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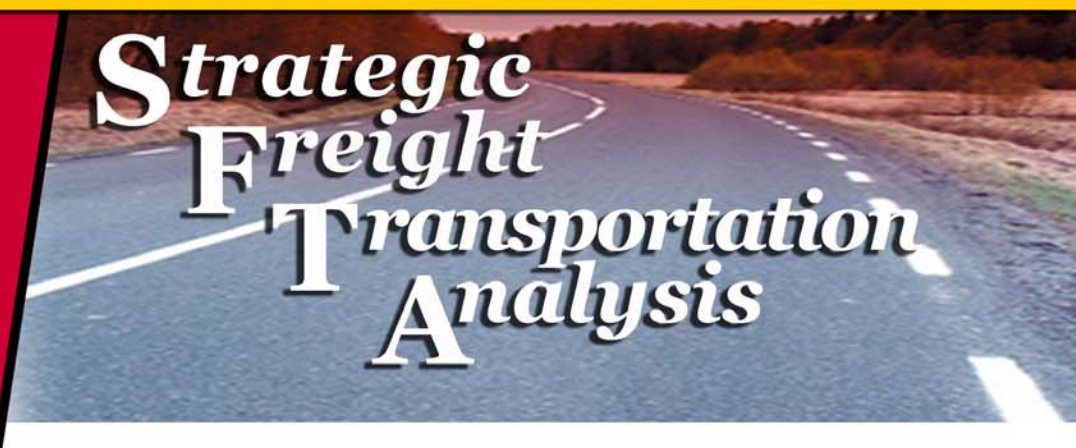

Freight Truck Origin and Destination Study:

Methods, Procedures and Data Dictionary

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SFTA Research Report # 2

December 2002

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SFTA Research Reports:
Background and Purpose

The Strategic Freight Transportation Analysis (SFTA) is a six year, $1.8 million comprehensive research and implementation analysis that will provide information (data and direction) for local, state and national investments and decisions designed to achieve the goal of seamless transportation.

The overall SFTA scope includes the following goals and objectives:

- Improving knowledge about freight corridors.
- Assessing the operations of roadways, rail systems, ports and barges – freight choke points.
- Analyze modal cost structures and competitive mode shares.
- Assess potential economic development opportunities.
- Conduct case studies of public/private transportation costs.
- Evaluate the opportunity for public/private partnerships.

The five specific work tasks identified for SFTA are:

- Work Task 1 - Scoping of Full Project
- Work Task 2 - Statewide Origin and Destination Truck Survey
- Work Task 3 - Shortline Railroad Economic Analysis
- Work Task 4 - Strategic Resources Access Road Network (Critical State and Local Integrated Network)
- Work Task 5 - Adaptive Research Management

For additional information about the SFTA or this report, please contact Eric Jessup or Ken Casavant at the following address:

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PREVIOUS SFTA REPORTS NOW AVAILABLE

1. Casavant, Kenneth L. and Eric L. Jessup. "SFTA Full Scope of Work." SFTA Research Report Number 1. December 2002.

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Methods, Procedures and Data Dictionary

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INTRODUCTION

This paper describes the methodology and procedures utilized for the statewide freight truck origin-destination (O-D) study, as part of the Strategic Freight Transportation Analysis (SFTA). Specific topics include: data collection issues and methods, interview team recruitment and training, data management and analysis procedures, geo-coding truck routes, and opportunities for future database enhancements.

SFTA follows and builds upon an earlier freight transportation research project known as the Eastern Washington Inter-modal Transportation Study (EWITS) that produced a variety of freight related research reports, working papers and databases to facilitate regional and statewide transportation planning efforts. One major element of this earlier research was a statewide O-D freight truck survey, which collected valuable freight data through direct personal interviews of truck drivers in 1993/1994. This statewide 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 statewide freight and goods movements.

The information collected by the very successful and widely used 1993/1994 freight truck origin-destination study was becoming a reason for concern. Databases become outdated and decisions based upon them could become, at best, misdirected, and at worst, wrong. The value and importance of this freight data was readily apparent and is in continual use by planners and policy makers, but the system underlying the traffic flows continues to undergo significant and dramatic changes. Many arising issues (changing NAFTA flows, increased border crossings and associated congestion, larger rail cars, e-commerce, changing Canadian transportation investments, economic development needs, etc.) require updated data, new analysis, and will most likely redirect the focus of U.S. and Washington investments to achieve desired results. New and increased NAFTA freight flows and inter-country flows are more common and traveling through border ports in increasing volumes. However, accurate and current data on these flows are unavailable. Thus, a new freight origin-destination study was undertaken as Task 2 under SFTA.

DATA COLLECTION ISSUES AND METHODS

Data Source Alternatives

There are several data sources, both government and private, for aggregate information on national U.S. freight truck movements. The U.S. Census Bureau, with cooperation from the Bureau of Transportation Statistics, conducts a Commodity Flow Survey (CFS) every five years to collect information on the national flow of goods, by mode. This survey is administered to a sample of 800,000 wholesale, mining and manufacturing business establishments and categorizes data into Standardized Classification of Transportation Goods (SCTG) codes, including attributes such as shipment weight, value, mode of transport and zip code of origin/destination. The U.S. Census Bureau also conducts a survey of the 60 million registered truck owners (sample of around 150,000) to collect information on the physical and operational characteristics of U.S. freight truck owners/operators. This data set, known as the Vehicle Inventory and Use Survey (VIUS), provides detailed information on truck and vehicle type, operating characteristics, base of operation, empty and gross weight, time of operation, trip length, commodities, and percentage of mileage by commodity type. Both the CFS and the VIUS data are available to the public. One private data source for U.S. freight truck shipments is the Transearch freight flow database compiled by Reebie and Associates. This data set provides aggregate information on commodity shipments between selected major cities, but limited information on shipments into smaller cities, towns and communities within state boundaries. These sources 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 sub-state 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 statewide freight truck O-D study, as part of SFTA. In particular, information on a wide array of freight truck characteristics is needed to plan effectively for the statewide freight and goods system. Examples include information on time of day movements, truck/trailer configuration, cargo type, payload weight, use of inter-modal facilities, and specific 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 and operators.

Several specific criteria were developed and followed with the SFTA Freight Truck O-D Study. These guidelines for the design of the statewide truck survey project include:

- 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 sub regions as well as the state as a whole.

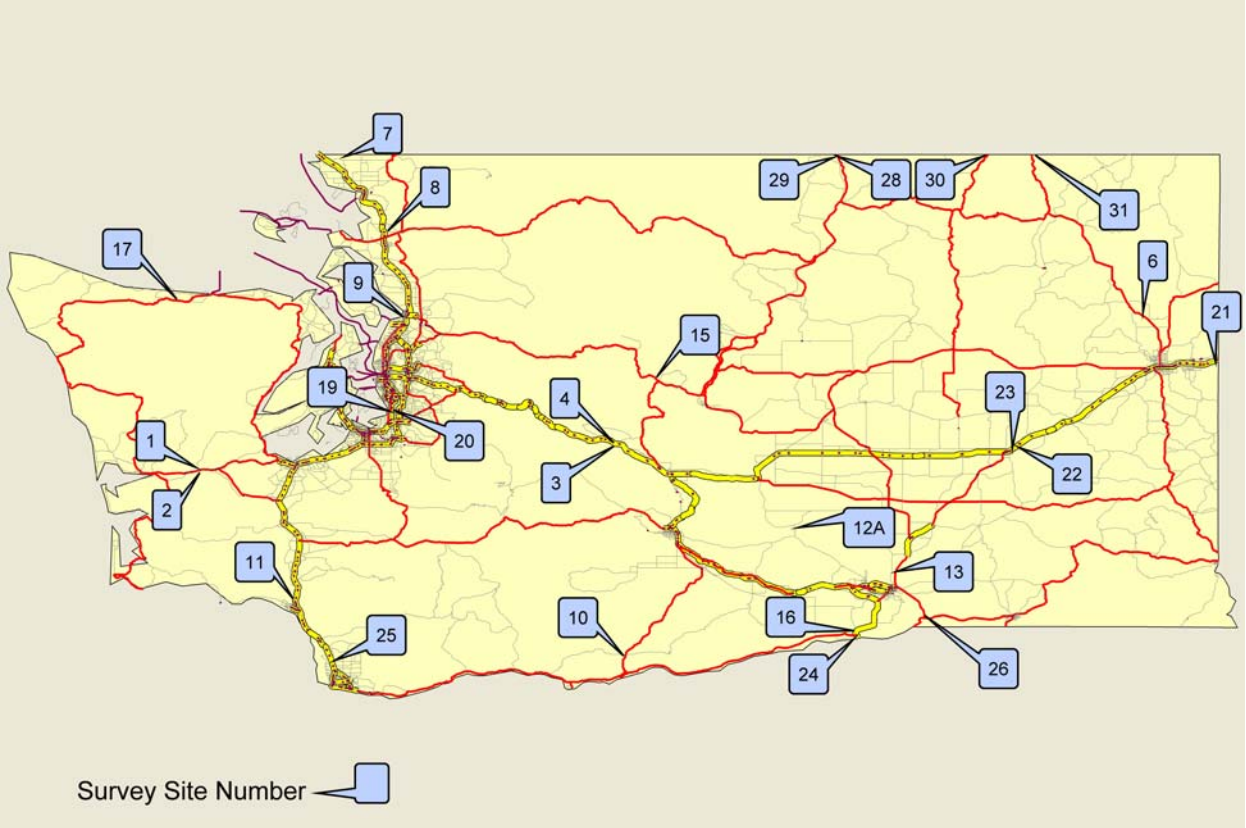
- Information, where available, should be developed over a continuous 24-hour period in each of the four seasons of the year.

