed from unrounded numbers and rounded.
[5] These figures do not include maintenance and maintenance facility energy use

5.1.1.2 Power Consumption for the Streetcar Alternative

Portland General Electric (PGE) would supply the energy that powers the streetcar. PGE's power supply mix consists of hydro (approximately 36 percent), coal (approximately 39 percent), natural gas (approximately 23 percent) and others such as nuclear, biomass and waste (approximately 2 percent).

Streetcars typically operate as a single car, requiring a peak current of 800 amps during acceleration. Streetcars operate at relatively low speeds, similar to travel speed on central city roadways. The low power requirements of streetcars allow the system to be fed at the supply utility's secondary voltage (between 120 volts and 480 volts).

Traction Power Substations (TPS) supply direct current electric power for operation of the Streetcar System. The traction power system, with transformer substations placed at approximately half-mile intervals, is able to maintain operational voltage levels while eliminating the need for adding underground conduits for a parallel feed cable. Streetcar substations do not require a dedicated utility feed at the primary distribution voltage and sometimes can be fed from existing transformers as additional load.

The existing Portland Streetcar system uses 750 volts of direct current (Vdc) traction power system. In the past, the Portland Streetcar has used substations supplied by the electrical utility at 400 volts of alternating current (Vac). Streetcars have regenerating capability to minimize the power demand. This voltage is commonly available and it is assumed that this voltage will be used to supply the substations for the Streetcar Alternatives (*Lake Oswego Streetcar DEIS Traction Electrification System Report*, LTK Engineering Services, March 2010).

5.1.2 Short-Term Energy Impacts

Short-term, direct energy impacts refer to the energy associated with construction of the Enhanced Bus Alternative and the Streetcar Alternative. Construction energy effects involve a one-time, non-recoverable energy cost associated with construction of roadways, structures, etc. The preliminary average cost, in 2010 dollars, for the construction of the Enhanced Bus Alternative and Streetcar Alternative was provided by URS Corporation (March 2010) as documented in Chapter 2 of the DEIS and the *Lake Oswego to Portland Transit Project Finance Report*, Siegel, Steven, Siegel Consulting, Finance Analysis, March 2010.

The No-Build Alternative would require minimal consumption of energy associated with construction. The construction energy would be in a form of indirect energy consumption due to maintenance cost per mile. The total roadway maintenance cost for the region, with respect to the vehicles miles traveled, would indicate a cost per mile per year. Since the differences in vehicles miles traveled on the Macadam/OR43 roadway alignment per year between the No-Build Alternative, with respect to the Enhanced Bus Alternative and Street Alternative, would be minimal, construction energy consumption values for the No-Build Alternative were not quantified.

The Enhanced Bus Alternative would require approximately 139 billion Btu or 1.12 million gallons of gasoline for construction of the project. The Streetcar Alternative with the Lake Oswego Terminus would require approximately 1,400 billion Btu or 11.2 million gallons of gasoline for construction of the project. The Streetcar Alternative with the Sellwood Bridge MOS would require approximately 536 billion Btu or 4.29 million gallons of gasoline for construction of the project. In addition, the maintenance facility storage yard, which includes building and equipment would require approximately 17.4 billion Btu or 140,000 gallons of gasoline for construction. As the project moves forward into the design process and additional detail becomes available, these energy use estimates may need to be updated.

Table 5-7 provides the results of the construction energy expenditures with respect to construction using gasoline fuel.

Table 5-7 Summary of Construction Energy Consumption

Alternative	**Construction Cost** (2010$)	**Energy Consumption** (Billions of Btu[1])	**Fuel Consumption** (Million Gallons of Gasoline)
No-Build Alternative	$0	Negligible	Negligible
Enhanced Bus Alternative	$16 Million	139	1.12
Streetcar Alternative:			
Lake Oswego Terminus	$160.5 Million	1,400	11.2
Sellwood Bridge MOS	$61.5 Million	536	4.29
Maintenance Facility	$2 Million	17.4	0.14

Sources: URS Corporation 2010, Metro 2010, TriMet 2010
[1] Btu = British Thermal Unit. One gallon of gasoline = 125,000 Btu.

5.2 Indirect Impacts

Indirect, or secondary, impacts are those impacts that may be caused by the Enhanced Bus Alternative or the Streetcar Alternatives, which would be later in the future time or further removed due to location and distance. However, they may be considered in a reasonably foreseeable future. No significant indirect energy impacts are expected to result from construction or operations of any of the project alternatives.

5.3 Cumulative Impacts

Cumulative impacts are the effects on the environment which result from the incremental outcome of the action when added to other past, present, and reasonably foreseeable future actions. Cumulative effects related to energy use are integrated into the long-term effects analysis since energy estimates are based on travel demand forecasts and their associated operational efficiency.

In terms of other expansion or growth that may occur in the future, there will be slow to moderate new development and some redevelopment in the following communities and neighborhoods; the Portland Central City, the South Waterfront area, the Johns Landing/North Macadam area, and the Lake Oswego Town Center. In the Lake Oswego Town Center area, the foothills area is likely to progress with a new street plan and some new development.

The project alternatives are not expected to have a cumulative effect on energy supply or consumption at a regional or local level. Construction and operation of any project alternative are not expected to affect local or regional fuel availability, or require the development of new energy sources. Additionally, there would be no cumulative impacts to the study area due to energy beyond those described, due to the region's adopted land use and development plans and policies and on the transportation projects included in the financially-constrained list of the current RTP[5].

[5] Refer to the Lake Oswego to Portland Transit Project *Draft Environmental Impact Statement*, Section 2.2.1.

6. POTENTIAL ENERGY MITIGATION MEASURES

One of the goals of the Lake Oswego to Portland Transit Project is to reduce demand for energy. Operation of the Streetcar Alternative would reduce operating energy consumption for the total transit system, as compared to the No-Build Alternative and the Enhanced Bus Alternative; therefore no energy mitigation measures are necessary for the Streetcar Alternative. The operating energy consumption for the Enhanced Bus is minimally higher than the No-Build Alternative and the construction energy of the Enhanced Bus is less than the Streetcar alternative and would not require mitigation.

6.1 Mitigation Measures for Direct Impacts

None of the project alternatives is expected to have a direct impact on energy supply or consumption at regional or local levels. Construction and operations of any of the project build alternatives are not expected to affect local or regional fuel availability, or require development of new energy sources. Therefore, no notable direct energy impacts are expected to result from the project alternatives. Consequently, no mitigation for direct energy impacts is proposed.

6.1.1 Mitigation Measures for Long-Term Direct Impacts

Future increases or reduction in energy consumption could be offset by reducing the number of single-occupant vehicles through the No-Build Alternative, Enhanced Bus Alternative or Streetcar Alternative, by increasing the availability of alternative modes of transportation. Future increases in energy consumption could be mitigated through the development of TDM measures. Energy conservation measures may include; reducing the use of single-occupancy vehicles such as alternative work arrangements, telecommuting, ridesharing and transit incentive programs, etc.

6.1.2 Mitigation Measures for Short-Term Direct Impacts

Innovative approaches such as new technologies, energy conservation methods, employment of sustainable design and techniques during construction, and maintenance programs may reduce the amount of energy the project would require during construction. Efforts to incorporate energy savings objectives may result in a reduction of overall construction energy use. Examples of energy-efficient construction practices that can help to minimize energy use include the following:

- Minimizing the number of hauling trips by using full trucks to and from the site;
- Using recycled materials when possible, so that energy is not used to create new products;
- Using regional products whenever possible to reduce the distance materials travel;
- Using bio-diesel or other non-petroleum fuels;
- Limiting vehicle idling;
- Locating staging areas near work sites; and
- Reusing construction signage, barriers, lighting, and other common materials to reduce energy in the production of materials

In addition to reducing energy use during construction, consideration should be given to reducing the energy required to operate and maintain the project; such as lighting, water collection and treatment, roadway materials, landscape maintenance, and structural maintenance.

6.2 Mitigation Measures for Indirect Impacts

None of the project alternatives is expected to have an indirect effect on energy supply or consumption at a regional level. Therefore, no notable indirect energy impacts are expected to result from construction or operations of any of the project alternatives, consequently, no mitigation for indirect energy impacts is proposed.

6.3 Mitigation Measures for Cumulative Impacts

No notable cumulative energy impacts are expected to result from this project; consequently, no mitigation for cumulative energy impacts is proposed.

Cumulative effects related to energy use are integrated into the long-term effects analysis since energy estimates are based on travel demand forecasts and their associated operational efficiency. Compared to the No-Build Alternative, operation of the Enhanced Bus Alternative and the Streetcar Alternatives would cumulatively add to the availability of energy by reducing overall VMT and associated energy consumption in the Portland metropolitan area. The overall energy analyses consider many of the expected changes to the transportation system that may take place between years 2009 and 2035. Accordingly, the analysis is cumulative in nature.

In summary, no notable direct, indirect or cumulative energy impacts are expected to result from this project; consequently, no mitigation measures are recommended for this project.

6.4 Summary of Permits Required

There is no specific federal, state, or local permits necessary with respect to energy use related to this project.

REFERENCES

Energy Resources

California Department of Transportation. *Standard Environmental References*, Chapter 13, Energy, 2003.

California Department of Transportation. *Energy and Transportation Systems Manual*, 1983.

California Department of Transportation. *Price Index for Construction Items, Energy and Transportation Systems*, 1983.

California Department of Transportation. *California Highway Construction Cost Index. Division Office Engineer*, 1996.

Energy Policy Act of 2005. Public Law 109-58, August 2005.

Federal Highway Administration Technical Advisory T6640.8A, Paragraph 22 Energy, 1987.

Intermodal Surface Transportation Efficiency Act of 1991, PL 102- 240, 1991.

Oregon Department of Energy. *Oregon Energy Outlook.* Salem, Oregon, 2000.

Oregon Department of Transportation. *Oregon Transportation Plan*, 2006.

Oregon Department of Transportation. 1999 *Oregon Highway Plan*, July 2006.

State of Oregon. *Oregon Statewide Planning Goals. Oregon Administrative Rules (OAR) 660-14*.

State of Oregon. *State of Oregon Energy Plan 2005*. Oregon Department of Energy, Transportation, 2005.

United States Department of Energy. *Energy Information Administration.* 2004.

Technical Sources

Lake Oswego to Portland Transit Project Conceptual Engineering. Jaff, Omar, PE, URS Corporation Capital Cost, March 2010.

Lake Oswego to Portland Transit Project Finance Report. Siegel, Steven, Siegel Consulting, Finance Analysis, March 2010.

Lake Oswego Streetcar DEIS Maintenance Facility and Streetcar Storage Report. Farnsworth, Scott, LTK Engineering Services, March 2010.

Lake Oswego Streetcar DEIS Traction Electrification System Report. Farnsworth, Scott, LTK Engineering Services, March 2010.

Lake Oswego to Portland Transit Project Transportation Technical Report. David Evans and Associates, Inc. March 2010)
South Corridor Portland to Milwaukie Light Rail Project SDEIS - Energy Results Report. David Evans and Associates, Inc. and Metro 2008).

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LIST OF APPENDICES

APPENDIX A

Regulations, Guidelines and Policies

(A1) FHWA Technical Advisory T6640.8
(A2) Transportation Planning Rule (OAR 660-12-035)
(A3) Oregon Transportation Plan (Goal 4, Policy 4.1 and 4.2)

U.S. Department of Transportation
Federal Highway Administration

TECHNICAL ADVISORY

GUIDANCE FOR PREPARING AND PROCESSING ENVIRONMENTAL AND SECTION 4(F) DOCUMENTS

T 6640.8A
October 30, 1987

1. Energy

Except for large scale projects, a detailed energy analysis including computations of BTU requirements, etc., is not needed. For most projects, the draft EIS should discuss in general terms the construction and operational energy requirements and conservation potential of various alternatives under consideration. The discussion should be reasonable and supportable. It might recognize that the energy requirements of various construction alternatives are similar and are generally greater than the energy requirements of the no-build alternative. Additionally, the discussion could point out that the post-construction, operational energy requirements of the facility should be less with the build alternative as opposed to the no-build alternative. In such a situation, one might conclude that the savings in operational energy requirements would more than offset construction energy requirements and thus, in the long term, result in a net savings in energy usage.

For large-scale projects with potentially substantial energy impacts, the draft EIS should discuss the major direct and/or indirect energy impacts and conservation potential of each alternative. Direct energy impacts refer to the energy consumed by vehicles using the facility. Indirect impacts include construction energy and such items as the effects of any changes in automobile usage. The alternative's relationship and consistency with a State and/or regional energy plan, if one exists, should also be indicated.

The final EIS should identify any energy conservation measures that will be implemented as a part of the preferred alternative. Measures to conserve energy include theuse of high-occupancy vehicle incentives and measures to improve traffic flow.

2. Construction Impacts

The draft EIS should discuss the potential adverse impacts (particularly air, noise, water, traffic congestion, detours, safety, visual, etc.) associated with construction of each alternative and identify appropriate mitigation measures. Also, where the impacts of obtaining borrow or disposal of waste material are important issues, they should be discussed in the draft EIS along with any proposed measures to minimize these impacts. The final EIS should identify any proposed mitigation for the preferred alternative

The Oregon Administrative Rules contain OARs filed through January 15, 2009

LAND CONSERVATION AND DEVELOPMENT DEPARTMENT

DIVISION 12

TRANSPORTATION PLANNING

660-012-0035

Evaluation and Selection of Transportation System Alternatives

(1) The TSP shall be based upon evaluation of potential impacts of system alternatives that can reasonably be expected to meet the identified transportation needs in a safe manner and at a reasonable cost with available technology. The following shall be evaluated as components of system alternatives:

(a) Improvements to existing facilities or services;

(b) New facilities and services, including different modes or combinations of modes that could reasonably meet identified transportation needs;

(c) Transportation system management measures;

(d) Demand management measures; and

(e) A no-build system alternative required by the National Environmental Policy Act of 1969 or other laws.

(2) Local governments in MPO areas of larger than 1,000,000 population shall, and other governments may also, evaluate alternative land use designations, densities, and design standards to meet local and regional transportation needs. Local governments preparing such a strategy shall consider:

(a) Increasing residential densities and establishing minimum residential densities within one quarter mile of transit lines, major regional employment areas, and major regional retail shopping areas;

(b) Increasing allowed densities in new commercial office and retail developments in designated community centers;

(c) Designating lands for neighborhood shopping centers within convenient walking and cycling distance of residential areas; and

(d) Designating land uses to provide a better balance between jobs and housing considering:

(A) The total number of jobs and total of number of housing units expected in the area or subarea;

(B) The availability of affordable housing in the area or subarea; and

(C) Provision of housing opportunities in close proximity to employment areas.

(3) The following standards shall be used to evaluate and select alternatives:

(a) The transportation system shall support urban and rural development by providing types and levels of transportation facilities and services appropriate to serve the land uses identified in the acknowledged comprehensive plan;

(b) The transportation system shall be consistent with state and federal standards for protection of air, land and water quality including the State Implementation Plan under the Federal Clean Air Act and the State Water Quality Management Plan;

(c) The transportation system shall minimize adverse economic, social, environmental and energy consequences;

(d) The transportation system shall minimize conflicts and facilitate connections between modes of transportation; and

(e) The transportation system shall avoid principal reliance on any one mode of transportation by increasing transportation choices to reduce principal reliance on the automobile. In MPO areas this shall be accomplished by selecting transportation alternatives which meet the requirements in section (4) of this rule.

(4) In MPO areas, regional and local TSPs shall be designed to achieve adopted standards for increasing transportation choices and reducing reliance on the automobile. Adopted standards are intended as means of measuring progress of metropolitan areas towards developing and implementing transportation systems and land use plans that increase transportation choices and reduce reliance on the automobile. It is anticipated that metropolitan areas will accomplish reduced reliance by changing land use patterns and transportation systems so that walking, cycling, and use of transit are highly convenient and so that, on balance, people need to and are likely to drive less than they do today.

(5) MPO areas shall adopt standards to demonstrate progress towards increasing transportation choices and reducing automobile reliance as provided for in this rule:

(a) The commission shall approve standards by order upon demonstration by the metropolitan area that:

(A) Achieving the standard will result in a reduction in reliance on automobiles;

(B) Achieving the standard will accomplish a significant increase in the availability or convenience of alternative modes of transportation;

(C) Achieving the standard is likely to result in a significant increase in the share of trips made by alternative modes, including walking, bicycling, ridesharing and transit;

(D) VMT per capita is unlikely to increase by more than five percent; and

(E) The standard is measurable and reasonably related to achieving the goal of increasing transportation choices and reducing reliance on the automobile as described in OAR 660-012-0000.

(b) In reviewing proposed standards for compliance with subsection (a), the commission shall give credit to regional and local plans, programs, and actions implemented since 1990 that have already contributed to achieving the objectives specified in paragraphs (A)-(E) above;

(c) If a plan using a standard, approved pursuant to this rule, is expected to result in an increase in VMT per capita, then the cities and counties in the metropolitan area shall prepare and adopt an integrated land use and transportation plan including the elements listed in paragraphs (A)-(E) below. Such a plan shall be prepared in coordination with the MPO and shall be adopted within three years of the approval of the standard.

(A) Changes to land use plan designations, densities, and design standards listed in subsections (2)(a)-(d);

(B) A transportation demand management plan that includes significant new transportation demand management measures;

(C) A public transit plan that includes a significant expansion in transit service;

(D) Policies to review and manage major roadway improvements to ensure that their effects are consistent with achieving the adopted strategy for reduced reliance on the automobile, including policies that provide for the following:

(i) An assessment of whether improvements would result in development or travel that is inconsistent with what is expected in the plan;

(ii) Consideration of alternative measures to meet transportation needs;

(iii) Adoption of measures to limit possible unintended effects on travel and land use patterns including access management, limitations on subsequent plan amendments, phasing of improvements, etc.; and

(iv) For purposes of this section a "major roadway expansion" includes new arterial roads or streets and highways, the addition of travel lanes, and construction of interchanges to a limited access highway

(E) Plan and ordinance provisions that meet all other applicable requirements of this division.

