HOV IMPROVEMENTS ON SIGNALIZED ARTERIALS IN THE SEATTLE AREA

VOLUME I:
2 CASE STUDIES

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Final Report
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16. ABSTRACT

This report presents an analysis of HOV improvements for two signalized arterials in the Seattle metropolitan area. The first involves a planned 1,000 foot (300 meter) queue jumper lane on NE Pacific Street in the University Disrict of Seattle. This planned improvement was studied prior to its implementation in Spring of 1990. As part of this study, an extensive before-data set was developed. The planned improvement is now in place, and an extensive after-study is now in progress as part of a follow-up project. The second study was more of a feasibility analysis of possible HOV improvements for a suburban arterial. Specifically, NE 85th/Redmond Way, an arterial that stretches 2.5 miles (4 km), from Interstate 405 in Kirkland to Willows Road in Redmond, was identified as one of the highest priority candidates for arterial HOV improvements.

Because of limited arterial HOV experience in Seattle and nationwide, the study of these two very different types of HOV arterial improvements provided important information for future arterial plans. This project investigated HOV improvements for arterials in the Seattle area, simulated the operation of those improvements for the two case studies, developed a data set for evaluating the impacts of the improvements, and carried out some preliminary evaluations.

The preliminary findings of these two case studies suggested favorable outcomes for the planned HOV improvements. Keeping in mind that these analyses must be evaluated in the context of the surrounding network, the results of these two case studies are optimistic.

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HOV -- Signalized Arterials

HOV IMPROVEMENTS ON SIGNALIZED ARTERIALS IN THE SEATTLE AREA:

VOLUME I: 2 CASE STUDIES

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DISCLAIMER

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SUMMARY

This report presents an analysis of high occupancy vehicle (HOV) improvements for two signalized arterials in the Seattle metropolitan area. The first involves a planned 1,000 foot (300 meter) queue jumper lane on NE Pacific Street in the University District of Seattle. This planned improvement was studied prior to its implementation in Spring of 1990. As part of this study, an extensive before-data set was developed. The planned improvement is now in place, and an extensive after-study is now in progress as part of a follow-up project. The second study was more of a feasibility analysis of possible HOV improvements for a suburban arterial. Specifically, NE 85th/Redmond Way (SR 908), an arterial that stretches 2.5 miles (4 kilometers), from Interstate 405 in Kirkland to Willows Road in Redmond, was identified as one of the highest priority candidates for arterial HOV improvements.

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The extensive before-data collection for the NE Pacific Street HOV study indicated that the commuter population had good mode shift potential. Additionally, the simulation runs for NE Pacific Street tended to reinforce the specific design decisions of the HOV facility plan. The suggested improvement met the rule-of-thumb criterion that specifies that HOV lane travel time should save its users at least one minute per HOV lane mile (This criterion has been applied to freeway HOV travel in the past and was shown by the current study to also work for arterials.) These facts, when considered in the context of the surrounding network of HOV facilities serving this arterial link, suggested that the planned 3+ (3 or more person carpool) queue jumper lane would in fact be considered successful.

Because of the extensive before-data collection developed for NE Pacific Street, this conclusion can and will be tested in an ongoing follow-up study sponsored by TransNow and Metro.

Similar findings were obtained for NE 85th Street, another suburban arterial. The traveler's survey indicated that existing traffic already contained a substantial number of two or more person (2+) carpoolers and suggested that a 2+ carpool lane would be cost-effective. The simulation results supported this conclusion for eastbound traffic and, with expected increased traffic volumes, indicated a similar conclusion for westbound traffic.

Thus, the preliminary findings of these two case studies suggested favorable outcomes for the planned HOV improvements. Keeping in mind that these analyses must be evaluated in the context of the surrounding network, the results of these two case studies are optimistic.

INTRODUCTION AND BACKGROUND

The Need for Arterial HOV Studies

Funding constraints and social and environmental impacts of new construction are forcing the Washington State Department of Transportation (WSDOT) to rely heavily on high occupancy vehicle (HOV) facilities for improving personal mobility in the state's urban areas. To encourage HOV usage, the WSDOT and various local agencies are providing incentives for people to use HOV modes by constructing and operating a system of facilities exclusively for HOVs and developing programs which encourage their use.

At the time of this study, very few HOV improvements had been planned or implemented on arterials in the Seattle area. A bus-only lane operated on Bothell Way (SR-522) just north of the Seattle city limits; the City of Seattle operated a HOV lane northbound on Aurora Avenue (SR-99) approaching the city limits; and the City of Seattle set aside peak period bus-only lanes on some downtown streets. However, the City of Seattle and METRO transit were also planning an HOV facility on NE Pacific Street in the University District. Additionally, as part of the Eastside Transportation Program (ETP), the cities of Kirkland and Redmond, METRO transit, and WSDOT were investigating ways to improve personal mobility in the urban and suburban areas east of Lake Washington. HOV improvements on arterials were being discussed as part of this program. Specifically, NE 85th/Redmond Way (SR 908), a 2.5 mile (4 km) stretch of arterial from interstate 405 in Kirkland to Willows Road in Redmond, was identified as one of the highest priority candidates for this type of arterial HOV improvement.

Because of limited arterial HOV experience in Seattle and nationwide, further study was required to determine what types of HOV improvements were appropriate for arterials in the Seattle area and to evaluate the impacts of those improvements. This project investigated such improvements, simulated the operation of those improvements, developed a data set for evaluating the impacts of implementing the improvements, and carried out some preliminary evaluations.

Research Objectives

The objectives for this project were to:

1) Investigate state-of-the-art techniques for providing high occupancy vehicle (HOV) incentives on arterial routes,

2) Generate HOV alternatives for use on arterials in Washington state urban areas,

3) Simulate the operation of selected HOV improvements in two arterial case study locations (NE Pacific Street in Seattle and NE 85th Street in Redmond and Kirkland),

4) Develop a complete before-data set for NE Pacific Street to be used in subsequent evaluations, and

5) Make preliminary evaluations of the selected arterial HOV improvements on the basis of the simulations of the two arterials noted above and field observations of NE Pacific Street.

REVIEW OF PREVIOUS WORK

Existing Applications

A thorough review of over 100 major references preceded the project study. This state-of-the-art review (See Volume II of this report) summarized the work concerning HOV improvements on both freeways and arterials and determined that the problems associated with HOV improvements on arterials were, by far, the most challenging. It was further determined that relatively few such applications existed, and that fewer studies of these applications were available. In fact, Seattle appeared to be one of the best sources of such information.

Seattle is one the few cities in the U.S. to have already implemented a restricted HOV lane on a non-CBD arterial; there are three such applications in the metropolitan area. Two of the three are on SR-522, a radial arterial that connects a freeway to the suburbs. It has a northbound HOV lane 0.92 miles (1.5 km) long, and a southbound HOV lane 3.27 miles (5.5 km) long. Both of these sections are restricted to buses and formerly operated only during their respective peak flows. Today the southbound HOV lane operates 24 hours a day, while the northbound HOV lane continues to operate in the afternoon peak period. SR-99, or Aurora Avenue, extends from the CBD to well beyond the city limits. Its HOV lane passes through what could be called a suburban business district, basically a strip development along the arterial. This northbound, 1.5 mile (2.5 km) HOV lane is open to transit vehicles and three or more person (3+) carpools; it is in operation 24 hours a day. All three arterial HOV sections have been in place since the early 1980s.

Long range plans generated by groups such as the Puget Sound Council of Governments (PSCOG), WSDOT, and the Eastside Transportation Program (ETP) show extension of the HOV network to all freeways and to many of the main arterials in the Seattle area. Spurred by these plans, both Snohomish and King counties are actively pursuing their implementation. In most cases, the arterials in this metropolitan area are overburdened 2- or 4- lane facilities that transport cars from bedroom communities to the freeways. When major improvements are necessary, the designers are charged with fully investigating the possibility of HOV lane additions. However, because of the lack of history and experience with regard to HOV lane implementation, each agency must struggle with many questions, including: how the priority lane should look and operate, where it should begin and end, how it will interact with its adjacent lanes, and how the purchase of the necessary right-of-way will be funded. Interestingly, funding is one of the main factors favoring the implementation of large scale arterial HOV projects. The State of Washington has set aside a portion of its gas tax revenues to be used for city and county projects on a discretionary basis. This fund prioritizes projects that include transit improvements and involve more than one jurisdiction. Obviously, an HOV lane improvement on an arterial that passes through the county and through one or more small cities would rank high on the discretionary list.