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. Following the successful data collection efforts from roadside interviews of earlier O-D studies, this research effort also utilizes roadside interviews to maintain data consistency and comparisons through time.

Site Selection

To maintain reliable statewide coverage and data consistency, interview sites at permanent weigh stations and ports of entry were selected to closely match those sites utilized by the earlier 1993/1994 O-D study. Twenty-six[1] of the 28 sites previously surveyed were utilized. One weigh station had been removed (Othello, Site Number 12) and was replaced with the Vernetta Bridge site. Please see Appendix A for a list of sites and locations.

Figure 1: Origin and Destination Survey Sites



[1] During the EWITS O-D, with the assistance of the WSP, data was collected at a site near Uniontown, WA. Data collection at this site was conducted only once in order to fulfill special needs identified at that time. Since no permanent weigh station exists there, it was not included in the SFTA O-D.

Selecting Interview Dates and Duration

Capturing effects of seasonal differences is important in those areas where predominant commodities, such as agricultural products, are moved for one or more seasons throughout the year. It was also important to collect data from the 27 interview sites that would allow seasonal comparisons. Thus, data was collected during a four-week period for each season (Spring (April 2002), Summer (July 2002), Fall (October 2002), Winter (January 2003)).

Scheduling the 27 interview sites was done systematically to avoid interviewing the same flow of trucks at multiple sites. For example, the northbound sites on I5 were not conducted during the same date. Given these requirements, it was determined that 4 weeks were needed to collect data at the 27 individual sites. Seven sites were operated each week for three weeks and then six sites were operated during the final week. Ideally, each site would collect data for 24-hrs, but because the Washington State Patrol (WSP) lacked the resources to operate all weigh stations for this length of time the data collection was restricted to the operational hours attainable by the WSP. Data collection was scheduled for the Wednesday of each week in order to avoid unusual traffic flow patterns at the beginning and end of the week.

In the event surveys were not able to be collected at a given site on the scheduled day, the site was rescheduled at a time later in the survey round. Considerable effort was taken to ensure it would not interfere with the data collection at other sites. The dates of actual data collection are included in Appendix B, including any sites that had been rescheduled prior to the writing of this report.

Questionnaire Design

The SFTA O-D project used two similar versions of the questionnaire. The spring 2002 survey was completed with a modified version of the questionnaire developed for EWITS. This previous questionnaire was altered to include a question asking for separate counts of axles for each truck/tractor, first trailer and second trailer. Questions were also added to allow for the collection of information for those trucks operating as less-than-truckload carriers (multiple pickups and/or deliveries).

Following the spring survey round, several improvements were made to the questionnaire, mainly to assist the interviewers with properly completing the survey, but also to clarify some questions. The first problem identified was the location of the question pertaining to carrier name. The modifications to the earlier EWITS survey form had caused the question to be located at the extreme top edge of the second page. This posed a problem for the interviewers because the clipboard would obscure the question as they moved from the first to the second page of the questionnaire.

The second problem was confusion regarding questions pertaining to unloaded weight and payload weight. During the spring survey round, many drivers had responded with their gross vehicle weight, instead of their payload weight. A third weight question was added, requesting the maximum registered weight of the vehicle, thereby insuring the interviewer would not accept a value that was too great for the payload weight.

The final change was to simplify the origin and destination questions. The older version of the questionnaire had separate sections to indicate origin and destination points for loaded and unloaded vehicles. This was condensed down into one section that asked for the origin and destination of the truck trip. A check box for empty or loaded was included to help identify the status of the vehicle. Two maps were also included with the questionnaire. One map was a statewide coverage of the major Washington State highways and the second map was a closer detail of roads in the Puget Sound region. Using these maps, respondents were able to quickly identify and highlight the Washington State highways used for their specific route.

The goal was to have a questionnaire that could be completed in approximately 3 minutes. This allowed for an effective flow of traffic through the weigh station while not detaining drivers any longer than necessary. The use of check boxes and well worded questions, plus the use of highlighting markers and maps for route identification, allowed for each survey to be administered smoothly and with minimum delay. Please see Appendix C for an example of the updated questionnaire.

Sampling Issues

Since it was not possible to collect surveys for a 24-hour duration at every site, and because it was also impossible to stop and interview every truck traveling through or past the weigh station in that period, a system of assuring an appropriate sampling frame was constructed.

The sampling frame differed by survey location and was constrained by the weigh station configuration, available parking and the number of interview personnel on-site. The earlier EWITS O-D study outlined a goal of stopping one out of ten trucks on the I5 corridor, one out of five trucks on other major corridors and one out of two trucks at the sites with the lowest truck traffic volumes. However, the SFTA O-D goal was to maximize the number of vehicles surveyed at each site and therefore, trucks would be stopped and interviewed if there was a) space available to safely park them and b) there was an interview person to immediately interview the driver. At the lower volume sites, this enabled for 60%-80% of the trucks passing through the station during its open hours to be interviewed. The sites with a higher volume saw between 5%-20% of the total trucks being surveyed. The lowest percentage of total trucks were interviewed at those sites where there was a high volume of truck traffic at the weigh station, and additional trucks were utilizing the Washington State Department of Transportation's Commercial Vehicle Information System Network bypass system.

On average for the first three survey seasons, 6,000 trucks were interviewed each month. Following this trend, roughly 24,000 trucks[2] will be interviewed over the course of four survey seasons. While this is fewer than the 28,000 trucks interviewed during the EWITS O-D in 1993/1994, a greater percentage of the truck traffic was generally surveyed at each site during the hours surveys were implemented. However, given that the total hours of operation for weigh stations throughout the state were less than in 1993/1994 (smaller time-window to collect surveys over a 24 hours period, but higher proportion of truck traffic surveyed within that time-window), less total surveys were collected.

[2] This report was written prior to completion of the final season of surveys.

INTERVIEW TEAM RECRUITMENT AND TRAINING

Interview Team Recruitment

Obtaining an accurate seasonal profile of truck movements throughout the state of Washington required conducting interviews simultaneously at six to seven sites across the state per week. This weekly survey activity was repeated for each week in the month long seasonal survey round. It was determined that hiring a team of interviewers to travel throughout the state and provide labor services to each site was not cost effective, nor did it meet the goals of the SFTA O-D project. Typically 15-18 people were required to cover a given 24-hour interview location. The number of people required at other sites was dependent upon the hours of operation and the parking space available at the weigh station. On average, each site had four to five people working each shift. During an average survey day, up to 90 interview personnel were required to staff all locations. Consequently, this created the need to obtain a very large, short-term labor force in order to successfully complete the statewide freight truck study.

