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HOV lane Hours Evaluation

**EVALUATION OF PUGET SOUND HOV LANE HOURS OF
OPERATION PILOT PROJECT: FINAL REPORT**

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16. ABSTRACT <p>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 freeway corridors in the Seattle area during the hours of 7:00 PM to 5:00 AM, seven days a week. After two years, the percentage and number of SOVs using the HOV lane increased at the start of the revised hours (7:00 PM) at most locations evaluated, and the percentage of all traffic using the HOV lane after 7:00 PM increased. At some locations SOV violation rates increased in the HOV lane during the transition periods (6:45 PM to 7:00 PM, and shortly after 5:00 AM); the increases were generally not large, with some exceptions at locations that also have significant general purpose PM congestion. Some locations saw a drop in violation rates. Traffic performance changes after 7:00 PM were difficult to determine, although estimates suggest a small shift toward slightly higher speeds in the GP lanes after 7:00 PM. There was almost no change in HOV lane performance after 7:00 PM.</p> <p>A review of collision records for the periods 2001-2002 and 2004-2005 indicated that generally there were no adverse safety effects related to revising the HOV lane hours of operation. The evaluation revealed a reduction in daily occurrence of run-off-road collisions, including during nighttime hours. Additionally, no adverse safety effects were identified during the 7:00 PM to 8:00 PM period or during the entire nighttime when the HOV lanes are open to general purpose traffic. There was evidence that safety improvements implemented before the start of the pilot project may have contributed to a lower rate of nighttime run-off-road type collisions.</p> <p>A traveler survey showed that among those who were already aware of the new policy, 31 to 45 percent associate the new hours of operation with perceived improvements in maneuverability, safety, and/or speeds, although a similar percentage of people surveyed did not perceive any change. There was sizeable support for the program among both SOV and HOV travelers, and a significant number of respondents had a more favorable opinion of the HOV system as a whole because of the new hours of operation. At the same time, only slightly less than one-half of those surveyed were aware of the revised hours of operation.</p>			
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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 two years 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, as well as data collected during the first two months of operation after the change in operating policy, after approximately one year of operation, and after approximately two years of operation, to describe changes that have occurred as a result of the new operating policy. The results are summarized 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. After two years of

operation, ten of the 12 locations analyzed showed at least a 10 percentage point increase in SOV use of the HOV lane after 7:00 PM. The greatest observed changes were on I-405 southbound near Newcastle and on SR 520 eastbound at 148th Ave NE, where the SOV percentage of HOV lane volumes increased by over 20 percentage points after 7:00 PM compared to before 7:00 PM, and on SR 167 southbound and northbound at Renton, where the SOV percentage increased by over 30 percentage points after 7:00 PM.

Only one location (I-405 southbound at Renton) showed a net two-year decrease in after-7:00 PM SOV use of the HOV lane, while one other location (SR 167 southbound at Auburn) showed a 5 percentage point increase over two years.

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, with some exceptions. 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, from 0.8 to 9.0 percent after one year of operation, and from 0.8 to 8.4 percent after two years of operation, for selected locations. During the 6:45 to 7:00 PM evening 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, from 0.0 to 8.9 percent after one year of operation, and from 0.0 to 9.3 percent after two years, for most but not all locations. There were some notable exceptions; the two highest SOV violation rates after two years were at SR 167 southbound PM at Renton (12.4 percent) and I-405 southbound PM near Newcastle (15.4 percent). These are locations that often feature evening GP congestion. One other location, SR 167 southbound in Auburn, had AM violation rates ranging from 25.6 (before) to 11.6 percent

(two years after) and PM rates of 16.6 percent (before) and 4.5 percent (two years after). This site has historically had high violation rates and is atypical because of its location just before the end of the HOV lane network, although the violation rates have dropped in the past year.

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. The causal relationship between the hours of operation and the performance change after 7:00 PM is not conclusive, given the data analyzed. However, an analysis of the distribution of estimated 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. Ten of the sites analyzed had estimated changes in average speed of 0 to +2 mph, while the other three locations showed estimated increases of +4 mph. All sites had average estimated speeds of more than 50 mph just prior to 7:00 PM. The 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 2005 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 45 percent of respondents indicating that they were aware of the new policy after one and a half years of operation. (This was up from 36 percent awareness after six months of operation.)

- 2) Approximately 26 to 32 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. Approximately 32 to 37 percent of survey respondents perceived no changes in freeway maneuverability, safety, or speeds since the start of the new hours of operation. Approximately 28 to 36 percent of all respondents did not know.
- 3) A substantial majority (68 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.
- 4) The new hours of operation affected the respondents' overall opinion of the HOV lane network, with 39 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 51 percent expressing no change in opinion.

Overall, there was a noticeable increase in SOV use of the HOV lanes at some locations when the revised hours of operation went into effect at 7:00 PM, with some increases in the SOV violation rate (varying by location) during the time period leading up to a change in the hours of operation. Performance improvements in the evening were relatively small and not conclusively the result of the revised hours of operation, since congestion often improves around 7:00 PM in any case. The public was generally supportive of the pilot program, although after one and a half years less than half of the people surveyed were aware that the hours of HOV lane operation had changed.

EFFECTS ON SAFETY

In 2001, the Washington State Department of Transportation (WSDOT) studied the potential effects of opening the Eastside freeway HOV lanes to general purpose traffic during nighttime hours. Forecasted traffic volumes indicated that a significant

amount of general purpose traffic would utilize the unrestricted lane, particularly during the one hour immediately before and immediately following the restricted 5:00 AM to 7:00 PM period. The study utilized the Federal Highway Administration's (FHWA) ROADSIDE model to predict the potential increase in run-off-the-road type collisions. The model findings indicated that the increased HOV lane traffic volume could result in an approximately 25 percent increase in this type of collision during nighttime hours. To mitigate for this potential increase, WSDOT included shoulder rumblestrip and raised profile edge line installations within the project limits. Similar installations have resulted in as much as a 30 percent decrease in run-off-the-road collisions, primarily on rural highways. The target of this investment was to achieve a minimum of a 10 percent annual decrease for all hours of the day and night.

The project's effect on safety was evaluated by utilizing collision data for the two-year periods before and after project implementation. The evaluation revealed a reduction in daily occurrences of run-off-road collisions, including during nighttime hours. In addition, no adverse safety effects were identified during the 7:00 PM to 8:00 PM period or during the entire nighttime when the HOV lanes are open to general purpose traffic.

Before implementing the project, WSDOT had predicted a 23 percent (15 collisions) increase in I-405 left shoulder and median nighttime collisions. The prediction was based on the expected increase in usage of the HOV lane during the nighttime hours. However, after the project, and despite increased traffic volumes, the number of collisions of this type on I-405 decreased by 33 percent (36 collisions). A similar result was achieved on SR 167, where the predicted increase had been 27 percent (6 collisions), but the two-year period after project implementation showed a decrease of 19 percent (5 collisions).

A similar before/after comparison was also performed for collisions of all types at night. On an overall corridor basis, I-405 and SR 520 showed a moderate decrease in the

number of nighttime accidents after the revised hours of operation began, while I-90 and SR 167 each showed a noticeable increase. During the 7:00 PM to 8:00 PM transition period, however, the number of accidents did increase on all of the affected corridors with the exception of SR 520.

Overall, from a safety standpoint, there appeared to be little or no effect from opening of the Eastside HOV lanes to general purpose traffic from 7:00 PM to 5:00 AM. Note that this before/after comparison included the potential effects of both the revised hours of operation and the safety improvements implemented by WSDOT in response to FHWA requirements (guard rails, shoulder rumble strips, raised lane markings, signage). There was evidence that the safety improvements implemented before the start of the pilot project may have contributed to a lower rate of nighttime run-off-road type collisions.

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 and two years 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 tasks 1, 2, and 5 after two years of pilot project operation, with selected notable results from the data collected, and results from WSDOT analyses of tasks 3 and 4.

Summary of Analyses: A summary of results after two years of the pilot project.

This document is the third and final report in a series of evaluation reports for this project and describes results from tasks 1, 2, and 5 of the evaluation effort, performed by the Washington State Transportation Center (TRAC) using available data sets, as well as results of evaluation tasks 3 and 4 involving analyses of safety and enforcement issues

performed by the WSDOT Northwest Region. (See Section 2, Background, for a description of the evaluation tasks.)

This report is an updated and expanded version of a technical working paper prepared one year after the start of the pilot program¹; it includes most of the text of that paper and adds a discussion of evaluation results from the second year of operation. All figures and tables from the working paper have also been updated with 2005 data as necessary.

¹ Hallenbeck, Nee, Ishimaru, and Kopf, "Evaluation of Puget Sound HOV Lane Hours of Operation: One-Year Results", Washington State Transportation Center, 2004.

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 levels 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 2002, the Washington State Transportation Commission directed the WSDOT to explore ways to enhance HOV lane utility. In the summer of 2003, following implementation of safety improvements required by the Federal Highway Administration, 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). Because of safety and operational considerations, Interstate 5's HOV lanes remain closed to SOVs at all times. 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. (Figure 3.1 shows the HOV lane network in the Seattle area, and the freeway segments affected by the pilot program.)

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 was 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 consisted of six tasks:

1. **Car occupancy analysis.** The focus of this task was 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. TRAC at the University of Washington performed this task.
2. **Traffic flow analysis.** This task involved an analysis of changes in freeway usage and performance in both the HOV and general purpose (GP) lanes. Principal measures included vehicle volumes, speeds, and congestion frequency. TRAC performed this task.
3. **Safety evaluation.** WSDOT evaluated 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 summarized enforcement activities and analyzed changes in HOV lane violation rates on the basis of HERO data. These results were also compared with related data collected for Task 1.
5. **Opinion Surveys.** WSDOT and TRAC performed opinion surveys of the general public, public officials, and other stakeholders.
6. **Report Generation.** Periodic evaluation reports were prepared by TRAC and WSDOT. These reports summarized TRAC and WSDOT analyses for the tasks listed above.

The remainder of this paper focuses on initial (2003), one-year (2004), and two-year (2005) results for tasks 1, 2, and 5 as analyzed by TRAC, and the results of tasks 3 and 4 as analyzed by WSDOT. This document represents completion of task 6.

INITIAL ACTIVITIES

The following activities were completed as part of this analytical effort for evaluation tasks 1, 2 and 5 (tasks 3 and 4 are described in Section 4):

- **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 (website: trac29.trac.washington.edu/hov). 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 and two-year "after" results were estimated in the springs and summers of 2004 and 2005, respectively.

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 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 automatically collected and 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. For task 5, data collection involved the distribution, collection, and processing of mail-back surveys.

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 license plate numbers for survey distribution, distributed surveys, and processed survey responses for task 5, while TRAC analyzed the results. (Tasks 3 and 4 are described in Section 4.) The following approaches were 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 support this HOV hours of operation evaluation. 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 ten 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. Data were collected during the springs and summers of 2002, 2003, 2004, and 2005. The resulting data set featured 38 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, although for this evaluation effort, only weekday data were processed. Two locations on I-5 were also analyzed; these locations were not part of the pilot program but were used as control sites to help evaluate whether observed changes at locations within the pilot program were also occurring at other locations outside the pilot program.

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-

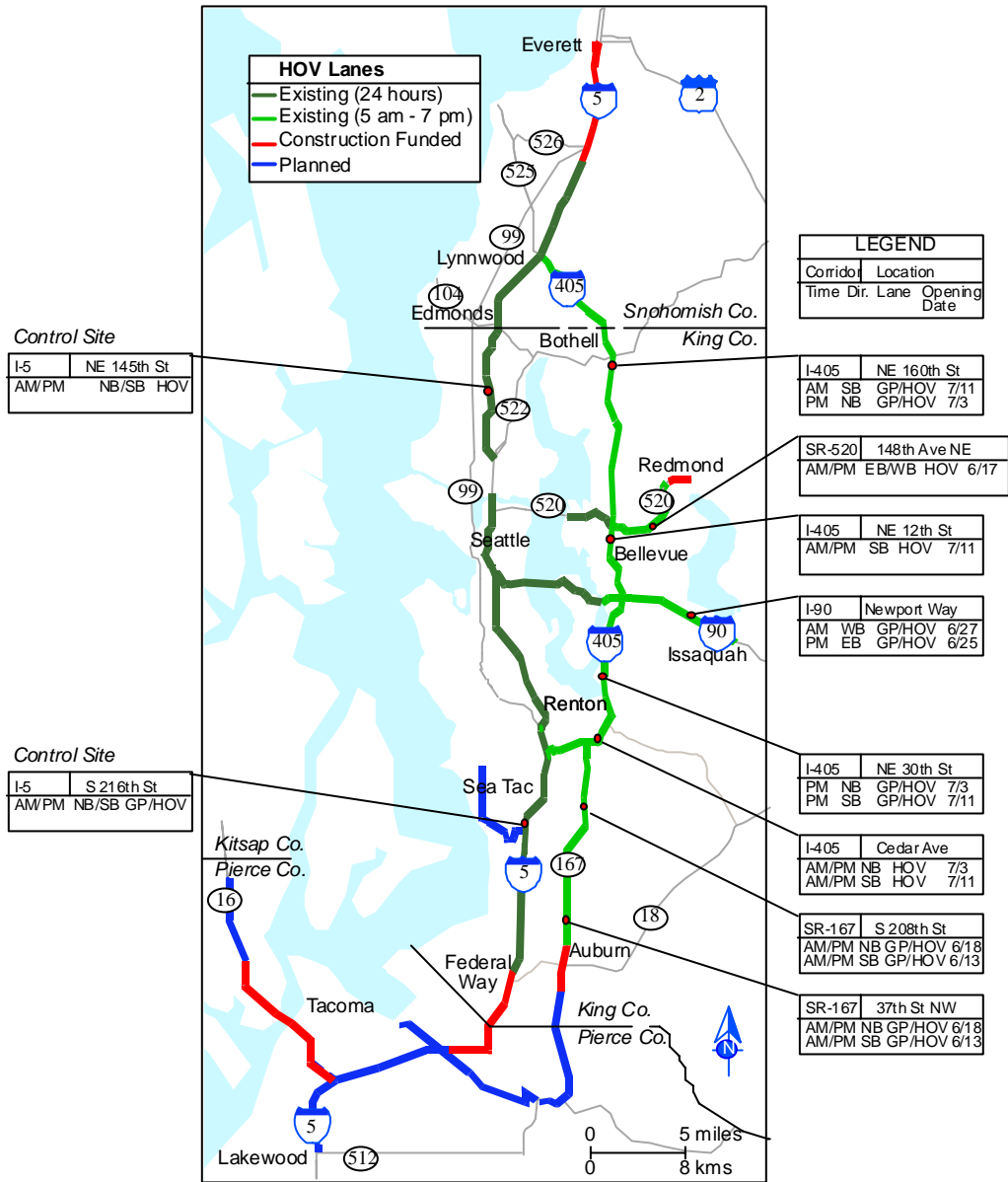


Figure 3.1. HOV Network and Measurement Sites

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 ten years by TRAC, uses specially developed software to compute detailed freeway performance measures. For each measurement of average vehicle occupancy, matching traffic flow (loop) data were extracted for the closest possible sensor location and time period. Data from the springs and summers of 2002, 2003, 2004, and 2005 were used, matching the data collection time periods for vehicle occupancy collection.

Task 5 data: The general analytical approach for Task 5 involved analyzing public opinion via an anonymous mailback questionnaire. A public opinion survey was conducted in the spring of 2004 and the spring of 2005 to evaluate public awareness and perceptions of the revised HOV lane hours of operation. This data collection effort was accomplished by adding questions to an existing HOV public opinion 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. (See Appendix C for survey question forms.) 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 in 2004, 1,209 surveys were returned and processed, for an overall response rate of approximately 23 percent. That 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. Of the 3,990 surveys sent out in 2005, 849 surveys were returned and processed, for an overall response rate of approximately

21 percent. That survey was conducted during late winter and spring of 2005, approximately 1.5 years after the new hours of operation began in the summer of 2003.

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** for average vehicle volume, **miles per hour** for average estimated vehicle speed, and **likelihood (percentage) that heavy congestion occurs** for frequency of heavy congestion, each of which varied by time of day. Heavy congestion was estimated by observing the frequency with which sensor loop occupancy values were above a threshold based approximately on Level of Service F. 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, one-year, and two-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 traffic characteristics changed 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 or two years of operation. Before-and-after comparisons were based on one “before” and three “after” 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, two other “after” time periods during the springs and summers of 2004 and 2005 were used. Estimation of public perceptions was based on surveys conducted approximately 6 to 8 months after the introduction of the revised hours of operation, as well as about 18 to 20 months after the start of the revised hours.

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.

Analyses of safety and enforcement issues were performed by the WSDOT. Results of those analyses are also discussed in this section.

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

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, although 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 HOV lane operating hours changed in the evening (at 7:00 PM). (Note that due to budget limitations, some locations were evaluated in only the predominant direction of traffic for each peak period, rather than both directions for both peak periods.)

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 Start of Revised Hours (2003)”) as time advanced 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 Start of Revised Hours (2004)”.) 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 near 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 as well as SR 520 westbound at NE 148th, 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, where traffic is typically lighter and there is less incentive to use the HOV lane.

Two years after the revised hours of operation began, eight of the 12 locations analyzed showed steadily increasing SOV shares of the HOV lane volumes during the 7:00 to 7:15 PM time period. Two other locations showed some drop in SOV share after two years in comparison to the one-year change, though both still showed a significant two-year net increase (a 16 percentage point increase on I-405 at NE 160th northbound, and an over 18 percentage point increase on SR 520 westbound at 148th Ave NE). Overall, only two locations showed a two-year change in SOV share of the HOV lane

volumes after 7:00 PM of less than +10 percentage points. One location, I-405 southbound at Cedar Avenue, showed a 10 percentage point increase in SOV share after the first year, but a two-year net drop in SOV share of slightly more than 3 percentage points. One other location, SR 167 southbound in Auburn, showed a little more than a 9 percentage point increase after the first year, but a two-year net increase in SOV share of slightly less than 5 percentage points. (These two locations were noted previously as having atypical “before” data. The Cedar Avenue location had a small sample size during the “before” time period that was used as the basis for comparison of these percentage point changes, while the Auburn location had an unusually high SOV share percentage in the “before” case. Both conditions could affect any before/after comparisons.)

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. After two years of operation, eight of the locations evaluated had an SOV share of 19 percent or higher, and eleven locations with sufficient data show SOV use of the HOV lane of 10 percent or greater after 7:00 PM. (This compares to two locations with an SOV share of 10 percent or more before the pilot project began, and nine locations one year after the pilot project began.)

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

Corridor	Location	Direction	Before Start of Revised Hours (2003)			After Start of Revised Hours (2003)			After Start of Revised Hours (2004)			After Start of Revised Hours (2005)		
			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	6:45-7:00 PM	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%	1.5%	17.5%	16.0%
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%	5.2%	20.3%	15.1%
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	n/a	n/a	n/a
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%	15.4%	37.8%	22.4%
I-405	Cedar Ave, Renton	N	1.2%	0.3%	-0.9%	0.9%	6.9%	6.0%	5.3%	14.9%	9.6%	0.5%	16.7%	16.2%
I-405	Cedar Ave, Renton	S	1.8%	13.5%	11.7%	3.9%	13.2%	9.4%	8.0%	23.3%	15.3%	2.9%	10.2%	7.3%
I-90	Newport Way, Issaquah	E	0.7%	0.8%	0.1%	1.3%	9.6%	8.3%	2.5%	7.2%	4.7%	6.0%	19.9%	13.9%
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%	9.3%	34.3%	25.0%
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%	12.4%	33.6%	21.2%
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%	0.0%	12.1%	12.1%
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%	4.5%	31.7%	27.2%
SR 520	NE 148th, Redmond	E	3.8%	5.7%	1.9%	2.0%	12.0%	10.0%	4.9%	19.4%	14.5%	0.0%	34.4%	34.4%
SR 520	NE 148th, Redmond	W	3.0%	2.2%	-0.8%	7.4%	12.5%	5.1%	8.5%	29.0%	20.5%	1.3%	20.8%	19.5%

Corridor	Location	Direction	SOV % Change during 7:00-7:15 PM		
			Initial Change (2003)	One-Year Change (2004)	Two-Year Change (2005)
I-405	NE 160th, Bothell	N	4.3%	17.7%	16.0%
I-405	NE 12th St, Bellevue	S	n/a	3.2%	16.9%
I-405	NE 30th St, Newcastle	N	8.1%	n/a	n/a
I-405	NE 30th St, Newcastle	S	7.5%	21.7%	29.1%
I-405	Cedar Ave, Renton	N	6.6%	14.6%	16.4%
I-405	Cedar Ave, Renton	S	-0.3%	9.8%	-3.3%
I-90	Newport Way, Issaquah	E	8.8%	6.4%	19.1%
SR 167	S 208th St, Renton	N	13.5%	22.6%	33.8%
SR 167	S 208th St, Renton	S	29.7%	29.0%	31.6%
SR 167	37th St. NW, Auburn	N	9.4%	1.4%	11.1%
SR 167	37th St. NW, Auburn	S	18.3%	9.5%	4.8%
SR 520	NE 148th, Redmond	E	6.3%	13.7%	28.7%
SR 520	NE 148th, Redmond	W	10.2%	26.8%	18.6%

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. After two years, six of those eight sites still had an ACO below 2.0; the other two were just above 2.0, while two other sites that had been at or above 2.0 after one year had dropped below 2.0 after two years.

As of 2005, the most notable examples are on southbound SR 167, SR 520 eastbound at 148th Ave NE, and I-405 southbound near Newcastle. At these locations, the ACO dropped to under 1.8.

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 two years, with every location showing further volume increases in each successive year. Therefore, the increase in the percentage of SOVs in the HOV lane most likely

corresponded to increased SOV volume, and not just 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)									
Corridor	Location	Dir.	Vehicle Volume				2003 Volume Change		2004 Volume Change		2005 Volume Change	
			Before (2003)	After (2003)	After (2004)	After (2005)	(%)	(number)	(%)	(number)	(%)	(number)
I-405	NE 160th, Bothell	N	109	159	192	236	46%	50	76%	83	117%	127
I-405	NE 12th St, Bellevue	S	128	170	176	223	33%	42	38%	48	74%	95
I-405	NE 30th St, Newcastle	N	142	215	245	253	51%	73	73%	103	78%	111
I-405	NE 30th St, Newcastle	S	203	317	352	379	56%	114	73%	149	87%	176
I-405	Cedar Ave, Renton	N	130	205	226	249	58%	75	74%	96	92%	119
I-405	Cedar Ave, Renton	S	147	259	316	361	76%	112	115%	169	146%	214
I-90	Newport Way, Issaquah	E	56	77	97	128	38%	21	73%	41	129%	72
SR 167	S 208th St, Renton	N	94	130	139	158	38%	36	48%	45	68%	64
SR 167	S 208th St, Renton	S	126	213	238	264	69%	87	89%	112	110%	138
SR 167	37th St. NW, Auburn	N	66	100	102	111	52%	34	55%	36	68%	45
SR 167	37th St. NW, Auburn	S	117	227	242	264	94%	110	107%	125	126%	147
SR 520	NE 148th, Redmond	E	51	68	75	83	33%	17	47%	24	63%	32
SR 520	NE 148th, Redmond	W	81	104	115	130	28%	23	42%	34	60%	49

HOV Vehicle Volume Trends			HOV Lane (7:00-7:15 PM)			
Corridor	Location	Dir.	ACO			
			Before (2003)	After (2003)	After (2004)	After (2005)
I-405	NE 160th, Bothell	N	2.15	2.12	1.96	2.01
I-405	NE 12th St, Bellevue	S	2.13	n/a	2.00	1.90
I-405	NE 30th St, Newcastle	N	2.06	2.18	n/a	n/a
I-405	NE 30th St, Newcastle	S	2.09	1.99	1.93	1.72
I-405	Cedar Ave, Renton	N	2.17	2.18	1.95	2.01
I-405	Cedar Ave, Renton	S	2.06	1.99	2.00	2.16
I-90	Newport Way, Issaquah	E	2.14	2.09	2.16	1.98
SR 167	S 208th St, Renton	N	2.35	2.04	1.86	1.80
SR 167	S 208th St, Renton	S	2.13	1.82	1.79	1.77
SR 167	37th St. NW, Auburn	N	2.22	2.18	2.09	2.28
SR 167	37th St. NW, Auburn	S	1.79	1.68	1.64	1.78
SR 520	NE 148th, Redmond	E	2.11	1.99	1.96	1.66
SR 520	NE 148th, Redmond	W	2.08	2.04	1.86	1.90

Table 4.2 (continued). ACO and Vehicle Volumes in the HOV Lane

HOV Vehicle Volume Trends			HOV Lane (7:00-8:00 PM)									
Corridor	Location	Dir.	Vehicle Volume				2003 Volume Change		2004 Volume Change		2005 Volume Change	
			Before (2003)	After (2003)	After (2004)	After (2005)	(%)	(number)	(%)	(number)	(%)	(number)
I-405	NE 160th, Bothell	N	366	537	658	774	47%	171	80%	292	111%	408
I-405	NE 12th St, Bellevue	S	419	518	583	781	24%	99	39%	164	86%	362
I-405	NE 30th St, Newcastle	N	526	789	900	969	50%	263	71%	374	84%	443
I-405	NE 30th St, Newcastle	S	677	1035	1239	1358	53%	358	83%	562	101%	681
I-405	Cedar Ave, Renton	N	481	738	839	941	53%	257	74%	358	96%	460
I-405	Cedar Ave, Renton	S	499	834	1088	1318	67%	335	118%	589	164%	819
I-90	Newport Way, Issaquah	E	181	248	311	439	37%	67	72%	130	143%	258
SR 167	S 208th St, Renton	N	349	478	524	618	37%	129	50%	175	77%	269
SR 167	S 208th St, Renton	S	462	752	867	987	63%	290	88%	405	114%	525
SR 167	37th St. NW, Auburn	N	240	366	387	439	53%	126	61%	147	83%	199
SR 167	37th St. NW, Auburn	S	416	783	865	967	88%	367	108%	449	132%	551
SR 520	NE 148th, Redmond	E	194	250	283	331	29%	56	46%	89	71%	137
SR 520	NE 148th, Redmond	W	276	357	425	481	29%	81	54%	149	74%	205

Overall Vehicle Volume Trends			All Lanes Combined (7:00-8:00 PM)									
Corridor	Location	Dir.	Vehicle Volume				2003 Volume Change		2004 Volume Change		2005 Volume Change	
			Before (2003)	After (2003)	After (2004)	After (2005)	(%)	(number)	(%)	(number)	(%)	(number)
I-405	NE 160th, Bothell	N	3817	4111	4211	4429	8%	294	10%	394	16%	612
I-405	NE 12th St, Bellevue	S	4730	4903	4753	4903	4%	173	0%	23	4%	173
I-405	NE 30th St, Newcastle	N	2826	3145	3201	3224	11%	319	13%	375	14%	398
I-405	NE 30th St, Newcastle	S	3536	3867	4019	4096	9%	331	14%	483	16%	560
I-405	Cedar Ave, Renton	N	3478	3889	3987	3782	12%	411	15%	509	9%	304
I-405	Cedar Ave, Renton	S	3392	3776	3981	4008	11%	384	17%	589	18%	616
I-90	Newport Way, Issaquah	E	2908	2881	3041	3247	-1%	-27	5%	133	12%	339
SR 167	S 208th St, Renton	N	2243	2461	2539	2688	10%	218	13%	296	20%	445
SR 167	S 208th St, Renton	S	3132	3307	3514	3640	6%	175	12%	382	16%	508
SR 167	37th St. NW, Auburn	N	2026	2243	2278	2388	11%	217	12%	252	18%	362
SR 167	37th St. NW, Auburn	S	2901	3122	3158	3270	8%	221	9%	257	13%	369
SR 520	NE 148th, Redmond	E	1695	1745	1773	1808	3%	50	5%	78	7%	113
SR 520	NE 148th, Redmond	W	2210	2250	2243	2291	2%	40	1%	33	4%	81

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 four years (2002, 2003, 2004, 2005). Looking at the 2003 values shows that 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 from spring to summer of 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, the year during which the pilot program was first implemented. A similar seasonal pattern was seen in 2004; here also, the magnitude of the change was smaller than that seen in 2003. In 2005, there was a slightly larger spring-to-summer change (usually between +2 percent and +4 percent) than in the pre-pilot project year of 2002 (usually +1 percent to +3 percent), but the change was still less than in 2003 when the hours of operation were revised.

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

Spring Traffic (7:00-7:30 PM)			Share of All Traffic Using HOV Lane (April-June)							
Corridor	Location	Mile Post	2005		2004		2003		2002	
			NB/EB	SB/WB	NB/EB	SB/WB	NB/EB	SB/WB	NB/EB	SB/WB
SR 167	S 208th St, Renton	22.92	20.9%	24.9%	19.7%	23.4%	15.8%	14.9%	16.2%	15.0%
SR 167	37th St. NW, Auburn	17.37	16.7%	28.1%	15.2%	26.0%	12.3%	14.5%	12.4%	16.4%
SR 520	NE 148th, Redmond	9.2	15.9%	19.2%	14.8%	17.9%	11.1%	12.6%	11.5%	11.4%
I-90	Newport Way, Issaquah	13.44	10.7%	10.0%	9.9%	9.5%	6.5%	8.5%	7.3%	9.1%
I-405	NE 160th, Bothell	22.46	16.7%	15.9%	16.5%	14.7%	9.9%	11.3%	10.1%	10.2%
I-405	NE 12th St, Bellevue	14.25	n/a	14.6%	10.3%	12.9%	8.1%	9.4%	7.7%	9.2%
I-405	NE 30th St, Newcastle	6.52	27.1%	32.9%	25.5%	30.5%	18.8%	20.3%	19.4%	20.0%
I-405	112th SE, Newcastle	8.92	25.0%	33.1%	23.5%	30.4%	17.5%	20.5%	17.7%	20.1%
I-405	Cedar Ave, Renton	3.57	22.1%	27.5%	18.3%	23.0%	14.0%	15.8%	15.3%	16.6%

Summer Traffic (7:00-7:30 PM)			Share of All Traffic Using HOV Lane (July-September)							
Corridor	Location	Mile Post	2005		2004		2003		2002	
			NB/EB	SB/WB	NB/EB	SB/WB	NB/EB	SB/WB	NB/EB	SB/WB
SR 167	S 208th St, Renton	22.92	22.9%	27.8%	20.7%	25.2%	19.7%	23.4%	16.7%	17.2%
SR 167	37th St. NW, Auburn	17.37	18.3%	30.4%	17.1%	28.3%	16.7%	26.1%	14.7%	19.0%
SR 520	NE 148th, Redmond	9.2	17.7%	21.2%	15.7%	18.8%	14.3%	16.0%	12.2%	12.8%
I-90	Newport Way, Issaquah	13.44	13.9%	14.1%	10.8%	10.8%	9.0%	10.7%	8.7%	10.5%
I-405	NE 160th, Bothell	22.46	18.6%	18.7%	16.6%	16.7%	13.7%	14.0%	11.7%	12.7%
I-405	NE 12th St, Bellevue	14.25	18.5%	16.9%	11.2%	13.4%	10.3%	12.0%	9.1%	10.5%
I-405	NE 30th St, Newcastle	6.52	30.2%	34.4%	28.6%	32.2%	25.5%	28.4%	22.1%	23.4%
I-405	112th SE, Newcastle	8.92	27.8%	34.8%	25.9%	32.1%	23.2%	28.9%	20.1%	24.2%
I-405	Cedar Ave, Renton	3.57	25.1%	35.2%	21.7%	29.5%	19.3%	24.2%	17.8%	24.4%

			Change in HOV Lane share (Summer vs. Spring)							
Corridor	Location	Mile Post	2005		2004		2003		2002	
			NB/EB	SB/WB	NB/EB	SB/WB	NB/EB	SB/WB	NB/EB	SB/WB
SR 167	S 208th St, Renton	22.92	2.1%	3.0%	1.0%	1.8%	3.9%	8.5%	0.5%	2.2%
SR 167	37th St. NW, Auburn	17.37	1.6%	2.3%	1.9%	2.3%	4.4%	11.6%	2.3%	2.6%
SR 520	NE 148th, Redmond	9.2	1.9%	1.9%	0.9%	0.9%	3.2%	3.4%	0.7%	1.4%
I-90	Newport Way, Issaquah	13.44	3.2%	4.1%	0.9%	1.3%	2.5%	2.1%	1.3%	1.3%
I-405	NE 160th, Bothell	22.46	1.9%	2.8%	0.1%	2.0%	3.7%	2.7%	1.6%	2.5%
I-405	NE 12th St, Bellevue	14.25	n/a	2.3%	0.9%	0.5%	2.2%	2.6%	1.4%	1.3%
I-405	NE 30th St, Newcastle	6.52	3.1%	1.5%	3.2%	1.7%	6.7%	8.1%	2.8%	3.4%
I-405	112th SE, Newcastle	8.92	2.8%	1.7%	2.4%	1.7%	5.6%	8.4%	2.4%	4.1%
I-405	Cedar Ave, Renton	3.57	3.0%	7.7%	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 and two years 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 start of revised hours 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. In 2005, the drop in ACO was 2.03 to 1.77. 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 and 2005.

Note also that in each of the “after” years, the ACO for the GP lanes increased after 7:00 PM (from 1.2 to 1.40 in 2003, from 1.20 to 1.27 in 2004, and from 1.04 to 1.09 in 2005). This could be the result of SOVs in the GP lane moving to the HOV lane, and/or some of the HOVs previously in the HOV lane moving to the GP lane. If the latter were occurring, the decrease in HOV lane ACO would not necessarily be 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, 2004, and 2005. (“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

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)	After (2005)	Before	After (2003)	After (2004)	After (2005)	Before	After (2003)	After (2004)	After (2005)
GP	1.22	1.20	1.14	1.10	1.20	1.19	1.20	1.04	1.22	1.40	1.27	1.09
HOV	2.18	2.17	2.14	2.12	2.21	2.11	2.05	2.03	2.13	1.82	1.79	1.77
SOV % in HOV lane	1.6%	2.4%	4.0%	4.4%	2.4%	8.4%	8.9%	12.4%	2.0%	31.7%	31.0%	33.6%

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			
	2005	2004	2003	2002	2005	2004	2003	2002	2005	2004	2003	2002
Spring	1833	1762	1664	1671	1377	1350	1416	1421	456	412	248	250
Summer	1893	1849	1757	1738	1366	1383	1345	1439	527	466	412	299
Volume change	60	87	93	67	-11	33	-71	18	71	54	164	49
%change	3.3%	4.9%	5.6%	4.0%	-0.8%	2.4%	-5.0%	1.3%	15.6%	13.1%	66.1%	19.6%

Vehicle Volume (7-7:30 PM)	HOV Lane Share			
	2005	2004	2003	2002
Spring	24.9%	23.4%	14.9%	15.0%
Summer	27.8%	25.2%	23.4%	17.2%

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			
	2005	2004	2003	2002	2005	2004	2003	2002	2005	2004	2003	2002
Spring	8326	8146	8220	8200	6741	6648	6725	6525	1585	1498	1495	1675
Summer	8335	8348	8160	8140	6427	6649	6520	6235	1908	1699	1640	1905
Volume change	9	202	-60	-60	-314	1	-205	-290	323	201	145	230
%change	0.1%	2.5%	-0.7%	-0.7%	-4.7%	0.0%	-3.0%	-4.4%	20.4%	13.4%	9.7%	13.7%

Vehicle Volume (5-7 PM)	HOV Lane Share			
	2005	2004	2003	2002
Spring	19.0%	18.4%	18.2%	20.4%
Summer	22.9%	20.4%	20.1%	23.4%

volume trends, one can see that the number of vehicles in the HOV lane grew by over 66 percent shortly 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, based on seasonal changes in the 2002 data. Meanwhile, the total (GP+HOV) directional roadway volume increased by over 5 percent from spring to summer 2003.

