

# Interstate-90

## Center Roadway Study

JULY 2006



**Washington State  
Department of Transportation**

*DKS Associates*



# Interstate-90

Center Roadway Study

## ACKNOWLEDGEMENTS:

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WASHINGTON DEPARTMENT OF TRANSPORTATION

CITY OF BELLEVUE

CITY OF MERCER ISLAND

CITY OF SEATTLE

KING COUNTY METRO

SOUND TRANSIT

PUGET SOUND REGIONAL COUNCIL

DKS ASSOCIATES



# Interstate-90

Center Roadway Study

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# INTRODUCTION

Seattle and the Central Puget Sound region is home to Fortune 500 corporations such as Microsoft, Boeing and Starbucks, while serving as a primary gateway for the movement of goods to and from East Asian markets through its world class ports and terminal facilities. With a strong economy, rich cultural opportunities, beautiful scenery and a healthy environment, the Central Puget Sound region has a steadily growing population base with an estimated population of 3.5 million people in 2005, up from 1.5 million in 1960. By 2030 the population is expected to grow to over 4.6 million. The region provides over 1.76 million jobs in King, Snohomish, Pierce and Kitsap Counties. The City of Seattle is the largest employment center in the greater Puget Sound Region with over 462,000 jobs. A majority of these jobs are located in downtown Seattle and in areas around downtown such as Capitol Hill, Seattle Center and the South Duwamish area.

What makes the Seattle area truly unique is the multi-modal nature of its transportation facilities and the role that geography plays in the



development of existing and future transportation roadways and networks. Located on the edge of Elliott Bay in Puget Sound, Seattle is located between two large bodies of water: Puget Sound to the west and Lake Washington to the east. Because of these physical geographic constraints, Seattle has only two transportation facilities crossing Lake Washington: the I-90 and SR-520 freeways.

Faced with a growing population and increased congestion on these key regional links, the region has conducted extensive studies to evaluate alternatives to increase mobility and access across the lake. For the I-90 Corridor, past studies and regional agreements have identified I-90 as the preferred corridor for high capacity transit (HCT).

The I-90 roadway links the City of Seattle with the island community of Mercer Island and communities on the east side of Lake Washington such as Bellevue and Issaquah with I-90 serving as the only connection between Mercer Island and the mainland. The roadway currently operates with three mixed-flow lanes in each direction and a two-lane, reversible center roadway that operates in the peak direction. Access to the center roadway is restricted to transit vehicles, High-Occupancy Vehicles (HOVs) (2 or more passengers) and all vehicles destined to or from Mercer Island. During an average weekday the I-90 roadway carries approximately 133,000 vehicles per day.

As one of the key transportation links across Lake Washington, the I-90 roadway serves a diverse market of transportation users and service providers. During commute hours, the corridor is heavily congested from commuters crossing the lake in both directions to jobs and employment centers in Seattle and the eastside. The primary peak flow direction is toward Seattle in the morning (AM) peak and toward the east side in the afternoon (PM) peak. The peak directional volumes are currently split approximately 55/45 with the trend being towards an evening of this split during the peak hours.

Transit service providers operating in the corridor include King County Metro and Sound Transit. King County Metro operates local and regional bus service across the lake connecting Seattle and eastside communities. Sound Transit operates express bus service connecting regional urban centers such as Bellevue, Issaquah and Renton to downtown Seattle. At the time of our study and analysis, Sound Transit has not yet settled specifically on light rail, but on Exclusive use of the center roadway for High-Capacity Transit (HCT).



The I-90 Corridor is also a key corridor for the movement of freight. I-90 is used by trucks moving freight from US markets to Asia and from Asian markets to the US using port facilities located along Seattle's waterfront harbor. According to Washington's Transportation Plan 2003-2022, roughly 65 percent of truck trips originating in the Puget Sound region are destined to stay in Western Washington.

*The regional transit initiative approved by voters in the Puget Sound Region in 1996, now known as 'Sound Move', includes a high-occupancy vehicle (HOV) expressway and bus components that will substantially improve transit service and facilities in the region. This Sound Transit I-90 Two Way Transit and HOV project would make transit improvements on the I-90 Corridor between Seattle and Bellevue crossing Lake Washington via Mercer Island. The primary goal of the Project is to improve speed, reliability, and access for regional transit. The Project purpose was expanded by the Project partners to include improvement to travel to HOVs (e.g., carpools and vanpools) in the corridor.*

*[In 2004] The Federal Highway Administration (FHWA) issued its Record of Decision (ROD) in September, agreeing with Sound Transit and the Washington State Department of Transportation that Alternative R-8A was the best choice [for safe transit and HOV operations] on Interstate 90 between Seattle and Bellevue. The preferred alternative [was] Alternative R-8A, which will add a fourth lane for buses/carpools on the outer roadways by narrowing the shoulders and traffic lanes, with the reversible center roadway maintained. [Out of the alternatives considered] R-8A was found to cause the least negative impacts on existing traffic and cause minimal environmental impacts.*

introduction

In July, 2005, The Washington State Department of Transportation (WSDOT) initiated an analysis to develop information on how the travel operations characteristics of the I-90 Corridor might respond to the conversion of the I-90 center roadway to exclusive use for high capacity transit. The I-90 Center Roadway Corridor Study was conducted by DKS Associates for WSDOT to evaluate the operational impacts to the I-90 roadway under different operating scenarios including the option to convert the reversible center roadway to high capacity transit use. Data generated from the study were used to inform key Department of Transportation decision makers and project stakeholders on the operational benefits of the future transportation investments considered for the corridor.

Two forecast years were selected to evaluate both short term (2015) and long term (2030) impacts of the proposed operating scenarios.

The findings of this study are organized around six (6) key issues and questions:

1. What is the effect of external roadway improvements on demand and volume in the I-90 Corridor?
2. What are the changes in travel time if the center roadway is converted to exclusive HCT use?
3. What are the changes in vehicle throughput if the center roadway is converted to exclusive HCT use?
4. What are the changes in person throughput if the center roadway is converted to exclusive HCT use?
5. What is the impact to Mercer Island surface streets and access?
6. What is the sensitivity of I-90 operations to improvements within the corridor?

Relevant documents to this study include:

- The 1976 Memorandum of Agreement
- The 2004 Amendment to the 1976 Memorandum of Agreement
- The 2005 SEIS on the Regional Transit Long-Range Plan that identified light rail or rail-convertible bus rapid transit as the preferred mode for HCT on I-90
- A motion of the Sound Transit Board of Directors on July 7, 2005
- Sound Transit 2 and Long Range Plan
- Nickel and Transportation Partnership Account project Lists
- The National Environmental Policy Act
- WSDOT Projects, I-90 Two-Way Transit Lanes & HOV

## STUDY OBJECTIVES

A primary objective of the study was to evaluate the operational impacts to the I-90 roadway under different operating scenarios including the option to convert the reversible center roadway to high capacity transit use. This report assesses the operational impact of converting the center roadway on I-90 to High Capacity Transit (HCT) operations. Modeling the interaction of the roadway ramps and interchanges under existing and future roadway volumes and geometric configurations demonstrated

that there are many factors and bottlenecks that influence congestion in the corridor. The roadway operations and interactions are complex and need to be considered as a whole and in the context of the regional benefits gained from implementing HCT and other regional programs and measures considered for the I-90 Corridor.



# CONTEXT



## HISTORICAL CONTEXT

Significant improvements were completed on I-90 between I-5 and I-405 in the late 1980's including the construction of three permanent lanes in the eastbound and westbound directions and a center, reversible lane roadway between the Mt. Baker Tunnel on the west shore of Lake Washington and Mercer Island. Prior to these improvements, I-90 across the lake operated as a four-lane roadway with a reversible lane that provided three lanes in the peak direction of travel. Construction of the 1980's improvements was founded upon a Memorandum of Agreement (MOA) between the Washington State Highway Commission, King County Metro and the cities of Seattle, Mercer Island and Bellevue. The 1976 MOA outlined conditions for the construction of improvements in the I-90 Corridor including the priorities for the use of the center roadway.

In 1998 Sound Transit initiated preliminary engineering and environmental analysis to study two-way transit and HOV operations on I-90 across Lake Washington. This study led to the selection of a preferred alternative (R-8A) which called for the construction of HOV lanes on the outside roadways and the dedication of the center roadway for future high capacity transit operations. To facilitate the construction of R-8A, the parties to the 1976 MOA completed a 2004 Amendment agreeing that alternative R-8A with high capacity transit in the center roadway is the ultimate configuration for the I-90 roadway.

Alternative R-8A will provide HOV lanes on the outer roadways. It will retain the existing reversible operations on the center roadway, with both lanes operating in the same direction; westbound in the AM and eastbound in the PM. Single occupant vehicles (SOVs) will only be allowed to use the center roadway between Rainier Avenue in Seattle and Island Crest Way on Mercer Island. The center and outer roadway HOV lanes will likely operate with a 2+ occupants per vehicle restriction.

## FUNDED REGIONAL IMPROVEMENTS

In 2003 the Washington State Legislature enacted the Nickel funding package to fund transportation improvements throughout the state. The Nickel funding provides \$3.9 billion dollars to fund 158 projects around the state including partial funding for stages 1 and 2 of the I-90 Two-Way Transit and HOV Operations Project. The Nickel package included some funding of improvements on I-405.

In 2005 the Legislature passed a 16-year expenditure plan to fund additional transportation needs throughout the state. The 2005 Package (known as the TPA funds) provided \$7.1 billion for 274 projects. The TPA funds provided additional money for I-90 R-8A and monies towards the construction of HOV lanes on SR-520 and additional lanes and interchange improvements on I-405.

Sound Transit is working with the Regional Transportation Investment District (RTID) on a plan for future investments in the regional transportation system. These potential transit and road improvements are scheduled to be sent before Central Puget Sound voters in November, 2007. The transit piece of the proposed improvements is called Sound Transit 2 (ST2) and will likely include more light rail, commuter rail and express bus services, along with additional transit centers, HOV access lanes and park-and-ride space throughout Central Puget Sound.



## FUTURE CONGESTION ON I-90

The Puget Sound Regional Council (PSRC) states that between 1970 and 1990 population in Central Puget Sound grew 60%, while registered vehicles increased 131% and that the average driver in the Seattle area spends more than twice the time stuck in congestion today as the same trip in 1970.

For the I-90 Corridor, congestion levels are projected to continue to increase in the future leading to a significant increase in travel times for all types of auto-orientated trips. If current trends continue, traffic congestion will increase in intensity and duration.

There is no one factor but multiple factors that influence congestion in the I-90 Corridor. Many of these factors are interrelated and difficult to model.

The flow of traffic across I-90 is influenced by complex factors that impact the operational performance of the roadway. These factors include geography—structures over waterways, elevation changes, tunnels—dense development areas, closely spaced interchanges, and connections to I-5 and I-405, among others. Regional demand modeling and similar modeling has shown that even small increases in traffic volume at key bottlenecks can cause a significant degradation in traffic operations. Also, improving one bottleneck in isolation may exacerbate other bottlenecks in the corridor and may not improve overall performance downstream of the bottleneck.

Increasing vehicle capacity through the corridor is constrained by key bottlenecks at I-405, Bellevue Way and I-5. Other bottlenecks occur at the Island Crest Way and East Mercer on-ramps.

Westbound travel time across the lake on I-90 during the peak periods will increase dramatically over the next 25 years. SOV travel time is projected to double in the westbound direction. Travel time in the eastbound direction will also increase but not as dramatically because congestion at the I-5 interchange restricts or constrains any increase in the volume of eastbound traffic onto the corridor.

## HIGH LEVEL FINDINGS

The 2015 and 2030 PSRC Regional Demand Model forecasts for the I-90 Corridor across the lake indicate that there will be a relatively small increase in peak period vehicle trips but a more significant increase in person trip demand. For purposes of this study, transit service levels were increased to account for some level of transit improvement in response to increased person trip demand. The increase in vehicular trips is constrained by the capacity of the existing roadway and bottlenecks such as the I-405 and I-5 interchange ramps which constrain the flow rate through the corridor.

# ROADWAY CONFIGURATIONS EVALUATED

## ALTERNATIVES

### THE MODEL

The modeled roadway extends from just east of I-405 to just west of I-5 along the I-90 Corridor and includes the mainline and center roadways including the connections into downtown Seattle via the D-2 roadway and 4th Avenue.

For all scenarios, assumptions regarding the completion of some programmed transportation improvements on transportation facilities within the region were the same. For the center roadway, access eligibility and operational rules were assumed to remain the same as present day conditions.

### EXISTING

The roadway currently operates with three mixed-flow lanes in each direction and a two-lane, reversible center roadway that operates in the peak direction. Access to the center roadway is restricted to transit vehicles, HOVs (2+) and vehicles destined to or from Mercer Island.

### NO ACTION

The No Action scenario assumed improvements developed under the R8-A Stage 1, in which the westbound HOV lane is extended to a new HOV ramp constructed at 80th Avenue SE on Mercer Island.

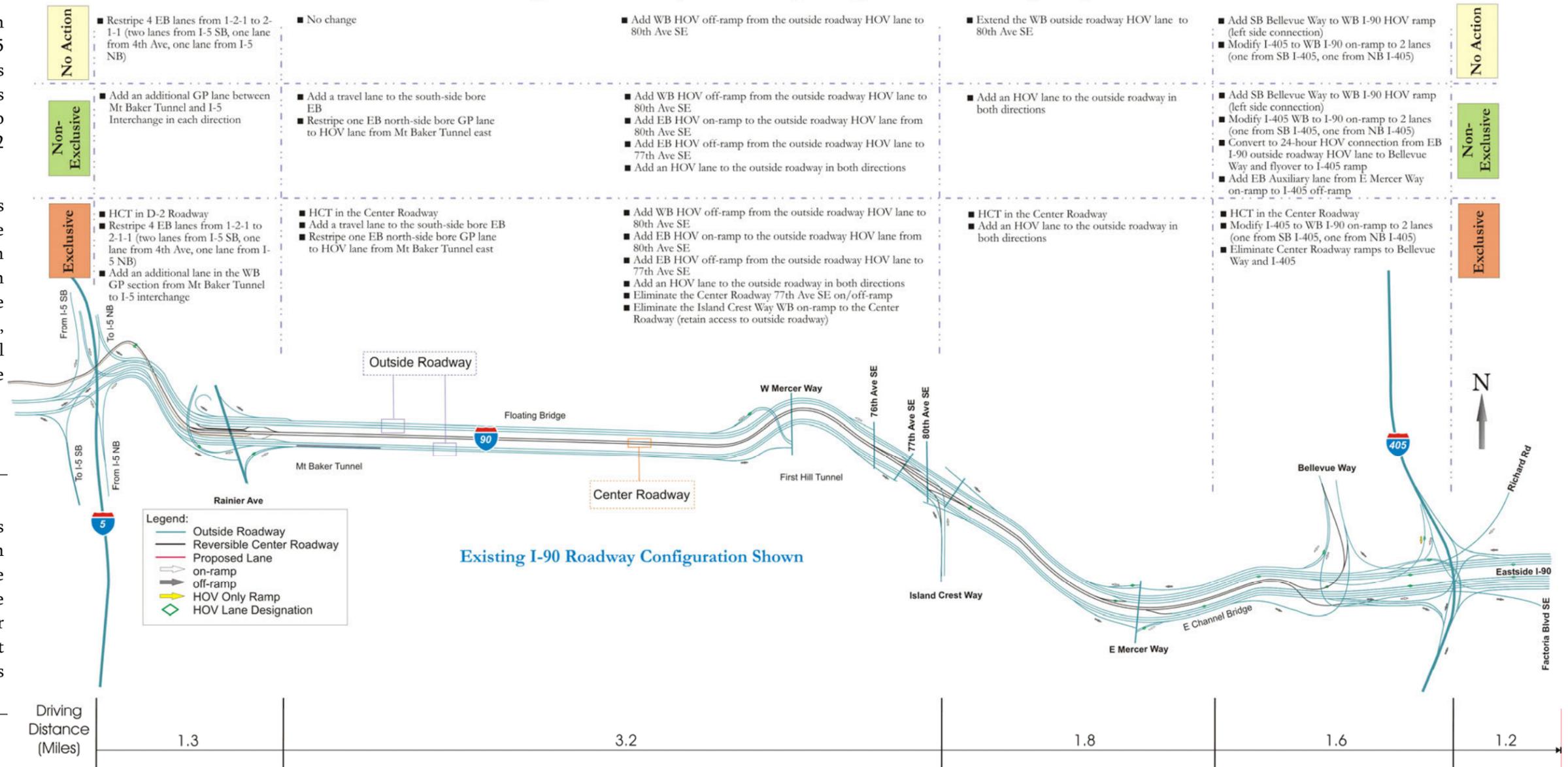
### EXCLUSIVE

The Exclusive scenario assumed that the center roadway would be used exclusively for high capacity transit such as light rail. This included the construction of a single HOV lane on the outside roadway in each direction to replace the loss of the HOV lanes in the center roadway. With Exclusive operations, the outside roadway would operate with three (3) general purpose lanes and one (1) HOV lane in each direction.