To meet this challenge, Washington State service organizations (Lions and Kiwanis Clubs) were offered the opportunity to conduct truck driver interviews as a club fund raising activity. The opportunity was first introduced at a statewide conference of Washington State Lions Clubs in February 2002. Many of the clubs had participated in the EWITS O-D survey in 1993/1994.

As a result of initial recruitment efforts, eight Lions Clubs and one Kiwanis Club agreed to provide members to serve as local interview teams. All clubs were based in the regions surrounding the selected interview sites. Their close geographic proximity minimized travel costs for the interview team. 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. Many of the club members participated multiple times at each of their club's assigned survey sites in each of the four interview rounds. Not only did this provide knowledgeable interview personnel in each survey round, it also allowed for experienced people to staff multiple sites in each round if their club was responsible for more than one location. These experienced teams not only allowed for quality data collection, they also reduced the overall effort by not requiring on-site management by research team members or continual re-training of personnel for each interview session.

Training

Interview team training is a critical component of any study involving personal interviews. A strong training program is essential when persons who are less experienced in interview procedure and data collection methods are utilized to conduct interviews. Regardless of their prior participation in the EWITS O-D project, each participating club was subjected to training prior to the start of the first interview round in April 2002. This training was followed up by on-site instruction and supervision before and during the interview process.

An individual and customized training session was conducted for each of the nine service clubs. Each training session began with an overview of the key project goals and objectives from the earlier 1993/1994 EWITS O-D study. This allowed those clubs/members that had participated in

the earlier research effort to see the results their efforts and it also provided some useful background for the clubs/members who weren't part of the prior survey project. Providing background information and an overview of the SFTA project also prepared interviewers to answer basic questions from truck drivers concerning the purpose of the study. 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 ask and phrase survey questions in such a manner to ensure adequate responses from the drivers was pertinent to the training.

Conducting personal interviews of truck drivers at busy weigh stations is a physically strenuous and potentially dangerous activity. The personal responsibility of each interviewer to be alert and promote on-site safety was stressed at the training. In addition, 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. Examples of safety requirements emphasized to the interview team members included: always wear safety vests and hats while on-site, never approach a truck unless it is completely stopped, 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 was only the beginning of what would be a continuous process to ensure quality interviews and personnel safety. A supervisor from the project management team provided ongoing training and instruction on-site at each location. 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

Each survey site was provided with the following supplies:

- Orange Mesh Safety Vests
- Pens, Pencils, Highlighting Markers, Pencil Sharpeners, Staplers, Staples
- Handheld Two-Way Radios
- "WSU Research Team" Hats
- Weatherproof Plastic Storage Boxes
- Clipboards
- Tally Counter
- Traffic Cones
- Headlamps (Where Applicable)
- "Survey Crew Ahead" Road Sign
- Blank Surveys

In addition to items necessary for successful data collection, such as general office supplies and clipboards, many items were provided to ensure the safety of the interview team members while they were on-site. Each team member was required to wear an orange safety vest while working at the site. In addition to safety vests, each interviewer was provided with a "WSU Research Team" embroidered hat to assist with identifying them to the respondents. Traffic cones were utilized for traffic control and to cordon off parking areas for the trucks. Although the volume of truck traffic varied greatly at each site, it was important for interview personnel to be visible by truck drivers navigating through the weigh station or border crossing. The orange safety vests accomplished this during the daytime hours, but for those sites where the hours of operation extended into or through the night, headlamps were also provided. Not only did this help drivers see the interview team members at night, it allowed for the survey to be completed in the reduced light situations.

Site Management

At each survey site a SFTA research team member from Washington State University was present during the initial survey season. Research team members were present for subsequent sessions/seasons, as needed. In a few instances, the management of a site was left up to the individual Lions organization, but only after the club had sufficient experience with how the survey was to be conducted. Most often, these clubs provided staffing for multiple sites during each survey season. This was sufficient to ensure they were able to provide competent site operation without direct supervision from a research team member.

Those research team members charged with managing a site were tasked with the responsibility of delivering material, setting up the site and monitoring activities throughout the course of the survey duration. Once at a site, they worked with the WSP Commercial Vehicle Enforcement Officers (CVEO) to determine the best and safest method for setting up the site. By combining the knowledge of the WSP officer with the needs of the survey, a site set-up plan meeting the data requirements of the survey was easily achieved, while keeping the area safe for the

interview team. It was important for the interviewers to be situated in a visible location while, at the same time, not impeding the flow of traffic. It was also important the activities of the survey did not interfere with the routine activities of the weigh station. Most importantly, a smooth traffic flow through the scale area had to be maintained to avoid traffic backups that extended into the lanes of oncoming traffic.

Although the layout of each weigh station varied greatly, the general method of setting up the sites were similar. One survey volunteer was placed at or near the scale. It was their responsibility to make initial contact with truck drivers to request their participation in the survey. Either the WSP officer used the red stoplight to have the truck stop or the interview team member signaled the driver to stop. Those drivers who consented were then directed to the area where they would be able to safely park and complete the survey. The person stationed at the scale was responsible for maintaining the flow of traffic and to know how many trucks could be safely parked at any one time. For those sites without automatic counters, they were also responsible for maintaining a count of total truck traffic that passed through the station.

Each site had an area where participating drivers were allowed to park their trucks. Some sites only allowed for trucks to park parallel to the lane of traffic. Other weigh stations and ports-of-entry interview sites had separate parking lot(s) available. Where it was appropriate, traffic cones were placed to cordon off the designated parking area. For those sites where there was a reasonable distance between the scale and the parking area, teams were able to use two-way radios to relay necessary information.

Site Safety

The setup and management of each site was designed and executed with safety of the interview team being first and foremost. Each team member was provided with an orange safety vest to ensure they were highly visible while they were on-site. In addition to the safety equipment, each site was managed in such a manner to ensure that the interviewers were located a safe distance from the path of moving traffic. This included choosing safe locations for the staging of supplies and for the parking of trucks participating in the survey. The exact setup of each site depended upon the various locations. If a site was sufficiently large, interviewers were able to set up and conduct interviews on the periphery of the parking area. Smaller sites had their parking area parallel to the entrance/exit lanes of the station. At the smaller sites, interviewers operated in the parking areas, but care was taken to maintain a safe distance from the flow of traffic. Please see figures 2, 3 and 4 for examples of different weigh stations setups.

