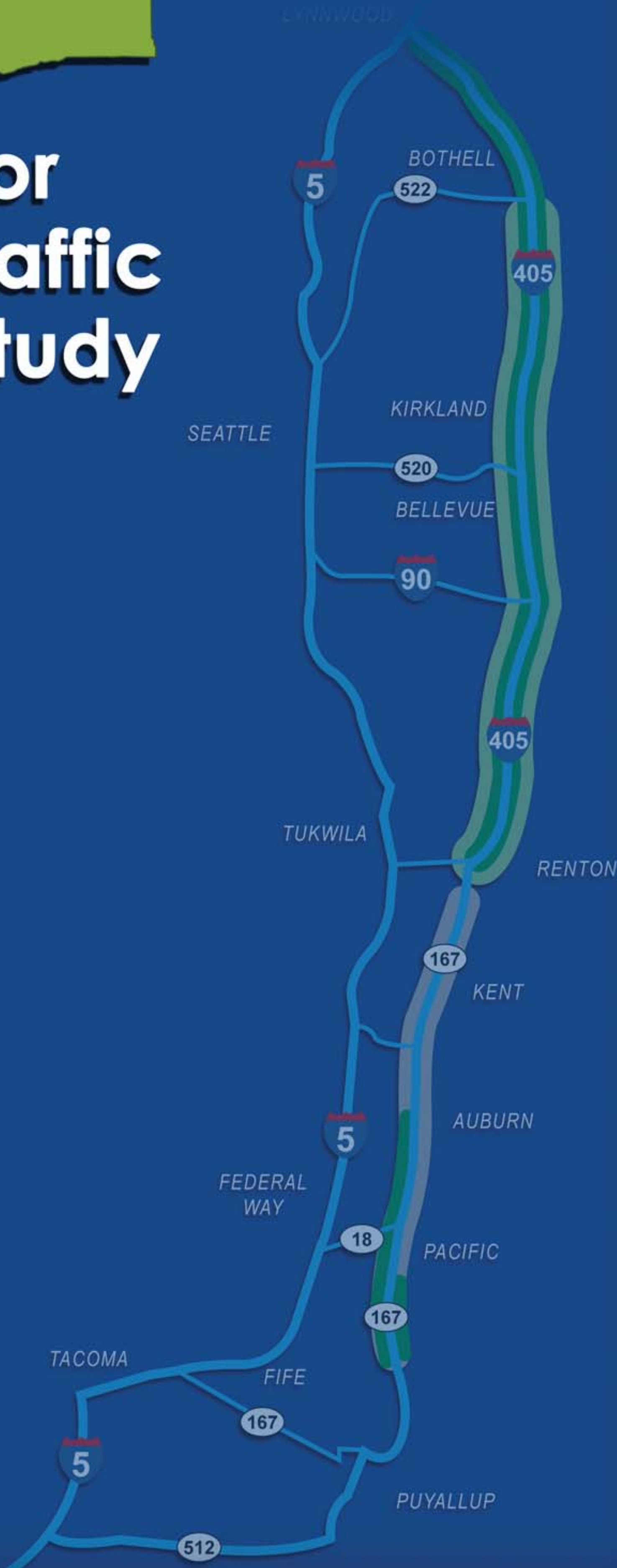
Eastside Corridor Independent Traffic and Revenue Study



prepared for

Washington State Transportation Commission

prepared by

Cambridge Systematics, Inc.

with

Resource Systems Group
Research Assurance, LLC

September 24, 2012

CAMBRIDGE SYSTEMATICS

final report

Eastside Corridor Independent Traffic and Revenue Study

prepared for

Washington State Transportation Commission

prepared by

Cambridge Systematics, Inc.
100 CambridgePark Drive, Suite 400
Cambridge, MA 02140

date

September 24, 2012

Disclaimer

The information and results presented in this report are estimates and projections that involve subjective judgments, and may differ materially from the actual future traffic and revenue. This report is not intended nor shall it be construed to constitute a guarantee, promise, or representation of any particular outcome(s) or result(s).

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Executive Summary

ES.1 Study Purpose

The purpose of this study was to conduct an independent traffic and revenue analysis of proposed Express Toll Lanes on I-405 and SR 167 (the Eastside Corridor), as directed by the Washington State Legislature in EHB 1382 (Section 4 1) (a)). Cambridge Systematics was retained by the Washington State Transportation Commission (WSTC) to conduct this study, providing answers to the following questions:

- Are the Express Toll Lanes a workable solution to managing mobility in the I-405/SR 167 corridor?
- How much revenue will they generate?
- How will Express Toll Lanes impact traffic operations?

In addition to the WSTC's independent traffic and revenue analysis, the legislation also requires the Washington State Department of Transportation (WSDOT) to develop a finance plan to fund improvements on the I-405/SR 167 corridor, and for WSDOT and the Commission to consult with a committee of local and state elected officials from the corridor and representatives from corridor transit agencies. The finance plan and consultation process are separate efforts that will use the gross toll revenue forecasts from this independent study.

What are Express Toll Lanes?

Express Toll Lanes are built adjacent to regular freeway lanes ("general purpose lanes"). Drivers of high-occupancy vehicles (and public transit vehicles) may use express toll lanes for free. Other vehicles may use the lanes by paying a toll. The idea is that drivers pay to use these lanes when they really want to be somewhere more quickly or to arrive at a more predictable time than the general purpose lanes would allow.

What makes express toll lanes work is that the toll is adjusted to ensure speeds of 45 miles per hour or better. Prices can be set dynamically, meaning they change in real time based on actual traffic levels, or they can be variable, changing according to a set schedule that varies by time of day and day of week and that is based on historical traffic patterns.

ES.2 Project Description

The proposed project would implement a 40-mile Express Toll Lane on I-405 and SR 167, from I-5 in Lynnwood in the north to the King/Pierce County line in the south[1] (see Figure ES.1, below). The corridor would consist of one to two Express Toll Lanes per direction, in addition to the two to three existing general purpose lanes per direction.

The project would be built in two phases. Phase 1, opening in the year 2014, would supplement the existing SR 167 Express Toll Lanes with new Express Toll Lanes on I-405 from NE 6th Street (downtown Bellevue) north to I-5 in Lynnwood (referred to as Area North, see Figure ES.2). This phase of the project would add two Express Toll Lanes in each direction between SR 520 and SR 522, and one Express Toll Lane in each direction from SR 522 to I-5.

Phase 2, opening in the year 2018, would complete a 40-mile corridor extending from I-5 in Lynnwood to Stewart Road SE in Pacific. This Phase closes the Express Toll Lane gap on I-405 between downtown Bellevue and SR 167 (referred to as Area Middle), adding two Express Toll Lanes in each direction in that segment. It also includes direct Express Toll Lane connections between SR 167 and I-405, and extends the existing SR 167 Express Toll Lane slightly further to the south. The SR 167 Express Toll Lanes are referred to as Area South.

[1] The project studied is Option 4 from the Washington State Department of Transportation *Eastside Corridor Tolling Study*, January 2010. Available at http://www.wsdot.wa.gov/Tolling/EastsideCorridor/Report.htm (last accessed August 31, 2012).

Figure ES.1 Project Phasing

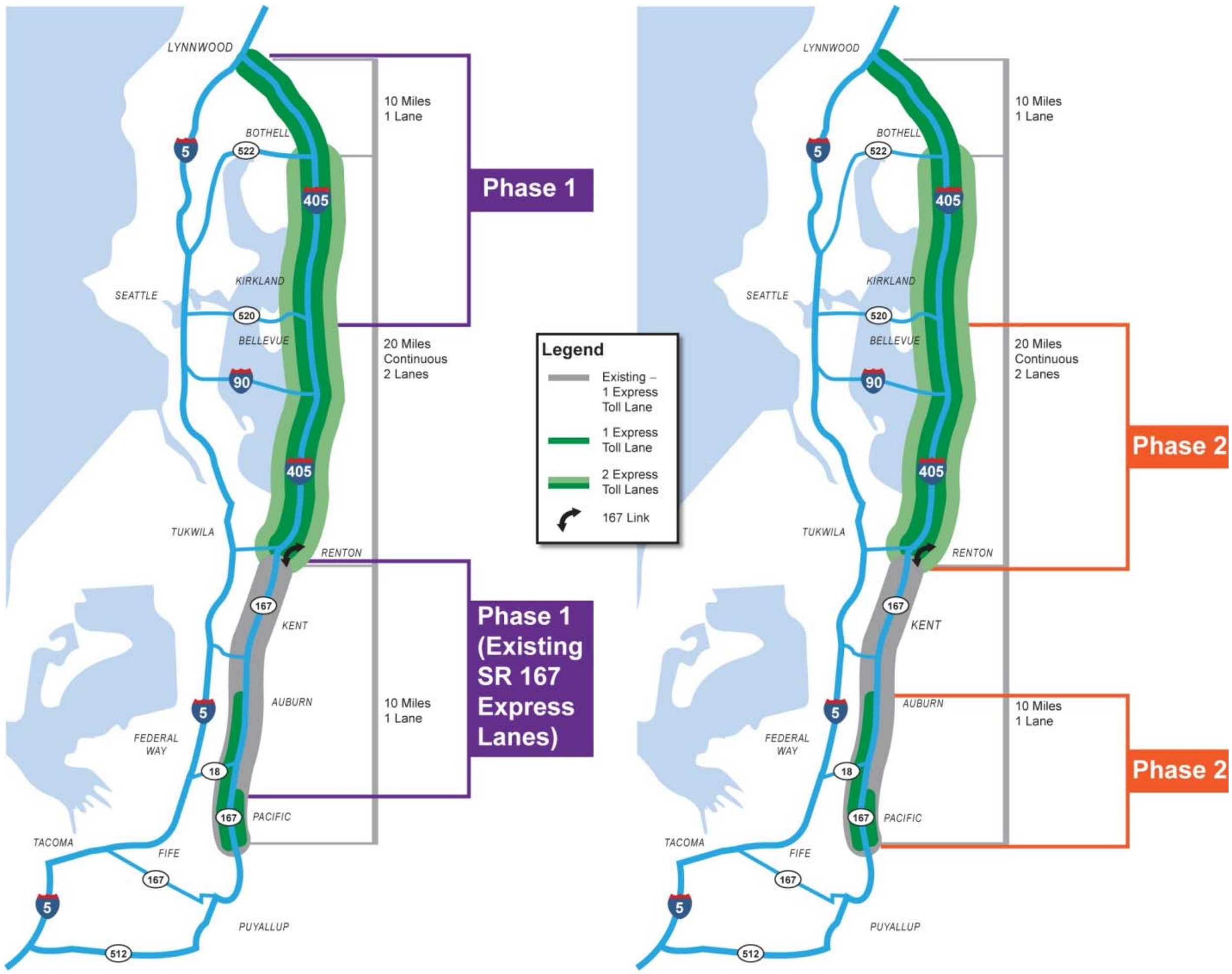
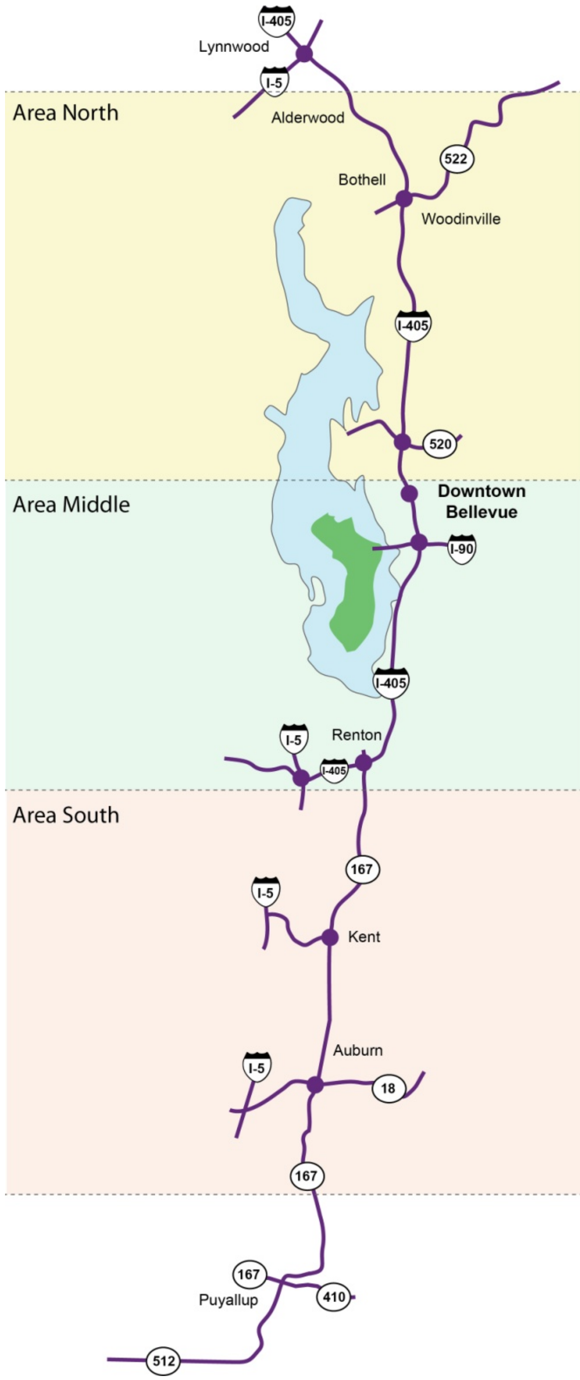


Figure ES.2 Project Areas



ES.3 Methodology

Cambridge Systematics reviewed WSDOT's data and models developed for their planning work in this corridor and implemented improvements to integrate the evaluation of corridor operations with toll setting. We also conducted new stated-preference and attitudinal surveys to update our understanding of people's willingness to pay tolls in the project region.

As directed by the legislation, we evaluated several different tolling policies that determine what type of user is allowed free access to the Express Toll Lanes and how prices are set:

- **Types of users allowed free access:**
  - *HOV 2+ free* (meaning that cars with two or more occupants travel for free);
  - *HOV 3+ free;*
  - *Mixed* Scenario where *HOV 3+ free* during peak periods and *HOV 2+ free* during off-peak periods; and
  - *HOV Discount* scenario, where all HOV pay a toll to use the lanes but receive a discount of about $1.00 during any period.
- **Ways of setting the price or toll rates:**
  - **Dynamic pricing,** where toll rates change according to actual traffic demand volumes in order to manage demand for the Express Toll Lanes and thus maintain minimum performance objectives in the Express Toll Lanes (e.g., at least 45 mph average speed during peak periods, 90 percent of the time).
  - **Variable pricing,** where prices are pre-set according to a published schedule, and vary by time of day and day of week in order to attempt to achieve similar performance objectives.
  - **Flat pricing,** where toll rates are constant throughout the day and do not vary according to traffic volumes or congestion levels.

Our quantitative analysis focused on the dynamic pricing approach and on the first three tolling policies described above, i.e., *HOV 2+ Free*, *HOV 3+ Free*, and the *Mixed* scenario, to generate estimates of future Express Toll Lane usage and revenue. We used a simplified "sensitivity analysis" approach to develop estimates for the remaining options, that is, the *HOV discount* option and the *variable* and *flat* pricing options.

The modeling approach extracted travel demand forecasts in the corridor from the Puget Sound Regional Council (PSRC) regional travel demand model, and used a traffic simulation model that reflected traffic operations and incorporated pricing and willingness to pay considerations.

Recognizing that there is uncertainty inherent in any forecast, we used an approach that incorporated risk into the traffic and revenue forecasts. While there are numerous inputs to the traffic and revenue models, we focused our risk analysis on those inputs that we considered to present the largest risks in terms of potential impact on future revenue outcomes. These are:

- **Transponder ownership,** that is, the percentage of vehicles in the corridor equipped with a transponder;

- **Growth in traffic demand** in the corridor predicted by the PSRC travel model;

- **Willingness to pay tolls,** as revealed by our 2011 surveys on the value of time; and

- **Uncertainty of revenue outcome from a given level of traffic,** as demonstrated by our analysis of a typical day described in Section 2.4.

We tested a variety of assumptions for each of these risk factors, for three different future horizon years. Using a Monte Carlo technique[2] we ran the model for 96 distinct scenarios to simulate 5,000 possible combinations of scenarios and reported the probability of achieving different revenue values rather than a single "point" forecast of future revenue.

We used this approach to forecast revenue generated by the dynamic pricing option for the *HOV 3+ free* and *HOV 2+ free* scenarios for the years 2014, 2018, and 2030. Using these results, we then estimated revenue for the *Mixed* scenario that combines *HOV 3+ free* in peak periods with *HOV 2+free* in the off-peak periods, using the relevant portions of the day from the *HOV 3+* and *HOV 2+* scenarios.

In addition to the risk factors that were explicitly incorporated into the revenue forecast, we also considered the fact that potential customers take varying amounts of time to become familiar with the new Express Toll Lanes before beginning to use them. This is known as the "ramp up" period for the project, during which something less than the full number of forecasted users would pay to use the lanes. The duration of ramp up will vary by project phase and segment, and we therefore reduced the revenues in the early years of each of the three corridor areas (north, middle, and south) by differing amounts. All three corridor areas were assumed to be running at 100 percent of forecast usage by 2020.

A number of other assumptions were necessary to complete the analysis. These include basic characteristics of the project and surrounding transportation system (e.g., Express Toll Lanes are well-maintained and marketed; no competing capacity improvements will be implemented other than those already present in regional plans out to the year 2030) as well as assumptions about the lack of potentially disruptive events well beyond the

[2] Monte Carlo simulation refers to a mathematical simulation of a real event where there is significant uncertainty in the numerous input factors that determine the outcome of that event. Monte Carlo simulations apply probability distributions for each input variable (in this study transponder ownership, traffic growth, and willingness to pay tolls) to produce hundreds or thousands of possible outcomes, which are then analyzed to reveal the probabilities of different outcomes occurring.

normal range of expectation (e.g., a national emergency that places restrictions on the use of motor vehicles). These are explained in more detail in Section 4.

ES. 4 Findings: Gross Toll Revenue

We simulated approximately 5,000 forecasts of gross toll revenue in 2012 dollars[3] for 2014, 2018, and 2030 and arranged the outcomes from low to high. We reported on the amount of revenue that was achieved by 15 percent, 50 percent, and 85 percent of all the individual outcomes, referred to the 15th, 50th, and 85th percentiles, respectively. Figure ES-3 provides an example for the *HOV 3+ Free* scenario in 2030.

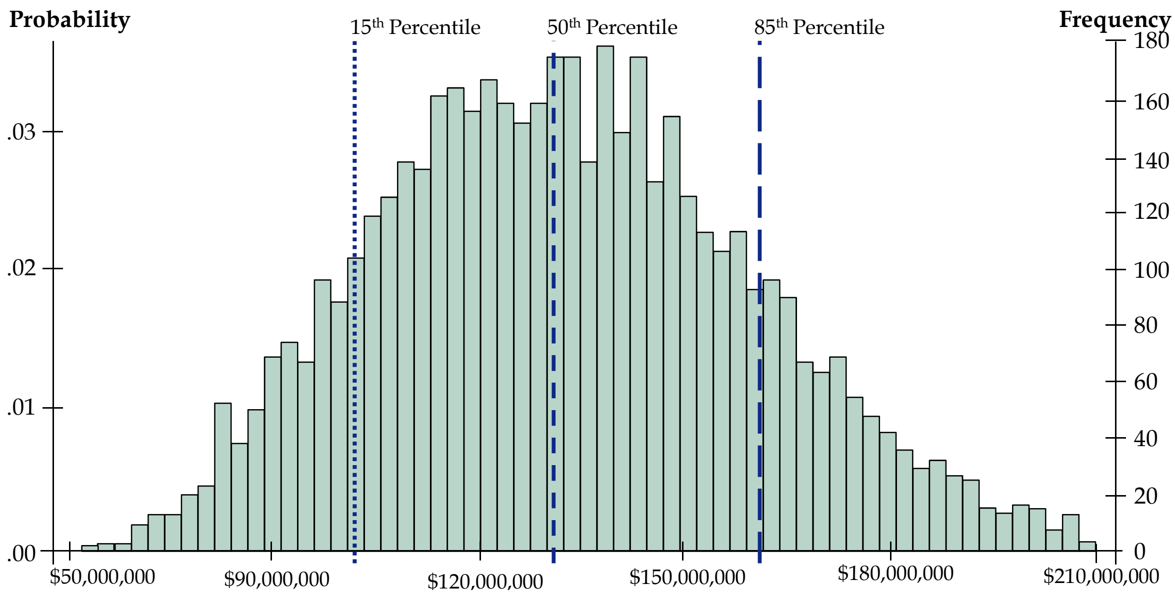
The 15th percentile is a reasonable lower bound to use for financial planning, as only 15 percent of the outcomes would be *below* that number. We refer to that as the "low" forecast. The 85th percentile is a reasonable upper bound as only 15 percent of outcomes would be *higher* than that number – referred to as the "high" forecast. The 50th percentile (also called the median) represents a level where a higher or lower amount is equally probable, but should not be interpreted as a "most likely" value.

We provide several comparisons of revenue:

- Range of Forecast 2030 Revenue Based on Type of Users Allowed Free Access;
- Forecast 40-year Annual Revenue Streams: 2014-2053 Forecast – 50th Percentile;
- Ranges of Revenue Streams by Scenario; and
- Comparison to WSDOT's 2009 Forecast for 2030.

[3] Our forecasts are of gross toll revenue in 2012$. WSDOT is preparing operating cost estimates, and will apply different assumptions with respect to inflation in its financial analysis.

Figure ES-3 Histogram of *HOV 3+ Free* Annual Revenues from Monte Carlo Simulation: 2030

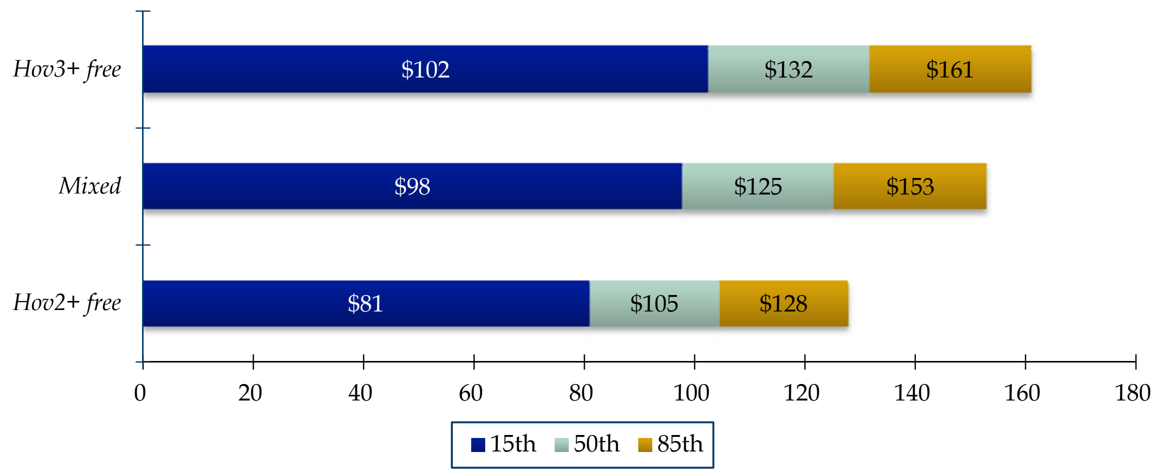


Range of Forecast 2030 Revenue Based on Type of Users Allowed Free Access

Figure ES.4 illustrates these forecast results for each of the three scenarios, indicating the year 2030 gross revenue for the 15th, 50th and 85th percentile outcomes. We forecast:

- The lowest revenue for the *HOV 2+ free* scenarios, ranging from $81 million per year at the low end to $128 million at the high end (58 percent higher).
- The *HOV 3+ free* scenarios have the highest revenue, ranging from $102 million to $161 million per year (the high also about 58 percent higher than the low).
- At the high end, the *HOV 3+ free* scenario is about 41 percent higher than the *HOV 2+ free* scenario and about 18 percent higher than the *Mixed* scenario. Note that the *Mixed* scenario revenue depends on the number of hours assumed for each type of operation (*HOV 2+* or *3+ free*), but in general, it should be possible to optimize revenue and operations through the mixed approach.
- At the low end, we forecast *HOV 3+ free* revenue to be 26 percent higher than *HOV 2+ free* revenue.

Figure ES.4 2030 Gross Revenue Forecast Ranges for Dynamic Pricing Scenarios (*in millions of 2012 dollars*)

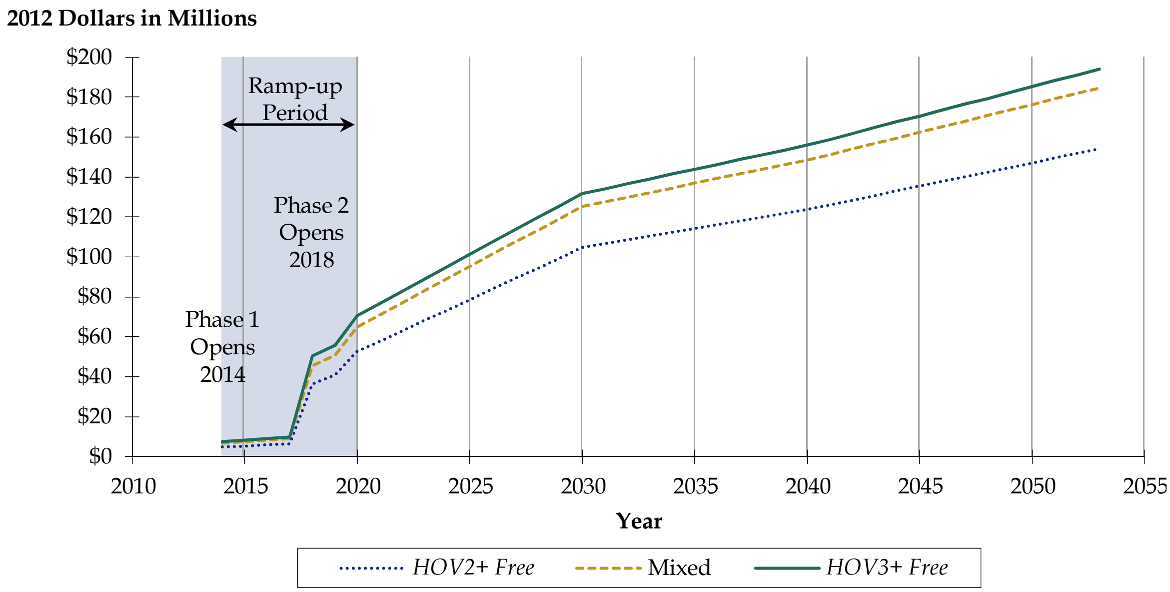


Forecast 40-year Annual Revenue Streams: 2014-2053 Forecast – 50th Percentile

Revenue from the Express Toll Lanes would grow over time as a result of various factors, primarily growth in traffic demand in the corridor and acquisition of transponders by a larger percentage of the potential user market.[4] Figure ES.5 illustrates the results of these assumptions and forecasts, comparing the annual revenue streams over 40 years for the three dynamic pricing scenarios, *HOV 2+ free*, *HOV 3+ free*, and *Mixed* peak/off-peak. Revenue during Phase 1 is expected to be low due to the limited extent of the system and fewer potential users. There is a large forecast increase in use and revenues when Phase 2 opens in 2018, as this phase closes the Express Toll Lane "gap" between SR 167 and the north portion of I-405 (refer to Figure ES.1, previously). After that initial rapid climb, we forecast revenue growth to moderate but continue steadily to 2030. We have assumed that transponder saturation of the target user market would reach 100 percent by 2030, and thus the rate of revenue growth moderates further at that point.

[4] While people's incomes, and thus, theoretically, customer "willingness to pay," has historically tended to grow at a rate slightly greater than the overall rate of inflation, we have assumed no change in willingness to pay over time, a reasonable assumption that should avoid over estimating revenue.

Figure ES.5 Comparison of Annual Revenues for Dynamic Pricing Scenarios: 2014-2053



Comparison to WSDOT's 2009 Forecast for 2030

We compared the 2030 revenue forecast developed for this study to the forecasts from the 2009 WSDOT traffic and revenue study (see Figures ES.6 and ES.7) and found that:

- Our forecast range is much narrower than WSDOT's because we quantified the most important risk factors that would affect revenue whereas WSDOT applied very conservative adjustment factors to guard against using overly optimistic assumptions for their financial analysis.
- Our forecasts are within, but at the lower end of the WSDOT forecast range.

Figure ES.6 2009 WSDOT and 2012 CS Revenue Forecast for *HOV 2+ Free*

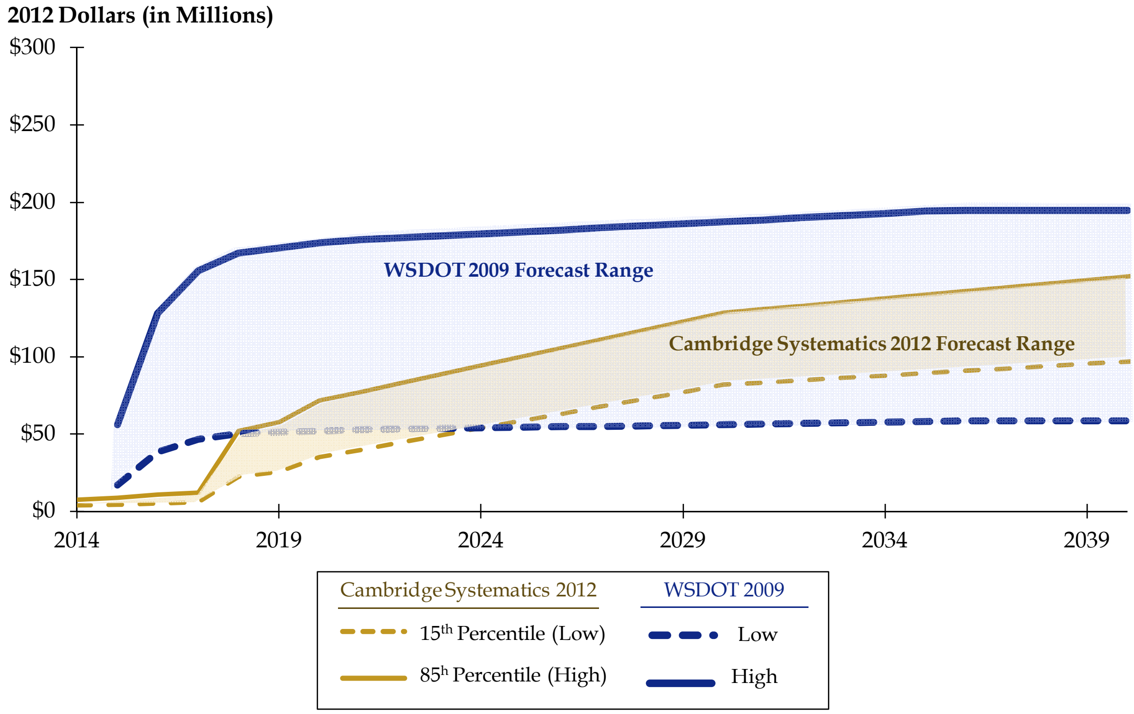
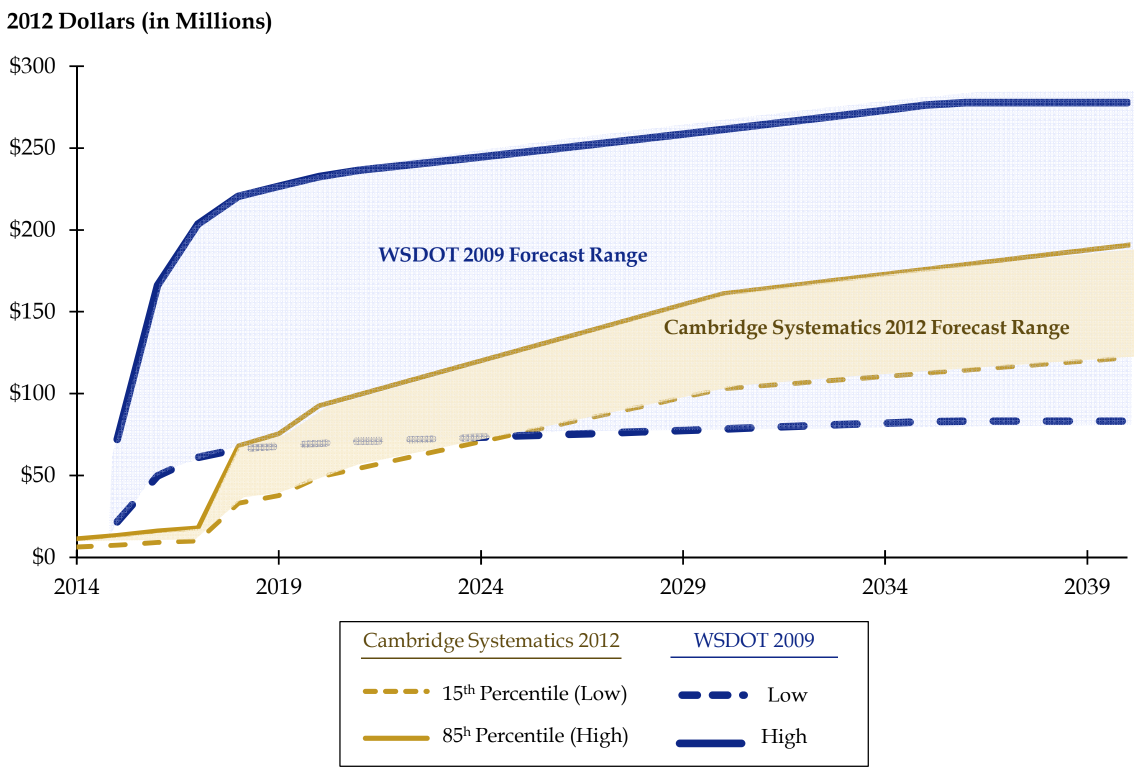


Figure ES.7 2009 WSDOT and 2012 CS Revenue Forecast for *HOV 3+ Free*



■ ES.5 Findings: Transportation System Performance

We extracted key traffic performance measures from the simulation modeling to enable meaningful comparisons across scenarios (*HOV 2+ free and HOV 3+ free)* for policy purposes. To ease this comparison we have focused on the scenarios that represent:

- 2030 conditions;
- Medium levels of growth; and
- Medium levels of value-of-time.

We considered traffic performance measures that address:

- Mobility, as measured by travel time and travel time savings;
- Throughput, as measured by how many vehicle miles of travel can be accommodated by the system; and
- Bottlenecks, where we identify the locations in the system that we expect will cause backup and delays.

High-Level Summary of Performance

Table ES.1 shows a high level comparison of performance outcomes for the *HOV 2+ Free* and *HOV 3+ Free* scenarios. We found relatively little difference in overall throughput of traffic in the corridor between these two approaches, with the *HOV 3+ Free* scenario processing 99 percent of that processed by the *HOV 2+ Free* scenario. Similarly, the average corridor speeds were slightly better with the *HOV 2+ free* scenario – 22.2 mph versus 21.1 mph – 5 percent better.

Table ES.1 Comparison of Forecast Performance Outcomes 2030
Medium Scenarios

	HOV 3+ Free	***HOV 2+ Free***	**Ratio of *HOV 3+ Free* to *HOV 2+ Free***
Throughput: Daily Corridor Vehicle Miles Traveled (000)	8,628	8,686	99%
Mobility: Average Daily Corridor Speed (mph)	21.1	22.2	95%
Annual Gross Revenue (millions 2012$)	133.4	106.4	125%

For a complete comparison, we also included the expected annual gross revenue in 2030 for each of these scenarios (described in more detail in the prior section). Annual gross revenue under the *HOV 3+ Free* scenario is forecast to be about 25 percent higher than the *HOV 2+ Free* scenario.

Bottlenecks

Beyond the basic carrying capacity are other operational issues that affect the mobility performance and carrying capacity of system – these are called “bottlenecks.” These are places where a geometric feature like a lane drop, a weave area, or a sharp curve in the road that performs poorly when traffic volumes increase and compromises long segments of the corridor. The introduction of a managed Express Toll Lane system can create a bottleneck or exacerbate an existing one.

In the course of our work, we identified several locations that could cause operational difficulties in the corridor. This is not unusual, as development of a complicated project such as this typically involves an iterative process of design, evaluation, and design refinement.

WSDOT has conducted detailed design work for the north area of the project, but only preliminary design of the middle and improvements to the south area, including the direct express toll lane connection flyover between SR 167 and I-405. Section 4 contains useful information for WSDOT as they move this project forward.

ES.6 Effects of Variable and Flat Pricing

EHB 1382 also called for an analysis of charging vehicles a flat rate (same toll rate all day) and variable pricing (toll rates pre-set by time of day). The toll rates assumed for this analysis were:

- *Variable* rate – from $1.00 up to $6.00 per area
- *Flat* rate – Area North: $1.25; Area Middle: $2.50; and Area South: $2.00

Table ES.2 shows the revenue forecast for the *Flat* rate and *Variable* rate sensitivity tests compared to the dynamically priced *HOV 3+ free* scenario as well as a comparison of vehicle miles traveled (VMT) and speed performance measures. We found that:

- *Variable* pricing revenue is forecast to generate 114 percent of the dynamic pricing scenario revenue. We expect that this is because we set the toll rates at a high enough level to ensure that the speed policy is achieved, which leads to higher prices paid and greater gross revenue. If we had set the variable prices differently the revenues could have been higher or lower, and potentially lower than the dynamic pricing scenario.

- *Flat* pricing revenue is forecast to be 96 percent of the dynamic pricing method of toll collection. As with variable pricing, this is largely a function of how we chose to set the rate. A range of alternative outcomes is possible.
- Traffic performance, as measured by VMT and speed, is best with the dynamic pricing option, but the differences are not all that dramatic. The forecast speeds with the variable pricing option are close to that of the dynamic option – 20.6 mph versus 21.1 mph (a difference of two percent), and the VMT (throughput) are forecast to be 99 percent of the dynamic option.

Table ES.2 VMT, Speed and Toll Revenues for Price Setting Sensitivity Tests (2030)

		Variable		Flat	
	Dynamic	Amount	Percent of Dynamic	Amount	Percent of Dynamic
Throughput: Corridor VMT (000)	8,628	8,555	99%	8,397	97%
Mobility: Average Corridor Speed (mph)	21.1	20.6	97%	19.0	90%
Annual Gross Revenue (millions 2012$)	133.4	152.5	114%	127.7	96%
Average Toll Rate (AM Period)	2.01	2.45	122%	2.04	101%
Average Toll Rate (PM Period)	2.03	2.27	112%	1.92	95%

It is difficult to draw definitive conclusions solely from these comparisons because the outcomes are influenced by the choice of how prices are set under both the variable and flat pricing concept. However, we can make the following observations:

- Dynamic pricing should be able to achieve the best performance for the corridor since it reacts in real time to traffic conditions.
- With *variable* pricing, the operator has to be cautious in setting tolls so that the performance objectives are achieved. As such, the operator will tend to err on the high side with respect to toll rates. This will yield more revenue, but at the loss of performance in the corridor. The toll lanes will tend to be underutilized, resulting in more congestion in the general purpose lanes than in the dynamic pricing scenario.
- A *flat* toll is completely at odds with the idea of an express toll lane. It is difficult to come up with a generic toll rate that would accomplish the primary objective of an express toll lane, which is to provide a reliable trip in the corridor in spite of substantial changes in traffic demand volumes and congestion. A single toll rate is simply too blunt an instrument to accomplish this.

■ ES.7 Effects of an HOV Discount Toll Policy

We tested the effect of a $1.00[5] discount on all HOV using the corridor and compared it to the *HOV 2+ Free* and *HOV 3+ Free* policies (Table ES.3). For the *HOV Discount* scenario, the 2030 annual revenues were estimated at $115.4 million, about 13 percent less than the *HOV 3+ Free* scenario and 8 percent higher than the *HOV 2+ Free* scenario. There were only small differences in the mobility and throughput measures.

Table ES.3 Comparison of Forecast VMT, Speed and Gross Annual Revenue *HOV Discount* to *HOV 3+ Free* and *HOV 2+ Free* Policies 2030

	HOV 3+ Free	*HOV 2+ Free*	*HOV Discount*	**Percent of** *HOV 3+ Free*	**Percent of** *HOV 2+ Free*
Throughput: Corridor VMT (000)	8,628	8,686	8,693	101%	100%
Mobility: Average Corridor Speed (mph)	21.1	22.2	21.9	104%	99%
Annual Gross Revenue (millions 2012$)	133.4	106.4	115.4	87%	108%
Average Toll Rate (AM Period)	2.01	2.00	1.89	94%	95%
Average Toll Rate (PM Period)	2.03	2.07	2.04	100%	99%

■ ES.8 Fundamental Findings

Among the many important findings of this study, the following stand out:

Narrower Range of Revenue Outcomes than Prior WSDOT Forecast. The range of revenue outcomes between the 15th and 85th percentile from this independent traffic and revenue forecast is narrower than the range of revenues used by WSDOT for prior financial planning. For both *HOV 2+ Free* and *HOV 3+ Free* scenarios, the 15th percentile of the independent revenue estimate was higher than WSDOT's low estimate, but the 85th percentile of the independent revenue estimate was lower than WSDOT's high estimate.

If people do not have transponders they cannot use the express toll lanes and revenue will be lower. This may seem obvious, but is an important risk factor. WSDOT did not promote the SR 167 express toll lanes – only 14 percent of corridor drivers had transponders in the fall of 2011. As a result, revenue was much lower than expected. Although transponder ownership was only one factor contributing to this outcome (the Great

[5] In 2014 dollars.

Recession was another factor), if more people have transponders, they have an opportunity to use the lanes.

In our analysis, a scenario with 45 percent transponder ownership in the corridor versus 20 percent ownership yielded three times more revenue. In the long run it is likely that new vehicles would be available equipped with integrated toll collection devices, and hand-held "smart phones" or their future equivalent will substitute as transponders for many different types of automated transactions, increasing the effective ownership rate for transponders. Until then, however, having more people with transponders will translate into more people able to use the express toll lanes.

Traffic growth drives revenue growth. While this is another obvious statement, it comes with more nuanced implications. Revenue growth will grow much faster than traffic growth because more corridor traffic demand will yield more corridor congestion and higher time savings provided by the express toll lanes. This in turn will drive up the toll rates to maintain the speed policy, which has enormous leverage on revenue. For example, for the median *HOV 3+* scenario, we forecast the average toll rate paid to increase by approximately 45 percent between 2018 and 2030, without any adjustment for inflation. However, the overall traffic demand in the corridor is only forecast to increase by 12.6 percent.

Demand will exceed capacity. We found that future traffic demand will exceed capacity, meaning that some demand will not be fully served. This means that some traffic may find other destinations or use different routes, beyond the levels that are captured in our models. Some revisions to the project design could enable more traffic throughput, but overall, we expect there to be unserved demand.

Complex system of frequent access. The proposed express toll lane system has access points an average of every 1.5 miles. This will cause frequent weaving that will have an effect on corridor performance and express lane utilization. Relative to the WSDOT findings, our analysis found a higher percentage of qualified HOV electing *not* to use the express lane for shorter trips.

***HOV 2+ Free* operations.** We found little difference between the management scenarios (*HOV 2+ free*, *HOV 3+ free*, and *Mixed*), with the *HOV 2+ free* scenario providing slightly better performance. However, managing the express toll lane is based on increasing toll rates to discourage paying customers from using the system in order to maintain the quality of flow. The percent of *HOV 2+ free* vehicles in the system is approaching 20 percent today. However, the express toll lane system will restrict ingress to and egress from the special lanes, meaning that some HOV 2 may not be able to get to the new express toll lane system because of their on and off locations (e.g., they need to get off before there is a convenient egress point). The pricing mechanism will not discourage toll-exempt vehicles. If there are too many toll exempt vehicles, WSDOT will not be able to manage traffic flow to the desired speed – 45 mph 90 percent of the time in the peak hours. Our modeling does not address 100 percent of the conditions that could occur over the course of a year. Reducing the number of toll-exempt vehicles by changing the HOV definition to three or more increases WSDOT's ability to manage traffic demand and maintain a reliable speed in the express toll lanes.

Complex interaction between express toll lanes and general purpose lanes. The operations of the express toll lanes cannot be fully isolated from the operations of the general purpose lanes. If a breakdown occurs in the general purpose lane and backs up traffic, blocking the access to and from the express toll lanes, then the express toll lanes could come to a standstill even though the traffic in the express toll lanes may not be high enough to be performing poorly. It will be important to consider improving bottlenecks in the general-purpose lanes and/or modifying express toll lane access to ensure that the express toll lanes operate as intended. Normal operations practices, including rapid incident detection and clearance, are important elements of an optimized system of express and general purpose lanes.

1.0 Introduction

1.1 Study Purpose and Objectives

The Washington State Department of Transportation (WSDOT) has evaluated numerous design and operational alternatives in the I-405/SR 167 corridor (the Eastside Corridor) over the past decade. A January 2010 study[7] evaluated five corridor alternatives and recommended Option 4 (described below) involving express toll lanes for implementation. The Eastside Corridor was evaluated by an expert review panel.[8]

This report documents an independent traffic and revenue study for the proposed Express Toll Lanes on I-405 and SR 167 as directed by the Legislature in EHB 1382 (Section 4 1) (a)). The bill directs the Transportation Commission to "*…retain appropriate independent experts and conduct a traffic and revenue analysis for the development of a 40-mile continuous express toll lane system that includes state route number 167 and Interstate 405. The analysis must include a review of the following variables within the express toll lane system:*

i. Vehicles with two or more occupants are exempt from payment;

ii. Vehicles with three or more occupants are exempt from payment;

iii. A variable fee; and

iv. A flat rate fee."

