HOV MONITORING AND EVALUATION TOOL

WA-RD 318.1

Final Technical Report
February 1994

Washington State
Department of Transportation

12/90

HOV Moni.

Washington State Transportation Commission
Transit, Research, and Intermodal Planning (TRIP) Division
in cooperation with the U.S. Department of Transportation
Federal Highway Administration

T[illegible]) TITLE PAGE

1. REPORT NO. WA-RD 318.1	3. RECIPIENT'S CATALOG NO.
4. TITLE AND SUBTITLE HOV MONITORING AND EVALUATION TOOL	5. REPORT DATE February 1994
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Matthew Benuska, Matthew Hansen, Cy Ulberg	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Washington State Transportation Center (TRAC) University of Washington, JD-10 University District Building; 1107 NE 45th Street, Suite 535 Seattle, Washington 98105-4631	10. WORK UNIT NO.
	11. CONTRACT OR GRANT NO. T9233, Task 7
12. SPONSORING AGENCY NAME AND ADDRESS Washington State Department of Transportation Transportation Building, MS 7370 Olympia, Washington 98504-7370	13. TYPE OF REPORT AND PERIOD COVERED Final technical report
	14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

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

16. ABSTRACT

This report summarizes the methodology used by the Washington State Transportation Center in fulfillment of the requirements for the Washington State Department of Transportation grant "HOV Lane Monitoring and Evaluation Tool." This report describes the types of data collected, how the data was collected, and the uses of the data. The report then makes some preliminary findings based on the analysis to date. Designing a system for evaluating the performance of high occupancy vehicle lanes includes establishing methods for collection and analysis of vehicle occupancy, travel time, and public opinion data. Secondary sources include data on enforcement of HOV lane restrictions, accidents, and transit ridership.

The objective of this report is to identify the most effective and efficient method for collecting and analyzing the required data. Issues addressed in identifying the most appropriate methodology included the following: selecting data collection sites, developing a computer program to facilitate data collection and storage, management of traffic observers, scheduling, developing computer programs for auditing and analyzing data, developing a system for mailing public opinion surveys to commuters observed in the field, and analysis of the public opinion data.

It is important to note that this report concerns the development of a methodology and is not designed to be an authoritative analysis of the effectiveness of high occupancy vehicle lanes. The analysis of the data described in this report will be published in a forthcoming report for the companion project, "HOV Lane Evaluation and Monitoring."

17. KEY WORDS HOV lane evaluation, traffic observation	18. DISTRIBUTION STATEMENT No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22616

19. SECURITY CLASSIF. (of this report)	20. SECURITY CLASSIF. (of this page)	21. NO. OF PAGES	22. PRICE
None	None	120	

Final Technical Report
Research Project T9233, Task 7
HOV Lane Usage Analysis and Evaluation Tool

HOV MONITORING AND EVALUATION TOOL

by

Matthew Benuska
Research Assistant
University of Washington

Matthew Hansen
Research Assistant
University of Washington

Cy Ulberg
Research Associate Professor
Graduate School of Public Affairs
University of Washington

Washington State Transportation Center (TRAC)
University of Washington, JD-10
University District Building
1107 NE 45th Street, Suite 535
Seattle, Washington 98105-4631

Washington State Department of Transportation
Technical Monitor
Eldon L. Jacobson
Traffic Engineer, FAME

Prepared for

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

February 1994

DISCLAIMER

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

There are currently 74 miles of high occupancy vehicle (HOV) lanes on the three interstate highways and six state routes in the greater Seattle area. Commuters and transportation planners alike agree that these lanes play an essential part in reducing traffic congestion in the Puget Sound region. Additional construction on the region's freeways will primarily be in the form of HOV lanes in the foreseeable future. Therefore, careful attention must be given to constructing HOV facilities in locations where they will do the most good and in forms that will provide the most effective service.

The purpose of this project is to establish a method of data collection and obtain baseline information to be used for monitoring and evaluating the impact of HOV lanes along selected routes in the Puget Sound region. Since July 1991, we have been designing a data collection procedure and gathering the data necessary to develop a useful database for measuring the effectiveness of HOV lanes. This report documents the data collection process and recommends continuing evaluation efforts. The results of this project will be used to improve the efficiency of existing HOV lanes, set priorities for building new HOV lanes, influence design decisions, and guide policy for the operation of HOV lanes.

The method for evaluating the effectiveness of HOV lanes is to employ human observers in the field, equipped with laptop computers and custom-written computer programs, to record data for both HOV and general purpose (GP) lanes. These observers collect vehicle occupancy data, travel time data, and license plate numbers so that registered vehicle owners may receive public opinion surveys. Traffic observers collect data on six different highway corridors at 48 sites. The principal investigator wrote all of the computer programs used in this project and provides overall management and supervision. An observer manager schedules traffic count sessions and ensures adequate coverage of the six highway corridors under observation. Two graduate research assistants compile and analyze the traffic data and public opinion data.

MEASURES OF EFFECTIVENESS

Because they are intended to reduce average travel time and increase travel time reliability, HOV lanes are expected to reduce roadway congestion and encourage transit use. These expected reductions in travel time and roadway congestion must be measured to determine whether the benefits of HOV lanes are worth the costs. Our data collection efforts have focused on the following measures: vehicle occupancy, traffic volumes, mode choice, travel times, HOV violations, safety of HOV lanes, and public opinion. Vehicle occupancy, travel time, and public opinion data are the three types of primary data collected in this evaluation method. Secondary data sources include accidents, enforcement, and transit ridership along bus routes that use HOV lanes.

VEHICLE OCCUPANCY AND TRAVEL TIME DATA

Vehicle occupancy data are gathered to develop a profile of commute patterns, congestion (vehicle throughput), and the average number of riders along commuter routes to contrast HOV lanes with GP lanes. Vehicle occupancy data serve a number of useful functions, from indicating the sheer volume of traveling vehicles (similar to loop data) to providing information on the frequency of different types of vehicles traveling between particular locations along a given corridor. Because observers record HOV lane traffic, violation rates during peak commutes can be estimated as well. Data collection involves stationing observers on overpasses to record vehicles. During winter months and low-light conditions, observers are situated along access ramps. Because data from mainline and ramp locations are different, a method of using ramp data to estimate mainline data is being developed.

Travel time data are used to estimate the speed and flow of traffic in the HOV and GP lanes to determine the travel time savings provided by HOV lanes. These data will also be used to determine compliance with state HOV lane policy standards. Travel time estimates are based on the time differential between two or more computers that traffic observers have used to record the license plate "partials" of passing vehicles. As with vehicle occupancy data collection, observers are situated on overpasses. Because this study is the first of its kind for the Puget Sound area, baseline data for both vehicle occupancy and travel time observations must first be established before the impact of HOV lanes can be fully evaluated. Once collected, these data will provide a measure of how existing and newly constructed HOV facilities will affect area congestion over time.

PUBLIC PERCEPTION OF HOV LANES

To measure public perception of HOV lanes we have been mailing surveys to randomly selected vehicle owners who drive in corridors where HOV lanes already exist. The surveys reveal a clear trend of support for HOV lanes and continued HOV lane construction. The data show that this trend of support is similar for commuters who drive alone, carpoolers, and transit users. However, there are some significant differences in between the opinions of commuters who normally drive alone and of those who do not. To illustrate the potential uses of the survey data, results have been grouped in three categories: commuter profiles, support for HOV lanes, and problems with HOV lanes. Survey data are also used when HOV lane safety and enforcement are evaluated.

SECONDARY DATA SOURCES

Data we are gathering from other sources include HOV lane safety, enforcement, and impacts on transit use. HOV lane safety is measured by analysis of the WSDOT accidents databank. We are particularly interested in the impact that opening an HOV lane has on accident rates and changes in accident rates over time. Enforcement and violation data include data from vehicle occupancy counts, the number of HOV violation tickets issued, and information from the HERO (violation reporting) program. We are also examining the outcomes of HOV violation citations, with the assistance of the Office of the Administrator of the Courts. Transit data indicate the impact of HOV lanes on bus ridership and route planning. These data also provide an indication of the travel time reduction and reliability associated with HOV lanes.

RECOMMENDATIONS

To improve the effectiveness of data collection and broaden the applicability of this project, we recommend the following.

- Increase the profile of the observations manager. Many of the errors in the data collection process could have been mitigated if there had been a stronger link between traffic observers and the observations manager. Allocating more time to the observations manager will allow him or her to better train observers, to better monitor and evaluate the performance of individual observers, and solve problems as they arise.

- Use travel time observations only for special studies. Because the cost of travel time observations is greater than average vehicle occupancy (AVO) observations in terms of observer costs, and because travel time observations require a greater volume of sessions to produce statistically significant data, we recommend that observations be only conducted for special studies. Furthermore, electronic means of data collection should be explored.

- Expand the number of sites. The data generated by this project will be instrumental in assessing the impact and effectiveness of HOV lanes. Therefore, it is important to collect data for highway segments both before and after HOV lanes have opened. This may mean increasing the number of collection sites within existing highway corridors into Pierce and Snohomish counties, or expanding to new corridors.

- Divide I-405 into discreet observation corridors. The number of observation sites within the I-405 corridor has reached the capacity of the file naming system. To increase coverage of this site (along with HOV lanes that are currently being built), we will need to section the corridor into three segments: one segment will be from Tukwila Parkway to I-90, another from I-90 to SR 520, and the third from SR 520 north to I-5. This will increase the current number of corridors under study from 6 to 8 and will likely require increased observer time to provide for travel to developed sites.

CHAPTER ONE

INTRODUCTION AND RESEARCH APPROACH

High occupancy vehicle (HOV) lanes play an essential part in reducing traffic congestion in the Puget Sound region. Additional construction on the area's freeways will be primarily in the form of HOV lanes in the foreseeable future. Even though there is a consensus on the need for new HOV lanes, they are expensive and funds for them are limited. As a result, careful attention needs to be given to constructing HOV facilities in locations where they will do the most good and in forms that will provide the most effective service. To provide this attention, the planning and decision making processes concerning HOV lane development require thorough, accurate data on the performance of existing HOV facilities and their impact on traffic congestion.

PURPOSE AND PRODUCTS

The purposes of this project are to establish a method of traffic data collection and obtain baseline information to be used for monitoring and evaluating the impact of HOV lanes along selected routes in the Puget Sound region. Since July 1991, we have been designing a data collection procedure and gathering the data necessary to develop a useful database for measuring the effectiveness of HOV lanes. The primary objective of this project, then, is to design a sound method for data collection, test it through observation, and develop a useful format to provide the data to transportation researchers, planners, and decision makers concerned with the development of HOV facilities. We will summarize our findings on the effectiveness of HOV lanes in the Puget Sound area as well. This report documents the data collection process and makes recommendations for continuing evaluation efforts. The recommendations include types of data required, data collection methodology, and the timing and format of evaluation reports. The results of this project will be used to improve the efficiency of existing HOV lanes, set priorities for building new HOV lanes, influence design decisions, and guide policy for the operation of HOV lanes.

STATE-OF-THE-ART REVIEW

The purpose of this project and the companion project, "HOV Monitoring and Evaluation," is to develop a database of valid information for evaluating the performance of the HOV lane system in Washington State. The data from this collection effort may not constitute an evaluation of the HOV lane system per se, but rather will provide the information necessary for conducting evaluations of the HOV lane system in the Puget Sound area.

In developing a valid methodology for evaluating the effectiveness of HOV lanes, it is crucial to understand how other HOV evaluations around the nation have been conducted. Different types of information collected and evaluation methods provide useful information on methods to emulate and pitfalls to avoid. While special circumstances surrounding HOV lanes in the Puget Sound may affect the design of an HOV lane evaluation methodology, assessing the efforts of other researchers in this field reveals options for designing the methodology.

The Texas Transportation Institute (TTI) of Texas A&M University conducted a nationwide survey of HOV lane evaluation methods in 1991 that provided valuable insights into the development of this study. The TTI report included analysis of HOV evaluation programs in Texas, Virginia, California, Washington, Minnesota, and New Jersey. TTI developed a suggested approach for designing HOV lane evaluation efforts, which contains the following elements:

1. clear articulation of project goals and objectives
2. identification of measures of effectiveness
3. identification of information needs
4. development of study design
5. "before" data collection
6. "after" data collection
7. ongoing monitoring and evaluation (Turnbull 1991)

Of most concern in designing this study were the articulation of goals and objectives. identification of measures of effectiveness and information needs, "before and "after" data collection. and the ongoing monitoring and evaluation components.

Goals and Objectives

The 1992 Washington State Freeway HOV System Policy states three objectives for the state HOV lane system. The freeway HOV lane system is designed 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 that use the facilities
- provide safe travel options for high occupancy vehicles without unduly affecting the safety of the freeway general purpose mainlines (WSDOT 1992)

These objectives are similar to ones outlined in other states' efforts. At the most basic level, the primary purpose of HOV lanes is to decrease traffic congestion by increasing the occupancy of vehicles using highways that contain HOV lanes. However, some states have developed different HOV lane objectives. For instance, when HOV lanes have been designed exclusively for use by public transit buses, objectives such as increasing the use and coverage of public transit have been included. TTI's evaluation of the I-45 contraflow HOV lane included cost-effectiveness, public support, and favorable impacts on air quality and energy consumption in the objectives of the HOV lane program (Turnbull 1991). While objectives may differ across states, it is important for any evaluation effort to be sure that it is measuring the ability of an HOV lane system to meet its intended goals.

This study goes beyond evaluating the extent to which the HOV lane system has achieved the WSDOT objectives described above by gathering information on public opinion of HOV lane effectiveness, violations of HOV lane restrictions, outcomes of those violations. and the effect of HOV lanes on transit ridership. This information will provide a more comprehensive understanding of the effectiveness of HOV lanes than would be possible by limiting the scope of the study to the three major objectives outlined above.

Measures of Effectiveness and Information Needs

To measure how well the HOV lane system meets the goals outlines above, WSDOT has outlined five measures of effectiveness: person throughput, vehicle occupancy, comparative and absolute general purpose and HOV lane travel times, travel time reliability, and accident rates. Again, the measures of the frequency of HOV violations, outcomes of violations, public opinion, and changes in transit ridership were added to this study. What distinguishes the measures of effectiveness outlined by WSDOT and this study from other HOV evaluation efforts around the country is that WSDOT has generated very few quantitative goals for evaluating HOV lanes. For instance, Minnesota's Department of Transportation projected a rise in vehicle occupancy from 1.23 in 1984 to 1.6 between 1993-2000 for its evaluation of the I-394 HOV lane system (Turnbull 1991). In contrast, WSDOT's goal is to increase vehicle occupancy. TTI was critical of non-quantitative goals because they offer no benchmark for judging the success of an HOV lane, i.e., an increase of 0.01 in vehicle occupancy is an increase, though not a significant one. The WSDOT HOV lane system policy does quantify other objectives, however. A new speed and reliability standard was developed in 1992, stipulating that HOV lane vehicles should maintain a speed of at least 45 miles per hour at least 90 percent of the time, measured over a consecutive 6-month period. This standard is used to determine HOV occupancy requirements (WSDOT 1992). Discussion of each of the measures of effectiveness used in this evaluation effort, and the accompanying information needs, are contained throughout this report.

Another important point raised by the TTI report is that evaluation of an HOV lane should include analysis of the impact of that HOV lane on the total transportation system. To measure the effect of an HOV lane, TTI recommends collecting data on the adjoining freeway mainline, park and ride lots, and even alternative arterial routes in addition to the HOV lane (Turnbull 1992). This study is collecting extensive data on the general purpose freeway mainlines and HOV lanes, but it does not address alternative arterial routes or other elements of the transportation system. One reason for excluding the other elements is that the wide area covered by this study requires significant resources. This erodes the ability to conduct traffic observations at sites not on area freeways.

Development of the traffic observation method itself was pioneered in 1988 by Ulberg and McCormack (Ulberg 1988). This work concentrated on determining the reliability of human observers and the frequency of counts required for statistically valid data. Other demonstration projects helped determine personnel management and operational aspects of this study (Mehyar 1990, and Ulberg and Farnsworth 1991).

"Before" and "After" Data Collection

This study follows TTI's recommendation of collecting and analyzing data both before and after an HOV lane opens to best measure the impact of the HOV lane on vehicle occupancy and traffic flows. However, in many cases the HOV lanes in the Puget Sound area opened before this study began. Whenever possible, traffic observations have been conducted before an HOV lane has opened, or before changes in HOV lane policy have affected the use of an HOV lane. For instance, extensive "before" data were collected on the southbound lanes of I-5 prior to the extension of the HOV lane from Mercer St. to Yesler in 1993. Several months after the new HOV lane opened, collection of "after" data commenced to measure changes in vehicle occupancy, traffic flows, and public opinion. Similarly, this study collected extensive "before" data on the general purpose lane conversion to an HOV lane on westbound I-90. Traffic observations will resume after sufficient time has elapsed for drivers to adjust their driving habits.

Ongoing Evaluation

The "before" and "after" classifications may be best understood to relate to evaluations of specific HOV lanes or groups of HOV lanes. However, an ongoing monitoring and evaluation effort that measures traffic patterns over time, this study takes a region-wide approach, as opposed to other studies in the past. A region-wide study will allow evaluation of the entire Puget Sound area HOV lane system, rather than only specific lane segments. In addition, current transportation improvement plans call for adding HOV lanes on many of the area's highways, and this study constitutes a significant "before" data collection effort. A region-wide approach also reflects the fact that people do not habitually use only one highway. Rather, people use disparate routes to reach their destinations, and it is necessary to take a wider scope to better understand overall travel behavior. Another reason for the region-wide character of this evaluation study is that the results of this study will provide valuable information to state transportation planners about the locations where new HOV facilities will do the most good and the kinds of HOV lanes that appear to have the greatest impact.

Data Collection Methods

The TTI report also described a need for more uniform methods of data collection and analysis for evaluations of HOV lanes nationwide. It is hoped that the inclusive nature of this evaluation will provide a useful tool for other jurisdictions in conducting HOV evaluations. Variability in the goals and measures of effectiveness for HOV lanes will exist as long as the lanes are designed and built for different purposes around the country. Fiscal considerations may also play a role in determining the scope and depth of an evaluation. But by documenting and making the methodology developed for this study widely available, other HOV lane evaluation efforts may benefit from the experience in Washington State.

Finally, it is important to note that the method of data collection in this study is highly automated. Human observers in the field use palmtop computers with specialized software to collect data, as opposed to the manual counts conducted in other jurisdictions. One goal for automating the data collection process is to reduce the time needed for data entry and analysis, reducing overall project costs. Another goal is to improve the reliability of the data. Extensive discussion of each computer program used in this project is included throughout this report. The programs required for data collection and analysis will be made available to transportation researchers evaluating HOV lanes nationwide.

WORK PLAN

This project is currently in the fourth stage of a five-stage process.

- Task One: Preparing for Initial Data Collection. This task included outfitting observers and data managers with the appropriate equipment, gaining efficient access to existing databases, and developing an initial data collection methodology.

- Task Two: Initial Data Collection. In this task, methods of data collection used in Task One were employed and their effectiveness was evaluated.

- Task Three: Data Collection Revision. This task involved the review of Tasks One and Two and concluded with an interim report describing the methods agreed upon for data collection throughout the remaining year of the project.

- Task Four: Continuing Data Collection. The data collection methods described in the interim report have been continued for the remainder of the project.

- Task Five: Reporting. A regular reporting system will be developed to disseminate the data on operations of HOV lanes in the Puget Sound region. This report will contain descriptions of some elements of this reporting system.

MEASURES OF EFFECTIVENESS

Because they are intended to reduce average travel time and increase travel time reliability, HOV lanes are expected to reduce roadway congestion and encourage carpooling, vanpooling, and transit use. These expected reductions in travel time and roadway congestion must be measured to determine whether the benefits of HOV lanes are worth the costs. Our data collection efforts have focused on the following measures:

- **Vehicle Occupancy**. Vehicle occupancy is measured by human observers in the field at 48 sites in the Puget Sound area. Data are being collected on HOV lanes, mainline highway lanes, and on- and off-ramps. Occupancies of transit vehicles that use HOV lanes are being collected as well.

- **Traffic Volumes**. The traffic volume of HOV lanes and mainline highway lanes is a basic measurement of the extent to which the region's commuters make use of HOV facilities. Traffic volumes are being collected at the same time that vehicle occupancy data are collected. These numbers are supplemented by inductance loop data from the Traffic Systems Management Center (TSMC).

- **Mode Choice**. Mode choice data can be derived from vehicle occupancy observations. The data are supplemented by transit ridership data and survey results from this project and from other agencies.

- **HOV Violations**. Data from average vehicle occupancy observations (AVO), the number of HOV violation tickets issued, adjudication results, and information from the HERO program indicate the frequency of HOV violations and the enforceability of current restrictions (see Chapter 6 for information on the HERO program). Survey results provide information about perceptions of violations by the region's commuters.

- **Safety**. The state accident database is being used to monitor the safety of the HOV lane system. Public opinion survey results provide information concerning commuter perceptions of HOV lane safety. These data measure the priority of safety concerns and the impact of safety on mode choice.

- **Travel Time**. Travel time data measure the effectiveness of HOV lanes in reducing commute time and in improving their reliability. A license plate matching method has been developed and used to measure and compare travel times on HOV lanes and general purpose lanes. Multiple counts at specific sites and roadway segments measure the travel time reliability function of HOV lanes. Analysis of TSMC data from inductance loops supplements this information.

- **Public Opinion**. Public opinion of HOV lanes provides an indication of how important and effective the HOV program is perceived to be, as well as ways in which the program may be modified to appeal to more of the region's drivers. Public opinion has been measured by randomly selecting commuters observed on freeways during peak commute periods along routes that contain HOV lanes and mailing surveys to them.

These measures of effectiveness will provide a useful basis for evaluating the impact of HOV lanes in the Puget Sound region. Decision makers and transportation planners will have ready access to this information, which will be updated quarterly and annually. Methods to present the data are under development to maximize ease of transmission and use.

STUDY LOCATIONS

Study sites have been chosen to provide a representative sample of data on all corridors within the Seattle metropolitan area that currently contain HOV lanes or where HOV facility expansions are planned. I-5, I-90, I-405, and SR 520 are included, and these routes are divided into six corridors. Through the end of this year of the project, 43 sites along the routes have been chosen according to traffic flow patterns to allow for maximum corridor coverage. Below is a list of the corridors presently under observation (see Appendix A for a more detailed list).

- North I-5, from Northgate to the King/Snohomish County line at SW. 236th St.
- Downtown I-5, from Downtown Seattle at Lakeview Blvd. E. to S. 144th St.
- South I-5, from the Southcenter Hill at S. 178th St. to S. 272nd St.
- I-90, from the Mount Baker Tunnel at 23rd Ave S. to Bellevue Way.
- I-405, from Southcenter at Tukwila Pkwy, north through I-90 to Kirkland/Redmond at SR 908.
- SR 520, from Medina at Hunt's Point to Bellevue/Kirkland at SR 908.

Because traffic varies widely along the I-5 corridor, it is presently divided into the North, Downtown, and South corridors. In the future, the other corridors should also be divided into sections.

The initial study locations have been limited to include areas with the most intense HOV lane development and to focus efforts on developing a methodology. Additional sites are under consideration for subsequent monitoring efforts.

DATA COLLECTION

Three of this project's objectives are to collect data to 1) determine the average number of people per vehicle during peak periods, 2) estimate the travel time savings of HOV lanes, and 3) obtain a random sample of commuter opinions. Because these tasks are not well suited to mechanization. we employ field observers who collect the following data:

- average vehicle occupancy (AVO) data for computing lane volumes. vehicle occupancy, throughput, and congestion impacts;
- travel time data to measure and compare average vehicle speeds and commute times between general purpose (GP) and high occupancy vehicle (HOV) lanes; and
- license plate numbers to facilitate distribution of a public opinion survey.

