TRUCK PARKING: AN EMERGING SAFETY HAZARD TO HIGHWAY USERS

Final Report

PROJECT 783

Oregon Department of Transportation

TRUCK PARKING: AN EMERGING SAFETY HAZARD TO HIGHWAY USERS

Final Report -- Draft

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16. Abstract

It is recognized nationwide that commercial motor vehicle operators are often unable to find safe and adequate parking to meet hours-of-service (HOS) regulations. This holds true in Oregon, where high-use corridor rest areas and truck stops are experiencing a demand for truck parking that exceeds capacity. With such a demand for truck parking, there is an inherent safety concern for all highway users, primarily due to trucks parking in undesignated areas or commercial motor vehicle drivers exceeding their HOS to find safe and adequate parking. This work takes a closer look at truck parking along a high-use corridor in Oregon, namely US-97. To accomplish this, a stated-preference survey is administered to truck drivers that utilize Oregon roadways to gather opinions in regards to truck parking. Next, a parking demand analysis is conducted to assess current and future truck parking demand along US-97. To finish, historical Oregon crash data is used to identify crash trends, crash hot spots, and crash harm estimates along US-97. Survey results indicate that nearly two-thirds of surveyed truck drivers encountered trouble when looking for safe and adequate parking. Further, crash trends in terms of time-of-day, day of the week, and month of the year follow the time periods drivers stated having trouble finding safe and adequate parking. Crash harm estimates suggest a substantial impact on the economy.

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Symbol	When You Know	Multiply By	To Find	Symbol	Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH					**LENGTH**		
in	inches	25.4	millimeters	mm	mm	millimeters	0.039	inches	in
ft	feet	0.305	meters	m	m	meters	3.28	feet	ft
yd	yards	0.914	meters	m	m	meters	1.09	yards	yd
mi	miles	1.61	kilometers	km	km	kilometers	0.621	miles	mi
		AREA					**AREA**		
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ft^2	square feet	0.093	meters squared	m^2	m^2	meters squared	10.764	square feet	ft^2
yd^2	square yards	0.836	meters squared	m^2	m^2	meters squared	1.196	square yards	yd^2
ac	acres	0.405	hectares	ha	ha	hectares	2.47	acres	ac
mi^2	square miles	2.59	kilometers squared	km^2	km^2	kilometers squared	0.386	square miles	mi^2
		VOLUME					**VOLUME**		
fl oz	fluid ounces	29.57	milliliters	ml	ml	milliliters	0.034	fluid ounces	fl oz
gal	gallons	3.785	liters	L	L	liters	0.264	gallons	gal
ft^3	cubic feet	0.028	meters cubed	m^3	m^3	meters cubed	35.315	cubic feet	ft^3
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NOTE: Volumes greater than 1000 L shall be shown in m^3.									
		MASS					**MASS**		
oz	ounces	28.35	grams	g	g	grams	0.035	ounces	oz
lb	pounds	0.454	kilograms	kg	kg	kilograms	2.205	pounds	lb
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°F	Fahrenheit	(F-32)/1.8	Celsius	°C	°C	Celsius	1.8C+32	Fahrenheit	°F

*SI is the symbol for the International System of Measurement

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DISCLAIMER

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1.0 INTRODUCTION

1.1 BACKGROUND

It is nationally recognized that commercial motor vehicle operators often cannot find safe and adequate parking for rest purposes. This is especially true for Oregon, where high-use corridor rest areas are experiencing a heavy demand for truck parking that exceeds capacity. These rest areas are intended for short-term safety breaks, yet they are increasingly used for long-term parking. Private truck stops are also experiencing capacity shortfalls. The economic recovery and driver hours-of-service (HOS) regulations have recently contributed to this rising demand. Winter weather conditions are another factor that adds to the demand of truck parking facilities. Recent studies performed by Pahukula et al. (2015) and Islam and Hernandez (2013) have shown factors related to weather and fatigue increase the injury severity level potential of commercial motor vehicle involved crashes.

Because of truck parking shortages and limits on stays in public rest areas (Oregon Administrative Rule 734-030-0010 allows a vehicle to remain in a rest area for up to 12 hours in a 24-hour period), commercial motor vehicle operators may be contributing to unsafe situations by driving without a required short break and/or by parking on roadway access ramps, shoulders, highway interchanges, and facilities running through cities and towns. Oregon law, ORS 811.550, prohibits parking on a throughway, yet enforcement of illegal truck parking has been a low priority for Oregon State Police and other Oregon law enforcement officers. This problem is expected to become an increasing hazard as freight movement by truck is forecast to increase approximately 70% (tonnage) by the year 2035 (*Office of Freight Management and Operations 2016*).

Related studies have simply addressed the issue of commercial vehicle parking availability at rest areas by identifying capacity needs in an ad-hoc manner with no mechanism to assess the effectiveness of any new capacity investment. There is a clear need for a methodology that addresses the issue of insufficient commercial vehicle parking capacity and also assesses the effectiveness and safety impacts of any rest area capacity enhancements. Recently, there was an active ODOT solicitation of interest for a trucking parking facility at Biggs Junction (I-84 at US 97) that sought to address the problem with creative and innovative ideas through a public/private partnership; however, this partnership failed. Although Oregon could benefit greatly by having ODOT develop a long-range plan that identifies a strategy and locations for accommodating the demands for truck parking throughout the state, this project is limited to Biggs Junction at I-84 and the entire US-97 route through Oregon. The Oregon Freight Plan (OFP), the Oregon Freight Advisory committee, the Federal Highway Administration (FHWA), and the Federal Motor Carrier Safety Administration (FMCSA) have all identified the shortage of truck parking as a major issue that needs to be addressed.

1.2 RESEARCH OBJECTIVES

The shortage of truck parking has been identified as an issue across the state of Oregon. The current study will focus on Biggs Junction at I-84 and the entire US-97 route through Oregon in order to contain the project scope, but the methodology could be applied to other freight corridors in Oregon. Therefore, to adequately assess commercial vehicle parking needs and analyze safety on high-use corridors in Oregon, the research objectives are as follows:

- Review and summarize what other states are doing to address the truck parking shortage and related safety implications
- Identify data available and methods to measure the extent of the problem (e.g., identifying truck parking supply and demand)
- Gather opinions of commercial motor vehicle operators and commercial truck stop operators with regard to parking shortages and parking decisions
- Estimate future demand for truck parking based on freight forecasts prepared in the OFP and identify priority locations where truck parking is currently an issue (e.g., rest stops, exit ramps, shoulder of the road), or likely to become an issue
- Identify safety impacts of potential truck parking enhancements

1.3 BENEFIT

An inadequate supply of truck parking spaces can have negative consequences. For example, tired truck drivers may continue to operate their vehicles because they are unable to find a place to park and rest, or they may choose to park at unsafe locations such as exit ramps or shoulders of the road. With projected increases in truck vehicle travel in the State of Oregon, demand for truck parking spaces is expected to surpass the available supply. Upon identifying supply and demand of safe truck parking, this research will provide ODOT with recommendations for potential solutions for the development of safe and economically viable truck parking.

This study will also provide a platform for ODOT to identify public-private partnership opportunities. With the anticipated growth in truck movements, the shortages in parking spaces for trucks will be exacerbated unless public and private sectors respond to address this need.

1.4 IMPLEMENTATION

Results from this research will be immediately available for implementation. Central Oregon Freight Corridor highway enhancement activity planned by ODOT Region 4, central Oregon counties and cities, and the Central Oregon Area Commission on Transportation can use the results of this research to make informed decisions when looking for opportunities to improve highway performance and safety, meet local livability needs, and support the local economy. This information will help decision makers prioritize projects, bundle projects, meet multiple needs more efficiently, and provide high returns on investment for safety projects. Specific implementation recommendations will be provided at the end of this report.

2.0 LITERATURE REVIEW

The following section provides detailed results obtained from the work performed in a thorough and comprehensive literature review regarding truck parking. The current study, however, does not include any provisions, rules, or regulations from the recent Fixing America's Surface Transportation Act (FAST), as it is not yet fully understood how the FAST Act will impact truck parking moving forward.[1] The literature review was divided into three categories:

- Jason's Law
- Department of Transportation Research Related to Truck Parking Issues
- Policy Review
  - Federal Truck Parking Related Policies
  - Oregon Truck Parking Related Policies

The DOT syntheses detail applicable research regarding truck parking studies, while the policy review details relevant research regarding legal policies that affect the nature of truck parking in the United States and, more specifically, in Oregon.

2.1 JASON'S LAW

Jason's Law was established to provide a "national priority on addressing the shortage of long-term parking for commercial motor vehicles on the National Highway System (NHS) to improve the safety of motorized and non-motorized users and for commercial motor vehicle operators" (*Office of Freight Management and Operations 2015*). Jason's Law directed the United States Department of Transportation (USDOT) to conduct a survey and a comparative assessment to:

- Evaluate the capability of each state to provide adequate parking and rest facilities for commercial motor vehicles engaged in interstate transportation.
- Assess the volume of commercial motor vehicle traffic in each state.
- Develop a system of metrics to measure the adequacy of commercial motor vehicle parking facilities in each state.

Truck parking shortages are a national safety concern. A number of studies over recent years have shown severe truck parking shortages in some regions. In particular, a lack of adequate information for truck drivers about parking capacities, challenges with routing and delivery requirements, and the projected increase of truck traffic on the NHS are among the primary

1 Although the impact on truck parking is still not fully understood, truck parking facilities are on the list of eligible programs that can be funded as part of the FAST Act (Trombino III and Wright 2015). At the State level, the Texas Department of Transportation has not defined any design guidelines under the FAST Act. However, as truck parking facilities are listed as an eligible project, the Texas Department of Transportation suggests developing a specific component of their FAST Act plan that focuses only on truck parking (Texas Department of Transportation 2012).

factors that impact truck parking and its associated safety concerns. The USDOT performed a survey of key stakeholders that included: State DOT personnel; State motor carrier safety officials; travel plaza and truck stop owners and operators; trucking industry firm management, logistics personnel, and fleet drivers; and, independent truck drivers. Supplementary to the surveys, these industry groups and public agency representatives provided a valuable range of perspectives on the issue of truck parking.

A total of 37 State DOTs (roughly 73%) responded affirmatively to the question: "Do you have a problem with commercial vehicle truck parking in your State?" States reported parking shortages in official parking locations, as well as observing truck parking issues in unofficial parking locations. In terms of official parking locations, the following applies:

- 30 states reported observing shortages in public rest areas.
- 16 states reported observing shortages in private truck stops.
- 16 states reported observing shortages in designated pullouts or vista points.
- 18 states reported observing shortages in commercial areas.
- 14 states reported observing shortages at highway weigh stations.

As for unofficial parking locations:

- 24 states reported observing trucks parking along freeway interchange ramps.
- 23 states reported observing trucks parking along freeway shoulders.
- 18 states reported observing trucks parking on conventional highway roadsides.
- 12 states reported observing trucks parking on local streets.

Figure 2.1 shows the locations that state officials are reporting for having truck parking problems. Whereas a few of the locations are unofficial and considered illegal parking locations, the vast majority of locations experiencing parking problems are designated parking areas.

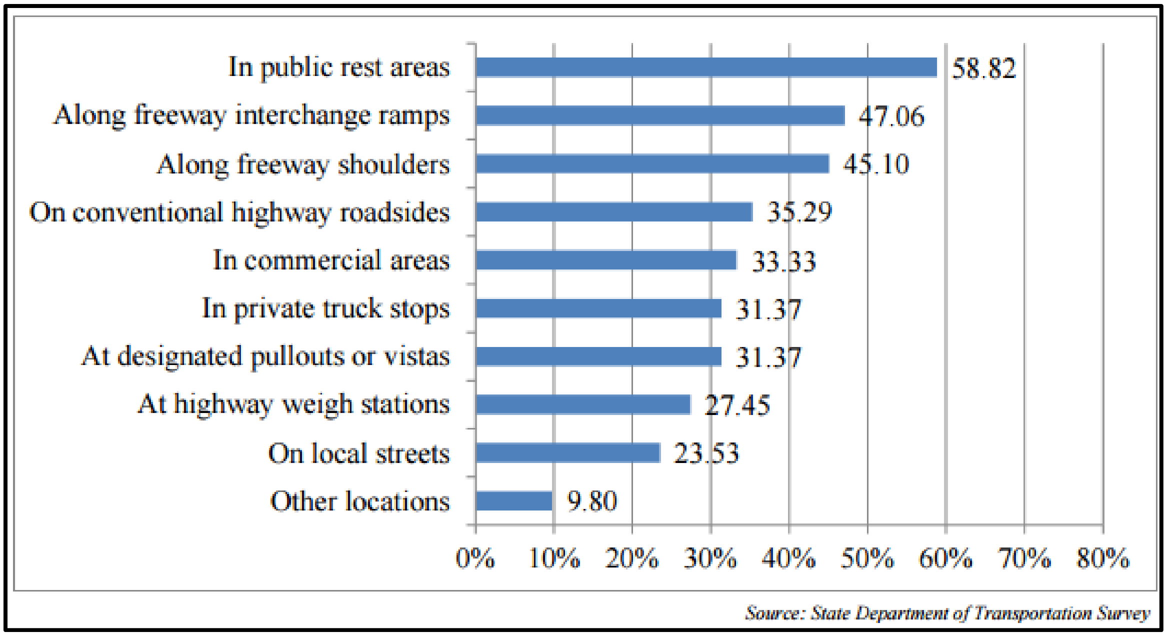

Figure 2.1: Locations of Truck Parking Problems as Reported by State DOTs

Figure 2.2 shows the unofficial locations that are favored by drivers as reported by State Motor Carrier Safety Personnel. Nearly half of the drivers choose to park on ramps if they park unofficially/illegally and 15% choose to park on local streets, which are often not designed to accommodate such a large vehicle.

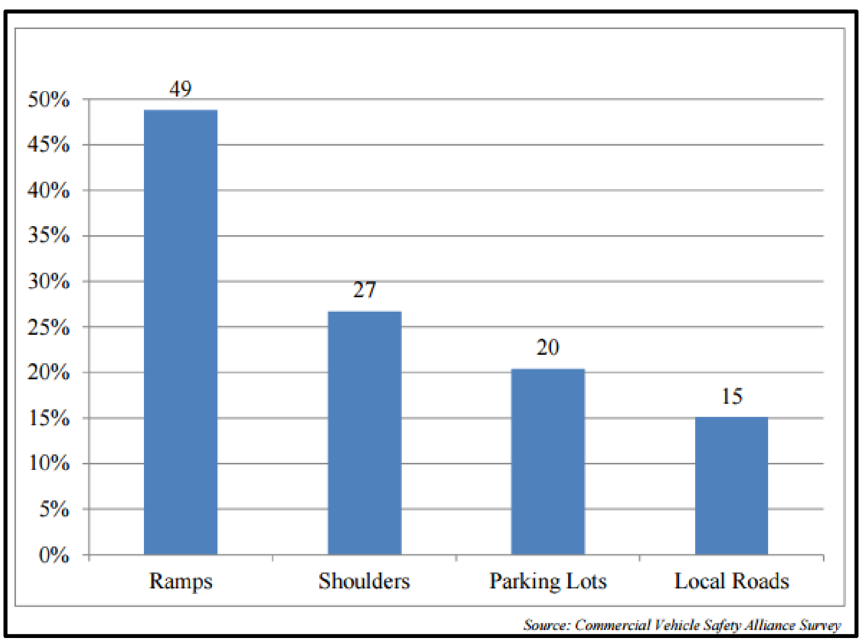

Figure 2.2: Unofficial Parking Locations as Reported by State Motor Carrier Safety Personnel

Figure 2.3 and Figure 2.4 show the level of difficulty that drivers have in finding safe and adequate parking. More than 60% of the drivers surveyed have trouble finding safe and adequate parking on a weekly basis. Similarly, those drivers have the most difficulty finding parking between 7:00 p.m. and 5:00 a.m.

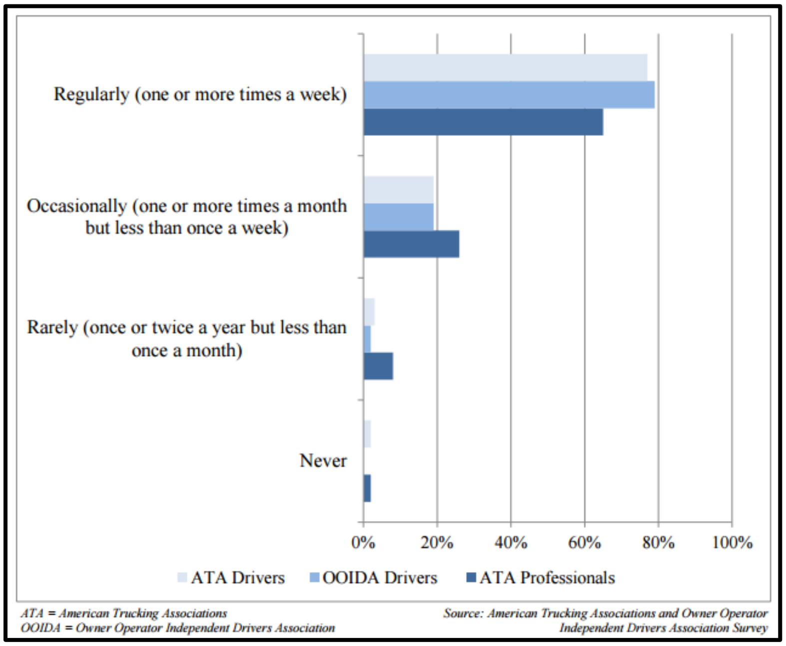

Figure 2.3: Frequency Drivers Experienced Difficulty in Finding Safe Parking Locations in the Past Year

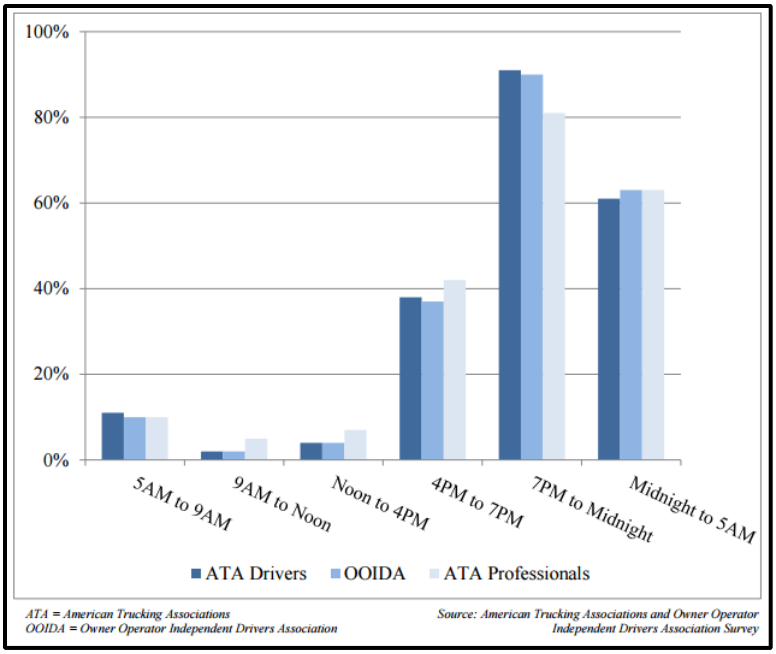

Figure 2.4: Time of Day When Drivers Experienced Most Difficulty in Finding Safe Parking during the Past Year

Jason's Law extended the eligibility of the National Highway Performance Program (NHPP), Surface Transportation Plan (STP), and Highway Safety Improvement Program (HSIP) to fund truck parking projects. Under Jason's Law, eligible projects may include the following:

- Constructing rest areas that include parking for commercial motor vehicles
- Constructing commercial motor vehicle parking facilities adjacent to commercial truck stops and travel plazas
- Opening existing facilities to commercial motor vehicle parking, including inspection stations, weigh stations, and Park-N-Ride facilities
- Promoting the availability of publicly or privately provided commercial motor vehicle parking on the NHS using intelligent transportation systems
- Making capital improvements to public commercial motor vehicle parking facilities currently closed on a seasonal basis to allow the facilities to remain open year-round
- Improving the geometric design of interchanges on the National Highway System to improve access to commercial motor vehicle parking facilities

Jason's Law also requires that all states conduct an inventory of existing truck parking, assess the volume of commercial motor vehicles in the state, and measure the adequacy of commercial motor vehicle parking facilities in the state. The results of this evaluation must be made available to the public.

2.2 DEPARTMENT OF TRANSPORTATION STUDIES

2.2.1 Minnesota Department of Transportation

Wilbur Smith Associates and the Center for Transportation Research and Education (CTRE) at Iowa State University prepared and conducted a study for the Minnesota Department of Transportation (MnDOT) *(Wilbur Smith Associates and Center for Transportation Research and Education at Iowa State University [CTRE] 2008)*. The primary goal of this study was to help MnDOT obtain the information necessary to support decisions regarding future solutions to truck parking issues in Minnesota. The study focused on examining the issues of Minnesota's role in the provision of truck parking, long term truck parking provisions that would impact the state's economy most positively, and actions that would positively affect traffic safety while taking advantage of the current state of the art technology (i.e., intelligent transportation systems [ITS]) and available federal funding. In order to answer these questions, Wilbur Smith Associates and CTRE performed an extensive review of existing literature and spilt the study into three primary tasks:

- Inventory Minnesota's interstates truck parking supply along three primary interstate corridors: I-90, I-35, and I-94
- Conduct a truck parking demand analysis
- Issue a survey to understand trucking company policies and attitudes regarding truck parking

Task one involved a detailed look at MnDOT maps using Google Earth Pro™, aerial photographs, The National Truck Stop Directory: The Trucker's Friend, and direct contact with truck stops. The study team contacted State Patrol enforcement officers and identified time periods that would best illustrate the parking variability at the facilities along the three corridors of interest. Officer suggestions and initial parking observation helped to identify three time periods for the study: (1) 4:00 a.m. to 10:00 a.m., (2) 12:00 p.m. to 6:00 p.m., and (3) 8:00 p.m. to 2:00 a.m.

Following task one, the researchers identified the demand for truck parking at the facilities. The truck parking demand analysis was conducted during the summer months of July and August. Field staff collected information about the demand for parking in public and private facilities along the identified Minnesota interstate routes. During site visits, field researchers recorded information about the number of spaces available, layout descriptions, ownership (public or private), services and entertainment available, and parking duration and limits. The field research team also gathered detailed vehicle information for several trucks parked at the observed parking locations. This information was then coupled with the Truck Parking Capacity Usages Database that is maintained by the MnDOT Rest Area Program. The team, along with the MnDOT Rest Area Program Manager, then identified a measure that would effectively demonstrate if a facility had reached or surpassed its overall capacity during peak volume hours. They defined over capacity as those facilities that observed more trucks parked than there were spaces to accommodate them. They looked at three levels of over capacity: 15%, 25%, or 50% of the time. Private parking facilities were less than amenable when it came to divulging the required information for the study, as they feared any published information may inevitably hurt their business. This is especially true if one or more facilities were identified as being overcapacity often, therefore possibly causing drivers to bypass the facility in search of other parking options.

During the demand study, carriers were identified at truck tops and rest areas along the three corridors. The issued survey consisted of nine questions and was sent to the 433 identified motor carriers from the Midwest and Canada. Of the 433 carriers identified, 178 responded to the survey by telephone, fax, US mail, or email. The survey asked rather open-ended questions, therefore providing feedback that was specific to each individual company and their opinions. The survey included statements requesting information of company parking policy, the type of operation they were involved with, and what type of freight was being hauled and by how many trucks. In a broad sense, the survey was seeking to answer the question: “What are the reasons that drivers are parking in a particular facility?”

The survey revealed that over two-thirds of the carriers (70%) had no company policies as to where to park. The remaining carriers identified a policy to park in a safe, well lit, and legal area. Many of those interviewed preferred the use of truck stops and rest areas being that such facilities typically have showers, telephones, and restrooms, to aid in a driver’s comfort while on the road. A majority of respondents explained the driver’s responsibility to find their own facilities for rest breaks. In addition, it was found that 98% of companies did not provide drivers with parking location information. Many stated that it was the driver’s responsibility to find safe parking. Yet, on the other hand, the survey showed that 96% of the drivers shared parking location information among themselves. The survey also found other reasons, as are shown in Figure 2.5.

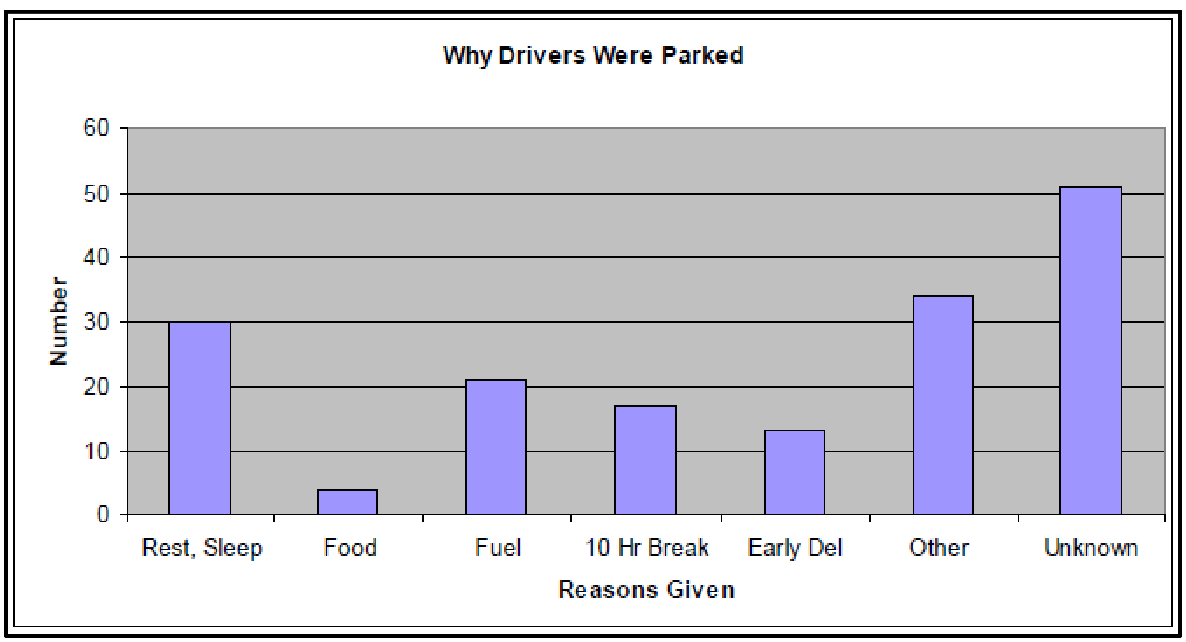

Figure 2.5: Reasons Drivers Were Parked (Source: *Wilbur Smith Associates and CTRE 2008*)

The most common and useful comments received from the survey and study are as follows:

- More staging areas for peak traffic times
- Overnight parking is in short supply around the Twin Cities
- I-35 and I-94 around Minneapolis have the largest problem in Minnesota during the evening hours
- Not enough parking in Minneapolis, as the nearest stop is one to one-half hours away
- Staging shortage within 30 miles of shippers/receivers (nationwide problem)
- Re-think rest area closures in Northern Minnesota considering rest areas at Forest Lake do not have adequate capacity
- All interstates lack capacity
- Every large city needs additional parking (radius of 100 miles) to accommodate pickups and delivery
- Need eastbound rest area between the Twin Cities and Hudson, WI, and needs to be designed to allow more room for drivers to maneuver

2.2.2 Virginia Department of Transportation

Kimley Horn (2015) prepared and conducted a truck parking study on behalf of the Virginia Department of Transportation. The truck parking study was conducted between September 2013 and June 2014 and provides VDOT with current information in regard to statewide truck parking challenges. The primary purpose of this study was to identify the frequency with which trucks are parking on interchange ramps, rest areas, and welcome centers along the Corridors of Statewide Significance (CoSS) and to determine if and where truck parking is needed. To answer this question, the researchers conducted a literature review of truck parking studies done at a national level and a state level. Following the review of truck parking studies, a review of related policies that affect truck parking were analyzed, explicitly focusing on federal and Virginia-specific truck parking related policies. Upon review of literature and truck parking related policies, the study turned to an inventory of the existing conditions of Virginia’s study corridors.

Truck parking needs in Virginia are accommodated mainly by private-owned commercial truck stops, and VDOT-owned rest areas and welcome centers. 133 truck parking facilities were confirmed in Virginia, consisting of 37 public facilities and 96 private facilities. A total of 7,464 truck parking spaces were reported, where approximately 90% were at private facilities and 10% were at VDOT safety rest areas and welcome centers. In addition, 49 truck parking facilities were confirmed to exist in adjacent states along the CoSS within 50 miles of the Virginia state line. Truck parking data was obtained for the surrounding states using a truck stop mobile application and commercial truck stop websites.

To gain a better understanding of the quality and quantity of truck parking in undesignated locations, specifically on shoulders of entrance ramps and mainline roadways, the study targeted five stakeholders for outreach efforts. The identified stakeholders included Virginia State Troopers, VDOT Residency Staff, VDOT Rest Area Staff, truck drivers that travel on Virginia roads, and owners/operators of Virginia truck stops. Each stakeholder group provided input regarding safety risks related to truck parking and provided unique perspectives related to challenges facing each stakeholder group. The study team developed questionnaires tailored for each stakeholder group, administered the surveys, and summarized the key findings. Following the stakeholder surveys, the study sought to understand the demand for truck parking on the study corridors.

To calculate the demand for truck parking, the study used two specific methodologies. The first methodology was adopted from a Federal Highway Administration (FHWA) study that provides an equation to determine truck parking demand independently of parking supply (*Fleger et al. 2002*):

$$Demand = AADT \times T\% \times \frac{L}{S} \times P_{avg} \tag{2.1}$$

Where $AADT$ is the annual average daily traffic on the roadway segment, $T\%$ is the percentage of trucks on the roadway segment, L is the length of the roadway segment, S is the average speed on the roadway segment, and P_{avg} is the average parking duration per hour of travel.

The second methodology used was presented by the Pennsylvania State Transportation Advisory Committee (2007). The study was used to “fine-tune” the methodology in the FHWA study. Following the demand calculations, the study made an effort to identify gaps in truck parking. Locations with a deficit of 250 to 700 truck parking spaces, and are at least 10 miles from a truck parking facility with more than 20 spaces, were identified as significant gap locations.

Kimely Horn and Associates made the following recommendations after the study was concluded:

- Partner with private industry and local governments to increase capacity and related improvements
- Provide accurate and real-time information about truck parking supply and availability in Virginia
- Improve the safety, effectiveness, and supply of truck parking spaces at Virginia owned facilities

2.2.3 Washington State Department of Transportation

The following section details the findings made by Parametrix (2005) on behalf of the Washington State Department of Transportation (WSDOT). The WSDOT Truck Parking Study evaluated the adequacy of truck parking along the primary freight corridors (I-5, I-90, and I-82) and identified several strategies with which to increase the availability of truck parking in the future.

WSDOT collected data on truck parking demand and utilization at all public rest areas (PRAs) along each of the study corridors. In addition to data gathered at public rest areas, the data collection effort also included a count of the number of trucks that were parked at unofficial truck parking areas, such as weigh stations, on-ramps and off-ramps, shoulders, and chain-up/chain-down areas. Parking demand was also summarized separately for each travel direction, as PRAs are generally only accessible in one travel direction. The consultant team surveyed commercial truck stop (CTS) employees along the study corridors to assess the supply and demand of truck parking at private facilities.

After collecting the truck parking data, future parking demand was estimated by multiplying existing truck parking demand by a growth factor developed for the study corridors. The growth factors for the corridors were developed based on the following:

- Washington State annual truck growth rates observed in WSDOT historical traffic volume data
- The Strategic Freight Transportation Analysis (2003) and Eastern Washington Intermodal Transportation Study (1999) truck volume databases (*Casavant 1999*; *Jessup et al. 2007*)
- WSDOT's Weigh-In-Motion recorders for truck traffic volumes
- Freight forecast estimates for the Port of Seattle and Port of Tacoma
- The Federal Highway Administration (FHWA) Study of Adequacy of Commercial Truck Parking Facilities (*Fleger et al. 2002*)
- The draft Freight Report for the 2005 Washington Transportation Plan Update *(WSDOT 2005)*

After analyzing the data, Parametrix (2005) determined that the annual growth rate for I-5, 1-90, and I-82 would be 3.5%, 4.0%, and 3.5%, respectively. After identifying the amount by which the demand would grow, the study focused on the existing conditions of truck parking along the corridors. It was found that I-5 in both directions, and I-90 westbound, were overcapacity in terms of utilization. Along with this, it was determined that increasing the number of parking spaces would not always be an answer to illegally parked trucks. It was shown that on the southern segment of northbound I-5 there were a total of 61 available truck parking spaces and, on average, a total of 65 trucks parked along the segment. Therefore, if all the legal spots were occupied, it is expected that only 6 trucks would be illegally parked. However, there were, on average, 21 illegally parked trucks along the segment. Solutions could include additional highway signs, a trucker's guide, or real-time truck parking information (such as variable message signs or a radio station) to inform drivers where there is available and easily accessible truck parking.

The study speculated that illegal truck parking occurred despite available capacity at nearby PRAs and CTSs based on:

- Drivers being unfamiliar with the area
- Drivers desiring to get as close as possible to their final destination
- Drivers wanting to maximize their drive times within HOS regulations
- Drivers find ramps and shoulders more convenient than PRAs and CTSs
- Many of today's trucks are longer than the parking spaces at PRAs which were originally designed to accommodate shorter trucks

The Washington State Truck Parking Study found the following:

- Five public rest area facilities currently have average truck parking demands that consistently exceed capacity.
- Eight commercial truck stops were regularly at, or over, capacity on a given night.
- Without added truck parking capacity, all study corridor segments and PRAs are expected to substantially exceed capacity by the year 2030.

The study put forth 8 strategies that could potentially alleviate the truck parking issues that the study corridors face:

- **Strategy 1:** Create new legal truck parking through new PRA construction, reconfiguring existing PRAs, or creating new truck-only facilities. This strategy could potentially add between 60 and 470 truck parking spaces and would cost between $30,000 and $75,000 per new space added.
- **Strategy 2:** Legalize truck parking at non-port-of-entry weigh stations and expand these facilities to accommodate more parking capacity. This strategy could potentially add between 150 and 280 truck parking spaces and would cost approximately $67,000 per new space added.
- **Strategy 3:** Implement public-private partnerships that would encourage new development of CTSs where PRAs are significantly over capacity. This strategy could potentially add between 30 and 180 truck parking spaces.
- **Strategy 4:** Implement public-private partnerships that would provide financial aid for increasing capacity at existing CTSs. This strategy could potentially add 100 truck parking spaces.
- **Strategy 5:** Develop shared-use parking agreements with existing parking lot owners, such as nighttime-only truck parking at large commercial parking lots and public Park-N-Rides. The amount of new truck parking spaces added from this strategy would depend

on the number of participating parking lot owners and the area of each site. However, it is estimated that this strategy could result in greater than 200 parking spaces.

- **Strategy 6:** Implement an information and communication program that provides current parking conditions at PRAs and CTSs.
- **Strategy 7:** Clearly designate truck parking from recreational vehicle parking at all PRAs.
- **Strategy 8:** Increase enforcement of existing truck parking laws.

2.2.4 Utah Department of Transportation

The following section details the findings made by the Utah Department of Transportation (UDOT) (2012). UDOT's I-15 Truck Parking Study sought to determine the answers to the following questions:

- Does the I-15 corridor have a truck parking problem?
- What do CMV drivers think about truck parking along the I-15 corridor and in Utah?
- If there is a truck parking problem, what can UDOT do to help alleviate the issues?

To answer these questions, the first step was to conduct a survey. Approximately 433 surveys were completed by commercial motor vehicle (CMV) drivers at commercial truck stops. When asked about parking and preferences, CMV drivers said the following:

- 97% decide themselves where to park, and 66% of the 97% make that decision while they are driving.
- 82% of commercial vehicle drivers say that ramps and shoulders are sometimes used for parking because there are no empty spaces at commercial truck stops or public rest areas; 72% stated it is due to no nearby parking facility; 33% stated it was due to an unawareness of the availability of parking in nearby commercial truck stops or public rest areas.
- Restrooms, convenience to highway, showers, and fuel are the most important features when selecting a place to park.
- Approximately 50% of the time, drivers find adequate parking facilities with the features they deem important.
- Drivers prefer a commercial truck stop for long-term rest (more than two hours) and food.

Figure 2.6 shows the types of services CMV drivers in Utah are looking for when deciding where to park, where the preferences shown are for Utah I-15 drivers and national drivers.

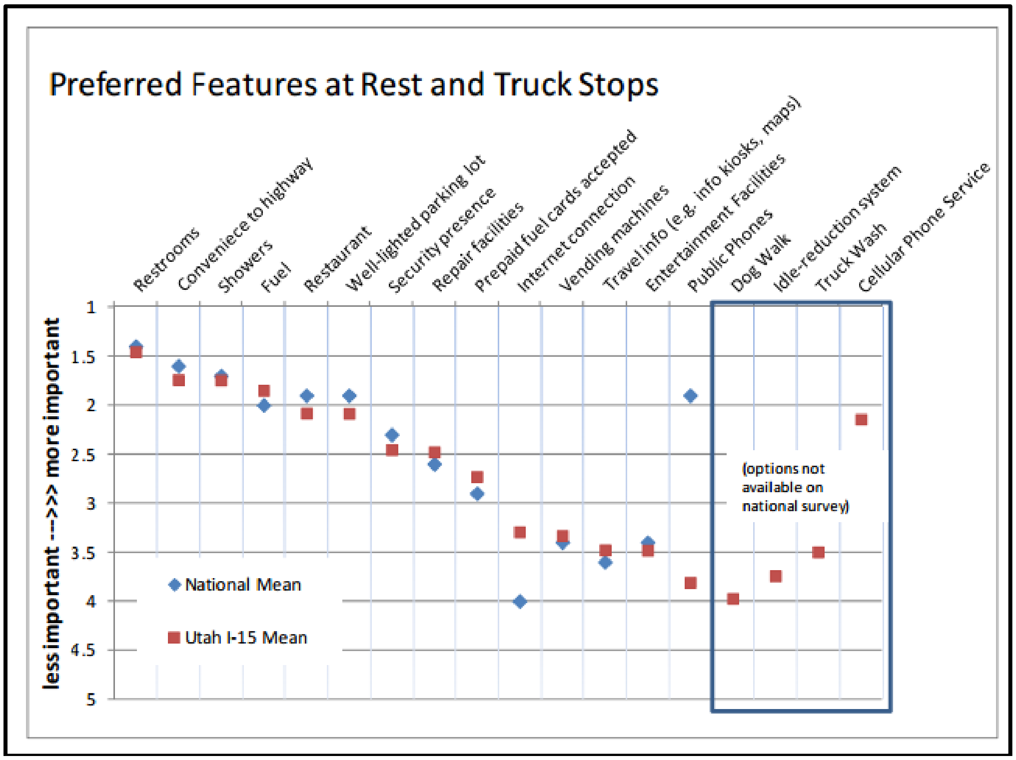

Figure 2.6: Utah's I-15 Commercial Motor Vehicle Driver Performance Pulled from Utah I-15 Truck Parking Study (*Source: UDOT 2012)*

Several avenues where explored as possible solutions. UDOT explored the option of utilizing warehouses as potential parking areas. However, after a survey of warehouses was conducted, it was found that owners and operators of warehouse locations were unwilling to allow CMV drivers to use their areas as parking locations. Another option was the development of a visor card or truck parking map that indicates the location of commercial truck stops and public rest areas along the freight corridors in Utah. UDOT has a smartphone application that is used for traffic updates, and they believe it can be of use to CMV drivers as well as the general public. Finally, UDOT created an I-15 truck parking website at www.udot.utah.gov/truckparking which has information about long-term truck parking issues in Utah. For CMV drivers, an interactive map is available on the website allowing them to determine the location of commercial truck stops and public rest areas along with amenities that they might utilize.

2.3 WISCONSIN DEPARTMENT OF TRANSPORTATION

In 2009, the Wisconsin Department of Transportation commissioned a study to look at possible low cost strategies to increase truck parking in Wisconsin (*Adams et al. 2009a*). The project sought to understand and analyze trends in truck parking, particularly as they relate to: specific truck parking issues, operational issues, locations where truck parking problems exist, and available low-cost solutions. Researchers identified problems, along with suggested solutions, by using web-based surveys directed at four separate groups of stakeholders: truckers/carriers, public freight planners, metropolitan planning organization representatives, and highway patrol officers. Researchers then used e-mail, telephone, and in-person contacts to solicit responses to the survey. Researchers also drew from information previously gathered by the Mississippi Valley Freight Coalition (MVFC) study "Low Cost Strategies for Short Term Parking on Interstate Highways of the MVFC" (*Adams et al. 2009b*). This study provided valuable information about additional interstate corridors in Wisconsin.

Major findings from this study, which were consistent with the MVFC truck parking study, included:

- The most common parking problems were related to insufficient parking capacity during peak demand hours, resulting in overflow parking on ramps.

- Parking problems occurred most often in the early evening or late at night.

- Truck drivers park on ramps and shoulders to avoid private rest stop disturbances in the form of solicitations from drug dealers and/or prostitutes.

- Truck drivers that experienced problems finding available parking tended to be from outside the area and knew little about Wisconsin's available parking or the means to obtain this information.

According to the truck drivers, design issues in public parking areas cause problems and capacity issues due to ineffective designs that make entry and exit movements difficult, and some trucks take up more than one spot due to poor lane markings.

2.4 POLICY REVIEW

2.4.1 Federal Truck Parking Related Policies

2.4.1.1 MAP-21

The Moving Ahead for Progress in the 21st Century Act (MAP-21) is a funding and authorization bill to govern federal surface transportation spending (*112th U.S. Congress 2012*). The bill was signed into law on July 6, 2012, and provides over $105 billion dollars for surface transportation programs. Sections related to truck parking and freight policy are summarized in more detail in the following sections.

2.4.1.2 §1115 National Freight Policy

Section 1115 of MAP-21 establishes a national policy to improve the condition and performance of the nation's freight infrastructure (*112th U.S. Congress 2012*). The goals and areas of improvement set out by the policy include congestion, safety, security, resiliency, use of advanced technology, environmental impacts, and accountability in the operation and maintenance of the network. Under Section 1115, states are required to do the following:

- Establish a national freight network to assist prioritization of resources for the improvement of freight movements on highways.
- Develop a national freight strategic plan and update the plan every five years.
- Develop tools to evaluate proposed transportation projects based on performance.
- Prepare a report every two years describing the performance and condition of the national freight network.

2.4.1.3 §1401 Jason's Law

In MAP-21, specific language is included to address the nation's shortage of long-term truck parking along the National Highway System. Section 1401 of MAP-21, also known as Jason's Law, extends the eligibility of National Highway Performance Program (NHPP), Surface Transportation Plan (STP), and Highway Safety Improvement Program (HSIP) to fund projects dealing with truck parking (*112th U.S. Congress 2012*).

Under Jason's Law, projects that are now eligible include the following:

- Construction of safety rest areas that include parking for commercial motor vehicles
- Construction of commercial motor vehicle parking areas adjacent to commercial truck stops and travel plazas
- Opening existing facilities to commercial motor vehicle parking, including inspection stations, weight stations, and Park-N-Ride facilities
- Promoting the availability of publicly- or privately-provided commercial motor vehicle parking on the National Highway System using intelligent transportation systems and other means
- Construction of turnouts along the National Highway System for commercial motor vehicles
- Capital improvements to public commercial motor vehicle parking facilities, that are currently closed on a seasonal basis, to allow the facilities to remain open year-round
- Geometric design improvements of interchanges on the National Highway System to improve access to parking facilities

Also required by Jason's Law is an inventory of existing truck parking for every state, assessment of the volume of commercial motor vehicles in the state, and a measurement of the adequacy of commercial motor vehicle parking facilities in the state. The results of this evaluation must be made available to the public.

