

Central Puget Sound
**FREEWAY NETWORK
USAGE AND
PERFORMANCE**



1999 Update, Volume 1

Research Report
Research Project T1803, Task 19
FLOW Evaluation

Central Puget Sound
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USAGE AND
PERFORMANCE
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Department of Transportation

and in cooperation with

U.S. Department of Transportation

Federal Highway Administration

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO. WA-RD 493.1	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.	
4. TITLE AND SUBTITLE Central Puget Sound Freeway Network Usage and Performance, 1999 Update, Volume 1		5. REPORT DATE May 2001	
		6. PERFORMING ORGANIZATION CODE	
7. AUTHOR(S) John M. Ishimaru, Jennifer Nee, and Mark E. Hallenbeck		8. PERFORMING ORGANIZATION REPORT NO.	
9. PERFORMING ORGANIZATION NAME AND ADDRESS Washington State Transportation Center (TRAC) University of Washington, Box 354802 University District Building; 1107 NE 45th Street, Suite 535 Seattle, Washington 98105-4631		10. WORK UNIT NO.	
		11. CONTRACT OR GRANT NO. Agreement T1803, Task 19	
12. SPONSORING AGENCY NAME AND ADDRESS Washington State Department of Transportation Transportation Building, MS 7370 Olympia, Washington 98504-7370 Project Manager Gary Ray, 360-705-7975		13. TYPE OF REPORT AND PERIOD COVERED Research report	
		14. SPONSORING AGENCY CODE	
15. SUPPLEMENTARY NOTES This study was conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration.			
16. ABSTRACT <p>This two-volume <i>summary</i> report presents an overview of the level of traveler usage (e.g., how many vehicles use the freeways) and travel performance (e.g., how fast they are traveling, where and how often congestion occurs) on the principal urban freeways in the central Puget Sound area. Volume 1 focuses on descriptive snapshots of 1999 freeway usage and performance, while Volume 2 provides a comparative analysis, looking at trends and variations in the usage and performance of the highway network as a function of different background conditions at selected locations. Data presented in this report were collected by the Washington State Department of Transportation's (WSDOT's) freeway surveillance system.</p> <p>The project that led to this report is intended to meet two separate purposes: 1) to enhance WSDOT's ability to monitor and improve its traffic management efforts on Seattle-area highways, and 2) to provide useful information to the public and decision makers about the status of the freeway system's operational performance. This report is primarily intended to meet the second of these objectives. However, the software developed for this project and many of the graphics presented in this report are directly applicable to the first objective.</p> <p>This report is one of three products resulting from this WSDOT project. In addition to this report, this project produced a set of software tools to assist in freeway data analysis, as well as a technical report describing the evaluation approach, process, and analytical tool set that were developed to analyze freeway usage and performance in the central Puget Sound region. The freeways studied in this project are managed by WSDOT using its FLOW system, a coordinated network of traffic monitoring, measuring, information dissemination, and control devices that operates on urban state and Interstate highways in the central Puget Sound region.</p>			
17. KEY WORDS Archived Data User Services (ADUS), congestion monitoring, freeway performance		18. DISTRIBUTION STATEMENT No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22616	
19. SECURITY CLASSIF. (of this report) None	20. SECURITY CLASSIF. (of this page) None	21. NO. OF PAGES	22. PRICE

Disclaimer

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Washington State Transportation Commission, Department of Transportation, or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

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Acknowledgments

A prerequisite for the type of analysis documented in this report is the availability of detailed traffic data and professional guidance from a variety of sources. This project was fortunate to have had the cooperation of numerous state and local agencies and their staff, who responded in a timely and professional manner to requests for data, as well as to follow-up questions. They also provided this project with valuable feedback regarding preliminary analytical results and offered important technical advice. This report would not have been possible without their enthusiastic support; we extend our sincere thanks to them all.

This project was made possible with the support and encouragement of the WSDOT Research Office and its director Martin Pietz, WSDOT's Northwest Region Traffic Systems group and Northwest Region's Regional Traffic Engineer Dave McCormick, and former WSDOT Northwest Region Assistant Regional Administrator Les Jacobson. The project researchers also wish to acknowledge the ongoing technical guidance of WSDOT Northwest Region staff, with particular thanks to Mark Morse.

This research effort was fortunate to have access to a multi-year traffic database for the central Puget Sound freeway network, which was the foundation for most of the results presented in this report. Valuable technical support for the use of this database and the associated Compact disc Data Retrieval (CDR) software was provided by WSDOT Northwest Region's Christian Cheney, Lanping Xu, Greg Leege, Michael Forbis, CDR's original programmer Alan Shen, and the Traffic Systems Management Center (TSMC). Additional assistance with traffic operations data was provided by Morgan Balogh, Paul Neel, and Mark Leth of WSDOT. Dan Dailey of the University of Washington provided technical assistance for selected performance measure algorithms used in this analysis.

Transit ridership data were provided by representatives of regional transit agencies, including Community Transit; King County Department of Transportation (Metro Transit); and Pierce Transit. Vehicle occupancy data were provided by William Brown and Eldon Jacobson of the WSDOT HOV Lane Evaluation project. Data collection assistance was also provided by Nicholas Roach and Joel Pfundt of the Puget Sound

Regional Council. WSDOT's Web site provided useful background information, as well as important input to the travel time estimation process via its State Route Viewer freeway image database.

Valuable suggestions were also received during presentations of preliminary project results to regional and state groups. Comments were provided by members of the Washington State Transportation Commission, as well as staff of the WSDOT Research Office, WSDOT Northwest Region Traffic and Freeway Operations group, WSDOT Office of Urban Mobility, WSDOT Transportation Data Office, WSDOT Advanced Technology Branch, Community Transit, Metro Transit, Pierce Transit, and the Puget Sound Regional Council.

The project researchers also wish to recognize the significant contributions made by the Washington State Transportation Center's technical staff. These include Duane Wright, who developed the project's analysis software tools and provided extensive computer graphics support; Stephanie MacLachlan, who contributed to the initial scoping and methodology design phase of this project; Mary Marrah, who was responsible for graphic design; and Amy O'Brien, who edited the text and supervised final document design, report layout, and integration. This report would not have been possible without their participation.

Glossary

GP Lanes	General purpose freeway lanes. GP freeway lanes can be used by any vehicle regardless of the vehicle type or the number of occupants in the vehicle.	Reversible Lanes	Freeway lanes that operate in only one direction during part of the day, and the opposite direction during the rest of the day. Vehicle occupancy requirements on reversible lanes (e.g., HOVs only) vary with location and time of day. In the central Puget Sound area, there are reversible lanes on I-5 between the Seattle central business district and Northgate, and on I-90 between Seattle and the east side of Mercer Island.
HOV Lanes	High occupancy vehicle freeway lanes. HOV freeway lanes can be used by a) any vehicle with at least 2 occupants, including the driver (3 occupants minimum on the westbound SR 520 HOV lane west of 108th Ave NE), b) motorcycles, and c) transit vehicles.	Vehicle Volume	The estimated total number of vehicles passing a particular freeway location over a given time period (daily, peak period, or peak hour). In the central Puget Sound area, electronic sensors embedded in individual freeway lanes are commonly used to collect these data.
Lane Occupancy	The percentage of time that a roadway sensor detects the presence of a vehicle at a particular freeway location. This value can be used to estimate different levels of traffic congestion. In the central Puget Sound area, electronic sensors embedded in individual freeway lanes are commonly used to collect these data.	Vplph	Also known as Vehicles Per Lane Per Hour, vplph is the estimated vehicle volume at a particular freeway location, adjusted for the number of lanes at that site and the time period of the measurement. For example, if vehicle volume has been collected at each of three lanes at a particular location for 5 minutes, vplph is determined by adding together the 5-minute vehicle counts for the three lanes, dividing that sum by the number of lanes (three), then multiplying the result by 12 to get an equivalent hourly volume (12 times 5 minutes = 1 hour); this produces a per-lane, per-hour equivalent volume. Vplph allows measurements of vehicle volume from different locations with different numbers of lanes to be more directly compared to one another.
Peak Hour Volume	The highest number of vehicles that pass a particular freeway location in a one- hour period during the AM hours (midnight to noon) or during the PM hours (noon to midnight).		
Peak Period Volume	The total number of vehicles that pass a particular freeway location per peak period. In this report, unless otherwise noted the AM peak period is defined as 6:00 AM to 9:00 AM, and the PM peak period is 3:00 PM to 7:00 PM.		
Person Volume	The estimated total number of persons passing a particular freeway location over a given time period (daily, peak period, or peak hour). Also referred to as person throughput. In this report, person volume is computed by using a combination of vehicle volume data (estimated number of vehicles) and vehicle occupancy data (estimated number of travelers per vehicle, based on data from transit agencies and field observations).		

Section 1. Introduction

Purpose of This Report

This report presents an overview of the level of usage and performance on the principal urban freeways in the central Puget Sound area during 1999. The freeways included in this report are managed by the Washington State Department of Transportation (WSDOT) through operation of its FLOW system, a coordinated network of traffic monitoring, measuring, information dissemination, and control devices that operates on urban state and interstate highways in the central Puget Sound region. This report is a product of a WSDOT-sponsored project whose purpose is twofold: (1) to enhance the Department's ability to monitor and thus improve the effects of its traffic management efforts on Seattle-area highways, and (2) to provide useful information to the public and other decision makers about the status of traffic performance in the region. This report is one of a planned series of periodic evaluations of the central Puget Sound urban highway network and the WSDOT FLOW system.

Several considerations should be kept in mind when interpreting the results in this report. First, this is a summary report intended to provide an overview of the freeway system's usage and performance based on information collected at selected locations. Generalizing to other locations in the freeway network requires caution, as performance can vary significantly even among closely spaced sites. (Note, though, that the data analysis procedures used for this project were designed to be general, and can be employed at locations other than those included in this report, provided that the appropriate data have been collected.)

Second, the analysis in this report is dependent on the availability and quality of traffic data for central Puget Sound freeways. Although the regional traffic data used for this report were generally detailed and comprehensive, data for some locations and time periods were occasionally unavailable or of variable quality because the measurement process was affected by construction activity, lack of sensor installations, or equipment problems. The analysis methods used for this report were designed to compensate for extended segments of unavailable or incomplete data as much as was practicable;

nevertheless, some of the results are considered tentative because of the nature of the input data upon which they are based.

Third, the measures reported in this document are usually average values based on many days of traffic data; they do not represent a particular day of traffic performance but rather a "typical" day of representative performance. In addition, measures such as speed, congestion, and travel time values are estimates based on approximate formulas; such measures are best treated as relative, rather than absolute, values, and used in a comparative way. Further information about data quality issues and the constraints and caveats of the analysis in this report are provided in the FLOW Evaluation Design Technical Report.

Geographic Scope

This report summarizes 1999 central Puget Sound area freeway usage and performance on I-5, I-405, SR 520, SR 167, and I-90, in an area approximately bounded by Puget Sound to the west, Redmond and Issaquah to the east, Sea-Tac and Auburn to the south, and Everett to the north. The results reflect the combined effects of all WSDOT traffic management efforts in the region. This is a "state of the system" report, and as such, it does not evaluate the individual contributions of specific traffic management system components, although the effects of some components may be apparent in these aggregate results.

This analysis covers sections of freeway for which 1999 data were available (Figure 1.1).

What Is in This Report

This report summarizes general measures of **facility usage** (e.g., how many vehicles are transported on the freeway network) and **facility performance** (e.g., how fast they are traveling, where and how often congestion occurs). These measures are meant to be succinct, yet provide sufficient detail to convey a sense of the complexity

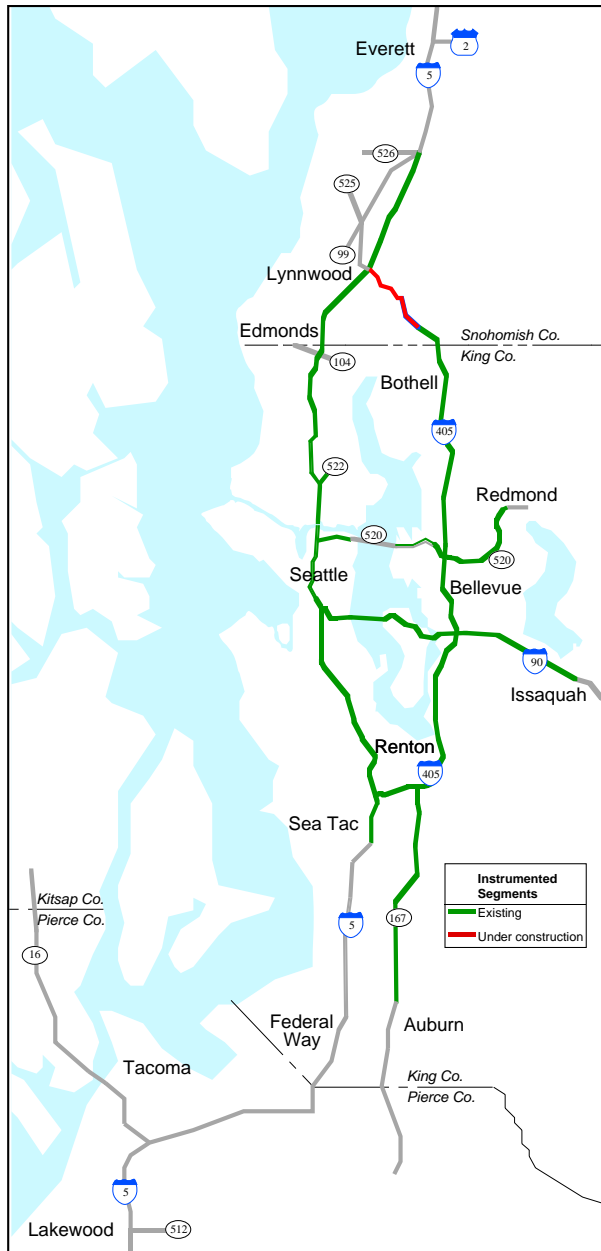


Figure 1.1. Instrumented Freeway Segments on Central Puget Sound Freeways

of highway performance variations as a function of location, time, and other conditions. In addition, this analysis is designed to be repeatable, i.e., the report's contents can be updated periodically with a consistent set of measures, so that trends can be monitored over time. This report is divided into the following sections:

System Usage: Selected Freeway Sites. Average volume measures taken at selected locations summarize the level of usage of the Seattle-area highway network. Usage is measured in terms of average weekday daily, peak hour, and peak period vehicle volumes for general purpose (GP), high-occupancy vehicle (HOV), and reversible lanes.

System Performance I: Freeway Corridors. The performance of the highway network along a corridor is summarized. Performance is indicated with the following measures: facility-wide traffic patterns (average congestion and frequency of congestion) as a function of time of day and location on the corridor; average travel times along selected routes; and variability and reliability of travel times on those routes.

System Performance II: Selected Freeway Sites. The performance of the highway network at selected locations is summarized. Performance is indicated with the following measures: average vehicle volume, average estimated speed range, and congestion frequency, all as a function of time of day.

HOV Lane Network. The usage and person-carrying capacity of the HOV lane network are discussed.

What's New In This Report

Although the overall structure of this report is similar to that of the first edition of this report (published March 1999), there are two principal differences:

New data and performance measures. Besides using updated data (primarily 1999), this report adds 10 additional measurement sites for daily and peak hour/period vehicle volumes (section 2); a discussion of corridor-by-corridor congestion frequency estimates with accompanying contour maps (section 3); a discussion of estimated travel time characteristics on 18 hypothetical trips in the region with accompanying 24-hour travel time profile graphs (section 3); and new performance information on SR 167, including 24-hour traffic profile data (section 4).

Additional trend analysis volume. The second major change is the addition of a second volume of this report to discuss regional freeway travel trends in more detail. While Volume 1 (this report) focuses on descriptive snapshots of 1999 freeway usage and performance, Volume 2 is a comparative analysis, looking at trends and variations in the usage and performance of the highway network as a function of different background conditions at selected locations. Volume 2 expands on the discussion that was formerly included in section 5 (System Performance III: Performance Variations) of the March 1999 edition of this report; it analyzes usage and performance trends from 1997 to 1999, weekday vs. weekend performance differences, and GP vs. HOV freeway usage.

About This Project

This report is a product of a WSDOT-sponsored project, FLOW Evaluation Framework Design. The overall objectives of this project are to 1) develop a methodology, framework, and detailed procedures for conducting an ongoing series of evaluations of the performance and effects of the FLOW traffic management system now in operation on Puget Sound area freeways; 2) create tools for performing those evaluations; and 3) use the developed framework to supplement earlier evaluation data with updated analyses about the state of the freeway system in the central Puget Sound region. This report reflects the results of work on the first two objectives and addresses the third objective.

Section 2. System Usage

This section summarizes general levels of usage of the freeway system in the central Puget Sound area. These statistics, based on 1999 data, are intended to provide an overview of freeway traffic patterns and comparative levels of use among different freeway segments.

How System Usage Was Measured

System usage was estimated in two ways for selected freeway locations in the study area:

Average Annual Weekday Vehicle Volume

The average weekday volume is a general measure of the level of usage of the freeway system at a specific location. This value equals the estimated total number of vehicles passing a given location during an average 24-hour weekday period (Monday through Friday), based on data collected during an entire year. The values in this section are based on available vehicle count data collected electronically by WSDOT for the 1999 calendar year.

Average Peak Vehicle Volume

The average peak volumes represent levels of system usage during the traditionally busiest periods of the day. Average peak vehicle volumes are estimated for four weekday time periods. These periods are

- 1) the morning peak period (defined as 6:00 AM to 9:00 AM)
- 2) the evening peak period (defined as 3:00 PM to 7:00 PM)
- 3) the AM peak hour (the one-hour AM interval with the highest vehicle volume)
- 4) the PM peak hour (the one-hour PM interval with the highest vehicle volume).

The peak periods represent the traditional morning and evening “rush hour” commute periods, whereas the peak hours represent the highest one-hour traffic volumes during

the day. The peak-period measurements are always based on the fixed time periods noted above; the average peak-hour volumes can be based on a different one-hour period from day to day, but always represent the AM and PM hour with the highest volumes. A peak hour normally, though not necessarily, occurs within a peak period; because severe congestion limits the number of vehicles that can use a freeway lane, peak volumes on congested roads can occur outside the fixed peak period.

As with the weekday vehicle volumes, peak vehicle volumes in this section are based on available vehicle count data collected electronically by WSDOT for the 1999 calendar year.

NOTE: Measurements at some locations began at different times after the first of the year. Average weekday and peak volume statistics at those locations are therefore based on data from less than a full year.

Where System Usage Was Measured

Summary system usage statistics were estimated at 21 freeway locations throughout the central Puget Sound freeway network: six locations on I-5, seven locations on I-405, two locations on I-90, three locations on SR 167, and three locations on SR 520. (See Figure 2.1.) These locations were selected on the basis of their traffic significance and the availability of data, and they are intended to be generally descriptive of the freeway system. There are 10 more sites in this report than were in the first summary report, including sites on a newly added corridor, SR 167, where measurement operations began in mid-1999. (Data were not available for most of SR 520 east of Bellevue Way in 1999 because of construction activity that affected data collection.)

Note that while the measurement locations were chosen to be in some way representative of the facilities on which they were located, caution should be exercised in attempting to generalize about an entire corridor on the sole basis of usage measurements at a few locations. Average traffic conditions can change significantly within a

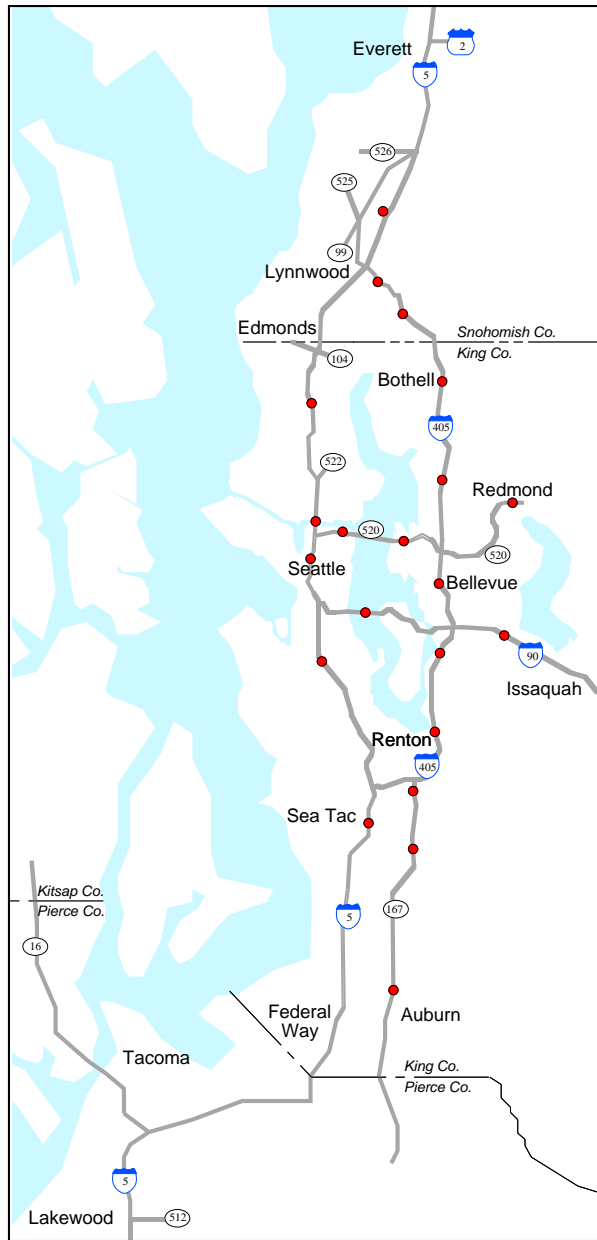


Figure 2.1. 1999 FLOW Evaluation Measurement Sites

short distance because of interchanges, on- and off-ramps, and other road and land use conditions.

In addition, the volumes presented in this section are vehicle volumes. Person usage of the system, and in particular the use of high-occupancy vehicle (HOV) versus general purpose (GP) lanes, is discussed later in this report in section 5, “The HOV Lane Network.”

Results for Selected Locations

Average Daily Vehicle Volumes

Average weekday daily vehicle volumes are summarized in Table 2.1. All traffic volume estimates are based on 1999 data. The following are summaries of the vehicle volume patterns in the major corridors.

Major North-South Facilities. Interstates 5 and 405 are the principal north-south urban highway facilities in the central Puget Sound area. Data collected in 1999 show that on an average weekday, Interstate 5 continues to carry the most vehicles in the area, with combined volumes (general purpose, HOV, and express lanes, in both directions) frequently exceeding 200,000 vehicles per day. The four I-5 sites that are within the Seattle city limits all have volumes of this magnitude. For example, spot checks of average weekday volumes along I-5 north of Boeing Field show an average of almost 238,000 vehicles, while in downtown Seattle the volume is nearly 250,000 vehicles. Spot volumes on the Ship Canal bridge just north of downtown Seattle are even higher, at over 280,000 vehicles per weekday, while further north at the Seattle city limits at NE 145th, average weekday volumes continue to be high, with almost 179,000 vehicles. North of Seattle, volumes of over 135,000 vehicles per weekday can be observed at 128th Street SW approaching Everett, while south of Seattle, average weekday volumes are also significant, with over 213,000 vehicles per day near Sea-Tac airport. Of these total vehicle volumes, HOV lane volumes represent approximately 12 percent of all vehicles measured at the south Seattle site (S. Pearl Street), with a similar percentage recorded among vehicles measured at the north Seattle city limit (NE 145th Street). Further north (128th Street SW), HOVs are about 13 percent of all vehicles.

Table 2.1. Average Weekday Vehicle Volumes at Selected Freeway Locations (1999 estimates)

Cabinet	Location	General Purpose (GP) Lanes			High Occupancy Vehicle (HOV) Lanes			Reversible (REV) Lanes*			Total (GP+HOV+REV)
		Daily Vehicle Volume			Daily Vehicle Volume			Daily Vehicle Volume			
		NB/EB	SB/WB	Total GP	NB/EB	SB/WB	Total HOV	NB/EB	SB/WB	Total REV	
I-5											
55	S 184th St	103,400	91,600	195,000	9,000	9,300	18,300				213,300
88	S Pearl St	108,100	100,400	208,500	14,100	15,100	29,200				237,700
111	University St	102,600	110,100	212,700		9,900	9,900	17,100	9,200	26,300	248,900
130/128	Ship Canal Br.	110,100	116,600	226,700				32,100	22,700	54,800	281,500
143	NE 63rd St.	-	-	-	-	-	-	-	-	-	-
165	NE 137th St.	-	-	-	-	-	-	-	-	-	-
168/167	NE 145th St	80,900	77,000	157,900	9,200	11,800	21,000				178,900
213	128th St SW	58,100	60,000	118,100	8,900	8,200	17,100				135,200
I-405											
638	Sunset Blvd	52,300	43,800	96,100	11,900	11,300	23,200				119,300
662	SE 52nd St	56,900	54,500	111,400	12,800	15,000	27,800				139,200
696	NE 14th St	97,100	95,400	192,500	9,100	10,100	19,200				211,700
716	NE 85th St	67,100	69,000	136,100	9,100	8,800	17,900				154,000
740	NE 160th St	58,200	62,800	121,000	7,100	7,400	14,500				135,500
754	231st St SE	40,200	45,000	85,200	13,800	9,200	23,000				108,200
761	Damson Road	48,700	48,700	97,400							97,400
I-90											
855/854	Midspan	65,900	64,800	130,700				8,900	5,100	14,000	144,700
910	161st Ave SE	41,100	42,700	83,800	3,300	3,400	6,700				90,500
SR 520											
504	Montlake Blvd.	35,600	39,000	74,600							74,600
514/516(HOV)	76th Ave NE	52,800	55,500	108,300		2,600	2,600				110,900
544	NE 60th St	-	-	-	-	-	-	-	-	-	-
547	Marymoor Park	34,200	34,100	68,300							68,300
SR 167											
314	43rd St NW	49,700	46,200	95,900	6,300	7,800	14,100				110,000
330	S 204th St	49,900	49,400	99,300	7,800	7,800	15,600				114,900
338	S 23rd St	48,400	54,300	102,700	11,200	6,800	18,000				120,700

Notes

- Blue: New locations as of this report
- GP = General Purpose, HOV = High Occupancy Vehicle
- A blank entry indicates that there is no HOV or reversible lane in that direction at that location.
- A "-" indicates that data were unavailable this year because of construction or limited data collection.
- At University St. and 76th Ave NE, there is no NB or EB HOV lane, respectively.
- At University St., REV lanes include one HOV lane SB AM, and no HOV lanes NB PM. University St. SB HOV volumes combine HOV SB and HOV REV SB.
- Average weekday volumes use AASHTO aggregation method when sufficient data are available (bold). Otherwise, an average is used.
- I-90 midspan taken from west highrise (855/854).
- SR 167 from cabinets 330 to 338 based on Q3 1999 and Q4 1999 data only.
- I-405 at 231st St SE (cabinet 754) based on Q4 1999 data only.
- Reversible lane (REV) volumes are determined using 12:00 PM as transition time.

The reversible (express) lanes between Northgate and downtown Seattle carry approximately 19 percent of all vehicles on I-5 when measured at the Ship Canal bridge.

Traffic volume growth from 1997 to 1999 has been marginal in the central sections of I-5. Only in the far north end have measured volumes shown anything other than marginal changes in traffic volumes.¹ Volume increases in the north have approached 2 percent per year, while volumes through downtown Seattle have remained essentially constant.

The other dominant north-south facility in the region is Interstate 405 between Lynnwood and Tukwila. Weekday volumes increase as one approaches downtown Bellevue from the north or south. To the south, volumes are about 119,000 vehicles in Renton (Sunset Boulevard), increasing to 139,000 vehicles at SE 52nd Street, about a mile south of the Coal Creek Parkway SE interchange. In downtown Bellevue (NE 14th Street), volumes grow to over 211,000 vehicles per weekday. A similar pattern occurs north of Bellevue; volumes are over 97,000 vehicles near the Lynnwood I-5 interchange (Damson Road), increasing steadily to 135,000 vehicles south of the SR 522 interchange in Bothell, and about 154,000 vehicles in Kirkland (NE 85th). HOV lane volumes² vary along the corridor, with HOVs making up approximately 20 percent of all vehicles at spot measurement points south of I-90, about 9 percent of all vehicles near downtown Bellevue, about 11 percent of all vehicles at measurement points between SR 520 and SR 522, and over 20 percent near Canyon Park between SR 522 and the Swamp Creek interchange at I-5 near Lynnwood.

SR 167 is a significant north-south facility in the south part of the region, linking I-405 (at Renton) to Kent and Auburn, and continuing south to Puyallup. SR 167, also known as the Valley Freeway, has combined GP and HOV weekday volumes (both directions combined) that are comparable to the GP bridge volumes on SR 520, ranging from

¹In 1997, data were not available for the south end of I-5 because of construction activity that affected data collection. Consequently, it is not possible to discuss the growth of I-5 traffic south of Boeing Field. In addition, no detection equipment existed north of Lynnwood in 1997. Because of the growth in population in both Snohomish and Pierce counties, it is expected that traffic volumes on I-5 in these areas are increasing.

²During 1997 and 1998, WSDOT changed the location of HOV lanes on I-405. HOV lanes were moved from an outside lane configuration to the inside lane.

120,700 per weekday near I-405, to 110,000 north of Emerald Downs in Auburn. HOV lane volumes make up about 13 to 15 percent of all vehicle traffic.

Major East-West Facilities. The two major east-west facilities in the region are State Route 520 and Interstate 90. SR 520 includes the Governor Albert Rosellini Evergreen Point Floating Bridge, which carries about 111,000 vehicles per weekday (both directions combined). I-90 includes the Homer Hadley and Lacey Murrow (Mercer Island) floating bridges, which carry about 145,000 vehicles per weekday. Volumes on SR 520 at Montlake Boulevard west of the bridge are approximately 75,000. The vehicles using the Montlake Boulevard and Lake Washington Boulevard on- and off-ramps have significant effects on SR 520 traffic, as suggested by the difference in volume between the Montlake Boulevard interchange measurements and those a short distance away on the bridge (75,000 vs. 111,000). Continuing east on SR 520, volumes drop, but they are still significant by the time one reaches Marymoor Park in Redmond (volume patterns along this corridor are inconclusive because of construction activities that affected data collection between the bridge and Redmond). On I-90, bridge volumes are significantly higher than those on the SR 520 bridge; however, I-90 also has more general-purpose lanes than SR 520 (three GP lanes in each direction, compared to two GP lanes per direction on SR 520). I-90 also features a two-lane reversible center section, while SR 520 has a single westbound HOV lane³ that ends at the east approach to the bridge. Reversible lane volumes represent about 10 percent of all vehicles on the I-90 bridge.

Average Peak Vehicle Volumes

Tables 2.2 (general purpose lanes) and 2.3 (HOV lanes) summarize average peak-period and peak-hour vehicle volumes at selected freeway locations in the central Puget Sound area. As with the daily volumes, all peak volumes are year-long weekday averages and are based on 1999 data.

³Data on the level of use of new HOV lanes on SR 520 east of I-405 are not yet available because of ongoing construction activity during 1999.

Table 2.2. Average Weekday Peak GP Vehicle Volumes at Selected Freeway Locations (1999 estimates)

Cabinet	Location	Northbound (I-5/I-405/SR 167) or Eastbound (SR 520/I-90)						Southbound (I-5/I-405/SR 167) or Westbound (SR 520/I-90)						Combined GP Volume	
		AM Vehicle Volume			PM Vehicle Volume			AM Vehicle Volume			PM Vehicle Volume			Both Directions	
		Peak Period (6-9 AM)	Peak Period (Per Hour)	Peak Hour	Peak Period (3-7 PM)	Peak Period (Per Hour)	Peak Hour	Peak Period (6-9 AM)	Peak Period (Per Hour)	Peak Hour	Peak Period (3-7 PM)	Peak Period (Per Hour)	Peak Hour	AM Peak Period	PM Peak Period
	I-5														
55	S 184th St	22,300	7,433	7,900	21,700	5,425	6,000	14,700	4,900	5,600	29,600	7,400	9,000	37,000	51,300
88	S Pearl St	19,700	6,567	7,300	25,200	6,300	6,900	16,900	5,633	6,100	25,100	6,275	6,800	36,600	50,300
111	University St	17,800	5,933	6,300	23,800	5,950	6,200	19,200	6,400	6,800	25,800	6,450	6,800	37,000	49,600
111	University St, REV				8,900	2,225	2,400	5,100	1,700	1,700				5,100	8,900
130	Ship Canal Bridge	15,100	5,033	6,600	27,800	6,950	7,200	20,300	6,767	7,100	26,400	6,600	7,100	35,400	54,200
128	Ship Canal REV				18,400	4,600	5,300	15,000	5,000	5,700				15,000	18,400
143	NE 63rd St	-	-	-	-	-	-	-	-	-	-	-	-	-	-
143	NE 63rd St, REV														
165	NE 137th St	-	-	-	-	-	-	-	-	-	-	-	-	-	-
168/167	NE 145th St	9,900	3,300	3,900	23,800	5,950	6,300	16,000	5,333	5,700	16,600	4,150	4,300	25,900	40,400
213	128th St SW	10,000	3,333	3,800	14,800	3,700	3,900	11,500	3,833	4,200	14,900	3,725	4,100	21,500	29,700
	I-405														
638	Sunset Blvd	7,000	2,333	3,400	12,700	3,175	3,400	8,000	2,667	2,800	9,000	2,250	2,600	15,000	21,700
662	SE 52nd St	9,100	3,033	3,600	13,500	3,375	3,700	8,800	2,933	3,200	13,300	3,325	3,400	17,900	26,800
696	NE 14th St	14,300	4,767	5,600	25,000	6,250	6,500	19,800	6,600	7,100	20,800	5,200	6,000	34,100	45,800
716	NE 85th St	9,500	3,167	3,600	18,500	4,625	4,900	15,200	5,067	5,300	15,000	3,750	4,200	24,700	33,500
740	NE 160th St	8,200	2,733	3,100	16,100	4,025	4,500	13,300	4,433	5,100	14,100	3,525	3,900	21,500	30,200
754	231st St SE	5,800	1,933	2,300	10,600	2,650	2,900	8,500	2,833	3,500	10,700	2,675	2,900	14,300	21,300
761	Damson Road	7,600	2,533	2,700	14,600	3,650	3,900	9,200	3,067	3,500	12,400	3,100	3,400	16,800	27,000
	I-90														
855/854	Midspan	13,900	4,633	5,400	18,300	4,575	5,100	13,200	4,400	5,100	19,500	4,875	5,100	27,100	37,800
854	Midspan, REV				5,500	1,375	1,900	3,600	1,200	1,700				3,600	5,500
910	161st Ave SE	5,000	1,667	2,200	14,100	3,525	4,000	11,700	3,900	4,500	9,200	2,300	2,500	16,700	23,300
	SR 520														
504	Montlake Blvd.	6,300	2,100	2,400	8,600	2,150	2,300	7,200	2,400	2,600	9,600	2,400	2,400	13,500	18,200
514(GP)	76th Ave NE	9,900	3,300	3,600	12,900	3,225	3,300	9,700	3,233	3,500	14,100	3,525	3,600	19,600	27,000
544	NE 60th St	-	-	-	-	-	-	-	-	-	-	-	-	-	-
547	Marymoor Park	4,000	1,333	1,600	11,600	2,900	3,200	9,600	3,200	3,500	6,800	1,700	2,000	13,600	18,400
	SR 167														
314	43rd St NW	10,100	3,367	3,600	9,900	2,475	3,100	6,300	2,100	2,400	12,700	3,175	3,500	16,400	22,600
330	S 204th St	9,900	3,300	3,700	9,900	2,475	2,900	6,600	2,200	2,500	13,300	3,325	3,600	16,500	23,200
338	S 23rd St	7,900	2,633	3,300	10,300	2,575	2,900	8,100	2,700	2,900	13,200	3,300	3,600	16,000	23,500

Notes

- 1) Blue: New locations as of this report
- 2) GP = General Purpose, HOV = High Occupancy Vehicle
- 3) A blank entry indicates that there is no HOV or reversible lane in that direction at that location.
- 4) A "-" indicates that data were unavailable this year because of construction or limited data collection.
- 5) Boxed peak HOV values are outside the fixed peak periods (6:00-9:00 AM and 3:00-7:00 PM)
- 6) At University St. and 76th Ave NE, there is no NB or EB HOV lane, respectively.
- 7) At University St., REV lanes include one HOV lane SB AM, and no HOV lanes NB PM. University St. SB HOV volumes combine HOV SB and HOV REV SB.

Table 2.3. Average Weekday Peak HOV Vehicle Volumes at Selected Freeway Locations (1999 estimates)

Cab. #	Location	Northbound (I-5/I-405/SR 167) or Eastbound (SR 520/I-90)						Southbound (I-5/I-405/SR 167) or Westbound (SR 520/I-90)						Combined HOV Volume	
		AM Vehicle Volume			PM Vehicle Volume			AM Vehicle Volume			PM Vehicle Volume			Both Directions	
		Peak Period (6-9 AM)	Peak Period (Per Hour)	Peak Hour	Peak Period (3-7 PM)	Peak Period (Per Hour)	Peak Hour	Peak Period (6-9 AM)	Peak Period (Per Hour)	Peak Hour	Peak Period (3-7 PM)	Peak Period (Per Hour)	Peak Hour	AM Peak Period	PM Peak Period
I-5															
55	S 184th St	3,140	1,047	1,270	1,870	468	490	490	163	370	4,450	1,113	1,310	3,630	6,320
88	S Pearl St	3,620	1,207	1,430	3,800	950	1,070	1,620	540	800	5,100	1,275	1,450	5,240	8,900
111	University St							430	143	350	3,350	838	970	430	3,350
111	University St, REV							1,570	523	670					
130/128	Ship Canal Bridge														
130/128	Ship Canal Br. REV														
143	NE 63rd St	-	-	-	-	-	-	-	-	-	-	-	-	-	-
143	NE 63rd St REV	-	-	-	-	-	-	-	-	-	-	-	-	-	-
165	NE 137th St														
168/167	NE 145th St	340	113	220	5,200	1,300	1,510	4,020	1,340	1,550	2,430	608	640	4,360	7,630
213	128th St SW	660	220	420	3,770	943	1,040	1,650	550	620	2,470	618	720	2,310	6,240
I-405															
638	Sunset Blvd	2,890	963	1,130	3,120	780	850	1,390	463	610	4,250	1,063	1,170	4,280	7,370
662	SE 52nd St	3,600	1,200	1,420	3,080	770	890	1,710	570	740	5,710	1,428	1,580	5,310	8,790
696	NE 14th St	1,340	447	480	3,430	858	970	1,750	583	660	3,900	975	1,160	3,090	7,330
716	NE 85th St	790	263	340	4,440	1,110	1,260	2,680	893	1,100	2,300	575	680	3,470	6,740
740	NE 160th St	580	193	280	3,250	813	920	2,420	807	960	1,830	458	530	3,000	5,080
754	231st St SE	2,060	687	790	4,880	1,220	1,360	2,230	743	870	2,310	578	650	4,290	7,190
761	Damson Road														
I-90															
855/854	Midspan														
854	Midspan REV														
910	161st Ave SE	230	77	150	1,640	410	510	1,130	377	550	930	233	260	1,360	2,570
SR 520															
504	Montlake Blvd.														
516 (HOV)	76th Ave NE							340	113	170	1,330	333	400	340	1,330
544	NE 60th St	-	-	-	-	-	-	-	-	-	-	-	-	-	-
547	Marymoor Park														
SR 167															
314	43rd St NW	1,650	550	670	1,350	338	400	450	150	300	3,630	908	1,010	2,100	4,980
330	S 204th St	2,240	747	910	1,610	403	450	430	143	320	3,580	895	1,010	2,670	5,190
338	S 23rd St	3,360	1,120	1,280	2,240	560	660	400	133	280	3,070	768	860	3,760	5,310

- 8) Average weekday volumes use AASHTO aggregation method when sufficient data are available (bold). Otherwise, an average is used.
- 9) I-90 midspan taken from west highrise (855/854).
- 10) SR 167 from cabinets 330 to 338 based on Q3 1999 and Q4 1999 data only.

- 11) I-405 at 231st St SE (cabinet 754) based on Q4 1999 data only.
- 12) Reversible lane (REV) volumes are determined using 12:00 PM as transition time.

Major North-South Facilities. As with the daily traffic volumes, I-5's peak period volumes are among the highest in the area. Spot volumes within the Seattle city limits (including reversible lanes when available) ranged from over 30,000 to over 50,000 vehicles during the three-hour morning peak period (10,000 to 16,800 vehicles per hour), and from about 48,000 to over 72,000 vehicles during the four-hour afternoon peak period (12,000 to 18,100 vehicles per hour). Peak period volumes remain high to the south of Seattle as well; the peak period volumes measured south of Southcenter near Sea-Tac are comparable to those north of Boeing Field. Measurements at the Ship Canal bridge indicate that the reversible express lanes carry over 42 percent of southbound morning peak period traffic, and about 39 percent of northbound afternoon peak period traffic.

On Interstate 405, peak period volumes are generally not as high as those on Interstate 5 in the Seattle area. Outside of downtown Bellevue, spot measurements ranged between 16,800 and 28,100 vehicles in the morning peak period (5,600 to 9,300 vehicles per hour), and from 27,000 to 40,200 in the afternoon peak period (6,700 to 10,000 vehicles per hour). Downtown Bellevue does have peak period volumes comparable to those on sections of Interstate 5, with over 37,000 vehicles in the morning peak period (12,300 per hour) and 53,000 vehicles in the evening peak period (13,200 per hour).

Spot measurements on SR 167 (the Valley Freeway) indicate AM peak period volumes of 18,500 to 19,800 vehicles (6,100 to 6,600 per hour) and PM peak period volumes of about 27,600 to 28,800 vehicles (6,900 to 7,200 per hour). These peak period volumes are comparable to corresponding volumes on SR 520 as well as parts of I-405.

Major East-West Facilities. The Evergreen Point Floating Bridge on SR 520 carries about 20,000 vehicles during the AM peak period (both directions), and about 28,300 vehicles during the PM peak period (6,600 per AM hour and 7,000 per PM hour). In the morning, the westbound volume is about the same at the bridge as it is at Redmond, while eastbound the volume in the Redmond area represents a drop of almost 60 percent in comparison to the bridge volume. In the afternoon, the situation is nearly reversed, with eastbound volumes dropping only about 10 percent between the bridge and Redmond, while westbound volumes more than double between Redmond and

the bridge. At the west end of SR 520, traffic entering and exiting at Lake Washington Boulevard and especially Montlake Boulevard (which serves the University of Washington campus) has a significant effect on SR 520 traffic. In the morning, about 25 percent (2,500 vehicles) of the westbound traffic exits at those two locations, while eastbound mainline traffic increases by about 57 percent (3,600 vehicles) as a result of traffic entering from those two locations. In the evening peak period, the situation is similar; eastbound traffic increases by 50 percent because of entering traffic from the two locations, and westbound traffic decreases over 30 percent from traffic exiting there.

Interstate 90 volumes at the floating bridge are about 30,700 during the AM peak period, and about 43,300 during the PM peak period (about 10,200 per AM hour and 10,800 vehicles per PM hour). Both volumes are significantly higher than the corresponding volumes on SR 520's floating bridge. This is in part a reflection of the increased capacity of the I-90 facility, which features eight lanes total (three GP lanes per direction, and two center reversible lanes), in comparison to the four lanes (two GP lanes per direction) of SR 520. The reversible lanes on the I-90 bridge, which include HOVs and Mercer Island traffic, carry 21 percent of westbound AM peak period bridge traffic and 23 percent of eastbound PM peak period bridge traffic.

Section 3. System Performance: Freeway Corridors

The previous section described the **level of use** of freeway facilities in the urban central Puget Sound region at selected locations, presenting summary values such as average weekday volumes to provide an overall measure of comparative traffic conditions. Beginning with this section, we shift our focus to the **performance** of the system, presenting a range of measures of personal mobility that focus on the traffic conditions freeway travelers experience.

This report describes system performance in two ways: by corridor (e.g., I-405) and by location (e.g., I-405 at NE 8th Street). In this section, summary measures of corridor-wide performance will be presented, in the form of average 24-hour traffic congestion patterns as a function of location along a corridor, the frequency of heavy congestion along the corridor, and average travel time, travel time variability, and frequency of congestion along selected trip routes. These measures are top-level views of freeway system performance that help to explain 1) how traffic conditions vary with location, and 2) how these conditions can affect a freeway trip. In section 4, traffic performance at specific locations will be analyzed. The principal performance measures used to evaluate traffic performance at a given location include traffic volume, estimated average speed, and congestion frequency; each is described as a function of time of day, direction of travel, and type of lane (general purpose or HOV).

How Freeway Corridor Performance Was Measured

Five measures of freeway corridor performance were used. These are listed below and are explained more fully in example graphs presented later.

Average Traffic Congestion Levels, by Time of Day and Location

To better understand how traffic conditions change as vehicles travel along the freeway network, the researchers measured general purpose lane congestion patterns at different points (mileposts) along each study corridor on each of the 261 weekdays of

1999. All the weekday data were then combined to produce an image of the “routine” traffic conditions along each corridor during an average 24-hour weekday.

Congestion Frequency, by Time of Day and Location

While average traffic congestion levels are useful, they do not describe the degree to which conditions can vary from that average condition. In particular, it is helpful to understand the frequency with which “bad” traffic conditions occur. Congestion frequency refers to the likelihood that significantly congested traffic will occur at a particular location and time of day, based on data from the entire year; this information is then combined into a summary image for each corridor during a 24-hour weekday.

Average Trip Travel Times, by Trip Start Time

Travel times are another measure of corridor-wide freeway performance. This measure is particularly useful for conveying corridor congestion because it is in a form that is readily understood and that individual travelers can compare to their own experiences. For this report, travel times were estimated for 18 trips (9 routes, traveling in both directions) that traverse one or more corridors in the central Puget Sound area, for a range of trip start times throughout an average 24-hour weekday. The routes of these hypothetical freeway trips were chosen to reflect the freeway portion of typical commuting and non-commuting (e.g., errands) travel in the region; each trip links major residential, employment, or other business centers. The resulting average general purpose lane travel times are based on data from the 261 weekdays during 1999.

90th Percentile Trip Travel Times, by Trip Start Time

While the average travel time is a useful barometer of trip performance, it is also helpful to understand the degree to which travel times can vary from that average. For this

reason, for each trip the 90th percentile weekday general purpose lane travel times were estimated for a range of trip start times throughout an average 24-hour weekday. A 90th percentile travel time of, for example, 30 minutes, would indicate that nine times out of ten (i.e., 90 percent of the time) a trip's travel time would be 30 minutes or less, based on 1999 data. The difference between the average trip time and the 90th percentile trip time can be thought of as an indicator of the variability or reliability of travel along the facility.

Frequency of “Slow” Trips, by Trip Start Time

Another useful indicator of travel variability on a given trip is the likelihood of a “slow” trip as measured by the average trip speed. This measurement provides the estimated likelihood (percentage of times) that the average overall trip speed would be below 35 mph for a given trip start time. For example, a frequency of 50 percent for a trip starting at 5:00 PM would mean that 50 percent of the time, a trip starting at 5:00 PM would have an average overall speed of 35 mph or less, based on the total trip time.

Where Freeway Corridor Performance Was Measured

Corridor performance was measured along all the corridors in the study area. This includes I-5 from South 184th Street near Sea-Tac to SR 526 in Everett; I-405 from Tukwila to Swamp Creek; SR 520 from Seattle to Bellevue Way (the remainder of SR 520 was not analyzed because of a lack of available data); SR 167 from Auburn to Renton; and I-90 from Seattle to Issaquah.

Results: Average Traffic Congestion Patterns, by Facility

In this section the average traffic congestion patterns for each corridor are discussed. The discussion begins with a brief explanation of how to read the corridor congestion pattern maps.

