Oregon Department of Transportation

Columbia River Crossing Investment Grade Traffic and Revenue Study

Columbia River Crossing First Phase Project

December 27, 2013

Image courtesy of CRC Project Office

CDM Smith

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Chapter 1

Introduction

1.1 Study Background

The Oregon Department of Transportation (ODOT) intends to toll the Interstate 5 (I-5) bridge between Portland, Oregon and Vancouver, Washington, beginning on Sept. 30, 2015.

The Interstate 5 Columbia River Crossing Project (CRC Project) will improve safety and congestion in the five-mile segment between state route (SR) 500 in Vancouver and Victory Boulevard in Portland. The CRC Project will replace the I-5 bridge, improve five miles of I-5, extend light rail to downtown Vancouver, and improve bicycle and pedestrian facilities. The I-5 bridge consists of two spans, each of which carries three lanes in one direction over the Columbia River between Oregon and Washington. The I-5 bridge originally opened as a single span carrying two-way traffic in 1917. Between 1958 and 1960 a second span was opened and each span was converted to carry traffic in one direction only. Since then, the older span has carried northbound traffic and the newer span has carried southbound traffic. The I-5 bridge requires replacement to address growing travel demand and congestion, travel delays due to bridge lifts for marine navigation, impaired freight movement, safety and vulnerability to incidents, substandard bicycle and pedestrian facilities, and seismic vulnerability. The CRC Project will address these issues by replacing the I-5 bridge, eliminating the need for bridge lifts, adding auxiliary lanes, extending light rail across the river, and meeting modern seismic and design standards.

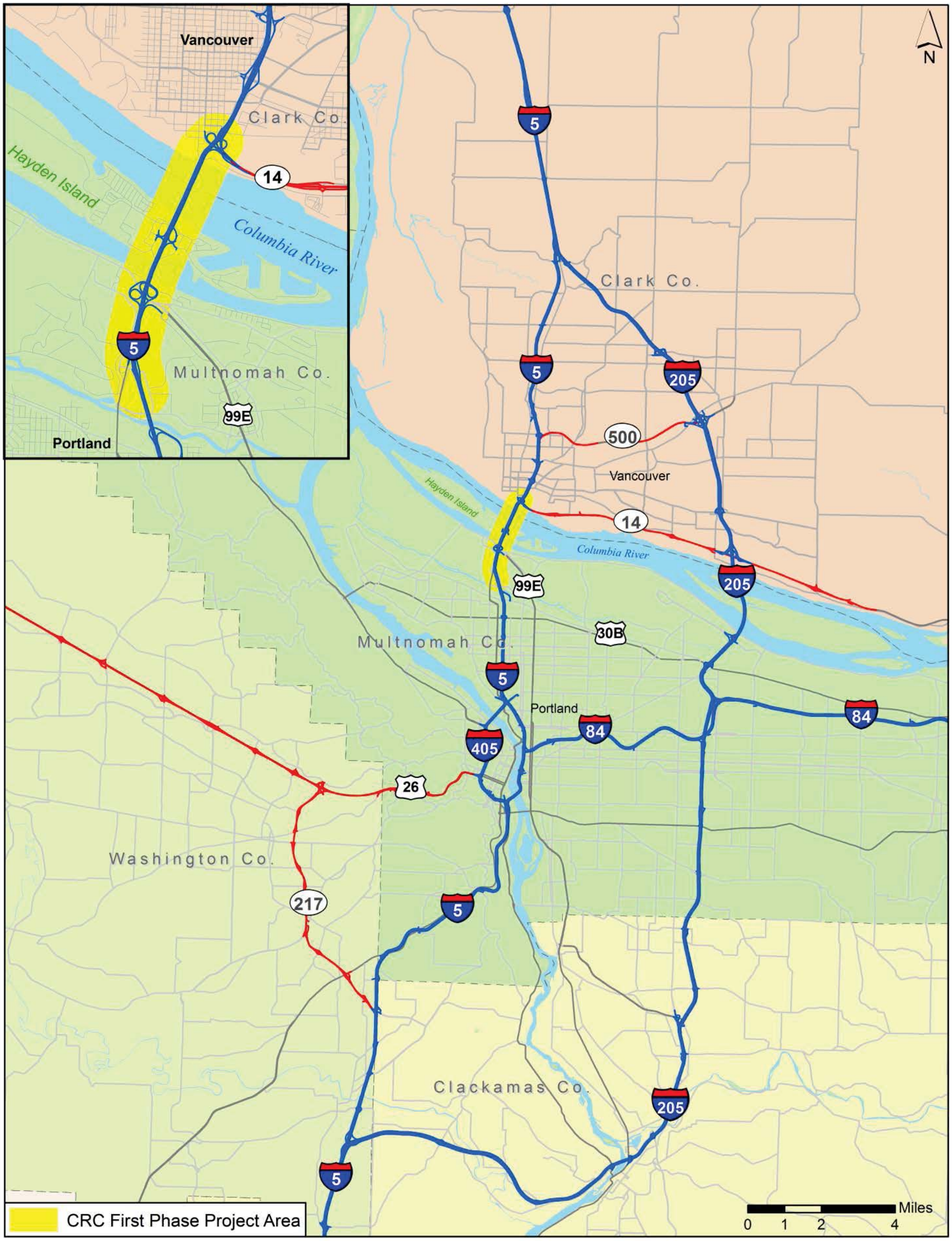
Previously the I-5 bridge was tolled to support the repayment of bridge financing bonds between 1917 and 1929 on the original span and between 1960 and 1966 as part of the bridge expansion project. A key part of the CRC Project financing assumes implementing tolls on the I-5 bridge. This will help manage congestion and, as with past tolling, the toll revenue raised will be used to support project funding.

This report documents the traffic and revenue (T&R) study conducted by CDM Smith at a level of detail sufficient for use in support of project financing. CDM Smith collected available model datasets and performed several surveys and studies to develop a traffic forecasting model used for the analysis of tolling scenarios. Details of the forecasting process and results are provided in subsequent chapters of this report. This study was conducted independent of previous environmental studies conducted for the CRC Project.

1.2 Project Description

1.2.1 Location

Figure 1-1 depicts the CRC First Phase Project area (highlighted in yellow) and its relationship to the surrounding transportation system. In the Portland area there is a web of 18 state highways, which includes interstate routes I-5, I-205, I-405, and I-84. Portland has a large public transportation system with bus and light rail routes. In the Vancouver urban area there are four limited access



COLUMBIA RIVER CROSSING FIRST PHASE PROJECT AREA

FIGURE 1-1

highways, which include the interstate routes, I-5 and I-205, and state routes, SR 14 and SR 500 between I-5 and I-205. There is bus service in Vancouver and Clark County. In the Portland-Vancouver area the only two crossings of the Columbia River for vehicular traffic are the I-5 bridge and the I-205 bridge.

1.2.2 Interstate 5 Columbia River Crossing Project

The CRC Project elements incorporated in this traffic and revenue study are generally consistent with the Locally Preferred Alternative (LPA) with highway phasing as presented in the Final Environmental Impact Statement (FEIS) (Chapter 2, Description of Alternatives). In addition to the highway phasing discussed in the FEIS, the construction of the CRC Project will be phased to match available funding, while providing significant transportation benefits. The first construction phase is referred to as the Columbia River Crossing First Phase Project (CRC First Phase Project). The main difference between the CRC Project LPA with highway phasing and the CRC First Phase Project is that the majority of the interchange improvements north of the SR 14 interchange are delayed. The CRC First Phase Project elements relevant to the traffic and revenue study include:

- A replacement I-5 bridge over the Columbia River north of Hayden Island, improvements to three interchanges north and south of the bridge and related enhancements to the local street network
- Extension of light rail transit from the Portland Metropolitan Exposition Center (Expo Center) in Portland to Clark College in Vancouver and associated transit infrastructure improvements
- A toll on vehicles during and after construction of the replacement I-5 bridge.

An overview of the toll program phasing assumptions for the CRC Project is shown in Table 1-1. It is assumed there will be three phases, including:

- Pre-completion Phase 1 - the current I-5 bridge is tolled beginning at the end of the first quarter of Fiscal Year (FY) 2016 (Sept.30, 2015) while the replacement I-5 bridge is being constructed
- Pre-completion Phase 2 – all traffic is shifted to the replacement southbound I-5 bridge span and continues to be tolled
- Post-completion – both replacement bridge spans are substantially complete and traffic is routed on them per the final project configuration.

The light rail extension is assumed to open on Sept. 1, 2019. It is assumed that the existing three through lanes in the project area will be maintained throughout construction.

Table 1-1 Toll Program Phasing Assumptions for CRC Project

Date	Description	Number of Lanes by Direction		Lane Width (feet)		
		Through Lanes	Add-Drop Lanes	Through Lanes	Inside Shoulder	Outside Shoulder
Sept. 30 2015	Pre-completion tolling Phase 1 (existing I-5 bridge)	3	0	11	minimal	minimal
July 1 2018	Pre-completion tolling Phase 2 (replacement SB bridge structure)	3	0	11	minimal	8
July 1 2021	Post-completion tolling (full project)	3	2	12	12	14

For purposes of this study, tolling on the existing I-5 bridge is assumed to begin on Sept. 30, 2015 at the start of pre-completion tolling. All passenger vehicles and trucks crossing the Columbia River main channel on the I-5 bridge are assumed to be tolled using tolling equipment covering all lanes of both I-5 bridge spans. Tolls are not assumed to be collected from bicyclists, pedestrians, or transit vehicles. Tolling is assumed to be all-electronic, with no option to pay using cash at traditional toll booths. Two payment methods, account based and non-account based, are assumed to be available. Account based payments include toll payments by transponder and may also include registering each vehicle's license plate on the account, also known as "pay by plate." Non-account based tolls, often referred to as "pay by mail," would be charged by identifying a vehicle's owner using the vehicle's license plate and sending the owner a bill. The non-account based payment method also may include a short term account for prepayment of tolls or payment of tolls shortly after bridge crossing. Two different toll rate structures are assumed for the CRC Project, one for account based and the other for non-account based payment. The non-account based toll rates are higher, with the increment relating to the additional costs and risks associated with this type of transaction.

1.3 CDM Smith Scope of Work

This work was conducted at a level of detail sufficient to support an investment grade traffic and revenue forecast for project financing. CDM Smith was retained to perform the necessary tasks leading to the development of this report. These tasks included the collection of data for calibration of a regional travel demand model which serves as the primary analytical tool. Existing data from the Washington State Department of Transportation (WSDOT), ODOT, and previous CRC Project work were reviewed. Inventories of the operating conditions such as vehicle classification counts, traffic volume counts by time-of-day, and travel time and speed studies, on competing and complementary routes within the study area were also conducted. The following discussion summarizes the primary tasks undertaken in this study. These tasks are explained in detail in subsequent chapters of this report.

1.3.1 Travel Time and Travel Speed Surveys

CDM Smith performed travel time surveys on the I-5 and I-205 bridges over the Columbia River and primary connecting facilities from several different starting and ending locations on the north and south sides of the Columbia River. The data collected were used to calibrate the travel demand model prior to using it for tolling analysis. Travel speed data were collected by Global Positioning System (GPS) using a probe car in spring 2013.

1.3.2 Travel Pattern Surveys

CDM Smith conducted a travel pattern survey between fall 2012 and winter 2013. Mail-back surveys were sent to users of the I-5 bridge over the Columbia River. To send these surveys, license plate numbers of vehicles using the bridge were collected to obtain address of vehicle owners. (All survey data reporting was aggregated such that responses are anonymous.) The survey provided information on origin and destination of travel, trip frequency, travel time of day, trip purpose, and vehicle occupancy. The data collected in this task was used to refine the travel demand model to reflect bridge user origins, destinations, and characteristics; assist in estimating market shares by payment type based on trip frequency and purpose; and provide guidance in assessing the reasonableness of traffic and revenue estimates.

1.3.3 Stated Preference Survey

A stated preference survey was conducted in spring 2013. The primary purpose of the survey was to estimate the willingness of passenger car and truck drivers to save travel time by paying a toll. Participants were recruited from a subset of the travel pattern surveys. The survey data were used to develop a statistical travel choice model which was used to forecast future travel behavior with tolls on the I-5 bridge. Changes in travel behavior evaluated with the choice model under tolled conditions included propensity to divert to alternate routes, changing destinations, combining trips or “trip chaining”, trip suppression (not making a particular trip), and shift to alternate travel modes.

1.3.4 Tolling Analysis Model Development

The Tolling Analysis Model development process involved:

- Compiling regional model datasets and documentation from Metro which is the Portland metropolitan planning organization (MPO)
- Converting regional model files to the CDM Smith format and checking converted files for consistency against source data
- Compiling existing and new traffic data
- Developing an initial highway traffic assignment model in the CDM Smith format
- Conducting model runs under toll-free conditions and comparing results against available traffic counts, travel time data, and the original Metro model runs to ensure that the initial model results were generally consistent with the observed conditions
- Calibrating the model in the immediate project area to ensure that traffic assigned to the roadway network compared closely to observed detailed traffic counts and speeds.

Once a calibrated traffic assignment model was developed, CDM Smith incorporated a tolling analysis algorithm within the assignment model. To enhance the original model empirical travel characteristics relevant to an investment grade traffic analysis, CDM Smith also incorporated results of the travel pattern survey, travel time and speed surveys, stated preference survey, and independent economic growth analysis.

1.3.5 Independent Corridor Growth Analysis

Socioeconomic activity is a primary input to all travel demand models. Regional planning agencies, Metro and the Southwest Washington Regional Transportation Council (RTC), are responsible for studying area-wide growth and development. An independent economic review which considered the forecasts produced by these regional planning agencies was conducted. This review resulted in a socioeconomic forecast to be used in this traffic and revenue study. This forecast utilized independent regional forecasts which accounted for the recession and overall economic downturn, data on economic and real-estate activity, and review of area development plans as the basis for population and employment forecasts for the region. These results were then incorporated into the Tolling Analysis Model for the four-county region.

1.3.6 Traffic and Revenue Analysis

CDM Smith utilized the Tolling Analysis Model to analyze the tolling structure approved for this study. The major steps in the traffic and revenue forecasting process included:

- Translating the proposed toll structure into the Tolling Analysis Model;
- Running the model to evaluate traffic and revenue impacts for key analysis years (FY 2016, FY 2020, FY 2022, and FY 2036); and
- Using the model results and other project characteristics to develop the expanded annual traffic and revenue forecast from FY 2016 to FY 2060.

Specific information on the tolling structure, associated toll and fee levels, and project details are provided in this report.

1.3.7 Sensitivity Tests

Sensitivity tests were performed to ascertain the impact of possible changes to input parameters and assumptions, and the effect on traffic and revenue. Changes to the following parameters and assumptions were evaluated:

- Value of time
- Account based payment type market share
- Socioeconomic forecasts
- Shifts to transit

1.4 Report Structure

The remainder of this report is presented in the following order:

- Chapter 2 presents an overview of the highway system connecting to the I-5 bridge over the Columbia River, including existing average annual traffic volumes and variation in traffic by day of week. The results of travel time surveys are also presented.

- Chapter 3 presents the results of the Travel Pattern Survey, including time periods of travel, trip purpose, trip frequency, vehicle occupancy, and origin and destination of travel.
- Chapter 4 includes a summary of the stated preference survey objectives, survey instrument, and basic results. It also summarizes model estimation, value of time, trip suppression, mode shift, and time shift.
- Chapter 5 includes a summary of the independent assessment of economic growth forecasts within the region. This includes a summary of data sources at the national, regional and local level. The baseline forecast for the investment grade analysis is presented.
- Chapter 6 describes the tolling operations assumed in this study. This chapter includes methods of payment, vehicle classes, and vehicles exempt from tolls. It also contains the assumed market shares for each payment type.
- Chapter 7 discusses the traffic and revenue analytical process. The methodology is outlined along with how it was applied to the overall traffic and revenue estimation process. The Tolling Analysis Model development is documented; the effect of exemptions presented, tolling and diversion is discussed. The last section in Chapter 7 presents the truck freight forecasting prepared for this study.
- Chapter 8 presents the traffic and gross revenue results. Comparisons to no-build and toll-free project conditions are also included.
- Chapter 9 presents the results of sensitivity testing of key model parameters and assumptions.

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Chapter 2

Existing Traffic Conditions

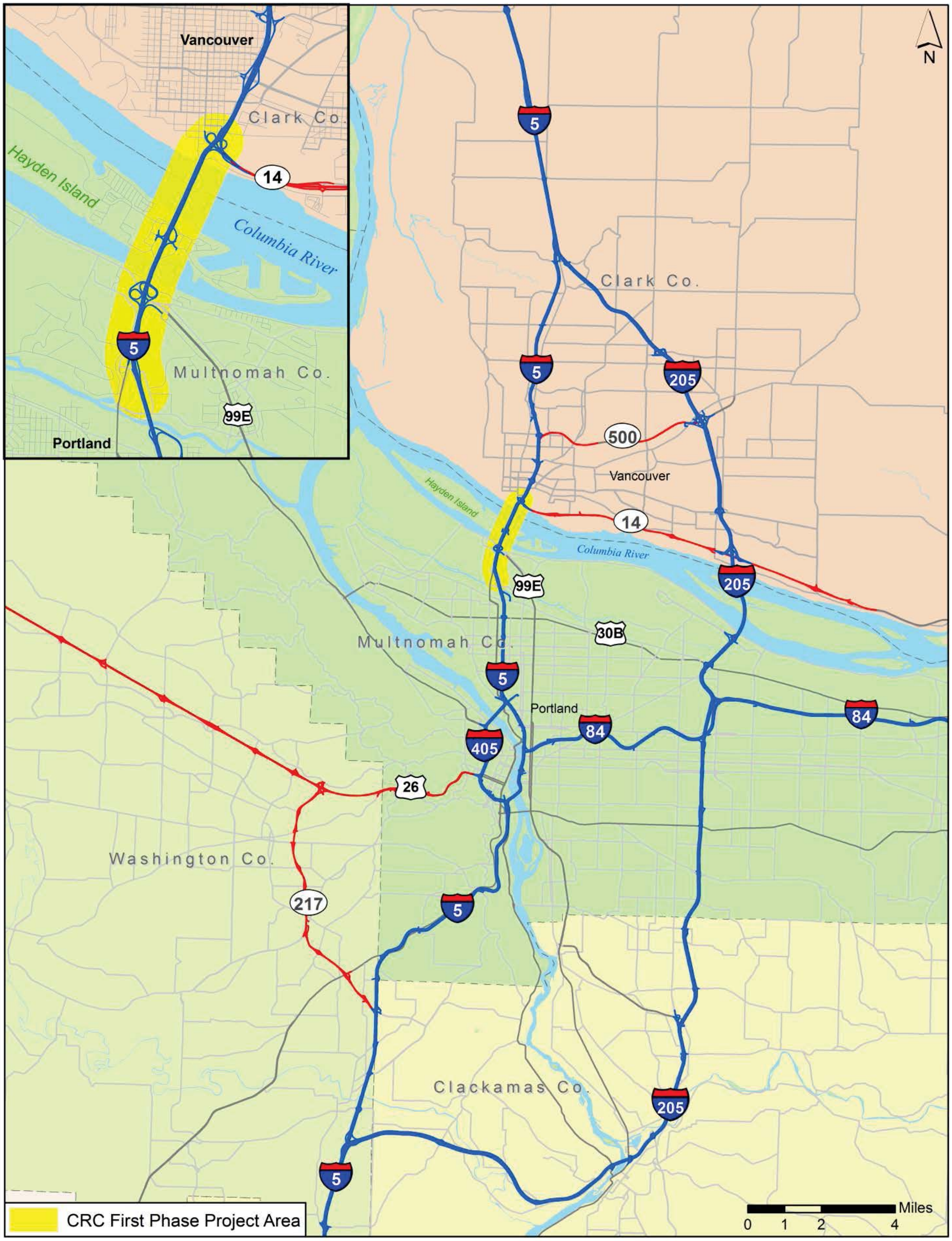
One of the important elements of any traffic study is understanding existing traffic volumes, operations and travel behavior. For this study, the understanding was achieved through extensive raw data collection and review of data collected and maintained by the Oregon Department of Transportation (ODOT) and the Washington Department of Transportation (WSDOT). The I-5 corridor through the Portland-Vancouver metropolitan area is an important interstate segment supporting the local economy and mobility, as well as serving transportation needs from Mexico to Canada. The importance of the corridor, the physical condition of the interstate and I-5 bridge, and the identification of potential improvements has been studied for over a decade. As such, extensive historical traffic data was available. This chapter summarizes the information that was either extracted through a review of available reports and documents or was collected by CDM Smith as part of this work.

The information provided in this chapter includes a description of the highway system in the Portland-Vancouver area, the operating conditions of major highways, exiting traffic volumes, traffic patterns, and travel time and speeds along the I-5 and I-205 corridors. The description of major highways is provided in terms of the number of lanes, major interchanges, and posted speed limits. Traffic flow is described in terms of Average Annual Daily Traffic (AADT) and Average Weekday Daily Traffic (AWDT) based on Automatic Traffic Recorders (ATR) stations that are located throughout the region. Annual traffic data were compiled to present traffic variation by month, weekday, weekend, and hour. Travel times and observed speeds along major routes in the project vicinity are based on CDM Smith data collection. Because of its importance as a freight corridor, extensive truck data was also analyzed.

2.1 Existing Highway System

Oregon and Washington have a robust highway system in the urban areas of Portland, Oregon and Vancouver, Washington. Figure 2-1 presents the major highways in the Portland-Vancouver area. In the Portland area there is a web of 18 state highways, which includes the interstate routes of I-5, I-205, I-405, and I-84. Portland also has a large public transportation system including bus and light rail. In the Vancouver urban area there are seven state highways, which include the interstate routes (I-5 and I-205); and state routes, SR 14 (a limited access corridor within the urban area) and SR 500 (a limited access corridor between I-5 and I-205, except for the NE 54th Ave and Falk Rd intersections). The public transportation system only includes bus service in Vancouver and Clark County. In the Portland-Vancouver area there are only two crossings of the Columbia River for vehicular traffic: I-5 and I-205.

The I-5 bridge between Portland and Vancouver provides connections to two major ports, deep-water shipping, up-river barging, two transcontinental rail lines, and a major international airport. It also provides critical infrastructure to support the movement of truck-hauled freight that is vital to the economy of the Portland-Vancouver region as well as to the Oregon and Washington state economies. I-5 is the only continuous, north-south interstate highway on the West Coast connecting Mexico, Canada, and points between.



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COLUMBIA RIVER CROSSING FIRST PHASE PROJECT AREA

FIGURE 2-1

In addition, the I-5 bridge is a primary transportation link between Vancouver and Portland, and the only direct connection between the downtown areas of these cities. Residents of Vancouver and Portland drive, ride buses, bike, and walk across the I-5 bridge for work, recreation, shopping, and entertainment. I-205 over the Columbia River is located 6.5 miles east of I-5. It is also an important transportation facility, but it serves more as a bypass and a suburban connection than a direct link between the cities of Portland and Vancouver.

Interstate 5 (I-5) is the primary north-south interstate through the west coasts states of California, Oregon, and Washington and is 1,400 miles long. I-5 through the metropolitan area of Portland and Vancouver traverses a distance of approximately 28 miles (I-205 to I-205), from the I-5/I-205 interchange in Tualatin, Oregon to the I-5/I-205 interchange in Salmon Creek, Washington. There are major employment centers and industrial areas on both sides of the I-5 bridge. The Port of Portland and Port of Vancouver are both near the I-5 bridge and depend on the bridge for daily operations. Commuter flow is generally southbound during the morning peak period and northbound during the afternoon peak period, with residents of Vancouver commuting to larger employment centers in Portland.

The I-5 bridge is a pair of nearly identical steel vertical lift, through-truss bridges approximately 3,500 feet long. The northbound bridge opened to traffic in 1917 as a single bridge carrying two-way traffic. Between 1958 and 1960 a second, twin span was opened and each span was converted to carry traffic in one direction only. There are three northbound and three southbound lanes. Lane widths are substandard and there are no shoulders. The speed limit is 50 mph over the bridge, from Marine Drive in Portland to Mill Plain in Vancouver.

The bridge is staffed by ODOT maintenance personnel 24 hours per day, seven days per week who monitor the bridge and requests to open the bridge for marine traffic. CRC project staff data shows that over a three year period (2005 to 2007) there were about 465 bridge lifts or gate closures per year on average. Columbia River marine traffic is granted right of way at the bridge by federal law. During peak commute times (6:30 AM to 9 AM and from 2:30 PM to 6 PM) bridge lifts are typically not conducted to help minimize congestion effects.

On the Oregon side, I-5 consists of three general purpose lanes in each direction and auxiliary lanes for merge, diverge, and weaving segments near some interchanges. Within the project limits, the speed limit is 55 mph hour south of Marine Drive and 50 mph north of Marine Drive. In the northbound direction. the inside lane is a High Occupancy Vehicle Lane (HOV) for 2+ carpools and buses. The HOV lane begins at mile post 304 in the vicinity of N Skidmore Street and extends to mile post 307 in the vicinity of the US 99 interchange. The HOV lane is only in operation on weekdays from 3:00 PM to 6:00 PM. Near the I-5 bridge, there exists short acceleration and deceleration lanes, short weave sections, and limited to no shoulders which likely contribute to congestion and rear-end and side-swipe crashes in this area.

On the Washington side immediately north of the bridge, ramp radii, merge distances, and vertical curves are substandard. These conditions contribute to congestion and crashes. North of the SR 14 interchange, I-5 is a relatively new freeway and generally meets current design standards.

I-5 has three general purpose lanes in each direction plus auxiliary lanes in this segment. The speed limit is 50 mph from the bridge to Mill Plain Boulevard, then 60 mph north of Mill Plain Boulevard. There are two auxiliary lanes between E Mill Plain Boulevard/SR 502 and E Fourth Plain Boulevard. There is one auxiliary lane in each direction between E Fourth Plain Boulevard and SR 500.

Interstate 205 (I-205) is a bypass of I-5 through the Portland-Vancouver urban area. It is approximately 37 miles long from the southern junction with I-5 across the Columbia River to the I-5 junction north of Vancouver.

I-205 in Oregon is 26 miles long and passes through the cities of West Linn, Oregon City, Gladstone, and Portland. On the Oregon segment, I-205 has two lanes in each direction from I-5 to the Clackamas River at the Oregon Route (OR) 43 interchange in the vicinity of Oregon City. North of the OR 43 interchange there is one auxiliary between the OR 43 Interchange and the SR 99 (locally referred to as Highway 99) Interchange. North of SR 99, I-205 has three-lanes in each direction. North of SE Division Street, I-205 has four lanes in each direction. Further north I-205 interchanges with US 30 and I-84. Just prior to the Columbia River, the NE Airport Way interchange provides access to the Portland International Airport on the west side of I-205. I-205 then continues across the Columbia River, approximately 6.5 miles to the east of I-5.

I-205 in Washington is 11 miles from the Columbia River to the north terminus at I-5. There are four interchanges: SR 14 on the north side of the river, SE Mill Plain Boulevard, SR 500 and Padden Parkway. I-205 passes through the City of Vancouver, and then Clark County. I-205 changes from four lanes in each direction to three lanes north of Mill Plain Boulevard.

The speed limit on I-205 in Oregon is 55 mph and 60 mph in Washington.

Interstate 84 (I-84) begins at I-5, approximately 6.5 miles south of the I-5 bridge and connects to I-205 to the east, continuing through eastern Oregon, southern Idaho, Utah, and then connects with I-80 which traverses the United States. I-84 is a three-lane facility in each direction with periodic auxiliary lanes between I-5 and I-205. East of I-205, I-84 eventually transitions from three lanes to two lanes in each direction. The speed limit from I-5 to beyond I-205 is 50 mph.

Interstate 405 (I-405) is a 4.3 mile bypass of I-5 through downtown Portland. The northern junction with I-5 is 5.2 miles south of the Columbia River. The facility is generally two lanes in each direction with auxiliary lanes between interchanges. The speed limit is 50 mph.

US 30 Bypass (NE Lombard Street) is an important urban highway linking I-5 and I-205. The facility works in conjunction with **Columbia Boulevard**. Both facilities have grade separated interchanges and signalized intersections at complimentary locations. US 30 is a four-lane facility and NE Columbia Boulevard is a five-lane facility.

State Route 14 (SR 14) in Washington is the state highway that begins at I-5 in Vancouver, follows the Columbia River on the north side, interchanges with I-205 and continues east to the tri-cities area in southeast Washington. SR 14 is a limited access facility, with two lanes in each direction, from I-5 to beyond I-205 all the way to Washougal, Washington. The speed limit is 60 mph on the limited access facility. East of Washougal, through the Columbia River Gorge, SR 14 is a two lane highway with many curves and narrow shoulders. Approximately 41 miles east of I-5 SR 14 connects with I-82 at the Bridge of the Gods, the next nearest crossing of the Columbia River after I-205.

SR 500 is the other east-west state highway in Vancouver between I-5 and I-205. SR 500 is a limited access highway between I-5 and I-205 with two lanes in each direction. It has signalized intersections at Falk Road and NE Stapleton Road. The speed limit is 55 mph. SR 500 provides connectivity in the Vancouver highway system and provides access to local residential and commercial, and office areas. East of I-205, SR 500 is a five-lane arterial and eventually becomes a two-lane rural highway ending in Washougal.

Table 2-1 provides a summary of the major highway routes described above and within the CRC Project study area.

Table 2-1 Summary of Major Highway Facilities – CRC Project Study Area

Route	Location	Length (miles)	Direction	Lanes (per direction)	Access Type	Posted Speed Limit (mph)
I-5	I-205 near Tualatin, OR to I-205 near Salmon Creek, WA	28	North-South	3 GP, frequent auxiliary lanes	Controlled	55/50/60
I-205	I-5 near Tualatin, OR to I-5 near Salmon Creek, WA	37	North-South	2/3/4/3	Controlled	55 WA 60 OR
I-84	I-5 to I-205	6	East-West	3 GP	Controlled	50
I-405	Marquam Bridge at I-5 to NW Fremont Bridge at I-5	4	North-South	2 GP, frequent auxiliary lanes	Controlled	50
US 30B	I-5 to I-205 (OR)	6	East-West	2	Controlled/ Signalized	30 -50
NE Columbia Blvd	I-5 to I-205 (OR)	6	East-West	2.5	Controlled/ Signalized	30 - 50
SR 14	I-5 to I-205 (WA)	6	East-West	4	Controlled	55
SR 500	I-5 to I-205 (WA)	5	East-West	2	Controlled/ Signalized	55

2.2 Traffic Trends and Variations

This section summarizes traffic data sources, traffic volumes with specific profile details, and information on vehicle occupancy. For the Columbia River Crossing project, traffic analysis includes the I-5 and I-205 bridges. These data form the basis for Tolling Analysis Model inputs and forecasting.

Seasonal, day-of-week, and hourly variations analysis provided the basis for the forecast process to take into account the variation in traffic volumes for these characteristics. Analysis of traffic variations was prepared with data from 2011 and 2012.

2.2.1 Data Sources

Traffic volume patterns presented in this section are based primarily on data collected by ODOT and WSDOT through permanent count stations. As shown in Figure 2-2, the count stations are:

- I-5 at MP 1.98 south of SR 500 interchange in Vancouver – WSDOT PTR (Permanent Traffic Recorder) P05
- I-5 bridge at mile post (MP) 307.97 – ODOT ATR (Automatic Traffic Recorder) Station 26-004
- I-5 at MP 304.66 in North Portland, south of the N Rosa Parks Way interchange – ODOT ATR Station 26-019
- I-84 at MP 3.35 at the N.E. 53rd Avenue undercrossing – ODOT ATR Station 26-014.

- I-205 Glen Jackson Memorial bridge at MP 25.5 – ODOT ATR Station 26-024
- I-205 at MP 29.34 north of the Mill Plain interchange in Vancouver – WSDOT PTR R051

Historical annual data at the Oregon locations was obtained from ODOT's annual reports on "Summary of Trends" at Automatic Traffic Recorder stations. In Washington State, the historical data was obtained from WSDOT's 2012 and historic annual traffic reports.

Monthly, day-of-week, and time-of-day variations were studied at the I-5 and I-205 bridges, based on hourly data provided by ODOT. The most recent and comprehensive twelve-month dataset available for this analysis covers the period from July 2011 through June 2012.

2.2.2 Annual Average Daily Traffic and Average Weekday Traffic

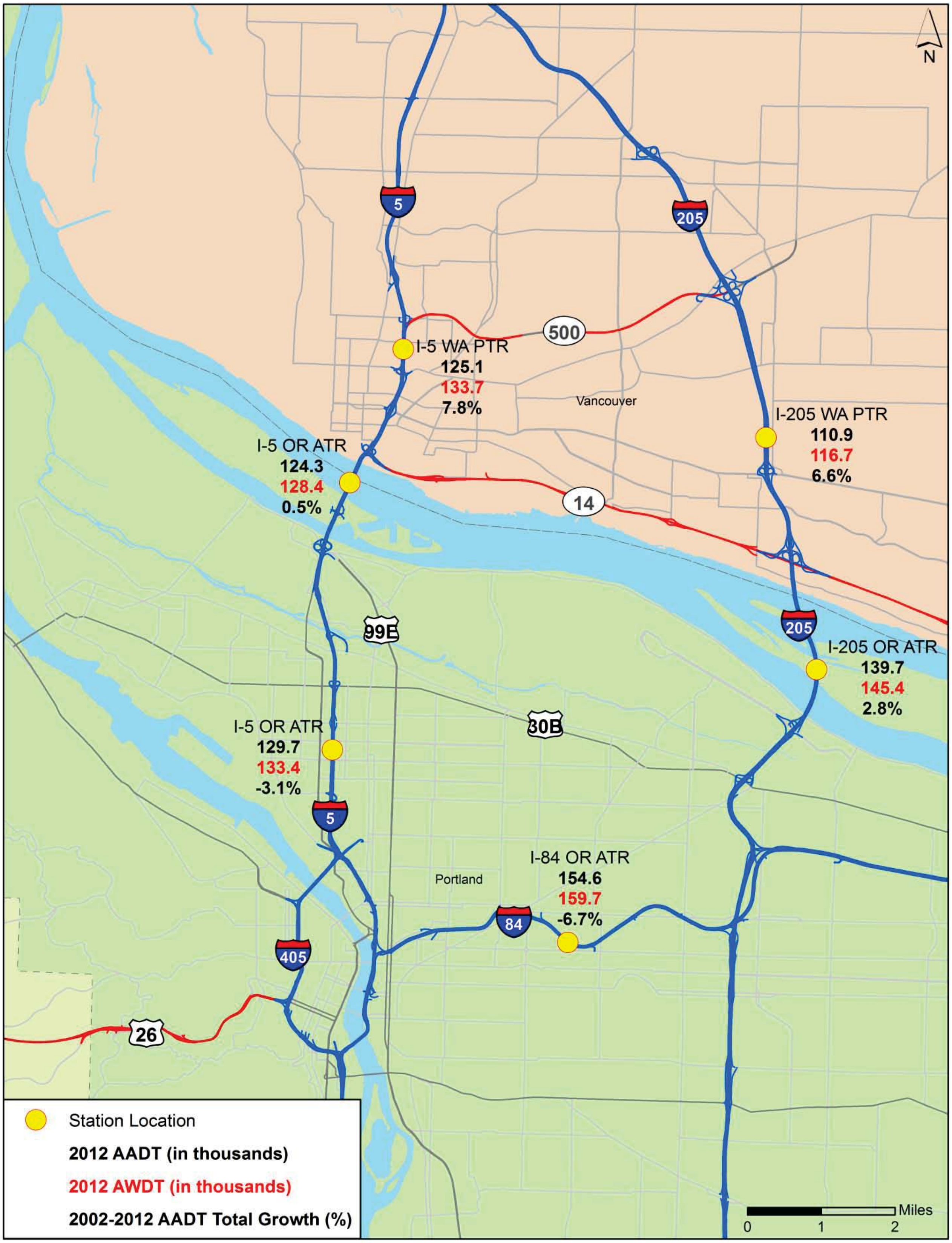
Figure 2-2 shows the location of the traffic stations, the 2012 AADT (Annual Average Daily Traffic), the 2012 AWDT (Average Weekday Daily Traffic) and the historical growth trend using data from the years 2002 and 2012. AADT and AWDT for year 2012 were derived from the ODOT and WSDOT annual reports.

In the study area, I-5, I-205 and I-84 all have high annual average daily and average weekday volumes. The highest volumes are observed on I-84, a major east-west route, which carries approximately 160,000 vehicles on an average weekday.

In 2012, the I-5 bridge carried about 128,000 vehicles each weekday. The I-205 bridge carried about 145,000 vehicles each weekday. Along I-5, traffic volumes tend to be higher north and south of the bridge compared to the volumes observed on the bridge itself. This is due to the I-5's connections with key east-west highways and local arterials north and south of the Columbia River.

Figure 2-2 also shows that the change in traffic from 2002 to 2012 has been relatively small at most studied locations. Two stations located in Portland have experienced a decrease of traffic volumes during this time period. At the river crossing itself, the growth has been limited (overall increase of 0.5 percent over 10 years on I-5, and 2.8 percent increase on I-205). Stations located in Vancouver on I-5 and I-205 have experienced slightly higher growth in traffic volumes.

Further discussion of historical traffic volume trends across the Columbia River over a longer period is provided below.



2012 ANNUAL AVERAGE DAILY TRAFFIC (AADT) AND AVERAGE WEEKDAY DAILY TRAFFIC (AWDT)

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FIGURE 2-2

2.2.3 Historical Traffic Trends

Figures 2-3 and 2-4 present an analysis of historical AADT trends between 1977 and 2012 at the I-5 and I-205 bridges. Figure 2-3 shows the AADT at each bridge, and Figure 2-4 shows the combined river crossing AADT. The I-205 bridge was opened in December 1982 and traffic data is available starting in 1983.

Figure 2-3 illustrates that since 1997, the I-205 bridge AADT has always exceeded the I-5 bridge AADT. Since 2001, the difference in AADT between the two bridges has remained fairly stable (in the order of 13,000 vehicles).

The share of the I-205 bridge in the total combined I-5 and I-205 river crossing has slightly increased over the years: it represented 52.9 percent of the overall traffic in 2012, compared to 50.8 percent in 1997.

The AADT at each bridge experienced strong growth between 1989 and 2002, with a CAGR (Compound Annual Growth Rate) of 2.6 percent for I-5 and 4.4 percent for I-205. Since 2002, however, the AADT growth has flattened (0.0 percent CAGR on I-5 and 0.3 percent on I-205). The economic recession which began in 2007 and the December 2008 snowstorms contributed to a reduction of AADT of more than 5,000 vehicles on each bridge between 2007 and 2008.

Figure 2-4 demonstrates similar historical trends for overall traffic crossing the Columbia River, combining AADTs at the I-5 and I-205 bridges. In the period 1982 to 2002, there was a strong growth of total river crossings, with a CAGR of 4.7 percent. Since 2002, however, the overall crossing traffic volume growth has flattened (0.2 percent CAGR).

Figure 2-3 Historic Average Annual Daily Traffic at I-5 and I-205 Bridges

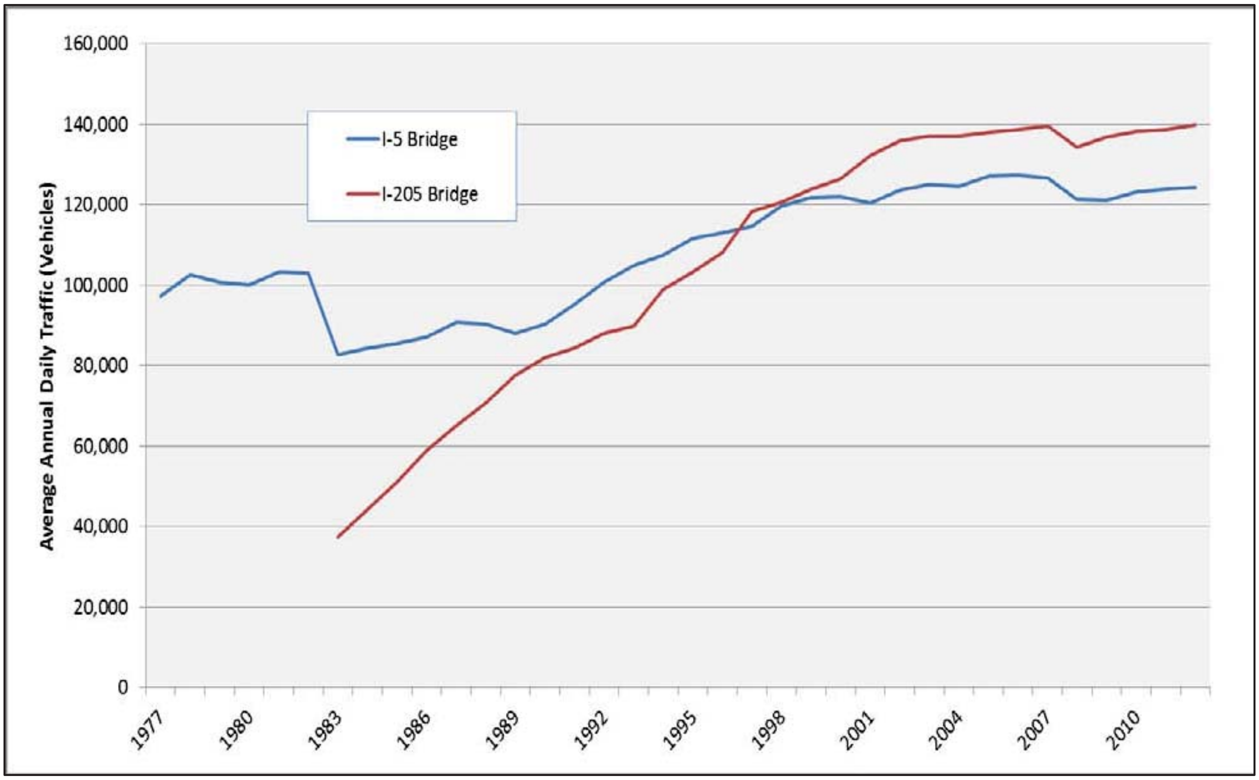
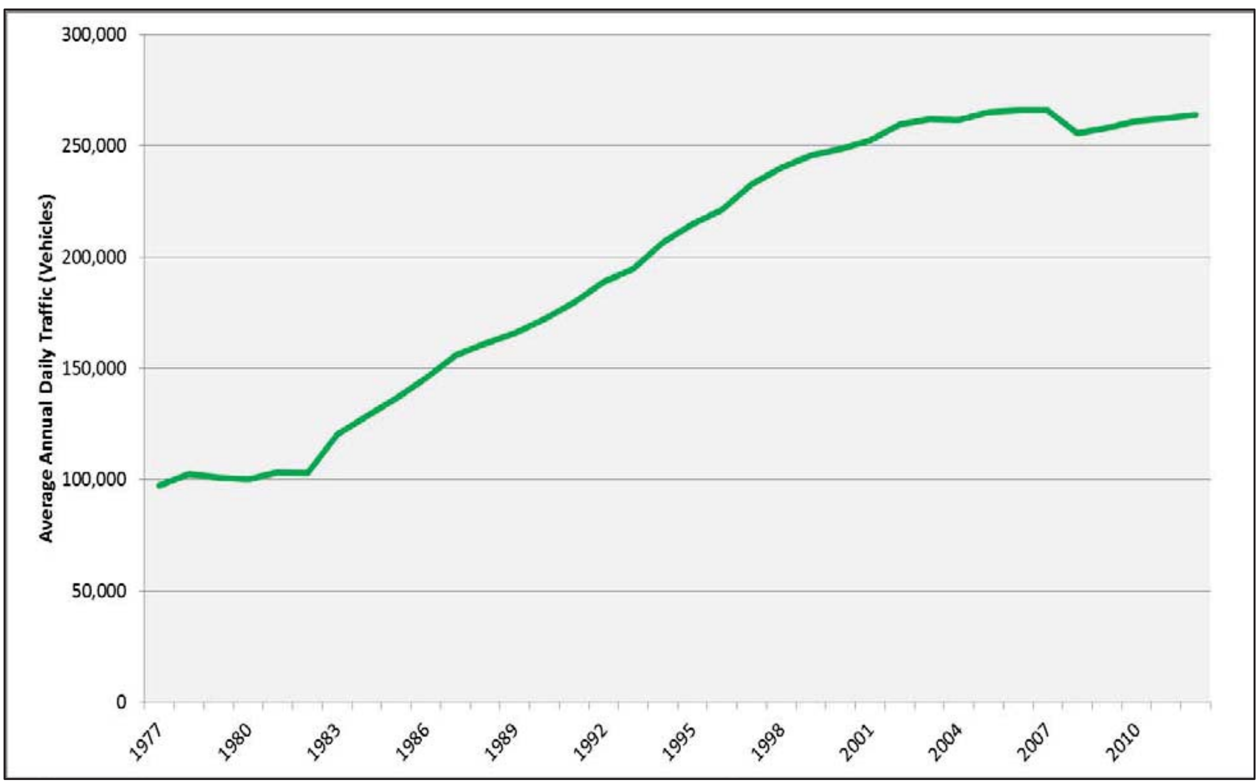


Figure 2-4 Historic Average Annual Daily Traffic for Total River Crossings



2.2.4 Seasonal/Monthly Traffic Variations

The data illustrating the monthly traffic variations at the I-5 and I-205 bridges was obtained from the hourly counts provided by ODOT for the period from July 2011 through June 2012.

To compare the data from month to month, an index value was calculated by dividing the average daily volume for each month by the AADT volume at that location (using total of both directions traffic volumes). Table 2-2 and Figure 2-5 present the monthly variation index at the I-5 bridge, I-205 bridge, and overall river crossing.

In general, the monthly traffic volumes are relatively stable throughout the year and follow the same pattern at both locations. The peak travel month is August and the lowest travel month is January.