The literature includes few studies of suburban arterial HOV lanes anywhere in the nation. Studies of HOV applications in the U.S. by the Institute of Transportation Engineers (ITE) in 1988 (1), and the Texas Transportation Institute (TTI) in 1990 (2) address only freeway HOVs on separate rights-of-way. Batz (3) produced the only significant report on arterial HOV treatments. However, of the 95 arterial applications that Batz listed, the vast majority were for some type of CBD bus lane. Only eight were located on facilities that could be considered suburban. And of those eight, three were for buses only, one was a queue jumper, and two were on the routes in Seattle. Not even the Nihan/Davis report, which constituted the state-of-the-art review for this project, was able to identify anything in the way of standard arterial HOV treatment. While little is known about arterial HOV lane applications, interest in the area is high. Participants at the

Transportation Research Board's 1991 national HOV conference, held in Seattle, informally expressed a real desire to know more about the feasibility and choices for arterial HOV treatments.

Not surprisingly, one of the most extensive studies exploring the possibility of adding a full-use HOV lane (carpools and transit) to a suburban arterial was conducted in Seattle. The draft report of the Highway 99 High Occupancy Vehicle study, funded by METRO and performed by the TRANSPO Group, Inc. (4) constitutes a proposal for a 15-mile (25 km) interagency project that involves four cities (Seattle, Edmonds, Lynnwood, and Everett), two counties (King and Snohomish), two transit agencies (Seattle METRO and Community Transit), and the Washington State Department of Transportation. This study is a classic example of multi-criteria evaluation wherein three different alternatives are rated on nine quantifiable criteria. In actuality, only one criterion, travel time savings, seemed to carry much weight. Yet, an assumption of constant demand before and after the HOV improvement was made. Such an assumption renders unrealistically good travel times for the general purpose traffic, thereby affecting the evaluation based on relative travel times. At the time that the METRO report was reviewed it was still in its draft form, and had many hurdles to clear before finding acceptance. Chief among these hurdles is the fact that its results must please no fewer than nine separate agencies as they view the reactions of the multitude of private and commercial owner/interests abutting the route.

Upon completion of the literature review for the current study, we concluded that previous work on arterial HOV improvements would not provide much insight into the parameters for this study. Not only were there few studies on this subject, but those that were reported in the literature did not have sufficient before-data to provide a basis for analysis of the impacts of such improvements. In fact, the dearth of before-data was singled out by Batz as one of the most critical impediments to the evaluation of existing arterial HOV improvements. For this reason, the research team for the current study decided to assemble a complete before-data set to be used as the basis for an anticipated follow-up study on the NE Pacific Street arterial section.

Problems to Overcome in Application of HOV Lanes to Arterials

Safety is a major problem in the application of HOV lanes to arterials. Because these lanes serve local bus routes, they normally must be situated on the right-hand side to allow passenger access, even though they are intended for high-speed traffic. Thus, we have the situation wherein carpools and buses traveling in free-flow conditions are sandwiched between the slow lane of the general purpose traffic and the pedestrian sidewalk. Additionally, entering and exiting traffic from the adjacent properties must cross this higher speed lane to complete their maneuvers.

Most of the safety concerns about arterial HOV improvements derive from engineering judgment, experience, and common sense; these hazards have not been well documented. Of the 95 arterials listed by Batz, nine were suspended because of poor enforcement or low utilization. Only two even mentioned safety as a problem, and one of those, an attempt to use a center left turn lane during peak hours, was actually closed due to accidents. The only report dealing exclusively with arterial HOV safety reviewed by this research team is by Larry Senn of WSDOT (5). This report addresses the safety issue for the Seattle area arterial HOV lanes. Of the two lanes on SR-522, which at the time were peak-hour bus-only, he found no increase in accidents. However, on the 24-hour, full use HOV lane on SR-99, he found that the accident rate was significantly greater than that of a comparable adjacent section with no HOV lane. The accidents were "almost all related to opposing left turns across the HOV lane and lane changes onto the HOV lane." Senn's recommendations are to restrict access and to increase the visibility of the HOV lane by adding painted diamonds and by adding dividing stripes and buttons that are more visible. The significance of community access to the arterial can be found in the comparison of accidents on the two Seattle arterials. Most of the HOV length on SR-522 has a median divider curb and there are few driveways; these features greatly reduce turning traffic across the HOV lane. However, on SR-99, there is a two-way left turn lane for the entire lane section and practically unrestricted access from abutting properties. There is no curb or gutter, and only some raised curb marking driveways. Several lots have car access along the entire length of their frontage. This amount of access not only creates an accident hazard; it also slows the priority vehicles down by making them negotiate all of the crossing traffic.

Another problem for arterial HOV lanes is the slowing and blocking effect of buses that use the lanes. While bus priority is a primary reason for the existence of HOV lanes, buses also deter carpools from using such lanes. There is little research on how carpoolers actually surmount the bus problem by either passing the bus and reentering the restricted lane, or by continuing in the general purpose lane. A very limited study by Rubstello (6) found that only 23 percent of carpools that entered the SR-99 carpool lane at the beginning were still in it a mile and half later. Whether this was due to bus traffic, turnouts at the corridor, or a lack of time advantage, was not clear. One way of getting buses out of the way is to provide widened pullouts at each bus stop. However, there are difficulties with this solution in terms of cost, right-of-way, and bus reentry problems. Other problems that are unique challenges for arterial improvements have yet to be covered adequately. These include conflicts and congestion caused by turning movements, conflicts with bicyclists and pedestrians, and the jurisdictional problems associated with arterials that run through two or more jurisdictions.

PROCEDURES

Before-Data Collection for the Planned NE Pacific Street HOV Facility

Figure 1 shows the location of the study site for the NE Pacific Street study; Figure 2 gives a closer view of the study boundary and planned improvement. Much of the before-data for this site was collected from existing sources. These data included geometric measurements, signalization data, Average WeekDay Traffic (AWDT) volume counts, transit information, accident summaries, and vehicle occupancy counts. Other data were collected from field observations during the course of the project. These included additional geometric measurements, signalization information, and other transit information. The key before-study measurements, however, were made with a five-person team in the Spring of 1990.

The before-measurements were taken by a five-person team that gathered data for either Montlake or NE Pacific during a series of collection periods. Data were collected simultaneously using synchronized laptop computers. In all cases the time of the observation was recorded automatically by the laptops, allowing the observations to be related. Person 1 recorded licenses at the upstream end of the system. Person 2 recorded sex of driver and vehicle occupancy for the same vehicles recorded by person 1. Person 3 recorded license plates at the downstream end. Person 4 recorded the length of the queue at the Montlake intersection for either NE Pacific Street or Montlake at the start of each green phase. Person 5 recorded the passing of each vehicle at the midway point between the upstream and downstream observation posts. These raw data provided the information necessary to create the various independent variables used in the analysis.

