CAMBRIDGE SYSTEMATICS

Portland Freight Data Collection Phase II

Task 10 - Summary Report

Task 10

Final Summary Report

prepared for

Portland Freight Data Collection Team

prepared by

Cambridge Systematics, Inc.

with

David Evans & Associates
Traffic Research and Analysis, Inc.
Quality Counts
Starboard Alliance LLC
Ken Cassavant
Eric Jessup
Keith Lawton

March 2007

www.camsys.com

Final Report

Portland Freight Data Collection Phase II

Task 10 - Summary Report

prepared for

Portland Freight Data Collection Team

prepared by

Cambridge Systematics, Inc.
555 12th Street, Suite 1600
Oakland, California 94607

with

David Evans & Associates
Traffic Research and Analysis, Inc.
Quality Counts
Starboard Alliance LLC
Ken Cassavant
Eric Jessup
Keith Lawton

date

March 2007

Table of Contents

1.0 Introduction 1-1

2.0 Summary of Freight Data Needs, Tasks 1-3 2-1
2.1 Summary of Phase I Data Needs Assessment and Tasks 1 and 3 2-1
2.2 Task 2: Review Metro's Truck Model 2-4

3.0 Summary of Data Collection Plans and Methodologies, Tasks 4-6 3-1
3.1 Task 4: Develop Data Gathering Methodology 3-1
3.2 Task 5: Collect Data Through Surveys 3-3
3.3 Task 6: Collect Vehicle Counts 3-6
3.4 Data Synthesis and Analysis 3-6

4.0 Roadside Intercept Surveys 4-1
4.1 Overview 4-1
4.2 Data Cleaning 4-2
4.3 Expansion Factors 4-3
4.4 Commodities 4-4
4.5 Payload Factors 4-6
4.6 Tonnage Flows 4-8
4.7 Trips To/From Portland Metropolitan area 4-9

5.0 Terminal Gateway Surveys 5-1
5.1 Overview 5-1
5.2 Data Cleaning 5-2
5.3 Commodities 5-3
5.4 Payload Factors 5-4
5.5 Trips To/From Portland Metropolitan Area 5-6

6.0 Truck Following Study 6-1
6.1 Overview 6-1
6.2 Data Collection Results 6-2
6.3 Expansion Factors 6-3
6.4 Data Analysis – Through Trips 6-5
6.5 Data Analysis – Major Streets Used 6-7
6.6 Data Analysis – Routing 6-9
6.7 Data Analysis – Top Internal Destinations 6-10

6.8 Conclusion 6-10

7.0 Vehicle Classification Counts 7-1

7.1 Overview 7-1
7.2 Comparison with Other Count Programs 7-2
7.3 Comparison by Type of Roadway Facility and Truck Type 7-4
7.4 Time-of-Day Characteristics of Freight Traffic 7-9
7.5 Day-to-Day Variation in Volumes 7-23
7.6 Model Validation 7-25
7.7 Regionwide GIS Analysis 7-25

8.0 Motor Carrier Surveys 8-1

8.1 Introduction 8-1
8.2 General Findings 8-1
8.3 Summary of Data Analysis Findings 8-2
8.4 Additional Analysis Methodology 8-4
8.5 Cross-Tabulation Results 8-5

9.0 Regional Truck Count Program 9-1

9.1 Factors Affecting Design of a Regional Truck Count Program 9-1
9.2 How Many Counts Should Be Collected and Where Should Counts be Collected? 9-4
9.3 How Often and for What Duration Should Counts be Conducted? 9-11
9.4 How Should the Counts be Collected? 9-12
9.5 How Should the Count Program Be Managed? 9-13
9.6 Recommended Truck Count Locations and Data Collection Durations 9-14

10.0 Data Querying Interface 10-1

10.1 Roadside Intercept Survey Data 10-1
10.2 Terminal Gateway Survey Data 10-2
10.3 Truck Following Study Data 10-2
10.4 Vehicle Classification Count Data 10-2

11.0 Conclusions 11-1

11.1 Origin-Destination (O-D) Data 11-1
11.2 Freight Facility Flow Information 11-3
11.3 Transportation Network Information 11-4
11.4 Truck Count Data 11-5
11.5 Commodity Information 11-5

11.6 Routing Information.....11-7
11.7 Temporal Variability of Freight Flows.....11-8
11.8 Truck Classification and Carrier Information.....11-10
11.9 Travel Time Data.....11-10
11.10 Other Data.....11-11
11.11 Summary of Freight Data Needs Satisfied.....11-11

Appendix A: Previously Prepared Deliverables.....A-1

Appendix B: Roadside Intercept Survey Data Cleaning.....B-1
Geocoding Fields: Data Cleaning and Results.....B-1
Attribute Fields: Data Cleaning and Results.....B-3
Commodity Information.....B-6

Appendix C: Motor Carrier Survey Tables.....C-1

Appendix D: Regionwide GIS Analysis.....D-1

List of Tables

Table 3.1 Roadside Survey Data Elements 3-4

Table 3.2 Motor Carriers Surveyed by Category 3-5

Table 4.1 Roadside Survey Locations and Dates 4-2

Table 4.2 Roadside Survey Expansion Factors 4-3

Table 4.3 Commodity Group Analysis 4-5

Table 4.4 Payload Factor Analysis 4-7

Table 4.5 Daily Tonnage Flow Analysis 4-8

Table 4.6 Trips by Internal District 4-11

Table 4.7 External End of Internal District Trips 4-12

Table 4.8 Cross-Tabulation of Internal Districts with External Trip Ends 4-12

Table 4.9 Cross-Tabulation of with External Trip Ends 4-13

Table 4.10 Reload Facility Analysis – Daily Truck Trips by Carrier Type 4-14

Table 4.11 Reload Facility Analysis – Daily Truck Trips by Commodity Group 4-15

Table 4.12 Through Trip Directionality 4-16

Table 5.1 Gate Survey Locations and Dates 5-2

Table 5.2 Commodity Group Analysis 5-3

Table 5.3 Top Commodity Groups by Gate Location 5-4

Table 5.4 Payload Factor Analysis 5-5

Table 5.5 Trip Categories by Gate Location 5-6

Table 6.1 Trucks Followed By Entry Point and Time Period: Weekday 6-2

Table 6.2 Trucks Followed By Entry Point and Time Period: Weekend 6-3

Table 6.3 Average Weekday Truck Counts by Entry Point and Time Period 6-4

Table 6.4 Expansion Factors by Entry Point and Time Period 6-4

Table 6.5 Percentages of Trucks that Crossed Through the Study Area by Entry Point and Time Period: Weekday 6-5

Table 6.6 Percentages of Trucks that Crossed Through the Study Area by Entry Point and Time Period: Weekend 6-5

Table 6.7 Percentages of Trucks in Each Truck Class that Crossed Through the Study Area 6-6

Table 6.8 Truck Class Percentages of Trucks that Crossed Through the Study Area 6-7

Table 6.9 Top Streets Used: Entry Point #1 (181st Avenue Just South of I-84) 6-7

Table 6.10 Top Streets Used: Entry Point #2 (207th Avenue Just South of I-84) 6-8

Table 6.11 Top Streets Used: Entry Point #3 (238th Avenue Just South of I-84) 6-8

Table 6.12 Top Streets Used: Entry Point #4 (U.S. 26 Just South of E. Powell Boulevard) 6-8

Table 6.13 Top Routing Combinations for Through Truck Trips 6-9

Table 6.14 Top Routing Combinations for Truck Trips With a Destination in the Study Area (Intraregional Trips) 6-9

Table 6.15 Top Destinations Internal to the Study Area 6-10

Table 7.1 Vehicle Classification Count Data Collection 7-1

Table 7.2 Comparison of Portland FDC Truck Counts With HPMS Truck Counts – Table 7-2

Table 7.3 Comparison of Portland FDC Truck Counts with Port of Portland TMP Truck Counts 7-3

Table 7.4 Comparison of Portland FDC Truck Counts with Clackamas County Truck Counts 7-4

Table 7.5 High Volume Portland FDC Truck Locations – Interstates 7-5

Table 7.6 High Volume Portland FDC Truck Locations – State Highways 7-6

Table 7.7 High Volume Portland FDC Truck Locations – Arterials 7-7

Table 7.8 Daily Variance in Total Truck Count from Three-Day Average – Freeways 7-23

Table 7.9 Daily Variance in Total Truck Count from 3-Day Average – State Highways 7-23

Table 7.10 Daily Variance in Total Truck Count from Three-Day Average – Arterials 7-24

Table 7.11 Comparison of Year 2000 Metro Model Output with FDC Truck Count Data, Sorted by Facility Type 7-26

Table 7.12 Comparison of Year 2000 Metro Model Output with TCP Truck Count Data, Sorted by Primary Screenline 7-27

Table 8.1 Cross-tabulation between Commodity Group and Type of Carrier 8-6

Table 8.2 Cross-tabulation between Commodity Group, Type of Carrier, and Truck Stop Activity 8-7

Table 8.3 Cross-tabulation between Number of Employees and Total Daily Shipments 8-8

Table 8.4 Cross-tabulation between Commodity Group and Payload....................8-9

Table 8.5 Cross-tabulation between Commodity Group and Payload, for Market Area Within the Region 8-10

Table 8.6 Cross-tabulation between Commodity Group and Payload, for Market Area Outside the Region 8-11

Table 8.7 Cross-tabulation between Commodity Group, Type of Carrier, and Trip Distance Categories....................8-12

Table 8.8 Cross-tabulation between Commodity Group, Type of Carrier, and Time of Day 8-14

Table 8.9 Cross-Tabulation between Market Area and Time of Day....................8-15

Table 8.10 Cross-Tabulation between Commodity Group and Type of Facility....................8-17

Table 9.1 Recommended Count Locations on Metro's Primary Screenlines.....9-6

Table 9.2 Recommended Count Locations that are Counted by Other Agencies for Other Purposes 9-7

Table 9.3 Number of Truck Count Locations by County 9-15

Table 9.4 Number of Truck Count Locations by Road Type 9-15

Table 9.5 Full List of Locations....................9-16

Table 11.1 Comparison of Freight Data Needs and Data Collection Efforts ...11-12

List of Figures

Figure 4.1 Roadside Intercept Survey Locations 4-1

Figure 4.2 Internal District Map 4-10

Figure 5.1 Terminal Gateway Survey Locations 5-1

Figure 6.1 Truck Following Study Area 6-1

Figure 7.1 Comparison of Portland FDC Truck Counts with HPMS Truck Counts - Graph 7-3

Figure 7.2 Location 3.1: I-405 at Fremont Bridge 7-10

Figure 7.3 Location 4.2: I-5 south of SW Corbett Avenue 7-12

Figure 7.4 Location 4.3: I-84 East of I-5 7-14

Figure 7.5 Location 4.4: OR 99E Between Bybee Boulevard and Tacoma Street 7-16

Figure 7.6 Location 4.7: Airport Way Between I-205 and 122nd Avenue 7-18

Figure 7.7 Location 5.3: OR 10 between 149th Avenue and Murray Boulevard 7-20

Figure 7.8 Location 5.7: OR 8 between 153rd Dr. and Murray Boulevard 7-22

Figure 11.1 Location 4.2: I-5 south of SW Corbett Avenue 11-9

1.0 Introduction

The Freight Data Collection Project, Phases I and II, was designed to conduct a comprehensive freight data needs analysis and to collect critical freight data for the Portland metropolitan region. The Oregon Department of Transportation Region I was the contracting entity for this project, and the Port of Portland was the lead agency for managing the project. Funds for the project were provided by the Oregon Department of Transportation, the Port of Portland, the Washington State Department of Transportation, Metro in Portland, the Southwest Washington Regional Transportation Council, and Multnomah County. Representatives of Clark County, Washington County, Clackamas County, the Port of Vancouver, and the Columbia River Crossing Project team also participated in the Technical Team for the project.

Phase I of the study identified freight data needs in the Portland metropolitan area (defined as Multnomah, Washington, and Clackamas counties in Oregon and Clark county in Washington State) and developed a menu of data collection options to address these needs. Regional freight data needs were identified through a combination of stakeholder interviews, a review of data uses in other regions, and a review of previous experiences of the consulting team. The combination roadside survey and truck count program was recommended as being the data collection program that would best meet the freight data needs. This conclusion was based on the ability of that program to generate origin-destination (O-D) data for key corridors and key freight facilities and to provide information for better understanding of truck trip patterns (spatial and temporal). In addition, the program would provide data for improving the Portland metropolitan area's truck model. A report summarizing the results of the Phase I effort was completed in May 2003.

Phase II of the study was managed by Cambridge Systematics (CS), with David Evans & Associates, Inc. as the prime contractor and the following other firms/individuals as subconsultants: Traffic, Research and Analysis; Quality Counts; Starboard Alliance Company; Ken Cassavant; Eric Jessup; and Keith Lawton. The primary objectives of the Phase II project, which began in May 2005, are as follows:

- Collect vehicle classification counts to better calibrate Metro's truck model;
- Conduct intercept surveys at key locations and/or use other data collection methods to obtain origin-destination, route and other freight movement information;
- Combine the results from the first two steps with additional freight data from existing sources to identify truck and commodity movement (volumes, origins/destinations, route choice and freight facility flow) in the Portland metropolitan region; and

- Develop a long-term regional truck count program.

The purpose of this report is to provide results from Phase II of the study. The remainder of this report is organized into the following sections:

- **Section 2: Summary of Freight Data Needs (Tasks 1-3).** Provides a summary of the conclusions of the Phase I effort that defined the freight data needs and the first three tasks of Phase II, which were Task 1: Review Existing Data; Task 2: Review Metro's Truck Model; Task 3: Verify Data Needs. These were the upfront tasks conducted in order to establish the data that should be collected for this study.
- **Section 3: Summary of Data Collection Plans and Methodologies (Tasks 4-6).** Provides a summary of Task 4: Develop Data Gathering Methodology, Task 5: Collect Data Through Surveys and Task 6: Collect Vehicle Classification Counts, which involved collecting five data elements: roadside intercept surveys, gate intercept surveys, a truck following study, vehicle classification counts, and motor carrier surveys.
- **Section 4: Roadside Intercept Surveys.** Provides data analysis results from the roadside intercept surveys, which involved stopping trucks at designated external roadside intercept locations to conduct driver interviews.
- **Section 5: Gate Intercept Surveys.** Contains data analysis results from the gate intercept surveys, which involved interviews of truck drivers who enter or exit identified freight facilities with a focus on reload facilities.
- **Section 6: Truck Following Study.** Provides data analysis results from the truck following study, which involved analysis of trucks followed within a focused study area in Multnomah County to collect both origin-destination (O-D) detail and routing information for each truck trip.
- **Section 7: Vehicle Classification Counts.** Contains data analysis results from the vehicle classification counts, which involved recording and processing traffic on video cameras at specified locations in the region.
- **Section 8: Motor Carrier Surveys.** Provides data analysis results from the motor carrier surveys, which involved phone interviews of key management staff from 30 motor carriers to understand truckload, LTL, and private trucking activity in the Portland metropolitan area.
- **Section 9: Regional Truck Count Program.** Provides recommendations for an on-going truck classification count program to update the region's traffic volume database at least every three years.
- **Section 10: Data Querying Interface.** Describes the data querying interface developed for the collected data.
- **Section 11: Conclusions.** Provides conclusions from the study tasks.

Appendix A provides a list of previous memos and other deliverables that were submitted for the project. These are available under separate cover.

2.0 Summary of Freight Data Needs, Tasks 1-3

2.1 Summary of Phase I Data Needs Assessment and Tasks 1 and 3

The data collection plan that was developed as the scope of work for the Phase II program was a direct outgrowth of the Phase I assessment of data needs. This assessment began with a detailed survey of regional stakeholders to determine the types of questions they were asking about freight transportation planning and policy development. From these questions, a set of data elements were defined that would be needed along with analytical methods to answer the key freight planning and policy questions.

The regional stakeholders identified five different categories of policy questions that were driving freight analysis and for which data and analysis methods were needed. These were:

- **Goods Movement and the Economy**. Stakeholders were interested in how the goods movement system supported regional jobs. They were also interested in how industrial supply chains work and how the performance of the transportation system affects supply chain performance. They wanted to understand how transportation performance affects competitiveness of local businesses and they wanted to know the transportation needs of specific industries. This has led to a focus on understanding what commodities move in the system, what routes they use, and how supply chains function. The design of the data collection program continued this focus by looking at the trade flow patterns of specific commodities that are being shipped to, from, and through the Portland metropolitan region (in roadside intercept surveys and surveys at major freight facilities) and by looking for trends and patterns in shipment activities of motor carriers that provide services to the distribution sector of local industries.
- **Land Use Interaction with Goods Movement.** Stakeholders want to better understand the relationship between business location decisions and the transportation network. They also want to better understand the types and amount of truck activity generated by different land uses so they can more effectively plan for new development. Stakeholders want to know how shippers use intermediate handling facilities and what freight routes are used at these locations. The design of the data collection program addressed these issues primarily in the truck count program by providing for counts along access routes to major freight facilities of different types

and in different parts of the region. The counts show the level of traffic accessing these facilities, their time of day characteristics, and the types of trucks that are used to serve these facilities and land uses.

- **Truck Routes.** Stakeholders want to know how best to designate truck routes and how existing designated truck routes vary from the preferred truck routes of truck drivers. The design of the data collection program placed significant emphasis on collecting information on truck routing. The extensive truck count program provides much useful information on how roadways of different types are used to route freight traffic through the region. The roadside intercept survey also collected extensive information about how trucks that move into and out of the region from outside locations are routed from origin to destination. The data collection program also used a novel data collection approach, a truck following study, to examine the routes that trucks take moving to and from two major parallel highway routes in Multnomah County. While this study was on a limited scale, it did provide much useful information about route preferences when there are choices and the different routings of trucks moving through an area as compared to those trucks that are accessing local businesses.
- **Relationship of the Truck Mode to Other Modes.** Stakeholders were interested in looking at issues in the regional freight rail system and how truck movements could be diverted to rail. They also wanted to better understand the interconnections between trucking and other modes. While the data collected were somewhat limited in this area, the study did collect surveys at the gates of major intermodal facilities (including port and rail intermodal terminals) to gather information on the types of commodities moved, origins and destinations, and routing choices.
- **Corridor Specific Project Data Needs**. There are a number of major freight corridors in the region that are undergoing study for improvements and stakeholders had many data needs for these projects. The most significant needs identified involved making improvements to the Metro truck model and this is discussed later in this section of the report. Other information that was typically needed were origin-destination studies for specific corridors, variation in types of goods and traffic patterns by time of day (especially as this relates to congestion management), understanding the relationship between local traffic and through traffic on specific routes, improving the performance of the Metro model for analyzing arterial movements, data on movements to and from ports and along their access routes, and understanding goods movement patterns at distribution, warehouse, and terminal facilities. The data collection program was able to address some of these issues through the collection of origin-destination and routing information for long haul trucking and to and from major freight facilities and by obtaining hourly truck counts on all of the region's major freight routes.

Ultimately, the analysis of these regional data needs suggested that the Phase II data collection program needed to focus on the following types of data to the maximum extent possible:

- Origin-destination (O-D) data;
- Facility flow information (i.e., traffic and commodity flows into and out of major freight facilities);
- Travel time data;
- Transportation network information (e.g., what are the major truck routes, how are trucks routed from specific origins to destinations); and
- Truck counts.

The data collection program that was developed based on these data needs used the following data collection approaches:

- **Roadside intercept surveys.** The roadside intercept surveys were used to collect O-D data as well as information about routes taken, commodities carried, cargo weights, and various other information useful in the Metro model. Unfortunately, these data could only be effectively collected for traffic flows into, out of, and through the region. Origin-destination data for local traffic proved very difficult to collect.
- **Gate surveys.** These were intercept surveys conducted at freight facility gates. Data on origins and destinations, commodities carried, cargo weights, and other useful information on facility flows were collected.
- **Motor carrier surveys.** These provided some information on trip generation characteristics of major motor carriers serving the warehouse and distribution sector, logistics processes of major industries, truck equipment used, and time of day patterns of movement. Limited origin-destination data were also collected.
- **Truck counts.** These provided much useful information on the locations of major freight routes, time of day characteristics of truck traffic by route, and freight flows near different land uses.

These data needs were verified in Task 3 of the Phase II program. In September 2005, CS provided the Technical Team with a memo that identified freight data needs in the Portland metropolitan area based on a review of the Phase I report, discussions with stakeholders, and previous experiences of the consulting team. These needs were classified into ten categories: O-D data, freight facility flow information, transportation network information, truck count data, commodity information, routing information, temporal variability of freight flows, truck classification and carrier information, travel time data, and other data. Since many of the questions that regional stakeholders are asking about freight policies and projects rely on the Metro truck model as a primary analytical tool, a separate review of the Metro model was conducted and data needs to support improvement of the model were identified. These data needs are summarized in Section 2.2 of this report.

Prior to developing the final data collection plan, CS reviewed available data sets that could be used in the development of the data collection plan or that could be combined with data collected in the project to form a more comprehensive regional freight data set. In June 2005, CS provided the Technical Team with a memo that listed the available data sources for the project and a brief description of how each would be used in the regional data collection program. Seven categories of data sources were identified:

- **Existing Count Data.** From ongoing vehicle classification count programs operated by agencies including the Oregon Department of Transportation, the Washington Department of Transportation, Washington County, and the Port of Portland, as well as counts conducted for specific projects and studies.
- **Freight Flow Data.** Information on commodities and origins/destinations at the county level, from the Oregon Statewide Commodity Flow Database, the Portland Regional Commodity Flow Database Update, and the FHWA Freight Analysis Framework.
- **Metro Travel Demand Model.** Information on the road network, model districts, land use and employment information, cutlines, and external cordons.
- **Plans and Studies.** General transportation plans, city transportation system plans, and freight-focused studies prepared by agencies throughout the Portland metropolitan area.
- **Potential Data Collection Locations.** Numerous locations that may be useful for truck counts or roadside surveys based on existing equipment or geometric considerations.
- **Company Lists.** Sources of company information necessary to perform the establishment surveys, including the Port of Portland freight facility database, the ES202 employment database, motor carrier lists from the Oregon Motor Carrier Division, the Oregon Department of Revenue Weight-Mile Tax Division, and interview lists from previous studies.

2.2 Task 2: Review Metro's Truck Model

In September 2005, CS provided the Technical Team with a memo that reviewed the Metro truck model to determine potential areas of improvement, identify data that should be collected to support model improvement, and determine vehicle classification count needs. The memo provides an overview of the modeling methodology, opportunities for model improvement (including data that would be needed to implement these improvements), and recommended data collection methods for model estimation and calibration.

The Metro truck model consists of seven steps. Each of these steps is summarized below along with recommended improvements and descriptions of the data that were collected in the freight data collection project to help with implementation of these improvements.

2.2.1 Step 1 – Regional Commodity Flows by Commodity Type and Market Segment

The model uses a regional commodity flow database to derive the truck trip tables that form the core of the model. The commodity flow database describes annual tonnage flows of each commodity by mode with origin-destination detail at the county level. In later steps of the model, this must converted into a daily truck trip origin-destination matrix of flows. This step prepares data for use in later steps in the model. New data collected in this study on commodity truck trips moving into and out of the region can be compared to the commodity flow database to determine how accurately these databases reflect what is actually observed on the ground. This type of comparison will be most effective for very aggregate commodity groups and for validating the directionality of the commodity flows.

2.2.2 Step 2 – Allocation of Commodity Flows to Origins and Destinations

In this step, the county level commodity flows must be disaggregated to a finer zone system (traffic analysis zones or TAZs). For flows that have either an origin or destination outside the region, this involves allocating the flows to specific entry or exit points (highways for truck flows and port, airport, and rail terminals for non-highway flows). Flows with an origin and/or destination within the region are allocated to zones using employment shares by industry and an association between the commodity and the industry that produces/consumes it. This step in the model could be improved primarily through the use of actual origin-destination surveys and truck counts. The roadside intercept surveys and truck counts conducted at the entry/exit highways in the region and at some of the key modal interface locations (ports and intermodal terminals) provide a new dataset with which to make adjustments to the model input data sets for external commodity flows. These datasets have both origin/destination data and commodity information that can be used to calibrate the model input tables.

Unfortunately, detailed origin-destination surveys of movements that have both an origin and a destination within the region (internal trips) continues to be a difficult dataset to obtain. There are few locations within the region at which roadside intercept surveys can be conducted and truck owners have been unwilling to participate in other types of origin-destination surveys.

2.2.3 Step 3 – Linkage of Commodity Flows to Reload Facilities or Terminals

Not all freight moves directly from a producer to a consumer so the model needs to account for flows that move through warehouses, distribution facilities, and terminals of various kinds. These facilities are known as reload facilities. The commodity flow database divides trucks into three submodes depending on the type of carrier that handles the movement and for each of the submodes there is an assumption about how much of the flow moves through a reload site. The model uses information about employment at reload sites in each zone (taken from a freight facility database developed for the region) to allocate the reload flows to specific TAZs. Data collected in the external roadside surveys and in the motor carrier surveys about the types of facilities from which and to which trips are going and the type of carrier making the trips will help in making adjustments to the factors in the model that determine what fraction of the commodity flows move through reload facilities. The model also currently assumes that there are no reload-to-reload trips and data from the motor carrier survey may be useful in making adjustments to this assumption.

2.2.4 Step 4 – Conversion of Commodity Flows to Vehicle Trips

The main input to this process is a payload factor which indicates the average cargo weight for a truck carrying each commodity. By applying this factor to the tonnage flows, the number of truck trips can be estimated for each flow. The payload factors were obtained from earlier roadside intercept surveys conducted by ODOT. The new roadside intercept survey collected payload information that can be used to estimate new payload factors for the model.

2.2.5 Step 5 – Accounting for Additional Vehicle Trips by Market Segment

In this step adjustments are made to the model to balance inbound and outbound trips by zone, to add empty truck trips, and to account for repositioning of trucks for their next load.

2.2.6 Step 6 – Addition of Through Trips

The model calculates truck trips at each of the highway locations at the entry/exit points to/from the region using the commodity flow data and compares this to truck counts at each of these locations. The difference between the two is assumed to be accounted for by truck trips that move through the region without either an origin or a destination in the region. The new data collected in the roadside intercept surveys provides a data source to estimate the number of through trips and their directionality directly from the data. This can provide an improvement to the model estimation process.

2.2.7 Step 7 – Assignment of Vehicle Trips to the Highway Network

This step in the model uses standard travel demand modeling software to assign the truck trips to the highway network along with auto trips taking congestion into account along with the origins and destinations of the trips. When the model was originally developed, there were limited data with which to validate the model (determine how accurately it matches actual truck volumes on the highway system) or to calibrate it (make adjustments to get better results). The truck count program conducted for the regional freight data collection program was designed to provide a database of truck counts that could be used to validate the results of the Metro truck model. In addition, there were data collected on the route choices of trucks making trips to/from/through the region that can be used to evaluate how effectively the model routes traffic for certain O-D pairs. Lastly, the truck count program provides enough data to estimate an origin-destination matrix using a process called origin-destination matrix estimation (ODME) that can be used to calibrate the truck origin destination matrix produced by the model to better match counts.

3.0 Summary of Data Collection Plans and Methodologies, Tasks 4-6

Based on the data needs verified in Tasks 2 and 3, a comprehensive data collection program was developed in Task 4. This task defined the methods by which data would be collected and the locations where surveys should be conducted. Tasks 5 and 6 involved finalizing the data collection plans, collecting the data, and delivering the data:

- **Task 5: Collect Data Through Surveys.** Finalize the specific sites for conducting surveys, develop the survey instrument, identify and train intercept staff, conduct surveys, and document the survey process.
- **Task 6: Collect Vehicle Classification Counts.** Conduct 24-hour and 72-hour video vehicle classification counts at over 100 locations in Multnomah, Washington, and Clackamas Counties in Oregon and Clark County in Washington State.

Each of these tasks are summarized below.

3.1 Task 4: Develop Data Gathering Methodology

To complete this task, CS prepared a series of memos that collectively proposed a comprehensive methodology for the collection of freight data in the Portland metropolitan area. These memos were as follows:

- **Roadside Intercept Survey Plan (September 2005).** CS proposed a methodology for collecting truck roadside intercept survey data. These surveys involve stopping trucks at designated roadside locations to conduct a brief interview with the truck drivers. The interviewer would begin each survey by recording visual observations of the truck with respect to the vehicle configuration and number of axles. This would be followed by a series of questions about the truck trip in process.

  The data obtained from these surveys would include: trip origin and destination; land use at origin and destination; commodity carried; cargo weight and percent empty; type of truck fleet; name of carrier; and name of shipper/receiver. It was proposed that each site be surveyed over a 24-hour period, with surveyor staffing levels depending on the hourly traffic volumes at each site and the space available to conduct interviews.

- **Gate and Establishment Survey Plan (September 2005).** CS proposed a methodology for collecting gate and establishment survey data. The gate surveys involve interviews of truck drivers who enter or exit identified freight facilities, with a focus on reload facilities: port terminals, intermodal rail yards, airport facilities, warehouses, distribution centers and truck terminals.

  The data obtained from the gate surveys would include: shipment by time of day; commodity types; vehicle and trailer configuration/style; number of axles; carrier name and address; unloaded vehicle weight; payload weight; origin/destination address of shipments; facility type for inbound/outbound shipments; street address for LTL shipments; and shipment routes.

  The data obtained from the establishment surveys would include: facility type; hours of operation; number of employees; facility square footage; number of loading/unloading bays; types of products handled; volume of inbound/outbound shipments; average payload weight; empty fractions; types of freight functions/services; daily and seasonal time distributions; primary highway access routes; market areas served; key bottleneck locations; expansion plans and location decision variables; and the method for performing routing decisions.

- **Vehicle Classification Count Plan (October 2005).** CS proposed a methodology for collecting vehicle classification count data. The vehicle counts involve recording traffic on video cameras, then processing this information to classify the vehicles according to the Federal Highway Administration (FHWA) 13-Category Classification System. Class 1-4 vehicles are not considered to be trucks; Class 5 vehicles are medium trucks (i.e., 2 axles, 6 tires); and Class 6-13 vehicles are heavy trucks (i.e., 3 axles or more). In accordance with the statement of work, the vehicle counts were obtained for 15 minutes within each hour and therefore were multiplied by four to obtain an hourly estimate.

  The memo established that up to 250 vehicle count locations would be conducted for this project, with each count representing 24 hours at a single bi-directional location. A total of 108 vehicle count locations were requested on Metro's primary screenlines, by jurisdictions and other agencies in the Portland metropolitan area, and as determined by CS to meet regional data needs. The budget saved by surveying a smaller number of locations was devoted to conducting multi-day counts at many of the locations to examine day to day variability of truck volumes. Of the 108 locations, 24 were 72-hour count requests along the top ten Metro primary screenlines, 32 were 72-hour count requests at other locations, and 52 were 24-hour count requests.

- **Options for Collecting O-D Data in Multnomah County (January 2006).** CS proposed two options for collecting O-D data in Multnomah County, within a defined area bounded by I-84, US 26, 181st St, and 257th St. The purpose of these data would be to determine the amount of through truck traffic that cuts through the study area. This information will be used to identify preferred truck routes and make associated improvements. The two options presented were the license plate matching survey and the truck-following study. The license plate survey would use video cameras to record license plates of trucks as they enter and leave the study area and along major routes. The truck following survey would have a car follow trucks as they move through the study area to record routes and stops.

The major drawback to the license plate matching survey method is the number of cameras that would be required to provide coverage throughout the study area. By comparison, the truck following study method has the advantage of collecting both O-D detail and information on routing for each truck trip. The truck following study was further identified as having advantages with respect to flexibility and ease of data collection. As such, the truck following study was recommended for the project.

- **Revised Approach and Budget for Gate and Establishment Surveys (July 2006).** Following the collection of gate survey information, the Technical Team determined that a revised data collection approach was warranted. While Technical Team contacts proved useful in securing permission to conduct gate surveys at port and intermodal terminals, there was a general unwillingness on the part of warehouse and distribution facility operators and truck terminal operators to grant this permission. CS proposed a revised data collection approach to involve interviews with motor carriers and owners of terminal gateway and reload facilities, and analysis of electronic dispatch records from motor carriers, if these could be obtained. Based on further discussion with the Technical Team, the primary focus of this approach became conducting interviews and collecting data from trucking companies and shippers with private fleets. Starboard Alliance LLC then developed a motor carrier survey form, as well as a list of target companies to interview. Starboard Alliance also conducted these interviews.

3.2 TASK 5: COLLECT DATA THROUGH SURVEYS

This task involved the collection of four distinct data elements: roadside intercept surveys, gate intercept surveys, the truck following study, and motor carrier surveys. The data collected through each element is described to follow.

Roadside Intercept Surveys

The intended uses of the roadside survey data are to:

- Evaluate external and through truck trips for the region;
- Calibrate the external trip table in the model and develop estimates of various model parameters;
- Update information on trips passing through external roadway gateways;

- Estimate payload factors by commodity and commodity types by trucking sub-modes;
- Identify key freight corridors in the region; and
- Evaluate routing choices.

Table 3.1 shows the data elements that were included in the roadside survey instrument.

Table 3.1 Roadside Survey Data Elements

Field Name	Data Type	Description
ID	Number	Unique identification number for each survey record
Last Stop: City	Text	City where last stop was made by the truck
Last Stop: State	Text	State where last stop was made by the truck
Last Stop: Street Address	Text	Street address of the last stop made by the truck
Last Stop: Facility Type	Numerical Code (1 - 11)	Type of facility where last stop was made by the truck (1: Factory; 2: Warehouse/Dist Center; 3: Truck Terminal; 4: Rail Yard; 5: Port; 6: Airport; 7: Retail Outlet; 8: Farm; 9: Mine; 10: Home Base; 11: Other)
Last Stop: Activity	Numerical Code (1 - 3)	Activity of truck at last stop location (1: Pickup; 2: Delivery; 3: Return to Base)
Last Stop: Major Route	Text	Major route used from last stop location to present location
Last Stop: Access Roads	Text	Access roads used by truck to access the freeway from last stop facility location
Next Stop: City	Text	City where next stop will be made by the truck
Next Stop: State	Text	State where next stop will be made by the truck
Next Stop: Street Address	Text	Street address of the location where next stop will be made by the truck
Next Stop: Facility Type	Numerical Code (1 - 11)	Type of facility where next stop will be made by the truck (1: Factory; 2: Warehouse/Dist Center; 3: Truck Terminal; 4: Rail Yard; 5: Port; 6: Airport; 7: Retail Outlet; 8: Farm; 9: Mine; 10: Home Base; 11: Other)
Next Stop: Activity	Numerical Code (1 - 3)	Activity of truck at next stop location (1: Pickup; 2: Delivery; 3: Return to Base)
Next Stop: Major Route	Text	Major route that will be used from present location to next stop location
Next Stop: Access Roads	Text	Access roads that will be used to access the next stop facility location from the freeway
Cargo: Primary Commodity	Text	Commodity (primary commodity if mixed goods) carried by the truck
Cargo: Weight in Pounds	Number	Weight of Cargo (payload weight) carried by the truck in pounds
Carrier Type	Numerical Code (1 - 3)	Type of truck carrier based on operation (1: Truckload; 2: Less-Than-Truckload (LTL); 3: Private Fleet)
Number of Axles	Number	Number of axles on truck
Number of Units	Number	Number of units on truck
Type of Truck	Numerical Code (1 - 6)	Type of truck based on physical characteristics (1: Straight Truck; 2: Straight Truck and Trailer; 3: Tractor Only; 4: Tractor and Trailer; 5: Tractor with 2 Trailers; 6: Tractor with 3 Trailers

The locations and dates of data collection, the quantity of data collected, and data analysis results are provided in Section 4: Roadside Intercept Surveys.

Gate Intercept Surveys

The intended uses of the gate intercept survey data are to:

- Help improve regional freight modeling, specifically related to intra-regional freight movements;
- Provide information on internal metropolitan freight activity;
- Help to identify key entry/exit points to access gateway terminals within the region; and

- Identify land use at trip origin/destinations.

The data fields for the gate surveys were the same as for the roadside surveys, as shown in Table 3.1. The locations and dates of data collection, the quantity of data collected, and data analysis results are provided in Section 5: Terminal Gateway Surveys.

Truck Following Study

The intended uses of the truck following study are to:

- Determine the percentage of inter-regional (i.e., cut-through) truck trips in Multnomah County between I-84 and US 26; and
- Capture information on truck routing patterns.

The locations and dates of data collection, the quantity of data collected, and data analysis results are provided in Section 6: Truck Following Study.

Motor Carrier Surveys

The motor carrier surveys were designed to enhance the understanding of the wide variety of freight moves in, out and through the Portland metropolitan area by various types of motor carriers. A total of 30 motor carriers were surveyed in fall 2006, grouped into four categories as shown in Table 3.2.

