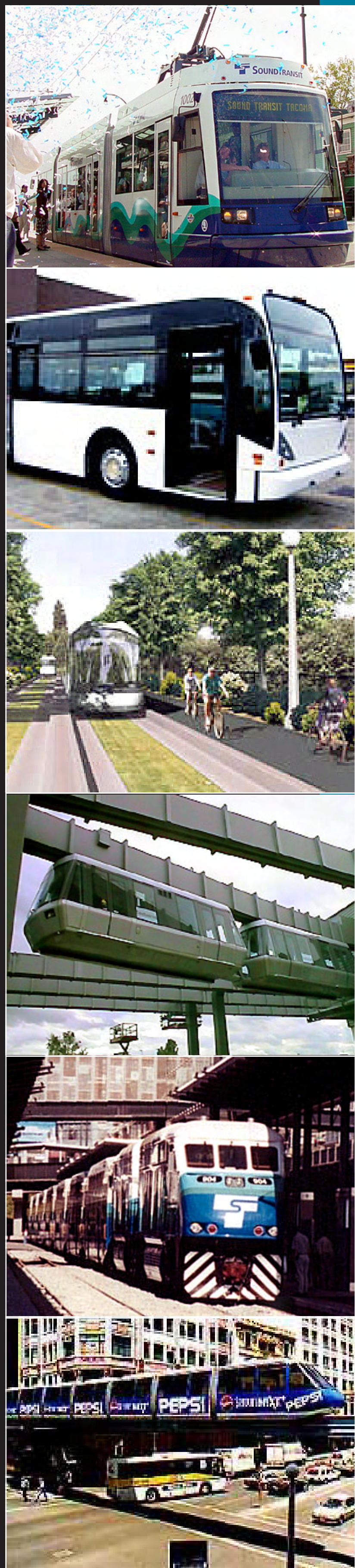

CENTRAL PUGET SOUND REGION

High Capacity Transit Corridor Assessment

TECHNICAL WORKBOOK

Prepared By

Puget Sound Regional Council

August 2004

The Puget Sound Regional Council is an association of local governments and state agencies in the central Puget Sound region of Washington State. It serves as a forum for developing policies and making decisions about important regional growth and transportation issues.

The Council is designated under federal law as the Metropolitan Planning Organization, and under state law as the Regional Transportation Planning Organization, for King, Kitsap, Pierce, and Snohomish Counties. In addition to the four counties, the Council's members include 77 cities in the region, three ports, two tribes, seven transit agencies, and two state agencies – the Washington State Department of Transportation and the Transportation Commission. Associate members of the council are the Daniel J. Evans School of Public Affairs, Island County, the Thurston Regional Planning Council, the Port of Bremerton, the Puyallup Tribal Council, and the Tulalip Tribes.

Funding for this workbook was provided by a contract with Sound Transit.

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CENTRAL PUGET SOUND REGION
HIGH CAPACITY TRANSIT CORRIDOR ASSESSMENT

Technical Workbook
August 2004

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Existing and Projected Population Density (4 maps)
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Existing and Projected Population and Employment Density (4 maps)
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1.0 INTRODUCTION

1.1 Project Summary and Scope

The Puget Sound Regional Council (PSRC) prepared this workbook as part of Sound Transit's recently initiated planning effort to update the long-range regional high capacity transit "vision." The high capacity transit vision is an essential part of the region's long-range transportation plan - *Destination 2030*. Updating the vision will help determine the type and level of future high capacity transit (HCT) investments that should be made after the investments now underway are completed.

The Puget Sound Regional Council assisted Sound Transit in this planning effort by establishing a base of fully updated population, employment, and travel demand forecasts. PSRC staff conducted an assessment of the updated land use and travel data to determine the relative potential of each study corridor to support high capacity transit. PSRC staff reviewed a range of high capacity transit technologies and analyzed them for future phase investments in each corridor. This technical work prepared by PSRC staff establishes a basis for more detailed planning studies, environmental analysis, and public outreach that Sound Transit will conduct over the next year. PSRC coordinates regional transit planning work with Sound Transit and will be using this information for the next update of the Metropolitan Transportation Plan.

The *Regional Transit Long-Range Transit Vision* was adopted in May 1996 by Sound Transit. The Sound Transit *Vision* identifies a system-level plan for implementing a range of high capacity transit investments throughout the three-county (King, Snohomish, and Pierce) area. The HCT investments identified in the *Vision* include express bus services primarily along high occupancy vehicle (HOV) lanes, commuter rail, and light rail as well as other supporting facilities. *Sound Move* outlines a ten-year implementation strategy for the first phase of transit investments in the long-range *Vision*. Many of these phase 1 investments have been completed (e.g., express bus transit and direct access HOV facilities, Tacoma Link light rail, and the Sounder commuter rail) and others will be completed by 2009 (e.g., Central Link light rail).

Sound Transit conducts their regional transit planning requirements under Washington State enabling legislation (RCW 81.104). These planning requirements define High Capacity Transit as *"…a system of public transportation services within an urbanized region operating principally on exclusive rights of way, and supporting services and facilities necessary to implement such a system, including interim express services and high occupancy vehicle lanes, which taken as a whole, provide a substantially higher level of passenger capacity, speed, and service frequency than traditional public transportation systems operating principally in general purpose roadways."*

The scope of this workbook focuses on:

- Analysis of land use, demographic, and travel pattern data to identify travel corridors and markets that would be most supportive of potential high capacity transit extensions in the near and long-term future.

- Assessment of the relative appropriateness of various high capacity transit technologies in each of the study corridors.

This workbook does not attempt to determine specific alignments within the study corridors nor does it identify the most appropriate high capacity transit technology for each corridor. The primary focus of the workbook is to determine when each corridor (or segments within a corridor) will support high capacity transit services and which technologies would be most appropriate to evaluate further.

The study corridors that are evaluated include all of the "potential rail extensions" that were identified in the 1996 Sound Transit Vision and subsequently incorporated in the region's long-range transportation plan – *Destination 2030.* These corridors include:

- Crosslake Corridor - Downtown Seattle to Bellevue CBD, with spurs to Issaquah and Redmond
- North Corridor – Northgate to Everett CBD via Lynnwood
- South Corridor – SeaTac to Tacoma, with spur to Dupont via Lakewood
- Eastside Corridor – SeaTac to Lynnwood via Renton and Bellevue

Note: An additional "potential rail extension" in the city of Seattle connecting downtown with Ballard and the University District neighborhoods is not included within these study corridors. These connections are included as part of the Seattle Monorail Project. Sound Transit will evaluate whether to keep these potential rail extensions in their long-range *Vision* based on more detailed alignment analysis as part of their overall phase 2 planning study.

Maps are attached at the end of this section for geographic reference:

Figure 1.5 – *High Capacity Transit Study Corridors,*
Figure 1.6 – *Sound Transit Ten-year Regional Transit System Plan (Sound Move),*
Figure 1.7 – *Sound Transit Regional Transit Long-range Vision,*
Figure 1.8 – *Seattle Monorail Project Long-range Plan, and*
Figure 1.9 – *Puget Sound Regional Council's VISION 2020*

Regional Policy Direction

VISION 2020 and *Destination 2030* provide the long-range growth management, economic development and transportation planning framework for the central Puget Sound region. VISION 2020 calls for locating development in urban growth areas so services can be provided efficiently, and farmlands, forests and other natural resources are conserved. Within urban areas, it supports creation of compact communities with employment and housing growth focused in centers. The strategy is designed to ensure that development in our communities makes it easier to walk, bicycle and use transit.

One of the most important factors influencing the region's development pattern is our transportation system. Regional travel trends continue to show more cars on the road, more trips per person, and increasing numbers of people driving alone. *Destination 2030* is the transportation component of VISION 2020. It establishes the regional direction for responding to these trends and provides the basis for the more detailed planning and investment decisions.

1.2 Role of the Independent Technical Review Committee

In coordination with the American Public Transportation Association (APTA), the Regional Council convened an Independent Technical Review Committee in March 2004 comprised of public transit industry professionals from other regions to review the Puget Sound Regional Council data and analysis contained in the draft workbook. Committee members included: Greg Hull, Director of Operations and Safety with the American Public Transportation Association; Michael Allegra, Chief Capital Development Officer with the Utah Transit Authority; Jim de la Loza, Executive Officer for County-wide Planning and Development with Los Angeles County MTA; and Rick Walsh, former General Manager with King County Metro.

The committee reviewed and commented on the data compiled, the analysis conducted, and the high capacity transit technology options surveyed. Specifically, the committee verified that the land use and travel characteristics associated with supporting high capacity transit were appropriately evaluated and that the range of transit technologies was properly analyzed in each corridor. The Technical Committee spent three days discussing land use and travel information about the corridors and touring the region. The tour covered segments of each of the four corridors analyzed. A public session was held for the committee to highlight some of its initial findings and present its recommendations for future consideration.

A detailed written report was submitted to the Regional Council and is attached as *Appendix D.*

Below is a list of questions that the independent technical review committee was asked to address:

- What land use and travel characteristics are associated with supporting high capacity transit? Of these characteristics, which are the most important determinants?

- Based on existing and planned land use and travel data, what geographic areas demonstrate the highest potential for supporting future high capacity transit extensions? In the near term (2010-2020)? In the long term (2020-2030)?

- Have land use and travel characteristics been appropriately considered to determine transit technology needs in each corridor?

- Which HCT technologies appear most appropriate to evaluate further in each corridor?

1.3 Summary of Initial Regional High Capacity Transit Investments

The Puget Sound region is making significant progress in its efforts to implement a high capacity transportation system. Many of these initial investments are outlined in *Sound Move – Ten year Regional Transit System Plan,* approved by Sound Transit in 1996 and currently being implemented. Additional supporting investments are being made by local transit agencies and Washington State Department of Transportation (WSDOT). Below are descriptions of existing and planned transit investments that form the foundation for a future high capacity transit system. For the purposes of this study, it is assumed that all of the planned transit improvements described below will be completed to support future high capacity transit phases. In addition to the regional transit investments described below, each of the local transit operators have significant plans to improve and upgrade local transit services and facilities that will support the regional improvements. See *Appendix E* for a summary of local transit operations and proposed investments.

***Sound Move* – Ten-Year Regional Transit System Plan**

In 1993, the Snohomish, Pierce and King county councils voted to create a Regional Transit Authority (RTA). Three years later the RTA Board adopted *Sound Move* (also known as the Phase I plan), a 10-year regional transit proposal. Submitted to voters at the November general election, the proposal was approved district-wide, authorizing a local 0.4% sales tax and 0.3% motor vehicle excise tax (MVET) to finance construction and operation of a regional transit system to include regional bus service (“Express”), commuter rail (“Sounder”), and light rail (“Link”). “Sound Transit” is the popular name for the RTA that provides these services. Parts of the *Sound Move* system of buses, commuter, and light rail are now in place and operating.

“Express” Regional Bus Service

The “Express” system includes both Sound Transit express bus routes that connect major regional urban and employment centers in Central Puget Sound and more than $850 million in transportation improvement projects including new and improved transit centers, park-and-ride lots and HOV access lanes and ramps. The phase I program of bus services called for 19 regional express routes. In September of 2002 the system’s full complement of routes was completed. With service running daily from 3:00 a.m. till 12:15 a.m., ST Express buses carry more than 24,000 people every weekday on routes that connect major employment and population centers in Snohomish, King and Pierce counties.

Sound Transit will spend more than $850 million on over 39 new or expanded transportation improvement projects to enhance transit speed and reliability. Projects that have already been opened include a new Bellevue Transit Center, the Overlake Transit Center, the Pacific Avenue Overpass in Everett and numerous park-and-ride lots. Ramps, such as those planned for the Ash Way area of Lynnwood, will provide direct access to HOV lanes, avoiding the need for vehicles to cross traffic to get in and out of the lane. Other regional investments, not related to Sound Transit, are targeted for completion through 2010 including the construction of approximately an additional 167 freeway

HOV lane miles for completion of the core freeway HOV system and other HOV missing links.

“Sounder” Commuter Rail Service

The commuter rail system called for in the Phase I plan runs between Lakewood and downtown Everett along 81 miles of existing track, serving 13 stations. Ten-year operational goals include 18 trains a day providing bi-directional service every thirty minutes during peak travel periods. Sounder is being launched in three segments — Tacoma to Seattle, Everett to Seattle and Tacoma to Lakewood.

- Between Tacoma and downtown Seattle, Sounder currently serves seven rail stations with three morning and three afternoon trips.

- Service from Seattle north to Edmonds and Everett started in December 2003 with one morning and one afternoon trip. The Everett to Seattle route will eventually include a station in Mukilteo.

- Service is projected to begin from Tacoma to Lakewood in late 2007, serving new stations in South Tacoma and Lakewood.

When the system is fully operational, trains will run every half-hour during peak commute hours. As of February 2004, Sounder commuter trains carry nearly 17,000 people a week.

“Link” Light Rail Service

The Phase I light rail system includes two segments: 1) Northgate to SeaTac Airport (Central Link) and 2) Tacoma Dome to the Theater District through downtown Tacoma (Tacoma Link).

- Central Link – This initial 14-mile line and its 11 operational passenger stations will serve downtown Seattle, the industrial area south of downtown, and residential and commercial neighborhoods in Beacon Hill, the Rainier Valley, Tukwila, and SeaTac. Once completed, it will serve as the backbone of a regional light rail system. Construction started in November 2003.

- Tacoma Link – This 1.6 mile line and its 5 stations started operating in August of 2003. Service runs at 10-minute headways, 14 hours a day and at 20-minute headways, 20 hours a day. Weekly average ridership, including Saturday and Sunday, is over 14,000.

Downtown Seattle Transit Tunnel (DSTT) and E-3 South Busway

The Downtown Seattle Transit Tunnel (DSTT) opened in 1990 to enable dual-power bus transit service to operate free of surface street congestion and as a pre-cursor to its ultimate intended use as a light rail transit corridor. The tunnel is 1.3 miles long and from its five stations serves thousands of commuters each day. Currently, 24 bus routes use the tunnel with a peak of up to 70 buses per hour in each direction. About 40 percent of all rush-hour bus trips through downtown Seattle pass through the tunnel. King County Metro operates all buses in the tunnel, some under contract with Sound Transit. The E-3 South Busway opened in 1991. This 2-mile above ground "extension" of the tunnel sits on an old Union Pacific right-of-way south of Royal Brougham and is the beginning of an exclusive right-of-way used by buses to access the DSTT. The E-3 South Busway has four stations. In normal operations, tunnel-routed buses continue into the tunnel portal, located near the I-90 overpass.

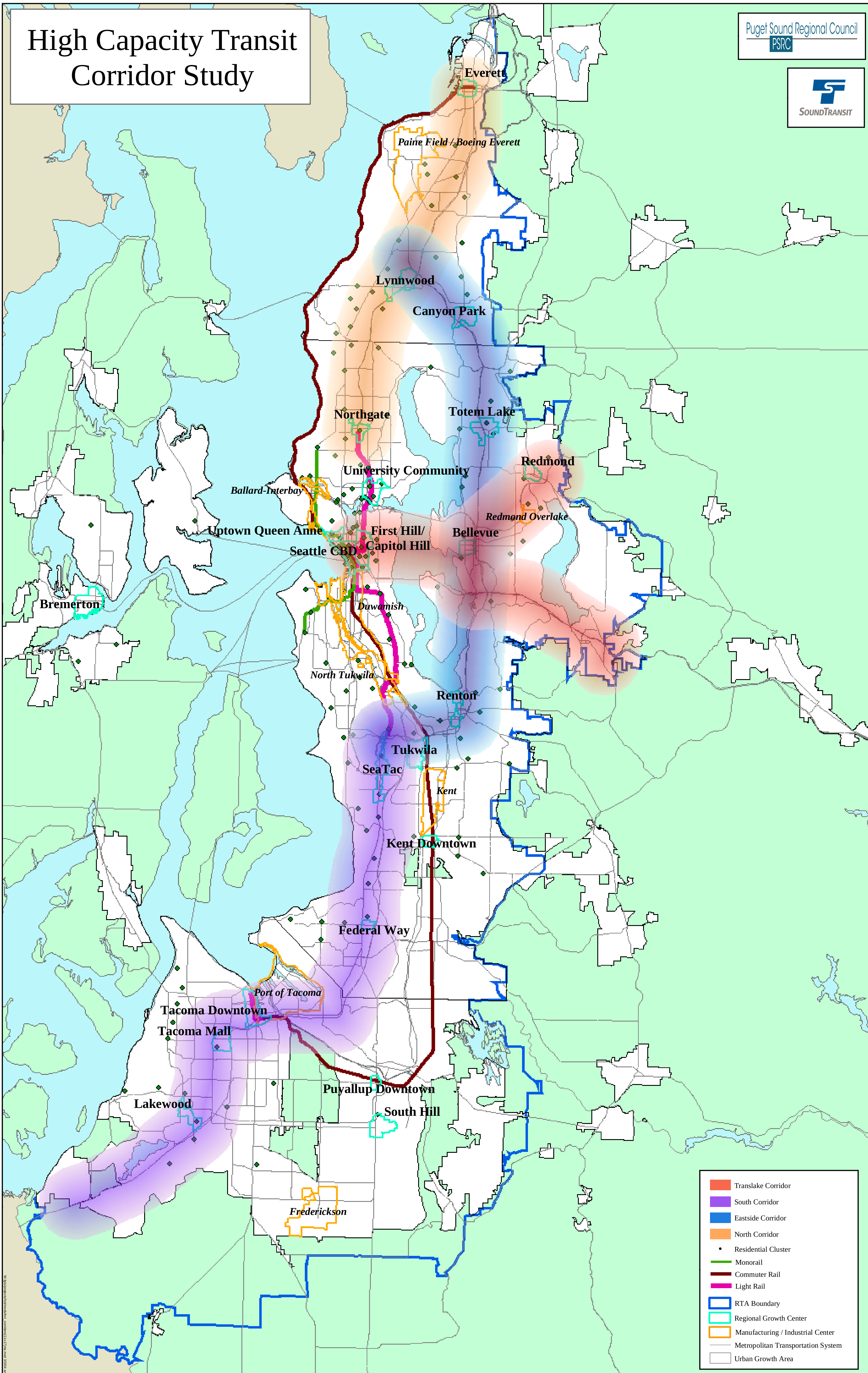
Seattle Monorail Project

In November 2002, Seattle residents voted to approve funding to build the 14-mile Monorail Green Line, “Phase 1” of a proposed 5-line citywide monorail system. Starting in Ballard at the north, the Green Line will pass through downtown, terminating in West Seattle. Future extensions will connect Ballard to the University District and the region’s light rail line. The project is scheduled to break ground in fall 2004, with segments opening in 2007. The entire Green Line is scheduled to be in operation in 2009.

1.4 Structure and Contents of this Workbook

The workbook includes a summary of prepared data, an outline of the analysis conducted, and a summary of initial PSRC staff and Technical Committee observations. Section 2.0 provides a summary of the land use and travel demand information that was compiled and the methodology used in assessing the individual study corridors. Section 3.0 includes a description of research that was conducted on various technologies and the methodology used to evaluate a range of high capacity transit technology options. Section 4.0 provides a summary of the land use and travel information that was compiled for each corridor and an assessment of how different high capacity transit technologies would meet the each individual corridor's needs. Section 5.0 provides a system-level summary of how the various components could be integrated over time for segments within each corridor. The Appendices attached to the end of the workbook include all of the data and other supporting information that was compiled and used as part of this report.

High Capacity Transit Corridor Study



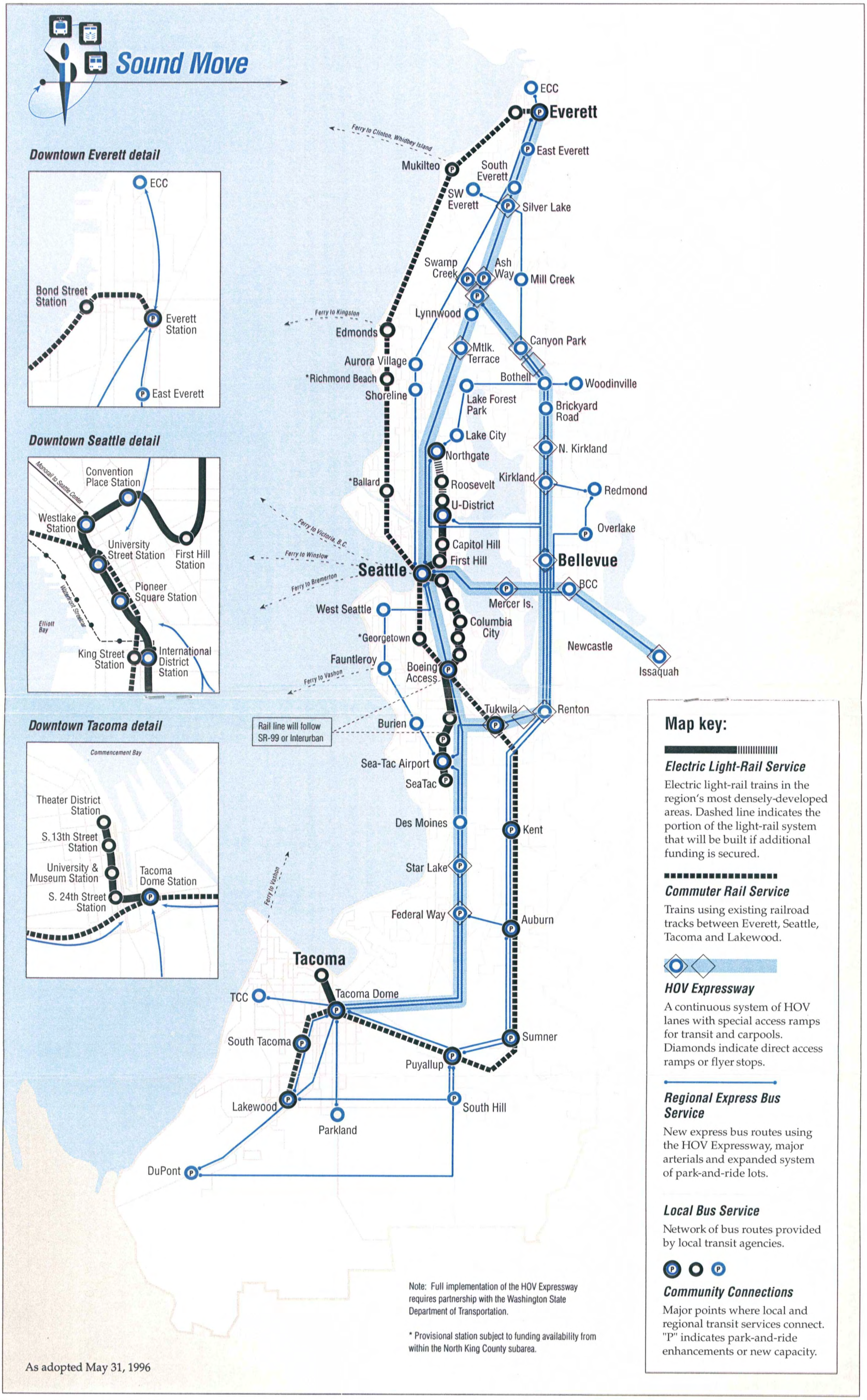
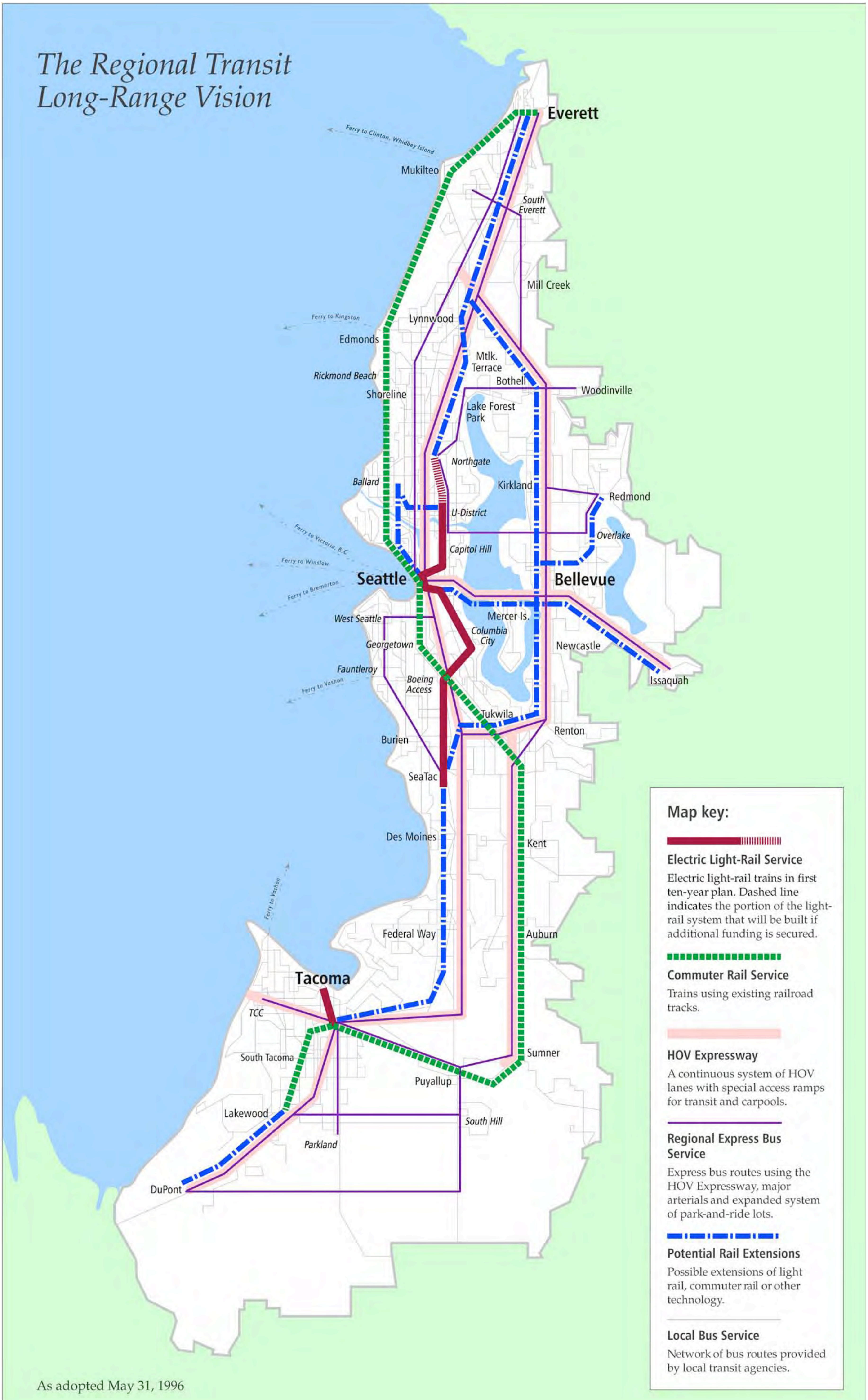

Sound Move
Downtown Everett detail
ECC
Bond Street Station
Everett Station
East Everett
Downtown Seattle detail
Monorail to Seattle Center
Convention Place Station
Westlake Station
University Street Station
First Hill Station
Pioneer Square Station
Waterfront Streetcar
Elliott Bay
King Street Station
International District Station
Downtown Tacoma detail
Commencement Bay
Theater District Station
S. 13th Street Station
University & Museum Station
Tacoma Dome Station
S. 24th Street Station
ECC
Everett
Ferry to Clinton, Whidbey Island
East Everett
Mukilteo
South Everett
SW Everett
Silver Lake
Swamp Creek
Ash Way
Mill Creek
Ferry to Kingston
Lynnwood
Edmonds
Canyon Park
Mtlk. Terrace
Aurora Village
*Richmond Beach
Shoreline
Bothell
Woodinville
Lake Forest Park
Brickyard Road
Lake City
N. Kirkland
Northgate
Kirkland
Roosevelt
Redmond
*Ballard
U-District
Overlake
Ferry to Victoria, B.C.
Capitol Hill
Ferry to Winslow
First Hill
Bellevue
Seattle
Ferry to Bremerton
BCC
Mercer Is.
West Seattle
Columbia City
*Georgetown
Newcastle
Fauntleroy
Issaquah
Boeing Access
Ferry to Vashon
Tukwila
Renton
Rail line will follow SR-99 or Interurban
Burien
Sea-Tac Airport
SeaTac
Des Moines
Kent
Star Lake
Ferry to Vashon
Federal Way
Auburn
Tacoma
TCC
Tacoma Dome
South Tacoma
Sumner
Puyallup
Lakewood
South Hill
Parkland
DuPont
Map key:
Electric Light-Rail Service
Electric light-rail trains in the region's most densely-developed areas. Dashed line indicates the portion of the light-rail system that will be built if additional funding is secured.
Commuter Rail Service
Trains using existing railroad tracks between Everett, Seattle, Tacoma and Lakewood.
HOV Expressway
A continuous system of HOV lanes with special access ramps for transit and carpools. Diamonds indicate direct access ramps or flyer stops.
Regional Express Bus Service
New express bus routes using the HOV Expressway, major arterials and expanded system of park-and-ride lots.
Local Bus Service
Network of bus routes provided by local transit agencies.
Community Connections
Major points where local and regional transit services connect. "P" indicates park-and-ride enhancements or new capacity.
Note: Full implementation of the HOV Expressway requires partnership with the Washington State Department of Transportation.
* Provisional station subject to funding availability from within the North King County subarea.
As adopted May 31, 1996

FIGURE 1.6



The Regional Transit Long-Range Vision
Everett
Ferry to Clinton, Whidbey Island
Mukilteo
South Everett
Mill Creek
Ferry to Kingston
Lynnwood
Edmonds
Mtlk. Terrace
Rickmond Beach
Bothell
Woodinville
Shoreline
Lake Forest Park
Northgate
Ballard
Kirkland
Redmond
U-District
Overlake
Ferry to Victoria, B.C.
Capitol Hill
Ferry to Winslow
Seattle
Bellevue
Ferry to Bremerton
Mercer Is.
West Seattle
Columbia City
Georgetown
Newcastle
Fauntleroy
Boeing Access
Issaquah
Ferry to Vashon
Tukwila
Renton
Burien
SeaTac
Des Moines
Kent
Ferry to Vashon
Federal Way
Auburn
Tacoma
TCC
South Tacoma
Sumner
Puyallup
Lakewood
South Hill
Parkland
DuPont
As adopted May 31, 1996
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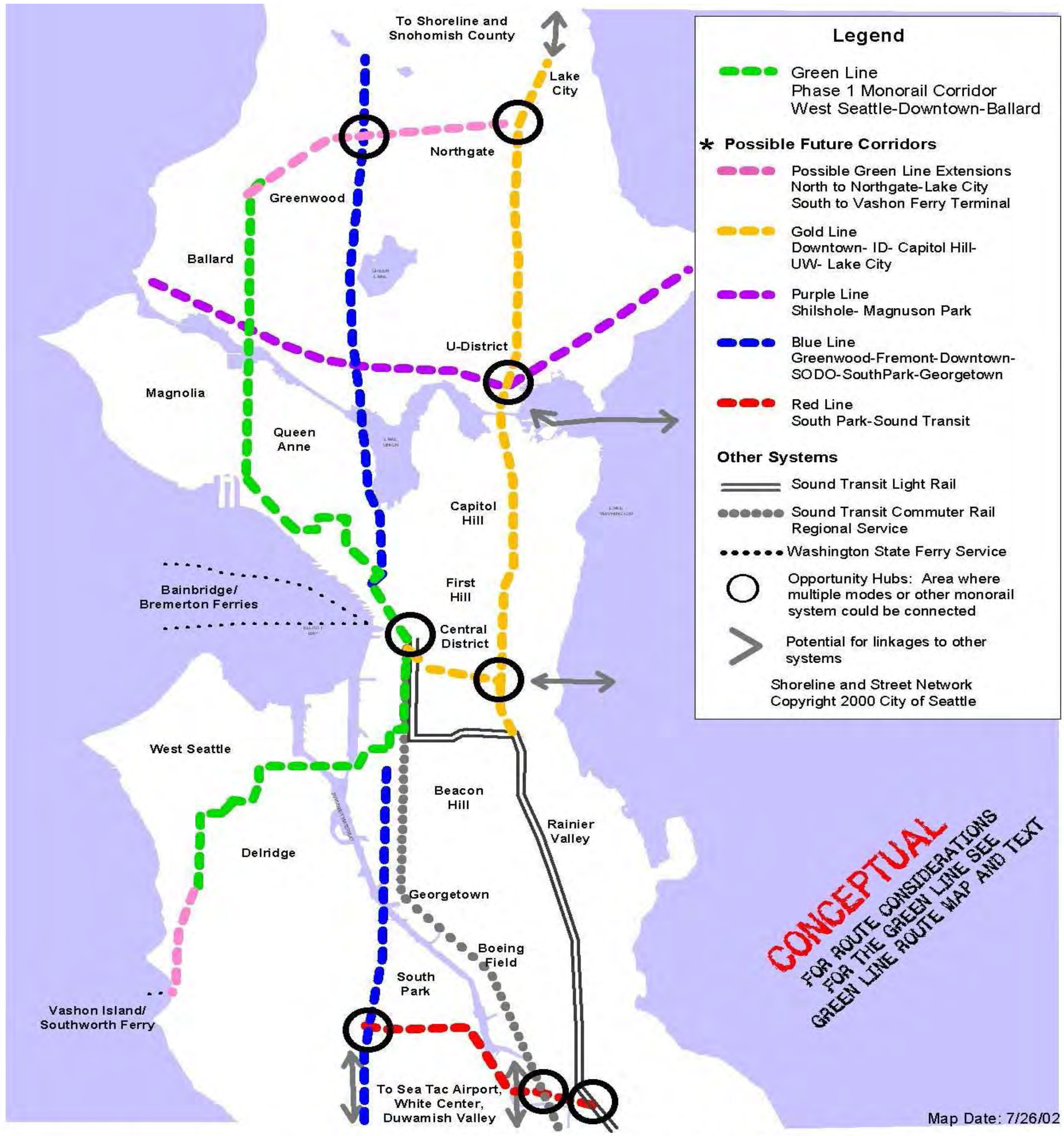
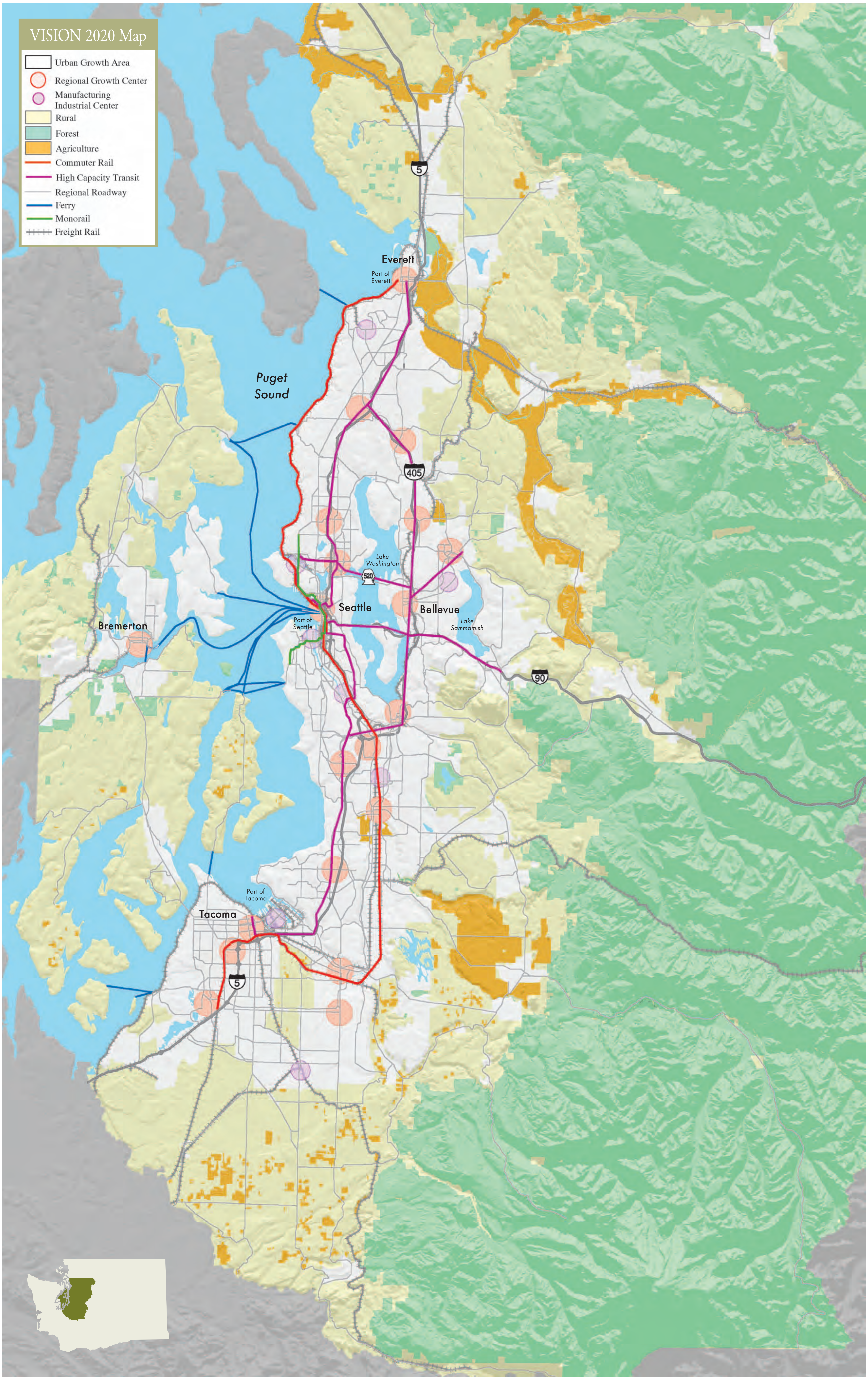
Electric Light-Rail Service
Electric light-rail trains in first ten-year plan. Dashed line indicates the portion of the light-rail system that will be built if additional funding is secured.
Commuter Rail Service
Trains using existing railroad tracks.
HOV Expressway
A continuous system of HOV lanes with special access ramps for transit and carpools.
Regional Express Bus Service
Express bus routes using the HOV Expressway, major arterials and expanded system of park-and-ride lots.
Potential Rail Extensions
Possible extensions of light rail, commuter rail or other technology.
Local Bus Service
Network of bus routes provided by local transit agencies.



*** Footnote: The specific location of future corridors and lines identified in the Plan is conceptual only, and may change over time as a result of future studies, public input, environmental review, and decision-making.**

SEATTLE MONORAIL PROJECT
Elevated Transportation Company A Seattle Public Development Authority

Citywide Map


VISION 2020 Map
Urban Growth Area
Regional Growth Center
Manufacturing Industrial Center
Rural
Forest
Agriculture
Commuter Rail
High Capacity Transit
Regional Roadway
Ferry
Monorail
Freight Rail
Everett
Port of Everett
Puget Sound
Lake Washington
Seattle
Bellevue
Port of Seattle
Lake Sammamish
Bremerton
Tacoma
Port of Tacoma
5
405
520
90

2.0 OVERVIEW OF LAND USE AND TRAVEL ASSESSMENT

The purpose of this assessment is to develop a framework to evaluate the land use and travel patterns in each study corridor to determine if high capacity transit services would be supported now or in the future. The assessment includes a review of land use and travel data compiled for existing conditions as well as future years (2010, 2020, 2030) based on Puget Sound Regional Council forecasts and local comprehensive plans. This section provides a description of the land use and travel characteristics that were evaluated and the methodology used to make a determination of relative support for HCT service within each corridor.

2.1 Land Use Characteristics Supporting High Capacity Transit

Land Use and Transit Connection

Multiple studies and experience in regions with high capacity transit indicate that travel corridors with a mix of different land uses at relatively high household and/or employment densities provide an excellent market for public transit (Puskarev/Zuppan 1977, Frank/Pivo 1994/95, Seskin/Cervero 1996, Newman/Kenworthy 1999, Hess/Moudon 2000, Cervero/Ewing 2001). In particular, land use development focused in clearly defined major activity centers (or central business districts) is a primary determinant of the success of a high capacity transit system. The more people that live and/or work in an activity center the greater the opportunity for encouraging high capacity transit use. A compact mix of land use activity helps to create an environment where people can rely on transit services to conduct essential trips, particularly commute trips. Land use characteristics that are important in supporting high capacity transit services and that are described in this section, include: 1) land use density, 2) mix of land uses, 3) pedestrian environment, and 4) parking supply and cost. *Appendix G* includes a complete list of sources and references.

Demographic / Land Use Data Inputs

To measure the level of land use activity, for both existing and future years, the study made extensive use of the Regional Council databases. For consistency, the demographic data variables were drawn from the Sub-County (Small Area) Forecasts. These are developed by Regional Council staff through a top-down methodology that incorporates a regional forecasting model known as STEP (Synchronized Translator of Econometric Projections) and a pair of land use allocation models, DRAM (Disaggregate Residential Allocation Model) and EMPAL (Employment Allocation Model). The final product is a database of base year (currently 2000) and forecast year (2010, 2020, and 2030) estimates of population, households, and employment for a zone system covering the four-county Central Puget Sound region.

The most recent update of the forecasts, released in December 2003 and revised in February 2004, was the version used in this study. Included in this release were actual Census 2000 results, along with an updated regional long-range (STEP model) forecast and an improved base year employment inventory. In addition, the current forecasts reflect changes made to improve the consistency between the forecasts and the updated growth planning targets adopted by King County in the summer of 2002.

For this study, the key inputs drawn from the Sub-County Forecasts were total population, households, and total employment. More information on how these variables are estimated is provided below:

- Total Population: The base year 2000 estimates were drawn directly from Census 2000 results, and include both household-based population, and people residing in group quarters. Future year forecasts of population from the PSRC models were evaluated versus the estimates provided by the Office of Financial Management, the agency responsible for developing the official population forecasts for growth management planning purposes, and found to be consistent.

- Households: Like total population, household estimates are taken from Census 2000 results initially, with the forecasting models predicting households as a function of demographic changes, including average household size.

- Total Employment: Initial year 2000 estimates were developed using the Regional Council's point-level database of Covered Employment in the region, developed in a partnership with the state Employment Security Department. From this database, factors are applied to estimate the 10-15 percent of jobs that are not captured through Covered Employment to arrive at Total Employment. A series of adjustments are then applied before imputing employment estimates into the model, of which the most significant is to drop the Resource/Construction sectors from the database, due to the difficulties associated with accurately estimating and forecasting the locations of these jobs.

Geographies Evaluated in this Study

The land use assessment reviewed existing and forecast land use characteristics on a corridor-wide basis and for a group of selected activity centers along each corridor.

Corridor Assessment. The corridor-wide assessment included a review of regional maps displaying data for population, household and employment densities, relative availability of automobiles per households, and continuity of the pedestrian and roadway network. The corridor assessment also involved research completed by the University of Washington that identifies clusters of residential development throughout the region (Moudon, 2003). These areas of concentrated population are referred to as "residential clusters." Residential clusters represent places that could help to support higher levels of transit services due to their relatively high residential densities and the existence of mixed-use development. *Appendix A* includes maps depicting the land use data that was compiled for the corridor assessment.

Activity Center Assessment. In addition to the general corridor-wide assessment, a more comprehensive land use assessment was conducted for a select group of major “activity centers” along the study corridors. The activity centers represent geographic areas where a large amount of the region’s land use activity either currently exists or is planned. The major activity centers analyzed in detail primarily include areas that have been identified by regional policy (i.e., “regionally-designated”) as focal points for future growth and as places where high capacity transit service should be provided to support desired land use changes. Twenty-three activity centers were selected for detailed evaluation. Of the 23 activity centers that were analyzed, 18 are regionally designated Regional Growth Centers, three are regionally-designated as Manufacturing / Industrial Centers, and two others are not regionally-designated growth centers, but are seen as potentially important transit markets in the identified corridors. See Figure 2.4-*Selected Activity Centers* for a map. Detailed information on density, mixed use, pedestrian environment, and parking was collected for each of the selected activity centers and is included in *Appendix C*.

Use of Land Use Forecasts. The structure of the Regional Council’s model supports the development of forecasts to a regional zone system, known as Forecast Analysis Zones (FAZs). From this 219-zone system, future year growth estimates are then split to a finer, Traffic Analysis Zone system comprised of 832 TAZs. Given that the DRAM/EMPAL models used to develop the FAZ level forecasts do not directly model land use designations, the forecast development process has always relied heavily on the detailed review of the results by local planners, and supporting land use capacity studies, to represent the impact of zoning and comprehensive plan designations. As such, there are a number of assumptions that are needed to apply the Regional Council forecasts to either specific areas, to geographies that do not correspond with FAZ boundaries, or when using the TAZ-level splits of the FAZ forecasts. It is strongly suggested that when using the forecasts prepared by the Regional Council, other sources of similar data, particularly data found in local or county comprehensive plans, should be considered.

For this study, estimates of future year forecasts in activity centers were made using the growth shown for TAZs corresponding roughly to the activity center. The growth rates in population, households, and employment were applied to the base year data assembled at Census block level, as a basis for estimating the growth that would occur in each center. While sufficient for initial planning work, users should recognize that the forecast data shown for the centers would not implicitly reflect the land use designations and policies that would impact how land in activity centers could develop differently than land in the rest of the FAZ or TAZ.

SELECTED ACTIVITY CENTERS FOR DETAILED EVALUATION - See Figure 2.4.

Regional Growth Centers: Seattle CBD, Bellevue CBD, Redmond CBD, Capitol Hill/First Hill, University District, Seattle Uptown, Northgate, Lynnwood CBD, Everett CBD, SeaTac CBD, Tacoma CBD, Federal Way CBD, Tacoma Mall, Lakewood, Tukwila CBD, Renton CBD, Totem Lake, Bothell/ Canyon Park
Manufacturing/Industrial Centers: Overlake, Paine Field, Port of Tacoma
Other major activity centers: Issaquah CBD, Dupont

2.1.1 Land Use Density

Many studies conducted over the past 25 years support the concept that higher population, household, and/or employment densities result in increased transit ridership (Puskarev/Zuppan 1977, Frank/Pivo 1994/95, Seskin/Cervero 1996, Newman/Kenworthy 1999, Hess/Moudon 2000, Cervero/Ewing 2001). These and other research efforts have found empirical evidence of a correlation between land use density and VMT reductions, fewer vehicle trips, lower auto ownership rates, increased walk trips, and increases in transit mode share.

Concentrations of residential development and employment have been found to be the most influential land uses determining whether a specific location has adequate land use activity to support high capacity transit services. A concentrated base of employment is an important land use variable in support of high capacity transit services. Job sites provide a regular daily destination at specific periods each day where frequent, high capacity transit service can be concentrated. Office employment provides opportunities for the greatest job-intensities and therefore the greatest ridership potential. Residential development provides a ready market for originating transit trips at peak periods and throughout the day.

Although the research is clear on the positive impact that land use density has on transit use, specific density thresholds are less definitive. Complicating the issue is that density is one among many factors that influence transit use and density can be measured in a wide variety of ways – gross vs. net density, small area vs. large area, combined land use activity vs. individual land uses. Additionally, the level of transit that is evaluated can include express vs. local services, all-day vs. peak-hour services, and other many other operational differences. For these and other reasons, the research does not identify a specific density number that can be said is necessary to support high capacity transit.

There is, however, a range of good research and experience that helps to provide a framework for evaluating the relationship between various density levels and support for high capacity transit. One study that looked at actual experiences in over 50 cities throughout the world (Newman/Kenworthy, 1999) found that densities of 100 people per hectare (40 people per acre) could support frequent all-day transit service. In a study conducted in the Puget Sound region (Pivo/Frank 1994), researchers found several density thresholds at which single-occupancy vehicle use drops and transit use increases. For major activity centers, significant transit ridership gains begin to occur when densities exceed 30 people (employees and/or residents) per gross acre and transit use expands most rapidly when densities exceed 45-50 jobs and residents per gross acre. A synthesis of research conducted for the Federal Transit Administration (Seskin/Cervero, 1996) documented additional studies with similar findings.

These and other studies were used to establish criteria for the designation process for Regional Growth Centers (*Designation Criteria for Regional Growth Centers and Manufacturing Industrial Centers*, adopted by the PSRC Executive Board June 26, 2003).

The Regional Growth Center density criteria calls for density targets that exceed 45 residents and jobs (total of both employees and population) per gross acre, which would be expected to be highly supportive of high capacity transit.

2.1.2 Mix of Land Uses

Mixed-use development refers to the variety of land uses that are in close proximity to one another. Taken together, a compact mix of land uses is where many different activities such as housing and jobs are clustered at relatively high densities within walking distance of each other. The key concept behind compact, mixed-use development is to create activity centers where a variety of daily activities are closely integrated rather than separated. Although less influential than density, increased mixed land use development patterns in activity centers have been found to have a positive relationship with decreases in vehicle miles traveled (VMT), lower automobile ownership rates, and increases in walking, biking and transit use (Rutherford/Wilkinson 1996, Seskin/Cervero 1996, Cervero/Ewing 2001).

Successful high capacity transit locations generally support service throughout the day—off-peak periods as well as peak periods. Ideally, a transit station area serves both as a destination (such as an employment location) and as a point of origin for trips from nearby residential development. Different transit station areas can successfully support high capacity transit with a mix of land uses, including employment, residential, commercial retail, public or civic uses, and recreational uses.

It is not necessary for activity centers to contain both jobs and housing in order to reduce auto use and support increased transit ridership. Dense employment in itself will generally increase transit mode shares. However, the synergy of associated land use activities will often have a beneficial effect on transit ridership levels. Non-residential uses (shops, restaurants, banks) are cited as supporting greater off-peak transit use as well as peak-period (commute trips) transit use because access to a car is not needed for trips during the workday. Residential uses in activity areas are beneficial because household activity also supports non-work transit use and residents help to support commercial activity.

2.1.3 Pedestrian Environment

Promoting walking opportunities by creating an attractive pedestrian environment is important for supporting high capacity transit services. Because high capacity transit generally serves dense activity centers, many of the riders will access the system by walking. In pedestrian-friendly areas, land use activities are designed and arranged in a way that emphasizes walking and biking. The factors that encourage people to walk are often subtle, such as building orientation and weather protection, but should generally focus on creating clear and safe paths for pedestrians. To achieve pedestrian-friendly design, the circulation network should serve as the framework for placing and orienting buildings and creating pedestrian routes. Clear, formalized, and interconnected streets and small blocks make destinations visible and easier to access. They also provide the shortest and most direct route for pedestrians and bicyclists. Research has found a strong relationship between the existence of dense, well-connected street networks and a greater pedestrian activity and transit use (Moudon/Hess 1999, Crane/Crepeau 1998, Cervero/Kockelman 1997).

2.1.4 Parking Supply and Cost

Actively managing the parking supply in geographic areas where transit is available is an excellent way to encourage the use of alternative modes of travel—including transit. Large parking lots can be barriers to pedestrians, while on-street parking can provide a buffer between pedestrians and the road. Parking costs also have a significant impact on whether people decide to drive or use transit. Shifting the cost of parking from the employer or retailer to the vehicle driver can significantly reduce driving and increase transit use. To encourage transit use, preferential parking rates can be given to short-term parking and higher rates charged for all-day parking. The relationship between parking cost/supply and transit use is well established in transit operations (Wilson/Shoop 1990, Bianco/Mildner/Strathman 1997, WSDOT 1999).