How to Read Corridor Congestion Maps

To better understand how traffic conditions change as vehicles travel from one location

to another on the freeway network, the researchers developed corridor maps showing general purpose lane congestion patterns at different points (mileposts) along the corridor during an average 24-hour weekday. (Thus, on some days conditions are much better than those illustrated, and on others they can be much worse.) Each map is presented in a contour format similar to that of a topographic or elevation map, with colors that indicate relative levels of congestion as a function of time of day and location (milepost) along a freeway corridor. Alongside each graph is a map of the freeway corridor with the approximate locations of major cross-streets.

Figure 3.1 shows a slice of a typical traffic congestion map for the southbound general purpose lanes on I-5 at the Ship Canal Bridge just north of downtown Seattle (mileposts 169 to 168). Vertically, the graph represents the length of the bridge. Horizontally, the graph shows a 24-hour day, from midnight to midnight. This example traffic profile represents average weekday traffic conditions based on data collected every 5 minutes during approximately 261 weekdays in 1997.

The colors on the profile represent congestion as follows:

- green means that traffic generally moves at or near the speed limit under uncongested, free-flow conditions
- yellow means that travelers encounter borderline traffic conditions with more restricted movements (for example, lane changing difficulties), but still travel near the speed limit
- red is more heavily congested traffic traveling perhaps between 45 and 55 mph
- blue is very congested, unstable traffic that ranges from stop and go to approximately 45 mph.

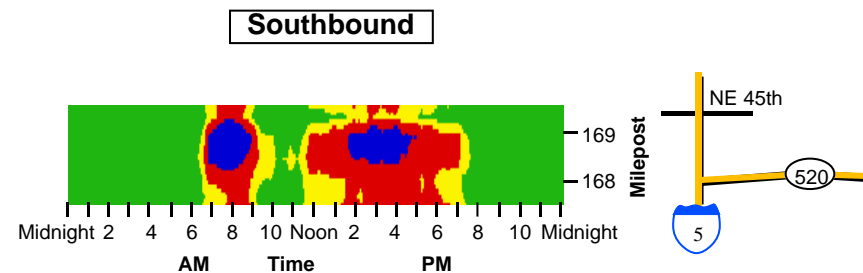


Figure 3.1. Traffic Profile: Southbound I-5 Ship Canal Bridge

Studying this portrait of the Ship Canal Bridge (southbound) shows that, on average, from midnight to about 6:30 AM traffic flows freely. This is followed by a brief period of rapidly increasing congestion (yellow to red to blue), so that by 7:00 AM traffic is very congested and may well be nearly stopped.

This congestion is a reflection of the increasing number of cars approaching the Ship Canal Bridge from farther up the freeway, and cars merging onto the freeway from the NE 50th and NE 45th Street on-ramps just north of the bridge. Notice that the worst traffic congestion (blue) is at the north end of the bridge near the NE 45th Street on-ramp, whereas at the south end of the bridge, which offers an exit to SR 520, traffic moves more freely. (As SR 520 traffic merges with I-5 southbound traffic, just south of where this picture ends, I-5 becomes more congested again.)

The high congestion level lasts until about 8:45 AM, after which traffic slowly clears out until about 10:00 AM. There is a brief period of freely flowing traffic, but the congestion build-up and slow-downs begin again about 11:30 AM. This congestion pattern continues until about 7:00 PM. By 8:00 PM traffic is free flowing once again.

The following are summary descriptions of each corridor congestion map shown in figures 3.2 through 3.8. Note that these maps show the estimated routine weekday congestion levels on **general purpose lanes** only. HOV lanes, collector-distributor lanes, and express/reversible lanes are not included.

North I-5 (Downtown Seattle to South Everett)

Overall: Between Everett and Northgate, southbound congestion tends to be heaviest in the AM peak period, while northbound congestion tends to occur during the PM peak period. Between Northgate and downtown Seattle, however, congestion in both directions tends to occur at various times throughout the day; in particular, southbound traffic in this section of I-5 tends to experience moderate to heavy congestion throughout much of the day, especially approaching the University District, Ship Canal bridge, and the SR 520 interchange. See Figures 3.2 and 3.3.

Northbound: Beginning in the midafternoon and continuing through the PM peak period, moderate to heavy congestion extends north from downtown Seattle past the I-

405 (Swamp Creek) interchange up to Everett, with the heaviest congestion occurring from Seattle up to and past NE 175th Street near the county line.

Southbound: In the morning, southbound congestion is moderate to heavy along much of this corridor segment beginning near Mill Creek and continuing south to downtown Seattle. Even after the AM peak period, southbound congestion persists to varying degrees along the corridor. Southbound traffic between Northgate and the approach to the SR 520 interchange is at least moderately congested during much of the day beginning approximately 6:30 AM, with a short respite during the midmorning after the AM peak period. As the afternoon progresses, traffic congestion again builds to moderate or heavy levels between Northgate and SR 520, and during the PM peak hours, the heaviest congestion often continues past SR 520 into downtown Seattle.

South I-5 (Tukwila to Downtown Seattle)

Overall: A frequent area of traffic is the section between downtown Seattle and Boeing Field, which has moderate to heavy congestion throughout much of the day in both directions (see Figure 3.3).

Northbound: In the morning, northbound congestion is moderate to heavy at Southcenter Hill near Tukwila, then builds again starting near the Boeing Access Road, becomes heavier past Boeing Field, and continues into downtown Seattle. In fact, northbound congestion is moderate to heavy north of Boeing Field to Seattle throughout much of the day (approximately 6:30 AM to 6:30 PM).

Southbound: Southbound congestion is moderate from downtown Seattle past the exit to the West Seattle Bridge throughout the day (approximately 6:00 AM to 7:00 PM). During the PM peak hours congestion builds approaching the Boeing Access Road, and again on the Southcenter hill at Tukwila, south of the I-405 interchange.

North I-405 (I-90 Interchange to Swamp Creek)

Overall: The north part of I-405 (Figure 3.4) is an example of what was formerly considered a typical commute pattern, namely a “tidal” pattern in which traffic moves predominantly in one direction in the morning and in the opposite direction in the

evening. In this case, congestion builds in the southbound direction during the morning, and then in the northbound direction in the evening. (Note: Analysis of traffic patterns between milepost 26 near Canyon Park and the Swamp Creek interchange at I-5 Lynnwood is not conclusive because of a lack of available data.)

Northbound and Southbound: Traffic is highly directional on I-405 north of SR 520, with moderate to heavy congestion southbound throughout the AM hours from 6:00 AM to about 10:00 AM, and moderate to heavy congestion northbound during the PM hours from about 3:00 PM to 7:00 PM. Congestion tends to be focused on the AM and PM peak hours; during that time, congestion extends along most of the north I-405 corridor segment. The segment between I-90 and the SR 520 interchange in the vicinity of downtown Bellevue is an area of persistent moderate or heavy congestion throughout much of the day.

South I-405 (Tukwila to I-90 Interchange)

Overall: Like the north part of I-405, the south section of I-405 between I-5 (Tukwila) and the I-90 interchange exhibits a tidal pattern of traffic congestion, though in the reverse direction, i.e., northbound in the morning, southbound in the afternoon. The tidal pattern is less clear in this case, however, because the peak period congestion tends to be of a somewhat longer duration, and varying degrees of congestion tend to persist at different times and locations throughout the day in both directions. (See Figure 3.5.)

Northbound and Southbound: Northbound traffic is generally heavily congested during the AM peak hours from about 6:00 AM to 10:00 AM between SR 167 and I-90, and also during much of the afternoon between SR 167 and the Kennydale hill area. Southbound traffic is also routinely congested in the afternoon between I-90 and SR 167. One area of persistent moderate or heavy congestion throughout much of the day is the segment between I-5 (at Tukwila) and the SR 169 interchange (Maple Valley Highway) in both directions.

SR 520 (I-5 to Redmond)

Overall: While routine heavy congestion exists at the approaches to the bridge deck

from both directions during both morning and afternoon peak periods, the congestion patterns are notably strong heading east in the morning and west in the afternoon, reflecting a strong “reverse” commute pattern on this facility. (See Figure 3.6.) NOTE: Because of extensive construction activity that affected data collection, 1999 data were not available east of Bellevue Way. Therefore, the data presented focus on the floating bridge and its approaches.

Eastbound: Congestion is moderate to heavy on the eastbound approach to the bridge from about 7:00 AM until about 10:00 AM. Congestion eases somewhat during midday hours, then builds again starting approximately 1:30 PM, reaching another congested period from about 3:00 PM to after 6:00 PM. Eastbound congestion approaching the bridge is worse in the morning than in the afternoon; note also that eastbound ramp meters on the Lake Washington and Montlake Boulevard on-ramps near the west approach to the bridge are not operated in the morning, while they are used in the afternoon.

Westbound: Congestion is heavy on the westbound approach to the bridge during the peak periods, with an extended period of heavy afternoon congestion approaching the bridge from approximately 3:30 PM to 7:30 PM.

I-90 (Downtown Seattle to Issaquah)

Overall: Heavy congestion on I-90 focuses on the AM and PM peak periods, and is relatively brief in comparison to other facilities in the region. There is generally little off-peak congestion (Figure 3.7). As with SR 520, there is a noticeable “reverse” commute volume on this facility, particularly in the westbound direction in the afternoon and early evening, where moderate to heavy congestion starts on the approach to the East Channel bridge and continues across Mercer Island to the main bridge deck.¹

Eastbound and Westbound: Congestion is generally moderate and limited to the peak period hours in either direction. In the morning, moderate westbound congestion runs along nearly the entire corridor, while eastbound congestion dissipates east of

¹The milepost reference numbering system used with I-90 data was updated in 1999, with the most significant numbering changes occurring on the segment between the I-5 interchange and Eastgate. Any comparisons based on data from before 1999 should take this numbering update into account.

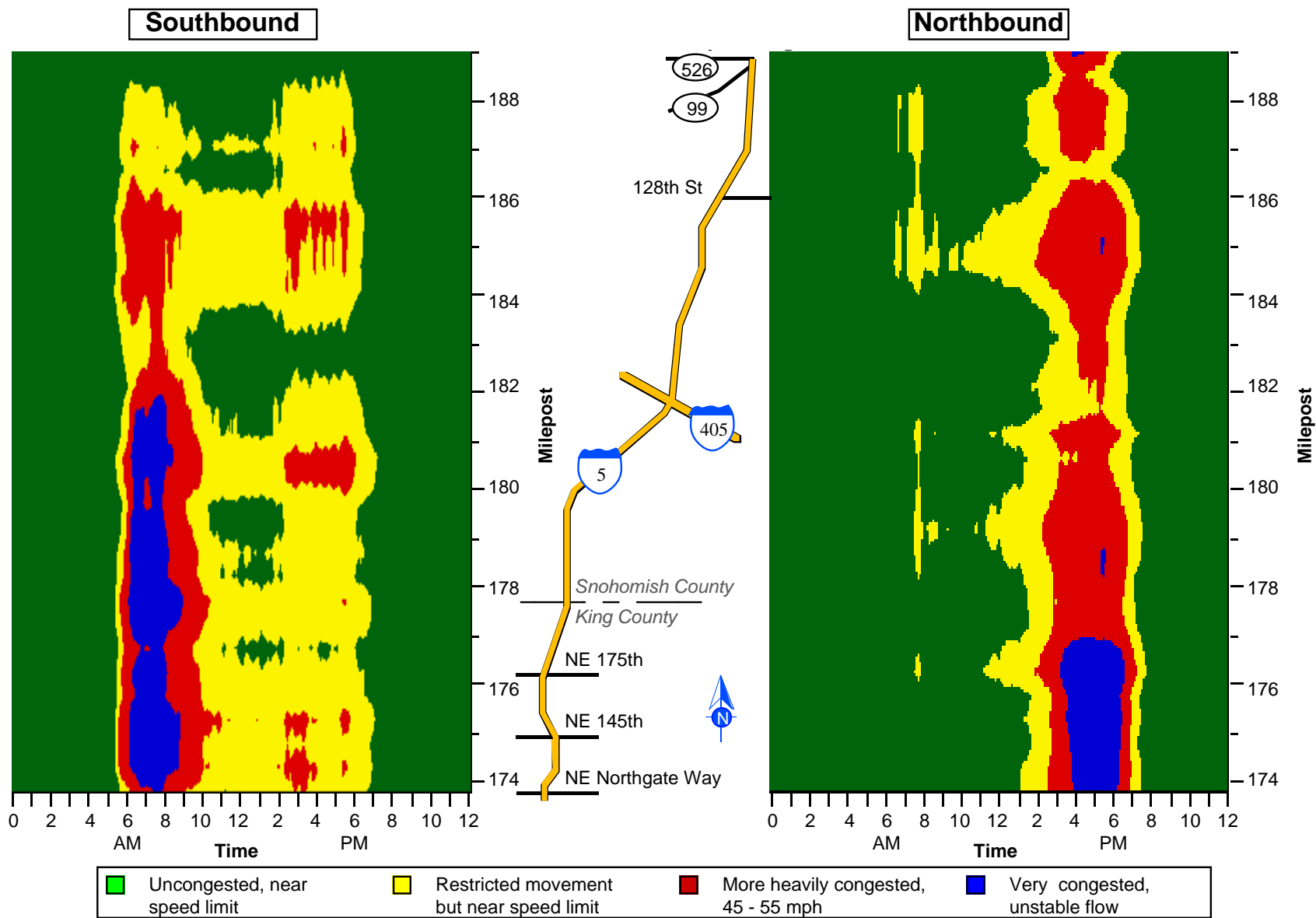


Figure 3.2. Interstate 5 North Traffic Profile: General Purpose Lanes, 1999 Weekday Average

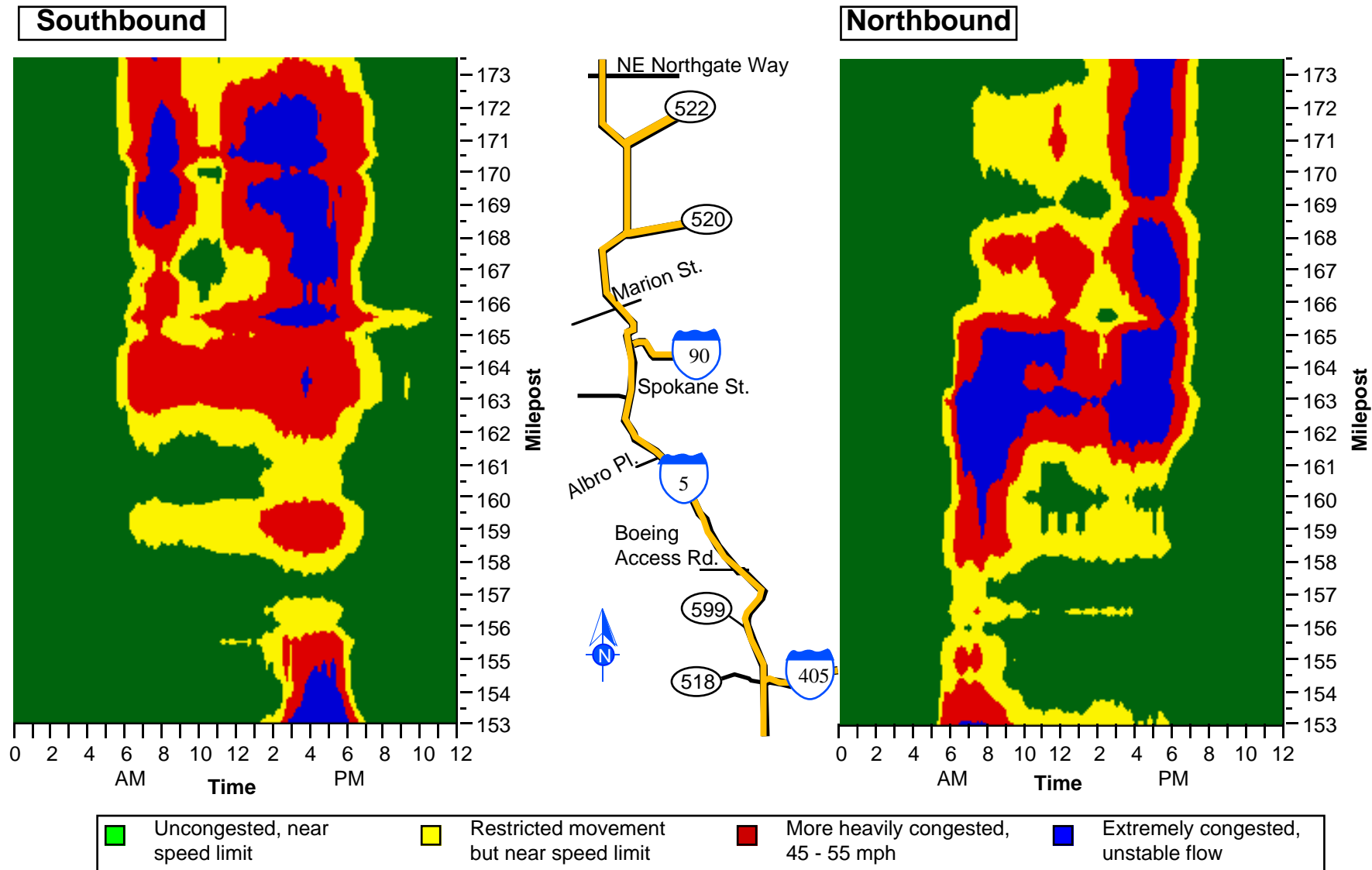


Figure 3.3. Interstate 5 South Traffic Profile: General Purpose Lanes, 1999 Weekday Average

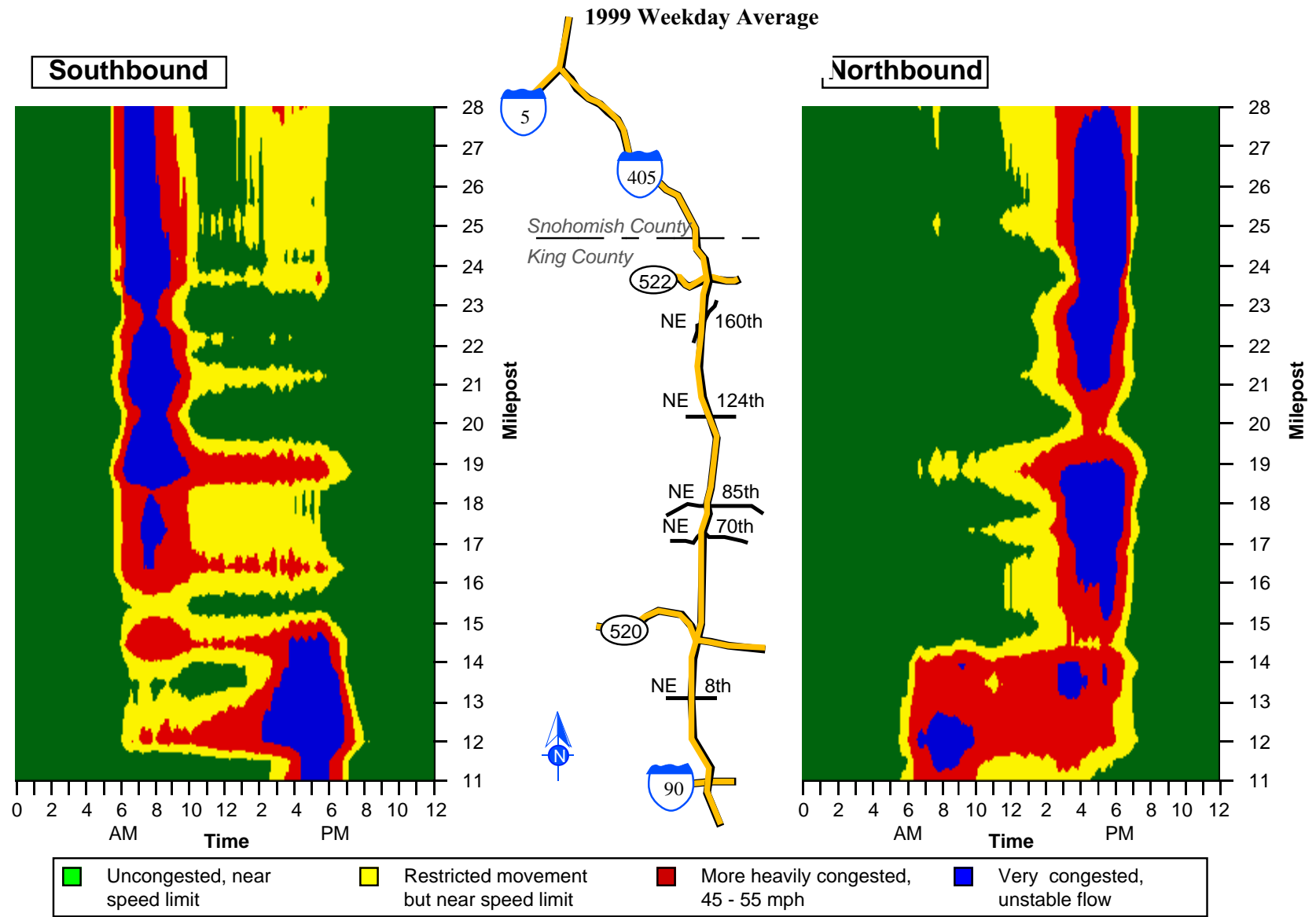


Figure 3.4. Interstate 405 North Traffic Profile: General Purpose Lanes, 1999 Weekday Average

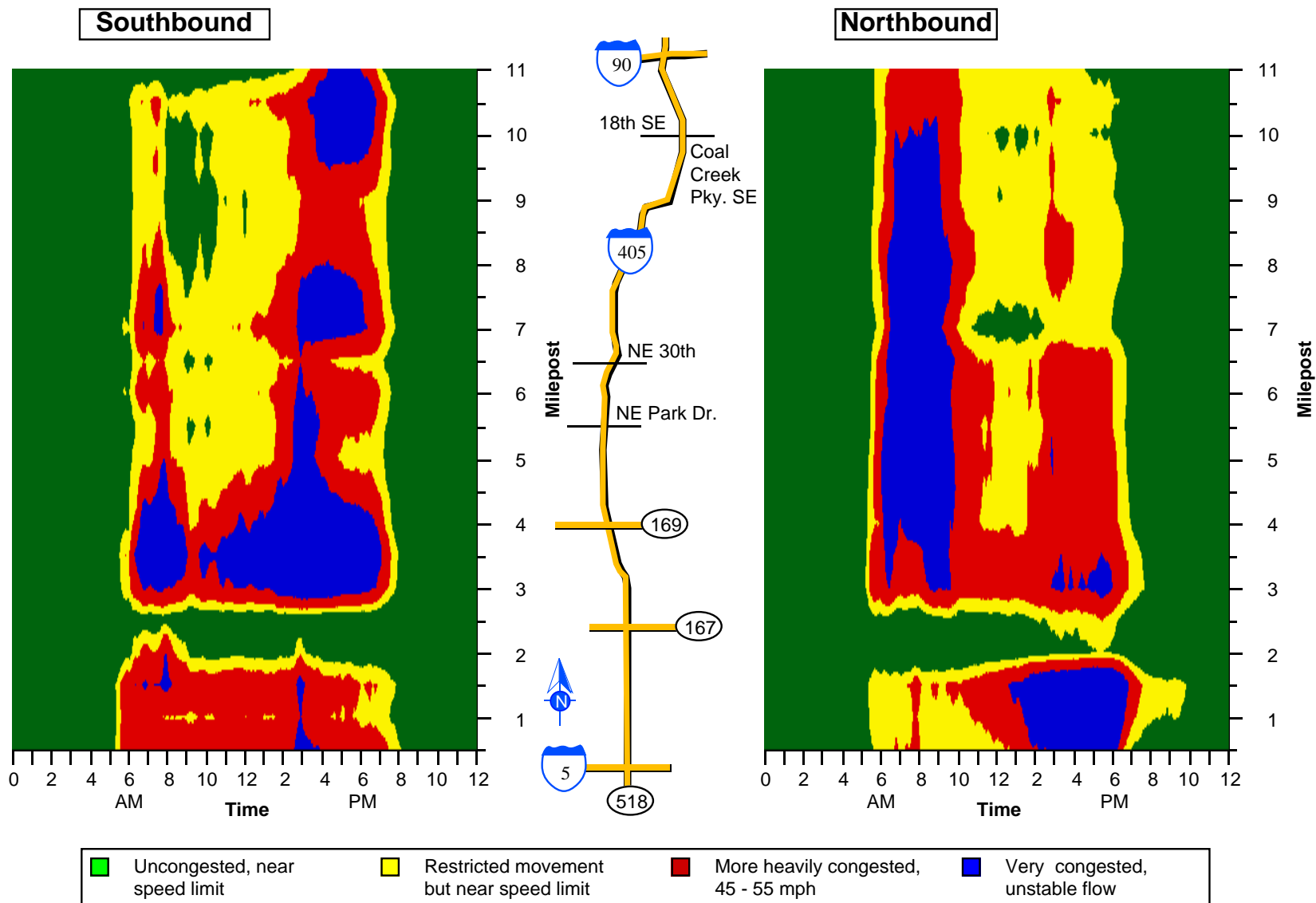


Figure 3.5. Interstate 405 South Traffic Profile: General Purpose Lanes, 1999 Weekday Average

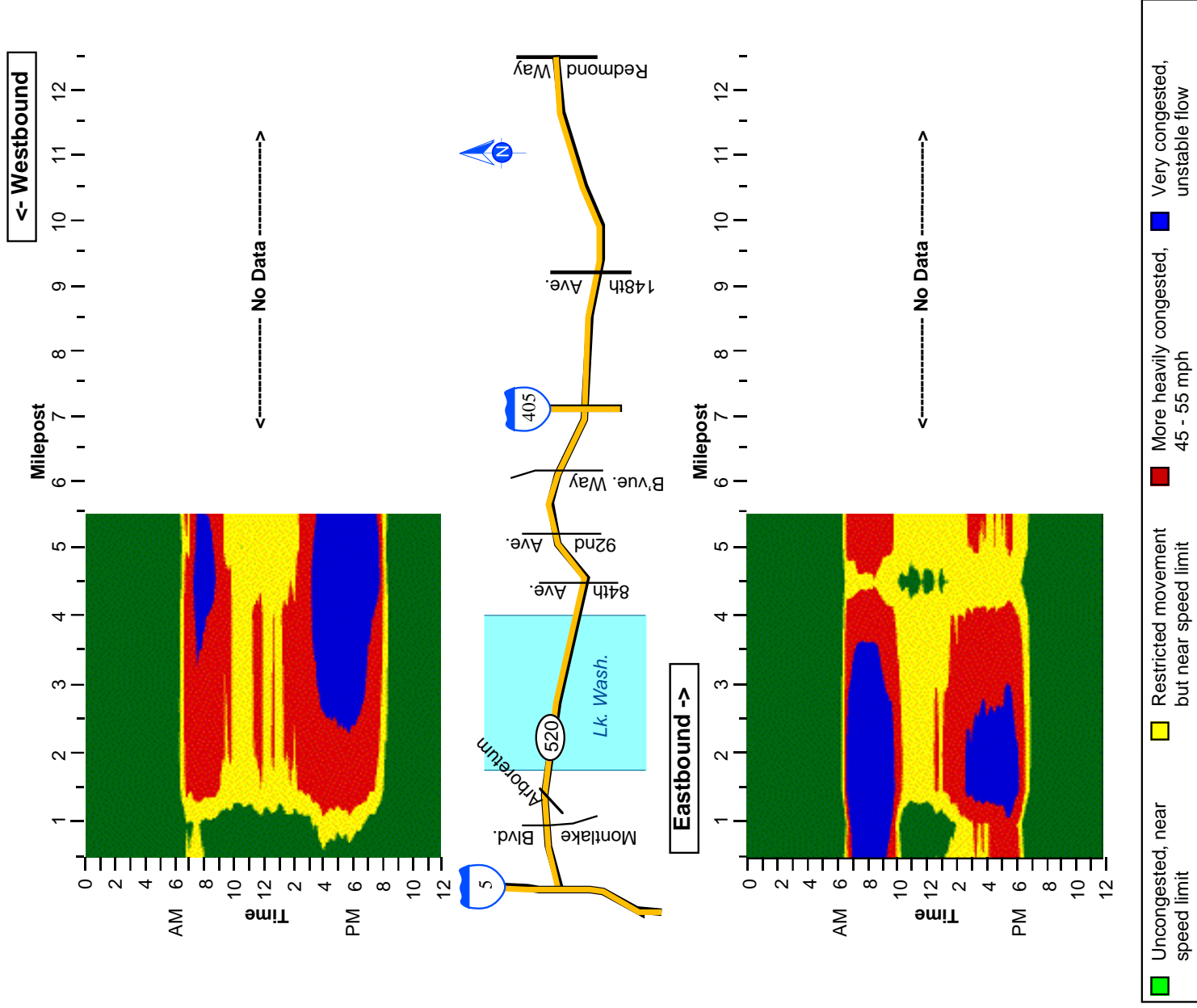


Figure 3.6. State Route 520 Traffic Profile: General Purpose Lanes, 1999 Weekday Average

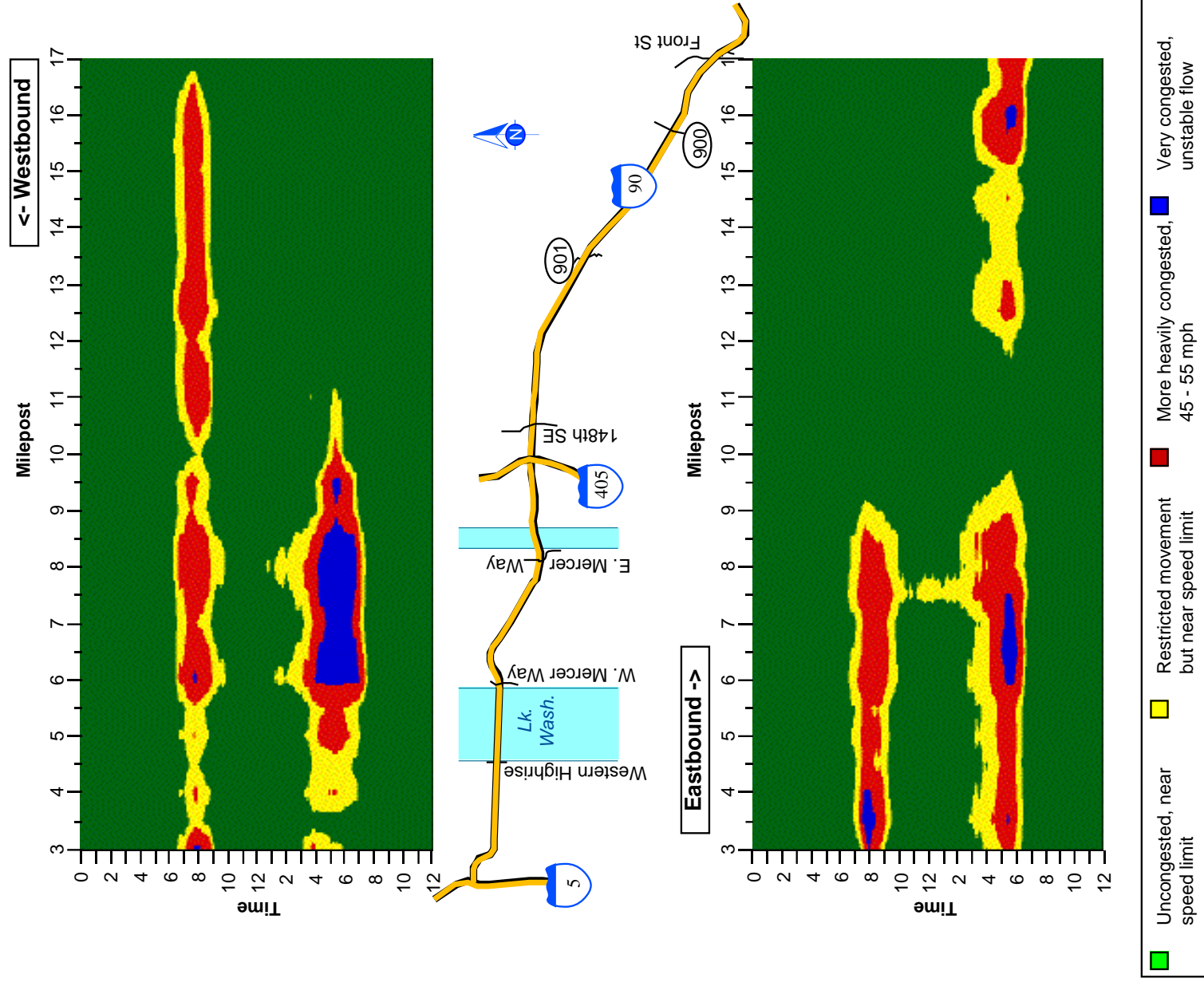


Figure 3.7. Interstate 90 Traffic Profile: General Purpose Lanes, 1999 Weekday Average

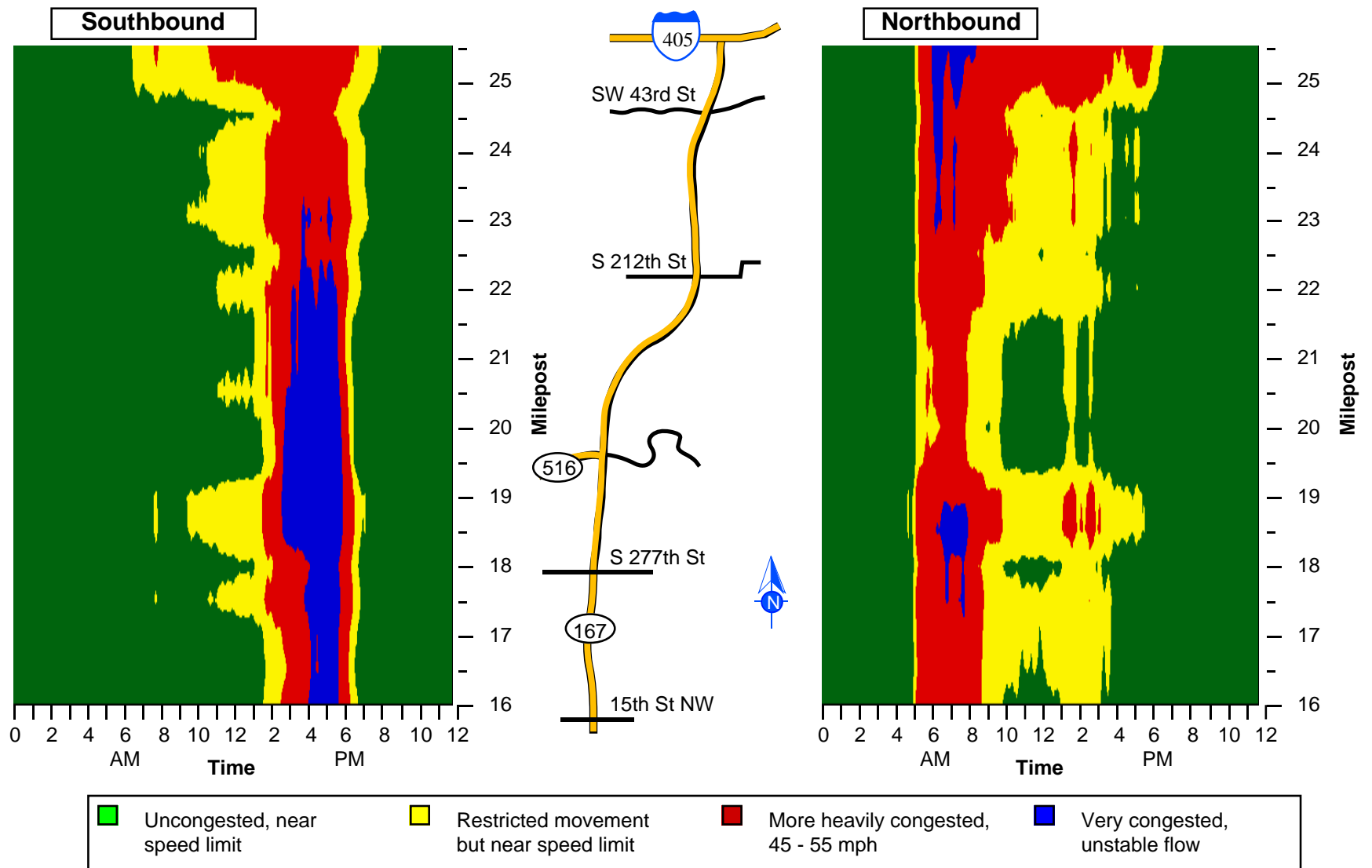


Figure 3.8. State Route 167 Traffic Profile: General Purpose Lanes, 1999 Weekday Average

Mercer Island. In the afternoon, westbound congestion is moderate to heavy from I-405 across Mercer Island to the bridge deck from approximately 4:00 PM to 7:00 PM, while eastbound traffic is moderate to heavy from Seattle to Mercer Island, eases from I-405 through the Eastgate area, then becomes moderately congested again approaching Issaquah from about 4:00 PM to 6:30 PM.

SR 167 (Auburn to Renton)

Overall: Congestion on SR 167 shows a strong “tidal” pattern, appearing primarily northbound in the morning and southbound in the afternoon. (See Figure 3.8.) The peak periods of congestion on SR 167 can extend 3 to 4 hours, depending on location.

Northbound and Southbound: Northbound congestion is heavy in the morning along most of the corridor, beginning about 5:30 AM and extending through much of the AM peak period. Southbound congestion is heavy in the afternoon from about 2:00 PM to 6:30 PM along nearly the entire corridor, with especially heavy congestion during the afternoon peak hours from South 212th Street in Kent to the SR 18 interchange in Auburn. The section of SR 167 near I-405 tends to be moderately to heavily congested in both directions (particularly northbound) throughout much of the day.

Results: Congestion Frequency, by Time of Day and Location

In this section the congestion frequency patterns for each corridor are discussed. The discussion begins with a brief explanation of how to read the congestion frequency pattern maps.

How to Read Congestion Frequency Maps

To better understand the likelihood of encountering significant traffic congestion as vehicles travel from one location to another on the freeway network, the researchers developed corridor maps showing general purpose lane congestion frequency patterns at different points (mileposts) along the corridor during a 24-hour weekday. The format is similar to the average congestion pattern maps that were discussed earlier, i.e., each map is presented in a contour format similar to that of a topographic or

elevation map, except that in this case the colors indicate the relative frequency of significant congestion (rather than average congestion conditions) as a function of time of day and location (milepost) along a freeway corridor. Alongside each graph is a map of the freeway corridor with the approximate locations of major cross-streets.

Figure 3.9 shows a slice of an example congestion frequency map for the southbound general purpose lanes on I-5 at the Ship Canal Bridge just north of downtown Seattle (mileposts 169 to 168). Vertically, the graph represents the length of the bridge. Horizontally, the graph shows part of a 24-hour day, from 6:00 AM to 8:00 PM. This example traffic profile represents average weekday traffic conditions, based on data collected every 5 minutes during 261 weekdays in 1999.

The colors on the profile represent the likelihood of encountering heavy congestion as follows:

- light gray means that traffic at that time and location is significantly congested less than 20 percent of the time (i.e., no more than one weekday per week, on average)
- dark gray means that traffic at that time and location is significantly congested 20 to 40 percent of the time (i.e., one to two weekdays per week, on average)
- light blue means that traffic at that time and location is significantly congested 40 to 60 percent of the time (i.e., two to three weekdays per week, on average)
- dark blue means that traffic at that time and location is significantly congested 60 to 80 percent of the time (i.e., three to four weekdays per week, on average)
- black means that traffic at that time and location is significantly congested 80 to 100 percent of the time (i.e., four to five weekdays per week, on average).

In this example of the Ship Canal Bridge, heavy congestion is not likely to be encountered until about 6:30 AM, as indicated by the light gray color. By about 7:00 AM, however, the likelihood of encountering significant congestion in the north part of the bridge has increased to a 60 to 80 percent chance (three to four weekdays per week), as indicated by the dark blue. The likelihood of heavy congestion stays high until about 8:30 AM on the north part of the bridge, and moderate (two to three weekdays per

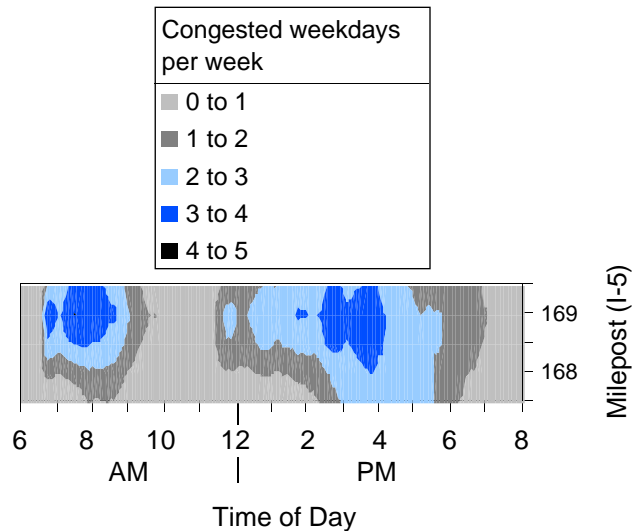


Figure 3.9. Congestion Frequency Profile: Southbound I-5 Ship Canal Bridge

week, or light blue) on the south part of the bridge. This higher likelihood of congestion at the north end of the bridge reflects the combination of increasing volumes of vehicles arriving at the Ship Canal from the north, and vehicles entering the freeway at the NE 45th and NE 50th street on-ramps, which are just upstream from the Ship Canal bridge. Congestion on the south end of the bridge is affected by traffic at the SR 520 interchange as well as the geographic extension of congestion approaching the downtown Seattle core.

From around 9:30 AM to 11:30 AM, heavy congestion is infrequent; however, another period of increasing congestion frequency begins to build starting around 11:30 AM. By 2:30 PM, the likelihood of encountering congestion on the bridge is moderate to high again and stays that way for several hours; the chances of traveling in significant congestion remain moderate (a 40 to 60 percent chance) the rest of the afternoon until around 5:30 PM, then gradually decrease until about 7:00 PM. After 7:00 PM the likelihood of significant congestion on the bridge returns to no more than 20 percent.

It is not uncommon that an area that shows heavy average congestion will also have a

moderate to high frequency of heavy congestion. For example, a location and time period on the average congestion contour map that is blue (heavy congestion) is also likely to be an area with a moderate to high frequency of heavy congestion on the congestion frequency contour map (light blue to dark blue). Examples of such areas include roadway sections affected by bottlenecks or other recurring congestion problems. However, more moderate conditions on the average congestion map may not be similarly highlighted on the congestion frequency map because of differences in day-to-day congestion patterns. For example, an area could have moderate average congestion as a result of either relatively constant moderate day-to-day traffic patterns or significant variations from one day to the next that happen to average to a moderate condition. The latter highly variable pattern, indicative of a roadway section frequently impacted by such occurrences as accidents or other incidents, would trigger a higher frequency of heavy congestion than the former steady pattern, even though both conditions might lead to the same average condition. The congestion frequency identifies the degree to which significant congestion is likely at certain times and locations and is a measure of the uncertainty of good travel performance. It can thus be considered an indicator of the “reliability” of good travel performance in that area.

The following are summary descriptions of the corridor congestion frequency maps shown in Figures 3.10 through 3.16. Note that these maps show the estimated likelihood of encountering significant weekday congestion on **general purpose lanes** only. HOV lanes, collector-distributor lanes, and express/reversible lanes are not included.

NOTE: The following describe the likelihood of encountering “significant” or heavy congestion (where “significant” is defined as Level of Service F, or unstable traffic speeds) at different locations and times. It is important to keep in mind, however, that the typical traveler may perceive the onset of congestion at a different threshold. For example, a traveler might feel that any freeway speed that is less than the speed limit “feels” like heavy congestion and might therefore believe that he or she experiences congestion more frequently than indicated by the following analysis.

North I-5 (Downtown Seattle to South Everett) Congestion Frequency

Northbound: Figures 3.10 and 3.11 show that on I-5 north of downtown Seattle, the chances of encountering heavy northbound congestion are highest during the afternoon commute period beginning about 3:30 PM and extending to about 6:30 PM, in the area from downtown Seattle north to NE 185th Street, approaching the county line. The likelihood of traveling in congestion in this area ranges from moderate to very high.

Southbound: Figures 3.10 and 3.11 show that the chances of encountering heavy southbound congestion are highest during the morning commute period beginning shortly after 6:00 AM and continuing to about 9:00 AM, in the area from the I-405 interchange at Swamp Creek south to Northgate, and also from near the Ship Canal bridge to downtown Seattle. The likelihood of traveling in congestion in this area ranges from moderate to high (a 40 to 80 percent chance). There is also a moderate to high likelihood of encountering heavy southbound congestion in the afternoon from Northgate through downtown Seattle to I-90.

South I-5 (Tukwila to Downtown Seattle) Congestion Frequency

Northbound: Figure 3.11 shows that on I-5 south of downtown Seattle, there is a moderate to high likelihood of encountering heavy northbound congestion starting about 6:30 AM as one approaches downtown Seattle, particularly between Boeing Field and downtown Seattle. Near the West Seattle Bridge and Spokane Street, there is a very high likelihood of encountering heavy congestion. Between Boeing Field and I-90, the chances of traveling in congestion are moderate to high throughout much of the day, with a respite in the early afternoon.

Southbound: South of downtown Seattle, the likelihood of southbound traffic encountering heavy congestion is highest near the Southcenter hill in the PM peak period.

North I-405 (I-90 Interchange to Swamp Creek) Congestion Frequency

Northbound and Southbound: The tidal pattern seen in the average congestion

contour maps can also be seen in the congestion frequency maps. (See Figure 3.12.) On I-405 north of SR 520, there is a high to very high likelihood of heavy congestion in the southbound direction during the AM peak period, and in the northbound direction during the PM peak period. Between SR 520 and I-90 there is a high to very high likelihood of northbound congestion approaching downtown Bellevue in the morning, and traveling southbound from SR 520 through downtown Bellevue to I-90 in the afternoon. (Note: Analysis of traffic patterns between milepost 26 near Canyon Park and the Swamp Creek interchange at I-5 Lynnwood is not conclusive because of a lack of available data.)

South I-405 (Tukwila to I-90 Interchange) Congestion Frequency

Northbound and Southbound: Here again the tidal pattern seen in the average congestion contour maps is also seen in the congestion frequency maps. (See Figure 3.13.) On I-405 south of I-90, there is a high to very high likelihood of heavy congestion in the northbound direction between about 6:30 AM and 10:00 PM from SR 169 north to I-90, and on the section from I-5 Tukwila to SR 169 beginning early in the afternoon. In the southbound direction there is a high to very high likelihood of heavy congestion in the Coal Creek area south of I-90 and on the approach to the Kennydale Hill area. The southbound approach from SR 900 through the Renton S-curves to the SR 167 interchange also experiences a high to very high frequency of heavy congestion during much of the afternoon. A factor in this congestion is the ramp queue as vehicles attempt to exit from I-405 to SR 167.