2.4.1.4 Hours-of-Service (HOS) Regulations

The Code of Federal Regulations, Title 49- Transportation Part 395, outlines the HOS regulations for truck drivers (Code of Federal Regulations 2016). The Federal Motor Carrier Safety Administration revised the federal HOS regulations in July 2013 to replace HOS regulations that were enacted in 2003. The HOS regulations that apply to commercial property-carrying drivers are:

- 11-hour driving limit: Drivers may drive a maximum of 11 hours after 10 consecutive hours off-duty.

- 14-hour limit: Drivers may not drive beyond the 14th consecutive hour after coming on-duty following 10 consecutive hours off-duty. Off-duty time does not extend the 14-hour period.

- Rest breaks: Drivers may drive only if eight hours or less have passed since the end of their last off-duty or sleeper berth period of at least 30 minutes.

- 60/70-hour on-duty limit: Drivers may not drive after 60/70 hours on duty in 7/8 consecutive days. A driver may restart a 7/8 consecutive day period after taking 34 or more consecutive hours off duty.

- Sleeper berth provision: Drivers using the sleeper berth provision must take at least eight consecutive hours in the sleeper berth, plus a separate two consecutive hours either in the sleeper berth, off-duty, or any combination of the two.

2.4.1.5 Limitations to Rest Area Commercialization

The Code of Federal Regulations, Title 23- Highways Part 752, defines a safety rest area as “a roadside facility safely removed from the traveled way with parking and such facilities for the motorist deemed necessary for his rest, relaxation, comfort and information needs” *(Code of Federal Regulations 2016)*. The code defines information centers as “facilities located at safety rest areas which provide information of interest to the traveling public”. Federal-Aid Highway Law (U.S. Code 23 §111) limits the commercialization of rest areas on the interstate highway system to only vending machines for the purpose of dispensing food, drink, or other articles that the state determines are appropriate and desirable.

2.4.1.6 Transportations of Hazardous Materials

Section 49 of the Code of Federal Regulations, Part 397, specifies federal regulations for the transportation of hazardous materials *(Code of Federal Regulations 2016)*. Trucks carrying materials that have been deemed as hazardous materials are subject to more stringent parking regulations. Trucks that are carrying hazardous materials must not park within five feet of the traveled portion of a public roadway or highway. In addition, these trucks are not permitted to park on private property, including truck stops, without consent from the private property manager who must be made aware of the hazardous materials being transported in the truck. These trucks also must not be located within 300 feet of bridges, tunnels, dwelling units, offices, or areas where people assemble other than for brief periods of time when it is impractical to park in any other place.

2.4.2 Oregon Truck Parking Related Policies

2.4.2.1 Oregon Revised Statutes (ORS)

§810.160 controlling parking on highways; limitations. Except as otherwise provided in this section, each road authority has exclusive authority to regulate, control or prohibit the stopping, standing and parking of vehicles upon its own highways. The Oregon Transportation Commission shall act as road authority under this section in lieu of the Department of Transportation.

§810.170 winter recreation parking locations; plowing; priorities; enforcement. The Oregon Transportation Commission shall designate winter recreation parking locations throughout this state where parking is prohibited.

§811.550 Places where stopping, standing and parking prohibited. This section establishes places where stopping, standing and parking a vehicle are prohibited, as summarized in the Oregon Driver's Manual.

§811.560 Exemptions from prohibitions on stopping, standing or parking. This section provides the following exemptions from ORS 811.550:

- When applicable, this subsection exempts school buses or worker transport buses stopped on a roadway to load or unload workers or children, providing that the flashing school bus safety lights on the bus are operating;
- When applicable, this subsection exempts vehicles stopped, standing or parked momentarily to pick up or discharge a passenger;
- This subsection exempts vehicles stopped, standing or parked momentarily for the purpose of and while actually engaged in the loading or unloading of property or passengers;
- This subsection exempts vehicles owned or operated by the state, a country or city when stopping, standing or parking is necessary to preform maintenance or repair work on the roadway;
- This subsection exempts vehicles from the prohibitions and penalties when the driver's disregard of the prohibitions is necessary to avoid conflict with other traffic;
- This subsection exempts vehicles acting in compliance with law or at the direction of a police officer or a traffic control device;

- This subsection exempts the driver of a vehicle that is disabled in such manner and to such extent that the driver cannot avoid stopping or temporarily leaving the disabled vehicle in a prohibited position;

- This subsection exempts vehicles owned or operated by the State Department of Fish and Wildlife when stopping, standing or parking is necessary to enable employees to release fish;

- This subsection exempts vehicles momentarily stopped to allow oncoming traffic to pass before making a right-hand or left-hand turn or momentarily stopped in preparation for or while negotiating an exit from the road;

- This subsection exempts commercial vehicles that are stopped, standing or parked when stopping, standing or parking is necessary to engage in any activity associated with the collection of solid waste, recyclable material or yard debris.

2.4.2.2 Oregon Administrative Rules (OAR)

OAR 734-020-0080, 734-020-0085, and 734-020-0090 provide insight on State Highway Right-of-Way Parking regulations. It is the policy of the Oregon Transportation Commission to permit the Chief Engineer to define areas within the state highway right-of-ways in which overnight parking of any motor vehicle shall be prohibited. Accessible areas are provided and motorist usage will be permitted for reasons of safety and rest by drivers in need thereof and to permit viewing of scenic vistas.

OAR 734-077-0035 and 734-077-0040 provide regulations and restrictions concerning the issuance of permits by the Department of Transportation for the movement of vehicles transporting certain agricultural products from which there is fluid leakage. Specifically, any parking permit may be revoked if there is excessive loss of fluid containing residue that can cloud the windshields of other vehicles, create a build-up of residue causing slippery pavement conditions, or if excessive loss of fluid from parked vehicles causes unsanitary conditions adjacent to restaurants or other businesses, or residences.

2.4.2.3 Oregon Driver Manual: Department of Motor Vehicles (DMV)

The Oregon Driver’s Manual is a general guide to the motor vehicle laws contained in the Oregon Revised Statutes and provides guidance on parking on public roads (Oregon Driver Manual, 2015). Drivers are advised to move as far from the travelled way as possible when parking on a public roadway. If a shoulder is present drivers should pull over as far as possible. If a curb is present drivers are prohibited from parking more than one foot away from the curb. In addition, the driver’s manual lists the following areas where drivers are prohibited from parking on public roads:

- Within an intersection

- On the roadway side of any parked vehicle

- On a sidewalk or crosswalk
- On or within seven and one-half feet of railroad tracks
- In a bicycle lane or path
- On a bridge or overpass or between separate roadways of a divided highway
- In a tunnel
- In front of a public or private driveway
- Within 10 feet of a fire hydrant
- Within 15 feet of the entrance to a fire station on the same side of the street, or within 75 feet on the opposite side of the street
- Within 20 feet of a marked or unmarked crosswalk at an intersection
- Within 50 feet of a traffic control device located at the side of the road if your vehicle hides it from view

2.5 SUMMARY OF TRUCK PARKING RELATED LITERATURE

Upon a thorough literature review, several components from the studies demonstrate approaches and strategies that could be applied to this study. The reviewed literature confirms that there are large shortages in truck parking across the nation. Jason's Law shows that shortages in Oregon have been seen at public rest areas, designated pullouts, and vista points. Also, it was found that trucks will unofficially park along freeway shoulders, interchange ramps, and on conventional highway roadsides. The use of surveys has been widespread and effective in gathering quantitative information and anecdotal information.

In contrast to what other studies have accomplished, the current study focuses more on public/private partnerships rather than focusing on the two sectors as individuals. In previous studies, commercial truck stops and public rest areas were considered to be separate from one another, but when considered together the trends and patterns of driver behavior may emerge and be easily identified. It has been noted by several previous studies that a public/private partnership can be a potential answer to truck parking issues along the nation's highway system. By beginning the study with that in mind, answers to the truck parking issue may emerge more easily and more readily.

3.0 AGENCY SURVEYS

To identify current efforts being done in regard to truck parking and its associated issues, the research team developed a stated-preference survey that was distributed to Oregon agencies, other state agencies, and federal agencies. Each question was selected based on its relevance to the current study and then reviewed by the Technical Advisory Committee (TAC). The survey was then emailed to several agencies, namely Oregon's Area Commissions on Transportation (ACT), Oregon's Metropolitan Planning Organizations (MPO), transportation engineers and planners in each Oregon county, the Commercial Vehicle Safety Alliance for states across the country, and FHWA administrators across the country using the Qualtrics platform through Oregon State University.

A total of 120 surveys were sent by email, 30 surveys were started, and 20 surveys were thoroughly completed and usable for the current research. Ultimately, six pertinent questions made the final survey and the results for each question are summarized in the coming section.

3.1 AGENCY SURVEY RESULTS

To present the survey results from the drivers, each question will be discussed separately, followed by summary remarks at the end of this section.

3.1.1 Which label best describes your agency?

This question was used to determine the responding agencies. In total, three agency types were represented in the survey as shown in Figure 3.1. There were no respondents from Oregon MPOs or any representatives at the county level (transportation engineers and/or planners), although there was one respondent from the city level. The majority of responses were from federal agencies and state departments of transportation, 4 and 14, respectively.

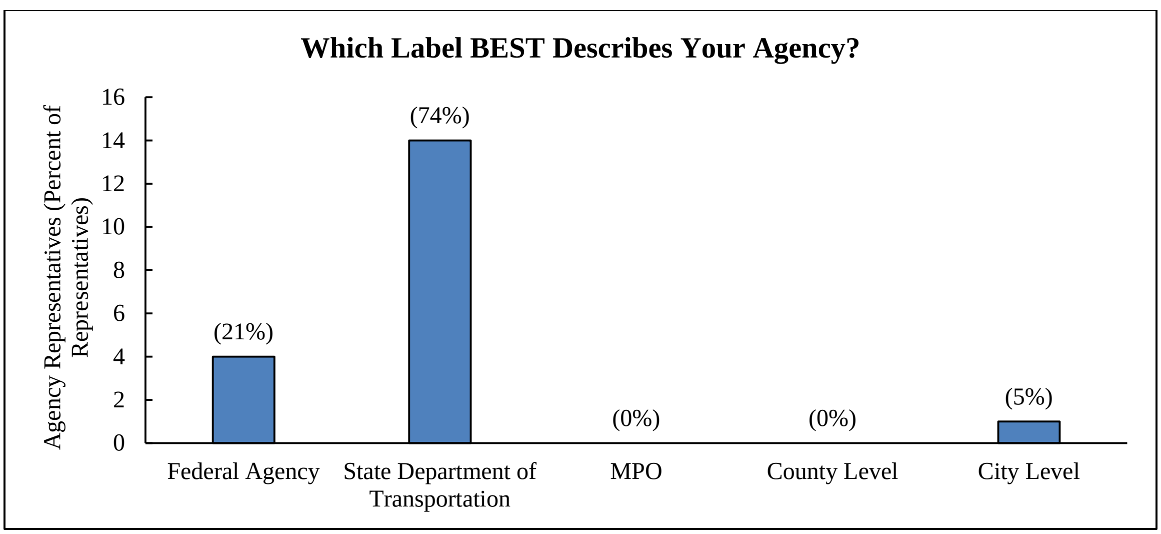

Figure 3.1: Which Label BEST Describes Your Agency?

3.1.2 Do you have a problem with commercial motor vehicle truck parking in your jurisdiction?

Nearly 75% of respondents felt that their jurisdiction is facing truck parking problems, while approximately 25% indicated they are not—see Figure 3.2. This question was a simple "yes or no" and underlying factors are not represented here. However, later questions in the survey allowed respondents to elaborate further and are discussed later.

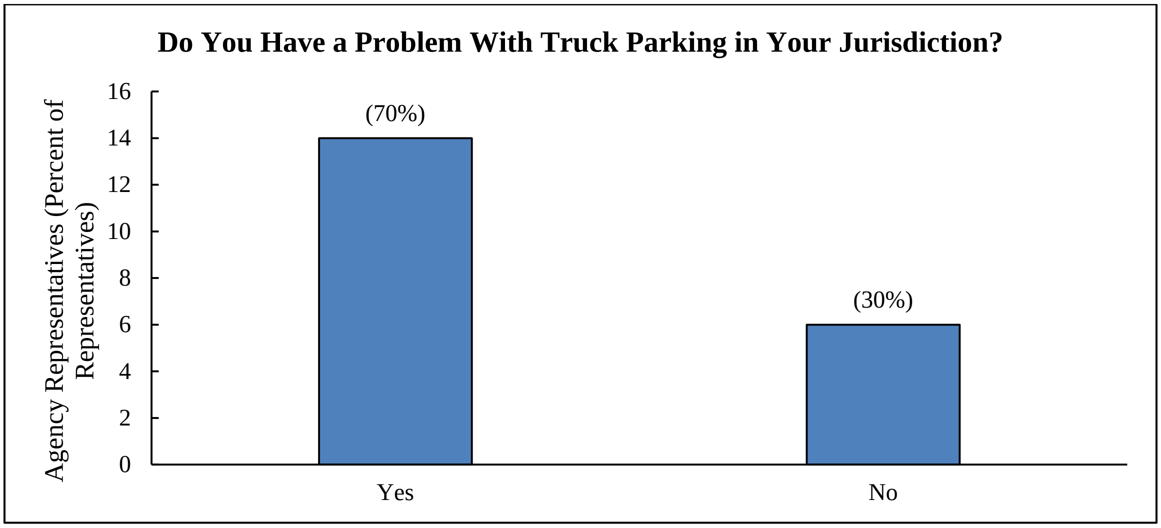

Figure 3.2: Do You Have a Problem with Truck Parking in Your Jurisdiction?

3.1.3 If yes (a problem with truck parking), how concerned are you with truck parking shortages on the following facilities?

This question allowed the researchers to determine, of the most used truck parking facilities, which are of the most concern to agencies. The following truck parking facilities were considered:

- Public Rest Areas
- Freeway Shoulders
- Designated Pullouts/Vista Points
- Freeway Interchange Ramps
- Conventional Highway Roadsides
- Local Streets Near Freeways

- Local Commercial Areas
- Private Truck Stop
- Highway Weight Stations
- Other
- Quality Assurance (Used to ensure each respondent is answering accordingly)

For each facility, the respondent was asked to select one of the following:

- Not at All Concerned
- Slightly Concerned
- Moderately Concerned
- Very Concerned
- Extremely Concerned

3.1.3.1 Public Rest Areas

Figure 3.3 shows that 45% of respondents are "moderately concerned" with truck parking at public rest areas, 11% are "very concerned," and 22% are "extremely concerned"; however, nearly one-quarter of the respondents are "slightly concerned" regarding truck parking in public rest areas. Geographical location is likely to be a factor (e.g., different truck parking laws) in the level of concern, still the majority were at least "moderately concerned" and no responses indicated "not at all concerned."

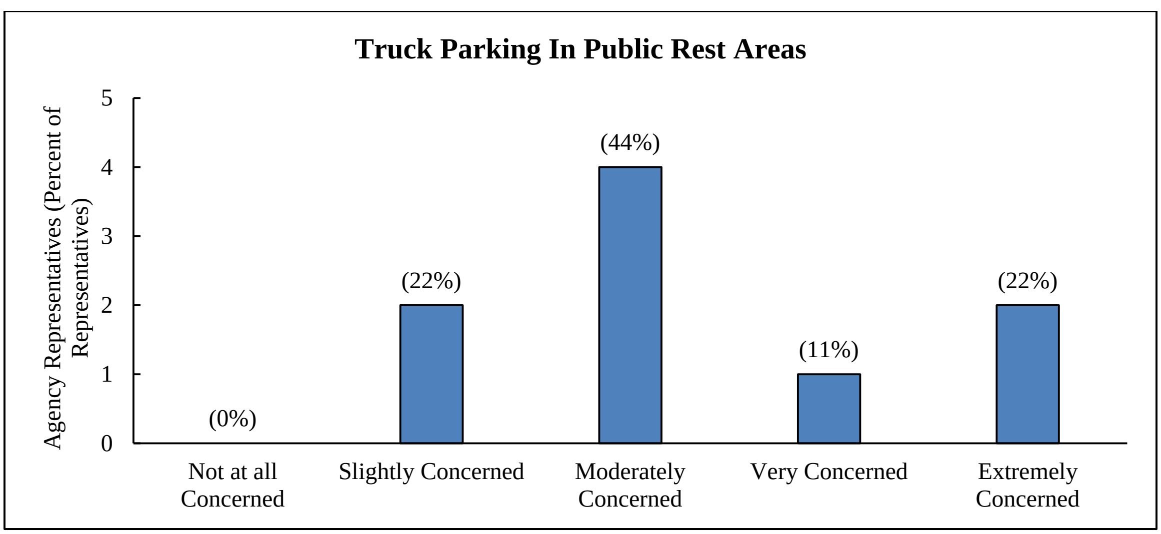

Figure 3.3: Level of Concern for Truck Parking in Public Rest Areas

3.1.3.2 Freeway Shoulders

Figure 3.4 displays the level of concern on behalf of truck parking on freeway shoulders, and over 50% of the agency representatives are "extremely concerned." In addition, 22% and 11% are "moderately concerned" and "very concerned" about parking on freeway shoulders, while a small percentage, 11%, indicated they are "not at all concerned."

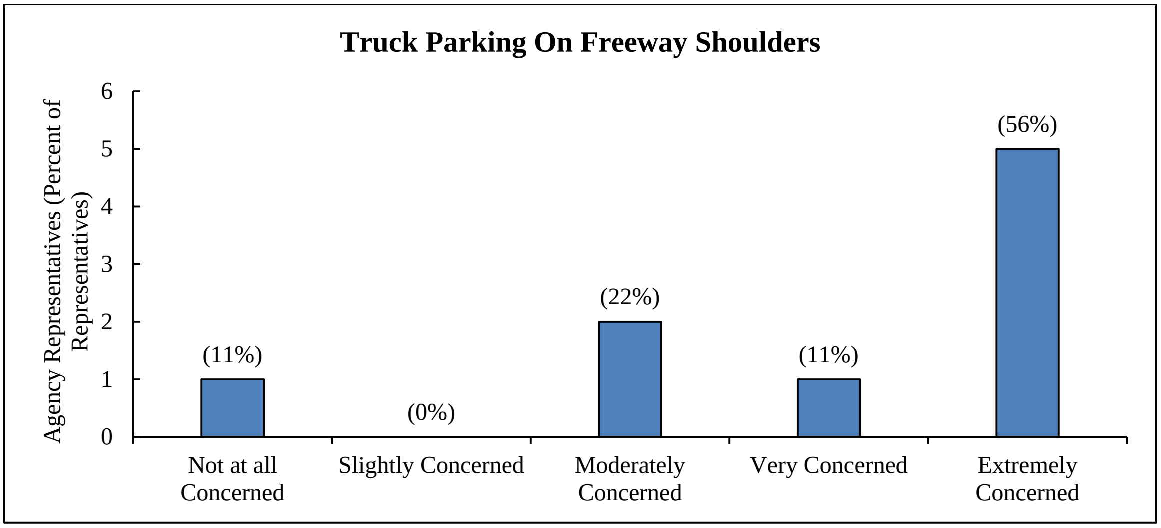

Figure 3.4: Level of Concern for Truck Parking on Freeway Shoulders

3.1.3.3 Designated Pullouts/Vista Points

For the level of concern regarding truck parking at designated pullouts/vista points, Figure 3.5 shows that 33% of the respondents are "extremely concerned," 11% are "very concerned," and 45% are "moderately concerned." Similar to freeway shoulders, a portion of the responses, 11%, are "not at all concerned" with truck parking at these locations.

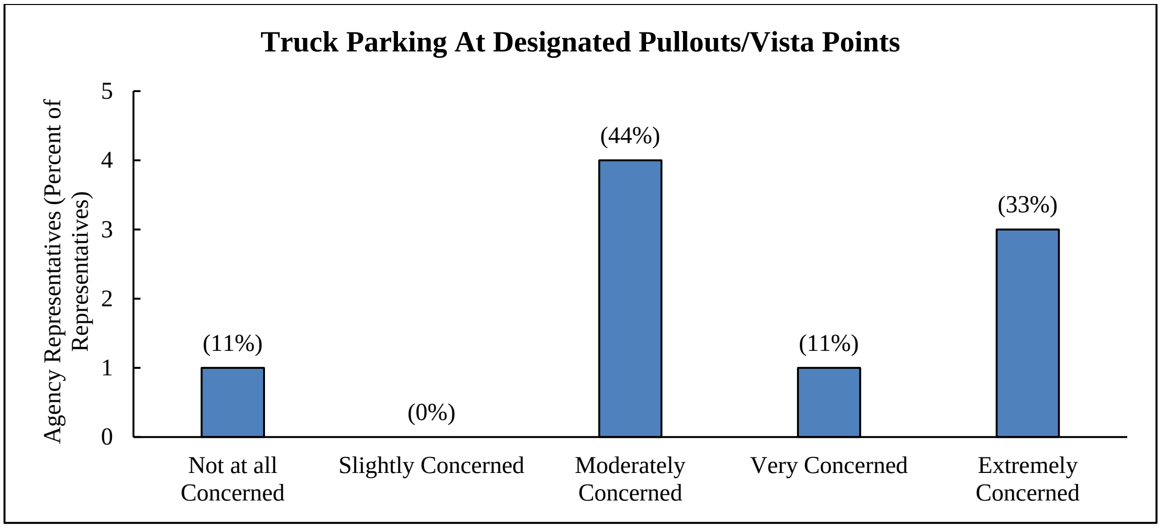

Figure 3.5: Level of Concern for Truck Parking at Designated Pullouts/Vista Points

3.1.3.4 Freeway Interchange Ramps

Freeway interchange ramps are clearly a concern based on the agency responses shown in Figure 3.6. For instance, 45% are "moderately concerned," 11% are "very concerned," and 44% are "extremely concerned." A possible reason for such concern may stem from the safety concerns associated with parking on freeway interchange ramps.

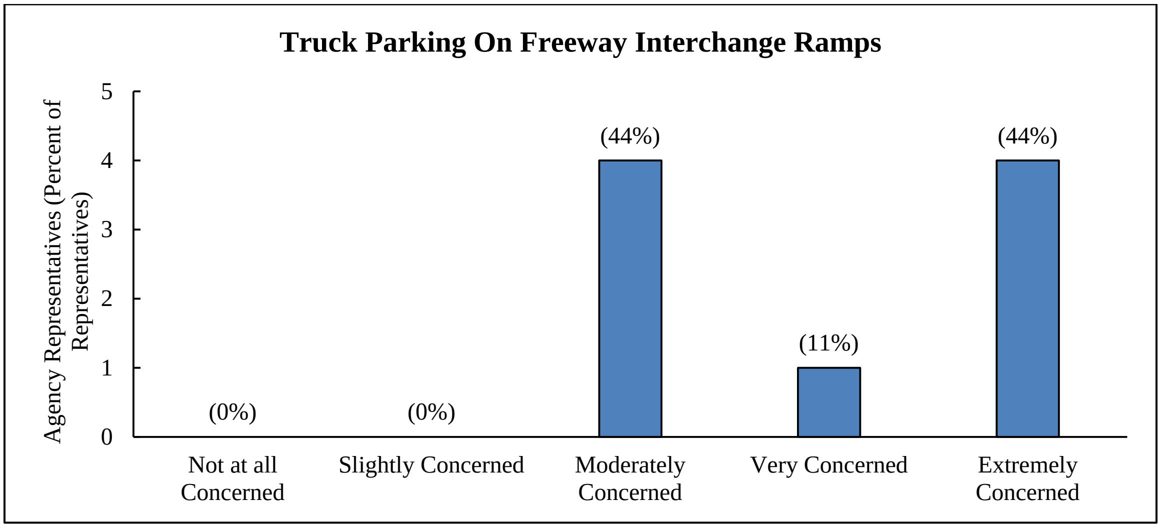

Figure 3.6: Level of Concern for Truck Parking on Freeway Interchange Ramps

3.1.3.5 Conventional Highway Roadsides

Figure 3.7 presents the levels of concern regarding truck parking on conventional highway roadsides. Similarly, to the previously discussed truck parking facility types (see

Figure 3.4 to Figure 3.6), the majority of responses express moderate to extreme concern. In particular, 45% are “extremely concerned,” 22% are “very concerned,” and 22% are “moderately concerned.”

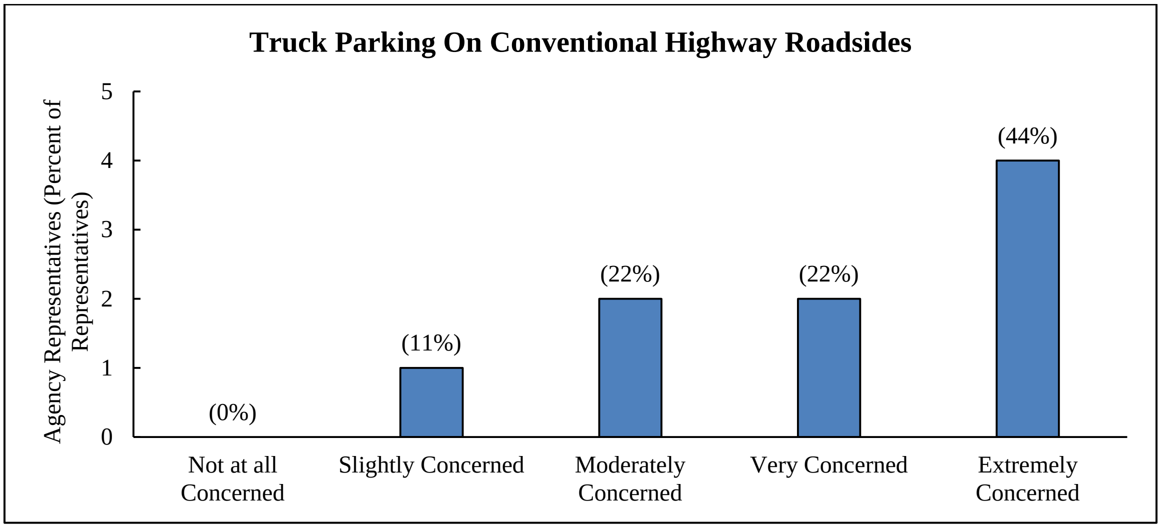

Figure 3.7: Level of Concern for Truck Parking on Conventional Highway Roadsides

3.1.3.6 Local Streets Near Freeways

Referring to Figure 3.8, 11% of the agency representatives expressed they are “not at all concerned” and 11% state they are “slightly concerned” with truck parking on local streets near freeways. The majority, again, exhibit some concern, as 34% are “moderately concerned,” 22% are “very concerned,” and 22% are “extremely concerned.”

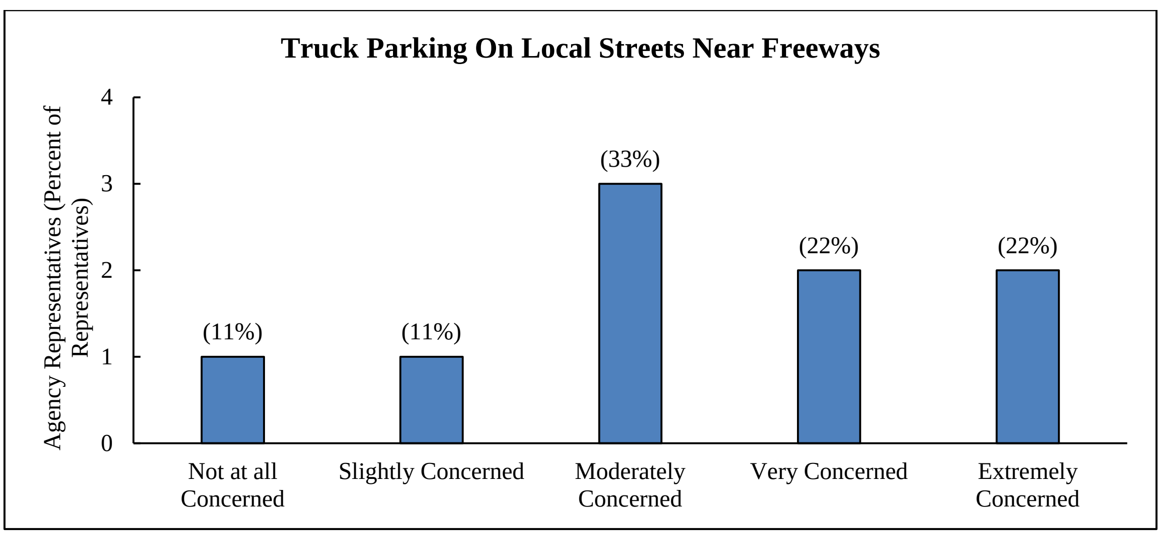

Figure 3.8: Level of Concern for Truck Parking on Local Streets Near Freeways

3.1.3.7 Local Commercial Areas

Figure 3.9 shows that just 11% of the surveyed agency representatives are "extremely concerned" with truck parking in commercial areas and 56% are "moderately concerned." Still, 11% are "not at all concerned" and 22% are just "slightly concerned."

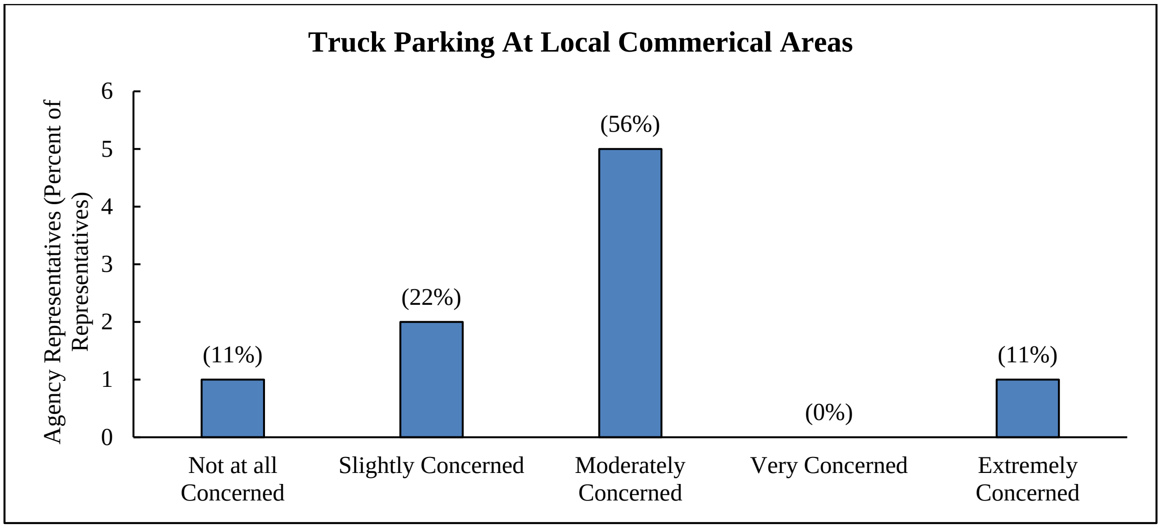

Figure 3.9: Level of Concern for Truck Parking at Local Commercial Areas

3.1.3.8 Private Truck Stop

From Figure 3.10, private truck stops have the largest percentage of "not at all concerned" responses at 34%, and 22% are "slightly concerned." This is the only facility in which the majority of responses express less concern regarding truck parking and is likely attributed to the private nature of these facilities. Although, 33% are "moderately concerned."

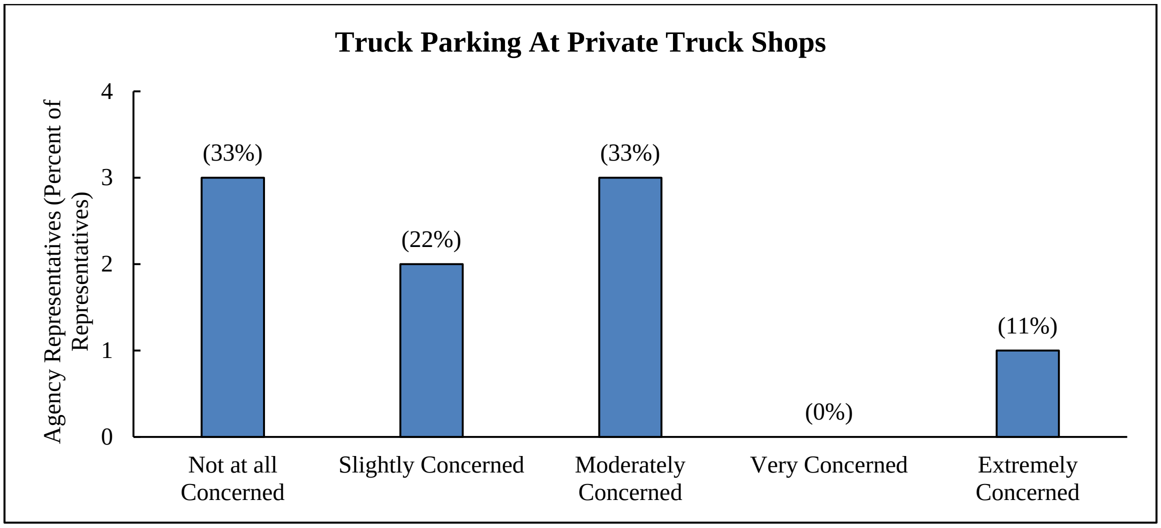

Figure 3.10: Level of Concern for Truck Parking at Private Truck Shops

3.1.3.9 Highway Weigh Stations

Figure 3.11 shows that the level of concern for truck parking at weigh stations is proportional in the extremes. For example, 11% are “extremely concerned” and 11% are “very concerned,” while 11% are “not at all concerned” and 22% are “slightly concerned.” There is still a large percentage (45%) that are “moderately concerned” about truck parking at highway weigh stations.

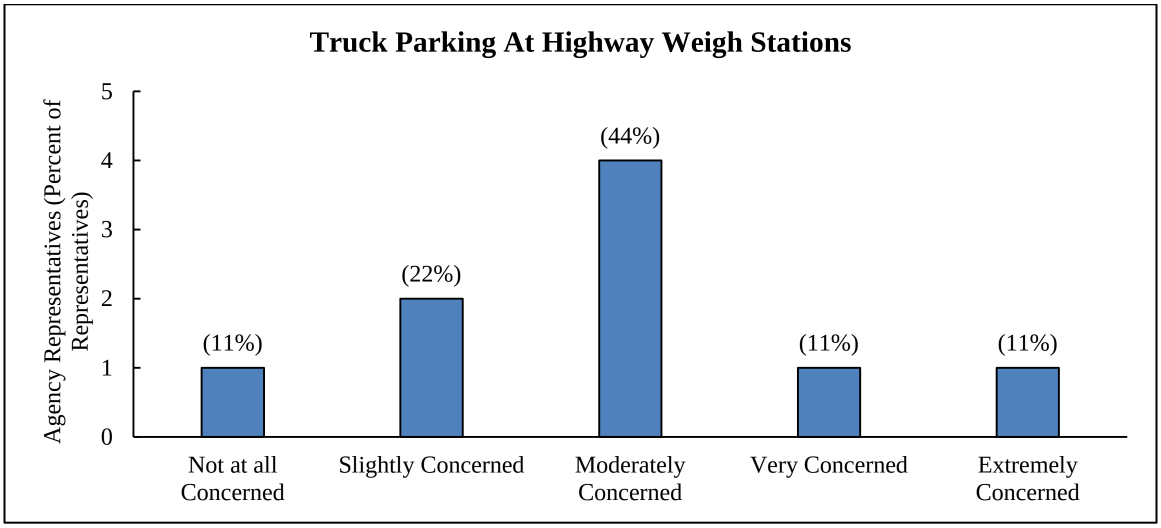

Figure 3.11: Level of Concern for Truck Parking at Highway Weigh Stations

3.1.3.10 Quality Assurance

To assess if the survey was being read and answered adequately, quality assurance questions are introduced. In this case, the respondents were asked to select “very concerned” and the results displayed in Figure 3.12 show that 100% of survey responses selected the correct level of concern.

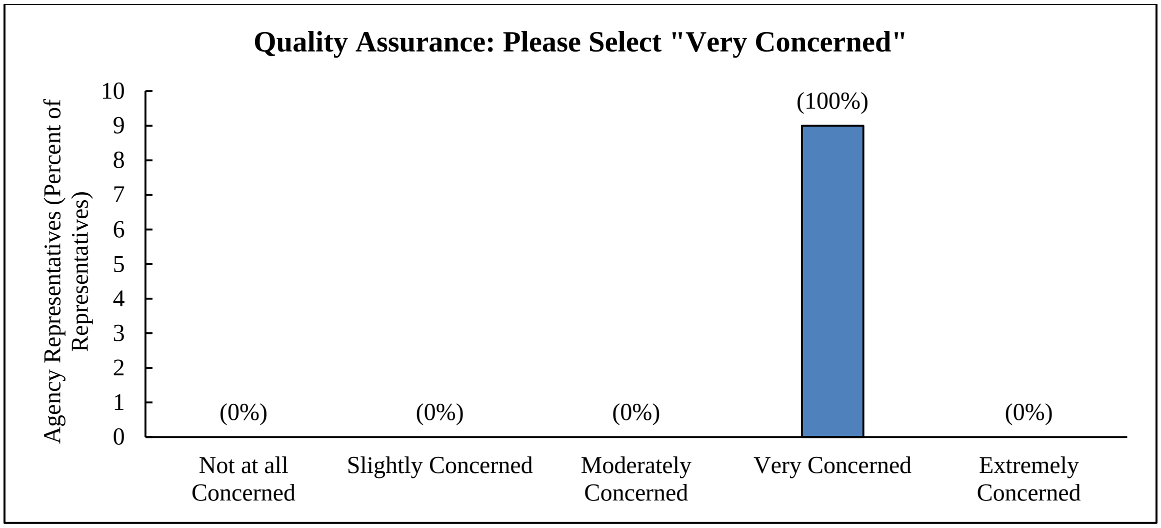

Figure 3.12: Quality Assurance: Please Select "Very Concerned"

3.1.3.11 In the space provided below, please describe the efforts your agency is undertaking to address shortages in commercial motor vehicle parking. Please be as detailed as possible.

This prompt allowed the agency representatives to detail current efforts undertaken to address the truck parking issue in their jurisdiction. Unfortunately, just five detailed responses were provided, yet they do offer some insight into truck parking efforts. For example, in Montana, trucks are permitted to park at weigh stations if they do not impede on normal operations. In addition, Montana is currently planning and constructing rest areas that will have provisions for commercial vehicle parking.

In Missouri, Jason's Law and MAP-21 have helped the state to become one of ten states that have ample truck parking areas, as well as a leading state with the most truck parking spaces per 100-thousand daily truck vehicle-miles-traveled. Nonetheless, Missouri still experiences parking issues (i.e., not enough spaces) for certain locations during typical peak hours, but does have a viable supply of commercial areas and private truck stops.

Nevada is trying to increase the number of truck parking locations to improve the number of available spaces, in conjunction with placing these locations at two-hour intervals. Nevada is also conducting research into the use of intelligent transportation systems (ITS) for truck parking signage to provide real-time information with regard to truck parking vacancies at each freeway/highway exit. Lastly, Nevada is discussing the implementation of a truck stop electrification service along major interstate routes to give truck drivers a substitute to idling their engines amid needed rest periods.

In Idaho, Idaho's primary law enforcement agency (Idaho State Police) is engaged with the Idaho Department of Transportation (ITD) to better the truck parking situation within the state. Notably, ITD is increasing the available truck parking in its state by adding areas to recently updated weigh stations and rest areas; still, this is limited in parts of the state with no current plans for truck parking development.

3.1.3.12 Please use this space to provide any additional information you wish to share with regard to commercial vehicle parking shortages.

Agency representatives utilized this section of the survey to share any beneficial information that was not included in the primary questions of the survey. To start, the state of Montana stated the following with respect to truck parking, "During the planning process for highway construction, truck parking needs are considered."

In the case of Missouri, the state has implemented a rather inexpensive approach to address the needs of truck parking by increasing the available spaces at public facilities. Specifically, when Missouri decommissions current rest areas or weigh stations, they destroy existing structures and add rock/gravel to the remaining concrete to create a 'truck only' parking zone. This provides additional safe truck parking that has gone over well with the trucking industry in Missouri.

The state of Nevada has 56 truck parking facilities along its major routes (I-15, I-80, etc.), but would prefer to have more facilities (with amenities) at two-hour intervals to provide further options for truck drivers to meet HOS regulations. Nevada, as of now, would like to add another truck parking facility with amenities along US-93 that extends from Las Vegas to Ely.

In 2004, an Oregon Region 3 manager stated that "most Southern Oregon rest areas are under-sized, obsolete, and need to be replaced." To elaborate, many of the rest stops the manager is referring to have 40- to 50-year-old structures that require renovations, as well as the water and sewer systems, to satisfy the obligatory health standards. Renovations for rest areas are often competing for funding with other transportation facilities, and on account of that, there is a heightened focus on the private sector in regard to alternative rest areas.

In Idaho, the truck parking issue has been an ongoing problem and continues to worsen. The Idaho representative believes that truck parking is an issue that each state should address with the cooperation of FHWA to devote truck parking efforts nationwide. Idaho, especially (according to the representative), does not have the funding to focus on truck parking issues outside of their current projects.

3.2 SUMMARY OF SURVEY RESULTS

Using the stated-preference survey, it was determined that agencies are moderately to extremely concerned with truck parking at several facilities. A total of six states were represented in the results and are shown in Table 3.1. One specific facility, private truck stops, was not a concern for a large percentage of agency representatives, yet freeway shoulders, designated pullouts/vista points, interchange ramps, and highway roadsides are of the most concern to the surveyed agency representatives.

Table 3.1: States Represented in Survey Results

Kentucky
Idaho
Missouri
Montana
Nevada
Oregon

These survey results provide a better understanding of what agencies are thinking in regards to truck parking, as well as shed light on the facilities that transportation engineers, planners, and policy makers should consider.

4.0 COMMERCIAL VEHICLE DRIVER SURVEYS

To gain insight regarding how and why drivers choose parking locations and identify the behavioral response to parking shortages, the research team developed a stated-preference survey to distribute to operators of commercial motor vehicles. Again, each question was selected based on its relevance to the current study and then reviewed by the TAC. Upon approval from the TAC, the stated-preference survey was administered utilizing the Qualtrics platform through Oregon State University. All survey participants were required to be from truck drivers originating, destined, or passing through the state of Oregon.

A total of 201 usable responses were obtained and consisted of 23 questions. This section will summarize the results from each question and then provide the location of the drivers that responded to the survey.

4.1 COMMERICIAL VEHICLE DRIVER SURVEY RESULTS

To present the survey results from the drivers, each question will be discussed separately, followed by summary remarks at the end of this section.

4.1.1 Do You Pick Up or Deliver Goods in the Pacific Northwest (Northern California, Idaho, Oregon, Washington, or British Columbia)?

Results from this question show that each driver surveyed, 100%, picks up or delivers goods in the Pacific Northwest and is shown in Figure 4.1. This is important, as the pilot corridor is located in Oregon. This indicates that the survey responses/comments are likely to be responses/comments based on current parking related issues, facilities, and conditions in the Pacific Northwest.

