**Interim Report**
Research Project T1803, Task 19
Frwy Perform Monitor

# WEEKEND FREEWAY PERFORMANCE AND THE USE OF HOV LANES ON WEEKENDS

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Prepared for

**Washington State Transportation Commission**
Department of Transportation
and in cooperation with
**U.S. Department of Transportation**
Federal Highway Administration

June 2000

# TECHNICAL REPORT STANDARD TITLE PAGE

| 1. REPORT NO. | 2. GOVERNMENT ACCESSION NO. | 3. RECIPIENT'S CATALOG NO. |
|---|---|---|
| WA-RD 488.1 | | |

| 4. TITLE AND SUBTITLE | 5. REPORT DATE |
|---|---|
| Weekend Freeway Performance and the Use of HOV Lanes on Weekends | May 2000 |
| | 6. PERFORMING ORGANIZATION CODE |
| 7. AUTHOR(S) | 8. PERFORMING ORGANIZATION REPORT NO. |
| Mark E. Hallenbeck, John M. Ishimaru, and Jennifer Nee | |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS | 10. WORK UNIT NO. |
| Washington State Transportation Center (TRAC)<br>University of Washington, Box 354802<br>University District Building; 1107 NE 45th Street, Suite 535<br>Seattle, Washington 98105-4631 | 11. CONTRACT OR GRANT NO.<br>Agreement T1803, Task 19 |
| 12. SPONSORING AGENCY NAME AND ADDRESS | 13. TYPE OF REPORT AND PERIOD COVERED |
| Research Office<br>Washington State Department of Transportation<br>Transportation Building, MS 47370<br>Olympia, Washington 98504-7370<br>Gary Ray, Project Manager, 360-705-7975 | Interim Report<br>14. SPONSORING AGENCY CODE |

15. SUPPLEMENTARY NOTES

This study was conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration.

16. ABSTRACT


Weekend traffic volumes in the Puget Sound region of Washington State are increasing, and public concern about congestion during non-commute periods has caused WSDOT to re-examine the current policy of restricting HOV lanes to transit vehicles and carpools 24 hours per day, 7 days per week. In many parts of the country, HOV lanes are open to general traffic during non-peak hours. Should WSDOT adopt this less restrictive lane use policy?

This report examines the trade-offs that a change in weekend HOV lane usage would involve. The basic issues that are examined include the following:

- What congestion relief benefits would result?
- Would these changes have adverse impacts on HOV formation and/or HOV lane compliance rates?
- Would highway and transit operational problems be created?
- Would the weekend use of HOV lanes by general purpose vehicles create safety concerns?
- What would be the monetary impacts of changing weekend HOV lane usage?

Supported by a variety of performance graphics and statistics, the report concludes that no improvement in mobility would be obtained by relaxing the current Puget Sound HOV lane operating restrictions to allow weekend use of the HOV lanes by general purpose traffic.


| 17. KEY WORDS | 18. DISTRIBUTION STATEMENT |
|---|---|
| HOV, HOV performance, freeway performance reporting | No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22616 |

| 19. SECURITY CLASSIF. (of this report) | 20. SECURITY CLASSIF. (of this page) | 21. NO. OF PAGES | 22. PRICE |
|---|---|---|---|
| None | None | | |

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# WEEKEND FREEWAY PERFORMANCE AND THE USE OF HOV LANES ON WEEKENDS

The Puget Sound region has some of the most severe traffic congestion in the country. To help combat this congestion, the region has built one of the nation's most extensive and successful HOV systems. During peak commute periods, the majority of the region's freeway HOV lanes carry more people, in fewer vehicles, at faster speeds, than the general purpose (GP) lane adjacent to them.

However, population and employment growth in the region continue to outstrip the region's ability to build roadway capacity. Weekend traffic volumes are increasing, and public concern about congestion during non-commute periods has caused WSDOT to re-examine the current policy of restricting HOV lanes to transit vehicles and carpools 24 hours per day, 7 days per week. In many parts of the country, HOV lanes are open to general traffic during non-peak hours. Should WSDOT adopt this less restrictive lane use policy?

This report examines the trade-offs that a change in weekend HOV lane usage would involve. The basic issues that need to be examined include the following:

- What congestion relief benefits would result?
- Would these changes have adverse impacts on HOV formation and/or HOV lane compliance rates?
- Would highway and transit operational problems be created?
- Would the weekend use of HOV lanes by general purpose vehicles create safety concerns?
- What would be the monetary impacts of changing weekend HOV lane usage?

This report primarily discusses the WSDOT freeway HOV system in the Puget Sound region. However, the reader must note that the region contains a significant number of short HOV segments on arterials. These facilities are normally designed as "queue jumps" that allow transit vehicles to by-pass known congestion locations. Opening these HOV facilities would have a significant impact on local congestion at those locations. These facilities are discussed only briefly in this report, and if they are considered for opening, they need to be analyzed individually.

## CONGESTION RELIEF

The amount of congestion relief that would result from opening the HOV lanes to general purpose traffic on weekends is a function of the congestion currently present in the general purpose lanes and the number of HOV eligible[1] vehicles currently using the roadways. In general, where no general purpose (GP) lane congestion exists, opening the HOV lanes to general traffic would have no effect on congestion. Similarly, if a large percentage of vehicles are HOV eligible but are not using the HOV lane because the GP lanes are moving well enough, opening the HOV lane to GP traffic would also have no effect on overall congestion levels.

While WSDOT has formally collected few vehicle occupancy data on weekends, the little data collection it has performed (both formally and informally by TRAC researchers) indicates that weekend car occupancy rates tend to be much higher than weekday car occupancy rates. In fact, the fraction of vehicles eligible to use HOV lanes

[1] HOV lane eligible vehicles are carpools legal for that facility, regardless of whether they are physically using the carpool lane.

on weekends appears to vary from between 30 and 60 percent, depending on the facility and time of day.

Given these occupancy rates, HOV lane usage on weekends is basically a function of sufficient "congestion" (where "congestion" means enough traffic to give drivers an incentive to choose the left-most lane of travel over the other lanes). The data collected from the FLOW system strongly support this hypothesis.

In almost all cases, HOV volumes are considerably lower than GP lane volumes until the GP lanes reach approximately Level of Service (LOS) C (the point at which the freedom to change lanes and pass vehicles begins to be slightly limited). At this point, HOV volumes begin to rise quickly until HOV lane volumes are only slightly lower than GP lane volumes. (See Figure 1.)

This same effect can be seen in the way motorists use the "fast" lane of the freeway. Motorists tend to avoid driving continuously in the left-most lane of a freeway until congestion in the other freeway lanes is sufficiently high to make continuously changing lanes bothersome. (See Figure 2.)

Given these general observations of motorist behavior, it is fairly easy to understand the potential effects of removing HOV lane restrictions on the weekends. Congestion information used in this section is based on data from the WSDOT freeway management system (FLOW) and assumes that readers are familiar with the performance reporting graphics WSDOT uses for monitoring congestion in the metropolitan region.[2]

[2] For instructions on how to read these graphics, please see the WSDOT report "Central Puget Sound Regional Freeway Network Usage and Performance," March 1999, WA.RD #466.1. To learn about the techniques used to create the graphics, please see the report "FLOW Evaluation Design Technical Report," WA.RD #466.2, March 1999.

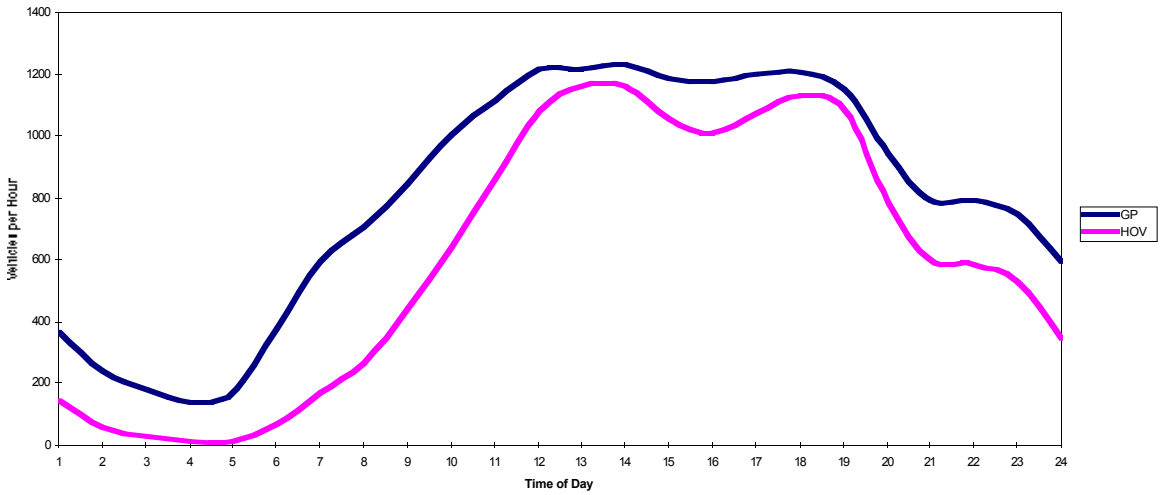


**Figure 1. I-5 at North Boeing Field, average northbound Saturday volumes**

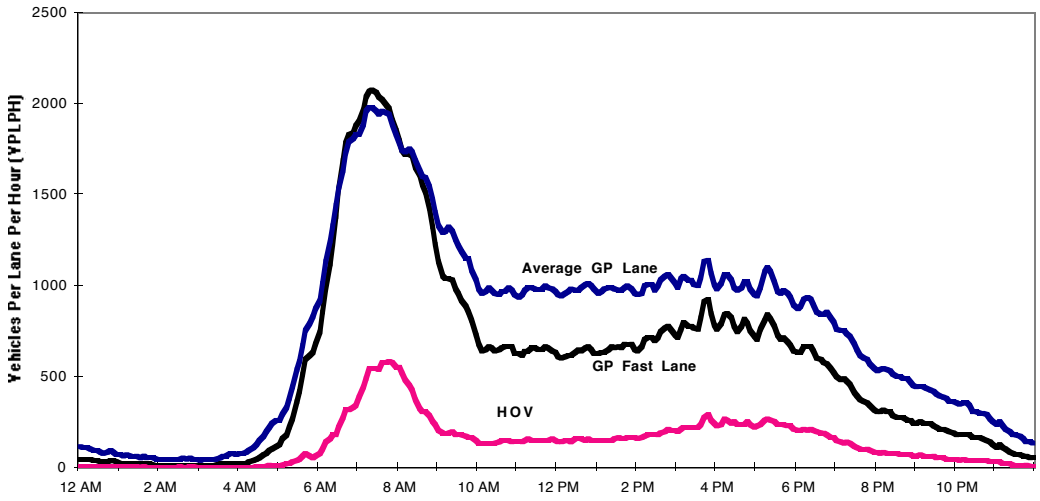


**Figure 2. I-90 at 161st Ave Southeast, westbound (1999 weekday average)**

## Congestion in General Purpose Lanes

For most of the Puget Sound freeway system, there is little "true congestion" on weekends, where "true congestion" is defined as Level of Service F (unstable speeds). However, several locations can be expected to experience LOS F congestion on several weekend days each month. A number of additional locations experience frequent LOS D conditions (that is, speeds are restricted to about 55 mph, and changing lanes requires effort and care). Many motorists expecting to find free flow conditions are likely to consider these conditions "congested" on weekends, whereas they would conclude that the freeway was working quite well if they encountered those same conditions on weekdays during the peak period. (This is because "bad congestion" is really a relative term. It most often means that traffic is worse than it "ought to be" in the eyes of the individual.)

Figures 3 through 7 show contour graphics[3] of the "average weekend" congestion condition on general purpose lanes in the Puget Sound freeway system for 1999. These graphics show that significant weekend congestion occurs only in two places in the metropolitan area. These are on I-5 approaching the downtown area (from both directions) and on I-405 approaching the SR 167 interchange (again from both directions). In both cases, a combination of high volumes and significant merge/diverge congestion causes routine slow downs and delay.