These initial patterns were sustained over the following years. Note that HOV volumes continued to increase, and the HOV lane share of 23 percent continued and even increased slightly. At the same time, the large increases in HOV usage and lane share of 2003 did not occur to the same extent in 2004 or 2005, 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, or the 20 percent growth in 2005. Note that the trends in vehicle volumes during the 2000-2003 time period are more difficult to interpret because of the more difficult economic conditions in the region during that time, which could affect commuting levels and HOV use.

While volumes were increasing in the HOV lane, including a significant number of SOVs, the distribution of vehicles by lane also changed. In 2005, the average volume distribution for this location changed from 20-42-38 percent (left HOV lane, middle GP

lane, and right GP lane, respectively) before 7:00 PM to 27-36-37 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 2005 (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. Similar patterns occurred in 2004 (see Table 4.6). 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 was 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 and two years 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. After two years of operation, the trend continued, with ACO going from 2.07 before 7:00 PM to 1.72 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, from 6.6 percent before 7:00 PM to 30.4 percent after 7:00 PM in 2004, and from 15.4 percent before 7:00 PM to 37.8 percent after 7:00 PM in 2005.

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

SR 167 Southbound at S. 204th Street
 7/1/05 through 8/31/05

July-August 2005	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	757	38.1%	710	36.9%
L2 = left GP lane	824	41.5%	684	35.6%
HOV = inside HOV lane	406	20.4%	530	27.5%

SR 167 Southbound at S. 204th Street
 7/1/04 through 8/31/04

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%

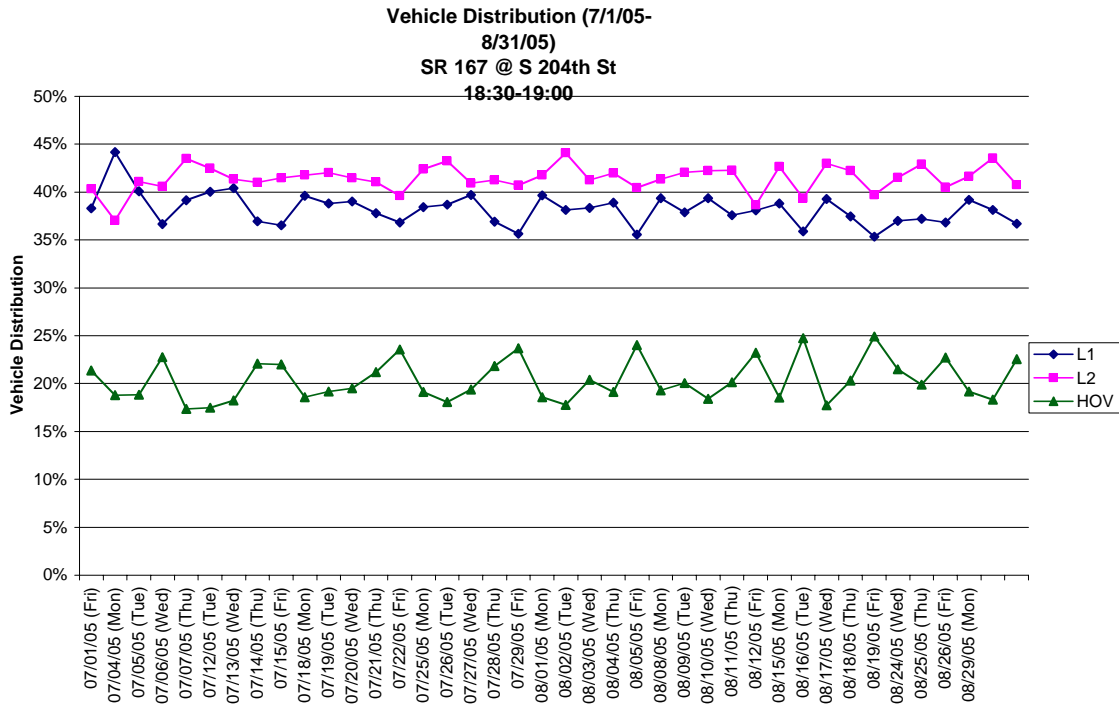


Figure 4.1. Distribution of Vehicles by Lane (6:30-7:00PM)

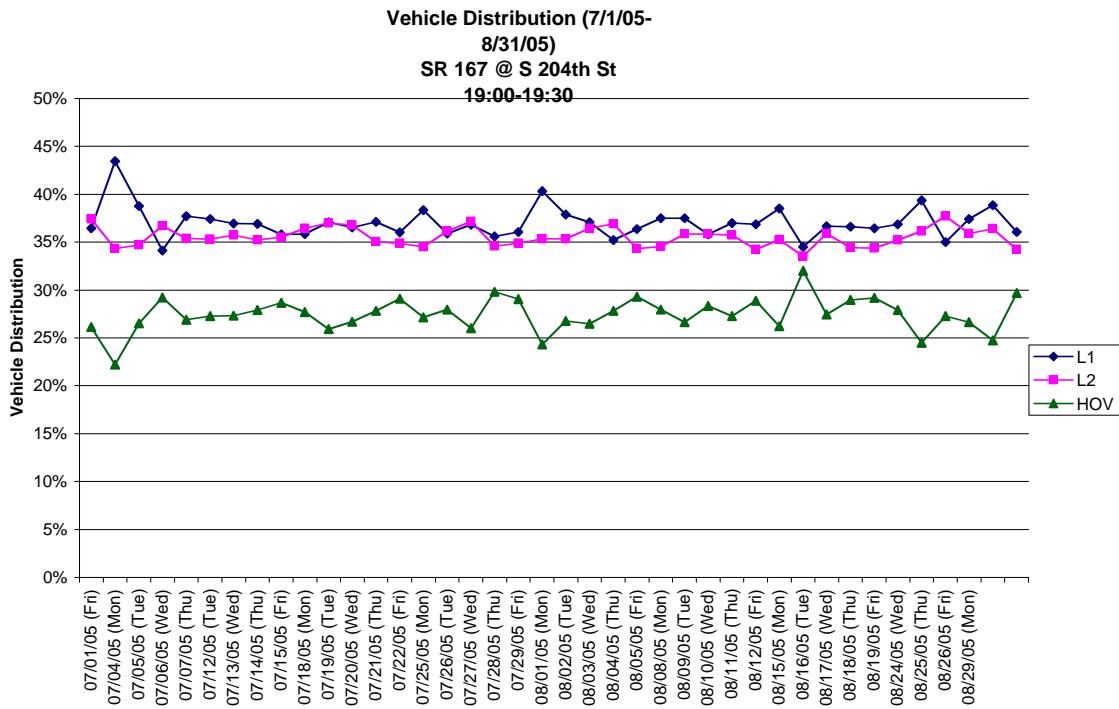


Figure 4.2. Distribution of Vehicles by Lane (7:00-7:30PM)

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

ACO	5-7 PM				6:45 to 7 PM				7 to 7:15 PM			
	Before	After (2003)	After (2004)	After (2005)	Before	After (2003)	After (2004)	After (2005)	Before	After (2003)	After (2004)	After (2005)
GP	1.08	n/a	1.1	1.08	1.16	n/a	1.09	1.18	1.26	n/a	1.02	1.33
HOV	2.16	2.15	2.26	2.14	2.19	2.12	2.22	2.07	2.09	1.99	1.93	1.72
SOV % in HOV lane	0.9%	0.6%	3.2%	7.0%	1.6%	1.5%	6.6%	15.4%	8.7%	16.2%	30.4%	37.8%

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, but several locations saw noticeable increases.

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 locations had an increase in violation rate of 1 percentage point or less. 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, although 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 based on limited data sampling.)

After two years, eight of the 12 locations showed a two-year net increase in violation rate of 1.1 percent or less (including some declines in violation rate) during the 6:45 to 7:00 PM period. Of the other four sites, two had net increases of 5.4 and 6.7 percentage points, while the other two had violation rate increases of 10 and 13.8

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	After (2005)	Two-Year SOV Shift
I-405	NE 160th, Bothell	N	1.5%	1.8%	0.3%	4.5%	3.0%	1.5%	0.0%
I-405	NE 12th St, Bellevue	S	4.7%	n/a	n/a	1.1%	-3.6%	5.2%	0.6%
I-405	NE 30th St, Newcastle	N	0.5%	3.0%	2.5%	n/a	n/a	n/a	n/a
I-405	NE 30th St, Newcastle	S	1.6%	1.5%	-0.1%	6.6%	5.0%	15.4%	13.8%
I-405	Cedar Ave, Renton	N	1.2%	0.9%	-0.3%	5.3%	4.1%	0.5%	-0.7%
I-405	Cedar Ave, Renton	S	1.8%	3.9%	2.0%	8.0%	6.2%	2.9%	1.1%
I-90	Newport Way, Issaquah	E	0.7%	1.3%	0.7%	2.5%	1.9%	6.0%	5.4%
SR 167	S 208th St, Renton	N	2.6%	5.5%	2.9%	8.1%	5.5%	9.3%	6.7%
SR 167	S 208th St, Renton	S	2.4%	8.4%	6.0%	8.9%	6.5%	12.4%	10.0%
SR 167	37th St. NW, Auburn	N	1.8%	2.8%	1.0%	0.0%	-1.8%	0.0%	-1.8%
SR 167	37th St. NW, Auburn	S	16.6%	25.5%	8.9%	15.4%	-1.2%	4.5%	-12.1%
SR 520	NE 148th, Redmond	E	3.8%	2.0%	-1.8%	4.9%	1.1%	0.0%	-3.8%
SR 520	NE 148th, Redmond	W	3.0%	7.4%	4.4%	8.5%	5.5%	1.3%	-1.7%
AM			5:00-7:00AM						
Corridor	Location	Dir	(before)	After (2003)	Initial SOV Shift	After (2004)	One-Year SOV Shift	After (2005)	Two-Year SOV Shift
I-405	NE 160th, Bothell	S	2.5%	2.7%	0.1%	0.8%	-1.7%	0.8%	-1.7%
I-405	NE 12th St, Bellevue	S	4.4%	n/a	n/a	8.4%	4.0%	2.2%	-2.2%
I-405	112th SE, Newcastle	N	5.6%	4.2%	-1.4%	9.0%	3.4%	6.9%	1.3%
I-405	NE 30th St, Newcastle	S	3.2%	3.3%	0.1%	n/a	n/a	n/a	n/a
I-405	Cedar Ave, Renton	N	2.6%	3.2%	0.6%	3.4%	0.8%	6.1%	3.5%
I-405	Cedar Ave, Renton	S	1.3%	n/a	n/a	0.9%	-0.4%	2.8%	1.5%
I-90	Newport Way, Issaquah	W	5.3%	1.6%	-3.6%	6.7%	1.5%	2.6%	-2.7%
SR 167	S 208th St, Renton	N	7.1%	2.6%	-4.5%	3.9%	-3.2%	2.8%	-4.3%
SR 167	S 208th St, Renton	S	7.5%	4.5%	-3.0%	2.9%	-4.6%	8.4%	0.9%
SR 167	37th St. NW, Auburn	N	5.1%	1.7%	-3.5%	3.5%	-1.6%	2.3%	-2.8%
SR 167	37th St. NW, Auburn	S	25.6%	16.5%	-9.1%	30.3%	4.8%	11.6%	-14.0%
SR 520	NE 148th, Redmond	E	1.4%	3.6%	2.2%	6.2%	4.8%	7.9%	6.5%
SR 520	NE 148th, Redmond	W	6.4%	7.3%	0.8%	2.3%	-4.1%	5.1%	-1.3%

percentage points. The latter two sites had the highest SOV violation rates after two years among the locations analyzed. Those locations were at SR 167 southbound at Renton (12.4 percent) and I-405 southbound near Newcastle (15.4 percent). These are locations that often feature evening GP congestion.

One other location, SR 167 southbound in Auburn, had AM violation rates ranging from 25.6 (before) to 11.6 percent (two years after) and PM rates of 16.6 percent (before) and 4.5 percent (two years after). 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 ends 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. Note, though, that the PM period rate dropped back to pre-pilot program levels in 2004, and then dropped further in 2005.

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 increased only 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 usually 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 did represent a slight overall increase in AM violation rates over the initial before/after comparison. The initial and one-year pattern of increases relative to initial 2003 results suggested the possibility of 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. After two years, however, only two locations had a two-year net increase of more than two percentage points.

Another source of data about violations in the HOV lane is the HERO program, an interagency effort that enables travelers to report violators in the HOV lanes by phone or on-line. A review of HERO data suggested that the number of calls to the HERO hotline was at approximately the same level in 2004-2005 as it was 2001-2002, and that there had not been a noticeable increase or decrease in the number of calls following implementation of the pilot project. In addition, there was no indication that any new "hot spot" locations (i.e., locations referenced by HERO callers more regularly) materialized in relation to the pilot project. For instance, locations that had traditionally been mentioned in HERO calls, such as the SR167/I-405 interchange, continued to be complaint locations.

Therefore, the HERO data were consistent with most of the other data reviewed; the hotline data did not show a significant rise in HOV lane violation rates, and were consistent with the results from the observed vehicle occupancy data.

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. The data samples showed that 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. Appendix A shows the average 24-hour GP and HOV performance graphs (overlying 2003 “before” and 2005 “after” data) for each location. In the graphs, the overall characteristics of the before and after patterns were usually similar to one another, although there were some 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, showed 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 immediately after 7:00 PM; some locations on I-405 and SR 520 also showed HOV volume increases. However, performance changes after 7:00 PM in terms of speed and congestion were difficult to determine from these graphs alone (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.

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.

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 gray 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.

One potential benefit of 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 discussed 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. These showed congestion during the PM peak period around 7:00 PM (see figures 4.3 through 4.14)³. 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 showed 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

³ For each graph, the 24-hour GP and HOV volume patterns are shown. The GP volume curve has an additional speed-based color.

the slow condition shortly after 7:00 PM. Similar patterns were seen at this location for selected days in May 2005, almost two years after the pilot program began.

At a location on I-405 (southbound at NE 30th near 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. Similar patterns were seen at this location for selected days in May 2005 as well.

While these examples were 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.

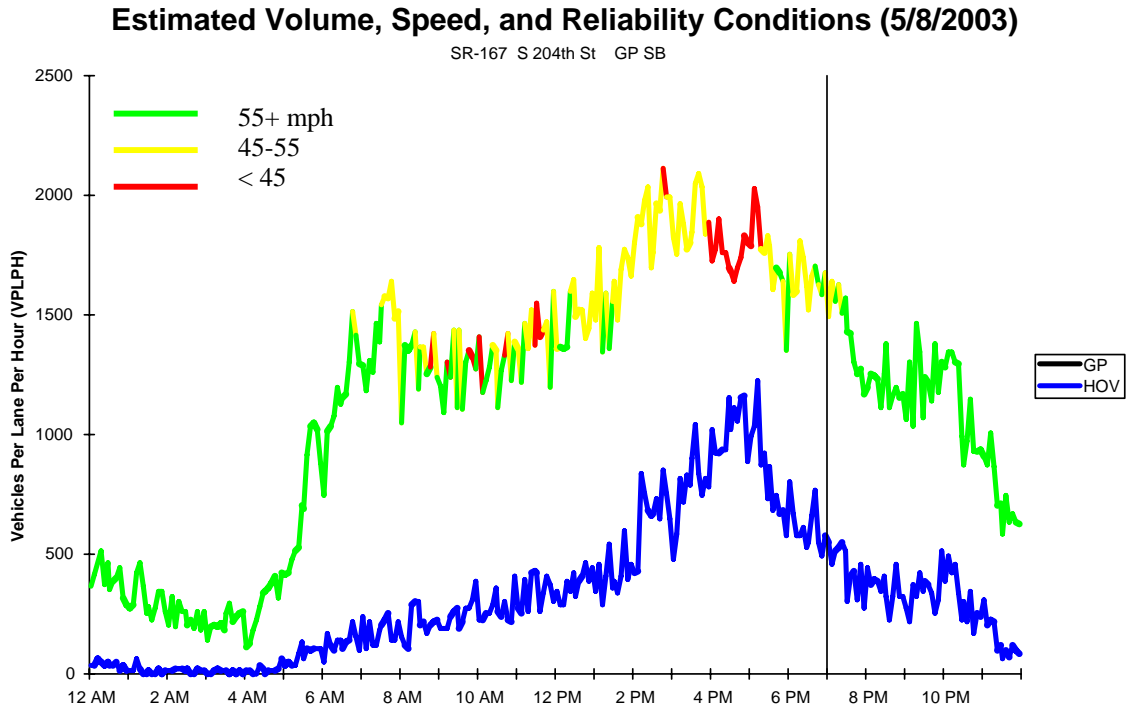


Figure 4.3. Performance Profile on SR 167 (May 8, 2003)

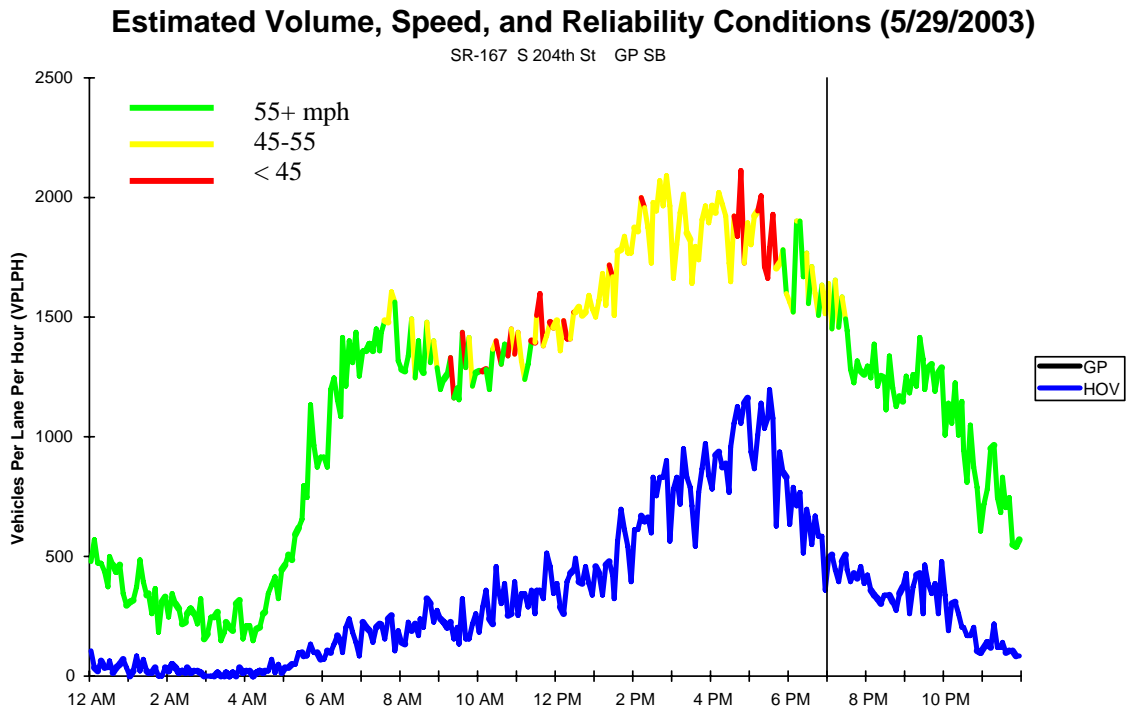


Figure 4.4. Performance Profile on SR 167 (May 29, 2003)

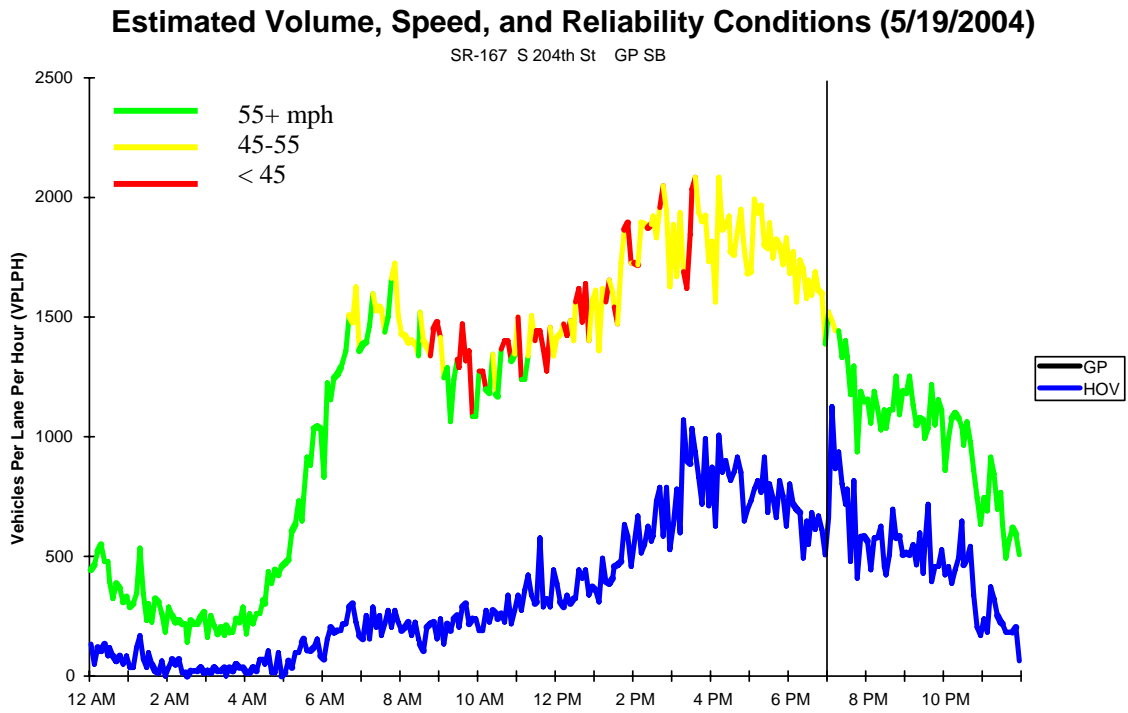


Figure 4.5. Performance Profile on SR 167 (May 19, 2004)

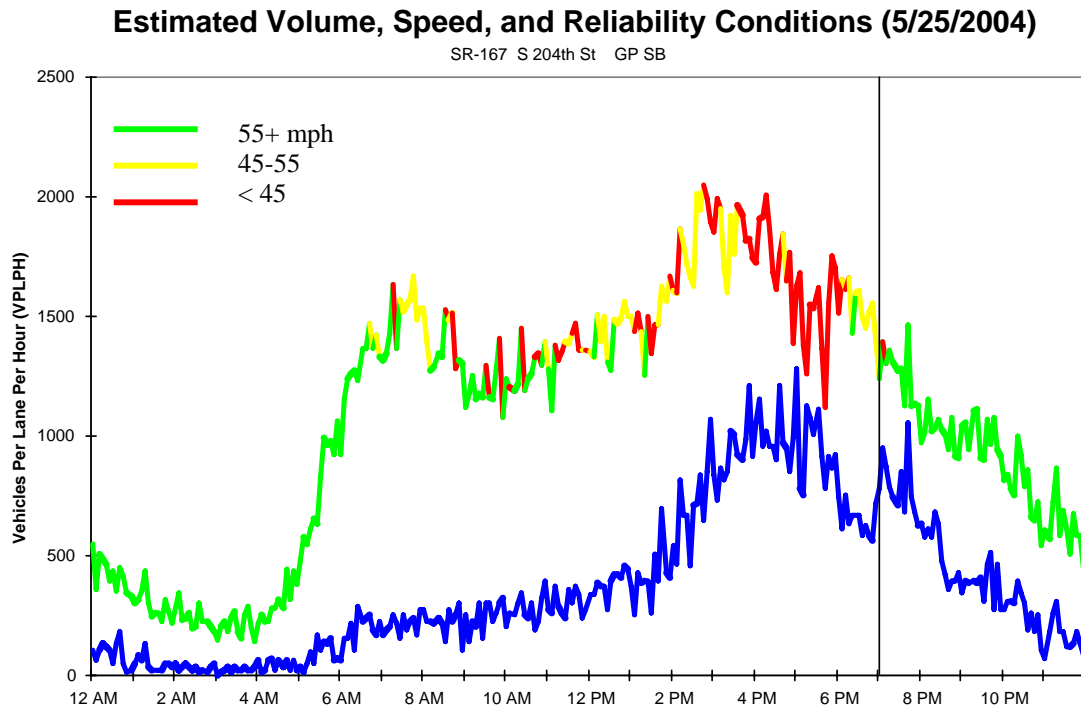


Figure 4.6. Performance Profile on SR 167 (May 25, 2004)

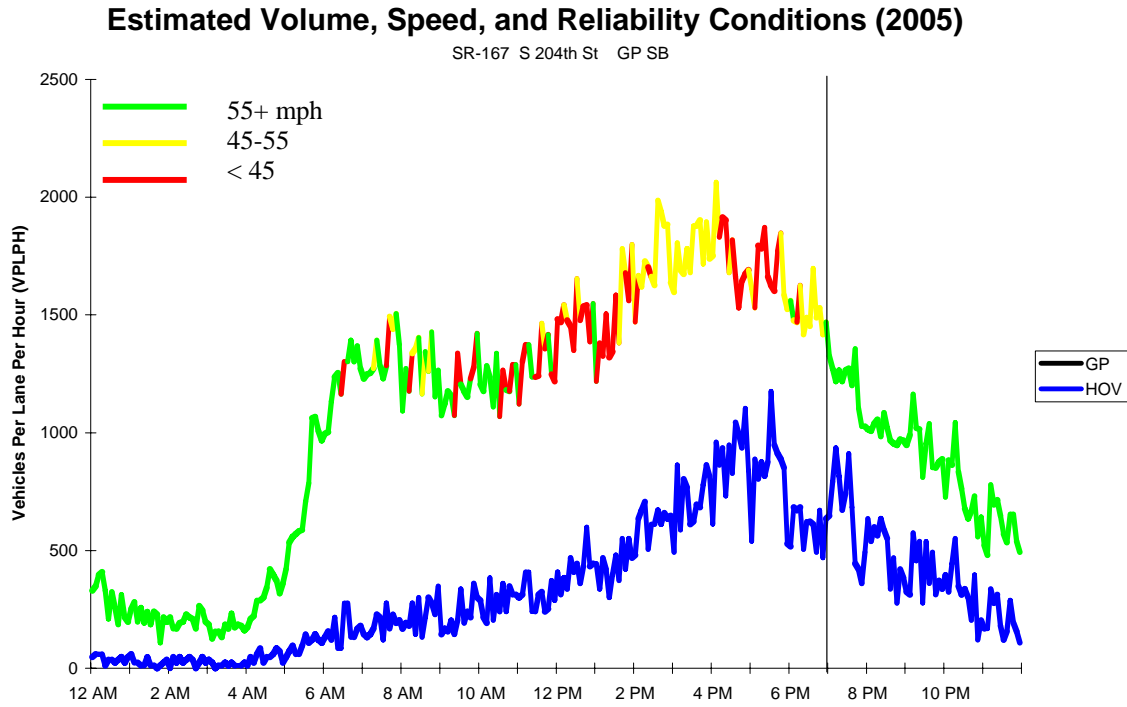


Figure 4.7. Performance Profile on I-405 (May 9, 2005)

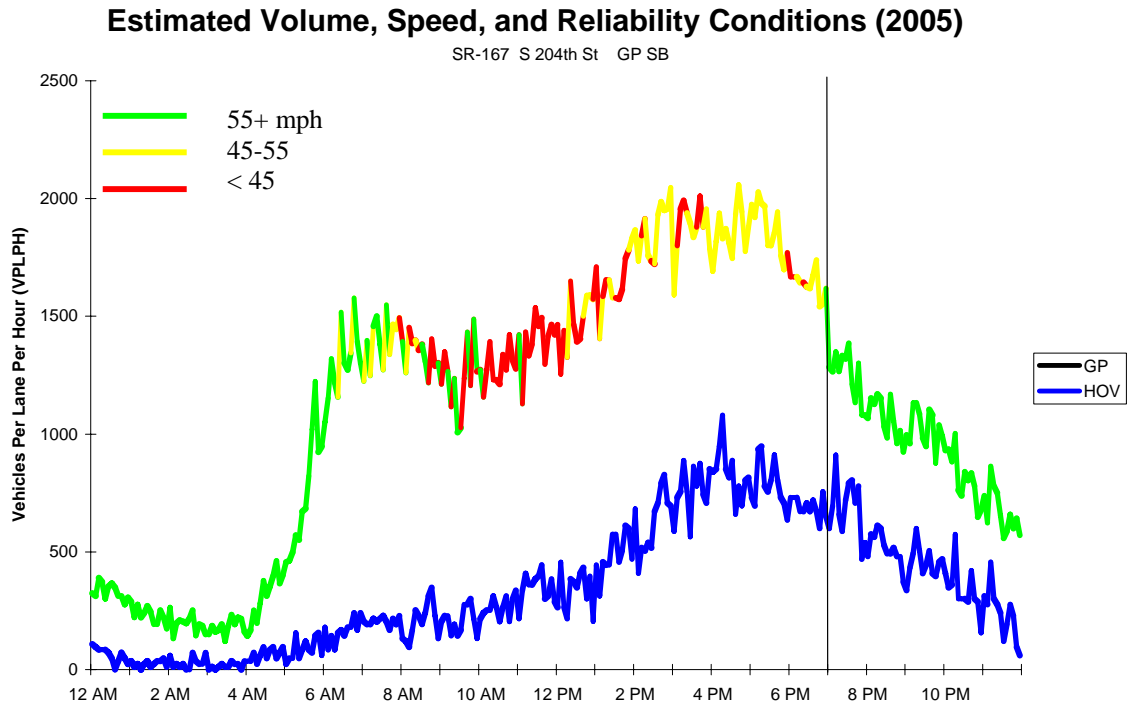


Figure 4.8. Performance Profile on I-405 (May 23, 2005)

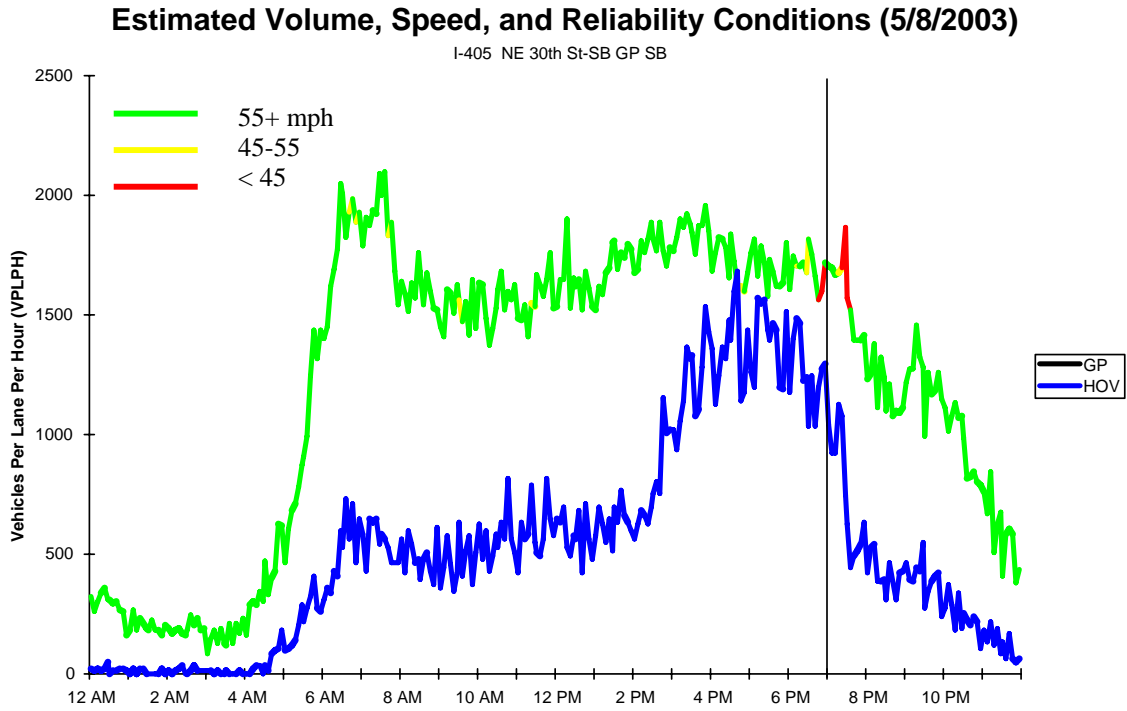


Figure 4.9. Performance Profile on I-405 (May 8, 2003)

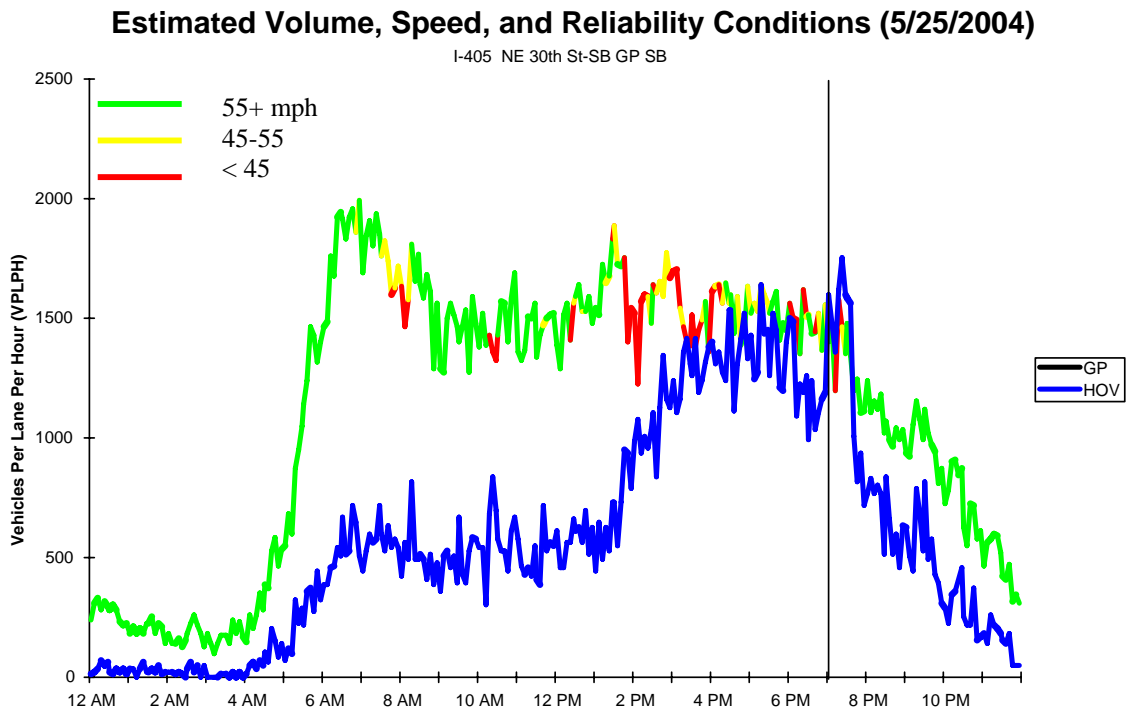


Figure 4.10. Performance Profile on I-405 (May 25, 2004)