### NON EXCLUSIVE

The Non Exclusive scenario assumed the completion of a single HOV lane on the outside roadway in each direction of travel and the continued restrictive use of the center roadway for HOV, transit and Mercer Island residents. Under the Non Exclusive scenario the outside roadway would contain one (1) HOV lane and three (3) general purpose lanes in each direction of travel. The center roadway would contain two reversible travel lanes operating in the peak direction of travel.

Existing & Assumed Proposed Roadway Configurations for Modeling Analysis



## PHYSICAL CONFIGURATION OF THE EXISTING ROADWAY

The existing I-90 roadway operates as a 6-lane freeway (3 lanes in each direction) between I-405 and I-5 with a 2-lane reversible roadway located between the westbound and eastbound lanes from Mercer Island to the Mt. Baker Tunnel. The exit and entry points to the reversible center roadway are located at the west end of the Mt. Baker Tunnel and on the west end of the East Channel Bridge connecting Mercer Island to Bellevue. Although the center roadway is configured for two lanes, the entry and exit points into the center roadway from the mainline general purpose lanes are limited to one lane. East of the center roadway, the eastbound and westbound lanes include an additional HOV lane (3 GP lanes + 1 HOV lane). The HOV lanes on both sides terminate at the entrance and exit points to the center roadway.

The existing configuration of I-90 between I-405 and I-5 includes 11 interchanges, starting from east to west:

- I-405
- Richards Road
- Bellevue Way
- East Mercer Way
- Island Crest Way
- 80th Avenue SE
- 77th Avenue SE
- 76th Avenue SE
- West Mercer Way
- Rainier Avenue
- I-5

The I-5 interchange includes a northbound and southbound collector distributor roadway that is separated from mainline I-5. All I-90 ramps connect to the collector distributor roadway. The westbound to northbound off-ramp is a two-lane ramp that merges with a single collector distributor lane on I-5. The westbound to southbound off-ramp is a single lane ramp that merges with eastbound traffic from SR 519 and the southbound collector distributor roadway. The southbound I-5 to eastbound I-90 on-ramp is a two lane ramp that merges into one lane as soon as it joins mainline I-90. The northbound I-5 to eastbound I-90 on-ramp is a single lane ramp that becomes an add lane once it joins with mainline I-90. Two lanes are provided eastbound from SR 519. The mainline I-90 geometric configuration between I-5 and the Mt. Baker Tunnel includes two 50 mph reverse curves.

The reversible center roadway ends on the west end of the Mt. Baker Tunnel. Between the Mt. Baker Tunnel and I-5, the existing configuration of I-90 is four lanes in each direction. The westbound center roadway lane becomes an add lane to westbound I-90 west of the tunnel and a drop lane for eastbound I-90. The center roadway connects directly to 5th Avenue via the D-2 roadway.



The Mt. Baker Tunnel at the west end of the lake provides four portals: one for westbound traffic, one for the reversible center roadway and two portals for eastbound traffic. Eastbound traffic destined to Mercer Island and/or to the eastside on the outside roadway is split between the north and south tunnel portals. Two narrow lanes with no shoulders carry eastbound traffic through the north portal and one lane with shoulders merges with the Rainier Avenue eastbound on-ramp in the south portal before joining the two lanes in the north portal east of the tunnel. The Rainier Avenue interchange is fully directional.

Fully directional interchanges are located on Mercer Island at East Mercer Way and Island Crest Way. The West Mercer Way, 76th Avenue, 77th Avenue and 80th Avenue interchanges provide connections in only one direction (to and from Seattle or to/from Bellevue). Connections to the center reversible roadway are provided at 77th Avenue (to/from Seattle), 80th Avenue (to/from Bellevue) and

Island Crest Way (to/from Seattle). The Island Crest Way westbound on-ramp provides access to both the center reversible roadway and the outside roadway. The connection to the outside roadway is a left-side on-ramp.

The I-405, Richards Road and Bellevue Way interchanges are spaced very close together. An additional auxiliary lane is provided westbound between Bellevue Way and East Mercer Way to provide additional capacity for weaving and merging movements. The Bellevue Way interchange includes dedicated HOV ramps connecting from the center roadway to Bellevue Way. There is also an eastbound HOV ramp that connects from the center roadway to general purpose northbound and southbound I-405 ramps. A dedicated HOV lane and ramp is also provided from southbound I-405 to westbound I-90. This ramp connects from the southbound general purpose lanes on I-405 to the westbound HOV lane on I-90. There are no direct HOV lane to HOV lane connections between I-405 and I-90.

# CORRIDOR OPERATIONS

The flow of traffic across I-90 is influenced by complex factors that impact performance and travel time. Simulation modeling has shown that even small increases in traffic volume at key bottlenecks can cause a significant degradation in traffic operations. Likewise, improving one bottleneck in isolation may exacerbate other bottlenecks in the corridor and may not result in improved performance downstream of the bottleneck. These factors can also have a disproportionate impact on different modes.

There is no one factor but multiple factors that influence congestion in the I-90 Corridor. Many of these factors are interrelated and difficult to model.

## I-405 CONGESTION

Significant congestion occurs around the I-405 interchange in the westbound direction. Factors that contribute to this congestion include:

1. Closely spaced ramps (ramp concentration): Three high volume ramps enter the I-90 mainline within a very short distance (less than a mile). These include the Richards Road on-ramp, the I-405 northbound and southbound on-ramps and the Bellevue Way on-ramp.
2. High Volumes: There is a great exchange of traffic between I-90 and I-405 and Bellevue Way. This results in a high volume of traffic exiting and entering the freeway over a short distance with limited capacity to handle the demand.

3. Weaving: HOV traffic entering I-90 from a right side ramp must weave across multiple lanes to enter the center roadway or the left side HOV lane.
4. The presence or absence of the left side HOV ramp connections to Bellevue Way and I-405 have impacts to I-90 traffic operations. It is unclear at this stage if these HOV ramps are preservable for Exclusive operations.

Reducing congestion at the I-405 interchange increases westbound traffic flow across the lake. This makes it more difficult for traffic to enter the freeway from Bellevue Way and from the Mercer Island ramps that connect to the outside roadway. Improving the I-405 bottleneck can also increase traffic flow at the west end of the corridor (I-5) causing more backups and longer queuing at the I-5 ramps.



## I-5 CONGESTION

Congestion at the I-5 interchange ramps has a detrimental impact on I-90 operations as traffic queues for the I-5 northbound and southbound ramps spillback onto the I-90 mainline during the AM and PM peak hours. This congestion creates additional delay and operational difficulties that impact both the center roadway and outside roadway traffic operations. Factors that contribute to this congestion include:

1. A high percentage of all westbound traffic from I-90 is destined to I-5 northbound and/or I-5 Southbound (40% of AM peak traffic is destined to I-5 northbound, 20% to I-5 southbound).
2. Traffic destined to the I-5 northbound ramp comes from both the center roadway slip ramp and from the outside roadway mainline.

3. Westbound traffic from the center roadway slip ramp must weave across multiple lanes of traffic from the left side slip ramp to the right side off-ramp to northbound I-5.
4. Westbound traffic on the outside roadway must weave at least one lane to access the southbound I-5 on-ramp. This traffic conflicts with the traffic weaving from the center roadway to the I-5 northbound on-ramp and traffic destined to 4th Avenue.
5. These weaving movements are exacerbated when additional lanes are added to I-90 because of the short weaving distance.
6. The freeway geometry between the Mt. Baker Tunnel and I-5 contributes to the difficulty in making the weaving maneuver. The existing 50 mph reverse curves and grade change between the tunnel

and the I-5 off-ramps make lane changing more difficult and reduces the operational speeds.

7. Eastbound entering traffic is constrained (metered) by congestion on I-5 and the interchange ramp capacities—one lane from northbound I-5, two lanes from southbound I-5—which limits the number of vehicles entering the I-90 corridor.

Increasing westbound traffic flow in the center roadway or on the outside roadway results in higher congestion at the I-5 ramps. As a result, reductions in delay that may be achieved elsewhere may not reduce the total travel time through the corridor if the delay is transferred from the east end and added to the existing delay at the west end (i.e., at the I-5 interchange).

# CORRIDOR OPERATIONS

## USE OF THE CENTER ROADWAY

High volume and demand in the center roadway can have a detrimental impact on traffic operations. This is caused by the weaving that occurs at the exit and entry points into and out of the center roadway. For example, westbound HOV traffic (vehicles and buses) destined to the center roadway from northbound I-405 must weave across multiple lanes to access the center roadway. This weaving or “swim” maneuver can cause significant congestion for the mainline. Likewise HOV and SOV traffic exiting the center roadway west of the Mt. Baker Tunnel can have a significant impact on mainline traffic as a result of the “swim” from the center roadway to the I-5 ramps.



Other factors include the “HOV swim” which occurs when traffic entering the freeway from a right side on-ramp weaves across mainline general purpose lanes to enter the HOV lane on the left side of the freeway. The “swim” also occurs when HOV vehicles in the left side HOV lane weave across the mainline general purpose lanes to exit to a right side off-ramp. Also, when SOVs enter from a left side on-ramp into a left side HOV lane, the SOV vehicles must “swim” through HOV traffic to exit the HOV lane. In the I-90 Corridor there are several “swim” movements that occur. These include:

- Right side on-ramp to left side HOV lane.
- Left side HOV lane to right side off-ramp.
- Right side on-ramp to center roadway entrance ramp (East Channel Bridge).
- Center roadway exit ramp to right side exit ramp (Mt. Baker Tunnel to I-5).

The level and intensity of the HOV “swim” maneuver is influenced by the HOV demand and the number of HOV vehicles that choose to enter the center roadway. When freeway traffic volumes are at acceptable levels, this “swim” maneuver has little impact on traffic operations. However, when traffic volumes on the mainline reach critical and congested levels (i.e., unstable flow) the “swim” maneuver can have a significant detrimental impact on traffic operations. Under these high volume conditions, the operation of an HOV lane on the left hand side of the mainline freeway can have isolated impacts, which may result in a slowing of mainline traffic, even though it increases the lane capacity of the roadway. Under constrained or congested conditions the impact of any “swim” movements is magnified.

## KEY BOTTLENECKS

*(I-405)* The congestion at the I-405 interchange is caused by the high demand and high volume of traffic on the interchange ramps and congestion on the I-405 mainline which spills back onto mainline I-90. When I-405 is congested, this constrains the flow of westbound traffic that is destined to Mercer Island and/or Seattle.



*(I-5)* The congestion at I-5 is caused by high volumes on the ramps and congestion on the collector/distributor roadway that spills back onto mainline I-90.

*(Bellevue Way)* The congestion at Bellevue way is caused by relatively high volumes entering the mainline coupled with the HOV “swim” to the center roadway and outside HOV lane.

*(West End Center Roadway Weave)* Westbound traffic from the center roadway entering the outside roadway west of the Mt. Baker Tunnel weaves across mainline traffic to access the northbound I-5 ramps.

*(Island Crest Way Left Side On-Ramp)* A majority of traffic from Island Crest Way on-ramp enters the center roadway during the AM peak hour. Eliminating the center roadway connection will force this traffic to enter the outside roadway from the left hand side.

*(East Mercer Eastbound On-Ramp)* The high volume East Mercer eastbound on-ramp merge causes backups for eastbound traffic in the morning and evening peak hours.

*(Mt. Baker Tunnel)* The geometric constraints of the Mt. Baker Tunnel constrain traffic capacity and flow rate through the tunnel.



**The operation of an HOV lane on the outside roadway will increase the HOV “swim”:**

Adding the HOV lane to the outside roadway increases the “swim” maneuver from right side on-ramps to the HOV lane and/or from the HOV lane to right side exit ramps. This maneuver can contribute to reduced travel speed for traffic in the general purpose lanes during periods of high volume and congestion.

**There are benefits and disbenefits with each alternative analyzed:**

Eliminating auto traffic in the center roadway has the benefit of eliminating the weaving at the entry and exit points into the center roadway. This improves traffic operations at the west end near I-5 and on the east end at the I-405/Bellevue Way interchanges.

Adding an HOV lane to the outside roadway will increase weaving across the general purpose lanes as HOV vehicles weave from left to right and/or from right to left at exit and entry points in the corridor.

**Some key improvements contribute to a benefit to traffic operations for all alternatives:**

Reconfiguring the eastbound lanes from I-5 to the Mt. Baker Tunnel could improve traffic flow (4 lanes for No Action and Exclusive, 5-lane configuration for Non Exclusive).

Providing an eastbound auxiliary lane from the East Mercer Way on-ramp to the I-405 off-ramp could improve traffic operations for all alternatives.

Maintaining the HOV connections from Bellevue Way and I-405 to the left side HOV lane could improve traffic operations across the East Channel Bridge.



# STUDY METHODOLOGY AND TOOLS

## STUDY METHODOLOGY AND TOOLS

The primary tools used for the analysis were the PSRC regional EMME/2 travel demand model, VISSIM and Synchro. The travel demand model was used to generate future year 2015 and 2030 estimates of travel across I-90 based upon forecasted land use, employment and population trends. The VISSIM micro simulation model was used to analyze the detailed operations of the roadway under different operating scenarios for each forecast year. Synchro was used to analyze and evaluate the impacts of converting the center roadway to HCT operations on Mercer Island surface street access and circulation.

## REGIONAL DEMAND MODEL

PSRC is responsible for the development and maintenance of the regional travel demand model. In late 2005, PSRC completed the development of an updated regional model with enhanced sensitivity to congestion and mode choice. The updated version of the PSRC model was used for this analysis.

Several modifications were made to the raw PSRC model to better reflect the level of future roadway investments and to comply with the study assumptions. These modifications included:

- Enhanced coding of the center roadway between Mercer Island and I-5 to reflect reversible lane operations and use by Mercer Island traffic.
- Enhanced coding of the Rainier Avenue interchange to better reflect existing access.
- Modification of the roadway network to reflect low, medium and high levels of roadway investments.
- Designation of 2+ HOV on I-90.

Modification of the 2030 PSRC land use and employment and population forecasts and assumptions to reflect 2015 conditions was completed by the WSDOT. Both the 2015 and 2030 models assumed a significant increase in bus transit service (95% increase) from current service levels. To better reflect a higher level of transit service in the corridor with HCT, the frequency of the forecasted bus service on the I-90 Corridor was increased (40% increase in bus transit service) for the Exclusive alternative.