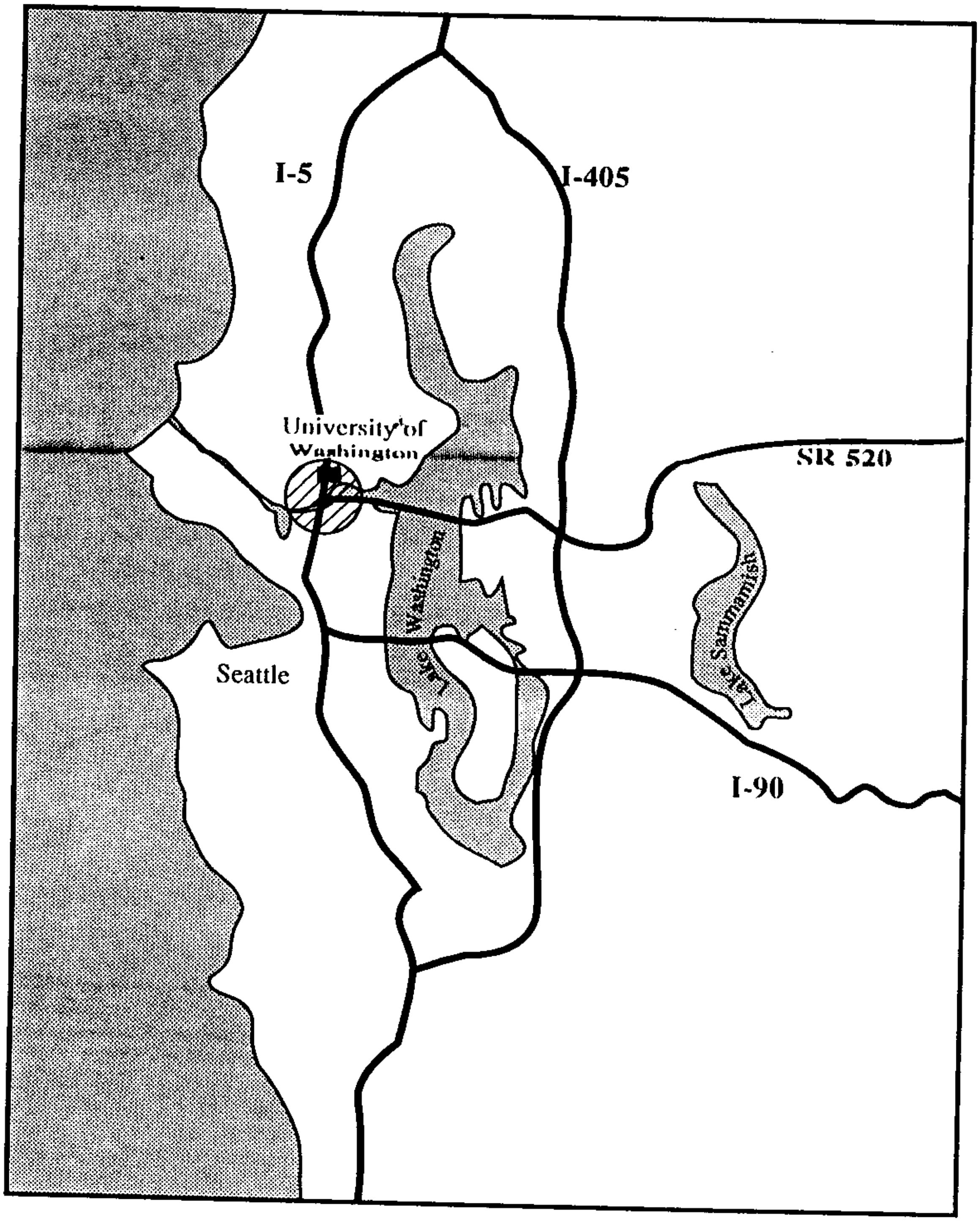

Figure 1. Location of NE Pacific Street Study Site

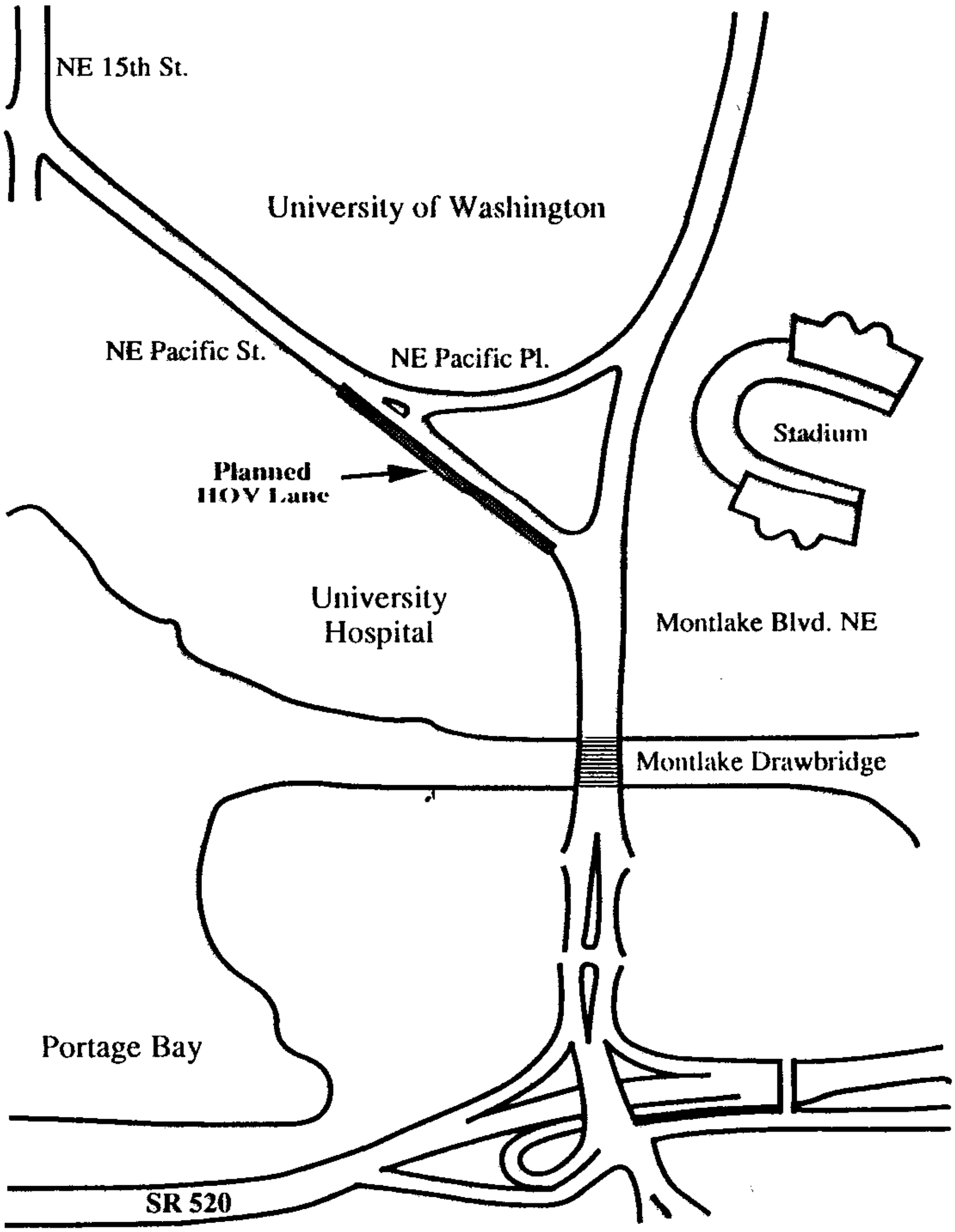

Figure 2. Location of the Planned NE Pacific HOV Lane.

Measurements were taken on five afternoons between March 30 and May 2. Taking into account the fact that the peak period is earlier in the U-district, beginning around 3:00 p.m., our observations were made from 2:40 p.m. until 3:30 p.m. and from 3:45 p.m. until 4:45 p.m. with a 15-minute break. Observations were not made in the rain, forcing several postponements. Otherwise, the weather was generally typical for Seattle, cool with occasional sun breaks. The five-person team's last task was to pass out mail-back postcards for the traveler's survey on the afternoon of May 23.

During the afternoon peak period from 2:30 until 5:30 p.m., May 23, 1990, a mail-back postcard survey was conducted on Montlake Boulevard NE and NE Pacific Street at the Montlake intersection. Figure 3 shows a questionnaire that was included on each postcard. Postcards were handed to motorists waiting in queues at the Montlake intersection. These postcards had the travel survey questionnaire on one side and the return address and prepaid postage bar code on the other. 850 cards were passed out at each of the Montlake and NE Pacific Street sites.

The survey had several purposes. Questions one to seven were expected to provide information about trip origins and destinations, travel times, vehicle occupancies, trip purpose, age, sex and income. Questions eight and nine were expected to provide a broad measure of attitudes with respect to carpooling and transit. The information was expected to provided a baseline against which changing origin-destination patterns, changing travel time patterns, and changing attitudes could be measured. Finally the surveys were expected to provide information for an estimated logit model for mode split analysis.

To obtain the same type of information from transit riders, an intercept was conducted at the bus stop in front of University hospital during the afternoon peak period of May 24, 1990. 50 people who were waiting for buses were interviewed and asked the same survey questions.

TRAFFIC SURVEY

1. **Origin of Trip** (neighborhood or city where this trip started).

   Neighborhood or City ____________ **ZIP CODE** ____________

2. **Destination of Trip** (neighborhood or city where this trip will end).

   Neighborhood or City ____________ **ZIP CODE** ____________

3. Please indicate the **number of people in your vehicle** on this trip.

   (Please include driver) ____________ (Bus Riders please skip this question)

4. Exact **time of your departure** from origin ____________PM

5. Exact **time of your arrival** at destination ____________PM

6. Please indicate the **purpose of your trip** (check one)

   [ ] WORK [ ] SHOPPING [ ] SCHOOL

   [ ] SOCIAL-RECREATION [ ] OTHER ____________

7. Your **Age** ________ **Sex** ________Approximate **Household Income $** ____________

8. (Check one) For me, driving alone is ...

