I-5 North High-Occupancy Vehicle Lane
2+ Occupancy Requirement Demonstration Evaluation

February 1992

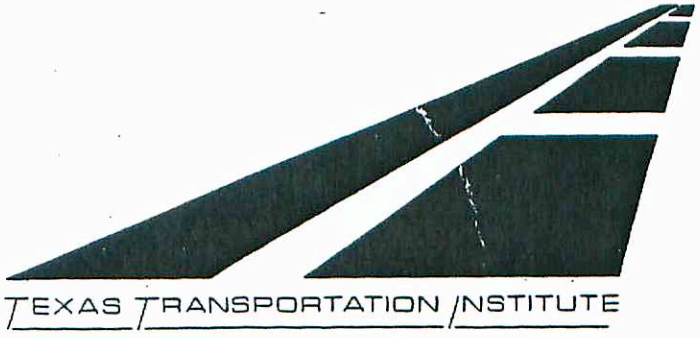
Prepared for the
Washington State Department of Transportation

By the

Washington State Transportation Center
University of Washington

and

Texas Transportation Institute
Texas A & M University



Washington State
Department of Transportation

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WORKING PAPER

Research Project T9233, Task 8
HOV Lane Evaluation and Monitoring

I-5 NORTH HIGH-OCCUPANCY VEHICLE LANE 2+ OCCUPANCY REQUIREMENT DEMONSTRATION EVALUATION

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EXECUTIVE SUMMARY

On July 29, 1991, the Washington State Department of Transportation (WSDOT) initiated a six-month demonstration project lowering the minimum vehicle occupancy requirement on the I-5 North HOV lanes from 3 or more persons per vehicle (3+) to 2 or more persons per vehicle (2+). The demonstration was undertaken to determine the impacts of reducing the occupancy requirement from 3+ to 2+ on the operation of the HOV lanes and the freeway general-purpose lanes. An evaluation program, conducted by the University of Washington and the Texas Transportation Institute under contract to the Washington State Department of Transportation, was undertaken to examine these impacts. The results of the evaluation are contained in this report, with the major elements summarized in this section.

Summary of Evaluation Elements

The WSDOT freeway HOV system objectives and measures of effectiveness were used as guidelines in the evaluation of the reduction in the I-5 North HOV lane vehicle occupancy requirement. The WSDOT objectives for the freeway HOV system include improving the capability of congested freeway corridors to move more people by increasing the number of persons per vehicle, providing travel time savings and a more reliable trip time to high-occupancy vehicles utilizing the facility, and providing safe travel options for high-occupancy vehicles which does not unduly impact the safety of the freeway general-purpose mainlanes. The five measures of effectiveness identified by WSDOT to determine if these objectives are being met include person throughput, vehicle occupancy levels, comparative and absolute general-purpose and HOV lane travel times, travel time reliability, and accident rates. Further, WSDOT has identified public support and public acceptance as critical to the success of the freeway HOV system.

A variety of data were collected, examined, and analyzed as part of the evaluation to determine the impact the reduction in the I-5 North HOV occupancy requirement has had on these measures of effectiveness. The results of this analysis are summarized in Table 1 and

Table 1. Summary of General Trends Associated with the I-5 North 2+ HOV Lane Demonstration

Measures of Effectiveness and Related Policies	General Trends in Change from 3+ Persons per Vehicle to 2+ Persons per Vehicle
Person Throughput	
HOV Lane Vehicle Volumes	Significant increase in peak hour volumes from approximately 400-500 vehicles to 1,200 to 1,400 vehicles or approximately 200%.
HOV Lane Person Volumes	Peak hour person volumes increased by approximately 1,200 or 35%.
General-Purpose Lane Vehicle Volumes	Remained approximately the same.
General-Purpose Lane Person Volumes	Remained approximately the same.
Bus Ridership Levels	Community Transit ridership to the University has increased. This appears to be result of the U-Pass Program. Ridership to downtown Seattle was stable or slightly declining.
Total Person Throughput	Increased during demonstration period by approximately 12%.
Vehicle Occupancy	
HOV Lane	Declined, due to more 2 person carpools and fewer 3 person carpools.
HOV and General-Purpose Lanes	Vehicle occupancy levels for the combined HOV and general-purpose lanes increased after the start of the demonstration, but have declined since to about the same level (1.2 persons per vehicle) as in 1989-1990.
Travel-Times and Travel-Time Reliability	
HOV Lane Travel Times	Morning peak hour travel times have remained about the same, while afternoon peak hour travel times have increased.
General-Purpose Travel Times	Morning peak hour travel times have decreased and afternoon peak hour travel times have increased.
HOV Lane Time Savings over General Purpose Lanes	HOV lane travel time savings decreased in the morning peak hour, but increased in the afternoon peak hour. These changes are due primarily to changes in travel speeds in the general-purpose lanes.
HOV Lane Travel Time Reliability	HOV travel time reliability has declined, especially in the afternoon peak hour.
General-Purpose Lanes Travel Time Reliability	Travel time reliability in the general-purpose lanes has remained about the same in the morning, but appears to have declined slightly in the afternoon peak hour.
Bus Service On-Time Performance	On-time performance appears to have declined slightly in the afternoon.

Table 1. Summary of General Trends Associated with the I-5 North 2+ HOV Lane Demonstration (continued)

Measures of Effectiveness and Related Policies	General Trends in Change from 3+ Persons per Vehicle to 2+ Persons per Vehicle
Accident Rates	
HOV and General-Purpose Lanes Accident Rates	No discernible trends were identified associated directly with the change. However, the areas downstream from both the northbound and southbound HOV lane reflect an increasing accident rate, which started before the implementation of the demonstration.
Public Perception	Surveys of bus riders, carpoolers, and motorists indicate that all three groups think the I-5 HOV lane is a good transportation improvement and between 59% to 74% think it is sufficiently utilized. 39% of the bus riders, 83% of the carpoolers, and 89% of the motorists survey felt permitting 2+ carpools to use the I-5 North HOV lane was a good move. 47% of the bus riders and 23% of the carpools indicated that travel times seem longer with the 2+ requirement, 23% said buses are not on schedule, and 5% reported missing connections. 23% of the carpoolers reported longer travel times and 21% reported problems entering or exiting the lane.
Other Federal, State, and Local Policies	
Transportation Policy Plan for Washington State	This plan emphasizes the movement of people rather than vehicles and advocates the provision of cost-effective alternatives to one-person vehicles, including transit and ridesharing. To the extent that the 2+ demonstration has resulted in more vehicles on the facility and lowered the overall occupancy vehicle rate, the results are counter to this plan.
Clean Air Act and Commute Trip Reduction Act	To the extent that more vehicles are moving through the I-5 corridor, due to the reduction in 3+ carpools, and to the extent that a degradation in the travel times and travel time reliability for HOVs have occurred, the demonstration is less supportive of these acts than the 3+ requirement.
Growth Management Act and PSCOG's Vision 2020	The demonstration evaluation did not examine possible land use or growth management impacts of the change, which would occur over a long time period. The impact on the Growth Management Act and other policies should be examined more closely.

briefly described in this section. Before discussing these, it is important to note the limitations of the evaluation. First, many factors other than the change in the HOV occupancy requirement may have influenced travel in the corridor during the demonstration. Identifying and evaluating the impact of these confounding variables, such as the introduction of the U-Pass program at the University of Washington, is difficult. Second, individuals' travel habits change over time, and, changes between modes, travel times, and routes could be expected in any corridor. However, while individual's travel habits change, it does take time to establish new routines and patterns. Thus, changes in travel characteristics may not emerge immediately after the implementation of a demonstration. The analysis was further limited by the availability of data, especially for the period immediately preceding the start of the demonstration.

Even with these limitations, the evaluation provides an indication of the general trends and impacts of the reduction in the I-5 North HOV lane occupancy requirement on the HOV and general-purpose lanes. Overall, the evaluation indicates that the trends resulting from the change to the 2+ vehicle occupancy requirement are less supportive of the WSDOT freeway HOV system objectives than the previous 3+ requirement.

As outlined in Table 1, the reduction in the vehicle occupancy requirement on the I-5 North HOV lane has resulted in a significant increase in vehicle volumes on the HOV lane. The peak hour volumes have increased from approximately 400 to 500 vehicles an hour to 1,200 to 1,400 vehicles an hour. These levels are close to the 1,500 vehicles an hour measure often used as a guideline for the desired vehicle volumes for an HOV lane. At the same time, the volumes in the general purpose lanes do not appear to have changed significantly. In addition, the vehicle occupancy level for the total freeway facility has returned to the 1989-1990 level of approximately 1.2, down from the 1991 level of approximately 1.3. Thus, more vehicles, with fewer people per vehicle, were moving in the corridor during the demonstration.

The impact of the change in the vehicle occupancy requirement on travel times and travel time reliability of vehicles in the HOV lanes and the general purpose lanes was mixed. Travel times for vehicles in the HOV lane remained about the same in the morning peak hour but

increased in the afternoon peak hour. Travel times for vehicles in the general-purpose lanes decreased in the morning peak hour, but increased in the afternoon peak hour. Thus, overall, the travel time savings from using the HOV lane decreased in the morning, but increased in the afternoon. The travel time reliability for vehicles using the HOV lane declined, with a more noticeable change in the afternoon. This appears to have affected the on-time performance of Community Transit buses, with buses more likely to be behind schedule during the demonstration than before the change. One reason for the slower travel times and less reliable trip times in the afternoon appear to be the result of increased congestion downstream from the end of the HOV lane. With more vehicles in the HOV lane, the merges and lane drops north of the HOV lane appear to have caused increased congestion and slower travel speeds.

No discernible accident or safety trends were identified during the demonstration that could be associated directly with the reduction in the HOV lane vehicle occupancy level. However, the accident rates for the areas downstream from both the northbound and southbound HOV lanes exhibited a trend toward an increasing accident rate before and during the demonstration. These trends may be indicative of the congestion problem noted above.

Overall, surveys of bus riders, carpoolers, and motorists indicated that all three groups think the I-5 North HOV lanes are good transportation improvements. Most carpoolers and motorists favored the change to the 2+ occupancy requirement, while only 39% of the bus riders did. Further, many bus riders and carpoolers reported longer travel times and 23% of the bus riders reported problems with buses operating behind schedule.

Although not examined in detail during the evaluation, trends during the demonstration appear to be less supportive of other federal, state, and local policies. These include the WSDOT Transportation Policy Plan, the Federal and State Clean Air Act, the State Commute Trip Reduction Act, and the Growth Management Act. The policies contained in these plans and acts address the operation of the Washington freeway system, environmental concerns and land use. The WSDOT Transportation Policy Plan outlines that transportation decisions should protect the natural environment, improve the built environment, and support land use decisions.

The decline in the vehicle occupancy level, reduced travel time savings and travel time reliability, and the increase in congestion levels in the afternoon peak hour, all indicate trends counter to the policies in these programs.

I. INTRODUCTION

High-occupancy vehicle (HOV) lanes are currently in operation on four freeways in the Seattle metropolitan area. In addition, HOV lanes are operated on a few arterial streets and HOV bypass lanes are provided at some metered freeway entrance ramps. The HOV lanes, and supporting park-and-ride lots, transit centers, transit service improvements, rideshare services, and travel demand management (TDM) programs, have been implemented to assist in managing traffic congestion, improving mobility, and addressing air quality and environmental concerns. The objectives of the freeway HOV system in the Puget Sound region, as defined in the Washington State Department of Transportation's *Washington State Freeway HOV System Policy*, are to improve the capability of congested freeway corridors to move more people by increasing the number of persons per vehicle, to provide travel time savings and a more reliable trip time for HOVs using the facilities, and to provide safe travel options for HOVs without unduly affecting the safety of the freeway general-purpose mainlanes.[1]

Many of the HOV lanes in the Seattle area, including the I-5 North HOV lanes examined in this demonstration, are concurrent flow HOV lanes using either the inside or outside lane or shoulder. These lanes, which operate with the HOV requirement on a 24 basis, are not physically separated from the general-purpose lanes. A painted line, along with special pavement marking and signing, is used to delineate the HOV lane from the general-purpose traffic lanes. Continuous access and egress is provided along the length of the lanes. The vehicle occupancy requirements for use of the different HOV lanes varies between 2 or more occupants per vehicle (2+) and 3 or more occupants per vehicle (3+).

In 1991, the Washington State Legislature approved a measure lowering the minimum vehicle occupancy requirements from 3 or more people to 2 or more people for all HOV lanes in the Seattle area. Although this measure was vetoed by the Governor, the Washington State

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[1]Washington State Department of Transportation. *Washington State Freeway HOV System Policy: Executive Summary*. Olympia: Washington State Department of Transportation, 1991.

Department of Transportation (WSDOT) initiated a six-month demonstration project, lowering the minimum occupancy requirement on the I-5 North HOV lanes from 3+ to 2+. The demonstration project was initiated on July 29, 1991.

Purpose of Demonstration and This Evaluation

The demonstration was initiated to determine the impacts of reducing the occupancy requirement from 3+ to 2+ persons per vehicle on the operation of the HOV lanes and the freeway general-purpose lanes. Specifically, the demonstration was intended to determine whether the change in occupancy requirement maintained or contributed to meeting the objectives of the HOV program. As noted, these include maximizing the person-carrying capacity of the highway system by providing incentives to use high-occupancy vehicles and providing capacity for future growth in travel demand. An evaluation program was undertaken to examine the impacts of the change in occupancy requirements. The Washington State Department of Transportation contracted with the University of Washington to conduct the evaluation and perform the data collection activities necessary to support the evaluation. The University of Washington, in turn, contracted with the Texas Transportation Institute (TTI), a part of The Texas A&M University System, to conduct specific elements of the evaluation and document the overall results. The I-5 North Demonstration Project Steering Committee, comprised of representatives from WSDOT, Seattle Metro, Community Transit, Pierce Transit, City of Seattle, Washington State Patrol, and the Federal Highway Administration (FHWA), provided guidance over the course of the evaluation.

Organization of This Report

This report contains the results of the evaluation of the six-month demonstration lowering the vehicle occupancy requirement on the I-5 North HOV lanes from 3+ persons per vehicle to 2+ persons per vehicle. The next chapter provides an overview of the I-5 HOV lane, the 2+ demonstration project, the Washington State Department of Transportation's HOV system objectives, and the measures used in the evaluation. This is followed by an analysis of the

impacts of the I-5 North HOV Lane 2+ Demonstration Project. The impacts are examined for the HOV lanes, the freeway general-purpose lanes, and the total freeway. The report concludes with a discussion of possible alternative approaches to managing vehicular demand on HOV lanes.

II. BACKGROUND

This chapter provides a brief overview of the I-5 North HOV lane and the HOV system objectives identified by the Washington State Department of Transportation. Further, it summarizes the major elements included in the evaluation process and the data collection methodologies.

I-5 North HOV Lane

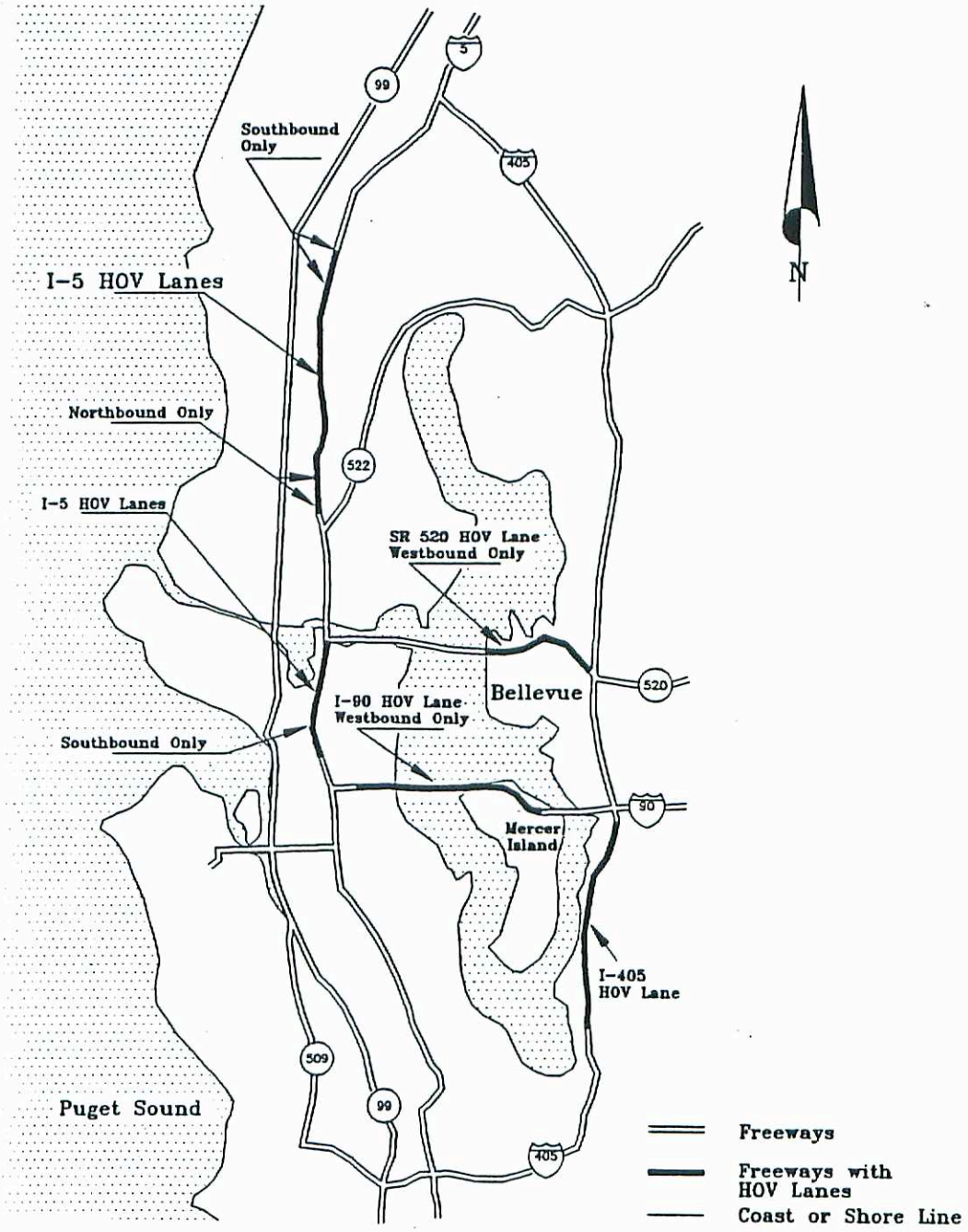
The segment of the I-5 North HOV lanes included in the demonstration is shown in Figure 1. Located to the north of downtown Seattle and the University of Washington, the southbound HOV lane is 7.7 miles in length and the northbound HOV lane is 6.2 miles in length. The lanes were opened in 1983 and operate with the HOV requirement on a 24-hour basis. From 1983 until July 29, 1991, a 3+ vehicle occupancy requirement was in effect. Under this requirement, a vehicle had to contain at least three people to be eligible to use the lane.

The I-5 North HOV lane is just one component of the regional freeway HOV lane system in the Puget Sound area. Other components include park-and-ride lots, transit centers, metered freeway entrance ramps, the surveillance and monitoring program, transit service improvements, rideshare services, travel demand management programs, and enforcement programs. These all represent important elements of the overall multi-agency program in the Puget Sound region to address traffic congestion, mobility, and environmental concerns.

Washington State Department of Transportation's HOV System Objectives

The Washington State Department of Transportation (WSDOT) has established a set of objectives to guide the development and operation of the freeway HOV lane system. These objectives are provided in Figure 2. The key aspects of these objectives focus on improving the capability of congested freeway corridors to move more people, rather than vehicles, providing

Figure 1
Location of I-5 North HOV Lanes



Source: *A Description of HOV Facilites in North America.* Texas Transportation Institute, July 1990.

Figure 2 - WSDOT Freeway HOV System Objectives

Preamble:

By satisfying the following overall objectives the HOV system is successfully providing mobility choices consistent with the mission of the Washington State Department of Transportation and the goals of recent growth management, commute trip reduction, and air quality legislation. Critical to the success of the HOV system is public support. These objectives and all decisions regarding the system must reinforce public acceptability of and support for HOV facility development.

The overall objectives of the HOV system are to accomplish the following:

- Improve the capability of congested freeway corridors to move more people by increasing the number of persons per vehicle.
- Provide travel time savings and a more reliable trip time to high-occupancy vehicles utilizing the facilities.
- Provide safe travel options for high-occupancy vehicles without unduly affecting the safety of the freeway general-purpose mainlanes.

Measures of effectiveness used to determine the impact of the HOV system include the following:

- Person throughput,
- Vehicle occupancy,
- Comparative and absolute general-purpose and HOV lane travel times,
- Travel time reliability, and
- Accident rates.

Source: Washington State Department of Transportation. *Washington State Freeway HOV System Policy: Executive Summary*. Olympia: Washington State Department of Transportation, 1991.

travel time savings for HOVs, and maintaining the safe operation of the freeway facility. A set of five measures of effectiveness have also been identified by WSDOT to be used in determining the impact of the HOV lane system. As shown in Figure 2, these include person throughput, vehicle occupancy, travel times, travel time reliability, and accident rates.

In addition to the WSDOT HOV system objectives and measures of effectiveness, other federal, state, and local policies may be influenced by the change in the vehicle occupancy requirement. Although not examined in detail during the evaluation, these include the WSDOT Transportaiton Policy Plan, the Federal Clean Air Act, the Sate Commute Trip Reduction Act, and the State Growth Management Act. These plans and acts address the operation of the freeway system, environmental concerns, and land use. The WSDOT Policy Plan indicates that transportation decisions should protect the natural environment, improve the built environment, and support land use decisions.