(d) Standards may include but are not limited to:

(A) Modal share of alternative modes, including walking, bicycling, and transit trips;

(B) Vehicle hours of travel per capita;

(C) Vehicle trips per capita;

(D) Measures of accessibility by alternative modes (i.e. walking, bicycling and transit); or

(E) The Oregon Benchmark for a reduction in peak hour commuting by single occupant vehicles.

(e) Metropolitan areas shall adopt TSP policies to evaluate progress towards achieving the standard or standards adopted and approved pursuant to this rule. Such evaluation shall occur at regular intervals corresponding with federally-required updates of the regional transportation plan. This shall include monitoring and reporting of VMT per capita.

(6) A metropolitan area may also accomplish compliance with requirements of subsection (3)(e), sections (4) and (5) by demonstrating to the commission that adopted plans and measures are likely to achieve a five percent reduction in VMT per capita over the 20-year planning period. The commission shall consider and act on metropolitan area requests under this section by order. A metropolitan area that receives approval under this section shall adopt interim benchmarks for VMT reduction and shall evaluate progress in achieving VMT reduction at each update of the regional transportation system plan.

(7) Regional and local TSPs shall include benchmarks to assure satisfactory progress towards meeting the approved standard or standards adopted pursuant to this rule at regular intervals over the planning period. MPOs and local governments shall evaluate progress in meeting benchmarks at each update of the regional transportation plan. Where benchmarks are not met, the relevant TSP shall be amended to include new or additional efforts adequate to meet the requirements of this rule.

(8) The commission shall, at regular intervals, evaluate the results of efforts to achieve the reduction in VMT and the effectiveness of approved plans and standards in achieving the objective of increasing transportation choices and reducing reliance on the automobile.

(9) Where existing and committed transportation facilities and services have adequate capacity to support the land uses in the acknowledged comprehensive plan, the local government shall not be required to evaluate alternatives as provided in this rule.

(10) Transportation uses or improvements listed in OAR 660-012-0065(3)(d) to (g) and (o) and located in an urban fringe may be included in a TSP only if the improvement project identified in the Transportation System Plan as described in section (12) of this rule, will not significantly reduce peak hour travel time for the route as determined pursuant to section (11) of this rule, or the jurisdiction determines that the following alternatives can not reasonably satisfy the purpose of the improvement project:

(a) Improvements to transportation facilities and services within the urban growth boundary;

(b) Transportation system management measures that do not significantly increase capacity; or

(c) Transportation demand management measures. The jurisdiction needs only to consider alternatives that are safe and effective, consistent with applicable standards and that can be implemented at a reasonable cost using available technology.

(11) An improvement project significantly reduces peak hour travel time when, based on recent data, the time to travel the route is reduced more than 15 percent during weekday peak hour conditions over the length of the route located within the urban fringe. For purposes of measuring travel time, a route shall be identified by the predominant traffic flows in the project area.

(12) A "transportation improvement project" described in section (10) of this rule:

(a) Is intended to solve all of the reasonably foreseeable transportation problems within a general geographic location, within the planning period; and

(b) Has utility as an independent transportation project.

Stat. Auth.: ORS 183, 197.040, 197.245

Stats. Implemented: ORS 195.025, 197.040, 197.230, 197.245, 197.712, 197.717

Hist.: LCDC 1-1991, f. & cert. ef. 5-8-91; LCDC 3-1995, f. & cert. ef. 3-31-95; LCDC 4-1995, f. & cert. ef. 5-8-95; LCDD 6-1998, f. & cert. ef. 10-30-98; LCDD 6-2006. f. 7-13-06, cert. ef. 7-14-06

http://arcweb.sos.state.or.us/rules/OARS_600/OAR_660/660_012.html

Appendix A3
Oregon Transportation Plan, Goal 4

GOAL 4 – SUSTAINABILITY

Overview

The concept of sustainability is increasingly applied to help ensure that future generations equitably enjoy the quality of life common to Oregonians today. Sustainability means creating a balance between environmental, economic and community objectives. Sustainability takes into account both local and global views, applying a timeframe that considers costs over lifetimes rather than biennia.

Transportation is a focus of sustainability because it is prominent in many issues that sustainable development and practices aim to address, including urban sprawl, global warming and peaking of the world oil supply. A sustainable transportation system strives to achieve objectives including, but not limited to, the following:

- Reinforce livable and economically strong communities,
- Encourage modal choice throughout the state,
- Support efficient land uses that reduce travel distances and increase travel options,
- Distribute system benefits and burdens equitably across society,
- Be affordable,
- Improve safety to reduce injuries and fatalities,
- Reduce emissions of greenhouse gases to reduce climate change,
- Protect air and water quality from pollutants,
- Operate with clean and fuel-efficient vehicles,
- Use maintenance and construction practices that are compatible with native habitats and species and which consider habitat fragmentation concerns,
- Minimize raw material use and disposal during construction and maintenance, and Apply life-cycle costs to transportation investments.

Goal 4, Sustainability, sets a policy framework that applies to all types of travel and transportation investments. The policies provide guidance on environmental quality, energy supply and creating communities that support the integration of land use and transportation including the key fundamentals of building street networks, connecting modes and utilizing land in efficient ways that reduce travel. Aesthetic and environmental values are underscored as a way to maintain Oregon as a prosperous place to visit, live, work and play. The policies recognize the importance of working with other agencies and jurisdictions on sustainability issues and working with other agency plans such as the *Oregon Conservation Strategy*.

Goal 4 – Sustainability

To provide a transportation system that meets present needs without compromising the ability of future generations to meet their needs from the joint perspective of environmental, economic and community objectives. This system is consistent with, yet recognizes differences in, local and regional land use and economic development plans. It is efficient and offers choices among transportation modes. It distributes benefits and burdens fairly and is operated, maintained and improved to be sensitive to both the natural and built environments.

Policy 4.1 – Environmentally Responsible Transportation System

It is the policy of the State of Oregon to provide a transportation system that is environmentally responsible and encourages conservation and protection of natural resources.

Strategy 4.1.1

Practice stewardship of air, water, land, wildlife and botanical resources. Take into account the natural environments in the planning, design, construction, operation and maintenance of the transportation system. Create transportation systems compatible with native habitats and species and help restore ecological processes, considering such plans as the Oregon Conservation Strategy and the Oregon Plan for Salmon and Watersheds. Where adverse impacts cannot reasonably be avoided, minimize or mitigate their effects on the environment. Work with state and federal agencies and other stakeholders to integrate environmental solutions and goals into planning for infrastructure development and provide for an ecosystem-based mitigation process.

Strategy 4.1.2

Encourage the development and use of technologies that reduce greenhouse gases.

Strategy 4.1.3

Evaluate the impact of geological hazards and natural disasters including earthquakes, floods, landslides and rockfalls, on the efficiency and sustainability of the location and design of new or improved transportation facilities as appropriate.

Strategy 4.1.4

Work collaboratively to streamline permit procedures and gain efficiencies to transportation system improvements while meeting or exceeding environmental benefits or regulations.

Strategy 4.1.5

In the construction and maintenance of transportation infrastructure and facilities, reduce the consumption of non-renewable construction materials, promote their efficient use and reuse, and reduce other environmental impacts such as stormwater impacts where appropriate.

Strategy 4.1.6

To determine the most cost-effective investments, consider using life-cycle costs in transportation maintenance, purchase of equipment, selection of materials, and design and engineering of infrastructure where appropriate.

Strategy 4.1.7

To accomplish environmental stewardship and increase efficiencies, use environmental management systems.

Policy 4.2 – Energy Supply

It is the policy of the State of Oregon to support efforts to move to a diversified and cleaner energy supply, promote fuel efficiencies and prepare for possible fuel shortages.

Strategy 4.2.1

Support efforts to develop a long range plan for moving toward a diversified and cleaner energy supply. Work with federal, state, regional and local jurisdictions and agencies as well as transportation providers, shippers and the general public.

Strategy 4.2.2

Support the conversion of passenger vehicles and public transportation fleets to more fuel-efficient and alternative fuel vehicles, especially to those using renewable and cleaner fuels. Review and change the tax credit provisions to encourage these activities as appropriate.

Strategy 4.2.3

Work with federal, state, regional and local jurisdictions and agencies as well as transportation providers, shippers and the general public to develop a contingency plan for fuel shortages affecting passenger and freight transportation.

APPENDIX B

Traffic Volume Data
(B1) Base Year 2009
(B2) Planning Horizon Year 2035
No-Build Alternative
Enhanced Bus Alternative
Streetcar Alternative
- with Willamette Shore Line Design Option
- with Macadam In-Street Design Option
- with Macadam Additional Lane Design Option

OPERATIONS ENERGY - Existing Year 2009

Traffic Data

Project Information

LOPT Project
Energy Technical Report

Name of Roadway link	Distance (miles)	Speed (mph)	NorthBound Peak Hour Autos	NorthBound Peak Hour Medium Trucks	NorthBound Peak Hour Heavy Trucks	NorthBound Peak Hour Total Trucks	NorthBound ADT Autos	NorthBound ADT All Trucks	NorthBound K-Factor	SouthBound Peak Hour Autos	SouthBound Peak Hour Medium Trucks	SouthBound Peak Hour Heavy Trucks	SouthBound Peak Hour Total Trucks	SouthBound ADT Autos	SouthBound ADT All Trucks	SouthBound K-Factor
Existing Street Network																
Segment One : John's Landing																
Bancroft Street to Hamilton Court	0.21	35	1,127	237	18	255	11,158	2,498	0.10096	954	194	10	204	9,102	2,065	0.10489
Hamilton Court to Boundary Street	0.37	35	1,094	230	18	248	10,834	2,426	0.10096	926	189	9	198	8,838	2,005	0.10489
Boundary Street to Pendleton Street	0.28	35	1,124	236	18	254	11,132	2,492	0.10096	951	194	10	204	9,080	2,060	0.10489
Pendleton Street to Nebraska Street	0.10	35	1,102	232	18	250	10,913	2,443	0.10096	933	190	9	199	8,902	2,019	0.10489
Nebraska Street to Nevada Street	0.30	35	1,090	229	17	246	10,791	2,416	0.10096	922	188	9	197	8,802	1,997	0.10489
Nevada Street to Taylors Ferry Road	0.12	35	1,127	237	18	255	11,158	2,498	0.10096	954	194	10	204	9,102	2,065	0.10489
Total	**1.37**															
Segment Two : Dunthorpe				Northbound							Southbound					
Taylors Ferry Road to Sellwood Bridge (Cemetery intersection)	0.57	35	1,337	345	10	355	11,703	3,099	0.11417	1,230	309	14	323	11,564	2,885	0.10651
Sellwood Bridge (Cemetery intersection) to Riverdale Road	1.02	40	921	238	7	245	8,061	2,134	0.11417	847	213	9	222	7,965	1,987	0.10651
Riverdale Road to Palatine Hill Road	0.35	45	913	236	7	243	7,992	2,116	0.11417	840	211	9	220	7,897	1,970	0.10651
Palatine Hill Road to Military Road	0.31	35	866	224	6	230	7,582	2,008	0.11417	797	200	9	209	7,492	1,869	0.10651
Military Road to Greenwood Road	0.44	35	875	226	6	232	7,659	2,028	0.11417	805	202	9	211	7,568	1,888	0.10651
Greenwood Road to Midvale Road	0.32	45	893	231	6	237	7,814	2,069	0.11417	821	207	9	216	7,722	1,926	0.10651
Midvale Road to Briarwood Road	0.24	45	898	232	7	239	7,858	2,081	0.11417	826	208	9	217	7,764	1,937	0.10651
Briarwood Road to Terwilliger Road	0.30	45	906	234	7	241	7,930	2,100	0.11417	834	210	9	219	7,836	1,955	0.10651
Total	**3.55**															
Segment Three : Lake Oswego				Northbound							Southbound					
Terwilliger Road to B Avenue	0.28	35	1,007	207	20	227	10,914	2,479	0.09225	1,038	230	23	253	10,344	2,510	0.10032
B Avenue to A Avenue	0.09	35	928	191	18	209	10,058	2,285	0.09225	956	212	21	233	9,533	2,313	0.10032
A Avenue to Foothills Road	0.13	35	1,264	260	25	285	13,689	3,110	0.09225	1,302	288	29	317	12,974	3,148	0.10032
Foothills Road to Northshore Road	0.13	35	1,207	248	24	272	13,076	2,970	0.09225	1,243	275	27	302	12,392	3,006	0.10032
Northshore Road to Middlecrest Road	0.18	35	1,183	243	23	266	12,812	2,910	0.09225	1,218	270	27	297	12,142	2,946	0.10032
Middlecrest Road to McVey Avenue	0.14	35	1,221	251	24	275	13,231	3,006	0.09225	1,258	279	28	307	12,540	3,042	0.10032
Total	**0.95**															
Grand Total	**5.88**						**206,365**	**49,168**						**189,559**	**45,593**	

Name of Roadway link	Both Directions Total Peak Autos	Total Peak All Trucks	Total ADT Autos	Total ADT All Trucks	Total VMT - Daily Autos	Total VMT - Daily All Trucks	Total VMT - Daily Total	Total VMT - Annual Autos	Total VMT - Annual All Trucks	Total VMT - Annual Total
Existing Street Network										
Segment One : John's Landing										
Bancroft Street to Hamilton Court	2,081	459	20,260	4,563	4,163	938	5,101	1,519,596	342,247	1,861,843
Hamilton Court to Boundary Street	2,020	446	19,672	4,431	7,250	1,633	8,883	2,646,368	596,079	3,242,447
Boundary Street to Pendleton Street	2,075	458	20,212	4,552	5,727	1,290	7,016	2,090,258	470,753	2,561,010
Pendleton Street to Nebraska Street	2,035	449	19,815	4,462	2,012	453	2,464	734,206	165,331	899,536
Nebraska Street to Nevada Street	2,012	443	19,593	4,413	5,845	1,316	7,161	2,133,244	480,478	2,613,721
Nevada Street to Taylors Ferry Road	2,081	459	20,260	4,563	2,375	535	2,910	866,940	195,254	1,062,194
Total					**27,372**	**6,165**	**33,536**	**9,990,611**	**2,250,140**	**12,240,752**
Segment Two : Dunthorpe										
Taylors Ferry Road to Sellwood Bridge (Cemetery intersection)	2,567	678	23,267	5,984	13,260	3,410	16,670	4,839,734	1,244,723	6,084,457
Sellwood Bridge (Cemetery intersection) to Riverdale Road	1,768	467	16,026	4,121	16,348	4,204	20,551	5,966,923	1,534,362	7,501,285
Riverdale Road to Palatine Hill Road	1,753	463	15,889	4,086	5,618	1,445	7,063	2,050,689	527,353	2,578,042
Palatine Hill Road to Military Road	1,663	439	15,074	3,877	4,719	1,214	5,933	1,722,504	443,024	2,165,529
Military Road to Greenwood Road	1,680	443	15,227	3,916	6,694	1,721	8,415	2,443,140	628,314	3,071,454
Greenwood Road to Midvale Road	1,714	453	15,536	3,995	5,029	1,293	6,322	1,835,440	471,974	2,307,414
Midvale Road to Briarwood Road	1,724	456	15,622	4,018	3,692	950	4,642	1,347,753	346,644	1,694,396
Briarwood Road to Terwilliger Road	1,740	460	15,766	4,055	4,709	1,211	5,920	1,718,748	442,060	2,160,808
Total					**60,068**	**15,448**	**75,516**	**21,924,932**	**5,638,455**	**27,563,386**
Segment Three : Lake Oswego										
Terwilliger Road to B Avenue	2,045	480	21,258	4,989	6,031	1,415	7,447	2,201,371	516,636	2,718,006
B Avenue to A Avenue	1,884	442	19,591	4,598	1,837	431	2,268	670,380	157,338	827,717
A Avenue to Foothills Road	2,566	602	26,663	6,258	3,474	815	4,290	1,268,108	297,634	1,565,743
Foothills Road to Northshore Road	2,450	574	25,468	5,976	3,188	748	3,936	1,163,738	273,068	1,436,806
Northshore Road to Middlecrest Road	2,401	563	24,954	5,856	4,367	1,025	5,392	1,593,937	374,052	1,967,989
Middlecrest Road to McVey Avenue	2,479	582	25,771	6,048	3,719	873	4,592	1,357,517	318,585	1,676,102
Total					**22,617**	**5,308**	**27,924**	**8,255,050**	**1,937,313**	**10,192,363**
Grand Total			**395,924**	**94,761**	**110,056**	**26,920**	**136,977**	**40,170,593**	**9,825,908**	**49,996,501**

Sources

Lake Oswego to Portland Transit Project Transportation Technical Report, David Evans and Associates, Inc. April 2010.