Figure 2: Site Set-Up and Traffic Control Plan at Smaller Weigh Stations

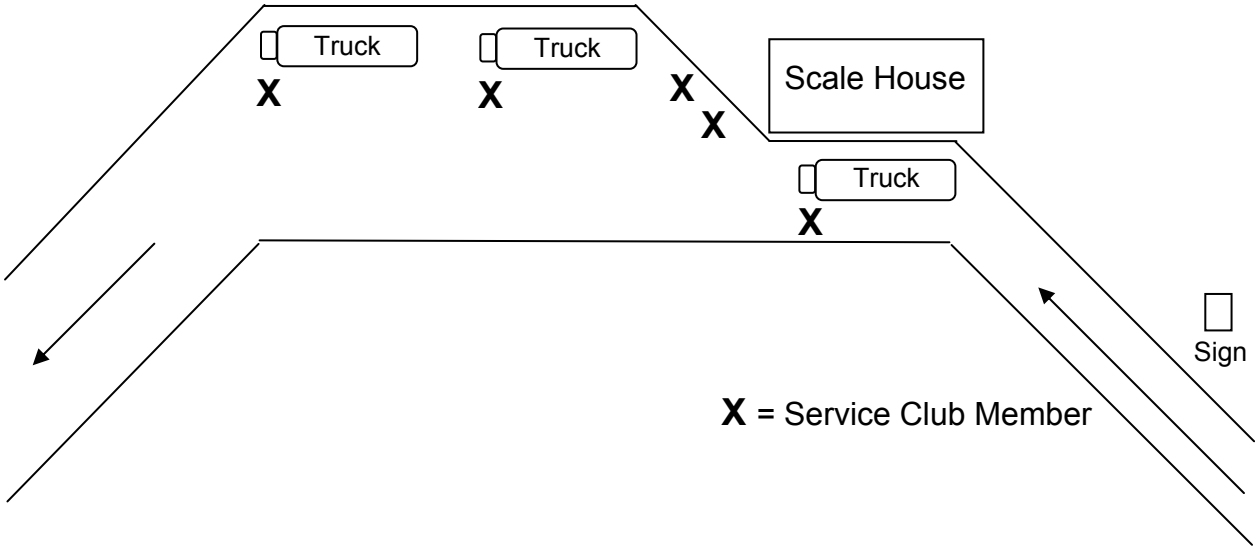


Figure 3: Site Set-Up and Traffic Control Plan at Larger Weigh Stations

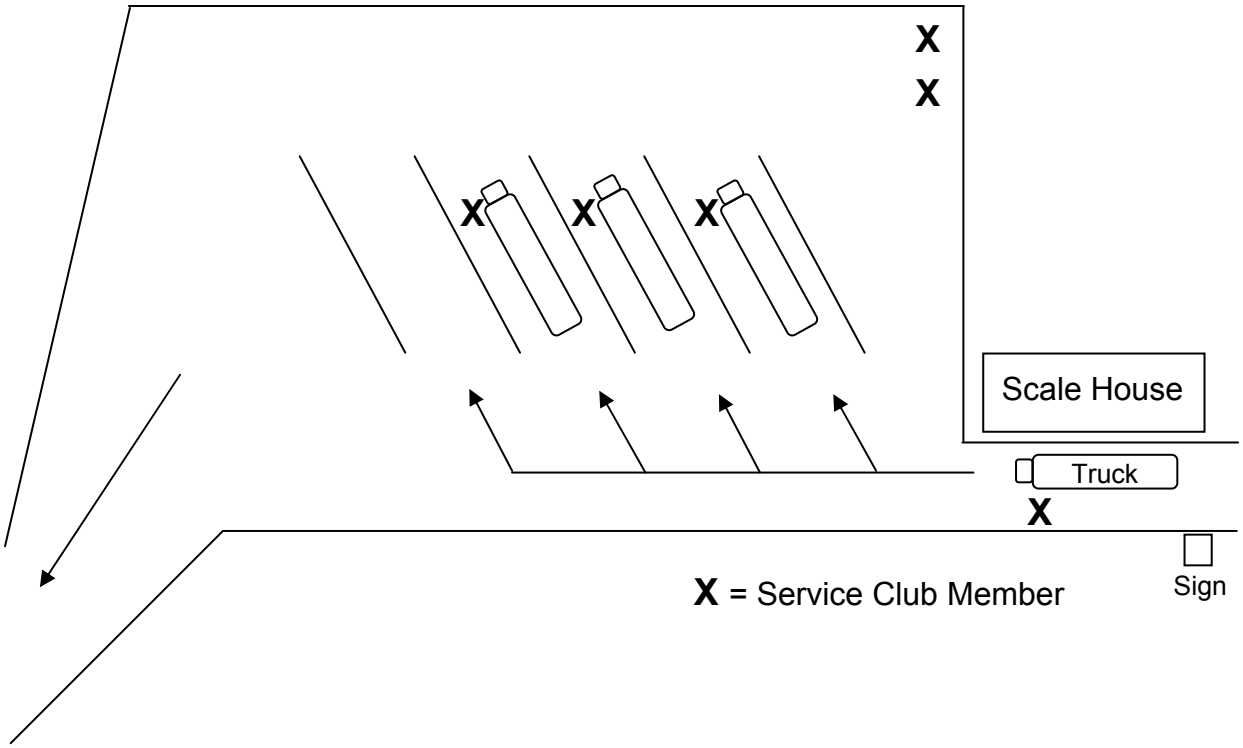
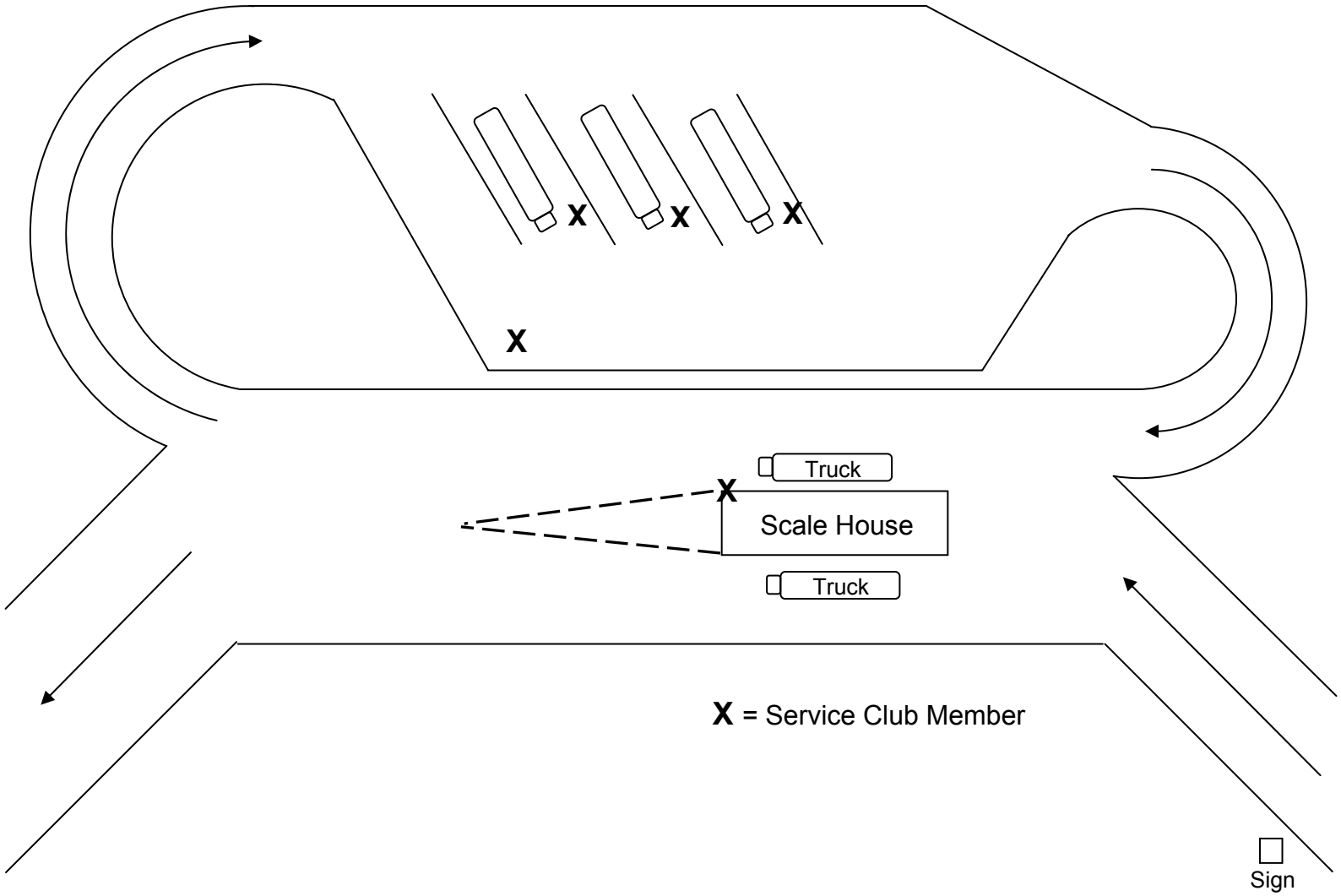


Figure 4: Alternative Site Set-Up and Traffic Control Plan at Larger Weigh Stations



Interview Procedure

Each interview was initiated when an interview team member made contact with the driver and requested their participation in the survey. Persons performing this task were instructed to not approach the truck until it was completely stopped and they were sure the driver was aware of their presence. It was important to make sure that there were no more trucks stopped than available personnel to immediately interview them.

Once the truck was parked, an interviewer approached the truck. As the truck was parking, the interviewers were able to complete the first page of the survey from visual inspection. They then approached the driver's door and proceeded to record the answers as they pertained to the second page of the survey. The final step was to have the driver highlight their route or for the interviewer to do this themselves if it was a simple or a familiar route. They then thanked the driver for their time and returned to the side of the parking area to await the next truck. Every measure was taken to ensure each driver was interviewed in the shortest amount of time possible.

DATA MANAGEMENT AND ANALYSIS

Data Management

It is important to maintain effective management of data during collection, entry into a database and during all subsequent analyses. Following and implementing appropriate management techniques helps ensure that the compiled database accurately reflect the statewide freight movements in Washington.

