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HOV lane Hours Evaluation

EVALUATION OF PUGET SOUND HOV LANE HOURS OF OPERATION: ONE-YEAR RESULTS

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EXECUTIVE SUMMARY

This report documents changes in the use and operational performance of the Puget Sound freeway high occupancy vehicle (HOV) lane system one year after the hours of operation for those facilities changed. It also describes the public's attitude toward those changes and HOV lanes in general.

In the summer of 2003, a two-year pilot program began that allows single-occupant vehicles (SOVs) to use HOV lanes on four of the five primary corridors in the region (I-405, SR 167, SR 520 east of I-405, and I-90 east of East Mercer Way on Mercer Island) during the hours of 7:00 PM to 5:00 AM, seven days a week. Interstate 5's HOV lanes remain closed to SOVs at all times, and between 5:00 AM and 7:00 PM, seven days a week, the entire Seattle-area freeway HOV lane network operates as an exclusive HOV-only system.

This report uses data collected before the start of the pilot program, during the first two months of operation after the change in operating policy, and after approximately one year of operation, to describe changes that have occurred as a result of the new operating policy. Preliminary results are discussed below.

SOV USE OF THE HOV LANE

On the basis of observed traffic volumes, some SOV travelers appeared to be making use of the new hours of operation. The extent of use varied by location and time of day, with evening use being greater than morning use. At some locations, there was a noticeable increase in the percentage and number of SOVs using the HOV lanes in the evening hours, and an increase in the share of all vehicles using the HOV lane after 7:00 PM. SOV use of the HOV lane was more noticeable on freeway segments with established evening congestion, such as sections of SR 167 and I-405. The greatest observed changes were on I-405 southbound at Newcastle, where the SOV percentage of

HOV lane volumes increased from about 7 percent before 7:00 PM to over 30 percent after 7:00 PM, and on SR 167 southbound at Renton and Auburn, where the SOV percentage increased by over 20 percentage points after 7:00 PM. Other locations showed little change in SOV use of the HOV lane.

COMPLIANCE WITH THE NEW HOV LANE POLICY

Violations in the HOV lane (i.e., SOVs using the HOV lane from 5:00 AM to 7:00 PM) generally increased only slightly in the evening hours just before 7:00 PM (when the revised HOV lane usage policy goes into effect each day) and also during the early AM hours. Some locations saw small reductions in violation rates. During the 5:00 to 7:00 AM period, the percentage of vehicles violating the HOV-only policy ranged from 1.3 to 7.5 percent before the start of the pilot program, and from 0.8 to 9.0 percent after one year of operation, for selected locations. During the 6:45 to 7:00 PM period, just before the HOV lane opens to all vehicles, the percentage of vehicles violating the HOV-only policy ranged from 0.5 to 4.7 percent before the start of the pilot program and from 0.0 to 8.9 percent after one year of operation, for selected locations. One outlier location, SR 167 southbound in Auburn, had AM violation rates ranging from 25.6 (before) to 30.3 percent (one year after) and PM rates of 16.6 percent (before) and 15.4 percent (one year after). However, this site has historically had high violation rates and is atypical because of its location just before the end of the HOV lane network.

CHANGES IN FREEWAY PERFORMANCE (SPEED AND CONGESTION)

Traffic performance improvement after 7:00 PM as a result of the revised hours of operation is difficult to determine from the data analyzed, in part because congestion typically dissipates by that time on most days at most locations. However, an analysis of the distribution of speeds before and after the pilot program start suggested a slight shift toward higher speeds in the general purpose (GP) lanes after 7:00 PM, though the

changes were no more than 1 to 3 mph on average. HOV lanes experienced little or no change in speeds after 7:00 PM, even with the additional SOV volumes.

PUBLIC PERCEPTIONS OF THE NEW HOV LANE POLICY

A survey of freeway travelers explored public awareness of the new policy, perceived effects on freeway conditions, and overall impressions of the policy.

1) Although traffic data suggested that some SOV travelers were making use of the new HOV lane hours of operation, responses to a public opinion survey suggested that awareness of the new hours was not high, with only 36 percent of respondents indicating that they were aware of the new policy as of spring 2004.
2) Approximately 21 to 28 percent of survey respondents felt that freeway conditions such as maneuverability, safety, or speeds were somewhat or much better since the start of the new hours of operation. These percentages were higher among those who had been aware of the new policy, and lower for those who had been unaware. Approximately 31 to 39 percent of survey respondents perceived no changes in freeway maneuverability, safety, or speeds since the start of the new hours of operation. Approximately 31 to 38 percent of all respondents did not know.
3) A substantial majority (67 percent) of respondents either somewhat or strongly agreed with the statement that the new policy was a good idea, while 17 percent somewhat or strongly disagreed. Respondents who typically drove alone during peak hours were even more supportive, with 73 percent either somewhat or strongly agreeing with the statement that the new policy was a good idea, and 13 percent somewhat or strongly disagreeing. Among those who used carpools, vanpools, or transit during peak periods, 59 percent

somewhat or strongly agreed with the new policy, while 23 percent somewhat or strongly disagreed.

4) The new hours of operation affected the respondents' overall opinion of the HOV lane network, with 41 percent saying that they had a somewhat or significantly more favorable opinion of the HOV lane network because of the new policy, 10 percent expressing a less favorable opinion, and 50 percent expressing no change in opinion. Among peak hour SOV users, 46 percent had a somewhat or significantly more favorable opinion of the HOV lane network because of the new policy, with 48 percent unchanged in their opinion. Among HOV users, 32 percent had a more favorable opinion because of the new policy, while 53 percent were unchanged in their opinion, and 15 percent had a less favorable opinion.

These results will be reviewed and updated as additional data are collected in the coming months. The next evaluation report will be produced following the end of the second full year of operation.

SECTION 1
INTRODUCTION

This report documents the analytical results of research sponsored by the Washington State Department of Transportation (WSDOT) to evaluate the effects of a pilot program to implement specific hours of high-occupancy vehicle (HOV)-only operation on selected corridors of the Seattle-area freeway HOV lane network. It summarizes the results of a preliminary analysis performed after two months of operation as well as analyses performed after one year of operation.

This document is organized as follows:

Background: A description of the research problem and the evaluation tasks that were performed.

Methodology: A description of the data collection and analysis process used in conducting tasks 1, 2, and 5 of the evaluation (evaluation of changes in vehicle occupancy and traffic flow, and results of a public opinion survey).

General Observations: An overview of the results from conducting tasks 1, 2, and 5 after one year of pilot project operation, with selected notable results from the data collected.

Summary of Analyses: A summary of results after one year of the pilot project.

This document is the second of a series of evaluation reports for this project and describes results from tasks 1, 2, and 5 of the full evaluation effort, using available data

sets[1]. Other components of the evaluation will be documented separately as those results become available.

[1] This report is an updated and expanded version of a technical working paper prepared two months after the start of the pilot program. See Hallenbeck, Nee, and Ishimaru, "Evaluation of Puget Sound HOV Lane Hours of Operation: Initial Results for Tasks 1 and 2," Washington State Transportation Center, 2003.

SECTION 2
BACKGROUND

Since its inception, the Puget Sound freeway HOV lane network has operated as an exclusive HOV-only facility, 24 hours a day, seven days a week. In recent years, discussions have taken place at the regional and state level regarding the potential use of the HOV lane network by single-occupant vehicles (SOVs) during particular times of the day or days of the week in an effort to maximize the use of existing facilities and enhance overall freeway network performance. In the summer of 2003, a two-year pilot program was begun to explore the potential costs and benefits of such a usage policy. Under this pilot program, the freeway HOV lane network is available for use by all vehicles, both HOVs and SOVs, during the hours of 7:00 PM to 5:00 AM, seven days a week, on four of the five primary corridors in the region (I-405, SR 167, SR 520 east of I-405, and I-90 east of East Mercer Way on Mercer Island). Interstate 5's HOV lanes remain closed to SOVs at all times, and between 5:00 AM and 7:00 PM, seven days a week, the entire Seattle-area freeway HOV lane network operates as an exclusive HOV-only system.

EVALUATION OVERVIEW

In association with this pilot program, an evaluation effort was developed to analyze the effects of this new policy. The focus of this effort is on the effects of the change in hours of HOV lane operation on freeway usage and performance, safety, and enforcement, as well as on public opinion. The overall evaluation effort consists of six tasks:

1. **Car occupancy analysis**. The focus of this task is a review of changes in per-car occupancy, particularly in the HOV lane, and changes in the violation rate—or SOV usage rate—for the HOV lane during different times of the day. The Washington State Transportation Center (TRAC) at the University of Washington will perform this task.

2. **Traffic flow analysis**. This task involves an analysis of changes in freeway usage and performance in both the HOV and general purpose (GP) lanes. Principal measures include vehicle volumes, speeds, and congestion frequency. TRAC is performing this task.
3. **Safety evaluation**. WSDOT will evaluate incident and accident data to determine any changes in the number and frequency of those events during the revised HOV lane hours of operation.
4. **Enforcement evaluation**. WSDOT will summarize enforcement activities and analyze changes in HOV lane violation rates on the basis of Washington State Patrol (WSP) and HERO data. These results will also be compared with related data collected for Task 1.
5. **Opinion Surveys**. WSDOT and TRAC will perform opinion surveys of the general public, public officials, and other stakeholders.
6. **Report Generation**. Periodic evaluation reports will be prepared by TRAC and WSDOT. These reports will summarize TRAC and WSDOT analyses for the tasks listed above.

The remainder of this paper focuses on initial (2003) and one-year (2004) results **for tasks 1, 2, and 5**. Other task results will be documented separately by TRAC and/or WSDOT as they become available.

INITIAL ACTIVITIES

The following activities were completed as part of this analytical effort for evaluation tasks 1, 2 and 5:

- **Collect data**. Vehicle occupancy data were collected via direct field observations. The data were then processed, filtered, and archived in a Web-

accessible database for subsequent analyses. WSDOT collected freeway usage data (primarily vehicle volumes and lane occupancy percentage) from its sensor (loop) network. The data were then archived onto CD for use with TRAC's performance estimation software.

- **Compute performance measures**. Selected data sets for specific locations and time periods were extracted and processed to produce performance measures.
- **Analyze data for initial before/after comparisons.** Comparisons were made and analyzed of freeway traffic characteristics before and after the revised hours of operation were implemented. The "before" period was defined as the two months before the implementation time period. (The implementation time period was defined as the approximately one month during which the revised hours of operation were phased in across the four affected corridors.) Two "after" periods are described in this report. Preliminary "after" results were estimated two months after the implementation period (summer 2003), while one-year "after" results were estimated in spring and summer 2004 after approximately one year of operation.

SECTION 3
METHODOLOGY DESCRIPTION

Below is a description of the data collection process, data collection matrix, and computed performance measures used to perform tasks 1, 2, and 5 of this evaluation.

OVERVIEW OF THE DATA COLLECTION PROCESS

The following approach was used to collect data for tasks 1, 2, and 5 of this evaluation.

Task 1 data: Vehicle occupancy was analyzed by using data collected by a field data observer group. This data collection effort is normally part of a separate, ongoing, WSDOT-sponsored project to monitor HOV lane network performance. Individuals in the observer group collect data by directly observing the number of occupants per vehicle at selected locations and time periods throughout the central Puget Sound freeway network, and then electronically recording that information. With support from WSDOT, the standard matrix of observation locations and times normally used by the observer group was supplemented with additional locations and times to enable this HOV hours of operation evaluation.

Task 2 data: Traffic flow analyses were performed with freeway surveillance data collected by the WSDOT Northwest Region's embedded freeway sensor loop network (the FLOW system). These data consist primarily of vehicle volumes and lane occupancy percentage values for each lane, at approximately 0.5-mile intervals, for 5-minute periods, 24 hours a day, seven days a week, throughout the freeway network. WSDOT archives these raw data, and TRAC analyzed them by using the TRAC-WSDOT FLOW analysis process. This process, developed over the last eight years by TRAC, uses specially developed software to compute detailed freeway performance measures.

Task 5 data: A public opinion survey was conducted in the spring of 2004 to evaluate public awareness and perceptions of the revised HOV lane hours of operation.

This data collection effort was accomplished by adding questions to a survey that is periodically distributed as part of the ongoing WSDOT project to monitor HOV lane network performance. That project's standard survey form was supplemented with additional questions about the revised HOV hours of operation, with distribution and collection of the survey performed with support from WSDOT..

TRAC performed tasks 1 and 2 in consultation with WSDOT staff, with data collection support from the HOV Lane Evaluation project and WSDOT Northwest Region. Staff of the HOV Lane Evaluation project collected survey data for Task 5, and TRAC analyzed the results.

DATA COLLECTION MATRIX

The general analytical approach for evaluation tasks 1 and 2 involved the analysis of vehicle occupancy data and sensor (loop) data for particular combinations of **location** (e.g., I-5 at milepost 170), **direction of travel** (e.g., northbound), **range of days** (e.g., July through September 2002, weekdays), **time period** (e.g., PM peak period from 5:00 PM to 7:15 PM), and **lane type** (GP or HOV). Ideally, one would want to analyze as many such combinations as possible, with dense geographic coverage of the freeway network. The primary practical limiting factor for the data collection process was the labor-intensive vehicle occupancy data collection effort, which requires human field observations and manual data collection. In contrast, sensor loop data are generally available at locations throughout the freeway network. For that reason, the matrix of data collection measurements used in this project was constrained by the availability of the more labor-intensive vehicle occupancy measurements.

Figure 3.1 shows the locations, times, and directions of travel of vehicle occupancy measurements taken for this initial evaluation process, along with the date when revised operating hours began. Measurements were taken at eleven locations that were selected to sample each of the corridors affected by the revised hours of operation.

For each location, efforts were made to collect data during both AM and PM peak periods (5:00-7:00 AM, 5:00-7:00 PM), with additional data collected from 7:00 PM to 7:15 PM, in both the GP and HOV lanes and usually in both directions of travel.

The resulting data set features 42 combinations of location, time, direction, and lane type. Multiple days of data collection were scheduled for each location so that results could be averaged. Measurements were made during both weekdays and weekends, though for this initial evaluation effort, only weekday data were processed.

For each measurement of average vehicle occupancy, matching traffic flow (loop) data were also extracted for the closest possible sensor location and time period.

The general analytical approach for task 5 involved analyzing public opinion via an anonymous mailback questionnaire. Survey questions related to the new HOV lane operating hours were added to WSDOT's existing annual HOV public opinion survey. Traffic observers for that project collected the license plate numbers of vehicles on GP and HOV freeway lanes at the vehicle occupancy measurement sites and also collected license plate numbers at park-and-ride lots. These license plate numbers were then sent to Olympia for processing by the state Department of Licensing. The resulting address list was used as the potential pool of survey recipients. Of the 5,349 surveys sent out, 1,209 surveys were returned and processed, for an overall response rate of approximately 23 percent. The survey was conducted during late winter and spring of 2004, approximately half a year after the new hours of operation began in the summer of 2003.

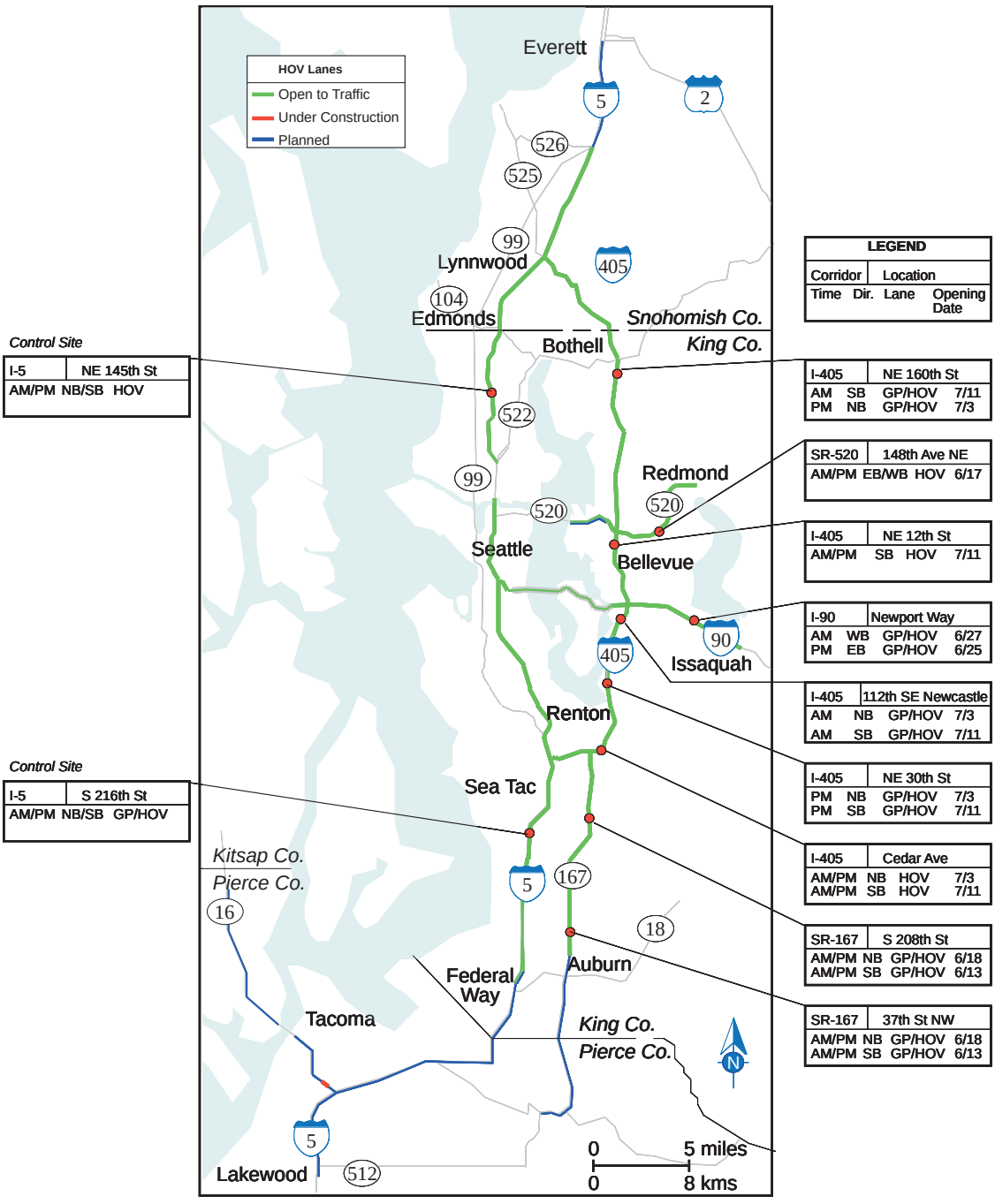

Figure 3.1. Measurement Sites

As with the vehicle occupancy observations, the limiting factor for the survey data collection process was the labor-intensive vehicle license plate data collection effort, which requires human field observations and manual data collection. Nevertheless, a significant number of survey responses were received.

PERFORMANCE MEASURES

The principal performance measures used in this initial evaluation were computed for each element (combination of location/time/direction/lane type) in the data measurement matrix. In general, individual observations were first averaged within each time period for each data collection day (e.g., 5:00-7:00 AM, 5:00-7:00 PM) and then averaged for longer periods (e.g., the average of all "before" data collection days). The performance measures were as follows:

1. **Average car occupancy (ACO).** This performance measure summarized the principal criterion for determining the eligibility of a vehicle to use the HOV lane. The unit of measure was **average number of occupants per vehicle**.
2. **SOV violation rate / SOV usage rate.** Individual field observations of vehicle occupancy were analyzed to determine the number and percentage of vehicles in the HOV lane that were below the usual minimum occupancy requirement. Because the HOV occupancy requirement is normally two or more persons, the unit of measure was **number or percentage of SOVs in the HOV lane**. Note that during the hours of 5:00 AM to 7:00 PM, this measure was considered a violation rate, while from 7:00 PM to 5:00 AM (when all vehicles can legally use the HOV lane), it was considered an SOV "usage" rate.

3. **Average vehicle volume.** Volume data collected by sensor loops were processed and averaged for locations and time periods that matched those of the vehicle occupancy data as closely as possible. Units of measure were **average number of vehicles per time period** (usually AM or PM peak period), **average number of vehicles per hour**, or **average number of vehicles per lane per hour**, depending on the type of analysis.
4. **HOV lane share**. Vehicle volume data for each lane at a location were processed to determine the percentage of all vehicles using the HOV lane. The unit of measure was **number or percentage of vehicles using the HOV lane**.
5. **Average 24-hour traffic profile.** While the measures listed above were aggregated across a time period, the average 24-hour traffic profile was intended to display the time-varying characteristics of traffic at a location, including the average vehicle volume, average estimated vehicle speed, and frequency of heavy congestion at 5-minute intervals throughout an average 24-hour day. Units of measure were **vehicles per hour, miles per hour,** and **likelihood (percentage) that heavy congestion occurs**, respectively, each of which varied by time of day. The averages were computed by processing all applicable days of sensor data for a given period of time (e.g., "before" or "after" weekday data).
6. **Day-to-day profiles.** Measures 1 through 4 were also displayed as a graph of successive days to determine day-to-day variations, particularly those days immediately before and after the hours of operation were implemented.

7. **Public opinion.** Public awareness and perception of the pilot program were estimated by analyzing the results of a survey. Responses to survey questions were based on a discrete scale of choices.

LIMITATIONS

Because of the labor-intensive data collection process for vehicle occupancy, the number of occupancy data measurements was limited for any given site. Similarly, public opinion survey responses were limited by the number of license plate numbers that could be manually collected. Both processes were subject to potential error given the manual collection methods employed. Sensor loop data were readily available but could vary in quality or be affected by sensor hardware or communications problems. To overcome these limitations as much as possible, efforts were made to review, filter, and verify all data before their use for this evaluation.

SECTION 4
GENERAL OBSERVATIONS

The following is a summary of initial and one-year results for selected locations in the Seattle area freeway network. Unless otherwise noted, results were usually based on "before vs. after" comparisons, i.e., how did traffic characteristics change following implementation of the new HOV lane hours of operation? Two types of before vs. after comparisons were made: a short-term comparison immediately following implementation, and a longer-term follow-up comparison to estimate the extent to which observed short-term changes in traffic characteristics were sustained after one year of operation. Before-and-after comparisons were based on three time periods. To evaluate short-term changes, a "before" time period from April 2003 through June 12, 2003, and an "after" time period from mid-July 2003 through September 2003 were used. These time periods preceded and followed the one-month period (June 13, 2003, through July 11, 2003) during which the new operating hours were phased in. To evaluate longer-term changes, another "after" time period during the spring and summer 2004 was used. Estimation of public perceptions was based on surveys conducted approximately 6 to 8 months after the introduction of the revised hours of operation.

Occupancy and traffic flow measurements were taken at 11 freeway locations on SR 167, SR 520, I-90 and I-405 (the corridors affected by the new operations policy). Only weekday data were processed for this analysis. Public opinion surveys were distributed on the basis of a sampling of vehicles at selected data collection locations.

The following observations are grouped into four categories: changes in HOV lane use by SOVs, changes in occupancy compliance in the HOV lane, changes in freeway performance, and public perceptions.

HOV LANE USE BY SINGLE-OCCUPANT VEHICLES (SOVS)

The first set of observations focuses on changes in the use of the HOV lane following implementation of the new hours of operation.

1. Car occupancy data suggest that SOV travelers in the evening utilized the new hours of HOV lane operation, though the extent of use varied by location.

Table 4.1 summarizes the results of an analysis of per-car person occupancy in the HOV lanes during the evening, both before and after the revised hours of operation began. Specifically, observers counted the percentage of vehicles in the HOV lane that had one occupant (i.e., SOVs) during the 15-minute periods before and after the operating hours changed (7:00 PM).

Before the start of the pilot program, when 24-hour HOV–only access was in effect, the percentage of SOVs illegally using the HOV lane changed only slightly in most locations after 7:00 PM. (Exceptions were on SR 167 at Auburn, where SOV percentages have historically been unusually high, and on I-405 southbound at Cedar Avenue, where a limited data sample was available.)

During the initial two-month period after initiation of the revised hours, an analysis of per-car person occupancy in the HOV lanes showed that shortly after the HOV lanes were opened to SOVs each weekday evening at 7:00 PM, the percentage of vehicles in the HOV lane that were SOVs increased, with the amount varying by location. Table 4.1 illustrates the average observed percentage of SOVs in the HOV lane (labeled "After Operational Change (Initial)") as time advances from the 6:45 PM-7:00 PM period (only HOVs allowed) to the 7:00 PM-7:15 PM period (all vehicles allowed) during the two-month "after" period. The SOV percentage in the HOV lane increased noticeably after 7:00 PM, with the largest increases on SR 167 southbound and on I-405 southbound near Newcastle. Increased SOV percentages of varying degrees were seen across all measured locations and travel directions.

An analysis of per-car person occupancy in the HOV lanes one year after the revised hours of operation began showed that the initial pattern of increase in the percentage of SOVs in the HOV lane after 7:00 PM continued. (See the section of Table 4.1 labeled "After Operational Change (One-Year)".) In most cases shown in the table, the number of SOVs in the HOV lane after 7:00 PM versus before 7:00 PM increased by 10 percentage points or greater. The highest observed changes were on I-405 southbound at Newcastle, where the number of SOVs increased from about 7 percent before 7:00 PM to over 30 percent after 7:00 PM, and on SR 167 southbound at Renton and Auburn, where the number of SOVs increased by over 20 percentage points after 7:00 PM. The smallest observed changes in SOV percentage after 7:00 PM were on I-405 southbound at NE 12th, where a limited data sample was available; on SR 167 northbound at Auburn (the northbound direction is opposite to the dominant traffic direction and, therefore, there is less incentive for SOVs to use the HOV lane); and on I-90 eastbound at Eastgate, when traffic is typically lighter and there is less need to use the HOV lane.

Furthermore, the magnitude of the SOV share of HOV lane traffic after 7:00 PM grew, on average. Initial results two months after the start of the program showed that the percentage of SOVs in the HOV lane after 7:00 PM was 19 percent or higher at only two of the 13 HOV locations evaluated. However, after one year of operation, seven of the 13 HOV lane locations evaluated had an SOV percentage of 19 percent or higher after 7:00 PM, while another location with limited data sampling was also above 19 percent. There was some variability, however; SOVs in four of the 13 locations comprised a smaller share of HOV traffic in 2004 (one-year) than in 2003 (initial), although two of those four locations (SR 167 southbound) still saw significant increases.