Raw model forecasts were post processed in accordance with the National Cooperative Highway Research Program's (NCHRP) 255 procedures to convert 3-hour AM and PM forecasts to peak hour volumes for individual ramps and mainline roadways. An adjustment factor of 40% was used to convert 3-hour general purpose forecasts to 1-hour peak volumes. This factor is consistent with measured volumes from I-90 loop data. For HOV forecasts a higher factor (50%) was used to reflect higher peaking characteristics of the HOV trips. The peak 1-hour vehicular forecasts were then balanced throughout the corridor for SOV and HOV vehicles using a route balancing tool developed by DKS for EMME/2 applications.

Transit forecasts for the I-90 Corridor from the PSRC model were compared with HCT forecasts developed by Sound Transit. The PSRC model transit forecasts were generally equal to or very close to the transit forecasts developed by Sound Transit.

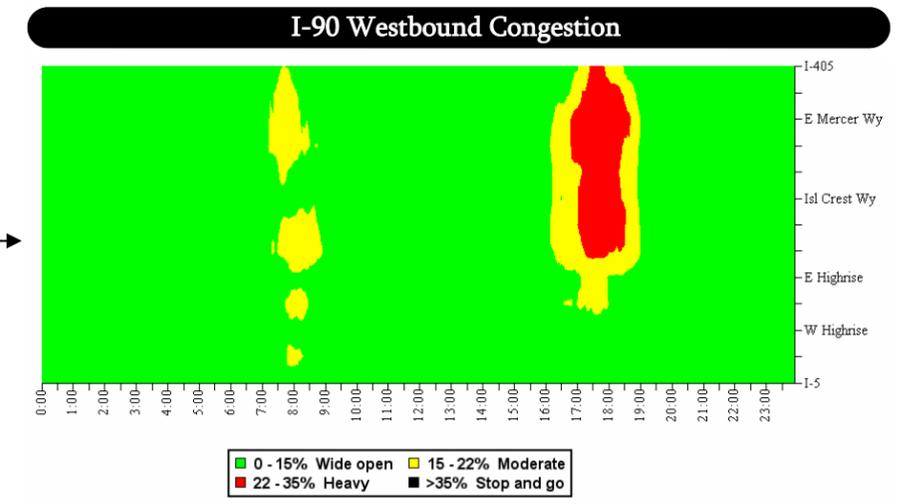
## VISSIM SIMULATION MODEL

VISSIM is a microscopic, time step, and behavior based traffic simulation model that simulates traffic conditions for a wide range of modes including auto, bus, light rail, and pedestrian. The VISSIM model has the capability to evaluate impacts and operating conditions by mode over a wide range of operating conditions.

Calibration of the VISSIM model was accomplished using loop occupancy data, congestion mapping, and travel time data collected in the field for the AM and PM peak hour periods. Sample calibration results are shown on the right. Ramp metering of freeway on-ramps was assumed for existing and future conditions. Several factors were critical in the development and calibration of the VISSIM model. These factors included:

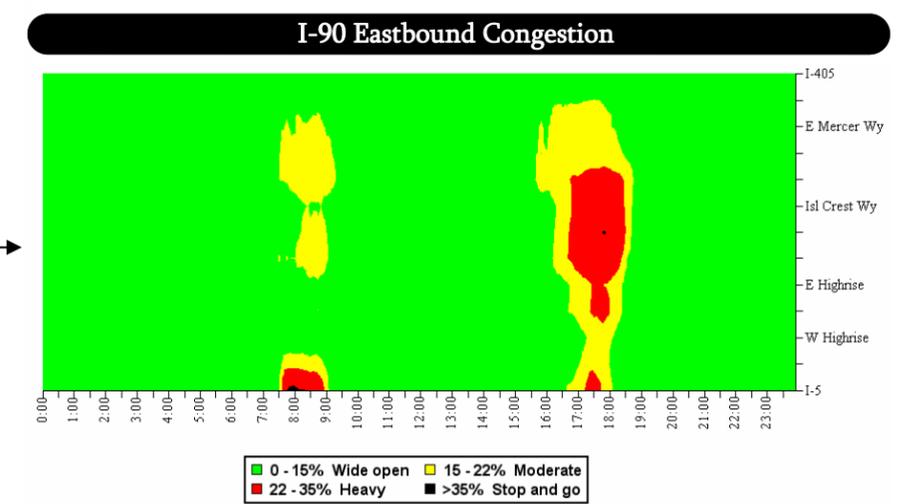
- Roadway Geometric Effects
- End Point Congestion
- Volume Distribution and Assignment
- Data Extraction Points

*continued on next page...*



(Average Tuesday-Thursday, March-May 2005)

These images, termed "brain scans" represent congestion levels on I-90 based on information obtained from WSDOT loops by utilizing the Compact-disk Data-Retrieval (CDR) program and datasets. Similar images were developed as one of the metrics used for calibrating the VISSIM model.



(Average Tuesday-Thursday, March-May 2005)

# STUDY METHODOLOGY AND TOOLS

...continued from previous page.

## ROADWAY GEOMETRICS

Roadway geometrics can have an impact on traffic flow and capacity by affecting vehicle speed and throughput. Great care was taken in the modeling of the I-90 Corridor to capture the unique geometrics of the corridor. Some of these effects included:

- The reverse curve and grade between the Mt. Baker Tunnel and I-5.
- Narrower lanes and shoulders through the Mt. Baker Tunnel.
- Multiple tunnel portals.
- Closely spaced interchanges.
- Changes in grade, lane width and roadway geometry.

The existing geometric features of the corridor were compiled and derived from multiple sources to develop geometric assumptions used in modeling the corridor. These sources included:

- Field reviews of the corridor
- Existing I-90 channelization plans
- Recent aerial photos of the roadway
- Design drawings and documentation

## END POINT CONGESTION

Congestion at the end points of the corridor (I-5 and I-405) can influence vehicle throughput and corridor operations. Under existing conditions congestion occurs on the westbound off-ramp to northbound I-5 in the AM peak hours and on both the northbound and southbound ramps in the PM peak hours. Similar conditions also exist at the I-405 interchange during the peak hours. This congestion at the freeway off-ramps was modeled by restricting the allowable speed on the off-ramp to 12-15 mph at these congestion points. This restriction was consistent with field-observed operating speeds.

## VOLUME DISTRIBUTION AND ASSIGNMENT

A trip distribution and profile was developed for each on- and off-ramp by mode (HOV and SOV). These profiles were developed based upon existing traffic counts and travel patterns and future EMME/2 forecasts from the Regional Model. Volumes by mode were balanced between interchanges and from both ends of the corridor for each alternative. In the eastbound direction, a trial and error process was used to balance volumes and congestion levels through the split eastbound tunnel portals to more accurately reflect the volume distribution that will naturally

occur when motorists choose one portal over another to balance the levels of congestion in the tunnel portals.

To further assist with the calibration of the VISSIM model, extensive video footage of existing AM and PM peak hour conditions were recorded and compared with modeled congestion and VISSIM simulation results.

## DATA EXTRACTION POINTS

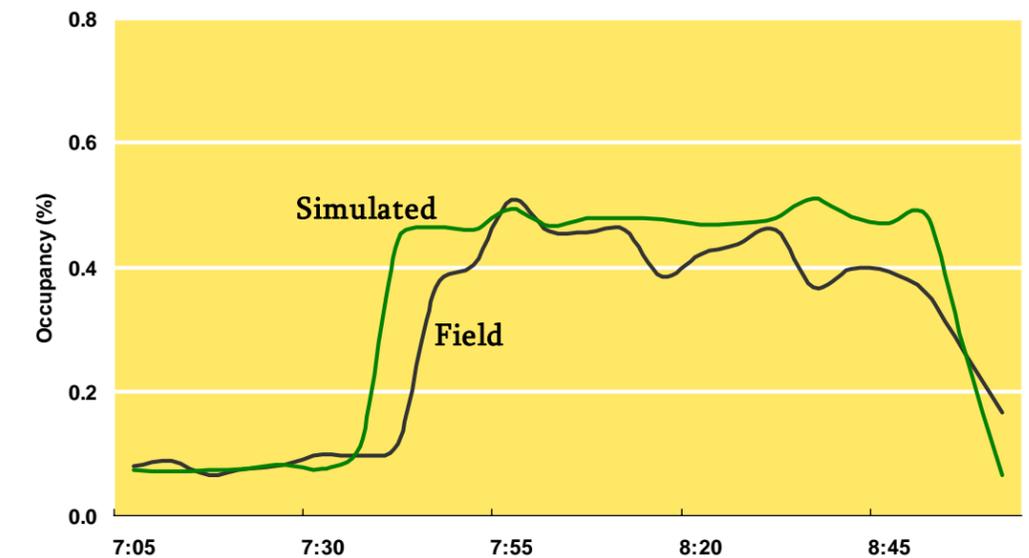
Data extraction points were strategically located throughout the model to facilitate an evaluation of the model results operational characteristics by mode, by lane type and by user type. The corridor was divided into four key segments:

- East of I-405 to the East Channel Bridge
- East Channel Bridge to Island Crest Way
- Island Crest Way to the Mt. Baker Tunnel
- Mt. Baker Tunnel to I-5

Data points were also located on key ramps such as the Bellevue Way, Island Crest Way and 76th Avenue ramps to measure the levels of delay and congestions for users who enter or leave the corridor at these critical locations. Two-hour AM and PM peak volumes were loaded into the VISSIM model for each alternative to evaluate how congestion and delay accumulates over the peak hour by segment and at key ramp entry points. The results from the highest uniform one-hour peak and two-hour peak are reported in the study results.

### I-90 Eastbound Lane Occupancy

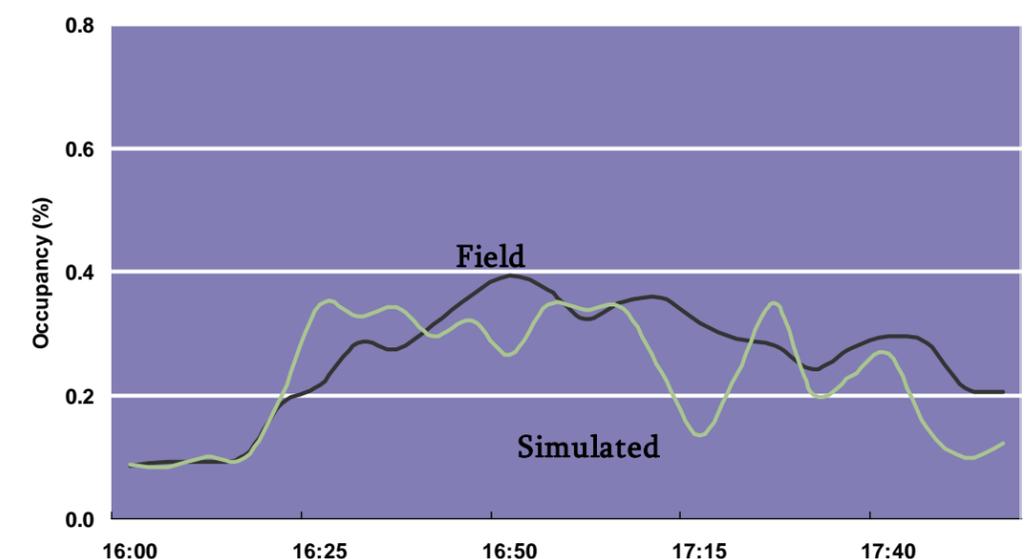
Near Rainier Avenue, Mile 3.41, AM Peak



These images show the results, in terms of lane occupancy rates, for both field and simulated (modeled) conditions — the close proximity of the two lines indicates that the level of calibration for the VISSIM model utilized for this project was very close to field conditions.

### I-90 Eastbound Lane Occupancy

Near Rainier Avenue, Mile 3.41, PM Peak



## SYNCHRO MODEL

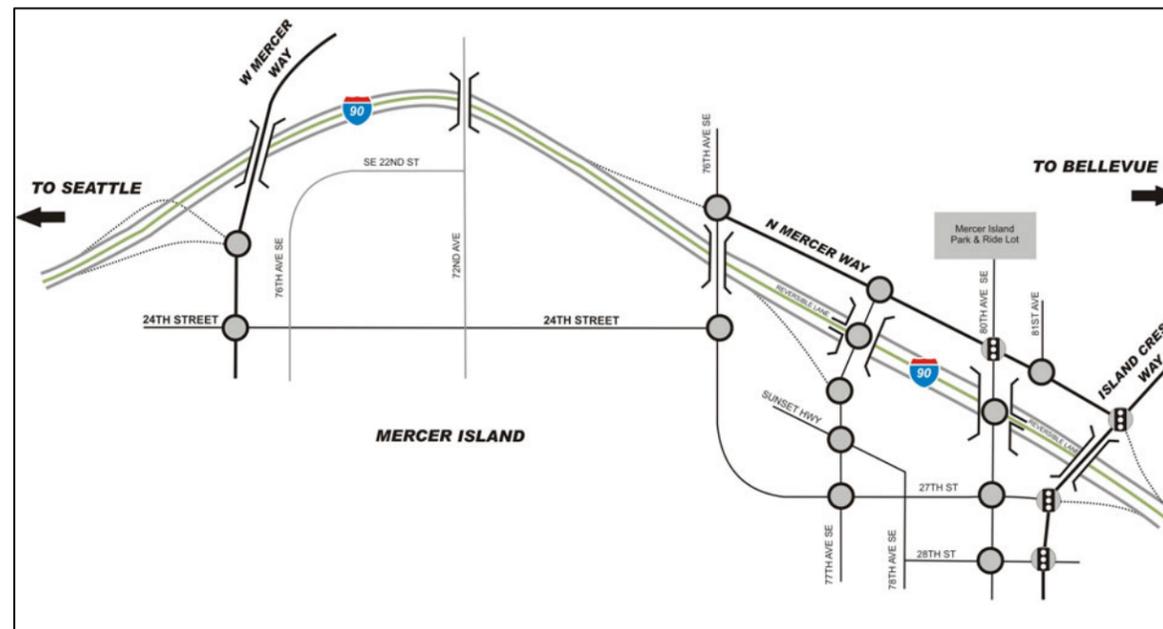
Synchro is a macroscopic simulation tool that evaluates traffic impact based on operating characteristics of the street system. It quantifies the traffic impact to measure congestion in terms of standard measures of effectiveness such as delay, level-of-service (LOS), and queuing. It allows for optimization of signal timing and the ability to test different operating conditions and improvements to find the optimal intersection operational solution. The Synchro model has the capability to evaluate impacts and operating conditions at intersections over a wide range of operating conditions and examine optimized signal timings.

The operating conditions of signalized intersections are evaluated based on volume to capacity (v/c) ratio which is a function of traffic demand flow rate, delay, and LOS. For signalized and unsignalized (all-way stop control) intersections the LOS measurements are based on average delay that is reported for the whole intersection.

The Synchro model was constructed using field collected geometric data and volume-data collected through turning movement counts and from the EMME/2 model. The adjacent image is a graphical representation of the modeled network. This analysis was done to determine whether changes in operation of the center roadway would change travel patterns—shifts in ramp volumes—and how the local street network would be impacted.

Future volumes were developed from the EMME/2 regional model and distributed through the local network. Intersection movements where regional model data was not available received an annualized average growth rate of one-percent to account for background growth.

Assumptions for the Synchro model were as follows: 1) no significant shifts to travel patterns occur on Mercer Island and growth is evenly distributed based upon regional demand model outputs; 2) no change to vehicle mode composition unique to the region; and, 3) deficient intersection operation would be improved to achieve Mercer Island level-of-service standards.



## FUTURE ROADWAY INVESTMENT LEVELS

Three levels of future roadway investment were considered in the study.

*(Low Level Investment)*— This level of investment assumed completion of the Nickel funded transportation improvements. A key assumption in the Low Level Investment is that SR-520 will remain a 4-lane freeway with no additional HOV lanes.