There are three possible sources of error that can be attributed to on-site data collection issues. Systemic problems arise from poorly worded questions, incorrect interview procedures and/or problems stemming from sub-optimal site selection. Data problems may come from drivers who provide inaccurate information in response to the survey questions. Finally, interview personnel may fill out the survey incorrectly, providing inaccurate data regarding vehicle information or driver responses.

Errors stemming from improper data collection technique were minimized through a constant monitoring of the survey and data entry personnel. On-site monitoring allowed specific problems to be immediately addressed with the interviewer. Problems identified during data entry were addressed during the following survey season.

Constant re-training and reviewing the procedures while on-site also assisted with reducing errors. At those sites where a research team member was present, a short review session was performed before the start of each day of survey collection. This was repeated for each shift when other club members arrived. Additional attention was given to any persons who had not previously participated. Oftentimes, those who had not participated before were allowed to shadow another interviewer for several interviews to allow them to see how the process was to be performed. Once comfortable, they were allowed to collect questionnaires on their own. Throughout the day, the research team member on-site also hand checked completed questionnaires and corrected any problems that were noticed. In spite of the steps taken to minimize any errors, it must be recognized that these errors cannot be completely eliminated.

Data entry personnel preformed a check on each questionnaire as it was entered into the database. They checked individual answers for consistency and being logical. Each highlighted route was verified that it corresponded to the origin and destination points provided within the survey. Origin and destination points were checked to make sure that the origin was before the weigh station and the destination was beyond the weigh station. Some drivers on round trip routes would incorrectly provide information about a trip segment that may have occurred earlier in the day and was not actually their current trip segment. Once it was determined that the answers on a survey were logically consistent, the questionnaire would then be entered.

This data review process included several decision rules that were followed to assist data entry persons with making uniform and consistent decisions. For example, for those questionnaires where the sum of the empty and payload weight was significantly greater than the Washington State legal limit of 105,500 pounds, it was assumed the recorded payload weight was actually the gross weight of the vehicle. Data entry persons revised the answers to reflect the correct information. The revised payload weight was calculated as gross weight minus empty weight.

Data Entry

During the data entry process, several checks were done to minimize keystroke errors. Microsoft Access was the database program used by the data entry persons. A data entry form was designed as a friendly, up-front interface to input data into the database. The use of a simple form allowed data entry personnel with computer skills, but little or no knowledge of Microsoft Access to enter data with minimal confusion.

Certain entry boxes within the form were set up with restrictions on what could be entered. For example, the information on the survey that was answerable via numerical values was restricted to the range of numerical values appropriate to the possible answers. Entering a value outside of that range would result in an error message being displayed. For example, the possible answers for truck type ranged from 1-6. The form only allowed for inputs of values less than 7. Anytime a value of 7 or greater was entered, the program gave an instant error message instructing the data entry person to fix the error.

In addition to restricting those answers that could be answered by simple numeric values, several other alpha and alphanumeric answers were also restricted to specific lists. All answers involving state or Canadian province names were restricted to a prepared list with full and correctly spelled names. This drop down style entry box would automatically fill in the correct data as the data entry person began inputting. For example, when the state name of "Washington" was being inputted, the "W" would bring up the complete name "Washington" in the list. Pressing enter would enter "Washington" into that box and move onto the next entry box and allow data entry personnel to continue entering data. This allowed for a consistent entering of state and province names and it also allowed for the process to be quick and easy for the data entry persons.

This procedure was also followed for the list of road names within Washington State. This allows for consistent naming of the routes as they were placed into the database. For example, entry of State Route 24, was restricted to being entered only as "SR24," not "Sr24," sr24" or "sr 24" etc. As with the other restrictions placed upon the entered data, this allowed for routes to be recorded in a consistent manner. This was important because the recorded routes would be later used in the geo-coding process.

Data Clean Up

In spite of the procedures employed during the data collection and entry processes, there was still a considerable amount of cleanup that needed to be performed. The first step was to sort the data set by the various column headings to visually inspect for missing or incorrect observations. Some categories were set up to provide zero as the default value. In some cases, this was a

desirable default. For example, if a survey indicated a truck type of "1", (Straight Truck) then "0" would be an acceptable value for trailer type. In other cases, "0" was an indicator of an unknown answer from an improperly filled out survey. At this time, all weights recorded in kilograms were converted to pounds.

A search for missing data was also performed on city and state/province names. Any blank answers were filled in as "Unknown" in the data set. This showed that the answer was not simply overlooked during data entry, but it was actually missing on the survey form. The only exception to this was when unknown state/province names could be easily deduced from the entered city. For example, an entered city name of "Seattle" with a blank state state/province category was filled in as "Washington," instead of being indicated as "Unknown."

Next, several cross tab checks were made to ensure that several of the data categories were consistent with the answers for each record. For example, if a record indicated a truck type of "1", then there should not be any value for trailer type and the survey should provide a value for the axle count relating to only that for a truck. Empty and payload weights were also compared. Empty trucks should have a "0" payload weight and in any case, the total weight (Empty, plus Payload) should generally be no greater than the Washington State legal limit of 105,500 pounds.

For those surveys that could not be corrected using the above methods, they were flagged and their records were set aside. These were then manually re-checked with the hard copies to correct any errors.

Data Analysis and Daily Truck Traffic Counts

In order to accurately assign statistical weights to the survey data, traffic counts from the WSDOT Traffic Data Office (TDO) were used. WSDOT and the Federal Highway Administration utilize a 15-category vehicle classification system to identify vehicles, however not all traffic recorders are able to provide that level of data. Instead, a 4-category system, based upon vehicle length, was used for the SFTA analysis. The first classification category was for cars and passenger vehicles, followed by three different categories for trucks. These truck categories were defined as; single trucks, double combinations (truck & trailer) and triple trucks (truck and two trailers).

It was found that, in a few cases, the TDO data was sometimes slightly greater than the actual counts performed during the time of the survey. This can be accounted for by the inclusion of vehicles such as buses and possibly larger non-commercial truck/trailer combinations (travel/5th wheel trailers, horse trailers etc.) into the categories for commercial trucks. This information could not be accurately extracted from the traffic counts and had to be included.

At some sites, data was unavailable from the TDO. In those cases, the sites affected were 24-hour sites and the actual counts from those sites were used in place of the TDO data. Please see Appendix D and E for maps of the locations of all WSDOT traffic data recorders.

Statistical Weight Factors

In order to present the survey data in a meaningful manner, the first step was to calculate a site-specific seasonal weight factor based upon the total number of trucks passing each survey site in the 24-hours surrounding the survey date. Those sites that operated 24-hours were able to provide a total truck count for the day of the survey. For those sites where surveys were taken for less than 24-hours, the WSDOT TDO provided truck counts collected from their data recorders located closest to the survey site.

To calculate the seasonal weight factor for each site/season, the total number of trucks in a 24-hour period was divided by the total number of surveys collected at each site. The seasonal weight factor is used to expand the collected data characteristics to represent the entire population of trucks at each survey location. This expanded information was a representation based upon the total number of daily truck trips.

The next step in data analysis required compiling information across seasons and then being able to combine information from multiple survey sites on the same corridor. To do this, a series of weighted averages was used. First, each site was broken into the total number trucks at each site for each season. Each season at each site was then given a weight factor based upon the total number of trucks at that site over the 4 seasons.

Table 1: Example 1

Site A	Season	Number of Trucks Surveyed	Seasonal Weight Factor	Weighted Value
	Spring	2,500	.255	638
	Summer	3,500	.357	1,250
	Fall	2,000	.204	408
	Winter	1,800	.184	331
	Total Trucks Surveyed Over All Seasons	9,800	Average Annual Total Daily Truck Trips at Site A	2,626

Example 1 shows a hypothetical Site A and the corresponding number of trucks that were present in the 24-hours of each day of data collection for each season. The seasonal weight factors are calculated by dividing the individual season totals by the total number of trucks over the four seasons. Taking the spring season as an example, the result is: 2,500/9,800=.255.

When these seasonal weight factors are applied to the seasonal truck totals and the results are summed, the result is a value representing the average total daily truck trips for that site over all seasons. As shown in Example 1, the average annual total daily truck trips at Site A was 2,626 trips.