Observations are scheduled to ensure complete coverage of all sites. Following the methods of monitoring vehicle occupancy that were established by a prior demonstration program, our goal is to collect an average of ten half-hour counts per location per quarter (Omar 1990:2). It is important to ensure that each scheduled observation is completed when it is assigned. To ensure that this objective is met, observers are coordinated by an observations manager. The observations manager is assisted by a graduate research assistant (RA), who maintains the collected traffic data to ensure that it is reliable and up-to-date for ready analysis. Observation sessions take place during morning and evening peak commute periods (weekdays from 6:00 am to 9:00 am and from 3:00 pm to 6:00 pm). During these times, observers record vehicle occupancy and travel time data using notebook computers. During breaks. they manually record license plate numbers for the public opinion survey. At the end of each week. the collected data are consolidated and the files are audited with a personal computer. Erroneous files are removed, and the remaining files are stored for future analysis. A second graduate research assistant uses the license plate numbers, in cooperation with the Department of Licensing, to obtain home addresses of the freeway users for the public opinion survey. The research assistant sends about 250 surveys weekly to commuters, supervises data entry of returned surveys, and analyzes the survey results.

REPORT ORGANIZATION

This chapter introduces the project. Chapter Two discusses the methods and issues concerning data collection for vehicle occupancy and travel time observations. Chapter Three describes vehicle occupancy data collection and analysis. Chapter Four discusses travel time data collection and analysis. Chapter Five describes the public opinion survey process and provides some initial findings from the survey. Chapter Six presents secondary data sources. These include information on enforcement of HOV lane restrictions, accident information, and transit impacts of HOV lanes measured by bus ridership figures. Chapter Seven presents our recommendations and conclusions and outlines the costs of this project. Extensive descriptions of traffic data. public opinion analysis. transit data, accident data, and enforcement data are contained in a separate report.

CHAPTER TWO

VEHICLE OCCUPANCY AND TRAVEL TIME DATA COLLECTION

The data collection processes for vehicle occupancy and travel time data are similar in many instances. Traffic observers gather both types of data using the same sites and computer program. Scheduling and maintaining the consistency of these observations and their data files are complex. Both tasks are monitored by an observations manager and a data research assistant, working with the primary investigator. Data collection is affected by the weather and light conditions of the locations, computer and transportation availability, and the school year. Since July 1, 1992, the normal schedule has consisted of eight observation sessions per day, five days a week: four sessions during each morning and evening commute. The data collected are consolidated and monitored for quality. In this and the proceeding two chapters, we describe the data consolidation and monitoring processes in detail.

For both vehicle occupancy and travel time data collection, traffic observation sites are selected using the following criteria (Miller 1992):

- Ease of access and use. Sites must be easy to find and use. Sitting and parking space must be available nearby for observer vehicles as well. For this reason, they generally are situated near freeway access ramps. Detailed directions for reaching locations and their descriptions are provided in writing to traffic observers.

- Observer and motorist safety. Sites must have features that allow observers to be out of the way of, and protected from traffic. Additionally, because observers may pose a distraction for motorists, observers ought to be hidden from traffic. Overpasses with sidewalks and access ramps with room behind concrete or steel barriers are preferred to open shoulders; these locations provide maximum protection for observers and remove observers from drivers' sights.

- Visibility. Sites must allow observers to see passing traffic clearly. Views must be unobstructed and situated to allow maximum visibility into vehicles under changing light conditions. For example, during the winter months, when less light is available, sites along access ramps are used because they are near street lamps.

Presently, there are five part-time observers drawn primarily from the University of Washington's pool of undergraduates. Some observers use their own cars to travel to and from observation sites and are reimbursed for mileage. Because some observers do not have cars, a vehicle from the WSDOT motor pool is also kept available for occasional use. Observation schedules must also take into account whether the observers have a vehicle, the location of and distance to the observation site, and observer time constraints.

To allow for travel time to the site, sessions are scheduled from 5:45 am to 9:15 am. and from 2:30 pm to 6:30 pm weekly. The sessions generally last from two and one-half to three hours. Observers are stationed at points that allow them line-of-sight views of traffic flow, facing oncoming traffic either next to or overlooking the roadway. The observers must be stationed close enough to the roadway that they are able to identify the license plates and the number of occupants in passing vehicles, yet not so close that their safety is compromised. For this reason overpasses are preferred for observing mainline traffic. When overpasses are not used (e.g., for AVO observations on access ramps), the observers are instructed to remain behind traffic barriers. Additionally, observers are instructed to carry regulation WSDOT safety vests and hard hats while recording data and are encouraged to carry identification as well. Because of their visibility and regular appearance on the freeways, traffic observers are often questioned by motorists, nearby residents, or the Washington State Patrol (WSP), who are called out to investigate occasional reports of potential road hazards (Miller 1992). TRAC has coordinated with the WSP, however, and the checks are routine.

This project originally maintained five Toshiba T100LE notebook computers for data entry (four plus one spare to allow for maintenance). The fifth computer was reserved for use when others were being serviced. However, one of the computers was stolen during the first quarter of 1993, leaving only the four necessary to conduct observations. Observers sign out for use of the computers when taking them into the field and must report malfunctions. For vehicle occupancy sessions, if a computer malfunctions, the observer performs hand-counts (described in Chapter Three) instead. Travel time observations, on the other hand, are impossible to conduct without the computers. For ease of handling, vehicle occupancy and travel time observations are recorded on separate floppy disks. Once a week's worth of data have been accumulated, the data files are then transferred to a hard disk under a separate subdirectory for each week. The subdirectory's name, prefixed by "AVO," indicates the month, beginning day of the week, and last digit of the year (e.g., the subdirectory containing data files for the first week of the study is named "AVO06292" to represent June 29, 1992).

Observers record data by using a FORTRAN program called "CT," developed especially for the project. This program allows observers to record (1) their location, (2) date and time of session, (3) type of session, (4) direction of traffic, and (5) comments regarding weather and unusual conditions for both types of observations (figure 1, 1a, and 1b). Observers are instructed to "note any unusual activity in...traffic volume, type or flow," as well as weather conditions that might affect the reliability of the data (Miller 1992). The data files are given unique names derived from this information (see Appendix B for a description of the file name). Computers are time-synchronized and kept charged on a weekly basis when not in use.

Once on site, observers rely on a number of items for data collection. Observers carry notebooks with hand-count forms and pencils, as well as spare computer disks in canvas bags obtained for the study. The observers also carry forms to record license plates for the public opinion survey. Because the observers are exposed to the weather during counting sessions, choice of clothing is important and varies with the season. Proper clothing is especially important during winter months, which can include freezing temperatures and rain. During a session, the observer remains stationary while entering data and can become quite cold and wet in typical Northwest weather. The computers are sensitive to bad weather and must also be protected from the elements during a session.

1.	After starting the portable computer, insert the 3 1/2" floppy disk containing CT. Switch to the "A:" drive by typing **A:** and pressing **<Return>**.
2.	At the A: prompt, type **CT** and press **<Return>**.
3.	CT requests that the corridor number be entered by displaying the following: 1 North I-5 2 Downtown I-5 3 South I-5 4 SR 520 5 I-90 6 I-405
4.	CT requests the location number by displaying the appropriate list of choices for that corridor (as in above).
5.	CT requests that the direction of travel be entered by displaying the following: n North s South w West e East
6.	CT requests that the type of count be entered: 1 Travel Time 2 Mainline AVO 3 On-ramp AVO 4 Off-ramp AVO
7.	CT displays the entered information and requests confirmation (Hit **<enter>** to accept, any other key to change). If you wish to change the information, press any other key and CT cycles through steps 3 through 7 again.
8.	CT displays today's date for you to confirm or change.
9.	CT displays the current time for you to confirm or change.
10.	CT requests that you enter your name.
11.	CT requests that you enter the current weather conditions.
12.	Depending on the type of count indicated, CT either begins an AVO (mainline or access ramp) or travel time session.

Figure 1. Steps for using CT

13.	(Mainline Session only) CT requests that you enter the lane number you are observing.
14.	CT requests that the count interval, in minutes, be entered (the default value of 30 minutes is used if no number is entered).
15.	CT then prompts you to begin data entry, displaying "Seconds to end = ". Enter observations by typing the number for the vehicle type seen (**0-9**; above).
16.	As each observation is entered, CT displays the vehicle classification.
17.	When the count reaches "0", CT requests that comments be entered.
18.	Once **<enter>** is depressed, CT ends.

Figure 1a. Steps for using CT (vehicle occupancy observations)

13.	CT requests that you begin entering license plates (press the **<enter>** key after each entry).
14.	To end, press **<control> + <E>**.
15.	CT will request that you enter comments ("Hit <enter> to end the program" is displayed).
16.	Once **<enter>** is depressed, CT ends.

Figure 1b. Steps for using CT (travel time observations)

Therefore, observers carry plastic dry-cleaning bags: at the first sight of rain, the observer places the computer in the bag and continues to enter data. Adverse weather not only increases observer discomfort and can damage the computer; but it reduces sight, affecting observation accuracy for AVO and travel time sessions.

To ensure adequate data collection at all observation sites, a part-time graduate student is employed (ten hours per week) to supervise the traffic observers. The observations manager's duties include scheduling observations, supervising and coordinating observer activity, monitoring observer performance, and hiring additional observers when necessary. If observations are missed or data are lost, the manager reschedules observations as soon as possible. To maintain up-to-date information of scheduled and completed observations, the manager keeps weekly records of scheduled observations, which s/he checks against the actual observations performed (see Appendix C). From this information, the manager compiles quarterly records and coordinates information with the data research assistant to ensure site coverage and observer performance.

In addition to the observations manager, a half-time graduate research assistant is employed to monitor data quality and assist with analysis. The data research assistant maintains the integrity and availability of collected data for analysis and reports on the quality of collected data as well as pertinent comments noted by the observers. To maintain quality, the research assistant examines and edits data weekly, removing erroneous files and flagging outlying observations. These results are then tracked and reported with observer comments to the observations manager and principal investigator, who adjust observer activity and schedule site locations accordingly. This process has required that a systematic method be established for tracking both the quantity and quality of data that are accumulated.

QUALITY ASSURANCE

Quality assurance plays an integral part in developing an HOV monitoring and evaluation tool because it allows us to ensure that the data being collected are reliable and error-free. We also track the number of data files that we accumulate for each location, and the proportion of hand-count files as part of this process. By tracking the number and quality of data files, we are able to

- know the availability of usable data for selected locations and commute periods,
- monitor traffic observer performance,
- more closely manage the data collection process by scheduling observations at sites that have fewer than ten counts per quarter,
- eliminate unproductive sites, and
- estimate the cost effectiveness of data collection.

For the rest of this report, the vehicle occupancy files will be referred to as AVO files since Average Vehicle Occupancy (AVO) is computed from these files.

AVO and travel time data files are initially audited by programs that display the data and summary statistics for each session. The programs are essentially the same for both observation types; "AVOCH" is used for the AVO data files, and "TTCH" is used for the travel time files (see figure 2; hereafter the programs will be referred to as AVO/TTCH). To audit data files using AVO/TTCH, the programs must be placed in the same root directory as the target subdirectories. When AVO/TTCH is run, it prompts the user for the desired week and searches the corresponding subdirectory for applicable data files. It then creates and displays a list of the files it has found for each day (named by using the name of the subdirectory: "AVO06292.lst" or "TT06292.lst," respectively); the program indicates out-of-sequence files by flashing their names on the screen. AVO/TTCH refers to this list to locate the appropriate files every time an audit is performed; subsequent audits do not display the list.

1.	Run AVO/TTCH.
2.	AVO/TTCH asks that the desired week be selected by using the Up and Down Arrow keys.
3.	AVO/TTCH searches the corresponding subdirectory for all AVO data files and displays the session names and the number of files for every day of the week, which will flash as AVO/TTCH is searching. If a list of the files for this week already exists, AVO/TTCH skips this step.
4.	Once AVO/TTCH has finished searching, press the Spacebar. AVO/TTCH goes into file audit mode and sequentially displays the sessions found.
5.	In audit mode, AVO/TTCH displays the files and summary information for a single section (use the Arrow keys to scroll, or the Spacebar to move to step 6).
6.	Following the file and summary information, AVO/TTCH displays the session's vehicle frequency.
7.	If you wish to return to the beginning of the audit for the current session, press the home key. If you wish to continue auditing, press any key to scroll.
8.	AVO/TTCH then displays the next file.
9.	Once AVO/TTCH has displayed all of the sessions for that week, it returns to DOS (if you wish to end AVO/TTCH at any point, press the escape key).

Figure 2. Steps for using AVO/TTCH

Once the files for that week have been found, AVO/TTCH goes into an audit mode. The programs display the files for each day's session, indicating the file name, beginning and ending times, weather conditions, and observer comments for each count (see Appendices D and E for examples). AVO/TTCH also displays the following summary information for each session.

- <u>**# of observations**</u>: total vehicles observed
- Observations/hour: estimated hourly throughput
- Obs. % of SOVs: observed proportion of single occupant vehicles
- Hist. % of SOVs: historical proportion of single occupant vehicles and
- Chi-squared (sig): statistical significance of the difference between the observed and historical proportions

Following the audit display, AVO/TTCH displays a frequency distribution of the vehicles observed during the session, expressed in terms of the rate of vehicles observed in 2 minutes. By examining these elements, project personnel can perform an audit of

AVO and travel time observations to check observer attention, whether the files were named properly, and computer operation. For instance, if the total number of vehicles per hour is significantly different from past observations, the file may be misnamed, the computer may not have been working properly, or the observer may have entered incorrect data during the session.

We monitor data quality according to the number of error-free files and the number of usable and unusable sessions they produce. Usable files are those that contain erroneous data but can be repaired by editing. Unusable files are files that either contain a combination of data errors or have too few data. In unusable files, the invalid data produce program faults, or there are so many errors that editing the file leaves too few data for the file to be usable. Files with too few data are generally defined as files that have fewer than 100 bytes. Up to (slightly beyond) this size, AVO and travel time files contain few data other than the file information logged at the start of "CT." Empty files or files with too little information exist for a number of reasons; usually the problem is due to the observer exiting the program before any data have been collected (often because of a computer malfunction). Although most data files are error-free, they must be audited to determine the existence of the following data quality problems:

a. outlying observations in a count
b. files with erroneous data
c. counts with lengthy or multiple time gaps
d. files containing low amounts of information
e. test counts
f. misnamed files

Except in instances of c, d, or e, or multiple instances of a or b, most problematic AVO data files are repairable. Once a problematic file has been located, repairing it is usually a simple matter of editing out the bad data, changing the file name, or deleting the file. If a file is deleted, the subdirectory listing must then be updated by either 1) editing it to remove the name(s) of the deleted file(s), or 2) deleting it entirely and running AVO/TTCH again for that week.

Any of these above problems dramatically reduce the reliability of the data. AVO/TTCH aids in the detection of files that contain potentially erroneous or "outlying" data (e.g., observations exceeding the normal distribution of a frequency spread). The program aids file detection in the following two ways: 1) it indicates when the number of observations exceeds 100 vehicles in a 2-minute period; and 2) it displays a plot of observation frequency for the session (see Appendix F). The likelihood of observing more than 100 vehicles in a single lane over a 2-minute period is exceedingly small, given the limits of the vehicle-carrying capacity of the lane. We can therefore interpret exceedingly high frequencies to be spurious observations that have resulted from a sticking computer key or an observer accidentally holding down a key. Frequency graphs of the sessions are useful because they can provide us with a picture of the throughput trend for the location in question. For evaluative purposes, this is useful because the programs can display extreme values that may be outliers but that do not exceed the "100 observations" threshold. In either instance, the erroneous files are noted and the extreme values are deleted.

The general procedure for editing or "cleaning" data files is to note the file name in which the "spike" occurred, along with the time range of the spike. The suspect file is then opened in an ASCII text editor and scanned until the erroneous range is found. This is easily done by converting the 24-hour time displayed in AVO/TTCH to seconds by multiplying it by 3,600 and then searching for a match. In AVO files, the erroneous data are easily located in conjunction with the time count because they show up as a string of consistent observation values in the data column (usually "1s"), and during the period, the count changes little in comparison to other areas of the data string. Another way to locate erroneous data is to scan the file while scrolling the text at a high speed: the anomalous text shows up as a uniform string of data. Correcting the data is then a matter of deleting the string from the series. To confirm the removal of the spike, the file is then reaudited; if necessary, the process is repeated.

A variant of the outlying observations problem occurs when AVO/TTCHs summary information indicates sessions with a negative number of observations, but the graph displayed contains multiple plots. This problems happens when observers erroneously set the time in CT. It is usually accompanied by abnormal time indications, either by total session times of "0:00" duration or by count start times that are later than their end times. Operators can repair files with erroneous data by opening them in a text editor and scanning the data stream until they find and delete the time error. Another variant of this problem is that AVO/TTCH may skip a file belonging to a session when it displays the summary information. The audit appears to be normal except that there is a large time gap, or the individual counts appear to be out of sequence. A way to confirm this error is to compare the number of session files displayed with the actual number of files in the subdirectory and then to edit the displayed session files in a text editor to ensure that the beginning and end times for each count do not overlap. The displayed session files must then be renamed so that their times are in sequence for the session.

The greatest problem with observation files occurs when they do not contain enough data. This is especially problematic for travel time files, which rely upon large numbers of observations to generate matches. While files can be "cleaned" in instances of "bad data," files containing few data have nothing to be cleaned and therefore must be deleted. AVO/TTCH highlights files with too few data by identifying time gaps between counts that are greater than 2 minutes long and indicates their length in minutes and seconds. This feature also allows us to monitor the performance of observers because it indicates exactly when an observer began and ended a count. File auditing therefore helps us to verify whether a count was performed at all.

Although AVO/TTCH is useful for examining individual files for data integrity, the quality of travel time data is tested by pairing the files and matching the observations within. Because evaluating travel time data requires the additional step of matching observations among multiple data files across a number of parameters, travel time files must be examined in pairs as well as individually. Travel time files are evaluated according to 1) the proportion of actual counts performed and 2) the number of license plate matches generated for the respective parameters. Travel time observations are matched by corridor, commute time, and traffic flow observed at originating and terminal sites.

We track data quality weekly, monitoring the proportion of sessions completed to sessions scheduled, the proportion of valid data sessions, the number of data files produced for each location, the proportion of hand-counts, and the proportion of erroneous files. We then summarize the collected data monthly and quarterly. Files are audited with the AVO/TTCH programs before they are used. Erroneous files are either edited before they are used or are deleted. The information from the weekly data check is then used to monitor program effectiveness, check observer performance, and direct the location and use of observation sites. This method, when used in conjunction with data extraction software, enables us to more effectively manage the collection process, ensure quality, direct information inquiries, and measure performance.

DATA AVAILABLE

From July 1, 1992, through July 5, 1993, we had accumulated data from 1,415 observation sessions (out of a total of 1,644 scheduled sessions). The data files take up approximately 18 MB of disk space and are contained in 53 subdirectories. The challenge is to present the data in a format that is useful to interested parties. When we break the 47 observation sites down by commute period and direction of traffic flow—according to AVO (ramp or mainline) or travel time—the possible number of observation site combinations increases to 154 (see Appendix F). Furthermore, the number of observation sites will likely increase. Because of this likely increase and the volume of data that is presently being collected (more than 1 million observations per year), the process of creating a procedure to track and summarize the data has become complicated; care must be taken to ensure that the information is summarized meaningfully.

We have received numerous requests for information, most of which have come from WSDOT's Traffic Operations and Public Affairs Offices for District 1. The information supplied has been used to monitor the effects of HOV system policy and has been incorporated into responses to citizen inquiries to explain HOV lane policy as well. These data are available for use by Metropolitan Planning Organizations in their efforts to plan transportation needs by modeling traffic impacts. In response to these requests for information, programs designed to summarize AVO and Travel time data have been developed. The following two sections discuss the methods by which AVO and travel time data collection and analysis differ and indicate the data that have been collected to date.

CHAPTER THREE

VEHICLE OCCUPANCY

The purpose of gathering vehicle occupancy data is to develop profiles of commute patterns, congestion (vehicle throughput), and average number of riders along commuter routes in general purpose (GP) lanes and HOV lanes. Beginning with this project, these data will provide a measure of how HOV facilities affect congestion in the Puget Sound region over time. For the greatest cost-effective use of personnel and resources, data are collected from prespecified locations during peak commute periods, rather than randomly for all locations at each time of day.

DATA COLLECTION

Observers record vehicle type and occupancy using CT (figure 1a). The AVO portion of CT records the vehicle type, the number of people in a passenger vehicle, and the exact time of the observation (number of seconds after midnight) (see Appendix G). After CT creates the data file, observers select the length of time they want the count to run, up to a maximum of 30 minutes (the usual value). Once started, while the program counts down the number of seconds that have elapsed, observers record every passing vehicle by using a number from 0 to 9 (depending on the type) as follows:

1 = 1-person passenger vehicle
2 = 2-person passenger vehicle
3 = 3-person passenger vehicle
4 = 4-person or more passenger vehicle
5 = Vanpool
6 = Transit bus (King County,* Community Transit, Pierce Transit)
7 = Other bus (school, Greyhound, airport shuttles, etc.)
8 = 2-axle truck (delivery trucks, recreational vehicles, etc.)
9 = 3-axle truck (or larger—semi-trucks, construction vehicles, etc.)
0 = Motorcycles

---

* Department of Metropolitan Services

At the end of the count, the observer restarts the program and begins another count, repeating the process until the session has been completed. CT automatically sequences the middle digit of the file name's extension so that the data files are not overwritten.

Observation sessions consist of three to five individual counts (each 30 minutes long), between which observers are encouraged to take 5- to 10-minute breaks. This timing is based on previous WSDOT supported research (Ulberg and McCormack 1991). Sessions consist of mainline or access ramp observations, depending on the site's location and season of the year. Observers conduct mainline sessions by watching vehicles traveling in a given lane, for each lane of an observation site (see Appendix H for a list of locations). The observer begins the session with a predetermined lane, cycling through the remainder until at least one count has been performed for each lane. Data from a single lane constitute an entire session. Data for access ramp sessions, on the other hand, consist of multiple counts conducted at the same ramp. Here, the observer notes every vehicle that passes, regardless of the number of lanes the ramp may have. The primary data of interest are obtained from mainline sessions. However, as a result of poor light conditions, ramp sessions have been used because of the greater visibility they provide.

It is important that observers have an unobstructed view of the interior of passing vehicles to be able to count the number of passengers. Since every vehicle already has a driver, it is preferred that observers be located so they can see the passenger seat occupancy. Tinted windows, windshield glare, and loss of sunlight make AVO observations difficult to conduct reliably. This problem is especially acute during winter months when light is limited during the mornings and evenings. Rain or snow limit visibility as well. The method we found to compensate for these impediments was to establish counts at ramp locations during the winter months. At ramps, overhead lighting enables observers to see inside passing vehicles (Ulberg and Farnsworth 1992). Because this method's relationship to observing mainline vehicle occupancy is unknown, we need to determine how representative ramp observations are of mainline conditions. Therefore, we are collecting both types of data so that we can study the relationship between observed traffic at the different locations. This information will then be used to evaluate the method.

METHOD

Technical problems with the computers and disks are unavoidable. In the case of a computer or disk malfunction, observers perform 30-minute manual counts using forms created for this purpose; the forms are available in "write-in-the-rain" paper. After logging the appropriate session information (listed above), the observer records the vehicle occupancy by making tick marks under appropriate columns for the type of occupancy observed. These hand-counts are then entered in an ASCII format (see Appendix I), which is later transformed by another program into a format that resembles the observations normally logged with CT (see figure 3). This format transformation is done so that the vehicle frequencies of the hand-count will resemble those normally observed, and so that data files can be properly audited using AVOCH and analyzed using AA.