*(Medium Level Investment)* — This level of investment assumed the completion of Nickel and TPA funded projects along with a modest unfunded package. Key assumptions include: the completion of a 6-lane freeway on SR-520 with two general purpose lanes and one HOV lane in each direction, and the completion of additional lanes and interchange improvements on I-405.

*(High Level Investment)* — This level of investment assumed the completion of Nickel and TPA funded projects plus additional unfunded investments on I-405 and I-90. This would include additional lanes on I-405 north of I-90 and additional lanes on I-90 east of I-405.

Regional PSRC model forecasts were developed for all three investment levels. Detailed VISSIM modeling and analysis was conducted for the Medium investment scenario. A limited low investment VISSIM model was built for the No Action and Exclusive alternatives to compare westbound travel times and performance with varying levels of roadway investment.



# EXISTING AND FUTURE TRAVEL PATTERNS

## EXISTING GENERAL TRAVEL PATTERNS

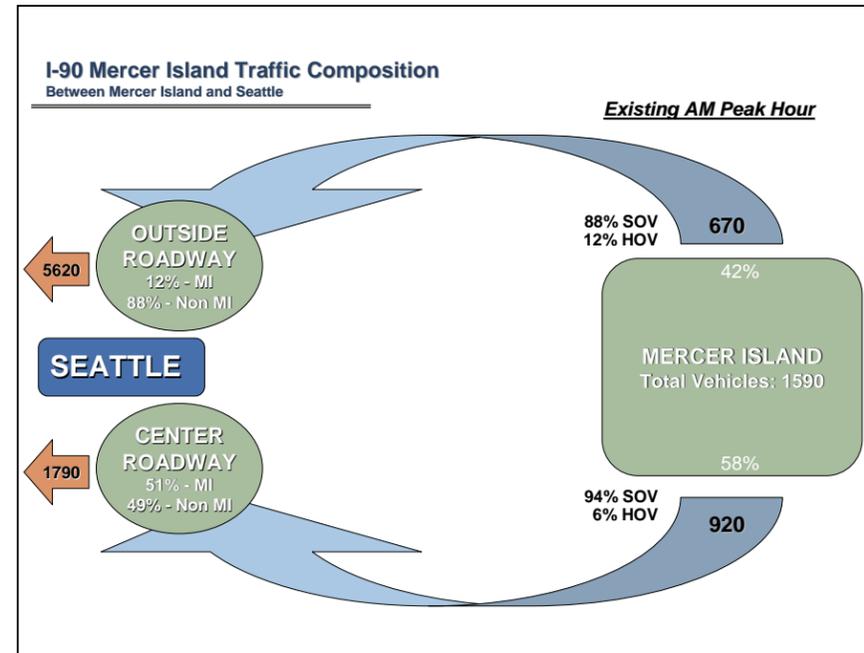
The I-90 roadway operates with three mixed-flow lanes in each direction and a two-lane, reversible center roadway. This center roadway operates westbound in the morning and eastbound in the evening. Access to the center roadway is restricted to transit vehicles, HOVs (2+) and vehicles destined to or from Mercer Island. During the average weekday the I-90 roadway carries approximately 133,000 vehicles per day, not including reversible traffic.

At the I-5 interchange, about twice as many vehicles are destined to northbound I-5 compared to southbound I-5. Volume entering the corridor from I-5 southbound is slightly greater than the volume entering I-90 from I-5 northbound. Thus, a greater proportion of traffic using the I-90 Corridor has a destination or origin that is north of the corridor.

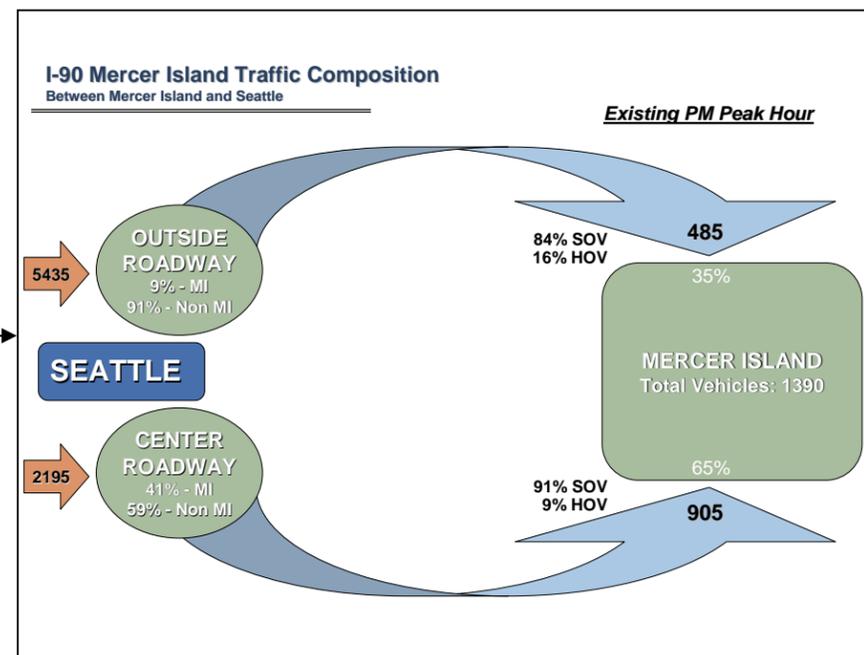
The Rainier Avenue interchange attracts significant volumes that are slightly less than the I-5 southbound ramp in the morning but slightly more in the evening. The Rainier Avenue interchange experiences the highest volumes of the non-freeway interchange ramps west of I-405. The Island Crest Way Interchange is a close second. Use of the Rainier Avenue interchange is significantly lower in the morning peak and slightly lower than I-5 northbound in the evening peak. The high volume of traffic using the Rainier Avenue interchange is associated with the medical (hospitals) and other employment centers near or around Capitol Hill and Beacon Hill in Seattle. Access to Rainier Avenue from the center roadway is not possible.

The Island Crest Way on-ramp is configured so that traffic entering from Mercer Island can choose to travel to Seattle on the outside roadway or the center roadway. Based upon existing count data, approximately fifty-eight percent (58%) of Mercer Island traffic chooses to enter the center roadway (see adjacent diagrams). In the evening peak period about 41% of the center roadway volume is Mercer Island traffic. Vehicle occupancy counts collected in 2005 at central Mercer Island ramps show that the HOV vehicles have an almost even distribution between the mainline and the center roadway.

Bellevue Way is a significant and important destination for eastbound and westbound trips in the morning. The South Bellevue Park-n-Ride is located on Bellevue Way near the interchange and provides a major hub



These diagrams exhibit the composition of traffic relating to Mercer Island and other trips for the outside (mainline) and center roadway's.

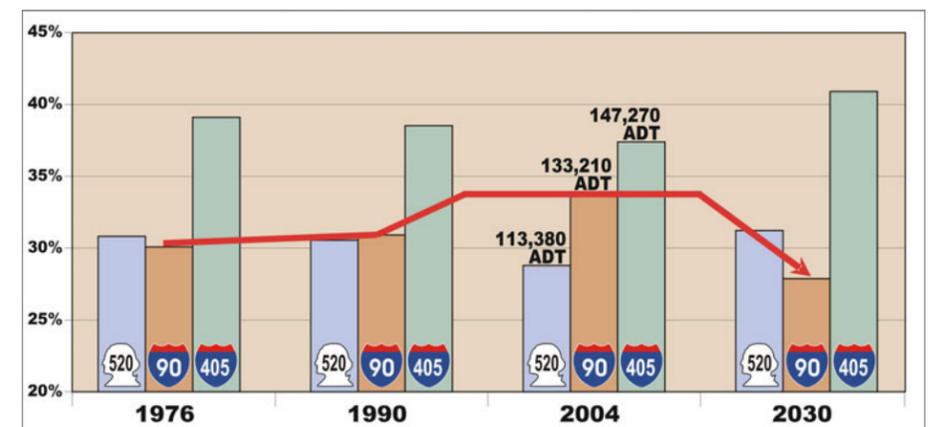


and transfer for eastside transit and carpools destined to downtown Seattle. East Mercer Way is the first eastbound exit on Mercer Island and experiences significant demand during the evening peak hour.

At the I-405 interchange during the peak periods in the westbound direction, slightly more traffic exits I-90 onto I-405 than enters. For mainline westbound, the total combined exiting volumes are greater than the entering volumes at the I-405 interchange and Bellevue Way. Trips entering from I-405 heading westbound on I-90 are higher from south of the corridor in the morning but lower than the evening. Exiting traffic to I-405 is about the same in the morning and evening with three-fifths (3/5) of the traffic traveling northbound.

## PERCENT OF TOTAL TRIPS CARRIED BY I-90

The graph below represents the total number of east-west trips that make use of the SR-520, I-90, and I-405 corridors, represented by the percent of total volume for each corridor. The trend-line demonstrates that for the last couple of decades, I-90's significance for carrying traffic has been increasing; however, I-405 is carrying a larger percentage of the total traffic. As shown below, referring to historical volumes, SR-520 attracted a greater number of trips than I-90 in 1976 and the change in volume distribution is likely attributed to the increased levels of congestion experienced today by SR-520. In the year 2030, the regional model, with the medium investment and no-action alternative, predicts a shift in the distribution of volume in these corridors with the percent of total trips for both SR-520 and I-405 increasing while the percent of total for I-90 drops sharply.



existing and future travel patterns

# EXISTING AND FUTURE TRAVEL PATTERNS

## TRAVEL BEHAVIOR AND PATTERNS

Travel behavior and patterns reflect the choices, preferences, and value systems of a region's citizens. Generally, the built-up areas along the I-90 Corridor are characterized by auto-orientated business districts and neighborhoods with single-family residential and low density development.

As one of the key transportation links across Lake Washington, the I-90 Corridor serves a diverse market of transportation users and service providers. During commute hours, the corridor is heavily congested from commuters crossing the lake in both directions to jobs and employment centers in Seattle and the eastside. The primary peak flow direction is toward Seattle in the morning peak and toward the east side in the evening peak. The peak directional volumes are split approximately 55/45 in the peak hours.

The I-90 Corridor serves a key role in connecting freight movement in Puget Sound to the east (Yakima, Ellensburg, Wenatchee) and west (Seattle, Mercer Island, Bellevue) and beyond. Although the percentage of total daily trips that freight comprises is not as great as general purpose trips, freight destined to eastern Washington and beyond is largely restricted to this corridor. Thus, the operation of the I-90 corridor is vital to the efficient movement of freight and the local economy.

## THE I-90 TRAVELSHED

A travelshed analysis was conducted to identify the forecasted travel behaviors and travel patterns in the I-90 Corridor. A travelshed is comprised of all the traffic that makes use of the facility for its origin and destination trips. In actuality the travelshed for some vehicles using this corridor extends beyond the reach of the State of Washington's borders due to the national significance of the I-90 Corridor. Since these boundaries are unrealistic for analytical purposes and this volume of traffic composing such a factor does not comprise a significant number of peak-hour vehicles making use of the facility, a percentage of the total users was devised to capture a more localized travelshed.

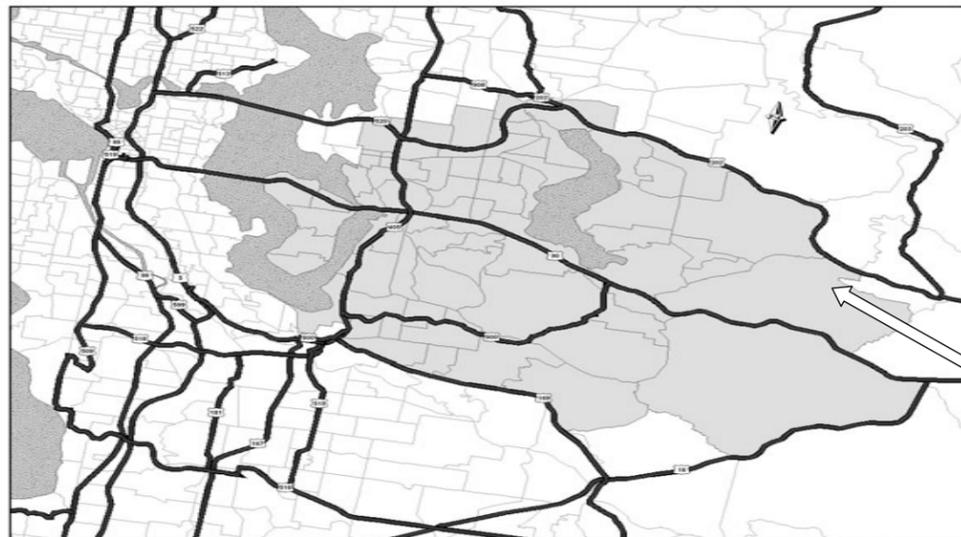
To further stratify and examine the nature of travel patterns and demand in

the corridor the westbound AM travelshed was determined to likely provide the greatest insight into the operations and characteristics of the I-90 roadway as it would demonstrate the most noticeable effects of growth in the corridor and the potential use of the center roadway. It was also selected due to the close proximity of the areas served by I-90 and SR-520 and would capture the results of the sensitivity of the corridor to regional improvements.

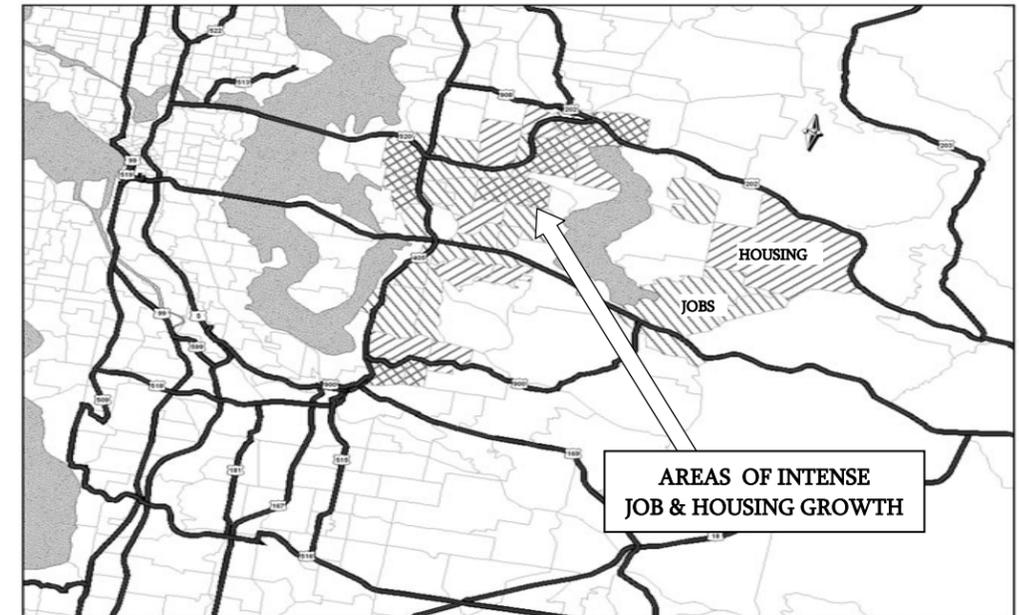
The westbound AM travelshed was defined by determining the zones from the PSRC regional model that would contribute eighty-five percent (85%) of all traffic that would cross the floating bridge in the year 2030. These zones were selected based on their proximity to the corridor and their trip density.

In present terms, this travelshed has an estimated 118,000 households or a population of roughly 295,000 people and a job base of about 250,000. This population is projected to grow to 156,000 households (375,000 people) and the job base to 390,000 by the year 2030. Areas with comparatively intense job and housing growth were identified to determine the zones with the highest demand needs for serving both origin and destination trips and also for zones which may show a relatively increased degree of internalization.

These factors translate to trips and today in the travelshed about fifty-six percent (56%) of all trips are "commute to work." By 2030 this will change to sixty-three percent (63%) "commute to work." Additionally, there will be an increased internalization of work trips, changing from 45% today to 49% in 2030. The regional model predicts that the percentage of travelshed commute trips using I-90 will change from 35% of trips today to 27% of trips in 2030.