Each site-specific seasonal weight is unique to each site. These may then be applied to the information tabulated from the data at each site.

Table 2: Example 2a

Site A	Season	Number of Empty Trucks Surveyed	Seasonal Weight Factor	Weighted Value
	Spring	1,250	.255	319
	Summer	1,100	.357	393
	Fall	1,500	.204	306
	Winter	700	.184	129
	Total Empty Trucks Surveyed Over All Seasons	4,550	Average Annual Total Daily Empty Truck Trips at Site A	1,146

Table 3: Example 2b

Site A	Season	Number of Loaded Trucks Surveyed	Seasonal Weight Factor	Weighted Value
	Spring	1,250	.255	319
	Summer	2,400	.357	857
	Fall	500	.204	102
	Winter	1,100	.184	202
	Total Loaded Trucks Surveyed Over All Seasons	5,250	Average Annual Total Daily Loaded Truck Trips at Site A	1,480

The tables for Example 2a and 2b show counts of empty and loaded trucks passing by the hypothetical survey Site A for each season. To calculate the weighted average total number of empty trucks, the seasonal weight factors for each season (from Example 1, above) are applied to the totals in Example 2a for each season. When those products are summed, the result is the weighted average annual total daily number of empty trucks at Site A across the four seasons. This same method is also applied to the totals in Example 2b. These examples show that an average of 1,146 empty and 1,480 loaded trucks per day passing through Site A. This average total number of trucks (2,626 trucks) corresponds with the average total number of trucks from Example 1, above.

This same procedure is also applied to other points of interest extracted from the data set. Some examples of such data characteristics that can be examined are; origin and destination combinations and truck/trailer configurations.

The above procedures demonstrate how to accurately represent the average number of trucks for a given site using the information from the four seasons. The use of weighted averages in this manner captures the seasonality of differing traffic flows that may occur at each site. The next step is to combine individual sites to examine the flow of traffic along traffic corridors. The major traffic corridors in Washington had multiple survey sites along their lengths. Although the

scheduling of these surveys was such that no two in the same direction were conducted at the same time, their data may need to be aggregated in a manner to accurately represent the average volume of truck traffic over a given section or the entire length of the corridor.

To accomplish this task, once data was weighted at the site/season level, each site along a corridor was given a weight based on the total number of trucks observed at each site over the four seasons.

Table 4: Example 3

Corridor X	Season	Average Daily Total Truck Trips	Seasonal Weight Factor	Weighted Value
	Site B	1,250	.325	406
	Site C	1,100	.286	314
	Site D	1,500	.390	584
	Total Trucks	3,850	Average Annual Daily Total Trucks on Corridor X	1,305

Example 3 shows three survey sites along a hypothetical Corridor X. All three sites are sampling traffic flows in the same direction. The average annual daily total truck trips were calculated for each site using the procedure outlined in Example 1, above. In order to arrive at an average annual daily truck count for the length of Corridor X, it was necessary to weight each site along the corridor based on the total number of trucks for the three sites. Once weighted, the result of 1,305 is the average annual daily number of truck trips along Corridor X.

Commodity Classification Procedure

The SFTA O-D project used an updated coding system provided by the United States Census Bureau. The North American Industry Classification System (NAICS, pronounced *"Nakes")* was adopted in 1997 to update the older Standard Industrial Classification (SIC) system, which was used to classify the EWITS O-D commodity data. While, similar to the older SIC system, the NAICS was expanded to include more categories.

Each driver of a loaded truck was asked to identify the commodity they were currently carrying. In order to accurately aggregate the various commodities into useful categories, each commodity indicated on a survey was given a classification code. The classification procedure was restricted to using three digit NAICS codes. See Appendix F for the list of codes used.

Geo-Coding

Documenting the geographic movement of freight truck shipments between individual cities and regions within the state of Washington is a key component of SFTA. Geographic coordinates (geo-codes) were developed for each Washington origin and destination identified by truck drivers participating in the origin-destination study. This process was performed within the Geographic Information System (GIS) software: ArcInfo. Utilizing an Arc Macro Language program, a list of five potential routes was developed for each origin-destination pair. The route that most closely matched the highway usage provided by the survey respondent was selected and assigned to each respective survey observation. The assignment of the truck origin-

destination data to geographic coordinates allows for very detailed and accurate analysis between any attributes from the survey data (truck configuration, commodity, weight, base of operation, origin, destination, facility type, etc.) to anything that has a geographical property (highway, land, people, socio-economic data, etc.).

APPENDIX A: SITE LOCATION INFORMATION

Weigh Station	Site Number	Road	Milepost	Traffic Direction Captured
Brady West	1	US12	13	West
Brady East	2	US12	14	East
Cle Elum East	3	I90	83	East
Cle Elum West	4	I90	83	West
Deer Park South	6	US395	179	South
Douglas North	7	SR543	270	North
Everett North	8	I5	193	North
Everett South	9	I5	193	South
Goldendale	10	US97	13	North/South
Kelso South	11	I5	39	South
Vernita Bridge	12A	SR24	-	East/West
Pasco	13	US395	27	South
Peshastin West	15	US2	185	West/South
Plymouth	16	SR14	167	East/West
Port Angeles	17	US101	246	West
Sea Tac South	19	I5	144	South
Sea Tac North	20	I5	152	North
E. Spokane	21	I90	285	West
Tokio East	22	I90	231	East
Tokio West	23	I90	231	West
Umatilla	24	US395	13	South
Vancouver North	25	I5	7	North
Wallula	26	US12	307	All
Osoyoos North	28	US97	336	North
Oroville South	29	US97	336	South
Danville	30	SR21	191	North and South
Laurier	31	US395	270	North and South

APPENDIX B: SITE SCHEDULE INFORMATION

Site Number	Survey Site	Season: Spring April 2002	Summer July 2002	Fall October 2002	Winter January 2003	Hours of Operation	Duration
1	Brady West	24th[3]	24th	16th	22nd	7AM-3PM	8hrs
2	Brady East	3rd	10th	2nd	8th	7AM-3PM	8hrs
3	Cle Elum East	10th	17th	9th	15th	7AM-3PM	8hrs
4	Cle Elum West	3rd	10th	2nd	8th	6AM-6AM	24hrs
6	Deer Park South	3rd	10th	2nd	8th	7AM-3PM	8hrs
7	Douglas North	-[4]	17th	9th	15th	7AM-7AM	24hrs
8	Everett North	17th	24th	16th	22nd	6AM-10PM	16hrs
9	Everett South	3rd	10th	2nd	8th	8AM-4PM	8hrs
10	Goldendale	17th	24th	16th	22nd	7AM-5PM	10hrs
11	Kelso South	17th	24th	16th	22nd	6AM-6PM	12hrs
12A	Vernetta Bridge	10th	17th	9th	15th	8AM-3PM	7hrs
13	Pasco	May 1st[5]	31st	23rd	29th	6AM-6PM	12hrs
15	Peshastin West	24th	31st	30th[6]	29th	7AM-5PM	10hrs
16	Plymouth	10th	17th	9th	15th	6AM-6AM	24hrs
17	Port Angeles	24th	31st	23rd	29th	7AM-3PM	8hrs
19	Sea Tac South	10th	17th	9th	15th	7AM-3PM	8hrs
20	Sea Tac North	24th	31st	23rd	29th	7AM-3PM	8hrs
21	E. Spokane	10th	17th	9th	15th	6AM-6AM	24hrs
22	Tokio East	3rd	10th	2nd	8th	7AM-5PM	10hrs
23	Tokio West	17th	24th	30th[7]	22nd	7AM-5PM	10hrs
24	Umatilla	17th	24th	16th	22nd	6AM-9PM	15hrs
25	Vancouver North	3rd	10th	2nd	8th	6AM-6AM	24hrs
26	Wallula	3rd	10th	30th[8]	8th	8AM-4PM	8hrs
28	Osoyoos North	24th	31st	23rd	29th	6AM-9PM	15hrs
29	Oroville South	17th	24th	16th	22nd	6AM-6PM	12hrs
30	Danville	24th	31st	23rd	29th	8AM-12PM	4hrs
31	Laurier	10th	17th	9th	15th	8AM-12PM	4hrs

3 The Brady West site was rescheduled from April 17th to April 24th, because of a lack of personnel.
4 Data collection at the Douglas site was canceled for the spring season due to facility problems.
5 The collection of surveys at the Pasco site in the spring season was rescheduled for May 1st due to scheduling problems on the original day, April 24th.
6 The Peshastin West location was rescheduled from October 23rd to October 30th, due to a conflict with scheduling interview personnel.
7 Tokio West was rescheduled from October 23rd to October 30th due to a scheduling conflict.
8 The fall season at Wallula was rescheduled for October 30th, due to an accident in the vicinity that required the attention of the WSP CVEO assigned to the weigh station on the original day, October 2nd.