Evaluation of the I-5 North HOV Lane 2+ Demonstration Project

This evaluation focuses on the impact the change in the vehicle occupancy requirement on the I-5 North HOV lanes has had on achieving the objectives established by WSDOT for the freeway HOV lane system. The objectives and measures of effectiveness developed by WSDOT, as identified in Figure 2, were used to guide the evaluation. First, the impact of the occupancy requirement change on the HOV lanes was examined. This included an analysis of changes in utilization levels, travel times, travel time reliability, bus ridership levels, park-and-ride lot use, and bus operations. The impact on the general-purpose lanes and the total freeway were also examined. Changes in vehicle volumes in the general-purpose lanes were examined, along with travel time and accident and safety data. The changes in average vehicle occupancy levels and person throughput were also analyzed. Public perception concerning the change and the HOV lanes in general was also measured through surveys of bus riders, carpoolers, and motorists.

A variety of data collection activities were conducted to support this analysis. Travel time surveys, using the license plate methodology, were taken of vehicles using both the HOV and general-purpose lanes. Utilization levels and lane vehicle volumes were obtained from loop detector data gathered as part of the ongoing WSDOT monitoring program. Accident data were obtained from the State Patrol and the number of calls to the HERO program were provided by Seattle Metro. Bus ridership levels and park-and-ride lot utilization rates were provided by Community Transit. Special surveys were conducted of Community Transit riders, carpoolers, and motorists to provide additional information on the impact of the change in the vehicle occupancy requirement and general attitudes toward the HOV lanes. The results of this analysis, and a more detailed description of the methodologies used for each of the data collection activities, is provided in the next chapter.

It is important to note that the change in the I-5 North HOV Lane occupancy requirement did not occur in a vacuum. Other factors may also be influencing changes in travel patterns and travel habits in the corridor. Identifying and evaluating the impact of these confounding variables is difficult. Over the course of the six month demonstration it appears that one of the more significant factors that may have influenced travel in the corridor was the new U-Pass program at the University of Washington. The U-Pass program provides bus passes for students and faculty at the University for $6.67 and $9.00 a month, respectively. The passes are distributed to all students and employees. Individuals who do not wish to use the U-Pass must return them for a refund. The program also includes a rideshare component and provides parking privileges to bus riders and carpoolers on days they need to drive. Initial indications are that the program has been very successful at increasing bus ridership to the University. Ridership on Seattle Metro service to the University in October was 20 percent higher than the previous year and, as discussed more extensively later in this report, ridership on Community Transit service to the University also increased significantly. The University and Seattle Metro are conducting an evaluation of this program which will provide greater detail on the impact of the different components of the U-Pass program.

III. ANALYSIS OF THE IMPACTS OF THE I-5 NORTH HOV LANE 2+ DEMONSTRATION

This chapter examines the impact of the reduction in the vehicle occupancy requirement from 3+ to 2+ persons per vehicle on both the I-5 North HOV lanes and the general-purpose lanes. The information used in this analysis was obtained through special surveys and from ongoing WSDOT monitoring efforts. Much of these data were collected for specific locations along the I-5 corridor. Figure 3 identifies the location of the HOV lanes and the different data collection points within the study area. The data stations indicate the locations of the WSDOT loop detectors, which collect vehicle lane volumes. For each data station, the milepost and street locations are also provided. The observation points for the license plate surveys, by which the travel time information was obtained, are identified, along with the site for the vehicle occupancy counts.

The availability of data from the different surveys and ongoing monitoring activities varies. The WSDOT lane volumes are available in computerized format for recent years. However, data older than 1990 is available only on microfiche, making it more difficult to obtain and analyze. Due to the quick implementation of the demonstration, travel time surveys and vehicle occupancy counts were conducted for only four days in July before the change was made. Thus, as will be discussed more extensively in the following sections, the ability to fully analyze many impacts is limited by the available data.

The major focus of this analysis is on the change in the vehicle occupancy requirement on traffic levels and traffic conditions during the morning and afternoon peak hours and peak periods. For the purposes of this analysis, the morning peak hour was defined as 7:00 a.m. to 8:00 a.m., the morning peak period was defined as the three hour period from 6:00 a.m. to 9:00 a.m., the afternoon peak hour was defined as 5:00 p.m. to 6:00 p.m., and the afternoon peak period was defined as the three hour period from 3:30 p.m. to 6:30 p.m. These times correspond to the periods when the greatest demands, and thus the greatest vehicle volumes, are typically placed on the general-purpose freeway and HOV lanes.

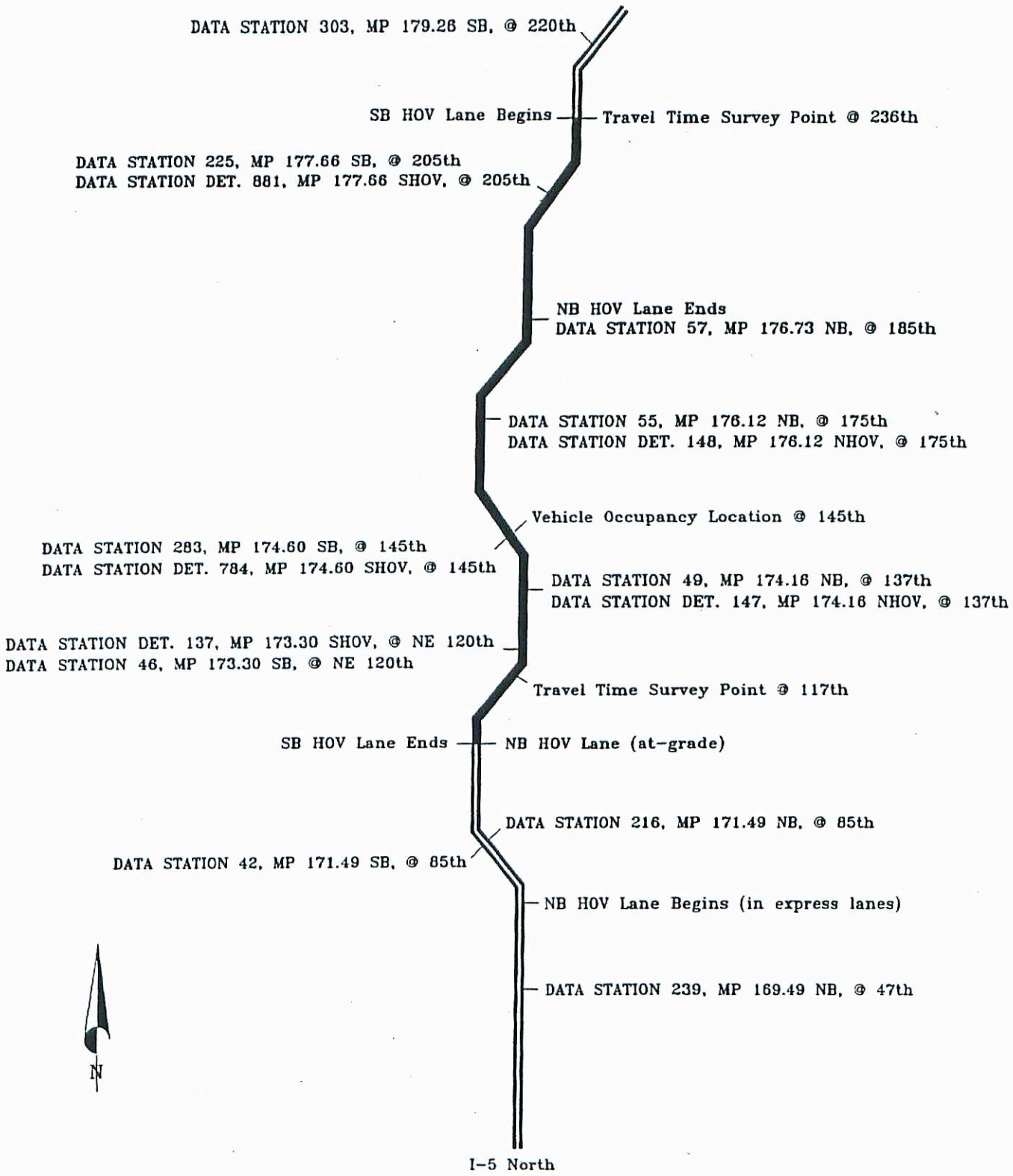


Figure 3 - Data Collection Locations in the I-5 North Study Area

Impact on the I-5 North HOV Lanes

As identified by WSDOT, the major objectives of the freeway HOV lane system include improving the capability of congested freeways to move more people by increasing the number of persons per vehicle and providing travel time savings and more reliable travel times to HOVs using the preferential facilities. This section examines the impact the reduction in the vehicle occupancy requirement on the I-5 North HOV lanes from 3+ to 2+ has had on utilization levels, travel times, travel time reliability, bus ridership levels, park-and-ride lot usage, and bus operations.

HOV Lane Utilization Levels

Data on HOV lane utilization levels were obtained from the WSDOT ongoing monitoring program on the I-5 North freeway. Loop detectors located in the pavement at selected sites along the HOV and general-purpose lanes record the number of vehicles passing over the detectors. Data from 1990 to the present can be accessed through the WSDOT computer system. However, data from before 1990 are stored on microfiche, making it harder to compile and analyze. For the purpose of this analysis, HOV lane utilization trends in 1990 and 1991, at the 3+ vehicle occupancy level, were compared with those during the six month demonstration period when the 2+ occupancy requirement was in effect. HOV lane volumes were examined for the three southbound and two northbound data stations identified in Table 2. The location of these stations is shown in Figure 3. Data for Mondays through Thursdays were examined together, with data from Fridays examined separately. This was done due to the different travel patterns often observed on Fridays.

Table 2. I-5 HOV Lane Data Stations

	Data Station	Mile Post	Street Location
Southbound	881	177.66	205th
	784	174.60	145th
	137	173.30	120th
Northbound	147	174.16	137th
	148	176.12	175th

In general, the peak hour and peak period volumes in the HOV lanes recorded at each station have more than doubled since the change to the 2+ vehicle occupancy requirement. However, slightly different trends appear to be emerging in the morning and afternoon periods. Figures 4-6 show the changes at three data stations in the southbound direction during the morning peak hour. As can be seen, the morning peak hour, peak direction HOV volumes have increased significantly with the change to the 2+ requirement and continued to increase over the course of the demonstration period. Focusing on data station 784 at 145th Street, which exhibits the highest volumes, indicates that HOV volumes have increased from approximately 500 vehicles an hour to between 1,200 to 1,400 vehicles an hour. Further, the number of vehicles using the HOV lane continued to increase over the course of the demonstration. The vehicle volumes in August and September, immediately after the change, averaged between 950 and 1,100 vehicles in the a.m. peak hour. However, as reflected in Figure 5, the peak hour HOV volumes have increased steadily, averaging between 1,300 and 1,400 vehicles in November and December. Similar trends are reflected in the morning peak period volumes. As illustrated in Figures 7-9, the a.m. peak period volumes have more than doubled and have continued to increase over the course of the demonstration.

The afternoon volumes in the HOV lane have also more than doubled for both the peak hour and the peak period. These trends are shown in Figures 10-13. The volumes recorded at data station 148 at 175th Street, indicate current p.m. peak hour volumes are averaging between 1,300 to 1,550 vehicles. This represents a significant increase from the average of 400 to 600 vehicles recorded in March through June, 1991, prior to the demonstration. In general, the p.m.