Table 4.1. Percentage of SOVs in HOV Lane by Time of Day

Corridor	Location	Direction	Before Operational Change (2003)			After Operational Change (Initial)			After Operational Change (One-Year)			Initial Change (2003)	One-Year Change (2004)
			6:45-7:00 PM	7:00-7:15 PM	Change	6:45-7:00 PM	7:00-7:15 PM	Change	6:45-7:00 PM	7:00-7:15 PM	Change	7:00-7:15 PM Change	7:00-7:15 PM Change
I-405	NE 160th, Bothell	N	1.5%	1.5%	0.0%	1.8%	5.7%	3.9%	4.5%	19.2%	14.7%	4.3%	17.7%
I-405	NE 30th St, Newcastle	N	0.5%	0.5%	0.0%	3.0%	8.7%	5.7%	n/a	n/a	n/a	8.1%	n/a
I-405	Cedar Ave, Renton	N	1.2%	0.3%	-0.9%	0.9%	6.9%	6.0%	5.3%	14.9%	9.6%	6.6%	14.6%
I-405	NE 12th St, Bellevue	S	4.7%	3.4%	-1.3%	n/a	n/a	n/a	1.1%	6.6%	5.5%	n/a	3.2%
I-405	NE 30th St, Newcastle	S	1.6%	8.7%	7.1%	1.5%	16.2%	14.7%	6.6%	30.4%	23.8%	7.5%	21.7%
I-405	Cedar Ave, Renton	S	1.8%	13.5%	11.7%	3.9%	13.2%	9.4%	8.0%	23.3%	15.3%	-0.3%	9.8%
I-90	Newport Way, Issaquah	E	0.7%	0.8%	0.1%	1.3%	9.6%	8.3%	2.5%	7.2%	4.7%	8.8%	6.4%
SR 167	S 208th St, Renton	N	2.6%	0.5%	-2.1%	5.5%	14.0%	8.6%	8.1%	23.1%	15.0%	13.5%	22.6%
SR 167	37th St. NW, Auburn	N	1.8%	1.0%	-0.8%	2.8%	10.4%	7.5%	0.0%	2.4%	2.4%	9.4%	1.4%
SR 167	S 208th St, Renton	S	2.4%	2.0%	-0.4%	8.4%	31.7%	23.3%	8.9%	31.0%	22.1%	29.7%	29.0%
SR 167	37th St. NW, Auburn	S	16.6%	26.9%	10.3%	25.5%	45.1%	19.6%	15.4%	36.4%	21.0%	18.3%	9.5%
SR 520	NE 148th, Redmond	E	3.8%	5.7%	1.9%	2.0%	12.0%	10.0%	4.9%	19.4%	14.5%	6.3%	13.7%
SR 520	NE 148th, Redmond	W	3.0%	2.2%	-0.8%	7.4%	12.5%	5.1%	8.5%	29.0%	20.5%	10.2%	26.8%

One result of these changes in SOV use in the HOV lane was that average car occupancy (ACO) in the HOV lane generally dropped after 7:00 PM following implementation of the new hours (see Table 4.2). Shortly before the start of the pilot program, only one of the 13 locations on the table had an average car occupancy below 2.0 after 7:00 PM (the minimum value expected when HOV-only usage is required). Shortly after the start of the pilot program, five of the 13 locations had an average car occupancy below 2.0. After one year, eight of the 13 sites had an ACO below 2.0.

As of 2004, the most notable example is on southbound SR 167 at Renton (S. 208th), where the ACO dropped to just under 1.8. (The ACO dropped below 1.7 on SR 167 at Auburn, but this is an atypical case for reasons related to location that will be described shortly.)

2. The increase in the percentage of SOVs in the HOV lane was accompanied by increases in the total HOV lane vehicle volumes during the 7:00 to 7:15 PM period (start of the new hours of operation).

In addition to increases in the percentage of SOVs in the HOV lane, as noted above, before/after comparisons during the 7:00-7:15 PM and the 7:00-8:00 PM periods showed that total vehicle volumes in the HOV lane at the selected locations consistently increased as well (see Table 4.2). For the 7:00-7:15 PM time period, every location showed a higher vehicle volume in the HOV lane shortly after the start of the pilot program than shortly before the start of the program, with percentage increases in HOV lane volume ranging from +28 percent on SR 520 westbound near Redmond to +94 percent on SR 167 southbound in Auburn. Furthermore, the trend continued over the next year, with every location showing further volume increases. Therefore, the increase in the percentage of SOVs in the HOV lane most likely corresponded to increased SOV volume, and not to a drop in the number of HOVs relative to the number of SOVs.

Table 4.2. ACO and Vehicle Volumes in the HOV Lane

HOV Vehicle Volume Trends			HOV Lane (7:00-7:15 PM)									
			Vehicle Volume			2003 Volume Change		2004 Volume Change		ACO		
Corridor	Location	Dir.	Before (2003)	After (2003)	After (2004)	(%)	(number)	(%)	(number)	Before (2003)	After (2003)	After (2004)
I-405	NE 160th, Bothell	N	109	159	192	46%	50	76%	83	2.15	2.12	1.96
I-405	NE 30th St, Newcastle	N	142	215	245	51%	73	73%	103	2.06	2.18	n/a
I-405	Cedar Ave, Renton	N	130	205	226	58%	75	74%	96	2.17	2.18	1.95
I-405	NE 12th St, Bellevue	S	128	170	176	33%	42	38%	48	2.13	n/a	2.00
I-405	NE 30th St, Newcastle	S	203	317	352	56%	114	73%	149	2.09	1.99	1.93
I-405	Cedar Ave, Renton	S	147	259	316	76%	112	115%	169	2.06	1.99	2.00
I-90	Newport Way, Issaquah	E	56	77	97	38%	21	73%	41	2.14	2.09	2.16
SR 167	S 208th St, Renton	N	94	130	139	38%	36	48%	45	2.35	2.04	1.86
SR 167	37th St. NW, Auburn	N	66	100	102	52%	34	55%	36	2.22	2.18	2.09
SR 167	S 208th St, Renton	S	126	213	238	69%	87	89%	112	2.13	1.82	1.79
SR 167	37th St. NW, Auburn	S	117	227	242	94%	110	107%	125	1.79	1.68	1.64
SR 520	NE 148th, Redmond	E	51	68	75	33%	17	47%	24	2.11	1.99	1.96
SR 520	NE 148th, Redmond	W	81	104	115	28%	23	42%	34	2.08	2.04	1.86

HOV Vehicle Volume Trends			HOV Lane (7:00-8:00 PM)						
			Vehicle Volume			2003 Volume Change		2004 Volume Change	
Corridor	Location	Dir.	Before (2003)	After (2003)	After (2004)	(%)	(number)	(%)	(number)
I-405	NE 160th, Bothell	N	366	537	658	47%	171	80%	292
I-405	NE 30th St, Newcastle	N	526	789	900	50%	263	71%	374
I-405	Cedar Ave, Renton	N	481	738	839	53%	257	74%	358
I-405	NE 12th St, Bellevue	S	419	518	583	24%	99	39%	164
I-405	NE 30th St, Newcastle	S	677	1035	1239	53%	358	83%	562
I-405	Cedar Ave, Renton	S	499	834	1088	67%	335	118%	589
I-90	Newport Way, Issaquah	E	181	248	311	37%	67	72%	130
SR 167	S 208th St, Renton	N	349	478	524	37%	129	50%	175
SR 167	37th St. NW, Auburn	N	240	366	387	53%	126	61%	147
SR 167	S 208th St, Renton	S	462	752	867	63%	290	88%	405
SR 167	37th St. NW, Auburn	S	416	783	865	88%	367	108%	449
SR 520	NE 148th, Redmond	E	194	250	283	29%	56	46%	89
SR 520	NE 148th, Redmond	W	276	357	425	29%	81	54%	149

Overall Vehicle Volume Trends			All Lanes Combined (7:00-8:00 PM)						
			Vehicle Volume			2003 Volume Change		2004 Volume Change	
Corridor	Location	Dir.	Before (2003)	After (2003)	After (2004)	(%)	(number)	(%)	(number)
I-405	NE 160th, Bothell	N	3817	4111	4211	8%	294	10%	394
I-405	NE 30th St, Newcastle	N	2826	3145	3201	11%	319	13%	375
I-405	Cedar Ave, Renton	N	3478	3889	3987	12%	411	15%	509
I-405	NE 12th St, Bellevue	S	4730	4903	4753	4%	173	0%	23
I-405	NE 30th St, Newcastle	S	3536	3867	4019	9%	331	14%	483
I-405	Cedar Ave, Renton	S	3392	3776	3981	11%	384	17%	589
I-90	Newport Way, Issaquah	E	2908	2881	3041	-1%	-27	5%	133
SR 167	S 208th St, Renton	N	2243	2461	2539	10%	218	13%	296
SR 167	37th St. NW, Auburn	N	2026	2243	2278	11%	217	12%	252
SR 167	S 208th St, Renton	S	3132	3307	3514	6%	175	12%	382
SR 167	37th St. NW, Auburn	S	2901	3122	3158	8%	221	9%	257
SR 520	NE 148th, Redmond	E	1695	1745	1773	3%	50	5%	78
SR 520	NE 148th, Redmond	W	2210	2250	2243	2%	40	1%	33

3. The percentage of all vehicles that used the HOV lane after 7:00 PM increased, but the magnitude varied noticeably by location.

Table 4.3 summarizes the percentage of all vehicle traffic that used the HOV lane during two time periods (spring and summer) during each of the past three years (2002, 2003, 2004). Looking at the 2003 values, the share of traffic in the HOV lane was higher during the 7:00 to 7:30 PM time period following the implementation of revised hours (summer) than it was just before implementation (spring), but the amounts varied considerably by location. Southbound locations on SR 167 and locations on I-405 between Renton and Bellevue showed the largest increases in vehicle use of the HOV lane shortly after the 7:00 PM change in 2003.

A comparison of the same two periods (spring and summer) during 2002 and 2004 provide a better understanding of any seasonal trends that would normally be present. Note that during the same two periods in the year 2002 the HOV lane's share of all traffic increased without any revised hours of operation; however, the magnitude of the 2002 change was smaller than the corresponding change in 2003. A similar seasonal pattern was seen in 2004; here also, the magnitude was smaller than that seen in 2003, the year during which the pilot program was first implemented.

Table 4.3. Share of Traffic in the HOV Lane during Weekdays (7:00-7:30 PM)

Corridor	Location	Mile Post	Spring Traffic (7:00-7:30 PM)		Share of All Traffic Using HOV Lane (April-June)			
			2004		2003		2002	
			NB/EB	SB/WB	NB/EB	SB/WB	NB/EB	SB/WB
SR 167	S 208th St, Renton	22.92	19.7%	23.4%	15.8%	14.9%	16.2%	15.0%
SR 167	37th St. NW, Auburn	17.37	15.2%	26.0%	12.3%	14.5%	12.4%	16.4%
SR 520	NE 148th, Redmond	9.2	14.8%	17.9%	11.1%	12.6%	11.5%	11.4%
I-90	Newport Way, Issaquah	13.44	9.9%	9.5%	6.5%	8.5%	7.3%	9.1%
I-405	NE 160th, Bothell	22.46	16.5%	14.7%	9.9%	11.3%	10.1%	10.2%
I-405	NE 12th St, Bellevue	14.25	10.3%	12.9%	8.1%	9.4%	7.7%	9.2%
I-405	NE 30th St, Newcastle	6.52	25.5%	30.5%	18.8%	20.3%	19.4%	20.0%
I-405	112th SE, Newcastle	8.92	23.5%	30.4%	17.5%	20.5%	17.7%	20.1%
I-405	Cedar Ave, Renton	3.57	18.3%	23.0%	14.0%	15.8%	15.3%	16.6%

Corridor	Location	Mile Post	Summer Traffic (7:00-7:30 PM)		Share of All Traffic Using HOV Lane (July-September)			
			2004		2003		2002	
			NB/EB	SB/WB	NB/EB	SB/WB	NB/EB	SB/WB
SR 167	S 208th St, Renton	22.92	20.7%	25.2%	19.7%	23.4%	16.7%	17.2%
SR 167	37th St. NW, Auburn	17.37	17.1%	28.3%	16.7%	26.1%	14.7%	19.0%
SR 520	NE 148th, Redmond	9.2	15.7%	18.8%	14.3%	16.0%	12.2%	12.8%
I-90	Newport Way, Issaquah	13.44	10.8%	10.8%	9.0%	10.7%	8.7%	10.5%
I-405	NE 160th, Bothell	22.46	16.6%	16.7%	13.7%	14.0%	11.7%	12.7%
I-405	NE 12th St, Bellevue	14.25	11.2%	13.4%	10.3%	12.0%	9.1%	10.5%
I-405	NE 30th St, Newcastle	6.52	28.6%	32.2%	25.5%	28.4%	22.1%	23.4%
I-405	112th SE, Newcastle	8.92	25.9%	32.1%	23.2%	28.9%	20.1%	24.2%
I-405	Cedar Ave, Renton	3.57	21.7%	29.5%	19.3%	24.2%	17.8%	24.4%

Corridor	Location	Mile Post	Change in HOV Lane share (Summer vs. Spring)					
			2004		2003		2002	
			NB/EB	SB/WB	NB/EB	SB/WB	NB/EB	SB/WB
SR 167	S 208th St, Renton	22.92	1.0%	1.8%	3.9%	8.5%	0.5%	2.2%
SR 167	37th St. NW, Auburn	17.37	1.9%	2.3%	4.4%	11.6%	2.3%	2.6%
SR 520	NE 148th, Redmond	9.2	0.9%	0.9%	3.2%	3.4%	0.7%	1.4%
I-90	Newport Way, Issaquah	13.44	0.9%	1.3%	2.5%	2.1%	1.3%	1.3%
I-405	NE 160th, Bothell	22.46	0.1%	2.0%	3.7%	2.7%	1.6%	2.5%
I-405	NE 12th St, Bellevue	14.25	0.9%	0.5%	2.2%	2.6%	1.4%	1.3%
I-405	NE 30th St, Newcastle	6.52	3.2%	1.7%	6.7%	8.1%	2.8%	3.4%
I-405	112th SE, Newcastle	8.92	2.4%	1.7%	5.6%	8.4%	2.4%	4.1%
I-405	Cedar Ave, Renton	3.57	3.3%	6.5%	5.3%	8.5%	2.5%	7.9%

A notable example of a change in HOV lane usage during the initial period following the start of revised hours of operation was on SR 167. Tables 4.4 through 4.5b summarize the changes in traffic characteristics for one location on southbound SR 167, South 208th Street in Renton, during the evening peak period. Table 4.4 describes the average per-car person occupancy pattern before and after revised hours began, as well as one year after the start of revised hours. Note that before the start of the pilot program, both GP and HOV vehicle occupancies were generally consistent for the three periods shown (peak period of 5:00-7:00 PM, and the two 15-minute time periods just before and after 7:00 PM), with little change from one period to the next. In contrast, the vehicle occupancy pattern after the revised hours began showed significant changes after 7:00 PM. In particular, during the 2003 "after" period, the per-car person occupancy in the HOV lane dropped from 2.11 before 7:00 PM to 1.82 after 7:00 PM. Similarly, in the 2004 "after" period, the ACO dropped from 2.05 before 7:00 PM, to 1.79 after 7:00 PM. A similar change was noted in the percentage of SOVs in the HOV lane. Before the pilot program, the SOV violation rate ranged from 1.6 to 2.4 percent between 5:00 PM and 7:15 PM; after the pilot program started, the SOV percentage averaged 2.4 percent for the entire 5:00-7:00 PM period, increasing to 8.4 percent just before 7:00 PM, then growing substantially to (a now legal) 31.7 percent just after 7:00 PM. A similar pattern was seen in 2004.

Note also that in both the 2003 and 2004 "after" periods, the ACO for the GP lanes increased after 7:00 PM (from 1.2 to 1.40 in 2003, and from 1.20 to 1.27 in 2004). This indicates that some of the HOVs previously in the HOV lane abandoned the HOV lane in favor of the GP lane, and thus the decrease in HOV lane ACO was not necessarily entirely due to increased SOV volume in that lane.

The changes in SOV percentage in the HOV lane were accompanied by changes in vehicle volumes as well. Table 4.5a summarizes the before/after comparisons of vehicle volumes for the GP lanes and HOV lane for the 7:00 to 7:30 PM period for 2002,

2003, and 2004. ("Spring" and "Summer" refer to the same spring and summer months used in Table 4.3; for 2003, they thus correspond to the time periods before and after the implementation of revised hours of operation.) Looking at the HOV vehicle volume trends, one can see that the number of vehicles in the HOV lane grew by over 66 percent after the pilot program began. The analysis of 2002 HOV data for the same time periods showed that seasonal differences alone would produce an expected increase of 19 percent. The rest of the 66 percent increase is presumed to be the result of the new operating hours policy. The share of all traffic using the HOV lane grew from 15 percent to over 23 percent shortly after the pilot program began; this is also greater than one would expect, given seasonal changes in the 2002 data. Meanwhile, the total (GP+HOV) directional roadway volume increased by over 5 percent.

These initial patterns were sustained over the following year. Note that HOV volumes continued to increase in 2004, and the HOV lane share of 23 percent was maintained and slightly increased in 2004. At the same time, the large increases in HOV usage and lane share of 2003 did not occur to the same extent in 2004, further reinforcing the idea that the changes in operational policy that occurred only in 2003 had a significant role in these trends.

While this change in HOV lane use was occurring after 7:00 PM, it must be noted (as can be seen in Table 4.5b) that while the HOV volume during the 5:00-7:00 PM peak period rose by about 10 percent after the start of the pilot program in 2003, this increase was actually less than the over 13 percent growth in PM peak period HOV volumes observed in comparison to the same periods the year before or the year after.

While volumes were increasing in the HOV lane, including a significant number of SOVs, the distribution of vehicles by lane also changed. Overall, the average volume distribution for this location changed from 19-42-39 percent (left HOV lane, middle GP lane, and right GP lane respectively) before 7:00 PM to 25-37-38 percent after 7:00 PM (see Table 4.6). Figure 4.1 shows the distribution of vehicles on each lane for the 6:30

to 7:00 PM period for each weekday for a two-month period in 2004 (thus reflecting the revised hours of operation). Figure 4.2 shows the corresponding data for the 7:00 to 7:30 PM period. A comparison of these graphs illustrates the increase in HOV lane use after 7:00 PM. Note also the definite day-of-week trend apparent in these graphs. The data show a distinct increase in HOV lane use before 7:00 PM on Fridays. It is not clear from the current analysis whether the cause is a greater number of HOV eligible vehicles (e.g., couples headed out together on Friday night) or an increase in violations.

A second example of a change in HOV lane usage during the initial period following the start of revised hours of operation was on I-405. Table 4.7 summarizes the changes in traffic characteristics for one location on southbound I-405, at NE 30th Street near Newcastle, during the evening peak period. The table describes the average per-car person occupancy pattern before and after the revised hours policy began, as well as one year after the start of revised hours. In comparison to the previous example of SR 167, there was somewhat more variability in the GP and HOV vehicle occupancy, especially shortly after the 5:00-7:00 PM peak period. However, after the hours were revised, a change similar to that on SR 167 occurred. HOV vehicle occupancy dropped from 2.12 before 7:00 PM to 1.99 shortly after 7:00 PM. After one year of operation, the drop was larger, going from a 2.22 average vehicle occupancy before 7:00 PM to 1.93 shortly after 7:00 PM. The percentage of SOVs in the HOV lane also showed a significant increase after 7:00 PM once the new hours began, increasing from 1.5 percent before 7:00 PM to 16.2 percent after 7:00 PM in the initial 2003 before/after period, and from 6.6 percent before 7:00 PM to 30.4 percent after 7:00 PM in 2004.

Table 4.4. Changes in ACO (SR 167 SB at S. 208th St, Renton)

ACO	5-7 PM			6:45 to 7 PM			7 to 7:15 PM		
	Before	After (2003)	After (2004)	Before	After (2003)	After (2004)	Before	After (2003)	After (2004)
GP	1.22	1.20	1.14	1.20	1.19	1.20	1.22	1.40	1.27
HOV	2.18	2.17	2.14	2.21	2.11	2.05	2.13	1.82	1.79
SOV % in HOV lane	1.6%	2.4%	4.0%	2.4%	8.4%	8.9%	2.0%	31.7%	31.0%

Table 4.5a. Changes in Vehicle Volumes during 7:00-7:30 PM (SR 167 SB at S. 208th St, Renton)

Vehicle Volume (7-7:30 PM)	Total			GP			HOV			HOV Lane Share		
	2004	2003	2002	2004	2003	2002	2004	2003	2002	2004	2003	2002
Spring	1762	1664	1671	1350	1416	1421	412	248	250	23.4%	14.9%	15.0%
Summer	1849	1757	1738	1383	1345	1439	466	412	299	25.2%	23.4%	17.2%
Volume change	87	93	67	33	-71	18	54	164	49			
%change	4.9%	5.6%	4.0%	2.4%	-5.0%	1.3%	13.1%	66.1%	19.6%			

Table 4.5b. Changes in Vehicle Volumes during 5:00-7:00 PM (SR 167 SB at S. 208th St, Renton)

Vehicle Volume (5-7 PM)	Total			GP			HOV			HOV Lane Share		
	2004	2003	2002	2004	2003	2002	2004	2003	2002	2004	2003	2002
Spring	8146	8220	8200	6648	6725	6525	1498	1495	1675	18.4%	18.2%	20.4%
Summer	8348	8160	8140	6649	6520	6235	1699	1640	1905	20.4%	20.1%	23.4%
Volume change	202	-60	-60	1	-205	-290	201	145	230			
%change	2.5%	-0.7%	-0.7%	0.0%	-3.0%	-4.4%	13.4%	9.7%	13.7%			

Table 4.6. Vehicle Volume Distribution (SR 167 SB at S. 208th St, Renton)

July-August 2004	6:30 - 7:00 PM		7:00-7:30 PM	
	Average Number of Vehicles	Average % of all Vehicles	Average Number of Vehicles	Average % of all Vehicles
L1 = right GP lane	762	38.9%	709	38.3%
L2 = left GP lane	827	42.2%	674	36.5%
HOV = inside HOV lane	371	18.9%	466	25.2%

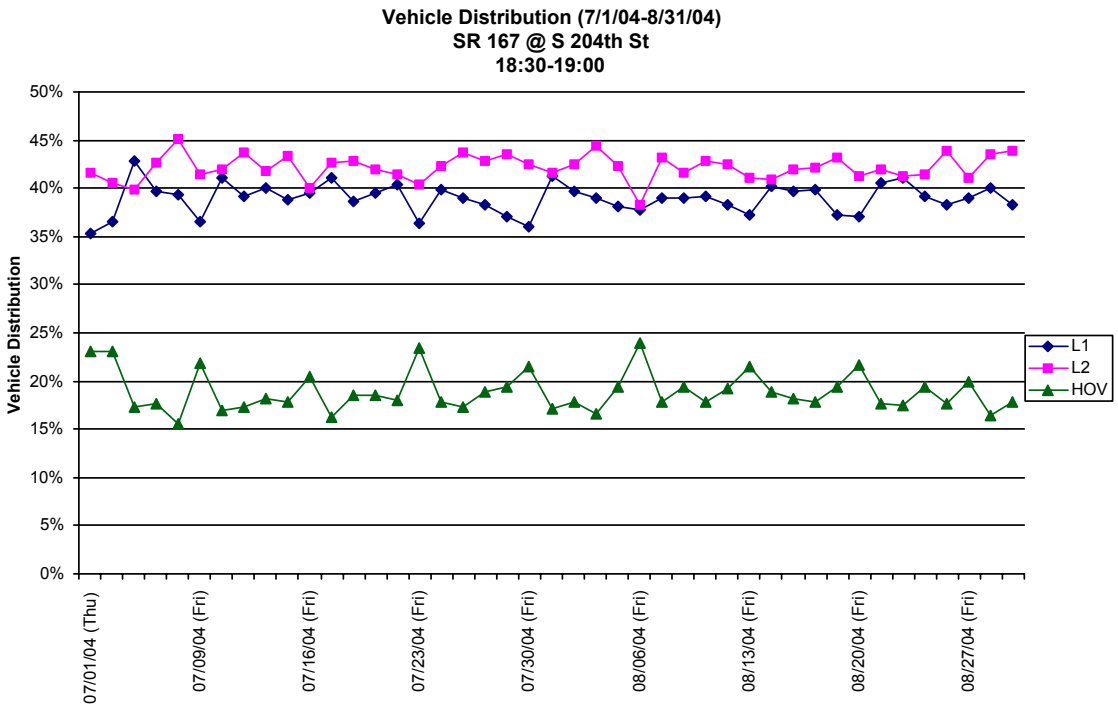

Figure 4.1. Distribution of Vehicles by Lane (6:30-7:00PM)

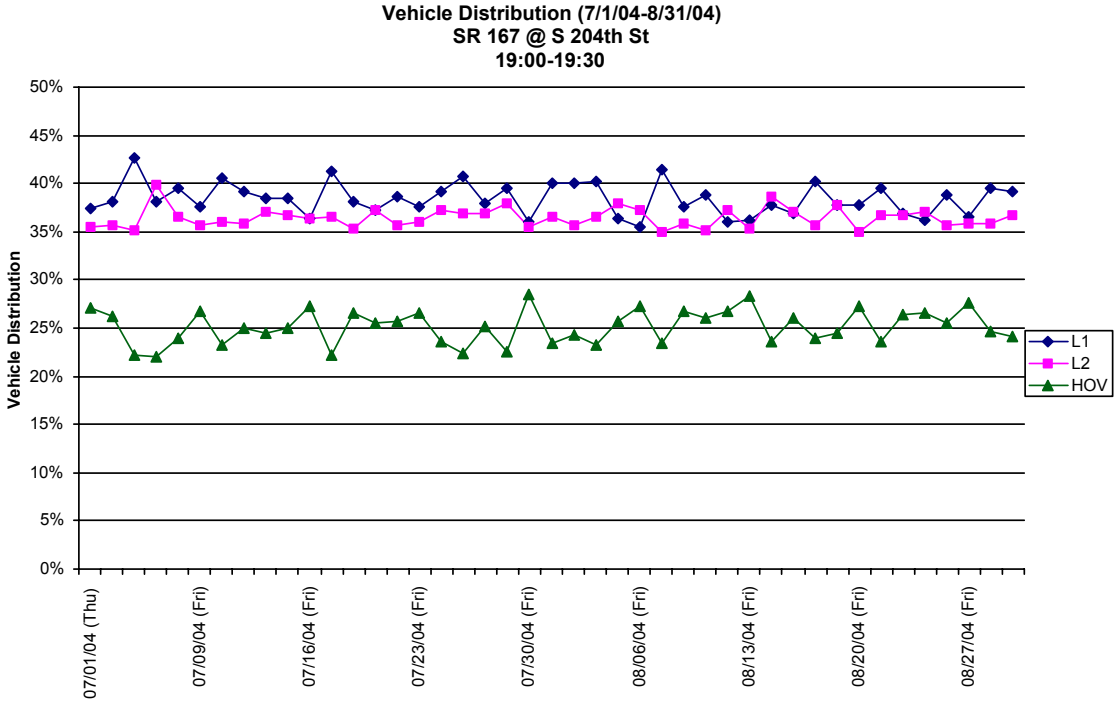

Figure 4.2. Distribution of Vehicles by Lane (7:00-7:30PM)

Table 4.7. Volume Distribution (I-405 at NE 30th in Newcastle, southbound)

	5-7 PM			6:45 to 7 PM			7 to 7:15 PM		
ACO	**Before**	**After (2003)**	**After (2004)**	**Before**	**After (2003)**	**After (2004)**	**Before**	**After (2003)**	**After (2004)**
GP	1.08	n/a	1.1	1.16	n/a	1.09	1.26	n/a	1.02
HOV	2.16	2.15	2.26	2.19	2.12	2.22	2.09	1.99	1.93
SOV % in HOV lane	0.9%	0.6%	3.2%	1.6%	1.5%	6.6%	8.7%	16.2%	30.4%

HOV LANE COMPLIANCE BY SINGLE-OCCUPANT VEHICLES

Another area of interest is the extent to which use of the HOV lane by SOVs occurs during hours when the HOV-only policy is in effect (5:00 AM to 7:00 PM).