OPERATIONS ENERGY - No-Build Alternative
Traffic Data

Project Information

LOPT Project
Energy Technical Report

Name of Roadway link	Distance (miles)	Speed (mph)	NorthBound Peak Hour Autos	Medium Trucks	Heavy Trucks	Total Trucks	NorthBound ADT Autos	All Trucks	K-Factor	SouthBound Peak Hour Autos	Medium Trucks	Heavy Trucks	Total Trucks	SouthBound ADT Autos	All Trucks	K-Factor	Both Directions Total Peak Autos	All Trucks	Total ADT Autos	All Trucks	Total VMT - Daily Autos	All Trucks	Total	Total VMT - Annual Autos	All Trucks	Total
Existing Street Network																										
Segment One : John's Landing																										
Bancroft Street to Hamilton Court	0.21	35	1,485	312	24	336	14,703	3,292	0.10096	1,257	256	13	269	11,993	2,721	0.10489	2,742	605	26,696	6,013	5,486	1,236	6,721	2,002,326	451,003	2,453,330
Hamilton Court to Boundary Street	0.37	35	1,713	360	27	387	16,956	3,796	0.10096	1,449	295	15	310	13,831	3,138	0.10489	3,162	697	30,787	6,934	11,347	2,556	13,902	4,141,610	932,794	5,074,403
Boundary Street to Pendleton Street	0.28	35	1,669	351	27	378	16,519	3,698	0.10096	1,412	288	14	302	13,474	3,057	0.10489	3,081	680	29,993	6,755	8,498	1,914	10,412	3,101,776	698,580	3,800,356
Pendleton Street to Nebraska Street	0.10	35	1,664	350	27	377	16,475	3,688	0.10096	1,408	287	14	301	13,439	3,049	0.10489	3,072	678	29,914	6,737	3,037	684	3,721	1,108,404	249,626	1,358,031
Nebraska Street to Nevada Street	0.30	35	1,640	345	26	371	16,234	3,634	0.10096	1,388	283	14	297	13,242	3,004	0.10489	3,028	668	29,476	6,638	8,793	1,980	10,773	3,209,283	722,731	3,932,014
Nevada Street to Taylors Ferry Road	0.12	35	1,660	349	27	376	16,431	3,679	0.10096	1,404	286	14	300	13,403	3,040	0.10489	3,064	676	29,834	6,719	3,498	788	4,285	1,276,618	287,511	1,564,129
Total	**1.37**																				**40,658**	**9,157**	**49,814**	**14,840,018**	**3,342,245**	**18,182,263**
Segment Two : Dunthorpe				Northbound							Southbound															
Taylors Ferry Road to Sellwood Bridge (Cemetery intersection)	0.57	35	1,931	499	14	513	16,908	4,477	0.11417	1,777	447	20	467	16,707	4,168	0.10651	3,708	980	33,615	8,645	19,157	4,927	24,083	6,992,206	1,798,234	8,790,440
Sellwood Bridge (Cemetery intersection) to Riverdale Road	1.02	40	1,532	396	11	407	13,411	3,551	0.11417	1,410	354	16	370	13,251	3,306	0.10651	2,942	777	26,662	6,857	27,197	6,995	34,192	9,927,000	2,553,051	12,480,051
Riverdale Road to Palatine Hill Road	0.35	45	1,524	394	11	405	13,338	3,532	0.11417	1,402	353	15	368	13,180	3,288	0.10651	2,926	773	26,518	6,820	9,377	2,412	11,788	3,422,504	880,213	4,302,717
Palatine Hill Road to Military Road	0.31	35	1,470	380	11	391	12,867	3,407	0.11417	1,353	340	15	355	12,714	3,172	0.10651	2,823	746	25,581	6,579	8,009	2,060	10,068	2,923,138	751,782	3,674,920
Military Road to Greenwood Road	0.44	35	1,422	368	10	378	12,450	3,297	0.11417	1,309	329	14	343	12,302	3,069	0.10651	2,731	721	24,752	6,366	10,881	2,798	13,679	3,971,407	1,021,411	4,992,818
Greenwood Road to Midvale Road	0.32	45	1,439	372	10	382	12,595	3,335	0.11417	1,324	333	15	348	12,445	3,105	0.10651	2,763	730	25,040	6,440	8,105	2,084	10,189	2,958,253	760,829	3,719,082
Midvale Road to Briarwood Road	0.24	45	1,437	371	10	381	12,577	3,330	0.11417	1,322	332	15	347	12,427	3,100	0.10651	2,759	728	25,004	6,430	5,910	1,520	7,430	2,157,163	554,734	2,711,897
Briarwood Road to Terwilliger Road	0.30	45	1,443	373	10	383	12,631	3,345	0.11417	1,328	334	15	349	12,481	3,114	0.10651	2,771	732	25,112	6,459	7,500	1,929	9,429	2,737,612	704,135	3,441,747
Total	**3.55**																				**96,135**	**24,724**	**120,859**	**35,089,284**	**9,024,387**	**44,113,672**
Segment Three : Lake Oswego				Northbound							Southbound															
Terwilliger Road to B Avenue	0.28	35	1,666	343	33	376	18,046	4,099	0.09225	1,716	380	38	418	17,103	4,149	0.10032	3,382	794	35,149	8,248	9,972	2,340	12,312	3,639,852	854,121	4,493,973
B Avenue to A Avenue	0.09	35	1,574	324	31	355	17,052	3,874	0.09225	1,621	359	36	395	16,161	3,921	0.10032	3,195	750	33,213	7,795	3,114	731	3,845	1,136,507	266,735	1,403,243
A Avenue to Foothills Road	0.13	35	2,179	448	43	491	23,601	5,361	0.09225	2,244	497	49	546	22,367	5,427	0.10032	4,423	1,037	45,968	10,788	5,990	1,406	7,395	2,186,266	513,084	2,699,350
Foothills Road to Northshore Road	0.13	35	2,011	414	40	454	21,785	4,949	0.09225	2,071	459	45	504	20,647	5,009	0.10032	4,082	958	42,432	9,958	5,312	1,247	6,559	1,938,893	455,022	2,393,915
Northshore Road to Middlecrest Road	0.18	35	1,929	397	38	435	20,899	4,747	0.09225	1,987	440	44	484	19,807	4,805	0.10032	3,916	919	40,706	9,552	7,124	1,672	8,795	2,600,096	610,134	3,210,230
Middlecrest Road to McVey Avenue	0.14	35	1,973	406	39	445	21,375	3,855	0.09225	2,032	450	45	495	20,257	4,915	0.10032	4,005	940	41,632	8,770	6,008	1,266	7,274	2,193,013	461,970	2,654,983
Total	**0.95**																				**37,520**	**8,660**	**46,180**	**13,694,627**	**3,161,066**	**16,855,693**
Grand Total	**5.88**						**326,853**	**76,946**						**301,231**	**72,557**				**628,084**	**149,503**	**174,312**	**42,542**	**216,854**	**63,623,929**	**15,527,698**	**79,151,628**

Sources

Lake Oswego to Portland Transit Project Transportation Technical Report, David Evans and Associates, Inc. April 2010.

OPERATIONS ENERGY - Enhanced Bus Alternative
Traffic Data

Project Information

LOPT Project
Energy Technical Report

Name of Roadway link	Distance	Speed	NorthBound							SouthBound						
	Distance	Speed	Peak Hour				ADT			Peak Hour				ADT		
Name of Roadway link	(miles)	(mph)	Autos	Medium Trucks	Heavy Trucks	Total Trucks	Autos	All Trucks	K-Factor	Autos	Medium Trucks	Heavy Trucks	Total Trucks	Autos	All Trucks	K-Factor
Existing Street Network																
Segment One : John's Landing																
Bancroft Street to Hamilton Court	0.21	35	1,487	313	24	337	14,724	3,296	0.10096	1,259	257	13	270	12,011	2,725	0.10489
Hamilton Court to Boundary Street	0.37	35	1,711	360	27	387	16,934	3,791	0.10096	1,447	295	15	310	13,813	3,134	0.10489
Boundary Street to Pendleton Street	0.28	35	1,658	348	27	375	16,409	3,674	0.10096	1,403	286	14	300	13,385	3,036	0.10489
Pendleton Street to Nebraska Street	0.10	35	1,653	348	26	374	16,365	3,664	0.10096	1,399	285	14	299	13,349	3,028	0.10489
Nebraska Street to Nevada Street	0.30	35	1,629	342	26	368	16,125	3,610	0.10096	1,378	281	14	295	13,153	2,984	0.10489
Nevada Street to Taylors Ferry Road	0.12	35	1,649	347	26	373	16,322	3,654	0.10096	1,395	284	14	298	13,314	3,020	0.10489
Total	**1.37**															
Segment Two : Dunthorpe				Northbound							Southbound					
Taylors Ferry Road to Sellwood Bridge (Cemetery intersection)	0.57	35	1,921	496	14	510	16,818	4,453	0.11417	1,768	444	20	464	16,618	4,146	0.10651
Sellwood Bridge (Cemetery intersection) to Riverdale Road	1.02	40	1,517	392	11	403	13,284	3,517	0.11417	1,396	351	15	366	13,126	3,275	0.10651
Riverdale Road to Palatine Hill Road	0.35	45	1,509	390	11	401	13,211	3,498	0.11417	1,389	349	15	364	13,054	3,257	0.10651
Palatine Hill Road to Military Road	0.31	35	1,455	376	11	387	12,740	3,373	0.11417	1,339	337	15	352	12,589	3,141	0.10651
Military Road to Greenwood Road	0.44	35	1,410	364	10	374	12,341	3,268	0.11417	1,297	326	14	340	12,195	3,042	0.10651
Greenwood Road to Midvale Road	0.32	45	1,424	368	10	378	12,468	3,301	0.11417	1,311	330	14	344	12,320	3,074	0.10651
Midvale Road to Briarwood Road	0.24	45	1,422	368	10	378	12,450	3,297	0.11417	1,309	329	14	343	12,302	3,069	0.10651
Briarwood Road to Terwilliger Road	0.30	45	1,428	369	10	379	12,505	3,311	0.11417	1,314	330	15	345	12,356	3,083	0.10651
Total	**3.55**															
Segment Three : Lake Oswego				Northbound							Southbound					
Terwilliger Road to B Avenue	0.28	35	1,648	339	33	372	17,852	4,055	0.09225	1,697	376	37	413	16,919	4,105	0.10032
B Avenue to A Avenue	0.09	35	1,558	321	31	352	16,879	3,834	0.09225	1,605	355	35	390	15,997	3,881	0.10032
A Avenue to Foothills Road	0.13	35	2,171	447	43	490	23,514	5,342	0.09225	2,236	495	49	544	22,285	5,407	0.10032
Foothills Road to Northshore Road	0.13	35	2,005	412	40	452	21,721	4,934	0.09225	2,065	457	45	502	20,585	4,994	0.10032
Northshore Road to Middlecrest Road	0.18	35	1,959	403	39	442	21,223	4,821	0.09225	2,018	447	44	491	20,114	4,880	0.10032
Middlecrest Road to McVey Avenue	0.14	35	2,003	412	40	452	21,699	4,929	0.09225	2,063	457	45	502	20,565	4,989	0.10032
Total	**0.95**															
Grand Total	**5.88**						**325,584**	**77,622**						**300,050**	**72,270**	

Name of Roadway link	Both Directions									
	Total Peak		Total ADT		Total VMT - Daily			Total VMT - Annual		
Name of Roadway link	Autos	All Trucks	Autos	All Trucks	Autos	All Trucks	Total	Autos	All Trucks	Total
Existing Street Network										
Segment One : John's Landing										
Bancroft Street to Hamilton Court	2,746	607	26,735	6,021	5,494	1,237	6,731	2,005,252	451,604	2,456,855
Hamilton Court to Boundary Street	3,158	697	30,747	6,925	11,332	2,552	13,884	4,136,229	931,583	5,067,812
Boundary Street to Pendleton Street	3,061	675	29,794	6,710	8,442	1,901	10,343	3,081,196	693,926	3,775,122
Pendleton Street to Nebraska Street	3,052	673	29,714	6,692	3,016	679	3,696	1,100,994	247,959	1,348,953
Nebraska Street to Nevada Street	3,007	663	29,278	6,594	8,733	1,967	10,700	3,187,725	717,940	3,905,666
Nevada Street to Taylors Ferry Road	3,044	671	29,636	6,674	3,474	782	4,257	1,268,146	285,585	1,553,731
Total					**40,492**	**9,119**	**49,611**	**14,779,541**	**3,328,597**	**18,108,138**
Segment Two : Dunthorpe										
Taylors Ferry Road to Sellwood Bridge (Cemetery intersection)	3,689	974	33,436	8,599	19,055	4,900	23,955	6,954,973	1,788,665	8,743,638
Sellwood Bridge (Cemetery intersection) to Riverdale Road	2,913	769	26,410	6,792	26,940	6,928	33,869	9,833,173	2,528,849	12,362,023
Riverdale Road to Palatine Hill Road	2,898	765	26,265	6,755	9,287	2,389	11,676	3,389,851	871,824	4,261,675
Palatine Hill Road to Military Road	2,794	739	25,329	6,514	7,930	2,039	9,969	2,894,342	744,354	3,638,696
Military Road to Greenwood Road	2,707	714	24,536	6,310	10,786	2,774	13,559	3,936,750	1,012,426	4,949,176
Greenwood Road to Midvale Road	2,735	722	24,788	6,375	8,023	2,063	10,087	2,928,482	753,150	3,681,631
Midvale Road to Briarwood Road	2,731	721	24,752	6,366	5,850	1,505	7,355	2,135,423	549,212	2,684,635
Briarwood Road to Terwilliger Road	2,742	724	24,861	6,394	7,425	1,910	9,335	2,710,249	697,049	3,407,298
Total					**95,297**	**24,508**	**119,805**	**34,783,243**	**8,945,529**	**43,728,772**
Segment Three : Lake Oswego										
Terwilliger Road to B Avenue	3,345	785	34,771	8,160	9,865	2,315	12,180	3,600,708	845,008	4,445,716
B Avenue to A Avenue	3,163	742	32,876	7,715	3,082	723	3,805	1,124,976	263,998	1,388,973
A Avenue to Foothills Road	4,407	1,034	45,799	10,749	5,968	1,401	7,368	2,178,228	511,229	2,689,457
Foothills Road to Northshore Road	4,070	954	42,306	9,928	5,296	1,243	6,539	1,933,136	453,651	2,386,787
Northshore Road to Middlecrest Road	3,977	933	41,337	9,701	7,234	1,698	8,932	2,640,401	619,651	3,260,052
Middlecrest Road to McVey Avenue	4,066	954	42,264	9,918	6,099	1,431	7,531	2,226,304	522,442	2,748,746
Total					**37,545**	**8,811**	**46,355**	**13,703,753**	**3,215,979**	**16,919,732**
Grand Total			**625,634**	**149,892**	**173,333**	**42,439**	**215,772**	**63,266,537**	**15,490,106**	**78,756,643**

Sources

Lake Oswego to Portland Transit Project Transportation Technical Report, David Evans and Associates, Inc. April 2010.

OPERATIONS ENERGY - Willamette Shore Line Alternative
Traffic Data

Project Information

LOPT Project
Energy Technical Report

Name of Roadway link	Distance (miles)	Speed (mph)	NorthBound Peak Hour Autos	NorthBound Peak Hour Medium Trucks	NorthBound Peak Hour Heavy Trucks	NorthBound Peak Hour Total Trucks	NorthBound ADT Autos	NorthBound ADT All Trucks	NorthBound K-Factor	SouthBound Peak Hour Autos	SouthBound Peak Hour Medium Trucks	SouthBound Peak Hour Heavy Trucks	SouthBound Peak Hour Total Trucks	SouthBound ADT Autos	SouthBound ADT All Trucks	SouthBound K-Factor
Existing Street Network																
Segment One : John's Landing																
Bancroft Street to Hamilton Court	0.21	35	1,474	310	24	334	14,593	3,267	0.10096	1,247	254	13	267	11,904	2,700	0.10489
Hamilton Court to Boundary Street	0.37	35	1,695	356	27	383	16,781	3,757	0.10096	1,434	292	14	306	13,688	3,105	0.10489
Boundary Street to Pendleton Street	0.28	35	1,642	345	26	371	16,256	3,639	0.10096	1,389	283	14	297	13,260	3,008	0.10489
Pendleton Street to Nebraska Street	0.10	35	1,638	344	26	370	16,212	3,630	0.10096	1,386	282	14	296	13,224	3,000	0.10489
Nebraska Street to Nevada Street	0.30	35	1,616	340	26	366	15,993	3,581	0.10096	1,367	279	14	293	13,046	2,959	0.10489
Nevada Street to Taylors Ferry Road	0.12	35	1,635	344	26	370	16,190	3,625	0.10096	1,384	282	14	296	13,207	2,996	0.10489
Total	**1.37**															
Segment Two : Dunthorpe			Northbound							Southbound						
Taylors Ferry Road to Sellwood Bridge (Cemetery intersection)	0.57	35	1,898	491	14	505	16,618	4,400	0.11417	1,747	439	19	458	16,421	4,097	0.10651
Sellwood Bridge (Cemetery intersection) to Riverdale Road	1.02	40	1,501	388	11	399	13,139	3,479	0.11417	1,381	347	15	362	12,983	3,239	0.10651
Riverdale Road to Palatine Hill Road	0.35	45	1,492	386	11	397	13,066	3,460	0.11417	1,374	345	15	360	12,911	3,221	0.10651
Palatine Hill Road to Military Road	0.31	35	1,439	372	10	382	12,595	3,335	0.11417	1,324	333	15	348	12,445	3,105	0.10651
Military Road to Greenwood Road	0.44	35	1,391	360	10	370	12,178	3,225	0.11417	1,280	322	14	336	12,034	3,002	0.10651
Greenwood Road to Midvale Road	0.32	45	1,408	364	10	374	12,323	3,263	0.11417	1,295	326	14	340	12,177	3,038	0.10651
Midvale Road to Briarwood Road	0.24	45	1,408	364	10	374	12,323	3,263	0.11417	1,295	326	14	340	12,177	3,038	0.10651
Briarwood Road to Terwilliger Road	0.30	45	1,414	365	10	375	12,378	3,277	0.11417	1,301	327	14	341	12,231	3,051	0.10651
Total	**3.55**															
Segment Three : Lake Oswego			Northbound							Southbound						
Terwilliger Road to B Avenue	0.28	35	1,628	335	32	367	17,636	4,006	0.09225	1,677	371	37	408	16,714	4,055	0.10032
B Avenue to A Avenue	0.09	35	1,538	316	30	346	16,663	3,785	0.09225	1,584	351	35	386	15,792	3,831	0.10032
A Avenue to Foothills Road	0.13	35	2,151	442	43	485	23,298	5,292	0.09225	2,215	490	49	539	22,080	5,357	0.10032
Foothills Road to Northshore Road	0.13	35	1,985	408	39	447	21,504	4,885	0.09225	2,045	453	45	498	20,380	4,945	0.10032
Northshore Road to Middlecrest Road	0.18	35	1,959	403	39	442	21,223	4,821	0.09225	2,018	447	44	491	20,114	4,880	0.10032
Middlecrest Road to McVey Avenue	0.14	35	2,003	412	40	452	21,699	4,929	0.09225	2,063	457	45	502	20,565	4,989	0.10032
Total	**0.95**															
Grand Total	**5.88**						**322,668**	**76,919**						**297,353**	**71,616**	

