Washington State Freight Truck Origin and Destination Study:

Methods, Procedures, and Data Dictionary

EWITS Research Report Number 3
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by

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EWITS Research Reports: Background and Purpose

This is the third of a series of reports prepared from the Eastern Washington Intermodal Transportation Study (EWITS). The reports prepared as a part of this study provide information to help shape the multimodal network necessary for the efficient movement of both freight and people into the next century.

EWITS is a six-year study funded jointly by the Federal government and the Washington State Department of Transportation as a part of the Intermodal Surface Transportation Efficiency Act of 1991. Dr. Ken Casavant of Washington State University is Director of the study. The Gillis Group, a private consulting firm based in eastern Washington, provided the WSU project team with research and management assistance. A state-level Steering Committee provides overall direction pertaining to the design and implementation of the project. The Steering Committee includes Jerry Lenzi, Regional Administrator (WSDOT, Eastern Region); Richard Larson (WSDOT, South Central Region); Don Senn (WSDOT, North Central Region); Charles Howard (WSDOT, Planning Manager), and Jay Weber (Douglas County Commissioner). Linda Tompkins represents the Washington State Transportation Commission on the Steering Committee. An Advisory Committee with representation from a broad range of transportation interest groups also provides guidance to the study. The following are key goals and objectives for the Eastern Washington Intermodal Transportation Study:

- *Facilitate existing regional and state-wide transportation planning efforts.*
- *Forecast future freight and passenger transportation service needs for eastern Washington.*
- *Identify gaps in eastern Washington's current transportation infrastructure.*
- *Pinpoint transportation system improvement options critical to economic competitiveness and mobility within eastern Washington.*

For additional information about the Eastern Washington Intermodal Transportation Study or this report, please contact Ken Casavant at the following address:

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The contents of this report reflect the views of the authors, who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Washington State Department of Transportation or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

EWITS PREVIOUS REPORTS NOW AVAILABLE

1. Gillis, William R. and Kenneth L. Casavant. "Linking Transportation System Improvements to New Business Development in Eastern Washington." EWITS Research Report Number 1. February 1994.

2. Gillis, William R. and Kenneth L. Casavant. "Lessons from Eastern Washington: State Route Mainstreets, Bypass Routes and Economic Development in Small Towns." EWITS Research Report Number 2. February 1994.

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INTRODUCTION

Providing for the efficient intermodal movement of freight and goods is a primary responsibility of State Departments of Transportation, Metropolitan Planning Organizations (MPOs) and many local governments. This responsibility has received increased emphasis as a result of the federal Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). ISTEA requires states and MPOs to include a specific focus on freight and goods mobility as one element of their updated plan.

Planning for the efficient movement of freight and goods is hindered by a lack of information on the source and characteristics of freight truck movements on state and regional highways. Freight movement by rail and water can be tracked adequately through Interstate Commerce Commission (ICC) waybill samples, the Corps of Engineers Waterborne Commerce data and other published sources. However, obtaining comprehensive information on truck freight movements is much more difficult due to the large number of carriers and the numerous potential origins and destinations.

To address this information gap, the Washington State Department of Transportation (WSDOT) initiated a state-wide freight truck origin and destination study in April of 1993. A region-wide freight truck origin and destination study was first proposed in Washington as an element of the Eastern Washington Intermodal Transportation Study (EWITS). EWITS is a six-year ISTEA planning study to define the multimodal network necessary for the efficient movement of freight and people throughout the region of Washington located on the east side of the Cascade Mountains. Supplemental funding provided by WSDOT enabled the EWITS freight truck origin and destination study to be expanded to include the entire state. Washington State University worked with The Gillis Group, a private consulting firm to conduct the study.

The Washington study is the first in the United States to collect state-wide freight truck origin and destination data through direct personal interviews of truck drivers. The state-wide study involved over 300 persons conducting personal interviews at 28 separate locations. A total of 28,000 truck drivers were interviewed providing Washington with an extensive database on state-wide freight and goods movements.

This paper describes the methodology and procedures utilized for the state-wide freight truck study. Specific issues include data collection issues and methods; data management analysis and modeling procedures; and opportunities for future enhancements to the database system.

DATA COLLECTION ISSUES AND METHODS

Data Source Alternatives

Aggregate information on U.S. freight truck movements can be obtained from a variety of government and private sector sources. For example, the Transearch freight flow database compiled by Reebie and Associates provides aggregate information on commodity movements by mode between major cities. The Census Bureau and the Federal Highway Administration produce the Truck Inventory and Use Survey, the Nationwide Truck Activity and Commodity Survey and the Commodity Transportation Survey. These government sources also provide a broad picture of major truck flows between regions. However, none of these sources are designed to provide information on freight truck movements on specific highways in substate regions outside major cities or local transportation corridors.

The development of a methodology that would provide statistically reliable and comprehensive information on truck movements throughout the entire state was needed to fulfill research goals outlined for the Washington State Freight Truck Origin and Destination Study. In particular, information on a wide array of freight truck characteristics is needed to plan effectively for the state-wide freight and goods system. Examples include information on time of day movements, truck/trailer configuration, cargo type, payload weight, use of intermodal facilities, and routes utilized between major origins and destinations. Because this information is not available from published secondary sources, it is necessary to collect data directly from trucking firms.

Several specific criteria were developed as guidelines for the design of the state-wide truck survey project including:

Data collected should provide statistically reliable information on truck characteristics and commodity flows for all major Washington highways.

The sample size should be large enough to provide useful freight and goods movement information for major transportation planning subregions as well as the state as a whole.

Information should be developed over a continuous 24-hour period in each of the four seasons of the year.

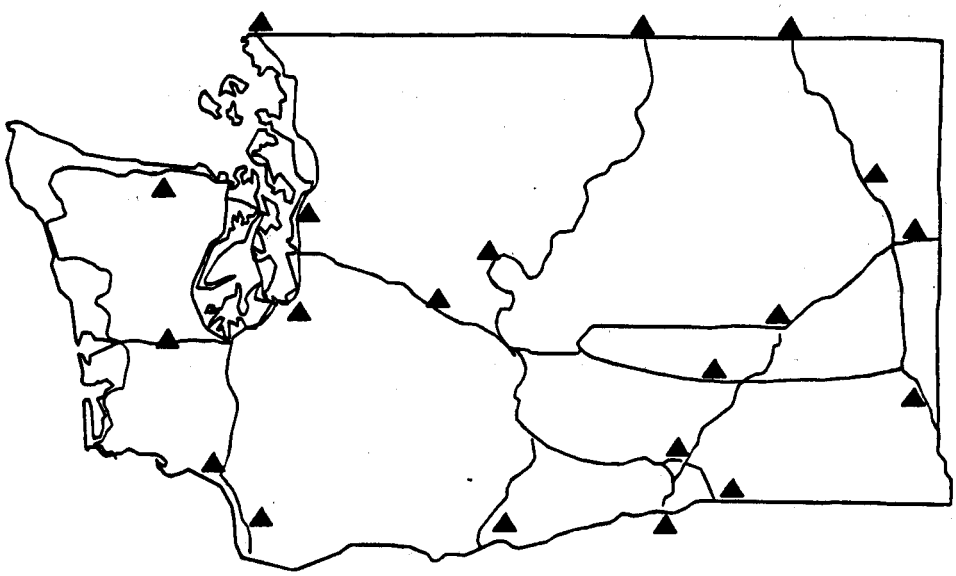
Among the alternatives, including mail or telephone surveys, roadside interviews of truck drivers are the most effective means of generating truck freight information addressing these three criteria. Several previous studies utilizing roadside interviews provided insights to the development of the Washington Freight Truck Origin and Destination Study. Among the most comprehensive of the previous studies is the Ontario Commercial Vehicle Survey of 1988. The Ontario Ministry of Transportation conducted roadside surveys of 19,225 commercial vehicles between March and November of 1988. The interviews were conducted by Ministry of Transportation staff at 41 weight scale locations and 16 additional roadside locations. The truck driver interviews collected a wide array of information ranging from axle counts to cargo type to vehicle weight. A similar study conducted by Washington State University in 1992 focused on northwestern Washington border crossings between Canada and the United States. Roadside interviews were conducted by student interviewers as trucks passed through the United States Ports of Entry. In addition to collecting information on the truck characteristics and commodity type, the Washington State University study documented specific highway routes utilized by the trucks.

Site Selection

Following the lead of the previous studies, permanent weigh stations and ports of entry were utilized as the primary data collection sites for the Washington truck survey. The specific weigh stations utilized as data collection sites were identified through analysis of WSDOT's traffic count and vehicle classification data. Data collection sites were established on all state highways with a significant volume of daily truck traffic. On Washington's major interstate corridors, multiple data collection sites were identified. Recognizing the importance of expanding international trade, plans were also established for roadside interviews at major United States/Canadian border crossings.

To obtain a complete profile of truck movements it is necessary to interview trucks traveling both directions on a given highway segment. On divided highways, this required identifying two separate interview sites on alternate sides of the highway. In total, interview sites were established at 21 Washington State Patrol weigh stations, 3 Canadian border locations and the Oregon Port of Entry in Umatilla (see Figure 1.1 on page 4).

Figure 1.1: Truck Interview Locations



Questionnaire Design

Questionnaire design is an important element of a successful methodology for roadside truck driver interviews. The Washington state-wide truck driver survey collected information on time of day movements, vehicle configuration, trucking company location, origin and intended destination, cargo type, vehicle and cargo weight, use of intermodal facilities and the specific route traveled (See Appendix A).

To encourage truck driver participation, the questionnaire was designed to be completed within 3 minutes. Approximately one-half of the questions (for example number of axles, trailer style, time of day, hazardous material placard) could be filled out by direct observation of trained interview personnel. Questions to be asked directly to the truck driver focused on cargo, weight, use of intermodal facilities and route of travel. To the extent possible, check boxes were utilized to enable rapid completion of each interview by minimizing necessary writing. A map of major Washington State highways was attached to each questionnaire. Utilizing this map, the interviewers are able to quickly highlight Washington highways utilized by drivers traveling between their stated origin and destination.

Appropriate phrasing of interview questions is also essential. For example, the preliminary questionnaire developed for the Washington truck driver survey requested information on the "payload weight." During the pretest phase of the project, many

drivers confused "payload weight" with "gross weight." Consequently, the questionnaire was revised to request "what is the weight of the cargo that you are carrying today?" Establishing a process for ongoing evaluation and modification to the survey questionnaire is essential.

Selecting Interview Dates and Duration

The Washington State Freight Truck Origin and Destination Study developed seasonal data for each of the four seasons: summer, fall, winter, and spring. Particularly in agricultural regions, seasonal differences in truck movements can be substantial. For example, grains are harvested in the summer while apples are harvested in the fall. Consequently, highways important to the transportation of these commodities may have significantly different truck volumes in different seasons.

The Washington truck survey is designed to provide a profile of state-wide truck movements during each season. Consequently, it is important to conduct interviews at all 25 sites within as short of time frame possible during each season. Data collection sites were systematically scheduled to avoid the practical problem of requesting an interview from the same truck driver on a given day. With these constraints, approximately five weeks were needed to complete each interview cycle at the 25 sites.