4. SOV violation rates during the PM shoulder period did not change significantly in most cases.

During the initial two-month period after the start of revised hours, a before-after comparison during the period leading up to the start of open access to the HOV lanes (6:45 to 7:00 PM) showed that the percentage of vehicles violating the HOV-only policy did increase somewhat, possibly in anticipation of the 7:00 PM start of general HOV lane use, though in most locations the difference was 3 percentage points or less (see Table 4.8). While the change was small at most locations (and sometimes statistically insignificant), nine of the 12 locations with valid data did show an increase in violations just before the 7:00 PM relaxation of the HOV eligibility rules. However, three of those eight locations had an increase in violation rate of less than 1 percentage point. Overall, only four of 12 locations had an "after" violation rate above 5 percent, and none were above 9 percent, except one outlier location that will be discussed shortly.

After one year, the percentage of vehicles violating the HOV-only policy during the 6:45 to 7:00 PM period had increased somewhat. Seven of the 12 locations had violation rates above 5 percent, though none was above 9 percent except one outlier. The highest overall violation rates of the sites analyzed were at SR 167 in Auburn and Renton (southbound) and at SR 520 westbound at Overlake. (I-405 southbound at Cedar Avenue and SR 167 northbound in Renton had similar values, but they were based on limited data sampling.)

The most significant outlier to the pattern of SOV violation rates was SR 167 southbound in Auburn in the evening transition period, with a 9 percentage point increase in the violation rate shortly after the start of the revised hours of operation (from 16.6 to

25.5 percent). This location is near the edge of the HOV lane network (the HOV lane stops about 1 mile downstream from this site), and the direction of travel is outbound toward the end of the HOV network. Locations near the end of HOV facilities traditionally have the highest violation rates, as can be seen by the very high initial violation rate of over 16 percent at this site. Consequently, the fact that the largest increase in violations would occur at such a location is perhaps not surprising. Note, though, that the rate dropped back to pre-pilot program levels in 2004.

This result does highlight the concern expressed by some Puget Sound Regional Council HOV Committee members before the demonstration project began that high violation rates tend to foster even more violations. That is, when violation rates are low, drivers are reluctant to violate because they stand out. But as violation rates increase, more and more drivers lose their reluctance to violate, thus dramatically increasing violation rates. The fact that the largest increase in violation rates occurred at the site that already had the highest violation rate before the demonstration began tends to support this concern and warrants additional study as the demonstration progresses.

Table 4.8. SOVs in the HOV lane, AM and PM

PM			6:45-7:00PM				
Corridor	**Location**	**Dir**	**Before**	**After (2003)**	**Initial SOV Shift**	**After (2004)**	**One-Year SOV Shift**
I-405	NE 160th, Bothell	N	1.5%	1.8%	0.3%	4.5%	3.0%
I-405	NE 30th St, Newcastle	N	0.5%	3.0%	2.5%	n/a	n/a
I-405	Cedar Ave, Renton	N	1.2%	0.9%	-0.3%	5.3%	4.1%
I-405	NE 12th St, Bellevue	S	4.7%	n/a	n/a	1.1%	-3.6%
I-405	NE 30th St, Newcastle	S	1.6%	1.5%	-0.1%	6.6%	5.0%
I-405	Cedar Ave, Renton	S	1.8%	3.9%	2.0%	8.0%	6.2%
I-90	Newport Way, Issaquah	E	0.7%	1.3%	0.7%	2.5%	1.9%
SR 167	S 208th St, Renton	N	2.6%	5.5%	2.9%	8.1%	5.5%
SR 167	37th St. NW, Auburn	N	1.8%	2.8%	1.0%	0.0%	-1.8%
SR 167	S 208th St, Renton	S	2.4%	8.4%	6.0%	8.9%	6.5%
SR 167	37th St. NW, Auburn	S	16.6%	25.5%	8.9%	15.4%	-1.2%
SR 520	NE 148th, Redmond	E	3.8%	2.0%	-1.8%	4.9%	1.1%
SR 520	NE 148th, Redmond	W	3.0%	7.4%	4.4%	8.5%	5.5%
AM			**5:00-7:00AM**				
Corridor	**Location**	**Dir**	**(before)**	**After (2003)**	**Initial SOV Shift**	**After (2004)**	**One-Year SOV Shift**
I-405	NE 160th, Bothell	S	2.5%	2.7%	0.1%	0.8%	-1.7%
I-405	112th SE, Newcastle	N	5.6%	4.2%	-1.4%	9.0%	3.4%
I-405	Cedar Ave, Renton	N	2.6%	3.2%	0.6%	3.4%	0.8%
I-405	NE 12th St, Bellevue	S	4.4%	n/a	n/a	8.4%	4.0%
I-405	NE 30th St, Newcastle	S	3.2%	3.3%	0.1%	n/a	n/a
I-405	Cedar Ave, Renton	S	1.3%	n/a	n/a	0.9%	-0.4%
I-90	Newport Way, Issaquah	W	5.3%	1.6%	-3.6%	6.7%	1.5%
SR 167	S 208th St, Renton	N	7.1%	2.6%	-4.5%	3.9%	-3.2%
SR 167	37th St. NW, Auburn	N	5.1%	1.7%	-3.5%	3.5%	-1.6%
SR 167	S 208th St, Renton	S	7.5%	4.5%	-3.0%	2.9%	-4.6%
SR 167	37th St. NW, Auburn	S	25.6%	16.5%	-9.1%	30.3%	4.8%
SR 520	NE 148th, Redmond	E	1.4%	3.6%	2.2%	6.2%	4.8%
SR 520	NE 148th, Redmond	W	6.4%	7.3%	0.8%	2.3%	-4.1%

5. SOV violation rates during the AM peak period did not change significantly in most cases.

The initial 2003 before-after comparison of SOV violation rates during the 5:00 AM to 7:00 AM period (i.e., following the 5:00 AM resumption of HOV-only access) showed that the SOV violation rate either decreased or only increased modestly (less than 1 percentage point). In only one case (SR 520 at Overlake eastbound) did the violation rate increase by more than 1 percentage point (from 1.4 percent to 3.6 percent), while in several cases marked decreases in violation rates occurred (see Table 4.8). After one year of operation, overall SOV violation rates had increased somewhat more, with five locations having increases in their violation rates of more than 1 percentage point. The highest increase was at SR 167 southbound at 37th Street NW, a location that historically has high violation rates. Other locations saw violation rates increase by between 1.5 and 4.8 percentage points.

The amount of the one-year increase was several percentage points at most, and half of the locations continued to show a drop in the SOV violation rate after one year of operation; nevertheless, the one-year condition does represent a slight overall increase in AM violation rates over the initial before/after comparison. While the data were not conclusive, the pattern of increases relative to initial 2003 results could reflect the increased awareness and legal use of the HOV lane by SOVs in the evening hours after 7:00 PM, followed by some "spillover" of those SOVs past 5:00 AM when the HOV-only requirement is again in effect.

GP AND HOV LANE PERFORMANCE

Data were collected to analyze the extent to which open access to the HOV lane during the revised hours of operation affected GP and HOV traffic performance.

6. Based on the initial and one-year (2004) data set, overall weekday freeway performance characteristics generally did not change significantly. HOV lane volumes increased noticeably just after 7:00 PM at some locations.

In general, before/after comparisons did not show a significant change in freeway performance at the measurement locations in terms of the general 24-hour pattern of average speed, volume, and frequency of congestion. Figures 4.3 through 4.28 show the average 24-hour GP and HOV performance graphs (overlaying 2003 "before" and 2004 "after" data) for each location. In the graphs, the overall characteristics of the before and after patterns are usually similar to one another, though there can be differences depending on time of day.[2] A comparison of the patterns for the period of interest, namely the PM peak period and the transition after 7:00 PM, shows that there were changes in usage (vehicle volume) in the HOV lane at some locations, consistent with the volume increases noted previously. Locations on SR 167 southbound showed the most notable change in freeway usage, primarily in HOV volumes, which increased noticeably immediately after 7:00 PM; some locations on I-405 and SR 520 also showed HOV volume increases. Performance changes after 7:00 PM in terms of speed and congestion were difficult to determine from these graphs alone, however (see observation #7 for further discussion on this issue).

Interestingly, several HOV lane locations on SR 167 and I-405 northbound showed volume increases beginning some time after 4:00 AM, followed by noticeable volume drops around 5:00 AM. While the data are not conclusive, this could represent SOVs using the HOV lane before 5:00 AM, then changing to the GP lanes at the approach or start of 5:00 AM HOV-only operations.

[2] Each figure displays two types of measures for each site: 1) a line curve showing average total vehicle volume by time of day, on an equivalent per-hour basis (use the vehicles/hour scale on the left axis of the figure) and 2) a graph showing the likelihood of encountering congestion (use the 0 to 100 percent probability scale on the right axis). The color lines are "before" conditions, while the black lines are "after" conditions. In addition, the "before" volume curve shows the average approximate "before" speed condition by time of day, using green for 55 mph and above, yellow for 45 to 55 mph, and red for less than 45 mph.