   [ ] **always** better than a carpool

   [ ] **usually** better than a carpool

   [ ] **sometimes** better than a carpool

   [ ] **seldom** better than a carpool

   [ ] **never** better than a carpool

9. (Check one) For me, driving alone is ...

   [ ] **always** better than a bus

   [ ] **usually** better than a bus

   [ ] **sometimes** better than a bus

   [ ] **seldom** better than a bus

   [ ] **never** better than a bus

10. **Thank you for helping.**

COMMENTS ____

____

____

Figure 3. Survey Questionnaire for NE Pacific Street Travel Survey

Northeast 85th HOV Travel Survey

As mentioned previously, the Eastside Transportation Program (ETP), a cooperative planning effort by all government agencies involved with transportation issues east of Lake Washington, recommended an integrated system of arterial HOV improvements linking eastside activity centers to the regional HOV system. Northeast 85th/Redmond Way, which connects Interstate 405 in Kirkland to Willows Road in Redmond, was identified as one of the highest priority candidates for this type of HOV improvement.

For this 2.5 mile (4 km) arterial, a motorist survey was handed out to collect data describing commuter trip behavior (see Figure 4). Questions about trip origin, destination, and purpose were asked to determine which residential and commercial zones were being served by Northeast 85th/Redmond Way, and for what purposes. The questionnaire also requested information about the duration of the trip and vehicle occupancy. These data were used as input for a mathematical model designed to predict the volumes on the facility one year after HOV lane implementation. The final questions on the survey concerned the motorists' own predictions about the likelihood of carpooling and asked them to describe the factors that prevented them from so doing.

Figure 5 shows the location of the Northeast 85th corridor in the Seattle metropolitan area; Figure 6 shows a close-up of the study boundary. It runs east/west between Kirkland and Redmond on the east side of Lake Washington. Its interchange with Interstate 405, the western terminus of the study area, is approximately 11 miles (18 km) from downtown Seattle by freeway. From the I-405 interchange in Kirkland, NE 85th runs east and south through Redmond. The eastern boundary of the study section is Willows Road, giving a length of 2.4 miles (4 km). This general location makes NE 85th an intra-suburban arterial that serves trips going to other suburban destinations more than trips to downtown Seattle. The suburban population served by this arterial is primarily auto-oriented.

TRAVEL PATTERN SURVEY

Station No. [ ][ ] Date [ ][ ][ ][ ][ ][ ]

Time [ ][ ] AM [ ] PM [ ]

Do not write above this line.

---

1. Origin of Trip (exact address, or closest intersection or place where this trip started.) ______________________ 1. [ ][ ][ ][ ]

2. Destination of Trip (exact address, or closet intersection or place where this trip will end.) ______________________ 2. [ ][ ][ ][ ]

3. Please indicate the number of people in your vehicle on this trip. (Please include driver) __________. 3. [ ][ ]

4. Exact time of departure from origin __________. 4. [ ][ ][ ][ ]

5. Exact time of arrival at destination __________. 5. [ ][ ][ ][ ]

6. Frequency of trips ______ per day or ______ per week using this route. 6a. [ ][ ][ ] 6b. [ ][ ][ ]

7. Please indicate the purpose of trip (check one) 7. [ ][ ][ ]

[ ] Work [ ] Shopping [ ] School
[ ] Social-recreation [ ] Other

8. If High Occupancy Vehicle (HOV) lanes were installed in both directions on Redmond Way (N.E. 85th), from I-405 to 148th N.E., how likely would you be to join a carpool for your commute to work? 8. [ ][ ]

[ ] Definitely would carpool [ ] Somewhat likely to carpool
[ ] Very likely to carpool [ ] Definitely would not carpool

9. Which of the following factors would make carpooling to work difficult for you? 9. [ ][ ]
[ ] Home location (few possible ridesharers nearby)
[ ] Work location (few possible ridesharers nearby)
[ ] Hours of the day you work (odd times or frequent O.T.)
[ ] Number of days of the week you go to work (less than 4 or irregular)

Comments: ______________________ [ ]

Figure 4. Survey Questionnaire for NE 85th Street Travel Survey.