1. 2.	Open PLATE.DXC in a text editor. Using the hand-count forms for a session, enter the data from each form into a separate count section.
3.	Save the session in the root directory naming the file according to its location, site, commute time, and direction.
4.	Repeat steps 1-3 until all forms have been entered.
5.	Create a directory of the hand-count files and name it **flist**.
6.	Edit the list to leave only the file names and transfer it to the same directory as MAKEAVO.
7.	Run MAKEAVO.
8.	MAKEAVO searches the root directory for each file contained in **flist**. When it finds a file, MAKEAVO displays the file's name and the corresponding existing files.
9.	MAKEAVO then updates the file's extension and saves it to the root directory.
10.	MAKEAVO repeats steps 8 and 9 and ends when the list has been exhausted.

(see Appendix J for a sample display of MAKEAVO and a sample file.)

Figure 3. Steps for converting manual AVO counts

The ASCII file used is named "PLATE.DXC." which is later renamed to resemble an AVO session file, except that the count digit is replaced with an "X" (e.g., "1407152a.nXs" rather than "1407152a.n0s"). The digit replacement is done to distinguish the unconverted hand-count files from computer entered data files and because one hand-count file, comprising a number of individual counts, contains the data for an entire session (as opposed to computer entered data files, where each, in and of itself, is an individual count). Each count contains the observer's name, weather conditions, comments, beginning and ending times, and the number of observations for each observation type.

The ASCII files are grouped into a single subdirectory, a directory of the files is made, and the conversion program is run (the conversion program must be located in the same root directory as the directory list).

The conversion program, called "MAKEAVO", reads the ASCII file data, randomly distributing the observations for each count of the session between the count's respective beginning and end times. MAKEAVO then names the newly created count and saves it in its appropriate subdirectory, first checking to determine whether a file of a similar name exists. If one or more similar files exist, MAKEAVO updates the converted file's count digit to follow the sequence of the existing files. MAKEAVO does this for each count within the session before proceeding to the next ASCII file.

DATA ANALYSIS

To summarize and provide customized access to data, a program called "AA" was developed for this project. With this program, we are able to extract summary information using a variety of parameter combinations (see Appendix J). Use of AA requires that several programs be installed in the root directory of the disk drive containing the observation data subdirectories.

a. CLEARAVO—creates disk space for MAVOCOMP

b. AVONAMES—a data file containing all possible data file names

c. MAVOCOMP—creates AVOCOMP

d. AVOCOMP—a batch file that creates a file listing from the subdirectories for the quarter in questions and that runs MKAVOLST and AVOSTORE

e. MKAVOLST—formats the list of data files found by AVOCOMP and names them "AVOLIST" (later converted to a quarter-specific filename, such as "392.lst" for the third quarter of the year 1992).

f. AVOSTORE—creates a compressed, quarterly data file by using the listing created by MKAVOLST to extract data from individual files. The hard disk must contain at least 2.24 megabytes of continuous disk space per quarter of data for AVOSTORE to work properly.

Figure 4 indicates the sequence in which these programs are used to prepare one quarter of data for analysis. To compress the multiple quarters of data for analysis, steps 2 through 4 must be repeated for each quarter.

Using AA (figure 5), we are able to summarize data for the following variables (see Appendix K for examples):

- number of occurrences of every vehicle type observed
- proportion of total observations that every vehicle type occurs
- total number of vehicles observed

1.	Run CLEARAVO. (Displays percentage complete at the bottom of the screen.)
2.	Run MAVOCOMP.
3.	MAVOCOMP asks for the desired quarter (1-4) and year (e.g., 92) together, e.g., "392". Press <enter>.
4.	Run AVOCOMP.
5.	AVOCOMP creates a list of data files for that quarter, named ***.lst**, where * represents the selected quarter.
6.	AVOCOMP runs **MKAVOLST**.
7.	MKAVOLST converts **AVOLST** into a format named ***.lst**.
8.	AVOCOMP runs AVOSTORE.
9.	AVOSTORE displays the cumulative number of observations for vehicle type (purple), total observations (yellow), number of data files (red), and the maximum number of data bits per cell (white).
10.	When AVOSTORE is finished, it displays the number of locations and the names of the new observation locations found.

Figure 4. Steps for preparing summary information files for AA

1.	Run AA.
2.	AA displays seven possible parameters, as follows: a. Quarter b. Highway corridor c. Site location d. Time of commute e. Direction of travel f. Type of count g. Day
3.	Move among the options by using the arrow keys.
4.	Select the parameters for the desired information by using the **<spacebar>**. Press **<enter>** when finished.
5.	AA searches the compressed files for the desired information. If no data are found, it displays a message.
6.	If AA finds data, it displays summary information (mentioned above).
7.	Either exit the program using the **<escape>** key, or select another set of parameters.

Figure 5. Steps for using AA

- average vehicle occupancy—this figure is calculated without including bus or van data ("4+" vehicles are weighted as being "4.1" for the purposes of this study)

For further analysis, AA is able to export the summary information into an ASCII file.

AVAILABLE DATA THROUGH SECOND QUARTER 1993

As of July 5, 1993, out of a possible 919 scheduled sessions, we had compiled data from 839 sessions (91 percent); 105 (11 percent) were from hand count sessions. (For a table, see Appendix L.) Of the 835 sessions, 232 (28 percent) were from mainline locations, and 607 (72 percent) were from access ramp locations. There were more data from access ramp than mainline observations because of the season in which these observations were conducted. Because the majority of sessions were conducted during the autumn and winter, the light conditions necessitated that more access ramp than mainline ramp locations be scheduled (636 observations (69 percent) versus 283 observations (31 percent), respectively).

As a measure of efficiency, we compared the number of scheduled observation sessions to the number of actual session data (as well as their qualities). For this period, the number of completed sessions (839) amounted to 91 percent of those sessions scheduled (919); 832 of the completed sessions (99 percent) contained quality data. For mainline sessions, of the 283 sessions scheduled, 232 session (82 percent) were completed, and 231 (99 percent) contained quality data. For access ramp observations, of the 636 sessions scheduled, 607 sessions (95 percent) were conducted, and 601 (99 percent) contained quality data. The quantity of ramp and mainline data was high because AVO observations were substituted when travel time observations could not be conducted as scheduled. In all, over 1 million vehicles were observed during this time.

CHAPTER FOUR

TRAVEL TIME OBSERVATIONS

Travel time observations are used to estimate the speed and flow of traffic in the general purpose (GP) and HOV lanes. These data are also used to estimate and compare the travel time savings between the two lane types. By comparing the lane types one can measure the relative travel time savings offered by HOV lanes and ensure that HOV lane policy is being upheld.

METHOD

Data collected from travel time observations are used to measure the average speed and time vehicles take to travel from one observation point to another. The speed of a vehicle that is observed at point "A" at a certain time and then at point "B" a few minutes later can be estimated when the distance between the two points is known. There are 25 pairs of travel time sites which generate 63 pairs of parameters when the direction of traffic and the commute time are taken into account (see Appendix M for a list of current locations). Observations are scheduled at consecutive sites along the same corridor. Travel time sessions differ from AVO sessions in that they require at least two observers instead of one. For efficiency, several observers are usually scheduled at the same time in a corridor; this allows the data collected from one site to be used more than once. To accurately estimate the time a vehicle takes to travel between two sites, the observers' computers must be time-synchronized. The distance between observation points is established from the WSDOT's State Highway Log (WSDOT 1992).

The travel time module of CT is designed to allow observers to record partial license plate numbers at the exact time the vehicle is observed (similar to the method in the AVO module; figure 1b). Observers first enter relevant session information (as with the AVO module) and then enter partial license plate numbers of vehicles traveling in the fast (inside) lane of non-HOV traffic (see Appendix N). The information recorded consists of the first three numbers of a license plate. immediately followed by the first letter to the right (e.g., "123-ABC" would be entered as "123A"). License plate numbers are drawn exclusively from Washington state plates bearing the image of Mt. Rainier. We chose this method to increase the number of successful matches. Typically, about 10 percent of the license numbers collected are matched. Observers also record the vehicle identification numbers of King County (Department of Metropolitan Services). Community Transit, and Pierce Transit buses traveling in both the fast and HOV lanes. Bus numbers can be distinguished from license plate "partials" because they contain no letters. As with the AVO data, once a week's worth of data has been recorded, the files are copied into their respective weekly subdirectory for analysis.

DATA QUALITY

In addition to being individually audited by TTCH, files must be matched according to the travel time parameters, and the matches edited to ensure "clean" data. The editing program, "SPEED" and "SPEEDM" (a mouse version), was designed to locate the pairs of files that fit the site parameters. The program displays the license plate matches found therein (Appendix O). The observations are displayed as a plot of the average speeds of vehicles (the y-axis) and as a function of the time they were observed (the x-axis) (Appendices P and Q). This is done separately for both the general purpose (GP) and HOV lanes.

SPEED matches the travel time sessions for the selected quarter using an ASCII list of the data files for that quarter (the list is named "travtime.*", where the extension represents the quarter and year; for example, "travtime.392" represents the third quarter for the 1992 list). The ASCII file must contain the names of all the travel time files in the quarter for the program to operate properly. When SPEED is executed, it leads the user through a series of menus to select the corridor, location, period of commute, direction, and date of observation session. SPEED proceeds to match the license plate "partials" of the selected files, using the difference between the corresponding times and the distance between the sites, to estimate each vehicle's speed. SPEED then displays a plot of calculated speeds. The user then cleans the file by removing the outlying and spurious matches. The remaining "good" matches are saved in a new file, which is given a unique name based on the location parameters, date, commute period, and direction of commute (see Appendices R and S for examples). The session file "match" is then placed in its respective subdirectory. Steps for using SPEED and SPEEDM are indicated in figures 6 and 7 below.

Once the travel time match files have been created, travel time trends can be examined for each quarter using a program called "TA". Using the match files created by

1.	Run SPEED
2.	SPEED displays a menu of available quarters from which to choose. Select the desired quarter using the <⇑> and <⇓> arrow keys to highlight the quarter and depress the **<spacebar>** to proceed through the following.
3.	SPEED then displays a menu of parameters from which to choose.
4.	SPEED then displays a menu of observation session dates from which to choose. Type "HOV" or "GP" next to the date, depending on whether a match file exists for that date. If this is the first time that a particular date is being examined, there will be no indication that files exist until after the date is audited.
5.	SPEED will search the respective files for the desired information. If no data are found, SPEED displays a message, "No matches."
6.	If SPEED finds data, it plots the time observed and average speed for all matches.
7.	To remove outliers, the user can, enter the maximum and minimum speeds.
8.	SPEED then produces a new plot to reflect the changed values. The user can repeat the process until most outliers have been eliminated.
9.	To remove additional outlying observations, the user can employ the arrow keys to draw a border around the "good" observations.
10.	To accept the plot, press **<enter>**. SPEED then highlights the selected plot and asks you to press **"a"** to accept the plot as is.
11.	SPEED then saves the edited file in the subdirectory for that week; if a previous version of the edited file exists, SPEED will ask whether you wish to override the file or not. Enter **"y"** to accept, any other key to proceed to the next step.
12.	You may then select another set of parameters (using the **<spacebar>**) or exit the program, using **<escape>** to successively back out of the levels.

Figure 6. Steps for using SPEED

1.	Run SPEEDM
2.	SPEEDM displays a menu of available quarters from which to choose. Select the desired quarter using the <⇑> and <⇓> arrow keys to highlight the quarter and depress the **<spacebar>** to proceed through the following.
3.	SPEEDM then displays a menu of parameters from which to choose.
4.	SPEEDM then displays a menu of observation session dates from which to choose. Type "HOV" or "GP" next to the date, depending on whether a match file exists for that date. If this is the first time that a particular date is being examined, there will be no indication that files exist until after the date is audited.
5.	SPEEDM will search the respective files for the desired information. If no data are found, it displays a message, "No matches."
6.	If SPEEDM finds data, it plots the time observed and average speed for all matches.
7.	To remove outliers, the user can enter the maximum and minimum speeds (negative values are acceptable). If **<enter>** is selected without maximum and minimum values, SPEED proceeds to step 7.
8.	SPEEDM will then produce a new plot to reflect the changed values. The user can repeat the process until most outliers have been eliminated.
9.	SPEEDM displays the message, "Use mouse to draw acceptable limits." To remove outlying observations, the user can use a mouse to draw a line between acceptable and unacceptable observations, beginning from the upper left-hand corner. Once the end of the screen is reached, the line will wrap across the bottom of the screen (as with SPEED). If you make a mistake, clicking the mouse button once will erase the line you've drawn and return you to the beginning of the step
10.	SPEEDM then highlights the acceptable observations, and displays the following options in the upper right-hand corner of the screen: • accept--accepts the matches (step 9) • next--proceeds to the next parameter set without saving the matches • limits--repeats, beginning with step 4 • lines--repeats, beginning with step 7
11.	SPEEDM then saves the edited file in the subdirectory for that week; if a previous version of the edited file exists, SPEEDM will ask whether you wish to override the file or not. Enter **"y"** to accept, any other key to proceed to the next step.
12.	You may then select another set of parameters (using the **<spacebar>**) or exit the program, using **<escape>** to successively back out of the levels.

Figure 7. Steps for using SPEEDM (mouse version of SPEED)

SPEEDM, TA indicates the number of sessions that exist for pairs of sites under both GP and HOV lanes, and then allows the user to compare the difference in vehicle speeds between the two lanes. TA first displays three charts, one each for the GP and HOV lanes, and then one that combines the two (see Appendix T). The charts show a plot for each day that a successful session was conducted, indicating the speed and time at which the vehicles were observed. TA then displays summary information, indicating the number of observations, the travel time difference between HOV and GP lanes, and the statistical significance of the results. This information can also be exported to an ASCII file for analysis. Steps for using TA are indicated below (figure 8).

AVAILABLE DATA THROUGH FIRST QUARTER 1993

As of July 5, 1993, of a possible 725 scheduled sessions, we had compiled data from 581 sessions (80 percent) (see Appendix T for a table of session data). Of these, 459 (79 percent) contained quality data. The files from the sessions providing quality data have produced 400 matched pairs (87 percent), of which 258 (65 percent) have generated valid travel time information. Therefore, of the 459 sessions compiled, only 56 percent generated usable data.

These figures are low for a couple of reasons. First, a high amount of observer coordination is required. Travel time observations require at least two observers to be successful; if one member of a pair of travel time observers is unavailable, or has computer trouble, the session must be canceled. The computers the observers use must also be time-synchronized. Second, a limited number of license plates are gathered from

1.	Run TA
2.	TA displays a menu of available quarters from which to choose. Select the desired quarter using the <⇑> and <⇓> arrow keys to highlight the quarter and depress the **<spacebar>** to proceed through the following.
3.	TA then displays a menu of parameters from which to choose, including the number of files for both HOV- and general purpose- lanes for each parameter.
4.	Using the data from the match files, TA then displays three successive charts of travel time frequencies, indicating the observation session date for each plot, as follows: a. HOV lane (green) b. General Purpose lanes (red) c. HOV- and General Purpose lanes, superimposed
5.	You may then select another set of parameters by pressing the **<spacebar>**, or exit the program using **<escape>** to successively back out of the program.

Figure 8. Steps for using TA

only one lane of traffic. This restricts the number of possible matches to only those vehicles that remain in that particular lane across the observation points: a vehicle observed at point "A" can only be matched if it is again observed at point "B." As distances between the data points increase, the number of valid matches decreases because commuters have more opportunity to change lanes and enter and exit the freeway.

Another problem that contributes to these low session figures is the uncertain reliability of the data. Because the variance in speed changes greatly from day to day, many observations are required to obtain statistically significant results. Travel time sessions, because they require two observers, cost more than AVO observations. If one observer is absent and a substitute cannot be found, the session must be canceled (the single observer is relegated to making AVO observations). Furthermore, if either observer has computer problems or makes errors while recording observations, the data are lost. The end result is that, although individual data sessions are accurate, matched sessions (valid average speeds) are very expensive to produce.

Other methods that could potentially be used for travel time data collection include the Department of Metropolitan Services's (King County) automatic vehicle location (AVL) system, an automatic transit location system (ATLS) being explored by Haselkorn and Dailey, or a video image tracking system being investigated by Nihan. King County's AVL system uses inductance loop detectors to monitor transit operations, obtaining travel information. The ATLS program would use global positioning system (GPS) technology in conjunction with the TIGER map (GIS) system to provide real-time transit information (Haselkorn and Daily 1993:1-2). Either of these systems, if accessed with the appropriate software, could provide travel time information. This software would first have to be developed, however, and in the case of the ATLS program, would require a substantial capital outlay ($1 to $4 million) to purchase the GPS receivers (Hallenbeck 1994). The video image tracking system would rely on pairs of video image recorders to detect and track passing vehicles to determine their speed. This system also is in its planning stage, with tracking units costing $50,000 per pair (Nihan 1993:1-2). In short, regardless of whether we rely on human observers or automated systems, efficient travel time estimation and monitoring of HOV and GP lanes is expensive, and not fully developed, technology. In consideration of these difficulties, we recommend that for the immediate future, travel time evaluations be only used for special studies, such as two- to three-month long efforts to assess the impact of changing occupancy requirements along a particular corridor.

CHAPTER FIVE

SURVEY OF PUBLIC PERCEPTION OF HOV LANES

Knowledge of public opinion concerning the effectiveness and desirability of high occupancy vehicle lanes is critical to HOV program evaluation and to HOV lane planning. This information provides a valuable complement to the travel time and average vehicle occupancy data we have collected so far. This section describes the opinion survey data collection and analysis procedures and provides some preliminary findings.

To measure public perception of HOV lanes we have been mailing surveys to randomly selected vehicle owners who drive in corridors where HOV lanes already exist. Because these individuals have direct experience traveling on HOV lanes or on roadways that have HOV lanes, they provide the most relevant points of view concerning the effectiveness of HOV lanes. They also provide a fairly broad cross section of public opinion about HOV lanes in general.

The surveys are coded for the highway corridor where the motorist was observed and for the occupancy of the vehicle. Through the end of June 1993, we had sent surveys to 5,444 registered vehicle owners. Thirty-two percent of those who received surveys responded, giving us a sample of 1,761 motorists (see Appendix U for a copy of the public opinion survey).

The public opinion survey is intended to generate the following three primary types of data.

- Commuter Profiles. A commuter profile is made up of mode choice, commute route, and history of HOV lane use.
- Commuter Opinions. Survey respondents are asked to provide their opinions on a variety of HOV-related issues. These issues range from support for the HOV lane program and travel time savings to safety and enforcement. Respondents are also asked to prioritize options for making HOV lanes more attractive for carpooling or bus riding.

- Demographic Information. The survey asks for information on respondents' gender, age, and education level. This section also provides data about the domestic conditions of respondents (i.e., number of people living in their house, the number of people who work outside the house, etc.).

PROCEDURE

The data collection procedure is a complex process that comprises 15 steps. A significant part of the complexity in this process comes from the fact that the information necessary to solicit public opinion takes many forms. These forms include hand-written license plate logs, several computer formats, and survey responses. A graduate research assistant coordinates the data collection and analysis processes, with assistance from the observer manager and principal investigator. The data collection process includes the following steps:

1. license plate number collection by traffic observers in the field
2. weekly aggregation of license plate numbers for entry
3. license plate number entry in the Department of Licensing data request format
4. data transmission to WSDOT via electronic mail
5. matching license plate numbers to the names and addresses of registered vehicle owners at the Department of Licensing
6. data transmission from WSDOT to TRAC via electronic mail
7. data conversion from Macintosh to DOS format
8. transformation of data into address label format, using a computer program developed for this study
9. identification and deletion of duplicate license plate numbers to avoid sending a vehicle owner two surveys (accomplished with another computer program)
10. deletion of other addresses not to receive surveys
11. production of mailing labels
12. stuffing appropriate surveys into mailing envelopes and mailing them
13. collection of returned surveys

14. entry of surveys into statistical program for analysis

15. analysis of data

Three weeks are generally needed for the process to run its course. Over time, we have resolved several inefficiencies and problems in the process. The data collection process is described in detail below.

License Plate Number Collection and Data Transmission

During each shift, each traffic observer collects the full license plate numbers for five high occupancy vehicles and five single occupant vehicles. Various data collection points and differing times of collection help generate a representative sample of the region's commuters. Daily license plate collections are aggregated at the end of each week. After 200 to 500 license plate numbers have been gathered, data entry staff (made up of traffic observers) enter the license numbers into a Macintosh computer. We use a Macintosh because the electronic mail system that links TRAC to WSDOT uses Microsoft Mail. The data are entered according to a Washington State Department of Licensing data request format, which includes codes for designating the corridor collection point and observed vehicle occupancy designation for each entry (See Appendix V for the Department of Licensing Information Systems Record Layout).

The corridor and occupancy code is a two digit number. The first digit represents the highway corridor in which the vehicle was observed. The second digit designates the observed occupancy of the vehicle. The codes are assigned as follows.

First Digit

1 = I-5 north of Northgate
2 = I-5 between Northgate and Southcenter
3 = I-5 south of Southcenter
4 = SR 520
5 = I-90
6 = I-405

Second Digit

1 = HOV
2 = SOV

For example, a car observed on I-5 south of Southcenter that carried two or more passengers would be designated as "31". An SOV observed in the same area would be designated as "32".

The data files are then sent via electronic mail to the Department of Transportation Planning Office. That office submits the data request to the Department of Licensing, which matches the names and addresses of registered owners to the vehicles observed in the field. WSDOT staff then send the data back to TRAC via electronic mail.

Data Transformation and Label Generation

The license plate collection and data transmission functions are the most time-consuming steps in the process. The remaining work involves putting the data we receive into a usable form and sending the appropriate surveys to the drivers of the automobiles we observe in the field. Putting the data into a usable form requires a series of "cleaning" steps. The cleaning process removes addresses of vehicle owners who have already received opinion surveys from the mailing list. Cleaning the data also includes removing corporate, rental, and out-of-region vehicle owners from the mailing list.

Once we receive the data from WSDOT, the data are converted to a DOS format using the Apple File Exchange program. We must transfer the data to a DOS format because all data manipulation, storage, and analysis occur on IBM-compatible machines. Once in DOS, the data are run through a computer program called MADDR for "Make Address," described in figure 9. MADDR rearranges the data for each entry and strips out irrelevant information. Such information includes the auto make and model, the vehicle's serial number, and other registration information. The MADDR program was developed exclusively for this project.

The MADDR program leaves each entry containing an HOV/SOV code, the license plate number, the name of the vehicle's registered owner, and the owner's address. A series of steps to "clean" the list of license plate numbers and registered owners follows. The complete file is copied and all data other than the license plate numbers are deleted from the duplicate file. The new list of license plate numbers is then compared to a comprehensive list of license plate numbers of vehicle owners who have already been sent surveys. This procedure utilizes another computer program written for this project, called DUPCHECK. The procedure for using DUPCHECK is described in figure 10.

Duplicate license plate numbers are identified and the associated addresses are removed from the original file. Less than 1 percent of the license plate numbers collected so far have been duplicates. Each week's list of license plates is then added to the comprehensive license plate list for future duplicate verification. The original list of registered owners and addresses is then checked to identify corporate cars, rental cars, and out-of-region owners. These addresses are deleted from the file. Some 3 percent to 5 percent of all license plate numbers recorded fall into these three categories. Thus, 4 percent to 6 percent of all license plate numbers recorded in the field are deleted from the mailing list.

1.	Copy new license plate file to computer directory that includes MADDR.
2.	Type "MADDR".
3.	MADDR asks that you indicate the name of the data file you wish to manipulate.
4.	The program then runs a macro to rearrange information in each entry and delete unneeded text.
5.	The program renames the file with file extension **.out** to indicate that the data have been run through the program.