2.2 Travel Pattern Characteristics Supporting High Capacity Transit

Success in attracting riders depends on more than the quality and frequency of service provided, regardless of modal type — be it bus, bus rapid transit, light rail, or heavy rail. To be successful transit should be competitive with the automobile; attract choice riders; and be cost-effective. Competitive transit service does not necessarily mean that travel times must match auto travel times. A variety of factors will define whether transit service is competitive, including parking supply, travel times, congestion, and other variables that influence travel choices.

Below are the travel pattern characteristics that were identified as important in evaluating high capacity transit needs within the study corridors. *Appendix B* includes maps and data tables with travel forecasts for each of the travel characteristics based on Puget Sound Regional Council travel demand model. The travel pattern assessment for each study corridor was based on existing and forecast travel characteristics throughout the 30-year time period (2000-2030). The travel data was compiled by geographic sub-areas, corridor screenlines, and by travel to activity centers (represented by Forecast Analysis Zones). Below is a general description of these geographies and measures used to relatively assess the level of support for high capacity transit service in each corridor.

2.2.1 Travel Flows across Major Screenlines

Screenlines represent a geographic “line” that measures travel across a number of transportation facilities along a given corridor. Travel across selected screenlines was evaluated to determine more specifically where travel flows are focused within each corridor and where volumes are highest. For each corridor 2-3 screenlines were selected and forecast data was collected for each. Data for each screenline includes total, peak, mid-day person trips by mode – transit, high-occupancy vehicle (HOV), and single-occupant vehicle (SOV).

For the major screenlines in each corridor the following data was compiled: total daily person trips, percent of daily person trips made during peak periods, percent of a.m. person trips made by public transit, percent of a.m. peak carpool/vanpool trips in the dominant direction, and total peak hour transit person trips per hour per direction (pphpd) in the morning peak. The total peak hour transit person trips per hour per direction (pphpd) was calculated as an indicator of the transit capacity needs in each corridor. The highest pphpd that was calculated in each corridor was used to establish the level of demand forecast for future years. Peak period ridership, specifically in the peak 60 minutes, is an important determinant of long-range transit capacity and service requirements. In estimating pphpd, a factor of 43 percent was used to convert the 3-hour peak to a one-hour peak (peak of the peak). This factor is based on existing patterns of transit ridership in the region and commonly found in other cities in the U.S.

The screenline pphpd data cannot be directly compared to the line-haul capacity calculations that were generated for each of the potential HCT technologies in Section

3.0. Screenline data can only be used to generally define overall transit demand in each "corridor." The screenline data represents travel on all facilities that pass across a given screen line. For example, the Crosslake screenline includes both SR-520 and I-90, while the North Corridor screenline includes I-5, SR-99, and a number of arterials running north/south between Seattle and Shoreline.

Travel model forecasts reflect the following peak-level transit demands across selected screenlines in each of the four study corridors for 2000 and 2030:

- Crosslake Corridor – 2,175 people per hour per direction (pphpd) (2000) - 5860 pphpd (2030)
- North Corridor – 3,500 pphpd (2000) - 9150 pphpd (2030)
- South Corridor – 2,077 pphpd (2000) - 3,780 pphpd (2030)
- Eastside Corridor – 942 pphpd (2000) - 3,730 pphpd (2030)

Satisfying the demand across a screenline could be accomplished with a variety of services on multiple routes. Therefore it is difficult to eliminate any specific technology because it does not have a calculated line-haul capacity equal to the projected screenline demand. The line-haul capacity calculations are most useful in comparing the relative capacity of each technology under consistent assumptions. For example, heavy rail has a very high potential capacity while personal rapid transit (PRT) and people-movers have relatively low line-haul capacities. These latter two systems are not geared toward serving single high "mass transit" demand alignments but are better used for serving demands spread across multiple alignments.

2.2.2 Travel Flows between Origins and Destinations

Travel flows between major subareas within each corridor were assembled to evaluate trip origins and destinations. The origin and destination data was compiled for total daily person trips and for peak hour person trips. Data was further broken down by auto person trips and transit person trips. Origins and Destinations were broken down as follows: 1) Subareas – 6 subareas in the region, two-three subareas in each corridor, 2) Districts – 19 districts in the region, five-eight districts in each corridor, and 3) Forecast Analysis Zones (FAZ) – over 200 FAZs in the region.

The region is divided into 6 "sub-areas" that are used for a variety of analysis purposes. For this study, the sub-areas were used to evaluate origin and destination patterns within the study corridors. A primary measure was the number of total person trips originating in a sub-area and destined for another sub-area within the corridor. The origin/destination data between sub-areas was compiled for total daily person trips, for peak hour person trips, auto person trips, and transit person trips. Travel destination data was further broken down by Forecast Analysis Zones (FAZs) that correspond with the selected activity centers evaluated in this study. The data collected for activity centers included the number of total person trips that would be destined for each activity center during the a.m. peak travel period. In conjunction with the land use data for each center this provides a good indication of the relative size of each center related to expected travel demand.

Park-and-ride data was also compiled by sub-area, including the total number of stalls (existing and planned) in each corridor. Park-and-ride facilities and feeder bus services to transit stations expand transit's catchment area, thereby potentially increasing patronage. Data compiled for park-and-ride lots includes total existing and planned stalls within the region. This data base was prepared as part of a Washington State Department of Transportation Puget Sound Park-and-Ride System Update (February 2001). In *Appendix B,* a map shows specific locations of existing and planned park-and-ride capacity and an accompanying table displays the total number of stalls by subarea.

2.2.3 Vehicle Volumes on Major Facilities within each Corridor

Existing levels of transit service is an indicator of where future service will also be needed. Data was compiled for current (2003) transit vehicle volumes along major routes for both local services in the a.m. peak and mid-day as well as express services in the a.m. peak and express services at mid-day. In addition, total daily volumes (transit, high-occupancy vehicles, and single-occupancy vehicles) on major roadways represent the total volume of vehicle travel for 2000 and projected for 2010, 2020, and 2030. Total vehicle volumes on major facilities helps to understand the relative travel demand on individually facilities across the selected screenlines. The combination of screenline data and vehicle volumes provides an important picture of travel demand within each of the study corridors.

The level of congestion on roadways can also indicate travel connections where transit services can be supported. *Appendix B* includes maps depicting proposed level of service (LOS) standards for the region’s roadways and the facilities that exceed those standards during peak periods. The maps indicate that all of the major transportation routes within each of the study corridors generally exceed the adopted LOS standards during the p.m. peak period.

2.3 Methodology for Assessing Land Use and Travel Characteristics

To evaluate the large volume and wide variety of land use and travel data, land use and travel indicators were identified and used as part of the evaluation. The indicators were established based on a combination of national research, experience in this region, and professional judgment. The selection of indicators was also influenced by the availability of data for current conditions and future years. The indicators provide a point of comparison to evaluate the relative ability of each activity center and corridor to support high capacity transit based on key land use and travel characteristics.

For both land use and travel, a single "primary indicator' was identified as well as a number of 'secondary indicators'. The primary indicators represent critical measures of activity that would indicate support (or lack of support) for high capacity transit that can be objectively measured for different time periods (2000, 2020, and 2030). The secondary indicators were determined to be either less influential in supporting high capacity transit or data was not as readily available to measure and compare future years. Regardless of their influence or data availability, all indicators were considered to some extent in the evaluation.

The individual indicators are not meant to be minimum requirements that must be reached for an activity center or corridor to support high capacity transit. Evaluating support for high capacity transit is based on a range of factors, all of which are dependent on each other and/or interrelated. For example, increases in densities tend to vary with increases in mixed-use development, higher parking costs, and decreased parking availability. Meeting or exceeding one or more of the established indicators is one way to objectively access how well an activity center (and corridor segment containing activity centers) could likely support high capacity transit now or in the future.

There is no magic number in any of the research in which high capacity transit becomes "supportable". Therefore, the indicators were considered along with other available data and information to make professional judgments. The primary and secondary indicators that were considered in the land use and travel assessment for each activity center and study corridor are described below. The actual measures for these indicators are included in *Section 4.0 Assessment of High Capacity Transit Corridors*.

Land Use Indicators

Primary Indicator

Land use densities play a strong role in determining whether a geographic area can support high capacity transit. As discussed above, densities within activity centers, in particular, have an enormous impact on mode choice. Residential and employment densities have the most significant influence on transit use and can be relatively easily measured for both existing conditions and future years.

A range of 30-45 residents and jobs (total of both employees and population) per gross acre was established as a primary land use indicator to evaluate the relative intensity of land use in each activity center. Activity centers that include a combination of between 30 and 45 residents and jobs per gross acre were credited with having sufficient densities to support some form of high capacity in the future. Activity centers with forecast densities that exceed 45 people and jobs per gross acre were generally considered to have land use densities that would be highly supportive of high capacity transit. This land use density indicator is consistent with the adopted Puget Sound Regional Council criteria for regionally-designated Regional Growth Centers (adopted June 26, 2003).

Based on existing land use, ten of the 23 major activity centers evaluated would meet or exceed this density range. Four activity centers currently have population/job densities that fall within the indicated range and six activity centers exceed 45 residents and/or jobs per gross acre. Based on land use forecasts, four centers would fall within the density range and 11would exceed the range by 2030. Details for each activity center are included in *Section 4.0* and *Appendix C* of this workbook.

Secondary Indicators
As described above *(2.1 Land Use Characteristics Supporting High Capacity Transit),* there are a number of other land use characteristic that have a strong correlation with transit mode choice and the ability to support high capacity transit. Below is a list of measures and a brief description of indicators that were used to assess transit-supportive land use characteristics.

- Ratio of jobs per households within activity centers – Indicates whether an activity center has an adequate balance of jobs to households. An activity center with a comparatively high or low ratio may not have an appropriate mix of land uses. Data is available for current and future years.
- Total residential base within an activity center – Indicates whether a center has a sufficient quantity of residential land use activity to support all-day transit travel and associated commercial/recreational opportunities within an activity center. Data is available for current and future years.
- Average block size within an activity center – Indicates the existence of a dense network of connected public streets. Small block sizes can minimize pedestrian travel distances and are generally supportive of walking and transit trips. Data is only available for existing land use but can be generally assessed for future years based on local plans.
- Supply/costs of parking within an activity center – Indicates relative ease and convenience for driving. Limited supply of cheap, all-day parking is a good predictor of high transit use. Data is available for a limited number of activity centers and only for current conditions. The future is generally assessed based on local plans, parking requirements for new development, and forecast densities.
- Number, location, and density of residential clusters along a corridor – Indicates concentrated points of relatively high population densities outside of the selected activity centers. These clusters would complement land use activity in centers and can indicate where there are opportunities for higher than average transit usage. Data is available for current and future years.

Travel Pattern Indicators

Primary Indicator
The existence of a major central business district that attracts trips from many locations throughout a region is considered an important influence on need and support for high capacity transit. The Seattle CBD serves this purpose in the central Puget Sound region. In addition, it is important to have other major destinations that will attract a significant number of riders each day to support the HCT system. Riders attracted to and originating from multiple locations will help to support high levels of both peak-hour and all-day transit services. The other selected activity centers that were evaluated serve this purpose.

Major activity centers are expected to generate (origination) and attract trips (destinations) throughout the day. Because the selected activity centers are primarily job centers, the greatest ridership potential will be for employees coming to work in a.m. or leaving work for home in the p.m. Based on experience in other regions, to support frequent, high capacity transit service (5-10 minute headways), approximately 1,000 to 10,000 peak-hour transit passenger trips would be needed in a given transit market (TCRP, 1999). The more successful high capacity transit markets generally support between 5,000 to 7,500 transit passengers during the peak travel period. These markets could be served by a single station or a group of stations serving a concentrated destination. Assuming a 25 percent mode share, these transit markets would need to attract between 20,000 to 30,000 a.m peak-hour person trips in order to generate this type of ridership.

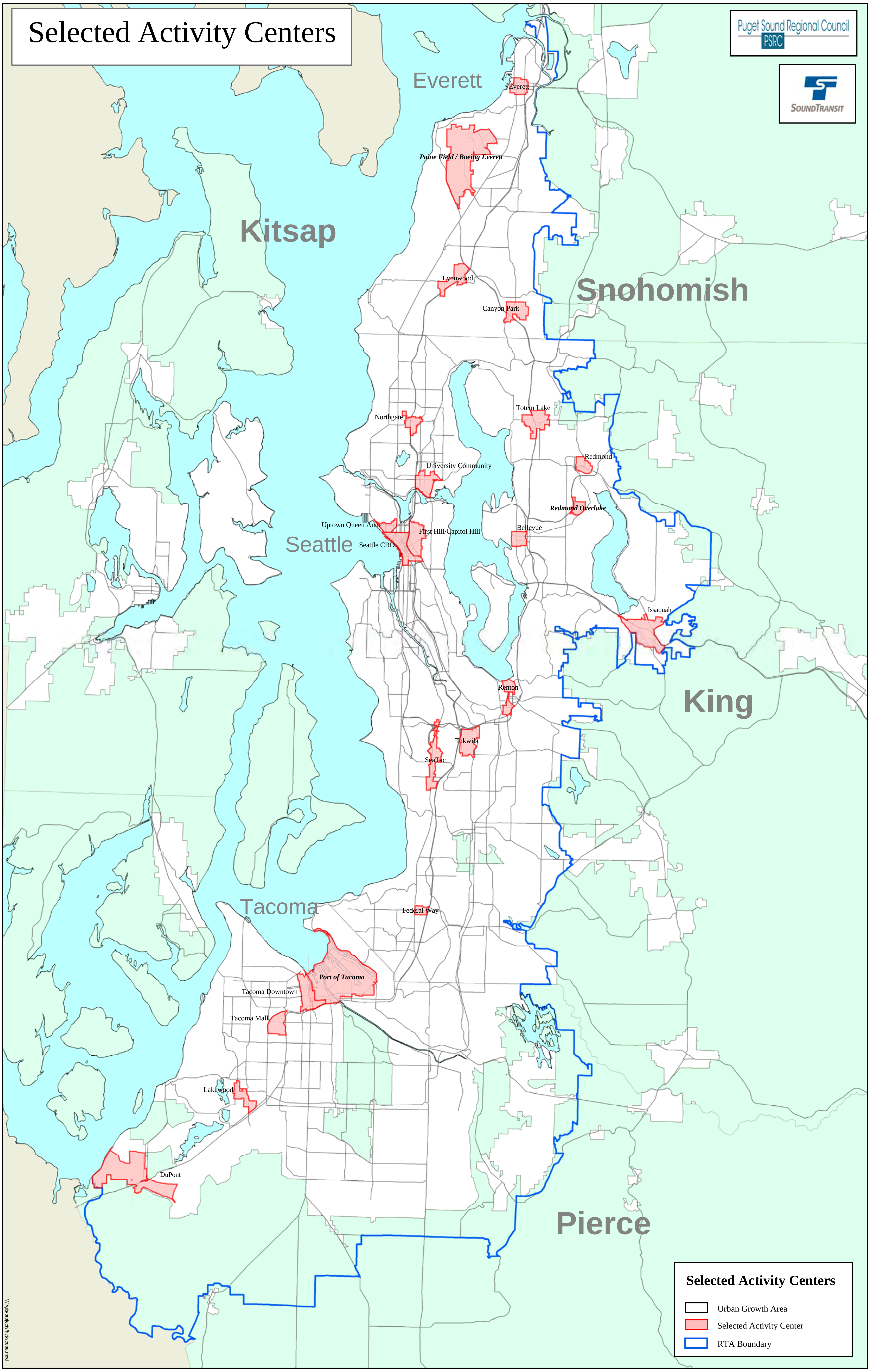
A range of 20,000 to 30,000 total a.m. person trips destined for a given activity center was established as an indicator of moderate support for high capacity transit services. Activity Centers that attract more than 30,000 total a.m. person trips were generally considered to support a high level of service. Based on current travel demand, 7 of the selected centers fall within the established range and 8 others exceed 30,000 total a.m. person trips. Travel demand forecasts indicate that 20 of the 23 selected activity centers will meet or exceed the range by 2030.

Secondary Indicators
Other indicators of sufficient travel demand to support high capacity transit were also considered.

- People per hour per direction (pphpd) for a.m. transit person trips within a corridor – Indicates the level of transit demand within a broadly defined corridor as measured across a selected screenline. Data is available for current and future years.
- Travel flows (transit trips and total person trips) between major sub-areas within a corridor – Indicates origin and destination of trips within a corridor during peak and off-peak travel periods. Data is available for current and future years.
- Park-and-ride supply within a corridor – Indicates potential collection points for attracting additional transit ridership in locations where land use densities and

connecting feeder transit services are low. Data is available for current conditions and for estimates of future demand based on a WSDOT study completed in February 2001.

- Level of congestion on major roadways – Indicates connections where transit priority treatments can provide transit with a competitive advantage to auto use. Data is available for current conditions only.



Selected Activity Centers
Puget Sound Regional Council
PSRC
SOUNDTRANSIT
Everett
Kitsap
Snohomish
Seattle
King
Tacoma
Pierce
Everett
Paine Field / Boeing Everett
Lynnwood
Canyon Park
Totem Lake
Northgate
Redmond
University Community
Redmond Overlake
Uptown Queen Anne
First Hill/Capitol Hill
Bellevue
Seattle CBD
Issaquah
Renton
Tukwila
SeaTac
Federal Way
Port of Tacoma
Tacoma Downtown
Tacoma Mall
Lakewood
DuPont
Selected Activity Centers
Urban Growth Area
Selected Activity Center
RTA Boundary

3.0 SURVEY OF HIGH CAPACITY TRANSIT TECHNOLOGY OPTIONS

There are a variety of high capacity transit technology options that have evolved in response to a diversity of local needs and preferences, and no one technology is appropriate for every application. Ideally, each transportation technology is applied where it is most effective. However, other factors must be considered such as compatibility between services, risk management, and impacts on a community. These complex set of factors should be considered in the process leading to the selection of a specific transit technology.

This chapter outlines the methodology that was used to analyze a range of alternative high capacity transit technologies. The purpose of this analysis is to 1) identify pros and cons of each technology based on system-wide needs, and 2) narrow the range of technologies to be carried forward to the corridor level analysis. The analysis is presented in three sections:

- Section 3.1 describes the technology characteristics that were evaluated and the indicators used to assess whether a technology will meet regional needs,
- Section 3.2 includes the evaluation of each technology, and
- Figure 3.3-*Summary of Technology Options & Characteristics* consolidates the analysis for each technology in a matrix for a quick reference and comparison among the different technologies.

Additional information on the various technologies is available in *Appendix D*.

3.1 Characteristics of Technologies Evaluated

Many characteristics were considered in evaluating HCT technologies appropriate to meet system-wide transit needs. Nine primary characteristics were identified to analyze each technology – 1) capacity, 2) speed, 3) station spacing, 4) typical headways, 5) system integration, 6) land use, 7) implementation risk, 8) schedule reliability, and 9) right-of-way requirements and profile. Three other characteristics are discussed, but they were not considered for each individual technology – universal access, marketing & branding, and capital & operating costs.

In addition to the primary characteristics evaluated, the following issues were considered throughout the analysis. These issues are consistently identified in passenger surveys as being of primary importance to transit riders:

- Travel times (the time needed to complete a journey)
- Reliability (passengers' expectations that their trips begin and end as scheduled)
- Comfort/capacity (there is sufficient seating or standing room; station sites are maintained and safe, the ride is smooth, and a comfortable environment is provided)

Capacity

The ability of a transit technology to carry forecasted passenger demands is an important consideration. There are two important ways to measure the capacity of a given technology: 1) line (or line-haul) capacity, and 2) point capacity. Line capacity measures the ability of a transit technology to carry passengers through a corridor and is generally expressed in "people per hour per direction" or pphpd. Line capacity is calculated based on the capacity of the vehicle(s) and how often the service operates. In addition to line capacity, point capacities are also important to consider. Point capacity reflects the ability of a given technology to carry forecasted riders through a constrained "point" or location in the corridor. Most point capacity constraints are realized in densely developed activity centers where it may be difficult to maintain headways because of congested conditions. For this evaluation, line capacity was considered in detail. Point capacity constraints need further analysis of operating conditions in activity centers. Some point capacity issues have been identified for further analysis in the *System Integration* section of the chapter.

Calculated Line Capacity

The calculation used to develop line-haul technology capacity numbers is listed below.

(Persons Per Car)
(Cars Per Train)
X (Trains Per Hour)
____
People Per Hour Per Direction

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The calculated line capacity indicates a theoretical range of people per hour per direction (pphpd) for the maximum seated and maximum standing alternatives for distinct vehicle sizes and train lengths. These capacity numbers were compared against the low and high-end screenline pphpd travel demand numbers forecasted for specific corridors. It is important to note that the screenlines used to estimate future capacity demands include a number of transportation facilities and, therefore, reflect demand across a number of "lines" or potential alignments. A HCT technology could potentially operate on one or more of these lines based on corridor needs and the technology selected. This issue needs to be considered where comparisons are made between screenline capacity demands and calculated line capacity.

Calculated line-haul capacity is not meant to define the potential maximum capacity of a particular technology. The purpose of the calculated line-haul capacity is to provide comparative levels of capacity that can be achieved with each technology given consistent assumptions. For this analysis a line-haul capacity was calculated based on a fixed headway (4 minute) and fixed train lengths (2 and 4 car train sets or bus platoons). Higher line-haul capacities could be achieved with more frequent headways and/or larger train sets (or bus platoons). On the other hand, lower capacities would be achieved if assumed headways and/or bus platoon operations could not be maintained because of congestion or other operational line-haul constraints.

Desired System Characteristics

The region's plans and policies encourage development in regionally-designated urban centers. HCT technologies must provide ample capacity to meet the demands created by the dense centers and suburban clusters included for each corridor in the land use analysis. For each corridor a theoretical line capacity was calculated. Each corridor has very different line-haul capacity needs. For 2030, the transit travel demand forecasts range between 3,500 pphpd to 9,000 pphpd depending on the corridor. This capacity range was considered in evaluating the potential application of the technologies in each corridor.

Selected Indicators

Seated and standing capacities for individual train cars and/or buses were gathered for specific systems as representative samples for each technology type. These specific systems were selected based on whether the technology is already operating within the region or whether the systems have the capability to be implemented in the region. A line capacity was calculated for each technology based on the number of cars per train and the number of trains traveling along a route within an hour based on an assigned headway. The calculated line capacity (expressed in people per hour per direction) was compared with the capacity forecasts in each corridor.

Operating Speed

Different technologies have varying travel speeds when climbing grades, carrying heavy loads, turning through a curve, or traveling in shared facilities. The analysis focused on maximum speed and average speed to indicate potential trip time. The day-to-day operating speeds of a transit system are determined by many factors, not solely by the capability of the specific technology used. The ability to accelerate rapidly and smoothly after a stop will reduce trip time. This becomes less important as the number of stops per miles of travel is reduced. With fewer stops the maximum speed becomes increasingly the determining variable for total trip time.

Desired System Characteristics
A regional high capacity transit system needs a transit technology that can generally compete with automobile travel on the region's roadways. A region with diverse land use intensities requires a flexible system that can operate at high average speeds in areas with fewer stations such as low-density suburban locations and slower average speeds in areas with many stations such as dense, urban locations. A system of this nature does not necessarily benefit from dramatically faster maximum speeds, it requires quick acceleration and deceleration characteristics which result in improved average operating speeds.

Selected Indicators
In evaluating regional needs, it was estimated that the vehicle should be able to achieve maximum travel speeds of at least 55-65 mph. In urban corridors with many stations, technologies would need to maintain average operating speeds of between 25-35 mph to be generally competitive with auto travel. Numbers provided in the discussion were developed as part of a larger review of related literature. A comparison between sources revealed generally accepted numbers for speeds as assigned to each technology.

Station Spacing
Identifying the distance between stations is an important element of balancing between operational efficiencies and accessibility for any transit system. Widely spaced stations allow for more distance to be covered within a shorter period of time and are appropriate for long commute trips, but longer distances can reduce the number of passengers that have access to the system. Closely spaced stations are more likely to gather more ridership due to improved localized access along an entire corridor, but they increase the overall trip time for longer rides.

Different transit technologies require different station types according to the train size, the number of riders using the system, the level of grade separation, and the services and amenities provided. The starting point of a transit trip determines the delay time for the vehicle and the number of people that can be boarded within an acceptable dwell time. Small stations tend to be associated with fewer boardings at more points of access throughout a wider geographic area having few amenities with fares collected on boarding or alighting. This end of the spectrum is vastly different from the multi-modal station with escalators, elevators, off-board fare sales and collections, benches, art, landscaping and spacious buildings with bicycle lockers and adjoining park-and-ride lots. These large stations have capacity for thousands of passengers. There are many intermediate steps between these two extremes, with varying capital and maintenance costs, community impacts and marketing options.

Desired System Characteristics
The Central Puget Sound is made up of a diverse group of communities. There are larger cities with dense, walkable, mixed-use locations where less space is available for station size and pedestrian and bicycle accessibility is particularly important. There are more widely dispersed growth centers targeted for such development in order to focus growth within the urban growth boundary. There are also suburban areas with lower densities,

less walkable environments, and more dispersed land uses. In addition there are suburban clusters with high residential densities but physical barriers in the community that limit local mobility.

In the development of a large regional system a balance must be found between operational efficiency and accessibility. With such a diverse group of communities it is important to consider technologies that are flexible enough to accommodate a diversity of station types. In order to cover the large regional geography it is important to have longer distances between stations in areas that are unlikely to attract significant growth and shorter distances between stations in areas targeted for densely developed land use growth.

Selected Indicators
In order to measure the flexibility of each system the range of distances between each station is provided for each technology. Some system types can accommodate a variety of station types and distances where others tend to require only large widely spaced stations. In evaluating station spacing, it was found that the technology should be able to accommodate distances ranging from roughly one half mile for improved accessibility and two miles for increased speeds and travel time for longer trips. The numbers provided were developed as part of a larger review of related literature. A comparison between sources revealed generally accepted numbers for station spacing as assigned by technology.

Typical Headway
The frequency of transit trips, or headways (minutes between trips), impacts total travel times in two ways. First, travelers must often schedule their trips to arrive at their destination at a particular time. Work, personal appointments and school trips are all examples of time sensitive arrivals. Infrequent headways often require travelers to arrive early to avoid being late. When calculating travel time comparisons with auto trips, one half of the headway is often added to the total when projecting transit ridership. Second, the out-of-vehicle time between transfers is increased when the connecting trips are infrequent.

Frequencies also in part determine the passenger capacity of a particular technology. More frequent trips with fewer seats can provide transportation for as many people as one larger infrequent vehicle. The specific headway (time span) between trains and passenger waiting time should be carefully evaluated because it impacts many issues, such as car fleet quantity, energy cost, and acceptability of vehicle designs.

Desired System Characteristics
A regional system with more frequent transit service provides convenience to the traveler as attention to route schedules becomes less necessary and transfers become less onerous. The selected system should be flexible enough to provide high frequencies throughout the day for densely developed areas, high frequencies for long peak hour commute trips, and acceptable frequencies for all day service.

Selected Indicators
In evaluating regional needs related to typical headways, four-minute headways were selected as a high-end measure of peak performance and 15-minute headways were selected as a low-end benchmark from which to evaluate the different technologies. The assessment is further complicated by the fact that each technology has a different number of cars or buses and those with a large capacity may not be efficient at high frequencies. The numbers provided were developed as part of a larger review of related literature and an assessment of headway standards for different systems already under development or operational within the region. A comparison between sources revealed manufacture suggested headways for each technology.

System Integration
Technologies should be capable of providing convenient and seamless passenger connections and transfers to currently operating or planned regional transit technologies within the corridor. Current regional technologies include: commuter rail, light rail, express bus, local bus, monorail, and ferry services. In addition, the technology should have the capability to accommodate access to the system from the full range of travel modes, including: foot, bicycle, auto, and transit feeder systems.

A deterrent for taking transit is a need for the passenger to transfer under uncertain conditions. Vertical or horizontal spatial separations of trip links will reduce the number of travelers willing to use a transit system. This is exacerbated by out-of-vehicle waits, and if combined with inconveniences such as a need to walk long distances or climb stairs to complete the next portion of the trip, transit usage may be significantly reduced. Transfers increase the time needed to complete a trip, with out-of-vehicle time perceived by passengers as at least double an equivalent travel time. System integration impacts can be associated with technologies that are forced to mix with traffic, but the street level operation also provides improved accessibility. The ability to share rights of way and/or station locations can reduce costs and community impacts. The primary purpose of evaluating technologies based on this characteristic is to determine how effectively the system will integrate with existing investments in transit systems.

Desired System Characteristics
Transit system integration and the ability to serve constrained geographic settings are particularly important measures for systems developed in the central Puget Sound. The recent investments in light rail and monorail have highlighted the need to develop multi-modal hub locations due to the constrained land pattern associated with downtown Seattle. Existing transit system investments for the Puget Sound area will need to be integrated with any new technology. These investments include the extensive express bus and direct-access HOV lane system, Central Link light rail line, Sounder commuter rail, the intermediate capacity monorail system within Seattle, and other local bus systems. Seamless passenger connections will be required, particularly in high-density locations. The 1999 Downtown Seattle Surface Report describes some of the integration challenges in Seattle’s CBD.

Selected Indicators
A variety of measures must be considered in determining whether a system will be able to integrate with other transit systems and how it will impact auto, pedestrian, and bicycle mobility. A number of conditions were considered in determining whether a system would be able to handle the constrained north-to-south oriented geography, travel patterns, and existing investments in transit facilities and services within the region. Primary considerations among these conditions were 1) whether the technology can directly and seamlessly interline with existing and planned transit technologies within the region, and 2) whether the technology is likely to have the capability to overcome physical barriers in areas with varying densities and land use characteristics.

Land Use
Technologies should have the capability to support local land use development plans, especially within defined urban activity centers that are directly served. Generally, activity center plans call for significant increases in dense, mixed use, and pedestrian-friendly land use development patterns. The technology must be appropriate for supporting these land use patterns and providing direct service to major concentrations of development within activity centers. Additionally, the movement of people through a region can impact land use patterns. Some systems are more appropriate for addressing trips between widely dispersed activities where others are more appropriate for service to more intensive urban locations. Transit technologies should have operating characteristics that encourage more intensive development in targeted station locations that in turn supports additional ridership.

Desired System Characteristics
The central Puget Sound region has established a policy to encourage mixed-use development, increase densities, incorporate pedestrian friendly design, and focus transportation improvements in designated growth centers.

> "RG-1 – Locate development in urban growth areas to conserve natural resources and enable efficient provision of services and facilities. Within urban growth areas, focus growth in compact communities and centers in a manner that uses land efficiently, provides parks and recreation areas, is pedestrian-oriented, and helps strengthen communities. Connect and serve urban communities with an efficient, transit-oriented, multimodal transportation system." (VISION 2020, adopted May 1995)

In keeping with this policy, each technology was evaluated based on their ability to support the development of these centers. Technologies should provide direct service to major concentrations of development within these activity centers and link the centers while providing much needed travel options. The centers, in turn, should provide densities needed to make HCT a successful venture. Stations and their locations are the site of major capital expenditure, signaling to developers a long-term commitment and stability of the transit option. Major stations will have the greatest influence on attracting development and help to further transit-oriented development. The implementation of the preferred HCT will ultimately include stations of sufficient size to benefit from and further transit-oriented development.

Selected Indicators

The evaluation considered the ability of a system to respond to changing land use patterns and address urban locations with high travel demand. The influence a transit system has on land use was a more difficult characteristic to evaluate. A number of indicators were selected to determine the relative support each technology offers for planned land use. These include: 1) whether the technology has the capability to provide a high degree of non-automobile accessibility in areas with planned high-density development, 2) whether the technology will support adequate volumes to encourage the development of mixed-use, pedestrian-friendly urban environments, and 3) whether the perceived permanence of the station facility would be adequate to attract private investment.

Implementation Risk

Transit agencies that choose to implement an unproven technology are taking a significant risk. Risks include the inability to deliver the system, costs exceeding estimates, disappointing final performance, and/or inability to maintain or replace equipment. To minimize risk, a technology must provide a clear functional benefit unmet by existing systems, such as the ability to provide travelers with increased safety, reliability, or fewer impacts. In addition, a proven supplier must be making a significant investment to assure parts, supplies, and equipment are available at competitive costs.

Desired System Characteristics

The constrained geographies and large bodies of water contribute to an extremely high cost for constructing major transportation projects in the central Puget Sound region. Wise use of public funds dictates that the selected HCT system should be well tested, meet transit demand far into the future, and be expandable.

Selected Indicators

A variety of indicators help in determining the implementation risk of a particular technology. The following were considered in this analysis: 1) whether the technology has been successfully implemented within the region, 2) the track record of successful implementation in other regions, and 3) whether there are a number of established suppliers that can easily accommodate additional orders and parts replacements for each technology.

Schedule Reliability

Travel in mixed traffic results in transit being slowed by congestion and schedules becoming difficult to maintain. Transit is slowed by mixed traffic but must also stop frequently to load and unload passengers and collect fares, merging in and out of traffic. Schedule reliability is degraded by these and other factors, increasing travel times as well as often missing scheduled arrival times.

Desired System Characteristics
For a system to work effectively in this region a balance needs to be struck between operating speed and accessibility. A system that mixes with traffic will have longer travel times, but for a technology to operate at higher speeds it will require costly exclusive right-of-way (ROW).

Selected Indicators
Conditions that were considered in the analysis were 1) whether the technology mixes with traffic or operates on a dedicated running way, 2) whether the technology will mix with freight on existing rail lines, and 3) the potential for operating characteristics such as automation or signal prioritization that can improve scheduling issues.

Right-of-Way Requirements and Profile
Right-of-way acquisition is the single most costly factor in the implementation of most transportation projects, in terms of dollars and community impacts. In addition to the loss of land and the creation of impassable corridors, transit infrastructure can greatly reduce the space available for other uses and can create barriers within a community.

Desired System Characteristics
The HCT options that have the fewest needs for right of way or provide more continuity of existing land uses and transportation systems are preferable. The ability of a technology to function at various grades (surface, elevated, tunnel) and various integration levels (separate, segregated, shared) will help reduce right of way impacts. Such flexibility will also allow for more seamless integration with other systems. Characteristics that provide for more flexibility also respond to different land use patterns and can address other potential constraints within a corridor.

Selected Indicators
Conditions that were considered in the analysis were 1) the amount of infrastructure that a particular system will require, 2) how effectively a system can share a running way with auto users, pedestrians, and bicyclists, and 3) the number of different ways (profile) in which a particular technology can be operated (surface, tunnel, elevated).

Characteristics Not Specifically Considered

This following discussion describes three characteristics that were not specifically considered in the assessment of the technologies. They were not directly evaluated due to lack of alignment and engineering specifics needed for the analysis or equal applicability across technologies, thereby providing little input into the evaluation.

Universal Access
The ability for the disabled to easily and safely board and be seated is federally mandated. There are numerous ways this is accomplished and each technology includes excellent access to all. The transfer from one vehicle to another must also be as seamless as possible for the disabled. Bicycling and walking are also an important consideration that expands opportunities for more people to access the regional transit system. Technologies will need to maintain and if possible improve the integration of these modes into the regional travel system**.** Accommodation can be made on all of the high capacity transit options for disabled individuals, bicycles and pedestrians.

Marketing and Branding
One of the less objective factors influencing the success of high capacity transit is the appearance and image it presents to the public. The appearance of the vehicles and the system as a whole can create an atmosphere of acceptance for transit riders. Standard buses are not known for their glamour. They are the workhorses of the transit world. Commuter trains are often perceived as a more desirable means of conveyance, with other options falling somewhere in the range between these two. The ability to brand one route or simple system and market its speed, amenities or other qualities, makes transit more alluring. Another feature of creating a different technology is that it simplifies the system for the traveling public. A set of specific equipment with a different appearance, including colors, schedules, and stations, is easily identified by the public.

Capital and Operating Costs
Costs will not be used as a criteria for corridor or regional level technology assessments in this study. This study does not include sufficient specific data to determine with accuracy the possible construction costs. The selected technology should be capable of being constructed, operated, and maintained meeting “least-cost” or “cost-benefit” objectives. This is not to say that the lowest cost technology(s) should be considered the best, but that there is an expectation that the relationship between total benefits and total costs be competitive with other HCT technologies being considered. Specific costs for technology are presented, when available, as found through extensive research. The following statement may give the reader a sense of the complexity and range of transit costs. The following quote from the American Public Transportation Association (APTA) aptly states the issues involved in cost estimating capital expenditures for major transit improvements. Operating costs similarly include variables not detailed in this study.

"Although data for public transportation infrastructure construction costs (e.g., new rail lines, high-occupancy-vehicle lanes, and busways) are reported to the Federal Transit Administration National Transit Database, data are not reported by complete project--only by year by mode, which could cover several projects being constructed simultaneously. Also, most projects are constructed over a period of several years, and only broad category data (vehicles, facilities, and other) are reported. Details on mileage, number of stations, size of parking lots, and other variables are not reported. Dozens of variables impact the cost of a project, and some costs, such as the quality of construction and the artistic beauty of a project, cannot be accurately measured. A few of those variables include:

1) land acquisition
2) land clearance and demolition
3) relocation of existing businesses and residences
4) availability of "free" or low-cost right-of-way such as abandoned railroads
5) utility relocation
6) number, size, and length of stations
7) number of tracks or lanes
8) length of trackage or roadway
9) number and size of maintenance yards and facilities
10) proportion in deep tunnel, shallow tunnel, on the surface, and elevated
11) number and size of parking lots or garages
12) number and size of bridges
13) station and right of way enhancements such as landscaping, works of art, information kiosks, benches, telephones, concession booths, fountains, etc.
14) type and number of fare vending and collection machines
15) inflation over the several-year time period needed for most projects
16) the going labor costs for and number of construction workers
17) type and number of propulsion, signal, communication, and other operating systems
18) when the project was constructed
19) the number of vehicles required
20) interest and other financing charges

For these reasons, it is not possible to develop accurate comparative construction cost data on a per-mile or any other basis since the detailed data on the above (and other) variables are not reported to allow identification of comparable projects."

(Source: American Public Transit Association, APTA)

3.2 System-wide Assessment of Technologies

Enhanced Bus

Meets many of the needs of a regional system and will be addressed at corridor level.

Enhanced bus service is characterized by signal prioritization, classic and/or articulated buses with on-vehicle fare collection, pass programs, comfortable seating and use of existing HOV lanes. Typically, enhanced bus serves a variety of markets, including work and non-work trips in urban and suburban areas, and is usually dependent on pedestrian, bike, and/or park-and-ride access. Enhanced bus includes some but not all of the properties of bus rapid transit (BRT). Sound Transit's Regional Express bus services could be classified as enhanced bus service. Buses generally travel in a combination of mixed traffic and HOV lanes. Currently enhanced bus services operate in most corridors. The following regional service standards and route selection criteria used by Sound Transit helps to define the operating characteristics of Enhanced Bus services.

- Carry a significant portion of inter-jurisdictional passengers.
- Provide interim trunk service, carrying high ridership.
- Operate at reasonably high speeds, generally averaging 20 mph (with stops) utilizing HOV lanes and other preferential treatments such as signal pre-emption.
- Higher operating speeds (45 mph) in the HOV lanes, at least 90 percent of the time during peak-use hours.
- Stop relatively infrequently, averaging ½ to 1 mile or more between stops.
- Operate frequently, generally with at least 15 minute, two-way service during the base period, but in no case with headways exceeding 30 minutes.
- Provide primary connections with commuter rail, light rail, ferries, other regional trunk buses, and local service networks.
- Serve two or more of the designated VISION 2020 Regional Growth Centers and/or Manufacturing and Industrial Centers.

Enhanced Bus Technology Characteristics

CAPACITY	
Indicator: 3,700-9,150 pphpd <u>Selected System:</u> ST, Express Bus Services <u>Base Passenger Capacity:</u> • Seated = 43 • Seated and Standing = 80 <u>Calculated Line Capacity:</u> (People/hour/direction) 1,290-2,400 – 2 buses w/4-min headway 2,580-4,800 – 4 buses w/4-min headway	**General Information:** Enhanced Bus capacity is 4,800 pphpd under some operating assumptions (4-minute headways) that could be difficult to maintain over-time. **Regional Application:** Even if enhanced bus is operated at extremely high frequencies it lacks capacity for many corridors in the near term or in future years. Additional buses traveling on existing facilities are likely to encounter congestion and if operated on new more exclusive facilities could create point capacity constraints in high volume locations. **Notes:** Typical 40-foot urban transit bus can normally seat 43 passengers and up to 37 additional standees if all of the aisle circulation space is filled. *(http://gulliver.trb.org/publications/tcrp/tcrp_webdoc_6-b.pdf)*

OPERATING SPEEDS	
Indicator: **Maximum at least 55-66 mph** **Average operating 25-35 mph** **Performance:** <u>Maximum Speed</u> 60-70 mph <u>Average Speed</u> 5 mph (CBD) 15 mph (Suburb)	**General Information:** Enhanced bus travels at the speed of auto traffic losing time at all stops for passenger loading, deceleration, and re-entry into traffic lanes. This generally results in significantly lower travel time. Existing services travel at very low speeds in the central business districts but can travel at high speeds between bus stops along HOV lanes if traffic allows. Further enhancements or HOV system development would improve speeds. **Regional Application:** Enhanced bus is unlikely to meet regional needs to compete with auto travel as existing facilities become more congested, including both HOV and general purpose lanes. **Notes:** Buses are estimated to average 5.2 mph overall in central business districts, 10 mph in cities, and 14.3 mph in suburban areas, including passenger stops. *(Characteristics of Urban Transportation Systems, Federal Transit Administration, September 1992).* Buses can generally operate at maximum speeds of 60 to 70 mph depending on the facilities. *(UTM 5/2/2003)*

STATION SPACING	
Indicator: **0.5 miles in high density areas** **2 miles in low density areas** **Performance:** 600-1200 Ft.	**General Information:** Large station facilities are not required and stops can be placed in any location where the vehicle can stop safely. Tightly spaced stations for buses can cause rough acceleration and deceleration causing passenger discomfort. **Regional Application:** Buses can serve a variety of land use characteristics and can respond quickly to changing growth patterns. **Notes:** Typical spacing: CBD – 600 feet, Urban Areas – 750 feet, Suburban Areas – 1000 feet, Rural Areas – 1250 feet (*Guidelines for the Location and Design of Bus Stops, TCRP Report 19*)

<table>
<tr><th colspan="2">TYPICAL HEADWAY</th></tr>
<tr><td>Indicator:
4 minutes – 15 minutes

Performance:
15 minutes – 45 minutes</td><td>General Information:
Enhanced bus frequencies are determined by different travel markets. The headways are limited due to congestion in high-density areas.

Regional Application:
Typical headways derived from actual operating characteristics are less frequent than will be needed to meet the long-term passenger travel demand. Increased headways will help meet demand but lead to system integration challenges.

Notes:
(Transit Capacity and Quality of Service Manual 1999, TRB)</td></tr>
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<table>
<tr><th colspan="2">SYSTEM INTEGRATION</th></tr>
<tr><td>Indicator:
Interlining with existing system
Barriers to implementation in areas with varying densities and land use characteristics
Other considerations
Performance:
Seamless integration with existing bus system. Tightly spaced stations and flexibility provide strong access to low-density areas. Barriers related to bus congestion in dense, urban areas.</td><td>General Information:
Buses can be used in mixed traffic merging easily into the existing transportation system. Routes can be adjusted to match up stations with transfer locations. Because of its flexibility, a bus system can “feed” other transportation modes, all of which can connect to various activity centers.

Regional Application:
Enhanced bus could run along multiple facilities in order to meet line capacity needs. There is, however, a growing transit demand that would require buses at such high frequencies that central business districts may experience dramatically increased levels of congestion. It can easily interline with access to park-and-ride facilities and transit terminals.

Notes:
(Survey of Transit Technologies, PB Farradyne 2002)
(Transit Technology Capabilities and Comparisons, Parsons Brinckerhoff, 2001)</td></tr>
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<table>
<tr><th colspan="2">LAND USE</th></tr>
<tr><td>Indicator:
Non-auto accessibility
All day/peak passenger volumes
Level of investment in stations
Performance:
No barriers to bike/pedestrian access and mobility. Limited passenger activity except transfer areas. Minor station investment yields little development.</td><td>General Information:
Buses are accessible to pedestrians and bicyclists because they run on local roads at grade and provide the system with route flexibility. However, when there is low investment in stations and varying routes, the system can be perceived as impermanent or provisional.

Regional Application:
Given capacity and speed limitations and the limited permanence of stations this transit option would not support the long-range land use plans and projected growth for the region. Flexible routing does allow the technology to reach low-density locations and gather passengers for higher capacity systems that could not directly access transfer centers. Service can also be rapidly adjusted to unexpected growth patterns.

Notes:
(Transit Capacity and Quality of Service Manual 1999, TRB)
(Land Use impacts of Transportation: A Guidebook, Parsons Brinckerhoff for TRB, 1998)</td></tr>
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<table>
<tr><th colspan="2">IMPLEMENTATION RISK</th></tr>
<tr><td>Indicator:
• Track record
• Number of established suppliers and availability of parts

Performance:
Very Low Risk: Operating in region and multiple US cities. Many established suppliers and manufacturers. High number of experienced drivers and mechanics.</td><td>General Information:
The outcomes of providing bus service are well known. Buses have been part of public transportation systems for decades. They have been improved over time and designed to handle the needs of transit operators throughout the United States. There are multiple manufacturers and the capabilities, costs, and operating characteristics are well known.

Regional Application:
Customer expectations are realistic due to the existence of a well-established system within the region. There is an existing link between suppliers/manufacturers and regional transit providers.

Notes:
Information based on historical application of existing systems and national experience. (Transit Capacity and Quality of Service Manual 1999, TRB)</td></tr>
</table>

<table>
<tr><th colspan="2">SCHEDULE RELIABILITY</th></tr>
<tr><td>Indicator:
• Level of segregation from traffic
• Mixing with freight
• Transit priority treatments

Performance:
Low-moderate reliability. Partial use of HOV or HOT lanes. Reliability reduced when running in mixed traffic. On-board fare collection and signal preemption add to reliability.</td><td>General Information:
The bus not only is slowed by mixed traffic but must also stop frequently to load and unload passengers and collect fares, merging in and out of traffic. The schedule adherence is degraded by these factors, increasing travel times as well as often missing arrival times at points throughout the trip.

Regional Application:
HCT systems that are implemented must improve upon the schedule reliability that currently exists on the existing bus system. The overuse of buses may lead to less reliability in urban areas within the region.

Notes:
Information based on operating characteristics within the region and national experience. (Transit Capacity and Quality of Service Manual 1999, TRB)</td></tr>
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<table>
<tr><th colspan="2">RIGHT OF WAY REQUIREMENTS</th></tr>
<tr><td>Indicator:
• Amount of infrastructure
• Cross-traffic challenges
• Profile options & flexibility in right-of-way

Performance:
Little infrastructure required. Partial ROW needs with HOV or HOT lanes. Minor congestion issues restrict cross-traffic movement. Surface or tunnel.</td><td>General Information:
No right of way is required to run buses in mixed traffic. The technology can run at-grade or below-grade.

Regional Application:
Enhanced bus operates in the existing Downtown Seattle Transit Tunnel (DSTT) having little impact on the surrounding city. The use of HOV lanes only partially restrict auto use on the highway system.

Notes:
(Transit Capacity and Quality of Service Manual 1999, TRB)</td></tr>
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Bus Rapid Transit (BRT)

Meets many of the needs of a regional system and will be analyzed at corridor level.

Bus Rapid Transit is a flexible bus service that can combine stations, vehicles, services, transit running ways, and ITS elements into a permanently integrated system with a quality image and strong identity. BRT systems are planned and designed to be appropriate to the market they serve and their physical surroundings, and they can be incrementally implemented in a variety of environments. There are a broad range of facility and service characteristics that can be used to define BRT. Locally, Metro has the following definition: frequent service (10 minute headways), longer stop distances, distinctive identity and transit priority. This transit priority could include traffic signal prioritization, parking removal, as well as separate transit or use of high occupancy vehicle lanes. According to the National Transit Institute, Bus Rapid Transit differs from enhanced bus service when it has the following seven features:

1) *Identity and branding.* This is accomplished by creating a simple route structure with visual cues such as a separate color for all signage, the vehicles and printed material. Marketing is undertaken for the BRT route as a separate entity. An example is the Silver Line in Boston.
2) *Transit running-ways treatment*: Ideally the route has a separate running lane with no competing traffic.
3) *Distinctive vehicle.* New vehicles used specifically for the BRT route are being developed and may soon be seen operating in the US. They have higher capacity, a different appearance and have new driver assistance systems such as Opticom or other Automatic Guideway Transit (AGT).
4) *Stops, stations and terminals.* BRT should have distinctive signage. Select stations are can be large, with parking and multiple connections to other modes.
5) *Off-board fare collection.* Collected at stations or stops prior to boarding the bus to reduce delay times.
6) *ITS applications.* If the route includes shared lanes then signal prioritization should be implemented to maintain higher travel speeds. Up-to-date traveler information should be provided at all stations and on vehicles.
7) *Limited-stop, frequent, all-day service.* Frequent intervals between buses reduces all out-of-vehicle wait times, while all-day service assures the travel that the system can be relied upon for multiple trip purposes at all times of the day. This increases the market share using the BRT system.

BRT has more capacity than enhanced bus, using larger coaches, traveling in platoons. It shares the problem of reduced speeds due to traffic congestion and may add to congestion in some dense locations. The system could be implemented by adding improvements to existing Enhanced Bus services. BRT supports increased densities through fairly substantial station investment and enhanced pedestrian activity at these more formal stopping locations. Dedicated lanes and stations could transition into dedicated, exclusive running ways in the future, making BRT with higher capacities and faster speeds or serving as a transitional step toward other HCT technologies in the corridors with lower travel demand.