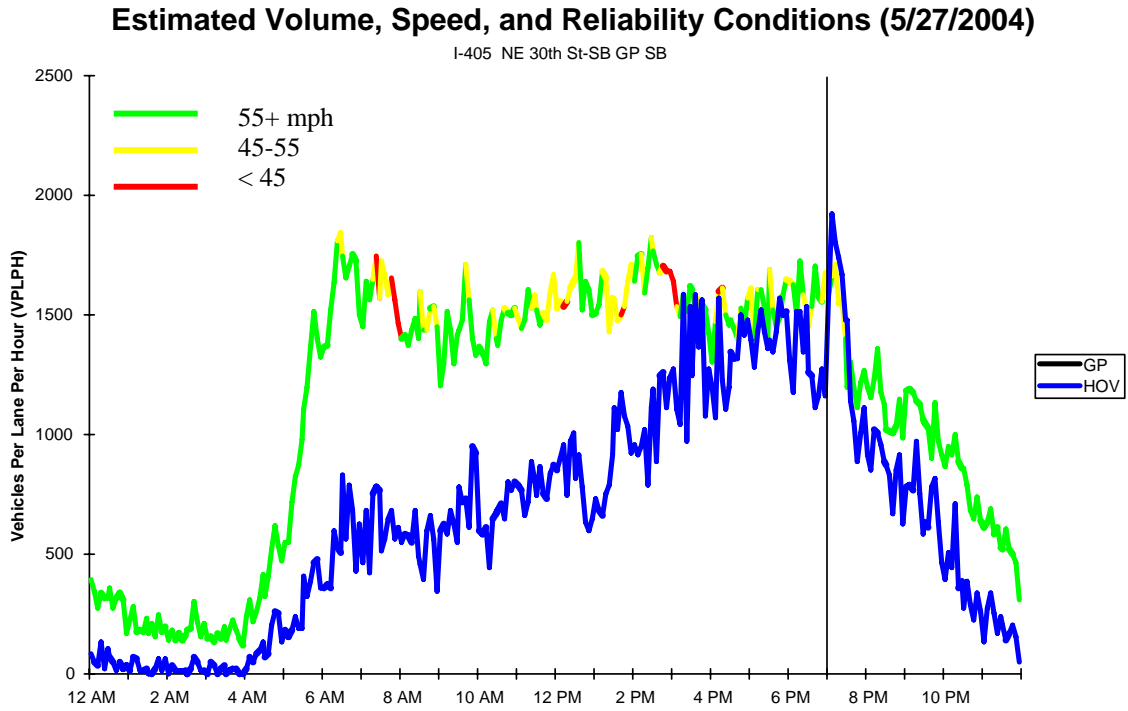


Figure 4.11. Performance Profile on I-405 (May 27, 2004)

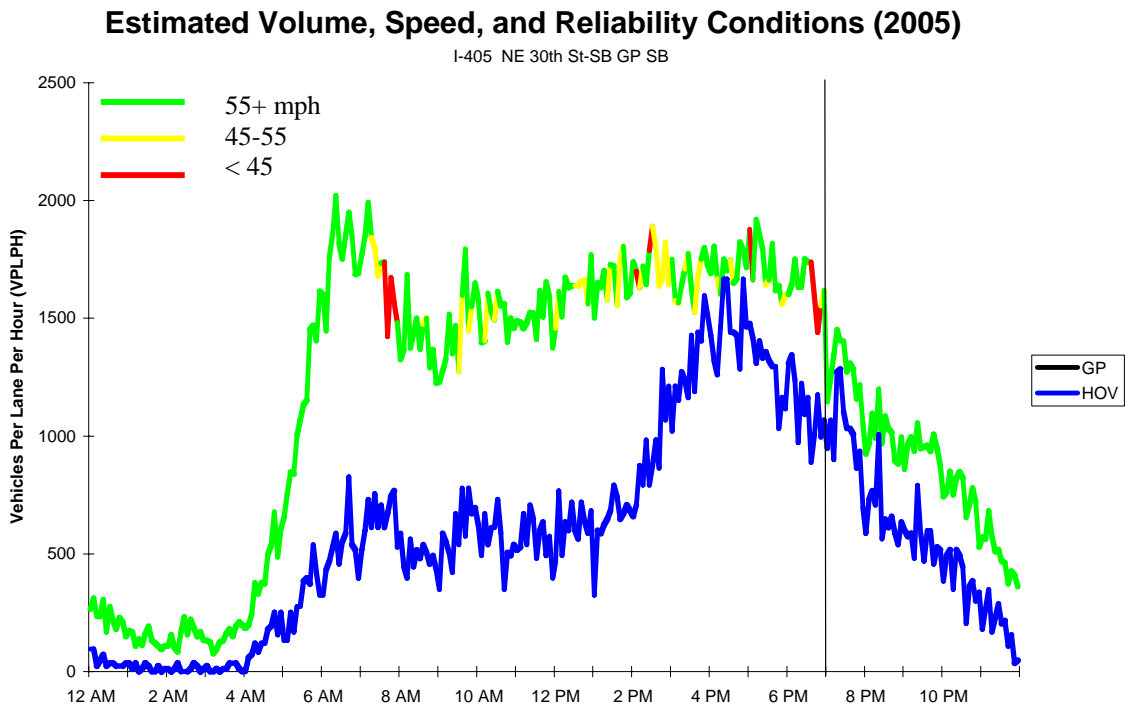


Figure 4.12. Performance Profile on I-405 (May 16, 2005)

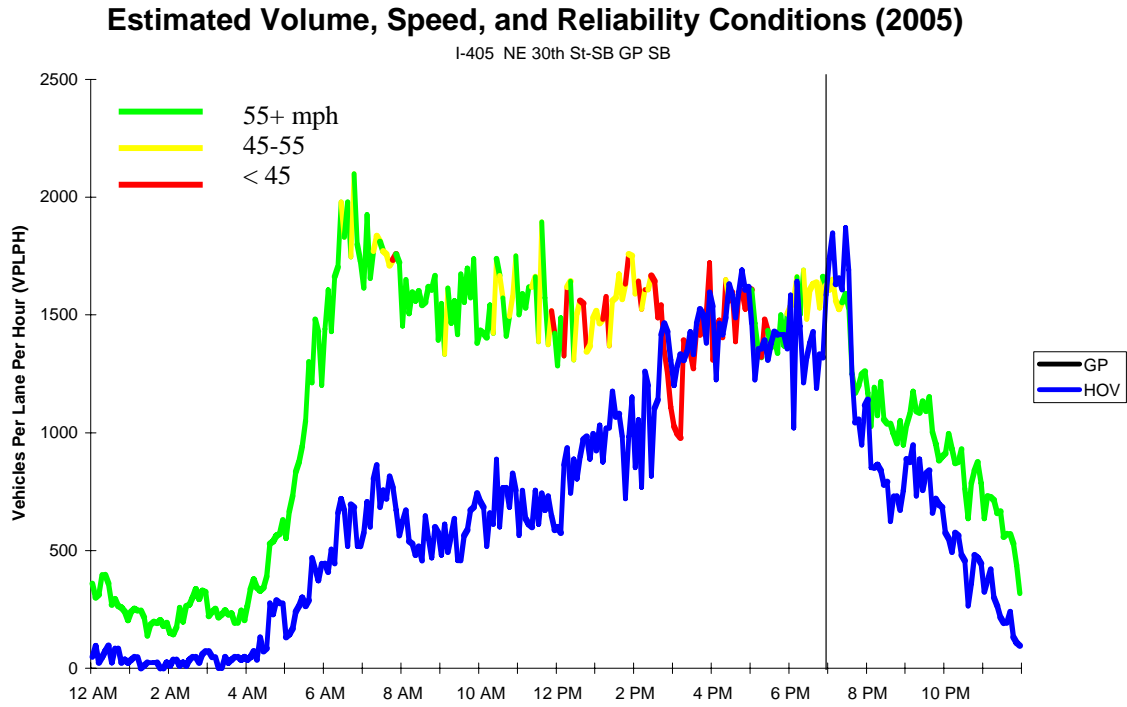


Figure 4.13. Performance Profile on I-405 (May 19, 2005)

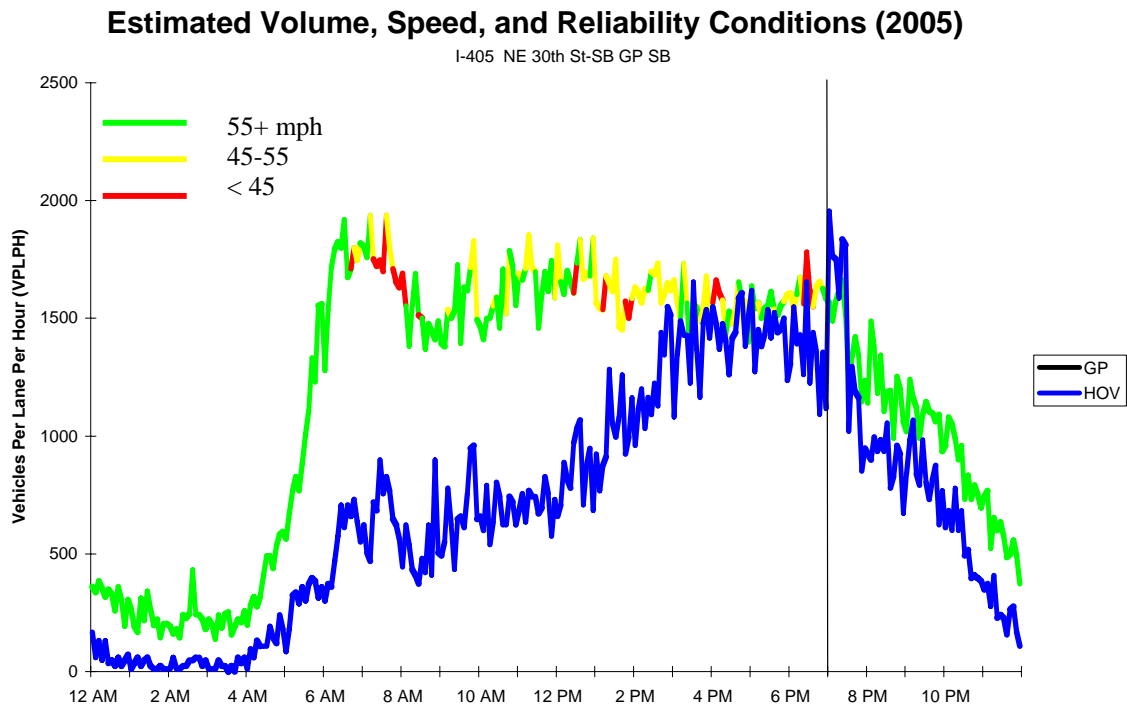


Figure 4.14. Performance Profile on I-405 (May 23, 2005)

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, 2004, and 2005 (2003 data were for a time period before the start of the pilot program, while 2004 and 2005 data represented “after” time periods). 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. The results showed 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 4.15 through 4.18 show the shift in speed distribution for the locations with the biggest increases in the 50-60 mph category after 7:00 PM.

Each year’s speed shift patterns were then compared with each other 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, for each year. While the speed shifts in each year were generally similar, there were some indications of differences in the patterns of 2003 (before the start of the pilot program) versus 2004 and 2005 (after the start). Note that the magnitude of the shifts in frequency of 50-60 mph speeds in the GP lanes in 2004 and 2005 was somewhat higher for some sites than the shift detected during the same periods in 2003 before the revised hours were implemented; this suggests the possibility that the observed change in GP speeds after 7:00 PM was more than what would normally have occurred at that time of day as traffic became lighter. In 2005, SR 167 southbound at Renton and Auburn (+12.9 percent and +17.1 percent), as well as southbound I-405 at Bellevue (+9.8 percent), showed the most significant increases in the frequency of higher (50-60 mph) GP speeds. Such changes could be attributed to the revised hours of operation.

Table 4.9. Distribution of Average 5-Minute Speeds Before/After 7:00 PM in GP and HOV Lanes (2003 through 2005).

Spring 2003 (before new hours)			GP Speed Distribution										
Corridor	Location	Dir.	6:45-7:00 PM					7:00-7:15 PM					mph
			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%	0%
I-405	NE 12th St, Bellevue	S	87%	1%	1%	3%	8%	94%	1%	1%	2%	2%	
I-405	NE 30th St, Newcastle	N	100%	0%	0%	0%	0%	100%	0%	0%	0%	0%	
I-405	NE 30th St, Newcastle	S	95%	3%	1%	1%	0%	96%	4%	0%	0%	0%	
I-405	Cedar Ave, Renton	N	93%	5%	0%	0%	2%	95%	3%	0%	0%	2%	
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	S 208th St, Renton	S	98%	2%	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	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 2003 (before new hours)			HOV Speed Distribution										
Corridor	Location	Dir.	6:45-7:00 PM					7:00-7:15 PM					mph
			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 12th St, Bellevue	S	96%	0%	2%	0%	2%	100%	0%	0%	0%	0%	
I-405	NE 30th St, Newcastle	N	100%	0%	0%	0%	0%	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	N	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	S 208th St, Renton	S	97%	3%	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	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 4.9 continued. Distribution of Average 5-Minute Speeds Before/After 7:00 PM in GP and HOV Lanes (2003 through 2005).

Spring 2004 (after one year)			GP Speed Distribution										
Corridor	Location	Dir.	6:45-7:00 PM					7:00-7:15 PM					mph
			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	93%	1%	3%	1%	1%	96%	1%	0%	1%	1%	
I-405	NE 12th St, Bellevue	S	92%	1%	3%	4%	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	NE 30th St, Newcastle	S	91%	7%	1%	1%	1%	93%	6%	1%	0%	0%	
I-405	Cedar Ave, Renton	N	95%	5%	0%	0%	0%	98%	2%	0%	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	S 208th St, Renton	S	88%	11%	1%	0%	0%	94%	6%	0%	0%	0%	
SR 167	37th St. NW, Auburn	N	100%	0%	0%	0%	0%	100%	0%	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 2004 (after one year)			HOV Speed Distribution										
Corridor	Location	Dir.	6:45-7:00 PM					7:00-7:15 PM					mph
			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	93%	0%	1%	1%	5%	92%	1%	0%	2%	5%	
I-405	NE 12th St, Bellevue	S	96%	0%	1%	0%	3%	100%	0%	0%	0%	0%	
I-405	NE 30th St, Newcastle	N	100%	0%	0%	0%	0%	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	N	100%	0%	0%	0%	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	S 208th St, Renton	S	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	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%	

Table 4.9 continued. Distribution of Average 5-Minute Speeds Before/After 7:00 PM in GP and HOV Lanes (2003 through 2005).

Spring 2005 (after two years)			GP Speed Distribution										
Corridor	Location	Dir.	6:45-7:00 PM					7:00-7:15 PM					mph
			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	87%	3%	5%	2%	2%	92%	4%	2%	2%	1%	
I-405	NE 12th St, Bellevue	S	83%	0%	3%	5%	9%	92%	0%	4%	0%	4%	
I-405	NE 30th St, Newcastle	N	98%	0%	1%	1%	1%	99%	1%	0%	0%	0%	
I-405	NE 30th St, Newcastle	S	85%	11%	0%	4%	1%	91%	8%	2%	0%	0%	
I-405	Cedar Ave, Renton	N	98%	0%	0%	0%	2%	99%	1%	0%	0%	0%	
I-405	Cedar Ave, Renton	S	98%	0%	0%	0%	2%	99%	1%	0%	0%	0%	
I-90	Newport Way, Issaquah	E	98%	0%	0%	0%	2%	98%	0%	0%	0%	2%	
SR 167	S 208th St, Renton	N	99%	1%	0%	0%	0%	100%	0%	0%	0%	0%	
SR 167	S 208th St, Renton	S	68%	31%	1%	0%	0%	81%	19%	0%	0%	0%	
SR 167	37th St. NW, Auburn	N	99%	1%	0%	0%	0%	100%	0%	0%	0%	0%	
SR 167	37th St. NW, Auburn	S	83%	17%	0%	0%	0%	100%	0%	0%	0%	0%	
SR 520	NE 148th, Redmond	E	99%	0%	0%	1%	0%	100%	0%	0%	0%	0%	
SR 520	NE 148th, Redmond	W	95%	0%	0%	0%	5%	99%	0%	0%	0%	1%	

Spring 2005 (after two years)			HOV Speed Distribution										
Corridor	Location	Dir.	6:45-7:00 PM					7:00-7:15 PM					mph
			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	91%	0%	0%	1%	8%	86%	1%	2%	2%	10%	
I-405	NE 12th St, Bellevue	S	92%	0%	2%	1%	5%	95%	0%	0%	2%	3%	
I-405	NE 30th St, Newcastle	N	99%	1%	0%	0%	0%	100%	0%	0%	0%	0%	
I-405	NE 30th St, Newcastle	S	99%	1%	0%	0%	0%	98%	2%	0%	0%	0%	
I-405	Cedar Ave, Renton	N	99%	0%	1%	0%	0%	100%	0%	0%	0%	0%	
I-405	Cedar Ave, Renton	S	99%	0%	1%	0%	0%	100%	0%	0%	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	S 208th St, Renton	S	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	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	98%	0%	0%	0%	2%	100%	0%	0%	0%	0%	

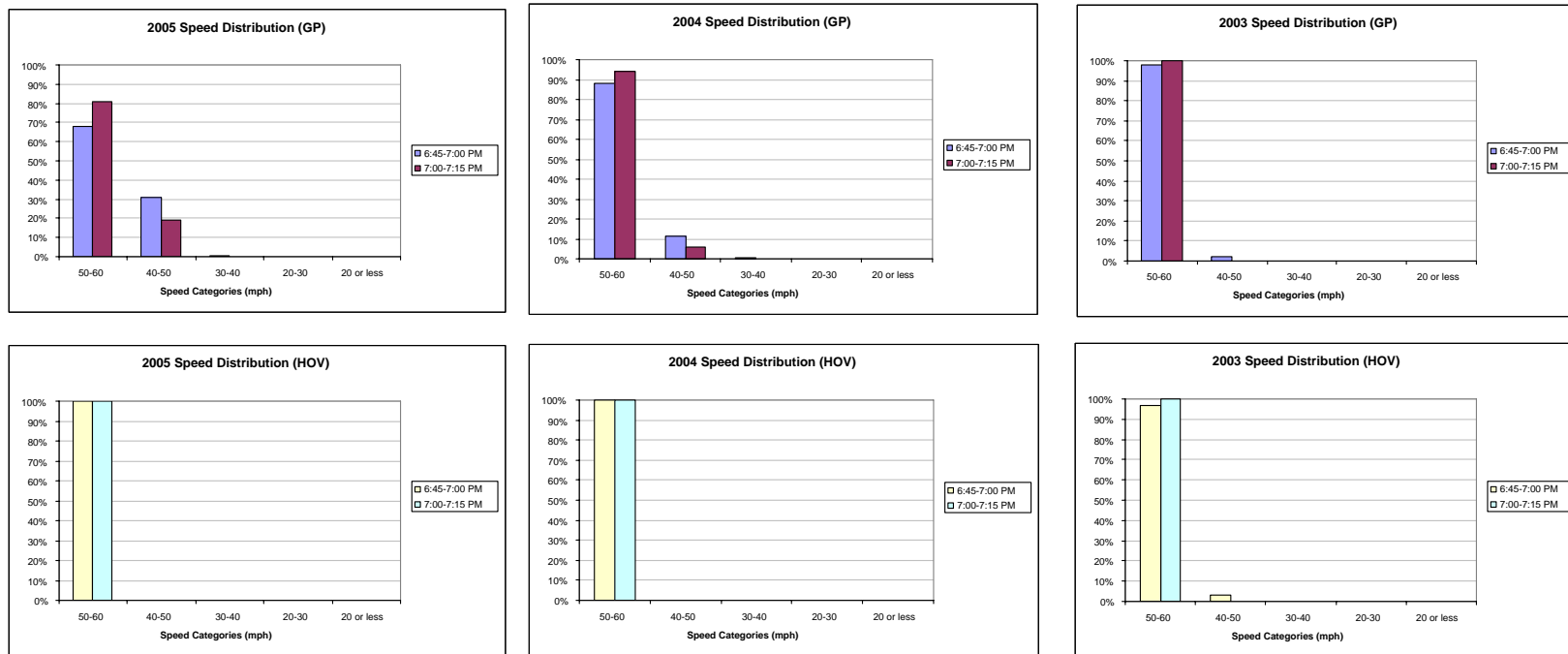


Figure 4.15. Change in Distribution of Average 5-Minute GP and HOV Speeds After 7:00 PM, I-405 SB at NE 12th Street (2003 through 2005).

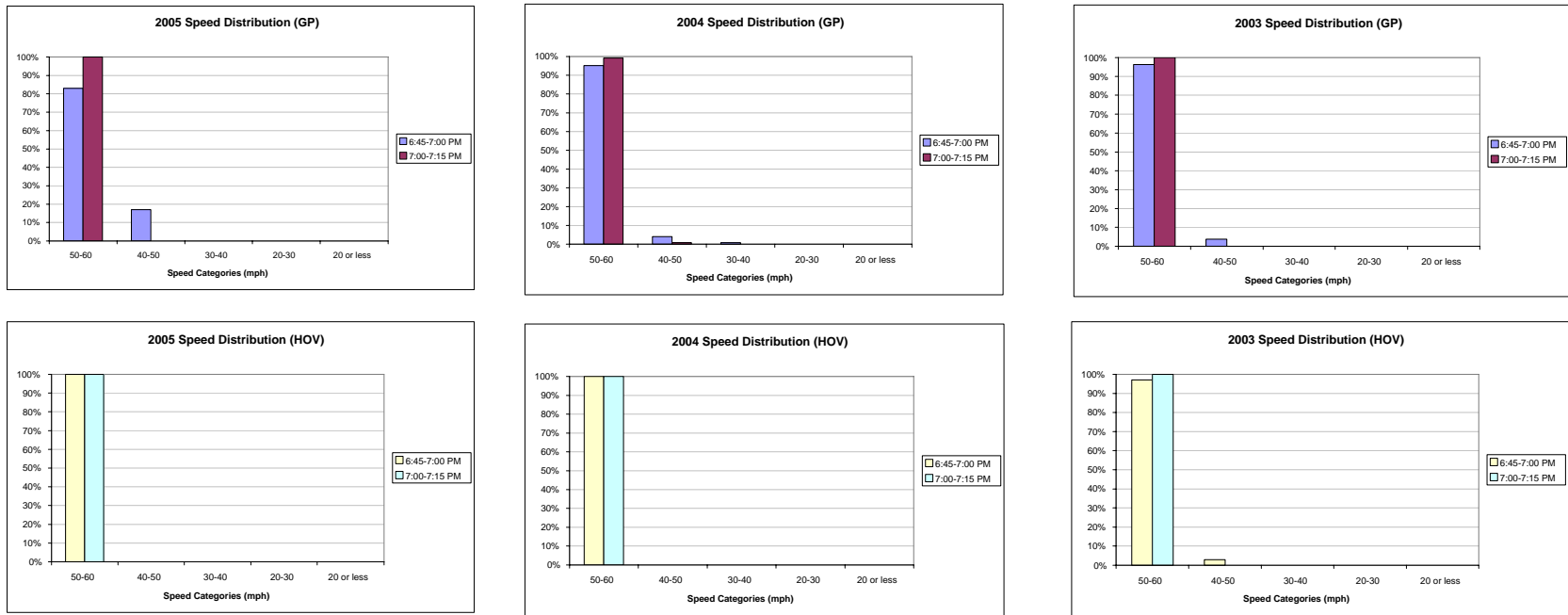


Figure 4.16. Change in Distribution of Average 5-Minute GP and HOV Speeds After 7:00 PM, SR 520 WB at NE 148th (2003 through 2005).

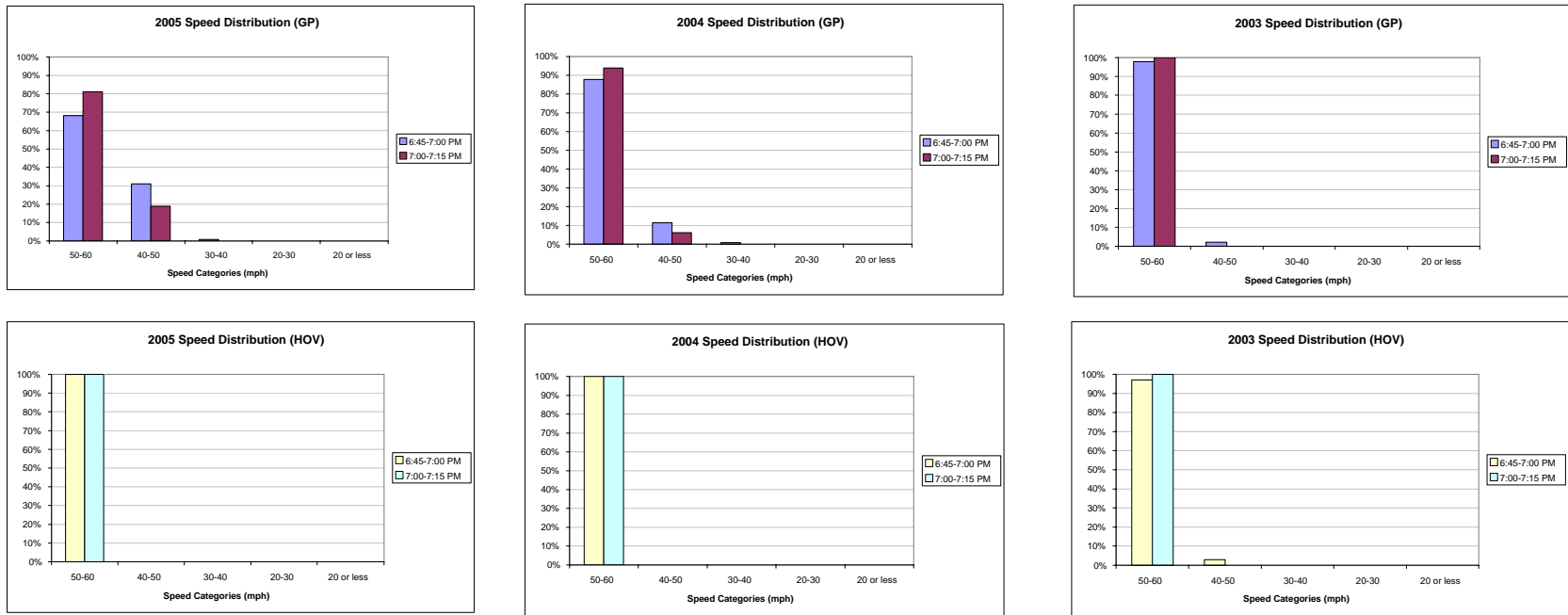


Figure 4.17. Change in Distribution of Average 5-Minute GP and HOV Speeds After 7:00 PM, SR 167 SB at S. 208th (2003 through 2005).

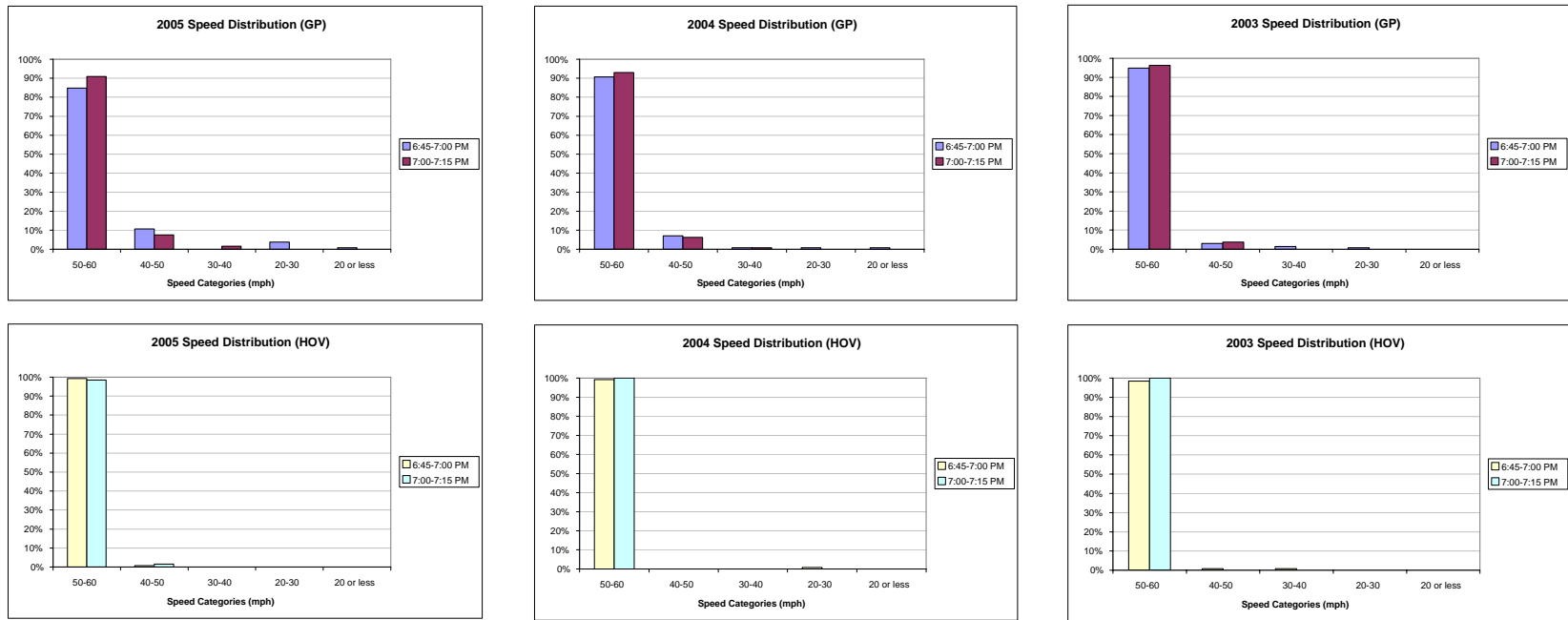


Figure 4.18. Change in Distribution of Average 5-Minute GP and HOV Speeds After 7:00 PM, I-405 SB at Cedar Avenue (2003 through 2005).

Table 4.10. Change in Average GP and HOV Speed Distribution Before/After 7:00 PM (2003 through 2005).

GP Spring Data			Change in Speed Distribution (7:00-7:15 PM vs. 6:45-7:00 PM)																
Corridor	Location	Dir.	2005 (two years after start of revised hours)					2004 (one year after start of revised hours)					2003 (before start of revised hours)						
			50-60	40-50	30-40	20-30	20 or less	mph	50-60	40-50	30-40	20-30	20 or less	mph	50-60	40-50	30-40	20-30	20 or less
I-405	NE 160th, Bothell	N	5.3%	0.8%	(3.8%)	(0.8%)	(1.5%)	3.0%	(0.0%)	(3.0%)	(0.0%)	(0.0%)	1.5%	(0.7%)	(0.7%)	0.0%	0.0%		
I-405	NE 12th St, Bellevue	S	9.8%	0.0%	0.8%	(5.3%)	(5.3%)	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	N	1.5%	0.8%	(0.8%)	(0.8%)	(0.8%)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		
I-405	NE 30th St, Newcastle	S	6.1%	(3.0%)	1.5%	(3.8%)	(0.8%)	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	N	1.5%	0.8%	0.0%	0.0%	(2.3%)	3.0%	(3.0%)	0.0%	0.0%	0.0%	1.5%	(2.3%)	0.0%	0.0%	0.8%		
I-405	Cedar Ave, Renton	S	1.5%	0.8%	0.0%	0.0%	(2.3%)	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	0.0%	0.0%	0.0%	0.0%	0.0%	(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	0.8%	(0.8%)	0.0%	0.0%	0.0%	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	12.9%	(12.1%)	(0.8%)	0.0%	0.0%	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	N	0.9%	(0.9%)	0.0%	0.0%	0.0%	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	S	17.1%	(17.1%)	0.0%	0.0%	0.0%	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	0.8%	0.0%	0.0%	(0.8%)	0.0%	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	4.5%	0.0%	0.0%	0.0%	(4.5%)	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)																
Corridor	Location	Dir.	2005 (two years after start of revised hours)					2004 (one year after start of revised hours)					2003 (before start of revised hours)						
			50-60	40-50	30-40	20-30	20 or less	mph	50-60	40-50	30-40	20-30	20 or less	mph	50-60	40-50	30-40	20-30	20 or less
I-405	NE 160th, Bothell	N	(5.3%)	0.8%	1.5%	1.5%	1.5%	(0.7%)	0.7%	(0.7%)	0.7%	0.0%	1.5%	0.0%	0.0%	0.0%	0.0%	(1.5%)	
I-405	NE 12th St, Bellevue	S	3.0%	0.0%	(2.3%)	1.5%	(2.3%)	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	N	0.8%	(0.8%)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		
I-405	NE 30th St, Newcastle	S	(0.8%)	0.8%	0.0%	0.0%	0.0%	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	N	0.8%	0.0%	(0.8%)	0.0%	0.0%	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	S	0.8%	0.0%	(0.8%)	0.0%	0.0%	(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%	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%	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%	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	N	0.0%	0.0%	0.0%	0.0%	0.0%	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	S	0.0%	0.0%	0.0%	0.0%	0.0%	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%	0.0%	0.0%	0.0%	0.0%	0.0%		
SR 520	NE 148th, Redmond	W	1.5%	0.0%	0.0%	0.0%	(1.5%)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		

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 or 2005, although in 2003, a small shift was noticeable at several locations.

While these data suggest an upward shift in GP speeds after 7:00 PM beyond the shift that would have been expected at that time of day, the magnitudes of the shift were usually not large and reflected a change from a base level that was already high. In addition, small speed changes near the boundaries of the speed categories could result in large changes in the percentage of speeds in each category (e.g., if speeds just under 50 mph increased slightly to speeds just over 50 mph). Note also that the examples shown in figures 4.15 through 4.18 highlighted only the locations with the largest estimated shifts toward higher speeds.

Another way to analyze these data was to summarize the change in speeds at 7:00 PM in terms of average speed (see Table 4.11). Overall, any changes in the average speed after 7:00 PM were usually small, especially given the corresponding changes during the 2003 “before” period. After two years, average GP speeds increased by 0 to 2 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). Three of the locations showed GP speed changes of up to +4 mph in 2005; those locations correspond to I-405 southbound at NE 12th, and SR 167 southbound in Renton and Auburn.

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.

Table 4.11. Average GP and HOV Speeds Before/After 7:00 PM (2003 through 2005).