Truck driver interviews at most locations were scheduled for a continuous 24-hour period to provide a comprehensive picture of state-wide movements. Interviews were also consistently scheduled for Wednesdays to obtain median traffic patterns rather than exceptionally heavy Monday or Friday flows. Maintaining consistent data collection at each site helps to avoid potential statistical bias when aggregating the data to profile state-wide movements.

Sampling Issues

Approximately 4,500 commercial vehicles travel Washington's I-5 corridor each day. Other major Washington freight truck corridors typically support 1,500 to 2,500 trucks per day. Interviewing every truck driver traveling these busy corridors is neither feasible nor necessary. A systematic sampling strategy was developed for the Washington truck survey.

An overall goal of obtaining at least 300 surveys over a 24-hour period at each site was established. One out of every 10 trucks on I-5 and one out of every 5 trucks on most other major Washington freight truck corridors were targeted for an interview. On several of the lower volume routes, one out of every two commercial vehicles was targeted for an interview. A total of approximately 7,000 truck drivers were interviewed during each of the four seasonal survey rounds, providing a database of 28,000 interviews for the year-long study.

INTERVIEW TEAM RECRUITMENT AND TRAINING

Interview Team Recruitment

To obtain an accurate seasonal profile of truck movements throughout the state of Washington, it was necessary to conduct interviews simultaneously at more than 6 sites across the state. The more typical approach of hiring a team of interviewers to travel from site to site over a period of weeks did not meet the research design goals established for the Washington study. Typically 15 people were required to cover a 24-hour interview session at each of the sites. On a given day, up to 90 interview personnel were required. Consequently, a particular challenge was to obtain a very large, short-term labor force to successfully complete the freight truck origin and destination study.

To meet this challenge, members of community service clubs were recruited and trained to conduct truck driver interviews. A community service organization with state-wide membership was sought for the project. The opportunity was first introduced at a state-wide conference of Washington State Lions Clubs. The Lions Clubs were offered the opportunity to conduct truck driver interviews as a club fund raising activity.

As a result of initial recruitment efforts, 15 Lions Clubs and 1 Kiwanis Club agreed to provide at least 15 members to serve as local interview teams. A total of over 300 service club members participated in the Washington study.

All the clubs were located in close proximity to the selected interview sites. Their close geographic proximity minimized travel costs for the interview team. The club members' personal knowledge of local roads and industries also proved to be a major advantage in communicating and understanding responses provided by truck drivers. Most of the same club members participated in each of the four interview rounds, creating a highly experience local interview team available for future projects.

Training

Interview team training is always an important component of any study involving personal interviews. A strong training program is essential when less experienced personnel are utilized to conduct interviews. A detailed training program for interview team members was conducted by The Gillis Group. The training program included both classroom and on-site instruction.

Figure 1.2: Interview Team Training Agenda

Topic	Time Allotted
Project goals and objectives	10 minutes
Overview of the interview questionnaire	20 minutes
Identifying truck and trailer configurations	15 minutes
Personal interview techniques	15 minutes
Safety requirements	10 minutes
Things to bring	5 minutes
Questions and answers	30 minutes

An individual and customized classroom training session was conducted for each of the 16 service clubs. Each training session began with an overview of the key project goals and objectives. Each interviewer was prepared to answer basic questions concerning the purpose of the study. This information was helpful to them in responding to questions from truck drivers. The interview questionnaire was reviewed in detail. Particular focus was given to ensuring the interview team members were able to accurately identify the different truck and trailer configurations. Personal interview techniques were also covered. In particular, advice on how to introduce the study purpose and request an interview from the truck driver was offered.

Conducting personal interviews of truck drivers at busy weigh stations is a strenuous and potentially dangerous activity. Every effort was made to design a site setup and traffic control plan to avoid the potential of an unwary interviewer stepping in the path of an oncoming truck. In addition, the personal responsibility of each interviewer to be alert and promote on-site safety was stressed at the training. Examples of safety requirements emphasized to the interview team members included: always wear safety vests and hats while on-site, never approach a truck when moving, do not allow traffic congestion to occur in the interview area and take regular breaks. A written manual outlining safety requirements, truck configurations, and other interview guidelines was provided to each team member at the conclusion of the classroom training.

The classroom training session is only the beginning of what should be a continuous process to ensure quality interviews and personnel safety. Ongoing training and instruction was provided by a supervisor assigned from the project management team to each site. Over time, most teams became highly adept at conducting the personal interviews and constant supervision was no longer necessary. However, periodic monitoring of interview activities continued throughout the project.

FIELD DATA COLLECTION PROCEDURES

Equipment Needs

Figure 1.3: Equipment Utilized at Each Interview Site

reflective safety vests	interview team hats
clipboards	pens, pencils and highlighters
survey crew sign	weather-proof boxes
head lamps	traffic cones

Proper equipment is necessary to ensure both interview personnel safety and accurate results. Equipment utilized at each interview site is identified in Figure 1.3. An adequate supply of basic equipment such as clipboards, pens, pencils, highlighters, and staplers is necessary. A large "Survey Crew" sign was utilized at each site. The sign served a dual purpose of informing truck drivers approaching the station that an official survey was taking place and also served as a caution that interview personnel are in the vicinity. All interview personnel were issued safety vests. It is important that high quality reflective vests be utilized when interview crews are operating in the dark. Head lamps were also provided to the night shift to help interview team members see and be seen. Weather proof boxes were provided at each site as storage for completed surveys.

Site Set-up and Traffic Control

Typical site set-up and traffic control plans utilized at interview sites are described by the figures on page 9. Figure 1.4 describes site set-up at smaller weigh station sites typical on lower traffic volume corridors. Figure 1.5 describes the site set-up at higher traffic volume locations typical on I-5 and at ports of entry. Procedures at both large and smaller sites are similar. Site set-up and traffic control plans at United States/Canadian border locations were similar to those utilized at weigh stations.

All interview scheduling was coordinated and approved by the Washington State Commercial Vehicle Enforcement Section, or U.S. and Canadian Customs officials in the case of data collection sites at border crossings. Cooperation from the Oregon Department of Transportation was received in conducting interviews at the Umatilla Port of Entry.

Figure 1.4: Site Set-up and Traffic Control Plan at Smaller Weigh Stations

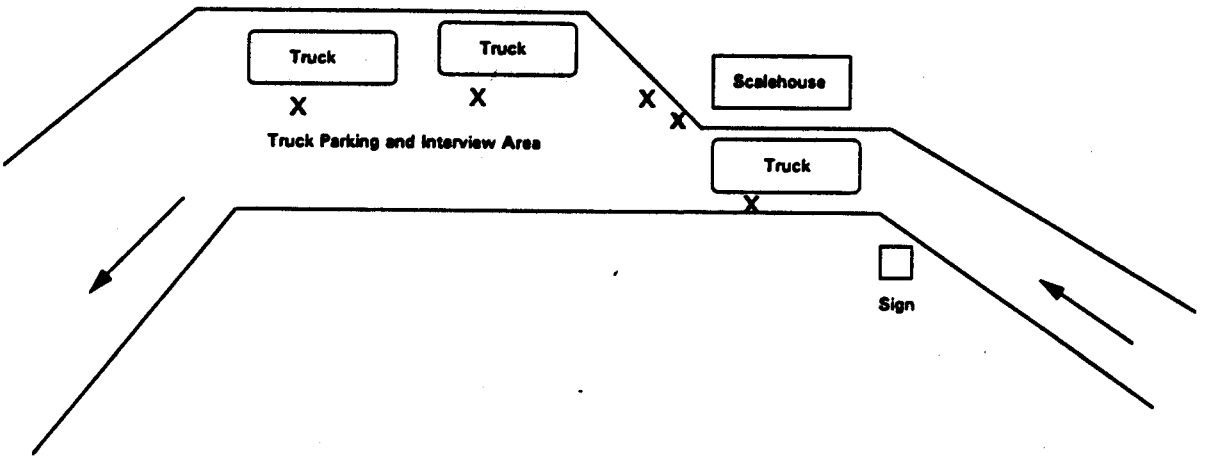
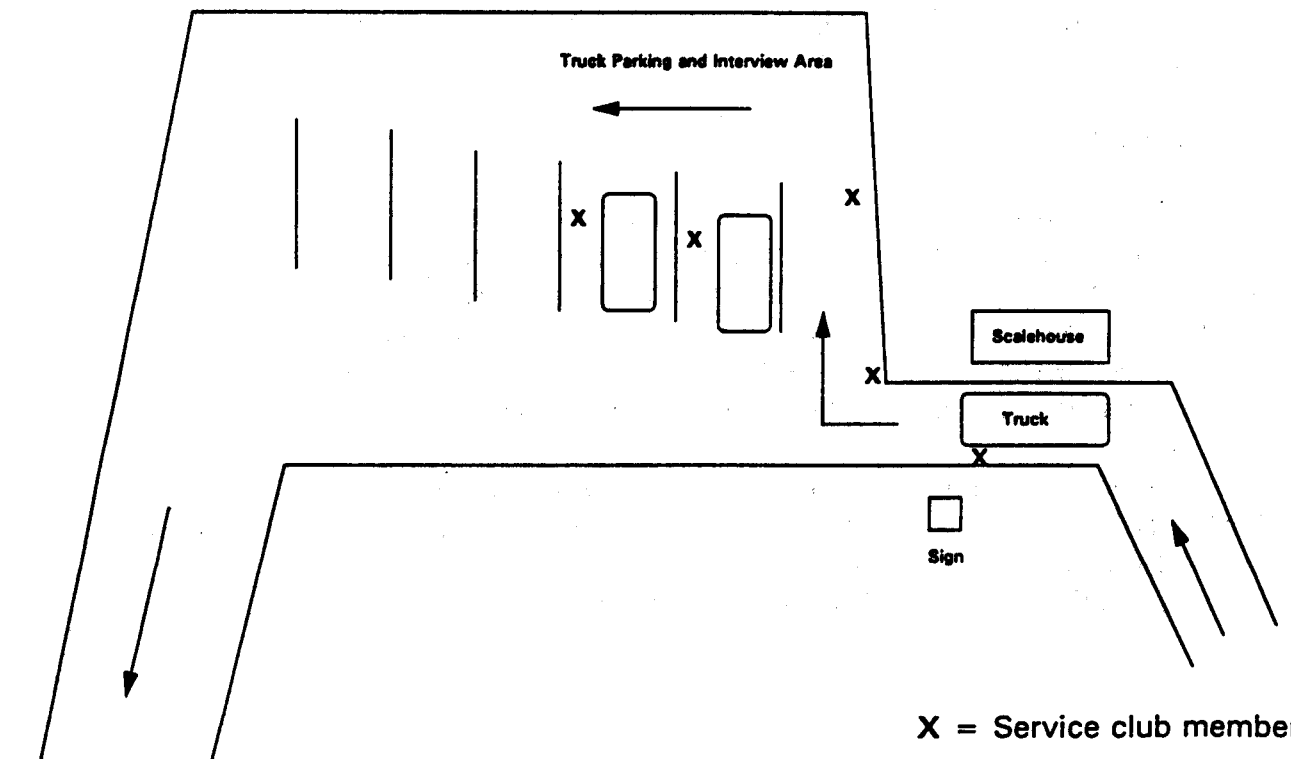


Figure 1.5: Site Set-up and Traffic Control Plan at Weigh Stations With a Large Parking Area



Uniformed officers at the weigh stations or ports of entry conducted enforcement activities as normal. Commercial vehicles entered the weigh station or port of entry check points following the usual procedures. After enforcement activities were complete, selected trucks would be directed into a designated interview area by the officer in charge or a member of the interview team. Truck drivers were selected for an interview according to predetermined interview procedures. For example, along I-5 every tenth truck was directed to the interview area. Along Interstate 90, every fifth truck was directed to the interview area. At some low volume locations, every other truck driver was selected for an interview.