Table 3.2 Motor Carriers Surveyed by Category

Category	Characteristics	Number Surveyed
A – Primarily Less than Truckload (LTL)	• Carrier's business is comprised of more than 60% LTL and/or parcel • Carrier performs cargo manipulation at its facility	10
B – Primarily Full Truckload (FT) and performs cargo manipulation	• Carrier's business is comprised of more than 70% FT • Carrier performs cargo manipulation at its facility	5
C – Primarily FT and does not perform cargo manipulation	• Carrier's business is comprised of more than 70% FT • Carrier does not perform cargo manipulation at its facility	7
D – Private fleet	• Beneficial cargo owners operating private fleets	8
TOTAL		**30**

Data analysis results from the motor carrier surveys are provided in Section 8: Motor Carrier Surveys.

3.3 Task 6: Collect Vehicle Counts

The intended uses of the vehicle classification counts are to:

- Analyze truck volumes by type of roadway facility and truck type (medium vs. heavy);
- Identify major freight corridors and most important access routes;
- Examine variation in volumes by time of day and day to day;
- Enable comparisons with other count programs;
- Facilitate model validation; and
- Identify trends in truck traffic over time (with implementation of a regional truck count program).

Information on the locations and dates of data collection, the quantity of data collected, and data analysis results are provided in Section 7: Vehicle Classification Counts.

3.4 Data Synthesis and Analysis

Following the completion and approval of the data collection plans, data were collected and delivered in accordance with those plans. The data were then synthesized and analyzed in order to develop and interpret relevant findings.

The locations and dates of data collection, the quantity of data collected, and data analysis results from the collected data are discussed for each data element in the following sections (Section 4: Roadside Intercept Surveys; Section 5: Terminal Gateway Surveys; Section 6: Truck Following Study; Section 7: Vehicle Classification Counts; Section 8: Motor Carrier Surveys).

4.0 Roadside Intercept Surveys

4.1 Overview

The truck roadside intercept surveys were conducted by Traffic Research Analysis, Inc. from November to December 2005. The surveys involved stopping trucks at designated roadside locations to conduct a brief interview with the truck drivers. The interviewer began each survey by recording visual observations of the truck with respect to the vehicle configuration and number of axles. This was followed by a series of questions about the truck trip in process. The data obtained from these surveys included: trip origin and destination; land use at origin and destination; commodity carried; cargo weight and percent empty; type of truck fleet; name of carrier; and name of shipper/receiver.

Figure 4.1 shows the locations where the roadside surveys were conducted, which were ten ports of entry and weigh stations located at external cordon locations for the Portland metropolitan area.

Figure 4.1 Roadside Intercept Survey Locations

Table 4.1 shows the number of roadside surveys collected by locations and by date. A total of 4,159 roadside surveys were collected during the 361 hours of data collection, with an estimated overall sampling rate of 6.3 percent.

Table 4.1 Roadside Survey Locations and Dates

Location ID	Highway	Direction	Milepost	Description	Dates of Data Collection	Total Hours of Data Collection	# of Surveys Collected	Estimated Sampling Rate
1	I-5	NB	274	Woodburn Weigh Station	Nov 1	24	275	4.0%
					Dec 7-8	24	274	3.9%
2	I-5	SB	274	Woodburn Port of Entry	Nov 1	24	364	5.8%
					Dec 7-8	24	352	5.6%
3	I-5	NB	15	Ridgefield WA Port of Entry	Oct 26-27	24	351	5.0%
					Nov 29-30	24	256	3.7%
4	I-5	SB	46	Kelso WA Weigh Station	Nov 16-17	24	356	5.6%
					Nov 29-30	24	250	4.0%
5	I-84	EB	45	Cascade Locks Port of Entry	Nov 3	14	150	10.4%
					Nov 8-9	31	384	12.0%
					Nov 30-Dec 1	14	152	10.5%
6	I-84	WB	54	Wyeth Weigh Station	Nov 2-3	24	207	8.7%
					Nov 8-9	30	381	12.8%
7	US 26	EB	36	Brightwood Weigh Station	Dec 6	14	78	19.6%
8	US 26	WB	36	Brightwood Weigh Station	Dec 7	14	47	13.4%
9	US 30	WB	16	Rocky Point Weigh Station	Nov 15	14	171	32.4%
10	US 30	EB	33	Deer Island Weigh Station	Nov 16	14	111	21.0%
				Total - All Locations		**361**	**4,159**	**6.3%**

All data was collected in the year 2005

4.2 Data Cleaning

The survey spatial and attribute data for the roadside intercept surveys were cleaned according to several data cleaning and editing procedures. The data cleaning procedures and results from the data cleaning are provided in Appendix B: Roadside Intercept Survey Data Cleaning.

Of the 4,159 completed roadside surveys:

- 3,852 surveys (93 percent) had *both* the origin and the destination geocoded (a more complete description of the geocoding process and results is contained in Appendix B);
- 3,737 surveys (90 percent) had a commodity code assigned; and
- 3,468 surveys (83 percent) had a geocoded origin and destination, as well as a commodity code assigned.

4.3 Expansion Factors

The roadside survey raw data need to be "expanded" in order to represent a 24-hour period of truck activity at each location. This involves expanding each usable survey according to the ratio of the 24-hour truck count versus the number of usable surveys by location. The 24-hour truck count data for the 10 roadside survey locations were obtained from the following sources:

- For the locations in Oregon, Oregon Department of Transportation (DOT) provided the data according to the Oregon vehicle classification system. The data were available for heavy trucks as defined by the Portland Tactical Model System (three axles or more), but not for light trucks (two axles six tires). The data were not provided for the U.S. 30 Deer Island location.
- For the Ridgefield, Washington and Kelso, Washington locations, the Washington State DOT provided the data according to the Federal Highway Administration (FHWA) vehicle classification system, which could be readily matched to the Portland Tactical Model System truck class definitions.

There were differences in sampling rates by time of day, as truck volumes were lower at night allowing for a higher percentage of trucks to be sampled at night. To compensate for this, expansion factors were developed for two time periods: day (6:00 a.m. to 7:00 p.m.) and night (7:00 p.m. to 6:00 a.m.). However, because the U.S. 26 and U.S. 30 locations were surveyed only for 14 hours during the day, expansion factors for those locations were not based on time of day.

Table 4.2 shows the calculated expansion factors (far right column).

Table 4.2 Roadside Survey Expansion Factors

Time of Day	Location ID	Highway	Direction	Description	24-Hour Truck Count	# of Surveys	**Expansion Factor**
Day	1	I-5	NB	Woodburn Weigh Station	4,576	312	**14.668**
Night	1	I-5	NB	Woodburn Weigh Station	1,990	215	**9.256**
Day	2	I-5	SB	Woodburn Port of Entry	4,598	358	**12.842**
Night	2	I-5	SB	Woodburn Port of Entry	1,669	329	**5.071**
Day	3	I-5	NB	Ridgefield WA Port of Entry	4,121	306	**13.466**
Night	3	I-5	NB	Ridgefield WA Port of Entry	2,136	281	**7.600**
Day	4	I-5	SB	Kelso WA Weigh Station	4,045	302	**13.394**
Night	4	I-5	SB	Kelso WA Weigh Station	1,983	278	**7.133**
Day	5	I-84	EB	Cascade Locks Port of Entry	1,789	421	**4.249**
Night	5	I-84	EB	Cascade Locks Port of Entry	745	239	**3.118**
Day	6	I-84	WB	Wyeth Weigh Station	1,599	390	**4.101**
Night	6	I-84	WB	Wyeth Weigh Station	661	168	**3.933**
Any	7	US 26	EB	Brightwood Weigh Station	681	63	**10.810**
Any	8	US 26	WB	Brightwood Weigh Station	603	33	**18.273**
Any	9	US 30	WB	Rocky Point Weigh Station	884	164	**5.390**
Any	10	US 30	EB	Deer Island Weigh Station	884	100	**8.840**

The following comments apply to the expansion factor calculations:

- The 24-hour truck counts were calculated based on the average of the days for which data were collected at each location (three days for Woodburn NB; two for Woodburn SB; two for Ridgefield NB; one for Kelso SB; five for Cascade Locks EB; four for Wyeth WB; one for Brightwood EB and WB; and two for Rocky Point WB). No data were available for Deer Island, so the Deer Island volume was assumed to be the same as the Rocky Point volume for expansion purposes.
- For Ridgefield and Kelso, data were provided as the 24-hour sum and not by hour. For these locations, the truck volume split between day and night was made based on the same split as the Woodburn locations (71.5 percent during the day, 28.5 percent at night).
- The 24-hour truck count and the number of surveys are based on heavy trucks only. In Oregon, most medium trucks are not subject to weight enforcement and are not required to stop at the ports of entry and weigh stations. Given the survey procedures, which involved intercepting trucks as they entered or exited the weight station, only heavy trucks were surveyed in Oregon (see the technical memo for Task 4 for a complete discussion of intercept survey procedures). A total of 174 roadside surveys (4.2 percent) were not used because they were not surveys of heavy trucks.
- An additional 26 roadside surveys (0.6 percent) were not used because they actually represented surveys of internal-internal truck trips (i.e., trucks with both an origin and a destination with the study region – see technical memo for Task 4 for description of the study region), which were not intended to be part of this data collection program.

Therefore, the expansion factors and the tabulations provided to follow are based on the use of 3,959 roadside surveys (4,159 minus 174 minus 26).

4.4 Commodities

On a periodic basis, Oregon DOT, the Port of Portland, and Portland Metro have partnered to fund the development of a commodity flow database for regional freight analysis. This database is also used as a primary input to the Portland Tactical Model System. The latest version of the commodity forecast database contains 41 commodity groups. As discussed in the February 2006 memorandum, analyzing the data at this level of commodity detail provides limited statistical value, as the sample sizes for each commodity group would be too small for use in estimating regional statistics. Therefore, a more aggregated commodity classification needed to be developed for analytical purposes for the current study.

Table 4.3 shows the results of the commodity analysis using a 16-commodity group system similar to that used for the 1992 Truck Inventory and Use Survey

(TIUS), conducted for possible application to the Portland Tactical Model, and subsequently updated to the Vehicle Inventory and Use Survey (VIUS). VIUS was, up until 2002, a national survey of trucks conducted by the U.S. Bureau of the Census. Among other data elements, it contains information on commodity carried, type of equipment, and payload. Appendix B provides the correspondence between the 41 commodity group system and the more aggregated 16-commodity group system.

The commodity groups with the highest daily truck volumes are Group 2: Food Products (6,140 trips, 18.6 percent); Group 8: Lumber or Wood Products, Furniture (5,140 trips, 15.6 percent); and Group 5: Non-Metallic Minerals and Mineral Products (2,888 trips, 8.8 percent). The type of commodity could not be identified for an estimated 2,846 truck trips, or 8.6 percent.

Table 4.3 Commodity Group Analysis

Group	Description	Daily Truck Trips	Percent
1	Live Animals, Agriculture, and Animal Products	2,164	6.6%
2	Food Products (incl. meat, fish, bakery, alcohol, tobacco)	6,140	18.6%
3	Stone, Sands, Gravel	500	1.5%
4	Base Metal, Articles of Base Metal	1,380	4.2%
5	Non-Metallic Minerals and Mineral Products (incl. plastic)	2,888	8.8%
6	Oil, Gas, Petroleum/Coal Products	773	2.3%
7	Chemicals, Chemical Products, Pharmaceuticals	911	2.8%
8	Lumber or Wood Products, Furniture	5,140	15.6%
9	Pulp, Paper, Printed Matter	2,354	7.1%
10	Textiles, Apparel, Leather Products	578	1.8%
11	Machinery and Electrical Equipment	1,566	4.8%
12	Transportation and Transportation Equipment	1,219	3.7%
13	Waste and Scrap	891	2.7%
14	Mixed Freight, Packages	2,087	6.3%
15	Misc. Manufactured Products and Instruments	1,534	4.7%
16	Metallic Ores and Coal	0	0.0%
99	Not Coded	2,846	8.6%
Total		32,963	100.0%

Note: Categories 15 and 16 represent additions to the category system presented in March 2006. Changes were made to categories 4, 6, 8, 10, and 11.

4.5 PAYLOAD FACTORS

Of the estimated 32,963 daily truck trips that pass through the external cordon locations of the Portland metropolitan area, 26,370 (80.2 percent) are carrying cargo (are not empty). The cargo weights for non-empty trucks were used to calculate payload factors by commodity group. Table 4.4 shows the results, and compares them to payload factors for heavy trucks from the 2002 VIUS from the State of Oregon, a principal source of payload data when no better local sources are available:

- The commodity groups with the highest payload factors are 3: Stone, Sands, Gravel (25.6 tons); 8: Lumber or Wood Products, Furniture (24.9 tons); and 6: Oil, Gas, Petroleum/Coal Products (24.7 tons). Groups with the lowest payload factors are 10: Textiles, Apparel, Leather (11.5 tons); 11: Machinery and Electrical Equipment (12.1 tons); and 12: Transportation and Transportation Equipment (13.3 tons).
- A reasonably good match between the survey and VIUS payload factors was observed for long haul commodities including Groups 7: Chemical and Chemical Products and 11: Machinery and Electrical Equipment. VIUS tends to indicate a lower payload factor for other types of commodities because it includes trucks performing local distribution activities (for example, retail or LTL related) which typically have lower payloads and were not captured in the surveys conducted at external cordon locations. Some of these commodities include Group 2: Food Products, 9: Pulp, Paper, Printed Matter, and 14: Mixed Freight, Packages.

Table 4.4 Payload Factor Analysis

Group	Description	Payload Factor (Pounds Per Truck)	Payload Factor (Tons Per Truck)	Payload Factor (Pounds; VIUS)	Difference (Surveys from VIUS)
1	Live Animals, Agriculture, and Animal Products	39,180	19.6	29,516	+32.7%
2	Food Products	35,185	17.6	22,916	+53.5%
3	Stone, Sands, Gravel	51,178	25.6	38,188	+34.0%
4	Base Metal and Articles	32,740	16.4	27,000	+21.3%
5	Non-Metallic Minerals and Mineral Products	32,554	16.3	39,600	-17.8%
6	Oil, Gas, Petroleum/Coal Products	49,350	24.7	59,728	-17.4%
7	Chemicals, Chemical Products	35,869	17.9	36,417	-1.5%
8	Lumber or Wood Products, Furniture	46,134	23.1	40,444	+14.1%
9	Pulp, Paper, Printed Matter	40,611	20.3	35,327	+15.0%
10	Textiles, Apparel, Leather Products	23,523	11.8	25,490	-7.7%
11	Machinery and Electrical Equipment	24,197	12.1	24,970	-3.1%
12	Transportation and Transportation Equipment	26,555	13.3	37,500	-29.2%
13	Waste and Scrap	32,077	16.0	35,575	-9.8%
14	Mixed Freight, Packages	29,258	14.6	23,100	+26.7%
15	Misc. Manufactured Products and Instruments	25,708	12.9	14,725	+74.6%
16	Metallic Ores and Coal	n/a		27,000	n/a
99	Not Coded	29,413	14.7	n/a	n/a
Total		35,493	17.7	33,984	+4.4%

4.6 TONNAGE FLOWS

Using a combination of the non-empty truck trips and the payload factors, Table 4.5 shows the estimated daily tons of cargo that pass through the external cordon locations of the Portland metropolitan area. The commodity groups with the highest tonnage flows are Group 8: Lumber or Wood Products (100,654 tons, 21.4 percent); Group 2: Food Products (89,595 tons, 19.1 percent); and Group 9: Pulp, Paper, Printed Matter (40,872 tons, 8.7 percent).

Table 4.5 Daily Tonnage Flow Analysis

Group	Description	Daily Truck Tonnage	Percent
1	Live Animals, Agriculture, and Animal Products	34,394	7.3%
2	Food Products (incl. meat, fish, bakery, alcohol, tobacco)	89,595	19.1%
3	Stone, Sands, Gravel	8,097	1.7%
4	Base Metal, Articles of Base Metal	18,484	3.9%
5	Non-Metallic Minerals and Mineral Products (incl. plastic)	38,586	8.2%
6	Oil, Gas, Petroleum/Coal Products	13,327	2.8%
7	Chemicals, Chemical Products, Pharmaceuticals	14,405	3.1%
8	Lumber or Wood Products, Furniture	100,654	21.4%
9	Pulp, Paper, Printed Matter	40,872	8.7%
10	Textiles, Apparel, Leather Products	6,314	1.3%
11	Machinery and Electrical Equipment	15,513	3.3%
12	Transportation and Transportation Equipment	13,573	2.9%
13	Waste and Scrap	11,564	2.5%
14	Mixed Freight, Packages	21,927	4.7%
15	Misc. Manufactured Products and Instruments	14,537	3.1%
16	Metallic Ores and Coal	0	0.0%
99	Not Coded	27,551	5.9%
Total		469,393	100.0%

4.7 TRIPS TO/FROM PORTLAND METROPOLITAN AREA

Of the estimated 32,963 daily truck trips that pass through the external cordon locations of the Portland metropolitan area:

- An estimated 15,778 (47.9 percent) are going to or coming from a location within the Portland metropolitan area (these are internal-external or external-internal trips, or trips to/from the Portland metropolitan area); and
- An estimated 17,185 (52.1 percent) are trips that pass through the Portland metropolitan area without a destination in the region (these are external-external trips, or through trips).

This section discusses findings pertaining to the trips to/from the Portland metropolitan area. The next section discusses findings pertaining to the through trips.

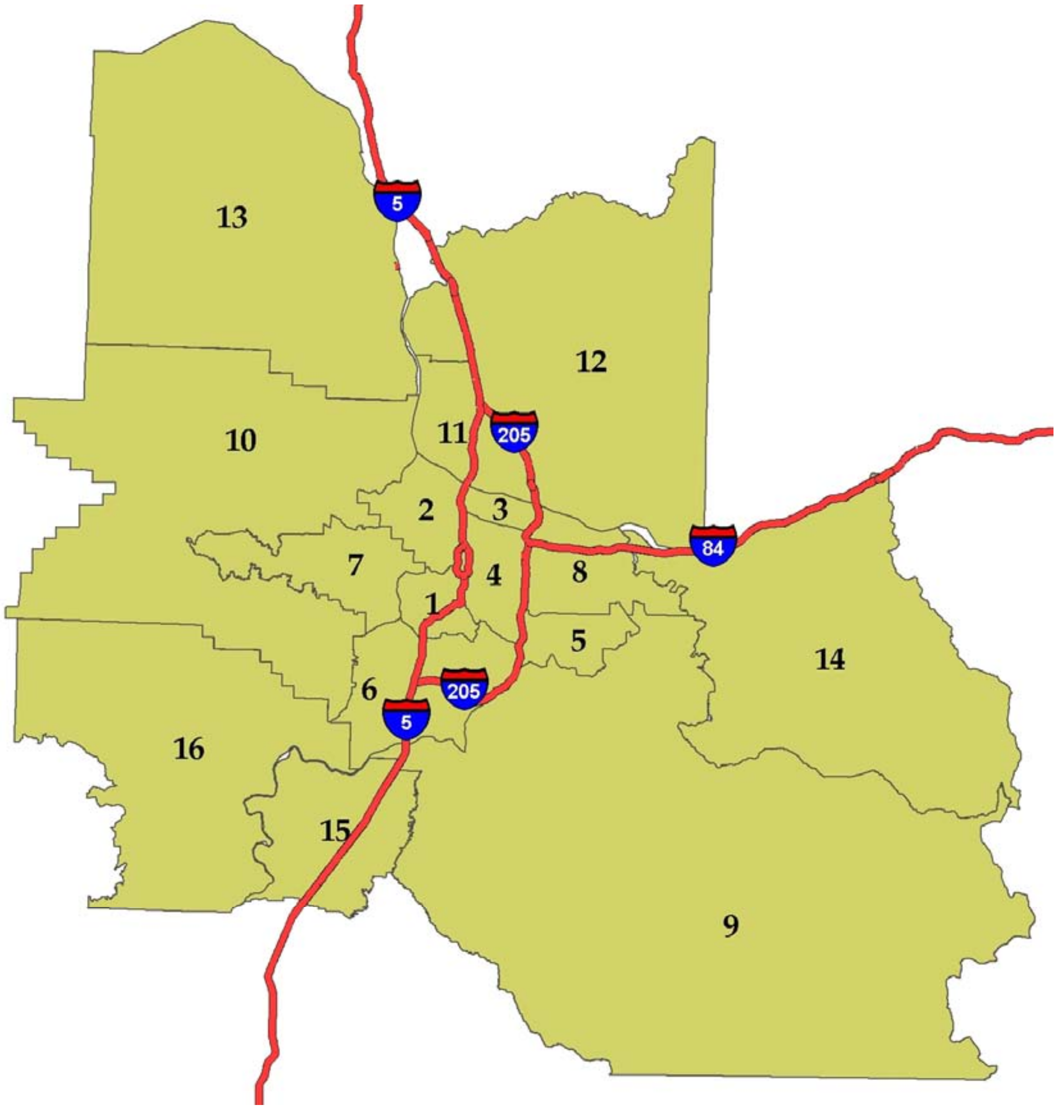
Trips by District

A district scheme for the Portland metropolitan area was developed according to the following criteria:

- Clustering TAZs with high truck trip productions and attractions into separate districts;
- Defining the boundaries for some of the districts to match as closely as possible with the existing Urban Growth Boundary (UGB);
- Defining the boundaries for some of the districts based on the highway network, so that city/street information from the surveys can be bridged to the corresponding district area; and
- Limiting the total number of districts to allow for greater statistical significance.

Figure 4.2 provides a district map of the Portland metropolitan area.

Figure 4.2 Internal District Map



Of the 15,778 trips to and from the Portland metropolitan area, 85 percent of the trips were geocoded to a particular internal location and 15 percent were not. For purposes of this analysis, the non-geocoded trips were distributed among the districts in accordance with the corresponding percentages of the geocoded trips.

Table 4.6 shows the estimated number and percentage of daily truck trips that were coming from or going to a destination within each district.

Table 4.6 Trips by Internal District

District #	Daily Truck Trips	Percent	District #	Daily Truck Trips	Percent
1	266	1.7%	9	503	3.2%
2	4,453	28.2%	10	282	1.8%
3	1,801	11.4%	11	577	3.7%
4	1,745	11.1%	12	251	1.6%
5	1,527	9.7%	13	0	0.0%
6	1,563	9.9%	14	137	0.9%
7	555	3.5%	15	0	0.0%
8	2,118	13.4%	16	0	0.0%
Total				15,778	100.0%

The districts with the highest truck volumes are within the central Portland area: District 2 (4,453 trips, 28.2 percent); District 8 (2,118 trips, 13.4 percent); District 3 (1,801 trips, 11.4 percent); and District 4 (1,745 trips, 11.1 percent). High truck trip productions and attractions in these districts relative to other districts in the study area can be attributed to the presence of trip generators, which are described below:

- High truck volumes in District 2 can be attributed to the concentration of marine terminals, which are one of the highest truck trip generators in the Portland metropolitan area. Union Pacific's (UP) near-dock intermodal yards (Albina and Barnes yards) in District 2 also generate significant number of truck trips.
- District 8 in east Multnomah county is a region with many truck terminals, air cargo terminals (in the northwest part of the district), and a major distribution center (Albertson's), which are the prime generators of high truck trips in the district.
- High truck volumes in District 3 are primarily associated with air cargo terminals and sorting facilities in and around the PDX airport.
- A large share of the truck trips generated in District 4 in Multnomah county (east of downtown Portland) can be attributed to UP's Brooklyn yard and some distribution centers located in the southern part of the district.

External Trip End

Table 4.7 shows the external end of the trips that originate from or are destined to the Portland metropolitan area internal districts, in terms of the direction relative to the Portland metropolitan area. About 38.4 percent of these trips have an external end that is south of the Portland metropolitan area, 31.1 percent have an external end north of Portland, and 26.0 percent have an external end east of Portland. Only 4.5 percent have an external end west of Portland.

Table 4.7 External End of Internal District Trips

Direction	Typical Locations	Daily Truck Trips	Percent
North (I-5 N)	western Washington, Vancouver BC	4,905	31.1%
South (I-5 S)	Oregon cities along I-5, California	6,063	38.4%
East (I-84, U.S. 26)	Oregon cities along I-84, eastern Washington	4,106	26.0%
West (U.S. 30)	Oregon cities west of Portland	704	4.5%
Total		15,778	100.0%

Table 4.8 shows a cross-tabulation of the internal districts with the external trip ends (for each internal district, the percentage of truck trips coming from or going to each direction relative to the Portland metropolitan area).

Table 4.8 Cross-Tabulation of Internal Districts with External Trip Ends

District #	North (I-5 N)	South (I-5 S)	East (I-84, U.S. 26)	West (U.S. 30)
1	30%	49%	18%	2%
2	30%	39%	24%	7%
3	40%	37%	23%	1%
4	32%	38%	26%	5%
5	21%	46%	32%	2%
6	32%	41%	23%	4%
7	24%	36%	26%	14%
8	28%	36%	35%	1%
9	26%	35%	38%	1%
10	14%	27%	21%	37%
11	48%	39%	10%	2%
12	38%	34%	28%	n/a
14	n/a	13%	78%	9%

Total	31%	38%	26%	4%

Districts 13, 15, and 16 did not have any truck trips in the dataset.

The internal districts that deviated the most from the overall dataset with respect to the locations of external trip ends were 3 and 11 (skewed with a relatively high percentage of trucks going to/from the north), 1 and 5 (skewed to/from the south), 9 and 14 (skewed to/from the east), and 10 (skewed to/from the west).

Table 4.9 shows a cross-tabulation of commodity groups with the external trip ends (for each commodity group, the percentage of truck trips coming from or going to each direction relative to the Portland metropolitan area).

Table 4.9 Cross-Tabulation of with External Trip Ends

Group	Description	North	South	East	West
1	Live Animals, Agriculture, and Animal Products	21%	47%	30%	1%
2	Food Products	31%	44%	24%	1%
3	Stone, Sands, Gravel	33%	41%	12%	14%
4	Base Metal and Articles of Base Metal	37%	27%	33%	4%
5	Non-Metallic Minerals and Mineral Products	27%	30%	32%	12%
6	Oil, Gas, Petroleum/Coal Products	21%	43%	24%	12%
7	Chemicals, Chemical Products	28%	42%	25%	6%
8	Lumber or Wood Products, Furniture	36%	31%	25%	8%
9	Pulp, Paper, Printed Matter	33%	47%	14%	6%
10	Textiles, Apparel, Leather Products	39%	38%	21%	2%
11	Machinery and Electrical Equipment	36%	35%	26%	3%
12	Transportation and Transportation Equipment	31%	39%	28%	2%
13	Waste and Scrap	27%	37%	32%	4%
14	Mixed Freight, Packages	37%	39%	22%	2%
15	Misc. Manufactured Products and Instruments	46%	32%	19%	3%
99	Not Coded	21%	39%	39%	1%
	Total	31%	38%	26%	4%

Group 16: Metallic Ores and Coal did not have any truck trips in the dataset.

The commodity groups that deviated the most from the overall dataset with respect to the locations of external trip ends were 15: Miscellaneous Manufactured Products and Instruments (skewed to/from the north), 1: Live Animals, Agriculture, and Animal Products (skewed to/from the south), and 9: Pulp, Paper, Printed Matter (skewed to/from the south).

Reload Activity

Of the 15,778 trips to/from the Portland metropolitan area, the carrier type (truckload (TL), less-than-truckload (LTL), or private) and the facility type within the region were recorded for 93 percent of the trips. For purposes of this analysis, the other 7 percent of trips were distributed among the carrier types and facility types in accordance with the corresponding percentages of the other 93 percent of trips.

Reload facilities are considered to be those where there is truck to truck transfer or reload activity taking place. The facilities that fall under this category are warehouses, distribution centers, and truck terminals. Other terminal facilities (i.e., ports, rail yards, and airports) may also have reload activity, but the transfer is between different modes. For purposes of this analysis, these facilities are not considered to be reload facilities. Other types of facilities (i.e., factories, retail outlets, farms, mines, home base, and other) in general do not have reload activity.

Table 4.10 shows the results of the reload facility analysis by carrier type.

Table 4.10 Reload Facility Analysis – Daily Truck Trips by Carrier Type

	TL	LTL	Private	Total
Reload Facility	1,773	3,147	3,365	8,286
	52.6%	59.4%	56.7%	56.7%
Rail Yard, Port, or Airport	254	363	439	1,056
	7.5%	6.9%	7.4%	7.2%
Factory	435	604	668	1,707
	12.9%	11.4%	11.3%	11.7%
Retail Outlet	126	261	249	637
	3.7%	4.9%	4.2%	4.4%
Home Base	142	281	507	931
	4.2%	5.3%	8.6%	6.4%
Other (includes farm, mine)	641	645	704	1,991
	19.0%	12.2%	11.9%	13.6%
Total	3,372	5,303	5,933	14,608
	100.0%	100.0%	100.0%	100.0%

Excludes 1,170 truck trips for which the facility type or the carrier type were not coded.

Findings from the reload facility analysis by carrier type are as follows:

- About 56.7 percent (8,286 daily) of truck trips to and from the Portland metropolitan area were coming from or going to a reload facility, while 43.3 percent (6,322 daily) were coming from or going to a non-reload facility. Among non-reload facility types, the top categories were other (13.6 percent; 1,991 trips), factory (11.7 percent; 1,707 trips), and rail yard, port, or airport (7.2 percent, 1,056 trips).
- A higher percentage of less-than-truckload (LTL) and private carriers used reload facilities, as compared to truckload (TL) carriers. TL carriers were the most likely of the carrier types to use factories; LTL carriers were the most likely to use retail outlets.

Table 4.11 shows a cross-tabulation of the commodity groups with the facility type (for each commodity group, the percentage of truck trips that served reload vs. non-reload facilities).

Table 4.11 Reload Facility Analysis – Daily Truck Trips by Commodity Group

Group	Description	Reload Facility	Non-Reload Facility
1	Live Animals, Agriculture, Animal Products	46%	54%
2	Food Products	70%	30%
3	Stone, Sands, Gravel	24%	76%
4	Base Metal and Articles of Base Metal	51%	49%
5	Non-Metallic Minerals and Mineral Products	47%	53%
6	Oil, Gas, Petroleum/Coal Products	55%	45%
7	Chemicals, Chemical Products	64%	36%
8	Lumber or Wood Products, Furniture	46%	54%
9	Pulp, Paper, Printed Matter	60%	40%
10	Textiles, Apparel, Leather Products	61%	39%
11	Machinery and Electrical Equipment	40%	60%
12	Transportation and Transportation Equipment	43%	57%
13	Waste and Scrap	57%	43%
14	Mixed Freight, Packages	73%	27%
15	Misc. Manufactured Products	65%	35%
99	Not Coded	63%	37%
	Total	57%	43%

Findings from the reload facility analysis by commodity group are as follows:

- The commodity groups that are most likely to use reload facilities are 14: Mixed Freight, Packages (73 percent) and 2: Food Products (70 percent).
- The commodity groups that are most likely to use non-reload facilities are 3: Stone, Sands, Gravel (76 percent) and 11: Machinery and Electrical Equipment (60 percent).

Through Trips

Of the 17,185 through trips, the directionality from the survey could be determined for 90 percent of the trips. For purposes of this analysis, the other 10 percent of trips were distributed among the six directionality pairs in accordance with the corresponding percentages of the other 90 percent of trips.

Table 4.12 shows the results of this analysis. About two-thirds of through trips (11,555 daily) are north-south (i.e., between western Washington or Vancouver BC and the Oregon cities along I-5 or California). The next largest directionality pairs are south-east (2,206; 12.8 percent) and north-east (1,934; 11.3 percent).

Table 4.12 Through Trip Directionality

Directionality Pair	Highway Pair	Daily Truck Trips	Percent
North – South	I-5 N to/from I-5 S	11,555	67.2%
North – East	I-5 N to/from I-84 or U.S. 26	1,934	11.3%
North – West	I-5 N to/from U.S. 30	719	4.2%
South – East	I-5 S to/from I-84 or U.S. 26	2,206	12.8%
South – West	I-5 S to/from U.S. 30	678	3.9%
East – West	I-84 or U.S. 26 to/from U.S. 30	92	0.5%
Total		17,185	100.0%

5.0 Terminal Gateway Surveys

5.1 Overview

The terminal gateway surveys were conducted by Traffic, Research and Analysis, Inc. in December 2005 and January 2006. The gate surveys involved interviews of truck drivers who enter or exit identified freight facilities, with a focus on reload facilities: port terminals, intermodal rail yards, airport facilities, and truck terminals. The data obtained from the gate surveys included: shipment by time of day; commodity types; vehicle and trailer configuration/style; number of axles; carrier name and address; unloaded vehicle weight; payload weight; origin/destination address of shipments; facility type for inbound/outbound shipments; street address for LTL shipments; and shipment routes.

Figure 5.1 shows the locations where the gate intercept surveys were conducted, which were eleven terminal gateways within the Portland metropolitan area.

Figure 5.1 Terminal Gateway Survey Locations

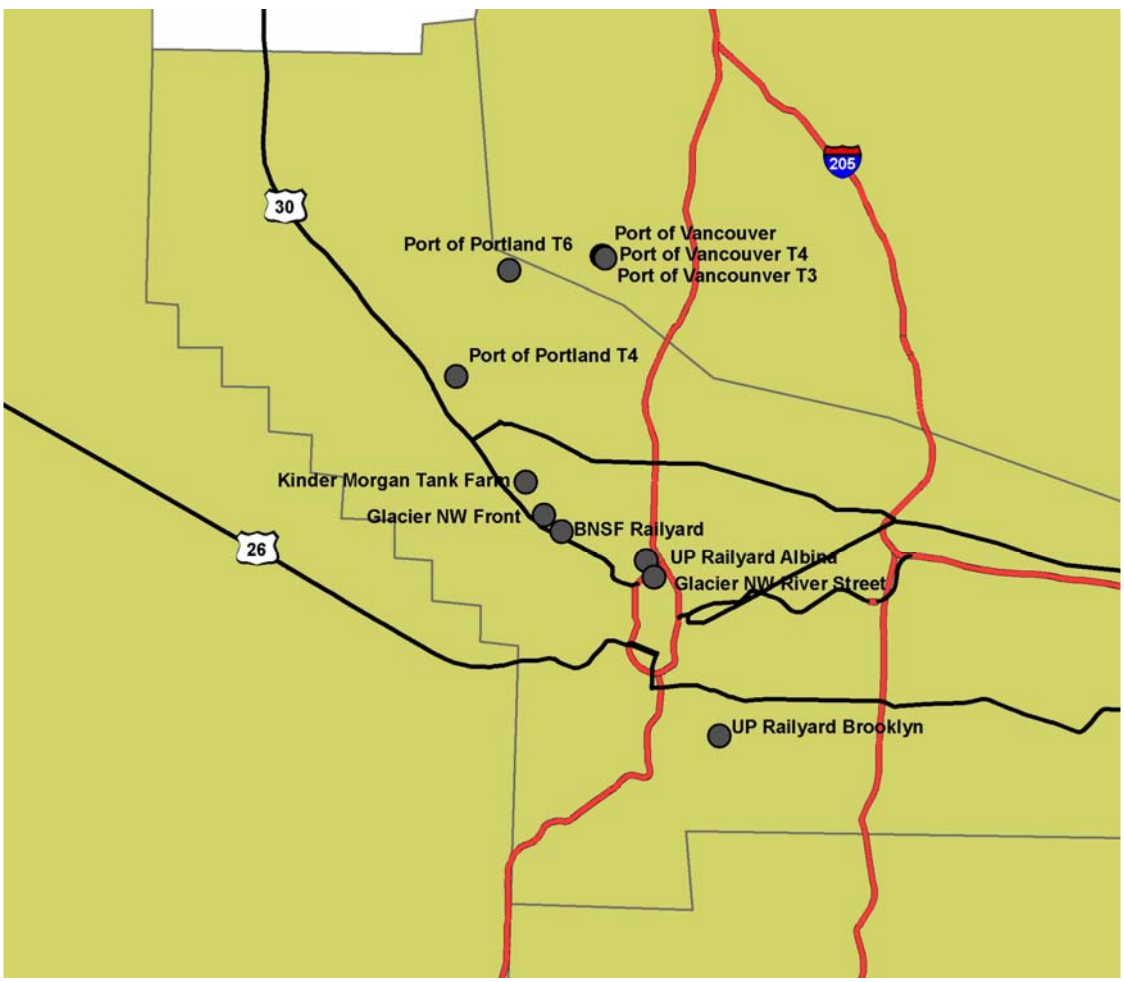


Table 5.1 shows the number of gate surveys collected by locations and by date. A total of 498 gate surveys were collected.

Table 5.1 Gate Survey Locations and Dates

Location ID	Description	Dates of Data Collection	# of Surveys Collected
1	BNSF Railyard	Dec 13, 2005	92
2	UP Railyard Albina	Dec 14, 2005	79
3	UP Railyard Brooklyn	Dec 14, 2005	58
4	Port of Vancouver	Dec 14, 2005	43
5	Port of Portland Terminal 4	Dec 15, 2005	5
6	Port of Portland Terminal 6	Dec 15, 2005	60
7	Kinder Morgan Tank Farm	Dec 15, 2005	46
8	Glacier NW Front	Jan 17, 2006	41
9	Glacier NW River St	Jan 17, 2006	8
10	POV T4 Subaru	Jan 17-19, 2006	38
11	POV T3 Valero	Jan 18, 2006	28
	Total - All Locations		**498**

5.2 Data Cleaning

As with the roadside intercept surveys, the spatial and attribute data for the terminal gateway surveys were cleaned according to several data cleaning and editing procedures described in Appendix B. Of the 498 completed gate surveys:

- 447 surveys (90 percent) had *both* the origin and the destination geocoded;
- 442 surveys (89 percent) had a commodity code assigned; and
- 395 surveys (79 percent) had a geocoded origin and destination, as well as a commodity code assigned.