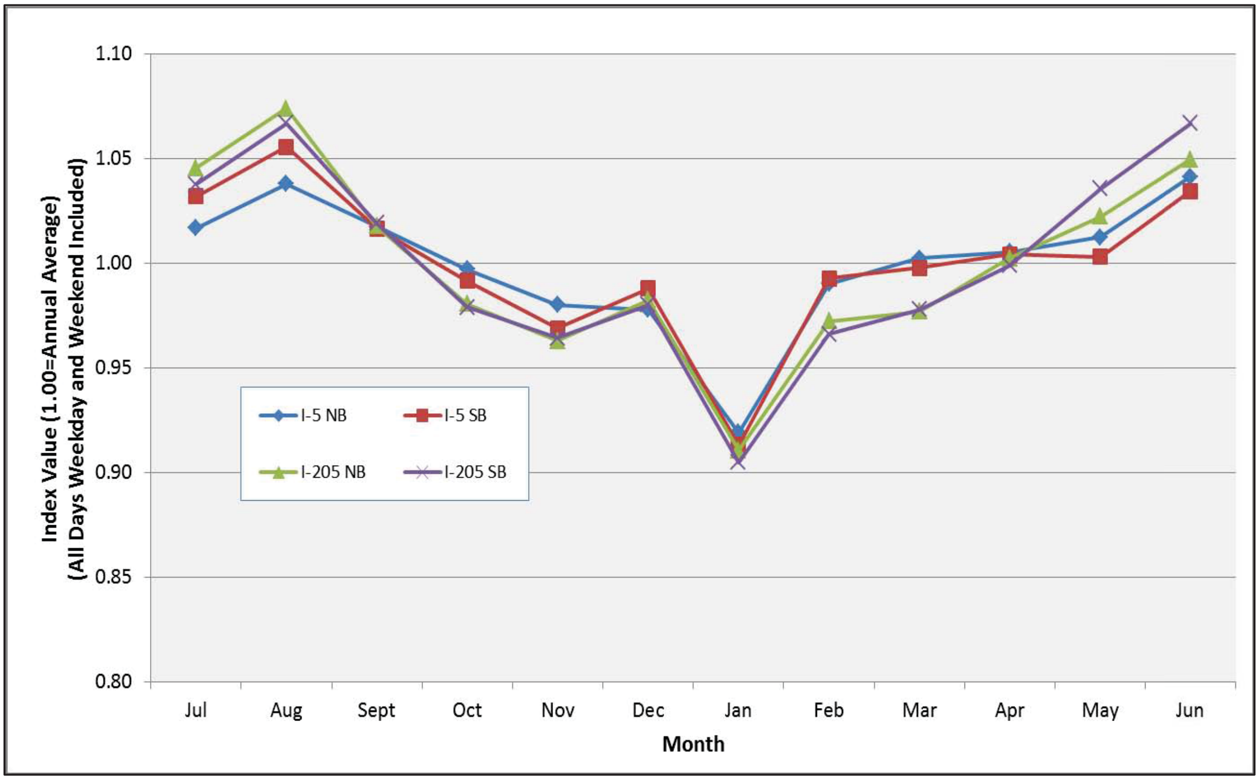
Table 2-2 Monthly Variation Index

Month	I-5 Bridge	I-205 Bridge	Total River Crossing
July	1.02	1.04	1.03
August	**1.05**	**1.07**	**1.06**
September	1.02	1.02	1.02
October	0.99	0.98	0.99
November	0.97	0.96	0.97
December	0.98	0.98	0.98
January	0.92	0.91	0.91
February	0.99	0.97	0.98
March	1.00	0.98	0.99
April	1.00	1.00	1.00
May	1.01	1.03	1.02
June	1.04	1.06	1.05

Note: 1.00 is annual average of all days (weekdays and weekends)
Source: ODOT ATR Data for July 2011 through June 2012

The monthly index values at the I-5 and I-205 bridges are similar to one another and all fall within a tight value range for all months. The highest value at each location is shown in bold. All index values range from 0.91 to 1.07, which is a range of just 0.16.

Figure 2-5 2011-2012 Monthly Average Annual Daily Traffic Variations at I-5 and I-205 Bridges



2.2.5 Day-of-Week Traffic Variations

The data illustrating the day-of-week traffic variations at the I-5 and I-205 bridges was obtained from the hourly counts provided by ODOT for the period from July 2011 through June 2012.

As with the monthly traffic volumes, the day-of-week volumes were converted to "index values" to compare trends at locations with different volume levels. The day-of-week index value was calculated by dividing the average daily volume for each day by the AADT volume at that location (using total of both directions traffic volumes). Table 2-3 present the day-of-week variation index at the I-5 bridge, I-205 bridge, and overall river crossing. The highest value at each location is shown in bold.

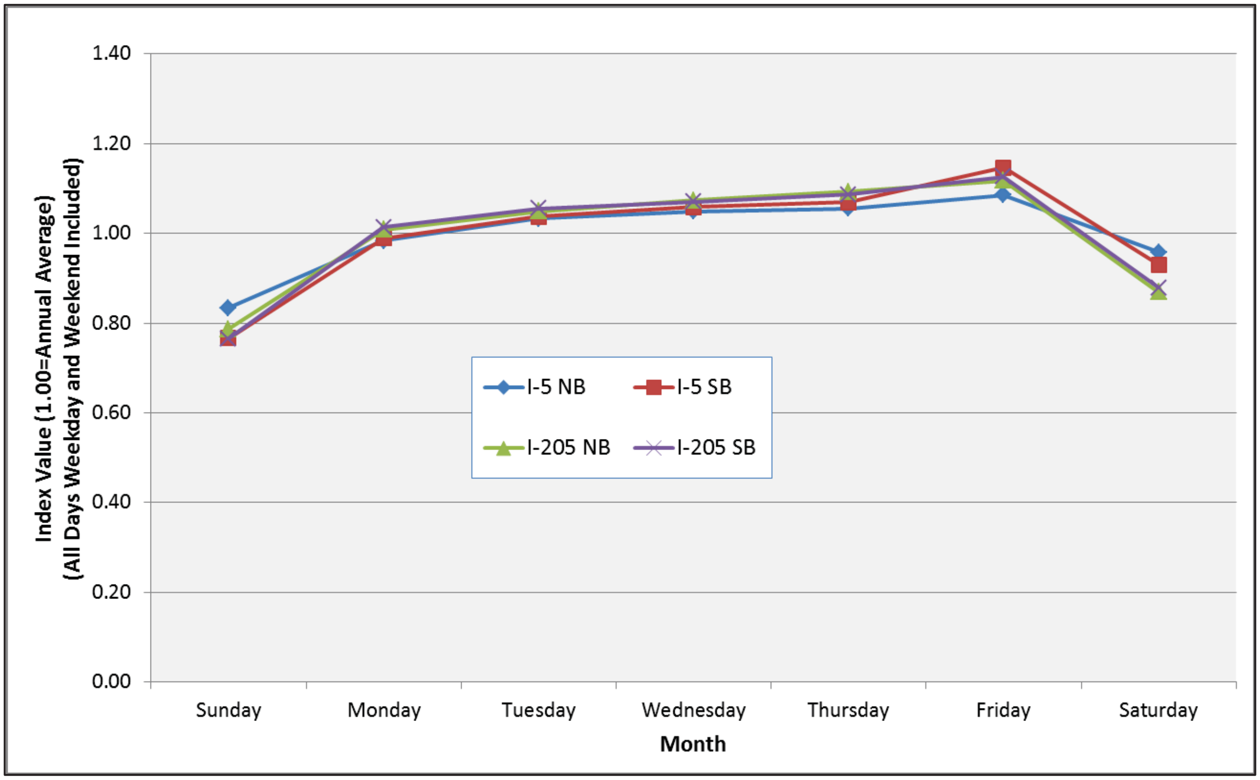
Table 2-3 Daily Variation Index

Month	I-5 Bridge	I-205 Bridge	Total River Crossing
Sunday	0.80	0.78	0.79
Monday	0.99	1.01	1.00
Tuesday	1.04	1.05	1.04
Wednesday	1.05	1.07	1.06
Thursday	1.06	1.09	1.08
Friday	**1.12**	**1.12**	**1.12**
Saturday	0.94	0.87	0.91

Note: 1.00 is annual average of all days (weekdays and weekends)
Source: ODOT ATR Data for July 2011 through June 2012

Figure 2-6 present the results of the day-of-week variation analysis at the bridges. The day-of-week traffic volumes follow the same trend at both locations. Weekend volumes, particularly Sundays, are significantly lower than weekday volumes. This pattern reflects the influence of heavy commuter traffic. Weekday volumes build up from a low on Monday to a high on Friday. Saturday volumes are higher than Sunday volumes but significantly lower than weekdays.

Figure 2-6 2011-2012 Daily Average Annual Daily Traffic Variations at I-5 and I-205 Bridges



2.2.6 Time-of-Day Traffic Variations

The hourly traffic data provided by ODOT for the period from July 2011 through June 2012 was used to review the daily traffic variations. Hourly volume profiles are presented for weekdays, Saturdays, and Sundays.

Weekday Hourly Traffic Pattern

For this analysis, major weekday holidays (New Year's, Memorial, Independence, Labor, Thanksgiving and Christmas) were excluded to derive a typical average weekday profile. The average weekday hourly profiles were produced for three locations: I-5 bridge, I-205 bridge, and I-84.

I-5 Bridge

Figure 2-7 shows the weekday hourly volume profile on the I-5 bridge for the southbound and northbound directions. Traffic volumes are typically at their highest during the morning commute period (6 AM to 9 AM) and the afternoon commute period (2 PM to 6 PM). During the morning peak, southbound traffic volumes are highest, whereas northbound traffic volumes are highest during the afternoon peak. This reflects an overall Portland-focused commuter pattern.

For the I-5 bridge, hourly traffic volumes in the northbound afternoon peak are lower than those observed in the southbound morning peak; this is likely due to heavy congestion conditions on northbound I-5 in the afternoon (contributing to diversion from I-5 to I-205), HOV lane presence limiting the number of general purpose lanes to two and a longer peak commute period in the afternoon spreading the demand.

In the southbound direction, traffic volumes remain very stable after the morning commute period (from 9 AM to 6 PM) and start dropping sharply after 6 PM.

In the northbound direction, the hourly profile shows a general increase of traffic volumes from the early morning hours until 6 PM (with the exception of the period from 8 AM to 10 AM). After 6 PM, volumes drop sharply.

I-205 Bridge

Figure 2-8 shows the weekday hourly volume profile on the I-205 bridge for the southbound and northbound directions. Traffic volumes are typically at their highest during the morning commute period (6 AM to 9 AM) and the afternoon commute period (2 PM to 6 PM). During the morning peak, southbound traffic volumes are highest, whereas northbound traffic volumes are highest during the afternoon peak, reflecting an overall Portland-focused commuter pattern.

Hourly traffic volumes in the northbound afternoon peak are similar to those observed in the southbound morning peak. However, the afternoon peak period lasts longer than the morning peak period (three hours of peak volumes in the northbound afternoon peak compared to one hour in the southbound morning peak).

In the southbound direction, traffic volumes remain very stable after the morning commute period (from 9 AM to 6 PM) and drop sharply after 6 PM.

In the northbound direction, the hourly profile shows a general increase of traffic volumes from the early morning hours until 5 PM (with the exception of the period from 8 AM to 10 AM). After 6 PM, volumes drop sharply.

Figure 2-7 I-5 Bridge Weekday Hourly Profile

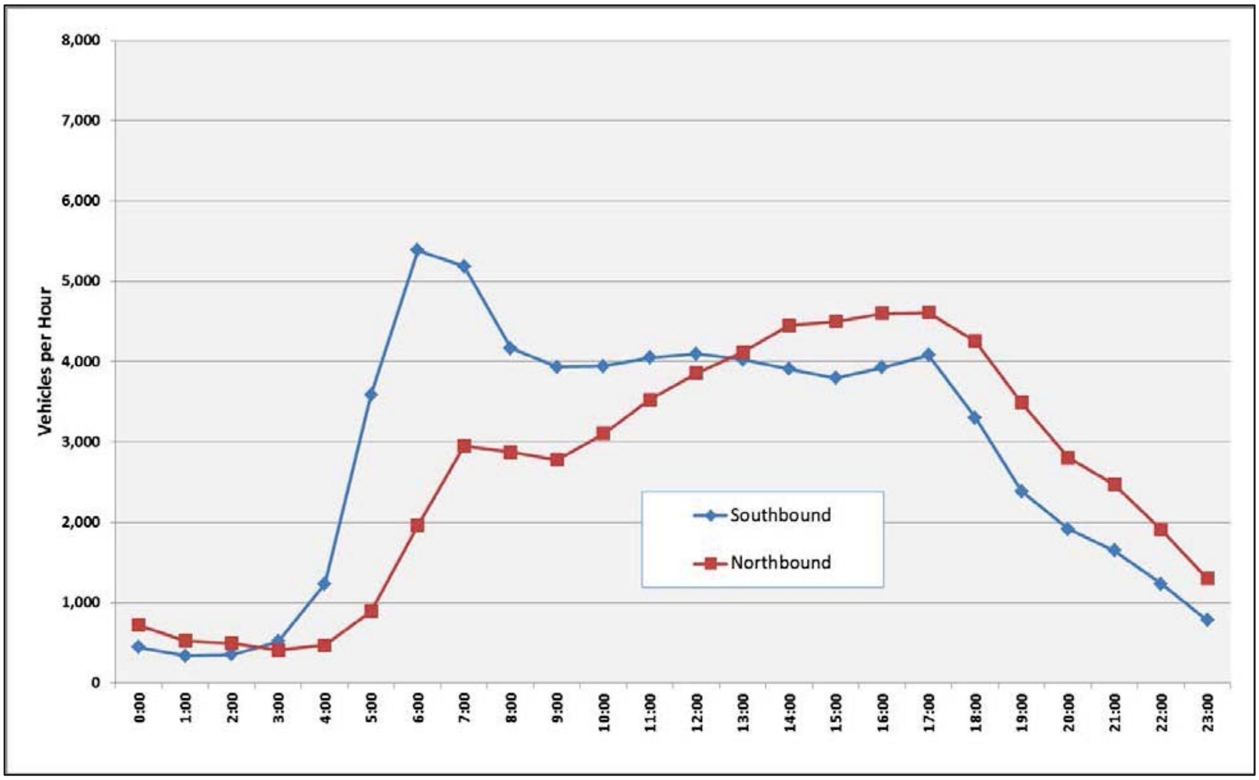
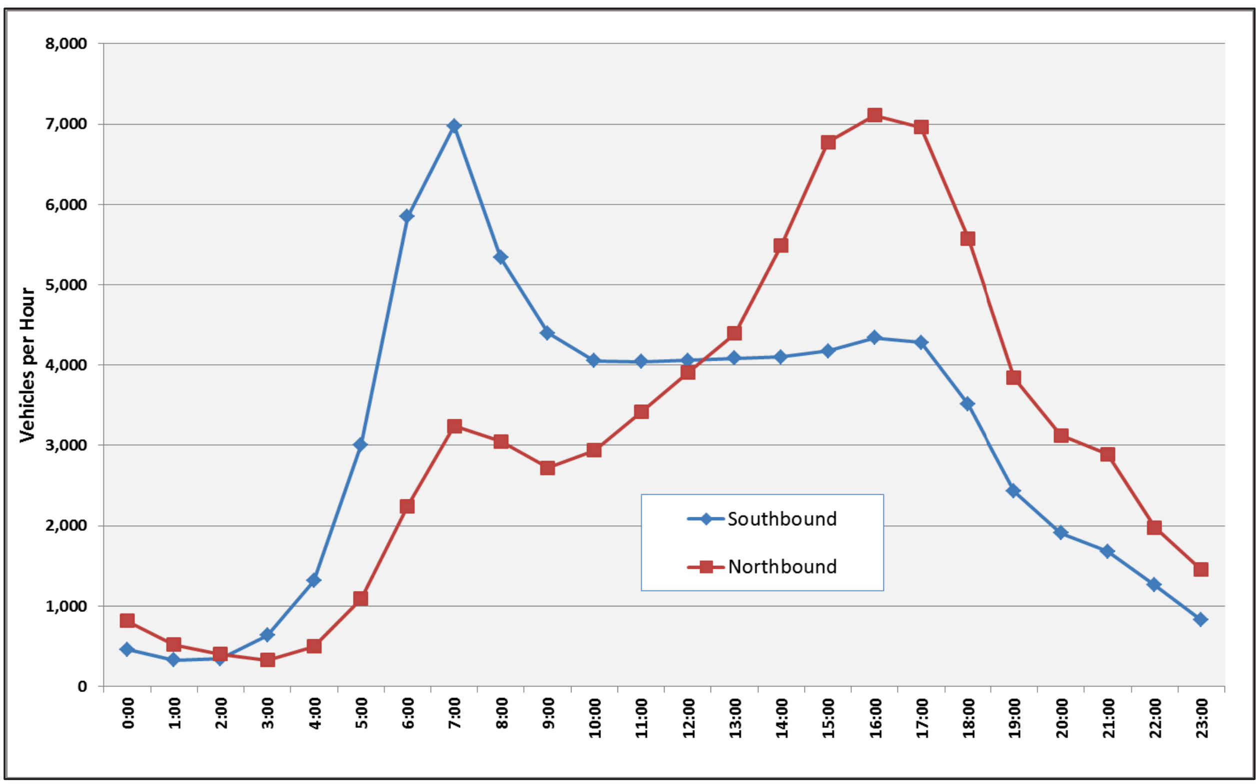


Figure 2-8 I-205 Bridge Weekday Hourly Profile



I-84

Figure 2-9 shows the weekday hourly volume profile on I-84 for the eastbound and westbound directions. The ODOT station used for this analysis is located about half-way between I-5 and I-205 (see location on Figure 2-2).

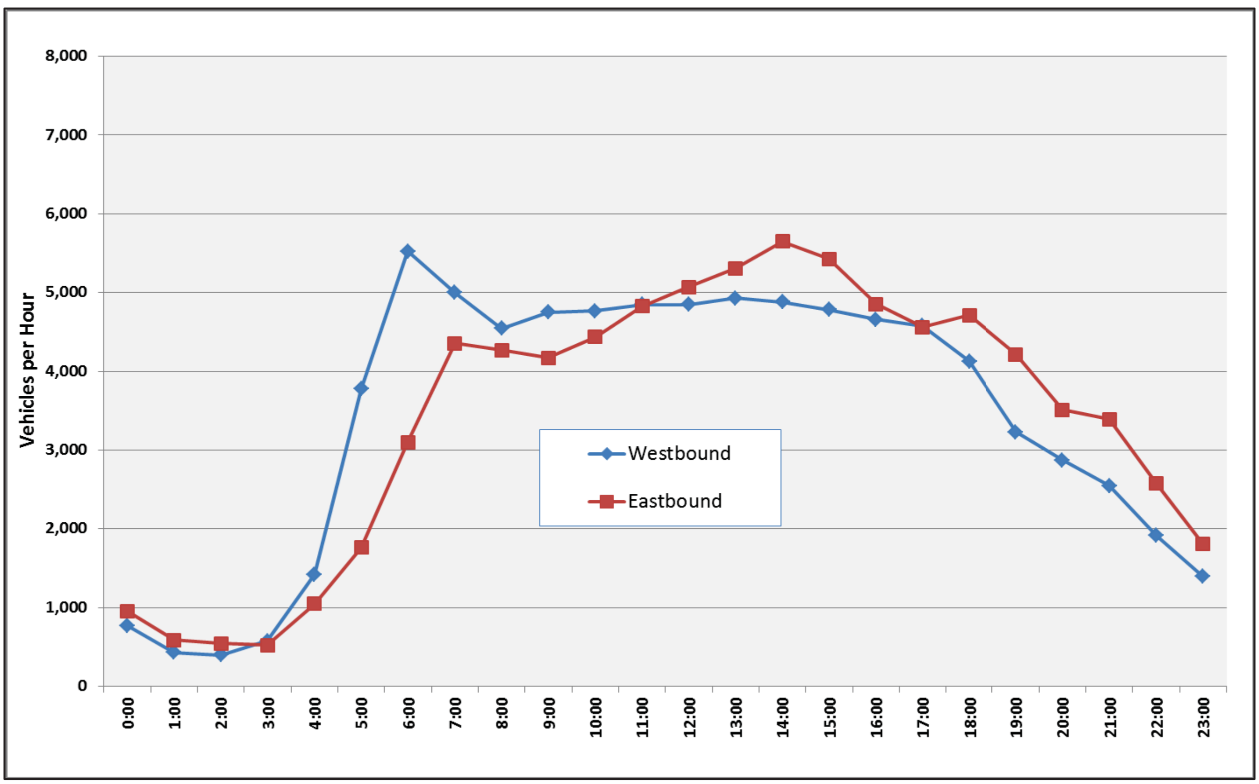
Traffic volumes are typically at their highest during the morning commute period and the early afternoon commute period. During the morning peak, westbound traffic volumes are highest, whereas eastbound traffic volumes are highest during the afternoon peak, reflecting an overall Portland-focused commuter pattern. The morning peak period on I-84 tends to be short (6 AM to 8 AM). The afternoon peak period occurs earlier than at the river crossing locations. On I-84, the highest afternoon hourly volumes are observed between 1 PM and 4 PM. Highest hourly traffic volumes in the eastbound afternoon peak are similar in value to those observed during the westbound morning peak.

In the westbound direction, traffic volumes remain very stable after the morning commute period (from 8 AM to 6 PM) and drop sharply after 6 PM.

In the eastbound direction, the hourly profile shows a general increase in traffic volumes from the early morning hours until 3 PM (with the exception of the period from 8 AM to 10 AM). After 7 PM, volumes drop sharply.

Note that overall traffic is very high on both directions of I-84 during the majority of the day. This generally indicates demand in both directions and may also indicate the facility operates near capacity volumes and experiences congestion often.

Figure 2-9 I-84 Weekday Hourly Profile



Weekday Hourly Distribution Summary

Table 2-4 summarizes the average weekday hourly patterns at the three studied locations. The table shows hourly traffic volumes in number of vehicles and percentage of daily traffic. The hour with the highest traffic volume is shown in bold for each location.

Table 2-4 Weekday Hourly Distribution

Hour Start	I-5 Bridge				I-205 Bridge				I-84			
	Southbound		Northbound		Southbound		Northbound		Westbound		Eastbound	
	Veh.	%	Veh.	%	Veh.	%	Veh.	%	Veh.	%	Veh.	%
0:00	442	*0.6%*	718	*1.1%*	459	*0.6%*	816	*1.1%*	769	*0.9%*	956	*1.2%*
1:00	338	*0.5%*	525	*0.8%*	329	*0.4%*	516	*0.7%*	431	*0.5%*	586	*0.7%*
2:00	349	*0.5%*	495	*0.8%*	343	*0.5%*	402	*0.5%*	399	*0.5%*	546	*0.7%*
3:00	512	*0.7%*	409	*0.6%*	637	*0.9%*	325	*0.4%*	577	*0.7%*	521	*0.6%*
4:00	1,234	*1.8%*	466	*0.7%*	1,316	*1.8%*	497	*0.7%*	1,423	*1.7%*	1,046	*1.3%*
5:00	3,587	*5.3%*	892	*1.4%*	3,006	*4.1%*	1,093	*1.5%*	3,777	*4.6%*	1,764	*2.2%*
6:00	**5,387**	***7.9%***	1,963	*3.1%*	**5,847**	***8.0%***	2,245	*3.0%*	**5,525**	***6.8%***	3,100	*3.8%*
7:00	5,190	*7.6%*	2,951	*4.7%*	6,975	*9.5%*	3,241	*4.3%*	5,001	*6.1%*	4,356	*5.3%*
8:00	4,170	*6.1%*	2,874	*4.6%*	5,337	*7.3%*	3,048	*4.1%*	4,542	*5.6%*	4,270	*5.2%*
9:00	3,935	*5.8%*	2,777	*4.4%*	4,400	*6.0%*	2,720	*3.6%*	4,750	*5.8%*	4,173	*5.1%*
10:00	3,946	*5.8%*	3,103	*4.9%*	4,053	*5.5%*	2,940	*3.9%*	4,765	*5.8%*	4,436	*5.4%*
11:00	4,051	*5.9%*	3,526	*5.6%*	4,041	*5.5%*	3,417	*4.6%*	4,846	*5.9%*	4,828	*5.9%*
12:00	4,096	*6.0%*	3,860	*6.1%*	4,056	*5.5%*	3,904	*5.2%*	4,845	*5.9%*	5,070	*6.2%*
13:00	4,024	*5.9%*	4,116	*6.5%*	4,083	*5.6%*	4,392	*5.9%*	4,927	*6.0%*	5,306	*6.5%*
14:00	3,907	*5.7%*	4,455	*7.1%*	4,099	*5.6%*	5,492	*7.3%*	4,881	*6.0%*	**5,646**	***6.9%***
15:00	3,799	*5.6%*	4,501	*7.1%*	4,177	*5.7%*	6,775	*9.1%*	4,782	*5.9%*	5,426	*6.6%*
16:00	3,931	*5.8%*	4,601	*7.3%*	4,341	*5.9%*	**7,112**	***9.5%***	4,656	*5.7%*	4,852	*5.9%*
17:00	4,085	*6.0%*	**4,612**	***7.3%***	4,279	*5.8%*	6,959	*9.3%*	4,579	*5.6%*	4,558	*5.6%*
18:00	3,304	*4.8%*	4,254	*6.7%*	3,509	*4.8%*	5,575	*7.5%*	4,127	*5.1%*	4,713	*5.8%*
19:00	2,383	*3.5%*	3,492	*5.5%*	2,429	*3.3%*	3,838	*5.1%*	3,231	*4.0%*	4,214	*5.2%*
20:00	1,918	*2.8%*	2,803	*4.4%*	1,908	*2.6%*	3,126	*4.2%*	2,873	*3.5%*	3,510	*4.3%*
21:00	1,647	*2.4%*	2,472	*3.9%*	1,679	*2.3%*	2,889	*3.9%*	2,547	*3.1%*	3,390	*4.2%*
22:00	1,231	*1.8%*	1,911	*3.0%*	1,260	*1.7%*	1,979	*2.6%*	1,913	*2.3%*	2,575	*3.2%*
23:00	780	*1.1%*	1,297	*2.1%*	828	*1.1%*	1,453	*1.9%*	1,395	*1.7%*	1,805	*2.2%*

Note: Average weekdays excluding major holidays
Source: ODOT ATR Data for July 2011 through June 2012

Saturday Hourly Traffic Pattern

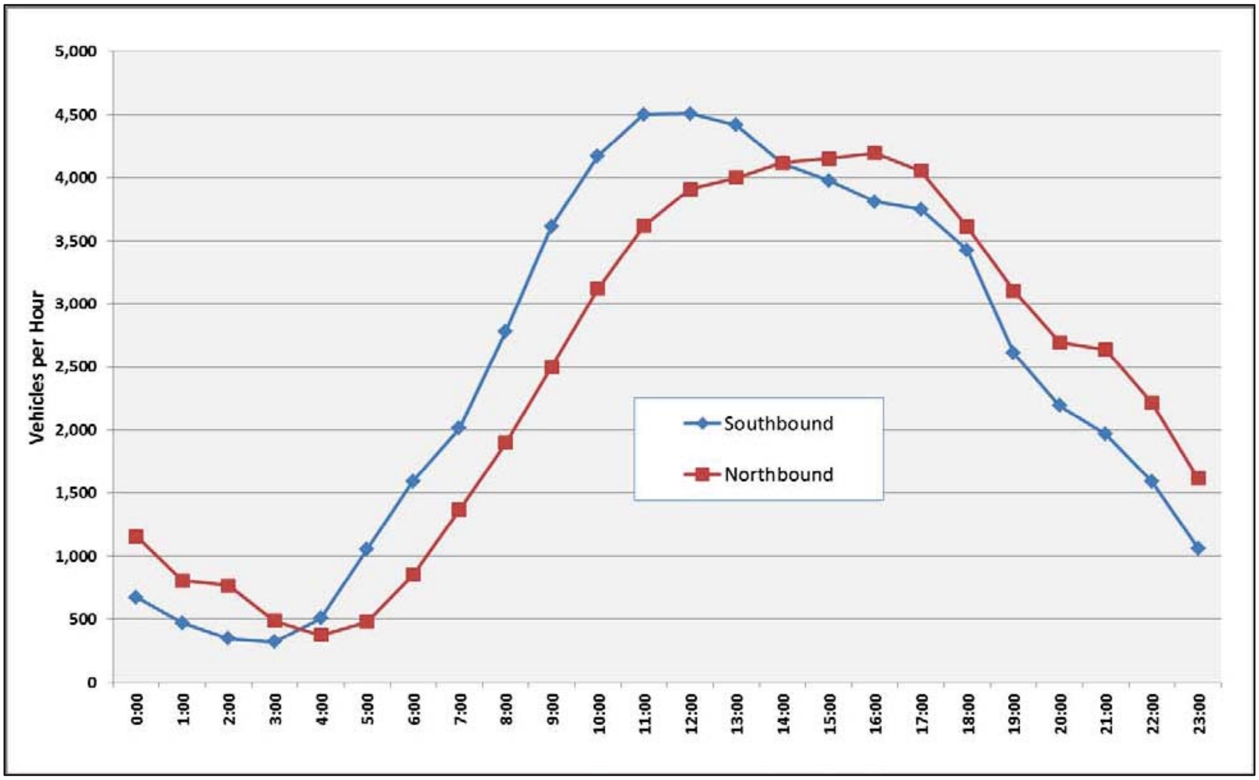
A typical average Saturday hourly profile at the I-5 bridge was derived from the ODOT data covering the period from July 2011 through June 2012. Note that holidays were not excluded in this analysis.

Figure 2-10 shows the Saturday hourly volume profile on the I-5 bridge for the southbound and northbound directions. Traffic volumes are typically at their highest between 10 AM and 6 PM. Until 2 PM, there is more traffic traveling southbound; after 2 PM, the northbound traffic is higher.

In the southbound direction, traffic volumes steadily increase from the early morning hours to 1 PM, and steadily decrease thereafter. The maximum hourly volume (about 4,500 vehicles between 12 PM and 1 PM) is well below the maximum hourly volume observed on a typical weekday (about 5,400 vehicles).

In the northbound direction, traffic volumes steadily increase from the early morning hours to 5 PM, and steadily decrease thereafter. The maximum hourly volume (about 4,200 vehicles between 4 PM and 5 PM) is lower than but fairly close to the maximum hourly volume observed on a typical weekday (about 4,600 vehicles).

Figure 2-10 I-5 Saturday Hourly Profile



Sunday Hourly Traffic Pattern

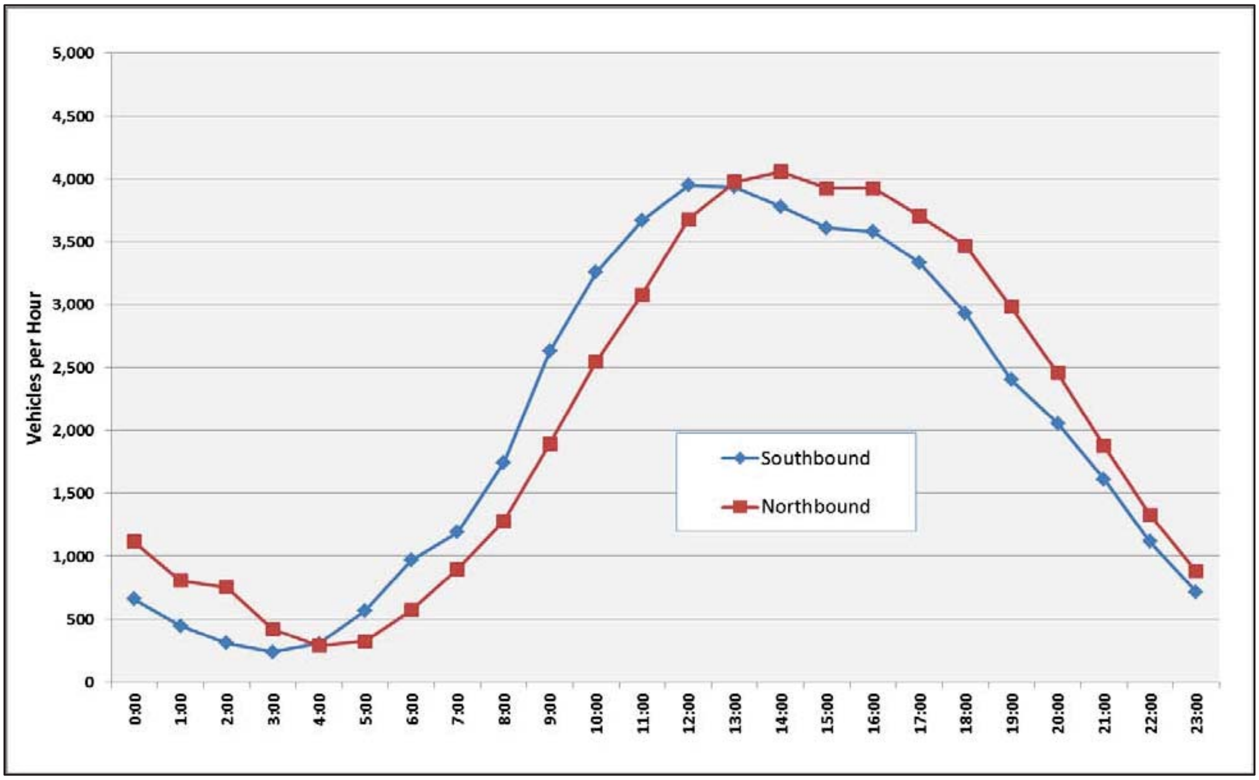
A typical average Sunday hourly profile at the I-5 bridge was derived from the ODOT data covering the period from July 2011 through June 2012. Note that holidays were not excluded in this analysis.

Figure 2-11 shows the Sunday hourly volume profile on the I-5 bridge for the southbound and northbound directions. Traffic volumes are typically at their highest between 11 AM and 6 PM. Similarly to the Saturday and weekday profiles, there is more traffic traveling southbound until 1 PM, and the northbound traffic is higher after 1 PM.

In the southbound direction, traffic volumes steadily increase from the early morning hours to 12 PM and steadily decrease after 2 PM. The maximum hourly volume (about 3,900 vehicles per hour between 12 PM and 2 PM) is significantly lower than the maximum hourly volume observed on a typical Saturday (about 4,500 vehicles). The southbound peak occurs during the same time period on Sundays and Saturdays.

In the northbound direction, traffic volumes steadily increase from the early morning hours to 3 PM and steadily decrease thereafter. The maximum hourly volume (about 4,100 vehicles between 2 PM and 3 PM) is similar to the maximum hourly volume observed on a typical Saturday (about 4,200 vehicles). The northbound peak occurs about two hours earlier on Sundays compared to Saturdays.

Figure 2-11 I-5 Sunday Hourly Profile



2.2.7 Vehicle Occupancy

Vehicle occupancy data was collected on the I-5 bridge on Tuesday October 30th, Thursday November 1st, and Saturday November 3rd, 2012. A camera was used to record traffic streams between 6:30 AM and 6:30 PM for all three lanes in the northbound and southbound directions. Vehicles were classified into single-occupancy, two-passenger, and more-than-two passenger vehicles. For this analysis, only passenger vehicles (cars, pickup trucks, vans, SUVs, etc.) were counted, not trucks (single unit vehicles, vehicles with trailers, dump trucks, semis, etc.), and not buses.

Weekday Occupancy Pattern

Weekday patterns were obtained by averaging the data collected over the two weekdays. Table 2-5 shows the results of the weekday vehicle occupancy data by time period. The table shows the percentage of vehicles in each occupancy category for each time period and each direction. The highest high-occupancy vehicle percentages for each direction are shown in bold.

Overall, between 6:30 AM and 6:30 PM on a weekday, two-passenger vehicles represent about 16 percent of the I-5 passenger vehicles, while vehicles with three or more passengers represent about 1.5 percent. The proportion of vehicles in each occupancy category is fairly similar in both directions.

The proportion of high-occupancy vehicles (more than two passengers) tend to be much higher during the midday off-peak period (about 22 percent) than during the morning peak period (about 11 percent). During the afternoon peak period, the proportion of high-occupancy vehicles remains high (about 19 percent). Overall, this pattern is normal for a major regional facility serving a commuter route. Morning travel to and from work is dominated by single occupant vehicles, while midday trips are often families traveling with children, retired persons, and business trips that have higher occupancy. Afternoon/evening trips will usually include families with children (especially after school) and more shopping trips which have a tendency to have higher occupancy.

The highest proportion of two-passenger vehicles is 24 percent (between 1 PM and 2 PM in the southbound direction). The highest proportion of more-than-two-passenger vehicles is 3 percent (between 3 PM and 4 PM in the southbound direction).

Table 2-5 Weekday Passenger Car Occupancy (%) at the I-5 Bridge

Time	Southbound			Northbound		
	1[a]	2	3+	1	2	3+
6:30-7 AM	90%	10%	0%	94%	5%	1%
7-8 AM	89%	10%	1%	93%	7%	0%
8-9 AM	89%	10%	1%	91%	9%	1%
9-10 AM	84%	14%	1%	86%	13%	1%
11 AM-12 PM	78%	20%	1%	81%	18%	1%
12-1 PM	76%	23%	2%	80%	18%	1%
1-2 PM	74%	**24%**	2%	80%	**19%**	1%
3-4 PM	78%	20%	**3%**	80%	18%	**2%**
4-5 PM	81%	16%	2%	83%	16%	**2%**
5-6 PM	80%	19%	2%	81%	17%	**2%**
6-6:30 PM	79%	19%	2%	84%	15%	**2%**
Total	82%	17%	1%	83%	15%	1%

a) Persons per vehicle
Data Sources: Quality Counts (10/30/12 and 11/01/12); Compiled by CDM Smith

Weekend Occupancy Pattern

Table 2-6 shows the results of the weekend vehicle occupancy data by time period. The table shows the percentage of vehicles in each occupancy category for each time period and each direction. The highest high-occupancy vehicle percentages for each direction are shown in bold.

Overall, between 6:30 AM and 6:30 PM on a weekend day, two-passenger vehicles represent about 36 percent of the I-5 passenger vehicles, while vehicles with three or more passengers represent about 5 percent. The proportion of vehicles in each occupancy category is fairly similar in both directions. These proportions are significantly higher than those observed on weekdays.

The proportion of high-occupancy vehicles steadily increases from the early morning hours until 12 PM. Between 12 PM and 6 PM, the proportion of high-occupancy vehicles remains stable and high (about 40 percent for two-passenger vehicles and 6 percent for more-than-two passenger vehicles).

Weekend trips are often with family or friends with less work commuting, resulting in higher occupancy.

Table 2-6 Weekend Passenger Car Occupancy (%) at the I-5 Bridge

Time	Southbound			Northbound		
	1[a]	2	3+	1	2	3+
6:30-7 AM	89%	9%	1%	85%	14%	1%
7-8 AM	79%	19%	2%	82%	17%	1%
8-9 AM	68%	29%	3%	74%	24%	3%
9-10 AM	62%	34%	4%	67%	29%	4%
11 AM-12 PM	51%	42%	**7%**	61%	37%	2%
12-1 PM	51%	41%	**7%**	59%	36%	4%
1-2 PM	49%	**44%**	**7%**	57%	38%	5%
3-4 PM	52%	42%	6%	58%	36%	**6%**
4-5 PM	54%	39%	**7%**	55%	**39%**	**6%**
5-6 PM	52%	41%	**7%**	55%	**39%**	5%
6-6:30 PM	55%	40%	5%	59%	38%	3%
Total	57%	37%	6%	61%	35%	4%

a) Persons per vehicle
Data Sources: Quality Counts (11/3/12); Compiled by CDM Smith

2.3 Travel Times and Travel Speeds

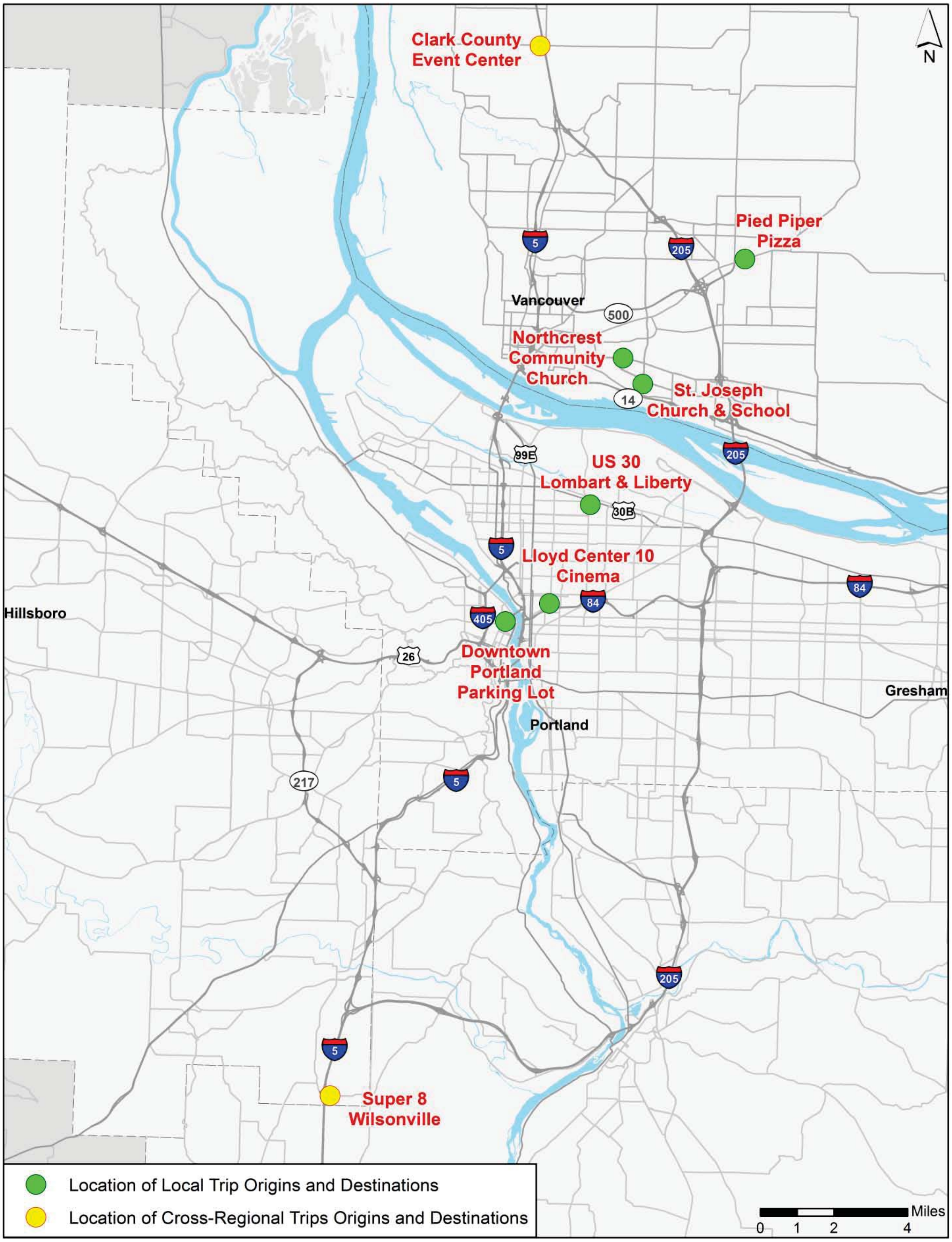
Travel time and speed surveys were conducted by CDM Smith in March, 2013. The surveys were used to obtain current and actual data of travel times and speeds in the corridor to support the Tolling Analysis Model development and calibration. The survey methodology and findings are described in this section.

2.3.1 Methodology

Two probe vehicles were equipped with a GPS device to record the vehicle's speed and position every two seconds. The travel time and speed data were collected across the metropolitan area and between various locations in Vancouver and Portland. The trip end locations are shown in Figure 2-12. Travel time and speed runs occurred on I-5 and I-205 between trip ends. In addition to I-5 and I-205, data were collected on major feeder routes including I-84, SR 500, SR 14, and US 30.

The surveys were conducted on March 18th, 19th, and 20th, 2013[1]. Surveys were performed from approximately 6 AM to 10 AM during the AM peak period and from approximately 3 PM to 7 PM during the PM peak period. The number of directional bridge crossings per time period varied between four and seven.

[1] A major accident occurred on the I-205 bridge on Monday, March 18th before the morning peak commute. All but one of the southbound lanes of I-205 was blocked during the entire morning peak period. The data collected on the morning of March 18th in the southbound direction was not used in the analysis due to the highly unusual traffic patterns resulting from the accident.



CDM Smith

TRIP END LOCATIONS

FIGURE 2-12

2.3.2 Route Travel Times

Table 2-7 shows the maximum and average travel times observed on I-5 and I-205 during the data collection runs. The observed travel times are compared to the free-flow travel time, as reported by Google maps for each route. Travel delay due to congestion is the difference between the observed and free-flow travel time. In the table, orange fill indicates a delay between 2 and 10 minutes; and red fill indicates a delay exceeding 10 minutes.

Table 2-7 Observed Travel Times for Peak Periods (March 2013 Survey)

From[1]	To[1]	Via I-5			Via I-205		
		Free[2]	Avg[3]	Max[4]	Free[2]	Avg[3]	Max[4]
AM Peak Period - Southbound Direction							
Pied Piper Pizza	Downtown Portland Parking Lot	22.0	29.4	36.7	24.0	31.9	39.4
Northcrest Comm. Church	Lloyd Center 10 Cinema	20.0	23.0	25.1	21.0	20.2	20.6
Clark County Event Center	Super 8 Wilsonville	37.0	53.3	53.3	45.0	48.6	48.6
PM Peak Period - Southbound Direction							
Pied Piper Pizza	Downtown Portland Parking Lot	22.0	22.0	23.8	24.0	24.8	27.2
St. Joseph Church and School	US-30 (Lombard & Liberty)	16.0	15.6	15.8	16.0	17.8	18.0
Pied Piper Pizza	Super 8 Wilsonville	37.0	47.7	47.7	39.0	43.7	43.7
AM Peak Period - Northbound Direction							
Lloyd Center 10 Cinema	Pied Piper Pizza	22.0	21.0	22.0	21.0	19.3	20.0
Downtown Portland Parking	St. Joseph Church/School	20.0	19.8	19.8	21.0	20.0	20.3
Super 8 Wilsonville	Northcrest Comm. Church	34.0	41.2	41.2	38.0	38.2	38.2
PM Peak Period - Northbound Direction							
Lloyd Center 10 Cinema	Pied Piper Pizza	22.0	24.1	24.1	21.0	21.8	21.8
Downtown Portland Parking	St. Joseph Church/School	20.0	20.0	21.5	21.0	22.5	26.8
US-30 (Lombard and Liberty)	Pied Piper Pizza	19.0	27.9	33.1	18.0	19.8	20.9
Super 8 Wilsonville	Clark County Event Center	36.0	65.5	65.5	44.0	74.3	74.3

1. Refer to Figure 2-12 for map of trip origins and destinations
2. Free flow travel time as reported by Google Map for this route
3. Average travel time measured during the runs for this route
4. Maximum travel time measured during the runs for this route

Source: CDM Smith Survey, March 2013

Southbound Travel Times

Travel times shown on Table 2-7 indicate that congested conditions occur southbound across the Columbia River during the AM peak period. Travel time delays for trips from Vancouver to downtown Portland during the morning period reach 15 minutes compared to free-flow conditions, whether travelers use I-5 or I-205/I-84. During the PM peak period, delays were also observed on trips from Vancouver to Wilsonville with congestion occurring in Portland and south of Portland. Delays were higher on I-5 compared to I-205.

Northbound Travel Times

In the northbound direction, congested conditions occur during the PM period. Travel time delays northbound across the metropolitan area reached 30 minutes using both I-5 and I-205. During the AM period, a 7-minute delay was observed on trips from Wilsonville to Vancouver using I-5. This delay was observed south of Portland.

2.3.3 Travel Speeds on Major Routes

Figure 2-13 through Figure 2-16 show travel speeds captured via GPS using a probe car, on area highways near the Columbia River. The figures show travel speed data during peak period congestion.

I-5 – Southbound

The southbound AM speed map (Figure 2-13) indicates that southbound I-5 is very congested during the morning peak between the SR 500 interchange and the Rosa Parks Way interchange. On the bridge itself, traffic flows at a speed over 30 mph, but observed speeds are below 30 mph before and after the bridge. Congestion and queuing is due to capacity limitations, and heavy merging and weaving movements at several closely spaced interchanges.

The southbound PM speed map (Figure 2-14) shows that southbound I-5 also experiences congestion during the PM peak (although it is less severe than during the morning peak). In the afternoon, congestion is observed approaching downtown Portland from the Going Street interchange to the Rose Quarter exit.

I-5 – Northbound

The northbound AM speed map (Figure 2-15) shows that northbound I-5 is generally free flowing during the morning peak. The only area that experiences some localized congestion is near the I-84 interchange.