While the truck was parking, a member of the interview team completed visual information such as the time of day, number of axles, truck configuration, and the presence of a hazardous material placard. After the truck came to a complete stop, a member of the team approached the driver requesting an interview. Truck driver participation in the survey was voluntary. Remarkably, approximately 96% of the truck drivers requested to complete an interview agreed to participate. The truck drivers were provided with a coupon for a free cup of coffee as a token of thanks for their participation.

At the smaller weigh station sites, only two and at most three trucks can be safely parked to the side. At stations with a large parking area, traffic cones were utilized to block-off up to four lanes as a designated truck interview area. In all cases, a lane was provided to allow trucks not selected for an interview to pass safely back onto the highway.

On average, an experienced interviewer can complete the questionnaire within three minutes. A crew of up to five interview personnel was maintained at each site throughout the 24-hour survey period. This enabled the crew to quickly begin a new interview as soon as the previous one was completed. In most cases space and personnel at the interview sites were adequate to ensure traffic continued to flow freely. However, during certain busy periods, trucks that would have otherwise been interviewed were allowed to pass because space to safely park them was not available.

Importance of Uniformed Officers

Cooperation and support from Commercial Vehicle Enforcement Officers and Customs officials was essential to the success of the field data collection project. Uniformed officers provided two critical services. First, their presence helped to ensure the safety of the interview personnel. Second, the presence of a uniformed officer was likely a major contributing factor to the high level of participation received from truck drivers asked to complete an interview. While passing through weigh stations or ports of entry, truck drivers are prepared to present their records and respond to questions pertaining to enforcement. Many of the truck drivers indicated they thought they were asked to park

for an enforcement violation. They expressed relief and willing cooperation when they learned they were only being asked a few questions about their destination and cargo.

Quality Control Procedures

A program of on-site quality control is essential to ensuring accurate data results from the interviews. A strong training program for the interview teams was one tool utilized to support accurate data collection. In addition, a supervisor from the project management team was assigned to each site. The supervisor checked questionnaires for accuracy as they were completed. Problem areas were immediately addressed with interview personnel as necessary.

A quality control award was established as an extra incentive for service clubs to perform quality work. Small bonus checks were awarded to clubs that provided data entry personnel with the most legible, accurate, and complete questionnaires. As a result, many clubs instituted their own quality control measures. Several clubs assigned one individual to check each completed questionnaire and make changes as necessary. Some clubs re-wrote questionnaires that were less legible.

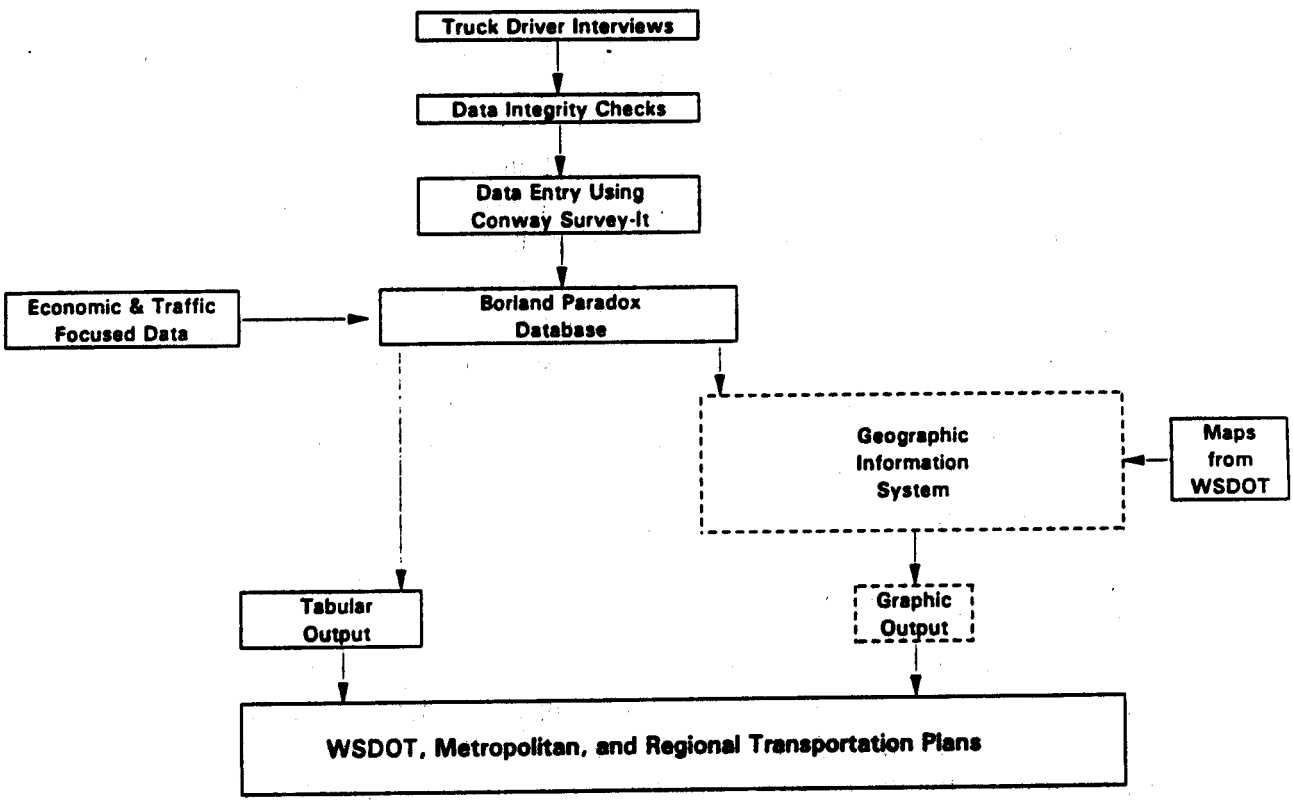
Data quality was also affected by the weather and other events beyond the control of the team. For example, rain showers dampened some paper questionnaires. Several of the interview sessions took place during snow storms. To protect the safety of the crew and ensure high quality data, interviews were often conducted inside the scale house during periods of bad weather. The selected truck drivers were asked to park and come inside the scale house for an interview.

Particularly along high traffic volume corridors, brief interruptions to the data collection occurred. For example, during high volume periods, the available capacity on the weigh station entry ramp may be inadequate. In these cases, to prevent congestion on the highway, it was necessary to briefly shut down enforcement and interview activities until the traffic could clear. In several cases, road construction in the vicinity of the weigh station made it necessary to cease interview operations for a period of several hours. At one station, a hazardous material spill resulted in the closing of an interview site for an entire afternoon. Interview teams recorded any breaks in activity or other problems affecting data quality on a site summary sheet provided to the project managers.

DATA MANAGEMENT, ANALYSIS AND MODELING PROCEDURES

The overall framework for data management, analysis and modeling of Washington State freight truck movements is depicted in Figure 2.1. Key data management, analysis, and modeling procedures utilized by the Eastern Washington Intermodal Transportation Study (EWITS) research team are highlighted in this section.

Figure 2.1:
Data Management, Analysis and Modeling Framework



Data Management

Implementation of carefully designed database management procedures is key to providing an accurate representation of state-wide and regional freight truck movements. Effective data management systems help minimize errors due to inaccurate field data collection and/or data entry.

There are at least three potential sources of error associated with field interviews of truck drivers. First, there are systematic problems caused by inappropriately worded questions, interview procedures, and/or site selection. Second, the truck drivers may provide inaccurate responses to questions. Third, interviewers may incorrectly record vehicle data or responses provided by drivers.

Potential systematic errors caused by flaws in the survey methodology were minimized through ongoing evaluation and adjustments to the interview questionnaire and site survey procedures. Improving the clarity of interview questions also helped to minimize potential errors due to drivers providing inaccurate responses. An ongoing program to provide training and supervision to community service club teams helped reduce errors associated with interviewers incorrectly recording responses provided by truck drivers. Despite these safeguards, field data collection errors can not be eliminated completely.

A data integrity review was implemented for each completed questionnaire prior to entering information into the database. Each questionnaire was reviewed to ensure the answers were logically consistent. Among the most frequent errors were completed questionnaires with a total combined payload and empty vehicle weight well above the legal limit for a particular axle configuration. In these cases the driver was generally providing the interviewer with the gross weight rather than the requested cargo weight. Another common error was a truck reported carrying cargo that was actually empty. The data integrity review process included the development of specific decision rules to revise incorrect data utilizing other information recorded on the questionnaire. For example, trucks with a reported combined cargo and empty vehicle weight in excess of 110% of the legal limit were assumed to be gross weights. Revised payload weights were estimated as gross weight minus the reported empty vehicle weight. Empty vehicle weights were generally reported accurately.

Using these techniques, data recorded incorrectly on the field interview questionnaires were identified and corrected prior to data entry. The research team utilized the Conway Survey-It software package for data entry purposes. Survey-It provides a user friendly menu driven data entry screen but has only limited database capabilities. Data entered into Survey-It were then exported into Borland Paradox. Paradox was used as the primary database software for the project. Additional data integrity checks were implemented utilizing cross-tab, edit, and search functions of Paradox.

Data Analysis and Modeling

Data collected through state-wide personal interviews of freight truck drivers provides valuable information for a wide variety of transportation planning applications. A number of specific examples of potential applications are listed in Figure 2.2 (page 15). Many of

the database applications listed in Figure 2.2 will be demonstrated by a future EWITS report which will be available early in 1995. The purpose of this report is to highlight the assumptions and procedures which underlie the analysis.

Statistical weighting of sample data

It was not feasible to interview every truck driver passing through Washington State weigh stations on designated survey dates. Consequently, statistical sampling procedures described in Section 1 of this report were utilized. For the purpose of analysis, statistical procedures are necessary to expand sample data to reflect characteristics of the entire population of trucks utilizing Washington highways. Specifically, two types of statistical weights may be required in conducting analysis. First, weights are needed to expand sample characteristics of trucks observed at each interview site to reflect the characteristics of the entire population of trucks passing through a given site. Second, weights are required to eliminate possible "double-counting" of truck characteristics when the analysis requires combining information from two or more contiguous interview sites.

Interview site weights are calculated as follows:

$$\text{Interview site weight at weight station x for season y} = \frac{\text{Total number of trucks passing through weigh station x during a selected 24-hour period in season y}}{\text{Number of trucks interviewed at weigh station x during a selected 24-hour period in season y}}$$

The interview site weight is unique to each weigh station where data is collected. The interview site weights for each data collection point generally also vary somewhat between seasons because of slight sampling differences. The interview site weight for a specific station and season is calculated by dividing the total number of trucks passing through the station by the number of trucks interviewed. For example if 200 out of a total of 1,000 trucks passing through a weigh station over a 24-hour period are interviewed, the site weight is 5.0. Multiplying a chosen sample characteristic times the site weight is the "best" statistical estimate of that characteristic for the entire population of trucks passing through the station. This can be illustrated by continuing the above example. If the 200 trucks sampled at the weigh station reported an aggregate cargo weight of 5,000 tons, the "best" estimate of the total aggregate weight passing through the station over a 24-hour period is 5,000 tons x 5.0 = 25,000 tons per day.