Gate survey data were not expanded, as 24-hour truck count control totals were not available. Therefore, survey results are based on raw unexpanded numbers.

5.3 Commodities

Table 5.2 shows the commodity analysis results from the gate surveys, using the simplified 16-commodity group system. The most common commodity groups are Group 5: Non-Metallic Minerals and Mineral Products (14.3 percent) and Group 14: Mixed Freight, Packages (13.3 percent). By comparison, for the roadside intercept surveys, the top commodity groups were Group 2: Food Products and Group 8: Lumber or Wood Products, Furniture.

Table 5.2 Commodity Group Analysis

Group	Description	Number	Percent
1	Live Animals, Agriculture, and Animal Products	17	3.4%
2	Food Products (incl. meat, fish, bakery, alcohol, tobacco)	21	4.2%
3	Stone, Sands, Gravel	6	1.2%
4	Base Metal, Articles of Base Metal	30	6.0%
5	Non-Metallic Minerals and Mineral Products (incl. plastic)	71	14.3%
6	Oil, Gas, Petroleum/Coal Products	46	9.2%
7	Chemicals, Chemical Products, Pharmaceuticals	28	5.6%
8	Lumber or Wood Products, Furniture	38	7.6%
9	Pulp, Paper, Printed Matter	42	8.4%
10	Textiles, Apparel, Leather Products	3	0.6%
11	Machinery and Electrical Equipment	6	1.2%
12	Transportation and Transportation Equipment	49	9.8%
13	Waste and Scrap	8	1.6%
14	Mixed Freight, Packages	66	13.3%
15	Misc. Manufactured Products and Instruments	11	2.2%
16	Metallic Ores and Coal	0	0.0%
99	Not Coded	56	11.2%
Total		498	100.0%

Table 5.3 shows the top two commodity groups for the individual terminal gateway locations.

Table 5.3 Top Commodity Groups by Gate Location

Terminal Gateway	Top Commodity Groups	
	#1	#2
1: BNSF Railyard	14 (17%)	5 (15%)
2: UP Railyard Albina	14 (18%)	9 (13%)
3: UP Railyard Brooklyn	14 (38%)	9 (19%)
4: Port of Vancouver	8 (44%)	4 (37%)
5: Port of Portland Terminal 4	14 (100%)	
6: Port of Portland Terminal 6	14 (15%)	1 (15%)
7: Kinder Morgan Tank Farm	6 (100%)	
8: Glacier NW Front	5 (80%)	3 (7%)
9: Glacier NW River St	5 (88%)	not specified
10: POV T4 Subaru	12 (100%)	
11: POV T3 Valero	7 (71%)	2 (18%)

Commodity group numbers refer to the group codes provided in Appendix B. Results for Terminal Gateways 5 and 9 are based on extremely small sample sizes (5 surveys and 8 surveys, respectively).

5.4 Payload Factors

Cargo weight information was provided for 399 of the surveyed truck trips (80.1 percent). The cargo weight information was used to calculate payload factors by commodity group, as shown in Table 5.3.

- The commodity groups with the highest payload factors are Group 8: Lumber or Wood Products (27.7 tons); and Group 6: Coal, Oil, Gas, Petroleum/Coal Products (26.3 tons).
- The commodity groups with the lowest payload factors are Group 11: Machinery and Electrical Equipment (9.9 tons); and Group 10: Textiles, Apparel, Leather, Products (12.5 tons).

Table 5.4 Payload Factor Analysis

Group	Description	Payload Factor (Pounds Per Truck)	Payload Factor (Tons Per Truck)	Payload Factor (Pounds; Roadside Surveys)	Difference (Gate from Roadside)
1	Live Animals, Agriculture, and Animal Products	34,000	17.0	39,180	-13.2%
2	Food Products	42,106	21.1	35,185	+19.7%
3	Stone, Sands, Gravel	41,968	21.0	51,178	-18.0%
4	Base Metal and Articles	46,216	23.1	32,740	+41.2%
5	Non-Metallic Minerals and Mineral Products	37,431	18.7	32,554	+15.0%
6	Oil, Gas, Petroleum/Coal Products	52,535	26.3	49,350	+6.5%
7	Chemicals, Chemical Products	43,851	21.9	35,869	+22.3%
8	Lumber or Wood Products, Furniture	49,430	24.7	46,134	+7.1%
9	Pulp, Paper, Printed	41,410	20.7	40,611	+2.0%
10	Textiles, Apparel, Leather Products	25,367	12.7	23,523	+7.8%
11	Machinery and Electrical Equipment	19,895	9.9	24,197	-17.8%
12	Transportation and Transportation Equipment	42,809	21.4	26,555	+61.2%
13	Waste and Scrap	n/a		32,077	
14	Mixed Freight, Packages	27,984	14.0	29,258	-4.4%
15	Misc. Manufactured Products and Instruments	28,518	14.3	25,708	+10.9%
99	Not Coded	25,853	12.9	29,413	-12.1%
Total		39,146	19.6	35,493	+10.3%

No cargo weight information was available in either dataset for group 16: Metallic Ores and Coal.

The payload factors for the gate surveys overall were 10.3 percent higher than for the roadside intercept surveys. Differences observed for individual commodity groups were in large part of a function of the relatively small sample sizes for the gate surveys.

5.5 Trips To/From Portland Metropolitan Area

Of the 498 truck trips surveyed at terminal gateway locations:

- 244 trips (49.0 percent) involved a last stop in the Portland metropolitan area and a next stop in the Portland metropolitan area;
- 150 trips (30.1 percent) involved one stop in the Portland metropolitan area and the other stop outside the Portland metropolitan area; and
- 104 trips (20.9 percent) involved a last stop outside the Portland metropolitan area and a next stop outside the Portland metropolitan area.

Table 5.5 shows this breakdown for the individual terminal gateway locations.

Table 5.5 Trip Categories by Gate Location

Terminal Gateway	Both Stops in Portland metropolitan area	One Stop in Region; One Stop External	Both Stops External to Region
1: BNSF Railyard	67%	23%	10%
2: UP Railyard Albina	52%	32%	16%
3: UP Railyard Brooklyn	53%	21%	26%
4: Port of Vancouver	26%	23%	51%
5: Port of Portland Terminal 4	100%	0%	0%
6: Port of Portland Terminal 6	50%	35%	15%
7: Kinder Morgan Tank Farm	24%	41%	35%
8: Glacier NW Front	98%	2%	0%
9: Glacier NW River St	38%	13%	50%
10: POV T4 Subaru	5%	95%	0%
11: POV T3 Valero	29%	14%	57%
Total	49%	30%	21%

Results for terminal gateways 5 and 9 are based on extremely small sample sizes (5 surveys and 8 surveys, respectively).

The gate surveys did not contain any trips that were truly external-external (i.e., through) trips, as all trips surveyed had an intermediate stop at the surveyed terminal gateway location.

Common locations served outside the Portland metropolitan area (i.e., 5 or more trucks per location) include Albany, Oregon; Bend, Oregon; Eugene, Oregon; Halsey, Oregon; Salem, Oregon; St. Helens, Oregon; Swan, Oregon; Camas, Washington; Longview, Washington; and Tacoma, Washington. Unlike the roadside intercept surveys, very few trucks (about 15, or 3 percent) originated from or were destined to locations outside of the States of Oregon, Washington, and Idaho.

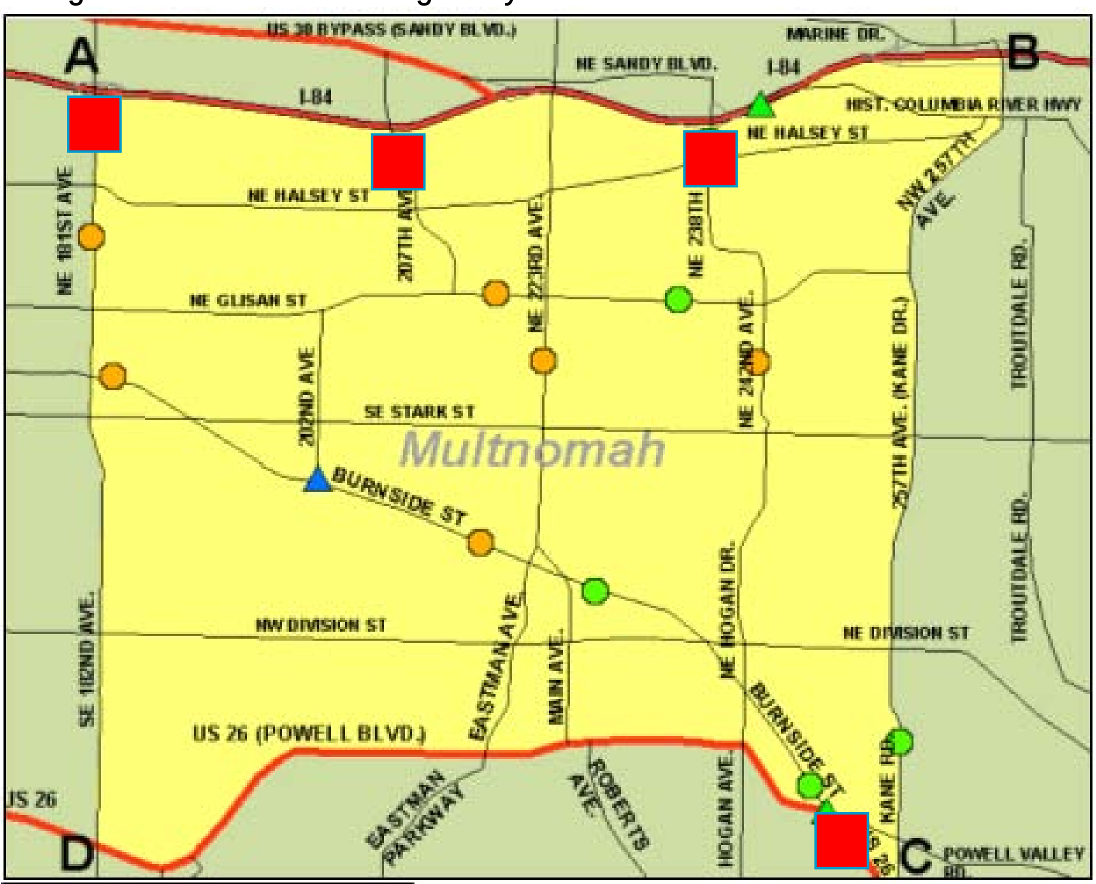
6.0 Truck Following Study

6.1 Overview

An analysis was requested to determine the amount of through truck traffic that cuts through a defined study area in Multnomah County, bounded by I-84, US 26, 181st St, and 257th St. Two options were proposed to collect this information: a license plate matching survey and a truck-following study. The major drawback to the license plate matching survey method was the number of cameras that would be required to provide coverage throughout the study area. By comparison, the truck following study method had the advantage of collecting both origin-destination detail and information on routing for each truck trip. As such, the truck following study was recommended for the project.

Figure 6.1 shows the study area and the four starting locations where trucks were followed (in red). These starting locations were Location 1: 181st Ave just south of I-84; Location 2: 207th Ave just south of I-84; Location 3: 238th Ave just south of I-84; and Location 4: US26 just south of E. Powell Boulevard. The Troutdale/257th St. interchange of I-84 was not included in the study as it was too far east of the primary cut-through route (Burnside Rd.)

Figure 6.1 Truck Following Study Area



The City of Gresham (where the truck following study area is located) does not have a designated truck route system. However, the neighboring City of Portland does. It includes three east-west routes which pass through the study area: Halsey St, Stark St. and Division St. If Gresham were to develop a designated truck-preferred route system, these three roads would likely be some of the roads designated as such. ODOT does not have any weight or length restrictions on I-84, US26, or Burnside Rd. in the study area.

A description of the National Highway System (NHS) routes in the truck following study area is as follows, as stated on page 86 of the 2002 Gresham Community Development Plan. "The focal point for freight related industries in Gresham is the intersection of I-84 and 181st Avenue where two NHS routes converge. This area is a gateway to Portland International Airport and the Columbia Southshore industrial area to the north where numerous reload facilities and truck terminals are located. To the south, the NHS route follows 181st Avenue to Burnside Street, passing through the Rockwood Town Center and the north edge of the Gresham Regional Center to US 26 and points east. Interstate 84 is a major east/west route in the National Highway System."

6.2 Data Collection Results

The truck following study was conducted by Traffic, Research and Analysis, Inc. on the following dates: July 10 to 13, 2006 (Monday to Thursday) and July 29 to 30, 2006 (Saturday to Sunday). A total of 667 trucks were followed: 562 on the weekdays and 105 on the weekends. Tables 6.1 and 6.2 provide the number of trucks that were followed by entry point. For the weekday data, the number is also provided by time period.

Table 6.1 Trucks Followed By Entry Point and Time Period: Weekday

	Time Period				
Entry Point	4:00 a.m.-6:00 a.m.	6:00 a.m.-9:00 a.m.	9:00 a.m.-3:00 p.m.	3:00 p.m.-8:00 p.m.	Total
181st Avenue just south of I-84	22	34	55	31	142
207th Avenue just south of I-84	19	31	41	25	116
238th Avenue just south of I-84	12	26	41	17	96
U.S. 26 just south of E. Powell Boulevard	28	46	68	66	208
Total	81	137	205	139	562

Table 6.2 Trucks Followed By Entry Point and Time Period: Weekend

Entry Point	Time Period: 4:00 a.m.-8:00 p.m.
181st Avenue just south of I-84	38
207th Avenue just south of I-84	23
238th Avenue just south of I-84	–
U.S. 26 just south of E. Powell Boulevard	44
Total	105

Among the 667 trucks followed, the following truck classification estimates were made:

- 159 (23.8 percent) were 2-axle 6-tire, single-unit trucks (such as small delivery trucks);
- 98 (14.7 percent) were 3 or more axle, single-unit trucks (such as cement and garbage trucks);
- 83 (12.4 percent) were 4 or fewer axle, multiple-unit trucks (such as large delivery trucks);
- 321 (48.1 percent) were 5 or more axle, multiple-unit trucks (such as semitrucks); and
- 6 (0.9 percent) did not have the truck classification determined.

6.3 Expansion Factors

Expansion factors were developed based on estimates of the number of trucks entering the study area at each of the major entry points. This required the collection of 16-hour weekday[1] truck count data at each of the major entry points.

Weekday count data were collected by Quality Counts in the same manner as the vehicle classification count portion of this study. For 238th Avenue just south of I-84, a single day of truck count data was collected. For the other three locations, three days of truck count data were collected. The results are shown in Table 6.3, representing the average daily truck counts in the same direction of travel for which the trucks were followed (i.e., leading into the study area).

[1] The truck counts used to expand data for the truck following study were drawn from the vehicle classification count component of the project. This data collection activity did not include weekend truck count data collection. Therefore, no truck counts were available to expand the weekend truck following data. Nonetheless, the raw weekend truck following data are included for comparative purposes.

Table 6.3 Average Weekday Truck Counts by Entry Point and Time Period

Entry Point	Dates of Count Data Collection (2006)	Time Period 4:00 a.m.-6:00 a.m.	6:00 a.m.-9:00 a.m.	9:00 a.m.-3:00 p.m.	3:00 p.m.-8:00 p.m.
181st Avenue just south of I-84	5/23-5/25	64	265	649	345
207th Avenue just south of I-84	5/23-5/25	17	91	192	68
238th Avenue just south of I-84	6/8	28	80	324	120
U.S. 26 just south of E. Powell Boulevard	5/23-5/25	21	120	368	131

There are a total of 16 expansion factors calculated: one for each entry point and each time period (i.e., a 4x4 matrix). Table 6.4 provides the calculated expansion factors, which are the ratios of the weekday truck count data (in Table 6.3) and the number of weekday trucks followed (in Table 6.1). For two locations in the early morning time period, the expansion factors are less than one (i.e., number of trucks followed exceeded the truck count). This is because the truck following study was conducted on different dates than when the truck counts were collected.

Table 6.4 Expansion Factors by Entry Point and Time Period

Entry Point	Time Period 4:00 a.m.-6:00 a.m.	6:00 a.m.-9:00 a.m.	9:00 a.m.-3:00 p.m.	3:00 p.m.-8:00 p.m.
181st Avenue just south of I-84	2.91	7.80	11.81	11.14
207th Avenue just south of I-84	0.91	2.92	4.68	2.72
238th Avenue just south of I-84	2.33	3.08	7.90	7.06
U.S. 26 just south of E. Powell Boulevard	0.76	2.61	5.41	1.98

6.4 Data Analysis – Through Trips

Tables 6.5 and 6.6 provide the percentage of trucks that crossed through the study area based on entry point and time of day, using expanded weekday and unexpanded weekend truck following study data. The remaining truck trips had a destination within the study area.

Table 6.5 Percentages of Trucks that Crossed Through the Study Area by Entry Point and Time Period: Weekday

	Time Period				
Entry Point	4:00 a.m.-6:00 a.m.	6:00 a.m.-9:00 a.m.	9:00 a.m.-3:00 p.m.	3:00 p.m.-8:00 p.m.	Total
181st Avenue just south of I-84	27.3%	29.4%	21.8%	38.7%	28.0%
207th Avenue just south of I-84	68.4%	35.5%	39.0%	32.0%	38.2%
238th Avenue just south of I-84	58.3%	19.2%	22.0%	52.9%	30.1%
U.S. 26 just south of E. Powell Boulevard	78.6%	65.2%	60.3%	77.3%	65.3%
Total	47.7%	36.7%	33.2%	48.2%	38.0%

Table 6.6 Percentages of Trucks that Crossed Through the Study Area by Entry Point and Time Period: Weekend

Entry Point	Time Period: 4:00 a.m.-8:00 p.m.
181st Avenue just south of I-84	50.0%
207th Avenue just south of I-84	39.1%
238th Avenue just south of I-84	–
U.S. 26 just south of E. Powell Boulevard	59.1%
Total	51.4%

The following main findings from this analysis are:

- **In total.** An estimated 38.0 percent of weekday truck trips crossed through the study area. The other 62.0 percent of truck trips had a destination within the study area. On the weekends, an estimated 51.4 percent of truck trips crossed through the study area and 48.6 percent had a destination within the study area.
- **By entry point.** The U.S. 26 entry point had considerably higher percentages of truck trips that crossed through the study area than the other entry points. This finding was consistent on both weekdays and weekends as well as across time periods.
- **By time period.** The early morning and morning peak time periods had higher percentages of truck trips that crossed through the study area (48.2 percent and 47.7 percent, respectively) than the midday and afternoon time periods (36.7 percent and 33.2 percent, respectively). This may reflect the hours of operation of facilities within the study area with lower percentages of through traffic in the midday and afternoon when trucks are accessing destinations within the study area.

Table 6.7 provides the percentage of trucks in each truck class that crossed through the study area, weekday and weekend.

Table 6.7 Percentages of Trucks in Each Truck Class that Crossed Through the Study Area

Truck Class	Weekday	Weekend
2 axle 6 tire, single-unit	16.7%	34.2%
3 or more axle, single-unit	38.1%	35.7%
4 or fewer axle, multiple-unit	34.8%	n/a
5 or more axle, multiple-unit	50.1%	70.6%
Total	38.0%	51.4%

Note: There were too few 4 or fewer axle, multiple unit trucks followed on the weekend to provide an estimate (only 2 trucks followed).

Large semi-trucks (5 or more axle, multiple-unit) were the most likely to cross through the study area, while small delivery trucks (2 axle 6 tire, single-unit) were the least likely. This finding was consistent on both the weekdays and weekends.

Table 6.8 builds on the results of Table 6.7 by showing the percentages by truck class of those trucks that crossed through the study area.

Table 6.8 Truck Class Percentages of Trucks that Crossed Through the Study Area

Truck Class	Weekday	Weekend
2 axle 6 tire, single-unit	9.9%	24.1%
3 or more axle, single-unit	13.9%	9.3%
4 or fewer axle, multiple-unit	16.1%	0.0%
5 or more axle, multiple-unit	60.1%	66.7%
Total	100.0%	100.0%

Note: Trucks for which the truck classification was not determined were omitted from this analysis.

Of the weekday trucks that crossed through the study area, 60.1 percent were 5 or more axle, multiple-unit trucks. During the weekends, this percentage was 66.7 percent.

6.5 Data Analysis – Major Streets Used

An analysis was also conducted to identify the percentage of times that major streets within the study area were used, by entry point. This analysis is based on the routing information provided for 534 of the 667 trucks that were followed (80 percent). Manual cleaning of street routing information for the other 20 percent of records could not be completed for this report.

Tables 6.9 to 6.12 show, for each of the four entry points, the top five streets within the study area that trucks used based on the routing information provided. The street on which the entry point was located is listed at 100 percent.

Table 6.9 Top Streets Used: Entry Point #1 (181st Avenue Just South of I-84)

Street	Percentage Used
181st Ave	100%
Burnside St	55%
San Rafael	18%
Halsey St	9%
Division St	7%

Table 6.10 Top Streets Used: Entry Point #2 (207th Avenue Just South of I-84)

Street	Percentage Used
207th Ave	100%
Glisan St	80%
Burnside St	45%
242nd Ave	37%
223rd Ave	29%

Table 6.11 Top Streets Used: Entry Point #3 (238th Avenue Just South of I-84)

Street	Percentage Used.
238th Ave	100%
242nd Ave	54%
Burnside St	37%
Halsey St	27%
Division St	7%

Table 6.12 Top Streets Used: Entry Point #4 (U.S. 26 Just South of E. Powell Boulevard)

Street	Percentage Used
U.S. 26	100%
Burnside St	67%
242nd Ave	39%
Glisan St	23%
181st Ave	23%

6.6 Data Analysis – Routing

Tables 6.13 and 6.14 show the top routing combinations of the trucks that were followed.

Table 6.13 Top Routing Combinations for Through Truck Trips

Routing Combination	Percentage of Interregional Trips
U.S. 26 – Burnside – 181st Ave	15.2%
181st Ave – Burnside	9.2%
207th Ave – Glisan – 242nd Ave – Hogan – Burnside	8.2%
U.S. 26 – Burnside – Hogan – 242nd Ave – 238th Ave	7.9%
238th Ave – 242nd Ave – Hogan – Burnside	4.7%
207th Ave – Glisan – 223rd Ave – Burnside	4.4%

Table 6.14 Top Routing Combinations for Truck Trips With a Destination in the Study Area (Intraregional Trips)

Routing Combination	Percentage of Intraregional Trips
U.S. 26 – Burnside	14.5%
181st Ave – San Rafael	14.2%
207th Ave – Halsey	8.0%
238th Ave – Halsey	6.8%
207th Ave – Glisan – 223rd Ave	5.7%
181st Ave – Burnside	5.1%
238th Ave – 242nd Ave	4.0%
U.S. 26 – Powell	3.4%
207th Ave – Glisan – 242rd Ave	3.1%
81st Ave – Halsey	2.6%

6.7 Data Analysis – Top Internal Destinations

Table 6.15 shows the top destinations of truck trips with a destination internal to the study area. No single destination had more than 3 percent of the total.

Table 6.15 Top Destinations Internal to the Study Area

Top Destinations	Percentage of Internal Trips.
Albertson's Distribution: 17505 NE San Rafael	2.8%
Charlie's Produce: 18332 NE San Rafael	2.6%
Fred Meyer Produce: 22855 Wood Village Blvd	1.4%
Lowes: 1000 Wood Village Blvd	1.4%
Penske Truck Rental: 18900 NE San Rafael	1.4%

6.8 Conclusion

The truck following study was able to provide information on the amount of through truck traffic that cut through a defined study area in Multnomah County, at a fraction of the likely cost of a license plate matching survey for collecting the same information. In addition, the truck following study provided detail on truck origins and destinations as well as routing information, which a license plate matching survey would not have provided. The truck following study was found to be a useful means of data collection that met the needs of the Portland freight data collection program in a flexible and efficient manner.

7.0 Vehicle Classification Counts

7.1 Overview

The vehicle classification counts were collected by Quality Counts in spring 2006. This involved recording traffic at select locations on video cameras, then processing this information to classify the vehicles according to the Federal Highway Administration (FHWA) 13-Category Classification System. Class 1-4 vehicles are not considered to be trucks; Class 5 vehicles are medium trucks (i.e., 2 axles, 6 tires); and Class 6-13 vehicles are heavy trucks (i.e., 3 axles or more). In accordance with the statement of work, the vehicle counts were obtained for 15 minutes within each hour and therefore were multipled by four to obtain an hourly estimate.

The vehicle classification counts were completed at a total of 108 locations (56 72-hour counts, 52 24-hour counts) on Tuesdays, Wednesdays, and Thursdays from April 2006 to June 2006. Of the 108 locations for which count data was requested, 106 of them had complete data collection. Table 7.1 provides a summary of where vehicle counts were requested, with a comparison of the hours of data collection requested versus the hours of data collection delivered.

Table 7.1 Vehicle Classification Count Data Collection

Region	Count Type	Number of Locations Requested	Number of 24-Hour Location Equivalents	Total Hours of Data Collection Requested	Total Hours of Data Collection Delivered	Percent of Hours Delivered
Clackamas County	Primary Screenline (72-Hr Count)	2	6	144	144	100.0%
Clackamas County	Additional 72-Hr Count Request	3	9	216	216	100.0%
Clackamas County	24-Hr Count Request	7	7	168	168	100.0%
Clark County	Additional 72-Hr Count Request	4	12	288	288	100.0%
Clark County	24-Hr Count Request	5	5	120	120	100.0%
Downtown Portland	Primary Screenline (72-Hr Count)	4	12	288	288	100.0%
Downtown Portland	Additional 72-Hr Count Request	5	15	360	360	100.0%
Multnomah County, Other	Primary Screenline (72-Hr Count)	9	27	648	646	99.7%
Multnomah County, Other	Additional 72-Hr Count Request	10	30	720	720	100.0%
Multnomah County, Other	24-Hr Count Request	15	15	360	360	100.0%
Port of Portland & Airport	Additional 72-Hr Count Request	5	15	360	360	100.0%
Port of Portland & Airport	24-Hr Count Request	17	17	408	408	100.0%
Port of Vancouver	Additional 72-Hr Count Request	2	6	144	144	100.0%
Port of Vancouver	24-Hr Count Request	3	3	72	72	100.0%
Washington County	Primary Screenline (72-Hr Count)	9	27	648	648	100.0%
Washington County	Additional 72-Hr Count Request	3	9	216	192	88.9%
Washington County	24-Hr Count Request	5	5	120	120	100.0%
Total: All Locations		**108**	**220**	**5,280**	**5,254**	**99.5%**

7.2 Comparison with Other Count Programs

For the most part, vehicle classification counts in the Portland FDC program were taken at locations that are not part of other count programs (see description of how locations for the FDC program were selected in the Task 4 technical memorandum). However, the FDC program did provide an opportunity to conduct 72-hour counts at a number of locations for which 24-hour counts are conducted by other organizations as part of on-going or one time count programs. Comparisons between the FDC results and the counts from these other programs provide an indication of the reliability of the counts.

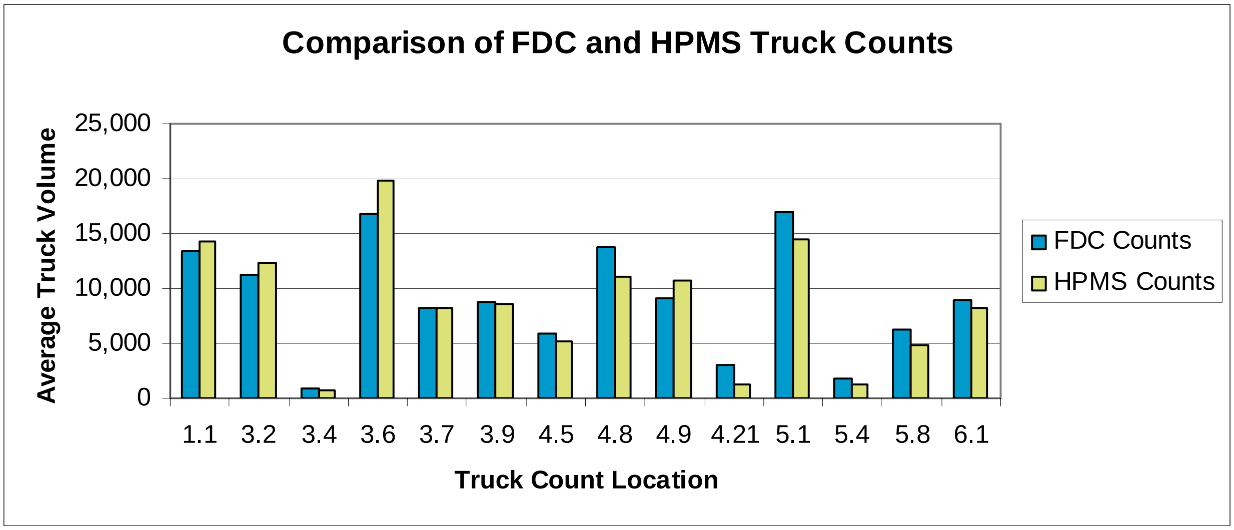
ODOT Highway Performance Monitoring System (HPMS) vehicle classification counts are collected by ODOT every three years. Data are collected on a single day of the year by either tube counts or by video. Video counts that are taken for less than 24 hours are factored to 24-hour average daily traffic (ADT) estimates.

Table 7.2 and Figure 7.1 provide a comparison of the Portland FDC truck count data with the HPMS truck count data for the 14 locations that were counted as part of both programs.

Table 7.2 Comparison of Portland FDC Truck Counts With HPMS Truck Counts – Table

Location ID	Roadway	Segment	TCP Counts		HPMS Counts			% Difference
			Time Period (hr)	Truck ADT	Year	Time Period (hr)	Truck ADT	
1.1	I-5	Between Victory and OR 99W	72	13,389	2005	24	14,204	-5.7%
3.2	I-5	Marquam Br.	72	11,224	2004	24	12,301	-8.8%
3.4	Morrison Br.	Between OR 99W and I-5	72	959	2004	24	775	23.7%
3.6	I-5	N. of I-405	72	16,771	2005	24	19,749	-15.1%
3.7	I-84	Grand St. Overcrossing	72	8,217	2005	24	8,300	-1.0%
3.9	US 30	W. of I-405	72	8,676	2004	24	8,517	1.9%
4.5	US 26 (Sunset Hwy)	E. of Highland Rd.	72	5,931	2005	24	5,212	13.8%
4.8	I-5	Interstate Br.	72	13,831	2004	24	10,985	25.9%
4.9	I-205	Glen Jackson Br.	72	9,087	2003	24	7,943	14.4%
4.21	181st Ave.	Between Halsey St. and Glisan St.	72	3,040	2004	16	1,274	138.6%
5.1	I-5	Between I-205 and Nyberg Rd.	72	16,904	2004	24	14,412	17.3%
5.4	OR 99W	S. of Cipole Rd.	72	1,708	2004	16	1,239	37.9%
5.8	US 26 (Sunset Hwy)	E. of Cornell Rd.	72	6,248	2005	24	4,746	31.6%
6.1	I-205	At 65th Ave Undercrossing (Clackamas/Washington County Line)	72	8,971	2004	24	8,272	8.5%

Figure 7.1 Comparison of Portland FDC Truck Counts with HPMS Truck Counts - Graph



The Portland FDC counts were higher than the HPMS counts for 10 of the 14 locations, and were lower for 4 of the 14 locations. The largest discrepancies in percentage terms were observed for locations with low truck volumes (4.21: 138.6 percent; 5.4: 37.9 percent; and 5.8: 31.6 percent). In general, the differences in the two count programs are within the range of what might be expected given random day-to-day variations. In addition, some of the HPMS counts were conducted in the fall rather than the spring, so that coupled with the difference in year might explain some of the variations with the spring count program.

Portland FDC count comparisons were also made with existing count programs conducted by the Port of Portland Traffic Monitoring Program (TMP) and in Clackamas County. These results are shown in Tables 7.3 and 7.4.

Table 7.3 Comparison of Portland FDC Truck Counts with Port of Portland TMP Truck Counts

Location ID	Roadway	Segment	FDC Counts		Port of Portland Traffic Monitoring Program (TMP) Counts			% Difference
			Time Period (hr)	Truck ADT	Year	Time Period (hr)	Truck ADT	
1.11	Alderwood Rd	N. of Columbia Blvd	24	340	2004	24	529	-35.7%
1.23	Lombard St	N. of Columbia Blvd (Rivergate area)	72	1,569	2004	24	1,985	-21.0%

Table 7.4 Comparison of Portland FDC Truck Counts with Clackamas County Truck Counts

Location ID	Roadway	Segment	FDC Counts		Clackamas County Counts			% Difference
			Time Period (hr)	Truck ADT	Year	Time Period (hr)	Truck ADT	
6.3	I-205	Between 82nd Dr. and Sunnybrook St.	72	12,901	2004	24	10,977	17.5%
6.6	OR-224	E. of Freeman Way	24	1,936	2004	24	3,435	-43.6%
6.8	OR-224	W. of OR 213 (Cascade Hwy)	24	2,952	2004	24	2,537	16.4%
6.10	OR-212/OR-224	Between 82nd Ave. and I-205	24	5,084	2004	24	4,145	22.7%

7.3 Comparison by Type of Roadway Facility and Truck Type

Tables 7.4 to 7.6 provide the count locations with the highest ADT truck volumes (truck ADT of more than 2,000). Table 7.4 provides this for interstates, Table 7.5 shows the high volume state highways, and Table 7.6 shows the high volume arterials:

- All 19 of the selected interstate locations had truck ADT over 2,000;
- 17 of the 31 selected state highway locations (55 percent) had truck ADT over 2,000; and
- 16 of the 58 selected arterial locations (28 percent) had truck ADT over 2,000.