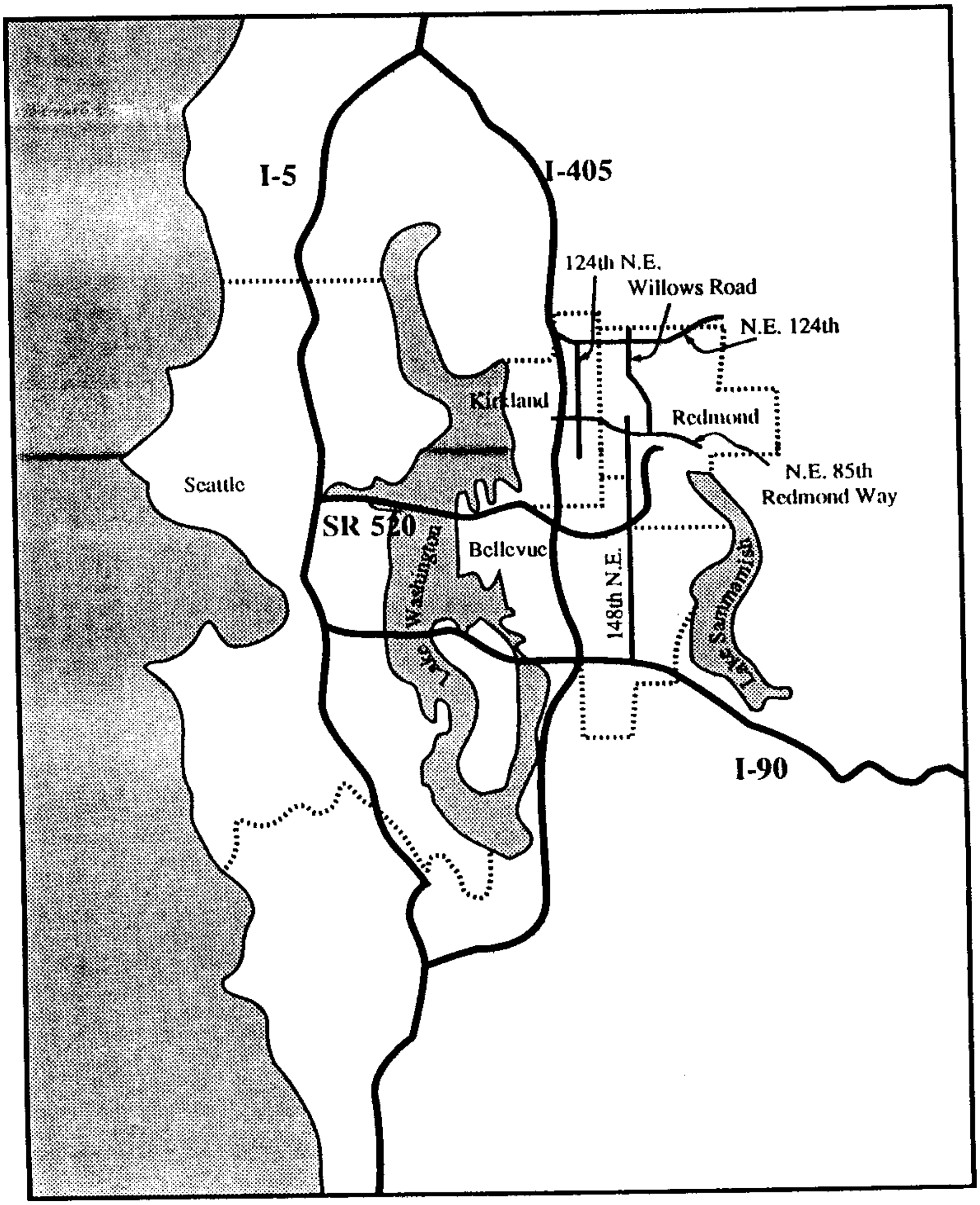

Figure 5. Metropolitan Area in Vicinity of NE 85th Street

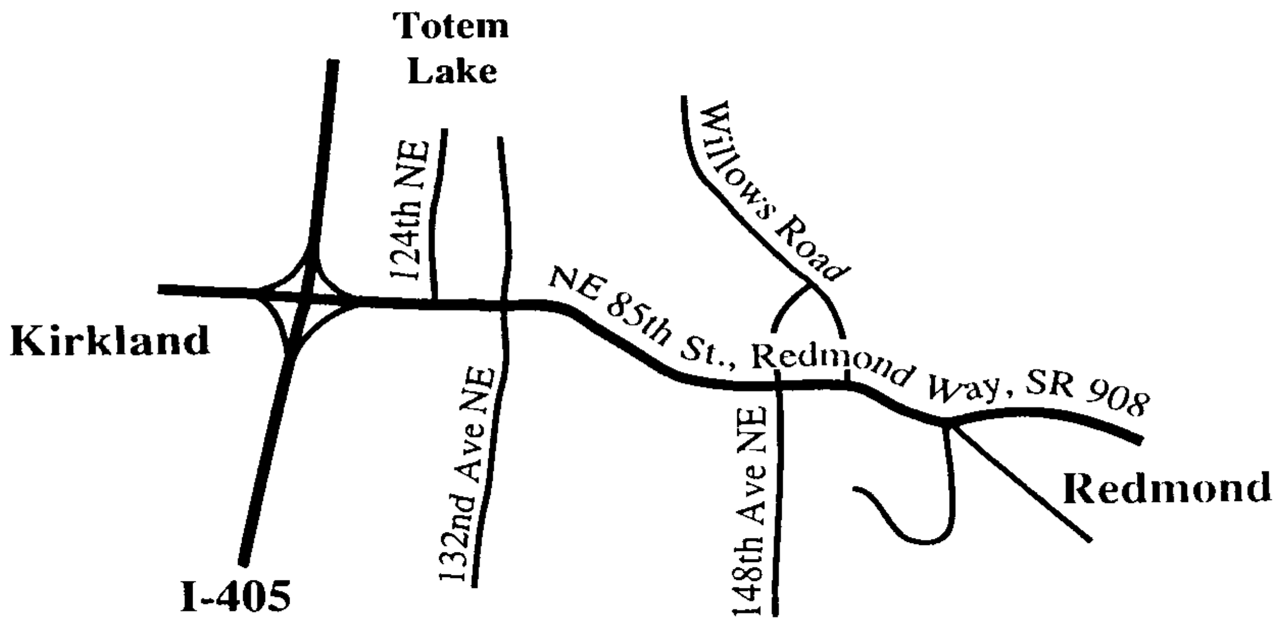

Figure 6. NE 85th Study Area

Another characteristic of the Kirkland/Redmond area typical of modern suburbs is the growth in that area in the number of high-tech jobs. These jobs, at the eastern end of the study area, create a traffic flow that is actually greater than that of the more traditional "inbound", or western flow. The westbound traffic is headed for employment in Kirkland and Bothell, and to a lesser extent, Seattle and Everett. Residential housing is located at all points on the compass from NE 85th. The city of Kirkland, west of I-405, is a mix of single-family residences, apartments, and condominiums. East of the freeway, housing is almost exclusively single-family in the areas near NE 85th. The Redmond section of the arterial is bordered, for the most part, by large apartment complexes set well back from the roadway. In addition to being near housing, NE 85th is the closest east/west arterial to the north end of Lake Samammish, and thus provides one of the few ways to travel west from the large residential development on the hills and plateaus, located to the east of Lake Samammish.

Two thousand copies of the postcard questionnaire were printed up and distributed to morning rush-hour traffic on NE 85th in Kirkland. The survey was handed out during the spread-out peak period from 6:15 to 9:30 a.m.. on a Thursday morning. 1,000 questionnaires were handed out to westbound traffic at the intersection with 124th NE. The remaining 1,000 were distributed to eastbound traffic at 132nd NE.

The balance of the data necessary for analysis was obtained through simple observation, field tests, or other data sources. Bus frequencies were taken from the METRO route schedules. Since bus occupancy was not available from METRO, observations were taken during the survey distribution. Study section travel speeds were acquired by driving the corridor several times using the floating car technique. Traffic counts were obtained from the cities of Kirkland and Redmond.

Traffic Simulation Using TRAF-NETSIM and TRANSYT-7F

The microscopic traffic simulation model TRAF-NETSIM was chosen for the initial analysis of Pacific Street. This model represents real traffic characteristics in greater detail than do macroscopic traffic simulation models; additionally, TRAF-NETSIM can simulate complex HOV lane traffic flow. However, as the project progressed, the research team found several "bugs" in TRAF-NETSIM that required correction. Extensive re-programming of the source code solved several of these problems. However, other problems with the simulation ultimately led the team to abandon use of the animated microscopic software package in favor of a less complicated simulation package. The research team did, however, learn several lessons from the runs made with the TRAF-NETSIM software; they are documented in Volume IV of this report.

The macroscopic arterial simulation package, TRANSYT-7F, was then chosen for use in the HOV simulation runs for both NE Pacific Street and NE 85th Street/Redmond Way. In order to use TRANSYT-7F for simulation of HOV traffic, a methodology had to be developed for calculating appropriate platoon dispersion factors. This methodology is described in Volume IV.

Several simulation runs were made for possible future scenarios. These included various combinations of expected HOV improvements and possible mode shifts and volume changes.

DISCUSSION

Before-Study of the Planned NE Pacific HOV Facility

This section describes the results of the before study. As previously discussed, the decision to design a before-and-after study and to carry out the before-study was based on the findings of the state-of-the-art literature review. The before-data were collected in the Spring of 1990, and a comparable data set was collected in the Spring of 1992 for evaluation in a follow-up study co-sponsored by METRO transit and Transportation Northwest (TransNow).

The final data set for NE Pacific Street for the before-study consisted of 298 observations. The data set for the Montlake arterial consisted of 223 observations. Table 1 summarizes the data obtained on the chosen evaluation variables for the before-study field observations. Regression analyses were performed using these data to identify existing relationships for future comparison with the after-study. These regression analyses are detailed in Davis, Chapter 6 (8).

The state-of-the-art review (Volume II) indicated that safety concerns are often expressed with regard to arterial HOV facilities. So that comparisons could be made later, it was important to obtain information on prevailing accident rates. The Seattle Engineering Department provided a listing of accidents along NE Pacific Street for the previous 75 month period, from January 1, 1984 to March 24, 1990. This listing provided information about the date of each accident, the type (auto, pedestrian, bike, other), weather, light, and road surface conditions, and whether or not there were injuries. The list was organized into seven different locations along NE Pacific Street. These locations are described in Table 1.

Table 1. Locations, Aggregations for Accident Data

Location	Description
1	15th Avenue NE and NE Pacific Street intersection
2	NE Pacific Street: 15th Avenue NE to 17th Avenue NE crosswalk
3	NE Pacific Street at the 17th Avenue NE crosswalk
4	NE Pacific Street: 17th Avenue NE crosswalk to NE Pacific Place
5	NE Pacific Place and NE Pacific Street intersection
6	NE Pacific Street: NE Pacific Place to Montlake Boulevard NE
7	Montlake Boulevard NE and NE Pacific Street intersection

Table 2 gives the summary of accident data by location along NE Pacific Street. Overall, the data show an average of 1.35 accidents per month for NE Pacific Street between 15th Avenue NE and Montlake Boulevard NE. Accident data collected after the implementation of the HOV facility will not be strictly comparable because other factors such as general growth presumably will have intervened during the six-year, before-period represented by these statistics. The baseline can only provide an indication of typical accident rates. Accidents are infrequent events with high variance. Hence, before-and-after comparisons will be difficult.

Of the 1,700 cards distributed on Montlake and Pacific, 503 or 30 percent were returned with responses to questions 8 and 9. On question 8, the respondent had to evaluate driving alone as compared to carpooling [see Figure (4)]. Question 9 was identical, except that 'bus' was substituted for 'carpool'. Responses were coded 1-5. "Always" was coded as 1, "Usually" as 2, and so on. The responses were averaged to provide an indication of where the attitude of the group as a whole could be represented on the scale. Table 3 summarizes the attitudes toward buses and carpools as reflected by the survey questionnaire. The replies to these attitude questions were interesting yet reasonable. The respondents in vehicles with one or two occupants (designated as low occupant vehicles (LOVs) for convenience), rated driving alone higher than did the carpoolers or bus riders. The sample for carpoolers was small, but carpoolers on NE Pacific Street ranked driving alone much lower (3.40). In other words, carpoolers demonstrated their support of carpools by rating driving alone as only sometimes, or seldom, better. Note, however, that the attitude toward carpools and buses was not as high among the Montlake carpoolers who were more supportive of driving alone.