APPENDIX C: INTERVIEW QUESTIONNAIRE

Record #: _____
[for Data Entry Use Only]

CONFIDENTIAL

Washington State Department of Transportation & Washington Strategic Freight Transportation Analysis Project: Truck

Season ***[Circle One]*** **Spring** **Summer** **Fall** **Winter**

1) Station Location: _____

2) Name of Interviewer: _____

3) Interview Shift: ***[Please Circle One]***

1. Day Shift	**2. Evening Shift**	**3. Night Shift**
6:00 a.m. – 2:00 p.m.	2:00 p.m. – 10:00 p.m.	10:00 p.m. – 6:00 a.m.

4) Time of Interview: _____ a.m. _____ p.m.

5) Truck Configuration ***[Please Check Only One]***	6) Trailer Style ***[If Appropriate, Check More Than One]***
1. ☐ Straight Truck	1. ☐ Van (Without Temperature Control)
2. ☐ Straight 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
6. ☐ Other: _____	6. ☐ Stake and Rack
	7. ☐ Concrete Mixer
	8. ☐ Tanker
	9. ☐ Float
	10. ☐ Dump
	11. ☐ Container
	12. ☐ Chip
	13. ☐ Animal Carrier
	14. ☐ Logging
	15. ☐ Other: _____

	# of Axles on Truck or Tractor	# of Axles on 1st Trailer	# of Axles on 2nd Trailer
7) Number of Axles on the Ground:	_____	_____	_____

8) Is a Hazardous Material Placard Displayed? ☐ Yes If Yes, ID #: _____ ☐ No

9) Carrier Name: _____
:

10) Carrier Home Base ***[City and State/Province]*** _____

11) What is the **Unloaded Weight** of this Vehicle?

_____ Lbs. [OR] _____ Kgs.

12) What is Your Estimated **Payload Weight?** *[Weight of cargo only, Please enter 0 if the rig is **EMPTY**]*

_____ Lbs. [OR] _____ Kgs.

13) What is the **Registered Maximum Weight** of this Vehicle?

_____ Lbs. [OR] _____ Kgs.

14) Is the vehicle **LOADED** or **EMPTY**? **LOADED** ☐ **EMPTY** ☐

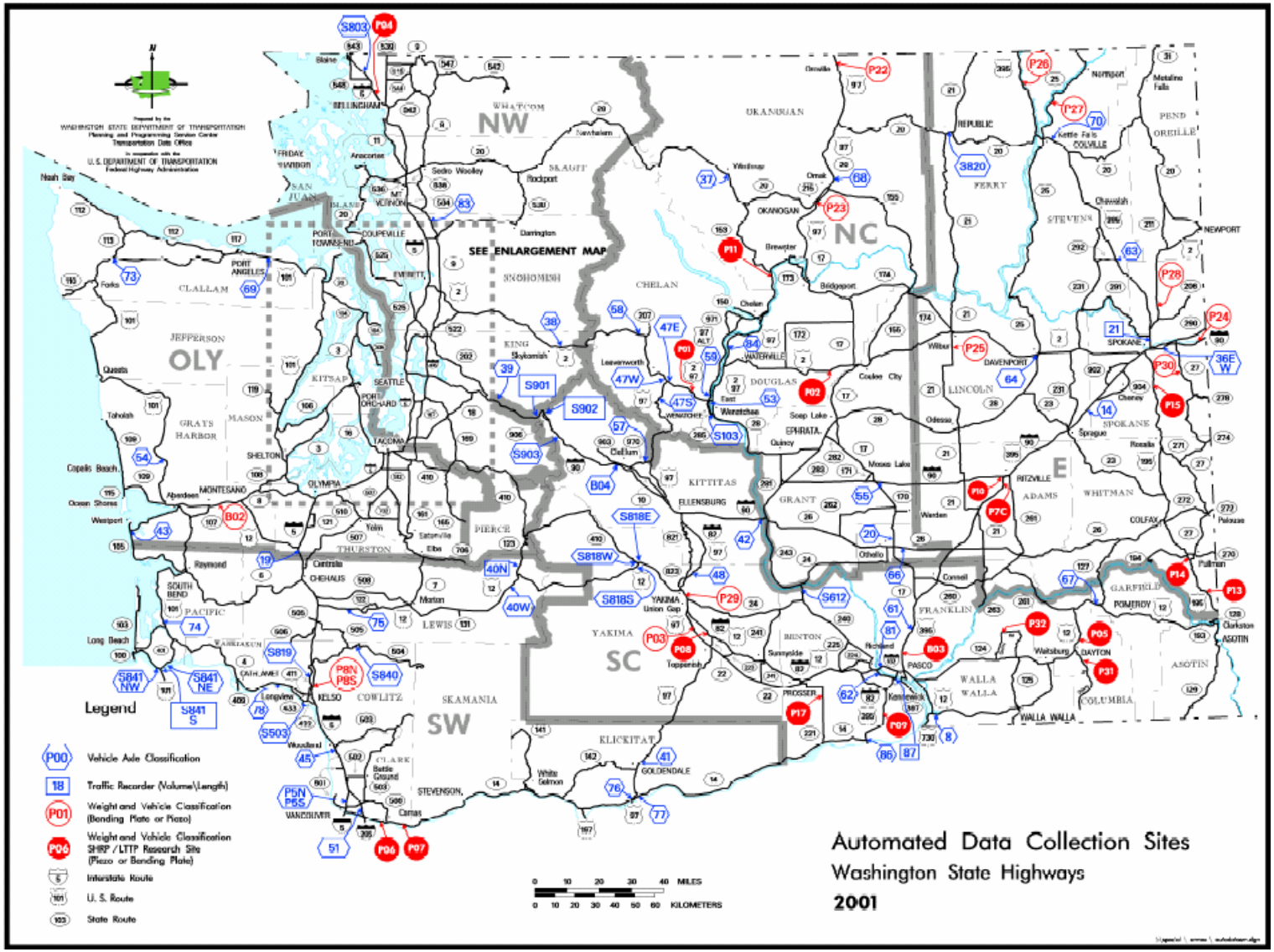
15) What is the **Major Co mmodity** on Board? _____

[Please fill out the following section COMPLETELY]