Shaded area represents 85% of the traffic that will cross the I-90 floating bridge in the morning traveling westbound to Seattle



## HIGH LEVEL FINDINGS

Westbound travel time across the lake on I-90 during the peak periods will increase dramatically over the next 25 years. SOV travel time will double in the westbound direction. Travel time in the eastbound direction will also increase but not as dramatically because congestion at the I-5 interchange restricts or constrains any increase in the volume of eastbound traffic onto the corridor.



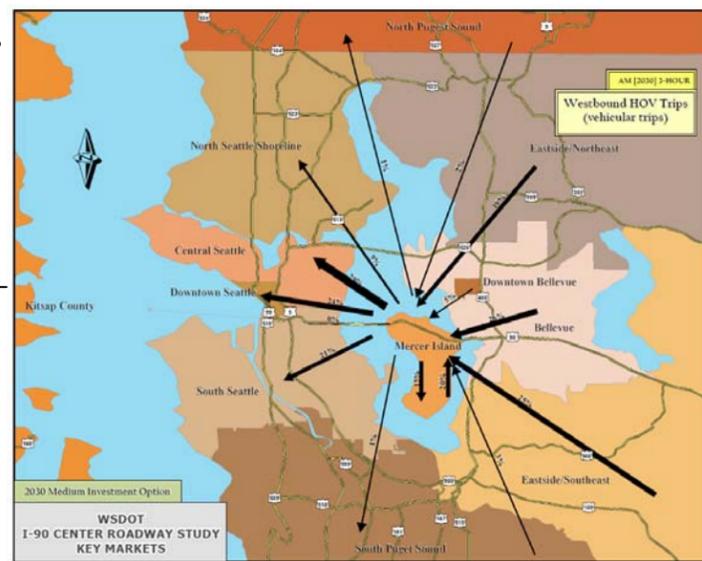
# EXISTING AND FUTURE TRAVEL PATTERNS

Traffic distribution profiles were developed for the East Channel Bridge (connecting Mercer Island to the east) and the I-90 Floating Bridge (connecting Mercer Island to the west) to provide insight into how vehicular traffic is predicted to use the I-90 roadway corridor across Mercer Island. The graphics found on this page indicate the proportion of users for both eastbound and westbound morning and evening peak periods based upon land use and employment projections provided by respective jurisdictions to PSRC for inclusion in the regional model.

Traffic flow maps accumulate to one-hundred percent (100%) of the total vehicular trips at each bridge for in-flowing and out-flowing traffic depending on direction of travel. Those percentages entering and exiting Mercer Island represent the percentage of the total volume on the I-90 roadway.

## FORECASTED (2030) FLOWS IN THE AM PEAK

Westbound morning peak hour traffic east of I-405 comprises about fifty percent (50%) of total traffic using the East Channel Bridge with eight percent (8%) originating from east of Issaquah. In the eastbound direction, only two percent (2%) of the total traffic is destined for east of Issaquah.



The Relatively low percentages east of Issaquah indicate that the majority of peak hour trips are occurring within a relatively close proximity to the East Channel Bridge and are not generated outside the region.

Mercer Island in the westbound AM peak direction has an almost equal exchange of eighteen percent (18%) exiting and twenty-one percent (21%) entering traffic. Importantly, the regional model assumes that almost a fifth (1/5) of the East Channel Bridge traffic is destined for Mercer Island in the AM peak. In the eastbound direction, the exchange of traffic at Mercer Island is not as equal with nineteen percent (19%) exiting and twenty-seven percent (27%) entering the roadway.

Another way of classifying the travelshed was by examining the percent of total trips by mode that was traveling west through Mercer Island. These trips could be stratified by mode choice, such that a projected number of SOVs and HOVs could be reported based on their own total. This analysis showed that about thirty-two percent (32%) of SOVs are forecasted to use I-90 via I-405 and come from areas southeast of I-90, whereas thirty-five percent (35%) of SOV traffic on I-90 is forecasted to come from the City of Bellevue and sixteen percent (16%) from Mercer Island.

The composition of HOV trips is slightly different in that twenty-eight percent (28%) are forecasted to arrive from areas south and east of I-90, thirty-one percent (31%) from the City of Bellevue, and twenty percent (20%) from Mercer Island.

Differences in percent of total composition are more evident with morning destined traffic as shown by this analysis. Regarding SOVs, about thirty-nine percent (39%) are destined to downtown and central Seattle and thirty-four percent (34%) to west and south Seattle.

HOVs trips show about fifty-three percent (53%) destined to downtown and central Seattle and twenty-one percent (21%) to west and south Seattle.

## FORECASTED (2030) FLOWS IN THE PM PEAK

Westbound evening peak hour traffic east of I-405 is forecasted to comprise about forty percent (40%) of total traffic using the East Channel Bridge with three percent (3%) originating from east of Issaquah. In the eastbound direction, eight percent (8%) of the total traffic is destined for east of Issaquah. These relatively low percentages east of Issaquah indicate similar conditions to morning flows.

Mercer Island in the westbound direction has a close exchange of twenty-seven percent (27%) exiting and twenty-two percent (22%) entering traffic. Again, it demonstrates that almost a fifth (1/5) of the East Channel Bridge traffic is destined for Mercer Island and that Mercer Island does not add a significant increase to the overall roadway's total peak hour traffic volumes. In the eastbound direction, the exchange of traffic at Mercer Island is the same with twenty-two percent (22%) exiting and entering the roadway.



Downtown and Central Seattle are major trip origin and destination locations for I-90 users. Because of the almost equal exchange of traffic destined to and from Mercer Island, the total volume of traffic on I-90 across the Lake Washington bridges does not change significantly. Mode choice distribution shows that fifty-three percent (53%) of future (2030) westbound HOVs are destined to downtown and central Seattle in the morning.

existing and future travel patterns

# MODELING RESULTS

This section describes the relative benefits and impacts to traffic volume and demand in the I-90 Corridor that would result from different levels of roadway investment in the regional and cross-lake transportation system. This analysis is based upon the comparison of raw EMME/2 travel demand forecasts from the PSRC regional travel demand model. The three levels of roadway investment are described in *Study Methodology and Tools (part 3)* and include the following:

*(Low Level Investment)* — This scenario does not include major investments on I-405 and does not include any investment on SR-520.

*(Medium Level Investment)* — This scenario includes a new 6-lane SR-520 (2 general purpose and 1 HOV lane in each direction) and moderate investments on I-405 (additional lanes and interchange improvements).

*(High Level Investment)* — This scenario includes a 6-lane SR-520, a high level of investment on I-405 (additional lanes on I-405 north of I-90) and additional lanes on I-90 east of I-405.

The raw PSRC regional model travel forecasts across Lake Washington on SR-520 and I-90 for the different levels of roadway investment are summarized in the adjacent table (depicts 2015/2030 Cross Lake Travel Demand for Forecasted 3-Hour Peak Period) for the AM and PM 3-hour peak volumes.

The purpose of this comparison was to assess the sensitivity of I-90 volumes to the Low, Medium, and High Investment strategies using the No Action configuration as a baseline. (Note: Raw model forecasts have not been adjusted to account for variances and/or discrepancies in the model calibration in accordance with NCHRP 255).

A *relative scale* comparison is shown above of raw EMME/2 travel demand forecasts from the PSRC regional travel demand model—the above volumes show the relative differences between alternatives and should not be construed as actual forecasts for the corridors—once this comparison was completed, raw volumes were post-processed and entered into the VISSIM model.

## SR-520 IMPROVEMENTS

The relative differences in cross-lake travel demand and behavior demonstrate the impact to I-90 if the SR-520 improvements are not built. Significant findings include:

- The low investment scenario resulted in higher volumes of traffic on I-90.
- A decrease in vehicle trips is forecasted in the I-90 Corridor with construction of SR-520 improvements.
- The highest demand for HOV trips across the lake occurs in the PM peak hour period.

- A significant increase in HOV trips is forecasted in the I-90 Corridor if the SR-520 HOV lane improvements are not built. Also, a significant increase in HOV trips is forecasted in the SR-520 Corridor with the construction of HOV lanes.

## I-405 IMPROVEMENTS

Roadway improvements on I-405 would divert some trips from the I-5 Corridor which would also use I-90. Thus, some diversion in demand for the I-90 Corridor would be expected from additional lanes on I-405. Comparing forecasted vehicular trips from the PSRC regional travel demand model for northbound I-5 to eastbound I-90 showed a significant decrease in vehicle trips and demand for this movement with the construction of the TPA funded projects on I-405. Some of the significant findings from the analysis and comparison of low, medium and high levels of investment are summarized below:

- A reduction in vehicular volume and trips from northbound I-5 to eastbound I-90 would result from the construction of improvements on I-405 in the medium level of investment.
- A high level of roadway investment on I-405 beyond the TPA funded projects did not reduce vehicle trips in the I-90 Corridor.
- The difference between volumes between 2015 and 2030 is not great, neither is it between Low and Medium Investment conditions.
- The addition of extra lanes on I-90 east of I-405 did not reduce vehicle trips in the I-90 Corridor.
- The greatest reduction in volume in the I-90 Corridor is forecasted to occur with the completion of the Nickel and TPA funded projects.

Investment Levels-	2015 - AM Peak			2030 - AM Peak			2015 - PM Peak			2030 - PM Peak			
	Low	Med	High										
<b>SR 520</b>													
Westbound	SOV	10,293	10,659	10,765	10,336	10,719	10,831	11,002	11,511	11,434	12,002	12,529	12,466
	HOV	814	1,797	1,805	810	1,802	1,813	1,658	3,183	3,208	1,664	3,707	3,743
	TRUCK	387	508	495	435	565	548	462	493	495	537	533	540
	<b>Total</b>	<b>11,495</b>	<b>12,964</b>	<b>13,064</b>	<b>11,581</b>	<b>13,086</b>	<b>13,192</b>	<b>13,122</b>	<b>15,187</b>	<b>15,137</b>	<b>14,203</b>	<b>16,769</b>	<b>16,749</b>
Eastbound	SOV	8,985	9,280	9,250	9,630	10,120	10,118	11,438	12,440	12,473	11,087	12,435	12,532
	HOV	712	1,127	1,133	744	1,304	1,315	929	3,227	3,185	945	3,131	3,195
	TRUCK	485	552	555	550	609	609	432	434	436	562	531	526
	<b>Total</b>	<b>10,181</b>	<b>10,959</b>	<b>10,938</b>	<b>10,924</b>	<b>12,032</b>	<b>12,042</b>	<b>12,799</b>	<b>16,101</b>	<b>16,094</b>	<b>12,594</b>	<b>16,097</b>	<b>16,253</b>
<b>I-90 - West of Mercer Island</b>													
Westbound	SOV	16,453	16,510	16,503	16,465	16,634	16,586	15,300	14,194	14,139	16,744	15,841	15,868
	HOV	2,223	1,645	1,606	2,217	1,607	1,575	2,337	1,726	1,714	2,274	1,418	1,409
	TRUCK	1,071	941	958	1,215	1,048	1,074	1,076	1,057	1,061	1,155	1,164	1,164
	<b>Total</b>	<b>19,747</b>	<b>19,096</b>	<b>19,067</b>	<b>19,897</b>	<b>19,289</b>	<b>19,234</b>	<b>18,713</b>	<b>16,977</b>	<b>16,914</b>	<b>20,174</b>	<b>18,423</b>	<b>18,441</b>
Eastbound	SOV	11,374	10,967	10,944	12,982	12,562	12,600	19,824	20,429	20,584	19,414	20,339	20,570
	HOV	879	671	670	955	698	697	4,314	3,244	3,266	4,039	3,305	3,239
	TRUCK	1,120	1,005	1,001	1,159	1,081	1,069	914	831	830	1,053	966	974
	<b>Total</b>	<b>13,372</b>	<b>12,643</b>	<b>12,615</b>	<b>15,097</b>	<b>14,341</b>	<b>14,365</b>	<b>25,052</b>	<b>24,504</b>	<b>24,680</b>	<b>24,506</b>	<b>24,611</b>	<b>24,784</b>
<b>I-90 - East of Mercer Island</b>													
Westbound	SOV	15,715	16,019	16,092	15,834	16,193	16,237	16,020	15,188	15,188	17,417	16,733	16,828
	HOV	2,103	1,511	1,479	2,114	1,503	1,475	2,732	2,067	2,069	2,687	1,786	1,794
	TRUCK	1,050	939	957	1,190	1,043	1,069	1,046	1,044	1,048	1,126	1,152	1,151
	<b>Total</b>	<b>18,867</b>	<b>18,469</b>	<b>18,528</b>	<b>19,137</b>	<b>18,738</b>	<b>18,781</b>	<b>19,798</b>	<b>18,299</b>	<b>18,305</b>	<b>21,229</b>	<b>19,672</b>	<b>19,774</b>
Eastbound	SOV	12,348	12,183	12,244	13,874	13,643	13,773	19,033	19,847	20,067	18,933	19,983	20,284
	HOV	1,298	1,074	1,080	1,357	1,093	1,095	4,428	3,288	3,326	4,228	3,428	3,377
	TRUCK	1,099	1,003	999	1,134	1,076	1,064	884	817	816	1,022	955	961
	<b>Total</b>	<b>14,745</b>	<b>14,259</b>	<b>14,324</b>	<b>16,365</b>	<b>15,812</b>	<b>15,932</b>	<b>24,345</b>	<b>23,952</b>	<b>24,209</b>	<b>24,184</b>	<b>24,366</b>	<b>24,623</b>
Cross-Lake	WB	31,242	32,060	32,132	31,478	32,374	32,427	31,835	32,164	32,051	34,376	35,192	35,190
Total Volume	EB	23,553	23,602	23,552	26,021	26,374	26,407	37,851	40,605	40,773	37,100	40,707	41,037

Generally, The difference between 2015 and 2030 forecasts is not great, nor is there much difference in the number of forecasted SOV vehicles on I-90 in the Low and Medium Investment scenarios. The greatest growth in vehicular volume is forecasted to occur prior to 2015.