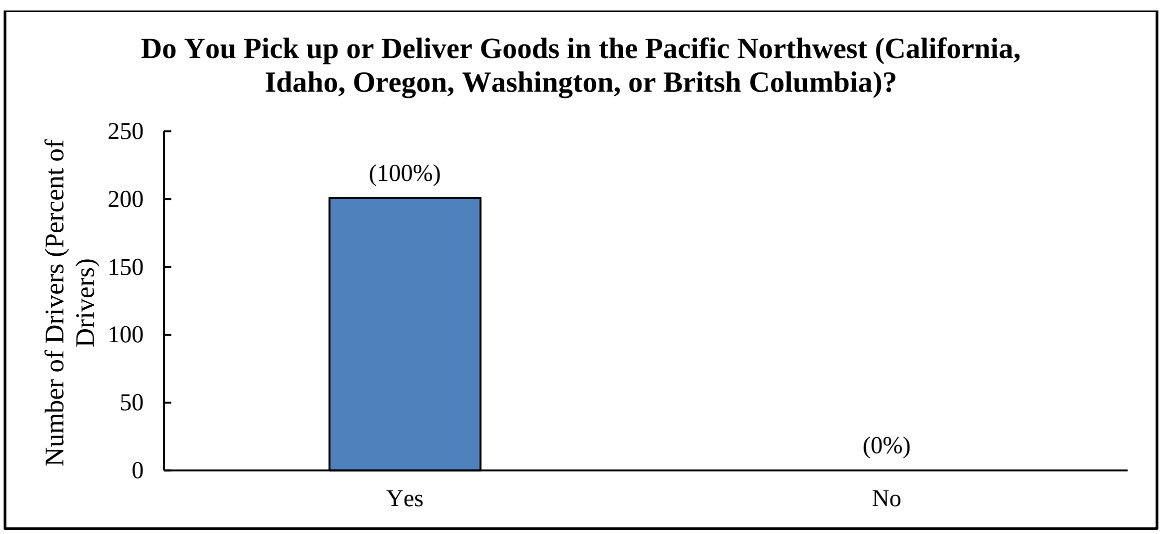

Figure 4.1: Do You Pick-Up or Deliver Goods in the Pacific Northwest?

4.1.2 Are You Male or Female?

As seen from Figure 4.2, roughly 84% of the drivers are male and nearly 16% are female (the percent of drivers is shown in parentheses).

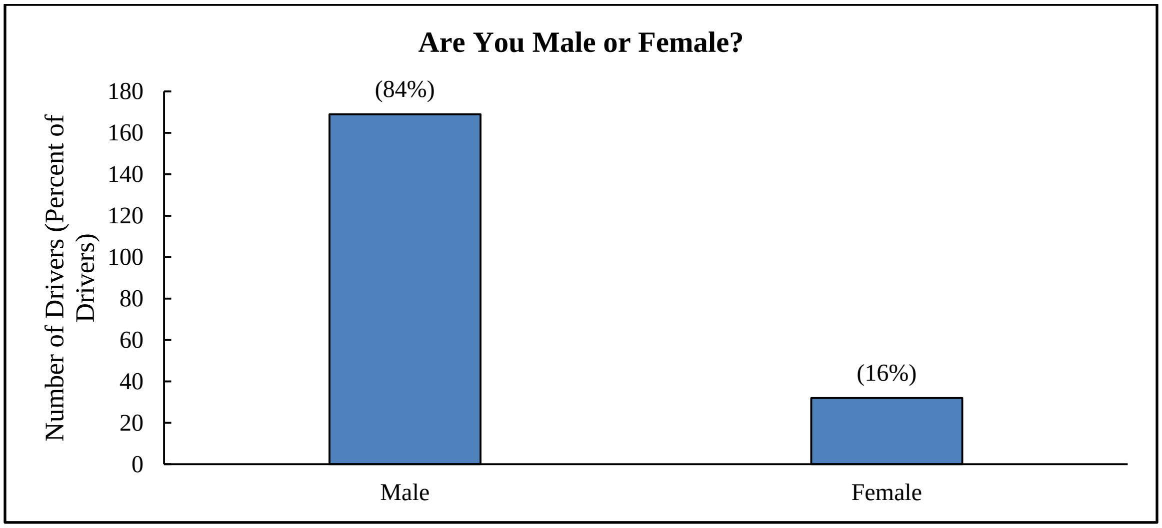

Figure 4.2: Are You Male or Female?

4.1.3 Which of the Following Age Category Best Describes You?

The age distribution of drivers surveyed is shown in Figure 4.3. The majority of drivers are 39 years of age or less, with about 23% in their twenties and roughly 29% in their thirties. Approximately one-quarter of drivers are in their forties and approximately 24% of drivers are 50 years of age or greater.

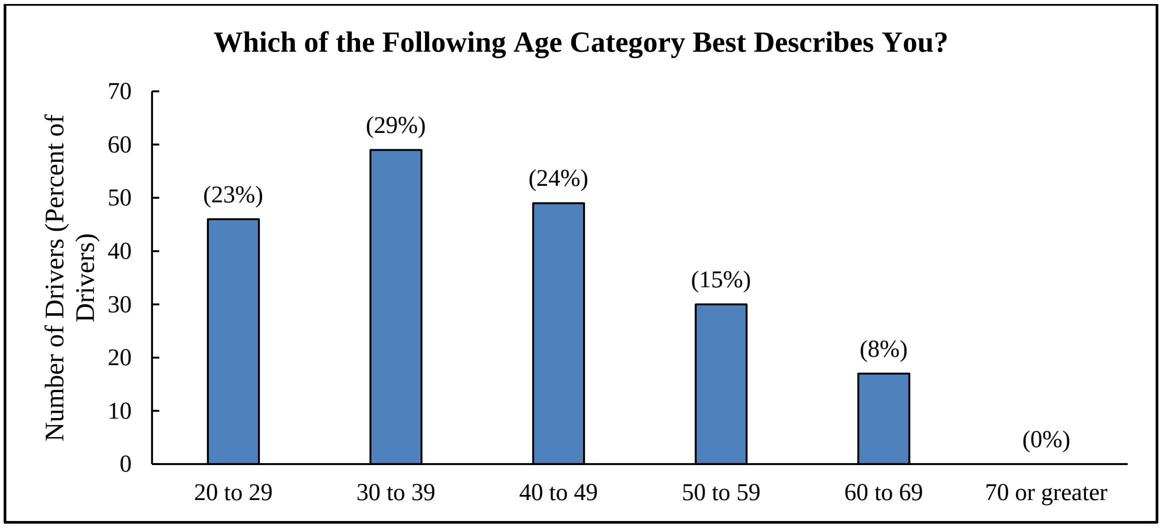

Figure 4.3: Which of The Following Age Category Best Describes You?

4.1.4 How Long Have You Been a Truck Driver?

The number of years that respondents have been a truck driver are presented in Figure 4.4. As seen below, more than half of the drivers (roughly 129) have been a truck driver for 10 years or less and 27 drivers have been driving for greater than 20 years. The minimum was one year and the maximum was 40 years, with a mean number of years of 10.87 and standard deviation of 9.18.

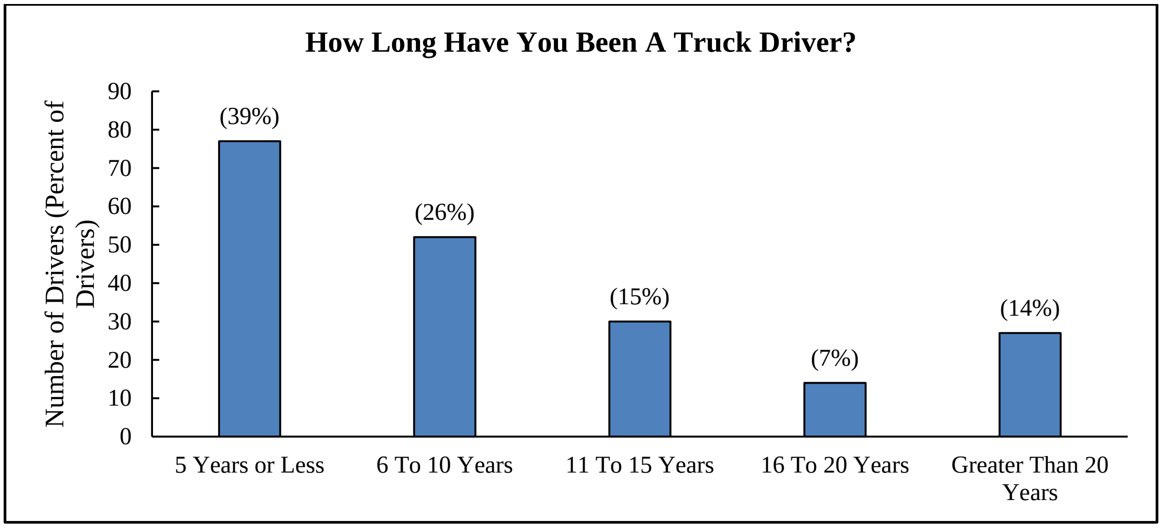

Figure 4.4: How Long Have You Been a Truck Driver?

4.1.5 What Type of Company Do You Work or Contract For?

Figure 4.5 illustrates the type of company the driver works or contracts for. In general, the drivers were split across the three choices. About 28% work or contract for for-hire companies, 36% work or contract for private carriages, and 34% work or contract for both for-hire companies and private carriages—2% did not know or simply refused to answer.

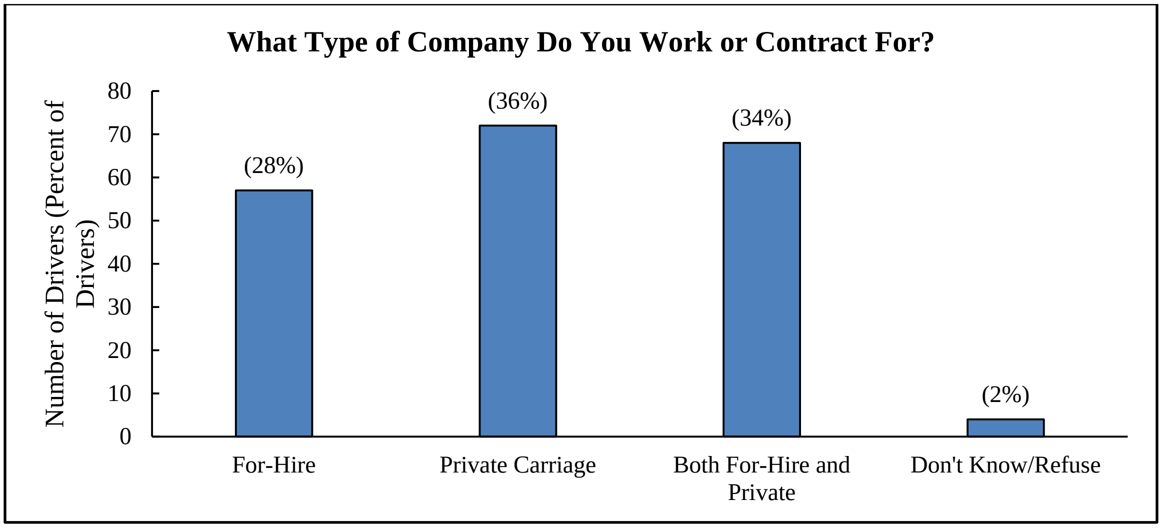

Figure 4.5: What Type of Company Do You Work or Contract for?

4.1.6 On Average, What Type of Shipments Do Your Trips Consist Of?

To better understand the type of shipments within the study area, refer to Figure 4.6. Nearly 78% of trips are truckload (TL), 15% are less-than-truckload (LTL), and 7% are parcel. American Transportation Research Institute (ATRI) in 2015 had similar results, as LTL accounted for 16% of the drivers and TL shipments accounted for 64% of the drivers (*Ford and Murray 2015*).

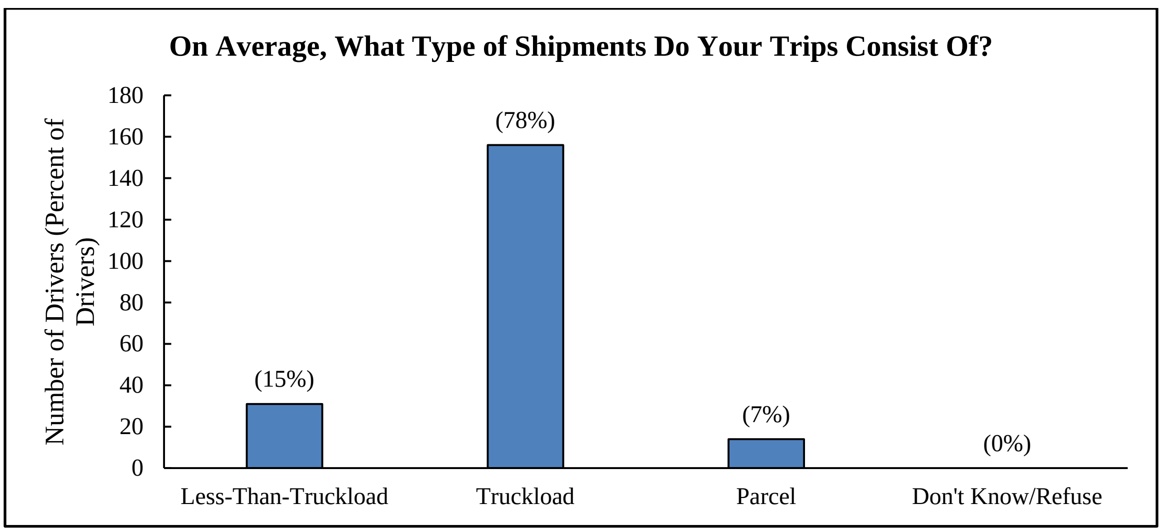

Figure 4.6: On Average, What Type of Shipments Do Your Trips Consist Of?

4.1.7 Do You Participate in Team Driving?

Figure 4.7 illustrates the percentage of drivers that participate in team driving. Surprisingly, about 3% indicated that they engage in team driving all of the time and about 8% indicated that they participate in team driving often. Roughly 25% of drivers sometimes take part in team driving, yet the majority never participate or rarely participate in team driving (29% and 35%).

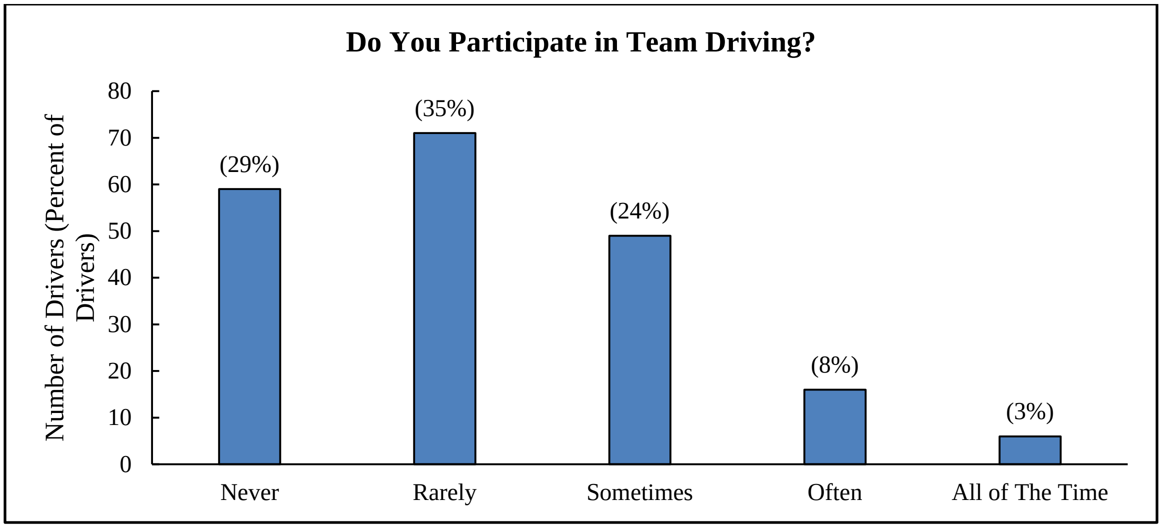

Figure 4.7: Do You Participate in Team Driving?

4.1.8 When it comes to deciding Where to Park:

Figure 4.8 displays who decides where to park. 85% of drivers make the decision for themselves, although 13% are told where to park by the company they drive for. Two of the drivers did not indicate how truck parking decisions are made, yet one driver stated that they return to their location of work to park their truck.

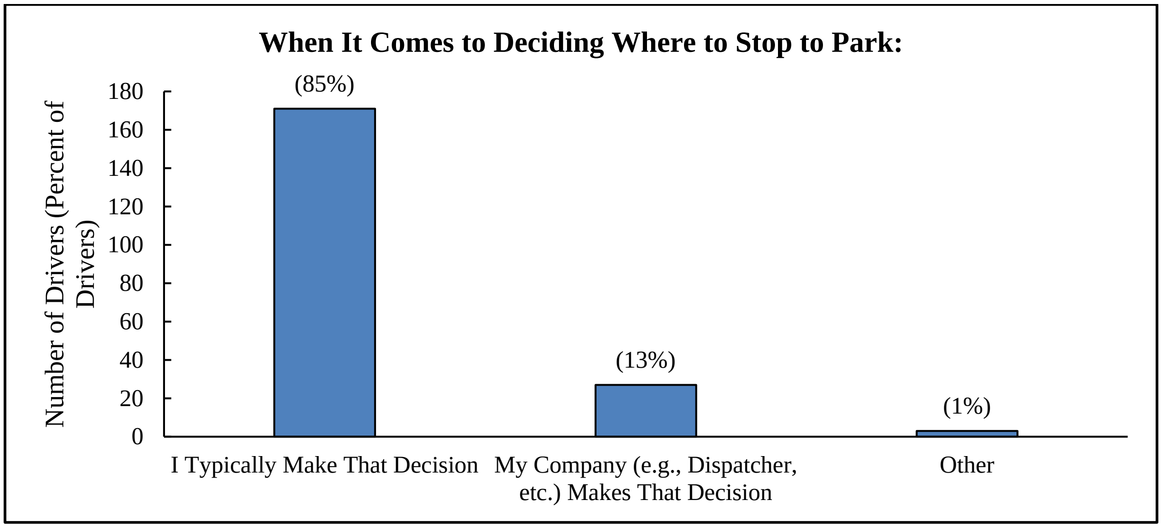

Figure 4.8: When It Comes to Deciding Where to Stop to Park

4.1.9 When required to rest, have you experienced any problems finding a safe and adequate location to park your truck?

Figure 4.9 shows the number of drivers that have encountered problems finding safe and adequate parking. Approximately 61% have encountered such problems, while about 39% of drivers stated they have experienced no problems. (Survey results were obtained after the HOS rule change.)

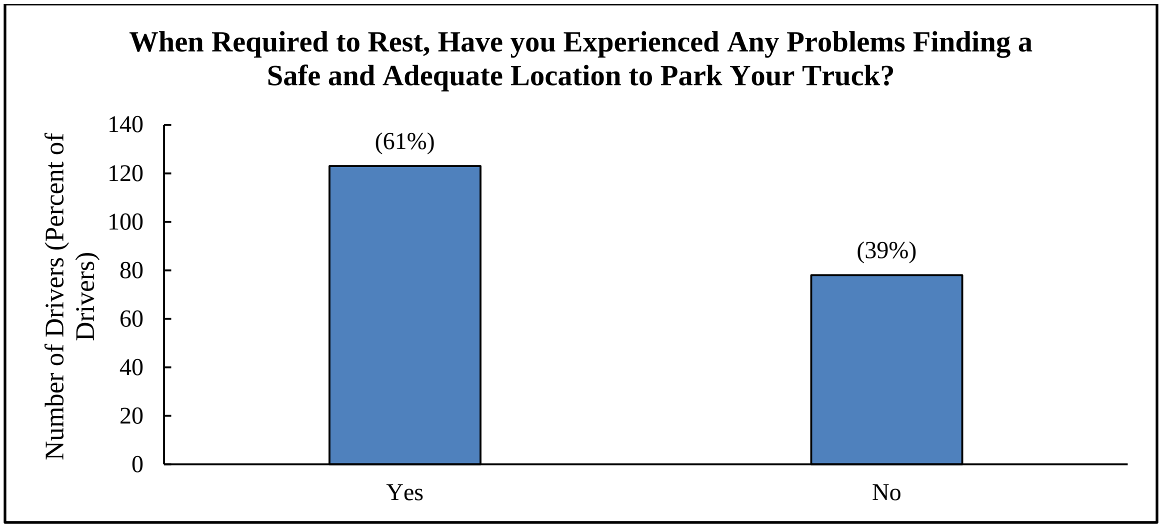

Figure 4.9: Experienced Any Problems Finding a Safe and Adequate Location to Park

4.1.10 In your experience, what times of the day have you found to be the MOST difficult in finding safe truck parking? (Please select all that apply)

The times of day found to be the most difficult to find safe and adequate parking are displayed in Figure 4.10. The largest number of drivers stated that early morning (65), afternoon (72), and evening (82) times are the most difficult to find safe parking. Still, 17 drivers indicated that they do not experience difficulty when finding a safe location to park.

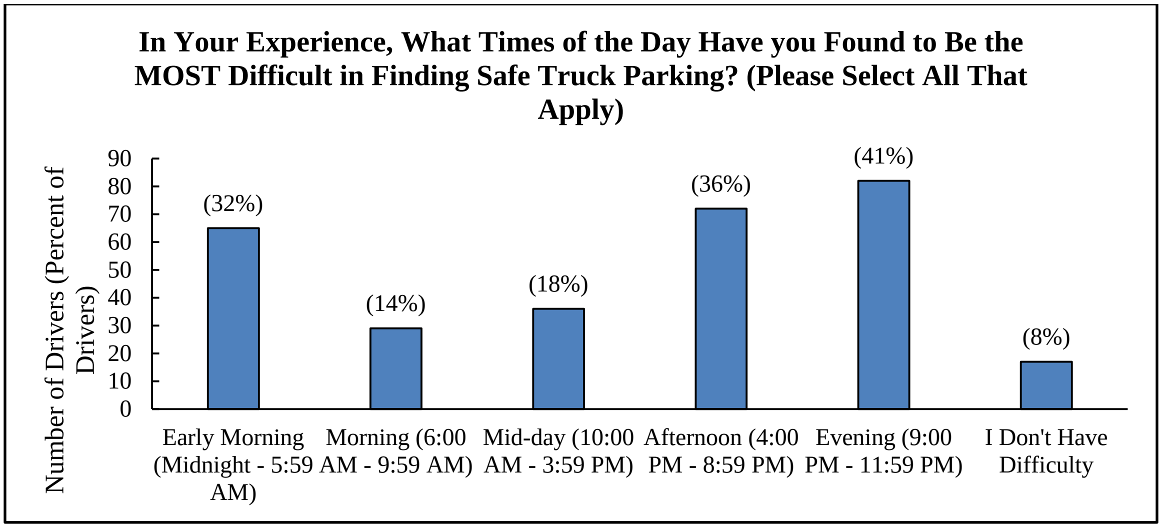

Figure 4.10: What Times of the Day Have You Found to Be the MOST Difficult in Finding Safe Truck Parking?

4.1.11 In your experience, what days of the week have you found to be the MOST difficult in finding safe truck parking? (Please select all that apply)

Figure 4.11 illustrates the days of the week that drivers have the most difficulty finding safe parking. Friday, Saturday, and Monday were selected most by drivers, while Sunday, Tuesday, Wednesday, and Thursday were selected the fewest times. More than half the drivers stated they have difficulty on Saturday (109), while 78 stated they find Monday to be the most difficult and 72 stated that Saturday results in the most difficulty. Again, a portion of the drivers stated they do not encounter any difficulty regarding parking on any day of the week (21). Figure 4.11 is shown on the following page.

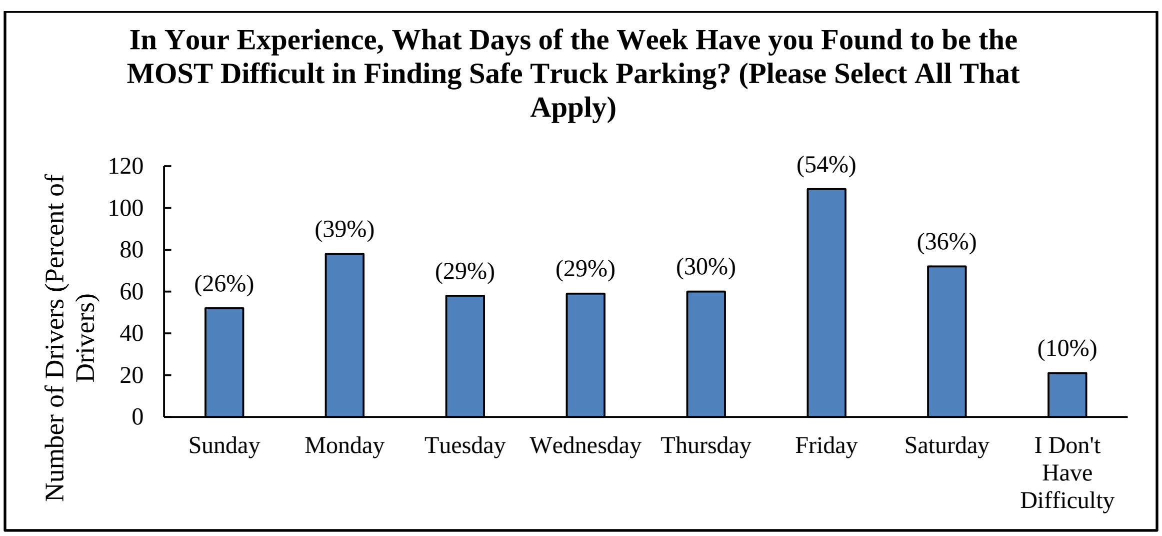

Figure 4.11: What Days of the Week Have You Found to be the MOST Difficult in Finding Safe Truck Parking?

4.1.12 Which months of the year have you found to be the MOST difficult in finding safe truck parking? (Please select all that apply)

Months of the year in which drivers have found to be the most difficult for finding safe parking are shown in Figure 4.12. Turning to Figure 4.12, 115 drivers stated the most difficult month to find safe parking is December. 80 drivers believe that the most difficulty finding safe parking happens in January, and 78 drivers selected November has the month with the most difficulty. The summer months of June and July were selected by 63 and 76 drivers, respectively, while August was chosen by 52 drivers. Once again, there were a number of drivers (24), who stated they do not have difficulty finding safe parking.

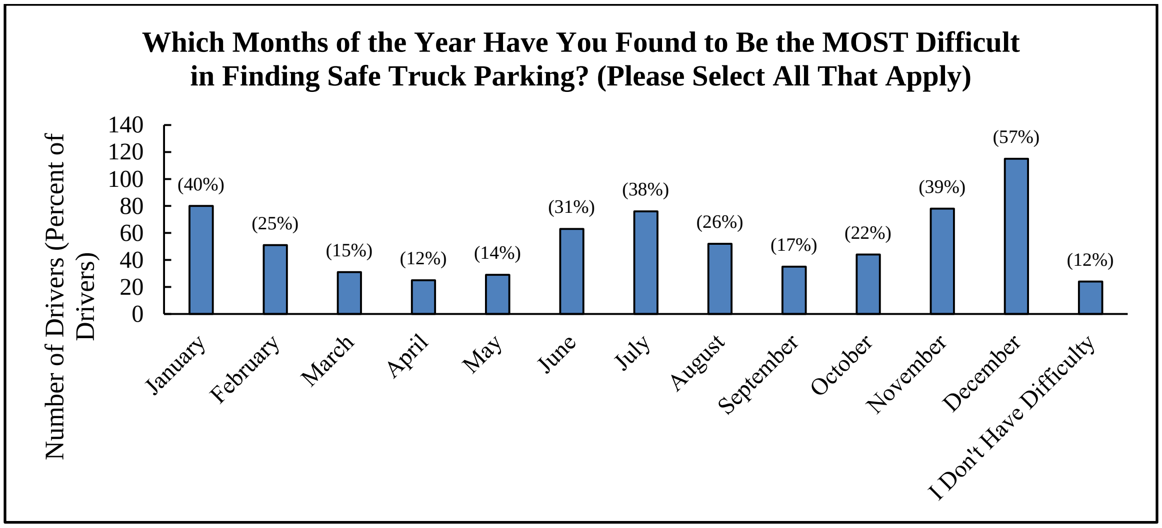

Figure 4.12: Which Months of the Year Have You Found to Be the MOST Difficult in Finding Safe Truck Parking?

4.1.13 In your opinion, why do you think ramps and shoulders are sometimes used for truck parking? Please rank the following on a scale of 1 to 9, where 1 is the "most probable reason" and the least.

This question gathered information regarding the reasons that drivers believe parking takes place on freeway ramps and shoulders. Drivers were given nine reasons to consider:

1. No Nearby Parking Facility
2. Nearby Truck Stops or Rest Areas Are Full
3. Nearby Parking Spaces Have Time Limits That Are Too Short
4. Difficulty Maneuvering Around Parking Lots
5. Empty Nearby Parking Spaces Are Blocked by Other Vehicles

6. The Ramp/Shoulder Is Convenient for Getting Back on the Road

7. Better Lighting on Ramp/Shoulder Than in Lot

8. Less Likely to be Bothered by Stranger (e.g., Drug Dealers, Prostitutes)

9. Other

Drivers were asked to rank each reason on a scale of 1 to 9, with 1 being the "Most Probable Reason" that drivers park on freeway ramps and shoulders, and 9 being the "Least Probable Reason" that drivers park on freeway ramps and shoulders. Results from this question begin on the following page.

4.1.13.1 No Nearby Parking Facility

Figure 4.13 presents the level of probability, from a driver's perspective, regarding truck parking on freeway ramps and shoulders. 27% believe that no nearby parking facility is the "Most Probable Reason" and roughly 16% ranked this reason a 2. Conversely, nearly 17% stated that this was the "Least Probable Reason" and approximately 9% ranked this an 8.

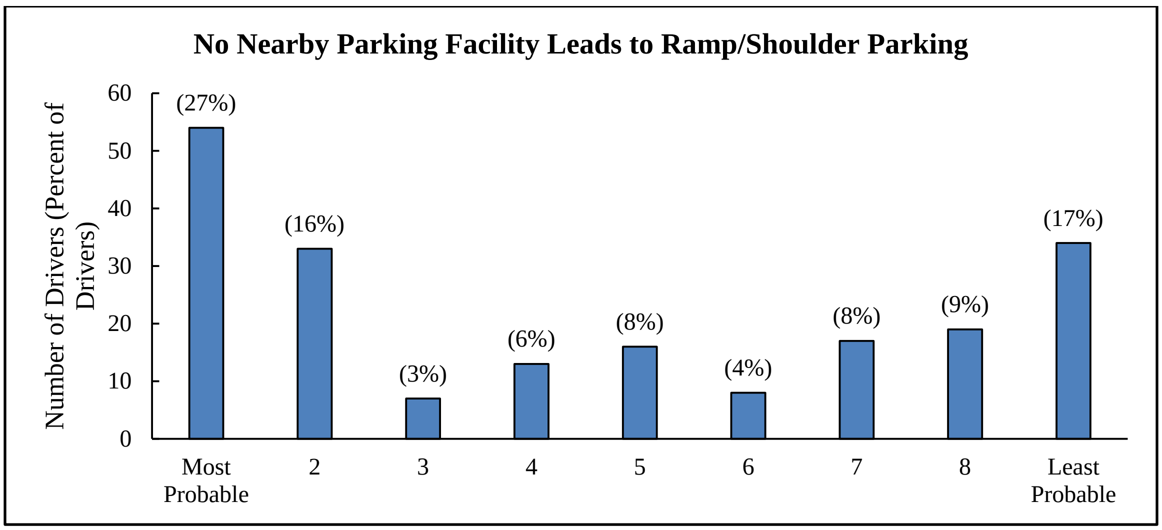

Figure 4.13: No Nearby Parking Facility Leads to Ramp/Shoulder Parking

4.1.13.2 Nearby Truck Stops or Rest Areas Are Full

The probability, from a driver's perspective, that nearby truck stops or rest areas being full leads to parking on freeway ramps and shoulders is shown in Figure 4.14. Roughly 15% of drivers ranked this the "Most Probable Reason" and 19% ranked this a 2. On the other end, nearly 8% of drivers ranked this the "Least Probable Reason" and 18% ranked this an 8.

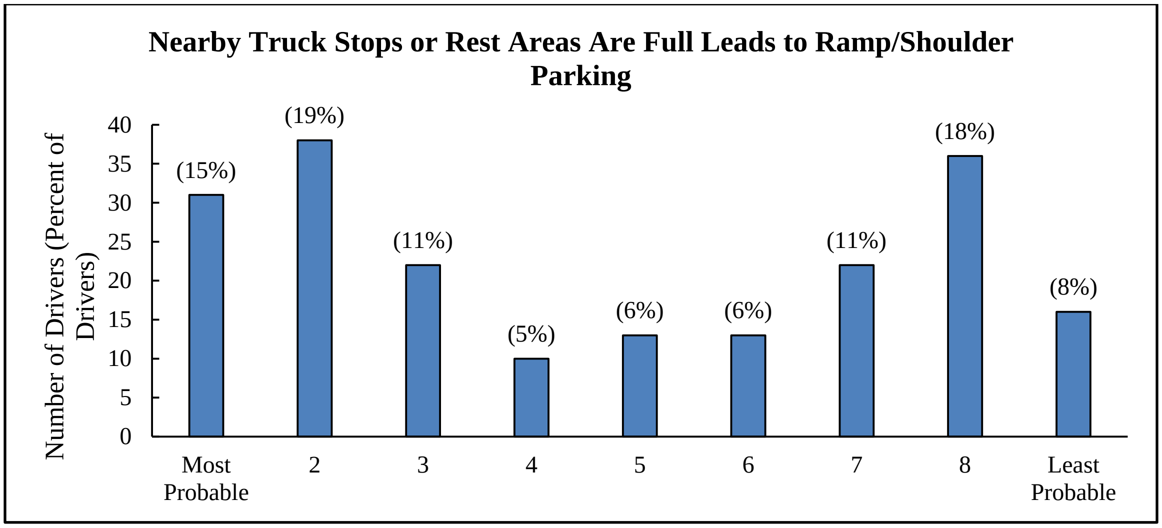

Figure 4.14: Nearby Truck Stops or Rest Areas Are Full Leads to Ramp/Shoulder Parking

4.1.13.3 Nearby Parking Spaces Have Time Limits That Are Too Short

The level of probability, according to drivers, that parking on freeway ramps and shoulders occurs due to nearby parking spaces having time limits that are too short is displayed in Figure 4.15. The majority of drivers do not believe that this leads to freeway ramp and shoulder parking, as roughly 59% ranked this a 5 or greater.

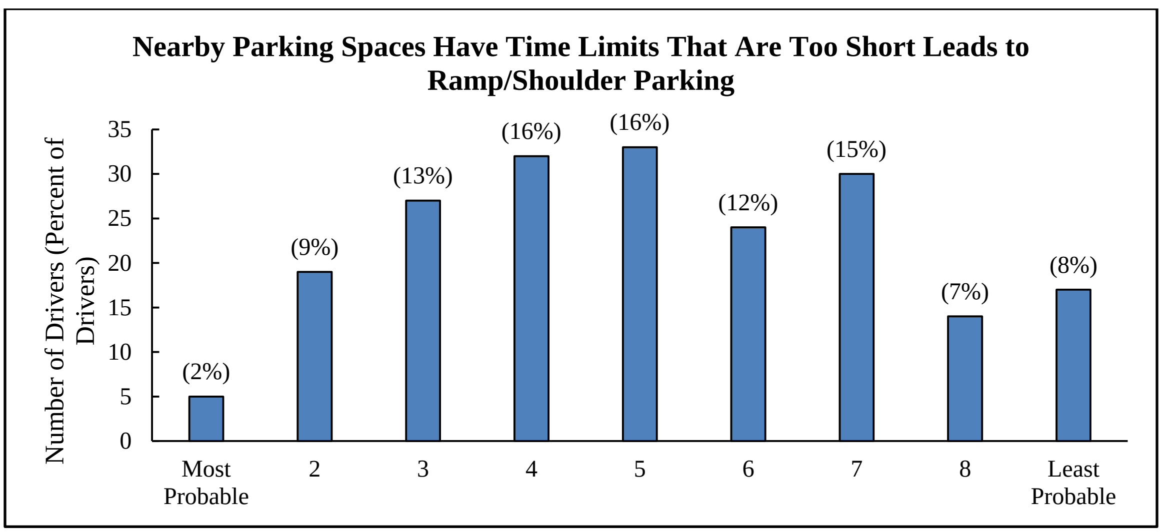

Figure 4.15: Nearby Parking Spaces Have Time Limits That Are Too Short Leads to Ramp/Shoulder Parking

4.1.13.4 Difficulty Maneuvering Around Parking Lots

Difficulty maneuvering around parking lots being a probable reason that drivers park on freeway ramps and shoulders is given in Figure 4.16. The majority of drivers (68%) ranked this a 4 or greater indicating that difficulty maneuvering around parking lots is not a probable reason.

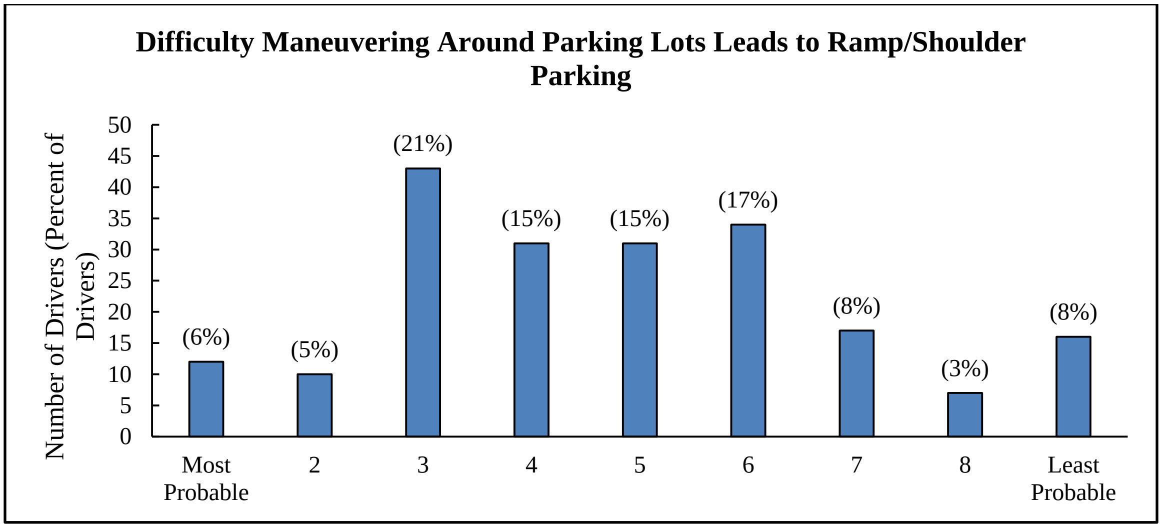

Figure 4.16: Difficulty Maneuvering Around Parking Lots Leads to Ramp/Shoulder Parking

4.1.13.5 Empty Nearby Parking Spaces Are Blocked by Other Vehicles

The probability, reported by the drivers that empty nearby parking spaces being blocked by other vehicles prompts parking on freeway ramps and shoulders is presented in Figure 4.17. Results show, in general, that this is not a probable reason for parking on freeway ramps and shoulders—64% of drivers ranked this a 5 or greater.

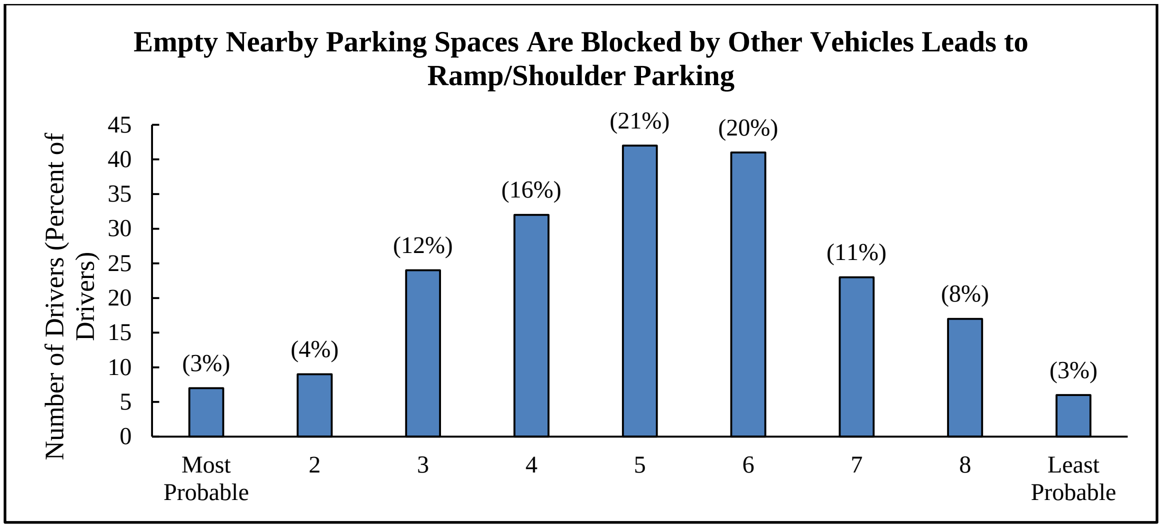

Figure 4.17: Empty Nearby Parking Spaces Are Blocked by Other Vehicles Leads to Ramp/Shoulder Parking

4.1.13.6 The Ramp/Shoulder is Convenient for Getting Back on the Road

Figure 4.18 illustrates the probability from a driver's view that freeway ramps and shoulders being convenient for getting back on the road results in trucks parking on freeway ramps and shoulders. This reason is one of the more evenly distributed reasons, yet the largest percentages are slightly leaning to "Most Probable" reason. Figure 4.18 is shown on the following page.

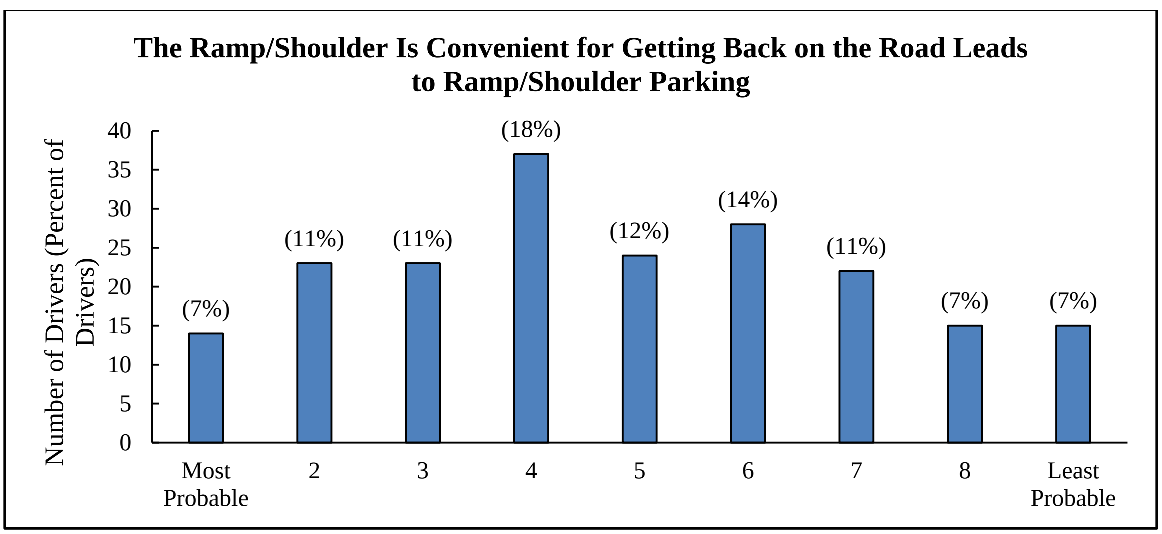

Figure 4.18: The Ramp/Shoulder Is Convenient for Getting Back on the Road Leads to Ramp/Shoulder Parking

4.1.13.7 Better Lighting on Ramp/Shoulder Than in Lots Leads to Ramp/Shoulder Parking

The probability, from a drivers' perception, that lighting on ramps and shoulders being better than truck parking lots results in trucks parking on freeway ramps and shoulders is displayed in Figure 4.19. The majority of drivers feel this is not a likely reason for parking on freeway ramps and shoulders, as 60% ranked it a 5 or greater.