Figure 2.2: Potential Applications for Freight Truck Origin and Destination Data

Corridor Planning

- Identify highway corridors most critical to key industries
- Pinpoint major freight truck generators for specific corridors
- Document routes most widely utilized for national and international trade
- Provide base data to project freight truck traffic growth and decline for specific corridors
- Provide base data to estimate the economic value of specific commodities shipped on specific corridors

Intermodal Systems Planning

- Delineate essential highways linked to rail, air, deep water, and river ports
- Evaluate intermodal systems most critical to key industries and international competitiveness
- Geographic proximity of intermodal facilities relative to origins and destinations of trucks utilizing those facilities
- Provide base data to project changes in highway usage that would result from rail-line abandonment or closing of key river ports

Pavement Management

- Document highway segments with the highest average freight cargo volumes and weights
- Provide base data to project future changes in freight cargo volumes and weights on specific highway segments

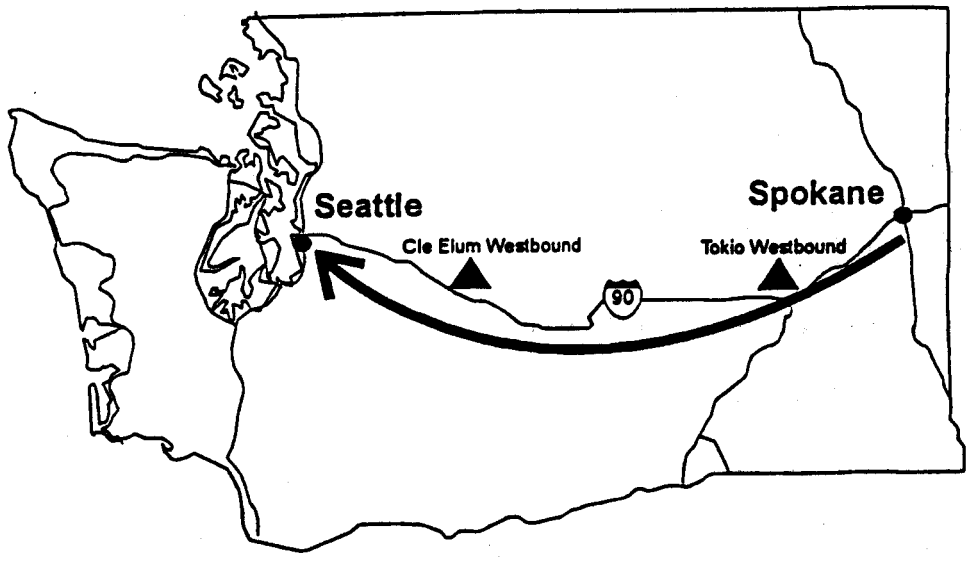
Congestion Management and Safety

- Document origins, destinations, and routes used by freight trucks traveling through congested urban areas
- Provide base data to evaluate opportunities to reduce freight truck traffic through urban areas during peak commute periods

The Washington State Freight Truck Origin and Destination Study included two interview sites that were special cases. Weigh Stations at Wallula Junction (SR 12/SR 730) and Othello (SR 26/SR 17) included sampling of trucks passing through the station from four different directions. Personal interviews of major freight generators in the vicinity of these two stations indicated that the sample data expansion method described by the equation appearing above resulted in a substantial overestimate of the actual number of trucks traveling to and from key origins and destinations. Consequently, the interview site weights for these two stations were recalibrated utilizing data collected directly from area shippers to better reflect actual truck movements.

A special analytical issue arises when combining data from two or more interview sites to profile state-wide and regional freight truck movements. Without an offsetting adjustment, the statistical aggregation of data pertaining to more than one interview site along a given route would result in multiple counting of a single truck and its associated cargo. This concept is illustrated in Figure 2.3 below. A truck carrying furniture from Spokane to Seattle on a given day would pass through interview sites at both Tokio and Cle Elum. Without an offsetting adjustment, the state-wide information including both Tokio and Cle Elum weigh stations would indicate two trucks with furniture traveling between Spokane and Seattle rather than the actual one truck with furniture.

Figure 2.3: Illustration of Double Counting When a Truck is Observed at Multiple Sites During a Single Trip



To offset potential multiple-counting of a single truck trip, individual "record weights" were calculated and applied to data collected from each interview. The formula utilized in calculating "record weights" is as follows:

$$\text{Record weight for truck k} = \frac{1}{\text{Number of interview sites passed through by truck k when using reported route j}}$$

Information collected directly from the drivers on the specific highway route they planned to utilize between a given origin and destination is a necessary component of calculating the record weight. From the example depicted in Figure 2.3 above, the truck would pass through two stations. Consequently the record weight for truck k would be 0.5.

The adjusted weight utilized to expand sample data obtained from personal interviews to reflect total regional and state-wide movements is calculated as follows:

Sample expansion weight for truck k interviewed at station x during season y = Record weight for truck k multiplied by the interview site weight for station x during season y

If the intended route of the truck driver only passes through the station where he was interviewed, the record weight would be 1. In this simple case the appropriate sample expansion weight would be equal to the interview site weight. However, if the intended route passes though more than one interview site, the record weight is less than one with a value ranging between 0.5 and 0.2 depending on the number of interview sites along the intended route. By utilizing the sample expansion weight to aggregate sample data for regional analysis, the multiple counting of a single truck trip is offset in developing the statistical population estimate.

Procedures for handling missing data

In general, the survey forms collected through field interviews of truck drivers were completed in a thorough manner. However, a significant number of completed survey forms include missing data. For example, a survey form indicating a truck carrying cargo may not include a "cargo weight." While the interview team member may have correctly highlighted the route reported by the truck driver, he may have inadvertently omitted the city of origin on the survey form. A variety of procedures were utilized to handle missing data cases such as these.

In many cases, missing data was confidently inferred from other questions on the survey form. For example, when the commodity is known, missing data for trailer style (chip truck, flatbed, tanker, etc.) can often be inferred with a high degree of confidence. If the highway route was highlighted on the attached map, it was generally possible to infer missing information on the city of origin or city of destination. When possible to infer missing data in this manner, the database was updated to reflect likely values for missing information. Missing data that could not be confidently inferred from other completed questions remains as a blank record entry in the state-wide database.

For purposes of analysis in the Eastern Washington Intermodal Transportation Study, minimal criteria for "usable data records" were established. Specifically, the ability to identify both the origin and destination of a truck trip was established as the minimum criteria for a usable data record. Approximately 96% of the completed interviews meet the criteria of minimal acceptance.

In most cases, survey forms with complete origin and destination information also included responses to all the other questions asked by the interviewer. Consequently, after eliminating surveys without complete origin and destination data, additional missing data problems were minimal.

There were cases when weigh stations had to be closed for several hours during a scheduled 24-hour interview period due to unforeseen problems. For example, a hazardous waste spill near the Everett Southbound weigh station resulted in a 6-hour closing during the winter interview period. Road construction resulted in a 12-hour closing of the Sea Tac southbound weigh station during the same season. A total count of the number of trucks passing by the weigh station during the scheduled interview period was kept even when the station was closed. Consequently, it was still possible to calculate an interview site weight reflecting the proportion of trucks actually sampled. In those few cases where it was not possible to conduct continuous interviews over the scheduled 24-hour time period, the interview site weight was larger than for seasons where no problems occurred. This provided a statistical adjustment for missing sample data.

There were two special cases where interviews for entire sites had to be canceled during the spring interview period. The stations at the Spokane Port of Entry and the Sea Tac southbound scale house were closed for the entire season due to major construction at each of the two sites. Omitting spring information for these two sites would produce a serious bias of results in a state-wide or regional analysis of truck movements. For purposes of analysis in the Eastern Washington Intermodal Transportation Study, it is assumed that spring and summer season truck movements are similar at these two stations. An analysis of the commodity structure and major origins and destinations for trucks utilizing these two sites verified that differences between spring and summer movements are not likely to be

significant. Consequently, data collected during the summer interview period were also utilized to reflect truck movements during the spring season for the Spokane Port of Entry and Sea Tac southbound sites.

Geo-coding Washington origins and destinations

Documenting the geographic movement of truck freight between individual cities and regions within the state of Washington is a key component of the Eastern Washington Intermodal Transportation Study. For the purposes of the EWITS analysis, geo-codes were developed for each Washington origin and destination identified by truck drivers participating in the study. U.S. Bureau of Census designated place codes were utilized for all Washington counties and census places when available. Additional codes were developed for reported origins and destinations that do not have an already established Census place code. The geo-coding of truck data enables aggregation of data for specific Washington counties or regions of interest in the Eastern Washington Intermodal Transportation Study.

Commodity classification procedures

Each truck driver was asked to report the commodity that they were carrying from the place of origin to their intended destination. The interviewers were instructed to obtain as detailed a description of the commodity as could be determined. Over 3,100 individual commodity categories were reported by the drivers. Commodity classification codes were established to enable aggregation of these diverse commodities for detailed analysis.

United States Standard Industrial Classification (SIC) codes were utilized for the EWITS analysis. Each of the 3,167 identified commodities were assigned to a two, three, or four digit SIC code depending upon the detail of description provided by the truck driver. For example, some drivers were able to report that they were carrying refried beans while others could only report that they were carrying "canned food products." Drivers carrying mixed cargo were asked to report the major commodity. In some cases, mixed cargo was simply reported as general freight or retail merchandise.

To the extent possible, the codes utilized were restricted to the agricultural, natural resource, or manufacturing categories (SIC 0111 - SIC 3999). Unique commodity classification categories were also established for general freight, mail, solid waste, and recycled materials. These commodities do not fit consistently with any of the established Standard Industrial Classification Codes. In general, the commodities transported by truck were classified as producer rather than consumer products. The supply side focus reflects

an emphasis in the analysis on the transportation needs of the economic generators of truck freight.

Estimating the economic value of truck cargo

Estimating the economic value of cargo carried by trucks on major Washington highways is central to the EWITS analysis. The 1977 U.S. Census of Transportation is the only available comprehensive data source providing estimates of dollar value per ton for specific commodities. This source was utilized as the base data set for estimating the value of commodities carried on Washington's highways.

The U.S. Census of Transportation economic value data is available for most three digit Standard Industrial Classification categories. The Census data for each SIC category were updated to 1994 dollar values utilizing the *Standard and Poors* producer price index. The *Standard and Poors* producer price index is the most comprehensive data available with a standardized benchmark year. The producer price index is available for nearly all two-digit SIC categories and for some three-digit SIC categories. The most detailed producer price index available was applied to the corresponding three-digit SIC dollar value per ton data from the 1977 U.S. Census of Transportation to obtain updated 1994 dollar values.