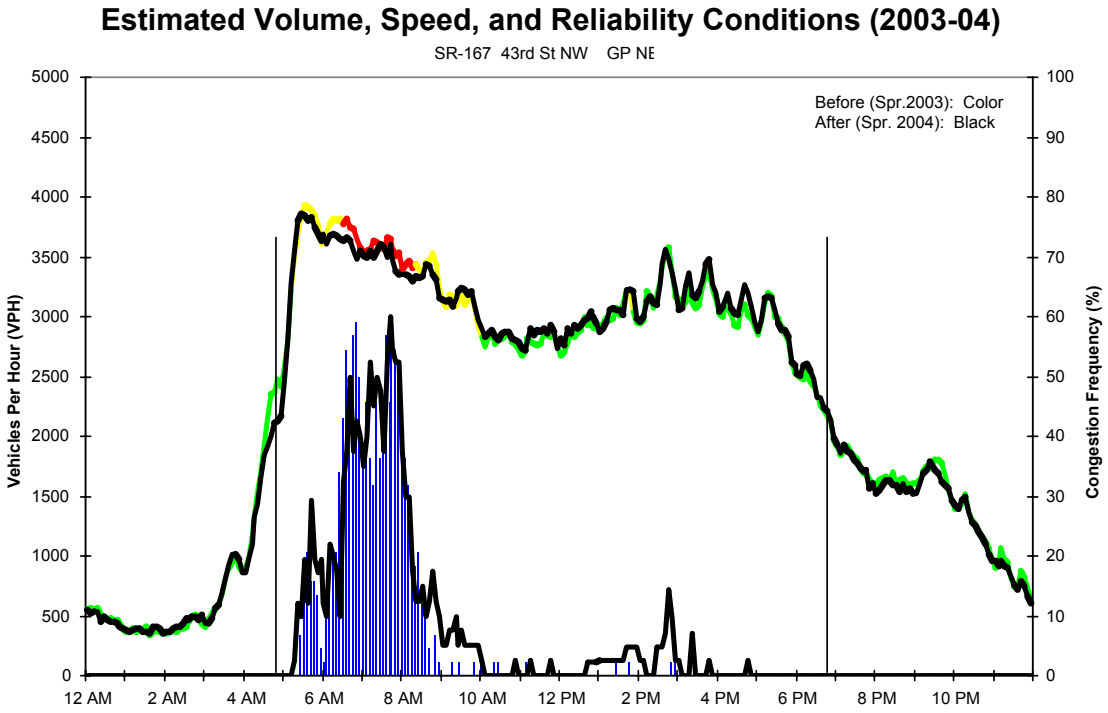

Figure 4.3. SR 167 NB near Auburn, GP

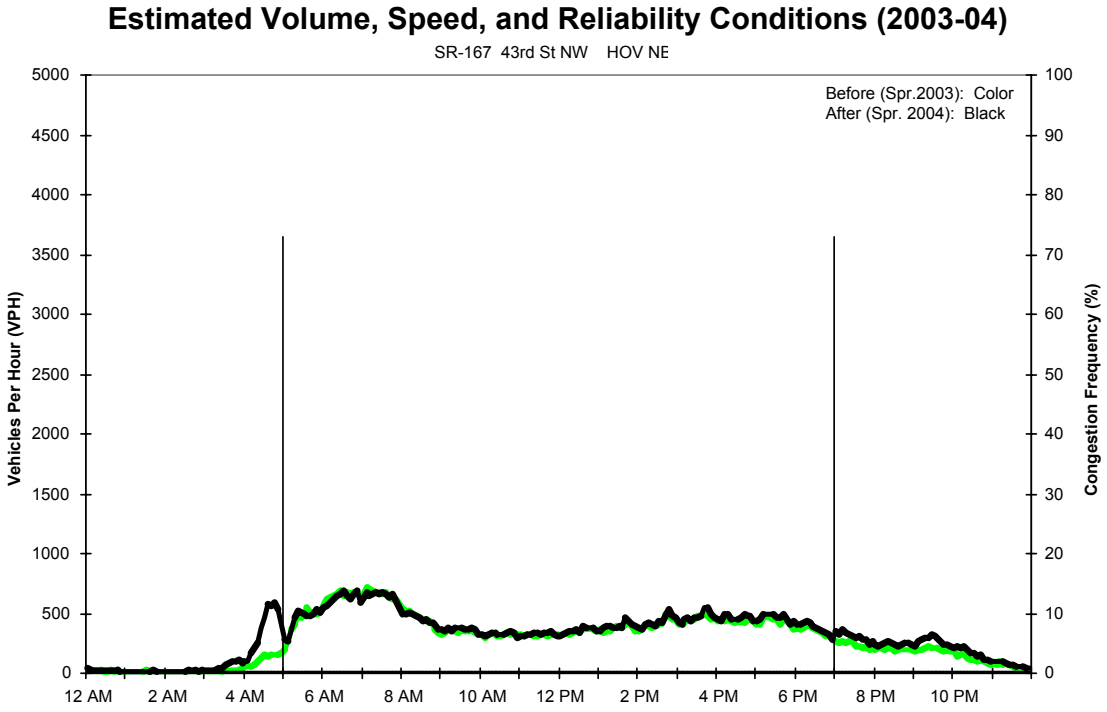

Figure 4.4. SR 167 NB near Auburn, HOV

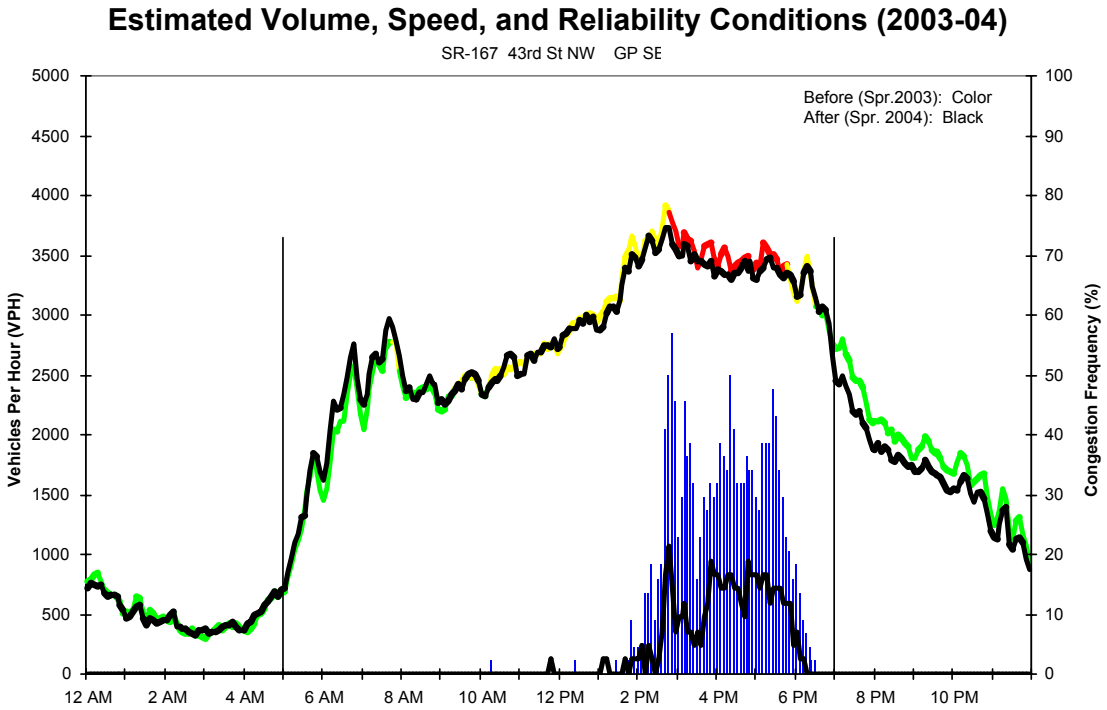

Figure 4.5. SR 167 SB near Auburn, GP

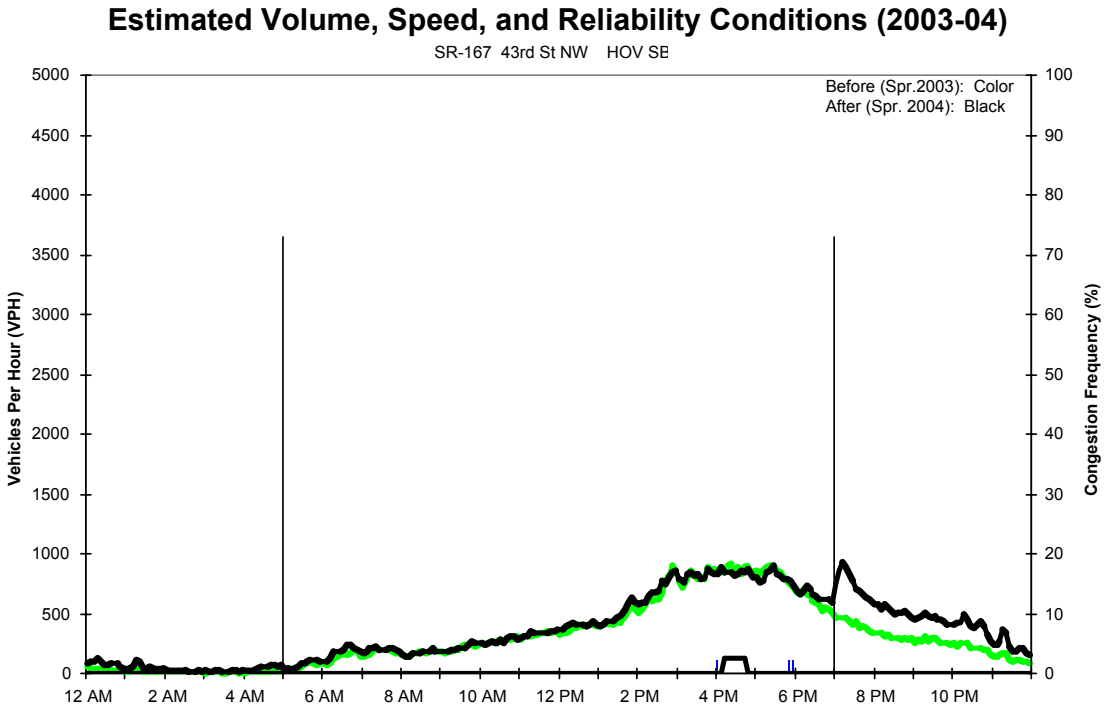

Figure 4.6. SR 167 SB near Auburn, HOV

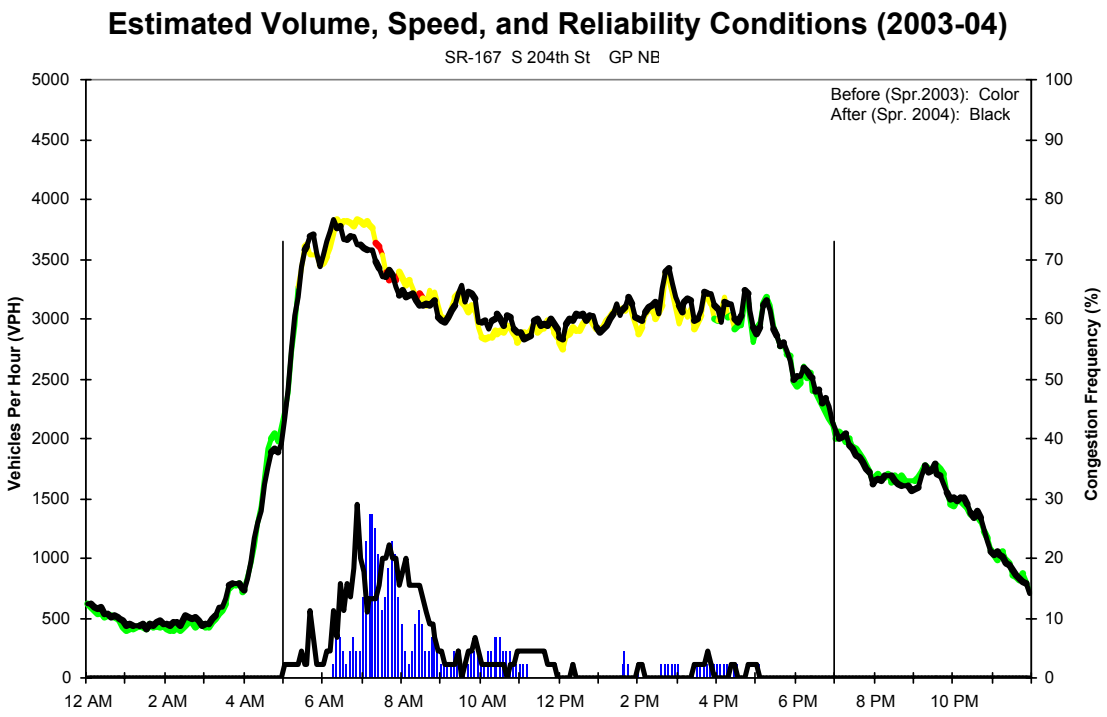

Figure 4.7. SR 167 NB near Renton, GP

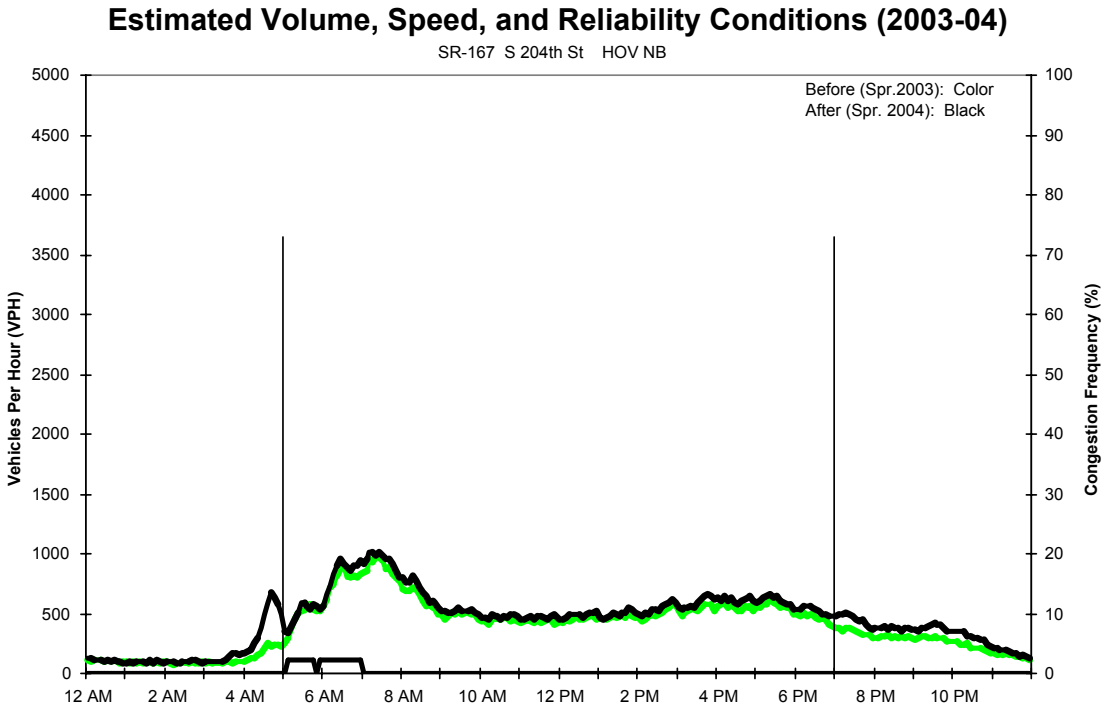

Figure 4.8. SR 167 NB near Renton, HOV

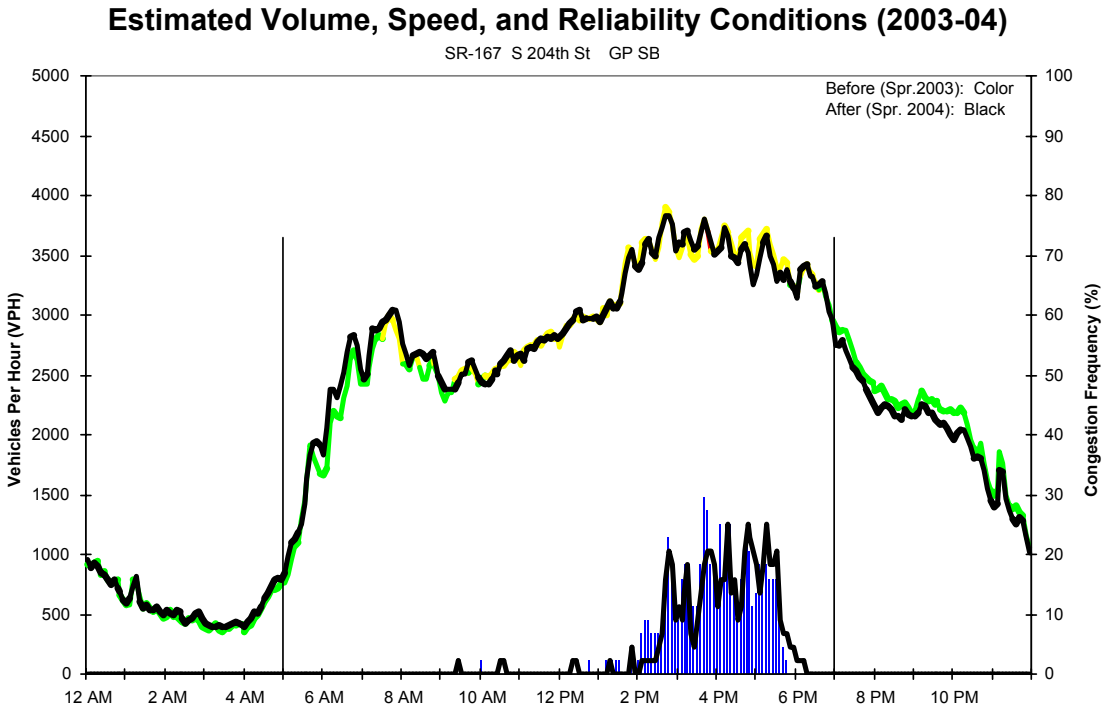

Figure 4.9. SR 167 SB near Renton, GP

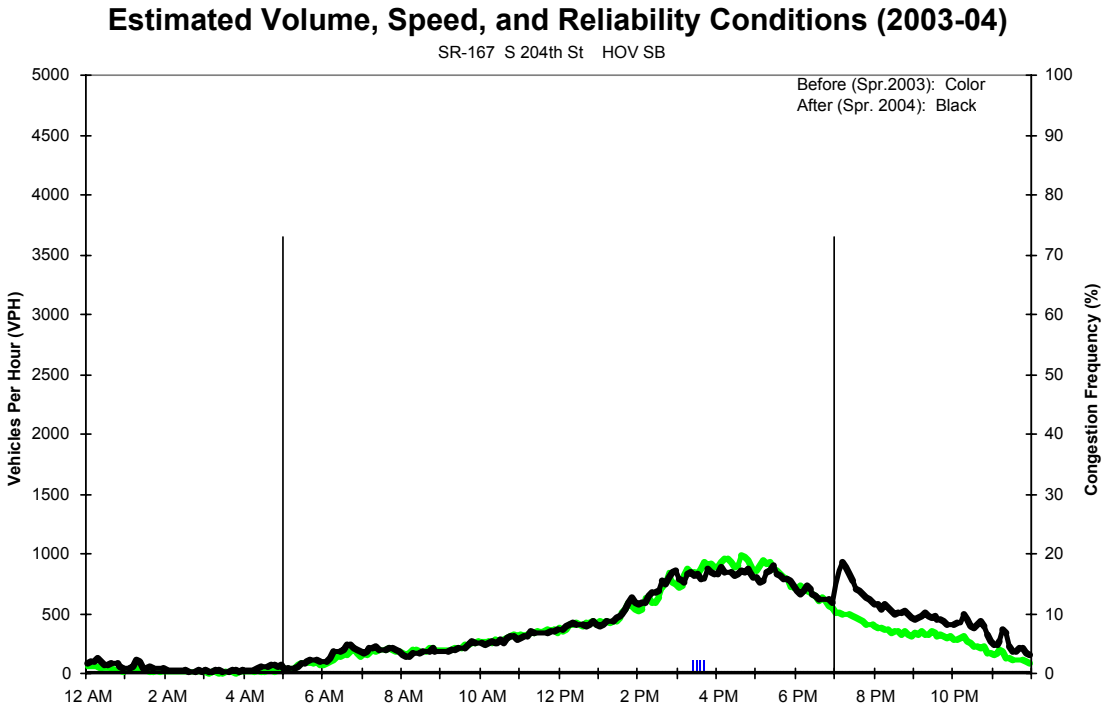

Figure 4.10. SR 167 SB near Renton, HOV

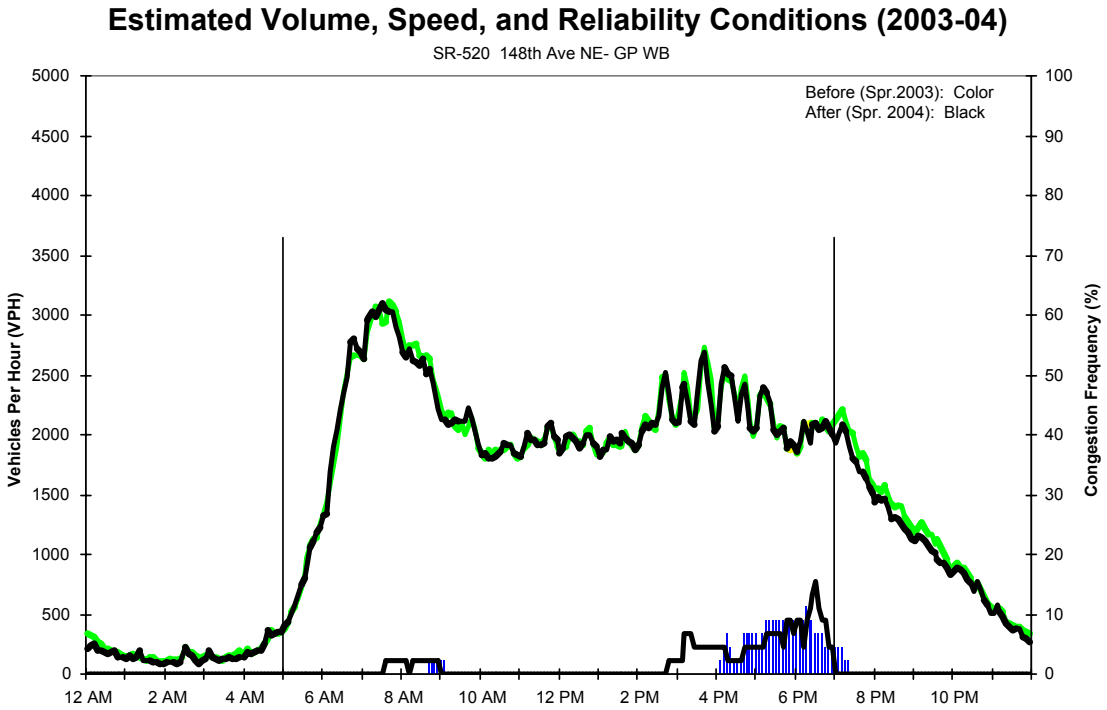

Figure 4.11. SR 520 WB near Redmond, GP

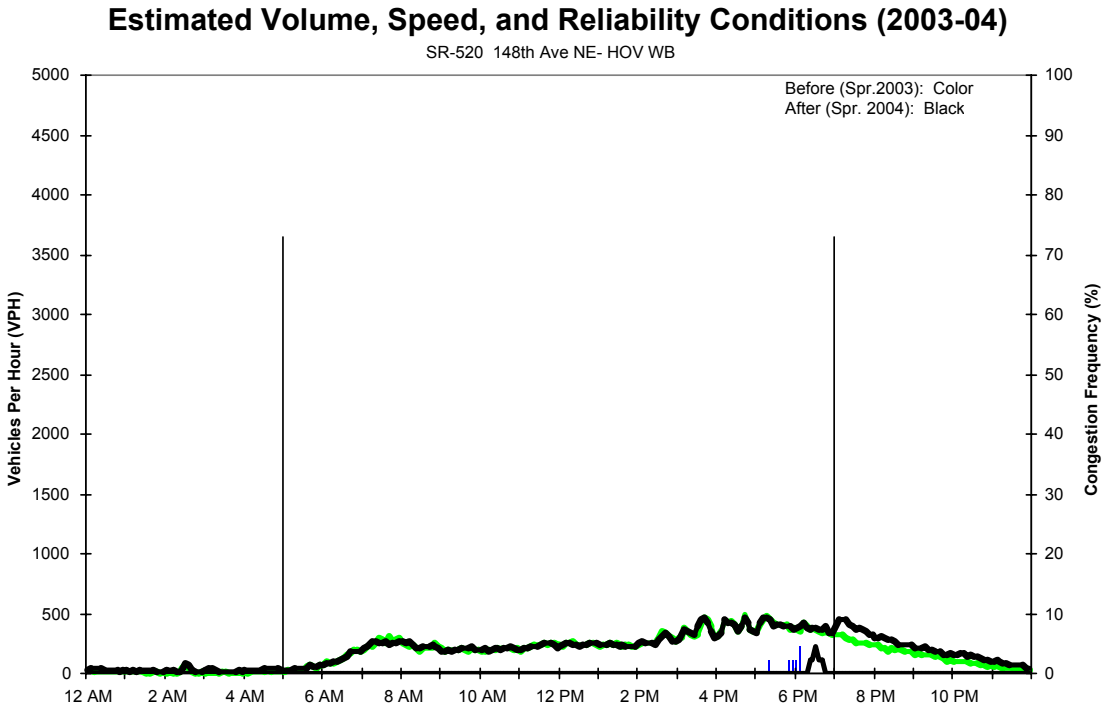

Figure 4.12. SR 520 WB near Redmond, HOV

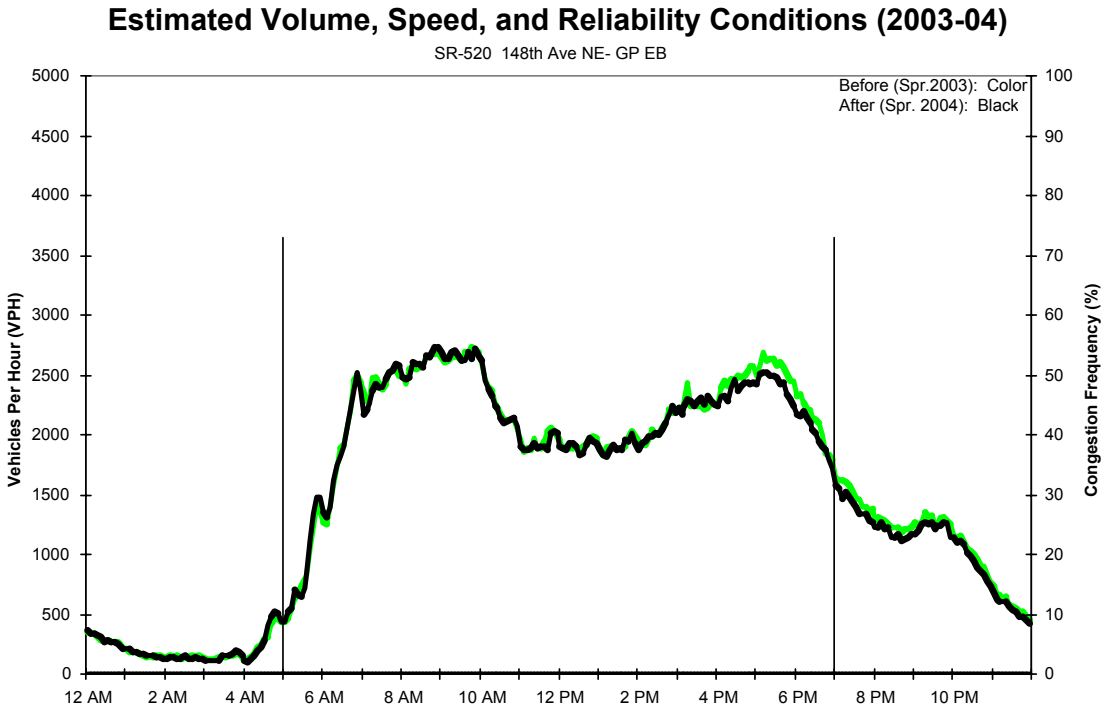

Figure 4.13. SR 520 EB near Redmond, GP

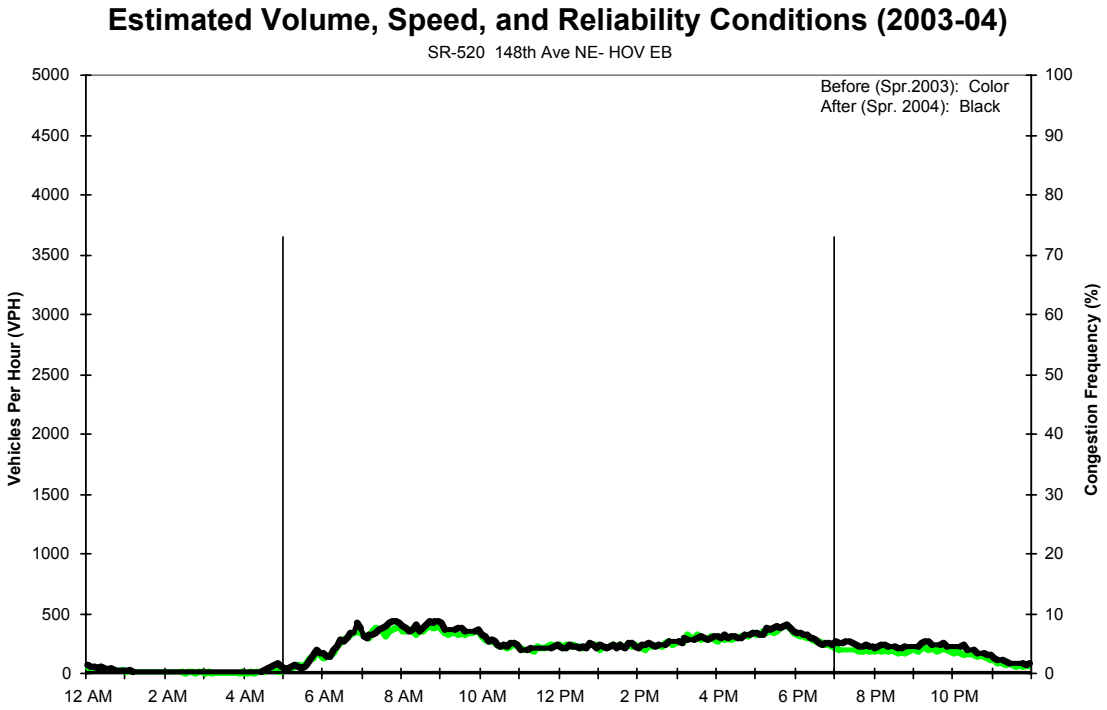

Figure 4.14. SR 520 EB near Redmond, HOV

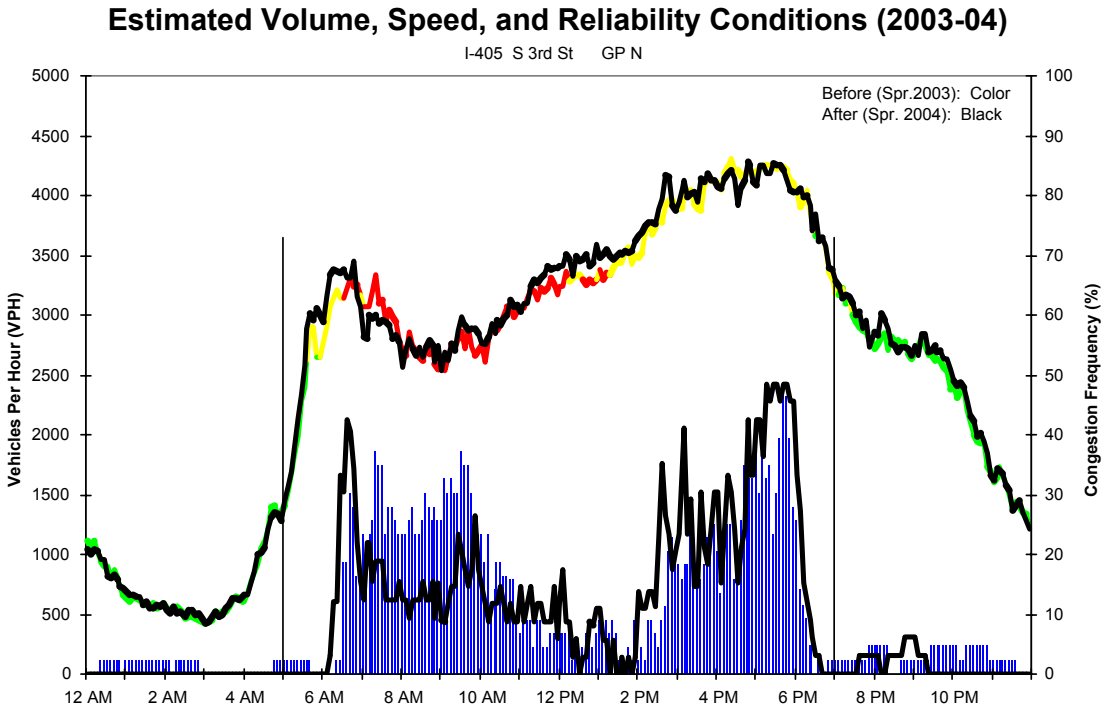

Figure 4.15. I-405 NB near Renton, GP

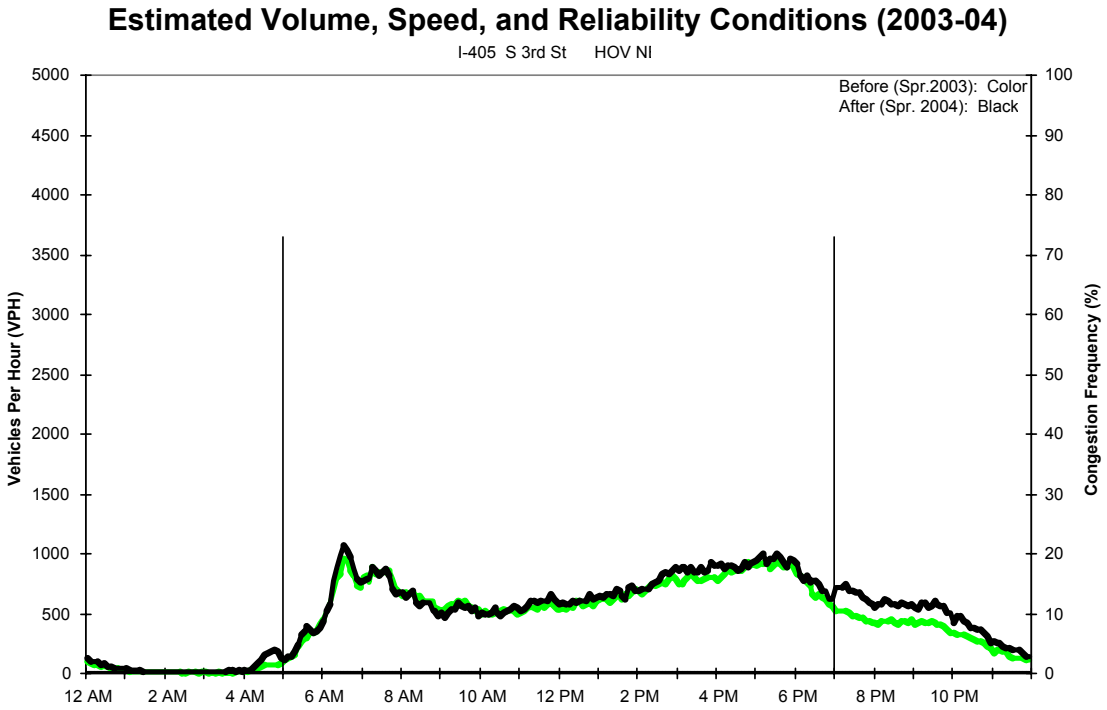

Figure 4.16. I-405 NB near Renton, HOV

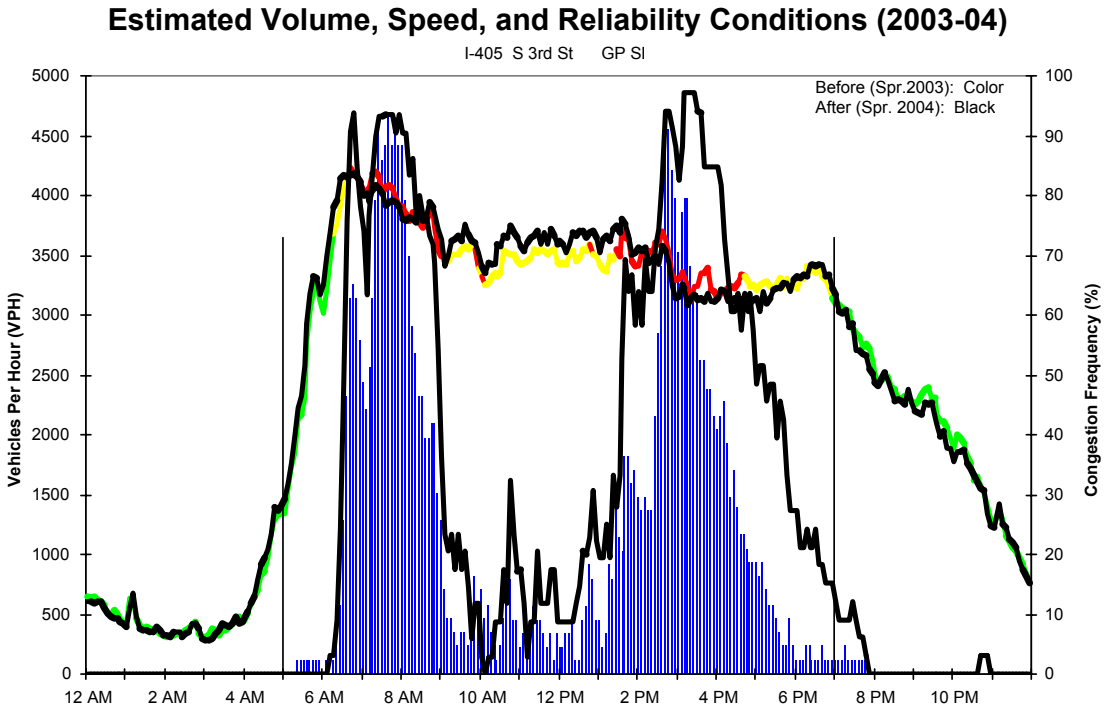

Figure 4.17. I-405 SB near Renton, GP

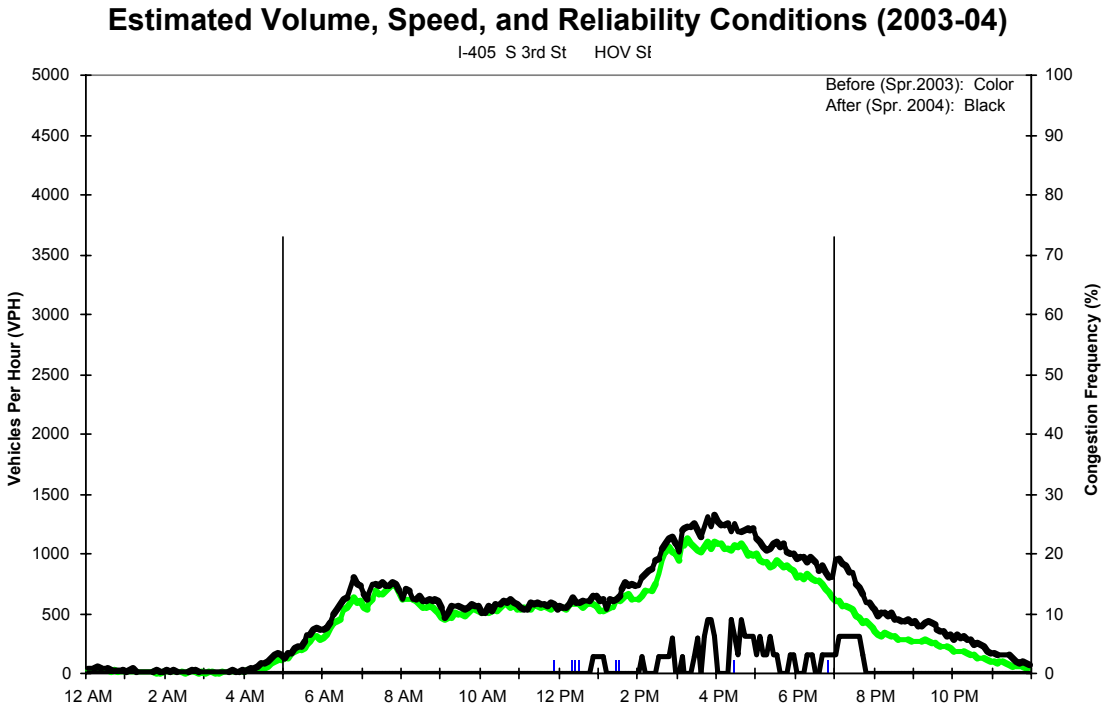

Figure 4.18. I-405 SB near Renton, HOV

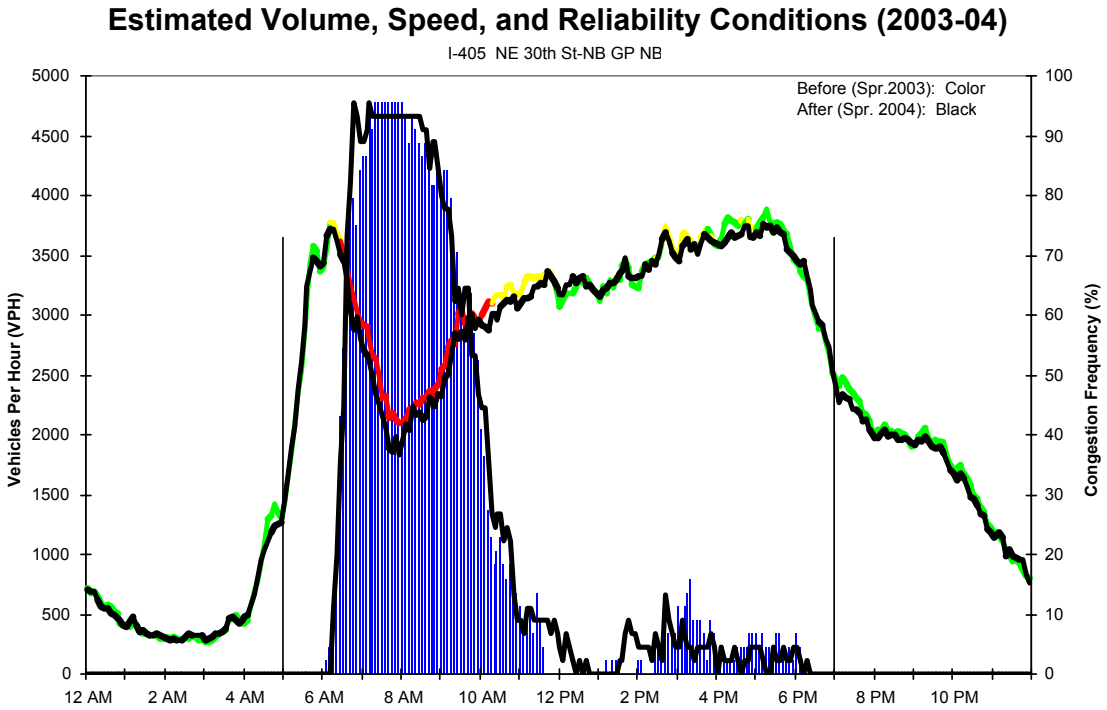

Figure 4.19. I-405 NB near Newcastle, GP

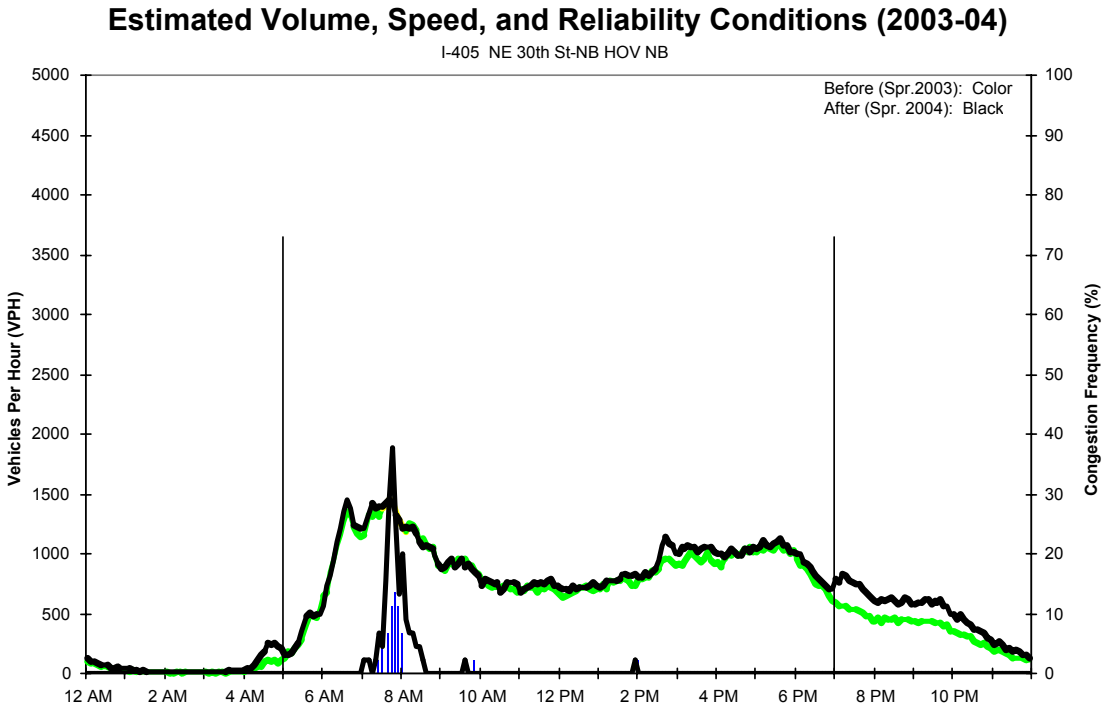

Figure 4.20. I-405 NB near Newcastle, HOV

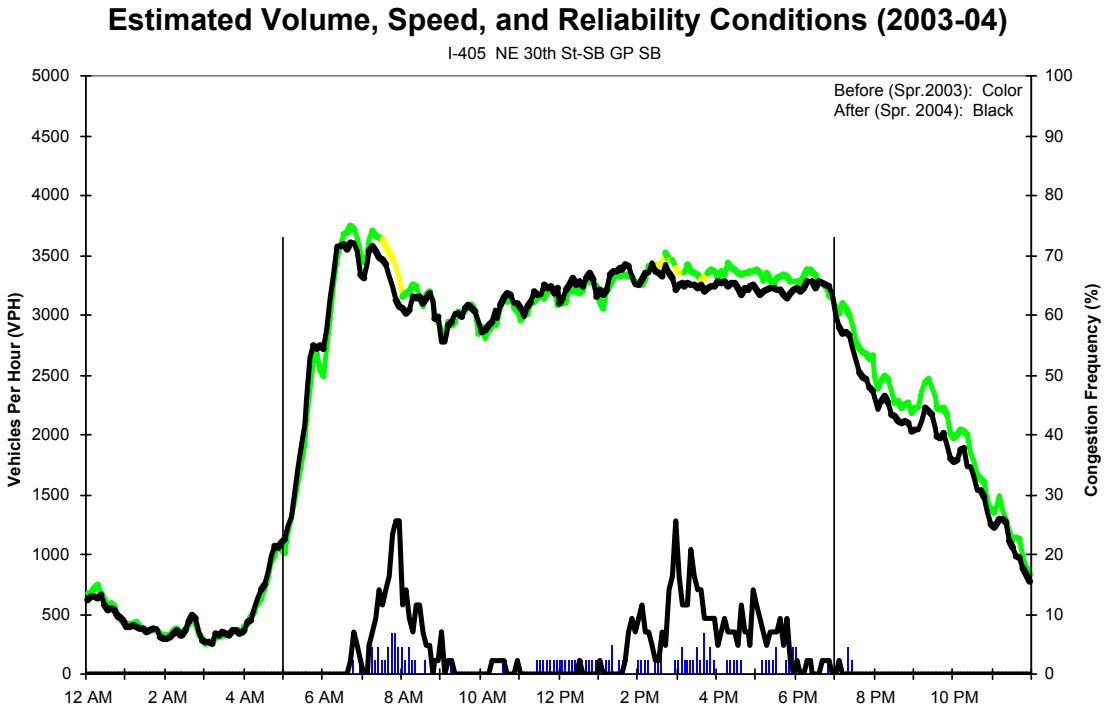

Figure 4.21. I-405 SB near Newcastle, GP

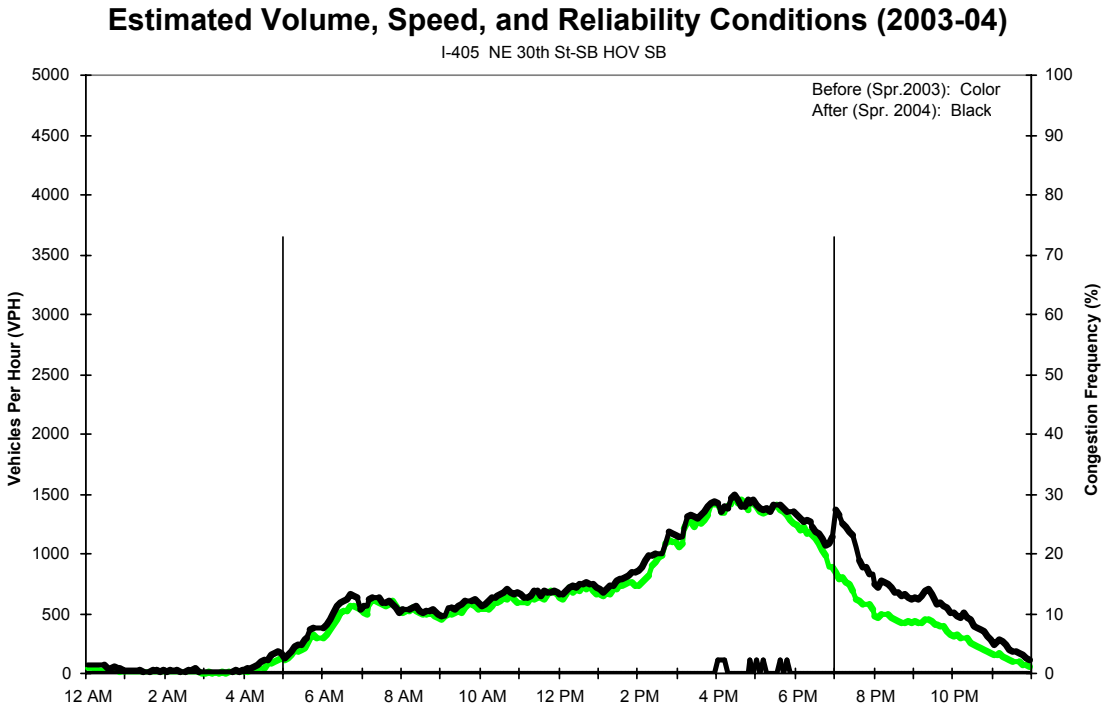

Figure 4.22. I-405 SB near Newcastle, HOV

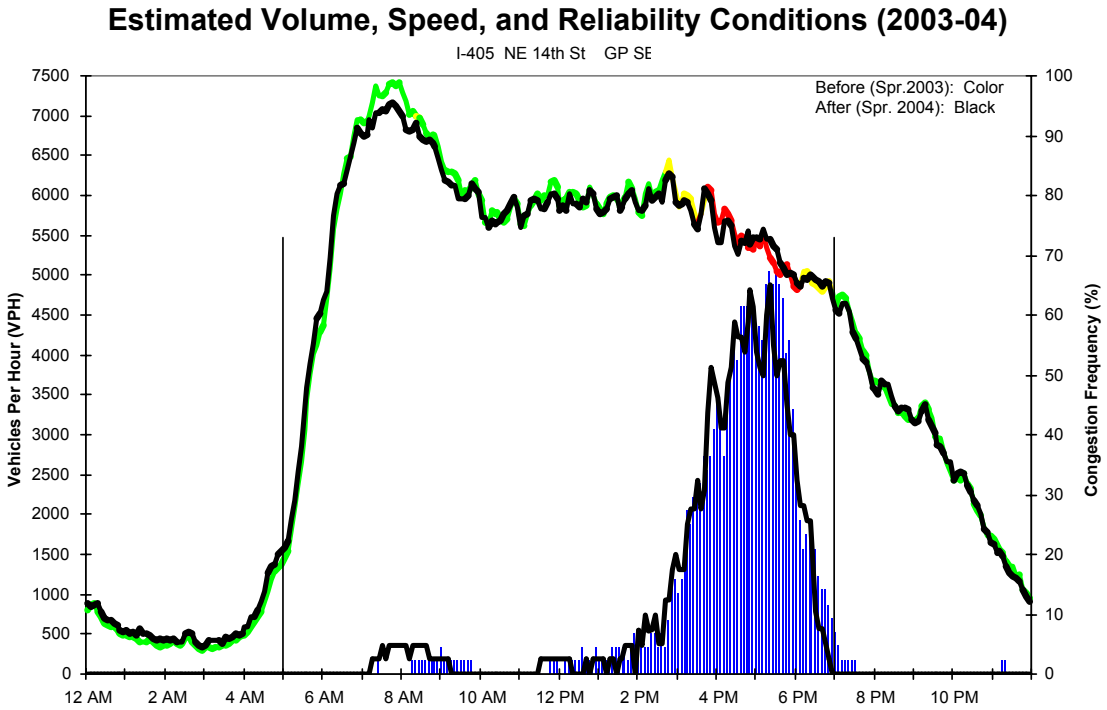

Figure 4.23. I-405 SB near Bellevue, GP

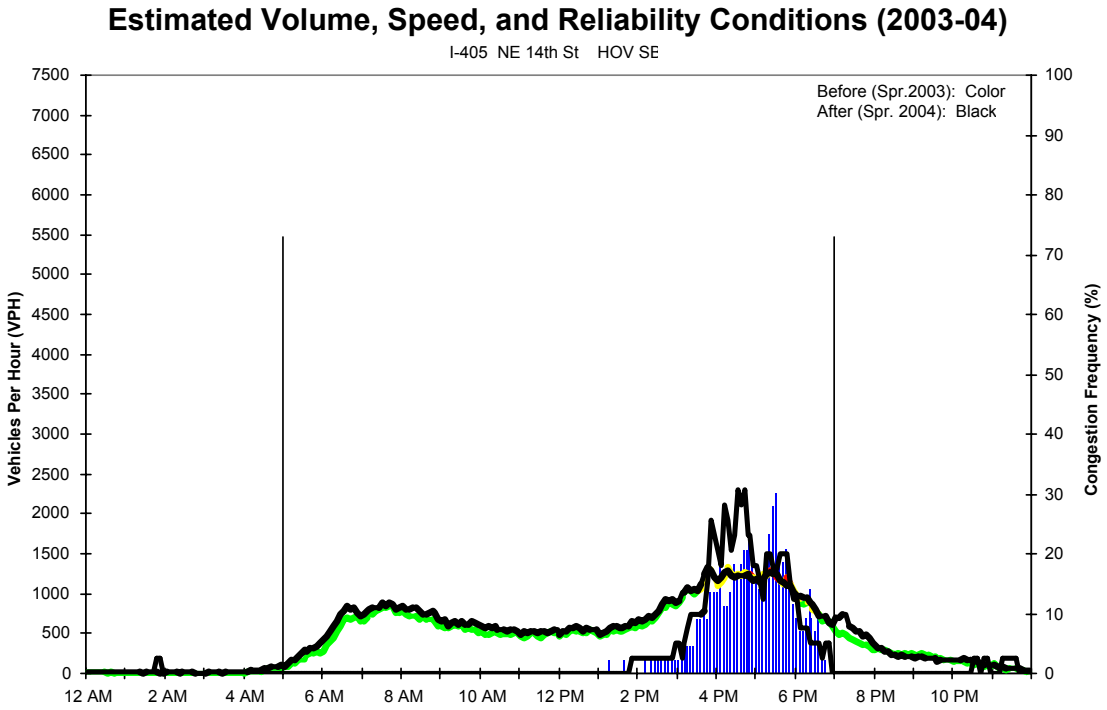

Figure 4.24. I-405 SB near Bellevue, HOV

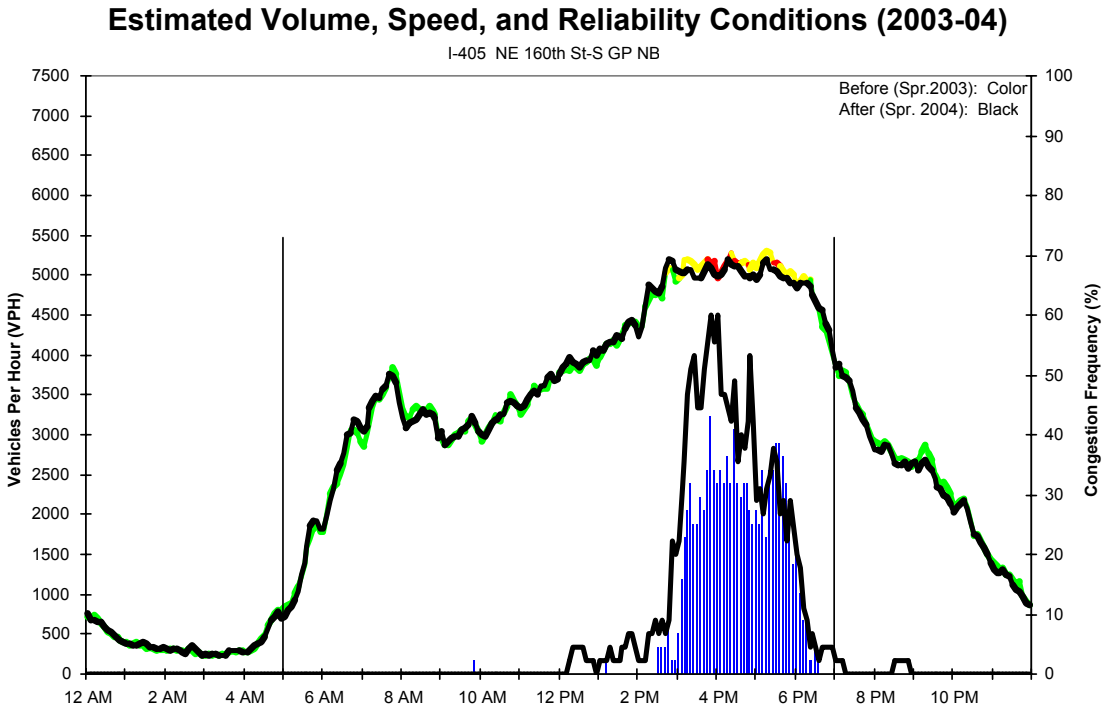

Figure 4.25. I-405 NB near Bothell, GP

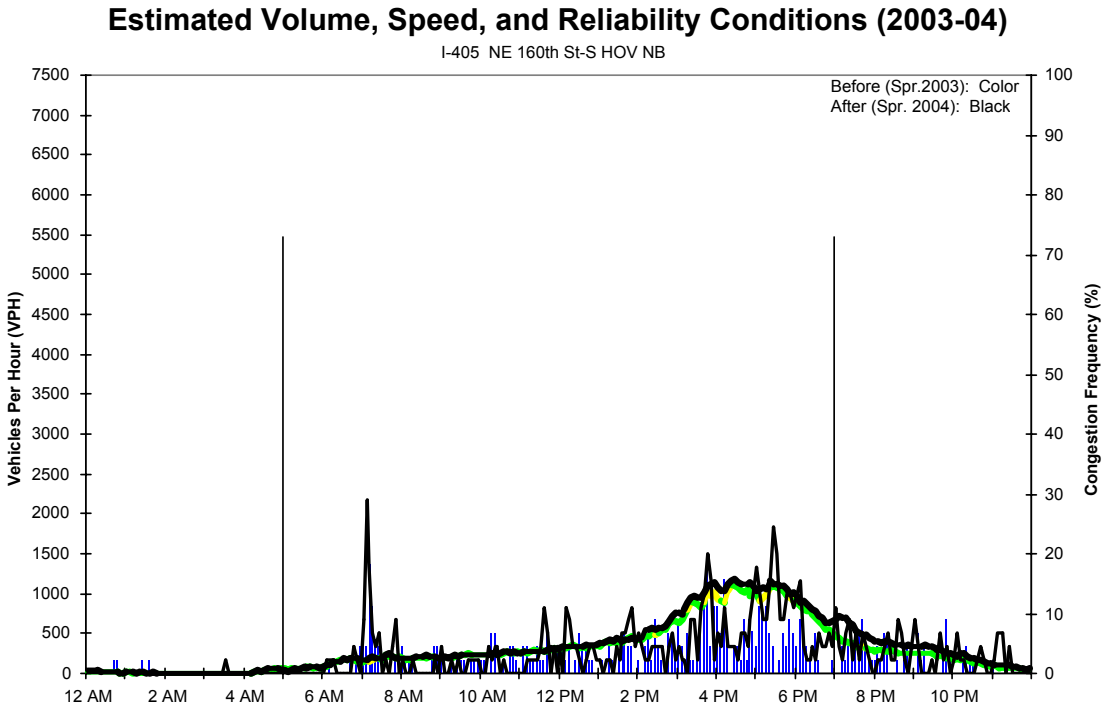

Figure 4.26. I-405 NB near Bothell, HOV

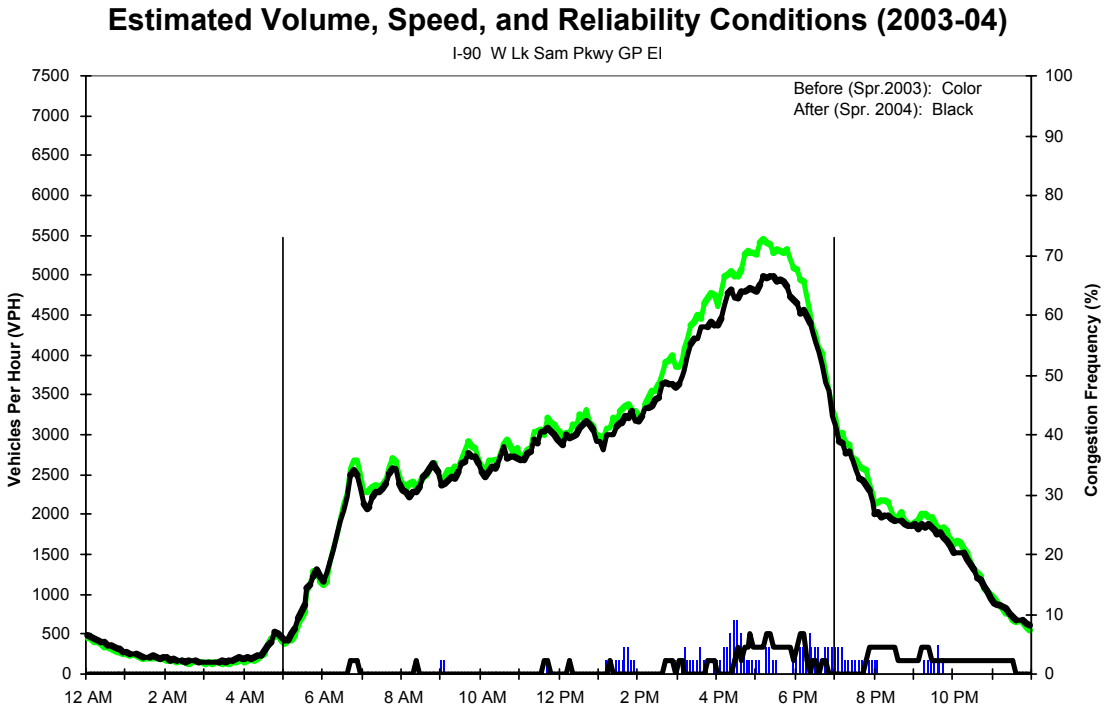

Figure 4.27. I-90 EB near Issaquah, GP

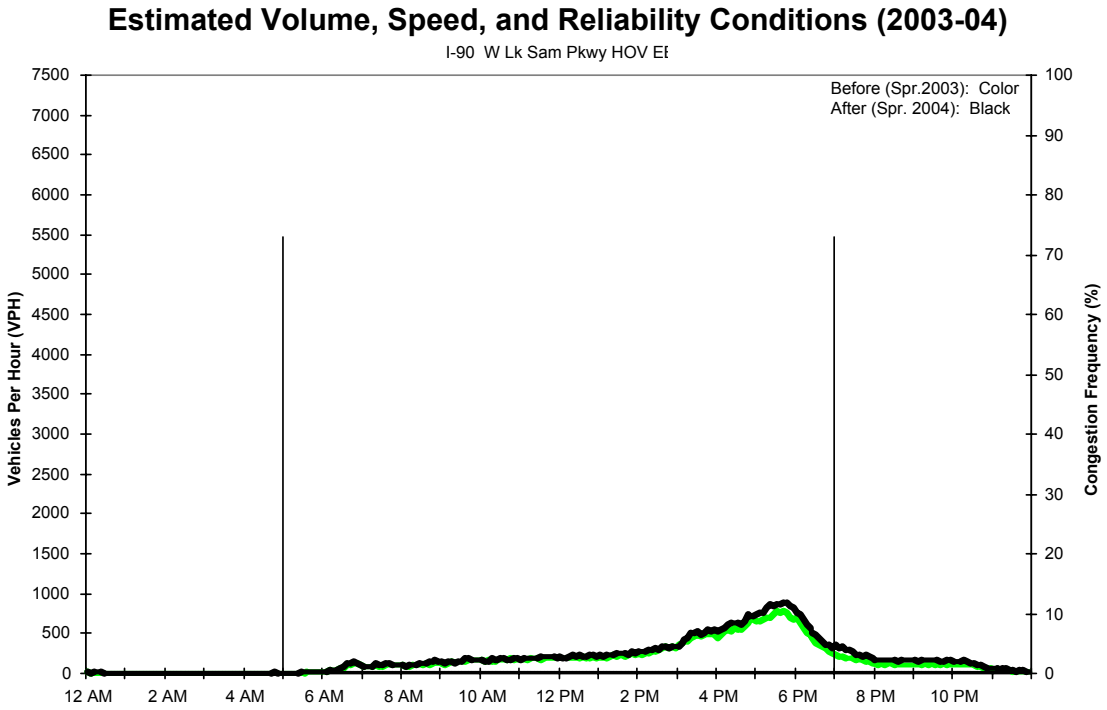

Figure 4.28. I-90 EB near Issaquah, HOV

7. Some changes in freeway performance were noted shortly after the 7:00 PM start of revised hours. There was a small increase in average speed in the GP lanes after 7:00 PM at most of the analyzed locations. There was little or no change in the average HOV lane speeds after 7:00 PM.

One potential benefit opening the HOV lane to all traffic in the evening was thought to be the ability to reduce the impact of congestion that had built up in the afternoon peak period and had not yet dissipated by 7:00 PM. The average performance profile graphs shown previously were inconclusive on this point; they showed that congestion frequently began to dissipate before 7:00 PM at the measurement locations, making it difficult to determine the potential effect of the HOV lane opening. Therefore, two additional methods were used to analyze the possibility that the opening of the HOV lane to general traffic might affect overall traffic performance.