On I-5 (see Figure 3), the southbound congestion starts at the Mercer weave and extends northward, sometimes as far as Northgate. Significant congestion occurs at the

[3] On these figures, the color green can be interpreted to indicate routine free flow conditions. Yellow means that the freeway is routinely "full" but operating at 60 mph. Red means that the freeway

Ship Canal Bridge as often as six to eight times a month (i.e., over half the time), can start as early as 11:00 AM, and can last as late as 8:00 PM. A combination of factors causes this congestion. These factors include high traffic volumes, the lack of an HOV lane, operation of the Express lanes northbound as opposed to southbound, the Mercer weave, and the merge/weave effects of the NE 45th Street ramp.

On I-5 northbound, the approach to the southern edge of downtown Seattle is also bad, although congestion is not as bad as at the Ship Canal Bridge. Northbound traffic routinely slows at the merge with the West Seattle Freeway and continues to experience congestion problems through the Mercer Weave. However, LOS F congestion occurs only two or three times a month.

(Note: On I-5 southbound, north of Everett, another bottleneck exists, but this congestion is north of the location where WSDOT has surveillance equipment. This bottleneck breaks loose south of Everett where the HOV system begins.)

I-405 congestion (see Figure 4) is similar in size and scope to that found on northbound I-5. Congestion extends both north and south of the SR 167 interchange. Traffic in both directions approaching the SR 167 interchange reaches LOS F three to five times per month.

The rest of I-405 experiences much lower levels of congestion. North of Renton, the freeway often operates in a nearly full condition, but it rarely breaks down in either direction. Crowded but free flowing conditions are common through Bellevue, Kirkland, and Totem Lake.

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occasionally operates below 55 mph, and breaks down occasionally. Blue means that LOS F conditions occur frequently (that is, more than 20 percent of the time).

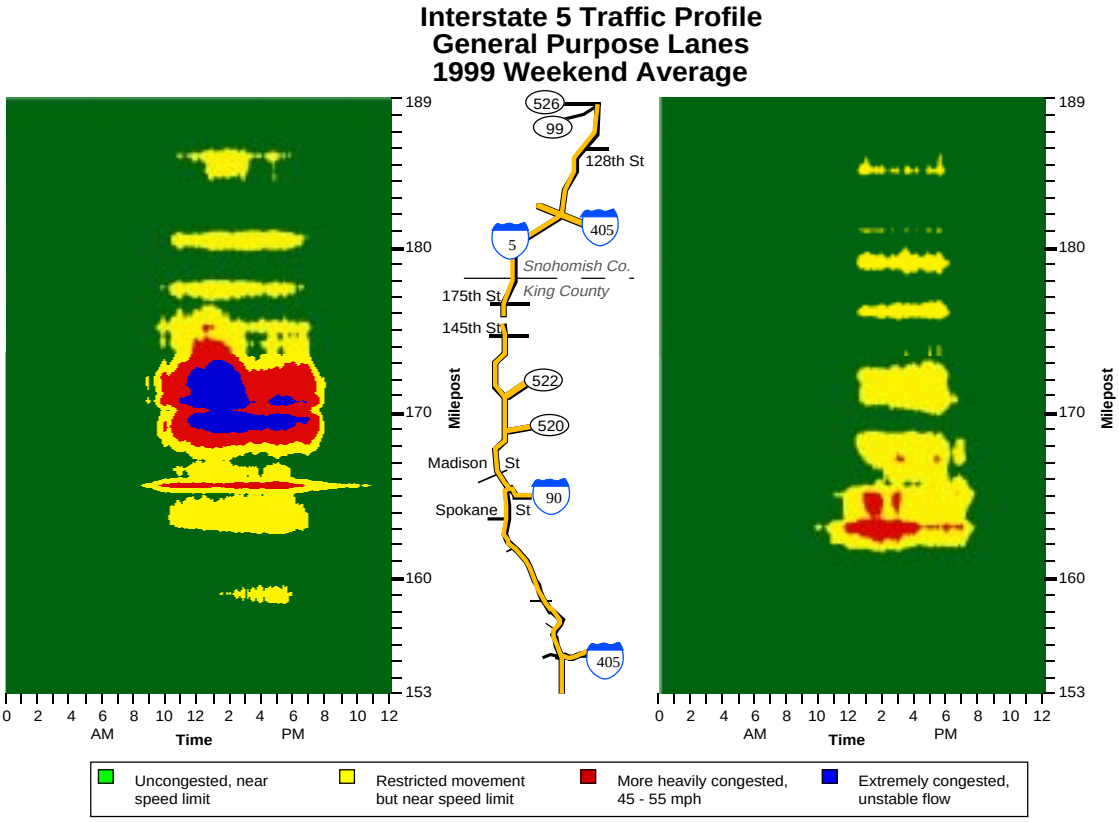


**Figure 3. I-5 traffic profile, general purpose lanes, 1999 weekend average**

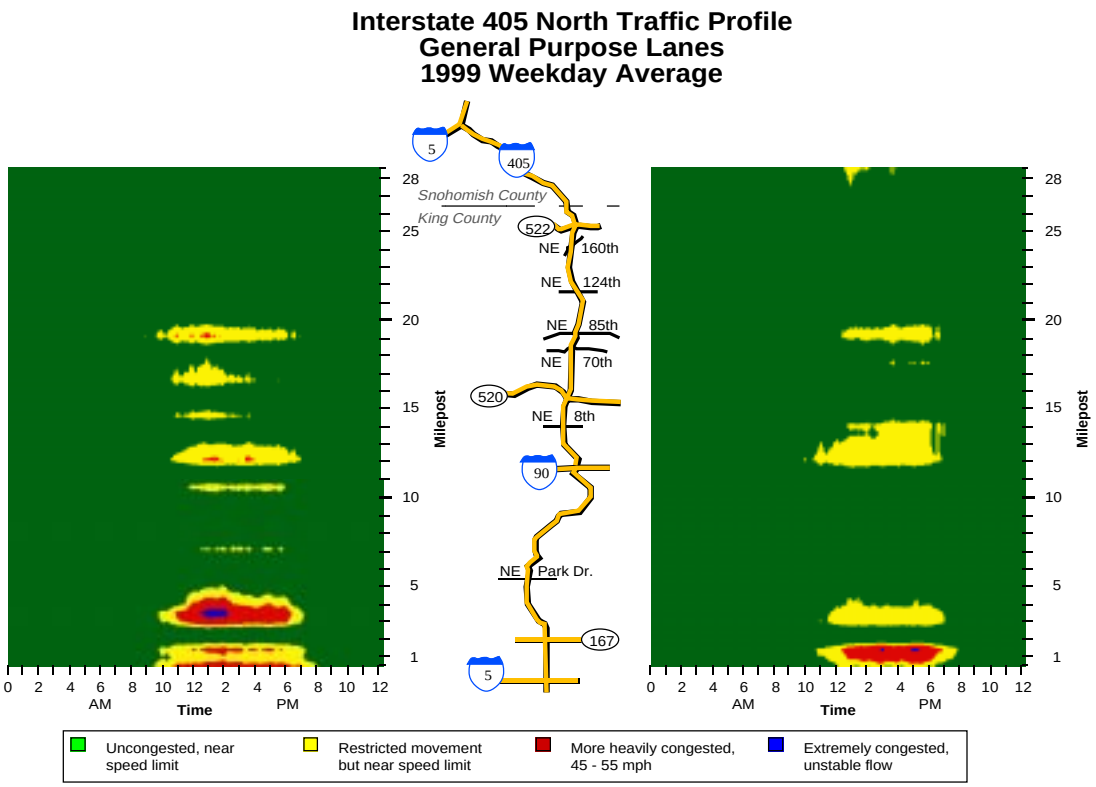


**Figure 4. I-405 north traffic profile, general purpose lanes, 1999 weekday average**

Likewise, SR 167 (see Figure 5) experiences very little actual congestion, although the merge at the I-405 interchange can slow traffic during the late afternoon and early evening.

SR 520 experiences more congestion than SR 167 but slightly less than I-405 in the south end. Westbound, SR 520 falls to LOS F roughly twice a month during both the early and late afternoon approaching the floating bridge (see Figure 6). Eastbound, the approaches to the bridge also become congested roughly twice a month.

Finally, I-90 is almost completely free of congestion outside of its interchange with I-5 and the exits to downtown Seattle. (See Figure 7, which does not include the ramp congestion.) The downtown interchange is dramatically affected by special event traffic. Outside of downtown Seattle, only occasional congestion at the exits to Issaquah cause congestion on the weekends.

**Volumes in HOV and General Purpose Lanes**

With a few exceptions, HOV volumes follow the trends described earlier. On average, volumes in HOV lanes are slightly lower than those in adjacent general purpose lanes. However, whenever congestion is present on weekend days, HOV lane volumes tend to be roughly equal to GP lane volumes. As a result, at times on weekends when congestion is routine, average GP volumes are only marginally higher than average HOV volumes. In addition, because GP volumes are high enough to warrant use of the HOV lane by eligible vehicles, HOV lane volumes are increasing faster than GP volumes.

Figures 8 and 9 illustrate these basic trends. They illustrate weekend volumes in 1995 and 1999, northbound on I-5 near Spokane Street. The volume differential has dropped from over 600 vehicles per hour in 1995 to about 400 vehicles per hour in 1999.