SR 520 (I-5 to Redmond) Congestion Frequency

Eastbound and Westbound: In the morning, heavy congestion occurs with moderate to high frequency on the eastbound approach to the bridge in the Montlake area from about 6:30 AM to 10:00 AM (with very high frequency from about 7:00 to 9:00 AM), and on the westbound approach to the bridge from about 7:30 AM to 9:00 AM. (See Figure 3.14.) In the afternoon, heavy congestion occurs with moderate frequency on the eastbound approach from about 3:00 PM to 6:00 PM, and with high to very high frequency on the westbound approach from about 3:30 PM to 7:00 PM. The reverse

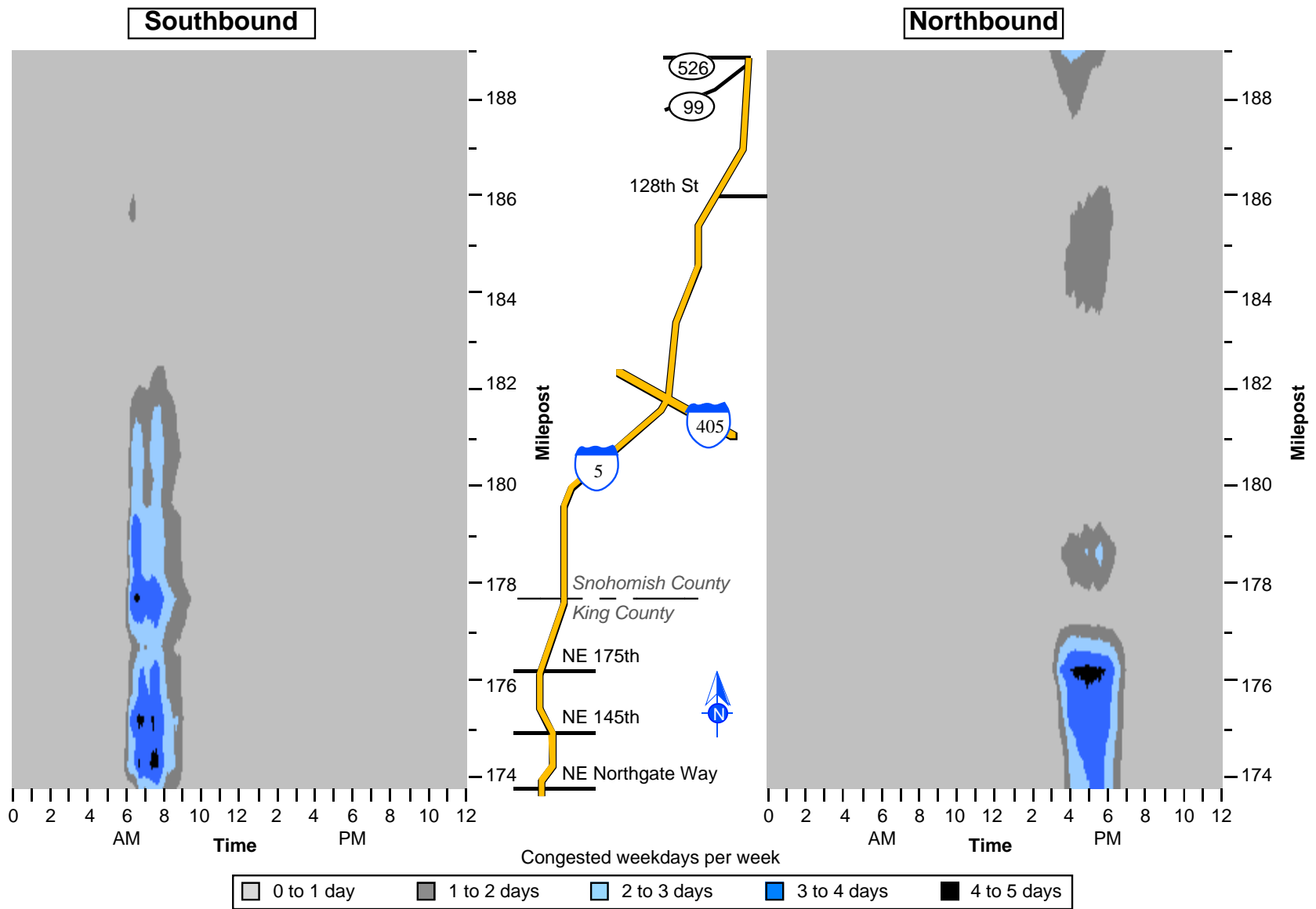


Figure 3.10. Interstate 5 North Congestion Frequency, General Purpose Lanes, 1999 Weekday Average

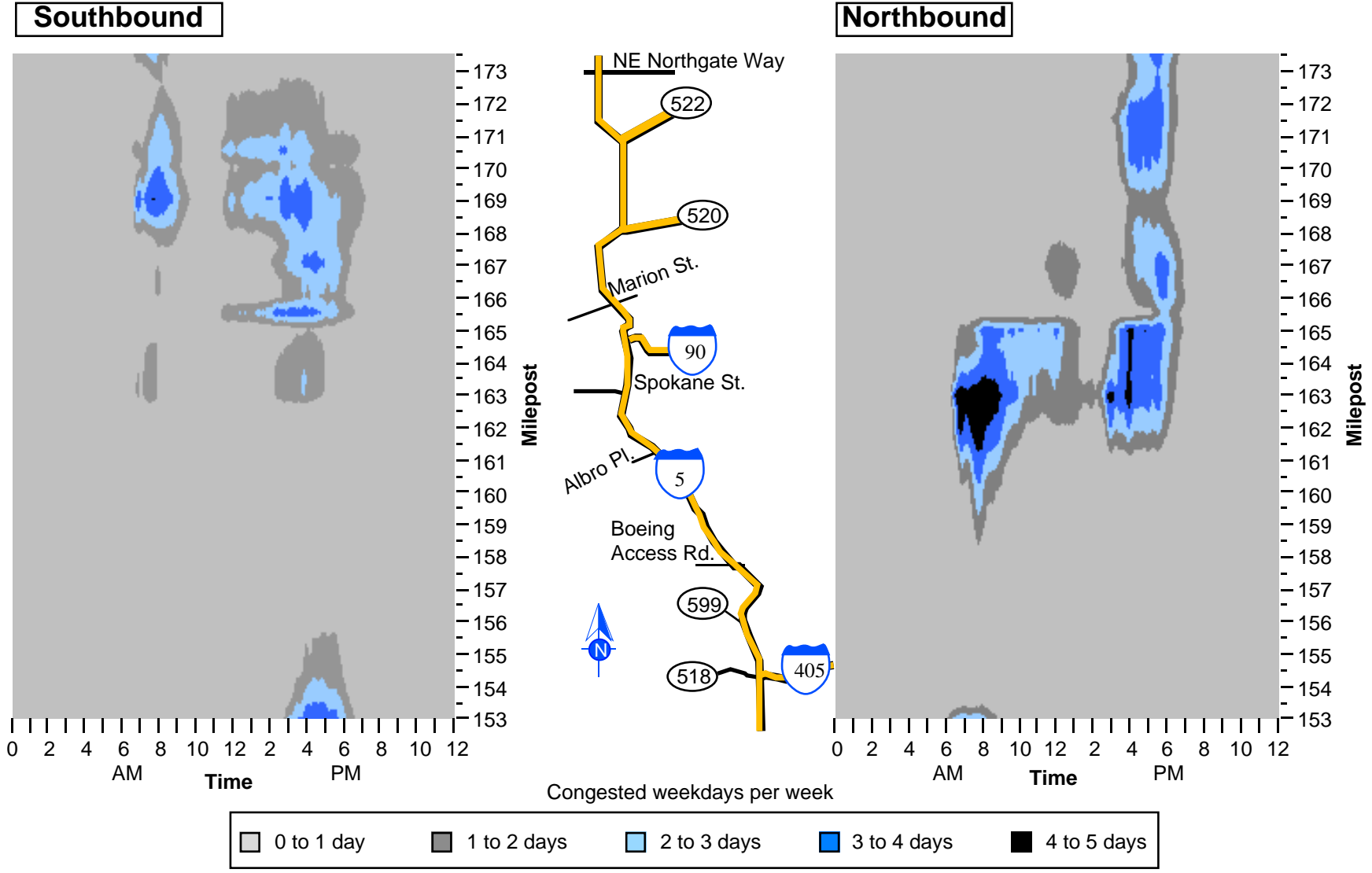


Figure 3.11. Interstate 5 South Congestion Frequency, General Purpose Lanes, 1999 Weekday Average

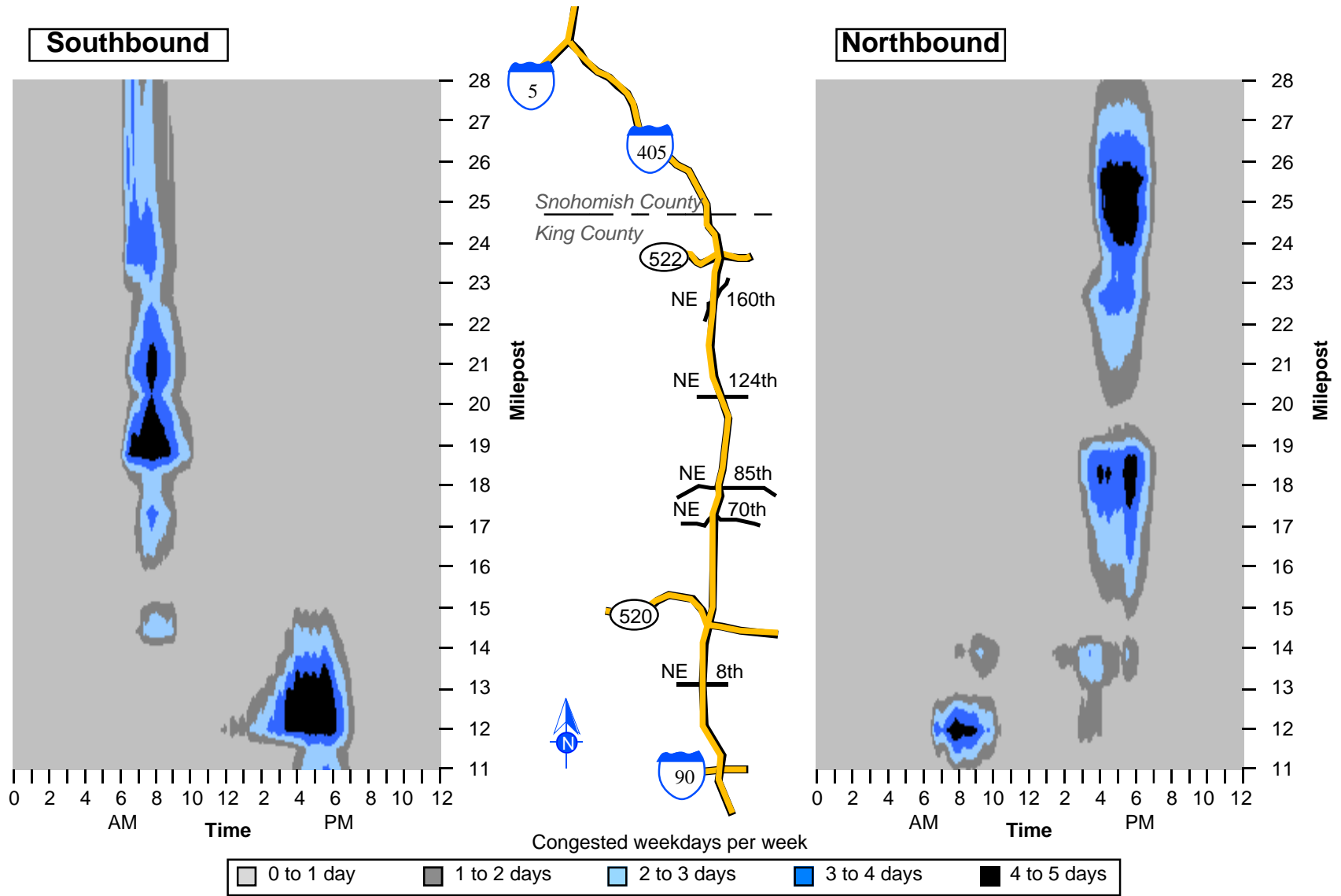


Figure 3.12. Interstate 405 North Congestion Frequency, General Purpose Lanes, 1999 Weekday Average

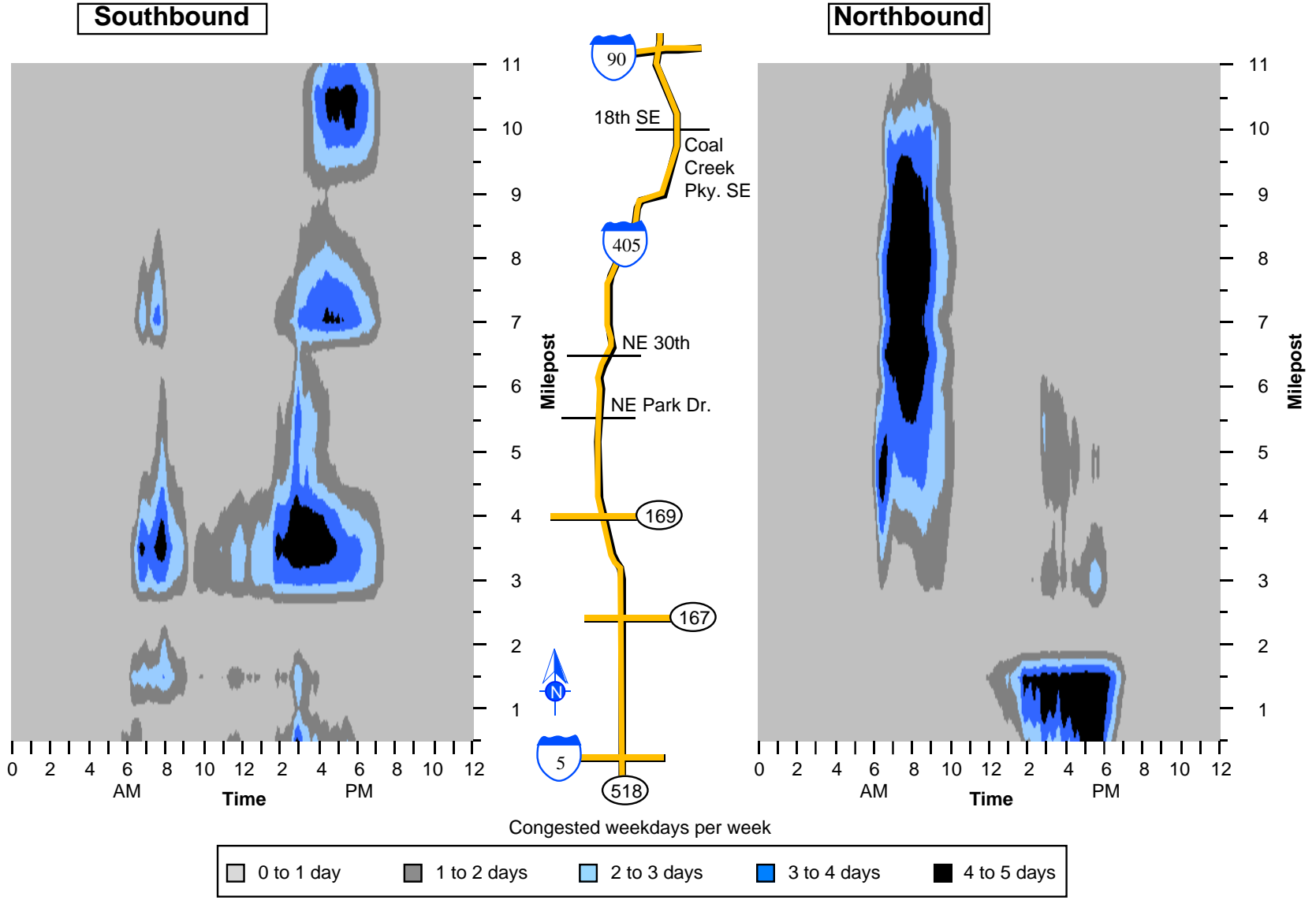


Figure 3.13. Interstate 405 South Congestion Frequency, General Purpose Lanes, 1999 Weekday Average

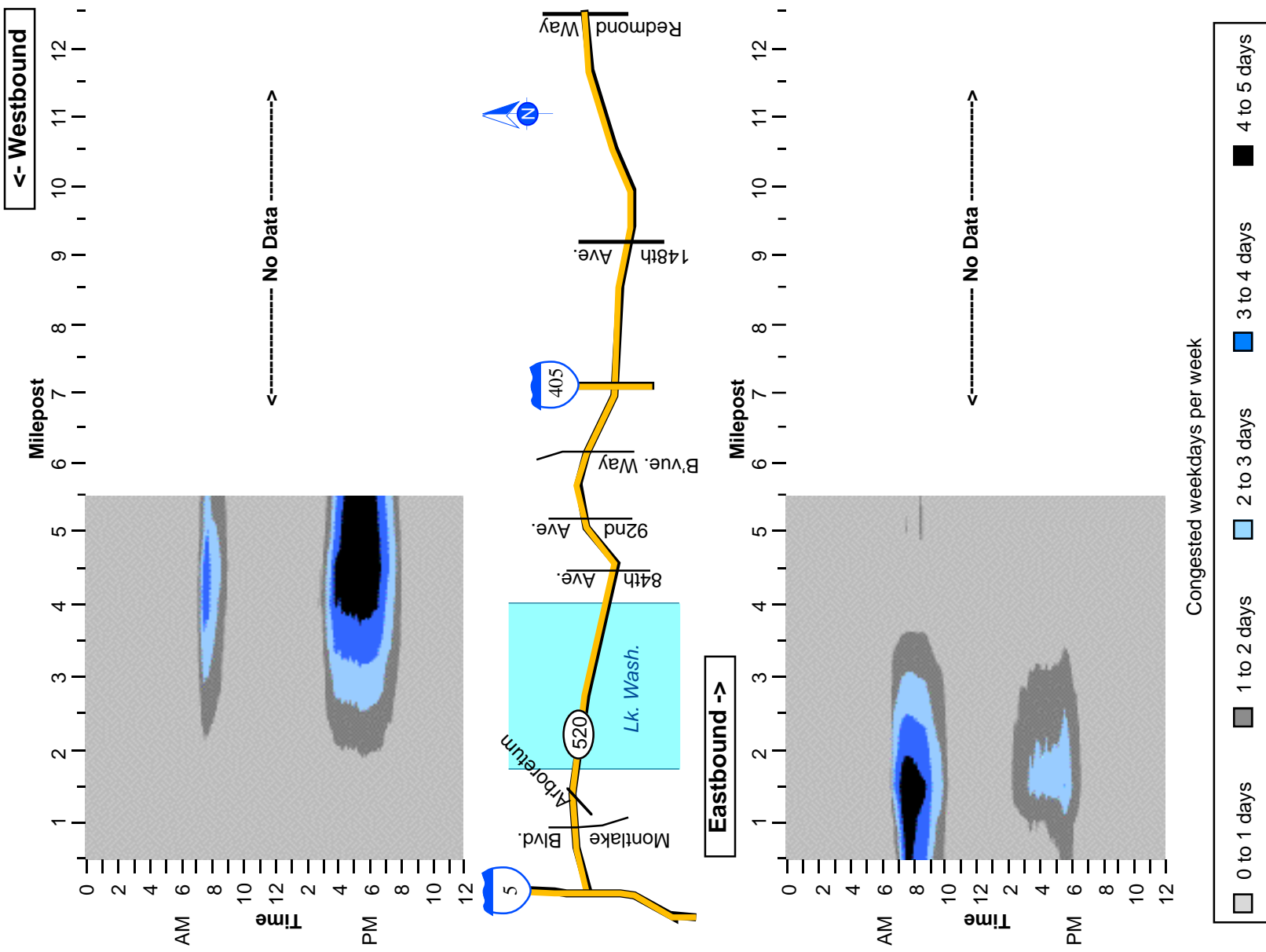


Figure 3.14. State Route 520 Congestion Frequency, General Purpose Lanes, 1999 Weekday Average

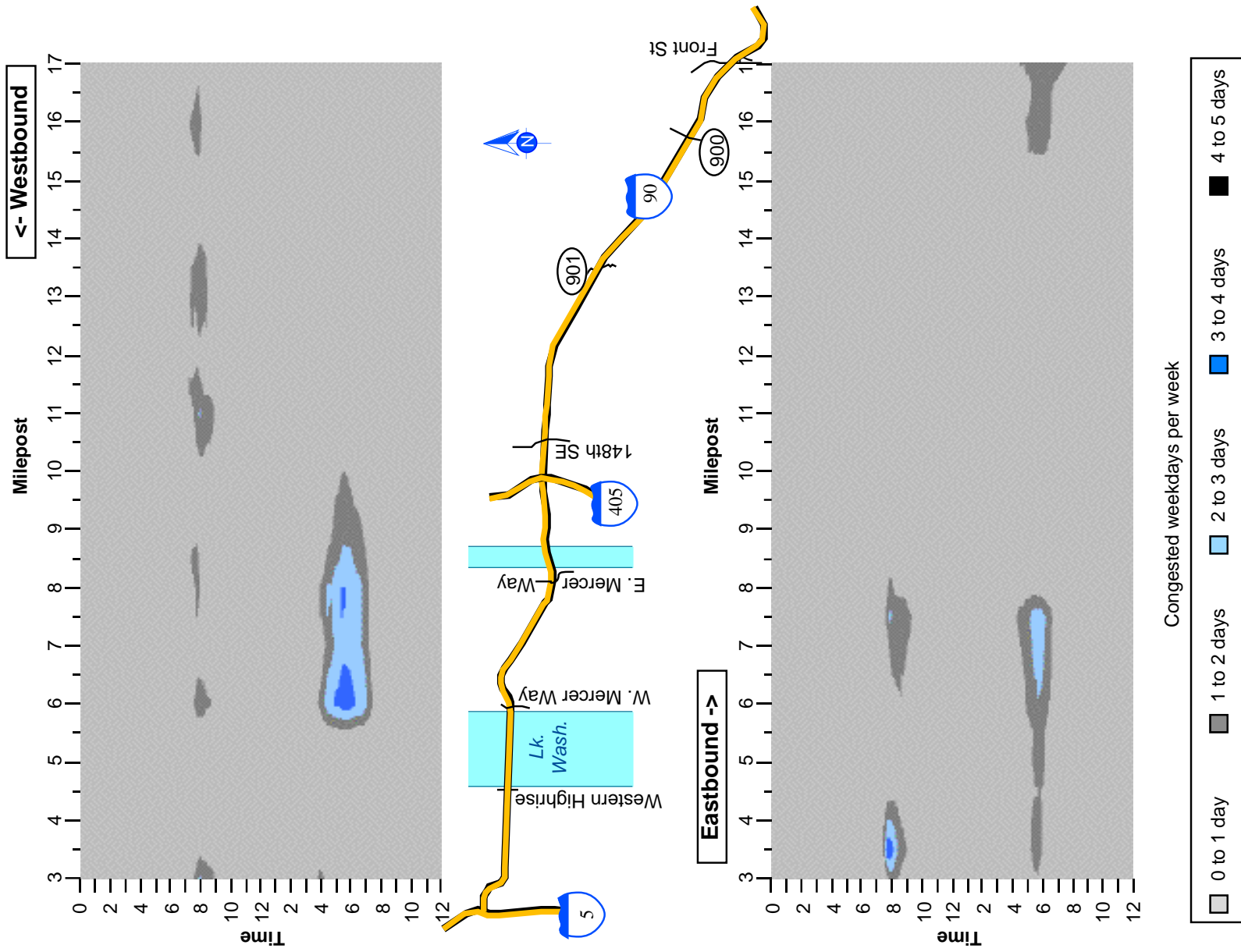


Figure 3.15. Interstate 90 Congestion Frequency, General Purpose Lanes, 1999 Weekday Average

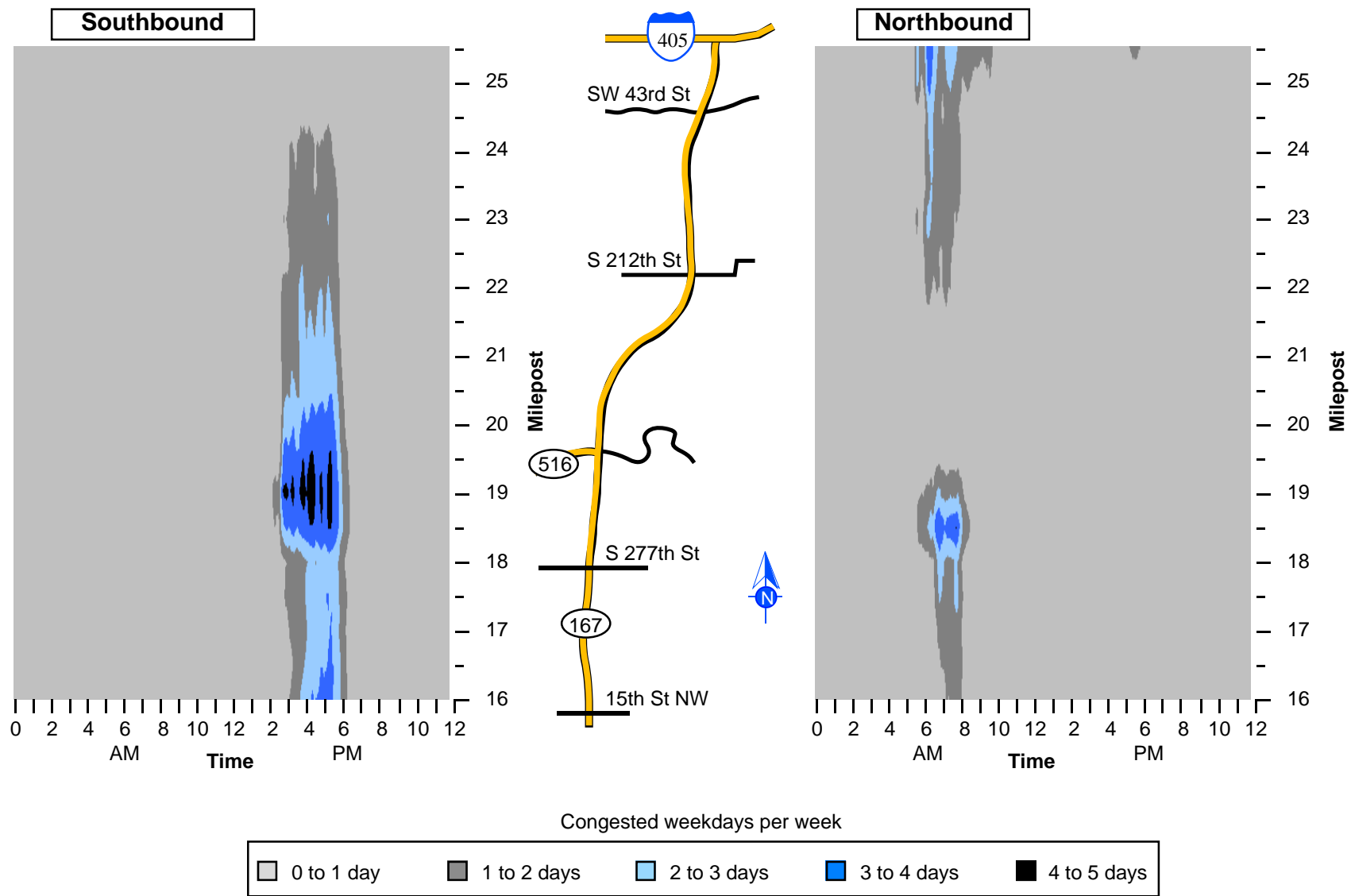


Figure 3.16. State Route 167 South Congestion Frequency, General Purpose Lanes, 1999 Weekday Average

commute pattern (eastbound to Bellevue AM, westbound to Seattle PM) can be seen here. NOTE: Because of extensive construction activity that affected data collection, 1999 data were not available east of Bellevue Way.

I-90 (Downtown Seattle to Issaquah) Congestion Frequency

Eastbound and Westbound: In general, heavy congestion does not occur with high frequency on this corridor. (See Figure 3.15.) There are a few exceptions. In the morning, heavy westbound congestion occurs with occasional to moderate frequency at sporadic locations along the entire corridor, as well as eastbound at the approach to the bridge and at mid-Mercer Island; even so, the duration is relatively short in comparison to congestion on other area freeways. In the afternoon, congestion occurs with moderate frequency eastbound on Mercer Island. The most noticeable frequent congestion occurs westbound in the afternoon peak period from about 4:30 to 6:30 PM across Mercer Island and approaching the bridge, where heavy congestion is moderate to high in frequency.

SR 167 (Auburn to Renton) Congestion Frequency

Northbound and Southbound: Northbound congestion on SR 167 occurs with moderate to high frequency from about 6:00 AM to 8:00 AM from Star Lake Road to Kent-Kangley Road, as well as from South 212th Street north to I-405. (See Figure 3.16.) Heavy southbound congestion occurs most frequently in the afternoon peak period from about 3:00 PM to 6:30 PM in the area from Kent-Kangley Road to Star Lake Road, and also near SR 18 in Auburn.

The segment of northbound SR 167 near I-405 offers an interesting comparison between the two types of contour graphs. Note that this freeway segment has significant and extended average congestion during the day (as seen in the average congestion contours), but less widespread frequency of heavy congestion (as seen in the congestion frequency contours). To understand how this combination of conditions can occur, recall that the frequency contour graphs reflect **significant variations from the average condition** (in the form of the frequency of heavy congestion), something that cannot be determined from the average congestion condition alone. In

this example, while northbound congestion approaching I-405 is moderate to significant, the roadway there may be “reliably” congested, i.e., the day-to-day variations from the average congestion condition may be small, and therefore, it is uncommon for heavy congestion that is significantly worse than average to occur. In such a case, the “hot spots” of high congestion frequency on the congestion frequency graph would be smaller than one might initially expect given the congested appearance of the average condition.²

Results: Average Trip Travel Times

In this section the estimated trip travel time characteristics of selected hypothetical trips are discussed. Tables 3.1 and 3.2 list details of the 11 hypothetical trip routes selected for travel time estimation. Table 3.1 lists north-south routes, while Table 3.2 lists predominantly east-west routes. Figure 3.17 graphically summarizes the eleven routes (note that two routes, #7 and #9, did not have sufficient 1999 data to estimate travel times because of construction activity that affected SR 520 data collection). For each of the nine routes described in this report, two trips were analyzed, one in each direction of travel, for a total of 18 trips. For each of the 18 trips, 1999 data were used to estimate three measures: 1) average travel time, 2) 90th percentile travel time (i.e., a measurement that indicates that nine times out of ten—90 percent of the time—a trip’s travel time will be less than a certain number of minutes), and 3) the likelihood of a “slow” trip, defined to be an average overall trip speed on the freeway of less than approximately 35 mph. These measures are all summarized graphically as a function of the trip start time and trip direction. All trips assume freeway-only routes on **general purpose mainline lanes and freeway-to-freeway ramps** during an average weekday. On- and off-ramps, HOV lanes, and express/reversible lanes are not included.

²Recall also that the interpretation of the congestion frequency graphs can be affected by potential differences between traveler perceptions of heavy congestion and the definition of heavy congestion that is used in the frequency graphs. As noted earlier, the frequency graphs use a relatively strict definition of heavy congestion (Level of Service F, or unstable freeway speeds). However, travelers may perceive that heavy congestion begins well before that definition is technically satisfied. Thus, travelers may perceive heavy congestion to be frequent, even when the strict technical definition of heavy congestion that is used in the frequency graph is not often met.

Table 3.1 North-South Routes Used for Travel Time Analysis

Route	Route Endpoints	Freeway Corridors	Route Type	Traffic Considerations
Route 1: Everett Seattle CBD	SR 526 University St	I-5	Suburb to Seattle	Snohomish County traffic heading to Seattle CBD via I-5
Route 2: Federal Way Seattle CBD	South 272nd University St	I-5	Suburb to Seattle	South-end traffic heading to Seattle CBD via I-5 (See Note 1 below)
Route 3: Mtlk Terrace Bellevue CBD	I-5 interchange NE 8th	I-405	Suburb to Suburban Center	North-end traffic heading to Bellevue CBD via I-405 (See Note 2 below)
Route 4: Tukwila Bellevue CBD	I-5 interchange NE 8th	I-405	Suburb to Suburban Center	South-end traffic heading to Bellevue CBD via I-405
Route 5: Auburn Renton	SR 18 I-405 interchange	SR 167	Suburb to Suburb	South-end traffic heading to Renton via SR 167

Notes:

- 1) The southernmost available I-5 freeway loop data are at South 184th Street near Sea-Tac; this location will be used as the interim southern endpoint of Route 2. In the future, travel time estimates on route 2 will begin at Federal Way (South 272nd Street) as data become available.
- 2) Data between SR 522 and Damson Road on I-405 were not available during 1999 because of construction activity. Therefore, NE 170th Street near SR 522 was used as the interim northern endpoint of the trip. In the future, travel time estimates on route 3 will begin at the I-405/I-5 interchange at Swamp Creek as data become available.
- 3) CBD = Central Business District (downtown)

Table 3.2. East-West Routes Used for Travel Time Analysis

Route	Route Endpoints	Freeway Corridors	Route Type	Traffic Considerations
Route 6: Issaquah Seattle CBD	Front St. University St.	I-90/I-5	Suburb to Seattle	Eastside (Issaquah) traffic heading to Seattle CBD via I-90
Route 7: Redmond Seattle CBD	NE 60th University St.	SR 520/I-5	Suburb to Seattle	Eastside (Redmond) traffic heading to Seattle CBD via SR 520 (see Note 1 below)
Route 8A: Bellevue CBD Seattle CBD	NE 8th University St.	I-405/ SR 520/I-5	Suburb to Seattle	Bellevue CBD to Seattle CBD via the SR 520 bridge
Route 8B: Bellevue CBD Seattle CBD	NE 8th University St.	I-405/I-90/ I-5	Suburb to Seattle	Bellevue CBD to Seattle CBD via the I-90 bridge
Route 9: Redmond Bellevue CBD	NE 60th NE 8th	SR 520/ I-405	Suburb to Suburban Center	Eastside (Redmond) traffic to Bellevue CBD (see Note 1 below)
Route 10: Issaquah Bellevue CBD	Front St. NE 8th	I-90/I-405	Suburb to Suburban Center	Eastside (Issaquah) traffic to Bellevue CBD

Notes:

- 1) Travel times on routes 7 and 9 were not being estimated for this year because of a lack of 1999 data caused by construction activity.
- 2) CBD = Central Business District (downtown)

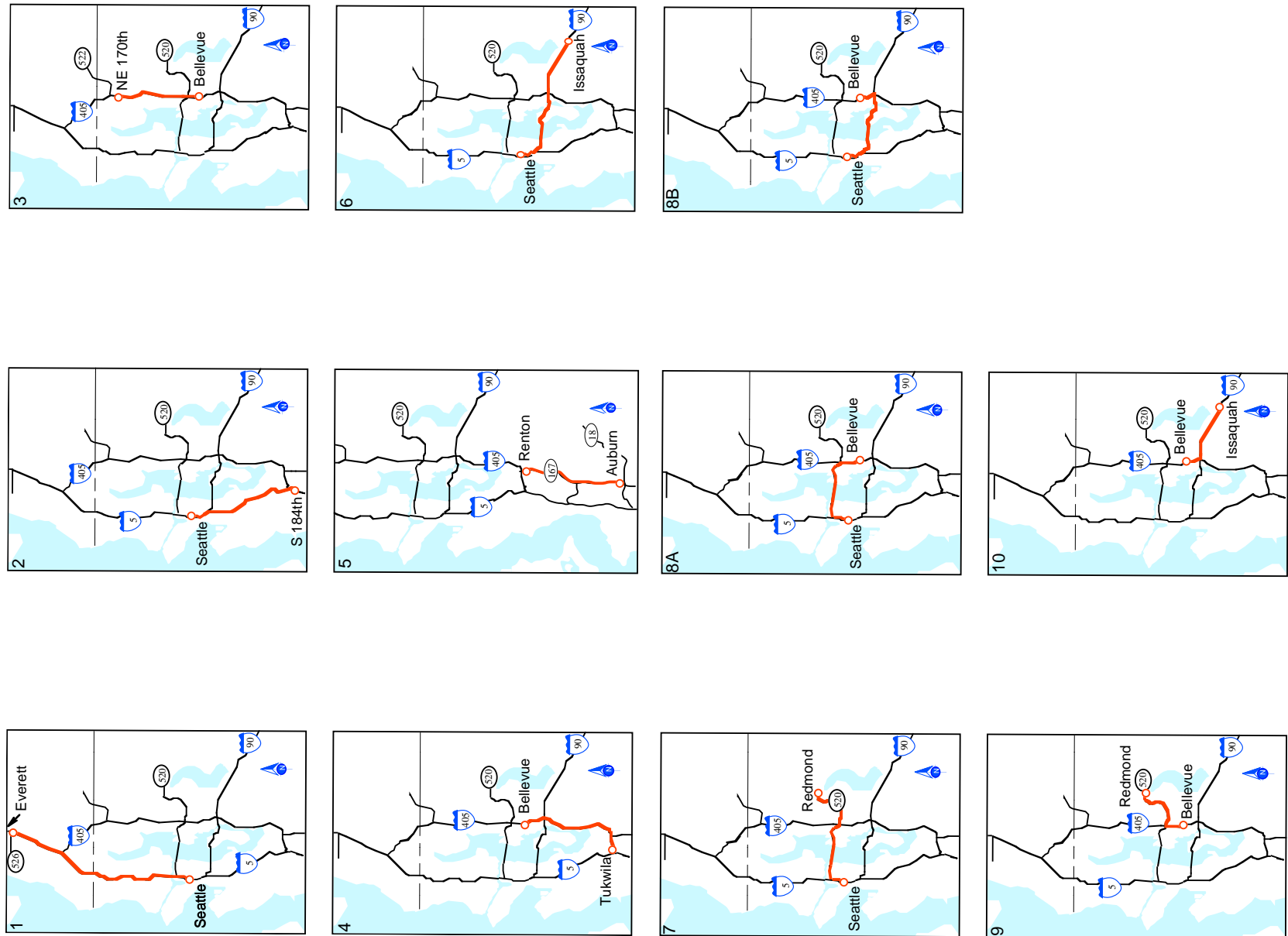


Figure 3.17. Summary of Routes Used for Trip Travel Time Estimates

Note that the three travel time-related performance measures (average trip time, 90th percentile trip time, and likelihood of slow trips) are estimates, and are used for comparative purposes rather than as absolute values. The travel times reflect “average” freeway conditions on these routes at different times of day; a specific travel time on a given day may differ from these estimates because of an individual’s driving style and vehicle characteristics, as well as that day’s traffic levels, congestion patterns, and weather conditions. Note also that the travel time estimates reflect the cumulative effect of all congestion along a given route; the overall trip time may be affected by one large section of congestion, or a number of smaller slowdowns along the way. It is therefore also useful to compare the travel time patterns with the geographic patterns of congestion seen in the earlier traffic congestion maps (figures 3.2 through 3.8) to gain a better understanding of the association between specific bottleneck locations and trip travel time.

The following is a brief explanation of how to read a travel time graph. This is followed by a discussion of the estimated travel time measures for each trip.

How to Read Travel Time Graphs

Figure 3.18 shows an 8-hour slice of a typical travel time graph, in this case for westbound SR 520 general purpose lanes, for a trip from Redmond Way to I-5. The estimated travel time is a function of the time of day that the traveler begins the trip, shown along the horizontal axis. The green line represents the average travel time, measured with the left vertical axis, which in this example varies from about 12 to 15 minutes for a person leaving Redmond at midday, to about 25 minutes during the evening commute.

The red line represents the 90th percentile travel time, which in this example can reach about 38 minutes in the evening peak, meaning that nine times out of ten (i.e., 90 percent of the time) the trip’s travel time will be 38 minutes or less. The 90th percentile travel time measure describes those conditions experienced on a “bad day” for that trip. The degree to which a trip’s 90th percentile travel time differs from its average travel time indicates the variability of conditions routinely experienced for that trip. So,

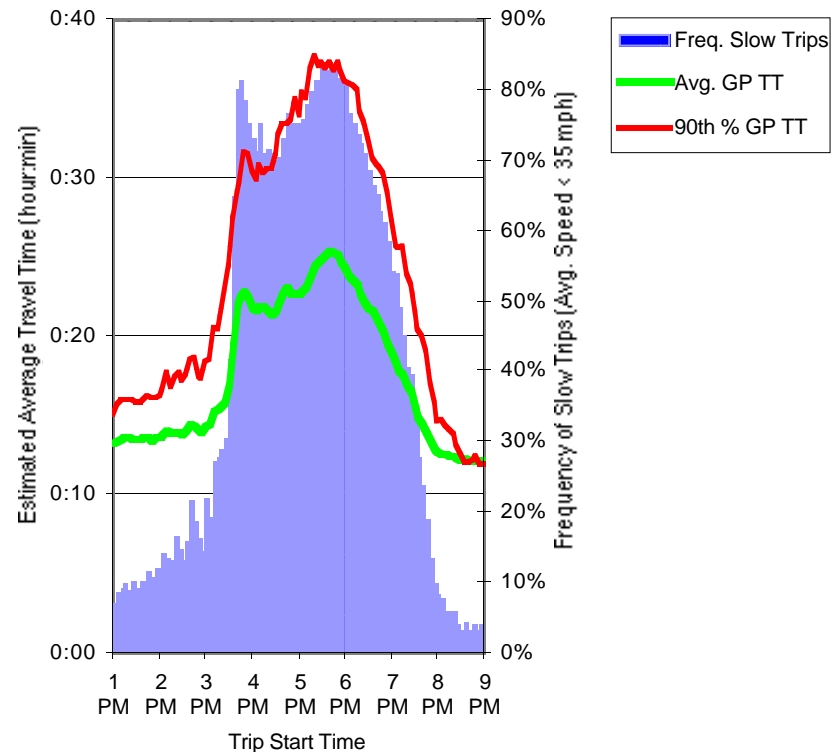


Figure 3.18. Estimated Average Weekday Travel Time (1997): Westbound SR 520, General Purpose Lanes, Redmond Way to I-5 (12.3 mi)

for someone leaving Redmond at 5:00 PM the trip ranges from 25 minutes, on average, to approximately 38 minutes or less 90 percent of the time.

Superimposed on the travel time lines is a column graph, measured along the right vertical axis, that illustrates the estimated frequency of a slow trip on a given route. This frequency is measured by the likelihood that the average trip speed will be below 35 mph for a given trip start time³. On the example trip, the frequency of 80 percent at

³ Average weekday traffic conditions in this report were based on all 261 weekdays in 1999 (subject to data availability), including weekday holidays (when one would expect lighter traffic). It is thus reasonable to expect that the volumes and congestion frequencies for the average non-holiday weekday would be slightly higher than those shown in this report.

5:30 PM indicates that there is approximately an 80 percent chance that the average overall trip speed will be less than 35 mph when the trip starts at 5:30 PM.

Below are descriptions of the travel time estimates of each trip.

Route 1. Everett to Seattle CBD, via I-5: 23.6 miles (Figures 3.19, 3.20)

Overall: This route runs along I-5 between Everett (at the SR 526 interchange) and downtown Seattle, a freeway segment that includes some of the highest vehicle volumes in the region. A review of the congestion contour maps (figures 3.2 and 3.3) for that section of I-5 shows that in the southbound direction an extended segment of slow AM traffic spans nearly the entire length of the route, with particularly heavy congestion between Alderwood Mall and the Ship Canal bridge during the peak hours of about 6:30 to 9:00 AM. Southbound traffic eases somewhat along this route during the rest of the day, with the exception of the segment between Northgate and downtown Seattle, which can fluctuate between very congested and reasonably free flow conditions. In the northbound direction, afternoon peak traffic is heavy along the entire route, particularly from downtown Seattle to about NE 175th Street.

Southbound: Travel times to downtown Seattle begin to increase shortly after 5:00 AM, peaking sharply during the morning peak period. During the AM peak, average trip times can rise up to about 80 percent higher than during off-peak times. Trip times fall during the midmorning hours, but they begin rising again shortly thereafter and throughout the afternoon, gradually peaking around 3:30 PM at about 45 percent higher than at off-peak uncongested times; after leveling off, trip times gradually fall to uncongested levels by about 7:30 PM. The large separation between 90th percentile trip times and average trip times during the AM and PM peak periods suggests the occurrence of considerable day to day variability in trip times during the peak periods. The likelihood of a southbound trip with an average speed of less than 35 mph is up to about 55 percent during the middle of the morning peak and up to almost 20 percent during the afternoon peak.

Northbound: Northbound trips from downtown Seattle to south Everett experience only minor slowing throughout the day until shortly after 2 PM, when trip times begin to steadily increase to a peak from about 4:00 PM to 5:30 PM, after which there is a

steady decline back to uncongested trip conditions by about 7:30 PM. During the afternoon peak, trip times are as much as 65 percent higher than during the off-peak. There is also considerable variability in trip times during the afternoon peak; this variability begins during the midday hours, then increases throughout the afternoon. There is a moderate likelihood of a slow trip during the afternoon peak period.

Route 2. Sea-Tac to Seattle CBD, via I-5: 12.9 miles (Figures 3.21, 3.22)

Overall: This route runs along I-5 between the Sea-Tac area (at South 184th Street) and downtown Seattle. A review of the I-5 congestion contour maps shows that northbound traffic toward downtown Seattle is affected by significant congestion levels throughout the day between north Boeing Field and the Seattle CBD. Morning northbound travel is further affected by extended congestion beginning near the south end of Boeing Field, as well as congestion in the Southcenter hill area. In the southbound direction, the segment between downtown Seattle and north Boeing Field experiences moderate to significant congestion throughout the day, with the addition of afternoon congestion in the south Boeing Field and Southcenter hill areas.

Northbound Travel time begins to increase significantly starting about 6:00 AM, peaking at about 7:30 AM when the trip times are up to 85 percent higher than during off-peak hours, accompanied by a high likelihood of slow trips. During the rest of the daytime hours, trip times fluctuate at lower levels (but still between 10 percent and 45 percent higher than free-flow levels), accompanied by a 10 to 20 percent likelihood of slow trips. Travel times return to free-flow conditions by about 7:00 PM. Trip time variability is moderate to high throughout the day. This trip has the highest midday level of congestion of all trips examined, based on the relatively slow midday trip times relative to free-flow conditions.

Southbound: Southbound trip times stay near off-peak levels with relatively small day-to-day travel time variations during much of the day until about 1:30 PM, when the average trip time begins to increase. They reach a maximum from about 3:30 PM to 5:30 PM, when average trip times are up to about 50 percent higher than off-peak times. During the PM peak period there is significant day-to-day variability in trip times and a moderate (about 30 percent) likelihood of slow trips.