Name of Roadway link	Both Directions Total Peak Autos	Total Peak All Trucks	Total ADT Autos	Total ADT All Trucks	Total VMT - Daily Autos	Total VMT - Daily All Trucks	Total VMT - Daily Total	Total VMT - Annual Autos	Total VMT - Annual All Trucks	Total VMT - Annual Total
Segment One : John's Landing										
Bancroft Street to Hamilton Court	2,721	601	26,497	5,967	5,445	1,226	6,671	1,987,400	447,553	2,434,954
Hamilton Court to Boundary Street	3,129	689	30,469	6,862	11,230	2,529	13,759	4,098,831	923,108	5,021,939
Boundary Street to Pendleton Street	3,031	668	29,516	6,647	8,363	1,883	10,246	3,052,446	687,411	3,739,857
Pendleton Street to Nebraska Street	3,024	666	29,436	6,630	2,988	673	3,661	1,090,693	245,662	1,336,355
Nebraska Street to Nevada Street	2,983	659	29,039	6,540	8,662	1,951	10,613	3,161,704	712,061	3,873,765
Nevada Street to Taylors Ferry Road	3,019	666	29,397	6,621	3,446	776	4,223	1,257,919	283,317	1,541,236
Total					**40,134**	**9,039**	**49,173**	**14,648,993**	**3,299,112**	**17,948,105**
Segment Two : Dunthorpe										
Taylors Ferry Road to Sellwood Bridge (Cemetery intersection)	3,645	963	33,039	8,497	18,828	4,842	23,671	6,872,394	1,767,448	8,639,842
Sellwood Bridge (Cemetery intersection) to Riverdale Road	2,882	761	26,122	6,718	26,646	6,853	33,499	9,725,943	2,501,297	12,227,240
Riverdale Road to Palatine Hill Road	2,866	757	25,977	6,681	9,185	2,362	11,548	3,352,681	862,273	4,214,954
Palatine Hill Road to Military Road	2,763	730	25,040	6,440	7,839	2,016	9,855	2,861,318	735,898	3,597,216
Military Road to Greenwood Road	2,671	706	24,212	6,227	10,643	2,737	13,380	3,884,765	999,109	4,883,874
Greenwood Road to Midvale Road	2,703	714	24,500	6,301	7,930	2,039	9,969	2,894,457	744,407	3,638,864
Midvale Road to Briarwood Road	2,703	714	24,500	6,301	5,791	1,489	7,280	2,113,682	543,604	2,657,286
Briarwood Road to Terwilliger Road	2,715	716	24,609	6,328	7,350	1,890	9,240	2,682,777	689,854	3,372,631
Total					**94,214**	**24,230**	**118,444**	**34,388,016**	**8,843,891**	**43,231,908**
Segment Three : Lake Oswego										
Terwilliger Road to B Avenue	3,305	775	34,350	8,061	9,746	2,287	12,033	3,557,112	834,756	4,391,868
B Avenue to A Avenue	3,122	732	32,455	7,616	3,043	714	3,757	1,110,570	260,610	1,371,180
A Avenue to Foothills Road	4,366	1,024	45,378	10,649	5,913	1,388	7,300	2,158,205	506,473	2,664,678
Foothills Road to Northshore Road	4,030	945	41,884	9,830	5,243	1,231	6,474	1,913,853	449,173	2,363,026
Northshore Road to Middlecrest Road	3,977	933	41,337	9,701	7,234	1,698	8,932	2,640,401	619,651	3,260,052
Middlecrest Road to McVey Avenue	4,066	954	42,264	9,918	6,099	1,431	7,531	2,226,304	522,442	2,748,746
Total					**37,278**	**8,748**	**46,026**	**13,606,444**	**3,193,106**	**16,799,550**
Grand Total			**620,021**	**148,535**	**171,626**	**42,017**	**213,643**	**62,643,454**	**15,336,109**	**77,979,562**

Sources

Lake Oswego to Portland Transit Project Transportation Technical Report, David Evans and Associates, Inc. April 2010.

OPERATIONS ENERGY -Macadam In Street Design Option & Additional Lane Design Option
Traffic Data

Project Information

LOPT Project
Energy Technical Report

Name of Roadway link	Distance (miles)	Speed (mph)	NorthBound Peak Hour Autos	NorthBound Peak Hour Medium Trucks	NorthBound Peak Hour Heavy Trucks	NorthBound Peak Hour Total Trucks	NorthBound ADT Autos	NorthBound ADT All Trucks	NorthBound K-Factor	SouthBound Peak Hour Autos	SouthBound Peak Hour Medium Trucks	SouthBound Peak Hour Heavy Trucks	SouthBound Peak Hour Total Trucks	SouthBound ADT Autos	SouthBound ADT All Trucks	SouthBound K-Factor	Both Directions Total Peak Autos	Both Directions Total Peak All Trucks	Both Directions Total ADT Autos	Both Directions Total ADT All Trucks	Total VMT - Daily Autos	Total VMT - Daily All Trucks	Total VMT - Daily Total	Total VMT - Annual Autos	Total VMT - Annual All Trucks	Total VMT - Annual Total
Existing Street Network																										
Segment One : John's Landing																										
Bancroft Street to Hamilton Court	0.21	35	1,478	311	24	335	14,637	3,277	0.10096	1,251	255	13	268	11,939	2,708	0.10489	2,729	603	26,576	5,985	5,461	1,230	6,691	1,993,326	448,903	2,442,229
Hamilton Court to Boundary Street	0.37	35	1,699	357	27	384	16,825	3,767	0.10096	1,438	293	14	307	13,724	3,113	0.10489	3,137	691	30,549	6,880	11,259	2,536	13,795	4,109,593	925,529	5,035,122
Boundary Street to Pendleton Street	0.28	35	1,646	346	26	372	16,291	3,647	0.10096	1,392	284	14	298	13,289	3,015	0.10489	3,038	670	29,580	6,662	8,381	1,888	10,269	3,059,065	688,962	3,748,027
Pendleton Street to Nebraska Street	0.10	35	1,640	345	26	371	16,234	3,634	0.10096	1,388	283	14	297	13,242	3,004	0.10489	3,028	668	29,476	6,638	2,992	674	3,666	1,092,175	245,958	1,338,133
Nebraska Street to Nevada Street	0.30	35	1,616	340	26	366	15,993	3,581	0.10096	1,367	279	14	293	13,046	2,959	0.10489	2,983	659	29,039	6,540	8,662	1,951	10,613	3,161,704	712,061	3,873,765
Nevada Street to Taylors Ferry Road	0.12	35	1,635	344	26	370	16,190	3,625	0.10096	1,384	282	14	296	13,207	2,996	0.10489	3,019	666	29,397	6,621	3,446	776	4,223	1,257,919	283,317	1,541,236
Total	**1.37**																				**40,202**	**9,054**	**49,256**	**14,673,781**	**3,304,731**	**17,978,512**
Segment Two : Dunthorpe				Northbound							Southbound															
Taylors Ferry Road to Sellwood Bridge (Cemetery intersection)	0.57	35	1,902	492	14	506	16,655	4,410	0.11417	1,751	440	19	459	16,457	4,106	0.10651	3,653	965	33,112	8,516	18,870	4,853	23,723	6,887,578	1,771,401	8,658,979
Sellwood Bridge (Cemetery intersection) to Riverdale Road	1.02	40	1,505	389	11	400	13,175	3,489	0.11417	1,385	348	15	363	13,018	3,248	0.10651	2,890	763	26,193	6,737	26,719	6,872	33,591	9,752,378	2,508,371	12,260,750
Riverdale Road to Palatine Hill Road	0.35	45	1,497	387	11	398	13,103	3,469	0.11417	1,377	346	15	361	12,947	3,230	0.10651	2,874	759	26,050	6,699	9,211	2,369	11,580	3,362,103	864,596	4,226,699
Palatine Hill Road to Military Road	0.31	35	1,443	373	10	383	12,631	3,345	0.11417	1,328	334	15	349	12,481	3,114	0.10651	2,771	732	25,112	6,459	7,862	2,022	9,884	2,869,545	738,069	3,607,615
Military Road to Greenwood Road	0.44	35	1,395	361	10	371	12,215	3,234	0.11417	1,284	323	14	337	12,069	3,011	0.10651	2,679	708	24,284	6,245	10,675	2,745	13,420	3,896,317	1,001,997	4,898,314
Greenwood Road to Midvale Road	0.32	45	1,412	365	10	375	12,360	3,273	0.11417	1,299	327	14	341	12,213	3,047	0.10651	2,711	716	24,573	6,320	7,954	2,046	9,999	2,903,081	746,652	3,649,733
Midvale Road to Briarwood Road	0.24	45	1,410	364	10	374	12,341	3,268	0.11417	1,297	326	14	340	12,195	3,041	0.10651	2,707	714	24,536	6,309	5,799	1,491	7,291	2,116,788	544,295	2,661,082
Briarwood Road to Terwilliger Road	0.30	45	1,416	366	10	376	12,396	3,282	0.11417	1,303	328	14	342	12,248	3,056	0.10651	2,719	718	24,644	6,338	7,361	1,893	9,254	2,686,593	690,944	3,377,537
Total	**3.55**																				**94,450**	**24,291**	**118,742**	**34,474,383**	**8,866,325**	**43,340,708**
Segment Three : Lake Oswego				Northbound							Southbound															
Terwilliger Road to B Avenue	0.28	35	1,632	336	32	368	17,679	4,016	0.09225	1,681	372	37	409	16,755	4,065	0.10032	3,313	777	34,434	8,081	9,769	2,293	12,062	3,565,810	836,827	4,402,638
B Avenue to A Avenue	0.09	35	1,542	317	31	348	16,706	3,795	0.09225	1,589	352	35	387	15,833	3,841	0.10032	3,131	735	32,539	7,636	3,051	716	3,766	1,113,444	261,294	1,374,738
A Avenue to Foothills Road	0.13	35	2,153	443	43	486	23,320	5,297	0.09225	2,217	491	49	540	22,101	5,362	0.10032	4,370	1,026	45,421	10,659	5,918	1,389	7,307	2,160,250	506,949	2,667,199
Foothills Road to Northshore Road	0.13	35	1,987	409	39	448	21,526	4,890	0.09225	2,047	453	45	498	20,401	4,949	0.10032	4,034	946	41,927	9,839	5,249	1,232	6,481	1,915,818	449,585	2,365,402
Northshore Road to Middlecrest Road	0.18	35	1,961	403	39	442	21,245	4,826	0.09225	2,020	447	44	491	20,134	4,885	0.10032	3,981	933	41,379	9,711	7,241	1,699	8,941	2,643,084	620,290	3,263,374
Middlecrest Road to McVey Avenue	0.14	35	2,005	412	40	452	21,721	4,934	0.09225	2,065	457	45	502	20,585	4,994	0.10032	4,070	954	42,306	9,928	6,106	1,433	7,538	2,228,517	522,969	2,751,485
Total	**0.95**																				**37,334**	**8,761**	**46,095**	**13,626,922**	**3,197,914**	**16,824,836**
Grand Total	**5.88**						**323,243**	**77,059**						**297,884**	**71,744**				**621,127**	**148,803**	**171,987**	**42,107**	**214,093**	**62,775,087**	**15,368,969**	**78,144,056**

Sources

Lake Oswego to Portland Transit Project Transportation Technical Report, David Evans and Associates, Inc. April 2010.

<u>APPENDIX C</u>

Methodology Sources

(C1) Price Index for Selected Highway Construction Items (Caltrans, 2008)
(C2) Construction Energy Factors, Input-Output Method (Caltrans, 1983)
(C3) Urban Fuel Consumption Rates (Caltrans, 1983)

California
Department of Transportation

Price Index for Selected Highway Construction Items

SUMMARY

First Quarter Ending March 31, 2010

Index this quarter	**346.1**
Point change from last quarter	**+ 141.5**
Percentage change from last quarter	**+ 69.2%**
Index last 12 months	**238.3**
Point change from previous report	**+ 17.8**
Percentage change from previous report	**+ 8.1%**

Average number of bidders this quarter	**8.9**
Change in number of bidders from last quarter	**- 0.4**

Notes: 1. All information shown in this publication was assembled using the 1987 base year.
2. New price indices using the Fisher formula and base year 2007 will be presented for comparison with the current indices in the next publication (second quarter 2010).
3. Beginning the third quarter 2010, only the new indices will be reported in the publication and historical information shown in the current publication will be converted accordingly.

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Date: 4/21/10

California Department of Transportation

Price Index for Selected Highway Construction Items

1st Quarter Ending March 31, 2010

Prepared by Division of Engineering Services - Office Engineer

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NOTE: All information shown in the publication was assembled using the 1987 base year.

The California Price Index for Selected Highway Construction Items for the first quarter of 2010 stands at 346.1, up 141.5 points (69.2 percent) from the fourth quarter of 2009 index of 204.6. The Index for the year-to-date (April 1, 2009 through March 31, 2010) is 238.3, up 17.8 points (8.1 percent) from the fourth quarter of 2009 year-to-date index of 220.5.

Cost increases were recorded in Roadway Excavation, Aggregate Base, Asphalt Concrete Pavement, Portland Cement Concrete (Structure), and Bar Reinforcing Steel, while cost decreases were recorded in Portland Cement Concrete (Pavement) and Structural Steel in the first quarter.

The average number of bidders per project in the first quarter of 2010 is 8.9, down 0.4 bidders per project as compared to 9.3 in the fourth quarter of 2009 and up 0.8 as compared to 8.1 in the corresponding quarter of 2009.

The Engineering News-Record's Construction Cost Index average for the first quarter of 2010 is 8667.6, up 57.8 points or 0.7 % from 8609.9 of the last quarter. The price index uses a 1913 = 100 base.

The U. S. Bureau of Labor Statistics' Consumer Price Index average for the first quarter of 2010 is 217.0, for U. S. City average of All Urban Consumers, up 0.9 points or 0.4 % from 216.2 of the last quarter. The price index uses a 1982-84 =100 base.

Projects Bid Opened

(January 1, 2010 through March 31, 2010)

Range ($)			Number of Projects	%	Amounts of Projects ($)	%
Up to 50,000			0	0.00	0	0.00
50,000	to	100,000	4	2.35	314,217	0.08
100,000	to	250,000	40	23.53	7,390,904	1.80
250,000	to	500,000	48	28.24	17,529,227	4.26
500,000	to	1,000,000	33	19.41	23,186,881	5.63
1,000,000	to	2,500,000	29	17.06	42,645,000	10.36
2,500,000	to	5,000,000	9	5.29	32,591,563	7.92
5,000,000 and above			7	4.12	287,910,887	69.95
Total			**170**	**100.00**	**$411,568,677**	**100.00**

Construction Item Costs Based on English Units

Roadway Excavation: $26.70 per cubic yard

The price increased $19.86 from the average unit price of $6.84 per cubic yard last quarter. Unit bid prices ranged from $10.00 to $1000.00 per cubic yard.

Aggregate Base: $21.79 per ton

The price increased $8.43 from the average unit price of $13.36 per ton last quarter. Unit bid prices ranged from $14.74 to $107.37 per ton.

Asphalt Concrete Pavement: $85.51 per ton

The unit price increased $0.64 from the average unit price of $84.87 per ton last quarter. Unit prices ranged from $50.00 to $894.00 per ton.

Portland Cement Concrete (Pavement): $116.22 per cubic yard

The unit price decreased $24.43 from the average unit price of $140.65 per cubic yard last quarter. Unit prices ranged from $115.00 to $264.00 per cubic yard.

Portland Cement Concrete (Structure): $609.73 per cubic yard

The unit price increased $182.93 from the average unit price of $426.80 per cubic yard last quarter. Unit prices ranged $230.00 to $8,000.00 per cubic yard.

Bar Reinforcing Steel: $0.775 per pound

The unit price increased $0.155 from the average unit price of $0.620 per pound last quarter. Unit prices ranged from $0.60 to $4.00 per pound.

Structural Steel: $2.297 per pound

The unit price decreased $3.151 from the average unit price of $5.448 per pound last quarter. Unit prices ranged from $0.91 to $9.07 per pound.

Construction Item Costs Based on Metric Units

Roadway Excavation: $34.92 per cubic meter

The price increased $25.97 from the average unit price of $8.95 per cubic meter last quarter. Unit bid prices ranged from $13.08 to $1307.95 per cubic meter.

Aggregate Base: $24.02 per tonn

The price increased $9.29 from the average unit price of $14.73 per tonn last quarter. Unit bid prices ranged from $16.24 to $118.35 per tonn.

Asphalt Concrete Pavement: $94.26 per tonn

The unit price increased $0.70 from the average unit price of $93.56 per tonn last quarter. Unit prices ranged from $55.12 to $985.47 per tonn.

Portland Cement Concrete (Pavement): $152.01 per cubic meter

The unit price decreased $31.95 from the average unit price of $183.96 per cubic meter last quarter. Unit prices ranged from $150.41 to $345.30 per cubic meter.

Portland Cement Concrete (Structure): $797.50 per cubic meter

The unit price increased $239.27 from the average unit price of $558.23 per cubic meter last quarter. Unit prices ranged $300.83 to $10,463.61 per cubic meter.

Bar Reinforcing Steel: $1.708 per kilogram

The unit price increased $0.342 from the average unit price of $1.366 per kilogram last quarter. Unit prices ranged from $1.32 to $8.82 per kilogram.

Structural Steel: $5.065 per kilogram

The unit price decreased $6.947 from the average unit price of $12.012 per kilogram last quarter. Unit prices ranged from $2.00 to $20.00 per kilogram.