> ***What are Express Toll Lanes?***
>
> *Express toll lanes are built adjacent to regular freeway lanes (called "general purpose lanes"). Drivers may use these lanes for free if they are an authorized user (either a transit vehicle or high-occupancy vehicle of a particular number of travelers) or by paying a toll. The idea is that people pay to use these lanes when they really have to be somewhere quickly.*
>
> *What makes express toll lanes work is that the price is set to ensure speeds of 45 miles per hour or better. Prices can be set dynamically, meaning they change in real time based on actual traffic levels, or they may be variable, changing according to a fixed time-of-day schedule based on historical traffic patterns.*

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[7] Washington State Department of Transportation, *Eastside Corridor Tolling Study*, January 2010. Available at http://www.wsdot.wa.gov/Tolling/EastsideCorridor/Report.htm (last accessed August 31, 2012).

[8] Washington State Department of Transportation, *I-405/SR 167 Corridor Tolling Study – Expert Review Panel, Final Report*, December 2010. Available at http://www.wsdot.wa.gov/NR/rdonlyres/EBD4BC88-9606-4388-92BA-B862AA566CEC/72822/405ExpertReviewFinalReport_a.pdf (last accessed September 6, 2012).

Cambridge Systematics was retained by the Washington State Transportation Commission (the Commission) to conduct this traffic and revenue study aimed at providing answers to the following questions:

- Are the Express Toll Lanes a workable solution to manage mobility in the I-405/SR 167 corridor?
- What range of revenue will they generate?
- How will Express Toll Lanes impact traffic operations?

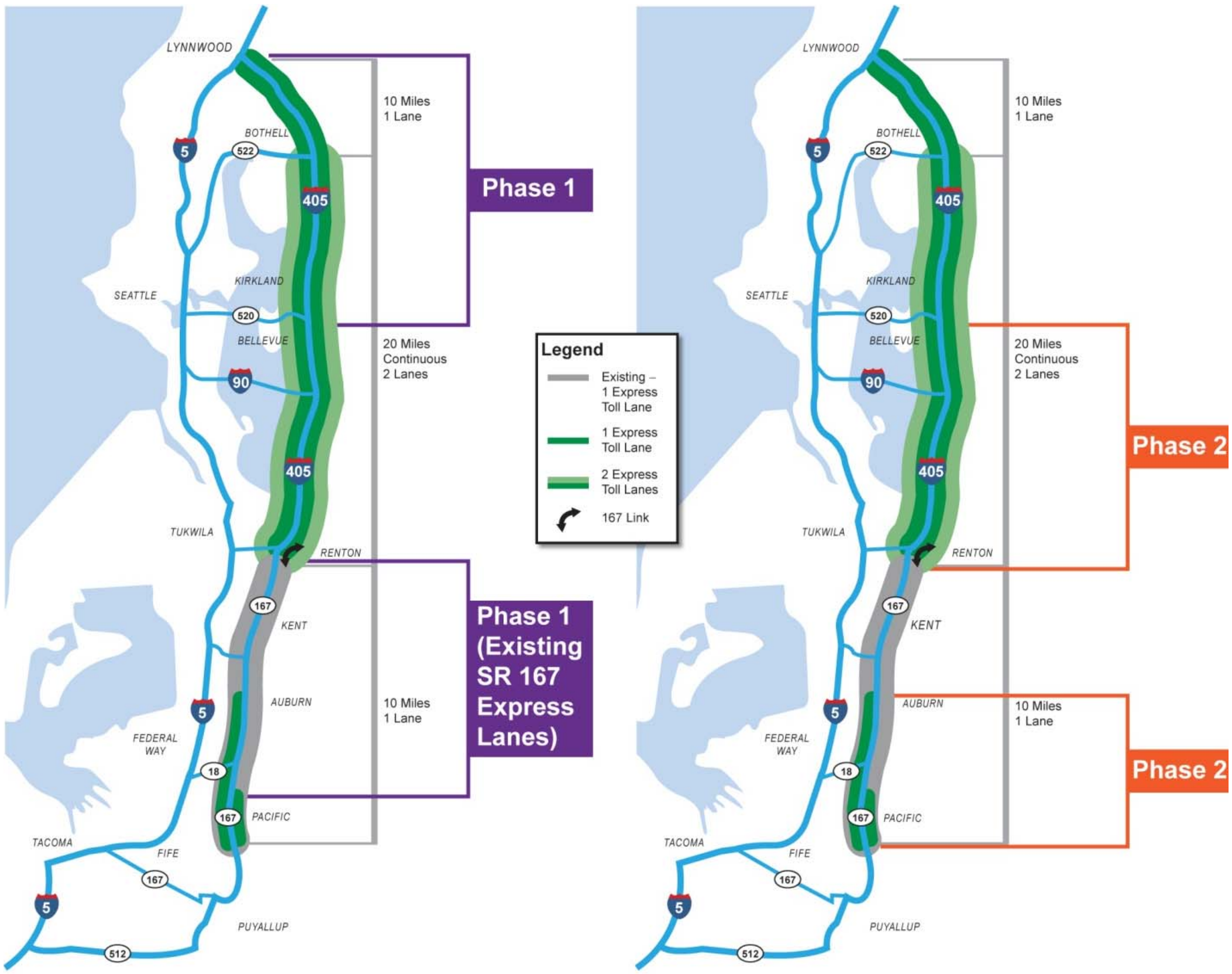
In addition to the Commission's independent traffic and revenue analysis, the legislation also requires WSDOT to develop a finance plan to fund improvements on the I-405/SR 167 corridor. The finance plan is a separate document that will be issued by WSDOT and it is not part of this report. EHB 1382 also requires that WSDOT and the Commission consult with a committee consisting of local and state elected officials from the I-405/SR 167 corridor and representatives of from corridor transit agencies while developing the finance plan and performance standards. The finance plan and consultation process are separate efforts that will use the gross toll revenue forecasts from this independent study.

1.2 Project Description

The proposed Eastside Corridor Express Lanes project would implement a 40-mile Express Toll Lane system on I-405 and SR 167, from I-5 in Lynnwood in the north to the King/Pierce County line in the south [9] (see Figure 1.1). The corridor would consist of one to two express toll lanes per direction, with two to three existing general purpose lanes per direction.

[9] Washington State Department of Transportation, *Eastside Corridor Tolling Study*, January 2010. Available at http://www.wsdot.wa.gov/Tolling/EastsideCorridor/Report.htm (last accessed August 31, 2012).

Figure 1.1 Project Phasing



The project would be built in two phases. Phase 1, opening in the year 2014, would supplement the existing SR 167 Express Toll Lanes with new Express Toll Lanes on I-405 from NE 6th Street (downtown Bellevue) north to I-5 in Lynnwood (referred to as Area North, see Figure ES.2). This phase of the project would add two Express Toll Lanes in each direction between SR 520 and SR 522, and one Express Toll Lane in each direction from SR 522 to I-5.

Phase 2, opening in the year 2018, would complete a forty-mile corridor extending from I-5 in Lynnwood to Stewart Road SE in Pacific. This Phase closes the Express Toll Lane gap on I-405 between downtown Bellevue and SR 167 (referred to as Area Middle,) adding two Express Toll Lanes in each direction in that segment. It also includes direct Express Toll Lane connections between SR 167 and I-405, and extends the existing SR 167 Express Toll Lane slightly further to the south. The SR 167 Express Toll Lanes are referred to as Area South.

1.3 WSDOT's Concept of Operations

Most express toll lanes are relatively short (less than 20 miles) and have only a few opportunities to get into and out of the lanes. The proposed I-405 Eastside Corridor express toll lanes would be 40 miles long, and have access points on average every 1.5 miles. WSDOT developed a tolling concept consisting of three levels of "geography" within the corridor, from longest to shortest (see Figure 1.2):

- Three toll areas. These are essentially three independent express toll lane facilities:
  - Toll Area South: SR 167;
  - Toll Area Middle: I-405 south of Downtown Bellevue; and
  - Toll Area North: I-405 north of Downtown Bellevue.
- Nine "toll zones." Each toll area is made up of three toll zones, labeled from A through I; and
- Segments. "Segments" describe the highway that stretches from one ingress/entrance point to the next egress.

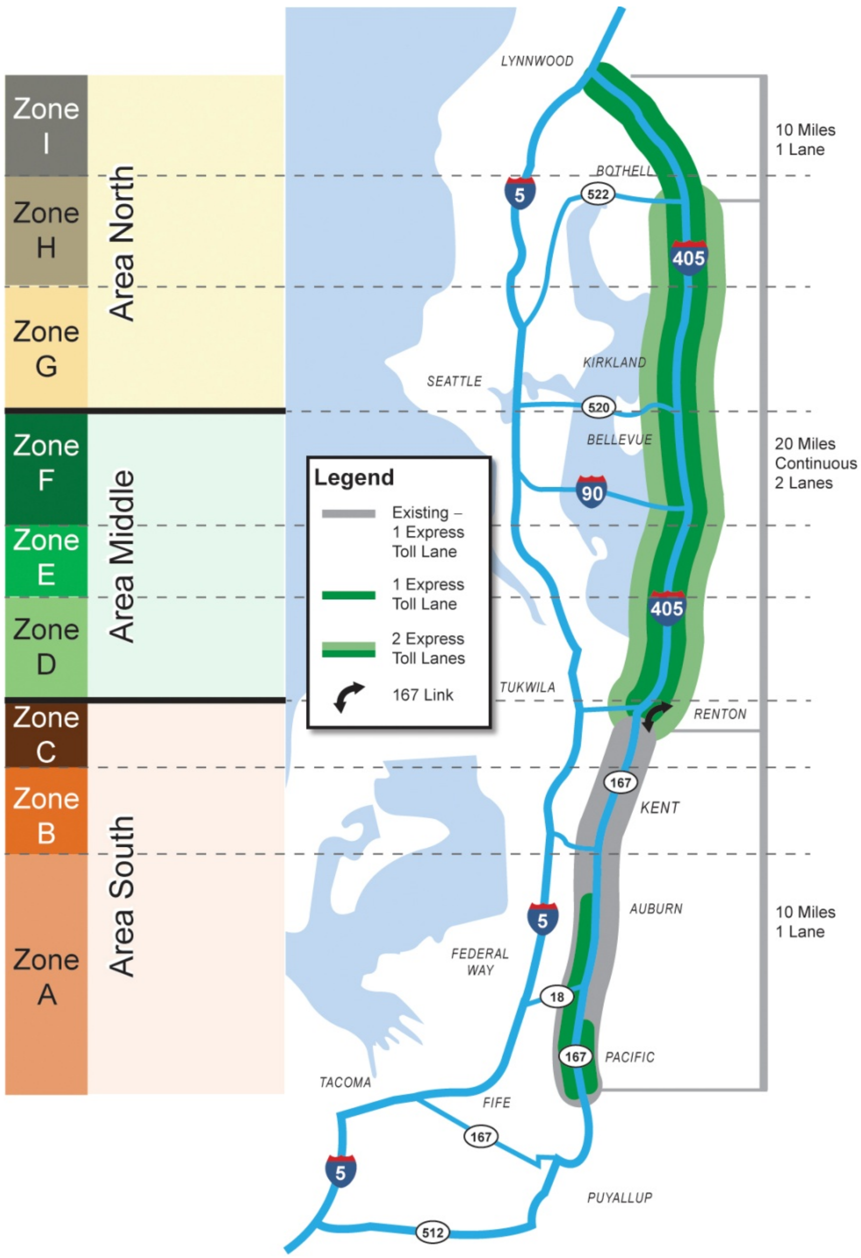
Toll rates would be posted for each ingress/entrance location for up to three downstream destinations within a single tolling area. The price would be based on a measure of speed and volume conditions on the way to the destination, with the intent of achieving the toll setting policy (45 mph, 90 percent of the time during peak period). Only holders of *Good to Go!* electronic toll devices would be eligible to use the express toll lanes, and carpools would be required to have a declarable pass to receive discount/exemption. Vehicles over 10,00 gross vehicle weight will be excluded from the Express Toll Lanes.

Under the dynamic tolling scenario, toll rates would be adjusted every five minutes. Toll rates will be changed in increments of $0.25. The minimum toll will be $0.50 (in 2012 dollars) when Phase 1 opens in 2014. When Phase 2 opens in 2018, the minimum toll will be $0.72 per toll area (in 2012 dollars)[10], with no maximum toll. In Phase 1, the Express Toll Lanes on SR 167 will continue operating from 5:00 a.m. to 7:00 p.m.; the new Express Toll Lanes on I-405 from Bellevue to Lynnwood will operate from 5:00 a.m. to 8:00 p.m. When Phase 2 opens the I-405/SR 167 Express Toll Lanes will operate seven days a week, from 5:00 a.m. to 8:00 p.m.

[10]Our analysis was done in 2012 dollars, with escalation due to inflation handled in WSDOT's financial plan. This means that minimum toll rates in the future are assumed to rise over time. This might equate to $0.83 in 2018, assuming an inflation rate of 2.5 percent per year.

Signs will show toll rates for the last egress/exit point for each of the three toll zones within a toll area. Rates for the next tolling area will be displayed just before a decision point to continue onto the next segment or exit the express toll lanes.

Figure 1.2 Levels of "Geography" – Toll Zones and Toll Areas

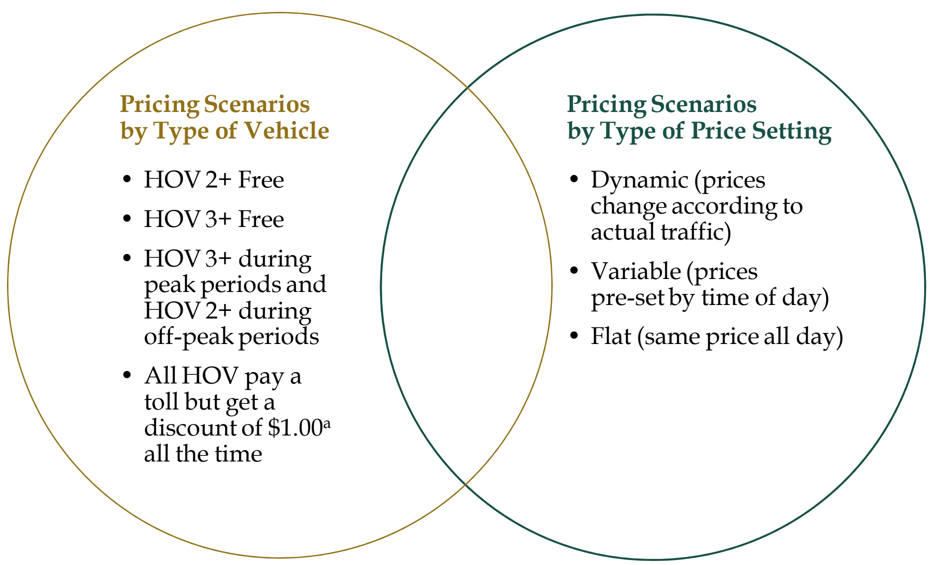


■ 1.4 Pricing Scenarios

The legislation directed that this study evaluate a range of pricing scenarios by the types of vehicles that travel free (HOV 2+ or 3+), and by how the prices are set (dynamic versus variable versus flat). CS worked with Commission staff to discuss the legislative intent of the options described in the bill and constructed an approach to address that intent.

There are many ways to set prices in express toll lanes, revolving around who has to pay tolls and how the toll rates are set to maintain reliable traffic flow (see Figure 1.3). Mixing and matching all possible options led to an unmanageable number of permutations. Therefore, we focused our quantitative analysis on the dynamic price-setting as directed by legislation, studying the first three pricing scenarios by type of vehicle in detail, and conducting a sensitivity test for a *HOV discount* option. Then, we conducted sensitivity tests of the other price-setting options: variable and flat.

Figure 1.3 Pricing Scenarios



[a] The HOV discount is $1.00 in 2014 dollars, assuming an annual inflation rate of 2.5 percent.

Pricing Scenarios by Type of Vehicle

This traffic and revenue study included analysis of the following pricing scenarios by vehicle type, for forecast years 2014, 2018, and 2030:

- *HOV2+ free* – All single occupancy vehicles (SOV) pay a toll to use the express lanes. Vehicles with two or more occupants are exempt.
- *HOV3+ free* – Vehicles with two passengers or less (i.e., SOV and HOV2) pay a toll to use the express lanes. Vehicles with three or more occupants use the facility at no cost.
- HOV3+ free during the peak periods and HOV2+ free during off-peak periods (*Mixed*) – During the peak hours (in the AM and PM) vehicle with three or more occupants can use the managed lanes are exempt from the toll to use the manage lanes. The exemption extends to HOV2 during the off-peak hours.
- *HOV+ discount*, where all HOVs get a discount of $1.00 (2014 dollars).

Pricing Scenarios by Type of Price Setting

The rate structure was evaluated per EHB 1382, including:

- *Dynamic pricing*, where toll rates change frequently in real time to reflect demand on the managed lanes;
- *Variable pricing*, where toll rates vary through a fixed time-of-day fee schedule based on historical traffic patterns (similar to that used on SR 91 in Orange County, California); and
- A *flat fee*, where a single toll rate is charged regardless of time of day or day.

1.5 Express Toll Lane and Willingness to Pay Experience Around the United States

Express Toll Lane Experience

There are 11 operating express toll lane projects in the United States with a variety of characteristics that can dramatically change the usage and revenue potential. Some of the more important characteristics are:

- Number of express lanes, usually one or two, sometimes reversible;
- Hours of operation;
- Exempt vehicles (usually 2+ or 3+ HOV, transit vehicles, and sometimes others); and
- Toll setting mechanism, either variable dynamic based on actual traffic conditions or variable with a published rate schedule based on historical traffic patterns.

Differences in these characteristics can make the difference between a project that barely covers operating expenses and one that has excess revenue to contribute to new capital investments or transit services. Existing HOT lanes facilities in the United States are relatively short (less than 20 miles) compared to the proposed Eastside Corridor. None of the existing HOT lane facilities are alike, making it difficult to draw comparisons and conclusions about general HOT lane characteristics that might be applicable to the Eastside Corridor.

For the most part, Express Toll Lane projects are built for their traffic management characteristics—the ability to maintain a free-flowing, reliable path at all times—rather than their ability to fund project construction. Most yield enough revenue to cover operating expenses, and some also contribute funds to corridor transit operations or to repay some capital expenses. There is one notable exception for project that have been opened to traffic.

The first Express Toll Lane--the SR 91 Express in Orange County California opened in 1995—was a public-private partnership where the government donated the right of way while the concessionaire was responsible designing, building, financing and operating two Express Toll Lanes in each direction. The project financing relied on toll revenue, and when the Orange County Transportation Authority bought the project in 2003, the concessionaire earned a profit.

There are several other projects that are under development that have used toll revenue to support debt:

- The I-495 Capital Beltway HOT Lanes, 14 miles of new construction of two new Express Toll Lanes in each direction in the Washington, D.C. region. Toll revenue is backing private activity bonds and TIFIA[11] bonds, representing close to 60 percent of the total project cost of $2 billion. The project is expected to open in 2013.
- North Tarrant Express, new Express Toll Lanes of about 13 miles in Tarrant County, Texas. About half the project cost was financed with private activity and TIFIA bonds.
- I-635 (LBJ Freeway) Managed Lanes, a $2.7 billion Express Toll Lane project in the Dallas, Texas area with 40 percent of the financing supported by private activity and TIFIA bonds.

None of these projects are open to traffic, so we cannot comment on the financial outcomes.

[11] TIFIA is the Transportation Infrastructure Finance and Innovation Act of 1998. It provides Federal credit assistance in the form of direct loans, loan guarantees, and standby lines of credit to finance surface transportation projects of national and regional significance.

Table 1.1 summarizes key characteristics of existing HOT lane facilities. These facilities are listed chronologically, by year of implementation. Further details are provided in the technical memorandum included in Appendix B.[12]

Willingness to Pay

Drivers' willingness to pay tolls is one of the most important factors when forecasting traffic and revenue for managed lanes. A driver's willingness to pay to use an express toll lane is based on a combination of the perceived travel time savings, perceived travel time reliability, and other factors such as perceptions of safety or desire for a premium travel experience. Since most express toll lanes do not display a travel time comparison between the express toll lane and the adjacent general purpose lanes, people must make their choice based on their expectations of conditions derived from their previous experience. There is a high level of uncertainty in these predictions, and drivers must make their choices relatively quickly based on imperfect information such as visual cues of traffic backups and traffic reports that might be available through the broadcast media or in-vehicle traffic information displays.

These uncertainties, combined with the fact that people's willingness to pay tolls varies based on the specific circumstances of each trip, make forecasting traffic and revenue for express toll lanes particularly challenging. For each circumstance, a traveler will make an internal calculation as to whether it is worthwhile to pay a toll. That calculation involves their estimate of how much time they will save, or how much they value the reliability of knowing with near certainty how long their trip will take.

There are three approaches to get at drivers' willingness to pay:

1. Through stated-preference (SP) surveys, which test drivers' reactions to different hypothetical conditions;

2. Through revealed-preference (RP) surveys, which measure the actual choices that people made, but do not have the ability to probe how that decision would be different under different circumstances; and

3. Through direct measurement of travel times savings compared to the toll rates paid, which indicates the lowest level of the value of travel time savings.

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[12] Cambridge Systematics, Inc. , *Eastside Corridor Independent Traffic and Revenue Study: Review of Available Data and Methods – Technical Memorandum*. Prepared for the Washington State Department of Transportation. December 2011.

Table 1.1 Characteristics of Existing Express Toll Lane Facilities

Name of Express Toll Lane Project	SR 91 Express	I-15 FasTrak	Northwestern (U.S. 290) Expressway	I-394 MnPASS Express Lanes
Location	Orange County, California	San Diego and Escondido, California	Houston, Texas	Minneapolis, Minnesota
Year Implemented	1995	1996	2000	2005
Length (Miles)	10	16	15.5	11
Number of Express Toll Lanes	2 in each direction	Existing: 2 lanes reversible After expansion: lanes (2+2 or 3+1 configuration)	1 reversible	West: 1 in each direction; East: 2 lane reversible
Hours of Operation	24/7	24/7	5:00-11:00 a.m. 2:00-8:00 p.m. 6:45-8:00 a.m. HOV2+ pay toll	6:00-10:00 a.m. 2:00-7:00 p.m. M-F In peak direction only
Vehicle with Free Access to HOT Lanes	HOV3+ Buses Motorcycles Emergency vehicles Zero emission vehicles Disabled license plates HOV3+ pay 50% of posted toll rate M-F, 4:00-6:00 p.m. eastbound	HOV2+ Buses Motorcycles Low-emission vehicles (with permit)	HOV2+ (except 6:45-8:00 a.m.) HOV3+ (all times) Buses Motorcycles Emergency vehicles	HOV2+ Buses Motorcycles
Tolling Strategy	Time of day	Dynamic pricing	Flat toll	Dynamic pricing
Frequency of Price Change with Dynamic Pricing	N/A	Every 3 minutes	N/A	Every 3 minutes
Toll Charged (Minimum/ Maximum)	$1.30/$9.75	$0.50/$8.00	$2.00	$0.25/$8.00 (by section)
Annual Toll Revenue	$35.7 million	$2.8 million	N/A	$1.96 million (includes I-35W)
Annual O&M Expenses (Excluding Debt Service)	$22.4 million	$2.4 million	N/A	$1.94 million (includes I-35W)
Ratio of O&M Expenses/Revenue	0.63	0.86	N/A	0.99
Share of Paying/ "Free" Vehicles, Peak Period/ Peak Direction per Lane	80%/20%	32%/68%	N/A	37%/63% (includes I-35W)
Share of Daily Paying/ "Free" Vehicles	77%/23%	15%/85%	N/A	48%/52% (includes I-35W)

Table 1.1 Characteristics of Existing Express Toll Lane Facilities (continued)

Name of Express Toll Lane Project	I-25 Express Lanes	SR 167	I-95 Express	Katy Managed Lanes (I-10)
Location	Denver, Colorado	Puget Sound Region, Washington	Miami-Dade County, Florida	Houston, Texas
Year Implemented	2006	2008	2008	2009
Length (Miles)	7	8 miles (southbound) 11 miles (northbound)	9	12
Number of Express Toll Lanes	2, reversible	1 in each direction	2 in each direction	2 in each direction
Hours of Operation	5:00-10:00 a.m. southbound; 12:00 p.m.-3:00 a.m. northbound	5:00 a.m.-7:00 p.m.	24/7	24/7
Vehicle with Free Access to HOT Lanes	HOV2+ Buses Motorcycles Low-emission vehicles Emergency vehicles	HOV2+ Buses Motorcycles Emergency vehicles	Registered HOV3+ Buses Motorcycles Low-emission vehicles Emergency vehicles	HOV2+ Buses Motorcycles Emergency vehicles During "HOV hours" 5:00-11:00 a.m. 2:00-8:00 p.m. for EZ Tag Motorcycles free only during HOV hours
Tolling Strategy	Time of day	Dynamic pricing	Dynamic pricing	Time of day
Frequency of Price Change with Dynamic Pricing	N/A	Every 5 minutes	Every 15 minutes, based on HOT lane congestion	N/A
Toll Charged (Minimum/ Maximum)	$0.50/$4.00	$0.50/$9.00	$0.25/$7.00	$1.00/$4.00 (full length)
Annual Toll Revenue	$2.5 million	$600,000	$15 million	$6.7 million
Annual O&M Expenses (Excluding Debt Service)	$1.3 million	N/A	$6.2 million	$2.8 million
Ratio of O&M Expenses/Revenue	0.52	N/A	0.41	0.42
Share of Paying/ "Free" Vehicles, Peak Period/Peak Direction per Lane	44%/56%	32%/68% (NB) 22%/78% (SB)	N/A	56%/44%
Share of Daily Paying/ "Free" Vehicles	44%/56%	15%/85%	N/A	68%/32%

Table 1.1 Characteristics of Existing Express Toll Lane Facilities (continued)

Name of Express Toll Lane Project	I-35W MnPASS Express Lanes	I-680	I-85 Express Lanes
Location	Minneapolis, Minnesota	Alameda County, California	Gwinnett County, Georgia
Year Implemented	2009	2010	2011
Length (Miles)	16 (completed) 2 (under construction)	14	16
Number of Express Toll Lanes		1, southbound only	1 in each direction
Hours of Operation	6:00-10:00 a.m. 2:00-7:00 p.m. M-F	5:00 a.m.-8:00 p.m. M-F	24 hours
Vehicle with Free Access to HOT Lanes	HOV2+ Buses Motorcycles	HOV2+ Buses Motorcycles	HOV3+ Motorcycles Buses Alternative Fuel Vehicles (AVF) with proper AVF license
Tolling Strategy	Dynamic pricing	Dynamic pricing	Dynamic pricing
Frequency of Price Change with Dynamic Pricing	Every 3 minutes	N/A	Every 5 minutes
Toll Charged (Minimum/ Maximum)	$0.25/$8.00 (by section)	$0.30 (off-peak) $1.00 (peak)/$6.00	$0.16 to $14.40 (full length)
Annual Toll Revenue	$1.96 million (includes I-394)	N/A	N/A (opened in October 2011)
Annual O&M Expenses (Excluding Debt Service)	$1.94 million (includes I-394)	N/A	N/A (opened in October 2011)
Ratio of O&M Expenses/Revenue	0.99	N/A	N/A
Share of Paying/ "Free" Vehicles, Peak Period/Peak Direction per Lane	37%/63% (includes I-394)	N/A	82%/18%
Share of Daily Paying/ "Free" Vehicles	48%/52% (includes I-394)	N/A	82%/18% (eight month average, October 2011 through May 2012)

Sources: Cambridge Systematics analysis and summary of HOT Projects survey information from The Urban Transportation Monitor, August 29, 2011, Volume 25 No. 6, pages 15-19. Information on I-680 was compiled from http://www.680expresslane.org/Home.asp. Information on I-85 Express Lanes was compiled from http://www.peachpass.com/peach-pass-toll-facilities/about-i-85-express-lanes and the Georgia State Road and Tollway Authority.

The common value in all these studies comes down to value of time (VOT). Most studies report value of travel time savings, while others attempt to quantify the value of reliability as well. Table 1.2 summarizes studies of value of time for express toll lanes from the last decade.

Table 1.2 Value of Time (VOT) Summary from Recent Literature *2001-2011*

Author(s)	Year	Corridor(s)	Data Source Used	VOT Estimation Method	VOT (Dollars per Hour)	VOT as Percent of Wage
Ghosh	2001	I-15	RP/SP[a]	Conditional logit model	$15-$17 (SP) $20-51 (RP)	26-91%
Brownstone and Small	2004	Orange County, California SR 91 San Diego, California I-15	RP/SP	Review of VOT estimation from 15 studies between 1998 and 2003	$20-$40 (RP) $4-$16 (SP)	50-90% (RP)
Tilahun and Levinson	2009	I-394 MnPASS	SP	Logit model	$10-$25 (SP)	N/A
Burris, Devarasetty, and Shaw	2011	Houston, Texas – Katy Freeway	SP	Multinomial logit model	N/A	40-50%
Burris, Devarasetty, and Shaw	2011	Houston, Texas – Katy Freeway	SP	Mixed logit model	N/A	63-132%
Burris, Devarasetty, and Shaw	2011	Houston, Texas – Katy Freeway	SP	Mixed logit model	$22	65%
Burris, Devarasetty, and Shaw	2011	Houston, Texas – Katy Freeway	Vehicle Sensor	Speed/volume data	$51	N/A
Patil, Burris, and Shaw	2011	Houston, Texas – Katy Freeway	SP	Mixed logit model		20-40%
Shaw, Patil, Burris, and Concas	2011	Houston, Texas – Katy Freeway	SP	Mixed logit model	$7.4-$8.6 (ordinary situation) $8-$47.5 (urgent situations)	N/A

[a] RP = Revealed Preference; SP = Stated Preference

Clearly, there is a wide variation in observed and anticipated experience with respect to the value of time in the context of express toll lanes. There are shortcomings to all analysis methods, and the uncertainty inherent in how much travel time drivers will actually save further complicates matters. This past experience supports CS' approach to estimating traffic and revenue on the Eastside Corridor:

- A new stated-preference survey was conducted in the corridor to provide a point of comparison to similar surveys done prior to the recession of 2007/2008;
- The cost coefficients in the toll choice component of the VISSIM simulation model were calibrated to actual conditions observed on SR 167 express toll lane; and
- A range of values from plus/minus 25 percent around the calculated values was used in the risk analysis.

2.0 Corridor Conditions and Trends

Cambridge Systematics obtained and reviewed traffic data for the Eastside Corridor from WSDOT to provide a thorough understanding of corridor traffic conditions and to inform the analytical methods for forecasting express toll lane usage. We evaluated:

- Annual traffic trends;
- Travel times in both the general purpose and managed lanes;
- Traffic and revenue experience to-date on the existing SR 167 express toll lanes; and
- Traveler value of time in the Eastside Corridor.

2.1 Annual Traffic Trends

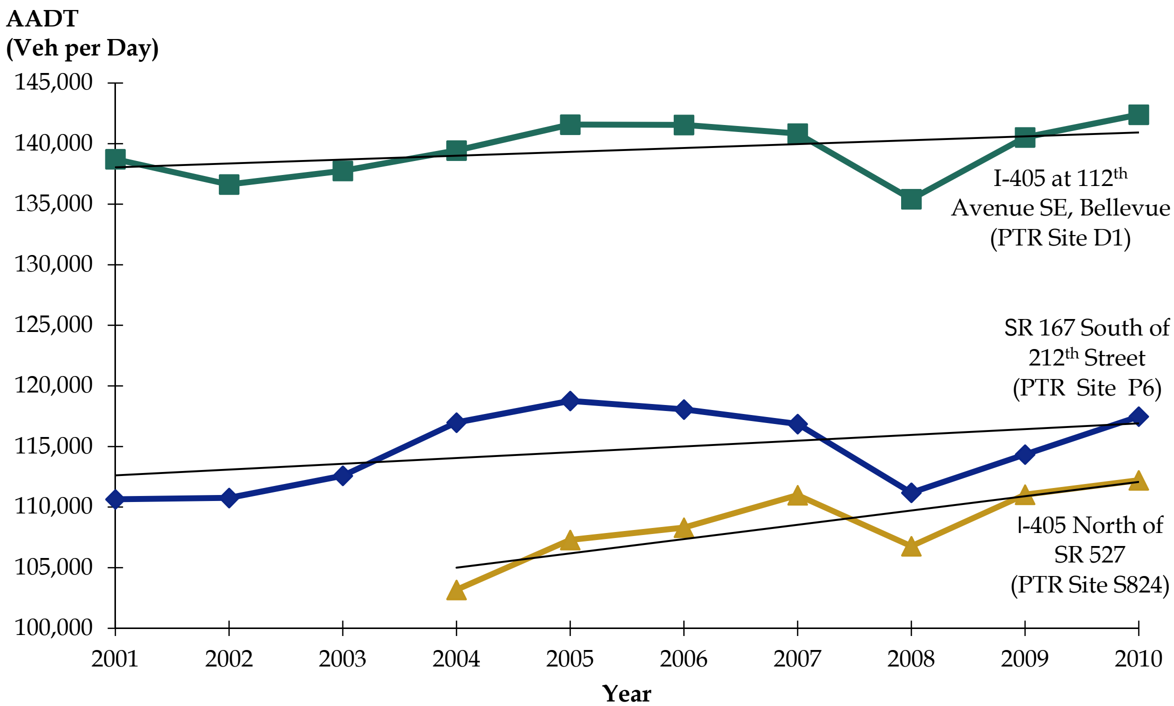
CS reviewed trends in Annual Average Daily Traffic (AADT) from 2001 through 2010 at the following sites along the Eastside Corridor that had permanent traffic recorders (PTR):

- SR 167 north of South 212th Street (PTR site P6);
- I-405 at 112th Avenue SE, Bellevue (PTR site D1); and
- I-405 North of SR 527 (PTR site S824).

All three locations showed sharp growth in average daily traffic volumes between 2002 and 2005, with growth at the northern location (I-405 north of SR 527) continuing through 2007 (Figure 2.1).[11] AADT growth stalled in the second half of the decade, with a significant drop in 2008, coinciding with the Great Recession. By 2010, traffic recovered to the higher values of a few years prior.

[11] Data is not available for the I-405 north of SR 527 location from 2001 to 2004.

Figure 2.1 Annual Average Daily Traffic (AADT) Trends at Selected Locations in the Eastside Corridor, 2001-2010



Source: WSDOT Annual Traffic Report.

■ 2.2 Average Travel Times in General Purpose and Managed Lanes in the Corridor

CS examined travel time data along the corridor in the general purpose lanes and the managed lanes. We analyzed travel times and time savings on I-405 and SR 167 separately in the subsections below. Note that the I-405 managed lane is an HOV lane, while some of the SR 167 managed lane operates as express toll lanes.

I-405 Travel Times. Table 2.1 displays the average travel times on I-405 for both the general purpose lanes and HOV lanes in both directions, including the average hourly travel time savings achieved by the HOV lanes in the different time periods. We found that:

- The HOV lanes consistently provide quicker travel times than the general purpose lanes.
- The largest average hourly time savings is about 14 minutes, which occurred during 5:00 p.m. to 6:00 p.m. for both directions.

Table 2.1 Average Weekday Travel Times, Travel Time Savings, and Speeds on I-405 by Hour in 2010

			General Purpose Lanes		HOV Lane		
Direction	Peak Period	Hour	Total Travel Time (Minutes)	Average Speed (MPH)	Total Travel Time (Minutes)	Average Speed (MPH)	Time Saved in HOV Lane (Minutes)
Northbound	**A.M.**	5	28.7	61	26.6	66	2.0
		6	31.1	56	27.7	63	3.5
		7	35.1	50	29.0	60	6.1
		8	35.9	49	29.1	60	6.7
		9	34.4	51	28.6	61	5.8
		10	31.5	55	27.8	63	3.8
	P.M.	1	30.4	57	27.5	63	2.9
		2	31.7	55	27.9	63	3.8
		3	36.8	47	29.2	60	7.6
		4	44.9	39	32.4	54	12.5
		5	47.8	37	33.9	52	13.9
		6	36.7	48	29.6	59	7.1
Southbound	**A.M.**	5	28.7	61	27.6	63	1.1
		6	33.5	52	28.8	61	4.7
		7	44.6	39	31.5	55	13.1
		8	43.2	40	31.3	56	11.9
		9	35.9	49	29.4	59	6.5
		10	31.6	55	28.4	62	3.2
	P.M.	1	32.8	53	28.5	61	4.3
		2	36.1	48	29.4	59	6.8
		3	41.0	43	31.2	56	9.9
		4	45.6	38	33.4	52	12.2
		5	48.4	36	34.0	51	14.4
		6	40.4	43	31.1	56	9.3

SR 167 Travel Times. For the 10.8 miles in the northbound direction and the 6.6 miles in the southbound direction, we found that, on average (Table 2.2):

- The express toll lane on SR 167 did not provide a significant saving in time over the general purpose lanes. For many periods, the savings was less than one minute.
- The 7:00 a.m. to 8:00 a.m. period offers the greatest travel time savings for the northbound direction with a savings of four minutes in the express lanes.
- The maximum time savings in the southbound direction was 1.8 minutes from 3:00-5:00 p.m.

Table 2.2 Average Weekday Travel Times, Travel Time Savings, and Speeds on SR 167 by Hour in 2010

			General Purpose Lanes		Express Toll Lanes		
Direction	**Peak Period**	**Hour**	**Total Travel Time (Minutes)**	**Average Speed (MPH)**	**Total Travel Time (Minutes)**	**Average Speed (MPH)**	**Time Saved in Express Toll Lanes (Minutes)**
Northbound	**A.M.**	5	11.1	58	10.0	64	1.1
		6	13.1	49	10.5	62	2.6
		7	15.1	43	10.9	59	4.2
		8	13.1	49	10.5	62	2.6
		9	11.6	56	10.2	63	1.4
		10	11.2	57	10.1	64	1.1
	P.M.	1	11.1	58	10.1	64	1.0
		2	11.2	58	10.1	64	1.1
		3	11.4	56	10.1	64	1.3
		4	11.5	56	10.2	63	1.3
		5	11.3	57	10.2	64	1.1
		6	10.7	60	10.0	65	0.7
Southbound	**A.M.**	5	6.4	62	6.2	64	0.2
		6	6.5	61	6.2	64	0.3
		7	6.6	60	6.3	63	0.3
		8	6.6	60	6.3	63	0.4
		9	6.6	60	6.3	63	0.4
		10	6.7	59	6.4	62	0.3
	P.M.	1	6.9	58	6.6	60	0.3
		2	8.0	49	6.8	58	1.2
		3	8.7	46	6.9	57	1.8
		4	8.7	46	6.9	57	1.8
		5	8.5	46	6.8	58	1.7
		6	7.4	54	6.6	61	0.8

2.3 State Route 167 Express Toll Lane Evaluation

CS examined the usage characteristics of the SR 167 Express Toll Lane pilot project, with the aim to:

- Evaluate the relationship between daily and annual revenue;
- Evaluate the relationship between VMT and revenue; and
- Evaluate the utilization of SR 167 managed lane.

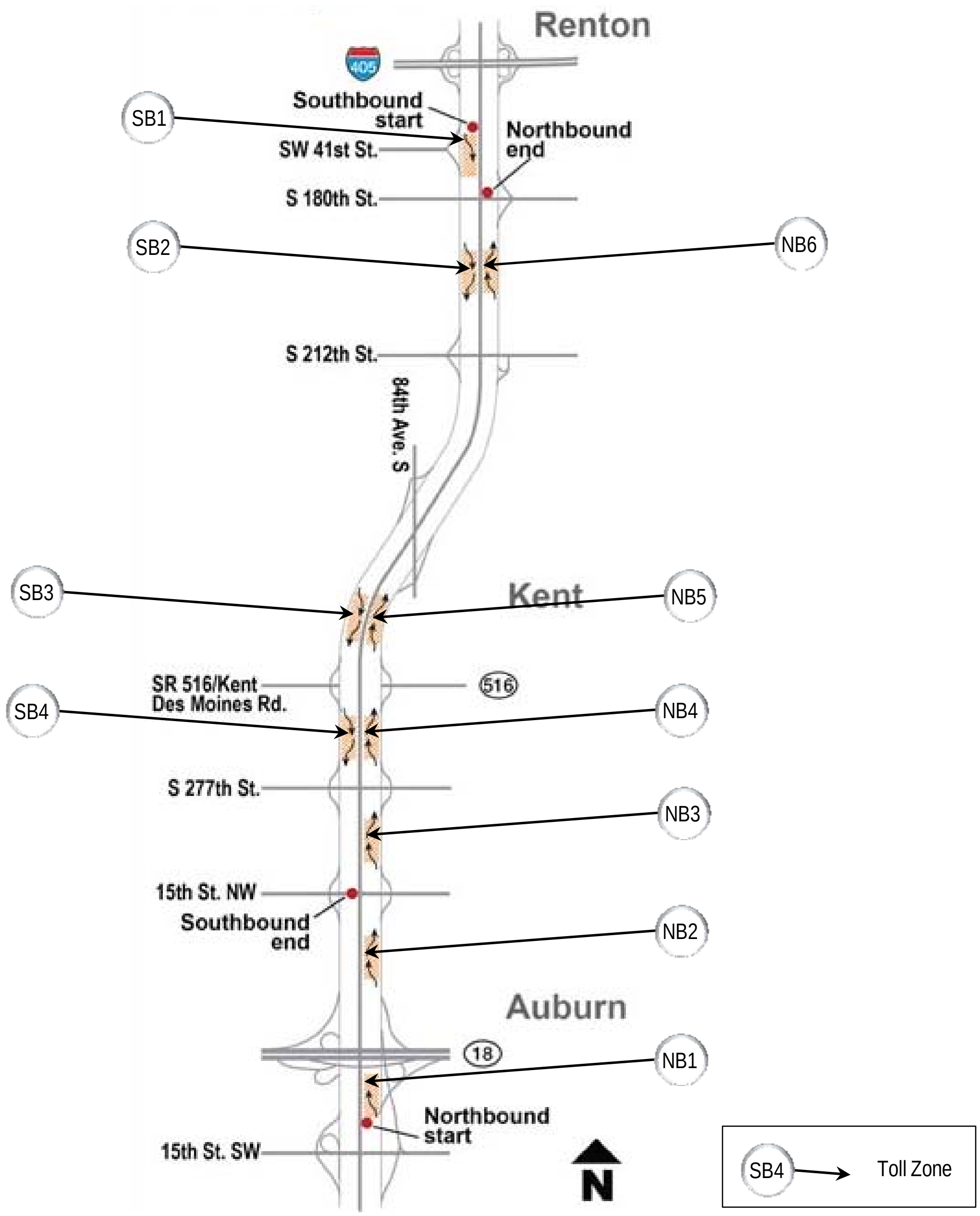
Existing SR 167 Express Toll Lanes Concept of Operations

WSDOT implemented the SR 167 Express Toll Lanes pilot program to learn how express toll lanes and other forms of variable tolling could be used in Washington State to make the highways operate more efficiently. WSDOT operates the express toll lanes to achieve a performance standard of 45 mph or faster at least 90 percent of the time during peak periods in the express toll lanes.

Existing SR 167 Express Toll Lanes Tolling Zones

There are six access points within the SR 167 express toll lanes lane corridor in the northbound direction over 10.76 miles, and four access points in the southbound direction covering 6.61 miles (Figure 2.2). Toll zones were constructed based on these access points as shown in Table 2.3.

Figure 2.2 SR 167 Express Toll Lanes – Existing Access Points



Source: WSDOT at: http://www.wsdot.wa.gov/Tolling/SR167HotLanes/userguide.htm.

Table 2.3 SR 167 Toll Zone Segment Length

Toll Zone	NB Tolling Segments		Length (Miles)
	From	To	
NB1	South of SR 18	SR 18	0.745
NB2	SR 18	37th Street	1.52
NB3	37th Street	Green River	2.175
NB4	Green River	SR 516	1.215
NB5	SR 516	South 212th Street	2.67
NB6	South 212th Street	South of South 34th Street	2.435
Total Length			**10.76**
Toll Zone	**SB Tolling Segments**		**Length (Miles)**
	From	**To**	
SB1	South of I-405	South 180th Street	1.36
SB2	South 180th Street	South 212th Street	1.85
SB3	South 212th Street	SR 516	2.575
SB4	SR 516	Green River	0.825
Total Length			**6.61**

Existing SR 167 Express Toll Lane Operating Hours

The operating hours for the express toll lanes are seven days a week from 5:00 a.m. to 7:00 p.m.

Existing SR 167 Express Toll Lane Pricing Policy

High-occupancy vehicles (transit, public vanpools and private carpools with two or more occupants) are eligible for a toll-free trip in the existing SR 167 express toll lanes, while single-occupant vehicles pay a toll for driving in the express toll lanes. Below is specific information on the SR 167 express toll lane pricing policy:

- Toll rates are a minimum of $0.50, with maximum of $9 set in increments of $0.25.
- The toll rate for paying drivers changes based on real-time traffic conditions to meter traffic flow into the express toll lanes such that they remain free-flowing even during peak travel periods. The performance standard for the lanes is 45 mph, or faster, at least 90 percent of the time during peak periods.
- The toll rate is set every five minutes to adjust to any changes in traffic, based on the location with the worst traffic conditions in each direction.

- The system has the ability to incorporate general-purpose lane traffic data into the toll rate calculation, but is not currently utilizing this capability.
- At each access location, a single toll rate is displayed for a trip in the express toll lane, for any distance trip in that direction of travel (i.e., NB or SB). The rate is the same regardless of the length of the trip in the SR 167 express toll lane.

SR 167 Express Toll Lane Traffic Patterns

CS analyzed the amount of traffic that uses the SR 167 express toll lanes from the perspective of how much of the lane capacity was typically used by vehicles that should be paying tolls and those that did not.[12] To do this, we combined the traffic volume data that does not distinguish between vehicle types, and the toll transaction data that only counts vehicles with valid transponders. CS aggregated all of WSDOT's traffic volume data for non-holiday weekdays in 2010 by toll zone by direction in 15-minute and hourly intervals.