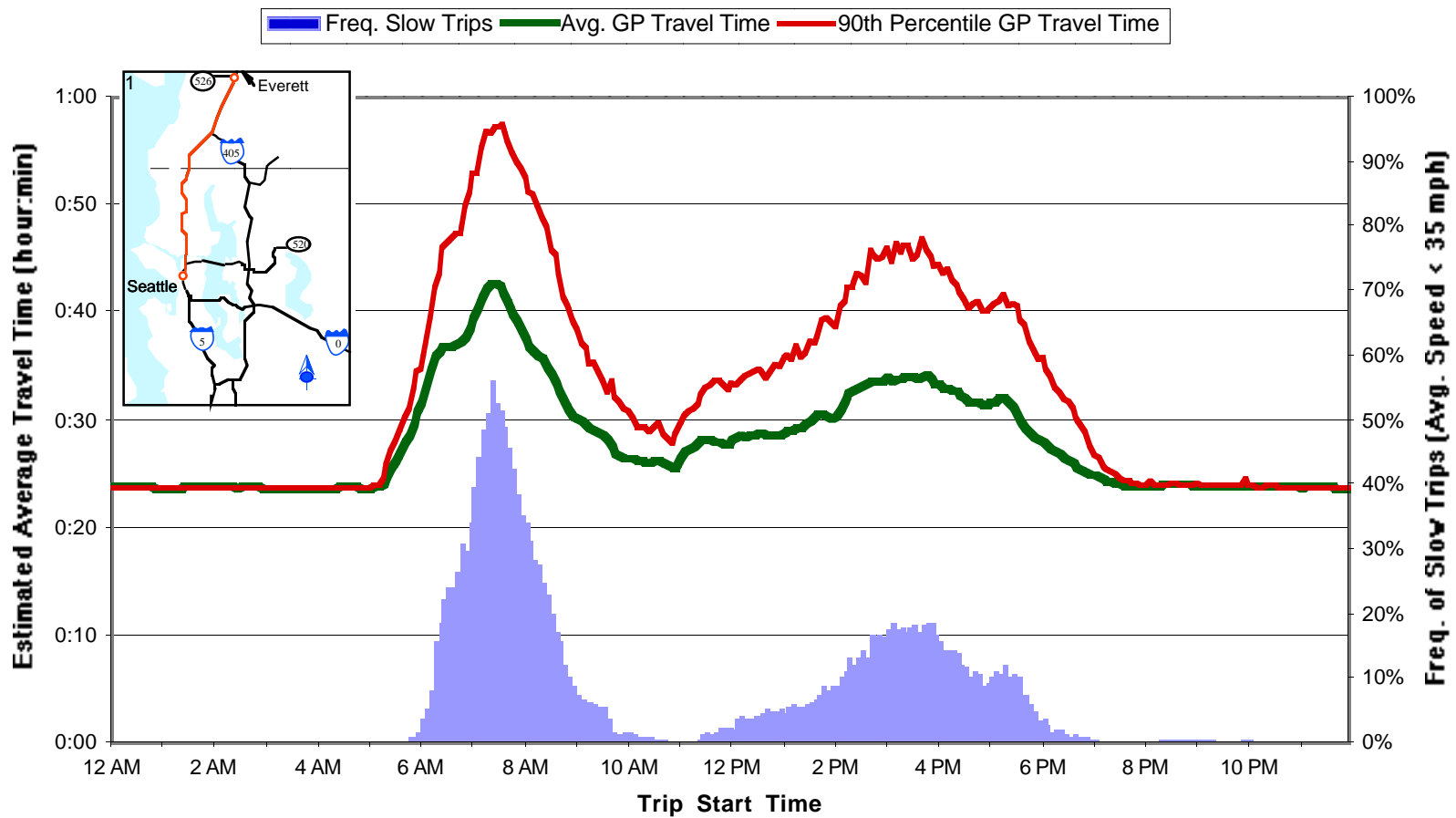


Figure 3.19. Estimated Average Weekday Travel Time (1999): SR 526 Interchange to Seattle CBD, General Purpose Lanes (23.7 mi)

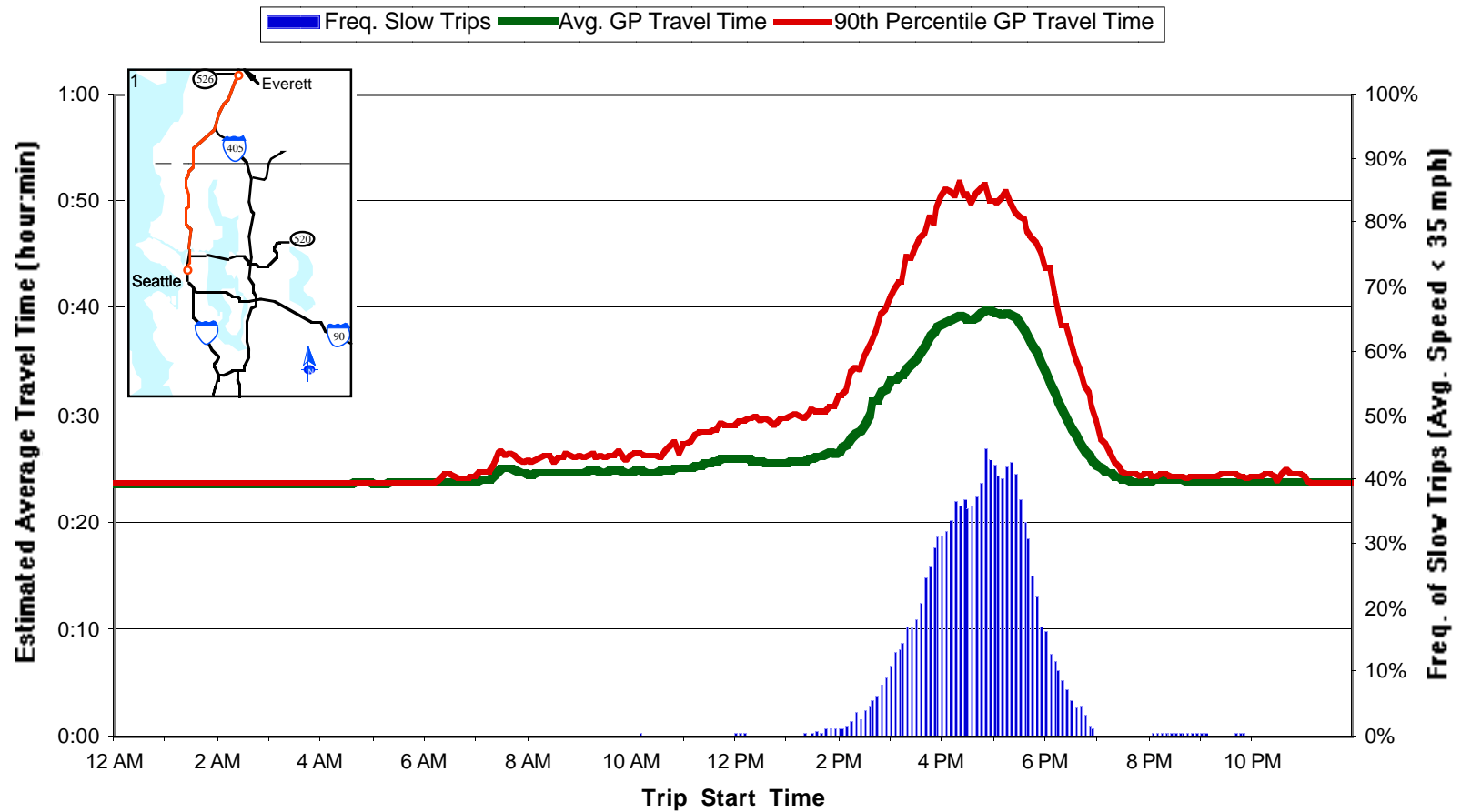


Figure 3.20. Estimated Average Weekday Travel Time (1999): Seattle CBD to SR 526 Interchange, General Purpose Lanes (23.7 mi)

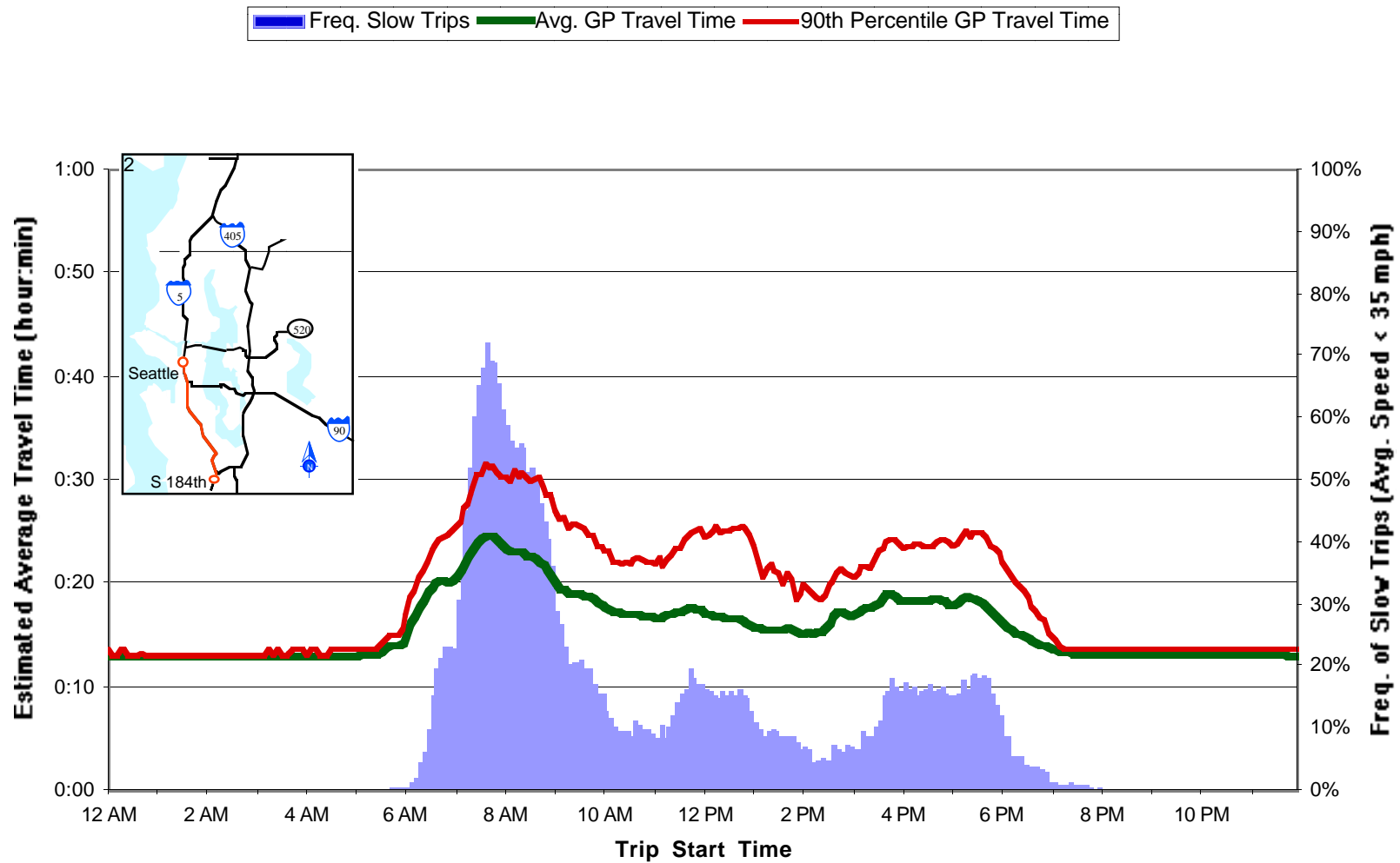


Figure 3.21. Estimated Average Weekday Travel Time (1999): SeaTac to Seattle CBD, General Purpose Lanes (12.9 mi)

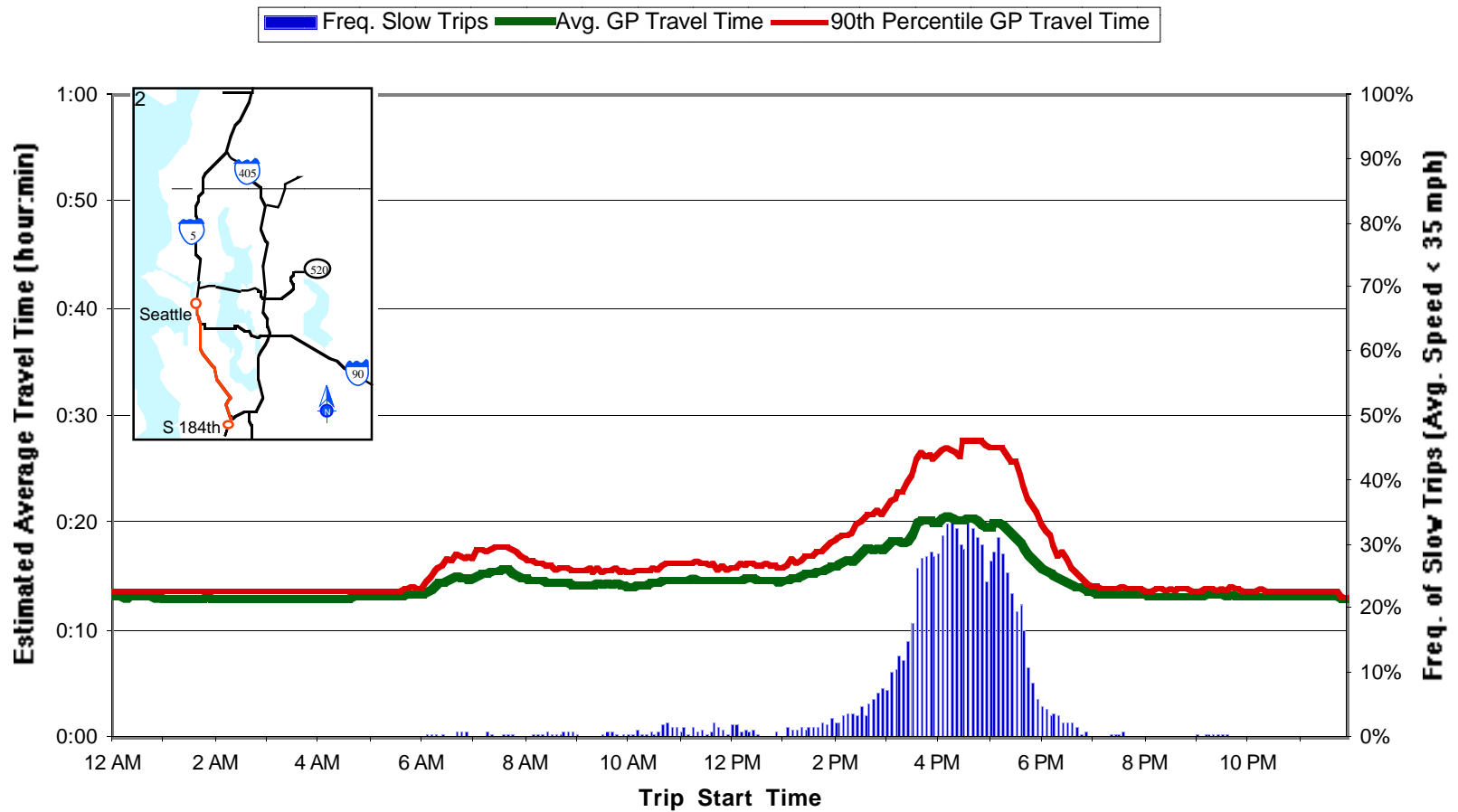


Figure 3.22. Estimated Average Weekday Travel Time (1999): Seattle CBD to SeaTac, General Purpose Lanes (12.9 mi)

Route 3. Bothell to Bellevue CBD, via I-405: 9.6 miles (Figures 3.23, 3.24)

Overall: This route runs along I-405 between Bothell (at NE 170th Street near the SR 522 interchange) and downtown Bellevue. This route experiences a “tidal” congestion pattern, in that southbound congestion is heavy in the morning peak period, whereas northbound congestion is heavy in the evening peak period. The exception to this pattern is the freeway segment between the SR 520 interchange and downtown Bellevue, which experiences heavy congestion in both directions much of the day.

Northbound: There is a noticeable increase in travel time in the afternoon, beginning around 2:30 PM and steadily growing to a peak between 4:00 PM and 5:30 PM, when trip times are up to 90 percent higher than during off-peak hours. There is considerable day-to-day variability in travel times during the midst of the afternoon peak period, with a 50 percent chance of a slow trip during that time.

Southbound: As the aforementioned “tidal” congestion pattern would suggest, the southbound travel time pattern is somewhat of a mirror image of the northbound pattern, with travel times peaking in the morning rather than the evening peak period. AM peak times can be over twice as high as those during the off-peak, making the average morning commute among the slowest measured, relative to free flow conditions. While the northbound trip times increase significantly only in the afternoon, the southbound morning “bump” in trip times is accompanied by a modest afternoon increase, with trip times peaking around 5:30 PM at about 35 percent higher than off-peak times. There is a moderate level of variability in southbound travel times during the AM peak period and a high likelihood of slower trips. The southbound evening trips experience only modest levels of travel time variability.

Route 4. Tukwila to Bellevue CBD, via I-405: 13.4 miles (Figures 3.25, 3.26)

Overall: This route runs along I-405 between Tukwila (at the I-5 interchange) and downtown Bellevue. While congestion contour maps show that this route experiences a “tidal” congestion pattern, with heavy northbound congestion toward Bellevue in the morning peak period, and heavy southbound congestion away from Bellevue in the evening peak period, there are segments with at least moderate congestion throughout much of the day.

Northbound: Travel times increase significantly during the AM peak period beginning about 5:30 AM. At their peak around 7:30 AM, travel times are almost 150 percent longer than they are during off-peak hours. During the AM peak, there is significant variability in trip times and a very high likelihood (about 90 percent) of having a slowed trip. The average travel times do not return to near off-peak levels until about 11:00 AM; they stabilize during the midday, then increase modestly in the afternoon. The AM portion of this trip has the largest percentage increase in “average” travel time (relative to free-flow conditions) among those studied⁴ and has the second largest percentage increase in “bad” (90th percentile speed) trip times. This is also affected by the limited number of lanes present.

Southbound: As the aforementioned “tidal” congestion pattern would suggest, southbound trips experience moderate travel time increases in the morning peak, as well as significantly higher increases throughout much of the afternoon, when there is a long flat peak period when trip times are up to 90 percent higher than the off-peak travel times. There is a moderate to high variability in trip times, especially during the PM peak. The likelihood of a slow trip is high (about 60 percent) during the afternoon, though not as high as morning northbound trips.

Route 5. Auburn to Renton, via SR 167: 9.8 miles (Figures 3.27, 3.28)

Overall: This route runs along SR 167 between Auburn (at 15th Street NW, north of SR 18) and Renton (at South 23rd Street, south of I-405). The congestion pattern on this freeway is tidal in nature, with congestion northbound toward Renton in the AM peak period and southbound in the PM peak period. Other congestion patterns of note occur on the segment of SR 167 near I-405, which is congested in both directions during much of the day, and the entire corridor southbound, which is moderately to heavily congested throughout much of the afternoon, particularly from about 2:30 PM to 6:30 PM.

Northbound: Northbound travel times show a noticeable increase during the AM peak period; trip times increase beginning about 5:00 AM, then level off from about

⁴Note that data for the afternoon Redmond to Seattle trip (which would be expected to have high average travel times as well) were not available for 1999.

6:00 AM to 7:30 AM when peak average trip times are about 65 percent higher than off-peak trip times. Average trip times return to near-free-flow levels during most of the rest of the day, with only a slight increase during the early to mid-afternoon. Travel time variability is modest during much of the day, except during the AM peak period. The likelihood of a slower (< 35 mph) trip increases to no more than about 20 to 30 percent, and this occurs only during the AM peak period.

Southbound: Southbound travel times stay at free-flow levels during the first half of the day, then increase steadily beginning about 1:30 PM, peaking at more than twice the off-peak trip time by about 4:30 PM to 5:00 PM. Travel time variability is high during the PM peak period, and there is at least a 50 percent likelihood of a slower trip during the middle of that peak. While southbound SR 167 does not experience the “all day” congestion of parts of I-405 or I-5, it does have the distinction of having the most variable peak period congestion. The PM 90th percentile trip time on this route is the highest (in terms of percentage increase relative to free-flow) among the trips studied, indicating that this route could be susceptible to major incident congestion to exacerbate its significant “routine” evening congestion.

Route 6. Issaquah to Seattle CBD, via I-90 and I-5: 15.5 miles WB and EB (Figures 3.29, 3.30)

Overall: This route runs between Issaquah at Front Street and downtown Seattle, via I-90 and the collector-distributor lanes on I-5. On most of this route (I-90), traffic congestion is limited to a narrow AM and PM peak period. In fact, this trip is among the least congested of the trips studied in this report. In the morning peak hours, there is moderate westbound congestion along the entire corridor, while eastbound AM traffic is similarly congested from I-5 across Mercer Island. In the afternoon, eastbound traffic is congested again from Seattle to Mercer Island, eases approaching Eastgate, then increases again approaching Issaquah. Westbound traffic in the afternoon is heavy on Mercer Island approaching the bridge from about 4:00 to 7:00 PM; afternoon westbound traffic on Mercer Island experiences the most significant congestion on I-90 in either direction at any time.

Westbound: Westbound travel times peak during both AM and PM peak periods, but they return to off-peak levels during much of the midday. AM and PM peak trip times

are up to approximately 45 percent higher than off-peak levels, depending on time of day. Travel time variability is moderate to high during the peak periods and is significantly higher during the westbound PM peak period than the AM peak period. The likelihood of a slow trip is also higher during the PM peak period than during the AM peak period, reaching about 30 percent.

Eastbound: The eastbound travel time pattern is similar to the westbound pattern, with moderate increases during the peak periods and a return to off-peak levels during most of the midday. AM and PM peak times are up to about 25 percent and 40 percent higher than off-peak levels, respectively. As with westbound traffic, travel time variability is higher in the PM peak period than the AM peak period. The likelihood of a slow trip is low during the AM peak period, and about 15 percent at its highest point during the PM peak period.

Route 7. Redmond to Seattle CBD, via SR 520 and I-5: Not included in this report because of a lack of available data

Route 8A. Bellevue CBD to Seattle CBD, via I-405, SR 520, and I-5: 10.5 miles WB, 10.1 miles EB (Figures 3.31, 3.32)

Overall: This is one of two routes (8A and 8B) in this report between downtown Bellevue and downtown Seattle (Route 8A uses SR 520, while Route 8B uses I-90). The congestion contour maps indicate that there is significant congestion along much of Route 8A during both peak periods and in both directions. The SR 520 approaches to the bridge are congested during both peak periods. The overall travel time patterns illustrate the large size of the “reverse” commute pattern, with slightly slower trips occurring eastbound in the AM peak period and westbound in the PM peak.

Eastbound: Eastbound travel times peak sharply during the AM peak period beginning about 6:30 AM, then return to near off-peak levels by about 10:30 AM. They remain so until mid-afternoon, then build gradually to another, slightly lower peak around 5:30 PM, before returning to off-peak levels by around 7:30 PM. At its AM peak (about 7:30 AM), the trip times are estimated to be up to about 95 percent higher than off-peak trip times, while PM peak trip times are up to about 80 percent higher than

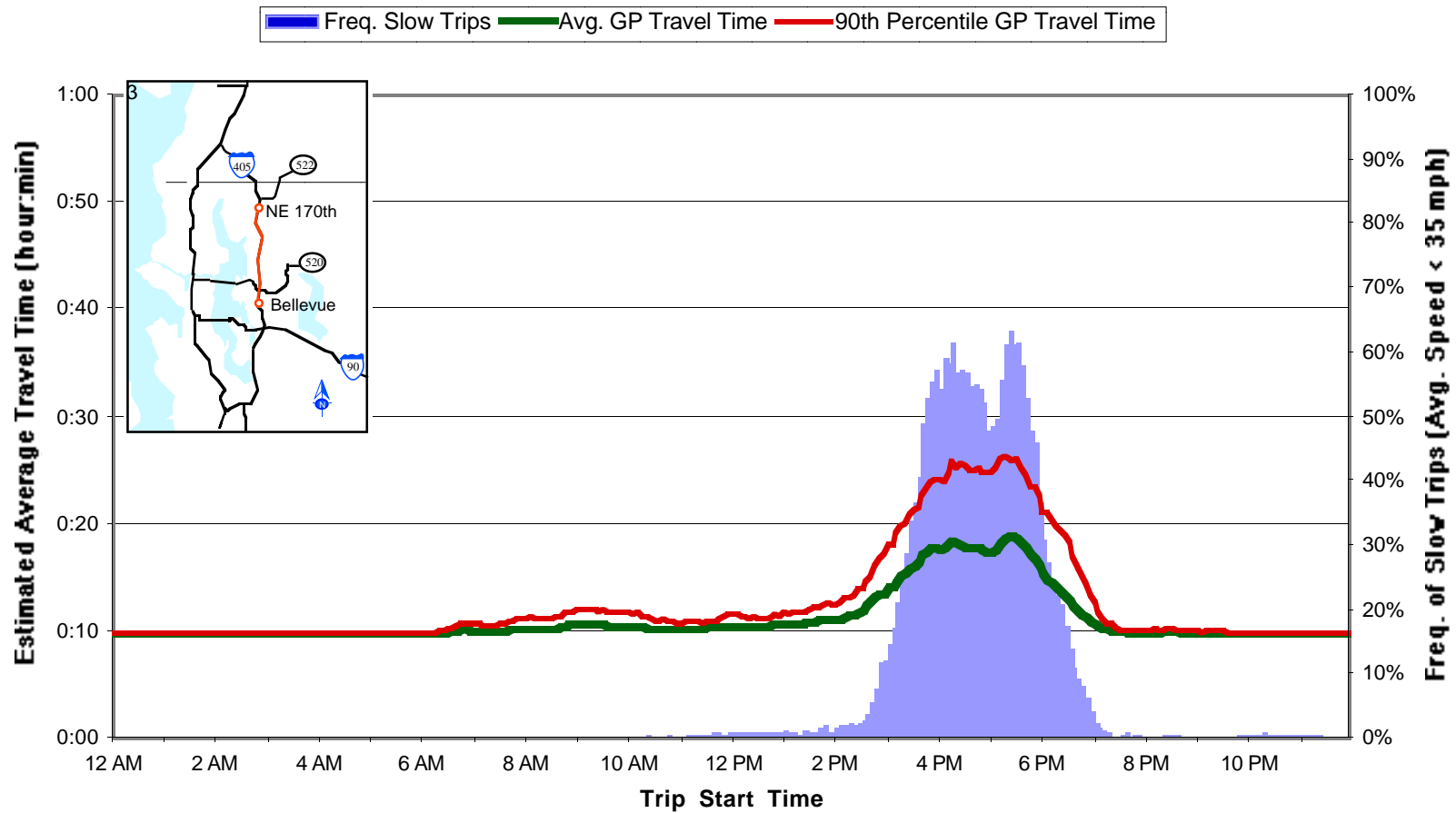


Figure 3.23. Estimated Average Weekday Travel Time (1999): Bellevue CBD to SR 522 Interchange, General Purpose Lanes (9.6 mi)

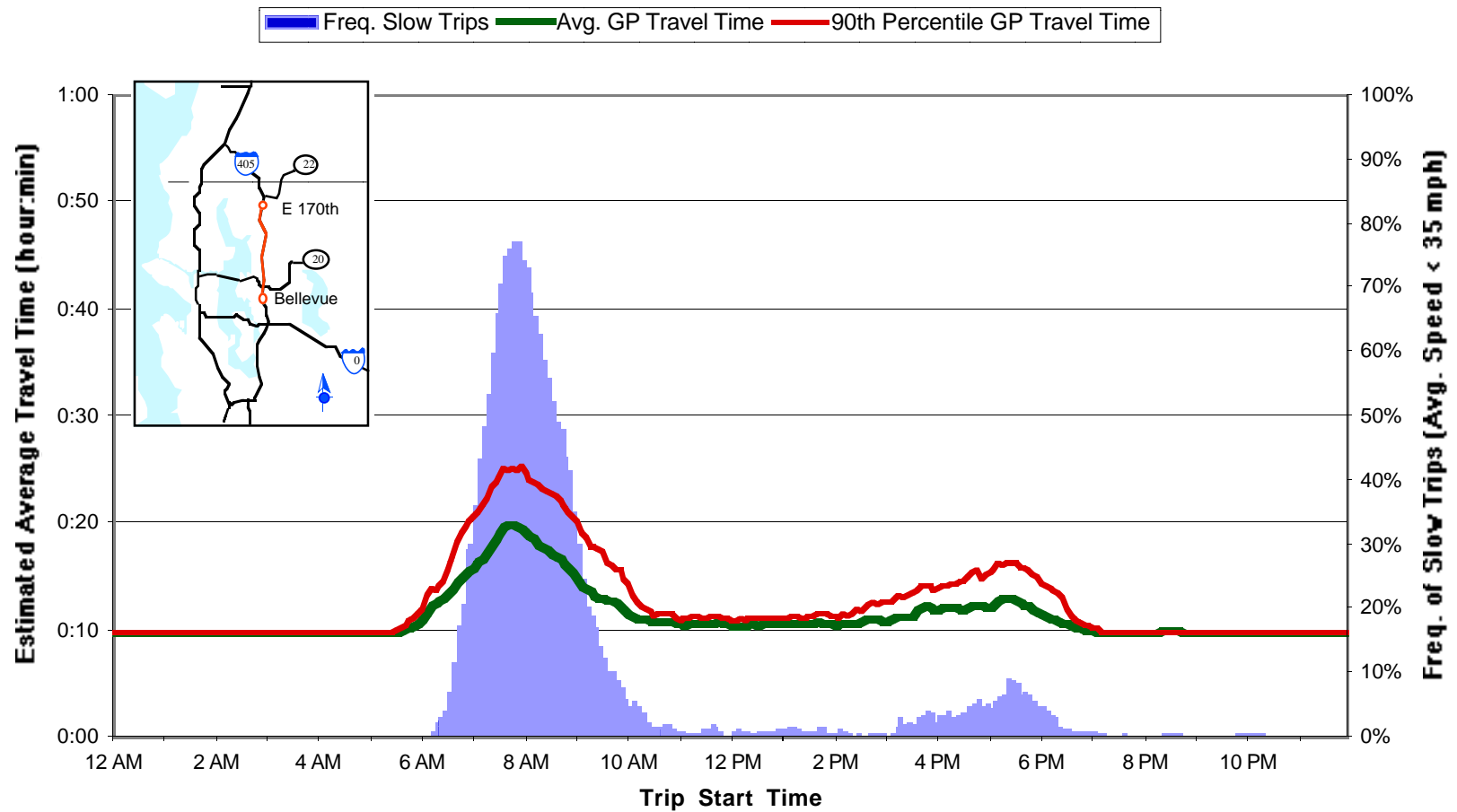


Figure 3.24. Estimated Average Weekday Travel Time (1999): SR 522 Interchange to Bellevue CBD, General Purpose Lanes (9.6 mi)

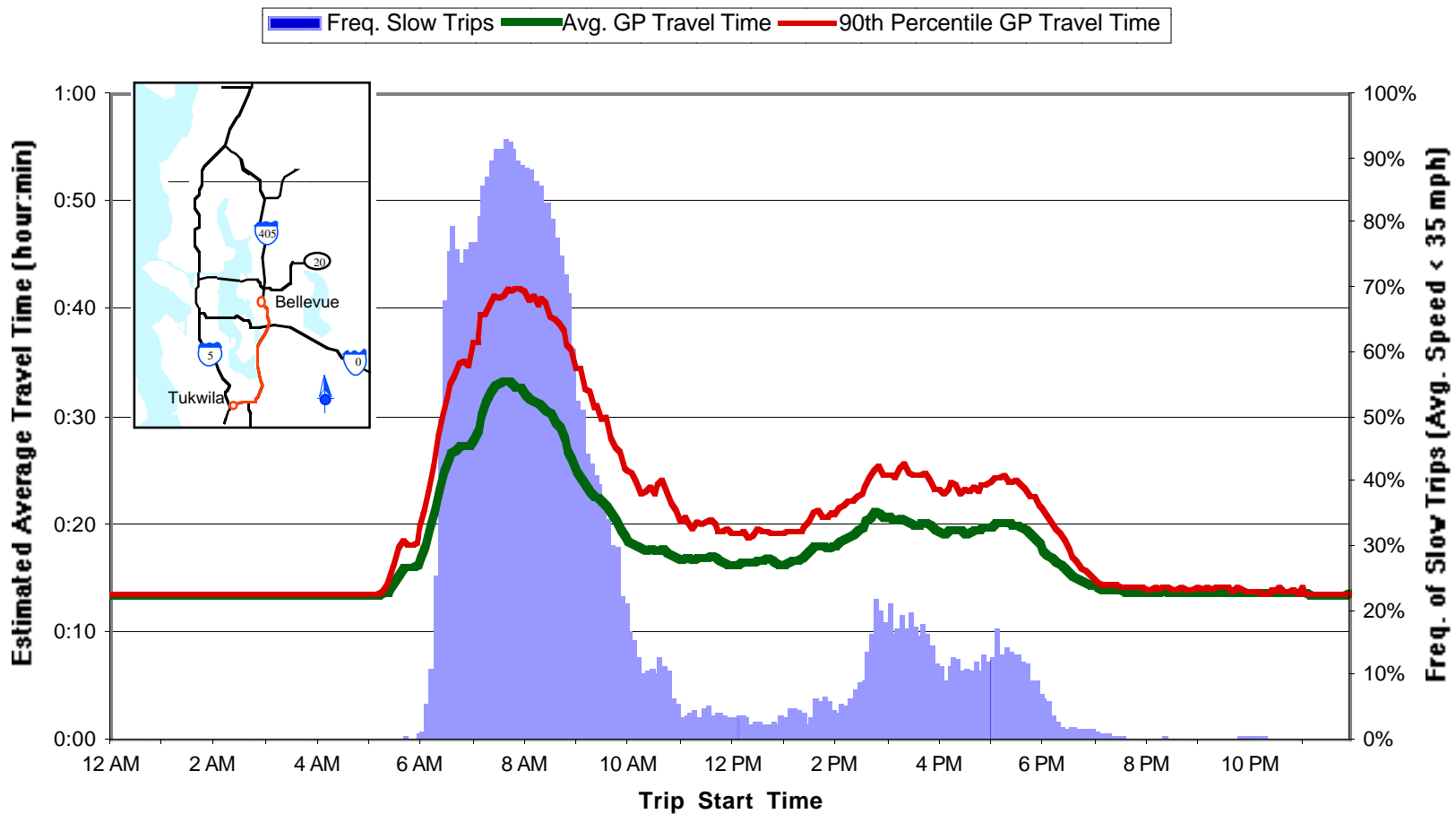


Figure 3.25. Estimated Average Weekday Travel Time (1999): Tukwila to Bellevue CBD, General Purpose Lanes (13.5 mi)

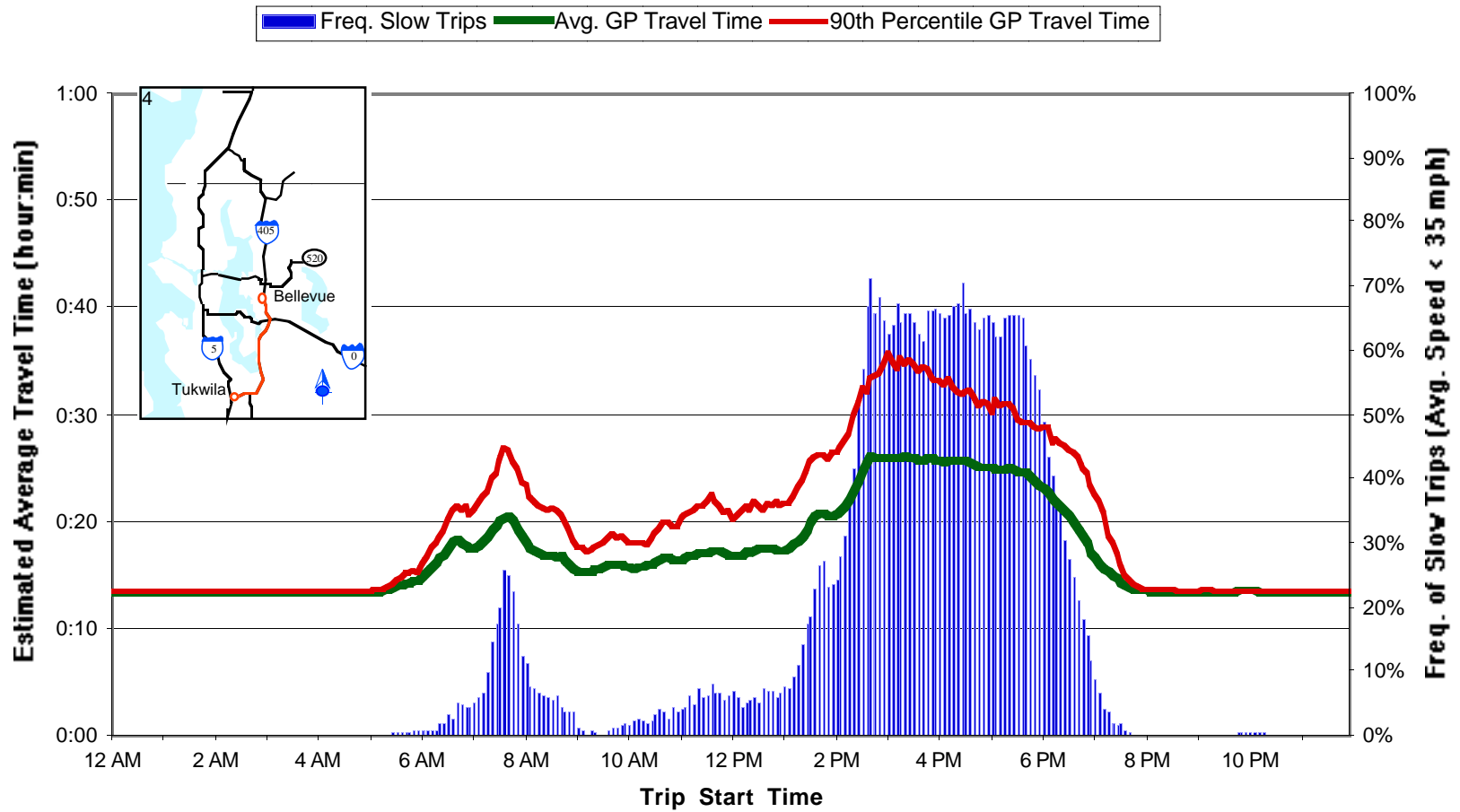


Figure 3.26. Estimated Average Weekday Travel Time (1999): Bellevue CBD to Tukwila, General Purpose Lanes (13.5 mi)

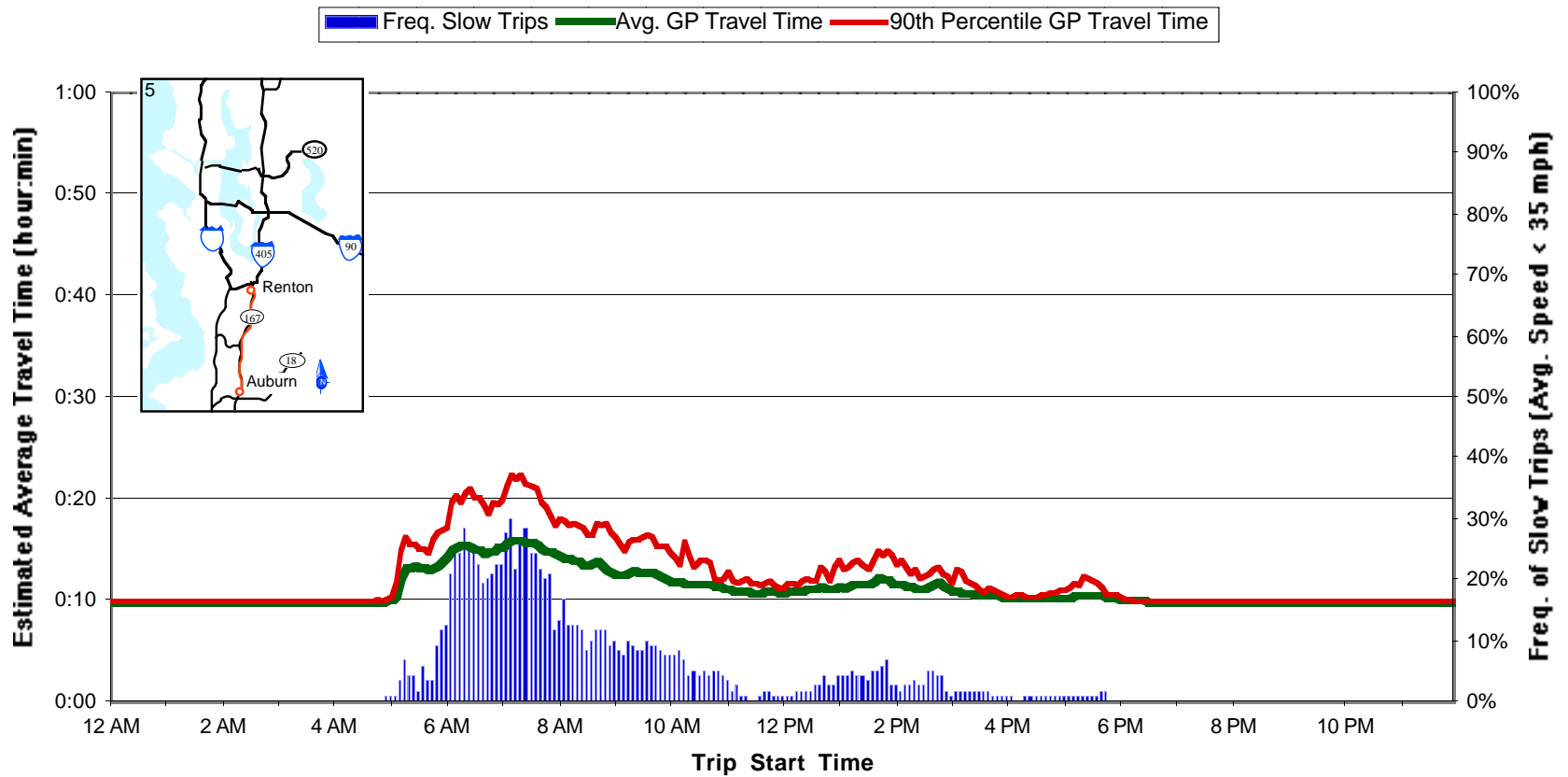


Figure 3.27. Estimated Average Weekday Travel Time (1999): Auburn to Renton, General Purpose Lanes (9.8 mi)

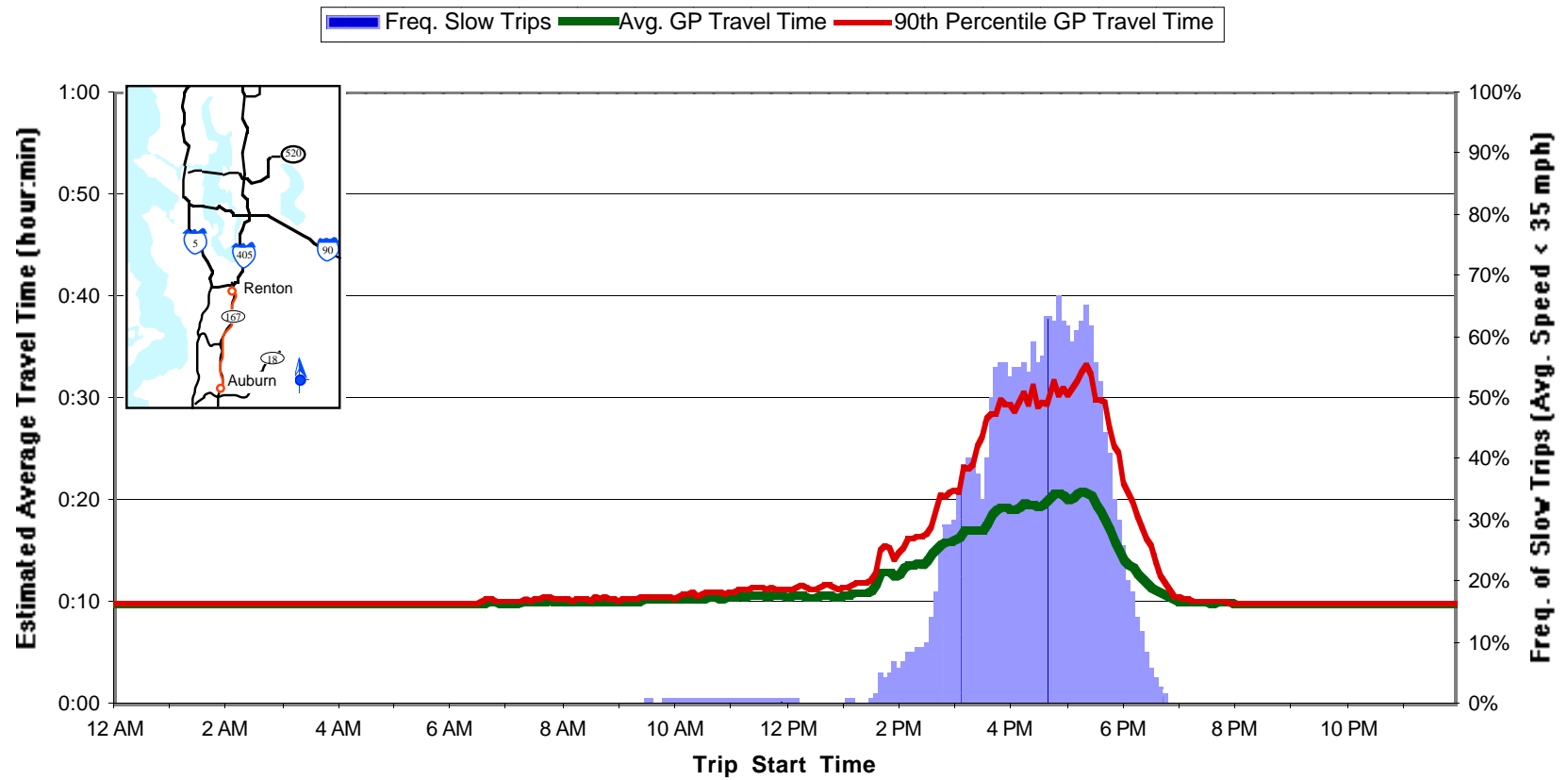


Figure 3.28. Estimated Average Weekday Travel Time (1999): Renton to Auburn, General Purpose Lanes (9.8 mi)

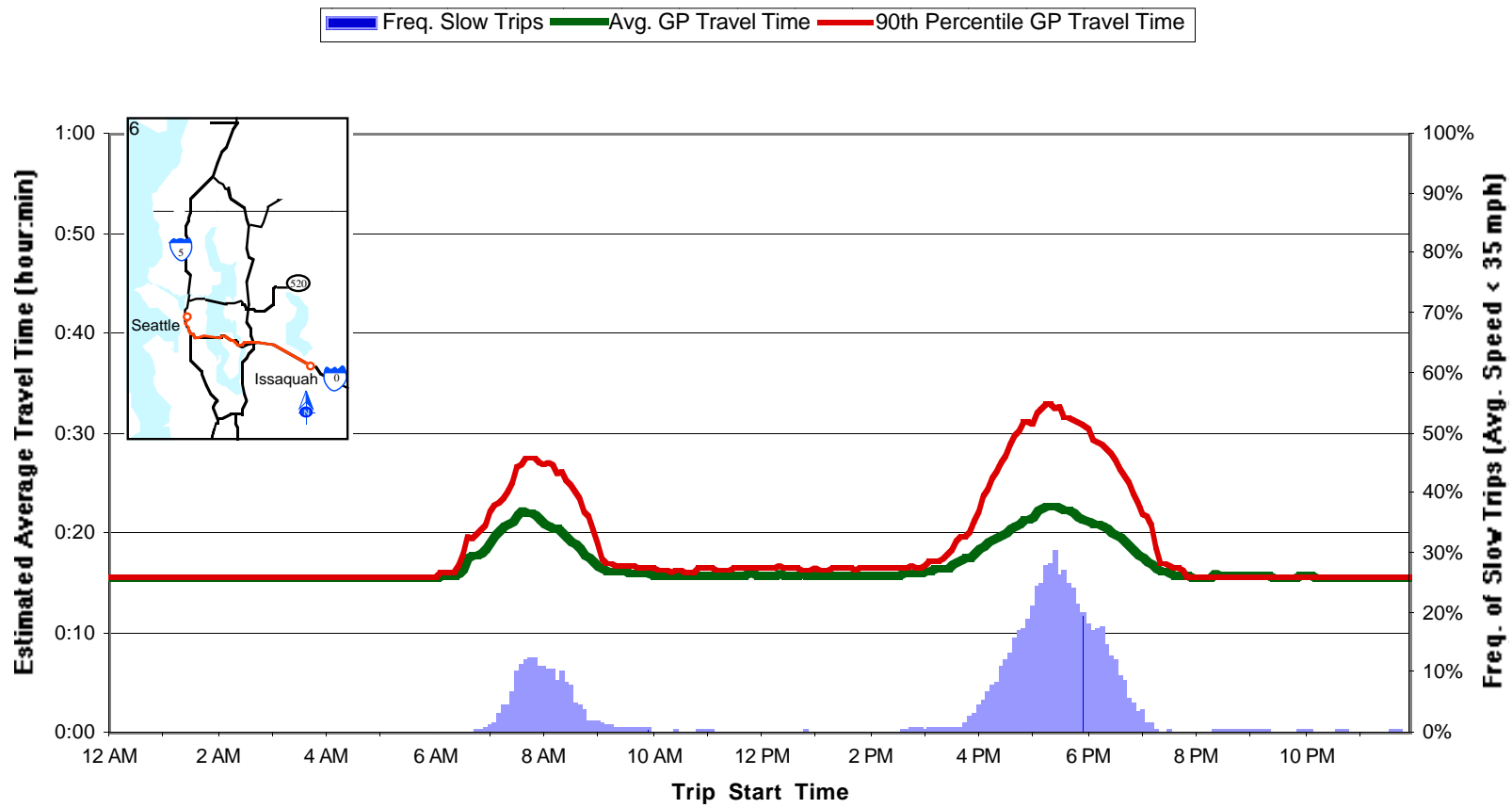


Figure 3.29. Estimated Average Weekday Travel Time (1999): Issaquah to Seattle CBD, General Purpose Lanes (15.5 mi)