EXHIBIT A

Price Index for Selected
Highway Construction Items
1987 = 100

YEAR		QTRLY	LAST 12 Months	Annual
1972				30.0
1973				31.2
1974				45.6
1975				46.7
1976				47.7
1977				53.7
1978				62.1
1979				80.1
1980				82.1
1981				90.6
1982				81.3
1983				81.9
1984				93.3
1985				92.7
1986				95.0
1987				100.0
1988				104.4
1989				111.3
1990				113.5
1991				108.2
1992				106.8
1993				113.1
1994				119.0
1995				115.0
1996				119.2
1997				124.8
1998				128.6
1999				139.2
2000				146.2
2001				154.1
2002				142.2
2003				148.6
2004				216.2
2005				268.3
2006	(1st Quarter)	252.8	243.0	
2006	(2nd Quarter)	386.6	265.4	
2006	(3rd Quarter)	380.3	276.1	
2006	(4th Quarter)	300.1		
	(Year)			280.6
2007	(1st Quarter)	363.9	335.3	
2007	(2nd Quarter)	401.4	341.2	
2007	(3rd Quarter)	262.2	309.9	
2007	(4th Quarter)	208.5		
	(Year)			261.1
2008	(1st Quarter)	243.6	249.3	
2008	(2nd Quarter)	250.8	235.7	
2008	(3rd Quarter)	318.4	241.1	
2008	(4th Quarter)	226.9		
	(Year)			252.7
2009	(1st Quarter)	276.5	258.2	
2009	(2nd Quarter)	195.3	253.3	
2009	(3rd Quarter)	301.4	250.2	
2009	(4th Quarter)	204.57		
	(Year)			220.5
2010	(1st Quarter)	346.1	238.3	

EXHIBIT B

California Department Of Transportation
Average Highway Contract Prices
(English Units)

	Roadway Excavation "1" Per Cu Yd	**Aggregate Base Per Ton**	**Asphalt Concrete Pavement Per Ton**	**PCC Pavement Per Cu Yd**	**Class "A" PCC Structure Per Cu Yd**	**Bar Reinforcing Steel Per Lb**	**Structural Steel "2" Per Lb**
1972	0.95	3.21	8.22	19.23	82.08	0.159	0.446
1973	0.75	3.14	9.02	19.24	93.60	0.169	0.635
1974	1.26	4.23	13.01	28.59	115.19	0.329	0.987
1975	1.19	4.70	14.24	30.63	132.10	0.239	0.838
1976	1.32	4.70	13.67	29.64	143.05	0.223	0.504
1977	1.76	5.44	15.15	35.17	150.03	0.239	1.228
1978	1.85	6.18	17.70	41.77	180.77	0.276	0.814
1979	2.36	7.49	22.40	52.39	234.24	0.383	1.960
1980	2.10	8.38	25.51	55.18	235.45	0.378	1.942
1981	3.14	8.63	28.53	59.45	226.84	0.386	2.091
1982	2.58	7.56	24.69	57.10	224.72	0.320	2.155
1983	2.10	9.20	27.57	52.04	225.84	0.335	2.155
1984	3.19	13.67	28.38	55.79	238.48	0.375	2.155
1985	2.77	11.55	30.15	64.13	232.39	0.413	2.288
1986	3.01	12.76	28.82	60.49	249.74	0.412	2.388
1987	2.97	17.57	27.54	70.62	280.40	0.418	2.546
1988	4.16	10.13	27.46	58.66	284.55	0.440	3.956
1989	4.19	10.62	29.43	73.78	303.49	0.483	3.103
1990	4.73	12.05	30.77	68.93	295.24	0.469	2.209
1991	3.08	10.07	33.43	62.64	295.21	0.431	2.284
1992	3.62	9.76	32.46	66.78	265.31	0.419	3.073
1993	4.53	9.89	35.41	66.76	243.79	0.464	2.706
1994	4.68	10.39	37.15	66.45	277.92	0.547	2.334
1995	4.10	10.18	35.29	63.85	298.80	0.499	2.266
1996	3.80	9.74	37.66	65.93	321.88	0.512	2.172
1997	5.25	10.29	36.07	78.48	308.54	0.496	2.337
1998	4.95	11.55	38.78	75.91	319.95	0.553	2.595
1999	6.55	12.86	40.14	77.95	321.22	0.521	3.215
2000	6.21	11.14	45.12	78.14	363.59	0.507	2.754
2001	5.83	14.58	43.89	75.74	425.17	0.612	3.906
2002	4.84	12.42	49.00	74.15	363.50	0.508	3.248
2003	5.05	15.05	48.35	109.96	362.75	0.600	1.710
2004	13.11	16.97	53.55	135.94	399.64	0.947	5.390
2005	14.13	20.61	75.72	171.22	567.31	0.968	2.666
2006	12.80	20.26	86.04	179.67	630.16	1.039	3.734
1st Quarter 2007	27.68	25.60	86.94	215.12	542.12	1.145	5.370
2nd Quarter 2007	29.61	27.30	91.46	223.54	742.32	0.974	7.696
3rd Quarter 2007	10.75	21.66	86.91	214.86	523.68	0.892	52.005
4th Quarter 2007	5.86	16.95	74.41	184.66	507.47	0.814	4.552
Year 2007	**10.84**	**20.54**	**85.48**	**204.69**	**566.25**	**0.935**	**6.966**
1st Quarter 2008	9.45	18.39	78.56	186.38	582.71	0.834	5.300
2nd Quarter 2008	8.10	18.29	85.02	200.07	597.84	1.076	4.923
3rd Quarter 2008	22.46	18.68	80.17	172.03	515.53	1.164	4.001
4th Quarter 2008	11.52	15.27	66.21	164.44	456.43	0.894	6.958
Year 2008	**11.39**	**17.90**	**78.50**	**177.91**	**553.62**	**0.938**	**5.183**
1st Quarter 2009	15.64	23.16	74.48	142.97	664.17	0.552	5.584
2nd Quarter 2009	7.59	14.55	61.38	145.41	479.45	0.664	8.532
3rd Quarter 2009	13.61	14.90	145.00	114.37	460.69	0.572	2.769
4th Quarter 2009	6.84	13.36	84.87	140.65	426.80	0.620	5.448
Year 2009	**9.37**	**14.91**	**80.38**	**125.41**	**484.78**	**0.593**	**4.492**
1st Quarter 2010	26.70	21.79	85.51	116.22	609.73	0.775	2.297

1. Unclassified.
2. Beginning 1st quarter 2003, structural steel includes the furnish and the erect structural steel (bridge).

EXHIBIT B

California Department Of Transportation
Average Highway Contract Prices
(Metric Units)

	Roadway Excavation "1" Per M3	**Aggregate Base Per Tonn**	**Asphalt Concrete Pavement Per Tonn**	**PCC Pavement Per M3**	**Class "A" PCC Structure Per M3**	**Bar Reinforcing Steel Per Kg**	**Structural Steel "2" Per Kg**
1972	1.24	3.54	9.06	25.15	107.36	0.351	0.983
1973	0.98	3.46	9.94	25.16	122.42	0.373	1.400
1974	1.65	4.66	14.34	37.39	150.66	0.725	2.176
1975	1.56	5.18	15.70	40.06	172.78	0.527	1.847
1976	1.73	5.18	15.07	38.77	187.10	0.492	1.111
1977	2.30	6.00	16.70	46.00	196.23	0.527	2.707
1978	2.42	6.81	19.51	54.63	236.44	0.608	1.795
1979	3.09	8.26	24.69	68.52	306.37	0.844	4.321
1980	2.75	9.24	28.12	72.17	307.96	0.833	4.281
1981	4.11	9.51	31.45	77.76	296.70	0.851	4.610
1982	3.37	8.33	27.22	74.68	293.92	0.705	4.751
1983	2.75	10.14	30.39	68.07	295.39	0.739	4.751
1984	4.17	15.07	31.28	72.97	311.92	0.827	4.751
1985	3.62	12.73	33.23	83.88	303.95	0.911	5.044
1986	3.94	14.07	31.77	79.12	326.65	0.908	5.265
1987	3.88	19.37	30.36	92.37	366.75	0.922	5.613
1988	5.44	11.17	30.27	76.72	372.18	0.970	8.721
1989	5.48	11.71	32.44	96.50	396.95	1.065	6.841
1990	6.19	13.28	33.92	90.16	386.16	1.034	4.870
1991	4.03	11.10	36.85	81.93	386.12	0.950	5.035
1992	4.73	10.76	35.78	87.34	347.01	0.924	6.775
1993	5.93	10.90	39.03	87.32	318.87	1.023	5.966
1994	6.12	11.45	40.95	86.91	363.51	1.206	5.146
1995	5.36	11.22	38.90	83.51	390.82	1.100	4.996
1996	5.09	10.74	41.51	86.23	421.00	1.129	4.788
1997	6.87	11.35	39.76	102.65	403.56	1.094	5.152
1998	6.47	12.73	42.75	99.29	418.48	1.219	5.721
1999	8.57	14.17	44.24	101.95	420.15	1.148	7.088
2000	8.12	12.28	49.73	102.21	475.55	1.118	6.071
2001	7.63	16.07	48.39	99.06	556.10	1.349	8.612
2002	6.32	13.70	54.01	96.99	475.44	1.120	7.160
2003	6.60	16.59	53.30	143.82	474.45	1.313	3.769
2004	17.15	18.70	59.03	177.81	522.71	2.087	11.883
2005	18.48	22.72	83.47	223.94	742.02	2.134	5.878
2006	16.75	22.34	94.84	235.00	824.21	2.291	8.231
1st Quarter 2007	36.20	28.22	95.84	281.37	709.07	2.524	11.839
2nd Quarter 2007	38.72	30.10	100.82	292.38	970.91	2.146	16.966
3rd Quarter 2007	14.06	23.87	95.81	281.02	684.95	1.966	114.651
4th Quarter 2007	7.66	18.68	82.02	241.53	663.75	1.794	10.036
Year 2007	**14.18**	**22.64**	**94.23**	**267.73**	**740.62**	**2.062**	**15.358**
1st Quarter 2008	12.36	20.27	86.60	243.78	762.15	1.838	11.685
2nd Quarter 2008	10.60	20.16	93.72	261.68	781.95	2.373	10.853
3rd Quarter 2008	29.38	20.59	88.38	225.01	674.29	2.566	8.822
4th Quarter 2008	15.07	16.83	72.98	215.07	596.99	1.970	15.340
Year 2008	**14.90**	**19.73**	**86.53**	**232.69**	**724.11**	**2.068**	**11.426**
1st Quarter 2009	20.45	25.53	82.10	187.00	868.70	1.216	12.311
2nd Quarter 2009	9.93	16.04	67.66	190.19	627.10	1.464	18.811
3rd Quarter 2009	17.80	16.42	159.84	149.59	602.56	1.261	6.104
4th Quarter 2009	8.95	14.73	93.56	183.96	558.23	1.366	12.012
Year 2009	**12.25**	**16.44**	**88.61**	**164.03**	**634.07**	**1.308**	**9.902**
1st Quarter 2010	34.92	24.02	94.26	152.01	797.50	1.708	5.065

1. Unclassified.
2. Beginning 1st quarter 2003, structural steel includes the furnish and the erect structural steel (bridge).

Exhibit C

California Department of Transportation

Number and Dollar Value of Highway Projects
Total Number of Bids and Average Number of Bidders
(January 1, 2010 through March 31, 2010)

	RANGE 1 Up to $50,000	**RANGE 2** $50,000 to $100,000	**RANGE 3** $100,000 to $250,000	**RANGE 4** $250,000 to $500,000	**RANGE 5** $500,000 to $1,000,000	**RANGE 6** $1,000,000 to $2,500,000	**RANGE 7** $2,500,000 to $5,000,000	**RANGE 8** $5,000,000 and above	**All Projects**
Road Projects									
Number of Projects	0	4	29	35	25	21	9	2	125
Total Value*	$0	$314,217	$5,249,370	$12,840,652	$18,009,038	$31,722,519	$32,591,563	$15,713,571	$116,440,930
Number of Bidders	0	35	274	335	213	163	64	22	1,106
Average No of Bidders	0	8.8	9.4	9.6	8.5	7.8	7.1	11.0	8.8
Structure Projects									
Number of Projects	0	0	11	13	8	7	0	2	41
Total Value*	$0	$0	$2,141,534	$4,688,574	$5,177,843	$9,559,135	$0	$40,248,039	$61,815,125
Number of Bidders	0	0	91	137	61	58	0	24	371
Average No of Bidders	0	0	8.3	10.5	7.6	8.3	0	12.0	9.0
Combination Projects									
Number of Projects	0	0	0	0	0	1	0	3	4
Total Value*	$0	$0	$0	$0	$0	$1,363,346	$0	$231,949,276	$233,312,622
Number of Bidders	0	0	0	0	0	8	0	28	36
Average No of Bidders	0	0	0	0	0	8.0	0	9.3	9.0
Summary									
Number of Projects	0	4	40	48	33	29	9	7	170
Total Value*	$0	$314,217	$7,390,904	$17,529,227	$23,186,881	$42,645,000	$32,591,563	$287,910,887	$411,568,677
Number of Bidders	0	35	365	472	274	229	64	74	1,513
Average No of Bidders	0	8.8	9.1	9.8	8.3	7.9	7.1	10.6	8.9

*Bid Items Only

Average Number of Bidders by Month

JAN	FEB	MAR
10.6	9.2	7.9

Appendix C2
Construction Energy Factors
Input-Output Method

Source: *Energy and Transportation Systems* , 1983. State of California Department of Transportation, Division of Engineering Services, Office of Transportation Laboratory.

Construction Activity	Code	Caltrans Construction Activity	Dollar-to-Energy Factor (Btu/1973$)	Page
Earthwork	13	Site Work	21,079	assumed
	14	Rural Freeway	119,104	C-49
	15	Rural Conventional Highway	113,596	C-49
	16	Rural Freeway Widen	74,354	C-49
	17	Rural Conventional Highway Widen	80,034	C-49
Pavement	18	Urban Freeway	47,332	C-49
	19	Urban Conventional Highway	43,201	C-49
	20	Urban Freeway Widen	42,340	C-49
	21	Urban Conventional Highway Widen	40,103	C-49
	22	Interchange	120,653	C-49
	23	Blanket	59,552	C-49
	24	Bridge Steel Girder	52,323	C-49
Bridges	25	Bridge Concrete Box Girder	48,364	C-49
	26	Landscape Planting	21,170	C-49
	27	Lighting Signals	20,310	C-49

	Dollar-to-Energy Factor (Btu/1973$)	1977$/ 1973$	Dollar-to-Energy	Page
Rural Freeway	69,200	1.721154	119,104	C-49
Rural Conventional Highway	66,000	1.721154	113,596	C-49
Rural Freeway Widen	43,200	1.721154	74,354	C-49
Rural Conventional Highway Widen	46,500	1.721154	80,034	C-49
Urban Freeway	27,500	1.721154	47,332	C-49
Urban Conventional Highway	25,100	1.721154	43,201	C-49
Urban Freeway Widen	24,600	1.721154	42,340	C-49
Urban Conventional Highway Widen	23,300	1.721154	40,103	C-49
Interchange	70,100	1.721154	120,653	C-49
Blanket	34,600	1.721154	59,552	C-49
Bridge Steel Girder	30,400	1.721154	52,323	C-49
Bridge Concrete Box Girder	28,100	1.721154	48,364	C-49
Landscape Planting	12,300	1.721154	21,170	C-49
Lighting Signals	11,800	1.721154	20,310	C-49

SOURCE: ODOT. 1988. Fuel Consumption Rate Estimates Obtained by using Revised Fuel Correction Factors from Caltrans as Predicted by the Motor Fuel Consumption Model, December

Urban Fuel Consumption Rates - HEAVY VEHICLES (gallons/mile)

Year	20 mph	25 mph	30 mph	35 mph	40 mph	45 mph	50 mph	55 mph
1990	5.291	5.780	6.173	6.494	6.711	7.092	7.092	7.246
1991	5.376	5.882	6.250	6.579	6.849	7.042	7.246	7.353
1992	5.435	5.952	6.369	6.667	6.944	7.143	7.353	7.463
1993	5.525	5.952	6.452	6.757	7.042	7.246	7.463	7.576
1994	5.618	6.135	6.536	6.835	7.143	7.353	7.576	7.692
1995	5.682	6.211	6.623	6.944	7.246	7.463	7.634	7.752
1996	5.682	6.211	6.623	6.944	7.246	7.463	7.634	7.752
1997	5.780	6.289	6.711	7.042	7.353	7.576	7.752	7.874
1998	5.848	6.369	6.803	7.143	7.407	7.634	7.874	8.000
1999	5.917	6.494	6.897	7.246	7.519	7.752	8.000	8.130
2000	5.917	6.494	6.897	7.246	7.519	7.752	8.000	8.130
2001	5.988	6.579	6.993	7.353	7.634	7.874	8.065	8.197
2002	6.098	6.667	7.092	7.463	7.752	8.000	8.197	8.333
2003	6.098	6.667	7.092	7.463	7.752	8.000	8.197	8.333
2004	6.098	6.667	7.092	7.463	7.752	8.000	8.197	8.333
2005	6.173	[illegible]	7.194	7.519	7.813	8.065	8.264	8.403
2006	6.173	6.711	7.194	7.519	7.813	8.065	8.264	8.403
2007	**6.452**	**7.042**	**7.519**	**7.874**	**8.197**	**8.475**	**8.696**	**8.850**
2008	6.452	7.042	7.519	7.874	8.197	8.475	8.696	8.850
2009	6.452	7.042	7.519	7.874	8.197	8.475	8.696	8.850
2010	6.452	7.042	7.519	7.874	8.197	8.475	8.696	8.850
2011	6.250	6.849	7.299	7.634	7.937	8.197	8.403	8.547
2012	6.250	6.849	7.299	7.634	7.937	8.197	8.403	8.547
2013	6.250	6.849	7.299	7.634	7.937	8.197	8.403	8.547
2014	6.250	6.849	7.299	7.634	7.937	8.197	8.403	8.547
2015	6.250	6.849	7.299	7.634	8.000	8.197	8.403	8.547
G-Rate	**0.007**	**0.007**	**0.007**	**0.006**	**0.007**	**0.006**	**0.007**	**0.007**
2016	6.292	6.896	7.348	7.683	8.056	8.244	8.461	8.604
2017	6.334	6.943	7.398	7.733	8.113	8.292	8.518	8.661
2018	6.376	6.990	7.448	7.783	8.170	8.340	8.576	8.718
2019	6.419	7.038	7.498	7.834	8.228	8.389	8.635	8.776
2020	6.462	7.086	7.548	7.885	8.286	8.437	8.693	8.834
2021	6.505	7.134	7.599	7.936	8.344	8.486	8.753	8.892
2022	6.548	7.183	7.650	7.987	8.403	8.536	8.812	8.951
2023	6.592	7.232	7.701	8.039	8.462	8.585	8.872	9.011
2024	6.636	7.281	7.753	8.091	8.522	8.635	8.933	9.070
2025	6.681	7.330	7.805	8.144	8.582	8.685	8.993	9.130
2026	6.725	7.380	7.858	8.197	8.643	8.736	9.055	9.191
2027	6.770	7.431	7.911	8.250	8.704	8.786	9.116	9.252
2028	6.816	7.481	7.964	8.303	8.765	8.837	9.178	9.313
2029	6.861	7.532	8.018	8.357	8.827	8.889	9.241	9.375
2030	6.907	7.583	8.072	8.412	8.889	8.940	9.304	9.437