First, performance profile graphs were prepared for specific days (rather than the previous yearly averages) when significant congestion persisted shortly before 7:00 PM. On those days, the pattern of volumes showed that the HOV volume usually increased at 7:00 PM, along with a decrease in GP volume and congestion. However, it was not clear from these data alone that the former contributed to the latter.

For example, an analysis of differences in the dissipation of congestion was performed at locations on SR 167 and on I-405, for selected days before and after the start of the new hours of operation that showed congestion during the PM peak period around 7:00 PM (see figures 4.29 through 4.35). At a location on SR 167 (southbound at S. 204th Street near Renton), performance profiles were produced for May 8 and 29, 2003 ("before") and May 19 and 25, 2004 ("after"). Results showed that on the "before" days, both GP and HOV volumes were already trending downward before 7:00 PM. Shortly after 7:00 PM, some intermittent and slight slowing dissipated after another 30 minutes or so. After one year of the new operating hours, the two days analyzed both show a significant increase in HOV volumes at 7:00 PM; on May 25th, HOV volumes increased over 60 percent, while on May 19th, volumes increased over 120 percent. In

the GP lanes, slight to moderate slowing led up to 7:00 PM, followed by a quick dissipation of the slow condition shortly after 7:00 PM.

At a location on I-405 (southbound at NE 30th in Newcastle), profiles were produced for May 8, 2003 ("before"), and May 25 and 27, 2004 ("after"). Results showed that on the "before" day, slowing occurred briefly after 7:00 PM, but the location was generally uncongested throughout the day. After implementation of the new hours, both days showed a sharp spike in HOV volumes, and any congestion in the GP lanes dissipated by 7:30 PM or so. In the case of May 25th, there was slight to moderate congestion leading up to 7:00 PM.

While these examples are consistent with the possibility that the revised hours of operation could have some effect on congestion dissipation by opening up the HOV lane to all vehicles, the extent to which general access to the HOV lane promotes this dissipation at 7:00 PM could not be determined from these profile graphs alone, especially because dissipation normally occurred at about the same time even before the start of the new policy in 2003.

A second analysis based on the distribution of 5-minute sample speeds at 7:00 PM produced some indication of changes in performance. Weekday speeds were estimated at 5-minute increments during the 15-minute periods just before and after 7:00 PM for a two-month period in 2003 and 2004 (i.e., before and after the start of the pilot program). The intent was to detect a shift in the distribution of 5-minute speeds at 7:00 PM that could be related to the revised hours of operation. Table 4.9 summarizes the results for both GP and HOV lanes. They show that approaching 7:00 PM, GP speeds at almost all locations were usually operating near the speed limit (50 to 60 mph). GP speed distributions after 7:00 PM were then skewed even more strongly toward the speed limit. Figures 4.36 through 4.39 (based on 2004 GP data) show the shift in speed distribution for the locations with the biggest increases in the 50-60 mph category after 7:00 PM.