Bus Rapid Transit Technology Characteristics

CAPACITY	
Indicator : 3,700-9,150 pphpd Selected System: Boston Silver Line Base Passenger Capacity: • Seated = 65 • Seated and Standing = 90 Calculated Line Capacity: (People/hour/direction) 1,950-2,700 w/4min headway – 2 bus platoon 3,900-5,400 w/4min headway – 4 bus platoon	**General Information:** BRT capacities were calculated to reach a maximum of 5,400 pphpd. **Regional Application:** The demand in some of the high travel market corridors would reach and possibly exceed the available capacity within the mid-range time frame. This is an issue for specific corridors in the future, leading to needs for higher capacity options or additions on parallel facilities. Any additional buses traveling on one facility are likely to encounter congestion and if operated on multiple facilities destined for the same location there is the potential for point capacity constraints in high volume locations. **Notes:** A 60-foot articulated bus can carry 31-65 seated-passengers with a maximum capacity of 80-90 passengers with standees. (*Journal of Public Transportation, May 2004*)

OPERATING SPEEDS	
Indicator: **Maximum at least 55-66 mph** **Average operating 25-35 mph** **Performance:** Maximum Speed 60 – 70 mph Average Speed 25 – 50 mph	**General Information:** BRT can operate more rapidly than enhanced bus due to the use of either dedicated running ways, off-board fare collection, or a number of treatments that give the buses priority when areas are congested. **Regional Application:** Travel speeds will compete well with auto speeds if service is provided on dedicated running ways and many BRT priority treatments are implemented. **Notes:** Average BRT operating speeds 40-50mph: non-stop express on busway/freeway lanes 25-30mph: all-stop local on busway/freeway lanes 14-19mph: arterial curb bus lanes, limited stops 11-14mph: arterial median busway (S. American) (*Transit Technology Capabilities and Comparisons, Parsons Brinckerhoff, 2001)*

STATION SPACING	
Indicator: **0.5 miles in high density areas** **2 miles in low density areas** **Performance:** .25 to 2 miles	**General Information:** BRT systems usually have wider station spacing than enhanced bus. The more stops the slower the speed. BRT stations range from simple “super” bus stops to major intermodal terminals, all with consistent design themes. The spacing depends on whether the station is located in the CBD, urban, or suburban areas. **Regional Application:** BRT can serve varying densities and land use characteristics and somewhat respond to changing growth patterns. Other systems can provide smoother rides and standing may be more comfortable on long-distance travel. **Notes:** (*Transit Technology Capabilities and Comparisons, Parsons Brinckerhoff, 2001)*

TYPICAL HEADWAY	
Indicator: **4 minutes – 15 minutes** **Performance:** 5-15 min peak	**General Information:** BRT systems often run at all times of the day with higher frequencies than Enhanced Bus. With the application of all BRT characteristics, it may be possible to reach 2-minute headways. Higher frequencies are possible with the use of bus platoons but can be difficult to maintain unless operating on exclusive ROW. **Regional Application:** BRT provides frequencies that meet customers' needs and facilitate transfers to other modes. Congestion may result in more dense areas in the region without the use of completely dedicated running ways. **Notes:** (*Transit Technology Capabilities and Comparisons, Parsons Brinckerhoff, 2001)*

SYSTEM INTEGRATION	
Indicator: • **Interlining with existing system** • **Barriers to implementation in areas with varying densities and land use characteristics** • **Other considerations** **Performance:** Seamless integration with existing bus system. Barriers related to bus congestion in dense, urban areas.	**General Information:** BRT can "feed" other transportation modes, all of which can connect to various activity centers. Intermodal and terminal stations reinforce the effectiveness of BRT operations by promoting transfer between BRT and connecting bus lines. **Regional Application:** Implementing a BRT line with dedicated off street transit running ways will be harder to fit into the current transit network. BRT could be run along multiple facilities in order to meet line haul capacity needs. Corridor specific performance evaluation measures need to be considered. A large increase in buses is likely to create congestion that impedes other transportation systems. There is a growing transit demand that would require buses at such high frequencies that central business districts, such as Seattle, may experience dramatically increased levels of congestion. **Notes:** (*Transit Technology Capabilities and Comparisons, Parsons Brinckerhoff, 2001)*

LAND USE	
Indicator: • **Non-auto accessibility** • **All day/peak passenger volumes** • **Level of investment in stations** **Performance:** Barriers to bike/pedestrian access if on dedicated running ways. Moderate volumes can promote development activity around stations. More permanent stations promote moderate density development.	**General Information:** BRT systems generate large volumes of people passing by and accessing a particular site. They have permanent facilities demonstrating a public commitment to an area and high levels of service. These are factors cited by developers as to why rapid transit station areas are appropriate for high density development. **Regional Application:** BRT stations can be designed according to existing and planned land use within the region. Large stations are often sizable capital investments representing permanence and lending themselves to increased pedestrian activity and densities of development. In areas where more flexible routing is employed, the technology can reach low-density locations and gather passengers for the higher capacity system. Service can also be somewhat rapidly adjusted to unexpected growth patterns. **Notes:** (*Transit Capacity and Quality of Service Manual 1999, TRB*) (*Land Use impacts of Transportation: A Guidebook, Parsons Brinckerhoff for TRB, 1998)*

<table>
<tr><th colspan="2">IMPLEMENTATION RISK</th></tr>
<tr><td>Indicator:
• Track record
• Number of established suppliers and availability of parts

Performance:
Low Risk: Improvement on currently operating service. Partially implemented in region and in a few US cities. Some established suppliers & manufacturers. Easily adapted to high number of experienced drivers and mechanics.</td><td>General Information:
Buses have been part of public transportation systems for decades. They have been specifically designed and equipped to handle the needs of transit operators throughout the United States. Bus parts are available from numerous manufacturers across the country and it employs familiar vehicle and running way technologies.

Regional Application:
There are local transit providers capable of providing operation and maintenance for BRT. The existing enhanced bus system can be transitioned to BRT with the application of transit priority treatments. Partial BRT application is under development in many areas throughout the region.

Notes:
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<tr><th colspan="2">SCHEDULE RELIABILITY</th></tr>
<tr><td>Indicator:
• Level of segregation from traffic
• Mixing with freight
• Transit priority treatments

Performance:
Moderate-good reliability. High use of HOV or HOT lanes. Gains reliability when operating on dedicated running ways. Off-board fare collection, signal preemption, level boarding at stations, branding, and marketing add to reliability.</td><td>General Information:
BRT application can range from operation in general traffic lanes with mixed traffic, to HOV lane usage, to completely separate and dedicated rights of way. Schedule reliability is degraded by the level of traffic congestion the bus encounters during its trip. BRT applications to the existing bus system include treatments that improve performance such as off-board fare collection for reduced dwell time, dedicated running ways to avoid congestion, and distinctive identity, branding, and vehicles that somewhat parallel rail service conditions.

Regional Application:
There are few areas with completely separate and dedicated rights of way for buses. Priority treatments within the region tend to involve signal preemption, a distinctive identity from local systems, and some locations with real-time schedule information. Additional BRT applications may be required in order to meet the reliability needs of the region.

Notes:
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• Amount of infrastructure
• Cross-traffic challenges
• Profile options & flexibility in right-of-way

Performance:
Moderate infrastructure required. Separate running-ways improve service, but increase conflicts with cross-traffic. Surface, tunnel or elevated flyovers.</td><td>General Information:
BRT can operate in a variety of physical and operating environments. It can transition from operating on a street with mixed traffic to segregated bus-only lanes and exclusive transit ways. The amount of right of way required for this system type is dependent on the need for dedicated travel lanes. Buses require the width of standard travel lanes, shoulders are preferable, and stations and/or pullouts are needed to maintain high quality operation. The technology can be used at-grade with varying levels of segregation, below-grade, and flyovers can be used to provide more direct access to station locations. Cross traffic is limited as dedicated running ways are built. However, speeds and point capacity constraints may result in decreased performance in shared lanes.

Regional Application:
The regional HOV system provides for a partial separation from auto traffic, but it does not afford the fixed, reliable service that characterizes higher levels of BRT. It is more difficult to provide for bus-only lanes in dense areas of the region with constrained corridors and street capacity.

Notes:
(Transit Technology Capabilities and Comparisons, Parsons Brinckerhoff, 2001)</td></tr>
</table>

Light Rail (LRT)

Meets the needs of a regional system and will be analyzed at corridor level.

Light rail vehicles can operate at street level in shared traffic lanes, in protected medians, in tunnels, and on elevated running ways. Track brakes (electromagnetic brakes that clamp onto the rail head) provide the high deceleration rate needed to operate in mixed traffic. The vehicles are powered from an overhead wire that does not interfere with ground traffic. Coupling cars easily changes train length with no change in train performance. LRT can be coupled into trains, with the car quantity limited by city block lengths and intersection considerations, platform length, or train line voltage capability. Station platform lengths and intersection spacing usually limit trains to 4 cars in length. Worldwide application and popularity of this technology has led to several available design alternatives. For a more detailed description of these system types refer to *Appendix D*.

Light rail has the ability to accommodate flexible capacity needs. LRT can be provided with a variety of seating arrangements; however, 2x2 is typically used, resulting in a lower passenger capacity per train length than a vehicle that is designed for those that are standing. It can operate at two-minute frequencies with additional cars easily added. Headways typically range from four to ten minutes with station spacing between ½ and two miles. Off board fare collection is typical of LRT and when combined with multiple large doors, station dwell times are low. This increases speeds, improves schedule reliability and customer convenience.

While at-grade operations save on capital costs, the operations can be negatively affected by traffic congestion, leading to longer travel times and greater headway variations. Elevated or underground sections of LRT systems have improved operations but have significantly higher capital costs. Sound Transit's proposed LINK light rail is actually a hybrid LRT. The proposed 20-mile system from Northgate to Seattle-Tacoma International Airport would be equal parts at-grade, elevated, and tunneled. The trains will have partial-low floors with level boarding.

Stations can be located at flexible intervals, including small platforms in existing streets or large stations with park and rides, bike lockers and other passenger amenities. The investment in high-use stations, the additional pedestrian activity generated near these locations, along with the permanent investment in rail tracks creates an opportunity for enhanced development activity along LRT travel corridors. It can also be phased into other areas in coming years. Sound Transit has adopted the following regional service standards and route selection criteria for their phase 1 LRT system:

- Direct connections to centers.
- Maximum pedestrian and transit access.
- Average speed of 25-35 mph, maximum speed 55-65 mph.
- 2 to 15 minute frequency.

- 4-6 car trains with 125 passengers per car (500-750 passengers).
- Point capacity of 22,000 people per hour per direction (pphpd) and line-haul capacity of 6,000-11,000 pphpd.
- Stations spaced 1-2 miles apart, more tightly spaced in high transit volume areas.
- Exclusive grade-separated and surface alignments, separated from parallel traffic flows, with prioritized signaling at grade crossings and intersections.

Light Rail Transit Technology Characteristics

CAPACITY	
Indicator: 3,700-9,150 pphpd Selected System: ST Link Light Rail Base Passenger Capacity: • Seated = 74 • Seated and Standing = 148 Calculated Line Capacity: (People/hour/direction) 2,220-4,440 w/4min headway – 2 cars 4,440-8,880 w/4min headway – 4 cars	**General Information:** Light Rail capacities were calculated to be at a maximum of 8,880 pphpd. **Regional Application:** Overall, four car LRT vehicles meet transit needs for the window of this study with room for additional growth. Light rail can accommodate the needs of the region along any one facility. As with all of the HCT technologies, LRT may be supplemented with parallel services along different facilities that cross each screenline. **Notes:** (*Transit Capacity and Quality of Service Manual 1999, TRB*)

OPERATING SPEEDS	
Indicator: **Maximum at least 55-66 mph** **Average operating 25-35 mph** **Performance:** Maximum Speed 45 – 65 mph Average Speed 25 – 40 mph	**General Information:** Light Rail can generally operate more rapidly than enhanced bus due to quicker loading and unloading. **Regional Application:** All operating speeds would compete with automobile speeds and thus meet regional needs. **Notes:** *(Urban Transportation Monitor 5/2003)*

STATION SPACING	
Indicator: **0.5 miles in high density areas** **2 miles in low density areas** **Performance:** .25 to 2 miles	**General Information:** Stations range from raised platforms, low platforms with wheel chair ramps, platforms with ticket vending machines, or large stations with multi modal connections and extensive parking. Stations can be tightly spaced in built environments to serve high-activity areas or widely spaced to provide increased efficiency. **Regional Application:** The flexibility in station spacing and station types allows for light rail service to the diverse land use environments that exist within the region. LRT systems can provide smooth rides and standing may be more comfortable on long-distance travel. LRT lacks flexibility in responding to unanticipated changes in growth patterns. **Notes:** *(Rail Transit Capacity, TCRP Report 13, TRB)* *(Urban Transportation Monitor 11/2001)*

TYPICAL HEADWAY	
Indicator: **4 minutes – 15 minutes** **Performance:** 2-10 min peak	**General Information:** Light rail vehicles can reach high frequencies due to rapid loading and unloading, off-board fare collection, dedicated running ways, and other priority treatments. **Regional Application:** Depending on the use of dedicated running ways, LRT can be operated at a frequency to meet foreseeable regional capacity needs with intervals that meet passenger needs for schedule flexibility. Trains can have cars added easily for special events or growing demand. Rail cars should provide adequate capacity without overly frequent headways or point capacity constraints. **Notes:** *(Urban Transportation Monitor 11/2001)* *(Transit Capacity and Quality of Service Manual, TCRP Web Document 6)*

SYSTEM INTEGRATION	
Indicator: • **Interlining with existing system** • **Barriers to implementation in areas with varying densities and land use characteristics** • **Other considerations** **Performance:** Seamless integration with Central Link system. Transfers at existing monorail and bus stations. Very few barriers due to high capacity, profiles, and station size flexibility.	**General Information:** LRT can work well with existing bus service and suburban feeder services through timed transfers and dual service. Inflexible routing and the limited ability to operate in mixed traffic somewhat limit its ability to connect with other systems at transfer points. **Regional Application:** LRT is currently under construction to operate in the DSTT, providing excellent integration options from merging corridors. There are very few barriers to interlining with the existing transportation system due to station flexibility and the ability to run at different profiles and levels of segregation. **Notes:** *(Survey of Transit Technologies, PB Farradyne 2002)* *(Transit Technology Capabilities and Comparisons, Parsons Brinckerhoff, 2001), (SCAG 1989)*

<table>
<tr><th colspan="2">LAND USE</th></tr>
<tr><td>Indicator:
• Non-auto accessibility
• All day/peak passenger volumes
• Level of investment in stations

Performance:
Large passenger volumes create activity around stations. Permanent stations promote dense development. Some barriers to bike/pedestrian access related to safety and surface running ways.</td><td>General Information:
Station investments and the permanent route structure are sizable permanent capital projects lending themselves to increased development. Pedestrian and bicycle accessibility are determined by the profile and level of segregation that is employed.

Regional Application:
LRT has the ability to respond to urban and suburban needs. The passenger volumes near the centers will help support planned growth near centers of both residential, commercial and employment development.

Notes:
(Land Use impacts of Transportation: A Guidebook, Parsons Brinckerhoff for TRB, 1998)</td></tr>
</table>

<table>
<tr><th colspan="2">IMPLEMENTATION RISK</th></tr>
<tr><td>Indicator:
• Track record
• Number of established suppliers and availability of parts

Performance:
Low Risk: Currently under construction in region and 26 US cities with 100 New starts proposed. Many established suppliers & manufacturers. High number of experienced drivers and mechanics.</td><td>General Information:
There are 26 LRT systems currently operating in the U.S. with multiple suppliers and manufacturers, making risks low. Costs of operation, construction, and manufacturing are unknown.

Regional Application:
A streetcar version of LRT is running in Tacoma and light rail is under construction in Seattle. Many of the associated challenges will be well tested within the region. Part of the system will be operational by 2009 and future investments can build upon the proposed line.

Notes:
(Transit Capacity and Quality of Service Manual 1999, TRB)</td></tr>
</table>

<table>
<tr><th colspan="2">SCHEDULE RELIABILITY</th></tr>
<tr><td>Indicator:
• Level of segregation from traffic
• Mixing with freight
• Transit priority treatments

Performance:
Good to excellent reliability depending on profile. Gains reliability when operating on dedicated running ways with fewer crossings. Off-board fare collection, signal prioritization, level boarding at stations, branding, and marketing add to reliability.</td><td>General Information:
Light rail has good to excellent reliability depending on profile and the level of segregation from traffic. Additional transit priority treatments improve performance such as off-board fare collection for reduced dwell time, dedicated running ways to avoid congestion, and distinctive identity, branding, and vehicles.

Regional Application:
The trains are not fully automated and the system performance is somewhat dependent on driver decision. Where crossings of general purpose lanes are required signal priority can help to ensure schedule reliability.

Notes:
(Transit Capacity and Quality of Service Manual 1999, TRB)</td></tr>
</table>

RIGHT OF WAY REQUIREMENTS	
Indicator: • **Amount of infrastructure** • **Cross-traffic challenges** • **Profile options & flexibility in right-of-way** **Performance:** Moderate infrastructure required. Cross-traffic conflicts depend on design (exclusive running ways or mixed with traffic). Surface, tunnel or elevated.	**General Information:** Light rail has a tremendous amount of flexibility in terms of profile and segregation from traffic. Right of way is required for LRT's dedicated tracks, but the system has the capability to operate in the street with mixed-traffic if necessary. Tracks can be shared with freight only through agreements for time of day travel. The technology can also run in protected medians of general purpose lanes with limited crossings. **Regional Application:** The existing investments in light rail employ a variety of profiles including tunneling through more dense areas, elevated tracks in some locations, and segregated surface running ways in medians. The technology has the ability to adapt to the different travel markets throughout the region. **Notes:** (*Transit Capacity and Quality of Service Manual 1999, TRB*)

Monorail

Meets many of the needs for a regional system and will be analyzed at corridor level.

Monorail is grade-separated (typically elevated) with the train literally wrapping itself around a concrete or steel beam for support and guidance. The technology is capable of providing a great range of passenger capacity. U.S. installations are under 5 miles in length with a longer system nearing completion in Las Vegas. The Japanese installations vary from 5 miles to 10 miles in length. For longer or more complex systems, monorail requires special adaptations to handle system failures. The major North American supplier is Bombardier. Hitachi is a Japanese supplier with several systems in operation.

Monorail systems typically have many crossovers or switches between two “guideways” to permit reverse direction operation. This allows the vehicles to bypass stations or track sections, when required for operational problems or maintenance activities. Monorails provide route switching via large guideway sections that either move horizontally or rotate in place. Capacity can be limited because it is relatively difficult to add cars and the need to switch tracks may limit headways. A passenger walkway may be required along the guideway to permit passengers to exit the vehicle in case of a safety problem. Elevated stations require waiting areas, elevators or escalators, and passenger boarding areas. This provides amenities but also requires sizable footprints and cost. Additionally, raised platforms must be integrated with below grade and at grade transit options and may be less convenient for passengers.

The rubber-tired monorail was made famous by its operation at Disney Resorts and Seattle's World Fair. The latest U.S. application is the Las Vegas system that is currently being tested for full service. This design offers an attractive vehicle with no visible undercarriage and a guideway designed for shuttle service operation. Guideway costs generally increase with added capacity.

There is a popular short monorail line operating in Seattle's downtown and a planned 14-mile line serving intermediate transit markets within the city. The system is being designed to have capacity to serve between 3,000 to 6,000 passengers per hour per direction. With 125 seated and standing individuals the system could theoretically accommodate 3,750-7,500 pphpd. Vehicle length varies greatly by supplier but the resulting train lengths for intermediate capacity operations are typically between 100 and 150 feet long. Vehicle floors align with station platforms for level boarding. Power is from an electrified third rail, eliminating the potential for at-grade crossings. Station spacing is typically one-half mile or less in urban areas and a mile or more in residential areas. Speeds will range between 30 to 50 miles per hour. Operations are automated (driverless) with headways ranging between four and six minutes.

For regional application, the system would likely support higher density development, create pedestrian activity and meet travel needs in activity centers within many of the corridors, but it is likely that alternative design higher-capacity regional monorail systems may not integrate well with the intermediate capacity system that is currently under development.

Monorail Technology Characteristics

CAPACITY	
Indicator: 3,700-9,150 pphpd Selected System: Seattle Monorail Project Base Passenger Capacity: • Seated = N/A • Seated and Standing = 125 Calculated Line Capacity: (People/hour/direction) 3,750 w/4min headway – 2 cars 7,500 w/4min headway – 4 cars	**General Information:** Monorail capacities were calculated at a maximum of 7,500 pphpd. **Regional Application:** Four car monorail vehicles will meet transit needs for the region within the horizon of this study. Capacity may be limited if switching tracks is required for a more complex system. It is not possible to temporarily increase the length of the trains due to the fact that monorail is manufactured as married pairs. This limits the ability to provide added capacity. **Notes:** *(Seattle Monorail Project: Preliminary Staff Recommendations for Alignments and Stations, 2003)*

OPERATING SPEEDS	
Indicator: **Maximum at least 55-66 mph** **Average operating 25-35 mph** **Performance:** Maximum Speed 50 mph Average Speed 20-30 mph	**General Information:** Monorail runs on exclusive tracks with no crossing or mixing with traffic. It is an automated system lending itself to good acceleration and deceleration at fairly high operating speeds. **Regional Application:** All operating speeds would compete with auto speeds and thus meet regional needs. **Notes;** *(KL Monorail and Monorail Society Web sites)* *(Seattle Monorail Project: Preliminary Staff Recommendations for Alignments and Stations, 2003)*

STATION SPACING	
Indicator: **0.5 miles in high density areas** **2 miles in low density areas** **Performance:** .25 to 2 miles	**General Information:** Stations are elevated and therefore include substantial passenger loading areas and access from elevators or escalators. These areas often require largely scaled stations. **Regional Application:** Each station's large footprint may make station frequency less flexible due to the large investment that is required. Still, Monorail should be able to serve the different land use environments within the region. **Notes:** *(Seattle Monorail Project: Preliminary Staff Recommendations for Alignments and Stations, 2003)*

TYPICAL HEADWAY	
Indicator: **4 minutes – 15 minutes** **Performance:** 2-30 min peak	**General Information:** Monorail generally operates at high frequencies and it is an automated system that does not depend on driver decision. Track switching coupled with train movements can result in slower speeds than other rail technologies and limit headways. **Regional Application:** Monorail can be operated at a frequency to meet foreseeable capacity needs with intervals that meet passenger needs for schedule flexibility. Consideration must be given to the number of single-track operations and the complexity of switching that can be employed without compromising the frequency and capacity. **Notes:** *(KL Monorail and Monorail Society Web sites)* *(Seattle Monorail Project: Preliminary Staff Recommendations for Alignments and Stations, 2003)*

SYSTEM INTEGRATION	
Indicator: • **Interlining with existing system** • **Barriers to implementation in areas with varying densities and land use characteristics** • **Other considerations** **Performance:** Different technology from existing monorail proposal. Regional use would require transfers at existing LRT, monorail, and bus stations. Some barriers due to station size needs and slow switching conditions.	**General Information:** Monorail is designed to run on a separate grade from all other forms of travel requiring stairs and ADA access where transfers are required. The associated inflexible routing and inability to operate in mixed traffic limits the ability to integrate monorail with other systems. **Regional Application:** Monorail can work well with existing bus service and suburban feeder services through timed transfers and dual service. Auto and freight traffic should not be adversely affected as facilities can be elevated to an adequate height. With the use of single guideways to reduce costs or impacts in neighborhoods, consideration must be given to the complexity of track switches that require time, thereby limiting frequency of service and thus capacity. In accessing downtown Seattle transfers will be required at all bus, existing monorail, and LRT stations unless a separate monorail route is constructed with its own separate alignment. **Notes:** *(Survey of Transit Technologies, PB Farradyne 2002)* *(Transit Technology Capabilities and Comparisons, Parsons Brinckerhoff, 2001)*

LAND USE	
Indicator: • **Non-auto accessibility** • **All day/peak passenger volumes** • **Level of investment in stations** **Performance:** Large passenger volumes create activity around stations. Permanent stations promote dense development. Some barriers to bike/pedestrian access related to elevated profile.	**General Information:** Stations and the permanent route structure are sizable capital projects, lending themselves to increased densities of development. The passenger volumes near the stations will help support growth of both residential and commercial land uses nearby. **Regional Application:** Monorail has the ability to respond to urban and suburban needs, however, it may face opposition related to the aesthetics of the guideways in single-family neighborhoods and other residential locations. The passenger volumes near the centers are likely to help support planned growth near centers of both residential, commercial and employment development. **Notes:** *(Integration of Bicycles and Transit, 2002)* (*Land Use Impacts of Transportation: A Guidebook, Parsons Brinckerhoff for TRB, 1998*)

IMPLEMENTATION RISK	
Indicator: • **Track record** • **Number of established suppliers and availability of parts** **Performance:** Moderate Risk: Primarily used for tourist operations only in Seattle. Intermediate capacity system proposed. Operating in few locations in the US. Few established suppliers & manufacturers. Automated system.	**General Information:** Moderate risk does exist. Operating issues and costs may be uncertain as no national systems of this length are operating. Vehicles are operating in a few locations but wide spread applications of monorail have not been developed in the US. Las Vegas has constructed a system that should become operational in 2004. **Regional Application:** Customer expectations should be realistic as there is a short system operating in downtown Seattle. An intermediate capacity system is under construction in in Seattle and many of the associated challenges will be well tested within the region. Part of the system is planned to be operational by 2007. Future investments can build upon the proposed line, but different guideways and cars will be needed in order to implement a system dedicated to regional commuting needs. **Notes:** *(Survey of Transit Technologies, PB Farradyne 2002)*

SCHEDULE RELIABILITY	
Indicator: • **Level of segregation from traffic** • **Mixing with freight** • **Transit priority treatments** **Performance:** Excellent reliability. Dedicated, elevated running ways avoid congestion. Fully automated system, Off-board fare collection, level boarding at stations, branding, and marketing add to reliability.	**General Information:** High reliability is assured as trains run on a dedicated, separate right of way. Additional transit priority treatments improve performance such as system automation, off-board fare collection for reduced dwell time and distinctive identity, branding, and vehicles. **Regional Application:** The trains are fully automated and the system performance will meet regional needs. Some challenges may occur associated with track switching. **Notes:** *(Seattle Monorail Project: Preliminary Staff Recommendations for Alignments and Stations, 2003)*

RIGHT OF WAY REQUIREMENTS	
Indicator: • **Amount of infrastructure** • **Cross-traffic challenges** • **Profile options & flexibility in right-of-way** **Performance:** Moderate infrastructure required. No cross-traffic conflicts if elevated. Not crossable at surface. Primarily only elevated service.	**General Information:** Right of way is required for Monorail for dedicated tracks and stations. The tracks are elevated with supporting columns and air rights for their construction may influence the extent of right of way issues. **Regional Application:** Experience implementing the Green line shows that monorail can block views from buildings in downtown areas and remove some parking and bike lanes if aligned on one side of the street. The existing historic Seattle monorail shows that monorail can present safety and circulation problems and remove a lane if aligned in the middle of the street. **Notes:** *(Seattle Monorail Project: Preliminary Staff Recommendations for Alignments and Stations, 2003)*

Skytrain

Meets many of the need for a regional system and will be analyzed at corridor level.

This steel wheeled, electrically powered vehicle uses conventional track and a two-power rail system. It offers a small cross section, which reduces the cost of tunnels and the impact of elevated structures. An automated, driverless system is typically provided. Skytrain is functionally similar to automated guideway transit (AGT) technologies such as monorail.

Currently operating in Canada, it is successfully providing a high capacity option. It must be totally grade separated as usually powered by a third rail, to electrical induction motors, and is fully automated. Sizeable stations are needed as with monorail. It has many of the features of LRT and monorail, and is sometimes referred to as elevated LRT. Elevated LRT has been implemented in Vancouver, Toronto, Detroit, Bangkok, and Kuala Lampur. A larger car design is being supplied for the new JFK Airport system.

The following parameters are for a four-car train (two married pairs): 227 feet long, 8-9 feet wide, 10-11 feet high, and its empty weight is 200,000 lbs. The train's operating characteristics include a speed of 50 mph, with a 6 percent maximum grade, two-axle trucks, and a minimum horizontal radius of 115 feet. The vehicles are powered by 600 volt DC, provided by two separate power rails that are located at the side of the track structure. High-level boarding is used. Passenger capacity is provided using a 2 x 2 seating configuration with 168 seats, 344 standees. Skytrain will serve the region in much the same way as Monorail. The system would likely support higher density development, create pedestrian activity and meet travel needs in activity centers within many of the corridors, but it lacks flexibility in varying grade level application.

Skytrain Technology Characteristics

CAPACITY	
Indicator: 3,700-9,150 pphpd Selected System: Vancouver B.C. Base Passenger Capacity: • Seated = 168 (married pair) • Seated and Standing = 512 (married pair) Calculated Line Capacity: (People/hour/direction) 1,260-3,840 w/4 min headways – 2 cars 2,520-7,680 w/4 min headways – 4 cars	**General Information:** Skytrain capacities were calculated at a maximum of 7,680 pphpd. **Regional Application:** Two car Skytrain vehicles can meet transit needs for the window of this study with possible future growth. As with all of the HCT technologies, Skytrain will need to be supplemented with parallel services along different facilities that cross each screenline. **Notes:** *(Survey of Transit Technologies, PB Farradyne 2002)*

OPERATING SPEEDS	
Indicator: **Maximum at least 55-66 mph** **Average operating 25-35 mph** **Performance:** <u>Maximum Speed</u> 50 mph <u>Average Speed</u> 25 mph	**General Information:** Skytrain runs on exclusive tracks using tunnels and elevated guideways, therefore, it can reach high speeds and appropriately decelerate and accelerate at stations. **Regional Application:** All operating speeds would compete with auto speeds and thus meet regional needs. **Notes:** *(Survey of Transit Technologies, PB Farradyne 2002)*

STATION SPACING	
Indicator: **0.5 miles in high density areas** **2 miles in low density areas** **Performance:** < 1 mile	**General Information:** Stations are elevated and therefore include substantial passenger loading areas and access from elevators or escalators. These areas often require largely scaled stations. **Regional Application:** Each station's large footprint may make station frequency less flexible due to the large investment that is required. Still, Skytrain should be able to serve the different land use environments within the region. **Notes:** Expo Line: 28 km/20 stations = 1.4 km = 0.87 miles Avg. <u>http://www.translink.bc.ca/Service_Info_and_Fares/SkyTrain/</u> <u>Station Travel Times.asp</u>

TYPICAL HEADWAY	
Indicator: **4 minutes – 15 minutes** **Performance:** 2 - 4 min peak	**General Information:** Skytrain is automated and separated from all other forms of travel. This allows for high frequencies without the challenges associated with switching tracks that monorail may face with higher capacity needs. **Regional Application:** Skytrain can be operated at a frequency to meet foreseeable capacity needs with intervals that meet passenger needs for schedule flexibility. No congestion should result in urban centers as service is elevated. **Notes:** Expo Line: 28 km = 17.4 miles 39 minutes/17.4 miles = 2.2 Min/Mile Avg. Longest Time Between Stations = 4 min. <u>http://www.translink.bc.ca/Service_Info_and_Fares/SkyTrain/</u> <u>Station_Travel_Times.asp</u>

<table>
<tr><th colspan="2">SYSTEM INTEGRATION</th></tr>
<tr><td>Indicator:
• Interlining with existing system
• Barriers to implementation in areas with varying densities and land use characteristics
• Other considerations

Performance:
Different technology from existing HCT systems. Regional use would require transfers at all existing stations. Some barriers due to station size needs.</td><td>General Information:
Skytrain is designed to run separate from all other forms of travel except where transfers and access are required. The associated inflexible routing and inability to operate in mixed traffic limit the ability to integrate Skytrain with other systems.

Regional Application:
Skytrain can work well with existing bus service and suburban feeder services through timed transfers and dual service. Auto and freight traffic should not be adversely affected as facilities can be elevated to an adequate height. The system would not be able to interline with the existing investment in light rail due to the third rail electricity needs. In accessing downtown Seattle transfers will be required at all bus, monorail, and LRT stations unless a separate elevated Skytrain route is constructed with its own separate alignment.

Notes:
(Survey of Transit Technologies, PB Farradyne 2002)</td></tr>
</table>

<table>
<tr><th colspan="2">LAND USE</th></tr>
<tr><td>Indicator:
• Non-auto accessibility
• All day/peak passenger volumes
• Level of investment in stations

Performance:
Large passenger volumes create activity around stations. Permanent stations promote dense development. Some barriers to bike/pedestrian access related to elevated profile.</td><td>General Information:
Stations and the permanent route structure are sizable capital projects, lending themselves to increased densities of development. Pedestrian and bicycle mobility and accessibility are not limited by Skytrain because it operates on elevated tracks, but transfers from buses will require the use of elevators or escalators even in low-density areas.

Regional Application:
The passenger volumes near the stations will help support growth of both residential and commercial land uses in activity centers throughout the region. Skytrain may face opposition related to the aesthetics of the elevated tracks in single-family neighborhoods and other residential locations.

Notes:
(Survey of Transit Technologies, PB Farradyne 2002)</td></tr>
</table>

<table>
<tr><th colspan="2">IMPLEMENTATION RISK</th></tr>
<tr><td>Indicator:
• Track record
• Number of established suppliers and availability of parts

Performance:
Moderate Risk: Well established system operating in a major urban area outside of the US. Similar technology to a few established suppliers & manufacturers. Automated system.</td><td>General Information:
Moderate risk does exist. This technology is not currently operating in the United States but is operating in Vancouver, B.C. It is a seldom used technology and there are few established suppliers and manufacturers.

Regional Application:
Customer expectations should be realistic as there is a system operating nearby in Vancouver B.C. It may be overly costly for the regional demand.

Notes:
(Survey of Transit Technologies, PB Farradyne 2002)</td></tr>
</table>

SCHEDULE RELIABILITY	
Indicator: • **Level of segregation from traffic** • **Mixing with freight** • **Transit priority treatments** **Performance:** Excellent reliability. Dedicated, elevated running ways and tunnels avoid congestion. Fully automated system, Off-board fare collection, level boarding at stations, branding, and marketing add to reliability.	**General Information:** High reliability is assured as trains run on a dedicated, separate right of way and Skytrain is an automated system. Additional transit priority treatments improve performance such as system automation, off-board fare collection for reduced dwell time and distinctive identity, branding, and vehicles. **Regional Application:** The trains are fully automated and the system performance will meet regional needs. **Notes:** *(Survey of Transit Technologies, PB Farradyne 2002)*

RIGHT OF WAY REQUIREMENTS	
Indicator: • **Amount of infrastructure** • **Cross-traffic challenges** • **Profile options & flexibility in right-of-way** **Performance:** Moderate infrastructure required. No cross-traffic conflicts due to profile. Tunnel or elevated.	**General Information:** Right of way requirements for Monorail, and Skytrain would be similar, including dedicated tracks and stations. The tracks are elevated so supporting columns and air rights for their construction may influence the extent of right of way issues. Skytrain can be more easily constructed to run in tunnels. **Regional Application:** Although this level of segregation is appropriate for congested locations, it is somewhat unnecessary in low-density areas. The replacement of parking, blocked views, and aesthetics of this system type may generate opposition within the region. **Notes:** *(Survey of Transit Technologies, PB Farradyne 2002)*

Diesel Multiple Units – (DMU)

Meets many of the needs of a regional system and will be analyzed at corridor level, with a limited number of possible applications.

These steel wheeled train cars use internal power and transmissions, typically with one undercarriage mounted high-speed diesel engine used for propulsion, and a smaller engine used for auxiliary power. A mechanical or electric transmission can be used. If a mechanical transmission is used with a single propulsion engine, one axle or two can be powered. If an electric transmission is used, two axles are powered with electric motors. DMUs do not require a wayside electric power supply and are an alternative to the widely used locomotive hauled commuter car. Unlike classic commuter trains with a locomotive pulling passenger cars, DMU vehicles all carry passengers. The maximum axle loading is approximately one half that of a locomotive and the smaller engines are easier to maintain. DMUs have flexible capacity as the quantity of cars per train can be changed without changing train performance. Additionally, external noise level may be lower and the fuel economy may be better than standard commuter rail.

The BUDD Company originally developed the Rail Diesel Car (RDC) about 50 years ago. An overhauled version of this car is in use in the Dallas segment of the Trinity Rail commuter service. Modern versions of these vehicles come in either of two basic car body designs. FRA body strength compliant designs have been offered by suppliers such as Bombardier and Nippon Sharyo. These vehicles are electric multiple unit cars already delivered to North American commuter agencies. Smaller, modular designs are available from Bombardier, Alstom, and Siemens with much lower, FRA noncompliant car-body compression capability. These have been purchased by the new Camden to Trenton (NJ) Commuter Line.

Recent DMU design is similar to the lightweight, modular designs recently offered for LRVs. The GTW model DMU offered by Adtranz (Bombardier) has the following features: train length 178 feet, width 9.8’, height 12.8’, empty weight 168,000, max speed 60 mph, 202 seats using 2x2, 134 standees, max grade 6 percent, low floor design with 67 percent at 22.4” above top of rail and 33% at 38.2” above top of rail, three doors per train side, two axle truck using a “power car module” concept, min horizontal curve radius 132’. Siemens (Desiro) and Alstrom (Coradia) also offer similar designs

BUDD cars are now operating in the United States with new innovations under development. Both diesel and electric versions may soon be available as well as models that can travel on tracks with freight. These cars are experimental; however their versatility may make their consideration along existing tracks in some of the corridors worthwhile. The DMU is particularly attractive for lower density corridors that require a short train of two or four cars.

Diesel Multiple Unit Technology Characteristics

CAPACITY	
Indicator: 3,700-9,150 pphpd Selected System: Dallas BUDD cars Train Car Passenger Capacity: • Seated = 96 • Seated and Standing = N/A Calculated Line Capacity: (People/hour/direction) 2,880 w/4min headway – 2 cars 8,640 w/4min headway – 6 cars	**General Information:** DMU capacities were calculated at a maximum of 8,640 pphpd. **Regional Application:** Four to Six car DMU trains can meet the transit needs for the time frame of this study. There may be challenges accommodating longer trains in particular locations. As with all of the HCT technologies, DMU will be supplemented with parallel services along different facilities that cross each screenline. **Notes:** *(Survey of Transit Technologies, PB Farradyne 2002)*

OPERATING SPEEDS	
Indicator: **Maximum at least 55-66 mph** **Average operating 25-35 mph** **Performance:** Maximum Speed 79 mph Average Speed 45 mph	**General Information:** DMU runs on dedicated tracks at very high speeds. If stations are spaced two to five miles apart, the technology can meet operating speed needs, but if they are spaced too tightly the system will have reduced operating speeds. This is due to the delays associated with rapid acceleration and deceleration. **Regional Application:** All operating speeds would compete with auto speeds and thus meet regional needs. **Notes:** *(Survey of Transit Technologies, PB Farradyne 2002)*

STATION SPACING	
Indicator: **0.5 miles in high density areas** **2 miles in low density areas** **Performance:** 2-5 miles	**General Information:** DMU stations cannot be spaced tightly due to the acceleration and deceleration needs of the technology. **Regional Application:** DMU generally has less frequent stops than what might be optimal for a regional system. It may be a viable option in low-density areas, but the tight station spacing necessary for accessibility needs in urban areas would be difficult to address. **Notes:** http://www.charmeck.org/Departments/CATS/Virtual+Transit/2025+TLUP+8.htm

TYPICAL HEADWAY	
Indicator: **4 minutes – 15 minutes** **Performance:** 2-4 min peak	**General Information:** DMU primarily has lower frequencies over longer distances, but it can operate at higher frequencies for shorter distances depending on freight travel and other scheduling conflicts. **Regional Application:** Depending on its application, it can be operated at a frequency to meet foreseeable regional capacity needs with intervals that meet passenger needs for schedule flexibility. **Notes:** *(Survey of Transit Technologies, PB Farradyne 2002)*

SYSTEM INTEGRATION	
Indicator: • **Interlining with existing system** • **Barriers to implementation in areas with varying densities and land use characteristics** • **Other considerations** **Performance:** Different technology from existing HCT systems. Regional use would require transfers at all existing stations. Barriers associated with freight movement. FRA guidelines may apply.	**General Information:** DMU has the potential to operate on freight routes using existing tracks. The inflexible routing and the inability to operate in mixed traffic associated with DMU sets limits on the opportunity to integrate with other systems. **Regional Application:** There is an existing regional rail line that may be abandoned in the future. DMU may work well with existing bus service and suburban feeder services through timed transfers and dual service. Auto and freight traffic should not be adversely affected except where at grade crossings of tracks are necessary. There are few opportunities to use or construct fully separated tracks in the region. **Notes:** *(Survey of Transit Technologies, PB Farradyne 2002)*

LAND USE	
Indicator: • **Non-auto accessibility** • **All day/peak passenger volumes** • **Level of investment in stations** **Performance:** Moderate volumes create some activity around stations. Impact on land use depends on existing rail alignment. Barriers to bike/pedestrian access related to the use of existing rail.	**General Information:** Usually implemented on existing rails. The investment in large stations and the permanent route structure represent sizable permanent capital projects lending themselves to somewhat increased dense development. Pedestrian and bicycle accessibility and mobility are limited due to safety concerns related to the use of existing freight tracks. Passengers are forced to access the system by pedestrian bridges or tunnels that go over the tracks. **Regional Application:** DMU has the ability to respond to suburban needs. With fewer stations DMU is likely to have less impact on land use, but the moderate passenger volumes near the centers will partially support the growth near these locations of both residential, commercial and employment development. **Notes:** *(Survey of Transit Technologies, PB Farradyne 2002)*

<table>
<tr><th colspan="2">IMPLEMENTATION RISK</th></tr>
<tr><td>Indicator:
Track record
Number of established suppliers and availability of parts
Performance:
High Risk: Extremely limited track record in North America (Operates in only 2 locations). Very few established suppliers & manufacturers.</td><td>General Information:
There is a high risk associated with DMU. With the exception of BUDD cars this technology is not currently operating in the United States. There are multiple vehicle types being developed, but the operating characteristics are not well known and there are few well established suppliers and manufacturers.

Regional Application:
For passengers, DMU operates somewhat similarly to commuter rail, which already operates in the region.

Notes:
(Survey of Transit Technologies, PB Farradyne 2002)</td></tr>
</table>

<table>
<tr><th colspan="2">SCHEDULE RELIABILITY</th></tr>
<tr><td>Indicator:
Level of segregation from traffic
Mixing with freight
Transit priority treatments
Performance:
Good reliability, Dedicated surface and tunnel running ways and tunnels avoid roadway congestion. ROW issues related to the use of freight corridors.</td><td>General Information:
High reliability is generally assured as DMU operates on a dedicated separate right of way.

Regional Application:
Where crossings or tracks are shared with freight there may be scheduling adherence problems.

Notes:
(Survey of Transit Technologies, PB Farradyne 2002)</td></tr>
</table>

<table>
<tr><th colspan="2">RIGHT OF WAY REQUIREMENTS</th></tr>
<tr><td>Indicator:
Amount of infrastructure
Cross-traffic challenges
Profile options & flexibility in right-of-way
Performance:
Extensive infrastructure required. Graded rail serves as partial barrier to cross-traffic mobility. Surface or tunnel.</td><td>General Information:
DMU operates almost exclusively at-grade on dedicated tracks. The construction of such tracks can create barriers between different communities. FRA approved models are available but many cannot operate in conjunction with freight train movements.

Regional Application:
Tracks could be shared with freight depending on vehicle specifications. There are a few locations with existing track where DMU could be implemented within the region. ROW needs on freight tracks have historically been expensive to acquire.

Notes:
(Survey of Transit Technologies, PB Farradyne 2002)</td></tr>
</table>

Commuter Rail (Sounder, Sound Transit)

An existing commuter rail system currently operates in the region, specific segments considered for system extensions will be discussed at the corridor level.

The commuter rail concept is available in many forms for use in a metropolitan area system. It is also used in regional systems. It typically operates over existing freight rail tracks and uses dual rails for both support and guidance. The use of existing at-grade tracks lowers the capital cost requirements of this transit mode, but commuter rail operations share these tracks with freight railroads and have to fit their schedule around freight movement and are subject to delays caused by freight operations. Cars can be self-powered (powered from an external electric supply), or hauled by either an electric or diesel-electric locomotive. Car designs can be single level, double level, or triple level, depending on needed passenger capacity and clearance restrictions. This is the only car concept in which structural and crashworthiness design standards are regulated by the FRA railroad standards and the APTA Press Standard Guidelines used in the industry. Therefore, these are heavier cars.

Headways for full-service systems typically range from 10 to 30 minutes with station spacing every three to five miles. Car length is typically 85'. Cab signaling is required to operate over 79 mph. Train speed can be 125 mph with car designs approved for this speed. Speed is limited by locomotive horsepower and by the use of axle hung motors on US style diesel-electric locomotives (the latter limit is about 100/110 mph). Train speeds are also limited by local speed limits, which are influenced by the type of protection offered at grade crossing. Car passenger boarding can be low level with several steps (Kawasaki & Nippon Sharyo), low level with one step or no steps (Bombardier, Alstom), or high level.

A new concept now in intercity use by Amtrak in the Seattle region is the Talgo Train. This concept is unique in providing a passive tilt train capability, allowing higher speeds to be accommodated with existing railroad curve radii. It uses short articulated cars with single axle shared by the ends of interior cars. The US version is diesel-electric locomotive hauled. A high-speed version is available for European service. This design can be used for commuter service or regional service.

Sounder is a popular commuter rail service currently running on existing rail corridors in the Puget Sound Region. This service currently runs successfully in the region between Everett and Seattle, and Tacoma and Seattle. It runs during rush hours, has high capacity and speeds with few station locations, operating as a true commuter service. Extensions to areas in the south are possible; however it is not an option in many of the corridors because it operates on existing railroad tracks. Commuter rail fills an inter-city role rather than the role of a regional connector running along corridors with many intermediate travel needs. Sound Transit has adopted the following regional service standards and route selection criteria:

- Maximum speed of 79 mph
- Average speed of 35 mph
- 30 minute peak frequencies becoming more frequent as ridership warrants
- 60 minute off-peak frequencies
- 3-10 car trains with capacity for 450-1,500 passengers
- Line-haul capacity of 6,000 pphpd
- Stations spaced 4-5 miles apart, more tightly spaced in high transit volume areas
- Operated on existing railroad tracks shared with freight with signalized crossings.

Commuter Rail Technology Characteristics

CAPACITY	
Indicator: 3,700-9,150 pphpd Selected System: Sounder Commuter Rail Base Passenger Capacity: • Seated = 134 • Seated and Standing = 255 Calculated Line Capacity: (People/hour/direction) 1,072 - 2,040 w/15-min headway – 2 cars 2,144 - 4,080 w/15-min headway – 4 cars	**General Information:** Commuter rail capacities were calculated at a maximum of 4,080 pphpd assuming that trains are running at aggressive 15-minute headways, higher than existing peak hour frequencies. **Regional Application:** Commuter rail trains meet transit needs for the time frame of this study, but not as a stand alone service. The large stations and separated tracks that make it possible to accommodate demand are difficult to accommodate in urban areas. **Notes:** *(Urban Transportation Monitor 5/2003)* *(Survey of Transit Technologies, PB Farradyne 2002)*

OPERATING SPEEDS	
Indicator: **Maximum at least 55-66 mph** **Average operating 25-35 mph** **Performance:** Maximum Speed 55-100 mph Average Speed 25-50 mph	**General Information:** Commuter rail operates on dedicated tracks at high speeds due to limited cross-traffic. **Regional Application:** Operating speeds compete with auto speeds and thus meet regional needs. **Notes:** *(Urban Transportation Monitor 5/2003)*

STATION SPACING	
Indicator: **0.5 miles in high density areas** **2 miles in low density areas** **Performance:** 2 to 5 miles	**General Information:** The slow acceleration/deceleration and train length associated with commuter rail does not allow for frequent stops. **Regional Application:** Commuter rail cannot accommodate the need for a high number of stations in the region's urban centers. Longer trips are extremely well served. **Notes:** *(Rail Transit Capacity, TCRP Report 13, TRB)* *(Urban Transportation Monitor 4/2003)*

<table>
<tr><th colspan="2">TYPICAL HEADWAY</th></tr>
<tr><td>Indicator:
4 minutes – 15 minutes

Performance:
20 - 40 min peak</td><td>General Information:
Generally commuter rail does not include frequent all-day service. Typical schedules include a few trips in the peak times of day in order to accommodate long distance commuters.

Regional Application:
Existing service provides three trips into the urban area each morning and three to the suburban residential areas each evening in order to accommodate commuter needs. Commuter rail does not accommodate passenger needs for schedule flexibility.

Notes:
(Urban Transportation Monitor 4/2003)</td></tr>
</table>

<table>
<tr><th colspan="2">SYSTEM INTEGRATION</th></tr>
<tr><td>Indicator:
• Interlining with existing system
• Barriers to implementation in areas with varying densities and land use characteristics
• Other considerations

Performance:
Seamless integration with Sounder commuter rail in selected rail segment to DuPont. Transfers required at multimodal hub locations. Barriers associated with freight movement. FRA guidelines apply.</td><td>General Information:
The inflexible routing and the inability to operate in mixed traffic associated with commuter rail sets limits on the opportunity to integrate with other systems. Commuter rail typically operates with bus feeders and extensive park-and-rides at outlying stations to integrate with auto travel on the road system.

Regional Application:
Integrating with freight requires negotiations and associated financing with Burlington Northern and local train freight users. Potential rail extensions exist, but there are few opportunities to use or construct fully separated tracks in the region.

Notes:
(Survey of Transit Technologies, PB Farradyne 2002)
(Transit Technology Capabilities and Comparisons, Parsons Brinckerhoff, 2001)</td></tr>
</table>

<table>
<tr><th colspan="2">LAND USE</th></tr>
<tr><td>Indicator:
• Non-auto accessibility
• All day/peak passenger volumes
• Level of investment in stations

Performance:
Large passenger volumes at suburban center parking stations can facilitate low-moderate density development. Barriers to bike/pedestrian access related to the use of existing rail.</td><td>General Information:
Pedestrian and bicycle accessibility and mobility are limited due to safety concerns related to the use of existing freight tracks. Passengers are forced to access the system by pedestrian bridges or tunnels that go over the tracks. The investment in large stations and the permanent route structure represent fairly sizable permanent capital projects lending themselves to increased low-moderate density development.

Regional Application:
High speeds and limited stops facilitate long trips and ease the commute from low-density areas. With fewer stations commuter rail is likely to have less impact on land use, but the passenger volumes near the stations will partially support the growth in centers.

Notes:
(Integration of Bicycles and Transit, 2002) (Highway Capacity Manual, 2000)
(Land Use impacts of Transportation: A Guidebook, Parsons Brinckerhoff for TRB, 1998)</td></tr>
</table>

IMPLEMENTATION RISK	
Indicator: • **Track record** • **Number of established suppliers and availability of parts** **Performance:** Low risk: Currently operating in region and many US cities. High number of established suppliers & manufacturers. High number of experienced drivers and mechanics.	**General Information:** This service is provided in many urban areas in the United States, there would be little risk in implementing the technology. **Regional Application:** Operating needs are known and suppliers and manufacturers are available due to existing implementation within the region. **Notes:** *(Survey of Transit Technologies, PB Farradyne 2002)*

SCHEDULE RELIABILITY	
Indicator: • **Level of segregation from traffic** • **Mixing with freight** • **Transit priority treatments** **Performance:** Good reliability, Dedicated surface and tunnel running ways and tunnels avoid roadway congestion. ROW issues related to the use of freight corridors.	**General Information:** Commuter rail has good to excellent reliability on a separate, dedicated right of way. Where crossings or tracks are shared with freight there may be scheduling adherence problems. **Regional Application:** There are few rail corridors in the region and performance heavily depends on freight movement because of the constrained geography. **Notes:** *Existing Operating Standards (As noted in discussion)* *(Survey of Transit Technologies, PB Farradyne 2002)*

RIGHT OF WAY REQUIREMENTS	
Indicator: • **Amount of infrastructure** • **Cross-traffic challenges** • **Profile options & flexibility in right-of-way** **Performance:** Extensive infrastructure Required. Graded rail serves as partial barrier to cross-traffic mobility. Surface or tunnel.	**General Information:** Commuter rail operates almost exclusively at-grade on dedicated tracks. The construction of such tracks can create barriers between different communities. FRA approved models are available to operate in conjunction with freight train movements. **Regional Application:** There are a few locations with existing track where Commuter rail can be implemented within the region. ROW needs on freight tracks have historically been expensive to acquire. **Notes:** *Existing Operating Standards (As noted in discussion)* *(Survey of Transit Technologies, PB Farradyne 2002)*

Heavy Rail

Exceeds many of the needs of a regional system relative to the investment required, thus it will not be analyzed at the corridor level.

Heavy rail typically is a grade-separated, dual steel rail system capable of moving large volumes of people to serve high travel demand routes in the 30,000 to 50,000 pphpd range. It typically serves a dense metropolitan area. The "heavy" terminology in the name refers to the volume of people carried, and generally equates to a high price for infrastructure.

Heavy rail cars can be short with a length of about 50 feet, such as those used in Chicago, Boston Blue Line and New York City that use the R-142 design. Typically, especially for new starts, longer cars have been used with a length of 70-75 feet, such as BART, LA Red Line, Atlanta and New York City that use the R-143 design. With subway operation typically used, power is provided from a third rail. Car design typically requires generous horizontal and vertical route curvatures that must be considered during the civil design. Station spacing is typically one mile or more and platforms are level with the car floor. Headways are typically three to six minutes for driver-operated trains. Maximum operating speed varies with the transit agency and the route, with typical speeds in the range of 55-75 mph.

