7. Technical Summaries

Projecting future travel

In transportation planning, travel demand models are commonly used to study the travel patterns of people and freight.

Travel demand models are based on the practical relationships between socioeconomic characteristics, land uses, and travel patterns. By approximating future travel patterns, models make it possible to assess the implications of growth, to compare alternative transportation solutions, and to provide a testing ground for changes in transportation policy.

How the model works

The key steps in travel demand modeling are:

Trip generation: The area to be studied is divided into a set of zones called Traffic Analysis Zones and the model estimates the potential number of trips beginning (productions) and ending (attractions) in each zone. The trip productions are based largely on estimates of the numbers of trips made by the average household (trip generation rates), for various residential land use types, developed from local and national surveys. Trip attractions are based on employment by land use category, student enrollment and special generators such as an airport.

Trip distribution: The model joins trip productions with trip attractions among the Traffic Analysis Zones throughout the region. Trip distribution does not identify whether the trip is made by car, walking, bike or transit, it simply says where each trip begins and ends.

Mode choice model: The model then "splits" trips among the most likely travel modes such as driving, transit, carpooling, bicycling or walking. Considering trip variables such as auto operating costs, transit fares, routes, travel time, waiting time and parking costs, the model estimates how many trips will be made by each travel mode. For all transit trips, the model also estimates how many people will walk and how many people will drive to get to the transit stop.

Traffic assignment model: Finally, the model determines the fastest paths or routes for each trip and assigns the traffic volume or transit ridership to those routes. The process considers the likely effect of congestion and delays on the most heavily-used facilities and diverts trips to other, less congested links.

Trip Purpose

The trip generation model divides trips by seven trip purposes. The first five assume that the traveler starts from home; they are: Home-based work; Home-based college; Home-based school; Home-based shop; Home-based other. The last two assume that the traveler starts from some place other than their home, for example makes a trip during the day starting from their job; these are: Non-home-based work; Non-home-based other.

Puget Sound Data

The home-based and non-home-based trip production and attraction models were updated using 1999 household travel surveys. (A 2006 household travel survey was recently completed, but was not available in time for the travel modeling work in this study.)

Trip purposes are defined by the activities reported in the household survey at the origin and destination of each trip. If a person's trip has one end at home and one end at work with no stops in between, then this trip is defined as a home-based work trip. If a person's trip begins at home, then involves stopping at the store to buy groceries and continues on to work, this set of trips is defined as a home-based shopping trip and a non-home-based trip. Home-based other trips include activities for visiting, free-time, personal business, and appointments. Non-home-based trips include any trips that begin and end at places other than home.

Trip production models for home-based trips were estimated using household travel survey data in the Puget Sound region. These models were developed from 5,387 households in the survey, out of a total of 6,000 (90 percent) processed to ensure that the data were complete and logical, based on a series of validation tests. The models were estimated for each trip purpose separately. Table 1 provides an overview of trip rates by purpose for households, persons and employees. The table shows that in the average household, all the people living there make almost ten trips a day, and that the average individual makes just under four trips a day. Looking at the data from a workplace perspective, the average number of trips for each worker is just over seven. This is higher than the average number of trips per person for all people, because people who are not working, whether too young, or retired or unemployed, travel less than people do work and have to commute to a job each day.

Trip Distribution Model

The trip distribution model is the second of the four primary model components identified as part of the four-step modeling process. The trip distribution models estimate the number of trips from one zone to other zones, and repeat the process for all zones. The trips are estimated as a function of the travel impedance such as travel time or distance from one zone to another.

Trip distribution model results are the trip tables by trip purpose. These can be summarized by the average trip length in both miles (distance) and minutes (travel time). Table 6 presents a summary of the trip distribution results for the daily trip tables. Average speeds are calculated from the distance and travel time for each purpose. Changes in trip distance reflect changes in chosen routes due to congestion, and changes in travel time reflect changes in chosen routes, as well as changes in time caused by the congestion.