Two additional steps were required in preparing final estimates of dollar values per ton for the EWITS study. First, current commodity values for agriculture commodities were obtained from the Washington State Agricultural Statistics Service. Second spot checks of key commodities were conducted to ensure the prices calculated from the 1977 U.S. Census of Transportation were in a reasonable range. Adjustments were made when necessary.

Commodity values utilized for the EWITS analysis are provided in Appendix B. It is recognized that the values utilized are broad averages for three-digit SIC commodity categories. There is substantial variance in the value of individual commodities within each three-digit category. However, these broad averages are the best information available and provide reasonable estimates of the aggregate economic value of commodities transported on Washington's highways.

An updated commodity value study for highway freight is currently being completed by the U.S. Census Bureau. Data is anticipated to be available from this study in 1995. This data will provide an important basis for future highway commodity flow studies.

Projecting future growth in cargo tonnage

Use of the Standard Industrial Classification codes for cargo transported by Washington trucks also provides a means to project future growth in cargo tonnage on selected Washington highway segments. After consideration of data alternatives, 20-year detailed industry output growth forecasts prepared by the U.S. Bureau of Labor Statistics were selected for use in projecting future growth in Washington highway freight traffic. This data source provides detailed industry-level output projections for the nation as a whole. Results from the analysis utilizing Bureau of Labor Statistics projections are appropriately viewed as an indicator of future growth expectations for cargo on Washington highways rather than precise estimates. The magnitude of cargo growth on Washington highways may differ significantly from projections for the nation as a whole due to regional comparative advantages and disadvantages at the production level as well as differing consumption patterns. However, the bias due to regional production and consumption function differences is tempered somewhat by the fact that Washington highways are utilized by trucks originating from all parts of the nation.

Projections of industry-level output growth specific to the state of Washington are not available. Projections of future industry-level employment growth specific to the state of Washington are available. However, employment growth or decline is not necessarily a good indicator of future cargo tonnage because industry-level productivity improvements will reduce the number of workers required to produce a given volume of output. That is, the volume of tonnage transported from a factory, forest, or field can increase substantially even though employment at the production location declines. Consequently, projections of future output growth are much preferred to projections in future employment growth when the use is to predict changes in future highway freight volumes.

The U.S. Bureau of Labor Statistics data is based upon a consistent methodology providing forecasts for most three-digit SIC nonfarm industries. This data series does not provide detailed estimates of future production growth for agricultural commodities. An alternative procedure was utilized to develop forecasts of growth in future agricultural commodity tonnage on Washington highways. Future output growth for agriculture industries were obtained from a variety of sources. Growth projections for fruit and major vegetable groups have been developed by the Washington State Department of Agriculture Economics and were utilized for this study. A statistical regression analysis of a 50-year production time series for the Washington wheat production was utilized to approximate future average annual growth in grain transportation needs. National growth projections developed by the U.S. Bureau of Labor Statistics were utilized for other agriculture commodities. Industry-level production output forecasts utilized for the Eastern Washington Intermodal Transportation Study are identified in Appendix C.

OPPORTUNITIES FOR FUTURE ENHANCEMENTS

The Washington State Freight Truck Origin and Destination Study provides a rich database for a wide variety of transportation planning applications. Opportunities for further enhancement to the existing database and analytical system are described in this section.

Linking Interview Data with WSDOT Automatic Highway Vehicle Classification Information

Interview data was consistently collected on Wednesdays for the Washington State Freight Truck Origin and Destination Studies. This provides a reliable profile of freight truck movements during the midweek periods for each of the four seasons. On most routes, however, the volume and possibly the composition of truck traffic varies significantly over the course of a week. An even more comprehensive picture of freight truck movements on Washington highways would be achieved by developing full-week extrapolations from the interview data.

One possible approach for obtaining full-week expansions on Washington freight truck movements is to link interview data with data collected by WSDOT at automatic data collection sites. WSDOT maintains 118 automatic data collection sites across the state. The location of these sites are noted on the maps appearing on pages 24 and 25. The data collection capabilities of equipment at each site varies. Total 24-hour traffic counts are available on a continuing basis at all the sites. Sites with Bending Plate, Piezo, or SHRP equipment provide 13-bin vehicle classification data providing the ability to segment total daily traffic counts into categories including passenger cars, buses, and trucks. Truck traffic measured by 13-bin classification systems can be further refined to reflect different axle and/or trailer configurations.

Thirteen-bin classification data is available at or near most Washington State Patrol weigh stations or ports of entry where truck driver interviews were conducted for this study. To the extent possible, equipment at these sites was checked by WSDOT officials prior to each interview session to ensure that it was in proper working order. In most cases, 13-bin classification data is available for a full-week period including the Wednesday interview date at the major weigh stations and ports of entry where interviews were conducted during each of the four seasons. By correlating truck information obtained through personal interviews with same day vehicle classification information obtained through WSDOT automatic data collection equipment, a vehicle profile matrix (cargo content, weight, origins, destinations, etc.) can be constructed for specific axle/trailer configurations recorded at each data collection site. Utilizing axle/trailer configurations recorded by WSDOT equipment for the other six days, the vehicle profile matrix constructed for each

site would provide a means to estimate cargo content, vehicle weights, origins, destinations, and so forth for a full seven day period during each season.

Full-week extrapolations based on observations obtained for a single day of the week are subject to error if there are wide daily variations in vehicle profiles associated with a given axle/trailer configuration at a particular site. For example, shipping schedules at ocean ports may be such that a large number of five-axle single-trailer vehicles transport container cargo over a specific route on Mondays. A vehicle profile matrix based exclusively on Wednesday observations would miss these container movements if ocean shipping schedules consistently require truck connections occur early in the week.

Systematic differences in daily truck movements will need to be identified and accounted for in developing full-week extrapolations. Washington State Patrol Commercial Vehicle Enforcement Officers familiar with each site can be a valuable source of information on potential variances in daily movements. Other potential information sources include personal interviews of managers at major freight generator facilities such as port managers and large shippers within the region. In some cases, further field data collection at weigh stations and ports of entry may be necessary. In general, this field work could be accomplished through observation at each station and should not require additional personal interviews of truck drivers. Information obtained through personal interviews of persons knowledgeable of local freight shipment patterns and personal observation can be utilized to further refine and calibrate vehicle profile matrixes at key locations.

Figure 3.1: WSDOT Automatic Data Collection Sites Except the Puget Sound Region

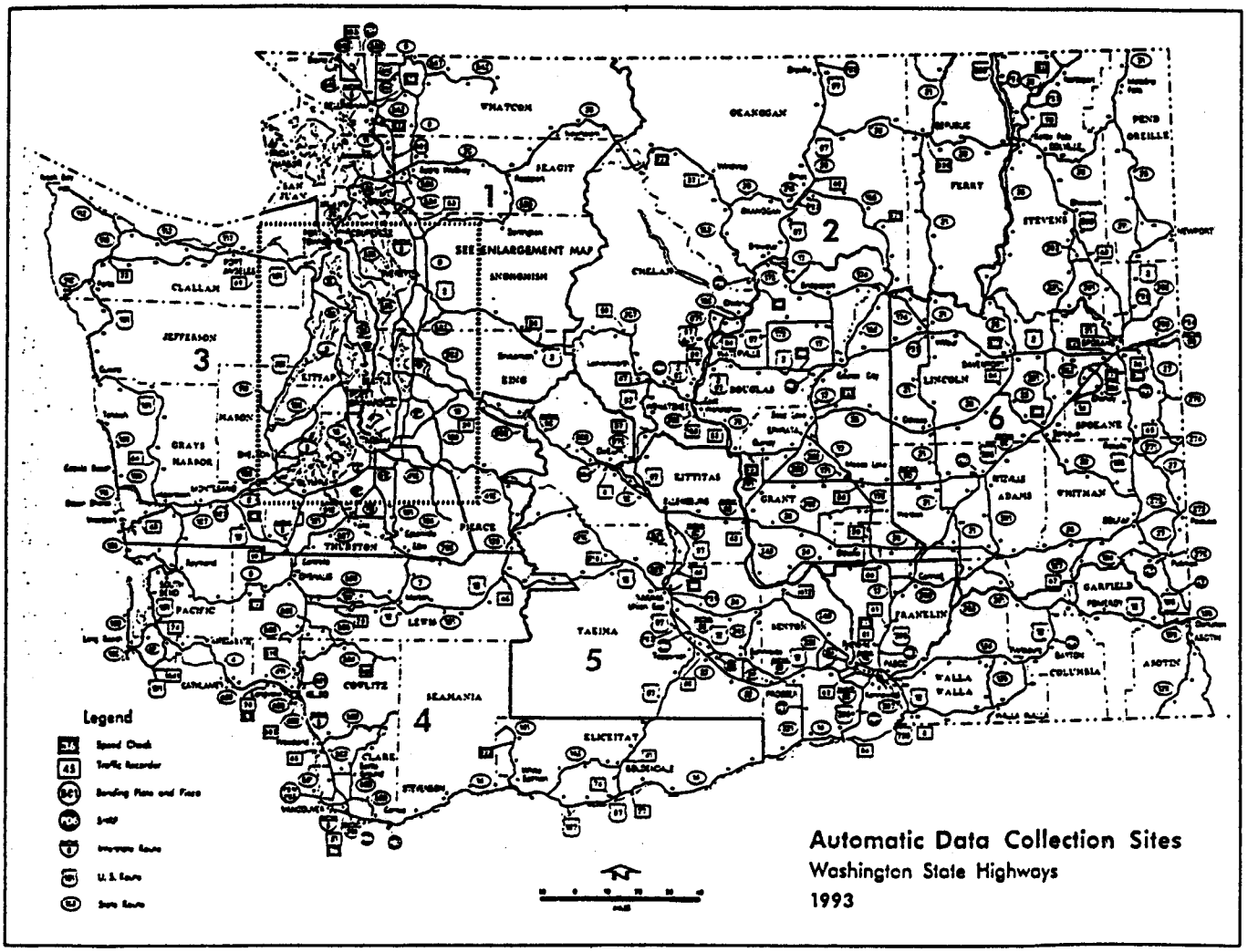
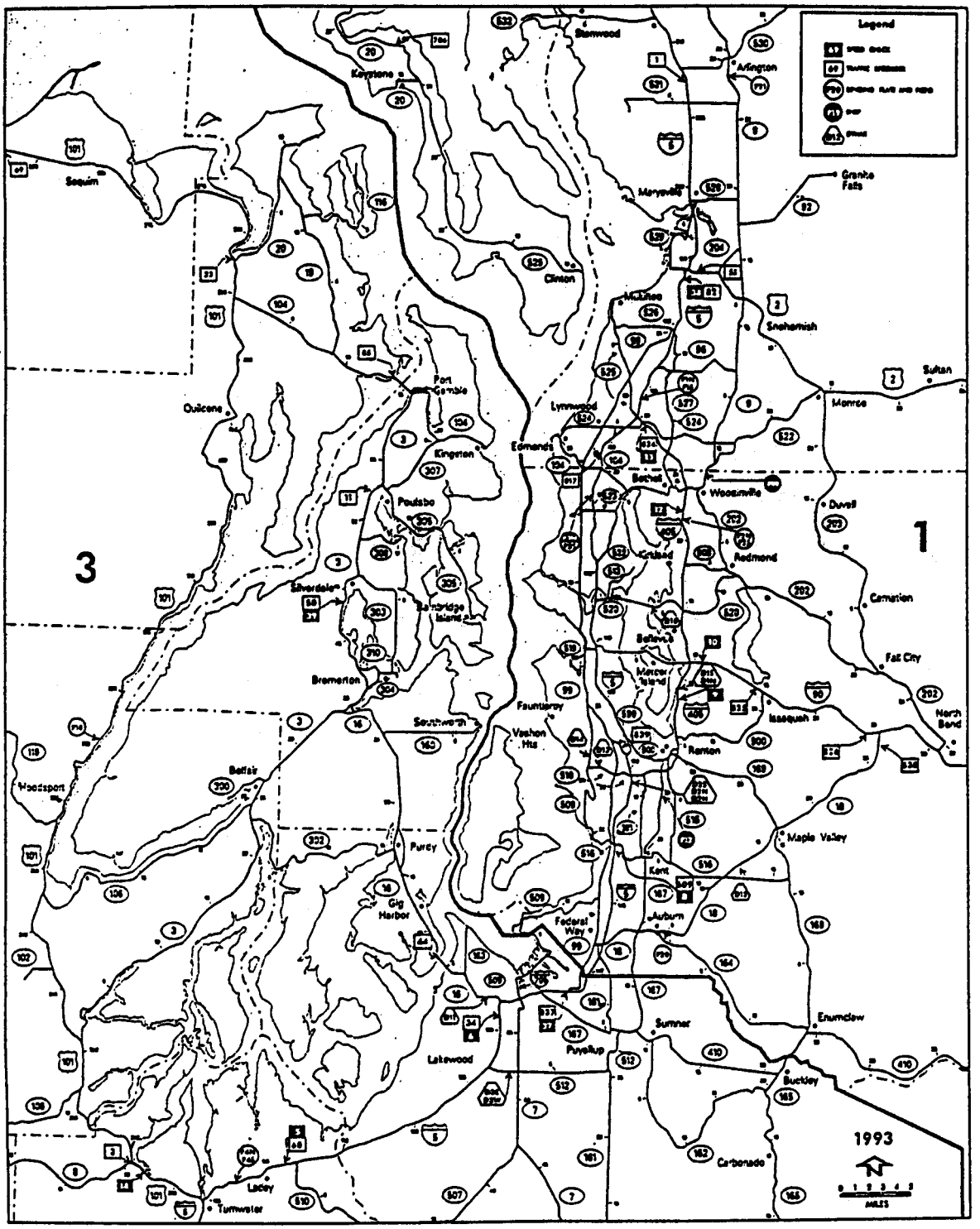