A heavy rail system may be applicable in the distant future, however, the high capacity associated with an intense financial investment in such systems may not be needed for many years to come in the Puget Sound Region. The urban centers and developing clusters in this region appear to be better served with more closely spaced stations than what is allowed by the operating characteristics of heavy rail. The technology may be an option for the very distant future but the travel markets here do not appear to require such an investment.

Heavy Rail Technology Characteristics

CAPACITY	
Indicator: 3,700-9,150 pphpd Selected System: San Francisco BART Base Passenger Capacity: • Seated = 344 (8 car) • Seated and Standing = 1,920 (8 car) Calculated Line Capacity: (People/hour/direction) 5,160-28,800 w/4min headway – 8 cars	**General Information:** Heavy rail capacities were calculated at a maximum of 28,800 pphpd with the use of 8-car trains. **Regional Application:** Heavy rail has more than enough capacity to handle travel demands within the region, however, the high cost and the use of a third rail associated with the investment may not warrant its implementation. **Notes:** *(Survey of Transit Technologies, PB Farradyne 2002)*

OPERATING SPEEDS	
Indicator: **Maximum at least 55-66 mph** **Average operating 25-35 mph** **Performance –** <u>Maximum Speed</u> 55 – 75 mph <u>Average Speed</u> 35 - 45	**General Information:** Heavy rail operates on dedicated tracks at high speeds due to limited cross-traffic. **Regional Application:** All operating speeds would compete with auto travel and meet regional needs. **Notes:** *(Urban Transportation Monitor 6/2000)*

STATION SPACING	
Indicator: **0.5 miles in high density areas** **2 miles in low density areas** **Performance:** 1 to 3 miles	**General Information:** Because of the station size, less frequent stops are generally associated with this technology, making it less optimal for travel within urban areas. **Regional Application:** Accommodating 8 car trains within the constrained urban environments of the region would require large stations that can be difficult to locate. **Notes:** *(Rail Transit Capacity, TCRP Report 13, TRB)*

TYPICAL HEADWAY	
Indicator: **4 minutes – 15 minutes** **Performance:** 2 - 10 min peak	**General Information:** Heavy rail vehicles can reach high frequencies due to rapid loading and unloading, off-board fare collection, dedicated running ways, and other priority treatments. **Regional Application:** The system could be operated at a frequency to meet foreseeable capacity needs. No congestion should result in urban centers due to the high capacity. **Notes:** *(Characteristics of Urban Transportation Systems, FTA, 1992)*

SYSTEM INTEGRATION	
Indicator: • **Interlining with existing system** • **Barriers to implementation in areas with varying densities and land use characteristics** • **Other considerations** **Performance:** Different technology from existing HCT systems. Regional use would require transfers at all existing stations. Some barriers due to station size needs FRA guidelines may apply.	**General Information:** Heavy rail operates on dedicated, separated tracks. Auto and freight traffic should not be adversely affected except at grade crossings of tracks. The associated inflexible routing and inability to operate in mixed traffic limit integration. **Regional Application:** Heavy rail can work well with existing bus service and suburban feeder services through timed transfers and dual service. Less dense areas would require exclusive tracks due to the need for a third rail. This may cause problems interlining with other systems. LRT is being constructed in Seattle's CBD as well as Monorail with heavy rail seen as a potential improvement if added capacity is needed beyond the planning horizon of this study. **Notes:** *(Survey of Transit Technologies, PB Farradyne 2002)* *(Transit Technology Capabilities and Comparisons, Parsons Brinckerhoff, 2001)*

LAND USE	
Indicator: • **Non-auto accessibility** • **All day/peak passenger volumes** • **Level of investment in stations** **Performance:** Barriers to bike/ped access related to safety concerns (electrical source). Very large passenger volumes create activity around stations. Permanent stations promote dense development.	**General Information:** Heavy rail systems operate through suburban and urban areas and primarily serve a commuter service. Pedestrian and bicycle accessibility and mobility are limited to widely spaced stations. The large passenger volumes near the stations are likely to add to growth. Stations and permanent route structure represent sizable capital investments and lend themselves to increased dense development. **Regional Application:** These systems work well in dense urban areas but stations may be too widely spaced and their footprint impact too great to meet the regional needs due to the moderate densities within the region. **Notes:** *(Integration of Bicycles and Transit, 2002) (Highway Capacity Manual, 2000)* *(Land Use impacts of Transportation: A Guidebook, Parsons Brinckerhoff for TRB, 1998)*

IMPLEMENTATION RISK	
Indicator: • **Track record** • **Number of established suppliers and availability of parts** **Performance:** Low Risk: Well established systems operating in other major urban areas. High number of established suppliers & manufacturers. High number of experienced drivers and mechanics.	**General Information:** These systems are in use in many of the large urban areas of the United States. The operational characteristics are known and there are multiple suppliers and manufacturers. **Regional Application:** Heavy rail is an investment more appropriate to established dense urban areas. The cost of implementing such a system may prove too high as much of the region is still under development and the region does not contain the higher densities necessary to support Heavy Rail. **Notes:** *(Survey of Transit Technologies, PB Farradyne 2002)*

SCHEDULE RELIABILITY	
Indicator: • **Level of segregation from traffic** • **Mixing with freight** • **Transit priority treatments** **Performance:** Excellent reliability. Dedicated running ways and tunnels avoid congestion. ROW issues related to the use of freight corridors or the construction of new rail facilities.	**General Information:** High reliability is generally assured as heavy rail runs on a dedicated separate right of way. There may be some challenges associated when mixed with freight. Off-board fare collection and other transit priority treatments are included. **Regional Application:** Dedicated tracks constructed within the region for heavy rail would assure that passenger scheduling needs would be met. **Notes:** *(Survey of Transit Technologies, PB Farradyne 2002)*

RIGHT OF WAY REQUIREMENTS	
Indicator: • **Amount of infrastructure** • **Cross-traffic challenges** • **Profile options & flexibility in right-of-way** **Performance:** Extensive infrastructure required. Graded rail serves as partial barrier to cross-traffic mobility. Surface or tunnel.	**General Information:** Right of way is required for heavy rail's dedicated tracks. These systems are powered with a third rail requiring strict grade separation. **Regional Application:** Considerable ROW requirements would need to be met for Heavy Rail. The entire track and station must be grade separated due to the need for a powered third rail. **Notes:** *(Survey of Transit Technologies, PB Farradyne 2002)*

Mag Lev and High Speed Rail Systems

Mag Lev & High Speed Rail will not be analyzed at the corridor level.

High Speed Rail
Characteristics associated with this technology typically include a speed over 125 mph as the primary indicator. Conventional steel wheel designs are operating or on order in several worldwide locations at speeds up to 175 mph. The speed is not limited by the equipment's ability and 200 mph speeds are being tested. The speed limits have been due to ground vibrations and audible noise along a particular route.

High speed rail provides competition for the airline service in other countries such as Japan's bullet train and France's high-speed rail from the Mediterranean to Paris. The Shinkansen (Japan), TGV (France), and ICE (German) designs are in service, with the lower speed Acela (Bombardier/Alstom) operating in the Amtrak Northeast Corridor service. The Talgo version of commuter rail also has a high-speed design.

Vehicle properties are not provided because of severe differences in design. A key question when considering high speed service, is not how fast the train can operate, but what the optimum speed limit is when considering economic and land use factors. As train speed increases there will be a significant increase in life cycle cost with track installation and maintenance cost, energy cost, power cost, and vehicle maintenance costs all increasing. The station spacing needed to achieve high-speed operation is only suitable for long-distance trips and does not support planned land use.

In a regional setting such as central Puget Sound the tight station spacing required would not allow the vehicles to take advantage of their maximum speed. The constant need to decelerate and stop for passengers lends itself to other technologies. An inter-regional or multi-state system would be a more appropriate application for this technology.

Mag Lev
If speeds in the 300 mph range are needed and can be economically justified, the MagLev concept is the only available ground operating technology. The modern high-speed concept uses magnetic fields to support, guide, and propel a passive vehicle.

It has not been proven in routine revenue service, having only operated in test tracks in Germany and Japan. Shanghai China has recently ordered a system from Germany, using the Transrapid design. The Japanese design requires the use of superconductivity, which will not be economically viable for some time.

A complex power distribution system must be used as each vehicle must have its own power source in each controlling distance segment, to externally control its speed in that segment using variable voltage and frequency. Cost information is not available for a regional system. There is limited onboard power available, means must be reliably provided for vehicle onboard power from the electrical subsystems. Vehicle vibration and audible noise also require careful review.

The FTA has proposed development of a lower speed urban MagLev. However this appears to require a more complex power distribution system because vehicles will operate at closer intervals, with more power control guideway segments. HSST, a Japanese maglev supplier, has been offering a lower speed design that uses an active vehicle, with a linear motor drive. This concept is likely to reduce the cost and complexity of the power distribution system; however, the issues of system efficiency and satisfactory vehicle power collection become important.

Mag Lev & High Speed Rail Technology Characteristics

CAPACITY	
Indicator: **3,700-9,150 pphpd** <u>Selected System:</u> Japanese Bullet Train <u>Base Passenger Capacity:</u> • Seated = 194 (2 sections) – 292 (4 sections) – ML • Seated and Standing = 304 (2 locomotives and 6 coaches) – HS <u>Calculated Line Capacity:</u> (People/hour/direction) Both run at very low frequencies.	**General Information:** The capacities for these systems were not calculated as their use is appropriate for interstate or inter-regional travel. **Regional Application:** MagLev and High Speed rail are not appropriate for regional travel. **Notes:** There are urban MagLev systems proposed but not operating. These would have slower speeds. *(Survey of Transit Technologies, PB Farradyne 2002)*

OPERATING SPEEDS	
Indicator: **Maximum at least 55-66 mph** **Average operating 25-35 mph** **Performance:** <u>Maximum Speed</u> 300 mph - ML 150 mph - HS <u>Average Speed</u>	**General Information:** Speeds are dependent on alignment, the condition of existing rail, opportunities for highway grade crossings, and the level of co-existence with freight operations. Bullet trains and MagLev vehicles travel at speeds between 200 and 300 mph. **Regional Application:** The short trips needed to fulfill the regional and corridor level travel needs would prevent the trains from reaching optimum speeds. **Notes:** *(Survey of Transit Technologies, PB Farradyne 2002)*

STATION SPACING	
Indicator: **0.5 miles in high density areas** **2 miles in low density areas** **Performance:** 10 miles	**General Information:** These systems are more appropriate for interstate and inter-regional services resulting in stations spaced miles apart. Stations need to be widely spaced in order to take advantage of the high speeds associated with these technologies. **Regional Application:** The Puget Sound Region's travel market would not be well served by this travel option due to the need for shorter distances between stations in urban centers. **Notes:** *(Survey of Transit Technologies, PB Farradyne 2002)*

TYPICAL HEADWAY	
Indicator: **4 minutes – 15 minutes** **Performance:** 20 min – ML Unknown – HS	**General Information:** These systems can provide rapid service between widely spaced urban areas, improving interstate and inter-region travel flexibility and frequency. **Regional Application:** High speed rail and Mag-Lev could provide rapid, somewhat frequent transportation between the Central Puget Sound region and other urban areas such as Olympia, Portland, Bellingham, and Vancouver, BC. It could not operate at a frequency appropriate to more localized travel along the study corridors within the region. **Notes:** *(Survey of Transit Technologies, PB Farradyne 2002)*

SYSTEM INTEGRATION	
Indicator: • **Interlining with existing system** • **Barriers to implementation in areas with varying densities and land use characteristics** • **Other considerations** **Performance:** Different technology from existing HCT systems. Regional use would require transfers at all existing stations. Severe barriers due to wide station spacing required for long-term high-speed travel.	**General Information:** High speed rail systems can operate on existing freight tracks. Mag-Lev is unable to join existing rail networks and requires the construction of new infrastructure. Both operate on exclusive, dedicated rights of way that can be difficult to directly interline with existing transit systems. **Regional Application:** LRT and monorail are under development in Seattle's CBD in addition to a strong bus system. These regional systems could feed a high-speed rail system with trains destined for other regions or states. **Notes:** *(Survey of Transit Technologies, PB Farradyne 2002)*

LAND USE	
Indicator: • **Non-auto accessibility** • **All day/peak passenger volumes** • **Level of investment in stations** **Performance:** Barriers to bike/ped access related to safety concerns (high speeds). Vary large passenger volumes create activity around stations. Permanent stations promote dense development.	**General Information:** Pedestrian and bicycle accessibility and mobility are limited due to safety concerns related to the use of exclusive tracks. Passengers would access the system by pedestrian bridges or tunnels that go over the tracks. Stations and permanent route structure represent sizable capital investments designed for interstate or larger regional travel. They are not typically used for daily commutes. **Regional Application:** With a very limited number of stations these systems are likely to have less impact on overall land use. The passenger volumes near the stations could support the growth in a few activity centers. **Notes:** *(Survey of Transit Technologies, PB Farradyne 2002)*

IMPLEMENTATION RISK	
Indicator: • **Track record** • **Number of established suppliers and availability of parts** **Performance:** ML – High Risk: One system in operation last year. Very limited number of suppliers & manufacturers. Few experienced drivers and mechanics. HS – Moderate Risk: Safe, efficient travel in Japan and Europe for 40 years but no operating system in US.	**General Information:** High speed rail systems have a good track record in areas outside of the US. Mag-Lev has only operated on test tracks and system maintenance needs are unknown. Historical application has been limited to very long distance travel. **Regional Application:** None of these systems have been applied in a more localized regional context and it is unlikely that they would be successful for shorter distance travel relative to the investment required. **Notes:** There are urban MagLev systems proposed but no long term track record has been established. *(Survey of Transit Technologies, PB Farradyne 2002)*

SCHEDULE RELIABILITY	
Indicator: • **Level of segregation from traffic** • **Mixing with freight** • **Transit priority treatments** **Performance:** ML – Unknown HS – Excellent reliability. Dedicated running ways and tunnels avoid congestion. ROW issues related to the construction of new rail facilities.	**General Information:** High reliability is generally assured as these systems run on a dedicated separate right of way. If combined on existing tracks with freight, schedule reliability is likely to suffer. **Regional Application:** Existing inter-regional travel has had trouble maintaining an on-time schedule because of mechanical problems aggravated by the condition of the railway. The reliability of the system could be improved with the construction of new infrastructure at a high cost. **Notes:** *(Survey of Transit Technologies, PB Farradyne 2002)*

RIGHT OF WAY REQUIREMENTS	
Indicator: • **Amount of infrastructure** • **Cross-traffic challenges** • **Profile options & flexibility in right-of-way** **Performance:** Extensive infrastructure required. No cross-traffic conflicts due to profile. Tunnel or elevated.	**General Information:** Right of way is required for dedicated tracks. These systems operate at very high speeds requiring strict grade separation. **Regional Application:** New or additional infrastructure would be needed in order to improve performance or provide for Maglev operation. There are few corridors that could accommodate such a system within the region. **Notes:** *(Survey of Transit Technologies, PB Farradyne 2002)*

People Movers

People Movers will not be analyzed at the corridor level.

Many designs are in operation and many other designs have been proposed. Generally this concept uses rubber tires for car propulsion, support and guidance, a concrete guideway with DC or three-phase AC power supplied as part of the guideway, and a control system for automatic operation.

Operation is typically in shuttle mode, at short distances and relatively low speeds (20 to 35 mph). Airports and activity centers are primary users of this technology, because the small cars require a small clearance envelope that reduces construction expense. This concept has also been used for downtown city circulators in Detroit, Miami and Jacksonville. Cars can be coupled to form higher capacity trains. Station doors are used for passenger protection. Few, if any, seats are provided due to short trip lengths.

The technology operates in many airports, but each system is unique. For all designs there are concerns: 1) travel times are slow, 2) people movers could not meet needed capacity and 3) the system is designed for frequent stops for making short trips. People movers work well at airports and other high activity areas but do not meet many of the regional travel needs for longer distance trips.

People Mover Technology Characteristics

CAPACITY	
Indicator: 3,700-9,150 pphpd Selected System: SeaTac Airport Circulator Base Passenger Capacity: • Seated = 8 • Seated and Standing = 100 Calculated Line Capacity: (People/hour/direction) 240 – 3,000 w/2min headway – 1 car	**General Information:** People Mover capacities were calculated at a maximum of 3,000 pphpd operating at higher frequencies than many of the other systems that were assessed. **Regional Application:** People Movers do not meet travel demand for the time frame of this study. Even with a 2-minute headway, the system would fall short of the demand in all of the corridors. **Notes:** *(Survey of Transit Technologies, PB Farradyne 2002)*

OPERATING SPEEDS	
Indicator: **Maximum at least 55-66 mph** **Average operating 25-35 mph** **Performance:** <u>Maximum Speed</u> 6-50 mph <u>Average Speed</u> 4-23 mph	**General Information:** People Movers generally operate at low-moderate speeds. **Regional Application:** For application at the regional level, operating speeds are slightly slower than auto speeds and would not significantly increase competitiveness with the automobile. **Notes:** *(Urban Transportation Monitor 9/1998)* *(Survey of Transit Technologies, PB Farradyne 2002)*

STATION SPACING	
Indicator: **0.5 miles in high density areas** **2 miles in low density areas** **Performance:** Airport service or a small number of city blocks.	**General Information:** People Movers have frequent stops to provide for direct access connections to tightly spaced urban activities or terminals at an airport. **Regional Application:** Frequent inflexible stops are typical for this technology. It is not applicable as a regional technology due to the need for longer distance travel. **Notes:** *(Rail Transit Capacity, TCRP Report 13, TRB)* *(Urban Transportation Monitor 4/2003)*

TYPICAL HEADWAY	
Indicator: **4 minutes – 15 minutes** **Performance:** 1 - 2 min peak	**General Information:** People Movers operate at very high frequencies, providing for a very dependable service for short trips. **Regional Application:** Even with higher frequencies than most of the other technologies it is unlikely that People Movers will be able to provide the capacity that will be needed in urban centers throughout the region. **Notes:** *(Urban Transportation Monitor 5/2002)*

SYSTEM INTEGRATION	
Indicator: • **Interlining with existing system** • **Barriers to implementation in areas with varying densities and land use characteristics** • **Other considerations** **Performance:** Different technology from existing HCT systems. Regional use would require transfers at all existing stations. Severe barriers due to low capacity and low speeds.	**General Information:** Challenging to fit in with existing infrastructure. The associated inflexible routing and inability to operate in mixed traffic limits integration. **Regional Application:** LRT is being constructed in Seattle's CBD as well as Monorail. People Movers could be seen as an additional improvement if added capacity is needed for inner city circulation or additional airport needs related to the third runway. **Notes:** *(Survey of Transit Technologies, PB Farradyne 2002)* *(Transit Technology Capabilities and Comparisons, Parsons Brinckerhoff, 2001)*

LAND USE	
Indicator: • **Non-auto accessibility** • **All day/peak passenger volumes** • **Level of investment in stations** **Performance:** Some barriers to bike/ped access related to elevated profile and small station size. Low passenger volumes create little activity around stations. Stations have little impact on land use.	**General Information:** The high number of stations and permanent route structure represent sizable, but dispersed capital projects lending themselves to increased dense development within short distances. However, lower passenger volumes near frequent and smaller stations may not add to the growth near these locations; rather, the system would add to and eases short trips. **Regional Application:** People Movers provide a moderate incentive to develop near major access points within specific urban centers in the region, but it is unlikely that such a system would have a large impact on land use throughout the region. **Notes:** *(Integration of Bicycles and Transit, 2002) (Highway Capacity Manual, 2000)* *(Land Use impacts of Transportation: A Guidebook, Parsons Brinckerhoff for TRB, 1998)*

IMPLEMENTATION RISK	
Indicator: • **Track record** • **Number of established suppliers and availability of parts** **Performance:** High Risk: Only operated in small airport systems. Moderate number of suppliers & manufacturers. Automated System.	**General Information:** These systems are in use in many of the airports of the United States. People Movers are often one-of-a-kind systems designed to specific needs, so there are risks with each new application of the technology. **Regional Application:** The SeaTac airport operates service between passenger terminals. This system could be expanded to accommodate potential needs associated with the addition of a third runway. The technology is unlikely to address the needs on a regional scale and it would require a drastically different design. **Notes:** *(Survey of Transit Technologies, PB Farradyne 2002)*

<table>
<tr><th colspan="2">SCHEDULE RELIABILITY</th></tr>
<tr><td>Indicator:
Level of segregation from traffic
Mixing with freight
Transit priority treatments
Performance:
Excellent reliability. Dedicated, elevated running ways avoid congestion. Fully automated system, Off-board fare collection, level boarding at stations, branding, and marketing add to reliability.</td><td>General Information:
High reliability is generally assured as the system runs on a dedicated separate right of way incorporating off-board fare collection, automation, and other transit priority characteristics.

Regional Application:
People Movers lack the speed necessary to provide for the frequent, dependable, long distance travel needed for the region.

Notes:
(Survey of Transit Technologies, PB Farradyne 2002)</td></tr>
</table>

<table>
<tr><th colspan="2">RIGHT OF WAY REQUIREMENTS</th></tr>
<tr><td>Indicator:
Amount of infrastructure
Cross-traffic challenges
Profile options & flexibility in right-of-way
Performance:
Extensive Infrastructure required. No cross-traffic conflicts due to profile. Tunnel or elevated.</td><td>General Information:
Right of way is required for dedicated tracks and the system would be powered with a third rail requiring strict grade separation.

Regional Application:
People Movers could serve connections between high activity areas within a city, but elevated infrastructure would have to cover the entire region in order for People Movers to deliver the trip connections that it is meant to provide.

Notes:
(Survey of Transit Technologies, PB Farradyne 2002)</td></tr>
</table>

Personal Rapid Transit

Personal Rapid Transit will not be analyzed at the corridor level.

PRT systems are a fleet of driverless cars each carrying 2-4 passengers between any two off line stations. The vehicles are guided by passenger selection and make no intermediate stops. A PRT system aims to replicate the flexibility of the arterial street and automobile system, allowing people and goods to travel from point to point without needing to share the vehicle or navigate a complicated transit network. This point-to-point operating concept differentiates PRT from people movers or other transit technologies. The systems require an extensive amount of infrastructure and a control system that will provide the complex switching and accommodate congestion at high activity sites as stations and guideways must be provided to all potential destinations.

The only deployed PRT system is at the campus of West Virginia University at Morgantown. Opened in 1975, the Morgantown system includes 8.7 miles of guideway, 5 stations, and 71 vehicles connecting the main downtown campus with the Morgantown CBD and two suburban campuses. The Morgantown system differs from a true PRT in three ways. 1) The cars are larger, accommodating 8 seated and 13 standing passengers. 2) It is a linear alignment rather than a grid system. 3) It can operate as scheduled service making all stops, depending on demand. Average daily ridership is 14,000 and design capacity is 3600 pphpd.

PRT's low speeds and limited capacity make it unsuitable for regional travel but a good fit for local service. The concept of small vehicles carrying up to eight people working on a complex AGT network would function well at airports and in highly dense urban areas. PRT, shuttle service or privately operated jitney services have a place in feeding the regional HCT system from activity centers. For example, a casino or shopping mall built several miles from an HCT station could provide shuttles at frequent intervals to their front door. A particularly dense urban area could be an area served by PRT or private jitney services running from the HCT to nearby major destinations.

Personal Rapid Transit Technology Characteristics

CAPACITY	
Indicator: 3,700-9,150 pphpd <u>Selected System:</u> Morgan Town Virginia <u>Base Passenger Capacity:</u> • Seated = 8 • Seated and Standing = 13 <u>Calculated Line Capacity:</u> (People/hour/direction) 1,920 –3,120 w/15sec headway	**General Information:** People Mover capacities were calculated to max out at 3,120 pphpd operating at extremely high frequencies. **Regional Application:** PRT does not meet travel demand for the time frame of this study. Even with a 15 second headway, PRT falls short of the demand in all of the corridors. **Notes:** *(Survey of Transit Technologies, PB Farradyne 2002)*

OPERATING SPEEDS	
Indicator: **Maximum at least 55-66 mph** **Average operating 25-35 mph** **Performance:** Maximum Speed 30 mph Average Speed N/A	**General Information:** PRT generally operates at moderate speeds. **Regional Application:** For application at the regional level, operating speeds are slightly slower than auto speeds and would not significantly increase competitiveness with the automobile. **Notes:** *(Urban Transportation Monitor 9/1998)*

STATION SPACING	
Indicator: **0.5 miles in high density areas** **2 miles in low density areas** **Performance:** Low traffic, all cars stop at all stations. High traffic, cars bypass.	**General Information:** People Movers have frequent stops to provide for direct access connections to tightly spaced urban activities or terminals at an airport. **Regional Application:** Frequent inflexible stops are typical for this technology. It is not applicable as a regional technology due to the need for longer distance travel. **Notes:** *(Rail Transit Capacity, TCRP Report 13, TRB)* *(Urban Transportation Monitor 4/2003)*

TYPICAL HEADWAY	
Indicator: **4 minutes – 15 minutes** **Performance:** 15 seconds	**General Information:** PRT operates at extremely high frequencies, providing for a very dependable service for short trips. **Regional Application:** Even with higher frequencies than all of the other technologies it is unlikely that PRT will be able to provide the capacity that will be needed in urban centers throughout the region. **Notes:** *(Urban Transportation Monitor 5/2002)*

SYSTEM INTEGRATION	
Indicator: • **Interlining with existing system** • **Barriers to implementation in areas with varying densities and land use characteristics** • **Other considerations** **Performance:** Different technology from existing HCT systems. Regional use would require transfers at all existing stations. Severe barriers due to low capacity per vehicle, infrastructure needs, and complex merging characteristics.	**General Information:** It is likely to be challenging to fit a PRT system in with existing infrastructure. The associated inflexible routing and inability to operate in mixed traffic limits integration. **Regional Application:** LRT is being constructed in Seattle's CBD as well as Monorail. PRT could be seen as an additional improvement if added capacity is needed for inner city circulation or additional airport needs related to the third runway. **Notes:** *(Survey of Transit Technologies, PB Farradyne 2002)* *(Transit Technology Capabilities and Comparisons, Parsons Brinckerhoff, 2001)*

LAND USE	
Indicator: • **Non-auto accessibility** • **All day/peak passenger volumes** • **Level of investment in stations** **Performance:** Some barriers to bike/ped access related to elevated profile and small station size. Minor passenger volumes create limited activity around stations. Stations have little impact on land use.	**General Information:** The high number of stations and permanent route structure represent sizable, but dispersed capital projects lending themselves to increased dense development within short distances. However, lower passenger volumes near frequent and smaller stations may not add to the growth near these locations; rather, the system would add to and eases short trips. **Regional Application:** PRT provides a moderate incentive to develop near major access points within specific urban centers in the region, but it is unlikely that such a system would have a large impact on land use throughout the region. **Notes:** *(Integration of Bicycles and Transit, 2002) (Highway Capacity Manual, 2000) (Land Use impacts of Transportation: A Guidebook, Parsons Brinckerhoff for TRB, 1998)*

IMPLEMENTATION RISK	
Indicator: • **Track record** • **Number of established suppliers and availability of parts** **Performance:** High Risk: Only operated in one location in the US. Very limited number of suppliers & manufacturers. Complicated automated system.	**General Information:** PRT has only been implemented in one location (Morgantown, WV). PRT is a one-of-a-kind systems designed to specific needs, so there are risks with each new application of the technology. There is a very limited number of suppliers and manufacturers and PRT involves the investment in a complicated automated system with few proven results. **Regional Application:** The technology is unlikely to address the needs on a regional scale and it would require a drastically different design. **Notes:** *(Survey of Transit Technologies, PB Farradyne 2002)*

SCHEDULE RELIABILITY	
Indicator: • **Level of segregation from traffic** • **Mixing with freight** • **Transit priority treatments** **Performance:** Good to excellent reliability. Dedicated, elevated running ways avoid congestion, but complex merging creates point capacity constraints at high-use locations. Fully automated system, Off-board fare collection, level boarding at stations, branding, and marketing add to reliability.	**General Information:** High reliability is generally assured as the system runs on a dedicated separate right of way incorporating off-board fare collection, automation, and other transit priority characteristics. **Regional Application:** Actual headways are reduced because individual, thirteen or fewer passenger vehicles take time to load and would have to be accommodated at stations that are too small to address the high numbers of passengers. Other issues related to the movement of the automated vehicles in and out of stations are likely to increase travel time. **Notes:** *(Survey of Transit Technologies, PB Farradyne 2002)*

RIGHT OF WAY REQUIREMENTS	
Indicator: • **Amount of infrastructure** • **Cross-traffic challenges** • **Profile options & flexibility in right-of-way** **Performance:** Extensive infrastructure required. No cross-traffic conflicts due to profile. Elevated only.	**General Information:** Right of way is required for dedicated tracks. PRT systems are powered with a third rail requiring strict grade separation. **Regional Application:** PRT could serve connections between high activity areas within a city, but elevated infrastructure would have to cover the entire region in order for PRT to deliver the necessary flexibility that it is meant to provide. **Notes:** *(Survey of Transit Technologies, PB Farradyne 2002)*

3.3 Summary of System-wide Technology Assessment

Assessment Summarized By Technology

Enhanced Bus (Local Express Bus Service)
Enhanced Bus meets many of the needs of a regional system and will be analyzed and discussed at the corridor level. The relatively low capacity of bus transit vehicles would eventually require an increasing number of buses. The buses travel in mixed traffic, contributing to and being slowed by congestion. Enhanced bus could be a feeder system to another technology. It currently operates in most corridors and could continue successfully in less developed portions of corridors with future phasing to a technology that uses dedicated rights of way.

Bus Rapid Transit (BRT)
BRT meets many of the needs of a regional system and will be analyzed at the corridor level. It can provide needed service in many corridors throughout this study's horizon. Dedicated lanes and stations could transition into dedicated, exclusive facilities in the future making BRT a transitional step toward higher capacities and faster speeds of other HCT technologies.

BRT has more capacity than the Enhanced Bus by using larger coaches and traveling in platoons. It shares the problem of being slowed by traffic congestion and may add to congestion in some of the corridors discussed. BRT often has dedicated lanes and signal priority, speeding travel times. It could be developed by adding improvements to Enhanced bus. Land use influences of increased density will be supported through substantial stations and increased pedestrian activity.

Light Rail (LRT)
LRT meets many of the needs of a regional system and will be analyzed at the corridor level. Light rail has high, and flexible, capacity. It can operate at two-minute frequencies, and additional cars can be easily added. Off-board fare collection is typical of LRT, and when combined with multiple large doors, station dwell times are low. This increases speeds and improves schedule reliability and customer convenience. Stations can be located at flexible intervals and can be constructed as small platforms in existing streets or large stations with park and rides, bike lockers and other passenger amenities. These stations, along with the perceived permanence of the tracks, can focus land use development. The pedestrian activity generated near these locations can additionally help support dense development. LRT will meet the needs of corridors in the region currently. It can also be phased into other areas in coming years. Raised platforms integrated with below-grade and at-grade transit options may be less convenient for passengers.

Monorail (Las Vegas Bombardier System or Seattle Monorail Project)
Monorail meets many of the needs of a regional system and will be analyzed at the corridor level. This intermediate monorail system lacks some of the capacity of LRT but would meet the travel demand in some corridor sections for many years. It is more difficult to add cars and switching tracks may limit headway frequencies, thereby limiting capacity. There is a popular short monorail line operating in Seattle's center. Stations are large as they are elevated, requiring elevators or escalators, waiting areas, and passenger boarding areas. This provides amenities but also requires sizable footprints. Would likely support higher density development, create pedestrian activity and meet travel needs in urban centers. Higher capacity monorail systems may not integrate well with the intermediate equipment and rails. Raised platforms integrated with below-grade and at-grade transit options may be less convenient for passengers.

Skytrain (Vancouver, B.C.)
Skytrain meets many of the needs of a regional system and will be analyzed at the corridor level. Currently operating in Canada, it is successfully providing a higher capacity option. It must be totally grade separated as usually powered by a third rail, to electrical induction motors, and is fully automated. Sizable stations are needed as with monorail. It has many of the features of LRT and monorail: elevated, automated and able to run powered by third rail or overhead catenary. Raised platforms integrated with below-grade and at-grade transit options may be less convenient for passengers.

Assessment Summarized By Technology – *cont'd*

Diesel Multiple Units - DMU (Dallas BUDD Cars)
DMU meets many of the needs of a regional system and will be analyzed at corridor level, with a limited number of possible applications. BUDD cars are operating in the United States with new innovations of this technology being developed. Both diesel and electric versions may soon be available as well as models that can carry passengers on tracks with freight train movements. These cars are experimental. However their versatility may make their consideration along existing tracks worthwhile.

Commuter Rail (Sounder, Sound Transit)
An existing commuter rail system currently operates in the region. Specific segments considered for system extensions will be discussed at the corridor level. This service currently runs in the region between Everett & Seattle, and Tacoma & Seattle. It runs during the rush hours, has high capacity and high speeds with few station locations, operating as a true commuter service. Although extensions are possible, it is not an option in many of the corridors. Commuter rail operates well on existing railroad tracks, aptly filling a regional inter-city role rather than the role of a regional connector along corridors with many intermediate travel needs.

Heavy Rail (San Francisco BART)
Heavy Rail exceeds many of the needs of a regional system relative to the investment required. Thus, it will not be analyzed at the corridor level. The high capacity available with these systems may not be necessary for many years into the future for the Puget Sound region. The stations are typically two or more miles apart in dense urban areas. The urban centers and developing clusters in this region appear to be better served with more closely spaced stations. This may be an option for the distant future but is not needed at this time.

Mag Lev and High Speed Rail Systems (Bullet Trains)
Mag Lev & High Speed Rail will not be analyzed at the corridor level. High speed rail service in other countries, such as Japan's bullet train and France's high-speed rail from the Mediterranean to Paris, provides competition with airline service. However, in a regional setting such as central Puget Sound the station spacing for a regional system would not allow for the vehicles to take advantage of their maximum speed. The constant need to decelerate and stop for passengers lends itself to other technologies. An inter-regional or multi-state system would be well served by this technology.

People Movers (Sea-Tac Airport Circulator)
People Movers will not be analyzed at the corridor level. People Movers work well at airports or other high activity areas but do not meet many regional needs. Currently travel speeds are slow, there would be difficulty in meeting needed additional capacity, and the system is intended for frequent stops and short trips.

Personal Rapid Transit (PRT Morgan Town Virginia System)
PRT will not be analyzed at the corridor level. PRT's low speeds and limited capacity make it unsuitable for regional travel but a good fit for local service. The concept of small vehicles carrying up to eight people and working on a complex AGT network would function well at airports and in highly dense urban areas, acting as a feeder to a regional system.

PRT, shuttle service or privately operated jitney services have a place in feeding the regional HCT system from activity centers. For example, a casino or shopping mall built several miles from an HCT station could provide shuttles at frequent intervals to their front door. A particularly dense urban area, such as First Hill, could be an area served by PRT or private jitney services running from the HCT to nearby major destinations.

FIGURE 3.3

Summary of Technology Options & Characteristics

Selected High Capacity Transit Technologies Evaluated

Technology Characteristics	*Enhanced Bus*	*Bus Rapid Transit*	*Light Rail*	*Monorail*	*Sky Train*	*Diesel Multiple Units BUDD Cars*	*Commuter Rail*	*Heavy Rail*	*Maglev / High Speed*	*People Movers Airport Circulators*	*Personal Rapid Transit*
Existing Operating Systems	Seattle Express Bus Local Operation	Journal of Public Transportation Well Documented	ST Link Light Rail Local Project	Seattle Monorail Project Local Project	Vancouver B.C. Only Example	Dallas Only U.S. Example	ST Sounder Local Operation	San Francisco BART Well Documented	Japanese Bullet Train Only Example	SeaTac Airport Local Operation	Morgan Town Virginia Only Example
Vehicle Capacity											
• Seated	43 - 40' bus	65 - 60' bus	74	N/A	168 (2 car, married pair)	96	134	344 (8 car)	194 (2 sections) – 292 (4 sections) – ML	8	8
• Seated and Standing	80 - 40' bus	90 - 60' bus	148	125 (1 car, top SMP #)	512 (2 car, married pair)	N/A	255	1,920 (8 car)	304 (2 locomotives and 6 coaches) – HS	100	13
Calculated Line Capacity											
• People/hour/direction *Selected Indicator 3,700 pphpd*	1,290 – 2,400 2 buses w/4-min headway 2,580-4,800 – 4 buses w/4-min headway	1,950-2,700 w/4-min headway – 2 bus platoon 3,900-5,400 w/4-min headway – 4 bus platoon	2,220-4,440 w/4-min headway – 2 cars 4,440-8,880 w/4-min headway – 4 cars	3,750 w/4-min headway – 2 cars (top SMP #) 7,500 w/4-min headway – 4 cars (top SMP #)	1,260-3,840 w/4-min headways – 2 cars 2,520-7,680 w/4-min headways – 4 cars	2,880 w/4-min headway – 2 cars 8,640 w/4-min headway – 6 cars	1,072 - 2,040 w/15-min headway – 2 cars 2,144 - 4,080 w/15-min headway – 4 cars	5,160-28,800 w/4-min headway – 8 cars	Both running at lower frequencies.	240 – 3,000 w/2-min headway – 1 car	1,920 –3,120 w/15-sec headway
Operating Speeds (mph)											
• Maximum	60 - 70	60 - 70	45 - 65	50	50	79	55 - 100	55 - 75	300 - ML 150 - HS	6 – 50	30
• Average *Selected Indicator* *Maximum at least 55-66 mph* *Average operating 25-35 mph*	5 (CBD) 15 (Suburban)	25 - 50	25 – 40	20-30	25	45	25 - 50	35 - 45	Dependent on alignment, condition of existing rail, highway grade crossings and co-existence with freight operations	4 - 23	N/A
Stations Spacing *Selected Indicator 0 to 2 miles*	600 to 1200 ft (Flexible)	.25 to 2 miles (Moderately Flexible)	.25 to 2 miles (Moderately Flexible)	.25 to 2 miles (Moderately flexible yet costly and elevated)	< 1 mile (Moderately flexible)	2 to 5 miles (Inflexible)	2 to 5 miles (Inflexible)	1 to 3 miles (Moderately flexible yet costly)	10 miles (Inflexible)	Airport service (Inflexible)	Low traffic, all cars stop at all stations. High traffic, cars bypass. (Flexible)
Typical Headway *Selected Indicator 4 – 15min*	15-45 min peak	5-15 min peak	2-10 min peak	2-30 min peak	2 - 4 min peak	2 - 4 min peak	20 - 40 min peak	2 - 10 min peak	20 min – ML Unknown – HS	1 - 2 min peak	15 sec
System Integration *Selected Indicators* • *Interlining with existing system* • *Barriers to implementation in areas with varying densities and land use characteristics* • *Other considerations*	Seamless integration with existing bus system. Tightly spaced stations and flexibility provide strong access to low-density areas. Barriers related to bus congestion in dense, urban areas.	Seamless integration with existing bus system. Barriers related to bus congestion in dense, urban areas.	Seamless integration with Central Link system. Transfers at existing monorail and bus stations. Very few barriers due to high capacity, profiles, and station size flexibility.	Regional use would require transfers at existing LRT, monorail, and bus stations. Some barriers due to station size needs and set train length and frequency may limit capacity.	Different technology from existing HCT systems. Regional use would require transfers at all existing stations. Some barriers due to station size needs.	Different technology from existing HCT systems. Regional use would require transfers at all existing stations. Barriers associated with freight movement. FRA guidelines may apply.	Seamless integration with Sounder commuter rail in selected rail segment to DuPont. Transfers required at multimodal hub locations. Barriers associated with freight movement.	Different technology from existing HCT systems. Regional use would require transfers at all existing stations. Some barriers due to station size needs FRA guidelines may apply.	Different technology from existing HCT systems. Regional use would require transfers at all existing stations. Severe barriers due to wide station spacing required for long-term high-speed travel.	Different technology from existing HCT systems. Regional use would require transfers at all existing stations. Severe barriers due to low capacity and low speeds.	Different technology from existing HCT systems. Regional use would require transfers at all existing stations. Severe barriers due to low capacity per vehicle, infrastructure needs, and complex merging characteristics.
Land Use *Selected Indicators* *Non-auto accessibility* • *All day/peak passenger volumes* • *Level of investment in stations*	Most passenger activity related to transfer areas. Station investment range from very high to low.	Moderate volumes create some activity around stations. More permanent stations promote moderate density development.	Large passenger volumes create activity around stations. Permanent stations promote dense development.	Large passenger volumes create activity around stations. Permanent stations promote dense development.	Large passenger volumes create activity around stations. Permanent stations promote dense development.	Moderate volumes create some activity around stations. Impact on land use depends on existing rail alignment.	Large passenger volumes at suburban center parking stations can facilitate low-moderate density development.	Very large passenger volumes create activity around stations. Permanent stations promote dense development.	Vary large passenger volumes create activity around stations. Permanent stations promote dense development.	Low passenger volumes create little activity around stations. Stations have little impact on land use.	Minor passenger volumes create limited activity around stations. Stations have little impact on land use.

FIGURE 3.3

Summary of Technology Options & Characteristics

Selected High Capacity Transit Technologies Evaluated

Technology Characteristics	*Enhanced Bus*	*Bus Rapid Transit*	*Light Rail*	*Monorail*	*Sky Train*	*Diesel Multiple Units BUDD Cars*	*Commuter Rail*	*Heavy Rail*	*Maglev / High Speed*	*People Movers Airport Circulators*	*Personal Rapid Transit*
Existing Operating Systems	Seattle Express Bus Local Operation	Journal of Public Transportation Well Documented	ST Link Light Rail Local Project	Seattle Monorail Project Local Project	Vancouver B.C. Only Example	Dallas Only U.S. Example	ST Sounder Local Operation	San Francisco BART Well Documented	Japanese Bullet Train Only Example	SeaTac Airport Local Operation	Morgan Town Virginia Only Example
Implementation Risk *Selected Indicators* • *Track record* • *Number of established suppliers and availability of parts*	Very low risk: Operating in region and multiple US cities. Many established suppliers & manufacturers. High number of experienced drivers and mechanics.	Low Risk: Improvement on currently operating service. Partially implemented in region and in a few US cities. Some established suppliers & manufacturers. Easily adapted to high number of experienced drivers and mechanics.	Low Risk: Currently under construction in region and 26 US cities with 100 New starts proposed. Many established suppliers & manufacturers. High number of experienced drivers and mechanics.	Moderate Risk: Primarily used for tourist operations only in Seattle. Intermediate capacity system proposed. Operating in few locations in the US. Few established suppliers & manufacturers. Automated system.	Moderate Risk: Well established system operating in a major urban area outside of the US. Similar technology to a few established suppliers & manufacturers. Automated system.	High Risk: Extremely limited track record in North America (Operates in only 2 locations). Very few established suppliers & manufacturers. Easily adapted to high number of experienced drivers and mechanics.	Low risk: Currently operating in region and many US cities. High number of established suppliers & manufacturers. High number of experienced drivers and mechanics.	Low Risk: Well established systems operating in other major urban areas. High number of established suppliers & manufacturers. High number of experienced drivers and mechanics.	ML – High Risk: One system in operation last year. Very limited number of suppliers & manufacturers. Few experienced drivers and mechanics. HS – Moderate Risk: Safe, efficient travel in Japan and Europe for 40 years but no operating system in US.	High Risk: Only operated in small airport systems. Moderate number of suppliers & manufacturers. Automated System.	High Risk: Only operated in one location in the US. Very limited number of suppliers & manufacturers. Complicated automated system.
Schedule Reliability *Selected Indicators* • *Level of segregation from traffic* • *Mixing with freight* • *Transit priority treatments*	Low-moderate reliability. Partial use of HOV or HOT lanes. Reliability reduced when running in mixed traffic. On-board fare collection and signal preemption add to reliability.	Moderate-good reliability. High use of HOV or HOT lanes. Gains reliability when operating on dedicated running ways. Off-board fare collection, signal preemption, level boarding at stations, branding, and marketing add to reliability.	Good to excellent reliability depending on profile. Gains reliability when operating on dedicated running ways with fewer crossings. Off-board fare collection, signal preemption, level boarding at stations, branding, and marketing add to reliability.	Excellent reliability. Dedicated, elevated running ways avoid congestion. Fully automated system, Off-board fare collection, level boarding at stations, branding, and marketing add to reliability.	Excellent reliability. Dedicated, elevated running ways and tunnels avoid congestion. Fully automated system, Off-board fare collection, level boarding at stations, branding, and marketing add to reliability.	Good reliability, Dedicated surface and tunnel running ways and tunnels avoid roadway congestion. ROW issues related to the use of freight corridors.	Good reliability, Dedicated surface and tunnel running ways and tunnels avoid roadway congestion. ROW issues related to the use of freight corridors.	Excellent reliability. Dedicated running ways and tunnels avoid congestion. ROW issues related to the use of freight corridors or the construction of new rail facilities.	ML – Unknown HS – Excellent reliability. Dedicated running ways and tunnels avoid congestion. ROW issues related to the construction of new rail facilities.	Excellent reliability. Dedicated, elevated running ways avoid congestion. Fully automated system, Off-board fare collection, level boarding at stations, branding, and marketing add to reliability.	Good to excellent reliability. Dedicated, elevated running ways avoid congestion, but complex merging creates point capacity constraints at high-use locations. Fully automated system, Off-board fare collection, level boarding at stations, branding, and marketing add to reliability.
Right-of-Way Requirements *Selected Indicators* • *Amount of infrastructure* • *Cross-traffic challenges* • *Profile options & flexibility in right-of-way*	Little infrastructure required. Partial ROW needs with HOV or HOT lanes. Minor congestion issues restrict cross-traffic movement. Surface or tunnel.	Moderate infrastructure required. Separate running-ways improve service, but increase conflicts with cross-traffic. Surface, tunnel or elevated flyovers.	Moderate infrastructure required. Cross-traffic conflicts depend on design (exclusive running ways or mixed with traffic). Surface, tunnel or elevated.	Moderate infrastructure required. No cross-traffic conflicts if elevated. Not crossable at surface. Primarily only elevated service.	Moderate infrastructure required. No cross-traffic conflicts due to profile. Tunnel or elevated.	Extensive infrastructure required. Graded rail serves as partial barrier to cross-traffic mobility. Surface or tunnel.	Extensive infrastructure Required. Graded rail serves as partial barrier to cross-traffic mobility. Surface or tunnel.	Extensive infrastructure required. Graded rail serves as partial barrier to cross-traffic mobility. Surface or tunnel.	Extensive infrastructure required. No cross-traffic conflicts due to profile. Tunnel or elevated.	Extensive Infrastructure required. No cross-traffic conflicts due to profile. Tunnel or elevated.	Extensive infrastructure required. No cross-traffic conflicts due to profile. Elevated only.

4.0 ASSESSMENT OF HIGH CAPACITY TRANSIT STUDY CORRIDORS

4.1 Crosslake Corridor

The Crosslake Corridor includes one interstate highway (I-90) and one limited access state highway (SR-520). Both freeways span Lake Washington on two floating bridges that connect one interstate highway (I-5) to another (I-405). The corridor connects the largest metropolitan cities of the region Seattle and Bellevue (see Map: *Crosslake Study Corridor*). The corridor also contains a strong travel market with the two bridges serving most of the trips. The northern bridge (SR-520) provides direct connections between the University of Washington and the east side of the lake. The wider and newer, southern bridge (I-90) provides a more direct connection across the lake between the major downtowns (Seattle and Bellevue). Express buses currently run in exclusive High Occupancy Vehicle (HOV) express lanes along the I-90 Bridge. The HOV lanes, which are reversible (toward Seattle a.m. and toward Bellevue p.m.) connect directly to the downtown transit tunnel in Seattle and direct access HOV connections are under development to provide improved HOV access to Bellevue CBD. See Figure 4.1.7- *Crosslake Study Corridor* for a map.

4.1.1 Land Use Assessment

Population along the Crosslake Corridor is projected to increase significantly over the next 30 years. The corridor connects a number of large to moderate sized activity centers that are projected to grow rapidly. Eight major activity centers were identified along the corridor and evaluated in detail, including: Seattle CBD, Bellevue CBD, Capitol Hill/First Hill, Seattle Uptown, University District, Overlake, Redmond and Issaquah. Of these activity centers, all (except Issaquah CBD) are designated either Regional Growth Centers or Manufacturing/Industrial Centers. Issaquah has been evaluated because it is located at the end of a potential I-90 spur and is projected to grow significantly over the planning period.

In terms of density, the Seattle CBD is by far the most highly concentrated urban area in the region followed by Bellevue CBD, Capitol Hill/First Hill, Uptown/Queen Anne, the University District, and Overlake for the Crosslake Corridor. The Seattle CBD, University District, and Capitol Hill/First Hill activity centers will be directly served by the Central Link light rail system. Connecting these centers with higher capacity transit services is an important regional objective. These activity centers meet the primary land use indicator supporting high capacity transit today, exceeding the range of 30-45 residents and jobs per gross acre. With the exception of Overlake activity center, they also meet all or most of the secondary indicators with a strong residential base, a good mix of jobs and households, smaller block sizes, and a limited supply of free parking. Redmond CBD and Issaquah were also found to contain many of the key attributes necessary to support high capacity transit in the mid to long-range (2010-2030). Figure 4.1.8: *Support For High Capacity Transit Crosslake Corridor Activity Centers (2000-2030)* compares these activity centers based on densities (population + employment per acre) and travel demand (trips destined for the center in the a.m. peak). The centers are determined to be more or less supportive of high capacity transit depending on whether they meet or exceed the density and travel demand ranges placed on the chart.

In addition to major activity centers, the Crosslake Corridor links a large number of residential clusters with higher-density residential activity. These clusters are characterized by areas of medium-density residential development in close proximity to retail and office uses. The clusters of residential activity contain about 40 percent of the residential population along the Crosslake Corridor. The Crosslake Corridor contains a number of diverse clusters. These residential clusters are located throughout both west (Seattle) and eastside communities. Average population densities in the residential clusters are projected to increase from 14 to 20 people per acre between 2000-2030. The clusters within the Crosslake Corridor have somewhat lower levels of density and travel demand than the major activity centers along the corridor. Overall, the land use characteristics and projected growth along the corridor indicate sufficient activity and densities to support high capacity transit now and in the long-term future. Figure 4.1.9– *Support For High Capacity Transit Crosslake Corridor Centers & Clusters (2000-2030)* evaluates the level of support for high capacity transit (travel demand and density) in residential clusters as compared to activity centers within the corridor.

(see Figure 4.1.4 - Summary of Land Use and Demographics)

4.1.2 Travel Pattern Assessment

Based on origin and destination data there is a high volume of travel between the two sub-areas in this corridor - East King County and Seattle / Shoreline -- primarily focused on I-90 and SR-520. A majority (67 percent) of the a.m. peak person trips traveling between these sub-areas originate in East King County and head west toward Seattle (currently about 49,000 a.m. peak person trips). Currently about five times as many transit person trips (2,850 vs. 580) are traveling west rather than east in the a.m. peak period. Eastbound transit ridership in the a.m. peak may be artificially low because transit service is only given priority in the afternoon peak via express lanes from Seattle to Bellevue. Approximately 47 percent of the travel in this corridor is concentrated in the 3 hour peak travel (a.m. & p.m.) periods.