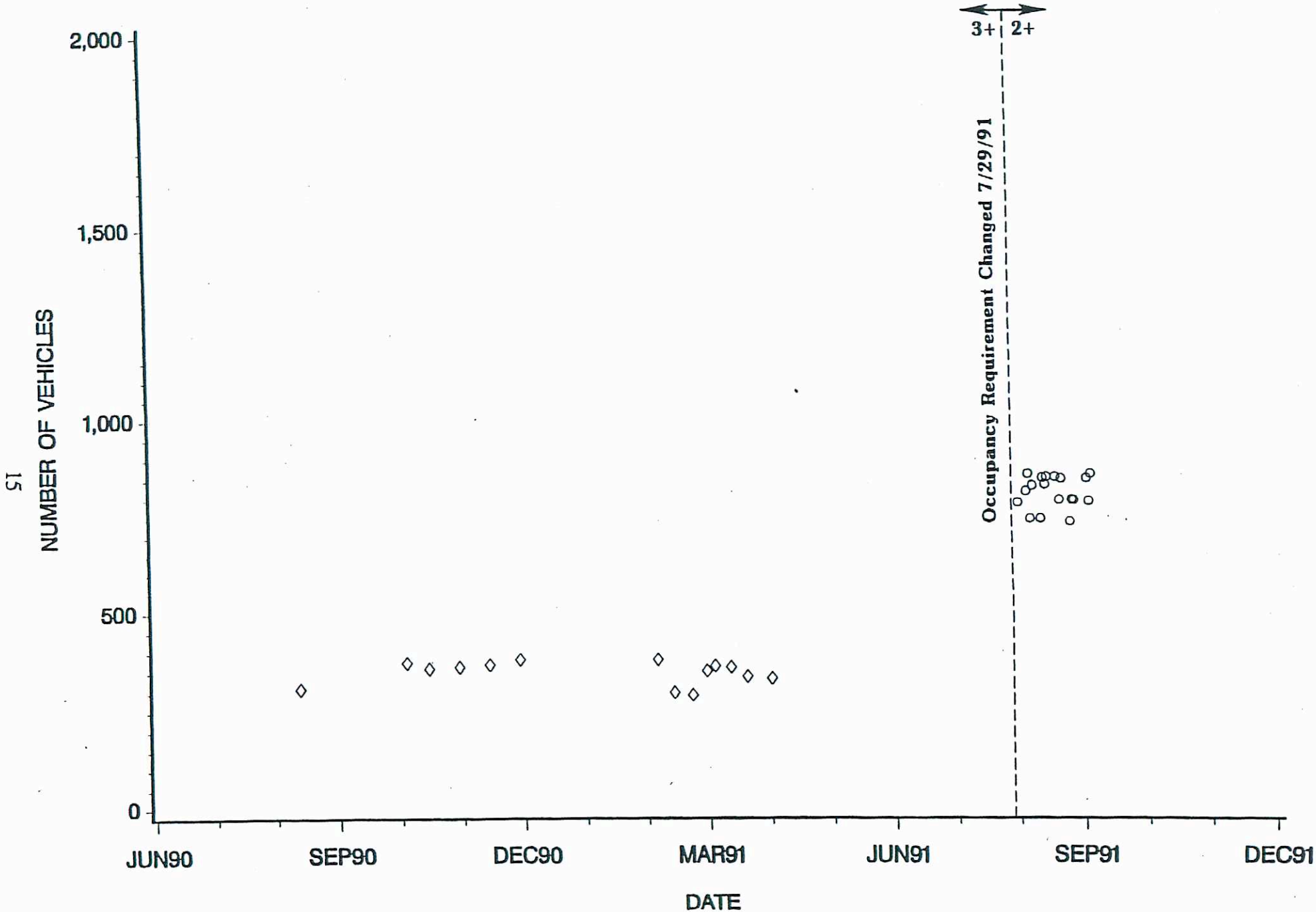


Figure 4. Morning Peak Hour HOV Volumes - Data Station 881, 205th Street

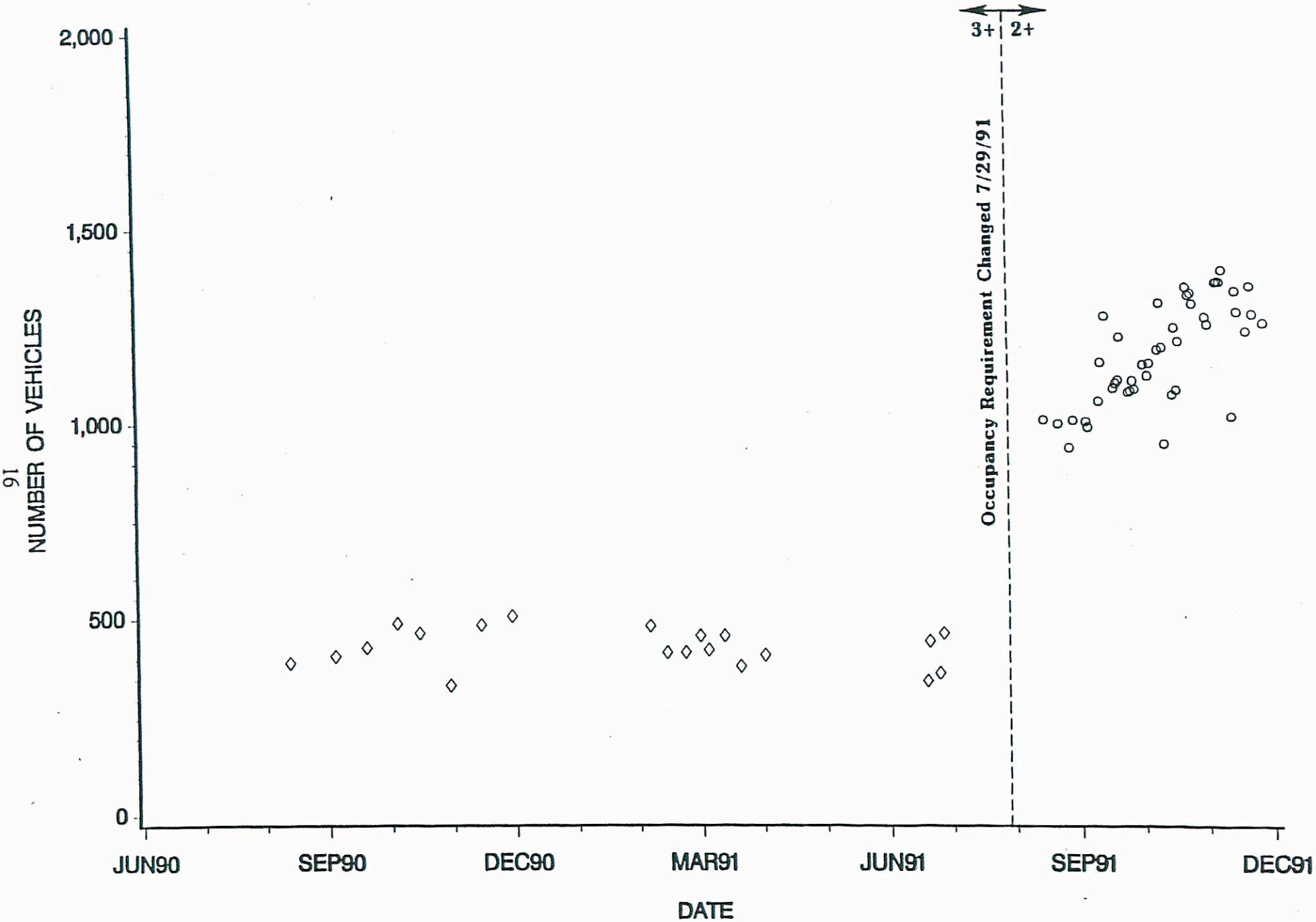


Figure 5. Morning Peak Hour HOV Volumes - Data Station 784, 145th Street

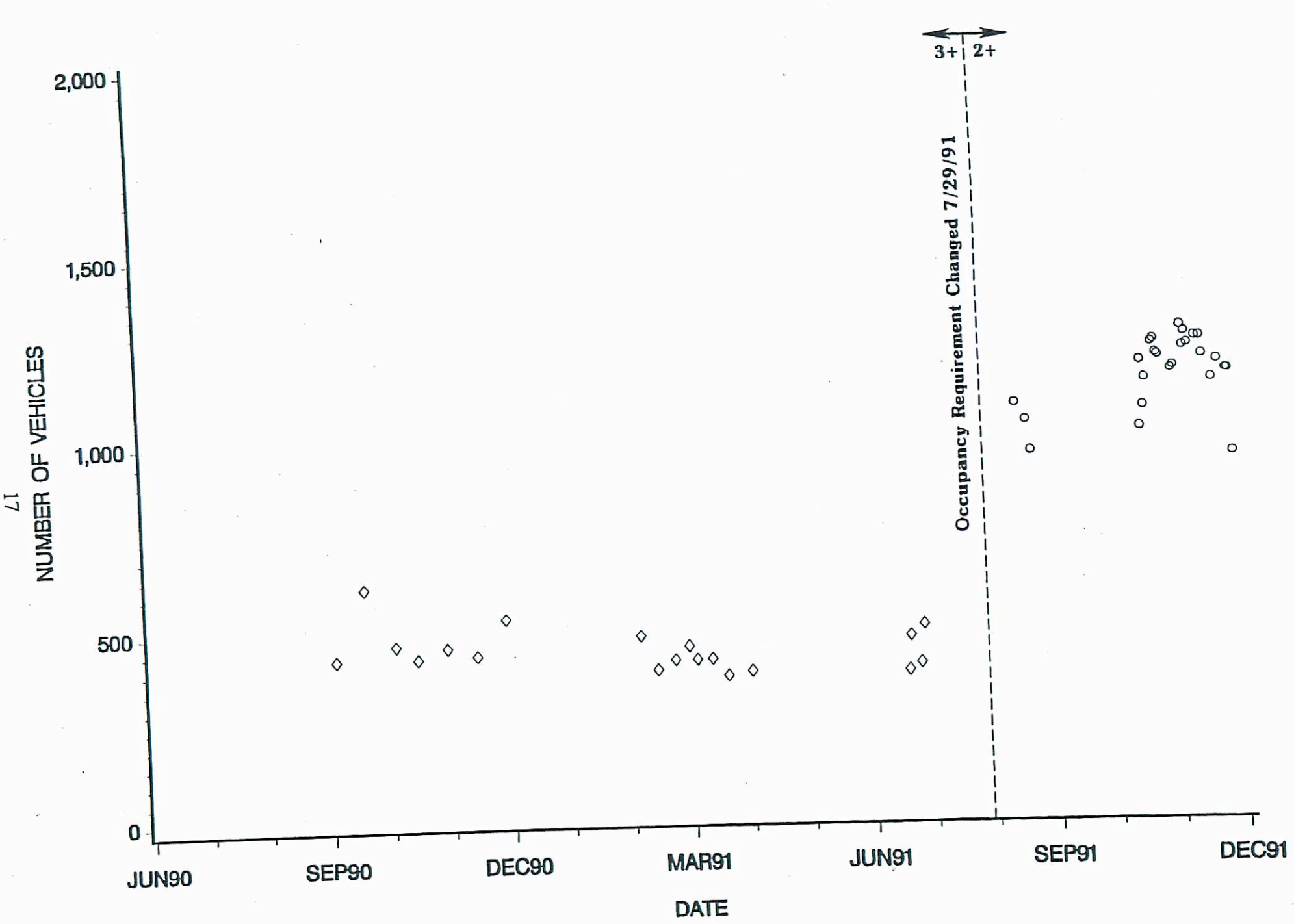


Figure 6. Morning Peak Hour HOV Volumes - Data Station 137, 120th Street

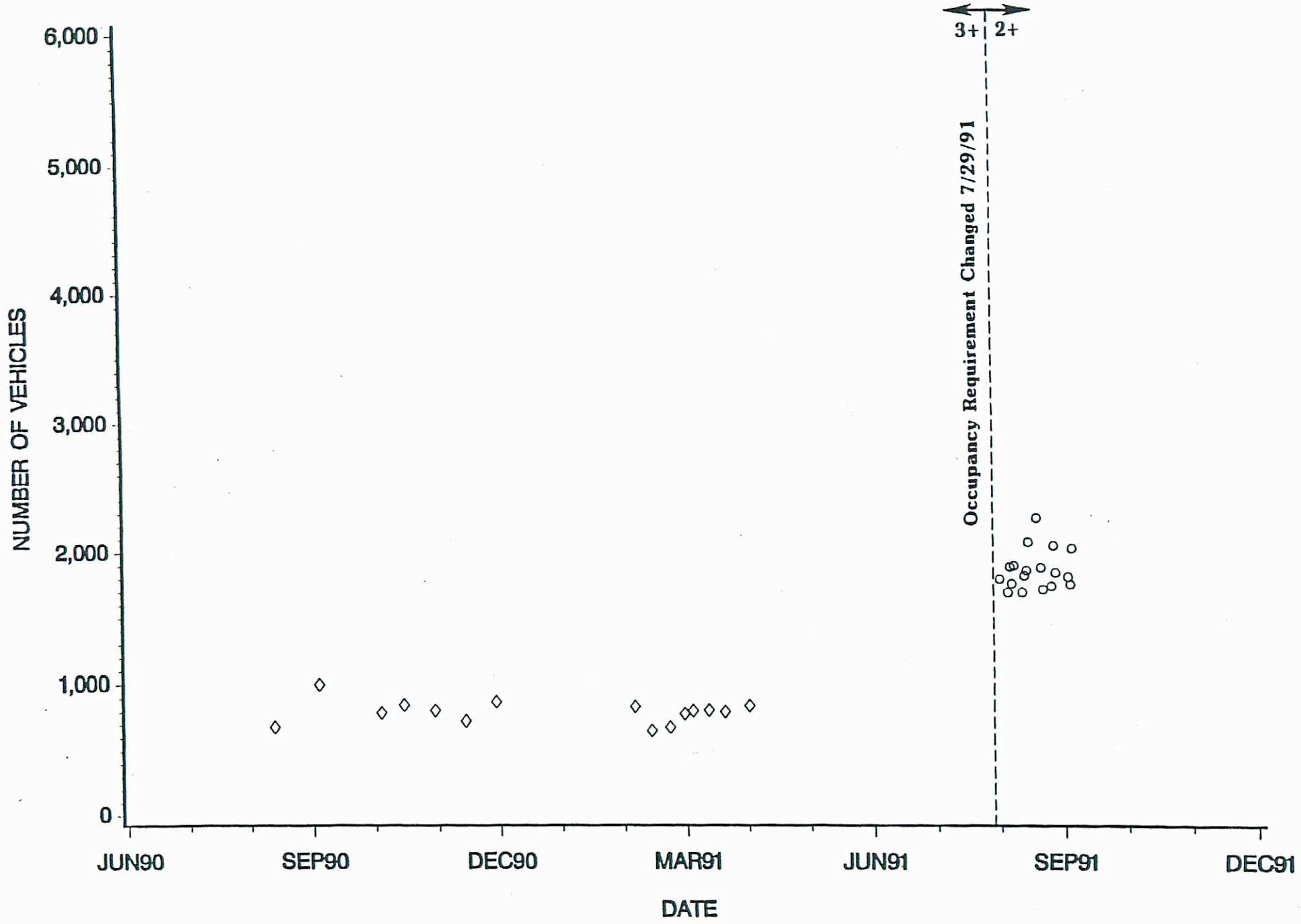


Figure 7. Morning Peak Period HOV Volumes - Data Station 881, 205th Street

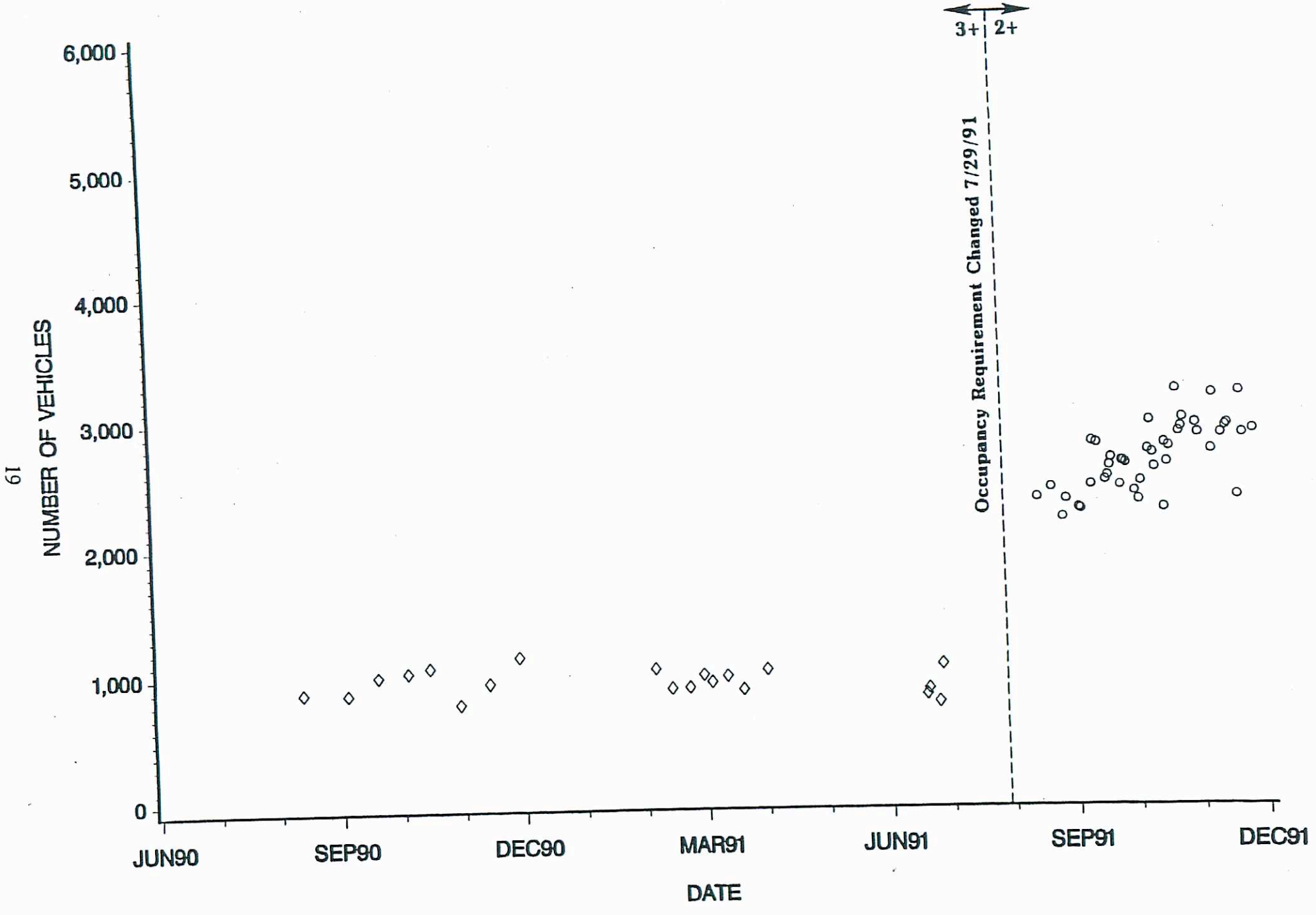


Figure 8. Morning Peak Period HOV Volumes - Data Station 784, 145th Street

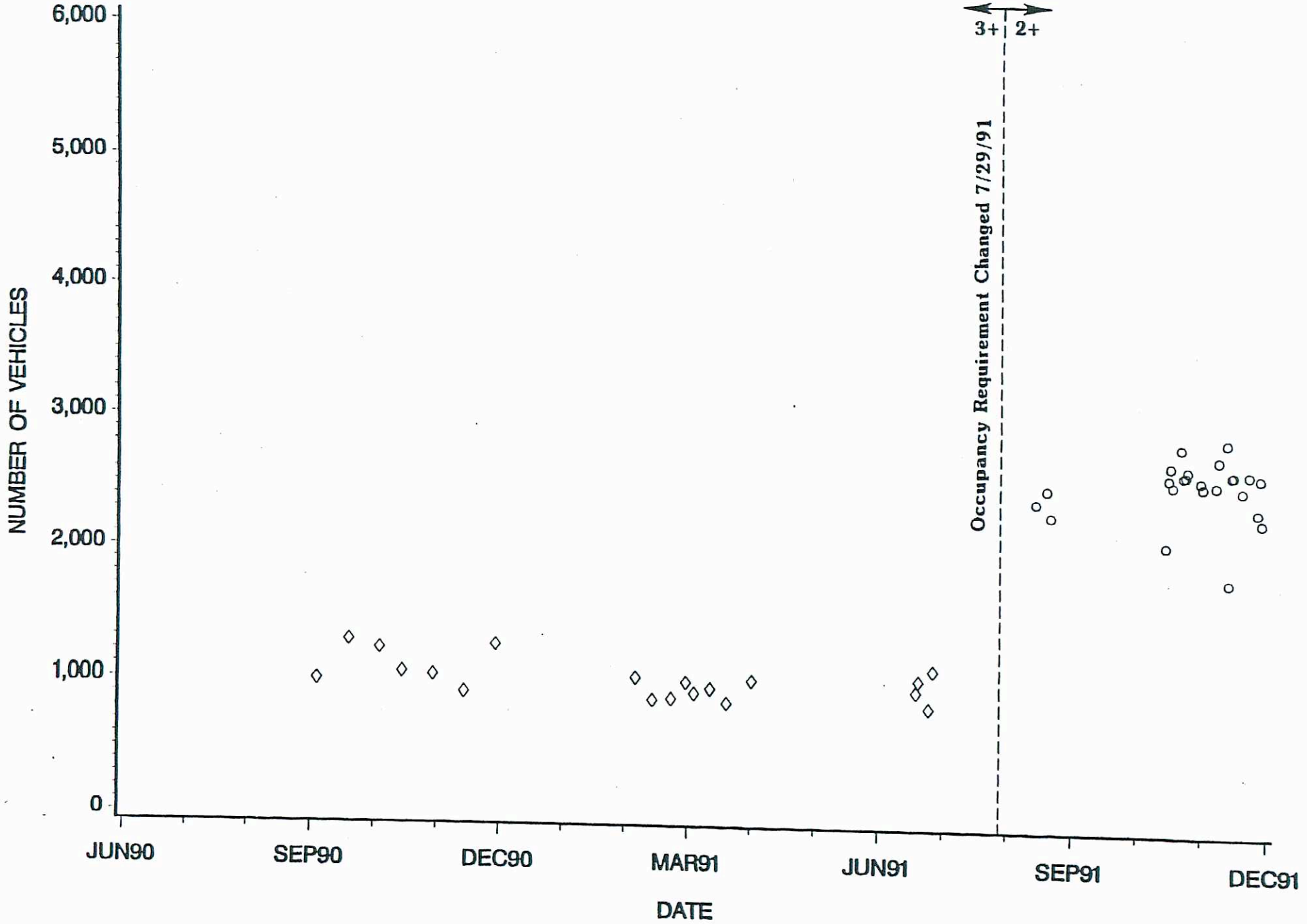


Figure 9 Morning Peak Period HOV Volumes - Data Station 137 120th Street

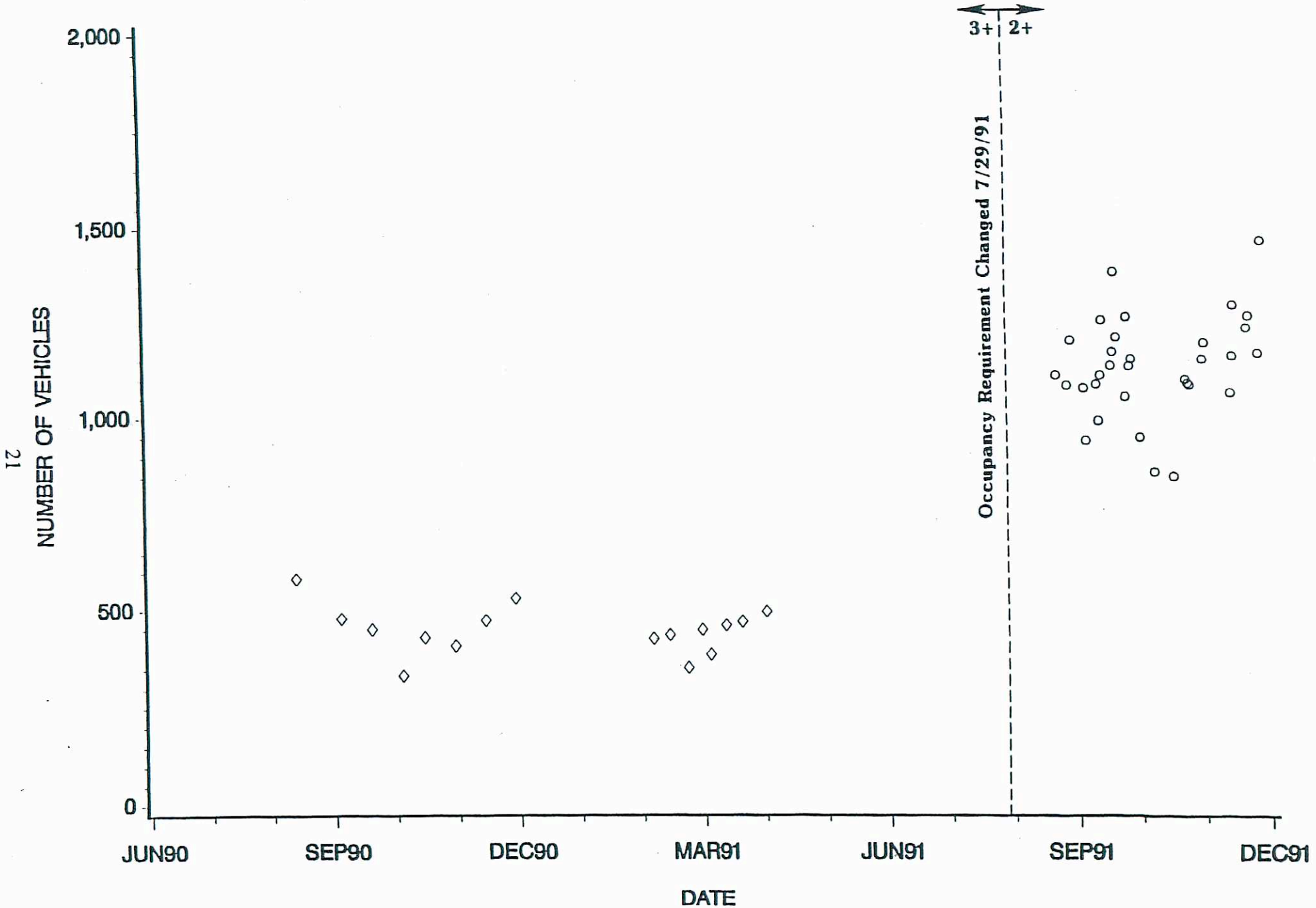


Figure 10. Afternoon Peak Hour HOV Volumes - Data Station 147, 137th Street

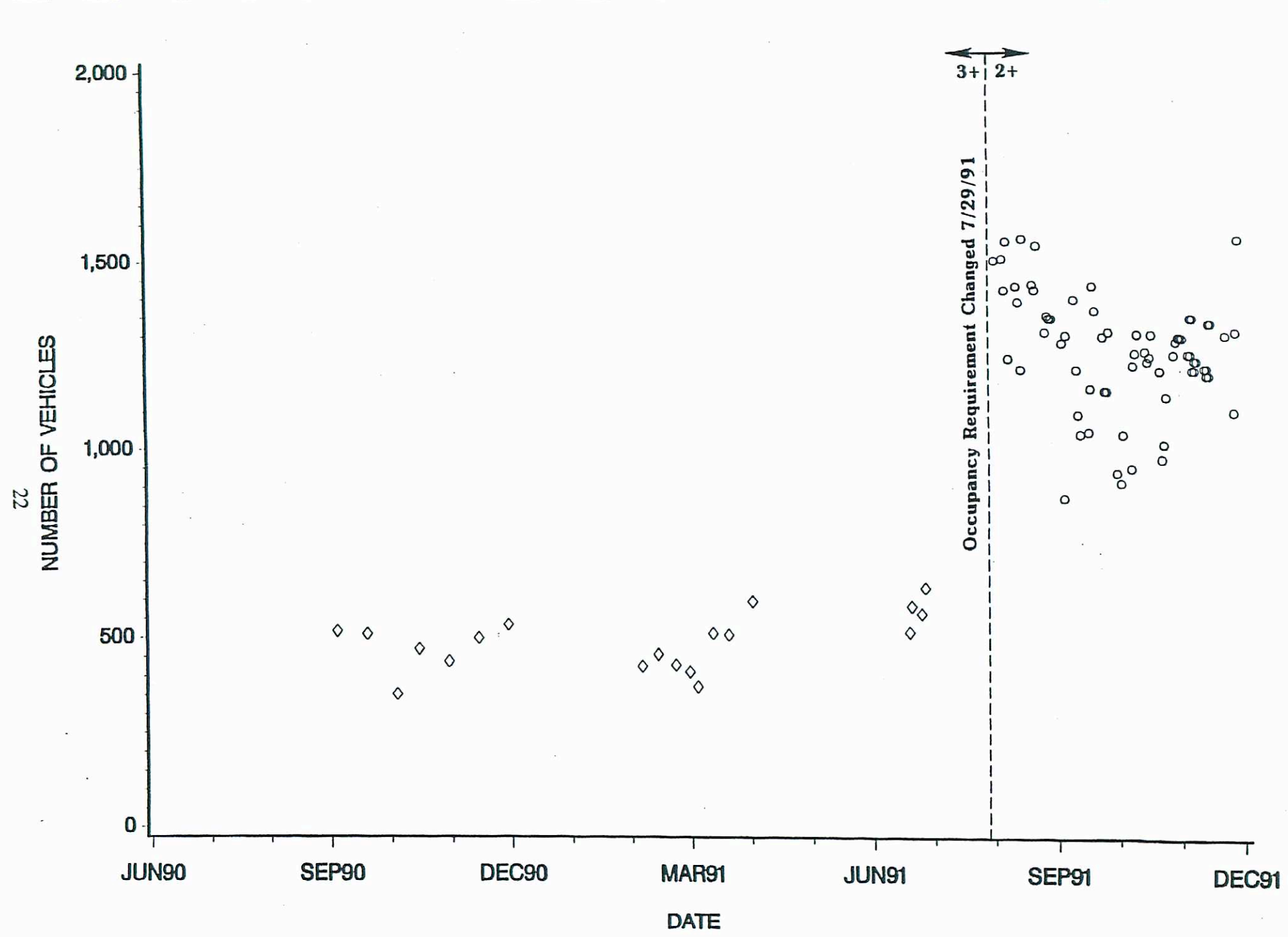


Figure 11. Afternoon Peak Hour HOV Volumes - Data Station 148, 175th Street

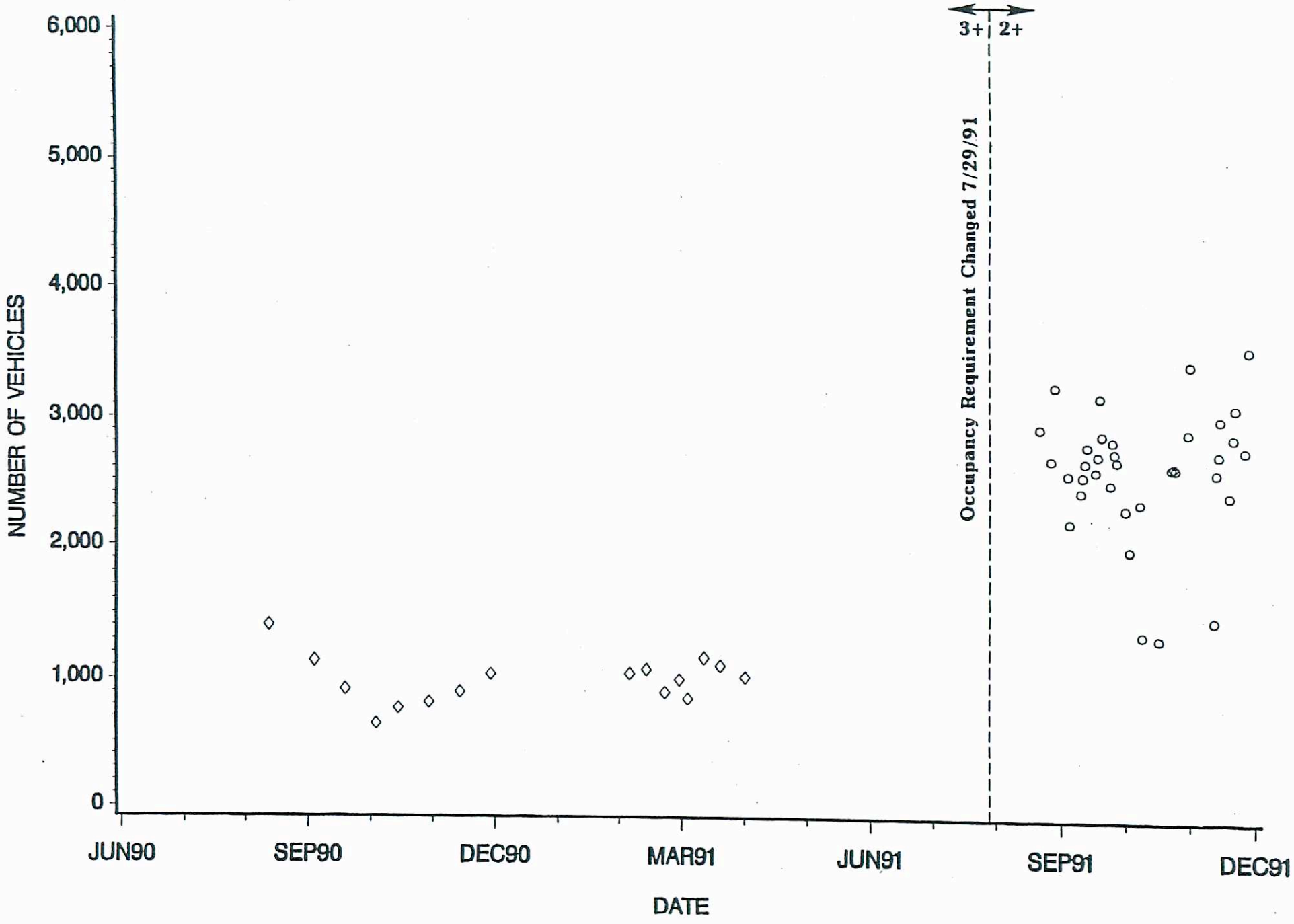


Figure 12. Afternoon Peak Period HOV Volumes - Data Station 147, 137th Street

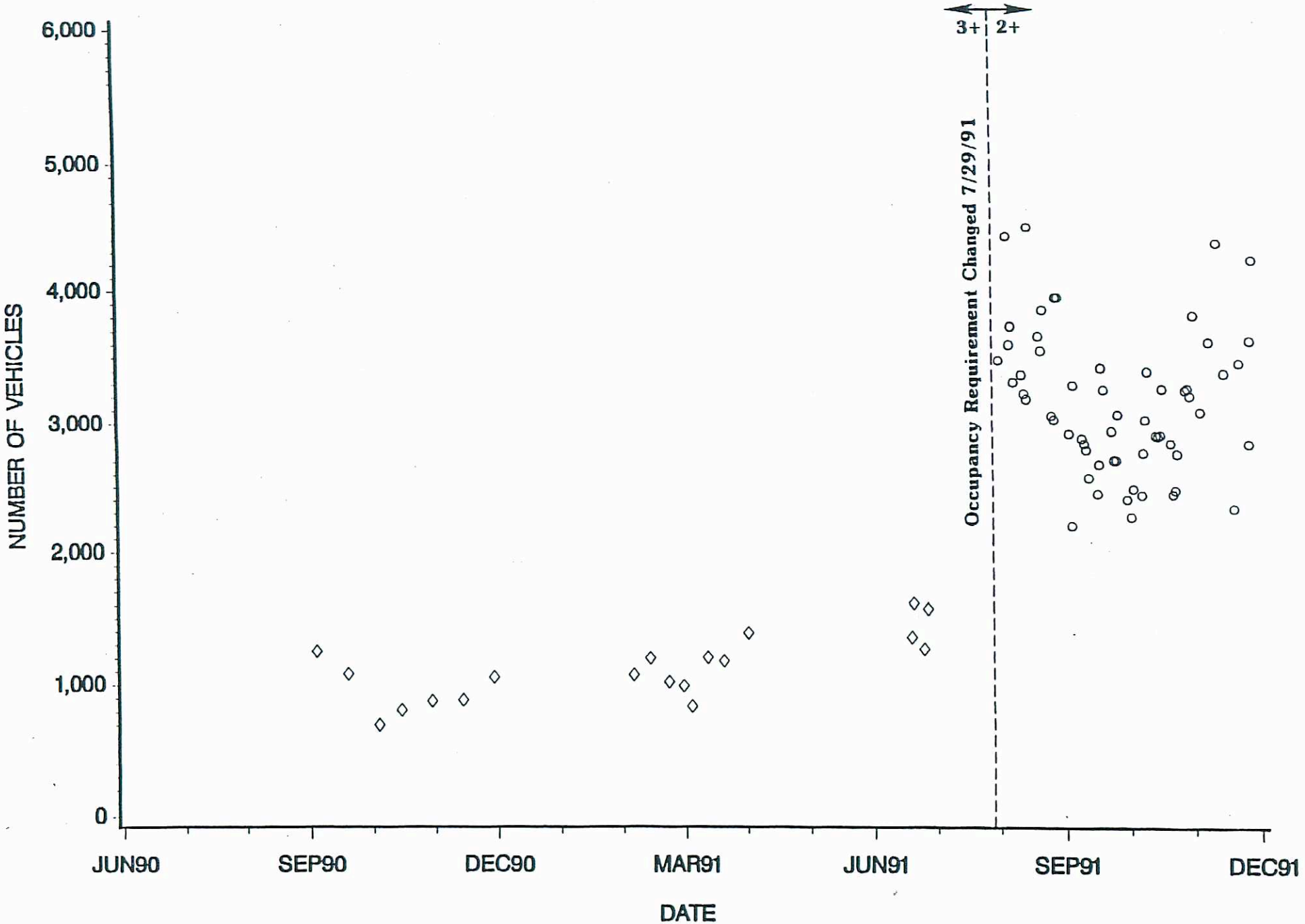


Figure 13. Afternoon Peak Period HOV Volumes - Data Station 148, 175th Street

peak hour HOV lane volumes are higher than those recorded during the morning peak hour. However, contrary to the morning trend of increasing growth in vehicle volumes, the afternoon data seem to indicate a slightly different trend. Some of the highest volumes were recorded in August, immediately after the change to the 2+ occupancy requirement. Since September, the HOV lane volumes are more erratic and a clear picture of increasing volumes, such as noted in the morning, does not emerge.

The vehicle volumes recorded for the HOV lanes on Friday mornings are fairly similar to the trends on Mondays through Thursdays. However, on Friday afternoons, the vehicle volumes recorded in the peak hour are slightly higher than those recorded on Mondays through Thursdays. These higher volumes are found both before and after the demonstration and probably reflect an increase in non-work travel often experienced on Friday afternoon. Prior to the implementation of the demonstration, the vehicle volumes in the Friday p.m. peak hour were averaging between 500 and 700 vehicles. After the demonstration, volumes as high as 1,500-1,600 vehicles per hour have been recorded.

Travel Times

Travel times for vehicles using the HOV lane were measured by recording the license plate numbers of vehicles in the lane at two locations in the corridor. The license plate information was recorded using a microcomputer that also records the time at locations close to the beginning and end of the HOV lanes. The two recording sites are 236th street and 117th street. The license plate numbers are then matched by computer and the travel time is computed. Due to the short time period before the demonstration project was implemented, only four days of "before" data are available for July, 1991.

Table 3 provides a summary of the average travel time before and after implementation of the demonstration. Overall, the travel times in the segment of the HOV lane included in the survey in the a.m. peak hour did not change significantly with the 2+ requirement. The average travel time was 5.82 minutes before the demonstration and 5.80 minutes after, even with the

Table 3. HOV Lane Travel Time Changes[1]

Time Period	Direction	Day of Week	Time Period[2]	Travel time (minutes)	Net Change (minutes)	% Change
A.M. Peak Hour (7:00-8:00 a.m.)	Southbound	M-Th	Pre Post	5.82 5.80	-0.02	-0.34%
		Friday	Pre Post	5.53 5.60	+0.07	+1.27%
P.M. Peak Hour (5:00-6:00 p.m.)	Northbound	M-Th	Pre Post	7.50 7.98	+0.48	+6.40%
		Friday	Pre Post	9.45 9.77	+0.32	+3.39%

[1]Travel times measured between 236th Street and 117th Street. Due to the location of the survey sites, in the afternoon the travel time figures include a portion of travel in the general-purpose lanes.

[2]The pre-time period data reflect the four survey points in July 1991 and the post data reflect survey points after July 29, 1991.

increase in the number of vehicles in the lane. In the p.m. peak hour, the travel time in the HOV lane increased from 7.50 minutes before the demonstration to 7.98 after.[2]

As important as the travel times of vehicles using the HOV lanes is the travel time savings the lanes provide over vehicles in the general-purpose lanes. Table 4 provides a comparison of the average travel time savings for HOVs in the HOV lanes with the travel times of vehicles in the general-purpose lanes. As shown in Table 4, the travel times savings for HOVs in the morning peak hour have decreased. As will be discussed in more detail later, this is due primarily to a decrease in travel times for vehicles in the general-purpose lanes. Thus, while the travel times for vehicles in the HOV lanes remained relatively constant, the travel times in the general-purpose lanes have decreased, resulting in less difference between travel times for vehicles in the HOV and general-purpose lanes.

Table 4 - I-5 North HOV Lanes - Travel Time Savings Over General-Purpose Lanes

Time Period	Direction	Day of Week	Time Period	Travel Time Savings[1] (minutes)
A.M. Peak Hour (7:00-8:00 a.m.)	Southbound	M-Th	Pre Post	2.15 .35
		F	Pre Post	.34 .13
P.M. Peak Hour (5:00-6:00 p.m.)	Northbound	M-Th	Pre Post	1.58 3.44
		F	Pre Post	6.12 9.66

[1]Represents the time savings of vehicles using the HOV over those in the general-purpose lanes.

[2]The location of the end survey point for the afternoon outbound direction extends beyond the end of the HOV lane. Thus the travel times are longer and include a portion of the HOV traffic in the general-purpose lanes.

The travel time savings for HOVs in the afternoon peak hour are greater during the demonstration than those experienced when the 3+ occupancy requirement was in effect. On Mondays through Thursdays the travel time savings have increased from 1.58 minutes to 3.44 minutes and on Fridays the increase has been from 6.12 minutes to 9.66 minutes. Since the travel times in the HOV lane in the p.m. peak hour have not decreased significantly, the increased travel time savings have resulted primarily from longer travel times in the general-purpose lanes occurring during the demonstration. This may be due to the seasonal variation of somewhat longer travel times in the fall and winter compared to the summer months. This results from the opening of schools, including the University, shorter daylight hours, and weather conditions.

Travel Time Reliability

Another important factor influencing the use of HOV lanes is the travel time reliability offered by these facilities. Thus, not only is the actual shorter travel time important to HOV lane users, the ongoing reliability of these savings is also important. The influence of the change in the vehicle occupancy requirement on travel time reliability was measured by calculating the standard deviation of speeds in the HOV lanes before and after the change. This measure provides an indication of the reliability of travel times for HOVs, with the higher numbers responding to a lower reliability level.

Figure 14 shows the results of this analysis. The analysis indicates that travel times are more reliable in the morning than in the afternoon. However, the increase in the standard deviation experienced in both time periods indicates that travel time reliability has suffered during the demonstration. Thus, travel times in the HOV lanes are not as reliable with the 2+ occupancy requirement as they were with the 3+ requirement. The analysis indicates that this change is strong and statistically significant.

Bus Ridership Levels

Bus service in the I-5 North corridor is provided by both Seattle Metro and Community Transit. However, due to the location of the HOV lanes and the orientation of service, only

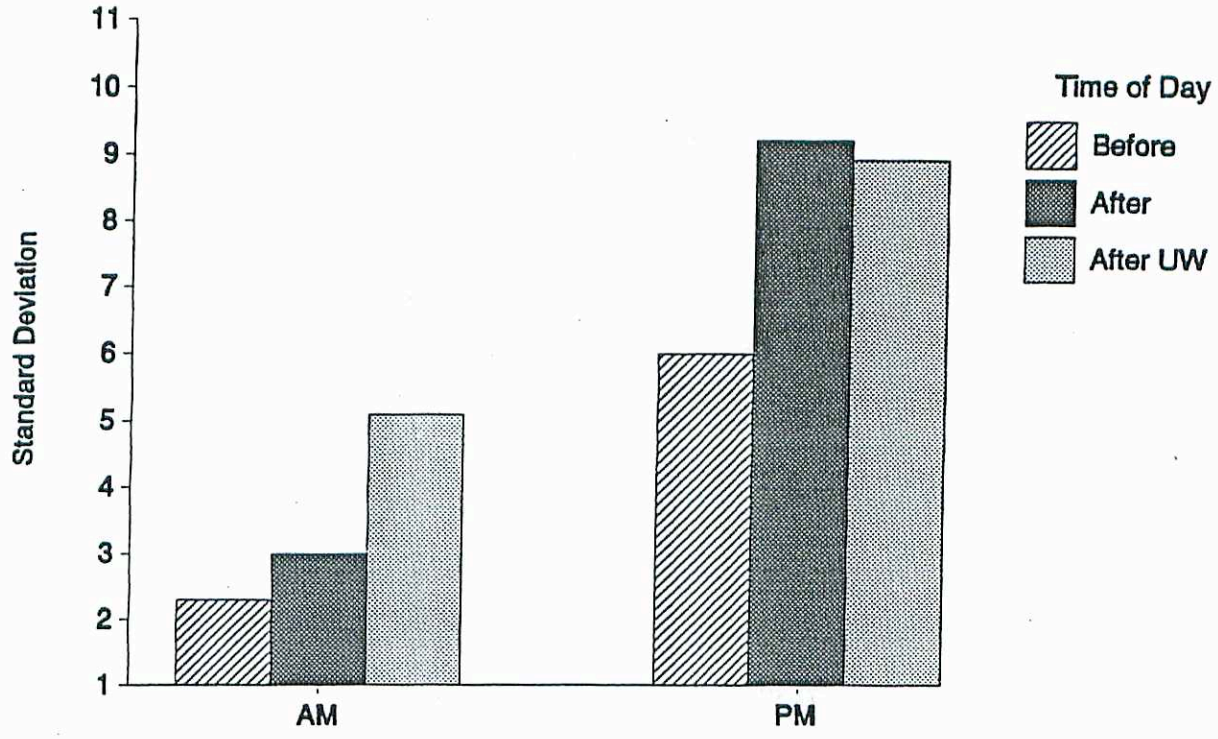


Figure 14. Overall Speed Variation for HOVs