Spring data			Average GP Speed								
Corridor	Location	Dir.	2005			2004			2003		
			6:45-7:00 PM	7:00-7:15 PM	Change (mph)	6:45-7:00 PM	7:00-7:15 PM	Change (mph)	6:45-7:00 PM	7:00-7:15 PM	Change (mph)
I-405	NE 160th, Bothell	N	56	58	2	58	59	1	60	60	0
I-405	NE 30th St, Newcastle	N	59	60	1	60	60	0	60	60	0
I-405	NE 12th St, Bellevue	S	53	57	4	58	60	2	55	58	3
I-405	NE 30th St, Newcastle	S	55	58	2	57	58	1	58	59	1
I-405	Cedar Ave, Renton	N	58	59	2	56	57	1	55	55	0
I-405	Cedar Ave, Renton	S	58	59	2	50	52	2	54	55	1
I-90	Newport Way, Issaquah	E	59	59	0	59	59	0	58	58	0
SR 167	S 208th St, Renton	N	60	60	0	60	60	0	60	60	0
SR 167	S 208th St, Renton	S	52	57	4	55	58	3	56	58	2
SR 167	37th St. NW, Auburn	N	60	60	0	60	60	0	60	60	0
SR 167	37th St. NW, Auburn	S	56	60	4	58	60	2	58	59	1
SR 520	NE 148th, Redmond	E	60	60	0	60	60	0	60	60	0
SR 520	NE 148th, Redmond	W	57	60	2	57	60	3	58	58	0

Spring data			Average HOV Speed								
Corridor	Location	Dir.	2005			2004			2003		
			6:45-7:00 PM	7:00-7:15 PM	Change (mph)	6:45-7:00 PM	7:00-7:15 PM	Change (mph)	6:45-7:00 PM	7:00-7:15 PM	Change (mph)
I-405	NE 160th, Bothell	N	56	54	-2	57	57	0	58	59	1
I-405	NE 12th St, Bellevue	S	57	58	1	58	60	2	59	60	1
I-405	NE 30th St, Newcastle	N	60	60	0	60	60	0	60	60	0
I-405	NE 30th St, Newcastle	S	56	56	0	60	60	0	60	60	0
I-405	Cedar Ave, Renton	N	60	60	0	60	60	0	60	60	0
I-405	Cedar Ave, Renton	S	60	60	0	59	57	-1	59	59	0
I-90	Newport Way, Issaquah	E	60	60	0	60	60	0	60	60	0
SR 167	S 208th St, Renton	N	60	60	0	60	60	0	60	60	0
SR 167	S 208th St, Renton	S	60	60	0	60	60	0	60	60	0
SR 167	37th St. NW, Auburn	N	60	60	0	60	60	0	60	60	0
SR 167	37th St. NW, Auburn	S	60	60	0	60	60	0	60	60	0
SR 520	NE 148th, Redmond	E	60	60	0	60	60	0	60	60	0
SR 520	NE 148th, Redmond	W	59	60	1	60	60	0	60	60	0

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 versus 2005 on I-405 southbound and on SR 167 southbound. These are both corridors that have frequent evening GP congestion (a condition that would tend to encourage SOV use of the HOV lane). Table 4.12 shows the HOV count across all lanes before and after 7:00 PM, in 2003, 2004, and 2005, for southbound I-405

near Newcastle and southbound SR 167 in Renton and Auburn. It shows that from 2003 to 2004, HOV volumes increased on SR 167 but decreased on I-405. However, after two years of the pilot program, net HOV formation trends showed the opposite; SR 167 HOV counts decreased, while I-405 volumes have increased somewhat. However, the SR 167 trends were complicated by a restriping project that removed a bottleneck, thereby improving GP performance significantly and thus reducing the incentive to bypass congestion via the HOV lanes. In addition, parallel Sound Transit service competed for HOV travelers. These results are not conclusive regarding the potential effect of the pilot project on HOV formation, although the speed analyses suggest that HOV lane performance was not adversely affected by the revised hours of operation.

As part of the analyses of performance changes, two locations on I-5 (where the revised hours of HOV lane operation were not in effect) were also monitored as control sites to evaluate any performance changes that might have occurred on the freeway network during the 2003-2005 period, independent of the revised hours of operation. At those two sites, there was generally little or no change in performance from 2003 to 2005 at the transition times of approximately 5:00 AM and 7:00 PM (see figures 4.19-4.26). In particular, performance changes observed at other locations that were subject to the revised hours of operation (e.g., the noticeable volume increase in the HOV lane shortly after 7:00 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.

Table 4.12. HOV and GP Volumes on I-405 and SR 167 Southbound Before/After 7:00 PM (2003 through 2005)

TOTAL Volume			6:45-7:00 PM		7:00-7:15 PM	
2005 Spring	Location	Direction	HOV	GP	HOV	GP
SR 167	S 208th St, Renton	S	165	786	167	770
SR 167	37th St. NW, Auburn	S	179	701	155	681
I-405	NE 30th St, Newcastle	S	357	727	410	676
2004 Spring	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
I-405	NE 30th St, Newcastle	S	295	785	233	823
2003 Spring	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
I-405	NE 30th St, Newcastle	S	319	713	348	625

Volume CHANGE			6:45-7:00 PM		7:00-7:15 PM	
2005 vs 2003	Location	Direction	HOV	GP	HOV	GP
SR 167	S 208th St, Renton	S	-103	142	-82	171
SR 167	37th St. NW, Auburn	S	-51	75	-41	71
I-405	NE 30th St, Newcastle	S	38	14	62	51
2005 vs 2004	Location	Direction	HOV	GP	HOV	GP
SR 167	S 208th St, Renton	S	-110	137	-98	136
SR 167	37th St. NW, Auburn	S	-91	99	-106	117
I-405	NE 30th St, Newcastle	S	62	-58	177	-147
2004 vs 2003	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
I-405	NE 30th St, Newcastle	S	-24	72	-115	198

Estimated Volume, Speed, and Reliability Conditions (2003-05)

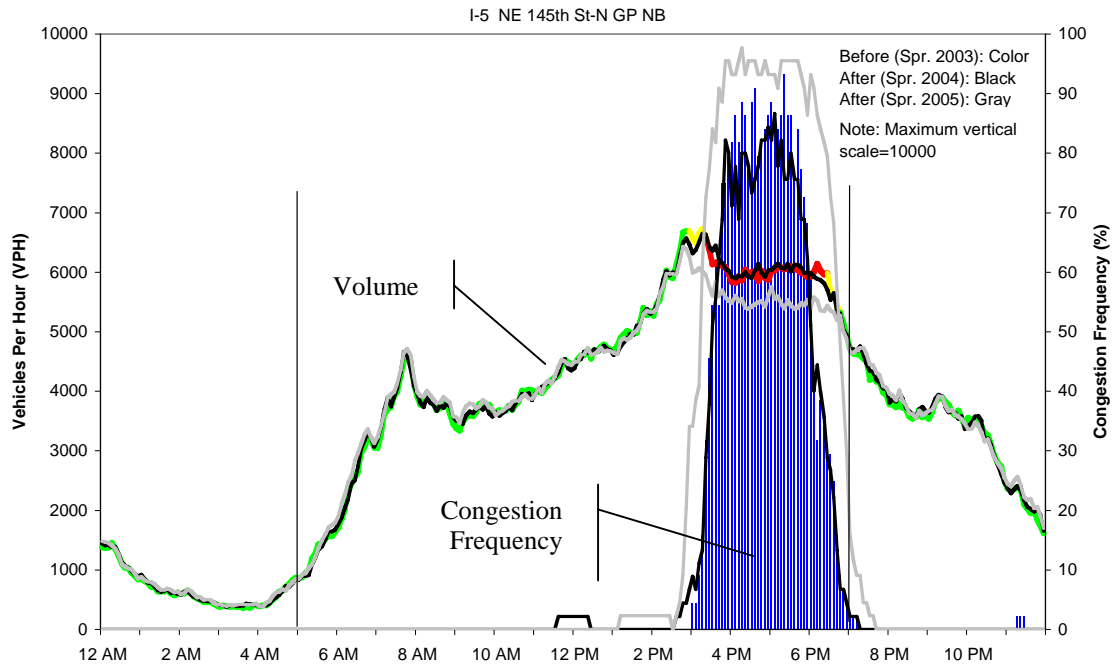


Figure 4.19. Change in 24-Hour Performance at Control Site, I-5 NB GP at NE 145th (2003 through 2005).

Estimated Volume, Speed, and Reliability Conditions (2003-05)

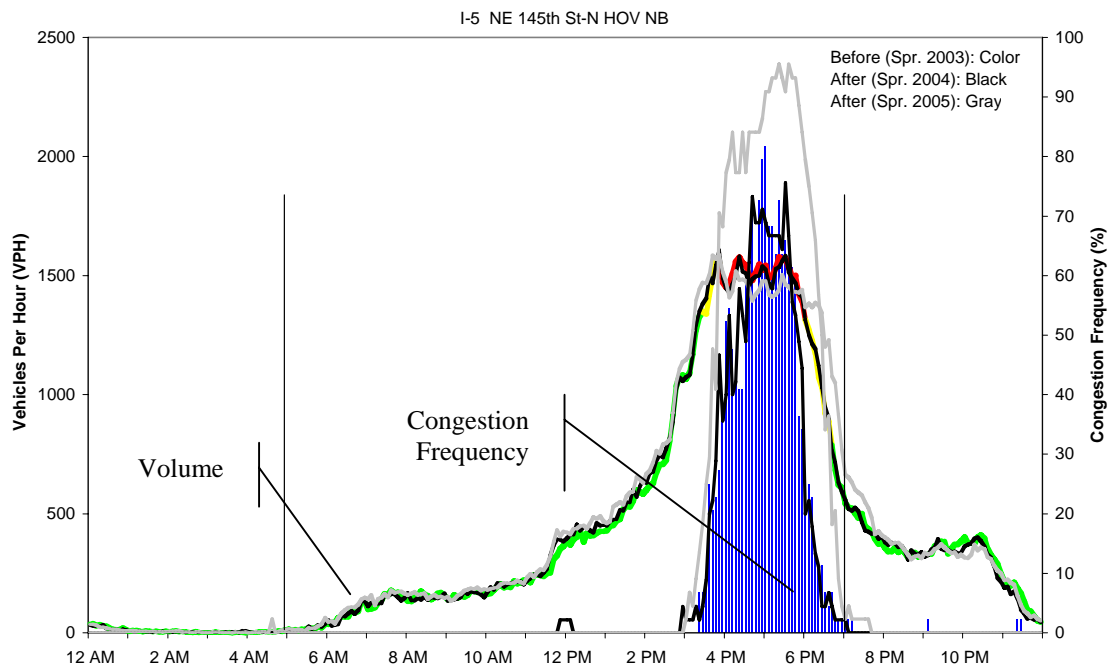


Figure 4.20. Change in 24-Hour Performance at Control Site, I-5 NB HOV at NE 145th (2003 through 2005).

Estimated Volume, Speed, and Reliability Conditions (2003-05)

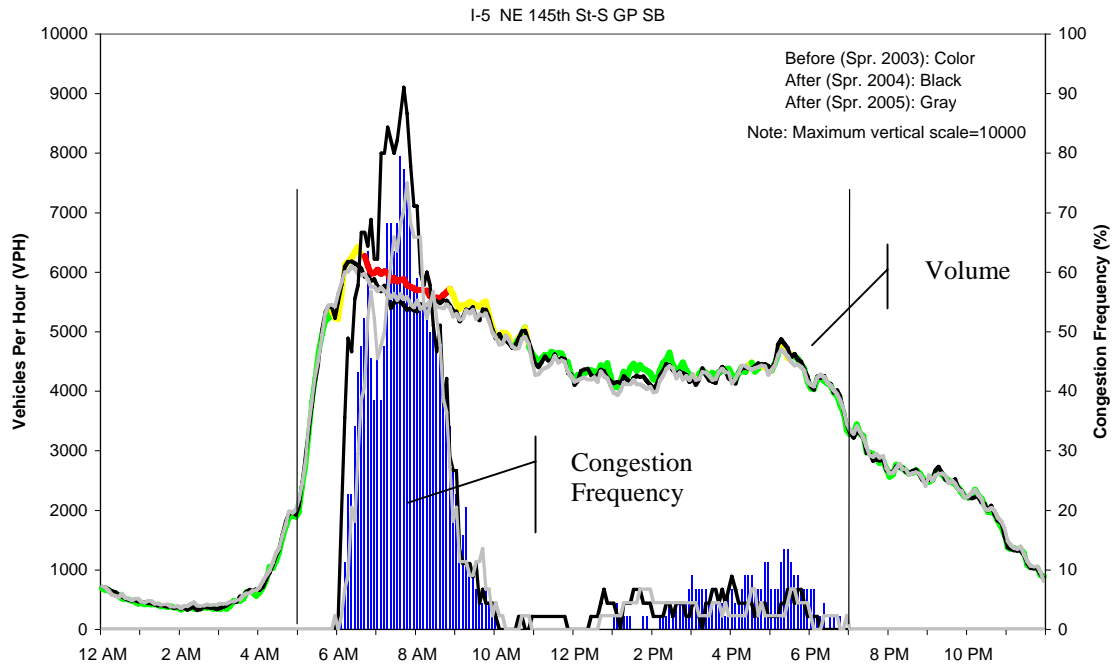


Figure 4.21. Change in 24-Hour Performance at Control Site, I-5 SB GP at NE 145th (2003 through 2005).

Estimated Volume, Speed, and Reliability Conditions (2003-05)

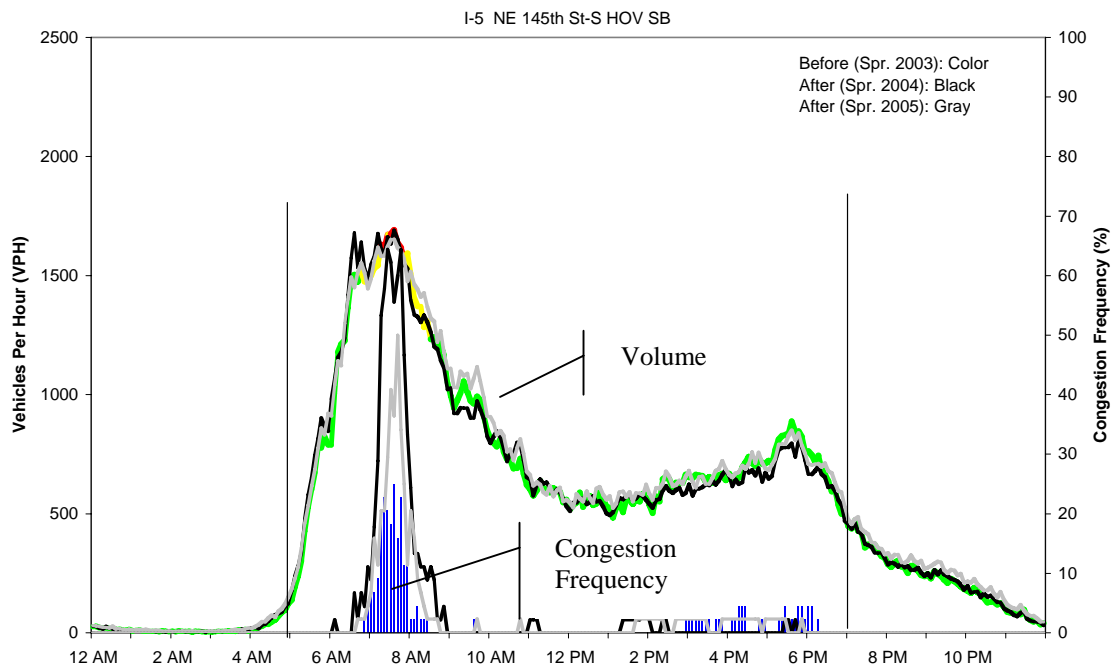


Figure 4.22. Change in 24-Hour Performance at Control Site, I-5 SB HOV at NE 145th (2003 through 2005).

Estimated Volume, Speed, and Reliability Conditions (2003-05)

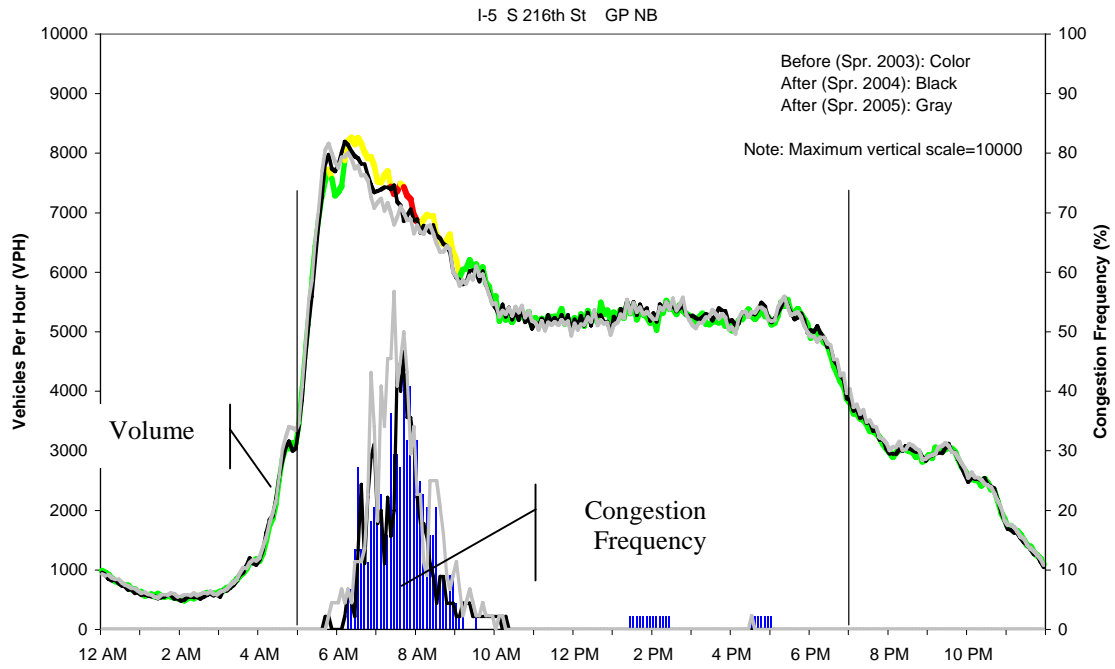


Figure 4.23. Change in 24-Hour Performance at Control Site, I-5 NB GP at S. 216th (2003 through 2005).

Estimated Volume, Speed, and Reliability Conditions (2003-05)

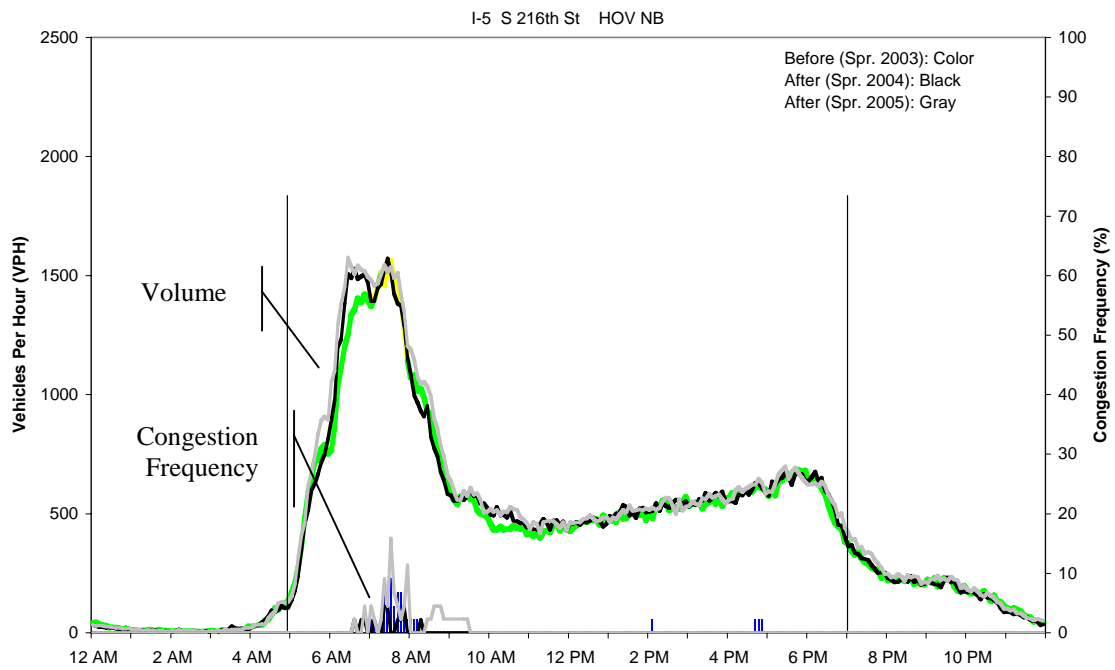


Figure 4.24. Change in 24-Hour Performance at Control Site, I-5 NB HOV at S. 216th (2003 through 2005).

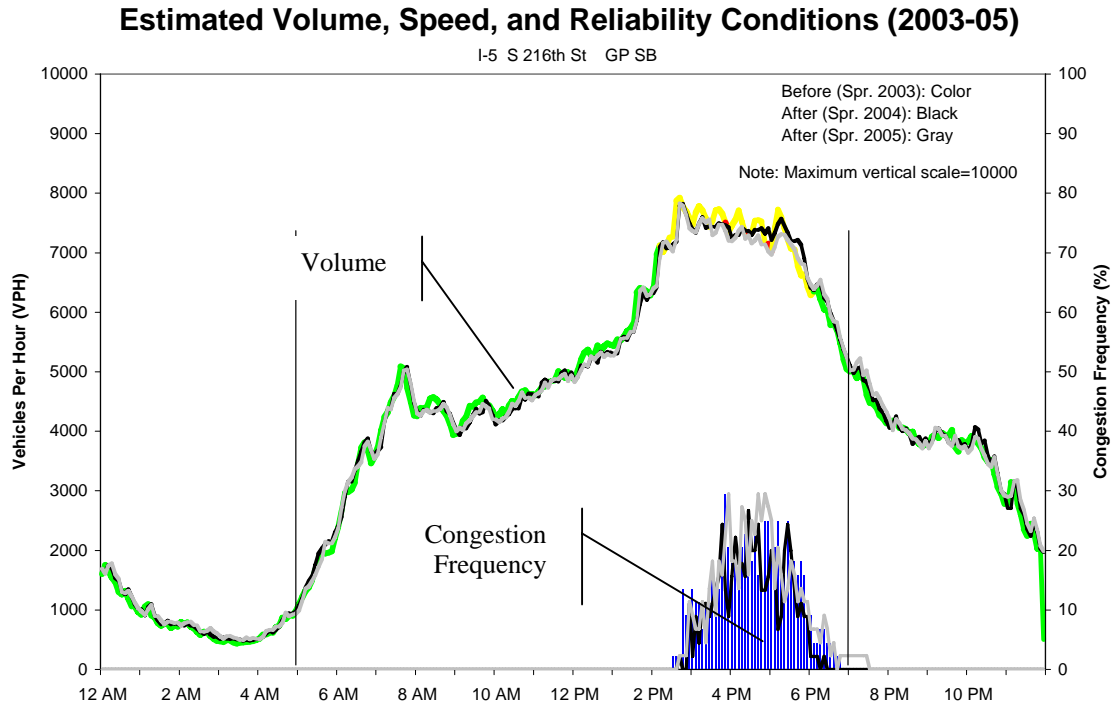


Figure 4.25. Change in 24-Hour Performance at Control Site, I-5 SB GP at S. 216th (2003 through 2005).

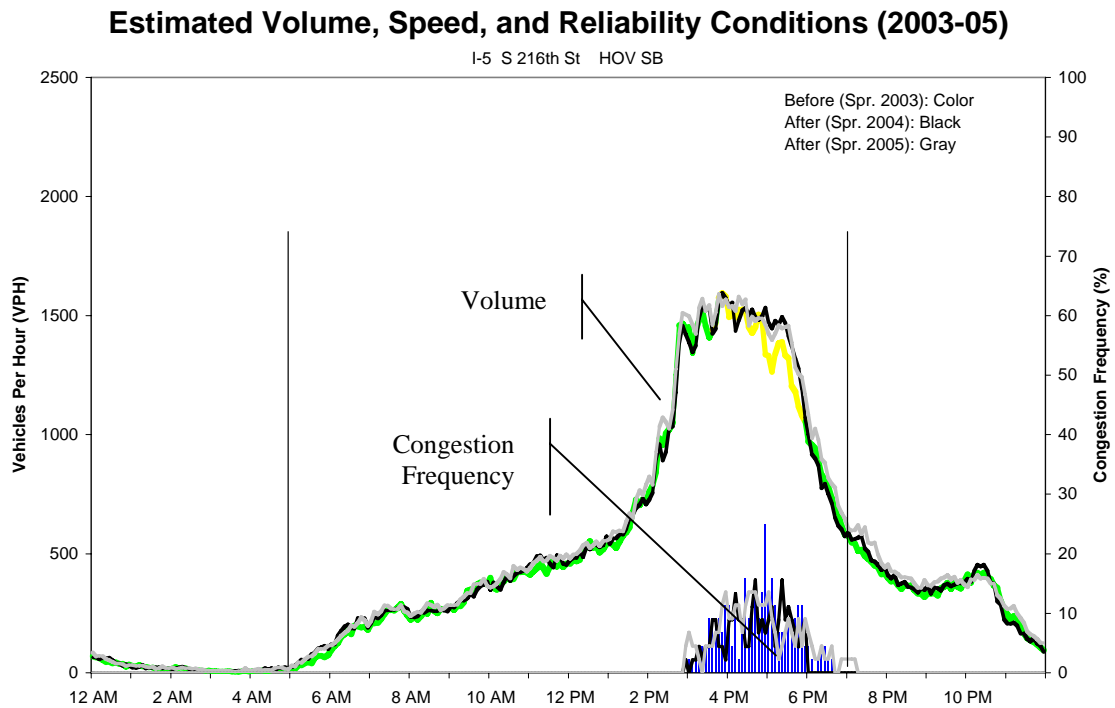


Figure 4.26. Change in 24-Hour Performance at Control Site, I-5 SB HOV at S. 216th (2003 through 2005).

PUBLIC PERCEPTIONS

A public opinion survey was performed in 2004 and 2005 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) in 2004, and 21 percent in 2005 (849 out of 3,990).

The responses to the 2005 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. The 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; however, the survey results revealed that only 45 percent of the respondents were aware of the new hours of operation after 1.5 years of operation. (This was up from 36 percent six months after the start of the pilot project.) Existing signage and public discussion of the new policy were 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 to one another, with 26 to 32 percent of respondents saying that the freeway conditions (maneuverability, safety, or speed) were somewhat better or much better than before, 32 to 37 percent saying that conditions were unchanged, and 1 to 6 percent saying conditions were somewhat worse or much worse. In addition, 28 to 36 percent said 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 45 percent of those who were aware of the new policy thought that driving maneuverability was improved, 35 percent thought overall safety had improved, and 31 to 36 percent thought average speeds in the HOV and GP lanes were faster during the evening hours. About 38 to 43 percent thought conditions were unchanged, while 2 to 7 percent thought conditions were worse. About 13 to 24 percent were unsure.

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 68 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 (65 percent positive).

11. For a significant number of survey respondents, the new HOV lane policy 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 39 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 51 percent had no change in opinion.

SAFETY

A safety analysis conducted prior to implementation of this pilot project revealed that approximately one-third of all run-of-the-road type collisions occurred between the hours of 7:00 PM and 5:00 AM. Typically this type of collision is severe because of the speed of impact and the type of object hit. The Federal Highway Administration's (FHWA) ROADSIDE predictive model was utilized to assess the potential increase in run-off-the-road collisions resulting from the project. The model results indicated that the number of collisions would increase because hourly traffic volumes were expected to be higher with general-purpose traffic allowed in the HOV lane during the evening hours. Nighttime run-off-the-road collisions were expected to increase by approximately 25 percent. To mitigate for this potential collision increase, shoulder rumblestrip and profiled edge line installations were incorporated into the project. The expectation was that these safety features would offset the effects of additional traffic using the HOV lanes during nighttime hours and would potentially provide added safety benefit during the remaining hours of the day.

Collision occurrence was evaluated along the project's freeway segments for the two-year periods before and after implementation of the HOV operational change and installation of shoulder safety features. The periods analyzed were 2001-2002 and 2004-2005. Median, left shoulder and total collisions were reviewed for each freeway

segment, with the exception of SR 520, where right-side collisions were evaluated. The review emphasized data from 7:00 PM to 5:00 AM, with 15 minutes extended on either side of this time period to evaluate the safety effects of general purpose traffic entering the HOV lane before 7:00 PM or lingering too long in the morning. The total number of collisions during the hour following removal of the HOV-only restriction (7:00 PM to 8:00 PM) was reviewed as well.

Median and Left Shoulder Nighttime Collisions

The number of nighttime median/left shoulder collisions that occurred on I-405 decreased significantly following implementation of the project (Figure 4.27). In 2000-2001, 109 collisions were reported in comparison to 73 in 2004-2005, a 33 percent decrease. The decrease was distributed throughout the corridor, with the exception of a few spot locations where measurable increases in collisions occurred.

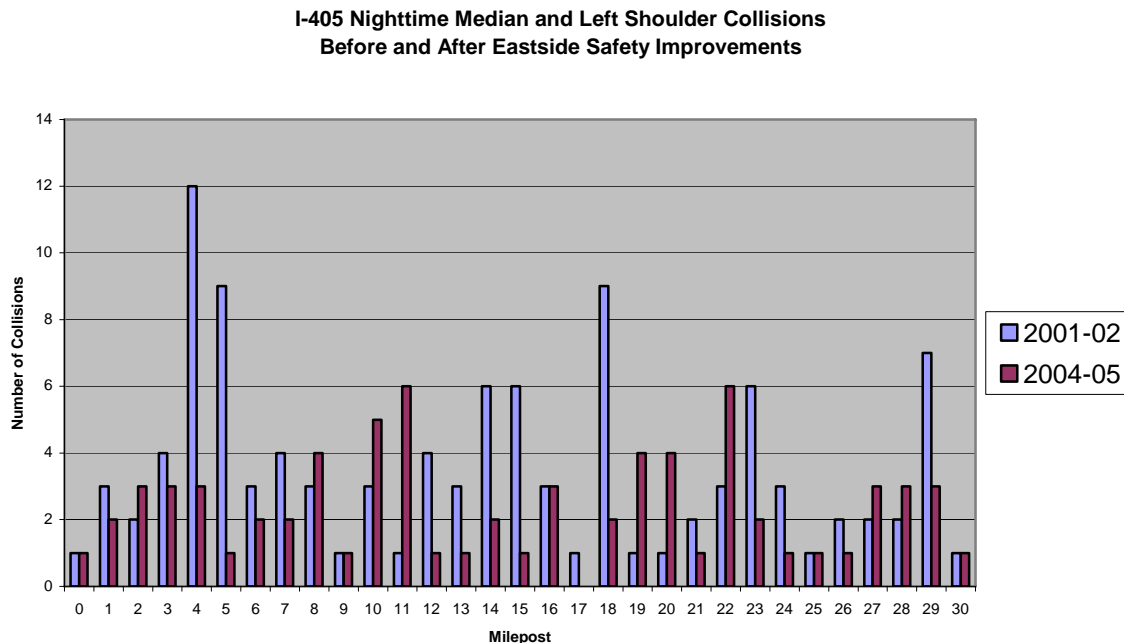


Figure 4.27. Change in Number of Nighttime Median/Left Shoulder Collisions on I-405 (2001-02 vs. 2004-05).

Individual collision reports were reviewed for each of the 1-mile segments that experienced significant increases in collisions. There was no conclusive correlation

between these few locations and the change in HOV hours of operation. Approximately 90 percent of those collisions were attributed to driving under the influence and/or driving at an excessive speed.

SR 167, SR 520, and I-90 had similar collision experiences following implementation of the operational and safety modifications (Figure 4.28). Generally, there were minor reductions in median/shoulder collisions: SR 167 had 26 collisions before and 21 after, a 19 percent reduction (Figure 4.29); SR 520 had eight collisions before and seven collisions after; and I-90 had only two collisions before and one collision after. For SR 520's right-side HOV lane, the evaluation was of right shoulder collisions and leaving-the-road collisions.

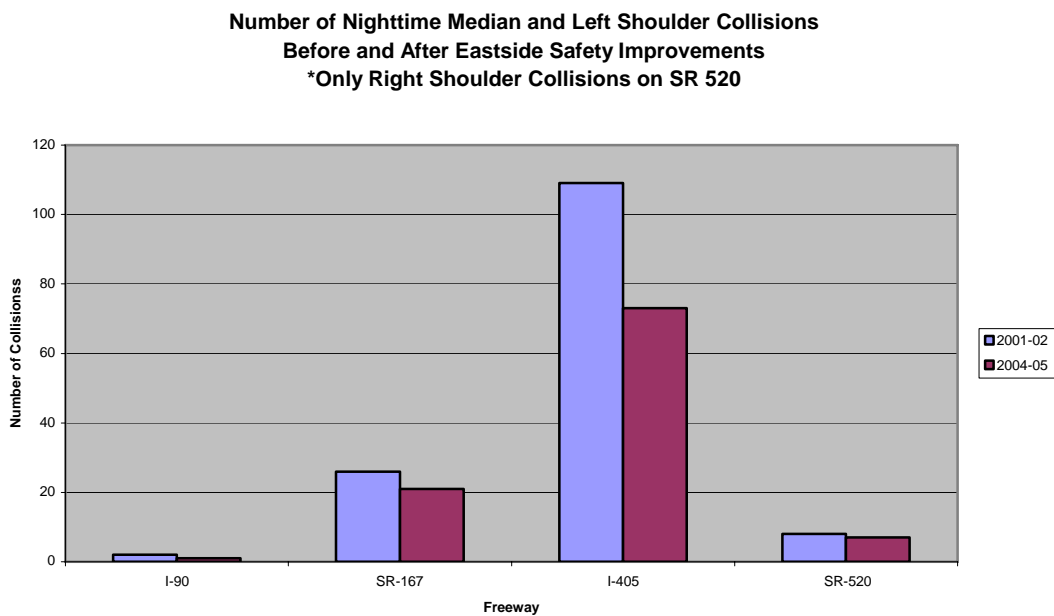


Figure 4.28. Change in Number of Nighttime Median/Shoulder Collisions (2001-02 vs. 2004-05).