Average Weekday Express Toll Lane Utilization

Figure 2.3 shows the average total use of the express toll lane by hour from 5:00 a.m. to 11:00 a.m. and from 1:00 p.m. to 6:00 p.m., as well as the volume of toll-paying traffic for the northbound direction. Figure 2.4 shows the same information in the southbound direction.

When reviewing this data, keep in mind that to be most efficient, a managed lane has the potential to carry as many as 1,650 vehicles per lane per hour. This volume rate is a steady and reliable flow rate that is not likely to break down due to congestion. At greater volumes, speeds will drop below the desired 45 miles per hour. We found that:

- The average weekday traffic volume on the SR 167 managed lanes have not exceeded 1,200 vehicles in any hour.
- The a.m. peak hour is 7:00 a.m. to 8:00 a.m. in the northbound direction and the p.m. peak hour is 4:00 p.m. to 5:00 p.m. in the southbound direction. These two hours also see the highest percentages of tolled vehicles on all toll zone segments.
- With the exception of section NB1, all toll zone segments carried between 800 and 1,100 vehicles on average during the peak hour.
- During the peak hour, the percentage of vehicles paying tolls ranged from 18 percent to 34 percent in the northbound direction in the a.m. peak hour, and from 12 percent to 18 percent in the southbound direction in the p.m. peak hour.

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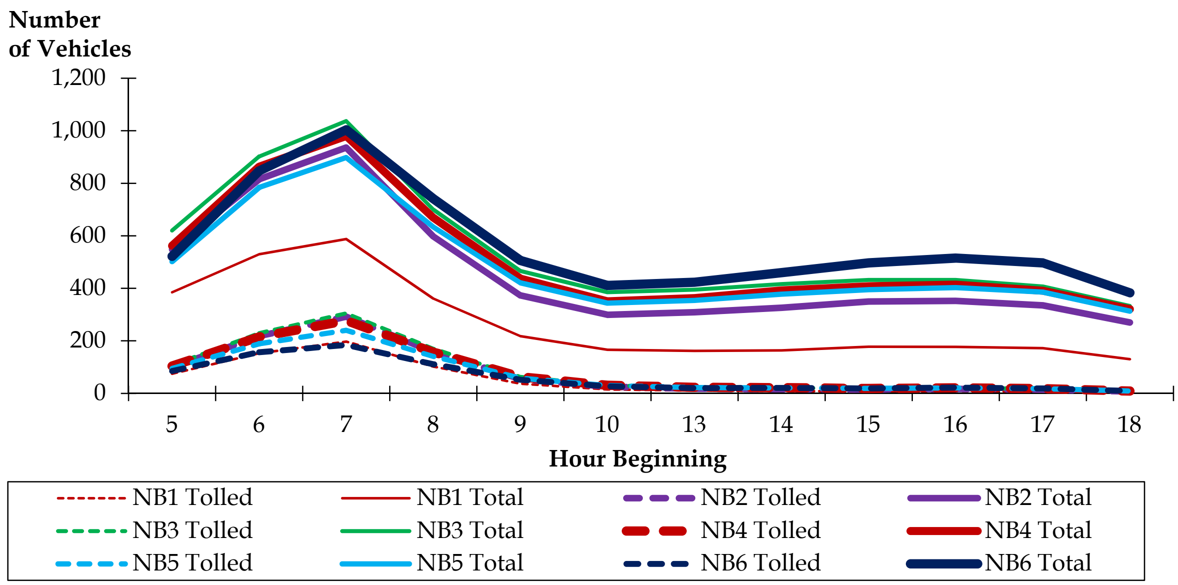
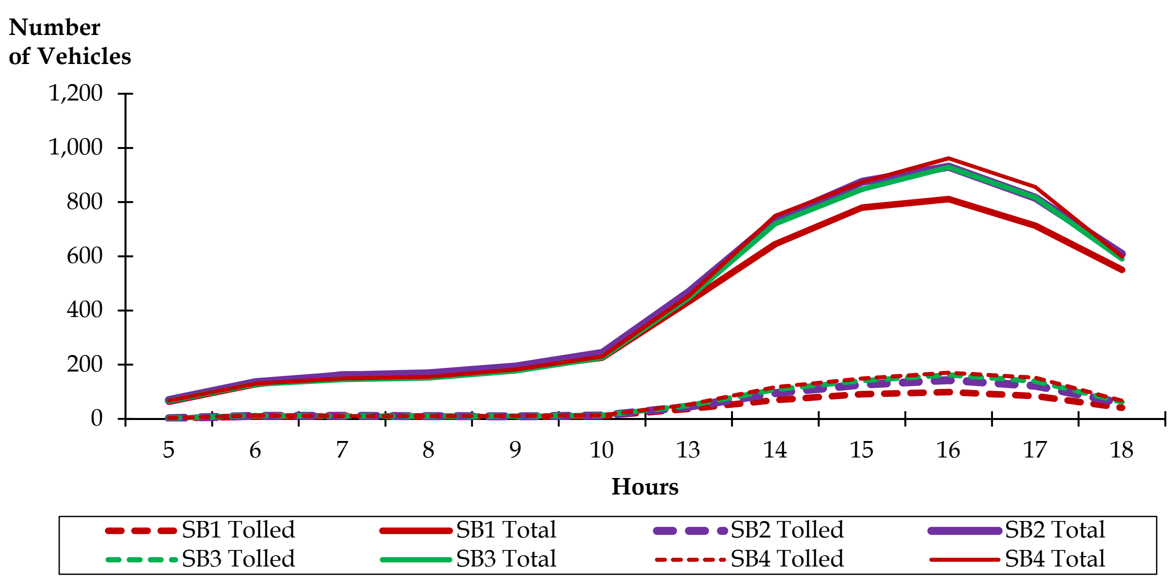
[12] All of the vehicles without transponders should be HOVs, but some vehicles will be toll violators.

Figure 2.3 2010 Average Weekday Volume of Total and Tolled Traffic
SR 167 Express Toll Lane – Northbound



Note: Data shown for hours 5:00 a.m.-11:00 a.m. and 1:00 p.m.-6:00 p.m.

Figure 2.4 2010 Average Weekday Volume of Total and Tolled Traffic
SR 167 Express Toll Lane – Southbound



Note: Data shown for hours 5:00 a.m.-11:00 a.m. and 1:00 p.m.-6:00 p.m.

Distribution of Express Toll Lane Utilization in 2010

Whereas Figures 2.3 and 2.4 above show average lane utilization, it also is useful to look at the distribution of lane utilization over the course of a year. We developed two ways to look at this data. Figure 2.5 shows traffic volume characteristics in the northbound direction and Figure 2.6 shows the southbound direction, with all traffic – both tolled and non-tolled – included.

In the northbound direction, the highest hourly volume in the entire year was about 1,050, with most hours having traffic of from 300 to 550 vehicles per hour (Figure 2.5a). The heaviest northbound volumes are in the morning peak (Figure 2.5b), with the hour beginning 7:00 a.m. the highest overall, and that hour generally serving from 700 to 1,100 vehicles per hour. Volumes during other hours in the morning peak period tended to be lower, with afternoon peak volumes considerably lower.

Lane utilization in the southbound direction is highest in the evening, with the highest hourly volume in the hour beginning at 4:00 p.m. where traffic flows of from 700 to 1,100 were typical. Other hours served less traffic, and the morning peak volumes were much lower.

Figure 2.5 SR 167 Express Toll Lane Utilization in 2010, All Traffic for All Hours of Express Toll Lane Operation over Entire Year – Northbound

Figure 2.5a Distribution of Hourly Volumes

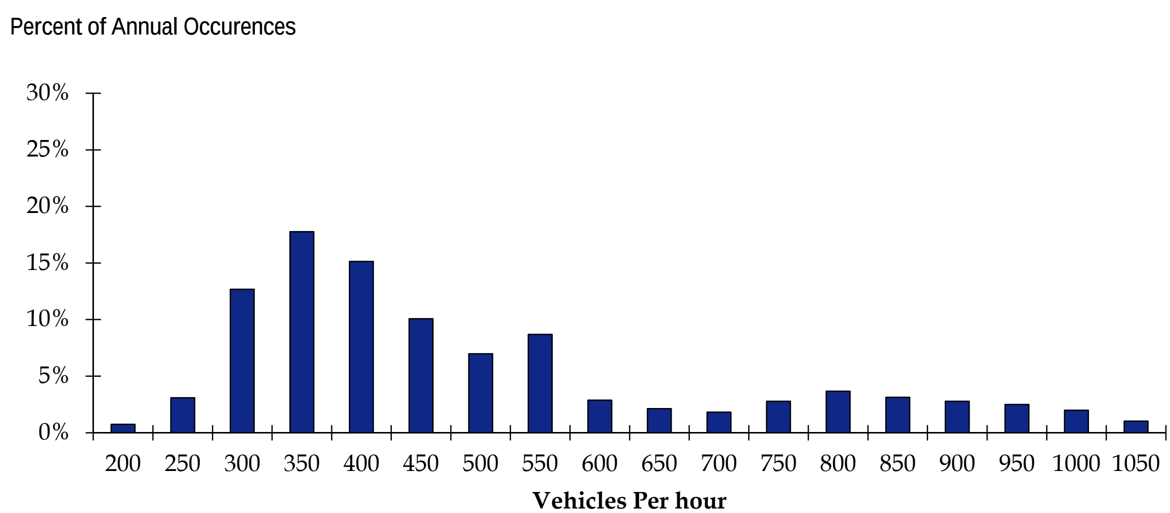


Figure 2.5b Distribution of Northbound Hourly Volume by Each Hour in the A.M.

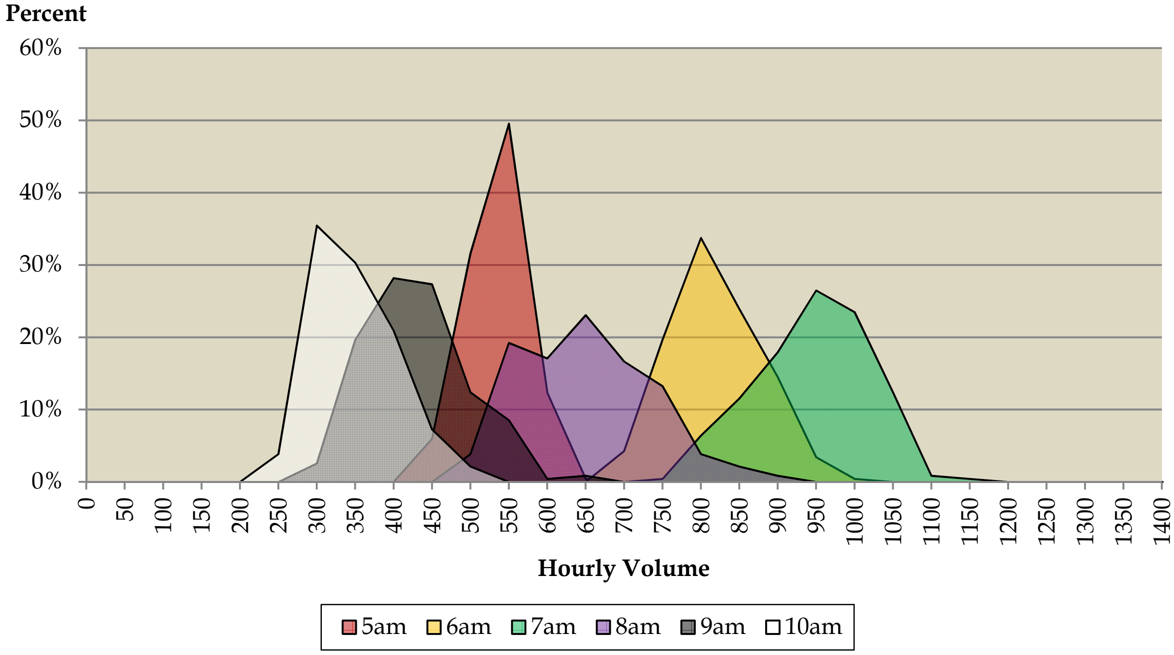


Figure 2.5c Distribution of Northbound Hourly Volume by Each Hour in the P.M.

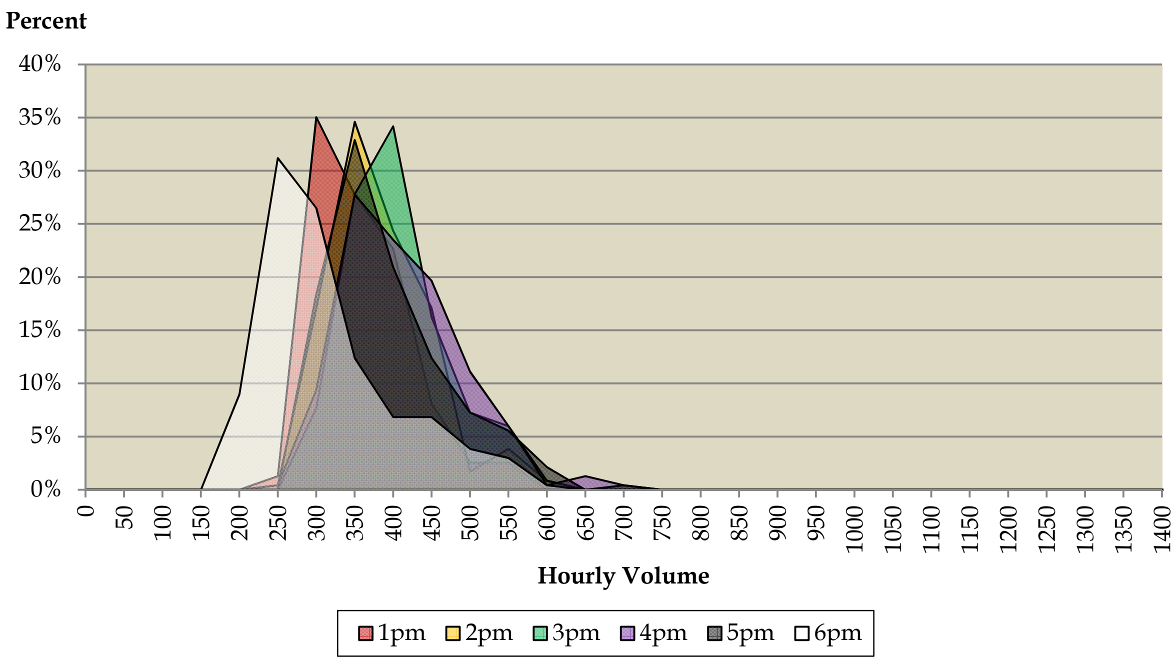


Figure 2.6 SR 167 Express Toll Lane Utilization in 2010, All Traffic for All Hours of Express Toll Lane Operation over Entire Year – Southbound

Figure 2.6a Distribution of Hourly Volumes

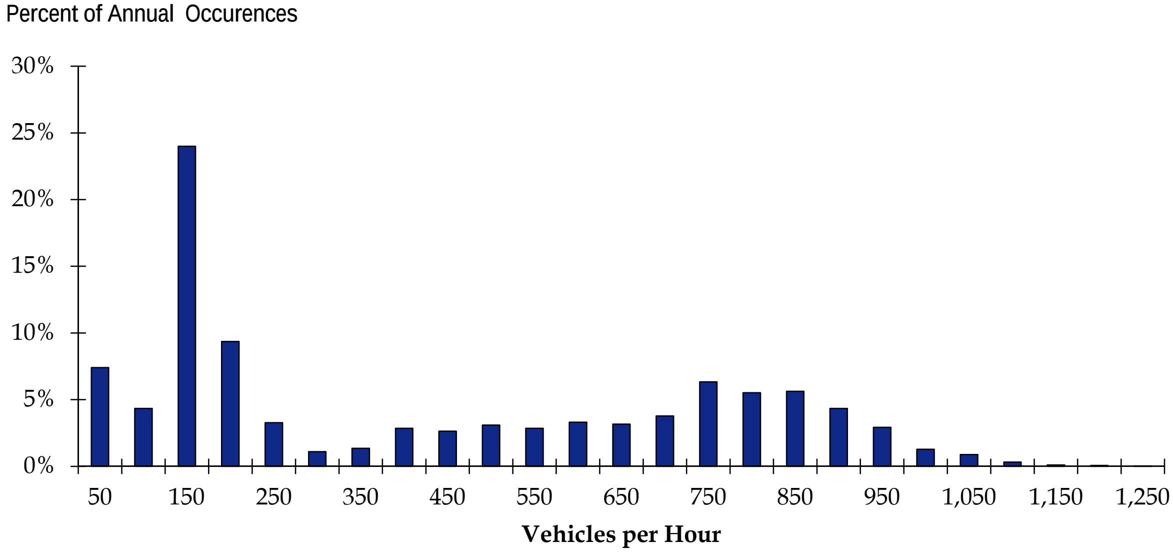


Figure 2.6b Distribution of Southbound Hourly Volume by Each Hour in the A.M.

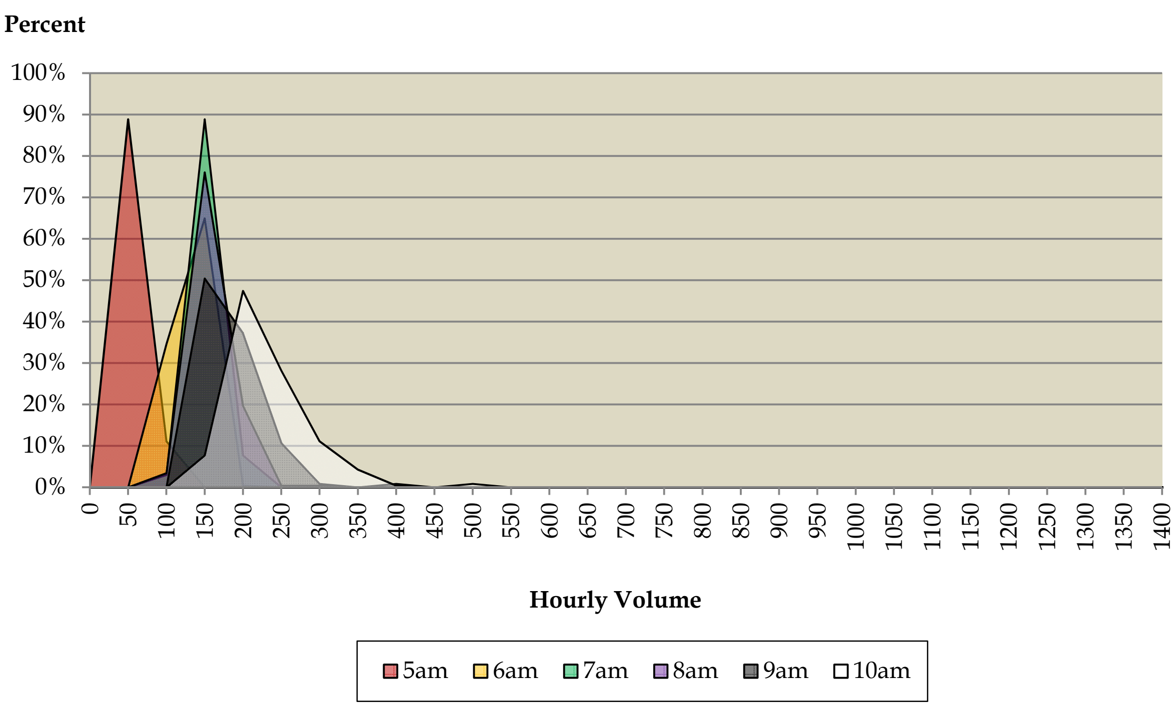
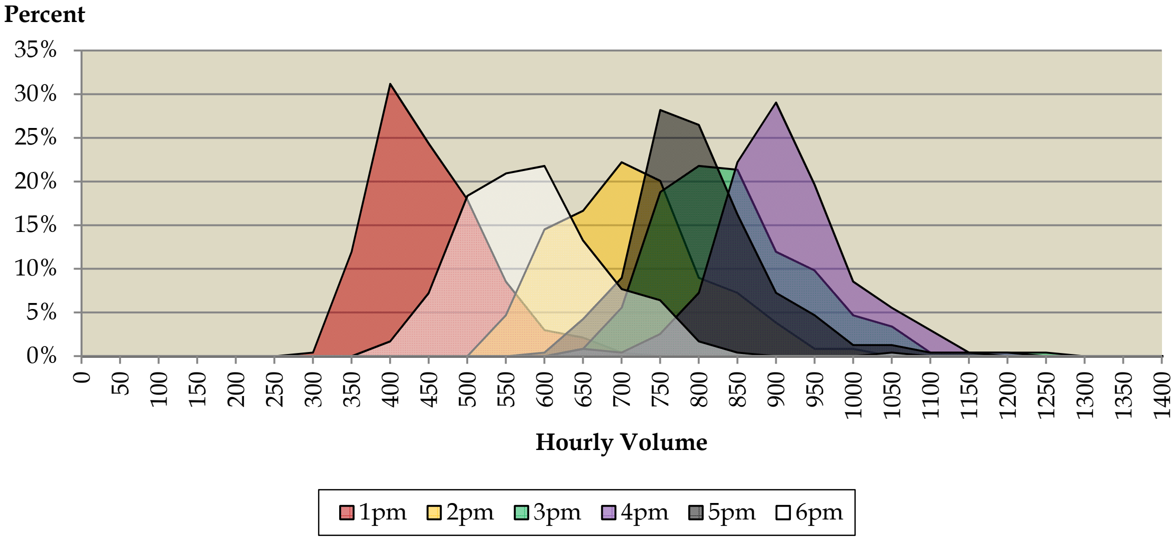


Figure 2.6c Distribution of Southbound Hourly Volume by Each Hour in the P.M.



Relationship between Speed, Volume, and Toll Rate

CS also analyzed the raw 15-minute data on SR 167 toll lane to understand the relationship between speed, volume, and toll rates on the existing SR 167 express toll lane. In order to get a clear picture of these relationships, we focused on one specific day as opposed to averages where this relationship is lost, and chose September 8, 2010 for illustrative purposes. In side-by-side graphs (Figures 2.7 and 2.8), we show the following information in 15-minute increments for morning northbound and evening southbound conditions for each of the toll zones illustrated previously in Figure 2.2:

- Left side:
  - Express lane traffic volume:
    - Toll-paying; and
    - Nontoll-paying.
  - Number of toll transactions entering the system at that location.
  - Average toll rate for vehicles entering the system at that location.
- Right side:
  - Average speed:
    - General purpose lane; and
    - Toll lane.
  - Average toll rate for vehicles entering the system at that location.

Figure 2.7 SR 167 Northbound Express Toll Lane Pricing
A.M. Peak Period (Wednesday, September 8, 2010)

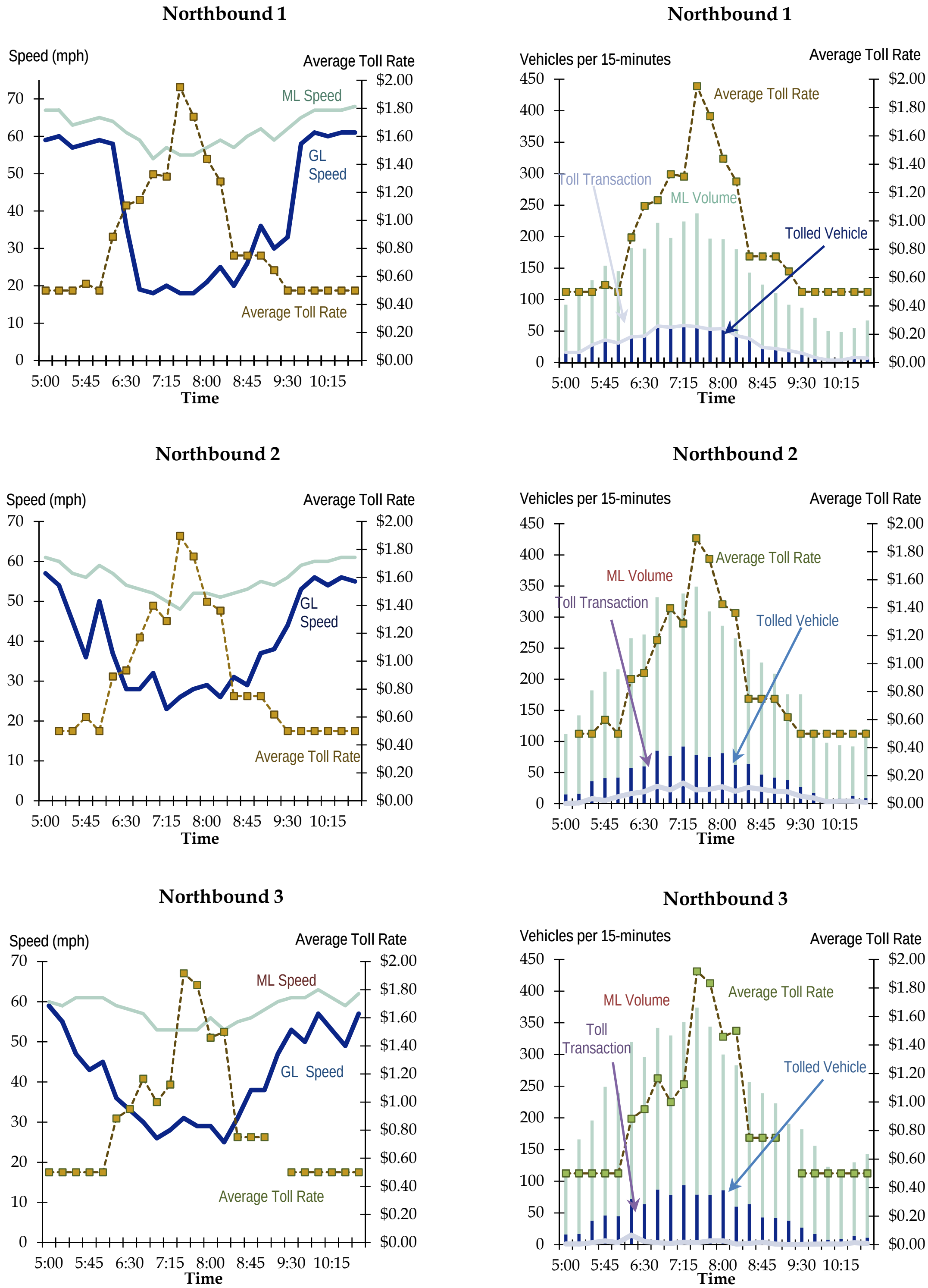
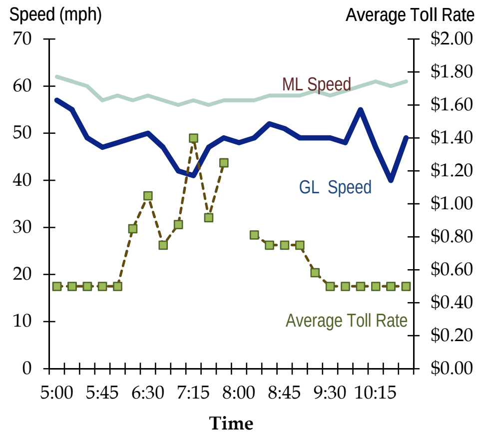


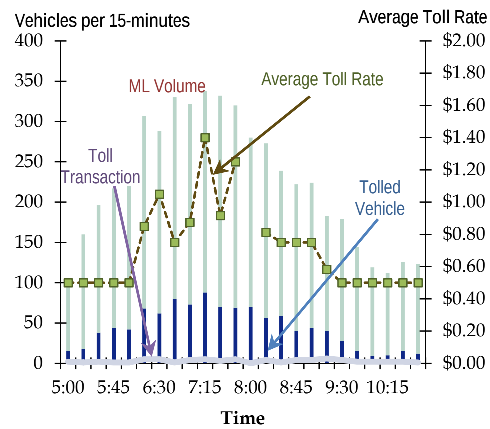
Figure 2.7 SR 167 Northbound Express Toll Lane Pricing (continued)

A.M. Peak Period (Wednesday, September 8, 2010)

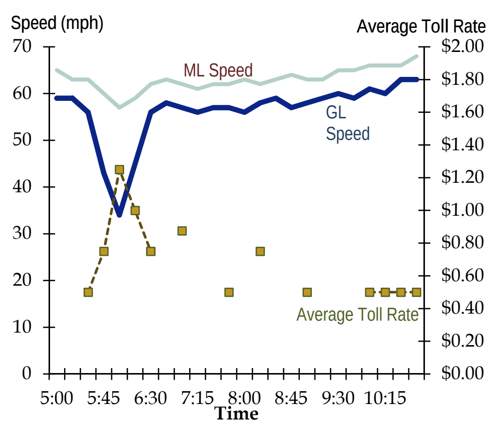
Northbound 4



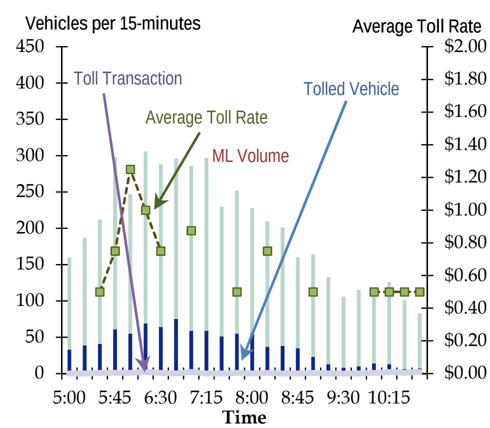
Northbound 4



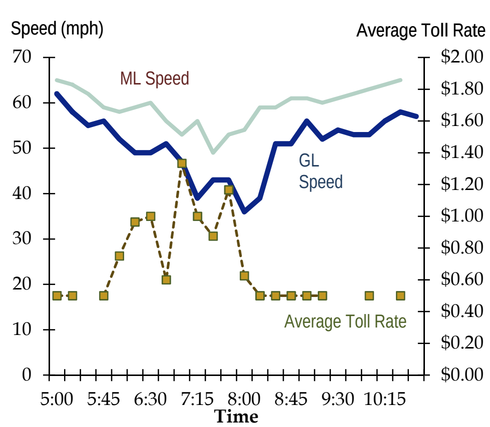
Northbound 5



Northbound 5



Northbound 6



Northbound 6

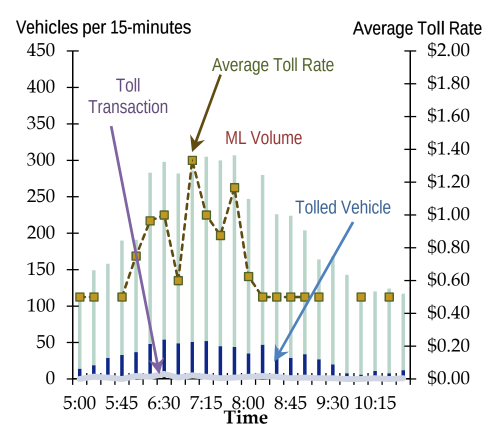


Figure 2.8 SR 167 Southbound Managed Lane Toll Pricing
P.M. Peak Period (Wednesday, September 8, 2010)

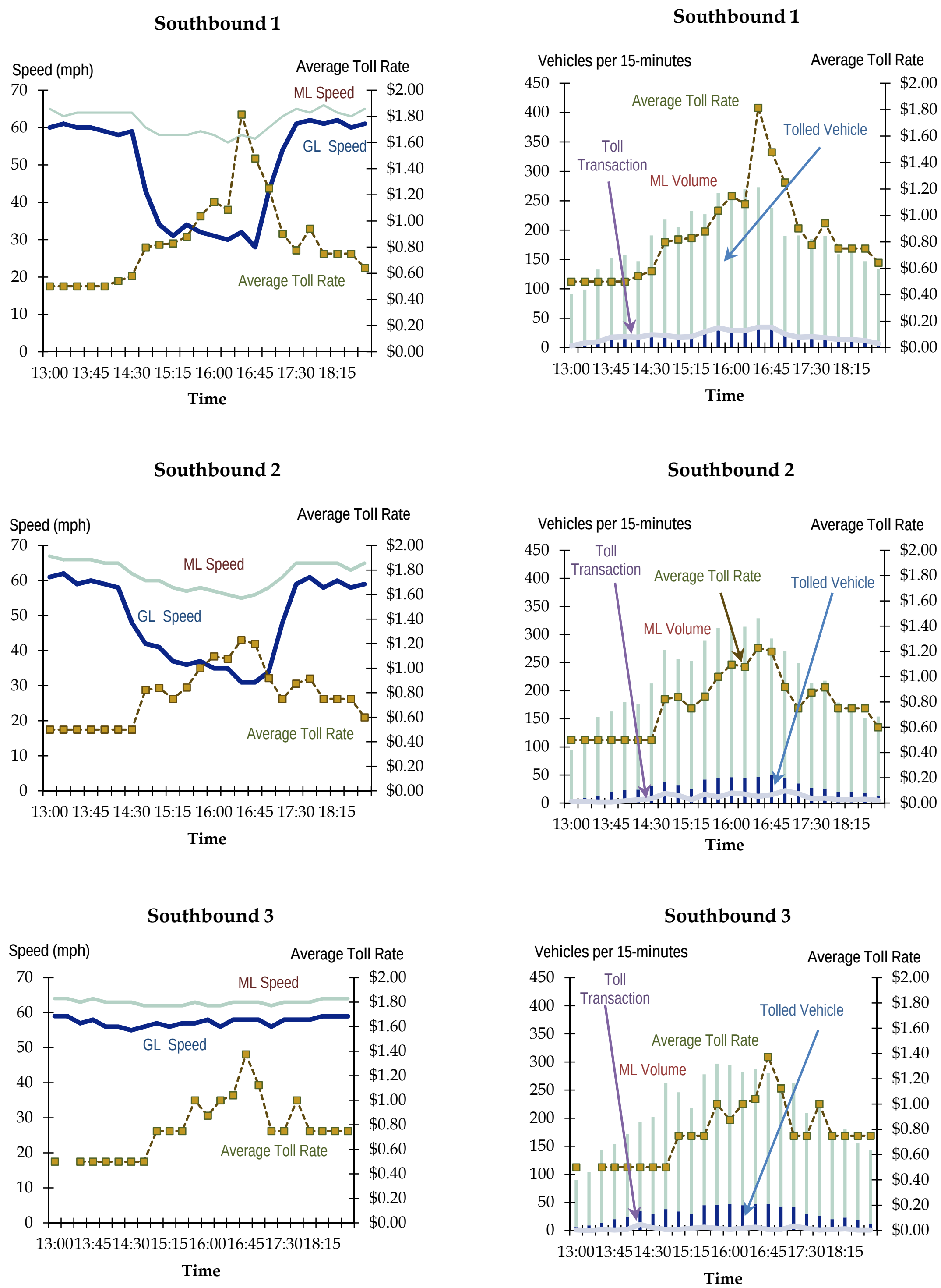
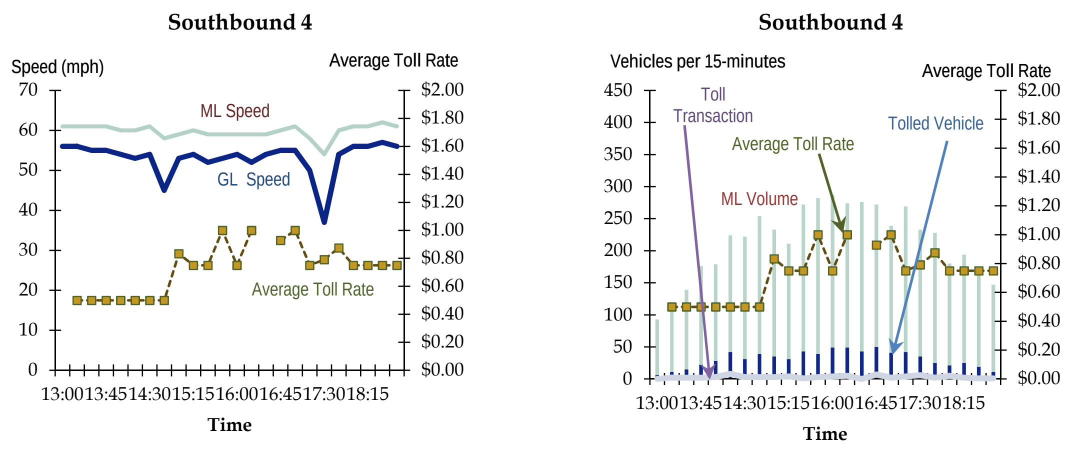


Figure 2.8 SR 167 Southbound Managed Lane Toll Pricing (continued)
P.M. Peak Period (Wednesday, September 8, 2010)



We found that there was considerable variation from day to day, and that it was difficult to make generalizations. Therefore, the observations below relate to this particular day, and provide some insights into the relationship between speed, volume, and toll rates charged.

Northbound SR 167 in the Morning

For morning northbound conditions on September 8, 2010, we found that (Figure 2.7):

- The speed experienced in the express toll lane was fairly consistent, with speeds above 50 mph at all times, and over 60 mph much of the time.
- The majority of toll-paying (SOV) entered the toll lane at NB1 and NB2, as indicated by the purple line at the bottom of the left side graphs.
- NB1 was the most congested segment in the general purpose lanes on that day. The speed in the general purpose lanes dropped below free-flow at around 6:30 a.m., reached a low point of 20 miles per hour at 6:45 a.m., and returned to free-flow at 9:45 a.m. This means that there were 195 minutes (3 hours, 15 minutes) in the morning peak period where drivers choosing to use the express toll lane would experience measurable travel time savings.
- At 6:15 a.m., the average toll rate increased from the minimum of $0.50 to $0.88, at the same time speed dropped further downstream at NB3.
  - The rate climbed to as high of $1.95 at 7:30, just after the speed in the toll lane dropped below 50 mph at NB2.
  - When speed at NB2 rose above 50 mph again 15 minutes later, the toll rate started dropping slowly to $0.75 at 8:30, an hour later.

- Speed in the general-purpose lane was still about 20 mph at 8:30.

- Traffic in the express toll lane rises slightly at the same time when congestion increases in the general purpose lanes, but never gets above 240 vehicles for a 15-minute period (equal to 1,000 per hour). Of the approximately 240 vehicles using the toll lane at 7:30, about 60 were toll-payers.

Southbound SR 167 in the Afternoon

For afternoon southbound conditions on September 8, 2010, we found that (Figure 2.8):

- As with the northbound direction, the toll lane speed stayed well above 50 mph throughout the afternoon.

- The majority of toll-paying SOV entered the toll lane at SB1 and SB2.

- SB1 was the most congested segment in the general purpose lanes on that day. The speed in the general purpose lanes dropped below free-flow at around 2:45 p.m., reached a minimum of 30 miles per hour at 3:00 p.m., and returned to free-flow at 5:30 p.m. This means that there were 165 minutes (2 hours and 45 minutes) in the afternoon peak period where express toll lane drivers saw measurable travel time savings.

- The highest number of vehicles on the managed lane occurred from 3:45 to 4:45 p.m., which coincided with the lowest recorded speed on the general lanes.
  - The highest toll rate on SB1 occurred at 3:30, at $1.81, brought on by speeds in the express toll lane dipping below 60 mph at 2:45, and a further dip of a few miles per hour at 3:15.
  - The toll rate dropped over the course of an hour to $0.78 at 5:30.
  - Traffic volume at SB1 in the express toll lane was steadily above 200 per 15 minutes (800 per hour) from 2:45 to 4:45 p.m., and above 250 per 15 minutes (1,000 per hour) for an hour.
  - Toll-paying traffic represented about 13 percent of express toll lane traffic at 4:30 – about 40 vehicles in 15 minutes.

Daily Variation in Average Daily Traffic and Revenue in Existing SR 167 Toll Lanes – 2010

Figure 2.9 shows the average number of vehicles that paid tolls and the average daily revenue by day of the week and for weekends/holidays. We found that:

- Toll-paying traffic is heaviest in the northbound direction with average daily vehicles ranging from 1,100 to 1,350 on weekdays.

- Wednesday is the most heavily traveled day in both the northbound and southbound directions, with Monday being the lowest traveled day.

- In the northbound direction, revenue is highest Tuesday through Thursday (ranging from $1,304 to $1,315), with a similarly high number of tolled vehicles that paid to use the corridor (ranging from 1,253 to 1,295). Comparatively, Friday has the least traffic and revenue among the weekdays with nearly 35 percent less revenue on Friday and nearly 150 fewer paid vehicles.

- Northbound, average toll rates ranged from $0.77 to $1.05 per vehicle on weekdays, and $0.57 on weekends/holidays.

- In the southbound direction, average toll rates ranged from $0.86 to $1.07 per vehicle on weekdays, and $0.64 on weekends/holidays.

- Weekends and holidays have considerably less traffic in both directions – about 16 percent of the highest day. Revenue is similarly lower, but the minimum toll rate keeps the average toll paid to about half of that paid on the highest day.

Monthly Variations in Average Daily Traffic and Revenue in Existing SR 167 Toll Lanes – 2010

Figure 2.10 shows variations in average daily toll paid and the number of toll-paying vehicles by month and direction for 2010. We found that:

- For both the northbound and southbound directions, the number of paid vehicles utilizing the express toll lanes steadily increased over the course of the year, with slight decreases in the months of July and August. For the northbound direction, there was a slight decrease in the number of paid vehicles in the toll lane in November and December, which is slightly mirrored in the southbound direction for the month of November.

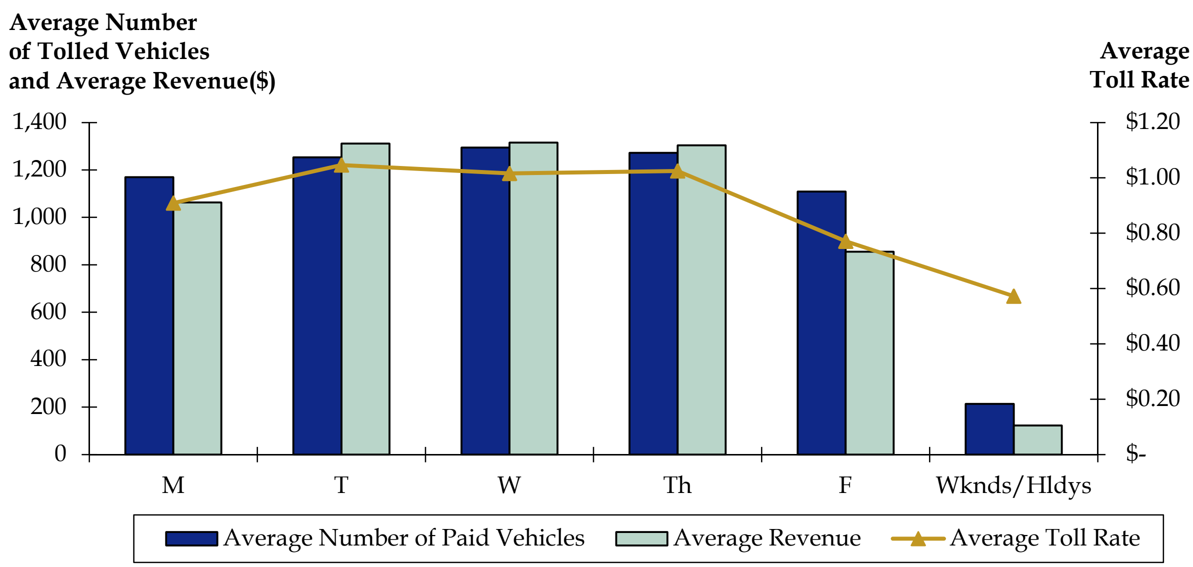
- The highest recorded month for paid vehicles traveling in the northbound direction is October, with an average of about 1,400 vehicles and the highest monthly revenue reported of $1,525, for an average toll of $1.12. October also is the highest traveled month in the southbound direction, with an average of 996 paid vehicles.

- The highest monthly revenue reported in the southbound direction was in July, in which an average of 887 paid vehicles traveled in the express toll lane, resulting in the highest average toll per vehicle of $1.24.