The attitude toward driving alone was lowest for the sample of bus riders who, as a group, would seldom rate driving alone as better than the bus (4.23). The attitude toward driving alone was higher for the LOVs on Montlake than on Pacific and the standard deviation was lower. Thus they were consistently supportive of driving alone. The highest group average for driving alone was from the Montlake group in comparison with riding the bus. This makes sense because there is less bus service available on Montlake than on NE Pacific Street.

Overall, the results from the survey were reasonable. They suggested that the travelers on NE Pacific may be less supportive of driving alone than the travelers on Montlake. They are encouraging because they suggest the possibility for mode shift. The results also provide a baseline for comparison if the same survey is repeated after HOV lane implementation.

Table 2. Summary of Accident Data By Location

Location Number	# of Accidents	% Involving Bicycles	% Involving Pedestrians	% Resulting In Injuries	% Accident Days Unclear Weather	% Ocurring at Dusk or Night	% Ocurring On Wet Road	Average # Monthly Accidents	% of Pacific St. Accidents
1	19	16	0	47	11	42	26	.25	.185
2	10	0	10	40	20	[illegible]	30	.13	.096
3	2	0	100	100	50	0	100	.03	.022
4	7	0	14	43	57	57	57	.09	.067
5	14	29	36	71	50	43	57	.19	.141
6	34	0	0	21	15	[illegible]	29	.45	.333
7	15	33	13	53	7	13	13	.20	.148
TT	101	12	11	50	22	25	34	1.35	

Table 3. Summary Attitudes Toward Buses and Carpools

(Mode) Loc.	# OBS	Q8 MEAN	Q8 SD	Q9 MEAN	Q9 SD
(LOV) Pacif	226	2.11	1.32	1.80	1.03
(LOV) Mont	250	1.79	0.99	1.68	0.89
(HOV) Pacif	10	3.40	1.51	2.30	1.57
(HOV) Mont	16	2.56	1.59	1.81	0.75
(BUS) Pacif	48	4.10	1.42	4.23	1.13

LOV = Persons in vehicles with 1 or 2 occupants
HOV = Persons in vehicles with 3 or more persons (Carpools)
BUS = Persons in buses

The sample of surveys for NE Pacific Street provided some general information about the number of trips starting or ending in the University District, the average trip length, and the number of persons traveling on NE Pacific Street during the peak. Summaries of general travel and travel profiles are provided in Tables 4 and 5.

Table 4. Age, Sex, and Income Profile (NE Pacific Street Travelers)

Mode	# OBS	Age	Male	Average Income
LOV	149	52	48%	$44,000
Carpool	11	53	27%	$53,000
Bus	46	35	28%	$31,000

Table 5. Trip Purpose, Origin, Destination, and Length (NE Pacific Street)

Mode	# OBS	Work	School	Origin UD	Destination UD	Distance (miles)
LOV	149	58%	7%	57%	17%	11.5
Carpool	11	45%	9%	45%	18%	9.9
Bus	46	65%	22%			9.9

The average age of persons in carpools and LOVs was high. This may be due, in part, to some sample bias, since younger persons apparently did not return the surveys as consistently as did older persons. Also, 58 percent of the LOV respondents and 45 percent of the carpool respondents marked the purpose of their trips as "work," corresponding to 7 percent and 9 percent respectively for "school" related trips.

The LOV users were evenly split between males and females, while the carpoolers and bus users were predominantly female. Household incomes were fairly high for persons using LOVs and carpools, and much lower for persons using buses.

The trips on NE Pacific Street were mostly work related. School trips comprised a small portion of the whole, though the portion of students using the bus (22 percent) was double the portion for LOVs and carpools (7 percent and 9 percent).

Most LOV and carpool trips had either originated or terminated in the University District. For NE Pacific Street, 57 percent of LOV trips and 45 percent of carpool trips had started in the University District, while 17 percent of the LOV trips and 18 percent of the carpool trips had destinations in the University District. Altogether, the majority of the LOV trips and the majority of the carpool trips had either an origin or destination in the University District. Note that because the bus sample was collected at a bus stop in the University District, all passengers were either originating in or destined for the University

District (Data on transfers were not taken for this study; i.e., those passengers who indicated that this stop was neither an origin nor destination were not interviewed and, therefore, dropped from this sample). The lengths of trips averaged about 10 miles. Trips for LOVs were slightly higher (11.5 miles) than were carpool or bus trips (both 9.9 miles).

Several generalizations can be made about trips on NE Pacific Street eastbound during the peak period (keeping the sample bias in mind). First, the trips were largely work related. Travelers on NE Pacific Street during this period were older and more affluent than might be expected. Most of the trips started in the University District. The results suggest that only a small portion of the travelers were using NE Pacific Street as a corridor for regional-type travel originating in neighborhoods other than the University District. Approximately 31 percent of the respondents were traveling to the eastside across SR-520. Another 36 percent were going to nearby neighborhoods in Seattle (Montlake and Capitol Hill). Of the remaining trips, 7 percent were going to the Rainier Valley area, 7 percent were going to destinations in South Seattle or Pierce County, and 2 to 3 percent had downtown, Queen Anne, West Seattle or Mercer Island destinations. The rest of the trips were divided among destinations scattered throughout the region.

Travel Survey For NE 85th Street

The balance in commute flows along NE 85th street is reflected in traffic counts taken by the cities of Kirkland and Redmond. Table 6 shows these a.m. peak-hour flows. The Kirkland figures are from the intersection of 124th NE; and the Redmond figures were taken at 140th NE.

Table 6. A.M. Peak-Hour Flows (VPH) Along NE 85th Street

	124th NE week of 9/24/90	140th NE 6/19/90
EB	1,278	1,355
WB	1,198	1,274

The travel survey contained questions asking for the address of, or nearest intersection to, the origin and destination of each trip. These locations were aggregated into zones to create origin-destination matrices for the trips along NE 85th. The zone boundaries used were those of the PSCOG. Volume III of this report includes a listing and a description of each PSCOG study zone.

The largest movements were for trips with neither origin nor destination in the Seattle CBD. The westbound origins show that 43 percent of the trips begin in West Redmond, 25 percent begin on the Sammamish Plateau, and 14 percent begin in NE Kirkland (Rose Hill). The westbound destinations show that 39 percent of all the trips are to NE or downtown Kirkland. This, compared with only 9 percent going to all parts of the city of Seattle, underscored the fact that travel on the arterial is suburb-to-suburb. Thus, for westbound traffic, NE 85th serves the zones immediately to the north and east of Lake Sammamish, and provides access to Kirkland and all parts of the metropolitan area via I-405.

Eastbound, 84 percent of the trips are destined for Redmond. They are broken up as follows: 44 percent to the Overlake area (which includes major employers such as: Microsoft, Nintendo, Safeco, and Group Health); 20 percent to downtown Redmond; 10 percent to the Bear Creek area; and 9 percent to the business parks along Willows Road. The origins are predominantly from NE and downtown Kirkland (32 percent) and from the Kirkland-Bothell-Woodinville area (26 percent). Longer trips that were significant included 6 percent originating from the Lynnwood area. Again, eastbound traffic is predominantly from zones in the immediate Kirkland-Redmond area, which means that travelers use this road during the week for many reasons other than just going to work.

Table 7 shows the vehicle occupancy results obtained from the survey. It is interesting to note the high percentage of carpool vehicles currently in the traffic stream on a route with relatively short trips and that does not offer currently HOV priority lanes in either direction. Eastbound the carpool volume is 11.1 percent of all trips, and westbound it is 14.1 percent! Obviously, there are other factors that already supply substantial rideshare incentives.

Table 7. Vehicle Occupancy

		Number	Percentage
EB	1	311	89.88
	2	30	9.65
	3+	5	1.45
WB	1	244	85.92
	2	30	10.56
	3+	10	3.52

The survey also obtained the average perceived travel time for trips during the a.m. commute. Table 8 shows these travel times by occupancy. The results were surprisingly similar, with the eastbound average at 28 minutes, 51 seconds and the westbound at 29 minutes, 31 seconds, a difference of only 2.31 percent. As expected, carpoolers are those with the longest trips; the carpool incentives are greatest in their cases.

Table 8. Travel Time by Occupancy (minutes:seconds)

	Eastbound	Westbound
1 person	28:17	29:36
1-2 persons	28:49	29:21
2+	34:37	30:43
3+	35:00	41:13

Table 9 shows the breakdown of trips by trip purpose obtained from the survey. Linked trips that were recorded as having additional purposes besides work were simply counted as work trips. The notable fact about the numbers in Table 9 is the higher number of social-recreational and other trips for the westbound traffic. This is probably due to the proximity of the westbound origin zones. People would be using NE 85th to access the freeway for these other trips.