Figure 3.2: WSDOT Automatic Data Collection Sites in the Puget Sound Region



Integration with WSU Geographic Information System

Initial development of the Washington Freight Truck Origin Destination Study focused on the creation of a database system flexible enough for a wide array of policy and transportation planning applications. Future development may include the integration of this database with the WSU Geographic Information System. The WSU system is based on ARCINFO software and includes a digitized map of all major Washington highways.

Initial steps of this integration include linking of truck profile data obtained through personal interviews with individual segments on the digitized map of major Washington highways. This will require the use of dynamic segmentation of the digitized highway network to establish data links for selected geographic reference points. Corresponding geographic reference links would also be required for individual routes associated with each interview record contained in the database. A match between reference points established on the digitized map with route segments contained in the database for each record enables the analysis and geographic portrayal of key freight truck characteristics pertaining to selected highway segments.

The bottom line purpose of the Washington State Freight Truck Origin and Destination Study is to provide information useful to the development of WSDOT, MPOs, and other regional transportation plans within the state of Washington. With this end purpose in mind, the use of geographic information systems provides two major advantages. First, a graphical presentation using GIS-T often illustrates research findings in a form more easily understood than the alternative of tabular output. Second, GIS-T enables a direct graphical interface with complementary planning data. For example, highway segments supporting the highest average daily cargo tonnage can be identified and directly compared with databases documenting pavement conditions for those segments.

Graphical output complements but does not replace tabular output as a means to communicate and analyze freight truck origin and destination study results. Graphical presentation is most appropriate for geographical comparison of aggregate characteristics such as total daily cargo tonnage on defined highway segments or key routes utilized by trucks traveling to a specific destination. However, tabular data is more appropriate for issues requiring desegregated information such as detailed distribution of commodities carried by trucks traveling on I-90 to Puget Sound Region ocean ports. Consequently, a combination of graphical output and the underlying data tables is needed to effectively communicate findings from the freight truck origin and destination study.

Appendix A:
Interview Questionnaire

For Office Use Only
Survey_____
QCA_____
Input ☐

Washington State Department of Transportation and
Washington State University
Truck Traffic Survey, Spring 1994

Please Remember - your Club is depending on YOU for the Quality Control Award!

✓ *Write neatly!* ✓ *Do not abbreviate!* ✓ *Complete all required questions!*

Thank You!

CONFIDENTIAL

1) Station Location: **Tokio Westbound**

2) Initials of Interviewer: _____

3) Interview shift:

1. Day Shift 7:00 a.m. - 3:00 p.m.
2. Evening Shift 3:00 p.m. - 11:00 p.m.
3. Night Shift 11:00 p.m. - 7:00 a.m.

4) Time of interview: _____ AM _____ PM

5) Is this truck a part of the "official sample"? 1) ☐ Yes 2) ☐ No

6) Truck Configuration	7) Trailer Style
[Check only one truck configuration]	*[If appropriate, check more than one trailer style]*
[see Quality Control Notes for definitions]	***[see Quality Control Notes for definitions]***
1. ☐ Straight truck	1. ☐ Van (without temperature control)
2. ☐ Truck and trailer	2. ☐ Van with temperature control
3. ☐ Tractor only	3. ☐ Flatbed
4. ☐ Tractor and trailer	4. ☐ Car carrier
5. ☐ Tractor with two trailers	5. ☐ Hopper or belly dump
6. ☐ Other (specify) _____	6. ☐ Stake and rack
	7. ☐ Concrete mixer
	8. ☐ Tanker
	9. ☐ Float or low boy
	10. ☐ Dump
	11. ☐ Container
	12. ☐ Wood Chip
	13. ☐ Animal Carrier
	14. ☐ Logging
	15. ☐ Belt
	16. ☐ Other (specify) _____

8) Total number of axles on the ground: _____

9) Is a hazardous material placard displayed? 1) ☐ Yes ID# _____ 2) ☐ No

[Please ask the following questions] **CONFIDENTIAL**

10) Trucking company name: _____
Very important! Do Not Abbreviate! Be exact!

11) Trucking company home base: City: _____ State/Province: _____

12) What is the unloaded weight of this vehicle? _____ lbs.

13) Is this vehicle carrying cargo or is it empty? ☐ carrying cargo *[Ask Q14-21]* ☐ empty *[Ask Q22-27]*

14) What is the major commodity on board: _____
DO NOT ABBREVIATE! BE SPECIFIC!

15) How much does the cargo you are carrying today weigh? _____ lbs.

Complete only the one column that applies to this trip. No round-trip information, please!

Trucks CARRYING cargo:	Trucks WITHOUT cargo:
Where did you pick-up this cargo?	Where did this trip without cargo begin?
16) City: _____	22) City: _____
17) State/Province: _____	23) State/Province: _____
18) Facility: *[see Quality Control Notes]*	24) Facility: *[see Quality Control Notes]*
1) ☐ trucking yard	1) ☐ trucking yard
2) ☐ railroad yard	2) ☐ railroad yard
3) ☐ river or ocean port	3) ☐ river or ocean port
4) ☐ airport	4) ☐ airport
5) ☐ factory, processing plant, or sawmill	5) ☐ factory, processing plant, or sawmill
6) ☐ warehouse/distribution center or post office	6) ☐ warehouse/distribution center or post office
7) ☐ farm or forest	7) ☐ farm or forest
8) ☐ retail store or gas station	8) ☐ retail store or gas station
9) ☐ job or construction site	9) ☐ job or construction site
10) ☐ other _____	10) ☐ other _____
What is the destination of your cargo?	Where will your trip without cargo end?
19) City: _____	25) City: _____
20) State/Province: _____	26) State/Province: _____
21) Facility: *[see Quality Control Notes]*	27) Facility: *[see Quality Control Notes]*
1) ☐ trucking yard	1) ☐ trucking yard
2) ☐ railroad yard	2) ☐ railroad yard
3) ☐ river or ocean port	3) ☐ river or ocean port
4) ☐ airport	4) ☐ airport
5) ☐ factory, processing plant, or sawmill	5) ☐ factory, processing plant, or sawmill
6) ☐ warehouse/distribution center or post office	6) ☐ warehouse/distribution center or post office
7) ☐ farm or forest	7) ☐ farm or forest
8) ☐ retail store or gas station	8) ☐ retail store or gas station
9) ☐ job or construction site	9) ☐ job or construction site
10) ☐ other _____	10) ☐ other _____

28) What Washington highways were used to travel between the two locations identified above?

_____ *(Remember, accurately highlight attached map!)*
Write out the highways used to get between the two locations identified above.

29) *Including this trip*, how many times has this truck traveled the above route in the past 7 days?
_____ Times ☐ Don't know

Appendix B:
1994 Dollar Values of Commodities*

SIC Code	Commodity	Dollar Value per Ton in 1994
0 0	Empty	$0.00
1 1	Grain	$126.00
1 3	Fresh potatoes	$100.00
1 4	Forage crops	$95.00
1 6	Fresh vegetables	$100.00
1 7	Fruit	$400.00
1 8	Nursery products	$250.00
1 9	Agriculture products (unclassified)	$176.00
2 1	Livestock	$500.00
2 5	Poultry	$720.00
2 7	Small animals	$700.00
7 8	Landscaping materials	$250.00
8 1	Tree farms	$250.00
9 1	Commercial fishing equipment	$1,500.00
10 3	Zinc	$1,000.00
12 2	Coal	$153.90
13 2	Propane	$173.00
14 1	Limestone	$120.00
14 2	Crushed rock	$6.00
14 4	Sand products	$4.00
14 5	Clay mining	$120.00
14 7	Potash and related minerals	$120.00
14 9	Nonmetalic minerals (unclassified)	$120.00
20 0	Food and kindred products (unclassified)	$754.85
20 1	Meat: fresh, chilled, frozen	$1,822.23
20 2	Dairy products	$910.13
20 3	Canned and preserved fruits, vegetables, seafoods	$1,081.54
20 4	Grain mill products	$333.84
20 5	Bakery products	$1,470.09
20 6	Sugar, beet and cane	$429.47
20 7	Confectionery and related products	$2,864.64
20 8	Beverages and flavoring extracts	$489.45
20 9	Miscellaneous food preparations	$634.95
21 1	Tobacco products	$6,656.87
22 1	Textile mill products	$4,040.84
22 2	Manmade fiber and silk broadwoven fabrics	$5,285.56
22 3	Broadwoven fabric products	$5,285.56
22 6	Linen and related textile	$4,040.84