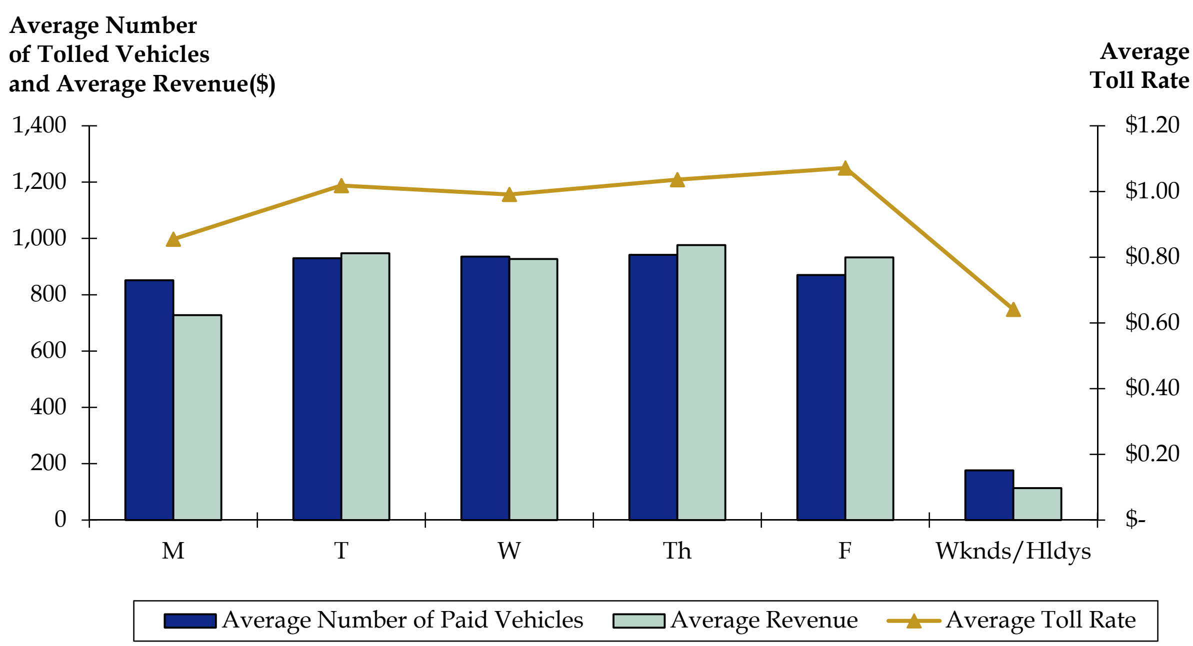
Figure 2.9 Average Daily Variations in Toll-Paying Traffic Volume and Revenue on SR 167 Express Toll Lanes

2010

Northbound

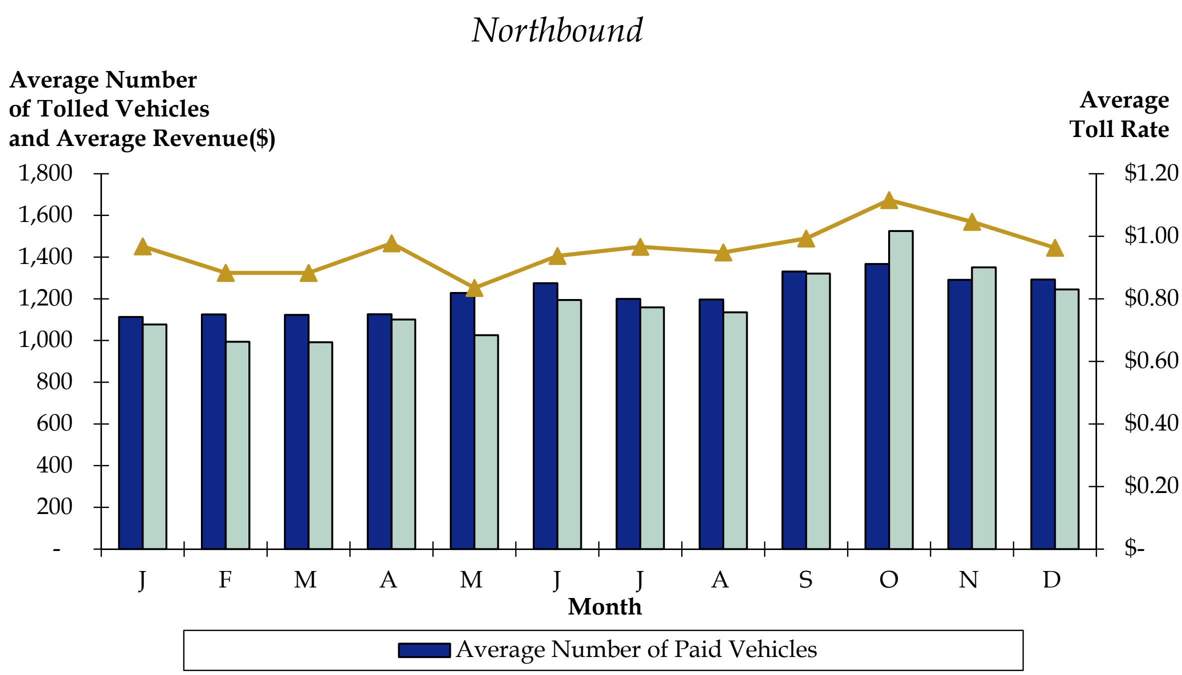


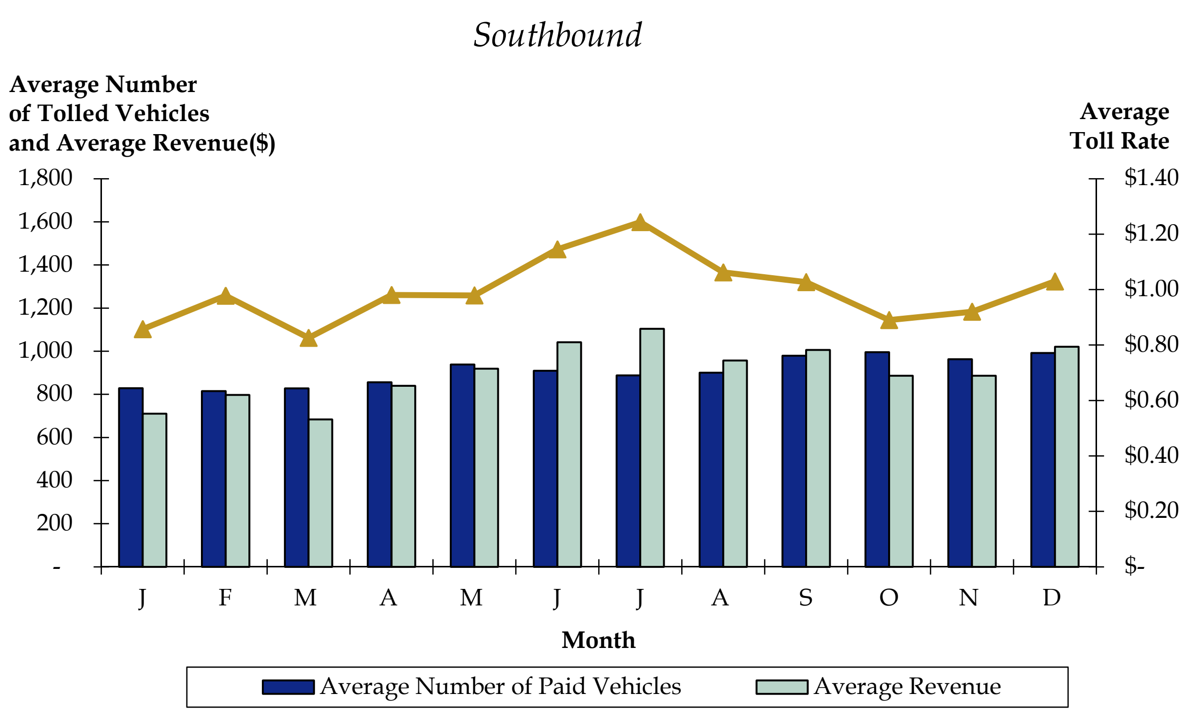
Southbound



Note: Non-holiday weekdays, with weekends and holidays shown separately.

Figure 2.10 Monthly Variations in Average Non-Holiday Weekday Toll-Paying Traffic Volume and Revenue on SR 167 Express Toll Lanes
2010

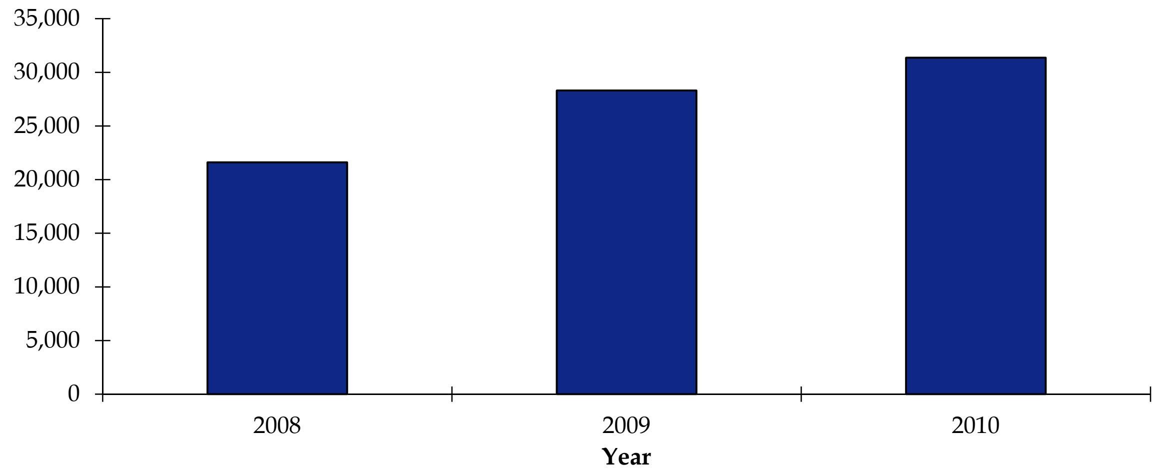




Good to Go! Transponder Ownership

All toll-paying users of the SR 167 express toll lane must have a *Good to Go!* transponder. Figure 2.11 displays the number of transponder owners that at some point used the SR 167 express toll lane from 2008 to 2010. This is a reasonable proxy for how many corridor users have transponders, since WSDOT also uses *Good to Go!* on the Tacoma Narrows Bridge. There has been a steady increase in unique transponders users from 2008 to 2010.

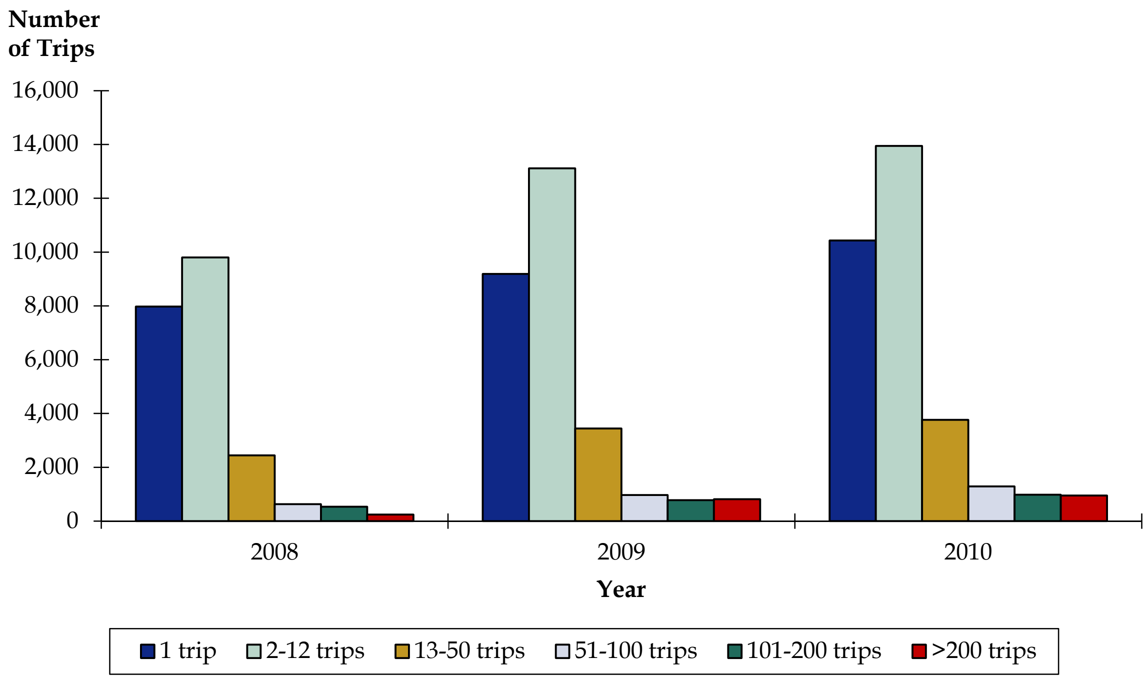
Figure 2.11 Individual Transponder Owners That Used SR 167 at Least Once
2008 to 2010



Source: WSDOT.

Figure 2.12 shows the frequency of trips by unique transponders. Most of the transponder users pay a toll infrequently, with approximately 80 percent of transponder users using the corridor less than 12 times a year (an average of less than once a month). Only about 10 percent used the facility at least once per week (50 or more times per week).

Figure 2.12 Distribution of Number of Annual Trips by Transponder
2008 to 2010



2.4 Relationship of Typical Day to Annual Revenue

An important component of the traffic and revenue estimates is the relationship between the revenue collected on a typical day and the revenue that might accrue over an entire year. With a traditional toll road, it is an easy matter to analyze traffic on an average day, multiply by an annualization factor that accounts for weekends and holidays, and thereby converting an average day value to a reasonable estimate of annual revenue. With an express toll lane, there is the added complication that toll rates are constantly changing, and that the toll revenue collected on a typical day is not so readily expanded to the amount of revenue expected over the course of an entire year.

CS evaluated how well the calculation of annual revenue from typical days of traffic works, using the traffic and revenue experience on SR 167. CS analyzed daily toll-paying traffic on the express toll lanes (represented by vehicle-miles traveled) and daily toll revenue for every day of 2010, classified as non-holiday weekdays (250) and weekend/holidays (115). Some days did not have traffic and/or revenue that passed our quality control procedures, so we did the analysis using the 317 days that had reliable data, representing 229 non-holiday weekdays and 88 weekends/holidays.

Table 2.4 shows the breakdown of toll revenue on non-holiday weekdays and on weekends/holidays in 2010, and in the days of 2010 for which we have reliable data. Whereas weekdays represent 69 percent of the days in 2010, they represented 96 percent of the revenue. The days in our reduced dataset had similar patterns. Since CS will base its traffic and revenue forecasts on non-holiday weekdays only, we will apply a ratio of 1.042 to the weekday revenue forecasts to arrive at total annual forecasts.

Table 2.4 Annual Toll Revenue by Type of Day

	In 2010		In Dataset	
	Number	**Percent**	**Number**	**Percent**
Days				
Weekdays	252	69.0%	229	72.2%
Weekend/Holiday	113	31.0%	88	27.8%
Total	**365**	**100.0%**	**317**	**100.0%**
Revenue				
Weekdays	$523,480	96.0%	$485,432	96.4%
Weekend/Holiday	$21,847	4.0%	$18,129	3.6%
Total	**$545,327**	**100.0%**	**$503,560**	**100.0%**
Ratio: Total/Weekday Revenue	1.042		1.037	

We looked at the data from two perspectives: revenue and traffic. Figure 2.13 shows the ranking of weekday revenue from the 229 valid non-holiday weekdays. The median, or 50th percentile day, had revenue of $2,025. To estimate annual revenue from this value, we multiplied by 250 weekdays to yield the estimated annual revenue from weekdays, and then factored the result by 1.042 to account for additional revenue on weekends. This estimated value was within 3.3 percent of the actual revenue value in 2010 (see Table 2.5).

Figure 2.13 Ranking of Daily Revenue by Day for Non-Holiday Weekdays
2010

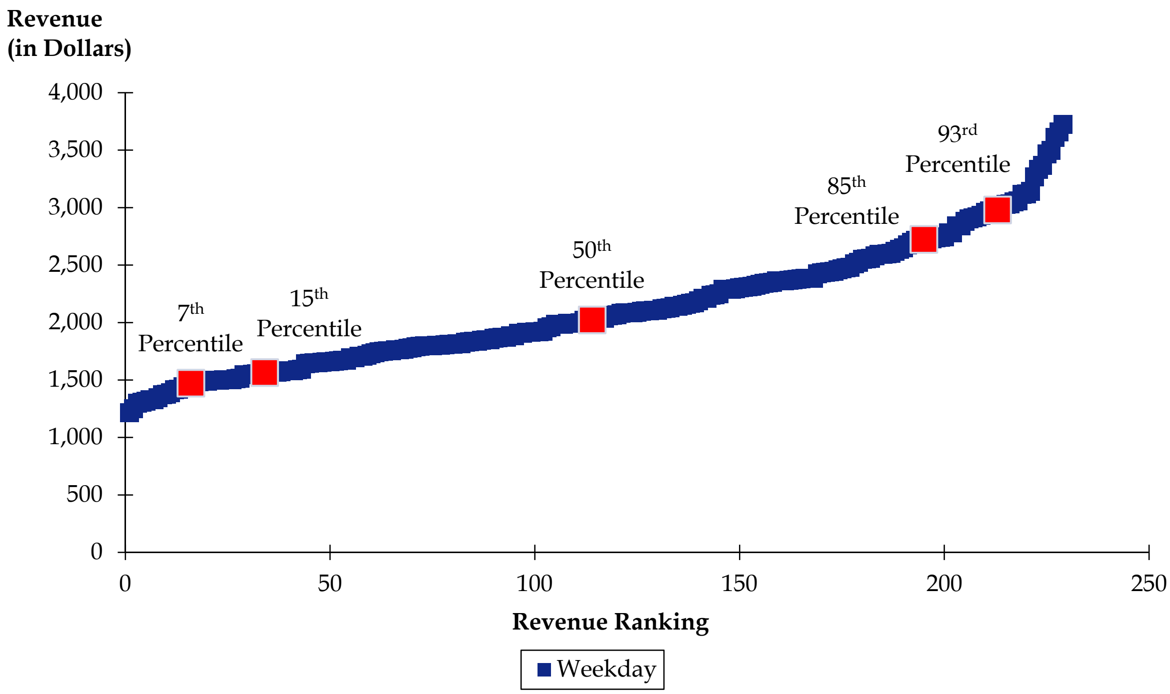


Table 2.5 Estimated Annual Revenue in 2010 Using the Median Revenue Day as a Basis

Revenue on Median Revenue Weekday	$2,009
Number of Non-holiday Weekdays	252
Annual Weekday Revenue Based on Median Revenue Weekday	$506,174
Factor for Weekends	1.042
Calculated Annual Revenue Based on Median Revenue Day	$527,433
Actual Annual Revenue	$545,327
Difference from Actual Revenue	-3.28%

This approach yields a result that is relatively close to the actual value. However, this approach is of limited value in revenue forecasting, because the median day of revenue may not occur on the same day as the median traffic day, due to the fluctuating toll rates.

What we really want to know is how well we can forecast annual revenue from traffic. Figure 2.14 shows the ranking of VMT for non-holiday weekdays only. The 50th percentile (median) day had a VMT of 786,303, which was October 13. The revenue on October 13 was $2,484, which was 22 percent higher than the median revenue day. If we use the median traffic day as a multiplier to get annual revenue, the result is an estimate that is 19 percent higher than the actual annual revenue (Table 2.6).

Figure 2.14 Ranking of Daily VMT by Day for Non-holiday Weekdays
2010

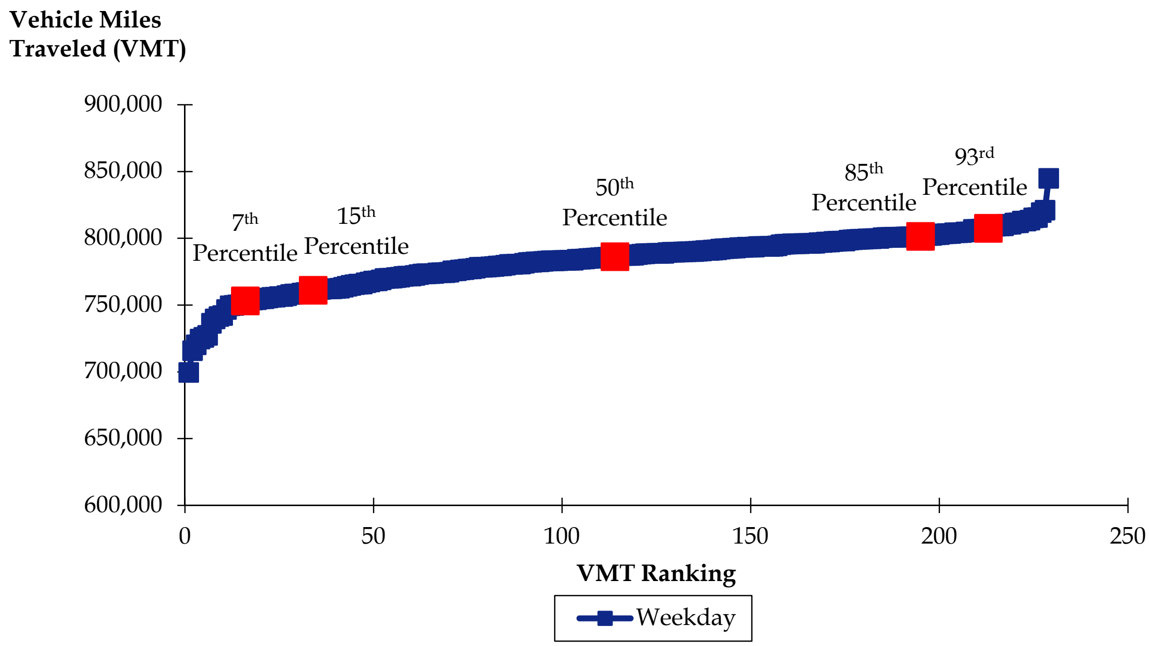


Table 2.6 Estimated Annual Revenue in 2010 Using the Median VMT Day as a Basis

Revenue on Median VMT Weekday	$2,484
Number of Non-holiday Weekdays	252
Calculated Annual Weekday Revenue Based on Median VMT Weekday	$625,968
Factor for Weekends	1.042
Calculated Annual Revenue Based on Median VMT Day	$652,259
Actual Annual Revenue	$545,327
Difference from Actual Revenue	19.6%

Ideally, we would like to estimate the revenue for every day of the year, but that would require running the forecast model to represent 365 different traffic levels. To try to get closer to the actual value, CS tested an alternative approach that used proxies for low, medium, and high traffic days, and developed multipliers for the number of days these values might represent. Looking at the traffic ranking chart in Figure 2.14 above, we chose the 7th percentile day to represent "low" days, the 93rd percentile day to represent "high" days, and the median day to represent the rest. Using these values to estimate annual revenue yielded a revenue estimate that was almost 28 percent higher than the actual revenue, even less accurate than using the median VMT day (see Table 2.7).

Table 2.7 Calculation of Revenue
VMT Percentile Method

				Total
VMT Percentile Days	7	50	93	
Represents This Number of Days	38	176	38	252
Corresponding Revenue on That Day	$3,471	$2,484	$2,601	
Revenue Based on Representative Number of Days	$131,898	$437,184	$98,838	$667,920
Weekend Factor				1.042
Calculated Annual Revenue (Dollars)				$695,973
Actual Annual Revenue				$545,327
Difference from Actual Revenue				27.6%

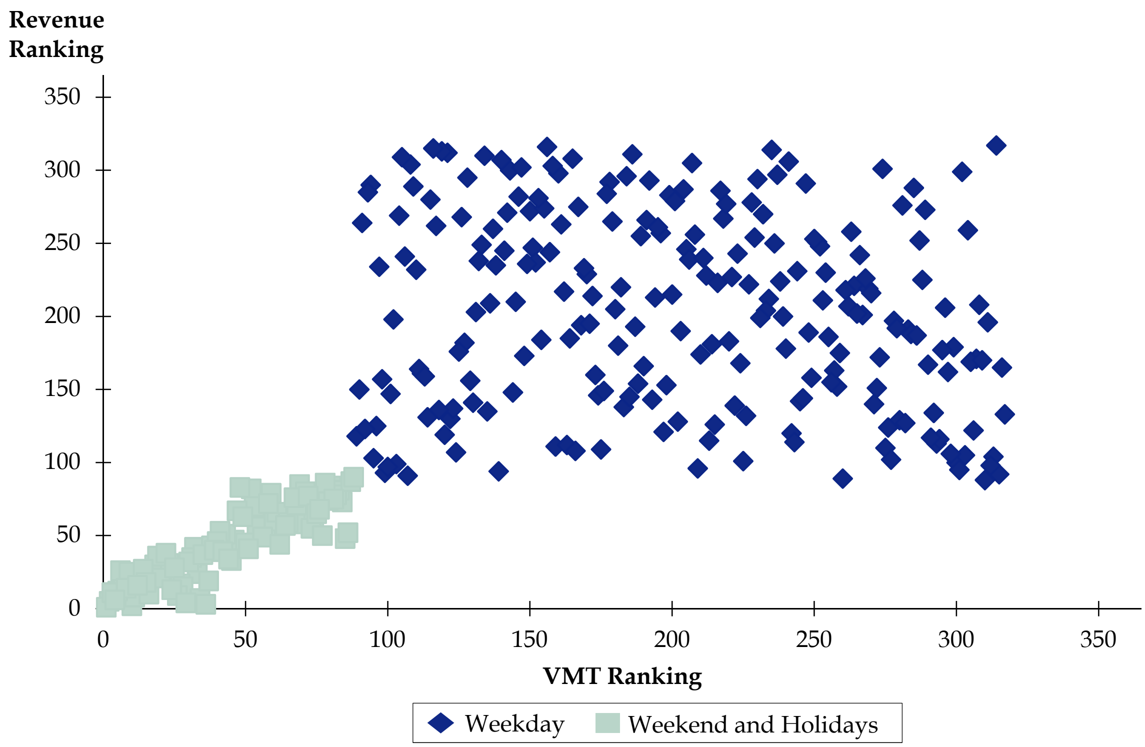
We explored the relationship between revenue ranking and VMT ranking further by plotting the rankings of daily revenue to daily VMT, with weekdays shown in blue and weekend/holidays shown in red (see Figure 2.15). If traffic and revenue were closely correlated, we would expect to see the points cluster along a diagonal line from the bottom left to the top right. We find this with the weekend/holiday traffic, in the lower left corner, but we found no correlation between VMT and revenue on the weekdays. This is a concern, as we try to use a typical day of traffic as a multiplier for annual revenue.

To further explore this concern, we chose to use the revenue from the day that ranked one before the median day and one after the median day. Given the number of days, this single day shift should not result in much of a difference in revenue. Table 2.8 shows the results of these tests. The day ranked one lower than the median day resulted in an annual revenue estimate almost 22 percent lower than actual revenue. The day ranked one higher than the median day resulted in revenue that was about 23 percent lower than actual.

Table 2.8 Calculation of Revenue Using One Day Lower and One Day Higher Than the Median Day

	Median	Median Day +1	Median Day -1
VMT	786,303	786,258	786,572
Revenue on Median VMT Weekday	$2,484	2,526	1,597
Number of Non-holiday Weekdays	252	252	252
Calculated Annual Weekday Revenue Based on Median VMT Weekday	$625,968	$636,552	$402,444
Factor for Weekends	1.042	1.042	1.042
Calculated Annual Revenue Based on Median VMT Day	$652,259	$663,287	$419,347
Actual Annual Revenue	$545,327	$545,327	$545,327
Difference from Actual Revenue	19.6%	21.6%	-23.1%

Figure 2.15 Ranking of VMT versus Revenue Ranking for Weekday and Weekend Traffic



The implications of this analysis are that the amount of revenue generated by a given level of traffic can vary significantly from day to day, which means that the usual means of multiplying an average day of traffic to annual levels needs to be reconsidered. The data implies that the risk-based approach to forecasting will need to include a risk of variation related to the translation of given traffic levels to a revenue amount. This variation associated with daily revenues was included as part of the risk analysis, as described in Section 3.0.

■ 2.5 Traveler Value of Time in the Eastside Corridor

When forecasting usage of a toll facility, an important component is how travelers value their time. We considered this issue from two perspectives:

1. Through stated-preference surveys; and
2. Through evaluation of the revealed-preferences of travelers based on tolls they paid and time they saved on the existing SR 167 express toll lanes.

We found the results from the stated-preference survey to be more statistically valid for use in this study, and describe that approach below.

Eastside Corridor Stated-Preference Survey

Stated-preference (SP) and attitudinal surveys were conducted by Resource Systems Group, Inc. (RSG) in September and October 2011.[13] The primary purpose of the surveys was to estimate the value of time of travelers in the Puget Sound Region who currently use the I-405/SR 167 corridor.

The survey was comprised of two main sections. The first section collected data from residents to measure their opinions about tolling and transportation policies. The second section asked respondents about their current travel behaviors, presented them with information about the proposed system of express toll lanes along the study corridor, and used stated-preference experiments to estimate travelers' VOT and their propensity to use the proposed express toll lanes under a range of conditions.

A total of 2,201 travelers answered the attitude questions, while 1,347 of those also completed the stated-preference questions. The stated-preference data were used to develop choice models to produce estimates of the value of time of travelers for four market segments:

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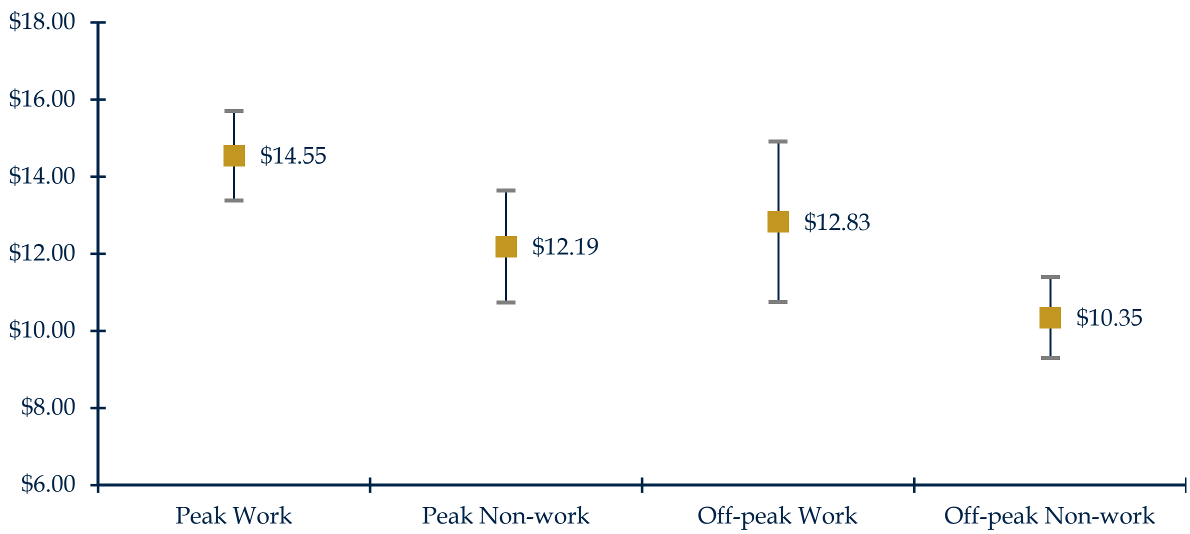
[13] Resource Systems, Inc., *Washington State I-405/SR 167 Travel Study Report*. Prepared for Cambridge Systematics, Inc. January 2012. Found on the Appendix CD.

- Peak work;
- Peak nonwork;
- Off-peak work; and
- Off-peak nonwork.

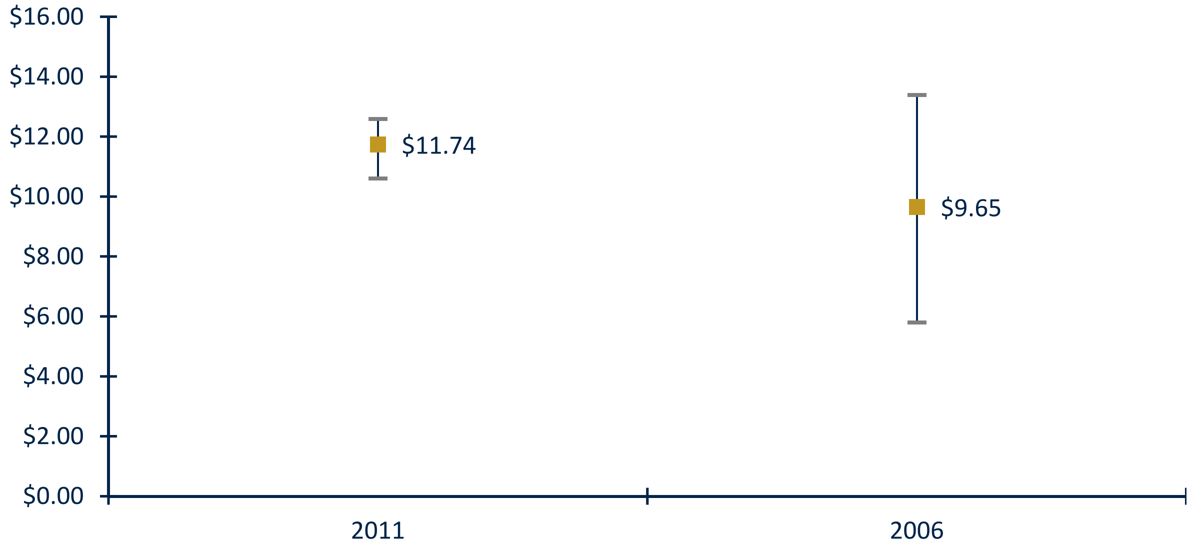
The values of time, based on the median income, ranged from a low of $10.35/hour for the off-peak nonwork segment to a high of $14.55/hour for the peak work segment, with an overall mean value of time of $13.40/hour. Figure 2.16 shows the mean values of time by trip purpose and time period at the 95 percent confidence level.

Figure 2.16 Value of Time at 95 Percent Confidence Level by Trip Purpose and Time Period



The value of time findings from the 2011 survey were generally consistent with the estimates from a study conducted in the same corridor in 2006 after accounting for differences in income and inflation. After adjusting for the aforementioned factors, the value of time for the 2006 SP survey was $9.65/hour, compared to $11.74/hour for the 2011 SP survey (all in 2006 dollars). While there is a difference of over $2 between the 2006 and 2011 SP surveys, the difference is not significant at the 95 percent confidence level (see Figure 2.17).

Figure 2.17 Values of Time at 95 Percent Confidence Level for 2006 and 2011 Stated-Preferences Surveys



3.0 Methodology

Cambridge Systematics was hired to prepare an independent forecast of traffic and revenue for the Eastside Corridor, but since WSDOT had done so much prior work in the corridor, it made sense to take advantage of that work to the extent we could verify the validity of the data and methods. Our approach was to review the available models and data, incorporate them into our analysis if we found them acceptable, and modify them or develop new methods if necessary. This approach provided the proper balance between independence and not redoing work that was acceptable.

Cambridge Systematics extensively reviewed WSDOT's data and models developed for their planning work in the Eastside Corridor and implemented improvements to integrate the evaluation of corridor operations with toll setting. Cambridge Systematics also conducted new stated-preference and attitudinal surveys, aimed at understanding people's willingness to pay tolls.

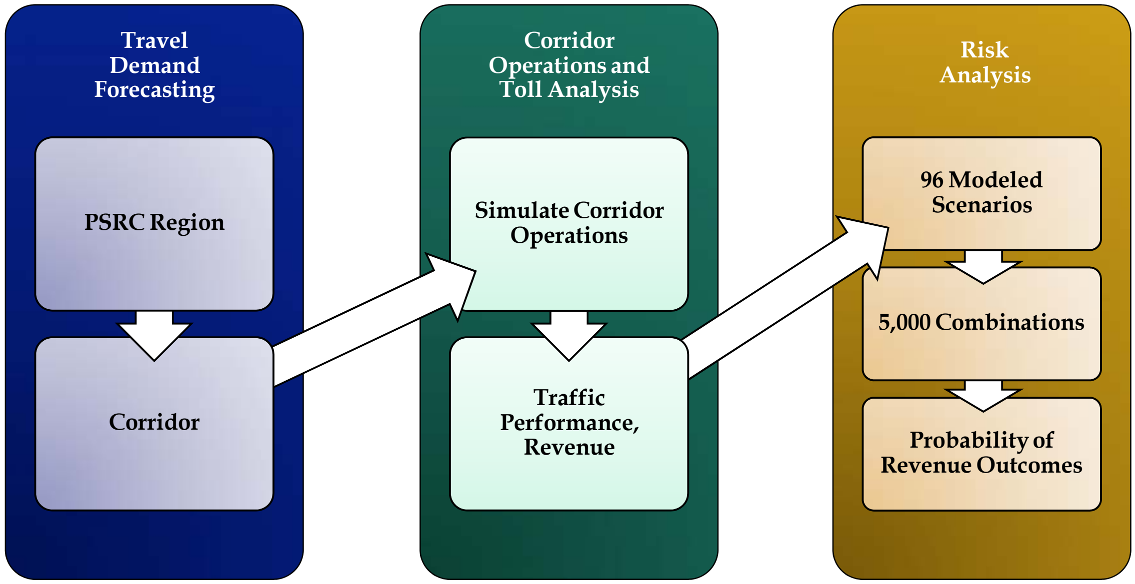
Our evaluation consisted of three main steps, as illustrated in Figure 3.1:

- **Travel demand forecasting –** After first evaluating the assumptions, we used the Puget Sound Regional Council (PSRC) regional travel demand model to forecast regional travel demand and extracted the demand that could be expected in the I-405/SR 167 corridor at four horizon years: 2014, 2018, 2030, and 2040.
- **Corridor operations and toll analysis –** We used an enhanced VISSIM traffic simulation model to forecast corridor traffic operations under different conditions, and incorporated a procedure to forecast drivers' willingness to pay different levels of tolls. Our forecast was based on new stated-preference survey data and used a simulation of the toll-setting mechanism that would carry out WSDOT's policy objectives.
- **Risk analysis –** Recognizing that there is uncertainty inherent in any forecast, we used an approach that incorporated risks into the traffic and revenue forecasts. We tested a range of assumptions relating to four factors having the greatest combination of uncertainty and impact on the results: Transponder ownership, traffic growth in the corridor, drivers' willingness to pay tolls, and the variation in revenue outcome from different traffic levels. We applied a Monte Carlo technique to simulate 5,000 possible combinations of scenarios. The result was a revenue forecast range from 15 percent to 85 percent probability of occurring.[14]

[14] Monte Carlo simulation refers to a mathematical simulation of a real event where there is significant uncertainty in the input factors that determine the outcome of that event. Monte Carlo simulations apply probability distributions for each input variable to produce hundreds or

(Footnote continued on next page...)

Figure 3.1 Traffic and Revenue Forecast Process



Our quantitative analysis focused on the dynamic pricing approach and on the first three tolling policies described in Section 1.3, i.e., *HOV 2+ Free*, *HOV 3+ Free*, and the *Mixed* scenario, to generate estimates of future express lane usage and revenue. We used a simplified "sensitivity analysis" approach to develop estimates for the remaining options, that is, the *HOV discount* option and the *variable* and *flat pricing* options.

■ 3.1 Travel Demand Forecasting

Regional Forecasts

In its work studying the I-405 Corridor Express Toll Lanes, WSDOT used the PSRC regional travel demand model to forecast changes in regional travel by purpose, origin-destination, mode of travel, and route. WSDOT then extracted origins and destinations within the corridor, creating a corridor model (see Figure 3.2). This provided corridor-level origin-destination matrices by vehicle type (SOV, HOV 2, etc.) for each time slice during the study period that was sensitive to future-year changes in demand and supply. Importantly, this approach accounts for changes in trip making by time of day, a feature of the PSRC regional model that is important to estimating travel demand for the Express Toll Lanes.

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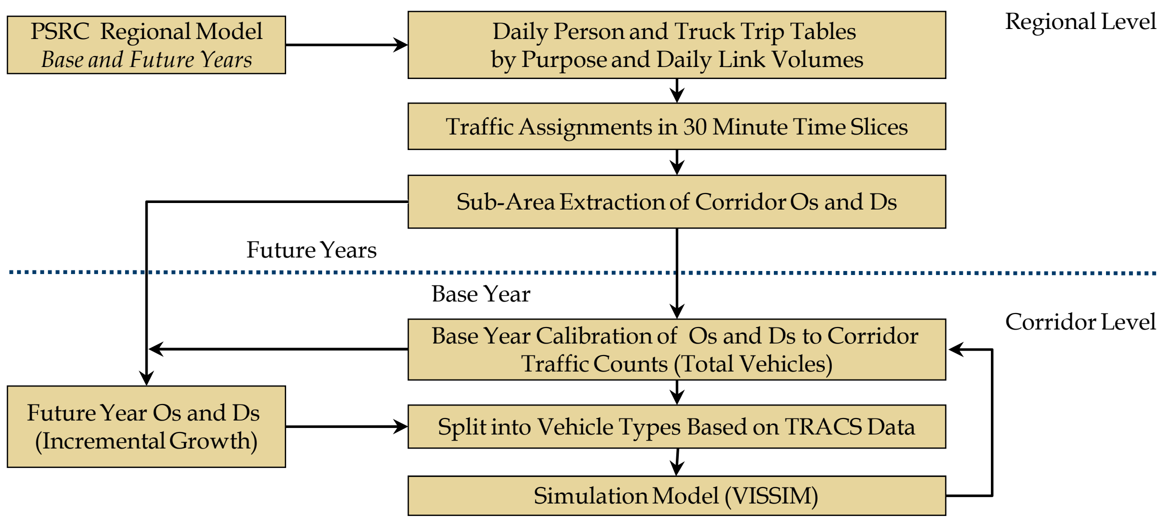
thousands of possible outcomes, which are then analyzed to reveal the probabilities of different outcomes occurring.

Figure 3.2 WSDOT's Use of Regional Model to Generate Corridor Trips



Before using them, Cambridge Systematics confirmed that the models provided by WSDOT were identical to those they used themselves. Details are provided in the *Review of Available Data and Methods – Technical Memorandum*.[15] CS then built upon the prior work through the process described below.

Socioeconomic Forecast and Traffic Growth[16]

Population and employment are important factors determining future traffic volumes. CS compared three forecasts for the Puget Sound Region (King, Kitsap, Pierce, and Snohomish Counties), and identified similarities and differences for the 2010-2040 period:

- The Puget Sound Regional Council (PSRC) forecast developed in 2006 for *Transportation 2040*;
- An independent forecast prepared in December 2010 for the SR 520 Investment Grade Traffic and Revenue Study by Common Attributes International (CAI); and
- A forecast prepared in July 2011 by Moody's Analytics, purchased by CS for this study.

The current economic climate is volatile and changes in the outlook for population and employment can have an important effect on future traffic. The Great Recession that

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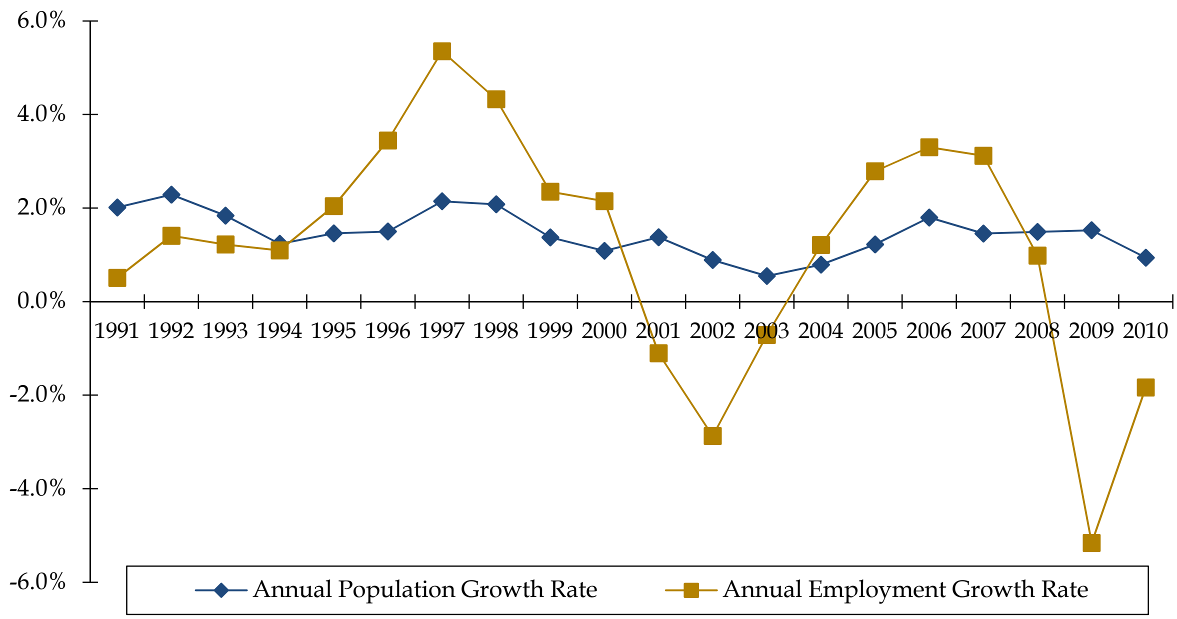
[15] Cambridge Systematics, Inc., *Eastside Corridor Independent Traffic and Revenue Study: Review of Available Data and Methods – Technical Memorandum*. Prepared for the Washington State Department of Transportation. December 2011. See Appendix B (in CD).

[16] Further details regarding this analysis are provided in the *Review of Available Data and Methods – Technical Memorandum* (December 2011). See Appendix B (in CD).

began in 2008 has produced lasting economic uncertainties, with sharp job losses throughout the nation and in the Puget Sound region. It remains to be seen when the lost jobs will be recovered and the country is on a more solid footing for more robust long-term jobs growth (e.g., a return to historical trend).

The effects of economic volatility on population growth are smaller but the recession does affect peoples' ability to move, as they may not be able to sell their current homes or may have to sell at a loss. Domestic in-migration is a significant factor contributing to the Puget Sound region's long-term population growth but currently, it is being restrained by the economy. Fertility rates also lower as people feel less confident about economic prospects. Figure 3.3 shows historical annual population growth rates for employment and population in the Puget Sound region and underlines the different volatility between jobs and population growth rates.

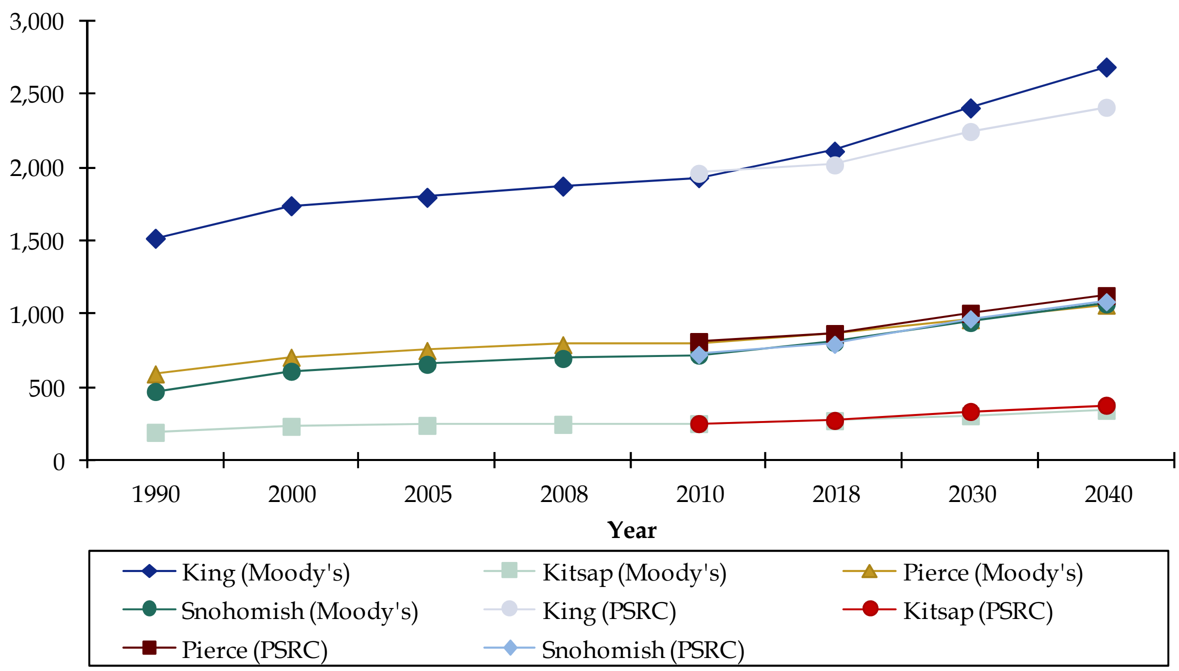
Figure 3.3 Historical Annual Growth Rates in the Puget Sound Region for Population and Employment
1991 to 2010



Source: U.S. Department of Commerce, Bureau of Economic Analysis, 2012.