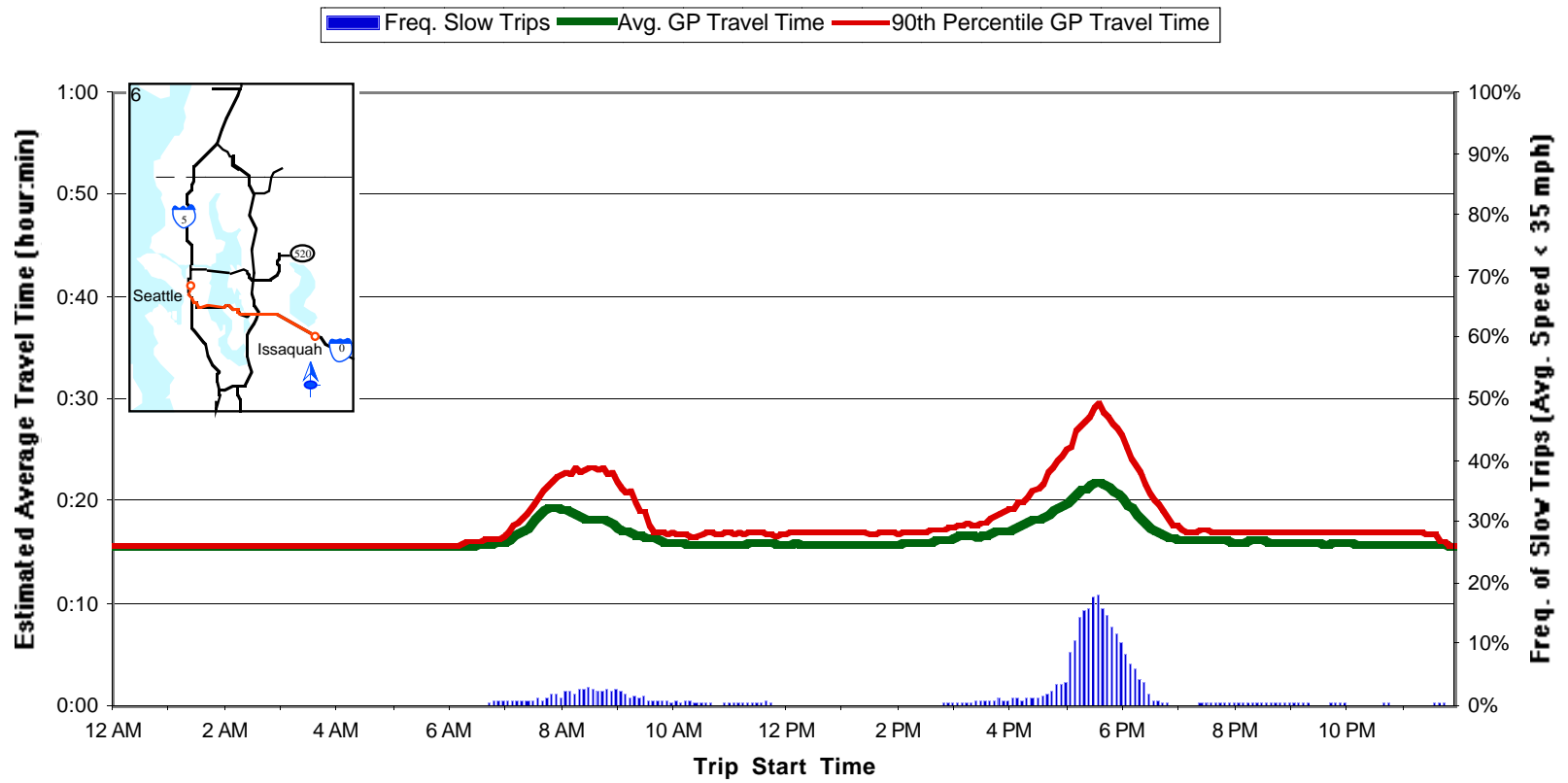


Figure 3.30. Estimated Average Weekday Travel Time (1999): Seattle CBD to Issaquah, General Purpose Lanes (15.5 mi)

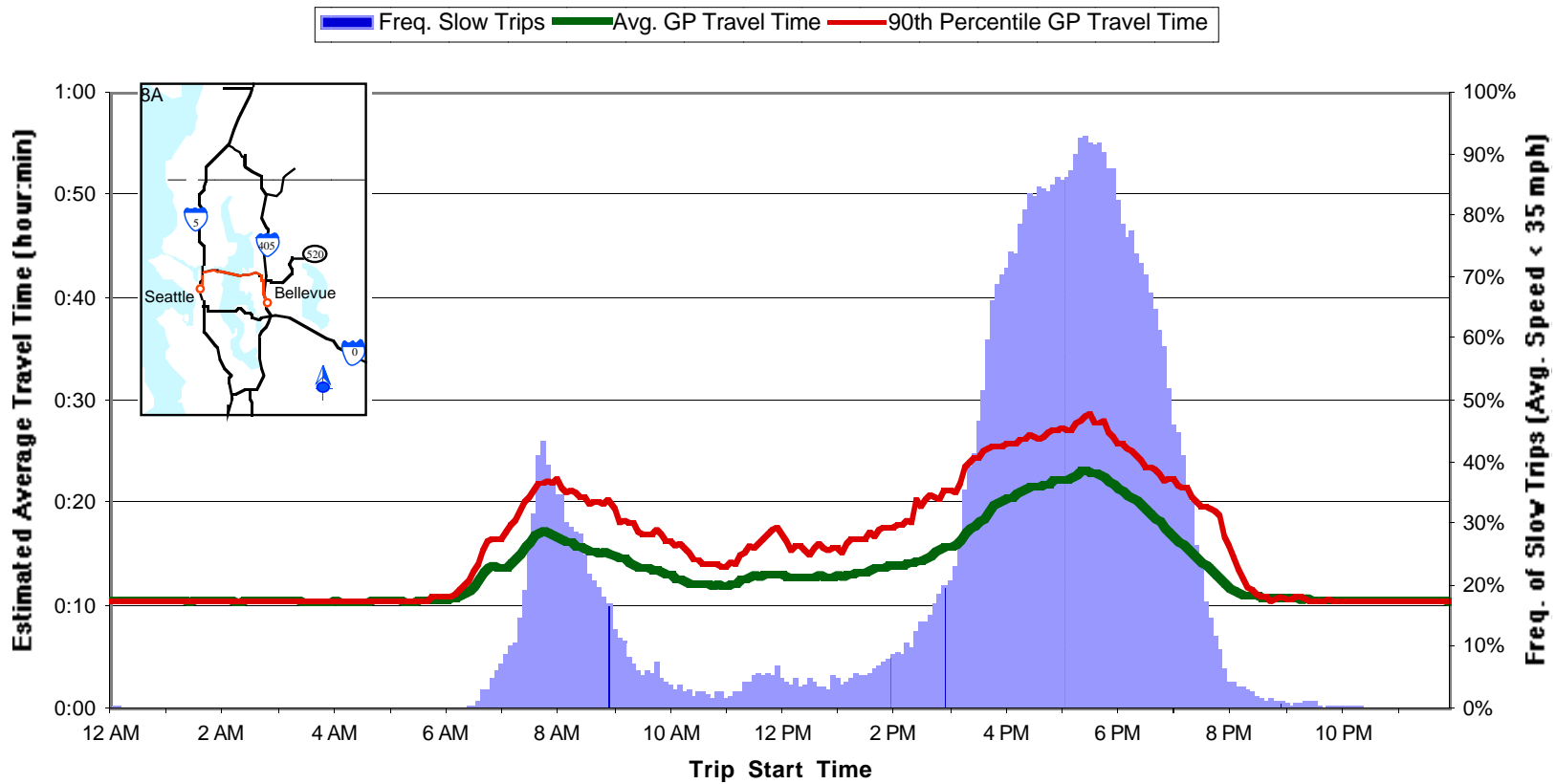


Figure 3.31. Estimated Average Weekday Travel Time (1999): Bellevue CBD to Seattle CBD via SR 520, General Purpose Lanes (10.5 mi)

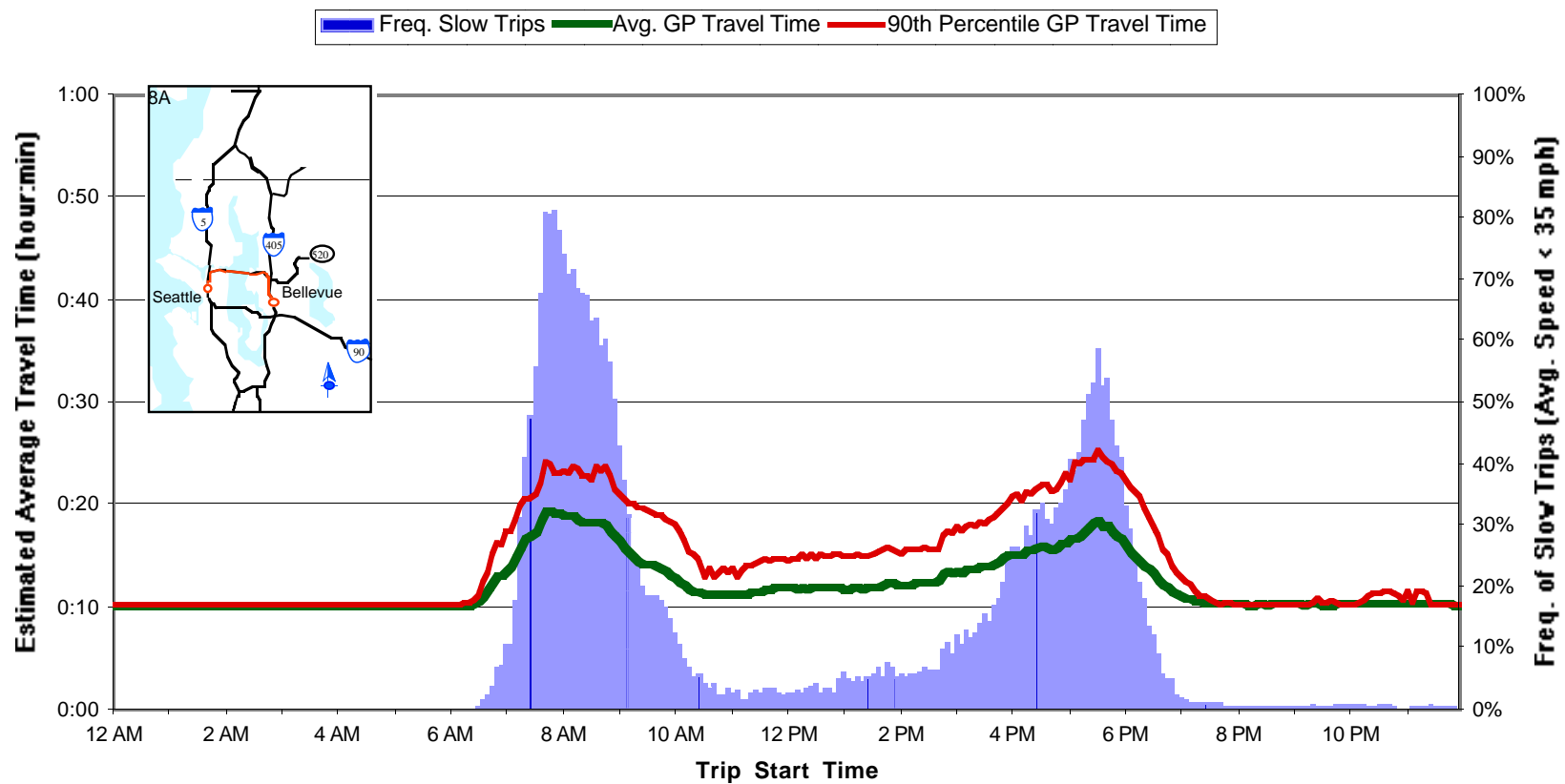


Figure 3.32. Estimated Average Weekday Travel Time (1999): Seattle CBD to Bellevue CBD via SR 520, General Purpose Lanes (10.1 mi)

during off-peak hours. Throughout the day, there is moderate variability in travel times, including the midday. There is a very high likelihood of a slow eastbound trip during the AM peak period, with a moderate likelihood during the PM peak.

Westbound: The westbound pattern is similar to the eastbound pattern (two peaks in the trip times, one in the morning and one in the afternoon), except that the afternoon peak period is by far the slower of the two peak periods. Westbound AM peak trip times are up to 65 percent higher than off-peak levels, while PM peak trip times are up to 120 percent higher. This afternoon commute trip has the second largest percentage increase in trip time relative to free-flow, among trips in this study. (It is second only to I-405's northbound morning trip time from Tukwila to Bellevue.) While the 90th percentile trip time on this route is not as bad as that on southbound SR 167, and the "average" trip time is not as bad as that on northbound I-405, the combination of intensity and duration of routine congestion in the afternoon peak period for this westbound trip is unmatched elsewhere in the region. Despite the availability of I-90 as an alternative route, for one third of all weekdays this trip averages less than 35 mph for almost four hours in the afternoon. The sheer volume of traffic attempting to cross Lake Washington in the "reverse" direction, combined with congestion present on the alternative routes, results in frequent, severe congestion on this route.

Route 8B. Bellevue CBD to Seattle CBD, via I-405, I-90, and I-5: 10.7 miles EB, 10.4 miles WB (Figures 3.33, 3.34)

Overall: This is the second of the two routes (8A and 8B) in this report between downtown Bellevue and downtown Seattle.

Congestion contour maps suggest that there is moderate westbound congestion along the entire route in the AM peak period and heavy westbound congestion along most of the route in the PM peak period. Eastbound congestion is moderate along much of the route during both peak periods, with the I-5 and I-405 segments experiencing moderate to heavy congestion during the peak periods. As with the other east-west bridge route (Route 8A), the "reverse" commute pattern is very apparent.

Westbound: There is a relatively moderate increase in westbound travel times during the AM peak that returns to off-peak levels by about 9:00 AM and stays that way until

mid-afternoon. By about 3:00 PM, trip times begin to climb, reaching a peak around 5:30 PM (when trip times are up to about 100 percent higher than in the off-peak); trip times gradually return to off-peak levels by about 7:30 PM. Trip time variability is moderate to high during the peaks (PM trips much more so than AM trips) and minimal during the midday hours. The likelihood of a slow trip is moderate to high in the afternoon.

Eastbound: The eastbound trip time pattern is somewhat reversed from the westbound pattern, with eastbound morning trip times somewhat higher than afternoon trip times. The variability of eastbound trip times is moderate to high during the peak periods, but significantly less during the midday. During the eastbound AM peak period there is a moderate likelihood of slow trips.

Route 9. Redmond to Bellevue CBD, via SR 520 and I-405: Not included in this report because of a lack of available data

Route 10. Issaquah to Bellevue CBD, via I-90 and I-405: 9.5 miles WB, 9.3 miles EB (Figures 3.35, 3.36)

Overall: This route from Issaquah to downtown Bellevue includes I-90, which experiences moderate congestion during the peak periods, and I-405, which is congested much of the day. Northbound I-405 (AM peak), southbound I-405 (PM peak), and eastbound I-90 near Issaquah (PM peak) have heavy average congestion.

Westbound: Westbound trips are affected by some congestion during the AM peak period. Trip times begin to grow about 6:00 AM and peak between 7:30 AM and 8:00 AM with trip times up to about 70 percent higher than trip times during off-peak hours. However, these times return to near-off-peak levels by 10:00 AM and stay near those levels (with some small to moderate fluctuations) the rest of the day.

Eastbound: The eastbound pattern is the opposite of the westbound pattern, with trip times increasing only in the afternoon peak period. There is a gradual increase in trip times and trip time variability throughout the afternoon, peaking at about 5:30 PM when times are up to 65 percent higher than during the off-peak. The likelihood of a slow trip is only moderate during the PM peak period.

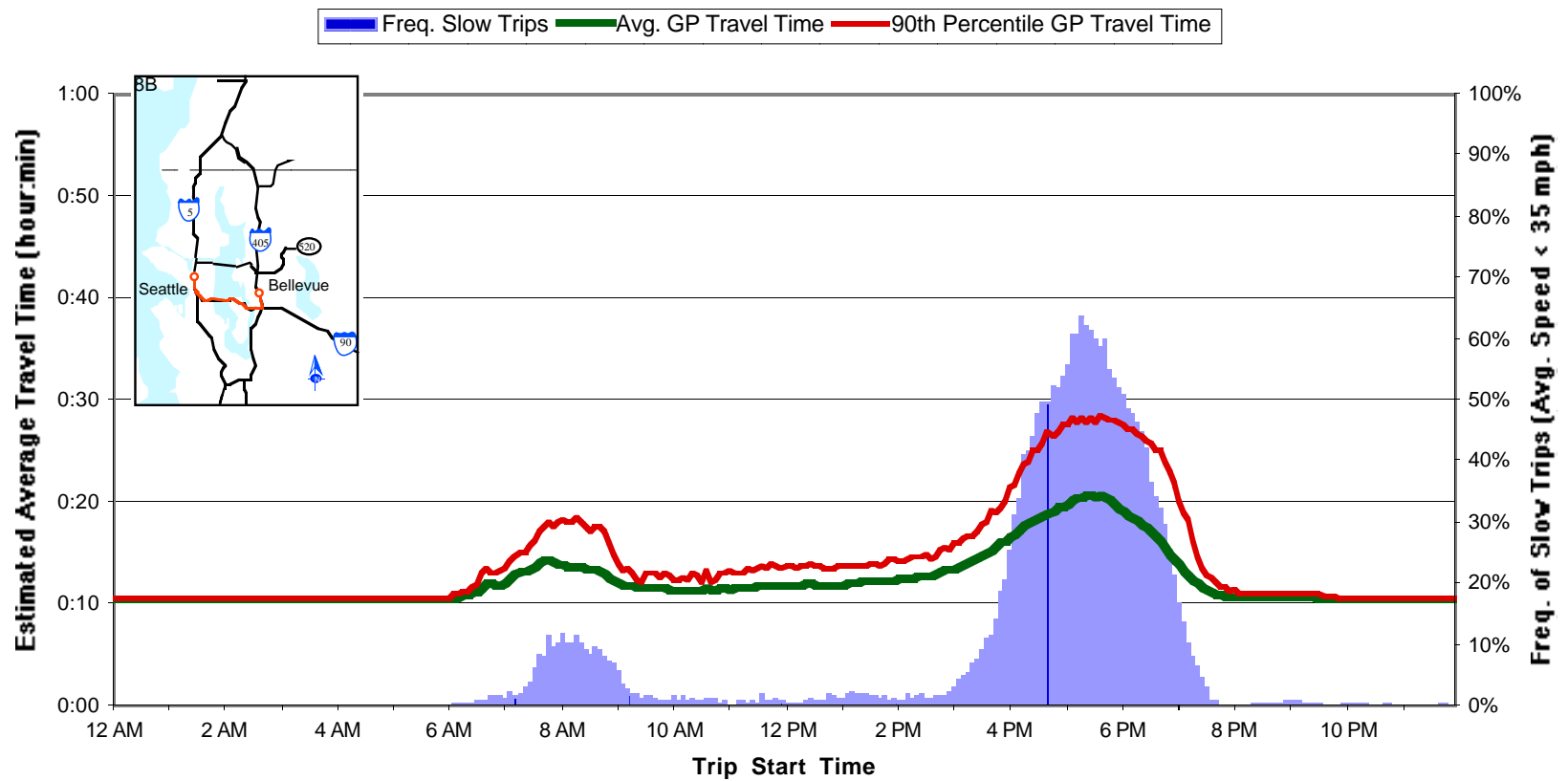


Figure 3.33. Estimated Average Weekday Travel Time (1999): Bellevue CBD to Seattle CBD via I-90, General Purpose Lanes (10.4 mi)

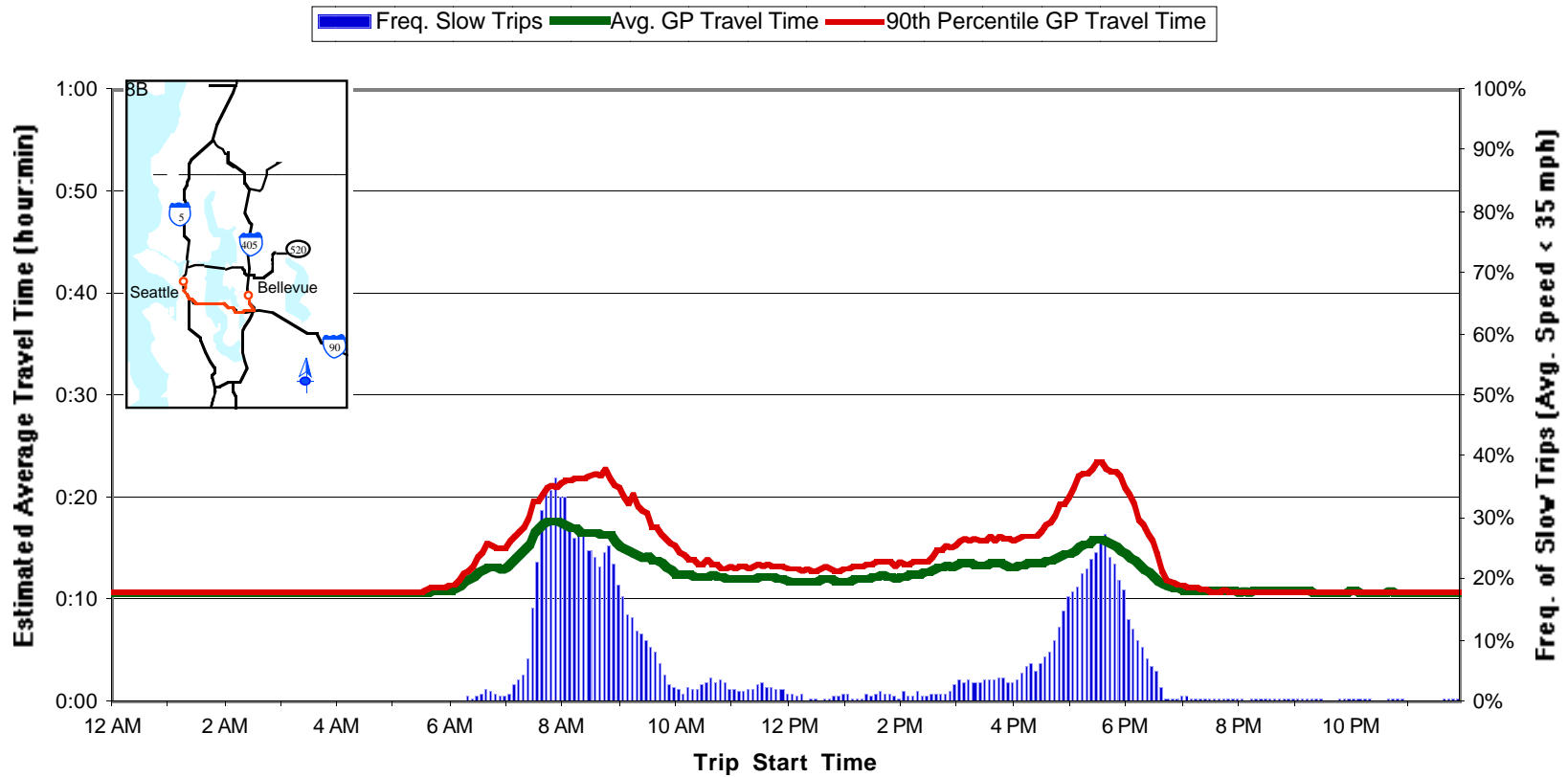


Figure 3.34. Estimated Average Weekday Travel Time (1999): Seattle CBD to Bellevue CBD via I-90, General Purpose Lanes (10.7 mi)

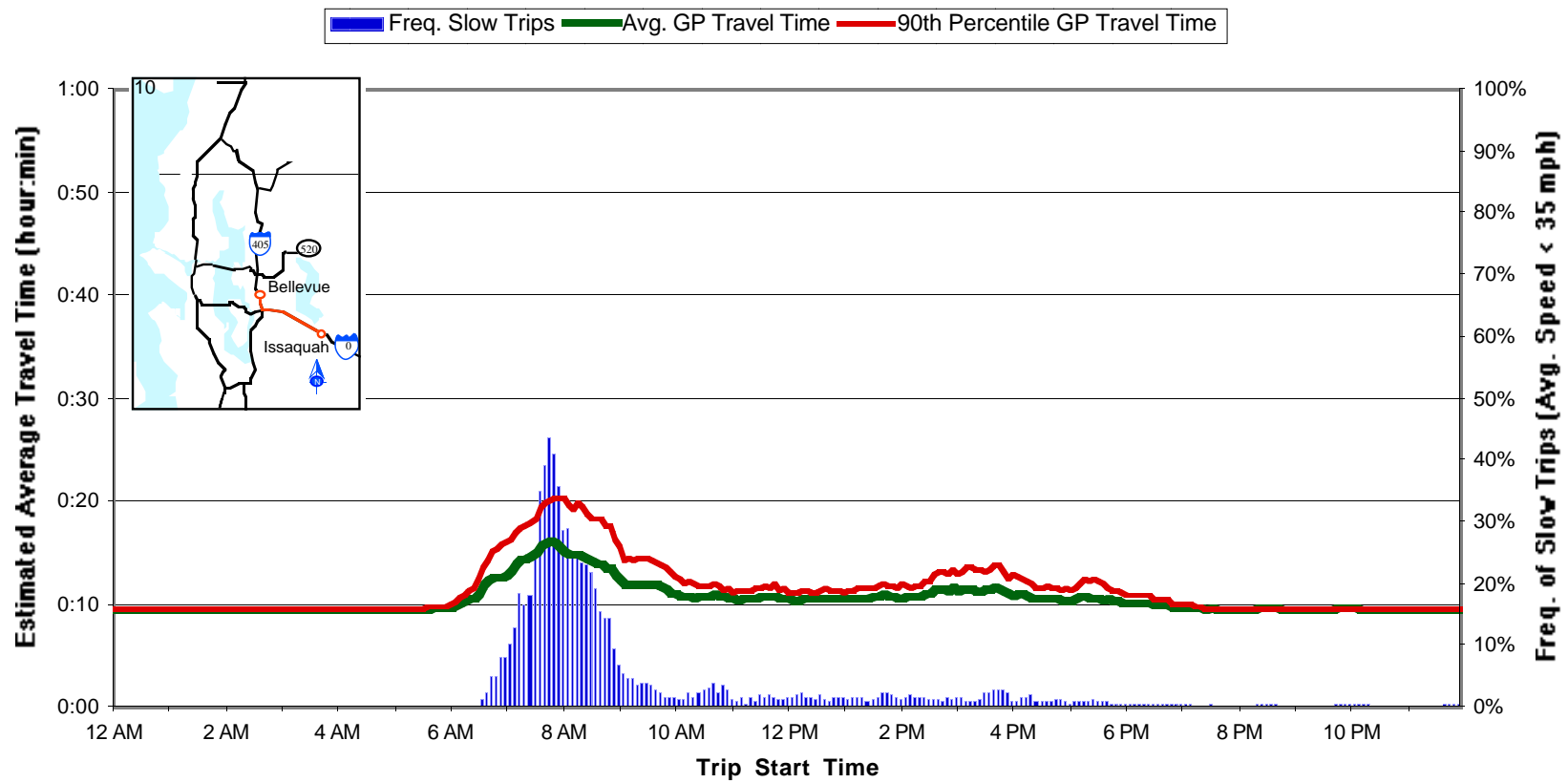


Figure 3.35. Estimated Average Weekday Travel Time (1999): Issaquah to Bellevue CBD, General Purpose Lanes (9.5 mi)

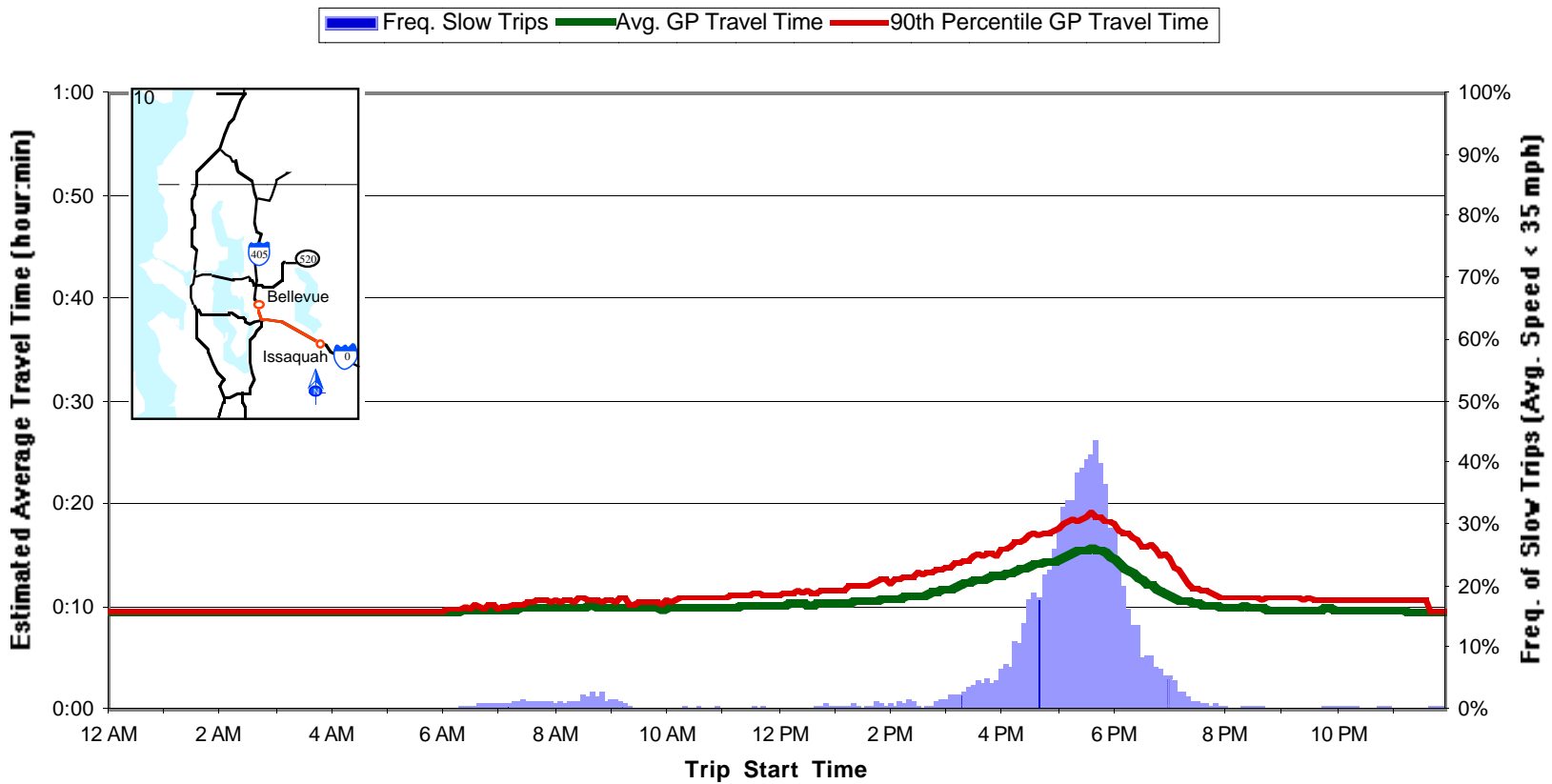


Figure 3.36. Estimated Average Weekday Travel Time (1999): Bellevue CBD to Issaquah, General Purpose Lanes (9.3 mi)

Section 4. System Performance: Selected Freeway Sites

The previous section described corridor performance, including average traffic congestion and congestion frequency patterns as a function of both time of day and location along a corridor, and average trip travel time, travel time variability, and trip congestion frequency. While these measures provide a top-level overview of system performance, they do not provide much detail about performance at any specific site. In this section, traffic performance at specific locations is analyzed. The principal measures used to evaluate traffic performance at a particular site include traffic volume, average speed, and congestion frequency; each is analyzed as a function of time of day, direction of travel, and type of lane (general purpose or HOV).

How Site-Specific Freeway Performance Was Measured

Three measures of system performance were used at selected freeway locations. They include the following:

Average Traffic Volume Profile at a Location, by Time of Day

Average traffic conditions at a site vary significantly over the course of a day. In the past, the typical weekday 24-hour volume “profile” was usually thought to be a pattern of high vehicle volumes during the morning and evening “rush hour” peak periods, and significantly lower volumes during non-peak hours. This pattern is changing as peak demand extends into the “shoulders” of traditional peak periods (i.e., the beginning and end of each peak period). Traffic during the peak period shoulders may include those who would have preferred to travel during the traditional peak period but shifted the timing of their trip to avoid congestion. In addition, some congested facilities also show “flatter” traffic volume profiles between the AM and PM peak periods, i.e., there is less of a dropoff in volume during the so-called “off-peak” period in the middle of the day.

Because both the magnitude and timing of volumes during the day are important considerations in trying to understand freeway performance, an average 24-hour

weekday traffic profile was estimated at selected freeway sites. Vehicle volumes were estimated at 5-minute intervals over an average 24-hour weekday at a given site; these volumes were then adjusted to a “per lane” hourly rate (vehicles per lane per hour, or **vplph**) to allow direct comparisons between sites with different numbers of lanes.

Average Speed at a Location, by Time of Day

Because traffic volumes are affected by the speed that vehicles can travel (and vice versa), average speeds were also estimated for the selected sites throughout the day.

Frequency of Heavy Congestion at a Location, by Time of Day

Average conditions do not represent the condition that always occurs; some days traffic conditions will be worse than average, and on other days conditions will be better. To describe how often a facility experiences “bad” traffic conditions, the researchers also estimated the frequency of congestion at the selected locations. Congestion frequency is measured by the likelihood that significantly congested traffic will be encountered at a given time of day. For example, a congestion frequency of 75 percent at 5:00 PM indicates that there is a 75 percent chance of encountering congested conditions at a particular location in a given direction of travel at 5:00 PM.

Where Site-Specific Freeway Performance Was Measured

Volume graphs for a core set of four central freeway measurement locations in the Seattle area “rectangle,” bounded by I-5, SR 520, I-405, and I-90, and one location on SR 167, are presented below. While those sites are not representative of all freeway sections, they provide considerable insight into the freeway system’s performance. The locations selected for this report are downtown Seattle on I-5 at University Street, downtown Bellevue on I-405 at NE 14th Street, SR 520 at the east end of the floating bridge, I-90 on the floating bridge, and SR 167 south of the I-405 interchange.

Results

Following an example of how to read the freeway performance graphs are descriptions of volume, speed, and congestion frequency conditions (using 1999 weekday data) for general purpose as well as HOV and/or reversible lanes (where they exist), presented by vehicle travel direction, for each of the five locations. Note that while these sites are good illustrations of facility use, other roadway sections can experience very different conditions.

Reading the Graphs

Figure 4.1 shows an example of a site-specific freeway performance graph for westbound SR 520 general purpose lanes at 76th Ave NE from 6:00 AM to 8:00 PM. The horizontal axis represents time of day. The shape of the line shows average weekday vehicle volume, measured along the left vertical axis in vehicles per lane per hour, by time of day. In a “traditional” commute pattern, volumes are heavy during the morning and afternoon peak hours but are substantially lower at midday. At this site, however, volumes remain fairly steady all day long, from before 7:00 AM to nearly 8:00 PM.

The volume line is further enhanced by color coding to reflect the approximate speed of vehicles on the average weekday:

- green indicates that traffic moves at or near the speed limit (55 mph and above)
- yellow represents speeds somewhat under the speed limit (approximately 45 to 55 mph)
- red represents traffic traveling slower than 45 mph.

Superimposed on the volume line is a column graph, measured along the right vertical axis, that illustrates the frequency of congestion, or how often a site experiences “bad” traffic conditions. Congestion frequency is measured by the likelihood that a traveler will encounter significantly congested traffic (Level of Service F, or unstable speeds) at a given time of day. At this location on westbound SR 520, for example, congestion frequency measures about 90 percent at 5:30 PM, indicating a 90 percent chance that commuters will experience congested conditions at 5:30 PM. From about 9:00 AM to 2:00 PM, however, travelers have only a 10 percent chance of encountering significant

congestion. Thus, at this site, even though volumes remain consistently high throughout much of the day, the occurrence of congestion varies greatly, as do speeds.

The following are descriptions of average 1999 weekday freeway performance at selected core sites in the Seattle area (see figures 4.2 - 4.20).

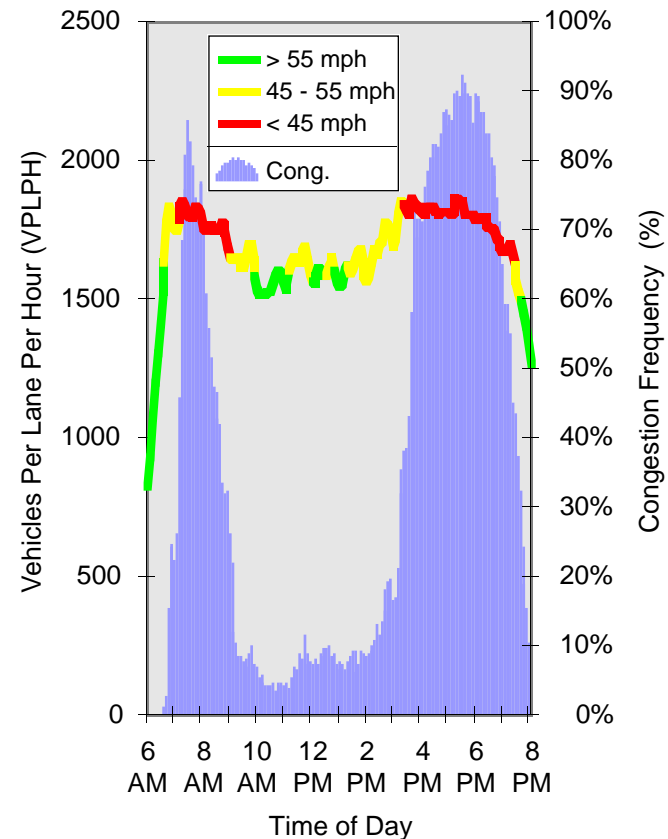


Figure 4.1. Estimated Weekday Volume, Speed, and Reliability Conditions (1997): Westbound SR 520, 76th Ave. NE, General Purpose Lanes

Downtown Seattle (I-5 at University Street)

Overall: This location includes southbound traffic from north Seattle, Snohomish County, and westbound SR 520, as well as northbound traffic heading to and through downtown Seattle. Peak period GP volumes are high in the AM and PM peak periods in both directions, with little drop-off in volume during the midday hours. Overall, southbound GP volumes during the day are slightly higher than northbound GP volumes, though northbound traffic has more frequent heavy congestion in the PM peak period.

Southbound HOV volumes are low in the morning but steadily increase in the afternoon. This is to be expected at this location, which is just south of several major downtown on- and off-ramps. Lower AM HOV volumes at this site would not be unexpected, given that much of the southbound I-5 HOV traffic in the morning is destined for downtown Seattle and therefore exits I-5 before reaching this location. In the afternoon, however, one expects the HOV lane to be more heavily used as it serves southbound HOV traffic starting from Seattle and heading south, as well as traffic from north of downtown that passes through the city.

This location also includes reversible lanes that operate southbound in the morning and northbound in the afternoon and evening (weekday schedule).

GP Northbound: Significant volumes (approximately 1,500 vplph) occur throughout the day (7:00 AM to 7:00 PM), with little drop-off in volumes during the midday. (See Figure 4.2.) The likelihood of encountering heavy congestion at this location peaks sharply during the PM peak period from about 5:00 PM to 7:00 PM, as traffic travels northbound away from downtown.

GP Southbound: Traffic volumes increase rapidly starting around 6:00 AM, with significant volumes (1,500+ vplph) that persist throughout much of the day (7:00 AM to 7:00 PM). (See Figure 4.3.) There is some drop in volume during the mid-morning hours (about 9:00 AM to 12:00 PM), after which volume levels rise again. Congestion is moderate throughout the day, with some reduction in the later morning hours and heavier congestion during the early PM peak (approximately 3:00 PM to 6:00 PM) as traffic moves southbound through downtown Seattle. The likelihood of encountering

heavy congestion increases during the mid-afternoon.

HOV Northbound: There is no mainline northbound HOV lane at this location.

HOV Southbound: Volumes build throughout the day to a significant (1,000 vplph) peak in the mid- to late afternoon (approximately 4:00 PM) as traffic moves through and away from downtown. (See Figure 4.4.) There is almost no heavy congestion in this HOV lane. (Note that the southbound HOV lane starts just north of this location; there is no HOV lane on the mainline between Northgate and the Seattle central business district.)

Reversible GP: Average weekday GP volumes increase sharply during the traditional AM and PM peak traffic hours on this north-south reversible facility, which reverses the direction of travel at midday on weekdays (Figure 4.5). In the mornings, southbound peak period traffic reaches over 1,800 vplph, while in the afternoons, the northbound peak period traffic reaches more than 1,200 vplph. (Note that at this location there are two GP lanes southbound in the AM hours, and three GP lanes northbound in the PM hours.) The southbound AM traffic becomes noticeably congested during peak hours, with significant congestion occurring from approximately 6:30 AM to 9:00 AM, and moderate congestion continuing after that until about 10:00 AM. Northbound afternoon and evening traffic experiences relatively little congestion at this site. This downtown Seattle location is near the end of the reversible lane facility in the morning when traffic is heading southbound, and therefore near the entry point of the reversible lane facility in the afternoon and evening when traffic is heading northbound away from downtown Seattle.

Reversible HOV: The I-5 reversible HOV lane operates in the southbound direction during the AM weekday hours, then switches direction at midday and becomes a GP northbound lane. While operating as an HOV lane in the morning, volumes are highest around 7:30 AM, reaching approximately 700 vplph. There is no congestion on the HOV lane during this time. See Figure 4.6.