The 2004 patterns were then compared with the corresponding 2003 results in an effort to determine whether the patterns changed since the start of the pilot program. Table 4.10 summarizes the magnitude and direction of the change in speeds in a comparison of the speed distributions after 7:00 PM to those before 7:00 PM. While the speed shifts in 2003 and 2004 were generally similar, there are some indications of differences in the patterns of 2003 (before the start of the pilot program) versus 2004 (after the start). Note that the magnitude of the shifts in the GP lanes in 2004 was somewhat higher than the shift detected during the same periods in 2003 before the revised hours were implemented; this suggests the possibility that the change in GP speeds after 7:00 PM that was observed in 2004 is more than what would normally occur at that time of day as traffic becomes lighter. These changes could be attributed to the revised hours of operation.

In the HOV lane, changes were less noticeable, in part because most HOV facilities were operating at or near the speed limit even before 7:00 PM. Most HOV locations did not experience noticeable upward shifts in speed distribution in 2004, though in 2003, a small shift was noticeable at several locations.

While these data suggest that there was an upward shift in GP speeds after 7:00 PM beyond the shift that might be expected at that time of day, the magnitudes of the shift were not large and reflect a change from a base level that was already high. Note that the previous examples shown in figures 4.36 through 4.39 highlighted only the locations with the largest estimated shifts toward higher speeds. For all the locations analyzed, the percentage point shift in the 50-60 mph category ranged from –0.7 to 7.7 percent, meaning that in the highest instance, the facility was operating near the speed limit about 100 percent of the time after 7:00 PM, compared to 92 percent of the time before 7:00 PM. Another way to evaluate the significance of the changes indicated in Table 4.10 is to note that a 2 percent increase in the 50-60 mph category corresponds to

about one additional weekday of near-speed limit conditions after 7:00 PM every two months, based on the sample used in this analysis.

Note that a similar result can be seen if the change in speeds at 7:00 PM is analyzed in terms of average speed (see Table 4.11). Average GP speeds increased by 1 to 3 mph at most locations, while average HOV speeds usually did not change after 7:00 PM (from a base level that was already at the speed limit in most cases). As with the speed distribution results, any changes in the average speed after 7:00 PM were small, especially given the corresponding changes during the 2003 "before" period.

Overall, these results suggest that GP lane users experienced a slight increase in overall speeds after 7:00 PM at most of the locations analyzed, while HOV lane users experienced little or no change in conditions. While the magnitudes of these speed changes were not large, recall that there were noticeable, sometimes significant, increases in HOV lane volumes just after 7:00 PM. This suggests that at least at some locations, many travelers perceived a benefit from moving to the HOV lane.

These results also suggest that at the volumes measured, the presence of SOVs in the HOV lane did not degrade performance in that lane. This is potentially significant, because if SOV traffic in the HOV lane adversely affects HOV speed and reliability, this might be a disincentive to form HOVs. To analyze this further, changes in observed HOV counts, as measured by the estimated number of HOVs in all lanes, were computed for 2003 versus 2004 on SR 167 southbound. While data are still tentative, they suggest that for corridors such as SR 167 that have frequent evening GP congestion (a condition that would tend to encourage SOV use of the HOV lane), the pattern of HOV volumes in 2004 was similar to that in 2003 (before the pilot program). Table 4.12 shows the HOV count across all lanes before and after 7:00 PM, in both 2003 and 2004, for southbound SR 167 in Renton and Auburn. It shows that HOV volumes have increased since 2003. HOV formation trends will continue to be tracked during the second year of the pilot program.

As part of the analyses of performance changes, two locations on I-5 (where the revised hours of HOV lane operation are not in effect) were also monitored as control sites to evaluate any performance changes that might have occurred on the freeway network during the 2003-2004 period, independent of the revised hours of operation. At those two sites, there was generally little or no change in performance from 2003 to 2004 at the transition times of approximately 5:00 AM and 7:00 PM (see figures 4.40-4.47). In particular, performance changes that were observed at other locations that are subject to the revised hours of operation (e.g., the noticeable volume increase in the HOV lane shortly after 7 PM) were not evident at these control sites. This suggests that such performance changes were more likely to be related to the revised hours of operation, and less likely to be the result of year-to-year changes that would have occurred anyway, regardless of the policy. The control sites will continue to be monitored during the second year of the pilot program.

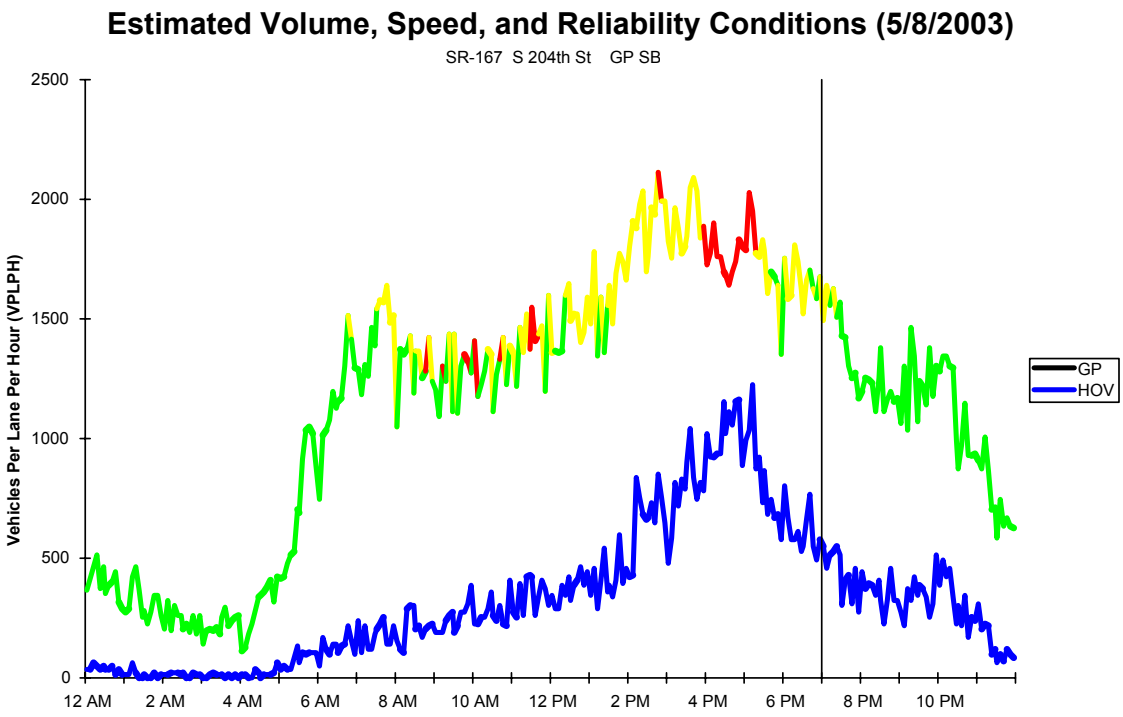

Figure 4.29. Performance Profile on SR 167 (May 8, 2003)

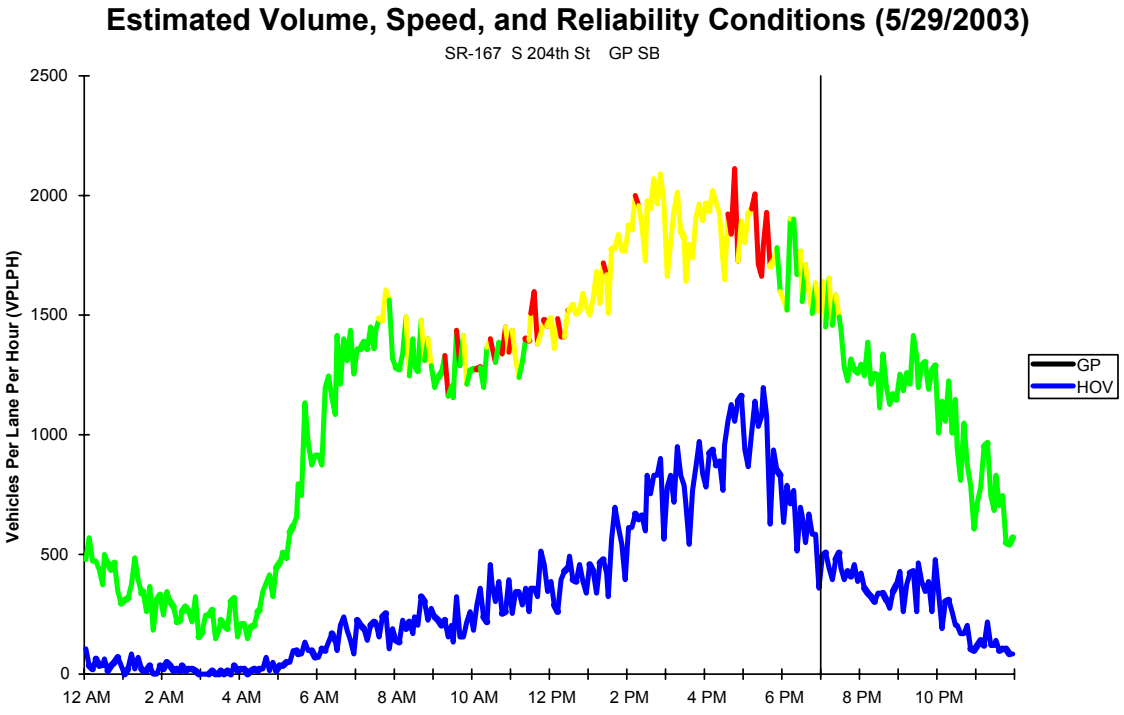

Figure 4.30. Performance Profile on SR 167 (May 29, 2003)

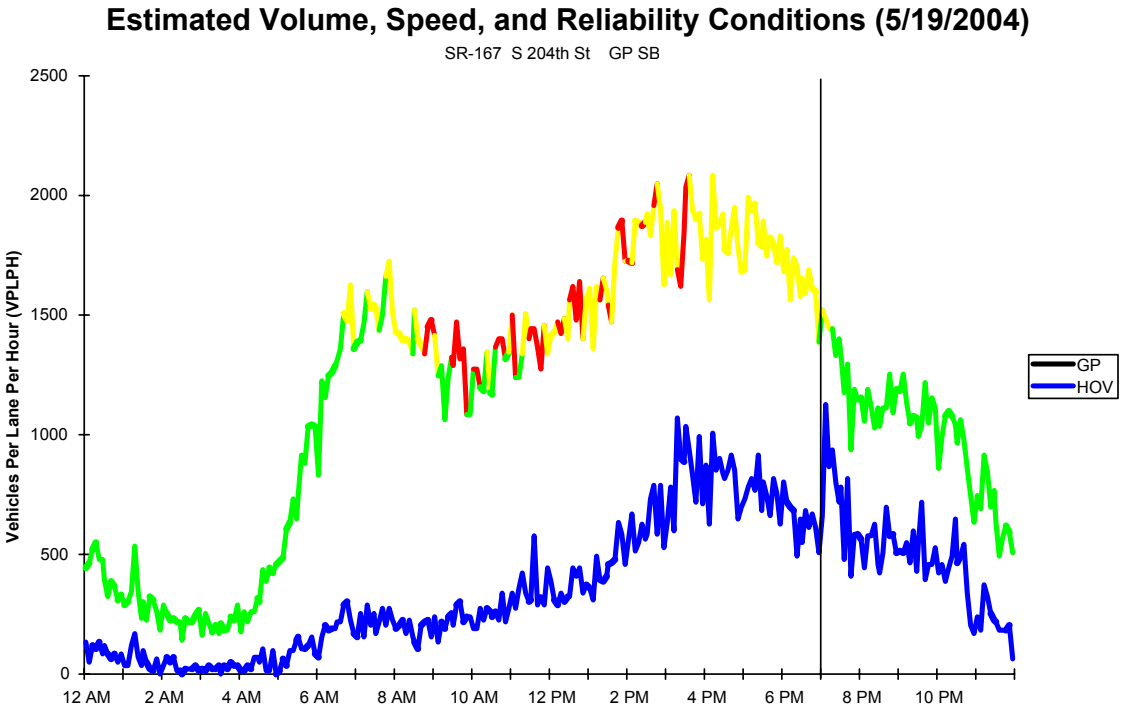

Figure 4.31. Performance Profile on SR 167 (May 19, 2004)

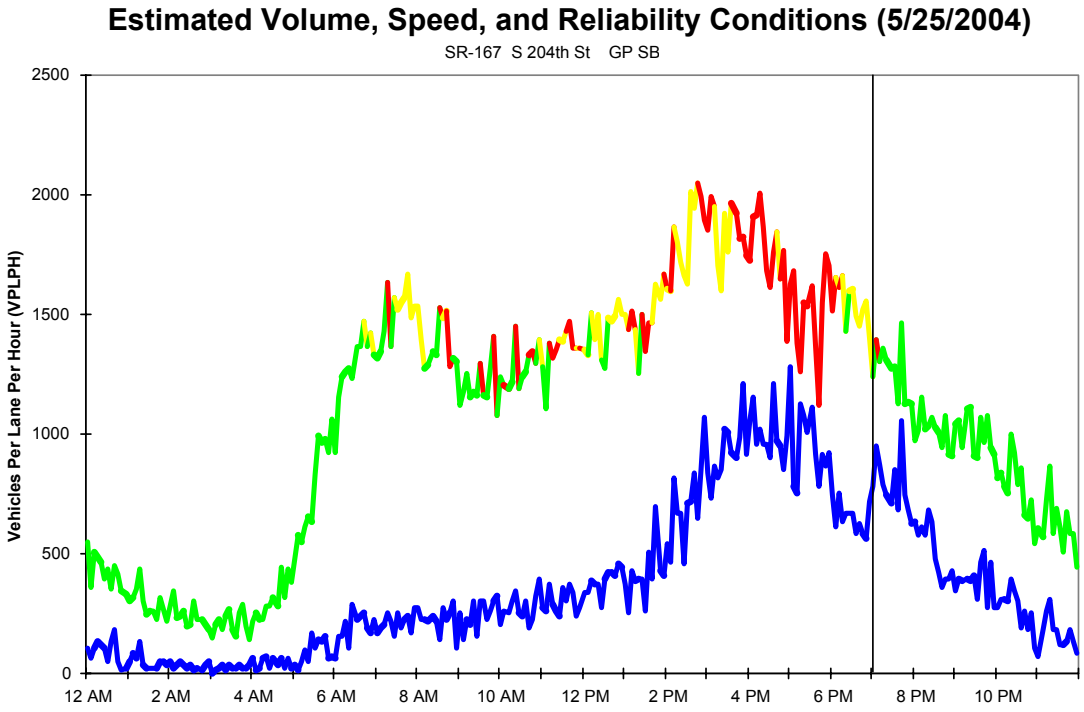

Figure 4.32. Performance Profile on SR 167 (May 25, 2004)

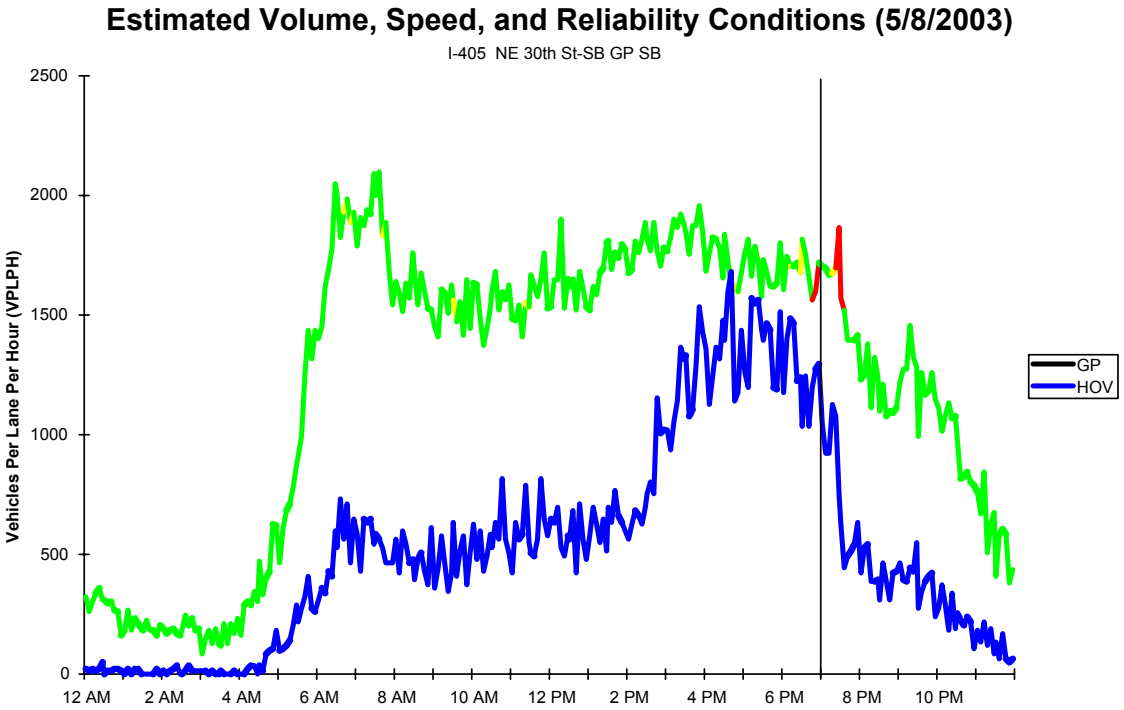

Figure 4.33. Performance Profile on I-405 (May 8, 2003)

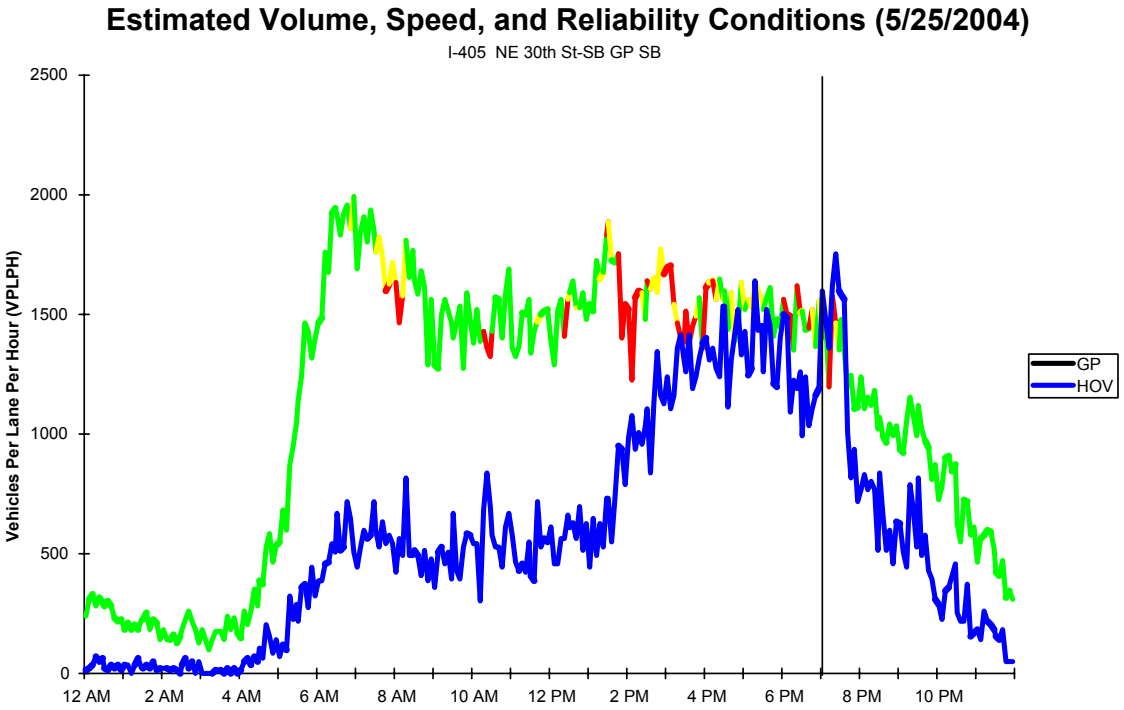

Figure 4.34. Performance Profile on I-405 (May 25, 2004)

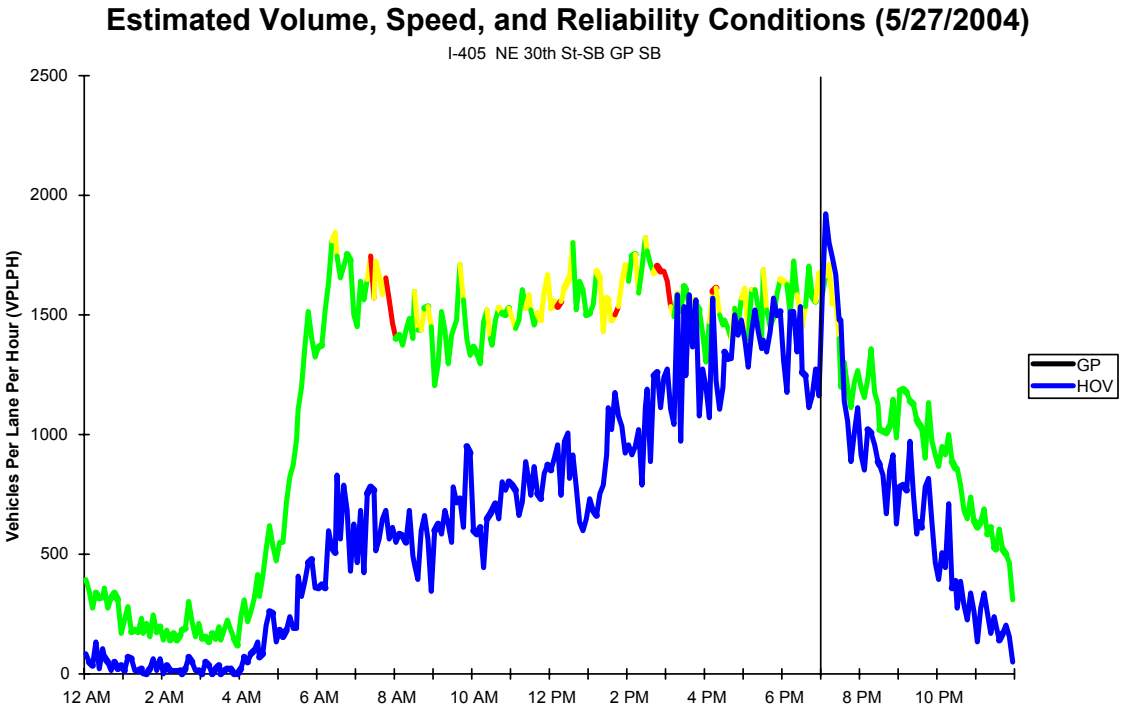

Figure 4.35. Performance Profile on I-405 (May 27, 2004)

Table 4.9. Distribution of Average 5-Minute Speeds Before/After 7:00 PM in GP and HOV Lanes (2003 and 2004).

Spring 2004 (one yr of pilot program)			GP Speed Distribution											
			6:45-7:00 PM						7:00-7:15 PM					
Corridor	Location	Dir.	50-60	40-50	30-40	20-30	20 or less	mph	50-60	40-50	30-40	20-30	20 or less	mph
I-405	NE 160th, Bothell	N	93%	1%	3%	1%	1%		96%	1%	0%	1%	1%	
I-405	NE 30th St, Newcastle	N	100%	0%	0%	0%	0%		100%	0%	0%	0%	0%	
I-405	Cedar Ave, Renton	N	95%	5%	0%	0%	0%		98%	2%	0%	0%	0%	
I-405	NE 12th St, Bellevue	S	92%	1%	3%	4%	0%		100%	0%	0%	0%	0%	
I-405	NE 30th St, Newcastle	S	91%	7%	1%	1%	1%		93%	6%	1%	0%	0%	
I-405	Cedar Ave, Renton	S	74%	11%	2%	9%	4%		79%	11%	1%	2%	7%	
I-90	Newport Way, Issaquah	E	98%	0%	0%	2%	0%		97%	1%	1%	1%	0%	
SR 167	S 208th St, Renton	N	100%	0%	0%	0%	0%		100%	0%	0%	0%	0%	
SR 167	37th St. NW, Auburn	N	100%	0%	0%	0%	0%		100%	0%	0%	0%	0%	
SR 167	S 208th St, Renton	S	88%	11%	1%	0%	0%		94%	6%	0%	0%	0%	
SR 167	37th St. NW, Auburn	S	95%	4%	1%	0%	0%		99%	1%	0%	0%	0%	
SR 520	NE 148th, Redmond	E	100%	0%	0%	0%	0%		100%	0%	0%	0%	0%	
SR 520	NE 148th, Redmond	W	93%	0%	1%	1%	6%		100%	0%	0%	0%	0%	

Spring 2003 (before revised hours)			GP Speed Distribution											
			6:45-7:00 PM						7:00-7:15 PM					
Corridor	Location	Dir.	50-60	40-50	30-40	20-30	20 or less		50-60	40-50	30-40	20-30	20 or less	
I-405	NE 160th, Bothell	N	99%	1%	1%	0%	0%		100%	0%	0%	0%	0%	
I-405	NE 30th St, Newcastle	N	100%	0%	0%	0%	0%		100%	0%	0%	0%	0%	
I-405	Cedar Ave, Renton	N	93%	5%	0%	0%	2%		95%	3%	0%	0%	2%	
I-405	NE 12th St, Bellevue	S	87%	1%	1%	3%	8%		94%	1%	1%	2%	2%	
I-405	NE 30th St, Newcastle	S	95%	3%	1%	1%	0%		96%	4%	0%	0%	0%	
I-405	Cedar Ave, Renton	S	89%	6%	0%	2%	3%		93%	2%	0%	2%	2%	
I-90	Newport Way, Issaquah	E	96%	0%	0%	0%	4%		95%	0%	0%	1%	4%	
SR 167	S 208th St, Renton	N	100%	0%	0%	0%	0%		100%	0%	0%	0%	0%	
SR 167	37th St. NW, Auburn	N	100%	0%	0%	0%	0%		100%	0%	0%	0%	0%	
SR 167	S 208th St, Renton	S	98%	2%	0%	0%	0%		100%	0%	0%	0%	0%	
SR 167	37th St. NW, Auburn	S	96%	4%	0%	0%	0%		100%	0%	0%	0%	0%	
SR 520	NE 148th, Redmond	E	100%	0%	0%	0%	0%		100%	0%	0%	0%	0%	
SR 520	NE 148th, Redmond	W	96%	0%	0%	0%	4%		96%	0%	0%	1%	4%	

Spring 2004 (one yr of pilot program)			HOV Speed Distribution											
			6:45-7:00 PM						7:00-7:15 PM					
Corridor	Location	Dir.	50-60	40-50	30-40	20-30	20 or less	mph	50-60	40-50	30-40	20-30	20 or less	mph
I-405	NE 160th, Bothell	N	93%	0%	1%	1%	5%		92%	1%	0%	2%	5%	
I-405	NE 30th St, Newcastle	N	100%	0%	0%	0%	0%		100%	0%	0%	0%	0%	
I-405	Cedar Ave, Renton	N	100%	0%	0%	0%	0%		100%	0%	0%	0%	0%	
I-405	NE 12th St, Bellevue	S	96%	0%	1%	0%	3%		100%	0%	0%	0%	0%	
I-405	NE 30th St, Newcastle	S	99%	0%	0%	1%	0%		100%	0%	0%	0%	0%	
I-405	Cedar Ave, Renton	S	95%	2%	0%	3%	0%		91%	3%	1%	4%	1%	
I-90	Newport Way, Issaquah	E	100%	0%	0%	0%	0%		100%	0%	0%	0%	0%	
SR 167	S 208th St, Renton	N	100%	0%	0%	0%	0%		100%	0%	0%	0%	0%	
SR 167	37th St. NW, Auburn	N	100%	0%	0%	0%	0%		100%	0%	0%	0%	0%	
SR 167	S 208th St, Renton	S	100%	0%	0%	0%	0%		100%	0%	0%	0%	0%	
SR 167	37th St. NW, Auburn	S	100%	0%	0%	0%	0%		100%	0%	0%	0%	0%	
SR 520	NE 148th, Redmond	E	100%	0%	0%	0%	0%		100%	0%	0%	0%	0%	
SR 520	NE 148th, Redmond	W	100%	0%	0%	0%	0%		100%	0%	0%	0%	0%	

Spring 2003 (before revised hours)			HOV Speed Distribution											
			6:45-7:00 PM						7:00-7:15 PM					
Corridor	Location	Dir.	50-60	40-50	30-40	20-30	20 or less		50-60	40-50	30-40	20-30	20 or less	
I-405	NE 160th, Bothell	N	96%	0%	0%	0%	4%		98%	0%	0%	0%	2%	
I-405	NE 30th St, Newcastle	N	100%	0%	0%	0%	0%		100%	0%	0%	0%	0%	
I-405	Cedar Ave, Renton	N	100%	0%	0%	0%	0%		100%	0%	0%	0%	0%	
I-405	NE 12th St, Bellevue	S	96%	0%	2%	0%	2%		100%	0%	0%	0%	0%	
I-405	NE 30th St, Newcastle	S	100%	0%	0%	0%	0%		100%	0%	0%	0%	0%	
I-405	Cedar Ave, Renton	S	95%	4%	1%	0%	0%		96%	2%	2%	0%	0%	
I-90	Newport Way, Issaquah	E	100%	0%	0%	0%	0%		100%	0%	0%	0%	0%	
SR 167	S 208th St, Renton	N	100%	0%	0%	0%	0%		100%	0%	0%	0%	0%	
SR 167	37th St. NW, Auburn	N	100%	0%	0%	0%	0%		100%	0%	0%	0%	0%	
SR 167	S 208th St, Renton	S	97%	3%	0%	0%	0%		100%	0%	0%	0%	0%	
SR 167	37th St. NW, Auburn	S	95%	5%	0%	0%	0%		100%	0%	0%	0%	0%	
SR 520	NE 148th, Redmond	E	100%	0%	0%	0%	0%		100%	0%	0%	0%	0%	
SR 520	NE 148th, Redmond	W	100%	0%	0%	0%	0%		100%	0%	0%	0%	0%	

Table 4.10. Change in Average GP and HOV Speed Distribution Before/After 7:00 PM (2003 and 2004).