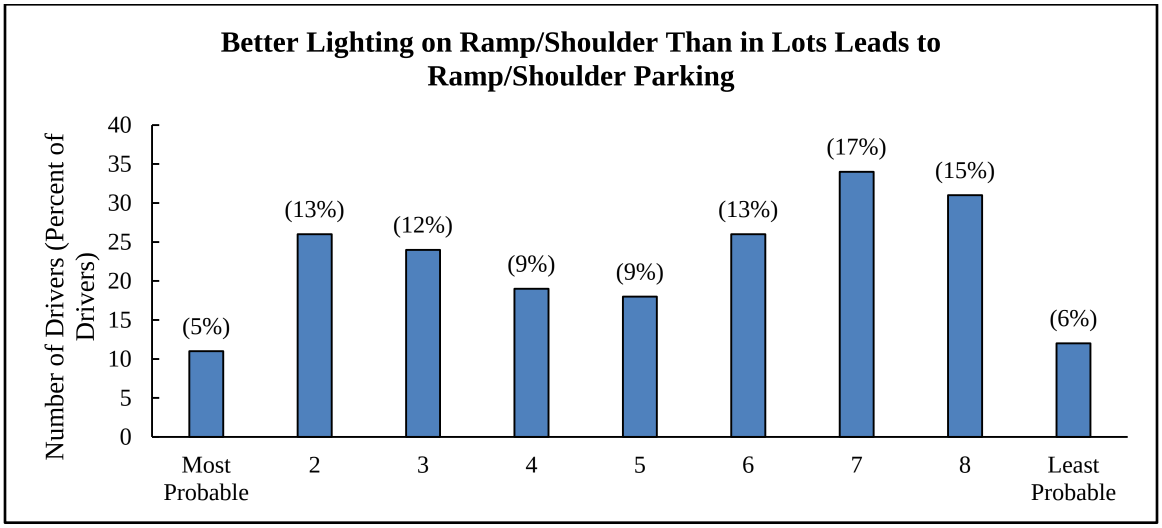

Figure 4.19: Better Lighting on Ramp/Shoulder Than in Lots Leads to Ramp/Shoulder Parking

4.1.13.8 Less Likely to Be Bothered by Strangers (e.g., Drug Dealers, Prostitutes)

Figure 4.20 shows the probability, according to the drivers, that parking on freeway ramps and shoulders is due to drivers believing that they are less likely to be bothered by strangers. More drivers feel that this is not a probable reason, as approximately 57% ranked this a 5 or greater.

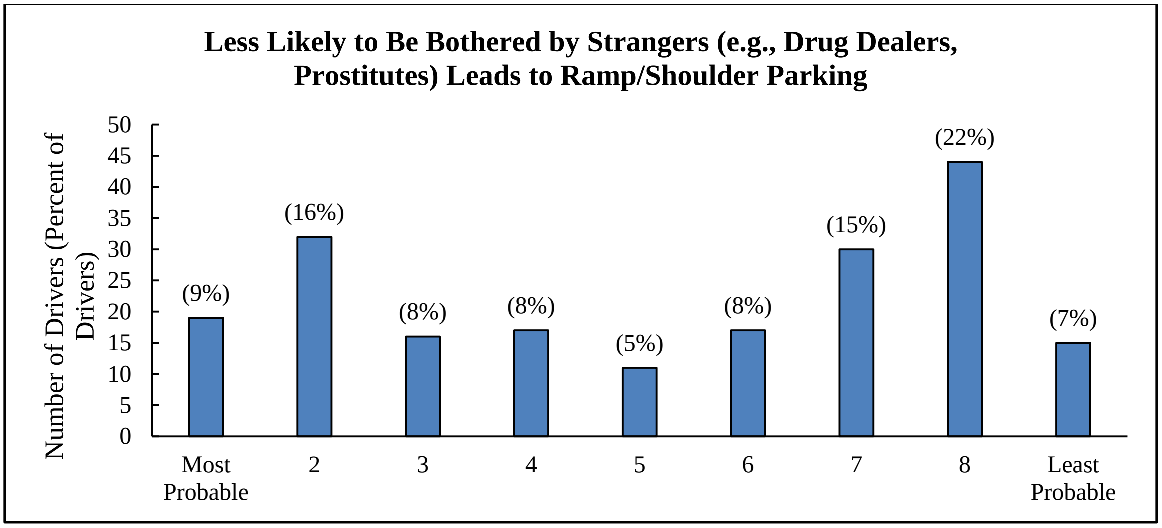

Figure 4.20: Less Likely to Be Bothered by Strangers Leads to Ramp/Shoulder Parking

4.1.13.9 Other Reasons

This portion of the question allowed drivers to provide their own reasons why they have, or would, park on freeway ramps and shoulders. The most common responses were that drivers are tired, parking on ramps and shoulders is easy, and those locations are quiet making it easier to fall asleep. Running out of hours was the next most common statement; in other words, drivers park their trucks there because they legally cannot drive them any farther. Truck drivers also stated that they park on freeway ramps and shoulders because they feel safer there and think they are not in the way.

To summarize each reason's probability, Table 4.1 is provided. For each reason, selections of 1 to 3 were considered to be "Probable," selections of 4 to 6 were considered to be "Not Probable or Improbable," and selections of 7 to 10 were considered to be "Not Probable."

Table 4.1: Probability of Reasons That Drivers Park on Freeway Ramps/Shoulders

Reason	Level of Probability
No Nearby Parking Facility	Probable
Nearby Truck Stops or Rest Areas Are Full	Probable
Nearby Parking Spaces Have Time Limits That Are Too Short	Not Probable or Improbable
Difficulty Maneuvering Around Parking Lots	Not Probable or Improbable
Empty Nearby Parking Spaces Are Blocked by Other Vehicles	Not Probable or Improbable
The Ramp/Shoulder is Convenient for Getting Back on the Road	Not Probable or Improbable
Better Lighting on Ramp/Shoulder Than in Lot	Not Probable
Less Likely to be Bothered by Strangers (e.g., Drug Dealers, Prostitutes)	Not Probable

4.1.14 Please rate how IMPORTANT the following features are to you when you park at a truck stop or rest area.

Drivers are going to park in locations that have amenities that meet their needs and those features are going to vary from driver to driver. The responses from this question assist in better understanding what the most important features are to commercial vehicle drivers. Drivers were asked to rank the following features from "not at all important" to "extremely important":

1. Convenience to Highway
2. Repair Facilities
3. Fuel
4. Restrooms
5. Showers
6. Well-Lighted Parking Lot
7. Security Presence
8. Convenience Store
9. Restaurants
10. Vending Machines
11. Travel Info (Info on Kiosks, etc.)
12. Internet Connections

13. Please Select “very important” (Quality Assurance)

14. Entertainment Facilities (e.g., Arcade, Movies)

15. Other

4.1.14.1 Convenience to Highway

Figure 4.21 displays the importance of truck stops or rest areas being conveniently close to the highway. Nearly 90% of the drivers stated that this is a very to extremely important feature. Roughly 52% of drivers indicated that convenience to highway is “very important” and 38% stated that convenience to highway is “extremely important.”

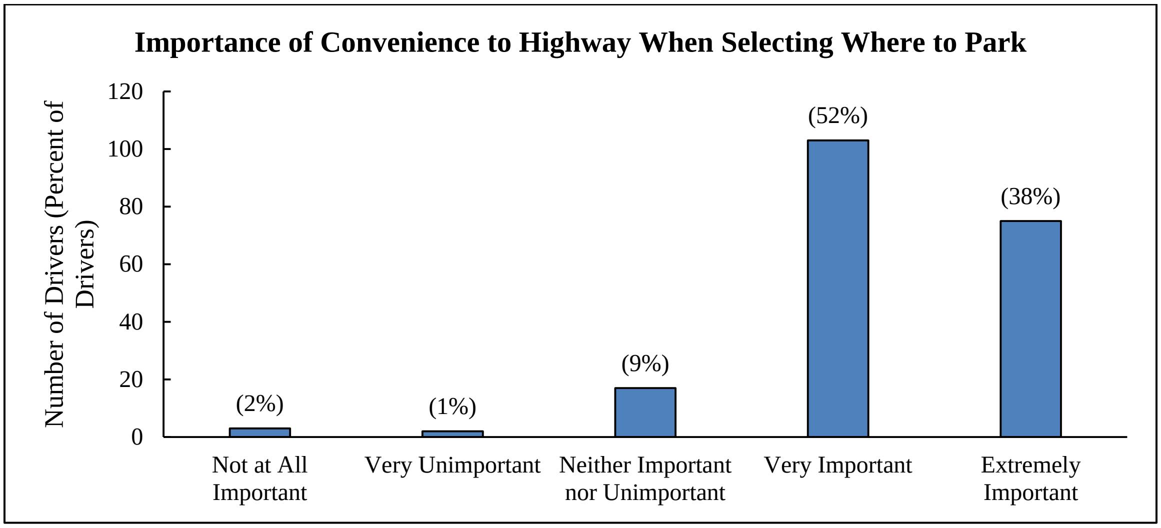

Figure 4.21: Importance of Convenience to Highway When Selecting Where to Park

4.1.14.2 Repair Facilities

The importance of repair facilities being located at truck stops or rest areas is presented in Figure 4.22. The majority of drivers believe repair facilities are “neither important nor unimportant” (38%). Still, 37% believe them to be “very important.” Figure 4.22 is shown on the following page.

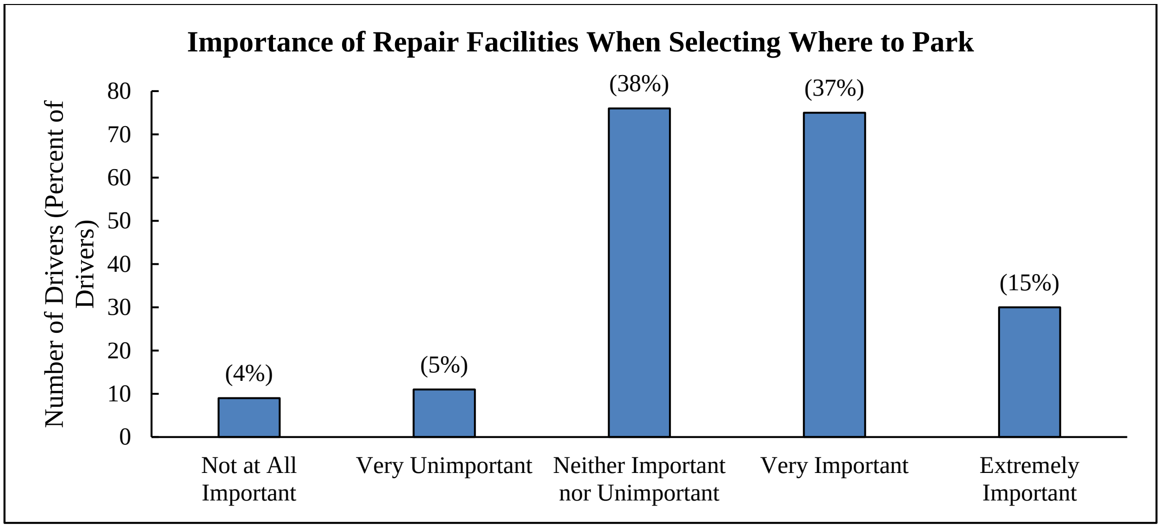

Figure 4.22: Importance of Repair Facilities When Selecting Where to Park

4.1.14.3 Fuel

The importance of fuel when selecting where to park is shown in Figure 4.23, and based on the responses from the drivers, this is clearly an important feature when selecting a location to park. For instance, roughly 42% consider fuel to be "very important" when selecting where to park and 41% believe the presence of fuel is "extremely important."

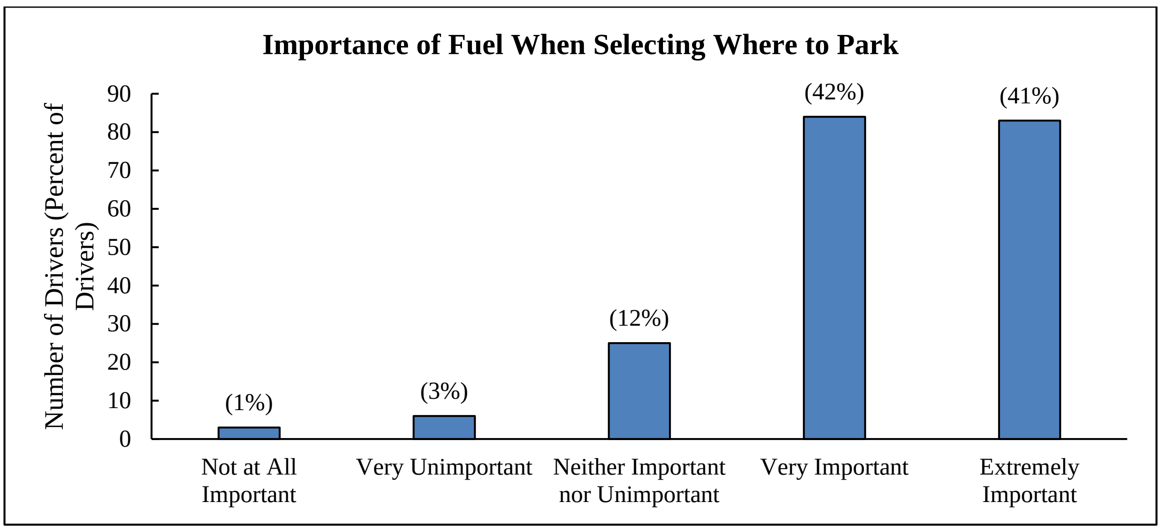

Figure 4.23: Importance of Fuel When Selecting Where to Park

4.1.14.4 Restrooms

Figure 4.24 illustrates the importance of restrooms when selecting a place to park, where restrooms are certainly an important factor when drivers select where to park. For instance, more than 90% of drivers indicate restrooms are “extremely important” and “very important.” No drivers selected “not at all important.”

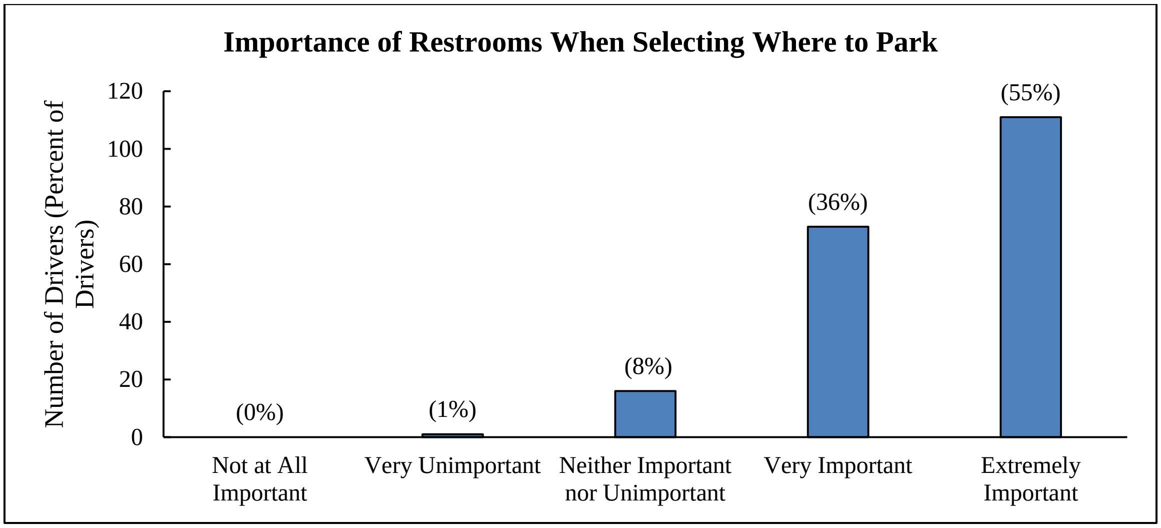

Figure 4.24: Importance of Restrooms When Selecting Where to Park

4.1.14.5 Showers

The importance of showers being present when selecting where to park is shown in Figure 4.25. Like the previous features, showers are seemingly an important influence when selecting where to park. 37% of the surveyed drivers believe showers to be “very important” and 26% believe showers to be “extremely important.”

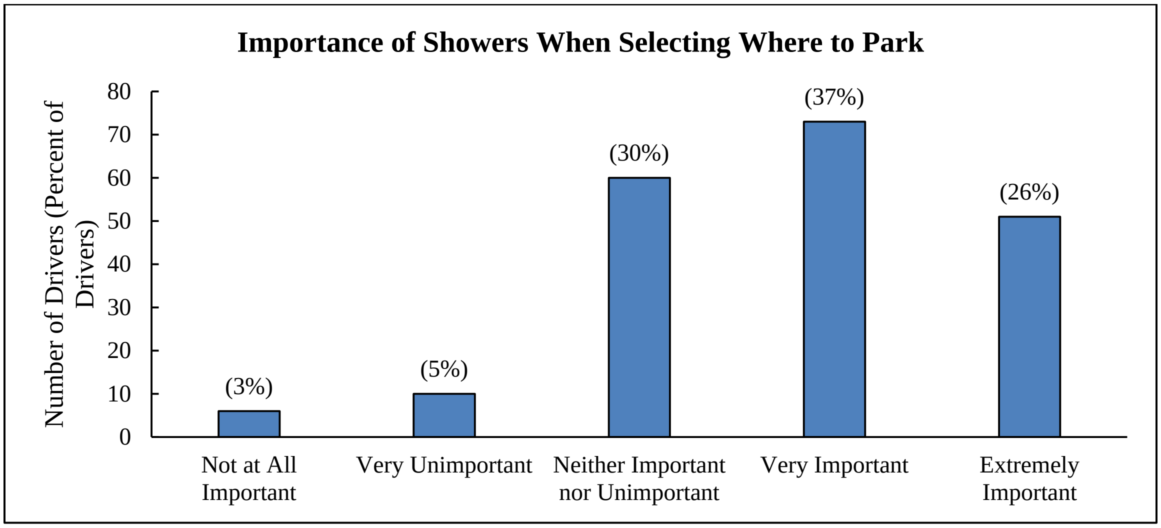

Figure 4.25: Importance of Showers When Selecting Where to Park

4.1.14.6 Well-Lighted Parking Lot

The importance of a well-lighted parking lot is shown in Figure 4.26. As seen from the figure, about 34% of drivers feel that well-lighted parking lots are "extremely important" and 41% believe that well-lighted parking lots are "very important." Less than 1% of drivers selected "not at all important" and roughly 2% of drivers selected "very unimportant."

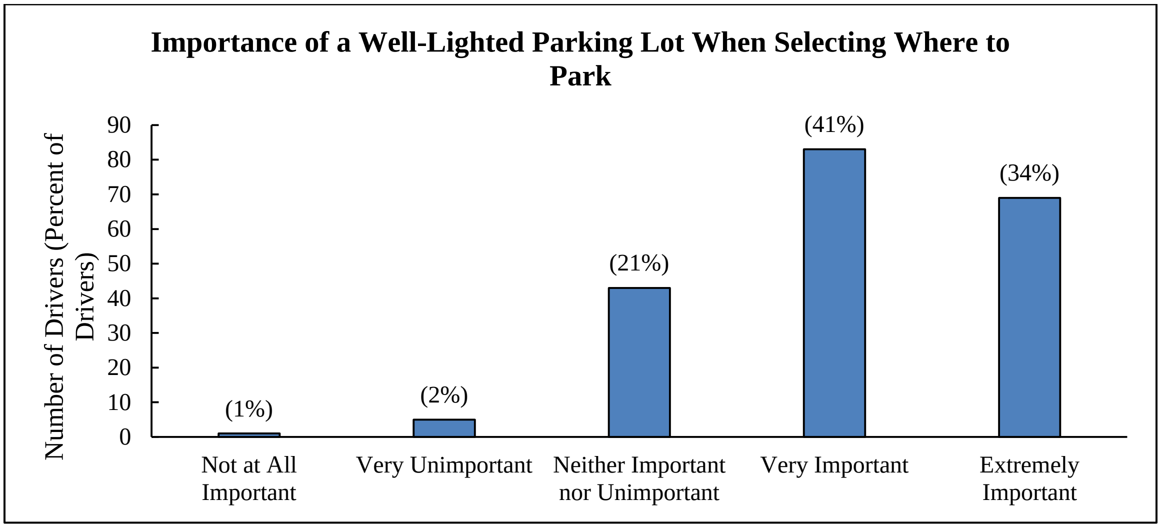

Figure 4.26: Importance of a Well-Lighted Parking Lot When Selecting Where to Park

4.1.14.7 Security Presence

The importance of security presence when selecting where to park is presented in Figure 4.27. About 26% of drivers indicated security presence is "extremely important" and nearly 45% of drivers believe security presence is "very important," although 21% of drivers feel that security presence is "neither important nor unimportant."

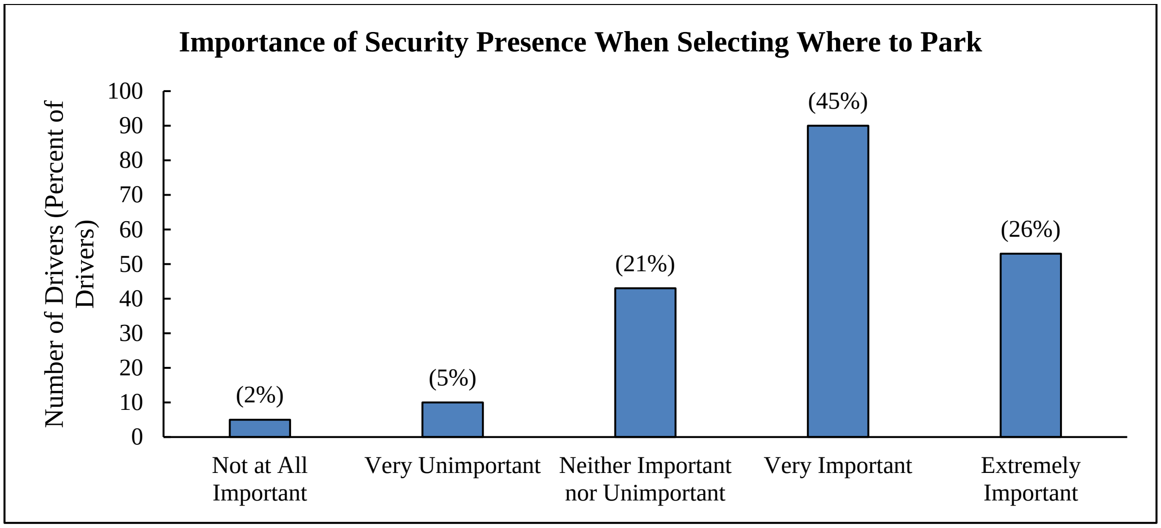

Figure 4.27: Importance of Security Presence When Selecting Where to Park

4.1.14.8 Convenience Store

Figure 4.28 shows the important of convenience stores being located at truck stops or rest areas. The majority of drivers feel that convenience stores are "very important" and "extremely important" at roughly 43% and 20%, respectively. Still, nearly 29% of drivers believe that convenience stores are "neither important nor unimportant."

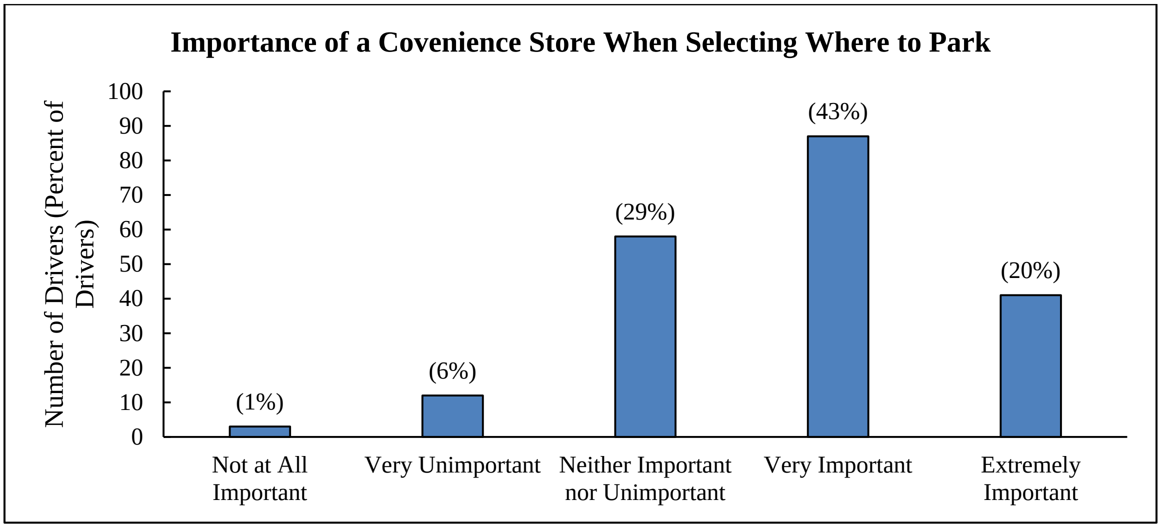

Figure 4.28: Importance of a Convenience Store When Selecting Where to Park

4.1.14.9 Restaurants

Figure 4.29 presents the importance of restaurants being located at truck stops or near rest areas. Roughly 18% of drivers think restaurants are "extremely important" and 43% think restaurants are "very important," whereas about 30% of drivers find restaurants to be "neither important nor unimportant."

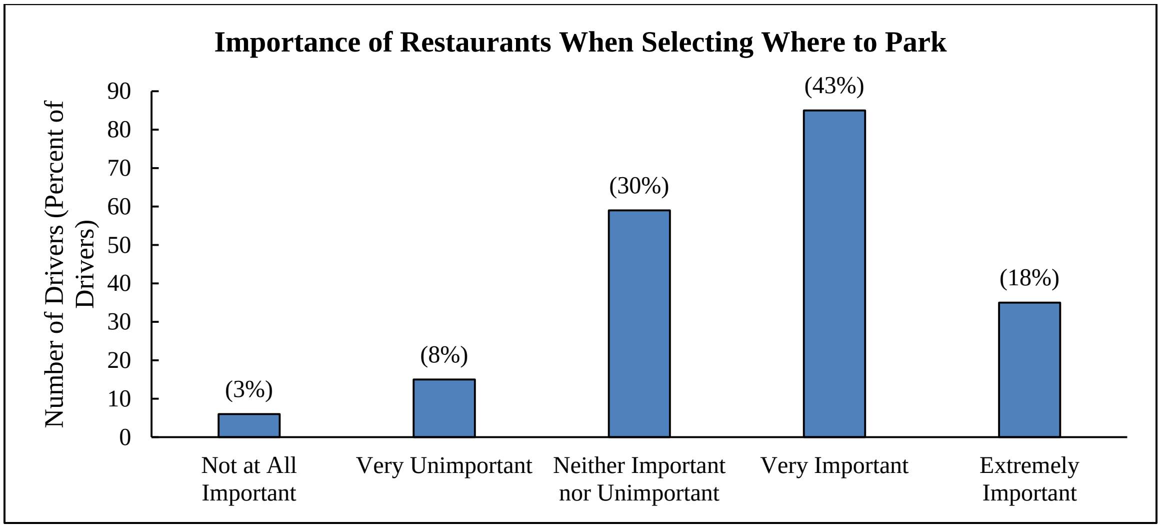

Figure 4.29: Importance of Restaurants When Selecting Where to Park

4.1.14.10 Vending Machines

The importance of vending machines being located at truck stops or rest areas is shown in Figure 4.30. The majority of drivers believe this feature to be "neither important nor unimportant" (37%) or "very important" (31%). The remaining options did not account for more than 13% of the drivers.

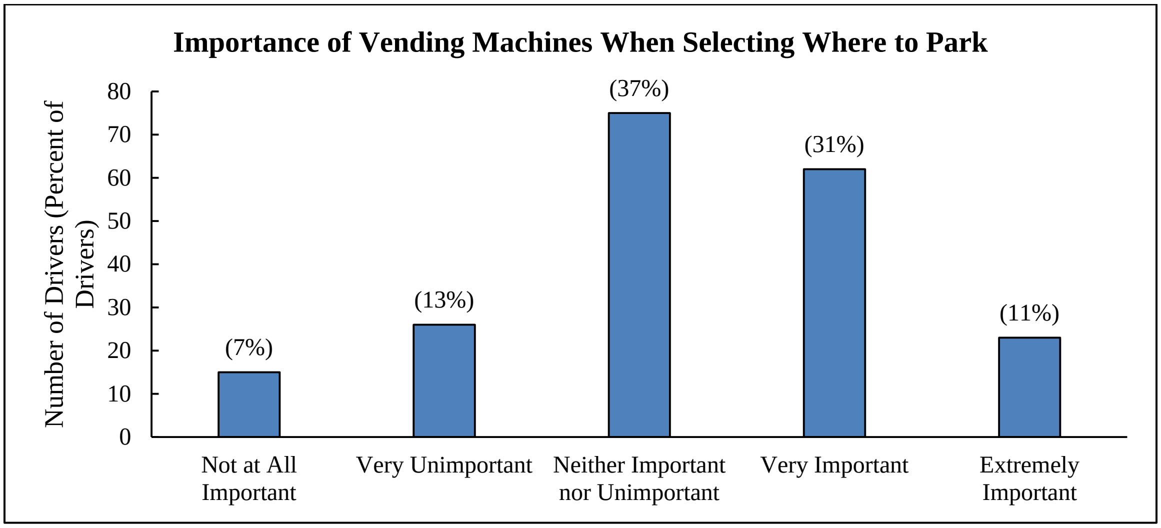

Figure 4.30: Importance of Vending Machines When Selecting Where to Park

4.1.14.11 Travel Information (Information on Kiosks, etc.)

The importance of travel information at truck stops or rest areas is presented in Figure 4.31. Roughly 11% feel it is “extremely important,” 21% believe it is “very important,” 33% feel it is “neither important nor unimportant,” 21% think it is “very unimportant,” and 14% consider travel information to be “not at all important.” At least 10% of drivers accounted for each.

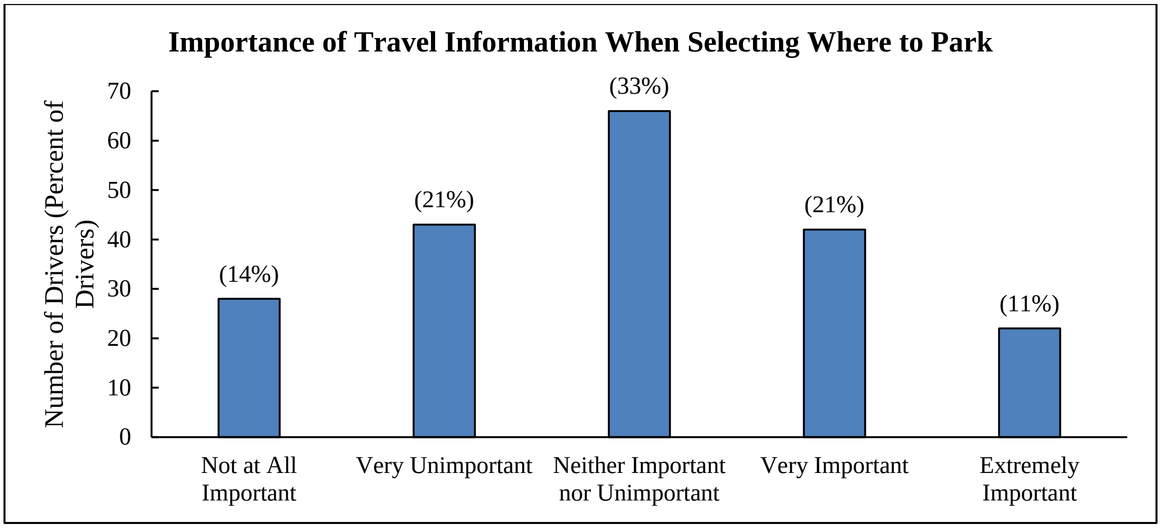

Figure 4.31: Importance of Travel Information When Selecting Where to Park

4.1.14.12 Internet Connections

Figure 4.32 presents the importance of internet connections at truck stops or rest areas. The majority of drivers feel that internet connections are “very important” or “extremely important” at 28% and 22%, respectively. However, 30% of drivers think an internet connection is “neither important nor unimportant.”

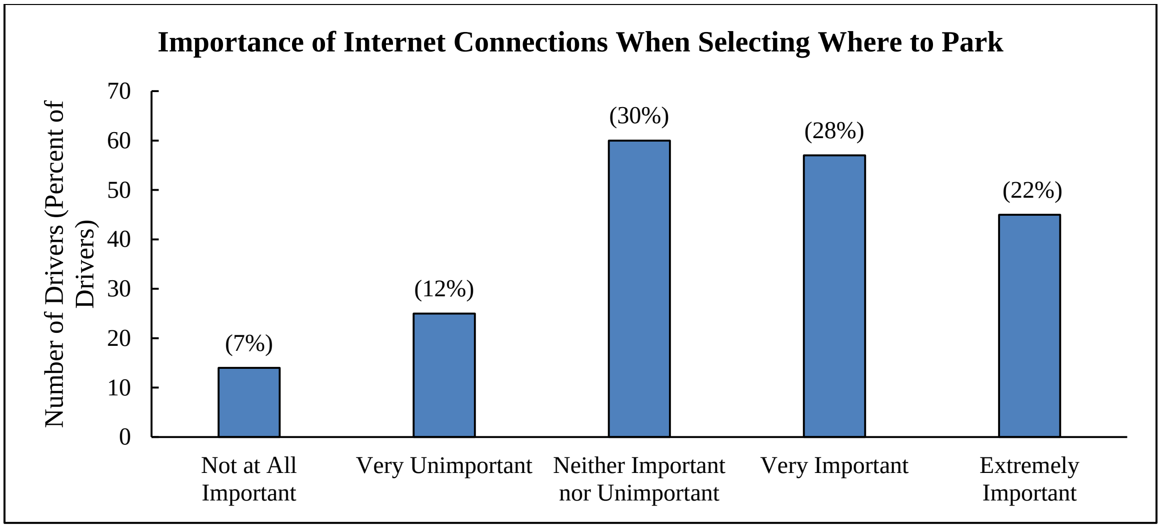

Figure 4.32: Importance of Internet Connections When Selecting Where to Park

4.1.14.13 Quality Assurance

Figure 4.33 shows the responses for the quality check question. The drivers were asked to select "very important" to ensure that the survey was being read correctly and answered adequately. 100% of the drivers selected "very important" indicating the survey responses are satisfactory.

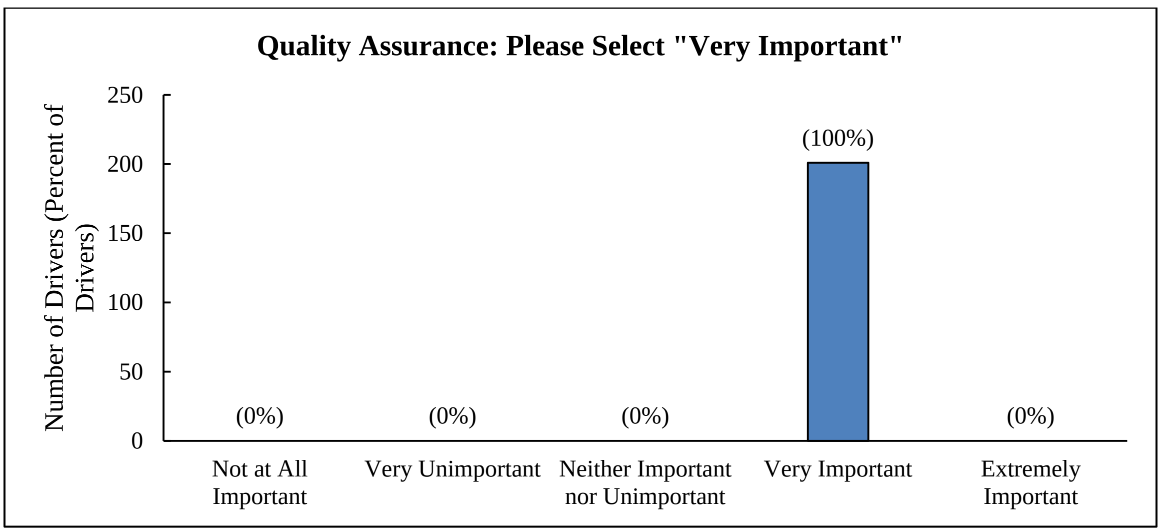

Figure 4.33: Quality Assurance: Please Select "Very Important"

4.1.14.14 Entertainment Facilities (e.g., Arcade, Movies)

The importance of entertainment facilities being located at truck stops or rest areas is displayed in Figure 4.34. Most drivers feel entertainment facilities are not an important feature, as roughly 25% think entertainment facilities are “not at all important,” 25% believe entertainment facilities are “very unimportant,” and 30% feel entertainment facilities are “neither important nor unimportant.”

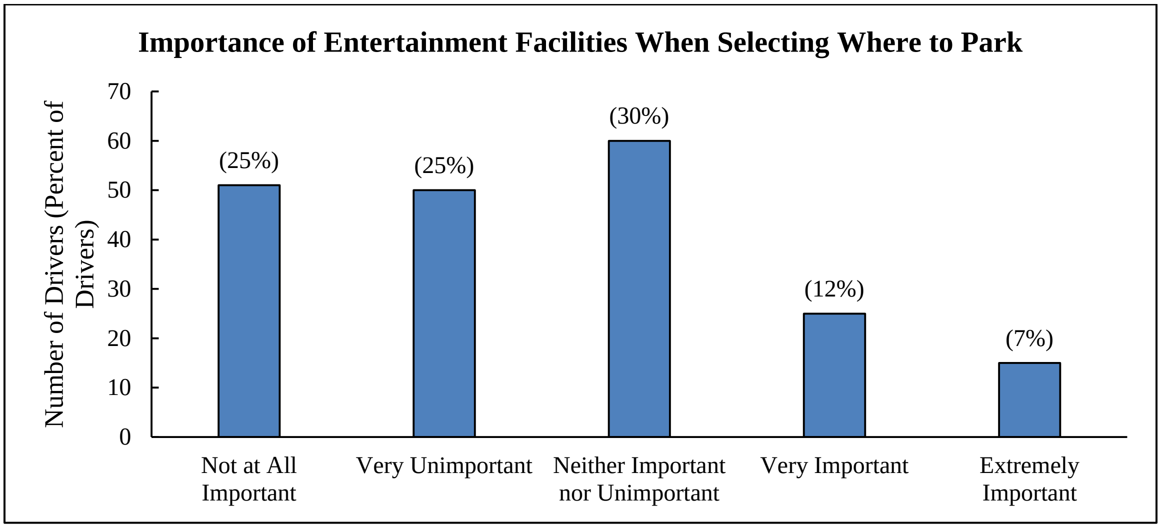

Figure 4.34: Importance of Entertainment Facilities When Selecting Where to Park

4.1.14.15 Other Features

This section allowed drivers to write-in key features that influence their decision to park at truck stops and/or rest areas. The presence of payphones and nearby coffee shops were the most common features provided by the drivers. Other write-in features included parking facilities where drivers can meet other drivers, facilities that have swimming pools, facilities that have full-sized parking spaces, facilities with friendly staff members, and facilities that do not have time limits. In addition, drivers also believe that nearby motels, grocery stores, laundry facilities, scanning and faxing abilities, bars, and a nearby gym are important features for truck stops and/or rest areas.

4.1.15 What type of real-time information on truck parking availability would help you plan in advance your stops while you drive? (Please select all that apply)

Drivers were given five choices regarding real-time information on truck parking availability that would help them plan stops in advance and results are presented in Figure 4.35. The largest percentage of drivers, approximately 39%, believe that the number of truck parking spaces available at upcoming parking facilities would help most to plan stops in advance, while 33% of drivers feel that information regarding the location of truck parking facilities along the planned route would help. Moreover, about 16% of drivers think the most helpful real-time information would be that of the available features located at an upcoming parking facility.

Drivers could also select “Other” and provide the real-time information that would be most useful to them, and roughly 4% selected “Other.” Because drivers were unable to select all, all drivers that selected "Other" indicated that each type of real-time information would help in planning stops in advance.

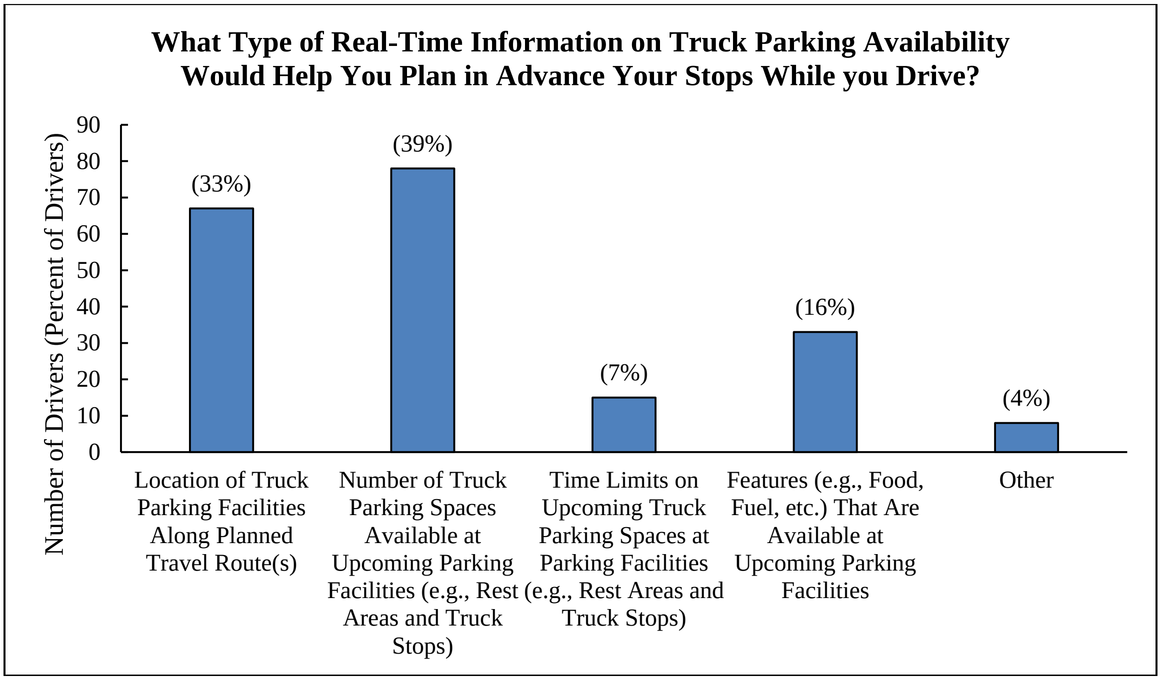

Figure 4.35: Real-Time Information on Truck Parking Availability That Would Help Plan in Advance

4.1.16 How would you like to receive the information on truck parking availability?

The manner in which drivers would like to receive information on truck parking availability is presented in Figure 4.36. More than one-half of the drivers, about 56%, would like to receive truck parking information through a smart phone application. However, using GPS and radio-in-vehicle to disseminate truck parking information were not as popular. 1% of drivers selected "Other," which accounted for two drivers. Both drivers stated that they would like to receive the real-time parking information via signage on the highway and one of the drivers wrote specifically about Michigan having digital road signs that report the available truck parking spaces and that it is "loved by truck drivers." Figure 4.36 is shown on the following page.