Figure 9. Steps for using MADDR

1.	Copy the whole file after running MADDR program.
2.	Create a Microsoft Word macro to delete all information except the license plate numbers in the copied file. The license plate number is in the first line of each entry.
3.	Rename the duplicate file **plates.new**. Place the renamed file in the same directory as DUPCHECK and the file containing the master license plate number file, called **plates.old**.
4.	Type DUPCHECK and hit **<enter>**.
5.	The program analyzes the old and new files for duplicates within each document. The program then checks for duplicates among files. Duplicate license plate numbers appear on screen and are saved in a new text file with the generic name, **plates.dup**.
6.	Open **plates.new** and delete duplicate numbers identified in **plates.dup**.
7.	Update **plates.old** by copying contents of **plates.new** at the end of the file.

Figure 10. Steps for using DUPCHECK

Sending the Surveys

The cleaned list of addresses is then printed in mailing label form. The vehicle owners are sent surveys coded for the roadway on which they were observed and for whether they were identified as an HOV or SOV. There are 12 survey designations, reflecting the six data collection corridors and the HOV and SOV vehicle types. Batches of 250 surveys are mailed weekly. However, data processing problems at the Department of Licensing stopped the process for most of December 1992 and January 1993. To get the process back on schedule, several very large batches of surveys were mailed in February 1993 and March 1993. TRAC support staff are frequently enlisted to stuff and mail the surveys.

Preliminary Analysis and Results

Once completed surveys are returned to TRAC, they are assembled for entry into a computer-based statistical package. We developed a data entry module specific to this survey on the SPSS computer program. The data entry module is designed to resemble the format of the survey to reduce the ambiguity of taking data from a written page and recording it on a computer screen. Three traffic observers are responsible for inputting the data. Each of the data entry personnel received a two-hour training session. A comprehensive manual for the data entry process was also prepared (see Appendix W). Data entry personnel now enter the surveys at a rate of about one survey per minute.

Several additional codes are added to the information contained in the survey. First, each survey is assigned a record number to facilitate record keeping. The record number is written on each document's back sheet and entered into the computer file. This process helps to ensure the integrity of the data by allowing personnel to identify non-conforming entries and refer back to the original document. Data entry personnel are assigned sets of record numbers so their work may be measured and evaluated. A second additional entry for each survey is the return date. Recording the return postage date stamped on each survey allows us to measure trends in responses over time. Each data entry session is saved as an individual file. The research assistant combines the individual files weekly for storage and analysis.

The survey is designed to allow several types of data analysis. We may examine the nature of respondents' commute patterns, their opinions about HOV lanes, and demographic data. The data are analyzed on SPSS mainly with frequency and cross-tabulation techniques. We plan to utilize a cluster analysis method to identify prevalent characteristics and attitudes of HOV and SOV drivers. The survey results may also be analyzed for trends over time. Another data analysis method is to compare the highway corridors in which commuters were observed to the corridors respondents claim to use in their normal commutes. Responses may also be compared to demographic data such as education level, age, and gender.

SURVEY CHARACTERISTICS

The anonymous survey we send selected commuters is designed to elicit information about commuters' travel patterns and preferences. It is also intended to uncover commuters' perceptions of HOV lane use and effectiveness. These public opinion data will be a valuable complement to the average vehicle occupancy and travel time data collected in other parts of this project.

The questionnaire is divided into three parts. In the first section commuters are asked to describe their commuting patterns. This section generates data on how many people use HOV lanes, what commuters' transit mode is when using HOV lanes, the locations of the HOV lanes they use, and the reasons they may sometimes choose not to use HOV lanes. The second section asks respondents about their opinions on a variety of issues. In the first subsection, respondents are asked to select from a list of options that would make HOV lanes more attractive for carpooling or bus riding. The second subsection asks respondents to indicate a degree of agreement or disagreement on a series of propositions. The 13 propositions address efficacy, safety, enforcement, and desirability issues associated with HOV lanes. The third section of the survey asks respondents to provide information about themselves. These demographic data help us to develop a profile of the region's commuters.

The structure of the survey is based on a survey used by a previous study of the I-5 3+ to 2+ HOV lane demonstration project (Ulberg, Farnsworth, et al. 1992). That project had already addressed many questions concerning the data such a survey could generate and the purposes of the data. In addition, this approach lowered the costs of producing the survey. Nevertheless, we are making some minor modifications to the survey. One change will be to delete the opinion question that asks about the level of support for designating all HOV lanes as 2+ instead of 3+. Because SR 520 and a small section of I-5 downtown are the only corridors under study that still have a 3+ designation, the question appears to have lost its relevance.

A second modification we will make to the survey will be to add two questions to the opinion section. The first question will ask respondents for their level of agreement with the following statement: "HOV lanes should be opened to all traffic during non-commute hours." The second question will ask the following: "Instead of building new HOV lanes, regular highway lanes should be converted to HOV lanes." We solicited the help of WSDOT staff in determining what its needs were with regards to comparing potential policy decisions about HOV lanes to public opinion.

Because we have a 33 percent response rate, we do not believe we should attempt to provide incentives for responding to the survey. Such incentives usually include mailing dollar bills to increase the likelihood of a response. In fact, the response rate is expected to improve as surveys from past mailings trickle back in. The response rate suffered because a large batch of surveys was mailed just before Christmas, a period notorious for low response rates.

RESULTS

A complete analysis of public opinion data will appear elsewhere. However, we will illustrate here how to use the public opinion data we have collected. The findings presented are significant in that they are based on over 1,800 cases. To simplify the presentation of the data we have aggregated the degrees of agreement and disagreement into categories titled agree/neutral/disagree. This categorization erodes some of the precision of our findings but serves the purposes of illustration well.

There is a general trend of support for HOV lanes and continued HOV lane construction. The data show that this general trend of support is similar for commuters who drive alone, carpoolers, and transit users. However, there are some significant differences in opinions among commuters who normally drive alone and those who do not. To illustrate the potential uses of the survey data, results have been grouped in to the following three categories: commuter profiles, support for HOV lanes, and problems with HOV lanes. Survey data are presented in the chapters concerning safety and enforcement as well.

Commuter Profiles

Early analysis has revealed an interesting fact: only 33 percent of all respondents do not usually drive alone to work, while roughly 50 percent of all surveys were sent to vehicles identified as HOV. Nineteen percent of respondents usually commute in two-person carpools. Six percent commute in carpools of three people or more. The totals for vanpools and bus ridership are very low (1 percent and 5 percent, respectively). We have not attempted thus far to survey those populations directly. Likewise, motorcyclists, bicyclists, and pedestrians are not represented in any significant way. However, the survey is generating a wealth of information concerning the commuting routes of auto users and the HOV lanes they use in the region.

Another important aspect of the commuter profile that provides valuable information about HOV lane usage is the section that addresses the reasons drivers choose not to use HOV lanes when they qualify to do so. The survey contains a series of questions that asks commuters about this issue. Fifty-three percent of respondents have qualified to use HOV lanes but have chosen not to use them. As a reason, 29 percent of respondents said that all traffic moves fast enough. Sixteen percent claimed that they forget to use the HOV lanes, and 11 percent said it is too much trouble to change lanes. Only 6 percent have chosen not to use the restricted lanes for safety reasons.

A potential use for these data is to attempt to determine the incentives that transportation planners and transit agencies may use to entice more people to carpool or use transit facilities. The data should be useful in determining the factors people like about HOV lanes and the factors that would make more people use them.

Support for HOV Lanes

Overall, support for HOV lanes is strong. Eighty-six percent of respondents agreed that HOV lanes are a good idea, 58 percent agreed strongly. Only 8 percent of respondents believed that HOV lanes are not a good idea. This public support for HOV lanes, in general, extends to future HOV lane action. Seventy-eight percent of respondents agreed that HOV lane construction should continue, while only 10 percent disagreed.

The following tables provide an illustration of the differences in support for HOV lanes between SOV commuters and HOV commuters. Cell, column, and row percentiles are given. A p-value indicating statistical significance of differences between HOV and SOV drivers and the sample size are provided below each table.

The responses shown in Table 1 suggest that, on average, people who regularly use HOV lanes believe they are easier to use than do their counterparts in single-occupant vehicles. It may be that once commuters become accustomed to driving in HOV lanes, they become used to the difficulties of changing lanes to get into HOV lanes and merging out of them when the lanes end. Even so, a majority of all respondents agree that HOV lanes are easy to use.

The data shown in Table 2 suggest that while there is overall support for future HOV lane construction, carpoolers support that proposition more strongly than

Table 1. Convenience of HOV Lanes

Proposition: HOV lanes are convenient to use.	Agree	Neutral	Disagree	% of Total
Usually rideshare	77	15	8	33
Usually drive alone	63	21	16	67
% of Total	68	19	13	100
(p < .0001, n = 1549)				

Table 2. Support for New HOV Facilities

Proposition: HOV lane construction should continue, in general.	Agree	Neutral	Disagree	% of Total
Usually rideshare	86	9	5	33
Usually drive alone	75	12	13	67
% of Total	79	11	10	100
(p < .0001, n = 1569)				

non-carpoolers. This is not surprising, as people inclined to carpool would most directly benefit from future HOV lane construction.

Problems With HOV Lanes

Table 3 compares public opinion on HOV lane usage by region. The table shows a clear trend of disagreement with the proposition; however, the chi-square statistic suggests that some regions do not reflect the general trend. The results show that commuters on I-5 North believe the HOV lanes on that roadway are being used to capacity. The HOV lanes on that section of roadway are among the older sections in the region, so it is possible that more people have decided to use the HOV lanes as traffic congestion has worsened.

Table 3. Perceptions of HOV Lane Usage

Proposition: HOV lanes are adequately used.		Agree	Neutral	Disagree	% of Total
1.	I-5 North	32	24	44	18
2.	I-5 Downtown	26	24	50	18
3.	I-5 South	23	19	58	17
4.	SR-520	22	24	54	14
5.	I-90	22	22	56	11
6.	I-405	28	20	52	22
% of Total		26	22	52	100

x^2 (chi-squared) = 16.913
($p = .0763$, $n = 1577$)

Complete data will be available in a forthcoming report. Nevertheless, the survey data have already been used to provide information concerning public opinion on HOV lanes. In the 1993 legislative session, lawmakers desired to increase enforcement of HOV lane violations were interested in a ticket-by-mail program. This survey has collected the only extensive data about public opinion on this question. Shortly after contacting TRAC for data on public opinion concerning this issue, the lawmakers found that 64 percent of those surveyed either agreed strongly or agreed with the proposition. Fourteen percent of respondents were neutral on the question, leaving roughly 20 percent of respondents in disagreement. However, the proposed legislation on enforcing HOV lane restrictions with ticket-by-mail programs failed to gain the support necessary to pass through the legislature.

Data Collection Issues

We are pleased to report that the data collection process is running efficiently and is producing results commensurate with our expectations. The response rate is higher than expected for mail-out surveys similar to this one. Nevertheless, some areas have required correction or adjustment to achieve our goals.

One issue of concern in the data collection process is the randomness of the sample we collect. For instance, some traffic observation staff have collected the license plate numbers at the end of their shift, rather than during breaks between travel time and AVO counts. Delaying the collection until the end of the shift skews the sample to weight later-hour commuters more than early- or mid-peak hour commuters. Even though this has not been a prevalent problem, we have reminded the observers to vary their license plate number collection times.

Analysis of the data must acknowledge the relative proportion of vehicles identified as HOV and SOV. The distribution of HOV and SOV vehicles counted over-represents HOVs. While the number of SOVs on the corridors observed is vastly greater than the number of HOVs, traffic counters collect equal numbers of the two types of vehicles. We collect the data this way to generate enough information for each group to analyze rather than to represent the true driving population. Any statements about overall opinions should either distinguish between the two groups or weight them appropriately.

CHAPTER SIX

SECONDARY DATA COLLECTION

The vehicle occupancy, travel time, and public opinion data collected for this project are augmented by three secondary data sets. The secondary data sets include the following: enforcement of HOV lane restrictions, accident information, and transit information. The secondary data sources will aid in developing a more comprehensive picture of the effectiveness of HOV lanes. For example, analysis of accidents data will show the safety impact of opening an HOV lane on a highway segment and the frequency of accidents on HOV lanes relative to mainline highway lanes. Each of the secondary data sets are available through agencies other than TRAC.

ENFORCEMENT, COMPLIANCE, AND ADJUDICATION

Information on enforcement and compliance with HOV definitions is necessary to understand and evaluate the HOV lane system. We are interested in identifying trends in the number, variety, and locations of HOV lane violations. The four main sources of violation and enforcement data are AVO observations, the Washington State HERO program, the Washington State Patrol, and the Washington State court system. These sources provide data on actual violations, reported violations, violators ticketed, and the penalties associated with actual violations.

The HERO program provides motorists with the means to report HOV lane violators. The HERO program utilizes a local telephone number posted at various points along roadways containing HOV lanes. Motorists who witness other motorists driving in an HOV lane without the required number of passengers in their vehicle may call the telephone number to report the violation. From the program's beginning in January 1989 through November 1992, over 73,000 violations were reported to the HERO program. HERO program personnel mailed 14,086 brochures to alleged HOV lane violators in 1992, a 7 percent increase over 1991. The Washington State Patrol sent 113 letters to repeat offenders in 1992, a 66 percent increase over 1991. The HOV lane study will collate the HERO program data for use with other sources.

Many HOV lane violators are caught and ticketed by the Washington State Patrol. Data from the Washington State circuit court system can provide information on the number of tickets issued by the WSP, the number and amount of fines paid, and the outcomes of contested cases. However, the courts data have been very difficult to obtain. Budget cuts at the Office of the Administrator of the Courts delayed our acquisition of the necessary data for several months. We are currently analyzing the data to identify any trends relevant to this project.

The public opinion survey data complement the other sources. Specifically, we seek to understand motorists' perceptions of HOV violations. These perceptions give us information on the priority of enforcement in commuters' minds and the perceived frequency of violations. One area in which there is little difference between the opinions of carpoolers and those of non-carpoolers is the issue of HOV lane restriction enforcement. The similarity in opinion on the enforcement issue is illustrated in Table 4.

The public opinion data, when combined with the HERO program data, courts data, and data from the Washington State Patrol, will provide a useful tool with which to judge HOV lane effectiveness. Violations and enforcement rates impact the efficacy of the HOV lane system. These measures, in turn, affect HOV lane planning and policy making. As noted above, the Washington State Legislature has used the public opinion data to measure the public's support of a ticket-by-mail HOV enforcement program.

Table 4. Perceptions of HOV Violation Rates

Proposition: HOV lane violations are common during rush hour.

	Agree	Neutral	Disagree	% of Total
Usually rideshare	61	24	15	33
Usually drive alone	58	25	17	67
Total	59	25	16	100

(p = .4996 no significant difference, n = 1549)

ACCIDENT INFORMATION

The safety of HOV lanes is an important concern for commuters and transportation planners alike. The opinion survey seeks to uncover public attitudes about the safety of HOV lanes. We are particularly interested in whether safety concerns deter commuters from using HOV lanes. In addition to this information, we have gathered accident data for each highway corridor we are studying. The Washington State Patrol records data on each accident that occurs on the state's highways. The accident data are then collated by WSDOT's Data Office.

Accident data provides measures of safety impacts and congestion impacts before and after HOV lanes have been opened. WSDOT's Data Office was helpful in defining the necessary data on accidents involving HOV lanes. The parameters include information on the location of the accident, occupancy of vehicles involved, traffic conditions before and after the accident, road design, weather and light conditions, time of day, proximity of accident to the driver's residence, and other circumstances contributing to the accident.

The data search was hampered by problems in gathering the data necessary to provide WSDOT with sufficient search parameters. The definition of the relevant highway segments requires identifying the exact mileposts associated with each HOV lane segment, the lane number within that segment, and the opening date of each HOV lane. One beneficial outcome of this data search has been the development of an HOV lane fact sheet for the highway segments we are studying. This fact sheet compiles precise lane locations, segment lengths, lane positions on the roadway, occupancy designations, and opening dates. The fact sheet is included in Appendix X.

Once the parameters of the search had been defined, the data office quickly generated the data relevant to this project using the WSDOT data bank. WSDOT initially returned the data in written form, which would have made statistical analysis very cumbersome. To make the analysis more efficient we had the data written to a set of computer disks. WSDOT's Data Office downloaded the accident data onto 12 separate computer text files, one file for each HOV lane segment covered by this project.

WSDOT supplied us with data on 16,444 accidents. The Data Office reported that 829, or 5 percent, of these accidents involved HOV lanes. Each case contained 170 variable values, only 50 of which are relevant to this study. These 50 values represent data for 28 variables. The research assistant in charge of survey management created a Macro on a word processing program to remove irrelevant variable values. The 28 remaining variables are listed below.

- Year
- Month
- Day
- Day of week
- Hour
- Minute
- State route number
- Milepost number
- HOV lane code
- Approximate accident location (when reported location is vague)
- Accident severity
- Number of injuries
- Number of fatalities
- Roadway surface conditions
- Number of vehicles involved
- Weather conditions
- Light conditions
- Impact location code (indicates exact location of accident on roadway layout)
- Collision type
- Driver 1's residence proximity
- Driver 2's residence proximity
- Driver 3's residence proximity
- Driver 1's first cause for accident
- Driver 1's second cause for accident
- Driver 2's first cause for accident
- Driver 2's second cause for accident
- Driver 3's first cause for accident
- Driver 3's second cause for accident

We are using several methods to measure the safety of HOV lanes. We are primarily interested in how opening an HOV lane affects the rate of accidents on individual roadway segments. We have collected data for the two years preceding the opening date for each HOV lane to provide this comparison. We also plan to measure the effect of seasonal, light, and weather conditions on HOV lane accident rates.

The public opinion survey devotes several questions to the issue of safety. There is no clear indication that the public believes HOV lanes are inherently unsafe. Only

28 percent of respondents selected making HOV lanes wider and safer as an option to make HOV lanes more attractive to commuters. Twenty-four percent of respondents agreed strongly or agreed with the proposition that cars dart in and out of HOV lanes too often for the lanes to be safe. However, a number of respondents have written in comments voicing concerns with the safety of HOV lanes on the right side of the road. Table 5 illustrates public opinion on the issue.

Table 5 shows little support for the idea that drivers who do not regularly use HOV lanes have a slight tendency to feel less safe on carpool lanes than drivers who regularly use the lanes.

TRANSIT INFORMATION

The other data the study will use to evaluate HOV lanes are bus ridership data. The three transit agencies, King County (Department of Metropolitan Services), Community Transit, and Pierce Transit, have been very helpful in providing us with data on the number of passengers riding bus lines that use HOV lanes. By presenting these data in a time series we will be able to provide information concerning HOV lane impacts on bus ridership and route planning. If HOV lanes positively affect transit ridership, we should see increases not only in ridership but in the number and frequency of bus routes that are assigned to use the HOV lanes.

Table 5. Perceptions of HOV Lane Safety

Proposition: Vehicles dart in and out of HOV lanes too often for the lanes to be safe.

	Agree	Neutral	Disagree	% of Total
Usually rideshare	22	31	47	33
Usually drive alone	25	31	44	67
% of Total	24	31	45	100

(p = .3498. no significant difference. n = 1546)

Pierce Transit has a program called the Seattle Express that uses HOV lanes on the I-5 South section. Since the Seattle Express program began in September 1990, Pierce Transit has counted 792,044 passenger trips for the route. A total of 380,249 passenger trips were counted in 1992. We have monthly totals for each year that Pierce Transit has collected data for the four routes in the Seattle Express program.

Snohomish county's Community Transit has several bus routes into Seattle and the Eastside that travel on HOV lanes. Community Transit staff provided us with ridership data for routes that use HOV lanes from January 1987 through March 1993. For January 1987 through March 1993, Community Transit reports carrying 157,787 passengers to the University District on buses that use HOV lanes. For the same period, Community Transit buses carried 439,556 passengers to the Seattle central business district.

King County (Department of Metropolitan Services) has many more bus routes that use HOV lanes than either Pierce Transit or Community Transit. The other two transit agencies have dedicated express routes that use HOV lanes, whereas King County's use of individual HOV lanes may change over time. As a result, King County needed very detailed search parameters to identify each route that uses HOV lanes and to determine the number of passengers using those routes. In addition to the information included in the fact sheet described above, King County found using a map to identify relevant bus routes to be very helpful. For 1992, King County reports carrying 55,659 passengers on HOV lanes, down from 58,572 passengers in 1991. King County uses a sampling method to estimate overall ridership totals on the basis of electronic sensors placed on selected buses.

One of the primary reasons HOV lanes are built is to increase the attractiveness of using transit services that use HOV lanes. By restricting access to segments of the highway system, buses, vanpools, and carpools are thought to reduce travel time and increase travel time reliability. The aggregate bus ridership data provide a measurement of the impact reduced travel time and increased travel time reliability have on ridership. It is important to analyze the impact of HOV lanes on transit route planning as well. Overall, the data can be used to assess the ability of HOV facilities to provide effective bus service. The data and analysis will be presented in a separate report.

CHAPTER SEVEN

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

The first three stages of this project have led to the establishment of a method of collecting data for the evaluation and monitoring of high occupancy vehicle lanes in the Puget Sound area. We are now gathering the data necessary to evaluate the performance of the HOV lane system. These data fall into three main categories: average vehicle occupancy, travel time, and public opinion. Data we are gathering from other sources include HOV lane safety, enforcement, and impacts on transit use. Because one portion of this project is designed to develop a data collection methodology, this report concentrates on establishing the process and reporting on its development rather than making substantive conclusions about the performance of HOV lanes.

This project is intended to have wide applicability for any researcher or decision maker concerned with measuring the efficacy of HOV lanes. All relevant data collected will be assembled into a database that will be updated quarterly. We will then determine ways to present the data so it will be as broadly accessible as possible. Encouraging use of these data is also an important consideration. We anticipate that the benefits of this project will be an improvement in the efficiency of existing HOV lanes, the establishment of priorities for building new HOV facilities, a positive influence on design decisions, and increased guidance in the operation of HOV lanes. The database and quarterly reports will be updated annually. The types of data collected may change as the focus of the study is expanded outside the Seattle/King County area. Although the methods and types of data collected may change as a result of this expansion, the methodology described here will serve as a basis to assess the effectiveness of HOV lanes in the entire Puget Sound region.

COST ESTIMATES

This project had an authorized budget of $223,900 for the two-year period ending June 30, 1993. The analysis in this section applies only to budget activity for the second year of that period, during which the traffic observations were fully in place. Table 6 outlines observer, management, and administration costs.

Tables 6 and 7 indicate that project administration accounts for roughly 20 percent of overall costs. The greatest variable costs are observer salaries, which are a function of the amount of data we wish to collect. If WSDOT decides to continue the HOV Evaluation and Monitoring Project under the direction of the Urban Systems Branch in the future, the estimated costs could change significantly. A possible change in

Table 6. Actual Costs by Quarter (July 1, 1992 - June 30, 1993)

Item	07/01/92-09/30/92	10/01/92-12/31/92	01/01/93-03/31/93	04/01/93-06/31/93	Total	Percent[3]
Traffic Observations						
Observer Salary	$18,538	$8,534	$10,279	$7,445	**$44,796**	34.1%
Observer Management	$2,107	$2,841	$1,600	$1,850	**$8,398**	6.4%
Data Management	$0	$2,885	$4,080	$2,720	**$9,685**	7.4%
Sub-Total					**$62,879**	**(48%)**
Public Opinion Survey						
Survey Management[1]	$0	$2,885	$4,080	$3,400	**$10,365**	7.9%
Postage[2]	$1,645	$1,645	$1,645	$1,645	**$6,578**	5.0%
Sub-Total					**$16,943**	**(12.9%)**
Benefits & Overhead						
Benefits	$338	$691	$789	$635	**$2,453**	1.9%
Travel Reimbursements	$1,629	$1,072	$1,483	$1,226	**$5,410**	4.1%
Overhead	$12,128	$10,276	$11,978	$9,460	**$43,842**	33.3%
Sub-Total					**$51,705**	**(39.3%)**
TOTAL COSTS	**$36,385**	**$30,829**	**$35,934**	**$28,381**	**$131,527**	**100%**

[1] Includes costs of developing access to and gathering data from other databases.