GP	Spring Data		Change in Speed Distribution (7:00-7:15 PM vs. 6:45-7:00 PM											
			2004 (one year after start of revised hours)						2003 (before start of revised hours)					
Corridor	Location	Dir.	50-60	40-50	30-40	20-30	20 or less	mph	50-60	40-50	30-40	20-30	20 or less	mph
I-405	NE 160th, Bothell	N	3.0%	(0.0%)	(3.0%)	(0.0%)	(0.0%)		1.5%	(0.7%)	(0.7%)	0.0%	0.0%	
I-405	NE 30th St, Newcastle	N	0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%	0.0%	
I-405	Cedar Ave, Renton	N	3.0%	(3.0%)	0.0%	0.0%	0.0%		1.5%	(2.3%)	0.0%	0.0%	0.8%	
I-405	NE 12th St, Bellevue	S	7.7%	(0.9%)	(2.6%)	(4.3%)	0.0%		6.8%	0.0%	0.0%	(0.8%)	(6.1%)	
I-405	NE 30th St, Newcastle	S	2.3%	(0.8%)	0.0%	(0.8%)	(0.8%)		1.5%	0.7%	(1.5%)	(0.7%)	0.0%	
I-405	Cedar Ave, Renton	S	5.1%	0.0%	(1.0%)	(7.1%)	3.0%		3.8%	(3.8%)	0.0%	0.8%	(0.8%)	
I-90	Newport Way, Issaquah	E	(0.7%)	0.7%	0.7%	(0.7%)	0.0%		(0.7%)	0.0%	0.0%	0.7%	0.0%	
SR 167	S 208th St, Renton	N	0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%	0.0%	
SR 167	37th St. NW, Auburn	N	0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%	0.0%	
SR 167	S 208th St, Renton	S	6.1%	(5.3%)	(0.8%)	0.0%	0.0%		2.2%	(2.2%)	0.0%	0.0%	0.0%	
SR 167	37th St. NW, Auburn	S	4.0%	(3.2%)	(0.8%)	0.0%	0.0%		3.7%	(3.7%)	0.0%	0.0%	0.0%	
SR 520	NE 148th, Redmond	E	0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%	0.0%	
SR 520	NE 148th, Redmond	W	7.4%	0.0%	(0.7%)	(0.7%)	(5.9%)		0.0%	0.0%	0.0%	0.7%	(0.7%)	

HOV	Spring Data		Change in Speed Distribution (7:00-7:15 PM vs. 6:45-7:00 PM											
			2004 (one year after start of revised hours)						2003 (before start of revised hours)					
Corridor	Location	Dir.	50-60	40-50	30-40	20-30	20 or less	mph	50-60	40-50	30-40	20-30	20 or less	mph
I-405	NE 160th, Bothell	N	(0.7%)	0.7%	(0.7%)	0.7%	0.0%		1.5%	0.0%	0.0%	0.0%	(1.5%)	
I-405	NE 30th St, Newcastle	N	0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%	0.0%	
I-405	Cedar Ave, Renton	N	0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%	0.0%	
I-405	NE 12th St, Bellevue	S	4.3%	0.0%	(0.9%)	0.0%	(3.4%)		3.8%	0.0%	(2.3%)	0.0%	(1.5%)	
I-405	NE 30th St, Newcastle	S	0.8%	0.0%	0.0%	(0.8%)	0.0%		0.0%	0.0%	0.0%	0.0%	0.0%	
I-405	Cedar Ave, Renton	S	(4.0%)	1.0%	1.0%	1.0%	1.0%		0.8%	(2.3%)	1.5%	0.0%	0.0%	
I-90	Newport Way, Issaquah	E	0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%	0.0%	
SR 167	S 208th St, Renton	N	0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%	0.0%	
SR 167	37th St. NW, Auburn	N	0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%	0.0%	
SR 167	S 208th St, Renton	S	0.0%	0.0%	0.0%	0.0%	0.0%		3.0%	(3.0%)	0.0%	0.0%	0.0%	
SR 167	37th St. NW, Auburn	S	0.0%	0.0%	0.0%	0.0%	0.0%		5.2%	(5.2%)	0.0%	0.0%	0.0%	
SR 520	NE 148th, Redmond	E	0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%	0.0%	
SR 520	NE 148th, Redmond	W	0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%	0.0%	

NE 12th St, Bellevue

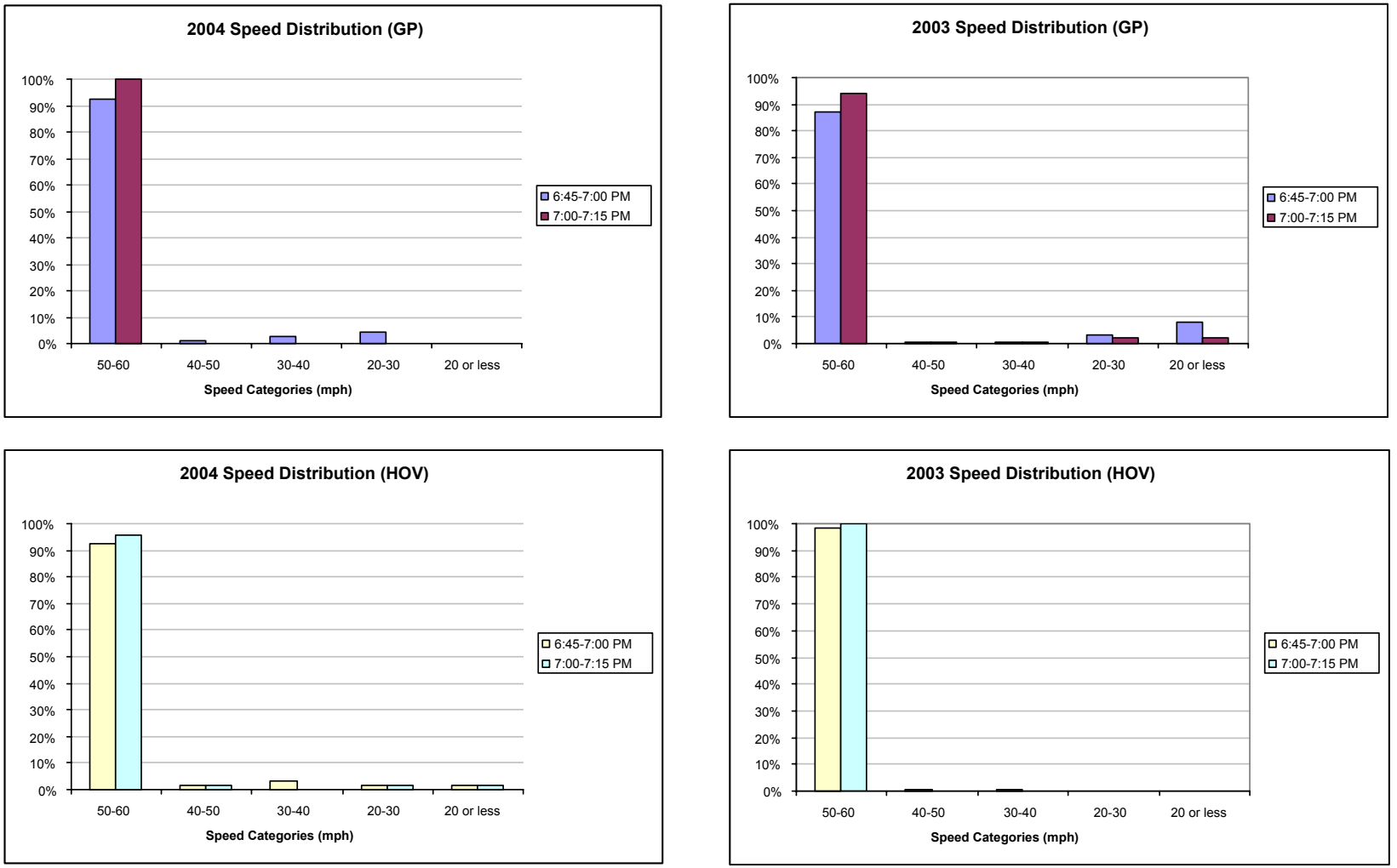

Figure 4.36. Change in Distribution of Average 5-Minute GP and HOV Speeds After 7:00 PM, I-405 SB at NE 12th Street (2003 and 2004).

NE 148th, Redmond

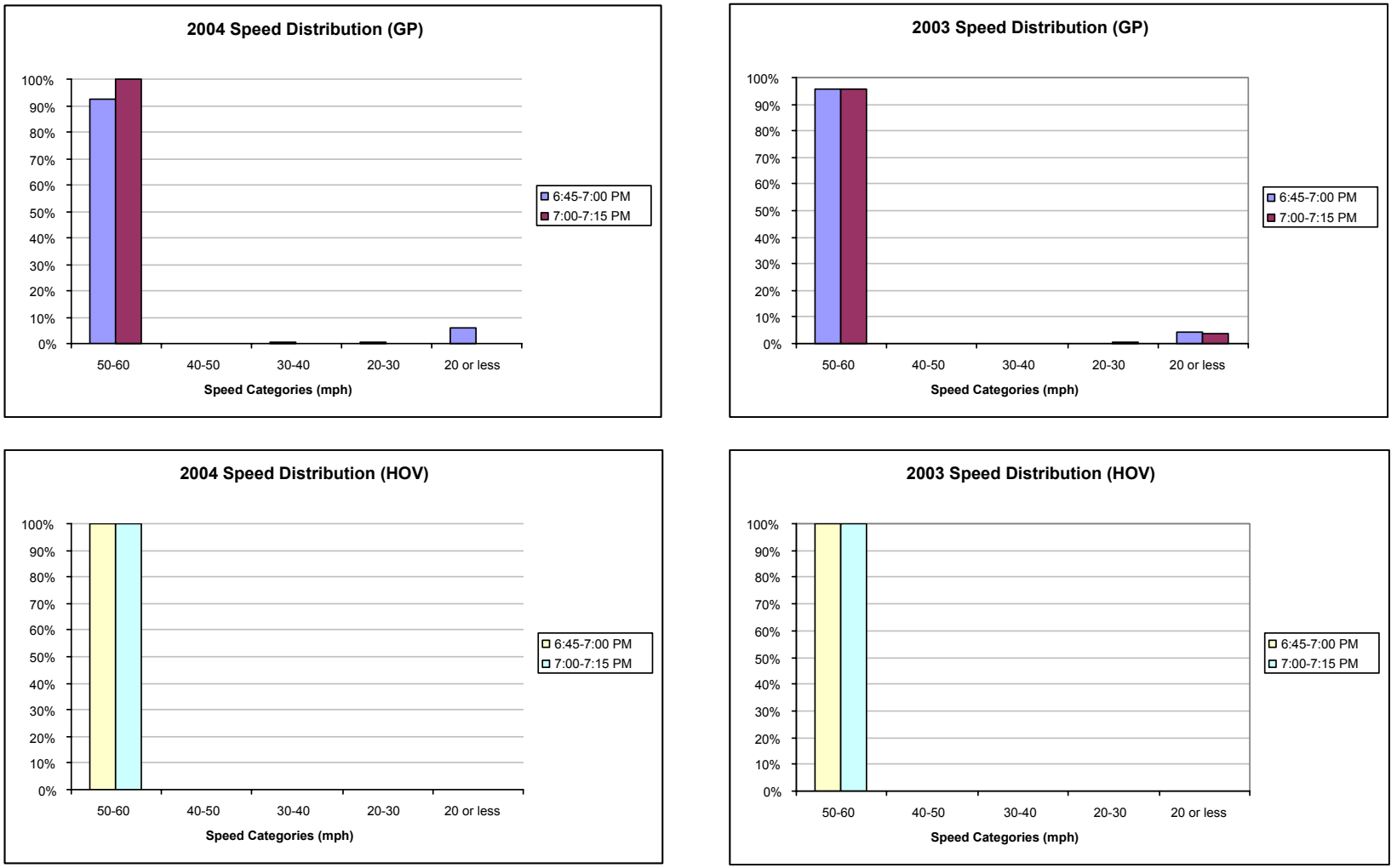

Figure 4.37. Change in Distribution of Average 5-Minute GP and HOV Speeds After 7:00 PM, SR 520 WB at NE 148th (2003 and 2004).

S 208th St, Renton

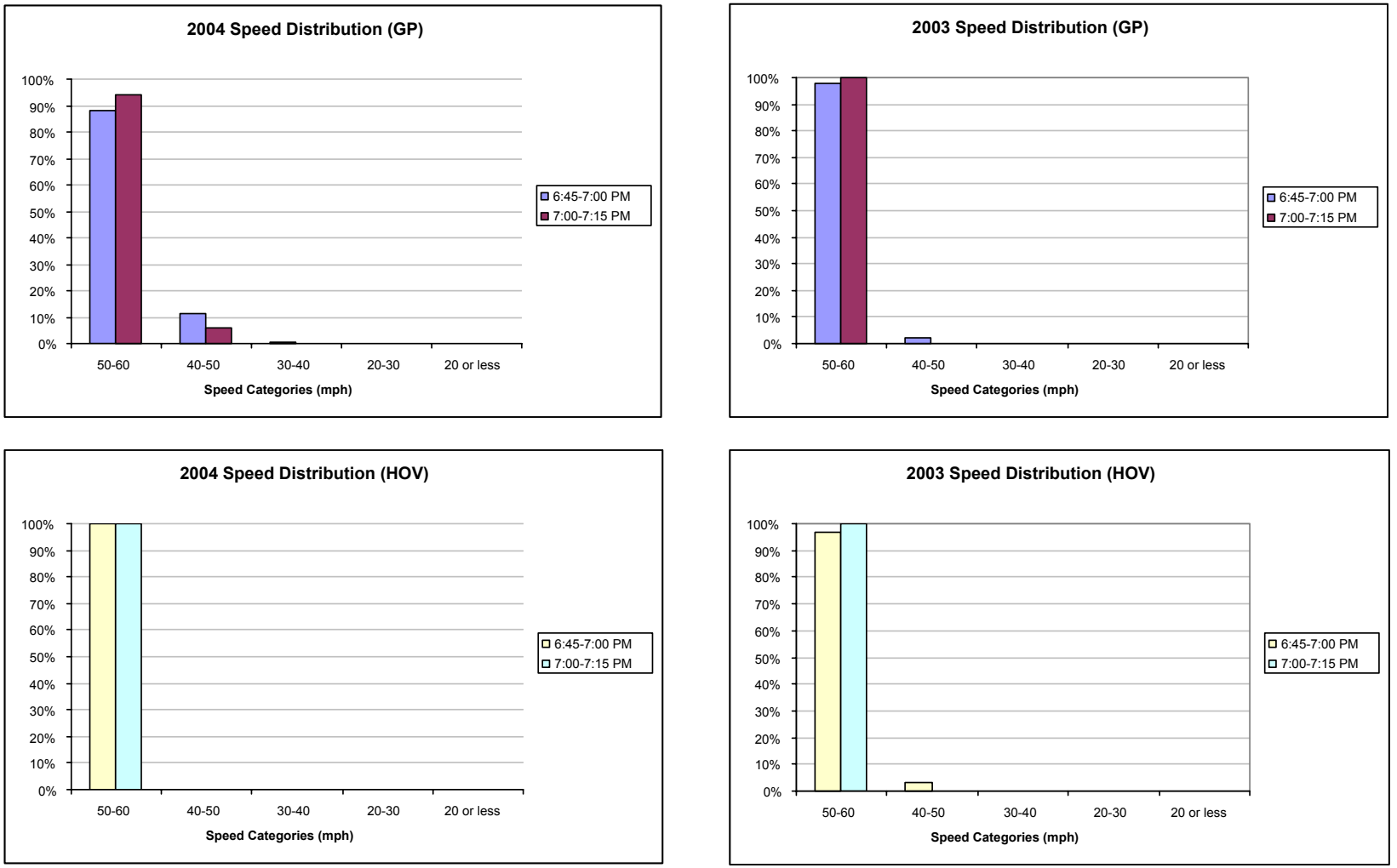

Figure 4.38. Change in Distribution of Average 5-Minute GP and HOV Speeds After 7:00 PM, SR 167 SB at S. 208th (2003 and 2004).

Cedar Ave, Renton

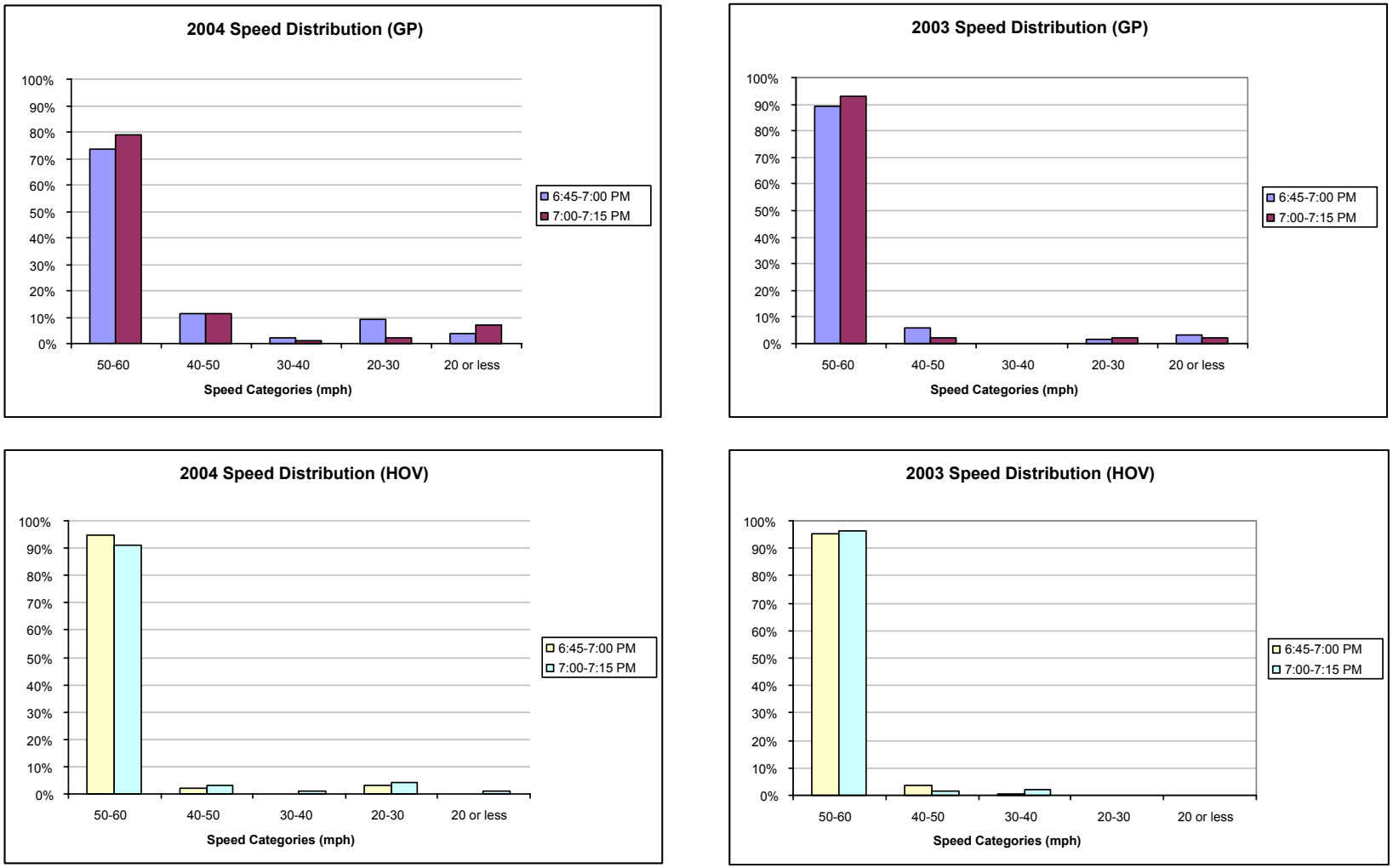

Figure 4.39. Change in Distribution of Average 5-Minute GP and HOV Speeds After 7:00 PM, I-405 SB at Cedar Avenue (2003 and 2004).

Table 4.11. Average GP and HOV Speeds Before/After 7:00 PM (2003 and 2004).

Spring data			Average GP Speed					
			2004			2003		
Corridor	Location	Dir.	6:45-7:00 PM	7:00-7:15 PM	Change	6:45-7:00 PM	7:00-7:15 PM	Change
I-405	NE 160th, Bothell	N	58	59	1	60	60	0
I-405	NE 30th St, Newcastle	N	60	60	0	60	60	0
I-405	Cedar Ave, Renton	N	56	57	1	55	55	0
I-405	NE 12th St, Bellevue	S	58	60	2	55	58	3
I-405	NE 30th St, Newcastle	S	57	58	1	58	59	1
I-405	Cedar Ave, Renton	S	50	52	2	54	55	1
I-90	Newport Way, Issaquah	E	59	59	0	58	58	0
SR 167	S 208th St, Renton	N	60	60	0	60	60	0
SR 167	37th St. NW, Auburn	N	60	60	0	60	60	0
SR 167	S 208th St, Renton	S	55	58	3	56	58	2
SR 167	37th St. NW, Auburn	S	58	60	2	58	59	1
SR 520	NE 148th, Redmond	E	60	60	0	60	60	0
SR 520	NE 148th, Redmond	W	57	60	3	58	58	0

Spring data			Average HOV Speed					
			2004			2003		
Corridor	Location	Dir.	6:45-7:00 PM	7:00-7:15 PM	Change	6:45-7:00 PM	7:00-7:15 PM	Change
I-405	NE 160th, Bothell	N	57	57	0	58	59	1
I-405	NE 30th St, Newcastle	N	60	60	0	60	60	0
I-405	Cedar Ave, Renton	N	60	60	0	60	60	0
I-405	NE 12th St, Bellevue	S	58	60	2	59	60	1
I-405	NE 30th St, Newcastle	S	60	60	0	60	60	0
I-405	Cedar Ave, Renton	S	59	57	-1	59	59	0
I-90	Newport Way, Issaquah	E	60	60	0	60	60	0
SR 167	S 208th St, Renton	N	60	60	0	60	60	0
SR 167	37th St. NW, Auburn	N	60	60	0	60	60	0
SR 167	S 208th St, Renton	S	60	60	0	60	60	0
SR 167	37th St. NW, Auburn	S	60	60	0	60	60	0
SR 520	NE 148th, Redmond	E	60	60	0	60	60	0
SR 520	NE 148th, Redmond	W	60	60	0	60	60	0

Table 4.12. HOV and GP Volumes on SR 167 Southbound Before/After 7:00 PM (2003 and 2004)

2004 Spring			6:45-7:00 PM		7:00-7:15 PM	
Corridor	**Location**	**Direction**	**HOV**	**GP**	**HOV**	**GP**
SR 167	S 208th St, Renton	S	274	650	265	634
SR 167	37th St. NW, Auburn	S	271	601	261	564

2003 Spring			6:45-7:00 PM		7:00-7:15 PM	
Corridor	**Location**	**Direction**	**HOV**	**GP**	**HOV**	**GP**
SR 167	S 208th St, Renton	S	267	645	249	599
SR 167	37th St. NW, Auburn	S	230	626	196	610

2004 vs 2003			6:45-7:00 PM		7:00-7:15 PM	
Corridor	**Location**	**Direction**	**HOV**	**GP**	**HOV**	**GP**
SR 167	S 208th St, Renton	S	7	5	16	35
SR 167	37th St. NW, Auburn	S	40	-24	65	-46

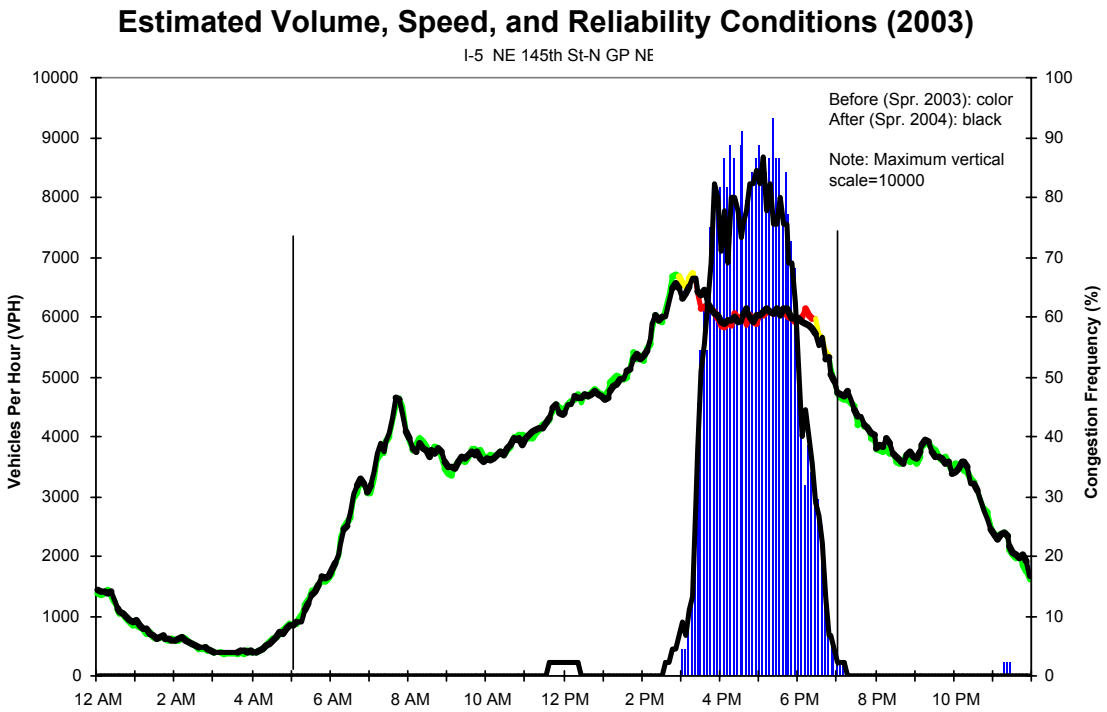

Figure 4.40. Change in 24-Hour Performance at Control Site, I-5 NB GP at NE 145th (2003 and 2004).