Based on screenline data, although most travel is currently headed west in the a.m. peak period, the reverse commute (west to east in the a.m.) is growing rapidly. Currently about 67 percent of all a.m. peak period person trips (SOV, HOV, and transit), crossing the two bridges, are headed westbound. The percentage of westbound transit travel during the a.m. peak period is higher at about 85 percent. 73 percent of the carpool/vanpool trips are headed westbound. Over the 30-year planning period, the pattern of directional travel will shift somewhat but not dramatically. In 2030, 64 percent of all person trips are projected to head west at a.m. peak periods, 78 percent of transit trips, and 76 percent of carpool/vanpool trips. Over time a greater share of total trips remain within the individual sub-areas, indicating that expanded localized travel may be important to serve in addition to longer-distance regional travel.

The volume of travel across the Lake Washington screenline is projected to grow between 2000 and 2030. Total person trips across the two bridges are projected to grow 15 percent between 2000 and 2030. Transit travel is projected to triple over the same time period. During the a.m. peak period, transit trips are projected to increase from 8 percent of total trips in 2000 to just over 20 percent of total trips in 2030. At the point of highest travel demand, westbound a.m. transit person trips per hour per direction increase from 2,175 to 5,860 between 2000 and 2030. Current levels of transit demand would generally support an investment in higher capacity transit services.

In terms of peak period travel, the Seattle CBD is by far the largest travel market in the region. Other major peak hour travel generators in the corridor include the University District, Overlake, Uptown/Queen Anne, Bellevue CBD, and Capitol Hill/First Hill. All of these activity centers currently meet or exceed the primary travel indicator (20,000 - 30,000 a.m peak-hour person trips) that was established to assess support for high capacity transit.

(see Figure 4.1.5 - Summary of Travel Patterns & Transportation)

4.1.3 Transit Technology Assessment

The technology assessment for the Crosslake Corridor specifically addressed Enhanced Bus, Bus Rapid Transit, Light Rail, Monorail, and Skytrain. Commuter Rail and DMU were not evaluated in this corridor because of the lack of exclusive rail right-of-way that would be needed to implement these technologies. The distinguishing characteristics of each technology that were evaluated included: capacity, operating speeds, reliability, station spacing, headways, system integration, land use impacts, implementation risk, right-of-way requirements and profile needs. Below are initial observations developed from the assessment of the relative appropriateness of these various transit technologies in the Crosslake Corridor. For discussion purposes, a number of related technology characteristics are grouped together (e.g., speed, headways, reliability).

Capacity
In the Crosslake Corridor, westbound peak hour transit demand is forecast to reach 5,860 passengers per hour per direction (pphpd) in 2030, based on the Puget Sound Regional Council travel demand model. This level of transit demand reflects a 150 percent increase over the current westbound peak hour transit demand in the Crosslake Corridor (2,175 pphpd). Based on this line-haul capacity need, all of the HCT technologies evaluated, except Enhanced Bus, could generally meet the long-term passenger demand forecasts. Enhanced Bus was calculated to reach its maximum capacity potential at approximately 4,800 pphpd under aggressive operating assumptions. Bus Rapid Transit could

potentially meet the long-term line-haul capacity needs. Meeting these needs would require that BRT maintain frequent headways and possibly entail the use of bus platoons to serve major activity centers.

Constraints on BRT capacity could be realized in accessing dense urban centers in the corridor. In particular, there are implications for BRT use in the corridor with the joint operation of light rail and bus platoons in the DSTT when the initial Central Link light rail segment (Seattle CBD south to SeaTac) begins service in 2009. A significant amount of analysis has been done to determine the available capacity in both the Downtown Seattle Transit Tunnel (DSTT) and the downtown surface streets (see references in *Appendix G: Bilbilography*). The total number of buses that could reasonably be operated through downtown is estimated to be between 700 to 800 per hour, assuming full operation of surface streets (450-550 buses) and the downtown tunnel (250 buses). The higher end of the range for downtown surface streets assumes operational changes that could be made to increase available downtown street capacity, such as bus-only lanes during peak hours or converting streets into transit-malls for transit use only. When the tunnel is eventually converted to a rail-only facility the number of buses needed to carry projected transit demands in Seattle CBD at peak-periods could eventually exceed available street capacity unless major changes are made in how those streets are used and managed. Further analysis is needed to determine more precisely the potential capacity limitations of Bus Rapid Transit in this corridor related to downtown Seattle street capacity. Further analysis is needed to determine more precisely the potential capacity limitations of bus rapid transit in this corridor related to street capacity in downtown Bellevue, particularly where Crosslake transit investments must align with the proposed BRT system in the Eastside Corridor.

Application of rail technologies (light rail, monorail, and Skytrain) in the corridor could achieve adequate long-term carrying capacities and also have the potential for line haul capacity expansion beyond the 30-year planning horizon.

Speeds, Headways, Reliability

Auto travel across Lake Washington is limited to the two floating bridges, making it a desirable transit corridor while also significantly contributing to challenges related to roadway congestion. Desired operating characteristics in the Crosslake Corridor include average operating speeds of between 25 and 35 mph, headways of 4 minutes (15 buses/trains per hour) and a high degree of schedule reliability for quick commute service between two of the region’s largest urban centers. All of the technologies evaluated, except Enhanced Bus, could generally meet these desired operating characteristics. As growth occurs, Enhanced Bus services are likely to become slower when operating in mixed traffic because of roadway congestion resulting in increased bus travel times, especially accessing major activity centers. Slow average speeds would result in longer headways between buses and reduced schedule reliability unless additional bus services were added.

BRT could meet the region's projections for transit travel demand in the Crosslake Corridor, but exclusive BRT lane capacity and more significant exclusivity would be needed to maintain frequencies, speeds, and reliability. This exclusive ROW could be provided by increasing HOV occupancy requirements, introducing a managed lane concept (e.g., HOT lanes), and/or creating bus-only lanes in the corridor. Changes to the HOV lane system would potentially require, at minimum, additional bi-direction HOV lanes (2+) on at least one of the bridges (I-90) providing direct access to Seattle CBD and/or other HOV lane treatments that would provide more direct access to the freeway HOV lane system.

Current planned improvements for increased HOV lane capacity and operations in the Crosslake Corridor could, however, prove to be inadequate in the long-term for successful BRT application. Potential negative impacts to other HOV travel options (carpool, vanpool, local bus) and/or general-purpose capacity could result if significant changes are made to existing HOV lane operating policy.

The fully grade-separated rail technologies (monorail, Skytrain) by definition would have the ability to maintain frequent headways at high average speeds with consistent schedule reliability. The ability to automate these technologies could also provide reliability advantages (as well as potential cost savings). Light rail could also offer similar speed and reliability demands if it is operated in primarily exclusive or semi-exclusive right-of-way. However, if significant portions were operated on surface streets in mixed-traffic (as is possible given the technologies profile flexibility) then speeds and reliability could be degraded and fall below desired levels of service.

System integration

Transit technologies should be capable of providing convenient and seamless passenger connections and transfers to currently operating regional transit technologies within the corridor. In addition, the technology should have the capability to accommodate access to the system from the full range of travel modes, including pedestrian, bicycle, auto, and transit feeder systems. Current operating assumptions are that the DSTT would operate with both light rail and bus platoons when the initial Central Link light rail segment (Seattle CBD south to SeaTac) begins service in 2009. When the North Link extension (Seattle CBD north to Northgate) is completed, the DSTT will be operated as a rail-only facility. Additionally, an intra-city, intermediate capacity monorail is under development in Seattle. The transit technology used in the corridor should have the capability to work effectively with these transit systems.

Enhanced Bus, BRT, and light rail have a distinct advantage under the established criteria given the other planned transit technologies that will be in operation in the Crosslake Corridor. Bus transit services and facilities already exist throughout communities on both sides of Lake Washington. Integrating bus transit technologies into the fabric of transportation services, while not without challenge, should not be a major barrier in this corridor. Aside from some potential capacity constraints, BRT would have the potential to operate on downtown streets providing good connections to other existing transit services in Seattle CBD, Bellevue CBD, and other activity centers.

For the purpose of this study, Link light rail services are assumed to be in operation by 2009 in the central Seattle corridor. A light rail connection in the Crosslake Corridor could directly interline with the Central Link system and operate jointly in the Downtown Seattle Transit Tunnel (DSTT). Current DSTT capacity estimates demonstrate that rail service in the downtown tunnel would have significant unused capacity (under rail-only use) to accommodate the region's projected transit demand in downtown Seattle beyond 2030. The ability to connect light rail services in the Crosslake Corridor directly with the planned transit investments in the central Seattle corridor would provide major operating advantages and passenger conveniences.

Completion of the Seattle Monorail Project (Green Line) is assumed in this study. The design of the proposed Green Line is not complete and the viability of a regional system will require more detailed analysis of engineering specifics. Direct connections between a regional monorail line and the Green Line could be expected to pose significant challenges. To meet the passenger needs in the Crosslake Corridor, a regional monorail line would require higher capacity needs than currently planned for the Green Line. The transit demands projected for the Green Line in combination with east-west regional transit travel demands would exceed capacity of the planned Seattle monorail system as it is currently designed. Even if the same train and guideway beam technology were used by both systems, it is likely the Green Line could not directly interline with a regional monorail line in downtown Seattle because of capacity limitations. This is not to say that an east-west Monorail line could not indirectly interline with future Seattle Monorail lines or have separate stations and guideways that could provide indirect connections (forced transfers) between the different systems.

As it operates in Vancouver, Skytrain is automated and fully grade separated. The system could be customized to accommodate the Crosslake corridor, but changes would be needed in order to fully integrate it with the existing system. Automated systems could not operate with mixed traffic in Bellevue or other eastside locations and it is unlikely that Skytrain could share the DSTT with light rail and/or bus.

Land Use

The Crosslake corridor contains a wide diversity of activity centers from existing high-density locations (University Community, Capitol Hill/First Hill, downtown Seattle, and Bellevue CBD) to low-density suburban centers with planning targets for considerable growth (Redmond, Overlake, Issaquah). Land use development decisions are influenced by high capacity transit services which can substantially increase passenger volumes to a given area. The financial magnitude of a transit investment and the relative permanence of that investment are often sited as reasons for attracting new land use development. A high capacity transit technology will support high-density development and increase opportunities for improved pedestrian access.

BRT, light rail, monorail, and Skytrain would be expected to have greater influence on land use than Enhanced Bus services. Given capacity and speed limitations and the limited permanence of stations, Enhanced Bus would be expected to have less influence on land use development than other HCT technologies. In particular, Enhanced Bus services may not provide adequate capacity to support the planned land use development in the largest activity centers in the corridor, Seattle CBD and Bellevue CBD. Other activity centers, such as Overlake, Redmond and Issaquah, could be served by Enhanced Bus but would have less influence on land use development than BRT or rail technologies.

BRT and rail technologies provide for greater accessibility and generally result in higher levels of investment in individual stations. One distinguishing characteristic of BRT is the potential difficulty in achieving exclusive bus operations in high-density activity centers, such as University District, Capitol Hill/First Hill, Bellevue, and downtown Seattle. Rail technologies generally provide a somewhat less challenging opportunity to provide reliable, direct congestion-free access to serve these high-density markets. Monorail and Skytrain could face some challenges related to land use changes as a result of profile inflexibility (see below) and potential negative affects of elevated guideways.

Right-of-Way Requirements and Profile Flexibility
Each of the technologies evaluated have different characteristics related to their flexibility in determining right-of-way needs and profile characteristics. Although specific alignments were not evaluated, consideration was given to the range of potential applications for each technology in the Crosslake Corridor. High capacity transit options in this corridor would need to operate across Lake Washington on the existing I-90 bridge deck and/or a rebuilt SR-520 bridge. (I-90 has been identified as the preferred crossing.) Beyond the bridge crossings, the primary consideration for right-of-way and profile needs will be treatments on either end of the lake. In order to balance accessibility and operational efficiency, a high capacity transit technology would need to be flexible enough to provide different levels of exclusivity depending on geographic constraints and the level of existing development in the corridor.

Monorail and Skytrain have the least flexible profile of the technologies investigated. Both technologies require fully grade-separated guideways throughout their entire system. These technologies are best implemented where full grade separation can be justified because of limited space and very high densities. While the aerial profile and full grade separation can be a distinct advantage for a regional system, it can also limit options for serving a variety of different urban environments. Although the Crosslake Corridor includes a number of very dense urban centers, much of the corridor, on the eastside in particular, is comprised of suburban locations where aerial/grade separation may not be needed and could be served nearly as well at grade. This profile flexibility can reduce costs and increase accessibility to the system.

Enhanced Bus, BRT, and light rail offer a significantly higher level of profile and ROW flexibility than Skytrain or monorail. These technologies can operate in full grade separation, mixed traffic, elevated, or various combinations. This profile and ROW flexibility does not come without cost, both in terms of securing ROW and in terms of system performance if operated with less exclusivity. However, profile flexibility does allow a high capacity transit service to fit specific area needs and limitations such as the Crosslake corridor's varying land use intensities. Engineering work is needed at an alignment level to make any specific distinctions between technologies regarding ROW needs and profile flexibility.

Crosslake Technology Summary

Enhanced Bus (Express Bus Service)
Enhanced Bus operations could support Crosslake Corridor needs in the very near term. However, the limited capacity, lower operating speeds, and reduced reliability of Enhanced Bus would limit its application long-term. Land use objectives and other corridor needs could potentially be better served with other transit technologies.

Bus Rapid Transit (BRT)
BRT could support corridor needs in the mid-term future (2010-2020) but may have limited expansion capabilities to meet long-term demands. BRT would generally support the long-range land use plans and projected growth in Bellevue and other activity centers in the corridor. Flexibility of the technology provides a wide range of options for serving transit markets in the corridor. High bus volumes on downtown Seattle streets could create significant challenges toward meeting travel demands and development objectives in Seattle CBD.

Light Rail (LRT)
Light Rail could meet the high capacity transit needs in the Crosslake Corridor over the long-term. The capacity, speed, and the permanence of stations support the long-range land use plans and projected growth in major activity centers in the corridor. Right-of-way and profile flexibility will support diverse geographies in the corridor. The system would provide an excellent high speed connection between Seattle and Bellevue and it has the potential to serve additional locations on the eastside as demand grows. More analysis is needed to assess the capacity for bus transfers at proposed stations.

Monorail
Monorail could meet corridor needs over the long-term. The capacity, speed, and the permanence of monorail stations support the long-range land use plans and projected growth in major activity centers in the corridor. The technology could provide a strong connection between Seattle and Bellevue and would well-serve other activity centers. More analysis is needed to fully understand the ability to facilitate connections with Seattle's planned monorail system. Limited profile flexibility will constrain how the technology is integrated within urban environments. Further study is needed to assess whether monorail vehicles and infrastructure could be accommodated on the bridges across the lake.

Skytrain
Skytrain meets many of the high capacity transit needs in the Crosslake corridor. Skytrain shares characteristics with both Light Rail and Monorail. It would have the ability to maintain frequent headways at high average speeds with consistent schedule reliability and could provide sufficient capacity over the long-term. Skytrain would involve the addition of an entirely new transit technology to the regional transit system and would require separate stations and guideways that are likely to pose multiple challenges for integration with existing transit services. The technology could support land use changes anticipated in local plans and the potential to automate operations could increase reliability and lower costs.

* DOWNTOWN SEATTLE SURFACE REPORT, 4/14/99, Sound Transit, King County and City of Seattle

(see Figure 4.1.6 - Summary of Technology Assessment)

FIGURE 4.1.4

Summary of Land Use and Demographics

CrossLake Corridor

Selected major Activity Centers evaluated in this corridor: Seattle CBD, Bellevue CBD, Capitol Hill/First Hill, University District, Seattle Uptown, Issaquah CBD, Overlake, Redmond CBD

	Current Conditions	Mid-Range (2020)	Long-Range (2030)
Primary Indicator			
Population and Employment in Activity Centers Indicators: 30-45 jobs and population per acre >45 jobs and population per acre	**Seattle CBD** contains just under 200,000 jobs and population at 211 per acre. **Bellevue CBD** (34,313 jobs and population @ 80 per acre), **Capitol Hill/ First Hill** (69,667 @ 76 per acre), **University Community** (52,293 @ 69 per acre), **Overlake** (19.700 @ 63 per acre), and **Uptown** (21,476 @ 70 per acre) also exceed the primary indicator range.	**Uptown** (33,491 @ 110 per acre) and **Overlake** (26,078 @ 84 per acre) continue to exceed the density range in 2020. Redmond will have over 25 jobs and population per acre, but only 13,000 total. Issaquah would have almost 21,000 jobs and population but at low (13 per acre) densities.	By 2030, *Redmond CBD* falls within the density range (34 per acre) but still has few total jobs and population (15,803). Issaquah has a significant total of jobs and population at 22,900 but densities remain low (15 per acre).
Secondary Indicators			
Population and Employment in Residential Clusters	**Average population density in Clusters is 14.6 people per acre.** Roughly 40 percent of the corridor population is contained within clusters outside of the activity centers.	**Average population density in Clusters is projected to increase to 18.2 people per acre** in 2020.	**Average population density in Clusters is projected to increase to 20.4 people per acre** in 2030.
Ratio of jobs to households in Activity Centers **Residential base in Activity Centers**	All Centers, except Overlake, have less than 16 jobs per household. Overlake's ratio is much higher at 24 jobs per household. Seattle CBD (11,400), Capitol Hill (21,000), and University District (6,600) have a base of greater than 5000 households. Bellevue (2,300), Issaquah (2,100), and Uptown (3,600) have a smaller but growing base. Overlake & Redmond have roughly 1000 households.	Ratio of jobs per households drops where it was high in Bellevue (14-to-6) and Seattle CBD (15-to-10) and increases where it was low in Redmond (5-to-7) and Issaquah (5-to-7). Overlake's ratio is projected to drop to 20 jobs per household by 2020. Bellevue and Uptown are forecast to have over 5,000 households by 2020. By 2020, Redmond and Overlake still have fewer than 2000 households.	Ratio in all Centers continues to gradually improve including Bellevue (6-to-4) and Seattle CBD (15-to-9). Overlake's ratio is projected to drop to 19 jobs per household by 2030. By 2030, Issaquah is forecast to have 3,000 households. Redmond and Overlake are forecast to contain approximately 2,000 households in each Center.
Roadway Network in Corridor **Block size in Activity Centers**	Seattle neighborhoods generally contain dense street networks, exceeding 1 intersection per acre. Bellevue and other eastside neighborhood generally have fewer intersections per acre. **Seattle CBD, Capitol Hill, Uptown, University District have relatively small blocks**, averaging under 5 acres. Bellevue, Issaquah and Redmond have larger block sizes, averaging over 10 acres. Overlake has very large blocks, averaging 39 acres.	Intersection density and roadway network cannot be forecast for future years but as the corridor urbanizes and grows it can be expected that eastside networks will improve and intersection density will increase. Based on plans for **Bellevue, Issaquah, and Redmond to connect roads and break-up super blocks**, it can be expected that block sizes would decrease and pedestrian networks improve. Overlake would likely still have relatively large blocks and other pedestrian barriers.	As the corridor urbanizes and grows it can be expected that eastside networks will improve and intersection density will increase. Based on plans, **all Activity Centers could be expected to have a significantly improved network** of pedestrian connections by 2030.
Parking Costs/Supply in Activity Centers	**Seattle CBD, Bellevue, Capitol Hill, U District, and Uptown have parking charges** for long-term parking, and short-term parking charges in some cases. Seattle CBD, Bellevue, Capitol Hill, U District, Bellevue have less than 1 stall per employee. Overlake has a significant parking supply.	Based on increasing density, parking policies and increasing land values it would be expected that **Redmond and Overlake would institute parking charges** during this period.	Based on increasing density, parking policies and increasing land values it would be expected that **Issaquah CBD would institute parking charges** by 2030.

FIGURE 4.1.5

Summary of Travel Patterns and Transportation

CrossLake Corridor

Selected major Activity Centers evaluated in this corridor: Seattle CBD, Bellevue CBD, Capitol Hill/First Hill, University District, Seattle Uptown, Issaquah CBD, Overlake, & Redmond

Criteria	Current Conditions	Mid-Range (2020)	Long-Range (2030)
Primary Indicator			
Activity Centers: Major Destinations 20,000-30,000 a.m. peak period person trips destined for activity center. >30,000 a.m. peak period person trips destined for activity center.	**Seattle CBD** (130,156) is by far the most significant destination in the corridor; **University Community** (45,031+), **Overlake** (39,516), **Uptown** (38,721), **Capitol Hill** (37,678), and **Bellevue CBD** (32,969) all exceed the primary indicator range. *Issaquah* (22,659) and *Redmond* (20,129) are within the low end of the range.	By 2020, **Redmond** (33,972) and **Issaquah** (30,404) are forecast to exceed the primary indicator range.	By 2030, **all of the activity centers** in the corridor are forecast to exceed the indicator range, continuing to attract over 30,000 person trips (a.m. peak).
Secondary Indicators			
Travel across screenlines (daily and peak periods) #32 east/west across Lake Washington (SR-520, I-90) ***Transit person trips per hour per direction (pphpd) reflects highest demand within corridor.***	Total daily person trips across screenline is 299,400 45% of daily person trips are made during peak periods 10% of a.m. person trips are made by public transit ***Westbound a.m. transit person trips per hour per direction (pphpd) is 2,175***	In 2020… 27% total trip growth rate. Total daily person trips across screenline is 381,000 47% of daily person trips are made during peak periods 15% of a.m. person trips are made by public transit ***Westbound a.m. transit person trips per hour per direction (pphpd) is 3,962***	In 2030… 32% total trip growth rate. Total daily person trips across screenline is 396,000. 47% of daily person trips are made during peak period. 18% of a.m. person trips are made by public transit. ***Westbound a.m. transit person trips per hour per direction (pphpd) is 5,860***
Growth in am peak person trips between sub-areas **Heading East:** Seattle/Shoreline to East King County **Heading West:** East King County to Seattle/Shoreline	5.9% of am peak person trips (23,600) originating in Seattle/Shoreline are destined for East King County. **2.4% of these trips (580) are transit person trips.** 15% of am peak person trips (49,100) originating in East King County are destined for Seattle/Shoreline. **5.8% of these trips (2,900) are transit person trips.**	By 2020 … 6.5% of am peak person trips (32,500) originating in Seattle/Shoreline are destined for East King County. **5% of these trips (1,600) are transit person trips.** 15.8% of am peak person trips (69,000) originating in East King County are destined for Seattle/Shoreline. **7.9% of these trips (5,500) are transit person trips.**	By 2030… 6.4% of am peak person trips (34,800) originating in Seattle/Shoreline are destined for East King County. **6% of these trips (2,100) are transit person trips.** 14.1% of am peak person trips (67,800) originating in East King County are destined for Seattle/Shoreline. **9% of these trips (6,100) are transit person trips.**
Park-and-Ride facilities Future year numbers reflect projected demand based on WSDOT analysis conducted in 2001.	3,600 P&R stalls in Seattle/Shoreline subarea 8,200 P&R stalls in East King County subarea	In 2020… 4,900 P&R stalls in Seattle/Shoreline subarea 12,500 P&R stalls in East King County subarea	In 2030… 5,500 P&R stalls in Seattle/Shoreline subarea 14,900 P&R stalls in East King County subarea

FIGURE 4.1.6

Summary of Technology Assessment

Crosslake Corridor

Technology Characteristics	*Enhanced Bus*	*Bus Rapid Transit*	*Light Rail*	*Monorail*	*Skytrain*
Capacity					
Seated	43 - 40' bus	74 - 60' bus	74 per car	--	168 (2 car, married pair)
Seated and standing	80 - 40' bus	104 - 60' bus	148 per car	125 per car	512 (2 car, married pair)
Projected Transit Demand 2,175 (2000) – 5,860 (2030) transit person trips per hour per direction (pphpd)	1,290 – 2,400 2 buses w/4min headway 2,580-4,800 – 4 buses w/4min headway	2,220-3,120 w/4min headway – 2 bus platoon 4,440-6,240 w/4min headway – 4 bus platoon	2,220-4,440 w/4min headway – 2 cars 4,440-8,880 w/4min headway – 4 cars	3,750 w/4min headway – 2 cars (top SMP #) 7,500 w/4min headway – 4 cars (top SMP #)	1,260-3,840 w/4 min headways – 2 cars 2,520-7,680 w/4 min headways – 4 cars
Station Spacing Flexibility needed- small stations for less developed areas and large stations with amenities to support activity centers.	Small stations can serve the lower densities within the corridor, but long distance travel and tightly spaced stations in dense locations could reduce schedule reliability.	Large to small stations can serve varying densities. Stations can be tightly or widely spaced.	Large to small stations can serve varying densities. Stations can be tightly or widely spaced.	Large elevated Stations. Stations can be tightly or widely spaced.	Large elevated Stations. Stations can be tightly or widely spaced.
System Integration Needs to work with service in the Downtown Seattle Transit Tunnel (DSTT), the Seattle Monorail Project, and address congested locations in downtown Seattle and Bellevue.	Large numbers of buses could add to congestion on limited arterials in Seattle. Bus will not directly interline with intensive rail service in DSTT.	Large numbers of buses could add to congestion on limited arterials in Seattle. Bus will not directly interline with intensive rail service in DSTT.	Profile flexibility can address system integration needs. System would have seamless connections with rail service in DSTT.	Difficult to integrate in some areas due to limited profile flexibility. Indirect connection with SMP system.	Introduces another technology.
Land Use Desire to support downtown development in Seattle and Bellevue, increase densities in outlying centers, support industries in Overlake, and address highly concentrated groupings of residential clusters on the east side of the lake	Enhanced Bus has modest influence on land use.	BRT has some influence on land use, supporting plans for connecting centers.	Strong support for higher density development.	Strong support for higher density development.	Strong support for higher density development.

CrossLake Study Corridor

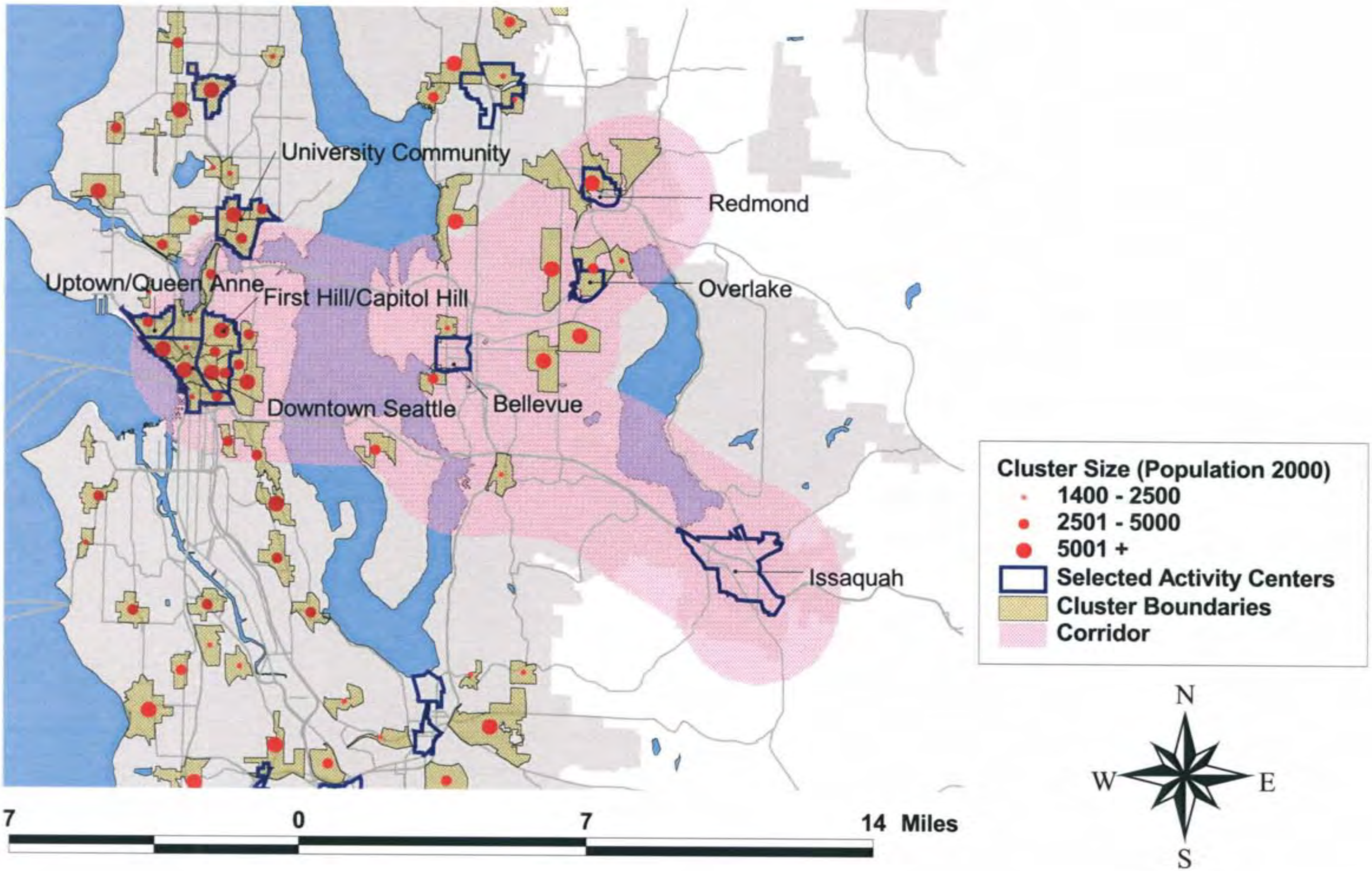
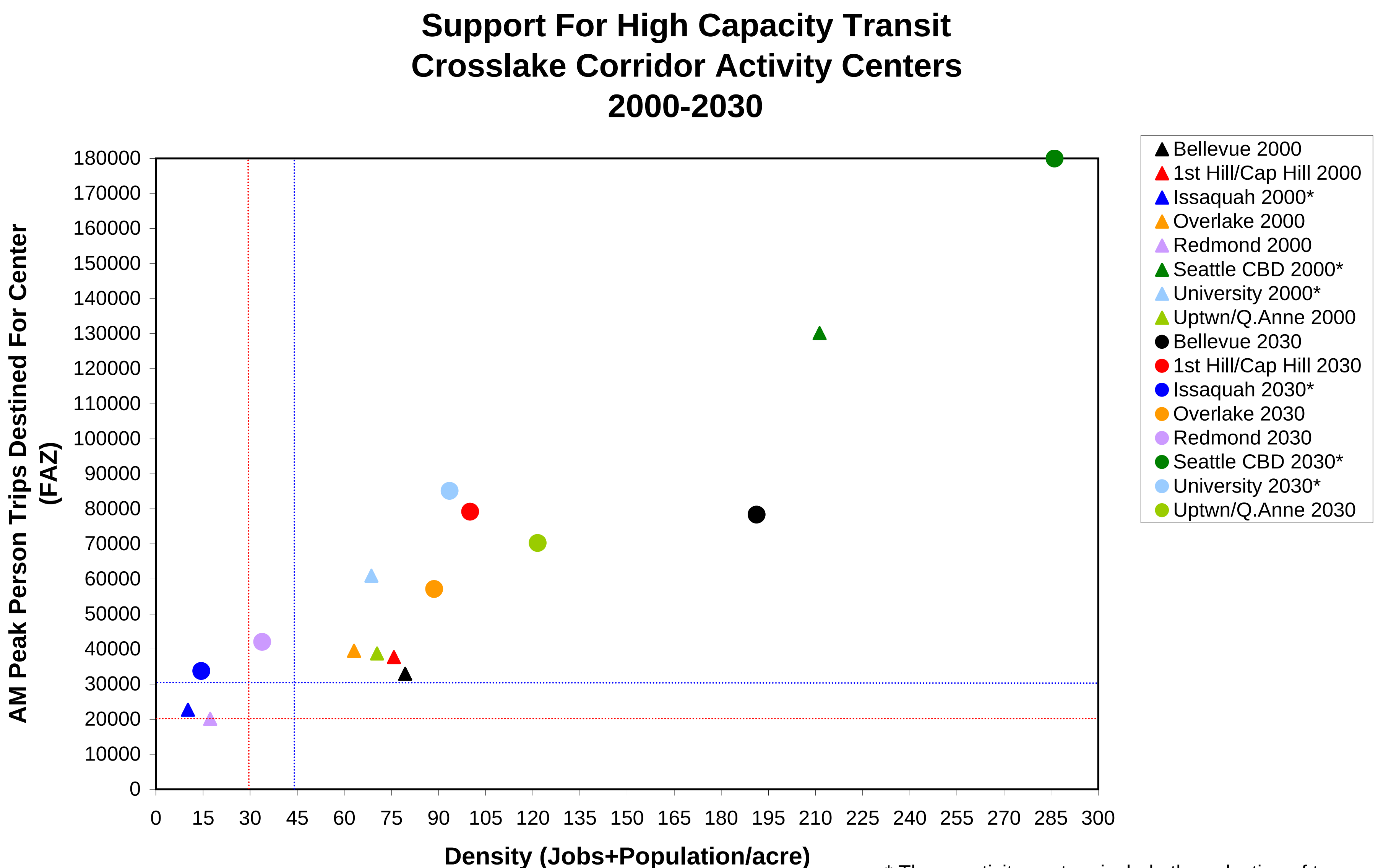
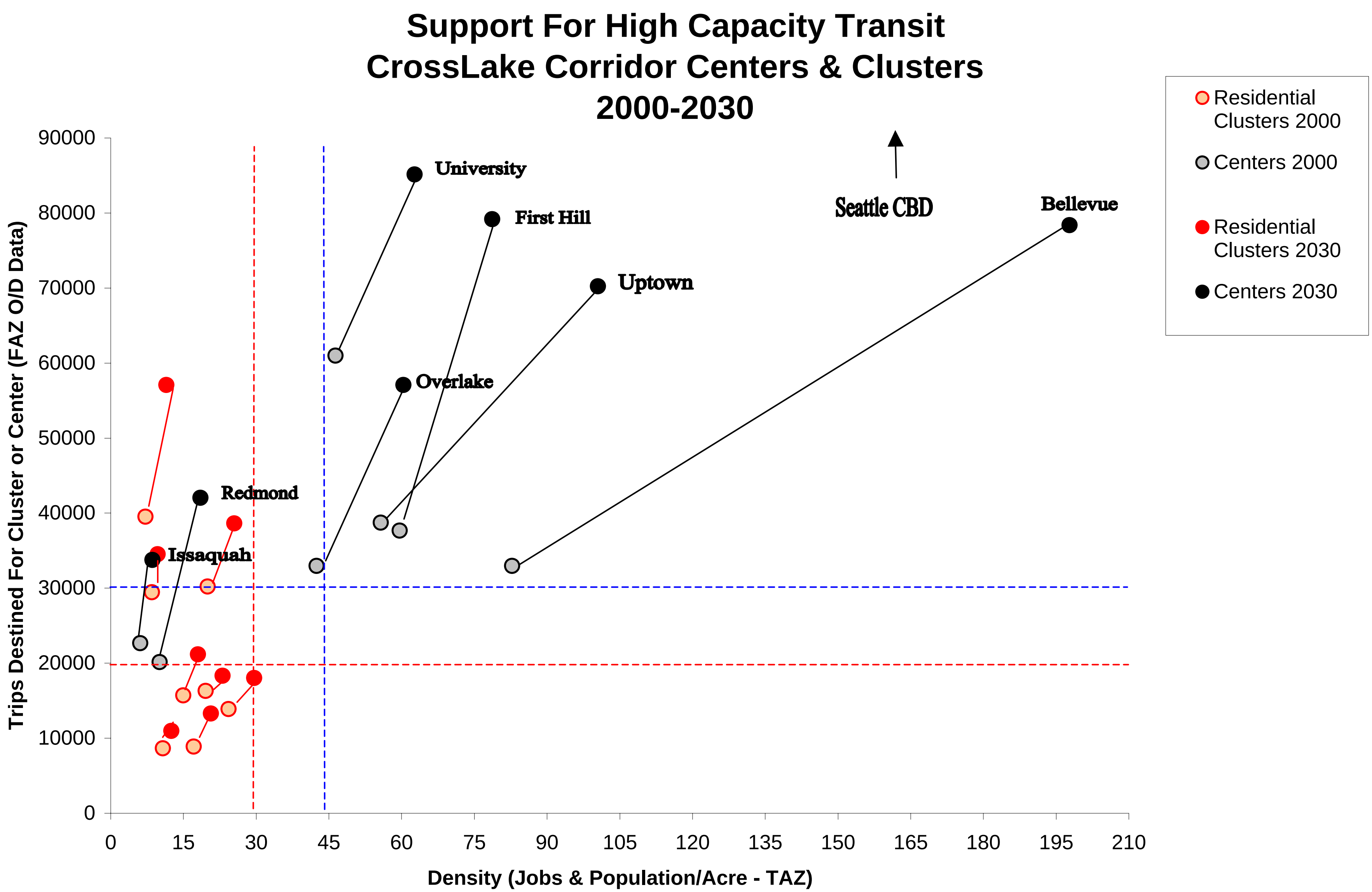


FIGURE 4.1.8



* These activity centers include the selection of two Forecast Analysis Zones for am peak travel data.

FIGURE 4.1.9


Support For High Capacity Transit
CrossLake Corridor Centers & Clusters
2000-2030
Residential Clusters 2000
Centers 2000
Residential Clusters 2030
Centers 2030
University
First Hill
Seattle CBD
Bellevue
Uptown
Overlake
Redmond
Issaquah
Trips Destined For Cluster or Center (FAZ O/D Data)
Density (Jobs & Population/Acre - TAZ)
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
0
15
30
45
60
75
90
105
120
135
150
165
180
195
210

4.2 North Corridor

The North Corridor includes one interstate highway (I-5) and one state highway with limited access in some locations (SR-99 north). Both facilities connect the largest metropolitan city (Seattle) to another large metropolitan city (Everett). (See Map: *North Study Corridor*) I-5 provides strong connections between job centers (specifically Northgate, Lynnwood CBD, and Everett) and opportunities to connect with transit facilities (large park-and-rides and a good local transit system) throughout Snohomish County. SR-99 is characterized by a number of strong residential concentrations aligned tightly along this historical state route where multiple auto-oriented businesses have located. Express buses currently run in separated High Occupancy Vehicle express lanes along the interstate highway. There are currently multiple proposals to improve transit mobility along SR-99 with the use of HOV lanes and additional transit priority treatments. Direct access HOV connections are also under development in the corridor. See Figure 4.2.7-*North Study Corridor* for a map.

4.2.1 Land Use Assessment

Corridor-wide land use characteristics and projected growth indicate that this corridor has sufficient land use activity and densities to support high capacity transit in the future. Population in the North Corridor is projected to increase significantly over the next 30 years. Four major activity centers were identified in the corridor and evaluated in detail, including: Everett, Lynnwood, Northgate (designated Regional Growth Centers), and Paine Field (a designated Manufacturing/Industrial Center). Connecting these centers with higher capacity transit services is an important regional objective once densities increase.

Northgate and Everett currently meet the primary land use indicator (30-45 residents and jobs per gross acre) for supporting HCT. Activity centers in the corridor vary as to how well they meet the secondary indicators: residential base, jobs /households ratio, block sizes, and supply/cost of parking. Lynnwood contains (existing and forecasted) many of the key attributes necessary to support high capacity transit in the long-range (2030). Because of its size and status as a manufacturing and industrial center, Paine Field could support high capacity transit service in the mid-range (2020) based on total employment and work trips, but is well below the density range. Figure 4.2.8– *Support For High Capacity Transit North Corridor Activity Centers (2000-2030)* compares these activity centers based on densities (population + employment per acre) and travel demand (trips destined for the center in the a.m. peak). The centers are determined to be more or less supportive of high capacity transit depending on whether they meet or exceed the density and travel demand ranges placed on the chart.

In addition to major activity centers, the North Corridor contains a large number of large clusters with higher-density residential activity. These residential clusters are characterized by areas of moderate to high-density residential developments in close proximity to retail and office uses. Clusters of residential activity include about 24 percent of the residential population within the corridor. The North corridor contains clusters with only moderate densities and moderate travel demand. Many of the identified residential clusters are located in close proximity to each other in the corridor, particularly along SR-99 (Aurora Avenue N) between Northgate and Lynnwood. Average population densities in residential clusters are projected to increase from 10 to over 16 people per acre between 2000-2030. The clusters within the North Corridor contain roughly the same level of density and travel demand as the activity centers, but they are not forecast to grow as rapidly. The clusters are generally forecast to have growth in both density and travel demand. Figure 4.2.9– *Support For High Capacity Transit North Corridor Centers & Clusters (2000-2030)* evaluates the level of support for high capacity transit (travel demand and density) in residential clusters as compared to activity centers within the corridor.

(See 4.2.4 - Summary of Land Use and Demographics)

4.2.2 Travel Pattern Assessment

Based on origin and destination data there is a high volume of travel between the two sub-areas in this corridor - Snohomish County and Seattle / Shoreline -- primarily focused on I-5 and SR-99. A majority (82 percent) of the a.m. peak person trips traveling between sub-areas originate in Snohomish County and head south toward Seattle (Over 53,000 a.m. peak person trips). Currently about 50 times more transit person trips (2,850 vs. 50) are traveling south (versus north) in the a.m. peak period. Approximately 43 percent of the travel in this corridor is concentrated in the peak travel (a.m. & p.m.) periods. Flows between sub-areas increase rapidly through 2020 and then more slowly between 2020 and 2030. Over time a greater share of total trips remain within the individual sub-areas and transit mode share within the corridor is projected to increase steadily.

Based on screenline data, although most travel is going south in the a.m. peak period, the reverse commute (south to north in the a.m.) is growing. Currently about 80 percent of all a.m. peak period person trips (SOV, HOV, and transit) are headed southbound. The percentage of southbound transit travel during the a.m. peak period is higher at about 90 percent and 93 percent of the carpool/vanpool trips are headed southbound. Over the 30-year planning period, the pattern of directional travel will shift, increasing northbound travel by 11 percent. In 2030, 69 percent of all person trips are projected to head south at a.m. peak periods (55 percent of transit trips and 93 percent of carpool/vanpool trips). Over time a greater share of total trips remain within the individual sub-areas, indicating that expanded localized travel may be important to develop once the HCT system has been established.

The volume of travel across the Northgate-Lynnwood screenline is projected to grow between 2000 and 2030. Total person trips across the major roadways are projected to grow 30 percent between 2000 and 2030. Transit travel is projected to almost quadruple. During the a.m. peak period, transit trips are projected to increase from 10 percent of total trips in 2000 to over 31 percent of total trips in 2030. At the point of highest travel demand, southbound a.m. transit person trips per hour per direction increase from 3,505 to 9,150 between 2000 and 2030. This level of transit travel demand could easily support an investment in higher capacity transit services.

In terms of travel, Paine Field is one of the largest travel markets in the region outside of the activity centers in the Crosslake Corridor. Paine Field exceeds the primary travel indicator that was established to assess support for HCT. Lynnwood and Northgate also generally support high capacity transit in the mid-range future (2010) and exceeds the range in the long-range (2020-2030). Everett has a slightly smaller travel market in the mid-range (2020), but is projected to have adequate demand in the long term (2030).

(See Figure 4.2.5 - Summary of Travel Patterns and Transportation)

4.2.3. Transit Technology Assessment

The technology assessment for the North Corridor specifically addressed Enhanced Bus, Bus Rapid Transit, Light Rail, Monorail, and Skytrain. Commuter rail is currently operating adjacent to the generally defined study corridor with limited trips during the peak period. Commuter rail ridership is moderate at this time, but may build with time and the addition of more train runs. The distinguishing characteristics of each technology that were evaluated included: capacity, operating speeds, reliability, station spacing, headways, system integration, land use impacts, implementation risk, right-of-way requirements and profile needs. Below are initial observations developed from the assessment of the relative appropriateness of these various transit technologies in the North Corridor. For discussion purposes, a number of related technology characteristics are grouped together (e.g., speed, headways, reliability).

Capacity

In the North Corridor, a southbound peak hour transit demand is projected to reach 9,150 passengers per hour per direction (pphpd) in 2030, based on the Puget Sound Regional Council travel demand model. This level of transit demand reflects a 170 percent increase over the current westbound peak hour transit demand in the North Corridor (3,505 pphpd). Based on this line-haul capacity need, all of the HCT technologies evaluated, except Enhanced Bus and BRT, could generally meet the long-term passenger demand forecasts.

Enhanced Bus upward capacity limit is 4,800 pphpd based on some fairly aggressive operating assumptions. Bus Rapid Transit could generally meet the long-term line-haul capacity needs assuming extensive use of exclusive running ways. It is likely that this corridor will require the use of multiple bus facilities with dedicated running ways. There are also implications for BRT use in the corridor with the operation of light rail when the Central Link light rail segment (Seattle CBD north to Northgate) begins service sometime after 2010. Further analysis is needed to determine the potential capacity limitations of bus rapid transit in this corridor related to street capacity in Northgate and downtown Everett.

Other rail technologies (light rail, monorail, and Skytrain) were found to have adequate long-term capacities and also have the potential for line haul capacity expansion beyond the 30-year planning horizon.

Speeds, Headways, Reliability

Much of the travel along the North Corridor is concentrated on SR-99 and I-5, making it a desirable transit corridor. Desired operating characteristics in the North Corridor include average operating speeds of between 25 and 35 mph, headways of 4 minutes (15 buses/ trains per hour) and a high degree of schedule reliability for quick commute service between two of the largest urban areas in the region. Higher speeds may be necessary in this corridor in order to make up for speed reductions due to tight station spacing in urban areas.

All of the technologies evaluated, except Enhanced Bus, could generally meet the desired average operating speeds, headways, and reliability needs. As growth occurs, Enhanced Bus is unlikely to maintain high average speeds because of the increased bus travel times in mixed traffic, especially accessing major activity centers. Slow average speeds would result in reduced schedule reliability and the need for additional vehicles. BRT could meet the region’s projections for transit travel demand in the North Corridor. Exclusive BRT lane capacity would be needed to maintain frequencies, speeds, and reliability. This exclusivity could be provided through a range of factors, such as increasing HOV occupancy requirements, introducing a managed lane concept (e.g., HOT lanes), and/or creating bus-only lanes in the corridor.

Current planned improvements for increased HOV lane capacity and operations in the North Corridor could, however, prove to be inadequate in the long-term for successful BRT application. Potential negative impacts on other HOV travel options (carpool, vanpool, local bus) or general-purpose capacity could result if HOV operating policies are changed.

The fully grade-separated rail technologies (monorail, Skytrain) by definition would have the ability to maintain frequent headways at high average speeds with consistent schedule reliability. Light rail could also offer similar speed and reliability demands if it is operated in primarily exclusive or semi-exclusive right-of-way. However, if significant portions were operated on surface streets in mixed-traffic (as is possible given the technologies profile flexibility) then speeds and reliability could be degraded and fall below desired ranges.

System integration

Transit technologies should be capable of providing convenient and seamless passenger connections with transfers to currently operating regional transit technologies within the corridor. In addition, the technology should have the capability to accommodate access to the system from the full range of travel modes, including pedestrian, bicycle, auto, and transit feeder systems. Convenient transfers will need to be established for the North Link extension of light rail (Seattle CBD north to Northgate). Additionally, an intra-city, intermediate capacity monorail is under development in Seattle. A technology should have the capability to connect effectively with these systems.

Enhanced Bus, BRT, and light rail have a distinct advantage under the established criteria given the other planned transit technologies that will be in operation in the North Corridor. Bus transit services and facilities already exist throughout communities in the north and south of the corridor. Integrating bus transit technologies into the fabric of transportation services, while not without challenge, should not be a major barrier in this corridor. Aside from some potential capacity constraints, BRT would have the potential to operate on downtown streets providing good connections to existing transit services in Northgate and Everett.

For the purpose of this study, Link light rail services are assumed to be in operation sometime after 2010 in the north Seattle corridor. A light rail connection in the North Corridor could directly interline with the Central Link system and operate in the Downtown Seattle Transit Tunnel (DSTT). The ability to tie light rail services in the North Corridor directly with the planned transit investments in the north Seattle corridor (i.e., Seattle CBD to Northgate) would provide major operating advantages and passenger conveniences.

Completion of the Seattle Monorail Project (Green Line) is assumed in this study and potential extensions to Northgate were considered. The design of the proposed Green Line is not complete and the viability of a regional monorail system will require more detailed analysis of engineering specifics, however, direct connections to a North Corridor monorail alignment could pose significant challenges. To meet the passenger needs in the North Corridor, a regional monorail line would need to serve much higher capacity needs than currently planned for by the Green Line. The transit demands projected for the Green Line in combination with longer distance north-south regional transit travel demands would exceed capacity of the proposed system as it is currently designed. Even if the same train and guideway beam technology were used, there would not be the ability to directly interline the Green Line with a regional monorail alignment. This is not to say that a long-distance, north-south monorail line could not indirectly connect with Seattle Monorail lines or have separate stations and guideways that could provide incidental connections (forced transfers) between the different systems.

As it operates in Vancouver, Skytrain is automated and fully grade separated. The system could be customized to accommodate the North Corridor, but changes would be needed in order to fully integrate it with the existing system. Automated systems could not operate with mixed traffic in lower density areas in the north and Skytrain could not operate in the DSTT unless significant modifications are made.

Land Use

The North Corridor contains a wide diversity of activity centers from existing high-density locations (Northgate and Everett) to low-density suburban centers (Lynnwood and Paine Field). Land use development decisions are influenced by high capacity transit services which can substantially increase passenger volumes to a given area. The financial magnitude of a transit investment and the relative permanence of that investment are often sited as reasons for attracting new land use development. A high capacity transit technology will support high-density development and increase opportunities for improved pedestrian access.

BRT, light rail, monorail, and Skytrain would be expected to have significantly greater influence on land use than Enhanced Bus services. Given capacity and speed limitations and the limited permanence of stations, Enhanced Bus does less to support the long-range land use plans and projected growth than these other HCT technologies. BRT and light rail provide for greater accessibility and generally result in higher levels of investment at individual stations. One distinguishing characteristic of BRT is the increased difficulty in achieving exclusive bus operations in high-density activity centers. Light rail provides a somewhat less challenging opportunity to provide reliable, direct congestion-free access to serve the high-density markets.

Like Light Rail, both Monorail and Skytrain would support substantial land use development opportunities. These technologies could face some challenges because of profile inflexibility (see below) and potential negative affects of elevated guideways.

Right-of-Way Requirements and Profile Flexibility

Each of the technologies evaluated have different characteristics related to their flexibility in determining right-of-way needs and profile characteristics. Although specific alignments were not evaluated, consideration was given to the range of potential applications for each technology in the North Corridor. The primary considerations for right-of-way and profile needs are at the termini of the corridor. In order to balance accessibility and operation efficiency, the selected technology should be flexible enough to provide different levels of exclusivity depending on geographic constraints and level of existing development in the corridor.

Monorail and Skytrain have the least flexible profile options of the technologies investigated. Both technologies require grade-separated guideways throughout their entire system. These technologies have been implemented where full grade separation can be justified because of limited space and very high densities. While the aerial profile and full grade separation can be a distinct advantage for a long-range regional system, it can also limit options for serving a variety of different urban environments. Although the North Corridor includes a few dense urban centers, much of the corridor, between Lynnwood and Everett in particular, is comprised of suburban locations where aerial/grade separation may not be needed and could be served nearly as well at grade and increase accessibility to the system.

Enhanced Bus, BRT, and light rail offer a significantly higher level of profile and ROW flexibility. These technologies can operate in full grade separation, mixed traffic, elevated, or various combinations. This profile and ROW flexibility does not come without cost, both in terms of securing ROW and in terms of system performance if operated with less exclusivity. However, profile flexibility does allow a high capacity transit service to fit specific area needs and limitations such as the North Corridor's varying land use intensities. Engineering work is needed at an alignment level to make any specific distinctions between technologies regarding ROW needs and profile flexibility.