SIC Code	Commodity	Dollar Value per Ton in 1994
22 7	Floor coverings	$3,884.30
22 8	Thread and yarn	$3,958.95
22 9	Miscellaneous textile goods	$2,989.54
23 0	Laundry and linen supplies	$6,991.14
23 2	Gloves	$11,161.72
23 5	Caps, hats and millinery	$11,161.72
23 8	Misc. apparel and accessories	$13,270.56
23 9	Miscellaneous apparel products	$6,991.14
24 0	Lumber and wood products, except furniture	$226.07
24 1	Sawlogs	$82.52
24 2	Lumber	$363.00
24 3	Millwork, plywood and prefabricated wood products	$1,259.91
24 4	Wood containers	$920.65
24 5	Manufactured homes	$1,259.91
24 6	Pulpwood and other wood chips	$26.72
24 9	Misc. wood products	$374.93
25 0	Furniture and fixtures (unclassified)	$3,847.06
25 1	Wood household furniture	$3,933.61
25 2	Wood office furniture	$3,933.61
25 3	Restaurant fixtures	$2,930.75
25 4	Partitions, shelving, lockers, fixtures, office, store	$2,930.75
25 9	Misc. furniture and fixtures	$5,555.72
26 0	Pulp, paper, and allied products	$898.82
26 1	Paper pulp	$26.72
26 2	Converted paper, paperboard products	$1,785.24
26 3	Press board	$1,005.06
26 5	Containers and boxes, paperboard	$1,005.06
26 7	Coated paper	$1,785.24
27 0	Printed matter	$3,347.27
27 4	Phone books	$3,347.27
27 9	Magazines and newspapers	$3,347.00
28 0	Chemical products (unclassified)	$582.70
28 1	Industrial inorganic and organic chemicals	$305.76
28 2	Plastic resin	$582.70
28 3	Medical chemicals	$15,870.00
28 4	Soap and other detergents	$1,795.93
28 5	Paint	$685.44
28 6	Industrial organic chemicals	$648.84
28 7	Agricultural chemicals	$215.18
28 9	Misc. chemical products	$648.84
29 0	Petroleum and coal products	$153.86
29 1	Products of petroleum refining	$173.11

SIC Code	Commodity	Dollar Value per Ton in 1994
29 5	Asphalt paving and roofing materials	$43.85
29 9	Misc. petroleum products	$546.21
30 0	Rubber and misc. plastics products	$3,344.58
30 1	Rubber tires	$4,175.00
30 5	Rubber or plastic hoses	$3,344.58
30 6	Rubber tubes	$3,345.01
30 8	Molded plastic products	$5,010.00
31 0	Leather and leather products	$14,124.91
31 4	Footwear, leather, and similar materials	$11,148.54
31 6	Travel cases	$14,125.00
32 0	Stone, clay, glass and concrete products	$79.37
32 1	Glass windows	$656.17
32 2	Glass and glassware, pressed and blown	$656.17
32 3	Glass mirrors	$656.17
32 4	Cement	$63.00
32 5	Structural clay products	$148.57
32 6	Pottery and related products	$1,827.05
32 7	Concrete, gypsum, and plaster products	$35.43
32 8	Concrete statuary	$79.00
32 9	Abrasives and asbestos products	$190.45
33 0	Primary metals (unclassified)	$863.02
33 1	Steel works and rolling mill products	$539.35
33 2	Cast iron products	$539.00
33 3	Nonferrous metal primary smelter products	$1,475.92
33 5	Nonferrous metal basic shapes	$2,583.72
33 6	Nonferrous metal castings	$4,120.36
33 9	Misc. primary metal products	$1,841.46
34 0	Fabricated metal products (unclassified)	$2,087.43
34 1	Metal cans	$462.00
34 2	Cutlery, hand tools and general hardware	$7,098.52
34 3	Plumbing fixtures and heating apparatus	$5,085.34
34 4	Fabricated structural metal products	$1,822.88
34 5	Metal screws	$1,841.08
34 6	Manufactured engines	$4,120.00
34 8	Ammunition	$4,120.00
34 9	Misc. fabricated metal products	$1,841.08
35 0	Machinery, except electrical	$9,429.16
35 1	Engines and turbines	$12,312.86
35 2	Farm machinery and equipment	$4,882.62
35 3	Construction materials handling equipment	$4,922.84
35 4	Metalworking machinery and equipment	$12,432.22
35 5	Special industry machinery	$13,240.22

SIC Code	Commodity	Dollar Value per Ton in 1994
35 6	General industrial machinery and equipment	$9,222.28
35 7	Office, computing, and accounting machines	$41,989.37
35 8	Refrigeration and service industry machines	$5,012.63
35 9	Misc. machinery and parts	$6,176.02
36 0	Electrical machinery, equipment and supplies	$7,258.42
36 1	Electrical transmission equipment	$7,577.02
36 2	Electrical industrial apparatus	$4,530.38
36 3	Household appliances	$3,430.23
36 4	Electric lighting and wiring equipment	$4,801.88
36 5	Radio and television receiving sets	$8,325.81
36 6	Communication equipment	$34,892.11
36 7	Electronic components and accessories	$24,933.03
36 9	Misc. electrical machinery, equip., supplies	$4,401.03
37 0	Transportation equipment	$5,294.27
37 1	Motor vehicles and equipment	$4,462.20
37 2	Aircraft and parts	$76,747.54
37 3	Boat building and repair	$5,294.52
37 4	Railroad equipment	$2,649.75
37 5	Motorcycles	$4,162.38
37 9	Misc. transportation equipment	$4,162.38
38 0	Instruments, photo, and medical goods, clocks	$13,521.97
38 2	Measuring and controlling instruments	$18,300.43
38 4	Medical, dental instruments, and supplies	$9,901.55
38 5	Optical equipment	$9,901.55
38 6	Photographic equipment	$13,521.97
38 9	Misc. instrument products	$13,521.97
39 0	Misc. products of manufacturing	$8,231.34
39 1	Jewelry, silverware, and plated ware	$75,933.98
39 3	Musical instruments	$6,266.56
39 4	Toys, amusement, sporting, and athletic goods	$6,266.56
39 5	Pens, pencils, other office and artists' materials	$8,535.76
39 6	Costume jewelry, novelties, buttons, and notions	$17,421.60
39 9	Misc. manufactured products	$5,524.53
42 0	General freight	$3,660.00
42 1	Household goods	$3,660.00
42 2	General retail merchandise	$3,660.00
43 1	Mail and packages	$3,660.00
45 8	Air freight	$10,980.00
49 5	Solid waste	$91.50
50 9	Recycled materials	$256.20

*Value per ton estimates based on the 1977 U.S. Census of Transportation. 1977 values updated to current value utilizing the *Standard and Poors* Producer Price Index series.

Appendix C:
Projected Annual Growth Rates of Commodities*

SIC Code	Commodity	Projected Percent Ave. Annual Growth
1 1	Grain	2.0
1 3	Fresh potatoes	3.9
1 4	Forage crops	2.2
1 6	Fresh vegetables	3.3
1 7	Fruit	6.8
1 8	Nursery products	2.2
1 9	Agriculture products (unclassified)	1.8
2 1	Livestock	0.9
2 5	Poultry	0.9
2 7	Small animals	0.9
7 8	Landscaping materials	2.2
8 1	Tree farms	1.6
9 1	Commercial fishing equipment	1.8
10 3	Zinc	0.6
12 2	Coal	1.4
13 2	Propane	-0.9
14 1	Limestone	1.5
14 2	Crushed rock	1.5
14 4	Sand products	1.5
14 5	Clay mining	1.5
14 7	Potash and related minerals	1.5
14 9	Nonmetalic minerals (unclassified)	1.5
20 0	Food and kindred products (unclassified)	1.2
20 1	Meat: fresh, chilled, frozen	0.9
20 2	Dairy products	1.0
20 3	Canned and preserved fruits, vegetables, seafoods	2.2
20 4	Grain mill products	1.4
20 5	Bakery products	0.3
20 6	Sugar, beet, and cane	0.2
20 7	Confectionery and related products	0.2
20 8	Beverages and flavoring extracts	1.3
20 9	Miscellaneous food preparations	1.7
21 1	Tobacco products	-0.2
22 1	Textile mill products	1.9
22 2	Manmade fiber and silk broadwoven fabrics	1.7
22 3	Broadwoven fabric products	1.6
22 6	Linen and related textile	1.6

SIC Code	Commodity	Projected Annual Growth Rate
22 7	Floor coverings	2.6
22 8	Thread and yarn	2.5
22 9	Miscellaneous textile goods	2.5
23 0	Laundry and linen supplies	2.1
23 2	Gloves	3.1
23 5	Caps, hats and millinery	3.1
23 8	Misc. apparel and accessories	3.1
23 9	Miscellaneous apparel products	3.1
24 0	Lumber and wood products, except furniture	1.9
24 1	Sawlogs	1.4
24 2	Lumber	1.7
24 3	Millwork, plywood, and prefabricated wood products	2.6
24 4	Wood containers	2.6
24 5	Manufactured homes	0.7
24 6	Pulpwood and other wood chips	1.7
24 9	Misc. wood products	1.9
25 0	Furniture and fixtures (unclassified)	2.8
25 1	Wood household furniture	1.9
25 2	Wood office furniture	1.9
25 3	Restaurant fixtures	1.9
25 4	Partitions, shelving, lockers, fixtures, office, store	1.9
25 9	Misc. furniture and fixtures	2.8
26 0	Pulp, paper, and allied products	2.1
26 1	Paper pulp	2.3
26 2	Converted paper, paperboard products	2.4
26 3	Press board	2.4
26 5	Containers and boxes, paperboard	1.2
26 7	Coated paper	2.1
27 0	Printed matter	2.4
27 4	Phone books	2.9
27 9	Magazines and newspapers	1.2
28 0	Chemical products (unclassified)	2.0
28 1	Industrial inorganic and organic chemicals	1.1
28 2	Plastic resin	2.7
28 3	Medical chemicals	3.2
28 4	Soap and other detergents	1.5
28 5	Paint	2.2
28 6	Industrial organic chemicals	1.1
28 7	Agricultural chemicals	1.6
28 9	Misc. chemical products	2.6
29 0	Petroleum and coal products	0.3
29 1	Products of petroleum refining	0.2

SIC Code	Commodity	Projected Annual Growth Rate
29 5	Asphalt paving and roofing materials	1.9
29 9	Misc. petroleum products	1.9
30 0	Rubber and misc. plastics products	3.4
30 1	Rubber tires	1.0
30 5	Rubber or plastic hoses	1.2
30 6	Rubber tubes	1.2
30 8	Molded plastic products	4.3
31 0	Leather and leather products	-1.4
31 4	Footwear, leather, and similar materials	-2.5
31 6	Travel cases	-0.6
32 0	Stone, clay, glass, and concrete products	1.3
32 1	Glass windows	1.1
32 2	Glass and glassware, pressed and blown	1.1
32 3	Glass mirrors	1.1
32 4	Cement	1.7
32 5	Structural clay products	0.8
32 6	Pottery and related products	0.8
32 7	Concrete, gypsum, and plaster products	1.7
32 8	Concrete statuary	0.8
32 9	Abrasives and asbestos products	0.8
33 0	Primary metals (unclassified)	0.6
33 1	Steel works and rolling mill products	0.2
33 2	Cast iron products	0.2
33 3	Nonferrous metal primary smelter products	0.1
33 5	Nonferrous metal basic shapes	1.0
33 6	Nonferrous metal castings	2.2
33 9	Misc. primary metal products	0.6
34 0	Fabricated metal products	1.0
34 1	Metal cans	-0.6
34 2	Cutlery, hand tools, and general hardware	1.2
34 3	Plumbing fixtures and heating apparatus	1.2
34 4	Fabricated structural metal products	1.1
34 5	Metal screws	0.7
34 6	Manufactured engines	0.9
34 8	Ammunition	1.2
34 9	Misc. fabricated metal products	0.8
35 0	Machinery, except electrical	2.2
35 1	Engines and turbines	0.9
35 2	Farm machinery and equipment	1.0
35 3	Construction materials handling equipment	2.2
35 4	Metalworking machinery and equipment	0.5
35 5	Special industry machinery	1.7