**SR 167 Nighttime Median and Left Shoulder Collisions
Before and After Eastside Safety Improvements**

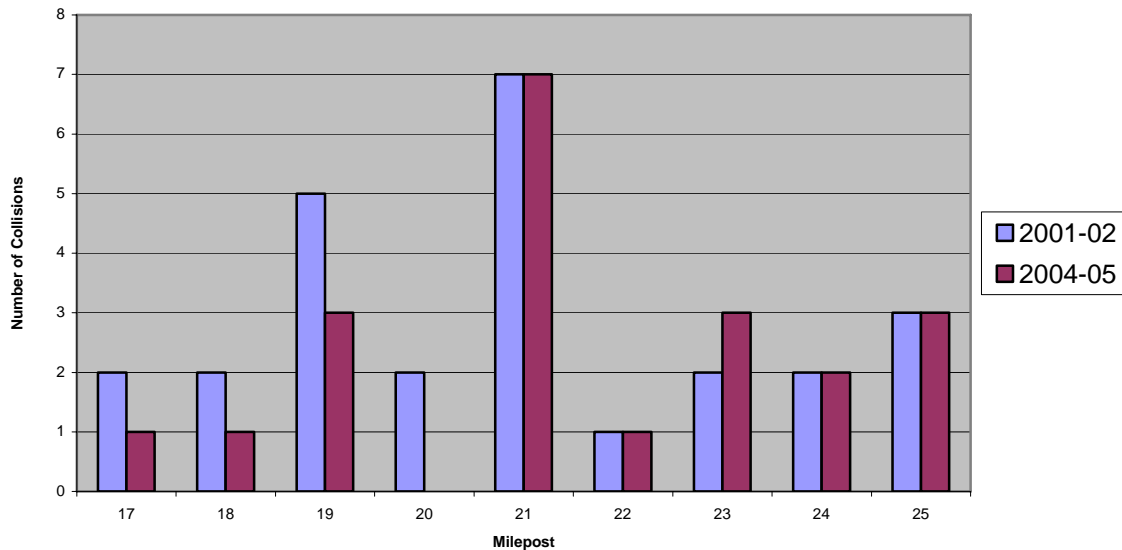


Figure 4.29. Change in Number of Nighttime Median Collisions on SR 167 (2001-02 vs. 2004-05).

On all the freeways affected by the change in hours of operation, no significant run-off-the-road collision "hot spots" were present during the two-year periods before and following project implementation.

Before implementing the operational change, WSDOT had predicted a 23 percent (15 collisions) increase in I-405 left shoulder and median nighttime collisions unless mitigation measures were included. This prediction was based on an expected increase in usage of the HOV lane during the nighttime hours when the restriction was lifted. However, after the project, and despite increased traffic volumes, the number of collisions of this type *decreased* by 33 percent (36 collisions). Similar results were achieved on SR 167, where the predicted increase was 27 percent (6 collisions), but the two-year period after project implementation showed a *decrease* of 19 percent (5 collisions).

As indicated in Figure 4.30, generally no significant changes occurred in the percentage of collisions caused by vehicles entering the median/shoulder area during nighttime hours versus the daily number of collisions that occurred in the median/shoulder area. I-90 was the one exception to this, but the percentage difference was skewed by the minimal number of collisions (two nighttime collisions out of four total collisions before the project began, and one nighttime collision out of five total collisions after project implementation).

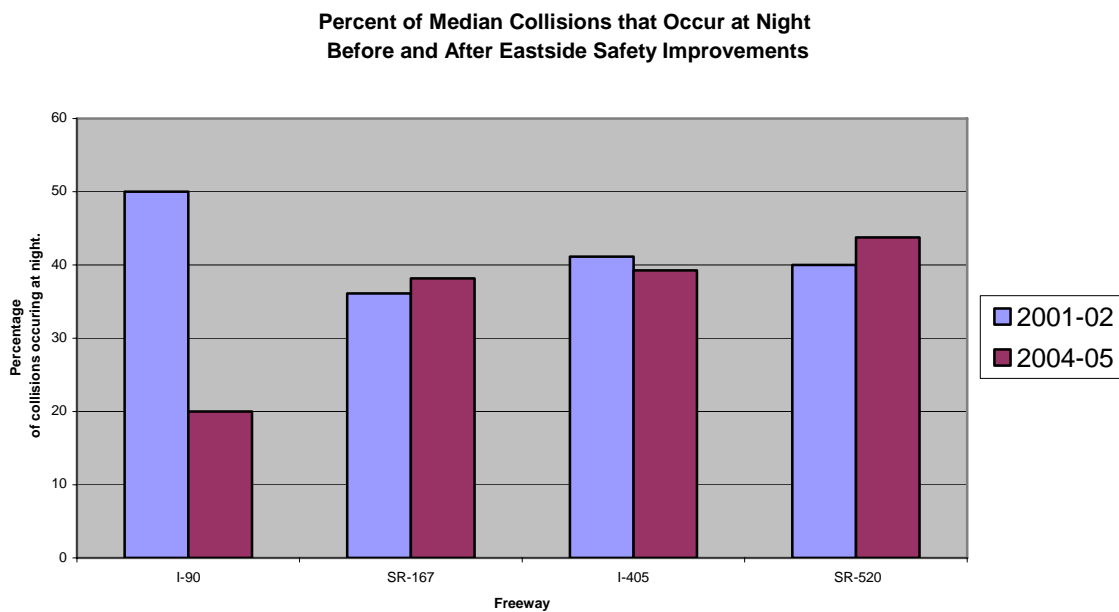


Figure 4.30. Percentage of Median/Adjacent Shoulder Collisions that Occurred at Night (2001-02 vs. 2004-05).

Nighttime Collisions – All Collision Types

As shown in Figure 4.31, the nighttime collision experience (all types) for I-405 was similar to that for median-type only, although the decrease within the study period was not as significant. Overall, nighttime collisions decreased by 10 percent (54 collisions).

Total Nighttime Collisions (All Types) Before and After Eastside Safety Improvements

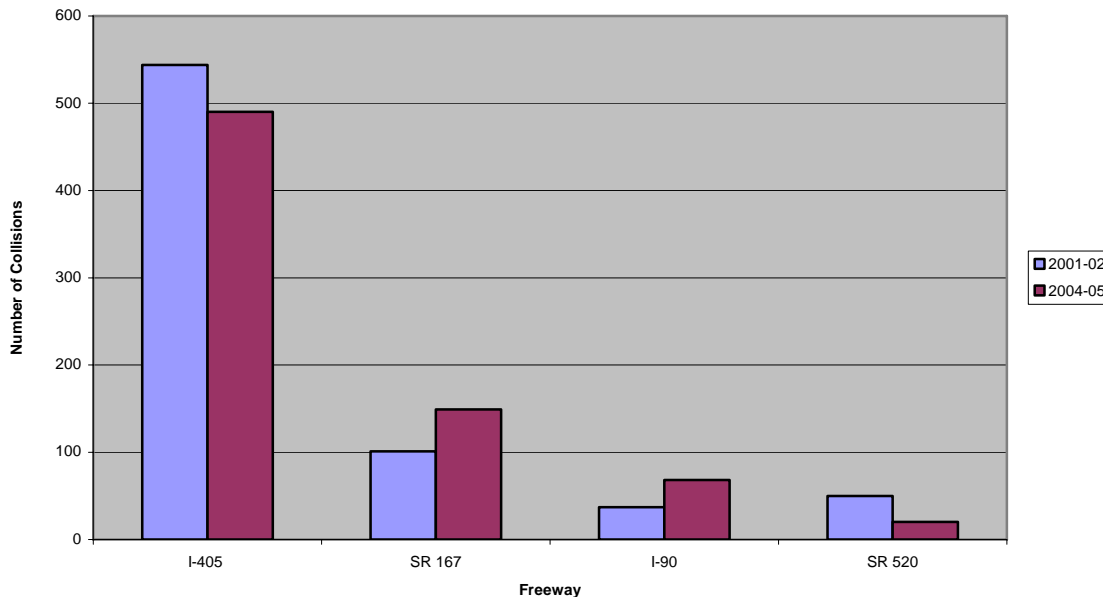


Figure 4.31. Change in Number of Nighttime Collisions – All Types (2001-02 vs. 2004-05).

The nighttime collision experience on SR 167 was significantly different. Where nighttime median collisions had decreased by 19 percent, all nighttime collisions increased by 48 percent (48 collisions). Similarly, I-90 experienced a very low number of median collisions. During the same time, total nighttime collisions increased by 84 percent (31 collisions). Nighttime collisions decreased dramatically during this same time period, dropping from 50 in 2001-02 to 20 in 2004-05. For all of the study freeway segments, there was no clear correlation between the project actions and the change in nighttime collision occurrence.

Figure 4.32 shows nighttime collisions as a percentage of daily collisions prior to and following the project. Generally, the percentage of daily collisions was relatively the same for I-405, SR 167 and I-90. The decrease for SR 520 was primarily related to the substantial decrease in nighttime collisions.

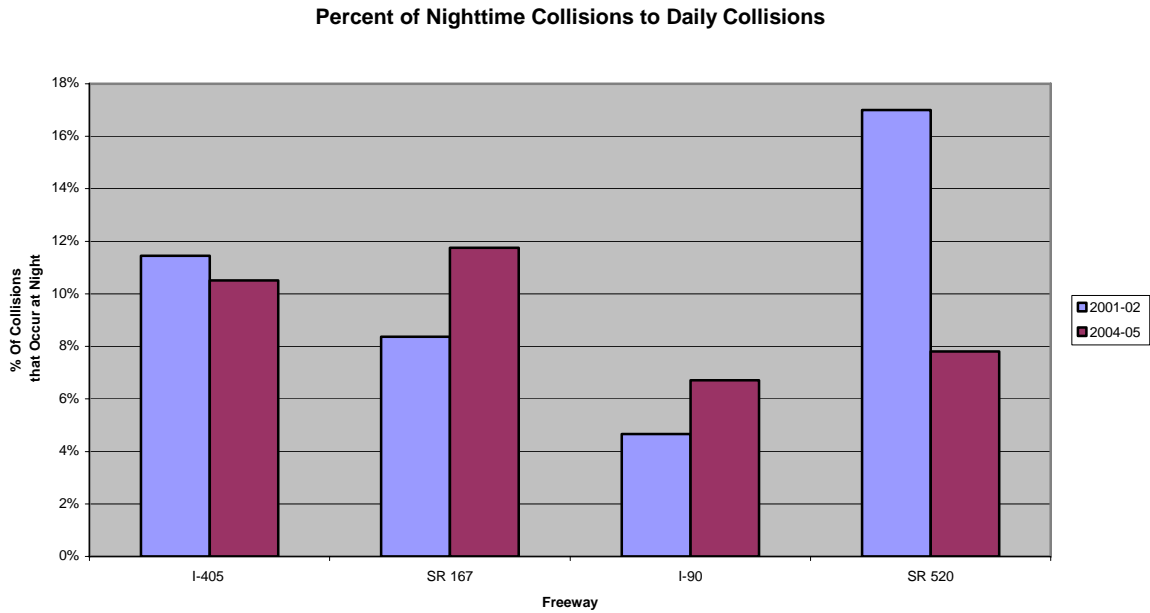


Figure 4.32. Change in Number of Nighttime Collisions as a Percentage of Daily Collisions (2001-02 vs. 2004-05).

A further analysis of collision experience during the 7:00 PM to 8:00 PM period revealed an increase in the number of collisions that occurred after the HOV hours of operation were changed (Figure 4.33). The most notable results were on I-405, where the number of collisions increased by 13 percent (13 collisions) during the two-year period following the operational change. This contrasts with an overall reduction in number of nighttime collisions of 10 percent (54 collisions). I-405 is the most congested of the Eastside freeways during the latter portion of the evening commute, and the increase may be partially attributable to increased lane changing between adjacent lanes that are operating at different speeds. Collision occurrences on SR 167, SR 520, and I-90 between 7:00 PM and 8:00 PM generally followed the same pattern observed for the nighttime hours between 7:00 PM and 5:00 AM.

**All Collisions 7pm to 8pm
Before and After Eastside Safety Improvements**

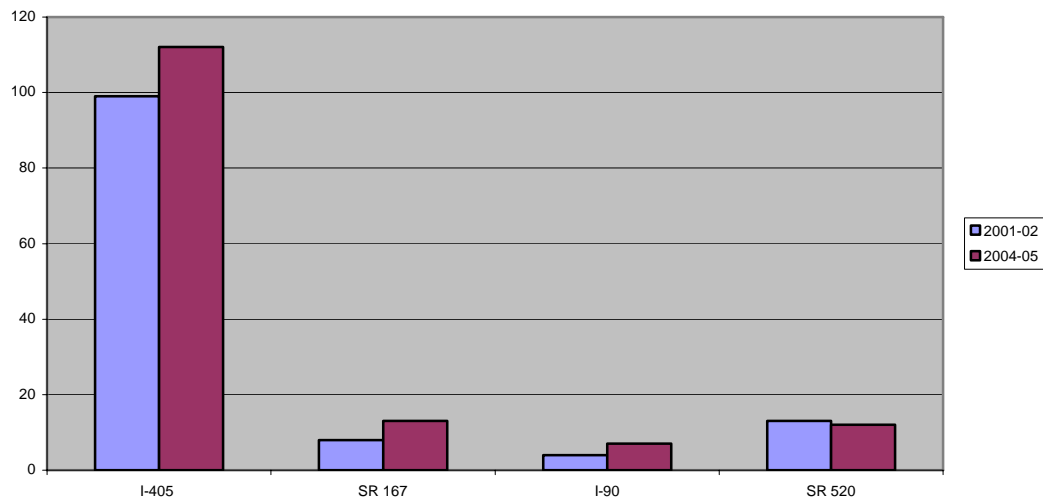


Figure 4.33. Change in Number of Collisions from 7:00 PM to 8:00 PM (2001-02 vs. 2004-05).

Conclusion

Analysis of collision data spanning two years before and after the project implementation indicates that the constructed safety improvements were beneficial in reducing the daily occurrence of run-off-road collisions, including during nighttime hours. No adverse safety effects have been identified during the 7:00 PM to 8:00 PM period or during the entire nighttime when the HOV lanes are open to general purpose traffic. A review of additional years of collision data will solidify whether this was a short-term outcome or a substantiated trend.

SECTION 5 SUMMARY OF ANALYSES

The data processed suggest that some travelers are 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 most 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 shortly after 7:00 PM. At the same time, survey results suggest that only slightly less than one-half 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) after two years; the increases are generally not large, with a few PM exceptions at locations that also have significant GP evening congestion. The violation rate has decreased at some locations.

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 started suggests that there is a slight shift toward higher speeds (approximately +1 to +4 mph) in the GP lanes after 7:00 PM, although there is almost no change in the HOV lane after 7:00 PM (which generally has already been operating at or near the speed limit by that time). At the same time, survey results suggest that among travelers who are already aware of the new policy, anywhere from 31 to 45 percent associate the new hours of operation with perceived improvements in maneuverability, safety, and/or speeds, although a similar percentage of people surveyed (38 to 43 percent) also do not perceive any change in freeway performance.

There is a sizeable level of support for the program among both SOV and HOV travelers, with 68 percent of respondents either somewhat or strongly agreeing that it is a good idea. Furthermore, a significant number of respondents (39 percent) have a more favorable opinion of the HOV system as a whole because of the new hours of operation.

A review of collision records for the periods of 2001-2002 and 2004-2005 indicated that, generally, there was no adverse safety effect related to revising the HOV lane hours of operation. The evaluation revealed a reduction in daily occurrences of run-off-road collisions, including during nighttime hours. Prior to implementing the operational change for the HOV lanes, WSDOT had predicted a 23 percent increase in I-405 left shoulder and median nighttime collisions unless mitigation measures were included. The prediction was based on the expected increase in usage of the HOV lane during the nighttime hours. However, the two-year results following project implementation, despite increased traffic volumes, showed a 33 percent decrease in collisions of this type. Similar results were achieved on SR 167, where the predicted increase had been 27 percent, but the two-year period after project implementation showed a decrease of 19 percent. Additionally, no adverse safety effects were identified during the 7:00 PM to 8:00 PM period or during the entire nighttime when the HOV lanes are open to general purpose traffic.

These before/after comparisons included the potential effects of both the revised hours of operation and the safety improvements implemented by WSDOT in response to FHWA requirements (guard rails, shoulder rumble strips, raised lane markings, signage). There was evidence that the safety improvements implemented before the start of the pilot project may have contributed to a lower rate of nighttime run-off-road type collisions.

The results described in this paper are based on data collected after two years of operation of the pilot program.

APPENDIX A. FREEWAY PERFORMANCE PROFILES

The following graphs summarize GP and HOV freeway performance at selected locations over an average 24-hour period for both the 2003 “before” time period and the 2005 “after” time period of the evaluation. 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 gray 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.

Estimated Volume, Speed, and Reliability Conditions (2003-05)

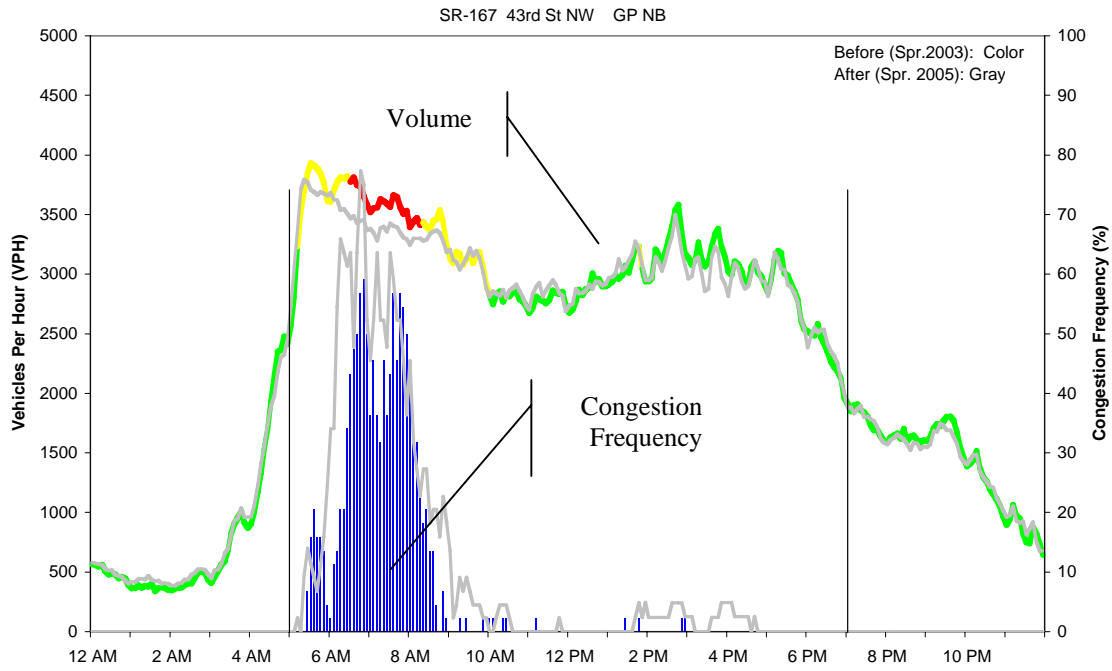


Figure A.1. SR 167 NB near Auburn, GP

Estimated Volume, Speed, and Reliability Conditions (2003-05)

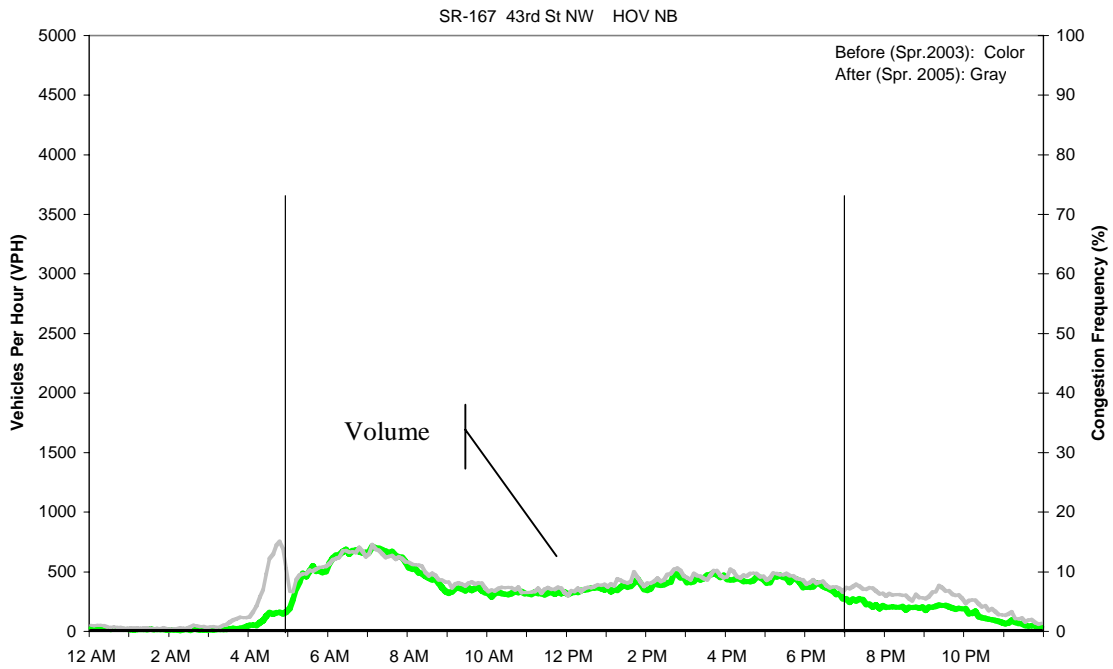


Figure A.2. SR 167 NB near Auburn, HOV

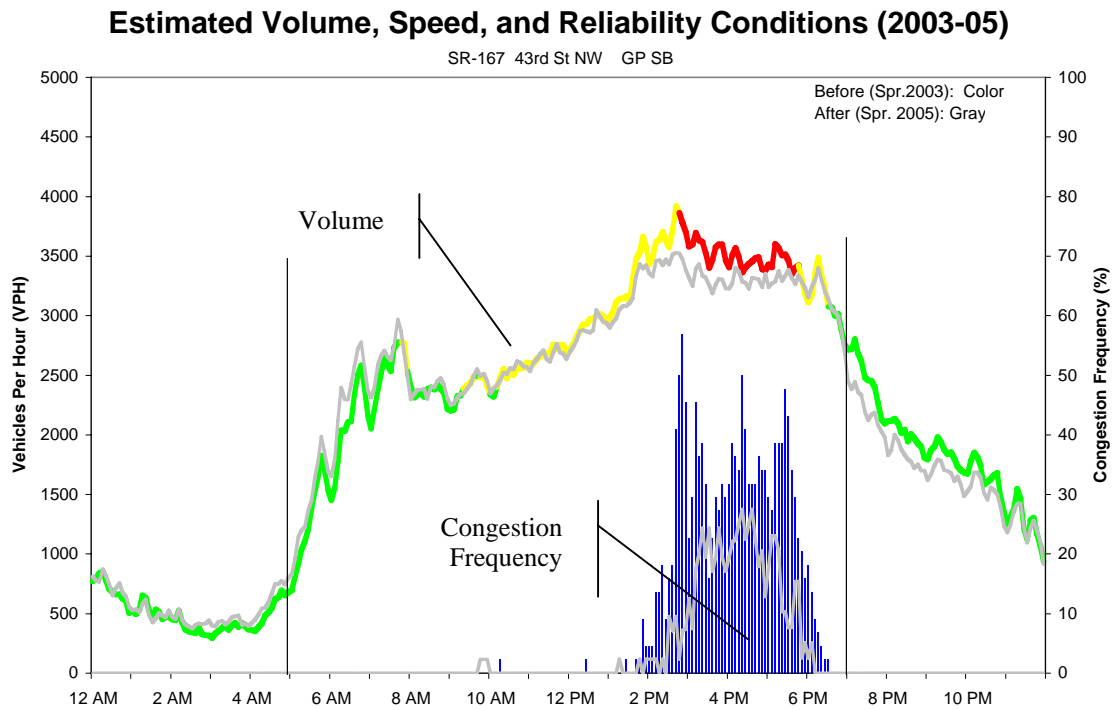


Figure A.3. SR 167 SB near Auburn, GP

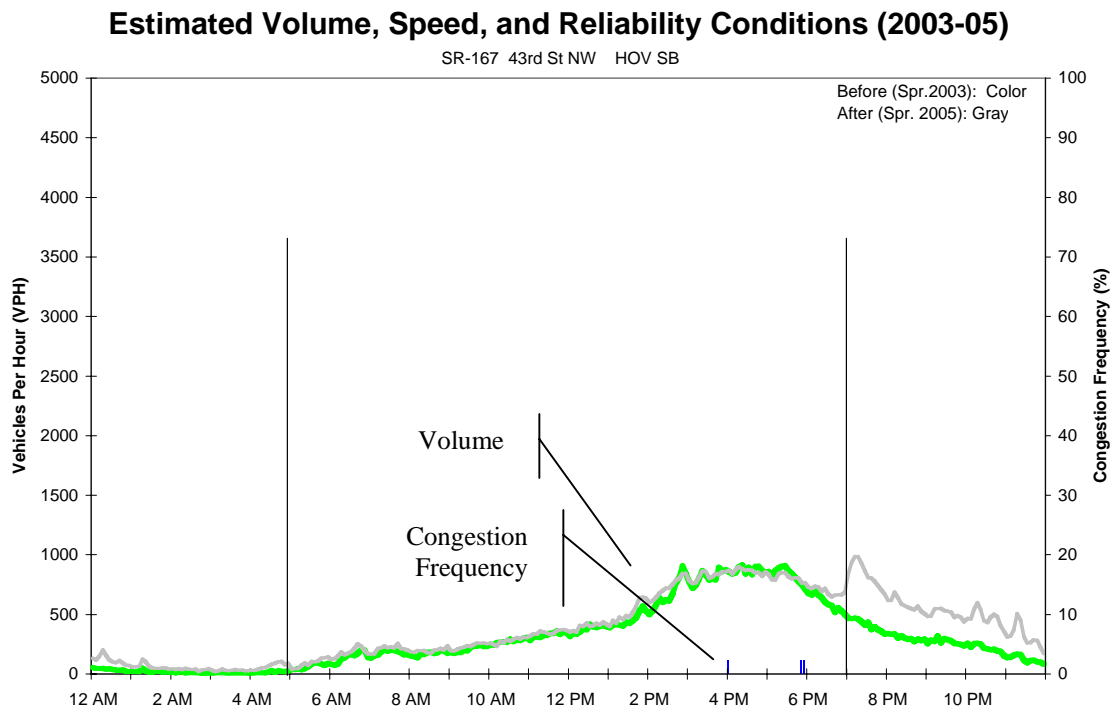


Figure A.4. SR 167 SB near Auburn, HOV

Estimated Volume, Speed, and Reliability Conditions (2003-05)

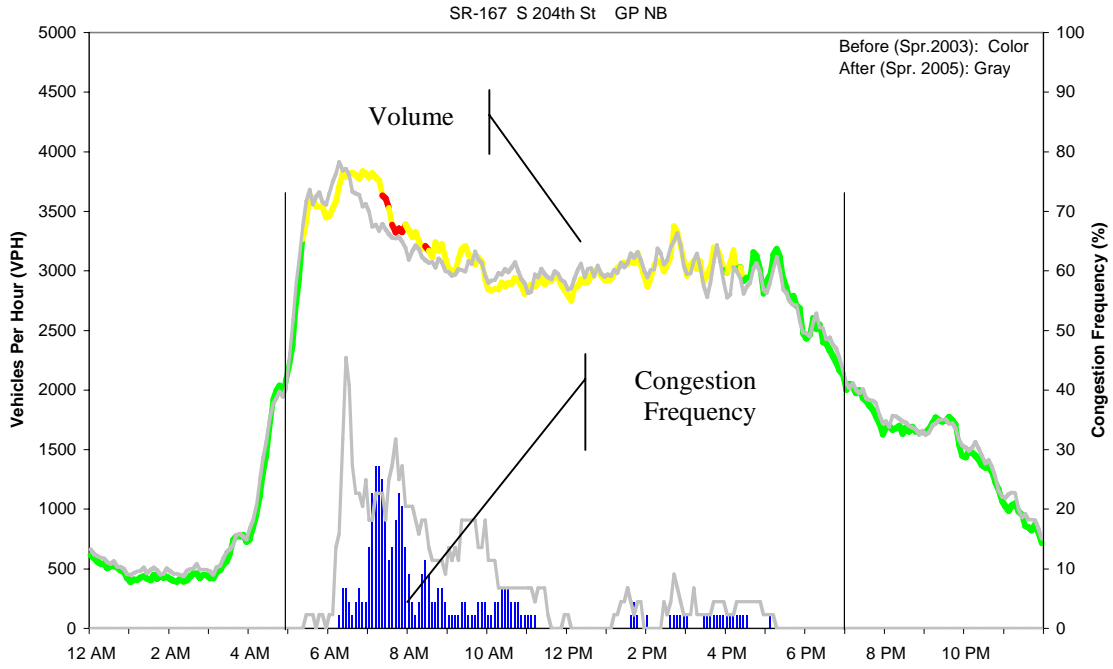


Figure A.5. SR 167 NB near Renton, GP

Estimated Volume, Speed, and Reliability Conditions (2003-05)

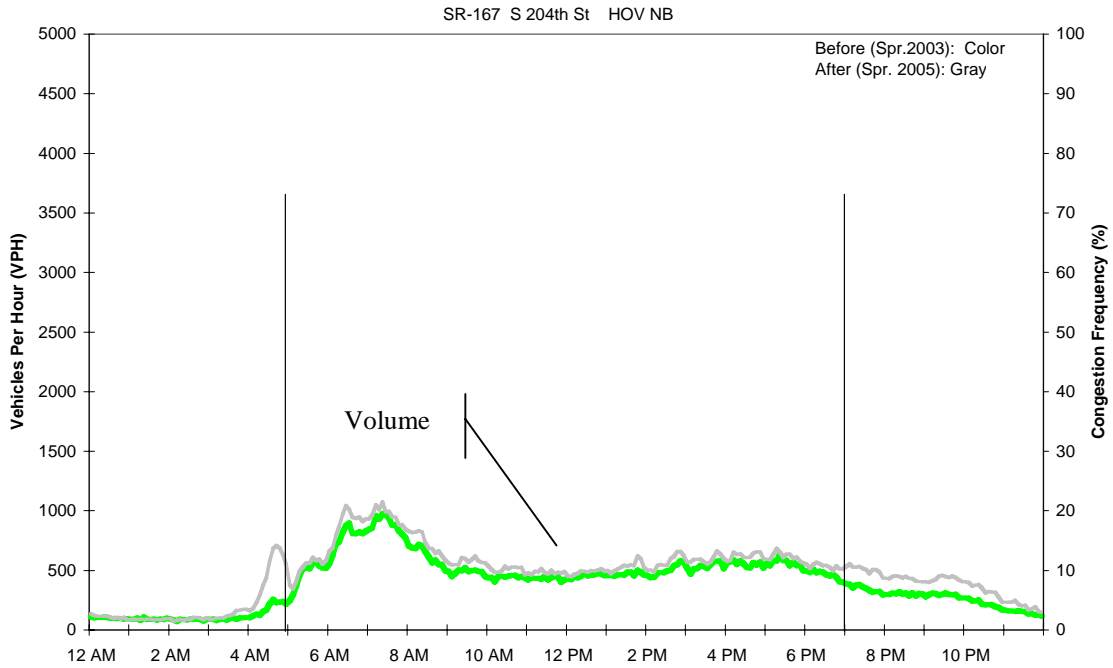


Figure A.6. SR 167 NB near Renton, HOV

Estimated Volume, Speed, and Reliability Conditions (2003-05)

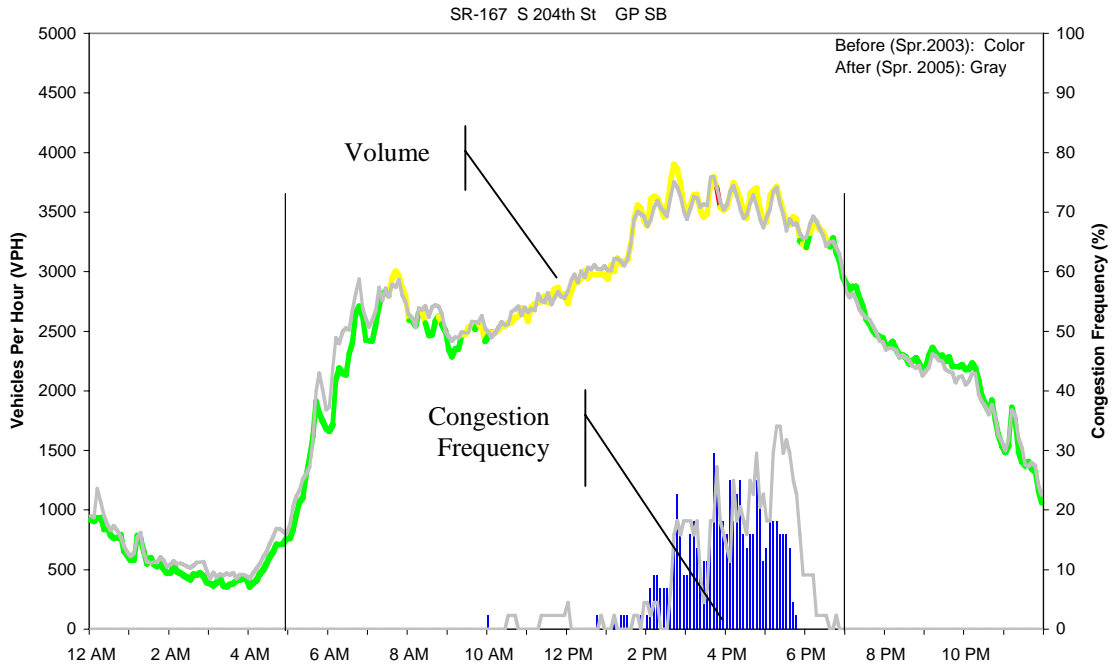


Figure A.7. SR 167 SB near Renton, GP

Estimated Volume, Speed, and Reliability Conditions (2003-05)

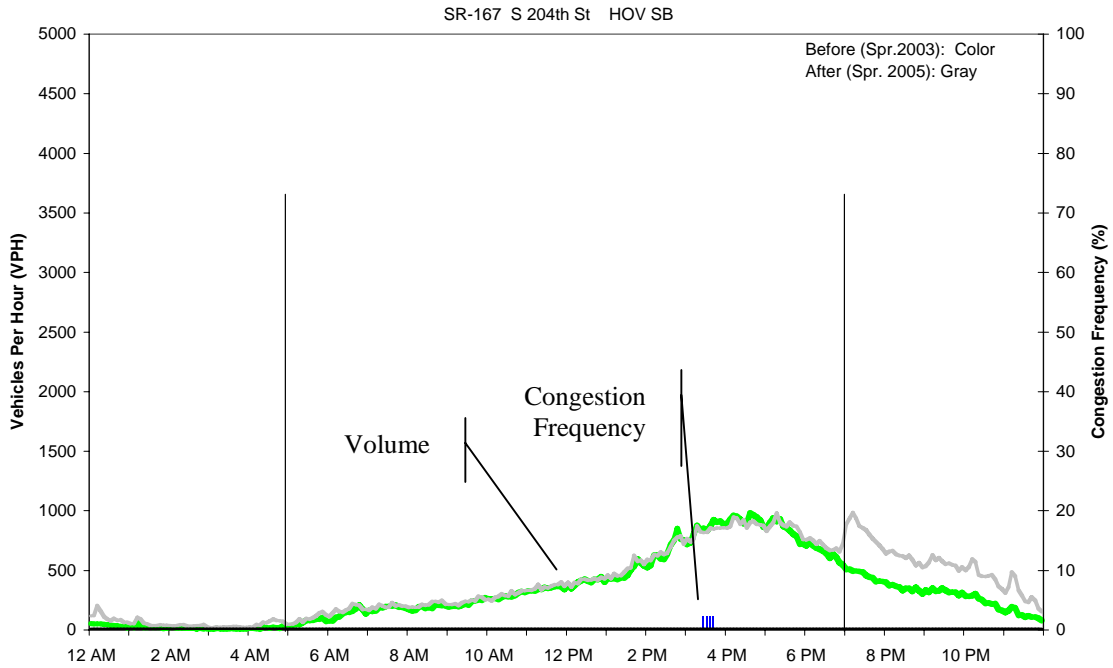


Figure A.8. SR 167 SB near Renton, HOV

Estimated Volume, Speed, and Reliability Conditions (2003-05)