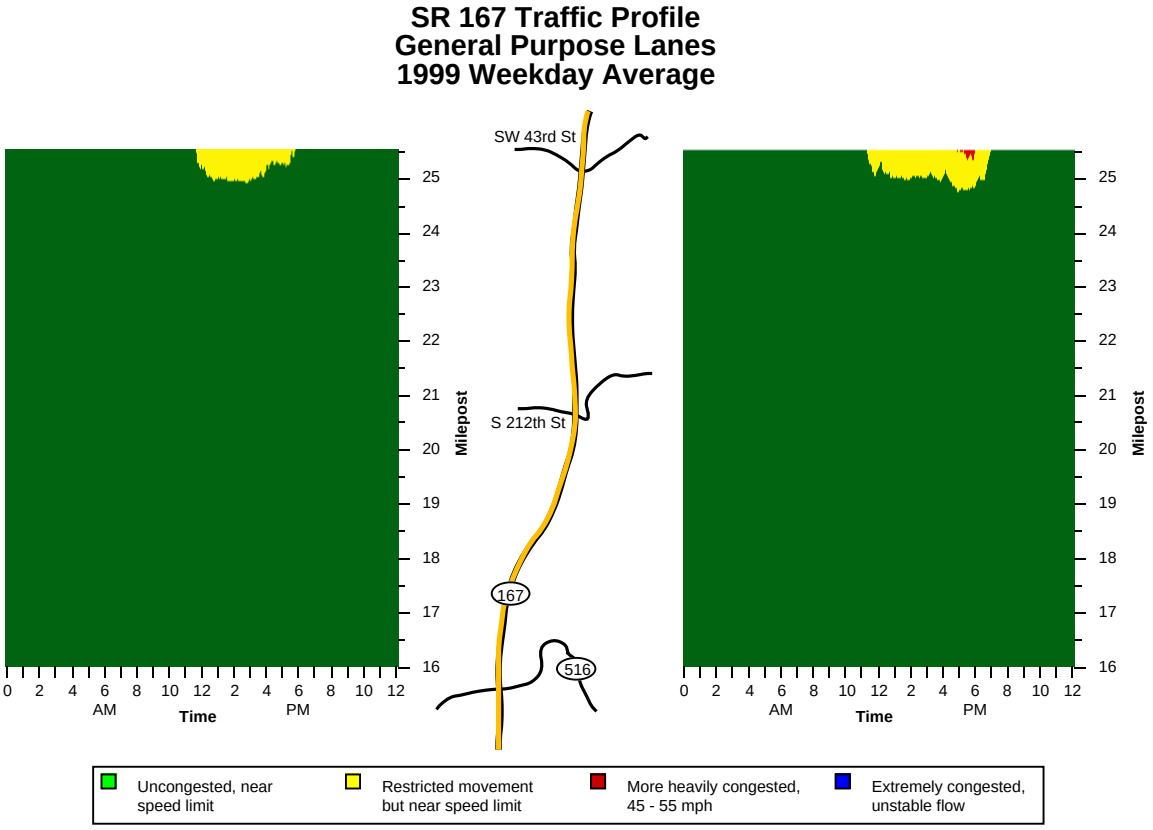


**Figure 5. SR 167 traffic profile, general purpose lanes, 1999 weekday average**

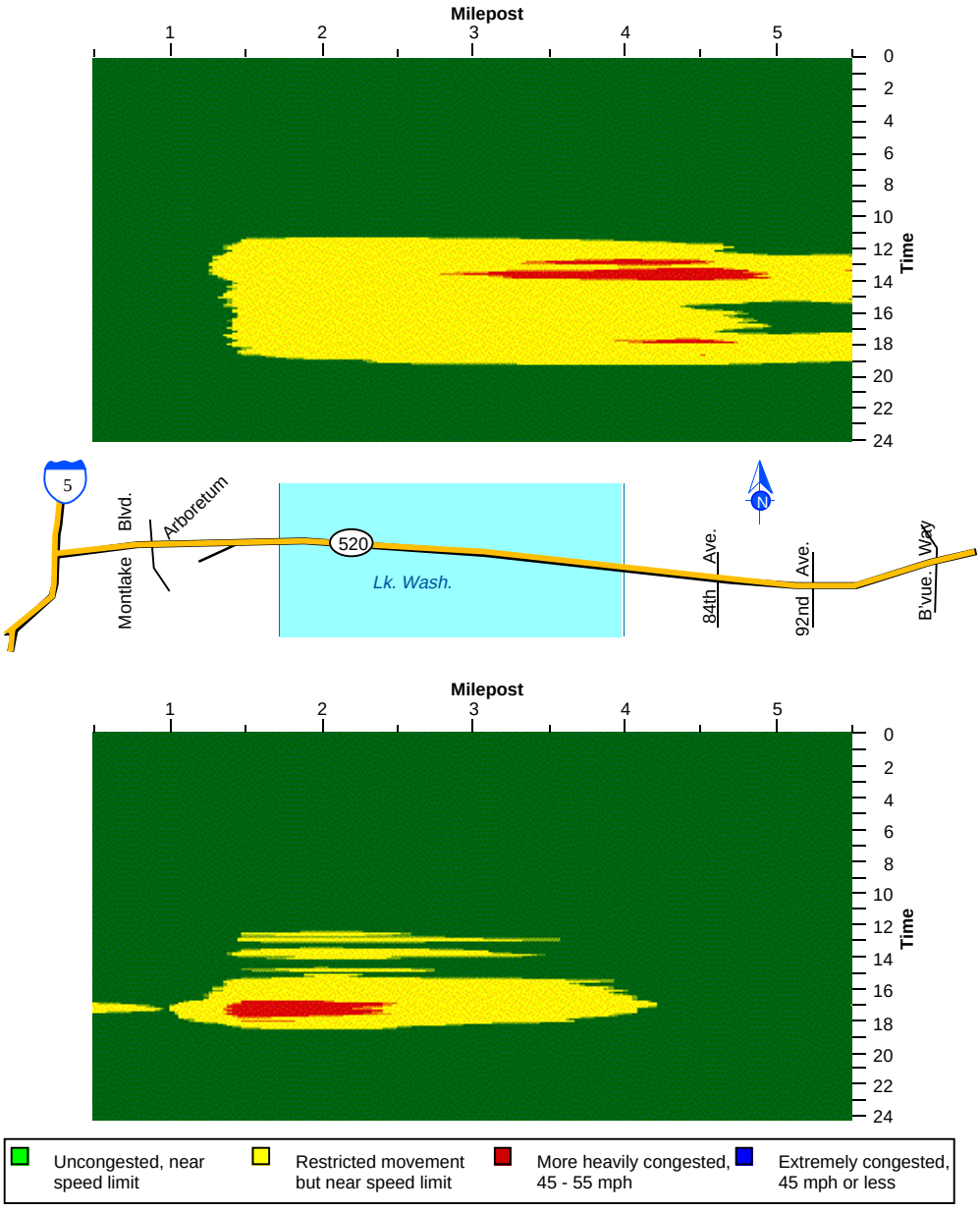


**Figure 6. SR 520 traffic profile, general purpose lanes, 1999 weekend average**

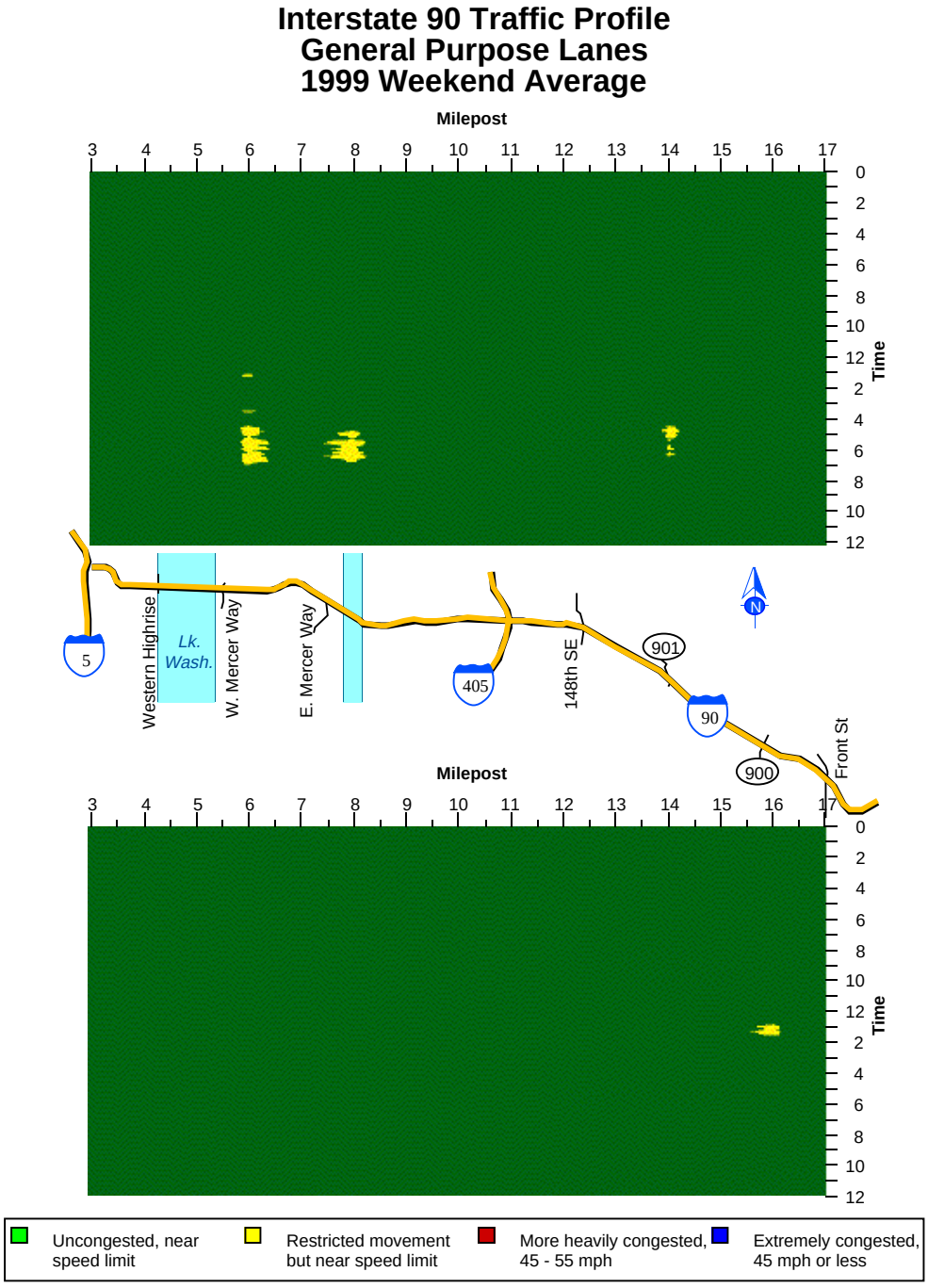


**Figure 7. I-90 traffic profile, general purpose lanes, 1999 weekend average**

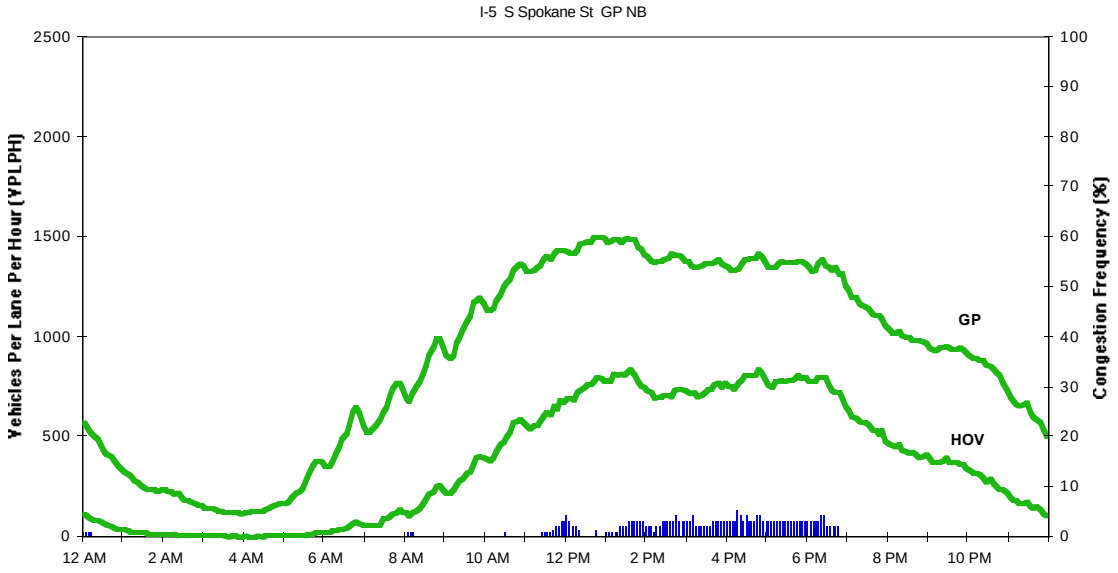


**Figure 8. Estimated weekend volume, speed, and reliability conditions (1995), I-5 S. Spokane Street, general purpose lanes, northbound**

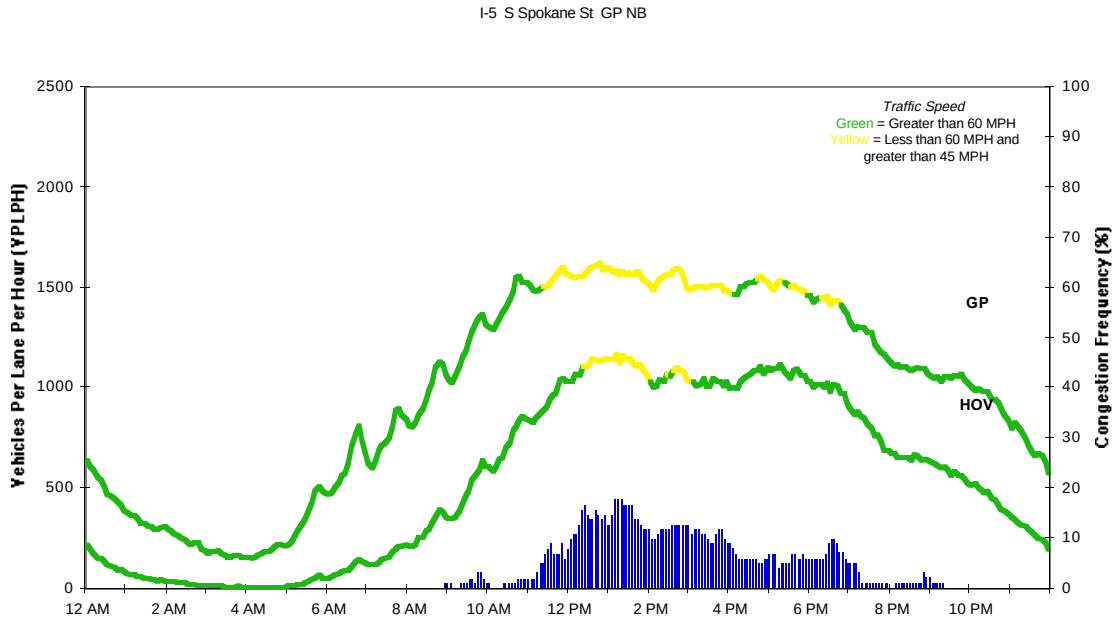


**Figure 9. Estimated weekend volume, speed, and reliability conditions (1999), I-5 S. Spokane Street, general purpose lanes, northbound**

Minor congestion has also begun to appear during the mid to late afternoon in both GP and HOV lanes. (The congestion frequency histogram is plotted only for GP lanes, although HOV lane speeds are also routinely below the speed limit at this location.)