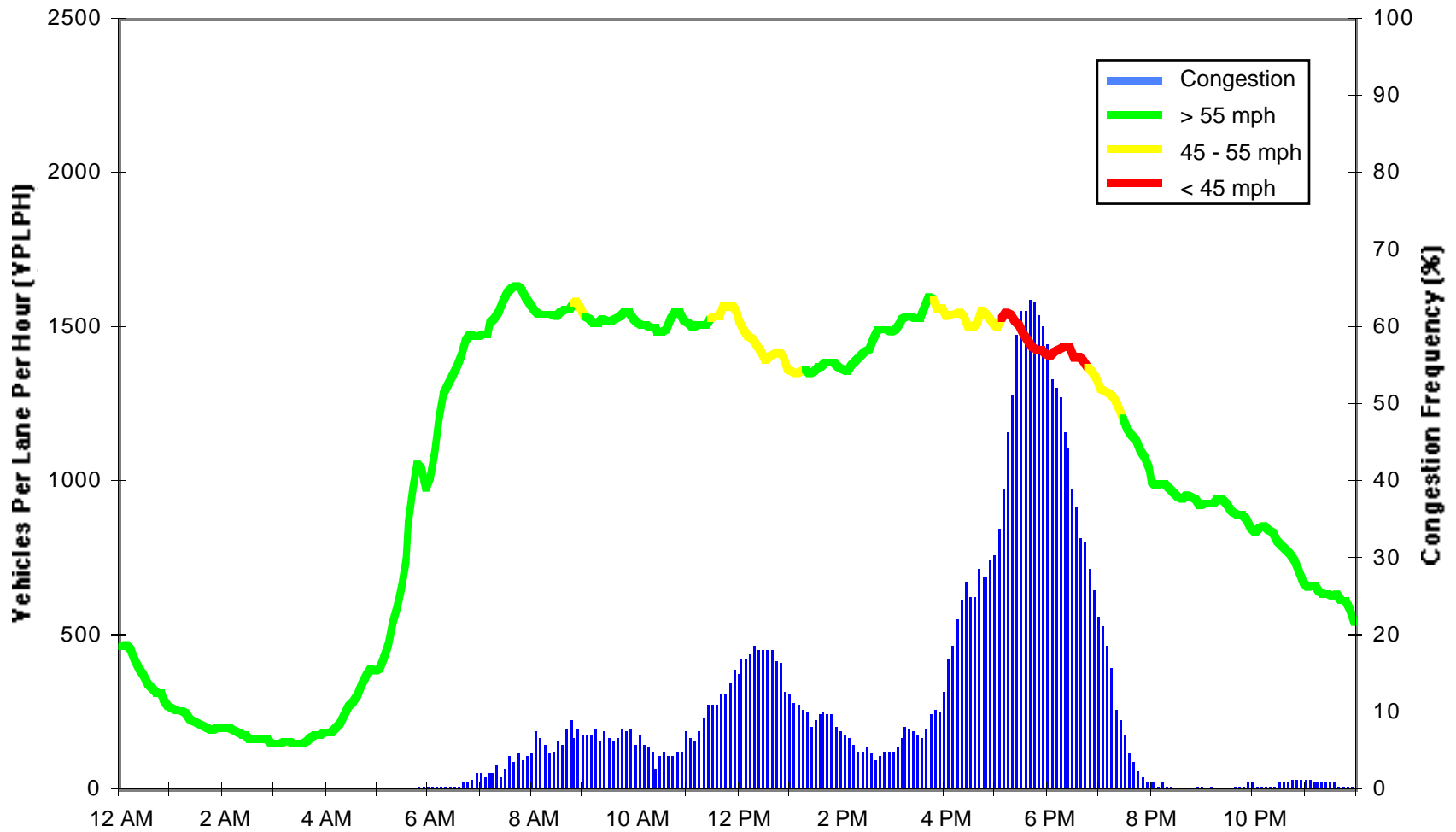


Figure 4.2. Estimated Weekday Volume, Speed, and Reliability Conditions (1999): Northbound I-5, University St, General Purpose Lanes

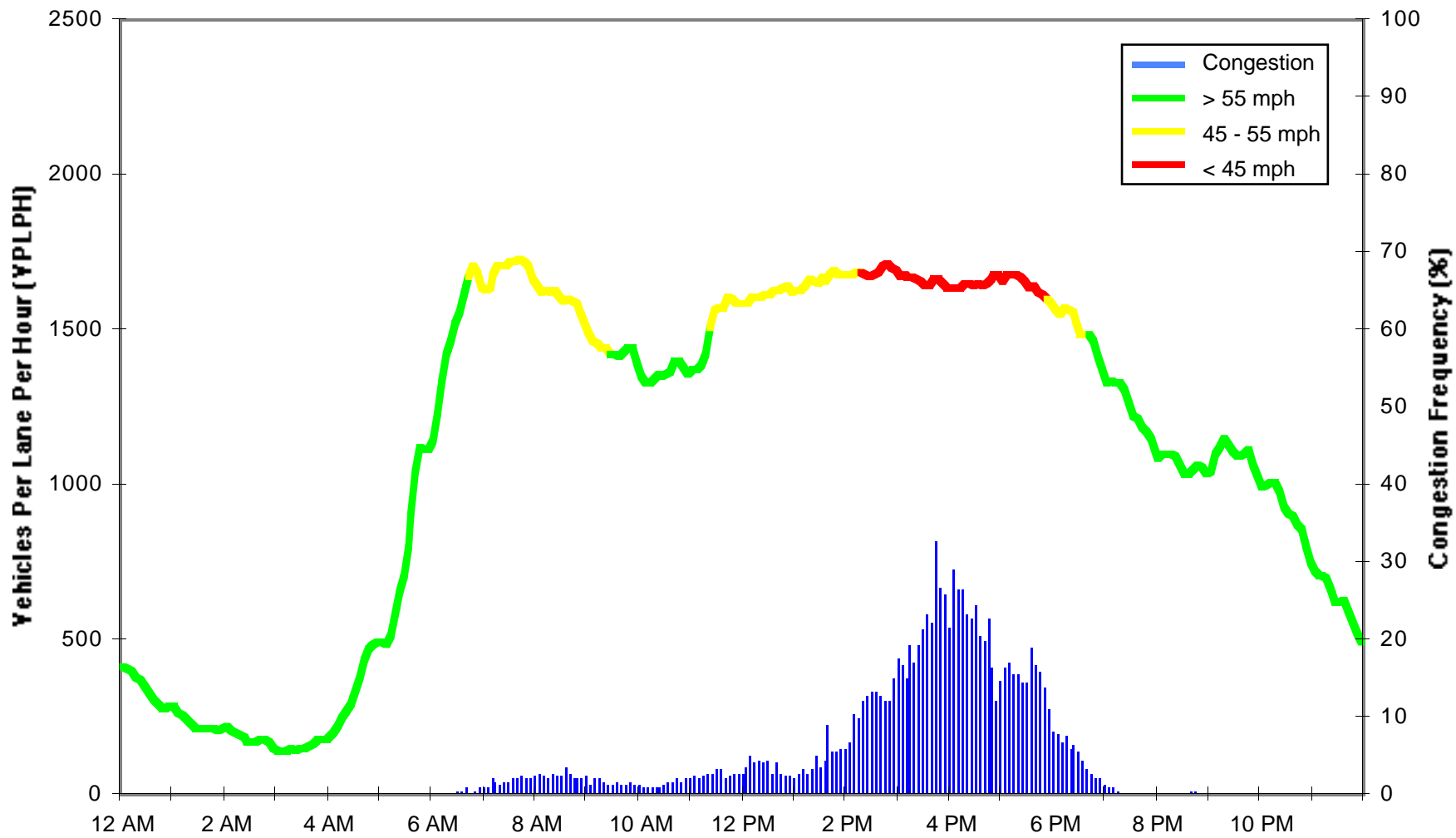


Figure 4.3. Estimated Weekday Volume, Speed, and Reliability Conditions (1999): Southbound I-5, University St, General Purpose Lanes

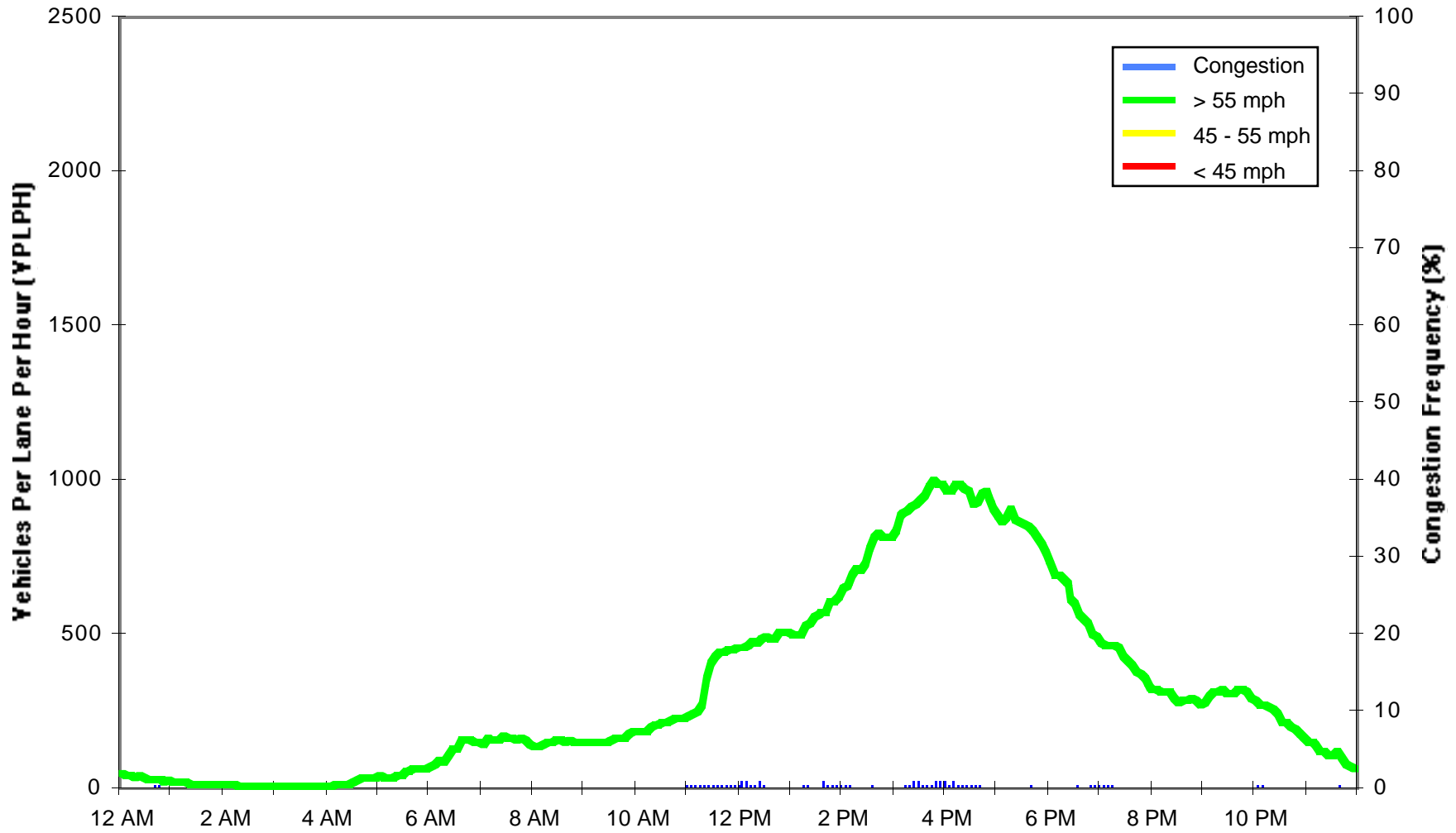


Figure 4.4. Estimated Weekday Volume, Speed, and Reliability Conditions (1999): Southbound I-5, University St, HOV Lanes

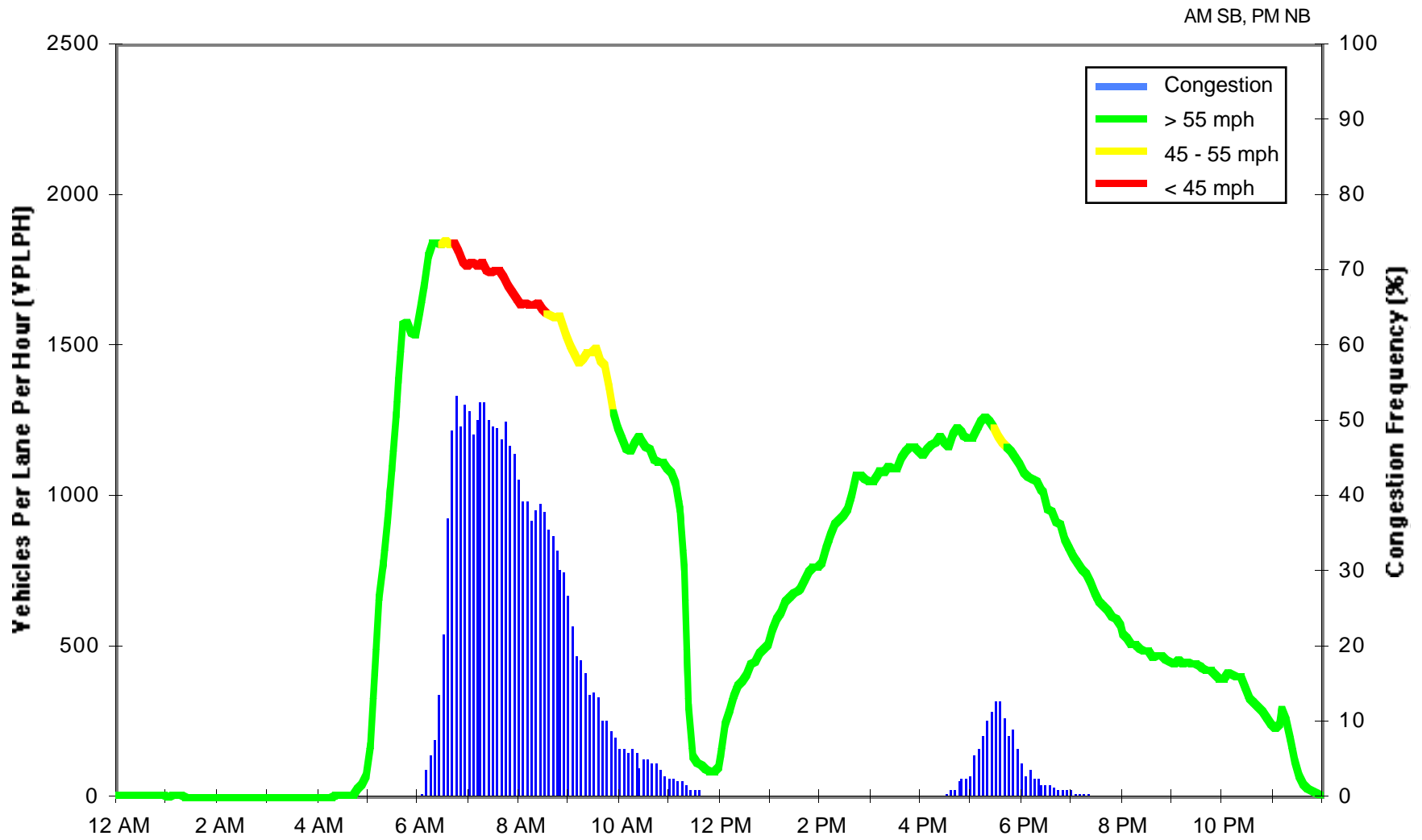


Figure 4.5. Estimated Weekday Volume, Speed, and Reliability Conditions (1999): I-5, University St, General Purpose Reversible Lanes

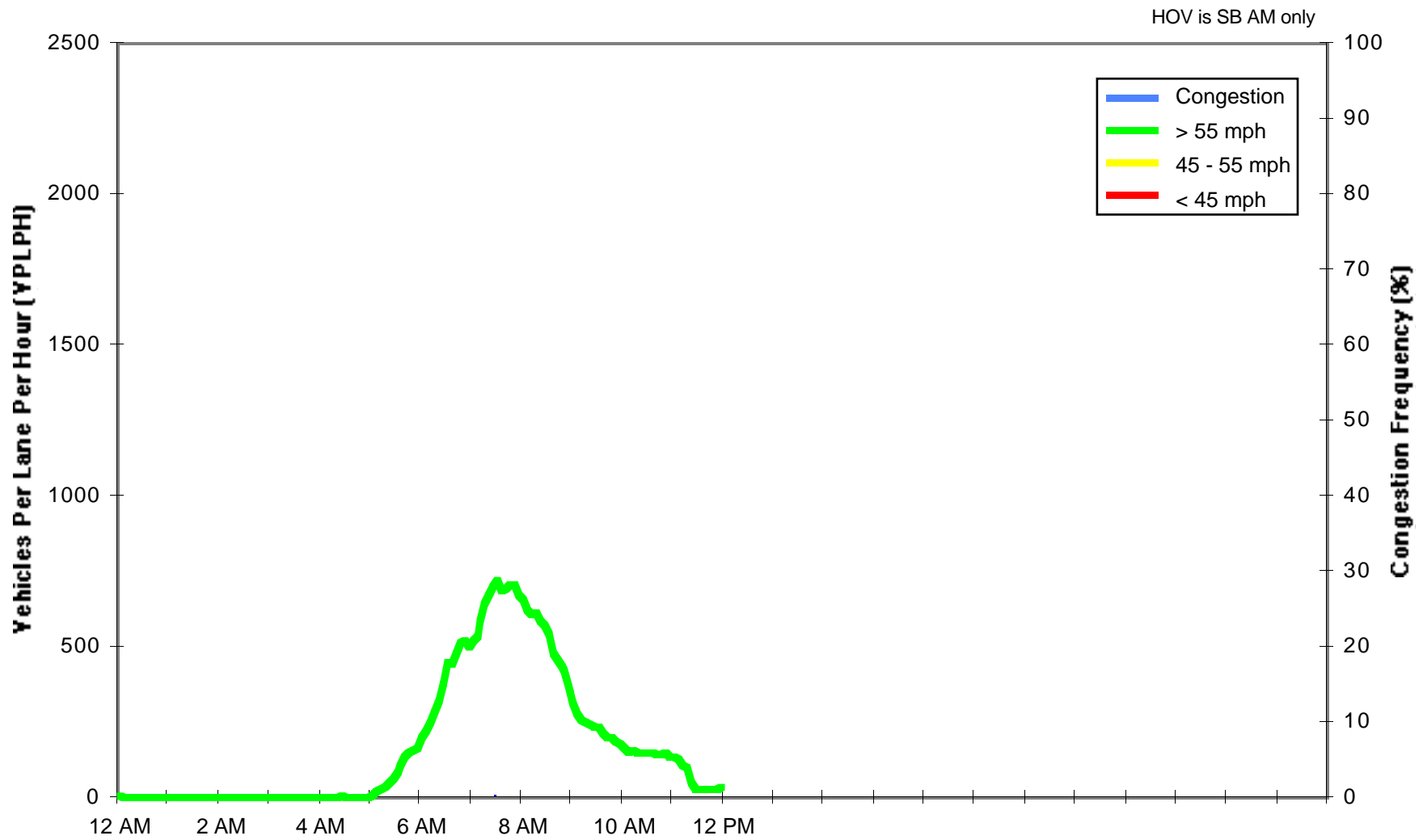


Figure 4.6. Estimated Weekday Volume, Speed, and Reliability Conditions (1999): I-5, University St, HOV Reversible Lanes

Downtown Bellevue (I-405 at NE 14th Street)

Overall: This location, just north of downtown Bellevue, includes traffic heading to and from Kirkland, SR 520, and other parts of northeast King County, as well as traffic traveling through Bellevue. GP volumes remain high throughout the day with persistent slowing in the northbound direction. HOV lane volumes in either direction are approximately 500 vehicles per hour during much of the day, increasing to approximately 1000 vplph during the afternoon peak hour, and are usually uncongested.

GP Northbound: Moderate to significant volumes persist throughout the day, beginning with moderate volumes (1,000 to 1,300 vplph) in the morning (from approximately 6:00 AM on). (See Figure 4.7.) At this location, northbound AM congestion can be affected by increased vehicle volumes on I-405 itself, combined with mixing of merging traffic (from the on-ramp from NE 8th, just south of this location) and exiting traffic (heading to the off-ramps leading to SR 520, just north of this location), as well as backups that may occur on the off-ramps to SR 520. Volumes build gradually during the day, reaching the highest volumes of the day in the PM peak (1,600+ vplph). Some congestion usually persists throughout the day from approximately 7:00 AM to 6:00 PM. The frequency of heavy congestion is highest during the AM peak period from approximately 8:00 AM to 10:00 AM.

GP Southbound: Significant volumes (1,400 to 1,800 vplph) persist throughout much of the day (Figure 4.8). The highest volumes of the day are in the AM peak period, but with little or no congestion. However, moderate to significant congestion occurs during the PM peak (traveling toward downtown Bellevue) as vehicles merging from downtown Bellevue add to significant southbound vehicle volumes on I-405. The likelihood of encountering heavy congestion increases significantly during the afternoon and early evening PM peak period.

HOV Northbound: HOV volumes reach approximately 400 to 500 vplph during the AM peak and remain at that level throughout much of the day. Volume builds in the afternoon, reaching a peak of 1000 vplph during the mid-afternoon and PM peak hours. There is generally no significant congestion on the northbound HOV lane at this location. (See Figure 4.9.)

HOV Southbound: HOV volumes reach approximately 500+ vplph during the AM peak and remain near that level throughout much of the day. As with northbound HOV traffic, the southbound HOV lane builds in volume during the afternoon, reaching 1000+ vplph during the PM peak hours (4:00 PM to after 6:00 PM). During the afternoon peak hours, congestion is moderate, with occasional congestion. (See Figure 4.10.)

Note about I-405 HOV lanes at this site: There are some notable differences between the 1999 HOV lane measurements at this site and the corresponding 1997 results in the previous version of this report. These differences are at least in part a reflection of one significant intervening change. In 1998, the northbound and southbound HOV lanes at this location were moved from the outside lane to the inside lane. This removed the effect of merging and exiting volumes at this site from subsequent measurements of HOV lane traffic levels and congestion patterns. It also removed from the HOV lane measurements at this site the volumes of HOVs starting or ending their trips in Bellevue, since at this location such vehicles would either have already left the inside HOV lane to get to the Bellevue exit, or would not yet have entered the HOV lane. It is not surprising, then, to see lower HOV volumes at some times of the day in 1999 in comparison to 1997, when right-side HOV lanes could include non-HOV vehicles that were entering or exiting the freeway, as well as entering and exiting HOVs. This change in lane configuration should be kept in mind when I-405 results in this report are compared with those from other analyses.

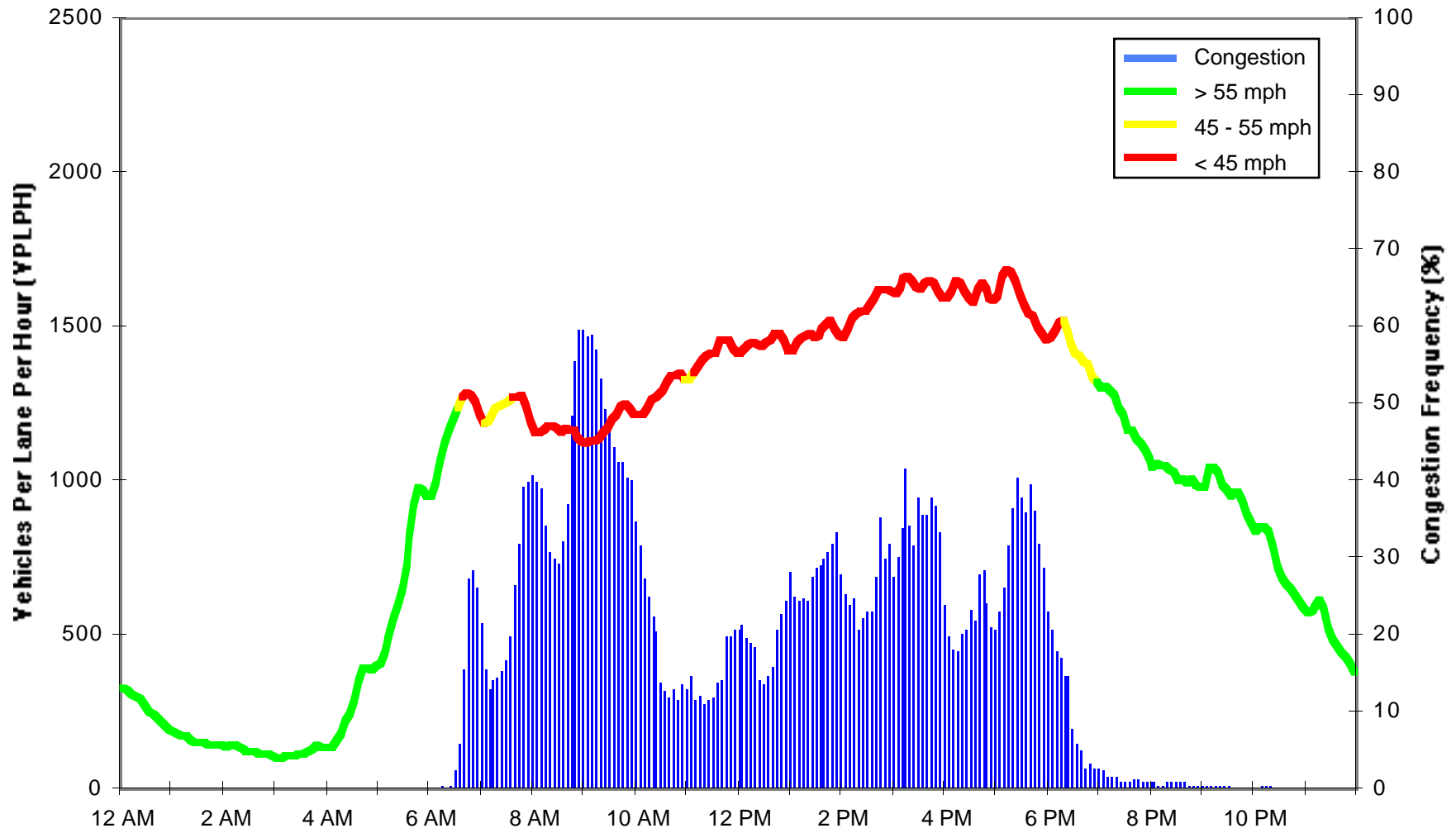


Figure 4.7. Estimated Weekday Volume, Speed, and Reliability Conditions (1999): Northbound I-405, NE 14th St, General Purpose Lanes

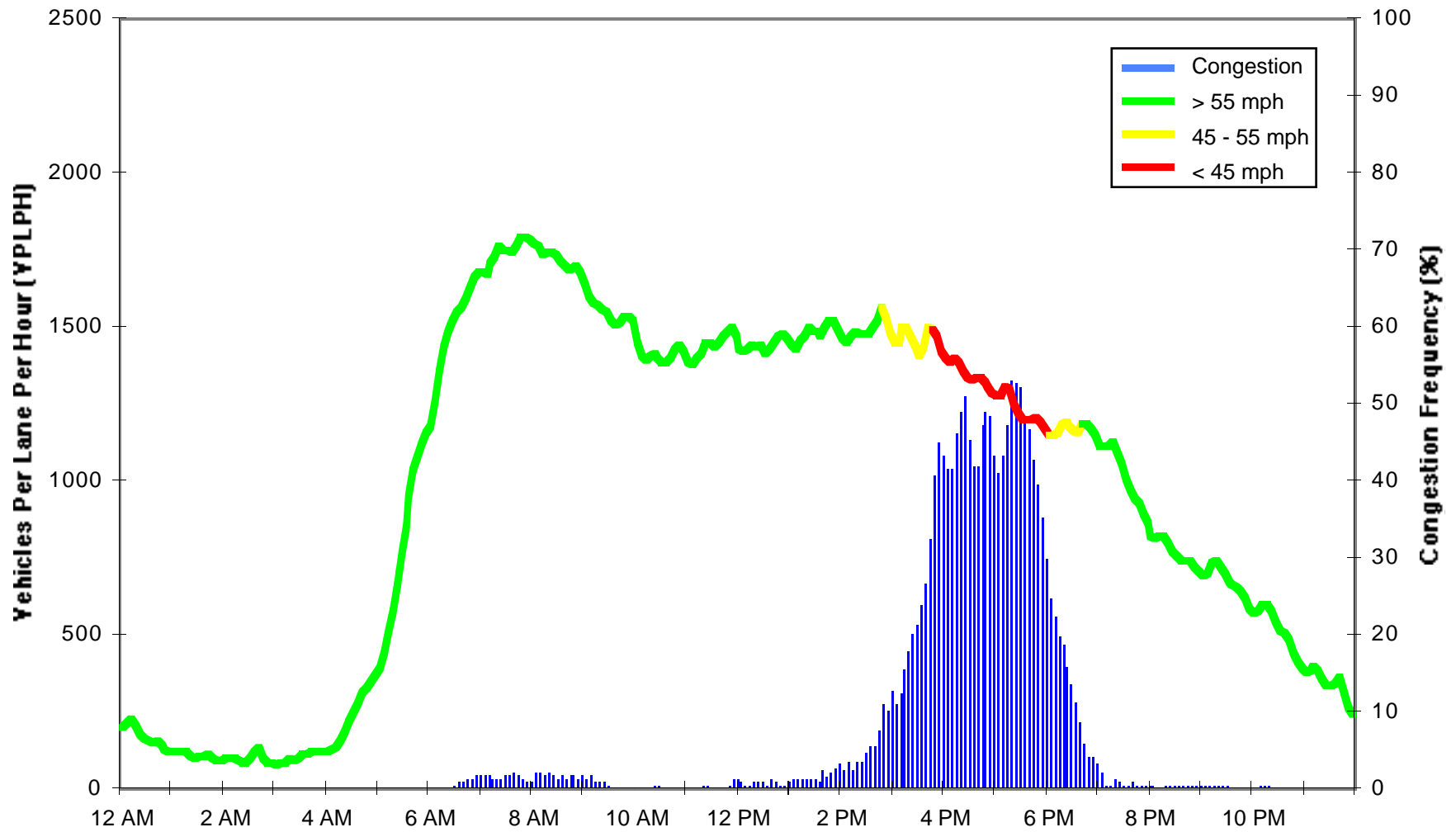


Figure 4.8. Estimated Weekday Volume, Speed, and Reliability Conditions (1999): Southbound I-405, NE 14th St, General Purpose Lanes

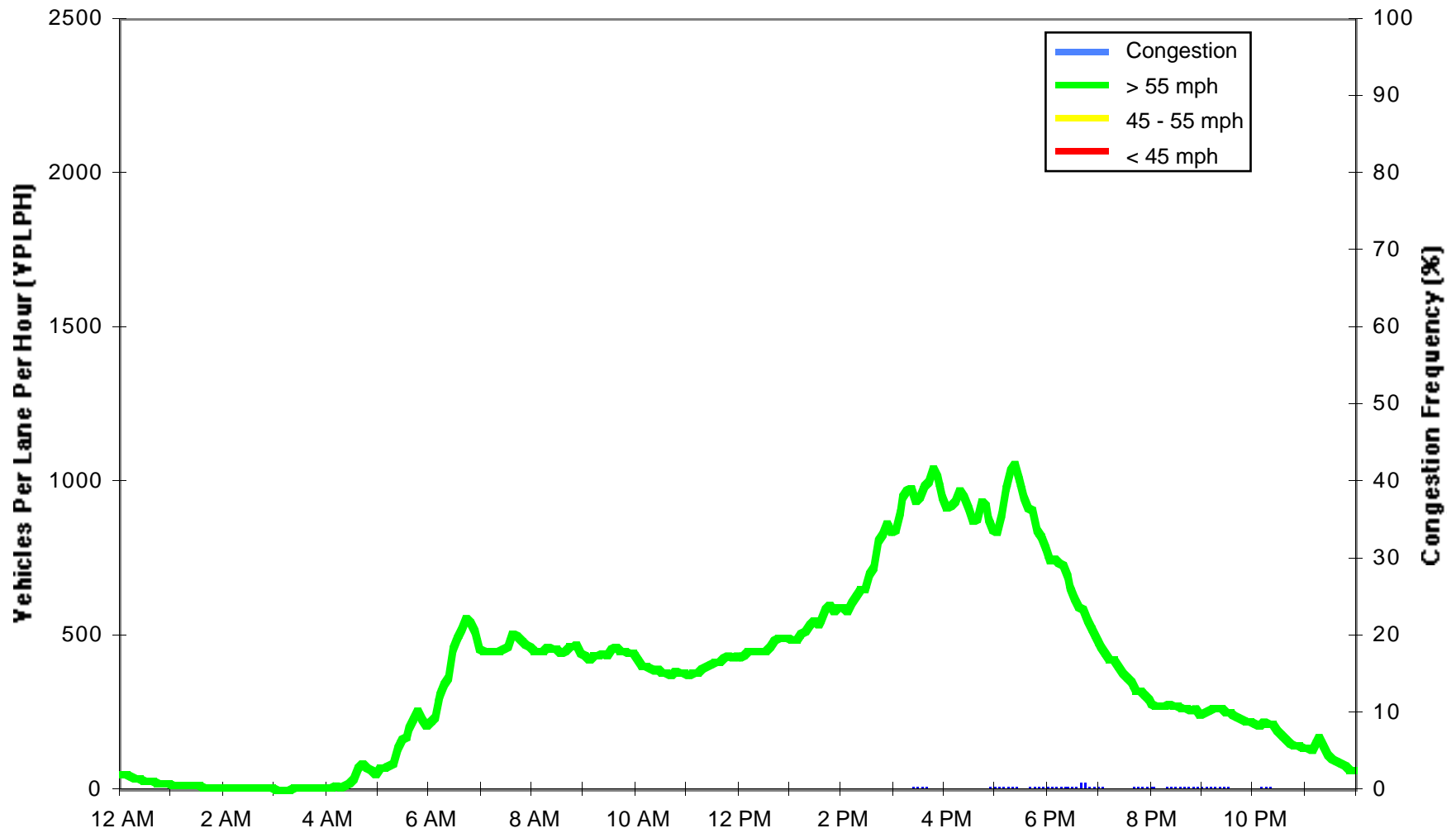


Figure 4.9. Estimated Weekday Volume, Speed, and Reliability Conditions (1999): Northbound I-405, NE 14th St, HOV Lanes

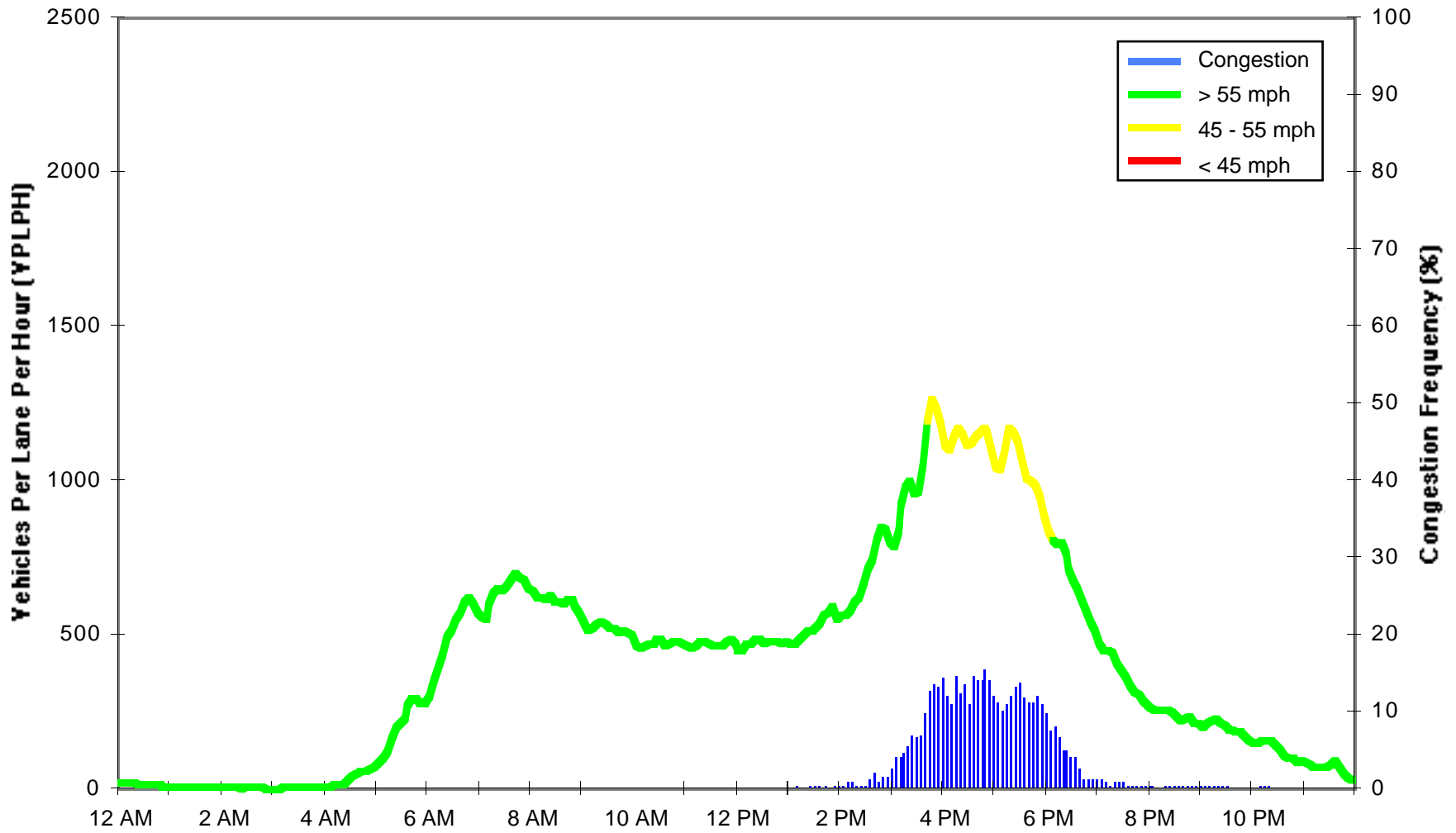


Figure 4.10. Estimated Weekday Volume, Speed, and Reliability Conditions (1999): Southbound I-405, NE 14th St, HOV Lanes

SR 520 (Evergreen Point) Floating Bridge (at NE 76th/NE 84th, just east of the bridge)

Overall: This location includes all SR 520 traffic that is approaching or has crossed the bridge span. GP volumes remain very high throughout the day and are comparable to the per-lane GP volumes carried during peak periods on I-5. Westbound GP frequency of congestion at this site is the highest of the five locations measured in this section of this report. The significance of what used to be referred to as a secondary “reverse” commute—i.e., traveling from Seattle to the Eastside in the morning, and returning from the Eastside back to Seattle in the evening—is evident in the GP volume profiles; volumes are approximately the same in both directions in the morning and evening. The (westbound) HOV lane is on the outside (right lane) in a converted shoulder and requires 3+ occupants; it ends just east of NE 76th, requiring HOVs to merge into general purpose traffic, contributing to congestion in the GP lane.

GP Eastbound: Volumes are routinely high (1,500 to 1,800 vplph) throughout the day at this location (eastbound just after crossing the bridge), with little drop-off at midday (Figure 4.11). While these results do not show frequent heavy congestion at this site, significant traffic slowing does occur elsewhere on eastbound SR 520 near the bridge, particularly at the west approach to the bridge in the Montlake area near the Lake Washington and Montlake Boulevard ramps, and continuing to the midspan of the bridge. By the time vehicles reach the east highrise of the bridge where the measurements were taken, however, they have normally broken free of significant congestion.

GP Westbound: Westbound volumes at the approach to the bridge are high throughout the day (about 1,500 to 1,800 vplph), with heavy congestion during both peak periods, and persistent high volumes and occasional congestion throughout the midday hours. (See Figure 4.12.) The frequency of heavy congestion is very high during both peak periods, with the PM peak period congestion extending from about 3:30 PM to nearly 7:30 PM. Note that congestion in the so-called “reverse commute” direction (westbound to Seattle in the evening) is more frequent, for a longer period, than that of the “traditional” westbound AM commute into Seattle.

HOV Eastbound: There is no eastbound HOV lane at this site.

HOV Westbound: Volumes are low to moderate (about 200 to 400 vplph) during peak

periods for westbound HOV traffic approaching the bridge (Figure 4.13). PM peak volumes are somewhat higher than AM peak period volumes; this may be due to a higher usage of buses in the morning because of better Seattle-bound AM transit service, or higher westbound PM carpool usage that may be in part a reflection of the relative lack of afternoon transit service in that direction. Note also that the lower HOV volumes reflect in part the more stringent 3+ person minimum carpool requirement on SR 520.

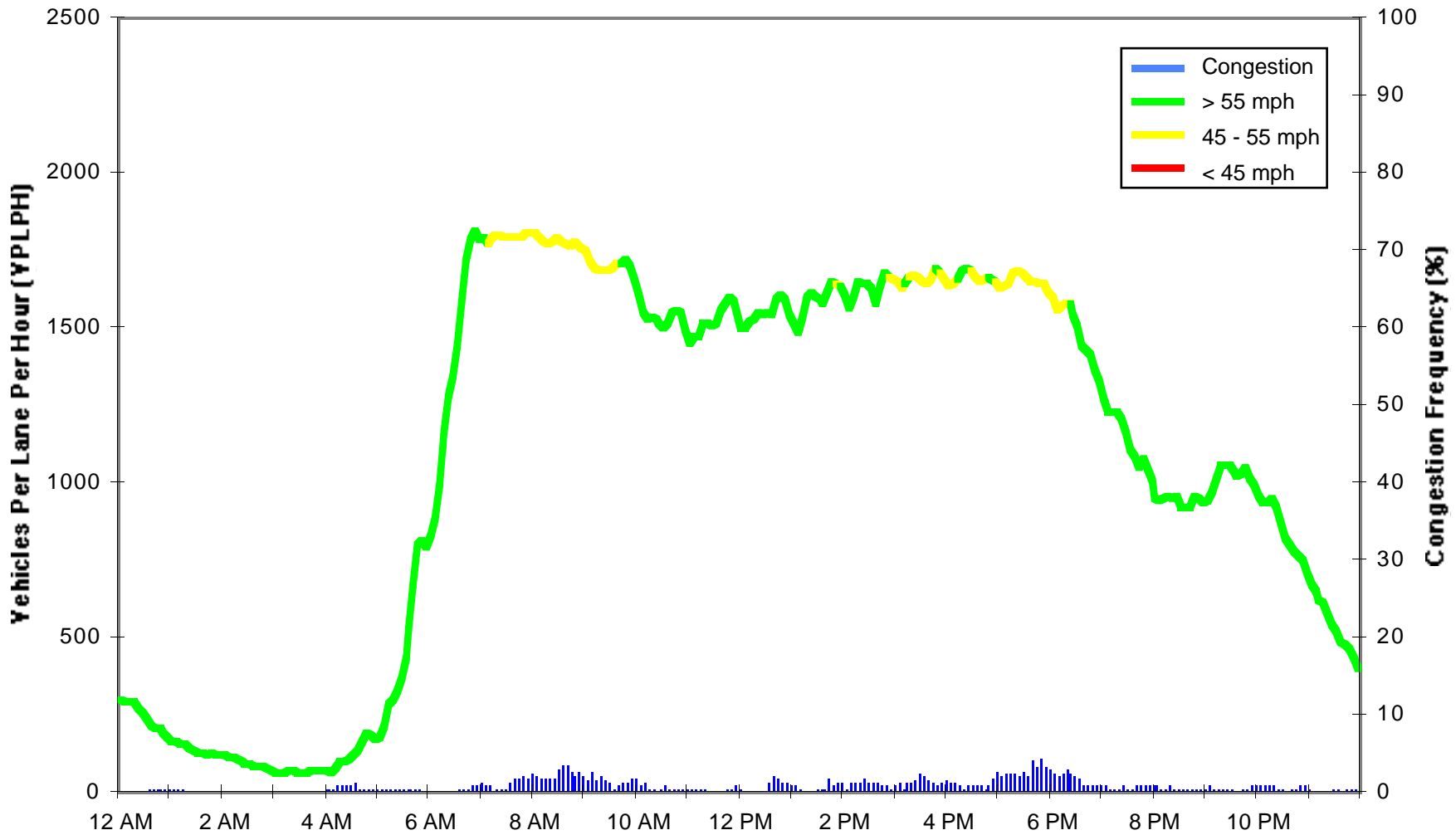


Figure 4.11. Estimated Weekday Volume, Speed, and Reliability Conditions (1999): Eastbound SR 520, 76th Ave NE, General Purpose Lanes

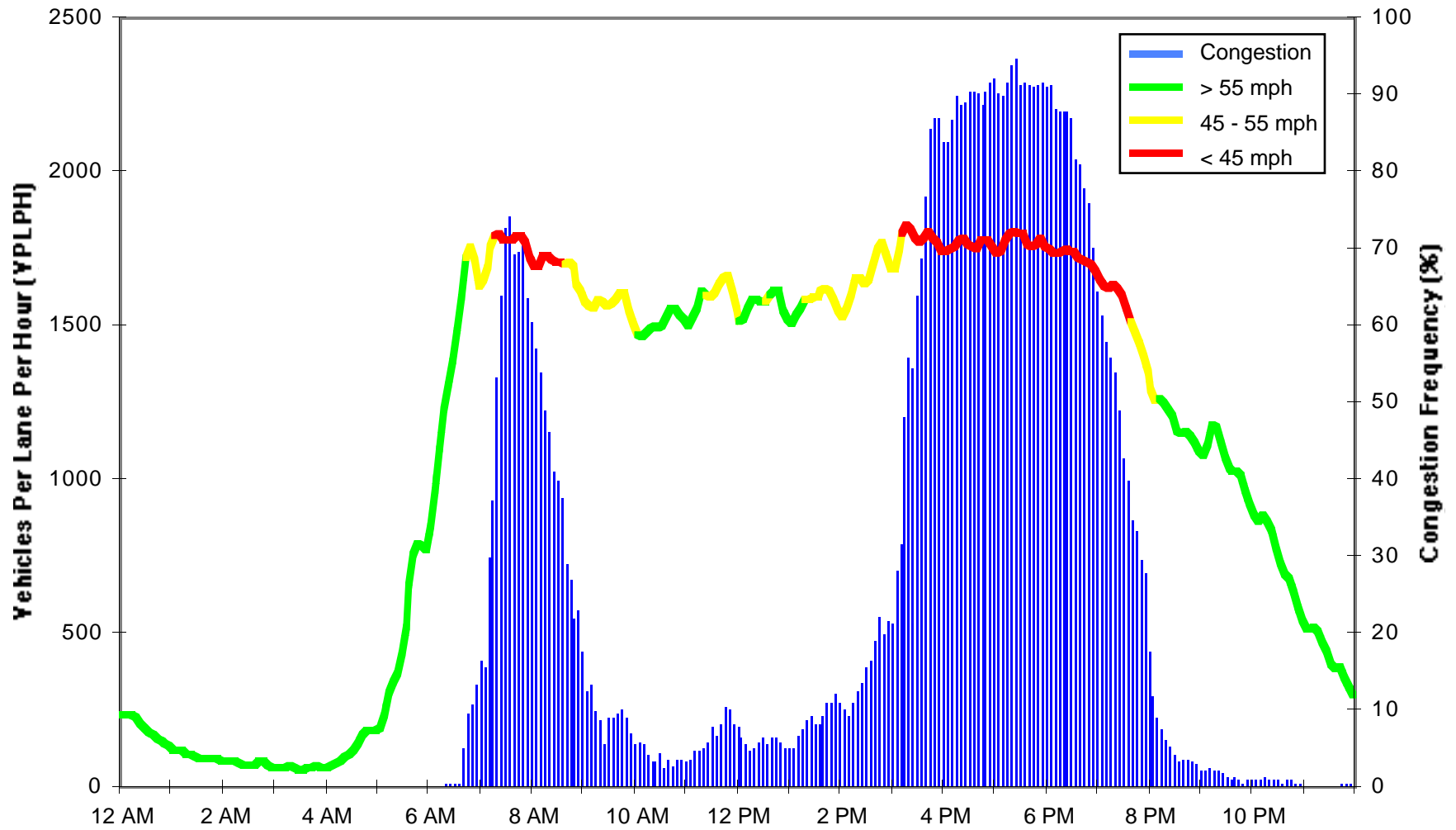


Figure 4.12. Estimated Weekday Volume, Speed, and Reliability Conditions (1999): Westbound SR 520, 76th Ave NE, General Purpose Lanes

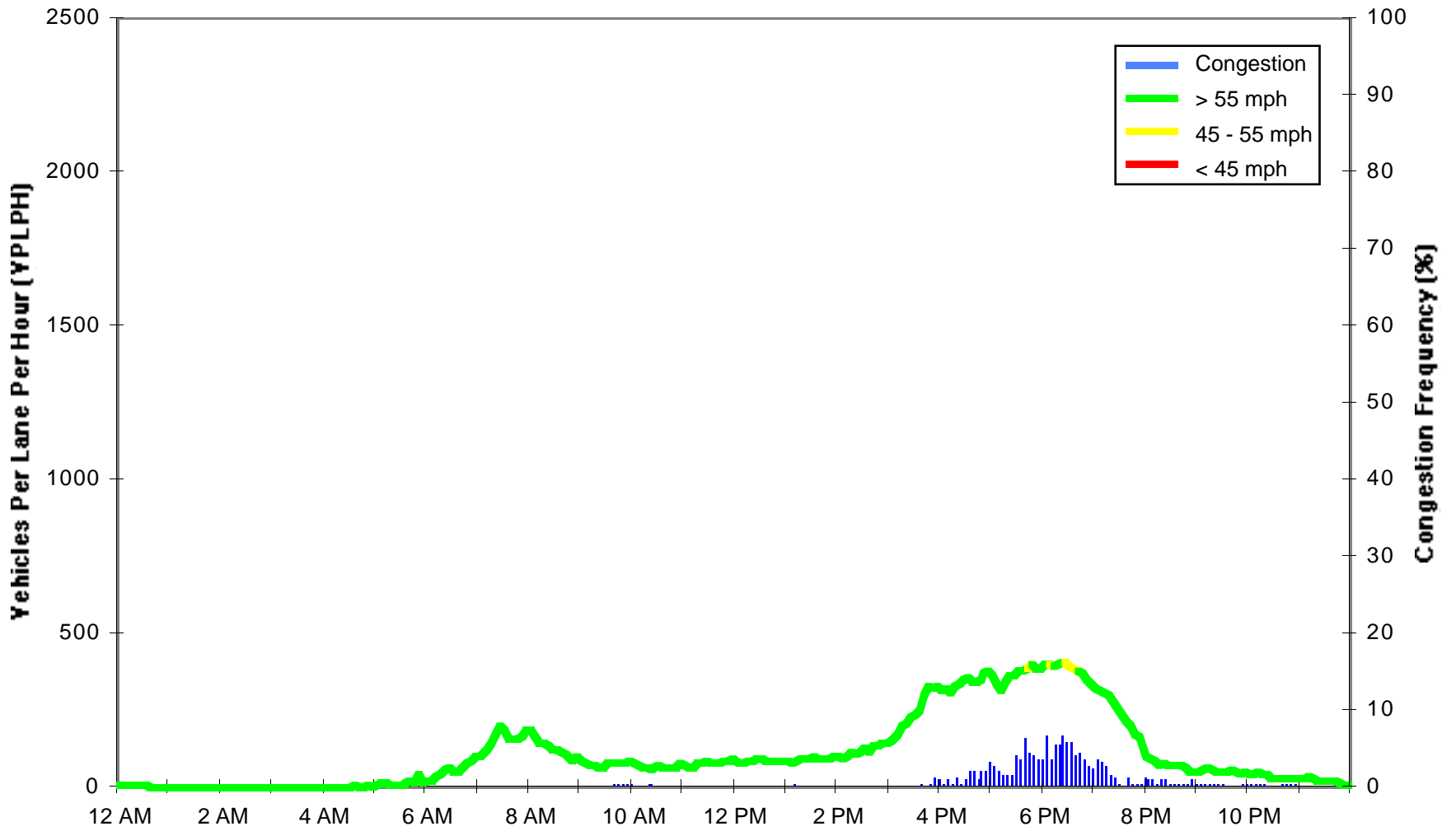


Figure 4.13. Estimated Weekday Volume, Speed, and Reliability Conditions (1999): Westbound SR 520, 84th Ave NE, HOV Lanes

I-90 (Mercer Island) Floating Bridge (Midspan)

Overall: The I-90 bridge has three general purpose lanes in each direction and two center reversible lanes (whereas the other east-west corridor, SR 520, has two GP lanes per direction and one westbound HOV lane). The reversible lanes operate westbound in the morning and eastbound in the afternoon and evening. This location still illustrates what was formerly considered a common pattern: high volumes in the peak period and significantly lower volumes during the midday. However, as with SR 520, these traffic profiles also show the significance of what was formerly considered a secondary “reverse” commute, i.e., Seattle to the Eastside in the morning, and Eastside back to Seattle in the evening. In fact, volumes on the GP lanes are very similar in both directions in the morning and evening. While this location is noteworthy from a traffic point of view, other locations on the I-90 corridor have different congestion patterns that are also worth noting. A broader view of the congestion patterns on this route can be found on the average congestion and congestion frequency corridor profiles for I-90, described in section 3 (figures 3.7 and 3.15).

GP Eastbound and Westbound: Both directions feature two prominent volume peaks (one AM, one PM), with peak levels of 1,500 to 1,800 vplph and reduced but still significant midday volumes (about 1,100 vplph). (See figures 4.14 and 4.15.) While the volume patterns are very similar eastbound and westbound during the day, the westbound afternoon peak volumes stay at higher levels (above 1,500 vplph) for a longer period of time (about 3:00 PM to 7:00 PM) than any of the other peak periods in either direction at this site.

HOV Eastbound and Westbound: There are no exclusive HOV lanes on the I-90 bridge span; reversible lanes are open to HOVs and Mercer Island traffic.