[2] Includes return postage for 1,300 surveys.

[3] Results include 1% variance.

Table 7. Average Monthly Costs by Quarter

Item	07/01/92-09/30/92	10/01/92-12/31/92	01/01/93-03/31/93	04/01/93-06/30/93	07/01/92-03/31/92	Percent[3]
Traffic Observations						
Observer Salary	$6.179	$2,845	$3,426	$2,482	**$3,733**	34.1%
Observer Management	$702	$947	$533	$617	**$700**	6.4%
Data Management	$0	$962	$1,360	$907	**$807**	7.4%
Sub-Total					**$5,240**	**(47.8%)**
Public Opinion Survey						
Survey Management[1]	$0	$962	$1,360	$1,133	**$864**	7.9%
Postage[2]	$548	$548	$548	$548	**$548**	5.0%
Sub-Total					**$1,412**	**(12.9%)**
Benefits & Overhead						
Benefits	$113	$230	$263	$212	**$204**	1.9%
Travel Reimbursements	$543	$357	$494	$409	**$451**	4.1%
Overhead	$4,043	$3,425	$3,993	$3,153	**$3,654**	33.3%
Sub-Total					**$4,309**	**(39.3%)**
TOTAL COSTS	**$12,128**	**$10,276**	**$11,977**	**$9,461**	**$10,961**	**100%**

[1] Includes costs of developing access to and gathering data from other databases.
[2] Includes return postage for 1,300 surveys.
[3] Results include 1% variance.

management and modification of the scope of this project will reduce the predictive value of these cost breakdowns. However, because training and startup costs are largely factored out, the first quarter 1993 cost breakdown may provide a good baseline for projecting future costs.

RECOMMENDATIONS

To improve the effectiveness of data collection and to broaden the applicability of this project, we recommend that the following changes be implemented for the next biennium:

- Increase the profile of the observations manager. Many of the errors in the data collection process could be mitigated if there were a stronger link between traffic observers and the observations manager. Allocating more time to the observation manager will allow him or her to better train observers, to better monitor and evaluate the performance of individual observers, and solve problems as they arise.

- Use travel time observations as special studies. Because the cost of travel time observations is relatively greater than AVO observations in terms of observer costs, and because travel time observations require a greater volume of sessions to produce statistically significant data, we recommend that observations be only conducted for special studies. Furthermore, electronic means of data collection should be explored.

- Expand the number of sites. The data generated by this project will be instrumental in assessing the impact and effectiveness of HOV lanes. Therefore, it is important to collect data for highway segments both before and after HOV lanes have opened. This may mean increasing the number of collection sites within existing highway corridors into Pierce and Snohomish counties, or expanding to new corridors.

- Divide I-405 into discreet observation corridors. The number of observation sites within the I-405 corridor has reached the capacity of the file naming system. To increase coverage of this site (along with HOV lanes that are currently being built), we will need to section the corridor into three segments: one segment will be from Tukwila Parkway to I-90, another from I-90 to SR 520, and the third from SR 520 north to I-5. This will increase the current number of corridors under study from 6 to 8 and will likely require increased observer time to provide for travel to developed sites.

REFERENCES

Hallenbeck, Mark, Associate Director of the Washington State Transportation Center, personal communication, June 1993.

Haselkorn, Mark, and Daniel J. Dailey. Automatic Transit Location System. Proposal to the Washington State Department of Transportation, June 1993.

Mehyar, Omar, Auto Occupancy Monitoring Program. Washington State Department of Transportation, September 1990.

Miller, Barbara. Traffic Observations: A Handbook For Observers. Washington State Transportation Center, October 1992.

Nihan, Nancy L. Video Image Tracking. Proposal to the Washington State Department of Transportation, August 1993.

Turnbull, Katherine, Russell Henk, and Dennis Christiansen, Suggested Procedures for Evaluating the Effectiveness of Freeway HOV Facilities. Texas Transportation Institute, February 1991.

Ulberg, C., and E. McCormack. Development of an HOV Lane Usage Analysis and Evaluation Tool. Project T9233, Task 7, Washington State Transportation Center, Seattle, Washington, July 1991.

Ulberg, C., and Gary Farnsworth, HOV Evaluation and Monitoring. Interim Report, Project T9233, Task 8, Washington State Transportation Center, Seattle, Washington, August 1992.

Ulberg, C., G. Farnsworth, G. Etchart, K. Turnbull, R. Henk, and D. Schrank, I-5 North High-Occupancy Vehicle Lane 2+ Occupancy Requirement Demonstration Evaluation, Final report, Washington State Department of Transportation, February 1992.

Ulberg, Cy, and Edward McCormack, Auto Occupancy Monitoring. Washington State Transportation Center (TRAC), June 1988.

Ulberg, Cy, Gary Farnsworth, and Graciela Etchart, I-5 North High-Occupancy Vehicle Lane 2+ occupancy Requirement Demonstration Evaluation. Washington State Transportation Commission, February 1992.

Washington State Department of Transportation, "Washington State Freeway HOV System Policy," Executive Summary. Olympia, Washington. November 1992.

WSDOT, Planning, Research, and Public Transportation Division, State Highway Log, 1992.

BIBLIOGRAPHY

Bullard, Diane. An Assessment of Carpool Utilization of the Katy High-Occupancy Vehicle Lane and the Characteristics of Houston's HOV Lane Users and Nonusers, Research Report 484-14 F, Texas Transportation Institute. Texas A&M University, October 1991.

Mehyar, Omar, Auto Occupancy Monitoring Program. Washington State Department of Transportation, September 1990.

Mehyar, Omar. Auto Occupancy Monitoring Program. Washington State Department of Transportation, Final Report, Prepared for Puget Sound Council of Governments, Washington State Transportation Center, and Washington State Energy Office, September 1990.

Miller, Barbara. Traffic Observations: A Handbook For Observers. Washington State Transportation Center. October 1992.

Turnbull, Katherine, Russell Henk, and Dennis Christiansen, Suggested Procedures for Evaluating the Effectiveness of Freeway HOV Facilities. Texas Transportation Institute, February 1991.

Ulberg, C. and Gary Farnsworth, HOV Evaluation and Monitoring. Interim Report. Project T9233, Task 8, Washington State Transportation Center, Seattle, Washington, August 1992.

Ulberg, C. HOV Lane Evaluation and Monitoring. Project T9233, Task 8, Washington State Transportation Center, Seattle, Washington, July 1991.

Ulberg, C., and E. McCormack. Development of an HOV Lane Usage Analysis and Evaluation Tool. Project T9233, Task 7, Washington State Transportation Center, Seattle, Washington, July 1991.

Ulberg, Cy, and Edward McCormack, Auto Occupancy Monitoring. Washington State Transportation Center (TRAC), June 1988.

Ulberg, Cy, Gary Farnsworth and Graciela Etchart, I-5 North High-Occupancy Vehicle Lane 2+ Occupancy Requirement Demonstration Evaluation. Washington State Transportation Commission, February 1992.

Ulberg, C., G. Farnsworth, G. Etchart, K. Turnbull, R. Henk, and D. Schrank. I-5 North High-Occupancy Vehicle Lane 2+ Occupancy Requirement Demonstration Evaluation, Final report, Washington State Department of Transportation, February 1992.

________. Washington State Freeway HOV System Policy Final Report, November 1991. Washington State Department of Transportation.

Washington State Department of Transportation, "Washington State Freeway HOV System Policy," Executive Summary. Olympia, Washington. November 1992.

APPENDIX A

DATA COLLECTION LOCATIONS

Current observation sites are numbered as follows:

NORTH I-5 (corridor 1)	**DOWNTOWN I-5 (corridor 2)**	**SOUTH I-5 (corridor 3)**
11 = SW. 236th St.	21 = Lakeview Blvd. E.*	31 = S. 178th St.
12 = N. 185th St.	22 = Holgate St.	32 = S. 188th / Orillia Rd.
13 = N. 175th St.	23 = Michigan St.	33 = S. 200th St.
14 = N. 145th St.	24 = Corson Ave. S.	34 = S. 216th St.
15 = N. 117th St.	25 = Albro Pl.	35 = SR 516—Kent/ DesMoines Rd.
16 = Northgate	26 = S. 144th St.	36 = SR 516—Kent Ramp
	27 = Olive St.	37 = SR 516—DesMoines Ramp
	28 = Howell & Yale	38 = S. 260th St.
	29 = Madison St.	39 = S. 272nd St.
	20 = Stewart St.	
SR 520 (corridor 4)	**I-90 (corridor 5)**	**I-405 (corridor 6)**
41 = Hunt's Point	51 = 23rd Ave S.	61 = Tukwila Pkwy. (Southcenter)
42 = Yarrow Point	52 = 35th Ave S.	62 = SR 167 (Renton)
43 = SR 908—Bellevue/ Kirkland	53 = 60th Ave SE/ W. Mercer Wy	63 = Benson Rd. S.
44 = 124th Ave NE.	54 = Island Crest Wy	64 = S. Park Dr.
45 = 148th Ave NE.	55 = East Mercer Wy	65 = 112th Ave SE./ Lake Washington Blvd
46 = 148th—Redmond Ramp	56 = Bellevue Wy	66 = SE 8th St. (Bellevue)
47 = 148th—Bellevue Ramp		67 = NE 8th St.
		68 = NE 12th St.
		69 = SR 908—Kirkland/ Redmond

*As of February 16, 1993, Roanoke has been used for vehicle occupancy data collection.

APPENDIX B

DATA FILE NAMES

AVO and travel time data files are named so that they do not repeat but can be consecutive. Each of the names' 11 characters corresponds to a particular site, date, commute, observation type, count, and direction of flow (the characters in bold represent the actual character that would be normally found):

_1_ _2_ _3_ _4_ _5_ _6_ _7_ _8_ . _9_ _10_ _11_

Observation site	1. Traffic Corridor **1-6**	(see site table)
	2. Location Point **0-9**	(see site table)
Month	3. M	
	4. M	
Day	5. D	
	6. D	
Year	7. Y	
Commute period	8. AM / PM	
	.	
Observation type	9. T=travel time; F=off ramp avo; N=on ramp avo; **1-5**=mainline avo lane	
Session count	10. **0-9**	
Flow direction	11. Northbound / Southbound ; Eastbound / Westbound	

Some examples of file names are:

1407152a.n2s = Morning AVO observation, second count, southbound on I-5 at the N. 145th St. on-ramp, July 15, 1992.

4410222p.f3e = Evening AVO observation, third count, eastbound on SR 520 at the 124th Ave. NE off-ramp, October 22, 1992.

5408062a.10w = Morning AVO observation, first count, westbound on I-90 mainline (lane 1) at Island Crest Way, August 6, 1992.

6809282p.t0n = Evening Travel Time observation, first count, northbound on I-405 at NE 12th St., September 28, 1992.

APPENDIX C

AVO AND TRAVEL TIME WEEKLY REPORTS

HOV Weekly Data Report - Week of 4/05/93

SCHEDULED			COMPLETED			QUALITY				
Session Code	Obs	Lanes	Done	Disk	Files	Good Data	Bad Data	Usable	Comments	Time
5204053a.t-w	DH		✓	# A-1	1	1				6:54 – 8:33
5504053a.t-w	PJ		✓	# A-3	1	1				6:54 – 8:55
4104053p.t-e	IG		✓	# A-3	1	1				15:08 – 17:58
4204053p.--e	JH	12121	✓	# A-4	5	5			on March # disk A-4	15:19 – 17:58
4304053p.t-e	PJ		✓	# A-1	1	1				15:25 – 17:59
3404063a.t-n	SH		✓	# A-1	1		1	1	comments before count (edited)	6:44 – 8:29
3804063a.t-n	Sh		✓	# A-2	1	1				6:54 – 8:47
3104063p.t-s	SN		✓	# A-1	2	2				15:53 – 18:03
3404063p.t-s	DH		✓	# A-2	1	1				16:02 – 18:52
3404063p.--s	IG	12341	✓	avo A-1	4	4				15:42 – 17:46
6104073a.--n	~~Sh~~	12341	✓	avo A-1	3	3			DH	7:02 – 8:35
6804073a.--s	~~DH~~	12341	✓	# A-1	3	1	2	2	1 empty file; 2 files recd LT/Sh	7:24 – 8:31
21040973p.--s	JH	12312	✓	avo A-4	5	4	1	Ø	Roanoke code 21/1234	15:00 – 17:52
2504073p.--s	SN	12341	✓	avo A-1	5	4	1	1	Spike (edited)	15:10 – 17:55
2504073p.--n	SH	12341	✓	avo A-2	5	5				15:14 – 17:57
1104083a.t-s	SH		✓	# A-2	2		2	2	comment ">10 obs x 10" * (edited)	7:05 – 8:25
1504083a.t-s	Sh		✓	# A-1	2	2			"CT too fast to read "t	6:38 – 8:43
3104083p.t-s	IG		✓	# A-4	1	1				15:21 – 18:51
3404083p.t-s	SH		✓	# A-1	1	1			12345	15:33 – 18:48
3404083p.--s	DH	23412	✓	avo B-1	5	5				15:34 – 18:09
2104093a.t-s	DH		✓	# B-1	1	1				6:48 – 8:31
2204093a.t-s	PJ		✓	# A-4	1	1				6:45 – 8:51
6804093p.t-n	SN		✓	# C-2	3	2	1	1	+1n +2n (16:44)	15:47 – 17:36
6904093p.t-n	JH		✓	# A-4	1	1				15:44 – 18:30
114073a.t-n	?					—			empty File	
6804093p.t-s	SH					—			Renamed +on (15:47-16:[illegible])	
									* program error in TTCH	
									+ CT = community Transit	
AVO - Ramp	Ø		Ø		Ø	Ø	–	–		
AVO - Main	8		8		35	31	4	3		
TT	16		16		21	17	4	4		
Total	24		24		53	45	8	7		

MB

HOV Weekly Data Report - Week of 4/05/93

NAME		MATCHES			
Session	Pair	HOV	GP	Total	Comments
5504053a.t-w	5s04053a.52w				
5604053a.t-w	5n04053a.52w				
4104053p.t-e	4s04053p.3e				
4304053p.t-e	4n04053p.3e				
3804063a.t-n	3s04063a.84n				
3404063a.t-n					
3104063p.t-s	3s04063p.14s				
3404063p.t-s					
1104083a.t-s	1s04083a.5s				
1504083a.t-s					
3104083p.t-s	3s04083p.14s				
3404083p.t-s					
2104093a.t-s	2s04093a.12s				
2204093a.t-s					
6804093p.t-n	6s04093p.89s				
6904093p.t-n					
					*no travel times done on 4/7
TT					
TOTAL					

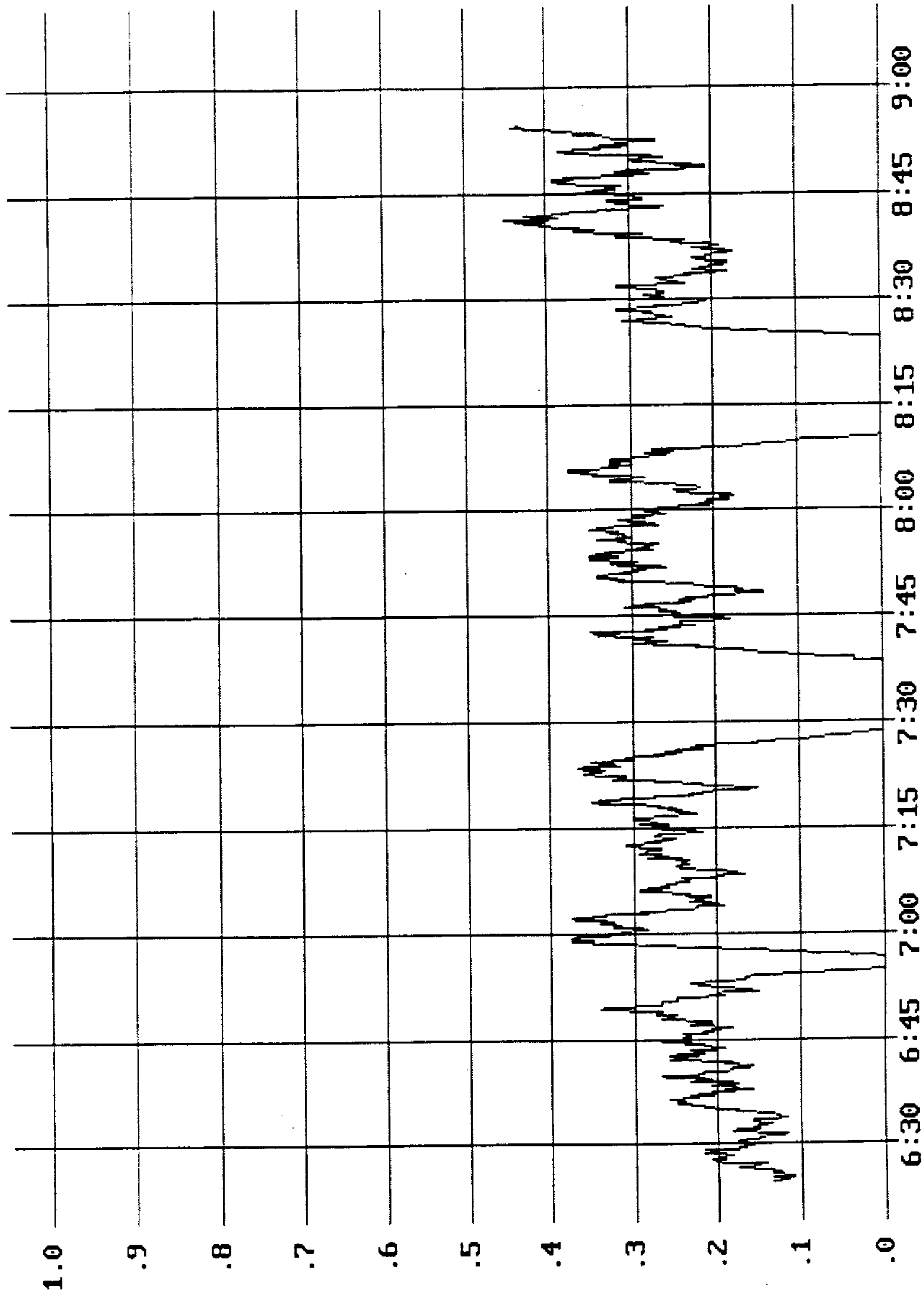
APPENDIX D

AVOCH

Below is a sample session audit for the morning southbound commute on September 8, 1992, observed at Lakeview Blvd E. on Downtown Interstate 5. Summary session information, including the corridor name, is displayed on the right side of the screen. Information regarding the data files comprising a session are displayed on the right (program-generated comments are in **bold**).In this example, the session consists of three counts.

AVO Audit		
Date:	09/08/1992 AM	6:24 **start** 2109082a.f0s dennis - rainy 6:54 **end** **No comment**
Observer:	dennis	
Weather:	rainy	
# of files:	3	
Total time:	1:30	6:54 **3:56 minute gap** 6:58 **start** 2109082a.f1s elvis - rainy cold 7:28 **end** **No comment**
Highway:	Downtown I-5	
Location:	Lakeview Blvd. E	
Direction:	South	
Type of obs.:	Off-ramp	
# of observations:		7:28 **12:03 minute gap** 7:40 **start** 2109082a.f2s dennis - cold windy **> 100 obs in last minute** 8:10 **end** **No comment** **end of file**
Observations/hour:		
Obs. % of SOVs:		
Hist. % of SOVs:		
Chi squared (sig):		

Below is a sample plot of the observations for this session.


1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
.0
6:30
6:45
7:00
7:15
7:30
7:45
8:00
8:15
8:30
8:45
9:00

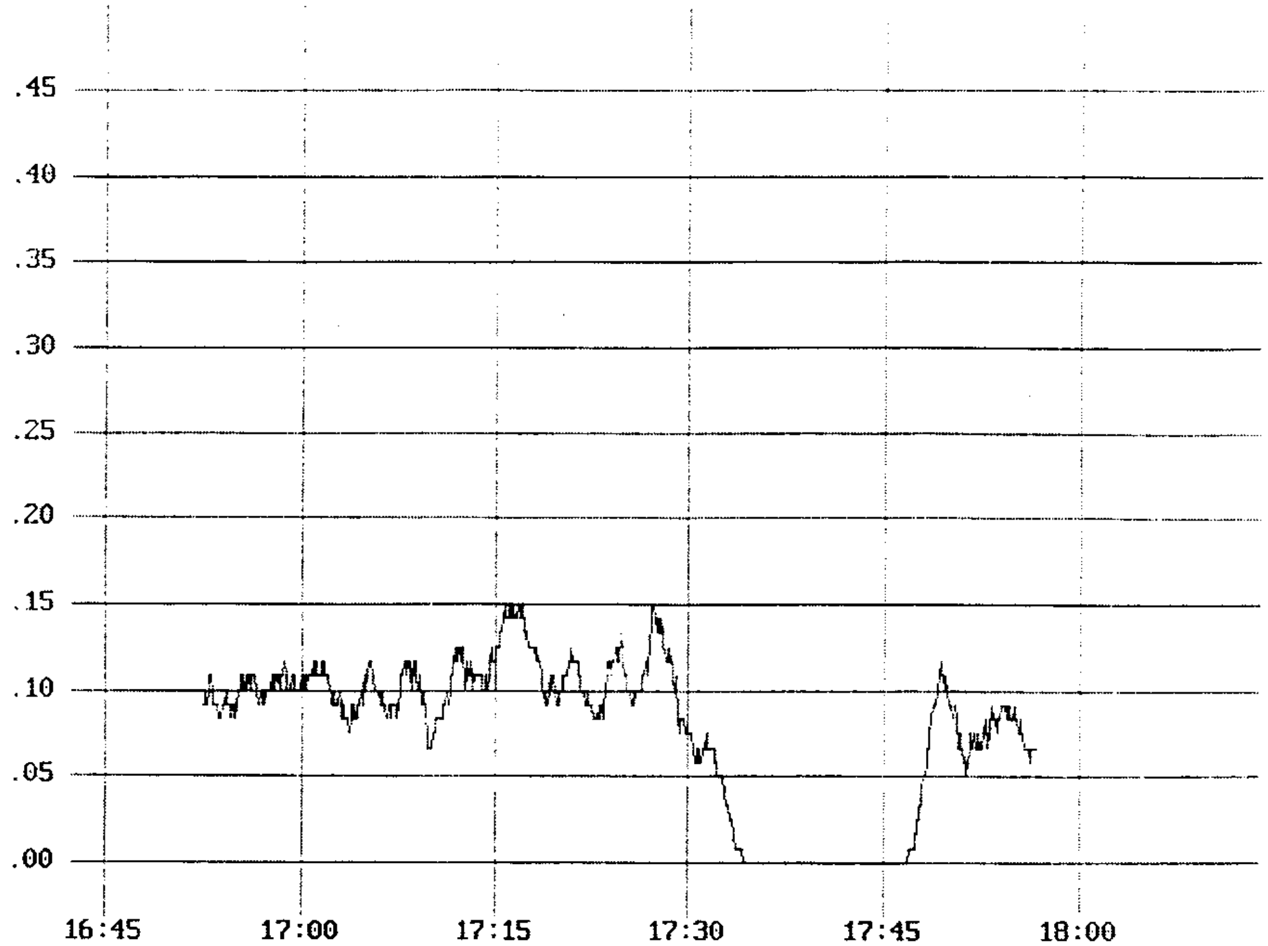
APPENDIX E

TTCH

Below is a sample session audit for the evening southbound commute on January 25, 1993, observed at S 178th St on South Interstate 5. Summary information, including the corridor name is displayed on the right side of the screen (program-generated comments are in **bold**). Information regarding the data files comprising the session are displayed on the right.