Completed in 2006, prior to the recession, the PSRC jobs forecast is now too high; it assumes pre-recession long-term historical growth rates would continue into the future. The CAI and Moody's forecasts, both completed during the recession, show slower jobs growth, with the Moody's forecast showing the lowest rate of increase. Population increases are more consistent between the three forecasts although the PSRC estimate for 2010 is slightly higher than the others. There is a larger difference between the forecasts, however, in the distribution of population within the Puget Sound region, with the Moody's forecast putting a relatively higher share of future growth in King County. During the recession, many larger U.S. cities with high levels of amenities such as Seattle experienced comparatively stronger population growth than outlying suburban areas. The Moody's forecast, although it does not include city-level data, reflects this shift (see Figure 3.4).

Figure 3.4 Puget Sound Region Population by County,
1990 to 2040; PSRC and Moody's Forecast Comparison; Population in Thousands



In testing the implications of different forecasts, we found that the PSRC model is sensitive to changes in population levels, but is not sensitive to changes in employment levels. This is common with regional models, because they assume that historical relationships between population and employment, and how they influence traffic, will remain constant over time. However, the potential changes in population and employment implied by the revised forecasts suggests that these historical relationships might not hold into the future, adding a level of uncertainty to traffic forecasting. To reflect this uncertainty, we developed the approach to regional traffic forecasting described below. This analysis, as well as considerations related to the PSRC travel demand model, led to the development of socioeconomic forecasts as described below.

Approach to Forecasting Traffic Growth

There are two sources of uncertainty related to the relationship between the socioeconomic forecasts and traffic growth: 1) the reliability of the forecasts themselves, as described above, and 2) the inability of the regional travel demand model to capture the impact of these forecast differences, especially with regard to varying levels of employment growth. In testing the effect of alternative socioeconomic forecasts, we found little effect from alternative forecasts on the overall level of traffic demand in the Eastside Corridor, thus suggesting that the model was not adequately capturing changes.

Socioeconomic forecasts are only one element of potential change in traffic over time. Other factors could include the amount of trip-making per household, and other structural changes in the economy that are difficult to predict. To account for this uncertainty, we adjusted the population and employment forecasts for the future years in a way to show more significant changes in traffic demand while preserving some of the trip distribution and time-of-day choice features of the regional model. We produced three levels of forecast: low, medium, and high, in two steps.

Base Forecast. The first step was to define a base, or medium forecast for each target year. For 2014, CS developed a medium-term population forecast that combined the CAI forecast's conservative estimate for the Puget Sound Region's 2016 population, just over 3.9 million, with Moody's geographical allocation by county in the region. The expected annual population growth rate for the region between 2010 and 2016, 1.0 percent, is indicative of the long-term slowing in the pace of the Puget Sound Region's growth, declining from 1.7 percent annual growth in the 1990s to 1.1 percent annual growth during the 2000s.

For employment, CS applied the annual growth rate used by PSRC, 1.4 percent in the Puget Sound region. This forecast assumes a moderate-paced economic recovery between 2010 and 2016. Using these medium-term forecasts, CS interpolated between 2010 and 2016 to forecast population and employment for 2014.

For 2018, 2030, and 2040, we estimated a midrange forecast of population and employment based on a combination of WSDOT and Moody's socioeconomic forecasts.

Forecast Range. The second step was to define the range surrounding the medium levels identified above. There is little if any spread amongst the forecasts with regard to population. There is a large variation with regard to employment estimates but the PSRC model is not sensitive to changes in employment levels. To capture the potential impact of these variations in employment growth, CS factored the 2030 population and employment forecast by +/- 10 percent. Since it is only a few years from now, CS used point forecasts for 2014 and 2018 since any deviation from the forecast would be minimal. We also used a point forecast for 2040, as this was used only as an indicator of potential growth beyond 2030. The resultant socioeconomic control totals by county for all regional forecast scenarios appear in Table 3.1.

Table 3.1 County-Level Socioeconomic Forecast Control Totals for 2010, 2014, 2018, 2030, and 2040
In Thousands

	2010	2014	2018 – Phase 2	2030 – Phase 2			2040
County	Base WSDOT	Medium CS	Medium CS	Low	Medium CS	High	Medium CS
Population							
King	1,961	2,016	2,065	2,094	2,327	2,560	2,550
Kitsap	252	260	272	288	320	352	360
Pierce	811	827	863	884	983	1,081	1,093
Snohomish	723	758	799	859	954	1,050	1,076
Region	**3,747**	**3,860**	**3,999**	**4,126**	**4,584**	**5,042**	**5,079**
Employment							
King	1,188	1,215	1,328	1,411	1,568	1,724	1,748
Kitsap	87	88	94	99	111	122	125
Pierce	305	290	314	328	364	401	407
Snohomish	246	261	280	307	341	375	394
Region	**1,825**	**1,853**	**2,016**	**2,145**	**2,383**	**2,621**	**2,674**

Treatment of Managed Lanes in Regional Demand Model

The PSRC demand model is not designed to account for variable pricing on the proposed managed lanes. In response, the WSDOT approach modeled the demand for the managed lanes by 'filling the lanes' to approximate maximum potential demand for the corridor. This was done by allowing all autos equal access without tolls but capping the volume to a predefined throughput. This is a reasonable approach given the tools available, and a similar methodology was used for this study

Time-of-Day Models

People will change their time of travel as congestion worsens. PSRC has a time-of-day choice model that provides sensitivity to traveler's temporal decisions together with sociodemographic and trip characteristics. PSRC's time-of-day models estimate the number of trips from each traffic analysis zone to each other TAZ in each time period. CS used the PSRC model time-of-day choice procedures and extended it to all of the modeled time periods, 5:00-11:00 a.m. and 2:00-8:00 p.m., in order to produce 30-minute estimates of demand for the corridor during peak periods.

Base-Year Corridor Origin-Destination Forecasts

CS applied WSDOT procedures, in which the regional model adjustment procedure called Matrix Estimation (ME) was used to calibrate the volumes within the corridor to total vehicle traffic counts for each of the 30-minute time slices. This resulted in a calibrated trip table that, when assigned to the corridor, produced traffic flows that closely match the counts.

Corridor-Level Mode Shares

CS' approach to forecasting mode shares relied on observed mode splits between HOV 2 and HOV 3+ in the corridor. The observed mode shares for HOV 2 and HOV 3+ were derived for the base year from a combination of Washington State Transportation Center (TRAC) and WSDOT's permanent count recorder (CDR) data. These 2010 observed mode shares were used as a baseline, and CS applied changes in mode shares as forecasted by the regional model to the validated base-year trip tables to estimate future changes in mode split in the corridor.

Forecast Origins and Destinations within the Project Corridor

CS used an incremental approach to estimating growth for particular corridor origins and destinations according to the following equation:

Forecast Future Demand = ***(Raw Future Demand - Raw Base-Year Demand) + Calibrated Base-Year Demand***

This approach applies the forecast the increment of traffic growth for each origin-destination pair to the calibrated values of traffic for that movement. CS applied this calculation to each half-hour time slice to each mode to capture the dynamics estimated by the regional model. This approach captures the changes in trip making activity and trip patterns (distribution) predicted by the PSRC model under future conditions.

The resulting origins and destinations became the basis for corridor demands that were further evaluated with simulation models, described in the next section.

3.3 Corridor Operations and Toll Analysis

WSDOT developed a VISSIM traffic operations model for its analysis of the Eastside Corridor. The traffic demand inputs for the operations model came from a separate proprietary model of price-setting and willingness to pay tolls. There was an iterative procedure back and forth between the two separate modeling processes to produce the final traffic and revenue forecasts for planning analysis. Cambridge Systematics was not given access to the proprietary model, so we could not review the assumptions and methods used.

Cambridge Systematics obtained and reviewed the WSDOT simulation model, and verified that we could obtain the same results as WSDOT when run in the same way. We then modified the WSDOT tool to include a comprehensive traffic simulation/pricing analysis tool that incorporates these elements:

- **Corridor Traffic Operations.** The VISSIM model simulates individual vehicles. Therefore the effects of traffic demand on corridor traffic operations are analyzed recognizing the implications of roadway geometrics; merging, diverging, and weaving movements; driver behavior; and resulting bottlenecks. The net result is a set of metrics that demonstrate performance in the corridor, with speed, travel time, and throughput. This model also provides travel time savings for different origin-destination pairs within the corridor, which is used to estimate how many vehicles would be willing to pay tolls.
- **Toll Setting Algorithm.** With Express Toll Lanes, the tolls are set to achieve certain policy objectives. In the case of the Eastside Corridor, WSDOT has a policy of achieving 45 miles per hour 90 percent of the time during the peak periods. CS developed a method to model this policy and built it into the VISSIM simulation model.
- **Willingness to Pay Tolls.** Drivers in the Express Toll Lane Corridor will face a choice of whether to continue to use the general-purpose lanes or pay a toll to use the Express Toll Lane. The main factor influencing that decision will be travel time savings and the perceived reliability of the trip in the Express Toll Lanes. CS built a model of how drivers will make these choices, and incorporated it into the VISSIM simulation model.

Corridor Traffic Operations Analysis

Cambridge Systematics reviewed the operations model prepared by WSDOT and modified it to incorporate the VISSIM Express Toll lane features that allow for the express toll decisions to be made.

The VISSIM model is stochastic, in that it involves multiple runs conducted with different random seeds and the average results reported. We conducted enough runs to achieve 95 percent confidence in the outcome and 5 percent error in network speed performance and total revenue. VISSIM reports numerous performance measures: travel time, vehicle miles of travel, toll price set, revenue-all for five-minute increments. These data were rolled up to 30 minute, hourly and daily levels as needed.

Appendix C (in CD) contains model summaries of all scenarios.

Toll Setting Algorithm

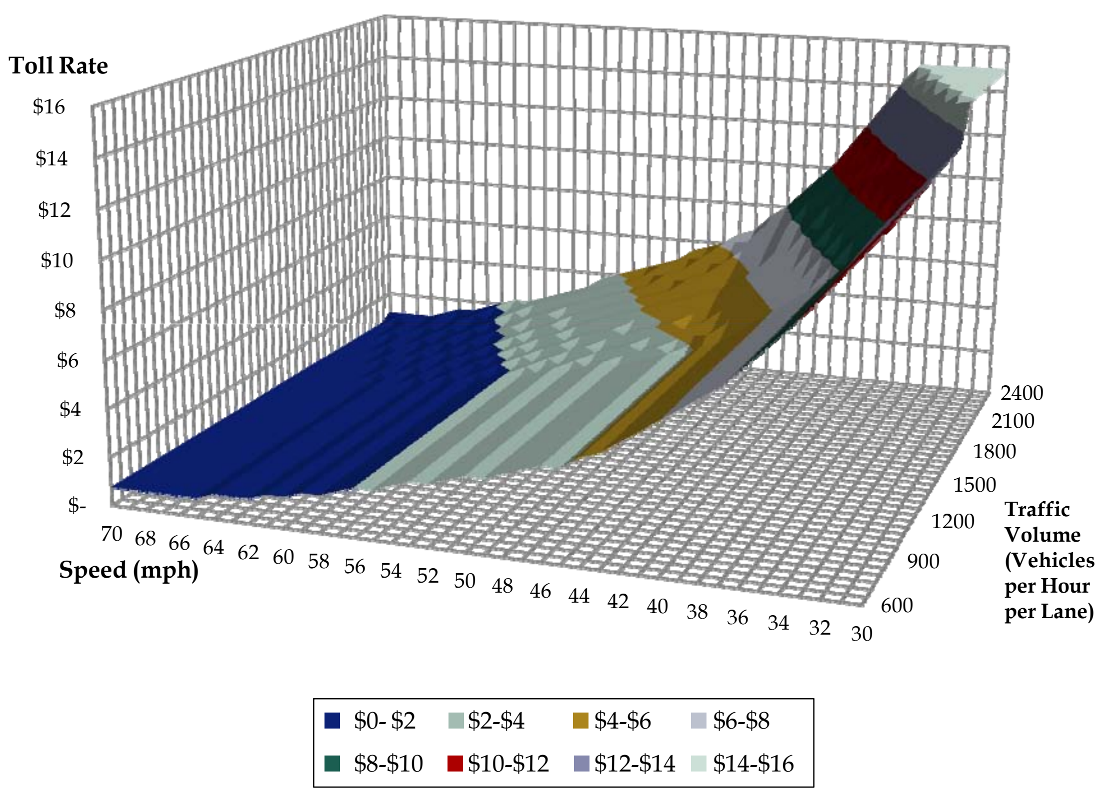
There are numerous ways that WSDOT could implement their toll policy with a tolling algorithm. WSDOT's toll algorithm is propriety, so CS developed a toll pricing algorithm that would be a reasonably foreseeable approach that WSDOT might take. How this will actually be carried out is uncertain, so CS used possible variation in outcome of the toll algorithm in the risk analysis.

WSDOT's toll-setting concept is based on adjusting the toll rates every five minutes based on data from traffic detectors in the Express Toll Lanes, for the previous five minutes of speed and volume data, adjust the toll rates. Figure 3.5 is a graphical representation of the toll setting algorithm, where:

- Speed is on the x-axis;
- Traffic volume in the Express Toll Lane is on the z-axis; and
- The resulting toll rate is on the y-axis.

When the critical speed of 45 miles per hour is approached, prices escalate more quickly. Prices drop as traffic speeds improve.

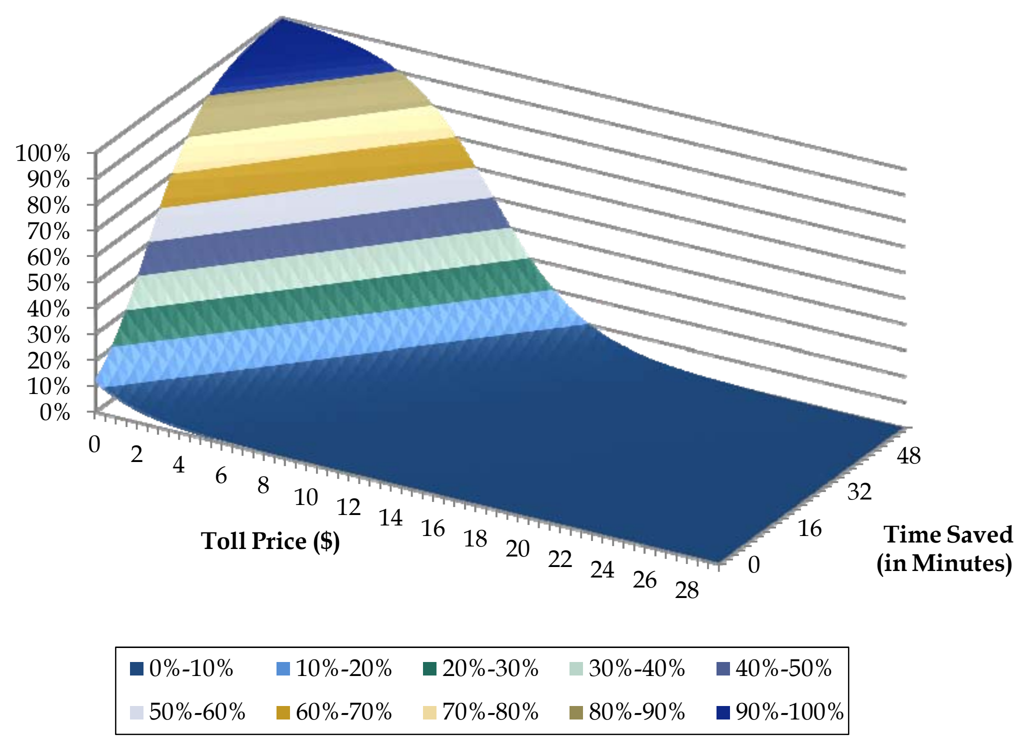
Figure 3.5 Toll Setting Algorithm



Willingness to Pay Tolls Analysis

Willingness to pay is defined as the probability of drivers choosing to use the Express Toll Lanes. Although this probability could be decided by a wide range of factors, such as household income, payment method, tolling price, travel time saved, and trip purpose, the decision model applied in this study assumes that the probability of using the Express Toll Lanes is related to tolling price and travel time saved. Data from the stated-preference survey (described in Section 2.5), specifically survey responders' choices, and the associated travel time savings and toll cost, were used to construct a set of probability equations which predicate drives' willingness to use the Express Toll Lanes. The equations were then used in the VISSIM decision model to calculate the probability of using the managed lanes, based on the level of travel time savings and toll rate (see Figure 3.6). For the purpose of developing the low and high ranges of willingness to pay, only the cost coefficient was adjusted in the VISSIM decision model.

Figure 3.6 VISSIM Decision Model with I-405/SR 167 Corridor Stated-Preference Survey Cost Coefficients



3.4 Risk Analysis

Traffic and revenue forecasts depend on a wide variety of assumptions relating to future travel, and differences between those assumptions and actual future conditions can have meaningful implications for traffic and revenue outcomes. There is considerable literature devoted to the topic of differences between traffic and revenue forecasts and outcomes.[17] Recognizing the uncertainty in forecasting, Cambridge Systematics developed toll revenue forecasts based on a range of potential input assumptions using a Monte Carlo simulation technique. This technique improves upon methods that involve simple sensitivity tests by estimating a probability distribution of the key input assumptions which leads to the range of outcomes expressed in probabilistic terms.

CS created a range of reasonably foreseeable scenarios related to future traffic growth and drivers' willingness to pay using the approach described below:

- Identified the most important risk factors;
- Estimated a range of assumptions with a probability distribution of the values;
- Developed scenarios that test the sensitivity of revenue outcomes to change in one variable while holding other variables constant;
- Ran the traffic model for the chosen scenarios;
- Developed regression models between input variables and the resultant toll revenues;
- Using the revenue outcomes for each year, developed the resultant cash flows; and
- Applied Monte-Carlo simulation to the revenue model to estimate a probability distribution of the present value of gross toll revenue.

Potential Risks Associated with Eastside Corridor Traffic and Revenue Outcomes

Some of the conditions that could affect future traffic and revenue in the Express Toll Lanes include, but are not limited to:

[17] A good, readable summary of the topic is available in Lemp and Kockelman, "Understanding and Accommodating Risk and Uncertainty in Toll Road Projects, A Review of the Literature," 2009, available at: http://www.caee.utexas.edu/prof/kockelman/public_html/TRB09Risk&UncertaintyTolledProjects.pdf.

1. Traffic growth;
2. Willingness to pay tolls;
3. Transponder ownership;
4. Accuracy of the toll setting system and/or relationship between traffic volumes and resulting revenue;
5. Price inflation;
6. Non-collectible revenue;
7. Realization of transportation improvements that could add to or detract from traffic in the corridor; and
8. Accuracy of the models used to create the forecasts.

Cambridge Systematics considered these potential risks and determined that the first four had the highest potential to impact future traffic and revenue in a meaningful way, independent from other factors. We discuss each of these four factors below and their probability distributions applied in the risk analysis, followed by a brief discussion of how the other risk factors may impact toll revenue forecasting.

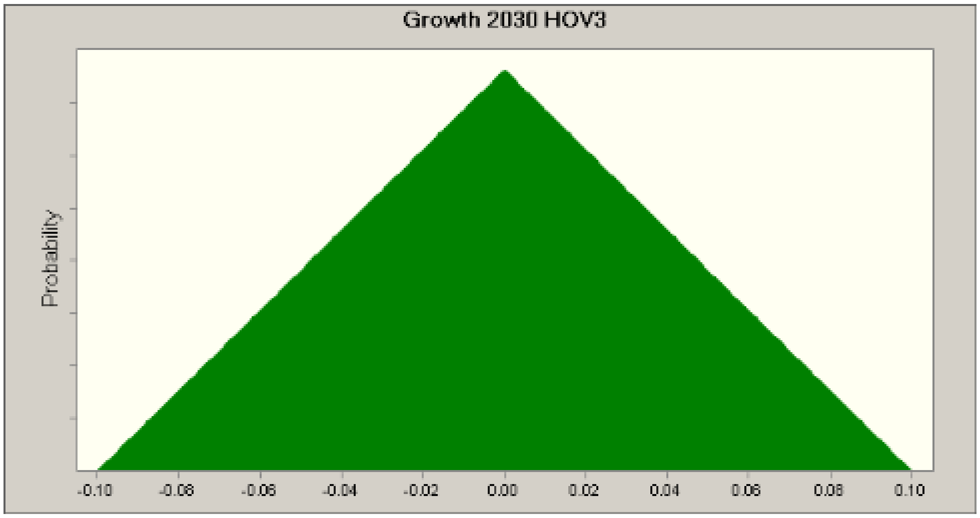
Traffic growth

Traffic growth will influence revenue in that the total number of people in the corridor will comprise the universe of people that might choose to use the Express Toll Lanes. Traffic growth will be influenced by:

- population growth and its location within the region;
- employment growth and its location within the region;
- gross domestic product (an indicator of economic activity);
- cost of operating and owning a vehicle, which includes fuel price, taxes, and repair costs, as well as the tendency of people to rideshare. The latter is particularly important since HOVs ride free in the Express Toll Lanes;
- availability of transit; and
- potential changes in travel characteristics over time (such as when women entered the work force in large numbers in the 1970s).

Our forecasts assumed no difference in growth between scenarios tested through 2018, since we did not forecast high growth during this period (see Section 3.1). Through 2030, however, we incorporated a range of +/- 10 percent around our baseline forecast. Beyond 2030, we used a single, relatively low-growth forecast. Figure 3.7 shows the probability distribution applied to traffic growth.

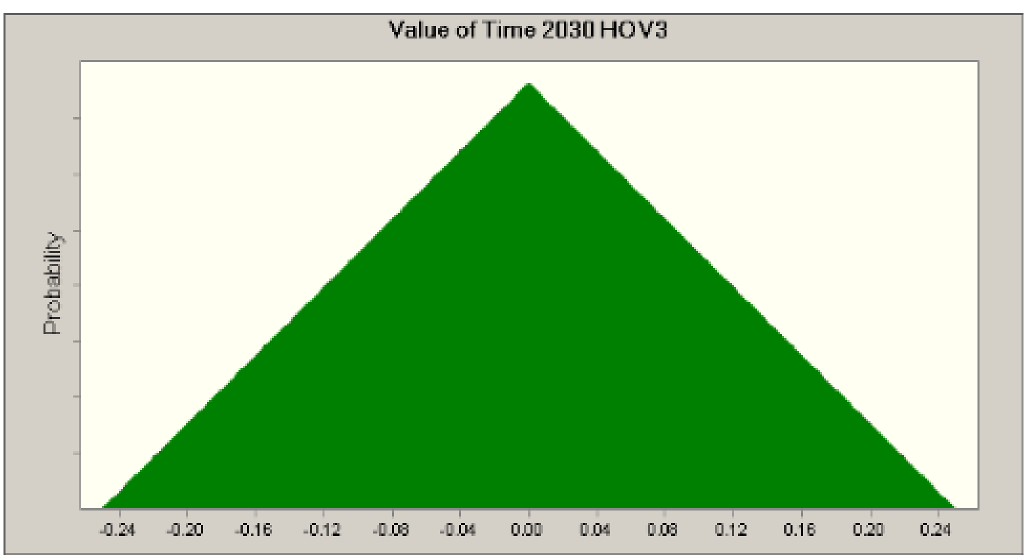
Figure 3.7 Probability Distribution for Risk Analysis
Traffic Growth



Value of Time

Value of time will influence how many people choose to pay a toll. Section 3.3 has a description of our method of estimating value of time based on stated-preference surveys and actual experience in the SR 167 corridor. Since value of time is so difficult to forecast with accuracy, we used a range of values +/- 25 percent around those we estimated based on the available data. A triangular probability distribution for the value of time was applied to the risk analysis (Figure 3.8) to all model years (i.e., 2014, 2018, and 2030).

Figure 3.8 Probability Distribution for Risk Analysis
Value of Time



Transponder Ownership

WSDOT's concept of operations requires that people have *Good-to-Go!* transponders in order to use the Express Toll Lanes. This means that some people who might otherwise desire to use the lanes would be ineligible if they did not have a transponder. The importance of transponder ownership is borne out by the low usage of the existing SR 167 Express Toll Lane.

Our survey in 2011 showed that about 14 percent of corridor drivers had transponders. Conventional wisdom is that this number has almost certainly risen since the SR 520 Bridge tolls began in December 2011, but we do not have updated data since then.

In the short term, we have assumed a range of transponder ownership as follows:

Year	Low	High
2014	20%	45%
2018	20%	100%
2030	100%	100%

The low assumption in 2014 presumes that there is little additional transponder ownership, while the high allows for some additional participation in the *Good-to-Go!* program. By 2018, it is possible that much higher transponder ownership could occur, but there is also still a chance of low ownership, hence we use a much wider spread. By 2030, we assumed that everyone would be eligible to use the facility, either through ubiquitous transponder ownership or a different technology.

Figures 3.9 and 3.10 show the probability distributions applied to the risk analysis for years 2014 and 2018, respectively. In 2014, the expected mean was 25 percent, with a probability range of -20% and +80% from the mean. In 2018, the expected mean was 45%, with a probability range of -55.6% and +122.2% from the mean.

Figure 3.9 Probability Distribution for Risk Analysis
Transponder Ownership, 2014

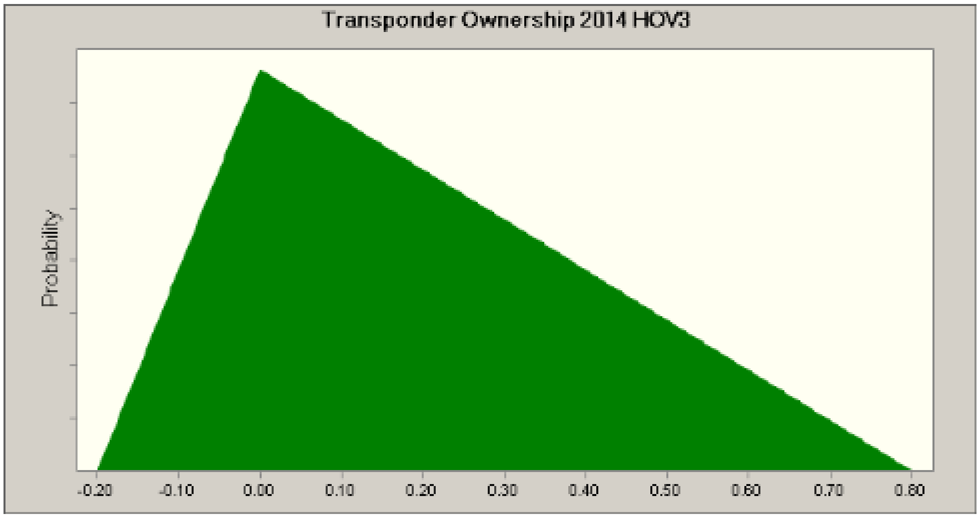
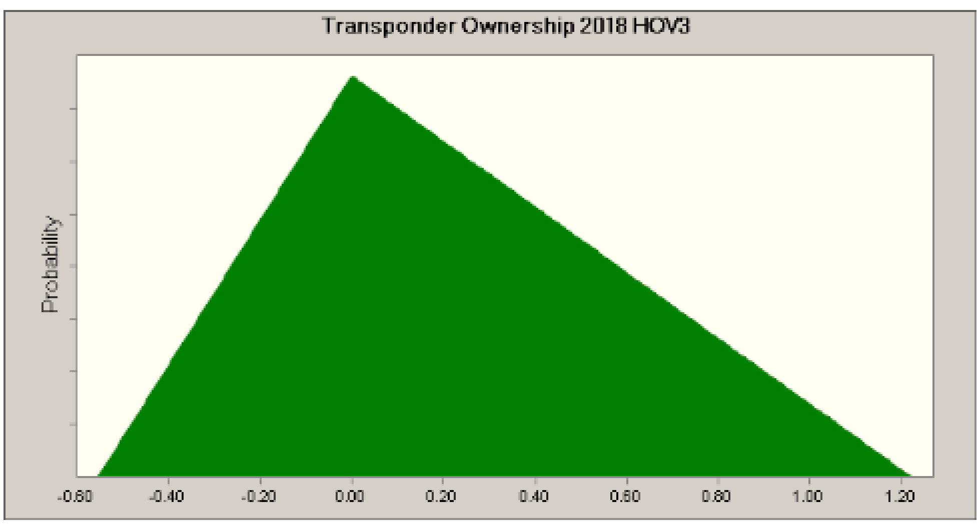


Figure 3.10 Probability Distribution for Risk Analysis
Transponder Ownership, 2018

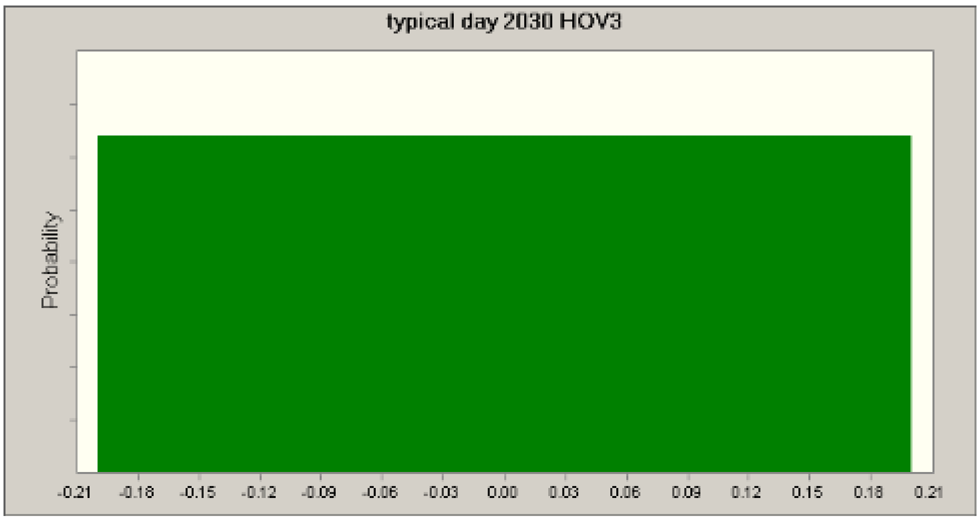


Accuracy of the toll setting system and/or relationship between traffic volume and resulting revenue

Forecasting is usually done on an average or typical day. For most purposes, this is fine. However, in an Express Toll Lane situation, the relationship between more traffic in the corridor and the value of toll revenue may not be linear. This means that simply multiplying the typical day times the number of weekdays may yield a forecast that is considerably different from the annual revenue that might occur.

In our analysis of existing SR 167 traffic, we found that there was little relationship between a given level of vehicle miles traveled in the corridor and the amount of revenue generated (see Section 2.4.) A uniform probability distribution of +/-20 percent from the mean was applied to the risk analysis (Figure 3.11) to all forecast years.

Figure 3.11 Probability Distribution for Risk Analysis
Typical Day



Other Risk Factors

We also considered other risk factors, but did not address them explicitly in our forecasts:

- **Cost inflation,** which will influence traveler value of time over the forecast period. Since tolls will vary according to traffic conditions, the algorithm that sets tolls will depend on how people value their time. If cost inflation is high, then tolls will be higher. If low, then tolls will be lower. Since toll rates will be set automatically to reflect traffic conditions, and drivers' responses to the expected delays will be related to their value of time savings, the revenue estimate can simply be multiplied by the appropriate factor of the consumer price index (or other applicable index) to yield alternative revenue estimates. This can most easily be done in the framework of the financial model that WSDOT is providing, so we did not address it in these traffic and revenue forecasts – all our forecasts are done in 2012 dollars.
- **Noncollectible revenue,** or toll evasion. WSDOT can incorporate different assumptions for non-collectibles in their financial model.
- **Realization of transportation improvements that could add to or detract from traffic in the corridor.** Our review of transportation improvements in the corridor did not reveal any that would significantly impact traffic and revenue.
- **Accuracy of the models used to create the forecasts.** We cannot know with certainty how effective the models we developed will be at forecasting traffic and revenue in

this corridor, and we have no basis on which to apply particular risk factors. We believe that the risk elements already included also can be a proxy for potential model accuracy issues.

Scenarios

We constructed 96 unique scenarios to run through the consolidated traffic simulation/pricing model based on the range of values discussed above (see Table 3.2). Each scenario was run five or more times to achieve a 95 percent confidence level.

Table 3.2 Range of Assumptions for Risk Analysis for both *HOV 2+ Free* and *HOV 3+ Free* Scenarios

	Risk Factor		
Year	Percent of corridor vehicles with transponder	Corridor Traffic Growth (difference from PSRC forecast)	Value of Time (difference from 2011 stated-preferences survey)
2014	20% 45%	Not tested	-25% 0% +25%
2018	20% 45% 100%	Not tested	-25% 0% +25%
2030	100%	-10% 0% +10%	-25% 0% +25%
2040 (HOV 3+ free only)	100%	0%	0%

We used this framework to evaluate the dynamic pricing option for the *HOV 3+ free* and *HOV 2+ free* scenarios for 2014, 2018, and 2030. We then estimated revenue for the *Mixed* scenario from the relevant portions of the day from the single-exemption scenarios.

For 2040, one scenario with the *HOV 3+ free* operation was used as a benchmark for growth.

3.5 Evaluation of Variable and Flat Tolling

The above methodology was applied to the dynamic pricing option of toll collection. To evaluate the implications of different tolling approaches, we conducted several test runs to compare against the dynamic pricing approach.

The test runs were applied to the medium corridor traffic growth, medium value of time for HOV 3+ free in 2030. Two pricing options were tested: 1) a *flat rate* (same toll rate all day); and 2) *variable pricing* (toll rates preset by time of day). We analyzed the toll rates for the *HOV 3+ free* scenario to develop a set of reasonable toll rates that could be applied under the *flat rate* and *variable pricing* scenarios.

For the *flat rate* scenario, we assumed that the toll rates by area would be the average toll rate from both the morning and afternoon periods for each toll area:

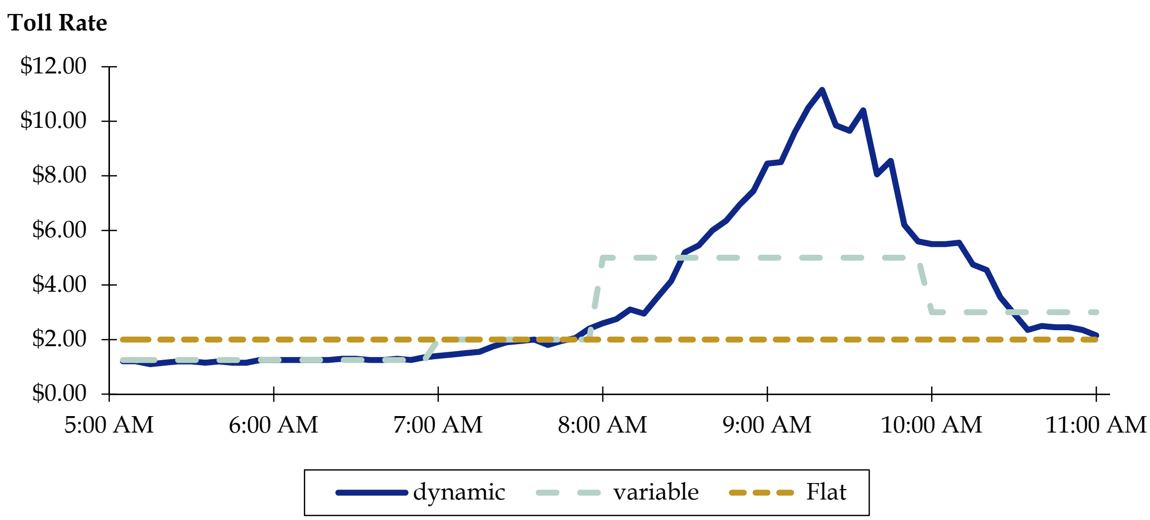
- Area North – $1.25;
- Area Middle – $2.50; and
- Area South – $2.00.

For the *variable pricing* scenario, we developed a toll rate schedule based on to the hourly toll rates derived from the dynamic pricing analysis from the *HOV 3+ free* scenario. In developing this toll schedule, we attempted to find a balance between enough changes in rates to maintain the speed policy without so many changes as to confuse customers. For the most part, we found rates that would be in place for a few hours at a time. Note that there are numerous potential solutions to this problem, and other solutions could yield different results.

Toll rates ranged from $1.00 up to $6.00 per area. For example, Area South morning toll rates start at $1.25 by 5 a.m., increasing to $2.00 by 7 a.m. and to $5.00 by 8 a.m. After 10 a.m., the toll rate drops to $3.00. The afternoon peak begins at $1.25, until it changes to $1.00 by 7 p.m.

These toll rates were then modeled in VISSIM to generate toll revenue estimates for the *flat rate* and *variable pricing* scenarios (further discussed in Section 4.3). Figure 12 shows an illustrative comparison of toll rates in the South area in the a.m. period under the three tolling concepts. Appendix D has the detailed toll rate tables for all areas and periods for the test run.

Figure 3.12 Toll Rate Comparison South Area



4.0 Traffic and Revenue Forecasts

4.1 Overview

This section describes our findings related to expected revenue from different Express Toll Lane operating plans as well as differences in transportation system performance.

Scenarios and Horizon Years

We evaluated several different tolling policies that determine what type of user is allowed free access to the Express Toll Lanes and how prices are set:

- **Types of users allowed free access:**
  - *HOV 2+ free* (meaning that cars with two or more occupants travel for free);
  - *HOV 3+ free;*
  - *Mixed* Scenario where HOV 3+ free during peak periods and HOV 2+ free during off-peak periods; and
  - *HOV Discount* scenario, where all HOV pay a toll to use the lanes but receive a discount of about $1.00 during any period.
- **Ways of setting the price or toll rates:**
  - **Dynamic pricing,** where toll rates change according to actual traffic demand volumes in order to manage demand for the Express Toll Lanes and thus maintain minimum performance objectives in the Express Toll Lanes (e.g., at least 45 mph average speed during peak periods, 90 percent of the time.)
  - **Variable pricing,** where prices are preset according to a published schedule, and vary by time of day and day of week in order to attempt to achieve similar performance objectives.
  - **Flat pricing,** where toll rates are constant throughout the day and do not vary according to traffic volumes or congestion levels.

Our quantitative analysis focused on the dynamic pricing approach and on the first three tolling policies described above, i.e., *HOV 2+ Free*, *HOV 3+ Free*, and the *Mixed* scenario, to generate estimates of future Express Toll Lane usage and revenue. We used a simplified "sensitivity analysis" approach to develop estimates for the remaining options, that is, the *HOV discount* option and the *variable* and *flat* pricing options.

We conducted our detailed studies at three benchmarks in time:

- 2014 – The assumed opening year of Phase 1;
- 2018 – The assumed opening year of Phase 2; and
- 2030 – A reasonable future horizon year, consistent with forecasts available from the PSRC travel demand model.

In addition, we used another benchmark at 2040 to assess potential growth in toll revenue beyond the year 2030.

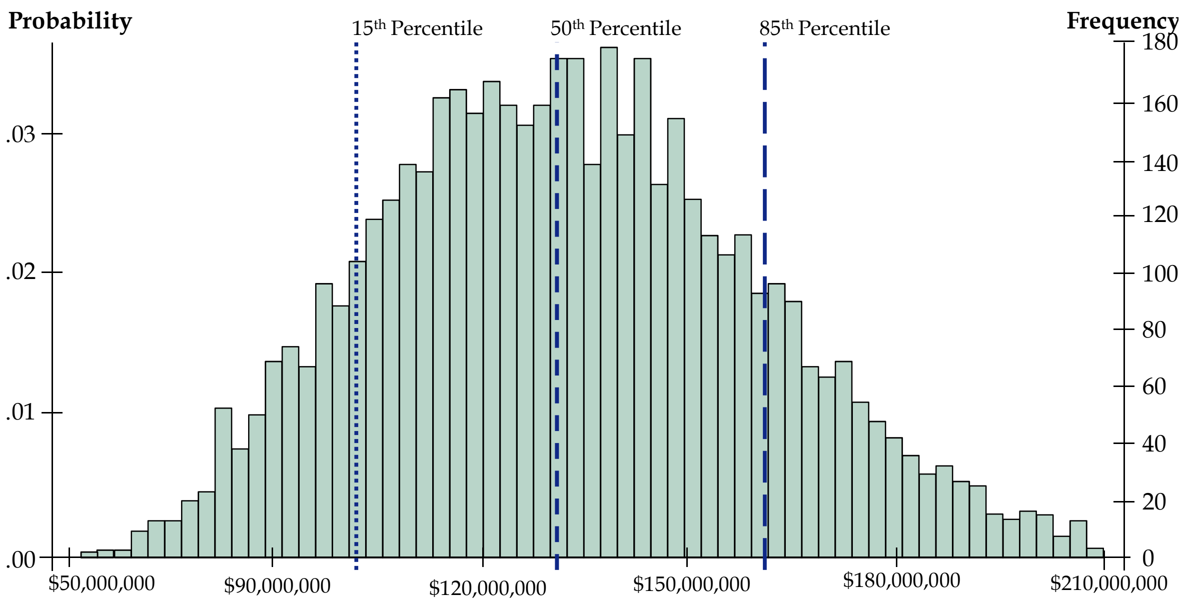
Risk-Based Approach

As noted in previous sections, we applied a Monte Carlo technique to simulate approximately 5,000 different combinations of input factors to forecast gross toll revenue in 2012 dollars[18] for the forecast years 2014, 2018, and 2030. The resulting estimates of toll revenue were arranged from low to high. We reported on the amount of revenue that was achieved by 15 percent, 50 percent, and 85 percent of all the individual outcomes, referred to the 15th, 50th, and 85th percentiles, respectively. Figure 4.1 illustrates this distribution of revenue outcomes for the *HOV 3+ Free* scenario in 2030, showing the full range of outcomes as well as the 15th, 50th, and 85th percentiles.

The 15th percentile is a reasonable lower bound to use for financial planning, as only 15 percent of the revenue outcomes would be *below* that number. We refer to that as the "low" forecast. The 85th percentile is a reasonable upper bound as only 15 percent of outcomes would be *higher* than that number – referred to as the "high" forecast. The 50th percentile (also called the median) represents a level where a higher or lower amount is equally probable, but should not be interpreted as a "most likely" value.

[18] Our forecasts are of gross toll revenue in 2012$. WSDOT is preparing operating cost estimates, and will apply different assumptions with respect to inflation in its financial analysis.

Figure 4.1 Probability Distribution of *HOV3+ Free* Revenues from Monte Carlo Simulation
2030



Remainder of this Section

Following a discussion of common assumptions among all scenarios, we provide revenue and traffic performance forecasts for the dynamic pricing operating plan. We then report on the differences that might occur with *variable* and *flat* pricing, as well as a sensitivity test of a dynamic pricing plan where all HOVs pay a toll, but at a discounted rate (*HOV discount* scenario).

When reviewing these findings, it is helpful to keep in mind the following:

- The gross revenue forecasts in this report do not tell the entire picture with respect to feasibility of the project. This can be discerned only by considering the capital and operating cost estimates being prepared separately by WSDOT, and WSDOT's financial plan.

- We have multiple dimensions to compare:
  - Type of users allowed free access;
  - Ways of setting the toll rates;
  - Horizon years; and
  - Probability of different outcomes.

We created simplified comparisons that hold one or more of these values constant while we investigate changes due to others.

■ 4.2 Common Assumptions

The traffic and revenue forecasts are predicated on the following basic assumptions:

- The project will be developed as described in this report with respect to roadway configuration, toll setting, and implementation schedule.

- The gross revenue forecasts are expressed in constant 2012 dollars, and do not show the effects of inflation. This is done to simplify comparison of revenue outcomes of the different future forecast years.

- We assumed that people's willingness to pay tolls increases over time at the same rate as inflation. Historically, over the long term, people's real income has risen faster than inflation, which would result over time in a higher willingness to pay. Whether that historical trend will continue in the future, given recent economic conditions, is uncertain. By assuming that future willingness to pay grows no faster than inflation, we are less likely to *over*estimate future willingness to pay.

  This is important if WSDOT decides to issue bonds based on the anticipated revenue from the Express Toll Lanes. If inflation occurs at a different rate than anticipated, this can have a large impact on how much revenue is collected. In fact, the rate of inflation is probably the largest risk factor facing the project if bonds are used to finance construction of the toll lanes. For this reason, it is appropriate for WSDOT to include inflation as a risk factor in its financial planning, rather than assuming a particular inflation rate in this study.

- The forecasts presented here represent an expected range of outcomes over the forecast period rather than a specific amount of revenue in a particular year. This acknowledges the normal ups and downs in traffic trends from year to year, and the likely resulting variation in revenue generation. This forecast does not try to capture these interim ups and downs, but rather the longer-term trend over the forecast period.