Table 7.5 High Volume Portland FDC Truck Locations – Interstates

Location ID	Roadway	Segment	Medium Trucks, #	Medium Trucks, %	Heavy Trucks, #	Heavy Trucks, %	**All Trucks, #**	**All Trucks, %**
			Average Daily Traffic (ADT)					
5.19	I-5	Between I-205 and Elligsen Rd.	3,402	2.5%	16,728	12.3%	**20,130**	**14.8%**
5.1	I-5	Between I-205 and Nyberg Rd.	4,235	2.9%	12,751	8.8%	**16,985**	**11.7%**
3.6	I-5	N. of I-405	3,671	2.4%	13,100	8.5%	**16,771**	**10.9%**
4.37	I-5	N. of Going St.	3,541	2.9%	13,109	10.7%	**16,651**	**13.6%**
4.23	I-5	Near Ridgefield Weigh Station	1,840	2.8%	12,596	18.8%	**14,436**	**21.6%**
4.2	I-5	S. of SW Corbett Ave. ramp	3,591	2.3%	10,475	6.8%	**14,065**	**9.1%**
4.8	I-5	Interstate Br.	2,957	2.2%	10,873	8.1%	**13,831**	**10.3%**
4.1	I-205	Btwn 92nd Ave. and Johnson Creek Blvd.	3,635	2.4%	10,108	6.8%	**13,743**	**9.2%**
1.1	I-5	Between Victory and OR 99W	2,157	2.1%	11,232	11.1%	**13,389**	**13.2%**
6.2	I-205/OR 212/213	Between 82nd Ave. and OR 213	3,461	2.3%	9,920	6.7%	**13,381**	**9.0%**
6.3	I-205	Between 82nd Dr. and Sunnybrook St.	3,389	2.7%	9,512	7.5%	**12,901**	**10.2%**
3.2	I-5	Marquam Br.	2,883	2.0%	8,341	5.8%	**11,224**	**7.7%**
4.3	I-84	W. of 122nd Ave.	2,007	1.8%	9,093	8.3%	**11,100**	**10.2%**
3.1	I-405	Fremont Br.	2,741	2.3%	7,009	5.9%	**9,751**	**8.2%**
6.14	I-205	Willamette River Br. In Oregon City	2,441	2.4%	6,851	6.8%	**9,292**	**9.2%**
4.9	I-205	Glen Jackson Br.	2,307	1.8%	6,781	5.2%	**9,087**	**7.0%**
6.1	I-205	At 65th Ave Undercrossing	1,991	2.3%	6,980	8.1%	**8,971**	**10.4%**
3.7	I-84	Grand St. Overcrossing	2,933	1.9%	5,284	3.4%	**8,217**	**5.2%**
4.35	I-84	E. of I-5	2,733	1.9%	5,028	3.4%	**7,761**	**5.3%**

Table 7.6 High Volume Portland FDC Truck Locations – State Highways

			Average Daily Traffic (ADT)					
Location ID	Roadway	Segment	Medium Trucks, #	Medium Trucks, %	Heavy Trucks, #	Heavy Trucks, %	**All Trucks, #**	**All Trucks, %**
3.9	US 30	W. of I-405	2,304	4.5%	6,372	12.5%	**8,676**	**17.0%**
1.4	US 30 (Yeon Ave.)	N. of Nicolai St.	1,636	4.0%	5,680	13.9%	**7,316**	**17.9%**
5.8	US 26 (Sunset Hwy)	E. of Cornell Rd.	2,617	2.2%	3,631	3.0%	**6,248**	**5.2%**
4.5	US 26 (Sunset Hwy)	E. of Highland Rd.	2,913	1.9%	3,017	2.0%	**5,931**	**3.9%**
6.10	OR 212	Between 82nd Ave. and I-205	1,268	2.8%	3,816	8.4%	**5,084**	**11.2%**
5.18	US 26 (Sunset Hwy)	W. of Shute Rd.	1,368	3.3%	2,384	5.8%	**3,752**	**9.2%**
1.2	US 30	South of St. Johns Br.	740	2.4%	2,796	9.0%	**3,536**	**11.3%**
7.5	SR 14	E. of I-205	1,484	1.8%	1,979	2.4%	**3,463**	**4.3%**
6.11	OR 213	S. of I-205	1,181	1.7%	2,108	3.1%	**3,289**	**4.8%**
6.8	OR 224	W. of OR 213 (Cascade Hwy)	748	1.5%	2,204	4.5%	**2,952**	**6.0%**
7.4	SR 14	E. of 192nd Ave.	789	1.9%	1,832	4.3%	**2,621**	**6.2%**
7.6	SR 14	W. of Lieser Rd.	891	1.4%	1,613	2.6%	**2,504**	**4.0%**
7.7	SR 500	E. of I-205	1,043	1.7%	1,296	2.2%	**2,339**	**3.9%**
5.14	OR 99W	Btwn Beaverton Tualatin Hwy and OR 217	932	1.9%	1,316	2.7%	**2,248**	**4.5%**
5.16	OR 99W	S. of Tualatin Sherwood Rd.	996	2.4%	1,192	2.9%	**2,188**	**5.3%**
6.9	OR 99E	N. of OR 224	1,136	2.2%	1,052	2.1%	**2,188**	**4.3%**
1.6	OR 99E	E. of I-5	644	4.2%	1,412	9.3%	**2,056**	**13.5%**

Table 7.7 High Volume Portland FDC Truck Locations – Arterials

Location ID	Roadway	Segment	Average Daily Traffic (ADT) Medium Trucks, #	Medium Trucks, %	Heavy Trucks, #	Heavy Trucks, %	**All Trucks, #**	**All Trucks, %**
1.20	Going St.	West of Greeley Ave.	1,904	5.4%	3,652	10.4%	**5,556**	**15.8%**
1.29	Marine Drive	W. of I-5	700	2.9%	4,708	19.8%	**5,408**	**22.7%**
5.27	Nyberg Rd.	Between Boones Ferry Rd. and I-5	1,800	3.2%	2,793	4.9%	**4,593**	**8.1%**
1.15	Columbia Blvd.	E. of I-5	928	3.9%	2,404	10.1%	**3,332**	**14.0%**
4.21	181st Ave.	Just South of I-84	1,052	2.7%	1,988	5.1%	**3,040**	**7.9%**
4.36	McLoughlin Blvd.	S. of EB Powell to SB McLoughlin Ramp	1,352	1.9%	1,504	2.2%	**2,856**	**4.1%**
4.7	Airport Way	Between I-205 and 122nd Ave.	1,305	4.3%	1,527	5.0%	**2,832**	**9.4%**
4.25	181st Ave.	Between I-84 and San Rafael St.	620	1.5%	2,168	5.2%	**2,788**	**6.7%**
5.6	Tualatin Sherwood Rd.	W. of Teton Ave.	809	3.5%	1,917	8.3%	**2,727**	**11.9%**
1.16	Columbia Blvd.	E. of OR 99W	768	4.1%	1,892	10.1%	**2,660**	**14.2%**
1.14	Columbia Blvd.	W. of OR 99W (Denver Ave.)	636	3.4%	1,912	10.3%	**2,548**	**13.7%**
1.17	Columbia Blvd.	N. of US 30 Bypass	868	4.7%	1,548	8.4%	**2,416**	**13.1%**
1.30	Marine Drive	NW of I-205	296	2.5%	1,840	15.3%	**2,136**	**17.7%**
1.13	Columbia Blvd.	S. of Burgard Rd.	244	3.2%	1,888	24.9%	**2,132**	**28.1%**
7.3	Padden	E. of 72nd Ave	908	2.3%	1,172	2.9%	**2,080**	**5.2%**
1.36	St. Johns Br.	North of US 30	548	2.4%	1,527	6.5%	**2,075**	**8.9%**

Some insights on truck traffic volumes on major freight corridors and freight access routes in the Portland metropolitan area are presented below:

- I-5 is the most critical freight corridor in the region with the highest truck traffic volumes relative to other freight corridors, particularly heavy trucks. I-5 in the southern part of the Portland Metro region, around the I-205 junction, experiences the highest truck traffic volumes. This is because of a large number of truck trips that are entering and exiting the region through I-5, as well as a high concentration of warehousing/distribution centers in Wilsonville that are generating significant truck trips. Trucks comprise about 12 percent of all vehicles surveyed on I-5, compared to an average of about 8 percent among all locations surveyed.
- Certain segments of I-205 (in Clackamas county, north of the OR224 junction, and further north halfway between US 26 and OR 224) have high daily truck volumes. This can be attributed to the high concentration of warehousing/ distribution activity in the Clackamas industrial area. A large share of the truck trips generated here use I-205 to access locations in the north.
- The dominant flow in the region is clearly north-south. With respect to east-west movements, the highest truck volumes occur on I-84 west of 122nd Avenue, with an average daily truck traffic of more than 11,000 trucks. I-84 is the major corridor used by trucks traveling between Portland and regions further east.
- On the state highways, few locations have more trucks than on the interstates and the truck percentages are generally lower. The east-west movements are the dominant flow for state highways. Notable non-interstate freight corridors in the region with high truck volumes include US 30 (used as a major freight corridor by truck trips to and from the marine terminals) and US 26 (Sunset Highway).
- Several of the arterial locations have high truck volumes and percentages, and this is significant. While nine of the state highway locations had more than 3,000 average daily trucks, five of the arterials also did. Also, some of the arterials have high fractions of heavy trucks (10 percent or more). These arterial locations serve as access routes to major freight facilities.
- The most heavily traveled freight access routes in the Portland metropolitan area by trucks include Going St (west of Greeley Avenue), Marine Drive (west of I-5), and OR 212 (between 82nd Drive and I-205), with more than 5,000 average daily truck trips. Going St provides access to a high concentration of transload facilities and trucking terminals, while Marine Drive and OR 212 provide access to/from marine terminals and warehousing/distribution centers in the Clackamas industrial area.
- Nyberg Road between Boones Ferry Road and I-5 is another high truck volume access route, used by trucks for access to transload facilities, and trucking terminals around the Tualatin area.

7.4 Time-of-Day Characteristics of Freight Traffic

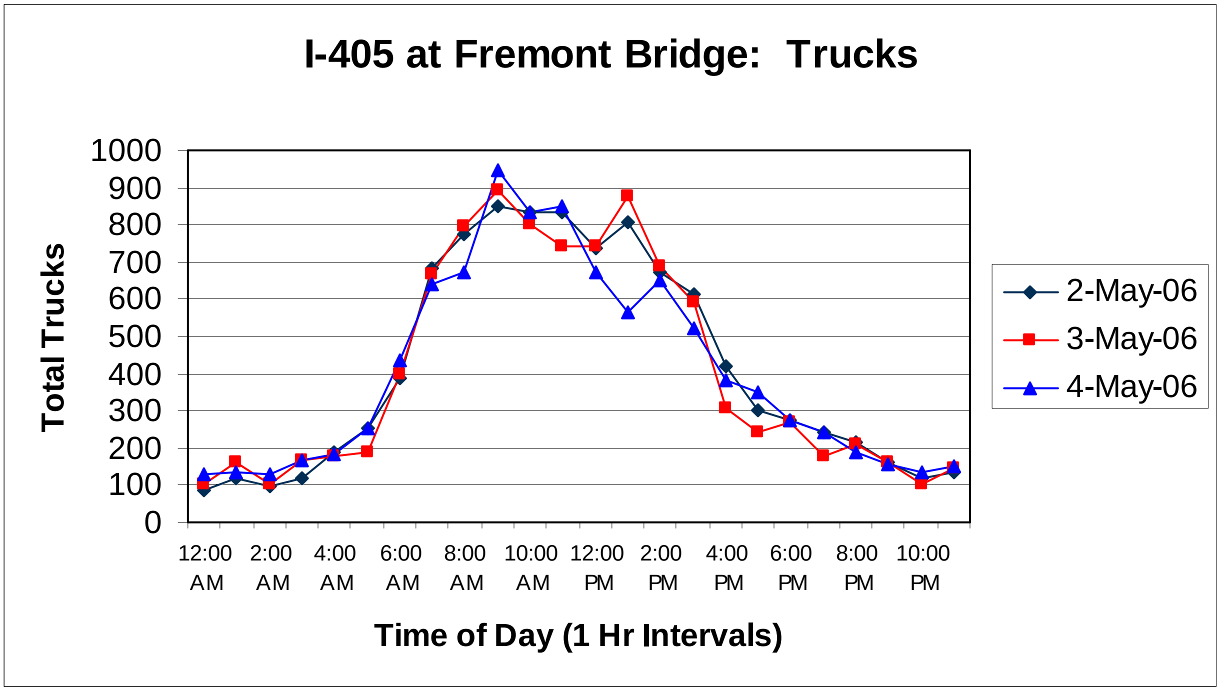
The Portland FDC truck count data can be used to analyze the variation of truck volumes by time of day, for a particular day of count data collection. Figures 7.2 to 7.8 show time of day characteristics for seven selected primary screenline locations. For each figure, the top diagram shows the patterns of truck traffic by time of day; the bottom diagram shows the patterns of all vehicle traffic by time of day. Several key features of these plots can be useful in analyzing truck traffic issues in the region over time:

- Overlap between truck activity and commute hours – For each type of facility and location, it is useful to examine the extent to which truck traffic and commuter traffic overlap and the size of trucks that are responsible for this overlap. Using the routing information from the roadside intercept surveys, it should also be possible to determine the degree to which this overlap is associated with long haul vs. local truck traffic. Trucks generally try to avoid commuter peaks but as local roadways become more congested and distribution centers are sited towards the perimeter of the region to obtain advantages of lower land costs and less restrictive land use regulations, trucks may be forced to operate in the commuter peaks to get to their destinations during the mid-day business hours. Watching this trend over time is useful.
- Degree to which time of day patterns vary by facility class (interstates vs. state highways vs. arterials) – This provides some indication of the types of truck trips that may be using these facilities.
- Day to day variation in truck trip time of day patterns.

Figure 7.2 presents time of day distribution of total truck and all vehicle traffic for Location 3.1: I-405 at the Fremont bridge. Some insights on time of day truck traffic characteristics at this location are presented below:

- There does not appear to be a significant day to day variation in time of day distribution of truck traffic at this location.
- Peak truck traffic is observed to occur on all the three days of count data collection during the 9:00 – 10:00 a.m. time period. There appears to be a second smaller peak during the 1:00 – 2:00 p.m. time period, though the average time of day distribution chart indicates a single morning peak.
- Also notable is the abrupt increase in truck traffic from the 6:00-7:00 am to the 7:00-8:00 am time periods.
- The time of day curve is not observed to be flat, indicating a marked difference in truck traffic between the day and night time periods.
- Morning and afternoon peaking is more pronounced for all vehicle traffic, as opposed to truck only traffic.

Figure 7.2 Location 3.1: I-405 at Fremont Bridge



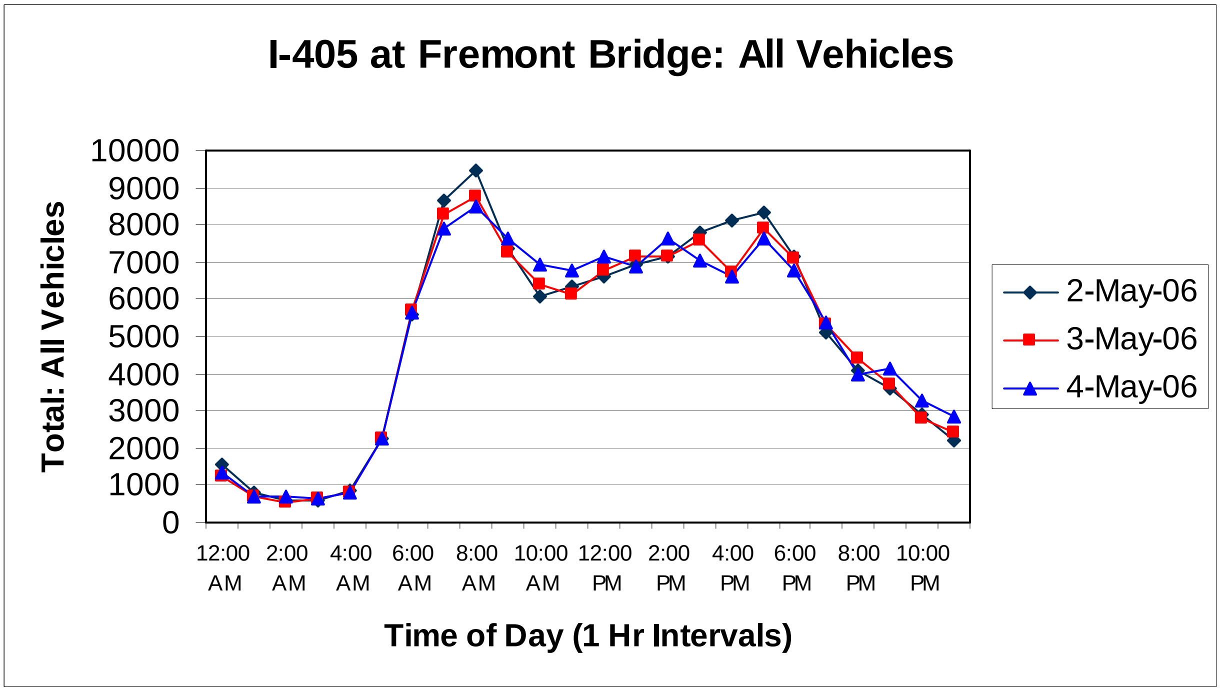
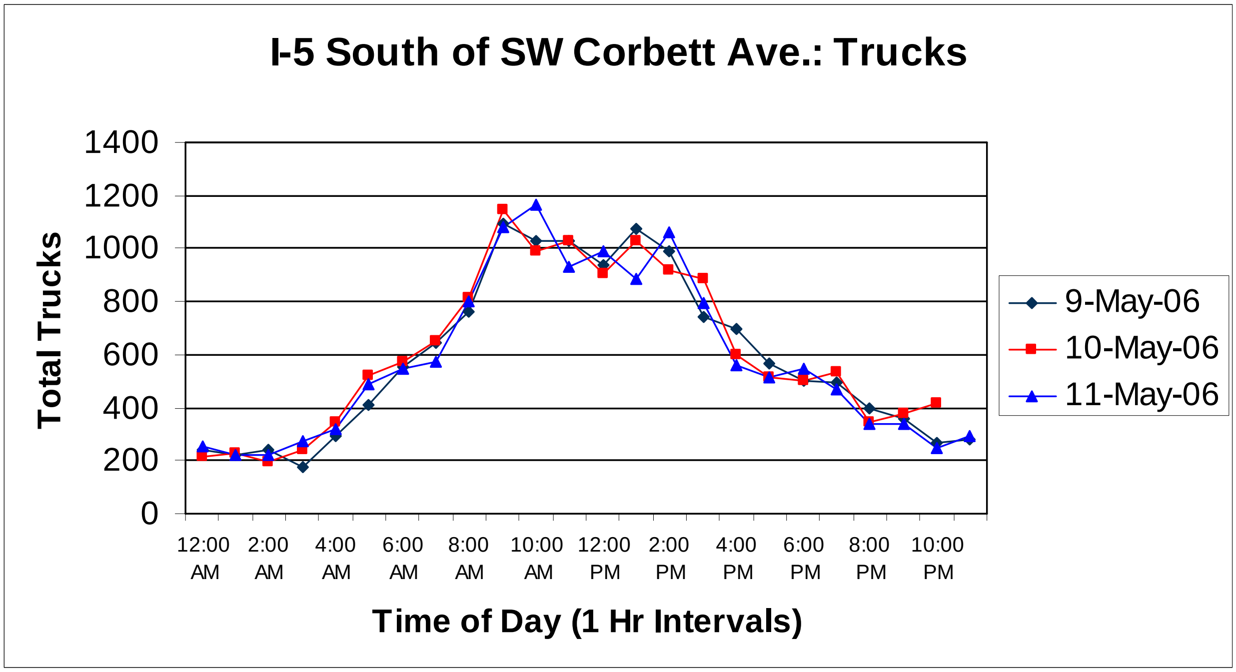


Figure 7.3 presents time of day distribution of total truck and all vehicle traffic for Location 4.2: I-5 south of SW Corbett Avenue. Some insights on time of day truck traffic characteristics at this location are presented below:

- There does not appear to be a significant day to day variation in time of day distribution of truck traffic at this location.
- Peak for average truck traffic volume is observed to be during the 9:00 – 10:00 am time period. Also, the hourly variation in truck traffic between 9:00 am and 2:00 p.m. is not very significant, indicating consistently high truck traffic during this time.
- The time of day curve is relatively flatter compared to I-405 at the Fremont bridge. A notable aspect of the time of day traffic distribution is the more flattened variation in hourly traffic volumes over distinct time periods during the day (9:00 pm – 6:00 am, 6:00 – 9:00 am, 9:00 am – 3:00 pm, 3:00 – 6:00 pm, and 6:00 – 9:00 pm). However, there is a sharp increase in truck traffic from the 8:00 – 9:00 am to the 9:00 – 10:00 am time periods.
- Morning and afternoon peaking is more pronounced for all vehicle traffic, as opposed to truck only traffic.

Figure 7.3 Location 4.2: I-5 south of SW Corbett Avenue



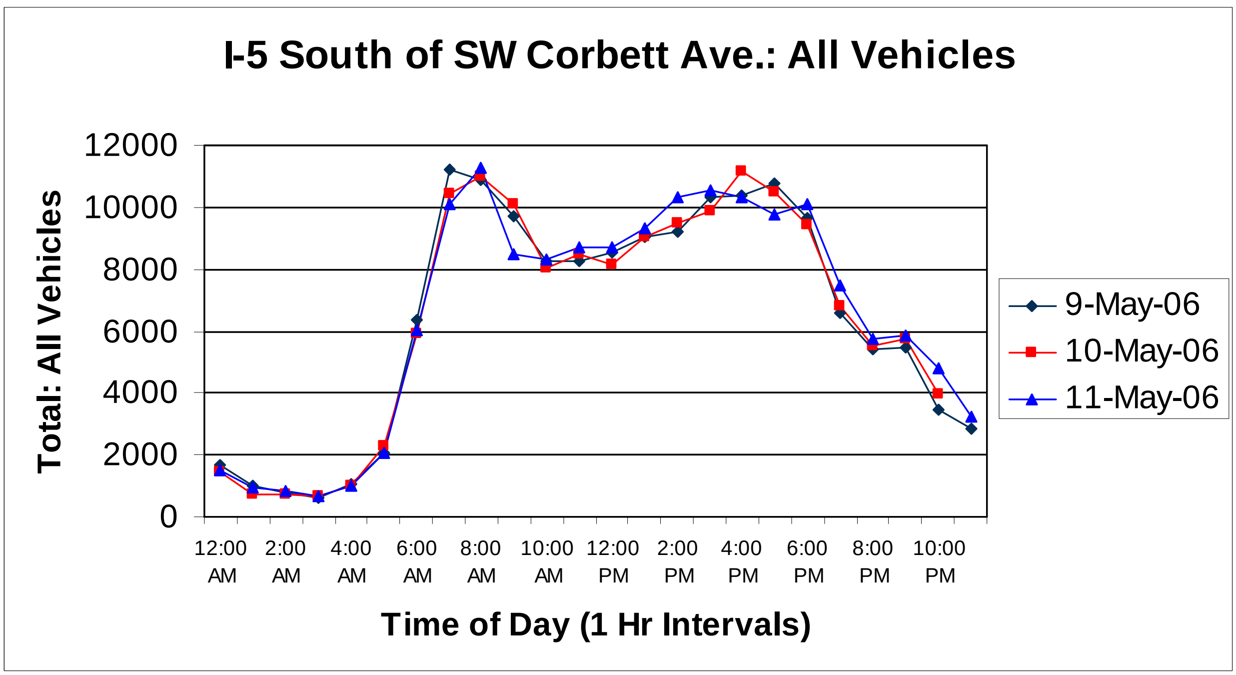
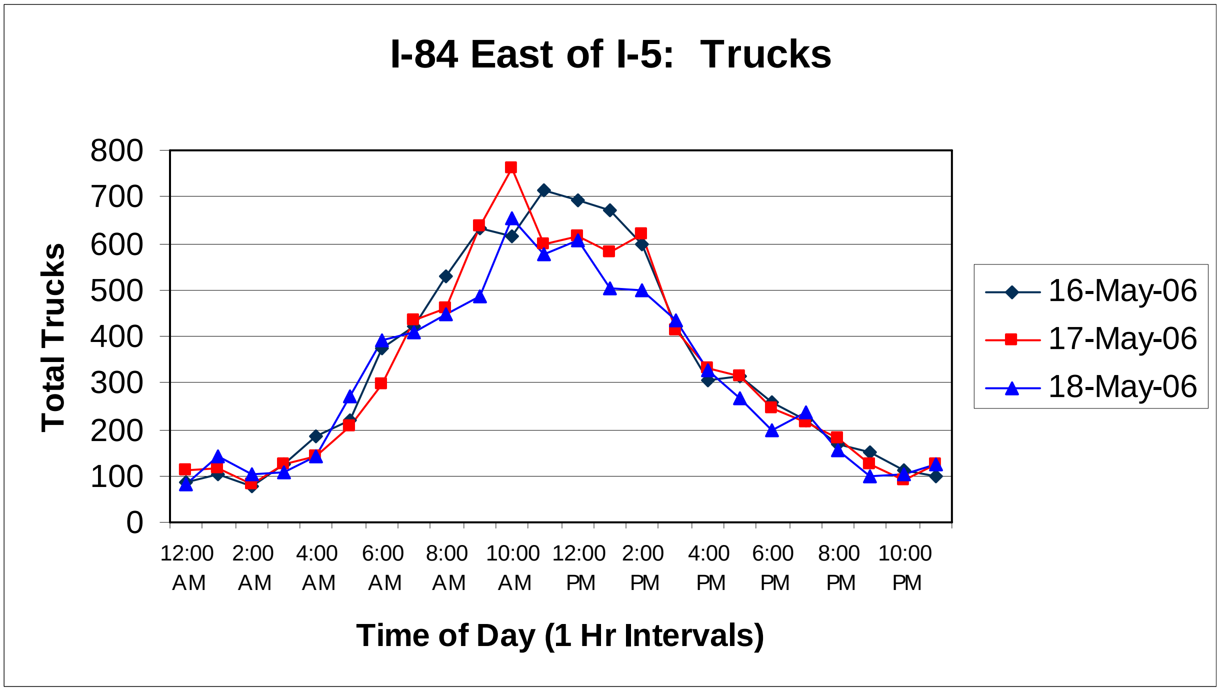


Figure 7.4 presents time of day distribution of total truck and all vehicle traffic for Location 4.35: I-84 east of I-5 (just east of the Grand Ave overcrossing). Some insights on time of day truck traffic characteristics at this location are presented below:

- There does not appear to be a significant day to day variation in time of day distribution of truck traffic at this location.
- Peak hour truck traffic is observed to occur during the following hours – Day 1 (11:00 am – 12:00 pm), Day 2 (10:00 – 11:00 am), and Day 3 (10:00 – 11:00 am). Peak hour for average truck traffic occurs during the 10:00 – 11:00 am time period.
- The time of day curve is not observed to be flat, indicating a marked difference in truck traffic between the day and night time periods.
- Morning and afternoon peaking is not pronounced for all vehicle traffic, with a fairly constant level of traffic from 7:00 am to 7:00 pm.

Multi-day counts taken at nearly the same location as this one (Location 3.07: I-84 at the Grand Ave overcrossing) indicated truck and all vehicle traffic volumes similar to this location.

Figure 7.4 Location 4.3: I-84 East of I-5



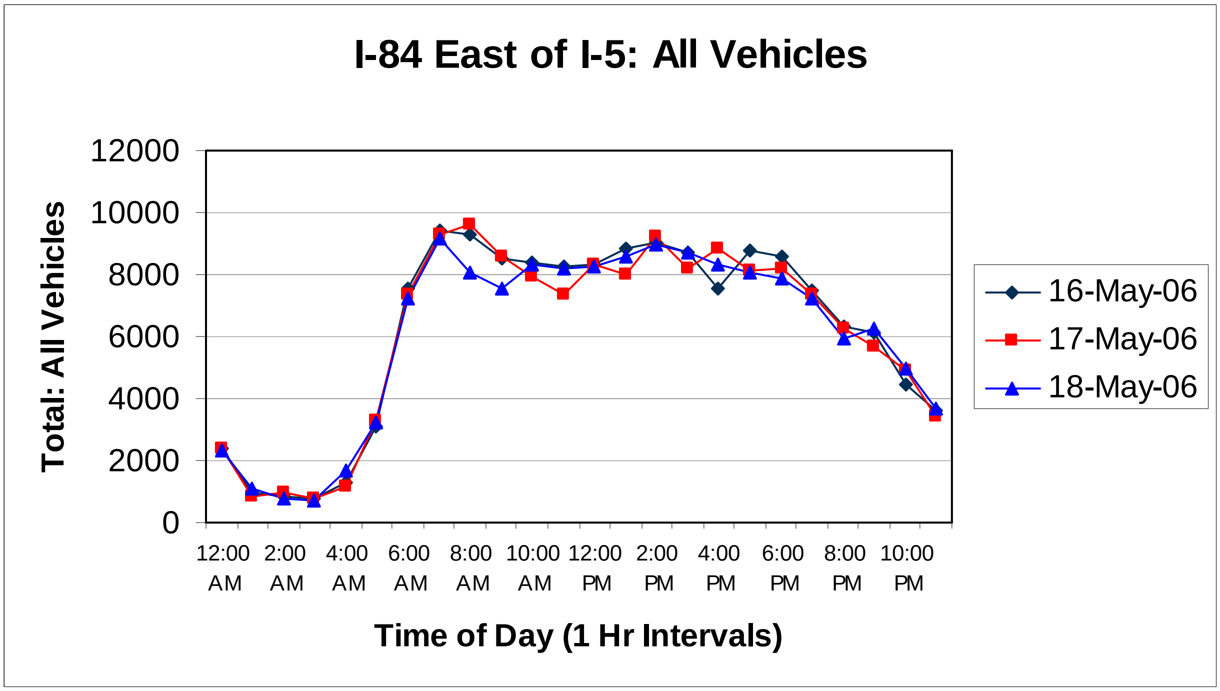
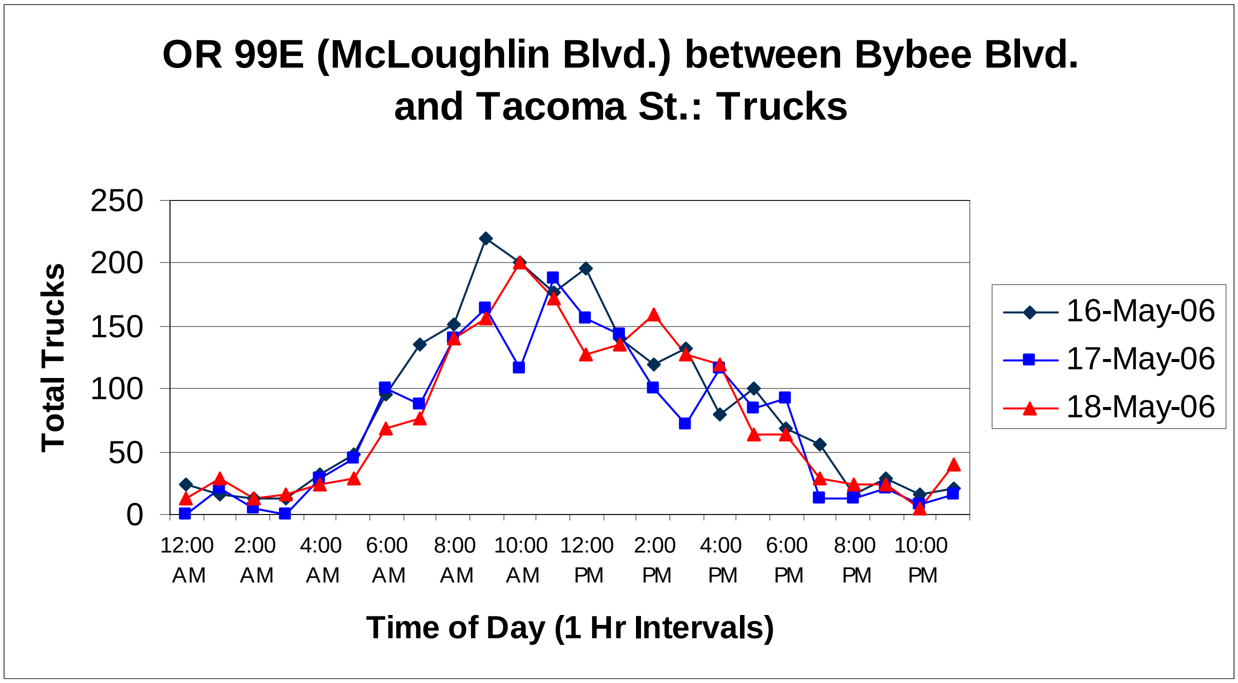


Figure 7.5 presents time of day distribution of total truck and all vehicle traffic for Location 4.4: OR 99E between Bybee Blvd. and Tacoma street. Some insights on time of day truck traffic characteristics at this location are presented below:

- There is significant day to day variation in time of day distribution of truck traffic at this location, particularly between the 9:00 am and 4:00 pm time period. This can be attributed to the lower magnitude of truck traffic volumes at this location.
- Peak hour truck traffic is observed to occur at a different time period during each day of count data collection – Day 1 (9:00 – 10:00 am), Day 2 (10:00 – 11:00 am), and Day 3 (11:00 am – 12:00 pm). Peak hour for average truck traffic occurs during the 9:00 – 10:00 am time period.
- Looking at the time of day distribution for average truck traffic, the curve does not appear to be flat. Particularly notable is the significant percent differences in hourly truck volumes between the night and day time periods.
- Morning and afternoon peaking is more pronounced for all vehicle traffic, as opposed to truck only traffic.

Figure 7.5 Location 4.4: OR 99E Between Bybee Boulevard and Tacoma Street



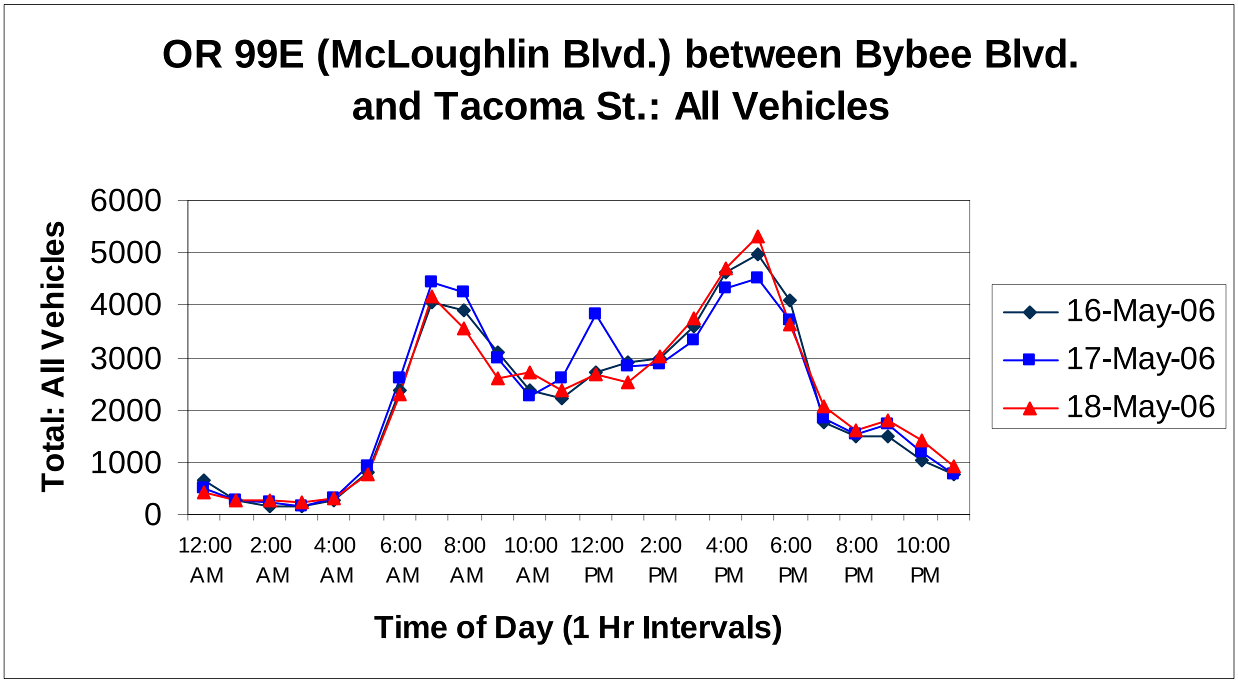
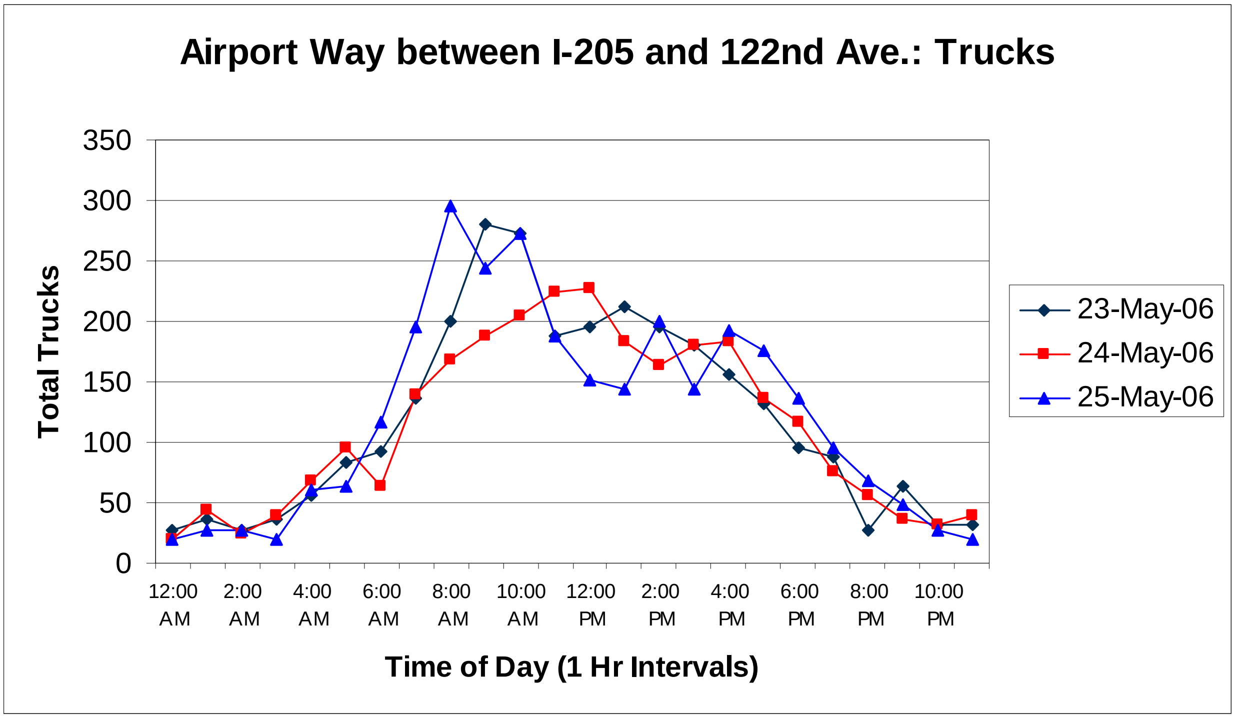


Figure 7.6 presents time of day distribution of total truck and all vehicle traffic for Location 4.7: Airport Way between I-205 and 122nd Avenue. Some insights on time of day truck traffic characteristics at this location are presented below:

- There is significant day to day variation in time of day distribution of truck traffic volumes at this location, particularly due to the lower magnitude of truck traffic volumes at this location.
- Peak hour truck traffic is observed to occur at a different time period during each day of count data collection – Day 1 (9:00 – 10:00 am), Day 2 (12:00 – 1:00 pm), and Day 3 (8:00 – 9:00 am). Peak hour for average truck traffic occurs during the 10:00 – 11:00 am time period.
- Looking at the time of day distribution for average truck traffic, the curve does not appear to be flat. Particularly notable is the significant percent differences in hourly truck volumes between the night and day time periods.
- There is no clear pattern of morning and afternoon peaking for either trucks or for all vehicles. Truck traffic generally appeared higher in the mornings, while all vehicle traffic appeared higher in the afternoons.