Table 6: Trip Rates by Purpose – Central Puget Sound

Trip Purpose	Trips Per Household	Trips Per Person	Trips Per Employee
Home-Based Work	1.55	0.61	1.13
Home-Based College	0.08	0.03	0.06
Home-Based School	0.69	0.27	0.51
Home-Based Shop	1.11	0.44	0.82
Home-Based Other	3.44	1.35	2.53
Non-Home-Based Work	0.88	0.34	0.65
Non-Home-Based Other	2.16	0.85	1.59
Total Person Trips	**9.91**	**3.88**	**7.27**

Table 7: Total Trips by Purpose Results for Central Puget Sound

Trip Purpose	Daily Trips in Region	Average Miles	Average Minutes	Average Speed
Home-based work	1,984,481	12.50	25.58	29.3
Home-based college	98,030	9.15	19.84	27.7
Home-based school	883,724	4.06	11.54	21.1
Home-based shop	1,427,492	6.17	13.72	27.0
Home-based other	4,418,377	6.61	15.10	26.3
Non-Home-Based Work	1,129,434	6.26	14.11	26.6
Non-Home-Based Other	2,774,412	7.08	14.88	28.5
Total Person Trips	**12,715,950**	**7.39**	**16.23**	**27.3**

Mode Choice Model

The mode choice model is the third stage of the four-step travel demand modeling process. Productions and attractions of the trip generation model are linked in trip distribution, creating zone-to-zone person-trip movements. These trips are then divided among the available travel modes through the application of the mode choice model.

Mode choice models can be used to analyze the effects of changes in policy, or changes in population and employment and characteristics. A wide range of transportation policies can be evaluated through the application of the behavioral-based mode choice models. Examples include scenarios evaluating the effectiveness of high-occupancy vehicle (HOV) lanes, toll-ways, rail transit, exclusive bus lanes, and changes in the price of parking.

Mode choice models are often used to look at how people commute to work. The mode choice model for the home-based work trips produces the following modes of transportation:

- Drive alone – Single-occupancy auto trips
- Shared ride 2 – Double-occupancy auto trips
- Shared ride 3+ – Auto trips with three or more occupants
- Transit – Walk access
- Transit – Auto access
- Bicycle
- Walk

The model predicts numbers of trips between every zone, and then these trips are divided between the road and transit network for further analysis. A regional summary of trips by various modes and trip purposes produced by the mode choice model for 2000 conditions is shown in Table 8.

Table 8: Regional Person Trips in 2000 for Central Puget Sound

Trip Purpose	Drive Alone	Shared Ride 2 People	Shared Ride 3+ People	Transit Walk to stop	Transit Drive to stop	Walk	Bike	Total
Work, to and from home	1,574,751	124,051	25,196	139,798	32,839	56,515	31,329	1,984,479
	79.4%	6.3%	1.3%	7.0%	1.7%	2.8%	1.6%	
College, to and from home	54,062	10,635		19,121		8,324	5,887	98,030
	55.1%	10.8%		19.5%		8.5%	6.0%	
School, to and from home	20,779	135,332	217,786			509,826		883,724
	2.4%	15.3%	24.6%			57.7%		
Non-work, to and from home	2,571,845	1,697,123	1,183,116	111,337		297,597	60,106	5,921,123
	43.4%	28.7%	20.0%	1.9%		5.0%	1.0%	
Trip that starts and ends away from home	1,937,757	962,933	645,323	81,587		268,151	28,028	3,923,779
	49.4%	24.5%	16.4%	2.1%		6.8%	0.7%	
TOTALS	6,159,195	2,930,074	2,071,420	351,842	32,839	1,140,413	125,350	12,811,134
	48.1%	22.9%	16.2%	2.7%	0.3%	8.9%	1.0%	

Trip Assignment Model

The trip assignment model is the last of the four primary model components identified as part of the four-step modeling process. The trip assignment model estimates the volume on each link in the transportation system for both highway and transit modes. In addition, the trip assignment model generates specific performance measures, such as the congested speed or travel time on a highway link or the boardings and alightings on a transit route. Trip assignment is performed separately for each mode (auto and transit) and time period (a.m. peak, off-peak, p.m. peak, evening, and night). For this study, transit trips were not analyzed in the trip assignment model.