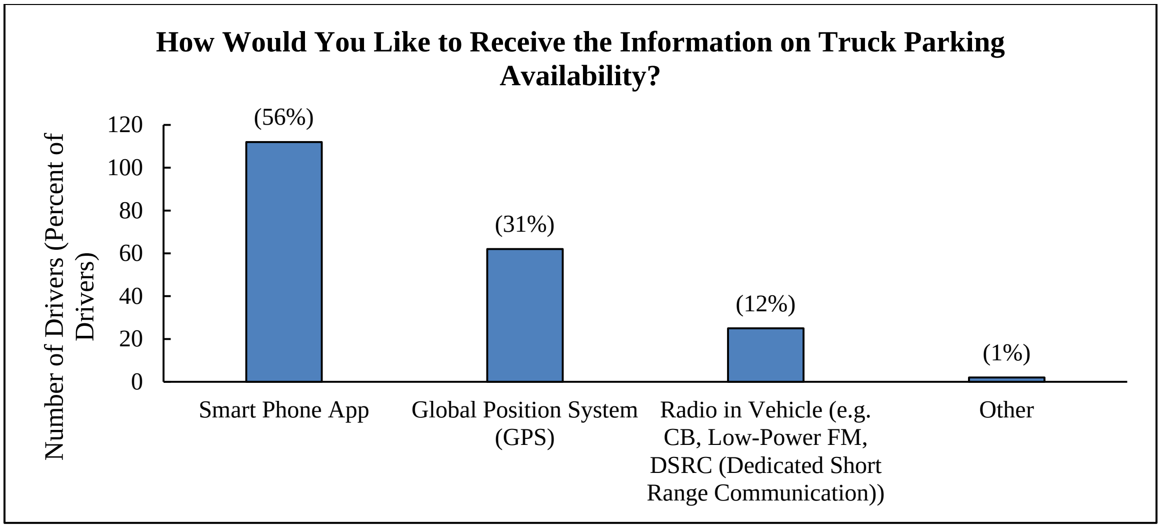

Figure 4.36: How Would You Like to Receive the Information on Truck Parking Availability?

4.1.17 In your view, how effective could these improvements be in improving your truck parking experience?

Truck stops may not have certain features and need improvements; therefore, this question is designed to gain feedback from drivers regarding their current truck parking experiences. Drivers were asked to rate the following from “very ineffective” to “very effective”:

1. Improve Lighting at Parking Facilities
2. Increase Security Presence at Parking Facilities
3. Landscape to Minimize Hiding Places for Criminals/Criminal Activity
4. Improve Amenities at Rest Areas
5. Build More Truck Stop Parking Spaces
6. Build More Rest Area Parking Spaces
7. Separate Truck, Car and RV Parking
8. Use Car Parking for Truck Parking During Peak Overnight Hours
9. Enforce Time Limits on Truck Parking
10. Eliminate Time Limits on Truck Parking
11. Improve Parking Layout/Configuration (e.g., More Diagonal Pull-Through)
12. Improve Signs and Roadway Information for Parking Facilities

13. Educate Drivers/Dispatchers About Planning Parking Stops Before Trip

14. Real-Time Information on Parking Space Availability

15. Adopt Standard Spacing Between Rest Areas

16. Please Select "very ineffective" (Quality Assurance)

17. Provide Alternate Parking (e.g., At Weigh Stations, Park-N-Ride, Private …)

18. Stop Enforcement Officers from Waking Driver

19. Other

4.1.17.1 Improved Lighting at Parking Facilities

The surveyed drivers' opinions on the effectiveness of improving the lighting at parking facilities to improve the truck parking experience is shown in Figure 4.37. The majority of drivers (43%) think improving the lighting at parking facilities would be "effective" and about 34% of drivers believe it would be "very effective." Nevertheless, some drivers feel that improved lighting would not be effective, as 2% of drivers think improved lighting would be "very ineffective," 3% believe improved lighting would be "ineffective," and 18% of drivers consider improved lighting to be "neither effective nor ineffective."

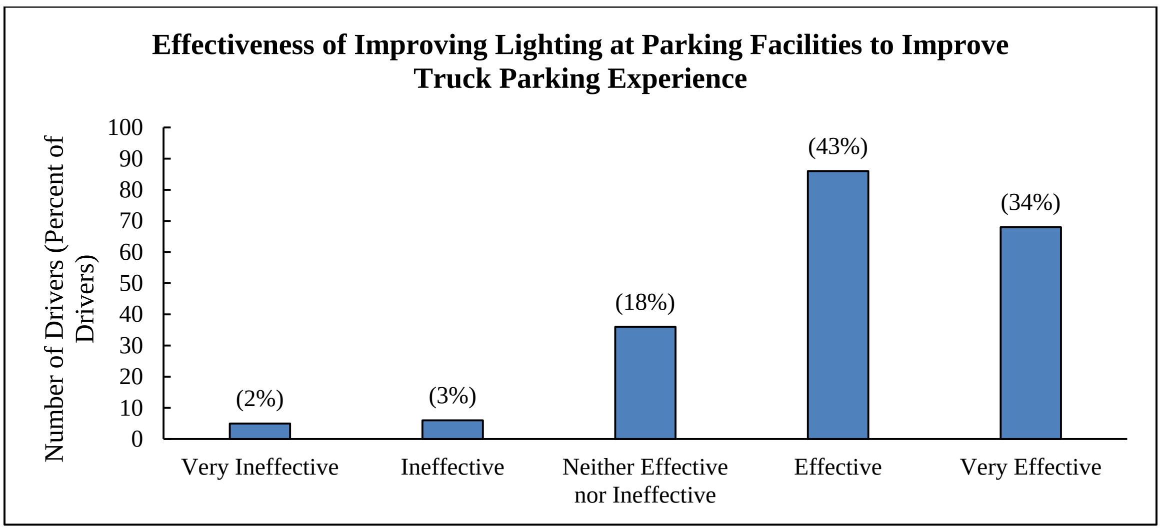

Figure 4.37: Effectiveness of Improving Lighting at Parking Facilities

4.1.17.2 Increase Security Presence at Parking Facilities

Figure 4.38 shows the effectiveness, based on the opinions of the surveyed drivers, of increasing security presence at parking facilities. The majority of drivers feel this would be effective, as about 34% believe it would be "very effective" and 41% think it be "effective." By contrast, roughly 18% of drivers think increasing security would be "neither effective nor ineffective."

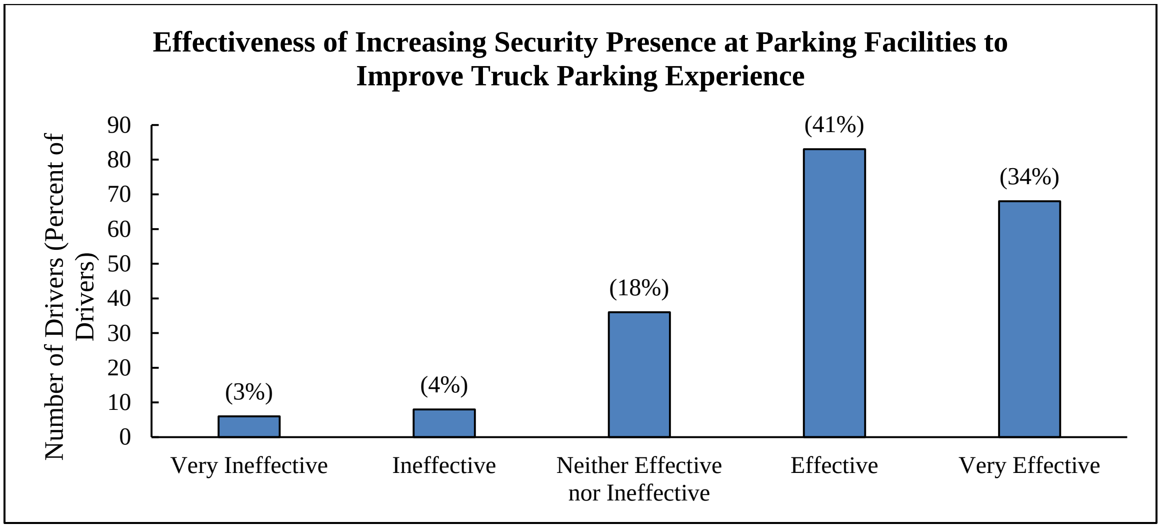

Figure 4.38: Effectiveness of Increasing Security Presence at Parking Facilities

4.1.17.3 Landscape to Minimize Hiding Places for Criminals/Criminal Activity

The effectiveness of adding landscape to minimize hiding places for criminals/criminal activity, according to the opinions of the surveyed drivers, is presented in Figure 4.39. Approximately 35% and 34% of drivers feel this would be "very effective" and "effective," respectively. Only 17% of truck drivers consider the addition of landscape to be "neither effective nor ineffective." Figure 4.39 can be seen on the following page.

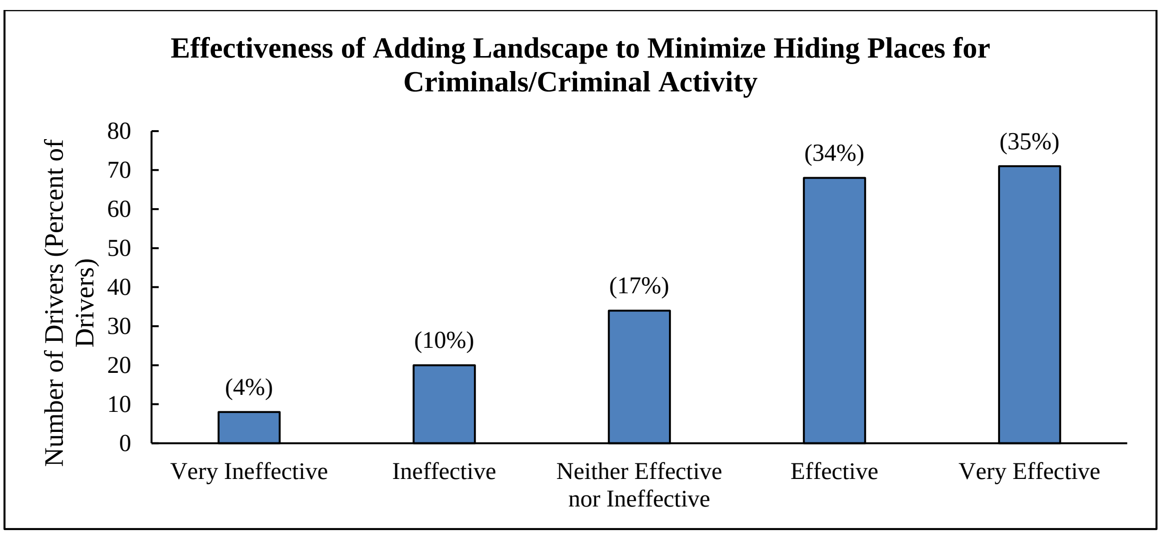

Figure 4.39: Effectiveness of Adding Landscape to Minimize Hiding Places for Criminals/Criminal Activity

4.1.17.4 Improve the Amenities at Rest Areas

Figure 4.40 shows the effectiveness of improving amenities at rest areas to improve the truck parking experience based on the opinions of the surveyed drivers. Roughly 33% of drivers feel improving the amenities would be "very effective" and 51% of drivers believe it would be "effective." Still, 13% of drivers believe that improving amenities would be "neither effective nor ineffective."

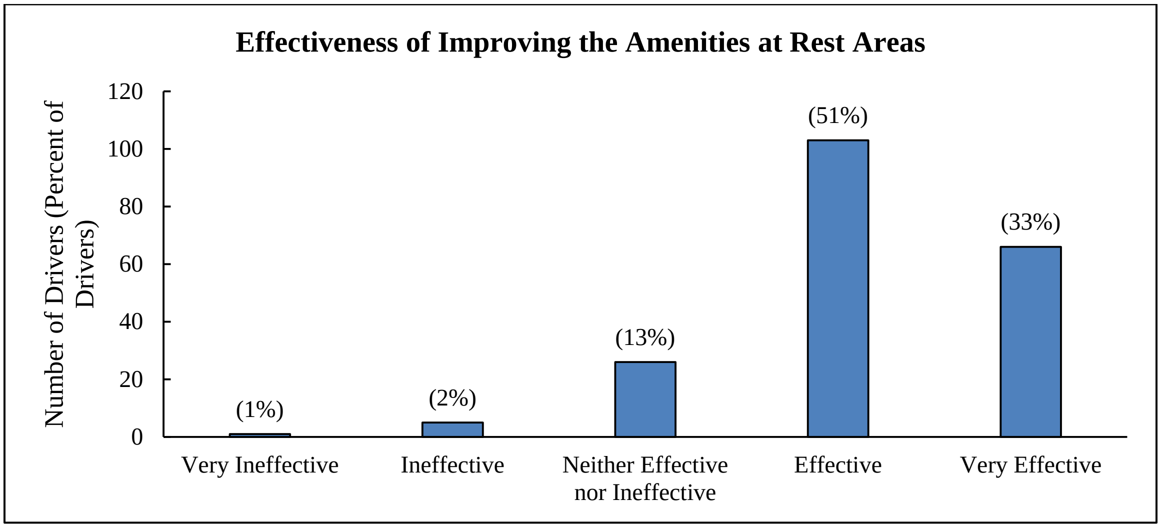

Figure 4.40: Effectiveness of Improving the Amenities at Rest Areas

4.1.17.5 Build More Truck Stop Parking Spaces

The effectiveness, corresponding to the surveyed drivers, of building more parking spaces at truck stops is shown in Figure 4.41. As anticipated, most truck drivers believe the addition of parking spaces would be effective. Surprisingly, about 6% of drivers think the addition of parking spaces would be "neither effective nor ineffective" and 2% believe it would be "ineffective."

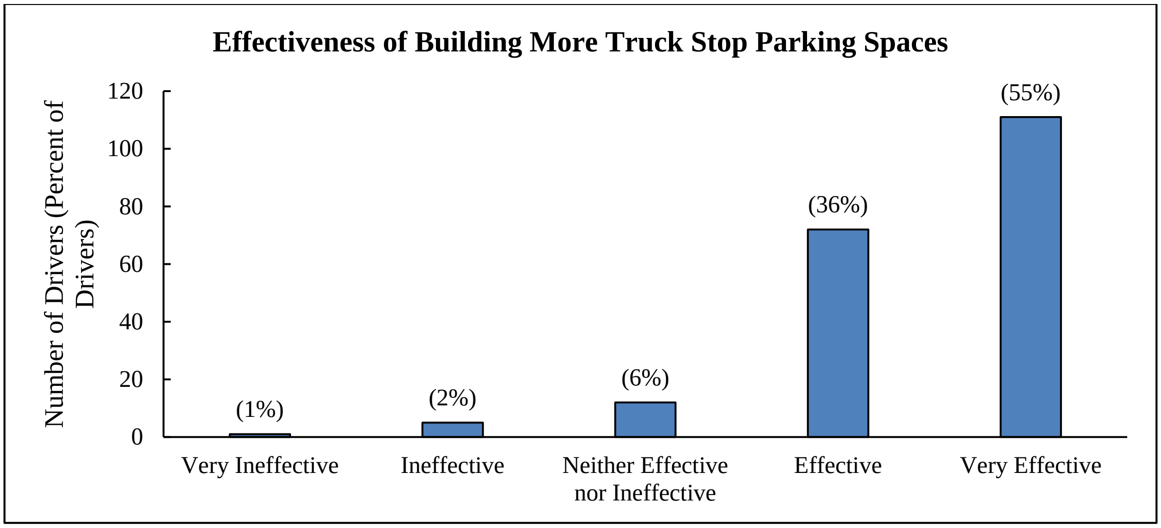

Figure 4.41: Effectiveness of Building More Truck Stop Parking Spaces

4.1.17.6 Build More Rest Area Parking Spaces

Figure 4.42 displays the effectiveness that building more parking spaces at rest areas would have on an improved truck parking experience according to the opinions of the surveyed drivers. Clearly, the majority of drivers believe that the addition of parking spaces at rest areas would be effective, yet 11% think it would be "neither effective nor ineffective."

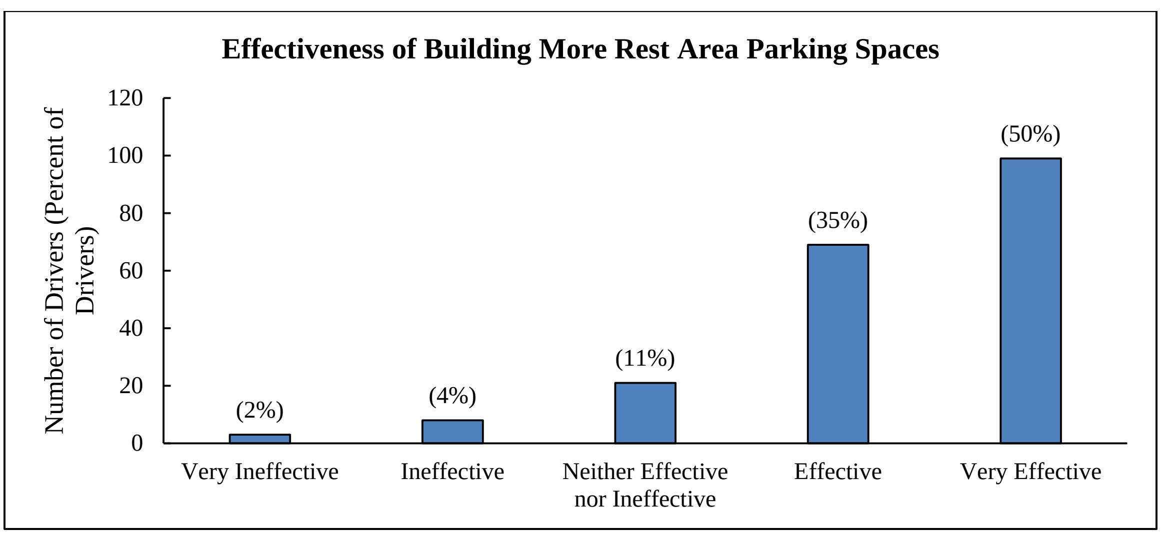

Figure 4.42: Effectiveness of Building More Rest Area Parking Spaces

4.1.17.7 Separate Truck, Car, and RV Parking

The effectiveness of separate truck, car, and RV Parking, according to the surveyed drivers, is illustrated in Figure 4.43. Implementing this would be effective from the drivers' perspective; however, 16% do think separate parking would be "neither effective nor ineffective."

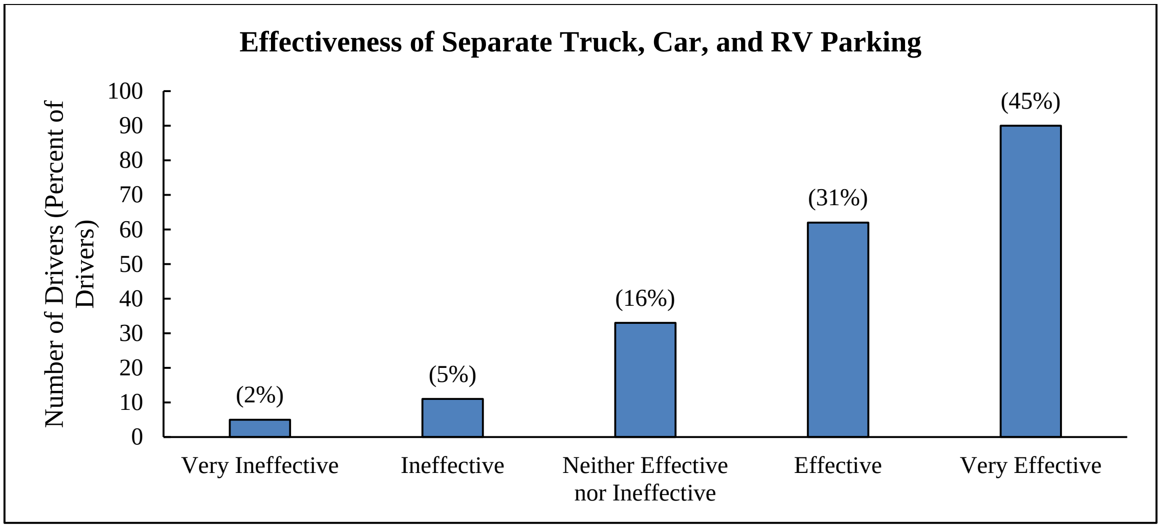

Figure 4.43: Effectiveness of Separate Truck, Car, and RV Parking

4.1.17.8 Use Car Parking for Truck Parking During Peak Overnight Hours

The effectiveness, based on the opinions of the surveyed drivers, of using car parking for truck parking during peak overnight hours is presented in Figure 4.44. The majority of drivers feel this would be "very effective" and "effective" at roughly 30% and 33%, respectively. However, roughly 20% think it would be "neither effective nor ineffective."

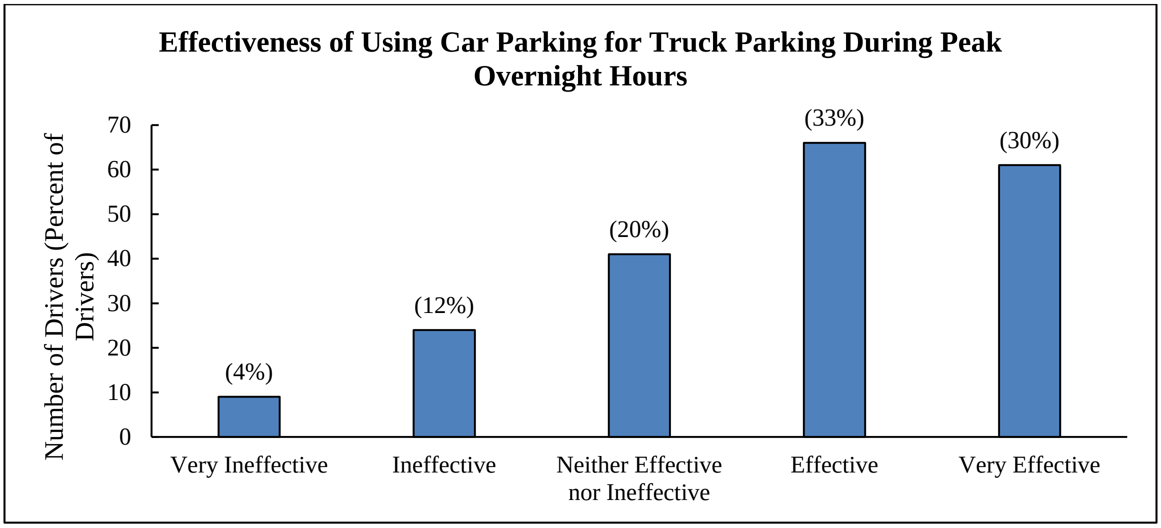

Figure 4.44: Effectiveness of Using Car Parking for Truck Parking During Peak Overnight Hours

4.1.17.9 Enforce Time Limits on Truck Parking

Figure 4.45 illustrates the effectiveness of enforcing time limits on truck parking according to the surveyed drivers. These responses were the most distributed and had the least number of drivers select "very effective" and "effective." Meanwhile, about 16% of drivers feel it would be "very ineffective," 20% believe it would be "ineffective," and 27% consider it to be "neither effective nor ineffective."

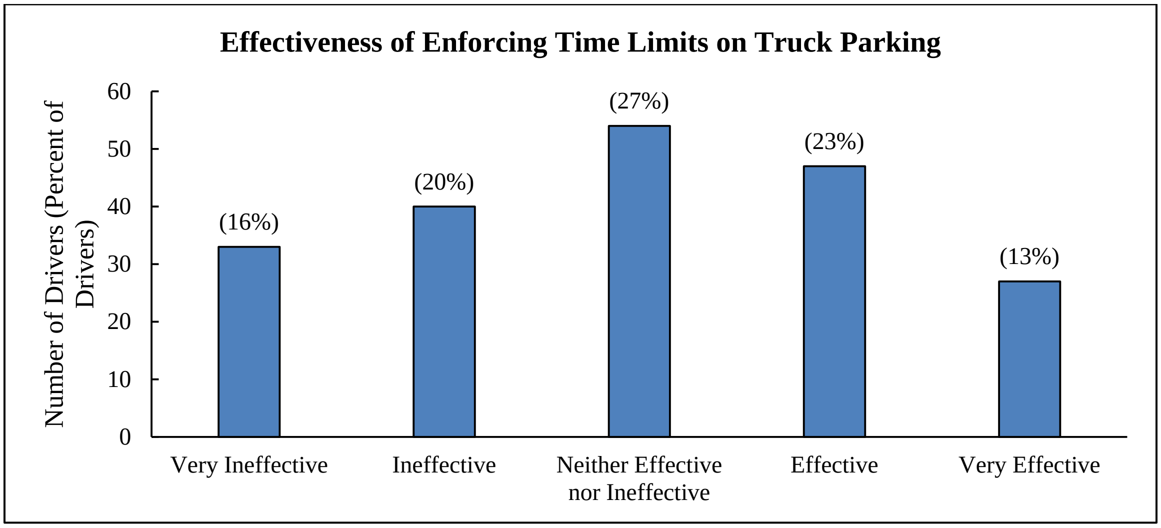

Figure 4.45: Effectiveness of Enforcing Time Limits on Truck Parking

4.1.17.10 Eliminate Time Limits on Truck Parking

Eliminating time limits on truck parking and its effectiveness according to the surveyed drivers is presented in Figure 4.46. This was the third most dispersed response; still, the majority of drivers feel that eliminating time limits on truck parking would be "very effective" and "effective."

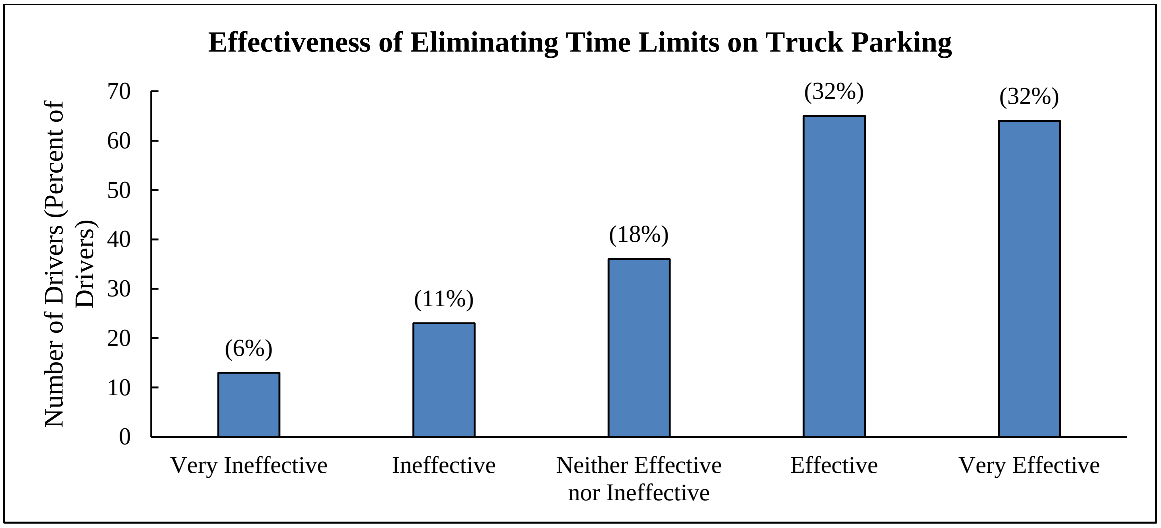

Figure 4.46: Effectiveness of Eliminating Time Limits on Truck Parking

4.1.17.11 Improve Parking Layout/Configuration (e.g., More Diagonal Pull-Through)

The effectiveness, according to the surveyed drivers, of improving parking layout/configuration is shown in Figure 4.47. As seen from the figure below, more than four-fifths (82%) of the drivers believe that improving parking layout/configuration would be effective, while14% think it would be "neither effective nor ineffective."

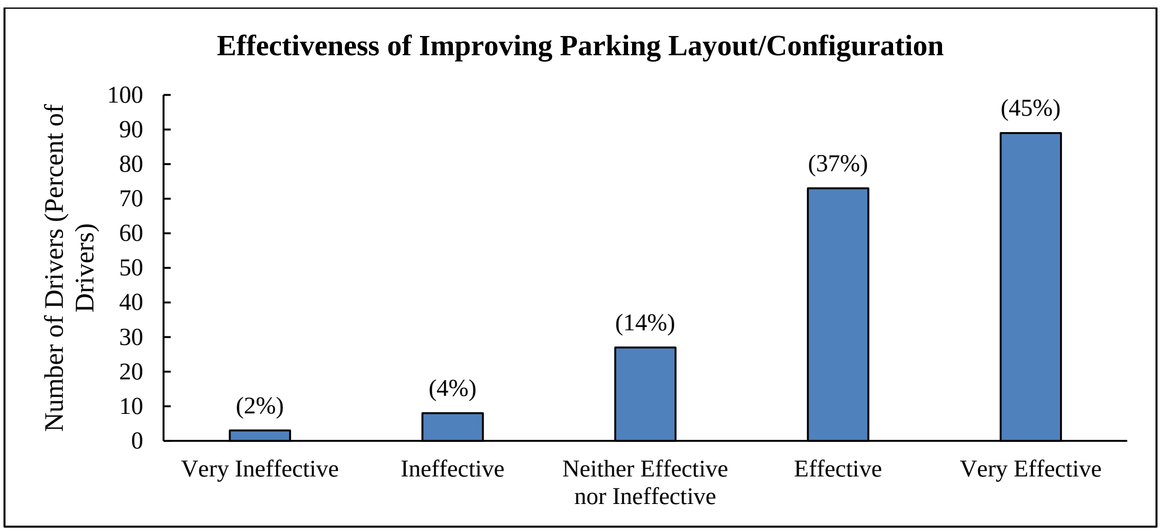

Figure 4.47: Effectiveness of Improving Parking Layout/Configuration

4.1.17.12 Improve Signs and Roadway Information for Parking Facilities

Figure 4.48 shows the effectiveness of improving signs and roadway information for parking facilities from the perspective of the surveyed drivers. Again, a large proportion of drivers (74%) feel this improvement would be effective, yet 18% feel indifferent about this improvement.

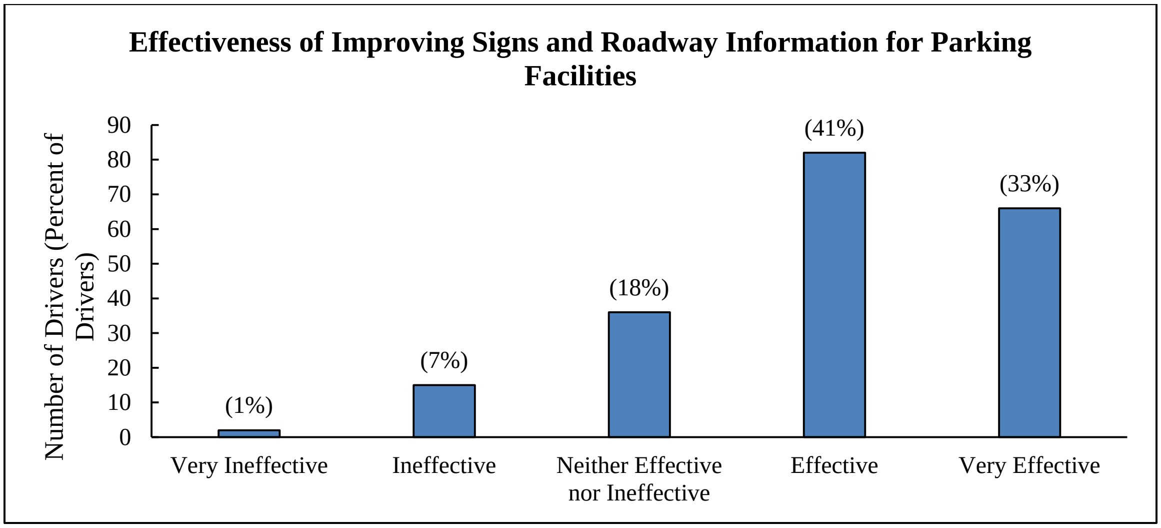

Figure 4.48: Effectiveness of Improving Signs and Roadway Information for Parking Facilities

4.1.17.13 Educate Drivers/Dispatchers About Planning Parking Stops Before Trip

Educating drivers/dispatchers about planning parking stops before trips and its effectiveness based on opinions of the surveyed drivers is shown in Figure 4.49. Despite roughly 21% of the drivers believing that this would be “neither effective nor ineffective,” the majority of drivers (68%) this it would be effective.

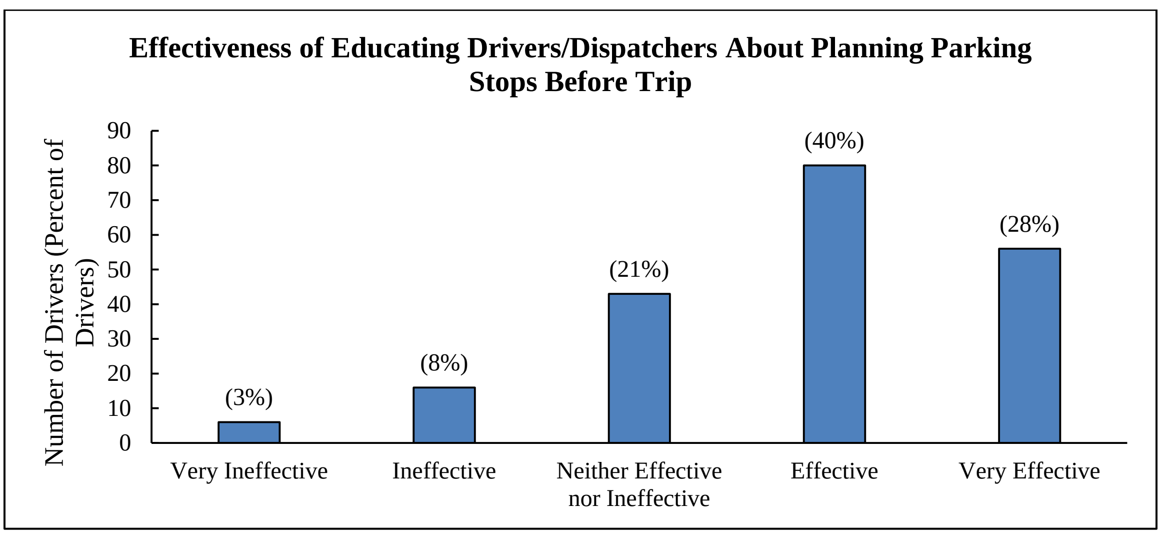

Figure 4.49: Effectiveness of Educating Drivers/Dispatchers About Planning Parking Stops Before Trip

4.1.17.14 Real-Time Information on Parking Space Availability

The effectiveness, based on views from the surveyed drivers that real-time information on parking space availability would have is presented in Figure 4.50. This improvement was one of the more popular choices among the drivers, as roughly 85% feel it would be effective.

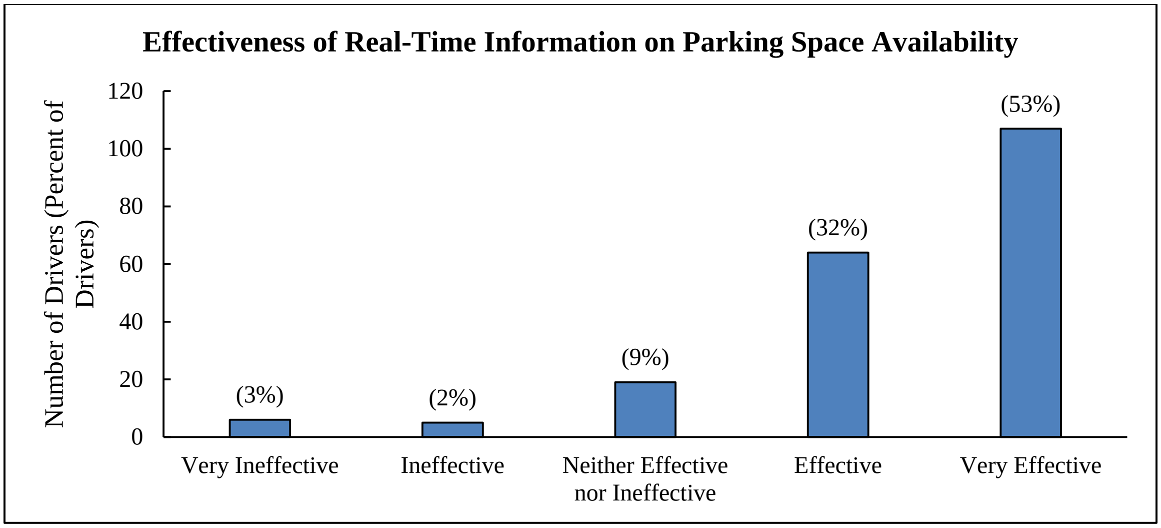

Figure 4.50: Effectiveness of Real-Time Information on Parking Space Availability

4.1.17.15 Adopt Standard Spacing Between Rest Areas

Figure 4.51 displays the effectiveness of adopting standard parking spacing between rest areas from the perspective of the surveyed drivers. Around 22% of drivers believe adopting standard parking spacing would be "neither effective nor ineffective," but the majority of drivers (69%) think it would be effective.

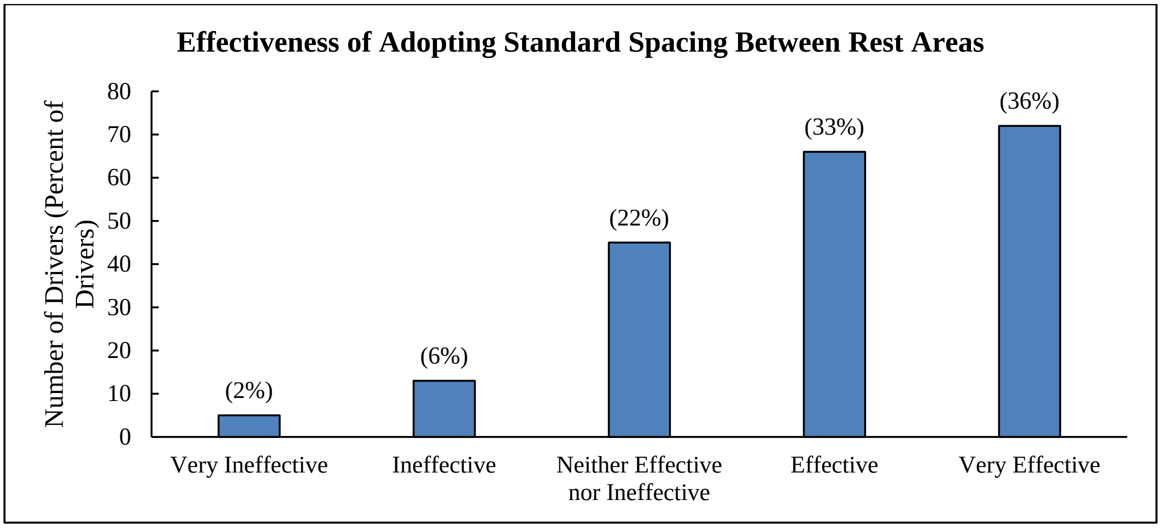

Figure 4.51: Effectiveness of Adopting Standard Spacing Between Rest Areas

4.1.17.16 Quality Assurance

This question was used to assure that drivers were reading the survey accurately and providing sufficient responses. Drivers were asked to select "very ineffective" and Figure 4.52 shows that 100% of the drivers selected the correct response.

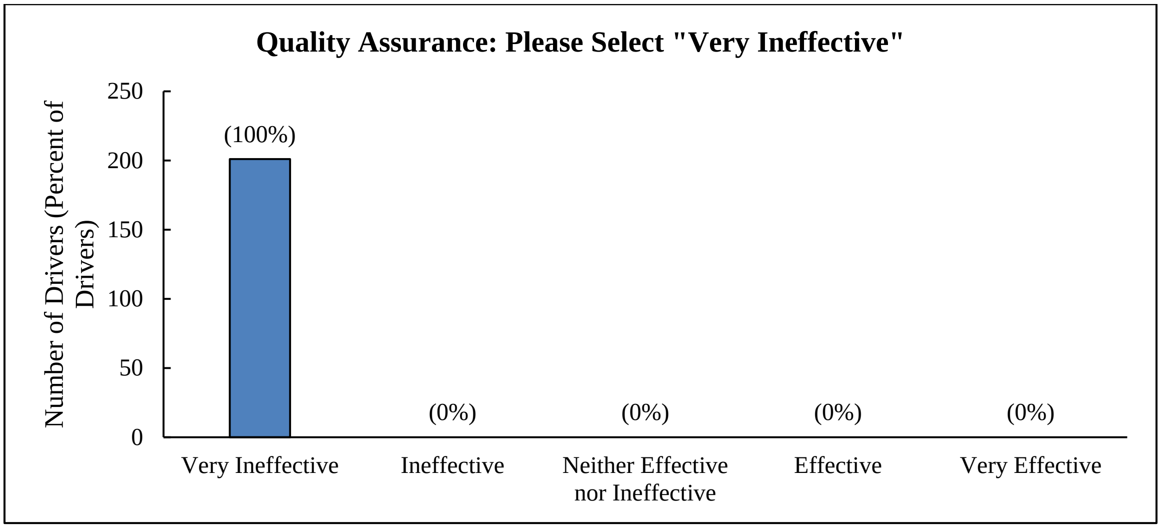

Figure 4.52: Quality Assurance: Please Select "Very Ineffective"

4.1.17.17 Provide Alternate Parking (e.g., At Weight Stations, Park-N-Ride, Private …)

Providing alternate parking locations and its effectiveness according to the surveyed drivers is shown in Figure 4.53. Once more, the majority of drivers (63%) think this improvement would be effective. However, more than one-quarter of drivers feel this would be "neither effective nor ineffective."