North Corridor Summary

Enhanced Bus (Express Bus Service)
Enhanced Bus operations could support North Corridor needs in the very near term. However, the limited capacity, lower operating speeds, and reduced reliability of Enhanced Bus would limit its application long-term. Land use objectives and other corridor needs would be better served with other transit technologies.

Bus Rapid Transit (BRT)
BRT could support corridor needs in the mid-term future (2010-2020) but may have limited expansion capabilities to meet long-term demands. BRT would generally support the long-range land use plans and projected growth in Northgate, Lynnwood, and other activity centers in the corridor. Flexibility of the technology provides a wide range of options for serving transit markets. High bus volumes in Northgate activity center transferring to North Link light rail could create significant challenges toward meeting travel demands and development objectives at Northgate.

Light Rail (LRT)
Light Rail could meet the high capacity transit needs in the North Corridor over long-term future. The capacity, speed, and the permanence of stations support the long-range land use plans and projected growth in major activity centers in the corridor. Right-of-way and profile flexibility will support diverse geographies in the corridor. The system would complete an excellent transit connection between Seattle and Everett and has the potential to serve additional locations in the North Corridor. More analysis is needed to assess the capacity for bus transfers at proposed stations.

Monorail
Monorail could meet corridor needs over the long-term. The capacity, speed, and the permanence of monorail stations support the long-range land use plans and projected growth in major activity centers in the corridor. The technology could provide a strong connection between Seattle and Everett and could serve other activity centers. More analysis is needed to fully understand the ability to facilitate connections with Seattle's planned monorail system. Limited profile flexibility will constrain how the technology is integrated within urban environments.

Skytrain
Skytrain meets many of the high capacity transit needs in the North Corridor. Skytrain shares characteristics with both Light Rail and Monorail. It would have the ability to maintain frequent headways at high average speeds with consistent schedule reliability and could provide sufficient capacity over the long-term. Skytrain would involve the addition of an entirely new transit technology to the regional transit system and would require separate stations and guideways that are likely to pose multiple challenges for integration with existing transit services. The technology could support land use changes anticipated in local plans and the potential to automate operations could increase reliability and lower costs.

(see Figure 4.2.6 - Summary of Technology Assessment)

FIGURE 4.2.4

Summary of Land Use and Demographics

North Corridor

Selected major Activity Centers evaluated in this corridor: **Northgate, Everett CBD, Lynnwood CBD, & Paine Field**

Key Considerations	Current Conditions	Mid-Range (2020)	Long-Range (2030)
Primary Indicator			
Population and Employment in Activity Centers Indicators: 30-45 jobs and population per acre >45 jobs and population per acre	*Northgate* (16,400 jobs and population @ 35 per acre) and *Everett* (15,664 @ 34 per acre) fall within the primary indicator density range, but they do not have significant totals. Paine Field has 38,273 total jobs and population but at very low densities (9 per acre). Lynnwood (13,500 @ 15 per acre) does not meet the primary indicator.	**Northgate** (23,759 @ 51 per acre) and **Everett** (23,400 @ 50 per acre) exceed the density range by 2020. Lynnwood has over 22,000 jobs and population in 2020, but the density is only 25 per acre. Paine Field has almost 50,000 jobs and population by 2020 but densities of only 12 per acre.	By 2030, *Lynnwood* (28,016 @ 31 per acre) falls within the primary indicator density range. Paine Field has over 57,000 jobs and population by 2030 but at densities of only 13 per acre.
Secondary Indicators			
Residential Clusters	**Average population density within Clusters is approximately 5 people per acre.** Over one-quarter (26%) of total population is located in defined Residential Clusters.	**Average population density in Clusters is forecast to increase to 14 people per acre in 2020.**	**Average density in Clusters is projected to increase to 16 people per acre in 2030.**
Ratio of jobs to households in Activity Centers **Residential base in Activity Centers**	Lynnwood (8), Everett (4), and Northgate (3) all have fewer than 15 jobs per household. Paine Field is job rich with over 21 jobs per household. No Centers in the corridor have a household base greater than 5000 households. Northgate (3,300), Everett (2,500) are highest, while both Paine Field and Lynnwood have fewer than 2000 households.	The ratio of jobs to households is projected to increase gradually in Lynnwood (10), Everett (5) and Northgate (4). Ratio in Paine Field is projected to decrease to about 16 jobs per household in 2020. By 2020, Northgate is projected to have 4,300 households and Everett 3,300. Paine Field household base reaches 2,700 by 2020.	By 2030, it would be expected that all Centers other than Paine Field would have 15 or fewer jobs to households. By 2030, Northgate is projected to exceed 5,000 households. Everett (3,800), Paine (3000), and Lynnwood (2000) also grow significantly but fall below threshold.
Roadway Network in Corridor **Block size in Activity Centers**	Seattle and Shoreline neighborhoods generally contain dense street networks, exceeding 1 intersection per acre. Snohomish County neighborhoods generally have fewer intersections per acre. **Everett has relatively small block sizes and a dense pedestrian network (block size avgerage 2 acres).** Northgate has generally good facilities but somewhat larger block sizes (12 acres average). Lynnwood has fewer pedestrian connections and large blocks (avg 22 acres). Block size at Paine Field average over 100 acres.	Intersection density and roadway network cannot be forecast for future years but as the corridor urbanizes and grows it can be expected that Snohomish County networks will improve and intersection density will increase. Based on plans to connect roads and break-up super blocks, it can be expected that **there would be relatively small block sizes and denser pedestrian networks in Northgate and Lynnwood**. Paine Field would still likely have relatively larger blocks and other pedestrian barriers.	As the corridor continues to urbanize it can be expected that road networks will improve and intersection density will increase throughout the corridor. Based on plans, **all Activity Centers could be expected to have a significantly improved network** of pedestrian connection by 2030. Paine Field could still have larger blocks and other pedestrian barriers.
Parking Costs/Supply in Activity Centers	**Everett is the only Center in the corridor with any parking charges** for long-term parking and/or short-term parking charges. Everett has less than 1 stall per employee. Others have a significant free parking supply.	Based on increasing density, parking policies and increasing land values, **Lynnwood and Northgate would be expected to institute parking charges** during this period. --	Paine Field is the only Activity Center that would likely not have parking charges during this time period. --

FIGURE 4.2.5

Summary of Travel Patterns and Transportation

North Corridor

Selected major Activity Centers evaluated in this corridor: **Northgate, Everett CBD, Lynnwood CBD, Paine Field**

Criteria	Current Conditions	Mid-range (2020)	Long-Range (2030)
Primary Indicator			
Activity Centers: Major Destinations 20,000-30,000 a.m. peak period person trips destined for activity center. >30,000 a.m. peak period person trips destined for activity center.	**Paine Field** currently attracts 31,870 a.m. peak person trips, exceeding the primary indicator range. *Lynnwood* (20,911) falls at the low end of the range. The other activity centers attract fewer than 20,000 person trips.	By 2020, **Lynnwood** is forecast to attract 32,520 a.m. peak person trips, exceeding the range. *Everett* (20,617) and *Northgate* (27,499) fall within the range.	By 2030, **Northgate** is forecast to exceed the range attracting 32,400 a.m. peak person trips. *Everett* is forecast to attract 23,600 a.m. peak person trips by 2030.
Secondary Indicators			
Travel across screenlines (daily and peak periods) #41 north/south between Northgate and Lynnwood ***Transit person trips per hour per direction (pphpd) reflects highest demand within corridor.*** #46 north/south between Lynnwood and Everett	Total daily person trips across screenline is 412,700. 44% of daily person trips are made during peak period. 11% of a.m. person trips are made by public transit. ***Southbound a.m. transit person trips per hour per direction (pphpd) is 3,505*** Total daily person trips across screenline is 323,200. 42% of daily person trips are made during peak period. 3% of a.m. person trips are made by public transit.	In 2020… 13% total trip growth rate. Total daily person trips across screenline is 468,200. 46% of daily person trips are made during peak period. 12% of a.m. person trips are made by public transit. ***Southbound a.m. transit person trips per hour per direction (pphpd) is 6,130*** 41% total trip growth rate. Total daily person trips across screenline is 454,800. 44% of daily person trips are made during peak period. 3% of a.m. person trips are made by public transit.	In 2030… 25% total trip growth rate. Total daily person trips across screenline is 518,000. 46% of daily person trips are made during peak period. 17% of a.m. person trips are made by public transit. ***Southbound a.m. transit person trips per hour per direction (pphpd) is 9,150*** 59% total trip growth rate. Total daily person trips across screenline is 514,200. 44% of daily person trips are made during peak period. 5% of a.m. person trips are made by public transit.
Growth in am peak person trips between subareas **Heading North:** Seattle/Shoreline to Snohomish County **Heading South:** Snohomish County to Seattle/Shoreline	2.9% of am peak person trips (11,700) originating in Seattle/Shoreline are destined for Snohomish County. **0.4% of these trips (50) are transit person trips.** 16.4% of am peak person trips (53,100) originating in Snohomish County are destined for Seattle/Shoreline. **5.0% of these trips (2,700) are transit person trips.**	By 2020 … 2.9% of am peak person trips (14,600) originating in Seattle/Shoreline are destined for Snohomish County. **0.7% of these trips (100) are transit person trips.** 16% of am peak person trips (80,000) originating in Snohomish County are destined for Seattle/Shoreline. **4.9% of these trips (3,900) are transit person trips.**	By 2030… 2.8% of am peak person trips (15,900) originating in Seattle/Shoreline are destined for Snohomish County. **0.8% of these trips (130) are transit person trips.** 14.7% of am peak person trips (84,100) originating in Snohomish County are destined for Seattle/Shoreline. **6% of these trips (6,100) are transit person trips.**
Park-and-Ride facilities Future year numbers reflected projected demand based on WSDOT analysis conducted in 2001.	3,600 P&R stalls in Seattle/Shoreline subarea 6,600 P&R stalls in Snohomish County subarea	In 2020… 4,900 P&R stalls in Seattle/Shoreline subarea 15,700 P&R stalls in Snohomish County subarea	In 2030… 5,500 P&R stalls in Seattle/Shoreline subarea 19,100 P&R stalls in Snohomish County subarea

FIGURE 4.2.6

Summary of Technology Assessment

North Corridor

Technology Characteristics	*Enhanced Bus*	*Bus Rapid Transit*	*Light Rail*	*Monorail*	*Skytrain*
Capacity					
Seated	43 - 40' bus	65 - 60' bus	4 per car		168 (2 car, married pair)
Seated and standing	80 - 40' bus	90 - 60' bus	148 per car	125 per car	512 (2 car, married pair)
Projected Transit Demand 3,500 (2000) – 9,150 (2030) transit person trips per hour per direction (pphpd)	1,290 – 2,400 2 buses w/4min headway 2,580-4,800 – 4 buses w/4min headway	1,950-2,700 w/4min headway – 2 bus platoon 3,900-5,400 w/4min headway – 4 bus platoon	2,220-4,440 w/4min headway – 2 cars 4,440-8,880 w/4min headway – 4 cars	3,750 w/4min headway – 2 cars (top SMP #) 7,500 w/4min headway – 4 cars (top SMP #)	1,260-3,840 w/4 min headways – 2 cars 2,520-7,680 w/4 min headways – 4 cars
Stations Spacing Flexibility needed- small stations for less developed areas and large stations with amenities to support activity centers.	Small stations can serve the lower densities within the corridor, but long distance travel and tightly spaced stations in dense locations could reduce schedule reliability.	Large stations or smaller stops can serve varying densities. Stations can be tightly or widely spaced.	Large stations or smaller stops can serve varying densities. Stations can be tightly or widely spaced.	Large elevated Stations. Stations can be tightly or widely spaced.	Large elevated Stations. Stations can be tightly or widely spaced.
System Integration Needs to work with service destined for the Downtown Seattle Transit Tunnel (DSTT), the Seattle Monorail Project (SMP), and other major transfer locations.	Large numbers of buses could add to congestion on limited freeway connections in Northgate and Everett.	Large numbers of buses could add to congestion on limited freeway connections in Northgate and Everett.	Profile flexibility can address many system integration needs.	Difficult to integrate in some areas due to limited profile flexibility. Indirect connection (transfer) with SMP system.	Introduces another new transit technology.
Land Use Desire to increase densities in Northgate and Lynnwood, support aviation industries at Paine Field, and address highly concentrated groupings of residential clusters.	Enhanced Bus has modest influence on land use.	BRT has some influence on land use, supporting plans for outlying centers.	Strong support for higher density development.	Strong support for higher density development.	Strong support for higher density development.

North Study Corridor

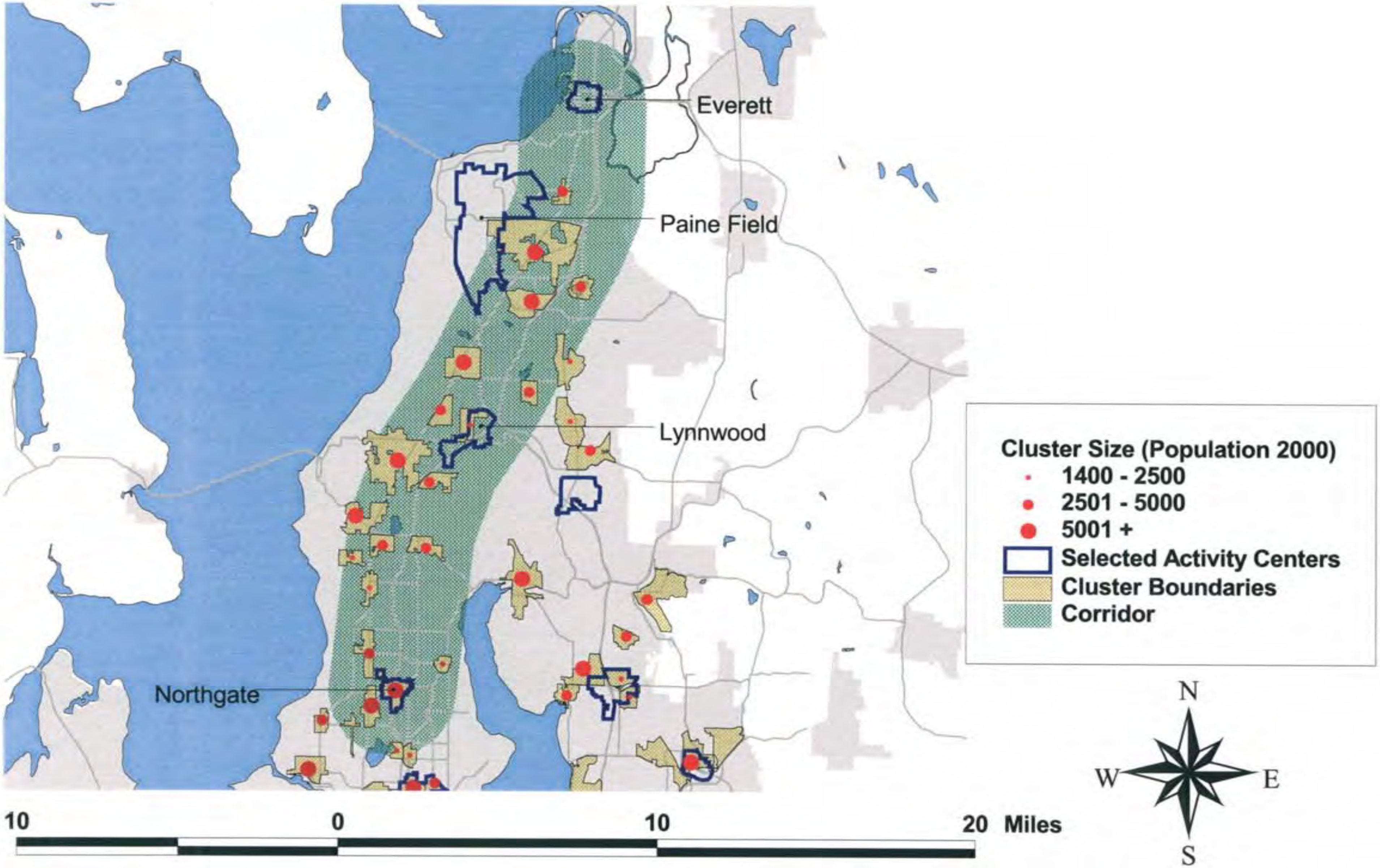
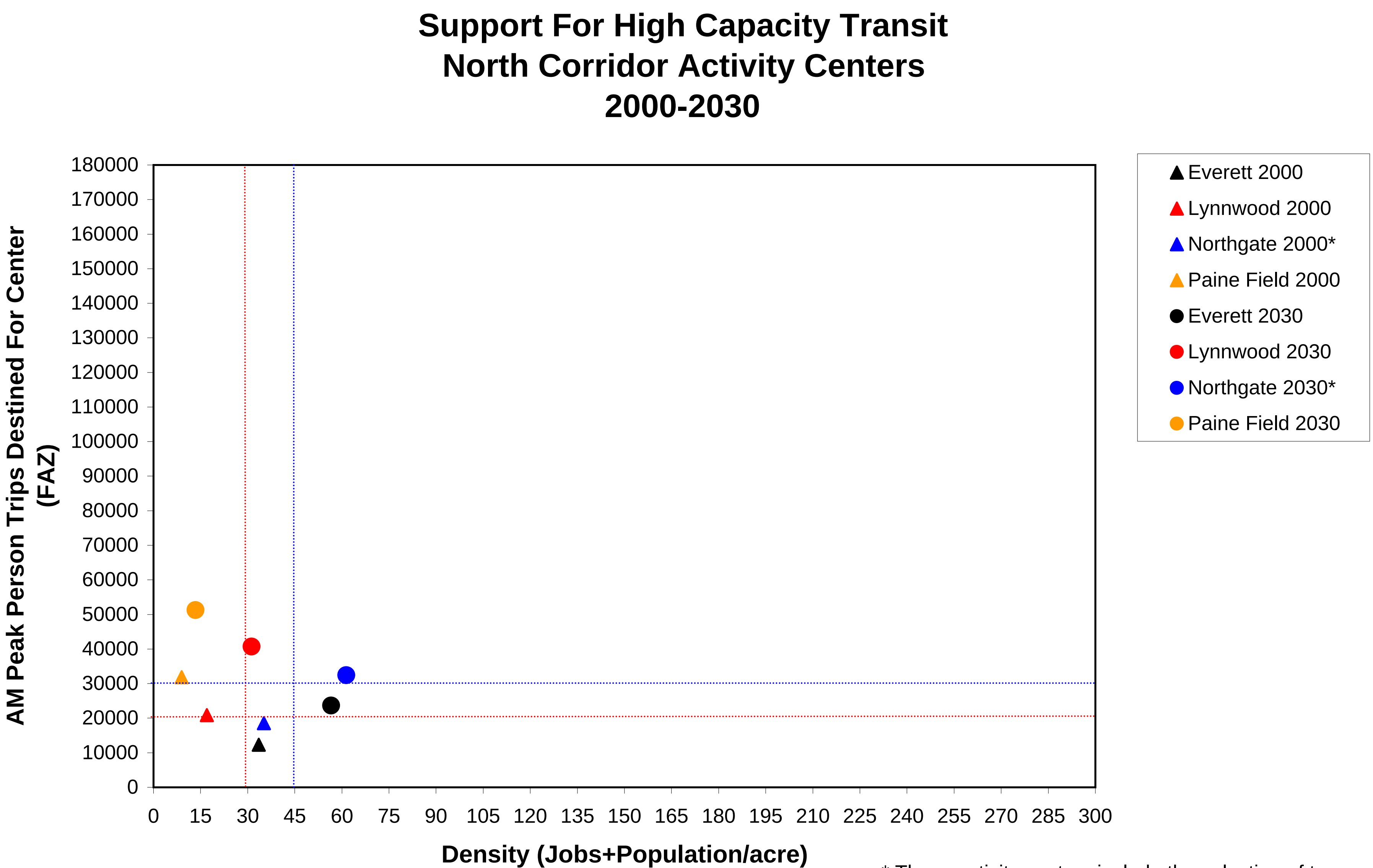
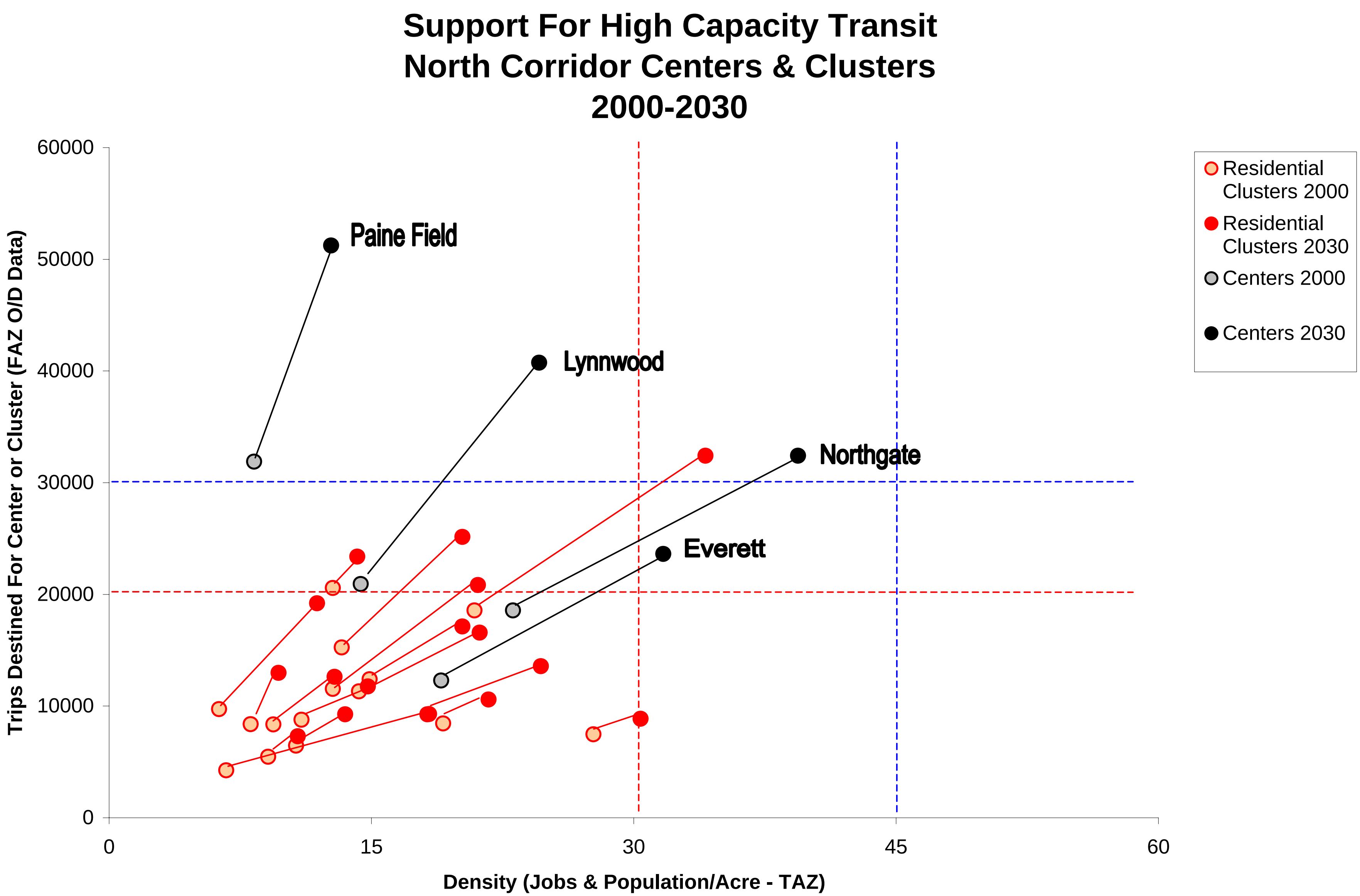


FIGURE 4.2.8



* These activity centers include the selection of two Forecast Analysis Zones for am peak travel data.

FIGURE 4.2.9



Support For High Capacity Transit
North Corridor Centers & Clusters
2000-2030
Trips Destined For Center or Cluster (FAZ O/D Data)
60000
50000
40000
30000
20000
10000
0
0
15
30
45
60
Density (Jobs & Population/Acre - TAZ)
Paine Field
Lynnwood
Northgate
Everett
Residential Clusters 2000
Residential Clusters 2030
Centers 2000
Centers 2030

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4.3 South Corridor

The South Corridor includes one interstate highway (I-5) and one semi-limited access state highway (SR-99 south) running south from Seattle's downtown through Tacoma toward Dupont. Both freeways provide connections between the airport and a large metropolitan city (Tacoma). They also provide the opportunity to connect to the light rail line under construction in Seattle. The corridor provides strong connections between important job centers (Port of Tacoma, South Center Mall, and Sea-Tac International Airport) with some minor multi-family residential concentrations at the midpoint between these locations. The corridor contains an existing one-mile light rail streetcar line in downtown Tacoma and the Sounder commuter rail. I-5 provides strong connections between the job centers and opportunities to link transit facilities (large park-and-rides & good local transit system). Express buses currently run in high occupancy vehicle (HOV) lanes along the interstate highway. See Figure 4.3.7-*South Study Corridor* for a map.

4.3.1 Land Use Assessment

Corridor-wide land use characteristics and projected growth indicate that this corridor has sufficient land use activity and densities to support high capacity transit in the future. Population in the South Corridor is projected to increase significantly over the next 30 years. The corridor contains two large sized activity centers and five low-moderate density locations. Seven major activity centers were identified in the corridor and evaluated in detail, including: SeaTac, Federal Way, Tacoma CBD, Tacoma Mall, Lakewood (designated Regional Growth Centers), Port of Tacoma (designated Manufacturing/Industrial Center) and Dupont.

Tacoma CBD currently meets the primary land use indicator (30-45 residents and jobs per gross acre) established to assess support for high capacity transit. Other activity centers would meet the primary land use indicator in the mid to long-range (2010-2030). The activity centers in the corridor currently vary as to how well they meet the secondary indicators with some having a strong residential base, a good mix of jobs and households, smaller block sizes, and a limited supply of parking. Federal Way was found to contain many of the key attributes necessary to support high capacity transit in the long-range (2030). Lakewood and SeaTac are still well below the density range within the planning horizon of the study, but in terms of land use totals they partially support high capacity transit service in the mid-range (2020). Figure 4.3.8– *Support For High Capacity Transit South Corridor Activity Centers (2000-2030)* compares these activity centers based on densities (population + employment per acre) and travel demand (trips destined for the center in the a.m. peak). The centers are determined to be more or less supportive of high capacity transit depending on whether they meet or exceed the density and travel demand ranges placed on the chart.

In addition to major activity centers, the South Corridor contains clusters of higher-density residential activity. These clusters are characterized by areas of medium to high-density residential development in close proximity to retail and office uses. Clusters of residential activity include about 26 percent of total residential population in the corridor. The South Corridor contains clusters with low densities, but they attract a moderate to significant amount of travel demand. Many of the identified residential clusters are located in close proximity to SR-99 between SeaTac and Federal Way. Additional clusters are located adjacent to Lakewood. Average densities in residential clusters will increase from 5 to over 15 people per acre between 2000-2030. Figure 4.3.9– *Support For High Capacity Transit South Corridor Centers and Clusters (2000-2030)* evaluates the level of support for high capacity transit (travel demand and density) in residential clusters as compared to activity centers within the corridor.

(see Figure4.3.4 - Summary of Land Use and Demographics)

4.3.2 Travel Pattern Assessment

Based on origin and destination data there is a high volume of travel between the two sub-areas in this corridor - Pierce County and South King County -- primarily focused on I-5 and SR-99. A majority (79 percent) of the a.m. peak person trips traveling between sub-areas originate in Pierce County and head north toward Seattle (currently around 39,000 a.m. peak person trips). Currently about 4 times more transit person trips (128 vs. 33) are traveling north (versus south) in the a.m. peak period. Approximately 44 percent of the travel in this corridor is concentrated in the peak travel (a.m. & p.m.) periods. Flows between sub-areas increase rapidly through 2010 and then more slowly between 2010 and 2030. Over time a greater share of total trips remain within the individual sub-areas. Transit mode share within the corridor is projected to increase slowly.

Based on screenline data, although most travel is going north in the a.m. peak period, the reverse commute (north to south in the a.m.) is growing. Currently about 77 percent of all a.m. peak period person trips (SOV, HOV, and transit) are headed northbound. The percentage of northbound transit travel during the a.m. peak period is higher at about 96 percent of total and 90 percent of the carpool/vanpool trips are headed northbound. Over the 30-year planning period, the pattern of directional travel will shift, increasing southbound travel by 33 percent. In 2030, slightly less (76 percent) of all person trips are projected to head north at a.m. peak periods, the same percentage of transit trips (96 percent) and a slightly higher number of the carpool/vanpool trips (93 percent). Over time a greater share of total trips remain within the individual sub-areas, indicating that expanded localized travel may be important to develop once the HCT system has been established.

The volume of travel across the Tacoma-SeaTac screenline is projected to grow between 2000 and 2030. Total person trips across the major roadways are projected to grow 27 percent between 2000 and 2030. Transit travel is projected to almost double. During the a.m. peak period, transit trips are projected to increase from 4 percent of total trips in 2000 to 6 percent of total trips in 2030. At the point of highest travel demand, northbound a.m. transit person trips per hour per direction increase from 2,050 to 3,782 between 2000 and 2030. This level of transit travel demand could generally support an investment in higher capacity transit services.

In terms of peak-period travel, SeaTac is the largest travel market in the corridor, followed by Tacoma CBD, Federal Way, DuPont, Tacoma Mall, Port of Tacoma, and Lakewood. SeaTac currently exceeds the primary travel indicator necessary to support HCT services. Currently, Tacoma CBD, Federal Way, and DuPont demonstrate moderate support for high capacity transit, attracting more trips than 20,000 a.m peak-hour person trips. Tacoma Mall has a strong travel market in the long-range future (2020-2030). Port of Tacoma and Lakewood continue to have only a moderate travel market into the long-range future (2030).

(see Figure 4.3.5 - Summary of Travel Patterns and Transportation)

4.3.3 Transit Technology Assessment

The technology assessment for the South Corridor specifically addressed Enhanced Bus, Bus Rapid Transit, Light Rail, Monorail, and Skytrain. Additional Commuter Rail/DMU service was considered as an opportunity for extending the existing commuter rail line from Lakewood to Dupont. The distinguishing characteristics of each technology that were evaluated included: capacity, operating speeds, reliability, station spacing, headways, system integration, land use impacts, implementation risk, right-of-way requirements and profile needs. Below are initial observations developed from the assessment of the relative appropriateness of these various transit technologies in the South Corridor. For discussion purposes, a number of related technology characteristics are grouped together (e.g., speed, headways, reliability).

Capacity
In the South Corridor, a southbound peak hour transit demand is forecast to reach 3,782 passengers per hour per direction (pphpd) in 2030, based on Puget Sound Regional Council travel demand model. This level of transit demand reflects an 84 percent increase over the current northbound peak hour transit demand in the South Corridor (2,050 pphpd). Based on this line-haul capacity need, all of the HCT technologies evaluated, except Enhanced Bus, could generally meet the long-term passenger demand forecasts.

Enhanced Bus was calculated to reach its maximum capacity at 4,800 pphpd, under some fairly aggressive operating assumptions. Bus Rapid Transit was also found to meet the long-term line-haul capacity needs. There are implications for Enhanced Bus and BRT use in the corridor regarding connections to light rail when Central Link light rail is extended to Sea-Tac Airport sometime after 2010. Further analysis is needed to determine more precisely the potential capacity limitations of bus rapid transit in this corridor related to street capacity at SeaTac and downtown Tacoma.

Commuter rail and/or DMU extension to DuPont appears to be a viable option as densities and travel demand increase over the long-term. The other rail technologies (light rail, monorail, and Skytrain) were found to have adequate long-term capacities and the potential for line haul capacity expansion beyond the 30-year planning horizon.

Speeds, Headways, Reliability

Desired operating characteristics in the South Corridor include average operating speeds of between 25 and 35 mph, headways of 4 minutes (15 buses/trains per hour) and a high degree of schedule reliability for quick commute service between two of the largest urban areas in the region. Higher speeds may be necessary in less dense locations of this corridor in order to make up for delays due to tight station spacing in Tacoma and urban areas further to the north. All of the technologies evaluated, except Enhanced Bus, could generally meet the desired average operating speeds, headways, and reliability.

As growth occurs, enhanced bus is unlikely to maintain high average speeds because of the increased bus travel times in mixed traffic, especially in and out of the major activity centers such as Tacoma CBD. Slow average speeds would result in longer headways between buses and reduced schedule reliability. With significant enhancements to the existing freeway HOV lane system, BRT may be able to meet the desired frequencies, speeds, and reliability. Current planned improvements for increased HOV lane capacity and operations in the South Corridor could, however, prove to be inadequate in the long-term for successful BRT application.

For BRT to meet the region's projections for transit travel demand in the South Corridor, additional HOV lane capacity and more significant exclusivity would be needed to maintain frequencies, speeds, and reliability. This exclusivity could be provided through a range of factors, such as increasing HOV occupancy requirements, introducing a managed lane concept (e.g., HOT lanes), and/or creating bus-only lanes in the corridor. The implications of providing greater BRT exclusive (or semi-exclusive) lanes are many, including potential negative impacts on other HOV travel options (carpool, vanpool, local bus) or general-purpose capacity.

The fully grade-separated rail technologies (monorail, Skytrain) by definition would have the ability to maintain frequent headways at high average speeds with consistent schedule reliability. Light rail could also offer similar speed and reliability demands if it is operated in primarily exclusive or semi-exclusive right-of-way. However, if significant portions were operated on surface streets in mixed-traffic (as is possible given the technologies profile flexibility) then speeds and reliability could be degraded and fall below desired ranges. Commuter rail or DMU could meet speed and reliability needs if extended to Lakewood.

System integration

Transit technologies should be capable of providing convenient and seamless passenger connections and transfers to currently operating regional transit technologies within the corridor. In addition, the technology should have the capability to accommodate access to the system from the full range of travel modes, including pedestrian, bicycle, auto, and transit feeder systems. Convenient transfers will need to be established for the Central

Link light rail (Seattle CBD to SeaTac). There is heavy freight activity originating at the Port of Tacoma and traveling along the tracks used for commuter rail service between Seattle and Tacoma. Additionally, an intra-city, intermediate capacity monorail is under development in Seattle and a small light rail segment system currently runs in Tacoma.

Enhanced Bus, BRT, and light rail have a distinct advantage under the established criteria given the other planned transit technologies that will be in operation in the South Corridor. Bus transit services and facilities already exist throughout communities in the north and south of the corridor. Integrating bus transit technologies into the fabric of transportation services, while not without challenge, should not be a major barrier in this corridor. Aside from potential capacity constraints, BRT has the potential to operate on downtown streets with good connections to existing transit in Tacoma and Seattle.

For the purpose of this study, Central Link light rail services are assumed to be in operation sometime after 2010. A light rail connection in the South Corridor could directly interline with the Central Link and Tacoma Link systems. The ability to tie light rail services in the South Corridor directly with the planned transit investments in Seattle and Tacoma would provide major operating advantages and passenger conveniences.

Completion of the Seattle Monorail Project (Green Line) and potential extensions to the Fauntleroy ferry were considered in this study. The design of the proposed Green Line is not complete and the viability of a regional system will require more detailed analysis of engineering specifics. To meet the passenger needs in the South Corridor, a regional monorail line would require higher capacity needs than currently planned for the Green Line. The transit demands projected for the Green Line in combination with longer distance north-south transit travel demands would exceed capacity of the proposed system as it is currently being designed. Even if the same train and guideway beam technology were used, there still may not be the ability to directly interline with the Green Line in West Seattle. This is not to say that a long-distance, north-south Monorail line could not interline with the intra-Seattle system or have separate stations and guideways providing indirect connections (forced transfers) between the systems.

As it operates in Vancouver, Skytrain is automated and fully grade separated. The system could be customized to accommodate the South Corridor, but changes would be needed in order to fully integrate it with the existing systems.

Land Use

The South Corridor contains a wide diversity of activity centers from existing high-density locations (Tacoma CBD) to lower-density suburban centers (Federal Way, Tacoma Mall, Lakewood, and SeaTac). Sea-Tac contains an international airport serving passenger flights as well as cargo shipments. The corridor also contains the Port of Tacoma. Land use development decisions are influenced by high capacity transit services, which can substantially increase passenger volumes to a given area. The financial magnitude of a transit investment and the relative permanence of that investment are often sited as reasons for attracting new land use development.

BRT, light rail, monorail, and Skytrain would be expected to have greater influence on land use than Enhanced Bus services. Given capacity and speed limitations and the limited permanence of stations, Enhanced Bus would be expected to have less influence on land use development than other HCT technologies. In particular, Enhanced Bus services may not provide adequate services to support the planned land use development in the largest activity centers in the corridor. BRT and rail technologies provide for greater accessibility and generally result in higher levels of investment in stations.

One distinguishing characteristic of BRT is the potential difficulty in achieving exclusive bus operations in high-density activity centers. Rail technologies generally provide a somewhat less challenging opportunity to provide reliable, direct congestion-free access to serve these high-density markets. Monorail and Skytrain could face some challenges to land use changes as a result of profile inflexibility (see below) and the potential negative affects of elevated guideways. Commuter rail and/or DMU have the ability to attract residential growth along the existing rail right-of-way south of Lakewood.

ROW Requirements and Profile Flexibility

Each of the technologies evaluated have different characteristics related to their flexibility in determining right-of-way needs and profile characteristics. Although specific alignments were not evaluated, consideration was given to the range of potential applications for each technology in the South Corridor. The primary considerations for right-of-way and profile needs are at the north termini of the corridor (SeaTac and its airport) and in Tacoma CBD. In order to balance accessibility and operational efficiency, a high capacity transit technology would need to be flexible enough to provide different levels of exclusivity depending on geographic constraints and the level of existing development in the corridor.

Monorail and Skytrain have the least flexible profile of the technologies investigated. Both technologies require fully grade-separated guideways throughout their entire system. These technologies are best implemented where full grade separation can be justified because of limited space and very high densities. While the aerial profile and full grade separation can be a distinct advantage for a regional system, it can also limit options for serving a variety of different urban environments. Although the South Corridor includes a number of very dense urban centers, much of the corridor is comprised of suburban locations where aerial/grade separation may not be needed and could be served nearly as well at grade. This profile flexibility can reduce costs and increase accessibility to the system.

Enhanced Bus, BRT, and light rail offer a significantly higher level of profile and ROW flexibility than Skytrain or monorail. These technologies can operate in full grade separation, mixed traffic, elevated, or various combinations. This profile and ROW flexibility does not come without cost, both in terms of securing ROW and in terms of system performance if operated with less exclusivity. However, profile flexibility does allow a high capacity transit service to fit specific area needs and geographic limitations.

Engineering work is needed at an alignment level to make any specific distinctions between technologies regarding ROW needs and profile flexibility.

South Corridor Summary

Enhanced Bus (Express Bus Service):
Existing travel demand in the South Corridor can be met by Enhanced Bus capacities. Given capacity and speed limitations and the limited permanence of stations it would have limited influence on long-range land use plans and projected growth in Tacoma, Federal Way, and SeaTac. A higher capacity system should be phased in over a longer period of time within this corridor.

Bus Rapid Transit (BRT):
Bus Rapid Transit can serve the population and travel demands within the South Corridor. Investment in grade-separated services and facilities may be needed to meet long-range demands. The capacity, speed, and station permanence for BRT could influence the long-range land use plans and projected growth in Tacoma, Federal Way, and SeaTac. Some features of a BRT system are currently used in this corridor. Service improvements could provide for long term needs, and the existing infrastructure could be converted to a higher capacity system in the future.

Light Rail (LRT):
Light Rail capacity meets the needs for the South Corridor in the near and long-term. Its right-of-way and profile flexibility allow for a strong response to the diverse land uses contained in the corridor. The higher capacity, speed, flexibility in frequency, and the permanence of light rail stations would support the long-range land use plans and projected growth in Tacoma, Federal Way, and SeaTac. Additional investments could support travel demand beyond the horizon year.

Monorail:
Monorail capacity could meet the needs for the South Corridor in the near future and the long-term. The capacity, speed, and the permanence of monorail stations support the long-range land use plans and projected growth in Tacoma, Federal Way, and SeaTac. The system would provide a good connection between SeaTac and Tacoma and it has the potential to serve additional locations on the south as demand grows beyond the capacity of existing bus services. Some characteristics of Monorail could present challenges when integrated with the existing transit system. More analysis is needed to fully understand the ability to have direct connections with Seattle's planned monorail system and a potential regional monorail application.

Skytrain:
Skytrain meets the needs for the South corridor because it shares many characteristics with Light Rail and Monorail. It would have the ability to maintain frequent headways at high average speeds with consistent schedule reliability. Skytrain would involve the addition of an entirely new transit technology to the regional transit system and would require separate stations and guideways that are likely to pose multiple challenges for integration with existing transit services.

Commuter Rail (Sounder, Sound Transit)
This service currently runs between Tacoma and Seattle. It runs during peak hours, has high capacity and speeds with few station locations, operating as a true commuter service. Commuter rail operates on existing railroad tracks, aptly filling a regional inter-city role rather than the role of a regional connector along corridors with many intermediate travel needs. It may be possible to have future service expansions running between Tacoma and Dupont along existing tracks. Schedule conflicts with freight trains in this corridor will need to be addressed.

Diesel Multiple Unit (DMU):
DMU cars would require an investment in additional rail facilities unless run on existing tracks. There are existing rail tracks south of Tacoma that could be considered for DMU linking Lakewood and Dupont.

(see Figure 4.3.6 - Summary of Technology Assessment)

FIGURE 4.3.4

Summary of Land Use and Demographics

South Corridor

Selected major Activity Centers evaluated in this corridor: **SeaTac CBD, Federal Way CBD, Port Tacoma, Tacoma CBD, Tacoma Mall, Lakewood, & Dupont**

Key Considerations	Current Conditions	Mid-Range (2020)	Long-Range (2030)
Primary Indicator			
Population and Employment in Activity Centers Indicators: 30-45 jobs and population per acre >45 jobs and population per acre	*Tacoma CBD* falls within the density range with 30,306 jobs and population at 30 per acre. The other Centers in the corridor are generally well below the density range at this time.	By 2020, **Tacoma CBD** (43,796 jobs and population at 43 per acre) almost exceeds the density range. *Tacoma Mall* is projected to grow significantly and would contain almost 19,757 jobs and population, meeting the low end of the range (29.4 per acre). Federal Way will have only 6,140 jobs and population but densities will be fairly high at 26 per acre.	By 2030, *Federal Way* (6,817 @ 28 per acre) virtually meets the density range and Lakewood (14,566 @ 26 per acre) comes close. The other Centers in the corridor remain below the density range.
Secondary Indicators			
Residential Clusters	**Average population density in Clusters is 11 people per acre.** One-quarter (23%) of corridor population is located in Residential Clusters.	**Average population density in Clusters is projected to be 13.6 in 2020.**	**Average density in Clusters is projected to increase to 14.7 per acre by 2030.**
Ratio of jobs to households in Activity Centers **Residential base in Activity Centers**	Tacoma CBD (7), Tacoma Mall (8), Lakewood (5), Federal Way (11), SeaTac (2) and Dupont (2) have fewer than 15 jobs per households. Port of Tacoma has a very high ratio at 115 jobs per household. No Centers in the corridor have a household base greater than 5000. SeaTac and Tacoma CBD have 4,300 and 3,300 households respectively. Lakewood and Tacoma Mall have a little over 1000 households. Federal Way and Port of Tacoma have under 500.	Between 2010 and 2020 the jobs per households mix does not change significantly in each center. The Tacoma CBD ratio reduces slightly (7-to-5) and the Port of Tacoma ratio increases to 122 jobs per household. Between 2010 and 2020, both SeaTac and Tacoma CBD exceed 5000 households. Dupont is projected to have 4,000 households. Lakewood and Tacoma Mall have about 2000 households. Federal Way and Port of Tacoma still have under 1000 households.	Jobs per household mix in each Activity Center does not change significantly through 2030. Dupont exceeds 5,000 households, but there is only a moderate increase in all other Centers between 2020-2030.
Ratio of jobs to households in Activity Centers **Residential base in Activity Centers**	A number of south King County neighborhoods and Tacoma area contain dense street networks, exceeding 1 intersection per acre. **Tacoma CBD has relatively small block sizes and a dense pedestrian network (block size average 2 acres).** Tacoma Mall (7 acres) and Lakewood (10 acres) has somewhat larger block sizes. SeaTac, Federal Way, and Port Tacoma have average block sizes of 20-30 acres.	Intersection density and roadway network cannot be forecast for future years but as the corridor urbanizes and grows it can be expected that networks will improve and intersection density will increase. Based on plans for **SeaTac and Federal Way to connect roads and break-up super blocks**, it can be expected that there would be relatively small block sizes and denser pedestrian networks by 2020. Port of Tacoma would still likely have larger blocks and other pedestrian barriers.	As the corridor urbanizes and grows it can be expected that the networks will improve and intersection density will increase throughout the corridor. Based on comprehensive plans, **all of the Activity Centers within corridor would be expected to have a significantly improved network** of pedestrian connection by 2030. **One exception might be Port of Tacoma** that has limited plans to improve pedestrian networks.
Parking Costs/Supply in Activity Centers	**Tacoma CBD has some short-term and long-term parking. SeaTac has parking charges related to the airport.** Tacoma CBD has less than 1 stall per employee. Others have a significant free parking supply.	Based on increasing density, parking policies and increasing land values it would be expected that **Federal Way, SeaTac, and Tacoma Mall would institute parking charges** during this period. --	**All Activity Centers (except Port of Tacoma) would be expected to have parking charges** for short and/or long-term parking after 2020. --

FIGURE 4.3.5

Summary Travel Patterns and Transportation

South Corridor

Selected major Activity Centers evaluated in this corridor: SeaTac CBD, Federal Way CBD, Port Tacoma, Tacoma CBD, Tacoma Mall, Tukwila, Lakewood, & Dupont

Criteria	Current Conditions	Mid-Range (2020)	Long-Range (2030)
Primary Indicator			
Activity Centers: Major Destinations 20,000-30,000 a.m. peak period person trips destined for activity center. >30,000 a.m. peak period person trips destined for activity center.	**SeaTac** (35,048) is the most significant destination in the corridor, exceeding the density range. *Tacoma CBD* (26,192), *Federal Way* (23,824), *Tukwila* (23,238), and *DuPont* (21,799) fall within the range.	By 2020, **Tacoma CBD** (39,510), **Tukwila** (35,095), and **Federal Way** (32,356) exceed the range.	By 2030, *Tacoma Mall* (21,743) falls within the range. The other centers do not meet the primary indicator.
Secondary Indicators			
Travel across screenlines (daily and peak periods) #20 north/south between SeaTac and Federal Way ***Transit person trips per hour per direction (pphpd) reflects highest demand within corridor.***	Total daily person trips across screenline is 553,569 42% of daily person trips are made during peak period. 4% of a.m. person trips are made by public transit. ***Northbound a.m. transit person trips per hour per direction (pphpd) is 2,050***	In 2020… 28% total trip growth rate. Total daily person trips across screenline is 663,863 43% of daily person trips are made during peak period. 5% of a.m. person trips are made by public transit. ***Northbound a.m. transit person trips per hour per direction (pphpd) is 3,352***	In 2030… 27% total trip growth rate. Total daily person trips across screenline is 704,135 43% of daily person trips are made during peak period. 6% of a.m. person trips are made by public transit. ***Northbound a.m. transit person trips per hour per direction (pphpd) is 3,782***
#4 north/south between Federal Way and Tacoma	Total daily person trips across screenline is 309,100. 41% of daily person trips are made during peak period. 3% of a.m. person trips are made by public transit.	33% total trip growth rate. Total daily person trips across screenline is 412,300. 42% of daily person trips are made during peak period. 5% of a.m. person trips are made by public transit.	42% total trip growth rate. Total daily person trips across screenline is 440,000. 42% of daily person trips are made during peak period. 5% of a.m. person trips are made by public transit.
Growth in am peak person trips between subareas **Heading North:** South King County to Pierce County	3% of am peak person trips (10,600) originating in Seattle/Shoreline are destined for Snohomish County. **0.3% of these trips (35) are transit person trips.**	By 2020 … 3.1% of am peak person trips (14,100) originating in Seattle/Shoreline are destined for Snohomish County. **0.3% of these trips (150) are transit person trips.**	By 2030… 3.1% of am peak person trips (15,700) originating in Seattle/Shoreline are destined for Snohomish County. **0.4% of these trips (60) are transit person trips.**
Heading South: Pierce County to South King County	11.1% of am peak person trips (39,000) originating in Snohomish County are destined for Seattle/Shoreline. **0.3% of these trips (130) are transit person trips.**	11.6% of am peak person trips (57,800) originating in Snohomish County are destined for Seattle/Shoreline. **0.3% of these trips (380) are transit person trips.**	11.2% of am peak person trips (61,600) originating in Snohomish County are destined for Seattle/Shoreline. **0.6% of these trips (370) are transit person trips.**
Park-and-Ride facilities Future year numbers reflected projected demand based on WSDOT analysis conducted in 2001.	9,000 P&R stalls in South King County subarea 7,500 P&R stalls in Pierce County subarea	In 2020… 14,000P&R stalls in South King County subarea 14,800 P&R stalls in Pierce County subarea	In 2030… 15,600 P&R stalls in South King County subarea 14,800 P&R stalls in Pierce County subarea

FIGURE 4.3.6

Summary of Technology Assessment

South Corridor

Technology Characteristics	*Enhanced Bus*	*Bus Rapid Transit*	*Light Rail*	*Monorail*	*Skytrain*	*Diesel Mobile Unit*	*Commuter Rail*
Capacity							
Standing	43 - 40' bus	65 - 60' bus	74 per car		168 (2 car, married pair)	96 per car	134 per car
Seated and standing	80 - 40' bus	90 - 60' bus	148 per car	125 per car	512 (2 car, married pair)	N/A	255 per car
Projected Transit Demand 2,077 (2000) – 3,780 (2030) transit person trips per hour per direction (pphpd)	1,290 – 2,400 2 buses w/4min headway 2,580-4,800 – 4 buses w/4min headway	1,950-2,700 w/4min headway – 2 bus platoon 3,900-5,400 w/4min headway – 4 bus platoon	2,220-4,440 w/4min headway – 2 cars 4,440-8,880* w/4min headway – 4 cars	3,750 w/4min headway – 2 cars 7,500 w/4min headway – 4 cars	1,260-3,840 w/4 min headways – 2 cars 2,520-7,680 w/4 min headways – 4 cars	2,880 w/4min headway – 2 cars 8,640 w/4min headway – 6 cars	1,072 - 2,040 w/15 min headway – 2 cars 2,144 - 4,080 w/15 min headway – 4 cars
Stations Spacing The South Corridor contains many areas with lower density development, generally requiring more widely spaced stops.	Small stations can serve the lower densities within the corridor, but long distance travel and tightly spaced stations in dense locations could reduce schedule reliability.	Large stations or smaller stops can serve varying densities. Stations can be tightly or widely spaced	Large stations or smaller stops can serve varying densities. Stations can be tightly or widely spaced.	Large elevated Stations. Stations can be tightly or widely spaced.	Large elevated Stations. Stations can be tightly or widely spaced.	Small stations can serve the lower densities within the corridor, but stations are limited to only a few locations as DMU uses existing rail lines.	Large stations with widely spaced stops can serve the lower densities within the corridor, but stations are limited to only a few locations on existing rail lines.
System Integration Needs to work with feeder bus, shuttles, park and rides, and address congested locations at SeaTac airport and downtown Tacoma.	Large numbers of buses could add to congestion on limited freeway connections in SeaTac and Tacoma.	Large numbers of buses could add to congestion on limited freeway connections in SeaTac and Tacoma.	Profile flexibility can address many system integration needs.	Difficult to integrate in some areas due to limited profile flexibility.	Introduces another new technology.	Potential service to Dupont on existing rail. Transfer to existing commuter rail services.	Potential service to Dupont on existing rail with seamless connections to the existing commuter rail service.
Land Use Desire to increase densities in Tacoma, SeaTac, and other major activity centers.	Enhanced Bus has modest influence on land use.	BRT has some influence on land use, partial support for centers.	Strong support for higher density development.	Strong support for higher density development.	Strong support for higher density development.	DMU has some influence on land use, partial support for centers.	Supports moderate density development.