Figure 7.6 Location 4.7: Airport Way Between I-205 and 122nd Avenue



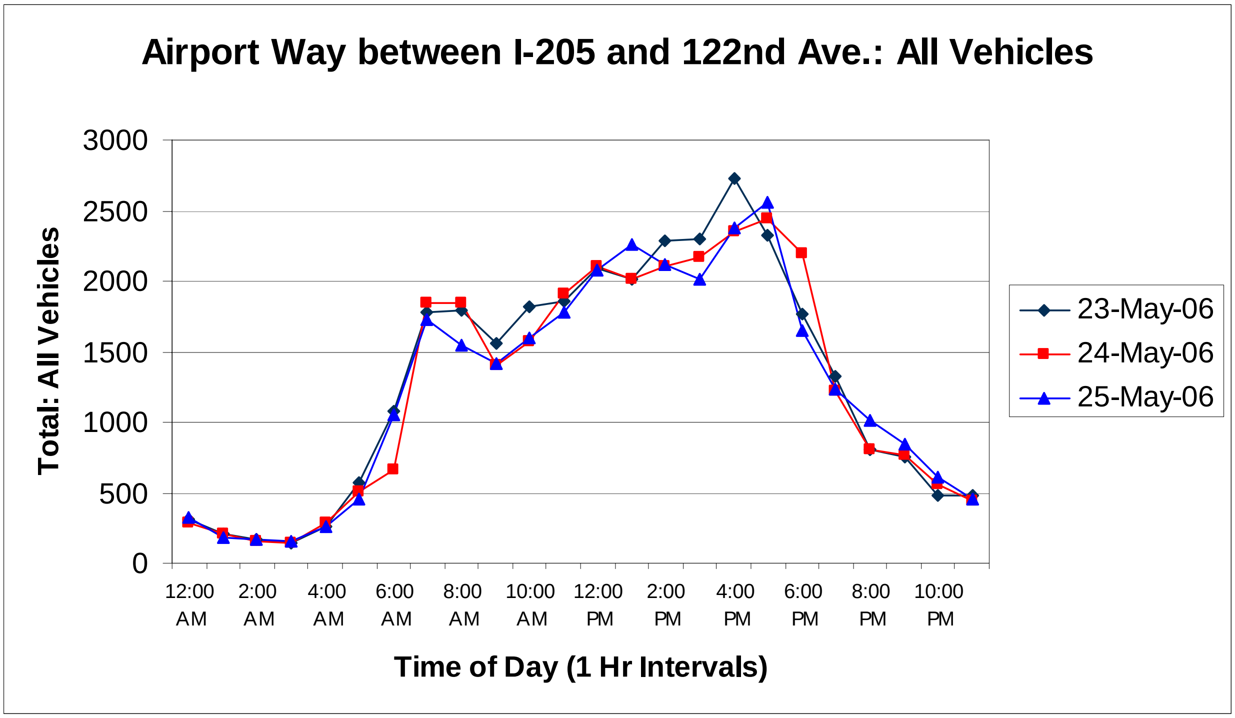
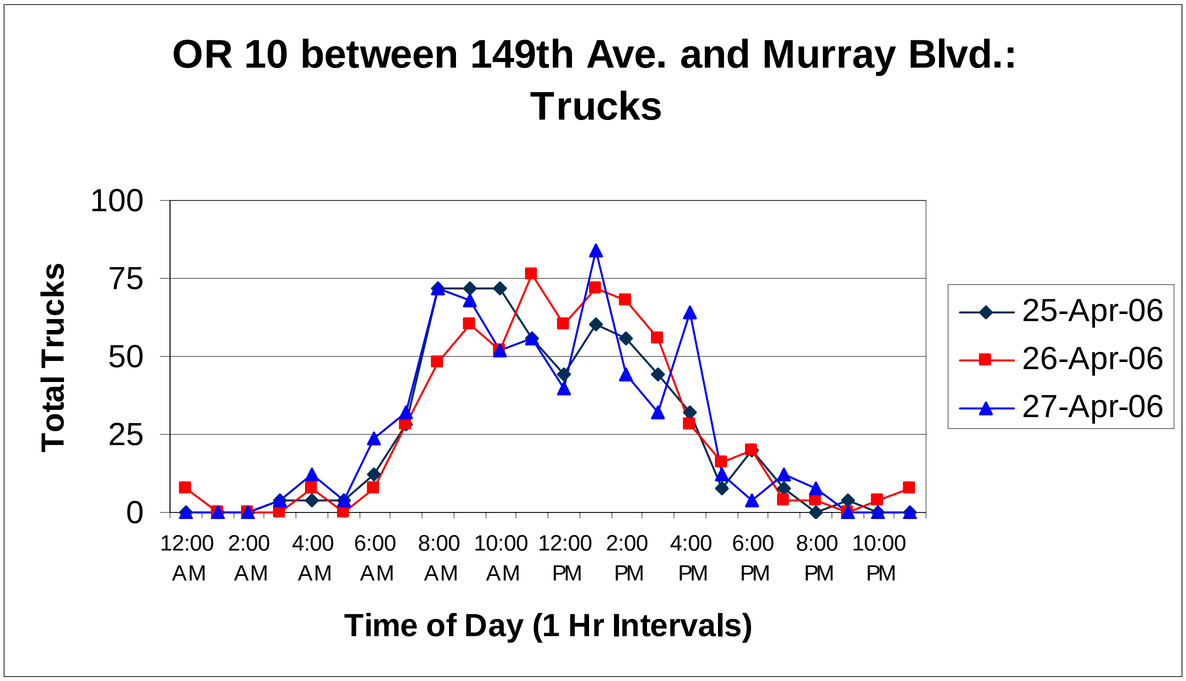


Figure 7.7 presents time of day distribution of total truck and all vehicle traffic for Location 5.3: OR 10 between 149th Avenue and Murray Boulevard. Some insights on time of day truck traffic characteristics at this location are presented below:

- There is significant day to day variation in time of day distribution of truck traffic at this location, particularly between the 8:00 am and 4:00 pm time period. This can be attributed to the lower magnitude of truck traffic volumes at this location.
- Peak hour truck traffic is observed to occur at a different time period during each day of count data collection – Day 1 (9:00 – 10:00 am), Day 2 (11:00 am – 12:00 pm), and Day 3 (1:00 – 2:00 pm). Peak hour for average truck traffic occurs during the 1:00 – 2:00 pm time period.
- Looking at the time of day distribution for average truck traffic, the curve does not appear to be flat. Particularly notable is the significant percent differences in hourly truck volumes between the night and day time periods.
- Morning and afternoon peaking is more pronounced for all vehicle traffic, as opposed to truck only traffic.

Figure 7.7 Location 5.3: OR 10 between 149th Avenue and Murray Boulevard



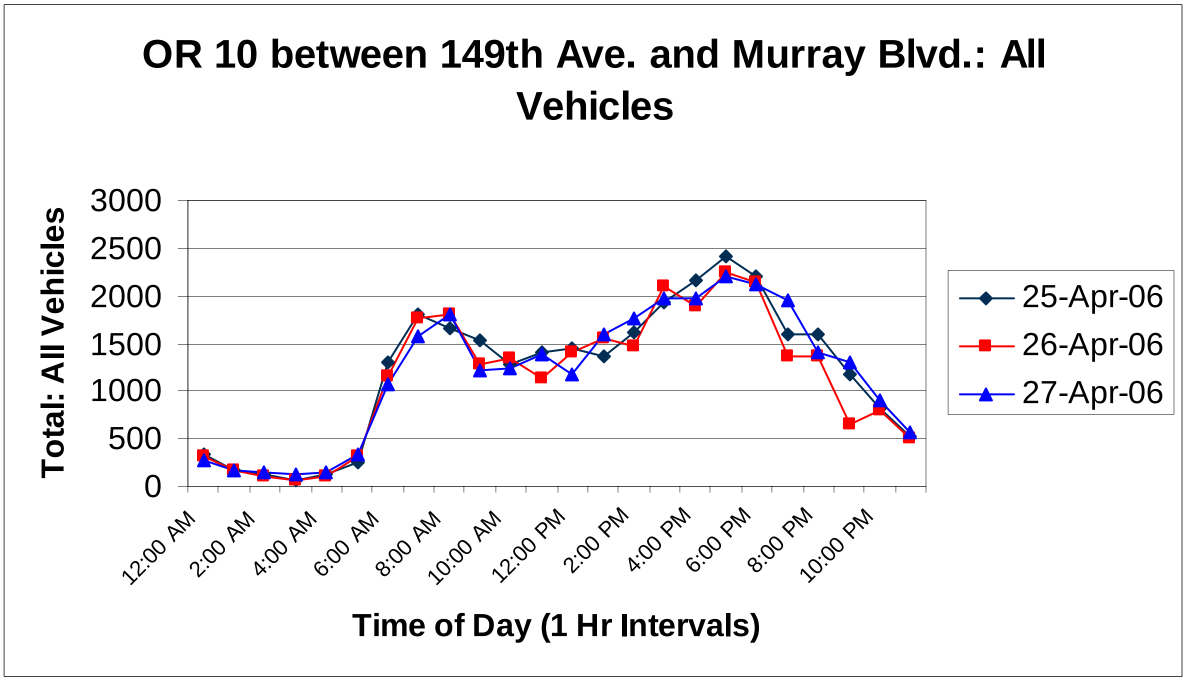
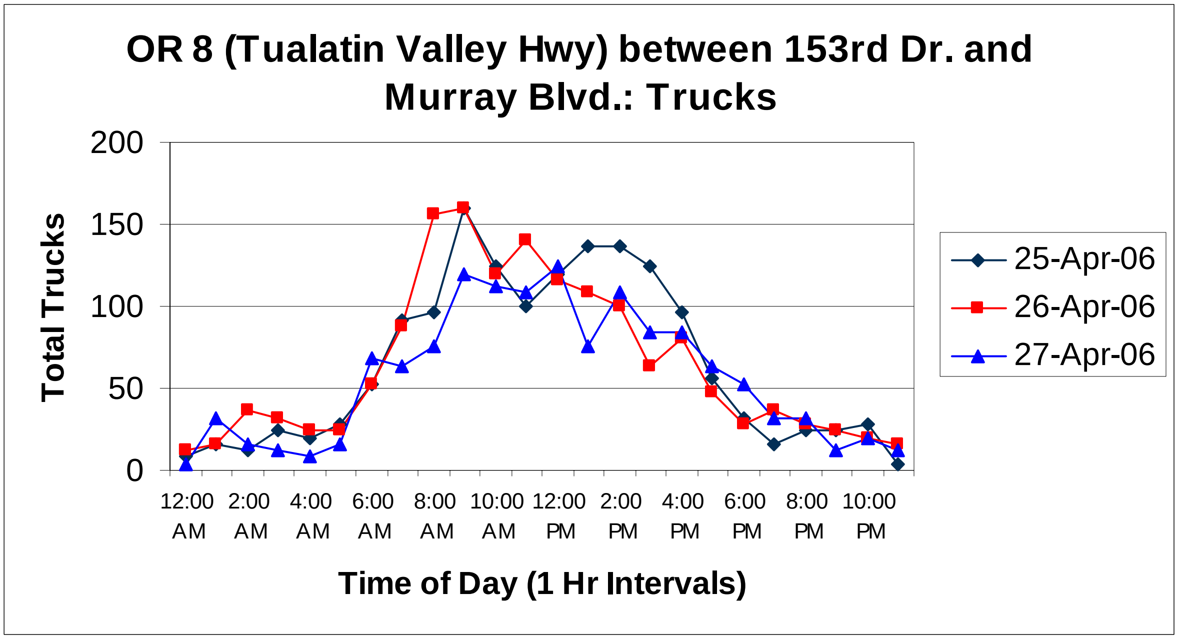
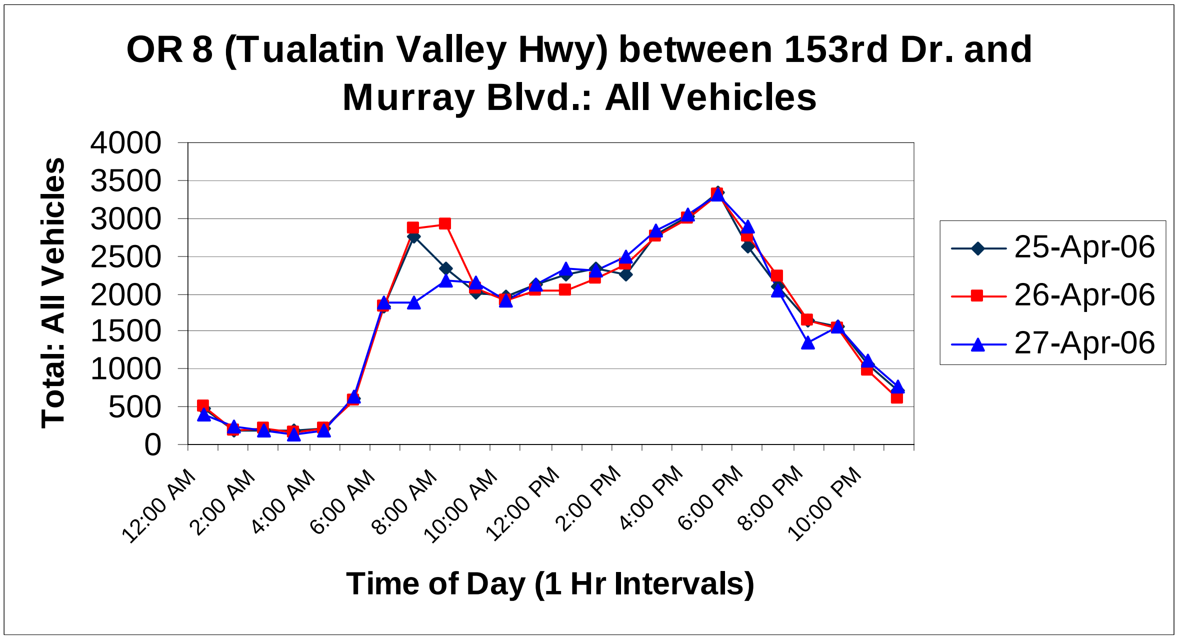


Figure 7.8 presents time of day distribution of total truck and all vehicle traffic for Location 5.7: OR 8 between 153rd Drive and Murray Boulevard. Some insights on time of day truck traffic characteristics at this location are presented below:

- There is significant day to day variation in time of day distribution of truck traffic at this location, particularly between the 8:00 am and 3:00 pm time period. This can be attributed to the lower magnitude of truck traffic volumes at this location.
- Peak hour truck traffic is observed to occur at the following time periods during each day of count data collection – Day 1 (9:00 – 10:00 am), Day 2 (9:00 – 10:00 am), and Day 3 (12:00 – 1:00 pm). Peak hour for average truck traffic occurs during the 9:00 – 10:00 am time period.
- Looking at the time of day distribution for average truck traffic, the curve does not appear to be flat. Particularly notable is the significant percent differences in hourly truck volumes between the night and day time periods.
- Morning and afternoon peaking is more pronounced for all vehicle traffic, as opposed to truck only traffic.

Figure 7.8 Location 5.7: OR 8 between 153rd Dr. and Murray Boulevard





7.5 Day-to-Day Variation in Volumes

The 72-hour Portland FDC truck count data can be used to analyze the day-to-day variation of truck traffic. Tables 7.7 to 7.9 provide this for all of the 72-hour count locations, except for locations 4.9 and 5.19 (which had data collection issues associated with a bad video angle and lost tapes).

Table 7.8 is for freeway locations, Table 7.9 is for state highway locations, and Table 7.10 is for arterial locations. The daily variance in total truck counts from the average of the three-day period tended to be higher for arterial locations than for freeway and state highway locations. These results suggest that a 24-hour count program should be sufficient for freeway locations but that multi-day data collection may provide more reliable averages on non-freeway locations.

Table 7.8 Daily Variance in Total Truck Count from Three-Day Average – Freeways

Location ID	Roadway	Segment	Day 1	Day 2	Day 3
1.1	I-5	Between Victory and OR 99W	-1.3%	0.0%	1.3%
3.1	I-405	Fremont Br.	-1.6%	0.5%	1.1%
3.2	I-5	Marquam Br.	-0.7%	3.2%	-2.5%
3.6	I-5	N. of I-405	4.2%	-4.8%	0.6%
3.7	I-84	Grand St. Overcrossing	-4.0%	-1.1%	5.1%
4.1	I-205	Between 92nd Ave. and Johnson Creek Blvd.	-1.9%	2.6%	-0.7%
4.2	I-5	S. of SW Corbett Ave. ramp	0.4%	-1.4%	1.0%
4.3	I-84	W. of 122nd Ave.	-2.4%	3.0%	-0.6%
4.8	I-5	Interstate Br.	1.3%	-2.9%	1.6%
4.35	I-84	E. of I-5	-4.3%	-0.7%	5.0%
4.37	I-5	N. of Going St.	-1.0%	-0.2%	1.2%
5.1	I-5	Between I-205 and Nyberg Rd.	0.3%	1.5%	-1.8%
6.1	I-205	At 65th Ave Undercrossing	-1.3%	1.9%	-0.7%
6.2	I-205/OR 212/213	Between 82nd Ave. and OR 213	-3.5%	3.4%	0.1%
6.3	I-205	Between 82nd Dr. and Sunnybrook St.	1.6%	3.5%	-5.1%
6.14	I-205	Willamette River Br. In Oregon City	-0.1%	7.1%	-7.0%

Table 7.9 Daily Variance in Total Truck Count from 3-Day Average – State Highways

Location ID	Roadway	Segment	Day 1	Day 2	Day 3
1.4	US 30 (Yeon Ave.)	N. of Nicolai St.	1.8%	-1.0%	-0.8%
3.9	US 30	W. of I-405	-0.8%	-0.2%	1.0%
4.4	OR 99E	Between Bybee Blvd. and Tacoma St.	-10.9%	8.8%	2.0%
4.5	US 26 (Sunset Hwy)	E. of Highland Rd.	-4.5%	10.5%	-6.0%
4.14	OR 99W	E. of I-5	5.7%	-6.9%	1.1%
4.28	US 26	Between Orient Drive and Burnside St	-1.8%	0.5%	1.3%
5.3	OR 10	Between 149th Ave. and Murray Blvd.	2.8%	-1.7%	-1.1%
5.4	OR 99W	S. of Cipole Rd.	4.7%	-7.0%	2.3%
5.7	OR 8	Between 153rd Dr. and Murray Blvd.	-4.4%	-4.4%	8.7%
5.8	US 26 (Sunset Hwy)	E. of Cornell Rd.	2.8%	2.2%	-5.0%
6.11	OR 213	S. of I-205	14.6%	1.4%	-16.0%
7.4	SR 14	E. of 192nd Ave.	5.5%	3.7%	-9.3%
7.5	SR 14	E. of I-205	-2.3%	1.0%	1.3%
7.6	SR 14	W. of Lieser Rd.	-0.6%	1.0%	-0.3%
7.7	SR 500	E. of I-205	-2.3%	-3.3%	5.6%

Table 7.10 Daily Variance in Total Truck Count from Three-Day Average – Arterials

Location ID	Roadway	Segment	Day 1	Day 2	Day 3
1.13	Columbia Blvd.	S. of Burgard Rd.	-4.7%	0.6%	4.1%
1.23	Lombard St.	N. of Columbia Blvd. (Rivergate area)	-2.0%	-6.0%	8.0%
1.36	St. Johns Br.	North of US 30	-0.3%	1.7%	-1.4%
2.1	26th Avenue	At Port of Vancouver terminal gate	10.0%	12.4%	-22.4%
2.4	Mill Plain Blvd.	W. of I-5 Interchange	-5.1%	0.6%	4.4%
3.3	Hawthorne Br.	Between OR 99W and I-5	7.8%	-4.7%	-3.1%
3.4	Morrison Br.	Between OR 99W and I-5	14.9%	-4.7%	-10.2%
3.10	Broadway St.	Between Larrabee Ave. and I-5	-2.0%	-1.4%	3.4%
3.11	Interstate Ave.	N. of Russell Street	-4.6%	11.2%	-6.5%
4.6	Marine Dr.	Between I-205 and 122nd Ave.	1.9%	8.9%	-10.8%
4.7	Airport Way	Between I-205 and 122nd Ave.	-0.6%	4.2%	-3.7%
4.20	181st Ave.	Between Sandy Blvd. and I-84	-2.8%	1.3%	1.5%
4.21	181st Ave.	Just South of I-84	1.2%	-0.5%	-0.7%
4.22	Birdsdale Dr.	Just North of US 26	-9.8%	-9.8%	19.5%
4.27	207th Ave.	Just South of I-84	-3.3%	-0.5%	3.8%
4.30	Glisan St.	Between 207th Ave. and 223rd Ave	5.6%	-1.5%	-4.1%
4.31	Eastman Parkway	Just North of Burnside	7.5%	-7.2%	-0.3%
5.2	Jenkins Rd.	Between Murray Blvd. and Bowerman Dr.	-3.3%	6.6%	-3.3%
5.5	Scholls Ferry Rd.	Between Murray Blvd. and Murray Scholls. Dr.	3.4%	6.9%	-10.3%
5.6	Tualatin Sherwood Rd.	W. of Teton Ave.	-1.1%	0.8%	0.2%
5.9	Walker Rd.	Between Murray Blvd. and Meadow Dr.	-27.1%	11.4%	15.7%
5.26	Boones Ferry Rd.	Between Nyberd St. and Tualatin Rd.	-7.4%	5.3%	2.1%
5.27	Nyberg Rd.	Between Boones Ferry Rd. and I-5	-6.9%	3.4%	3.5%

7.6 Model Validation

The Portland FDC truck count data were compared with year 2000 Metro model outputs at the 24 matching locations. The Portland FDC truck count data were collected in 2006, while the Metro model outputs are for the year 2000. Because of this six-year time difference, the Metro model outputs would be expected to be lower than the Portland FDC counts. On average:

- The Metro model results were 14.3 percent lower than the FDC counts for the medium truck comparison;
- The Metro model results were 14.4 percent lower than the FDC counts for the heavy truck comparison, excluding locations 3.03 and 5.09 for which small truck volumes resulted in large percentage discrepancies.

Table 7.11 provides the comparison with locations sorted by facility type, separately for medium and heavy trucks. The percentages show the difference between the Metro model and the Portland FDC count; differences of more than +/- 50 percent are highlighted. The freeway locations tended to have smaller percentage deviations than the state highway or arterial locations. This is understandable in light of the much higher volumes on freeways relative to state highways and arterials. In general, the model tends to underpredict truck volumes on state highways and arterials relative to its performance on freeways. There are a number of factors which could create these results. One possibility is potential inaccuracies in the origin-destination patterns in the model that would tend to affect access to freight facilities along the small roadways but would be less noticeable in relation to larger general flow patterns. A second possibility is that the assignment procedures route more traffic on freeways because of higher speeds and shorter travel times. The models do not take into account the relative reliability of these facilities which may also affect routing decisions.

Table 7.12 provides the comparison with locations sorted according to primary screenline. The primary screenline locations are used by Metro for model validation (see Technical Memorandum for Task 2: Review of Metro's Truck/Freight Model, for an explanation of the model screenlines). The differences were smallest for screenlines W-19 (Multnomah County, Other), R-5 (Multnomah County, Other) and R-7 (Multnomah County, Other), which were all freeway location comparisons. The differences were largest for arterial locations on screenlines R-2 (Downtown Portland), E-09 (Multnomah County, Other), and W-03 (Washington County).

7.7 Regionwide GIS Analysis

Appendix D: Regionwide GIS Analysis (11" x 17" printout) presents average daily truck traffic volumes (ADTT) at each count location as a share of average daily total traffic (ADT) as a GIS map.

Table 7.11 Comparison of Year 2000 Metro Model Output with FDC Truck Count Data, Sorted by Facility Type

Location ID	Roadway	Segment	Facility Type	Avg Weekday Two-Way Total: Medium Trucks (2 Axle, 6 Tire) From Truck Counts	From Truck Model	Percent Difference	Avg Weekday Two-Way Total: Heavy Trucks (3 Axles or More) From Truck Counts	From Truck Model	Percent Difference
3.1	I-405	Fremont Br.	Freeway	2,741	2,159	-21.2%	7,009	6,939	-1.0%
3.2	I-5	Marquam Br.	Freeway	2,883	2,489	-13.7%	8,341	7,102	-14.9%
4.1	I-205	Btwn 92nd Ave. & Johnson Creek Blvd.	Freeway	3,635	2,828	-22.2%	10,108	6,815	-32.6%
4.2	I-5	S. of SW Corbett Ave. ramp	Freeway	3,591	3,817	6.3%	10,475	9,276	-11.4%
4.3	I-84	W. of 122nd Ave.	Freeway	2,007	2,273	13.3%	9,093	6,725	-26.0%
4.8	I-5	Interstate Br.	Freeway	2,957	2,994	1.2%	10,873	9,299	-14.5%
4.9	I-205	Glen Jackson Br.	Freeway	2,307	2,502	8.5%	6,781	5,724	-15.6%
5.1	I-5	Between I-205 and Nyberg Rd.	Freeway	4,235	3,358	-20.7%	12,751	8,697	-31.8%
6.1	I-205	At 65th Ave Undercrossing (County Line)	Freeway	1,991	1,409	-29.2%	6,980	4,688	-32.8%
6.2	I-205/OR 212/213	Between 82nd Ave. and OR 213	Freeway	3,461	2,547	-26.4%	9,920	6,091	-38.6%
4.4	OR 99E	Between Bybee Blvd. and Tacoma St.	State Highway	948	303	-68.0%	943	496	-47.4%
4.5	US 26 (Sunset Hwy)	E. of Highland Rd.	State Highway	2,913	2,229	-23.5%	3,017	5,755	90.7%
5.3	OR 10	Between 149th Ave. and Murray Blvd.	State Highway	275	291	5.9%	343	394	15.0%
5.4	OR 99W	S. of Cipole Rd.	State Highway	799	641	-19.7%	909	1,235	35.8%
5.7	OR 8	Between 153rd Dr. and Murray Blvd.	State Highway	695	319	-54.1%	769	507	-34.1%
5.8	US 26 (Sunset Hwy)	E. of Cornell Rd.	State Highway	2,617	1,328	-49.3%	3,631	4,503	24.0%
3.3	Hawthorne Br.	Between OR 99W and I-5	Arterial	437	296	-32.3%	40	203	407.5%
3.4	Morrison Br.	Between OR 99W and I-5	Arterial	672	930	38.4%	287	427	49.0%
4.6	Marine Dr.	Between I-205 and 122nd Ave.	Arterial	467	977	109.4%	1,201	822	-31.6%
4.7	Airport Way	Between I-205 and 122nd Ave.	Arterial	1,305	1,665	27.6%	1,527	835	-45.3%
5.2	Jenkins Rd.	Btwn Murray Blvd. and Bowerman Dr.	Arterial	303	53	-82.5%	224	127	-43.3%
5.5	Scholls Ferry Rd.	Btwn Murray Blvd & Murray Scholls. Dr.	Arterial	289	132	-54.4%	411	195	-52.5%
5.6	Tualatin Sherwood Rd.	W. of Teton Ave.	Arterial	809	512	-36.7%	1,917	817	-57.4%
5.9	Walker Rd.	Between Murray Blvd. and Meadow Dr.	Arterial	192	191	-0.5%	88	630	615.9%

Table 7.12 Comparison of Year 2000 Metro Model Output with TCP Truck Count Data, Sorted by Primary Screenline

Location ID	Roadway	Segment	Facility Type	Avg Weekday Two-Way Total: Medium Trucks (2 Axle, 6 Tire) From Truck Counts	From Truck Model	Percent Difference	Avg Weekday Two-Way Total: Heavy Trucks (3 Axles or More) From Truck Counts	From Truck Model	Percent Difference
Screenline R-2: Downtown Portland									
3.01	I-405	Fremont Br.	Freeway	2,741	2,159	-21.2%	7,009	6,939	-1.0%
3.02	I-5	Marquam Br.	Freeway	2,883	2,489	-13.7%	8,341	7,102	-14.9%
3.03	Hawthorne Br.	Between OR 99W and I-5	Arterial	437	296	-32.3%	40	203	407.5%
3.04	Morrison Br.	Between OR 99W and I-5	Arterial	672	930	38.4%	287	427	49.0%
Screenline E-21: Multnomah County, Other									
4.01	I-205	Btwn 92nd Ave. & Johnson Creek Blvd.	Freeway	3,635	2,828	-22.2%	10,108	6,815	-32.6%
4.04	OR 99E	Between Bybee Blvd. and Tacoma St.	State Highway	948	303	-68.0%	943	496	-47.4%
Screenline W-19: Multnomah County, Other									
4.02	I-5	S. of SW Corbett Ave. ramp	Freeway	3,591	3,817	6.3%	10,475	9,276	-11.4%
Screenline E-09: Multnomah County, Other									
4.03	I-84	W. of 122nd Ave.	Freeway	2,007	2,273	13.3%	9,093	6,725	-26.0%
4.06	Marine Dr.	Between I-205 and 122nd Ave.	Arterial	467	977	109.4%	1,201	822	-31.6%
4.07	Airport Way	Between I-205 and 122nd Ave.	Arterial	1,305	1,665	27.6%	1,527	835	-45.3%
Screenline W-07: Multnomah County, Other									
4.05	US 26 (Sunset Hwy)	E. of Highland Rd.	State Highway	2,913	2,229	-23.5%	3,017	5,755	90.7%
Screenline R-5: Multnomah County, Other									
4.08	I-5	Interstate Br.	Freeway	2,957	2,994	1.2%	10,873	9,299	-14.5%
Screenline R-7: Multnomah County, Other									
4.09	I-205	Glen Jackson Br.	Freeway	2,307	2,502	8.5%	6,781	5,724	-15.6%
Screenline W-03: Washington County									
5.01	I-5	Between I-205 and Nyberg Rd.	Freeway	4,235	3,358	-20.7%	12,751	8,697	-31.8%
5.02	Jenkins Rd.	Btwn Murray Blvd. and Bowerman Dr.	Arterial	303	53	-82.5%	224	127	-43.3%
5.03	OR 10	Between 149th Ave. and Murray Blvd.	State Highway	275	291	5.9%	343	394	15.0%
5.04	OR 99W	S. of Cipole Rd.	State Highway	799	641	-19.7%	909	1,235	35.8%
5.05	Scholls Ferry Rd.	Btwn Murray Blvd & Murray Scholls. Dr.	Arterial	289	132	-54.4%	411	195	-52.5%
5.06	Tualatin Sherwood Rd.	W. of Teton Ave.	Arterial	809	512	-36.7%	1,917	817	-57.4%
5.07	OR 8	Between 153rd Dr. and Murray Blvd.	State Highway	695	319	-54.1%	769	507	-34.1%
5.08	US 26 (Sunset Hwy)	E. of Cornell Rd.	State Highway	2,617	1,328	-49.3%	3,631	4,503	24.0%
5.09	Walker Rd.	Between Murray Blvd. and Meadow Dr.	Arterial	192	191	-0.5%	88	630	615.9%
Screenline W-14: Clackamas County									
6.01	I-205	At 65th Ave Undercrossing (County Line)	Freeway	1,991	1,409	-29.2%	6,980	4,688	-32.8%
Screenline E-27: Clackamas County									
6.02	I-205/OR 212/213	Between 82nd Ave. and OR 213	Freeway	3,461	2,547	-26.4%	9,920	6,091	-38.6%

8.0 Motor Carrier Surveys

8.1 Introduction

Motor carrier surveys were conducted by Starboard Alliance Company LLC from September through November 2006 to ascertain freight flows by different types of trucking companies in, out and through the Portland metropolitan area. The list of target truckload, less-than-truckload (LTL) and private (beneficial cargo owners operating their own fleets) motor carriers for the surveys was developed based on knowledge of the trucking industry in the region, and in consultation with several trucking industry experts.

All of these carriers were targeted because they operate out of terminal facilities (which are represented as a type of reload facility in the Metro freight model) or they serve other reload facilities (warehouse and distribution facilities). Reload activities are an increasingly important component of freight activity, as logistics and supply chains have become more complex. Yet the truck trip patterns of these facilities are not well understood, and may not be effectively represented in the current freight model (see Technical Memorandum for Task 2 for further discussion of this issue). This survey was meant to provide some further insight into truck trip patterns associated with these facilities.

The final survey list included a wide variety of motor carriers to ensure the sample was as representative as possible of the trucking industry in the region. The list included motor carriers differing by size (small, medium, and large); market area (local, regional and national); type of carrier (full truckload (FT); less-than-trailerload (LTL) and private); type of commodity carried (general commodity, and specialized haulers such as steel, household goods, refrigerated products, and lumber); and drayage (airport and harbor).

Sections 8.2 and 8.3 provide the general findings and summary of the data analysis findings, as prepared by Starboard Alliance. The complete technical report from Starboard Alliance is available under separate cover. Sections 8.4 and 8.5 provide additional cross-tabulatory analyses of the data collected from the motor carrier surveys, conducted by Cambridge Systematics (CS), to help answer key questions related to trucking activity in the Portland metropolitan area.

8.2 General Findings

Analysis results from the motor carrier surveys revealed a trend for motor carriers to diversify and offer an assortment of services to customers. In the past, motor carriers tended to be either less-than-truckload (LTL) or full truckload (FT or TL), specialized or general haulers, regional or national. Today, the lines between carrier types have become blurred, with each carrier trying to capture as much business as possible, regardless of the type. Even some carriers that may have previously focused on a particular region seem now to haul outside of that geographic scope to a certain degree.

Carriers have unique business models and operating behaviors even within categories - from operating hours to types and quantities of cargo hauled and markets served. Motor carriers rely on the Portland metropolitan areaal transportation network to haul local as well as national loads. From the results of this survey, one can surmise that the Portland metropolitan area including Clark County is a key origin and destination for the carriers interviewed, and also an area through which cargo traverses on its way to somewhere else. Import, export and domestic products flow in and out of the region, but it is not clear from the survey in what proportions. Cargo is trucked all over the U.S., but Oregon and Washington were mentioned by most firms as key areas. The Port of Portland and Portland International Airport are served, but the motor carriers surveyed more often pick up and deliver to customer distribution centers, warehouses, manufacturing and processing facilities, reload centers, and stores.

The types of products handled vary widely across the carrier base. Specialty carriers tend to haul a limited variety of products and stick to their niches (i.e. steel, lumber, household goods, etc.). General haulers carry a diverse range from fast moving consumer goods that are often imported, to foodstuffs and beverages, paper products and building materials. Motor carriers view the critical, major freight arteries around the Portland metropolitan area – specifically I-5, I-205, and I-84 – as congested, and this impacts their ability to serve their customers effectively and operate profitably. Many motor carriers operate around the clock during weekdays and some even on weekends. Night work helps even out the flow of shipments and enables the carriers to be more productive due to lighter highway traffic. No dramatic seasonal volume fluctuations emerged.

8.3 Summary of Data Analysis Findings

Data was cross-tabulated according to the following four categories: A – primarily LTL; B – primarily TL and performs cargo manipulation; C – primarily TL and does not perform cargo manipulation; D – private fleet.

Facility Functions. All types of motor carriers store trucks at their facilities, and load and/or unload cargo at their facilities, and refueling is fairly common. Seven companies, all in category C, do not perform cargo manipulation at their facilities. These motor carriers pick up cargo at one location and deliver to another, generally without stopping at their terminals except for refueling.

Facility Operating Hours. There is no real pattern in operating hours. Beneficial cargo owners operating their own fleets often operate nearly around the clock, including weekends, since some are supplying products to their own stores or moving perishable products.

Employees per Facility. Category A: 26 to 1,767. Category B: 40 to 206. Category C: 5 to 330. Category D: 23 to 560.

Truck Drivers. Category A: 4 to 365. Category B: 10 to 150. Category C: 0 to 220. Category D: 11 to 135.

Trucks Owned or Leased. Category A: 14 to 492. Category B: 11 to 90. Category C: 5 to 200. Category D: 12 to 105.

Empty Moves. Category A firms do the best job in keeping empty moves to a minimum, with all reporting empty moves of 20 percent or less. Firms in categories B, C and D have wide ranges from 5 percent to 80 percent, from 4 percent to 50 percent, and from 15 percent to 75 percent respectively. Most tend to follow one of two patterns; 1) they leave their facilities empty, pick up a load and deliver it, and then return to their facilities empty; or 2) they depart their facilities with a load, deliver it, and then return to the facilities empty.

Inbound Truck Shipments. Companies in all categories use tractor semi-trailers as their primary piece of equipment for cargo originating from within the Portland metropolitan area. Category A carriers also use straight trucks, doubles and triples. Category B companies use straight trucks, but no doubles or triples. Three Category C companies also use doubles, but none use straight trucks or triples. Three Category C firms use straight trucks, one uses doubles, and none use triples.