Travel Time Audit		
Date:	01/25/1993 PM	16:58 **start** 3101253p.t0s
Observer:	evan	evan - cold drizzle and i
Weather:	cold drizzle and i	forgot my damn glove
# of files:	2	17:34 **end**
Total time:	1:06	traffic fluctuated --less traf in
Highway:	South I-5	this lane than the righthand one
Location:	S 178th St.	17:34 **14:38 minute gap**
Direction:	South	17:48 **start** 3101253p.t1s
Type of obs.:	Travel time	evan - coldwetdarkandscary
# of observations:	299	7:28 **12:03 minute gap**
Observations/hour:	270	17:58 **end**
Obs. % of SOVs:		traffic very light
Hist. % of SOVs:		
Chi squared (sig):		

Below is a sample plot of the observations for this session.



.45
.40
.35
.30
.25
.20
.15
.10
.05
.00
16:45
17:00
17:15
17:30
17:45
18:00

APPENDIX F

AVO AND TRAVEL TIME PARAMETERS: LOCATION AND COUNT CODES

HOV Monitoring and Evaluation Project
LOCATION/COUNT CODES

I-5 NORTH

SW 236th St	11—3a.t-s	tt-sb	am	
	11—3a.n-s	avo-on/r sb	am	
	11—3p.f-n	avo-off/r nb	pm	
N 185th St	12—3p.t-n	tt-nb	pm	
N 175th St	13—3a.n-s	avo-on/r sb	am	
	13—3p,f-n	avo-off/r nb	pm	
N 145th St	14—3a.–s	avo-ml sb	am	
	14—3p.–n	avo-ml nb	pm	
	14—3a.n-s	avo-on/r sb	am	
	14—3p,f-n	avo-off/r nb	pm	
117th Ave NE	15—3a.t-s	tt-sb	am	
	15—3p.t-n	tt-nb	pm	
Northgate	16—3a.n-s	avo-on/r sb	am	
	16—3p.f-n	avo-off/r nb	pm	

I-5 DOWNTOWN

Lakeview Boulevard	21—3a.t-s	tt-sb	am	
	21—3p.t-s	tt-sb	pm	
	21—3a.t-n	tt-nb	am	
	21—3p.t-n	tt-nb	pm	
	21—3a.f-s	avo-off/r sb	am	Mercer off/ramp
	21—3p.f-s	avo-off/r sb	pm	"
	21—3a.n-n	avo-on/r nb	am	Mercer on/ramp
	21—3p.n-n	avo-on/r nb	pm	"
Holgate St.	22—3a.t-s	tt-sb	am	
	22—3p.t-s	tt-sb	pm	
	22—3a.t-n	tt-nb	am	
	22—3p.t-n	tt-nb	pm	
Michigan St.	23—3a.n-n	avo-on/r nb	am	
	23—3p.n-n	avo-on/r nb	pm	
Corson Ave.	24—3a.f-s	avo-off/r sb	am	
	24—3p.f-s	avo-off/r sb	pm	
Albro Place	25—3a.t-n	tt-nb	am	
	25—3p.t-n	tt-nb	pm	
	25—3a.t-s	tt-sb	am	
	25—3p.t-s	tt-sb	pm	
	25—3a.–n	avo-ml nb	am	
	25—3p.–n	avo-ml nb	pm	
	25—3a.–s	avo-ml sb	am	
	25—3p.–s	avo-ml sb	pm	

S 144th St.	26—3a.t-n	tt-nb	am	
	26—3p.t-s	tt-sb	pm	
Olive St.	27—3a.n-n	avo-on/r nb	am	
	27—3p.n-n	avo-on/r nb	pm	
Howell/Yale Sts.	28—3a.n-s	avo-on/r sb	am	
	28—3p.n-s	avo-on/r sb	pm	
Madison St.	29—3a.f-n	avo-off/r nb	am	
Stewart St.	20—3a.f-s	avo-off/r sb	am	
	20—3p.f-s	avo-off/r sb	pm	
Roanoke St.	??—3a.--s	avo-ml sb	am	
	??—3p.--s	avo-ml sb	pm	
	??—3a.--n	avo-ml nb	am	
	??—3p.--n	avo-ml nb	pm	
	??—3a.f-s	avo-off/r sb	am	
	??—3p.f-s	avo-off/r sb	pm	

I-5 SOUTH

S 178th St.	31—3p.t-s	tt-sb	pm	
S 188th/Orillia Rd	32—3a.n-n	avo-on/r nb	am	
	32—3p.f-s	avo-off/r sb	pm	
S 200th St.	33—3a.n-n	avo-on/r nb	am	
	33—3p.f-s	avo-off/r sb	pm	
S 216th St.	34—3a.t-n	tt-nb	am	
	34—3p.t-s	tt-sb	pm	
	34—3a.--n	avo-ml nb	am	
	34—3p.--s	avo-ml sb	pm	
SR 516	35—3p.f-s	avo-off/r sb	pm	
SR 516	36—3a.n-n	avo-on/r nb	am	Kent ramp
SR 516	37—3a.n-n	avo-on/r nb	am	DesMoines ramp
S 260th St.	38—3a.t-n	tt-nb	am	
S 272nd St.	39—3a.n-n	avo-on/r nb	am	
	39—3p.f-s	avo-off/r sb	pm	

SR 520

Hunt's Point	41—3a.t-w	tt-wb	am
	41—3p.t-e	tt-eb	pm
Yarrow Point	42—3a.--w	avo-ml wb	am
	42—3p.--e	avo-ml eb	pm

SR 908	43—3a.t-w	tt-wb	am	
	43—3p.t-e	tt-eb	pm	
	43—3a.n-w	avo-on/r wb	am	Kirkland ramp
	43—3p.f-e	avo-off/r eb	pm	"
124th Ave NE	44—3a.n-w	avo-on/r wb	am	
	44—3p.f-e	avo-off/r eb	pm	
148th Ave NE	45—3a.t-w	tt-wb	am	
	45—3p.t-e	tt-eb	pm	
	45—3a.–w	avo-ml wb	am	
	45—3p.–e	avo-ml eb	pm	
148th Ave NE	46—3a.n-w	avo-on/r wb	am	Redmond ramp
	46—3p.f-e	avo-off/r eb	pm	"
148th Ave NE	47—3a.n-w	avo-on/r wb	am	Bellevue ramp
	47—3p.f-e	avo-off/r eb	pm	"
I-90				
23rd Ave S.	51—3p.t-e	tt-eb	pm	
35th Ave S.	52—3a.t-w	tt-wb	am	
60th Ave SE	53—3a.n-w	avo-on/r wb	am	
	53—3p.f-e	avo-off/r eb	pm	
Island Crest Way	54—3a.–w	avo-ml wb	am	
	54—3p.–e	avo-ml eb	pm	
	54—3a.n-w	avo-on/r wb	am	
	54—3p.f-e	avo-off/r eb	pm	
East Mercer Way	55—3a.t-w	tt-wb	am	
	55—3p.t-e	tt-eb	pm	
	55—3a.n-w	avo-on/r wb	am	
	55—3p.f-e	avo-off/r eb	pm	
Bellevue Way	56—3a.n-w	avo-on/r wb	am	
	56—3p.f-e	avo-off/r eb	pm	
I-405				
Tukwila Parkway	61—3a.t-n	tt-nb	am	
	61—3p.t-n	tt-nb	pm	
	61—3a.t-s	tt-sb	am	
	61—3p.t-s	tt-sb	pm	
	61—3a.–n	avo-ml nb	am	
	61—3p.–n	avo-ml nb	pm	
	61—3a.–s	avo-ml sb	am	
	61—3p.–s	avo-ml sb	pm	

SR 167	62—3a.n-n	avo-on/r nb	am
	62—3p.n-n	avo-on/r nb	pm
	62—3a.f-s	avo-off/r sb	am
	62—3p.f-s	avo-off/r sb	pm
Benson Rd S	63—3a.t-n	tt-nb	am
	63—3p.t-n	tt-nb	pm
	63—3a.t-s	tt-sb	am
	63—3p.t-s	tt-sb	pm
S Park Dr	64—3a.n-n	avo-on/r nb	am
	64—3p.n-n	avo-on/r nb	pm
	64—3a.n-s	avo-on/r sb	am
	64—3p.n-s	avo-on/r sb	pm
	64—3a.f-n	avo-off/r nb	am
	64—3p.f-n	avo-off/r nb	pm
	64—3a.f-s	avo-off/r sb	am
	64—3p.f-s	avo-off/r sb	pm
112 SE/Lk Wash	65—3a.t-n	tt-nb	am
	65—3p.t-n	tt-nb	pm
	65—3a.t-s	tt-sb	am
	65—3p.t-s	tt-sb	pm
	65—3a.–n	avo-ml nb	am
	65—3p.–n	avo-ml nb	pm
	65—3a.–s	avo-ml sb	am
	65—3p.–s	avo-ml sb	pm
SE 8th St	66—3a.n-n	avo-on/r nb	am
	66—3p.n-n	avo-on/r nb	pm
	66—3a.n-s	avo-on/r sb	am
	66—3p.n-s	avo-on/r sb	pm
	66—3a.f-n	avo-off/r nb	am
	66—3p.f-n	avo-off/r nb	pm
	66—3a.f-s	avo-off/r sb	am
	66—3p.f-s	avo-off/r sb	pm
NE 8th St	67—3a.f-s	avo-off/r sb	am
	67—3p.n-n	avo-on/r nb	pm
NE 12th St	68—3a.t-n	tt-nb	am
	68—3p.t-n	tt-nb	pm
	68—3a.t-s	tt-sb	am
	68—3p.t-s	tt-sb	pm
	68—3a.–n	avo-ml nb	am
	68—3p.–n	avo-ml nb	pm
	68—3a.–s	avo-ml sb	am
	68—3p.–s	avo-ml sb	pm
SR 908	69—3a.t-s	tt-sb	am
	69—3p.t-n	tt-nb	pm
	69—3a.n-s	avo-on/r sb	am
	69—3p.f-n	avo-off/r nb	pm

APPENDIX G

AVO DATA

Below is a sample file of a computer count. The first column indicates the type of observation; the following columns indicate the elapsed time:

DENNIS
OVERCAST, DAMP SPOTS ON ROADWAY
155590
455600
155615
255663
155693
155735
155750
355772
After dark it's difficult to see # of occupants unless headlights for behind car

APPENDIX H

MAINLINE AVO COUNT LOCATIONS

Corridor/ Location/ Number of Lanes	HOV Lane
NORTH I-5	
145th Ave. NE	
Northbound - 5 lanes	*#5 (inside)*
Southbound - 4 lanes	*#4 (inside)*
DOWNTOWN I-5	
Roanoke St.	
Northbound - 3 lanes	*No*
Southbound - 4 lanes	*No*
Lakeview Blvd.	
Northbound - 4 lanes	*No*
Southbound - 4 lanes	*No*
Holgate St.	
Northbound - 4 lanes	*No*
Southbound - 4 lanes	*No*
Albro Pl.	
Northbound - 4 lanes	*No*
Southbound - 4 lanes	*No*
S 144th	
Northbound - 5 lanes	*No*
Southbound - 7 lanes	*#7 (inside)*
SOUTH I-5	
S 216th St.	
Northbound - 4 lanes	*#5*
Southbound - 4 lanes	*#5*
SR 520	
148th Ave. NE	
Eastbound - 2 lanes	*No*
Westbound - 2 lanes	*No*
Yarrow Pt.	
Eastbound - 2 lanes	*No*
Westbound - 3 lanes	*#1*
I-90	
Island Crest Way	
Eastbound - 3 lanes	*reversible lane*
Westbound - 3 lanes	*between mainlines*
I-405	
Tukwila Pkwy.	
Northbound - 4 lanes	*#4*
Southbound - 4 lanes	*#4*
Lake Washington Blvd.	
Northbound - 3 lanes	*#1*
Southbound - 3 lanes	*#1*
NE 12th St.	
Northbound - 4 lanes	*No*
Southbound - 4 lanes	*No*

APPENDIX I

MANUAL OCCUPANCY COUNT FORM AND DATA FILE

Below is a sample file of the hand-count. as entered into its computer format before transformation. The first column indicates the type of observation: the following columns indicate the number of observations.

Observers Name: Steve Cooke
Weather: Cloudy
Comments: Handcount
Beginning Time: 15:40
1495
2093
3009
4003
5003
6004
7000
8005
9004
0000
Ending Time: 16:10

(The figures in **bold** represent the file template onto which the data are entered.)

AVO HAND COUNT LOG

DATE: 6-22-93 CORRIDOR: ________ DIRECTION: NB OBSERVER: Shawn

TIME: 7:40 to 7:55 LANE #: 1 LOCATION: S. 216th ST

WEATHER: Overcast, overlying ...

1	2	3	4	5	6	7	8	9	0
TOTAL: 290	TOTAL: 25	TOTAL: 8	TOTAL: 0	TOTAL: 0	TOTAL: 0	TOTAL: 0	TOTAL: 9	TOTAL: 18	TOTAL: 0

COMMENTS:

APPENDIX J

MAKEAVO

Below is a sample screen of a hand-count conversion using MAKEAVO:

2903053A.FXN
    2903053A.F3N   878
    2903053A.F4N   831
    2903053A.F5N   692
3602013A.NXN
    3602013A.N3N   589
    3602013A.N4N   343
    3602013A.N5N   151
6106302A.1XN
    6106302A.11N   702
6106302A.2XN
    6106302A.22N   434
    6106302A.23N   311
6106302A.3XN
    6106302A.31N   31

(The filenames in **bold** are the handcount data files. The filenames below each handcount filename are the corresponding files that were found. The numbers to the right are the number of observations for each file.)

APPENDIX K

AA

Below are three sample screens of AA, using the location of N 145th St. on the North I-5 corridor. The first screen shows the menu from which parameters to summarize data are selected.

Quar.	Highway	Location	Time	Dir.	Type	Day
3/92	**North I-5**	**N 145th St.**	**AM**	S	HOV lanes	**All**
4/92	Downtown I-5	SW 236th St.	PM		GP lanes	Mon
1/93	South I-5	N 185th St.	5:30		**All lanes**	Tue
2/93	SR 520	N 175th St.	5:45		All ramps	Wed
	I-90	N 145th St.	6:00		Lane 1	Thu
	I-405	117th St. NE	6:15		Lane 2	Fri
		Northgate	6:30		Lane 3	
			6:45		Lane 4	
			7:00		Lane 5	
			7:15		On ramp	
			7:30		Off ramp	
			7:45			
			8:00			
			8:15			
			8:30			
			8:45			
			9:00			
			9:15			
			12:30			
			2:45			
			3:00			
			3:15			

Quar.	Highway	Location	Time	Dir.	Type	Day
3/92	North I-5	N 145th St.	AM	S	All lanes	All
4/92						
1/93						

SOV	14871	77.9%	**Average Vehicle Occupancy**
2 person	3166	16.6%	
3 person	277	1.5%	1.21
4+ person	39	.2%	
van	24	.1%	**Total Vehicles Observed**
public transit	132	.7%	
other bus	10	.1%	19097
2 axle truck	220	1.2%	
3+ axle truck	275	1.4%	
motorcycle	83	.4%	

The summary below is for the same location, but for the Northbound evening commute.

Quar.	Highway	Location	Time	Dir.	Type	Day
3/92 4/92 1/93	North I-5	N 145th St.	PM	N	All lanes	All

SOV	13764	72.9%	**Average Vehicle Occupancy**
2 person	3917	20.7%	
3 person	366	1.9%	1.21
4+ person	113	.6%	
van	24	.1%	**Total Vehicles Observed**
public transit	124	.7%	
other bus	15	.1%	19097
2 axle truck	240	1.3%	
3+ axle truck	242	1.3%	
motorcycle	83	.4%	

APPENDIX L

ACCUMULATED AVO AND TRAVEL TIME DATA

Below is a table of the number of scheduled versus collected and valid data sessions that have been accumulated for the first four quarters of the project.

	Quarter																			
	Q 3/92				Q 4/92				Q 1/93				Q 2/93				TOTAL			
Sessions	Scheduled	Actual	Valid	Percent	Scheduled	Actual	Valid	Percent	Scheduled	Actual	Valid	Percent	Scheduled	Actual	Valid	Percent	Scheduled	Actual	Valid	Percent
Access Ramp	201	170	168	84%	163	177	173	106%	201	198	198	99%	71	62	62	87%	565	545	5	95%
Mainline	96	54	62	65%	41	33	38	93%	49	49	48	98%	97	96	96	99%	186	136	148	80%
Subtotal	**297**	**224**	**230**	**77%**	**204**	**210**	**211**	**103%**	**250**	**247**	**246**	**98%**	**168**	**158**	**158**	**94%**	**751**	**681**	**687**	**91%**
Travel Times	239	181	181	76%	148	99	79	53%	176	148	146	83%	162	149	53	33%	563	428	406	72%
TOTAL	**536**	**405**	**411**	**77%**	**352**	**309**	**290**	**82%**	**426**	**395**	**392**	**92%**	**330**	**307**	**211**	**64%**	**1,314**	**1,109**	**1,093**	**83%**

APPENDIX M

TRAVEL TIME OBSERVATIONS PARAMETERS

The following is a list of current travel time locations, including the distance between sites.

Corridor/ Location	Distance Between Crossings (miles)*
NORTH I-5	
SW 236th St --> 117th Ave. NE	5.12
Southbound / AM	
117th Ave. NE --> N 185th St.	3.57
Northbound / PM	
DOWNTOWN I-5	
Lakeview Blvd. -->Holgate St.	3.08
Southbound / AM & PM *Northbound / AM & PM*	
Holgate St.--> Albro Pl.	2.75
Southbound / AM & PM *Northbound / AM & PM*	
Albro Pl. --> S 144th St.	5.89
Southbound / PM *Northbound / AM*	
SOUTH I-5	
S 260th St. --> S 216th St.	2.66
Northbound / AM	
S 178th St. --> S 216th St.	2.82
Southbound / PM	
SR 520	
Hunt's Point --> SR 908	1.69
Westbound / AM *Eastbound / PM*	
SR 908 --> 148th Ave. NE	3.21
Westbound / AM *Eastbound / PM*	
I-90	
East Mercer Way --> 35th Ave. S	4.12
Westbound / AM	
23rd Ave. S --> East Mercer Way	4.81
Eastbound / PM	
I-405	
Tukwila Pkwy. --> Benson Rd. S	2.09
Southbound / AM & PM *Northbound / AM & PM*	
Benson Rd. S --> Lake Wshington Blvd.	6.40
Southbound / AM & PM *Northbound / AM & PM*	
Lake Wshington Blvd. --> NE 12th St.	4.86
Southbound / AM & PM *Northbound / AM & PM*	
NE 12th St. --> SR 908	3.72
Southbound / AM & PM *Northbound / AM & PM*	

APPENDIX N

TRAVEL TIME DATA

Below is a sample travel time file (the number in bold is a transit bus):

Ingrid
cloudy, cold
30346141c
30360m727
303765861
30398642a
3040**9797l**
30419z232
30428991c
30481276a
getting dark.

APPENDIX O

SPEED(M) PARAMETERS

Below is a listing of the parameters used for matching travel time observation files, using SPEED and SPEEDM.

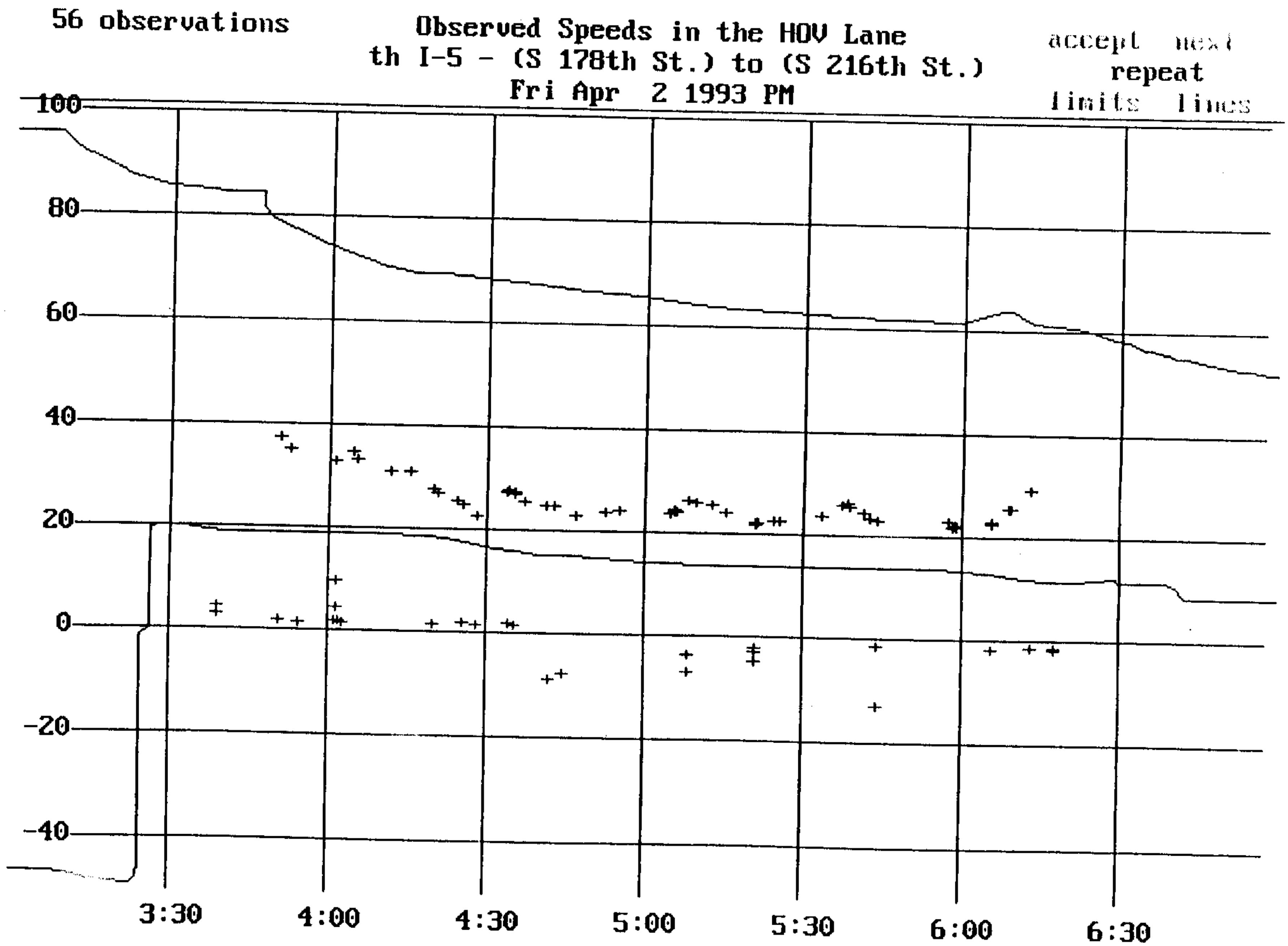
Site	Description
11-->15	- North I-5 (AM/SB) - SW 236th St. to 117th St. NE
15-->12	- North I-5 (PM/NB) - 117th St. NE to N 185th St.
21-->22	- Downtown I-5 (AM/SB) - Lakeview E to Holgate St
	- Downtown I-5 (PM/SB) - Lakeview E to Holgate St.
21-->25	- Downtown I-5 (AM/SB) - Lakeview E to Albro Pl.
	- Downtown I-5 (PM/SB) - Lakeview E to Albro Pl.
21-->26	- Downtown I-5 (PM/SB) - Lakeview E to S 144th St.
22-->21	- Downtown I-5 (AM/NB) - Holgate St. to Lakeview E
	- Downtown I-5 (PM/NB) - Holgate St. to Lakeview E
22-->25	- Downtown I-5 (AM/SB) - Holgate St. to Albro Pl.
	- Downtown I-5 (PM/SB) - Holgate St. to Albro Pl.
22-->26	- Downtown I-5 (PM/SB) - Holgate St. to S 144th St.
25-->21	- Downtown I-5 (AM/NB) - Albro Pl. to Lakeview E
	- Downtown I-5 (PM/NB) - Albro Pl. to Lakeview E
25-->22	- Downtown I-5 (AM/NB) - Albro Pl. to Holgate St.
	- Downtown I-5 (PM/NB) - Albro Pl. to Holgate St.
25-->26	- Downtown I-5 (PM/SB) - Albro Pl. to S 144th St.
26-->21	- Downtown I-5 (AM/NB) - S 144th St. to Lakeview E
26-->22	- Downtown I-5 (AM/NB) - S 144th St. to Holgate St.
26-->25	- Downtown I-5 (AM/NB) - S 144th St. to Albro Pl.
31-->34	- South I-5 (PM/SB) - S 178th St. to S 216th St.
38-->34	- South I-5 (AM/NB) - S 260th St. to S 216th St.
43-->41	- SR 520 (AM/WB) - SR 908 to Hunt's Pt.
	- SR 520 (PM/WB) - SR 908 to Hunt's Pt.
45-->41	- SR 520 (AM/WB) - 148th Ave. NE to Hunt's Pt.
41-->43	- SR 520 (PM/EB) - Hunt's Pt. to SR 908
45-->43	- SR 520 (AM/WB) - 148th Ave. NE to SR 908
41-->45	- SR 520 (PM/EB) - Hunt's Pt. to 148th Ave. NE
43-->45	- SR 520 (PM/EB) - SR 908 to 148th Ave. NE
51-->55	- I-90 (PM/EB) - 23rd Ave. S to East Mercer Way
55-->52	- I-90 (AM/WB) - East Mercer Way to 35th Ave. S
61-->63	- I-405 (AM/NB) - Tukwila Pkwy. to Benson Rd. S
	- I-405 (PM/NB) - Tukwila Pkwy. to Benson Rd. S
61-->65	- I-405 (AM/NB) - Tukwila Pkwy. to 112th Ave SE
	- I-405 (PM/NB) - Tukwila Pkwy. to 112th Ave SE
61-->68	- I-405 (AM/NB) - Tukwila Pkwy. to NE 12th St.
	- I-405 (PM/NB) - Tukwila Pkwy. to NE 12th St.
61-->69	- I-405 (PM/NB) - Tukwila Pkwy. to SR 908
63-->61	- I-405 (AM/SB) - Benson Rd. S to Tukwila Pkwy.
	- I-405 (PM/SB) - Benson Rd. S to Tukwila Pkwy.
63-->65	- I-405 (AM/NB) - Benson Rd. S to 112th Ave SE
	- I-405 (PM/NB) - Benson Rd. S to 112th Ave SE
63-->68	- I-405 (AM/NB) - Benson Rd. S to NE 12th St.
	- I-405 (PM/NB) - Benson Rd. S to NE 12th St.