# MODELING RESULTS

## TRAVEL TIME

Travel time represents the total time to travel between two fixed points in the corridor including any stopped delay from ramp metering or roadway congestion. To isolate and analyze congestion points and travel time differences, the travel time through the I-90 Corridor was divided into four segments (2030 peak 1-hour travel time results shown to the right and on the next page represent popular trips that are derived from summing travel times under medium investment conditions from the sections described following and their respective ramps):

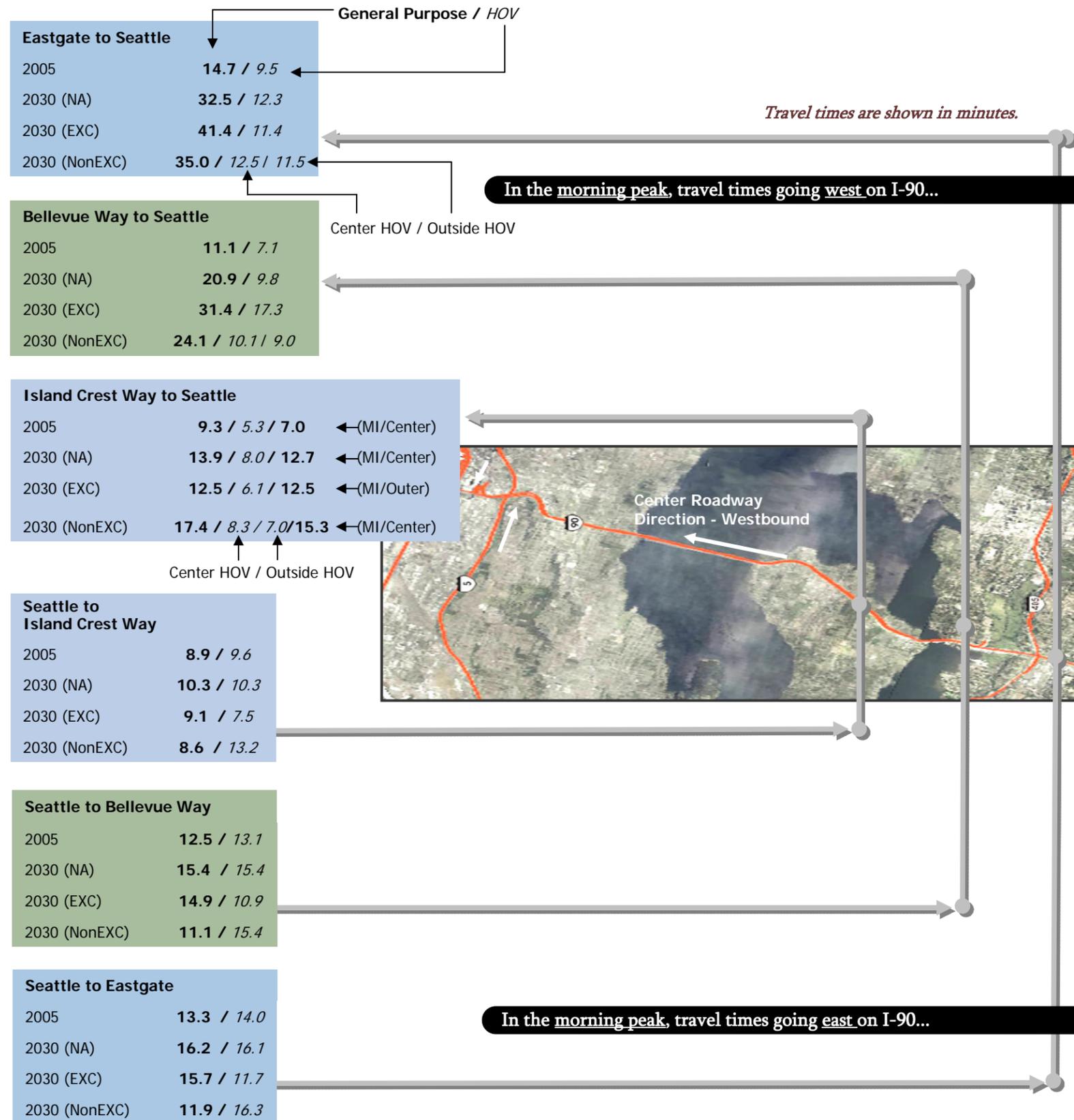
- *East of I-405 to the East Channel Bridge.* This section captures the delay and travel time for vehicles entering the corridor from the east (i.e., Issaquah) and from Bellevue Way and I-405. This section captures the delays and congestion caused by the high volumes of traffic that enter and exit I-90 in the I-405 interchange area.
- *East Channel Bridge to Island Crest Way.* This section captures the delay around the east exit and entry points into and out of the reversible center roadway and the congestion caused by the high volume of traffic that enters and exits I-90 at East Mercer Way and Island Crest Way.
- *Island Crest Way to the Mt. Baker Tunnel.* This section captures the delay caused by traffic entering westbound I-90 from Island Crest Way, delays caused by traffic entering or exiting Mercer Island west of Island Crest Way and delay caused by weaving and/or merging at the west exit and entry points to the reversible center roadway.
- *Mt. Baker Tunnel to I-5.* This section captures the delay caused by vehicles swimming from the center roadway to exit northbound I-5, delay at the I-5 ramps and eastbound delay for vehicles entering into the Mt. Baker Tunnel.

The VISSIM simulation model developed for the I-90 Corridor provided travel time data by mode and by lane type (general purpose lanes, HOV lane and center roadway). Travel time profiles for auto and HOV vehicles were developed for existing, No Action, Exclusive and Non Exclusive operations within the corridor. To evaluate the accumulation of delay over the peak hour period, 2-hour peak period volumes were loaded into VISSIM. 1-hour travel times by popular commutes are reported to the right with 2-hour travel times following later.

### 2030 PEAK 1-HOUR TRAVEL TIME RESULTS

The 1-hour 2030 peak travel time represents the travel time measured during the highest levels of congestion during the 2-hour peak period modeled in VISSIM.

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# MODELING RESULTS

## TRAVEL TIME

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The 1-hour peak travel time is reported for four different destinations to demonstrate the differences in travel time that occur between alternatives for different users of the roadway. The four user groups include:

- **Island Crest Way to Seattle:** This group represents users of I-90 who enter the corridor from Island Crest Way and are destined to downtown Seattle in the westbound direction and users who enter the I-90 Corridor from downtown Seattle and exit onto Island Crest Way in the eastbound direction.
- **Bellevue Way to Island Crest Way:** This group represents users of I-90 who enter the corridor from Bellevue Way and exit to Island Crest Way in the westbound direction. In the Eastbound direction it is assumed that these users enter at Island Crest Way and exit at Bellevue Way.
- **Bellevue Way to Seattle:** This group represents users of I-90 who enter the corridor from Bellevue Way and are destined to downtown Seattle in the westbound direction and users who enter the I-90 Corridor from downtown Seattle and exit onto Bellevue Way in the eastbound direction.
- **Eastgate to Seattle:** This group represents users of I-90 who enter the corridor from areas east of I-405 (Eastgate, Issaquah) and are destined to downtown Seattle in the westbound direction and users who enter the I-90 Corridor from downtown Seattle and continue east of I-405.

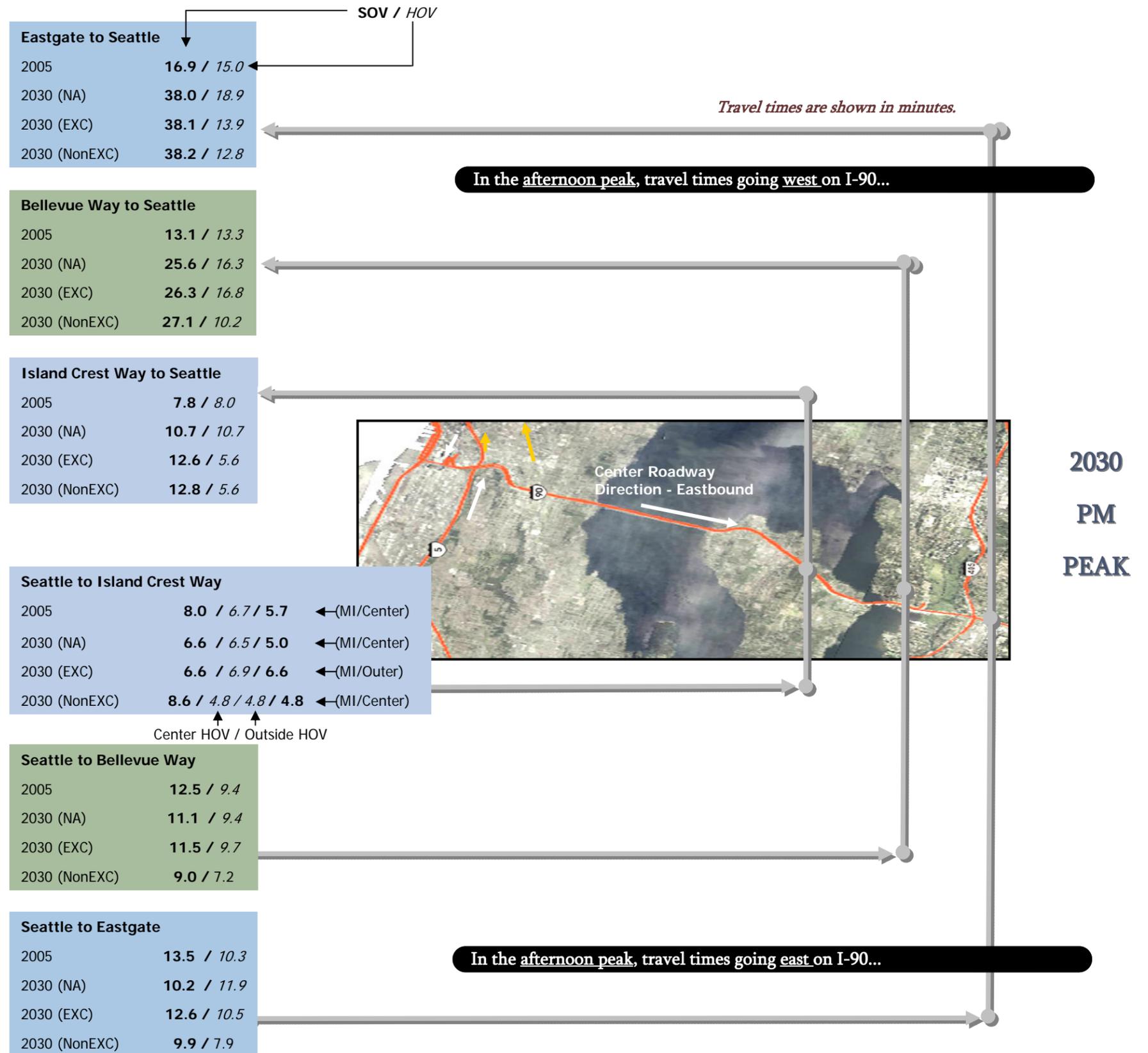
Travel times to downtown Seattle for SOV traffic was compared for all alternatives (for SOV traffic) using the northbound I-5 on-ramp to I-5 as the end point. For the existing, No Action and Non Exclusive alternatives, the HOV travel time to downtown Seattle was measured assuming HOV vehicles will use the D-2 roadway to 5th Avenue. For comparison to the Exclusive Alternative, HOV travel time was measured using the travel time to 4th Avenue via the SR 519 ramps due to the loss of the D-2 roadway to HCT.

Examples of the Westbound 2030 1-hour AM peak and the eastbound 2030 1-hour PM peak travel times for each user group are provided for illustration. Additional profiles were developed for the off-peak directions. These results assume the medium level of roadway investment.

The key findings developed from this analysis include:

- The level of impacts and/or benefits of conversion of the center roadway will vary for each user group.

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- Westbound travel for SOV vehicles will grow substantially over the next 25 years.
- Westbound travel time for HOV vehicles that enter I-90 from Bellevue Way will increase substantially if the Bellevue HOV ramp connections are not maintained.
- The Exclusive Alternative has a greater impact on trips destined to Seattle from Bellevue Way and/or Eastgate in the AM peak hour.
- The Non Exclusive Alternative has a greater AM peak travel time impact on SOV trips destined to Seattle from Island Crest Way. This is due to the higher congestion levels between the Mt. Baker Tunnel and I-5 with the Non Exclusive Alternative.
- In the Westbound PM peak direction, SOV travel times for the Exclusive and Non Exclusive alternatives are relatively equal.
- Eastbound HOV vehicles destined to Bellevue Way will experience higher travel times if the Bellevue HOV ramp connections are not maintained.
- The Exclusive alternative has a greater impact on trips destined to Bellevue Way and/or Eastgate during the PM peak hour.

## 2-HOUR TRAVEL TIME RESULTS (I-405 TO DOWNTOWN SEATTLE)

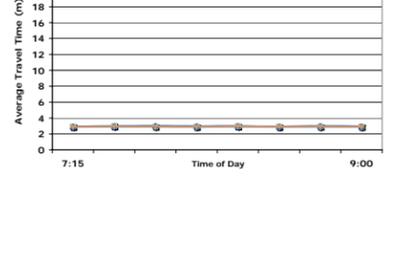
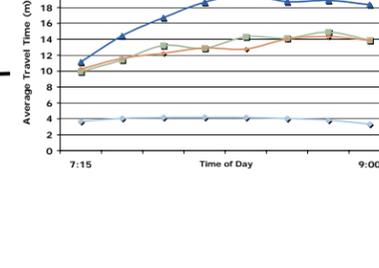
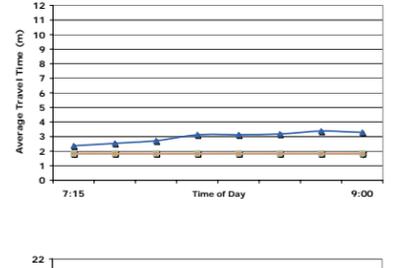
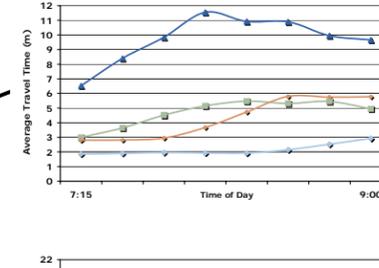
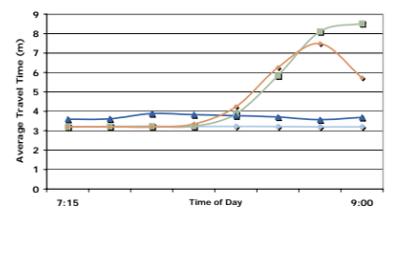
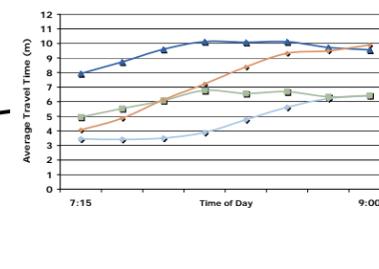
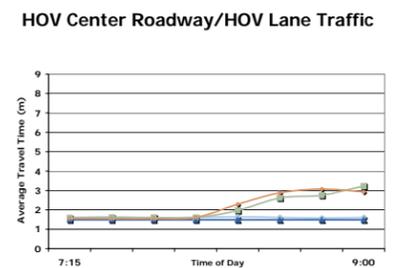
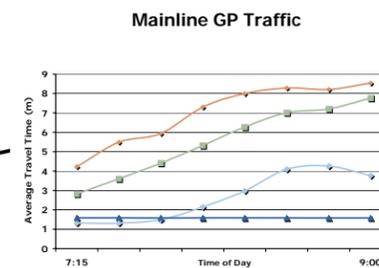
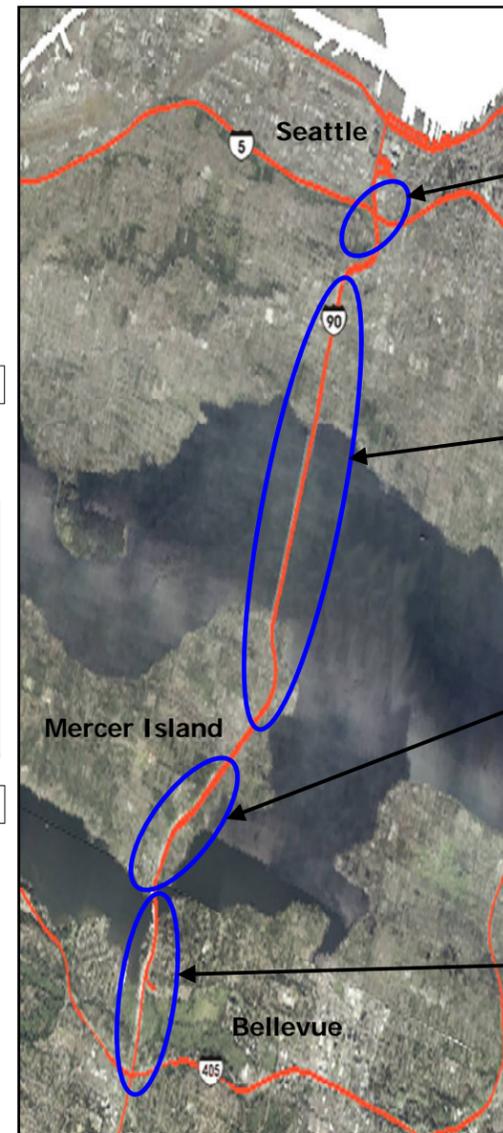
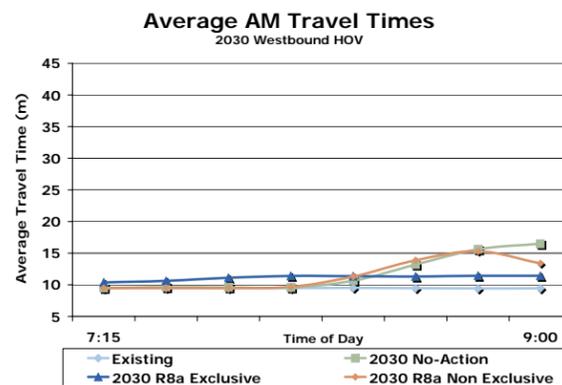
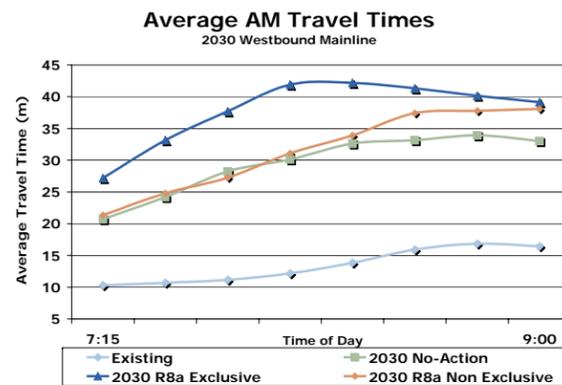
The analysis of the travel time differences between I-405 and downtown Seattle were estimated and evaluated for all alternatives for a 2-hour peak period for the 2015 and 2030 travel demand forecasts. The comparison of the travel times to downtown Seattle for SOV traffic was developed for all alternatives using the northbound on-ramp to I-5 as the trip end point. For the existing, No Action and Non Exclusive alternatives the HOV travel time to downtown Seattle was estimated assuming HOV vehicles will use the D-2 roadway to 5th Avenue. For comparison to the Exclusive alternative, HOV travel time was measured using the travel time to 4th Avenue via the SR 519 ramps due to the loss of the D-2 roadway to HCT.