For shipments originating outside the Portland metropolitan area, there is a wide divergence in the percentage of shipments that move in the four trailer sizes for Category A carriers. In Category B, the results are more defined with the majority of moves being in tractor semi-trailers and only three companies reporting moves of 20 percent or less in straight trucks. Category C companies are heavy users of tractor semi-trailers and doubles. Two Category D companies use straight trucks for a small percentage of moves and all are heavy users of tractor semi-trailers.

Outbound Truck Shipments. Category A companies move cargo is each of the four size trucks to destinations within the Portland metropolitan area to varying degrees. In Category B, straight trucks are frequently used, with three companies reporting 70 percent or over. Moves in tractor semi-trailers are more dispersed, with answers ranging from 20 percent to 100 percent. In Category C, no straight trucks or triples are used. Answers vary widely in terms of percentage moved in tractor semi-trailers and doubles. The majority of moves in Category D are in straight trucks and tractor semi-trailers.

There is no clear pattern of truck size usage among Category A firms for moves destined outside the Portland metropolitan area, with all sizes in use. Tractor semi-trailers are the prime piece of equipment in use by Category B companies, with straight trucks being secondary. Only one company uses doubles and none use triples. Category C firms use tractor semi-trailers and doubles only. There is no clear pattern of truck size usage among Category D companies, with all sizes in use.

Inbound Commodities. Motor carriers handle a wide variety of products and many were unable to provide data for specific commodities; rather they classify their cargo in a "general commodity" category. Cargo originates all over the U.S., but the majority of the freight handled by these motor carriers originates in western states, with OR and WA being key. Most inbound long haul shipments for Category A carriers fall in the over 101 mile grouping, but shipments of all lengths are made. Results for Category B firms are less well defined. Most inbound shipments for Category C companies fall in the over 101 mile group. Results for Category C firms are less well defined

Outbound Commodities. Outbound cargo is also quite diverse. Motor carriers report they haul products to destinations all over the U.S., but OR and WA are the dominant destination regions. Most outbound long haul shipments for Category A carriers fall in the over 101 mile grouping, but shipments of all lengths are made. Only one Category B carrier makes moves in the first three distance categories. The bulk of moves for all five carriers are over 101 miles. Over 101 miles is also the heaviest distance grouping for Category C carriers, though three also handle some shipments for shorter distances. Results for Category D firms are less well defined, with all distance categories represented.

Key Origins and Destinations. The Portland metropolitan area and Clark County are key origins and destinations for these motor carriers. The types of facilities served include customer distribution centers, manufacturing and processing facilities, stores, mills, reload centers, warehouses, job sites, restaurants, institutions, cold storage warehouses, the Port of Portland and PDX.

Transportation Issues. Congestion is clearly the biggest issue facing carriers, with transportation cost and scheduling/time sensitivity following close behind. Travel time/predictability is also viewed somewhat as a concern. Most companies do not seem to be terribly troubled by seasonal road closures, weight restrictions or state regulations, though many report they have simply learned to operate within the confines of these issues.

8.4 Additional Analysis Methodology

The additional analyses conducted by CS include a set of cross-tabulations using the motor carrier survey data to understand trucking activity patterns as a function of the type of commodities handled, market area, type of truck, and carrier type (truckload, LTL, or private). In the process of generating these list of cross-tabulations, a commodity group classification was developed, based on information gathered from the survey, to categorize commodities into broader commodity groups for ease of interpretation of the cross-tabulation results. The commodity group classification along with specific commodities falling into each group that were observed in the survey is presented in Appendix C: Motor Carrier Survey Tables.

The commodity group classification developed for the cross-tabulations is different from the one used for the roadside intercept surveys, since it has been developed to represent specific trucking activity patterns that are characteristic of individual commodities falling into each commodity group. For example, building materials have unique trucking activity characteristics in terms of the types of trucks/equipment used, facilities served, and market area. Similarly, food/grocery products have specific trucking activity patterns associated, for example, with local distribution activity, while commodities falling under machinery are specific in their usage of the type of trucks, their payloads, as well as market areas (particularly, long haul activity). Also, since the sample size for the motor carrier surveys was small, considering more detailed commodity classifications (similar to the one used for the roadside intercept surveys) would have generated tabulations/results not statistically representative of trucking activity characteristics of each commodity class. The coding system used in the cross-tabulations for commodity groups and facility types is presented in Appendix C.

8.5 CROSS-TABULATION RESULTS

Cross-Tabulation: Commodity Group and Type of Carrier

The cross-tabulation between commodity group and type of carrier (truckload, less than truckload or LTL, private) illustrates the fraction of total daily shipments of each commodity group by carrier type. From Table 8.1, truckload accounts for the primary trucking operation for lumber and wood products, other consumer goods products, and machinery. Truckload also accounts for the largest share of trucking operations for building materials, food/grocery products, office products, and other manufactured products, though these commodities are also handled by LTL and private carriers. All the small packaged freight shipments in the sample and 60 percent of the shipments of General Commodities/Freight All Kind (FAK) are observed to be handled by LTL carriers. Principal commodities handled by Private carriers include Chemicals and Allied Products, Building Materials, and Other Manufactured Products (appliances, paper products, etc.)

Table 8.1 Cross-tabulation between Commodity Group and Type of Carrier

Commodity Code	Commodity Description	Type of Carrier			Total
		Truckload	LTL	Private	
1	Lumber and Wood Products	100%	0%	0%	100%
2	Building Materials	57%	12%	31%	100%
3	Food/Grocery Products	68%	24%	8%	100%
4	Other Consumer Goods	92%	8%	0%	100%
5	Chemicals and Allied Products	3%	5%	93%	100%
6	Office Products	79%	12%	10%	100%
7	Machinery	95%	5%	0%	100%
8	Manufactured Products (all other)	65%	14%	21%	100%
9	General Commodities/FAK	39%	60%	1%	100%
10	Small Packaged Freight	0%	100%	0%	100%

The above cross-tabulation indicates the fraction of shipments of each commodity group occurring by each trucking sub-mode from the motor carrier survey data. This information can be potentially used to improve the accuracy of the allocation of commodity flows to trucking sub-modes in the Metro truck model (currently obtained from the commodity flow database), which can further improve the model in terms of modeling commodity flows through reload and terminal facilities, based on the understanding of reload activity of truckload, LTL, and private carriers by specific commodity group.

Cross-Tabulation: Commodity Group, Type of Carrier, and Truck Stop Activity

The survey asked questions of the carrier to deterimine if truck trips involved multi-stop tours (multiple stop) or were "out-and-back" trips (no stop). The cross-tabulation between commodity group, carrier type, and truck stop activity indicates any relationship between the type of commodity and the existence of tour activity in truck shipments, and if there are any differences in the relationship based on the type of carrier. From Table 8.2, there are clear differences in truck stop activity based on the type of commodity, as well as the type of carrier.

Some notable truck stop activity patterns are listed below:

- Truckload trucking has the lowest share of tour activity compared to LTL and private trucking in the Portland metropolitan area. Nonetheless, truckload carriers do have some significant tour behavior.

- Almost all the truckload shipments of Chemicals and Allied Products, and Machinery are no-stop shipments occurring between trucking terminals, and manufacturing facilities or distribution centers.
- Multiple stop truckload shipments are observed for Lumber and Wood Products, Building Materials, Other Consumer Goods (apparel), and Other Manufactured Products (appliances), which can be attributed to goods moving between trucking terminals, and multiple manufacturing facilities/distribution centers.
- Multiple stop shipments account for a larger share for LTL shipments of most commodities except for Other Consumer Goods (48 percent), and Machinery (35 percent).
- Multiple stop activity accounts for a larger share for all commodity groups handled by private carriers, as many private carriers make multiple stops between terminals and customer locations for pick-up or drop-off typically to maximize equipment utilization, and save time/costs.

Table 8.2 Cross-tabulation between Commodity Group, Type of Carrier, and Truck Stop Activity

Commodity Code	Commodity Description	Truckload		LTL		Private	
		Multiple Stop	No Stop	Multiple Stop	No Stop	Multiple Stop	No Stop
1	Lumber and Wood Products	32%	68%	-		-	
2	Building Materials	11%	89%	71%	29%	75%	25%
3	Food/Grocery Products	80%	20%	87%	13%	60%	40%
4	Other Consumer Goods	31%	69%	48%	52%	-	
5	Chemicals and Allied Products	3%	97%	80%	20%	89%	11%
6	Office Products	80%	20%	97%	3%	60%	40%
7	Machinery	2%	98%	35%	65%	-	
8	Manufactured Products (all other)	31%	69%	87%	13%	62%	38%
9	General Commodities/FAK	68%	32%	72%	28%	60%	40%
10	Small Packaged Freight	-		100%	0%	-	

Cross-Tabulation: Number of Employees and Total Daily Shipments

The cross-tabulation of data on number of employees at the carrier and the number of total daily shipments they handle is useful in analyzing trip generation characteristics of motor carrier terminals. Table 8.3 shows a general positive relationship between the number of employees and the total daily shipments (inbound + outbound) occurring at a facility. The weighted average truck trip generation rate from the data is determined to be approximately 0.67 trips/employee.

Table 8.3 Cross-tabulation between Number of Employees and Total Daily Shipments

Number of Employees	Total Daily Shipments			
	<50	50-100	100-250	>250
<50	73%	18%	9%	0%
50-100	20%	20%	40%	20%
100-500	0%	14%	58%	28%
>500	0%	0%	33%	67%

Cross-Tabulation: Commodity Group and Payload

The cross-tabulation of data on commodity group and payload provides the fraction of total shipments of each commodity group having different payload ranges. This cross-tabulation is useful in determining weighted average payload factors for each commodity group as well as providing an indication of the importance of using different payload factors for different commodity groups when converting data on comodity flow tonnages to numbers of truck trips.

From Table 8.4, most of the commodity groups are observed to have shipments with different payload ranges. This can be attributed to the fact that they are handled by truckload as well as LTL, and private carriers. For commodities handled predominantly by truckload carriers like Lumber and Wood Products, and Machinery, the payload is observed to be over 50,000 pounds. Most of the building material shipments are observed to be over 30,000 pounds due to the inherent heavy weights of building materials, and the predominance of truckload activity for these commodities. Commodities like food/grocery products, other consumer goods, office products, and general commodities/FAK, are observed to have shipments with payloads of less than 5,000 pounds, which can be attributed in part to the low density of these products, in part to the types of trucks handling these deliveries (smaller trucks), and the fact that the delivery patterns for these trucks may involve trucks making multiple stops and therefore being partially loaded much of the time.

The weighted average payload factors by commodity group derived from Table 8.4 is presented in Appendix C.

Table 8.4 Cross-tabulation between Commodity Group and Payload

Commodity Code	Commodity Description	Payload (lbs)						
		< 5,000	5,000 - 10,000	10,000 - 20,000	20,000 - 30,000	30,000 - 40,000	40,000 - 50,000	> 50,000
1	Lumber and Wood Products	0%	0%	0%	0%	0%	0%	100%
2	Building Materials	6%	0%	0%	17%	22%	50%	6%
3	Food/Grocery Products	29%	0%	29%	0%	14%	14%	14%
4	Other Consumer Goods	33%	0%	0%	0%	0%	50%	17%
5	Chemicals and Allied Products	33%	0%	0%	17%	17%	33%	0%
6	Office Products	29%	0%	29%	0%	14%	14%	14%
7	Machinery	0%	0%	0%	0%	0%	0%	100%
8	Manufactured Products (all other)	25%	0%	10%	5%	20%	30%	10%
9	General Commodities/FAK	5%	35%	20%	0%	5%	25%	10%
10	Small Packaged Freight	n/a						

Payload ranges for "Small Packaged Freight" could not be determined due to insufficient data.

Cross-Tabulation: Commodity Group, Market Area, and Payload

The cross-tabulation of data on commodity group, market area, and payload provides the fraction of total shipments of each commodity group having different payload ranges, based on market area (within or outside the Portland metropolitan region). In addition to determining weighted average payload factors for each commodity group, this cross-tabulation is useful in understanding the variations in payload factors based on trip distances (for example, if local trips have lower payloads compared to long-haul trips). Tables 8.5 and 8.6 provide the cross-tabulations between commodity group and payload ranges, for two cases of market area (within and outside the region), respectively.

From Tables 8.5 and 8.6, there seems to be a clear effect on the payload distribution of shipments for many commodity groups, based on the market area (within or outside the region). For most of the commodity groups (except building materials, and other consumer goods), all the shipments with market area within the region are observed to have payloads less than 20,000 pounds. This can be attributed to the low density of many of these commodity groups like food/grocery products, office products, and general commodities/FAK, the potential usage of smaller trucks for local distribution activity, and the presence of multi-stop tour activity with partial payloads (for example, most of the chemical and allied product shipments are associated with private carriers many of which perform local multi-stop tour activity). The majority of the short-haul shipments of building materials fall under the 20,000 – 40,000 lbs payload range. The relatively higher payload for this group can be attributed to the high-density of these commodities.

For shipments with market area outside the region, there is a clear shift in the payload distribution of shipments towards higher payload ranges for most of the commodity groups. This can be attributed to the predominance of full truckload activity for long haul shipments, which typically have higher payloads (for example, all the shipments of "lumber and wood products" and "machinery" with market area outside the region have payloads greater than 50,000 lbs). Long haul shipments are also dominated for most commodities by tractor semi-trailers, and do not typically involve multi-stop tour activity.

Table 8.5 Cross-tabulation between Commodity Group and Payload, for Market Area Within the Region

Commodity Code	Commodity Description	Payload (lbs)						
		< 5,000	5,000 - 10,000	10,000 - 20,000	20,000 - 30,000	30,000 - 40,000	40,000 - 50,000	> 50,000
1	Lumber and Wood Products	n/a						
2	Building Materials	3%	0%	0%	43%	54%	0%	0%
3	Food/Grocery Products	67%	0%	33%	0%	0%	0%	0%
4	Other Consumer Goods	0%	0%	0%	0%	0%	100%	0%
5	Chemicals and Allied Products	100%	0%	0%	0%	0%	0%	0%
6	Office Products	17%	0%	83%	0%	0%	0%	0%
7	Machinery	n/a						
8	Manufactured Products (all other)	67%	0%	33%	0%	0%	0%	0%
9	General Commodities/FAK	16%	80%	4%	0%	0%	0%	0%
10	Small Packaged Freight	n/a						

Payload ranges for "Small Packaged Freight" for market area within the region could not be determined due to insufficient data.

Table 8.6 Cross-tabulation between Commodity Group and Payload, for Market Area Outside the Region

Commodity Code	Commodity Description	Payload (lbs)						
		< 5,000	5,000 - 10,000	10,000 - 20,000	20,000 - 30,000	30,000 - 40,000	40,000 - 50,000	> 50,000
1	Lumber and Wood Products	0%	0%	0%	0%	0%	0%	100%
2	Building Materials	0%	0%	0%	23%	1%	76%	0%
3	Food/Grocery Products	0%	0%	0%	0%	0%	100%	0%
4	Other Consumer Goods	n/a						
5	Chemicals and Allied Products	0%	0%	0%	0%	0%	100%	0%
6	Office Products	0%	0%	0%	0%	0%	6%	94%
7	Machinery	0%	0%	0%	0%	0%	0%	100%
8	Manufactured Products (all other)	0%	0%	0%	0%	13%	51%	36%
9	General Commodities/FAK	0%	0%	0%	0%	0%	58%	42%
10	Small Packaged Freight	n/a						

Payload distribution for shipments of "Other Consumer Goods" and "Small Packaged Freight" for market area outside the region could not be determined due to insufficient data.

Cross-Tabulation: Commodity Group, Type of Carrier, and Trip Distance

The cross-tabulation of data for commodity group, type of carrier, and trip distance provided in Table 8.7 is useful in determining trip length characteristics of trucking operations in the Portland metropolitan area based on the type of commodity carried, as well as the type of carrier. Some notable trip length characteristics of trucking operations in the Portland metropolitan area based on the commodity group and the type of carrier are presented below:

- Except for Lumber and Wood Products, and Manufactured Products (other than machinery), truckload shipments of all the other commodity groups have trip lengths greater than 100 miles.
- Manufactured Products (all other) including appliances, paper products, and steel products, are the only commodities observed to have short-haul (< 25 miles) truckload operations.
- The share of trips with trip lengths greater than 100 miles is lower for LTL and Private carrier shipments compared to truckload shipments due to the presence of local/short-haul trucking activity performed by LTL and private carriers.
- More than half of the Small Packaged Freight shipments in the sample are short haul trips with trip lengths less than 25 miles. All these trips are multiple stop, short-haul LTL trips.

Table 8.7 Cross-tabulation between Commodity Group, Type of Carrier, and Trip Distance Categories

Commodity Code	Truckload					LTL					Private				
	<=25	25-50	50-100	>100	Total	<=25	25-50	50-100	>100	Total	<=25	25-50	50-100	>100	Total
1	0%	2%	4%	94%	100%	n/a					n/a				
2	0%	0%	0%	100%	100%	1%	1%	3%	95%	100%	19%	5%	16%	61%	100%
3	0%	0%	0%	100%	100%	1%	3%	20%	76%	100%	18%	3%	9%	71%	100%
4	0%	0%	0%	100%	100%	3%	3%	10%	85%	100%	n/a				
5	0%	0%	0%	100%	100%	2%	3%	12%	83%	100%	11%	9%	14%	66%	100%
6	0%	0%	0%	100%	100%	1%	1%	9%	89%	100%	18%	3%	9%	71%	100%
7	0%	0%	0%	100%	100%	5%	3%	1%	92%	100%	n/a				
8	12%	3%	4%	81%	100%	24%	24%	13%	39%	100%	6%	5%	5%	84%	100%
9	0%	0%	0%	100%	100%	4%	4%	2%	90%	100%	18%	3%	9%	71%	100%
10	n/a					52%	2%	2%	44%	100%	n/a				

Ranges are shown in miles.

n/a: could not be determined due to insufficient data.

Cross-Tabulation: Commodity Group, Type of Carrier, and Time of Day

The cross-tabulation of data on commodity group, type of carrier, and time of day shown in Table 8.8 provides the fractions of total shipments of each commodity group by type of carrier that occur in different time periods during the day. Some essential time of day characteristics of trucking operations in the sample are presented below:

- For most of the commodity groups, the largest share of truckload activity occurs during the day, with an approximately balanced distribution between the morning peak period (6 am – 9 am), mid-day (9 am – 3 pm), and the evening peak period (3 pm – 6 pm). The only significant variance in this time of day distribution is observed for Chemicals and Allied Products, with the largest share of truckload activity occurring during the night time.
- LTL trucking activity across all time periods is observed to be more evenly distributed compared to truckload activity in the Portland metropolitan area, especially due to increased LTL activity in the late evening and night time periods (LTL trucking activity in the 6 pm – 9 pm and 9 pm – 6 am time periods is more significant compared to truckload trucking for most of the commodity groups).
- Night time (9 pm – 6 am) is the most predominant time period for private trucking activity for most commodity groups. This can be attributed to the increased productivity and efficiency realized by private companies while operating their trucking fleet during the night compared to during the day.
- What is most striking about the results across the board for the reload facilities and carriers that serve them is that the time of day behavior seems markedly different than the general truck travel patterns on the road. This suggests that additional investigation into the time of day decisions and flexibility of these types of facilities would be useful.

Table 8.8 Cross-tabulation between Commodity Group, Type of Carrier, and Time of Day

Commodity Code	Truckload						LTL						Private					
	6 am - 9 am	9 am - 3 pm	3 pm - 6 pm	6 pm - 9 pm	9 pm - 6 am	Total	6 am - 9 am	9 am - 3 pm	3 pm - 6 pm	6 pm - 9 pm	9 pm - 6 am	Total	6 am - 9 am	9 am - 3 pm	3 pm - 6 pm	6 pm - 9 pm	9 pm - 6 am	Total
1	34%	32%	32%	2%	0%	100%	n/a						n/a					
2	29%	33%	10%	3%	25%	100%	29%	22%	15%	11%	23%	100%	17%	26%	9%	10%	38%	100%
3	34%	34%	32%	0%	0%	100%	14%	32%	22%	17%	15%	100%	20%	20%	5%	5%	50%	100%
4	30%	20%	20%	30%	0%	100%	23%	20%	20%	18%	19%	100%	n/a					
5	30%	10%	5%	5%	50%	100%	19%	10%	12%	24%	35%	100%	20%	20%	5%	5%	50%	100%
6	34%	33%	33%	0%	0%	100%	13%	37%	15%	15%	20%	100%	20%	20%	5%	5%	50%	100%
7	30%	20%	20%	30%	0%	100%	30%	30%	30%	9%	1%	100%	n/a					
8	26%	17%	31%	6%	20%	100%	15%	50%	14%	12%	9%	100%	29%	18%	14%	14%	25%	100%
9	38%	27%	29%	4%	2%	100%	23%	31%	16%	18%	12%	100%	20%	20%	5%	5%	50%	100%
10	n/a						12%	24%	6%	12%	46%	100%	n/a					

n/a: could not be determined due to insufficient data.

Cross-Tabulation: Market Area and Time of Day

The cross-tabulation of data on market area (within or outside the region) and time of day (in ranges) tabulates the fractions of total shipments by market area that occur in different time periods during the day. This tabulation was conducted to deterimine if carriers handled their local shipments at different times of day as their long haul shipments. If this is the case, it could explain some of the difference in time of day behavor of these trucks as compared to general trucks. From Table 8.9, there does not seem to be any significant impact on time of day distribution of trucking activity by the market area of shipments.

Table 8.9 Cross-Tabulation between Market Area and Time of Day

Market Area	Time of Day					
	6 am - 9 am	9 am - 3 pm	3 pm - 6 pm	6 pm - 9 pm	9 pm - 6 am	Total
Within Portland	24%	28%	19%	9%	21%	100%
Outside Portland	23%	26%	16%	11%	25%	100%

Cross-Tabulation: Commodity Group and Type of Facility

The cross-tabulation between commodity group and type of facility served, shown in Table 8.10, provides the fractions of total shipments of each commodity group that are associated with different types of facilities. This information is useful in determining what types of facilities in the Portland metropolitan area impact trucking activity based on the type of commodities handled by them. Some essential freight facility and related trucking activity characteristics in the region are presented below:

- Primary commodities generating Marine Terminal related trucking activity in the region include Lumber and Wood Products, Food/Grocery Products, Office Products, Manufactured Products (other than machinery), and General Commodities.
- Manufacturing Facilities account for the largest share of trucking activity for more than half of the commodity groups, which include Building Materials, Other Consumer Goods, Chemicals and Allied Products, Machinery, General Commodities/FAK (for example, a retail manufacturing facility), and Small Packaged Freight.
- Commodities with Distribution Centers (DCs) having a notable share of their total trucking activity through freight facilities include Lumber and Wood Products (for example, IKEA), Food/Grocery Products (for example, Wal-Mart), Chemicals and Allied Products, Manufactured Products (other than machinery), General Commodities/FAK, and Small Packaged Freight.
- From the survey data, it is observed that commodities don't move "between" trucking terminals, as share of trucking activity serving truck terminals (code 8) from the table is observed to be zero for all commodity groups.

Table 8.10 Cross-Tabulation between Commodity Group and Type of Facility

Commodity Code	Commodity Description	Type of Facility Code									
		Wholesale Warehouse	Public Warehouse	Distribution Center	Manufacturing Facility	Airport	Marine Terminal	Rail yard	Truck Terminals	Retail Facility	Other (homes, schools, hospitals)
1	Lumber and Wood Products	0%	0%	28%	30%	0%	41%	0%	0%	0%	1%
2	Building Materials	3%	6%	17%	33%	0%	20%	14%	0%	7%	0%
3	Food/Grocery Products	0%	0%	21%	19%	0%	60%	0%	0%	0%	0%
4	Other Consumer Goods	0%	0%	12%	88%	0%	0%	0%	0%	0%	0%
5	Chemicals and Allied Products	0%	0%	30%	70%	0%	0%	0%	0%	0%	0%
6	Office Products	0%	0%	18%	16%	0%	66%	0%	0%	0%	0%
7	Machinery	0%	0%	2%	98%	0%	0%	0%	0%	0%	0%
8	Manufactured Products (all other)	0%	0%	49%	28%	0%	23%	0%	0%	0%	0%
9	General Commodities/ FAK	0%	0%	30%	42%	8%	20%	0%	0%	0%	0%
10	Small Packaged Freight	0%	0%	50%	50%	0%	0%	0%	0%	0%	0%

9.0 Regional Truck Count Program

This section examines considerations and makes recommendations for the design of an ongoing regional truck count program, of value to numerous regional stakeholders. The program would involve the collection of both auto and truck classification count data throughout the Portland metropolitan area in a coordinated and efficient fashion, using a consistent methodology and in a single data format. This document can be used to have initial discussions regarding managing, funding, and utilizing the truck count data.

9.1 Factors Affecting Design of a Regional Truck Count Program

In developing a design for an ongoing regional truck count program a number of factors need to be considered. These include:

- What types of locations should be counted (i.e. usage of the facilities in a regional "freight system?"
- What mix of roadway functional classes should be counted?
- How many counts of each type should be conducted?
- What should be the jurisdictional mix of count locations and the area type mix (i.e., urban industrial, central business district, suburban, rural)?
- What should the duration of the count period be (e.g., less than 24 hours and factored, 24 hours, 72 hours)?
- At what frequency should counts be taken?
- What technologies should be used to compile counts and what types of factoring methodologies should be used?
- Who should be responsible for managing the count programs and what elements should comprise the management plan?
- How should the program be funded?

Each of these factors will be discussed in more detail with respect to how they were considered in developing the recommendations for a truck count program contained in this section. Prior to this more detailed discussion a summary that highlights key issues is presented below.

The first set of factors/questions presented above relate to how locations for counts are chosen and how many counts should be conducted. In order to answer these questions it is useful to review some of the uses of truck counts in regional freight planning:

- They can be used to validate and calibrate the regional truck model. This suggests counts should be conducted on model screenlines and a sufficient number of counts should be conducted with good geographic and facility type distributions to allow for estimation of a synthetic origin-destination table that could be used in base year model calibration.
- They can be used to identify the key freight routes and to track time of day and average daily truck traffic (ADTT) trends on these routes over time to help inform planning decisions. The key freight routes in the region have been previously defined in terms of the interstate and state highway system.
- They can be used to analyze time of day and ADTT trends on freight access routes. These link to major freight generators and can be used in analyzing the truck trip generation characteristics of these facilities as well as in analyzing choke points that might impede throughput at these facilities. The types of freight facilities include the region's ports, airports, warehouse districts, rail and intermodal terminals, truck terminals, and major industrial districts.
- They can be used to analyze how changes over time in time of day congestion characteristics of major commuter routes interact with freight usage of these same routes. This would focus counts on key interstate and state highway corridors.
- They can be used to analyze the different usage patterns, both time of day and type of truck, associated with different roadway functional classes (requiring a reasonable distribution across these different functional classes).

With respect to each of these considerations in selecting the number and locations of counts, we feel that the process used to develop the truck count program for this study provides a reasonable model for an ongoing truck count program and this is described in further detail later in this section.

The second set of factors/questions presented above relate to how often and for what duration counts should be conducted. Based on our experience in other states and metropolitan areas, we believe that unless there are major changes in the freight infrastructure or freight demand characteristics of a region, a three or five year cycle would be sufficient to meet most needs and not be cost-prohibitive. With respect to duration of counts the choices are less than 24-hours focusing on the commuter peak and mid-day periods, 24-hour counts, or 72-hour counts. The longer count durations would allow for better averaging of data when there is a high degree of day-to-day variability in truck traffic at a particular location. The results of the 72-hour count program conducted for this study provides guidance on how to take this factor into account in the design of the count program.

The third set of factors/questions presented above relate to how the counts should be collected. There are four basic approaches that can be used for vehicle classification counts: 1) pneumatic tubes, 2) loop detectors, 3) videography, and 4) manual observation. Cost, accuracy, and reproducibility of results should be considered in selecting from among these methods and the results from this study should provide useful information for making this selection. The study also provides guidance on how partial periods of data can be factored to develop hourly and daily count totals if necessary.

The fourth and final set of factors/questions presented above relate to how the count program should be managed. In looking at the management of the truck count program, the following functions need to be part of the design:

- An entity needs to be responsible for conducting the counts or contracting for the counts to be conducted. How this is done may affect the costs of the program.
- An entity needs to be responsible for implementing and managing a quality control program that reviews all of the data as it is collected to ensure that it meets certain specified standards. Clear rules should be adopted for how and when lost data should re-counted.
- An entity needs to be responsible for storing the count data. A data format should be specified that is generally accessible to all potential users and a method for ongoing access to the data should be provided.

The elements of this type of management plan are further described later in this section.

9.2 How Many Counts Should Be Collected and Where Should Counts be Collected?

As described previously in this section, the factors to consider in developing the truck count program are similar to those considered during the truck count portion of this study in Spring 2006 and the process by which these count locations were specified provides a good model for the design of the ongoing regional truck count program. This design process started with a defined number of counts that could be taken based on budget constraints. This number of counts turned out to provide reasonable coverage with respect to most of the factors described previously so it is also a good starting point for considering an on-going count program. Selection of count locations for the Spring 2006 program next focused on allocating counts based on providing good coverage of different types of freight route facilities and ensuring that there were adequate data to conduct validation of the Metro truck model. This meant that truck counts were ultimately allocated to types of locations taking into account the following:

- Coverage of Major Freight Corridors;
- Coverage of Freight Access Routes;
- Validation of the Metro Truck Model;
- Complementing Existing Vehicle Classification Count Programs in the region (i.e., reduce duplication of locations with on-going count programs in order to leverage the project resources).
- Meeting specific near-term planning needs of specific jurisdictions.

In preparing for the Spring 2006 truck count program, Cambridge Systematics reviewed prior regional freight route designations as well as the regional freight facilities database to identify candidate locations on major freight routes and access routes for major freight facilities in the region. This procedure is documented in the technical memorandum for Task 4 of this study. In conducting the analysis of major freight routes, the results from the Metro model and prior count programs were used to identify locations on these routes that had the highest truck volumes and that were distributed geographically. Selection of major freight access routes was conducted based on visual inspection of likely routes to the most significant regional freight facilities and these results were reviewed with the project Technical Team. The results were then reviewed to determine the degree of coverage by jurisdiction and facility type.

A further criterion that was used to develop the original list of counts in the Spring 2006 program was coverage of screen lines that could be used to validate the Metro truck model. Generally, screen lines are selected to cross parallel facilities where there are major flows of the vehicle traffic that are being estimated in the model. The idea behind a screen line as a validation tool is that the assignment of traffic to specific roads in the model is always subject to some degree of inaccuracy when there are parallel route choices serving similar origin-destination pairs, but if more aggregate directional flows in the model are shown to agree with counts, then the model is likely to have a reasonable representation of O-D flows. Screen lines for trucks should be selected to cross major flows of truck traffic, which may be different than the flows of automobile traffic. However, in the absence of a more detailed and accurate analysis of truck flow patterns prior to conducting the truck count program, Cambridge Systematics and the Metro modeling staff agreed to use the primary screen lines that are currently used to validate the regional travel demand model. These major screen lines do cut major traffic flows in the region that also include a number of locations with high volumes of truck traffic. A review of the truck volumes predicted by the model for these screen lines showed that for most of the screenlines, well over 90 percent of the truck traffic occurs on a very small number of the facilities that are cut by the screenlines. This information was used to limit the number of locations that were included in the truck count program to satisfy this need. It was also noted that several of these locations are also locations for which ODOT conducts HPMS counts and so there was no need to duplicate these count locations in the new regional truck count program. We recommend that as a starting point, these same locations should be included in the on-going regional truck count program for the purpose of meeting Metro model validation needs. However, over the next several years as part of Metro's efforts to continually upgrade their truck model, we recommend that a review of alternative screen line locations be conducted. We believe that wherever the final screenlines for truck model validation are chosen to be, the number of counts designated for this purpose should be the same as recommended in this section.

In Table 9.1, the 24 count locations along Metro's primary screenlines that are recommended for the regional truck count program are highlighted in yellow. Based on Metro model results, these 24 locations have very high truck volumes relative to the other 46 locations along the same screenlines. Many of these 24 locations are also among the locations with the highest truck volumes in the region (i.e., average daily truck traffic of 3,000 or more).

Table 9.1 Recommended Count Locations on Metro's Primary Screenlines

Screenline	ID	Roadway	Segment	Medium Truck ADT (2 axle, 6 tire)	Heavy Truck ADT (3 axles or more)
R-2: Downtown Portland	3.01	I-405	Fremont Br.	2,159	6,939
R-2: Downtown Portland	3.02	I-5	Marquam Br.	2,489	7,102
R-2: Downtown Portland	3.03	Hawthorne Br.	Between OR 99W and I-5	296	203
R-2: Downtown Portland	3.04	Morrison Br.	Between OR 99W and I-5	930	427
R-2: Downtown Portland	n/a	Highest among 4 other locations (Ross Island Bridge)		371	586
E-21: Multnomah County, Other	4.01	I-205	Between 92nd Ave. & Johnson Creek Blvd.	2,828	6,815
E-21: Multnomah County, Other	4.04	OR 99E	Between Bybee Blvd. and Tacoma St.	303	496
E-21: Multnomah County, Other	n/a	Highest among 8 other locations (SE 82nd Ave; SE Bell St)		113	161
W-19: Multnomah County, Other	4.02	I-5	S. of SW Corbett Ave. ramp	3,817	9,276
W-19: Multnomah County, Other	n/a	Highest among 4 other locations (OR 43 - SW Macadam Ave)		250	185
E-09: Multnomah County, Other	4.03	I-84	W. of 122nd Ave.	2,273	6,725
E-09: Multnomah County, Other	4.06	Marine Dr.	Between I-205 and 122nd Ave.	977	822
E-09: Multnomah County, Other	4.07	Airport Way	Between I-205 and 122nd Ave.	1,665	835
E-09: Multnomah County, Other	n/a	Highest among 14 other locations (NE Sandy Blvd; SE Foster St)		333	143
W-07: Multnomah County, Other	4.05	US 26 (Sunset Hwy)	E. of Highland Rd.	2,229	5,755
W-07: Multnomah County, Other	n/a	Highest among 5 other locations (NW Cornell Rd)		193	115
R-5: Multnomah County, Other	4.08	I-5	Interstate Br.	2,994	9,299
R-7: Multnomah County, Other	4.09	I-205	Glen Jackson Br.	2,502	5,724
W-03: Washington County	5.01	I-5	Between I-205 and Nyberg St.	3,358	8,697
W-03: Washington County	5.02	Jenkins Rd.	Between Murray Blvd. and Bowerman Dr.	53	127
W-03: Washington County	5.03	OR 10	Between 149th Ave. and Murray Blvd.	291	394
W-03: Washington County	5.04	OR 99W	S. of Cipole Rd.	641	1,235
W-03: Washington County	5.05	Scholls Ferry Rd.	Between Murray Blvd & Murray Scholls. Dr.	132	195
W-03: Washington County	5.06	Tualatin Sherwood Rd.	W. of Teton Ave.	512	817
W-03: Washington County	5.07	OR 8	Between 153rd Dr. and Murray Blvd.	319	507
W-03: Washington County	5.08	US 26 (Sunset Hwy)	E. of Cornell Rd.	1,328	4,503
W-03: Washington County	5.09	Walker Rd.	Between Murray Blvd. and Meadow Dr.	191	630
W-03: Washington County	n/a	Highest among 9 other locations (SW Scholls Ferry; SW Boones Ferry)		58	88
W-14: Clackamas County	6.01	I-205	At 65th Ave Undercrossing (County Line)	1,409	4,688
W-14: Clackamas County	n/a	SW Borland Rd	In Clackamas County	34	58
E-27: Clackamas County	6.02	I-205/OR 212/213	Between 82nd Ave. and OR 213	2,547	6,091
E-27: Clackamas County	n/a	OR 99	Between I-205 and Arlington St	278	231

In preparing for the Spring 2006 truck count program, a comprehensive analysis of existing count programs (ODOT HPMS counts, Port of Portland TMP counts, County count programs, etc.) in the region was performed to avoid duplication of sites and to maximize how the spring program complements the existing count programs. A number of locations were identified that while counted by other agencies for other purposes, should be considered to be part of the ongoing regional truck count program. Table 9.2 lists these locations and the organization that is responsible for conducting the counts. Of these 15 locations, 14 were selected because they are high volume locations on Metro's primary screenlines (i.e., satisfies need for Metro truck model validation) and one was selected because it is located on a major freight corridor.