The northbound PM speed map (Figure 2-16) shows that northbound I-5 experiences severe congestion during the PM peak. On the I-5 bridge itself, traffic flows at a speed over 30 mph, but observed speeds are below 30 mph from the I-405 split (just north of downtown Portland) all the way to the I-5 bridge. Congestion and queuing is due to capacity limitations, and heavy merging and weaving movements at several closely spaced interchanges.

I-205 – Southbound

The southbound AM speed map (Figure 2-13) indicates that southbound I-205 is experiencing congestion between the Airport Way interchange and the junction with westbound I-84. The bottleneck is created by congestion on westbound I-84 backing up onto southbound I-205.

The southbound PM speed map (Figure 2-14) shows that southbound I-205 experiences little congestion during the PM peak.

I-205 – Northbound

The northbound AM speed map (Figure 2-15) shows that no congestion was observed on northbound I-205 near the Columbia River during the morning peak.

In the PM peak, Figure 2-16 indicates that northbound I-205 experiences severe congestion conditions south of the Columbia River. Observed speeds are below 30 mph from Exit 21A (Stark Street) all the way to Government Island.

I-84 – Westbound

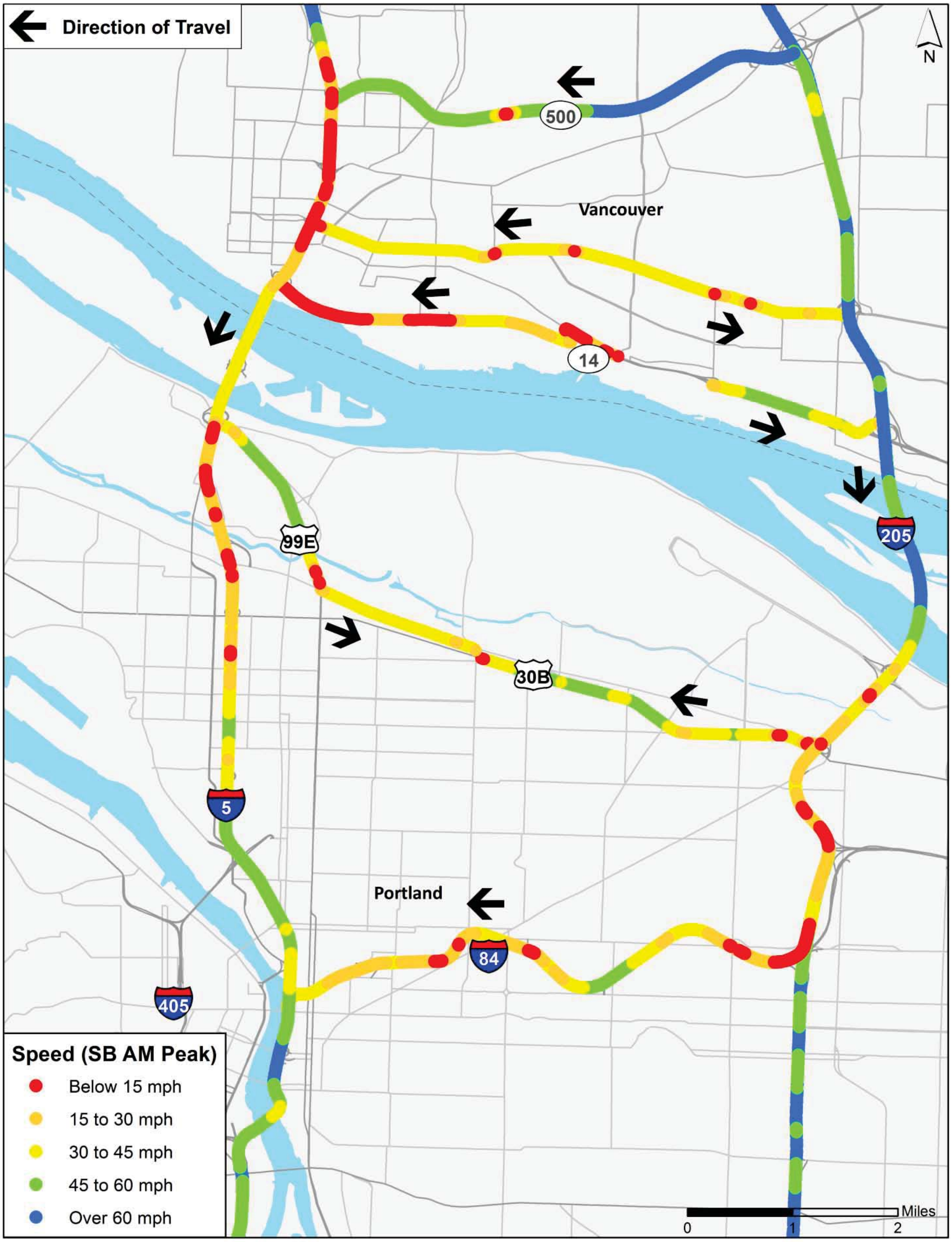
Figure 2-13 also illustrates speeds observed on westbound I-84 during the morning peak. Severe congestion is observed all the way between the I-205 merging point and I-5 with speeds generally below 30 mph. Congestion and queuing is due to capacity limitations, and heavy merging and weaving movements at several closely spaced interchanges.

This section of westbound I-84 does not experience any congestion in the afternoon and evening peak period (as shown on Figure 2-14).

I-84 – Eastbound

The section of eastbound I-84 does not experience any congestion in the morning peak period (as shown on Figure 2-15).

As shown on Figure 2-16, some congestion is observed on eastbound I-84 during the PM peak. The congestion is less severe than what is observed during the morning peak period in the opposite direction. Traffic moves at a speed below 15 mph immediately east of I-5 in the Lloyd District. Further east, traveling speeds increase and are generally over 30 mph.



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OBSERVED AVERAGE TRAVEL SPEED – SOUTHBOUND AM PEAK

FIGURE 2-13

OBSERVED AVERAGE TRAVEL SPEED – SOUTHBOUND PM PEAK

FIGURE 2-14

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OBSERVED AVERAGE TRAVEL SPEED – NORTHBOUND AM PEAK

FIGURE 2-15

CDM Smith

OBSERVED AVERAGE TRAVEL SPEED – NORTHBOUND PM PEAK

FIGURE 2-16

2.4 Vehicle State-of-Plate on I-5 Bridge

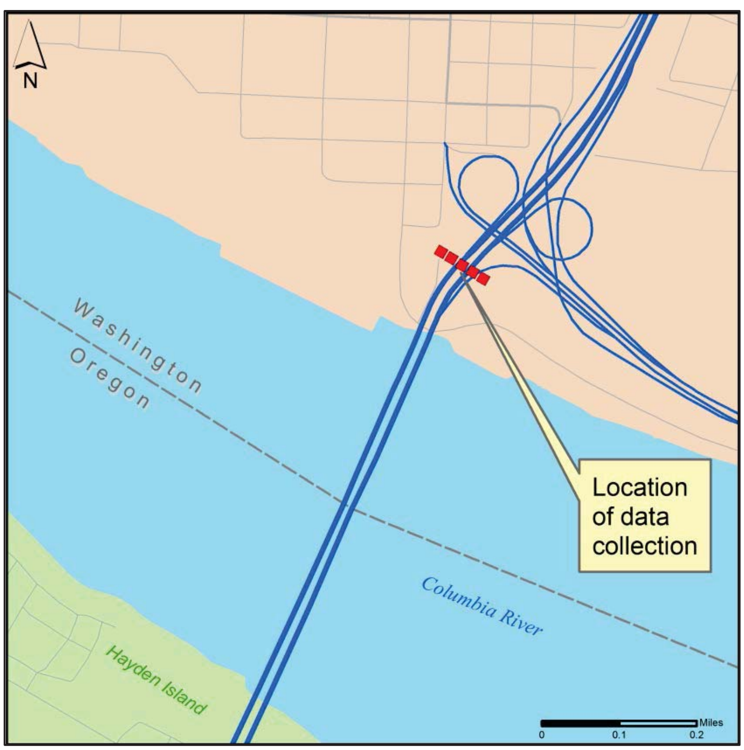
A travel pattern survey was performed as part of the study as described in Chapter 3. A key component of that survey was video collection of license plate information to get mailing address information for cross-river travelers. The data was also analyzed to determine the state-of-plate for vehicles using I-5. The state-of-plate information was compiled to estimate the number of plates crossing the I-5 bridge from six different areas (Canada, Mexico, Oregon, Washington, California, and all others).

2.4.1 Data Collection Methodology

Video data were recorded during daytime hours on one weekday and one weekend day. About 95 percent of the weekday state-of-plate data was recorded on Wednesday, October 24, 2012 and the weekend state-of-plate data were recorded on Sunday, November 4, 2012. The weekday data was supplemented by a small amount from Thursday, October 25, and the weekend by a small amount from Saturday, October 27 and Sunday, October 28. The videos were generally recorded between 8:15 AM and 5:30 PM on the weekday and between 8 AM and 5 PM on the weekend. The videos were manually processed by National Data & Surveying Services (NDS), a subcontractor to CDM Smith. The weekday state-of-plate, plate numbers, and vehicle type (passenger car or truck) were recorded. For the purposes of this data collection, passenger cars were assumed to be Federal Highway Administration (FHWA) classes 1, 2, or 3 and trucks were assumed to be classes 4 or above.

Figure 2-17 shows the location of the video recording used to collected state-of-plate information on the I-5 bridge. Video data collection presents some challenge in reading small fonts, specialized plates, non-standard plate placements – especially on trucks, and poor weather conditions. However, identification rates were higher than expected. Truck identification rates were lower than passenger car, giving more uncertainty to the truck results.

Figure 2-17 State-of-Plate Video Data Collection Location



2.4.2 State-of-Plate Survey Results

The state of license plate identification rates for vehicles using the I-5 bridge is summarized in Table 2-8.

Table 2-8 License Plate Identification Rates

	I-5 Northbound				I-5 Southbound			
	Weekday		Weekend Day		Weekday		Weekend Day	
	Cars[1]	Trucks[2]	Cars[1]	Trucks[2]	Cars[1]	Trucks[2]	Cars[1]	Trucks[2]
Number Vehicles	34,246	2,940	27,638	840	32,812	3,109	29,265	705
Percent Identified	80%	49%	85%	48%	74%	59%	83%	69%
Percent Unidentified	20%	51%	15%	52%	26%	41%	17%	31%

1. Cars refers to FHWA Classes 1, 2, and 3
2. Trucks refers to FHWA Classes 4 through 13.

The state-of-plate information is summarized in Table 2-9. Washington and Oregon license plates were around 97 percent to 98 percent of the passenger car plates for both weekdays and weekends while truck plates were about 90 percent on weekdays and 80 percent on weekends. Washington passenger car plates were twice as many as Oregon plates.

For trucks, the number of Oregon plates was significantly higher than Washington plates in the weekday southbound direction but lower than Washington plates in the northbound direction. On the weekend there were more Washington plates than Oregon plates for trucks. No plates were identified from Mexico and a small number were identified from Canada. The state of Indiana was added because of the relative prevalence in truck traffic. The truck plates for Indiana are due to the relative ease of licensing in Indiana compared to other states.

Table 2-9 State-of-Plate on I-5 Bridge

	I-5 Northbound				I-5 Southbound			
	Weekday		Weekend Day		Weekday		Weekend Day	
	Cars[1]	Trucks[2]	Cars[1]	Trucks[2]	Cars[1]	Trucks[2]	Cars[1]	Trucks[2]
Number Plates Identified	27,478	1,454	23,387	405	24,154	1,843	24,196	485
Washington + Oregon	98%	90%	97%	80%	98%	92%	98%	79%
Washington	66%	50%	66%	43%	63%	34%	66%	49%
Oregon	32%	41%	32%	37%	35%	58%	31%	29%
California	1%	2%	1%	3%	1%	1%	1%	1%
Indiana	0%	3%	0%	10%	0%	5%	0%	10%
Canada	0%	0%	0%	1%	0%	0%	0%	5%
Mexico	0%	0%	0%	0%	0%	0%	0%	0%
All Others	1%	5%	1%	5%	1%	3%	1%	4%

1. Cars refers to FHWA Classes 1, 2, and 3
2. Trucks refers to FHWA Classes 4 through 13.

2.5 Truck Data

This study includes an in-depth analysis of truck volume data because of: the relatively high number of trucks currently traveling on the I-5 bridge, trucks tend to make longer trips than passenger cars on average (and therefore tend to make more through-trips), and the anticipated higher truck toll rates than cars resulting in truck volumes having a bigger impact on toll revenue than transactions.

2.5.1 Sources of Truck Data

Available Data by Vehicle Class

The gathering of existing data included existing vehicle classification data from ODOT and WSDOT including:

- Historical traffic and truck data crossing the I-5 bridge
- Daily and peak period traffic and truck volumes
- Annual and hourly vehicle classification data on regional facilities

ODOT and WSDOT use the following 13 vehicle classifications established by FHWA :

- Class 1 (Bikes)
- Class 2 (Cars and Trailers): light vehicles less than 16,000 pounds.
- Class 3 (2-Axle Long) light vehicles less than 16,000 pounds.
- Class 4 (Buses): Any vehicle manufactured as a bus with at least two axles and six tires that is used to carry passengers. Modified buses were considered to be trucks.
- Class 5 (Two-axle, six-tire, single unit trucks): Includes camping and recreational vehicles in addition to normal single framed trucks with two axles and dual rear wheels. Note that truck tractor units traveling without a trailer are considered to be single unit trucks.
- Class 6 (Three-axle, single unit trucks): Includes camping and recreational vehicles in addition to normal single framed trucks with at least three axles. Note that truck tractor units traveling without a trailer are considered to be single unit trucks.
- Class 7 (Four or more axle single unit trucks): Same as Class 6 except with four or more axles.
- Class 8 (Four or less axle single trailer trucks): All vehicles with four or less axles consisting of two units, one of which is a tractor or straight truck power unit.
- Class 9 (Five-axle single trailer trucks): Same as Class 8 except with five axles.
- Class 10 (Six or more axle single trailer trucks): Same as Class 8 except with six or more axles.
- Class 11 (Five or less axle multi-trailer trucks): All vehicles with five or less axles consisting of three or more units, one of which is a straight truck power unit.
- Class 12 (Six-axle multi-trailer trucks): Same as Class 11 except with six axles.

- Class 13 (Seven or more axle multi-trailer trucks): Same as Class 11 except with seven or more axles.

For the purposes of tolling analysis, the classification data was grouped by axles rather than FHWA classification. This was to remain consistent with the assumed toll rate policy for CRC which is also by axles.

New Vehicle Classification Data

In addition to existing data, new vehicle classification data was collected by CDM Smith:

- Truck volume and classification data by axle were collected to help determine the impact of toll rate policy, which is assumed to be based on the number of axles, on truck travel.
- A truck through trip survey was conducted to help determine the amount of through trucks with origins and destinations outside the region versus the amount of trucks travelling within the region.

The FHWA classes described previously were combined into three truck groups for the truck through trip survey: Class 4, Classes 5 to 7 and Classes 8 to 13. Classes 5 to 7 are typically referred to as "medium trucks" and Classes 8 to 13 are referred to as "heavy trucks". Note that the FHWA Class 5 includes two axle six-tire vehicles and Class 2 may include more than two axle vehicles (cars with trailers). It would have been preferred to conduct the through truck survey by axles rather than FHWA classes to remain consistent with the per axle tolling policy, but this was not technologically possible. Despite this limitation, analysis shows the potential differences between the two designations (FHWA classes 5 and over compared to 3 or more axles) to be relatively small. Thus, the travel pattern results of the through truck survey are taken to be applicable to the tolling analysis.

2.5.2 Existing Truck Trip Characteristics

Freight Volume by Truck

Trucks carry more freight than the other five modes (rail, ocean, barge, pipeline, and air) used to move freight in the Portland-Vancouver region as shown in Table 2-10. The market for commodities is sensitive to transport time and shipping cost. Rail is more cost effective for large tonnages, but it cannot meet the delivery schedule requirements for many commodities. Therefore the majority of freight within the Portland-Vancouver region moves by truck. The data also shows that trucks carry 67 percent of all freight in the region, and this is expected to grow to 73 percent by 2030.

Table 2-10 Portland-Vancouver Region Freight Tonnage by Mode

Mode	Year 2000 Volume		Year 2030 Volume		Annual Growth
	Tons (millions)	Percent	Tons (millions)	Percent	2000 - 2030
Truck	197.2	67%	390.5	73%	2.3%
Rail	32.9	11%	50.9	10%	1.5%
Ocean	28.4	10%	40.3	8%	1.2%
Barge	15.1	5%	19.8	4%	0.9%
Pipeline	22.2	7%	28.8	5%	0.9%
Air	0.4	<1%	1.3	<1%	4.0%
Total	**296.2**	**100%**	**531.6**	**100%**	**2.0%**

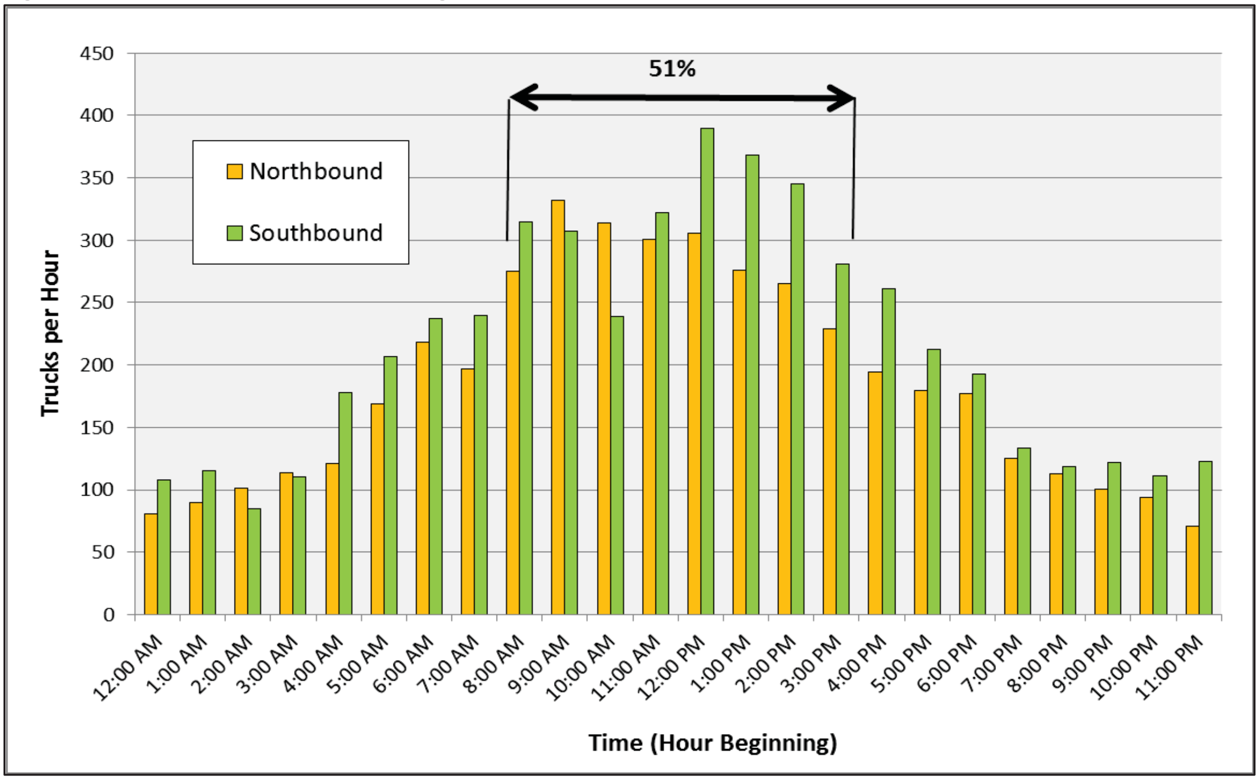
Source: Columbia River Crossing Project: Portland/Vancouver International Domestic Trade Capacity Analysis, 2006

2.5.3 Existing Truck Volumes

Truck volumes on the I-5 mainline are a mix of truck trips generated by industrial and commercial land uses that access I-5 and through truck trips. Figure 2-18 presents 24 hour truck volumes across the I-5 bridge by direction. The volumes show that most trucks travel during the middle of the day, with 51 percent of the daily volume occurring between 8 AM and 4 PM. This is in contrast to cars which show the highest volumes in the AM and PM peaks. Trucks generally attempt to avoid congested peak periods due to the costs associated with additional travel time. Southbound trips are generally stronger and particularly stronger early afternoon than northbound trips. This is likely due to truck activity that began in the Seattle region in the morning reaching the bridge about this time.

The daily truck trips over the I-5 bridge show a greater number of trucks southbound than northbound. This imbalance has been consistently observed in truck volume data in past analyses and studies. This imbalance can be partially explained by truck trips traveling southbound on I-5, then eastbound on I-80 that do not return via I-80 and I-5. Some trucks continue their journey and return to the greater Oregon/Washington area via I-90 in Washington or other state highways. This observation is consistent with the *Oregon Freight Plan*.

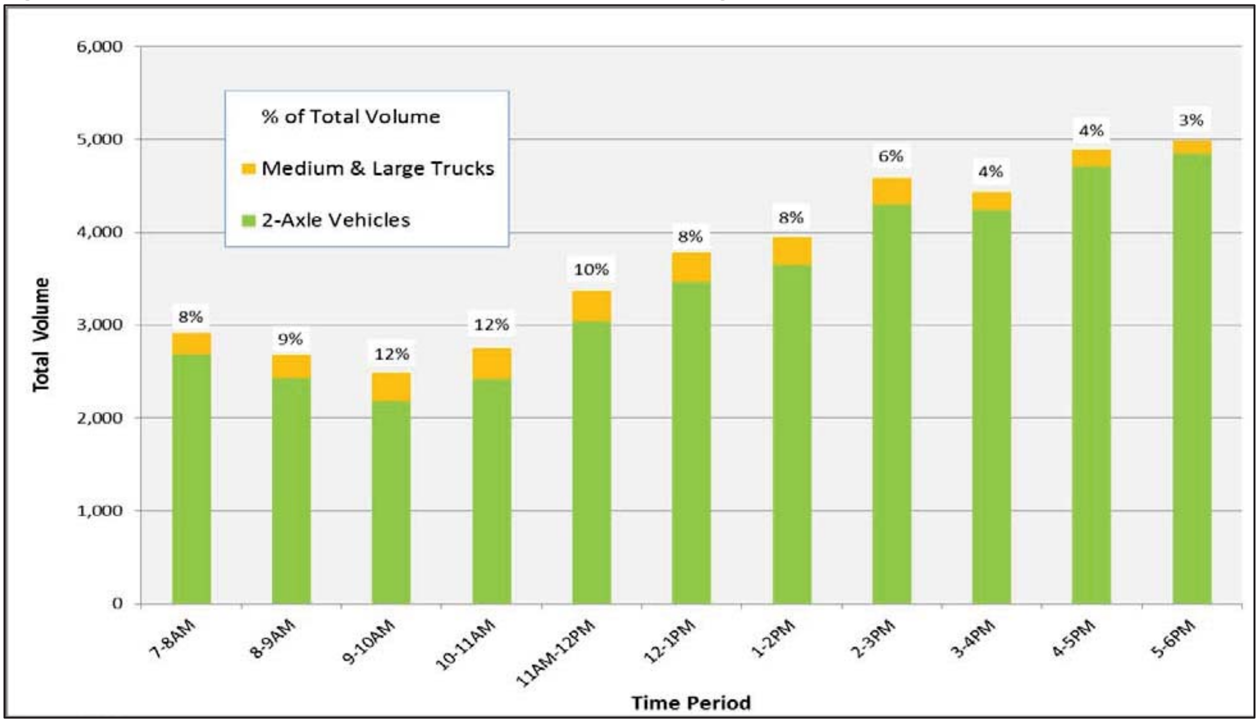
Figure 2-18 Truck Volumes on I-5 Bridge



Source: ODOT Automatic Traffic Recorder (ATR) at Station 26-004, supplemental short counts (11/14/2011).

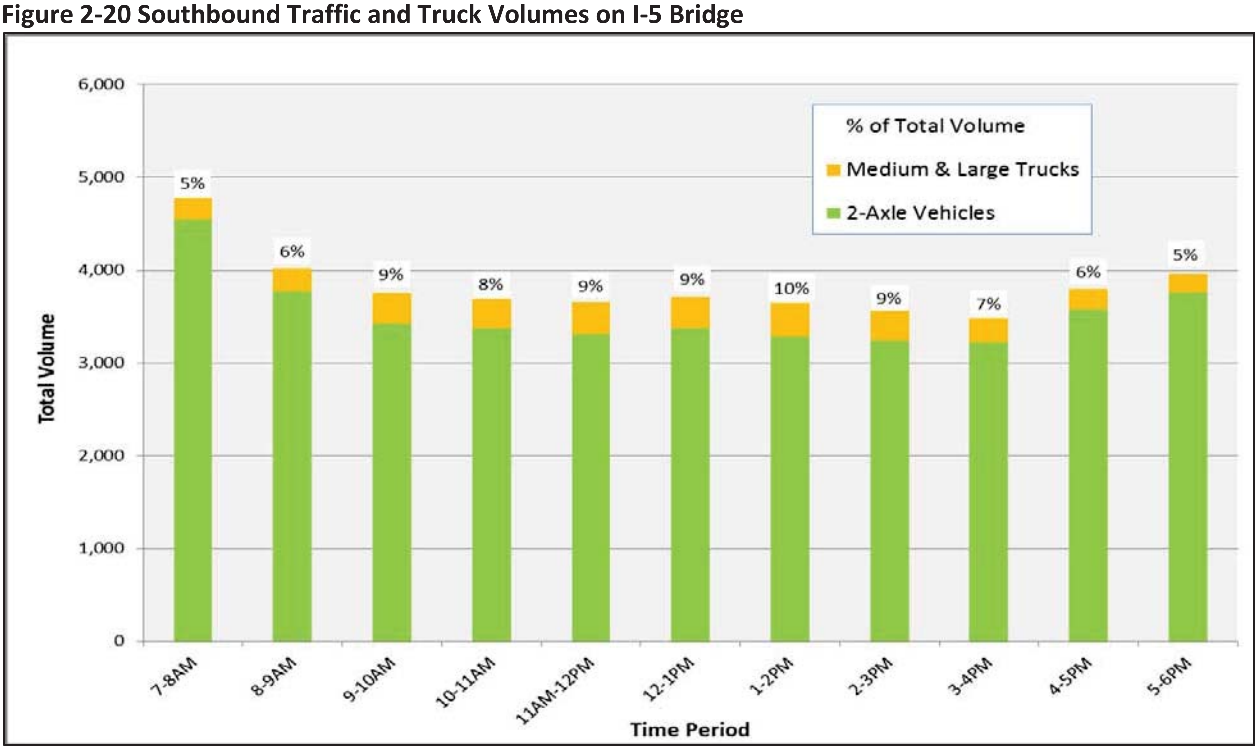
Figure 2-19 shows the hourly 7 AM to 6 PM traffic pattern for northbound total traffic and portion of trucks over the I-5 bridge. These data show how the PM peak hour commute traffic begins to increase in the northbound direction about 2 PM and the portion of trucks decreases. Figure 2-20 shows the southbound direction which illustrates a similar pattern but with less drop-off into the afternoon and early evening hours. Since northbound travel is generally more congested in the afternoon than southbound travel, trucks likely avoid northbound afternoon movements at a greater rate than southbound.

Figure 2-19 Northbound Traffic and Truck Volumes on I-5 Bridge



Source: Quality Counts, video data collection between 6:30 AM AND 6:30 PM. Average of Tuesday, 10/30/12, and Thursday, 11/01/12. Compiled by CDM Smith.

Figure 2-20 Southbound Traffic and Truck Volumes on I-5 Bridge



Source: Quality Counts, video data collection between 6:30 AM and 6:30 PM. Average of Tuesday, 10/30/12, and Thursday, 11/01/12. Compiled by CDM Smith.

Truck Volume Data by Axle

Truck volume and classification data by axle were collected by CDM Smith during the week of October 29 to November 3, 2012 between 6:30 AM and 6:30 PM. The data collection used video cameras to collect images roadside and the number of axles was counted in a lab during video review. Axle counts using video data have been shown to be more accurate than pneumatic tube-based traffic counting machines or data from inductive loop-based automatic traffic recorders. Thus this data collection was important to determine axle distributions for the tolling analysis.

The volume data by axle for an average weekday is summarized in Table 2-11. This data indicates a higher proportion of 5-Axle vehicles than other truck axle classes. Given the predominance of 5-axle semi-trucks used throughout the country for shipping, this is not surprising. Trucks with six or more axles and 3 axle trucks were the next strongest truck categories. In Washington and Oregon, it is relatively easy to operate trucks with gross weights above the 80,000 lb standard limit through special permits provided axle loading limits are not exceeded. This results in a relatively high share of truck combinations with six or more axles in the two states.

Table 2-11 I-5 Daytime Bridge Vehicle Classification Summary

Weekday Vehicle Class[1]	2-Axle Car	3-Axle Truck	4-Axle Truck	5-Axle Truck	6+ Axle Truck
	92.9%	1.4%	0.7%	3.5%	1.5%

1. Average between 6:30 AM and 6:30 PM
Source: Quality Counts. Average of Tuesday, 10/30/12 and Thursday, 11/01/12.
Compiled by CDM Smith.

Historic Truck Volumes

Studies of truck volume and truck travel for the CRC Project began in 2005. The change in economic conditions had an effect on truck travel. Historcial weekday truck information is shown in Table 2-12. Truck volumes appear to decrease from 2005 to 2011 and then increase as of fall 2012. Note that the comparison in Table 2012 is based on a limited sample as all counts are based on data collection conducted on one day or over two days. Thus, care should be taken when using this table for more than general trend observations.

Table 2-12 Bridge Historical Weekday Truck Volumes 7 AM to 5 PM

I-5 Bridge Trucks	Oct 2005	Oct 2008	Nov 2011	Oct/Nov 2012
Southbound	3,654	3,210	3,067	3,170
Northbound	3,507	3,032	2,639	2,848
Total	**7,161**	**6,242**	**5,706**	**6,018**

Sources
Oct 2005: Vehicle Classification collected for CRC project. 10/18/2005
Oct 2008: Vehicle Classification collected for CRC project. 10/15 and 10/16/2008
Nov 2011: ODOT ATR Supplemental Short Counts at station 26-004 (11/14/2011)
Oct/Nov 2012: Quality Counts. Average of Tuesday, 10/30/12 and Thursday, 11/01/12.
Compiled by CDM Smith.

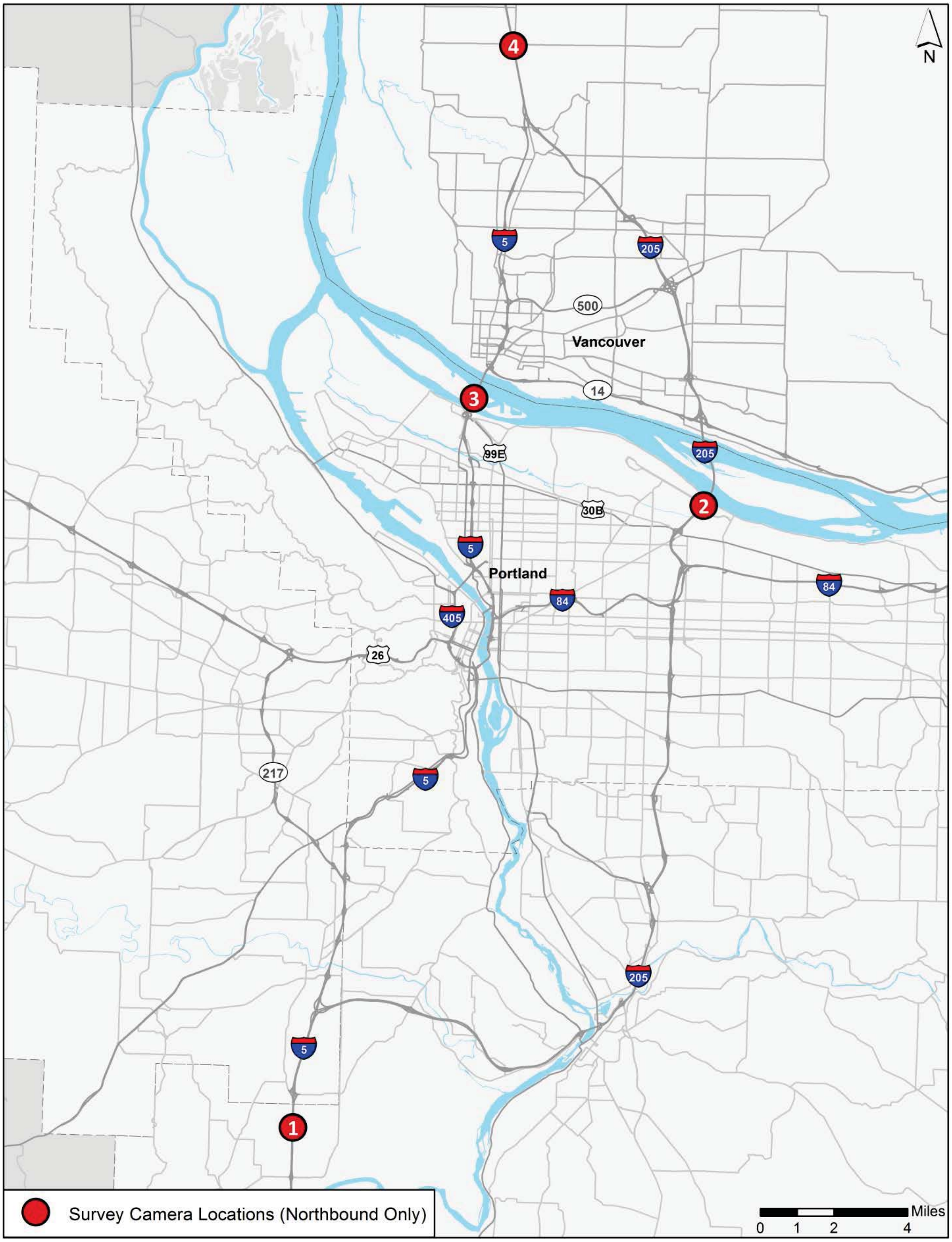
2.5.4 Truck Through Trip Survey

A truck through trip survey was also conducted the week of October 29 to November 3, using video recordings of license plates. License plates were captured south of the I-5/I-205 interchange in Oregon and north of the I-5/I-205 interchange in Washington, and on the I-5 and I-205 bridges. In this way, the proportion of trucks travelling through the region, especially across the bridges, can be determined. In the context of this study, "through trips" refer to vehicle trips that have both their origin and destination outside of the greater Portland/Vancouver study area. In the travel demand modeling process "through trips" are referred to as "external to external trips" (E-E trips).

Modeling for through truck trips is primarily based on long distance commodity data and forecasts. Local truck trip modeling is based more heavily on local economic activity, particularly in employment growth in key sectors. It is generally found that through truck trips are much more difficult to analyze in models than local truck trips. Thus, the through truck trip survey is important to the overall traffic and revenue study in that it allows through truck travel patterns used in the Tolling Analysis Model to be validated.

Survey Locations

Four locations were selected to capture the long distance truck trips through the Portland-Vancouver region and which bridge they use over the Columbia River. The four locations are shown in Figure 2-21. The survey was conducted only in the northbound direction due to the high survey cost. The northbound direction was selected to capture the high northbound congestion during the PM peak. Southbound patterns can be generally ascertained from the northbound patterns.



CDM Smith

THROUGH TRUCK SURVEY LOCATIONS (NORTHBOUND ONLY)

FIGURE 2-21

The results of the truck through trip survey are summarized in Table 2-13. As described previously, the survey included medium and heavy trucks from the FHWA 13 vehicle type classification. The survey locations provide an estimate of the E-E trips as well as the external to internal trips. The matching process from the license plate video data has inherent inaccuracies and so the results are presented as a range.

Table 2-13 Weekday Medium and Heavy Truck Trip Patterns on I-5 and I-205 (Northbound)

Start Observation Location[1]	Daily Start Volume	End Observation Location	Northbound Trip Pattern	Lower Match Volume[2]	Upper Match Volume	% of Start
1	6,722	4	External (south) to external (north)	945	1,207	14 to 18%
1	6,722	2	External (south) to passing over I-205 bridge	254	442	4 to 7%
1	6,722	3	External (south) to passing over I-5 bridge	722	1,016	11 to 15%
1	6,722	2 or 3	External (south) to passing over Columbia River	976	1,458	15 to 22%
1	6,722	-	External (south) to somewhere south of Columbia River	5,264	5,746	78 to 85%
2	3,210	4	Passing over I-205 bridge to external (north)	856	1,105	27 to 34%
3	5,177	4	Passing over I-5 bridge to external (north)	1863	2,326	36 to 45%
2 or 3	8,387	4	Passing over Columbia River to external (north)	2,719	3,431	32 to 41%
2 or 3	8,387	-	Passing over Columbia River to somewhere south of location 4	4,956	5,668	59 to 68%

1. Locations are shown in Figure 2-21
2. A matching algorithm was run by NDS and additional adjustments were applied by CDM Smith
Source data was collected by National Data & Surveying (NDS) in November, 2012.

Location 1, a location external to the Portland urban area south of the I-5/I-205 interchange, has a daily northbound volume of 6,722 medium and heavy trucks. Of those trucks, from 14 percent to 18 percent crossed over either the I-5 bridge or the I-205 bridge and continued north of the I-5/I-205 interchange in Clark County (location 4). These are the northbound "through-trips".

Of the trucks starting at the same location 1, approximately 11 percent to 15 percent were observed to travel across the I-5 bridge, and approximately 4 percent to 7 percent were observed to travel across the I-205 bridge. This gives a total of 15 to 22 percent that traveled across the Columbia River. Subtracting the northbound through trips from this (14 to 18 percent), that leaves between 1 and 6 percent (not shown in Table 2-13) of the 6,722 medium and heavy trucks at location 1 that likely had a destination in

Clark County such as the Port of Vancouver and industrial areas near I-5 in Vancouver, or used one of the state highways other than I-5 to exit the region.

Of the 5,177 trucks that were observed to cross the I-5 bridge northbound, approximately 36 percent to 45 percent travelled to I-5 north of the I-5/I-205 interchange. Similarly, of the 3,210 medium and heavy trucks that were observed to cross the I-205 bridge northbound, approximately 27 percent to 34 percent travelled to I-5 north of the I-5/I-205 interchange. The similar percentages of trucks from the Portland Urban area on I-5 and I-205 that travel to north of the I-5/I-205 interchange reflects the distribution of industrial land use along the Columbia Corridor, from the Port of Portland to I-205 and in the vicinity of the Portland International Airport.

Chapter 3

Travel Pattern Data

An online travel pattern survey, including origin-destination (O-D) survey, was conducted of motorists that traveled across the I-5 bridge over the Columbia River. The survey was conducted to obtain actual data on trip travel characteristics including; time periods of travel, trip purpose, frequency of travel over the bridge, vehicle occupancy, and origin and destination of trips. The first seven sections of this chapter present the methodology and results of this survey.

Travel pattern data was also obtained in the form of cellular O-D information to supplement the online travel pattern survey results. This cellular data is discussed in the final section of this chapter.

3.1 Online Survey Methodology

Motorists were identified for the survey by capturing license plate numbers using video in both directions on the I-5 bridge, on the northbound I-5 exit ramp to Hayden Island, and on the southbound I-5 entrance ramp from Hayden Island. The survey was conducted on both weekdays and weekend days. About 95 percent of the weekday plate numbers were from daytime hours on Wednesday, October 24, 2012 and the other 5 percent on Thursday, October 25, 2012. The weekend plate numbers were from daytime hours on Sunday, November 4, 2012. The plate numbers were queried with the Oregon Department of Motor Vehicles (DMV) and the Washington State Department of Licensing (DOL) to obtain the addresses of the vehicle owners. Addresses were obtained from Oregon on December 7, 2012 and from Washington on January 10, 2013. A postcard was mailed on January 23, 2013 to the vehicle owners to invite them to take an online O-D survey. The survey asked about their most recent trip on the I-5 bridge.

The first survey responses were received on January 28, 2013 and the online form remained open until February 18, 2013. The survey contained nine questions, including one question to ask respondents if they would be willing to participate in a follow-up survey. (This is the stated preference survey discussed in Chapter 4).

3.1.1 License Plate Capture Rates

The license plate capture rates are shown in Table 3-1. A total of 154,041 vehicles were observed in the license plate capture process, with 129,101 (84 percent) having visible license plates. Of the visible license plates, 95 percent (123,000) were passenger cars. In past O-D surveys it has been found that truck license plate capture rates were not high enough to be statistically valid, so only passenger car plates were retained for use in the survey. Duplicate plate numbers occurred in the data collection when the same license plate was observed multiple times during the collection period. Thirty percent of the total visible passenger car plates were duplicates and removed as shown in the table.

Table 3-1 License Plate Capture Rates

Comparison	All Vehicles		Passenger Car Visible Plates				
	Total	Visible Plates	Total	Oregon	Wash-ington	Other	Unknown
Weekday NB	42,526	35,954	33,602	11,857	19,070	638	2,037
Weekday SB	41,054	32,810	30,384	11,805	15,510	520	2,549
Weekend NB	34,632	30,002	29,297	11,527	16,308	754	708
Weekend SB	35,829	30,335	29,717	11,572	16,946	675	524
Weekday Both Dir.	83,580	68,764	63,986	23,662	34,580	1,158	4,586
Weekend Both Dir.	70,461	60,337	59,014	23,099	33,254	1,429	1,232
Total	154,041	129,101	123,000	46,761	67,834	2,587	5,818
Total w/out duplicates	NA	90,975	86,111	32,182	47,085	2,085	4,759

Source: CDM Smith, 2013

Table 3-2 presents the response rates resulting from the license plate query to determine addresses, the number of postcards mailed, and the number of survey responses. Plates with state names that could not be identified (listed as Unknown in Table 3-1) were queried by both the Oregon DMV and Washington DOL resulting in a higher number of queries than the capture rates. Additional duplicates were identified in the query process and also removed. The overall match rate of 80 percent for Oregon was much higher than the 49 percent match rate for Washington. The available query process with the Washington DOL was less precise because Washington distinguishes between the numerical zero character and the letter "O" character on their plates while Oregon treats them all as zeros. This factor made formatting the plates for the Washington DOL query challenging and more prone to errors.

The resulting survey response rate, as shown in the far right columns of Table 3-2, was 9 percent with 4,891 responses to 55,007 postcards mailed. This response rate compares well with other surveys conducted by CDM Smith in urban areas. Of the total responses, 95 percent (4,667) were usable which is also normal based on CDM Smith's experience conducting similar surveys.

Table 3-2 License Plate Address Query and Survey Response Rates

Comparison	Known State Queries	Unknown State Queries	Total Queries	Address Match	Total Match Rate	Post-cards Mailed	Total Re-sponses	Usable Re-sponses
Weekday OR	16,004	4,452	20,456	14,592	71%	14,129	1,118	1,057
Weekday WA	26,011	4,453	30,464	15,361	50%	15,211	1,587	1,515
Weekend OR	16,104	1,138	17,242	15,433	90%	14,996	1,122	1,086
Weekend WA	23,614	1,035	24,649	11,862	48%	10,671	1,012	980
OR Total	32,108	5,590	37,698	30,025	80%	29,125	2,240	2,143
WA Total	49,625	5,488	55,113	27,223	49%	25,882	2,599	2,495
Total	81,733	11,078	92,811	57,248	62%	55,007	4,891	4,667

Notes:

• Most plates from unknown states were queried with both the OR DMV and WA DOL. Differences between the two states are due to additional duplicate plates being removed for the WA query after the OR query was finalized.

• Duplicate plate numbers between weekdays and weekend days were removed from the OR query but not the WA query because of how the queries were structured.

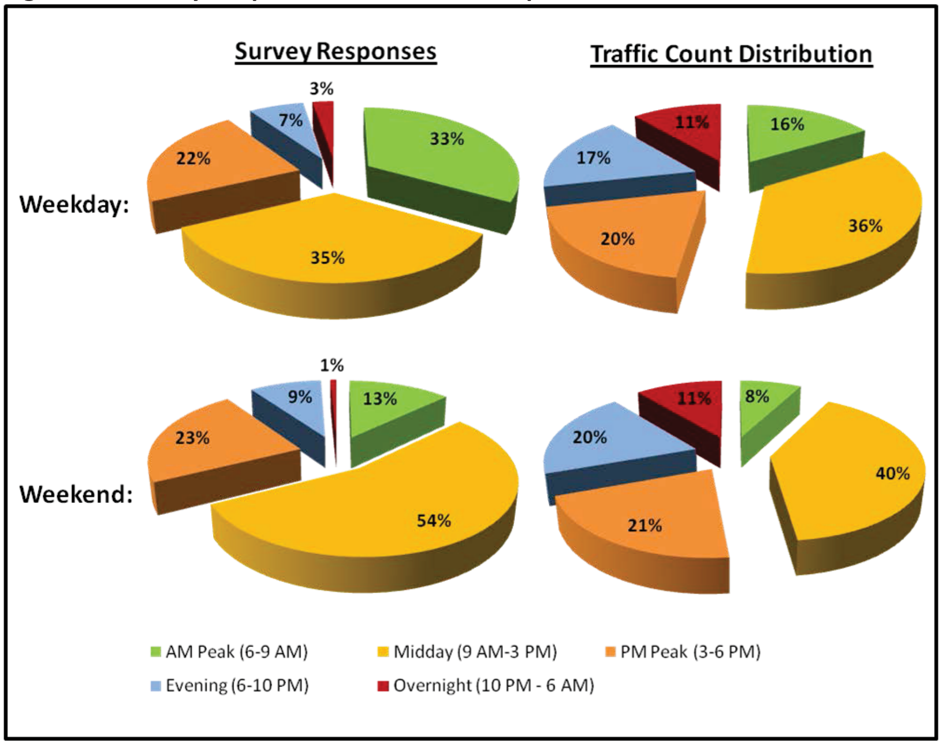
• The "Total" row in the survey response columns includes survey responses where the state of query was unknown. Thus, "Total" is larger than adding the "OR" and "WA" rows together.

Source: CDM Smith, 2013

3.2 Online Survey Time Period of Trip

The first question on the survey asked respondents during what time of day they made their recent trip on the I-5 bridge. Respondents were requested to check one of five time periods (AM, midday, PM, evening, and overnight). Figure 3-1 presents a comparison of the survey response (left side of Figure 3-1) relative to traffic counts during these time periods for all traffic (right side of Figure 3-1). The figure shows that the weekday AM peak period is over-represented in the survey and the weekday evening and overnight periods are under-represented. For weekends, the survey respondents are over represented during the AM period, midday, and slightly for the PM period.

Figure 3-1 Survey Response Distribution Comparison



3.3 Online Survey Trip Purpose

Figure 3-2 shows the percentage of respondents within each trip purpose by time period. Commuter trips to and from work accounted for 44 percent of all weekday trip purposes. Commuter trips were, not surprisingly, concentrated in the AM and PM peak periods. During the AM peak 77 percent of respondents were commuting to work.

On weekends social, shopping, and vacation/recreation trips accounted for nearly three quarters of all trip purposes as shown in Figure 3-3. As expected, work trips made up a much smaller share of trip purposes than on the weekdays.