Examples of the Westbound 2015 2-hour AM peak SOV travel time and 2015 HOV travel time are provided for illustration. Additional profiles were developed for eastbound and 2030 peak hours. These results assume the medium level of roadway investment.

A summary of the key differences in travel time between the No Action, Exclusive and Non Exclusive alternatives is provided in the table on the following page which summarizes the 2-hour travel time results and comparisons for I-405 to Downtown Seattle.

**In the morning peak, the two-hour travel time change going west on I-90...**

**2030 VISSIM Results**



# MODELING RESULTS

Peak Period	SOV Travel Time Findings	HOV Travel Time Findings
WESTBOUND AM PEAK	<p>The Exclusive alternative experiences higher travel times between I-405 and the East Channel Bridge and across Mercer Island. Factors that contribute to this increase in congestion include the loss of the Bellevue Way HOV ramps, the left side Island Crest Way on-ramp volume and weaving between Mercer Island right side on-ramps and the left side HOV lane. Travel time delay increases throughout the duration of the 2-hour peak period for all alternatives between I-405 and the East Channel Bridge.</p> <p>Travel times in the corridor will increase over existing conditions by the year 2015.</p> <p>Congestion at the I-5 interchange causes delay to accumulate on the west end of the corridor causing travel times to degrade throughout the duration of the 2-hour peak period.</p> <p>The HOV weave from vehicles operating in the left side HOV lane and merging to a right side ramp (and vice versa) degrades the travel time for general purpose mainline traffic in the Exclusive and Non Exclusive alternatives.</p> <p>The No Action and Non Exclusive alternatives experience increased travel time at I-5 due to the weave from the center roadway exit to the I-5 NB ramp. The Exclusive alternative experiences less congestion because this weave is eliminated and higher congestion downstream meters traffic.</p>	<p>There are no significant differences in HOV travel time to downtown Seattle using the D-2 roadway and/or 4th Avenue.</p> <p>Center roadway HOV and Mercer Island traffic destined to I-5 northbound will experience higher travel time between the Mt Baker Tunnel and the I-5 interchange with the Non Exclusive alternative.</p>
WESTBOUND PM PEAK	<p>Travel times in the corridor will increase over existing conditions by the year 2015.</p> <p>The No Action alternative has the higher travel time in the PM peak. The travel times for the Exclusive and Non Exclusive alternatives are equivalent.</p> <p>Travel time delay increases throughout the duration of the 2-hour peak period for all alternatives between I-405 and the East Channel Bridge.</p>	<p>HOV Travel time for the No Action alternative is greater. The average travel times for the Exclusive and Non Exclusive alternatives throughout the 2-hour peak are equivalent.</p>
Peak Period	SOV Travel Time Findings	HOV Travel Time Findings
EASTBOUND AM PEAK	<p>The Non Exclusive alternative has the lowest travel time for SOV traffic destined from I-5 to east of I-405. Travel time is highest on the East Channel Bridge with the No Action and Exclusive alternatives and congestion on this segment builds over time increasing the travel time over the peak hour period. The Non Exclusive alternative includes an eastbound auxiliary lane from the East Mercer on-ramp to Bellevue Way. This movement is a merge in all other alternatives. The Exclusive alternative eliminates the eastbound HOV connection to Bellevue Way and the eastbound HOV connection to southbound I-405.</p> <p>Travel time delay does not increase throughout the duration of the 2-hour peak period for all alternatives.</p>	<p>HOV travel time is highest with the No Action alternative. Both the Exclusive and Non Exclusive alternatives include an EB HOV lane.</p>
EASTBOUND PM PEAK	<p>The No Action alternative has the highest congestion through the corridor. Both the Exclusive and Non Exclusive alternatives included channelization improvements between I-5 and the Mt Baker tunnel to improve traffic flow. The Non Exclusive alternative has a lower travel time due to less congestion on the East Channel Bridge and at the Mt Baker tunnel. The No Action alternative has only 3 lanes through the Mt Baker tunnel and does not include an eastbound auxiliary lane on the East Channel Bridge. The Exclusive alternative does not include a slip ramp/drop lane to the center roadway and does not include the auxiliary lane across the East Channel Bridge.</p> <p>Travel time delay does not increase throughout the duration of the 2-hour peak period for all alternatives.</p>	<p>The Non Exclusive alternative has the lower HOV travel times. The HOV travel time for other alternatives are relatively equivalent.</p>

# MODELING RESULTS

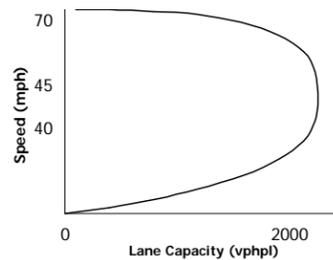
## VEHICLE THROUGHPUT

### VEHICLE THROUGHPUT

Vehicle throughput is the measurement of the vehicular flow rate at a fixed point in the corridor and is influenced by speed, roadway geometrics and roadway congestion. Person throughput is the measurement of the number of persons carried by all vehicles moving across the same fixed point. For the I-90 Corridor vehicle throughput was measured from the VISSIM model at four fixed locations in the corridor for the 2030 peak hour period. The four fixed measurement points were:

- Rainier Avenue
- Mid span on the I-90 Floating Bridge
- Island Crest Way
- Mid span on the East Channel Bridge

Vehicular throughput is influenced by a wide range of factors including roadway geometrics, operating speeds and the mix of vehicles in traffic. Roadway geometrics such as lane width, shoulder width, sight



distance, and roadway grades, reduce the vehicular capacity of the roadway. Trucks, buses, and other heavy vehicles occupy more space, take longer to accelerate and require greater spacing between vehicles. However, the single most critical factor in determining the vehicular throughput is the operating speed of the roadway. Vehicular throughput is greatest when operating speeds fall between 40 to 50 mile-per-hour.

As vehicles slow and speeds drop below 40 miles-per-hour, there is a significant drop in vehicular throughput. In stop and go conditions, vehicular throughput is significantly compromised as vehicles speed up and slow down, reducing the efficiency of the roadway.

The 2030 Medium Investment forecasts were used to compare and contrast the vehicular and person throughputs for each of the roadway configuration alternatives.

The results for westbound and eastbound vehicle throughput for the morning and evening peak hours are summarized in the adjacent table. Throughput volumes are taken directly from the VISSIM model which is capable of tracking each vehicle by mode. Splits (mode use) are taken from the regional demand model and projected traffic conditions.

### KEY FINDINGS FOR VEHICLE THROUGHPUT

As volumes increase and congestion worsens, there will be a loss of vehicular throughput in the I-90 Corridor. This loss is greatest on the east end of the corridor between Island Crest Way and I-405, and occurs under all three future scenarios analyzed. The greatest reduction in vehicular throughput occurs westbound at Island Crest Way in the PM peak hour.

A significant variable in the vehicular throughput calculation is the number of carpools that are forecasted to use the HOV lane and center roadway lanes. Without the completion of the HOV lanes on SR-520 (under Medium Investment), the regional demand model predicts that some SR-520 carpools would divert down to I-90 and the number of carpools that will use the I-90 Corridor will increase (under Low Investment). This reduction is seen in the table below when comparing existing carpool demand with future carpool demand.

In the westbound direction there is a drop in vehicular throughput in both the AM and PM peak hours. The loss of throughput is caused by *continued on next page...*

2030 Medium Investment—Peak Hour Throughput for Vehicles

	Eastbound in the Morning				Westbound in the Morning				Eastbound in the Evening				Westbound in the Evening			
	Existing	No Action	Exclusive	Non Exclusive	Existing	No Action	Exclusive	Non Exclusive	Existing	No Action	Exclusive	Non Exclusive	Existing	No Action	Exclusive	Non Exclusive
<b>I-5 and Rainier Ave (MTB cut)</b>																
Single occupancy vehicles	3,641	4,063	3,864	4,389	4,260	4,703	4,113	4,655	3,927	4,088	3,872	4,428	3,207	3,353	3,378	3,486
Two-person carpools	344	224	239	224	1,020	660	736	678	1,668	1,117	1,270	1,290	764	458	461	463
3-plus carpools (including Vanpools)	118	77	82	76	320	229	255	235	579	400	455	461	270	172	171	174
Trucks	370	313	331	338	244	281	234	278	158	266	227	287	231	165	251	171
Transit	10	64	72	64	35	68	96	68	35	68	96	68	10	64	72	64
<b>Total</b>	<b>4,483</b>	<b>4,740</b>	<b>4,587</b>	<b>5,090</b>	<b>5,879</b>	<b>5,940</b>	<b>5,434</b>	<b>5,913</b>	<b>6,367</b>	<b>5,939</b>	<b>5,919</b>	<b>6,534</b>	<b>4,482</b>	<b>4,211</b>	<b>4,333</b>	<b>4,358</b>
<b>I-90 Floating Bridge (MTB cut)</b>																
Single occupancy vehicles	4,423	4,619	4,611	4,968	5,014	5,174	4,131	4,958	4,886	5,056	4,553	5,496	4,017	4,040	4,040	4,159
Two-person carpools	449	333	368	342	1,104	715	781	720	1,823	1,321	1,282	1,298	994	585	588	596
3-plus carpools (including Vanpools)	154	114	127	117	346	248	271	250	633	473	459	465	352	219	218	224
Trucks	450	355	393	382	287	308	235	296	196	327	265	355	289	198	299	204
Transit	11	64	72	64	35	68	96	68	35	68	96	68	10	64	72	64
<b>Total</b>	<b>5,487</b>	<b>5,485</b>	<b>5,571</b>	<b>5,872</b>	<b>6,786</b>	<b>6,513</b>	<b>5,514</b>	<b>6,291</b>	<b>7,573</b>	<b>7,245</b>	<b>6,655</b>	<b>7,682</b>	<b>5,661</b>	<b>5,105</b>	<b>5,217</b>	<b>5,246</b>
<b>Island Crest Way (Is. Crest Cut)</b>																
Single occupancy vehicles	3,764	3,543	3,613	4,027	4,146	3,973	2,746	3,931	3,774	3,704	3,540	4,176	3,366	2,857	2,916	3,011
Two-person carpools	393	294	307	305	862	636	578	628	1,340	1,064	1,025	984	603	409	403	412
3-plus carpools (including Vanpools)	134	100	106	105	270	221	200	218	466	381	367	352	213	153	149	154
Trucks	383	273	309	310	238	238	158	235	152	241	208	271	242	141	217	148
Transit	9	64	72	64	35	68	96	68	35	68	96	68	8	64	72	64
<b>Total</b>	<b>4,683</b>	<b>4,274</b>	<b>4,407</b>	<b>4,811</b>	<b>5,551</b>	<b>5,135</b>	<b>3,778</b>	<b>5,080</b>	<b>5,767</b>	<b>5,458</b>	<b>5,235</b>	<b>5,851</b>	<b>4,432</b>	<b>3,623</b>	<b>3,757</b>	<b>3,789</b>
<b>I-405 and East (ECB Cut)</b>																
Single occupancy vehicles	4,575	4,796	4,879	5,451	5,123	4,727	3,273	4,927	4,743	4,864	4,664	5,467	4,396	3,546	3,737	3,791
Two-person carpools	606	341	422	382	946	809	772	795	1,703	1,379	1,369	1,455	729	617	606	618
3-plus carpools (including Vanpools)	227	131	162	147	286	269	258	264	589	490	488	517	262	236	228	237
Trucks	415	356	392	404	322	297	207	309	193	322	282	362	309	241	272	257
Transit	11	64	72	64	32	68	96	68	32	68	96	68	10	64	72	64
<b>Total</b>	<b>5,834</b>	<b>5,688</b>	<b>5,927</b>	<b>6,448</b>	<b>6,709</b>	<b>6,170</b>	<b>4,606</b>	<b>6,363</b>	<b>7,260</b>	<b>7,123</b>	<b>6,899</b>	<b>7,869</b>	<b>5,705</b>	<b>4,703</b>	<b>4,915</b>	<b>4,967</b>

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the reduction in operating speeds resulting from increased congestion in the corridor. The loss of throughput is greatest between I-405 and Mercer Island.

In the AM peak, the Exclusive alternative has the greatest loss of vehicular throughput due to the loss of the center roadway. The loss of the center roadway also produces the greatest congestion westbound between I-405 and Island Crest Way which further reduces operating speeds and vehicular throughput.

The Non Exclusive alternative has a significantly higher eastbound vehicular throughput across the East Channel Bridge due to the eastbound auxiliary lane. If this auxiliary lane is assumed for the No Action and Exclusive scenarios, the throughput would increase.

The Exclusive alternative has a lower eastbound vehicular throughput between I-5 and the Mt. Baker Tunnel when compared to the No Action and Non Exclusive alternatives. One of the factors that determines the vehicular throughput in this section is the balancing of volume and congestion between the two eastbound tunnel portals. This balancing is most critical when one of the tunnel lanes is an HOV lane. In the VISSIM model this balancing was accomplished through a trial and error process by adjusting the assigned volumes through the two tunnel portals based upon the level of congestion. Further refinement and balancing of the Exclusive alternative would likely produce a slightly higher vehicular throughput.

### PERSON THROUGHPUT

The focus of this study was to answer questions about the possible conditions vehicular traffic on I-90 would experience under future configurations. The question of person throughput is also important, but necessitates a detailed evaluation of both the vehicular (non-transit) and transit components moving across I-90.

Focusing solely on the future person throughput in non-transit vehicles, the pattern is similar to that for vehicular throughput – all future scenarios will likely be lower than what we see today due to increased congestion. As such, in order to maintain or increase total corridor person throughput, investments that increase the transit component of person throughput or capacity will be necessary.