SIC Code	Commodity	Projected Annual Growth Rate
35 6	General industrial machinery and equipment	1.0
35 7	Office, computing, and accounting machines	4.6
35 8	Refrigeration and service industry machines	1.4
35 9	Misc. machinery and parts	1.4
36 0	Electrical machinery, equipment, and supplies	3.1
36 1	Electrical transmission equipment	0.8
36 2	Electrical industrial apparatus	1.3
36 3	Household appliances	2.0
36 4	Electric lighting and wiring equipment	1.8
36 5	Radio and television receiving sets	2.9
36 6	Communication equipment	2.5
36 7	Electronic components and accessories	5.6
36 9	Misc. electrical machinery, equip., supplies	3.7
37 0	Transportation equipment	1.8
37 1	Motor vehicles and equipment	2.6
37 2	Aircraft and parts	1.4
37 3	Boat building and repair	2.5
37 4	Railroad equipment	0.3
37 5	Motorcycles	1.7
37 9	Misc. transportation equipment	1.7
38 0	Instruments, photo, and medical goods, clocks	3.1
38 2	Measuring and controlling instruments	1.8
38 4	Medical, dental instruments, and supplies	4.6
38 5	Optical equipment	3.7
38 6	Photographic equipment	2.3
38 9	Misc. instrument products	3.1
39 0	Misc. products of manufacturing	1.1
39 1	Jewelry, silverware, and plated ware	0.8
39 3	Musical instruments	1.1
39 4	Toys, amusement, sporting, and athletic goods	1.1
39 5	Pens, pencils, other office and artists' materials	1.1
39 6	Costume jewelry, novelties, buttons, and notions	1.1
39 9	Misc. manufactured products	1.1
42 0	General freight	3.0
42 1	Household goods	3.0
42 2	General retail merchandise	2.5
43 1	Mail and packages	3.0
45 8	Air freight	2.6
49 5	Solid waste	1.8
50 9	Recycled materials	2.2

*Nonfarm industry output estimates based on U.S. Bureau of Labor and Industry Projections. Agriculture commodity growth based on historical production trends.

Appendix D:
Data Dictionary for Public Data File

Data collected through the Washington State Freight Truck Origin and Destination Study is available for public use in regional transportation planning. The data was provided by truck drivers to the research team in confidence. Consequently, the public data file does not include information that would associate information provided by drivers to a specific company.

A description of data included in the public data file is included in this appendix. The public data file is available in Paradox database format which is compatible with most standard database software. Requests for an electronic copy of the state-wide freight truck origin and destination data should be addressed to:

Amy Arnis
Washington State Department of Transportation
PO Box 47370
Olympia, WA 98504-7370

Tel: 206-705-7923

Figure D1: Content of Public Data File

FIELD NAME	TYPE	SIZE	DESCRIPTION
SURVEY NUMBER	N		A number was assigned to each site, the surveys were then numbered sequentially starting from 1 with each season. For example: Brady East is site 1 so the survey for each season is 1001.
SEASON	A	8	The name of the season that the surveys were taken.
STATUS	S		Each survey was assigned a status. Status 1 = first time surveyed, Status 2 = surveyed previously, Status 3 = refused to participate in survey.
STATION	S		Each station was given a unique number. See Scales.db for site location and numbers.
SHIFT	S		Surveys were taken during 3 shifts. Shift 1 = 7:00 am - 3:00 pm, Shift 2 = 3:00 pm - 11:00 pm, Shift 3 = 11:00 pm - 7:00 am.
TIME (AM)	N		Survey times during the morning. 12:00 am (midnight) was entered as .01 am
TIME (PM)	N		Survey times during the evening. 12:00 pm (noon) was entered as .01 pm.
TRUCK CONFIGURATION	S		1= straight truck, 2=truck & trailer, 3=tractor only, 4=tractor & trailer, 5=tractor w/2 trailers, 6=other.
OTHER TRUCK CONFIGURATION	A	30	When TRUCK CONFIGURATION =6 then this field is available for a description of the truck.
TRAILER STYLE	S		1=van w/o temp control, 2=van w/temp control, 3=flatbed, 4=car carrier, 5=hopper or belly dump, 6=stake & rack, 7=concrete mixer, 8=tanker, 9=float or low boy, 10= dump, 11=container, 12=wood chip, 13=animal carrier, 14=logging, 15=belt, 16=other.
OTHER TRAILER STYLE	A	30	When TRAILER STYLE=16 then this field is available for a description of the trailer.
AXLES	S		Number of axles on the ground.
HAZARDOUS	S		Is there a hazardous material placard displayed? 1=yes, 2=no.

FIELD NAME	TYPE	SIZE	DESCRIPTION
HAZARDOUS PLACARD NUMBER	N		The hazardous material placard number displayed on the truck.
EMPTY TRUCK WEIGHT	N		The unloaded weight of this vehicle. This includes both the truck and the trailer.
COMMODITY	A	50	The major commodity on board.
PAYLOAD WEIGHT	N		The weight of the cargo that is being carried today.
CARGO ORIGIN CITY	A	25	City where the cargo was picked up.
CARGO ORIGIN STATE	A	2	State where the cargo was picked up. If the driver only gave Canada then CD was entered. If the driver only gave Mexico then MX was entered in the state field.
CARGO ORIGIN FACILITY	S		The type of facility where the cargo was picked up. 1=trucking yard, 2=railroad yard, 3=river or ocean port, 4=airport, 5=factory, processing plant or sawmill, 6=warehouse/distribution center or post office, 7=farm or forest, 8=retail store or gas station, 9=job or construction site, 10=other.
OTHER ORIGIN FACILITY	A	30	When CARGO ORIGIN FACILITY = 10 other, this field is available for a description of the facility.
CARGO DEST CITY	A	25	City where the cargo was dropped off.
CARGO DEST STATE	A	2	State where the cargo was delivered. If the driver only gave Canada then CD was entered. If the driver only gave Mexico then MX was entered in the state field.
CARGO DEST FACILITY	S		The type of facility where the cargo was delivered. 1=trucking yard, 2=railroad yard, 3=river or ocean port, 4=airport, 5=factory, processing plant or sawmill, 6=warehouse/distribution center or post office, 7=farm or forest, 8=retail store or gas station, 9=job or construction site, 10=other.
OTHER DEST FACILITY	A	30	When CARGO DEST FACILITY = 10 other, this field is available for a description of the facility.

FIELD NAME	TYPE	SIZE	DESCRIPTION
ROUTE	A	150	The Washington highways that were used to travel between the origin and destination cities.
TRAVEL SAME IN 7 DAYS	S		How many times this truck traveled the same route in the past 7 days.
COMMENTS	A	100	Any comments from the driver or surveyer.

Figure D2: Location and Identification Codes for Interview Sites

Weigh Station	Site Number	Direction of Traffic	Road Designation
Brady West, WA	1	West	12
Brady East, WA	2	East	12
Cle Elem East, WA	3	East	I90
Cle Elem West, WA	4	West	I90
Deer Park South, WA	6	South	395
Douglas POE, (BC Border)	7	North	I5
Everett North, WA	8	North	I5
Everett South, WA	9	South	I5
Goldendale, WA	10	North/South	97
Kelso South, WA	11	South	I5
Othello, WA	12	All 4	17
Pasco, WA	13	South	395
Peshastin West, WA	15	West	2
Plymouth POE, WA	16	North	395
East Port Angeles Westbound, WA	17	West	101
Sea Tac South, WA	19	South	I5
Sea Tac North, WA	20	North	I5
East Spokane POE, WA	21	West	I90
Tokio East, WA	22	East	I90
Tokio West, WA	23	West	I90
Umatilla POE, OR	24	South	395
Vancouver North, WA	25	North	I5
Wallula POE, WA	26	All 4	12;395,730
Osoyoos, BC (BC Border)	28	North	97
Oroville, WA (US Border)	29	South	97

Figure D3: Total Recorded 24-Hour Truck Count by Season for Each Interview Site

Weigh Station	Site Number	Total Recorded 24-Hour Truck Count: Summer 93	Fall 93	Winter 94	Spring 94
Brady East, WA	1	489	407	456	481
Brady West,WA	2	270	740	360	402
Cle Elem East, WA	3	1511	2018	1800	1848
Cle Elem West,WA	4	1477	1841	1689	1978
Deer Park South,WA	6	211	173	212	216
Douglas POE, BC	7	670	1130	940	1386
Everett North, WA	8	4175	3266	2879	2800
Everett South,WA	9	3776	3133	2563	3023
Goldendale,WA	10	450	401	497	448
Kelso South,WA	11	3710	3775	4061	4090
Othello, WA	12	826	690	667	675
Pasco, WA	13	1388	1067	753	1204
Peshastin West, WA	15	355	291	177	275
Plymouth POE, WA	16	929	1168	1078	1126
East Port Angeles, WA	17	277	237	334	408
Sea Tac South, WA	19	4133	4479	4677	NA
Sea Tac North, WA	20	4052	4576	5459	5516
East Spokane POE, WA	21	1083	1004	748	NA
Tokio East, WA	22	956	1426	1201	1511
Tokio West, WA	23	1317	1396	1192	1344
Umatilla POE, OR	24	1365	1232	1247	1070
Vancouver North, WA	25	3980	4196	3982	4575
Wallula POE, WA	26	951	950	862	815
Osoyoos, BC	28	58	44	36	67
Oroville, WA	29	60	41	37	76

Note: No data is available for Sea Tac South and East Spokane Port of Entry during the spring interview period because these sites were closed due to construction.

Appendix E: Data Sources

Type of Data	Source
Characteristics of Washington State Truck Movements	Primary data collected through personal interviews described in this report
Commodity Classification Codes	US Office of Management and Budget. Standard Industrial Classification Manual, 1987.
Geo-Codes	Washington State Office of Financial Management. "Census county, city and place identification codes, 1990."
Economic Value of Commodities	• US Department of Commerce, Bureau of the Census. U.S. Census of Transportation, 1977.
Projected Growth in Commodity Output	• US Bureau of Labor Statistics, Office of Employment Projections. Outlook for Industry Output and Job Growth, 1990-2005. • Washington State University, Department of Agricultural Economics. Trends in Consumption and Acreage Shares for Selected Fruits in Washington, 1990 -2010. • Washington State University, Department of Agricultural Economics. Trends in Consumption and Acreage Shares for Selected Vegetables in Washington, 1990 - 2010. • Washington Wheat Commission. Washington State Wheat Production Data, 1949-1994.