Figures 10 and 11 illustrate weekend HOV and GP volumes on I-405 in Renton. At this location near the SR 169 interchange (north of SR 167), the 1999 southbound HOV lane volumes in the middle of the day are only 200 to 300 vehicles per hour lower than the general purpose lane volumes. In 1997, the midday volume difference between these lanes was closer to 500 vehicles per hour. At the same time, it also apparent that the GP lanes are heavily congested 15 to 20 percent of the time in the afternoons, and these congested periods are likely to be both holding down average volumes and encouraging HOV eligible vehicles to use the HOV lane.

Two areas where exceptions to the "conventional" HOV volume patterns occur are on SR 520 approaching the bridge and on SR 167 approaching I-405. On SR 520, HOV volumes remain very low. The 3+ occupancy requirement and the tight shoulder configuration of the HOV lane on this facility discourage use of the lane. HOV volumes have actually decreased slightly from 1997 to 1999. (See Figures 12 and 13.) The decrease is almost entirely due to a reduction in the frequency of congestion on this facility in the afternoons. TRAC speculates that this reduction is a result of the opening of the I-90 ramps into downtown Seattle, with their improved service to Safeco Field and the old Kingdome.[4] This new facility makes travel to the stadium area south of downtown much easier via I-90 and consequently draws traffic away from SR 520 during some of the peak weekend periods. These peak period demand reductions lower the

[4] Construction activity in 1997 may also have increased the frequency of congestion on this route.

frequency of congestion on SR 520 and consequently reduce the need for HOV eligible vehicles to use the shoulder lane.

SR 167 has lower HOV volumes approaching the I-405 interchange (see Figure 14) for different reasons. In this case, the data collection location is within 1/2 mile of the exit ramp to northbound I-405. Thus many HOV vehicles have already exited the left-hand HOV lane in order to weave across the GP lanes to use the right-hand exit to northbound I-405. Some HOVs are also likely to have exited the lane at this point to travel southward on I-405. An analysis of HOV volumes farther south on SR 167 (see Figure 15) shows a GP to HOV volume relationship equivalent to what is seen elsewhere in the region.

**Speed and Performance of HOV and GP Lanes**

HOV lane speeds tend to be slightly higher than speeds in the general purpose lanes. Even when the general purpose lanes are free flowing, vehicles in the HOV lanes tend to travel slightly faster. (See Figures 16 and 17.) HOV lane speeds on the weekend tend to average 70 mph in free flow conditions, whereas GP lanes average closer to 60 or 65 mph. This speed differential is consistent with the basic idea that HOV lanes are used on the weekends primarily by HOV eligible vehicles that wish to go slightly faster than traffic in the GP lanes. Thus, under free flow conditions, most HOV lane users are drivers who wish to go 70 mph. As GP speeds slow down, more and more HOV eligible vehicles use the HOV lanes, and speeds drop slightly as these motorists are more likely to be happy driving at 60 to 65 mph.

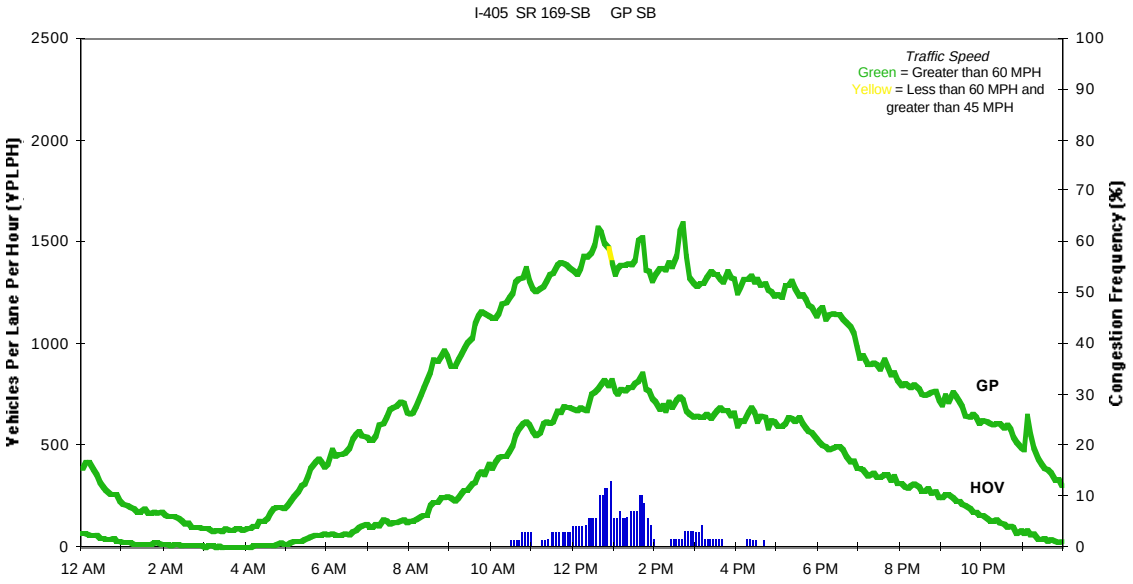


**Figure 10. Estimated weekend volume, speed, and reliability conditions (1997), I-405 at SR 169, general purpose lanes southbound**

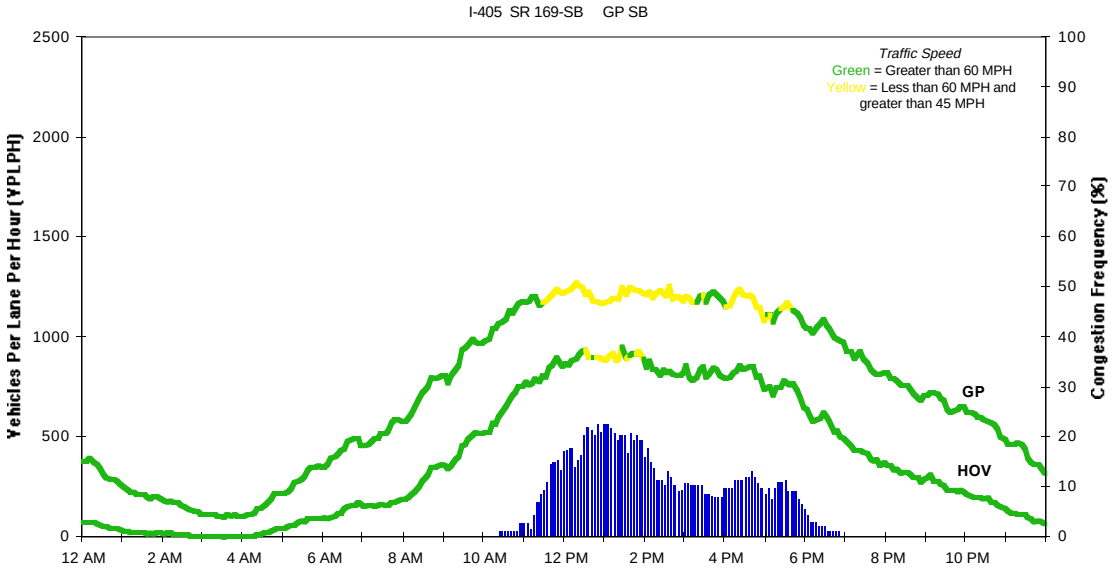


**Figure 11. Estimated weekend volume, speed, and reliability conditions (1999), I-405 at SR 169, general purpose lanes southbound**

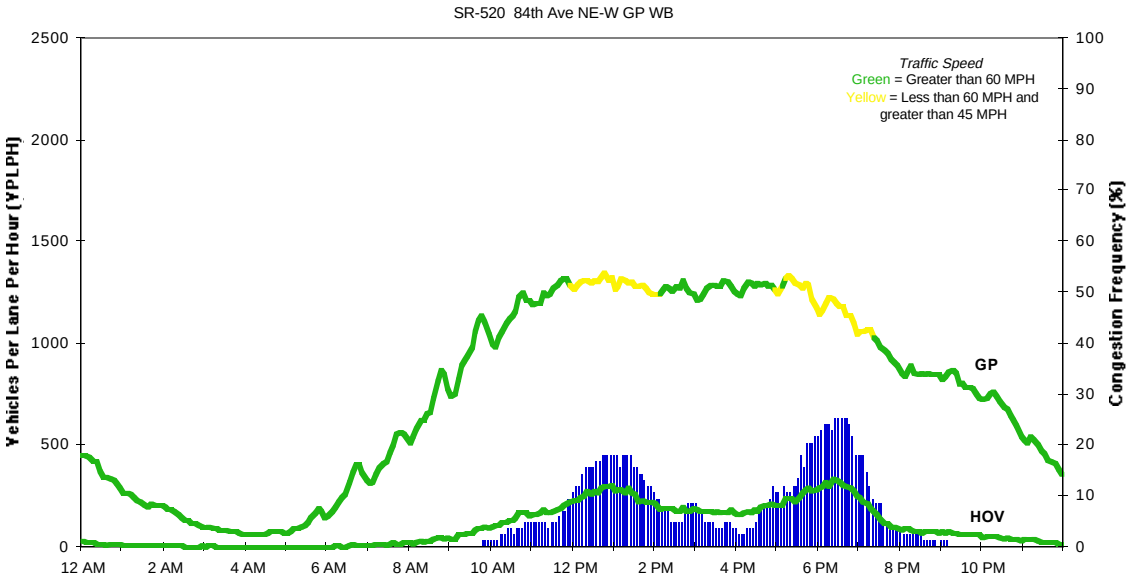


**Figure 12. Estimated weekend volume, speed, and reliability conditions (1997), SR 520 at 84th Ave Northeast, general purpose lanes westbound**

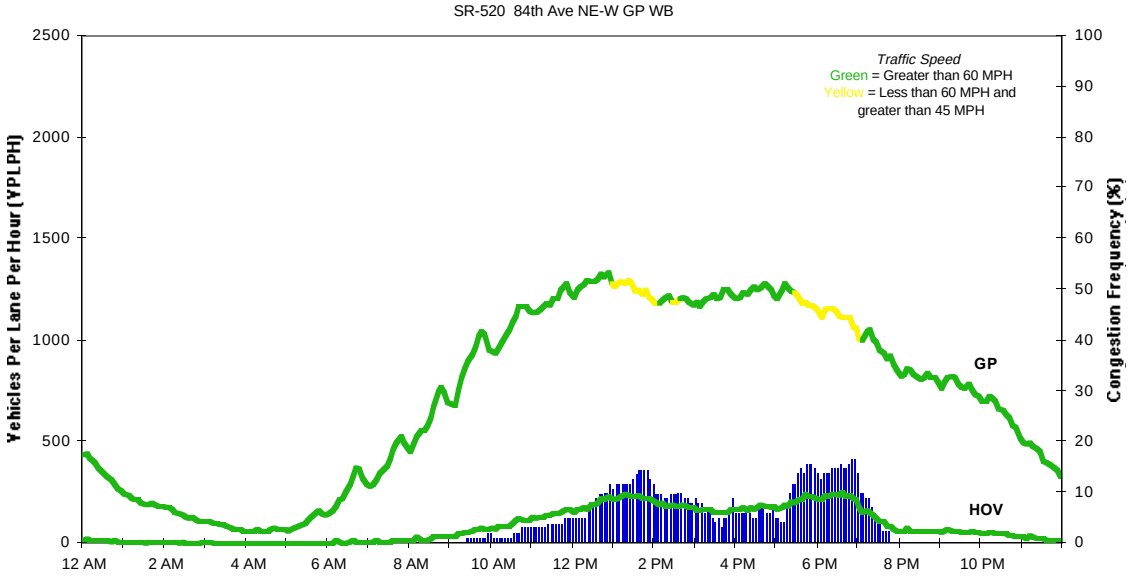


**Figure 13. Estimated weekend volume, speed, and reliability conditions (1999), SR 520 at 84th Ave Northeast, general purpose lanes westbound**