South Study Corridor

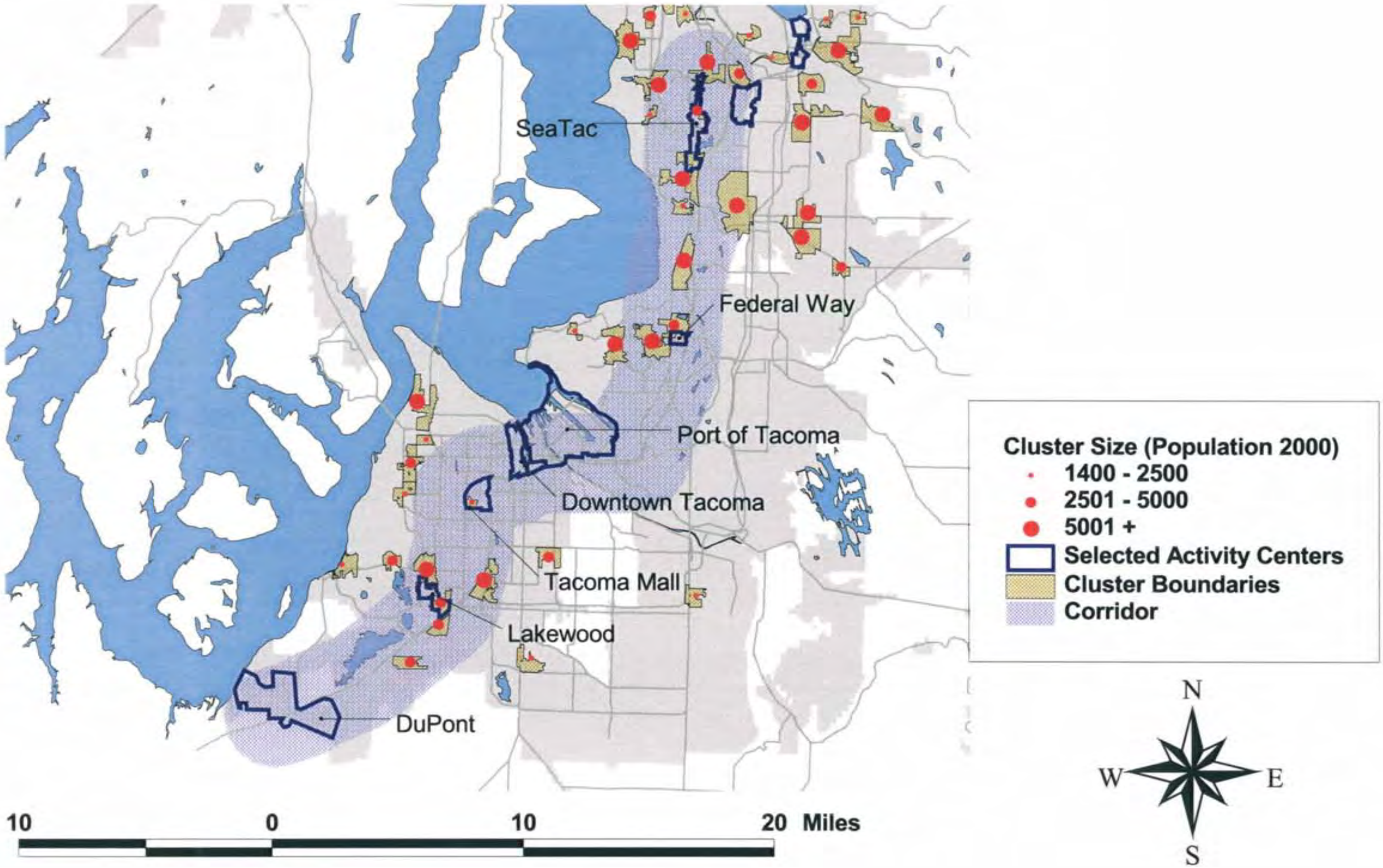
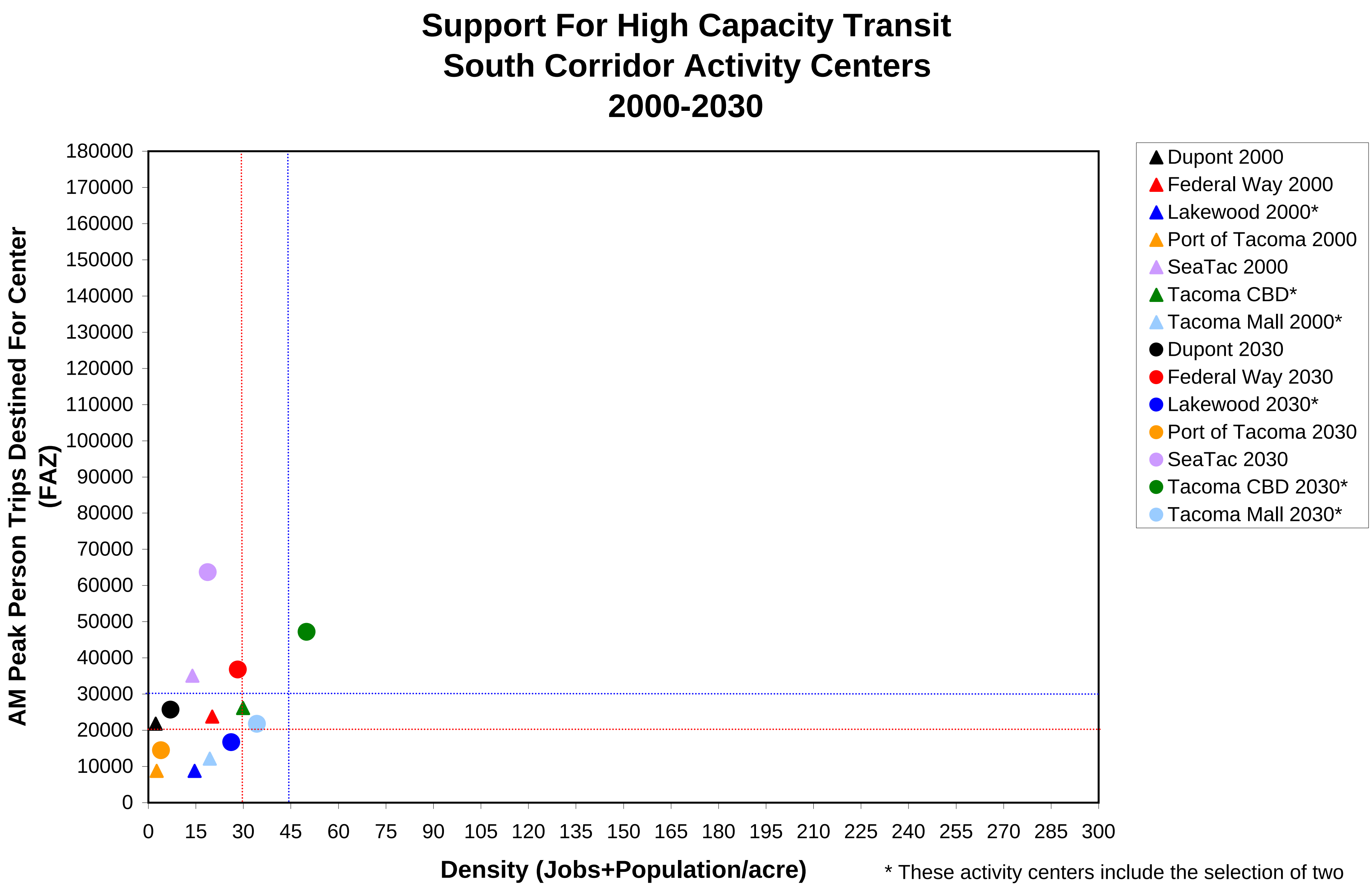
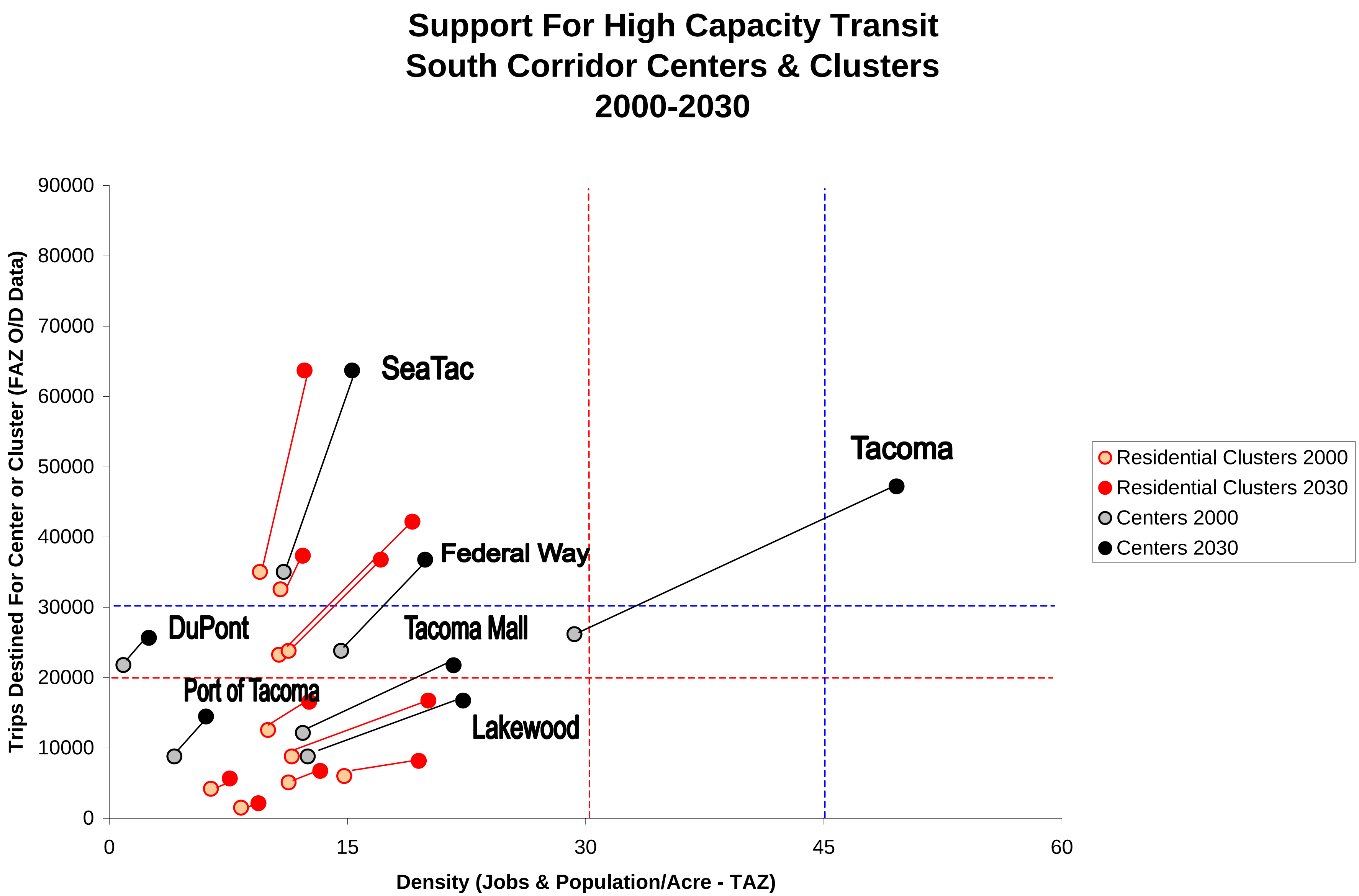


FIGURE 4.3.8



* These activity centers include the selection of two Forecast Analysis Zones for am peak travel data.

FIGURE 4.3.9


Support For High Capacity Transit
South Corridor Centers & Clusters
2000-2030
Trips Destined For Center or Cluster (FAZ O/D Data)
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
0
15
30
45
60
Density (Jobs & Population/Acre - TAZ)
SeaTac
Tacoma
Federal Way
DuPont
Tacoma Mall
Port of Tacoma
Lakewood
Residential Clusters 2000
Residential Clusters 2030
Centers 2000
Centers 2030

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4.4 Eastside Corridor

The Eastside Corridor includes one interstate highway (I-405) that forms connections with all of the other corridors. The route serves a major metropolitan city (Bellevue) and it provides the opportunity to form indirect connections to downtown Seattle by circumnavigating a major lake (Lake Washington). The study corridor provides strong connections between important job centers (consolidated Boeing operations & three major malls) with multi-family residential concentrations at the midpoint between these locations. Express buses currently run in separated High Occupancy Vehicle express lanes along the interstate highway. Direct access HOV connections are under development in Bellevue, Lynnwood, and Renton. See Figure 4.4.7-*Eastside Study Corridor* for a map.

4.4.1 Land Use Assessment

Corridor-wide land use characteristics and projected growth indicate that this corridor has sufficient land use activity and densities to support high capacity transit in the future. Population in the Eastside Corridor is projected to increase significantly over the next 30 years. The corridor contains seven major activity centers that were evaluated in detail, including: Lynnwood, Canyon Park, Totem Lake, Bellevue, Renton, Tukwila, and SeaTac. All of these activity centers are designated Regional Growth Centers.

In terms of density, Bellevue is one of the most highly concentrated urban centers in the region. The Eastside Corridor also includes Renton CBD, Tukwila CBD, Totem Lake, Lynnwood CBD, SeaTac CBD, and Canyon Park. Connecting SeaTac to Bellevue with higher capacity transit services will be an important regional objective once other factors contribute to increased travel between the two activity centers. Bellevue CBD currently exceeds most of the land use indicators for supporting high capacity transit. Other activity centers currently vary as to how well they meet the established land use indicators. Tukwila CBD and Renton CBD currently contain many of the key land use characteristics necessary to support high capacity transit based on existing land use. All centers except Canyon Park have some level of support for high capacity transit service in the long-range (2020-2030). Figure 4.4.8– *Support For High Capacity Transit Eastside Corridor Activity Centers (2000-2030)* compares these activity centers based on densities (population + employment per acre) and travel demand (trips destined for the center in the a.m. peak). The centers are determined to be more or less supportive of high capacity transit depending on whether they meet or exceed the density and travel demand ranges placed on the chart.

In addition to major activity centers, the Eastside Corridor contains a number of concentrated clusters with higher-density residential activity. These clusters are characterized by areas of medium to high-density residential development in close proximity to retail and office uses. Clusters of residential activity include about 28 percent of total residential population in the corridor. The Eastside Corridor contains clusters with somewhat lower densities than other corridors, but they attract a moderate to significant amount of travel demand. Many of the identified residential clusters are located in close proximity along the corridor. Average densities in residential clusters are forecast to increase from 10 to over 14 people per acre between 2000-2030. Figure 4.4.9– *Support For High Capacity Transit North Corridor Centers and Clusters (2000-2030)* evaluates the level of support for high capacity transit (travel demand and density) in residential clusters as compared to activity centers within the corridor.

(see Figure4.4.4 - Summary of Land Use Characteristics)

4.4.2 Travel Pattern Assessment

Based on origin and destination data there is a high volume of travel between the three sub-areas in this corridor - Snohomish County, East King County, and South King County -- primarily focused on I-405. A majority (70 percent) of the a.m. peak person trips traveling between the sub-areas originate in Snohomish County and South King County heading north and south toward Bellevue and the Crosslake Corridor (currently around 59,500 a.m. person trips). The share of trips headed to Bellevue increases slowly between 2000-2030. There are far fewer trips that travel between the Snohomish County sub-area and the South King County sub-area (between 2,000-4,000). The number of transit (a.m.) person trips between these sub-areas is currently quite small. Roughly 4 times more transit person trips (246 vs. 64) are traveling towards Bellevue (versus away) in the a.m. peak period. Approximately 42 percent of the travel in this corridor is concentrated in the peak travel (a.m. & p.m.) periods. Flows between sub-areas are projected to increase rapidly through 2020 and then more slowly between 2020 and 2030. Over time a greater share of total trips are forecast to remain within the individual sub-areas.

Based on screenline data, although most travel is going to Bellevue in the a.m. peak period, travel away from Bellevue is growing. Currently about 66 percent of all a.m. peak period person trips (SOV, HOV, and transit) are headed toward Bellevue. The percentage of transit travel toward Bellevue during the a.m. peak period is higher at about 86 percent and 70 percent of the carpool/vanpool trips are headed into the city. Over the 30-year planning period, the pattern of directional travel is projected to shift, increasing travel away from Bellevue. In 2030, 62 percent of all person trips are projected to head toward Bellevue at a.m. peak periods and 77 percent of transit trips, however 76 percent of the carpool/vanpool trips continue to head into Bellevue. Over time, a greater share of total trips are forecast to remain within the individual sub-areas, indicating that expanded localized travel may be important to develop once the HCT system has been established.

Total person trips across the selected screenlines are projected to grow 54 percent north of Bellevue and 46 percent south of Bellevue between 2000 and 2030. Transit travel is projected to quadruple in the north and grow by almost 7 times over what it was in the south. During the a.m. peak period, transit trips are projected to increase from 1-2 percent of total trips in 2000 to over 6 percent of total trips in 2030. At the point of highest travel demand (north of Bellevue CBD), northbound a.m. transit person trips per hour per direction increase from 942 to 3,733 between 2000 and 2030. This level of transit travel demand could easily support an investment in higher capacity transit services in the near future.

In terms of travel, SeaTac is the largest travel market in the corridor, followed by Bellevue, Tukwila, Lynnwood, Renton, Totem Lake, and Canyon Park. Both SeaTac and Bellevue currently exceed the primary travel indicator for HCT support. Tukwila, Lynnwood, Renton, and Totem Lake have many of the travel characteristics that support HCT and each of the centers exceed the range in the long-range (2020-2030).

(see Figure 4.4.5 - Summary of Travel Patterns and Transportation)

4.4.3 Transit Technology Assessment

The technology assessment for the Eastside Corridor specifically addressed Enhanced Bus, Bus Rapid Transit, Light Rail, Monorail, Skytrain, Commuter Rail, and DMU. The distinguishing characteristics of each technology that were evaluated included: capacity, operating speeds, reliability, station spacing, headways, system integration, land use impacts, implementation risk, right-of-way requirements and profile needs. Below are initial observations developed from the assessment of the relative appropriateness of these various transit technologies in the Eastside Corridor. For discussion purposes, a number of related technology characteristics are grouped together (e.g., speed, headways, reliability).

Capacity
In the Eastside Corridor, a southbound peak hour transit demand was calculated to be 3,733 passengers per hour per direction (pphpd) in 2030. This level of transit demand reflects close to a 300 percent increase over the current peak hour transit demand in the Eastside Corridor (942 pphpd). Based on this line-haul capacity need, all of the HCT technologies evaluated could generally meet the long-term passenger demand forecasts.

Enhanced Bus capacities could potentially serve 4,800 pphpd, under some fairly aggressive operating assumptions. Bus Rapid Transit was found to meet the long-term line-haul capacity needs, also under aggressive assumptions regarding headways and the use of bus platoons. Further analysis is needed to determine more precisely the potential capacity limitations of bus rapid transit in this corridor related to street capacity in downtown Bellevue, particularly where Crosslake transit investments must align with the proposed BRT system in the Eastside Corridor.

Commuter rail and DMU capacities could meet corridor needs if operated at headways above existing peak service. The other rail technologies (light rail, monorail, and Skytrain) were found to have adequate long-term capacities and also have the potential for line haul capacity expansion beyond the 30-year planning horizon.

Speeds, Headways, Reliability

Desired operating characteristics in the Eastside Corridor include average operating speeds of between 25 and 35 mph, headways of 4 minutes (15 buses/trains per hour) and a high degree of schedule reliability for quick commute service between Bellevue and other areas in the region. Higher speeds may be necessary along the highway in this corridor in order to make up for speed reductions due to non-freeway based access to Bellevue or Renton. All of the technologies evaluated, except Enhanced Bus, could generally meet the desired average operating speeds, headways, and reliability.

As growth occurs, Enhanced Bus services would be expected to become slower because of the increased bus travel times in mixed traffic, especially in and out of the major activity centers such as Bellevue and Renton. Slow average speeds would result in longer headways between buses and reduced schedule reliability.

For BRT to meet the region's projections for transit travel demand in the Eastside Corridor, exclusive BRT lane capacity and more significant exclusivity would be needed to maintain frequencies, speeds, and reliability. This exclusive ROW could be provided by increasing HOV occupancy requirements, introducing a managed lane concept (e.g., HOT lanes), and/or creating bus-only lanes in the corridor. Such efforts are underway in the corridor. The implications of providing greater BRT exclusive (or semi-exclusive) lanes are many, including potential negative impacts on other HOV travel options (carpool, vanpool, local bus) or general-purpose capacity.

Current planned improvements for increased HOV lane capacity and operations in the Eastside Corridor should prove to be adequate in the mid-range future and potentially in the long-term. Potential negative impacts to other HOV travel options (carpool, vanpool, local bus) or general-purpose capacity could result if existing roadways are converted to HOV.

Stations may be spaced less frequently, giving Commuter Rail and DMU the capability to serve the less dense eastside. The fully grade-separated rail technologies (monorail, Skytrain) by definition would have the ability to maintain frequent headways at high average speeds with consistent schedule reliability. Light rail could also offer similar speed and reliability demands if it is operated in primarily exclusive or semi-exclusive right-of-way. However, if significant portions were operated on surface streets in mixed-traffic (as is possible given the technologies profile flexibility) then speeds and reliability could be degraded and fall below desired ranges.

System integration

Transit technologies should be capable of providing convenient and seamless passenger connections and transfers to currently operating regional transit technologies within the corridor. In addition, the technology should have the capability to accommodate access to the system from the full range of travel modes, including pedestrian, bicycle, auto, and transit feeder systems. Convenient transfers will need to be established with the Central

Link light rail (Seattle CBD south to SeaTac). An existing rail line may be preserved for public use that runs precisely along the Eastside Corridor.

Enhanced Bus, BRT, and light rail have a distinct advantage under the established criteria given the other planned transit technologies that will be in operation in the Eastside Corridor and the other corridors it connects to. Bus transit services and facilities already exist throughout communities in the north and south of the corridor. Integrating bus transit technologies into the fabric of transportation services, while not without challenge, should not be a major barrier in this corridor. Aside from some potential capacity constraints, BRT has the ability to operate on downtown streets providing good connections to existing transit services in Bellevue.

For the purpose of this study, Central Link light rail services are assumed to be in operation sometime after 2010 in the Seattle corridor. Completion of the Seattle Monorail Project (Green Line) is also assumed in this study. The design of the proposed Green Line is not complete and the viability of a regional system will require more detailed analysis of engineering specifics, however, direct connections between an Eastside monorail alignment and future SMP monorail investments could pose challenges. Even if the same train and guideway beam technology were used, there still may not be the ability to directly interline with the Green Line or other potential monorail extensions in Seattle. This is not to say that a regional monorail line could not indirectly connect (forced transfers) with future Seattle Monorail lines with separate stations and guideways .

As it operates in Vancouver, Skytrain is automated and fully grade separated. The system could be customized to accommodate the Eastside corridor, but changes would be needed in order to fully integrate it with the existing system. Automated systems could not operate with mixed traffic in lower density areas.

Commuter Rail and DMU could run along the existing abandoned BNSF rail line that is under consideration to be preserved for public use, but there would be challenges in interlining the Eastside system with other systems operating in the other corridors.

Land Use

With the exception of Bellevue, the activity centers in the Eastside Corridor have relatively low densities, but significant growth is planned. SeaTac contains an international airport serving passenger flights as well as cargo shipments throughout the state. Land use development decisions are influenced by high capacity transit services, which can substantially increase passenger volumes to a given area. The financial magnitude of a transit investment and the relative permanence of that investment are often sited as reasons for attracting new land use development.

BRT, light rail, monorail, and Skytrain would be expected to have significantly greater influence on land use than Enhanced Bus services. Commuter rail and DMU could also have a moderate impact in suburban locations slated for future development, but the

BNSF route that would be used does not directly connect with many of the activity centers in the corridor. Given capacity and speed limitations and the limited permanence of stations, Enhanced Bus does less to support the long-range land use plans and projected growth than other HCT technologies.

Monorail and Skytrain could be expected to support the land use objectives within the corridor. Commuter rail is likely to be less accessible to pedestrians due to the need for dedicated rail, but it will moderately contribute to land development and it would serve the low-density locations very effectively.

BRT and light rail have greater flexibility in accessibility. Each could have significant impacts depending on the specific application in the Eastside corridor. One distinguishing characteristic of BRT is the increased difficulty in achieving exclusive bus operations in high-density activity centers such as Bellevue.

Right-of-Way Requirements and Profile Flexibility

Each of the technologies evaluated have different characteristics related to their flexibility in determining right-of-way needs and profile characteristics. Although specific alignments were not evaluated, consideration was given to the range of potential applications for each technology in the Eastside Corridor. The primary considerations for right-of-way and profile needs are at the center of the corridor where it intersects with cross-lake travel and at the south terminus (SeaTac and its airport). In order to balance accessibility and operational efficiency, the selected technology should be flexible enough to provide different levels of segregation and exclusivity, except where existing rights-of-way may be purchased for public use.

Monorail and Skytrain have the least flexible profile of the technologies investigated. Both technologies require grade separated guideways and full grade-separation throughout their entire system. These technologies have been implemented where full grade separation can be justified because of limited space and very high densities. Although the Eastside Corridor includes a few dense urban centers, much of the corridor, outside of Bellevue in particular, is comprised of suburban centers where aerial/grade separation may not be needed and could be served nearly as well at grade, improving accessibility.

Enhanced Bus, BRT, and light rail offer a significantly higher level of profile and ROW flexibility. These technologies can operate in full grade separation, mixed traffic, elevated, or various combinations. This profile and ROW flexibility does not come without cost, both in terms of securing ROW and in terms of system performance if operated with less exclusivity. However, profile flexibility does allow a high capacity transit service to fit a specific area needs and limitations and address the Eastside Corridor's varying land use intensities. Engineering work is needed at an alignment level to make any clear distinctions between technologies regarding ROW needs and profile flexibility.

Commuter Rail and DMU may be able to run on a Burlington Northern line under consideration for public use. The route does not directly interline with many of the activity centers in the corridor, but it runs adjacent to many of the areas targeted for service and land use development. The cost of ROW purchases have been quite high in other areas of the region and a study is underway to evaluate whether the land purchase would be advantageous.

Eastside Corridor Summary

Enhanced Bus (Express Bus Service):
In the long-term, travel demand in the Eastside Corridor may exceed Enhanced Bus capacities leading to the need for higher capacity transit options. Given capacity and speed limitations and the limited permanence of stations it could be difficult to support the long-range land use plans and projected growth in Bellevue, Renton, Totem Lake, Lynnwood, Tukwila, and SeaTac. A higher capacity system may be phased in over a period of time in some parts of this corridor.

Bus Rapid Transit (BRT) :
The WSDOT I-405 Corridor Study has identified Bus Rapid Transit as the technology that will be most appropriate in the near and mid-term (2010-2020). The capacity, speed, and station permanence for BRT would support the long-range land use plans and projected growth in activity centers. BRT may not be able to meet long term travel needs in Bellevue, SeaTac, and Lynnwood without additional HCT services in the other corridors. Existing bus service expansion could provide for near term needs and the existing infrastructure could be converted to a higher capacity system in the future.

Light Rail (LRT)
Light Rail capacity meets and exceeds the needs for the Eastside corridor in the near term and long-term. The higher capacity, speed, flexibility in frequency, and the permanence of light rail stations fully support the long-range land use plans and projected growth in Bellevue and other activity centers in the corridor. Additional investments could support travel demand beyond the horizon year with higher frequencies. This technology would provide a strong connection between each of the corridors and it has the potential to draw from residential clusters between these larger activity centers.

Monorail:
Monorail capacity exceeds the needs for the Eastside corridor in the near term and long-term. The higher capacity, speed, and the permanence of Monorail stations support the long-range land use plans and projected growth of the activity centers in the corridor. Some characteristics of Monorail could present challenges when integrated into the systems developed along other corridors. More analysis is needed to fully understand the ability to have direct and/or indirect connections with other technologies.

Skytrain
Skytrain meets the needs for the Eastside corridor in the long range as it shares many characteristics with Light Rail and Monorail. Skytrain can be automated and is fully grade separated. The system could be customized to accommodate the Eastside corridor, but changes would be needed in order to fully integrate it with the systems developed along other corridors. At-grade facilities may be needed for long distant travel in the low-density areas between Bellevue and Lynnwood or SeaTac. It would have the ability to maintain frequent headways at high average speeds with consistent schedule reliability. Skytrain would involve the addition of an entirely new transit technology to the regional transit system and would require separate stations and guideways that are likely to pose multiple challenges for integration with existing transit services.

Commuter Rail (Sounder, Sound Transit)
Commuter rail operates on existing railroad tracks, aptly filling a regional inter-city role rather than the role of a regional connector along corridors with many intermediate travel needs. There is a potential right-of-way corridor (BNSF) connecting many eastside communities. Given the character of the right-of-way, the communities served, and the travel demands, a DMU or other rail technology may be more appropriate than commuter rail in this corridor.

Diesel Multiple Unit (DMU):
DMU cars could run on existing tracks (BNSF) on the eastside. Although the speed and capacity support the needs of the Eastside Corridor, it is likely that the long distances between stations and the less flexible ROW requirements could limit the ability to support the long-range land use plans and projected growth in Bellevue and Renton.

(see Figure 4.4.6 - Summary of Technology Assessment)

FIGURE 4.4.4

Summary of Land Use and Demographics

Eastside Corridor

Selected major Activity Centers evaluated in this corridor: SeaTac CBD, Tukwila CBD, Renton CBD, Bellevue CBD, Totem Lake, Bothell (Canyon Park), and Lynnwood CBD

Key Considerations	Current Conditions	Mid-Range (2020)	Long-Range (2030)
Primary Indicator			
Population and Employment in Activity Centers Indicators: 30-45 jobs and population per acre >45 jobs and population per acre	**Bellevue CBD** (34,313 jobs and population @ 80 per acre) is the only activity center to exceed the density range. *Renton* (18,972 @ 34 per acre) falls within the range and Tukwila (22,771 @ 27 per acre) comes close. The other Centers are below the density range.	By 2020, **Renton** (26,358 @ 48 per acre) exceeds the range, *Tukwila* (31,992 @ 38 per acre) is forecast to be at the high end of the range, and Lynnwood (22,504 @ 25 per acre) is close to meeting the primary indicator.	By 2030, **Tukwila** (29,331 @ 45) exceeds the range and *Lynnwood* (28,016 @ 31.3 per acre) falls within the range and Totem Lake (37,821 @ 26 per acre) is close to falling within the range. The other centers do not meet the primary indicator.
Secondary Indicators			
Residential Clusters	**Average population density in Clusters is 9.6 people per acre.** About one-quarter (28%) of total corridor population is located within Residential Clusters.	**Average population density in Clusters is projected to increase to 12.2 people per acre in 2020.**	**Average population density in Clusters is projected to increase to 13.6 people per acre.**
Ratio of jobs to households in Activity Centers **Residential base in Activity Centers**	Bellevue (14), Bothell (6), Lynnwood (9), Totem Lake (3), and SeaTac (2) have fewer than 15 jobs per household. Renton exceeds the threshold slightly at 17 jobs per household. Tukwila is job rich with well over 1000 jobs per household. SeaTac, Totem Lake, and Bellevue CBD have 4,300, 4,000 and 2,300 households respectively. Lynnwood, Renton, Bothell have roughly 1300 households. Tukwila has virtually no households in the Center.	By 2020, jobs per households drops to 15 in Renton CBD. Bellevue's ratio drops to 6 and Lynnwood's increases to10. Tukwila does not add households and ratio remains very high. By 2020, Totem Lake, SeaTac, and Bellevue exceed 5,000 households. Renton, Bothell, and Lynnwood have fewer than 2000. Tukwila is not projected to have much households growth through 2020.	All Centers except Tukwila have jobs to household ratios of less than 15. Lynnwood, Renton, and Bothell have roughly 2,000 households in the Center by 2030. Tukwila remains primarily a employment and commercial center.
Roadway Network in Corridor **Block size in Activity Centers**	Most neighborhoods in the corridor contain generally sparse street networks, less than 1 intersection per acre. Bellevue and other eastside neighborhood generally have more intersections per acre. **Renton has average blocks of 8 acres.** Tukwila, SeaTac, and Lynnwood have large average block sizes of 20-30 acres. Bellevue block size is over 10 acres on average. Block sizes in Totem Lake average over 70 acres.	Intersection density and roadway network cannot be forecast for future years but as the corridor urbanizes and grows it can be expected that eastside networks will improve and intersection density will increase. Based on plans to connect roads and break-up super blocks, it can be expected that there would be relatively **small block sizes and denser pedestrian networks in Renton and Bellevue.**	As the corridor urbanizes and grows it can be expected that networks will improve and intersection density will increase. Based on plans it could be expected that **Lynnwood, Totem Lake, and SeaTac would have significantly improved network** of pedestrian connections and smaller average blocks by 2030.
Parking Costs/Supply in Activity Centers	**Bellevue CBD has some short-term and long-term parking. SeaTac has parking charges related to airport.** Bellevue has less than 1 stall per employee. Others have a significant free parking supply.	Based on increasing density, parking policies and increasing land values it would be expected that **Renton, SeaTac, and Lynnwood would institute parking charges** during this period. --	It would be expected that **Tukwila and Totem Lake would institute parking charges** during this period. --

FIGURE 4.4.5

Summary of Travel Patterns and Transportation

Eastside Corridor

Selected major **Activity Centers evaluated in this corridor:** SeaTac CBD, Tukwila CBD, Renton CBD, Bellevue CBD, Totem Lake, Bothell (Canyon Park), and Lynnwood CBD

Criteria	Current Conditions	Mid-Range (2020)	Long-Range (2030)
Primary Indicator			
Activity Centers: Major Destinations 20,000-30,000 a.m. peak period person trips destined for activity center. >30,000 a.m. peak period person trips destined for activity center.	**SeaTac** (35,048) and **Bellevue** (32,969) exceed the primary indicator range. *Tukwila* (23,238) and *Lynnwood* (20,911) fall within the range. Renton (19,657) falls very close to the range.	By 2020, **Tukwila** (35,095), **Renton** (32,492), and **Lynnwood** (32,522) exceed the range and *Totem Lake* (24,831) falls within the range.	By 2030, **all of the centers (with the exception of Canyon Park)** continue to attract a high number of trips, all of the other centers exceed the range with the exception of Totem Lake.
Secondary Indicators			
Growth in a.m. peak person trips between subareas **Heading North:** South King County to East King County	5.8% of am peak person trips (20,700) originating in South King County are destined for East King County. **0.7% of these trips (140) are transit person trips.**	By 2020 … 6.7% of am peak person trips (30,600) originating in South King County are destined for East King County. **1.6% of these trips (380) are transit person trips.**	By 2030… 6.1% of am peak person trips (30,300) originating in South King County are destined for East King County. **1.9% of these trips (570) are transit person trips.**
East King County to Snohomish County.	3.6% of am peak period trips (11,900) originating in East King County are destined for Snohomish County. **0.1% of these trips (8) are transit person trips.**	3.8% of am peak period trips (16,800) originating in East King County are destined for Snohomish County. **0.1% of these trips (20) are transit person trips.**	4% of am peak period trips (19,200) originating in East King County are destined for Snohomish County. **0.1% of these trips (20) are transit person trips.**
Heading South: Snohomish County to East King County	12% of am peak period trips (38,700) originating in Snohomish County are destined for East King County. **0.3% of these trips (110) are transit person trips.**	13.7% of am peak period trips (68,000) originating in Snohomish County are destined for East King County. **0.6% of these trips (440) are transit person trips.**	13.6% of am peak period trips (78,000) originating in Snohomish County are destined for East King County. **0.8% of these trips (600) are transit person trips.**
East King County to South King County.	4.4% of am peak period trips (14,300) originating in East King County are destined for South King County. **0.4% of these trips (55) are transit person trips.**	5.2% of am peak period trips (22,700) originating in East King County are destined for South King County. **1.1% of these trips (240) are transit person trips.**	5.2% of am peak period trips (24,900) originating in East King County are destined for South King County. **1.6% of these trips (410) are transit person trips.**
Travel across screenlines (daily and peak periods) #37 north/south between Bellevue and Totem Lake ***Transit person trips per hour per direction (pphpd) reflects highest demand within corridor.***	Total daily person trips across screenline is 455,700. 42% of daily person trips are made during peak period. 2% of AM person trips are made by public transit. ***Southbound a.m. transit person trips per hour per direction (pphpd) is 942***	In 2020… 43% total trip growth rate. Total daily person trips across screenline is 653,400. 44% of daily person trips are made during peak period. 5% of AM person trips are made by public transit. ***Southbound a.m. transit person trips per hour per direction (pphpd) is 2,501***	In 2030… 143% total trip growth rate. Total daily person trips across screenline is 697,900. 44% of daily person trips are made during peak period. 6% of AM person trips are made by public transit. ***Southbound a.m. transit person trips per hour per direction (pphpd) is 3,733***
#30 north/south between Renton and Bellevue	Total daily person trips across screenline is 75,055. 41% of daily person trips are made during peak period. 1% of AM person trips are made by public transit. AM hour person trips per hour is 20,900. AM Peak hour transit person trips per hour is 320.	36% total trip growth rate. Total daily person trips across screenline is 486,500. 42% of daily person trips are made during peak period. 3% of AM person trips are made by public transit. AM hour person trips per hour is 28,500. AM Peak hour transit person trips per hour is 750.	137% total trip growth rate. Total daily person trips across screenline is 528,800. 43% of daily person trips are made during peak period. 7% of AM person trips are made by public transit. AM hour person trips per hour is 31,600. AM Peak hour transit person trips per hour is 2,200.
Park-and-Ride facilities Future year numbers reflected projected demand based on WSDOT analysis conducted in 2001.	9,000 P&R stalls in South King County subarea 8,200 P&R stalls in East King County subarea 6,600 P&R stalls in Snohomish County subarea	14,000 P&R stalls in South King County subarea 12,500 P&R stalls in East King County subarea 15,700 P&R stalls in Snohomish County subarea	15,600 P&R stalls in South King County subarea 14,900 P&R stalls in East King County subarea 19,100 P&R stalls in Snohomish County subarea

FIGURE 4.4.6

Summary of Technology Assessment

Eastside Corridor

Technology Characteristics	*Enhanced Bus*	*Bus Rapid Transit*	*Light Rail*	*Monorail*	*Skytrain*	*Diesel Mobile Unit*	*Commuter Rail*
Capacity Seated Seated and standing	 43 - 40' bus 80 - 40' bus	 65 - 60' bus 90 - 60' bus	 74 per car 148 per car	 125 per car	168 (2 car, married pair) 512 (2 car, married pair)	 96 per car N/A	 134 per car 255 per car
Projected Transit Demand 942 (2000) – 3,730 (2030) transit person trips per hour per direction (pphpd)	1,290 – 2,400 2 buses w/4min headway 2,580-4,800 – 4 buses w/4min headway	1,950-2,700 w/4min headway – 2 bus platoon 3,900-5,400 w/4min headway – 4 bus platoon	2,220-4,440 w/4min headway – 2 cars 4,440-8,880 w/4min headway – 4 cars	3,750 w/4min headway – 2 cars 7,500 w/4min headway – 4 cars	1,260-3,840 w/4 min headways – 2 cars 2,520-7,680 w/4 min headways – 4 cars	2,880 w/4min headway – 2 cars 8,640 w/4min headway – 6 cars	1,072 - 2,040 w/15 min headway – 2 cars 2,144 - 4,080 w/15 min headway – 4 cars
Stations Spacing With the exception of Bellevue, the Eastside Corridor contains many areas with low-density development, needing more widely spaced stops.	Small stations can serve the lower densities within the corridor, but long distance travel and tightly spaced stations in dense locations could reduce schedule reliability.	Large stations or smaller stops serve varying densities.	Large stations or smaller stops can serve varying densities. Stations can be tightly or widely spaced.	Large elevated stations. Stations can be tightly or widely spaced.	Large elevated stations. Stations can be tightly or widely spaced.	Small stations can serve the lower densities within the corridor, but stations are limited to only a few locations as DMU uses existing rail lines.	Large stations with widely spaced stops can serve the lower densities within the corridor, but stations are limited to only a few locations on existing rail lines.
System Integration Needs to work with feeder bus, shuttles, park and rides, and address congested locations at SeaTac airport and downtown Bellevue.	Large numbers of buses could add to congestion on limited freeway connections in SeaTac and Bellevue.	Selected by I-405 corridor analysis as preferred option.	Profile flexibility can address many system integration needs.	Difficult to integrate in some areas due to limited profile flexibility.	Introduces another new technology.	Stations can be located near centers on existing rail, but other service connections may be challenging.	Stations can be located near centers on existing rail, but other service connections may be challenging.
Land Use Desire to increase densities in Bellevue and other major activity centers.	Enhanced Bus has modest influence on land use.	BRT has some influence on land use, supporting plans for outlying centers.	Strong support for higher density development.	Strong support for higher density development.	Strong support for higher density development.	DMU has some influence on land use, partial support for centers.	Supports moderate density development.

Eastside Study Corridor

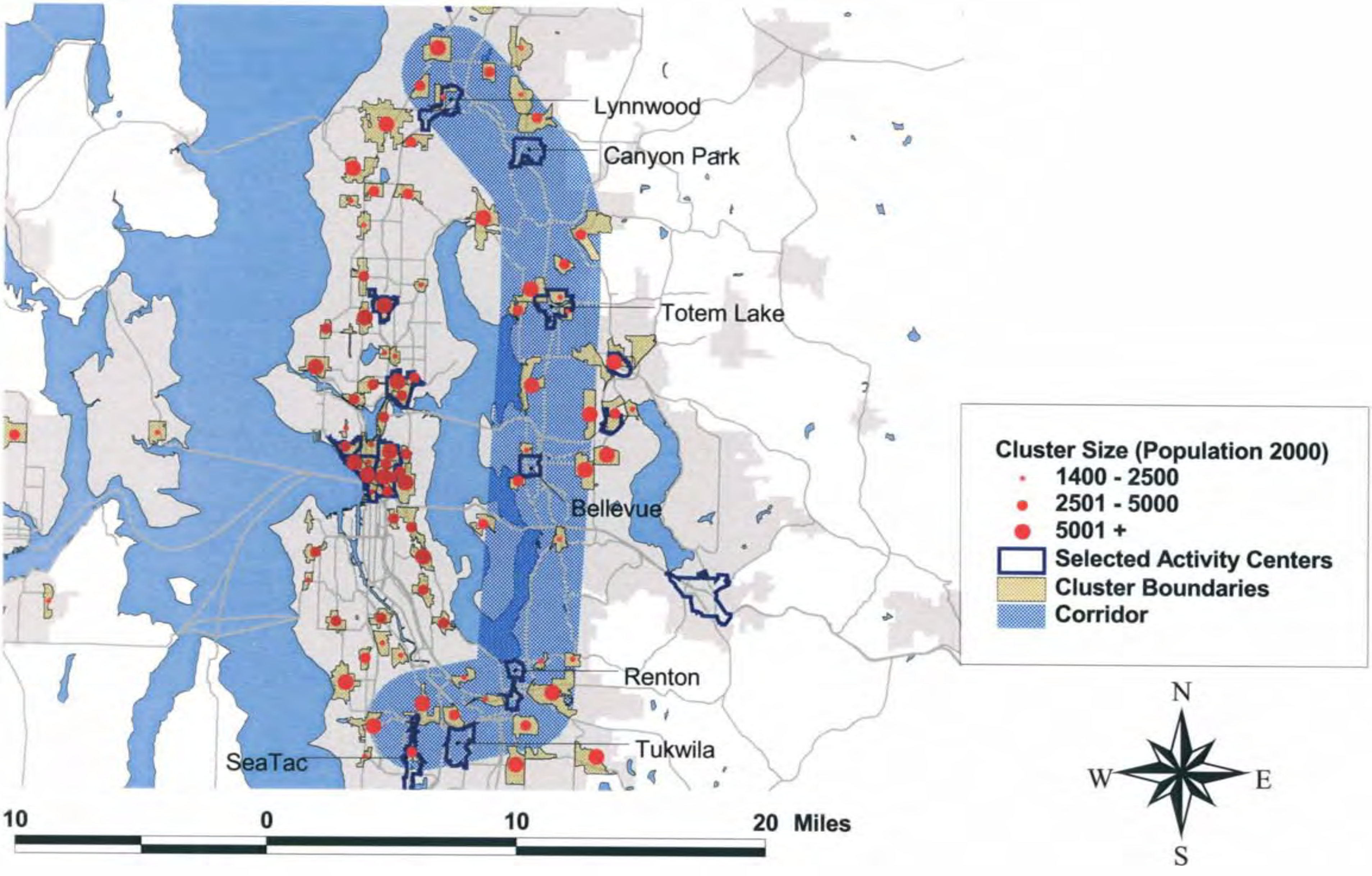
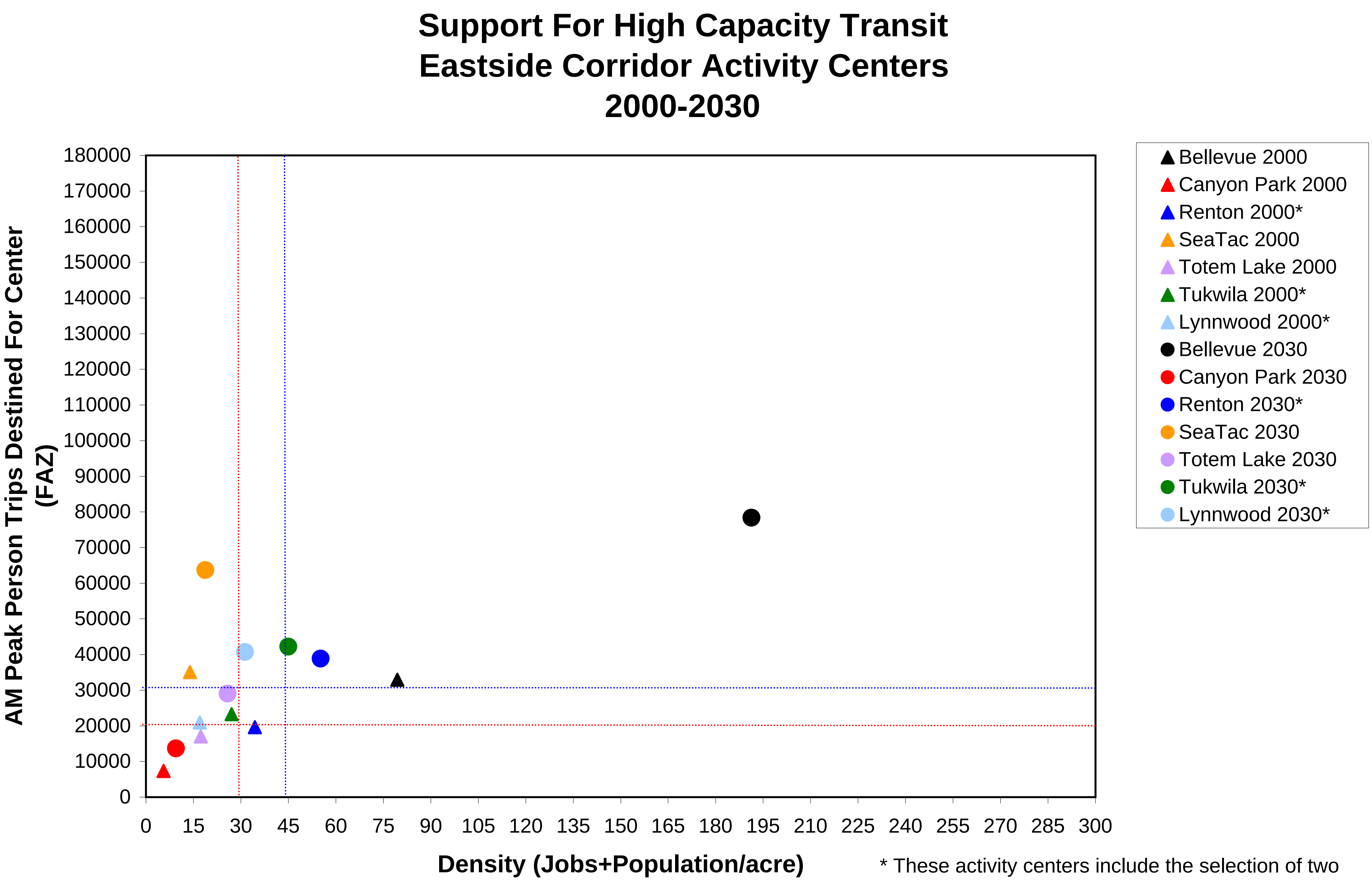
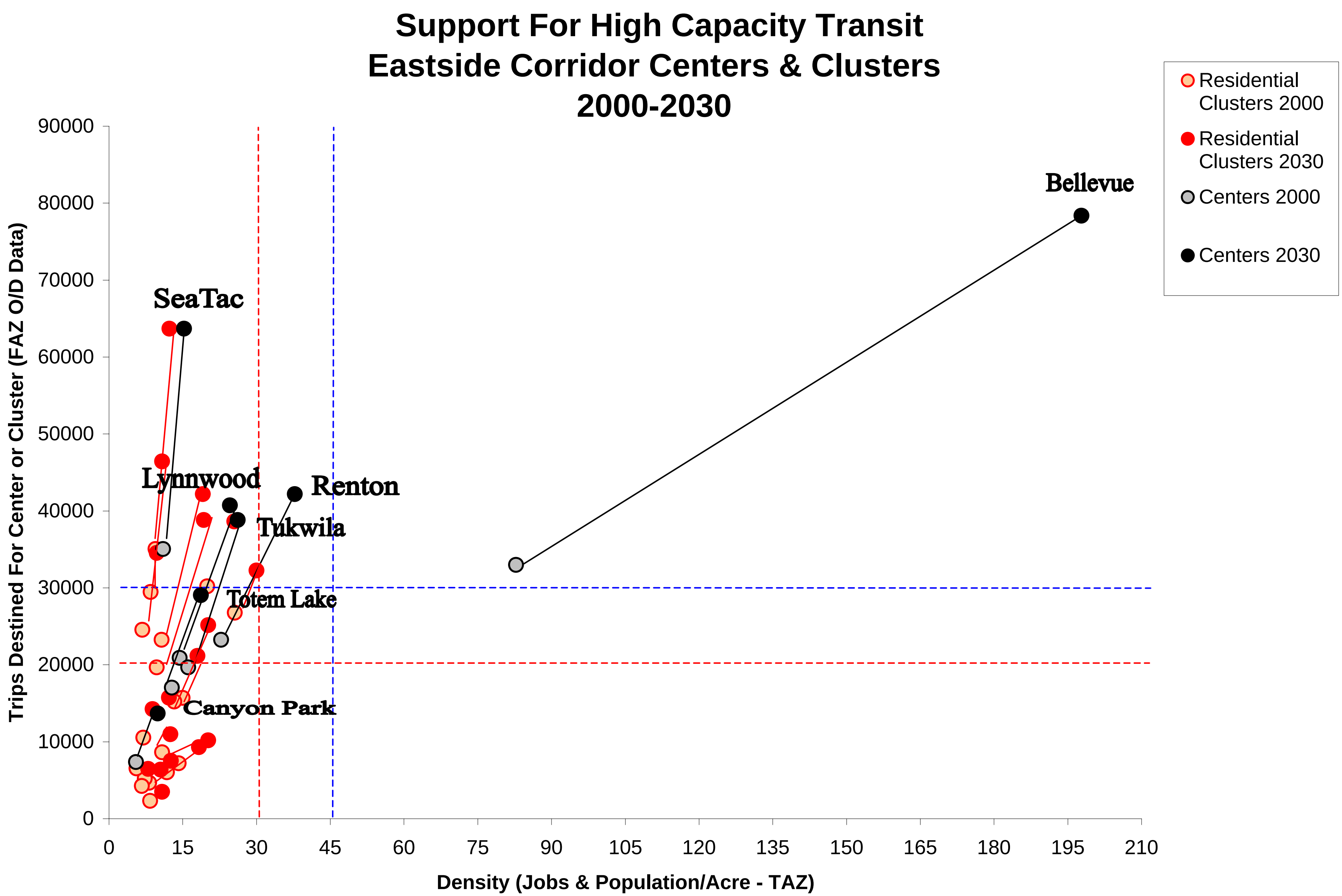


FIGURE 4.4.8



* These activity centers include the selection of two Forecast Analysis Zones for am peak travel data.