Figure 3-2 Weekday Trip Purpose by Time Period

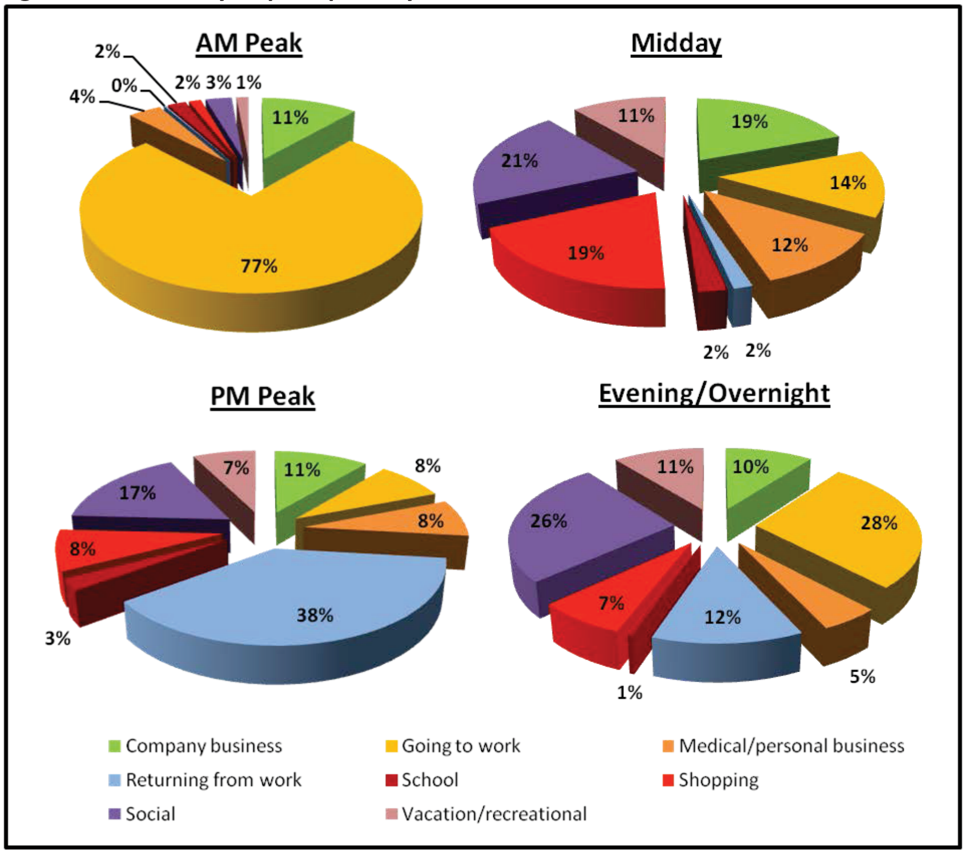
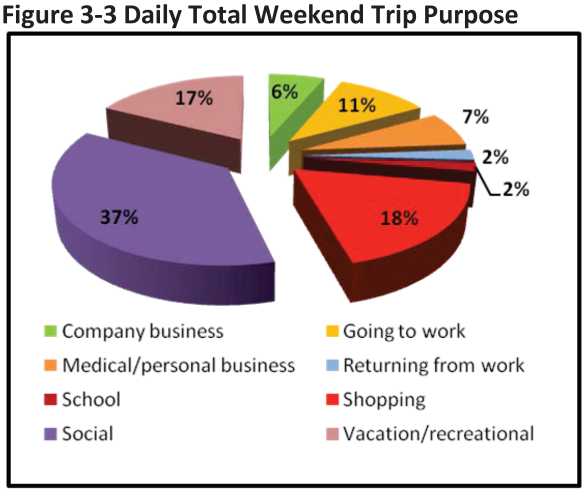


Figure 3-3 Daily Total Weekend Trip Purpose



3.4 Online Survey Trip Frequency

Figure 3-4 shows the weekday trip frequency for each travel time period. The highest trip frequencies were less than one time per week and five times per week. These two frequencies accounted for approximately 57 percent of responses. However, there is a sharp difference between the four time periods. During the AM peak period (when most drivers are traveling to work), the five-times-per-week travelers was 54 percent and the less-than-one-time-per-week rate was 9 percent. During the Midday period this comparison is flipped, with less-than-one-time-per-week at 43 percent and five-times-per-week at 10 percent. In the PM peak period and Evening/Overnight periods these two categories are more similar.

Figure 3-5 shows the weekend daily trip frequency. The one-every–few-months and one-to-three-per-month frequencies were the most prevalent responses.

Figure 3-4 Weekday Trip Frequency per Week by Time Period

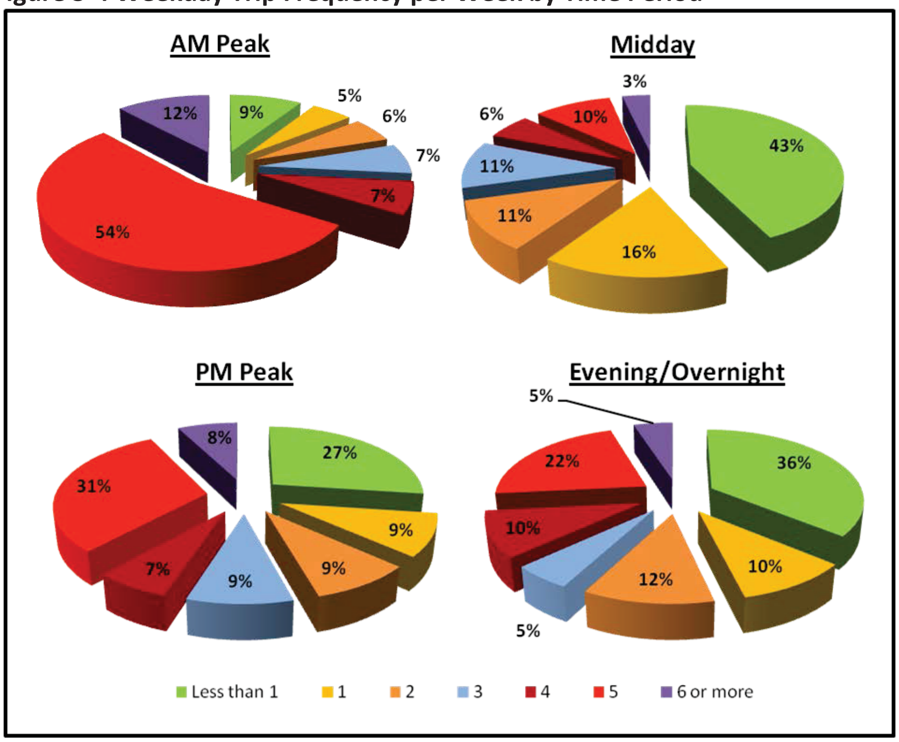
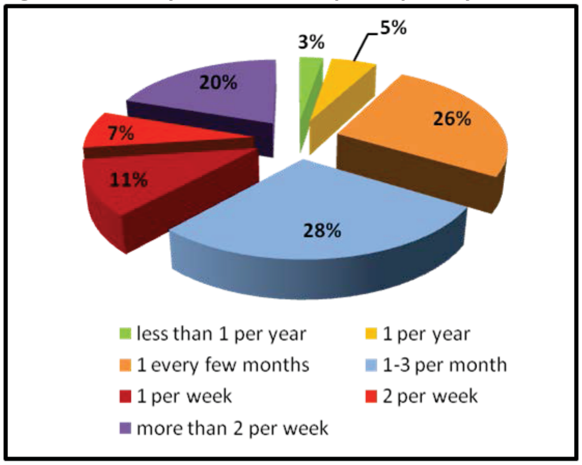


Figure 3-5 Daily Weekend Trip Frequency



3.5 Online Survey Vehicle Occupancy

For vehicle occupancy data the respondent was asked if there was one occupant, 2 occupants, or 3 or more occupants. The results are presented in Table 3-3 for weekday trips and weekend trips. The average occupancy reported was higher than from the manual occupancy count performed on the I-5 bridge by CDM Smith in fall, 2012 as discussed in Chapter 2. For example, the manual count was 83 percent single occupant on a weekday compared to 67 percent single occupant reported for survey trips. On weekends, the manual count was 59 percent single occupancy compared to 36 percent reported in the survey.

Table 3-3 Vehicle Occupancy

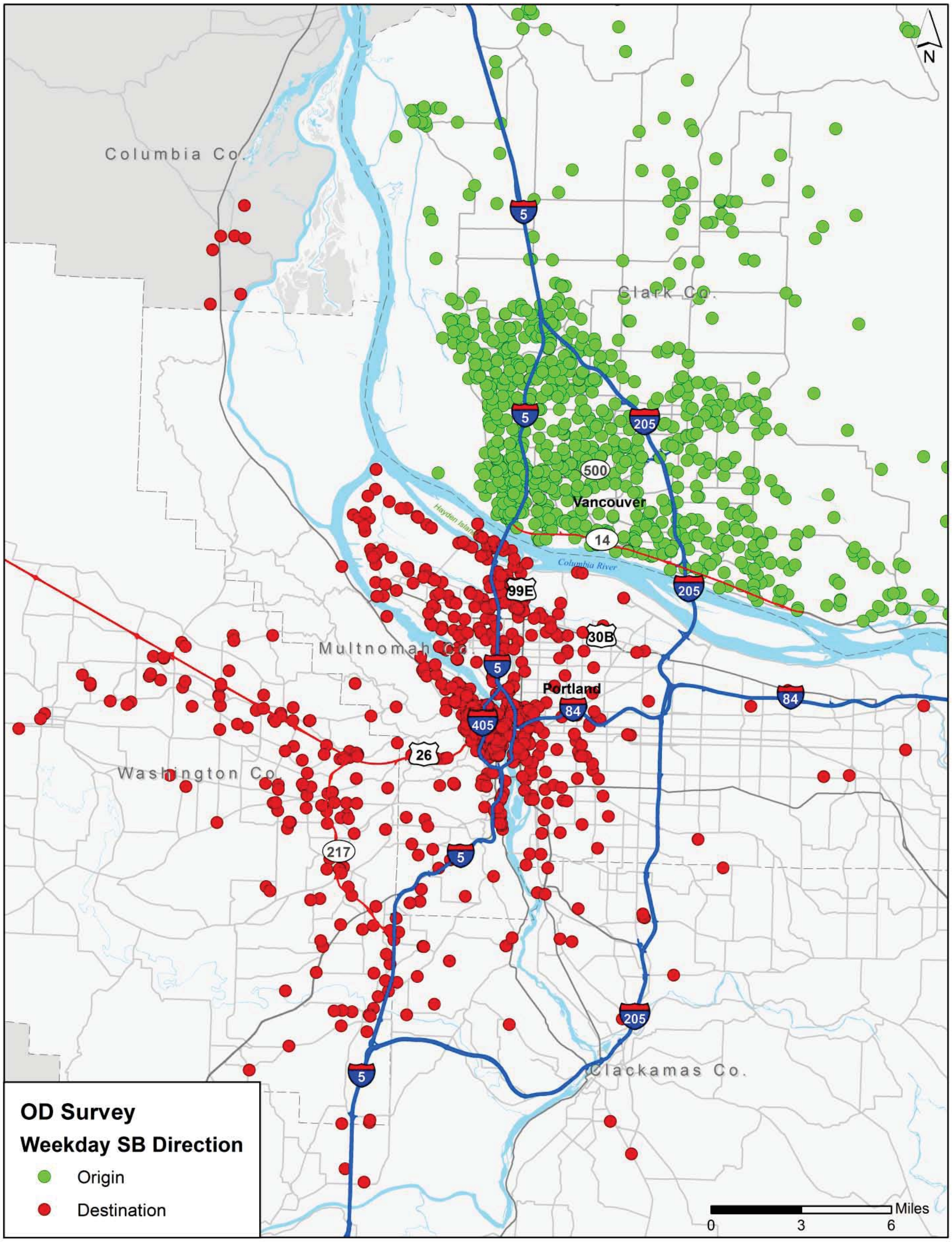
Number of Occupants	Weekday	Weekend
1	67%	36%
2	25%	44%
3 or more	8%	20%

3.6 Online Survey Trip Origin and Destination

Survey results of trip origins and destinations are summarized in Table 3-4. Portland and Vancouver are the most common origins and destinations on both the weekdays and weekends. Other cities in the Portland region including Beaverton and Hillsboro in Oregon; Battle Ground, Ridgefield and Camas in Washington, were each from 1 to 3 percent of origins and destinations. The Puget Sound metropolitan area of Seattle/Tacoma/Olympia showed a high weekend destination of 10 percent of trips. Between 97 and 99 percent of the origins and destinations were within Oregon and Washington. Origins and destinations are shown graphically for the Portland/Vancouver region in Figure 3-6 and Figure 3-7.

Table 3-4 Trip Origins and Destinations

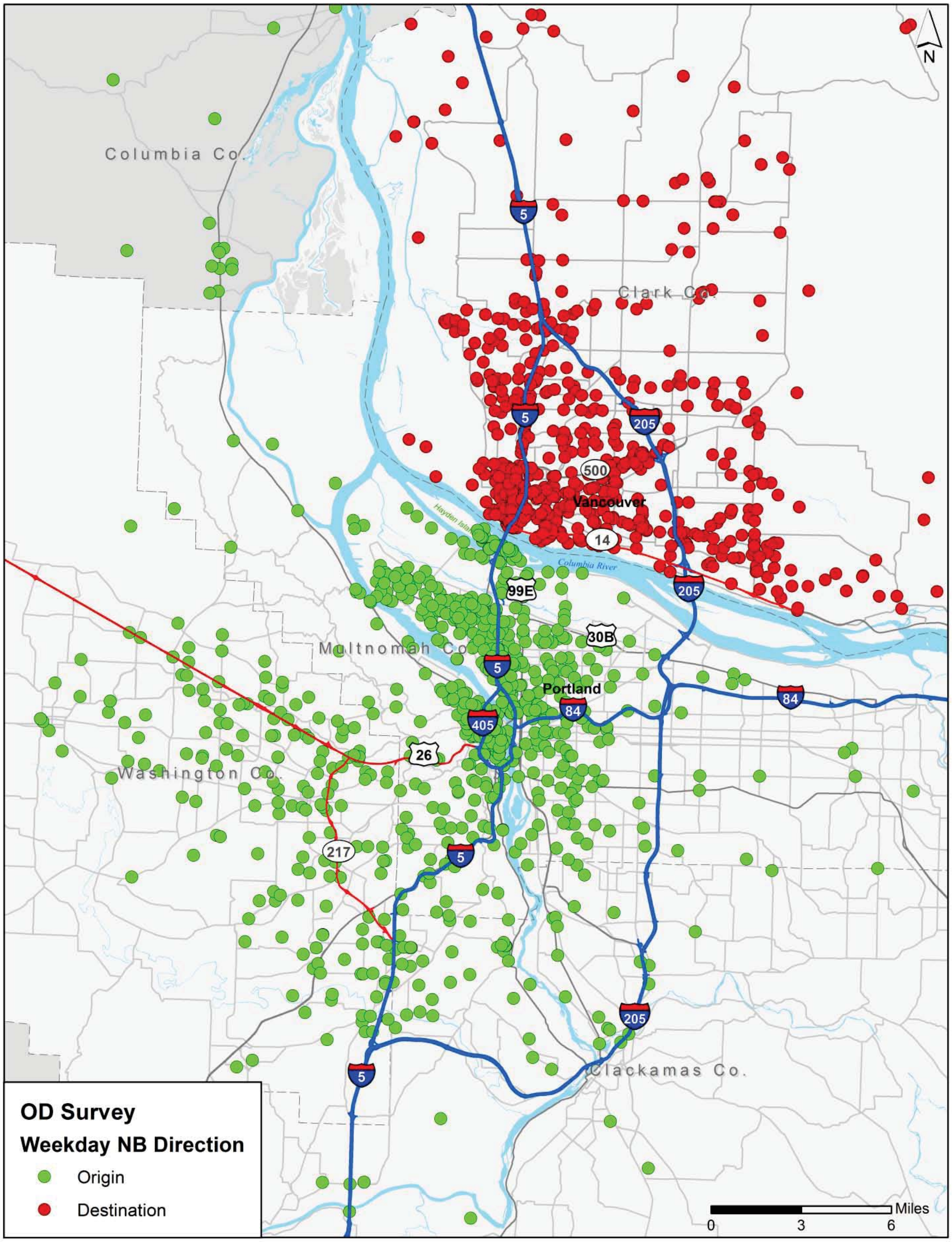
Subareas	Weekday		Weekend	
	Origin	Destination	Origin	Destination
Portland	31%	42%	36%	36%
Vancouver	38%	33%	33%	28%
Beaverton	3%	3%	2%	3%
Battle Ground	2%	1%	2%	1%
Ridgefield	2%	1%	2%	1%
Hillsboro	2%	1%	1%	1%
Camas	2%	1%	2%	1%
Rest of Portland/ Vancouver Metro	10%	6%	8%	6%
Seattle/Olympia Metro	2%	4%	3%	10%
Rest of Oregon	3%	3%	6%	5%
Rest of Washington	3%	3%	3%	4%
Other	2%	2%	1%	3%
Total	100%	100%	100%	100%
Total Portland-Vancouver Metro				
Total Portland/ Vancouver Metro	90%	88%	86%	77%
By State				
Oregon	45%	53%	51%	49%
Washington	53%	45%	47%	48%
Other States or Countries	2%	2%	1%	3%
Total	100%	100%	100%	100%



SOUTHBOUND I-5 BRIDGE ORIGINS AND DESTINATIONS IN THE PORTLAND-VANCOUVER REGION

CDM Smith

FIGURE 3-6



NORTHBOUND I-5 BRIDGE ORIGINS AND DESTINATIONS
IN THE PORTLAND-VANCOUVER REGION

FIGURE 3-7

3.7 Travel Pattern Survey Conclusions

Below are conclusions made based on the survey results presented in this chapter. This section also indicates how the results were used in the remainder of the study.

- Responses are somewhat overrepresented in the morning for weekdays and mornings and midday on the weekends. It is likely when asked about a recent trip, most people will think of their first trip which would usually be from home. For most weekdays, this is the commute trip and for weekends is either commute or shopping. However, this should not affect the remainder of the survey responses since all these trips should have return to home segments.
- Commuter trips are high during AM and PM weekday peak periods and low on weekends. This reaffirms the facility's importance as a commuter route on weekdays and was used to help calibrate the time periods of the Tolling Analysis Model for weekdays.
- Trip frequency on weekdays also shows a typical commute pattern with a strong morning commute and a somewhat weaker PM commute that gets spread out into evening/overnight. The results reaffirm the commute nature of the facility and help with determining the evening/overnight patterns for model calibration. In addition, the frequency was tied to the likelihood of account based toll payments.
- Survey vehicle occupancy results show a low number of three or more occupant vehicles, as can be expected. The results help to verify the stated-preference survey questions regarding occupancy and willingness to form carpools and could be useful if a discount or exemption is considered for multi-occupant vehicles.
- Trip origin-destination indicates the vast majority of trips are between Vancouver and Portland. The information was used to calibrate the Tolling Analysis Model trip table to reflect the river crossings that exist today.

3.8 Cellular Origin-Destination Information

From past CDM Smith experience, one segment of travel that is not well represented in the online O-D survey is through trips (also known as external-external trips) which have both an origin and destination outside of the study area. Since these trips are important to the overall total traffic and revenue, additional information was sought on these trips.

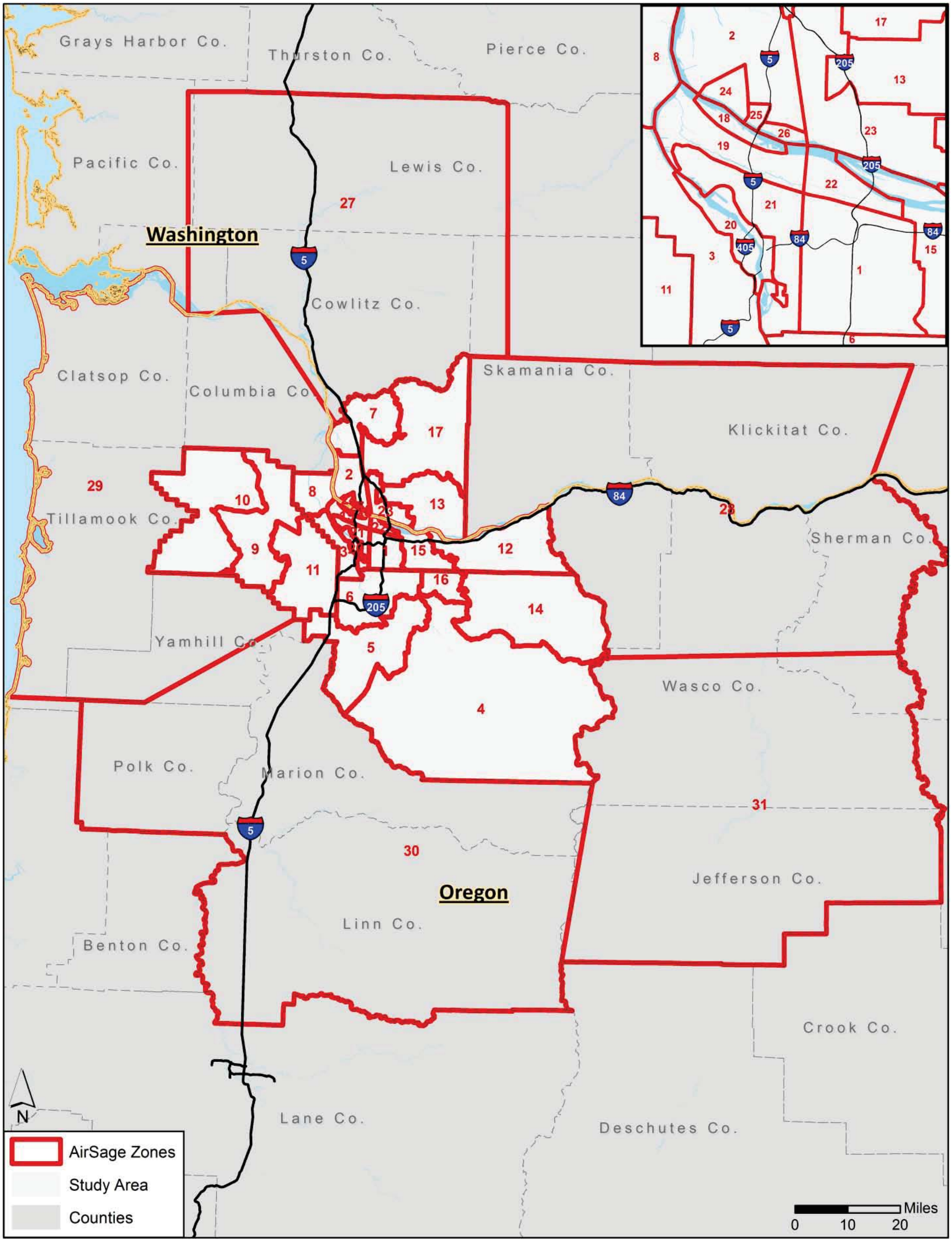
One emerging source of O-D data is cellular network traffic that has been processed for a specific area. Cellular data has the potential to both help validate the results of the O-D survey and provide basic information on through trips. Many private sector companies use cell phone signal data to determine location information. One of these companies, AirSage, has started to market their location information to transportation planning agencies as a source of O-D data. AirSage partners with two wireless carriers (Sprint and Verizon) to collect and analyze real-time mobile signals. Locations are collected by cell phone tower triangulation each time a mobile device starts a call, ends a call, uses text messaging, or performs a data transfer. Datasets may be therefore missing segments of individual trips, but can provide good indications of overall longer distance travel patterns. On a major highway such as I-5 and I-205 through the Portland/Vancouver region, a significant portion of the vehicle traffic can be captured by this data. Data capture improves if multiple wireless carriers are used, as was the case in this study. The main deliverable from AirSage is an O-D matrix table by day and time.

There are some limitations to cellular data. First, some bias exists in the data as it only includes people who have cell phones from certain carriers. It is also not possible to get the data broken down by vehicle classes because, for example, a passenger car and a semi-truck would look the same in the analysis. Third, vehicles with multiple passengers who are all using cell phones will be over-represented in the analysis. Despite these limitations, the data provides an overview which is helpful in refining travel demand model trip tables.

Because it is an emerging data source, there are few examples of lessons learned currently available from projects using cellular data for O-D estimation. Publicly available research indicates relatively large zones are needed to obtain a reasonable number of external matches. Consequently, CDM Smith developed an aggregated analysis zone system, based on the detailed system used in the Metro travel demand model, which would provide specific information regarding travel across the Columbia River. Figure 3-8 shows the aggregated 31-zone layout.

Approximately 173 million origin-destination records for weekdays and 47 million origin-destination records for weekends were received from the raw cellular data analysis. These data were based on trips that took place between October 1, 2012 and October 31, 2012. They represent daily averages of about 7.5 million weekday and 5.8 million weekend trips.

The data was compiled into a 31 by 31 matrix trip table to show the proportion of travel between different O-D pairs as they relate to the two Columbia River crossings. Once complete, this data was compared to aggregated trip table and travel pattern survey information to determine where particular adjustments should be made. The comparison showed relatively more long distance trips and more trips with destinations to downtown Portland and the western Portland region in the AirSage data. After comparison, the travel demand model trip tables were adjusted to reflect this.



AGGREGATED ANALYSIS ZONES FOR CELLULAR DERIVED ORIGIN-DESTINATION DATA

FIGURE 3-8

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Chapter 4

Stated Preference Survey

In order to help estimate the response of existing I-5 bridge users to tolling, a special survey technique called a stated preference survey was used to understand their sensitivities and how they trade off time, cost, and convenience. Stated preference surveys provide the ability to estimate demand models for the facility that can be used to predict how travelers are likely to utilize the facility under different pricing and congestion scenarios, which is difficult to assess through conventional survey techniques or existing travel patterns alone. The stated preference survey presented hypothetical scenarios within the context of the respondent's actual travel, and asked respondents to choose from a set of possible options. CDM Smith teamed with Resource Systems Group (RSG) to design the survey, administer it to current bridge users, and evaluate the results.

A primary objective of the stated preference survey was to provide information to develop an assessment of current bridge users' willingness to pay tolls. The survey also provided a basis to estimate changes in travel behavior that would:

- Result in less trip making, such as forgoing trips or choosing a different destination
- Result in changing to alternative modes including transit
- Result in shifting time of travel

The survey results provide sufficient detail for analysis of traveler responses to different toll structures and for analysis of toll sensitivities by travel mode and trip type sufficient to support modeling of route diversion, mode shifts, and changes in the time of travel.

The analysis of state preference survey results requires the use of complicated statistical choice and economic utility modeling applied to transportation forecasting theories. These theories have been developed over several decades, are considered state of the practice for travel demand forecasting, and are used throughout the country. Consequently, some terminology provided in this chapter may be beyond the scope of the reader. However, it is important to include the details such that technical readers can understand the techniques used and that current state of the practice has been applied.

4.1 Survey Approach

Two versions of stated preference survey questionnaires, one for passenger vehicles and one for trucks, were developed and implemented to gather information from those who currently use the I-5 bridge. The questionnaires collected data on current travel behaviors, presented respondents with information about bridge improvements, and used stated preference experiments to collect data that were used to estimate travelers' value of time (VOT) and propensity to use the tolled facility.

The survey instrument was a computer-assisted self-interview developed using RSG's proprietary software. The customized survey software adapted to respondents' previous answers by modifying question wording and stated preference tradeoff values. These dynamic features allowed presentation of future conditions that made the conditions realistic for the survey participant while allowing aggregation of the results for analysis.

The passenger vehicle survey was administered over the Internet to travelers using three methods: through in-person intercepts at sites located at either end of the I-5 corridor; through an email recruitment effort to respondents who had recently completed the travel pattern survey conducted prior to the stated preference survey; and through an email recruitment to members of an online market research panel. RSG contracted with ResearchNow, an online market research panel, to provide additional stated preference survey respondents. Panel members had a home ZIP code in Portland, Oregon or Vancouver, Washington.

The truck survey was administered to travelers through in-person intercepts at sites located at either end of the I-5 corridor. As indicated by different types of survey administration applied, steps were taken to assure the range of I-5 users included in the survey appropriately represent the overall I-5 user market

4.2 Survey Questionnaires

Two separate stated preference questionnaires were developed—one for passenger vehicle drivers and one for truck drivers. Both questionnaires followed the same general approach and outline, although individual questions were customized depending on the type of respondent. The questionnaires contained questions grouped into four main sections:

- Screening and Trip Detail Questions
- Stated Preference Questions
- Debrief and Opinion Questions
- Traveler Information Questions

4.2.1 Screening and Trip Detail Questions

Passenger Cars

Initially, passenger car survey candidates were asked several questions, including if they had made a recent trip on the I-5 bridge, to determine if they were eligible to participate in the survey. Those who were eligible were then asked questions related to their most recent trip across the bridge. They were asked to think of this trip as their "reference trip". These "revealed preference" questions provided the respondents actual behavior related to particular topics. The questions included:

- Date the trip was made
- Purpose of the trip
- Origin and destination locations
- Trip departure time, travel time, and delay
- Flexibility in arrival time
- Vehicle occupants
- Use of I-205 as an alternate bridge
- Trip frequency

- Transponder ownership

The origin and destination questions used on-screen maps and address location features to determine if the participant's origin and destination would reasonably match a trip on the I-5 bridge. Those with invalid responses were asked to correct their information or use a different trip on the I-5 bridge as their reference trip. Participants who indicated unusually long or short travel times compared to their stated origin and destination were asked to confirm or correct their travel time.

Trucks

Initially, truck survey candidates were asked several questions, including their role as a driver (owner-operator, contract owner-operator, fleet driver, or other) and whether they made routing decisions at their company to determine if they were eligible to participate in the survey. They were then asked a second set of eligibility questions to determine if they had made a recent trip on the I-5 bridge. Those who were eligible were then asked questions related to their most recent trip across the bridge. The questions included:

- Date of trip
- Origin and destination locations
- Trip length (number of days), distance, and travel time
- Time of crossing the Columbia River using I-5 bridge
- Travel delays
- Number of vehicle axles
- Trip frequency
- Tolls paid
- Transponder ownership

Similar to passenger cars, the origin and destination questions used on-screen maps and location features to determine the participant's origin and destination. However, truck respondents were only asked the city and state/province for their locations instead of the exact address. Also, rather than the origin and destination for their entire trip, truck respondents were asked to report the approximate location of their last commercial stop before using the I-5 bridge and their next commercial stop after crossing the bridge.

4.2.2 Stated Preference Questions

Passenger Cars

At the beginning of the stated preference questions, passenger car participants were provided information on the CRC Project and explanations of proposed payment options including account based payment using a transponder and non-account based payment using pay by mail video tolling.

Stated preference questions asked respondents what they are most likely to do given a certain set of circumstances. The stated preference section of the questionnaire contained quantitative experiments to estimate respondents' preferences for travel under hypothetical scenarios. Each respondent was presented with ten trade-off scenarios. In each scenario, the respondent was asked to select from up to five possible travel options once tolling begins on the I-5 bridge. Each option generally included total travel time, cost, and mode. The specific alternatives presented to each respondent depended on the details of their reference trip. All respondents were presented the following two alternatives:

- Make your trip using the tolled I-5 bridge by driving at current departure time
- Make your trip using the toll-free I-205 bridge by driving at current departure time

Respondents who reported a trip with a peak period departure time (6 AM to 10 AM or 3 PM to 7 PM) were shown a third alternative:

- Make your trip using the tolled I-5 bridge, departing before or after a specified peak period

Respondents who reported a trip with fewer than three vehicle occupants (single occupancy vehicles–SOV or vehicles with two occupants–HOV2) were shown a fourth alternative:

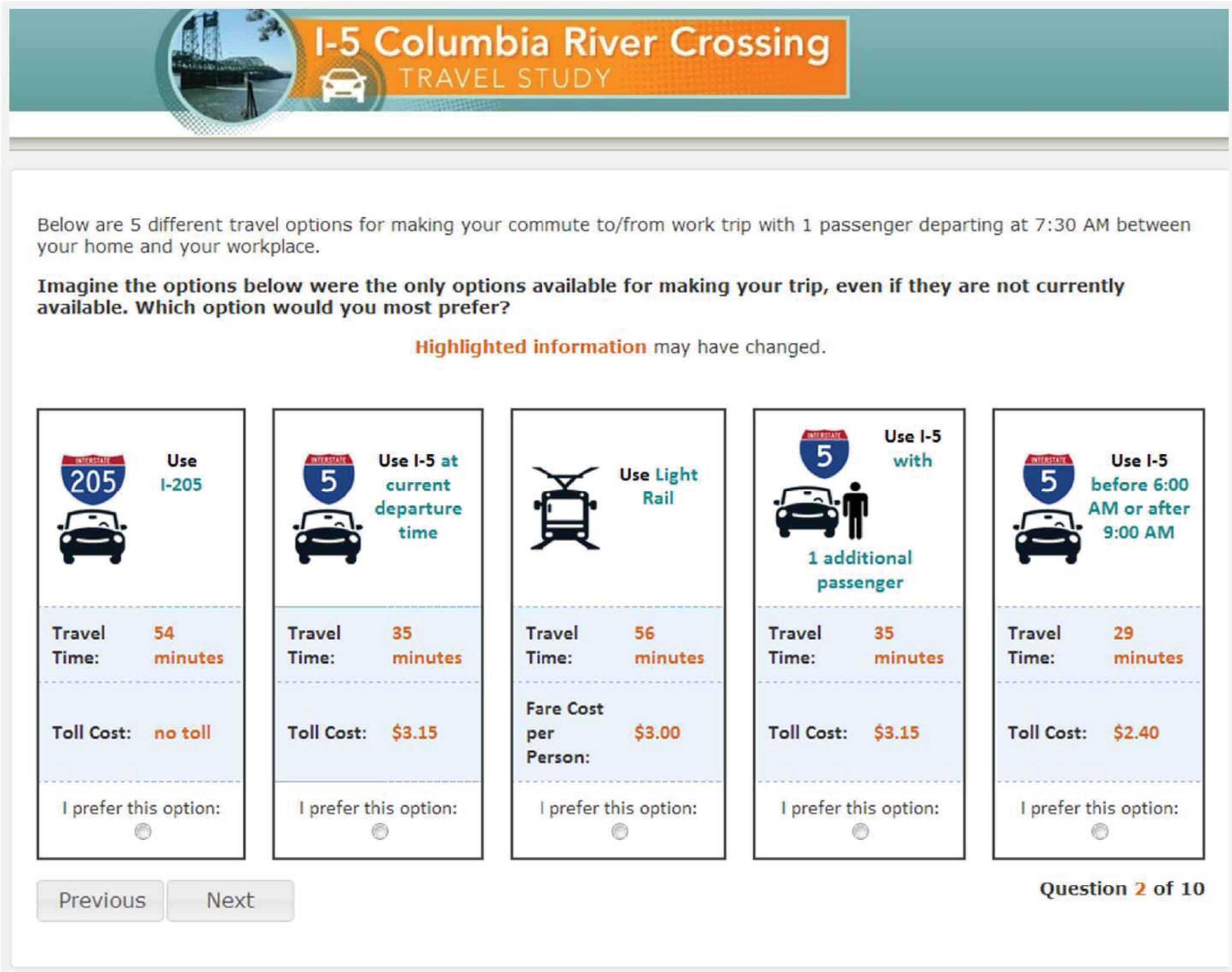
- Make your trip using the tolled I-5 bridge by driving at current departure time with additional passenger(s)

Finally, respondents who reported a local trip (with total distance of less than 30 miles) were shown a fifth alternative:

- Make your trip using public transit (bus or light rail) at current departure time

As noted above, the alternatives included the travel time and travel cost for each. For respondents with a reference trip in the peak period, the alternatives included the time of departure.

Figure 4-1 presents a sample stated preference scenario for a peak-period reference trip with one passenger. An explanation of the options follows.



SAMPLE PASSENGER CAR STATED PREFERENCE SCENARIO

FIGURE 4-1

In Figure 4-1, the respondent is asked to choose between five options:

- Using the I-205 bridge without paying a toll during the peak period but taking 19 more minutes of travel time than the I-5 bridge with a toll
- Using the I-5 bridge during the peak period and paying a toll of $3.15
- Traveling via transit during the peak period with 21 more minutes of travel time (due to accessing the transit vehicle and/or transit travel time difference) and paying a transit fare of $3.00
- Carpool with an additional passenger (vehicles with three occupants–HOV3) on the I-5 bridge and travel during the peak period, and paying the same toll of $3.15
- Using the I-5 bridge outside of the peak period and paying a lower toll of $2.40 with a six minutes of travel time savings

Respondents were asked to choose the alternative they would most prefer for making their trip in the future based on the scenarios presented, resulting in their "stated preference" (their actual preference or "revealed preference" would not be known until tolling begins on the bridge and the respondent makes their trip). In this way, respondents' trade-off the various attributes, expressing their sensitivity to travel choices, time, and cost.

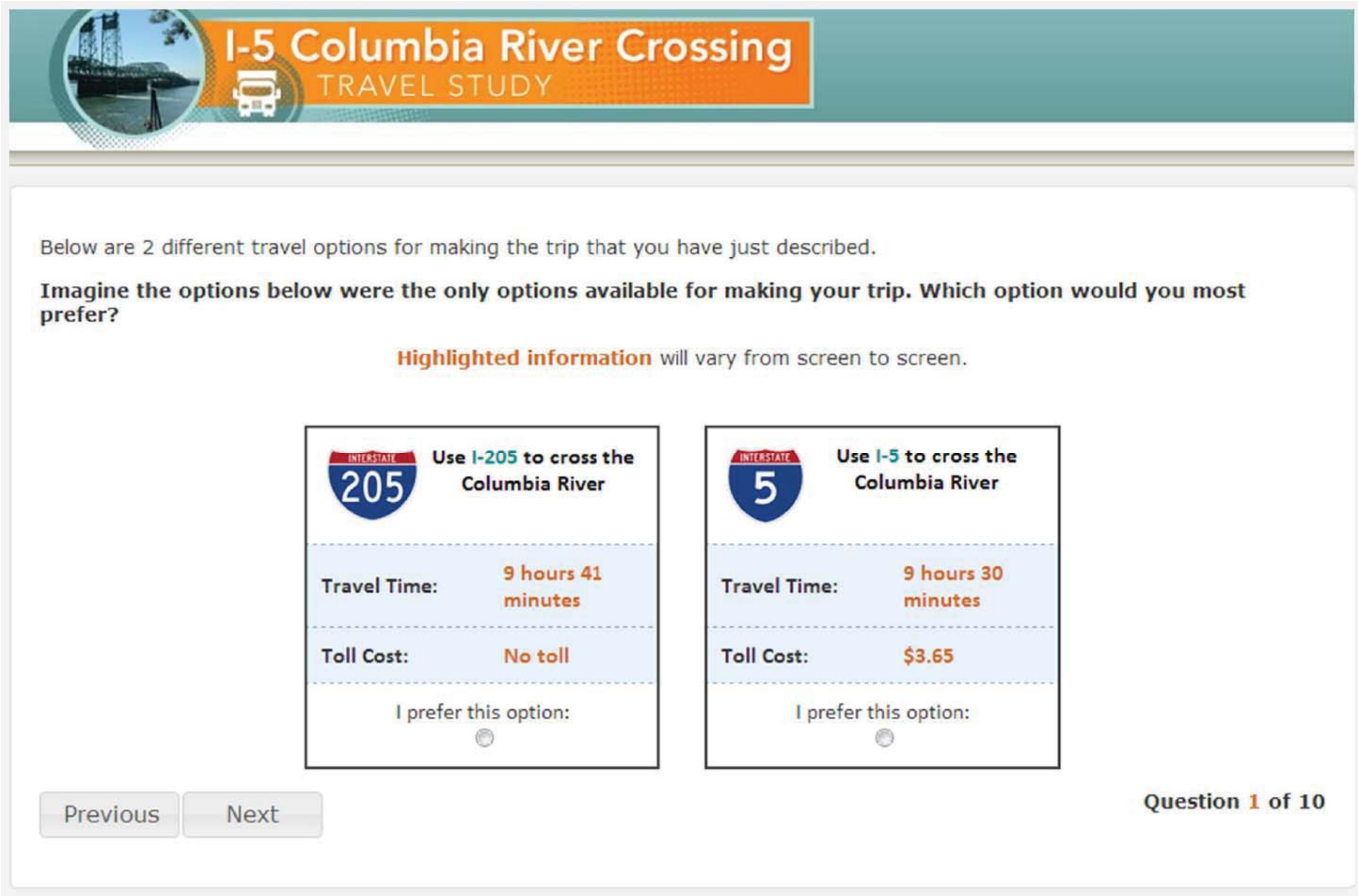
Over the course of the choice experiments, several distinct combinations of parameters in the options listed above were tested. The range of options was tested over many experiments and many respondents to infer the full range of value of time and travel preferences for bridge users. For instance, in the above example, a toll discount for HOV3 carpooling might be shown in an experiment. The experimental design, which ensured information was collected in a statistically efficient manner, contained 100 such stated preference experiments divided into ten groups of ten. One group was selected for each participant and presented in random order.

Trucks

At the beginning of the stated preference questions, truck driver participants were provided information on the CRC Project and explanations of proposed payment options including account based payment using a transponder and non-account based payment using pay by mail video tolling.

In the same way as the passenger car stated preference questions, the stated preference questions for truck drivers asked respondents what they are most likely to do given a certain set of circumstances. The stated preference section of the questionnaire contained quantitative experiments to estimate respondents' preferences for travel under hypothetical scenarios. Each respondent was presented with ten trade-off scenarios. In each scenario, the respondent was asked to select from two possible travel options once tolling begins on the I-5 bridge, to travel on I-5 or I-205. This is fewer than passenger cars, which had up to five alternative options. The alternatives included the travel time and travel cost.

Figure 4-2 presents a sample stated preference scenario for a truck driver. In this case, the driver had a very long reference trip. As with passenger cars, the experimental design ensured information was collected in a statistically efficient manner. The truck design included 50 stated preference experiments divided into five groups of ten. One group was selected for each participant and presented in random order.



SAMPLE TRUCK STATED PREFERENCE SCENARIO

FIGURE 4-2

4.2.3 Debrief and Opinion Questions

Passenger Cars

To further understand how respondents could change their travel in the future once the I-5 bridge is tolled, follow-up questions were asked of participants based on stated preference responses. Passenger Car participants were asked to indicate:

- If, given a certain travel time and toll cost, would they change the frequency of their reference trip and by how much
- If they would make fewer trips due to tolling, how much would they reduce their trips and how would they achieve that (such as not making a trip or combining it with another trip across the I-5 bridge)
- If the toll alternatives were never selected in a scenario, the primary reason they were not selected (such as opposition to paying tolls, toll cost too high, or time savings not great enough)
- If an alternative that included a change in the departure time was selected, whether they would leave earlier or later, as well as the primary reason for their choice (such as lower toll cost or lower travel time)
- If an alternative that included a change in departure time was not selected, the primary reason for their choice (such as not having time flexibility or insufficient cost savings)
- If transit was never selected, conditions that would make the participant take transit such as more frequent service or lower transit cost
- If the participant did not have a transponder and indicated a tolled option, likelihood of paying tolls – by transponder (account based) or via pay by mail (non-account based), depending on cost of each as presented

After answering the more specific trip related questions, participants were then asked a series of questions about their opinion of the CRC Project and their attitudes toward tolling in general. They were also asked to indicate their familiarity with the Portland and Vancouver transit systems and frequency of using bikes for transportation.

Trucks

Truck respondents were asked two main sets of follow-up questions. First, if the toll alternatives were never selected in a scenario, the primary reason they were not selected was asked. Second, a series of questions about their opinions of the CRC Project and their attitudes toward tolling in general were asked.

4.2.4 Traveler Information Questions

To conclude the survey, participants were asked several questions to identify differences in responses among traveler segments, and to verify that the sample contained a diverse cross-section of the population that use the I-5 bridge. Demographic information collected for passenger car respondents included zip code, gender, age, employment status, household size, vehicle ownership, and annual household income. Truck respondents were asked about their company location, number of vehicles in their company, average trip length, delivery schedules, timeframe structure, the party responsible for paying tolls, and information sources for routing decisions. All respondents were then given the opportunity to provide their comments about the survey or the proposed improvements. All survey responses are confidential and reporting is sufficiently aggregated to protect confidentiality of individual responders.

4.3 Survey Administration

The focus of the administration plan was to produce a generally representative sample of automobile and truck travelers in the study region in an efficient, timely, and cost-effective way. The sampling plan was designed to include a sufficient range of travelers and trip types to support the statistical estimation of the coefficients of a choice model. The passenger and truck surveys were administered entirely online. Three methods were used to recruit potential respondents to the survey website:

- In-person recruitment at intercept locations at either end of the I-5 bridge (passenger and truck surveys)
- Email invitation to travelers who had recently completed an origin-destination (OD) survey and agreed to participate in a follow-up survey (passenger vehicle survey only)
- Email invitation to members of an online research panel (passenger vehicle survey only)

Survey administration began on April 5, 2013 and concluded on April 29, 2013. A total of 1,985 passenger vehicle drivers and 368 truck drivers completed the stated preference survey during this time. The administration methods and number of complete surveys by survey type are presented in Table 4-1.

Table 4-1 Responses by Recruitment Source

Data Source	Passenger Car Survey	Truck Survey
In-person intercept	525	368
OD survey respondents	1,158	0
Online research panel	302	0
Total	**1,985**	**368**

4.4 Survey Results

As noted previously, 1,985 passenger car respondents and 368 truck respondents completed the survey. Additional data checks and survey validation reduced the number of survey responses used for analysis to 1,906 for passenger cars and 333 trucks. Passenger car respondents were grouped into four market segments by departure time and trip purpose as well as three market segments by departure time only. These are peak work trips, peak non-work trips, off-peak work trips, off-peak non-work trips; total peak trips, total off-peak trips, and total weekend trips.

It should be noted that the stated preference survey sample is not intended to be a comprehensive representation of the population across items such as trip purpose and frequency. Furthermore, the sampling techniques used could result in a bias. Consequently, as described previously, several demographic questions were asked to identify differences in responses among traveler segments and to verify that the sample contained a diverse cross-section of the population that uses the I-5 bridge over the Columbia River. This helped to form a firm basis for the results.

4.4.1 Trip Details and Revealed Preference

Passenger Cars

The analysis indicated that passenger car respondents' trip origins are scattered primarily north-south with the biggest share of small-to-medium distance trips clustered around southwest Vancouver, WA and northwest Portland, OR. Origins of long distance trips were scattered around the Portland region, especially in the southwest. Destination patterns were generally similar to origin patterns.

The majority of all reported trips were either commute trips or social/recreational trips. Commute trips are more frequently made during the peak period and social/recreational trips are more frequently made during the off-peak period (including weekends). During peak periods, about 48 percent of the respondents reported trips that were work commutes while another 12 percent reported a business trip.

Fifty-one (51) percent of all reported trips are made less than one time per week, although there are significant variations across the different trip purposes. As expected, work trips were the ones with the highest frequency, with 54 percent of peak work travelers indicating they make the same trip at least five times per week. Non-work and off-peak trips tended to be made less frequently.

A majority of the reference trips started during the peak periods: 35 percent between 6 AM and 10 AM, and 19 percent between 3 PM and 7 PM. Midday trips were 37 percent of total reported trips and nighttime trips represented about 9 percent.