Reversible GP and HOV: There are two prominent peak volumes (Figure 4.16) of about 900 vplph at 8:00 AM (westbound traffic) and approximately 1,000 vplph at 5:30 PM (eastbound traffic). There is generally no significant congestion. While the reversible lane volume is moderately high during the peak commute hours, the vehicle count includes vehicles traveling between Seattle and Mercer Island, which are not subject to a minimum vehicle occupancy requirement.

SR 167 (South of the I-405 interchange)

Overall: At this location, SR 167 has two general purpose lanes and one HOV lane in each direction. This location is just south of the interchange with I-405 and is affected by the considerable traffic that exits and enters there. While the pattern here is generally tidal, with predominantly northbound traffic in the AM peak period and southbound traffic in the PM hours, there are significant GP volumes throughout the day.

GP Northbound and Southbound: Northbound traffic patterns at this location are atypical in some respects in comparison to the other freeway sites described earlier. See Figure 4.17. Volumes begin to increase earlier in the morning around 4:00 AM, and to peak early as well (around 5:30 AM) at about 1,800 vplph. Volumes decrease to about 1,200 vplph by 8:00 AM, but then rise somewhat and level off at about 1,400 vplph throughout the midday and afternoon. Varying levels of slowing are persistent during much of the AM and early afternoon hours. By contrast, the southbound pattern is largely free of heavy congestion throughout the day. (See Figure 4.18.) Volumes begin to increase starting about 4:00 AM and reach 1,400 to 1,500 vplph by about 7:00 AM. After dropping somewhat to about 1,300 vplph by 9:00 AM, volumes begin to increase again, reaching 1,800 vplph southbound by midafternoon. Volumes then steadily decline during the rest of the day, first gradually, then more quickly after about 7:00 PM.

HOV Northbound and Southbound: Northbound HOV volumes begin to grow about 4:00 AM, reaching a high of over 1,300 vplph (relatively high for an HOV lane) by 6:30 AM. This peak volume is accompanied by some congestion. The volume begins to drop, then levels off at between 500 and 700 vplph by about 10:00 AM, where it stays throughout much the day. The southbound HOV lane volumes gradually increase to a peak of over 800 vplph during the afternoon peak period; the southbound HOV lane is generally uncongested throughout the day. (See figures 4.19 and 4.20.)

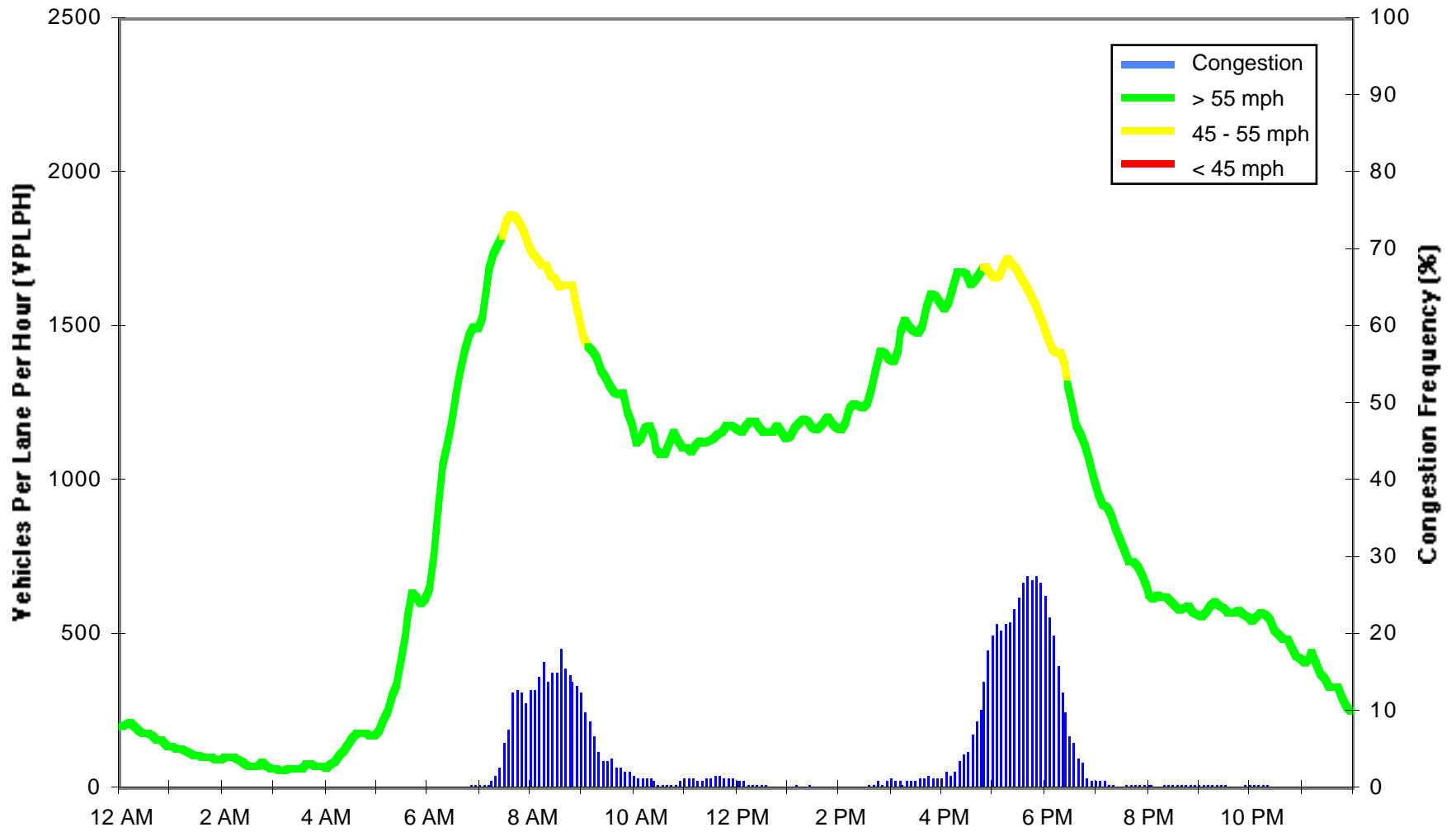


Figure 4.14. Estimated Weekday Volume, Speed, and Reliability Conditions (1999): Eastbound I-90, Midspan, General Purpose Lanes

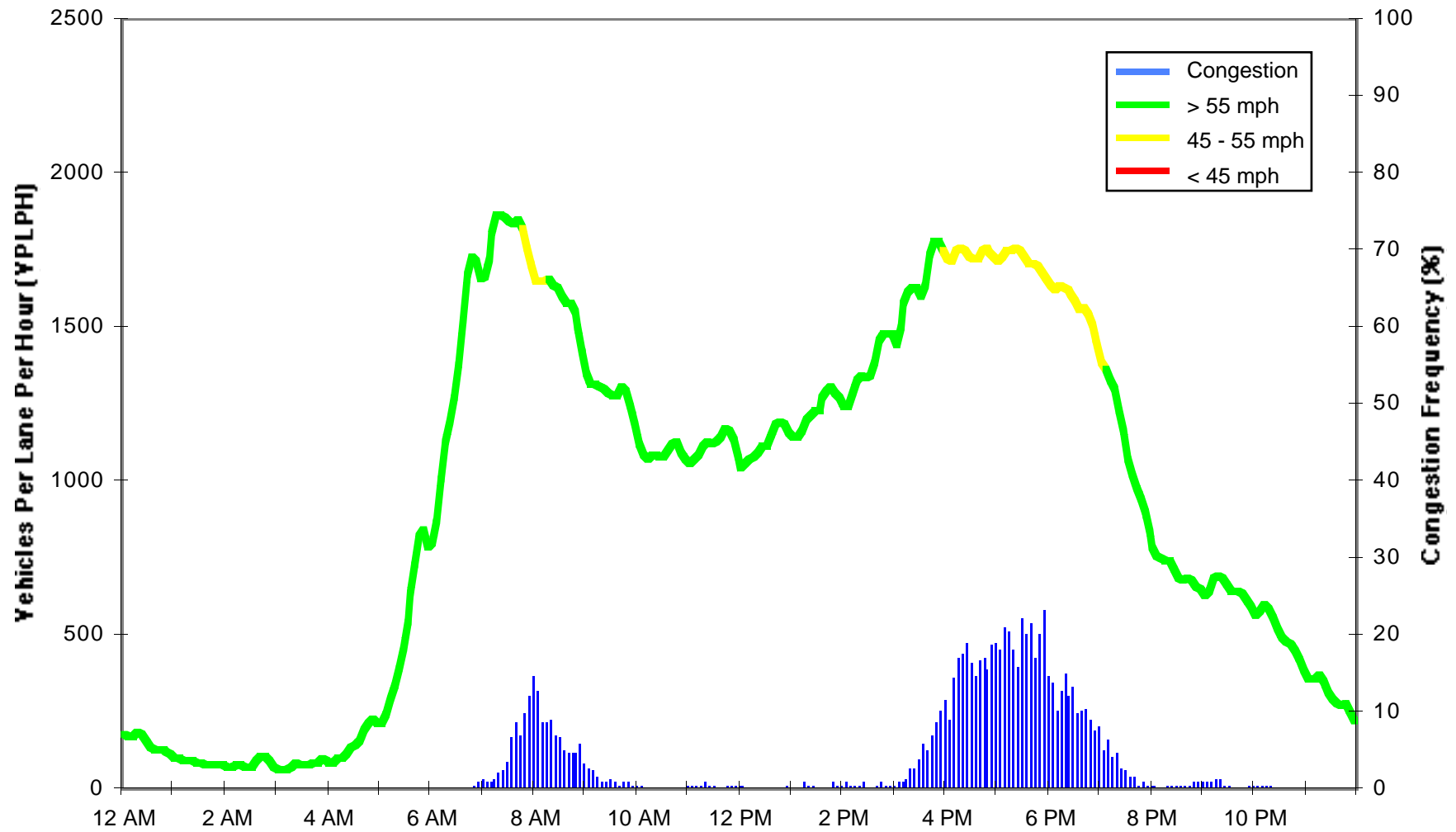


Figure 4.15. Estimated Weekday Volume, Speed, and Reliability Conditions (1999): Westbound I-90, Midspan, General Purpose Lanes

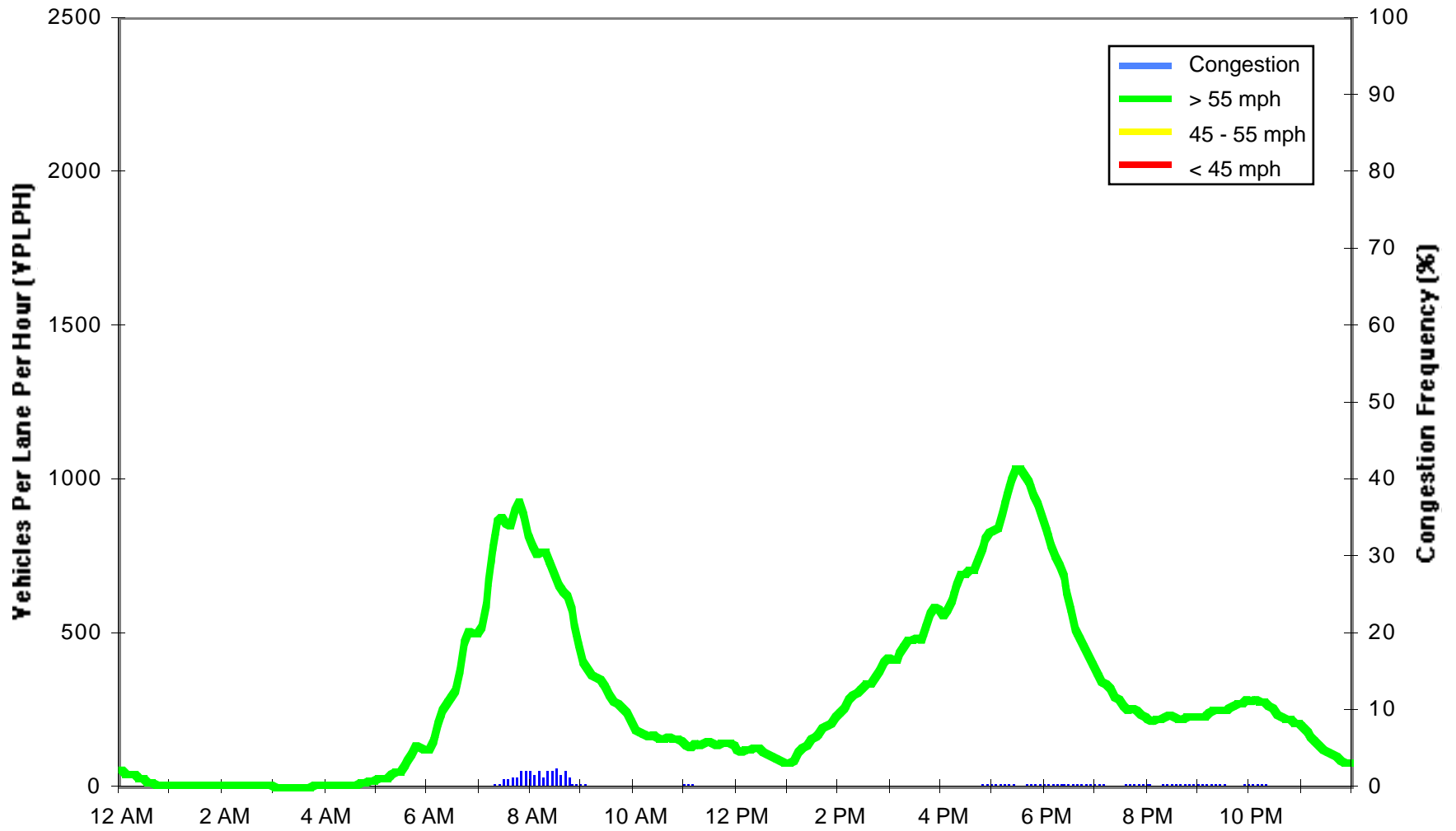


Figure 4.16. Estimated Weekday Volume, Speed, and Reliability Conditions (1999): I-90, West Highrise, General Purpose Reversible Lanes

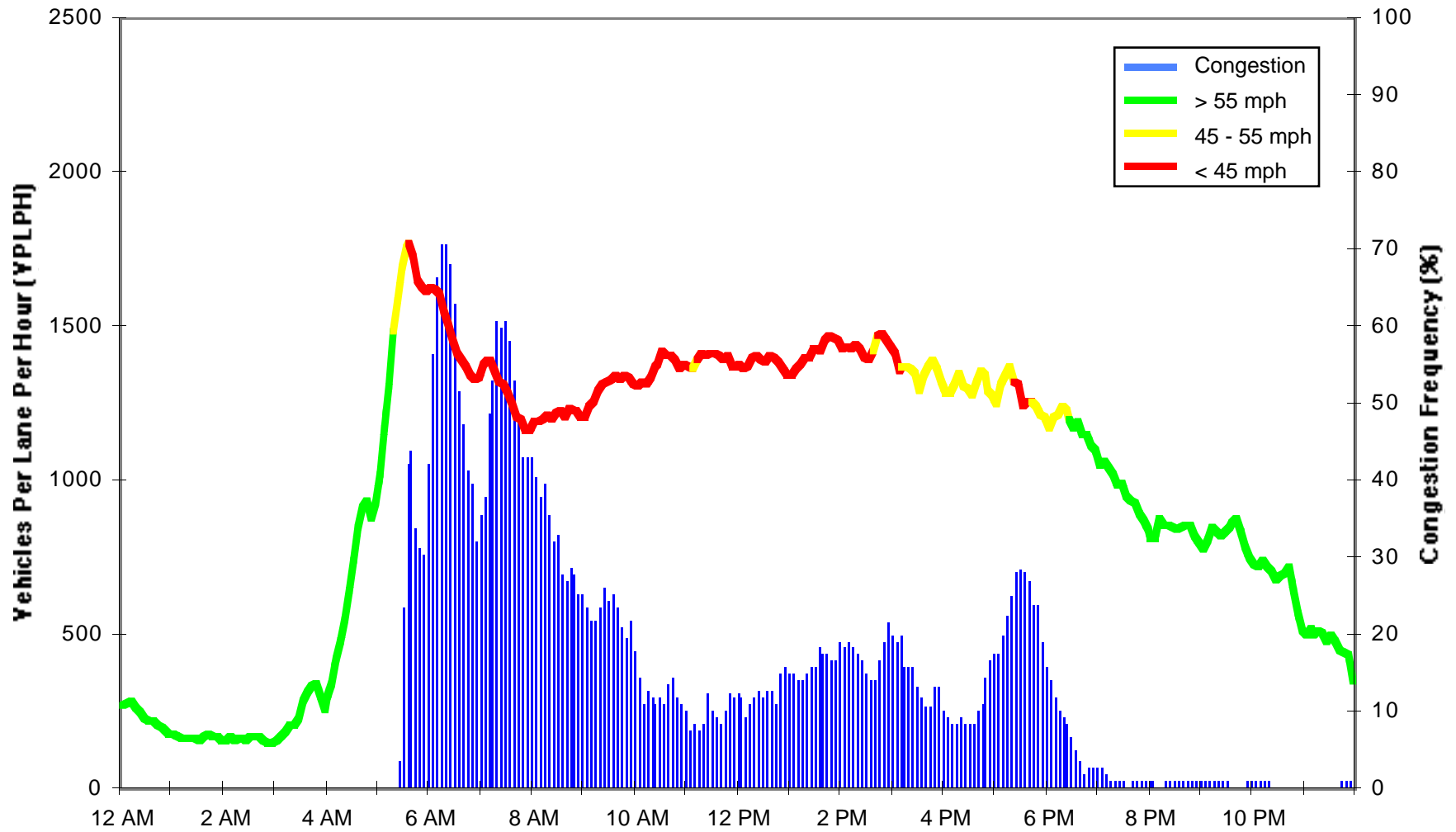


Figure 4.17. Estimated Weekday Volume, Speed, and Reliability Conditions (1999): Northbound SR 167, South 23rd St, General Purpose Lanes

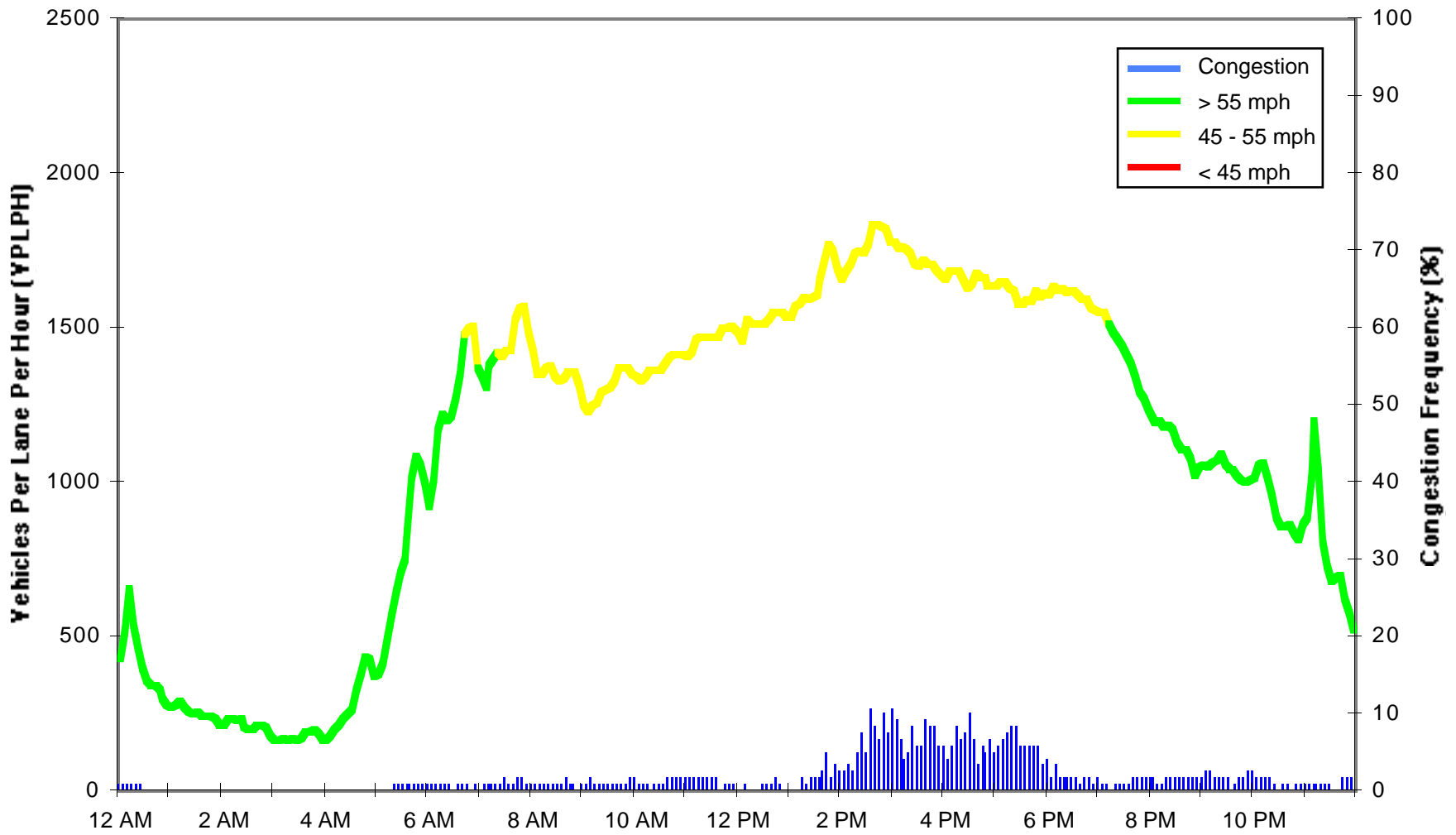


Figure 4.18. Estimated Weekday Volume, Speed, and Reliability Conditions (1999): Southbound SR 167, South 23rd St, General Purpose Lanes

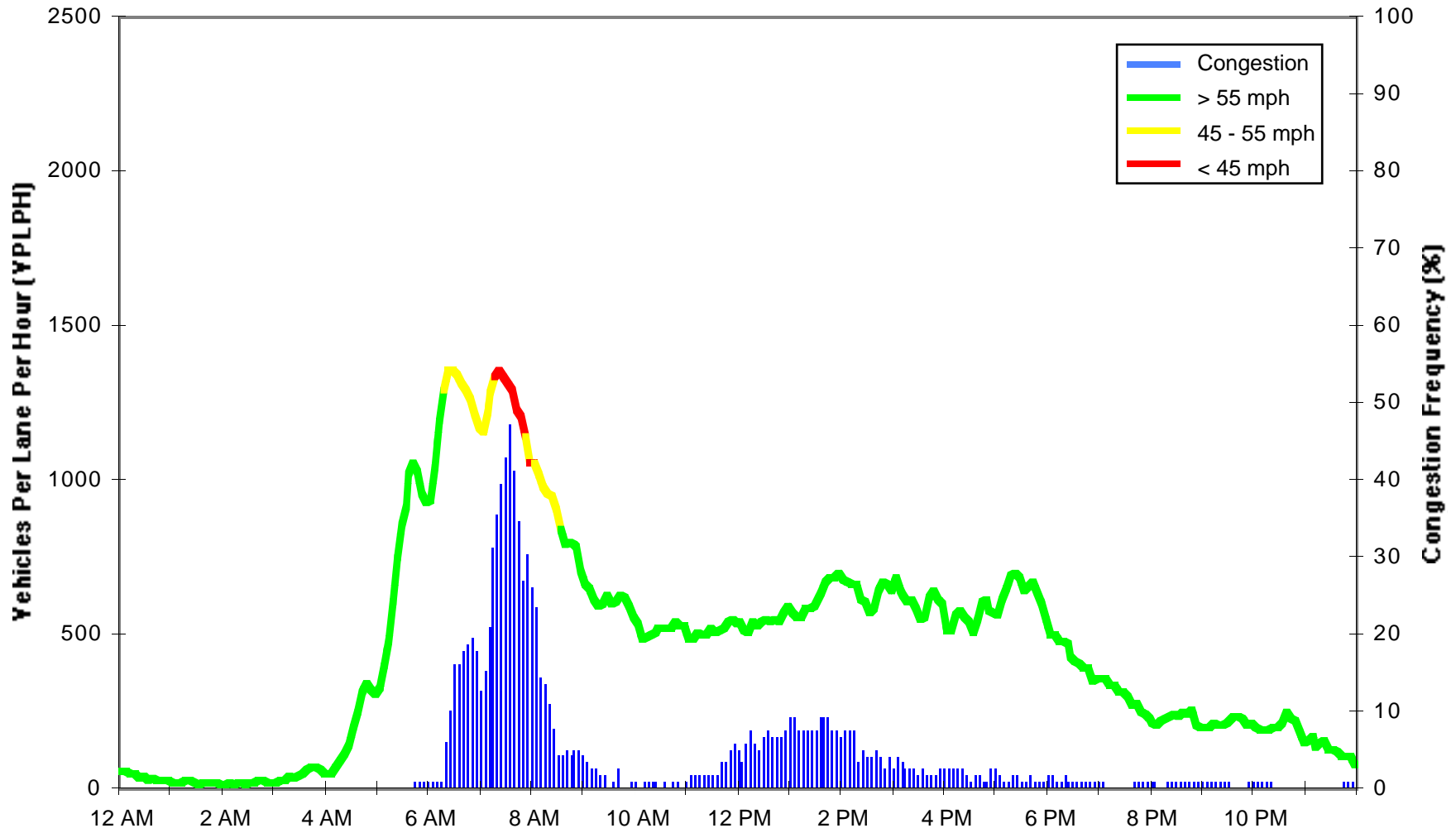


Figure 4.19. Estimated Weekday Volume, Speed, and Reliability Conditions (1999): Northbound SR 167, South 23rd St, HOV Lane

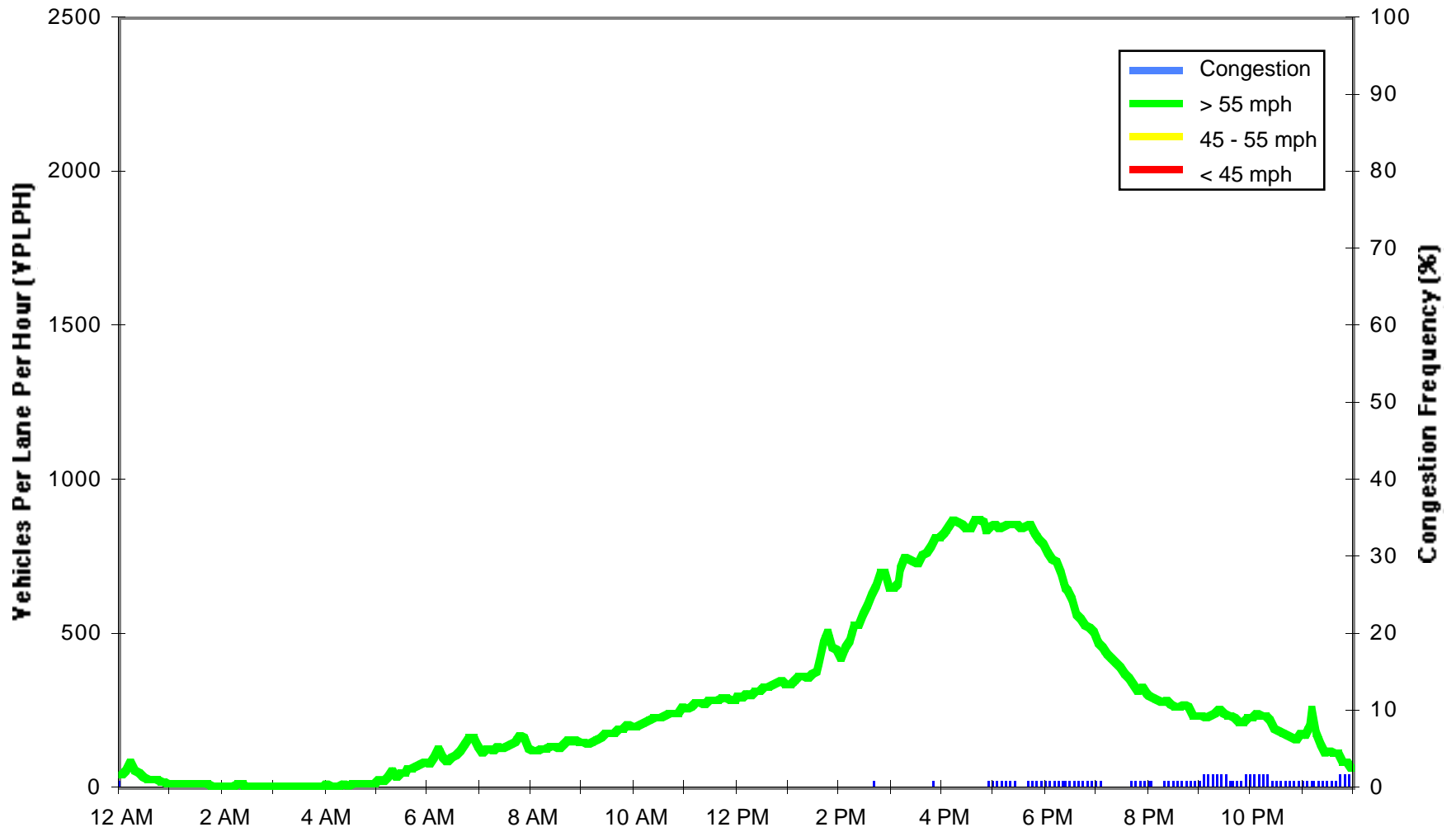


Figure 4.20. Estimated Weekday Volume, Speed, and Reliability Conditions (1999): Southbound SR 167, South 23rd St, HOV Lane

HOV lanes are designed to improve the people-carrying capacity of the system by encouraging informal and formal carpooling and the use of public transportation. This philosophy is formalized in Washington State's transportation policy, which notes that the HOV lane network plays an important role in increasing the movement of people, as opposed to simply the movement of vehicles. The HOV lane network is intended to enhance the people-moving capability of the freeway system by providing HOV lane users with a time benefit and a travel reliability advantage in comparison to travelers on general purpose lanes. This is particularly important for public transit agencies, for which travel time savings and better schedule reliability have a direct effect on costs and ridership.

Washington state has established a policy standard regarding the desired speed and reliability of an HOV lane. This standard calls for an average speed of 45 mph or better, 90 percent of the time during the peak hour.

How HOV Lane Usage Was Measured

Two measures of HOV lane usage are used in this section:

Number of Vehicles (GP and HOV)

The number of vehicles traveling per lane per hour (vplph), as a function of time, on GP and HOV lanes is measured at selected locations along the corridor. Vehicle volumes were estimated for an average 24-hour weekday in 1999.

Number of Persons (GP and HOV)

The number of persons traveling per lane per hour, during the peak periods, on GP and HOV lanes are measured at selected locations along the corridor. Person volumes were estimated by combining vehicle volumes with per-vehicle person occupancy data collected from the WSDOT HOV Lane Evaluation project (automobile data) and King County Metro and Community Transit (bus and vanpool data). Person volumes were estimated during peak periods and peak directions of travel for an average weekday in 1998.

Where HOV Lane Usage Was Measured

HOV lane vehicle volumes and person volumes were estimated at eight sites on the major freeway corridors (I-5, I-405, SR 520, I-90, SR 167) in the central Puget Sound area. The sites were selected on the basis of their traffic significance as well as the availability of sufficient volume and vehicle occupancy data. The locations used were as follows:

I-5:	112th SW (Everett) NE 137th Street (north Seattle) Pearl Street (south of Seattle CBD)
I-405:	NE 85th Street (Kirkland) SE 59th Street (south of I-90 interchange)
SR 520:	84th Avenue NE (east of floating bridge)
I-90:	Midspan (floating bridge)
SR 167:	South 204th/208th (Kent)

Results: HOV Lane Usage at Selected Locations

The following discussion is based on analyses using the most recently available data. Vehicle volumes were estimated based on data from 1999, while person volumes were estimated based on data from 1998 (the most recent year for which average vehicle occupancies were estimated).

Number of Vehicles

Figures 5.2 through 5.9 summarize average weekday vehicle volumes in HOV lanes compared to GP lanes as a function of time of day, at selected locations along each corridor analyzed in the central Puget Sound region. Like general purpose traffic volumes, HOV lane use varies by time of day and location. In general, the more congestion an HOV lane can bypass, the greater incentive there is to use the HOV lane, and therefore the more people will use it. Similarly, the better the transit service, the higher the number of people using transit in the HOV lane, which translates to higher person volumes in the HOV lane. As a result, HOV vehicle volumes are generally at

their peak during the traditional peak commute periods. At the eight sites shown, average peak GP volumes can exceed 1,500 vplph, occasionally approaching 2,000 vplph. Peak period HOV lane volumes are generally between 400 and 1,000 vplph, though they can on occasion approach 1,500 vplph, primarily on I-5 and some parts of I-405. In some cases, HOV lane vehicle volumes are comparable to (and occasionally exceed) the volumes on adjacent GP lanes during the peak period, on a per-lane basis. Examples include several of the I-5 and I-405 sites that are shown in the figures. HOV lane use on a given corridor generally increases near major urban employment centers.

Note that SR 520 HOV lane usage is affected by the more strict vehicle occupancy requirement on that facility (3+ persons per vehicle, vs. 2+ persons elsewhere). Also, the I-90 HOV volumes shown are actually reversible lane volumes, which at this location on I-90 allow mixed traffic, including both HOVs and Mercer Island GP and HOV traffic.

Number of Persons

Figures 5.10 through 5.17 present summary information on peak period vehicle and person HOV use at the selected central Puget Sound region locations. The upper graphs show the percentage of all vehicles and travelers at a given site that are traveling on the HOV lane or on GP lanes. Not unexpectedly, the multiple GP lanes combined carry more vehicles and persons than the single HOV lane at a location (although at some sites, especially on I-5 and I-405, HOV person volume can be a very high percentage of total person volume).

The lower graphs also compare person and vehicle volumes on GP and HOV lanes, but on a per lane basis. The columns represent the average number of persons or vehicles per GP or HOV lane (numerical values are shown above each column). The percentages in the HOV columns indicate the percentage difference in the number of people or vehicles carried in the HOV lane in relation to those in an average GP lane at the same location. For example, an HOV person volume percentage of +70 percent indicates that at that site, the HOV lane carries on average 70 percent more people than the average GP lane. AVO_{HOV} and AVO_{GP} are the average number of people per vehicle in an HOV or GP lane, respectively.

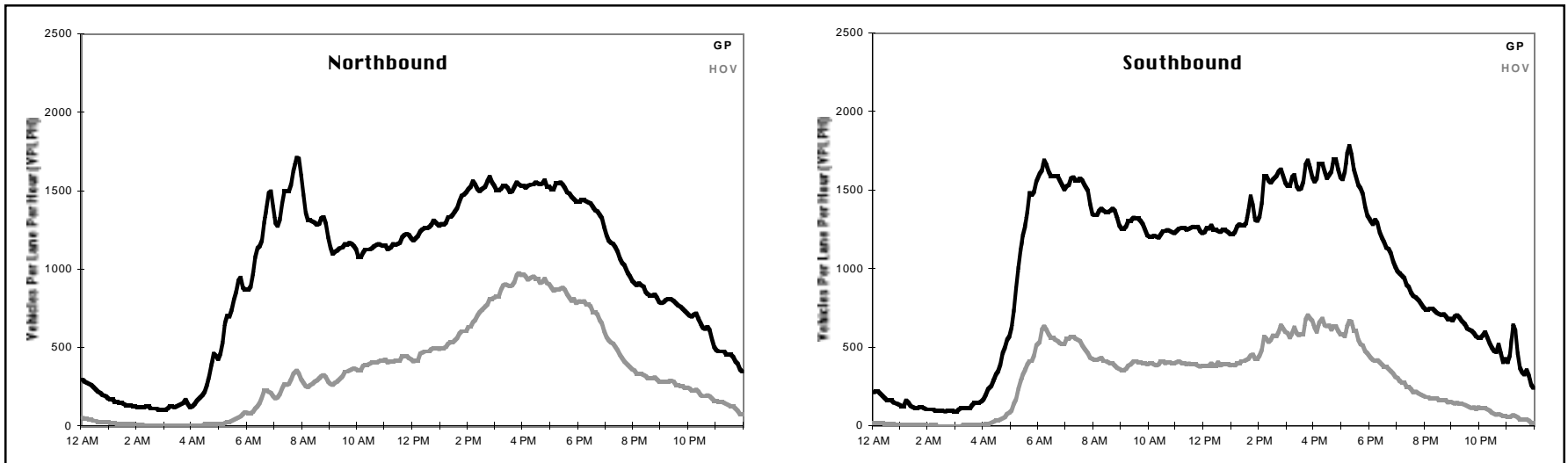


Figure 5.2. Estimated Weekday Volume Profiles: GP and HOV Lanes (1999), I-5 at 112th St SW, Northbound and Southbound

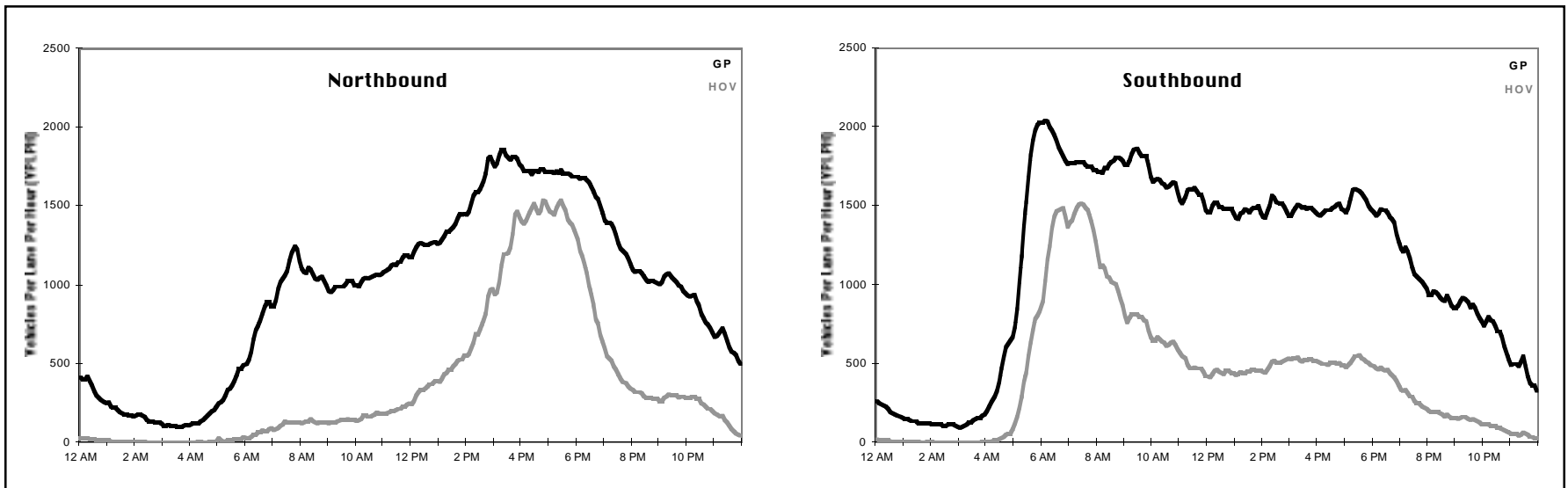


Figure 5.3. Estimated Weekday Volume Profiles: GP and HOV Lanes (1999), I-5 at NE 137th St, Northbound and Southbound

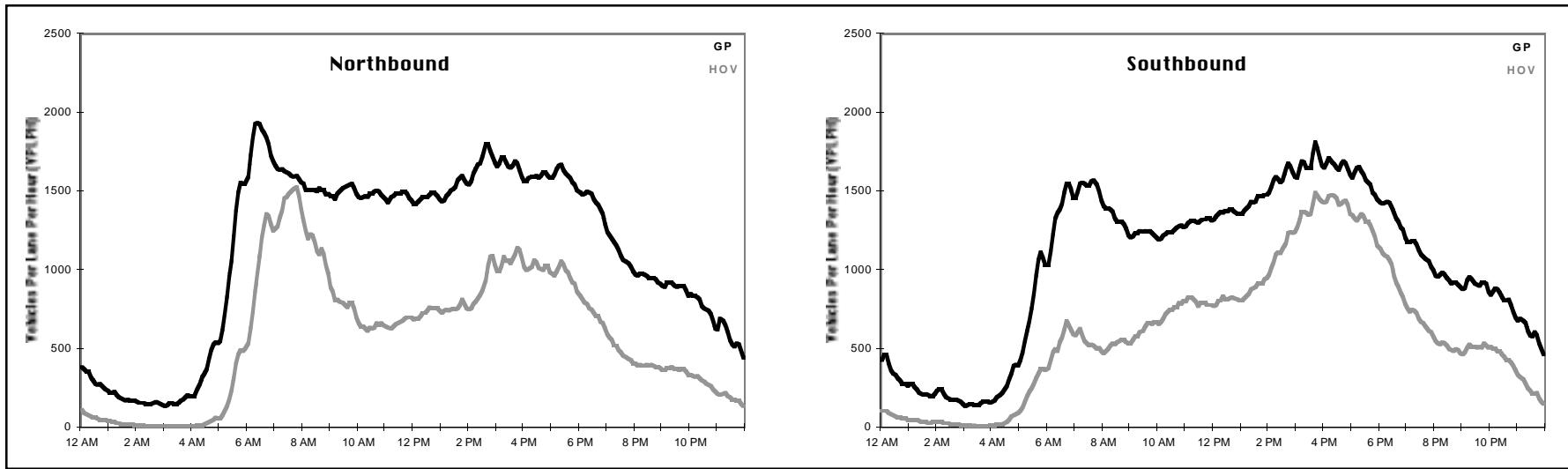


Figure 5.4. Estimated Weekday Volume Profiles: GP and HOV Lanes (1999), I-5 at S Pearl St, Northbound and Southbound

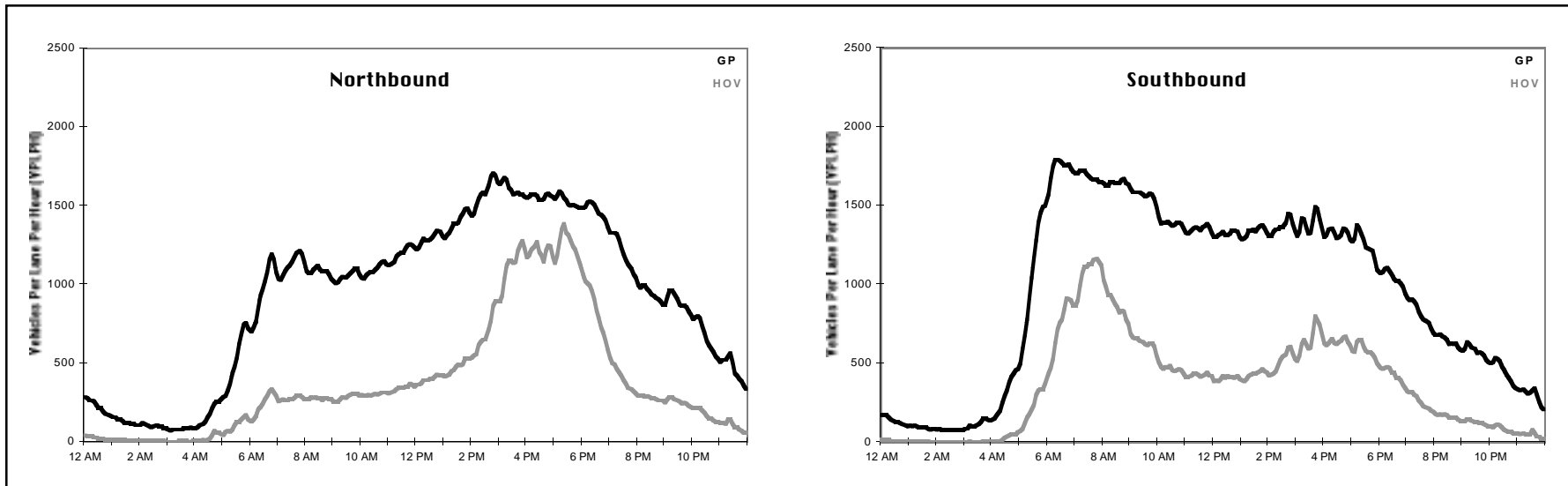


Figure 5.5. Estimated Weekday Volume Profiles: GP and HOV Lanes (1999), I-405 at Southbound NE 85th St, Northbound and Southbound

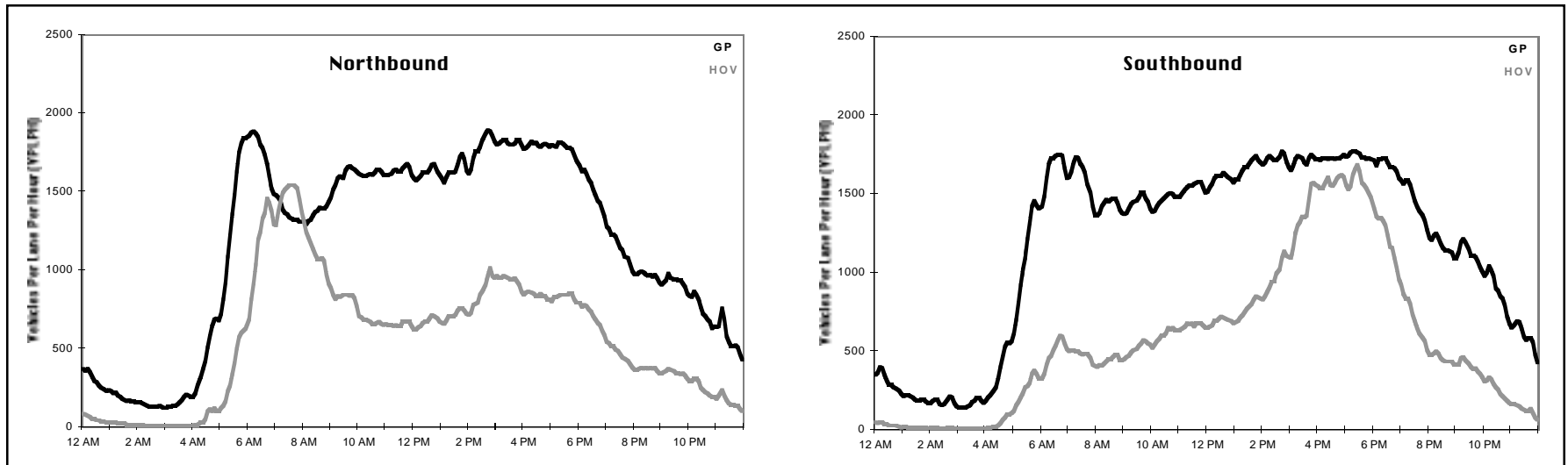


Figure 5.6. Estimated Weekday Volume Profiles: GP and HOV Lanes (1999), I-405 at SE 59th St, Northbound and Southbound

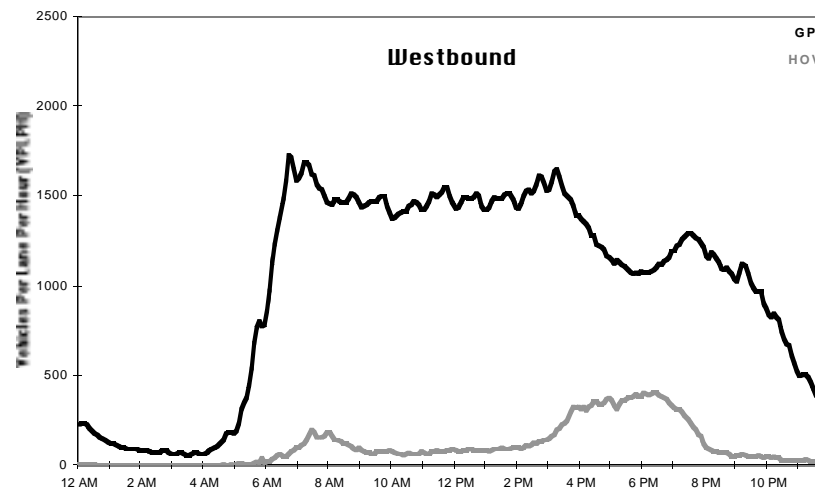


Figure 5.7. Estimated Weekday Volume Profile: GP and HOV Lanes (1999), SR 520 at 84th Ave NE, Westbound