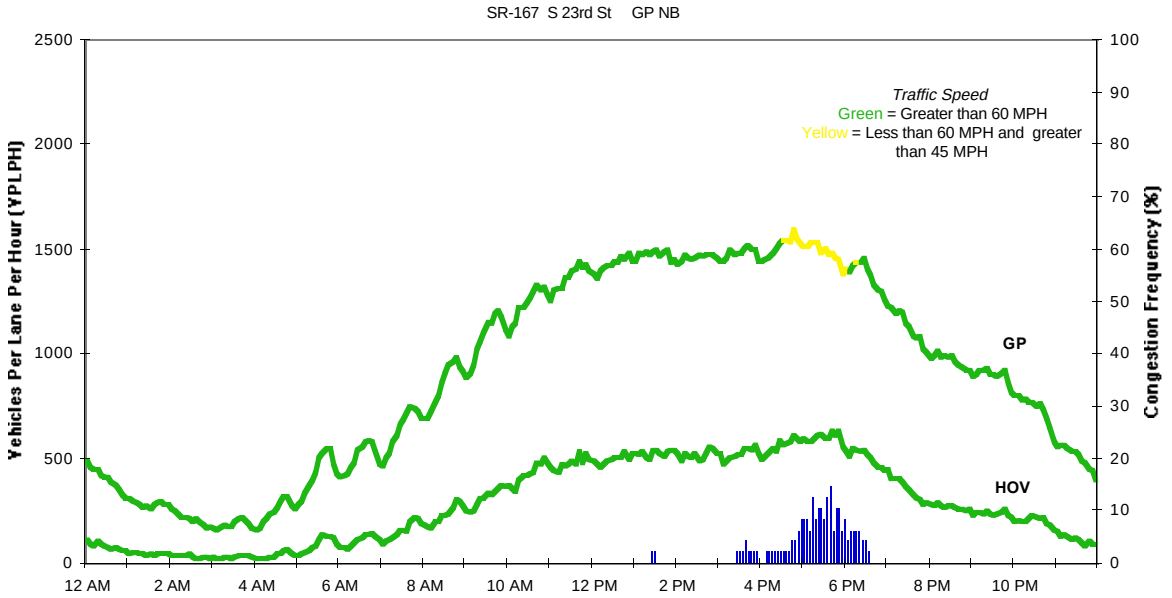


**Figure 14. Estimated weekend volume, speed, and reliability conditions (1999), SR 167 at South 23rd St, general purpose lanes northbound**

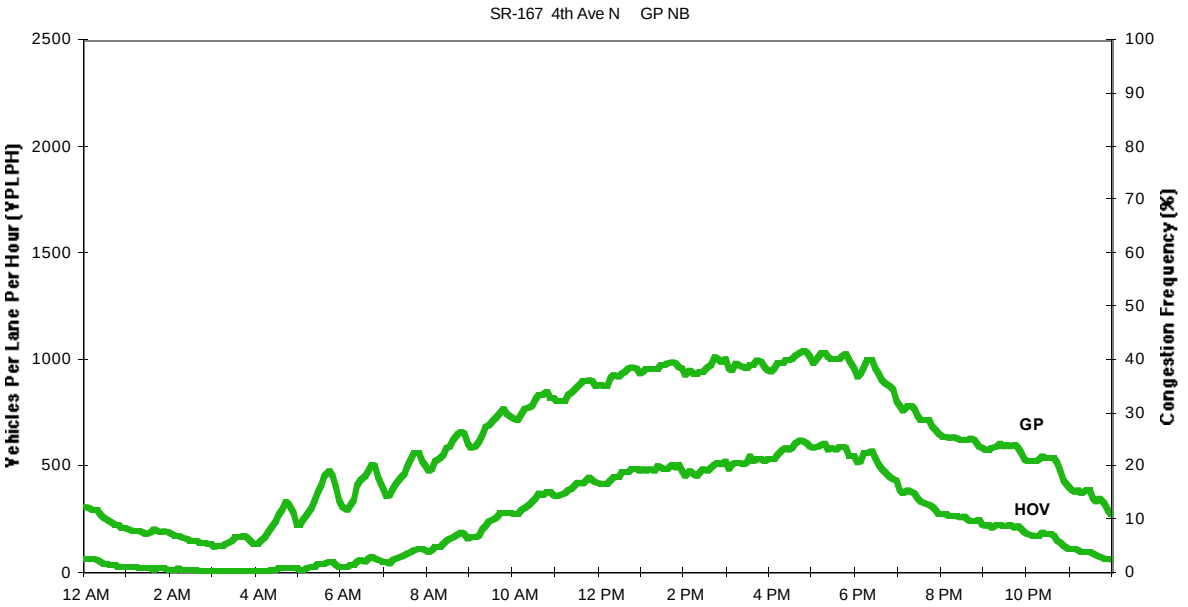


**Figure 15. Estimated weekend volume, speed, and reliability conditions (1999), SR 167 at 4th Ave North, general purpose lanes northbound**

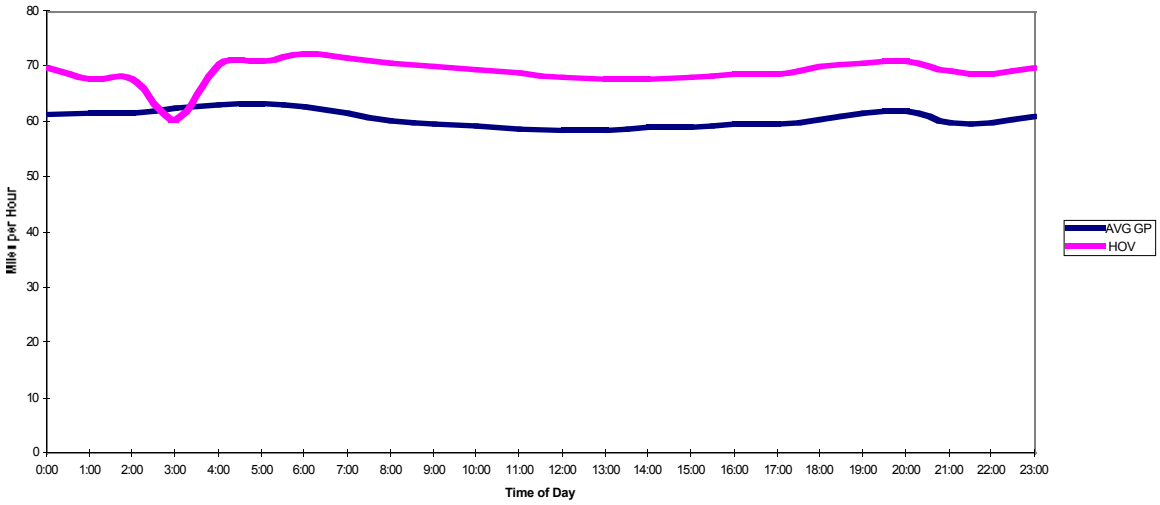


**Figure 16. I-405 at Northeast 24th St., Saturday northbound speeds**

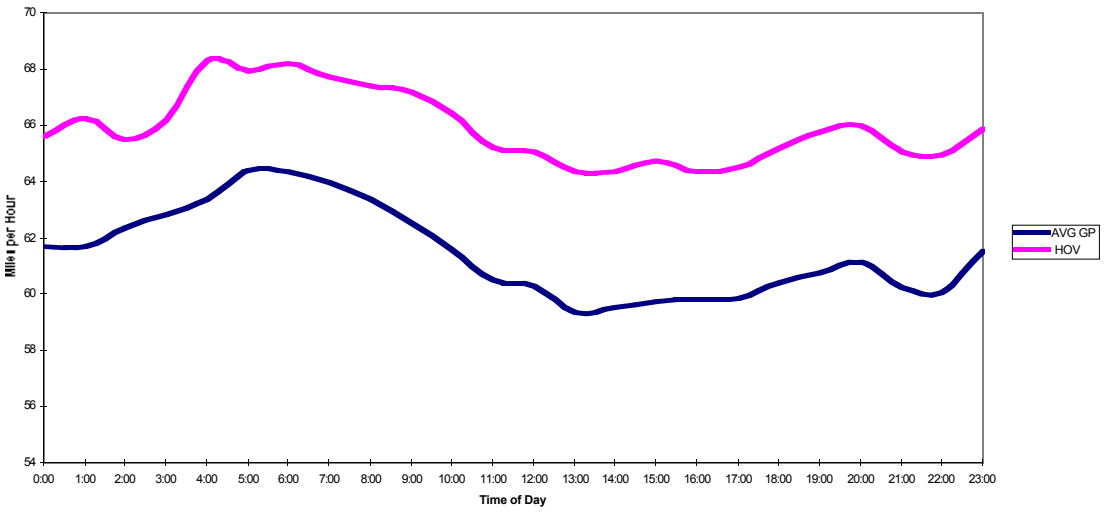


**Figure 17. I-405 at Northeast 24th St., Sunday southbound speeds**

**Effect of "Perception" on Congestion Frequency**

The issue of using the HOV lanes to "go fast" on the weekends is consistent with much of the desire to open up the HOV lanes to GP traffic. While theories are difficult to quantify scientifically, many in the traffic engineering profession believe that a significant fraction of the driving public wishes to drive faster than the speed limit partly out of the desire to "make up for time spent stuck in traffic elsewhere," partly because modern cars are easily driven at faster speeds, and partly because time constraints in personal lives put pressure on drivers to get where they are going as quickly as possible. Access to the HOV lanes would allow this segment of the population greater freedom to relieve their frustration at being constrained by other vehicles' speeds by giving them additional space in which to pass slower moving vehicles, even though those vehicles are traveling at or near the speed limit.

To these individuals, "congestion" is defined as traffic volumes that constrain their ability to travel at the speed they select (rather than the legal speed posted). To illustrate the effect of perception on a driver's view of facility performance, we have revised the contour graphic shown in Figure 3. This time, instead of illustrating the "average weekend condition" the same contour technique illustrates the frequency with which "congestion" occurs. Figure 18 shows how frequently I-5 becomes congested on weekends when the definition of "congestion" is the beginning of LOS F (that is, where vehicle speeds become unstable). In this graph, light gray represents up to one weekend day per month of congestion. Gray represents more than one day but no more than two days per month of congestion. Light blue represents more than two, but less than three

days of congestion. Dark blue is more than three but no more than six days of congestion. Black represents more than six days of congestion per month.

Keeping the same color scale but changing the definition of "congestion" to the beginning of LOS E (speeds of 45 to 55 mph, little room to change lanes) produces an image of worse congestion on southbound I-5. (See Figure 19.) Changing the definition of congestion to the beginning of LOS D (speeds below 60 mph, care required to change lanes because of high volumes) produces extremely frequent congestion on I-5. (See Figure 20.)

For drivers intent on driving faster than 65, Figure 20 is probably a closer representation of what they consider "congestion" than the image that shows congestion from a pure traffic engineering standpoint (Figure 18). These drivers also correctly observe that vehicles in the HOV lanes are traveling faster than those in the GP lane (although not much faster) and want to reduce their frustration by using that lane. The frustration they feel by not being able to always use that lane creates the political push to open the HOV lanes for general purposes on weekends.