The majority of trips, about 41 percent, took 20 to 39 minutes from origin to destination. About 25 percent took 40 to 59 minutes. Only 9 percent took less than 20 minutes, and 25 percent took more than one hour.

Overall, 70 percent of respondents did not experience any delay during their trip. Respondents reporting a trip made during the peak period were much more likely to experience delay than those traveling in off-peak periods or on the weekend.

Eighty-six (86) percent of work trips were made in single occupant vehicles (SOV), while only 41 percent of non-work trips were SOV. Overall, the mean occupancy was 1.70 people per vehicle.

Respondents reported how they would change the number of trips they make in the future if pricing were implemented on the I-5 bridge given a certain travel time and toll cost. Overall, 46 percent of respondents indicated that they would reduce the number of trips they make in the future and 53 percent indicated that they would not change their current number of trips. One percent said they would make more trips. Trips for work purposes were less likely to be reduced than trips for non-work purposes.

Respondents were asked to indicate how frequently they use public transportation in the Portland-Vancouver area. Eighty-nine (89) percent of respondents were familiar with public transportation in the Portland-Vancouver region. Of those, 13 percent use it one time per week or more, 47 percent use it less than one time per week, and 40 percent indicated that they never use public transportation.

Trucks

Over half (56 percent) of truck survey respondents were fleet drivers. Owner-operators constituted the second largest group (23 percent). A majority of respondents (59 percent) made their own routing decisions, while about one-quarter (27 percent) made some, but not all routing decisions.

Regarding trip origin and destination locations, the most frequently reported trip was from Oregon to Washington (41 percent of responses), while the second most frequent trip was from Washington to Oregon (26 percent). Only 3 percent of trips began or ended outside of the United States, specifically in Canada.

Fifteen (15) percent of trips were multiday trips which were typically two or three days in length. Forty-two (42) percent of all trips were at least 500 miles in total length and half (50 percent) of all trips were at least seven hours in total travel time.

Thirty-two (32) percent of truck travelers reported crossing the Columbia River using the I-5 bridge during a peak period (weekdays 6 AM to 10 AM or 3 PM to 7 PM) while the remaining 68 percent crossed during off-peak times.

Overall, 47 percent of the sample reported having experienced delay due to traffic congestion related to the I-5 bridge. As expected, delays were reported more frequently and were of longer duration during the AM and PM peak periods than during off-peak periods.

Respondents were asked if they paid a toll during their trip. A vast majority (92 percent) did not report having paid a toll. Additionally, 35 percent of respondents' vehicles were equipped with an Electronic Toll Collection (ETC) transponder. Among those, 10 percent had a Washington state electronic tolling system Good To Go! transponder and the other 25 percent reported having another type of transponder.

Respondents reported how much flexibility they have in their delivery schedule. Almost two-thirds (63 percent) reported having a flexible delivery schedule with one-quarter of those respondents reporting having 6 or more hours of flexibility. Over half (56 percent) reported not have a penalty or incentive time frame structure for deliveries.

Finally, respondents reported how toll costs, if incurred, are paid for. Thirty-five (35) percent reported that they pay tolls out of pocket, while 57 percent reported their company pays tolls directly or they are reimbursed by their company for tolls. The remaining 8 percent of respondents reported never using toll roads.

4.4.2 Stated Preference Results

The stated preference section of the survey was used to ascertain responses to different travel scenarios. In each stated preference scenario, respondents were presented alternatives for making a future trip. A series of ten stated preference scenarios were presented to each passenger car respondent with between two and five hypothetical alternatives. The alternatives were described by attributes of travel time, toll/fare cost, departure time, the number of additional passengers, and transit mode.

Truck respondents also received a series of ten stated preference scenarios that always had two hypothetical alternatives—using I-5 or I-205 to cross the Columbia River. Each of these alternatives was described by two attributes: travel time and toll cost.

After compiling this information over all respondents, a passenger car dataset of 19,060 observations and a truck dataset of 3,330 observations were available for further analysis. This process included screening to make sure trips included in the results were realistic. Responses with unreasonable origin-destination pairs, travel times, travel speeds, and vehicle occupancies were excluded. Also, respondents with very short survey completion times were excluded from the analysis.

The resulting observations were used to develop a multinomial logit mode choice model. This type of statistical model is used very frequently in the transportation industry to forecast traveler responses to trip parameters. Separate models were estimated for passenger vehicle respondents and truck respondents. The statistical estimation and specification testing of the mode choice model was completed using a maximum likelihood procedure that estimated a single set of model coefficients.

The models were then used to estimate: values of time (VOT) specific to the I-5 bridge users (for passenger cars and trucks); trip suppression, mode split, time shifting, and shift to carpooling (for passenger cars only). These estimates are discussed in more detail below.

4.4.3 Value of Time

The marginal rate of substitution between the travel time and toll cost coefficients of the multinomial logit mode choice model provides the implied toll value that travelers would be willing to pay for a given amount of travel time savings on the proposed tolled bridge crossing. The VOT is calculated by dividing the travel time coefficient by the toll cost coefficient after taking into account the effect of income on the toll cost variable.

The following equations detail the value of time calculation method:

$$\text{Passenger Vehicle VOT} = 60 * \frac{\beta_{time}}{\beta_{\cos t}} * Ln\left(\frac{Income}{1000}\right)$$

$$\text{Commercial Vehicle VOT} = 60 * \frac{\beta_{time}}{\beta_{\cos t}}$$

Among which:

β_{time} : is the travel time coefficient

$\beta_{\cos t}$: is the toll cost coefficient

$Income$: is traveler’s annual household income

Within the Tolling Analysis Model, different VOTs for passenger vehicles were used depending on trip time period (peak, off-peak) and the income level (low, medium, high). Table 4-2 gives the income ranges for the three income levels and shows the median income of each level. High occupancy vehicles were assumed to have a VOT that is 20 percent higher than single occupancy vehicles. VOTs for single occupancy passenger vehicles used in the Tolling Analysis Model are shown in Table 4-3. For weekends, the passenger vehicle VOT derived from the stated preference survey was $11.86 dollars per hour (in 2013 dollars).

Table 4-2 Income Level used in Model (in 2013 Dollars)

Income Level	Income Range	Median Income
Low	< $39,412	$22,456
Medium	$39,412 - $78,823	$58,533
High	> $78,823	$120,490

Table 4-3 Model Weekday Single Occupancy Vehicle Values of Time (in 2013 Dollars)

Time Period	Income Level	VOT ($ per hour)
Peak	Low	$9.62
	Medium	$12.58
	High	$14.82
Off-peak	Low	$8.31
	Medium	$10.86
	High	$12.79

For trucks, different VOTs were used for medium trucks (3 and 4 axles) and heavy trucks (5 or more axles). Truck VOTs derived from the stated preference survey and used in the Tolling Analysis Model are shown in Table 4-4.

Table 4-4 Truck Values of Time (in 2013 Dollars)

Truck Segment	VOT ($ per hour)
3-4 axles	$17.36
5 or more axles	$30.33
Aggregate	**$28.66**

These values of time are within the range found in other metropolitan areas across the country. VOTs derived from the 2013 survey were compared to those derived from 2009 survey also conducted by RSG for the CRC Project. The aggregate passenger vehicle VOT derived from the 2013 survey is similar to the one derived from the 2009 survey ($12.92 in 2009 dollars) which means a real dollar reduction in VOT after accounting for inflation. The lack of growth in VOT in recent years is consistent with the national trend of real incomes having held constant or even decreased since the start of the great recession.

The aggregate truck VOT derived from the 2013 survey is somewhat higher than the one estimated from the 2009 survey ($22.14 in 2009) which can be partly explained by the difference in years. However the difference in truck VOT is not statistically significant.

4.4.4 Trip Suppression

Trip suppression was estimated for passenger cars and included three sources of suppression: combining some trip with trips already made (trip combination), trips to a different destination to avoid crossing the Columbia River, and trips no longer made. Trip suppression was not estimated for trucks as they have been found to show this type of behavior much less often.

A trip suppression statistical model was developed as part of the stated preference survey analysis, derived from the passenger car participants' responses. The amount of trip suppression depends on a number of factors including trip type (trip purpose and time of day), trip distance, and traveler income. The results showed that trip suppression rates increase sharply for higher tolls, particularly for non-work trip purposes. However, the trip suppression is offset somewhat if the toll increases result in a reduction in delay and improvement in travel time on the I-5 bridge.

The trip suppression model equation is shown below. Table 4-5 shows the coefficient values for this equation.

$$\text{Percent Reduction} = \alpha * \frac{\beta_{time} * \Delta T + \beta_{cost} * \frac{Toll}{Ln(\frac{Income}{1000})}}{Ln(Dist)}$$

Among which:

α : is the regression coefficient

β_{time} : is the travel time coefficient

β_{cost} : is the toll cost coefficient

ΔT : is travel time saving after bridge is tolled

$Toll$: is toll cost

$Dist$: is travel distance

$Income$: is traveler's annual household income

Table 4-5 Model Coefficients for the Trip Suppression Model Equation - Weekdays

Market Segment	Coeff.	BetaTime	BetaCost
Peak Work	-0.19098	-0.0803	-1.46
Peak Non-Work	-0.26114	-0.0739	-1.55
Off-Peak Work	-0.19690	-0.0594	-1.27
Off-Peak Non-Work	-0.27676	-0.0686	-1.57
Weekend	-0.26316	-0.0731	-1.51

A Monte Carlo simulation process was used to develop an aggregate trip suppression rate for river crossing traffic, found to be approximately 9.7 percent for FY 2016, 10.1 percent for FY 2020, 14.1 percent for FY 2022, and 13.1 percent for FY 2036. This aggregate suppression rate was utilized to adjust the effect of tolling in Metro's trip distribution model. Table 4-6 shows the detailed river crossing suppression.

Table 4-6 River Crossing Trip Suppression by Trip Purpose

Market Segment	FY 2016	FY 2020	FY 2022	FY 2036
Peak Work	9.0%	9.0%	12.5%	11.5%
Peak Non-Work	12.7%	13.1%	18.2%	16.7%
Off-Peak Work	6.4%	6.6%	9.5%	8.7%
Off-Peak Non-Work	10.8%	11.6%	16.2%	15.5%
Aggregate	**9.7%**	**10.1%**	**14.1%**	**13.1%**

Since Metro does not have a weekend trip distribution model, the trip suppression equation was used directly in weekend calculations with specific coefficients for weekends.

4.4.5 Shift to Transit

When the CRC Project's light rail extension opens, transit ridership is expected to increase due to existing, un-served demand for transit and increased travel time reliability on transit across the Columbia River in the I-5 corridor. In 2006, transit ridership on the I-5 bridge was about 3,300 transit trips each weekday. The CRC Project's transit modeling forecasts that the provision of light rail as part of the project would more than double transit ridership in 2030 on I-5 across the Columbia River. The purpose of the transit analysis in this report is to determine the impact of transit on I-5 bridge usage under tolling. This analysis was accomplished by augmenting traditional mode split analysis by results from the stated preference survey specifically dealing with shifts to transit as a result of tolling.

A set of utility functions was statistically estimated from the stated preference survey results which included pertinent variables related to shifts between travel modes including travel time and costs by mode, and vehicle occupancy. Economic consumer theory defines a "utility function" as a single objective function representing the attractiveness of an alternative in terms of its attributes. Economic theory assumes consumers will make their choice based on maximizing their utility. The concept is often used to model consumer behavior. The resulting utility functions gave the relative usefulness of:

- Using the same route at the same travel time
- Using the same route at alternative times
- Traveling at the same time and route but forming a carpool (HOV)
- Traveling an alternative route at same time
- Traveling on transit

When tolls are implemented, additional travelers are expected to shift to transit. However, when tolls are applied, the set of utility functions suggested that the shift from automobile to transit is affected not only by the transit travel time and cost but also by other factors such as automobile travel time, automobile travel cost, amount of time to shift trip before or after peak period, and vehicle occupancy.

Also, it was found that respondents' choices varied based on their response to a separate question on whether they were opposed or not opposed to the overall Columbia River Crossing project.

The utility functions derived from stated preference survey are shown in the following equations with the coefficient values in Table 4-7.

$$U_1 = \beta_1 \times TT_{Nopp} + \beta_2 \times TT_{opp} + \beta_3 \times Cost_{Nopp} \div Ln\left(\frac{Income}{1000}\right) + \beta_4 \times Cost_{Opp}$$

$$U_2 = \beta_1 \times TT_{Nopp} + \beta_2 \times TT_{opp} + \beta_3 \times Cost_{Nopp} \div Ln\left(\frac{Income}{1000}\right) + \beta_4 \times Cost_{Opp} + \beta_5 \times T_{ShiftE} + \beta_6$$

$$U_3 = \beta_1 \times TT_{Nopp} + \beta_2 \times TT_{opp} + \beta_3 \times Cost_{Nopp} \div Ln\left(\frac{Income}{1000}\right) + \beta_4 \times Cost_{Opp} + \beta_7 \times T_{ShiftL} + \beta_6$$

$$U_4 = \beta_1 \times TT_{Nopp} + \beta_2 \times TT_{opp} + \beta_8$$

$$U_5 = \beta_1 \times TT_{Nopp} + \beta_2 \times TT_{opp} + \beta_3 \times Cost_{Nopp} \div Ln\left(\frac{Income}{1000}\right) + \beta_4 \times Cost_{Opp} + \beta_9 \times Occ + \beta_{10}$$

$$U_6 = \beta_{11} \times TT_{Transit} + \beta_{12} \times Fare + \beta_{13} \times Mode + \beta_{14}$$

Among which:

U_i: is the utility for each choice which is 1 for using I-5 bridge, 2 for traveling earlier, 3 for traveling later, 4 for using I-205 bridge, 5 for shifting to HOV, and 6 for using transit.

TT_{Nopp}: is travel time for toll non-opposed traveler

TT_{opp}: is travel time for toll opposed traveler

$Cost_{Nopp}$: is toll cost for toll non-opposed traveler

$Cost_{Opp}$: is toll cost for toll opposed traveler

T_{ShiftE}: is amount of time a traveler can shift earlier if he has such flexibility

T_{ShiftL}: is amount of time a traveler can shift later if he has such flexibility

Occ: is the number of passenger a traveler is willing to add

$TT_{Transit}$: is transit travel time

$Fare$: is transit fare

$Mode$: is transit mode

$Income$: is traveler's annual household income

β_i: is coefficient for each independent variable as shown below in the Table 4-7.

Table 4-7 Coefficients for the Utility Functions from Stated Preference Survey

Coefficient	Peak Work	Peak Non Work	Off Peak Work	Off Peak Non Work	Weekend
β_1	-0.0803	-0.0739	-0.0594	-0.0686	-0.0731
β_2	-0.0304	-0.0304	-0.0304	-0.0304	-0.0304
β_3	-1.4600	-1.5500	-1.2700	-1.5700	-1.5100
β_4	-0.6080	-0.6080	-0.6080	-0.6080	-0.6080
β_5	-0.0216	-0.0216	-0.0216	-0.0216	-0.0216
β_6	-0.5240	-0.5240	-0.5240	-0.5240	-0.5240
β_7	-0.0143	-0.0143	-0.0143	-0.0143	-0.0143
β_8	0.2160	0.2160	0.2160	0.2160	0.2160
β_9	-1.5700	-1.5700	-1.5700	-1.5700	-1.5700
β_{10}	0.9910	0.9910	0.9910	0.9910	0.9910
β_{11}	-0.0524	-0.0524	-0.0524	-0.0524	-0.0524
β_{12}	-0.3980	-0.3980	-0.3980	-0.3980	-0.3980
β_{13}	-1.2600	-1.2600	-1.2600	-1.2600	-1.2600
β_{14}	1.1900	1.1900	1.1900	1.1900	1.1900

CDM Smith developed a process to use the utility functions to study the tolling effects on travel behavior change. It revealed that under tolling additional vehicle trips would convert to transit at the following rates: 6 percent of peak hour work trips, 4 percent of peak hour non work trips, 1 percent of off-peak hear work trips, and 3 percent of off-peak hour non-work trips. An aggregated 3 percent mode shift to transit due to toll was used to adjust Metro's mode shift model. Note that these percentages only represent the incremental shift to transit directly attributable to tolling, and are in addition to the expected increase of transit ridership due to the light rail extension. The same process was followed to develop the weekend mode shift rates, but with coefficients specific for weekends. An aggregated 2 percent mode shift to transit due to tolls was used for weekends.

4.4.6 Changes in Trip Timing

The same analysis of the stated preference survey results showed that only very marginal time shifting away from peak periods would occur as a result of toll implementation with variable toll rates.

4.4.7 Shift to Carpooling

The analysis also showed that very few travelers would be willing to add one additional passenger to distribute toll costs among passengers unless there was a very significant toll discount.

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Chapter 5

Economic Growth Review

Current economic activity and economic growth is an important factor in evaluating the expected future revenue from a toll facility. This traffic and revenue study will be used in support of project financing for the CRC Project. For such a purpose, the state of the practice is that an independent analysis of expected regional economic growth be conducted. This analysis provides independently-developed socioeconomic forecasts used as input to the Tolling Analysis Model.

The independent economist for this study is ECONorthwest of Portland, Oregon. ECONorthwest performs economic and financial analyses for businesses, attorneys, and governments throughout the Pacific Northwest. ECONorthwest provides public and private clients with regional modeling and forecasting services. Currently active transportation related forecasting models by ECONorthwest include macroeconomic models for the Portland metropolitan area, the Puget Sound Region, and the State of and various counties in California. ECONorthwest has developed and maintained macroeconomic models of the Portland, Oregon regional economy for over 22 years. These models were originally developed to forecast revenue for Tri-County Metropolitan Transportation District of Oregon (TriMet), the Portland-area transit agency, which relies primarily on payroll taxes to pay for its operations. Over the years, the models have been enhanced and used to support a variety of investment analyses, revenue forecasts, and needs analyses for public agencies and private clients.

5.1 The Current State of the Portland Regional Economy

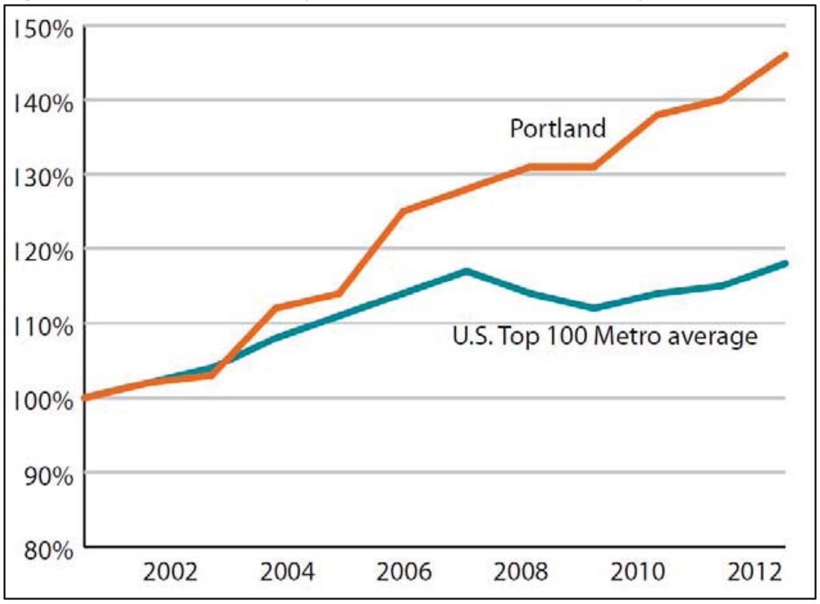
The 2013 update of the Greater Portland metropolitan region's economic condition, a study conducted by ECONorthwest for the Value of Jobs Coalition (which includes the Portland Business Alliance, Associated Oregon Industries, Oregon Business Association, Oregon Business Council, and the Port of Portland) indicates a positive outlook for the region. Focusing on three measures of the Greater Portland metropolitan area's economy – Gross Metropolitan Product (GMP), employment, and income – the region's growth continues to outperform the vast majority of U.S. metropolitan areas and has shown improvement in both employment and incomes.

Among the top 100 Metropolitan Statistical Areas (MSAs) in the United States, the Portland metropolitan area ranks second in GMP growth, the market value of all the goods and services produced in a MSA, during its recovery from the recent economic recession. Figure 5-1 illustrates the performance of the Portland MSA in comparison to the average performance of the top 100 MSAs.

The Portland metropolitan area's GMP bottomed out in 2009. From then through the second quarter of 2012, the region's GMP increased by 22 percent. Over the last year, the average of the top 100 MSAs grew faster than the Portland area, at an average rate of 2.7 percent, versus 1.2 percent for the Portland area. However, from the recessionary trough of 2009 through 2012, the Portland metropolitan area grew at a significantly higher rate than the average MSA.

Approximately 72,400 non-farm jobs were lost in the Portland metropolitan area from 2008 to 2009. In 2013, about 65,900 jobs had been recovered in the region, representing a continuing loss of 0.5 percent. This recovery has outpaced the U.S. metro average, which is still one percent below the 2007 peak level.

Figure 5-1 Portland Metropolitan Area GMP vs. U.S. Top 100 Metro Average (2001-2012)



Source: Brookings Metro Monitor, http://www.brookings.edu/research/interactives/metromonitor#overall, 2013

While manufacturing fell in both the Portland metropolitan area and the U.S. overall, the Portland area did not fall as far as the national metro average, and has recovered at a faster pace. Although manufacturing jobs were added back in the region, the Portland metro's recovery in durable-goods jobs slowed in 2013 compared to 2012, while the 2013 recovery in non-durable goods manufacturing jobs has remained on pace with 2012. In comparison, the U.S. metro average saw no additional jobs added in 2012 or 2013 for both the durable and non-durable goods manufacturing sector jobs.

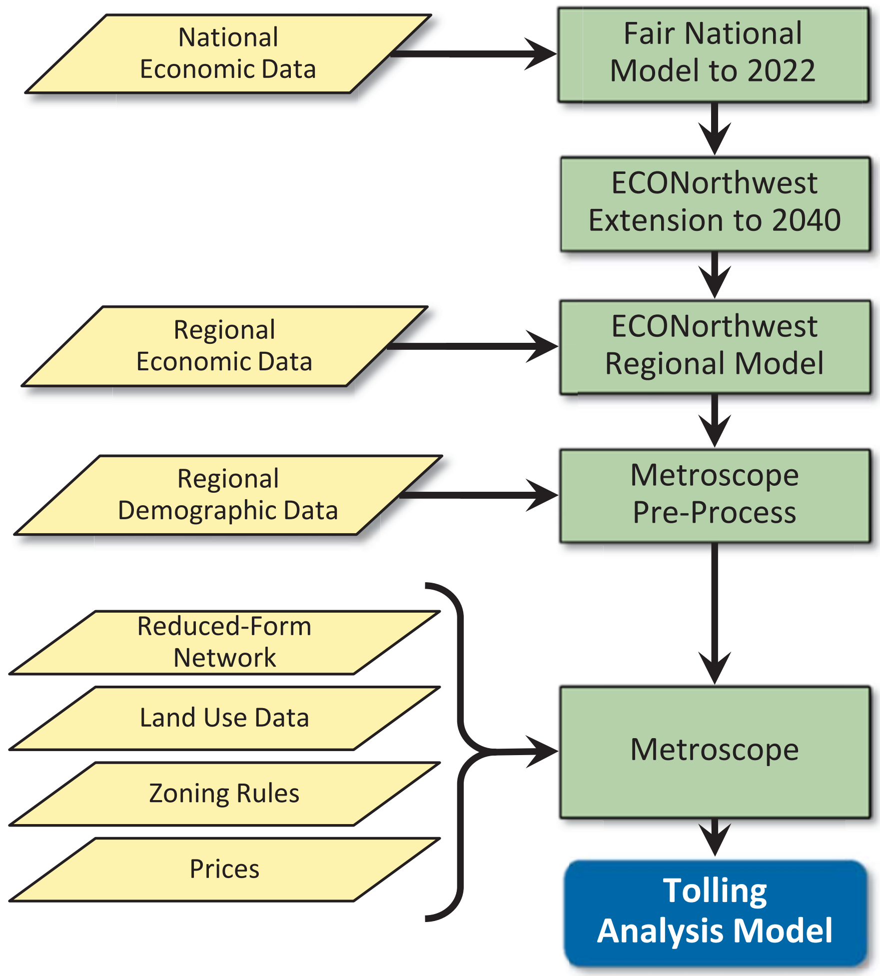
Despite the on-going recovery in jobs, the median household income is still lagging behind the 2008 level in real terms, although recent trends are encouraging. In 2012 dollars, the 2012 median household income in the Portland metro region was 8 percent lower than in 2008. However, the median household income increased by 1.7 percent between 2011 and 2012, the first increase since 2008.

5.2 Modeling Approach

5.2.1 Model Overview

The ECONorthwest socioeconomic forecast employs a model system, implemented as a series of linked forecasting modules. The overall modeling process is illustrated in Figure 5-2. The model system links a national economic model developed by Professor Ray Fair of Yale University (the Fair model) to a top-level regional model, and then to a series of regional sub-models. These sub-models provide economic sectoral dimensionality.

The national Fair model is an open source model of the U.S. economy, which has been extended out to 2040 by ECONorthwest, and used to provide inputs for forecasting the region's economy. Most national economic models have shorter forecast horizons than required by planning processes. The Fair model has a 10-year horizon, and requires policy and data input forecasts (i.e. exogenous variables) to drive its 10-year national macro forecast. ECONorthwest developed and implemented a model that extended the input data series for the Fair model and, hence, the forecast horizon.



CDM Smith

OVERALL ECONORTHWEST SOCIOECONOMIC MODELING PROCESS

FIGURE 5-2

The regional model has been developed by ECONorthwest and is a high-level model of the economy of the greater Portland region. The economic model links the performance of Portland's economy with that of the U.S. economy through estimation of relationships over a 30-year historical period. A forecast of the U.S. economy produced by the extended Fair model is then used to drive the forecast values of key economic variables in the regional model.

The regional forecasts of households and personal income derived from the regional model were used as control totals for Metro's Metroscope model, which proportionally fits numbers of household categories (by income, size, age, and presence of children) in each model year so they add up to the regional forecast totals. Employment by industry category is supplied to the Metroscope model directly by the regional forecast.

The Metroscope model was then used to solve for household and employment locations in each model year, subject to land-use constraints and input control totals. Metroscope incorporates a reduced-form travel demand model to estimate impedances given household and employment locations. Due to output parameter characteristics, Metroscope's household output is then run through a map-back procedure to develop household input to the travel demand model. Employment output from Metroscope is in a form to be directly input to the travel demand model.

Consequently, the preparation of transportation analysis zones (TAZ) land use inputs into the Tolling Analysis Model for analyzing traffic and revenue for the CRC Project involves the following basic procedures.

- The selection and extension of a forecast of the U.S. economy through the analysis time horizon (2040).
- The implementation of a model of the Portland metropolitan region's economy to produce a regional socioeconomic forecast through the analysis time horizon.
- The preparation of data from the regional socioeconomic model to be used in the Metroscope land use and transportation interaction model of the Portland metropolitan region.
- The implementation of the Metroscope model and the preparation of model results into appropriate employment and household categories at the TAZ geography to be used in the travel demand portion of the Tolling Analysis Model.

More detail on each of these steps is included in subsequent sections. The final section of this chapter contains the results of the forecasting process.

5.2.2 The FAIR National Model

Dr. Ray Fair of Yale University maintains a model of the economies of the U.S. and 38 other nations. The Fair model is a dynamic, nonlinear model with a simultaneous set of equations that solve for future levels in the economy given a small number of exogenous assumptions about policy. The model is regularly updated and the data and forecast products, as well as the model itself, are readily available on his website.

Primary equation blocks in the Fair model include those relating to:

- Age distributions - the age distribution data that are used in the estimation of the U.S. model are from the U.S. Census Bureau, monthly population estimates.
- Household expenditures and labor supply - the two main decision variables of a household in the theoretical model are consumption and labor supply.
- Firm sectors - in the maximization problem of a firm in the theoretical model there are five main decision variables: the firm's price, production, investment, demand for employment, and wage rate.
- Money demand - the model contains two demand for money equations: a demand for money equation for the firm sector and a demand for currency equation.
- Other financial equations relating to market structure and stock prices.
- Imports - includes per capita expenditures on consumption and investment, a price deflator for domestically produced goods relative to the import price deflator.
- Unemployment benefits – the equation contains as explanatory variables the level of unemployment, the nominal wage rate, and the lagged dependent variable.
- Interest rate rule - this equation explains the behavior of the Federal Reserve.

The latest version of the model employs the set of exogenous assumptions shown in Table 5-1. The assumed growth rates in are listed in Table 5-1 along with historical growth values between the fourth quarter of 1989 (1989:4) and the fourth quarter of 2007 (2007:4). The fourth quarter of 2007 covers the time period before the stimulus measures began in 2008. In general, the Fair model captures the Great Recession in its historical data.

The Fair model makes no attempt to represent changes in tax rates or government spending in the future. The current forecast is conditioned on no future tax changes and on the assumptions about government spending listed above. The basic Fair model is a baseline forecast that supports policy analysis of the effects of spending cuts and tax increases. State and local governments are assumed to essentially keep balanced budgets and no assumption is needed about monetary policy as monetary policy is determined endogenously by an estimated interest rate rule.

The current forecast assumes that if there are no shocks, no further tax increases, and no government spending cuts, the economy grows well enough to stabilize the unemployment rate at 6.6 percent. The assumption of no shocks, which is used for the forecast, means that stock prices, housing prices, and import prices grow at historically normal rates. No negative wealth shocks occur through falling stock prices and housing prices and no positive price shocks through rapidly rising import prices (due, for example, to a depreciating dollar and/or rising dollar oil prices). Asset prices like stock prices, housing prices, exchange rates, and oil prices are less predictable. The forecast assumes asset prices to follow their historical averages.

Table 5-1 Key Growth Assumptions for the Fair Model National Forecast

Growth Rates (annual rates)	Forecast Assumptions	Actual 2007:4 - 1989:4
Real federal government transfer payments to households	4.0	4.0
Real federal government purchases of goods	2.0[a]	2.3
Federal government civilian employment	1.0	-0.7
Real federal government transfer payments to state and local gov't.	2.0	5.3
Real state and local government transfer payments to households	8.0	5.7
Real state and local government purchases of goods	1.0	3.9
State and local government employment	1.0	1.5
Real exports	7.0[b]	6.0
Import price deflator	1.0	1.2

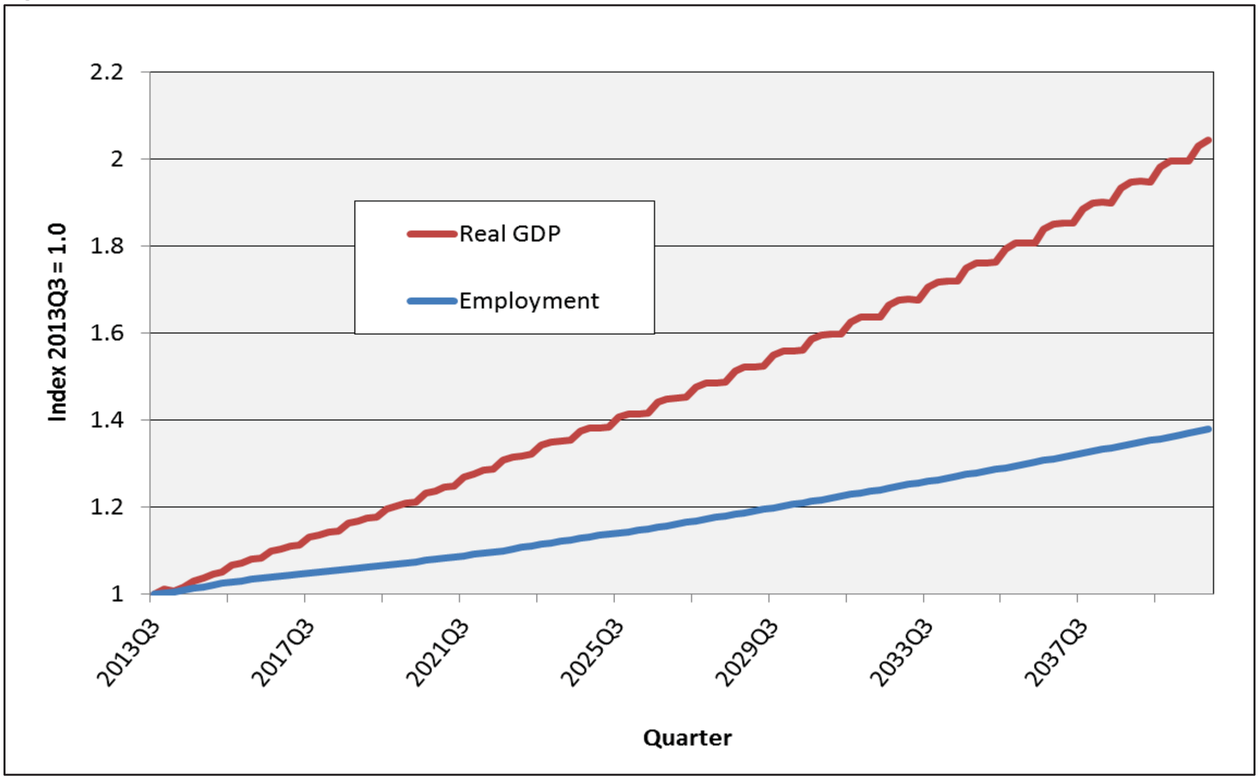
a) 1.0 for first three quarters
b) 3.0 for first three quarters

The Fair model forecast of national economic growth is in line with other commercial forecasts. For example, the December 2013 Oregon Economic and Revenue Forecast, which is based on information provided by Global Insight, predicts national employment growth at an average rate of 1.1 percent over the next 10 years, a little faster than the Fair model.

5.2.3 Extension of the FAIR National Model

The Fair model has a 10-year forecast horizon, and requires exogenous variables to drive its national macroeconomic forecast. The inputs into traffic and revenue analysis for the Columbia River Crossing require a forecast horizon of 2040. Consequently, ECONorthwest has developed special procedures for extending the Fair model beyond its terminal point in 2022. The process for extending the Fair model involves estimating equations for the key national variables without relying on exogenous variables. This method takes advantage of available information about relationships between endogenous variables (variables that are estimated by the model) avoids simple trending, and does not require choosing and relying on a potentially-inconsistent long-term forecast from another source. Figure 5-3 displays selected results from the extension of the Fair model through 2040. The results are represented as an index with the 3rd quarter of 2013 equal to 1.00.

Figure 5-3 Selected Extended Fair Model National Forecast Results



Source: Fair model and ECONorthwest

5.2.4 Development of the Portland Regional Economic Model

ECONorthwest has developed a high-level model of the economy of the greater Portland metropolitan region. The economic model links the performance of Portland's economy with that of the U.S. economy through estimation of relationships over a 30-year historical period. A forecast of the U.S. economy produced by the extended Fair model is used to drive the forecast values of key economic variables representing future expectations about Portland's economic performance.

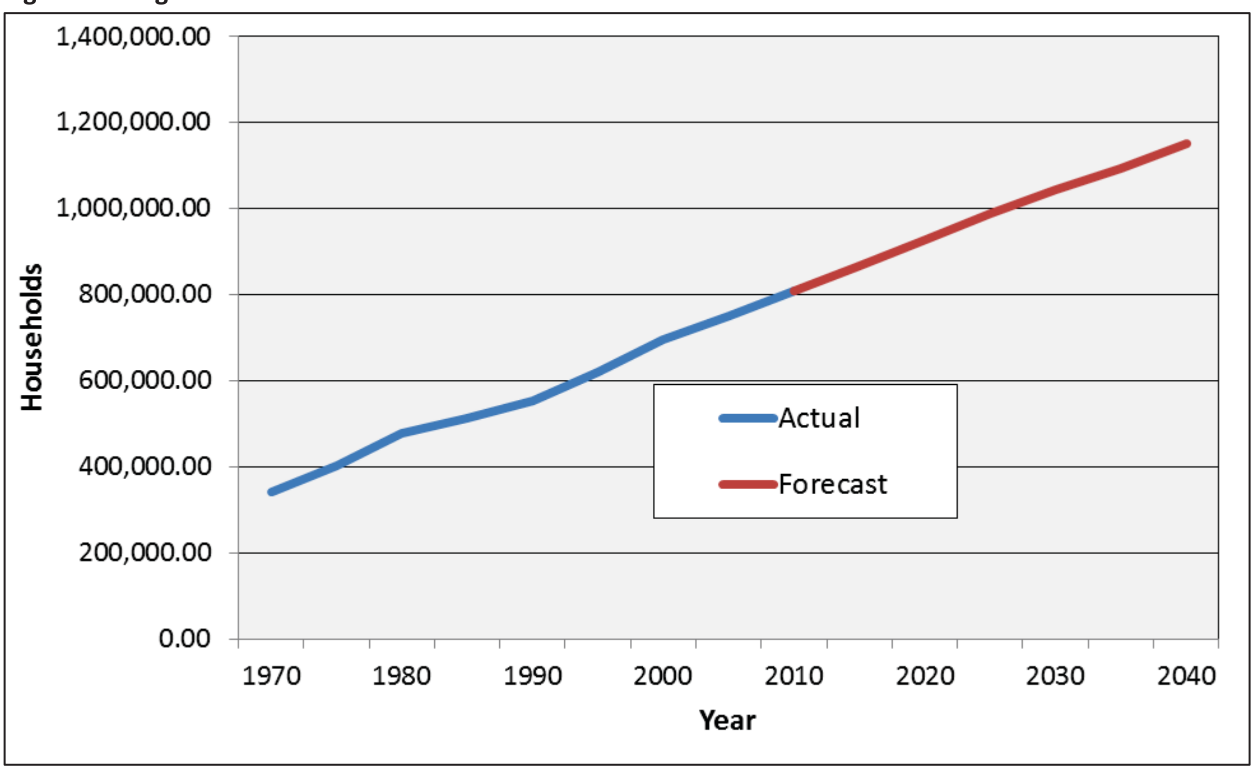
The regional economic model makes use of a variety of data sources including results from the Fair model (GDP, GDP deflator, disposable income, export price deflator, average hourly earnings in the non-financial private sector, national civilian employment); household counts from the U.S. Census; Portland consumer price index from the Office of Economic Analysis; employment data from the Oregon Employment Department, the Washington Employment Security Department, and the U.S. Census; and personal and wage and salary income from the Bureau of Economic Analysis. Table 5-2 below displays both historical data for selected variables and the regional economic model's forecasted values through 2040.

The resulting household and employment forecasts for the four-county area are shown in Figures 5-4 and 5-5. Historical trends are included from 1970 to 2010 for context.

Table 5-2 Selected Historical and Forecast Data

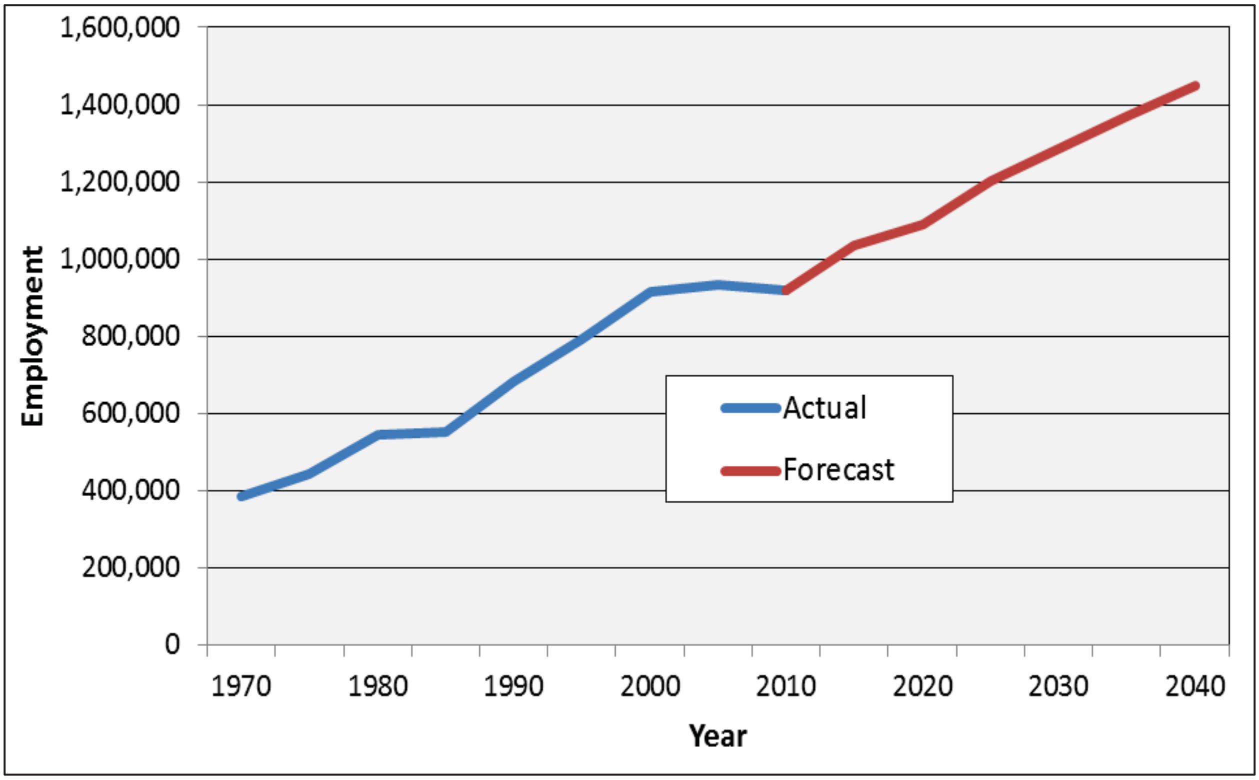
Year	Portland, OR CPI	Nominal Personal Income for MSA (Thousands)	MSA Population	4-County Households	4-County Employment
1990	127.4	30,885,506	1,423,831	553,107	683,341
1995	153.2	44,347,454	1,623,530	620,752	792,319
2000	178.0	64,045,563	1,796,065	696,669	914,477
2005	196.0	74,789,023	1,919,220	750,905	932,721
2010	218.3	87,940,255	2,072,935	809,363	919,502
2015	247.4	114,477,320	2,375,125	866,598	1,037,096
2020	283.4	149,727,379	2,521,889	928,791	1,091,445
2025	327.9	201,961,564	2,680,824	990,627	1,202,749
2030	375.0	263,462,241	2,842,048	1,044,352	1,286,424
2035	426.8	341,317,319	2,996,423	1,095,138	1,369,778
2040	485.1	440,773,552	3,146,131	1,150,823	1,449,115
2010 - 2040	2.7%	5.5%	1.4%	1.2%	1.5%
2010 - 2025	2.7%	5.7%	1.7%	1.4%	1.8%
2025 - 2040	2.6%	5.3%	1.1%	1.0%	1.3%
1990 - 2000	3.4%	7.6%	2.3%	2.3%	3.0%
2000 - 2010	2.1%	3.2%	1.4%	1.5%	0.1%

Figure 5-4 Regional Household Forecast



Source: ECONorthwest

Figure 5-5 Regional Employment Forecast



Source: ECONorthwest

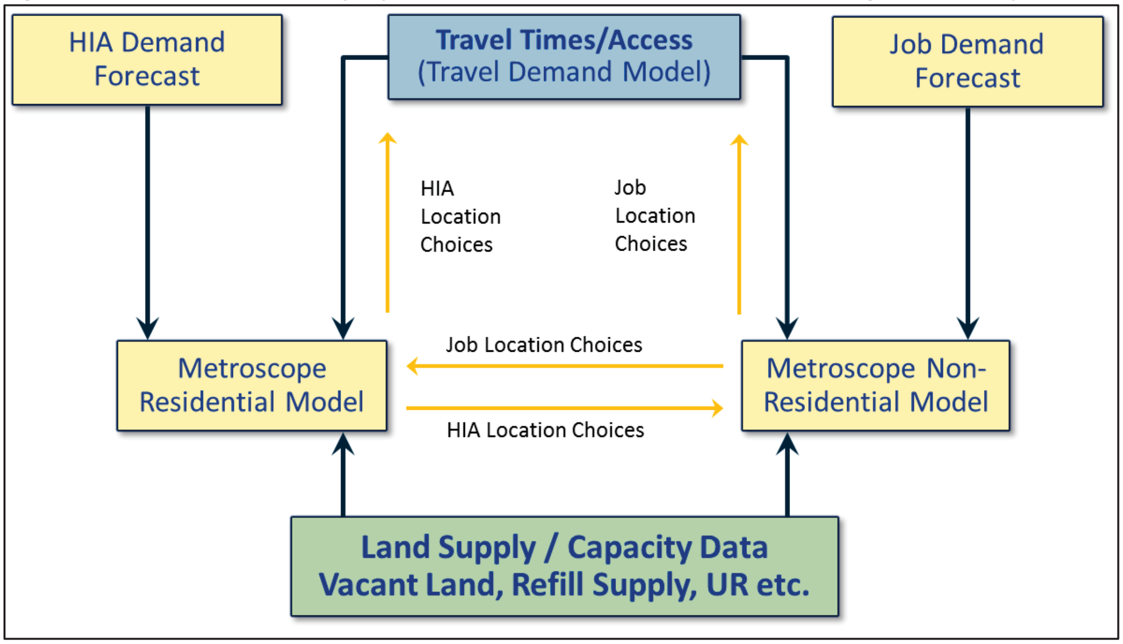
5.2.5 Data Pre-Processing for the Metroscope Model

Starting with the output of the regional forecast, ECONorthwest used a data preparation process to generate sufficiently detailed inputs to the Metroscope models. Metroscope utilizes households grouped into a set of household categories that describe the household features of interest. These household characteristics include number of persons, presence and number of children, age of head of household, and income. The process is an iterative proportional fitting routine that uses marginals for nearly four thousand household categories, already available from Metro, and then translates the results into the 400 household categories currently employed by the Metroscope model system.

5.2.6 The Metroscope Model

Metroscope is a set of linked models used by Metro to support planning decision analysis. The model system is comprised of 1) an economic and demographic model, 2) a reduced form travel model, and 3) two real estate location choice models. The linked models produce information about the location of households and jobs throughout the region over the forecast period in 5-year increments. The model framework allows for interactions between land use policy, the spatial distribution of land uses, and the performance of the transportation systems. The representation of this dynamic urban system is displayed in the Metroscope schematic in Figure 5-6 below.