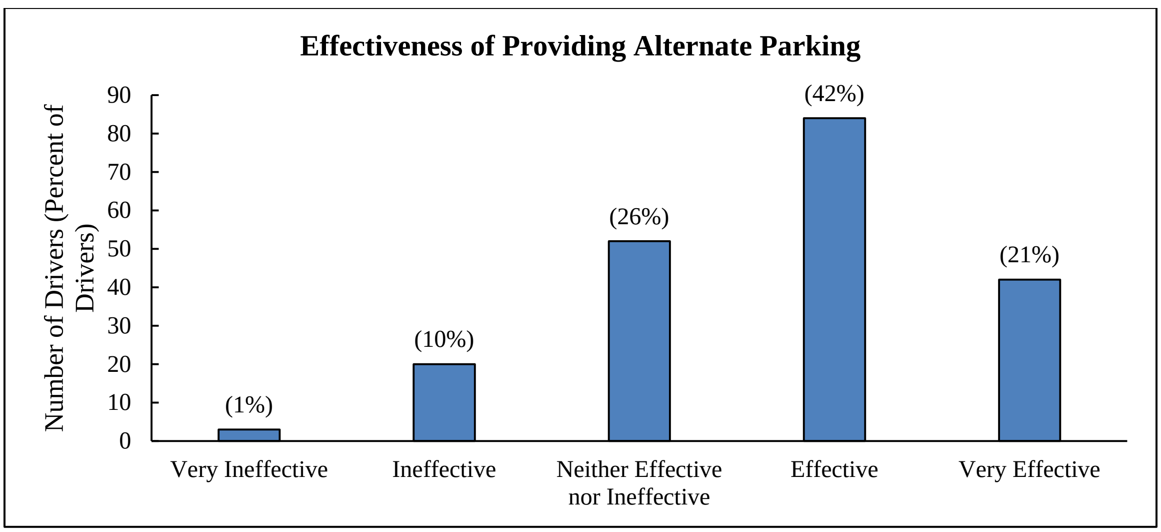

Figure 4.53: Effectiveness of Providing Alternate Parking

4.1.17.18 Stop Enforcement Officers from Waking Driver

The effectiveness, from the perception of the surveyed drivers, of stopping enforcement officers from waking drivers is illustrated in Figure 4.54. About 32% of drivers believe that stopping enforcement officers from waking drivers would be “very effective” and 30% think it would be “effective,” while 21% think it would be “neither effective nor ineffective.”

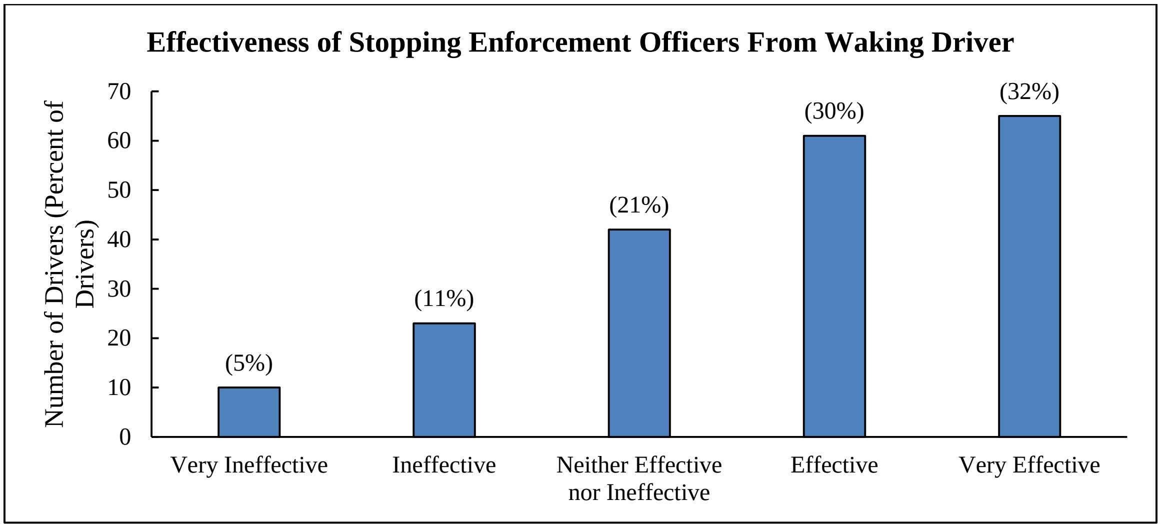

Figure 4.54: Effectiveness of Stopping Enforcement Officers from Waking Driver

4.1.17.19 Other

This part of the question encouraged drivers to provide improvements that they feel would improve the truck parking experience based on their knowledge of truck parking. Two specific improvements were seen written-in more than once: (1) provide oversize load specific parking/bigger parking spaces and (2) ensure that parking facilities do not just have restrooms, but clean restrooms. Some drivers recommended replacing the majority of car parking spaces with permanent truck parking spaces, while another response was to ensure that companies and owners/operators comply with the present rules when it comes to truck parking.

Some drivers feel that truck parking attendants or customer service would help improve the truck parking experience and that large companies should provide parking before or after deliveries. Other notable improvements from the drivers' perspective include reserving parking spaces in advance for a certain time period, create available overflow parking during the winter months, provide more safety precautions, provide places to power driver electronics, eliminate triple-trailers, repair/renovate inadequate parking spaces, and find a way to make women drivers feel safer. To summarize, Table 4.2 displays the level of effectiveness and percentage of drivers for each potential improvement.

Table 4.2: Percentage of Drivers by Level of Effectiveness for Potential Improvement

Potential Improvement	Percentage of Drivers		
	Effective	Neither	Ineffective
Improve Lighting at Parking Facilities	77%	18%	5%
Increase Security Presence at Parking Facilities	75%	18%	7%
Landscape to Minimize Hiding Places for Criminals/Criminal Activity	69%	17%	14%
Improve Amenities at Rest Areas	84%	13%	3%
Build More Truck Stop Parking Spaces	91%	6%	3%
Build More Rest Area Parking Spaces	84%	11%	6%
Separate Truck, Car, and RV Parking	76%	16%	8%
Use Car Parking for Truck Parking During Peak Overnight Hours	63%	20%	16%
Enforce Time Limits on Truck Parking	37%	27%	36%
Eliminate Time Limits on Truck Parking	64%	18%	18%
Improve Parking Layout/Configuration (e.g., More Diagonal Pull-Through)	81%	14%	6%
Improve Signs and Roadway Information for Parking Facilities	74%	18%	8%
Educate Drivers/Dispatchers About Planning Parking Stops Before Trip	68%	21%	11%
Real-Time Information on Parking Space Availability	85%	9%	5%
Adopt Standard Spacing Between Rest Areas	69%	22%	9%
Provide Alternative Parking (e.g., At Weigh Stations, Park-N-Ride, Private ...)	63%	26%	11%
Stop Enforcement Officers from Waking Driver	63%	21%	16%

4.1.18 Do you have any other comments, questions or concerns you would like to share?

For aspects that were not provided in the survey, drivers were asked to provide any additional comments, questions or concerns regarding truck parking issues. Although not all drivers provided questions, comments, or concerns, the drivers that did respond provided valuable insight on truck parking issues they face.

One driver emphasized that there is a truck parking problem nationwide and articulated that drivers park where they can because they simply expend their hours-of-service. The driver goes on to suggest that pinpointing driver shutdown distances can drastically vary due to uncontrollable factors that impact driving times (e.g., weather, crashes, congestion, delays with loading/unloading) and then leads to drivers parking at the first convenient location. The driver finishes by stating that there is clearly a need for adequate truck parking facilities along major corridors due to the aforesaid factors.

A separate driver acknowledged that the transportation industry is growing much faster than its corresponding accommodations. As such, there is added frustration to an already demanding job. This driver states that it has become essential, if possible, to plan their trip in accordance with layover availability. The comment is concluded by disclosing that their freight typically contains hazardous materials and that the law has strict regulations regarding where such shipments are permitted to park.

Another driver spoke strongly about helping the Federal Motor Carrier Administration amend their laws on hours-of-service. The driver essentially argues that drivers would police themselves and stop when they become too tired to drive. The driver continues to contend that hours-of-service and the insufficient number of truck stops are the real problem. Specifically, if a driver is not tired but out of hours, that driver is now taking up available parking spaces, and the drivers in need of rest are the unfortunate ones.

It was also recommended that truck stops or rest areas have a security patrol officer present or provide a sleeping facility, but to not wake the drivers. One driver implies that the addition of more truck stops and rest areas close to coastal cities would be beneficial, as this is where several of their shipments are. The most common write-in was regarding the survey itself and several drivers stated that they appreciated the survey, that crucial questions were addressed within the survey, and that they hope to see some of the changes implemented in the future.

4.1.19 Location of Driver

The origins of the drivers in the survey are displayed in Figure 4.55 on the following page. The cities with the most drivers represented in the survey are: (1) Clifford, KS; (2) Los Angeles, CA; (3) Chicago, IL; and, (4) New York, NY. Clifford, KS, a city located roughly 40 miles northeast from Wichita, KS, had 12 drivers in the survey. Los Angeles had 9 drivers, Chicago had 7 drivers, and New York had 6 drivers. Other notable Pacific Northwest cities include Tacoma, Seattle, Portland, Boise, and Spokane. Tacoma and Portland had the most drivers at 5 and 4, respectively, while the remaining cities each had 2 drivers.

Figure 4.55: Location of Origin for the Surveyed Drivers

4.2 SUMMARY OF COMMERCIAL VEHICLE DRIVER SURVEY RESULTS

Through the administered survey, the researchers were able to gain a better understanding of the truck parking issues from the drivers' perspective. Several questions were asked in which the drivers were instructed to select the most adequate answer, and if applicable, to select other and to provide their own reasoning. In addition, the survey had three distinct questions that allowed drivers to rank factors from least to most probable, from least to most important, and from least to most effective.

All drivers, 84% male and 16% female, who participated in the survey deliver and/or pick-up goods in the Pacific Northwest. The age group represented most in the survey was 30 to 39 years and accounted for 29% of all drivers. The survey mostly consisted of drivers less than or equal to 49 years of age, as 77% of all drivers were not older than 49 years. As for the number of years the surveyed drivers have been a truck driver, 129 of the 201 have been driving a truck for 10 years or less. Further, the type of companies the drivers work or contract for were fairly evenly distributed between for-hire, private carriage, and both for-hire and private carriage, although a small percentage did not know or refused to answer the question. Despite the distributed types of companies the drivers work or contract for, 78% of the surveyed drivers' trips generally consist of truckload shipments. In regard to team driving, the majority of drivers rarely participate and never participate in team driving at 35% and 29%, respectively. However, nearly one-quarter of the surveyed drivers indicated that they sometimes do participate in team driving. Around 85% of the drivers make parking decisions themselves without assistance from their company, but 13% of the drivers stated that their company makes the parking decisions.

The drivers were then asked if they encounter problems finding a safe and adequate location to park when required to rest. While the majority of drivers (61%) stated that they do encounter problems, 39% stated that they do not experience problems. Regarding the time of day drivers experience the most difficulty finding safe parking, three specific times of day are of concern: (1) 12:00 a.m. to 5:59 a.m., (2) 4:00 p.m. to 8:59 p.m., and (3) 9:00 p.m. to 11:59 p.m. The drivers followed up by selecting the days of the week that they have the most difficulty finding safe parking, and more than half of the drivers stated that Friday is the most difficult day. Monday and Saturday were the second and third most difficult days, respectively, but each day of the week was implied to have difficulty by at least 25% of the drivers. After selecting times of day and days of the week with the most difficulty finding safe and adequate parking, drivers were asked to select the months of the year with the most difficulty. The most difficult months were the winter months (November, December, and January) and the summer months of June and July.

To better understand why trucks park on freeway ramps and shoulders, drivers were given specific reasons and asked to rank them from the most probable reason to the least probable reason. The most probable reasons, according to the drivers, is that there are no nearby parking facilities and that nearby truck stops and/or rest areas do not have available parking spaces. Drivers were indifferent regarding time limits, difficulty maneuvering, and blocked parking spaces. The least probable reasons selected were lighting and being bothered.

The next set of rankings were used to determine the most important truck stop, or rest area, features that drivers consider when selecting a place to park. The most important features are the convenience to the highway, fuel, well-lighted parking lot, and restrooms. Other features that drivers considered important, but not the most important, were repair facilities, showers, security presence, convenience stores, and restaurants. Travel information and entertainment facilities were selected as the least important features when deciding where to park.

To accompany the previous two questions (why trucks park on freeway ramps/shoulders and the most important features), perception concerning real-time information was queried. The majority of drivers indicated that real-time information about the location of truck parking facilities along the planned travel route and the number of available spaces at upcoming facilities would be most beneficial at helping to plan stops in advance. Over 50% of the drivers stated that a smart phone application would be the preferred method in receiving the real-time information; however, approximately 31% of drivers indicated that GPS would be the favored method.

Upon gaining some insight into what features drivers believe to be of the most importance, the drivers ranked potential truck stop or rest area improvements based on their effectiveness in improving the truck parking experience. The most effective improvements, as ranked by the drivers, in improving the truck parking experience were to build more truck parking spaces, have separate parking for trucks, cars and RVs, improve the parking layout/configuration, and provide real-time information. Just one improvement was found to be ineffective to the drivers: changing the enforcement of time limits on truck parking.

The end of the survey allowed the drivers to add any additional comments or concerns that were not addressed in the survey, and the location of the driver was identified. Ten or more drivers in the survey were from California, Kansas, New York, Washington, Michigan and Pennsylvania, and nine drivers were from Indiana and Tennessee. Four drivers were from the state of Oregon, and each were located in Portland. The most occurring comment from the drivers was about the survey, specifically, that the survey was appreciated by them and their peers, the survey focused on all the crucial questions/concerns regarding truck parking, and hope that the survey will prompt change.

The results from the driver survey produced essential information regarding truck parking and its associated problems from a driver’s outlook. Times of day, days of the week, and months of the year that there is difficulty finding adequate parking were identified. The probable reasons that drivers park on freeway ramps and shoulders, the importance of truck stop or rest area features, and the effectiveness of truck stop or rest area improvements were also described. Lastly, a look at the wide range of geographical locations that drivers are from and additional comments/concerns from the drivers were provided.

5.0 CURRENT CONDITIONS

Large truck crash trends for an eight-year period (2007 to 2014) will be described for the pilot corridor of US-97 and Biggs Junction, and the entire state of Oregon. Upon identifying crash trends within the study area, a hot spot analysis will be conducted to determine statistically significant hot spots for large truck crashes while establishing the hot spot locations in relation to existing truck stops or rest areas in the study region.

5.1 LARGE TRUCK CRASH TRENDS

Utilizing Oregon crash reported data (both police-reported and self-reported) and Oregon AADT data[2] from 2007 to 2014, crash characteristics and trends are summarized to gain a better understanding of large truck crashes along US-97 and at Biggs Junction (the I-84 and US-97 junction), as well as crash trends throughout the entire state of Oregon. Figures are provided for key trends and other notable trends are summarized near the end of this section. Figure 5.1 shows the total vehicle-miles-traveled (VMT) on US-97 and Figure 5.2 shows the large truck VMT on US-97 by year from 2007 to 2014, while Figure 5.3 and Figure 5.4 show total and large truck VMT for the state of Oregon. Figure 5.5 illustrates the total number of injuries by injury severity on US-97. Figure 5.6 displays the total number of large truck injuries by injury severity on US-97, and the total number of injuries and large truck number of injuries by injury severity for the state of Oregon are shown in Figure 5.7 and Figure 5.8, respectively. The total number of crashes per 100-million VMT by injury severity on US-97 are presented in Figure 5.9 and the number of large truck crashes per 100-million VMT by injury severity on US-97 are shown in Figure 5.10. Crash rates by injury severity for the state of Oregon are presented in Figure 5.11 and Figure 5.12. Lastly, the large truck proportion of the total number of injuries by severity are presented in Figure 5.13 and Figure 5.14, respectively.[3]

[2] Average-annual-daily-traffic (AADT) data was obtained from ODOT's .ftp website and the statewide VMT values were provided by ODOT. VMT was calculated by multiplying the ADDT by the segment length, summing VMT values, then multiplying by 365.

[3] The provided crash data indicated that zero "Serious" large truck injury crashes occurred along US-97 in 2013.

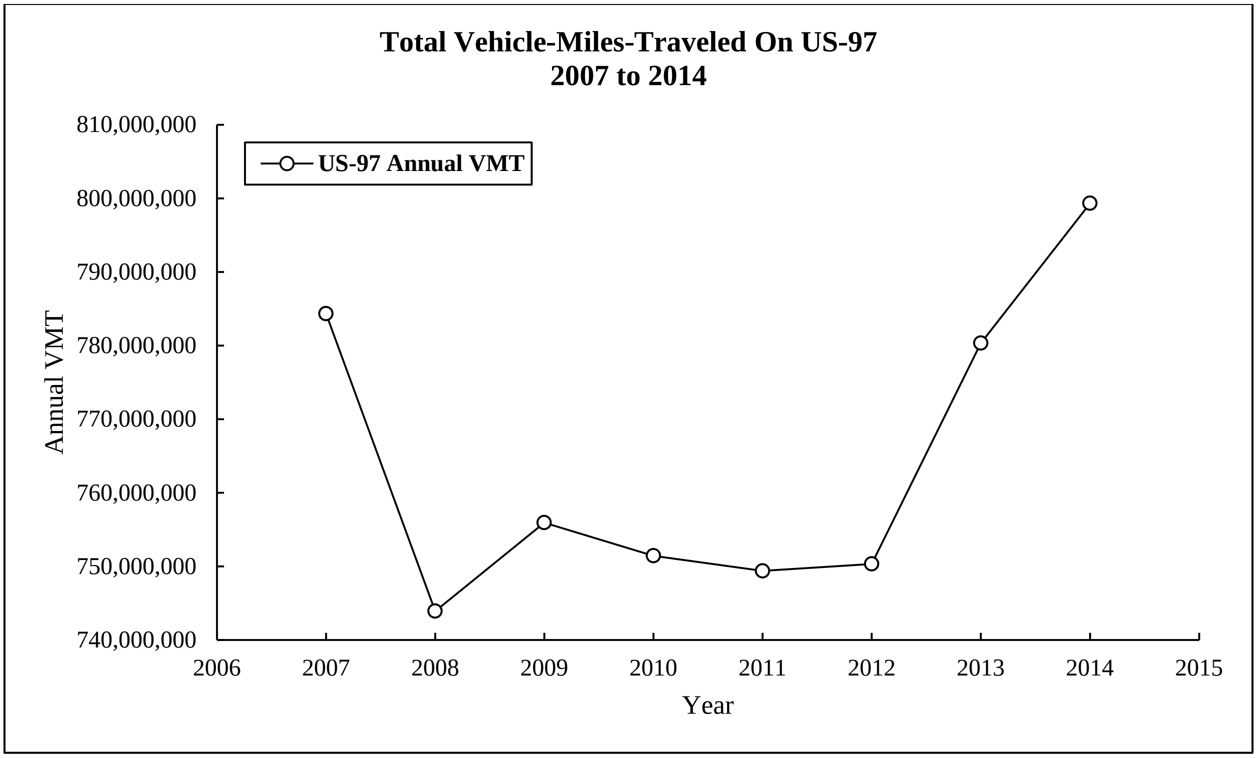

Figure 5.1: Total Vehicle-Miles-Traveled (VMT) on US-97 by Year (2007 to 2014)

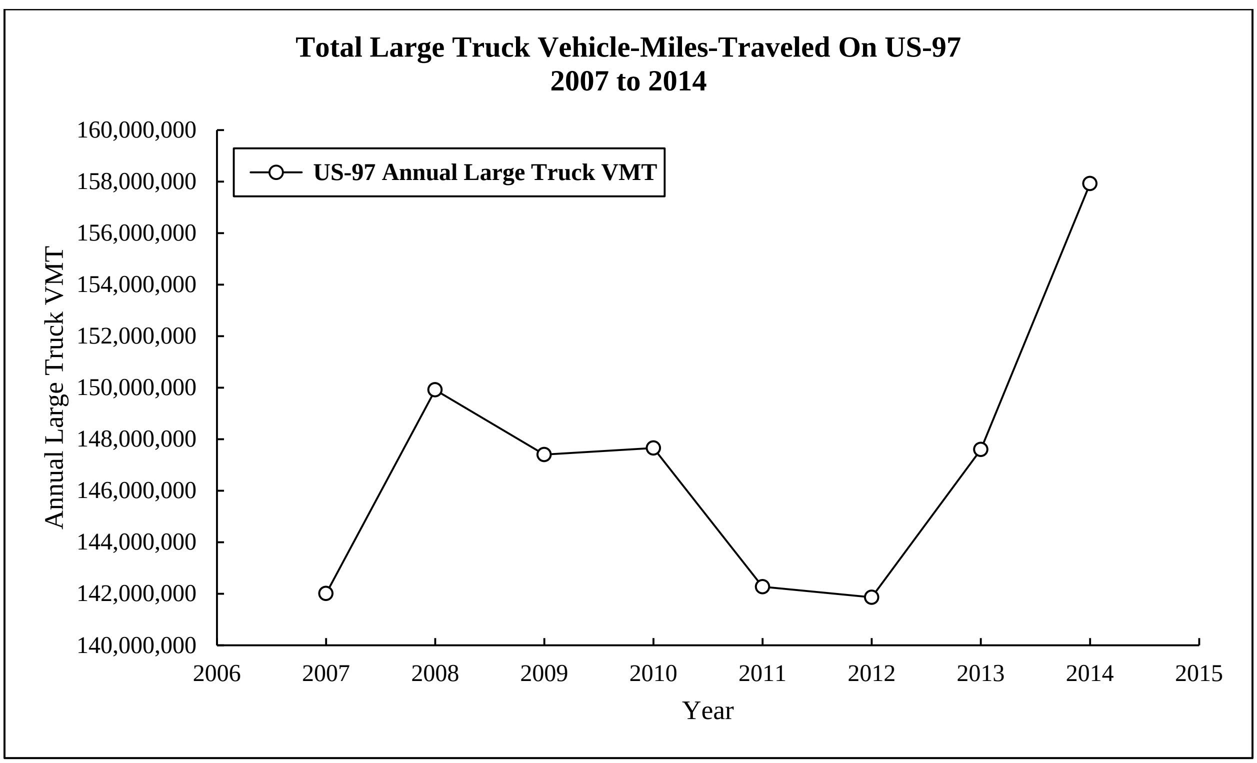

Figure 5.2: Large Truck Vehicle-Miles-Traveled (VMT) on US-97 by Year (2007 to 2014)

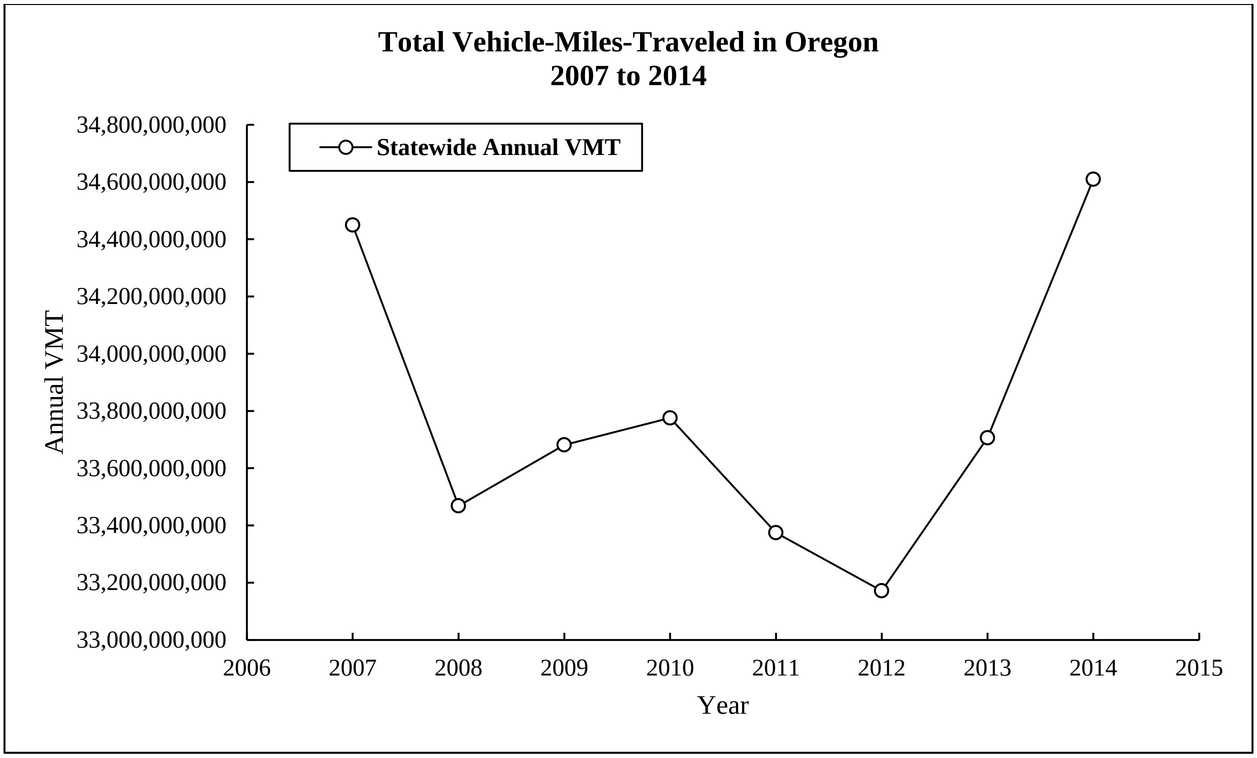

Figure 5.3: Total Vehicle-Miles-Traveled (VMT) in Oregon by Year (2007 to 2014)

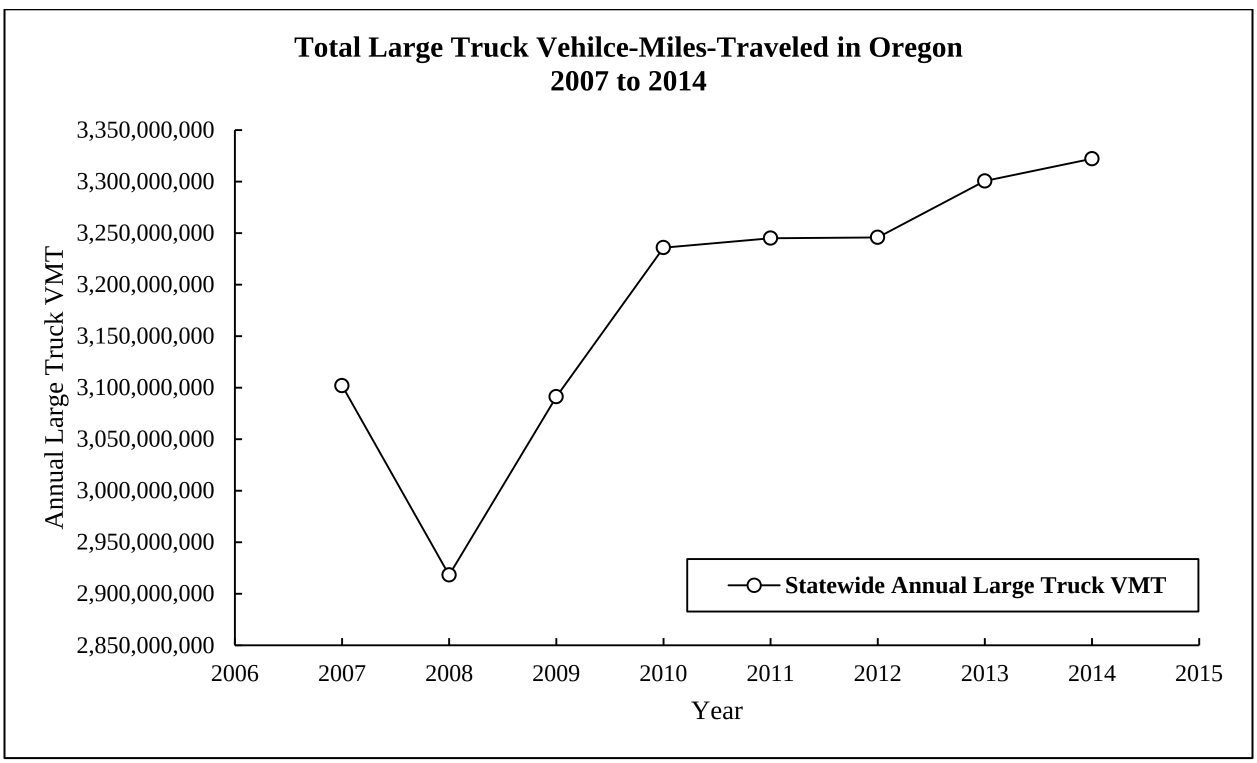

Figure 5.4: Total Large Truck Vehicle-Miles-Traveled (VMT) in Oregon by Year (2007 to 2014)

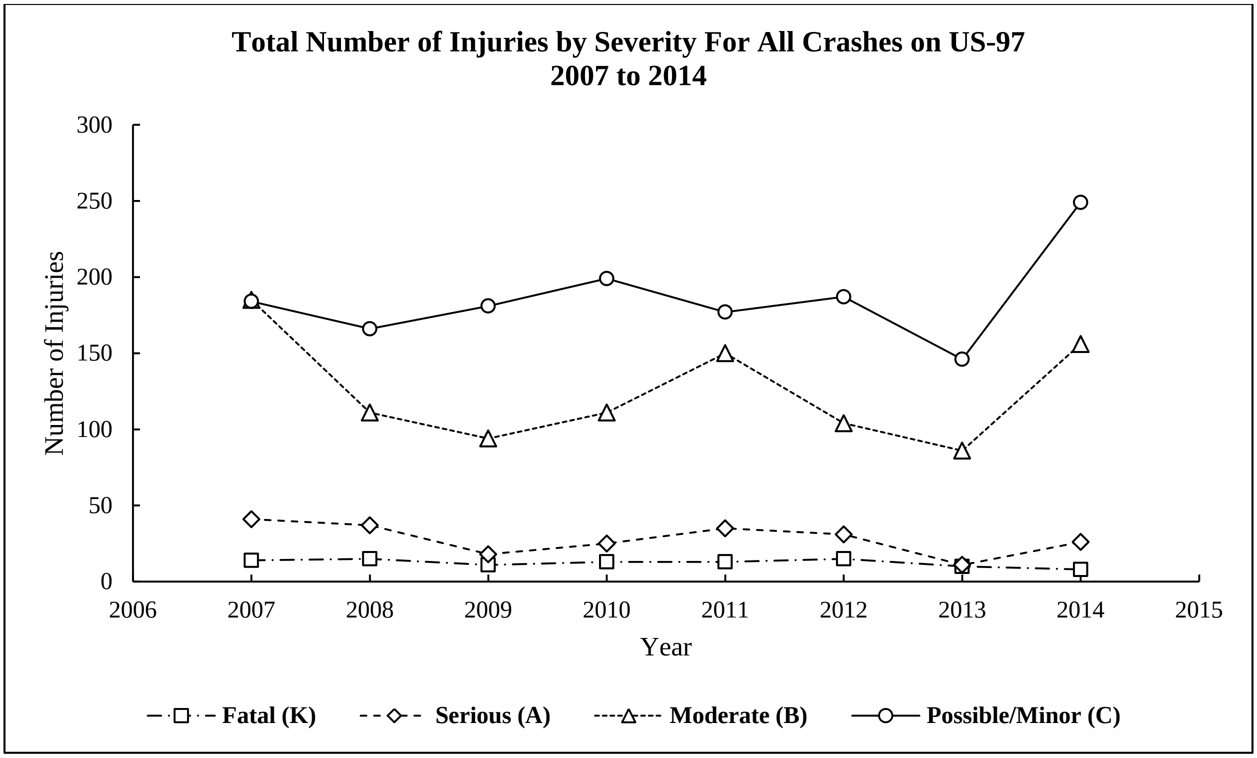

Figure 5.5: Total Number of Injuries by Severity for All Crashes on US-97 by Year (2007 to 2014)

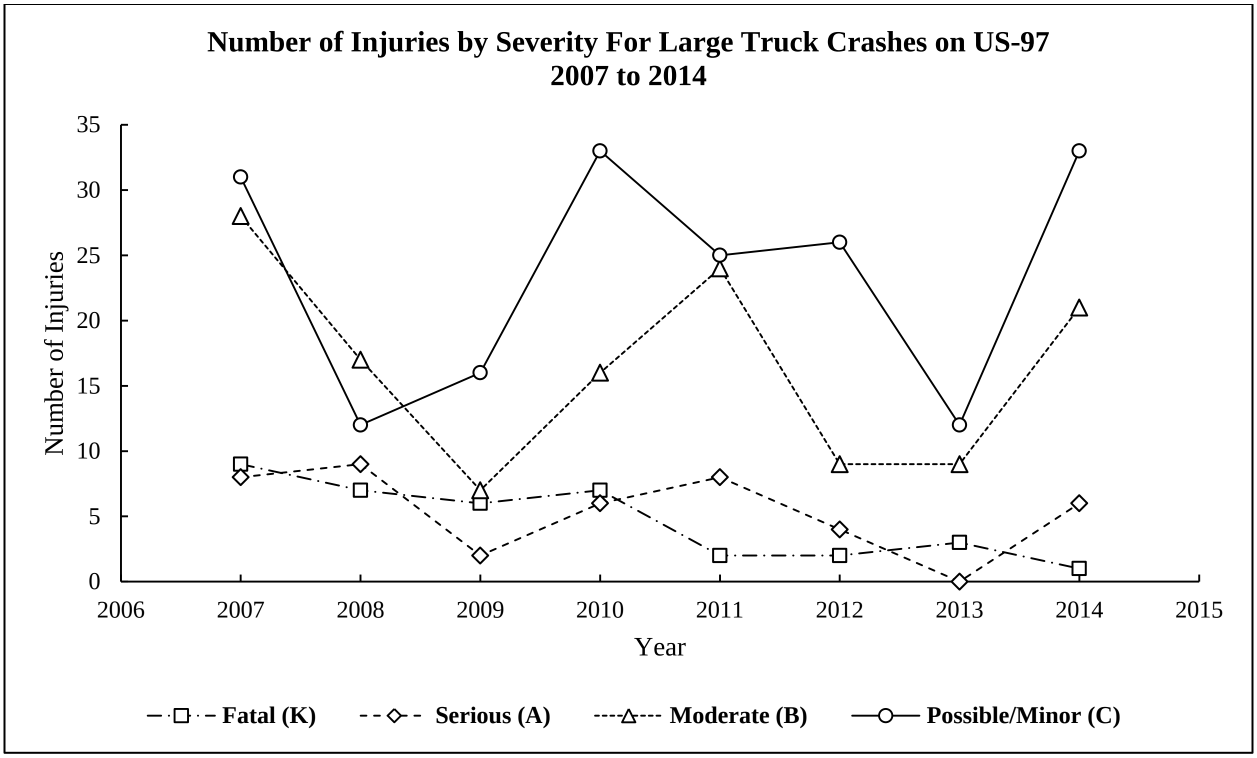

Figure 5.6: Number of Injuries by Severity for Large Truck Crashes on US-97 by Year (2007 to 2014)

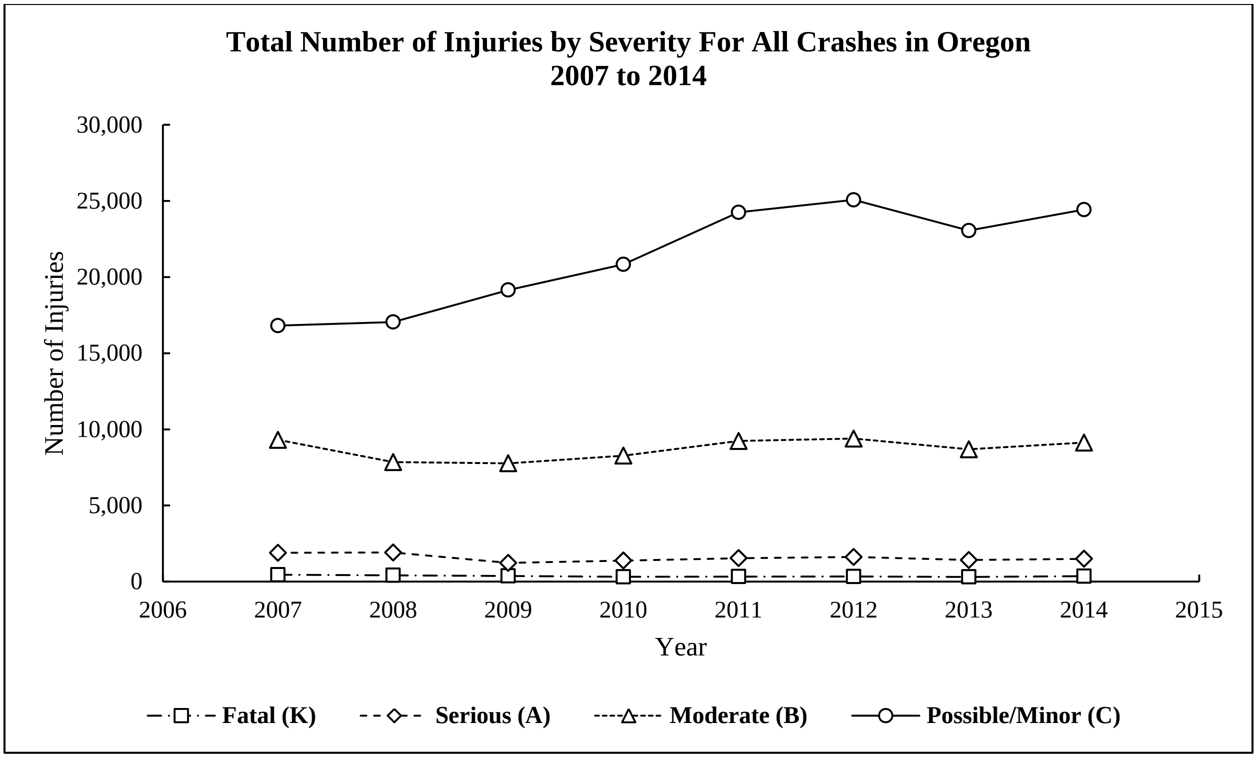

Figure 5.7: Total Number of Injuries by Severity for All Crashes in Oregon by Year (2007 to 2014)

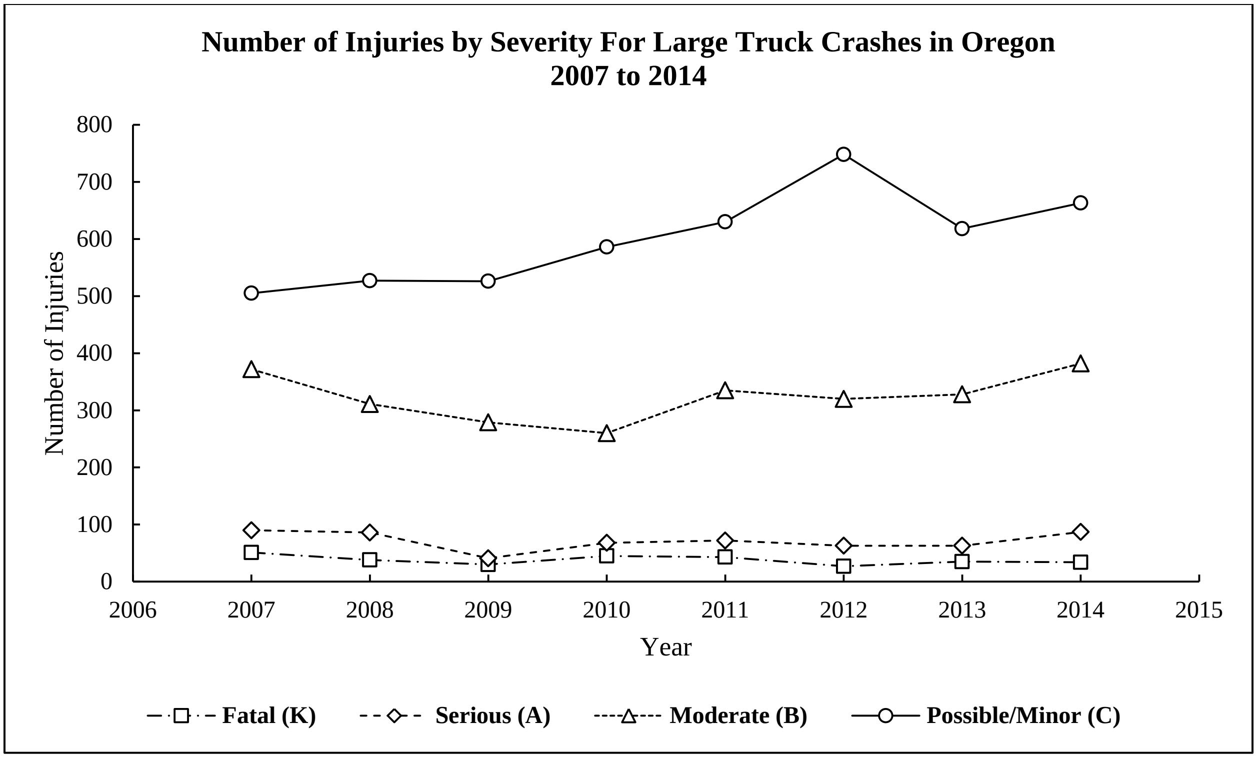

Figure 5.8: Number of Injuries by Severity for Large Truck Crashes in Oregon by Year (2007 to 2014)

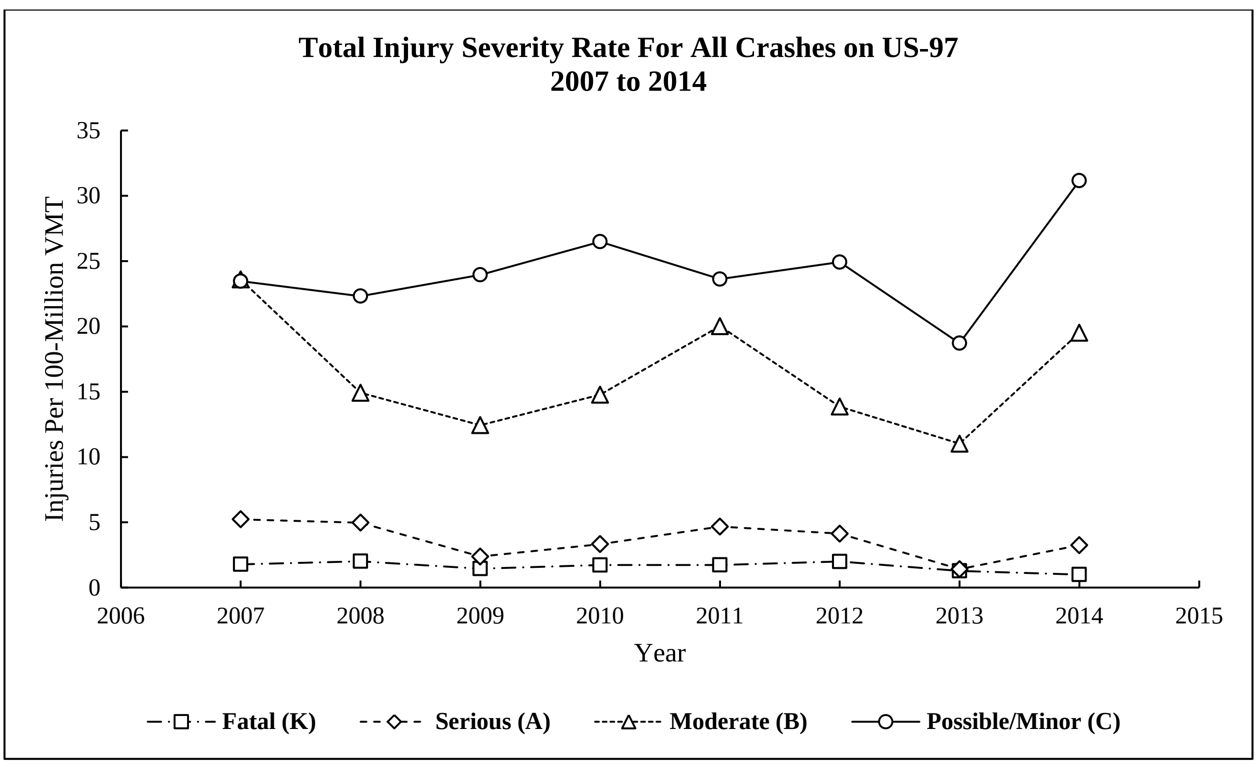

Figure 5.9: Total Injury Severity Rate for All Crashes on US-97 by Year (2007 to 2014)