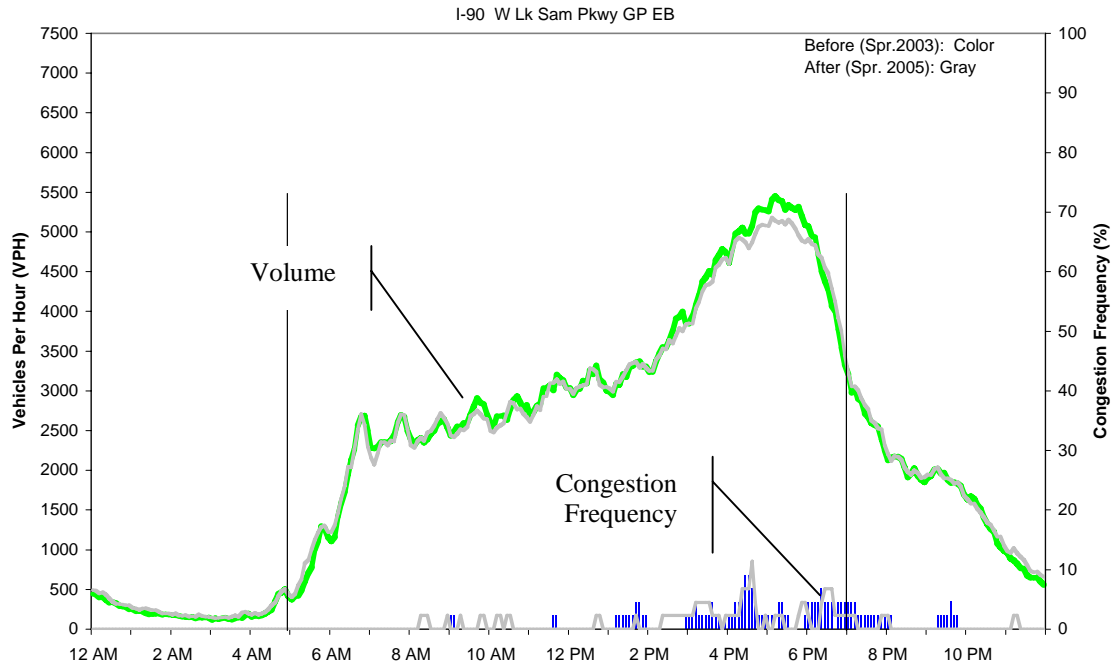


Figure A.9. I-90 EB near Issaquah, GP

Estimated Volume, Speed, and Reliability Conditions (2003-05)

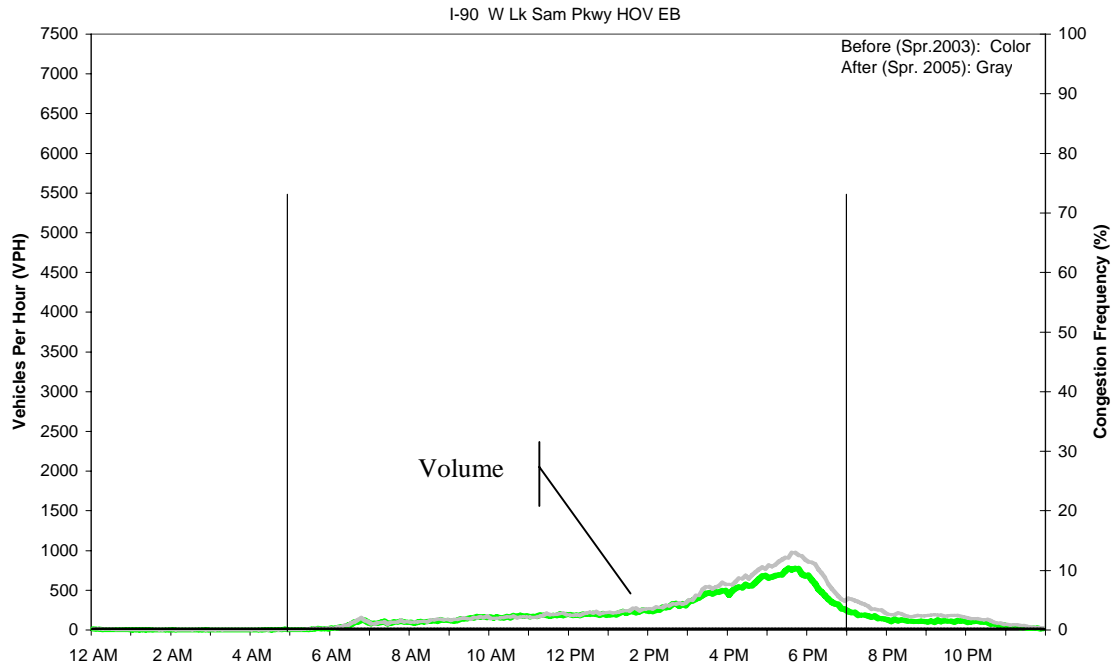


Figure A.10. I-90 EB near Issaquah, HOV

Estimated Volume, Speed, and Reliability Conditions (2003-05)

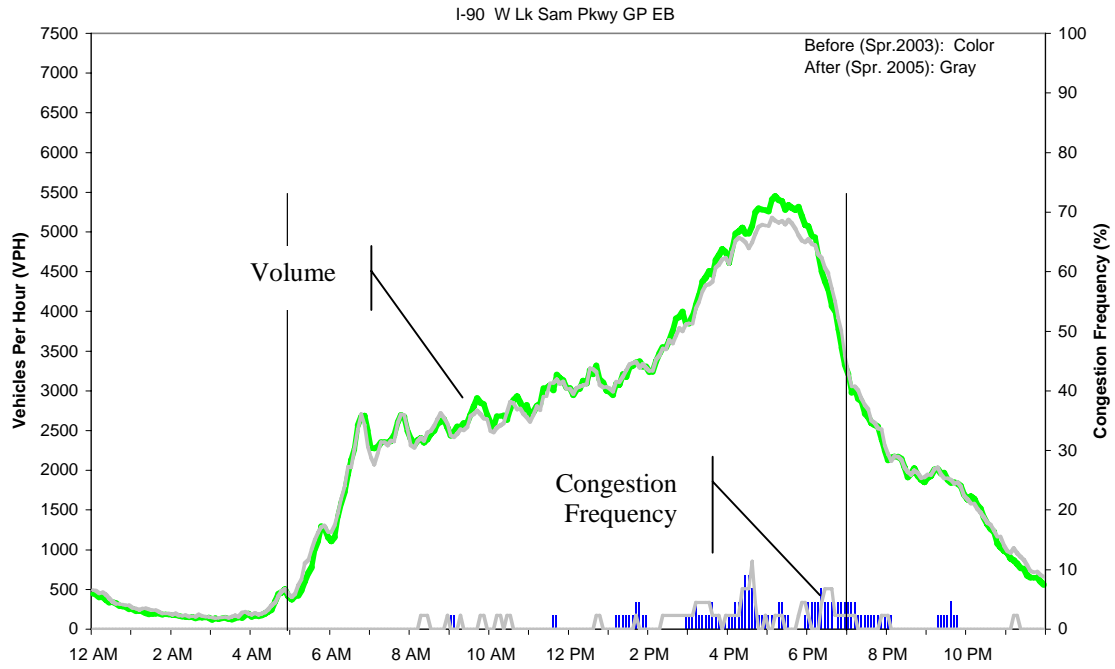


Figure A.9. I-90 EB near Issaquah, GP

Estimated Volume, Speed, and Reliability Conditions (2003-05)

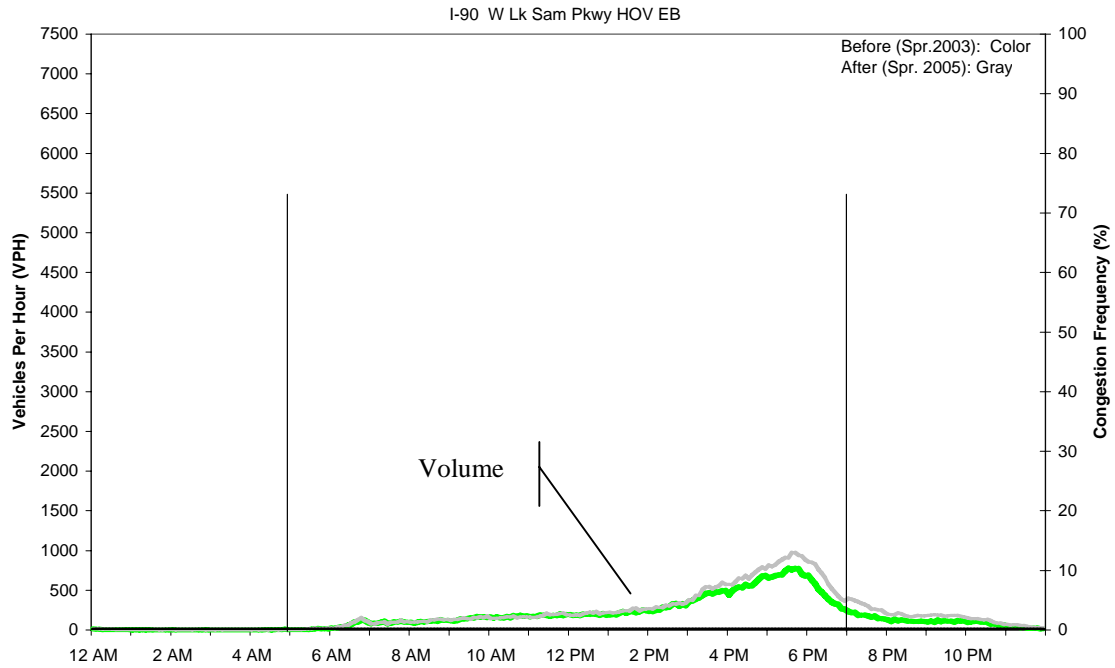


Figure A.10. I-90 EB near Issaquah, HOV

Estimated Volume, Speed, and Reliability Conditions (2003-05)

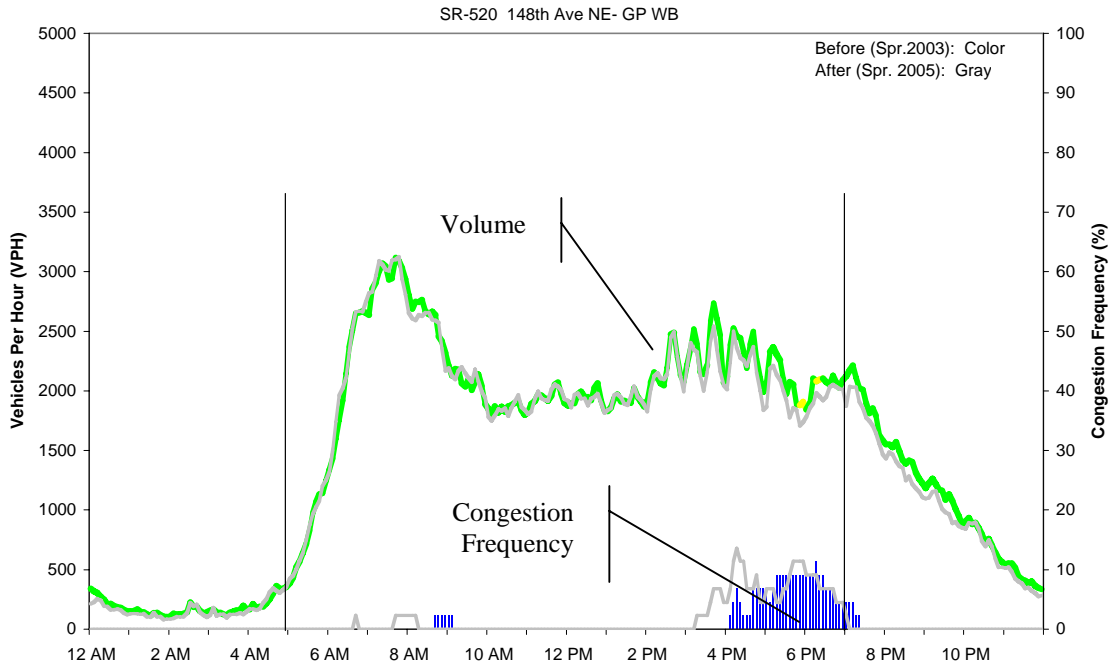


Figure A.11. SR 520 WB near Redmond, GP

Estimated Volume, Speed, and Reliability Conditions (2003-05)

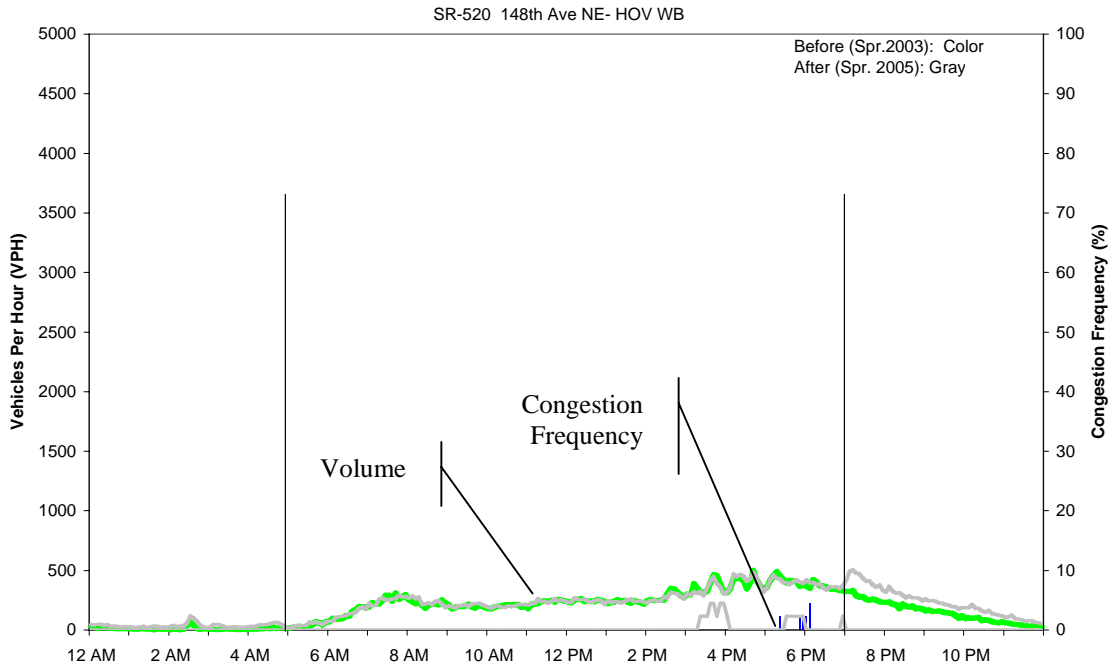


Figure A.12. SR 520 WB near Redmond, HOV

Estimated Volume, Speed, and Reliability Conditions (2003-05)

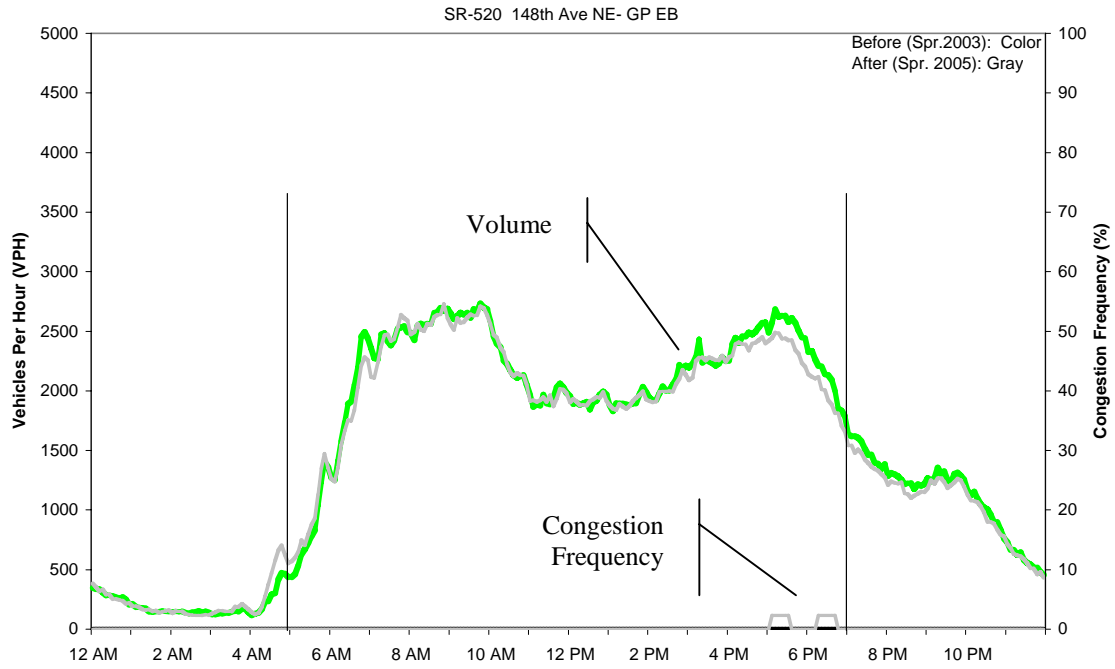


Figure A.13. SR 520 EB near Redmond, GP

Estimated Volume, Speed, and Reliability Conditions (2003-05)

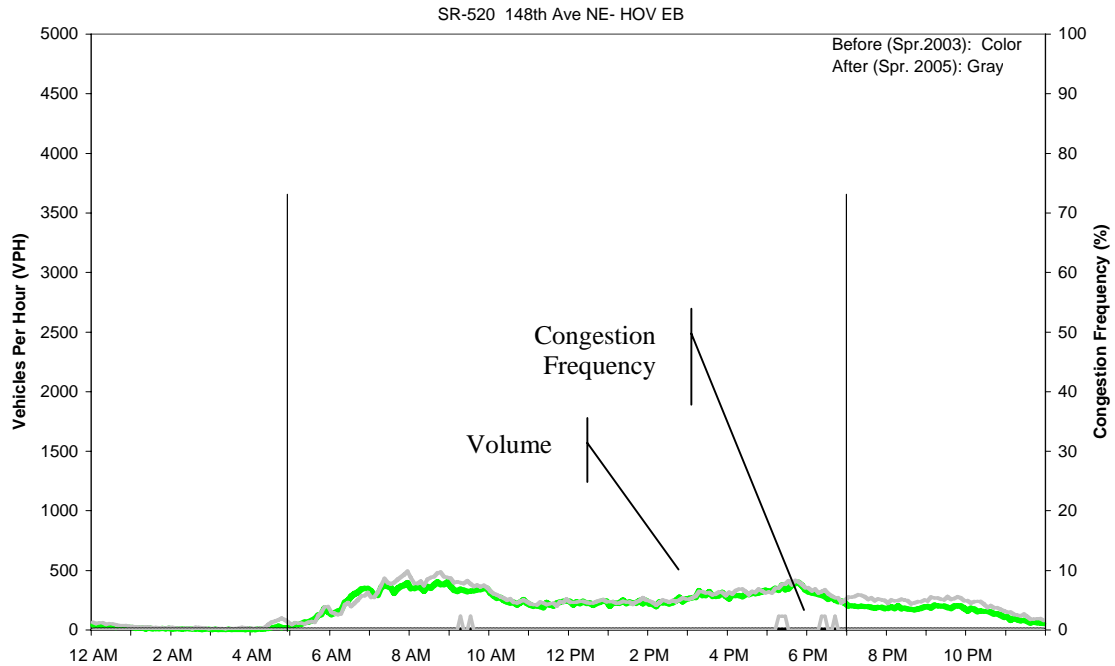


Figure A.14. SR 520 EB near Redmond, HOV

Estimated Volume, Speed, and Reliability Conditions (2003-05)

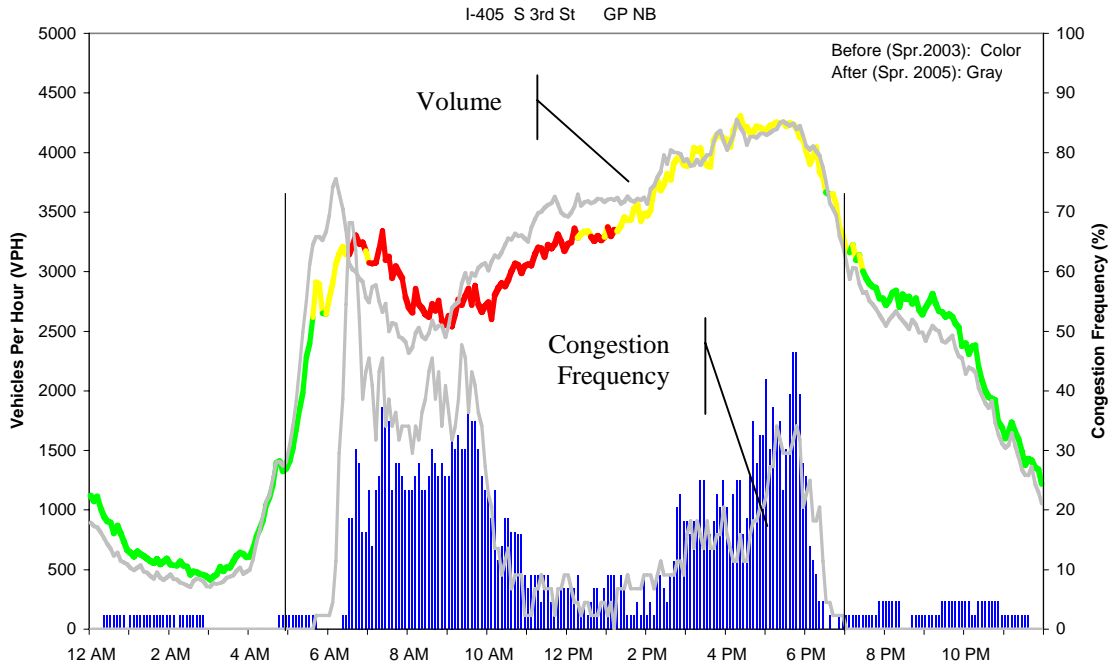


Figure A.15. I-405 NB near Renton, GP

Estimated Volume, Speed, and Reliability Conditions (2003-05)

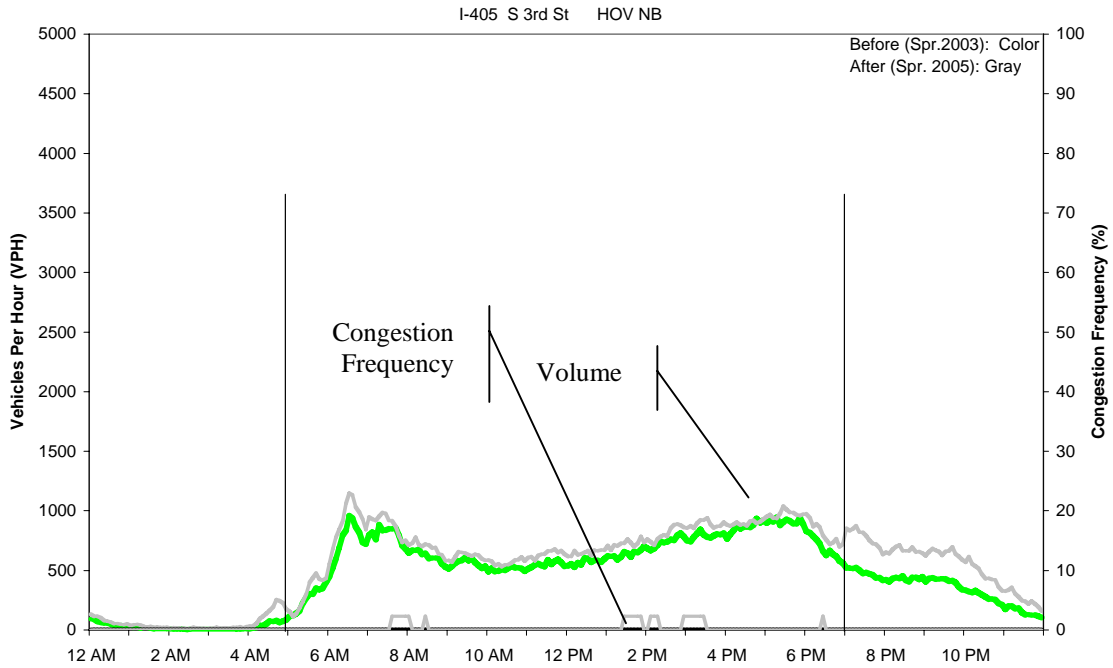


Figure A.16. I-405 NB near Renton, HOV

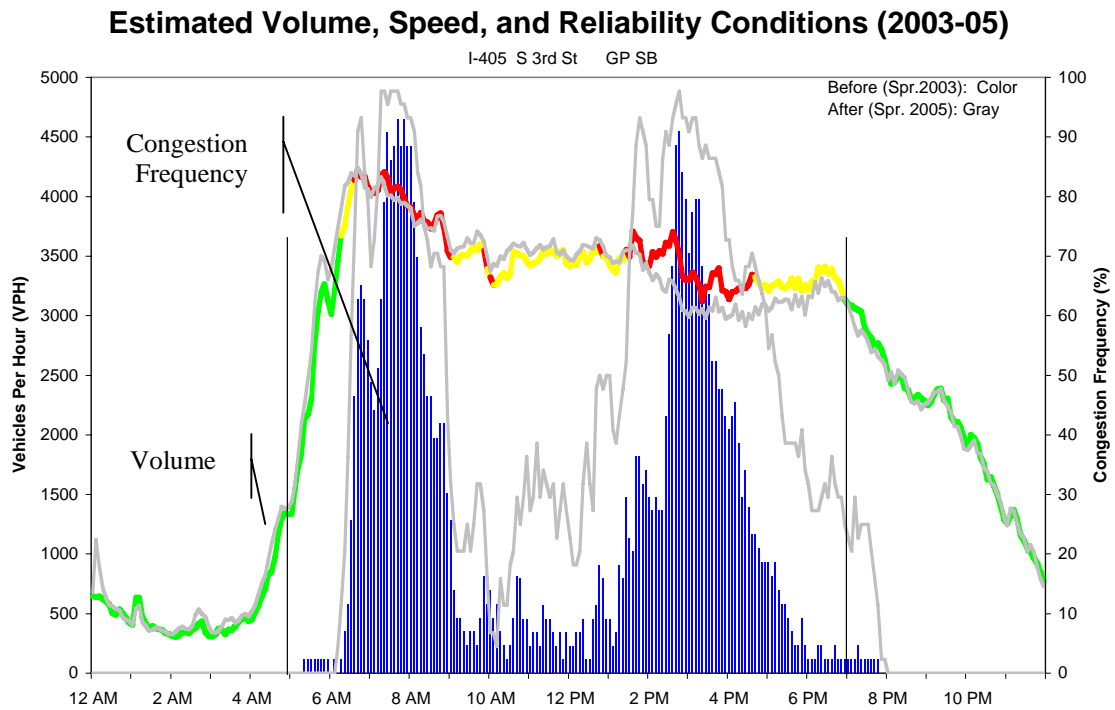


Figure A.17. I-405 SB near Renton, GP

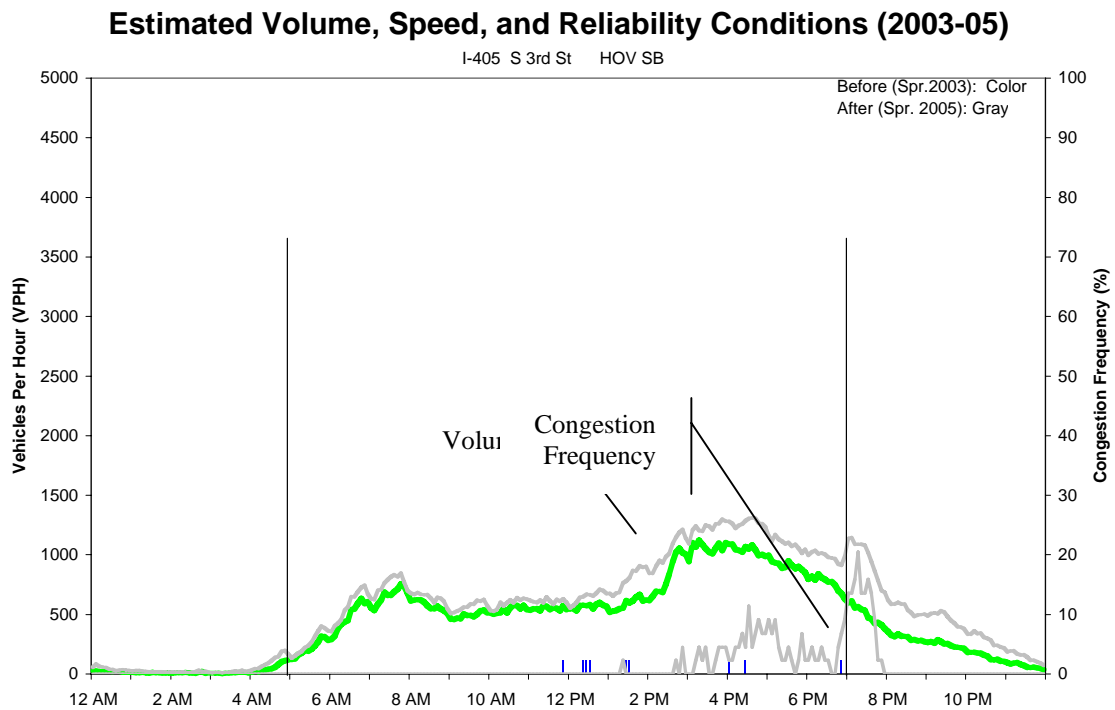


Figure A.18. I-405 SB near Renton, HOV

Estimated Volume, Speed, and Reliability Conditions (2003-05)

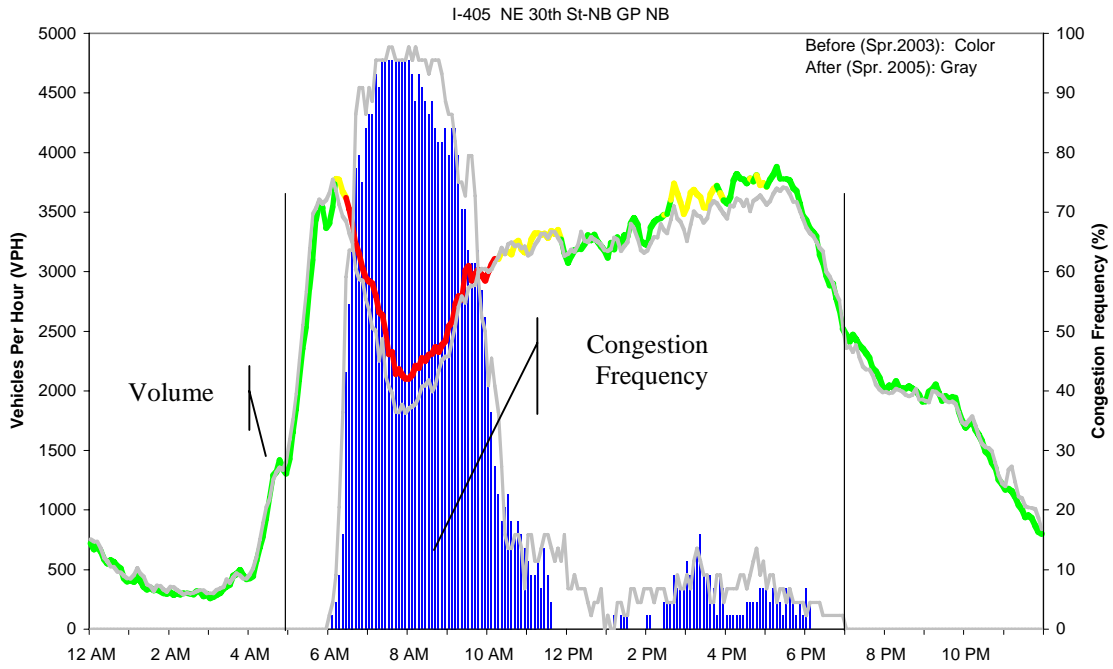


Figure A.19. I-405 NB near Newcastle, GP

Estimated Volume, Speed, and Reliability Conditions (2003-05)

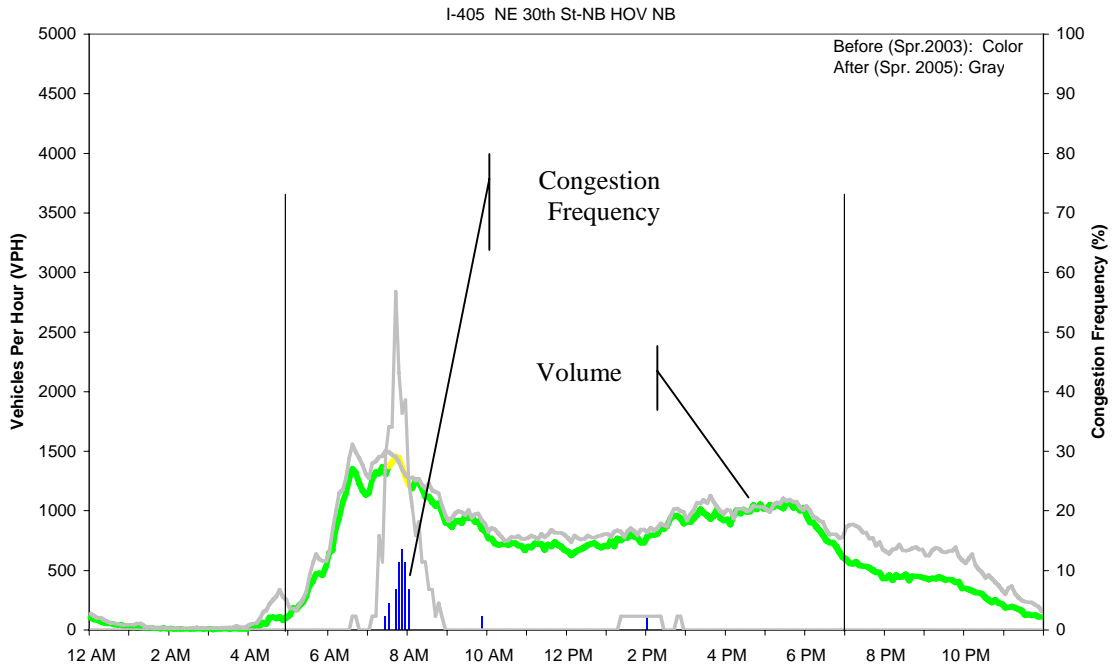


Figure A.20. I-405 NB near Newcastle, HOV

Estimated Volume, Speed, and Reliability Conditions (2003-05)