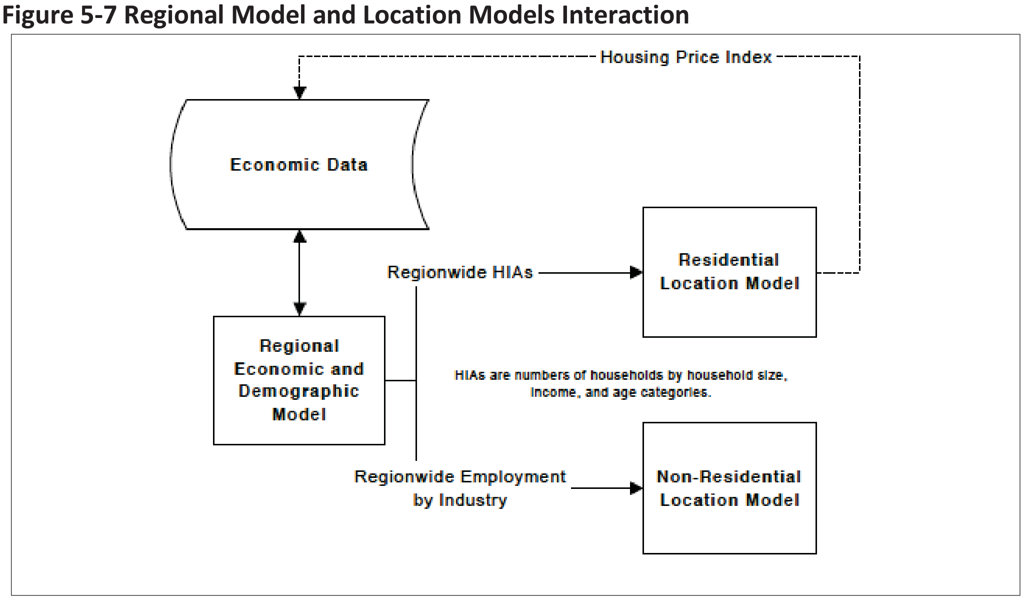
Figure 5-6 Household and Employment Forecast Allocation to Zones Through Metroscope



Note: HIAs are numbers of households by household size, income, and age categories.
Source: Metro Metroscope Documentation

The regional economic model supplies total households and jobs to the residential and non-residential location models. In this instance, the ECONorthwest regional economic model is the basis for the control totals for household demand and job demand rather than the default Metroscope regional economic and demographic model. Figure 5-7 depicts the interaction between the regional economic model and the location models.

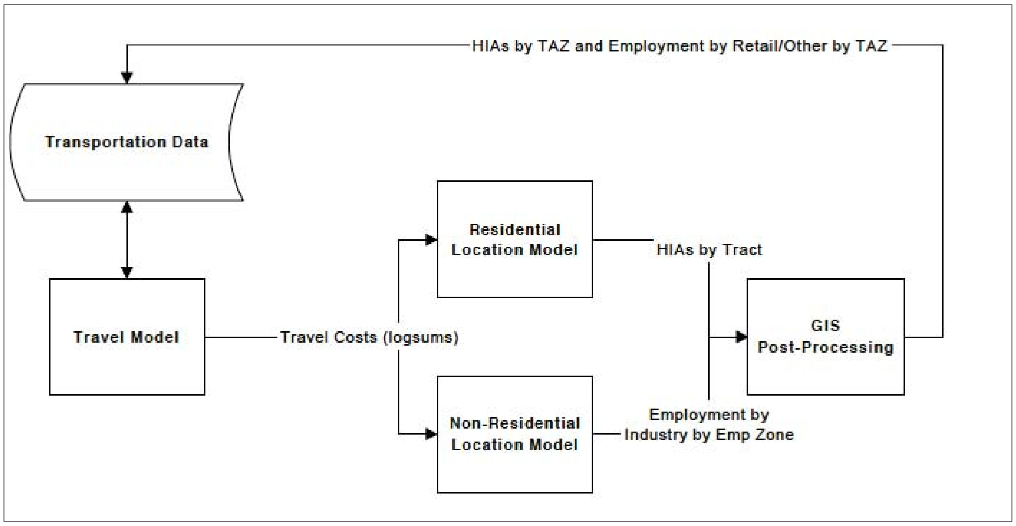
Figure 5-7 Regional Model and Location Models Interaction



Source: Metro Metroscope Documentation

The travel model provides the residential and non-residential location choice models with zone-to-zone accessibility measures. These measures of travel costs influence the location of households (by household category) and jobs (by industry category). New households are placed in census tracts and new jobs are placed in employment zones. Figure 5-8 depicts the interaction between Metroscope's travel model and its location models.

Figure 5-8 Travel Model and Location Models Interaction



Source: Metro Metroscope Documentation

The solution of household and job locations within Metroscope is a result of household and job characteristics, location choice parameters, zone-to-zone travel costs, and land development policies and constraints. In this way the Metroscope results respect both adopted land use policy and the interaction between changes in land uses and transportation performance over time within the forecast period.

5.2.7 The Metroscope Map-Back Process

Metroscope has less spatial detail and more disaggregate categories of households than Metro's regional travel demand model, so a map-back procedure was used to consolidate household categories and distribute households over TAZs within each Metroscope zone. The resulting numbers of households by category by TAZ for each model year become direct inputs to the regional travel demand model.

Metroscope makes use of 400 household categories that must be aggregated to 64 categories for use in the Metro travel model. In addition, the travel model contains a greater number of geographic zones than Metroscope, so that households and jobs are distributed down to this finer-grain spatial detail. The travel model has 2,174 transportation analysis zones while Metroscope has 425 residential zones and 71 non-residential (employment) zones.

The employment results from the Metroscope main process and the household results from the Metroscope map-back process then provide direct input to the travel demand model. For this study, the Tolling Analysis Model has been derived by CDM Smith from the Metro travel demand model as outlined later in this report.

5.3 Baseline Scenario Results

The final results of the forecasting and data preparation process are a set of household and employment datasets representing TAZ inputs into travel modeling. The results are presented for the four-county Metro model coverage area illustrated in Figure 5-9. Household are categorized by size, age of head of household, and income; jobs are categorized by large industry sector. The details are included in modeling input files but are summarized in aggregate below. Tables 5-3 and 5-4 include results for the four county region total and results broken out by Clark County, Washington and the three Oregon Counties (i.e. Clackamas, Multnomah and Washington Counties).

Table 5-3 Employment Forecasts

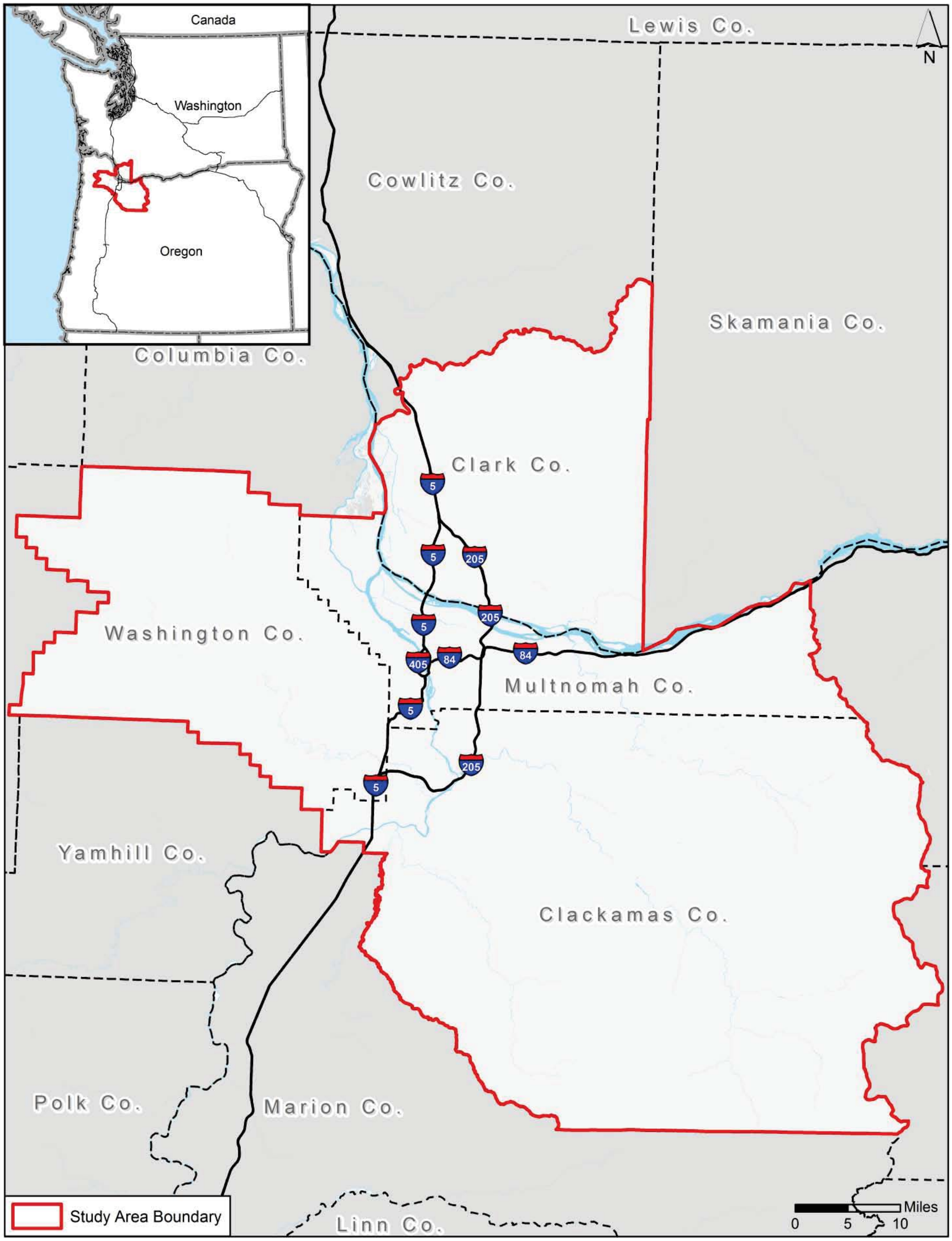
Year	Current Employment Forecasts		
	Four-County	Clark County	Three-County
2010	919,502	126,733	792,769
2015	1,037,096	142,176	894,921
2020	1,091,445	149,954	941,491
2025	1,202,749	172,211	1,030,538
2030	1,286,424	189,076	1,097,349
2035	1,369,778	205,102	1,164,675
2040	1,449,115	218,196	1,230,919
2010 - 2040	1.53%	1.83%	1.48%
2010 - 2025	1.81%	2.07%	1.76%
2025 - 2040	1.25%	1.59%	1.19%

Source: ECONorthwest

Table 5-4 Household Forecasts

Year	Current Households Forecasts		
	Four-County	Clark County	Three-County
2010	809,363	158,099	651,264
2015	866,598	167,538	699,059
2020	928,791	185,866	742,925
2025	990,627	200,380	790,246
2030	1,044,352	210,124	834,228
2035	1,095,138	215,994	879,143
2040	1,150,823	221,025	929,797
2010 - 2040	1.18%	1.12%	1.19%
2010 - 2025	1.36%	1.59%	1.30%
2025 - 2040	1.00%	0.66%	1.09%

Source: ECONorthwest



METRO MODEL COVERAGE AREA

FIGURE 5-9

Figures 5-10 and 5-11 compare the ECONorthwest employment and household forecasts for the four-county Metro model coverage area to the Metro forecasts. (The Metro forecasts shown are Metro 2012 "Gamma" forecasts.) Compared to the Metro's employment forecast for the four-county region, ECONorthwest's forecast is 0.5 percent lower in 2015. In 2020 and 2025, ECONorthwest projects 3.7 and 2.2 percent lower employment than Metro, respectively. In 2030, 2035, and 2040, ECONorthwest projects 2.2, 3.0, and 3.9 percent lower employment than Metro, respectively. ECONorthwest's forecast of the number of households for the four-county region is at least five percent lower than the Metro forecast for the period 2015 through 2040, with the largest differences of 7.3 and 6.6 percent in 2020 and 2030, respectively. This comparison illustrates that the ECONorthwest forecast results in significantly lower employment and household estimates for most of the forecast horizon than projected by Metro.

Figure 5-10 ECONorthwest and Metro Employment Forecasts for Four-County Region

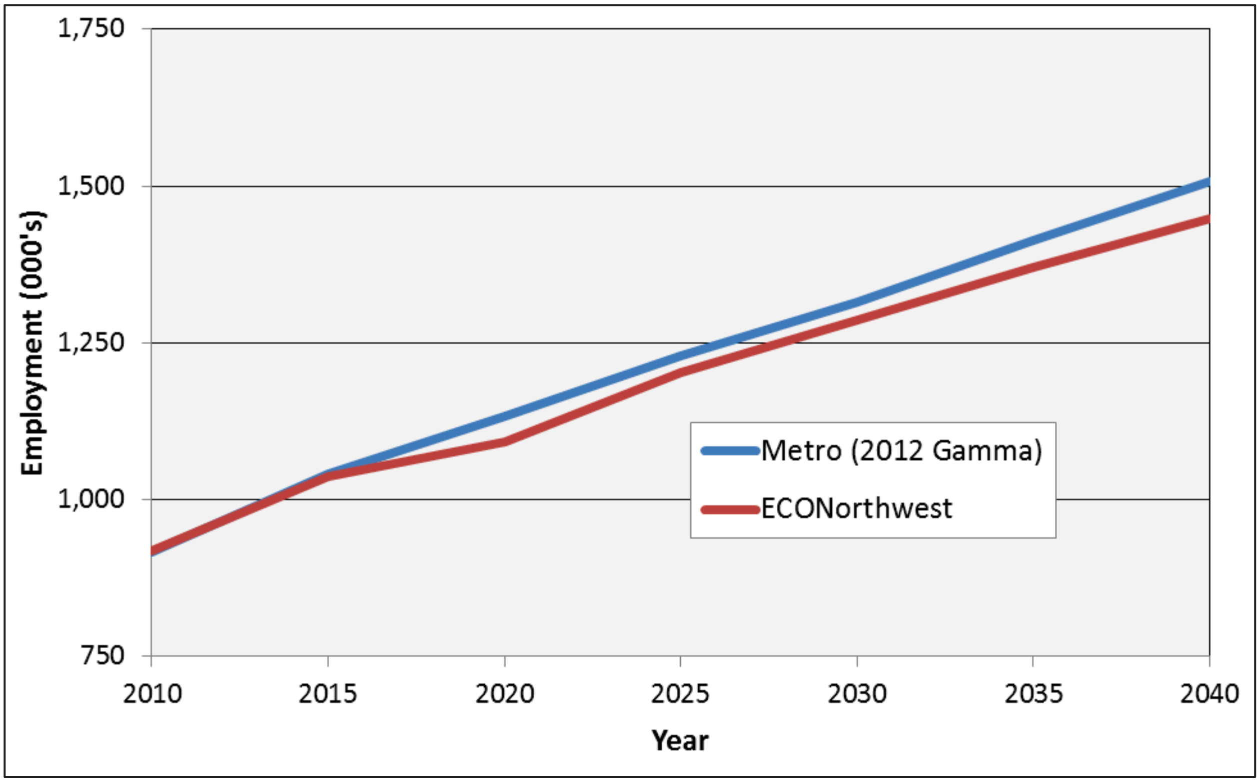
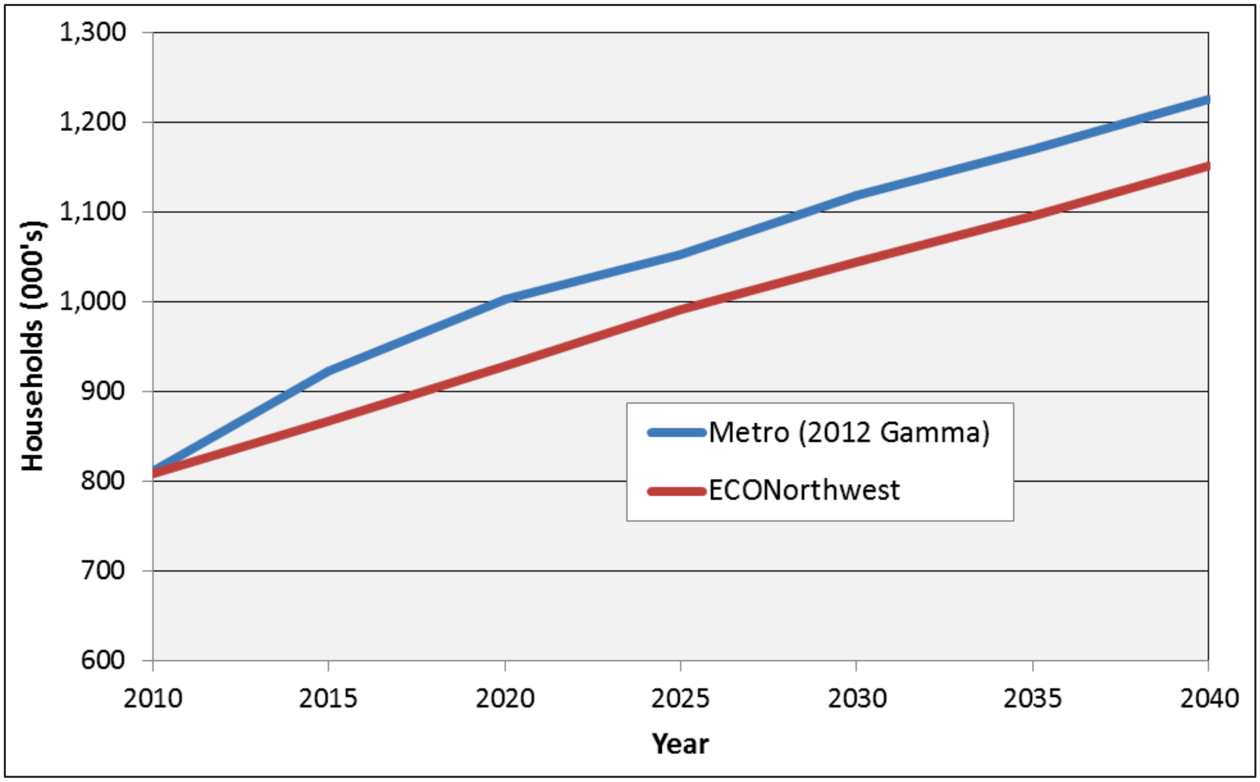


Figure 5-11 ECONorthwest and Metro Households Forecast for Four-County Region



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Chapter 6

Tolling Operations

The Oregon Department of Transportation intends to collect tolls on the existing I-5 bridge and on a future replacement bridge spanning the main channel of the Columbia River.

Tolls will be collected in both directions of travel. The toll rate will be same in both directions. Toll rates will vary by time of day and day of week with higher tolls during peak demand periods. Initially, during construction, tolls will not be collected during the overnight period (defined as 8 PM to 5 AM). Once construction of both spans of the replacement bridge is complete, from FY 2022 onwards, tolls will be collected during the entire day. The weekday toll schedule will apply Monday to Friday, with the exception of certain major holidays. A separate weekend toll schedule will apply Saturday and Sunday.

This chapter summarizes the tolling assumptions used in developing traffic and revenue estimates. Tolling is assumed to be all-electronic, with no option to pay using cash at traditional toll booths. Two main payment methods, account based and non-account based, are assumed to be available. Two different toll rate structures are assumed for the CRC Project, one for account based and the other for non-account based payment. The non-account based toll rates are higher, with the increment (surcharge) relating to the additional costs and risks associated with this type of transaction.

The assumed market shares of each payment type are presented in this chapter. These assumptions were developed based on a review of payment type market shares on other all-electronic toll facilities and the results of the CRC Project travel pattern survey.

6.1 Toll Structure and Rates

6.1.1 Toll Rate Selection

Several factors were taken into account when selecting the CRC Project toll rates, most importantly: toll rates on similar facilities currently in operation, consideration of the financing requirements of the project, and a review of project objectives.

To consider toll rates on similar facilities currently in operation, toll rates on 42 toll bridges and tunnels in urban areas were evaluated. Table 6-1 lists the published passenger car and 5-axle truck rates per crossing, such that toll rates are divided by two for facilities that only charge in one direction. The rates listed are for electronic toll collection, in peak periods, if applicable. (See Table 6-1 footnotes for additional details.)

Table 6-1 Per Crossing Toll Rates for Major Urban U.S. Bridges and Tunnels

Agency	Facility	Per Crossing		
		Passenger Car	Truck Multiplier	5-Axle Truck
Bay Area Toll Authority (San Francisco)	Antioch Bridge	$2.50	5.00	$12.50
Bay Area Toll Authority (San Francisco)	Bay Bridge	$3.00	4.17	$12.50
Bay Area Toll Authority (San Francisco)	Benicia-Martinez Bridge	$2.50	5.00	$12.50
Bay Area Toll Authority (San Francisco)	Carquinez Bridge	$2.50	5.00	$12.50
Bay Area Toll Authority (San Francisco)	Dumbarton Bridge	$2.50	5.00	$12.50
Bay Area Toll Authority (San Francisco)	Richmond-San Rafael Bridge	$2.50	5.00	$12.50
Bay Area Toll Authority (San Francisco)	San Mateo-Hayward Bridge	$2.50	5.00	$12.50
Golden Gate Bridge Hwy and Trans. District (San Francisco)	Golden Gate Bridge	$2.50	5.00	$12.50
Delaware River and Bay Authority	Delaware Memorial Bridge	$2.00	6.25	$12.50
Maryland Transportation Authority	Francis Scott Key Bridge	$3.60	6.67	$24.00
Maryland Transportation Authority	Baltimore Harbor Tunnel	$3.60	6.67	$24.00
Maryland Transportation Authority	Fort McHenry Tunnel	$3.60	6.67	$24.00
Massachusetts Department of Transportation	Tobin Memorial Bridge	$1.25	3.00	$3.75
Massachusetts Department of Transportation	Sumner Tunnel	$1.75	2.50	$4.38
Massachusetts Department of Transportation	Ted Williams Tunnel	$1.75	2.50	$4.38
Detroit International Bridge Company	Ambassador Bridge	$4.60	5.98	$27.50
Detroit-Windsor Tunnel LLC	Windsor Tunnel	$3.85		
Burlington County Bridge Commission (New Jersey)	Burlington-Bristol Bridge	$1.00	4.50	$4.50
Burlington County Bridge Commission (New Jersey)	Tacony-Palmyra Bridge	$1.00	4.50	$4.50
Delaware River Port Authority of Pennsylvania and New Jersey	Ben Franklin Bridge	$2.50	7.50	$18.75
Delaware River Port Authority of Pennsylvania and New Jersey	Betsy Ross Bridge	$2.50	7.50	$18.75
Delaware River Port Authority of Pennsylvania and New Jersey	Commodore Barry Bridge	$2.50	7.50	$18.75
Delaware River Port Authority of Pennsylvania and New Jersey	Walt Whitman Bridge	$2.50	7.50	$18.75
Port Authority of New York and New Jersey	Bayonne Bridge	$5.50	6.36	$35.00
Port Authority of New York and New Jersey	George Washington Bridge	$5.50	6.36	$35.00
Port Authority of New York and New Jersey	Goethals Bridge	$5.50	6.36	$35.00
Port Authority of New York and New Jersey	Holland Tunnel	$5.50	6.36	$35.00
Port Authority of New York and New Jersey	Lincoln Tunnel	$5.50	6.36	$35.00
Port Authority of New York and New Jersey	Outerbridge Crossing	$5.50	6.36	$35.00
Metropolitan Transportation Authority (NYC)	Verrezano Narrows Bridge	$5.33	4.93	$26.26
Metropolitan Transportation Authority (NYC)	Robert F. Kennedy Bridge	$5.33	4.93	$26.26
Metropolitan Transportation Authority (NYC)	Bronx-Whitestone Bridge	$5.33	4.93	$26.26
Metropolitan Transportation Authority (NYC)	Throgs Neck Bridge	$5.33	4.93	$26.26
Metropolitan Transportation Authority (NYC)	Brooklyn-Battery Tunnel	$5.33	4.93	$26.26
Metropolitan Transportation Authority (NYC)	Queens Midtown Tunnel	$5.33	4.93	$26.26
Metropolitan Transportation Authority (NYC)	Henry Hudson Bridge	$2.44		
Metropolitan Transportation Authority (NYC)	Gil Hodges Memorial Bridge	$2.00	6.57	$13.13
Metropolitan Transportation Authority (NYC)	Cross Bay Bridge	$2.00	6.57	$13.13
New York State Thruway Authority	Tappan Zee Bridge	$2.38	6.89	$16.38
Rhode Island Turnpike and Bridge Authority	Newport Bridge	$0.83	12.05	$10.00
Washington State Department of Transportation	Tacoma Narrows Bridge	$2.13	2.51	$5.33
Washington State Department of Transportation	SR-520 Floating Bridge	$3.70	2.49	$9.20
All Major Urban Facilities				
Average Per Crossing Rate		$3.31	5.62	$18.58
Median Per Crossing Rate		$2.50	7.03	$17.56

Note: Rates listed are electronic (or cash if electronic is not offered) toll rates. If rates vary by time of day, peak rates are listed. Truck multiplier is ratio of 5-axle truck to passenger car toll. Commuter discounts and other "non-typical" specific special payment programs are not included. Toll Rates are current as of December 4, 2013.

As shown, the average per crossing rate for all facilities is $3.31 for passenger cars and $18.58 for 5-axle trucks. The median is $2.50 for passenger cars and $17.56 for 5-axle trucks. Toll rates on Bay Area Toll Authority and Washington State Department of Transportation facilities are important to consider in more detail because of their geographic proximity to the CRC Project (western U.S.) and because many of these facilities are relatively new or have had recent major construction projects. Passenger car toll rates on the facilities operated by these agencies are similar to the overall average and median rates. However, the 5-axle truck toll rates are lower.

Another observation from Table 6-1 is that toll rates charged on major urban bridges and tunnels vary widely across the U.S. For example, the lowest passenger car toll is $0.83 and the highest is $5.50. As can be seen with the multiplier (5-Axle truck rate divided by the passenger car rate), rate structures between vehicle classes also vary widely. However, these variations are expected as nearly all bridge and tunnel facilities have unique toll setting histories affected by factors such as facility age, financing characteristics, maintenance and operation costs, diversion of toll revenues to other non-facility related uses, context and economics of facility location, and political influences. Thus, it is important that financing requirements and project objectives be considered in addition to toll rates on similar facilities.

A desired minimum level of toll revenue to meet project needs was established. The relationship of toll rates to toll revenue generation was considered in preliminary traffic and revenue analysis. Based on that analysis, it was possible to determine what the selected toll rates would need to be to generate toll revenue sufficient to meet the desired minimum level of revenue from tolling.

Considering project objectives, several were identified specifically by CRC Project staff to consider when selecting toll rates. These include:

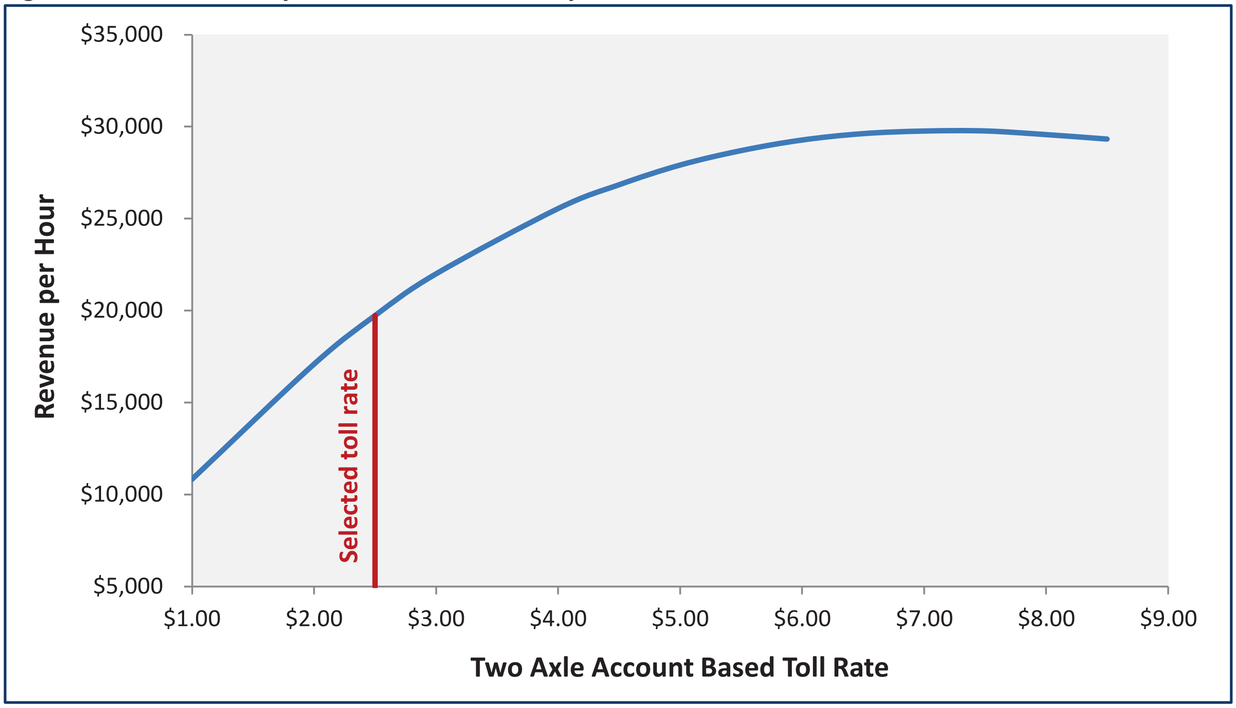
- Passenger car toll rates should not exceed $2.50 in FY 2016.
- Passenger car toll rates should not exceed $3.62 in FY 2022.
- Toll rates that vary by time of day should be used.
- Toll rates should not escalate in the post completion phase after FY 2022.
- The difference between account based and non-account based transactions (surcharge) should be $1.52 in FY 2016 and increase annually at the rate of inflation (assumed at 2.5 percent) to $1.77 in FY 2022. It should not escalate after FY 2022.

Additionally, overall CRC project objectives were considered. Of the six problems identified in the "What problems does this project seek to fix?" section of the Final Environmental Impact Statement for the CRC project, the first two, "Growing travel demand and congestion" and "Impaired freight movement," were most applicable to consider when evaluating toll rates. Setting toll rates to best utilize available capacity in the I-5 corridor and keeping truck rates relatively low were viewed as strategies to address these problems. However, these strategies were secondary to the five specific toll rate evaluation process objectives listed above.

An analysis was performed to determine the relationship of the toll rate to revenue generated. As the toll rate is increased revenue is increased until the rate goes so high that additional increases in toll rate cause big enough losses in traffic such that revenue starts to decrease. The toll rate that this inflection occurs at is called the revenue maximizing toll rate. It was found that the maximum toll rate permitted by the guidelines was well below the revenue maximizing toll rate. This was true for both

FY 2016 and FY 2022 and for all time periods. The relationship of revenue to toll rate for peak hour weekday for FY 2016 is shown in Figure 6-1. The conclusion of this analysis is that for the purpose of revenue generation toll rates could be set as high as the maximum permitted until the guidelines. Other considerations were then used to determine where the rate should fall below the maximum.

Figure 6-1 Toll Sensitivity Curve FY 2016 Weekday Peak Period 7-8 AM

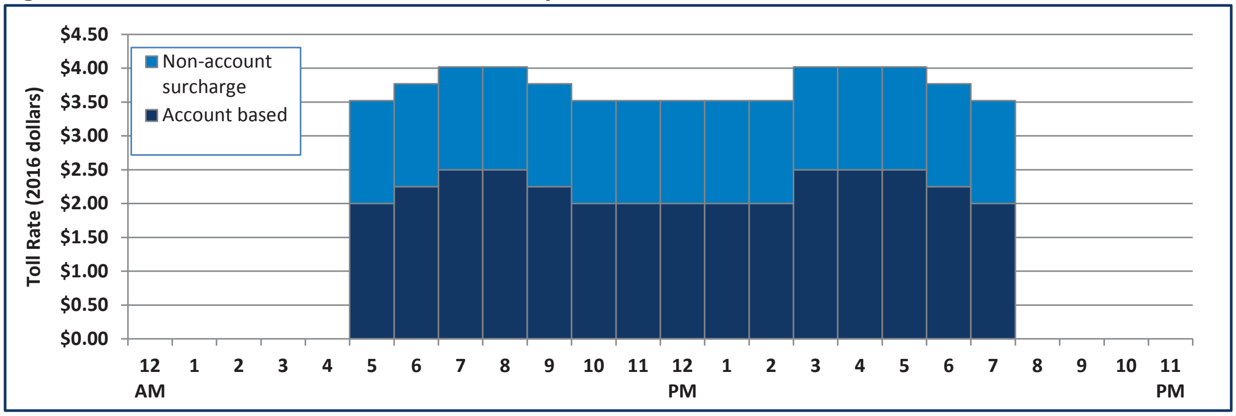


Another objective, to limit scheduled single year toll increases to a maximum of 15 percent, was based on past experience with toll financings. Scheduling very large single year toll increases is not preferred because of the expectation that large increases are less likely to be implemented due to anticipated public and political pressure when the increase is to take effect. A 15 percent single year toll increase between pre-completion (before FY 2022) and post-completion (starting in FY 2022) phases was the maximum considered reasonable in the selection process.

6.1.2 Assumed Toll Structure and Rates

Toll rates were approved for use in the study by CRC Project staff in November, 2013. The approved toll rates meet the factors discussed previously in the toll rate selection process. Figure 6-2 shows the first year of tolling weekday toll rate structure by time of day. Weekend toll rates do not vary by time of day. Table 6-2 shows the account based toll rates assumed for the project. Table 6-3 shows non-account toll rates. Higher non-account based tolls are to help cover the additional costs and leakage or nonpayment associated with this type of transaction. Note that no tolls are assumed to be collected during the overnight period (8 PM-5 AM) before FY 2022 (pre-completion period) as noted in the toll rate tables. This will help support overnight bridge closures which may be needed during the construction period.

Figure 6-2 Assumed FY 2016 Two Axle Weekday Toll Rates



To vary the toll rates by number of axles, the "n-1" rate structure is assumed for truck (three or more axle vehicle) account based toll rates. In this structure, the truck toll rate is calculated by reducing the number of axles of a truck by one and then multiplying that by the passenger car (2-axle) toll rate. For example, a toll rate for a five axle vehicle account based payment is four times that of a passenger car account based payment. This formula would only apply to truck account based toll rates. For truck non-account based toll rates, the truck account based toll rate would be calculated by applying the axle multiplier then the same surcharge as between passenger car account based and passenger car non-account based toll rates would be applied. As a result, the surcharge does not vary by number of axles.

These toll rates meet the toll rate selection factors discussed above in that:

- Maximum FY 2016 passenger car toll rates are $2.50
- Maximum FY 2022 toll rates are under $3.62
- Toll rates vary by time of day and are higher during the peak periods
- Toll rates reach $3.25 maximum in FY 2022 and do not increase afterward
- The recommended surcharge is used
- Tolling the facility and having higher toll rates during peak periods will help manage demand on the facility and lower congestion
- The maximum year to year increase in toll rates is 15 percent going from FY 2021 to FY 2022
- Between FY 2016 and FY 2021 the annual rate increase was assumed to keep pace with inflation (assumed to be 2.5 percent annually).

Table 6-2 Assumed Account Based Toll Rate Schedule

Fiscal Year	Weekday									Weekend	
	5-6AM	6-7AM	7-9AM	9-10AM	10AM-3PM	3-6PM	6-7PM	7-8PM	8PM-5AM	5AM-8PM	8PM-5AM
2-Axle											
2016	$2.00	$2.25	$2.50	$2.25	$2.00	$2.50	$2.25	$2.00	-	$2.00	-
2017	$2.05	$2.31	$2.56	$2.31	$2.05	$2.56	$2.31	$2.05	-	$2.05	-
2018	$2.10	$2.36	$2.63	$2.36	$2.10	$2.63	$2.36	$2.10	-	$2.10	-
2019	$2.15	$2.42	$2.69	$2.42	$2.15	$2.69	$2.42	$2.15	-	$2.15	-
2020	$2.21	$2.48	$2.76	$2.48	$2.21	$2.76	$2.48	$2.21	-	$2.21	-
2021	$2.26	$2.55	$2.83	$2.55	$2.26	$2.83	$2.55	$2.26	-	$2.26	-
2022-60	$2.60	$2.93	$3.25	$2.93	$2.60	$3.25	$2.93	$2.60	$2.60	$2.60	$2.60
3-Axle											
2016	$4.00	$4.50	$5.00	$4.50	$4.00	$5.00	$4.50	$4.00	-	$4.00	-
2017	$4.10	$4.62	$5.12	$4.62	$4.10	$5.12	$4.62	$4.10	-	$4.10	-
2018	$4.20	$4.72	$5.26	$4.72	$4.20	$5.26	$4.72	$4.20	-	$4.20	-
2019	$4.30	$4.84	$5.38	$4.84	$4.30	$5.38	$4.84	$4.30	-	$4.30	-
2020	$4.42	$4.96	$5.52	$4.96	$4.42	$5.52	$4.96	$4.42	-	$4.42	-
2021	$4.52	$5.10	$5.66	$5.10	$4.52	$5.66	$5.10	$4.52	-	$4.52	-
2022-60	$5.20	$5.86	$6.50	$5.86	$5.20	$6.50	$5.86	$5.20	$5.20	$5.20	$5.20
4-Axle											
2016	$6.00	$6.75	$7.50	$6.75	$6.00	$7.50	$6.75	$6.00	-	$6.00	-
2017	$6.15	$6.93	$7.68	$6.93	$6.15	$7.68	$6.93	$6.15	-	$6.15	-
2018	$6.30	$7.08	$7.89	$7.08	$6.30	$7.89	$7.08	$6.30	-	$6.30	-
2019	$6.45	$7.26	$8.07	$7.26	$6.45	$8.07	$7.26	$6.45	-	$6.45	-
2020	$6.63	$7.44	$8.28	$7.44	$6.63	$8.28	$7.44	$6.63	-	$6.63	-
2021	$6.78	$7.65	$8.49	$7.65	$6.78	$8.49	$7.65	$6.78	-	$6.78	-
2022-60	$7.80	$8.79	$9.75	$8.79	$7.80	$9.75	$8.79	$7.80	$7.80	$7.80	$7.80
5-Axle											
2016	$8.00	$9.00	$10.00	$9.00	$8.00	$10.00	$9.00	$8.00	-	$8.00	-
2017	$8.20	$9.24	$10.24	$9.24	$8.20	$10.24	$9.24	$8.20	-	$8.20	-
2018	$8.40	$9.44	$10.52	$9.44	$8.40	$10.52	$9.44	$8.40	-	$8.40	-
2019	$8.60	$9.68	$10.76	$9.68	$8.60	$10.76	$9.68	$8.60	-	$8.60	-
2020	$8.84	$9.92	$11.04	$9.92	$8.84	$11.04	$9.92	$8.84	-	$8.84	-
2021	$9.04	$10.20	$11.32	$10.20	$9.04	$11.32	$10.20	$9.04	-	$9.04	-
2022-60	$10.40	$11.72	$13.00	$11.72	$10.40	$13.00	$11.72	$10.40	$10.40	$10.40	$10.40
6-Axle											
2016	$10.00	$11.25	$12.50	$11.25	$10.00	$12.50	$11.25	$10.00	-	$10.00	-
2017	$10.25	$11.55	$12.80	$11.55	$10.25	$12.80	$11.55	$10.25	-	$10.25	-
2018	$10.50	$11.80	$13.15	$11.80	$10.50	$13.15	$11.80	$10.50	-	$10.50	-
2019	$10.75	$12.10	$13.45	$12.10	$10.75	$13.45	$12.10	$10.75	-	$10.75	-
2020	$11.05	$12.40	$13.80	$12.40	$11.05	$13.80	$12.40	$11.05	-	$11.05	-
2021	$11.30	$12.75	$14.15	$12.75	$11.30	$14.15	$12.75	$11.30	-	$11.30	-
2022-60	$13.00	$14.65	$16.25	$14.65	$13.00	$16.25	$14.65	$13.00	$13.00	$13.00	$13.00

Table 6-3 Assumed Non-Account Based Toll Rate Schedule

Fiscal Year	Weekday									Weekend	
	5-6AM	6-7AM	7-9AM	9-10AM	10AM-3PM	3-6PM	6-7PM	7-8PM	8PM-5AM	5AM-8PM	8PM-5AM
2-Axle											
2016	$3.52	$3.77	$4.02	$3.77	$3.52	$4.02	$3.77	$3.52	-	$3.52	-
2017	$3.61	$3.87	$4.12	$3.87	$3.61	$4.12	$3.87	$3.61	-	$3.61	-
2018	$3.70	$3.96	$4.23	$3.96	$3.70	$4.23	$3.96	$3.70	-	$3.70	-
2019	$3.79	$4.06	$4.33	$4.06	$3.79	$4.33	$4.06	$3.79	-	$3.79	-
2020	$3.89	$4.16	$4.44	$4.16	$3.89	$4.44	$4.16	$3.89	-	$3.89	-
2021	$3.98	$4.27	$4.55	$4.27	$3.98	$4.55	$4.27	$3.98	-	$3.98	-
2022-60	$4.37	$4.70	$5.02	$4.70	$4.37	$5.02	$4.70	$4.37	$4.37	$4.37	$4.37
3-Axle											
2016	$5.52	$6.02	$6.52	$6.02	$5.52	$6.52	$6.02	$5.52	-	$5.52	-
2017	$5.66	$6.18	$6.68	$6.18	$5.66	$6.68	$6.18	$5.66	-	$5.66	-
2018	$5.80	$6.32	$6.86	$6.32	$5.80	$6.86	$6.32	$5.80	-	$5.80	-
2019	$5.94	$6.48	$7.02	$6.48	$5.94	$7.02	$6.48	$5.94	-	$5.94	-
2020	$6.10	$6.64	$7.20	$6.64	$6.10	$7.20	$6.64	$6.10	-	$6.10	-
2021	$6.24	$6.82	$7.38	$6.82	$6.24	$7.38	$6.82	$6.24	-	$6.24	-
2022-60	$6.97	$7.63	$8.27	$7.63	$6.97	$8.27	$7.63	$6.97	$6.97	$6.97	$6.97
4-Axle											
2016	$7.52	$8.27	$9.02	$8.27	$7.52	$9.02	$8.27	$7.52	-	$7.52	-
2017	$7.71	$8.49	$9.24	$8.49	$7.71	$9.24	$8.49	$7.71	-	$7.71	-
2018	$7.90	$8.68	$9.49	$8.68	$7.90	$9.49	$8.68	$7.90	-	$7.90	-
2019	$8.09	$8.90	$9.71	$8.90	$8.09	$9.71	$8.90	$8.09	-	$8.09	-
2020	$8.31	$9.12	$9.96	$9.12	$8.31	$9.96	$9.12	$8.31	-	$8.31	-
2021	$8.50	$9.37	$10.21	$9.37	$8.50	$10.21	$9.37	$8.50	-	$8.50	-
2022-60	$9.57	$10.56	$11.52	$10.56	$9.57	$11.52	$10.56	$9.57	$9.57	$9.57	$9.57
5-Axle											
2016	$9.52	$10.52	$11.52	$10.52	$9.52	$11.52	$10.52	$9.52	-	$9.52	-
2017	$9.76	$10.80	$11.80	$10.80	$9.76	$11.80	$10.80	$9.76	-	$9.76	-
2018	$10.00	$11.04	$12.12	$11.04	$10.00	$12.12	$11.04	$10.00	-	$10.00	-
2019	$10.24	$11.32	$12.40	$11.32	$10.24	$12.40	$11.32	$10.24	-	$10.24	-
2020	$10.52	$11.60	$12.72	$11.60	$10.52	$12.72	$11.60	$10.52	-	$10.52	-
2021	$10.76	$11.92	$13.04	$11.92	$10.76	$13.04	$11.92	$10.76	-	$10.76	-
2022-60	$12.17	$13.49	$14.77	$13.49	$12.17	$14.77	$13.49	$12.17	$12.17	$12.17	$12.17
6-Axle											
2016	$11.52	$12.77	$14.02	$12.77	$11.52	$14.02	$12.77	$11.52	-	$11.52	-
2017	$11.81	$13.11	$14.36	$13.11	$11.81	$14.36	$13.11	$11.81	-	$11.81	-
2018	$12.10	$13.40	$14.75	$13.40	$12.10	$14.75	$13.40	$12.10	-	$12.10	-
2019	$12.39	$13.74	$15.09	$13.74	$12.39	$15.09	$13.74	$12.39	-	$12.39	-
2020	$12.73	$14.08	$15.48	$14.08	$12.73	$15.48	$14.08	$12.73	-	$12.73	-
2021	$13.02	$14.47	$15.87	$14.47	$13.02	$15.87	$14.47	$13.02	-	$13.02	-
2022-60	$14.77	$16.42	$18.02	$16.42	$14.77	$18.02	$16.42	$14.77	$14.77	$14.77	$14.77

The size of the passenger car (two axle) toll rates recommended here are reasonable when compared to rates on current major urban toll bridge and tunnel facilities. The n-1 rate structure for trucks translates to a relatively low rate (four times the passenger car rate for a 5-axle vehicle) compared to the national average truck toll rates on major urban facilities (5.6 times the passenger car rate for a 5-axle vehicle). Keeping truck rates relatively low was considered important to help address the current problem of impaired freight movement discussed previously.

The weekend toll schedule will apply to certain major holidays when they fall on weekdays. These are assumed to be, New Year's Day, Labor Day, Independence Day, Memorial Day, Thanksgiving Day, and Christmas Day. Because of their linking to a calendar day, New Year's Day, Independence Day, and Christmas Day may fall on different days of the week in different years. In the revenue analysis, especially when interpolating between different model analysis years, all three of these days were assumed to fall on weekdays. This was to avoid over-estimating revenue in certain interpolated years.

The tolling operation plan assumes all passenger cars and trucks would pay a toll when crossing the I-5 bridge over the main channel of the Columbia River between Hayden Island and mainland Washington State. Bicyclists, pedestrians, and local transit buses are assumed to not pay a toll.

6.2 Payment Type and Market Share

Tolling is assumed to be all-electronic, with no option to pay using cash at traditional toll booths. Two primary payment methods, account based and non-account based, are assumed to be available. Account based payments include toll payments by transponder and may also include registering a vehicle's license plate on the toll account, also known as "pay by plate". Non-account based tolls, often referred to as "pay by mail", would be charged by identifying a vehicle's owner using the vehicle's license plate and sending the owner a bill. The non-account based payment method may also include a short term account for prepayment of tolls or payment of tolls shortly after facility usage. As shown previously, two different toll rate structures are assumed for the CRC Project, one for account based and the other for non-account based payment.

6.2.1 Background

There are no toll facilities currently in operation in the Portland-Vancouver region. Thus, assumed account based and non-account based payment market shares were determined based on national experience on other all-electronic toll facilities and the results of the CRC Project travel pattern survey. "Market shares" in this context refer to the resulting percentage of each payment type on the tolled I-5 bridge.

Table 6-4 gives the account based market shares for all-electronic toll facilities with video tolling (facilities that offer both account based and non-account based payment options). The data is generally taken from 2012 operations. The comparison is grouped with seven facilities above 80 percent, 13 facilities between 70 and 80 percent, and six facilities below 70 percent. This shows a wide range of account based market share depending on facility, with a national low, median, and high of 54 percent, 77 percent, and 92 percent, respectively.

In context of the CRC Project, it is important to consider facilities with similar characteristics; those located on the west coast and recently opened facilities in areas with little experience in tolling. These include west coast facilities: the SR-520 bridge (tolls recently added to existing bridge prior to improvements), the Port Mann bridge (tolls recently added to a new bridge with improvements compared to the previous toll-free bridge), and the Golden Gate Bridge (recently converted to all-electronic); and also includes the Triangle Expressway which began tolling in early 2012 and is the only toll facility in North Carolina. Similar to the overall list, the account based shares for these facilities vary widely with the SR-520 bridge at around 81 percent, the Port Mann bridge at around 80 percent, the Golden Gate Bridge at 75 percent, and the Triangle Expressway at 54 percent.