- We did not adjust the gross toll revenue forecasts to account for noncollection of tolls that are due. WSDOT should incorporate a reasonable set of such assumptions in its financial analysis.

- The regional transportation system network will be implemented consistent with the Puget Sound Regional Council's Transportation 2040 plan.

- The entire Eastside Corridor system will be well-maintained, efficiently operated, and effectively signed and promoted to optimize usage.

- Regional and corridor growth in population and employment will occur as described in this report.
- Motor fuel will continue to remain in adequate supply to motorists and the long-term rate of price change will generally track with the overall rate of change in consumer prices.
- No local, regional, national, or international emergency will arise which would abnormally restrict the use of motor vehicles, or substantially alter economic activity or freedom of mobility.

Ramp Up Assumptions

It is usual for potential customers to take some time to become familiar with transportation facilities, and the demand "ramps up" at a rapid rate over the first few years of operation. The impact of ramp up on Express Toll Lane utilization is difficult to predict and represents a significant revenue risk in the early years. This behavioral characteristic is not explicitly simulated in the traffic models, with the likely result that fewer people will pay to use the Express Toll Lanes in the early years than is initially forecast by our models. We adjusted for the potential impact of ramp up by discounting the revenues in the early years of each project phase.[19]

Although the existing SR 167 Express Toll Lanes have been in operation for four years, it is reasonable to assume that they are still in the latter years of their ramp up phase. This is because WSDOT did not promote the SR 167 project heavily and did not make an effort to encourage corridor drivers to get transponders.

Table 4.1 shows the adjustments to revenue that we applied in the early project years to reflect the impact of ramp up. Toll revenues from the south area of the project (SR 167) are expected to be at 75 percent of the modeled value by 2014, increasing to 100 percent by 2017. Toll revenues generated in the north end of the corridor (from Bellevue north to I-5) are assumed to start at 50 percent of the modeled value in 2014, increasing to 100 percent by 2018. By the time the middle portion (from SR 167 to Bellevue) opens in 2018, it is expected that drivers in the corridor will be more familiar with the project, so a 75 percent of modeled revenue was assumed in the opening year (2018), increasing to 100 percent by 2020.

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[19] Increasing transponder ownership over time, one of several factors considered in the formal risk analysis, is likely to be correlated with ramp up. Thus we did not also include ramp up as one of the explicit factors in the risk analysis.

Table 4.1 Percent of Modeled Revenue by Corridor Area and Year

	Corridor Area		
Year	North	Middle	South
2014	50%	N/A	75%
2015	60%	N/A	85%
2016	75%	N/A	95%
2017	85%	N/A	100%
2018	100%	75%	100%
2019	100%	85%	100%
2020	100%	100%	100%

4.3 Findings: Dynamic Pricing Toll Collection Concept

Revenue Forecasts

We provide several comparisons of revenue:

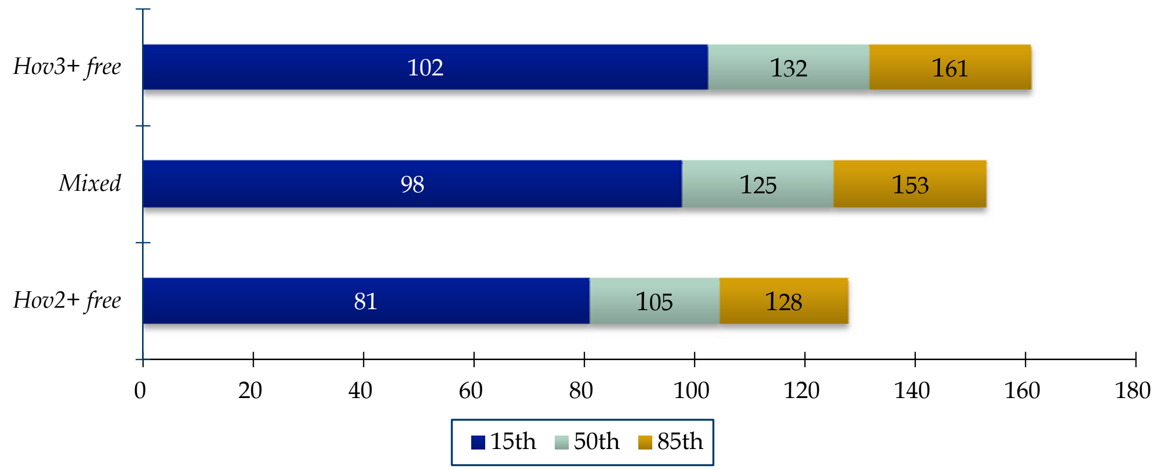
- Range of Forecast 2030 Revenue Based on Type of Users Allowed Free Access;
- Forecast 40-year Annual Revenue Streams: 2014 to 2053 Forecast – 50th Percentile;
- Contribution of Each Toll Area to Gross Revenue;
- SR 167 Revenue Trends Compared to 2014 Forecasts;
- Ranges of Revenue Streams by Scenario; and
- Comparison to WSDOT's 2009 Forecast for 2030.

Range of Forecast 2030 Revenue Based on Type of Users Allowed Free Access

We forecast the *HOV 3+ Free* scenario to generate the most revenue in 2030, ranging from $102 million per year (in 2012$)[20] at the low end (15th percentile) to $161 million per year at the high end (85th percentile,) as shown in Figure 4.2. This is generally about 25 percent higher than the forecast revenue with the *HOV 2+ Free* scenario ($81 million to $128 million.) The *Mixed* scenario is in between the two, and closer to the *HOV 3+ Free* forecast. The high end of the forecast (85th percentile) is about 60 percent higher than the low end, with the *HOV 2+ free* scenario at $128 million and the *HOV 3+ free* scenario at $161 million per year.

[20] All revenue forecasts in this report are in 2012 dollars.

Figure 4.2 2030 Gross Revenue Forecast Ranges
Millions of 2012 Dollars



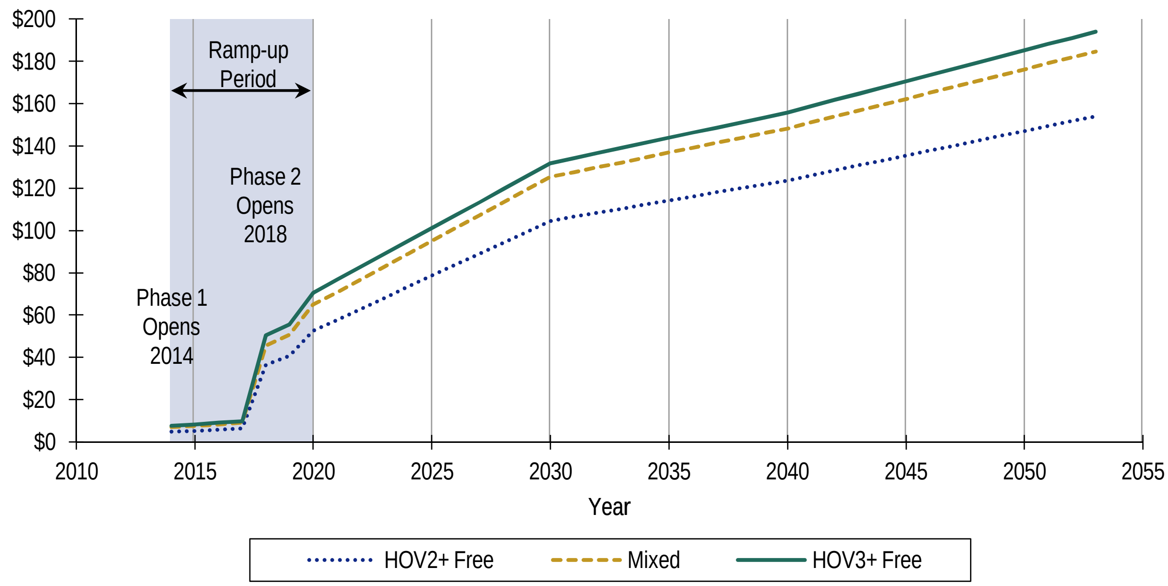
Forecast 40-Year Annual Revenue Streams: 2014 to 2053 Forecast – 50th Percentile

We developed 40-year gross revenue streams from our analysis of 2014, 2018, and 2030 toll revenue, in addition to our assumptions regarding ramp up of traffic in the early years of operation. For ease of comparison, we show these revenue streams for the 50th percentile forecast in Figure 4.3. Similar trends are evident in the 15th and 85th percentile forecasts.

When Phase 1 opens in 2014, forecast revenues range from $5.5 million per year from *HOV 2+ Free* to $8.7 million for *HOV 3+ free*. When Phase 2 opens in 2018, we forecast revenue to increase dramatically, as the Express Toll Lane "gap" between SR 167 and the north portion of I-405 is closed, to $36.4 million for the *HOV 2+ Free* scenario and $50.0 million for the *HOV 3+ Free* scenario. After two years where drivers become accustomed to the project, we forecast steady growth through 2030 – an average of 7.1 percent per year for *HOV 2+ Free* and 6.5 percent for *HOV 3+ Free*. After 2030, we forecast more moderate growth, of 1.7 percent per year for both scenarios.

The revenue growth forecast is considerably higher than the forecast of traffic growth in the corridor discussed in Section 3.0. This is because when highways become congested, a small amount of additional traffic leads to a large amount of additional delay. When delay increases in the general purpose lanes, drivers are more likely to choose the Express Toll Lanes, which, in turn, will result in higher prices in the toll lane. This has a significant effect on the revenue streams. As an example, if a given level of congestion results in the price for a trip on the toll lane to be $1.00, but another results in a toll of $2.00, the same amount of traffic in the toll lane will yield twice as much revenue.

Figure 4.3 Forecast 40-Year Annual Revenue Streams: 2014 to 2053
50th Percentile Forecast
Millions of 2012 Dollars



Contribution of Each Toll Area to Gross Revenue

The contribution of each area to the toll revenue in 2014, 2018, and 2030 for the three dynamic pricing scenarios under the 50th percentile (median) forecast is provided in Table 4.2. In Phase 1, Area North (I-405 between Lynnwood and Bellevue) generates almost two-thirds of the total revenue. With the completion of Phase 2 in 2018, Area Middle (I-405 between Bellevue south to SR 167) generates the most revenue, at 48 percent of the total. By 2030, the revenue share of Area Middle increase to 56 percent of the total. Revenues in Area North are forecast to grow at a slower rate compared to both Areas Middle and South.

Table 4.2 Share of Annual Revenue Forecasts by Year

North, Middle, and South Median Forecast, Thousands of 2012$

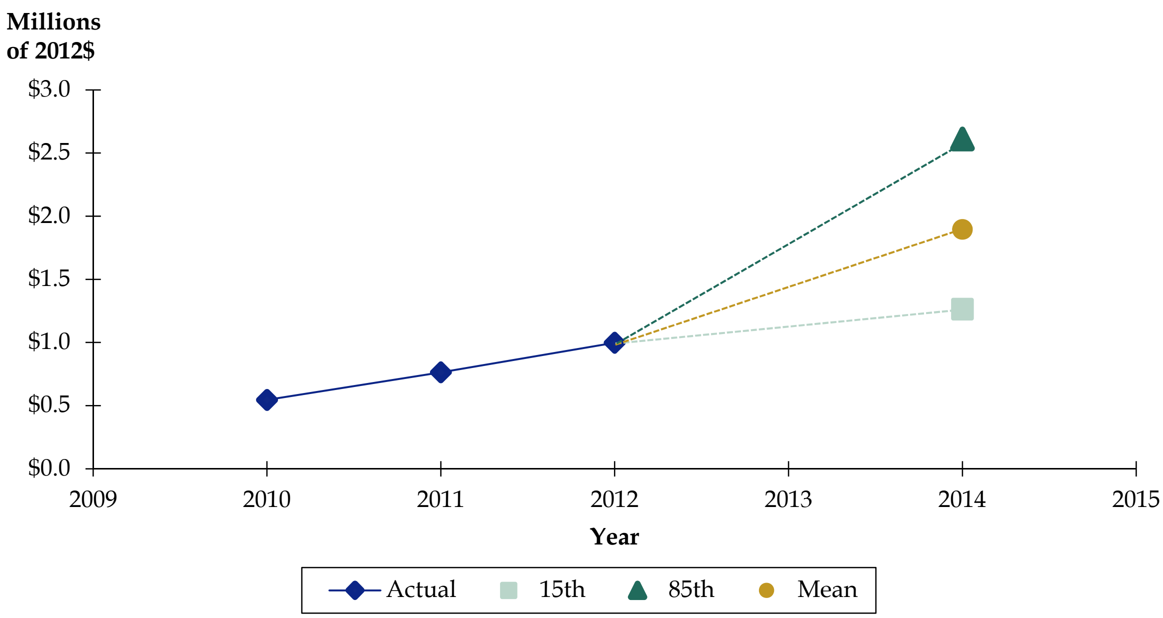
	North		Middle		South		Total
Scenario	**Revenue**	**Percent**	**Revenue**	**Percent**	**Revenue**	**Percent**	**Revenue**
2014							
HOV 2+ Free	$3,597	65%	$0	0%	$1,895	35%	$5,492
HOV 3+ Free	$5,710	65%	$0	0%	$3,009	35%	$8,719
Mixed	$5,181	65%	$0	0%	$2,730	35%	$7,911
2018							
HOV 2+ Free	$14,484	29%	$23,899	48%	$11,587	23%	$49,970
HOV 3+ Free	$10,564	29%	$17,431	48%	$8,451	23%	$36,446
Mixed	$13,250	29%	$21,862	48%	$10,600	23%	$45,712
2030							
HOV 2+ Free	$20,934	20%	$58,614	56%	$25,120	24%	$104,668
HOV 3+ Free	$26,359	20%	$73,807	56%	$31,631	24%	$131,797
Mixed	$24,970	20%	$69,916	56%	$29,964	24%	$124,850

SR 167 Revenue Trends Compared to 2014 Forecasts

Annual revenue on the existing SR 167 HOT lanes has grown from about $555,000 in FY 2010 to $998,000 in FY 2012, expressed in 2012 dollars (Figure 4.4).[21] We forecast the FY 2014 revenue for the south area of the Phase 1 project (SR 167) for the *HOV 2+ Free* scenario (the same policy as is in place today) to be between $1.3 million and $2.6 million in 2012$, which is 27 percent to 162 percent higher than 2012 revenue. This demonstrates a reasonable correlation between the recent trends and the early year forecasts.

[21] Based on the consumer price index for the Seattle-Tacoma-Bremerton Metropolitan Statistical Area. We forecast the FY 2012 value based on three quarters of data, assuming the last quarter would have the same revenue as the third quarter.

Figure 4.4 SR 167 Revenues, Actual and Estimated for 2010 to 2012 and Forecast Range for 2014
HOV 2+ Free Scenario, Millions of 2012 Dollars

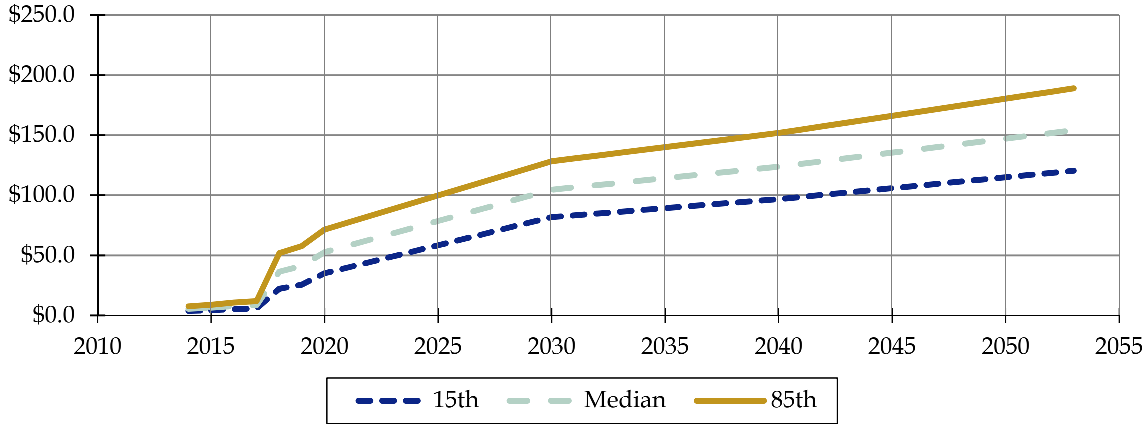


Ranges of Revenue Streams by Scenario

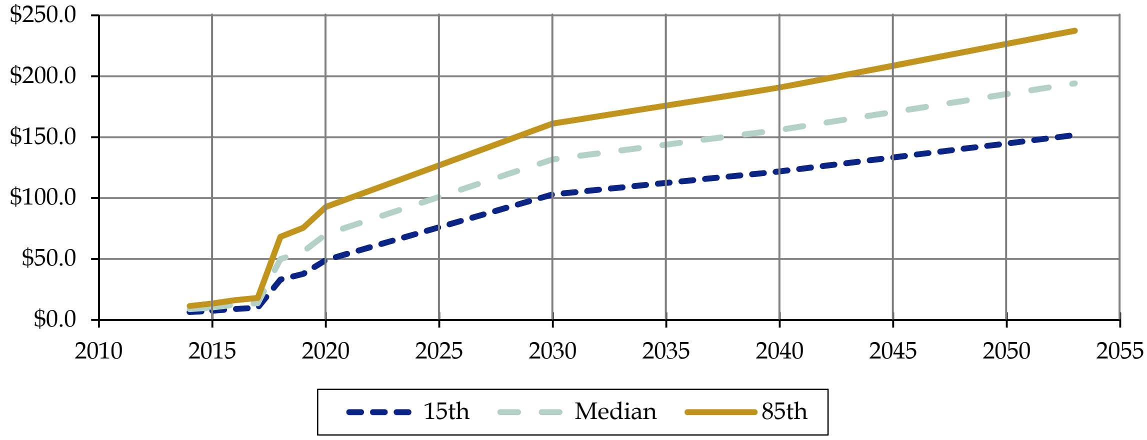
We prepared a range of gross revenue forecasts for 2014 through 2053 bracketing the 15th to 85th percentile of potential outcomes. Figure 4.5 illustrates the revenue streams for the *HOV 2+ Free, HOV 3+ Free,* and *Mixed* scenarios. Tables with annual revenue streams are provided in Appendix E.

Figure 4.5 Gross Toll Revenue Streams
2014 to 2053, Millions of 2012 Dollars

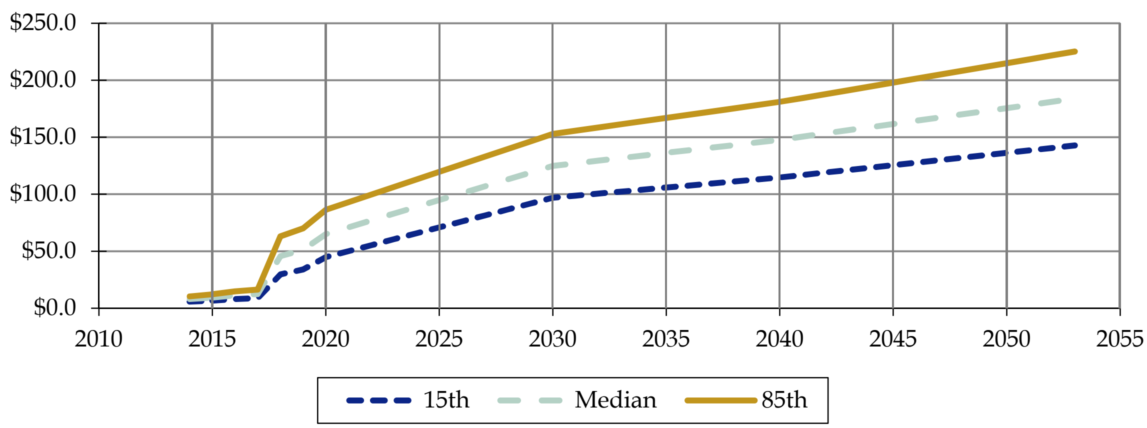
HOV 2+ Free



HOV 3+ Free



Mixed



Comparison to WSDOT's 2009 Forecast for 2030

We compared the forecast revenue streams developed for this study to the forecasts from the 2009 WSDOT traffic and revenue study (see Figures 4.6 and 4.7) and found that:

- Our forecast range is narrower than WSDOT's because we quantified the most important risk factors that would affect revenue whereas WSDOT applied very conservative adjustment factors to guard against using overly optimistic assumptions for their financial analysis.
- Our forecasts are within, but at the lower end of the WSDOT forecast range.

Figure 4.6 2009 WSDOT and 2012 CS Revenue Forecast for *HOV2+ Free*
Millions of 2012 Dollars

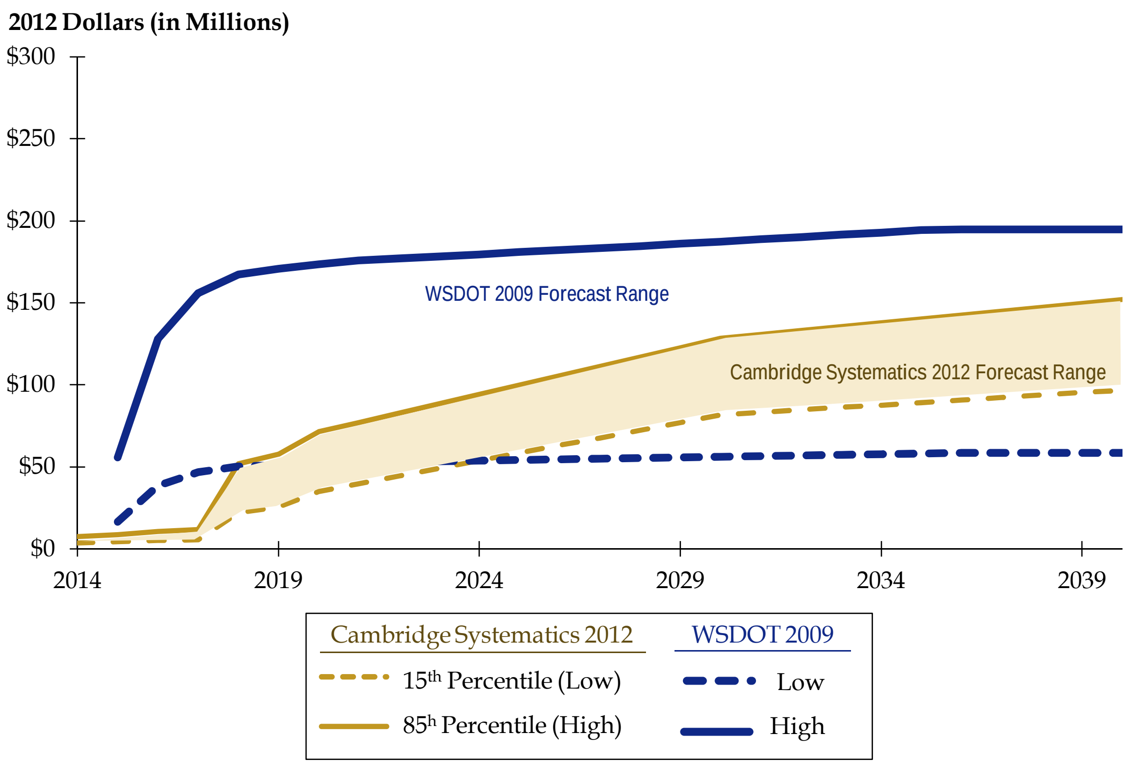
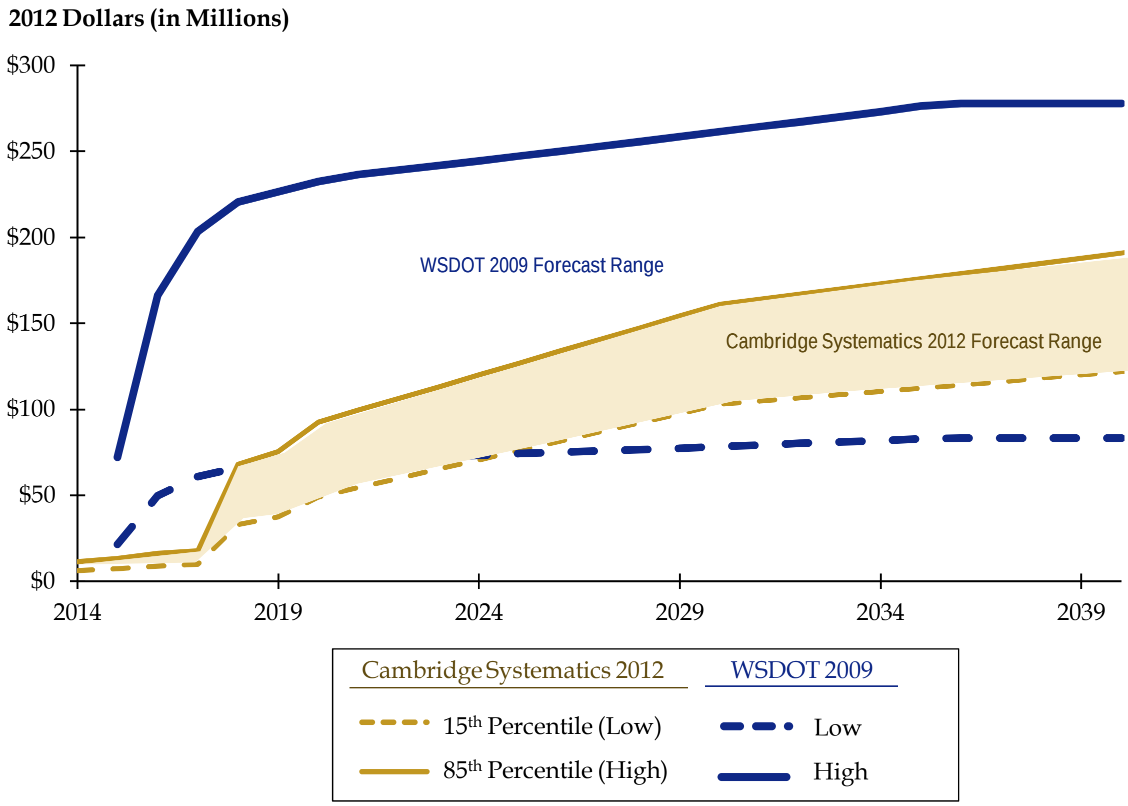


Figure 4.7 2009 WSDOT and 2012 CS Revenue Forecast for *HOV3+ Free*
Millions of 2012 Dollars



Traffic Performance Comparisons

The consolidated microsimulation traffic analysis and revenue forecasting approach allowed us to consider traffic conditions on a second-by-second basis at all locations throughout the 40-mile corridor simultaneously. The consolidated model used this information to simulate the setting of toll rates and the decisions by drivers to pay these toll rates. The accumulation of all these traffic patterns and individual driver decisions led to the gross revenue forecasts discussed in the first part of this section.

Revenue is only one component of the decision that needs to be made in the Eastside Corridor. Distinguishing the traffic performance expected from the different scenarios also is important. The simulation model reported numerous traffic performance measures throughout the 40-mile corridor, both in the general-purpose and Express Toll Lanes. Most measures were reported in five-minute increments during the A.M. and P.M. periods for each of the nine tolling zones. These are some of the performance measures:

- Travel time in the Express Toll Lanes and general purpose lanes, plus a calculation of travel time savings;

- Vehicle miles traveled in express toll and general purpose lanes;
- Traffic volumes across screenlines;
- Revenue;
- Posted toll rates;
- Toll rates paid; and
- Speed and traffic volume by specific location and time of day, displayed graphically to enable identification of bottlenecks.

Detailed reports of these measures are provided in Appendix C for each of the 106 unique model runs[22] that we ran to develop the range of traffic and revenue forecasts. We used these detailed reports to assess the validity of the model and to identify issues that might be of help to WSDOT as it refines the design in the corridor. The detailed appendices may be of continuing value to WSDOT as it continues its design refinement efforts.

In this section, we extract the key elements of the traffic performance evaluation to enable meaningful comparisons across scenarios (*HOV 2+ free and HOV 3+ free)* for policy purposes. To ease this comparison we have focused on the scenarios that represent:

- 2030 conditions;
- Medium levels of growth; and
- Medium levels of value-of-time.

We first provide a high-level comparison that enables direct comparison across HOV free scenarios, and then provide additional detail for the *HOV 3+ Free* scenario to illustrate the kinds of performance forecasted by subarea, direction, and time of day.

We consider traffic performance measures that address:

- Mobility, as measured by travel time and travel time savings;
- Throughput, as measured by how many vehicle miles of travel can be accommodated by the system; and
- Bottlenecks, where we identify the locations in the system that we expect will cause backup and delays.

For the most part, the bottleneck locations are consistent across scenarios, with the main difference being the extent and duration of congestion.

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[22] Includes sensitivity analysis runs.

High-Level Summary of Performance

Table 4.3 shows a high-level comparison of performance outcomes for the *HOV 2+ Free* and *HOV 3+ Free* scenarios. We found relatively little difference in overall throughput of traffic in the corridor between these two approaches, with the *HOV 3+ Free* scenario processing 99 percent of that processed by the *HOV 2+ Free* scenario. Similarly, the average corridor speeds were slightly better with the *HOV 2+ free* scenario – 22.2 mph versus 21.1 mph – five percent better.

Table 4.3 Comparison of Forecast Performance Outcomes
2030, Medium Scenarios

	HOV 3+ Free	HOV 2+ Free	Ratio of HOV 3+ Free to HOV 2+ Free
Throughput: Daily Corridor VMT (000)	8,628	8,686	99%
Mobility: Average Daily Corridor Speed (mph)	21.1	22.2	95%
Annual Gross Revenue (millions 2012$)	133.4	106.4	125%

For a complete comparison, we also included the expected annual gross revenue in 2030 for each of these scenarios (described in more detail in the prior subsection.) Annual gross revenue under the *HOV 3+ Free* scenario is forecast to be about 25 percent higher than the *HOV 2+ Free* scenario.

Mobility Measures for the HOV 3+ Free Scenario in 2030

Figure 4.8 shows the forecast travel time and average travel speed by direction, by area, and by lane type (express toll or general purpose lane.) We also show the differential in travel time and speed. The measures are by A.M. and P.M. peak hours, representing 8:00 to 9:00 A.M. and 5:00 to 6:00 P.M. The following findings are of note:

- A.M. northbound direction
  - Both the south and middle areas show speeds below the target 45 miles per hour in the Express Toll Lane. This is primarily due to excessive congestion in the general purpose lanes that causes backups exiting the Express Toll Lanes.
  - Travel time savings is 33 minutes average for the south area Express Toll Lane, and 25 minutes for the middle area.
  - Operating conditions are generally smooth for most part of north area with an average speed of 62 mph in the general purpose lanes. As a result, travel time saving is marginal in that section.

- A.M. southbound direction
  - The middle area is forecast to have speeds below the target 45 miles per hour in the Express Toll Lane, also due to general purpose lane congestion clogging egress from the Express Toll Lanes.
  - Southbound travel time savings is nine minutes average for the north area Express Toll Lane, and four minutes for the middle area.
  - Southbound operations are good for most part of south area with travel time saving of four minutes.
- P.M. northbound direction
  - The average speed going through middle area is forecast to be 18 mph through the general purpose lanes and 37 mph in the Express Toll Lanes with a travel time savings of 18 minutes.
  - Conditions in the north area yield 11 minutes of time savings, with the Express Toll Lanes flowing well while the general purpose lanes flow at 35 mph.
  - The south area is expected to have good operations in both general purpose and Express Toll Lanes, with time savings of three minutes.
- P.M. southbound direction
  - Both middle and south areas are expected to have speeds in the Express Toll Lanes in the mid-40 mph range, but with conditions in the general purpose lanes even worse, there are still expected to be generous time savings of 12 and 16 minutes, respectively.
  - The Express Toll Lanes are expected to operate well in the north area, with travel time savings is 13 minutes.

Figure 4.8 Summary of Peak Hour Travel Times and Speeds Express Toll and General Purpose Lanes 2030, *HOV 3+ Free Scenario*, with Medium Growth and Medium Willingness to Pay

Southbound

Area North

Travel Time (min)

Peak	ET Lanes	GP Lanes	TT Saving
AM	18	27	9
PM	17	30	13

Speed (mph)

Peak	ET Lanes	GP Lanes	Spd Diff
AM	52	35	17
PM	58	32	26

Area Middle

Travel Time (min)

Peak	ET Lanes	GP Lanes	TT Saving
AM	15	19	4
PM	14	26	12

Speed (mph)

Peak	ET Lanes	GP Lanes	Spd Diff
AM	40	31	9
PM	43	23	20

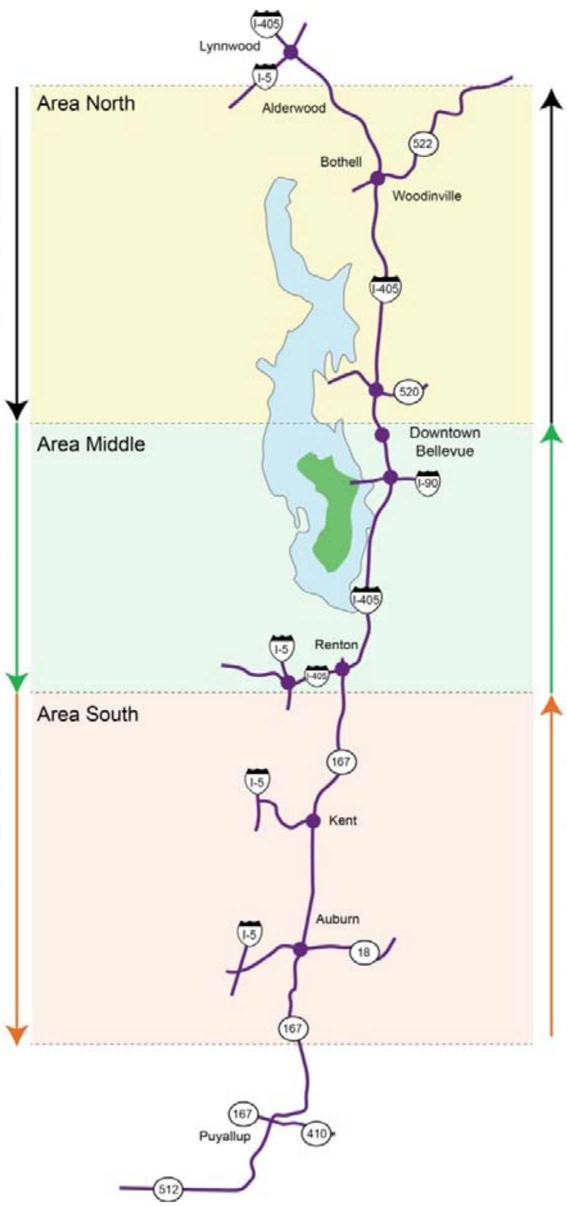
Area South

Travel Time (min)

Peak	ET Lanes	GP Lanes	TT Saving
AM	14	15	1
PM	18	34	16

Speed (mph)

Peak	ET Lanes	GP Lanes	Spd Diff
AM	61	57	4
PM	45	25	20



Northbound

Area North

Travel Time (min)

Peak	ET Lanes	GP Lanes	TT Saving
AM	15	16	1
PM	16	27	11

Speed (mph)

Peak	ET Lanes	GP Lanes	Spd Diff
AM	64	62	2
PM	61	35	26

Area Middle

Travel Time (min)

Peak	ET Lanes	GP Lanes	TT Saving
AM	15	40	25
PM	16	34	18

Speed (mph)

Peak	ET Lanes	GP Lanes	Spd Diff
AM	42	15	27
PM	37	18	19

Area South

Travel Time (min)

Peak	ET Lanes	GP Lanes	TT Saving
AM	23	56	33
PM	15	16	1

Speed (mph)

Peak	ET Lanes	GP Lanes	Spd Diff
AM	38		18
PM	58	55	3

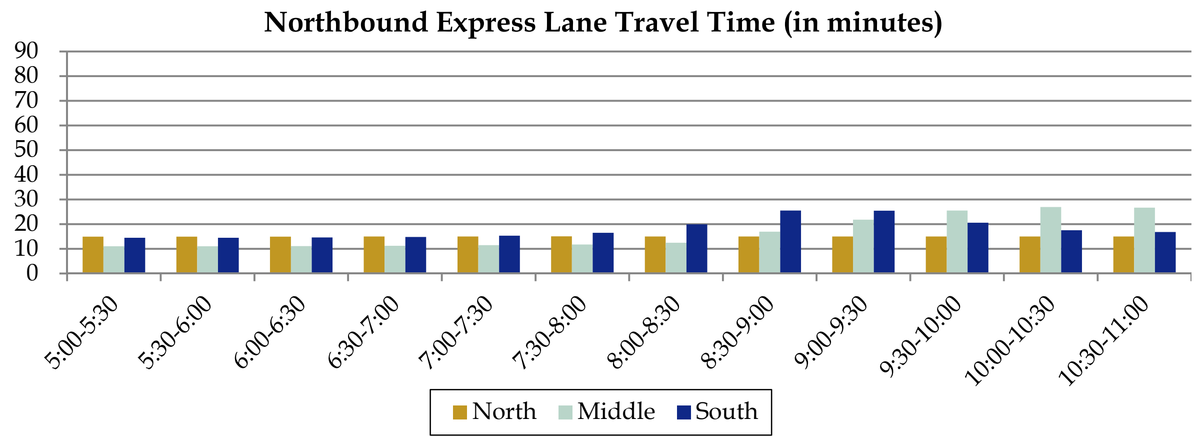
Note: A.M. represents the hours between: 8:00 A.M. and 9:00 A.M.
P.M. represents the hours between: 5:00 P.M. and 6:00 P.M.

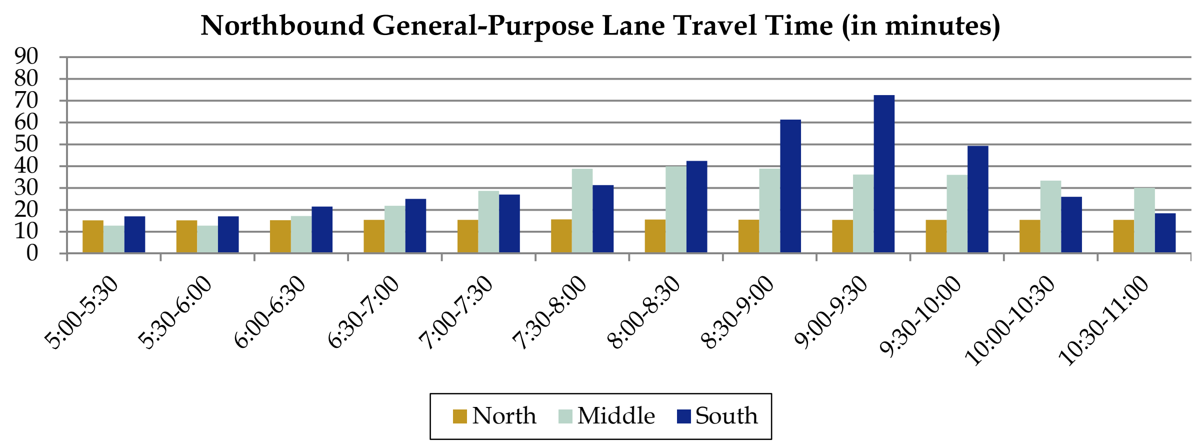
The discussion above highlights average speeds and time savings for the peak hour. In reality, the speeds and time savings will vary quite a bit during the longer peak periods. Figures 4.9-4.12 illustrates that variation by direction and time period:

- A.M. Peak Period
  - Figure 4.9: Northbound.
  - Figure 4.10: Southbound.
- P.M. Peak Period
  - Figure 4.11: Northbound.
  - Figure 4.12: Southbound.

In all cases, the top graph shows travel time in the Express Toll Lane, with the green bar for the north area, the red bar for the middle area, and the blue bar for the south area. The middle graph shows travel time in the general purpose lane, and the bottom graph the difference between the two, or the travel time savings.