Community Transit buses use the I-5 North HOV lanes in the study area on a regular basis. The information on the number of buses using the lane, ridership levels, and park-and-ride lot use summarized in this section was provided by Community Transit. In addition to examining trends in bus utilization on I-5 North, comparisons are also provided with bus volumes and ridership levels associated with HOV facilities in other metropolitan areas in North America.

Community Transit operates a total of 19 weekday routes in the I-5 North Corridor. Of these, 14 routes are oriented toward downtown Seattle, 4 routes are oriented toward the University of Washington, and 1 route provides service to the North Seattle Community College. A total of approximately 109 inbound and 116 outbound buses provide weekday service to downtown Seattle, while 48 inbound and 44 outbound buses serve the University. One inbound and one outbound bus serves the Community College. Of these, approximately 59 buses operate

during the morning peak hour, and 40 operate during the afternoon peak hour. Service is oriented from both neighborhood areas and park-and-ride lots located in Snohomish County. In addition, connections are provided to both the Edmonds and Mukilteo ferry service.

Table 5 provides a comparison of the morning peak hour bus volumes on the I-5 North HOV lane with those on other HOV lanes in North America. As shown in Table 5, the I-5 North HOV lane has the highest bus volumes for a concurrent flow HOV lane. Further, the volumes are higher than a number of the exclusive HOV facilities within freeway right-of-ways. Thus, buses represent a significant component in the success of the I-5 North HOV lane system.

Overall, ridership on the Community Transit systems has grown dramatically over the past five years. In 1986, the daily average ridership on the commuter routes to downtown Seattle was approximately 3,400. By 1990, this figure had increased to some 7,400. Over the past year ridership has leveled off slightly. This is partially due to the fact that no significant service improvements or expansions have been made recently. Currently, many runs are at capacity, with little room for additional riders. These trends are shown in Figures 15 and 16, which indicates the average August daily ridership for routes destined to downtown Seattle over the past five years.

The ridership trends for the months of August through January 1992, are shown in Table 6 for routes oriented toward downtown Seattle. While ridership levels remained relatively stable in August and December, slight declines in ridership were experienced in September, October, November, and January. It appears that this stabilization and slight decline may be attributable to a number of factors. First, most runs are at capacity with little room for new riders. Second, the general slowdown in the economy may have resulted in fewer bus riders in the corridor. Third, although ridership for the month of January, 1992 was above that of December, 1991, it was lower than the previous January. According to the Community Transit monthly summary, ridership levels in January and February, 1991 were the highest ever experienced due to inclement weather and poor traffic conditions.

Table 5. A.M. Peak Hour Bus Volumes and Ridership on Selected HOV Facilities in North America

Location	HOV Facility	Number of Buses in the A.M. Peak Hour[1]	Number of Riders in the A.M. Peak Hour
Exclusive Facilities, Separate Right-of Way			
Ottawa	Ottawa Transitway	180	11,000
Pittsburgh	South Busway	51	5,892
Pittsburgh	East Busway	103	2,098
Exclusive Facility, Freeway Right-of-Way			
Hartford	I-84	20	600
Houston	I-45N	75	2,810
Houston	I-45S	26	840
Houston	I-10W	46	1,820
Houston	U.S. 290	17	600
Los Angeles	San Bernardino Busway	71	2,750
Pittsburgh	I-279	13	485
Washington, D.C.	I-395	161	5,621
Concurrent Flow			
Denver	US 36	28	1,000
Fort Lee, N.J.	I-95	36	1,800
Orange County	Rt. 55	3	50
Orange County	I-405	4	120
San Francisco	U.S. 101	57	1,995
San Jose	Rt. 237	18	630
Seattle	I-90	34	1,250
Seattle	SR. 520	56	3,140
Seattle	**I-5 North**	**59**	**2,500**
Vancouver	H-95	27	1,080

[1]In the peak direction.

Source: Turnbull, Katherine F. and James W. Hanks Jr. *A Description of High-Occupancy Vehicle Facilities in North America.* College Station, Texas: Texas Transportation Institute, 1990.

Table 6. Community Transit Commuter Service to Seattle-Percent Change in Ridership from Previous Year

Month	Percent Change in Ridership from Previous Year
August, 1991	+0.4%
September, 1991	-1.4%
October, 1991	-1.1%
November, 1991	-5.0%
December, 1991	+0.3%
January, 1992	-5.0%

Source: Community Transit, Monthly Service Reports.

In addition, some former bus riders may have changed to carpooling with the new 2+ occupancy requirement or driving alone. The results from the surveys of carpoolers using the I-5 HOV lane identified that 2 of the 42 individuals responding to the specific questions indicated they had changed from riding the bus to carpooling within the last 6 months. While these results indicate that a few individuals have changed from riding the bus to carpooling since the start of the demonstration, no statistically valid conclusion can be drawn due to the low response rate to the carpool survey. Also, these trends may simply reflect a normal carpool formation rate within the corridor. In addition, some riders may have stopped using the bus in response to complaints about slower service and missed connections since the reduction in the vehicle occupancy requirement.

Trends on the Community Transit service to the University of Washington have experienced significant increases in ridership since the start of the fall semester. As shown in Table 7, the average daily ridership during the school year increased from 1,593 in February to 2,739 in October. This trend, which has also been experienced on Seattle Metro service to the University, appears to be the result of the new U-Pass Program. Community Transit representatives have indicated that articulated buses have replaced regular buses in some routes to accommodate the increased ridership levels.

Table 7. Community Transit-Ridership Changes on Service to the University of Washington

Month	Total Monthly Ridership	Average Daily Ridership
July, 1990	33,669	1,603
August, 1990	32,085	1,395
September, 1990	24,228	1,275
October, 1990	47,568	2,162
November, 1990	40,107	1,900
December, 1990	29,378	1,470
January, 1991	43,679	1,617
February, 1991	31,855	1,593
May, 1991	43,206	1,878
August, 1991	32,209	1,464
September, 1991	30,379	1,447
October, 1991	63,003	2,739
November, 1991	46,954	2,348
December, 1991	41,221	1,963
January, 1992	51,853	3,050

Source: Community Transit, Monthly Service Reports.

Approximately 10,000 daily riders are carried to downtown Seattle and the University of Washington on Community Transit buses using the I-5 North HOV lane. In the morning peak hour, some 2,500 riders are carried on buses using the HOV lane. As shown in Table 5, the morning peak hour bus passenger volumes on the I-5 North HOV lane compare very favorably with levels on other HOV lanes in North America. The I-5 facility carries the second largest number of bus riders in the morning peak hour of the concurrent flow HOV lanes and records higher bus passenger volumes than some of the exclusive freeway HOV lanes. Further, Community Transit has plans to expand service to downtown Seattle in the future. This includes adding buses on existing routes and establishing new routes. These services will use the I-5 HOV lanes.

Park-and-Ride Lot Utilization

In addition to bus ridership trends, the use of park-and-ride facilities in the corridor provides another indication of bus ridership levels and possible carpool and vanpool use. There are currently 13 park-and-ride lots served by Community Transit. Figure 17 provides a summary of the utilization of the 5 major and 8 minor lots by quarter for the last three years. As noted,

only October information was available for the fourth quarter of 1991. Overall, these figures indicate that the park-and-ride lots are well utilized. Further, the trends seem to indicate that use of the major lots peaks during the fourth quarter of each year; a trend that appears to be continuing in 1991. Use of the minor lots has been increasing over time.