There are also important differences to consider when comparing account based shares from these facilities with CRC:

- The SR-520 floating bridge in Seattle, Washington recently opened as a toll facility (December 2011). However, it is on a route that has a higher share of commuter traffic and much less truck traffic than the I-5 bridge over Columbia River. It also initially included a small amount of time-limited free toll credit for those signing up for account based payments, which is not assumed for the CRC Project facility.
- The Port Mann bridge in Vancouver, British Columbia recently opened as a toll facility (December 2012). However, this facility has implemented steep passenger car discounts in the first year of operations and free trips promotion for some of those who have adopted account based payment methods. The assumed toll rate schedules for the CRC Project do not assume any similar discounts and promotions.
- Both the SR-520 and Port Mann bridges opened in regions with some recent experience in tolling and The Golden Gate Bridge has a long operating history as a toll facility in a region with many other toll facilities.
- The Triangle Expressway is different in that it is a more suburban route, is not a single crossing of a body of water, and is not on a major regional travel corridor like the I-5 bridge.

Because of these differences it was assumed that the CRC Project opening year account based share would be somewhat lower than the three west coast bridges described, but somewhat higher than the Triangle Expressway.

Table 6-4 Account Based Share Comparison for All-Electronic Toll Facilities with Video Tolling

Facility	Type	State
Above 80%		
East-West (Dolphin) Expressway Extension	Road	FL
Inter County Connector	Road	MD
Homestead Extension	Road	FL
Snapper Creek Expressway	Road	FL
Gratigny Parkway	Road	FL
South Dade (Don Shula) Expressway	Road	FL
SR-520 Floating Bridge	Bridge	WA
Between 70% and 80%		
Port Mann Bridge	Bridge	Canada
Lee Roy Selmon Crosstown Expressway	Road	FL
Loop 1	Road	TX
SH 45 North	Road	TX
Addison Airport Toll Tunnel	Road	TX
Mountain Creek Lake Bridge	Bridge	TX
Lewisville Lake Toll Bridge	Bridge	TX
President George Bush Turnpike	Road	TX
Sam Rayburn Tollway	Road	TX
Dallas North Tollway	Road	TX
183A	Road	TX
Golden Gate Bridge	Bridge	CA
E-470	Road	CO
Below 70%		
Northwest Parkway	Road	CO
President George Bush Turnpike Western Extension	Road	TX
SH 130 Segments 5-6	Road	TX
SH 130 Segments 1-4	Road	TX
SH 45 Southeast Extension	Road	TX
Triangle Expressway	Road	NC
Account Based Percentage – National Statistics		
Low	54%	
Median	77%	
High	92%	
Average (simple average)	77%	

The results of the CRC Project travel pattern survey were also reviewed in context of the payment market share analysis. (The survey is discussed in more detail in Chapter 3.) The share of frequent users, who are more likely to use account based payments, were reviewed and compared with the results of the travel pattern survey conducted on users of the SR-520 bridge in September 2009. Since the SR-520 travel survey was conducted only in the outbound (eastbound) direction, the CRC Project outbound (northbound) results only were used for comparison. Table 6-5 shows the results of this comparison, with positive in the table indicating the CRC Project survey frequency results were higher than SR-520. For example, the 6 percent in the "Less than 1" row and "Entire Day" column indicates approximately 6 percent more respondents in the CRC Project travel pattern survey traveled less than one time a week as compared with the SR-520 survey.

Table 6-5 Travel Pattern Survey Weekday Frequency Results Comparison CRC to SR-520

Trips Per Week	AM Peak (6-9 AM)	Midday (9 AM-3 PM)	PM Peak (3-6 PM)	Evening (6-10 PM)	Overnight (10 PM-6 AM)	Entire Day
Less than 1	7.3%	12.0%	9.0%	19.4%	-20.8%	5.6%
1	3.6%	2.7%	2.7%	3.5%	6.5%	2.3%
2	-0.8%	-5.1%	-1.6%	-1.1%	0.9%	-2.6%
3	-2.1%	-2.4%	-1.1%	-3.8%	3.3%	-1.7%
4	0.6%	-1.0%	-1.6%	-2.8%	7.3%	-0.7%
5	-8.9%	-4.1%	-6.5%	-10.2%	2.8%	-1.5%
6 or more	0.4%	-1.8%	-0.9%	-5.9%	0.1%	-1.3%

Note: Positive indicates the CRC percentage is higher than SR-520

The results show that the CRC Project travel survey has around 8 percent more respondents making one or fewer trips per week. Considering respondents making two or more trips per week, the comparison shows about 8 percent fewer. This indicates that the SR-520 bridge likely has a larger commuter base than the I-5 bridge, as would be expected by their route types and geographic locations. This would also indicate that the CRC Project account based market share should be less than recent experience on SR-520.

6.2.2 Assumptions

The assumed account based market share is shown in Table 6-6 for the key project analysis years. The grand total assumptions for opening year FY 2016 are based on national experience on other all-electronic toll facilities and the travel pattern survey frequency results presented previously. Note that the market shares in this context refer to the percentage of account based payments of total toll payments made on the tolled I-5 bridge. These are the analysis output shares which may be different than those used as inputs to the Tolling Analysis Model.

Table 6-6 Output Account Based Market Share Assumptions

Fiscal Year	Passenger Cars / 2 Axles			Trucks / 3+ Axles			All Vehicles		
	Weekday	Weekend	Total	Weekday	Weekend	Total	Weekday	Weekend	Grand Total
2016	68.9%	61.1%	67.0%	66.2%	54.9%	64.9%	68.7%	60.9%	66.9%
2020	72.7%	66.0%	71.1%	71.1%	59.9%	69.9%	72.6%	65.8%	71.0%
2022	74.1%	68.1%	72.7%	72.4%	61.2%	71.0%	74.0%	67.8%	72.6%
2036	78.9%	73.8%	77.7%	80.2%	69.1%	79.0%	79.0%	73.6%	77.8%

The opening year grand total account based market share is assumed to be about 67 percent. Referring back to Table 6-4, this would be on the lower end of account based shares on all-electronic toll facilities around the country. The characteristics of the CRC Project versus comparable facilities as noted above justifies the difference between the project and those facilities. It can also be seen that the opening year weekend account based share is about 8 percent less than the weekday and the opening year truck share is about 2 percent less than the passenger car share. The weekend and weekday difference in assumptions are made to account for the higher share of infrequent users on weekends.

Interoperability with WSDOT toll facilities (Tacoma Narrows bridge, SR-520 bridge, and SR-167 HOT lanes) is not specifically assumed in this analysis. Even if interoperability is assumed, the account based market share assumptions for the CRC Project would not change significantly. A main factor is the distance between the I-5 bridge and the toll facilities in Washington State being relatively long (140 miles to the closest facility – the Tacoma Narrows Bridge). Consequently, only a small number of passenger cars will likely regularly travel on both the I-5 bridge and Washington State toll facilities. Also, trucks, even though they make longer trips than passenger cars and therefore might use the distant Washington facilities and the CRC Project regularly, are a very low proportion of transactions on the Washington State toll facilities. Thus the amount of trucks that will regularly travel on the I-5 bridge and Washington State toll facilities is also assumed to be small.

Table 6-6 shows the account based market share is assumed to grow in the future, with higher growth in the early years. For example, about 4 percent grand total growth is assumed between FY 2016 and FY 2020 (four years) and about 5 percent grand total growth between FY 2022 and FY 2036 (14 years). The concentrated growth assumption in the early years assumes users becoming more familiar with the toll facility during those years.

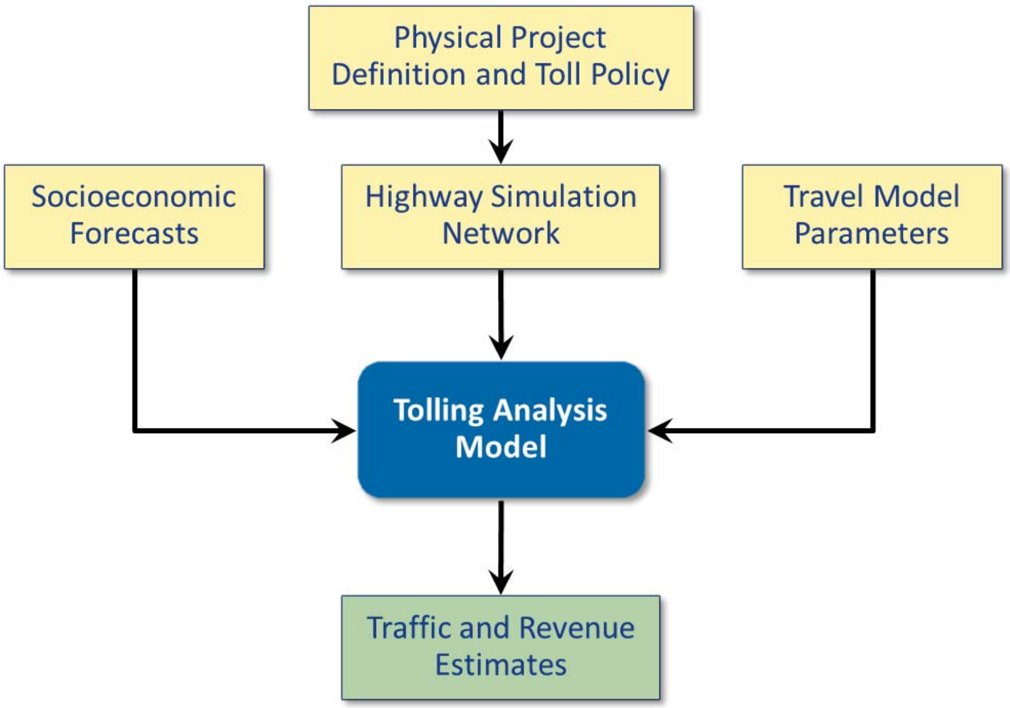
Currently, there is movement in the toll industry towards national interoperability. While it remains unclear when this would be implemented, it is likely that some form of national interoperability will be in place by FY 2036. This would likely increase the account based market share for trucks more than passenger cars since they are more likely to make long distance trips and have accounts with other toll facilities around the country. This is reflected in the truck account based share becoming higher than that for passenger cars between FY 2022 and FY 2036.

Chapter 7

Traffic and Revenue Approach

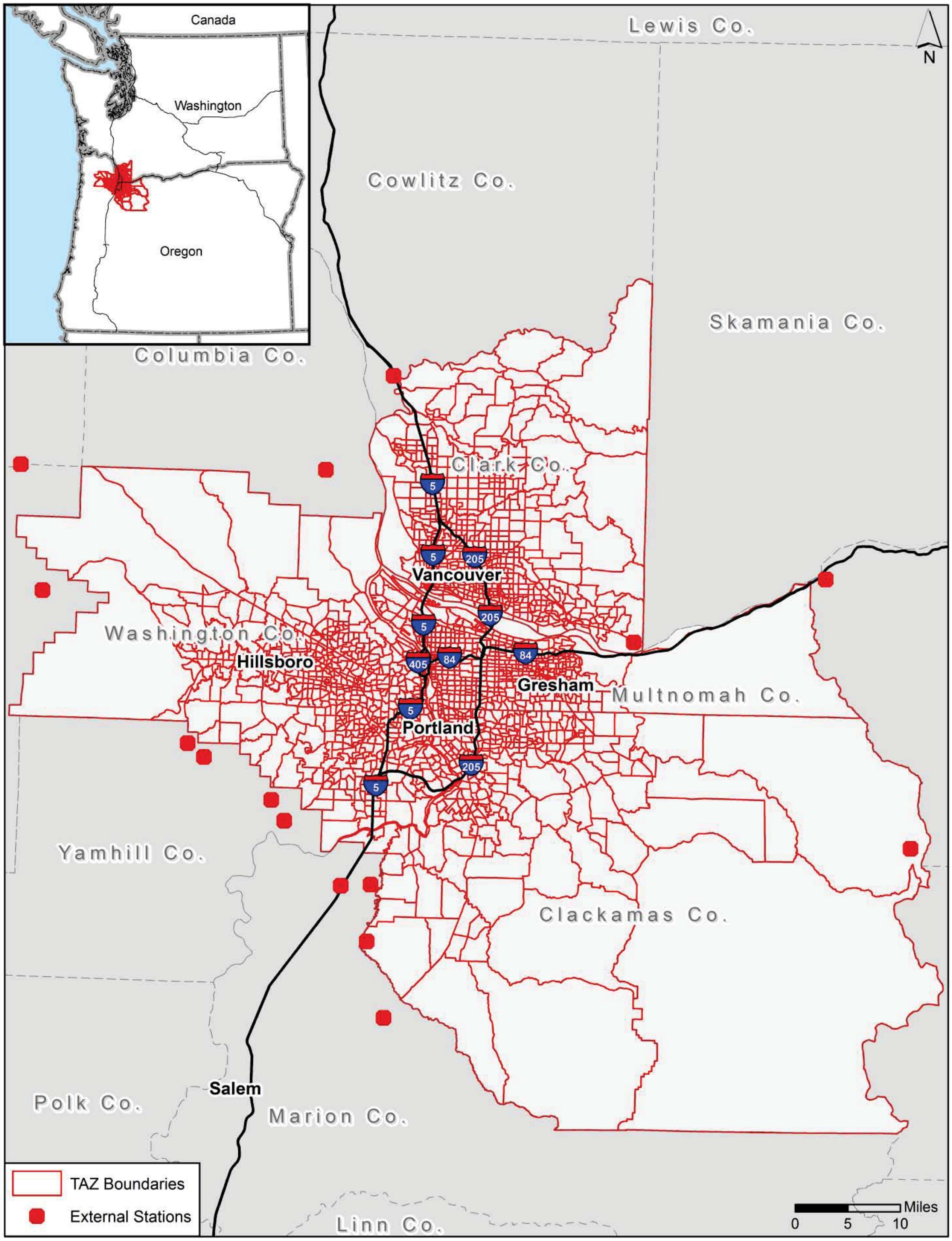
The general process for developing traffic and revenue estimates is shown in Figure 7-1. The top box in Figure 7-1, "Physical Project Definition and Toll Policy," is the essential starting point for traffic and revenue estimation describing the toll facility under study and the toll rates to be assessed. The CRC Project is described in Chapter 1 and the toll policy is detailed in Chapter 6.

Figure 7-1 Traffic and Revenue Estimation Process



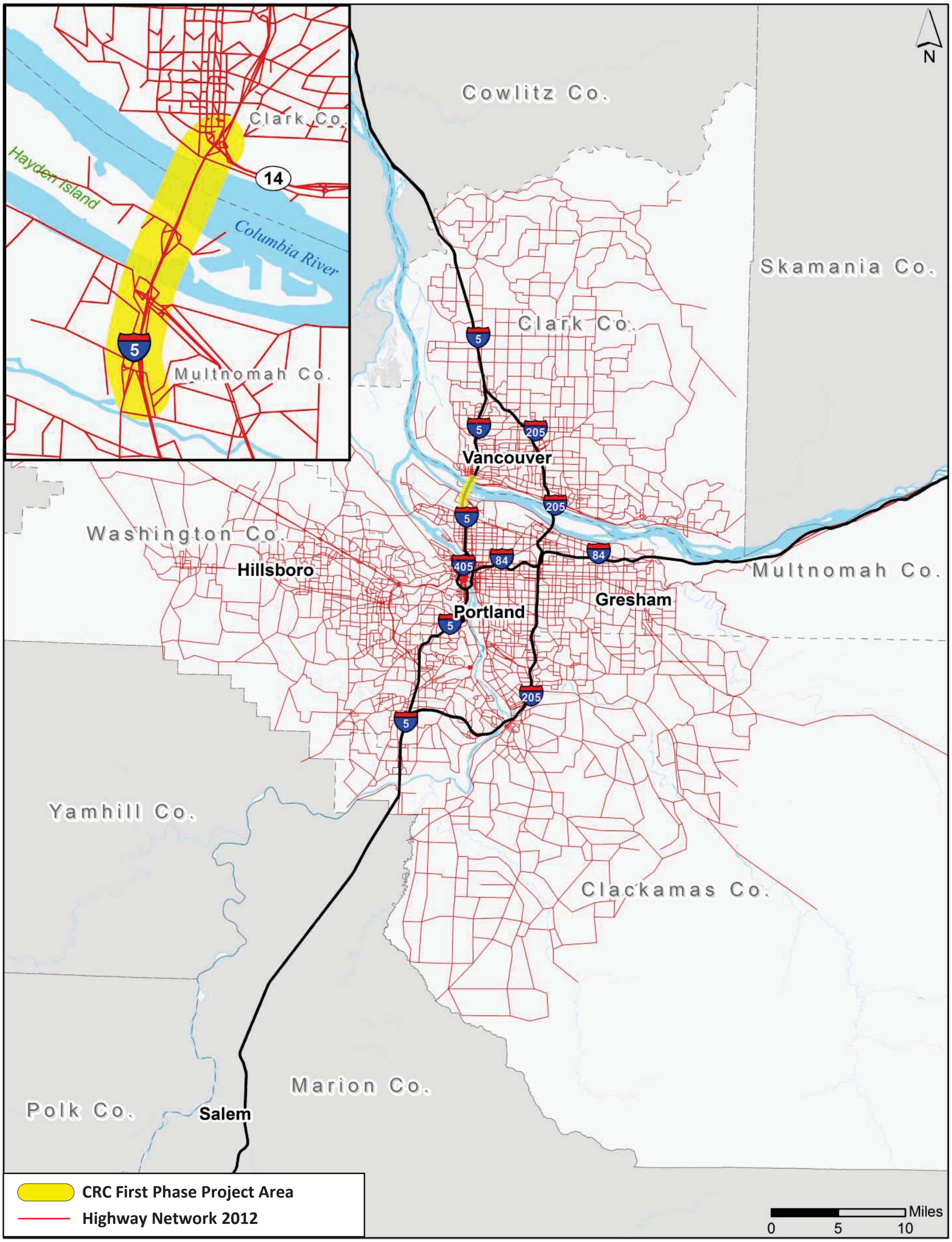
The "Socioeconomic Forecasts" box in Figure 7-1 is a key input depicting how the region is expected to look in the future. The base case socioeconomic forecast is described in Chapter 5.

Metro maintains a sophisticated regional travel demand model for the area. The model geographically divides the area into 2174 transportation analysis zones. Figure 7-2 is a map of the Metro zone system. Metro regional travel demand model files were obtained and used as the basis for the Tolling Analysis Model developed for this study. Extensive and very helpful interactions with Metro staff occurred during the Tolling Analysis Model development phase. One of the files obtained from Metro was a coded highway network which formed the basis for the "Highway Simulation Network" used in this analysis. Figure 7-3 is a map of the existing system coded highway simulation network.



METRO ZONE SYSTEM

FIGURE 7-2



CDM Smith

EXISTING SYSTEM CODED HIGHWAY SIMULATION NETWORK

FIGURE 7-3

The "Travel Model Parameters" box in the Figure 7-1 includes the parameters that are input to the modeling process itself. Some of the most important of these parameters are those that play an important role in estimating the trade-off travelers make between paying a toll or making a another choice to avoid the toll. The travel model parameters were derived from the travel pattern and stated preference surveys of current I-5 users. Chapter 3 describes the travel pattern survey and Chapter 4 describes the stated preference survey.

The "Tolling Analysis Model" box is where the travel demand model and other analytical steps are performed to develop the traffic and revenue estimates. The remainder of this chapter describes this process in detail.

7.1 Tolling Analysis Model Steps

The steps in the Tolling Analysis Model are shown in Figure 7-4. The process employs a traditional four step travel demand model, a widely accepted travel forecasting system. The first three steps of the four step process are shown in the first column of green colored boxes in Figure 7-4. These are the steps of trip generation, trip distribution, and mode split. The results of these steps are vehicle triptables to be used in the remainder of the modeling process. As truck traffic is an important element of the traffic and revenue estimation process and truck triptables developed by traditional modeling methods are often lacking, a separate analysis of truck movements was made to better enhance the truck component.

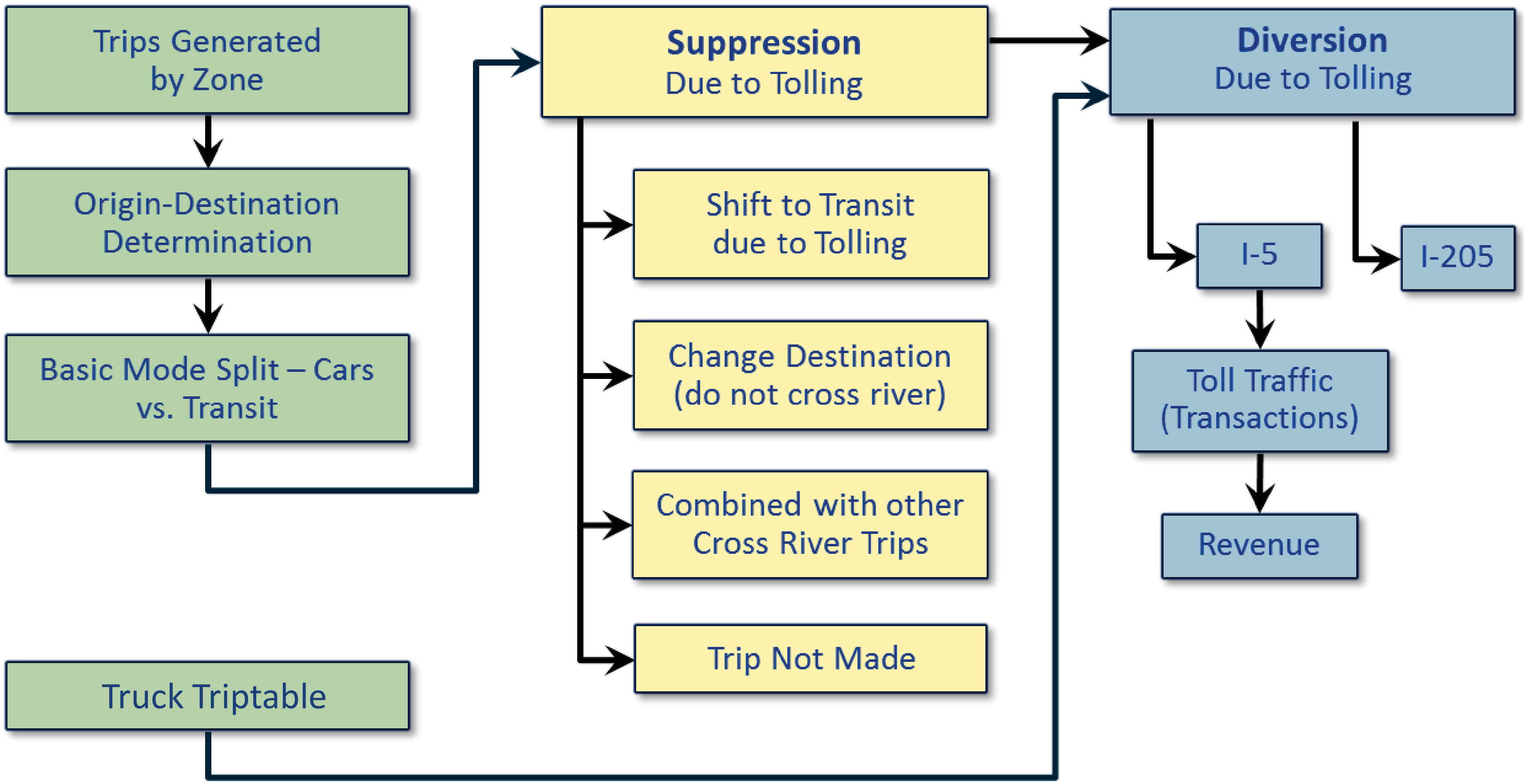
The second column of yellow boxes is an additional part of the modeling specifically to deal with suppression effects as a result of tolling. Suppression in this context refers to vehicle trips that would cross the Columbia River in the absence of tolling on I-5 but do not cross the river when tolling is imposed.

The third column of blue boxes is the fourth step of the traditional modeling process, trip assignment. This part of the process includes route diversion which, in this context, is the changing of path for a trip that would, in the absence of tolling, cross the river on I-5 changing path to cross on I-205.

7.2 Truck Forecasting

Truck traffic is an important element of the traffic and revenue estimation process since it constitutes a significant proportion of the estimated traffic and revenue and improvement of truck traffic is a stated goal of the CRC Project. Consequently, separate analysis of truck movements was made to better enhance the truck component.

Existing and forecast freight data involved a comprehensive review of available data sources, research of potential sources, conference calls, and meetings to understand the applicability of freight data sources in this tolling and revenue analysis. Table 7-1 presents a bibliography and summary of the data sources researched for this analysis. Extensive research of both truck travel pattern and cargo data was conducted to determine if there were sources available from research agencies and from recent technology applications.



TOLLING ANALYSIS MODEL

FIGURE 7-4

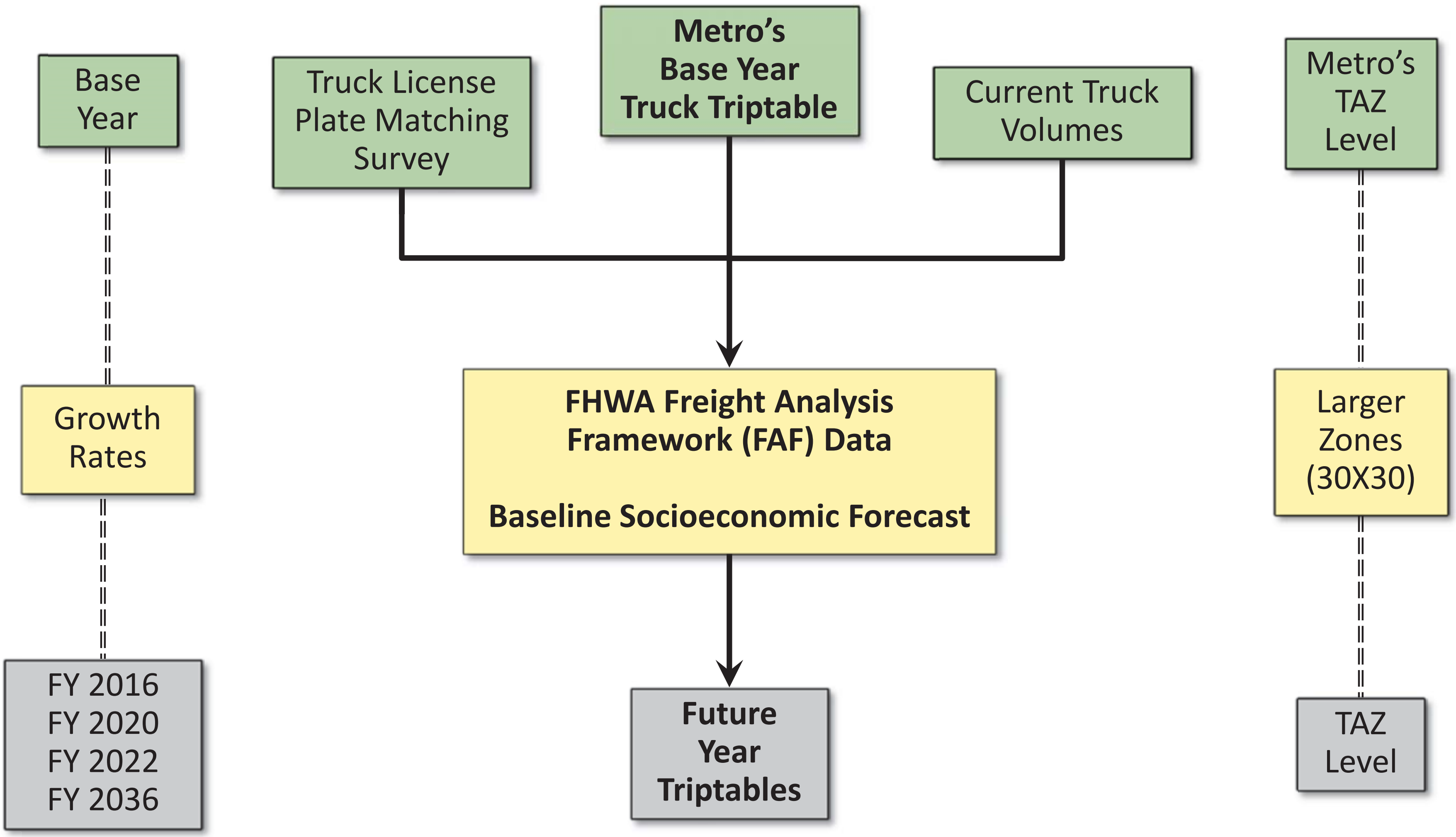
Table 7-1 Summary of Truck and Cargo Data Sources Researched for this Analysis

Source	Description
Freight Analysis Framework (FAF) – Federal Highway Administration	With data from the 2007 Commodity Flow Survey and additional sources, FAF version 3 (FAF^3) provides estimates for tonnage, value, and domestic ton-miles by region of origin and destination, commodity type, and mode for 2007, the most recent year, and forecasts through 2040. Also included are state-to-state flows for these years plus 1997 and 2002, summary statistics, and flows by truck assigned to the highway network for 2007 and 2040.
INRIX	Smart Driver Network of anonymous GPS-enabled vehicles.
Metropolitan Infrastructure Initiative, The Brookings Institute	This study used the geographic Freight Analysis Framework (FAF) data published by Federal Highways.
ODOT Transportation Planning Analysis Unit (TPAU)	TPAU developed a Statewide Integrated Model (SWIM) that uses FAF and Commodity Flow Survey data to develop input for model. The Commodity Flow database was prepared for the Port of Portland in 1997, updated in 2002, and most recently validated and augmented by a 2006 trade capacity study. The data used were metrics of freight tonnage and value and there was not an emphasis on actual truck count calibration. The model was used in the state freight plan to assess the effects of changes in economic conditions and a range of outcomes.
Oregon Weight-Mile Tax and available data	ODOT is conducting a pilot project to automate the recording and invoicing for the weight-mile tax using GPS devices with trucking industry partners. The pilot project included heavy trucks over 26,000 pounds (medium and heavy trucks). A computer application was prepared for receiving GPS coordinate signals from a modified smart phone device. At the start of trip the driver entered the weight of their truck (tractor plus all trailers) and number of axles. As the truck traveled through the state, signals were received from the GPS device and the application mapped and converted the coordinates to weight-mileage totals. The pilot project has been successful.
Portal Data, Portland State University	These data are total volumes and speeds. There are no vehicle classification data.
Portland Freight Data Collection Program	This comprehensive data collection program occurred in 2006 by the Port of Portland. The program included: vehicle classification counts throughout the Portland urban area and Clark County; external truck gateway roadside intercept surveys; gate intercept and establishment surveys at terminal gateways and re-load facilities; and a Multnomah County truck following study. The data were used in Metro Truck Model validation
Metro Truck Model and Truck Triptables	This is the primary truck model used by Metro for travel demand forecasting and formed the initial basis of the truck triptable used in this study. The truck model forecasts the quantity, type, and distribution of truck trips generated by the flow of goods into, out from, and within the four-county Portland region. The model is based on a Commodity Flow survey database with forecasts of annual tonnage flows for 44 commodity groups (2-digit SCTG) by primary mode, origin and destination regions, and forecast year (2000 to 2035, in 5-year increments). The Commodity Flow database was prepared for the Port of Portland in 1997, updated in 2002, and most recently validated and augmented by a 2006 trade capacity study.
WSDOT Freight Map Application	The data contained on the layers of maps include average travel speeds, trucks travelling 60 percent below average speed from the WSDOT/UW GPS truck monitoring study (see description below). The map also includes the WSDOT Freight and Goods Transportation System Data (FGTS). The FGTS data essentially reflects the number of truck trips.
WSDOT and UW Truck Travel GPS Research	The WSDOT has a contract with a vendor of GPS equipment for trucks. There are about 6,000 trucks in the WSDOT data base. Data collected are speed and travel time. The speed data are shown in the WSDOT Freight Map application. WSDOT did not recommend extrapolating these data.

An analysis of the Metro truck model and available data sources disclosed that the greatest need for understanding truck travel patterns are the truck trips that travel from locations external to the region to internal locations and vice versa. The conclusion of the research was there was no comprehensive definitive source of truck moment data for the region, but individual sources could be pieced together to get a reliable as possible assessment of truck movements.

One of the data sources reviewed was the Federal Freight Analysis Framework (FAF) data. This is a federally created dataset of freight flows by mode. The FAF 3 data file is the most current version file of the FAF datasets. It includes observed freight flows and forecasts of future freight flows. The FAF3 truck forecasts appeared to offer the best and most reasonable, long range, average forecast growth control totals when compared to historical data and other sources

The process to develop the truck triptables is shown in figure 7-5. The model datasets obtained from Metro included a base year truck triptable at the Metro travel model zone network level. As the freight and truck data mentioned above is generally not available at this detail level, the truck triptable was aggregated to larger zones in order to make base year adjustments and prepare forecasts for each analysis year. The zone aggregation allows evaluation of major movements over the I-5 bridge of four main truck trip types: external to external, external to internal, internal to external, and internal to internal. As a first step, this triptable was reviewed and adjusted for consistency with the truck license plate matching survey data described in Chapter 2 and current truck volume data over the bridges were applied as control totals. Future year triptables were developed by growing this base triptable with FAF3 forecast data and allocating the growth within the region to zones based on zonal truck related employment forecasts.



TRUCK FORECASTING PROCESS

FIGURE 7-5

7.3 Travel Demand Model Calibration

The Tolling Analysis Model used in this study has as a key component a travel demand model for the Portland-Vancouver metropolitan area. The model used is a time of day model for an average weekday that is specifically structured to address toll facilities. Prior to the travel demand model being used for estimating toll traffic, it is necessary to ensure it can replicate travel patterns in the absence of tolling. The travel demand model maintained by Metro that is the basis for the Tolling Analysis Model used in this analysis is well calibrated, but CDM Smith performed additional analysis to be sure the model was closely calibrated for the corridor under study.

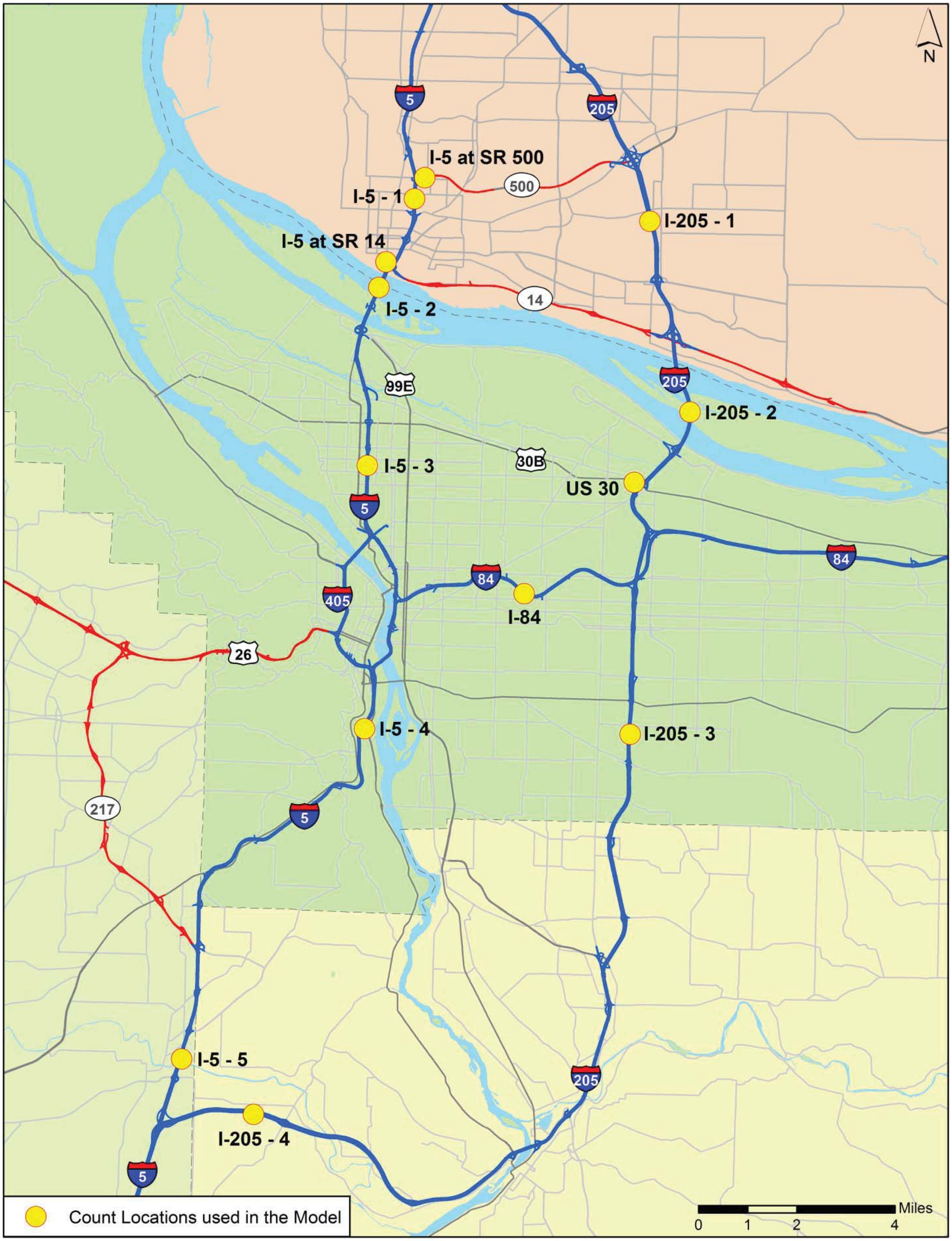
The calibration was performed for a base year of 2010. Traffic was modeled for this base year for an average weekday by hourly time periods. Model traffic estimates on key highway routes were compared to actual traffic count data. Model parameters were adjusted to get as good a match as possible. The locations of traffic counts used in calibration are shown in Figure 7-6. A location code for each traffic count point is shown on the map and used in the calibration results tables. Table 7-2 shows selected results for locations in the area of interest except for the I-5 and I-205 bridges. The hourly results for the routes of most importance for this analysis, the I-5 and I-205 bridges are shown by hour and by direction in Table 7-3. Finally, Table 7-4 shows the calibration results of river crossings just for trucks.

All of the calibration results were well within desired levels and meet nationally accepted best practices for travel model calibration. Consequently the model was deemed well calibrated.

Table 7-2 Selected Calibration Results for Locations other than the I-5 and I-205 Bridges

Location[1]	7AM-8AM			12PM-1PM			4PM-5PM		
	Count	Model	Diff%	Count	Model	Diff%	Count	Model	Diff%
I-5 - 1	7,110	7,271	2%	7,898	7,995	1%	9,651	9,694	0%
I-5 - 3	8,894	8,773	-1%	8,665	8,769	1%	7,207	7,282	1%
I-5 - 4	11,032	11,131	1%	9,224	9,338	1%	10,366	10,409	0%
I-5 - 5	11,786	11,881	1%	10,430	10,549	1%	12,180	12,203	0%
I-205 - 1	7,440	7,386	-1%	6,432	6,435	0%	8,768	8,788	0%
I-205 -3	10,115	10,056	-1%	9,404	9,371	0%	11,005	10,971	0%
I-205-4	5,997	6,049	1%	4,952	5,093	3%	5,968	6,005	1%
I-5 at SR 500	2,180	2,169	-1%	1,851	1,819	-2%	2,146	2,111	-2%
I-5 at SR 14	873	964	10%	1,027	1,082	5%	1,364	1,385	2%
US 30	3,563	3,504	-2%	3,068	3,089	1%	3,960	3,832	-3%
I-84	10,244	10,088	-2%	10,397	9,952	-4%	10,191	10,178	0%

1. Location number as shown on Figure 7-6



COUNT LOCATIONS USED IN CALIBRATION

FIGURE 7-6

Table 7-3 Total Traffic Calibration Results for the I-5 and I-205 Bridges

Model Hours	Dir	I-5 Bridge - All Traffic			I-205 Bridge - All Traffic		
		2010 Count	Model	Diff %	2010 Count	Model	Diff %
5:00-6:00	NB	881	879	0%	1,014	1,010	0%
	SB	3,230	3,230	0%	2,919	2,927	0%
6:00-7:00	NB	1,889	1,893	0%	2,149	2,168	1%
	SB	5,030	5,155	2%	5,973	5,855	-2%
7:00-8:00	NB	2,844	2,845	0%	3,084	3,101	1%
	SB	4,803	4,911	2%	7,037	6,952	-1%
8:00-9:00	NB	2,839	2,847	0%	2,945	2,945	0%
	SB	4,044	4,081	1%	5,316	5,297	0%
9:00-10:00	NB	2,808	2,815	0%	2,711	2,701	0%
	SB	3,933	3,948	0%	4,334	4,306	-1%
10:00-11:00	NB	3,147	3,169	1%	2,970	2,962	0%
	SB	3,944	3,992	1%	4,104	4,049	-1%
11:00-12:00	NB	3,647	3,658	0%	3,470	3,460	0%
	SB	4,126	4,182	1%	4,086	4,025	-1%
12:00-13:00	NB	3,979	4,019	1%	3,919	3,921	0%
	SB	4,137	4,212	2%	4,107	4,056	-1%
15:00-16:00	NB	4,473	4,562	2%	6,787	6,771	0%
	SB	3,770	3,772	0%	4,194	4,222	1%
16:00-17:00	NB	4,531	4,603	2%	7,222	7,201	0%
	SB	3,848	3,847	0%	4,213	4,227	0%
18:00-19:00	NB	4,171	4,165	0%	5,280	5,262	0%
	SB	3,289	3,299	0%	3,482	3,476	0%
19:00-20:00	NB	3,440	3,445	0%	3,621	3,624	0%
	SB	2,389	2,400	0%	2,442	2,442	0%
20:00-21:00	NB	2,810	2,805	0%	3,023	3,026	0%
	SB	1,936	1,947	1%	1,917	1,911	0%
21:00-22:00	NB	2,501	2,497	0%	2,832	2,832	0%
	SB	1,684	1,686	0%	1,676	1,674	0%
22:00-23:00	NB	1,879	1,881	0%	1,981	1,981	0%
	SB	1,260	1,262	0%	1,274	1,266	-1%
23:00-24:00	NB	1,294	1,299	0%	1,423	1,422	0%
	SB	791	791	0%	812	811	0%

Note: Some hours are not included since not all hours were used for calibration

Table 7-4 Truck Traffic Calibration Results for the I-5 and I-205 Bridges

Model Hours	Dir	I-5 Bridge - Truck Traffic			I-205 Bridge - Truck Traffic		
		2010 Count	Model	Diff %	2010 Count	Model	Diff %
5:00-6:00	NB	166	173	4%	98	99	0%
	SB	183	181	-1%	125	125	0%
6:00-7:00	NB	196	200	2%	140	139	0%
	SB	189	198	5%	229	226	-1%
7:00-8:00	NB	216	229	6%	192	192	0%
	SB	221	232	5%	244	244	0%
8:00-9:00	NB	256	262	2%	210	211	0%
	SB	253	265	5%	232	231	0%
9:00-10:00	NB	338	336	-1%	191	191	0%
	SB	347	347	0%	227	225	-1%
10:00-11:00	NB	385	383	0%	166	173	4%
	SB	336	333	-1%	241	238	-1%
11:00-12:00	NB	359	357	-1%	218	217	0%
	SB	387	385	0%	213	212	-1%
12:00-13:00	NB	327	354	8%	253	258	2%
	SB	374	387	3%	216	223	3%
15:00-16:00	NB	196	259	32%	239	239	0%
	SB	282	282	0%	227	227	0%
16:00-17:00	NB	173	215	24%	218	218	0%
	SB	230	229	-1%	209	209	0%
18:00-19:00	NB	160	150	-6%	147	129	-12%
	SB	167	179	7%	111	101	-9%
19:00-20:00	NB	157	157	0%	112	99	-11%
	SB	187	198	6%	89	85	-5%
20:00-21:00	NB	153	152	0%	102	103	0%
	SB	163	163	0%	72	74	2%
21:00-22:00	NB	138	138	0%	94	94	0%
	SB	172	173	1%	75	75	0%
22:00-23:00	NB	134	134	0%	90	89	-1%
	SB	153	153	0%	63	63	-1%
23:00-24:00	NB	98	103	6%	63	63	0%
	SB	158	157	-1%	65	64	-1%

Note: Some hours are not included since not all hours were used for calibration

7.4 Trip Suppression

Suppression refers to vehicle trips that would cross the Columbia River in the absence of tolling on I-5 but do not cross the river when tolling is imposed. This could be as result of any of the following four causes:

- The trip is made between the same origin and destination but the travel mode shifts to transit eliminating the vehicle crossing the river
- The destination of the trip changes so the destination is on the same side of the river and river crossing is not required
- The trip is combined with another trip between the same origin and destination resulting in one less river crossing to accomplish the same purpose
- The trip is simply not made

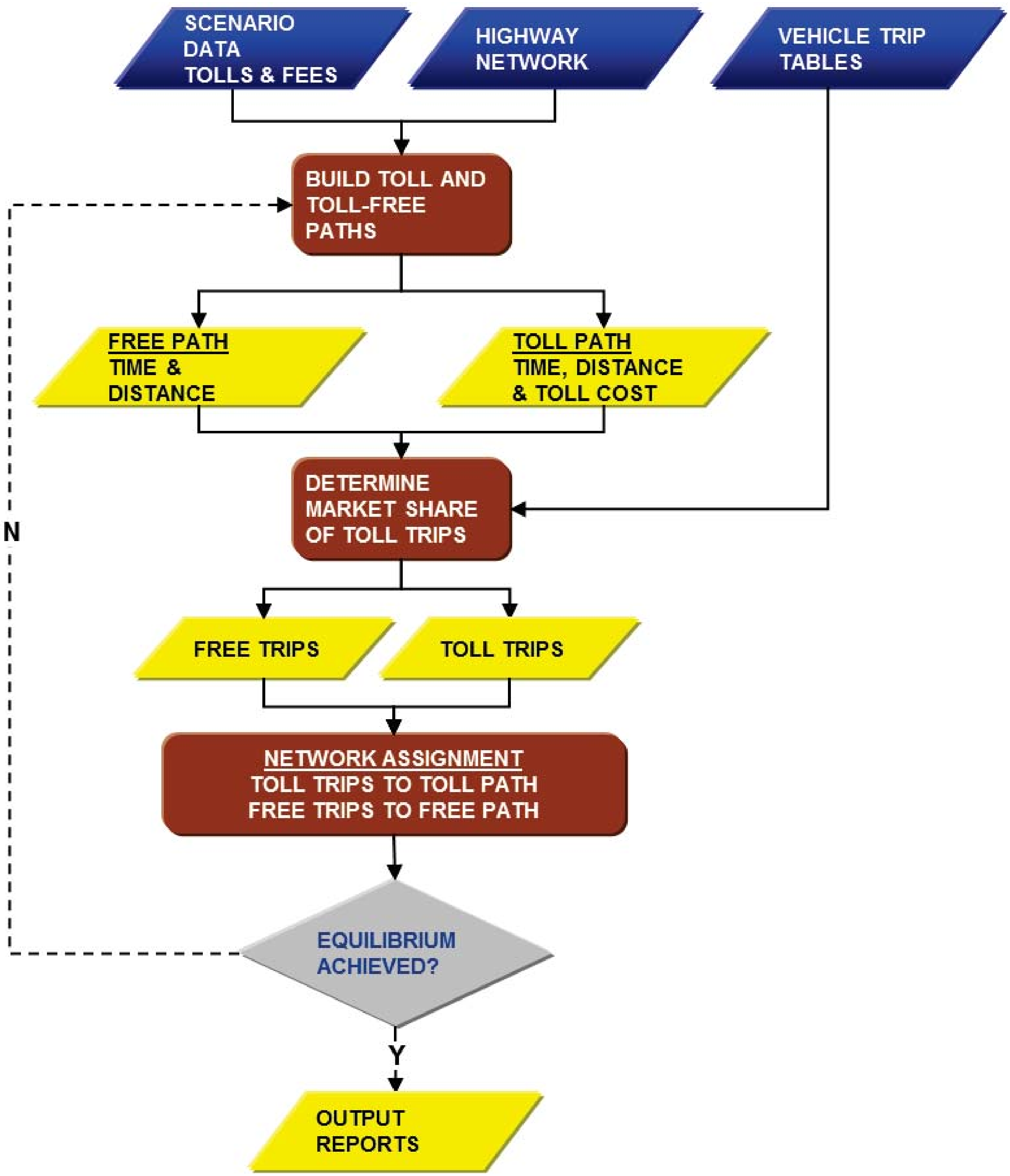
In these trip suppression steps, river crossing trips are adjusted downward by applying suppression equations. The equations determining the trip suppression due to tolling were developed from the stated preference survey of current cross-river travelers. The stated preference survey and resulting equations are described in Chapter 3.