SOURCE: ODOT. 1988. Fuel Consumption Rate Estimates Obtained by using Revised Fuel Correction Factors from Caltrans as Predicted by the Motor Fuel Consumption Model, December

Urban Fuel Consumption Rates - AUTOMOBILES (gallons/mile)

Year	20 mph	25 mph	30 mph	35 mph	40 mph	45 mph	50 mph	55 mph
1990	19.608	21.277	22.727	23.810	24.390	25.000	25.641	26.316
1991	20.000	21.739	22.727	23.810	25.000	25.641	26.316	27.027
1992	20.000	21.739	23.256	24.390	25.000	26.316	26.316	27.027
1993	20.408	22.222	23.256	24.390	25.641	26.316	27.027	27.778
1994	20.408	22.222	23.256	24.390	25.641	26.316	27.027	27.778
1995	20.408	22.222	23.810	25.000	25.641	26.316	27.027	27.778
1996	20.833	22.727	23.810	25.000	26.316	27.027	27.778	28.571
1997	21.277	22.727	24.390	25.641	26.316	27.027	27.778	28.571
1998	21.277	23.256	24.390	25.641	27.027	27.778	28.571	28.571
1999	21.277	23.256	25.000	26.316	27.027	27.778	28.571	29.412
2000	21.739	23.810	25.000	26.316	27.027	27.778	28.571	29.412
2001	21.739	23.810	25.000	26.316	27.027	27.778	28.571	29.412
2002	21.739	23.810	25.641	26.316	27.778	28.571	29.412	29.412
2003	22.222	23.810	25.641	27.027	27.778	28.571	29.412	30.303
2004	22.222	24.390	25.641	27.027	27.778	28.571	29.412	30.303
2005	22.222	24.390	25.641	27.027	27.778	28.571	29.412	30.303
2006	22.222	24.390	25.641	27.027	27.778	28.571	29.412	30.303
2007	**22.222**	**24.390**	**25.641**	**27.027**	**27.778**	**28.571**	**29.412**	**30.303**
2008	22.222	24.390	25.641	27.027	27.778	28.571	29.412	30.303
2009	22.222	24.390	25.641	27.027	28.571	29.412	29.412	30.303
2010	22.222	24.390	25.641	27.027	28.571	29.412	29.412	30.303
2011	22.727	24.390	26.316	27.027	28.571	29.412	30.303	30.303
2012	22.727	24.390	26.316	27.027	28.571	29.412	30.303	30.303
2013	22.727	24.390	26.316	27.778	28.571	29.412	30.303	30.303
2014	22.727	24.390	26.316	27.778	28.571	29.412	30.303	30.303
2015	22.727	24.390	26.316	27.778	28.571	29.412	30.303	31.250
G-Rate	0.006	0.005	0.006	0.006	0.006	0.007	0.007	0.007
2016	22.862	24.524	26.471	27.950	28.753	29.604	30.506	31.466
2017	22.997	24.658	26.626	28.122	28.935	29.797	30.711	31.683
2018	23.134	24.793	26.783	28.296	29.119	29.991	30.917	31.901
2019	23.271	24.929	26.940	28.471	29.304	30.187	31.124	32.121
2020	23.408	25.066	27.099	28.648	29.490	30.383	31.333	32.343
2021	23.547	25.203	27.258	28.825	29.677	30.582	31.543	32.566
2022	23.686	25.341	27.419	29.003	29.866	30.781	31.754	32.790
2023	23.827	25.480	27.580	29.182	30.055	30.982	31.967	33.017
2024	23.968	25.619	27.742	29.363	30.246	31.184	32.181	33.244
2025	24.110	25.760	27.905	29.544	30.438	31.387	32.397	33.474
2026	24.253	25.901	28.069	29.727	30.631	31.592	32.614	33.705
2027	24.396	26.043	28.234	29.911	30.826	31.798	32.833	33.937
2028	24.541	26.185	28.400	30.096	31.022	32.005	33.053	34.171
2029	24.686	26.329	28.567	30.282	31.219	32.214	33.275	34.407
2030	24.832	26.473	28.735	30.470	31.417	32.424	33.498	34.644

SOURCE: ODOT. 1988. Fuel Consumption Rate Estimates Obtained by using Revised Fuel Correction Factors from Caltrans as Predicted by the Motor Fuel Consumption Model.

Urban Fuel Consumption Rates - HEAVY VEHICLES (gallons/mile)

Year	20 mph	25 mph	30 mph	35 mph	40 mph	45 mph	50 mph	55 mph
1990	0.189	0.173	0.162	0.154	0.149	0.141	0.141	0.138
1991	0.186	0.170	0.160	0.152	0.146	0.142	0.138	0.136
1992	0.184	0.168	0.157	0.150	0.144	0.140	0.136	0.134
1993	0.181	0.168	0.155	0.148	0.142	0.138	0.134	0.132
1994	0.178	0.163	0.153	0.146	0.140	0.136	0.132	0.130
1995	0.176	0.161	0.151	0.144	0.138	0.134	0.131	0.129
1996	0.176	0.161	0.151	0.144	0.138	0.134	0.131	0.129
1997	0.173	0.159	0.149	0.142	0.136	0.132	0.129	0.127
1998	0.171	0.157	0.147	0.140	0.135	0.131	0.127	0.125
1999	0.169	0.154	0.145	0.138	0.133	0.129	0.125	0.123
2000	0.169	0.154	0.145	0.138	0.133	0.129	0.125	0.123
2001	0.167	0.152	0.143	0.136	0.131	0.127	0.124	0.122
2002	0.164	0.150	0.141	0.134	0.129	0.125	0.122	0.120
2003	0.164	0.150	0.141	0.134	0.129	0.125	0.122	0.120
2004	0.164	0.150	0.141	0.134	0.129	0.125	0.122	0.120
2005	0.162	0.149	0.139	0.133	0.128	0.124	0.121	0.119
2006	0.162	0.149	0.139	0.133	0.128	0.124	0.121	0.119
2007	**0.155**	**0.142**	**0.133**	**0.127**	**0.122**	**0.118**	**0.115**	**0.113**
2008	0.155	0.142	0.133	0.127	0.122	0.118	0.115	0.113
2009	0.155	0.142	0.133	0.127	0.122	0.118	0.115	0.113
2010	0.155	0.142	0.133	0.127	0.122	0.118	0.115	0.113
2011	0.160	0.146	0.137	0.131	0.126	0.122	0.119	0.117
2012	0.160	0.146	0.137	0.131	0.126	0.122	0.119	0.117
2013	0.160	0.146	0.137	0.131	0.126	0.122	0.119	0.117
2014	0.160	0.146	0.137	0.131	0.126	0.122	0.119	0.117
2015	0.160	0.146	0.137	0.131	0.125	0.122	0.119	0.117
G-Rate	**-0.007**	**-0.007**	**-0.007**	**-0.006**	**-0.007**	**-0.006**	**-0.007**	**-0.007**
2016	0.159	0.145	0.136	0.130	0.124	0.121	0.118	0.116
2017	0.158	0.144	0.135	0.129	0.123	0.121	0.117	0.115
2018	0.157	0.143	0.134	0.128	0.122	0.120	0.117	0.115
2019	0.156	0.142	0.133	0.128	0.122	0.119	0.116	0.114
2020	0.155	0.141	0.132	0.127	0.121	0.119	0.115	0.113
2021	0.154	0.140	0.132	0.126	0.120	0.118	0.114	0.112
2022	0.153	0.139	0.131	0.125	0.119	0.117	0.113	0.112
2023	0.152	0.138	0.130	0.124	0.118	0.116	0.113	0.111
2024	0.151	0.137	0.129	0.124	0.117	0.116	0.112	0.110
2025	0.150	0.136	0.128	0.123	0.117	0.115	0.111	0.110
2026	0.149	0.135	0.127	0.122	0.116	0.114	0.110	0.109
2027	0.148	0.135	0.126	0.121	0.115	0.114	0.110	0.108
2028	0.147	0.134	0.126	0.120	0.114	0.113	0.109	0.107
2029	0.146	0.133	0.125	0.120	0.113	0.113	0.108	0.107
2030	**0.145**	**0.132**	**0.124**	**0.119**	**0.112**	**0.112**	**0.107**	**0.106**

SOURCE: ODOT. 1988. Fuel Consumption Rate Estimates Obtained by using Revised Fuel Correction Factors from Caltrans as Predicted by the Motor Fuel Consumption Model.

Urban Fuel Consumption Rates - AUTOMOBILES (gallons/mile)

Year	20 mph	25 mph	30 mph	35 mph	40 mph	45 mph	50 mph	55 mph
1990	0.051	0.047	0.044	0.042	0.041	0.040	0.039	0.038
1991	0.050	0.046	0.044	0.042	0.040	0.039	0.038	0.037
1992	0.050	0.046	0.043	0.041	0.040	0.038	0.038	0.037
1993	0.049	0.045	0.043	0.041	0.039	0.038	0.037	0.036
1994	0.049	0.045	0.043	0.041	0.039	0.038	0.037	0.036
1995	0.049	0.045	0.042	0.040	0.039	0.038	0.037	0.036
1996	0.048	0.044	0.042	0.040	0.038	0.037	0.036	0.035
1997	0.047	0.044	0.041	0.039	0.038	0.037	0.036	0.035
1998	0.047	0.043	0.041	0.039	0.037	0.036	0.035	0.035
1999	0.047	0.043	0.040	0.038	0.037	0.036	0.035	0.034
2000	0.046	0.042	0.040	0.038	0.037	0.036	0.035	0.034
2001	0.046	0.042	0.040	0.038	0.037	0.036	0.035	0.034
2002	0.046	0.042	0.039	0.038	0.036	0.035	0.034	0.034
2003	0.045	0.042	0.039	0.037	0.036	0.035	0.034	0.033
2004	0.045	0.041	0.039	0.037	0.036	0.035	0.034	0.033
2005	0.045	0.041	0.039	0.037	0.036	0.035	0.034	0.033
2006	0.045	0.041	0.039	0.037	0.036	0.035	0.034	0.033
2007	**0.045**	**0.041**	**0.039**	**0.037**	**0.036**	**0.035**	**0.034**	**0.033**
2008	0.045	0.041	0.039	0.037	0.036	0.035	0.034	0.033
2009	0.045	0.041	0.039	0.037	0.035	0.034	0.034	0.033
2010	0.045	0.041	0.039	0.037	0.035	0.034	0.034	0.033
2011	0.044	0.041	0.038	0.037	0.035	0.034	0.033	0.033
2012	0.044	0.041	0.038	0.037	0.035	0.034	0.033	0.033
2013	0.044	0.041	0.038	0.036	0.035	0.034	0.033	0.033
2014	0.044	0.041	0.038	0.036	0.035	0.034	0.033	0.033
2015	0.044	0.041	0.038	0.036	0.035	0.034	0.033	0.032
G-Rate	**-0.006**	**-0.005**	**-0.006**	**-0.006**	**-0.006**	**-0.006**	**-0.007**	**-0.007**
2016	0.044	0.041	0.038	0.036	0.035	0.034	0.033	0.032
2017	0.043	0.041	0.038	0.036	0.035	0.034	0.033	0.032
2018	0.043	0.040	0.037	0.035	0.034	0.033	0.032	0.031
2019	0.043	0.040	0.037	0.035	0.034	0.033	0.032	0.031
2020	0.043	0.040	0.037	0.035	0.034	0.033	0.032	0.031
2021	0.042	0.040	0.037	0.035	0.034	0.033	0.032	0.031
2022	0.042	0.039	0.036	0.034	0.033	0.032	0.031	0.030
2023	0.042	0.039	0.036	0.034	0.033	0.032	0.031	0.030
2024	0.042	0.039	0.036	0.034	0.033	0.032	0.031	0.030
2025	0.041	0.039	0.036	0.034	0.033	0.032	0.031	0.030
2026	0.041	0.039	0.036	0.034	0.033	0.032	0.031	0.030
2027	0.041	0.038	0.035	0.033	0.032	0.031	0.030	0.029
2028	0.041	0.038	0.035	0.033	0.032	0.031	0.030	0.029
2029	0.041	0.038	0.035	0.033	0.032	0.031	0.030	0.029
2030	**0.040**	**0.038**	**0.035**	**0.033**	**0.032**	**0.031**	**0.030**	**0.029**

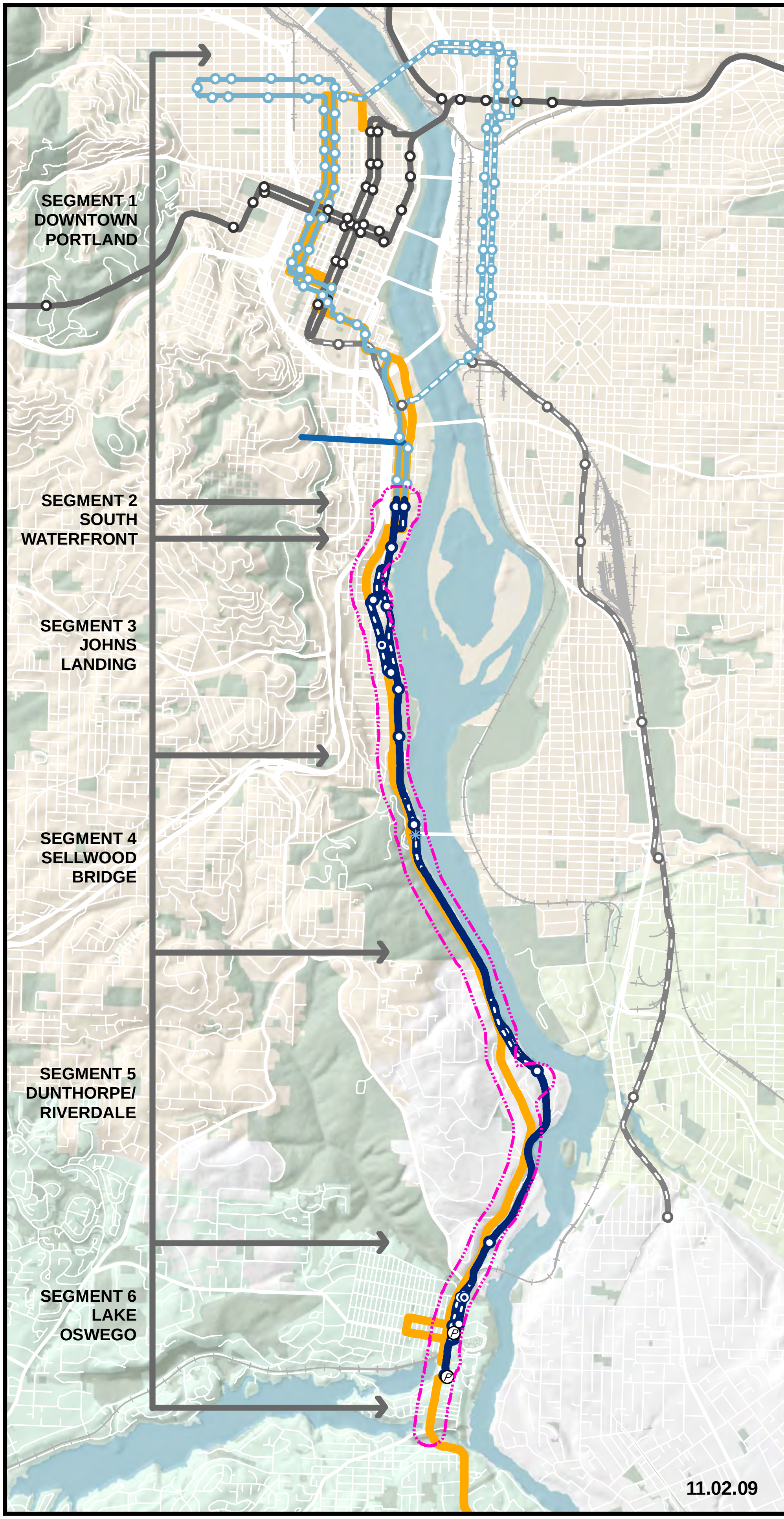
APPENDIX D

Energy Analysis Study Area

Lake Oswego to Portland
TRANSIT PROJECT

Energy Analysis Study Area

Figure 3.12-1



Study Area for Energy Analysis

Streetcar Alternative

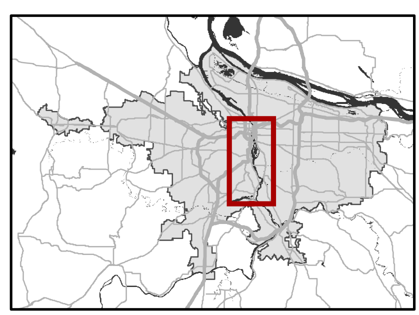
- Streetcar Alternative
- Streetcar Alternative design option
- Station
- Possible Future
- Park-and-Ride
- Streetcar Minimum Operable Segment

Enhanced Bus Alternative

- Enhanced Bus Alternative

Transit: Existing/Planned

- Streetcar, Existing
- Streetcar, Under Construction
- Streetcar, Planned
- MAX, Existing
- MAX,Planned
- Portland Aerial Tram



0 0.4 0.8 Miles

<u>APPENDIX E</u>

Operations Energy Calculations

(E1) <u>Corridor Analysis Energy Analysis Calculations</u>
(E2) <u>Regional Analysis Energy Analysis Calculations</u>

Lake Oswego to Portland Transit
Operations Energy Calculations
Corridor Analysis

Conversion Factors

Energy Conversi	Gas	125,000
	Diesel	138,700

GIVEN DATA AND TABLES

2005 Vehicle Distribution; Portland Metropolitan Area

Vehicle Type	Percent of VMT[1]	Avg Fuel Consumption (MPG)[2]
LD Gas Automobiles	49.4	22.4
LD Gas Trucks	29.0	18.7
MD Gas Trucks	11.0	14.2
HD Gas Trucks	3.2	5.9
LD Diesel Automobiles	0.1	28.3
LD Diesel Trucks	0.2	24.0
HD Diesel Vehicles	6.5	6.3
Transit Bus Vehicles (Diesel)	0.2	6.3
Commuter Rail (Diesel)	0.0	6.3
Motorcycles (Gas)	0.4	50.0

[1]DEQ 2000

[2]FHWA 2000

Average Weekday Corridor[1] Transit Service Characteristics, Year 2035

TRANSIT VMT	No-Build	Enhanced Bus	Macadam In-Street	WSL
Bus	3,230	3,800	2,310	2,310
Streetcar[2]	280	280	1,290	1,260
Total	3,510	4,080	3,600	3,570

Source: Metro, 2010.