FIGURE 4.4.9


Support For High Capacity Transit
Eastside Corridor Centers & Clusters
2000-2030
Residential Clusters 2000
Residential Clusters 2030
Centers 2000
Centers 2030
Bellevue
SeaTac
Lynnwood
Renton
Tukwila
Totem Lake
Canyon Park
Trips Destined For Center or Cluster (FAZ O/D Data)
Density (Jobs & Population/Acre - TAZ)
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
0
15
30
45
60
75
90
105
120
135
150
165
180
195
210

5.0 SYSTEM-WIDE SUMMARY

Based on existing and forecast land use and travel characteristics, all of the study corridors would be capable of supporting some form of high capacity transit services within the 30-year plan horizon. Some corridor segments studied could support immediate implementation of frequent, all-day, bi-directional high capacity transit service. Other corridor segments would not fully support high capacity transit at this time but are projected to have significantly greater transit travel and more transit supportive land use development patterns in the long term. A logical implementation strategy would be to adopt a phased approach to completing a high capacity transit system region-wide.

Considerations for System-wide Implementation

This section summarizes initial Puget Sound Regional Council staff observations regarding a potential system-wide implementation strategy of high capacity transit services in the region. These observations should be considered preliminary based on the corridor-level analysis that was conducted for this study. Actual phasing recommendations will require further study, including analysis of alternative alignments, more detailed travel pattern evaluation, and a more specific technology assessment.

The system-wide assessment is based on the land use and travel assessment conducted in *Section 4.0* for each of the study corridors. The system-wide assessment attempts to compare information about each corridor and use it to determine a potential phasing schedule of high capacity transit services over a thirty-year period. Much of the system-wide assessment is focused on a comparative analysis of the 23 selected major activity centers and their ability to support high capacity transit – in the near term (2000-2010), mid-range (2010-2020) and long-term (2020-2030). Primary data points considered include the land use characteristics in the activity centers and the forecast of travel destined for the centers. Origin/destination flows and screenline data were also considered.

Below is a general assessment of the relative ability of each corridor segment to support implementation of high capacity transit services under current conditions, mid-range (2010-2020), and long-range (2020-2030). Figure 5.2 – *Potential System-wide Integration of High Capacity Transit (2000 – 2030)* provides a summary assessment of specific activity centers and corridor segments. The assessment on the matrix generally displays relative support for high capacity transit based on existing and forecast land use and travel characteristics. Figures 5.1 through 5.1.5 – *Support For High Capacity Transit Activity Centers & Clusters By Corridor 2000-2030*– display information on two key data points for each corridor in 2000, 2010, 2020, and 2030. The two data points on these tables are – job and population density within activity centers and clusters and a.m. person trips destined for activity centers and clusters. These measures were considered along with other land use and travel forecast to make preliminary observations regarding potential integration of high capacity transit into segments within each corridor.

The relative assessments (i.e., Strong support, Moderate support, and Little support) were based on the corridor assessment materials in *Section 4.0* of the workbook. *"Strong support"* for high capacity transit is defined as centers or segments meeting most or many of the key land use and travel criteria identified in *Section 4.0*. *"Moderate support"* is defined as those meeting some of the key criteria but not most or all. "*Little Support*" is defined as centers and/or segments that do not meet key criteria. Also, attached at the end of this section are maps illustrating potential phasing possibilities for each general time period – Figure 5.2.1 – *Current Conditions (2000),* Figure 5.2.2 – *Mid-range (2020),* and Figure 5.2.3 – *Long-range (2030).*

Near-term Implementation (2000-2010)

Seattle CBD to Bellevue CBD
Based on the corridor analysis conducted, the connection between downtown Seattle and Bellevue CBD appears to justify near-term implementation of high capacity transit. These activity centers represent two of the most significant transit markets in the region and both are projected to grow considerably over the next 10-15 years. Seattle CBD is by far the largest transit attraction in the region and it draws travel from throughout east King County. Bellevue CBD is projected to contain a significant number of jobs and households at densities that could easily support high capacity transit service in the near future. A high capacity transit connection to Bellevue would also serve as a major transfer point for the large and growing eastside travel market. Although the North Corridor could have higher line capacity demands than the Crosslake Corridor, the importance of establishing a direct connection from the eastside to downtown Seattle would justify the Seattle to Bellevue connection as a high capacity transit priority.

Mid-Range Implementation (2010-2020)

Northgate to Lynnwood CBD
Extending the Central Link high capacity transit service to the north is well supported in terms of travel demand. The connection between Northgate and Lynnwood CBD should be a priority for high capacity transit implementation in this corridor, given the land use activity and travel demand projected in that segment. This link has the highest total transit demand and the highest percentage of transit trips of all the study corridor segments. Although transit demand is high between these centers, neither Lynnwood nor Northgate are significant high capacity transit markets in themselves. Much of the travel within this segment is ultimately headed for downtown Seattle. Land use characteristics are forecasted to improve and travel demand between Northgate and Lynnwood is expected to increase in the near term as both locations are targeted for intensive development between now and 2020.

SeaTac CBD to Tacoma CBD via Federal Way CBD

The connection between SeaTac and Tacoma CBD could support high capacity transit implementation given the travel demand projected in that segment sometime between 2010-2020. Some of the high capacity transit system needs are already addressed along this corridor with existing commuter rail service between Seattle and Tacoma. However, it will be important to more directly serve the cultural, educational, recreational, and trade-oriented attractions located in the Tacoma CBD as well as the travel demands to Sea-Tac Airport. Travel demand is expected to increase south of the airport with the forecasted and planned increases in job and household density in Tacoma CBD and Federal Way CBD.

Bellevue CBD to Overlake

A high capacity transit extension to Overlake offers an opportunity to serve a number of large residential clusters as well as additional job centers. A connection to Overlake is supported by travel demands and land use activity, with over 25,000 jobs and households at relatively high densities by 2020. In addition, because of it's location, Overlake could function as a more appropriate terminus location on the eastside (than Bellevue CBD) for a high capacity system.

Totem Lake to SeaTac via Bellevue and Renton

A high number of trips are gathered up just north and south of Bellevue between Renton and Totem Lake. The Eastside Corridor is made up of a mixture of locations ranging from high-density markets with more supportive land use characteristics such as Bellevue CBD to lower-density retail environments such as Lynnwood and Tukwila. Residential clusters are somewhat less concentrated throughout this corridor. The connection between downtown Bellevue and Renton CBD to the south and a connection between Bellevue and Totem Lake to the north would support high capacity transit implementation in this corridor between 2010-2020. A high capacity transit connection between Renton and SeaTac via Tukwila could also be supported in this time period to connect Boeing employment in Renton, Sea-Tac Airport, and Southcenter Mall in Tukwila.

Long-Range Implementation (2020-2030)

Lynnwood CBD to Everett CBD

Extensions to Everett could be supported in the long-term. The corridor segment contains few residential concentrations and, despite the high number of jobs in Paine Field, job and household densities are currently fairly low. Travel is expected to increase as Everett experiences growth and invests in housing development and regional attractions such as its special events center. The segment between Lynnwood and Everett would more fully support high capacity transit service by 2020-2030. Commuter rail service currently provides a high capacity transit connection between Seattle and Everett but does not serve Lynnwood or Paine Field.

Tacoma CBD to Dupont

Extensions beyond Tacoma CBD are targeted for commuter rail service along an existing rail line. A station along this line would not be well supported in Dupont until more development occurs by 2020. By 2030 a commuter rail station could support high capacity transit based on travel demand and land use forecasts. A commuter rail connection to Dupont could be supported earlier but would depend more heavily on significant park-and-ride access.

Bellevue to Redmond

Redmond CBD is expected to grow significantly over the 30-year planning horizon – containing over 14,000 jobs and households at over 30 jobs and households per acre. The growth of Redmond CBD as well as the considerable growth expected north, south, and east of Redmond would support high capacity transit services in the long-range. A Redmond terminus with park-and-ride access would significantly expand the high capacity transit coverage in the Crosslake Corridor as well as the Eastside Corridor.

Bellevue to Issaquah

The land use characteristics and travel demand are less strong in Issaquah and potential high capacity transit extensions could rely on the use of large park-and-ride capacity in order to gather auto trips and transit transfers from the greater Lake Sammamish plateau area. Forecasts indicate that there will be some intensive growth and plans do call for focused development, such as Issaquah Highlands. Issaquah could support a more fully developed high capacity transit system at some point during 2020-2030.

Lynnwood to Totem Lake via Bothell (Canyon Park)

Land use and travel demand forecasts would support a fully developed high capacity system extending to the north in the Eastside Corridor by 2020-2030. Lynnwood would contain over 25,000 jobs and households at nearly 30 jobs and households per acre and geographic areas to the north and east are also forecast to grow significantly in this time frame.

FIGURE 5.1

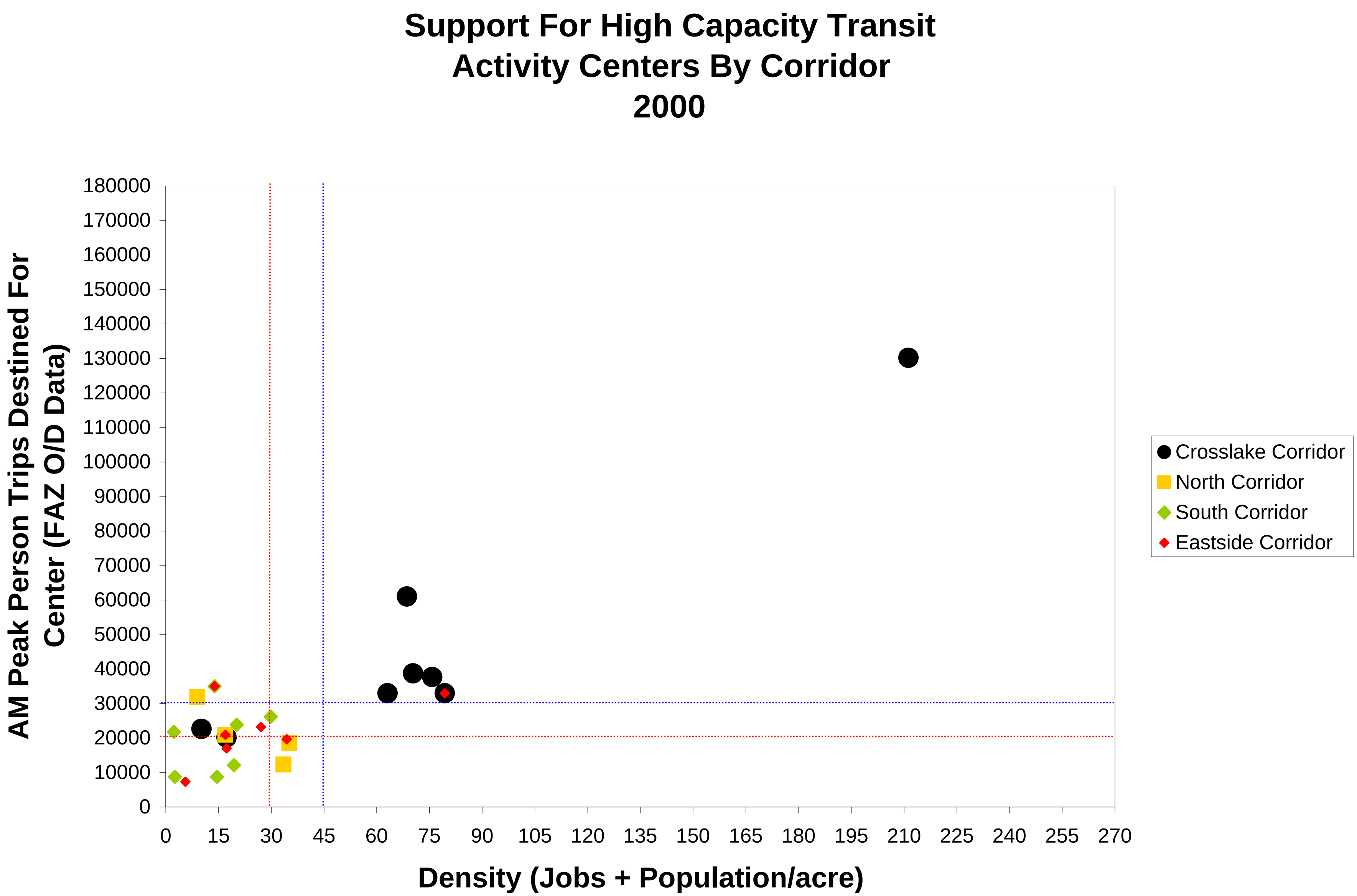

Support For High Capacity Transit
Activity Centers By Corridor
2000
AM Peak Person Trips Destined For Center (FAZ O/D Data)
180000
170000
160000
150000
140000
130000
120000
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
0 15 30 45 60 75 90 105 120 135 150 165 180 195 210 225 240 255 270
Density (Jobs + Population/acre)
Crosslake Corridor
North Corridor
South Corridor
Eastside Corridor

FIGURE 5.1.1

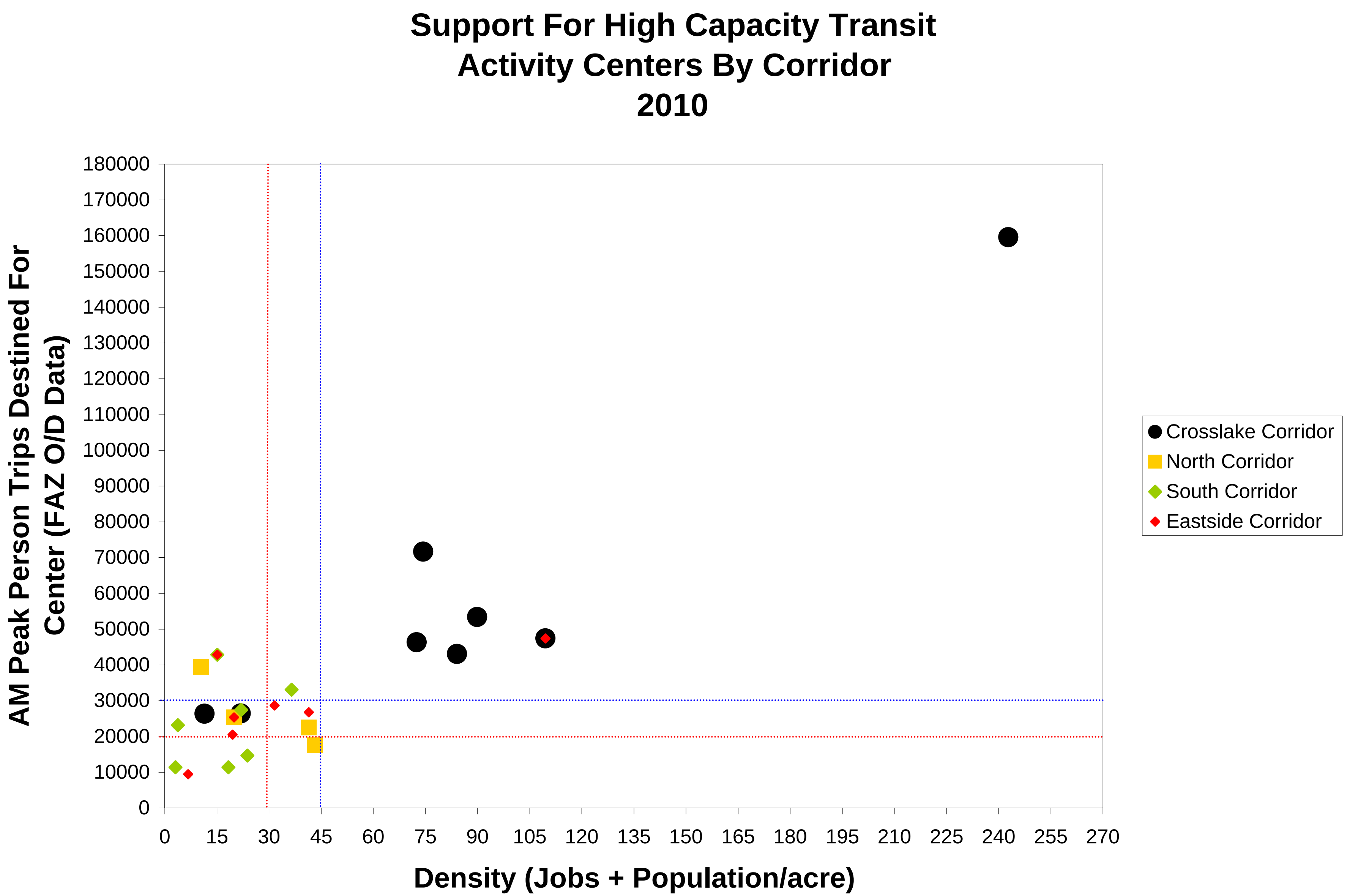
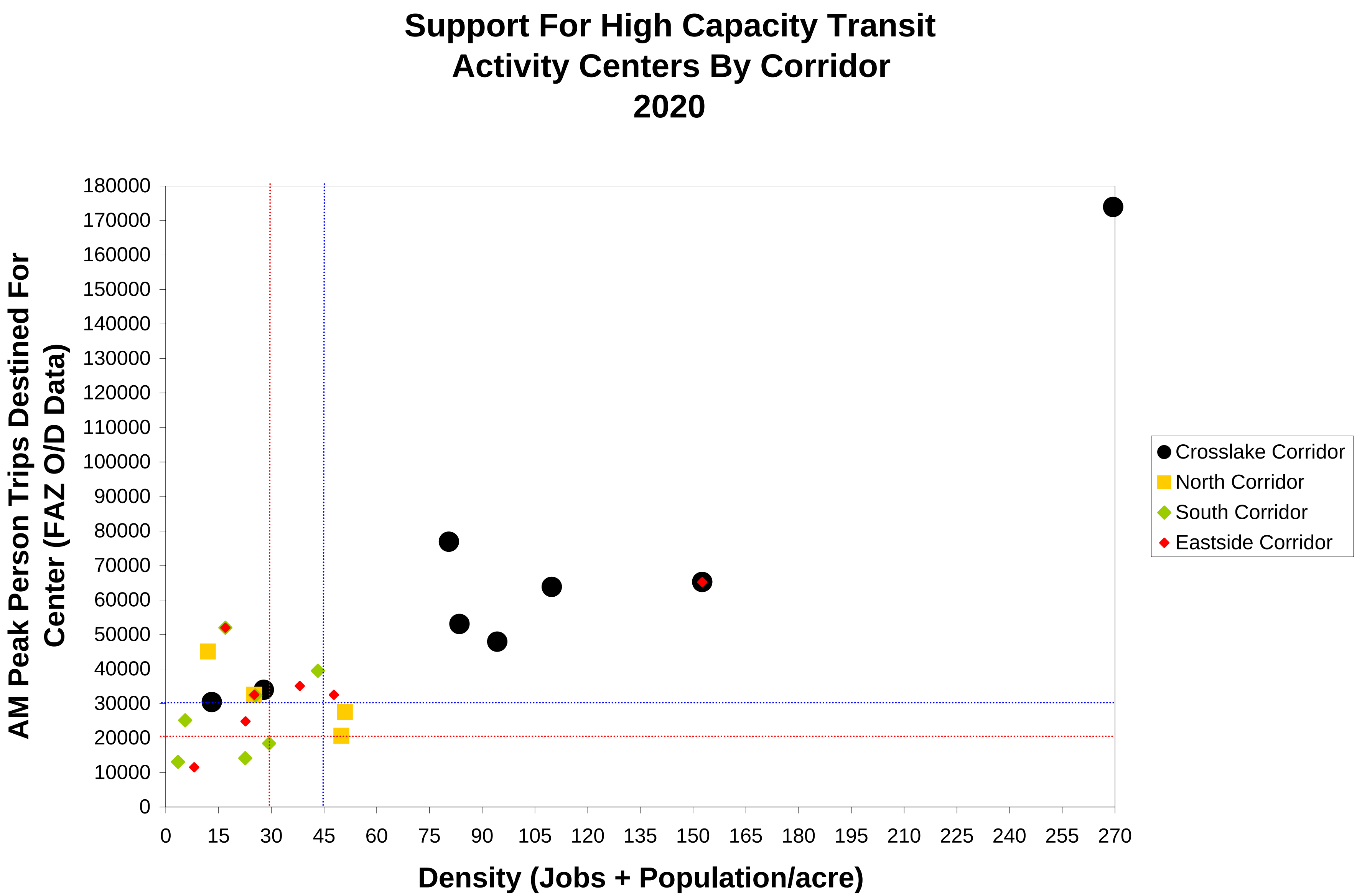
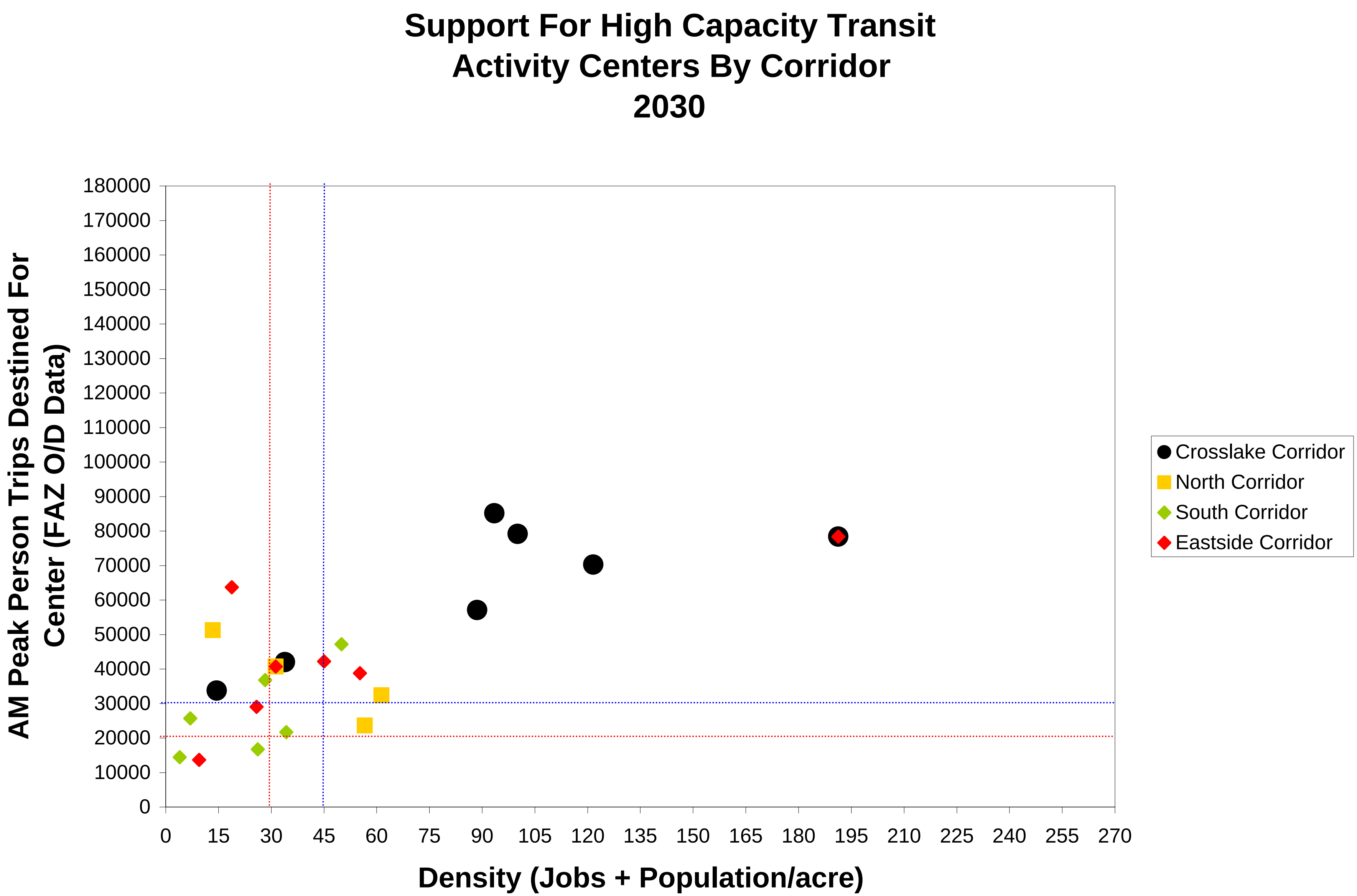

Support For High Capacity Transit
Activity Centers By Corridor
2010
AM Peak Person Trips Destined For Center (FAZ O/D Data)
180000
170000
160000
150000
140000
130000
120000
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
0
15
30
45
60
75
90
105
120
135
150
165
180
195
210
225
240
255
270
Density (Jobs + Population/acre)
Crosslake Corridor
North Corridor
South Corridor
Eastside Corridor

FIGURE 5.1.2



Support For High Capacity Transit
Activity Centers By Corridor
2020
AM Peak Person Trips Destined For Center (FAZ O/D Data)
180000
170000
160000
150000
140000
130000
120000
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
0
15
30
45
60
75
90
105
120
135
150
165
180
195
210
225
240
255
270
Density (Jobs + Population/acre)
Crosslake Corridor
North Corridor
South Corridor
Eastside Corridor

FIGURE 5.1.3



Support For High Capacity Transit
Activity Centers By Corridor
2030
AM Peak Person Trips Destined For Center (FAZ O/D Data)
180000
170000
160000
150000
140000
130000
120000
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
0
15
30
45
60
75
90
105
120
135
150
165
180
195
210
225
240
255
270
Density (Jobs + Population/acre)
Crosslake Corridor
North Corridor
South Corridor
Eastside Corridor

FIGURE 5.1.4

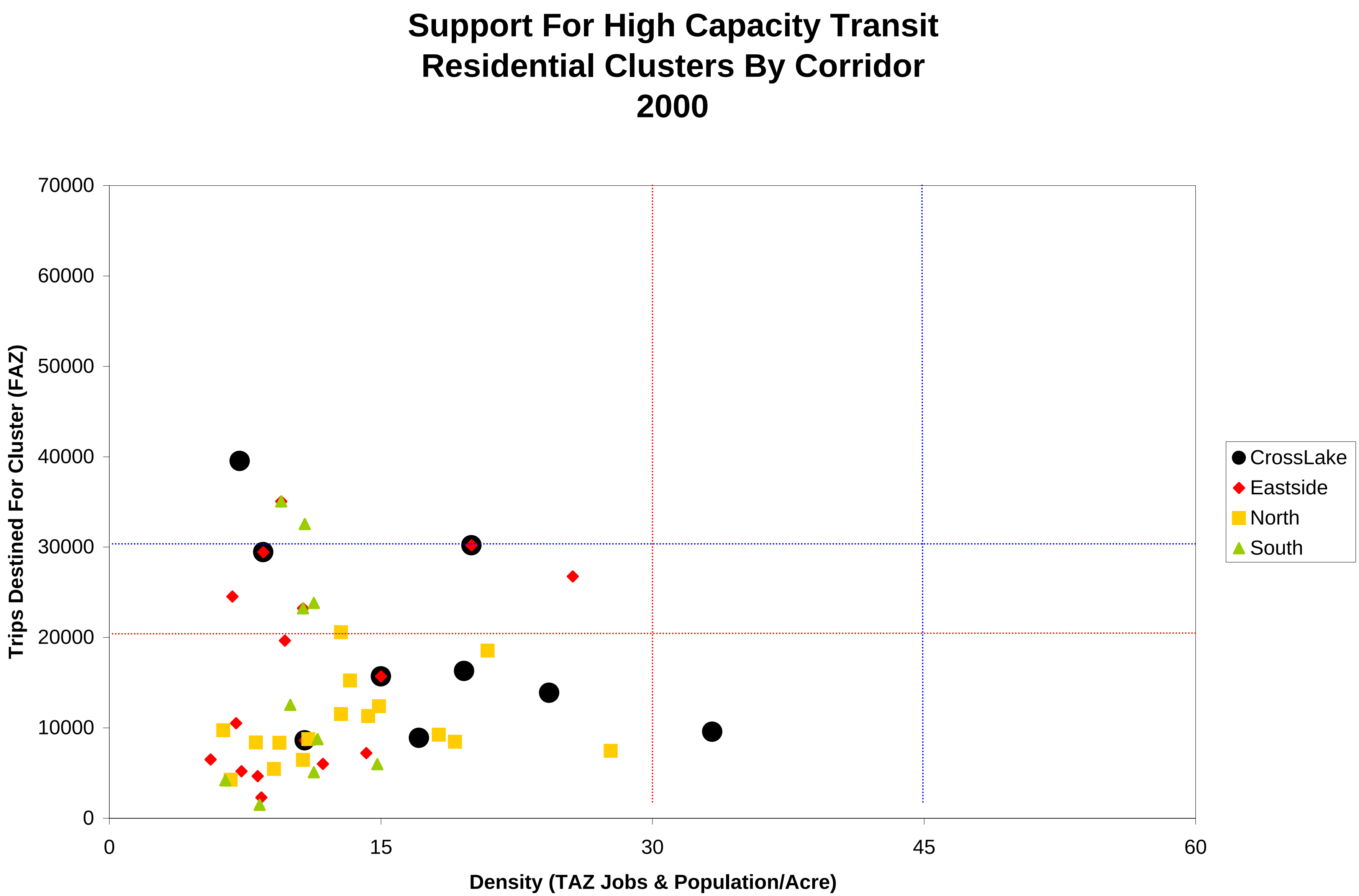
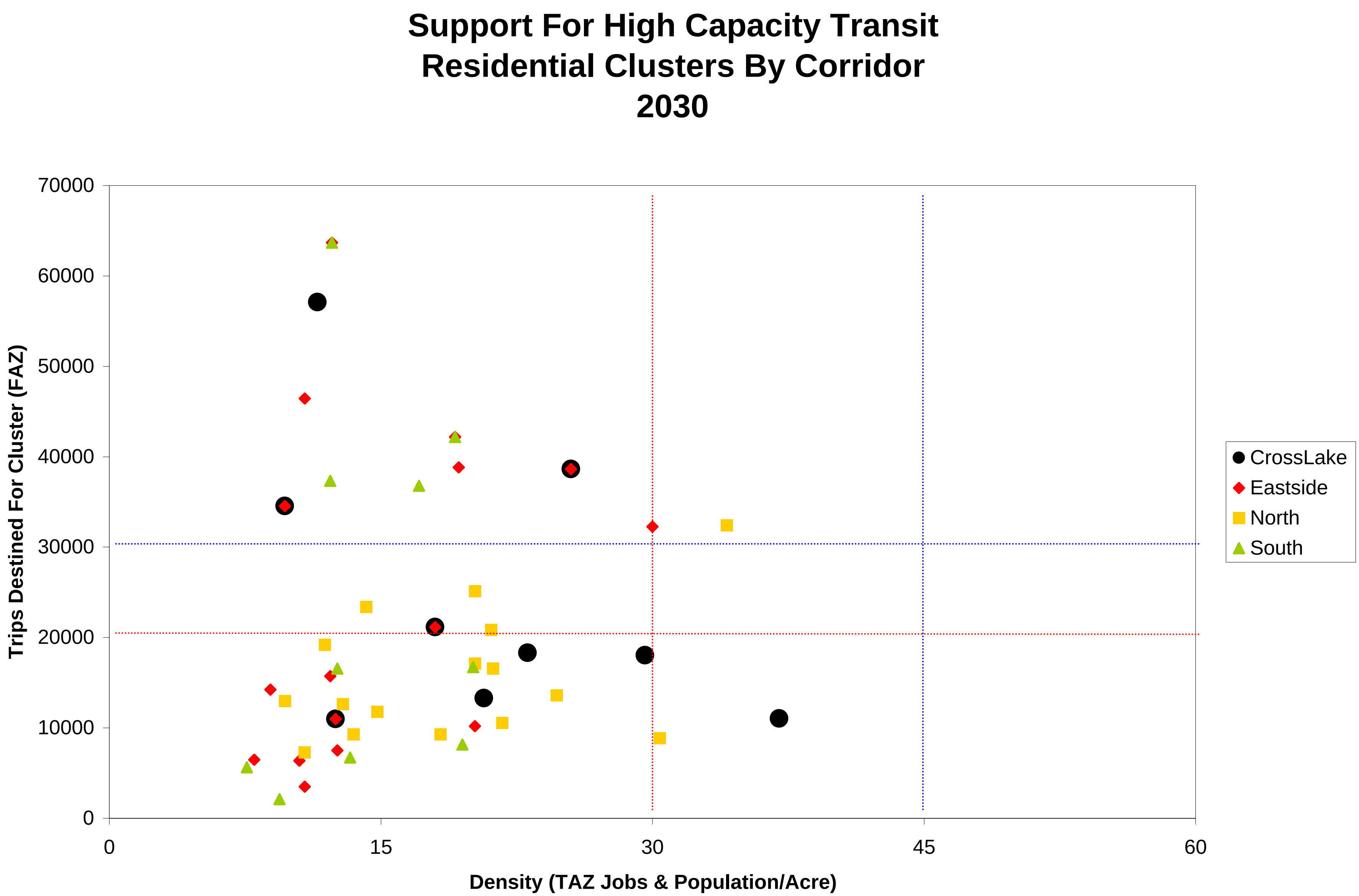

Support For High Capacity Transit
Residential Clusters By Corridor
2000
Trips Destined For Cluster (FAZ)
70000
60000
50000
40000
30000
20000
10000
0
0
15
30
45
60
Density (TAZ Jobs & Population/Acre)
CrossLake
Eastside
North
South

FIGURE 5.1.5



Support For High Capacity Transit
Residential Clusters By Corridor
2030
70000
60000
50000
40000
30000
20000
10000
0
Trips Destined For Cluster (FAZ)
0
15
30
45
60
Density (TAZ Jobs & Population/Acre)
CrossLake
Eastside
North
South

FIGURE 5.2

Potential System-wide Integration of High Capacity Transit (2000 – 2030) – Preliminary Observations

The following matrix displays relative support for high capacity transit based on existing and forecast land use and travel characteristics for specific activity centers and corridor segments. The relative assessments (i.e., Strong support, Moderate support, and Little support) were based on the corridor assessment materials described in *Section 4.0* of the workbook.

	CROSSLAKE			NORTH CORRIDOR			SOUTH CORRIDOR			EASTSIDE CORRIDOR		
Criteria	**Today**	**2010- 2020**	**2020-2030**	**Today**	**2010- 2020**	**2020-2030**	**Today**	**2010- 2020**	**2020-2030**	**Today**	**2010- 2020**	**2020-2030**
Activity Centers												
Strong Support for High Capacity Transit	Seattle CBD Bellevue CBD Capitol Hill University Dist Seattle Uptown	Seattle CBD Bellevue CBD Capitol Hill University Dist Seattle Uptown Overlake	Seattle CBD Bellevue CBD Capitol Hill University Dist Seattle Uptown Overlake Redmond		Northgate Everett	Northgate Everett Lynnwood	Tacoma	Tacoma SeaTac	Tacoma Federal Way SeaTac Tacoma Mall	Bellevue	Bellevue Tukwila Renton SeaTac	Bellevue Tukwila Renton SeaTac Lynnwood Totem Lake
Moderate Support for High Capacity Transit	Overlake	Redmond Issaquah	Issaquah	Northgate Everett	Lynnwood Paine Field	Paine Field	SeaTac	Federal Way Tacoma Mall Lakewood	Lakewood	Tukwila Renton SeaTac	Lynnwood Totem Lake	
Little Support for High Capacity Transit	Issaquah			Lynnwood Paine Field			Federal Way Tacoma Mall Lakewood Dupont Port ofTacoma	Dupont Port ofTacoma	Dupont Port ofTacoma	Lynnwood Totem Lake Bothell	Bothell	Bothell
Corridor Segments												
Strong Support for High Capacity Transit	Seattle CBD to Bellevue	Seattle CBD to Bellevue Bellevue to Overlake	Seattle CBD to Bellevue Bellevue to Overlake Overlake to Redmond Bellevue to Issaquah	Seattle CBD to Northgate (Phase 1)	Seattle CBD to Northgate (Phase 1) Northgate to Lynnwood	Seattle CBD to Northgate (Phase 1) Northgate to Lynnwood Lynnwood to Everett via Paine Field	Seattle CBD to SeaTac (Phase 1)	Seattle CBD to SeaTac (Phase 1) SeaTac to Tacoma CBD	Seattle CBD to SeaTac (Phase 1) SeaTac to Tacoma CBD Lakewood to Dupont		SeaTac to Bellevue Bellevue to Totem Lake	SeaTac to Bellevue Bellevue to Totem Lake Totem Lake to Lynnwood
Moderate Support for High Capacity Transit	Bellevue to Overlake	Overlake to Redmond Bellevue to Issaquah		Northgate to Lynnwood	Lynnwood to Everett via Paine Field		SeaTac to Tacoma CBD	Lakewood to Dupont		Renton to Bellevue Bellevue to Totem Lake	Totem Lake to Lynnwood	
Little Support for High Capacity Transit	Overlake to Redmond Bellevue to Issaquah			Lynnwood to Everett via Paine Field			Lakewood to Dupont			SeaTac to Renton via Tukwila Totem Lake to Lynnwood		

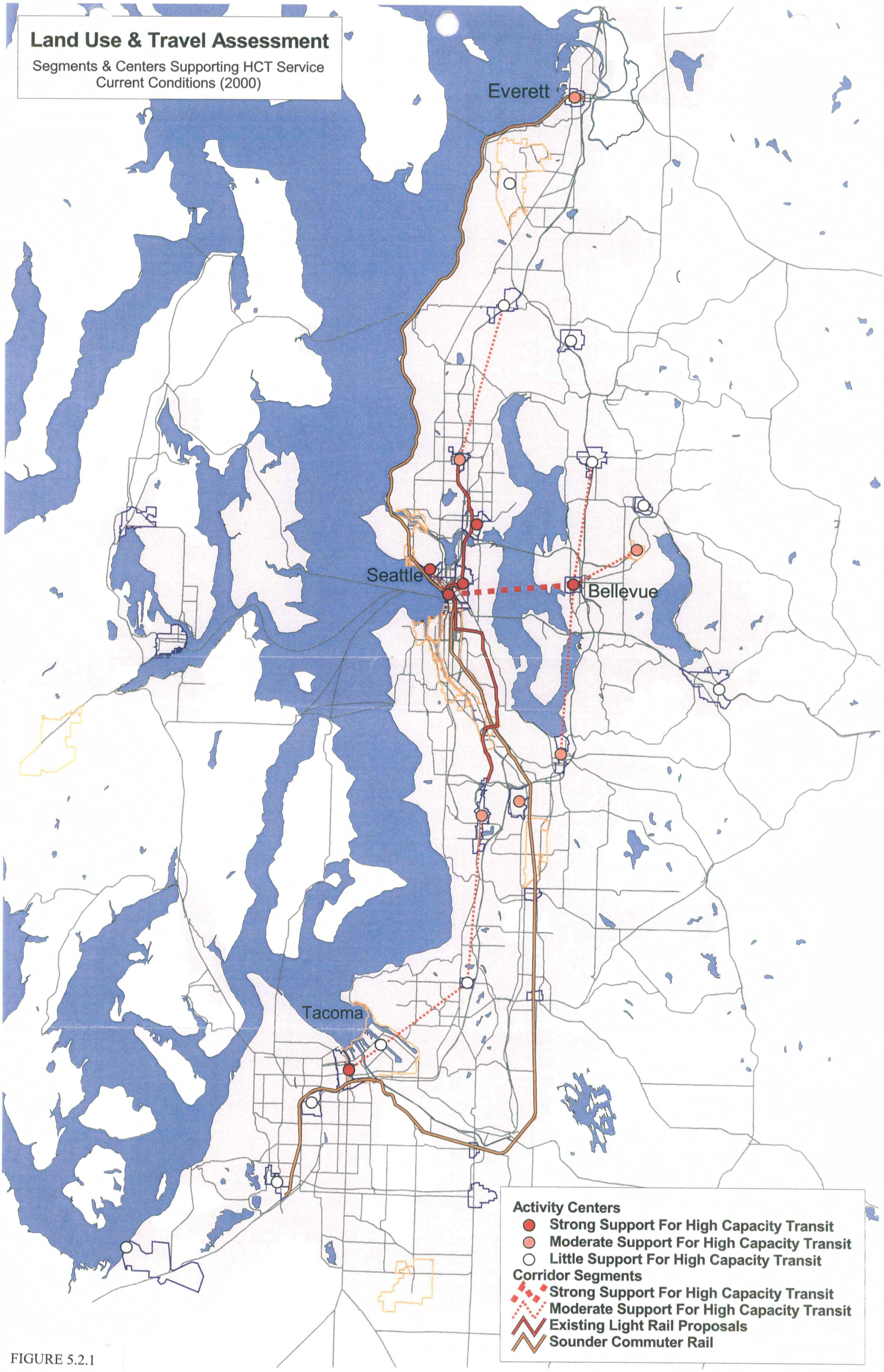

Land Use & Travel Assessment
Segments & Centers Supporting HCT Service
Current Conditions (2000)
Everett
Seattle
Bellevue
Tacoma
Activity Centers
Strong Support For High Capacity Transit
Moderate Support For High Capacity Transit
Little Support For High Capacity Transit
Corridor Segments
Strong Support For High Capacity Transit
Moderate Support For High Capacity Transit
Existing Light Rail Proposals
Sounder Commuter Rail

FIGURE 5.2.1

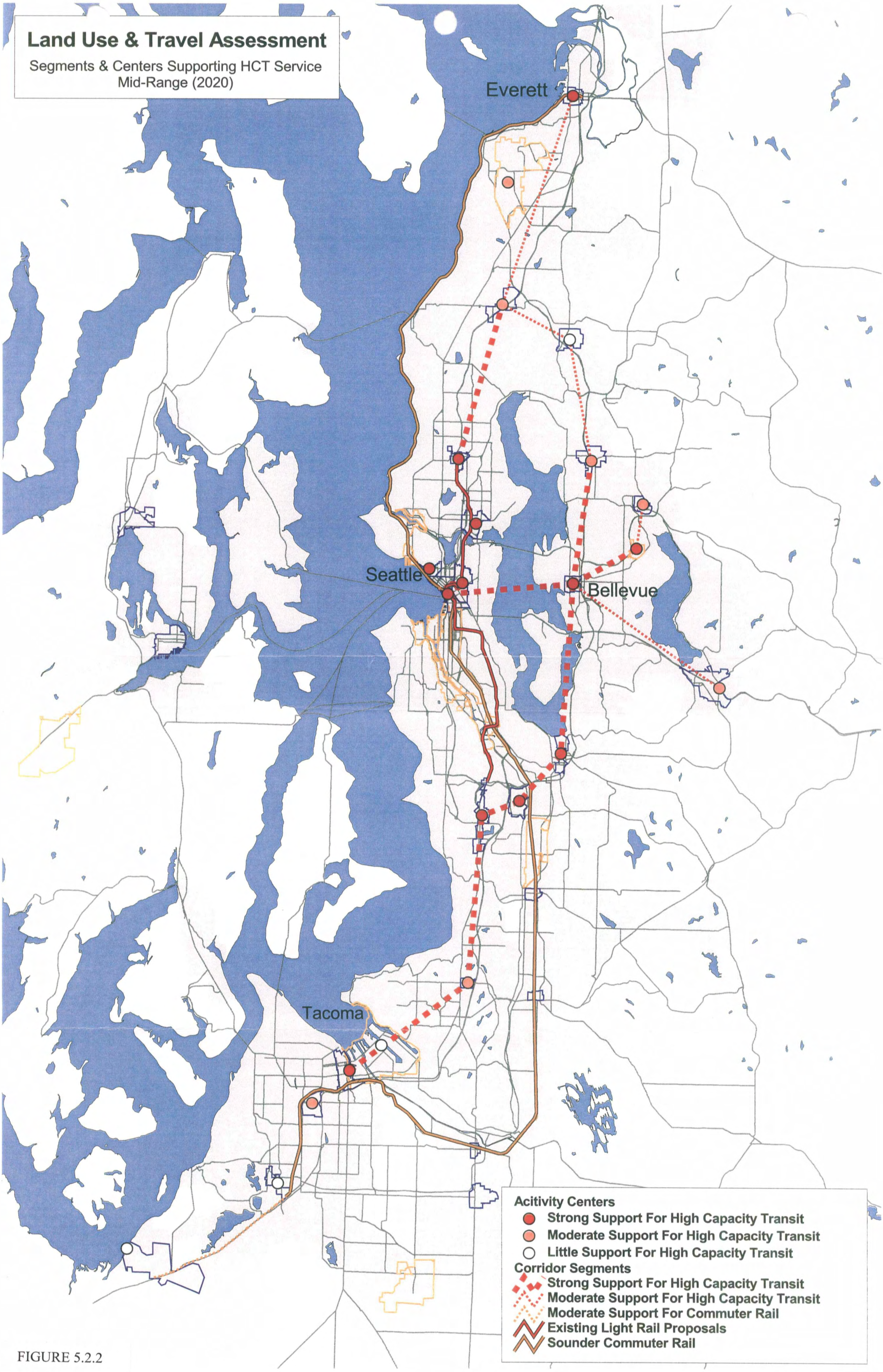

Land Use & Travel Assessment
Segments & Centers Supporting HCT Service
Mid-Range (2020)
Everett
Seattle
Bellevue
Tacoma
Acitivity Centers
Strong Support For High Capacity Transit
Moderate Support For High Capacity Transit
Little Support For High Capacity Transit
Corridor Segments
Strong Support For High Capacity Transit
Moderate Support For High Capacity Transit
Moderate Support For Commuter Rail
Existing Light Rail Proposals
Sounder Commuter Rail

FIGURE 5.2.2

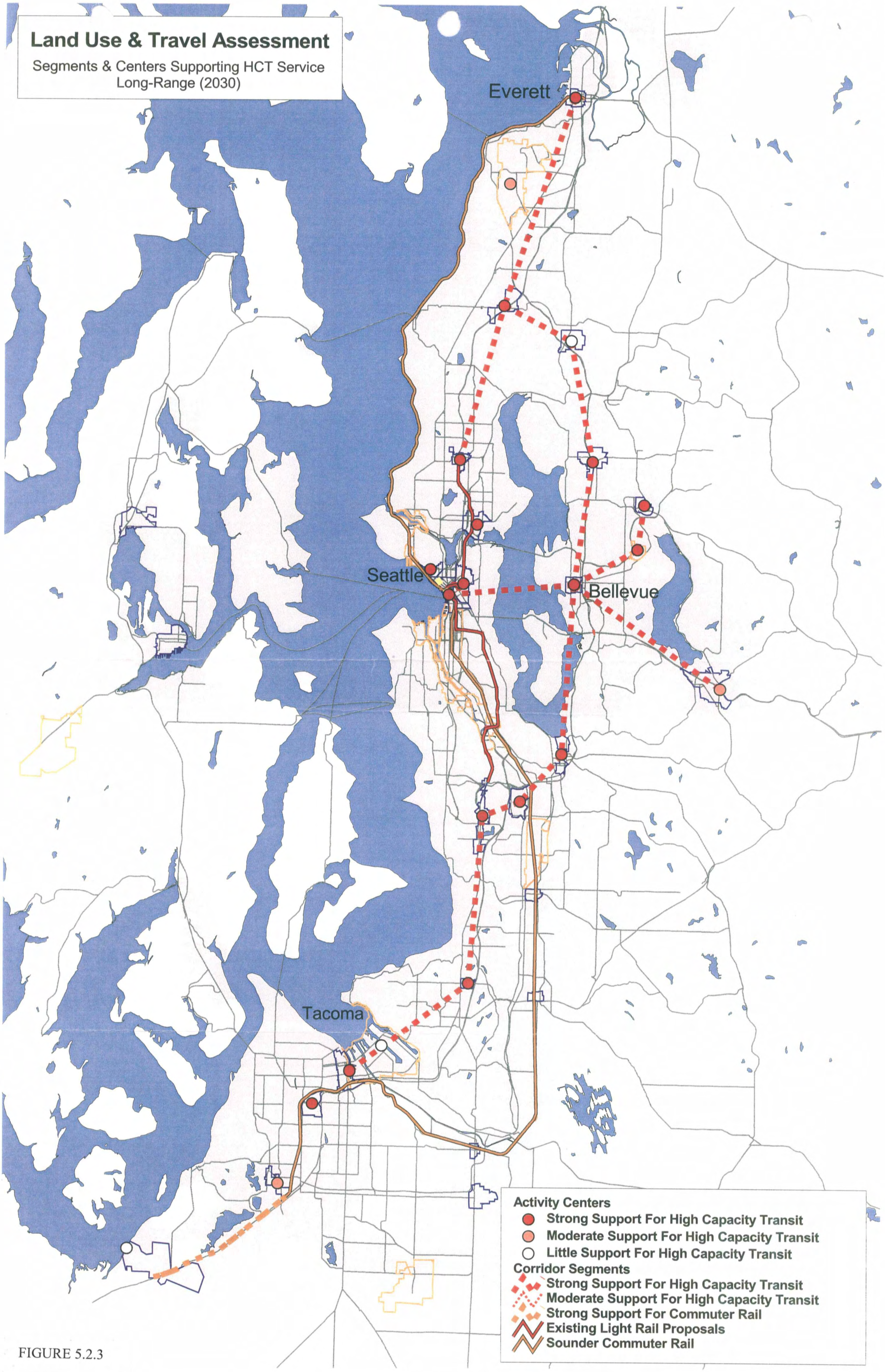

Land Use & Travel Assessment
Segments & Centers Supporting HCT Service
Long-Range (2030)
Everett
Seattle
Bellevue
Tacoma
Activity Centers
Strong Support For High Capacity Transit
Moderate Support For High Capacity Transit
Little Support For High Capacity Transit
Corridor Segments
Strong Support For High Capacity Transit
Moderate Support For High Capacity Transit
Strong Support For Commuter Rail
Existing Light Rail Proposals
Sounder Commuter Rail

FIGURE 5.2.3