Modeling traffic at intersections

Based on professional judgment regarding which intersections in southeast Seattle are likely to be most congested now and in the future, the study selected 47 intersections for detailed analysis. To calculate intersection levels of service, the following traffic data were assembled:

- Vehicle volumes for all movements
- Signal cycle length and specific signal operation such as signal phasing and length of green time
- Intersection geometry such as availability of left turn pocket and its length
- On-street parking
- Width of traffic lanes
- Pedestrian volumes
- Heavy vehicle volumes such as buses and trucks

Upon completing all of these steps, the congested intersections in the study area were identified. The most congested intersections of those analyzed are discussed in the Vehicles Section. The maps on the following pages show the results for all intersections studied.

Modeling improvements at congested intersections

Based on the analysis of projected 2030 peak-hour conditions at the 47 intersections studied, the most congested intersections were identified as candidates for improvements to reduce vehicle delay. Each of these was reviewed with a large working group made up of the project team along with SDOT staff from various divisions.

Ultimately, the project team decided to propose improvements at ten of the intersections:

- Rainier Ave. S. and S. Dearborn St.
- Rainier Ave. S. and 23rd Ave. S.
- Beacon Ave. S. and S. Spokane St.
- Beacon Ave S. and S. Columbian Way
- Swift Ave. S. and I-5 Northbound Off-Ramp
- Swift Ave. S. and S. Albro Place
- 15th Ave S. and S. McClellan St.
- Wilson Ave. S. and S. Dawson St.
- 15th Ave. S. and S. Columbian Way

Conceptual designs were developed for each of these locations and the intersections were then evaluated again to determine likely delay in 2030 with the improvements in place. In all cases, significant reductions in delay were projected.

Final project recommendations

As work continued on SETS, some of the original conceptual designs for the congested intersections were modified and the modified designs were not re-evaluated. Refer to specific project sheets for modeling results, or see Appendices for full documentation.