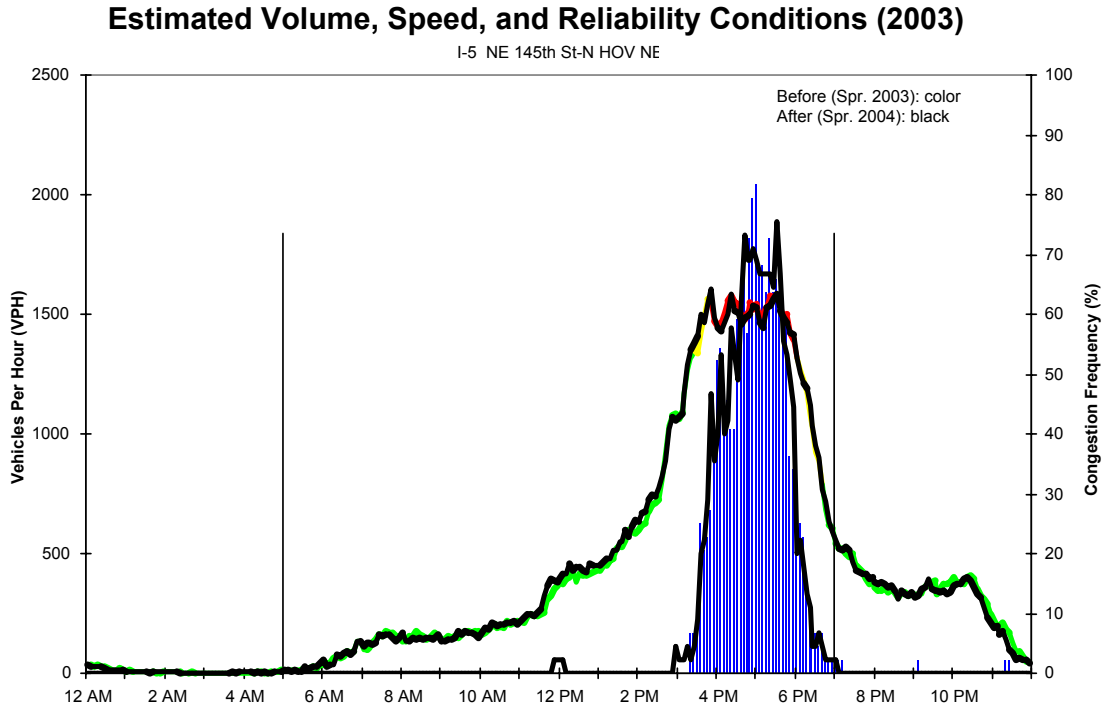

Figure 4.41. Change in 24-Hour Performance at Control Site, I-5 NB HOV at NE 145th (2003 and 2004).

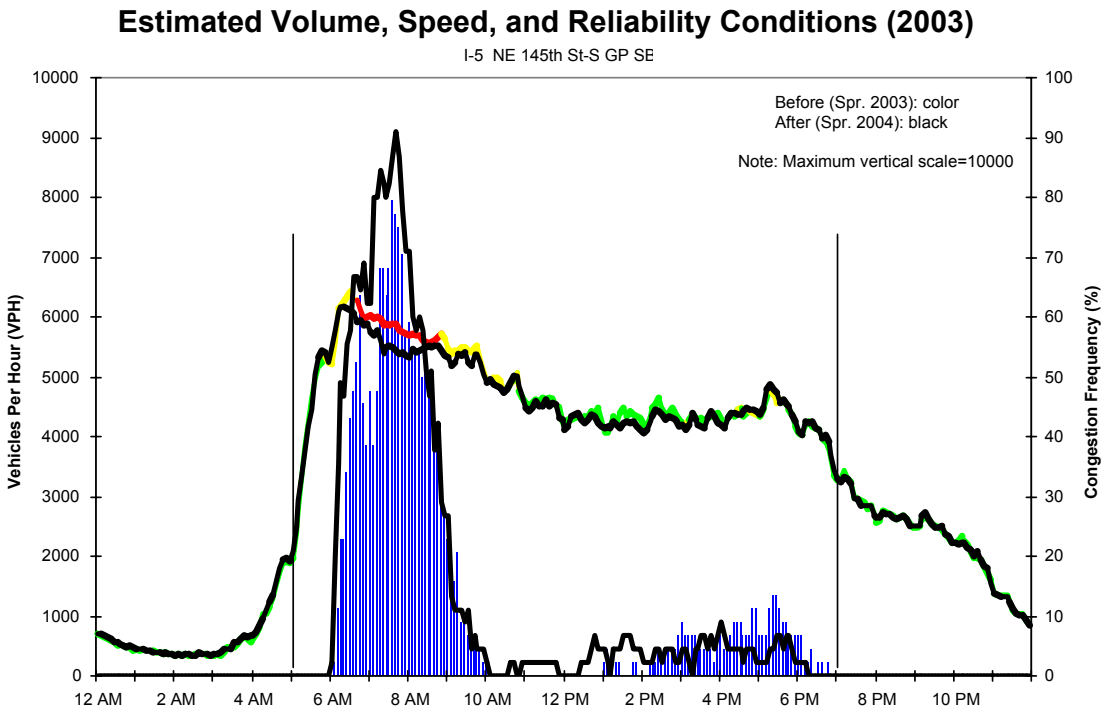

Figure 4.42. Change in 24-Hour Performance at Control Site, I-5 SB GP at NE 145th (2003 and 2004).

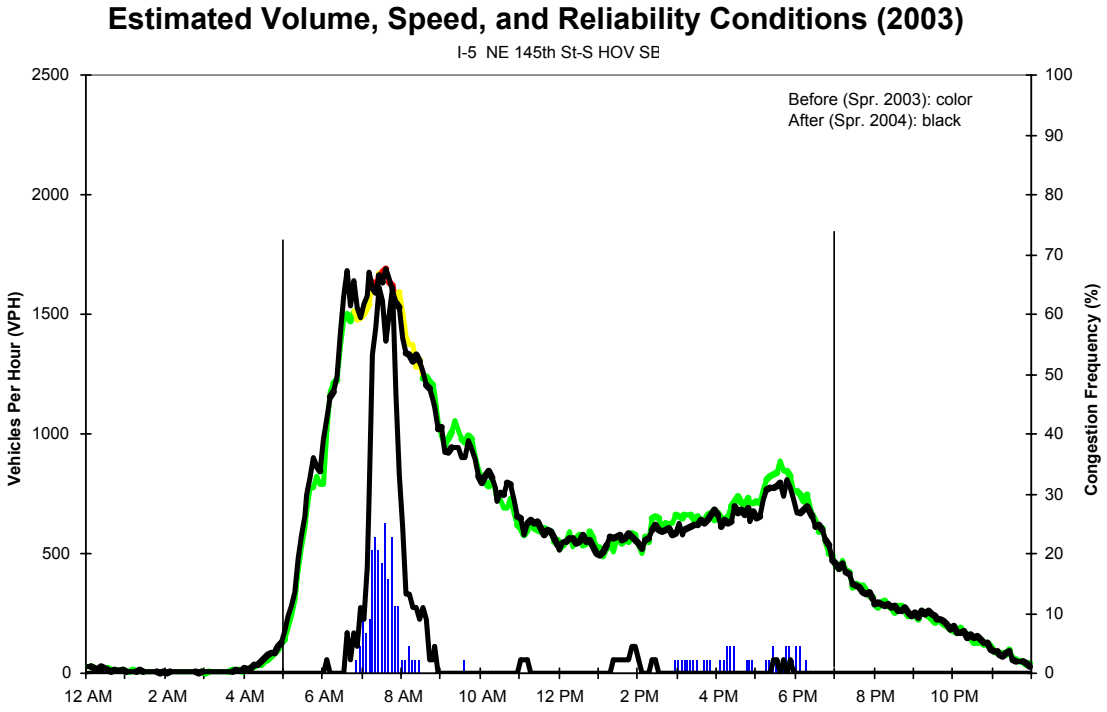

Figure 4.43. Change in 24-Hour Performance at Control Site, I-5 SB HOV at NE 145th (2003 and 2004).

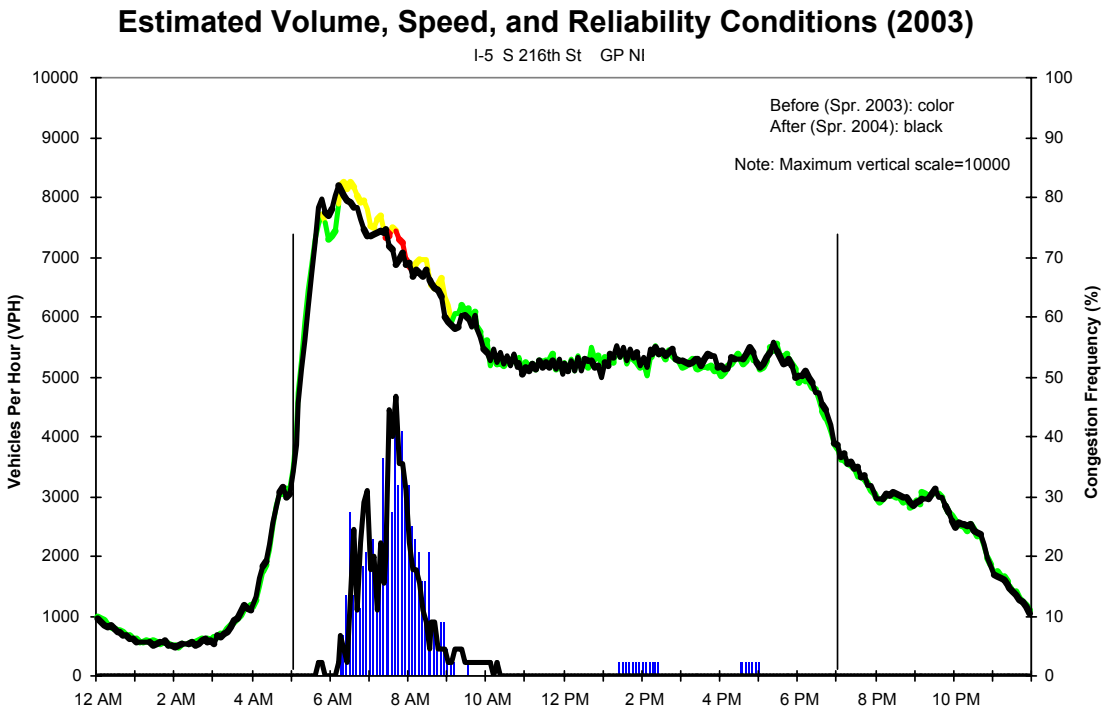

Figure 4.44. Change in 24-Hour Performance at Control Site, I-5 NB GP at S. 216th (2003 and 2004).

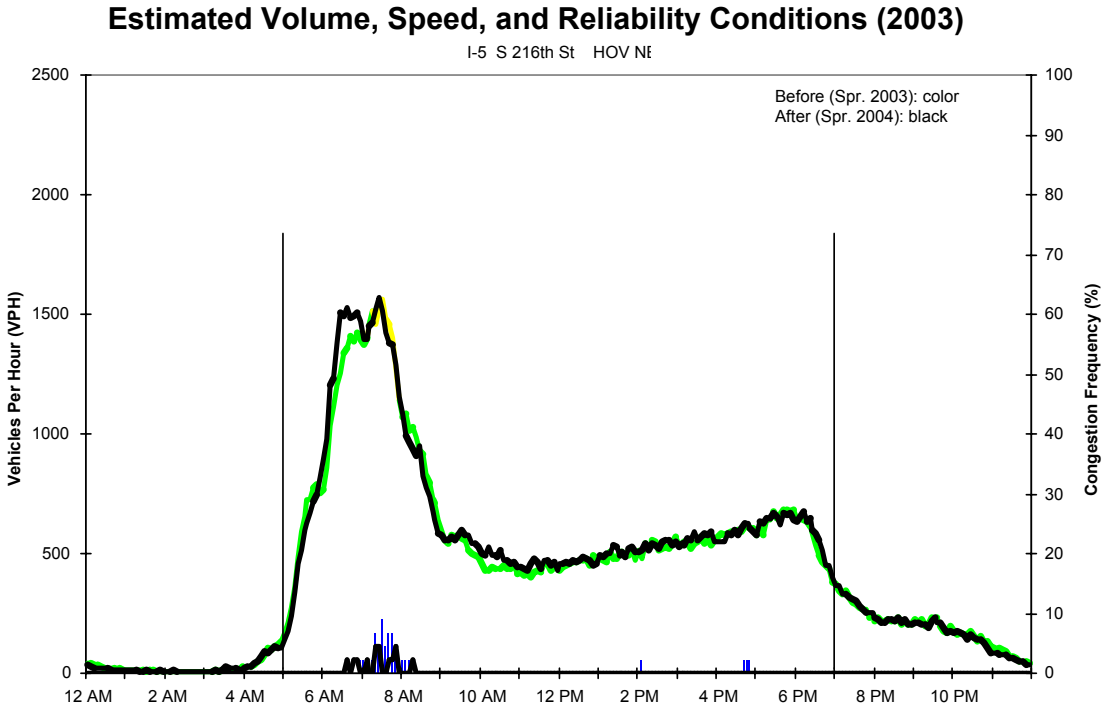

Figure 4.45. Change in 24-Hour Performance at Control Site, I-5 NB HOV at S. 216th (2003 and 2004).

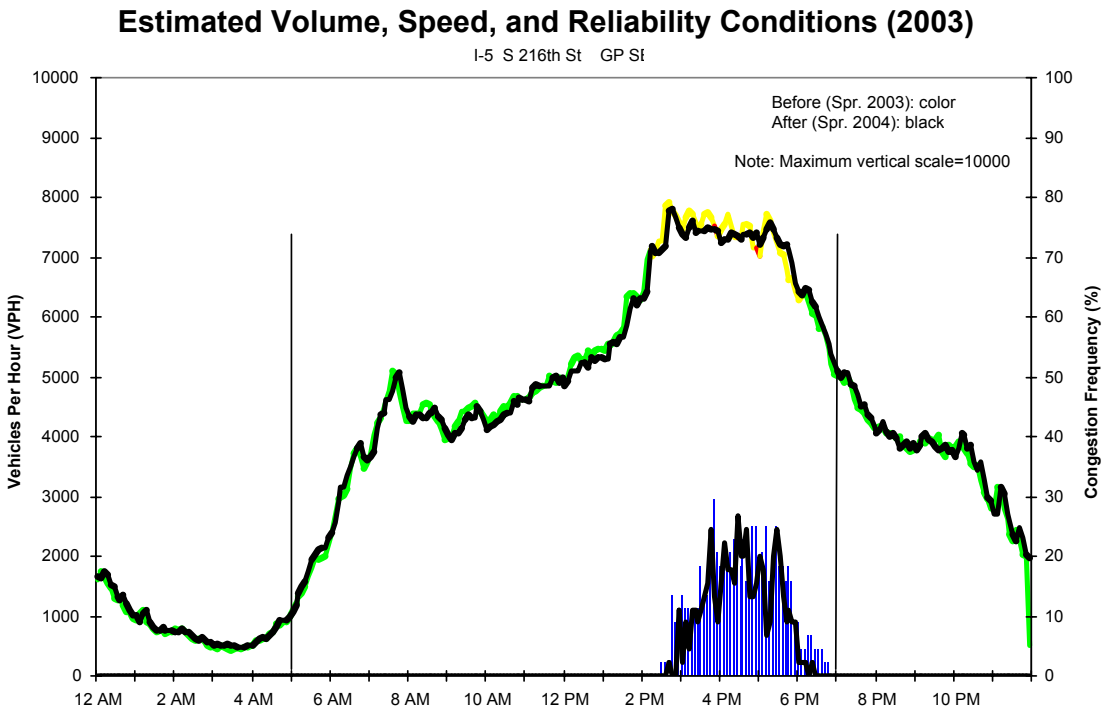

Figure 4.46. Change in 24-Hour Performance at Control Site, I-5 SB GP at S. 216th (2003 and 2004).

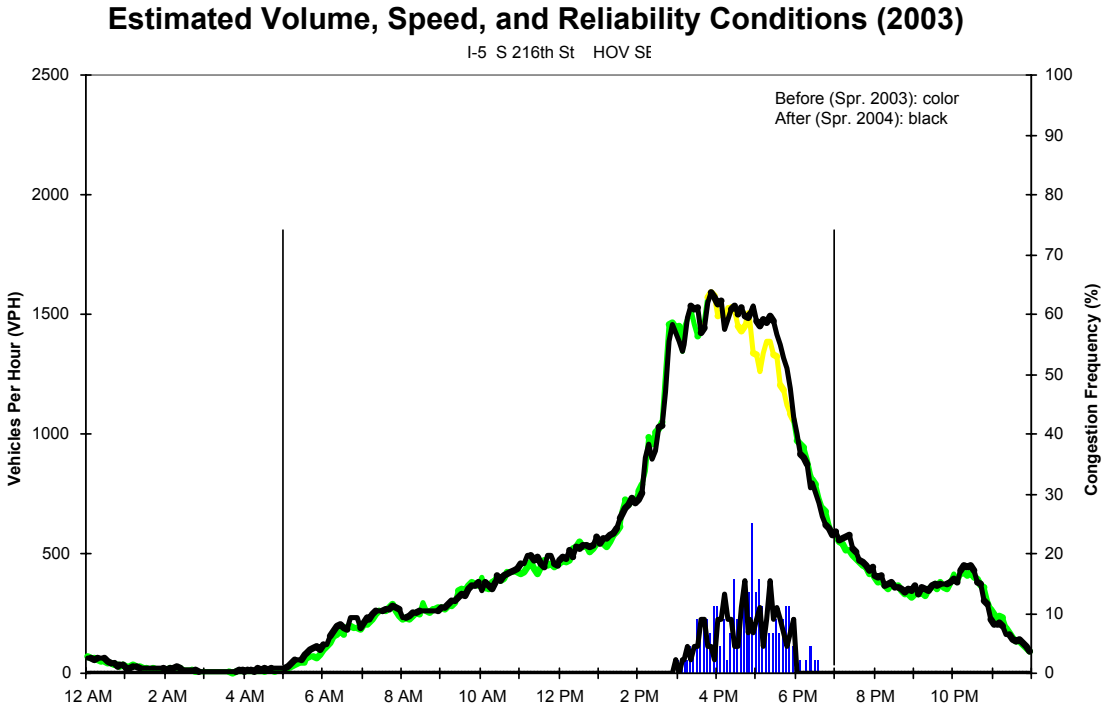

Figure 4.47. Change in 24-Hour Performance at Control Site, I-5 SB HOV at S. 216th (2003 and 2004).

PUBLIC PERCEPTIONS

A public opinion survey was performed to gauge the level of awareness of the revised hours of operation; perceived changes in freeway conditions such as driving maneuverability, safety, and speeds after the new HOV lane hours of operation began; and overall impressions of the new operational policy and the HOV system in general. The overall response rate was almost 23 percent (1,209 received out of 5,349 mailed surveys).

The responses to the 2004 survey are summarized below.

8. The level of awareness of the new HOV lane hours of operation was not high among survey respondents.

Survey participants were asked to indicate whether they were aware of the new HOV lane hours of operation on the affected freeways. While vehicle volume data and vehicle occupancy data showed changes in HOV lane volumes and patterns of vehicle occupancy at 7:00 PM, suggesting that at least some travelers were aware of the revised hours of operation and were using the HOV lanes differently as a result, the survey results revealed that only 36 percent of the respondents were aware of the new hours of operation. Existing signage and public discussion of the new policy was apparently not sufficient to expand awareness of the new policy as much as desired.

9. Survey respondents perceived some improvements in freeway conditions following the start of the new hours of operation.

Survey participants were asked to compare freeway conditions after the start of the new hours of operation policy to conditions before the policy began. They indicated their answers on a 5-point scale (significantly worse than before, somewhat worse than before, unchanged, somewhat better than before, and significantly better than before, as well as "don't know") in the areas of a) driving maneuverability in the GP lanes (e.g., ability to change lanes), b) overall safety, and c) speeds in the HOV and GP lanes during the evening hours of 7:00 PM to 9:00 PM. The survey results showed that respondents

perceived some improvements in freeway conditions following the start of the new HOV lane hours. Overall, responses to each of the questions about driving conditions were similar, with 21 to 28 percent of respondents saying that the freeway conditions (maneuverability, safety, or speed) were somewhat better or much better than before, 31 to 39 percent saying that conditions were unchanged, and 3 to 4 percent saying conditions were somewhat worse or much worse, with 31 to 38 percent saying that they did not know.

The response pattern was different among the subset of respondents who were aware of the policy change, with more positive responses overall. About 42 percent of those who were aware of the new policy thought that driving maneuverability was improved, 31 percent thought overall safety had improved, and 34 percent thought average speeds in the HOV and GP lanes were faster during the evening hours. About 39 to 48 percent thought conditions were unchanged, while 1 to 5 percent thought conditions were worse. About 10 to 21 percent were unsure.

By comparison, respondents who were unaware of the policy change had a higher degree of uncertainty about changes in freeway conditions, with 43 to 52 percent responding "not sure". There were also fewer responses indicating improved freeway conditions (13 to 23 percent) or unchanged conditions (26 to 36 percent).

10. Most survey respondents had a positive reaction to the new hours of operation.

Survey participants were asked for their overall impression of the new HOV lane hours of operation. Approximately 67 percent of the respondents either somewhat agreed or strongly agreed with the statement that opening the HOV lanes to both SOVs and HOVs from 7:00 PM and 5:00 AM was a good idea, while 17 percent somewhat or strongly disagreed. The response was positive whether survey participants were already aware of the new policy (74 percent positive), or were just learning about the changes from the survey (64 percent positive). Respondents who typically drove alone during

peak hours were generally very supportive, with 73 percent either somewhat or strongly agreeing that the new policy was a good idea, and 13 percent somewhat or strongly disagreeing. Respondents who used carpools, vanpools, or transit during peak periods were also supportive, though somewhat less so, with about 59 percent answering positively and 23 percent disagreeing.

11. For a significant number of survey respondents, the new HOV lane policy has improved their overall opinion of the HOV lane network.

Survey participants were asked whether the new HOV lane hours policy had affected their overall opinion of the HOV lane network. Approximately 41 percent of survey respondents had a somewhat more favorable or significantly more favorable opinion of the HOV lane network because of the change in HOV lane policy, and only 10 percent had a less favorable opinion. About 50 percent had no change in opinion. Respondents who typically drove alone during peak hours were more supportive, with 46 percent having a somewhat or strongly more favorable opinion of the overall HOV system, while 48 percent were unchanged in their opinion. Respondents who used carpools, vanpools, or transit during peak periods were somewhat less supportive, with about 32 percent answering that their opinion of the HOV system was more favorable, while 53 percent were unchanged in their opinions, and 15 percent had a somewhat or significantly less favorable opinion of the HOV network.

SECTION 5
SUMMARY OF ONE-YEAR ANALYSES

The data processed thus far suggest that some travelers appear to be aware of the revised hours of operation and are taking advantage of the new policy. The percentage and number of SOVs using the HOV lane at the start of the revised hours (7:00 PM) increased at many of the locations evaluated, and the percentage of all traffic using the HOV lane after 7:00 PM increased. In some locations, notably on SR 167, there is a significant increase in SOV usage of the HOV lane after 7:00 PM. At the same time, survey results suggest that only slightly more than one-third of travelers are aware of the revised hours of operation.

The results also suggest that at some locations there is an increase in SOV violation rates in the HOV lane during the transition periods (6:45 PM to 7:00 PM, and after 5:00 AM); the increases are generally not large but are somewhat higher after one year of operation than they were shortly after the new policy began. This is true for both the AM peak period and the PM peak transition period.

Traffic performance improvement after 7:00 PM as a result of the revised hours of operation is difficult to determine from the data analyzed. However, an analysis of the distribution of speeds before and after the pilot program start suggests that there was a slight shift toward higher speeds in the GP lanes after 7:00 PM, though there was almost no change in the HOV lane after 7:00 PM (which was generally already operating at or near the speed limit by that time). At the same time, survey results suggest that among travelers who were already aware of the new policy, anywhere from 31 to 42 percent associate the new hours of operation with perceived improvements in maneuverability, safety, and speeds, though a significant percentage of people surveyed also did not perceive any change in freeway performance. Of those survey respondents who were not previously aware of the new policy, there was more uncertainty about the

performance effects, with only 13 to 23 percent associating the new policy with improvements in freeway conditions, and 43 to 52 percent responding that there was no change.

Nevertheless, there was a sizeable level of support for the program among both SOV and HOV travelers, with 67 percent of respondents either somewhat or strongly agreeing that it is a good idea. Furthermore, a significant number of respondents (41 percent) had a more favorable opinion of the HOV system as a whole because of the new hours of operation.

The results described in this paper are based on data collected after one year of operation of the pilot program, and they will be reviewed and updated as additional data are collected in the coming months. The next evaluation report will be produced following the end of the second full year of operation.