63-->69	- I-405 (PM/NB) - Benson Rd. S to SR 908
65-->61	- I-405 (AM/SB) - 112th Ave SE to Tukwila Pkwy.
	- I-405 (PM/SB) - 112th Ave SE to Tukwila Pkwy.
65-->63	- I-405 (AM/SB) - 112th Ave SE to Benson Rd. S
	- I-405 (PM/SB) - 112th Ave SE to Benson Rd. S
65-->68	- I-405 (AM/NB) - 112th Ave SE to NE 12th St.
	- I-405 (PM/NB) - 112th Ave SE to NE 12th St.
65-->69	- I-405 (AM/NB) - 112th Ave SE to SR 908
	- I-405 (PM/NB) - 112th Ave SE to SR 908
68-->61	- I-405 (AM/SB) - NE 12th St. to Tukwila Pkwy.
	- I-405 (PM/SB) - NE 12th St. to Tukwila Pkwy.
68-->63	- I-405 (AM/SB) - NE 12th St. to Benson Rd. S
	- I-405 (PM/SB) - NE 12th St. to Benson Rd. S
68-->65	- I-405 (AM/SB) - NE 12th St. to 112th Ave SE
	- I-405 (PM/SB) - NE 12th St. to 112th Ave SE
68-->69	- I-405 (AM/NB) - NE 12th St. to SR 908
	- I-405 (PM/NB) - NE 12th St. to SR 908
69-->61	- I-405 (AM/SB) - SR 908 to Tukwila Pkwy.
69-->63	- I-405 (AM/SB) - SR 908 to Benson Rd. S
69-->65	- I-405 (AM/SB) - SR 908 to 112th Ave SE
	- I-405 (PM/SB) - SR 908 to 112th Ave SE
69-->68	- I-405 (AM/SB) - SR 908 to NE 12th St.
	- I-405 (PM/SB) - SR 908 to NE 12th St.

APPENDIX P

SPEEDM (HOV LANE)

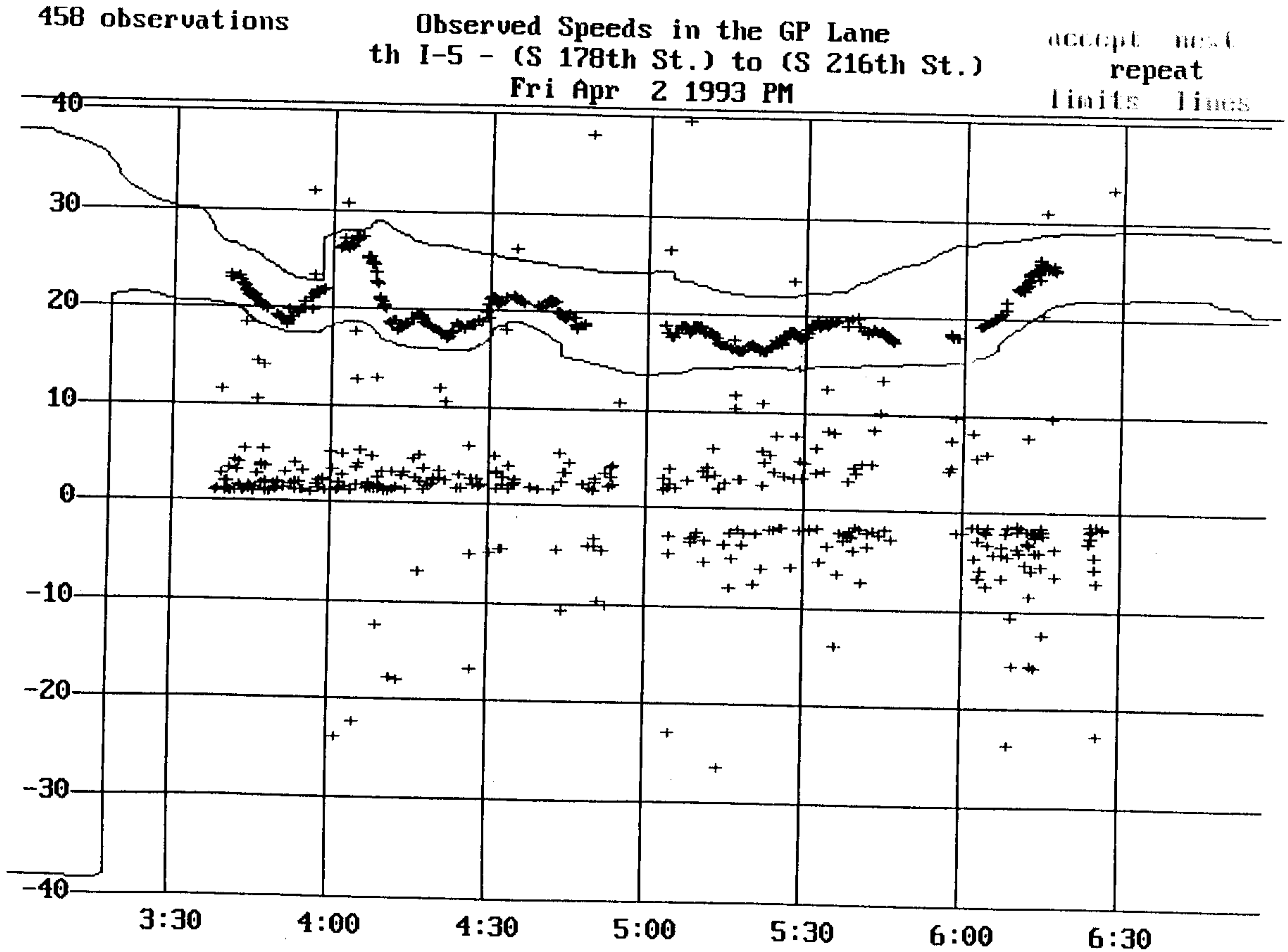
Below is a sample screen of SPEEDM.EXE, displaying a plot of the matches found for the HOV lane on South I-5, from S. 178th St. to S. 216th St..


56 observations
Observed Speeds in the HOV Lane
th I-5 - (S 178th St.) to (S 216th St.)
Fri Apr 2 1993 PM
accept next
repeat
limits lines
100
80
60
40
20
0
-20
-40
3:30
4:00
4:30
5:00
5:30
6:00
6:30

APPENDIX Q

SPEEDM (GP LANE)

Below are sample screens of SPEEDM.EXE. displaying a plot of the matches found for the General Purpose (fast) lane. same location.


458 observations
Observed Speeds in the GP Lane
th I-5 - (S 178th St.) to (S 216th St.)
Fri Apr 2 1993 PM
accept next
repeat
limits lines
40
30
20
10
0
-10
-20
-30
-40
3:30
4:00
4:30
5:00
5:30
6:00
6:30

APPENDIX R

SPEED(M) DATA MATCH FILE NAMES

Travel time data files matched by SPEED(M) are named so that they do not repeat but can be consecutive. Each of the names' 11 characters corresponds to a particular corridor, date, lane type, commute, origin and end of observation points, and direction of flow (the characters in **bold** represent the actual character that would be normally found):

___ ___ ___ ___ ___ ___ ___ ___ . ___ ___ ___
1 2 3 4 5 6 7 8 9 10 11

Traffic corridor	1. **1-6**	(see site table)
Lane type	2. **G**eneral Purpose or **H**OV	
Month	3. M	
	4. M	
Day	5. D	
	6. D	
Year	7. Y	
Commute period	8. **A**M / **P**M	
	.	
Pint of origin	9. **0-9**	(see site table)
Point of termination	10. **0-9**	(see site table)
Commute direction Westbound	11. **N**orthbound / **S**outhbound : **E**astbound /	

Some examples of file names include the following:

2g11232p.26s = Travel time session, southbound along the general purpose lane of Downtown I-5 during the evening commute, from Holgate St. to S. 144th St., on November 23, 1992.

4h10222p.51e = Travel time session, eastbound along the HOV lane of SR 520 during the evening commute, from 148th Ave. NE to Hunt's Pt., on October 22, 1992.

5g08062a.52w = Travel time session, westbound along the general purpose lane of I-90 during the morning commute, from East Mercer Way to 35th Ave. S., on August 6, 1992.

6h09282a.93s = Travel time session, southbound along the HOV lane of I-405 during the morning commute, from SR 908 to Benson Rd., September 28, 1992.

APPENDIX S

SPEED(M) DATA TIME MATCH FILES

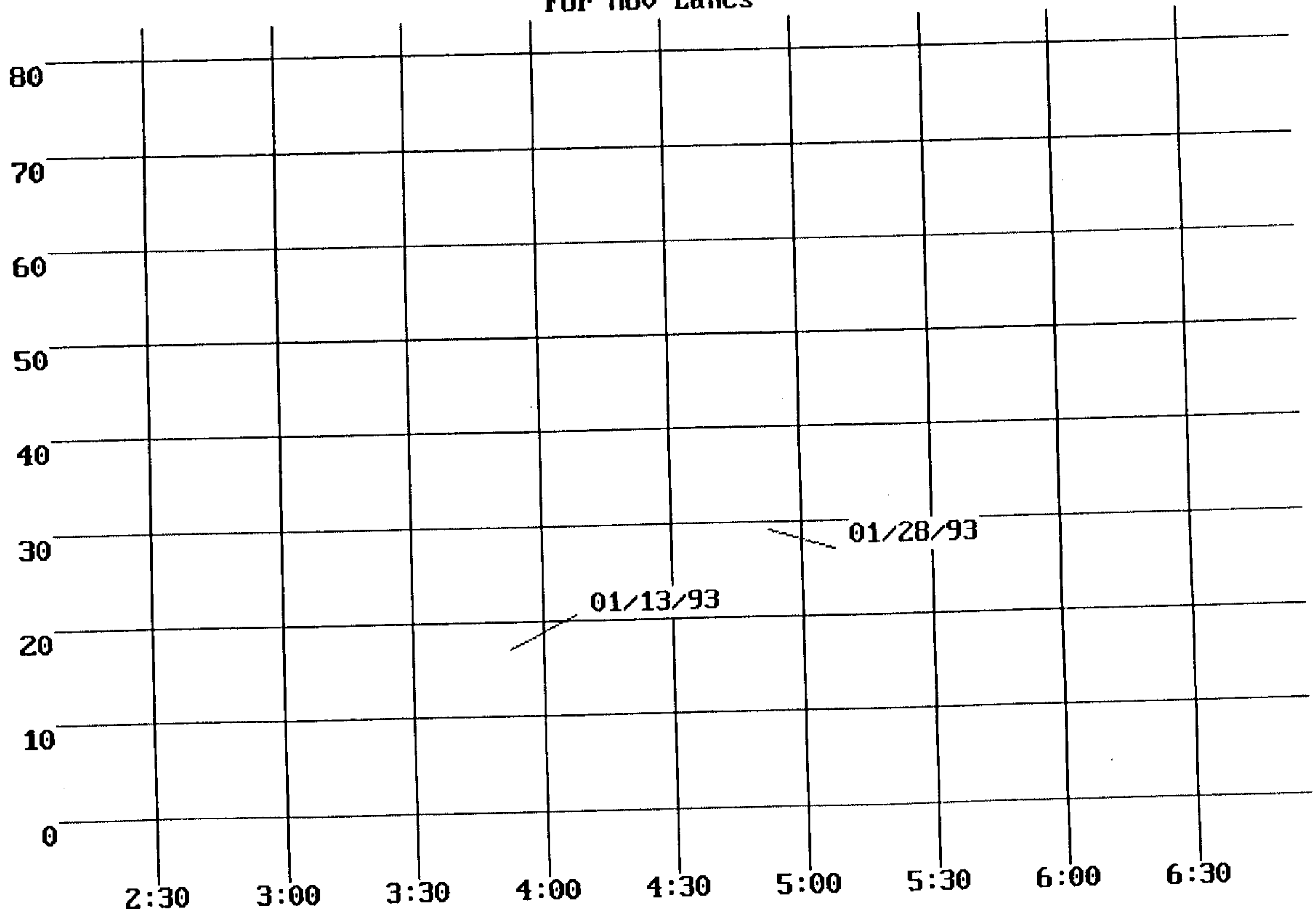
Below is a sample data file created by SPEED(M), containing observation matches. The first collumn indicates the time (in seconds); the second indicates the vehicle speed.

13652	5.19
13662	5.24
13745	5.28
13769	5.28
13769	4.60
14846	16.81
14879	17.36
14886	17.39
14901	17.49
14931	17.86
14940	17.97
14947	17.74
14979	17.72
14984	17.69
14997	17.63
15100	18.00
15110	18.57
15194	18.94
15204	18.85
15211	18.54

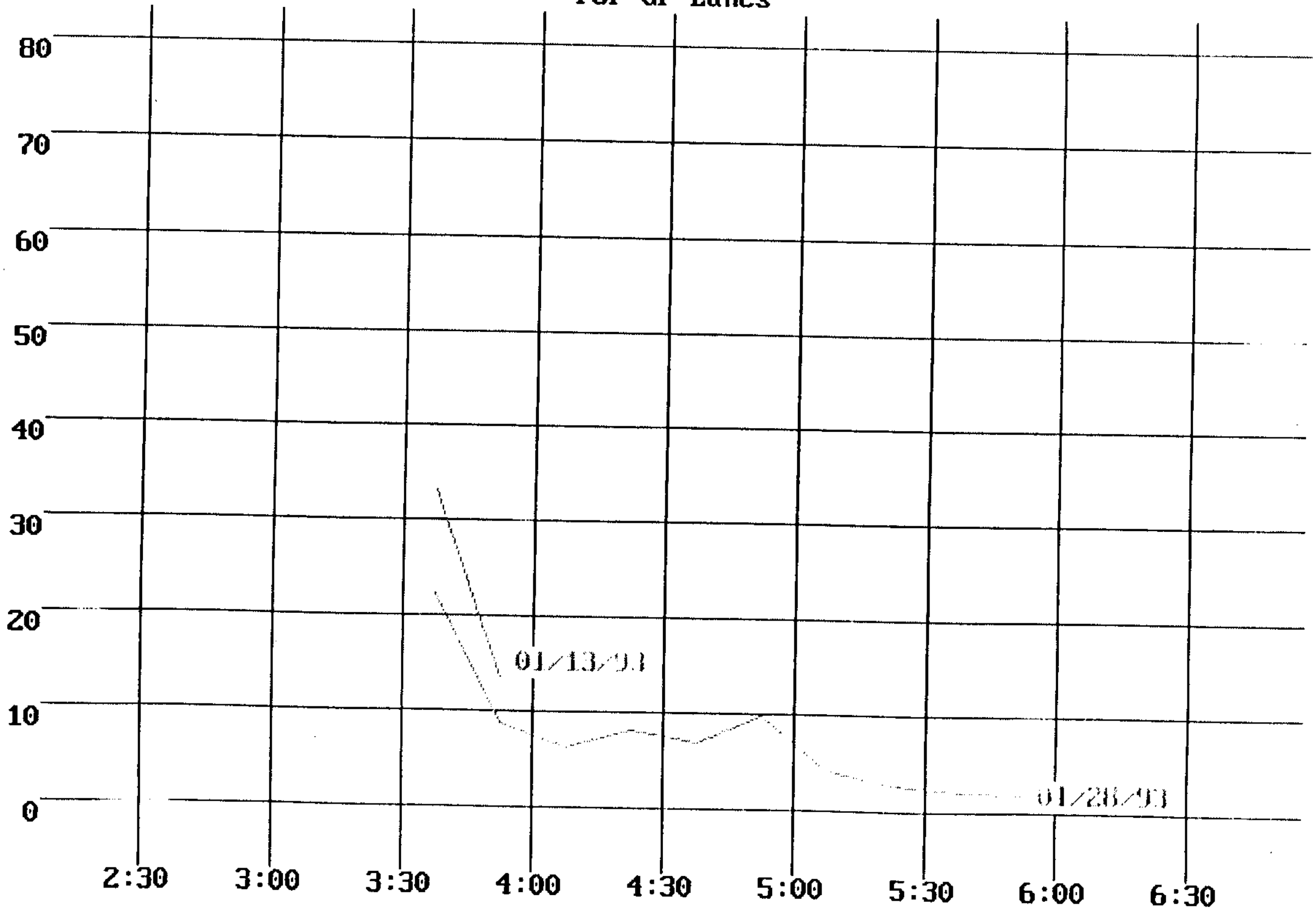
APPENDIX T

SAMPLE PLOTS OF OBSERVATION MATCHES AS DISPLAYED BY TA.EXE

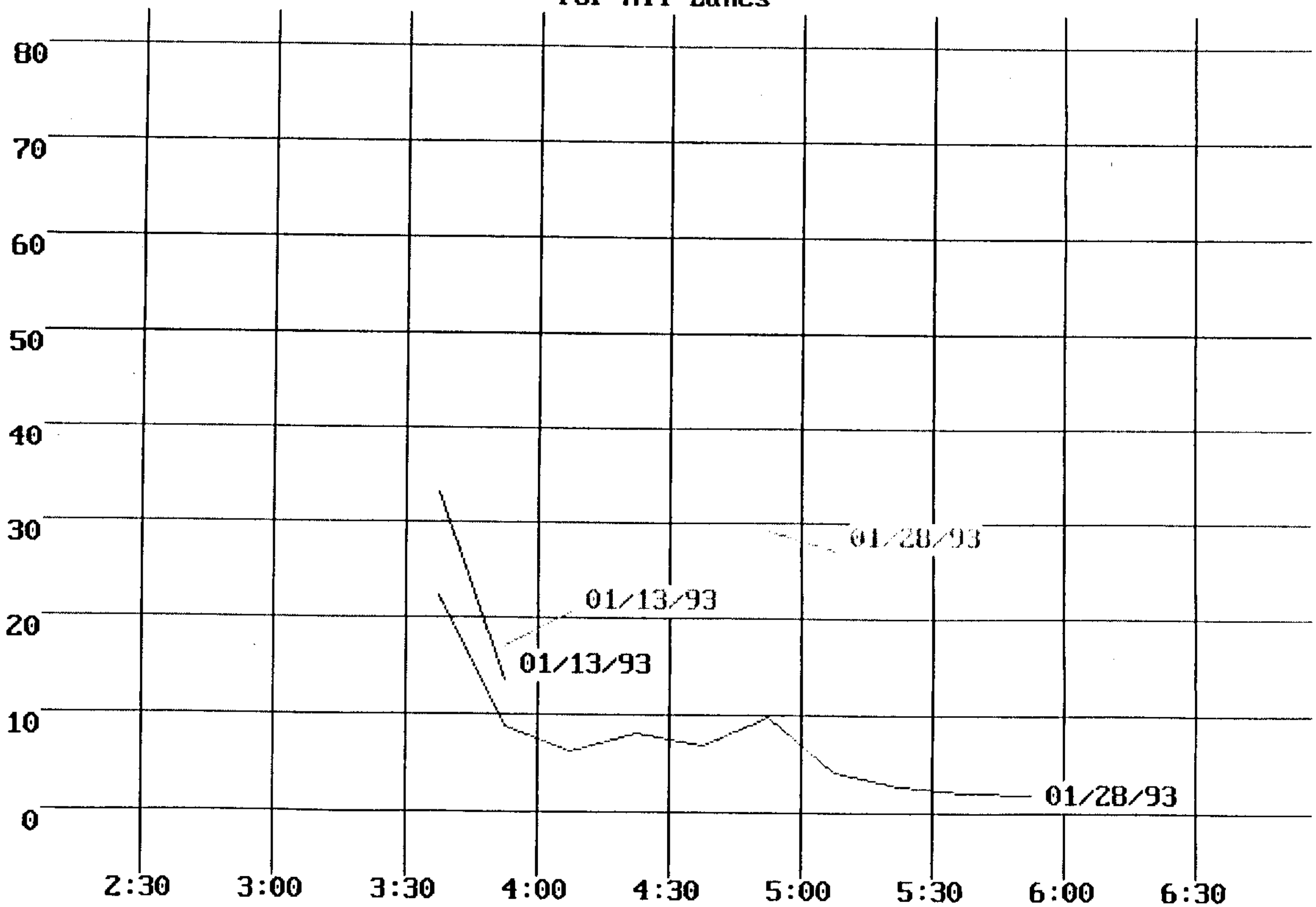
Downtown I-5 (PM/SB) - Lakeview E to Holgate St.
For HOV Lanes



Downtown I-5 (PM/SB) - Lakeview E to Holgate St.
For GP Lanes



Downtown I-5 (PM/SB) - Lakeview E to Holgate St.
For All Lanes



APPENDIX U

PUBLIC OPINION SURVEY

Washington State Department of Transportation

University of Washington

Washington State Transportation Center

HIGH OCCUPANCY VEHICLE LANE ANALYSIS PUBLIC OPINION SURVEY

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

Please give this survey to the person in your household who most often commutes to work. Ask him or her to fill out the survey and return it by mail within one week. We would appreciate your response. No postage is necessary.