[1] Excludes Downtown Portland and NY Portland Districts to isolate transit lines that primarily serve the corridor.

[2] For Streetcar, transit VMT is measured in train miles, rather than in car miles.

** In energy calculations to right, we used streetcar in car miles

2035 Vehicle Distribution; Portland Metropolitan Area

Vehicle Type	Percent of VMT[1]	Avg Fuel Consumption (MPG)[2]
LD Gas Automobiles	49.4	22.9
LD Gas Trucks	29.0	18.7
MD Gas Trucks	11.0	14.2
HD Gas Trucks	3.2	5.9
LD Diesel Automobiles	0.1	28.3
LD Diesel Trucks	0.2	24.0
HD Diesel Vehicles	6.5	6.3
Transit Bus Vehicles (Diesel)	0.2	6.3
Commuter Rail (Diesel)	0.0	6.3
Motorcycles (Gas)	0.4	50.0

[1]DEQ 2000

[2]FHWA 2000

Transportation Operations Energy Consumption in 2035
No-Build Alternative

Vehicle Type	Percent of VMT[1]	Daily VMT[2]	Average Fuel Consumption (MPG)[3]	Daily Fuel Consumption (Gallons)	Daily Energy Consumption (Billions of Btu)
LD Gas Automobiles		174,312		5,489	0.686
LD Gas Trucks					
MD Gas Trucks					
HD Gas Trucks					
LD Diesel Automobiles					
LD Diesel Trucks					
HD Diesel Vehicles		42,542		4,873	0.676
Transit Bus Vehicles		3,230	6.3	513	0.071
Commuter Rail					
Motorcycles					
Subtotal	**0.0**	**220,084**		**10,875**	**1.433**
Non-Fuel Source Transit System[4]					0.00000
Vehicle Maintenance[5]					0.161
LDV 505 Btu/Mile					0.088
MDV 1,186 Btu/Mile					0.000
HDV 1,714 Btu/Mile					0.073
Bus 1,714 Btu/Mile					0.006
Rail 1,714 Btu/Mile					0.000
LRT Maintenance Facility Operation					0.001
Bus Maintenance Facility Operation					0.055
Park and Ride Operation					
Total				**14,533**	**1.817**

Notes:Btu=British Thermal Unit, Btu/gallon of gasoline=125,000(gross), Btu/gallon of diesel=138,700(gross)

HD=Heavy Duty, HDV=Heavy Duty Vehicle, LD=Light Duty, LDV=Light Duty Vehicle, MD=Medium Duty

[1]DEQ 2000

[2]Metro 2010; distribution for LD Gas Vehicles is adjusted from 49.5 to 49.4 to assure total distribution equals 100%

[3]FHWA 2000

[4]Includes MAX, Portland Streetcar, and Portland Aerial Tram

[5]CALTRANS 1983

Transportation Operations Energy Consumption in 2035
Enhanced Bus Alternative

Vehicle Type	Percent of VMT[1]	Daily VMT[2]	Average Fuel Consumption (MPG)[3]	Daily Fuel Consumption (Gallons)	Daily Energy Consumption (Billions of Btu)
LD Gas Automobiles		173,333		5,459	0.682
LD Gas Trucks					
MD Gas Trucks					
HD Gas Trucks					
LD Diesel Automobiles					
LD Diesel Trucks					
HD Diesel Vehicles		42,439		4,862	0.674
Transit Bus Vehicles		3,800	6.3	603	0.084
Commuter Rail					
Motorcycles					
Subtotal	**0.0**	**219,572**		**10,924**	**1.440**
Non-Fuel Source Transit System[4]					0.00000
Vehicle Maintenance[5]					0.161
LDV 505 Btu/Mile					0.088
MDV 1,186 Btu/Mile					0.000
HDV 1,714 Btu/Mile					0.073
Bus 1,714 Btu/Mile					0.007
Rail 1,714 Btu/Mile					0.000
LRT Maintenance Facility Operation					0.001
Bus Maintenance Facility Operation					0.055
Park and Ride Operation					
Total				**14,593**	**1.824**

Notes: Btu=British Thermal Unit, Btu/gallon of gasoline=125,000(gross), Btu/gallon of diesel=138,700(gross)

HD=Heavy Duty, HDV=Heavy Duty Vehicle, LD=Light Duty, LDV=Light Duty Vehicle, MD=Medium Duty

[1]DEQ 2000

[2]Metro 2010; distribution for LD Gas Vehicles is adjusted from 49.5 to 49.4 to assure total distribution equals 100%

[3]FHWA 2000

[4]Includes MAX, Portland Streetcar, and Portland Aerial Tram

[5]CALTRANS 1983

Transportation Operations Energy Consumption in 2035
Willamette Shore Line Alternative

Vehicle Type	Percent of VMT[1]	Daily VMT[2]	Average Fuel Consumption (MPG)[3]	Daily Fuel Consumptio n (Gallons)	Daily Energy Consumpti on (Billions of Btu)
LD Gas Automobiles		171,626		5,405	0.676
LD Gas Trucks					
MD Gas Trucks					
HD Gas Trucks					
LD Diesel Automobiles					
LD Diesel Trucks					
HD Diesel Vehicles		42,017		4,814	0.668
Transit Bus Vehicles		2,310	6.3	367	0.051
Commuter Rail					
Motorcycles					
Subtotal	**0.0**	**215,953**		**10,586**	**1.394**
Non-Fuel Source Transit Systen		5.88			0.00012
Vehicle Maintenance[5]					0.159
LDV 505 Btu/Mile					0.087
MDV 1,186 Btu/Mile					0.000
HDV 1,714 Btu/Mile					0.072
Bus 1,714 Btu/Mile					0.004
Rail 1,714 Btu/Mile					0.000
LRT Maintenance Facility Operation					0.001
Bus Maintenance Facility Operation					0.055
Park and Ride Operation					
Total				**14,176**	**1.772**

Notes: Btu=British Thermal Unit, Btu/gallon of gasoline=125,000(gross), Btu/gallon of diesel=138,700(gross)

HD=Heavy Duty, HDV=Heavy Duty Vehicle, LD=Light Duty, LDV=Light Duty Vehicle, MD=Medium Duty

[1]DEQ 2000

[2]Metro 2010; distribution for LD Gas Vehicles is adjusted from 49.5 to 49.4 to assure total distribution equals 100%

[3]FHWA 2000

[4]Includes MAX, Portland Streetcar, and Portland Aerial Tram

Energy consumption calculated as (6kwh/car mile) x (5.88 car miles) x (3,412 Btu/kwh)

[5]CALTRANS 1983

Transportation Operations Energy Consumption in 2035
Macadam In-Street Alternative

Vehicle Type	Percent of VMT[1]	Daily VMT[2]	Average Fuel Consumption (MPG)[3]	Daily Fuel Consump tion (Gallons)	Daily Energy Consumptio n (Billions of Btu)
LD Gas Automobiles		171,987		5,416	0.677
LD Gas Trucks					
MD Gas Trucks					
HD Gas Trucks					
LD Diesel Automobiles					
LD Diesel Trucks					
HD Diesel Vehicles		42,107		4,824	0.669
Transit Bus Vehicles		2,310	6.3	367	0.051
Commuter Rail					
Motorcycles					
Subtotal	**0.0**	**216,404**		**10,607**	**1.397**
Non-Fuel Source Transit Syster		6.00			0.00012
Vehicle Maintenance[5]					0.159
LDV 505 Btu/Mile					0.087
MDV 1,186 Btu/Mile					0.000
HDV 1,714 Btu/Mile					0.072
Bus 1,714 Btu/Mile					0.004
Rail 1,714 Btu/Mile					0.000
LRT Maintenance Facility Operation					0.001
Bus Maintenance Facility Operation					0.055
Park and Ride Operation					
Total				**14,200**	**1.775**

Notes: Btu=British Thermal Unit, Btu/gallon of gasoline=125,000(gross), Btu/gallon of diesel=138,700(gross)

HD=Heavy Duty, HDV=Heavy Duty Vehicle, LD=Light Duty, LDV=Light Duty Vehicle, MD=Medium Duty

[1]DEQ 2000

[2]Metro 2010; distribution for LD Gas Vehicles is adjusted from 49.5 to 49.4 to assure total distribution equals 100%

[3]FHWA 2000

[4]Includes MAX, Portland Streetcar, and Portland Aerial Tram

Energy consumption calculated as (6kwh/car mile) x (5.88 car miles) x (3,412 Btu/kwh)

[5]CALTRANS 1983

SUMMARY

Daily Corridor Transportation Operations Energy Consumption in 2035 (Billions of Btu) Alternatives Summary

Vehicle Type	No-Build	Enhanced Bus	WSL	Macadam In Street
LD Gas Automobiles	0.6861	0.6824	0.6756	0.6770
LD Gas Trucks				
MD Gas Trucks				
HD Gas Trucks				
LD Diesel Automobiles				
LD Diesel Trucks				
HD Diesel Vehicles	0.6759	0.6744	0.6677	0.6691
Commuter Rail (Diesel)				
Motorcycles (Gas)				
Motor Vehicle Operations	1.3620	1.3567	1.3433	1.3461
Vehicle Maintenance[5]	0.1610	0.1610	0.1590	0.1590
Subtotal - Motor Vehicle Energy Use	**1.5230**	**1.5177**	**1.5023**	**1.5051**
Transit Bus Vehicles (Diesel)	0.0711	0.0837	0.0509	0.0509
Non-Fuel Source Transit System[4]	0.0000	0.0000	0.0001	0.0001
Subtotal - Transit Energy Use	**0.0711**	**0.0837**	**0.0510**	**0.0510**
Bus Vehicle Maintenance Operations	0.0055	0.0065	0.0040	0.0040
Bus Maintenance Facility Operation	0.0550	0.0550	0.0550	0.0550
LRT Maintenance Facility Operation	0.0010	0.0010	0.0010	0.0010
Subtotal Transit Maintenance Energy	**0.0615**	**0.0625**	**0.0600**	**0.0600**
LDV 505 Btu/Mile	0.0880	0.0875	0.0867	0.0869
MDV 1,186 Btu/Mile	0.0000	0.0000	0.0000	0.0000
HDV 1,714 Btu/Mile	0.0729	0.0727	0.0720	0.0722
Rail 1,714 Btu/Mile	0.0000	0.0000	0.0000	0.0000
Subtotal Rail & Deisel Energy Use	**0.1609**	**0.1603**	**0.1587**	**0.1590**
Park and Ride Operation	0.0000	0.0000	0.0000	0.0000
Total (Billions of Btu/day)	**1.8166**	**1.8242**	**1.7720**	**1.7751**
Total (gallons/day)	14,533	14,593	14,176	14,200

Notes: Btu=British Thermal Unit, Btu/gallon of gasoline=125,000(gross), Btu/gallon of diesel=138,700(g

HD=Heavy Duty, HDV=Heavy Duty Vehicle, LD=Light Duty, LDV=Light Duty Vehicle, MD=Medium Duty

[1]DEQ 2000

[2]Metro 2010; distribution for LD Gas Vehicles is adjusted from 49.5 to 49.4 to assure total distribution equals 100%

[3]FHWA 2000

[4]Includes MAX, Portland Streetcar, and Portland Aerial Tram, Energy consumption calculated as (6kwh/car mile) x (6 car miles) x (3,412 Btu/kwh)

[5]CALTRANS 1983

Summary of Annual[1] Energy Consumption by Alternatives (Billions of Btu[2])

Alternatives	Motor Vehicle[3] Annual Energy Use	Bus Annual Energy Use	LRT Annual Energy Use	Total Annual Operations Energy (Billions of Btu2)	Total Fuel Consumption (gal/year)	Annual Operational Energy Savings[4]
No-Build Alternative	548	45	0.34	593	4,747,735	0.00
Enhanced Bus Alternative	542	49	0.34	592	4,734,218	1.69
Willamette Shore Line Alternativ	547	37	0.38	585	4,681,378	8.29
Macadam In-Street Alternative	549	37	0.38	586	4,689,813	7.24

Sources:

[1]Assumes an annualization factor of 340 days per year.

[2]Btu = British Thermal Units. One gallon of gasoline = 125,000 Btu

[3]Not including buses.

[4]As compared to No-Build Alternative

Comparison of Corridor Operations Energy Consumption, Future Year 2035

	Daily			Annual[2]		
Project Alternatives and Design Options (DO)	Vehicle Miles Traveled (Daily VMT)	Energy Consumption[1] (Billions of Btu/day)	Fuel Consumption (gal/day)	Vehicle Miles Traveled (Annual VMT)	Energy Consumption[1] (Billions of Btu/year)	Fuel Consumption (gal/year)
No-Build Alternative	220,084	1.817	14,533	79,151,628	593	4,747,735
Enhanced Bus Alternative	219,572	1.824	14,593	78,756,643	592	4,734,218
Streetcar Alternative						
with Willamette Shore Line DO	215,953	1.772	14,176	77,979,562	585	4,681,378
with Macadam In-Street DO	216,404	1.775	14,200	78,144,056	586	4,689,813
with Macadam Additional Lane DO	216,404	1.775	14,200	78,144,056	586	4,689,813
Percent Decrease in Energy Consumption as Compared to the No-Build Alternative						
Enhanced Bus Alternative	0.23%	-0.42%	-0.42%	0.50%	0.28%	0.28%
Streetcar Alternative						
with Willamette Shore Line DO	1.88%	2.46%	2.46%	1.48%	1.40%	1.40%
with Macadam In-Street DO	1.67%	2.29%	2.29%	1.27%	1.22%	1.22%
with Macadam Additional Lane DO	1.67%	2.29%	2.29%	1.27%	1.22%	1.22%
Net Difference In 2035 Energy Consumption as Compared to the No-Build Alternative						
Enhanced Bus Alternative	512	(0.008)	(61)	394,985	1.68968338	13,517
Streetcar Alternative						
with Willamette Shore Line DO	4,131	0.045	357	1,172,066	8.294702262	66,358
with Macadam In-Street DO	3,680	0.042	332	1,007,572	7.240305601	57,922
with Macadam Additional Lane DO	3,680	0.042	332	1,007,572	7.240305601	58,800

Sources: URS Corporation 2010, Metro 2010, DEA, Inc. 2010

Lake Oswego to Portland Transit Project Transporation Technical Report (DEA Inc. and Metro/TriMet, March 2010)

Btu = British Thermal Unit

VMT = Vehicle Miles Traveled

[1] Energy Consumption, Auto: Btu/gallon = 125,000, Trucks: Btu/gallon of diesel = 139,000

[2] Annual energy consumptions are estimates only and do not accurately account for variations in seasonal energy use

Lake Oswego to Portland Transit

Operations Energy Calculations

Regional Analysis

GIVEN DATA AND TABLES

2005 Vehicle Distribution; Portland Metropolitan Area

Vehicle Type	Percent of VMT[1]	Avg Fuel Consumption (MPG)[2]
LD Gas Automobiles	49.4	22.4
LD Gas Trucks	29.0	18.7
MD Gas Trucks	11.0	14.2
HD Gas Trucks	3.2	5.9
LD Diesel Automobiles	0.1	28.3
LD Diesel Trucks	0.2	24.0
HD Diesel Vehicles	6.5	6.3
Transit Bus Vehicles (Diesel)	0.2	6.3
Commuter Rail (Diesel)	0.0	6.3
Motorcycles (Gas)	0.4	50.0

[1]DEQ 2000

[2]FHWA 2000

Average Weekday Regional Roadway Data, Year 2035

	No-Build	Enhanced Bus	Macadam In-Street	WSL
Vehicle Miles Traveled (VMT)[1]	63,090,900	63,049,900	63,025,500	63,022,900
VMT Change from No-Build	N/A	-41,000	-65,400	-67,900
Vehicle Hours Traveled (VHT)[1]	2,371,900	2,368,600	2,366,500	2,366,200
VHT Change from No-Build	N/A	-3,300	-5,400	-5,700
Vehicle Hours of Delay (VHD)[1,2]	49,300	49,100	48,900	48,900
VHD Change from No-Build	N/A	-200	-400	-400

Source: Metro, 2010.

[1] Based on average weekday conditions in 2035.

[2] Based on P.M. peak-hour conditions in 2035 on freeways, major and minor arterials and collector streets.