Table 9. Trip Purpose

		Number	Percentage
EB	Work	327	94.51
	Shopping	2	0.58
	School	7	2.02
	Soc-Rec	8	2.31
	Other	2	0.58
WB	Work	256	90.14
	Shopping	2	0.70
	School	6	2.11
	Soc-Rec	11	3.87
	Other	9	3.17

Table 10 shows the survey response to the question asking how likely the person would be to carpool to work if HOV lanes were installed on NE 85th from I-405 to 148th NE. The numbers are virtually identical, with the biggest difference in any category being only 1.11 percent. It is interesting that the percentage of eastbound motorists in the two groups that were most likely to carpool to work (10.65 percent) is very close to the existing carpool volume for all trip purposes (11.46 percent). For westbound traffic, on the other hand, there are fewer people who are most likely to carpool to work (9.00 percent), than are currently doing so for all trip purposes (17.30 percent). This reflects the high percentage of non-work carpools currently in the westbound traffic.

Table 10. Likelihood of Carpooling (Number and Percentage)

	Eastbound		Westbound	
Definitely Would Carpool	14	4.14	10	3.60
Very Likely to Carpool	22	6.51	15	5.40
Somewhat Likely to Carpool	77	22.78	65	23.38
Definitely Would not Carpool	225	66.57	188	67.63

Table 11 shows the survey response to the question dealing with some of the problems usually associated with carpool membership. As it turned out, one of the most common reasons was left off the questionnaire, but some 90 people took the time to write it in. That reason was the need to use one's own car at work for business, or for personal use on the commute. Adding in this oft-cited reason, the results are shown in terms of number of responses and percentage of observations. Note that the percentages do not add up to 100 percent because this was one question which multiple answers were allowed. There do not appear to be any significant differences due to direction of travel in this response. The length of the questionnaire did not allow the research team to learn any more about the most troublesome problem, hours of the day worked. It is not clear whether the problem is due to long hours, unpredictable overtime, part-time work, or an unusual shift. Most of the reasons are probably very valid carpooling deterrents. Having to go in to work early or stay late just to catch a ride would be very unusual for American suburbanites.

Table 11. Carpooling Problems (number and percentage)

	Eastbound		Westbound	
Home Location	143	40.97	109	37.72
Work Location	72	20.63	83	28.72
Hours Worked	214	61.32	182	62.98
Days Worked	28	8.02	33	11.42
Need Car	52	14.90	46	15.92

Home location is a problem that appears to be more formidable than it actually is. The great majority of commuters along NE 85th come from well established, relatively densely developed, suburban communities. The fact that 40 percent of these motorists believe that no one who lives near them would be interested in carpooling is most likely due to their never really having investigated the possibility. It would be very interesting to see the results of a carpool matching service in this area.

Finally, the comment section at the bottom of the travel questionnaire was used, in one form or another, by 334 of the 638 respondents, (52 percent). Comments that were more or less transportation related were grouped into 19 topics. These, and their breakdown by direction, are shown in Table 12. Not all comments, by any means, advocated additional construction. In fact, a few respondents did not want any improvements simply because they did not want to contend with the months and years of construction, that seem so prevalent in the Seattle area these days.

Again, multiple comments were recorded for individual questionnaires. The percentage of transportation-related comments from eastbound traffic was virtually the same as that from westbound (39.83 percent vs. 39.45 percent). The sum of negative comments (those asking for construction of some other facility first, or those simply opposing HOV lane implementation here or anywhere else), comes to 46 responses, or 13.18 percent, for eastbound traffic and 35 responses, or 12.11 percent, for westbound. Thus, similarities between the two directions show up in this question as well.

The differences between the two directions are interesting. Eastbounders want improvements to I-405 much more, which is reasonable since more of them use it to travel to and from distant zones. Conversely, they are also more opposed to HOV lanes in general, and are much more interested in having additional bike lanes.

The eastbound population, therefore, can be considered somewhat more heterogeneous than can the westbound. This assessment can be explained by the fact that their origins are more widely dispersed.

After the previously mentioned comments about needing a car at work, the next most popular theme was the need for better transit. People said that if they could ride a bus, they would; but that the routes either did not go where they wanted, when they wanted, or that they took so long that it was unreasonable. As mentioned in the introduction, this is the plight of the suburbanite. The suburban land use configuration has effectively prevented transit from being able to serve all of the geographically dispersed residential and employment centers.

Table 12. Survey Comments

	EB	WB
Fix the SR 520/Avondale Road intersection first	1	6
Taking kids to daycare creates carpool problems	6	7
Build HOV lanes on I-405 first	10	3
Build ramp meters on I-405 first	2	1
Build HOV lane somewhere else first	0	1
HOV lane on NE 85th good idea	2	3
HOV lane on NE 85th bad idea	6	9
Need car for personal use during the day	6	4
Need car for personal use during commute	9	4
Need car for work	37	38
Suggest regional rail project be built first	6	9
Build more roads	7	5
Improve the transit service	17	11
Coordinate the signals on N.E. 85th	2	5
Prefer 2+ lane occupancy if HOV lane is installed	6	2
Prefer 3+ lane occupancy if HOV lane is installed	1	0
No more construction	2	2
Build more bike lanes	10	1
Against HOV lanes in general	9	3

Simulation Results

As noted in the Procedures section, both TRAFNET-SIM and TRANSYT-7F were used to simulate potential impacts of HOV improvements on NE Pacific Street in Seattle and NE 85th Street in the Kirkland/Redmond area. After several iterations of program refinement with the TRAFNET-SIM software, the research team decided to use the macroscopic TRANSYT-7F results because they were thought to provide the more reliable forecasts. A complete description of the simulations and their significance is contained in Volume IV of this report. Only the final TRANSYT-7F simulation results will be discussed in this section.

NE Pacific Street Simulation. Table 13 gives the simulation results for the expected impacts of HOV improvements to NE Pacific Street. Alternative 1 represents the existing system with no HOV improvement. Alternative 2 includes adding one general lane in front of University Hospital. Alternative 3 (the planned HOV improvement) includes adding one HOV lane in front of University Hospital. Alternative 4 includes extension of the general lane back to 15th Avenue NE. Alternative 5 includes extension of an HOV lane back to 15th Avenue NE. As shown in the table, the improvements on NE Pacific Street have little effect on traffic on Montlake Blvd.. This is to be expected, if there is no change in signal timing due to the HOV improvement. (Note that the planned advanced green time for buses on NE Pacific Street was not modeled in this study because of time limitations.)

**Table 13. Seattle NE Pacific Street
Simulation Travel Time (sec) Outputs**

Simulation Alt. Name	Pacific Street			Montlake Boulevard		
	Auto	Carpool	Bus	Auto	Carpool	Bus
01. Existing Design	175.8	175.8	266.4	181.2	181.2	258.0
02. Add one gen. lane University Hospital	157.1	157.1	249.6	181.7	181.7	258.0
03. Add one HOV lane University Hospital	167.7	151.9	244.8	181.4	181.4	258.0
04. Add one gen. lane 15th Avenue	139.3	139.3	240.0	181.7	181.7	258.0
05. Add one HOV lane 15th Avenue	162.2	126.3	235.2	181.4	181.4	258.0

As expected, adding one general lane to NE Pacific Street improved conditions for general traffic with a savings of 18.7 seconds for auto and carpool and a savings of 16.8 seconds for bus. The planned HOV lane improvement in front of the University Hospital improved carpool travel time by 23.9 seconds and bus travel time by 21.6 seconds without hurting general traffic (auto actually improved by 8.1 seconds). Adding one general lane all the way to 15th Avenue NE improved traffic flow for all modes with a decrease in time for auto and carpool of 36.5 seconds and bus of 26.4 seconds. Adding an HOV lane back to 15th Avenue NE further improved carpool and bus travel times (savings of 49.5 and 31.2 seconds respectively) at the expense of general traffic. However, general traffic still had a savings of 13.6 seconds for this alternative as compared with the existing design.

Although the travel time savings for this very short section of arterial may not seem great, they must be considered in the context of the entire surrounding system of HOV improvements.