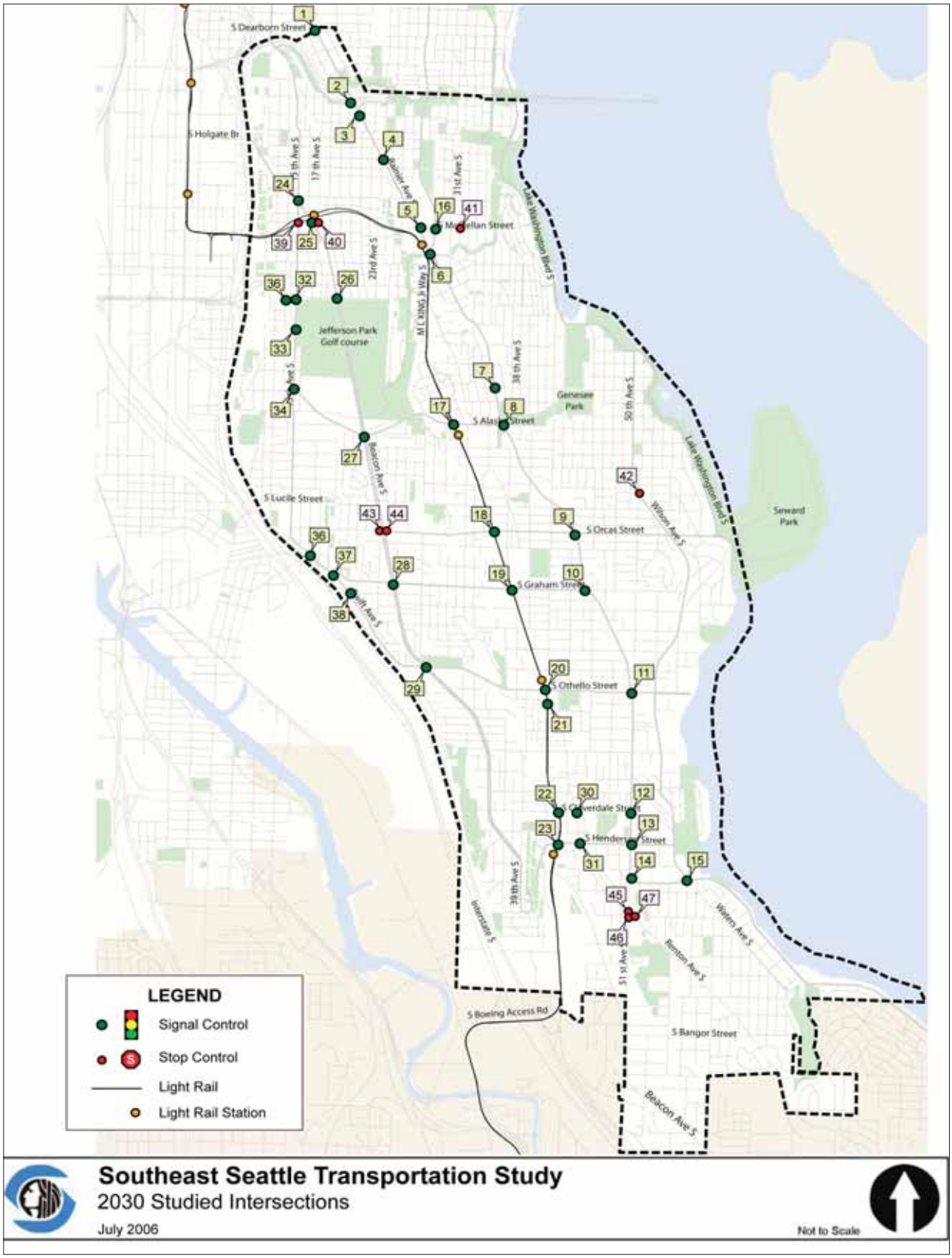

Figure 25: Intersections analyzed for 2030 performance
Source: Mirai

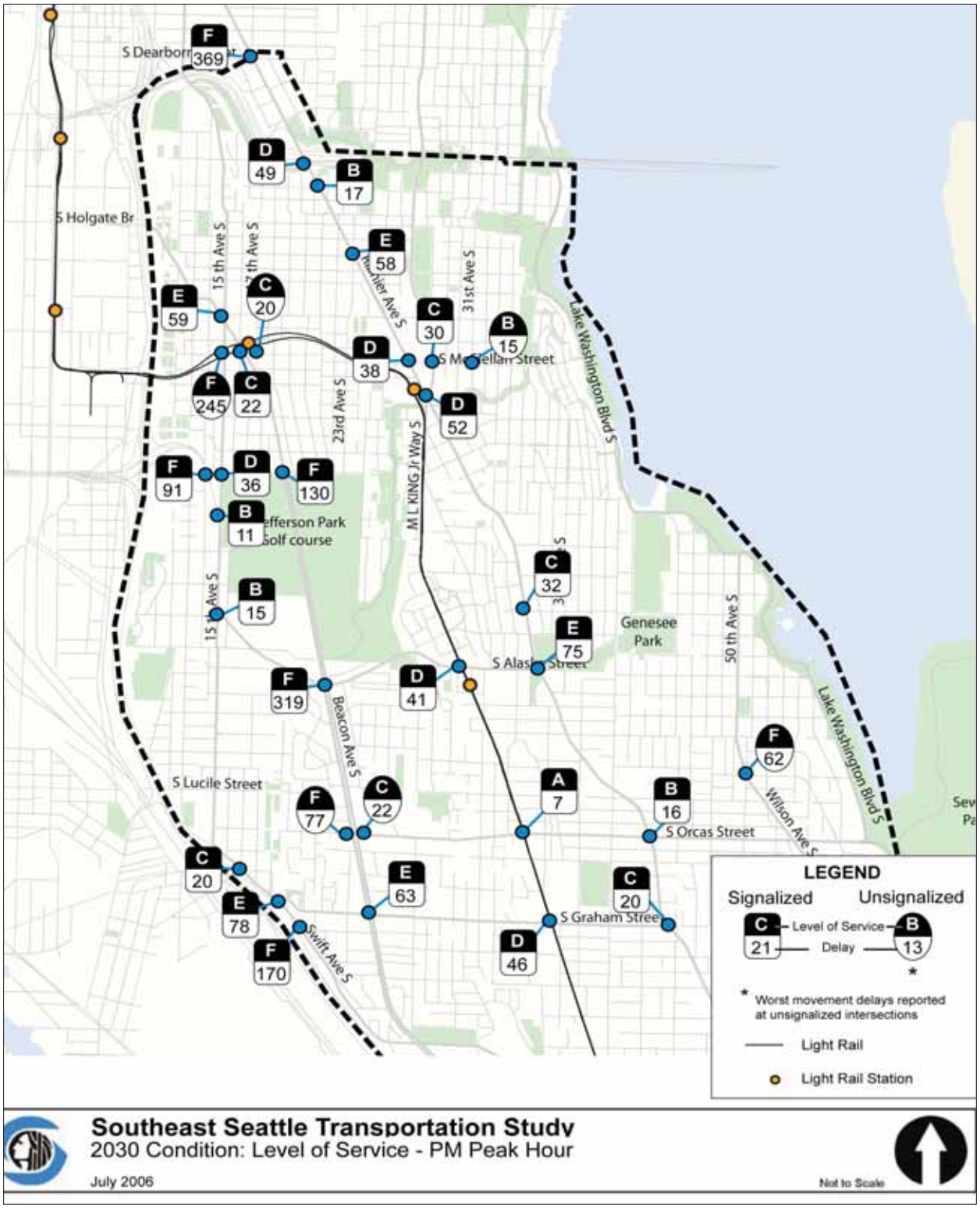

Figure 26: North Study Area – Intersection Analysis Results: Peak Hour 2030 Level-of-Service and Seconds of Delay
Source: Mirai