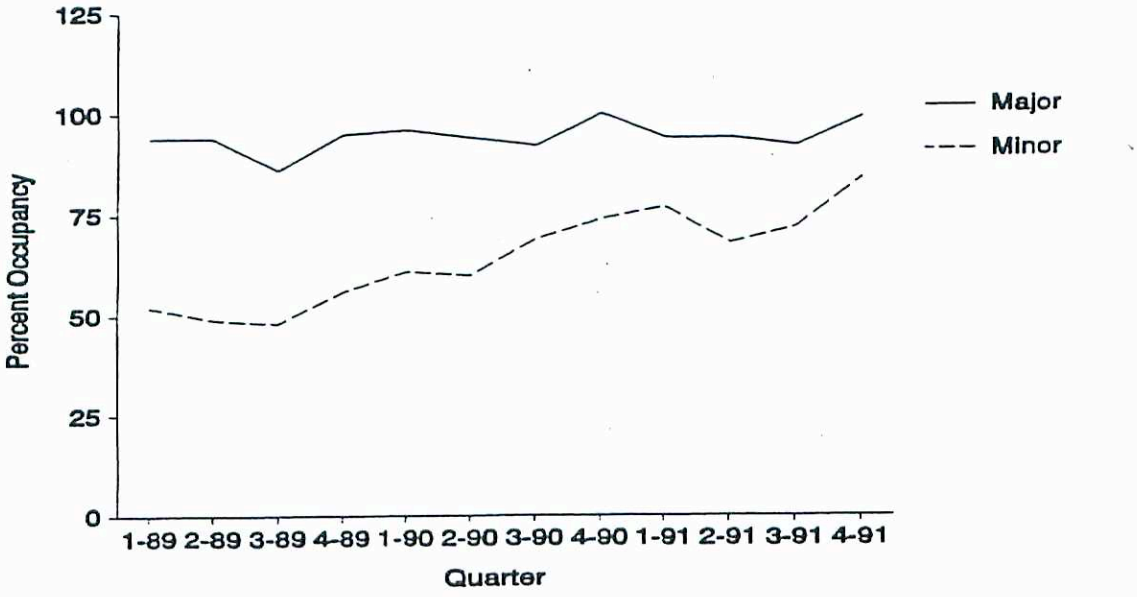


Figure 17. Park-and-Ride Lot Utilization Levels

Bus Operations

HOV lanes are often implemented to improve the ability of transit buses to compete with the single occupant automobile by decreasing travel times for buses and providing increased travel time reliability. As noted previously, the I-5 North HOV lanes and the expanded service offered by Community Transit have attracted a significant number of new bus riders in the corridor. Most of these are "choice" riders; individuals with other travel alternatives available who choose to ride the bus. Thus, it is important to examine the impact the reduction in the HOV lane occupancy requirement has had on bus operations in the corridor. On-time performance information from Community Transit, comments from bus operators, and responses on the bus rider surveys were all examined as part of this analysis.

Community Transit representatives have indicated that they have received feed back from both drivers and customers that bus schedule reliability has been degraded during the demonstration. Most of the complaints concern afternoon trips. Similar responses were received on the bus ridership survey. Approximately 23% of the respondents indicated that buses were not always on schedule and 5% reported missed connections since the start of the demonstration. Community Transit monitors the on-time performance of its buses on an ongoing basis. A review of this information indicates that buses were arriving at their destinations a little later during the demonstration than they were during the first half of 1991.

Impact on the I-5 North Freeway General-Purpose Lanes

This section examines the impact of the reduction in the vehicle occupancy requirement for the I-5 North HOV lanes on the I-5 North general-purpose lanes. The WSDOT Freeway HOV System objectives note that the HOV lane system should provide safe travel for high-occupancy vehicles which does not unduly impact the safety of the freeway general-purpose lanes. This section examines the trends in vehicle volumes and travel times in the general-purpose lanes before the change in the HOV occupancy requirement and over the course of the six-month demonstration. Accident and safety information for both the HOV lanes and the general-purpose lanes are examined in a later section.

Vehicle Volumes

Vehicle volumes for the I-5 North general-purpose lanes were obtained from the WSDOT ongoing monitoring program on the I-5 North freeway. Loop detectors located in the pavement at selected sites record the number of vehicles passing over the detectors. Volume data were examined over the course of the demonstration and for the 12 month period prior to the demonstration. This allowed for a comparison of the demonstration time period with the July to December time period in 1990. Volumes from before 1990 were not examined due to the difficulty of obtaining the data from the microfiche files. As noted previously, loop detectors may be affected by the weather and computer problems, and are periodically turned off for repairs. Thus, gaps in the data may exist.

Figures 18 through 23 provide an overview of the vehicle volumes in the general-purpose lanes in the peak direction for the morning and afternoon peak hours. Figures 18 through 20 show the vehicle volumes for the a.m. peak hour at three locations; before the start of the southbound HOV lane, at a midpoint, and downstream from the HOV lane. The cross section at all three locations includes three general-purpose lanes. The volumes before and during the demonstration, show a good deal of variability. However, the vehicle volumes are generally similar over the complete time period, with no significant changes emerging during the demonstration.

Figures 21 through 23 show the general-purpose freeway lane volumes for the p.m. peak hour for a location just prior to the start of the northbound HOV lane, a location with the HOV lane, and a location where the HOV lane ends. All three of these sections include three general-purpose lanes. Overall, the vehicle volumes appear to be relatively constant at all three locations, both before and during the demonstration. As in the morning, the afternoon peak hour volumes display a good deal of variability. However, as was the case in the morning, no changes in vehicle volumes are noticeable during the demonstration period.

Travel Times

Table 8 identifies the average morning and afternoon peak hour travel times for vehicles in the general-purpose lanes before and during the demonstration. On average, travel times have declined in the a.m. peak hour, while they have increased in the p.m. peak hour. Two one-hour periods were examined in the afternoon; 5:00 - 6:00 p.m. and 4:00 p.m. to 5:00 p.m. This was done as travel time data were not collected in December for the 5:00 - 6:00 p.m. time period due to darkness. Thus, the figures for this period represent travel times for the July through October period. Field observations indicate that the increase in the afternoon travel time appears to be caused in part by traffic congestion resulting from the lane drop and merging occurring at the north end of the HOV lane.

An attempt was made to estimate travel speeds using data obtained from the permanent loop detectors. This procedure uses a formula based on vehicular volumes, vehicle occupancy data, which is the percentage of time a loop detector is occupied by a vehicle, and an adjustment

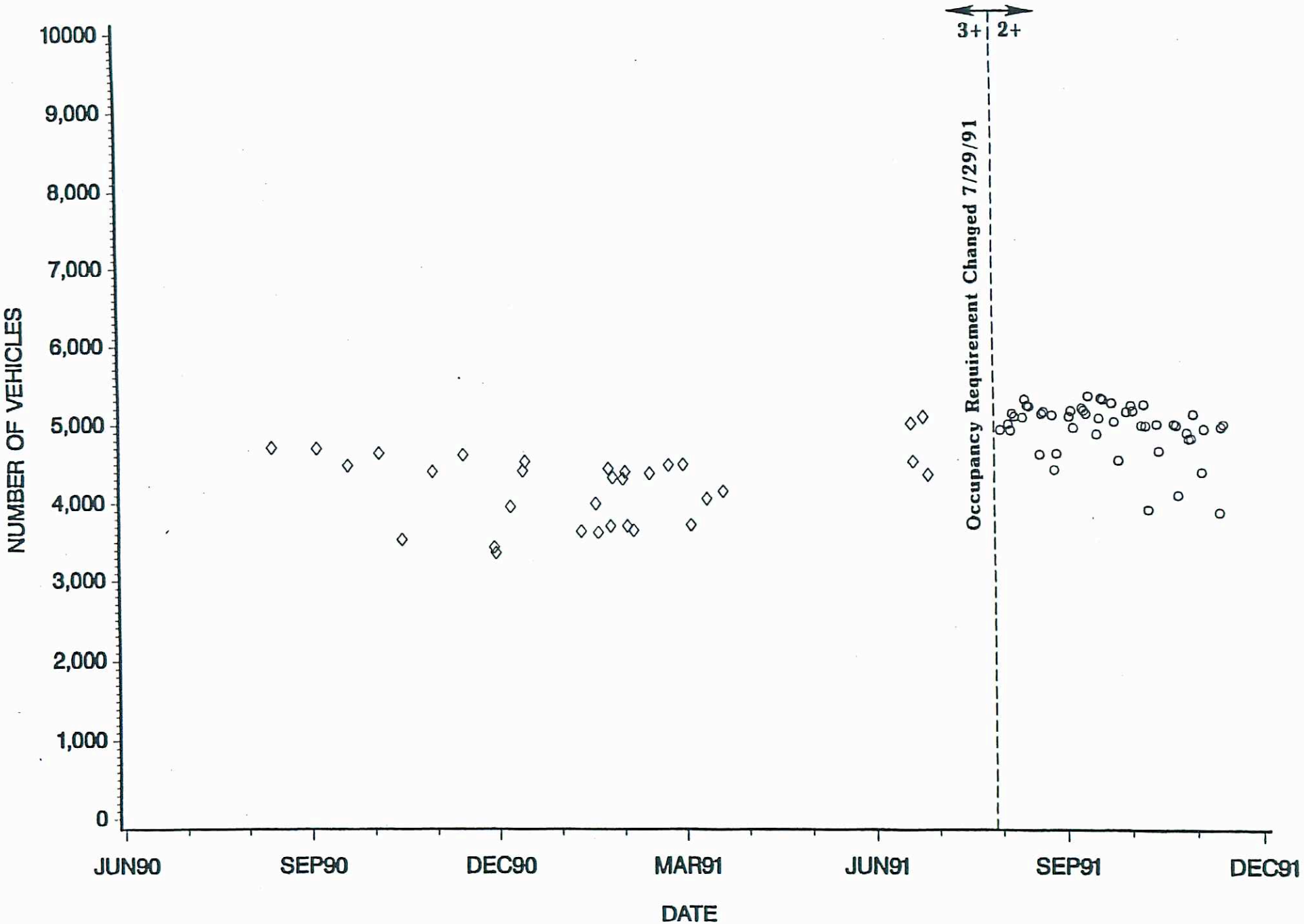


Figure 18 Morning Peak Hour General-Purpose Lane Volumes - Data Station 303, 220th Street

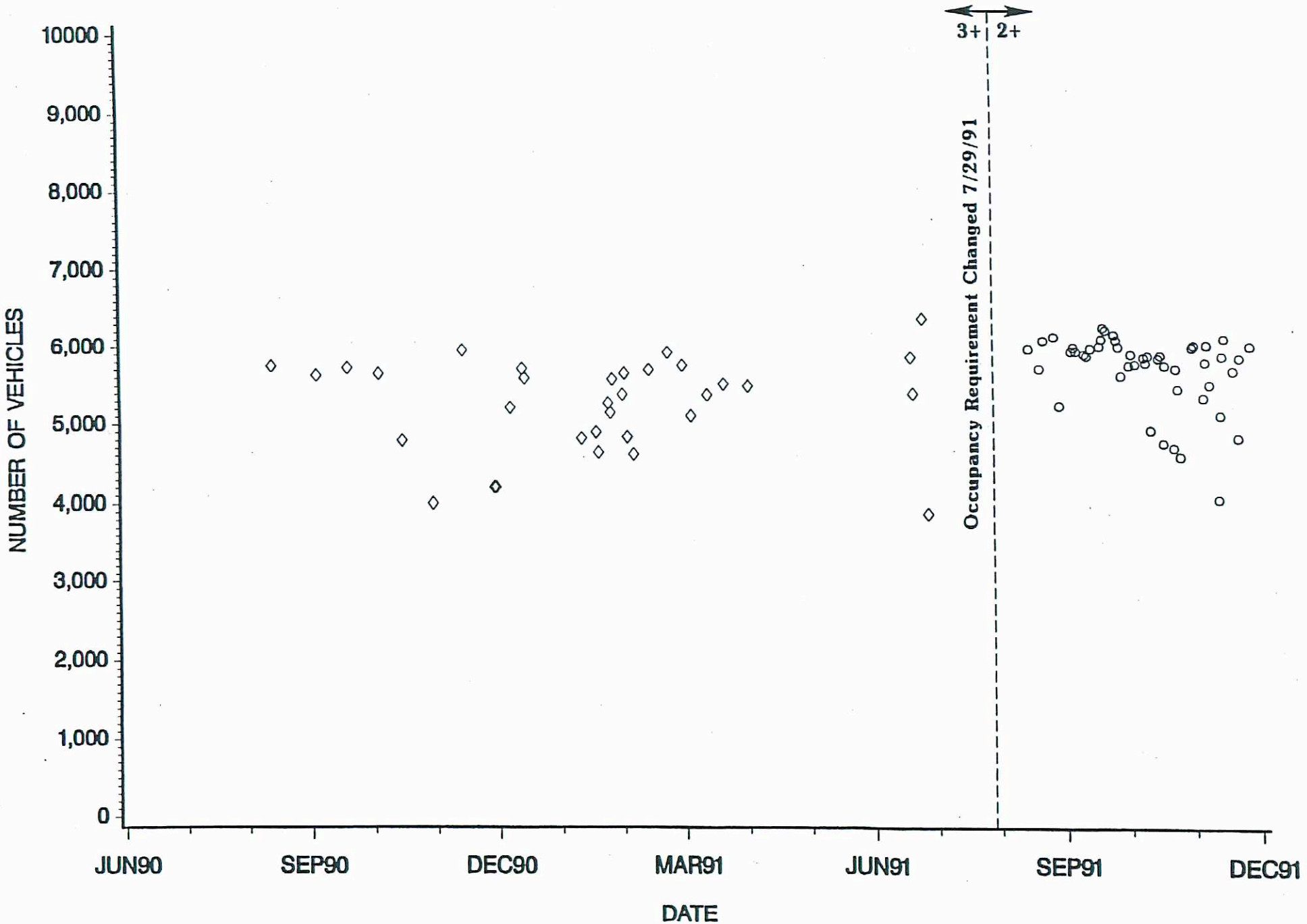


Figure 19 Morning Peak Hour General-Purpose Lane Volumes - Data Station 283, 145th Street

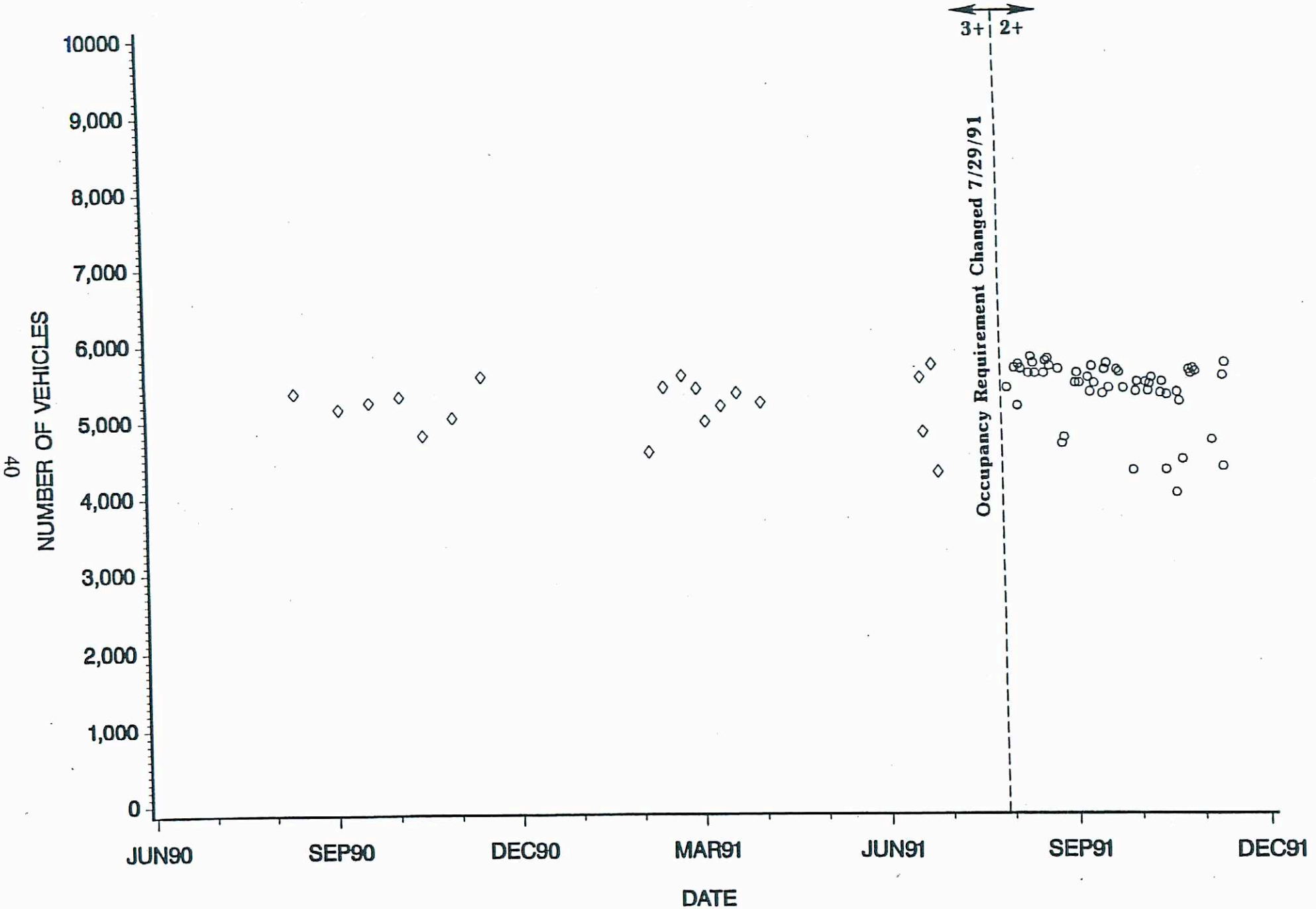


Figure 20. Morning Peak Hour General-Purpose Lane Volumes - Data Station 42, 85th Street

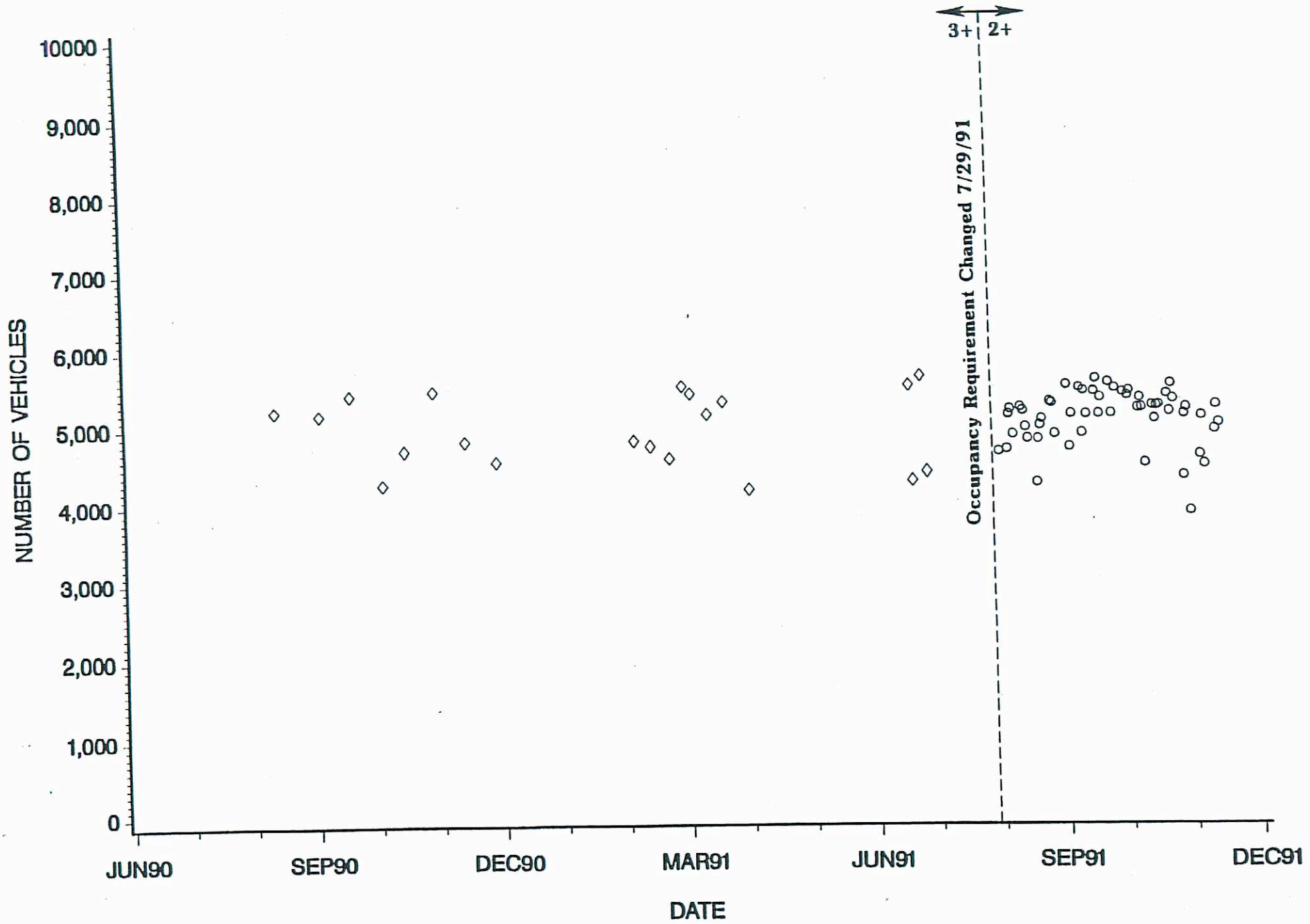


Figure 21. Afternoon Peak Hour General-Purpose Lane Volumes - Data Station 216, 85th Street