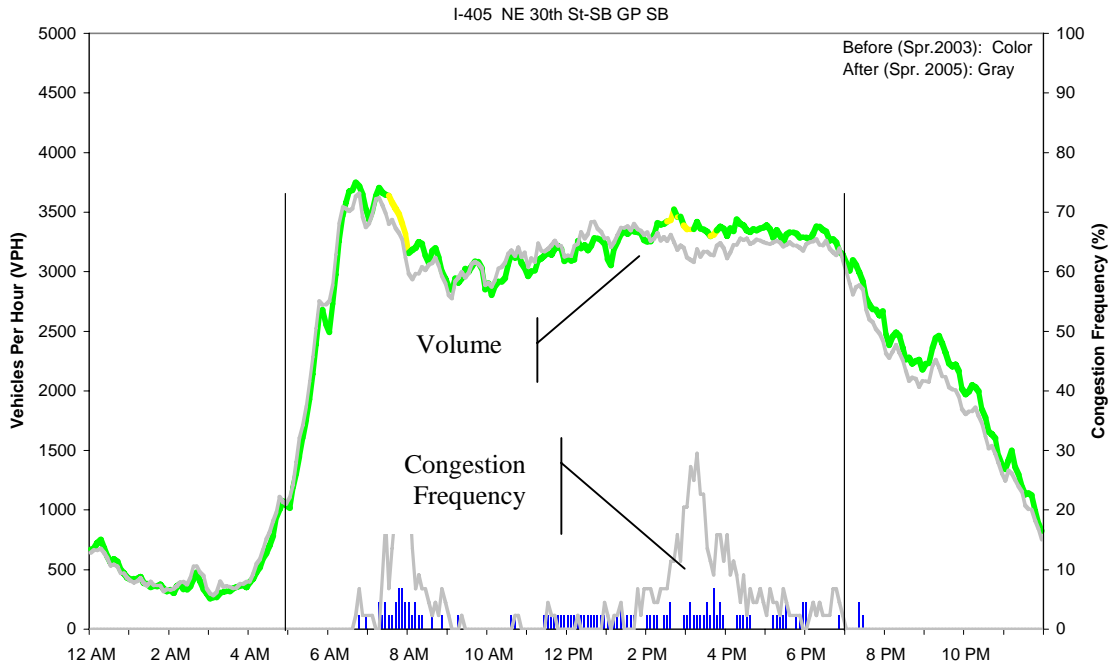


Figure A.21. I-405 SB near Newcastle, GP

Estimated Volume, Speed, and Reliability Conditions (2003-05)

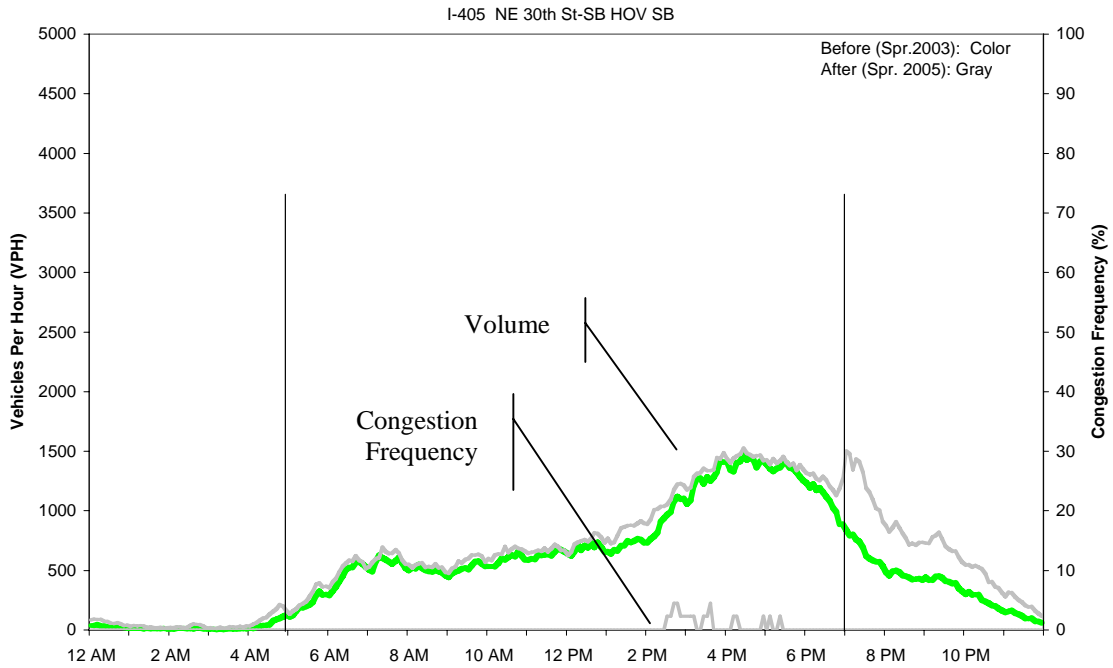


Figure A.22. I-405 SB near Newcastle, HOV

Estimated Volume, Speed, and Reliability Conditions (2003-05)

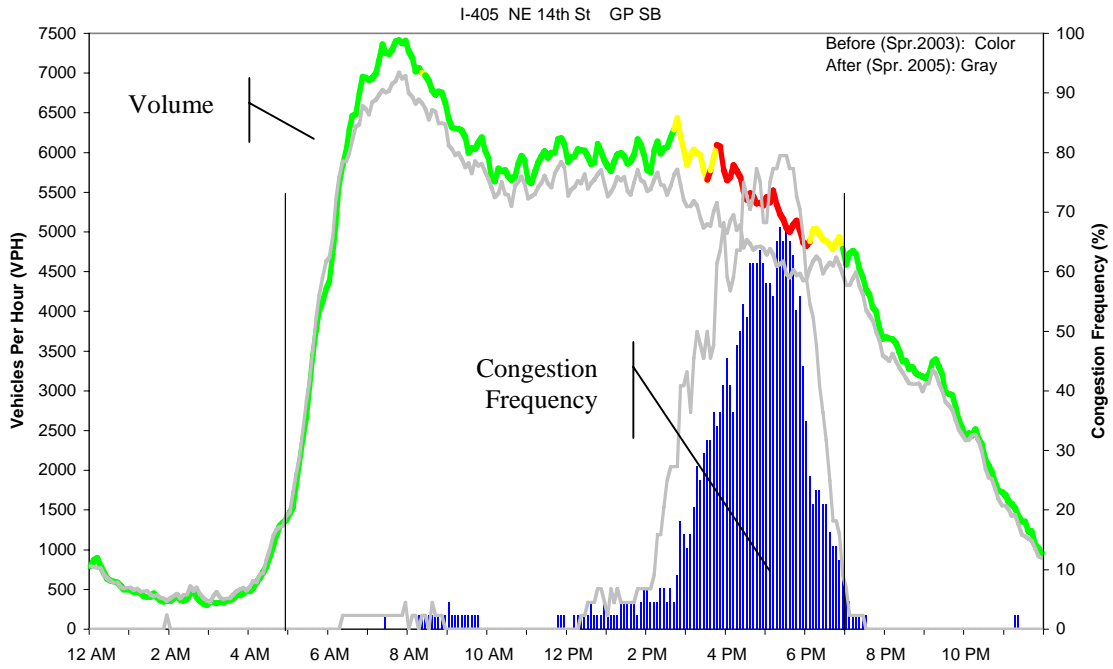


Figure A.23. I-405 SB near Bellevue, GP

Estimated Volume, Speed, and Reliability Conditions (2003-05)

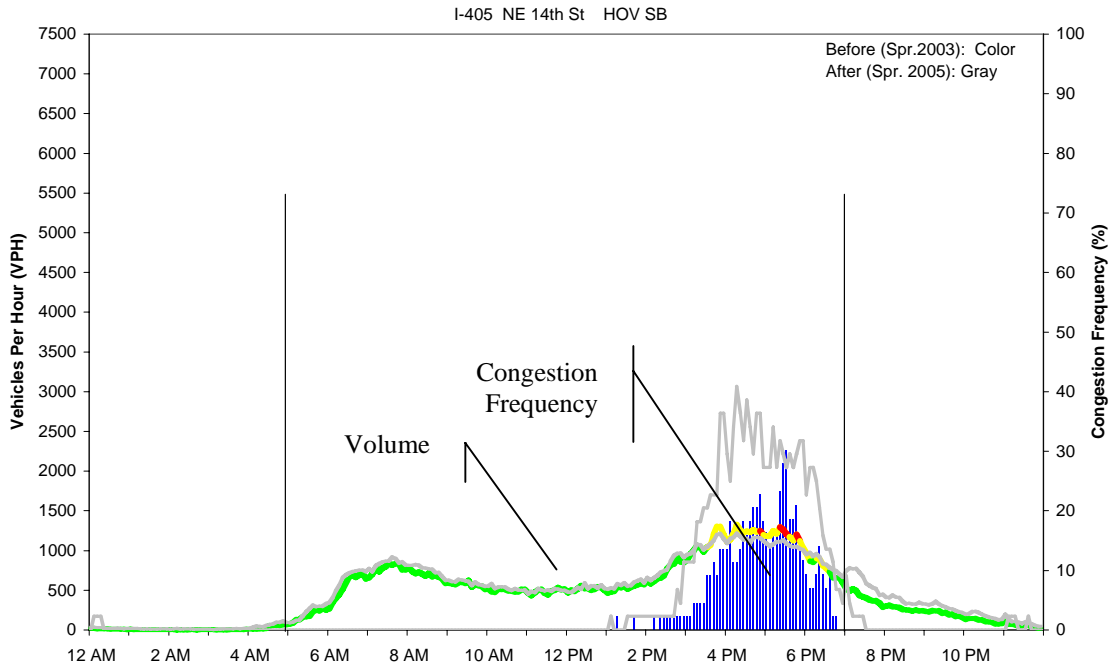


Figure A.24. I-405 SB near Bellevue, HOV

Estimated Volume, Speed, and Reliability Conditions (2003-05)

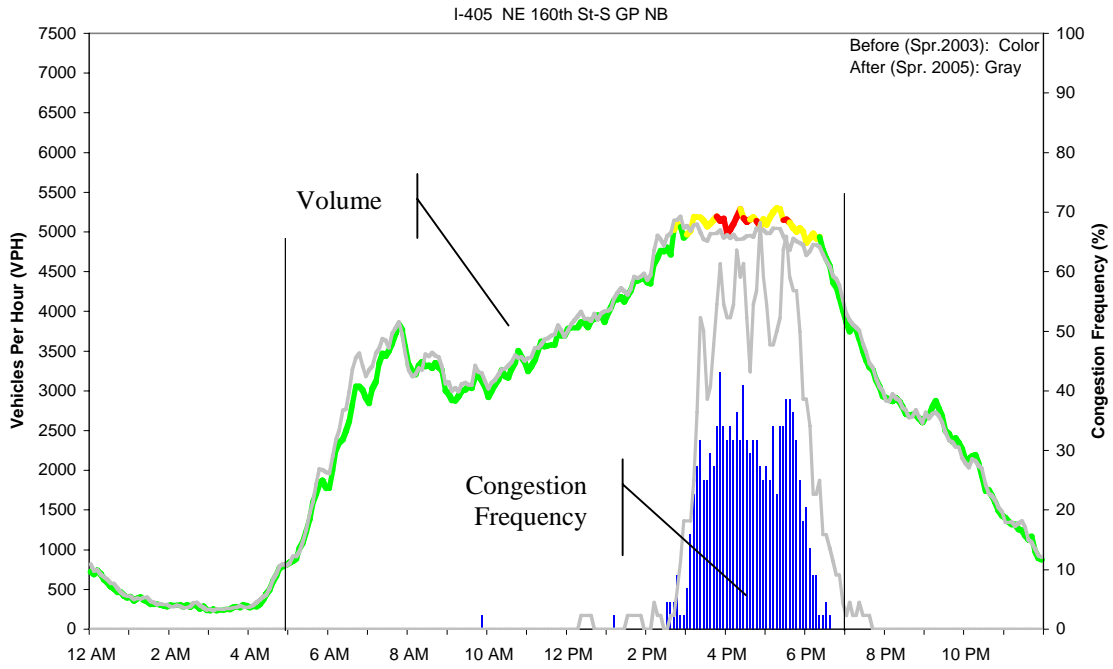


Figure A.25. I-405 NB near Bothell, GP

Estimated Volume, Speed, and Reliability Conditions (2003-05)

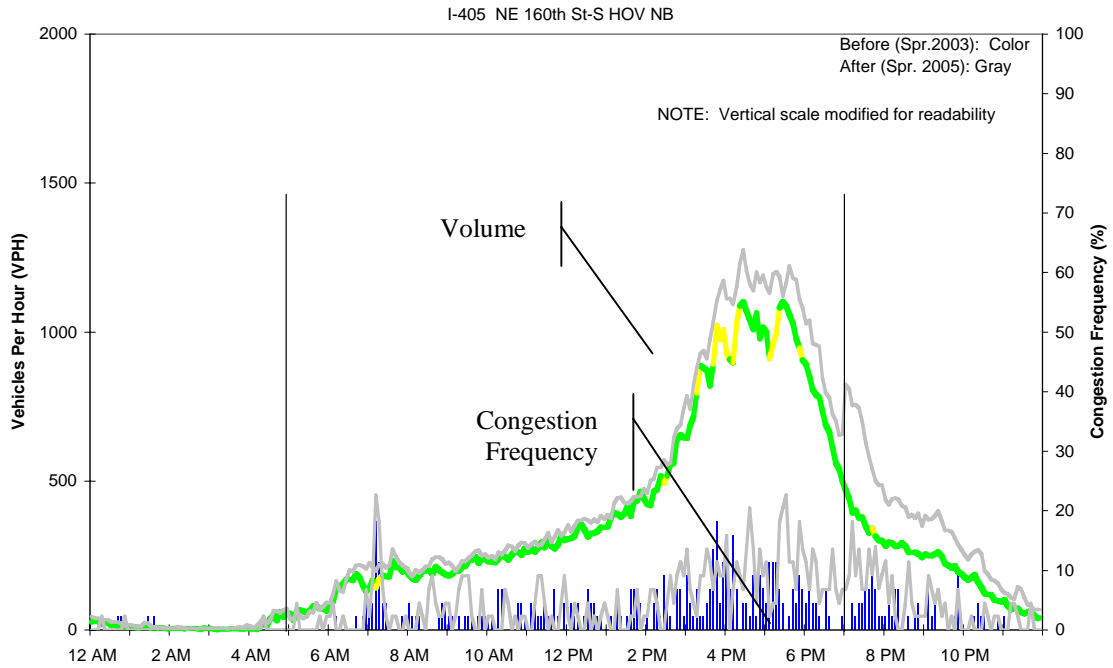


Figure A.26. I-405 NB near Bothell, HOV

APPENDIX B. SURVEY RESULTS

In the winter and spring of 2004 and 2005, mailback surveys were conducted to evaluate public opinion regarding the revised HOV hours of operation pilot program. The following are summary results from the 2004 and 2005 surveys. (Additional discussion of survey results can be found in this report in Section 4, Public Perceptions.)

AWARENESS AND USAGE

Figure 1 shows that the majority of survey respondents in 2004 were not aware of the new hours of operation. In 2005, awareness of the new hours of operation slightly improved, increasing from 36 percent awareness to 45 percent.

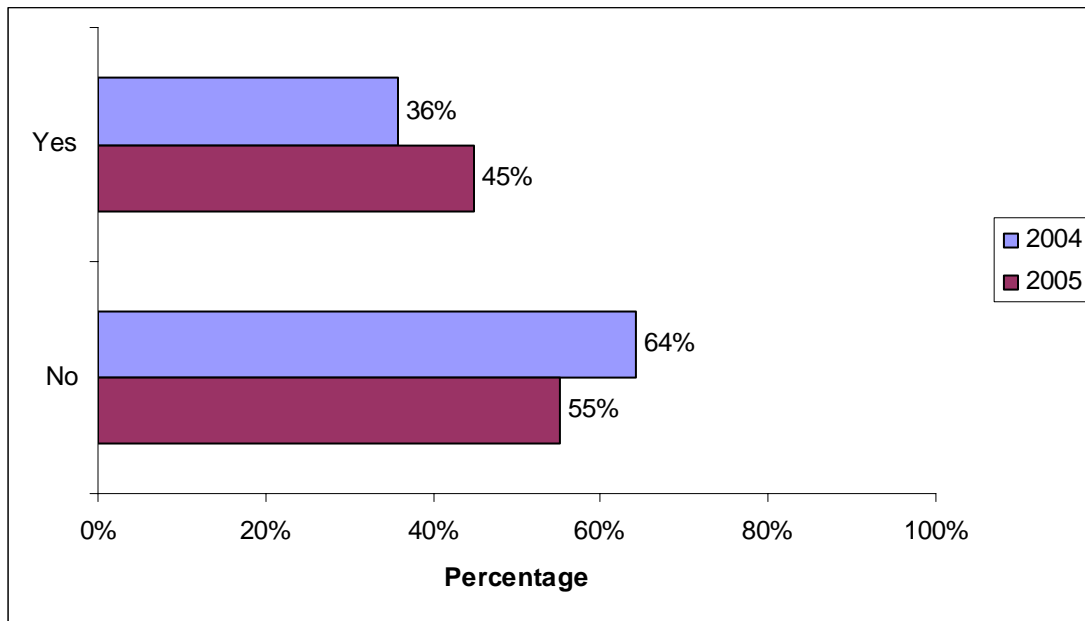


Figure 1. 2004 vs. 2005 survey respondent awareness of new hours of operation for Eastside HOV lanes

To evaluate possible differences between the survey responses of motorists who were aware of the new hours of operation vs. those who were not, some of the following discussion specifically compares the respondents who were aware of the new hours of operation in 2004 to those who were aware in 2005. In those discussions, such respondents will be referred to as “aware respondents.”

After the new hours of operation were implemented, 44 percent of 2004 respondents used the HOV lanes during those hours (see Figure 2). In 2005, 53 percent of respondents used the HOV lanes during the new hours of operation.

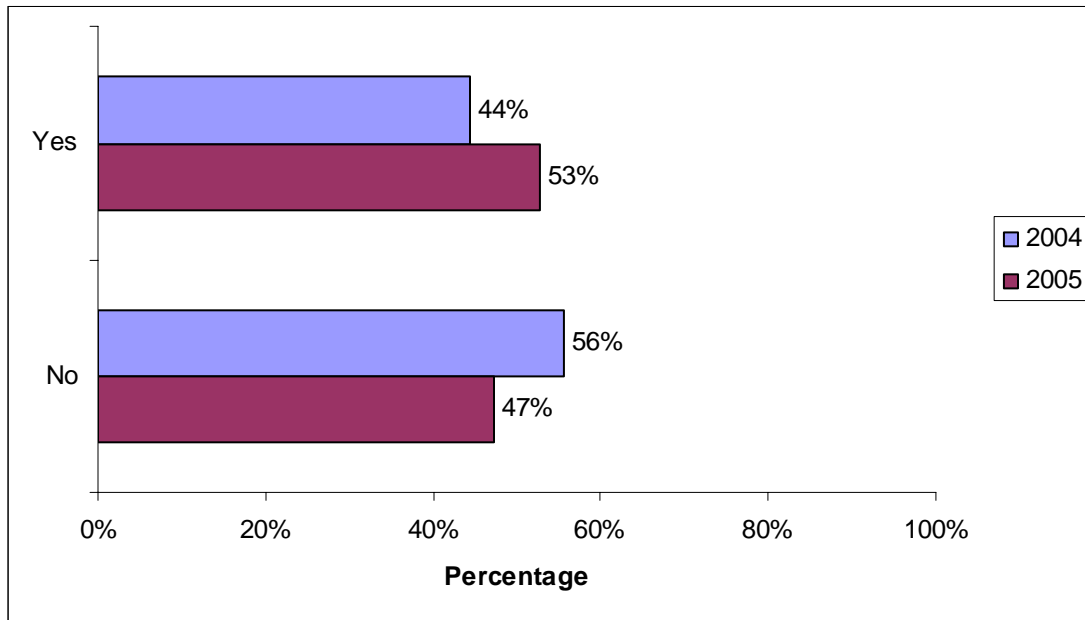


Figure 2. 2004 vs. 2005 respondent use of HOV lanes during the new hours of operation

On the basis of only the subset of aware respondents, since the new hours of operation were implemented, 59 percent of 2004 aware respondents used the HOV lanes during those hours (see Figure 3). In 2005, that number increased to 66 percent.

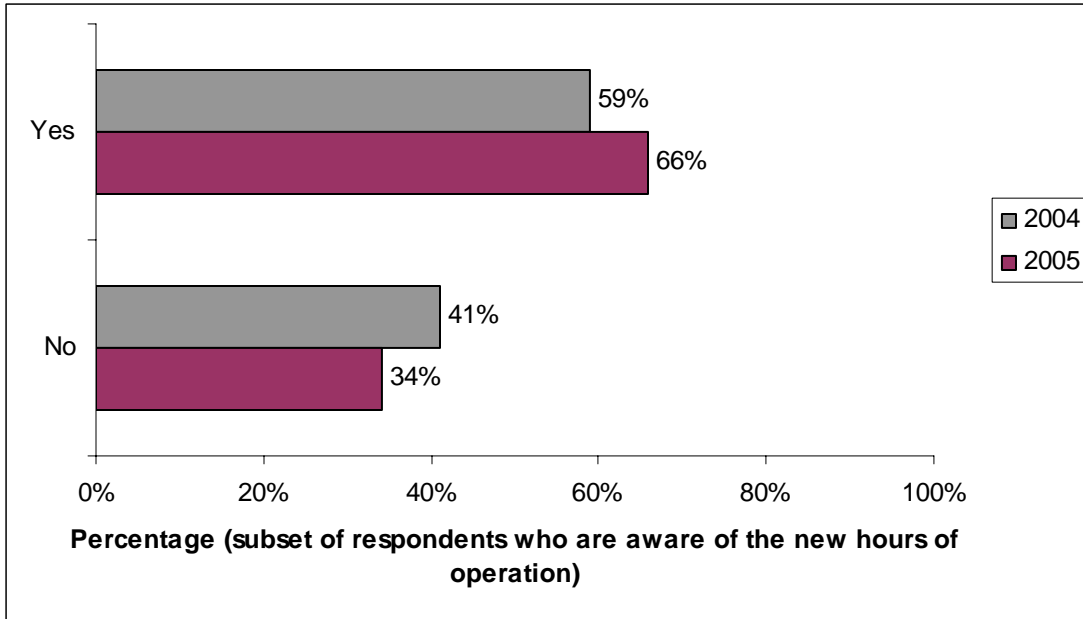


Figure 3. 2004 vs. 2005 aware respondent use of HOV lanes during the new hours of operation

Looking specifically at the respondents who had used the HOV lanes during the new hours, Figure 4 displays their mode of travel. The results show little change between 2004 and 2005.

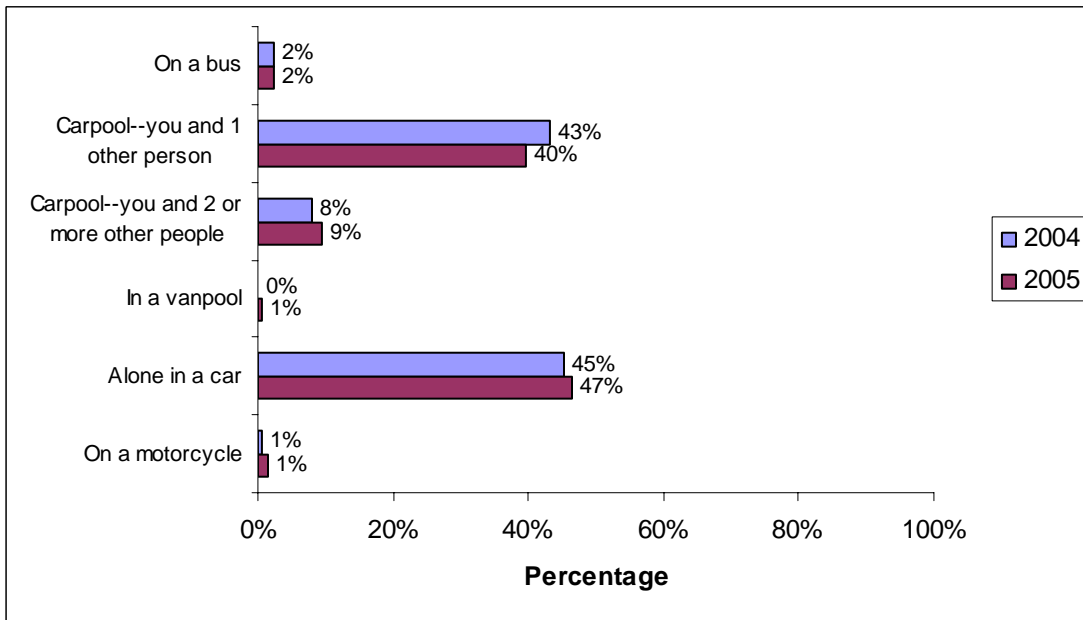


Figure 4. 2004 vs. 2005 mode of use of HOV lanes during the new hours of operation

Figure 5 summarizes the use of the different freeways' HOV lanes during the new hours of operation. Most respondents used the HOV lanes on I-405.

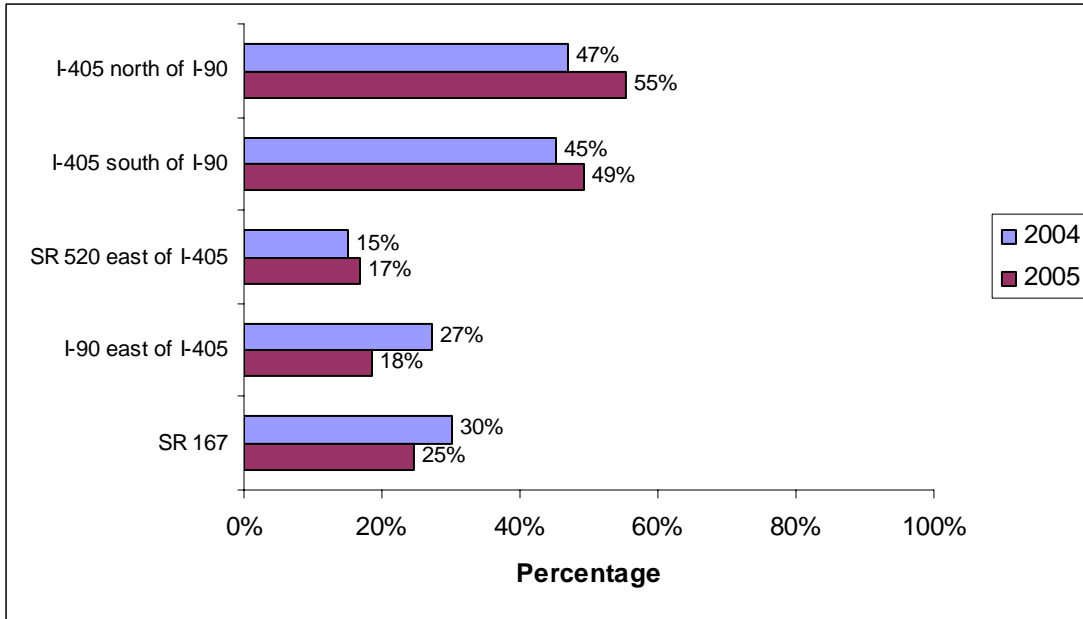


Figure 5. Typical HOV lanes used during the new hours of operation (2004 vs. 2005)

The majority of respondents used the HOV lanes during the new hours of operation one day or less per week (see Figure 6). Respondents in 2005 used the lanes less frequently than those in 2004.

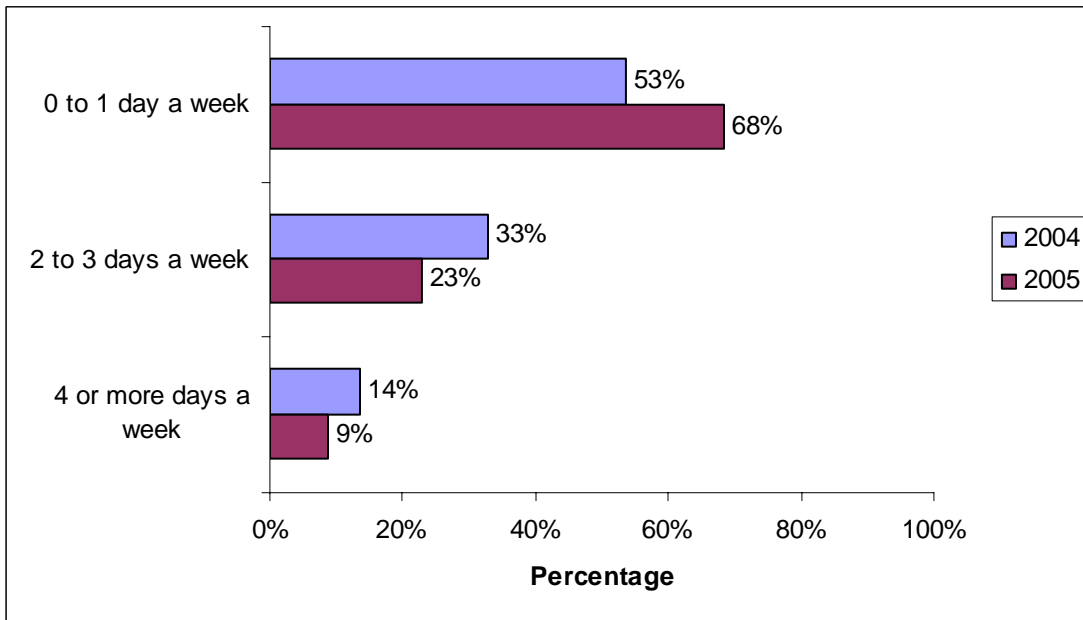


Figure 6. Weekly frequency of use of HOV lanes during new hours of operation (2004 vs. 2005)

PUBLIC OPINIONS ON NEW HOV LANE HOURS OF OPERATION

The survey addressed public opinion regarding perceived changes in freeway conditions due to the new HOV lane hours of operation. Figure 7 shows respondent opinions about changes in driving maneuverability during the new hours. Of the respondents in 2005, 32 percent felt that driving maneuverability was better than before, whereas 27 percent had this opinion in 2004. Almost 40 percent of respondents felt that driving maneuverability remained unchanged.

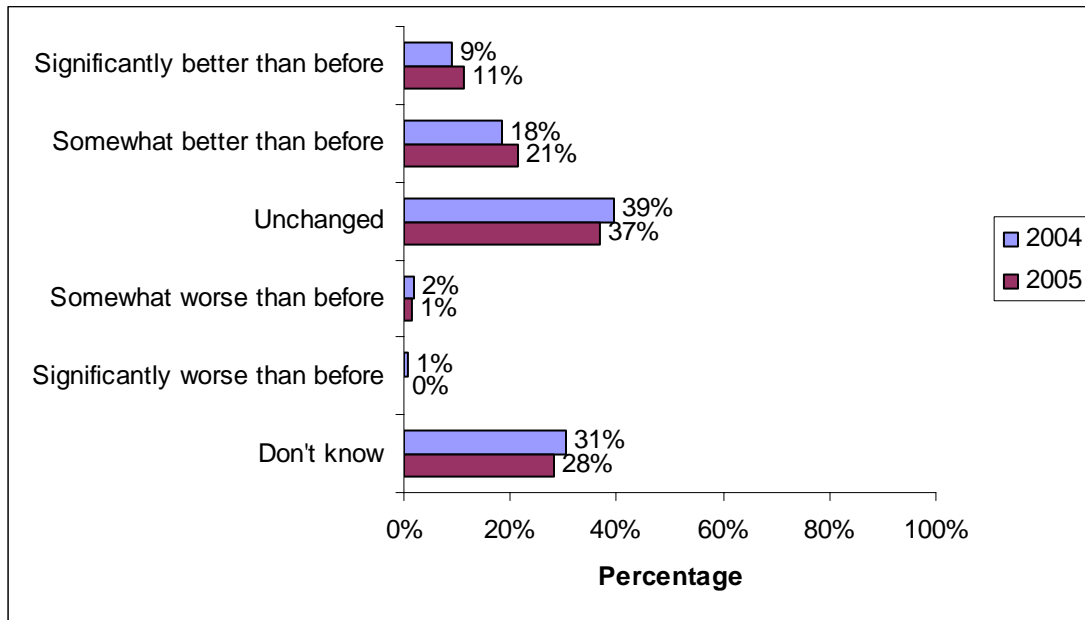


Figure 7. Opinions regarding change in driving maneuverability during new HOV lane hours of operation (2004 vs. 2005)

The response pattern was somewhat different among the subset of aware respondents. Of aware respondents in 2005, 45 percent felt that driving maneuverability had improved. Figure 8 shows that aware respondents were more likely to have an opinion about the HOV lanes. Note that between 28 and 31 percent of all respondents did not have an opinion about driving maneuverability, whereas only 10 to 13 percent of aware respondents did not have an opinion.

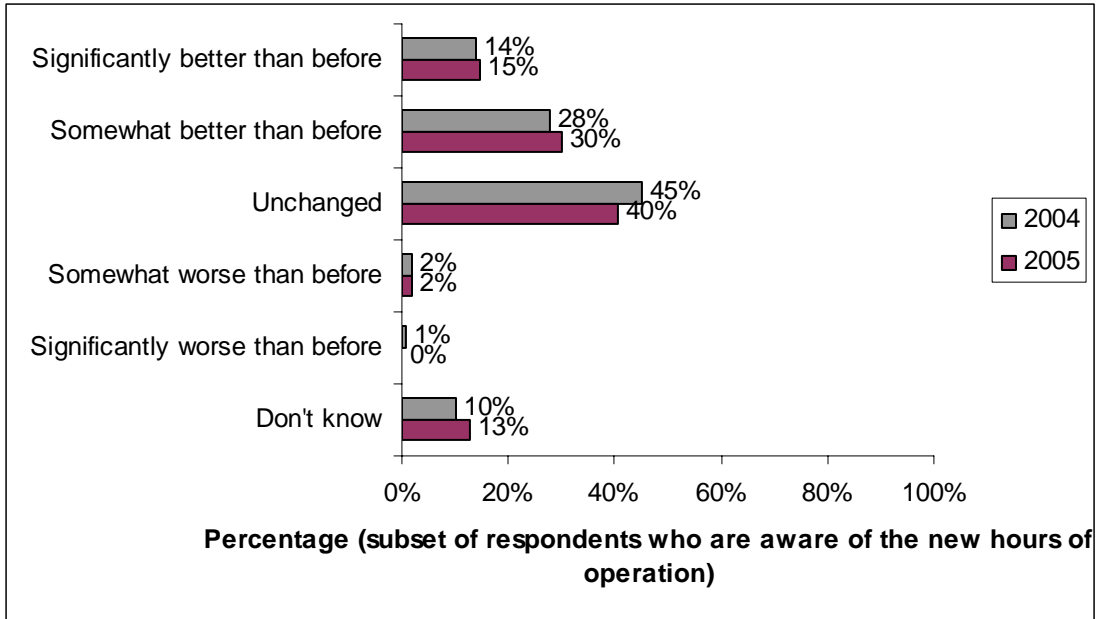


Figure 8. Opinions regarding change in driving maneuverability during new HOV lane hours of operation (2004 vs. 2005)

Similar responses were recorded for opinions on the overall safety of the freeway (see Figure 9). Six percent more of 2005 respondents felt that safety had improved (21 percent in 2004 versus 27 percent in 2005).