Figure 4.9 Forecast A.M. Peak Period Travel Times and Travel Time Savings in 30-Minute Increments, *HOV 3+ Free Scenario*
2030 – Medium Growth and Medium Willingness to Pay
Northbound Direction





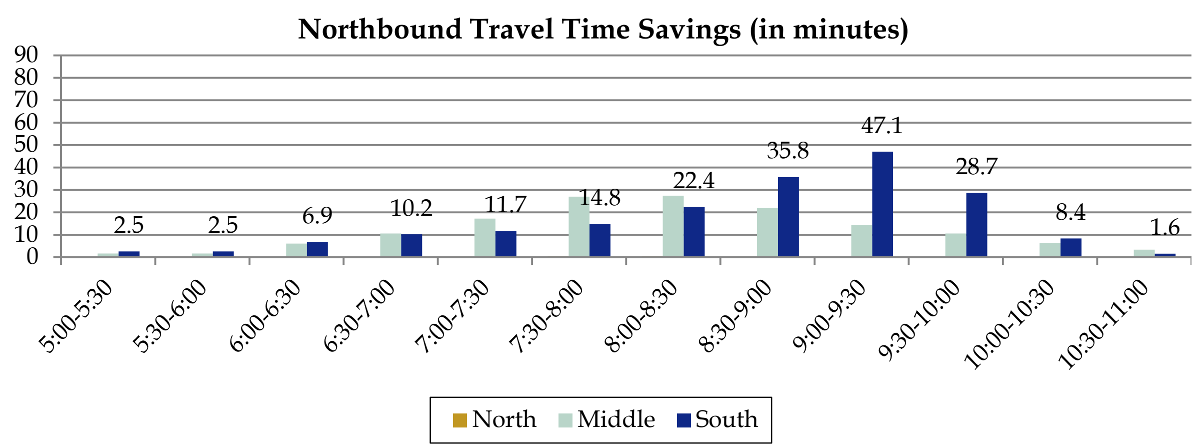
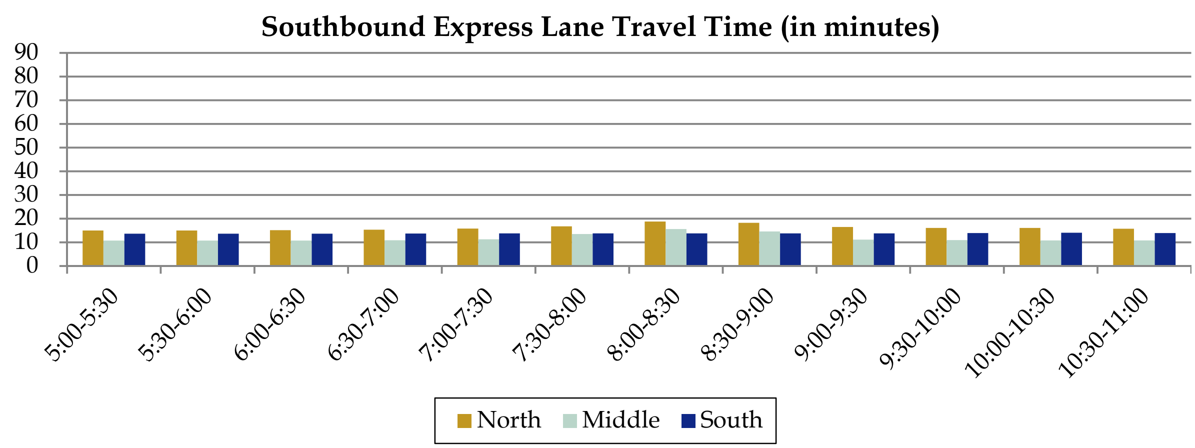
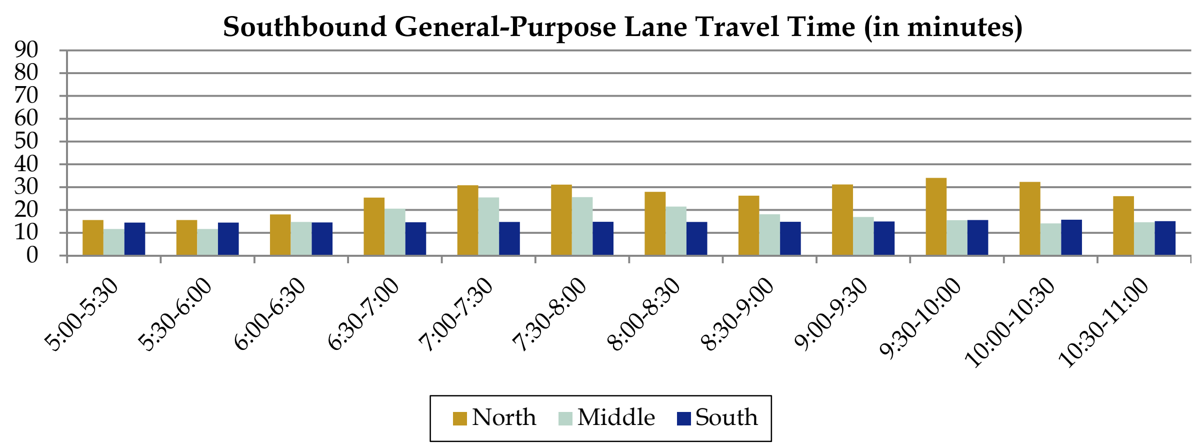


Figure 4.10 Forecast A.M. Peak Period Travel Times and Travel Time Savings in 30-Minute Increments, HOV 3+ Free Scenario

2030 – Medium Growth and Medium Willingness to Pay
Southbound Direction





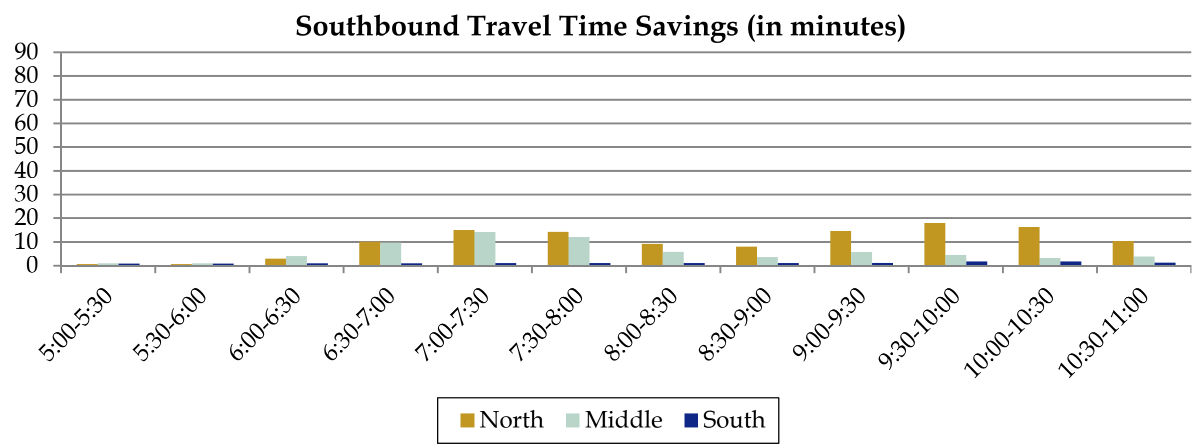
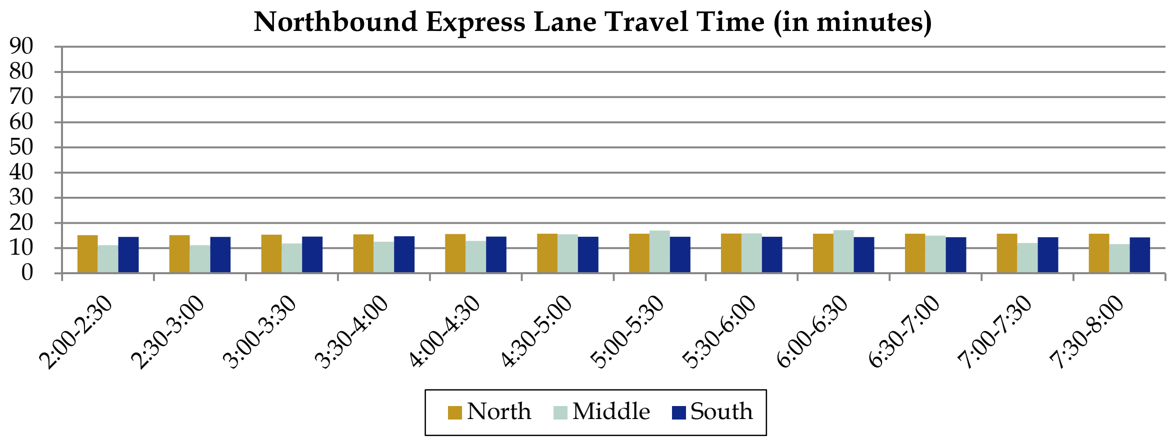
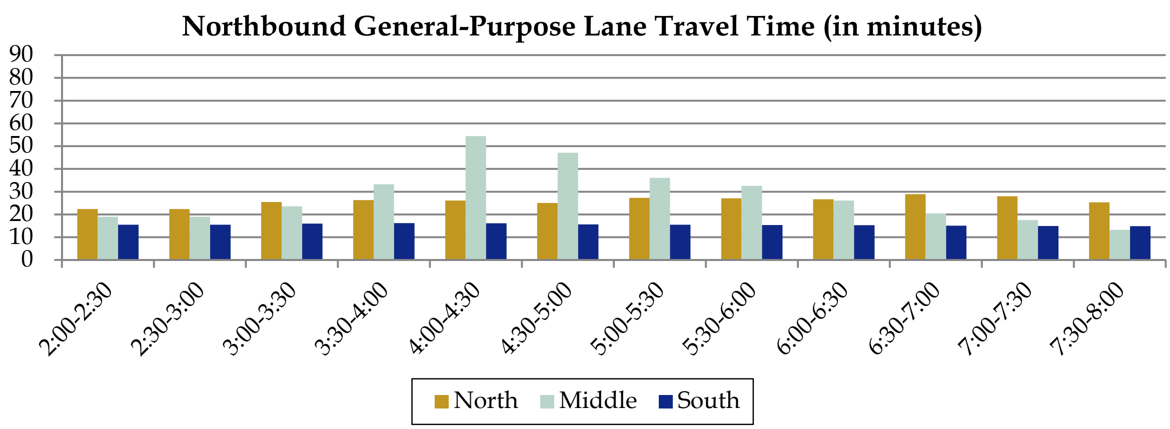


Figure 4.11 Forecast P.M. Peak Period Travel Times and Travel Time Savings in 30-Minute Increments, HOV 3+ Free Scenario
2030 – Medium Growth and Medium Willingness to Pay
Northbound Direction





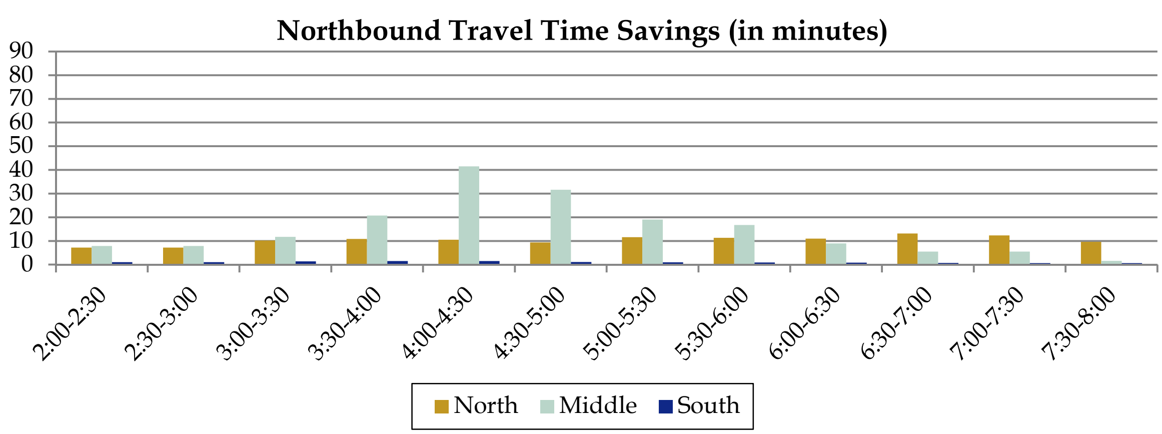
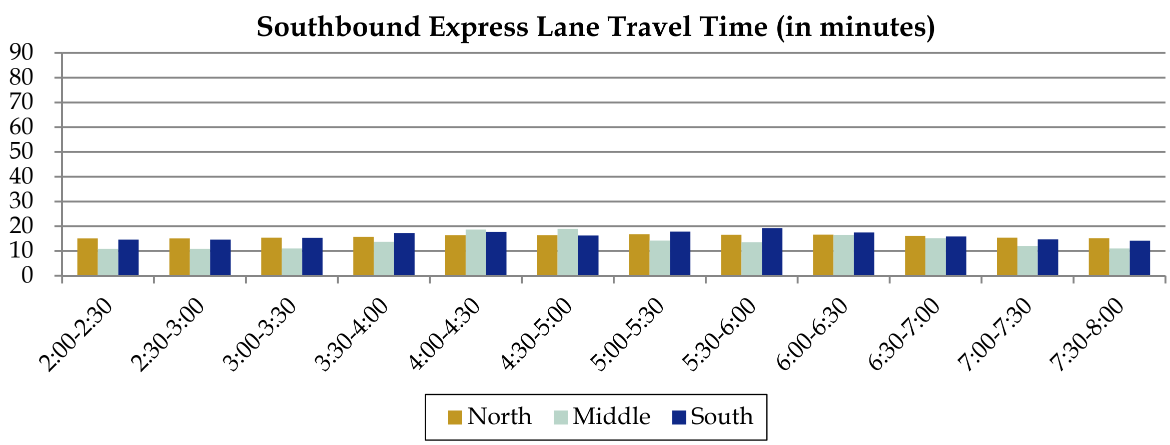
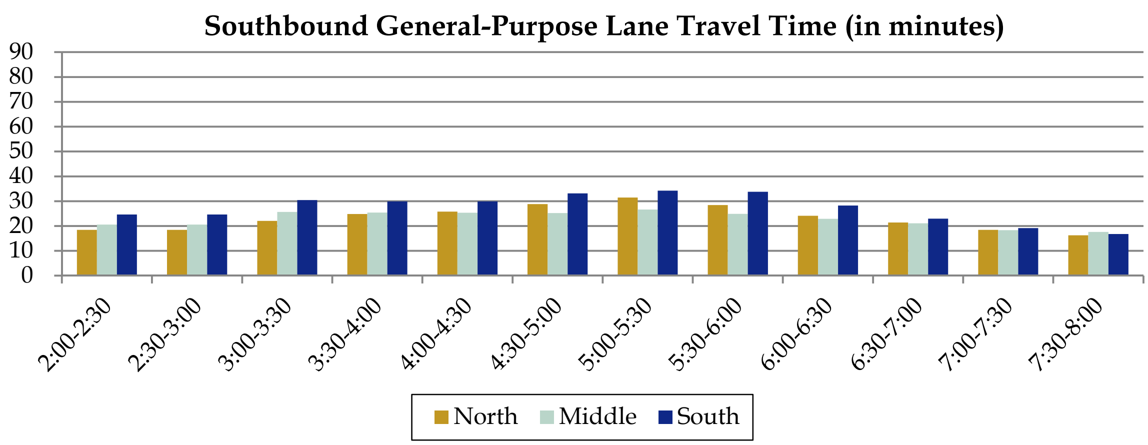
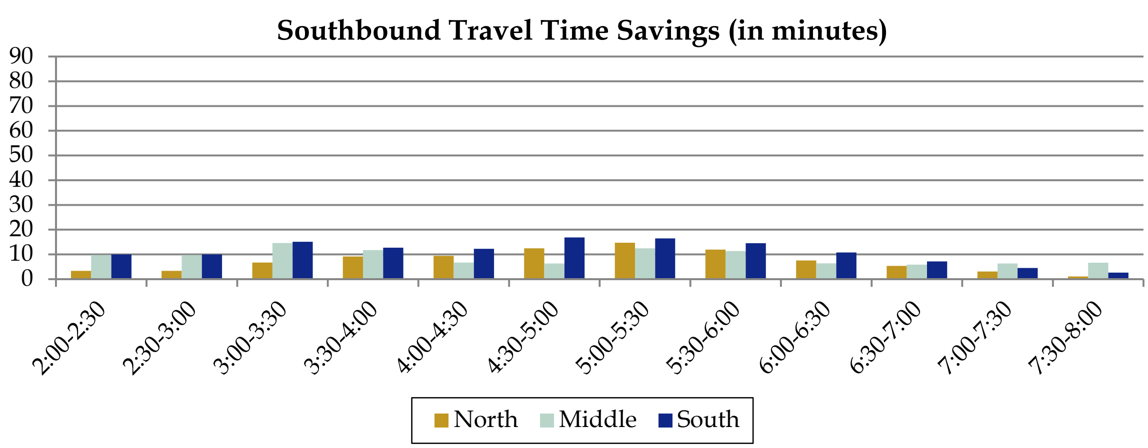


Figure 4.12 Forecast P.M. Peak Period Travel Times and Travel Time Savings in 30-Minute Increments, HOV 3+ Free Scenario
2030 – Medium Growth and Medium Willingness to Pay
Southbound Direction







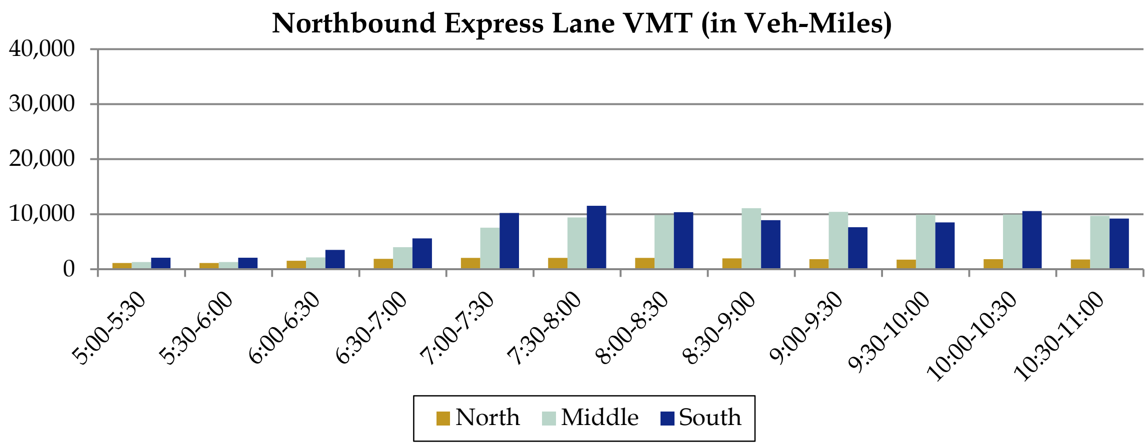
Throughput Measures for the HOV 3+ Free Scenario in 2030

The amount of traffic that can be serviced in the entire corridor – throughput – can be represented by a measure of vehicle miles traveled (VMT). This is the product of the number of vehicles traveling times the number of miles. Our model starts out by assuming the same travel demand for each scenario for a particular year, with the same origin-destination patterns. Theoretically, then, all scenarios should accommodate the same VMT. However, under congested conditions, not all traffic can be accommodated in the corridor. Some of that traffic may decide to travel elsewhere, or at a different time, or forego the trip.

Figures 4.13 through 4.16 show the variation in corridor VMT by time period, direction, and area for each half-hour segment of the peak period.

Figure 4.13 Forecast A.M. Peak Vehicle Miles Traveled in 30-Minute Increments, *HOV 3+ Free* Scenario

2030 – Medium Growth and Medium Willingness to Pay
Northbound Direction



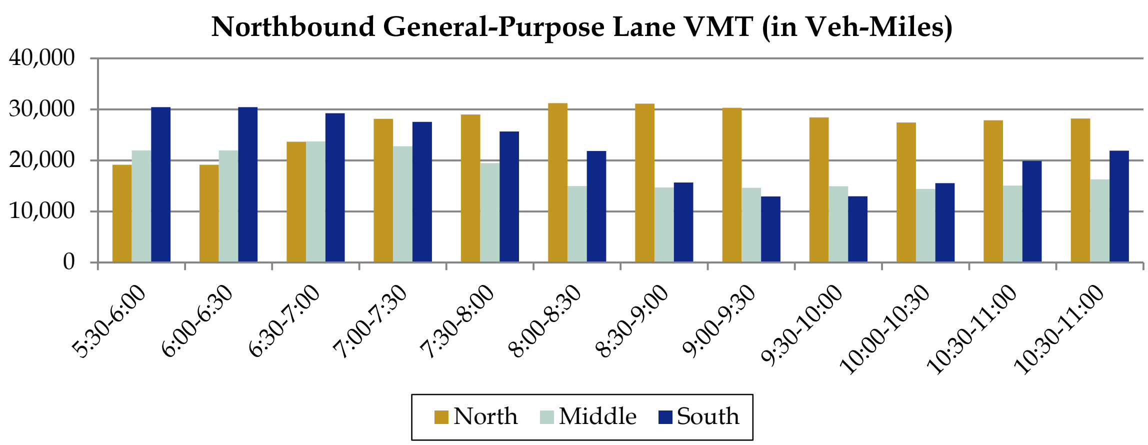
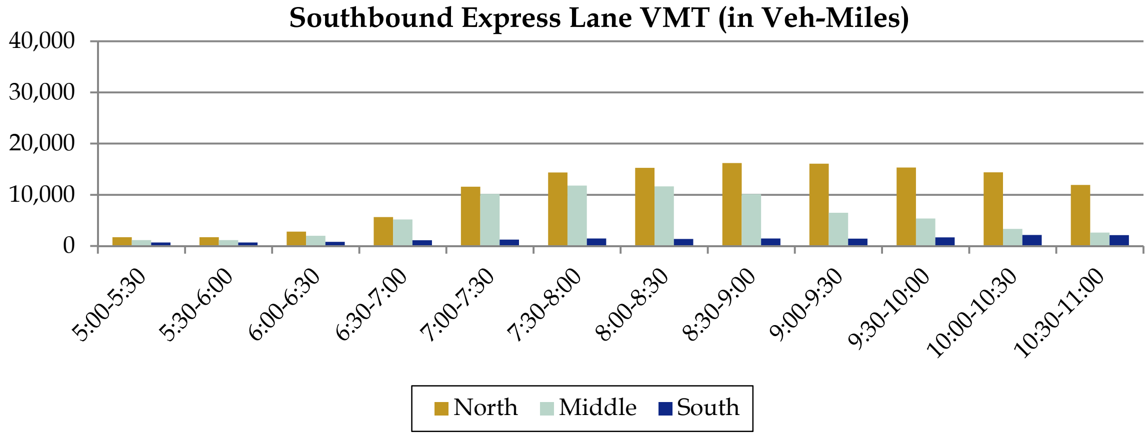


Figure 4.14 Forecast A.M. Peak Vehicle Miles Traveled in 30-Minute Increments, *HOV 3+ Free* Scenario

2030 – Medium Growth and Medium Willingness to Pay
Southbound Direction



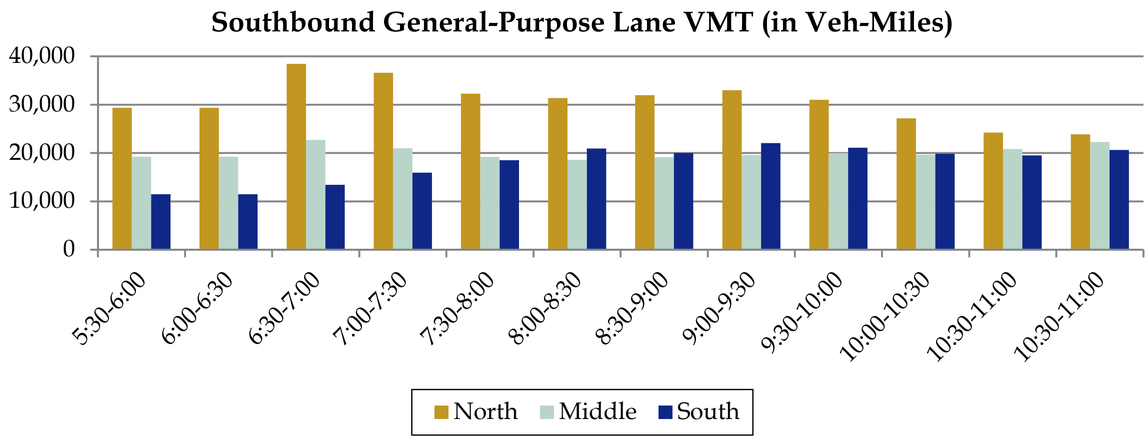
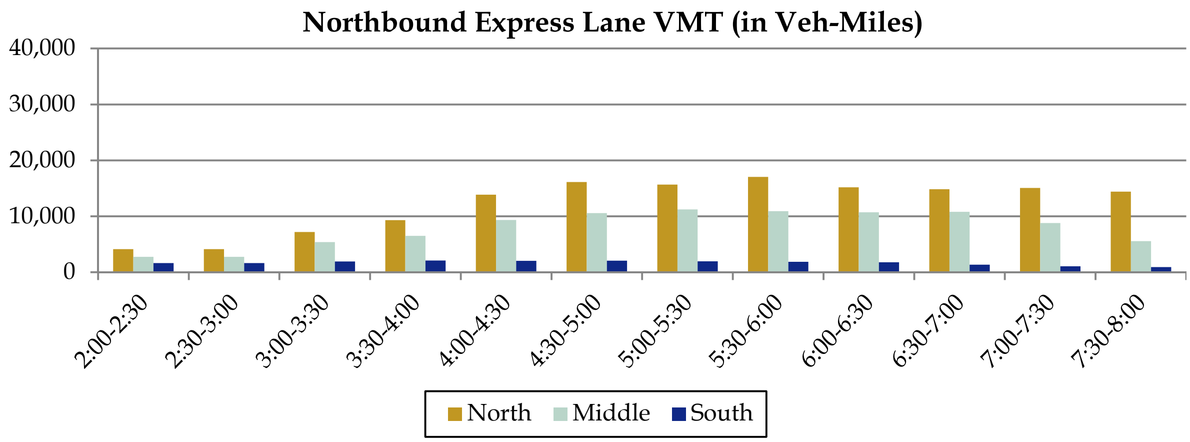


Figure 4.15 Forecast P.M. Peak Vehicle Miles Traveled in 30-Minute Increments, *HOV 3+ Free* Scenario
2030 – Medium Growth and Medium Willingness to Pay
Northbound Direction



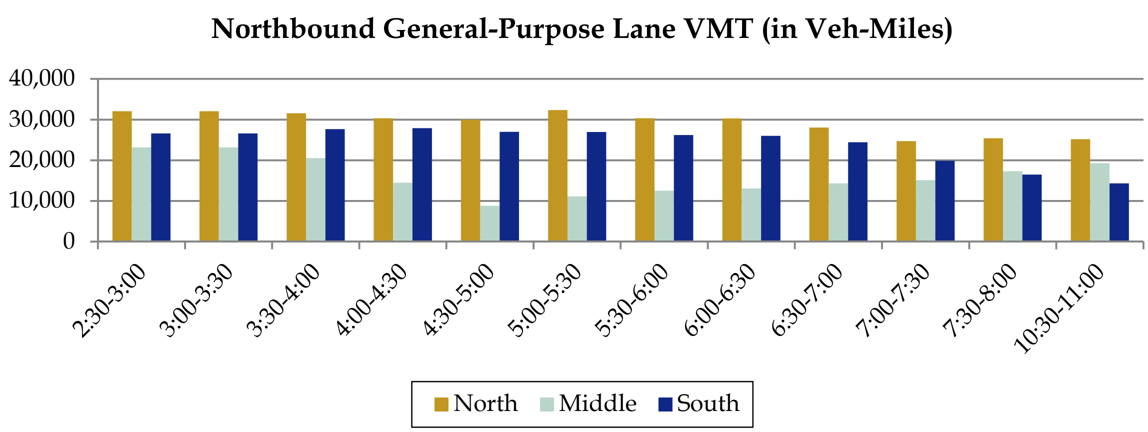
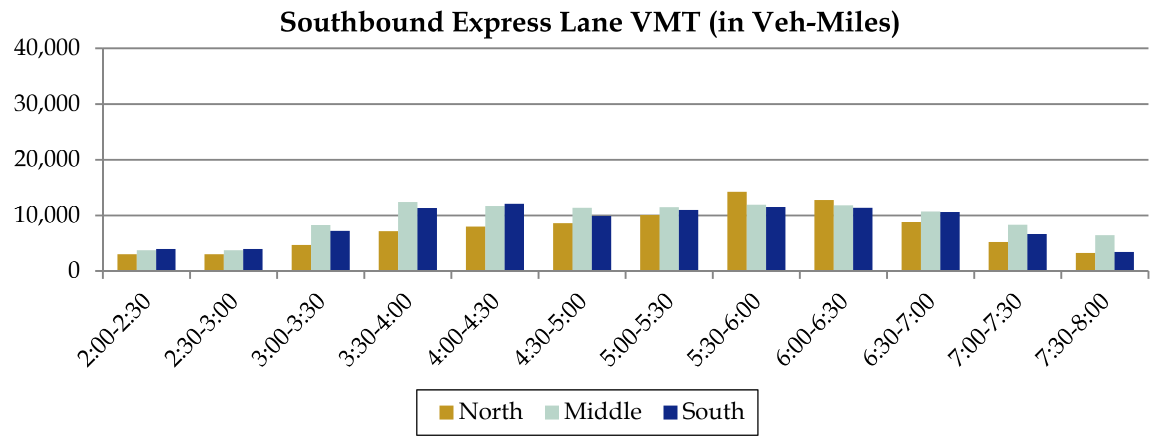
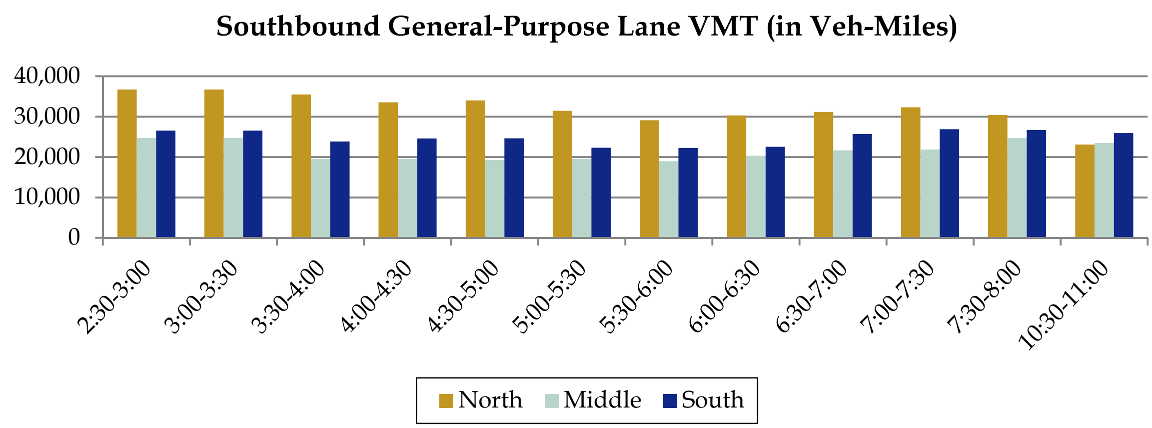


Figure 4.16 Forecast A.M. Peak Vehicle Miles Traveled in 30-Minute Increments, *HOV 3+ Free* Scenario
2030 – Medium Growth and Medium Willingness to Pay
Southbound Direction





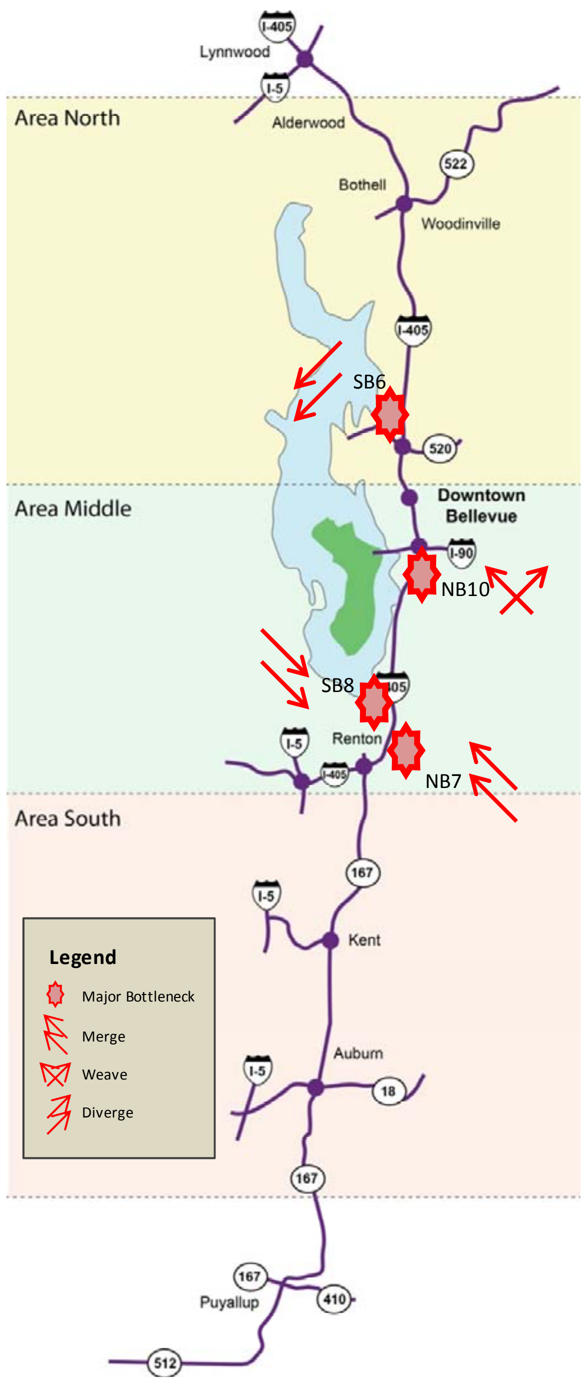
Bottlenecks

In the course of our work, we identified several locations that could cause operational difficulties in the corridor. This is not unusual, as development of a complicated project such as this typically involves an iterative process of design, evaluation, and design refinement.

WSDOT has conducted detailed design work for the north area of the project, but only preliminary design of the middle and improvements to the south area, including the direct Express Toll Lane connection flyover between SR 167 and I-405. The information provided in this section should contain useful information for WSDOT as they move this project forward. We have limited our review in the main body of the report to the 2030 condition for the *HOV 3+ Free* scenario. Similar conditions occur in the *HOV 2+ Free* scenario, and some variations may be present in the Phase 1 condition. Details on these may be found in our Appendix C material.

A.M. Peak Bottlenecks. The major bottlenecks that we identified in the A.M. peak period are illustrated in Figure 4.17.

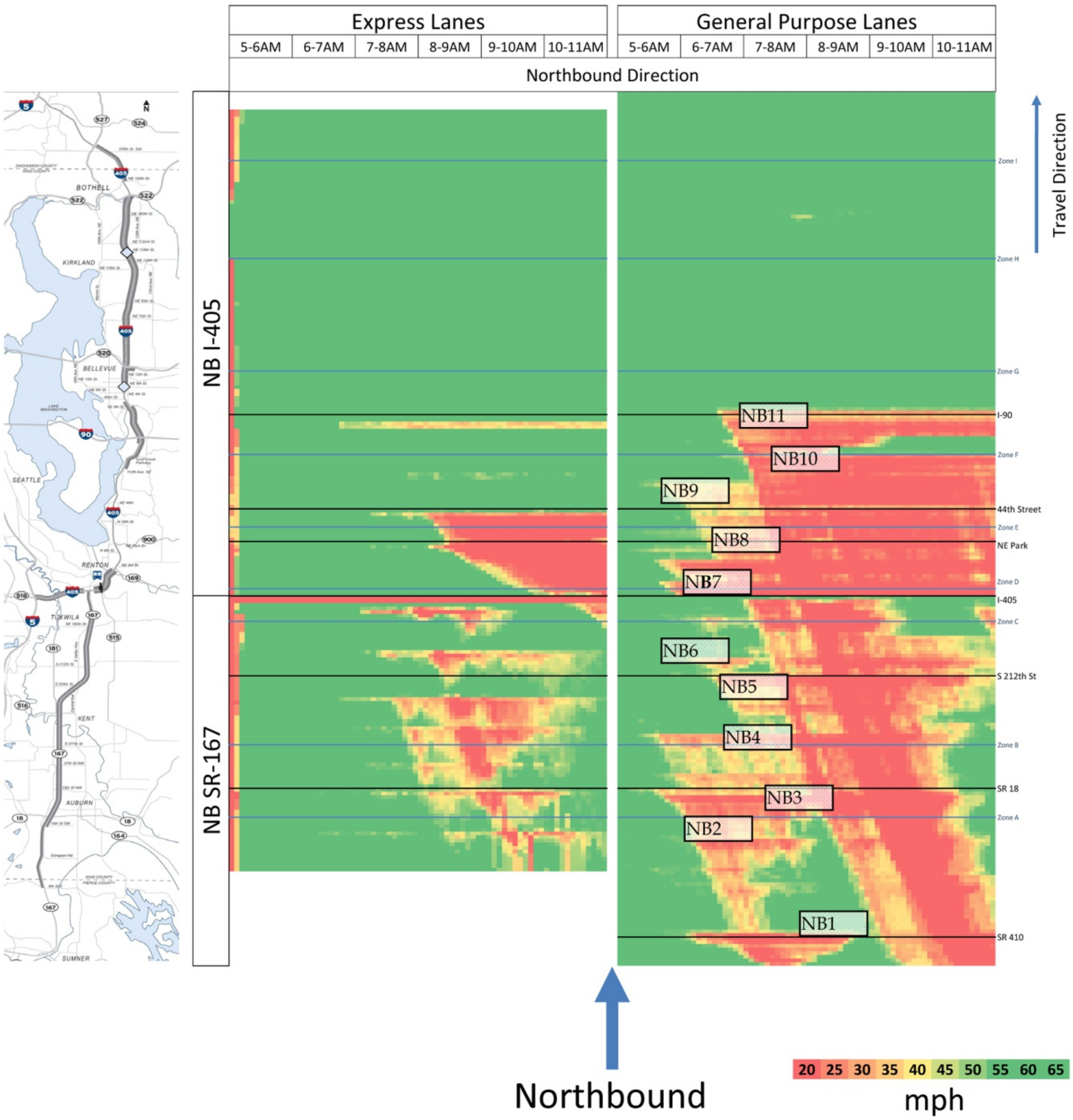
Figure 4.17 A.M. Period Major Bottlenecks
HOV 3+ Free Scenario
2030



All A.M. bottlenecks are shown in Figure 4-18 and 4-19 for northbound and southbound traffic, respectively. The cause of each of the bottlenecks labeled on the charts is discussed below:

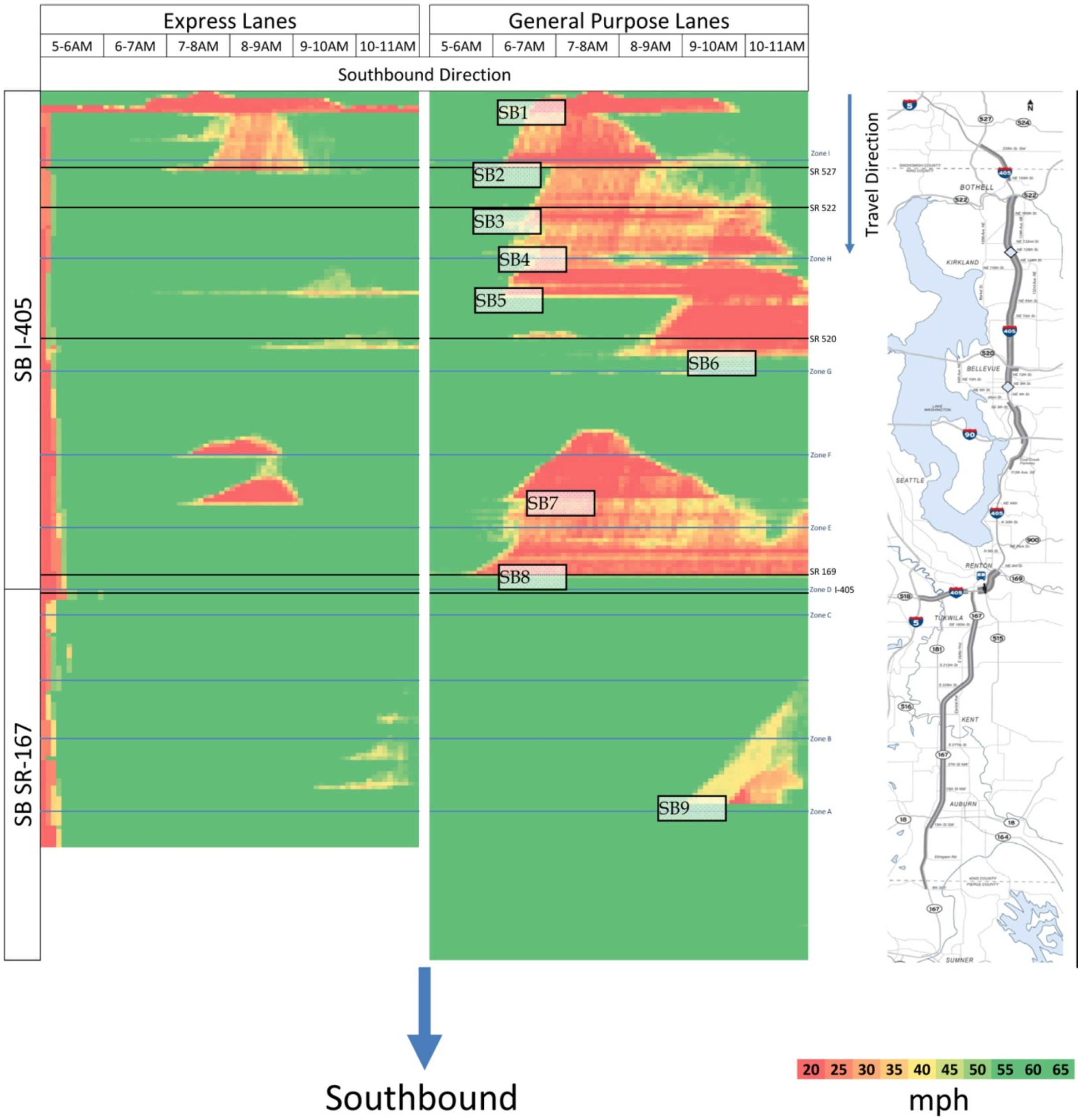
- NB1: On-ramp merge from SR 410.
- NB2: On-ramp merge from Ellingson Road.
- NB3: On-ramp merge from SR-18, combined with lane-drop before 15th St NW, creates congestion that spills back to Express Toll Lane.
- NB4: Heavy on-ramp merge from S 277th St; congestion spills back to the Express Toll Lane.
- NB5: Weaving traffic between Central Avenue and S 212th St.
- NB6: On-ramp merge from S 212th St.
- NB7: High on-ramp demand from SR 167, SR 515, and SR 169, and Sunset creates heavy congestion on the northbound I-405 general purpose lanes and spillback to the Express Toll Lanes on both I-405 and SR 167.
- NB8: On-ramp merge from NE Park. The merge occurs immediate after the Express Toll Lane ingress point at Park; short weaving distance between Express Toll Lane ingress and egress at Park; queue blocks Express Toll Lane.
- NB9: Weaving between NE 44th St and SR 112 creates congestion that spills back to Express Toll Lanes opening and blocks Express Toll Lane exiting traffic.
- NB10: Heavy weaving between Coal Creek and I-90; congestion spills back to upstream I 405 general purpose lanes.
- NB11: Weaving between I-90 and SE 8th St, slightly slows down upstream Express Toll Lane weaving area.
- SB1: Heavy diverge to SB Express Toll Lane.
- SB2: On-ramp merge from SR 527; congestion spillback to Express Toll Lane.
- SB3: Weaving between SR 522 on-ramp and off-ramp to NE 160th St.
- SB4: Slow down due to freeway curve.
- SB5: On-ramp merge from NE 116th St, slightly slow on Express Toll Lane egress traffic.
- SB6: High off-ramp demand to SR 520, creates heavy congestion.
- SB7: Freeway curve, off-ramp diverge to NE 44th St., and downstream Express Toll Lane weaving traffic.
- SB8: On-ramp merge from SR 169, spills back to Express Toll Lane lanes.
- SB9: Congestion resulted from NB congestion at SR 18 interchange.

Figure 4.18 A.M. Period Northbound Bottleneck Locations
HOV 3+ Free Scenario
2030



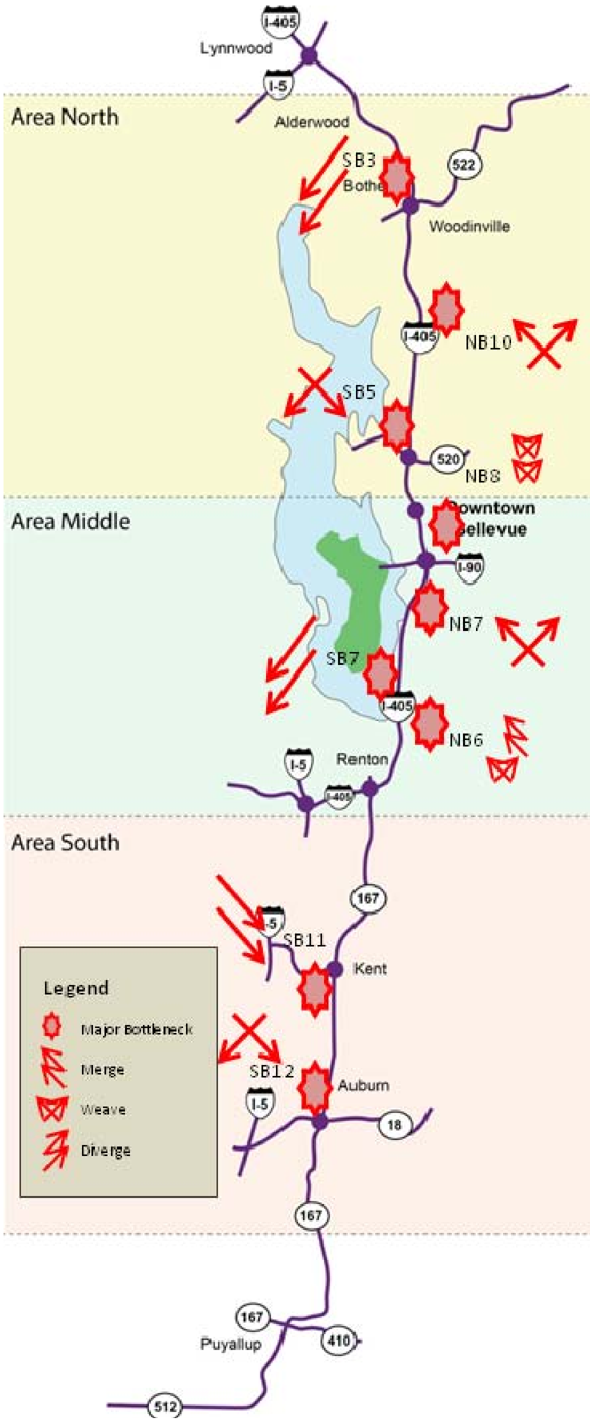
Congestion flow plots are useful illustration of congestion on a freeway facility. In these illustrations acceptable speeds 50mph or greater are in green while speeds approaching unacceptable are yellow and orange. Unacceptable speeds are shown in red. Red shading represents the driving experience of stop and go traffic on the freeway or a "queued" vehicles. The congestion plots show both the length of the queue (vertical axis) and the duration of the (horizontal access).

Figure 4.19 A.M. Period Southbound Bottleneck Locations
HOV 3+ Free Scenario
2030



P.M. Peak Period Bottlenecks. Major bottlenecks occur in the P.M. model are shown in Figure 4.20.

Figure 4.20 P.M. Period Major Bottlenecks
HOV 3+ Free Scenario
2030



All P.M. bottlenecks location are shown in Figures 4-21 and 4-22. Causality of each bottleneck is discussed below:

- NB1: Northbound general purpose lane drop at SR 512 interchange.
- NB2: Northbound on-ramp merge from SR 18, slightly slows down mainline traffic and affects managed lane ingress traffic.
- NB3: Off-ramp diverges to S 212 St. occurs after on-ramp merge from 84th Avenue.
- NB4: Diverge to southbound SR 167 and northbound managed lane; high on-ramp merge from NB/SB 167.
- NB5: heavy on-ramp merge from Sunset.
- NB6: on-ramp merge from NE Park; merge occurs immediate after Express Toll Lane ingress point at Park; short weaving distance between Express Toll Lane ingress and egress at Park; queue blocks Express Toll Lane.
- NB7: congestion starts downstream of I-90 on-ramps to northbound I-405; later on, congestion lingers south of I-90 and weaving demand at interchange with I-90 slows traffic; queue spills back to Coal Creek and blocks Express Toll Lane egress.
- NB8: on-ramp merge from I-90, mixed with Express Toll Lane opening and downstream diversion to SE 8th St.
- NB9: High on-ramp traffic demand merging from SR 520 to I-405 causes congestion occurs in the P.M. peak period and continues throughout the entire P.M. peak period, causing long queues.
- NB10: Traffic diverges to off-ramp to NE 116th St and northbound Express Toll Lane ingress. This congestion also lingers throughout the entire peak period.
- SB1: Heavy diverge to southbound Express Toll Lane.
- SB2: On-ramp merge from SR 527.
- SB3: Diverge to SR 522.
- SB4: Diverge to NE 85th St. and Express Toll Lane ingress; occasionally spills back to Express Toll Lane.
- SB5: On-ramp merge from NE 70th St; diverge to SR 520.
- SB6: Diverge to I-90 and on-ramp merge from SE 8th St.
- SB7: Off-ramp diverge to NE 44th St; spill back to Express Toll Lane.
- SB8: On-ramp merge from Park.
- SB9: On-ramp merge from SR 169.
- SB10: On-ramp merge from SW 41st St, spillback to Express Toll Lane.
- SB11: On-ramp merge from SR 516, spillback to Express Toll Lane.
- SB12: Diverge to SR 18 and Express Toll Lanes, spillback to Express Toll Lane egress.
- SB13: On-ramp merge from 15th St SW.
- SB14: Slowdowns for curve at SR 410.