## Volume and Performance Effects of Using the HOV Lanes for General Purposes on Weekends

In the author's opinion, for most Puget Sound freeways, converting HOV lanes to GP lanes on weekends will have very little effect on either traffic volumes or vehicle speeds. In almost all cases, the number of vehicles eligible to use the carpool lane is already sufficient to make the HOV lanes as full as the GP lanes. Those vehicles simply do not choose to use the HOV lanes unless congestion warrants it. In the vast majority of cases, when congestion appears, the HOV lanes are heavily used.

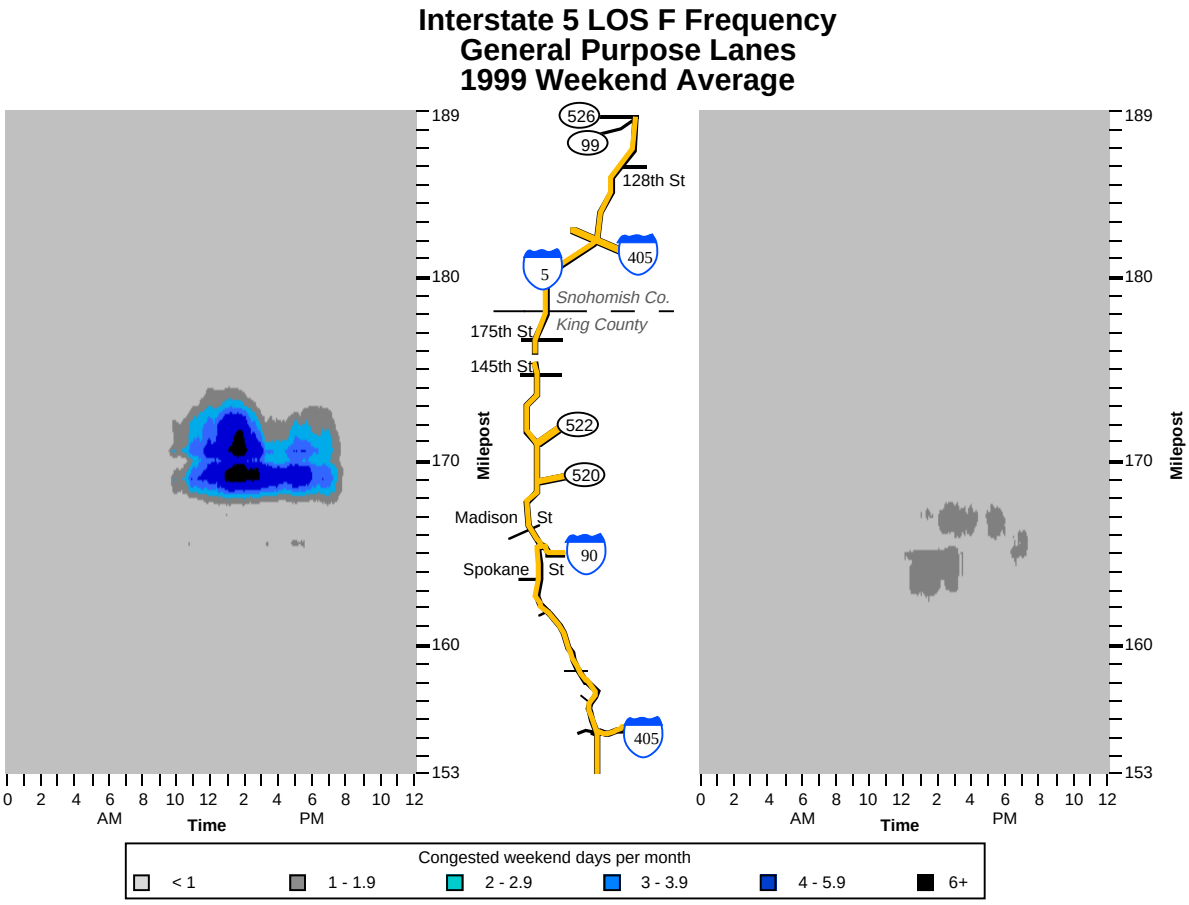


**Figure 18. I-5 LOS F frequency, general purpose lanes, 1999 weekend average**

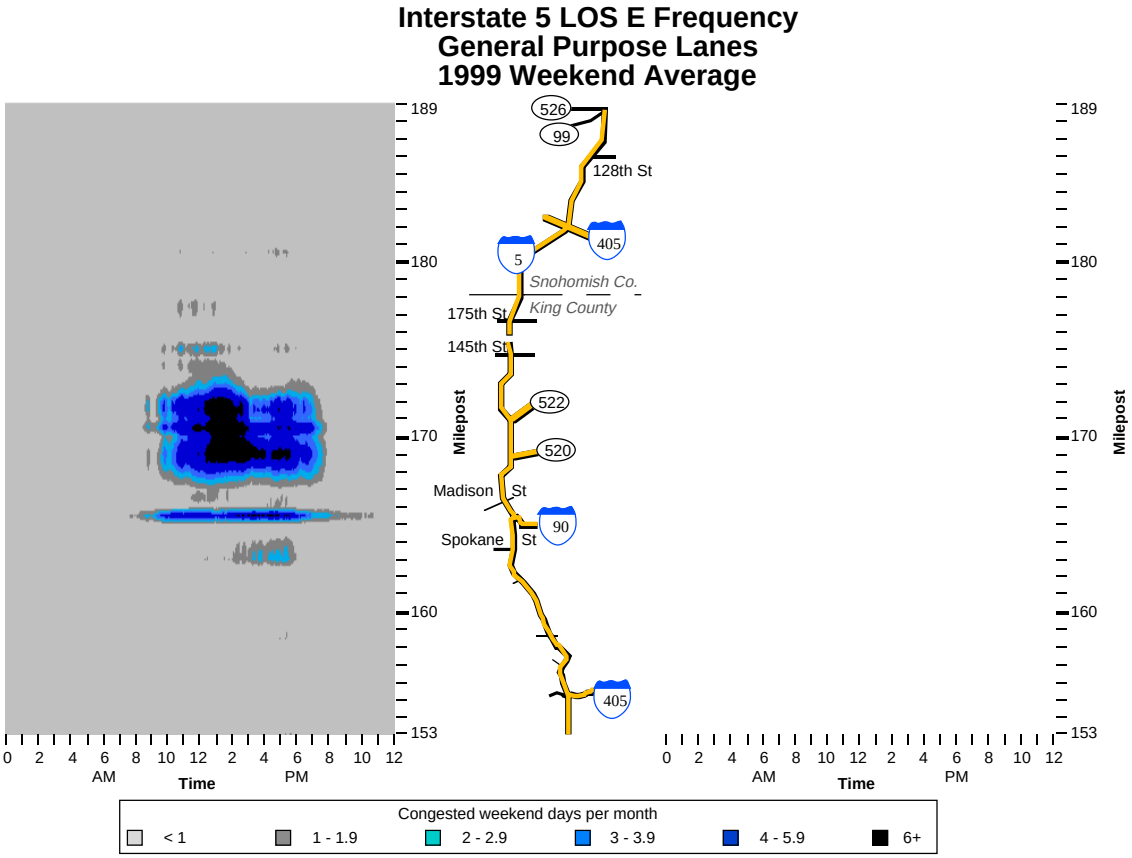


**Figure 19. I-5 LOS E frequency, general purpose lanes, 1999 weekend average**

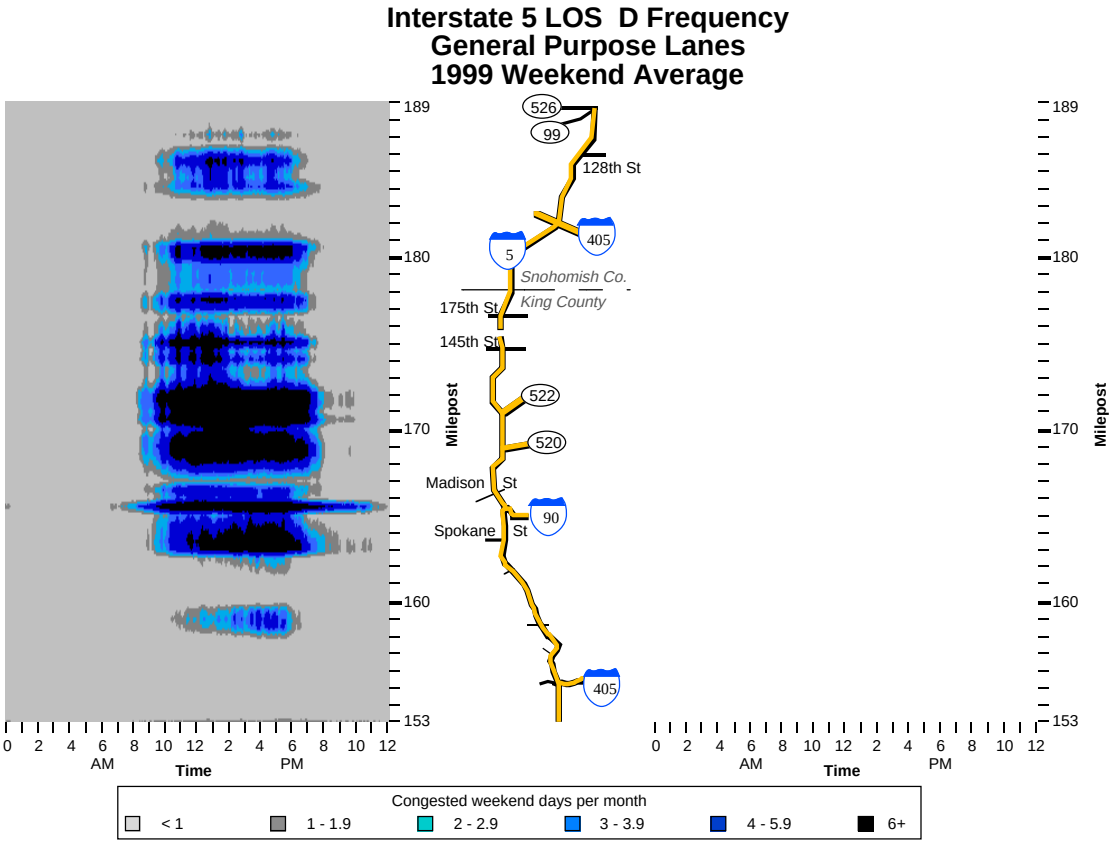


**Figure 20. I-5 LOS D frequency, general purpose lanes, 1999 weekend average**

In a few cases, particularly bottleneck situations, encouraging GP vehicles to use the HOV lane system will cause a bad situation to get worse, such as on SR 520 approaching the bridge. In the case of I-405 at SR 167, it is unclear what the benefits will be. Some improvement in vehicle speed might be obtained for vehicles that remain on I-405. (A more detailed analysis of the relative size of the competing movements at this interchange is needed to determine actual benefits that would be obtained.) However, vehicles trying to exit to SR 167 will receive no benefit, and the added lane of through-traffic may in fact create a safety hazard at the collector-distributor gore point as vehicles try to drive past the exit ramp queue and push in to the line at the gore point itself. (This already occurs at the SR 520 / I-405 interchange, where the completion of the new HOV lane has created this exact situation.) If WSDOT receives funding to improve this interchange (according to the Northwest Region this project is one of the highest rated projects in the area), the congestion that currently exists at this interchange will essentially disappear. In that case, no benefit will be gained from opening up the HOV lane to GP traffic.