7.5 Toll Route Diversion Methodology

Toll route diversion occurs when a vehicle trip that without tolling would have used a particular path changing from that path to another path to avoid the toll. In this study it specifically means a trip that would use I-5 to cross the Columbia River diverting to cross the river on I-205. Note this definition of toll route diversion can be considered one component of overall toll diversion which includes the suppression effects as discussed above.

As shown in Figure 7-7, the toll route diversion process is based on comparing toll free and toll paths based on time, distance, and toll cost to the traveler. Time is converted to a cost by using a value of time and distance is converted to a cost by using operating cost per mile. The values of time used are determined by the stated preference survey described in Chapter 4.

The assignment of traffic to a toll free or a toll path is not all or nothing. A portion of the total traffic between an origin-destination zone pair is assigned to each path based on an equation that considers the cost of both paths. The cost of a path is a monetary equivalent of all travel considerations: distance, delay, toll, travel time, etc. Also note that in this assignment process, travel time on a specific network link is affected by the amount of traffic on the link. As more traffic is assigned to a link, its travel time increases. The process is iterative as shown in Figure 7-7 until equilibrium is reached.



TOLL ROUTE DIVERSION METHODOLOGY

FIGURE 7-7

7.6 Weekend Traffic and Revenue Calculations

As indicated above, Metro maintains an average weekday model for the Metro area and the average weekday toll model was built off that Metro model. A model for weekends corresponding to the weekday model is not available; consequently a different process explained below had to be used to estimate average weekend day results.

Weekend trip pattern data for river crossing vehicle trips was available from the Airsage data and the origin-destination survey (both presented in Chapter 3). Also, weekend traffic count data for the I-5 and I-205 bridges was available. All these data sets are discussed in Chapters 2 and 3. Using the Airsage and origin-destination survey trip data in conjunction with river crossing count data, an hourly weekend triptable for river crossing trips was developed for a base year of 2010. The weekend triptable is for the two river crossings only, not the entire region. The weekend triptable was extrapolated into future years by using the growth rates from the weekday portion of the Tolling Analysis Model. Then, the same process as used for weekdays of applying trip suppression and trip diversion was carried out for weekends.

Since the weekend triptables included only river crossing trips, the effects of network congestion on trip diversion could not be considered. Since weekend traffic is lighter with less congestion, this is not a major concern. Also, by not accounting for congestion, the numbers are conservative with respect to the revenue from the I-5 bridge. In other words, the weekend technique applied does not account for congestion on I-205 such that the time component of the trip diversion calculation relies on free-flow speeds and consequently the technique might over estimate weekend diversion to I-205. However, by using this weekend method, weekend toll rates, weekend values of time, and weekend trip suppression results from the stated preference survey can be used in these calculations directly. Consequently, this method is believed to be superior to the typical method of applying an annualization factor to weekdays to estimate full year results.

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Chapter 8

Traffic & Gross Revenue

This chapter provides the results of the baseline estimates of traffic and gross revenue for the CRC Project. Major assumptions made in the estimation process are included in Tables 8-1 and 8-2. Estimates were made from the assumed start of tolling on September 30, 2015 (92 days into FY 2016) through June 30, 2060 (the end of FY 2060). Estimates were made for an average weekday and weekend day using the methodology described in Chapter 7. This chapter describes the process to calculate the annual estimates from the daily estimates and presents the results. The fiscal year gross revenue results are intended for use in financing the CRC Project. The traffic impacts of tolling and building the I-5 replacement bridge are also presented in context of I-5 traffic, I-205 traffic, and total river crossings.

8.1 Weekday and Weekend Traffic Estimates

The analysis described in the previous chapter was applied to estimate daily toll traffic for weekdays and weekends. Traffic assignments performed for FY 2016, FY 2020, FY 2022, and FY 2036 were used to directly develop toll traffic estimates for those years. Estimates for years between FY 2016 and FY 2020, FY 2020 and FY 2022, and FY 2022 and FY 2036 were developed by interpolation. The method to estimate the post FY 2036 years is described later in this chapter. Table 8-3 shows the results in terms of average weekday daily traffic, average weekend daily traffic, and average annual daily traffic on the I-5 bridge.

Between FY 2016 and FY 2020 traffic volumes increase because of anticipated travel demand growth and an anticipated increased participation in the account based payment program. Any growth in overall travel demand will have a substantial impact on the tolled I-5 bridge as there is little available capacity on I-205 after tolling I-5. As I-205 becomes increasingly congested, the incentive to pay the toll and use the less congested I-5 bridge becomes greater. Also, toll rates are lower for account based users. Thus, by increasing levels of account based users more potential users will experience the lower toll rate resulting in less diversion and more I-5 bridge usage. These increases more than offset declines in bridge usage due to light rail starting in FY 2020 (September 1, 2019) when the light rail extension is assumed to open over the Columbia River. This extension is anticipated to attract some previous toll bridge traffic to transit in addition to capturing cross river transit users. Note that through the end of FY 2021, the tolling period is from 5 AM to 8 PM only. The traffic listed in the "Untolled" column corresponds to 8 PM to 5 AM traffic.

The estimated volume change from FY 2020 to FY 2022 is a result of several factors:

- The fully-completed replacement bridge is assumed to open in FY 2022 with additional capacity and operational advantages. These factors have a positive effect on usage.
- The approximately 15 percent toll increase in FY 2022 has a downward effect on toll traffic.
- The beginning of overnight (8 PM to 5 AM) tolling in FY 2022 reduces overnight traffic but increases the number of vehicles being tolled.

The net effect of these factors is a small reduction in total traffic between FY 2020 and FY 2022.

Table 8-1 Major Assumptions for Columbia River Crossing Traffic and Revenue Forecast (Part 1)

General Assumptions
Improvements in the current Metro *Regional Transportation Plan* and Southwest Washington Regional Transportation Council *Metropolitan Transportation Plan* will be implemented as planned. No new competitive toll-free facilities or additional capacity will be constructed during the projection period other than those assumed in the plans.
Economic growth in the project study area will occur as forecasted herein based on forecasts from the independent socioeconomic consultant, ECONorthwest. (See Ch. 5 - Economic Growth Review)
The facility will be well maintained, efficiently operated, effectively signed, and promoted to encourage maximum usage.
Inflation will average 2.5% annually over the forecast horizon.
Motor fuel will be in adequate supply and no national/regional emergency will arise that would abnormally restrict use of motor vehicles. Fuel prices are assumed to increase with inflation.
The aggregate value of time for passenger cars is $12.68 per hour during peak periods and $10.95 during off peak periods. The value of time for medium trucks is $17.36 per hour and for heavy trucks is $30.33 per hour. All of these values are in 2013 dollars. (See Ch. 4 - Stated Preference Survey)
I-5 Columbia River Bridge Configuration (See Ch. 1 - Introduction)
Pre-completion tolling Phase 1: (FY 2016 - beginning 9/30/2015 - to FY 2018) Tolling is on the existing facility with three general purpose lanes in each direction and narrow shoulders.
Pre-completion tolling Phase 2: (FY 2019 to FY 2022) Both directions of traffic are shifted to the replacement southbound I-5 bridge structure and continued to be tolled with three general purpose through lanes in each direction with medium outside and narrow inside shoulders.
Post-completion: (FY 2022 to FY 2060) Project configuration is as described in the FEIS as the LPA with highway phasing except that the majority of the interchange improvements north of the SR 14 interchange are delayed and for purposes of this analysis are assumed to not be completed. The bridge configuration includes three general purpose lanes in each direction, and two collector-distributor lanes in each direction on the main I-5 bridge span with full shoulders.
Light rail extension from Expo Center in Portland to downtown Vancouver / Clark College is assumed to open on September 1st, 2019.
Toll Collection (See Ch. 6 - Tolling Operations)
The toll collection is all electronic; there will be no cash toll collection.
Toll collection on the existing bridge will commence September 30, 2015. Tolling will continue through FY 2060 on the existing bridge and on the replacement spans as they are opened.
Toll payment methods will be account based or non-account based.
The percentage of payment types will be consistent with the ranges assumed for this study. The percentage of bridge users using account-based transactions is assumed to increase from 67% in FY 2016 to 78% in FY 2036 and remain at 78% through FY 2060.
Toll collection will be effectively enforced.
Tolls will be collected such that all vehicles (with the exception of local transit buses) crossing the main span of the I-5 bridge over the Columbia River will pay the toll.

Table 8-2 Major Assumptions for Columbia River Crossing Traffic and Revenue Forecast (Part 2)

Toll Rates (See Ch. 6 - Tolling Operations)
Toll rates will be the same for either direction on the bridge.
High occupancy vehicles will pay the same toll rates as single occupant vehicles.
There will be no night time tolling (8 PM to 5 AM) from FY 2016 to FY 2021. Tolls will be charged during all 24 hours starting in FY 2022.
The maximum account based toll rate for 2-axle vehicles is $2.50 on weekdays and $2.00 on weekends in FY 2016. The maximum toll rate for non-account based two axle vehicles includes a incremental charge and is $4.02 on weekdays and $3.52 on weekend days in FY 2016.
At the beginning of FY 2017 and for each subsequent year through FY 2021 (on July 1 of 2016, 2017, 2018, 2019, and 2020) both weekday and weekend account based toll rates will increase by approximately 2.5 percent.
At the beginning of FY 2017 and for each subsequent year through FY 2021 (on July 1 of 2016, 2017, 2018, 2019 and 2020) the incremental charge for non-account based payments will increase by approximately 2.5 percent.
Toll rates increase by approximately 15 percent in FY 2022 for account based payments. The corresponding incremental charge for non-account based payments increases by approximately 2.9 percent.
Account based toll rates for multi-axle vehicles (more than two axles on the ground) are determined using the number of axles minus one multiplied by the two axle toll rate. For example, a toll rate for a five-axle vehicle account based payment would be four times that of a passenger car / two-axle vehicle account based payment.
The non-account based toll rates for multi-axle vehicles is determined by adding the same incremental charge for 2-axle non-account based payments to the account based multi-axle toll rates.
No toll rate escalation is assumed after FY 2022.
The complete set of assumed toll rates are as shown in Tables 6-2 and 6-3 in the report.
Construction Closures
The number of through lanes are assumed to be maintained throughout construction with the exception of these closures: Full weekend closures of the bridge from 11 PM on Friday to 5 AM on Monday two times per year in FY 2016 through FY 2022 except for FY 2019 when three full weekend closures are assumed.
All access movements to/from existing interchanges are assumed to be maintained throughout construction with the exception of ramps between SR-14 and downtown Vancouver, northbound I-5 and downtown Vancouver, and Hayden Island ramps to northbound I-5. These ramps will be closed during various points of the construction process. However, analysis indicates their effect on I-5 bridge toll traffic will be negligible.
Ramp-Up
Annualized traffic was adjusted downwards to take into account possible initial resistance to tolling. Ramp up reductions of 2% and 1% are applied in FY 2016 and FY 2017 respectively. Ramp up reductions of 2% and 1% are also applied in FY2022 and FY 2023 respectively to reflect the increase in toll rates with the opening of the completed bridge.

Table 8-3 Traffic Results on the I-5 Bridge

Fiscal Year	Tolled Passenger Cars		Tolled Trucks		Untolled	Total
	Account based	Non-account based	Account based	Non-account based		
Average Weekday Daily Traffic						
2016	45,600	19,700	3,500	1,800	18,800	89,400
2020	50,400	18,900	4,100	1,700	19,300	94,400
2022	64,100	22,400	5,200	2,000	-	93,700
2036	87,300	23,400	7,800	1,900	-	120,400
Average Weekend Daily Traffic						
2016	30,000	19,100	900	700	19,800	70,500
2020	34,400	17,700	1,000	700	21,200	75,000
2022	42,900	20,100	1,400	900	-	65,300
2036	58,500	20,800	2,000	900	-	82,200
Average Annual Daily Traffic						
2016	41,000	19,500	2,700	1,500	19,100	83,800
2020	45,700	18,500	3,200	1,400	19,900	88,700
2022	57,800	21,700	4,100	1,700	-	85,300
2036	78,700	22,600	6,100	1,600	-	109,000

Notes:
The above numbers are not adjusted for ramp-up effects and weekend construction closures
Numbers may not add or compare exactly with other tables due to rounding
"Untolled" is traffic that travels over the bridge during the toll-free hours (8 PM to 5 AM)

After FY 2022, toll rates are not increased. Thus, with inflation the real value of tolls decreases post FY 2022, which has a positive effect on bridge traffic volumes. Also, regional growth, as described in Chapter 5, contributes to increased toll usage. This growth has the direct effect of increasing the demand for the toll bridge and the indirect positive effect on toll bridge usage by increasing congestion on the competing I-205 bridge.

8.2 Traffic Analysis

A primary effect of tolling the I-5 bridge is that some motorists will divert to the I-205 bridge to avoid paying the toll. It is also anticipated there will be further reduction in travel due to a variety of factors collectively referred to as suppression. Suppression is caused by changes in destination choice, combining trips, or simply reduced trip frequencies. Additional travel reduction is due to shifts to transit (bus and light rail) from vehicular travel. These diversion, suppression, and shift to transit effects can vary depending on the year, especially starting in FY 2020 with the opening of the light rail extension and starting in FY 2022 with the opening of the replacement bridge with significant additional capacity and operational benefits. The 15 percent toll increase in FY 2022 assumed in the toll rate schedule also has an impact starting in that year.

Traffic impacts are analyzed by comparing model outputs for different futures: no build; toll free build; and, build, with tolling. The toll free build is included for analysis purposes only. It is not a future that will ever be realized; tolls are necessary to fund construction of the CRC Project.

Tables 8-4, 8-5, and 8-6 present the results of analysis of traffic impacts due to the effects described above for FY 2016, FY 2022, and FY 2036, respectively. These years are presented as they are critical years in the project schedule, with FY 2016 being the start of tolling, FY 2022 being the opening of the full replacement bridge, and FY 2036 representing a twenty year horizon from tolling inception.

Table 8-4 contains "Toll-Free Traffic" which refers to the forecasted traffic for FY 2016 if the facility was not tolled. Tables 8-5 and 8-6 include Toll-Free Traffic (No-Build), Toll-Free Traffic (Build), and Tolled Traffic. The No-Build information is the forecasted traffic if the existing facility remained and was not tolled. Toll-Free (Build) is the forecasted traffic if the facility was built and opened, but was not tolled. Finally, Tolled Traffic is the forecasted traffic with the facility built and tolled. Table 8-7 presents the diversion from I-5 and the reduction in overall river crossings as percentages of toll-free traffic.

In FY 2016 a total of 42,400 vehicles a day are expected to divert from I-5 due to tolling, compared to toll free conditions (40 percent diversion). Of those, 26,800 a day are expected to divert to the I-205 bridge and the remaining 15,600 are lost due to suppression or shifts to transit. In FY 2022 the diversion from I-5 is expected to increase to 76,700, with 39,500 diverting to the I-205 bridge. Two reasons for the increasing diversions are the beginning of overnight (8 PM to 5 AM) tolling and the 15 percent toll increase in FY 2022. It can also be seen in Table 8-7 that there is a larger percentage reduction in total (passenger car and truck) river crossings in FY 2022 than in FY 2016. A major reason for this is increased shifts to transit starting in FY 2020 with the light rail line opening. In FY 2036 the diversion from I-5 decreases relative to FY 2022 to 68,800 and the percentage reduction in river crossings also decreases. After FY 2022 toll rates do not increase thus with inflation toll rates in real dollar terms are lower than in FY 2022 resulting in the fewer diversions and a lower suppression effect..

Table 8-4 Fiscal Year 2016 Average Annual Traffic Impacts Analysis 5 AM to 8 PM

Result	I-5	I-205	Total River Crossings
Passenger Cars			
Toll-Free Traffic (5 AM-8 PM)	99,800	114,900	214,700
Traffic Change with Tolling	-39,300	23,900	-15,400
Toll Traffic	60,500	138,800	199,300
Trucks			
Toll-Free Traffic (5 AM-8 PM)	7,300	4,800	12,100
Traffic Change with Tolling	-3,100	2,900	-200
Toll Traffic	4,200	7,700	11,900
Total Traffic			
Toll-Free Traffic (5 AM-8 PM)	107,100	119,700	226,800
Traffic Change with Tolling	-42,400	26,800	-15,600
Toll Traffic	64,700	146,500	211,200

Notes:
Values are not adjusted for ramp-up effects and weekend construction closures
Numbers may not add or compare exactly with other tables due to rounding

In addition to the tolling impacts, Tables 8-5 and 8-6 also show the impact of opening the I-5 replacement bridges in toll-free analysis results. It can be seen that the new replacement I-5 bridge if implemented without tolling would be expected to increase river crossings on I-5 by 27,200 in FY 2022 and by 44,700 in FY 2036.

Table 8-5 Fiscal Year 2022 Average Annual Daily Traffic Impacts Analysis

Result	I-5	I-205	Total River Crossings
Passenger Cars			
Toll-Free Traffic (No-Build)	124,900	143,400	268,300
Traffic Change with Project	26,600	2,700	29,300
Toll-Free Traffic (Build)	151,500	146,100	297,600
Traffic Change with Tolling	-72,000	35,100	-36,900
Toll Traffic	79,500	181,200	260,700
Trucks			
Toll-Free Traffic (No-Build)	9,900	6,000	15,900
Traffic Change with Project	600	-200	400
Toll-Free Traffic (Build)	10,500	5,800	16,300
Traffic Change with Tolling	-4,700	4,400	-300
Toll Traffic	5,800	10,200	16,000
Total Traffic			
Toll-Free Traffic (No-Build)	134,800	149,400	284,200
Traffic Change with Project	27,200	2,500	29,700
Toll-Free Traffic (Build)	162,000	151,900	313,900
Traffic Change with Tolling	-76,700	39,500	-37,200
Toll Traffic	85,300	191,400	276,700

Notes:
Values are not adjusted for ramp-up effects and weekend construction closures
Numbers may not add or compare exactly with other tables due to rounding

Table 8-6 Fiscal Year 2036 Average Annual Daily Traffic Impacts Analysis

Result	I-5	I-205	Total River Crossings
Passenger Cars			
Toll-Free Traffic (No-Build)	126,400	146,600	273,000
Traffic Change with Project	38,900	5,400	44,300
Toll-Free Traffic (Build)	165,300	152,000	317,300
Traffic Change with Tolling	-64,000	33,300	-30,700
Toll Traffic	101,300	185,300	286,600
Trucks			
Toll-Free Traffic (No-Build)	11,800	6,800	18,600
Traffic Change with Project	700	-300	400
Toll-Free Traffic (Build)	12,500	6,500	19,000
Traffic Change with Tolling	-4,800	4,500	-300
Toll Traffic	7,700	11,000	18,700
Total Traffic			
Toll-Free Traffic (No-Build)	138,200	153,400	291,600
Traffic Change with Project	39,600	5,100	44,700
Toll-Free Traffic (Build)	177,800	158,500	336,300
Traffic Change with Tolling	-68,800	37,800	-31,000
Toll Traffic	109,000	196,300	305,300

Note: Numbers may not add or compare exactly with other tables due to rounding

Table 8-7 presents diversion percentages and river crossing vehicle trip reductions. Trip diversion is calculated by taking the difference between toll free build traffic on I-5 and tolled traffic on I-5 and dividing it by the toll free build traffic. River crossing vehicle reduction is calculated as the difference between toll free build river crossings and tolled river crossings.

Table 8-7 FY 2016 - FY 2036 Diversion and River Crossing Reduction

Fiscal Year	Diversion from I-5	Reduction in Vehicular River Crossings
Passenger Cars		
2016	-39%	-7%
2022	-48%	-12%
2036	-39%	-10%
Trucks		
2016	-42%	-2%
2022	-45%	-2%
2036	-38%	-2%
Total Traffic		
2016	-40%	-7%
2022	-47%	-12%
2036	-39%	-9%

8.3 Estimated Annual Traffic and Revenue

8.3.1 Traffic and Revenue Stream

For each modeled year the daily weekday and weekend traffic and revenue were used as inputs to calculate the annual traffic and revenue. Daily traffic was extrapolated to a full year using the number of weekend and weekday days in a given year. As described in Chapter 7, the weekday and weekend models were formulated so the six major holidays that may fall on weekdays were included in the weekend analysis. As described in Chapter 6 these holidays (New Year's Day, Labor Day, Independence Day, Memorial Day, Thanksgiving Day, and Christmas Day) are assumed to have the weekend toll schedule even if they fall on a weekday. Because of their linking to a calendar day, New Year's Day, Independence Day, and Christmas Day may fall on different days of the week in different years. In the analysis, especially when interpolating between different model analysis years, all three of these days were assumed to fall on weekdays. This was a slightly conservative assumption that was made to avoid over-estimating revenue in certain interpolated years. Other weekday holidays not listed above, such as Veteran's Day and Martin Luther King Day, assumed weekday toll rates.

The annual traffic and revenue estimates were made for the key years of FY 2016, FY 2020, FY 2022, and FY 2036. Intermediate year results were derived by interpolation. For the growth and extrapolation of traffic estimates from FY 2037 to FY 2045, transaction growth was assumed to decline and then reach a nominal growth for FY 2046 and beyond. With the additional available capacity on the I-5 bridge starting in FY 2022, sufficient capacity on I-5 is anticipated to be available to handle this future year growth.

8.3.2 Ramp-up and Construction Impacts

The annualized traffic and revenue were further adjusted to reflect "ramp-up". Ramp-up is a phenomenon that is often applied to forecasts for new facilities that may experience a high rate of growth in the first few years to reach the full forecast level as people become familiar with the facility. In the case of most new facilities, ramp-up duration typically occurs over five years with the start-up year near 80 percent. In case of the CRC Project, this adjustment is intended to reflect an initial negative reaction to paying a toll on a previously non-toll route before a better understanding of the benefit of using the tolled facility prevails. Since this is an existing facility, the issue of "finding out" that there is a new route does not exist. For this reason, the ramp-up adjustments as shown in Table 8-8 were shorter in duration and less aggressive than for new facilities.

Also included in Table 8-8 are construction impacts listed in the form of assumed weekend closures. In general, construction impacts are assumed to be minimal based on a review of the proposed construction process. The existing three lanes on the bridge in both directions are anticipated to be maintained throughout construction. There will be some ramp closures in the SR-14 and Hayden Island interchanges but they are not anticipated to have a material impact on I-5 bridge traffic due to relatively low traffic and adequate detours. There will, however, be some full weekend closures (11 PM Friday to 5 AM Monday for each closure) of the I-5 bridge during construction. The assumed closure schedule is listed in Table 8-8. The transactions and revenue estimates were reduced to reflect the impacts of these closures.

Table 8-8 Ramp Up Factor and Weekend Closure Assumptions

Fiscal Year	Ramp Up Factor	Weekend Closures
2016	98%	2
2017	99%	2
2018	100%	2
2019	100%	2
2020	100%	3
2021	100%	2
2022	98%	2
2023	99%	0
2024+	100%	0

8.3.3 Results

Table 8-9 presents the annual transactions and gross toll revenue by fiscal year for the financing period. Figure 8-1 provides the transactions and revenue streams as a graph. The revenue is expressed in terms of year of collection dollars. Note that for FY 2016 the estimates are for about 9 months only as tolling was assumed to start on September 30, 2015. The results included the ramp-up and construction impacts (weekend closures) discussed previously.

Toll revenue estimates presented are gross revenue. This is the revenue that would result if each vehicle passing through the toll collection point paid exactly the published toll rate based on the vehicle's classification, time of day, day of week, and toll payment method. The gross revenue shown does not include the effects of overpayments, underpayments, uncollectible tolls, or toll evasion. No analysis of these toll variance factors is included in this report.

Overall, transactions will grow in the future in part because regional economic growth and consequential growth in traffic contributes to increased toll bridge usage directly by increasing the number of potential users; and in-directly by increasing congestion levels on alternate routes making using the toll bridge more attractive. Participation in the account based payment program is very likely to increase which will result in more potential users basing their usage decision on a lower toll. As described in Chapter 6, the account based program growth is assumed to be higher between FY 2016 and FY 2020 than in other years.

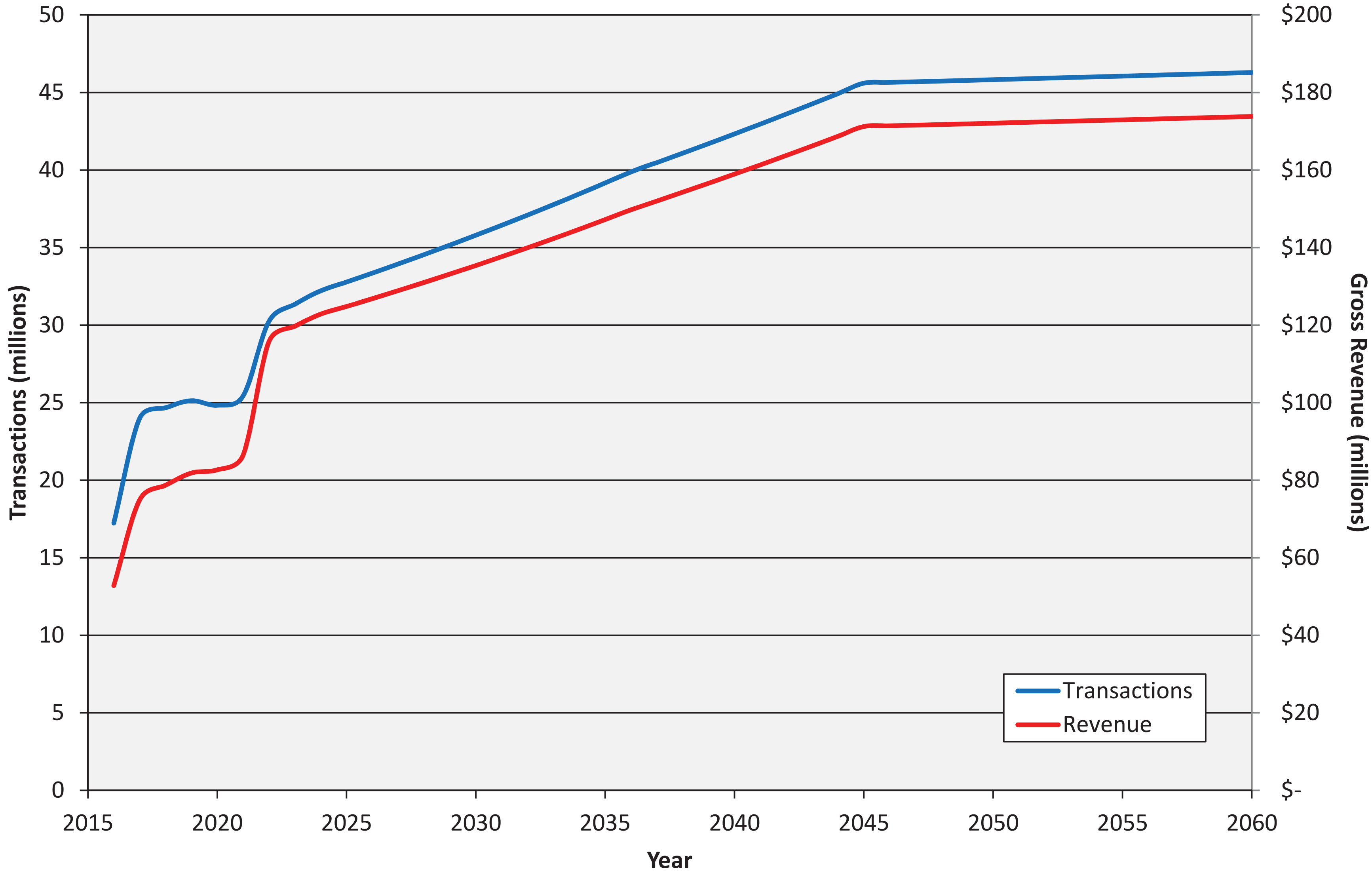
The forecasts from FY 2016 through FY 2017 indicate a 39.2 percent increase in transactions and 41.9 percent increase in revenue. The main reason for such a large increase is that FY 2016 tolling is only for about three quarters of a full year (about 9 months). Additionally declining ramp-up effects in FY 2017 also increase the growth. This declining ramp-up effect is also reflected in FY 2018, FY 2023, and FY 2024. Revenue growth is observed to be higher than transaction growth between FY 2017 and FY 2021 due to annual toll increases. These are scheduled to be 2.5 percent between FY 2017 and FY 2021. It can be seen that the growth comparison between revenue and transactions is slightly lower than 2.5 percent. This is due to the increasing number of users in the account based program paying a lower toll per transaction.

FY 2022 shows a large increase in transactions due to the start of overnight tolling. However the revenue growth is much higher than transaction growth due to the 15 percent toll increase for account based transactions and corresponding increases for non-account based transactions.

Table 8-9 Annual Transaction and Gross Revenue (millions)

Fiscal year	Transactions				Revenue			
	Account based	Non-account based	Total	Growth %	Account based	Non-account based	Total	Growth %
2016	11.530	5.704	17.234	-	$ 29.452	$ 23.358	$ 52.810	-
2017	16.304	7.688	23.992	39.2%	42.686	32.239	74.925	41.9%
2018	17.023	7.648	24.671	2.8%	45.788	32.897	78.685	5.0%
2019	17.596	7.531	25.127	1.8%	48.623	33.234	81.857	4.0%
2020	17.639	7.193	24.832	-1.2%	50.105	32.579	82.684	1.0%
2021	18.312	7.114	25.426	2.4%	53.413	33.039	86.452	4.6%
2022	21.945	8.296	30.241	18.9%	73.194	42.564	115.758	33.9%
2023	22.869	8.474	31.343	3.6%	76.278	43.416	119.694	3.4%
2024	23.630	8.583	32.213	2.8%	78.886	43.947	122.833	2.6%
2025	24.172	8.606	32.778	1.8%	80.768	44.040	124.808	1.6%
2026	24.726	8.629	33.355	1.8%	82.694	44.133	126.827	1.6%
2027	25.292	8.653	33.945	1.8%	84.666	44.227	128.893	1.6%
2028	25.872	8.676	34.548	1.8%	86.686	44.320	131.006	1.6%
2029	26.465	8.699	35.164	1.8%	88.753	44.414	133.167	1.6%
2030	27.072	8.723	35.795	1.8%	90.870	44.508	135.378	1.7%
2031	27.693	8.746	36.439	1.8%	93.037	44.602	137.639	1.7%
2032	28.328	8.770	37.098	1.8%	95.256	44.697	139.953	1.7%
2033	28.977	8.794	37.771	1.8%	97.528	44.791	142.319	1.7%
2034	29.641	8.817	38.458	1.8%	99.854	44.886	144.740	1.7%
2035	30.321	8.841	39.162	1.8%	102.235	44.981	147.216	1.7%
2036	31.016	8.865	39.881	1.8%	104.674	45.077	149.751	1.7%
2037	31.481	8.998	40.479	1.5%	106.244	45.753	151.997	1.5%
2038	31.953	9.133	41.086	1.5%	107.837	46.439	154.276	1.5%
2039	32.433	9.270	41.703	1.5%	109.455	47.136	156.591	1.5%
2040	32.919	9.409	42.328	1.5%	111.097	47.843	158.940	1.5%
2041	33.413	9.550	42.963	1.5%	112.763	48.560	161.323	1.5%
2042	33.914	9.693	43.607	1.5%	114.455	49.289	163.744	1.5%
2043	34.423	9.839	44.262	1.5%	116.172	50.028	166.200	1.5%
2044	34.939	9.986	44.925	1.5%	117.914	50.778	168.692	1.5%
2045	35.463	10.136	45.599	1.5%	119.683	51.540	171.223	1.5%
2046	35.499	10.146	45.645	0.1%	119.803	51.592	171.395	0.1%
2047	35.534	10.156	45.690	0.1%	119.922	51.643	171.565	0.1%
2048	35.570	10.166	45.736	0.1%	120.042	51.695	171.737	0.1%
2049	35.605	10.177	45.782	0.1%	120.162	51.747	171.909	0.1%
2050	35.641	10.187	45.828	0.1%	120.283	51.798	172.081	0.1%
2051	35.676	10.197	45.873	0.1%	120.403	51.850	172.253	0.1%
2052	35.712	10.207	45.919	0.1%	120.523	51.902	172.425	0.1%
2053	35.748	10.217	45.965	0.1%	120.644	51.954	172.598	0.1%
2054	35.784	10.228	46.012	0.1%	120.764	52.006	172.770	0.1%
2055	35.819	10.238	46.057	0.1%	120.885	52.058	172.943	0.1%
2056	35.855	10.248	46.103	0.1%	121.006	52.110	173.116	0.1%
2057	35.891	10.258	46.149	0.1%	121.127	52.162	173.289	0.1%
2058	35.927	10.269	46.196	0.1%	121.248	52.214	173.462	0.1%
2059	35.963	10.279	46.242	0.1%	121.369	52.266	173.635	0.1%
2060	35.999	10.289	46.288	0.1%	121.491	52.319	173.810	0.1%

Notes:
Tolling is assumed to start on September 30, 2013 and the full new I-5 bridge is assumed to open on July 1, 2022
Revenues are expressed in nominal dollars (year of collection dollars)
Ramp up factors are assumed to be 98 percent in FY 2016 and FY 2022 and 99 percent in FY 2017 and FY 2023
Gross revenue does not include the effects of overpayments, underpayments, uncollectible tolls, or toll evasior



PROJECTED TRANSACTIONS AND GROSS REVENUE

FIGURE 8-1

The average annual rate of transactions and revenue increase between FY 2022 and FY 2036 is 2.0 percent and 1.9 percent, respectively. As there are no toll rate changes beyond FY 2022, the dollar value of tolls in real dollars decreases with inflation assumed to be 2.5 percent per year. This effect, along with regional growth in traffic, results in a modest but steady annual growth in transactions and revenue. Also, the revenue growth lags the transaction growth because growing traffic using the facility will distribute in a higher proportion to off-peak periods when revenue per transaction is lower than peak periods.

Beyond FY 2036 through the end of forecast period, the annual growth rates are anticipated to decrease. A smaller traffic growth of 1.5 percent annually is assumed between FY 2037 and FY 2045 with a nominal growth of 0.1 percent annually after FY 2045. Thus, the traffic and revenue growth rate seen in this period is low and primarily the result of the decreasing cost of the toll rate in real dollars.

8.3.4 Additional Notes on Traffic

Near and long-term traffic growth on the tolled I-5 bridge is forecasted. This is in contrast to the relatively flat traffic levels (and declines in traffic associated with the Great Recession of 2008 to 2009) on the I-5 bridge in the recent past. This result is expected for a number of reasons:

- Traffic under the existing toll-free operating condition on the I-5 bridge reached nominal capacity several years ago, especially considering the substandard widths of lanes and shoulders on the facility. The I-5 bridge has little or no room for additional growth in most peak periods, and capacity constraints have limited growth over the last decade.

- While moderate recovery from the Great Recession has occurred in the past few years, volumes on the I-5 bridge remain below their pre-recession levels. The underlying socioeconomic forecasts assume continued recession recovery, which is expected to result in traffic increases.

- The establishment of tolling on I-5 is expected to reduce total cross-river travel demand as well as cause diversion to I-205. As cross-river and regional travel demand grows after tolling begins, congestion on I-205 and the regional network will encourage traffic growth on the tolled I-5 bridge.

- The improved I-5 bridge including additional lanes in each direction, lane widths and shoulder width improvements will increase the effective capacity of the crossing after FY 2022. The completion of the CRC project will allow the capacity of the regional network, particularly at peak periods, to accommodate the ongoing growth.

- Only inflationary toll increases are planned from FY 2016 through FY 2021. Only one toll increase beyond these inflation increases is scheduled in FY 2022, when both spans of the I-5 replacement bridge open to traffic. Even with nominal inflation, in real dollars the toll rates will decrease over time throughout the remainder of the forecast period. As a result, the implicit diversion potential to I-205 will decrease over time, further contributing to the higher level of sustained growth on the I-5 replacement bridge.

These and other factors are expected to result in a level of annual traffic growth which would be higher in the future under a tolled condition than has been experienced in recent years under a heavily constrained toll-free condition.

Chapter 9

Sensitivity Tests

This chapter includes the results of a series of tests that were conducted to provide a measure of the sensitivity of revenue forecasts to changes in key study assumptions. The assumptions chosen for the tests are those that present risks because they are subject to variability and have impacts on the magnitude of the revenue estimate. The sensitivity tests were conducted for fiscal years 2016, 2022, and 2036. Each parameter was tested individually. The following sensitivity tests were performed:

- Change in value of time (VOT)
- Variation in socioeconomic forecasts
- Change in the account based payment market share
- Mode split change.

The first three of the tests above are commonly used in investment-grade studies. Mode split changes are included in this study to test potential variations in transit ridership, especially considering the project's new light rail line over the Columbia River. The sensitivity tests were performed independently of each other and as such, the results may not be able to be added directly to estimate an overall impact of changes if they were to occur simultaneously.

Table 9-1 provides the sensitivity test results in table form and Figure 9-1 provides the results graphically. Details of the tests and a discussion of the results are provided below.

Table 9-1 Sensitivity Test Results as a Percent Comparison with the Base Case

Sensitivity Test	Transactions			Revenue		
	FY 2016	FY 2022	FY 2036	FY 2016	FY 2022	FY 2036
Value of Time 20 Percent Lower	-5.3%	-6.4%	-3.8%	-5.5%	-6.5%	-3.8%
Low Socioeconomic Growth		-4.8%	-3.8%		-4.4%	-3.4%
Account Based Market Share:						
10 Percent Higher (Input)	1.5%	1.7%	1.0%	-3.3%	-2.7%	-3.4%
10 Percent Lower (Input)	-1.6%	-1.7%	-0.9%	3.3%	2.7%	3.6%
Higher Mode Shift to Transit		-6.8%			-6.0%	

9.1 Value of Time

The VOT test quantified the revenue impact of the actual VOT being lower than what was assumed in the base forecasts. The VOT is very important to the revenue forecast but can be difficult to quantify, making sensitivity testing important. The test was for VOT 20 percent lower than the VOT used in the baseline analysis. The 20 percent variation is somewhat arbitrary but is consistent with other investment grade studies.

The results are shown in Table 9-1 labeled "20 Percent Lower Value of Time." The biggest difference compared to the base forecast is for FY 2022, at about 6.5 percent lower. Compared to FY 2022, FY 2016 shows about 1.0 percent less of a decline and FY 2036 shows about 3.0 percent less. The two main reasons for the impacts changing in different years are toll costs and travel time changing in relative terms over time. The 15 percent toll increase in FY 2022 and the beginning of overnight tolling likely combine to make the FY 2022 decline larger than both FY 2016 and FY 2036. Overnight drivers are more likely to be able to divert to I-205 given that there is no congestion. A lower VOT has more effect in the overnight than daytime. The lower declines in FY 2036 are partly due to toll rates decreasing in real dollars as time goes on (there are no toll increases after FY 2022), making the cost of the toll a smaller factor in the routing decision versus total travel time. Also, the average network congestion increases over time which increases the total travel time factor in the routing decision, making diversion to I-205 a less attractive option.

9.2 Socioeconomic Forecasts

The socioeconomic sensitivity test quantified the variation in traffic and revenue from a lower socioeconomic forecast. In this study, the base socioeconomic forecasts were obtained from ECONorthwest as described in Chapter 5. In addition to the base forecasts, a low forecast scenario was also developed by ECONorthwest and was used in the sensitivity test.

As described in Chapter 5, the economic scenarios were developed in a three-step process. The national context was considered first. Then a Portland area estimate was derived. Finally, this regional estimate was divided into small geographic units called transportation analysis zones for the tolling analysis. To develop the low scenario, the forecast of national real Gross Domestic Product (GDP) was adjusted down by almost 25 percent of the standard error. The low national GDP inputs were then used in the ECONorthwest regional economic model, to generate regional control totals for population, households, and employment. Metro's integrated land use and transportation forecast model – Metroscope – was then used by ECONorthwest in order to geographically distribute the regional population, households, and employment forecast totals to traffic analysis zones. Table 9-2 compares the resulting household and employment growth for the base case and the low scenario.

Table 9-2 Base and Low Socioeconomic Forecasts Total Growth

Fiscal Year	Households		Employment	
	Low	Base	Low	Base
2011 to 2022	12%	16%	17%	22%
2011 to 2036	26%	35%	30%	49%

The results of these tests are shown in Table 9-1 labeled as "Low Socioeconomic Growth". These tests indicate that the long-term revenue potential on the I-5 bridge is not heavily dependent on future economic growth in the region. While some economic growth is certainly anticipated, this growth accounts for a relatively small share of future revenue. For example, the results of the low sensitivity test showed that revenue would be reduced by at the most about four and a half percent in FY 2022 even with households and employment growth being reduced 24 percent and 22 percent, respectively.

From the standpoint of revenue risk, this is a positive indication. In general, economic growth forecasts are one of the most significant areas of uncertainty in the traffic and revenue forecasting process. The higher the dependence on future economic growth, the higher the long-term risk to the forecast. In this case, since the I-5 corridor has a strong, well-established pattern of existing usage, it is less dependent than most other new toll facilities on future economic growth. This inherently reduces the magnitude of risk associated with this important factor.

9.3 Account Based Payment Market Share

This test examined the impact on traffic and revenue of account based payment market shares differing from that assumed in the investment grade base case. The account based payment share assumptions used in the base case were reasonable given the detailed review of account based payment shares on other all-electronic tolling facilities and the results of the travel pattern survey as described in Chapter 6. However, this test was especially warranted given the unique characteristics of tolling the I-5 bridge which made direct comparison with existing facilities difficult.

The baseline scenario assumes that in FY 2016, 66.9 percent of the I-5 bridge users make account based payments. This 66.9 percent is the Tolling Analysis Model output account based market share. For this sensitivity test, a plus and minus change of 10 percentage points of the Tolling Analysis Model input account based market share was tested. For FY 2016 the resulting high and low tests output account based market shares were 76.8 percent and 57.8 percent, respectively. Table 9-3 shows these results as well as the results for FY 2022 and FY 2036. (The base results are included as presented previously in Chapter 6.)

Table 9-3 Account Based Market Share Output of Sensitivity Tests and the Base Case

Fiscal Year	Low	Base	High
2016	57.8%	66.9%	76.8%
2022	63.3%	72.6%	81.4%
2036	68.4%	77.8%	86.9%

The transaction and revenue results of the test are shown in Table 9-1 labeled under "Account Based Market Share" as "10 Percentage Points Higher (Input)" and "10 Percentage Points Lower (Input)." In FY 2016 the revenue results are plus or minus a little more than 3.0 percent. Recall, as described in Chapter 6, that there is an incremental non-account surcharge in FY 2016 of $1.52. The compensating effects with higher account based market share are more transactions because the effective toll rate is lower for more people but the revenue per transaction is lower. The effect is the same in reverse for a lower account based market share. In other words, as account based market share increases, transactions will increase due to fewer diversions away from the bridge but each of those new transactions pays a lower toll such that the two effects move revenue in opposite directions, resulting in a small effect overall. FY 2022 and FY 2036 show similar affects.

9.4 Mode Split Changes

As indicated previously, a mode split sensitivity test is included in this study to test a potential variation in transit ridership, especially considering the new light rail line over the Columbia River. Among the travel parameters modeled in this study, one is the response to tolling of I-5 bridge users in terms of their trip-making characteristics. This includes responses that involve shifting trips formerly made by driving across the I-5 bridge to transit. This type of shifting becomes more important to consider after September 1, 2019 (FY 2020) when the new light rail line is assumed to open between Portland and Vancouver. The light rail line is anticipated to increase transit usage over the Columbia River compared to early project years (between the start of tolling on September 30, 2015 and September 1, 2019) that only have options to shift to bus transit.

The mode split sensitivity test was completed for FY 2022 assuming the total amount of transit ridership crossing the river was double what was forecast in the base case with a consequent reduction in cross river vehicular trips. Note this level of usage is not supportable by the expected transit system operational characteristics to be place in that year and as such there is no judgment that this increase could be feasibly implemented. The test was conducted by increasing the transit utility in the mode split portion of the Tolling Analysis Model. The results of the test are shown in Table 9-1 labeled “Higher Mode Shift to Transit.” The results indicate about a seven percent reduction in transactions and a six percent reduction in revenue in FY 2022. The results show that even a drastic increase in forecasted transit ridership over the river (100 percent increase) leads to a relatively small change in I-5 bridge transactions and revenue. (It is important to note that the implementation of the light rail line is estimated to attract a large number of transit eligible trips in addition to trips changing to transit due to tolling. This sensitivity test assumes that aggregate transit trips over the Columbia River are double that of the baseline.)

Disclaimer

CDM Smith used currently-accepted professional practices and procedures in the development of these traffic and revenue estimates. However, as with any forecast, it should be understood that differences between forecasted and actual results may occur, as caused by events and circumstances beyond the control of the forecasters. In formulating forecast estimates, CDM Smith reasonably relied upon the accuracy and completeness of information provided (both written and oral) by the Oregon Department of Transportation, Metro, and the Washington State Department of Transportation. CDM Smith also relied upon the reasonable assurances of independent parties and is not aware of any material facts that would make such information misleading.

CDM Smith made qualitative judgments related to several key variables in the development and analysis of the traffic and revenue estimates that must be considered as a whole; therefore, selecting portions of any individual result without consideration of the intent of the whole may create a misleading or incomplete view of the results and the underlying methodologies used to obtain the results. CDM Smith gives no opinion as to the value or merit of partial information extracted from this report.

All estimates and projections reported herein are based on CDM Smith's experience and judgment and on a review of information obtained from multiple agencies, including the Oregon Department of Transportation, Metro, and the Washington State Department of Transportation. These estimates and projections may not be indicative of actual or future values, and are therefore subject to substantial uncertainty. Future developments cannot be predicted with certainty, and may affect the estimates or projections expressed in this report, such that CDM Smith does not specifically guarantee or warrant any estimate or projection contained within this report.

While CDM Smith believes that the projections or other forward-looking statements contained within the report are based on reasonable assumptions as of the date of the report, such forward-looking statements involve risks and uncertainties that may cause actual results to differ materially from the results predicted. Therefore, following the date of this report, CDM Smith will take no responsibility or assume any obligation to advise of changes that may affect its assumptions contained within the report, as they pertain to socioeconomic and demographic forecasts, proposed residential or commercial land use development projects and/or potential improvements to the regional transportation network.

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