Table 9.2 Recommended Count Locations that are Counted by Other Agencies for Other Purposes

ID	Roadway	Segment	Need Satisfied	Count Source
3.02	I-5	Marquam Br.	Metro Truck Model Validation	ODOT
3.03	Hawthorne Br.	Between OR 99W and I-5	Metro Truck Model Validation	ODOT
3.04	Morrison Br.	Between OR 99W and I-5	Metro Truck Model Validation	ODOT
3.09	US 30	W. of I-405	Truck Volumes on Major Freight Corridors	ODOT
4.05	US 26 (Sunset Hwy)	E. of Highland Rd.	Metro Truck Model Validation	ODOT
4.08	I-5	Interstate Br.	Metro Truck Model Validation	ODOT
4.09	I-205	Glen Jackson Br.	Metro Truck Model Validation	ODOT
5.01	I-5	Between I-205 and Nyberg St.	Metro Truck Model Validation	ODOT
5.02	Jenkins Rd.	Between Murray Blvd. and Bowerman Dr.	Metro Truck Model Validation	County
5.04	OR 99W	S. of Cipole Rd.	Metro Truck Model Validation	ODOT
5.05	Scholls Ferry Rd.	Between Murray Blvd. and Murray Scholls. Dr.	Metro Truck Model Validation	County
5.06	Tualatin Sherwood Rd.	W. of Teton Ave.	Metro Truck Model Validation	County
5.08	US 26 (Sunset Hwy)	E. of Cornell Rd.	Metro Truck Model Validation	ODOT
5.09	Walker Rd.	Between Murray Blvd. and Meadow Dr.	Metro Truck Model Validation	County
6.01	I-205	At 65th Ave Undercrossing (Clackamas/Washington County Line)	Metro Truck Model Validation	ODOT

With respect to the last category of counts, regional stakeholders may wish to allocate a certain percentage of count resources on an annual basis for "roving"counts that meet specific near-term jurisdictional needs as was done in this study. This would be an additional cost to the program but was reasonably accommodated within the count budget of this study. Based on the above considerations, a total of 108 locations were selected for the Spring 2006 truck count data collection. Thus, the spring data collection program represents a good start for identifying locations for the ongoing truck count program.

Based on the above considerations, a total of 108 locations were selected for the Spring 2006 truck count data collection. To increase the effectiveness of the truck count program, we applied a filtering to the original 108 locations to estimate the amount that would potentially remain in the truck count program using the methodology stated above. The filter excludes locations on major freight corridors and freight access routes, based on minimum thresholds for truck volumes on these facilities. These minimum thresholds are developed based on a comparative analysis of truck volumes observed on different segments, to identify breakpoints in truck volumes defining these freight facilities in the Portland metropolitan area. The filter also excludes counts that are physically too close together. This avoids duplication of counts on the same highway facility. This results in a total of 77locations remaining in the truck count list. Note that all locations for Metro truck model validation have been retained, since they satisfy a high priority need in the region. Results of the filtering process are shown on the following pages.

In addition to the 77 count locations recommended based on the criteria and methodology described above, we suggest allocating an additional 31 count locations that could be at undesignated locations to be determined as part of an annual planning process. Based on the site selection methodology employed for the regional truck count program, the 108 locations represent a comprehensive list to meet truck count data needs in the region for metro model validation, truck volumes on freight corridors and routes, as well as around freight facilities, at this time. The methodology also enables the regional truck count program to be expanded in the future to account for the dynamic freight activity environment in the region. Some examples that would entail a potential expansion of the truck count program in the future are described below.

- Incorporating sites for metro model validation into the program if Metro defines additional truck model validation screenline locations in the future.
- Adding sites for truck volumes around freight facilities, based on the development of new freight facilities (for example, warehousing/distribution centers) in the region (this would require monitoring of land use trends in the region to track new freight facility developments).
- Adding sites to meet additional agency specific truck count data needs in the future

A final consideration in determining the number and location of counts for the program is the need to provide the ability to estimate a synthetic origin-destination matrix for the purpose of calibrating the Metro truck model. A variety of techniques have been demonstrated in other regions that use existing truck counts and an initial estimate of truck O-D patterns to develop a truck trip table that produces good agreement with actual counts. In the case of the Metro model, the initial "seed" matrix could the trip table estimated using the existing trip distribution techniques in the model. One such method is described below with a discussion of factors that would need to be taken into account in selecting the number and location of counts to support such an approach.

The Origin Destination Matrix Estimation (ODME) process used for trip table calibration is an optimization model using a linear programming approach. In this linear programming model, the objective is to minimize the differences between model outputs (link traffic volumes generated by the model after assignment) and the observed truck counts, by iteratively adjusting the input truck trip table of the model, which acts as an initial seed matrix in the optimization model. The usual form of the objective function in an ODME process is the minimization of the total impedance (link travel times or costs) from the traffic assignment process, under the constraint that the model assignment volumes must match with truck counts for all links where truck counts are available. The result of the ODME optimization process is the calibrated input OD truck trip table, link truck volumes generated from which after traffic assignment match with observed truck counts. The ODME process can be performed in EMME\2, which is the present modeling software for the Metro truck model.

Verifying the accuracy of the OD trip table calibration from the ODME process is a particularly difficult undertaking. The best way to doing this is to compare the calibrated OD trip table from the ODME process with an "observed" OD trip table. Since an observed OD trip table is not readily available, and too cumbersome to generate, this method of verifying accuracy is not feasible. The ODME is a maximum entropy process, implying that the calibrated trip table resulting from the ODME process has the highest probability of being an accurate representation of the observed truck counts (in other words, a lot of different OD trip tables can meet the constraint criteria in the ODME optimization process, but the final trip table generated from the ODME is the one which has the maximum entropy). This feature of the ODME process also makes comparisons with an observed trip table not an accurate process, since the observed trip table might not represent maximum entropy. Note that validating the model truck traffic volumes resulting from the calibrated OD trip table with the observed counts is not an approach for measuring the accuracy of the ODME process, because the calibrated trip table itself was generated out of this validation procedure, resulting in a case of circular reasoning.

An important truck count data question to answer in performing an ODME process is if the available number of counts are sufficient for calibrating the OD trip table using an ODME. This can be done by comparing the calibrated OD trip table generated by the ODME process with the initial OD trip table (seed matrix for the ODME process). If it is observed that many cells in the calibrated table remain unchanged compared to the seed matrix (implying that the ODME process was not effective), then it is likely that no counts are available along the links connecting the OD pairs associated with those cells. A general rule of thumb for the adequacy of the counts in the ODME process is a change in values in the calibrated trip table compared to the seed matrix for at least 70 percent of the cells.

Other truck count data issues useful to consider before performing an ODME include the following:

- Based on the process by which ODME works, it cannot calibrate intra-zonal trips since the model does not assign these trips on the highway network. Consequently, observed link truck counts used for the ODME process that capture a large share of intra-zonal trips will affect the inter-zonal trips in the calibrated OD trips table. A good way to address this is by mainly selecting counts on links crossing TAZ boundaries for the ODME instead of links lying on the central part of the TAZs.
- Consistency of observed counts is another important factor affecting the accuracy of the ODME process. For example, using counts collected at different times of the year at different locations will generate an OD trip table with trips on links that are inconsistent with each other with respect to time period (this can be particularly important if there are significant seasonal variations in truck volumes).

The following aspects of the truck count data collected as part of the study provide some useful direction on the design of the Regional Truck Count Program for performing an ODME process for the calibration of the OD trip table for the Metro truck model:

- **Number of truck counts.** The spring truck count program collected data at 108 locations, representing a comprehensive list of highway facilities supporting significant trucking activity in the Portland metropolitan area. As described earlier, there is no robust way of determining the "number" of count locations for performing an effective ODME on the OD trip table of the Metro truck model. However, comparing the calibrated maximum entropy OD trip table with the initial seed matrix and observing the number of cells with changes in cell values can help determine if the number of counts are insufficient for the ODME process. Since an ODME has not been performed so far with the spring count data, this information could not be used for the design of the Regional Truck Count Program in terms of determining the number of count locations for an ODME process.
- **Location of truck counts.** In addition to the consideration of the various needs for truck volumes in the Portland metropolitan region, an important factor impacting the selection of the 108 locations for the spring truck count program was the geographical coverage area of the data collection program. The 108 locations provide a good coverage of all the major highway facility locations in the Portland metropolitan area. A more disaggregate analysis of the truck counts to account for intra-zonal trips for the entire region is expected to be prohibitive owing to the extent of the zone system of the Metro truck model. Consequently, the only consideration in deciding the count locations for the Regional TCP with regard to an ODME process is ensuring adequate geographical coverage of the Portland metropolitan region.
- **Truck counts by truck class.** The Regional truck count program will collect truck counts for all the 9 FHWA truck classes (FHWA Class 5 to 13), thus

ensuring flexibility in performing the ODME process for the Metro truck model based on truck class (currently, medium vs. heavy).

9.3 How Often and for What Duration Should Counts be Conducted?

There are three principal options for duration of truck counts that should be considered:

- Conduct counts for less than 24-hours focusing resources on the commuter peaks and mid-day truck peaks and factor to daily volumes using factors derived from the Spring 2006 program.
- Conduct counts for a 24-hour period to represent daily volumes.
- Conduct counts for a 72-hour period and average these to obtain ADT estimates.

The main advantage of the first option is reduced cost. However, this does introduce potential inaccuracies in the count data and it is not a general practice for count programs in the State. Therefore, this option was discarded. The 24-hour option also helps minimize costs and is appropriate for locations that are not expected to exhibit significant day-to-day variation in truck volumes. As illustrated in the data analysis presented in the Task 7 tech memo, data collected in the Spring of 2006 indicate that day-to-day truck volume fluctuations are uncommon on interstates, but occur on some of the non-interstate facilities. Therefore, we are recommending that all interstate facilities be counted for 24-hour periods, while all other facilities are counted for 72-hour periods.

The cost of the program can be further reduced by developing a rotating cycle of counts; that is a fraction of the total number of counts is collected in each year of a multi-year cycle. The maximum number of years that should be considered for this rotation is five years to correspond to current federal requirements for long range transportation plan updates (i.e., for any MTP cycle, no count used to validate an updated model would be older than when the last MTP update was developed). Given the rapidly evolving freight transportation patterns of the region and the current focus on freight issues, however, we recommend that counts be collected every three years, with all counts to be collected in the same year in order to enable direct volume comparisons. As a body of historical data are compiled, a future evaluation of whether or not to switch to a longer cycle can be conducted.

9.4 How Should the Counts be Collected?

There are four basic approaches that were considered for collecting classification count data. Each of these is described below.

- **Manual Observation.** Manual counting procedure involves a trained observer collecting vehicle classification counts at a location based on vehicle observation. Typically, the manual counting procedure is used for short durations of count data collection (for example, peak hour), and in cases where available resources do not justify use of automated counting equipment. Typical equipment used in manual counting include tally sheets, mechanical count boards, and electronic count boards.
- **Pneumatic Tubes.** This data collection approach involves placing pneumatic tubes across travel lanes for automatic recording of vehicles. These tubes use pressure changes to record the number of axle movements to a counter placed on the side of the road. They can record count data for 24 hour periods or more, and are easily portable. Some drawbacks of this data collection method include limited lane coverage, displacement, or dislodging by roadway equipment (for example, snow ploughs).
- **Loop Detectors.** This data collection approach involves embedding one or more loops of wire in the pavement, and connecting to a control box, excited by a signal (typically ranging in frequency from 10 KHz to 200 KHz). When a vehicle passes over the loop, the inductance of the loop is reduced, indicating the presence of a vehicle. One of the main benefits of this approach is the reliability of count data, under all weather conditions. They are mainly used as permanent recorders, at locations where counts are required for a longer time duration.
- **Videography.** Videography involves collecting vehicle classification counts using video tape recorders, and tallying them manually by observing vehicles on the video. Similar equipment, as described under the manual observation data collection approach above, can be used for tallying the data. A primary advantage of videography is the ability to stop time, and review data, if necessary.

Cost, accuracy, and reproducibility of results should be considered in selecting from among these methods and the results from this study should provide useful information for making this selection. Based on a comparison of the four vehicle classification count data collection methods described above, video counts are proposed for collecting counts for the Regional truck count program. This method was also used for the spring truck count program of the study. Some main advantages of videography compared to other counting methods are described below:

- Videography offers the ability to reproduce count data for review and quality assessment/checking, if necessary.

- It can be used for recording vehicles over long time durations
- It is more reliable, especially for vehicle classification counts, since exact observations on the type of vehicle and number of axles can be made simultaneously from video tapes.

The method for performing the truck counts for this study was to collect video data at each site and then count the first 15 minutes of each hour. This method costs less than counting a full hour, but still provides 24-hour coverage. Results from the 72-hour counts collected at the same locations as permanent ODOT count stations also demonstrated that this approach was very accurate in matching prior counts.

Using this same method, we estimate the cost of collecting data at a 24-hour site to range from $250 to $700 per site for both directions based on bid prices received for the freight data collection project. The cost of collecting data for a 72-hour period would be $750 to $2,100. To collect data at each of the 77 locations recommended in this study (16 24-hour locations and 61 72-hour locations), is estimated to cost between $50,000 and $140,000. To collect 24-hour count data at an additional 31 roving locations is estimated to cost between $8,000 and $22,000. Additionally, there will be a small cost to manage and maintain the regional truck count program.

9.5 How Should the Count Program Be Managed?

There are several options for the institutional arrangements supporting the management of the count program.

- Metro or ODOT, both having jurisdiction for the entire region within Oregon, could manage the program.
- An existing university research center, such as the center at Portland State University (PSU) could manage the program.
- Management or elements of the program could be contracted to a private traffic data firm.
- Some combination of the options presented above could be used.

All other things being equal, it would be beneficial to have a single organization responsible for the overall management of data collection with the storage and dissemination of data. We recommend that if a satisfactory cost and contractual relationship can be negotiated, that this responsibility be handled by PSU as this could be combined with other data and research functions that might benefit the program both in terms of cost efficiencies and synergies among different data programs. The actual collection of the counts could be contracted to a private traffic data firm.

The management functions would include:

- Establishing and maintaining data quality standards and data collection procedures;
- Contracting for actual data collection;
- Conducting data quality control checks;
- Storage of the data and production of standard data digests (these would be short standard summary reports of the data to be provided to participating entities);
- Maintaining the data query system and providing access to the data. Access to the data could be either by providing data files directly to all the program participants or the data could be maintained on a central server along with other data resources that could be accessed on-line.

Data should be prepared in an Excel format, with columns for location identification; region; roadway; segment; direction; date; hour; need satisfied; count for each vehicle classification; total truck count; and total count of all vehicles. The common data format for counts collected from all locations also enables transferability of data between agencies in the region.

The Excel data could then be copied into the Access database querying tool developed by the freight data collection team that enables semi-automated truck count analysis. An essential utility of the database querying tool is the ability to analyze the entire highway system in the region using a single user interface.

9.6 Recommended Truck Count Locations and Data Collection Durations

The following tables summarize the draft list of locations selected for the Regional truck count program based on applying the methodology and filtering process discussed in this memorandum. The first two tables (Tables 9.3 and 9.4) summarize how these counts can be divided into jurisdictions based on county and road type. The next table (Table 9.5) lists each of the 77 locations. In addition to the locations shown in Table 9.5, another 31 roving locations are recommended for the program.

Table 9.3 Number of Truck Count Locations by County

County	Number of Count Locations		
	24 hour	**72 hour**	**Total**
Clackamas, OR	4	5	8
Multnomah, OR	10	33	40
Washington, OR	1	13	14
Clark, WA	1	10	10
Total	**16**	**61**	**77**

Table 9.4 Number of Truck Count Locations by Road Type

Facility Type	Number of Count Locations		
	24 hour	**72 hour**	**Total**
Interstate	16	-	16
Arterial	-	35	35
State Highway	-	26	26
Total	**16**	**61**	**77**

Table 9.5 Full List of Locations

ID	Count Type	Location	Roadway	Segment	Need
1.02	24-Hour Count	Multnomah - Port, Airport	US 30	South of St. Johns Br.	Corridor
1.04	72-Hour Count	Multnomah - Port, Airport	US 30 (Yeon Ave.)	N. of Nicolai St.	Corridor
1.06	24-Hour Count	Multnomah - Port, Airport	OR 99E	E. of I-5	Routes
1.08	24-Hour Count	Multnomah - Port, Airport	82nd Ave.	N. of Columbia Blvd.	Facility
1.13	72-Hour Count	Multnomah - Port, Airport	Columbia Blvd.	S. of Burgard Rd.	Facility
1.14	24-Hour Count	Multnomah - Port, Airport	Columbia Blvd.	W. of OR 99W (Denver Ave.)	Facility
1.15	24-Hour Count	Multnomah - Port, Airport	Columbia Blvd.	E. of I-5	Facility
1.17	24-Hour Count	Multnomah - Port, Airport	Columbia Blvd.	N. of US 30 Bypass	Facility
1.20	24-Hour Count	Multnomah - Port, Airport	Going St.	West of Greeley Ave.	Facility
1.23	72-Hour Count	Multnomah - Port, Airport	Lombard St.	N. of Columbia Blvd. (Rivergate area)	Facility
1.26	24-Hour Count	Multnomah - Port, Airport	Lombard St.	W. of OR 99W (Interstate Ave.)	Facility
1.28	24-Hour Count	Multnomah - Port, Airport	Marine Drive	E. of OR 99E	Facility
1.29	24-Hour Count	Multnomah - Port, Airport	Marine Drive	W. of I-5	Facility
1.30	24-Hour Count	Multnomah - Port, Airport	Marine Drive	NW of I-205	Facility
1.33	24-Hour Count	Multnomah - Port, Airport	Nikolai St.	W. of US 30	Facility
1.35	24-Hour Count	Multnomah - Port, Airport	St. Helens Rd.	South of US 30	Facility
1.36	72-Hour Count	Multnomah - Port, Airport	St. Johns Br.	North of US 30	Facility
2.03	24-Hour Count	Port of Vancouver	4th Plain Blvd.	W. of I-5 Interchange	Routes
2.04	72-Hour Count	Port of Vancouver	Mill Plain Blvd.	W. of I-5 Interchange	Routes
2.05	24-Hour Count	Port of Vancouver	78th Street	W. of I-5 Interchange	Routes
3.01	24-Hour Count*	Multnomah - Downtown	I-405	Fremont Br.	Model
3.02	24-Hour Count*	Multnomah - Downtown	I-5	Marquam Br.	Model
3.03	72-Hour Count*	Multnomah - Downtown	Hawthorne Br.	Between OR 99W and I-5	Model
3.04	72-Hour Count*	Multnomah - Downtown	Morrison Br.	Between OR 99W and I-5	Model
3.09	72-Hour Count	Multnomah - Downtown	US 30	W. of I-405	Corridor
3.10	72-Hour Count	Multnomah - Downtown	Broadway St.	Between Larrabee Ave. and I-5	Facility
3.11	72-Hour Count	Multnomah - Downtown	Interstate Ave.	N. of Russell Street	Facility
4.01	24-Hour Count*	Multnomah - Other	I-205	Between 92nd Ave. and JC Blvd	Model
4.02	24-Hour Count*	Multnomah - Other	I-5	S. of SW Corbett Ave. ramp	Model
4.03	24-Hour Count*	Multnomah - Other	I-84	W. of 122nd Ave.	Model
4.04	72-Hour Count*	Multnomah - Other	OR 99E	Between Bybee Blvd. and Tacoma St.	Model
4.05	72-Hour Count*	Multnomah - Other	US 26 (Sunset Hwy)	E. of Highland Rd.	Model
4.06	72-Hour Count*	Multnomah - Other	Marine Dr.	Between I-205 and 122nd Ave.	Model
4.07	72-Hour Count*	Multnomah - Other	Airport Way	Between I-205 and 122nd Ave.	Model
4.08	24-Hour Count*	Multnomah - Other	I-5	Interstate Br.	Model
4.09	24-Hour Count*	Multnomah - Other	I-205	Glen Jackson Br.	Model
4.19	24-Hour Count	Multnomah - Other	US 26 (Powell Blvd.)	E. of OR 99E	Facility
4.20	72-Hour Count	Multnomah - Other	181st Ave.	Between Sandy Blvd. and I-84	Facility
4.23	24-Hour Count	Multnomah - Other	North I-5	Near Ridgefield Weigh Station	Corridor

Table 9.5 Full List of Locations (continued)

ID	Count Type	Location	Roadway	Segment	Need
4.24	24-Hour Count	Multnomah - Other	Marine Dr.	Between 223rd Ave. and Sundial Rd.	Routes
4.25	24-Hour Count	Multnomah - Other	181st Ave.	Between I-84 and San Rafael St.	Routes
4.33	24-Hour Count	Multnomah - Other	Burnside Rd.	Between 3rd St. and E. Powell Blvd.	Routes
4.34	24-Hour Count	Multnomah - Other	US 26	Between Palmquist Rd. and Hilyard Rd	Routes
4.35	24-Hour Count	Multnomah - Other	I-84	E. of I-5	Corridor
4.36	24-Hour Count	Multnomah - Other	McLoughlin Blvd.	S. of EB Powell to SB McLoughlin Ramp	Routes
4.37	24-Hour Count	Multnomah - Other	I-5	N. of Going St.	Corridor
5.01	24-Hour Count*	Washington County	I-5	Between I-205 and Nyberg Rd.	Model
5.02	72-Hour Count*	Washington County	Jenkins Rd.	Between Murray Blvd. and Bowerman Dr.	Model
5.03	72-Hour Count*	Washington County	OR 10	Between 149th Ave. and Murray Blvd.	Model
5.04	72-Hour Count*	Washington County	OR 99W	S. of Cipole Rd.	Model
5.05	72-Hour Count*	Washington County	Scholls Ferry Rd.	Between Murray Blvd. and Murray Scholls. Dr.	Model
5.06	72-Hour Count*	Washington County	Tualatin Sherwood Rd.	W. of Teton Ave.	Model
5.07	72-Hour Count*	Washington County	Tualatin Valley Hwy (OR 8)	Between 153rd Dr. and Murray Blvd.	Model
5.08	72-Hour Count*	Washington County	US 26 (Sunset Hwy)	E. of Cornell Rd.	Model
5.09	72-Hour Count*	Washington County	Walker Rd.	Between Murray Blvd. and Meadow Dr.	Model
5.14	24-Hour Count	Washington County	OR 99W	Between Beaverton Tualatin Hwy and OR 217	Corridor
5.15	24-Hour Count	Washington County	OR 99W	Between OR 217 and 78th Ave.	Corridor
5.16	24-Hour Count	Washington County	OR 99W	S. of Tualatin Sherwood Rd.	Corridor
5.18	24-Hour Count	Washington County	US 26 (Sunset Hwy)	W. of Shute Rd.	Corridor
5.19	24-Hour Count	Washington County	I-5	Between I-205 and Elligsen Rd.	Corridor
5.27	72-Hour Count	Washington County	Nyberg Rd.	Between Boones Ferry Rd. and I-5	Facility
6.01	24-Hour Count*	Clackamas County	I-205	At 65th Ave Undercrossing (Clackamas/Washington County Line)	Model
6.02	24-Hour Count*	Clackamas County	I-205/OR 212/213	Between 82nd Ave. and OR 213	Model
6.03	24-Hour Count	Clackamas County	I-205	Between 82nd Dr. and Sunnybrook St.	Corridor
6.06	24-Hour Count	Clackamas County	OR 224	E. of Freeman Way	Routes
6.08	24-Hour Count	Clackamas County	OR 224	W. of OR 213 (Cascade Hwy)	Routes
6.09	24-Hour Count	Clackamas County	OR 99E	N. of OR 224	Routes
6.10	24-Hour Count	Clackamas County	OR 212	Between 82nd Ave. and I-205	Facility
6.11	72-Hour Count	Clackamas County	OR 213	S. of I-205	Facility
6.14	24-Hour Count	Clackamas County	I-205	Willamette River Br. In Oregon City	Corridor
7.01	24-Hour Count	Clark County	Fourth Plain/SR 500	E. of SR 503	R/Corridor
7.03	24-Hour Count	Clark County	Padden	E. of 72nd Ave	R/Corridor
7.04	72-Hour Count	Clark County	SR 14	E. of 192nd Ave.	R/Corridor
7.05	72-Hour Count	Clark County	SR 14	E. of I-205	R/Corridor
7.06	72-Hour Count	Clark County	SR 14	W. of Lieser Rd.	R/Corridor
7.07	72-Hour Count	Clark County	SR 500	E. of I-205	R/Corridor
7.08	24-Hour Count	Clark County	SR 503	N. of Padden	R/Corridor

*Primary model screenline

10.0 Data Querying Interface

All of the data collected for the regional freight data program are available to regional freight stakeholders in conventional data formats – either Microsoft Excel spreadsheet formats or Microsoft Access database formats. This makes if possible to analyze the data using a variety of tools contained in these software packages or to export the data to a variety of statistical analysis packages. However, in order to make the data more accessible to users unfamiliar with these softwares, a data querying interface was developed for the project. This allows the user to display data in a variety of standardized formats but with some user flexibility in specifying what data he or she wishes to view. The Portland Regional Freight Data Collection querying data interface was developed for the following four datasets:

- Roadside Intercept Survey Data (4,159 completed survey records);
- Terminal Gateway Survey Data (498 completed survey records);
- Truck Following Study Data (667 records of trucks followed); and
- Vehicle Classification Count Data (5,254 hours of data collected).

Note that the raw data for the motor carrier surveys are confidential, and no data querying interface was prepared for that dataset.

10.1 Roadside Intercept Survey Data

The roadside intercept survey querying interface contains the following queries:

- Daily truck trips by commodity group (using 16-commodity group system).
- Daily truck cargo tonnage by commodity group.
- Payload factors (average tons per truck) by commodity group.
- Daily truck trips by three categories: inbound to the Portland region, outbound from the Portland region, and through trips passing through the Portland region.
- Daily truck trips with one endpoint in the Portland metropolitan area, by district of the corresponding endpoint (16 internal districts were defined).
- Daily truck trips with one endpoint in the Portland metropolitan area, by direction of external trip end relative to the region (north of region; south of region; east of region; west of region).
- Daily through (i.e., external-external) truck trips, by directionality pair relative to the Portland metropolitan area (north – south; north – east; north – west; south – east; south – west; east - west).

- Cross-tabulation of daily truck trips by trip type (inbound, outbound, through) by intercept location.
- Cross-tabulation of number of daily truck trips by trip type (inbound, outbound, through) by time of day.

10.2 TERMINAL GATEWAY SURVEY DATA

The gate intercept survey querying interface contains the following queries:

- Number of trips across all gate surveys by commodity group.
- Cross-tabulation of truck trips by commodity group by location.
- Payload factors (average tons per truck) by commodity group.

10.3 TRUCK FOLLOWING STUDY DATA

The truck following study querying interface contains the following queries:

- Percentage of through (i.e., external-external) trips by entry point by weekday time period (4:00 am – 6:00 am; 6:00 am – 9:00 am; 9:00 am – 3:00 pm; 3:00 pm – 8:00 pm). Percentages on weekends is provided separately.
- Percentage of through trips by weekday/weekend by truck class (2 axle 6 tire - single unit; 3 or more axle - single unit; 4 or fewer axle – multiple unit; 5 or more axle – multiple unit).

10.4 VEHICLE CLASSIFICATION COUNT DATA

The vehicle classification count querying data interface contains the following queries:

- Average daily truck traffic by location, sorted by region (Port of Portland and Airport; Port of Vancouver; Downtown Portland; Multnomah County other than Port, Airport, and Downtown; Washington County; Clackamas County; Clark County) then by facility type (freeway; state regional or district highway; arterial).
- Trucks as percentage of total vehicles by location, sorted by region then by facility type.
- Average daily truck traffic, by location by type of truck (medium: 2 axles, 6 tires; heavy: 3 axles plus).
- Trucks as percentage of total vehicles, by location by type of truck.
- Hourly truck traffic for individual locations.

A map of all vehicle count locations is provided in this report (Figure 7.9).

11.0 Conclusions

The data needs of the participating agencies in this study were initially identified in the first phase of this study and confirmed in Task 3. The freight data needs were classified into 10 categories:

- Origin-Destination (O-D) Data;
- Freight Facility Flow Information;
- Transportation Network Information;
- Truck Count Data;
- Commodity Information;
- Routing Information;
- Temporal Variability of Freight Flows;
- Truck Classification and Carrier Information;
- Travel Time Data; and
- Other Data.

This chapter is structured to mirror the structure of the technical memorandum developed for Task 3 to assess how well the overall study met the data needs of the participating agencies, based on the data synthesis and analysis results provided in the previous sections of this report. It should be noted that there was a limit on the resources that were to be expended for this study whereas the data needs were chronicled in an unrestrained fashion. Therefore, as expected the data needs were greater than the data that could be collected for the project. Nevertheless, there were some significant achievements in terms of meeting the primary freight data needs of the transportation stakeholders in the region. For each data item, this chapter describes the types of needs as noted in the Task 3 memorandum, discusses the data collected that match with the data need and summarizes any data gaps that still exist between the collected data and the stated data need.

11.1 Origin-Destination (O-D) Data

As stated in the Task 3 Technical Memorandum, a primary need for the region is the development of O-D data at a fine level of detail to better calibrate the Metro Truck Model. The Metro Truck Model currently is not calibrated based on an O-D commodity flow matrix, which impacts the accuracy of the truck flows with the destination and/or the origin outside the region. There is also a specific need to determine the origins and destinations of commodity flows across the I-5 and I-205 bridges over the Columbia River. These are major freight routes that link the Portland metropolitan area to Washington and Canada. O-D data would also support economic analyses of the impacts of routing requirements due to potential bridge limitations. Stakeholders were also interested in commodity O-D flows by time of day between major freight facilities in the region, including regional manufacturing facilities, warehouse and distribution centers, marine and air cargo terminals, and intermodal rail yards.

There was a significant amount of origin-destination data collected as part of this study. Origin-destination data were collected as part of the roadside intercept surveys, the terminal gateway surveys, the truck following study and the motor carrier survey. The most comprehensive set of origin-destination data was collected as part of the roadside origin-destination surveys. This survey effort included 4,159 surveys at 10 different locations around the metropolitan area. The data collected through this analysis has enabled the region to improve its truck travel demand forecasting by allowing for the external portion of the model to be calibrated based on an origin-destination commodity flow matrix. Four of the ten survey locations were along I-5 which was noted as being of particular concern by the region's stakeholders. Origin-destination information was collected at the address level for locations within the Portland metropolitan area and city/state detail for locations outside of the Portland metropolitan area.

The roadside intercept surveys also collected information on the routes associated with each of the trips that were intercepted. Thus it is possible to identify particular segments of roadway that are used for these external trips and determine the fraction of the traffic that is local and the fraction that is long haul and to determine the O-D characteristics of the long haul traffic that uses these segments of highway. For example, it is possible to determine how much of the external traffic that uses the I-5 Columbia River Crossing, to determine the fraction of total traffic that this represents (through and long haul traffic with at least an origin or a destination within the region), and to determine the O-D patterns of these long haul trips.

The origin-destination data collected as part of the terminal gateway surveys included 498 surveys performed at 11 locations including intermodal rail facilities and port truck gates. The data obtained in this survey included: shipment by time of day, commodity types, vehicle and trailer configuration/style, number of axles, carrier name and address, unloaded vehicle weight, payload weight, origin-destination, facility type for inbound and outbound shipments, street address for LTL shipments and shipment routes. The origin-destination level of detail for this survey was at the address level for each shipment.

Origin-destination data were also collected as part of the truck following study in East Multnomah County. The purpose of this study was to determine the amount of through truck traffic in a primarily residential portion of the county. The rough study area boundaries were 257th Street, I-84, 181st Street, and US26. Data were collected by having data collectors trail trucks that entered the region at four different locations. Trucks were followed until the vehicle either stopped within the study area or exited the study area. The specific entry point along with the exit point or stop location was collected for each vehicle surveyed in this effort.

The motor carrier survey captured origin-destination information through a series of interviews of 30 motor carrier operators in the region. Data collected as part of this survey included commodity, type of carrier, number of truck stops in typical route, number of employees, payload, and origin-destination information. The O-D data for this effort were more generalized into shipments within the Portland metropolitan area and shipments outside the Portland metropolitan area.

Due to the lack of adequate locations for performing roadside intercept surveys in the inner Portland area, there is not detailed data on I-5 and I-205 in the center portions of the city. However, much information regarding these roadways and their use and performance can be obtained from the four roadside O-D surveys that were performed on I-5 along with the routing information that was collected as part of the other studies. If more O-D information is needed on I-5 and I-205 in the center portions of the city, then a truck-following study of these facilities should be considered as one potential method to collect this information. This limitation also precluded the development of a comprehensive O-D matrix for truck trips where both the origin and destination of the trip is within the region – a significant fraction of total regional truck activity. While several methods were attempted, there was no effective way of getting local truck owners to participate in a usable O-D survey for internal trips.

11.2 Freight Facility Flow Information

A primary freight data need identified in the region is to determine the commodities moving through freight facilities. The existing regional freight facility database compiled by the Port of Portland is not exhaustive. In addition, a significant amount of data items are missing for several of the facilities in the database. Improved freight facility flow data could improve the modeling of time-of-day truck trip generation rates using local data, instead of using national Institute of Transportation Engineers (ITE) truck trip generation rates. There is also a need to identify the primary regional and national transportation networks that are used by freight moving through each of the freight facilities.

Freight facility information was collected as part of the roadside intercept surveys, the terminal gateway survey, the vehicle classification counts and the motor carrier survey. For the roadside intercept survey, information was collected on the land use at the origin and destination for each of the 4,159 trucks surveyed. Land uses included reload facilities, rail yard/port/airport, factory, retail outlet, home base and other (includes farm, mine, etc). Using these data, it is possible to estimate the types of facilities that are being accessed by trucks on each of the major roadways in the region. The terminal gateway surveys are freight facility surveys. Therefore, all of the data collected in this effort is directly related to freight facility flow information. These data can be used to describe the type and number of trucks generated at each of the major port and rail facilities in the region. They can also be used to understand the trip patterns of trucks generated at these facilities. The routing information collected through these surveys can be used to understand the primary and national transportation networks that are of importance to each facility.

The motor carriers surveyed were stratified by truckload, LTL and private companies. The data collected as part of this effort will allow for an understanding of the range of activities that can occur at these types of facilities throughout the region. Specifically, there are data that showed the correlation between the number of employees and the number of shipments at motor carrier facilities. This will also go a long way to eliminating the need to use data from other regions or national data for estimating truck trips at these types of facilities.

11.3 Transportation Network Information

Primary needs of freight stakeholders in the Portland metropolitan area related to the transportation network include:

- The identification of key freight corridors in the region;
- An understanding of the complexity of the regional truck freight network; and
- An understanding of how key freight corridors connect to major freight facilities.

Prior to this data collection effort, there was an inconsistency between the classification of the regional transportation network and the actual truck usage of the network in the region. There is a need for better classification of the network into truck-only, truck-recommended, and truck-prohibited routes based on updated network operating characteristics, such as truck volumes, volume-capacity ratios, and truck speeds.

A significant amount of transportation network information was collected. For each of the truck survey efforts, information was collected on vehicle routing. This allows for the identification of the key freight corridors in the region. The routing information collected at the major freight facilities provides an understanding of how key freight corridors connect to the major freight facilities. The data collected in this study also illustrated the complexity of the regional truck freight network. For example, for the motor carrier survey, it was noted that the roads used by the aggregated survey respondents included every major roadway. Additionally, each freight facility had a unique set of transportation needs.

11.4 Truck Count Data

Truck count data are needed by stakeholders in the Portland metropolitan area to address many freight issues. Currently, the Metro Truck Model is not validated for each of the screenlines in the regional travel demand model because of the lack of classification count data at model cutline locations. Truck counts are needed at these cutlines to validate Metro Truck Model results with observed truck volumes. There is also a need for truck count data to prioritize each of the region's corridors in terms of carrying freight. Truck count data are also needed on key arterial corridors since they form an integral part of the Portland regional truck freight network. Overall, truck count data can help support many of the freight data needs described by stakeholders, including identifying key freight routes, understanding flows to major freight generators, and related information.

Truck count data were collected to fulfill data needs for each of the participating agencies. Specific truck count needs were fulfilled for improving the Metro model, to ensure geographic coverage throughout the region, to capture the primary roadways in the region, and to capture truck activity nearby to the region's primary freight facilities. The formal vehicle classification count program in Task 5 of the study included a total of 108 locations. 56 of these locations were 72-hour counts and 52 were 24-hour counts. Counts were collected on Tuesdays, Wednesdays, and Thursdays in the Spring of 2006. The vehicle classification scheme for this program was the truck portion of the FHWA vehicle classification system (Classes 5-13). Data were collected for the first 15 minutes of each hour and expanded to a full hour by multiplying by four. This data collection methodology was successful in collecting the most data for the available resources. It was found through this data collection effort that day-to-day truck volume differences on the interstate are minor and that these facilities can be surveyed for a 24-hour period rather than for 72 hours. For other locations, a 72-hour truck count smoothed out the day-to-day variability. The truck count data were also successful in that they allowed for several inferences to be made regarding truck activity in the region as described in Section 5.3.

As noted earlier, truck count data were also required to expand the survey data to 24-hour periods. This requirement resulted in truck count data being available from each of the terminal gateways. Number of shipment data was requested as part of the motor carrier surveys. This can be relatively easily translated into truck volume information at each facility using a shipment to number of trucks conversion that factors in the operation of empty trucks.

11.5 Commodity Information

Key commodity-specific information, including O-D data and commodity flows by major freight facility, was also identified by stakeholders as a freight data need. Additional commodity-specific data needs for the region included commodity flows by value to measure time-sensitivity of freight flows, truck reload volumes and percentages by commodity, and commodity-specific payload factors for converting commodity flows to truck trips in the Metro Truck Model. Some jurisdiction-specific commodity information needs included the Port of Portland's need for information to develop a mechanism to link commodity shipments with specific truck movements, and Washington County's need for information on agricultural goods movements across the urban goods boundary.