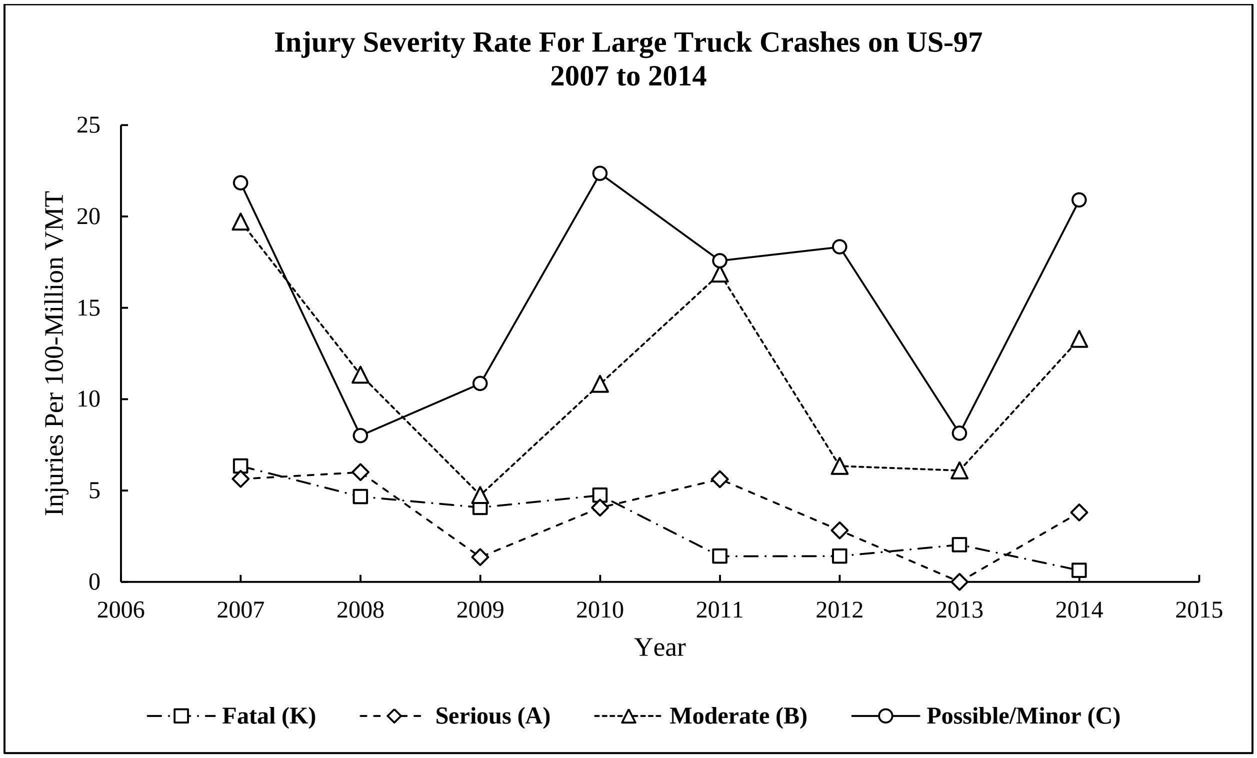

Figure 5.10: Injury Severity Rate for Large Truck Crashes on US-97 by Year (2007 to 2014)

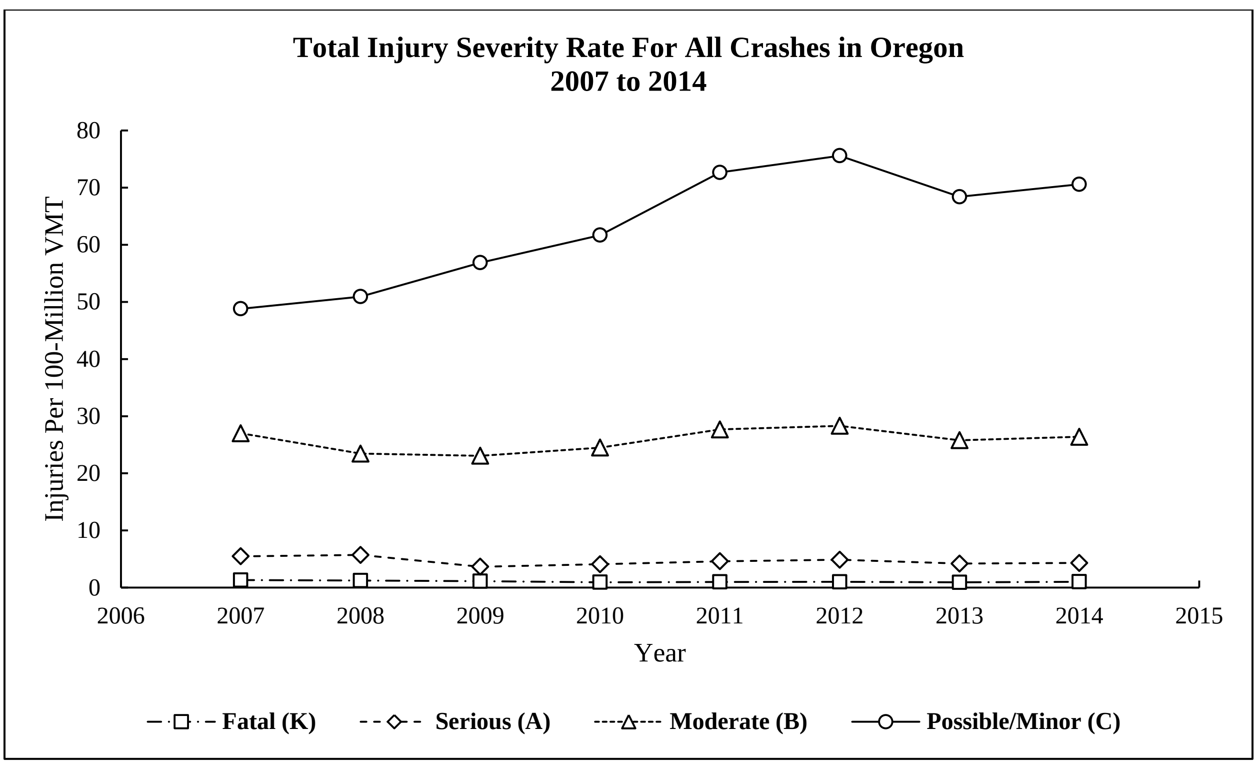

Figure 5.11: Total Injury Severity Rate for All Crashes in Oregon by Year (2007 to 2014)

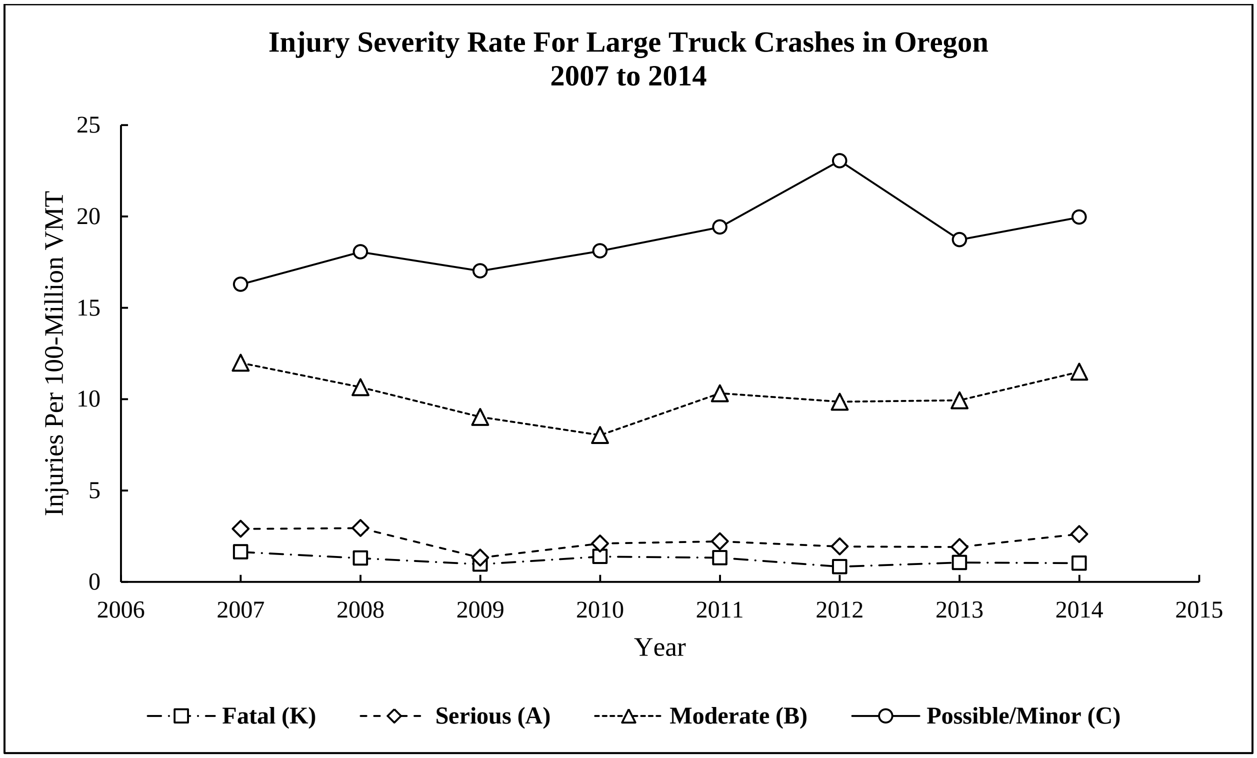

Figure 5.12: Injury Severity Rate for Large Truck Crashes in Oregon by Year (2007 to 2014)

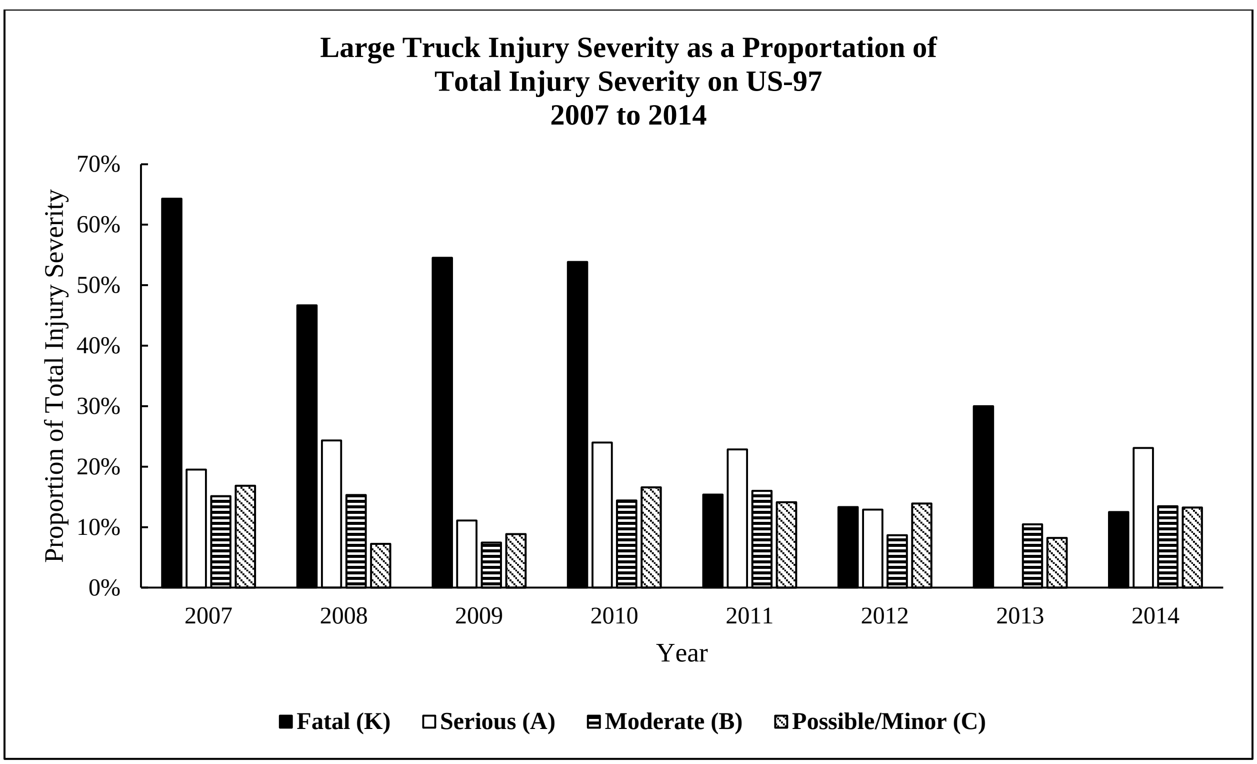

Figure 5.13: Large Truck Injury Severity as a Proportion of Total Injury Severity on US-97

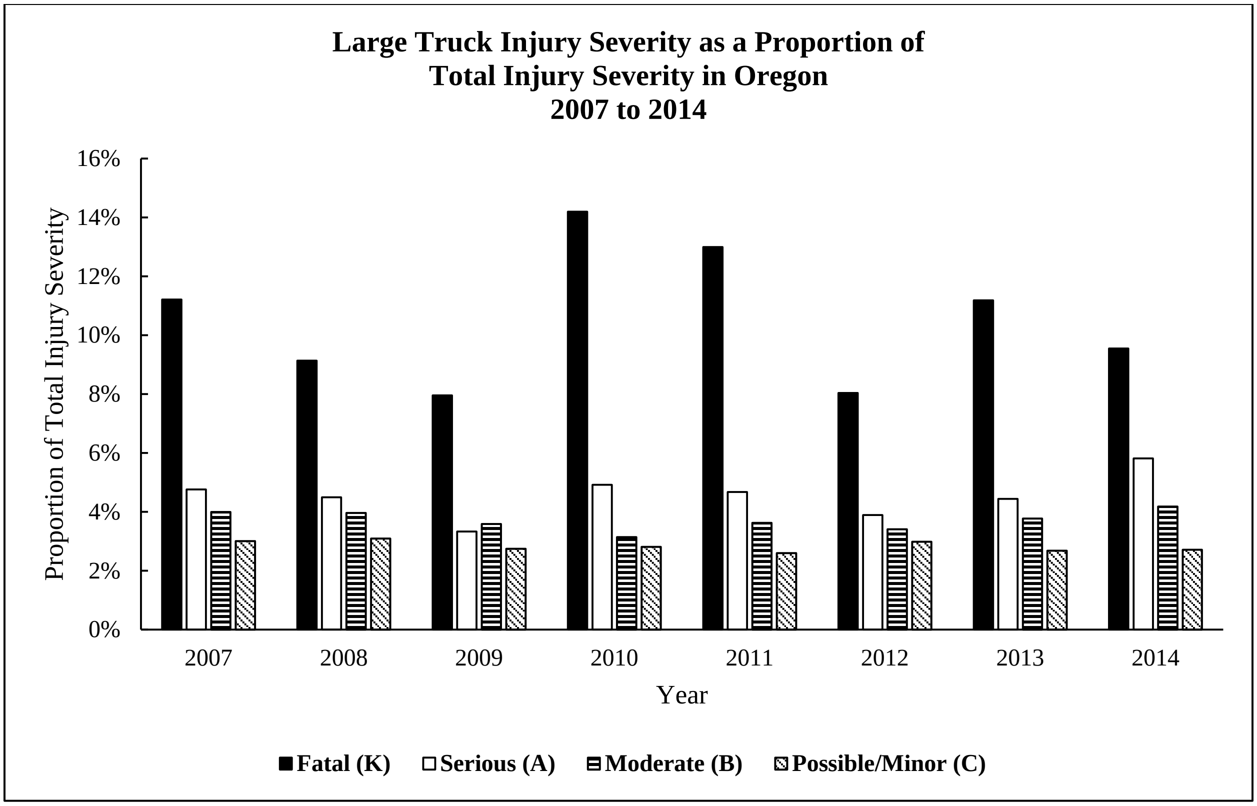

Figure 5.14: Large Truck Injury Severity as a Proportion of Total Injury Severity in Oregon

Figure 5.15 presents large truck crashes by time of day during the years 2007 to 2014. Nearly one-quarter of the crashes occur in the morning, 5:00 a.m. to 10:00 a.m., at roughly 23%, while approximately the same number of crashes occur in the evening, 3:00 p.m. to 8:00 p.m., at 24%. The largest percent of crashes take place during midday, 10:00 a.m. to 3:00 p.m. at 28%, and the hours 5:00 a.m. to 8:00 p.m. see approximately 76% of all crashes.

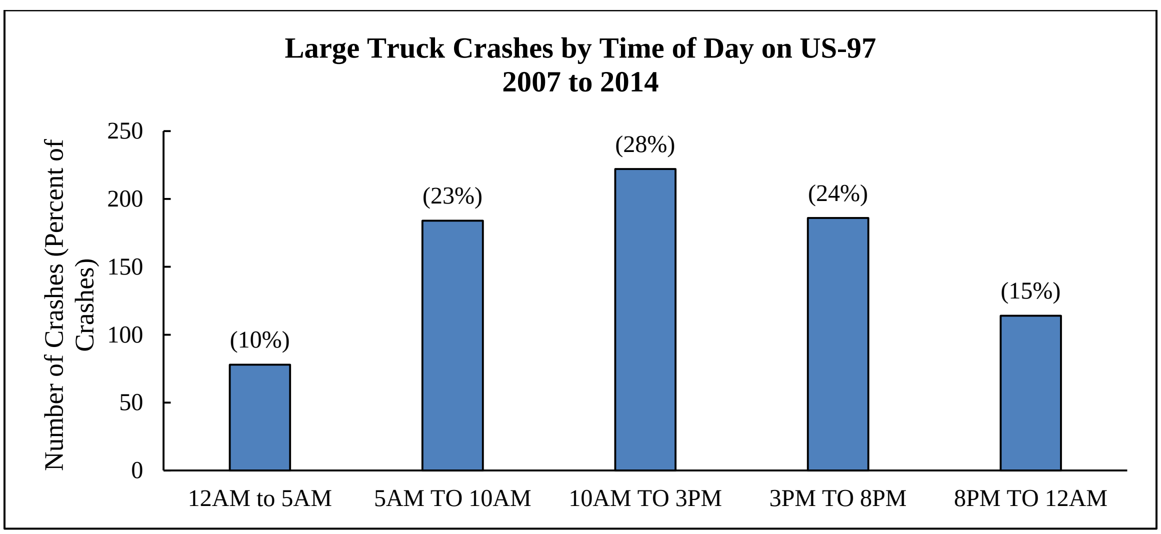

Figure 5.15: Large Truck Crashes by Time of Day from 2007 to 2014

Large truck crashes by day of the week from 2007 to 2014 are shown in Figure 5.16. The majority of crashes took place on Friday and Saturday, accounting for roughly 19% and 17% of crashes during that time period, respectively. Wednesday and Thursday account for significant number of crashes as well, approximately 16% and 15%, respectively. Monday and Tuesday had the smallest percentage of crashes over the eight-year time frame at about 8% and 12%, respectively.

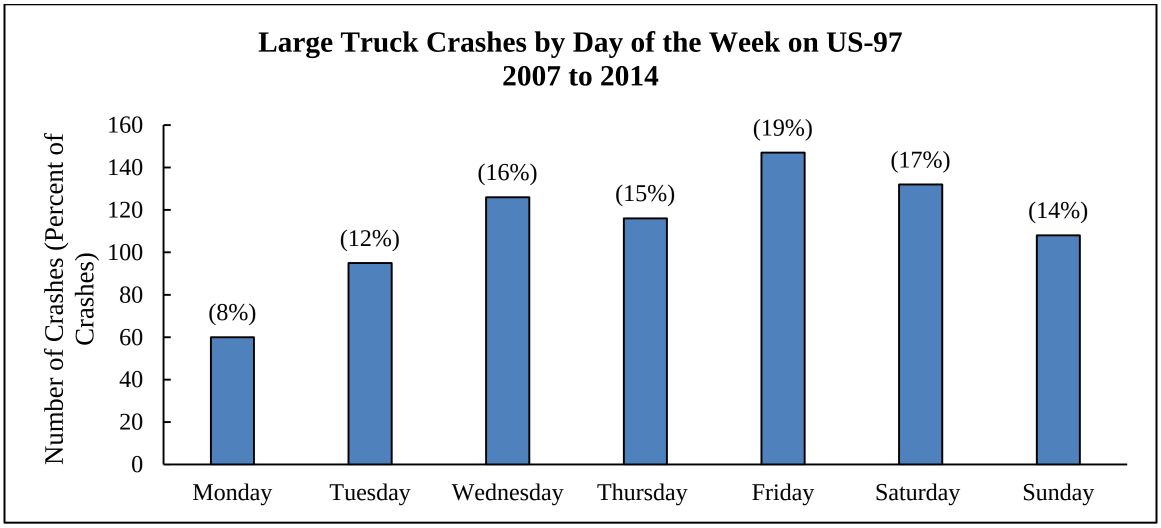

Figure 5.16: Large Truck Crashes by Day of the Week from 2007 to 2014

Figure 5.17 presents the percentage of large truck crashes by month, and readily, it is observed that the largest percentage of crashes occurred in the winter months of November, December, January, and February. Roughly 14% of the 784 crashes happened in November, 18% of crashes took place in December, 11% of crashes occurred in January and 9% of crashes happened in February. The remaining months of the year, March through October, each account for less than 7% or less of the 784 crashes from 2007 to 2014.

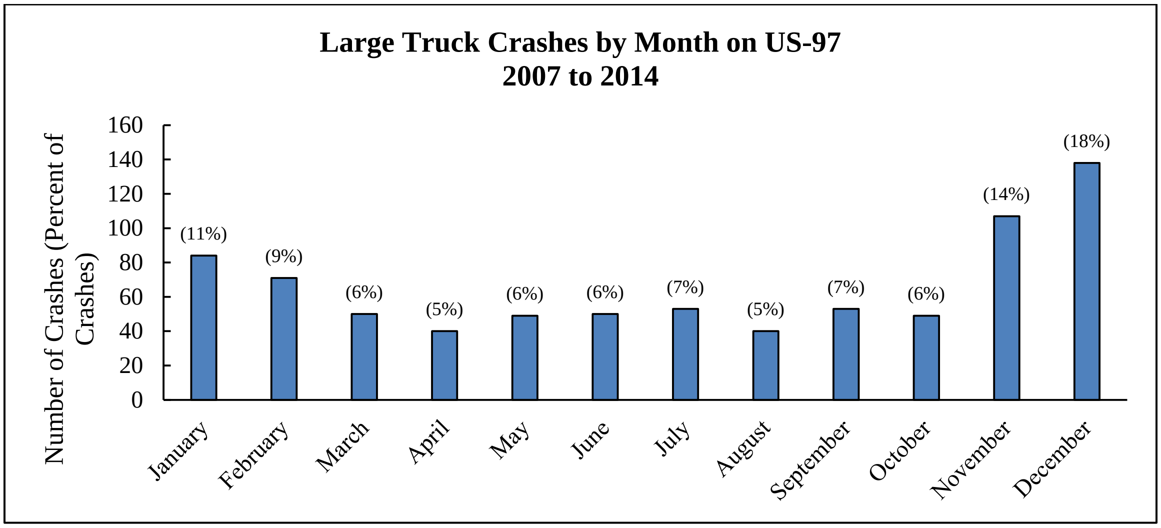

Figure 5.17: Large Truck Crashes by Month from 2007 to 2014

Large truck crashes from 2007 to 2014 by crash severity are presented in Figure 5.18. Approximately 63% of the crashes (490) from 2007 to 2014 were property-damage-only crashes (no injuries were sustained), 34% of the crashes (264) resulted in an injury (any injury that was not fatal) and 4% of the crashes (30) had loss of life.

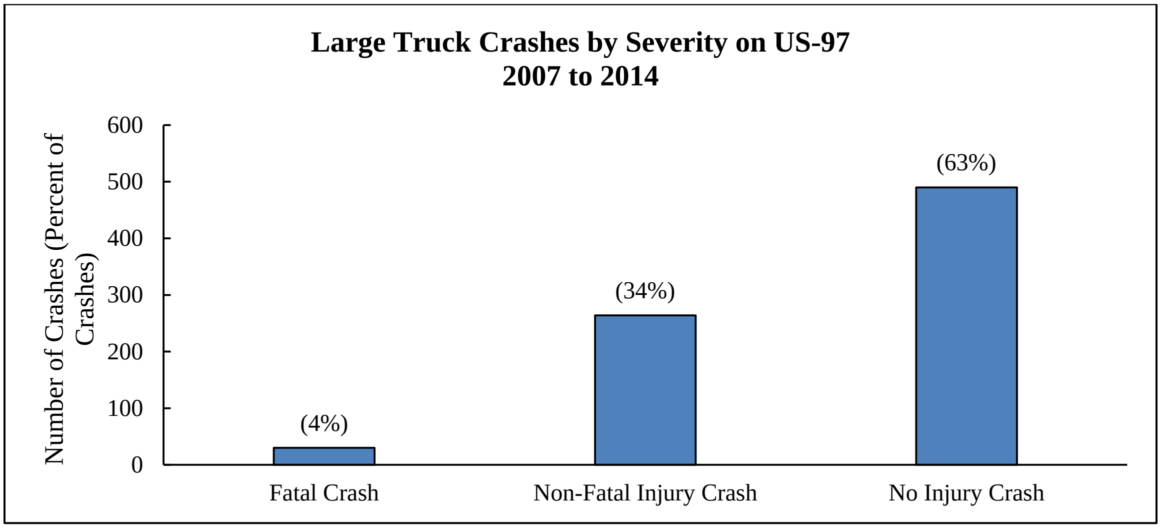

Figure 5.18: Large Truck Crashes by Crash Severity from 2007 to 2014

Large truck at-fault crashes are shown in Table 5.1. Large truck at-fault crashes are crashes in which the large truck is considered to be the cause of the crash. Of the 784 large truck crashes from 2007 to 2014, 708 were at-fault and the values shown in the figure below are based on the number of at-fault crashes (e.g., 1.6% due to reckless driving out of 708 at-fault crashes).

Table 5.1: Large Truck At-Fault Crashes

Cause	Number of Drivers	Percentage
Speed Too Fast for Conditions (Not Exceeding Limit)	237	33.5%
Other Improper Driving	68	9.6%
Following Too Close	64	9.0%
Careless Driving	58	8.2%
Did Not Yield Right-Of-Way	56	7.9%
Improper Overtaking	44	6.2%
Straddled the Center Line	39	5.5%
Improper Change of Lanes	33	4.7%
Improper Turn	31	4.4%
Fatigue	18	2.5%
Inattention	18	2.5%
Disregarded Traffic Signal	12	1.7%
Reckless Driving	11	1.6%
Driving in Excess of Posted Speed	8	1.1%
Passed Stop Sign or Red Flasher	6	0.8%
Improperly Parked	3	0.4%
Disregarded Other Traffic Control Device	1	0.1%
Wrong Way on One-Way Road or On Wrong Side of Road	1	0.1%
Total	**708**	**100%**

Figure 5.19 shows the number of large truck crashes by year from 2007 to 2014. A total of 784 crashes occurred during this time period within the study area and the largest number, 136, happened in 2014. There was a decline from 2007 to 2008, 102 crashes to 79 crashes, but there was a steady increase from 2009 to 2011, 88 crashes to 116 crashes. Again, a decline is seen from 2011 to 2013, 116 crashes to 79 crashes, but then had the largest increase from 2013 to 2014.

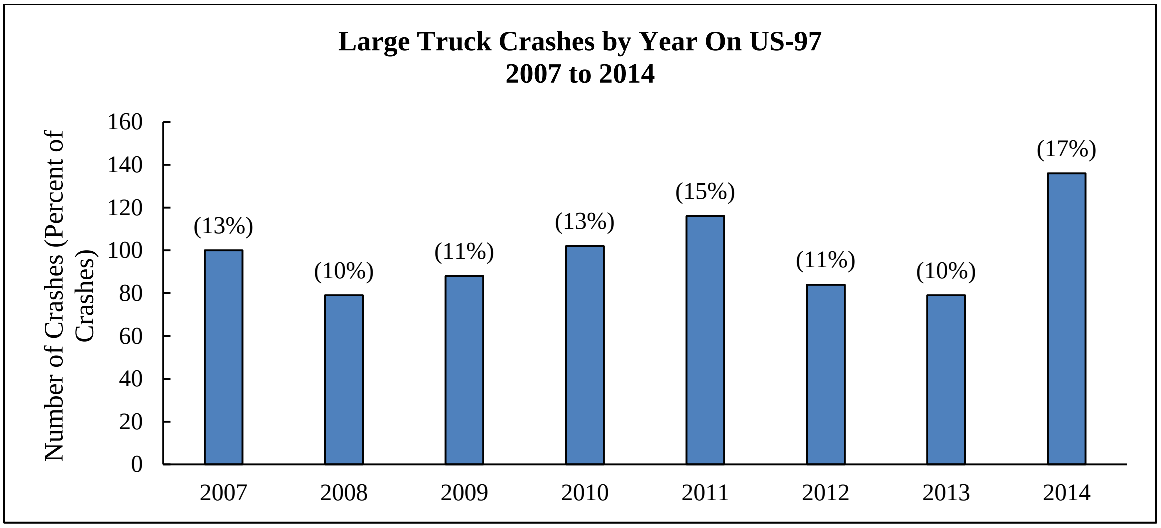

Figure 5.19: Large Truck Crashes by Year from 2007 to 2014

Other notable crash trends from 2007 to 2014 are as follows:

- 67.3% of crashes occurred in areas that have a 55 miles per hour speed limit.
- 58.7% of crashes took place on straight roadway segments.
- 74.3% of crashes happened on roadway segments that have no median.
- 23.4% of crashes were with a fixed object and 19.01% of crashes involved vehicles traveling in the same direction – both vehicles going straight.
- 47.1% of crashes occurred in clear weather conditions.
- 52.4% of crashes happened on dry surfaces and 33.72% of crashes happened on icy surfaces.
- 57.6% of crashes took place in daylight and 32.57% of crashes took place in the dark where no street lights were present.
- 57.8% of crashes involved two vehicles and 34.35% of crashes involved one vehicle.
- 30.2% of crashes were caused due to traveling too fast for the conditions (not exceeding the speed limit).
- 2.7% of crashes involved alcohol and 1.15% of crashes involved drugs.

5.2 LARGE TRUCK HOT SPOT ANALYSIS

The Oregon crash data was used to conduct a hot spot analysis and generate large truck crash hot spots and their location in relation to existing truck stops. The large truck crash hot spot map is shown in Figure 5.20, and hot spots are based on statistical significance through the use of a *z*-statistic. Specifically, the tool within ArcGIS utilizes a Getis-Ord Gi* statistic that works by investigating each crash within the context of neighboring crashes and produces corresponding *z*-statistics (*ESRI 2014*). To be significant, a crash will have a high value and be surrounded by other crashes with high values. The Getis-Ord Gi* statistic is then calculated as (*ESRI 2014*):

$$G_i^* = \frac{\sum_{j=1}^{n} w_{i,j} x_j - \bar{X} \sum_{j=1}^{n} w_{i,j}}{S \sqrt{\frac{\left[n \sum_{j=1}^{n} w_{i,j}^2 - \left(\sum_{j=1}^{n} w_{i,j}\right)^2\right]}{n-1}}} \tag{5.1}$$

Where x_j is the attribute values for large truck crash j; $w_{i,j}$ is the spatial weight between crash i and crash j; n is the number of total crashes; and:

$$\bar{X} = \frac{\sum_{j=1}^{n} x_j}{n} \tag{5.2}$$

$$S = \sqrt{\frac{\sum_{j=1}^{n} x_j^2}{n} - (\bar{X})^2} \tag{5.3}$$

Referring to Figure 5.20, the Biggs Junction area is a large truck crash hot spot with 99% confidence and also a location that has a truck stop. In addition, there are two crash hot spots near The Dalles with 99% confidence and 90% confidence, respectively. Headed south on US-97 there are no crash hot spots until just south of the Peter Skene Ogden Wayside; in particular, there are two large truck crash hot spots both with a 99% level of confidence. Continuing south, there are two hot spots with a 95% level of confidence located roughly 15 to 30 miles south of Bend. The following hot spots are located directly near Gordy's Truck Stop, both with a 90% level of confidence. Of the remaining three hot spots, two are located between the Beaver Marsh rest areas and the rest area in Chiloquin. The indicated hot spots between the two aforementioned rest areas are of a high level of confidence, 99% and 95%, respectively. Lastly, there is hot spot with 90% confidence located just south of the Pilot Travel Center in Klamath Falls, OR.

Hot spot analysis results show that large truck crash hot spots are located immediately near an existing truck parking location, or along a segment between parking locations. Further, these results suggest there may be a correlation between large truck parking facilities and the locations that experience a large number of large truck crashes.

Figure 5.20: Large Truck Crash Hot Spots Within Study Area

5.3 SUMMARY OF CURRENT CONDITIONS

Using Oregon crash data and AADT data from 2007 to 2014, key large truck crash trends were identified. The time-of-day periods with the largest number of crashes were 5:00 a.m. to 10:00 a.m. at 23%, 10:00 a.m. to 3:00 p.m. at 28%, and 3:00 p.m. to 8:00 p.m. at 24%. As for crashes by the day of the week, approximately 50% of all crashes took place on a Wednesday, Friday, or Saturday and roughly 50% of all crashes happened during the winter months of November, December, January, and February. In regard to crash severity, 62.6% of all crashes did not have an injury (property-damage-only), 33.6% involved an injury, and 3.8% resulted in a fatality. The crashes per year were presented and a decrease was observed from 2007 to 2008, followed by a steady increase from 2008 to 2011, and another decrease from 2001 to 2013. The largest number of crashes happened in 2014 and was 57 more crashes than 2013. However, large truck VMT also increased from 2013 to 2014 by approximately 10 million (roughly a 7% increase in VMT).

In regard to large truck VMT compared to the total VMT along US-97, large trucks account for, on average, 19% of the total VMT from 2007 to 2014. This percentage of total VMT is larger when compared to the entire state of Oregon, as large truck VMT accounts for an average of 9% statewide from 2007 to 2014. Turning to injury severity proportions, large trucks account for a significantly higher percentage of total injury severity on US-97 when compared to statewide values. In total, large truck crash trends and statistics are substantially higher in terms of the proportion of crashes, injury severity, and rates along US-97 compared to statewide values based on current ODOT crash data and traffic data.

The large truck crash hot spot analysis provided key locations within the study that are crash hot spots with a level of statistical confidence. For example, Biggs Junction is a large truck crash hot spot with 99% confidence. The stretch of US-97 from Biggs Junction to Madras, OR does not have any crash hot spots; however, there are several hot spots from Peter Skene Ogden Wayside to the Oregon-California border. For instance, there are two hot spots just south of Peter Skene Ogden Wayside, two hot spots just south of Bend, and another two hot spots just south of Gordy's Truck Stop. The remaining hot spots are located just north of the Chiloquin rest area and just south of the Pilot Travel Center in Klamath Falls. Hot spots appear to be correlated with the location of parking facilities; however, no association between parking facilities (parking) and large truck crashes is known for certain.

6.0 CURRENT DEMAND AND FUTURE DEMAND

In an attempt to identify current and future truck parking demand along US-97, the Federal Highway Administration's (FHWA) commercial motor vehicle parking assessment model was utilized (*Pécheux et al. 2002*). Recently, this methodology has been applied to a case study along the New Jersey Turnpike (*Higgins et al. 2015*). To apply the FHWA's commercial motor vehicle parking assessment model, it was necessary to collect average-annual-daily-traffic (AADT) data. This data was obtained from ODOT's .ftp website[4] and was used to determine 2014 base year truck counts along the pilot corridor (US-97) and a specific segment of I-84 (see Data section). In addition, the Oregon Statewide Integrated Model (SWIM)[5] provided the researchers with annual freight growth rates along US-97 for a 20-year period to forecast truck parking demand for 5 cases, namely forecasts for years 2015, 2020, 2025, 2030, and 2035.

6.1 DATA

To employ the method developed by FHWA, the following specific data were needed:

- Rest areas on US-97 and their corresponding number of truck parking spaces
- Truck stops on US-97 and their corresponding number of truck parking spaces
- Length of the analysis segment and average speed on segment
- Number of daily trucks on segment

The Trucker Path application[6] was used to confirm active truck stops and rest areas along US-97 and their corresponding number of truck parking spaces. Trucker Path is a smartphone application that provides information (e.g., total/available parking spaces, amenities, etc.) for truck parking locations along a given corridor. The locations and number of truck parking spaces were then verified through Google Earth Pro™. All truck stops and rest areas along US-97 that were considered for analysis are displayed in Figure 6.1 and the number of corresponding truck parking spaces at each location are presented in Table 6.1.

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[4] ftp://ftp.odot.state.or.us/tdb/trandata/GIS_data/
[5] http://www.oregon.gov/ODOT/TD/TP/pages/statewide.aspx
[6] https://truckerpath.com/

Figure 6.1: Truck Stops and Rest Areas on US-97

Table 6.1: Truck Parking Locations and Spaces on US-97

Facility Type	Location	Parking Spaces
Truck Stops	Biggs Junction (Pilot Travel Center)	55
	Madras Truck Stop	20
	Gordy's Truck Stop	192
	Chemult (Pilot Travel Center)	34
	Crater Lake Junction Travel Center	20
	Klamath Falls (Pilot Travel Center)	75
Rest Areas	Rest Area SB/NB (Cow Canyon)	16
	Peter Skeen Ogden Way Side	5
	Rest Area SB (Beaver Marsh)	15
	Rest Area NB (Beaver Marsh)	25
	Rest Area SB/NB (Chiloquin, OR)	10
	Rest Areas SB/NB (Klamath Falls, OR)	35

As part of the FHWA methodology, it was necessary to first identify segments (corridors) for the analysis. The following three segments were identified: (1) The Dalles, OR to Rufus, OR along I-84, (2) Washington-Oregon border to Grass Valley, OR along US-97, and (3) Grass Valley, OR to the Oregon-California border along US-97. Figure 6.2 illustrates the segment of I-84 considered for the analysis. The length of the segment corresponds to the location of the truck counts, and all truck parking demand is assumed to be at the Biggs Junction truck stop. In other words, any large truck that passes Biggs Junction on this segment of I-84 is assumed to park at the Biggs Junction truck stop if required to stop. The analysis segment from the Washington-Oregon border to Grass Valley is shown in Figure 6.3. Similar to the I-84 segment, Biggs Junction is assumed to take all truck parking demand along this segment and the length of the segment is based on truck count locations. The final segment for analysis, Grass Valley to the Oregon-California border, can be seen in Figure 6.4. For this segment, each truck parking location in Figure 6.4, excluding Biggs Junction, takes on the truck parking demand. The length of this section also corresponds to the location of the truck counts.

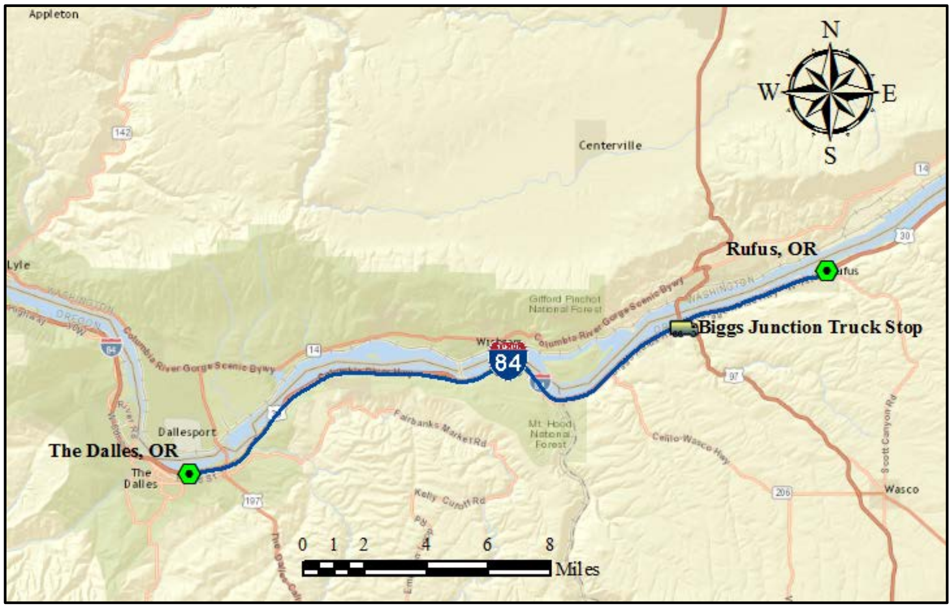

Figure 6.2: I-84 Analysis Segment (The Dalles to Rufus)

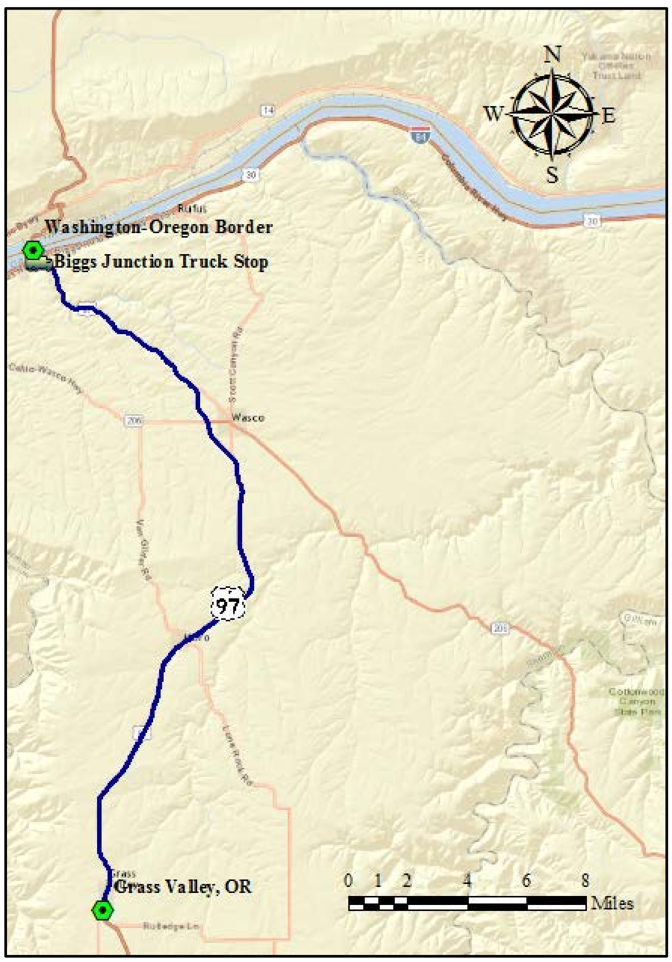

Figure 6.3: US-97 Analysis Segment I (Washington-Oregon border to Grass Valley)

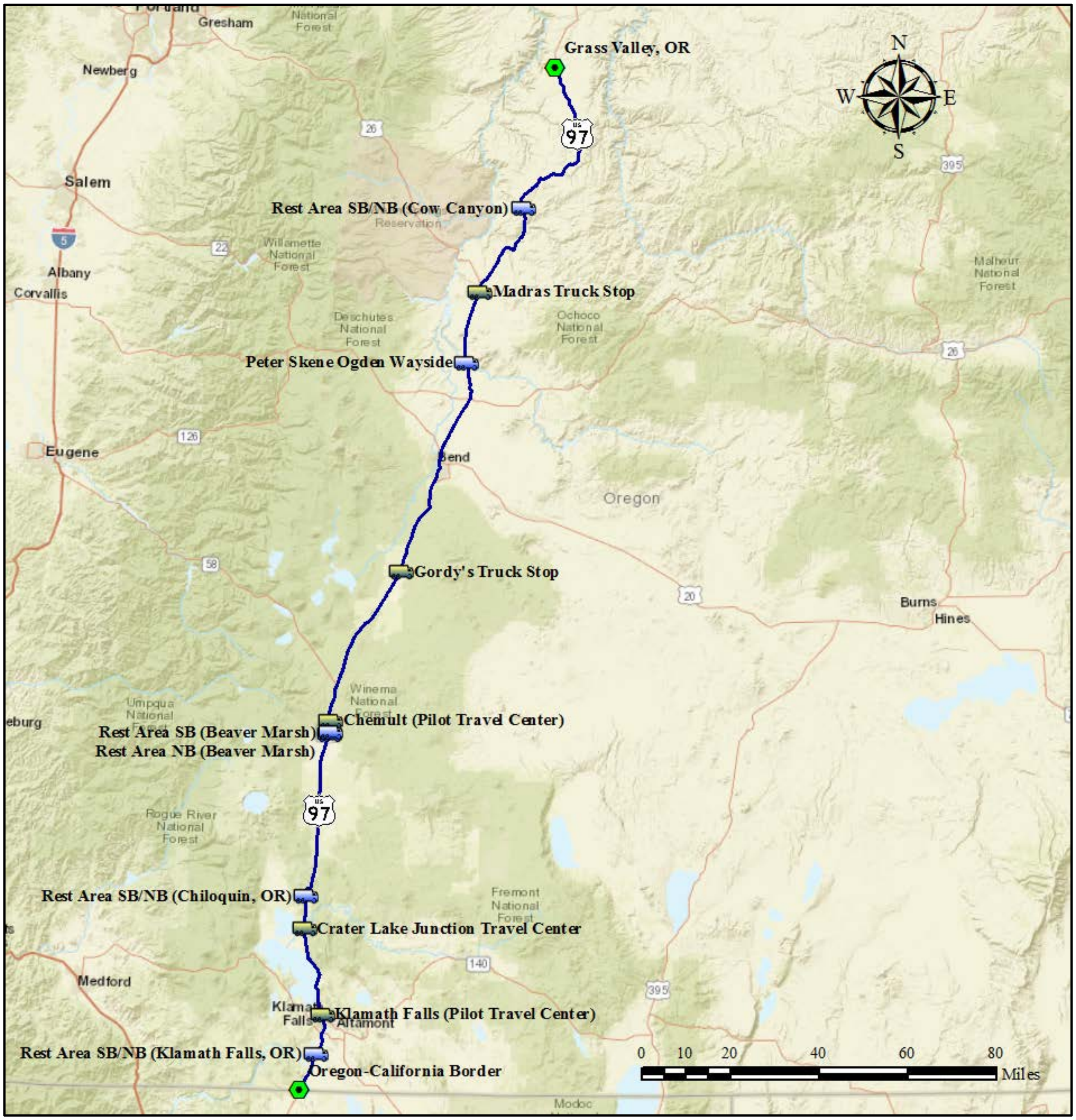

Figure 6.4: US-97 Analysis Segment II (Grass Valley to Oregon-California Border)

After identifying and defining the segments considered for analysis, a count of the daily number of trucks were necessary to apply the FHWA method. Unique truck counts are preferred for this approach to yield the most accurate results, but this data was unavailable for the current study. To overcome this drawback, AADT data along the analysis segment was used to create the most viable truck counts and further used to generate forecasts based on a 20-year annual growth rate provided by ODOT's SWIM model. Figure 6.5 displays the location of utilized truck counts along the I-84 segment. Figure 6.6 shows truck count locations and corresponding growth rates along US-97 from the Washington-Oregon border to Grass Valley, and truck count locations with corresponding growth rates from Grass Valley to the Oregon-California border are presented in Figure 6.7.