This survey is anonymous. Your answers will not be associated with your name. If you are willing to be contacted by telephone, you may so indicate in Section C of this survey. You may also contact Cy Ulberg at 543–0365 between 8:00 A.M. and 5:00 P.M. if you wish to discuss the survey.

Section A: Your Commute Trip

1. Indicate how you *usually* get to and from work.

___ Drive alone
___ Carpool—you and 1 other person
___ Carpool—you and 2 or more other people
___ Vanpool
___ Bus
___ Bicycle, Walk
___ Motorcycle
___ Other: ___________

2. Have you ever used the HOV lanes while traveling in the Seattle area? Please mark yes or no for each.

Yes	No	
___	___	on a bus
___	___	in a 2 person carpool
___	___	in a 3 person carpool
___	___	in a vanpool
___	___	alone in a car
___	___	on a motorcycle

3. If you have used HOV lanes while traveling in the Seattle area, on which freeway do you usually use them?

___ I-5 north of Northgate
___ I-5 between Northgate and Southcenter
___ I-5 south of Southcenter
___ I-90
___ SR-520
___ I-405

4. Do you ever have enough people in your vehicle to qualify for HOV lanes but don't use them?

Yes___ No___ If yes, why? (check all applicable)

___ slower than regular lanes
___ too much trouble to change lanes
___ the HOV lanes are not safe
___ all traffic moves fast enough
___ forget to use HOV lanes
___ other ___________

Section B: Your Opinions

5. Place an "X" by the *three options* that you think would most likely make HOV lanes more attractive for carpooling or bus riding.

- ___ Wider and safer lanes.
- ___ Connection of these lanes with other HOV lanes.
- ___ HOV lanes on the right side of the freeway rather than on the left side of the freeway.
- ___ Park & ride lots near freeway entrances/exits.
- ___ Better police enforcement against violators.
- ___ Employers' help with paying for part or all of bus passes or parking for carpoolers.
- ___ Opening all HOV lanes to 2 person carpools.

6. Please indicate the extent to which you agree or disagree with the following statements.

	Agree Strongly	Agree	Neutral	Disagree	Disagree Strongly
HOV lanes are a good idea.	___	___	___	___	___
Vehicles dart in and out of HOV lanes too often for the lanes to be safe.	___	___	___	___	___
HOV lanes help save all commuters a lot of time.	___	___	___	___	___
Constructing HOV lanes is unfair to taxpayers who choose to drive alone.	___	___	___	___	___
Existing HOV lanes are being adequately used.	___	___	___	___	___
HOV lane violators commit a serious traffic violation.	___	___	___	___	___
HOV lane violators are common during the commute hours.	___	___	___	___	___
Many more people would carpool if the HOV lanes were more widespread.	___	___	___	___	___
HOV lanes should be opened to all traffic.	___	___	___	___	___
HOV lanes are convenient to use.	___	___	___	___	___
HOV lane construction should continue, in general.	___	___	___	___	___
HOV lanes should be enforced with police who observe violators and mail tickets to the owner of the auto.	___	___	___	___	___
2-person carpools should be allowed to use all HOV lanes.	___	___	___	___	___

APPENDIX V

LICENSING DATA RECORD

APPLICATION
· OVERNIGHT LAW ENFORCEMENT INQUIRY RESPONSE FORMAT

DEPARTMENT OF LICENSING - INFORMATION SYSTEMS
RECORD LAYOUT

DATE ~~5/14/~~

PAGE 1 OF 2

TAPE OUTPUT FORMAT	1	2	3	4	5	6	7	8			9
	N	A/N	-	N	A/N	A/N	A/N	N			N
. 1600 BPI, 9 TRACK . UNLABELED, EBCDIC . FIXED RECORD - 267 . 10 RECORDS / BLOCK	REQ CODE	LICENSE PLATE NUMBER	S FLAG	MOD YR.	MAKE	SERIES AND BODY TYPE	VIN NUMBER	INQUIRY DATE			SD
								MM	DD	YY	MM
	1	3	10	11	13	18	26	43	45	47	49

	9		10	11
	A/N		A/N	A/N
(CONTINUED)	STAMP DATE		REGISTED OWNER NAME FIELD 1	REGISTERED OWNER NAME / ADDRESS
	DD	YY		
	51	53	55	85

	11	12	13
	A/N	A/N	A/N
(CONTINUED)	FIELD 2	REGISTERED OWNER NAME / ADDRESS FIELD 3	REGISTERED
		115	145

	13	14
	A/N	A/N
(CONTINUED)	OWNER NAME / ADDRESS FIELD 4	REGISTERED OWNER NAME / ADDRESS FIELD 5
		175

APPENDIX W

ENTRY MANUAL FOR HOV SURVEY

GENERAL INFORMATION

At the end of each shift, traffic counters record the license plates of ten vehicles. Five of the plates are HOV vehicles, the other five are SOV vehicles. Those license plate numbers are then sent to the DOT in Olympia and the DOT sends TRAC the names and addresses associated with the plates. Each driver then receives a survey coded for the area where the license was recorded (I-5 North, I-90, etc.) and whether the vehicle was HOV or SOV. Once the surveys are returned, the results are entered into SPSS for analysis.

The entry you will be doing is very important to the HOV project. The results will be used by state lawmakers and planners for future HOV lane planning. Other states and transit agencies will probably be very interested in the results as well. I can't stress enough how important it is, then, that your data entry be as accurate as possible. Accuracy is as high a priority as speed.

I designed the data entry program to be very easy to use. The entry form looks almost exactly like the questionnaire. Once you are acquainted with how SPSS operates, you should have few problems entering tons and tons of data. We expect to receive 5,000 to 10,000 surveys.

GETTING INTO SPSS DATA ENTRY

NOTE: I will give you a tutorial at the outset. Even so, keep these instructions by your side for reference.

1) You will need to be at a terminal that has SPSS to get anything done. The computer at my desk in Room H and the Compaq in the TRAC main office both currently have the necessary software. Other stations can be outfitted as needs be. If you have an IBM PC or clone at home and can load SPSS onto your computer, feel free to work at home.

2) **Create a new data file.** This is very important, so be clear about it. The file you want to copy this new document from is called "SURVEY.TEM". SURVEY.TEM is a template of the data entry document and it is on your data disk. Name the new file according to the following parameters: Your initials (two digits) + month (two digits) + day (two digits) + year (two digits), then the file extension HOV. So if I were creating a new document today, January 8, 1993, I would call it "MH010893.HOV". To

create this file (on your floppy disk, mind you) get to the "A" prompt. Type "copy SURVEY.TEM (space) MH010893.HOV" and hit Return.. When you are finished with your entry session, back the file up on your floppy disk to make sure we have a safe copy around. Do this by typing "copy MH010893.HOV (space) MH010893.BAK" and hit Return.

WE ARE NOT DOING ANY ENTRY WITH FILES LOADED ONTO THE HARD DRIVES. IT IS ALL ON YOUR OWN DISK.

The reason we are creating new files for each day's entry is that if your file crashes, then we only lose that day's entry, not your cumulative entry. This is a pain, but a necessary step.

3) **Go to the C prompt.** Most computers default to this directory. If you are unsure where you are, type: "C", then colon ":", then "Enter".

4) **Get into the SPSS sub-directory** by typing "cd (space) spss" and then hit "Enter".

5) **Type "SPSSPC/DE" and hit "Enter" to load the data entry program.** Note that the slash in the "SPSSPC/DE" command is a forward slash, not a backslash.

YOU MAY PERFORM STEPS 3-5 ALL AT ONCE BY TYPING THE PATH "C:\SPSS\SPSSPC/DE" AND HITTING ENTER.

GETTING INTO THE DATA ENTRY DOCUMENT

6) You will be presented with two gray menus. The top one is the Main Menu. **Select the Files Menu by entering "Shift + F2".**

7) Among the options in the Files Menu is the **Get File Option. Select this by entering "F2".**

8) A red box will appear, asking you what kind of file you want to call up. The default is an SPSSPC file, so hit "Enter" Another red box appears, asking you to input the filename you wish to call up. Type "**A:\XXXXXXXX.HOV**" and hit "Enter" The XXXXXXXX reflects your initials and the date -- the name of the file you just created and saved to the A drive. Hit "Enter" and the file will come up.

9) Some summary information about the file appears. Hit the space bar and it will go away.

10) The File and Main Menus will appear again. To get to the data entry, hit "Shift + F5". Hit the space bar again and the menus will go away..

HOW TO MOVE AROUND & FIELD EXPLANATION

The only parts of the survey document you can edit are the response fields. All you have to do is to enter the value given on the survey and the cursor is pushed to the next entry field.

Moving From Field to Field

Use "TAB" to move to the next field without entering or changing data for the field you want to leave. Likewise, use "Shift + TAB" to go backwards. These commands only work if the field is highlighted and the cursor is not blinking within the field. If the cursor is blinking within a field, SPSS wants you to enter some data. Hit "Escape" to stop the blinking.

Moving Within a Case

"Home" moves you to the first field on whatever page within a case you are working on. "End" moves you to the last. The Page Up and Page Down commands allow you to move between the six pages that make up each case. While you are entering data, the page will flip automatically as you enter the last field on a page. Use Tab to jump from field to field. The Enter key also moves you from field to field without overriding the data already entered. You may also use the Left and Right cursor arrows. But I caution against this for reasons described below.

Moving From Case to Case

The cursor arrows Up and Down allow you to jump from case to case. It seems as if this should move you from field to field but it doesn't. Look at the index at the top left corner of the screen -- as you scroll up or down with the cursor, the information in this area changes, telling you what page on what document you're on.

The reason I don't like using the Left and Right cursor keys to move from field to field is that it is very easy to mess up and go to a different case. If you don't catch this, you will end up mixing the data and skewing the results. It's best to be very clear where you are. Once you are comfortable working in SPSS, make up your own mind.

"Control + Home" moves you to the first case in the document. "Control + End" moves you to the last. This is handy when you are starting your entry session.

Escape Saves the Day!

No matter where you are, no matter what you are doing, if you freakout or are uncomfortable with the command you gave, the data you entered, or the response the computer had, just hit **"ESCAPE"**. This will back you out of whatever operation you might be trying. Escape also restores data if you mistakenly override previously entered values. Two quick "Escape"s exits the data entry stream. But don't panic if you get out of the data stream, because SPSS will not lose the data you entered. You do not have to re-do the "Get Files" process to get back into the data entry module. Just hit "Shift + F5" to get back to "XXXXXXSV.HOV". Make sure to save the data before you intend to exit the program for good.

To Change Data

If you see that you have entered some data incorrectly, highlight the field you want to amend, type in the new values, and hit Enter.

SPECIAL FEATURES

Entry Rules

There are guidelines for valid and invalid data. Most questions have a universe of three possible responses; 1 (yes), 0 (no), and 9 (no response). So if you enter a 7, you'll hear a beep and a note will appear saying you goofed. Hit the space bar to get rid of the note and re-enter the data.

EACH AND EVERY FIELD GETS A RESPONSE! Many respondents do not fill in the "No" box when they mean No. But you must enter this as a "No". **Only when a whole section is left blank do you use the No Response option.** On the second question, assume if someone checks "Yes" for two options, that the rest are "No". Again, do not use No Response unless the whole section is blank. Two notable exceptions to this rule are the Address and final Comments sections. Either people want us to have their address or they do not. If the respondent left the field blank, don't enter these fields as No Response, but as No(0).

Add Cases On

SPSS will not automatically create a new case record every time you finish entering data for the last case. To create new entry records, you must press F6 for "Add Cases On". If this feature is running, there will be a little note on the bottom part of the screen.

Skips and Fills

The point of Skips and Fills is to save time. For instance, if all of the entries for a given set of questions are the same, why not have a command that enters them all at once so you don't have to? For instance:

NO RESPONSE FILL -- Some people may not respond to a set of questions on the survey. The code for "No Response" is 9. If you enter a 9 for the first question in a group, then SPSS automatically enters 9's for the whole set. The cursor then skips to the next set of questions.

If you inadvertently hit a Skip and Fill command and want to change the data, don't worry. Hit Escape and use the Shift+TAB to move back to the field you want to change the entry for.

HELP!

F1 always gives you Help options. The help sections in SPSS are generally pretty easy to understand. I also have a Data Entry manual in my desk which you have unlimited access to. Explore the program if you like.

SAVING YOUR WORK

SPSS Data Entry has bugs. In fact, just before we turned you loose on the entry, my copy of the entry document and all of its backups crashed, leaving a bunch of unopenable files. To guard against losing data we have designed a system to keep the impact of potential crashes at a minimum. You will be creating a new file for each data entry session. The instructions for this have been given earlier.

You can save your work at any time by doing the following: Hit F1 to see the menus. Select F2 for File Menus. Select F3 to Save File. A box will appear, asking what kind of file you want to save. Accept the default SPSSPC file by hitting Enter. Enter the name of the file. ALWAYS USE THE NEW TEMPLATE FILE WITH YOUR INITIALS AND DATE ON IT -- ALWAYS. Hit Enter. SPSS then asks if you want to override existing file. Type "y" and hit Enter. SPSS then asks if you want to compress the file, say "N" for no and hit Enter. The computer then saves the file and puts you back at the menus. Hit Shift+F5 to get back to data entry. SPSS puts you back exactly where you left off.

When you finish your session, back the file up in DOS. Instructions for this have already been given and appear again on the last page.

ACCOUNTING

There are a couple of things you need to do to make sure the data is valid. Make sure to put a **Document Number** on each computer record and **write the same document number on the survey itself**. This helps you make sure you do not enter the same record twice. Please make sure when you begin and end your entry session that the numbers you wrote on the surveys match the numbers on the computer screen. Also make sure that the total number of surveys listed on the index matches the total number of hard copy surveys you have entered.

I have a central box for unentered surveys that you may just grab a pile from when you come in to enter data. Then, as you enter data and write document numbers on the surveys, you can put them in a binder so we don't mix surveys up. **This accounting is as important as saving.**

Finally, you will be given a log sheet to keep track of the files you have created, the document numbers you have used and the hours you have worked. Keep accurate records, please.

FIELD VALUES

The survey entry form goes like this:

1) *Document Number*: This is a five-digit number that identifies the document and person who entered it. You will be given a sequence of numbers in increments of, say, 1,000 which you will use for these ID numbers. Write the document number on the survey itself so we can go back and check individual cases if needs be. The document number also serves as a reminder to you what you've entered and what you haven't. Keep track of the numbers you are assigned, the numbers you have used, and the next set of numbers you use on your written log

2) *Return Date*: Simple. Look at the post mark on the survey for this. Enter as two digits -- January = 01, June = 06, December = 12, 1992 = 92, 1993 = 93. So a survey returned in November, 1992 would be entered as "1192".

3) *Survey Type*: two-digit code giving info on vehicle type and location -- i.e. SOV 4 = 42, HOV1 = 11, This information is on the lower left corner of the last page of the survey. A key is provided on the last page of this document.

4) *Question 1 -- How do you usually get to work?*

   People are supposed to select only one variable, but might select more. As always, 1 = selected or "yes",0 = not selected or "no", and 9 = No Response. We suspect most people drive to work alone, so if you enter "1" for drive alone, the rest of the fields will fill up "0"'s and move you the to next question.

   The "Other" field has two sub-fields. The first is whether the respondent used the written field or not. If there is a written response, type it in the larger "Other" field. Most people do not enter "Other" responses, so just hit Enter to move to the next field.

5) *Question 2 -- Have you used HOV lanes in the Seattle area?*. Remember that people may not follow the instructions and not check "No" when they mean no. Do not confuse this with No Response. Only use No Response when the whole question is left blank. 1 = selected. 0 = not selected. 9 = no response.

6) *Question 3 -- On which freeway have you used HOV lanes?* 1 = selected. 0 = not selected. 9 = no response.

7) *Question 4 -- Do you qualify for HOV lanes but don't use them?* This one is kind of tricky. If the respondent says No to the first question, then a fill

rule fills in all "0's" for the following selections. If the first question is a positive response, fill in all selected options. If there are options selected, but the first question is not, fill that first one in anyway.

8) *Question 5 -- Three options for making HOV lanes more attractive.* Three options should get a "1", the rest get a "0", or all get "9s".

9) *Question 6 -- Opinion Section.* There are seven possible responses for each question. I will provide you with a key to make sure you use the appropriate codes.

1 = agree strongly
2 = agree
3 = neutral
4 = disagree
5 = disagree strongly
6 = multiple responses
(use when there is no clear single response)
9 = NO RESPONSE

10) *Question 7 -- Gender.* Enter a 0 for male, 1 for female, 9 = No Response.

11) *Question 8* -- Age. Like the Opinion section, this has a different code than the normal 1 = yes, 0 = no.

1 = under 31
2 = 31-40
3 = 41-50
4 = 51-64
5 = 65+
9 = NO RESPONSE

12) *Question 9* -- Education. This question also has different coding.

1 = did not finish high school
2 = high school
3 = community college or trade school
4 = college/university
5 = post graduate
9 = NO RESPONSE

13) *Question 10* -- How many people live in your house? Since some people might live large group houses, we allowed for two-digit entry. **So make sure that if you are not confirming entries with the Enter key, you enter "02" for two occupants, not just "2".** If you do hit only one key, then the next entry you make will appear in the second digit column and throw the rest of your entries out of synch. NO RESPONSE in this and the following fields = "99".

14) *Question 11* -- How many in your house are over age 15? Same guidelines as above -- two digits required.

15) *Question 12* -- How many people who live in your house work outside the home? Same.

16) *Question 13* -- How many vehicles in working order do you have? Same. Pity those who have more than 9 cars, though.

17) *Question 14 a* -- Work Zip Code. Enter Work Zip Code. NO RESPONSE = "99999".

18) *Question 14.b* -- Home Zip Code. Enter Home Zip Code.

19) *Question 15* -- Which freeways do you usually use in your commute? 1 = selected, 0 = not selected, 9 = no response.

20) *Question 16* -- Willingness to answer follow-up questions. Enter 1 if they did put an address or phone number. Enter 0 if they put nothing.

22) *Question 17* -- Comments -- Did they have comments -- DO NOT WRITE OUT COMMENTS. Just put 1 for yes, 0 for no.

23) *Address* -- If the respondent put down an address, then enter it on the four lines provided. If not, then punch out four enters.

24) Then move on to the next document. Remember, you must have Add Cases On ("F6") enabled.

25) REMEMBER TO SAVE!

HOW TO GET OUT OF SPSS

Once you are finished entering data, hit Escape to turn the cursor off. Hit Escape again to go to the Main Menu. Hit "Shift+F10" to exit the Data Entry program. If you have not saved changes, SPSS will ask you to.

BACKUP TIME!!!!

When you exit DE, you will return to the DOS prompt. Go to the A drive by typing "A + : (colon)" and hitting Enter. Backup your day's entry on a floppy disk by typing "copy XXXXXXXX.HOV (space) A:\XXXXXXXX.BAK." The BAK file extension shows that this is a backup file. THANK YOU FOR SAVING.

We appreciate your work on this part of the project. Even more, we appreciate the work you do in the field. After counting cars one moderately cold, windy day, I have only this to say -- BRAVO!!

QUICK REFERENCE GUIDE

Survey Codes

Area	HOV (X1.	Area	SOV (X2)
HOV1	11	SOV1	12
HOV2	21	SOV2	22
HOV3	31	SOV3	32
HOV4	41	SOV4	42
HOV5	51	SOV5	52
HOV6	61	SOV6	62

CURSOR MOVEMENT COMMANDS
TAB -- Next field
SHIFT+TAB -- Previous field
HOME -- First field on a given page
END -- Last field on a given page
CONTROL+HOME -- First case
CONTROL+END -- Last case
CURSOR ARROW UP -- Previous case
CURSOR ARROW DOWN -- Next case
CURSOR ARROW LEFT -- Previous field
CURSOR ARROW RIGHT -- Next field
PAGE UP -- Previous page
PAGE DOWN -- Next page
To create new entry file -- Get to A prompt. Type "copy SURVEY.TEM (space) XXXXXXXX.HOV" and hitting Enter. The file name is your initials, the month, day, and year.
To Backup the day's entry file -- Go to A prompt. Type "copy XXXXXXXX.HOV (space) XXXXXXXX.BAK" and hit Enter.

APPENDIX X

HOV LANE FACT SHEET

Table X-1. Existing Sections of HOV Lanes

SR Direction	Section	Mileposts	LaneMiles	Date Opened	Inside/ Outside (I/O.	3+/2+	(Comments)
(* Indicates corridor included in this study)							
I-5 SB	212th SW to 236th SW	179.8-178.3	1.5	5-25-93	I	2+	
*I-5 SB	236th SW to Exp Ln Entrance	178.3-172.4	5.9	8-29-83	I	2+	3+ 8/29/83 to 8/18/91
*I-5 SB	Roanoke to Mercer (Express Lanes)	168.06-167.15	.91	1985	I	2+	
I-5 SB	Mercer to Cherry (Express Lanes)	167.15-165.51	1.64	Early 1970's	I	2+	
*I-5 SB	Mercer to Yesler	165.18-166.4	1.22	4-91	I	3+	
*I-5 SB	Foster to I-405	154.53-155.33	.8	1990	I	2+	
*I-5 SB	Tukwilla to SR 516 (Interim)	149.4-154.36	4.96	8-19-91	I	2+	3+ 8/19/91 to 12/7/92
*I-5 NB	S 272nd to S 200th(Interim)	149.6-150.9	1.3	8-19-91	I	2+	3+ 8/19/91 to 12/21/92
*I-5 NB	Boeing Access Rd. to Steele	158.16-160.47	2.31	12-91	I	2+	3+ 12/91 to 12/14/92
I-5 NB	Lake City Way to Express Lane Entrance (Express Lanes)	170.6-172.17	1.57	1987	I	2+	3+ 1987 to 8/18/91
*I-5 NB	Express Lane Ent. to NE 185th	172.43-176.7	4.27	8-29-83	I	2+	3+ 8/29/83 to 7/28/91
SR 99 NB	NE 117th to NE 145th	38.97-40.47	1.5	6-22-79	O	3+	City of Seattle HOV Lane
*I-405 SB	Coal Creek to Sunset	5.02-10.47	5.47	1-8-86	O	2+	
*I-405 SB	South Renton to Tukwilla	0.32-2.98	2.66	12-1-90	I	2+	
*I-405 NB	Tukwilla to South Renton	0.09-2.76	2.67	11-26-90	I	2+	
*I-405 NB	Sunset to Coal Creek	4.62-10.56	5.94	1986	O	2+	
*I-90 WB	Mercer Island to Rainier Ave. (Interim)	3.49-8.54	5.05	1989	I	2+	3+ 1989 to 2/92 2/92 Switched to Inside
*I-90 EB	5th Ave. to Rainier Ave.	1.98-3.49	1.54	2-17-92	I	2+	
*I-90 EB	First Hill Lid to S. Bellevue Way	6.00-9.92	3.92	1989	I	2+	
*SR 520 WB	108th NE to 76th	4.23-6.38	2.15	1973	O	3+	1973-1975 Transit Only
SR 509 NB	SW Cloverdale to 1st Ave. So. Bridge	29.38-29.73	.80	3-18-89	O	2+	3+ 3/18/89 to 4/91
SR 522 EB	NE 135th to NE 147th	3.72-4.30	.58	7-19-86	O	—	Transit Only
SR 522 WB	NE 73rd to NE 147th	4.43-7.46	3.03	Early 1970's	O	—	Transit Only
TOTAL LANE MILES			**61.7**				

Sources: State Highway Log, Vol. 1, Vol. 2, 1992.
WSDOT Roadway Data Office.
WSDOT, District 1.