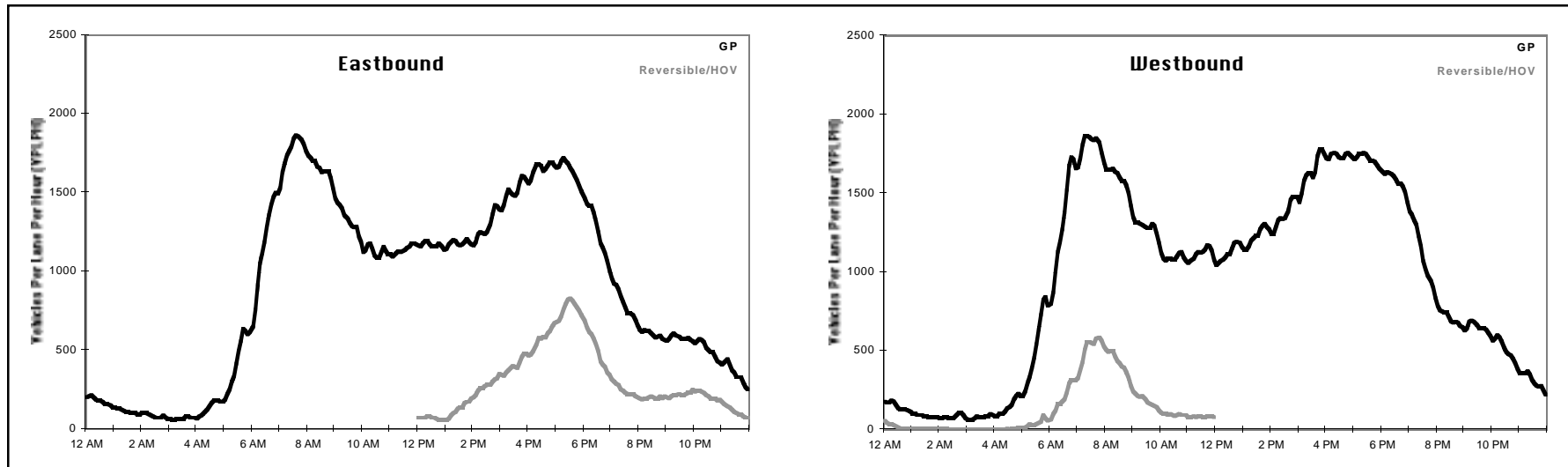


Figure 5.8. Estimated Weekday Volume Profiles: GP and HOV Lanes (1999), I-90 at Midspan, Eastbound and Westbound

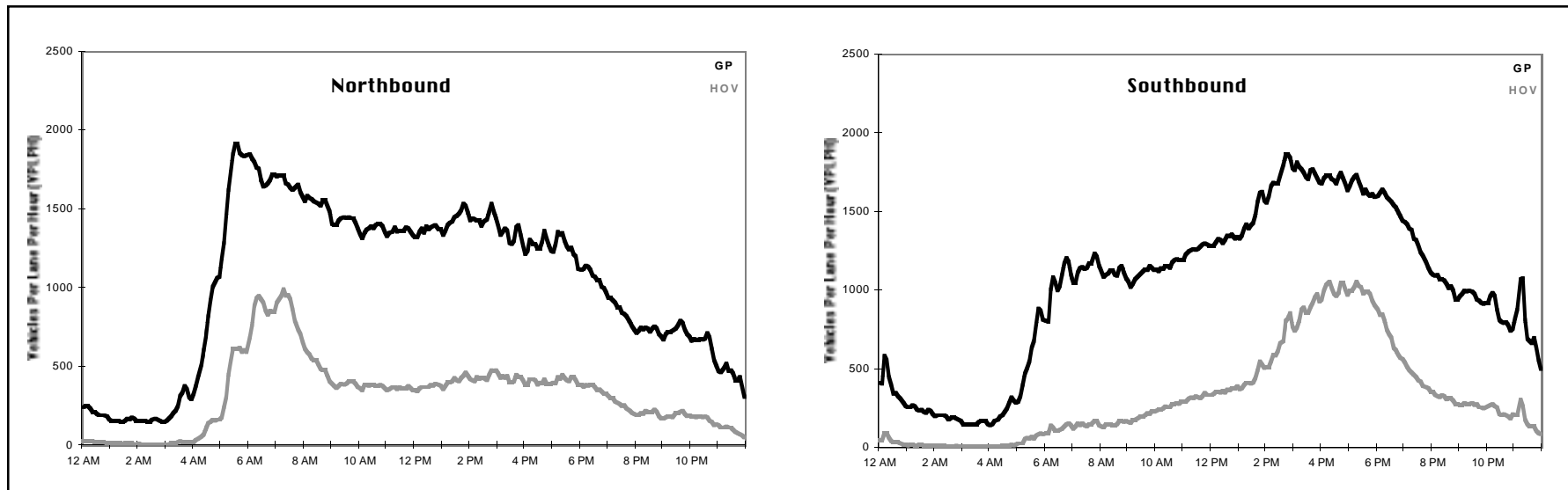
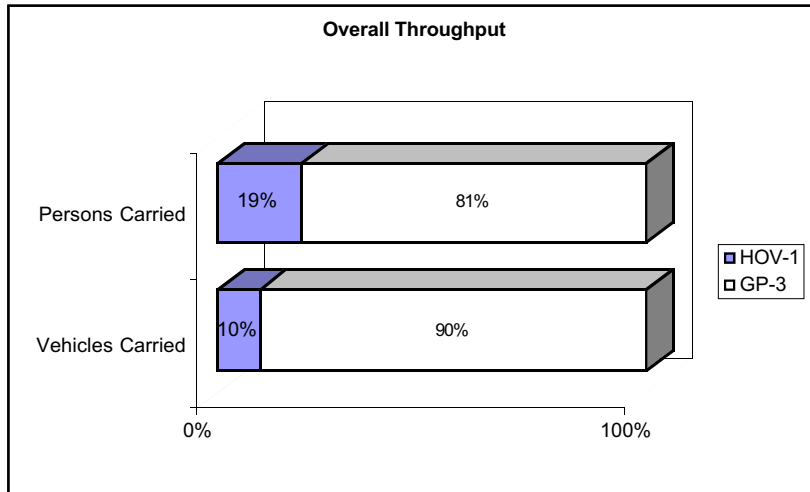
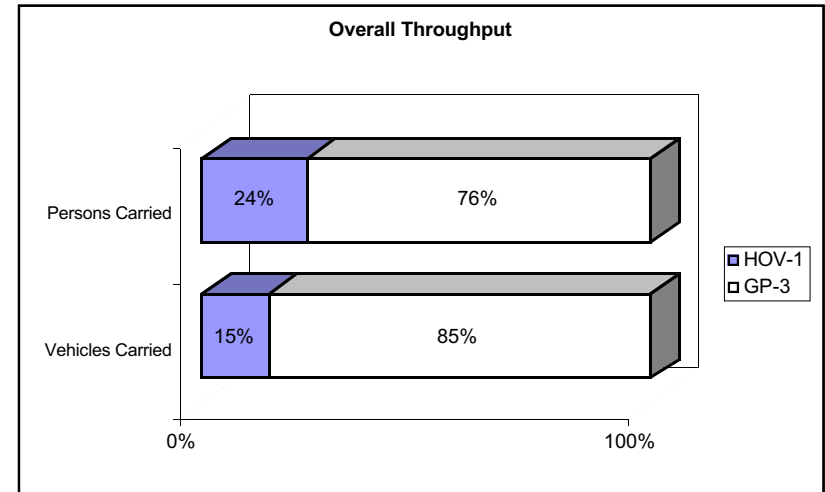


Figure 5.9. Estimated Weekday Volume Profiles: GP and HOV Lanes (1999), SR 167 at S 204th St, Northbound and Southbound

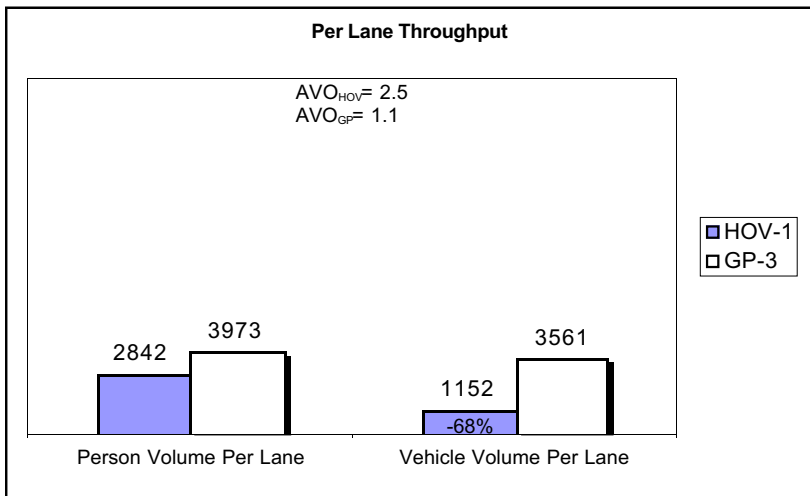
AM Peak Period: Southbound



PM Peak Period: Northbound



Per Lane Throughput



Per Lane Throughput

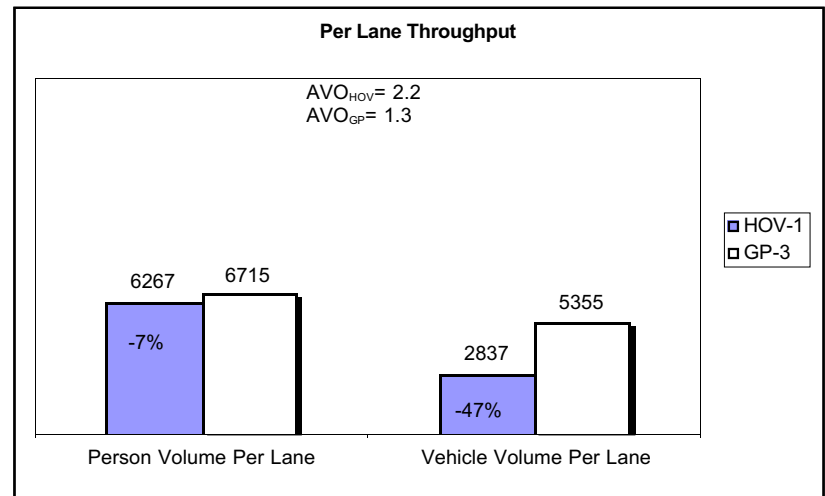
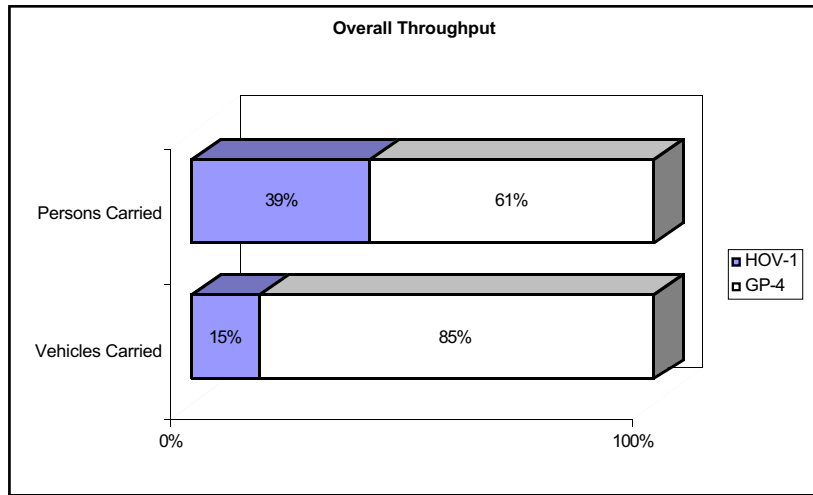


Figure 5.10. General Purpose versus HOV Throughput Comparison (1998): I-5 at 112th SE

AM Peak Period: Southbound



PM Peak Period: Northbound

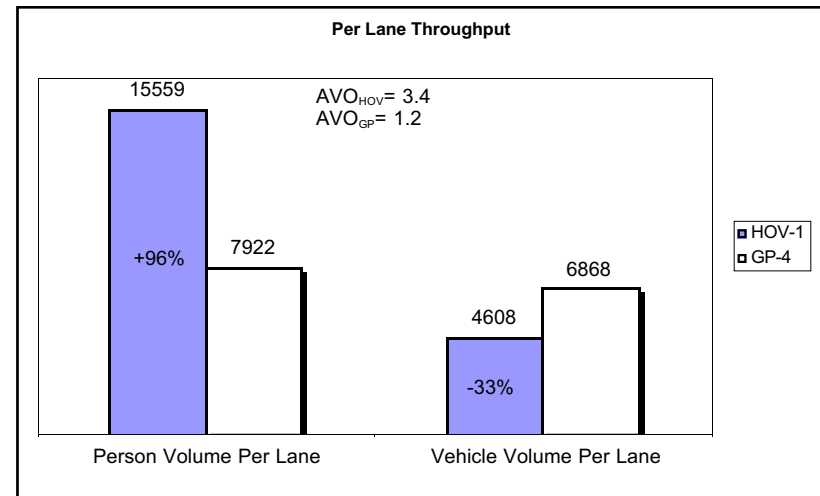
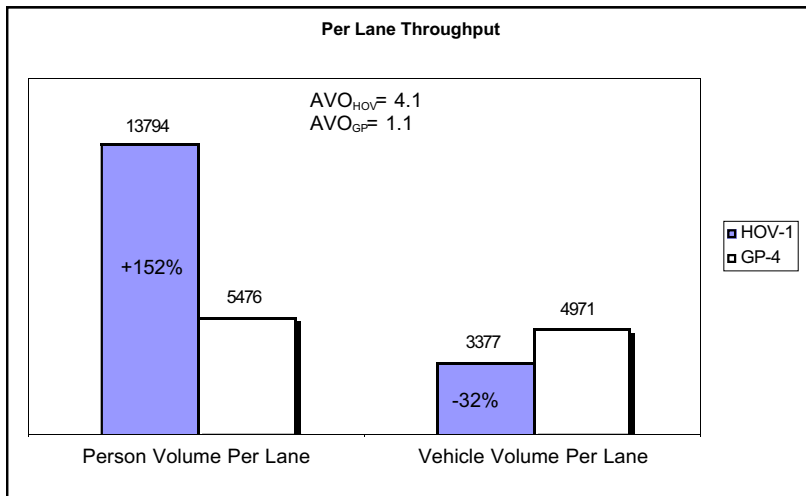
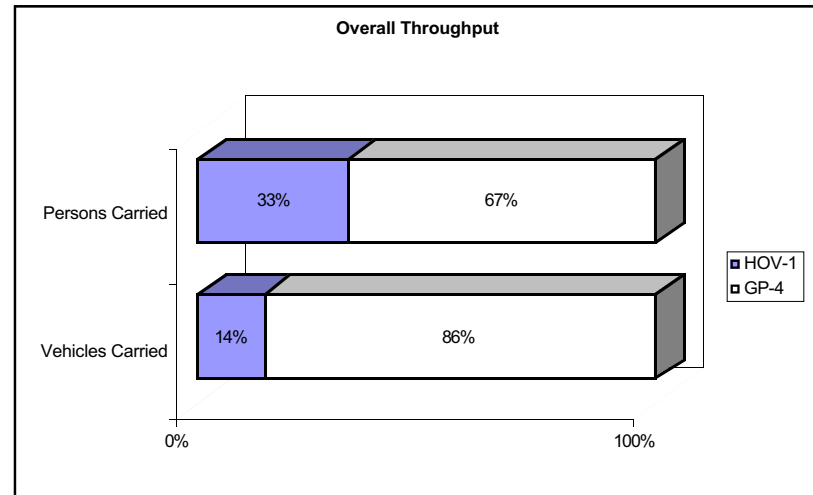
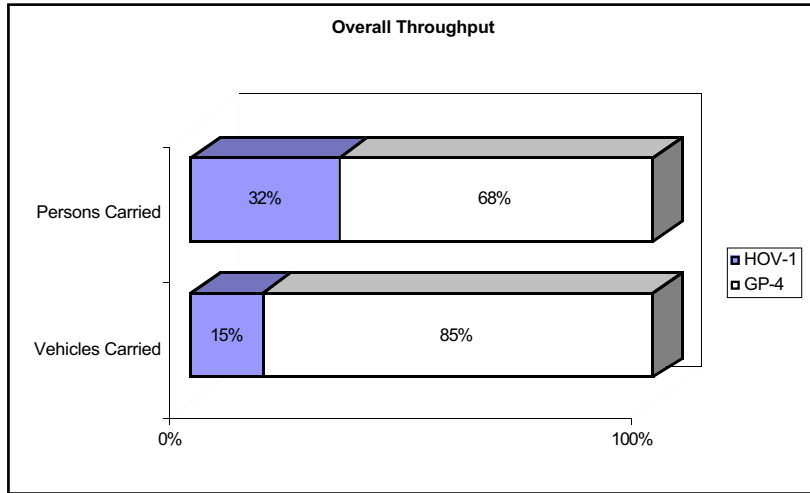
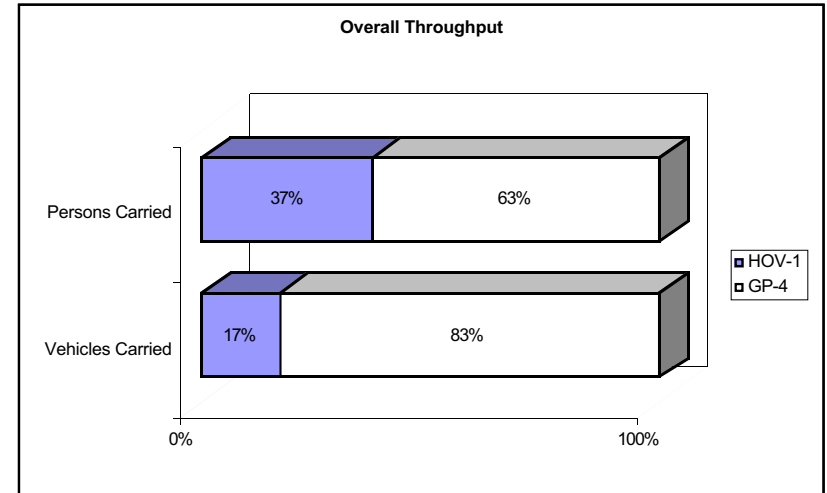


Figure 5.11. General Purpose versus HOV Throughput Comparison (1998): I-5 at NE 137th St

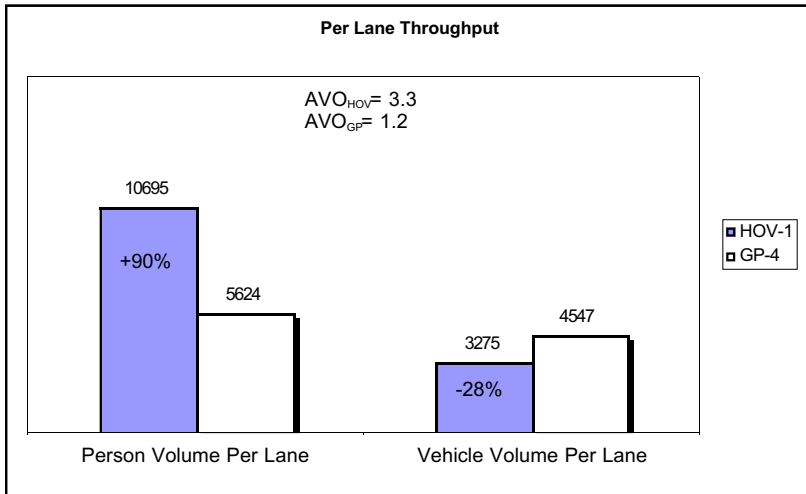
AM Peak Period: Northbound



PM Peak Period: Southbound



Per Lane Throughput



Per Lane Throughput

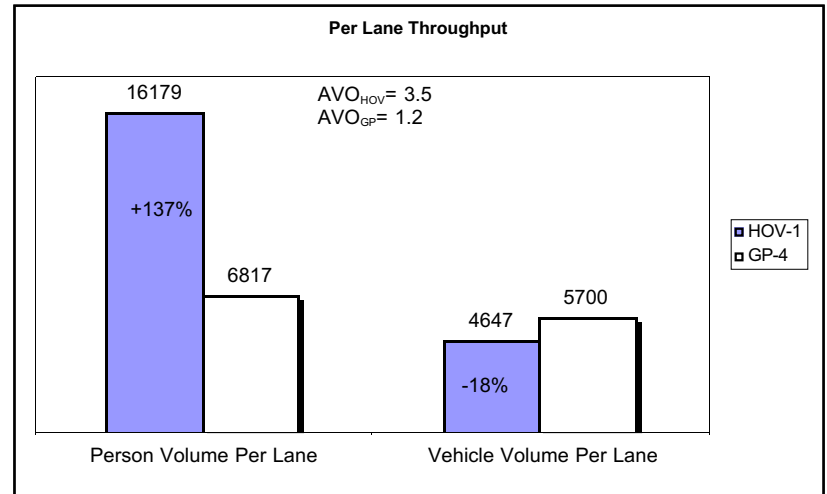
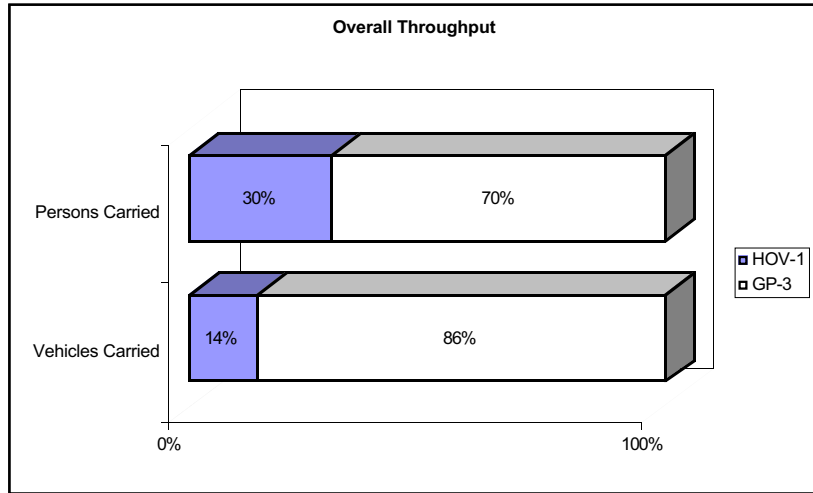


Figure 5.12. General Purpose versus HOV Throughput Comparison (1998): I-5 at Albro Place

AM Peak Period: Southbound



PM Peak Period: Northbound

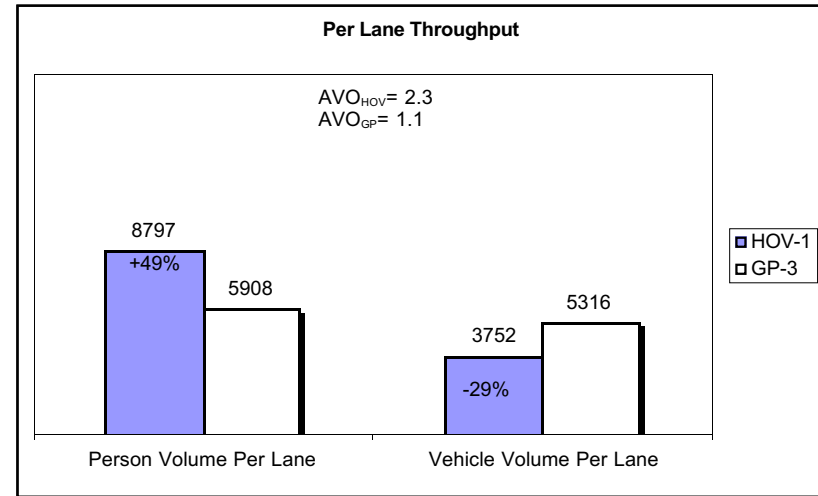
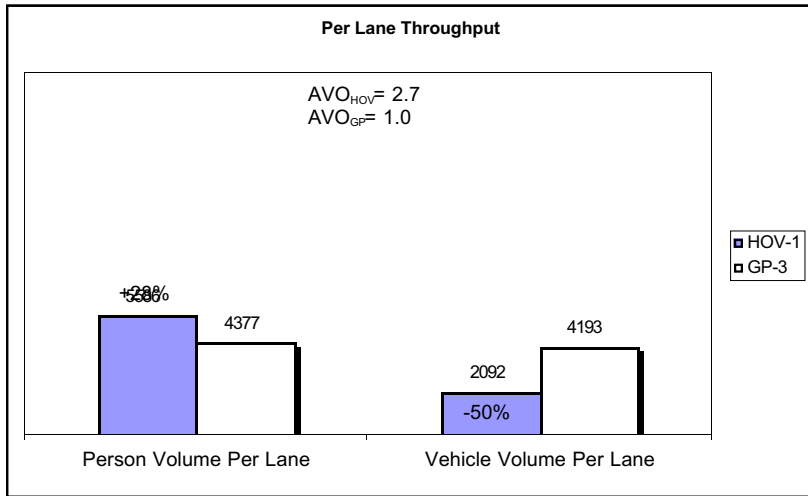
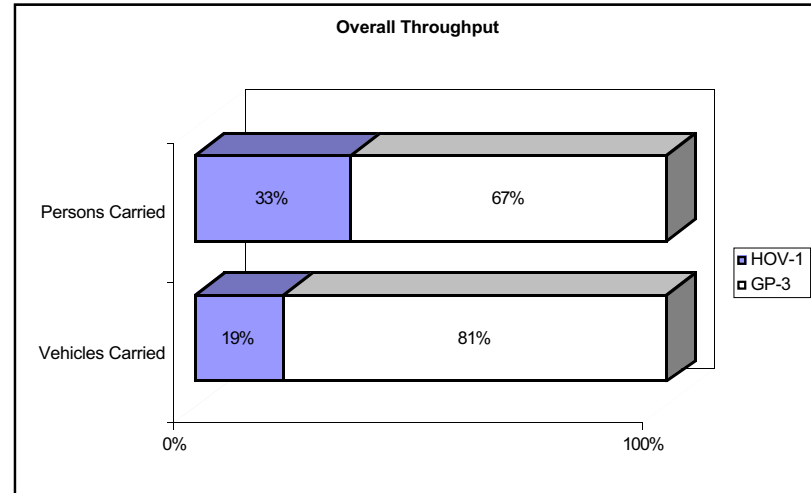
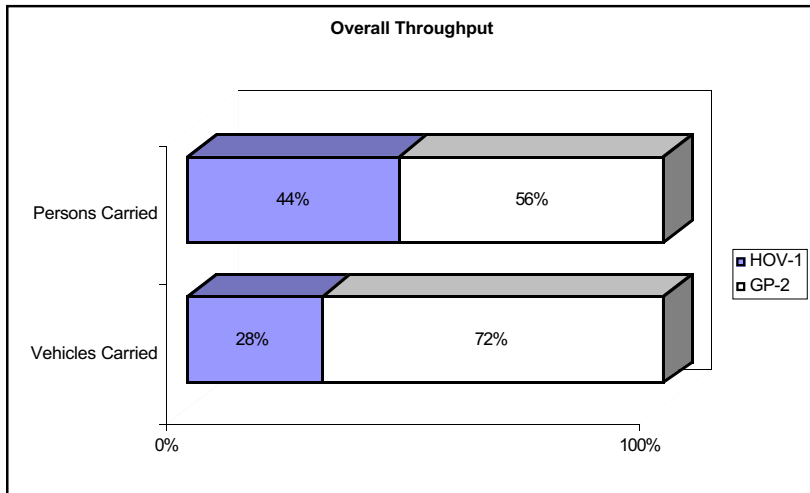
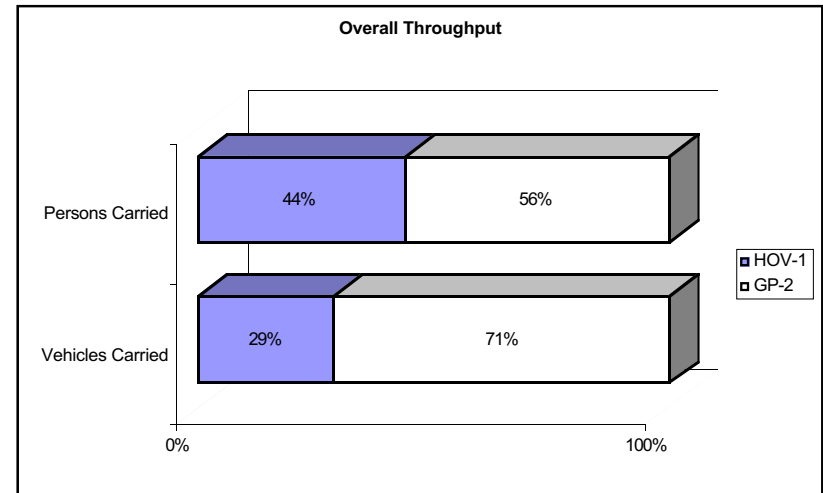


Figure 5.13. General Purpose versus HOV Throughput Comparison (1998): I-405 at NE 85th St

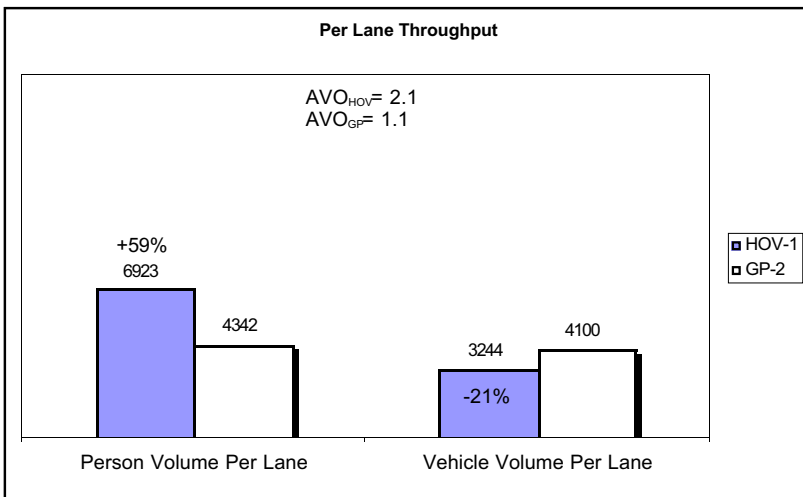
AM Peak Period: Northbound



PM Peak Period: Southbound



Per Lane Throughput



Per Lane Throughput

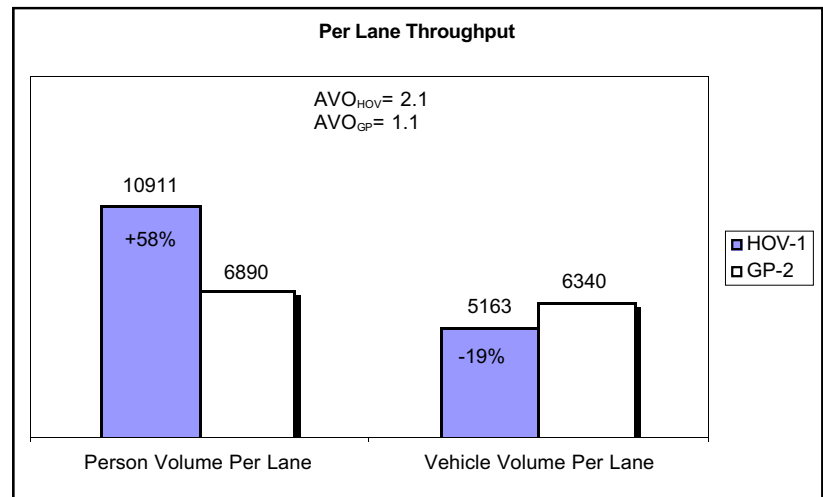
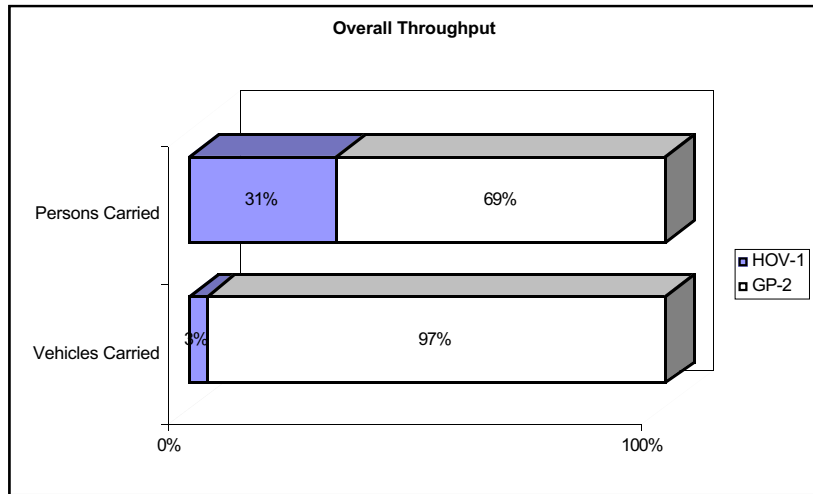


Figure 5.14. General Purpose versus HOV Throughput Comparison (1998): I-405 at SE 59th St

AM Peak Period: Westbound



PM Peak Period: Westbound

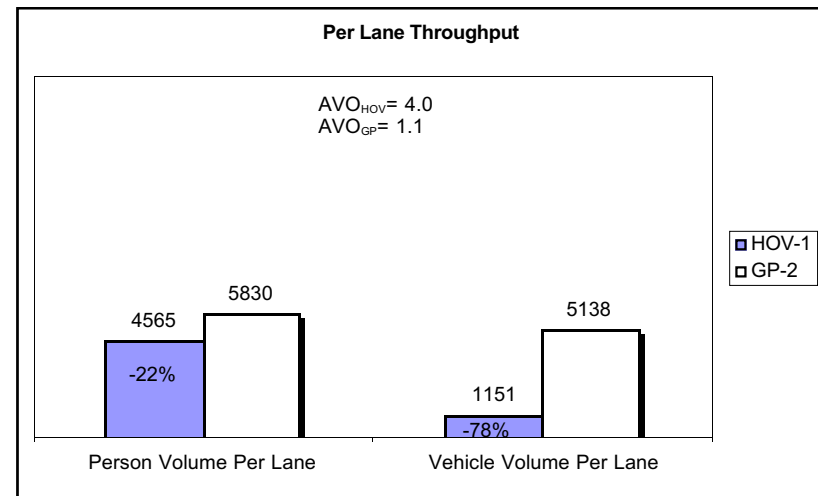
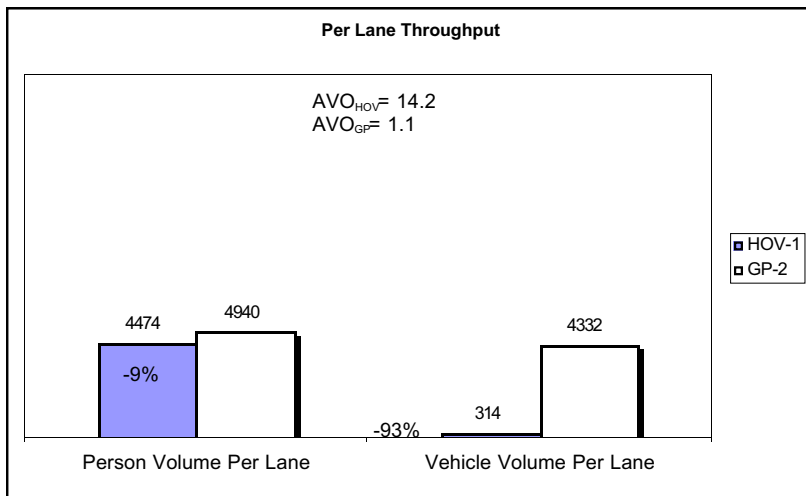
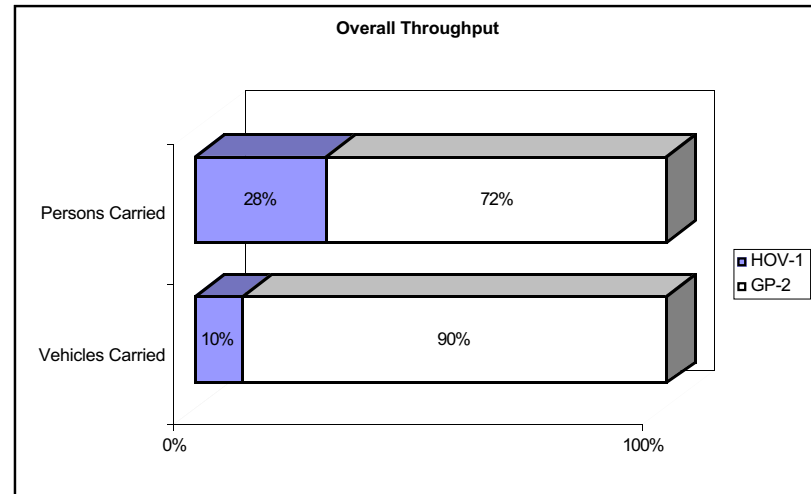
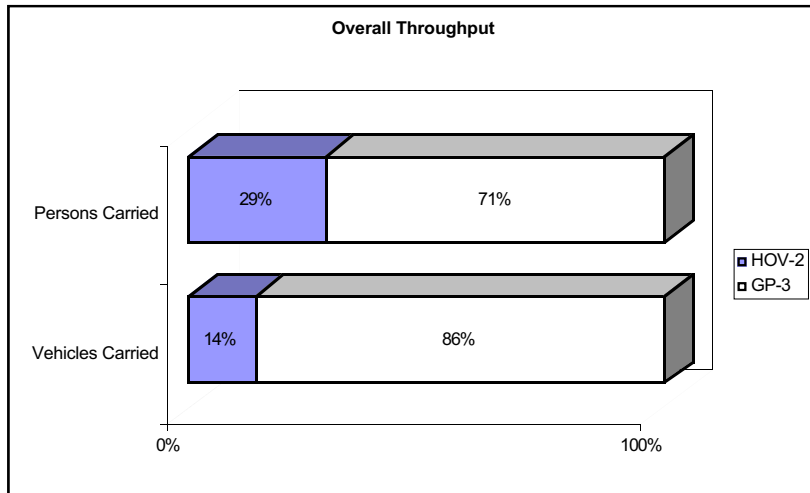
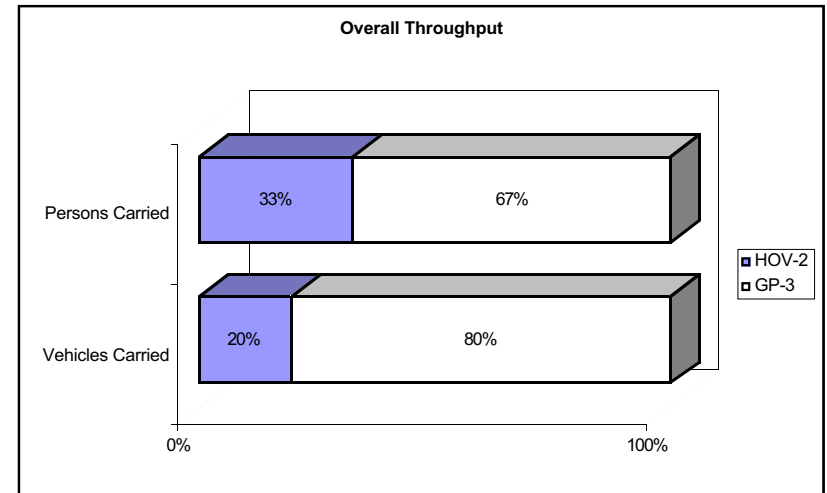


Figure 5.15. General Purpose versus HOV Throughput Comparison (1998): SR 520 at 84th Ave NE

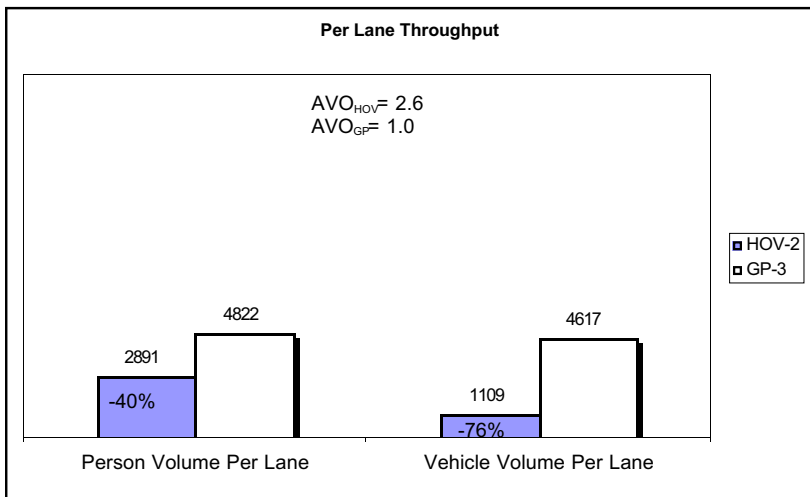
AM Peak Period: Westbound



PM Peak Period: Eastbound



Per Lane Throughput



Per Lane Throughput

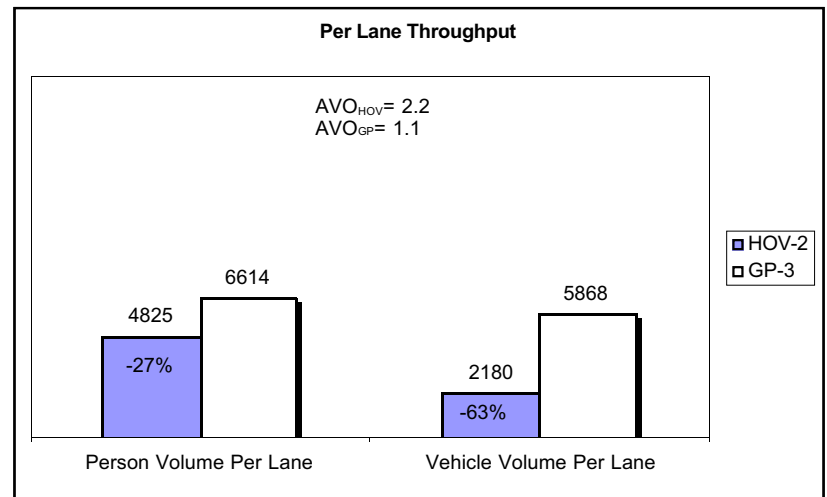
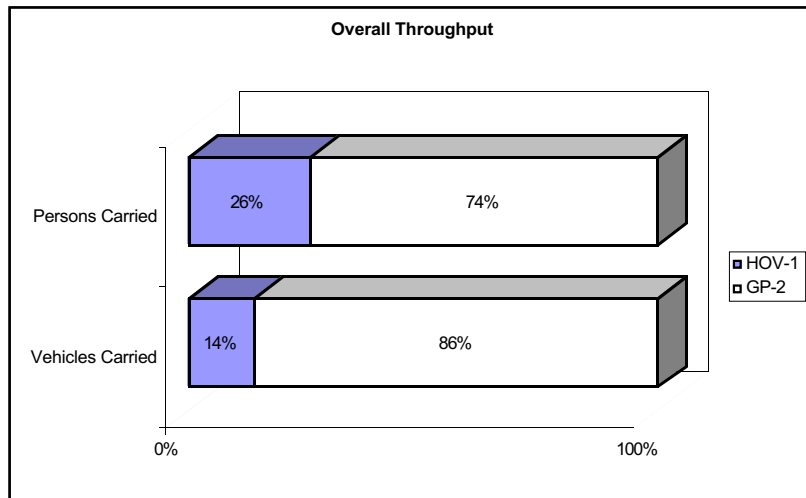


Figure 5.16. General Purpose versus HOV Throughput Comparison (1998): I-90 at Midspan

AM Peak Period: Northbound



PM Peak Period: Southbound

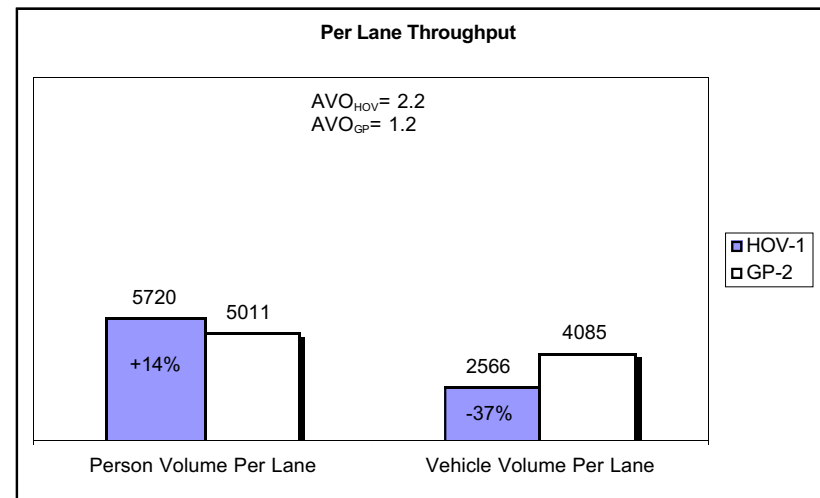
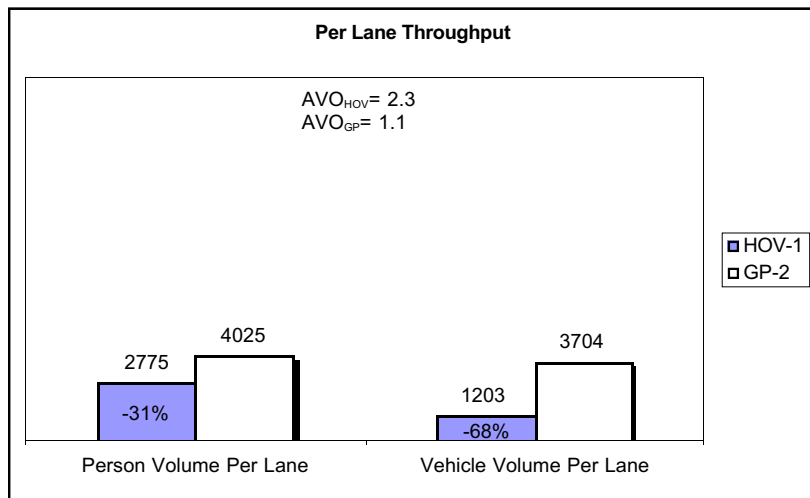
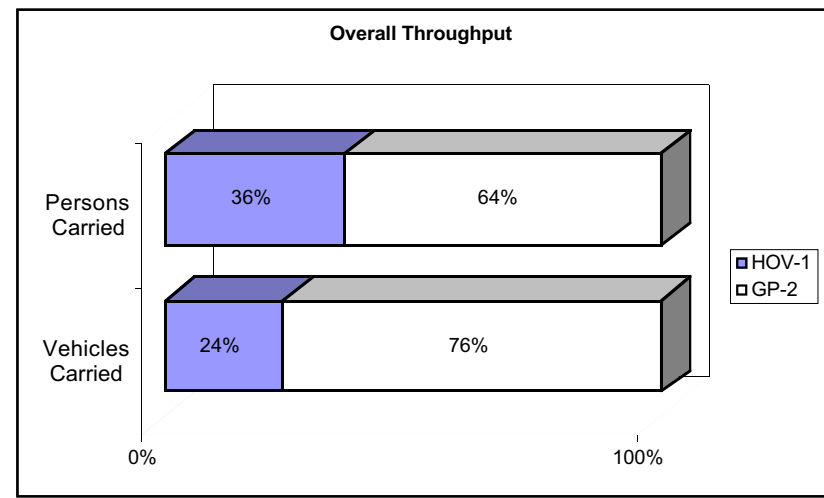


Figure 5.17. General Purpose versus HOV Throughput Comparison (1998): SR 167 at S 208th