The roadside intercept survey, terminal gateway survey and motor carrier surveys each requested information on commodity as part of the analysis. Each survey allowed the survey participant to describe their specific commodity. During post-processing, for the roadside intercept surveys and terminal gateway surveys, these commodity descriptions were translated into one of the following commodity groups:

- Live Animals, Agriculture, and Animal Products
- Food Products
- Stone, Sands, Gravel
- Base Metal and Articles
- Non-Metallic Minerals and Mineral Products
- Oil, Gas, Petroleum/Coal Products
- Chemicals, Chemical Products
- Lumber or Wood Products, Furniture
- Pulp, Paper, Printed Matter
- Textiles, Apparel, Leather Products
- Machinery and Electrical Equipment
- Transportation and Transportation Equipment
- Waste and Scrap
- Mixed Freight, Packages
- Misc. Manufactured Products and Instruments
- Metallic Ores and Coal

For the motor carrier surveys, the commodity group classification is different since it was developed to represent specific trucking activity patterns that are characteristic of individual commodities falling into each commodity group. Ten commodity groups were used for the motor carrier surveys (Lumber and Wood Products; Building Materials; Food/Grocery Products; Other Consumer Goods; Chemicals and Allied Products; Office Products; Machinery; Manufactured Products (all other); General Commodities/FAK; Small Packaged Freight).

These commodity group systems can be easily matched with other commodity classification systems such as STCC, SCTG, VIUS and the Harmonized System (HS). Due to the large amount of data collected during the roadside intercept survey, commodity information can be correlated to several other truck activity variables such as O-D patterns, land use at trip ends, payload, truck type, and motor carrier type. Through combining the roadside intercept survey data on land use with the terminal gateway surveys, information on the commodities in and out of the region's key gateway facilities can be extracted.

11.6 Routing Information

Truck routing information for the region was identified as being needed to identify differences between the designated truck freight network and current truck operating patterns. There was also a need to identify factors, other than distance or travel time that may affect truck routing decisions. Specifically, Clark County needed information on truck routes that include SR 14 to avoid Oregon fees incurred on I-84. More information on freight route choice behavior in the region could be used to improve truck trip assignment methods, as well as to conduct feasibility analysis of major freight corridor investments. The Port of Vancouver, for example, needs information on freight route choice behavior to assess the potential truck volumes that can be diverted from the I-5 bridge to a proposed arterial route west of the existing bridge across the Columbia River. Routing information will also begin to provide the Metro Truck Model with much needed behavioral data regarding truck trips. This kind of detail will also enhance O-D data in the context of influencing policy decisions.

Routing information was captured in all of the surveys performed for this study, except the motor carrier survey. For the roadside survey and terminal gateway study, survey participants were asked which of the major roadways they would use or did use for their current trip (I-5, I205, etc.). Using these data, it is possible to determine if truck trips are avoiding select roadways even when those roadways are the shortest distance between the origin and destination. Using the data collected in the motor carrier survey, the routing information can be combined with trip chaining information to provide a sense of how long haul and short haul trips vary in terms of the number and location of stops between freight loading and drop-off locations.

Collecting routing information was the core methodology used for the truck following analysis. For each truck surveyed, routing information was collected that included details on each street that was turned on to and what the specific exit point or stop point was for each truck. This effort was successful in determining the amount of through truck traffic in the small study area of concern. This methodology could potentially be applied to answer many of the specific questions of the stakeholders such as I-5 truck diversion and truck routing to avoid fee collection locations.

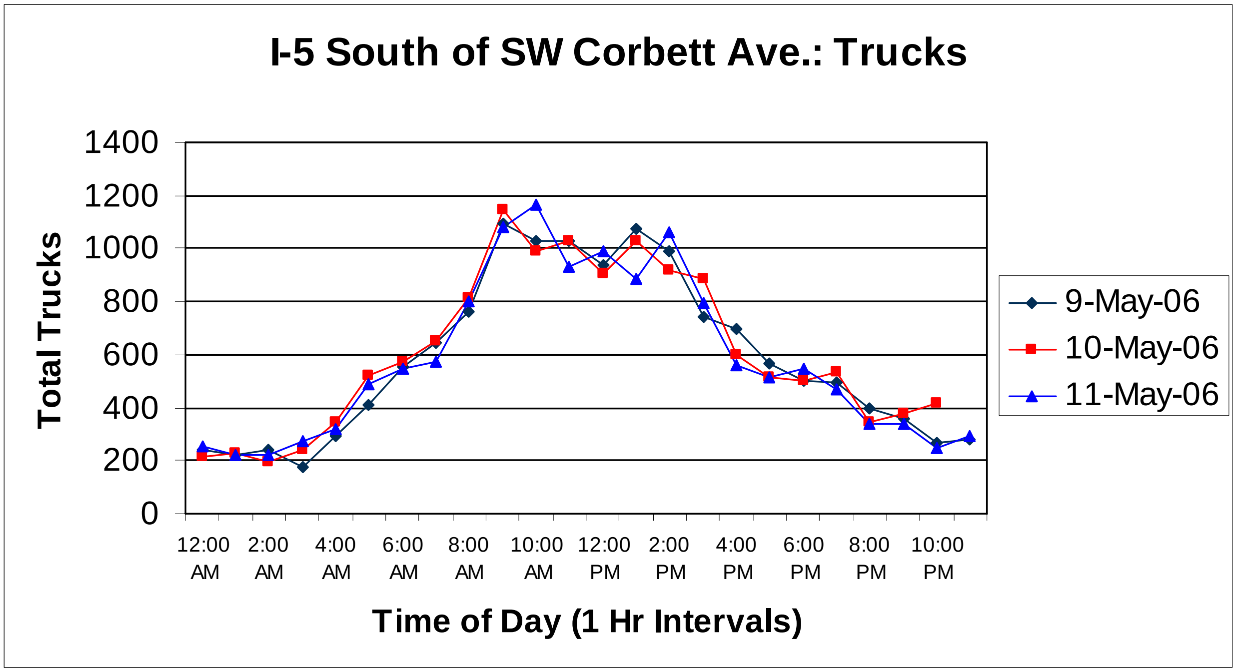
11.7 Temporal Variability of Freight Flows

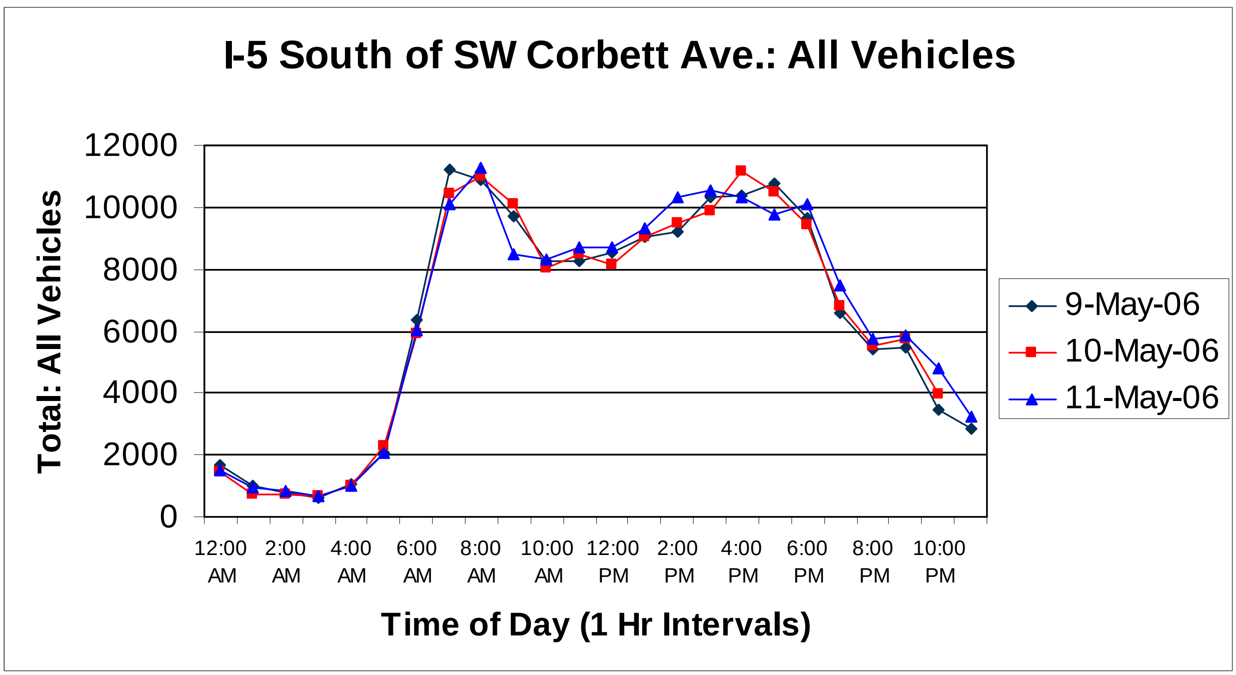
At the onset of this study, it was known that there is significant temporal variability in certain types of freight activity. Many commodities are produced and/or shipped only during certain times of the year. There is also a significant increase in certain types of shipments in preparation for the Christmas holiday. Additionally, trucks have different peaking patterns during the days of the week and the time of day. There is a much larger drop-off in truck activity during the weekend relative to passenger cars. Trucks also tend to have peak activity in the middle of the day rather than the morning and evening commute periods that are the primary operating times for passenger cars.

Information was needed on both time-of-day and seasonal variation of freight flows, particularly on freight-intensive state highways and arterials for which there are no current automatic traffic recording devices. This will allow transportation planners to understand the temporal variations in the operating conditions of the regional truck freight network. Understanding temporal variation can improve the analysis of the interaction between passenger and truck movements, particularly during congested time periods. This information is also critical for model purposes because often times truck and other freight data are presented in annual terms. To estimate monthly, daily and peak hour truck volumes from these annual numbers, estimates of the fraction of truck activity in each season, day of week and hour of day must be known.

The vast majority of the information collected in this study regarding temporal variability was through the vehicle classification count data. The counts were collected 24 hours a day which provided insight on how truck activity varies throughout the day on different roadway types (interstate, arterial), different facility types (rural interstate, port, intermodal yard) and throughout the region. Most notable was the different peaking activity of cars relative to trucks. This was notable at virtually every location and is shown below for I-5 near Corbett Avenue in Figure 7.1.

Figure 11.1 Location 4.2: I-5 south of SW Corbett Avenue





Truck count data were collected on Tuesdays, Wednesdays and Thursdays. Over 50 locations were counted for 72-hours periods. These data showed little day-to-day truck count variability on freeway locations, but some variability on non-freeway locations. To conserve project resources, truck count data were not collected on weekends or during seasons other than Spring. However, the results shown above indicate that to collect these data most efficiently, 24-hour counts can be performed on the region's freeways and the variability of these facilities are a reasonable proxy for the variability of truck activity in the region as a whole.

11.8 Truck Classification and Carrier Information

Prior to this study's data collection effort, there was a need to collect data on truck types used to move freight within the region. There was a lack of good information about the percentage of truck trips by different truck classes or information on truck types used by major truck carriers operating in the region. There is also a need to develop better conversion factors between truck classification schemes. A common truck classification conversion, for example, is transforming from number of axles (commonly used in automated truck count programs) to gross vehicle weight rating of trucks (used by the U.S. Environmental Protection Agency (EPA) to model emissions).

The vehicle classification count data collection was counted using the truck portion of the FHWA classification scheme (Classes 5-13) program. This allowed for capturing count information on nine separate truck classes and provided good information on how truck volumes vary by hour of day and on a day-to-day basis for each of these nine vehicle classes. Several of the analyses were performed to identify differences between medium trucks (Class 5) and heavy truck (Classes 6-13). The truck class differentiation can also be extended to the freight facilities in the region through the truck counts taken at those locations. So the percentage of medium and heavy trucks at these locations can be estimated as well. Information was not collected on the correlation between gross vehicle weight rating and axle/trailer configurations. This could be covered in future roadside origin-destination surveys or motor carrier surveys.

11.9 Travel Time Data

There are two types of travel time data that are needed. The first is the on-road travel time between key O-D pairs. The second is the time needed to complete other freight-related activities. These data needs include time to transfer cargo at intermodal terminals to support modal diversion studies, time for commodity reloads for less than truckload (LTL) shipments to estimate LTL travel times, and travel time reliability measurements for performance assessment of the regional freight system.

There was limited travel time data collected as part of this study. The truck following study recorded the beginning and end times of the trucks that were followed as they entered and exited the study area or stopped within the study area. This provides generalized information on travel time for the trucks in this region. However, more exhaustive data on travel times would be more efficiently collected using either speed studies of key corridors or GPS technology attached to a sample of trucks over an extend period of time. There have been studies in the region that have covered this topic and those should be reviewed prior to collecting additional detail on this data item.

11.10 Other Data

There were some additional data items that were mentioned by select stakeholders that were not explicitly covered in this data effort. Thy include truck value of time to support alternative financing analysis, correlating economic activity and truck activity, industrial location decision factors and levels of error for existing freight data sources. These items are important for certain types of analysis. However, collecting information on these topics was outside the scope of this study.

11.11 Summary of Freight Data Needs Satisfied

A synopsis of the data collection efforts and how they satisfied generalized freight data needs is shown in Table 7.1. Each data collection effort satisfied multiple freight data needs. Except for the travel time data, each freight data need was actually covered by at least three of the data collection efforts. Therefore, the data collection efforts appear to have met the freight data needs of the stakeholders in the region. Another successful aspect of this study was the collection of all of the freight data elements within the same time period. This allows for easy correlation of data across data collection efforts without requiring growth factors, economic conditions or seasonal considerations to override the matching of data items. This will be important as data are extracted from this study and used in future analyses and policy discussions. The data collected through this study can be used as a template for freight data collection in other regions. This data collection effort can also be replicated in the Portland metropolitan region in the future when updated freight data are needed.

Table 11.1 Comparison of Freight Data Needs and Data Collection Efforts

	Data Collection Effort				
Data Type	Roadside Intercept Survey	Terminal Gateway Survey	Truck Following Study	Vehicle Classification Counts	Motor Carrier Surveys
Origin-Destination Data	X	X	X		
Freight Facility Flow Information		X		X	X
Transportation Network Information	X	X			X
Truck Count Data	X			X	
Commodity Information	X	X			X
Routing Information	X	X	X		
Temporal Variability of Freight Flows	X	X	X	X	X
Truck Classification and Carrier Information	X	X	X	X	X
Travel Time Data			X		

Appendix A: Previously Prepared Deliverables

- **Task 1: Review of Existing Data.** Submitted May 23, 2005.
- **Task 1: Memorandum on Existing Literature.** Submitted Jun 22, 2005.
- **Task 2: Review of Metro's Truck/Freight Model.** Submitted Sep 12, 2005.
- **Task 3: Freight Data Needs.** Submitted Sep 16, 2005.
- **Task 4: Roadside Intercept Survey.** Submitted Sep 8, 2005.
- **Task 4: Gate and Establishment Survey Plan.** Submitted Sep 16, 2005.
- **Task 4: Truck Count Data Collection Plan.** Submitted Oct 6, 2005. Revised Aug 10, 2006.
- **Task 4: Options for Collecting O-D Data in Multnomah County.** Submitted Jan 19, 2006.
- **Task 4: Workplan for Truck-Following Data Collection in East Multnomah County.** Submitted Apr 14, 2006.
- **Task 4: Revised Approach and Budget for Gate and Establishment Surveys.** Submitted May 11, 2006. Revised Jul 18, 2006.
- **Task 5: Data Delivery Commitments to Support Metro's Short Term Model Update.** Submitted Nov 10, 2005.
- **Task 5: Roadside Intercept Survey Instructions and Form.** Submitted Oct 26, 2005.
- **Task 5: Gate Intercept Survey Form.** Submitted Nov 16, 2005.
- **Task 5: Cleaned Attribute Datafiles for Roadside and Gate Intercept Surveys.** Submitted Jan 31, 2006.
- **Task 5: Shapefiles for Roadside and Gate Intercept Surveys.** Submitted Feb 6, 2006.
- **Task 5: Truck Following Study Raw Data.** Submitted Aug 11, 2006.
- **Task 5: Motor Carrier Survey Form.** Submitted Sep 15, 2006.
- **Task 6: Vehicle Classification Count Data.** Submitted in two batches; the first on Jun 29, 2006, the second on Jul 14, 2006. The data was later combined into a single file.

- **Task 7: Summary of Data Collected Through Surveys and Counts.** Submitted Feb 7, 2006.
- **Task 7: Memo Regarding Possible Time of Day Expansion.** Submitted Feb 13, 2006.
- **Task 7: Multnomah County Truck Following Study Draft Report.** Submitted Aug 11, 2006.
- **Task 7: Spring Truck Count Analysis Report.** Submitted Aug 18, 2006.
- **Task 7: Motor Carrier Survey Technical Report.** Submitted Dec 16, 2006.
- **Task 7: Data Synthesis and Analysis Draft Report.** Submitted Jan 26, 2007.
- **Task 7: Truck Count Analysis to Meet Additional ODOT Requests.** Submitted Jan 26, 2007.
- **Task 8: Regional Truck Count Program Development for the Portland Metropolitan Region.** Submitted Nov 17, 2006. Revised Jan 26, 2007.
- **Task 9: Develop Query Data Interface.** Submitted Jan 8, 2007. Revised Jan 15, 2007.

Appendix B: Roadside Intercept Survey Data Cleaning

Geocoding Fields: Data Cleaning and Results

The truck trip origin and destination data cleaning and geocoding procedures for the roadside surveys were conducted in a six-step process:

- <u>Step 1:</u> Identify and geocode all origins and destinations with exact street address data (within the designated study region). The geocoding tool in GIS was used to identify and geocode these records. The survey data and the appropriate street shapefiles were used in this geocoding step. The records that were geocoded using this methodology are coded as "EXACT ADDRESS" in the "METHOD" field of the geocoded shapefile attribute table.
- <u>Step 2:</u> Identify and geocode origins and destinations with almost exact address data (within the study region). This step was used for data for which address data are available, but the geocoding tool did not find an exact address. The geocoding tool in GIS includes a matching address wizard that was used to identify and geocode these. The geocoding tool did not find an exact address for one of the following reasons: spelling errors in the street name; no matching street number was found; the suffix of the street was incorrect (i.e. "street" was used instead of "expressway"); or street intersection data without any street number was provided. Each of these cases was reviewed interactively in this geocoding step. The zip code step, described in step 4, was used if uncertainty about origin and destination locations existed during this step. The records that were geocoded using this methodology are coded as "CLOSE ADDRESS" in the "METHOD" field.
- <u>Step 3:</u> Identify and geocode origins and destinations for businesses or other facilities (within the study region). This step was used for data for which business or facility name only were provided, without a street address. The exact street address for these origins and destinations were identified using the world wide web and other sources and then geocoded by using the geocoding tool in GIS. The records that were geocoded using this methodology are coded as "ADDRESS LOOKUP" in the "METHOD" field.
- <u>Step 4:</u> Identify and geocode origin and destination zip codes (within the study region). This step was used for data for which city names only were provided, and for vague street address data for records that could not be geocoded in Steps 1 and 2. Zip codes for these cities and streets were identified, to the extent possible. The survey data fields indicating

entrance/exit ramps (depending on origins or destinations), access roads and major routes were reviewed as well. The geocoding tool in GIS was then used to assign these origins and destinations to the centroid of the zip code area. For large cities (i.e., Portland), a street name (with no number) was used to help pick the zip code if the street was short enough. Otherwise it was not practical to make a zip code selection because the choices were too many. The records that were geocoded using this methodology are coded as "ZIP CODE" in the "METHOD" field. The actual zip codes used are coded in the "NOTES" field.

- Step 5: Identify and geocode external cities and states outside of the study region. The points on the roadway network where the external trips enter or exit the study region (highway gateways) were identified, and the origins and destinations were assigned to those points. The records that were geocoded in this way are coded as "EXTERNAL" in the "METHOD" field. The actual entry or exit point used are coded in the "NOTES" field.
- Step 6: All other records were examined on a case by case basis to determine whether it was possible to geocode these in any way.

Table A-1 shows the number and percent of origins and destinations geocoded by method.

Table A-1 Roadside Survey Geocoding Results (out of 4,159 records)

Geocoding Method	# of Origins Geocoded	Percent of Total Records	# of Destinations Geocoded	Percent of Total Records
1: EXACT ADDRESS	306	7%	107	3%
2: CLOSE ADDRESS	160	4%	224	5%
3: ADDRESS LOOKUP	141	3%	103	2%
4: ZIP CODE	459	11%	384	9%
5: EXTERNAL	2,919	70%	3,194	77%
TOTAL	**3,985**	**96%**	**4,012**	**96%**

A total of **3,852 survey records (93 percent)** had both the origin and the destination geocoded. Of these records:

- 1,841 (48 percent) had one trip end within the Portland metropolitan area and one trip end external to the region.
- 1,988 (52 percent) had both trip ends external to the Portland metropolitan area (i.e., through trips).

ATTRIBUTE FIELDS: DATA CLEANING AND RESULTS

The attribute data fields for the roadside surveys were separated from the spatial data fields used for the geocoding of origins and destinations. The attribute and spatial data fields can be linked using the "ID" field (the roadside surveys are numbered starting from 1; the gate surveys are numbered starting from 10001). **Table 2** shows the data cleaning procedures that were applied to the roadside survey attribute data.

Table A-2 Roadside Survey Attribute Data Cleaning

Field Name	Data Cleaning/Editing Methodology	% of Records Corrected
	Facility Type (Last Stop and Next Stop)	
Coding Error: Last Stop or Next Stop	Assign facility code 1-9 to records identified as facility code 11: Other, based on the description in the "Other Description" field.	7%: last stop; 9%: next stop
Missing Code: Last Stop or Next Stop	Assign facility code based on the description in the "Other Description" field or from the business type at the given street address, if provided. For other records for which the "Activity" field was coded as 3: Return to Base, assign the facility code as 10: Home Base.	10%: last stop; 16%: next stop
	Activity (Last Stop and Next Stop) and Cargo Load Level	
Coding Error: Inconsistency Between Activity: Last Stop, Activity: Next Stop, and Cargo Load Level	If cargo load level (empty) is consistent with the cargo weight (= 0), then reverse last stop and next stop activity codes. Otherwise, assign cargo load level code of 2: Fully Loaded or 3: Partially Loaded based on the cargo weight and truck type.	2% (last stop pickup, next stop delivery, empty load)
	If cargo load level (empty) is consistent with the cargo weight (= 0), then correct last stop activity to 2: Delivery. Otherwise, assign cargo load level code of 2: Fully Loaded or 3: Partially Loaded based on the cargo weight and truck type.	<1% (last stop pickup, next stop home base, empty load)
	If cargo load level (fully loaded) is consistent with the cargo weight, then reverse last stop and next stop activity codes. Otherwise, assign cargo load level code of 1: Empty.	<1% (last stop delivery, next stop pickup, fully loaded)
	If cargo load level (partially loaded) is consistent with the cargo weight, then reverse last stop and next stop activity codes. Otherwise, assign cargo load level code of 1: Empty.	<1% (last stop delivery, next stop pickup, partially loaded)

Field Name	Data Cleaning/Editing Methodology	% of Records Corrected
	If cargo load level (empty) is consistent with the cargo weight (= 0), correct next stop activity code to 1: Pickup or 3: Return to Base, based on next stop facility type information. Otherwise, if cargo weight corresponds to partially loaded truck, correct cargo load level to 3: Partially Loaded. Otherwise, if cargo weight corresponds to fully loaded truck, correct cargo load level to 2: Fully Loaded, and correct last stop activity to 1: Pickup or 3: Return to Base, based on last stop facility type information.	<1% (last stop delivery, next stop delivery, empty load)
	If cargo load level (fully loaded) is consistent with the cargo weight, correct last stop activity code to 1: Pickup or 3: Return to Base, based on last stop facility type information. Otherwise, correct next stop activity code to 1: Pickup or 3: Return to Base, based on next stop facility type information.	3% (last stop delivery, next stop delivery, fully loaded)
Coding Error: Same Activity at Last Stop and Next Stop	If cargo load level is 1: Empty, then correct last stop activity code to 2: Delivery or 3: Return to Base, based on last stop facility type information. If cargo load level is 2: Fully Loaded or 3: Partially Loaded, correct next stop activity code from 1: Pickup to 2: Delivery or 3: Return to Base, based on next stop facility type information.	3% (pickup activity at last stop and next stop)
	If cargo load level is 1: Empty, then correct last stop activity code to 2: Delivery or next stop activity code to 1: Pickup, based on last stop/next stop facility type information. If cargo load level = 2: Fully Loaded or 3: Partially Loaded, correct last stop activity code to 1: Pickup or next stop activity code to 2: Delivery, based on last stop/next stop facility type information.	<1% (return to base activity at last stop and next stop)
Missing Activity Code	Assign missing activity code(s) based on the activity code provided at the other stop, the cargo load level, and/or facility type information. For example, for Next Stop: Pickup and Cargo Load Level: Empty, assign last stop activity code as 2: Delivery or 3: Return to Base, based on last stop facility type information.	5%: last stop; 10%: next stop; 2%: both last and next stop
Activity Code Range Error	For activity code not equal to 1, 2, or 3, assign activity code based on the activity code provided at the other stop, the cargo load level, and/or facility type information.	<1%
	Cargo Weight	
Missing Cargo Weight	If cargo load level is empty, then assign cargo weight of zero. If cargo load level is fully/partially loaded, assign cargo weight as the average payload weight of the commodity group for that truck configuration. The average payload factors by commodity group and truck configuration were derived from the survey data.	16%
Cargo Weight Range Error	Correct out of range cargo weights based on the maximum allowable cargo weight for each truck configuration, as derived from the maximum allowable Gross Vehicle Weight (GVW) ratings specified by Oregon Administrative Rules (OAR) Chapter 818: Vehicle Limits by number of axles, and average tare weights by truck class derived from	5%

Field Name	Data Cleaning/Editing Methodology	% of Records Corrected
	VIUS. Cargo weights over 10,000 pounds of the maximum cargo weights were considered as GVWs and subtracted from the average tare weights to determine the cargo weights.	
Truck Type, Number of Units, Axle Configuration		
Inconsistency between Truck Type and Number of Units	If number of axles is consistent with type of truck, correct the number of units to be consistent with the truck type. If number of axles is consistent with number of units but not with the truck type, correct truck type to be consistent with number of units and axles. For all other cases of inconsistency, assume truck type information is correct, and correct number of units to be consistent with truck type.	6%
Missing Field: Truck Type, # Units, and/or # Axles	Assign range error for truck type based on number of units and number of axles. Assign range error for number of units based on truck type. Assign range error for number of axles based on truck type and cargo weight.	5%
Range Error: Truck Type, # Units, and/or # Axles	Correct range error for truck type based on number of units and number of axles. Correct range error for number of units based on truck type. Correct range error for number of axles based on truck type and cargo weight.	1%

A summary of the attribute data cleaning is as follows:

- About 85 percent of the roadside survey records have both last stop and next stop facility type information.
- 100 percent of the records have last stop and next stop activity information.
- 100 percent of the records have cargo load level (i.e., empty, fully loaded or partially loaded) information.
- 99 percent of the records have cargo weight information.

COMMODITY INFORMATION

While the Metro model currently uses 16 commodity groups, the new commodity forecast database contains 41 groups. Metro would like to maintain the 41 groups if possible, in order to handle more disaggregate commodities in the future. The roadside surveys with a description of the primary commodity provided were coded according to this 41-group system to the extent possible. **Table A-3** shows the number of coded surveys by commodity group. A total of **3,737 survey records (90 percent)** had a commodity code assigned.

Table A-3 Roadside Surveys: 41-Commodity Group System

Commodity Code	Code Description	# of Surveys	Commodity Code	Code Description	# of Surveys
1	Live animals and live fish	20	22	Logs and rough wood	148
2	Cereal grains	52	23	Wood products	350
3	Agricultural products	175	24	Pulp, newsprint, paper, & paperboard	177
4	Products of animal origin	28	25	Paper or paperboard articles	72
5	Meat, fish, seafood, & preparations	85	26	Printed products	38
6	Grain and bakery products	40	27	Textiles, leather, and articles	77
7	Food and alcohol	638	28	Nonmetallic mineral products	259
8	Tobacco products	0	29	Base metal	77
9	Monumental or building stone	10	30	Articles of base metal	93
10	Natural sands	11	31	Machinery	90
11	Gravel and crushed stone	36	32	Electronic and office equipment	101
12	Nonmetallic minerals	45	33	Vehicles	162
13	Metallic ores	0	34	Transportation equipment	9
14	Coal	0	35	Precision instruments	2
15	Crude oil	13	36	Furniture and lighting	67
16	Gas, fuel, petroleum/coal products	90	37	Misc. manufactured products	190
17	Base chemical	24	38	Waste and scrap	71
18	Pharmaceutical products	14	39	Mixed freight	182
19	Fertilizer and fertilizer materials	13	40	Mail and express traffic	91
20	Chemical products & preparations	65	41	Empty containers	58
21	Plastics and rubber	64	99	Not codable	422

The commodity groups with fewer than 30 coded surveys are shaded. It will be necessary to combine these groups with other groups for analysis purposes in order to generate statistically significant results. **Table A-4** shows a grouping system with 16 commodity groups similar to that used for the original 1992 Truck Inventory and Use Survey (TIUS), conducted for possible application to the Portland Tactical Model.

Table A-4 Roadside Surveys: 16-Commodity Group System

Group	Description	Matches with Codes	# of Surveys
1	Live Animals, Agriculture, and Animal Products	1-4	266
2	Food Products (incl. meat, fish, bakery, alcohol, tobacco)	5-8	734
3	Stone, Sands, Gravel	9-11	53
4	Base Metal, Articles of Base Metal	29-30	162
5	Non-Metallic Minerals and Mineral Products (incl. plastic)	12, 21, 28	342
6	Oil, Gas, Petroleum/Coal Products	15-16	94
7	Chemicals, Chemical Products, Pharmaceuticals	17-20	110
8	Lumber or Wood Products, Furniture	22-23, 36	551
9	Pulp, Paper, Printed Matter	24-26	278
10	Textiles, Apparel, Leather Products	27	73
11	Machinery and Electrical Equipment	31-32	175
12	Transportation and Transportation Equipment	33-34	158
13	Waste and Scrap	38, 41	124
14	Mixed Freight, Packages	39-40	268
15	Misc. Manufactured Products and Instruments	35, 37	182
16	Metallic Ores and Coal	13-14	0
99	Not Coded		389
Total			3,959

200 of the 4,159 surveys were not used in this analysis as they were not surveys of heavy trucks or actually represented surveys of internal-internal truck trips.

Appendix C: Motor Carrier Survey Tables

Commodity Group Classification

Commodity Code	Commodity Group	Commodities
1	Lumber and Wood Products	Lumber, Wood Chips
2	Building Materials	Construction materials
3	Food/Grocery Products	Frozen Foods, Dairy Products, Beverages, General Grocery, etc.
4	Other Consumer Goods	Shoes, Apparel
5	Chemicals and Allied Products	Paint, Chemicals
6	Office Products	Office Supplies
7	Machinery	Heavy Equipment
8	Manufactured Products (all other)	Steel, Appliances, Paper Products, Tires
9	General Commodities/FAK	General Commodities/FAK
10	Small Packaged Freight	Packages

Facility Coding System

Facility Code	Type of Facility
1	Wholesale warehouses
2	Public warehouses (including 3PL, cold storage)
3	Distribution Centers (DCs)
4	Manufacturing Facilities (incl. Mills, Food processors, steel fabricators)
5	Airport
6	Marine Terminals
7	Rail yards
8	Truck Terminals
9	Retail Outlets (including stores)
10	Other (homes and businesses, restaurants, schools, hospitals, prisons, cafeterias, etc.)

Weighted Average Payload Factors by Commodity Group

Commodity Code	Commodity Group	Payload (Lbs)
1	Lumber and Wood Products	55,000
2	Building Materials	37,900
3	Food/Grocery Products	23,975
4	Other Consumer Goods	32,675
5	Chemicals and Allied Products	25,875
6	Office Products	23,975
7	Machinery	55,000
8	Manufactured Products (all other)	29,375
9	General Commodities/FAK	24,250
10	Small Packaged Freight	n/a

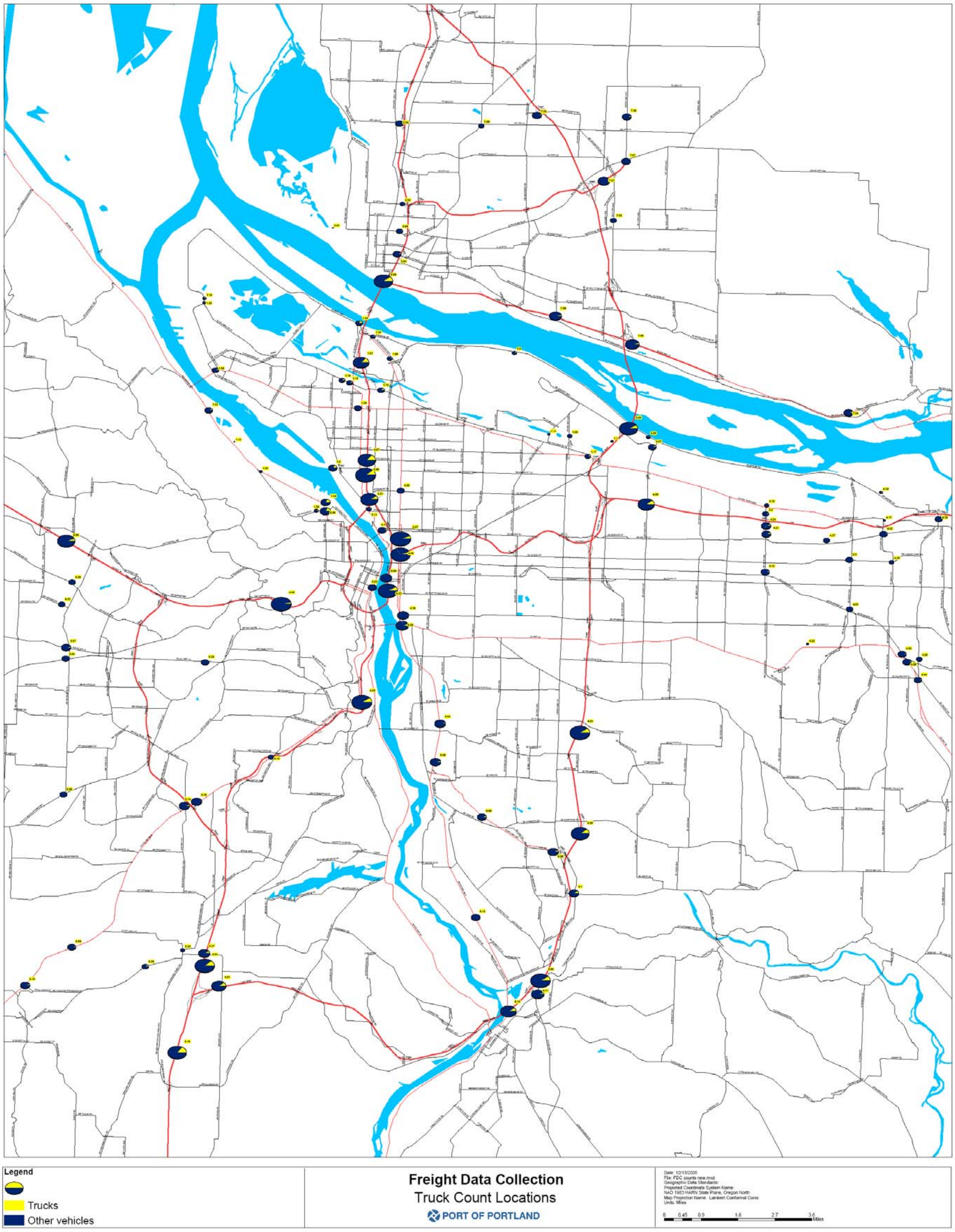
Appendix D: Regionwide GIS Analysis

The 11″ x 17″ printout on the next page presents average daily truck traffic volumes (ADTT) at each of the 108 count locations as a share of average daily total traffic (ADT) as a GIS map. The pie charts at each count location represent total traffic volumes with the yellow sections of the circles providing the truck volume shares of total traffic. The size of the circles is directly proportional to the magnitude of total traffic volume at the location.

Locations with high daily truck traffic volumes (> 12,000 trucks) in the region include the following:

- Tualatin Sherwood Road in Washington County west of Teton Avenue
- I-5 in Wilsonville
- U.S. 30 west of I-405 around downtown Portland
- Burnside Road between 181st and 185th Avenue
- OR 99W east of I-5 near Tigard
- I-5 on the Interstate Bridge
- I-5 north of Going Street (north of downtown Portland)
- I-205 between 92nd and Johnson Creek Boulevard
- I-5 between Victory and OR 99W south of the Interstate Bridge
- OR 213 South of I-205 near Oregon City
- OR 212 west of U.S 26 (east Clackamas County)

ADT and ADTT Volumes at Vehicle Classification Count Locations



Legend: Symbol Size and AADT