Quantifying the person throughput potential for transit requires a different analytical approach and level of effort than could be done within the timeframe of this study. The primary reason that this type of effort is more complex is the variability in key factors that affect the future network of transit service and support infrastructure. Variables such as extent of geographic coverage, arterial street capacity, travel time reliability, park and ride capacity, route structure, service frequency, and the extent of transit-supportive land use will all play major roles in a prediction of transit ridership and capacity across I-90.

# MODELING RESULTS

## MERCER ISLAND



Part of this study focused on the operation of Mercer Island roadways that provide access to the I-90 facility in the central area of Mercer Island. In addition to assessing intersection operability from existing (2005) to future (2015)

conditions, the impacts to the Mercer Island roadway network with the I-90 center roadway converted to HCT use were assessed. This analysis evaluated ramp ingress/egress conditions under Exclusive operations and estimated any shift in travel patterns or potential adverse queuing that may occur in the immediate vicinity of the freeway ramps.

This analysis assumed that Mercer Island travel patterns would not change within the study area and that growth would be evenly distributed. Other assumptions included no change to vehicle composition and some level of investment would be made to maintain the City of Mercer Island's level-of-service standard of C from Existing to No Action to Exclusive. Since the majority of traffic growth is expected to occur sooner rather than later, 2015 conditions were analyzed across access point to I-90.

See the *Roadway Configurations Evaluated* sections graphic titled *Existing and Assumed Proposed Roadway Configurations for Modeling and Analysis* for geometric changes assumed.

### Existing Conditions

The existing condition analysis showed that all intersections operate within an acceptable LOS range per Mercer Island standards. This indicates that prevailing traffic patterns are representative of 'normal' conditions based on the ability of local traffic and little re-routing or diversion is occurring due to congestion. Although ramps such as Island Crest Way experience heavy peak use and some queuing (see photo), ramp metering and spill back queue detection minimizes the impacts through active ramp management.



### Future Conditions under the No Action Scenario

Future No Action conditions show that study area intersections are projected to operate at acceptable LOS with some exceptions, such as the intersection of 77th Avenue & 27th Street and 77th Avenue & North Mercer Way which may not meet the LOS standard of C and may need some level of improvement.

### Future Conditions under the Exclusive Scenario

Future Exclusive conditions show that all of the study area intersections operate at an acceptable LOS with the exception of I-90 westbound on-ramp intersection at 76th Avenue and North Mercer Way in the morning peak. The additional delay at this intersection was the result of additional volume and some minor re-routing of traffic due to the closure of the reversible access ramps. No significant delay was associated with the evening peak.



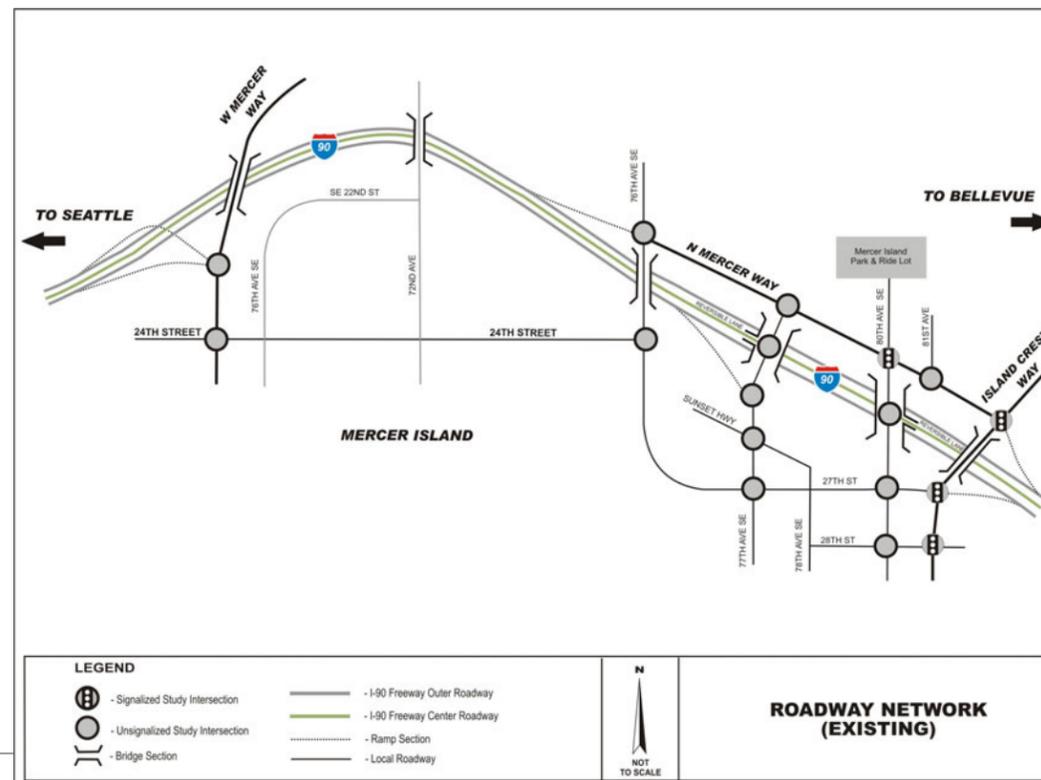
On the exiting I-90 mainline westbound exit to Island Crest Way, ramp queuing and congestion is forecasted. This queuing can be significantly reduced by rechannelizing the off-ramp to allow dual westbound left

turns. This improvement would increase intersection capacity and queue storage.

Entering westbound I-90 mainline from Island Crest Way with Exclusive operations showed an increase in travel time of about eight (8) seconds from existing conditions in the morning and no change in the evening.



Entering eastbound I-90 from Island Crest Way at 27th Street in the PM peak showed increased queuing similar to existing peak conditions. Under these conditions, when queuing from the ramp meter reaches to the intersection, it triggers the spill back detection and adjusts the ramp meter rate, reducing the queue. VISSIM was used to assess future ramp queuing conditions. Two types of queues were examined, the primary (ramp meter) and the secondary (I-90 merge). If the secondary queue is the cause of congestion then ramp management will not assist in reducing the ramp queue. VISSIM analysis results showed that the secondary queue was not a limiting factor in the ramp operations and confirmed that existing ramp meter and spill back detection would be sufficient to manage future projected queues. Present day operation of converting the on-ramp into two-lane operation during the PM peak by use of the shoulder is still needed.



### KEY FINDINGS

Future intersection operation on Mercer Island will not significantly impact access to the I-90 corridor. Background traffic growths on the Island indicates that improvements to one or two local intersections may be required to maintain the City's Level-of-Service standards.

Channelization modifications are recommended on the westbound approach at the Island Crest Way & North Mercer Way/I-90 westbound off-ramp to reduce queue lengths that may occur under the No Action scenario.

For the Exclusive scenario, signalization of the 76th Avenue & North Mercer Way/I-90 westbound on-ramp may be necessary to achieve an acceptable LOS.

# MODELING RESULTS

## SENSITIVITY ANALYSIS

The sensitivity of I-90 operations to internal improvements within the corridor was evaluated using the VISSIM simulation model. The analysis was conducted using the Medium Investment forecasts for the corridor. The improvements evaluated included:

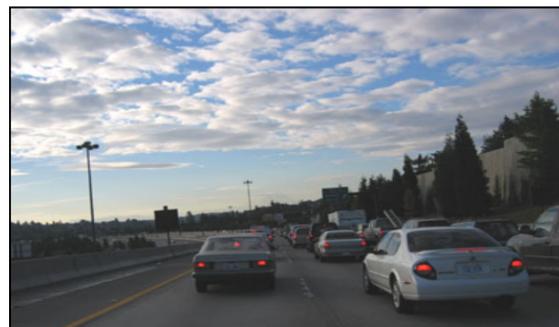
- Reduced congestion at the I-5 off-ramps
- Improved channelization eastbound on I-90 between I-5 and the Mt. Baker Tunnel
- Eastbound auxiliary lane between East Mercer Way and the I-405 off-ramp
- Bellevue Way HOV ramp connections
- Island Crest Way on-ramp
- Management of the HOV lane

### CONGESTION AT I-5

Congestion at the I-5 interchange ramps has a detrimental impact on I-90 operations. When traffic queues on the I-5 northbound and southbound ramps spillback onto the I-90 mainline during the morning and evening peak hours, this congestion creates additional delay and operational difficulties that impact both the center roadway and outside roadway traffic operations. This congestion will continue to worsen in the future under all three future roadway configurations.

The effects of different levels of congestion on the I-5 ramps were modeled in VISSIM by adjusting the speed and flow rates on the I-5 ramps. Improving the flow rate on the ramps resulted in a significant reduction in congestion on the ramps and on I-90. Even small improvements in flow rate (i.e., increasing the ramp speed from 13 to 18 mph) resulted in a substantial reduction in congestion.

Current programmed funding levels do not include any improvements for the I-5/I-90 interchange and ramps. Physical constraints—topography, limited right-of-way, geometrics—make improvements to this interchange difficult. For example, the westbound-to-northbound off-ramp is a two-lane ramp so additional ramp capacity is unlikely to be constructed. However, it is equally unlikely that volume on the northbound I-5 collector distributor roadway will increase in the future due to bottlenecks at the entrance to the collector distributor roadway which constrain the flow rate. This bottleneck constrains the number of I-5 vehicles that merge with I-90 traffic.



### EASTBOUND BETWEEN I-5 AND MT. BAKER

The existing channelization between I-5 and the Mt. Baker Tunnel consists of four (4) lanes that merge to three (3) lanes through the Mt. Baker Tunnel when the center roadway is closed to eastbound traffic. With the construction of R-8A, 5 lanes are proposed between I-5 and the Mt. Baker Tunnel with the fifth lane dropping into the center roadway. When the center roadway is closed to eastbound traffic, the fifth lane would merge into four (4) lanes (3 general purpose with one HOV lane) through the tunnel. VISSIM was used to test the sensitivity of future roadway configurations to a four (4) lane channelization configuration that would provide 2 lanes from I-5 southbound, 1 lane from downtown Seattle (via Atlantic Street) and one lane from northbound I-5. Modeling of the 4-lane configuration demonstrated significant benefits for the No Action and Exclusive alternatives. The Non Exclusive alternative was not simulated with a 4-lane configuration because the fifth lane (inside lane) would drop into the center roadway in the PM peak hour and merge into the HOV lane (rather than a general purpose lane) in the AM peak hour.

### EASTBOUND AUXILIARY LANE

R-8A Stage Two improvements included the construction of an eastbound auxiliary lane from the East Mercer Way on-ramp to the I-405 off-ramp. This improvement was assumed in the Non Exclusive Alternative but not the Exclusive Alternative due to the additional width potentially needed by HCT in the center roadway across the East Channel Bridge. Modeling of the Exclusive alternative with the eastbound auxiliary lane demonstrated significant benefits and reduction in eastbound travel time could be gained with the additional lane.

### BELLEVUE WAY HOV RAMP CONNECTIONS

Elimination of the Bellevue Way HOV connections under the Exclusive alternative would significantly increase travel time for HOV traffic destined to or from Bellevue Way and the South Bellevue Park-n-Ride. These results are demonstrated in the travel time summaries.

The adjacent table compares the travel time from Bellevue Way onto I-90 for each of the four scenarios (Existing, No Action, Exclusive, and Non Exclusive). The travel time is measured from the end of the ramp westbound onto I-90 and results do not include any delay that may be incurred on Bellevue Way due to congestion and queuing. The Existing and Exclusive alternatives do not include the Bellevue Way HOV direct access ramp connections. The construction of the Bellevue Way direct access ramps reduces the delay for both SOV and HOV vehicles and provides a significant travel time advantage for transit and HOVs. Some



improvement in SOV travel time is also expected with the construction of the HOV direct access ramps because HOV vehicles and buses are removed from the congested merge onto I-90 and would not be required to “swim” across the westbound general purpose lanes to access the HOV land and/or the center roadway. Using the model results from the No Action and Non Exclusive alternatives, the travel time savings for HOV and transit vehicles under Exclusive operations with the HOV ramp connections is estimated to range from 4.5 minutes to 8.5 minutes per vehicle.

	Westbound AM Peak		Westbound PM Peak	
	SOV Ramp	HOV Ramp	SOV Ramp	HOV Ramp
<b>Existing</b>				
2005	0.50	--	1.13	--
<b>No Action</b>				
2015	2.01	0.43	5.74	0.38
2030	2.55	0.44	6.38	0.38
<b>Exclusive</b>				
2015	5.20	--	5.18	--
2030	8.94	--	5.90	--
<b>Non Exclusive</b>				
2015	1.78	0.43	5.26	0.43
2030	2.55	0.38	6.42	0.38

### NEXT STEPS: LANE MANAGEMENT

Early testing of HOV lane management shows promise for improving overall operations on the I-90 corridor. These early tests examined hypothetical conditions that managed the number of vehicles that could make use of the inside most lane and how this would impact its operations. Further analysis is required to develop finer adjustments of what managing this corridor would entail and how these strategies and travel patterns would impact roadway use while preserving certain operational conditions. At the time of this report, WSDOT is considering this analysis as a potential next step.

## SUMMARY OF KEY FINDINGS

THE KEY FINDINGS OF THIS STUDY ARE ORGANIZED AROUND THE SIX (6) KEY STUDY ISSUES AND QUESTIONS. THESE FINDINGS ARE SUMMARIZED BELOW.

**What are the changes in vehicle throughput if the center roadway is converted to exclusive HCT use?**

As volumes increase and congestion worsens, there will be a loss of vehicular throughput in the I-90 Corridor. This loss is greatest and most critical on the east end of the corridor between Island Crest Way and I-405. The greatest reduction in vehicular throughput occurs westbound at Island Crest Way in the evening peak hour.

**What is the impact of external roadway improvements on demand and volume in the I-90 Corridor?**

Construction of HOV lanes on SR-520 and additional lanes on I-405 would reduce traffic volumes on I-90. The greatest reduction in volume in the I-90 Corridor is forecasted to occur with the completion of the Nickel and TPA funded projects. Higher levels of investment on I-405 and I-90 did not achieve substantial reductions in total traffic across Lake Washington.

**What is the sensitivity of I-90 operations to improvements within the corridor?**

Several improvements, if completed, would benefit I-90 operations. These include:

- Construction of a 4-lane channelization configuration on eastbound I-90 between I-5 and Mt. Baker.
- Construction of an eastbound auxiliary lane between East Mercer Way and the off-ramp to I-405.
- Maintenance of the Bellevue Way HOV ramp connections is important in reducing delay for HOV and transit trips to and from Bellevue Way.
- Westbound congestion is very sensitive to the volume of traffic that enters mainline I-90 from Island Crest Way in the peak period.
- Aggressive management of the HOV lane would improve both HOV lane and general purpose lane performance in the westbound direction during the peak periods.

**What are the changes in person throughput if the center roadway is converted to exclusive HCT use?**

The Exclusive alternative provides increased person throughput by increasing the transit capacity in the corridor. A key variable in the analysis of the throughput potential of the Exclusive alternative is the ridership forecast for HCT. If HCT is successful in attracting higher ridership than forecasted in this analysis, the potential increase in person throughput could be substantial.

**What is the impact to Mercer Island surface streets and access?**

Surface streets will experience increases in delay as a result of background growth. Local street travel patterns are expected to change slightly with conversion of the center roadway to exclusive HCT use due to ramp reconfigurations and will increase the delay at certain ramps such as the 76th Street westbound on-ramp. Delays to eastbound access are not expected to be significant.

**What are the changes in travel time if the center roadway is converted to exclusive HCT use?**

The level of impacts and/or benefits of converting the center roadway will vary depending upon the destination and exit and entry points of the user. Conversion of the center roadway increases the travel time for trips across the East Channel Bridge. Conversion of the center roadway decreases travel time between Mercer Island and downtown Seattle due to less weaving and congestion at the west end of the corridor under Exclusive operations.