NE 85th Street Simulation. Table 14 shows the simulation results for a proposed HOV lane addition in each direction on NE 85th Street and its comparison with the existing geometric design and with a corresponding general lane or HOV lane addition in each direction. For the eastbound traffic, travel time savings for general traffic are 112.7 seconds and 65.5 seconds for the general lane addition and for the HOV lane addition respectively. Corresponding travel time savings for carpools were 112.7 seconds for the general lane addition and 130.6 seconds for the HOV lane addition. A comparison of carpools using the HOV lane vs. general traffic showed a travel time difference of 65.1 seconds, which means that carpoolers save slightly more than one minute over general traffic for this short section of arterial. In the westbound direction, the savings were less dramatic but were still possibly significant when viewed with other HOV improvements as a contributing piece of a larger arterial network.

Table 14. NE 85th Street Simulation Travel Time (sec) Outputs

Eastbound NE 85th Street

	120th to 132nd		132nd to Willows		Total	
	Auto	Carpool	Auto	Carpool	Auto	Carpool
Alt. 01 Existing Geometric Design	122.6	122.6	344.0	344.0	466.6	466.6
Alt. 02 Add one Gen. Lane (140th-Wil.)	122.6	122.6	231.3	231.3	353.9	353.9
Alt. 03 Add one HOV Lane (140th-Wil.)	122.6	122.6	278.5	213.5	401.1	336.0

Westbound NE 85th Street

	Will.to 132nd		132nd to 120th		Total	
	Auto	Carpool	Auto	Carpool	Auto	Carpool
Alt. 01 Existing Geometric Design	195.0	195.0	203.9	203.9	398.9	398.9
Alt. 02 Add one Gen. Lane (132nd-120th)	195.0	195.0	145.9	145.9	340.9	340.9
Alt. 03 Add one HOV Lane (132nd-120th)	195.0	195.0	171.6	134.3	366.6	329.3

Evaluation Criteria. The simulation results for the suggested HOV lane additions on NE Pacific Street and NE 85th Street give some positive indications of success for both of these arterial improvements. One of the most popular performance values used in freeway HOV lane evaluation is the "one minute per mile of HOV lane rule" [FUHS (9), Hank and Lomax (10)]. This rule of thumb stipulates that the travel time savings for HOV lane traffic must be at least one minute per mile (0.60 minutes per kilometer) of HOV lane in order for a successful mode shift to occur. Volume IV of this report develops a parallel justification for applying this same rule to arterial HOV lane evaluation. Addition of the 1000 ft. (300 meter) queue jumper in front of University Hospital on NE Pacific Street produces a travel time difference between carpools and general traffic of 1.39 minutes per HOV lane mile (0.83 minutes per HOV lane kilometer). According to this criterion, then, it can be argued that the HOV incentive in this case is sufficient to attract new carpoolers from the general traffic. Although bus time does improve over the status quo, it is still not competitive with general traffic, so a mode shift here is less likely. The results for the 4,200 ft. (0.48 km) eastbound HOV lane on NE 85th Street are similar. The travel time savings for those using the HOV lane on this arterial are 1.36 minutes per HOV lane mile (0.82 minutes per HOV lane kilometer). (Since bus traffic is virtually nonexistent on this route, it is not a factor in the evaluation.) On westbound NE 85th St, however, the travel time savings for carpoolers is only .78 minutes per HOV lane mile (0.47 minutes per HOV lane kilometer). Therefore, if this were the sole criterion for success, then the westbound HOV lane addition would not be viable.

Another rule-of-thumb cited in the literature is that people are likely to switch to the HOV mode if their travel time savings are five minutes or more per trip [Wesemann (11)]. Since the arterial improvements in question make up only a portion of the travelers' trips as documented by our origin and destination studies, we must look at these HOV improvements in the context of the larger network. In one of the two case studies described herein, the arterial in question connects directly with a freeway that includes an

HOV lane bypass on the freeway ramp. The HOV lane for travelers on NE Pacific Street leads into the HOV ramp bypass on SR-520; the proposed eastbound NE 85th facility would lead into the planned I-405 HOV ramp bypass and the future I-405 HOV lanes. Thus, if the travel time savings for HOV improvements are aggregated with other supplemental HOV facilities, then these improvements look even better. Accordingly, the simulations indicate that these HOV lane projects will contribute to improving the existing traffic congestion by encouraging people to shift mode from SOVs to HOVs.

APPLICATION AND IMPLEMENTATION

The results of the current study will be widely disseminated throughout the region and used by the Washington State Department of Transportation, the Eastside Transportation Program, and METRO Transit in assessing plans for other HOV improvements in the region's arterial network. There are extensive plans for HOV improvements on our freeway and arterial system in both King and Snohomish Counties over the next decade. It is hoped that the two case studies analyzed in this report will provide good preliminary information for other such projects that are now in the works and that it will give some insight into how these innovations will contribute to the larger system of both freeway and arterial network improvements.

The extensive before-data set developed for the NE Pacific Street study will be used in a follow-up study co-sponsored by Metro Transit and Transportation Northwest (TransNow). This before-data set collected in the Spring of 1990 will be compared to a similar after-data set collected in the Spring of 1992. This will culminate in one of the few documented before-and-after studies for HOV arterial improvements in the nation and should be useful for future planning.

CONCLUSIONS AND RECOMMENDATIONS

The extensive before-data collection for the NE Pacific Street HOV study showed that of 1,869 vehicles sampled on NE Pacific Street during the before-study, 129 (7 percent) had three or more occupants (3+). For Montlake, 48 of 963 vehicles (5 percent) were 3+ carpools. In addition to this existing pool of 3+ vehicles, the traveler's survey found a population with mode shift potential. Most of the eastbound peak-period travelers on NE Pacific were older, work-related commuters coming from the University District. Their attitudes toward transit and carpooling were favorable as opposed to those of travelers on nearby Montlake Boulevard. The simulation runs for NE Pacific Street tended to reinforce the specific design decisions of the HOV facility plan. The suggested HOV improvement passed the rule-of-thumb criterion of a difference in travel time between the general traffic and the HOV lane of over one minute per HOV lane mile (0.60 minutes per HOV lane kilometer). The literature suggests that this difference is enough to encourage mode shift from SOVs to carpools. These facts, coupled with the surrounding network of HOV facilities including the 520 HOV bypass accessed by a significant portion of NE Pacific Street traffic, suggests that the planned 3+ queue jumper lane will, in fact, be successful. Because of the extensive before-data collection developed for this case study, this conclusion can and will be tested in an ongoing follow-up study co-sponsored by TransNow and Metro.

Similar findings were obtained for NE 85th Street, a suburban arterial. The traveler's survey showed that existing traffic already contained over 11 percent of 2+ carpoolers in the eastbound direction and over 14 percent of such carpoolers westbound. The simulation results indicated that the eastbound traffic also passed the HOV lane travel time savings criterion. With increased traffic volumes, it is expected that the westbound traffic will continue to satisfy this criterion in the future. These preliminary results, plus the extensive planned HOV improvements on the eastside (including the HOV bypass on I-405), suggest that the addition of a 2+ HOV lane in the eastbound and westbound directions on NE 85th Street would be operationally successful. This should be coupled with an aggressive ride matching and commuter information program since the traveler's survey indicated that a significant number of those travelers who are not currently carpooling were unaware of other travelers who share their origins and destinations.

Thus the preliminary findings of these two case studies suggest favorable outcomes for the planned HOV improvements. Planners should, however, keep in mind that there are so many factors that bear on actual utilization of an HOV application that one cannot make a judgment based solely on the data presented in this report. It must also be remembered that in each both cases the arterial in question is but a small link in a very extensive system of region-wide priority lanes. One cannot justify the system by evaluating its pieces in isolation. Each segment of the network provides much of its value simply by being a part of the whole. With these caveats in mind, the report on the two case studies presented herein is optimistic.

REFERENCES

1. Institute of Traffic Engineers, "The Effectiveness of High-Occupancy Vehicle Facilities," 1988.

2. Texas Transportation Institute, Katherine F. Turnbull and James W. Hanks, Jr., "Description of High-Occupancy Vehicle Facilities in North America," 1990.

3. Batz, T.M., "High Occupancy Vehicle Turnouts, Impacts, and Parameters," FHWA, NTIS #PB87 203212/HDM, August 1986, 2 volumes.

4. The TRANSPO Group, Inc., "Highway 99 High Occupancy Vehicle Study, Technical Report 2," 1991.

5. Larry Senn, Washington State Transportation Center, working paper, 1990.

6. Les O. Rubstello, term paper, University of Washington, 1991.