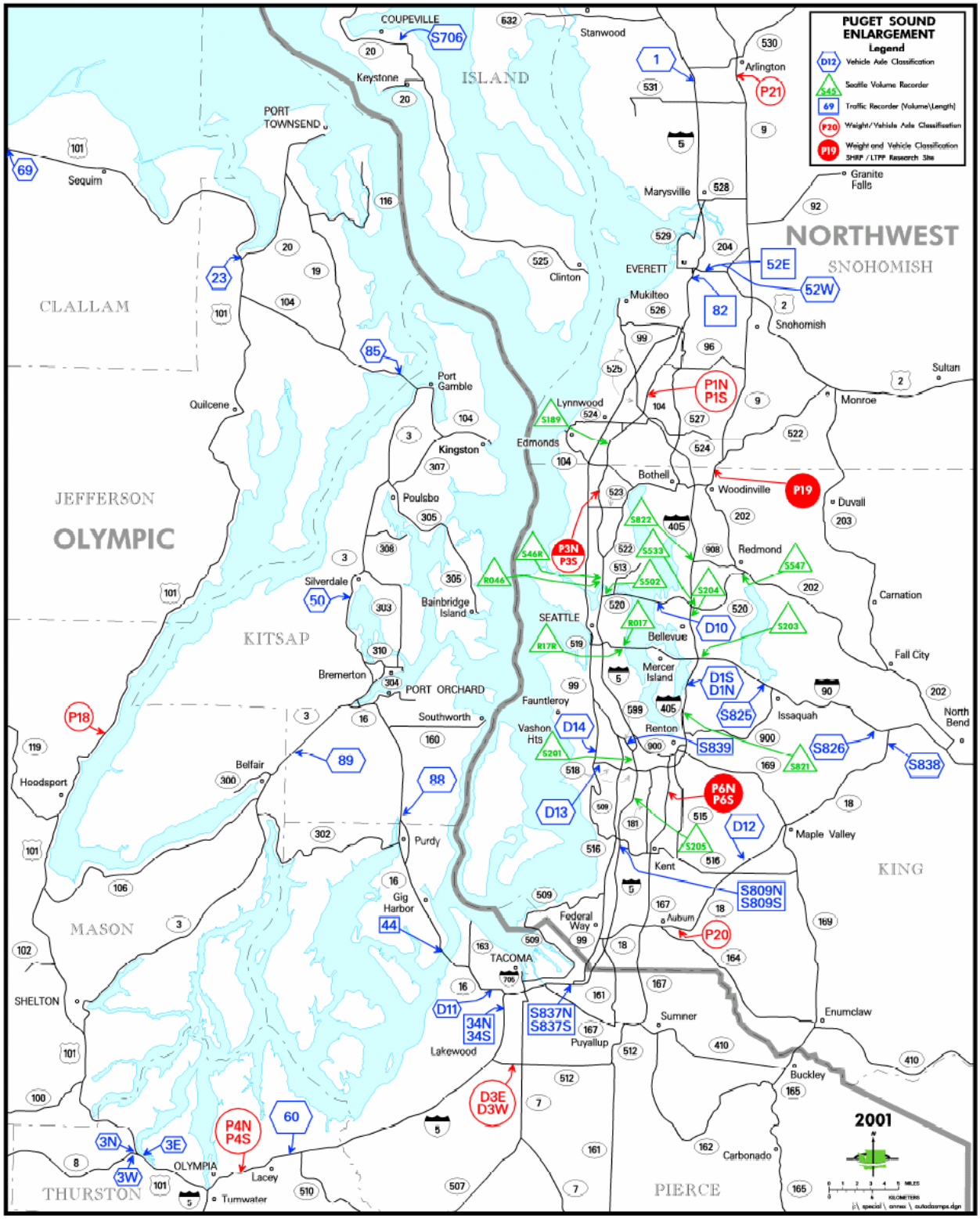
Where Did **THIS** Trip Begin?	Where Will **THIS** Trip End?
16) **City, State/Province :** _____	19) **City, State/Province:** _____
17) Facility: 1. ☐ Truck Terminal 2. ☐ Rail Terminal 3. ☐ Marine Terminal 4. ☐ Air Terminal 5. ☐ Factory 6. ☐ Warehouse/Distribution Center 7. ☐ Farm 8. ☐ Point of Sale/ Consumption 9. ☐ Other : _____	20) Facility: 1. ☐ Truck Terminal 2. ☐ Rail Terminal 3. ☐ Marine Terminal 4. ☐ Air Terminal 5. ☐ Factory 6. ☐ Warehouse/Distribution Center 7. ☐ Farm 8. ☐ Point of Sale/Consumption 9. ☐ Other: _____
18) If LTL, List Origin **Cities, States/Provinces:** a. _____ b. _____ c. _____ d. _____	21) If LTL, List Destination **Cities, States/Provinces:** a. _____ b. _____ c. _____ d. _____
[Please Go to Question #1 9]	***[Please Go to Question #22]***

22) Please Identify the Washington State Highways Used to Travel from the Listed Origin to Destination on the Attached Map.

APPENDIX D: WSDOT AUTOMATIC DATA COLLECTION SITES



APPENDIX E: WSDOT AUTOMATIC DATA COLLECTION SITES (PUGET SOUND REGION)



APPENDIX F: NAICS CODE LIST

NAICS Code	Category
11	Agriculture, Forestry, Fishing and Hunting
111	Crop Production
112	Animal Production
113	Forestry and Logging
114	Fishing, Hunting and Trapping
115	Support Activities for Agriculture and Forestry
21	Mining
211	Oil and Gas Extraction
212	Mining (except Oil and Gas)
213	Support Activities for Mining
22	Utilities
221	Utilities
23	Construction
233	Building, Developing, and General Contracting
234	Heavy Construction
235	Special Trade Contractors
31-33	Manufacturing
311	Food Manufacturing
312	Beverage and Tobacco Product Manufacturing
313	Textile Mills
314	Textile Product Mills
315	Apparel Manufacturing
316	Leather and Allied Product Manufacturing
321	Wood Product Manufacturing
322	Paper Manufacturing
323	Printing and Related Support Activities
324	Petroleum and Coal Products Manufacturing
325	Chemical Manufacturing
326	Plastics and Rubber Products Manufacturing
327	Nonmetallic Mineral Product Manufacturing
331	Primary Metal Manufacturing
332	Fabricated Metal Product Manufacturing
333	Machinery Manufacturing
334	Computer and Electronic Product Manufacturing
335	Electrical Equipment, Appliance, and Component Manufacturing
336	Transportation Equipment Manufacturing
337	Furniture and Related Product Manufacturing
339	Miscellaneous Manufacturing
42	Wholesale Trade
421	Wholesale Trade, Durable Goods
422	Wholesale Trade, Nondurable Goods

NAICS Code	Category
44-45	Retail Trade
441	Motor Vehicle and Parts Dealers
442	Furniture and Home Furnishings Stores
443	Electronics and Appliance Stores
444	Building Material and Garden Equipment and Supplies Dealers
445	Food and Beverage Stores
446	Health and Personal Care Stores
447	Gasoline Stations
448	Clothing and Clothing Accessories Stores
451	Sporting Goods, Hobby, Book, and Music Stores
452	General Merchandise Stores
453	Miscellaneous Store Retailers
454	Nonstore Retailers
48-49	Transportation and Warehousing
481	Air Transportation
482	Rail Transportation
483	Water Transportation
484	Truck Transportation
485	Transit and Ground Passenger Transportation
486	Pipeline Transportation
487	Scenic and Sightseeing Transportation
488	Support Activities for Transportation
491	Postal Service
492	Couriers and Messengers
493	Warehousing and Storage
51	Information
511	Publishing Industries
512	Motion Picture and Sound Recording Industries
513	Broadcasting and Telecommunications
514	Information Services and Data Processing Services
52	Finance and Insurance
521	Monetary Authorities - Central Bank
522	Credit Intermediation and Related Activities
523	Securities, Commodity Contracts, and Other Financial Investments and Related Activities
524	Insurance Carriers and Related Activities
525	Funds, Trusts, and Other Financial Vehicles
53	Real Estate and Rental and Leasing
531	Real Estate
532	Rental and Leasing Services
533	Lessors of Nonfinancial Intangible Assets (except Copyrighted Works)
54	Professional, Scientific, and Technical Services
541	Professional, Scientific, and Technical Services

NAICS Code	Category
55	Management of Companies and Enterprises
551	Management of Companies and Enterprises
56	Administrative and Support and Waste Management and Remediation Services
561	Administrative and Support Services
562	Waste Management and Remediation Services
61	Educational Services
611	Educational Services
62	Health Care and Social Assistance
621	Ambulatory Health Care Services
622	Hospitals
623	Nursing and Residential Care Facilities
624	Social Assistance
71	Arts, Entertainment, and Recreation
711	Performing Arts, Spectator Sports, and Related Industries
712	Museums, Historical Sites, and Similar Institutions
713	Amusement, Gambling, and Recreation Industries
72	Accommodation and Food Services
721	Accommodation
722	Food Services and Drinking Places
81	Other Services (except Public Administration)
811	Repair and Maintenance
812	Personal and Laundry Services
813	Religious, Grantmaking, Civic, Professional, and Similar Organizations
814	Private Households
92	Public Administration
921	Executive, Legislative, and Other General Government Support
922	Justice, Public Order, and Safety Activities
923	Administration of Human Resource Programs
924	Administration of Environmental Quality Programs
925	Administration of Housing Programs, Urban Planning, and Community Development
926	Administration of Economic Programs
927	Space Research and Technology
928	National Security and International Affairs