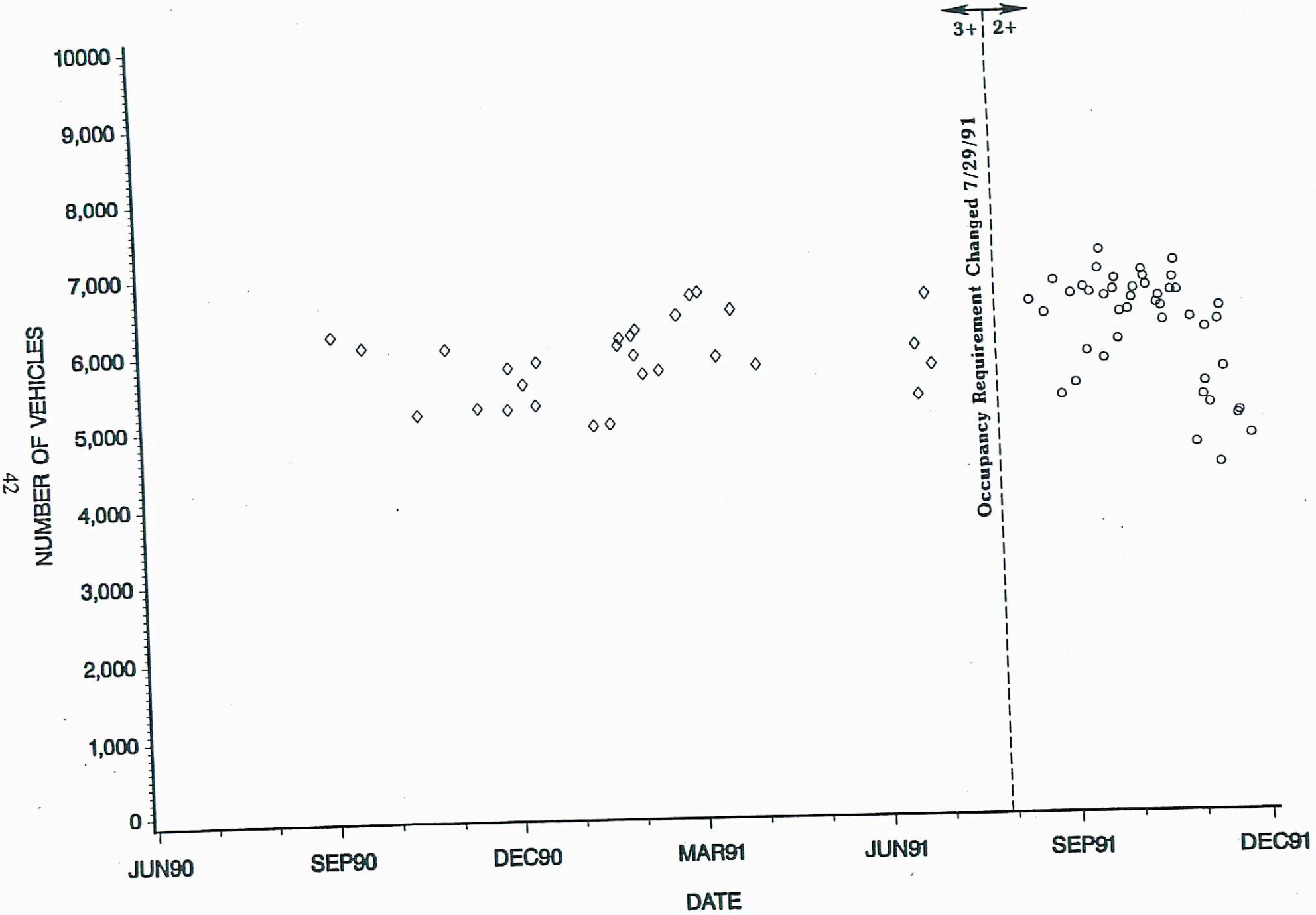


Figure 22. Afternoon Peak Hour General-Purpose Lane Volumes - Data Station 55, 175th Street

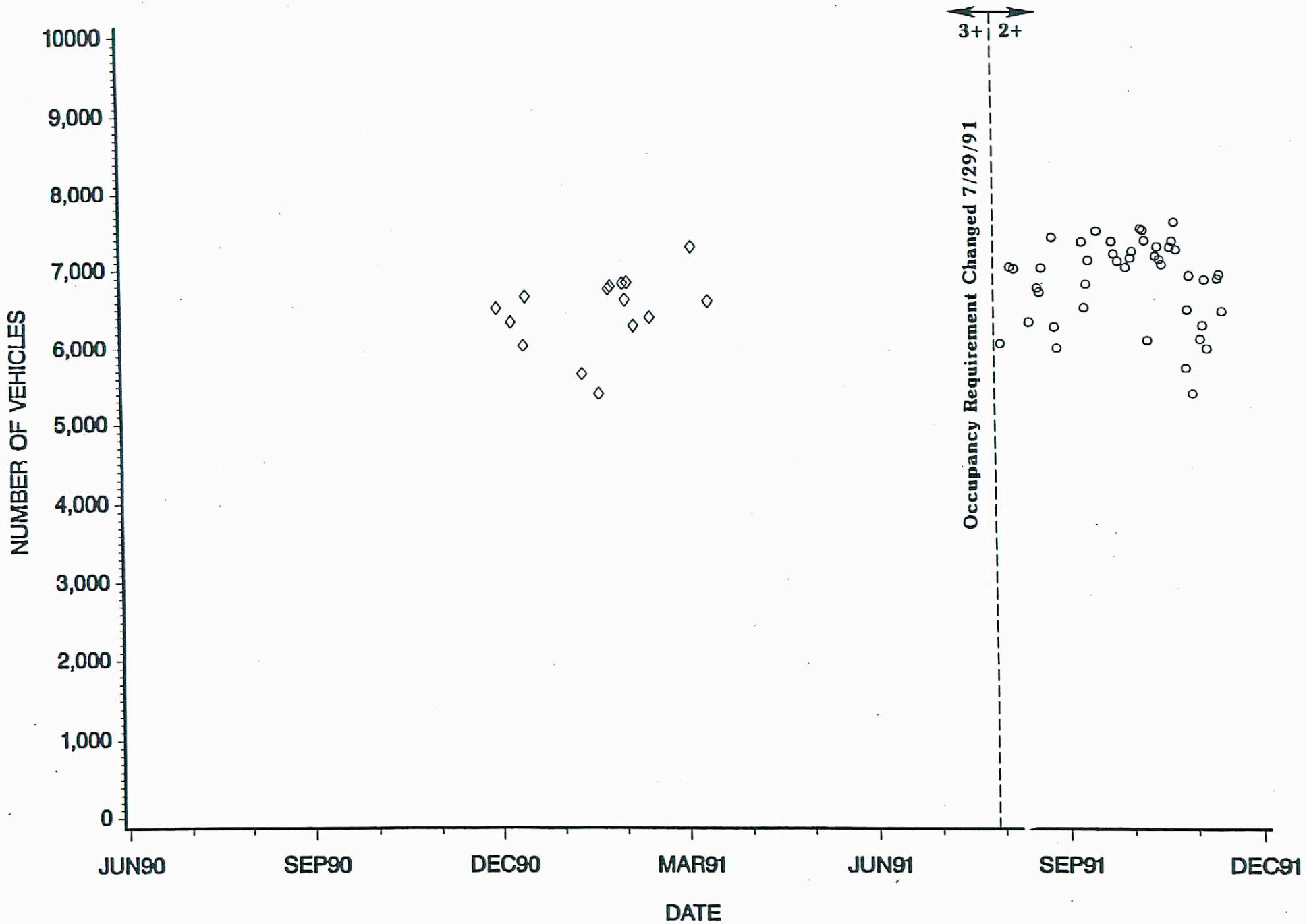


Figure 23. Afternoon Peak Hour General-Purpose Lane Volumes - Data Station 57, 185th Street

Table 8. General-Purpose Traffic Lanes Travel Time Changes[1]

Time Period	Direction	Day of Week	Time Period[2]	Travel time (minutes)	Net Change (minutes)	% Change
A.M. Peak Hour[3] (7:00-8:00 a.m.)	Southbound	M-Th	Pre Post	7.97 6.15	-1.82	-22.84%
		Friday	Pre Post	5.87 5.73	-0.14	- 2.39%
P.M. Peak Hour[4] (5:00-6:00 p.m.)	Northbound	M-Th	Pre Post	9.08 11.42	+2.34	+25.8%
		Friday	Pre Post	15.57 19.43	+3.86	+24.8%
P.M. 4:00 - 5:00 p.m. Hour[3]	Northbound	M-Th	Pre Post	9.75 10.35	+.60	+6.0%
		Friday	Pre Post	15.75 18.94	+3.19	+20.3%

[1]Travel times measured between 236th Street and 117th Street. Due to the location of the survey sites, in the afternoon the travel time figures include a portion of travel in the general-purpose lanes.

[2]The pre-time period data reflect the four survey points in July 1991 and the post data reflect survey points after July 29, 1991.

[3]Travel time data for the 7:00 - 8:00 a.m. and 4:00 - 5:00 p.m. time periods were collected in July, August, September, October, and November.

[4]Travel time data for the 5:00 - 6:00 p.m. time period were collected in July, August, September, and October. Due to darkness during this time period, no data were collected in November.

factor. This analysis was undertaken to examine seasonal variations in travel speeds. However, due to limited data, the results of this analysis prove inclusive. Thus, additional historical data on vehicle lane volumes, which is contained in the WSDOT microfiche files, would need to be examined to provide a full understanding of the seasonal variations and how these may have affected travel speeds and travel times during the demonstration period.

Changes in Vehicle Occupancy Levels

As noted previously, one of the objectives of the freeway HOV system is to improve the capability of congested freeway corridors to move more people by increasing the number of persons per vehicle. This section examines the changes in the personal vehicle occupancy levels on the I-5 facility during the demonstration period. Changes in bus ridership levels were discussed previously. Personal vehicle occupancy levels on the I-5 facility were measured in 1989 and 1990 as part of the WSDOT Vehicle Occupancy Monitoring Project. Vehicle occupancy information was also collected for four days in July, 1991, prior to the start of the demonstration. Similar surveys were also conducted over the first five months of the demonstration. All of the vehicle occupancy data were collected at 145th Street.

For analysis purposes, the data were analyzed for the following four different periods.

- 89-90 - data collected from November, 1989 through September, 1990.
- Before - data collected on four days before the beginning of the demonstration starting on July 23, 1991.
- After - data collected from the beginning of the 2+ demonstration (July 29, 1991) to the opening of the University of Washington (September 30, 1991).
- After UW - data collected from the opening of the University of Washington through the first half of December, 1991.

Figure 24 identifies the changes in two person vehicles during the morning and afternoon peak period over the time period noted above. In general, the percentage of 2 person carpools

is higher in the afternoon peak period, relating to the fact that there are more non-work trips in the afternoon, which tend to have higher occupancy levels. The results indicate that there was an increase in two person vehicles from 1989 to July 1991. After the initiation of the 2+ demonstration, 2 person carpools increased from some 10.5% to 16.5% during the morning peak period. A similar, although smaller, increase also occurred in the afternoon peak period. However, the number of 2 person carpools declined during the October to December time period, returning to approximately the same percentage as the period before the demonstration.

The trend in 3 person carpools is shown in Figure 25. Historically, the percentage of 3 person carpools on the facility has been about 4%. During August and September, the first two months of the demonstration, the percentage of 3 person carpools remained about the same. However, the percentage of 3 person carpools dropped off considerably for the October through December period. Currently, 3 person carpools account for approximately 1% of the morning peak period volumes. It appears that the loss of the advantage of using the HOV lane took away the incentive for forming and maintaining 3 person carpools.

Trends in the percentage of single occupant vehicles (SOVs) on the I-5 North freeway are shown in Figure 26. Single occupant vehicles represent the largest percentage of vehicles using the facility. The percentage of SOVs in the morning peak hour decreased slightly after the start of the demonstration, reflecting the increase in 2 person carpools noted earlier. However, reflecting the mirror image of the trends described earlier, the percentage of SOVs increased again after October to a level slightly below the previous high in 1989 and 1990. Figure 27 illustrates the average personal vehicle occupancy levels for the I-5 North freeway facility. This figure provides a summary of the previous information. As shown, the average vehicle occupancy level in the morning peak period is currently approximately 1.2 persons per vehicle; the same level as in 1989-1990.

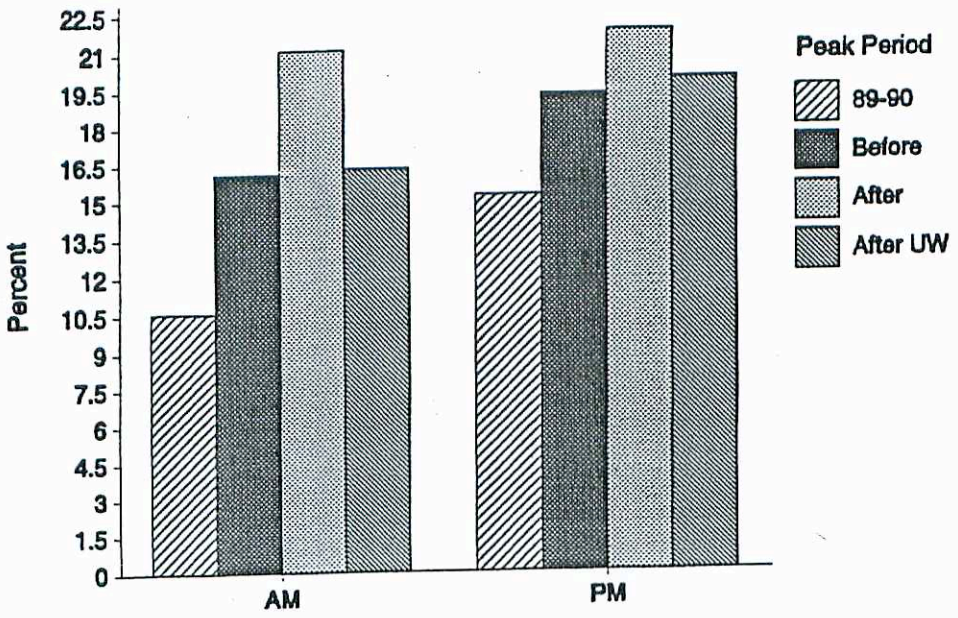


Figure 24. Percentage of 2 Person Carpools for the I-5 North HOV and General Purpose Lanes

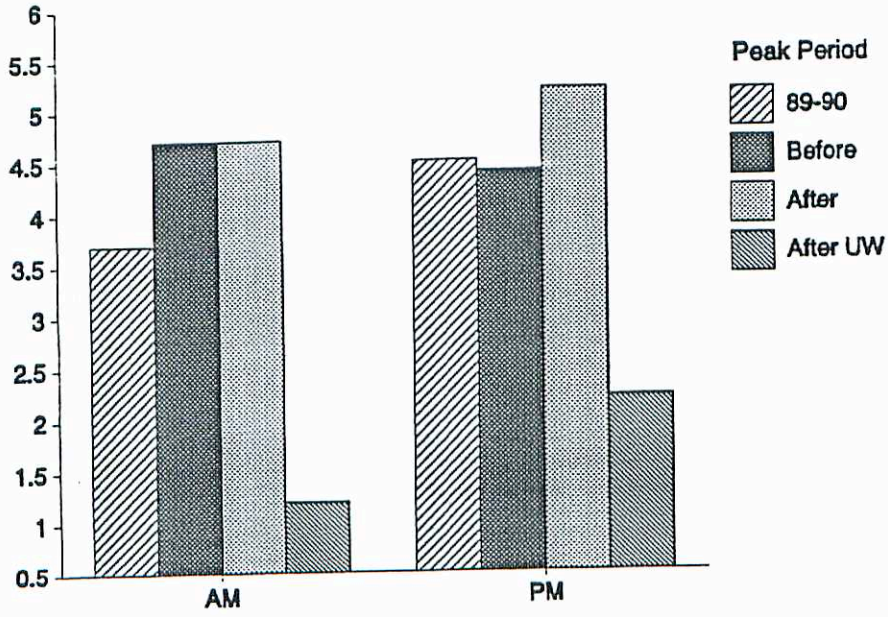


Figure 25. Percentage of 3 Person Carpools for the I-5 North HOV and General-Purpose Lanes

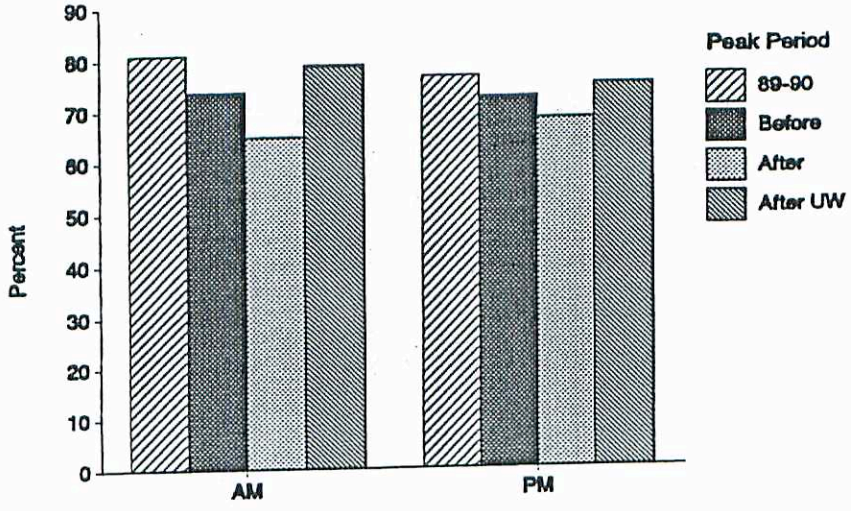


Figure 26. Percentage of Single Occupancy Vehicles on the I-5 North Freeway

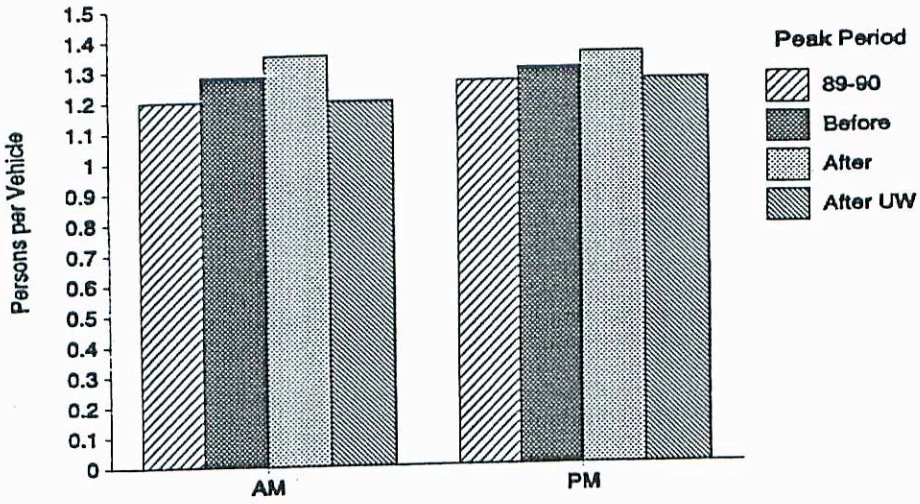


Figure 27. Average Personal Vehicle Occupancy Levels I-5 North Freeway

Person Movement

The change in the vehicle occupancy requirement has influenced not only the number of vehicles using the HOV lane, but also the number of people using the facility. Given the information from Community Transit, it appears that ridership to downtown Seattle has decreased very slightly during the demonstration, while ridership to the University of Washington has increased significantly. In order to determine the impact the change in the occupancy requirement has had on the person-movement levels in the I-5 North HOV lanes and the general-purpose lanes, a number of factors were examined. These included the increase in vehicles using the lane, changes in the observed vehicle occupancy levels, and the results from the surveys of bus riders, carpoolers, and motorists. The general reactions of these user groups to the change in the vehicle occupancy requirements is provided in a later section, but information concerning recent mode changes is presented here.

The Community Transit on board ridership survey was conducted on Thursday, November 21, 1991. Approximately 1,300 surveys were distributed and 925 were returned for a response rate of about 71%. License plates were recorded in November of carpools in the HOV lane and motorists in the general-purpose lanes. Surveys were then mailed to these two groups. A total of 534 surveys were mailed to motorists, with 160 returned, accounting for a response rate of 30%. 600 surveys were mailed to carpoolers, with 57 completed forms returned for a response rate of 10%. The low response rate to the carpool and motorist surveys may be due to the holidays. As a result of the low response rate it is not possible to draw statistically significant conclusions from the carpool and motorist surveys. However, the results can be used to identify what appear to be general trends.

Individual's travel habits change over time and, as a result, in any given corridor one could expect to see changes between modes, changes in travel times, and changes in routes. One of the purposes of the surveys of bus riders, carpoolers, and motorists was to attempt to determine if the reduction in the carpool occupancy requirement had any change on mode choice. More specifically, the carpool survey was designed to obtain a better insight into how 2+ carpools

were formed. The survey results indicate that 15 of the respondents formed a carpool within the last six months, which equates to the approximate start of the demonstration. All of these were 2+ carpools. Of these, 12 individuals previously drove alone, while 2 were former bus riders. It is not known how these figures relate to the rate of normal carpool formations and turnover of carpools in the corridor. Further, 57% of the respondents were in 2+ carpools, 20% were in 3+ carpools, and the remainder were in 4+ carpools or vanpools. Thus, from the survey results it appears that the 2+ carpools using the HOV lane represent new 2+ carpool formations and shifts of existing 2+ carpools from the general-purpose lanes. The information from the vehicle occupancy surveys further indicate that there are fewer 3+ carpools in the traffic stream, which seems to indicate a breakdown of some previous 3+ carpools. The survey results also indicate that a few bus riders have left Community Transit service to form carpools, with 2 of the 14 new carpools formed by former bus riders. However, it is important to note that due to the low response rate, these do not provide statistically valid results.

Figure 28 shows the change in person movement or person throughput for the HOV and general-purpose lanes in the a.m. and p.m. peak hours. The four time periods reflect information from 1989-1990, the few data points collected immediately prior to the start of the demonstration, the demonstration period in August and September prior to the start of classes at the University of Washington, and after the start of the University in late September. As shown in Figure 28, the person throughput increased initially after the start of the demonstration, but has since come down a little. However, overall, the throughput levels are still higher than before the demonstration, indicating that more people are being moved on the facility with the 2+ occupancy requirement.