On I-5, no HOV facility crosses the Ship Canal bridge southbound on weekends. Thus, relaxation of the HOV rules will have no impact whatsoever on the weekend's worst congestion location. Northbound, the HOV lane is congested almost as often as the GP lanes. (See Figure 21.) To further illustrate this point, the WSDOT database was searched for weekend days when congestion occurred on both I-5 and I-405. The volumes in the GP and HOV lanes were then compared. Figure 22 shows the effect of congestion on northbound I-5 at Spokane Street. Figure 23 shows the effect of congestion on southbound I-405 at SR 169 (just north of SR 167). In both cases, HOV

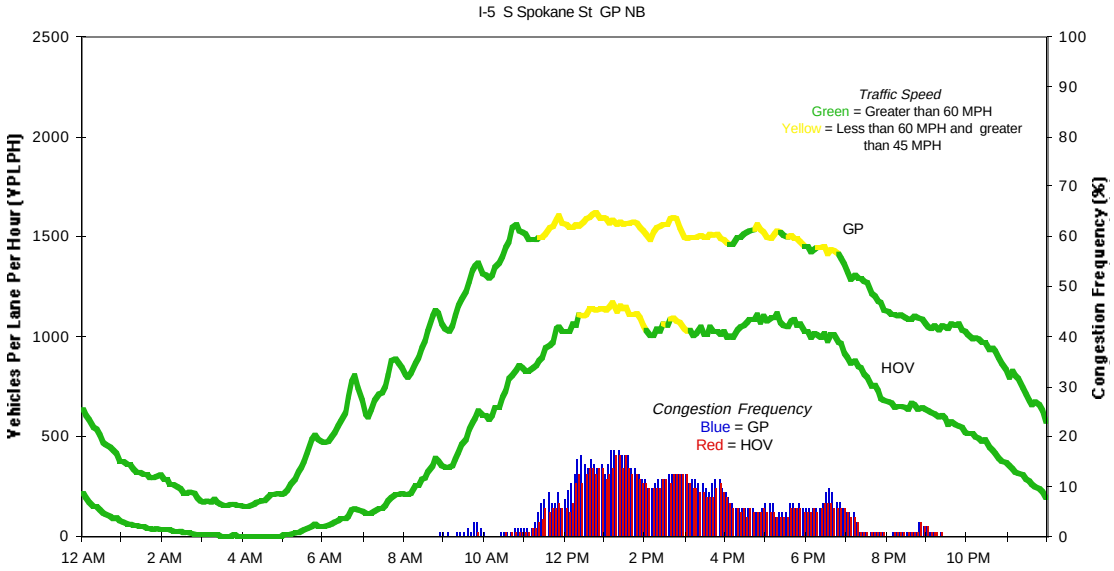


**Figure 21. Estimated weekend volume, speed, and reliability conditions (1999), I-5 at South Spokane St, general purpose lanes northbound**

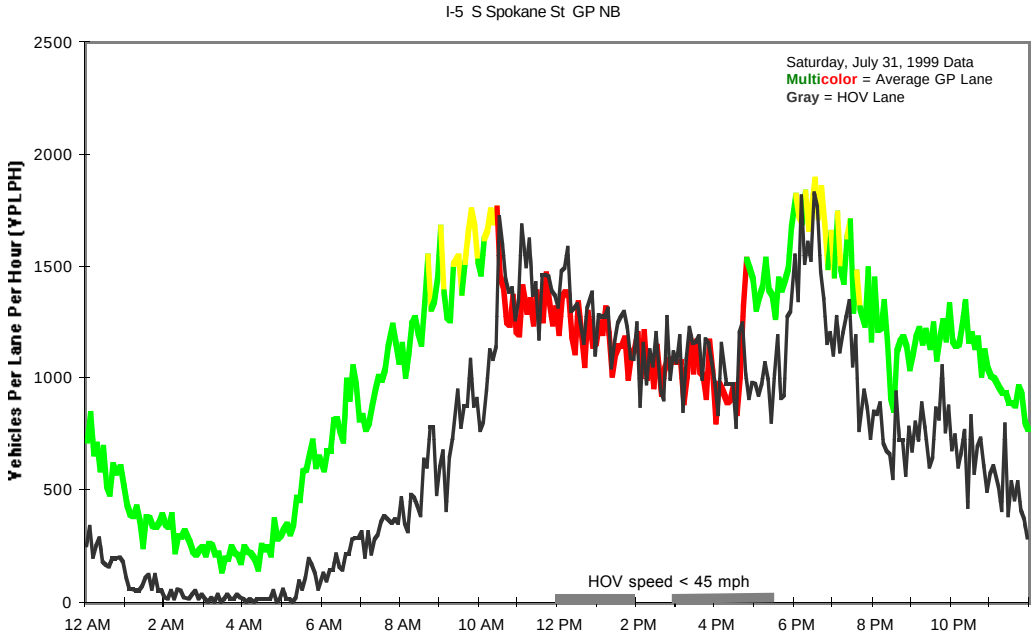


**Figure 22. Estimated general purpose and HOV volume and speed conditions, I-5 at South Spokane St., general purpose lanes northbound**

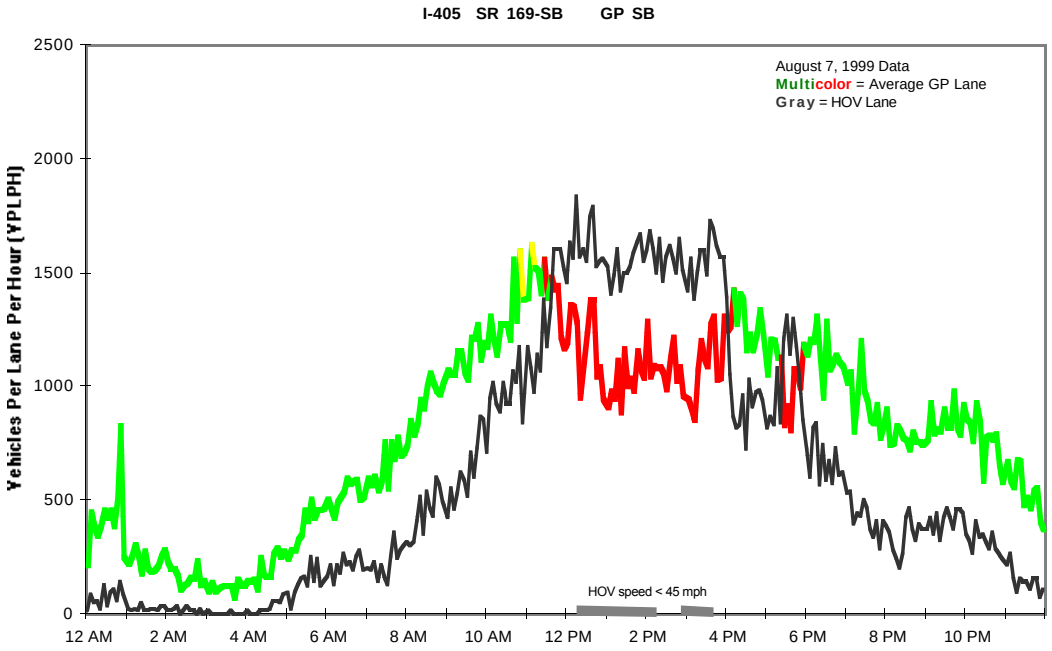


**Figure 23. Estimated general purpose and HOV volume and speed conditions, I-405 at SR 169, general purpose lanes southbound**

lane volumes are lower than GP lane volumes until congestion starts to occur. At that time, HOV lane volumes either equal GP lane volumes (on I-5) or exceed GP lane volumes (on I-405, where the HOV lane is affected less by the backup from the SR 167 exit). Neither of these results is surprising, given the high level of vehicles eligible to use the carpool lane on weekends. Thus, relaxation of the HOV rules may provide a slight increase in HOV lane use, but little or no actual congestion relief will occur because the HOV lanes are congested whenever significant congestion occurs in the GP lanes.

## IMPACTS ON HOV FORMATION AND COMPLIANCE RATES

A major concern with the use of HOV lanes by general traffic in off-peak periods is that HOV lane violations would increase during periods when the HOV lanes were restricted.

Experience elsewhere in the country has indicated that violation rates increase near the beginning and end of the HOV-only time period. In Virginia, the DOT had to install electronic clocks on its variable message signs (VMS) to eliminate arguments about the time from the enforcement process. (Motorists would argue that according to their watch, GP vehicles were legal in the HOV lane.) While the installation of VMS clocks could reduce those problems, it would significantly increase the cost of signage and maintenance.

Experience has also shown that violations tend to generate other violations. That is, the more violations that motorists observe, the more likely they are to violate those restrictions themselves.

How much of an impact opening the HOV lanes would have on violation rates would be a function of how well the public understood the new rules and how heavily those rules were enforced. WSDOT staff currently believe that opening the HOV lanes on weekends would probably have a less dramatic impact on violation rates than relaxation of midday weekday restrictions. However, WSDOT staff are especially concerned about the effects that a "partial removal" of lane restrictions would have. (That is, if some HOV lanes were opened to general traffic but not others.) The concern is that motorists would a) not understand which lanes could be used when, and b) use the

opening of some lanes as an excuse for using other HOV facilities that had not been opened to general traffic, producing a significant increase in violations.

## SAFETY ISSUES

The WSDOT is concerned about a number of major safety issues that should be addressed before HOV lanes are opened to general traffic. Safety and operational information in this section is based on data from project files for the construction of the HOV system, current WSDOT Design Standards, and interviews with local representatives from the Federal Highway Administration (FHWA).

Much of the HOV lane system was built to a lower design standard than the general purpose lanes. These "design deviations" have been made because during most of the day relatively modest traffic volumes are expected in the HOV lanes, and during peak travel times, the majority of drivers using the facility are commuters familiar with the decision points and traffic conditions on a particular roadway. Under these conditions, FHWA permits (on a case by case basis) modest relaxation of normal Interstate design standards. Figure 24 highlights some of the more significant design deviations that were allowed in the construction of the region's HOV system.

If the HOV lane regulations were changed, the basic assumptions about their operating conditions would no longer be valid. FHWA would then require a complete review of these design deviations before allowing the adoption of new operating rules. Geometric changes might also be necessary to address safety and liability concerns caused by design based on geometry that was sub-standard for routinely high volumes of general traffic.

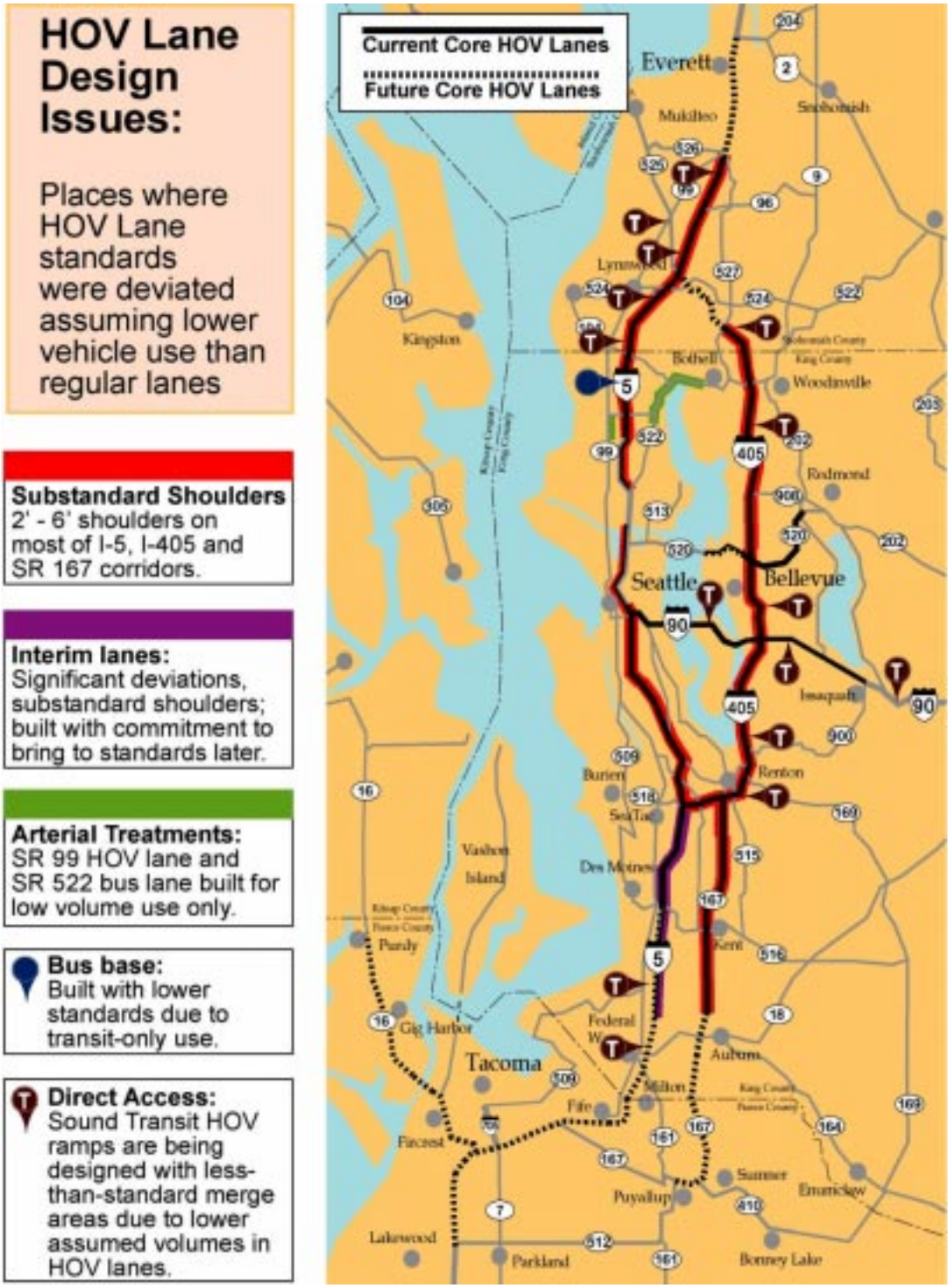


**Figure 24. Locations where HOV lane standards deviate from general purpose lane standards**

Examples of problematic design deviations that must be considered before HOV lanes are opened to general traffic are as follows.