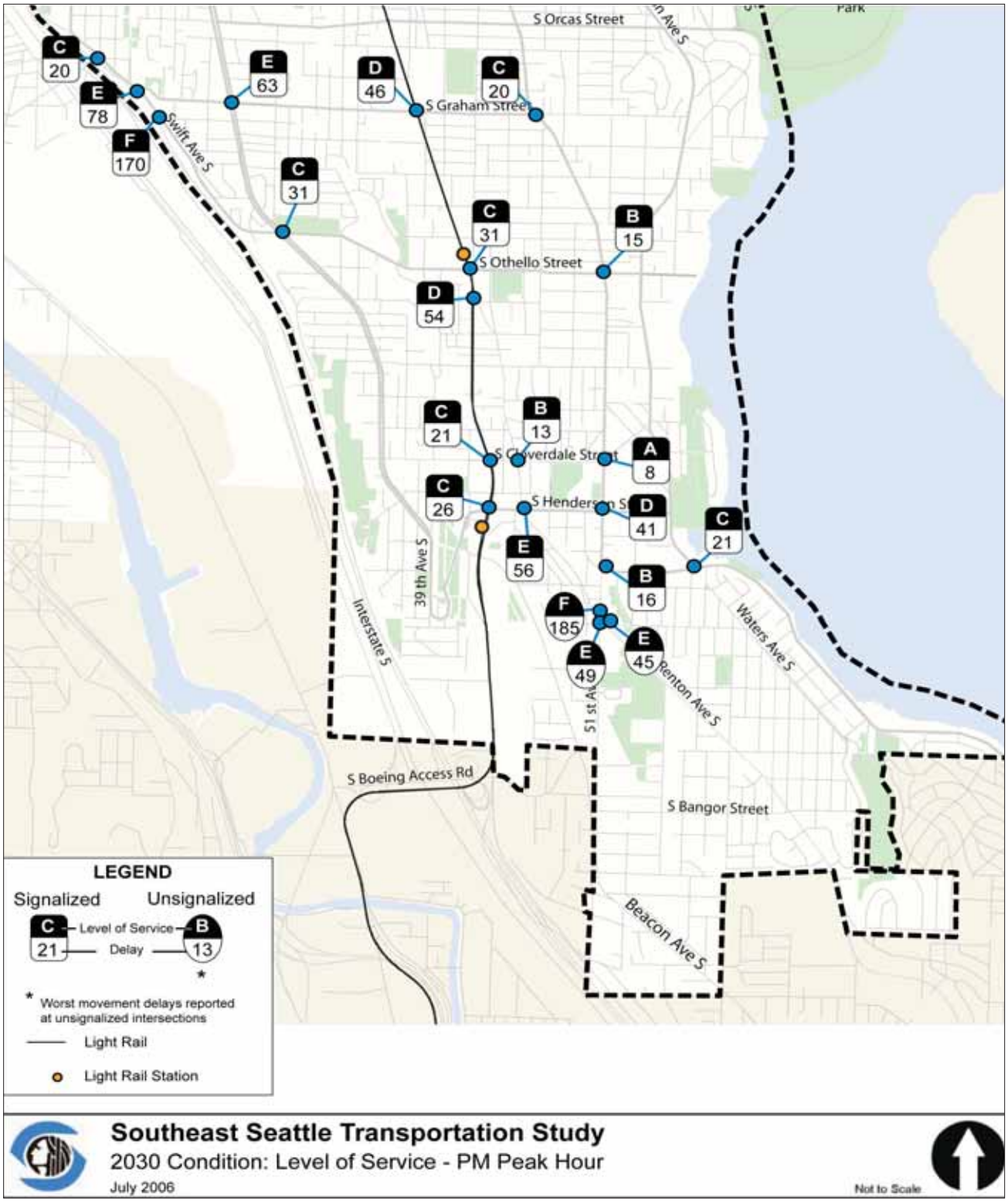

Figure 27: South Study Area – Intersection Analysis Results: Peak Hour 2030 Level-of-Service and Seconds of Delay Source: Mirai

Cost Estimates

The project recommendations prepared for this study vary greatly with regards to level of detail. Some projects, such as Project #51, bicycle access across I-5, are too preliminary to detail the type of structure necessary or where it might be built. For others, such as Project #5, reconfigure the intersection of Beacon Ave. S. and 17th Ave. S, more detailed concepts have been developed, but no formal design work has been done.

Developing cost estimates for the recommended projects, therefore, can only be done at a sketch planning level of detail. The resulting estimates are rough figures, helpful in giving SDOT and the public a general idea of the order of magnitude of project costs, as well as how projects might compare to each other. It is important to note, however, that final project costs will depend on the final designs prepared for each of the recommended projects, which may vary substantially from the conceptual designs presented here.

How cost estimating is done

When a project is ready to go out to bid, Seattle Department of Transportation (SDOT) prepares a detailed cost estimate based on literally hundreds of individual elements. Each element is assigned a 'unit cost' which is multiplied by a 'quantity' to calculate the estimate. Unit costs are adjusted periodically to reflect actual market conditions. Quantities are developed as part of the design work and are most commonly measured in square feet, lineal feet, square yards, cubic yards, or on a per item basis.

A few examples of 2007 unit prices applied to SDOT projects illustrate the complexity of the cost estimating process and why detailed designs are required to prepare detailed estimates:

- Pavement, cement concrete CL 6.5 (12 in): $110 per square yard. (In all there are 29 different types of concrete pavement that might be specified.)
- Gate valve for water main, 4 inch: $500 each. (There are five sizes of gate valves, seven sizes of butterfly valves, and one type of valve box.)
- Erosion control topsoil Type A: $50 per cubic yard. (There are only two types of topsoil.)
- Roadside planting, coniferous evergreen tree, 8 ft to 10 ft: $230 each. (Thirteen different types/sizes of trees are specified.)
- Temporary traffic control: $60 per hour.

Cost estimates for SETS projects

SETS project costs were estimated in 2007 dollars based on a simplified schedule of unit costs. For example, instead of more than thirty possible storm drain and sanitary sewer elements, SETS aggregated estimates into two categories, "Storm Drainage – New" and "Storm Drainage – Modify" and assigned each a single cost per lineal foot. Similarly, "Landscaping, Irrigation, Planters and Restoration" is single unit cost item, calculated by lineal foot.

Quantities for SETS projects were estimated based on conceptual sketches, supplemented where available by SDOT's existing sketches of the right-of-way. Unit costs include material and labor. If additional right-of-way is needed to construct a project, right-of-way purchase costs are calculated based on square feet. Costs for mobilization, traffic control, and contingency are all calculated as a percentage of constructions costs. Engineering/management is calculated as a percentage of construction and right-of-way costs. Surveying and design are not included in the project cost estimates.