Accident and Safety Impacts

One of the objectives of the WSDOT freeway HOV system policy states that the HOV lanes should provide safe travel options for HOVs without unduly affecting the safety of the freeway general-purpose lanes. The intent of the safety analysis was to determine whether the reduction in the vehicle occupancy requirements altered the levels of safety on the segment of I-5 North

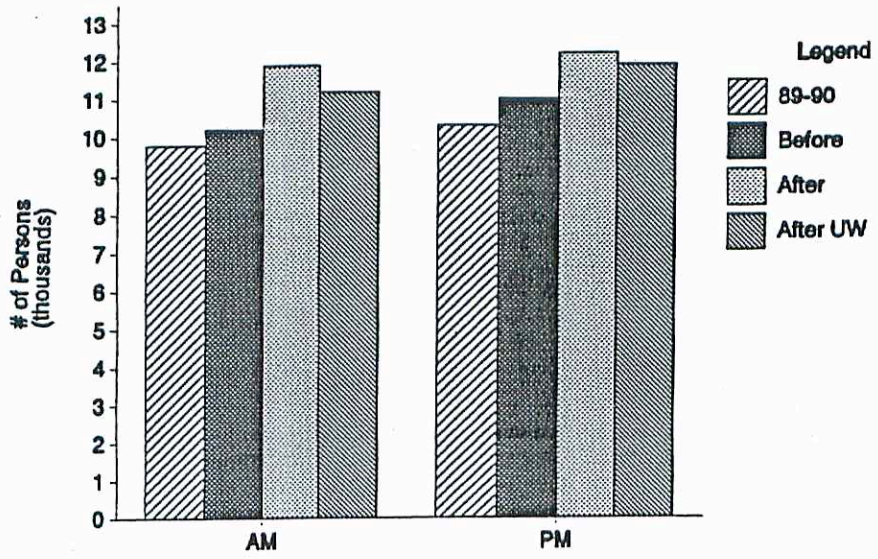


Figure 28. Total Person Throughput for the I-5 North HOV and General-Purpose Lanes

under study. The analysis focused on identifying any changes in safety conditions in both the HOV and general-purpose lanes in the study area and examining possible causes if any changes were found.

In addition to examining the HOV and general-purpose lanes, the area under study was extended two and one-half miles at both ends. This was done to determine if the change in the HOV lane vehicle occupancy requirements caused any geographical shifts in the location of accidents. The period included in this analysis was from January 1, 1987, to November 30, 1991.

Two principal data sources were used in the analysis. First, for the period of January 1, 1987 to September 30, 1991, the accidents database maintained by the WSDOT Transportation Data Office was examined. Second, for the period October 1 to November 30, 1991, the accident reports issued by officers of the Washington State Patrol were reviewed. All accident data included in the WSDOT database were provided by the Washington State Patrol. Thus,

essentially every accident on the highway reported by an officer was included. In addition, data on roadway characteristics, such as the number of lanes by milepost range, were obtained from the State Highway Log issued by the WSDOT.

The accident data were examined for all lanes together, both northbound and southbound. Each lane was divided into three segments: the section between the mileposts relating to the area including the HOV lane, and the immediate pre- and post-HOV lane sections. For the northbound area, the three segments were from MP 170.40 to MP 172.80, from MP 172.81 to MP 178.10 and MP 178.11 to MP 180.70. For the southbound area, the sections were from MP 181.00 to MP 176.60, from MP 176.59 to MP 170.85, and from MP 170.84 to MP 168.35.

The accident occurrence rate was calculated using the running average method on the basis of the annual period preceding the month. As shown in Figures 29 and 30, the accident occurrence rates in both the southbound and northbound directions of the study area segment of I-5 reflect a highly variable pattern over the 5-year time period. In the southbound direction the highest rates were recorded in early 1988. Since that time, the accident rates have been on a general, although uneven, downward trend. There was a slight increase in the months preceding the demonstration, but since the introduction of the lower occupancy requirement in the HOV lane, the rate has again been on a downward trend. In the northbound direction, the recorded rates were highest in 1989 through early 1990. Since July 1991, the rates have shown a downward trend.

Figures 31 and 32 illustrate the accident occurrence rates on the I-5 segments to the north and south of the study area. In the northbound direction, the segment to the south of the HOV shows a downward trend starting in early 1991 and continuing through the demonstration period. To the north of the HOV lane, the trend, both immediately before and during the demonstration reflects a slight increase in the accident rate. In the southbound direction, the segment before the start of the HOV lane has reflected a relatively similar accident rate over the five year period. However, in the section after the end of the HOV lane, the rate began to increase at the beginning of 1991 and this trend has continued through the demonstration period. The analysis

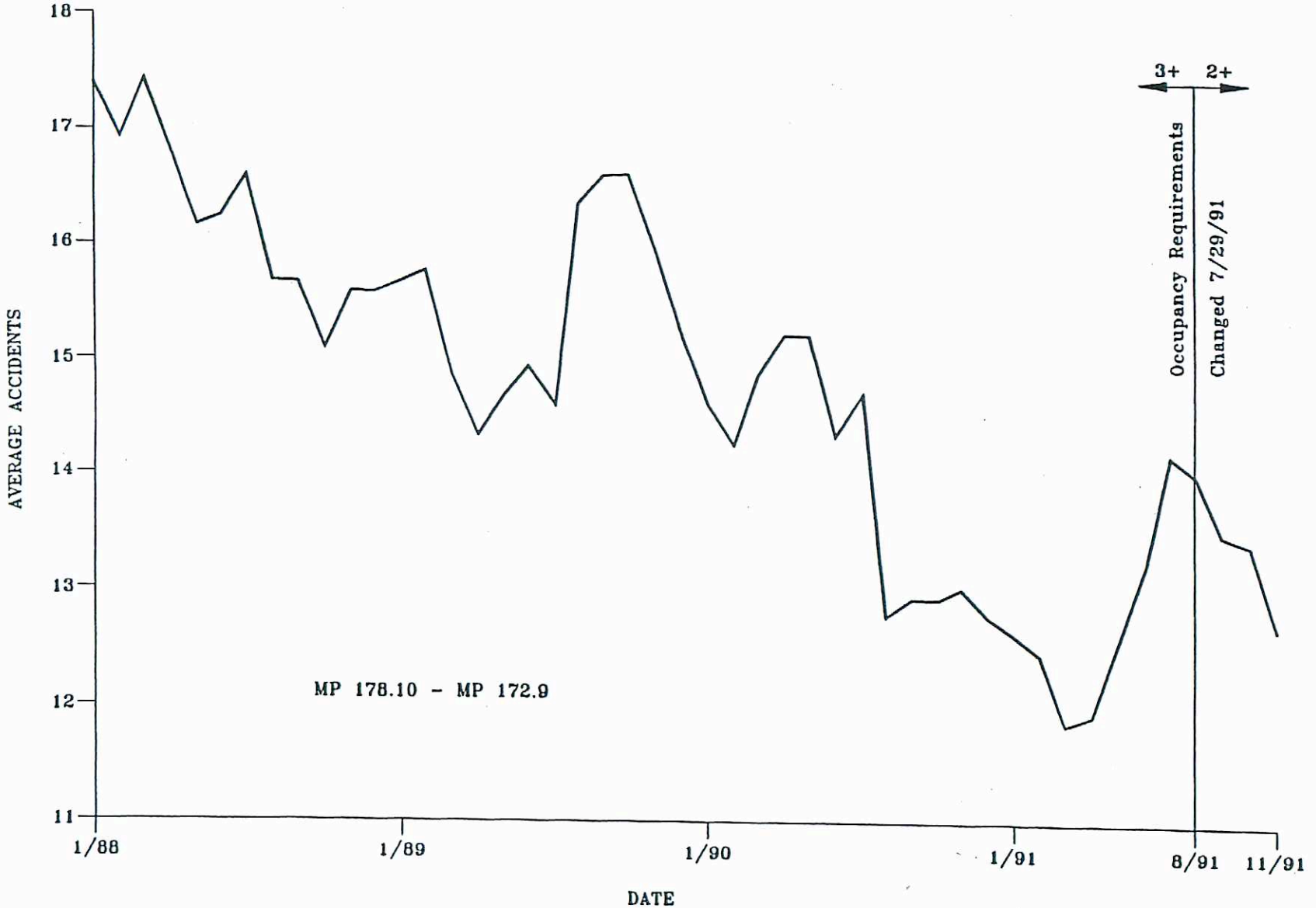


Figure 29 - I-5 North Average Accidents in Southbound Direction

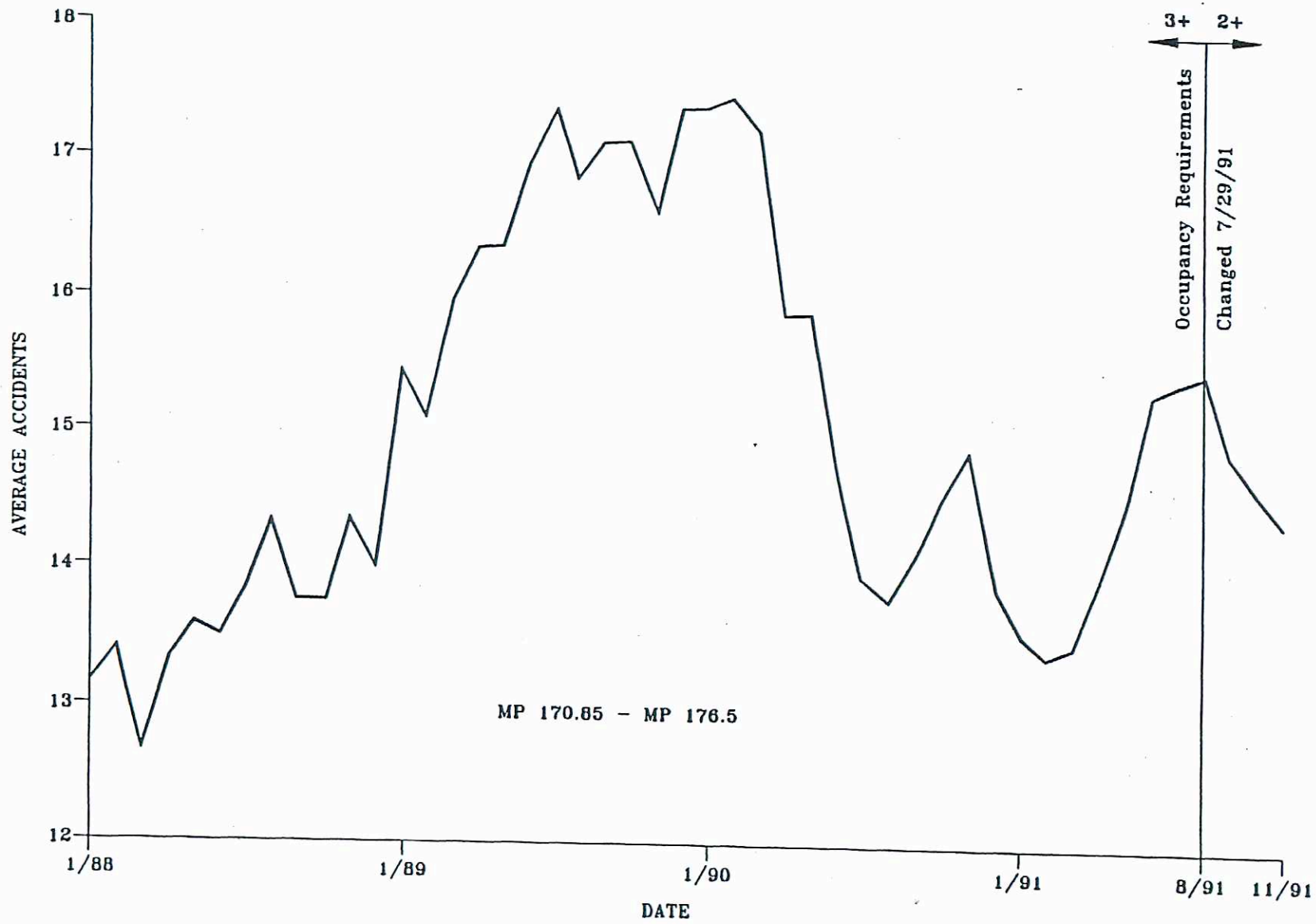


Figure 30 - I-5 North Average Accidents in Northbound Direction

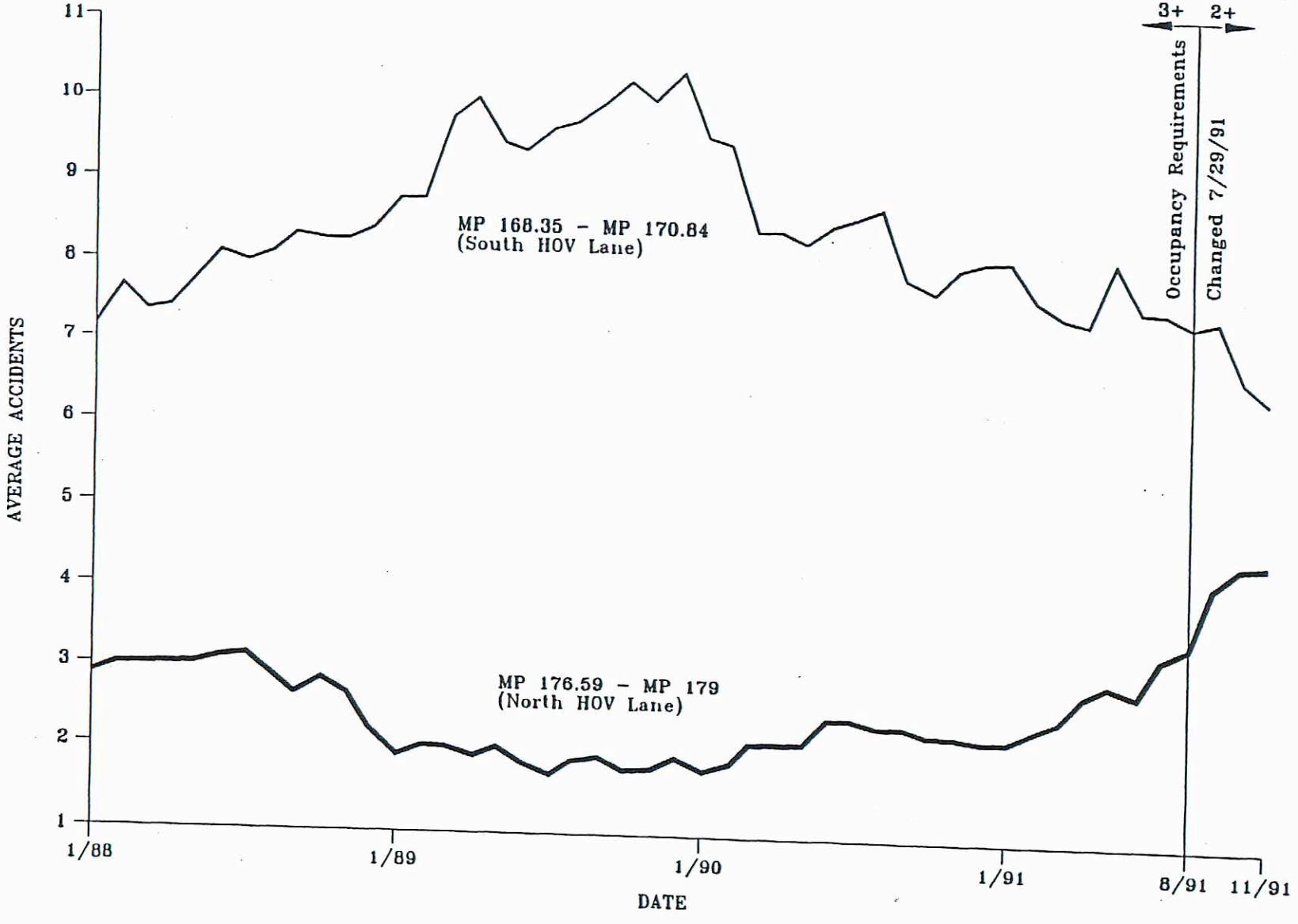


Figure 31. I-5 North Average Accidents South and North of HOV Lane - Northbound Direction

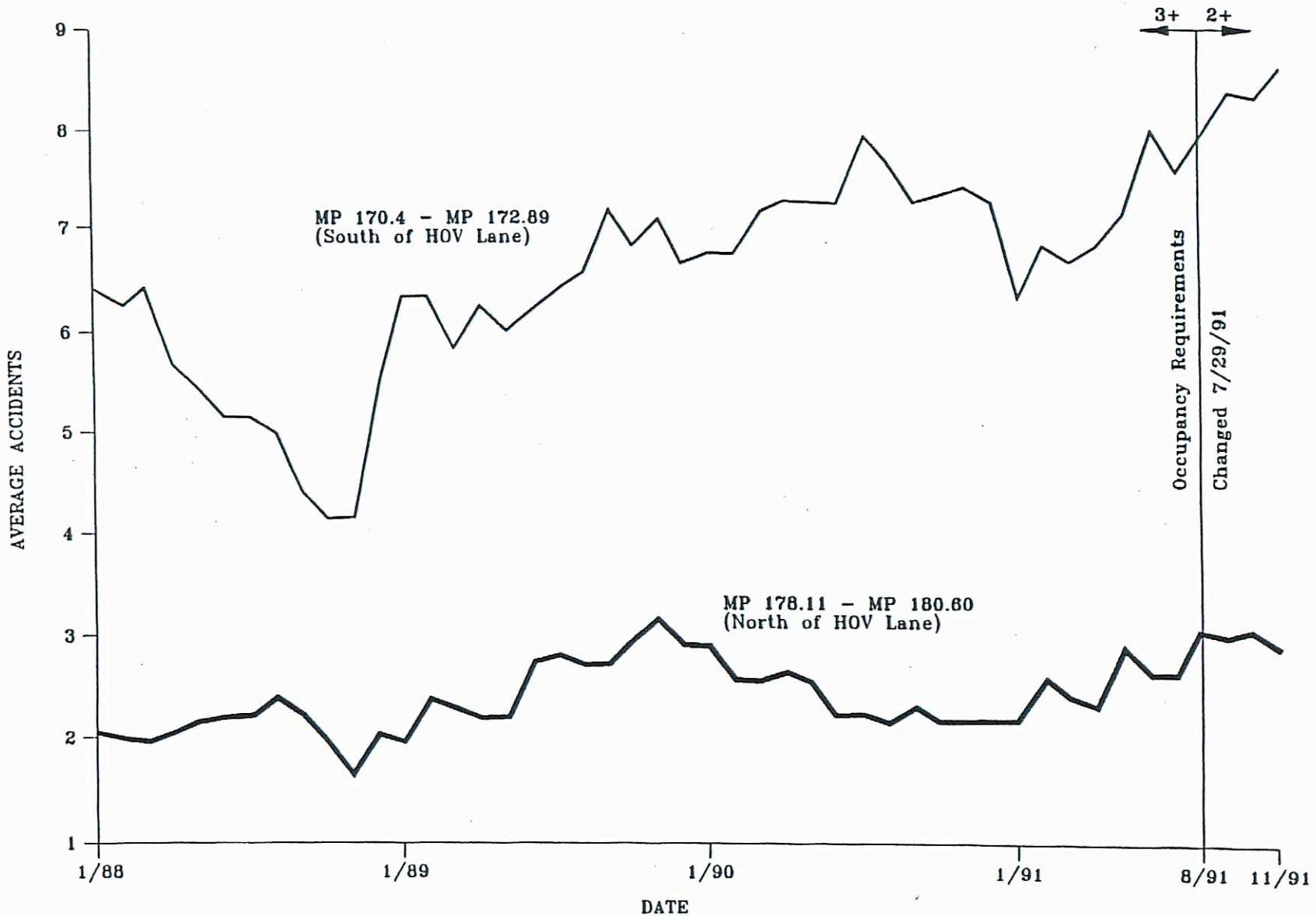


Figure 32. I-5 North Average Accidents North and South HOV Lane - Southbound Direction

of the accident occurrence rates did not identify any specific trends or variations in the existing patterns that could be associated directly with the reduction in the vehicle occupancy requirements on the I-5 North HOV lanes. However, the accident rates for the location downstream of both the northbound and southbound HOV lanes show an increase for the period immediately before and during the demonstration. Continued monitoring of the accident rates in these areas would be appropriate.

Changes in the Number of HERO Calls

In order to identify any changes in the violation rates occurring on the I-5 North HOV lanes since the start of the 2+ demonstration, information on the number of calls to the HERO hot line was examined. Figure 33 shows the rolling average in the percentage of the calls received by the HERO hot line relating to complaints of HOV lane violators in the I-5 North corridor. The information indicates that there has been a long-term tendency toward fewer calls in the corridor. However, since the beginning of the demonstration, the percentage of calls has increased. This increase could be due to a number of factors. Some people may not be aware of the 2+ requirements, and, thus, may still be calling in 2+ carpools as violators. With the increased awareness in the corridor due to the demonstration, it may also be that more people are calling in single occupant vehicles violating the 2+ requirement.

Public Perception

The preamble to the freeway HOV system objectives outlined by WSDOT notes that public support is critical to the success of the HOV system. Previous surveys conducted by WSDOT and Seattle Metro have indicated that the HOV lanes have been received positively by users, non-users, and the general public in the Seattle area. The results of the surveys of Community Transit bus riders, carpoolers, and motorists indicates a general support for the HOV lanes, but provides a mixed response to the reduction in the occupancy requirement on the I-5 North HOV lanes.