2035 Vehicle Distribution; Portland Metropolitan Area

Vehicle Type	Percent of VMT[1]	Avg Fuel Consumption (MPG)[2]
LD Gas Automobiles	49.4	22.9
LD Gas Trucks	29.0	18.7
MD Gas Trucks	11.0	14.2
HD Gas Trucks	3.2	5.9
LD Diesel Automobiles	0.1	28.3
LD Diesel Trucks	0.2	24.0
HD Diesel Vehicles	6.5	6.3
Transit Bus Vehicles (Diesel)	0.2	6.3
Commuter Rail (Diesel)	0.0	6.3
Motorcycles (Gas)	0.4	50.0

[1]DEQ 2000

[2]FHWA 2000

Conversion Factors

Energy Conversion	Gas	125,000
	Diesel	138,700

Transportation Operations Energy Consumption in 2035
No-Build Alternative

Vehicle Type	Percent of VMT[1]	Daily VMT[2]	Average Fuel Consumption (MPG)[3]	Daily Fuel Consumption (Gallons)	Daily Energy Consumption (Billions of Btu)
LD Gas Automobiles	49.4	31,166,905	22.9	1,361,000	170.125
LD Gas Trucks	29.0	18,296,361	18.7	978,415	122.302
MD Gas Trucks	11.0	6,939,999	14.2	488,732	61.092
HD Gas Trucks	3.2	2,018,909	5.9	342,188	42.773
LD Diesel Automobiles	0.1	63,091	28.3	2,229	0.309
LD Diesel Trucks	0.2	126,182	24.0	5,258	0.729
HD Diesel Vehicles	6.5	4,100,909	6.3	650,938	90.285
Transit Bus Vehicles	0.2	126,182	6.3	20,029	2.778
Commuter Rail	0.0	0	6.3	0	0.000
Motorcycles	0.4	252,364	50.0	5,047	0.631
Subtotal	**100.0**	**63,090,900**		**3,853,836**	**491.024**
Non-Fuel Source Transit System[4]					0.30700
Vehicle Maintenance[5]					57.715
LDV 505 Btu/Mile					25.075
MDV 1,186 Btu/Mile					8.231
HDV 1,714 Btu/Mile					10.489
Bus 1,714 Btu/Mile					0.216
Rail 1,714 Btu/Mile					0.000
LRT Maintenance Facility Operation					0.037
Bus Maintenance Facility Operation					0.147
Park and Ride Operation					0.011
Total				**4,746,021**	**593.253**

Notes: Btu = British Thermal Unit, Btu/gallon of gasoline = 125,000 (gross), Btu/gallon of diesel = 138,700 (gross)

HD=Heavy Duty, HDV=Heavy Duty Vehicle, LD=Light Duty, LDV=Light Duty Vehicle, MD=Medium Duty

[1]DEQ 2000

[2]DEA 2010; distribution for LD Gas Vehicles is adjusted from 49.5 to 49.4 to assure total distribution equals 100%

[3]FHWA 2000

[4]Includes MAX, Portland Streetcar, and Portland Aerial Tram

[5]CALTRANS 1983

Transportation Operations Energy Consumption in 2035
Enhanced Bus Alternative

Vehicle Type	Percent of VMT[1]	Daily VMT[2]	Average Fuel Consumption (MPG)[3]	Daily Fuel Consumption (Gallons)	Daily Energy Consumption (Billions of Btu)
LD Gas Automobiles	49.4	31,146,651	22.9	1,360,116	170.014
LD Gas Trucks	29.0	18,284,471	18.7	977,779	122.222
MD Gas Trucks	11.0	6,935,489	14.2	488,415	61.052
HD Gas Trucks	3.2	2,017,597	5.9	341,966	42.746
LD Diesel Automobiles	0.1	63,050	28.3	2,228	0.309
LD Diesel Trucks	0.2	126,100	24.0	5,254	0.729
HD Diesel Vehicles	6.5	4,098,244	6.3	650,515	90.226
Transit Bus Vehicles	0.2	126,100	6.3	20,016	2.776
Commuter Rail	0.0	0	6.3	0	0.000
Motorcycles	0.4	252,200	50.0	5,044	0.630
Subtotal	**100.0**	**63,049,900**		**3,851,332**	**490.705**
Non-Fuel Source Transit System[4]					0.30700
Vehicle Maintenance[5]					57.903
LDV 505 Btu/Mile					25.058
MDV 1,186 Btu/Mile					8.225
HDV 1,714 Btu/Mile					10.483
Bus 1,714 Btu/Mile					0.216
Rail 1,714 Btu/Mile					0.000
LRT Maintenance Facility Operation					0.037
Bus Maintenance Facility Operation					0.147
Park and Ride Operation					0.011
Total				**4,744,740**	**593.092**

Notes: Btu = British Thermal Unit, Btu/gallon of gasoline = 125,000 (gross), Btu/gallon of diesel = 138,700 (gross)

HD=Heavy Duty, HDV=Heavy Duty Vehicle, LD=Light Duty, LDV=Light Duty Vehicle, MD=Medium Duty

[1]DEQ 2000

[2]DEA 2010; distribution for LD Gas Vehicles is adjusted from 49.5 to 49.4 to assure total distribution equals 100%

[3]FHWA 2000

[4]Includes MAX, Portland Streetcar, and Portland Aerial Tram

[5]CALTRANS 1983

Transportation Operations Energy Consumption in 2035
Willamette Shore Line Alternative

Vehicle Type	Percent of VMT[1]	Daily VMT[2]	Average Fuel Consumption (MPG)[3]	Daily Fuel Consumption (Gallons)	Daily Energy Consumption (Billions of Btu)
LD Gas Automobiles	49.4	31,133,313	22.9	1,359,533	169.942
LD Gas Trucks	29.0	18,276,641	18.7	977,360	122.170
MD Gas Trucks	11.0	6,932,519	14.2	488,206	61.026
HD Gas Trucks	3.2	2,016,733	5.9	341,819	42.727
LD Diesel Automobiles	0.1	63,023	28.3	2,227	0.309
LD Diesel Trucks	0.2	126,046	24.0	5,252	0.728
HD Diesel Vehicles	6.5	4,096,489	6.3	650,236	90.188
Transit Bus Vehicles	0.2	126,046	6.3	20,007	2.775
Commuter Rail	0.0	0	6.3	0	0.000
Motorcycles	0.4	252,092	50.0	5,042	0.630
Subtotal	**100.0**	**63,022,900**		**3,849,683**	**490.495**
Non-Fuel Source Transit System[4]		5.88			0.30712
Vehicle Maintenance[5]					57.729
LDV 505 Btu/Mile					25.048
MDV 1,186 Btu/Mile					8.222
HDV 1,714 Btu/Mile					10.478
Bus 1,714 Btu/Mile					0.216
Rail 1,714 Btu/Mile					0.000
LRT Maintenance Facility Operation					0.037
Bus Maintenance Facility Operation					0.147
Park and Ride Operation					0.011
Total				**4,741,519**	**592.690**

Notes: Btu = British Thermal Unit, Btu/gallon of gasoline = 125,000 (gross), Btu/gallon of diesel = 138,700 (gross)

HD=Heavy Duty, HDV=Heavy Duty Vehicle, LD=Light Duty, LDV=Light Duty Vehicle, MD=Medium Duty

[1]DEQ 2000

[2]DEA 2010; distribution for LD Gas Vehicles is adjusted from 49.5 to 49.4 to assure total distribution equals 100%

[3]FHWA 2000

[4]Includes MAX, Portland Streetcar, and Portland Aerial Tram, Energy consumption calculated as (6kwh/car mile) x (5.88

[5]CALTRANS 1983

Transportation Operations Energy Consumption in 2035
Macadam In-Street Alternative

Vehicle Type	Percent of VMT[1]	Daily VMT[2]	Average Fuel Consumption (MPG)[3]	Daily Fuel Consumption (Gallons)	Daily Energy Consumption (Billions of Btu)
LD Gas Automobiles	49.4	31,134,597	22.9	1,359,589	169.949
LD Gas Trucks	29.0	18,277,395	18.7	977,401	122.175
MD Gas Trucks	11.0	6,932,805	14.2	488,226	61.028
HD Gas Trucks	3.2	2,016,816	5.9	341,833	42.729
LD Diesel Automobiles	0.1	63,026	28.3	2,227	0.309
LD Diesel Trucks	0.2	126,051	24.0	5,252	0.728
HD Diesel Vehicles	6.5	4,096,658	6.3	650,263	90.191
Transit Bus Vehicles	0.2	126,051	6.3	20,008	2.775
Commuter Rail	0.0	0	6.3	0	0.000
Motorcycles	0.4	252,102	50.0	5,042	0.630
Subtotal	**100.0**	**63,025,500**		**3,849,842**	**490.515**
Non-Fuel Source Transit System[4]		6.00			0.30712
Vehicle Maintenance[5]					57.611
LDV 505 Btu/Mile					25.049
MDV 1,186 Btu/Mile					8.222
HDV 1,714 Btu/Mile					10.478
Bus 1,714 Btu/Mile					0.216
Rail 1,714 Btu/Mile					0.000
LRT Maintenance Facility Operation					0.037
Bus Maintenance Facility Operation					0.147
Park and Ride Operation					0.011
Total				**4,740,753**	**592.594**

Notes: Btu = British Thermal Unit, Btu/gallon of gasoline = 125,000 (gross), Btu/gallon of diesel = 138,700 (gross)

HD=Heavy Duty, HDV=Heavy Duty Vehicle, LD=Light Duty, LDV=Light Duty Vehicle, MD=Medium Duty

[1]DEQ 2000

[2]DEA 2010; distribution for LD Gas Vehicles is adjusted from 49.5 to 49.4 to assure total distribution equals 100%

[3]FHWA 2000

[4]Includes MAX, Portland Streetcar, and Portland Aerial Tram, Energy consumption calculated as (6kwh/car mile) x (6 car miles) x (3,412 Btu/kwh)

[5]CALTRANS 1983

SUMMARY

Daily Regional Transportation Operations Energy Consumption in 2035 (Billions of Btu) Alternatives Summary

Vehicle Type	No-Build Alternative	Enhanced Bus Alternative	Willamette Shore Line Alternative	Macadam In-Street Alternative
LD Gas Automobiles	170.13	170.01	169.94	169.95
LD Gas Trucks	122.30	122.22	122.17	122.18
MD Gas Trucks	61.09	61.05	61.03	61.03
HD Gas Trucks	42.77	42.75	42.73	42.73
LD Diesel Automobiles	0.31	0.31	0.31	0.31
LD Diesel Trucks	0.73	0.73	0.73	0.73
HD Diesel Vehicles	90.29	90.23	90.19	90.19
Commuter Rail (Diesel)	0.00	0.00	0.00	0.00
Motorcycles (Gas)	0.63	0.63	0.63	0.63
Motor Vehicle Operations	488.2464	487.9291	487.7201	487.7402
Vehicle Maintenance[5]	57.7153	57.9028	57.7291	57.6113
Subtotal - Motor Vehicle Energy Use	**545.9617**	**545.8319**	**545.4492**	**545.3515**
Transit Bus Vehicles (Diesel)	2.7780	2.7762	2.7750	2.7751
Non-Fuel Source Transit System[4]	0.3070	0.3070	0.3071	0.3071
Subtotal - Transit Energy Use	**3.0850**	**3.0832**	**3.0821**	**3.0822**
Bus Vehicle Maintenance Operation	0.2163	0.2161	0.2160	0.2161
Bus Maintenance Facility Operation	0.1470	0.1470	0.1470	0.1470
LRT Maintenance Facility Operation	0.0370	0.0370	0.0370	0.0370
Subtotal - Transit Maintenance Energy	**0.4003**	**0.4001**	**0.4000**	**0.4001**
LDV 505 Btu/Mile	25.0745	25.0582	25.0475	25.0485
MDV 1,186 Btu/Mile	8.2308	8.2255	8.2220	8.2223
HDV 1,714 Btu/Mile	10.4894	10.4826	10.4781	10.4785
Rail 1,714 Btu/Mile	0.0000	0.0000	0.0000	0.0000
Subtotal - Rail & Deisel Energy Use	**43.7947**	**43.7663**	**43.7475**	**43.7493**
Park and Ride Operation	0.0110	0.0110	0.0110	0.0110
Total (Billions of Btu/day)	**593.24**	**593.08**	**592.68**	**592.58**
Total (gallons/day)	4,746,021	4,744,740	4,741,519	4,740,753

Notes: Btu = British Thermal Unit, Btu/gallon of gasoline = 125,000 (gross), Btu/gallon of diesel = 138,700 (gross)

HD=Heavy Duty, HDV=Heavy Duty Vehicle, LD=Light Duty, LDV=Light Duty Vehicle, MD=Medium Duty

[1]DEQ 2000

[2]Metro 2010; distribution for LD Gas Vehicles is adjusted from 49.5 to 49.4 to assure total distribution equals 100%

[3]FHWA 2000

[4]Includes MAX, Portland Streetcar, and Portland Aerial Tram, Energy consumption calculated as (6kwh/car mile) x (6 car miles) x (3,412 Btu/kwh)

[5]CALTRANS 1983

Summary of Annual[1] Energy Consumption by Alternatives (Billions of Btu[2])

Alternatives	Motor Vehicle[3] Annual Energy Use	Bus Annual Energy Use	LRT Annual Energy Use	Total Annual Operations Energy (Billions of Btu2)	Total Fuel Consumption (gal/year)	Annual Operational Energy Savings[4]
No Build	199,573	1,068	121	200,761	1,606,091,120	0
Enhanced Bus	199,519	1,067	121	200,708	1,605,660,297	54
WSL	199,383	1,067	121	200,571	1,604,568,594	190
Macadam In-Street	199,351	1,067	121	200,538	1,604,307,847	223

Sources:

[1]Assumes an annualization factor of 340 days per year.

[2]Btu = British Thermal Units. One gallon of gasoline = 125,000 Btu

[3]Not including buses.

[4]As compared to No-Build Alternative

Comparison of Regional Operations Energy Consumption, Future Year 2035

	Daily			Annual[2]		
Project Alternatives and Design Options (DO)	Vehicle Miles Traveled (Daily VMT)	Energy Consumption[1] (Billions of Btu/day)	Fuel Consumption (gal/day)	Vehicle Miles Traveled (Annual VMT)	Energy Consumption[1] (Billions of Btu/year)	Fuel Consumption (gal/year)
No-Build Alternative	63,090,900	593	4,746,021	21,450,906,000	200,761	1,606,091,120
Enhanced Bus Alternative	63,049,900	593	4,744,740	21,436,966,000	200,708	1,605,660,297
Streetcar Alternative						
with Willamette Shore Line DO	63,022,900	593	4,741,519	21,427,786,000	200,571	1,604,568,594
with Macadam In-Street DO	63,025,500	593	4,740,753	21,428,670,000	200,538	1,604,307,847
with Macadam Additional Lane DO	63,025,500	593	4,740,753	21,428,670,000	200,538	1,604,307,847
Percent Decrease in Energy Consumption as Compared to the No-Build Alternative						
Enhanced Bus Alternative	0.06%	0.03%	0.03%	0.06%	0.03%	0.03%
Streetcar Alternative						
with Willamette Shore Line DO	0.10%	0.11%	0.11%	0.10%	0.09%	0.09%
with Macadam In-Street DO	0.11%	0.09%	0.09%	0.11%	0.11%	0.11%
with Macadam Additional Lane DO	0.10%	0.11%	0.11%	0.10%	0.11%	0.11%
Net Difference In 2035 Energy Consumption as Compared to the No-Build Alternative						
Enhanced Bus Alternative	41,000	0.160	1,282	13,940,000	54	430,823
Streetcar Alternative						
with Willamette Shore Line DO	65,400	0.658	5,268	22,236,000	190	1,522,525
with Macadam In-Street DO	68,000	0.563	4,502	23,120,000	223	1,783,273
with Macadam Additional Lane DO	65,400	0.658	5,268	22,236,000	223	1,783,273

Sources: URS Corporation 2010, Metro 2010, DEA, Inc. 2010

Lake Oswego to Portland Transit Project Transporation Technical Report (DEA Inc. and Metro/TriMet, March 2010)

Btu = British Thermal Unit

VMT = Vehicle Miles Traveled

[1] Energy Consumption, Auto: Btu/gallon = 125,000, Trucks: Btu/gallon of diesel = 139,000

[2] Annual energy consumptions are estimates only and do not accurately account for variations in seasonal energy use

APPENDIX F

Construction Energy Calculations

CONSTRUCTION ENERGY

Lake Oswego to Portland Transit
Energy Technical Report

Item	Cost (2010$)	Cost (1973$)	Energy Conversion (BTU/1973$)	Energy Consumption (BTU)	Fuel Consumption (Gallons of Gasoline)
Short-Term Construction Costs					
No-Build Alternative	$ -	$ -	61,615	0.00E+00	0.00E+00
Enhanced Bus Alternative	$ 16,000,000	$ 2,263,946	61,615	1.39E+11	1.12E+06
Streetcar					
Lake Oswego Terminus	$ 160,500,000	$ 22,710,204	61,615	1.40E+12	1.12E+07
Sellwood Bridge MOS	$ 61,500,000	$ 8,702,041	61,615	5.36E+11	4.29E+06

Maintenance Facility Construction Energy

Item	Cost (2010$)	Cost (1973$)	Energy Conversion (BTU/1973$)	Energy Consumption (BTU)	Fuel Consumption (Gallons of Gasoline)
Storage Yard (Building and Equipment)	$ 2,000,000	$ 282,993	61,615	1.74E+10	1.39E+05

Notes

*= Costs do not include Right-of-Way

Methodology:

Construction Energy Consumption

Input/Output Approach for Urban Conventional Highway Construction (CalTrans' Energy and Transportation Systems, July 1983)

Construction Energy Formula

E = C x EF x DC
E = Energy consumed (Btu)
C = Cost of a particular construction activity (2007$)
DEF = Dollar-to-Energy Factor (Btu/1973$)
DC = Dollar Conversion (1973$/2007$)

Conversation Factors

2009 Price Escalation
31.2/220.5 = 0.141497

Energy Conversion Factor: 125,000 Btu's = one gallon of gasoline

References and Source:

[1] Preliminary Construction Cost Estimate by Omar Jaff, PE
[2] Caltrans Construction Activity, Energy and Transportation Systems, 1983, State of California Department of Transportation
[3] Price Index for Selected Highway Construction Items, First Quarter Ending March 2010, State of California Department of Transportation
[4] Energy Conversion Factor: Btu/Gallons of Gasoline = 125,000