Figure 4.21 P.M. Period Northbound Bottleneck Locations
***HOV 3+ Free* Scenario**
2030

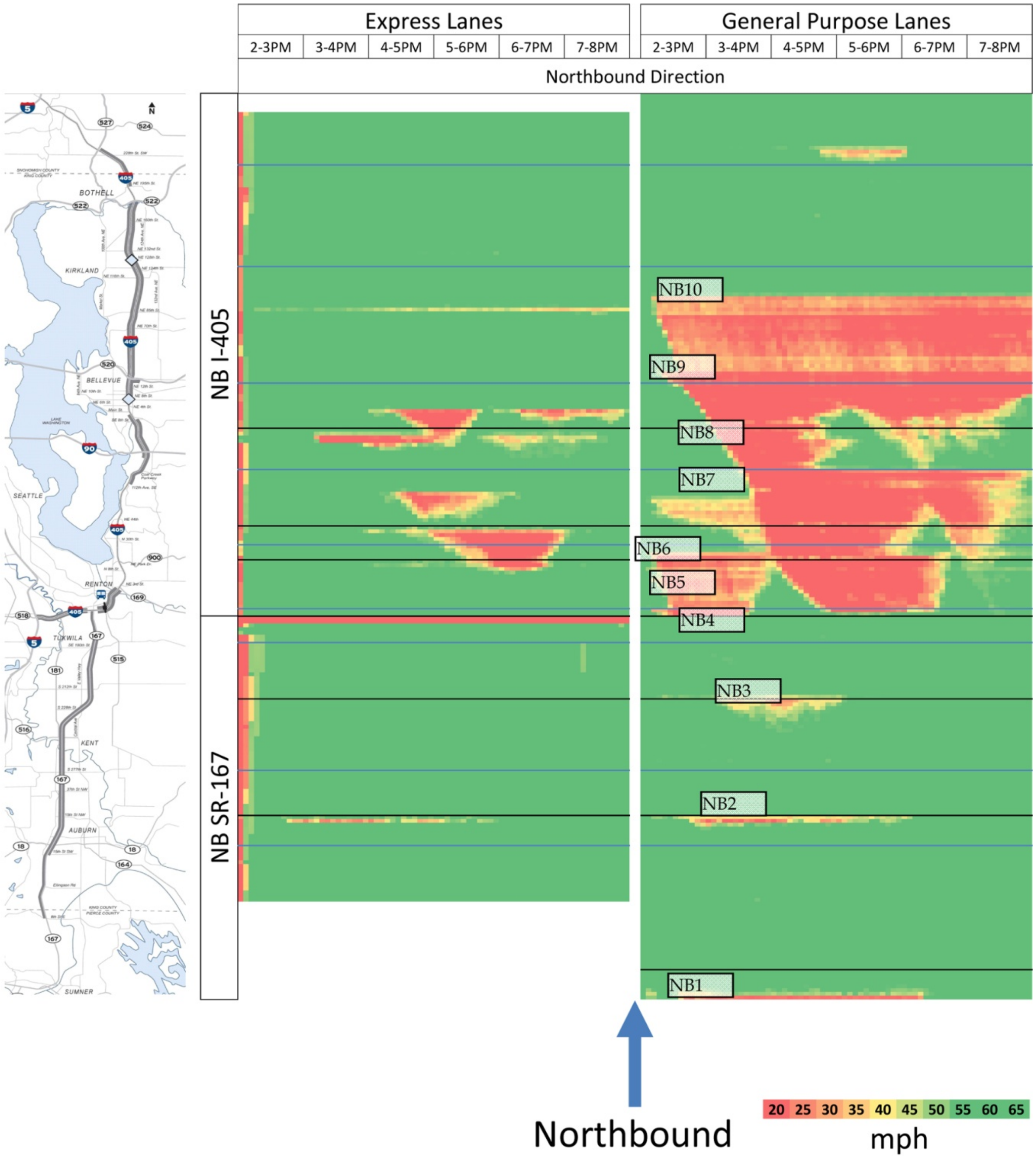
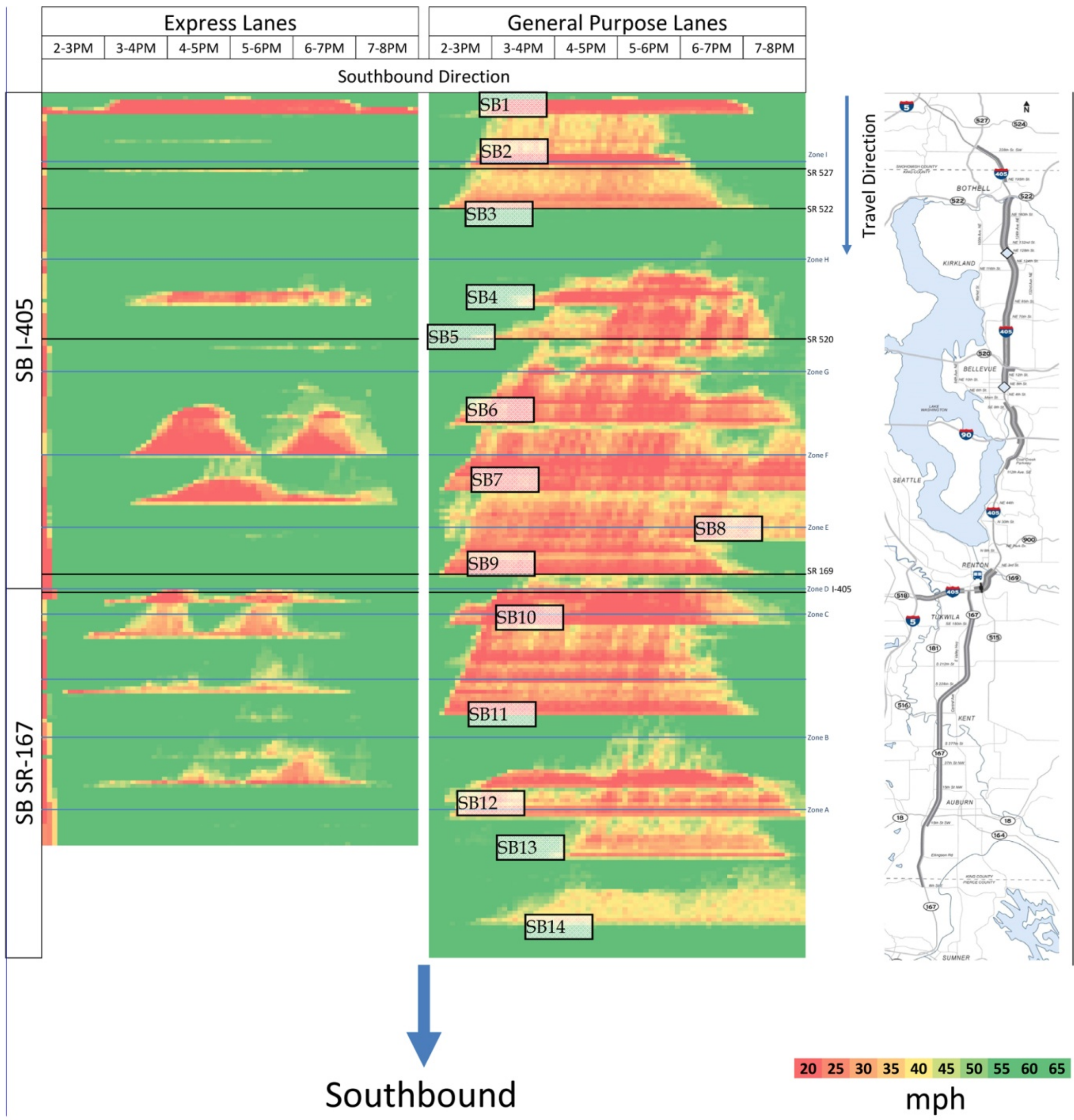


Figure 4.22 P.M. Period Southbound Bottleneck Locations
***HOV 3+ Free* Scenario**
2030



4.4 Effects of Variable and Flat Pricing

EHB 1382 also called for an analysis of charging vehicles a flat rate (same toll rate all day) and variable pricing (toll rates preset by time of day). Table 4.4 shows the revenue forecast for the *Flat* rate and *Variable* rate sensitivity tests compared to the dynamically priced *HOV3+ free* scenario as well as a comparison of VMT and speed performance measures. We found that:

- *Variable* pricing revenue is forecast to generate 114 percent of the dynamic pricing scenario revenue. We expect that this is because we set the toll rates at a high enough level to ensure that the speed policy is achieved, which leads to higher prices paid and greater gross revenue. If we had set the variable prices differently the revenues could have been higher or lower, and potentially lower than the dynamic pricing scenario.
- *Flat* pricing revenue is forecast to be 96 percent of the dynamic pricing method of toll collection. As with variable pricing, this is largely a function of how we chose to set the rate. A range of alternative outcomes is possible.
- Traffic performance, as measured by VMT and speed, is best with the dynamic pricing option, but the differences are not all that dramatic. The forecast speeds with the variable pricing option are close to that of the dynamic option – 20.6 mph versus 21.1 mph (a difference of two percent), and the VMT (throughput) are forecast to be 99 percent of the dynamic option.

Table 4.4 Comparison of Forecast VMT, Speed and Gross Annual Revenue
Variable and Flat Rate to Dynamic Toll Collection Concept HOV 3+ Free Scenario, 2030

		Variable		Flat	
	Dynamic	**Amount**	**Percent of Dynamic**	**Amount**	**Percent of Dynamic**
Throughput: Corridor VMT (000)	8,628	8,555	99%	8,397	97%
Mobility: Average Corridor Speed (mph)	21.1	20.6	97%	19.0	90%
Annual Gross Revenue (millions 2012$)	133.4	152.5	114%	127.7	96%
Average Toll Rate (A.M. Period)	2.01	2.45	122%	2.04	101%
Average Toll Rate (P.M. Period)	2.03	2.27	112%	1.92	95%

It is difficult to draw definitive conclusions solely from these comparisons because the outcomes are influenced by the choice of how prices are set under both the variable and flat pricing concept. However, we can make the following observations:

- Dynamic pricing should be able to achieve the best performance from the corridor since it reacts in real time to traffic conditions.
- With *variable* pricing, the operator has to be cautious in setting tolls so that the performance objectives are achieved. As such, the operator will tend to err on the high side with respect to toll rates. This will yield more revenue, but at the loss of performance in the corridor. The toll lanes will tend to be underutilized, resulting in more congestion in the general purpose lanes than in the dynamic pricing scenario.
- A *flat* toll is completely at odds with the idea of an Express Toll Lane. It is difficult to come up with a generic toll rate that would accomplish the primary objective of an Express Toll Lane, which is to provide a reliable trip in the corridor in spite of substantial changes in traffic demand volumes and congestion. A single toll rate is simply too blunt an instrument to accomplish this.

4.5 Effects of an HOV Discount Toll Policy

We tested the effect of a $1.00 discount on all HOV using the corridor and compared it to the *HOV 2+ Free* and *HOV 3+ Free* policies (Table 4.5). For the *HOV Discount* scenario, the 2030 annual revenues were estimated at $115.4 million, about 13 percent less than the *HOV3+ Free* scenario and 8 percent higher than the *HOV 2+ Free* scenario. There were only small differences in the mobility and throughput measures.

Table 4.5 Comparison of Forecast VMT, Speed and Gross Annual Revenue
HOV Discount to HOV 3+ Free and HOV 2+ Free Policies, 2030

	HOV 3+ Free	HOV 2+ Free	HOV Discount	Percent of HOV 3+ Free	Percent of HOV 2+ Free
Throughput: Corridor VMT (000)	8,628	8,686	8693	101%	100%
Mobility: Average Corridor Speed (mph)	21.1	22.2	21.9	104%	99%
Annual Gross Revenue (millions 2012$)	133.4	106.4	115.4	87%	108%
Average Toll Rate (A.M. Period)	2.01	2.00	1.89	94%	95%
Average Toll Rate (P.M. Period)	2.03	2.07	2.04	100%	99%

4.6 Fundamental Findings

Among the many important findings of this study, the following stand out:

Narrower Range of Revenue Outcomes than Prior WSDOT Forecast. The range of revenue outcomes between the 15th and 85th percentile from this independent traffic and revenue forecast is narrower than the range of revenues used by WSDOT for prior financial planning. For both *HOV2+ Free* and *HOV 3+ Free* scenarios, the 15th percentile of the independent revenue estimate was higher than WSDOT's low estimate, but the 85th percentile of the independent revenue estimate was lower than WSDOT's high estimate.

If people do not have transponders they cannot use the Express Toll Lanes and revenue will be lower. This may seem obvious, but is an important risk factor. WSDOT did not promote the SR 167 Express Toll Lanes – only 14 percent of corridor drivers had transponders in the fall of 2011. As a result, revenue was much lower than expected. Although transponder ownership was only one factor contributing to this outcome (the Great Recession was another factor), if more people have transponders, they have an opportunity to use the lanes.

In our analysis, a scenario with 45 percent transponder ownership in the corridor versus 20 percent ownership yielded three times more revenue. In the long run it is likely that new vehicles would be available equipped with integrated toll collection devices, and hand-held "smart phones" or their future equivalent will substitute as transponders for many different types of automated transactions, increasing the effective ownership rate for transponders. Until then, however, having more people with transponders will translate into more people able to use the Express Toll Lanes.

Traffic growth drives revenue growth. Another obvious statement, with more nuanced implications. Revenue growth will grow much faster than traffic growth because more corridor traffic demand will yield more corridor congestion and higher time savings provided by the Express Toll Lanes. This in turn will drive up the toll rates to maintain the speed policy, which has enormous leverage on revenue. For example, for the median *HOV3+* scenario, we forecast the average toll rate paid to increase by approximately 45 percent between 2018 and 2030, without any adjustment for inflation. However, the overall traffic demand in the corridor is only forecast to increase by 12.6 percent.

Demand will exceed capacity. We found that future traffic demand will exceed capacity, meaning that some demand will not be fully served. This means that some traffic may find other destinations or use different routes, beyond the levels that are captured in our models. Some revisions to the project design could enable more traffic throughput, but overall, we expect there to be unserved demand.

Complex system of frequent access. The proposed Express Toll Lane system has access points an average of every 1.5 miles. This will cause frequent weaving that will have an effect on corridor performance and express lane utilization. Relative to the WSDOT findings, our analysis found a higher percentage of qualified HOV electing *not* to use the express lane for shorter trips.

***HOV 2+ Free* operations.** We found little difference between the management scenarios (*HOV 2+ free*, *HOV 3+ free*, and *Mixed*), with the *HOV 2+ free* scenario providing slightly better performance. However, managing the Express Toll Lane is based on increasing toll rates to discourage paying customers from using the system in order to maintain the quality of flow. The percent of *HOV 2+ free* vehicles in the system is approaching 20 percent today. However, the Express Toll Lane system will restrict ingress to and egress from the special lanes, meaning that some HOV 2 may not be able to get to the new Express Toll Lane system because of their on and off locations (e.g., they need to get off before there is a convenient egress point). The pricing mechanism will not discourage toll-exempt vehicles. If there are too many toll exempt vehicles, WSDOT will not be able to manage traffic flow to the desired speed – 45 mph 90 percent of the time in the peak hours. Our modeling does not address 100 percent of the conditions that could occur over the course of a year. Reducing the number of toll-exempt vehicles by changing the HOV definition to three or more increases WSDOT's ability to manage traffic demand and maintain a reliable speed in the Express Toll Lanes.

Complex interaction between Express Toll Lanes and general purpose lanes. The operations of the Express Toll Lanes cannot be fully isolated from the operations of the general purpose lanes. If a breakdown occurs in the general purpose lane and backs up blocking the access to and from the Express Toll Lanes, then the Express Toll Lanes could come to a standstill even though the traffic in the Express Toll Lanes may not be high enough to be performing poorly. It will be important to consider improving bottlenecks in the general-purpose lanes and or modifying Express Toll Lane access to ensure that the Express Toll Lanes operate as intended. Normal operations practices, including rapid incident detection and clearance, are important elements of an optimized system of express and general purpose lanes.

Appendix A – Stated Preferences and Attitudinal Survey Report

Provided in enclosed CD.

Appendix B – Eastside Corridor Independent Traffic and Revenue Study: Review of Available Data and Methods: Technical Memorandum

Provided in enclosed CD.

Appendix C – Model Summaries

Provided in enclosed CD.

Appendix D – Toll Rates for *Variable Pricing* Scenario

Direction	Area	Ingress	Egress	length (miles)	5:00 AM	6:00 AM	7:00 AM	8:00 AM	9:00 AM	10:00 AM	2:00 PM	3:00 PM	4:00 PM	5:00 PM	6:00 PM	7:00 PM
Northbound	South Area	SR-167 at Stewart	N of Ellingson Rd	2.01	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of SR18	4.32	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of 15th St NW	5.78	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of S 277th St	7.80	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of SR516	9.47	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of S 212th St	12.03	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of S 180th St	14.31	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
		SR-167 at N of Ellingson Rd	N of SR18	2.04	1.25	1.25	2.00	5.00	6.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of 15th St NW	3.50	1.25	1.25	2.00	5.00	6.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of S 277th St	5.52	1.25	1.25	2.00	5.00	6.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of SR516	7.19	1.25	1.25	2.00	5.00	6.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of S 212th St	9.75	1.25	1.25	2.00	5.00	6.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of S 180th St	12.03	1.25	1.25	2.00	5.00	6.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
		SR-167 at N of SR18	N of 15th St NW	1.26	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of S 277th St	3.29	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of SR516	4.96	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of S 212th St	7.52	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of S 180th St	9.80	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
		SR-167 at N of 15th St NW	N of S 277th St	1.73	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of SR516	3.40	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of S 212th St	5.96	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of S 180th St	8.24	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
		SR-167 at N of S 277th St	N of SR516	1.39	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of S 212th St	3.94	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of S 180th St	6.23	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
		SR-167 at N of SR516	N of S 212th St	2.27	1.25	1.25	1.50	3.00	3.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of S 180th St	4.56	1.25	1.25	1.50	3.00	3.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
		SR-167 at N of S 212th St	N of S 180th St	2.00	1.25	1.25	1.50	3.00	3.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
	Middle Area	SR-167 at N of 180th St	N of Sunset Blvd	3.22	1.00	1.00	1.25	3.00	5.00	5.00	1.00	1.00	1.25	3.00	3.00	1.50
			N Park Dr	3.73	1.00	1.00	1.25	3.00	5.00	5.00	1.00	1.00	1.25	3.00	3.00	1.50
			NE 44th St	5.54	1.00	1.00	1.50	3.00	5.00	5.00	1.00	1.00	1.25	3.00	3.00	1.50
			112th Ave SE	7.48	1.00	1.00	1.25	3.00	5.00	5.00	1.00	1.00	1.25	3.00	3.00	1.50
			N of I-90	9.99	1.00	1.00	1.25	3.00	5.00	5.00	1.00	1.00	1.25	3.00	3.00	1.50
		I-405 at SR-167	N of Sunset Blvd	2.82	1.00	1.25	1.25	3.00	5.00	5.00	1.25	1.25	1.25	3.00	3.00	1.50
			N Park Dr	3.32	1.00	1.25	1.25	3.00	5.00	5.00	1.25	1.25	1.25	3.00	3.00	1.50
			NE 44th St	5.13	1.00	1.25	1.25	3.00	5.00	5.00	1.25	1.25	1.25	3.00	3.00	1.50
			112th Ave SE	7.08	1.00	1.25	1.25	3.00	5.00	5.00	1.25	1.25	1.25	3.00	3.00	1.50
			N of I-90	9.59	1.00	1.25	1.25	3.00	5.00	5.00	1.25	1.25	1.25	3.00	3.00	1.50
		I-405 at N of Sunset Blvd	N Park Dr	0.51	1.00	1.00	1.50	3.00	5.00	5.00	1.00	1.25	3.00	5.00	3.00	1.50
			NE 44th St	2.32	1.00	1.00	1.50	3.00	5.00	5.00	1.00	1.25	3.00	5.00	3.00	1.50
			112th Ave SE	4.26	1.00	1.00	1.50	3.00	5.00	5.00	1.00	1.25	3.00	5.00	3.00	1.50
			N of I-90	6.77	1.00	1.00	1.50	3.00	5.00	5.00	1.00	1.25	3.00	5.00	3.00	1.50
		I-405 at N Park Dr	NE 44th St	1.53	1.00	1.00	1.25	3.00	5.00	5.00	1.00	1.50	3.00	5.00	3.00	1.50
			112th Ave SE	3.48	1.00	1.00	1.25	3.00	5.00	5.00	1.00	1.50	3.00	5.00	3.00	1.50
			N of I-90	5.99	1.00	1.00	1.25	3.00	5.00	5.00	1.00	1.50	3.00	5.00	3.00	1.50
		I-405 at NE 44th St	112th Ave SE	1.57	1.00	1.00	1.25	1.25	1.25	1.25	1.00	1.50	3.00	5.00	3.00	1.50
			N of I-90	4.08	1.00	1.00	1.25	1.25	1.25	1.25	1.00	1.50	3.00	5.00	3.00	1.50
		I-405 at 112th Ave SE	N of I-90	2.17	1.00	1.00	1.25	1.25	1.25	1.25	1.00	1.50	3.00	5.00	3.00	1.50

Direction	Area	Ingress	Egress	length (miles)	5:00 AM	6:00 AM	7:00 AM	8:00 AM	9:00 AM	10:00 AM	2:00 PM	3:00 PM	4:00 PM	5:00 PM	6:00 PM	7:00 PM
Northbound	South Area	SR-167 at Stewart	N of Ellingson Rd	**2.01**	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of SR18	**4.32**	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of 15th St NW	**5.78**	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of S 277th St	**7.80**	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of SR516	**9.47**	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of S 212th St	**12.03**	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of S 180th St	**14.31**	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
		SR-167 at N of Ellingson Rd	N of SR18	**2.04**	1.25	1.25	2.00	5.00	6.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of 15th St NW	**3.50**	1.25	1.25	2.00	5.00	6.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of S 277th St	**5.52**	1.25	1.25	2.00	5.00	6.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of SR516	**7.19**	1.25	1.25	2.00	5.00	6.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of S 212th St	**9.75**	1.25	1.25	2.00	5.00	6.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of S 180th St	**12.03**	1.25	1.25	2.00	5.00	6.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
		SR-167 at N of SR18	N of 15th St NW	**1.26**	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of S 277th St	**3.29**	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of SR516	**4.96**	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of S 212th St	**7.52**	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of S 180th St	**9.80**	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
		SR-167 at N of 15th St NW	N of S 277th St	**1.73**	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of SR516	**3.40**	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of S 212th St	**5.96**	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of S 180th St	**8.24**	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
		SR-167 at N of S 277th St	N of SR516	**1.39**	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of S 212th St	**3.94**	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of S 180th St	**6.23**	1.25	1.25	2.00	5.00	5.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
		SR-167 at N of SR516	N of S 212th St	**2.27**	1.25	1.25	1.50	3.00	3.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
			N of S 180th St	**4.56**	1.25	1.25	1.50	3.00	3.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
		SR-167 at N of S 212th St	N of S 180th St	**2.00**	1.25	1.25	1.50	3.00	3.00	3.00	1.25	1.25	1.25	1.25	1.25	1.00
	Middle Area	SR-167 at N of 180th St	N of Sunset Blvd	**3.22**	1.00	1.00	1.25	3.00	5.00	5.00	1.00	1.00	1.25	3.00	3.00	1.50
			N Park Dr	**3.73**	1.00	1.00	1.25	3.00	5.00	5.00	1.00	1.00	1.25	3.00	3.00	1.50
			NE 44th St	**5.54**	1.00	1.00	1.50	3.00	5.00	5.00	1.00	1.00	1.25	3.00	3.00	1.50
			112th Ave SE	**7.48**	1.00	1.00	1.25	3.00	5.00	5.00	1.00	1.00	1.25	3.00	3.00	1.50
			N of I-90	**9.99**	1.00	1.00	1.25	3.00	5.00	5.00	1.00	1.00	1.25	3.00	3.00	1.50
		I-405 at SR-167	N of Sunset Blvd	**2.82**	1.00	1.25	1.25	3.00	5.00	5.00	1.25	1.25	1.25	3.00	3.00	1.50
			N Park Dr	**3.32**	1.00	1.25	1.25	3.00	5.00	5.00	1.25	1.25	1.25	3.00	3.00	1.50
			NE 44th St	**5.13**	1.00	1.25	1.25	3.00	5.00	5.00	1.25	1.25	1.25	3.00	3.00	1.50
			112th Ave SE	**7.08**	1.00	1.25	1.25	3.00	5.00	5.00	1.25	1.25	1.25	3.00	3.00	1.50
			N of I-90	**9.59**	1.00	1.25	1.25	3.00	5.00	5.00	1.25	1.25	1.25	3.00	3.00	1.50
		I-405 at N of Sunset Blvd	N Park Dr	**0.51**	1.00	1.00	1.50	3.00	5.00	5.00	1.00	1.25	3.00	5.00	3.00	1.50
			NE 44th St	**2.32**	1.00	1.00	1.50	3.00	5.00	5.00	1.00	1.25	3.00	5.00	3.00	1.50
			112th Ave SE	**4.26**	1.00	1.00	1.50	3.00	5.00	5.00	1.00	1.25	3.00	5.00	3.00	1.50
			N of I-90	**6.77**	1.00	1.00	1.50	3.00	5.00	5.00	1.00	1.25	3.00	5.00	3.00	1.50
		I-405 at N Park Dr	NE 44th St	**1.53**	1.00	1.00	1.25	3.00	5.00	5.00	1.00	1.50	3.00	5.00	3.00	1.50
			112th Ave SE	**3.48**	1.00	1.00	1.25	3.00	5.00	5.00	1.00	1.50	3.00	5.00	3.00	1.50
			N of I-90	**5.99**	1.00	1.00	1.25	3.00	5.00	5.00	1.00	1.50	3.00	5.00	3.00	1.50
		I-405 at NE 44th St	112th Ave SE	**1.57**	1.00	1.00	1.25	1.25	1.25	1.25	1.00	1.50	3.00	5.00	3.00	1.50
			N of I-90	**4.08**	1.00	1.00	1.25	1.25	1.25	1.25	1.00	1.50	3.00	5.00	3.00	1.50
		I-405 at 112th Ave SE	N of I-90	**2.17**	1.00	1.00	1.25	1.25	1.25	1.25	1.00	1.50	3.00	5.00	3.00	1.50

Direction	Area	Ingress	Egress	length (miles)	5:00 AM	6:00 AM	7:00 AM	8:00 AM	9:00 AM	10:00 AM	2:00 PM	3:00 PM	4:00 PM	5:00 PM	6:00 PM	7:00 PM
Southbound	North Area	I-405 at S of I-5	N of Nothell Everett	1.22	1.00	1.25	2.00	5.00	2.00	1.50	1.25	1.25	1.25	1.50	1.50	1.25
			N of NE 195th st	2.92	1.00	1.25	2.00	5.00	2.00	1.50	1.25	1.25	1.25	1.50	1.50	1.25
			NE 128th st	8.31	1.00	1.25	2.00	5.00	2.00	1.50	1.25	1.25	1.25	1.50	1.50	1.25
			N of NE 85th st	9.58	1.00	1.25	2.00	5.00	2.00	1.50	1.25	1.25	1.25	1.50	1.50	1.25
			N of SR520	12.52	1.00	1.25	2.00	5.00	2.00	1.50	1.25	1.25	1.25	1.50	1.50	1.25
		I-405 at N of Nothell Everett	N of NE 195th st	1.32	1.00	1.25	2.00	3.00	2.00	1.50	1.00	1.25	1.25	1.25	1.50	1.25
			NE 128th st	6.72	1.00	1.25	2.00	3.00	2.00	1.50	1.00	1.25	1.25	1.25	1.50	1.25
			N of NE 85th st	7.99	1.00	1.25	2.00	3.00	2.00	1.50	1.00	1.25	1.25	1.25	1.50	1.25
			N of SR520	10.93	1.00	1.25	2.00	3.00	2.00	1.50	1.00	1.25	1.25	1.25	1.50	1.25
		I-405 at N of NE 195th st	NE 128th st	5.02	1.00	1.25	1.25	1.50	2.00	1.50	1.00	1.25	1.25	1.25	1.50	1.25
			N of NE 85th st	6.29	1.00	1.25	1.25	1.50	2.00	1.50	1.00	1.25	1.25	1.25	1.50	1.25
			N of SR520	9.24	1.00	1.25	1.25	1.50	2.00	1.50	1.00	1.25	1.25	1.25	1.50	1.25
		I-405 at NE 160th st	NE 128th st	1.71	1.00	1.00	1.25	1.25	2.00	1.50	1.00	1.00	1.00	1.25	1.50	1.00
			N of NE 85th st	2.98	1.00	1.00	1.25	1.25	2.00	1.50	1.00	1.00	1.00	1.25	1.50	1.00
			N of SR520	5.92	1.00	1.00	1.25	1.25	2.00	1.50	1.00	1.00	1.00	1.25	1.50	1.00
		I-405 at S of NE 160th st	NE 128th st	0.99	1.00	1.00	1.25	1.25	2.00	1.50	1.00	1.00	1.00	1.25	1.75	1.00
			N of NE 85th st	2.27	1.00	1.00	1.25	1.25	2.00	1.50	1.00	1.00	1.00	1.25	1.75	1.00
			N of SR520	5.21	1.00	1.00	1.25	1.25	2.00	1.50	1.00	1.00	1.00	1.25	1.75	1.00
		I-405 at NE 128th st	N of NE 85th st	1.27	1.00	1.00	1.25	1.50	4.00	1.75	1.00	1.00	1.00	1.50	3.00	1.00
			N of SR520	4.21	1.00	1.00	1.25	1.50	4.00	1.75	1.00	1.00	1.00	1.50	3.00	1.00
		I-405 at N of NE 85th st	N of SR520	2.19	1.00	1.00	1.25	1.25	1.50	1.75	1.00	1.00	1.00	1.25	1.25	1.00
	Middle Area	I-405 at N of SR520	Downtown Bellevue	2.32	1.00	1.00	1.75	3.00	1.25	1.00	1.00	2.00	5.00	3.00	3.00	2.00
			S of SE 8th St	3.63	1.00	1.00	1.75	3.00	1.25	1.00	1.00	2.00	5.00	3.00	3.00	2.00
			Coal Creek Pkwy	5.63	1.00	1.00	1.75	3.00	1.25	1.00	1.00	2.00	5.00	3.00	3.00	2.00
			NE 44th St	8.29	1.00	1.00	1.75	3.00	1.25	1.00	1.00	2.00	5.00	3.00	3.00	2.00
			N Park Dr	10.14	1.00	1.00	1.75	3.00	1.25	1.00	1.00	2.00	5.00	3.00	3.00	2.00
			N of Sunset Blvd	11.01	1.00	1.00	1.75	3.00	1.25	1.00	1.00	2.00	5.00	3.00	3.00	2.00
			W of SR167	13.62	1.00	1.00	1.75	3.00	1.25	1.00	1.00	2.00	5.00	3.00	3.00	2.00
			S of SR167	14.23	1.00	1.00	1.75	3.00	1.25	1.00	1.00	2.00	5.00	3.00	3.00	2.00
		I-405 at Downtown Bellevue	S of SE 8th St	1.30	1.00	1.00	2.00	3.00	1.25	1.00	1.00	2.00	5.00	5.00	3.00	3.00
			Coal Creek Pkwy	3.31	1.00	1.00	2.00	3.00	1.25	1.00	1.00	2.00	5.00	5.00	3.00	3.00
			NE 44th St	5.97	1.00	1.00	2.00	3.00	1.25	1.00	1.00	2.00	5.00	5.00	3.00	3.00
			N Park Dr	7.82	1.00	1.00	2.00	3.00	1.25	1.00	1.00	2.00	5.00	5.00	3.00	3.00
			N of Sunset Blvd	8.68	1.00	1.00	2.00	3.00	1.25	1.00	1.00	2.00	5.00	5.00	3.00	3.00
			W of SR167	11.30	1.00	1.00	2.00	3.00	1.25	1.00	1.00	2.00	5.00	5.00	3.00	3.00
			S of SR167	11.90	1.00	1.00	2.00	3.00	1.25	1.00	1.00	2.00	5.00	5.00	3.00	3.00
		I-405 at S of SE 8th St	Coal Creek Pkwy	1.15	1.00	1.00	2.00	5.00	1.25	1.00	1.00	2.00	5.00	5.00	3.00	3.00
			NE 44th St	3.81	1.00	1.00	2.00	5.00	1.25	1.00	1.00	2.00	5.00	5.00	3.00	3.00
			N Park Dr	5.66	1.00	1.00	2.00	5.00	1.25	1.00	1.00	2.00	5.00	5.00	3.00	3.00
			N of Sunset Blvd	6.52	1.00	1.00	2.00	5.00	1.25	1.00	1.00	2.00	5.00	5.00	3.00	3.00
			W of SR167	9.13	1.00	1.00	2.00	5.00	1.25	1.00	1.00	2.00	5.00	5.00	3.00	3.00
			S of SR167	9.74	1.00	1.00	2.00	5.00	1.25	1.00	1.00	2.00	5.00	5.00	3.00	3.00
		I-405 at Coal Creek Pkwy	NE 44th St	1.46	1.00	1.00	1.50	3.00	1.25	1.00	1.00	1.50	4.00	4.00	2.00	2.00
			N Park Dr	3.31	1.00	1.00	1.50	3.00	1.25	1.00	1.00	1.50	4.00	4.00	2.00	2.00
			N of Sunset Blvd	4.17	1.00	1.00	1.50	3.00	1.25	1.00	1.00	1.50	4.00	4.00	2.00	2.00
			W of SR167	6.79	1.00	1.00	1.50	3.00	1.25	1.00	1.00	1.50	4.00	4.00	2.00	2.00
			S of SR167	7.39	1.00	1.00	1.50	3.00	1.25	1.00	1.00	1.50	4.00	4.00	2.00	2.00
		I-405 at NE 44th St	N Park Dr	1.52	1.00	1.00	1.25	1.25	1.25	1.00	1.00	1.25	1.25	1.50	1.25	1.25
			N of Sunset Blvd	2.39	1.00	1.00	1.25	1.25	1.25	1.00	1.00	1.25	1.25	1.50	1.25	1.25
			W of SR167	5.00	1.00	1.00	1.25	1.25	1.25	1.00	1.00	1.25	1.25	1.50	1.25	1.25
			S of SR167	5.60	1.00	1.00	1.25	1.25	1.25	1.00	1.00	1.25	1.25	1.50	1.25	1.25
		I-405 at N Park Dr	N of Sunset Blvd	0.51	1.00	1.00	1.25	1.25	1.25	1.00	1.00	1.25	1.50	1.50	1.25	1.00
			W of SR167	3.13	1.00	1.00	1.25	1.25	1.25	1.00	1.00	1.25	1.50	1.50	1.25	1.00
			S of SR167	3.73	1.00	1.00	1.25	1.25	1.25	1.00	1.00	1.25	1.50	1.50	1.25	1.00
		I-405 at N of Sunset Blvd	W of SR167	2.61	1.00	1.00	1.25	1.25	1.25	1.00	1.00	1.25	1.25	1.25	1.25	1.00
			S of SR167	3.22	1.00	1.00	1.25	1.25	1.25	1.00	1.00	1.25	1.25	1.25	1.25	1.00

Direction	Area	Ingress	Egress	length (miles)	5:00 AM	6:00 AM	7:00 AM	8:00 AM	9:00 AM	10:00 AM	2:00 PM	3:00 PM	4:00 PM	5:00 PM	6:00 PM	7:00 PM
Southbound	South Area	SR167 at S of SR167	N of S 180th St	**1.50**	1.00	1.00	1.00	1.00	**1.25**	**1.50**	**1.25**	**3.00**	**3.00**	**4.00**	**2.00**	**1.50**
			N of S 212th St	**4.66**	1.00	1.00	1.00	1.00	**1.25**	**1.50**	**1.25**	**3.00**	**3.00**	**4.00**	**2.00**	**1.50**
			N of SR516	**6.15**	1.00	1.00	1.00	1.00	**1.25**	**1.50**	**1.25**	**3.00**	**3.00**	**4.00**	**2.00**	**1.50**
			N of S 277th St	**8.21**	1.00	1.00	1.00	1.00	**1.25**	**1.50**	**1.25**	**3.00**	**3.00**	**4.00**	**2.00**	**1.50**
			N of 15th St NW	**9.80**	1.00	1.00	1.00	1.00	**1.25**	**1.50**	**1.25**	**3.00**	**3.00**	**4.00**	**2.00**	**1.50**
			N of SR18	**12.00**	1.00	1.00	1.00	1.00	**1.25**	**1.50**	**1.25**	**3.00**	**3.00**	**4.00**	**2.00**	**1.50**
			N of Ellingson Rd	**13.30**	1.00	1.00	1.00	1.00	**1.25**	**1.50**	**1.25**	**3.00**	**3.00**	**4.00**	**2.00**	**1.50**
		SR167 at N of S 180th St	N of S 212th St	**2.88**	1.00	1.00	**1.25**	**1.25**	**1.25**	**1.50**	**1.25**	**2.00**	**3.00**	**3.00**	**3.00**	**1.50**
			N of SR516	**4.37**	1.00	1.00	**1.25**	**1.25**	**1.25**	**1.50**	**1.25**	**2.00**	**3.00**	**3.00**	**3.00**	**1.50**
			N of S 277th St	**6.43**	1.00	1.00	**1.25**	**1.25**	**1.25**	**1.50**	**1.25**	**2.00**	**3.00**	**3.00**	**3.00**	**1.50**
			N of 15th St NW	**8.02**	1.00	1.00	**1.25**	**1.25**	**1.25**	**1.50**	**1.25**	**2.00**	**3.00**	**3.00**	**3.00**	**1.50**
			N of SR18	**10.22**	1.00	1.00	**1.25**	**1.25**	**1.25**	**1.50**	**1.25**	**2.00**	**3.00**	**3.00**	**3.00**	**1.50**
			N of Ellingson Rd	**11.52**	1.00	1.00	**1.25**	**1.25**	**1.25**	**1.50**	**1.25**	**2.00**	**3.00**	**3.00**	**3.00**	**1.50**
		SR167 at N of S 212th St	N of SR516	**1.22**	1.00	**1.25**	**1.25**	**1.25**	**1.25**	**3.00**	**1.25**	**1.75**	**3.00**	**3.00**	**3.00**	**1.50**
			N of S 277th St	**3.28**	1.00	**1.25**	**1.25**	**1.25**	**1.25**	**3.00**	**1.25**	**1.75**	**3.00**	**3.00**	**3.00**	**1.50**
			N of 15th St NW	**4.87**	1.00	**1.25**	**1.25**	**1.25**	**1.25**	**3.00**	**1.25**	**1.75**	**3.00**	**3.00**	**3.00**	**1.50**
			N of SR18	**7.07**	1.00	**1.25**	**1.25**	**1.25**	**1.25**	**3.00**	**1.25**	**1.75**	**3.00**	**3.00**	**3.00**	**1.50**
			N of Ellingson Rd	**8.37**	1.00	**1.25**	**1.25**	**1.25**	**1.25**	**3.00**	**1.25**	**1.75**	**3.00**	**3.00**	**3.00**	**1.50**
		SR167 at N of SR516	N of S 277th St	**1.78**	1.00	**1.25**	**1.25**	**1.25**	**1.25**	**3.00**	**1.25**	**1.75**	**3.00**	**3.00**	**4.00**	**1.50**
			N of 15th St NW	**3.37**	1.00	**1.25**	**1.25**	**1.25**	**1.25**	**3.00**	**1.25**	**1.75**	**3.00**	**3.00**	**4.00**	**1.50**
			N of SR18	**5.57**	1.00	**1.25**	**1.25**	**1.25**	**1.25**	**3.00**	**1.25**	**1.75**	**3.00**	**3.00**	**4.00**	**1.50**
			N of Ellingson Rd	**6.87**	1.00	**1.25**	**1.25**	**1.25**	**1.25**	**3.00**	**1.25**	**1.75**	**3.00**	**3.00**	**4.00**	**1.50**
		SR167 at N of S 277th St	N of 15th St NW	**1.30**	1.00	**1.25**	**1.25**	**1.25**	**1.25**	**2.00**	**1.25**	**2.00**	**5.00**	**5.00**	**5.00**	**1.50**
			N of SR18	**3.49**	1.00	**1.25**	**1.25**	**1.25**	**1.25**	**2.00**	**1.25**	**2.00**	**5.00**	**5.00**	**5.00**	**1.50**
			N of Ellingson Rd	**4.80**	1.00	**1.25**	**1.25**	**1.25**	**1.25**	**2.00**	**1.25**	**2.00**	**5.00**	**5.00**	**5.00**	**1.50**
		SR167 at N of 15th St NW	N of SR18	**1.86**	1.00	1.00	1.00	1.00	**1.25**	**1.25**	**1.25**	**1.25**	**1.50**	**1.50**	**1.50**	**1.50**
			N of Ellingson Rd	**3.16**	1.00	1.00	1.00	1.00	**1.25**	**1.25**	**1.25**	**1.25**	**1.50**	**1.50**	**1.50**	**1.50**
		SR167 at N of SR18	N of Ellingson Rd	**1.02**	1.00	1.00	1.00	1.00	**1.25**	**1.25**	**1.25**	**1.25**	**1.50**	**1.50**	**1.50**	**1.25**

Appendix E – Annual Revenue Forecasts

- Table E.1: *HOV2+ Free* Scenario.
- Table E.2: *HOV3+ Free* Scenario.
- Table E.3: *Mixed* Scenario.

Table E.1 *HOV 2+ Free* Scenario
Millions of 2012 Dollars

Year	15th	Mean	85th
2014	$3.7	$5.5	$7.6
2015	$4.3	$6.5	$8.9
2016	$5.2	$7.8	$10.7
2017	$5.8	$8.6	$11.9
2018	$22.2	$36.4	$51.9
2019	$25.7	$41.1	$57.7
2020	$35.1	$52.7	$71.5
2021	$39.7	$57.9	$77.2
2022	$44.4	$63.1	$82.9
2023	$49.1	$68.3	$88.6
2024	$53.8	$73.5	$94.2
2025	$58.4	$78.7	$99.9
2026	$63.1	$83.9	$105.6
2027	$67.8	$89.1	$111.3
2028	$72.5	$94.3	$117.0
2029	$77.1	$99.5	$122.7
2030	$81.8	$104.7	$128.3
2031	$83.3	$106.6	$130.7
2032	$84.8	$108.5	$133.1
2033	$86.3	$110.4	$135.4
2034	$87.8	$112.3	$137.8
2035	$89.3	$114.3	$140.1
2036	$90.8	$116.2	$142.5
2037	$92.3	$118.1	$144.8
2038	$93.8	$120.0	$147.2
2039	$95.3	$121.9	$149.5
2040	$96.8	$123.9	$151.9
2041	$98.6	$126.2	$154.7
2042	$100.5	$128.5	$157.6
2043	$102.3	$130.9	$160.5
2044	$104.1	$133.2	$163.3
2045	$105.9	$135.5	$166.2
2046	$107.8	$137.8	$169.0
2047	$109.6	$140.2	$171.9
2048	$111.4	$142.5	$174.7
2049	$113.2	$144.8	$177.6
2050	$115.0	$147.2	$180.5
2051	$116.9	$149.5	$183.3
2052	$118.7	$151.8	$186.2
2053	$120.5	$154.2	$189.0

Table E.2 *HOV 3+ Free* Scenario
Millions of 2012 Dollars

Year	15th	Mean	85th
2014	$6.4	$8.7	$11.4
2015	$7.5	$10.3	$13.4
2016	$9.0	$12.4	$16.2
2017	$10.0	$13.7	$18.0
2018	$33.1	$50.0	$68.1
2019	$37.7	$55.9	$75.6
2020	$49.2	$70.2	$92.7
2021	$54.6	$76.4	$99.5
2022	$59.9	$82.6	$106.4
2023	$65.3	$88.7	$113.2
2024	$70.7	$94.9	$120.1
2025	$76.1	$101.0	$126.9
2026	$81.5	$107.2	$133.8
2027	$86.8	$113.3	$140.6
2028	$92.2	$119.5	$147.5
2029	$97.6	$125.6	$154.3
2030	$103.0	$131.8	$161.1
2031	$104.9	$134.2	$164.1
2032	$106.8	$136.6	$167.1
2033	$108.7	$139.0	$170.0
2034	$110.5	$141.5	$173.0
2035	$112.4	$143.9	$175.9
2036	$114.3	$146.3	$178.9
2037	$116.2	$148.7	$181.8
2038	$118.1	$151.1	$184.8
2039	$120.0	$153.5	$187.7
2040	$121.9	$156.0	$190.7
2041	$124.2	$158.9	$194.3
2042	$126.5	$161.8	$197.9
2043	$128.8	$164.8	$201.5
2044	$131.1	$167.7	$205.0
2045	$133.3	$170.6	$208.6
2046	$135.6	$173.6	$212.2
2047	$137.9	$176.5	$215.8
2048	$140.2	$179.4	$219.4
2049	$142.5	$182.4	$223.0
2050	$144.8	$185.3	$226.6
2051	$147.1	$188.2	$230.2
2052	$149.4	$191.2	$233.8
2053	$151.7	$194.1	$237.3

Table E.3 Mixed Scenario
Millions of 2012 Dollars

Year	15th	Mean	85th
2014	$5.7	$7.9	$10.4
2015	$6.7	$9.3	$12.2
2016	$8.1	$11.2	$14.7
2017	$8.9	$12.4	$16.3
2018	$29.7	$45.7	$63.0
2019	$33.9	$51.3	$70.1
2020	$44.9	$65.0	$86.4
2021	$50.1	$71.0	$93.0
2022	$55.3	$77.0	$99.7
2023	$60.5	$82.9	$106.3
2024	$65.7	$88.9	$113.0
2025	$70.9	$94.9	$119.6
2026	$76.1	$100.9	$126.3
2027	$81.3	$106.9	$132.9
2028	$86.5	$112.9	$139.6
2029	$91.7	$118.9	$146.2
2030	$97.0	$124.9	$152.9
2031	$98.7	$127.1	$155.7
2032	$100.5	$129.4	$158.5
2033	$102.3	$131.7	$161.3
2034	$104.1	$134.0	$164.1
2035	$105.8	$136.3	$166.9
2036	$107.6	$138.6	$169.7
2037	$109.4	$140.9	$172.5
2038	$111.2	$143.2	$175.3
2039	$112.9	$145.5	$178.1
2040	$114.7	$147.7	$180.9
2041	$116.9	$150.5	$184.3
2042	$119.0	$153.3	$187.7
2043	$121.2	$156.1	$191.1
2044	$123.4	$158.9	$194.6
2045	$125.5	$161.6	$198.0
2046	$127.7	$164.4	$201.4
2047	$129.8	$167.2	$204.8
2048	$132.0	$170.0	$208.2
2049	$134.2	$172.8	$211.6
2050	$136.3	$175.5	$215.0
2051	$138.5	$178.3	$218.4
2052	$140.6	$181.1	$221.8
2053	$142.8	$183.9	$225.2