**Right Side HOV Lanes**

Traffic from on- and off-ramps weaves through right side HOV lanes. Where ramp tapers and merging and diverging areas have been designed to accommodate high volumes of traffic, safety is not an issue. On SR 520, however, the HOV facility was added after construction of the original lanes and uses the original shoulder of the freeway. The original ramp tapers and merging areas are largely unchanged from the pre-existing configuration. The resulting merging areas are only appropriate for low volumes of mainline traffic. The HOV designation west of I-405 is three or more because of the concern about traffic merging through the on- and off-ramps. It would not be feasible to change the occupancy designation on SR 520 (or tolerate substantial increases in shoulder lane traffic) without extensive reconstruction.

**Transit-Only Facilities**

Several facilities in the region have been designed for the exclusive use of transit. Clearly it is not feasible to open the facilities to general use traffic because of the purposes they serve and the safety issues that would arise if non-transit vehicles were to use the lanes. Examples of transit-only facilities are the entrances to the Seattle Transit Tunnel, the Metro North Bus Base, freeway flyer stops, and entrances to some park-and-ride facilities near the freeway.

**Arterial HOV Lanes**

Arterial HOV lanes are not the primary focus of this analysis. However, they pose serious safety issues. Opening arterial HOV lanes to general traffic would likely require the adoption of access restrictions for turning traffic (e.g., limiting left turns to signalized intersections with left turn bays and left turn arrows), if those restrictions do not already exist. WSDOT has shown that there is a link between increased crashes and high volume arterials with two-way left turn lanes and seven-lane cross sections. Access restrictions would be needed to prevent any increase in accidents.

**Major Decision Points**

At the entrance to the express lanes drivers make a basic decision about what route is most advantageous. Some drivers make the choice early on, deliberately moving over to the lanes well before the decision point. However, experience has shown that other drivers make the choice at the last minute, moving over several lanes in just a few hundred feet. At the I-5 express lanes southbound WSDOT has experienced the consequences of this behavior. For many years the entrance to the express lanes was the only location on the I-5 mainline in the Northwest Region that was classified as a High Accident Location. This was primarily due to motorists racing to the end of the GP lane when the express lanes were closed and then forcing their way back into traffic. A WSDOT project recently corrected that situation by continuing the GP lane southbound. If general traffic were allowed in the HOV lanes, the hazardous situation that was eliminated with the construction project a few years back would be recreated. This situation would be repeated in other locations where the HOV lane ends with a merge to the GP lanes (e.g., in the express lanes on I-5 under the Convention Center).

**Independent Alignments**

I-5 has three locations near Southcenter where the HOV lanes separate from the general purpose lanes and traverse independent alignments. There is also one location on SR 509 approaching the First Avenue South Bridge. In these cases the alignments were specifically designed for HOV traffic. As in the case of the express lane entrances, some motorists wait until the last possible minute to decide which lane offers the best advantage. This decision is more complex on I-5 at Southcenter because drivers have to weave through traffic exiting to I-405. (See Figure 25.) The added complications of having general traffic make that choice in an already complex area is a safety concern.


**Figure 25. I-5 southbound at Southcenter near an independent alignment**

(When this design was approved, it was assumed that HOV lane users would quickly become familiar with the alignment and, as a result, would not be placed in a situation of having to make these complex decisions unexpectedly. This assumption is acceptable for commute traffic but not for general weekend traffic.)

**Sound Transit Direct Access Projects**

Sound Transit will be building a series of ramps from local streets and park-and-rides that tie directly to the freeway HOV lanes. Because the access points serve the HOV system, they enter and exit the roadway on the left hand side. Opening those interchanges to general traffic would create a series of left hand off-ramps throughout the Puget Sound. Several issues would have to be addressed in the design of those ramps because currently they are being designed with HOV traffic specifically in mind. FHWA has required that Sound Transit address the changes in traffic patterns that would result from such a revision in its design documentation. At a minimum, this would require delay to the Sound Transit program as the analysis was completed. In the worst case, the new Sound Transit ramps would create hazardous merging conditions if volumes in the HOV lanes were substantially higher than designed for. WSDOT would need to see the results of the analysis to determine how the change might affect project costs or the approval of the permit to add the ramps.

**HIGHWAY AND TRANSIT OPERATIONAL ISSUES**

WSDOT and the transit authorities that use the HOV lanes have a number of concerns about the removal of HOV designations. The largest of these is the loss of transit schedule reliability, which would entail a substantial increase in the cost of transit

service, as discussed above. However, a number of other operational issues would have to be addressed before HOV facilities could be opened to general traffic.

**Ramp Meter Bypasses**

Ramp meter bypasses are lanes that are not required to stop when a ramp meter is active. Currently most of the ramps in the Puget Sound region allow HOV traffic to bypass the ramp meter when it is active. As an example, the WSDOT currently meters southbound I-5 traffic on many weekend afternoons to help relieve the congestion illustrated in figures 18, 19, and 20. Allowing cars to by-pass the meters would degrade metering effectiveness and increase congestion on this roadway. Opening bypasses to all vehicles would also increase merging and passing on ramps, thereby creating a safety problem. Therefore, it is recommended that HOV ramp meter bypasses not be opened to general traffic.

**Effects on Traffic Patterns on Local Streets**

It is not possible within the scope of this report to determine the effects on local streets of removing freeway HOV lane restrictions. In the past, Seattle has asked WSDOT to consult with the city before switching the HOV designation of ramps that directly serve the downtown core. The effects of the change in traffic patterns on streets in downtown Seattle and for any of the Sound Transit direct access ramps would have to be quantified.

**Consistency and Driver Expectations**

One last concern that WSDOT traffic engineers have is the ability to maintain consistent operational policy throughout the region. Good traffic engineering practice

attempts to operate all facilities in a consistent manner. This allows motorists to concentrate on the movement of vehicles around them, and not on the signs that indicate what rules apply at a particular location at a particular time. Increasing the variety of rules under which HOV lanes operate ("this facility can be used for GP traffic starting on weekends, that facility cannot be used at 9:00 AM") produces motorist confusion and decreases the average driver's ability to concentrate on the driving task. This both decreases operational efficiency and increases accident risk.

## MONETARY COSTS

WSDOT engineers point out that the cost of changing HOV lane restrictions is greater than simply painting new signs, which is more expensive than might be thought. In most cases, sign removal requires nighttime work and traffic control because shoulders on the freeways are too narrow to allow safe sign replacement without these precautions.

In addition to the issue of signs, a significant amount of money would be required to "fix" any design deficiencies that are not acceptable for general traffic conditions. This work might include widening existing shoulders, removing or relocating signs and signal heads, and a variety of other geometric improvements.

Finally, changes in HOV lane designations have the potential to violate environmental commitments WSDOT has made both to the federal government (Federal Highway Administration and Environmental Protection Agency) and various local communities. The cost of required mitigation is not easily determined without further study.

FHWA has stated that opening HOV lanes to general traffic on weekends is a significant action, and WSDOT would be required to complete project documentation

required by the National Environmental Policy Act (NEPA.) Part of that process is documentation of previous environmental commitments. A partial review of WSDOT documentation found that corridor-wide commitments were made in the I-90 corridor and in the SR 522 corridor, as well as at the locations of transit-only interchanges and other facilities throughout the region. Additional study would be necessary to further document environmental commitments and impacts to FHWA.

A preliminary cost estimate for converting HOV lanes to allow general traffic on weekends for the southern section of I-405 and all of SR 167 was more than $1,000,000.[5] These costs included all construction, signing, environmental reviews, and other costs.

## SUMMARY AND RECOMMENDATIONS

Use of HOV lanes for general traffic on weekends would have little or no beneficial effect, in that HOV lanes on weekends already operate at capacity when conditions warrant their use.

The costs for achieving these limited benefits would be significant. HOV lanes were not designed for high volume, general traffic, and their design would be deficient for such volumes. Safe freeway operations would require these deficiencies to be studied, and in some cases, eliminated or otherwise corrected.

WSDOT engineers firmly believe that there are better ways to spend the resources needed to convert HOV lanes to general traffic. The two most promising congestion relief mechanisms currently waiting for funding are

- the provision of Service Patrols on the Puget Sound freeway system

[5] Dave McCormick, presentation at the April 20th, 2000 Washington State Transportation Commission meeting.

- an increase in staffing that would allow WSDOT to decrease the time needed to switch the direction of express lane operation and increase its flexibility to use the reversible roadways to meet changing travel demands.

In a report to the legislature in 1998, WSDOT documented that motorist service patrols are one of the most cost effective measures that WSDOT can undertake to improve the efficiency of the freeway system. Provision of service patrols would reduce congestion, reduce response times to accident scenes, and reduce traffic accidents in virtually every freeway corridor in the Puget Sound metropolitan region. In the 2000 legislature an initial pilot project was funded on a limited basis to demonstrate the best method of implementing the service patrol concept.

Expanded operation of the express lanes on weekends and weekdays would also provide some congestion relief. In 1998, 109 incidents near the Kingdome were classified as major events. In 1999, with both the Kingdome and Safeco Field facilities operating, that number grew to 141. These numbers suggest that operating the I-5 express lanes dynamically on the basis of event traffic in the off peak would provide some advantage. On normal weekends without major event traffic, traffic patterns follow a traditional commute pattern; that is, traffic moves into Seattle in the morning and out of Seattle in the afternoon or evening, although not at the same time or at the same concentrations as on weekdays. Congestion would be reduced if the express lanes were operated to cater to that traffic demand. In addition, it takes up to an hour to switch the express lanes from southbound to northbound operation. That represents time that the express lanes are closed to all users. Shortening the time that the express lanes are closed to traffic by providing additional staff to conduct the switch would help reduce congestion.

Both of these actions are likely to result in far greater congestion relief than removal of HOV lane restrictions, and neither has significant downsides in terms of safety, environmental impacts, or HOV violation rates.

Finally, production of this report was hampered by the lack of an ongoing, comprehensive data collection program to provide information about the condition of the HOV system in the off-peak and weekends. Also lacking was a single, comprehensive location for storing information about design deviations and environmental commitments related to the HOV system. To be able to evaluate changes in the HOV system at the level required by FHWA, such data collection is essential. Funding for a systematic, sustainable mechanism for reporting on the condition of the HOV system in the off-peak and on weekends is essential to evaluating the performance of the system for possible operational policy changes.