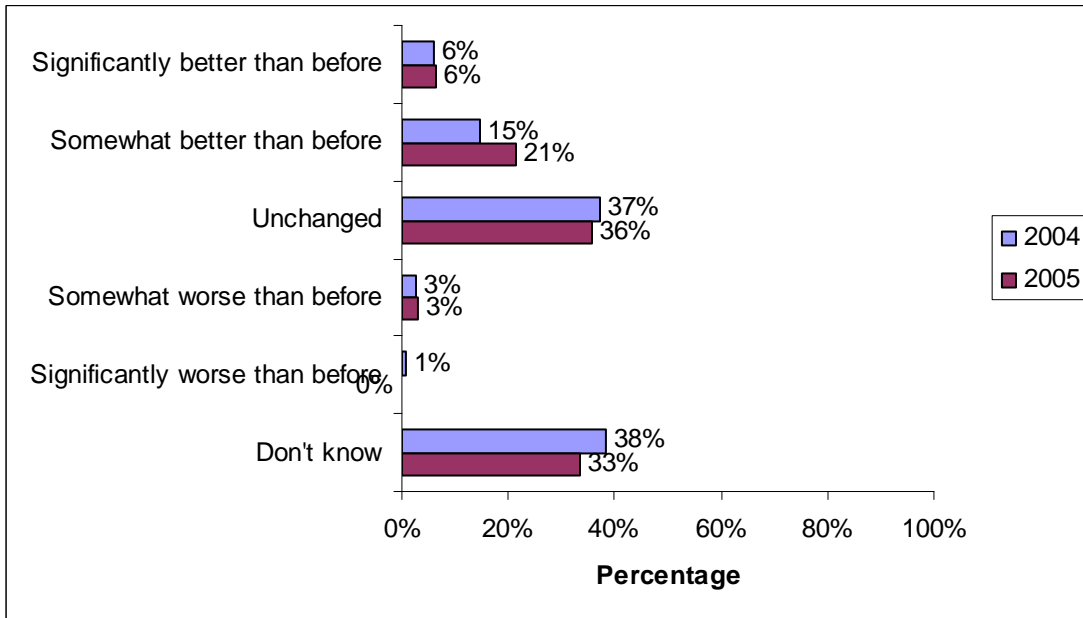


Figure 9. Opinions regarding change in overall safety on the affected freeways (2004 vs. 2005)

The response pattern was somewhat different among the subset of aware respondents. Similar to Figure 8, Figure 10 shows that more of the aware respondents had opinions about safety. Note that between 33 and 38 percent of all respondents did not have an opinion about overall safety, whereas only 18 percent of aware respondents did not have an opinion. A larger proportion (about 10 percent more) of aware respondents felt safety had improved than was seen in the overall respondent population.

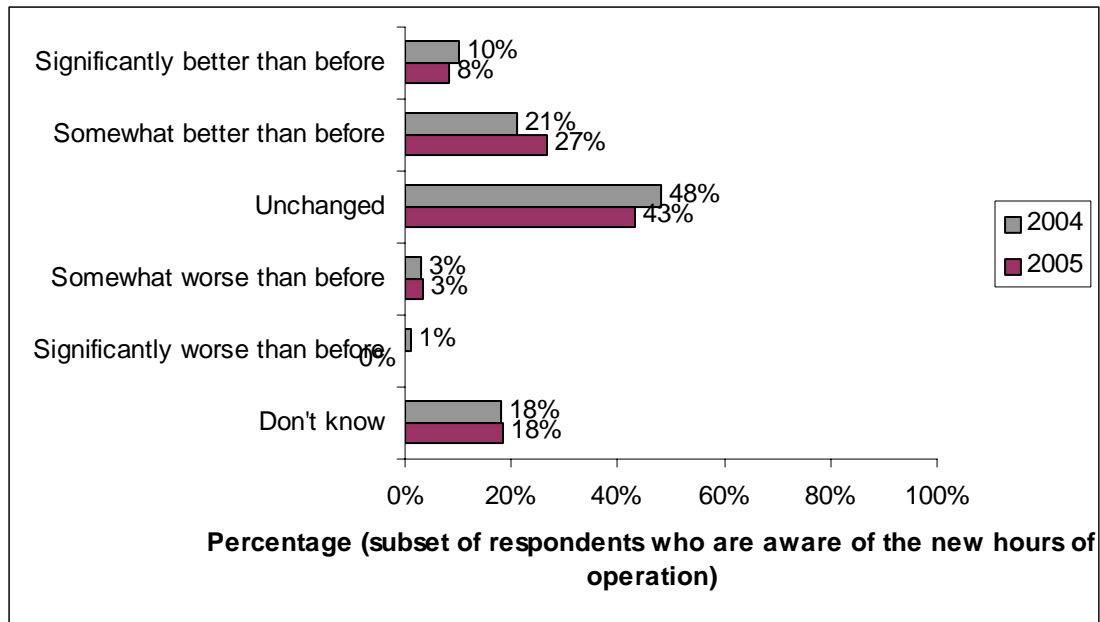


Figure 10. Opinions regarding change in overall safety on the affected freeways (2004 vs. 2005)

The respondents were also asked about the driving speeds on the freeways as a result of the new hours of operations. Many respondents were unsure whether speeds in the HOV lanes had changed (see Figure 11). The majority of respondents felt that the speeds were unchanged or faster than before. There was not a noticeable difference between the 2004 and 2005 responses.

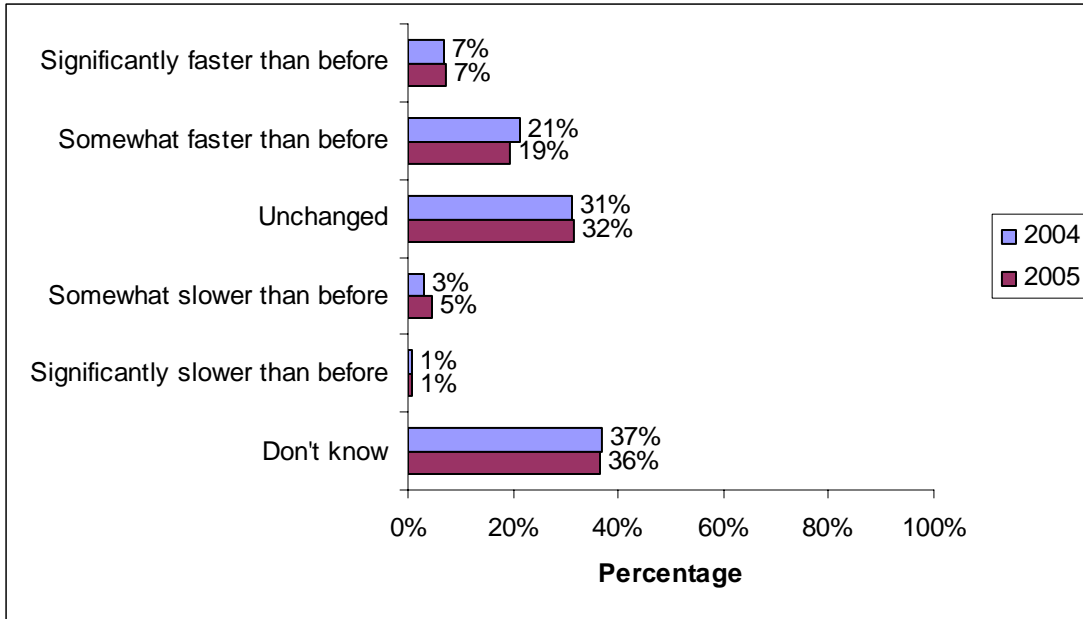


Figure 11. Opinions regarding change in speeds in HOV lanes on weekday evenings (7:00 to 9:00 PM)

Similar responses were recorded regarding speeds in the general-purpose lanes during the new hours, as displayed in Figure 12. Although many respondents were unsure of a speed difference, the majority of respondents felt that the speeds were either unchanged or faster in the general-purpose lanes. The number of respondents in 2005 who felt that the speeds changed increased by 4 percent from 2004.

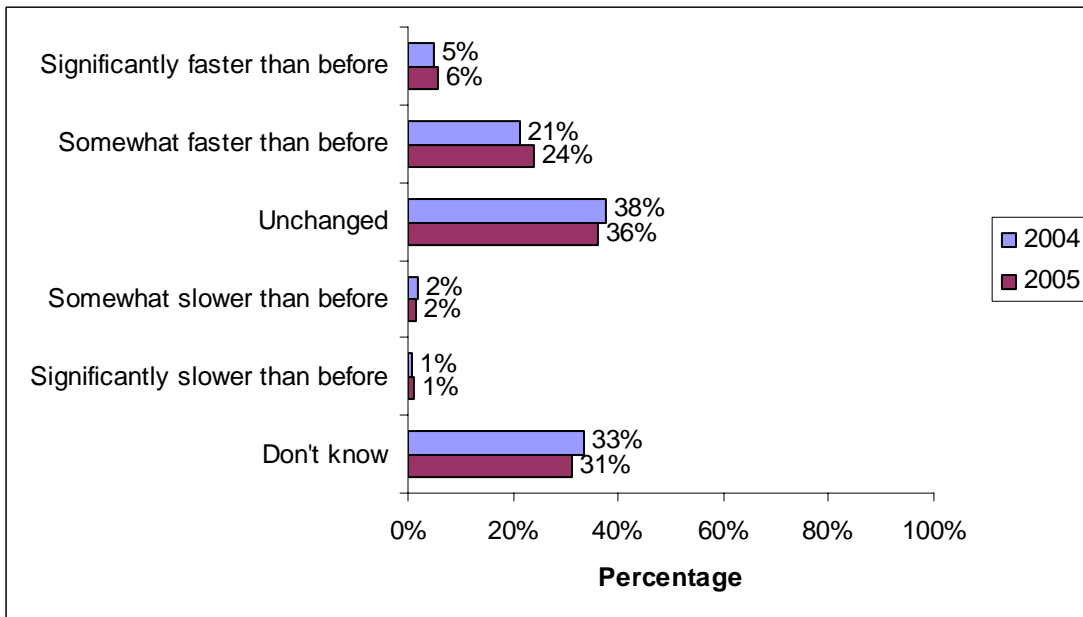


Figure 12. Opinions regarding change in speeds in general purpose lanes on weekday evenings (7:00 to 9:00 PM)

Figures 13 and 14 display the opinions of aware respondents regarding speed changes. A slightly higher proportion of aware respondents felt that speeds in the HOV and GP lanes had increased than was seen in the overall respondent population.

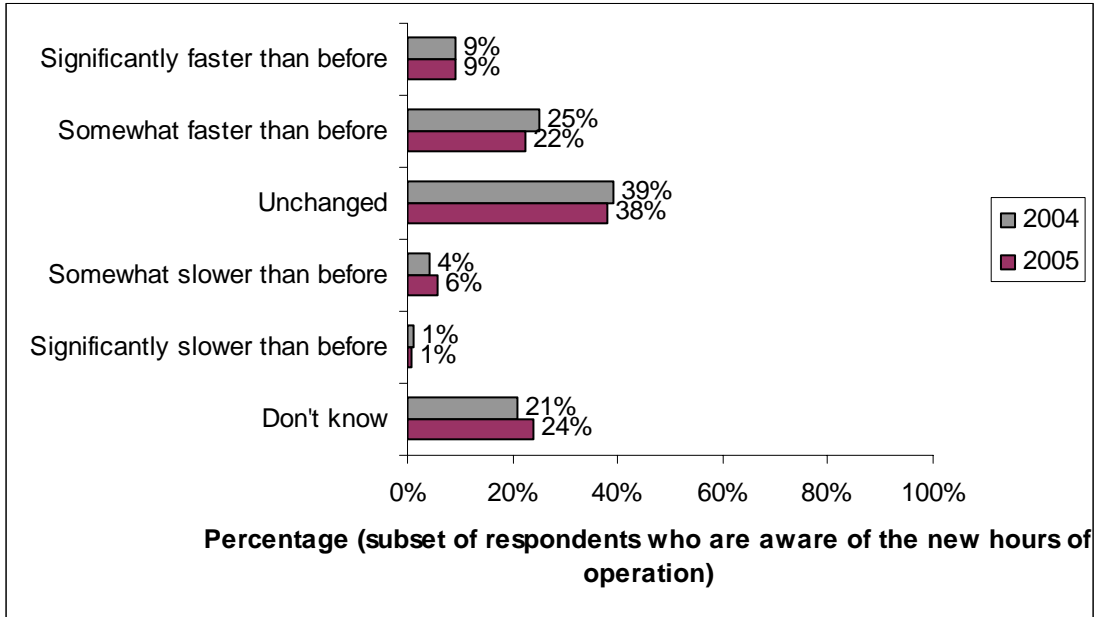


Figure 13. Aware respondent opinions regarding change in speeds in HOV lanes on weekday evenings (7:00 to 9:00 PM)

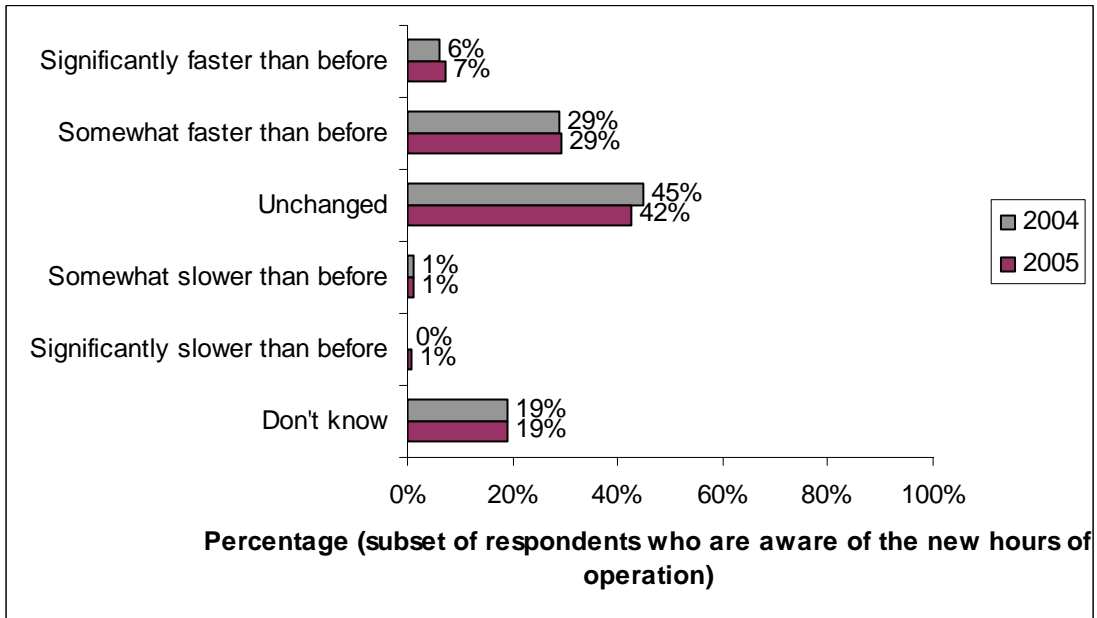


Figure 14. Aware respondent opinions regarding change in speeds in general purpose lanes on weekday evenings (7:00 to 9:00 PM)

The survey asked general questions about drivers' overall opinions of the new HOV lane hours of operation. Figure 15 shows that the majority of respondents thought that the opening of HOV lanes during the hours of 7:00 PM to 5:00 AM was a good idea. Overall, responses did not change significantly from 2004 to 2005.

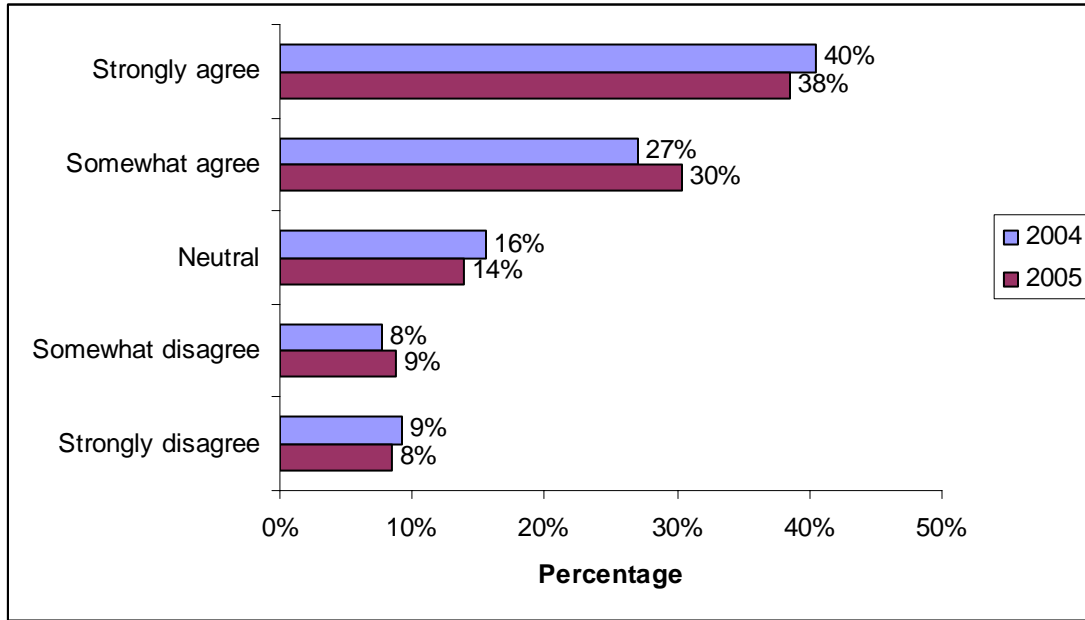


Figure 15. Opening the HOV lanes to all vehicles during the hours of 7:00 PM to 5:00 AM is a good idea

Respondents who were aware of the new hours of operation were more likely to think that the policy changes were a good idea. Of the aware respondents, 45 percent strongly agreed that opening the lanes during the hours of 7:00PM to 5:00AM was a good idea (see Figure 16).

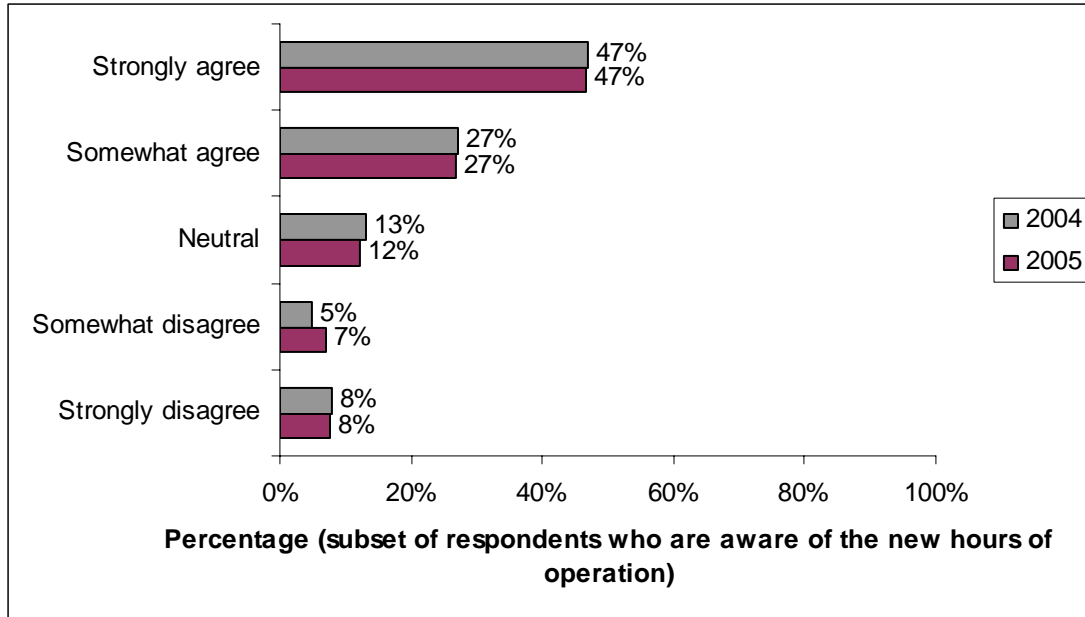


Figure 16. Opening the HOV lanes to all vehicles during the hours of 7:00 PM to 5:00 AM is a good idea (aware respondents)

The decision to alter the HOV lane hours of operation has changed views of the HOV system as a whole. Respondents were asked about their overall feelings on the HOV lane system (see Figure 17). About 50 percent of respondents said that their opinions of the HOV lane system were unchanged since the new hours of operation. Approximately 40 percent stated that their opinions of the system were more favorable because of the new hours of operation. Overall, responses did not change significantly from 2004 to 2005. Figure 18 shows that a small additional percentage of aware respondents had more favorable opinions of the HOV lane system.

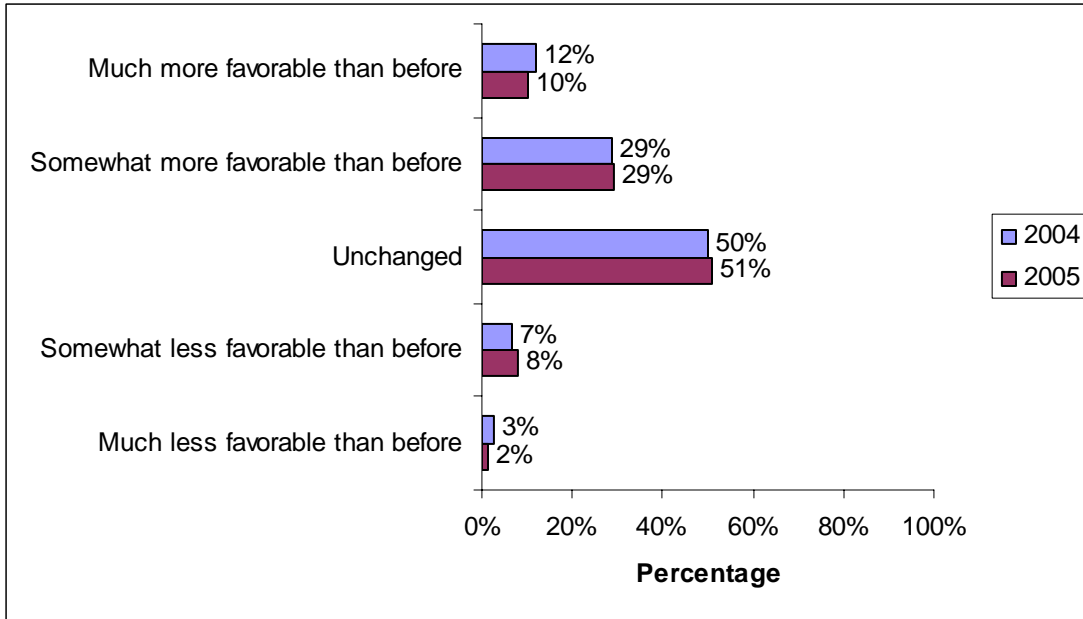


Figure 17. Overall opinion of HOV lane system because of the new HOV lane hours of operation

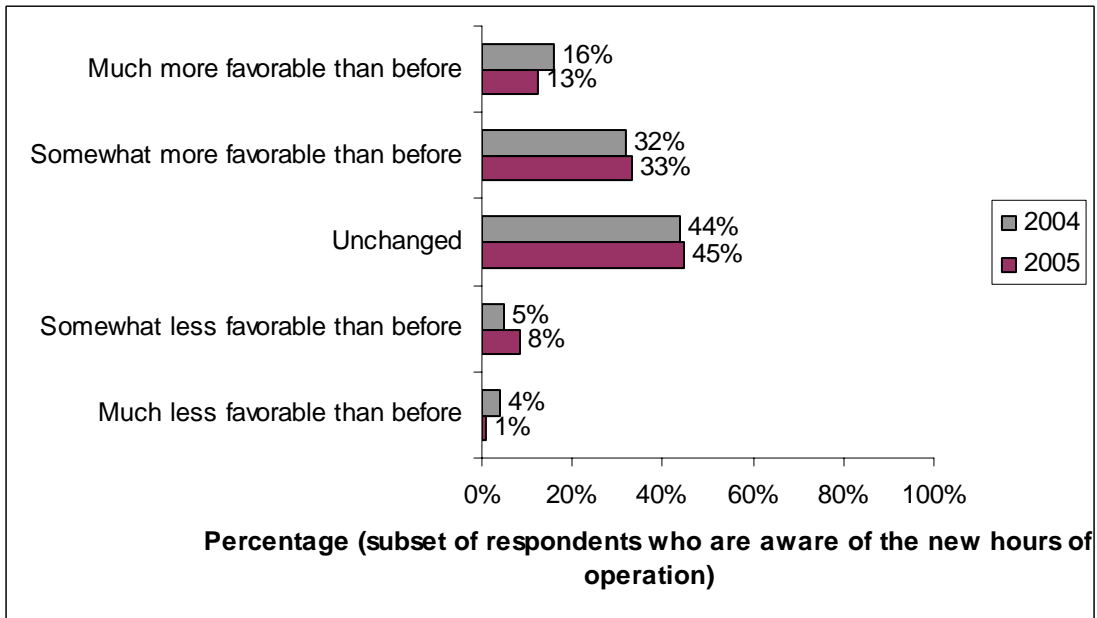
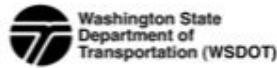


Figure 18. Overall opinion of HOV lane system because of the new HOV lane hours of operation (aware respondents)

APPENDIX C. SURVEY QUESTIONS

The following is the public opinion survey discussed in Appendix B. Note that the overall survey was designed for the ongoing WSDOT HOV evaluation project, while the questions in section C of the survey were included specifically for the HOV Hours of Operation pilot project evaluation.



High Occupancy Vehicle Lane Analysis 2005 Public Opinion Survey

The Washington State Department of Transportation (WSDOT) and the Washington State Transportation Center (TRAC) at the University of Washington are working together to study high occupancy vehicle (HOV) lanes, also known as carpool lanes, in the Puget Sound region. We would like to understand your commuting preferences and your perception of HOV lane use and effectiveness.

Please ask the person in your household who most often travels on the freeways in the Puget Sound area to complete this survey (it requires approximately 5 to 10 minutes to complete). No personal information is recorded, and identities cannot be traced. But if you wish to discuss the survey, please contact Eldon L. Jacobson at 206.685.3187 between 7:30 AM and 4:00 PM, or send an e-mail to eldon@u.washington.edu.

After the survey is completed, re-fold the form so that the **University of Washington** address is displayed, secure with tape, and drop it in a mailbox. No postage is necessary. Thank you for participating.

Section A. Your Commute Trip

1. Which freeways do you frequently use? Please select all that apply.*

- | | | |
|--|---------------------------------|---|
| <input type="checkbox"/> I-5 north of downtown Seattle | <input type="checkbox"/> I-90 | <input type="checkbox"/> SR 512 |
| <input type="checkbox"/> I-5 south of downtown Seattle | <input type="checkbox"/> SR 520 | <input type="checkbox"/> none of the above, |
| <input type="checkbox"/> I-405 north of I-90 | <input type="checkbox"/> SR 16 | <input type="checkbox"/> or I do not use freeways during my commute |
| <input type="checkbox"/> I-405 south of I-90 | <input type="checkbox"/> SR 167 | |

2. Indicate your usual mode of travel between 6:00 to 9:00 AM and 3:00 to 7:00 PM (please select one).**

- | | | |
|---|-------------------------------------|----------------------------------|
| <input type="radio"/> drive alone | <input type="radio"/> bus | <input type="radio"/> motorcycle |
| <input type="radio"/> carpool--you and 1 other person | <input type="radio"/> bicycle, walk | <input type="radio"/> other |
| <input type="radio"/> carpool--you and 2 or more other people | <input type="radio"/> vanpool | |

3. Have you ever used HOV lanes while traveling in the Puget Sound area?

- yes no (if no, please proceed to **Section B** on the next page)

How have you used HOV lanes? Please select all that apply.

- | | | |
|--|---------------------------------------|--|
| <input type="checkbox"/> carpool--you and 1 other person | <input type="checkbox"/> on a bus | <input type="checkbox"/> alone in a car |
| <input type="checkbox"/> carpool--you and 2 or more other people | <input type="checkbox"/> in a vanpool | <input type="checkbox"/> on a motorcycle |

Why do you typically use the HOV lanes? Please select one.

- | | |
|--|--|
| <input type="radio"/> work-related trips | <input type="radio"/> recreation |
| <input type="radio"/> non-work errands | <input type="radio"/> I frequently use the HOV lanes for multiple purposes |

If you use a carpool/vanpool, how are the members of your carpool/vanpool related?

- all from the same household from more than one household

If you are currently a carpool/vanpool user, would you still participate in a carpool/vanpool if there were no HOV lanes?

- yes, definitely yes, probably not sure probably not definitely not no opinion

* Checkboxes: please **select all that apply**

** Circles: **select one**

SOV HOV P&R

Section B. Your Opinions

4. Please indicate the extent to which you agree or disagree with the following statements:	Agree strongly	Agree	Neutral	Disagree	Disagree strongly
a HOV lanes are a good idea.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b Allowing drivers of single-occupant vehicles to pay a fee to use available space in free-flowing HOV lanes is a good idea.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c HOV lanes help save all commuters a lot of time.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d Constructing HOV lanes is unfair to taxpayers who choose to drive alone.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e Existing HOV lanes are being adequately used.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
f HOV lane violators commit a serious traffic violation.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
g HOV lane violations are common during the commute hours.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
h Constructing direct entrance and exit ramps that connect with inside (left side) HOV lanes will improve the freeway.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
i HOV lanes should be opened to all traffic, all the time.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
j HOV lanes are convenient to use.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
k HOV lane construction should continue.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
l More police enforcement is needed for HOV lanes.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
m HOV lanes should be opened to all traffic during non-commute hours.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
n The HERO program helps reduce HOV lane violations [by encouraging commuters to report HOV lane violators at (206) 764-HERO].	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
o How would you describe driving conditions in the general-purpose (non-HOV) lanes compared to the HOV lane?	<input type="radio"/> general-purpose lanes are much safer than HOV lanes <input type="radio"/> general-purpose lanes are somewhat safer than HOV lanes <input type="radio"/> general-purpose lanes and HOV lanes are equally safe <input type="radio"/> HOV lanes are somewhat safer than general purpose lanes <input type="radio"/> HOV lanes are much safer than general-purpose lanes				

Section C. HOV Lane Hours of Operation

Beginning in the summer of 2003, all freeway motorists (both carpools and non-carpools) are allowed to use most Eastside HOV lanes at night between 7:00 PM and 5:00 AM every day. The affected freeways are I-405, SR 167, SR 520 east of Bellevue Way, and I-90 east of Mercer Island. (On all other locations and at all other times, the HOV lane remains HOV-only.)

5. Were you aware of the new hours of operation for Eastside HOV lanes?

yes no (if no, please proceed to Question 7)

6. Since the new HOV lane hours of operation were implemented in the summer of 2003, have you used any of the affected HOV lanes while traveling between the hours of 7:00 PM and 5:00 AM?

yes no (if no, please proceed to Question 7)

- 6a How do you **typically** use the HOV lanes between the hours of 7:00 PM and 5:00 AM? Please **select one**.

on a bus in a vanpool
 carpool--you and 1 other person alone in a car
 carpool--you and 2 or more other people on a motorcycle

- 6b In a **typical** week, which HOV lanes do you usually use between the hours of 7:00 PM and 5:00 AM? Please **select all that apply**.

I-405 north of I-90 I-90 east of I-405
 I-405 south of I-90 SR 167
 SR 520 east of I-405

- 6c In a **typical** week, how frequently do you use HOV lanes between the hours of 7:00 PM and 5:00 AM? Please **select one**.

0 to 1 day a week 2 to 3 days a week 4 or more days a week

7. Please complete the following statements on the basis of your personal experience on the freeways affected by the new hours of operation (I-405, SR 167, SR 520 east of Bellevue Way, and I-90 east of Mercer Island). For each statement, compare the freeway conditions **now** (under the new HOV hours of operation policy) to the freeway conditions **before** the policy began (that is, when HOV lanes were HOV-only 24 hours a day). (If you do not travel on the affected freeways, please proceed to Question 8.)

- 7a When traveling between the hours of 7:00 PM and 5:00 AM on the affected freeways, my driving maneuverability (ability to change lanes or pass vehicles) in the general purpose (non-HOV) lanes is ...

significantly better than before somewhat worse than before
 somewhat better than before significantly worse than before
 unchanged don't know

- 7b Because of the new HOV lane hours of operation, overall safety on the affected freeways is ...

significantly better than before somewhat worse than before
 somewhat better than before significantly worse than before
 unchanged don't know

- 7c When traveling on weekday evenings (7:00 PM to 9:00 PM), speeds in the HOV lane are ...

significantly faster than before somewhat slower than before
 somewhat faster than before significantly slower than before
 unchanged don't know

Section C. HOV Lane Hours of Operation (continued)

7d When traveling on weekday evenings (7:00 PM to 9:00 PM), speeds in the general-purpose (non-HOV) lanes are ...

- | | |
|--|--|
| <input type="radio"/> significantly faster than before | <input type="radio"/> somewhat slower than before |
| <input type="radio"/> somewhat faster than before | <input type="radio"/> significantly slower than before |
| <input type="radio"/> unchanged | <input type="radio"/> don't know |

8. Please answer/complete the following statements on the basis of your personal experience:

8a Opening the HOV lanes to all vehicles during the hours of 7:00 PM to 5:00 AM is a good idea.

- | | |
|--------------------------------------|---|
| <input type="radio"/> strongly agree | <input type="radio"/> somewhat disagree |
| <input type="radio"/> somewhat agree | <input type="radio"/> strongly disagree |
| <input type="radio"/> neutral | |

8b Because of the new HOV lane hours of operation, my overall opinion of the HOV lane system is ...

- | | |
|---|---|
| <input type="radio"/> much more favorable than before | <input type="radio"/> somewhat less favorable than before |
| <input type="radio"/> somewhat more favorable than before | <input type="radio"/> much less favorable than before |
| <input type="radio"/> unchanged | |

Section D. About Yourself (optional)

9. **Gender** male female

10. **Age** under 31 31-40 41-50 51-64 65+

11. **ZIPcode** home workplace

12. **Approximate household income level:**

<input type="radio"/> Under \$19,000	<input type="radio"/> \$50,000 to \$100,000
<input type="radio"/> \$19,000 to \$30,000	<input type="radio"/> Above \$100,000
<input type="radio"/> \$30,000 to \$50,000	

Comments: _____