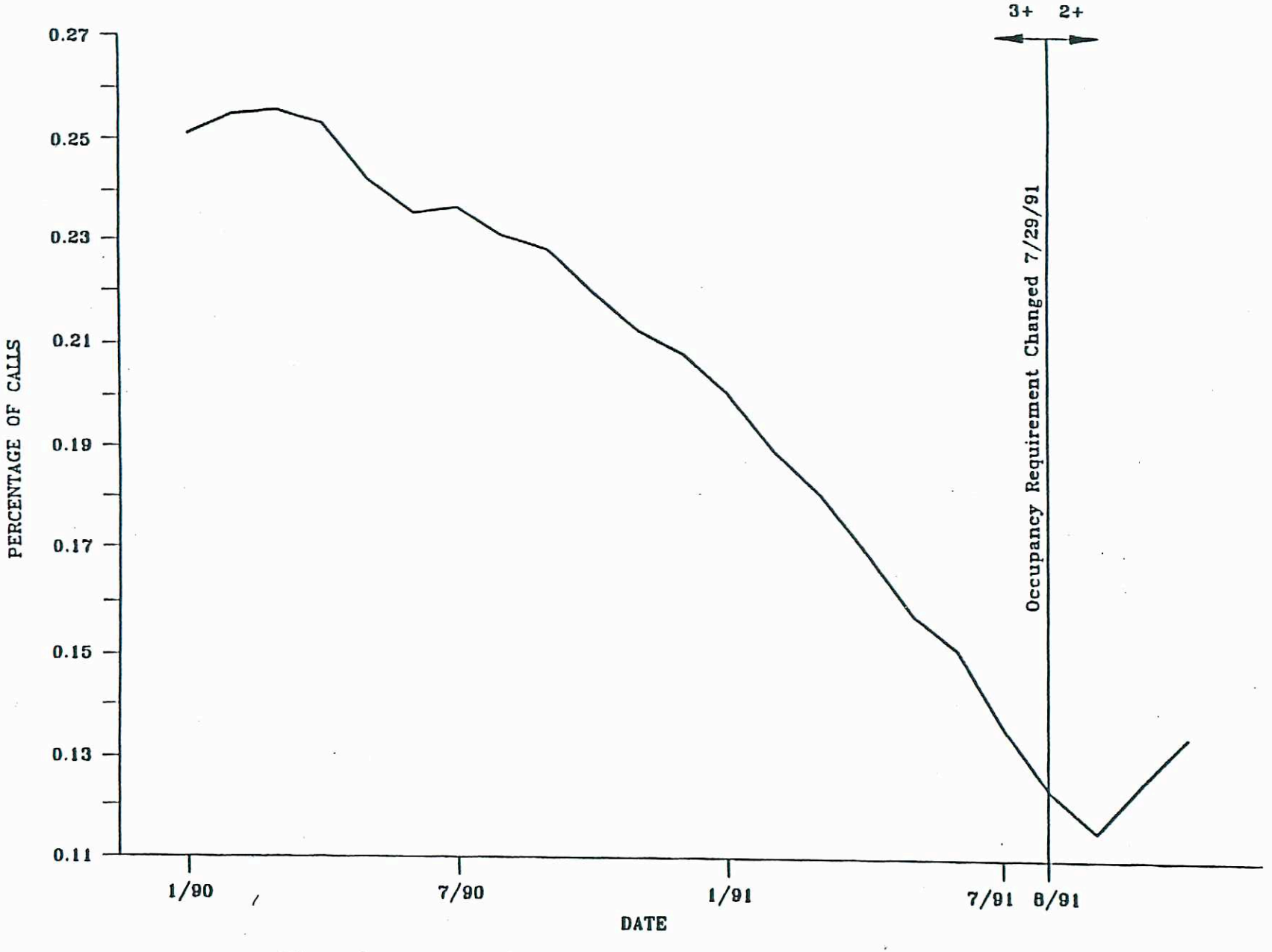


Figure 33 - 12 Month Rolling Average of HERO Calls - I-5 North Corridor

As shown in Table 9, over 90% of the bus riders and carpoolers and 82% of the motorists surveyed feel the I-5 HOV lane is a good transportation improvement. A lower percentage, ranging from 42% to 74%, indicated that they feel the lane is currently being sufficiently utilized. Slightly over half of the motorists surveyed felt traffic conditions in the general-purpose lanes had improved since the change in the occupancy requirement was made and only 15% reported encountering problems in the general traffic lanes that may have resulted from the lower occupancy requirement. Almost half of the carpool respondents indicated they have not encountered any difficulties with the HOV lanes since the change. However, 23% of those responding to the questions indicated that travel times seem longer and 21% reported problems entering or exiting the lane. An even larger number of bus riders reported problems since the occupancy change was made. Some 47% indicated that travel times seem longer, 23% reported buses were not always on schedule, and 5% noted they had missed connections. More problems were noted by bus riders with the afternoon trip than in the morning. Finally, the response to the question on whether permitting 2+ carpools was a good move varied by user groups. Motorists and carpoolers indicated strong support for the change, while only 39% of the bus respondents favored the change.

Many of the respondents to all three surveys provided additional comments. A number of bus riders indicated problems with slower travel times and many strongly supported a return to the 3+ occupancy requirement. These concerns were also reflected in a petition received by Community Transit in September and telephone calls from bus riders complaining about the negative impacts on bus service since the change. A number of comments on all three surveys strongly supported extending the HOV lane further in the northbound direction.

Table 9. Survey Responses on General Perception of HOV Lanes and Changes in the I-5 Occupancy Requirement

Question	Survey Responses								
	Bus Riders			Carpoolers			Motorists		
	Yes	No	Not Sure	Yes	No	Not Sure	Yes	No	Not Sure
Do you feel the I-5 HOV lane is a good transportation improvement?	95%	1%	4%	91%	7%	2%	82%	5%	13%
Do you feel the I-5 North HOV lane is, at present, being sufficiently utilized?	67%	15%	18%	74%	21%	5%	42%	42%	16%
In your opinion, have traffic conditions on the I-5 North Freeway regular traffic lanes improved since 2+ carpools began using the lane?							52%	20%	28%
Have you encountered any difficulties on the I-5 North freeway regular traffic lanes recently that you feel is a result of permitting 2+ carpools?							15%	85%	
Have you experienced any difficulties in carpooling on the I-5 North HOV lanes since 2+ carpools began using the lanes?				23% travel times seem longer 3% travel times not consistent 21% problems entering or exiting	48%				
Have you encountered any difficulties in riding the bus on the I-5 North HOV lanes since 2+ carpools began using the lanes?	47% travel times longer 23% not always on schedule 5% missed connections	22%							
All things considered, do you feel permitting 2+ carpools to use the I-5 North HOV lane was a good move?	39%	42%	19%	83%	12%	5%	92%	3%	5%

IV. ALTERNATIVES FOR MANAGING VEHICULAR DEMAND ON HOV LANES

As noted previously, HOV facilities are intended to provide travel time savings and travel time reliability to HOVs. These two benefits serve as incentives for individuals to choose a higher occupancy mode, which, in turn, can increase the person-movement capacity of the roadway by moving more people in fewer vehicles. In establishing the vehicle occupancy requirement for use of an HOV lane, the intent is to maintain a smooth flow of traffic on the facility, thus ensuring travel time savings and travel time reliability to users, while at the same time ensuring that the lane is well utilized. Thus, the occupancy level for an individual HOV lane should be established based on local traffic conditions and local policies and objectives.

The carpool vehicle occupancy requirements for existing HOV facilities in North America vary between 2+ and 3+ persons per vehicle. Sixteen HOV lanes currently utilize a 3+ occupancy requirement, while sixteen also use a 2+ requirement. Some areas with multiple HOV facilities, such as San Jose and Washington, D.C., utilize the same occupancy requirement on all HOV lanes. Other areas such as Seattle, Los Angeles/Orange County, and Houston, have different requirements on different HOV facilities.

The Katy Transitway in Houston is the only HOV facility that changes occupancy requirements over the course of the day. A 2+ occupancy requirement is utilized during all operating periods except between 7:00 a.m. and 8:00 a.m. and 5:00 p.m. to 6:00 p.m., when a 3+ requirement is in effect. The change in the a.m. requirement was implemented in October 1988 in response to declining travel speeds on the transitway resulting from increased use of the facility. At the time, vehicle volumes on the transitway were exceeding 1,500 vehicles per hour (vph) during the a.m. peak hour. This caused considerable delay, diminishing the travel time savings to which users of the facility were accustomed. The change represented the first time vehicle occupancy requirements had been increased on an HOV facility and the first use of variable occupancy requirements. In the fall of 1991, the p.m. peak hour occupancy requirement was also raised to 3+ in response to increasing vehicular volumes.

A number of alternatives may be considered for managing vehicular demand on HOV facilities. These include maintaining a consistent vehicle occupancy requirement, varying the occupancy requirement by time of day, and varying the requirement by direction of travel. Figure 34 outlines some of these alternatives. The approach most appropriate in any given area and for a specific facility will depend on local traffic conditions, the goals and objectives the HOV lanes are intended to meet, and local public and political acceptance. The requirements should be kept simple enough so as to be easily understood by the public and so that they are enforceable by the state patrol or other enforcement officials.

Figure 34. Alternative Approaches to Managing Demand on HOV Lanes

- Maintain constant HOV requirement (2+, 3+, or higher) 24 hours a day
- Utilize 3+ occupancy requirement during the a.m. and p.m. peak hours and a 2+ requirement at other times
- Utilize 3+ occupancy requirement in the peak travel direction and 2+ in off-peak travel direction
- Utilize HOV lane only in peak direction of travel

As summarized in Figure 35, each of these alternatives has advantages and disadvantages. Maintaining a constant vehicle occupancy requirement is the easiest for the public to understand. This should reduce any confusion about use of the lane and simplify enforcement of the facility. Identifying the appropriate vehicle occupancy level should be accomplished based on technical and policy guidelines. The other alternatives, which include the use of variable hour or variable occupancy requirements over the course of the day, could be designed to protect the peak period person-movement capability of the facility. However, these alternatives may be more confusing to the public and harder to enforce. These advantages and disadvantages will need to be considered in establishing the vehicle occupancy requirement and operating policy for an HOV facility.

Figure 35. Advantages and Disadvantages of Alternative Approaches to Managing Demand on the I-5 North HOV Lanes

Alternative	Advantages	Disadvantages
2+ Occupancy Requirement 24 Hours a Day	• Public support among 2+ carpoolers and motorists. • More vehicles in HOV lane and higher person volumes. • Travel times improved for general-purpose traffic in the morning.	• Lowers vehicle occupancy level for I-5 facility and number of 3+ carpools dropped. • Close to reaching capacity in the HOV lane in the p.m. peak hour. • In the afternoon, the travel-time reliability for HOV lane users is down and travel times for both HOV and general-purpose lane users are slightly longer.
3+ Occupancy Requirement 24 Hours a Day	• Higher vehicle occupancy level, providing more efficient use of facility by moving more people in fewer vehicles. • Improved travel time reliability for HOV users providing greater incentives to carpool, vanpool or use the bus.	• Fewer vehicles in HOV lane, may be perception that lane not used. • Less support among 2+ carpoolers. • May take time to reestablish 3+ carpools.
Variable Hour Occupancy Requirement	• Higher vehicle occupancy level in peak period, providing more efficient use of facility by moving more people in fewer vehicles. • Maintains travel time reliability and travel time advantages for HOV lane users in peak period, providing greater incentives to carpool, vanpool or use the bus.	• May be harder for public to understand. • Enforcement more difficult. • Fewer vehicles in HOV lane in peak period, may be perception that lane is not used.

The results of the surveys of carpoolers and motorists in the general-purpose lanes indicated support among these two groups for the 2+ vehicle occupancy requirement initiated during the demonstration. The 2+ occupancy requirement resulted in more vehicles and a higher person volume for the HOV lane. In addition, travel times for motorists in the general-purpose lanes increased in the morning peak hour. However, the 2+ occupancy requirement has resulted in a decline in the vehicle occupancy level on the I-5 facility, with the number of 3+ carpools declining significantly. In the afternoon peak hour, volumes in the HOV lane have averaged

between 1,200 and 1,400 vehicles, which is close to the 1,500 vehicles an hour often used as the capacity of an HOV lane. This leaves little room for growth in HOV use at the 2+ occupancy level. In addition, travel-time reliability for HOV users was less dependable during the demonstration in the afternoon peak hour, providing less of an incentive for individuals to carpool or use the bus. Further, travel times for vehicles in both the HOV and general-purpose lanes were slower in the afternoon during the demonstration.

Returning to a 3+ vehicle occupancy requirement would increase the vehicle occupancy level, resulting in the more efficient use of the facility by moving more people in fewer vehicles. By maintaining the travel time reliability and travel time advantages for HOV lane users, it also provides greater incentives for individuals to carpool or use the bus. It also allows for growth in HOV use. However, the lower vehicle volumes in the HOV lane may result in the perception that the lane is not being used. A change back to a 3+ occupancy requirement would probably not have much support among 2+ carpoolers. In addition, it may take time to reestablish 3+ carpools.

The different alternatives that utilize variable hour occupancy requirements would result in higher vehicle occupancy levels during the peak period, providing for the efficient use of the facility by moving more people in fewer vehicles. It would also provide greater incentives for individuals to carpool, vanpool, and use the bus by maintaining travel time reliability and travel time advantages to HOV users. However, variable hour requirements are more difficult for the public to understand and make enforcement of the occupancy requirement harder. Further, the perception that the lane is not being used could be an issue with the variable hour alternatives.

V. CONCLUSIONS

The measures of effectiveness used in this evaluation were primarily based on the *Washington State Freeway HOV System Policy*, recently established by the Washington State Department of Transportation. This report describes available data related to these measures of effectiveness. However, as noted in the introduction, other state and regional policies must also be considered in the evaluation of the demonstration project. The *Washington State Freeway HOV System Policy* specifically requires consideration of environmental and land use issues. The General HOV Policy Statement in this document contains the following two passages:

- WSDOT regards the HOV system as a high capacity transportation system whose goal is to maximize the people moving capability of the state highway system, mitigate transportation-related pollution, and reduce dependency on fossil fuels.

- Through the state transportation planning process and regional transportation planning organizations, WSDOT shall take a pro-active role in promoting and coordinating the development of HOV systems, transportation demand management activities, and related transportation system management activities. This will be accomplished through support of local jurisdictions and participation in their transportation and land-use planning efforts statewide.

Because reference to other policies is embedded in the *Washington State Freeway HOV System Policy*, the conclusions include consideration of the following relevant policies:

- **Freeway operations** - policies directly related to the efficiency and operating characteristics of the freeway system, including the *Washington State Freeway HOV System Policy* and the *Transportation Policy Plan for Washington State*;

- **Environmental protection** - policies meant to benefit or reduce harm to the environment, such as the state's *Clean Air Act* or the related *Commute Trip Reduction Act*; and

- **Land Use** - policies that promulgate specific objectives concerning the rate and location of residential and commercial development, such as the state's *Growth Management Act* or the former Puget Sound Council of Government's *Vision 2020.*

The conclusions presented here are organized according to the three main objectives outlined in the *HOV System Policy* statement: 1) movement of people in high occupancy vehicles, 2) travel time saving and travel time reliability for HOVs, and 3) safety considerations.

People Movement/Vehicle Occupancy

The first objective of the *HOV System Policy* is to "improve the capability of congested freeway corridors to move more people by increasing the number of persons per vehicle." The demonstration results indicate that more people are traveling on the I-5 facility during the peak period. However, the number of persons per vehicle was lower during the October to December period than it was in the week before the demonstration started. The percentage of SOVs has increased, and the percentage of 3+ carpools has decreased significantly. The percentage of 2 person carpools increased initially, but went back down to pre-demonstration levels. Data also indicate that on a monthly basis Community Transit ridership levels to the downtown during the demonstration were approximately the same or slightly lower than those of the previous year.

Some questions remain concerning these data. The decrease in 3+ person carpools appears to be attributable to the change in the occupancy requirement. However, the increase in SOVs probably comes from several sources, including shifts from parallel arterials, shifts from earlier and later time periods, and latent demand filling the additional capacity, as well as the break up of carpools and people shifting from transit. Ridership on Community Transit increased to the University, at a level comparable to the increase experienced by Metro Transit attributable to the U-Pass. The lower ridership levels from the previous year to downtown Seattle may be partially attributable to the lack of increase in service, the general downturn in the economy, and poor weather conditions in the previous year which resulted in some of the highest ridership levels recorded by Community Transit. However, survey data and other responses from bus riders show that they have noticed a decline in the service reliability for buses using the I-5 HOV lanes.

The reasons for the decrease in vehicle occupancy levels are numerous. However, it appears that at least some of the decrease is due to the change in the vehicle occupancy requirement.

To the extent that it is a result of the change, the 2+ definition for carpools is less supportive of the first objective of the *HOV System Policy* than a 3+ definition is.

While an increase in the number of people moved on the freeway is consistent with the personal mobility goal stated in the *Transportation Policy Plan for Washington State*, the plan also clearly emphasizes the movement of people rather than vehicles in the provision of urban mobility. Specifically, it advocates provision of "cost-effective alternatives to one-person vehicles, including transit and ridesharing, to ensure a high level of mobility." Further, *Vision 2020* contains the policy to "promote programs encouraging use of transit and ridesharing options, modifying mode choice behavior." The decline in 3+ person carpools, the slight decrease or slow growth in transit ridership, and the increase in SOVs raise questions about the consistency of the 2+ carpool definition and the objectives stated in these two policies.

The Washington State *Clean Air Act* emphasizes a reduction in vehicle miles traveled (VMT) as the major transportation remedy for air pollution. Because the number of vehicles on the I-5 facility increased during the demonstration, the potential negative impact of the change in carpool definition should be considered. If most of the additional vehicles came from other routes or other time periods, the impact on VMT is small. The proportion of the change in VMT attributable to the shift in carpool definition is unknown. To the extent that the extra trips have been generated from shifts from ridesharing or transit or as a result of latent demand filling the additional capacity, the 2+ carpool definition is inconsistent with the objectives of the *Clean Air Act*.

Travel Time Savings and Travel Time Reliability for HOVs

The second objective in the *HOV System Policy* is to "provide travel time savings and a more reliable trip time to high-occupancy vehicles utilizing the facilities." During the demonstration, high-occupancy vehicles still saved time, on the average, by using the HOV lanes. However, the travel time savings in the morning decreased, and the increase in travel time savings in the

afternoon resulted from a decrease in speed in the general purpose lanes. Furthermore, reliability of travel time was degraded. Therefore, the consistency of the 2+ definition with the second objective should be questioned.

During the demonstration, conditions in the morning and afternoon peak periods were quite different. In the morning peak hour, the travel time for HOVs did not changed significantly. Travel times in the general purpose lanes actually decreased during a season when increased congestion is normal. This improvement in general purpose travel times may be due to a combination of an increase in transit usage to the University, resulting from the U-Pass, and the ability of 2 person carpools to use the HOV lanes.

In the afternoon, the results were different, with travel times in both the HOV lanes and the general purpose lanes increasing. The major difference in the two time periods is partially a result of an existing bottleneck at the north end of the corridor, in the northbound direction, where the HOV lane ends, a general purpose lane drops, and merging results. The impact of this bottleneck was exacerbated during the demonstration by the large volumes of vehicles in the HOV lane. The increase in volume is due partially to increased demand historically experienced in the fall. Unfortunately, comparable travel time information is not available from previous years to compare this year's change to the normal seasonal change in congestion.

The travel time savings for HOVs is different in the morning and afternoon primarily because of differences in travel times for traffic in the general purpose lanes. HOV travel time in the morning was not significantly different and the increase in average travel time in the afternoon for HOVs was relatively small. Thus, the impact on travel time savings were mixed. Therefore, the consistency of the 2+ definition with this aspect of the second *HOV System Policy* objective is ambiguous. However, with peak hour volumes in the HOV lanes approaching 1,500 vehicles, it is important to follow the impact on travel times for HOV lane vehicles closely.

Travel time reliability for HOVs declined during the demonstration. The standard deviation for travel speed doubled in the morning and increased by approximately 50 percent in the afternoon. On-time performance for Community Transit buses declined compared with the first part of the year. Bus riders reponding to the surveys noted that travel time reliability, especially in the afternoon was worse during the demonstration and additional complaints have been received by Community Transit.

It appears that travel time reliability declined even when the average travel time did not change significantly. The reason for this is that with a 3+ carpool definition and vehicle volumes no higher than 500-600 in the peak hour, vehicles in the HOV lane have virtually always enjoyed free flow conditions. With the additional vehicles in the HOV lane resulting from the change to the 2+ definition, traffic volumes are reaching a level where the flow occasionally breaks down. Although average travel speeds don't change much with occasional breakdowns, variability increases significantly. How much of this breakdown should be tolerated is a policy decision, which cannot be answered on purely technical grounds.

The reduction in travel time reliability appears to be attributable to the increased volumes of traffic in the HOV lanes resulting from the change to the 2+ person carpool definition. As traffic demand increases over time, the reduction in travel time reliability can also be expected to continue.

With the mixed results in travel time savings and a degradation in travel time reliability for HOVs, the incentive to rideshare or use transit has been reduced during the demonstration. This is contrary to the *Transportation Policy Plan* and *Vision 2020*, which both call for policies and programs that increase incentives to rideshare and use transit.

Traffic in the morning moved better in both the HOV lane and the general purpose lanes. This should result in better vehicle operating efficiency, which in turn should decrease air pollution and energy use. However, in the afternoon, vehicles in both the HOV lanes and the general purpose lanes experienced congested conditions more often. The resultant stop and go

traffic means vehicles operate less efficiently and produce more pollution, contrary to environmental protection policies. Disregarding the impact on VMT, the demonstration appears to have had an ambiguous relationship with state environmental policy.

Safety Considerations

The last HOV system objective is to "provide safe travel options for high-occupancy vehicles which does not unduly impact the safety of the freeway general-purpose mainlanes." Data show that accident rates in the demonstration corridor and the sections upstream and downstream were highly variable. The results show no significant change in safety resulting from the demonstration. Thus, the impact of the change in the vehicle occupancy requirement on this objective is unknown. However, since accidents generally increase with increasing traffic volumes, this result should be continuously monitored.

Overall Conclusions

The results of the 2+ demonstration to this point show some mixed and some ambiguous evidence concerning the relationship between the 2+ carpool definition and objectives contained in the *HOV System Policy* and other related policies. However, the evidence is primarily in a direction suggesting that the achievement of many policy objectives has been compromised. On the other hand, according to the survey results, there is fairly strong public support for the 2+ carpool definition. Thus, given the mixed results of the demonstration and the lack of specific performance standards to compare the results with, a return to the 3+ vehicle occupancy requirement may generate public opposition.

The development and use of a specific performance standard, that is understandable to the public, may assist in the evaluation of the I-5 North demonstration and communicating the results to the public. Further, it may also be of benefit in examining other HOV lanes in the area. Reliability of travel time in the HOV lane appears to be a good candidate for such a performance standard. Since the public supports HOV lanes in general, if travel time advantages

in the HOV lane were compromised seriously, the public would probably understand the need to change to a higher carpool definition. On the other hand, if the travel time advantage and travel time reliability is not seriously compromised, most of the policy objectives discussed previously should be achieved.