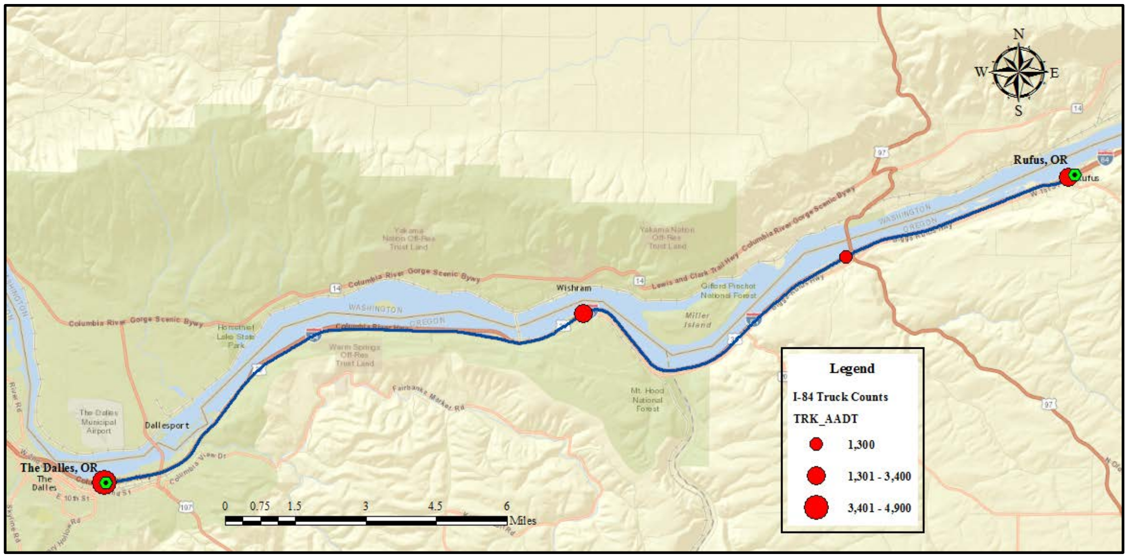

Figure 6.5: Truck Count Locations on I-84 Analysis Segment

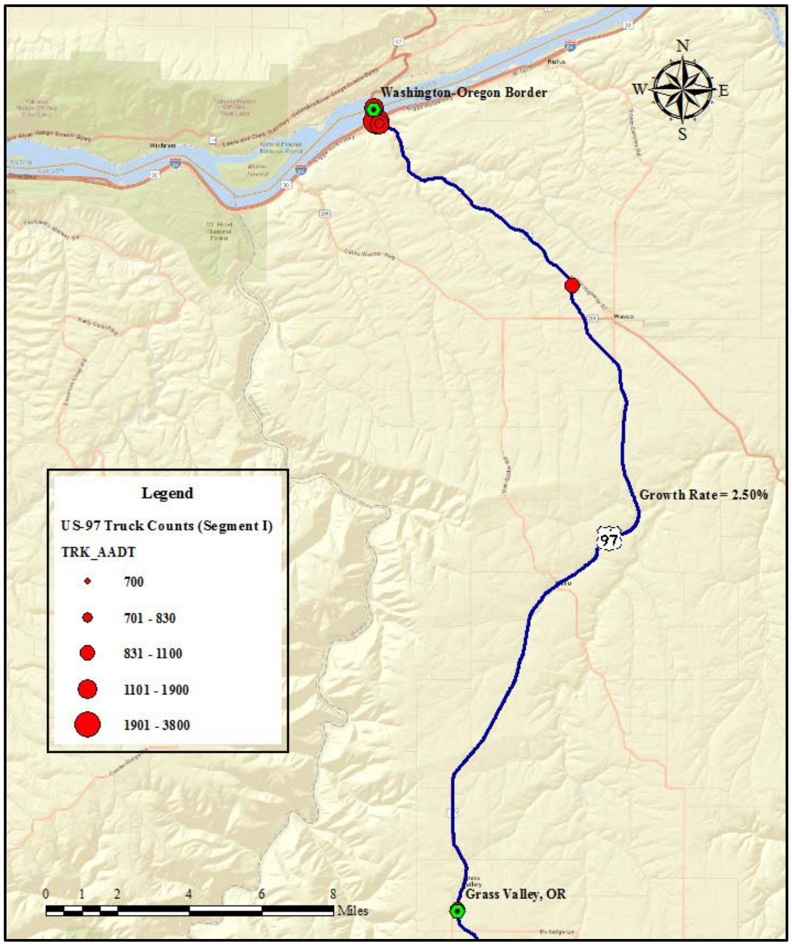

Figure 6.6: Truck Count Locations on US-97 Analysis Segment I

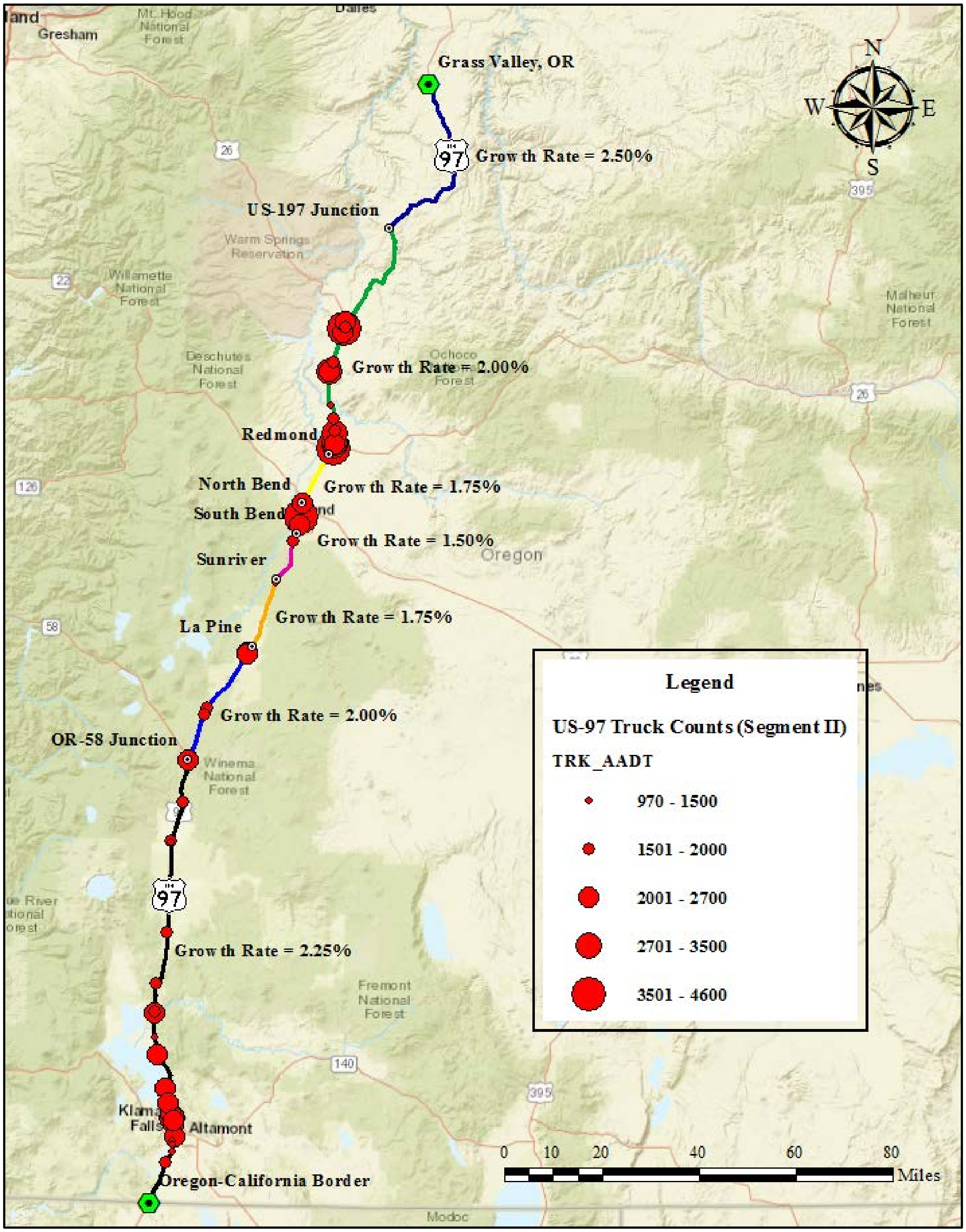

Figure 6.7: Truck Count Locations on US-97 Analysis Segment II

Referring to the above figures, four truck count observations were used to calculate a number of daily trucks based on AADT values along the I-84[7] segment shown in Figure 6.5. Seven observations were used to determine the number of daily trucks along the segment of US-97 shown in Figure 6.6 and 47 observations were used for the segment of US-97 displayed in Figure 6.7. Truck counts were recorded for each segment entrance along the analysis segment, and the largest truck count was used at the beginning and end of each analysis segment. The length of the I-84 segment begins at the location of the truck count in The Dalles and ends at the location of the truck count in Rufus. Similarly, the length of US-97 analysis Segment I begins at the Washington-Oregon border and ends at the truck count location in Grass Valley, while the length of Segment II begins at the count location in Grass Valley and ends at the Oregon-California border. Ultimately, the average of the AADT values for each analysis segment were calculated and used as the daily number of trucks in the base year. For a summary of the necessary data and the data process, refer to Table 6.2 and Figure 6.8.

Table 6.2: Summary of Data Needed for Parking Assessment Model

Analysis Segment	Average AADT	Max AADT	Min AADT	Length (Miles)	Average Speed Limit (MPH)
I-84	3,250	4,900	1,300	26.3	55
US-97 (Segment I)	1,776	3,800	830	28.2	55
US-97 (Segment II)	2,219	4,600	970	261	55

[7] No freight growth rate for this segment was available; hence, 2014 was the only year analyzed along the I-84 segment.

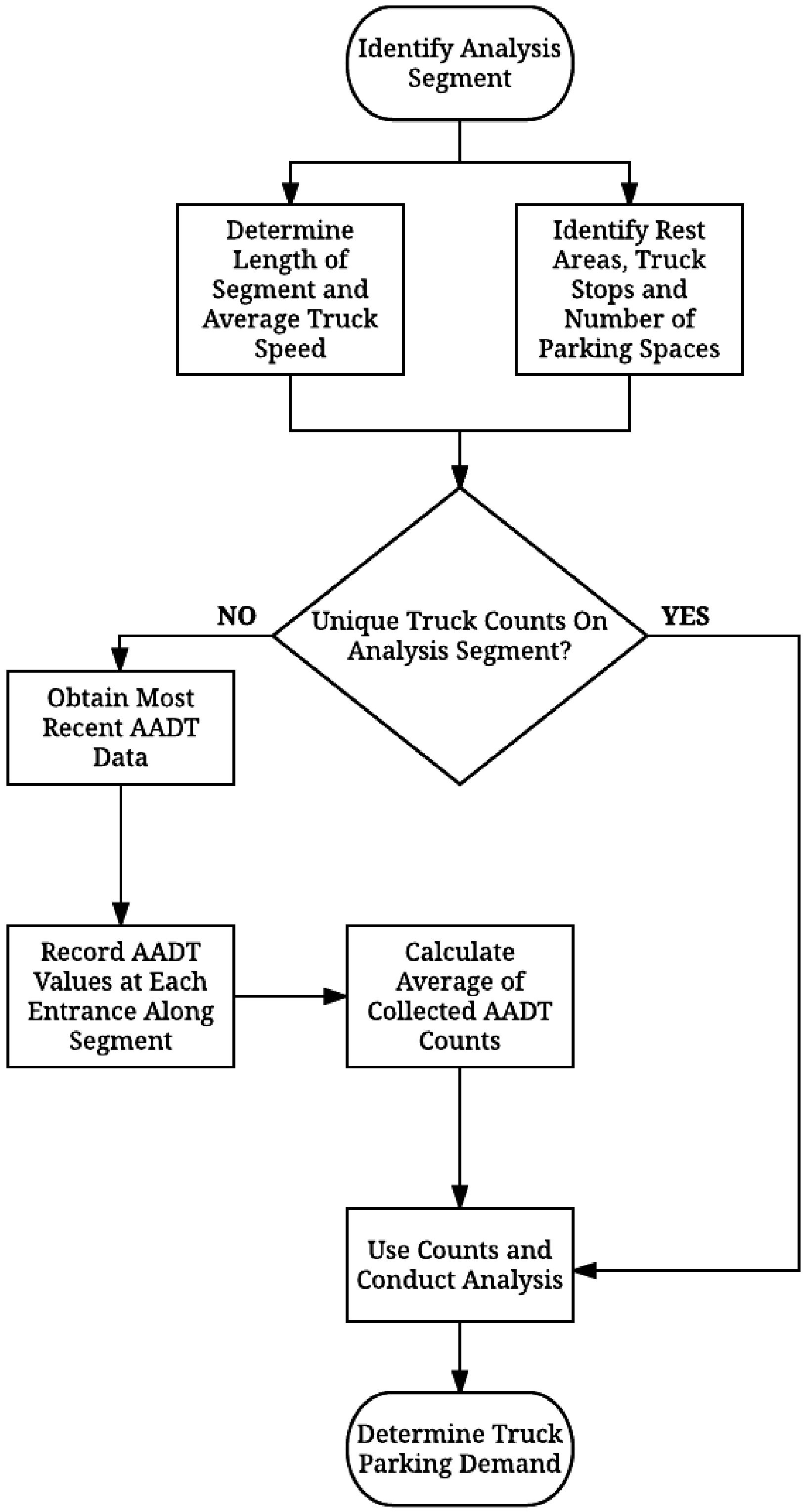

Figure 6.8: Data Process Flowchart

6.2 ASSESSMENT METHOD

6.2.1 Truck Parking Demand

As stated previously, the current study adopts the FHWA's commercial motor vehicle parking assessment model (*Higgins et al. 2015*; *Pécheux et al. 2002*). In this method, truck parking demand is based on total truck-hours of travel and the ratio of short-haul to long-haul trucks along the corridor. The key parameter in this method is the number of parking hours required based on the hours of travel (*Pécheux et al. 2002*). The following discussion presents the method and its application in greater detail.

The first step in the method is to determine the average-truck-travel-time of the analysis segment and is estimated by:

$$TT = \frac{L_i}{S_i} \tag{6.1}$$

Where TT is the average-truck-travel-time, L_i is the length of analysis segment i, and S_i is the speed limit or average truck speed on analysis segment i. The next step is to estimate the daily truck-hours of travel for short-haul and long-haul trucks through the following:

$$THT_{SH} = P_{SH} \times V_i \times TT \tag{6.2}$$

$$THT_{LH} = P_{LH} \times V_i \times TT \tag{6.3}$$

where THT_{SH} and THT_{LH} are the daily truck-hours of travel for short-haul and long-haul, respectively; P_{SH} and P_{LH} represent the proportion of short-haul and long-haul trucks, respectively; V_i is the number of daily trucks on analysis segment i; and, TT is the average-truck-travel-time. P_{SH} and P_{LH} take on the values of 0.36 and 0.64, respectively, based on overnight observations at truck stops and rest areas spanning eight states (*Pécheux et al. 2002*)[8]. Using results from Eq. (6.2) and Eq. (6.3), the daily short-haul hours of parking demand can be estimated by:

$$THP_{SH} = \frac{D_{ST} THT_{SH}}{60} \tag{6.4}$$

[8] The values of 0.36 and 0.64 are applied to analysis segments within 200 miles of a city with a population of at least 200,000.

Where THP_{SH} is the daily short-haul hours of parking demand, D_{ST} is the duration of short-term stops per hours traveled, and THT_{SH} is the daily truck-hours of travel for short-haul trucks. Following Pécheux et al. (2002), the assumption that a driver must stop for a duration of 5 minutes for every hour of driving to meet hours-of-service was implemented; hence, D_{ST} is equal to 5. Now, the daily long-haul hours of parking demand can be estimated by the following equation:

$$THP_{LH} = \frac{\text{Parking Time}/\text{Week}}{\text{Driving Time}/\text{Week}} \times THT_{LH} \times \frac{D_{ST}THT_{LH}}{60} \tag{6.5}$$

Where THP_{LH} is the daily long-haul hours of parking demand; $\text{Parking Time}/\text{Week}$ is the time obtained by subtracting the maximum number of hours driving according to HOS, average hours spent at home, average hours spent loading and unloading, and average hours spent waiting at shippers and receivers from the 192 hours in an 8 day HOS period; $\text{Driving Time}/\text{Week}$ is the maximum number of hours allocated by HOS in an 8 day period; THT_{LH} is the daily truck-hours of travel for long-haul trucks; and, D_{ST} is the duration of short-term stops per hours traveled as described in Eq. (6.4). In regard to $\text{Parking Time}/\text{Week}$, a value of 49 hours is used based on the responses from the truck drivers surveyed by Pécheux et al. (2002)[9].

Until this point, the number of trucks has not been estimated. Therefore, using the previous results obtained, the estimated truck parking demand for short-haul and long-haul trucks can be determined by the following set of equations:

$$PHP_{SH} = PPF_{SH} \times THP_{SH} \tag{6.6}$$

$$PHP_{LH} = PPF_{LH} \times THP_{LH} \tag{6.7}$$

where PHP_{SH} and PHP_{LH} are the parking demand for short-haul and long-haul trucks, respectively; PPF_{SH} and PPF_{LH} represent the peak-parking factor for short-haul and long-haul trucks, respectively; and, THP_{SH} and THP_{LH} denote the daily short-haul and long-haul hours of parking demand, respectively. In conjunction with Pécheux et al. (2002), PPF_{SH} and PPF_{LH} were taken to be 0.02 and 0.09—these values were derived from the same overnight field observations previously referenced. Lastly, the truck parking demand at truck stops and rest areas can be estimated. Once more, a proportion derived from the survey results used by Pécheux et al. (2002)

[9] This survey allowed Pécheux et al. (2002) to determine average hours loading and unloading, average hours spent at home and average hours spent waiting to unload or load based on truck driver respones pertaining to travel patterns. By adding these values to the known allocated driving time based on HOS and subtracting from the number of hours in an 8 day period, a parking time per week of 49 hours can be estimated.

was used. The derived proportions are based on driver answers regarding preferences for different activivities and amenities, and as a result, the parking demand at truck stops and rest areas is estimated by:

$$PHP_{SH/RA} = P_{RA} \times PHP_{SH} \tag{6.8}$$

$$PHP_{SH/TS} = P_{TS} \times PHP_{SH} \tag{6.9}$$

$$PHP_{LH/RA} = P_{RA} \times PHP_{LH} \tag{6.10}$$

$$PHP_{LH/TS} = P_{TS} \times PHP_{LH} \tag{6.11}$$

where $PHP_{SH/RA}$ and $PHP_{SH/TS}$ represent the short-haul parking demand at rest areas and truck stops, respectively; $PHP_{LH/RA}$ and $PHP_{LH/TS}$ denote the long-haul parking demand at rest areas and truck stops, respectively; P_{RA} is the proportion of demand at rest areas; and, P_{TS} is the proportion of demand at truck stops. P_{RA} and P_{TS} were determined through a survey of more than 2,000 drivers and found to be 0.23 and 0.77, respectively.

6.2.2 Forecast Truck Parking Demand

As discussed in Section 6.1, three specific analysis segments were identified; however, freight growth rates provided by ODOT's SWIM model were not uniform along each segment as is shown in Table 6.3. Accordingly, the growth rates presented in Table 6.3 were applied to corresponding truck count locations to ensure each count was forecasted based on the correct growth rate. The increase in the number of large trucks over the forecasted years is illustrated in Figure 6.9. For instance, truck count locations from I-84 to the US-197 junction were given a 2.50% annual growth rate, while truck count locations from Redmond to Bend were given a 1.75% annual growth rate. The provided growth rates were used to determine the number of average daily trucks along US-97 for 2014 to 2035.

An example calculation is provided in Appendix A and includes all calculations used to determine the parking demand for a given year.

Table 6.3: Average Annual Freight Growth Rates on US-97 Over 20 Years

Location Along US-97	Growth Rate
I-84 to US-197 Junction (Madras)	2.50%
Madras to Redmond	2.00%
In Redmond	2.00%
Redmond to Bend	1.75%
In Bend	1.50%
Bend to Sunriver	1.50%
Sunriver to La Pine	1.75%
La Pine to OR-58	2.00%
OR-58 to California Border	2.25%

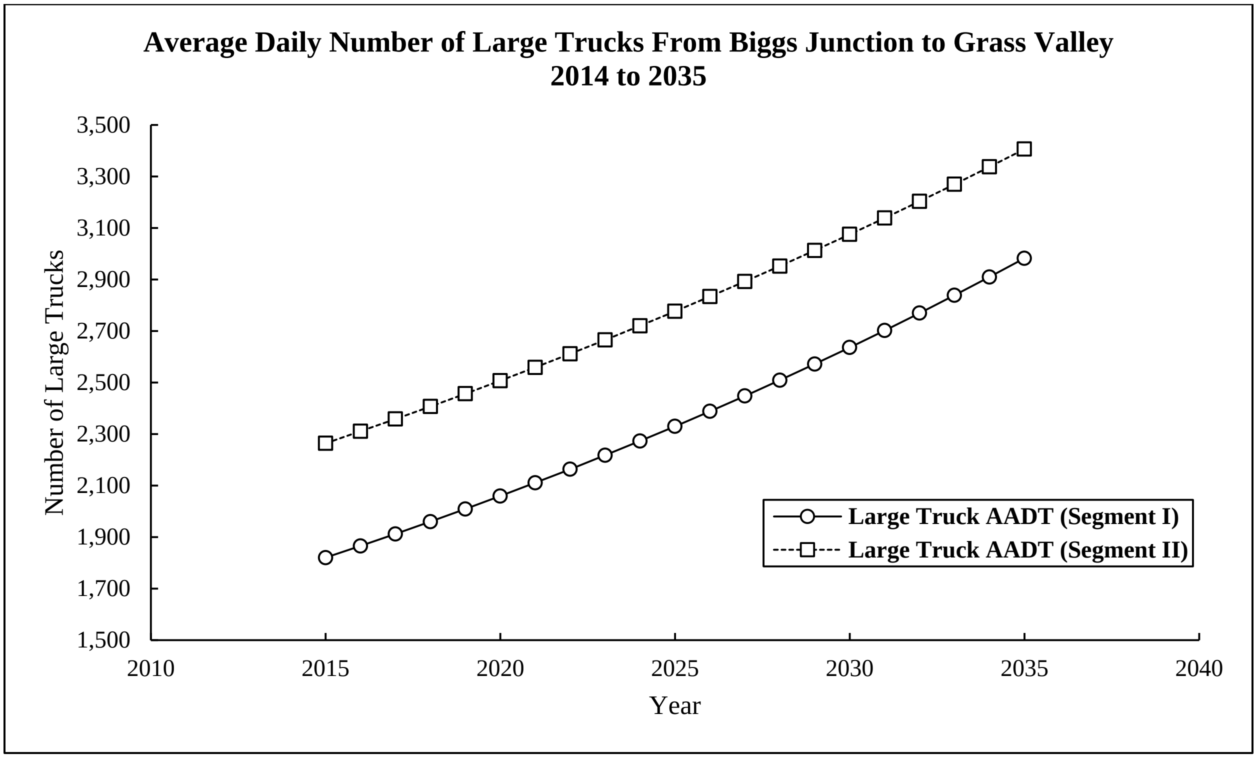

Figure 6.9: Average Daily Number of Large Trucks on US-97 From 2015 to 2035

6.3 ASSESSMENT RESULTS

6.3.1 Current Parking Demand

The most recent traffic data available through ODOT's .ftp website were 2014 traffic counts; as such, these counts were utilized for the parking demand analysis. Truck parking counts come from ODOT's traffic counting program[10]. For the I-84 segment, in 2014, there is a shortage of 16 rest area parking spaces. There is no rest area here to account for truck parking demand;

[10] http://www.oregon.gov/ODOT/td/tdata/Pages/tsm/tvt.aspx

therefore, each required parking space is a shortage. Biggs Junction has no surplus or shortage in 2014; that is, Biggs Junction has the precise number of parking spaces to accommodate 2014 demand.

Pertaining to Segment I of the US-97 corridor, there is a surplus of 23 parking spaces at Biggs Junction in 2014. Rest area parking spaces, however, have a shortage of 10 spaces. Once again, no rest areas are located along this segment, and any rest area parking demand will be a shortage. Along Segment II, there is a shortage of 5 parking spaces at rest areas and a shortage of 30 parking spaces at truck stops.

Although this method is not recommended to analyze two segments simultaneously, the demand at Biggs Junction was explored by considering traffic from I-84 and Segment I of US-97. To examine the demand at Biggs Junction, while considering traffic from both segments, the counts were summed, and the length of the two segments were summed. The results illustrate a shortage of 52 parking spaces at rest areas and a shortage of 120 parking spaces at truck stops. It is evident that including truck counts from both corridors that intersect at Biggs Junction has a substantial impact on the demand. In the future, truck counts from both segments need to be considered when assessing truck parking demand at Biggs Junction.

6.3.2 Future Parking Demand

As previously stated, forecasts were generated for years 2015, 2020, 2025, 2030, and 2035. Due to the most current available traffic data being 2014 counts, the current study uses the forecasts for year 2015 as the base year. Based on forecasted 2015 truck counts, Segment I experiences a surplus of 22 parking spaces at Biggs Junction, but is short 10 rest area parking spaces due to no rest area locations along this segment of US-97. As for Segment II, there are 341 truck parking spaces located at truck stops and 106 parking spaces at rest areas. Taking that into account, there is a shortage of 7 spaces at rest areas and 37 spaces at truck stops.

Forecasting ahead five years to 2020, Segment I still sees a surplus of parking spaces at the Biggs Junction truck stop, but it has been decreased to 18. Likewise, the shortage of rest area parking spaces has increased to 11. In regard to Segment II, the shortages have increased; rest areas now have a shortage of 19 parking spaces and truck stops a shortage of 78 parking spaces.

In 2025, the same increase in rest area shortages and decrease in Biggs Junction surplus is seen. For instance, the rest area shortage is now 13, and the Biggs Junction surplus is now 13. Along Segment II, however, the shortages at both rest areas and truck stops continue to increase. Specifically, there is a shortage of 33 rest area parking spaces and 123 truck stop parking spaces.

Moving forward to 2030, the same pattern is seen for Segment I. Although Biggs Junction has a surplus of 7 parking spaces, it is still decreasing. The shortage of rest area parking spaces only increases by one from 2025 to 2030. The shortages continue to worsen for Segment II in 2030, as there is a shortage of 47 rest area parking spaces and 173 truck parking spaces.

Lastly, in 2035, Biggs Junction still has a surplus of parking spaces, albeit one space. Rest area parking spaces along Segment I have a shortage of 16. As anticipated, the shortages along

Segment II are the greatest. For rest areas, there is a shortage of 64 parking spaces and truck stops have a shortage of 228 parking spaces.

Figure 6.10 shows the decrease in surplus parking spaces at Biggs Junction from 2015 to 2035, and the increase in the rest area parking shortage. It is likely that the surplus seen on Segment I is due to the exclusion of the truck traffic on I-84, but no growth rates were provided for I-84 and estimating future truck counts would be inaccurate. This would also impact the shortage of rest area parking spaces, as there is no rest area along this section of US-97 and inclusion of I-84 truck counts would likely generate a significant increase in the rest area shortages illustrated in Figure 6.10.

The increase in shortages along Segment II is displayed in Figure 6.11. Parking space shortages at rest areas along Segment II increase from 7 to 64 from 2015 to 2035, but increase less rapidly than shortages at truck stops. For instance, parking space shortages at truck stops along Segment II have a substantial increase from 37 to 228 over the same 20-year period. This distinctly illustrates a need for additional truck parking spaces at both rest areas and truck stops.

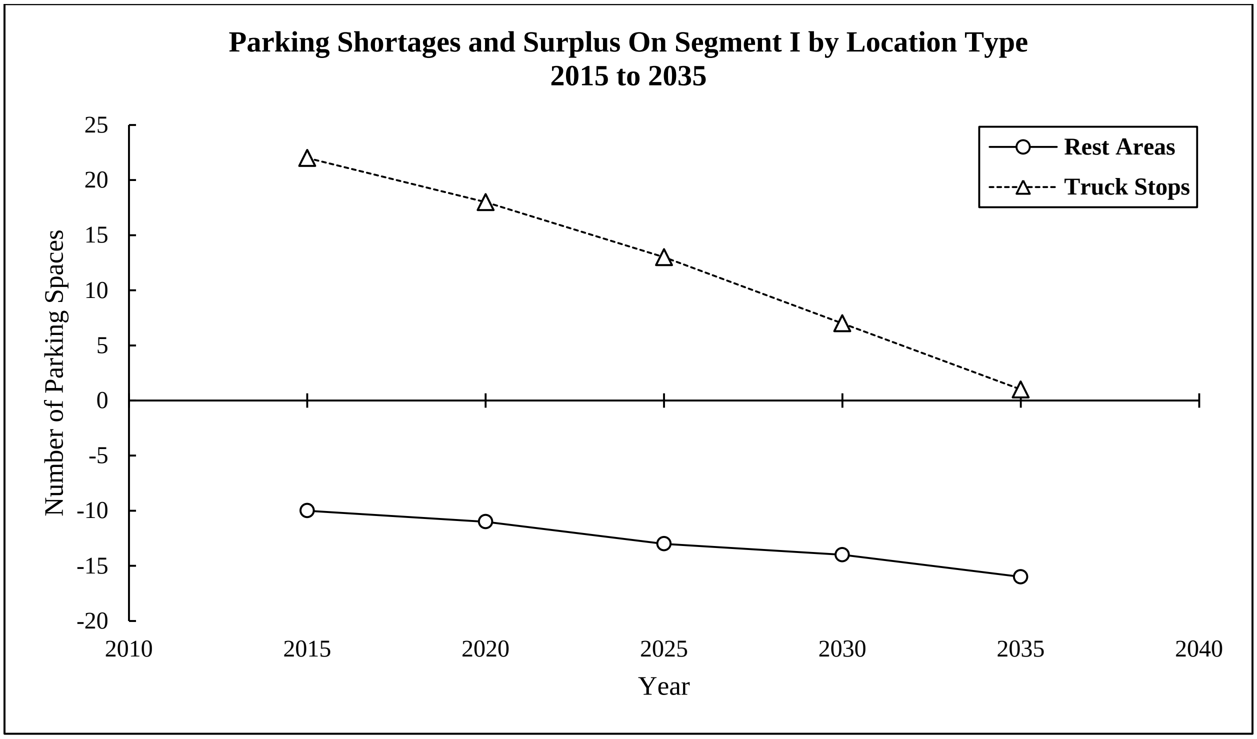

Figure 6.10: Parking Space Shortages and Surplus on US-97 Analysis Segment I

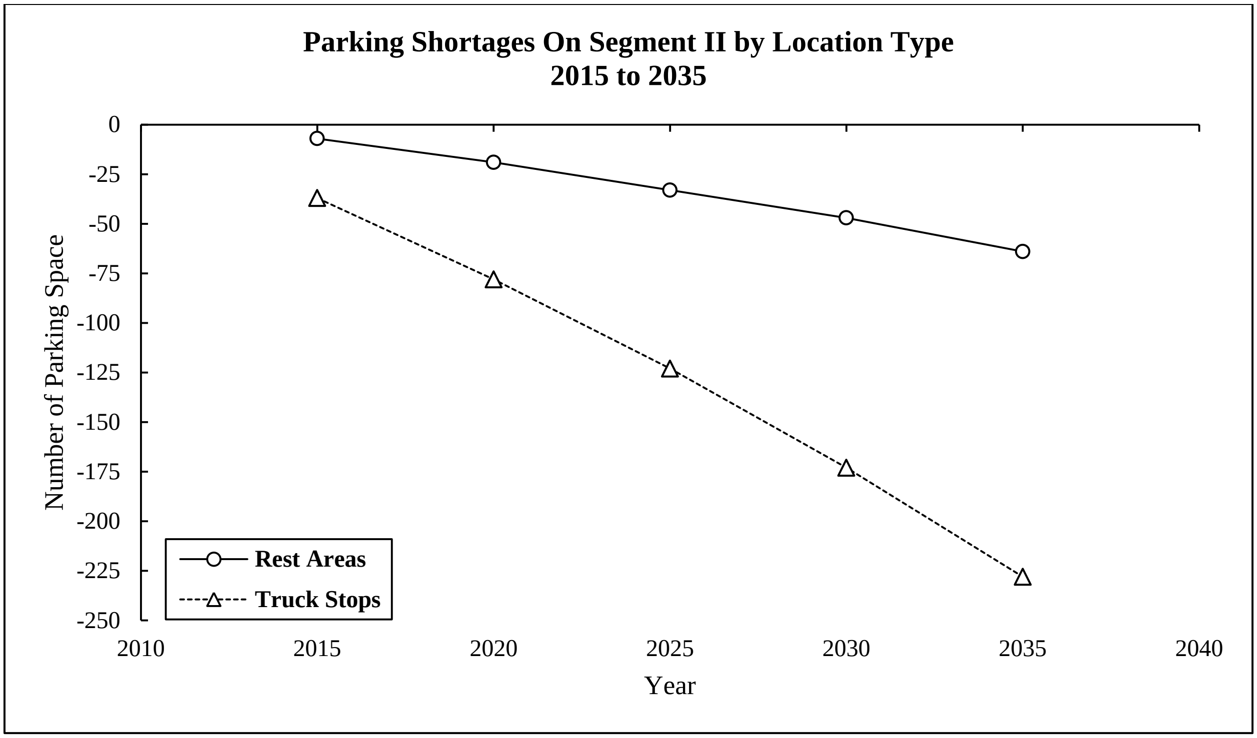

Figure 6.11: Parking Space Shortages on US-97 Analysis Segment II

6.3.3 Sensitivity Analysis

To investigate the effect of the default model assessment parameters proposed by Pécheux et al. (2002), the current study will determine the effect that the long-haul to short-haul ratio and the effect that average truck speed have on parking demand. Specifically, the researchers will determine the parking demand of all three segments for a 10% increase and 10% decrease in the percentage of short-haul trucks. Furthermore, the observed average truck speed has the potential to be lower than the posted speed limit; therefore, the effect of a 50 miles per hour and 45 miles per hour average truck speed will be examined.

With regard to a 10% increase in the percentage of short-haul trucks, the proportion of short-haul to long-haul trucks is now 0.40 to 0.60. This increase in short-haul trucks creates a decrease of shortages and increase of surplus for the combined analysis, I-84 analysis, and the US-97 Segment I analysis. For instance, the combined analysis of the I-84 segment and Segment I of US-97 results in a shortage of 50 rest area parking spaces and 111 truck stop parking spaces, a 3.9% decrease in rest area shortages and a 7.8% decrease in truck stop shortages. Similar effects were observed when considering truck traffic from only I-84, as rest area shortages decrease from 16 to 15 and the truck stop surplus increases from zero to three. Segment I of US-97 (Biggs Junction to Grass Valley) experiences a slight decrease in rest area shortages and a slight increase in truck stop surplus for each year. As for Segment II, a decrease in both rest area shortage and truck stop shortage was observed each year when the percent of short-haul trucks is increased by 10%.

With a 10% decrease in the percentage of short-haul trucks, the proportion of short-haul to long-haul trucks is now 0.32 to 0.68. As for the combined analysis (I-84 and Segment I of US-97), there is a 5.6% increase in parking space shortages at rest areas and an 8% increase in parking space shortages at truck stops. In regard to I-84, a 10% decrease in short-haul percentage increases rest area shortage by one space and creates a shortage of three parking spaces at truck stops. Over the years considered for analysis, US-97 Segment I experiences an increase in rest area shortage and a decrease in truck stop surplus while US-97 Segment II experiences an increase in parking space shortages at rest areas and truck stops.

The change in shortages and/or surplus on US-97 due to the percentage of short-haul trucks is illustrated in Figure 6.12 and Figure 6.13.

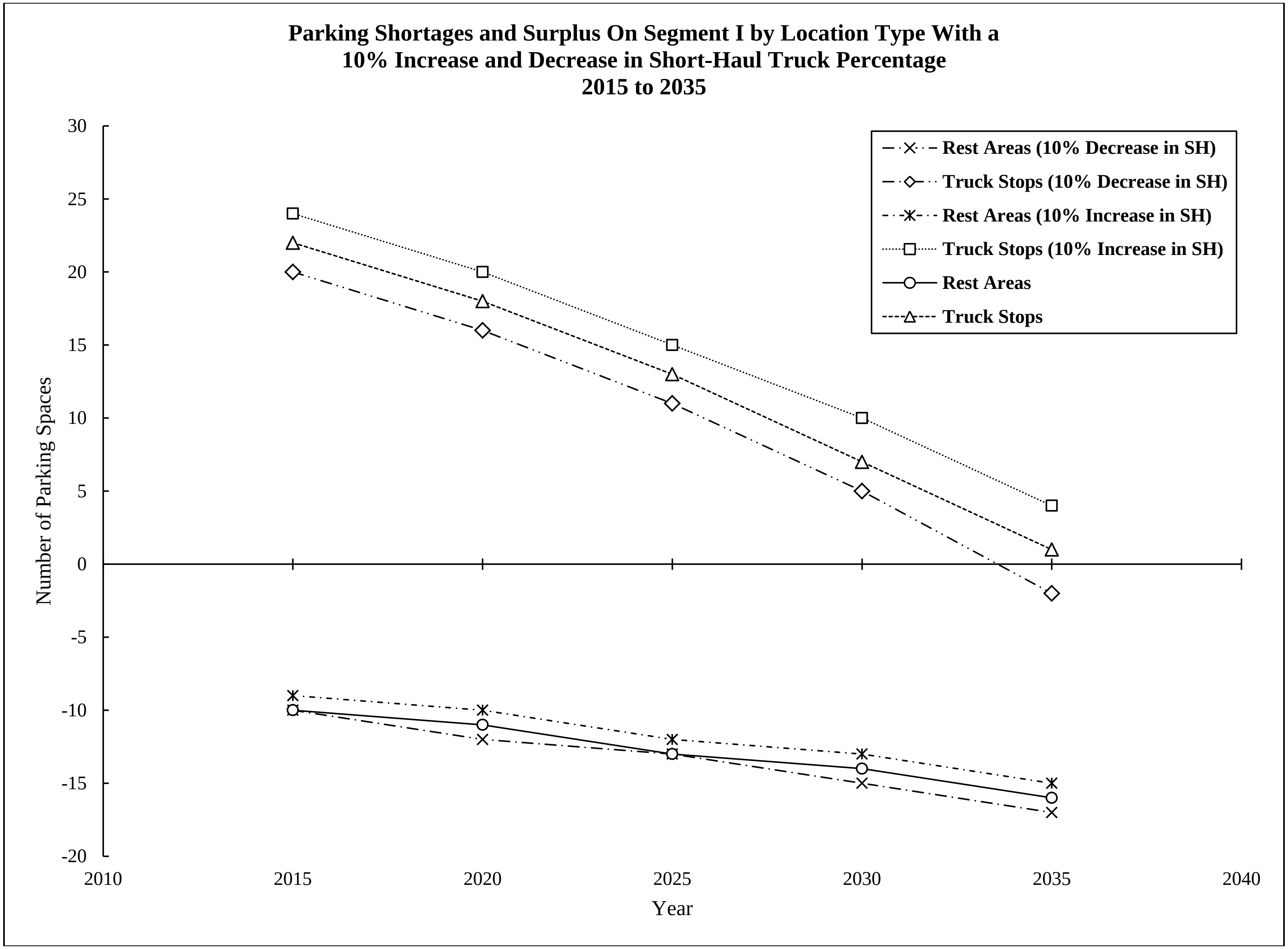

Figure 6.12: Parking Shortages and Surplus On US-97 Analysis Segment I for All Short-Haul Percentages

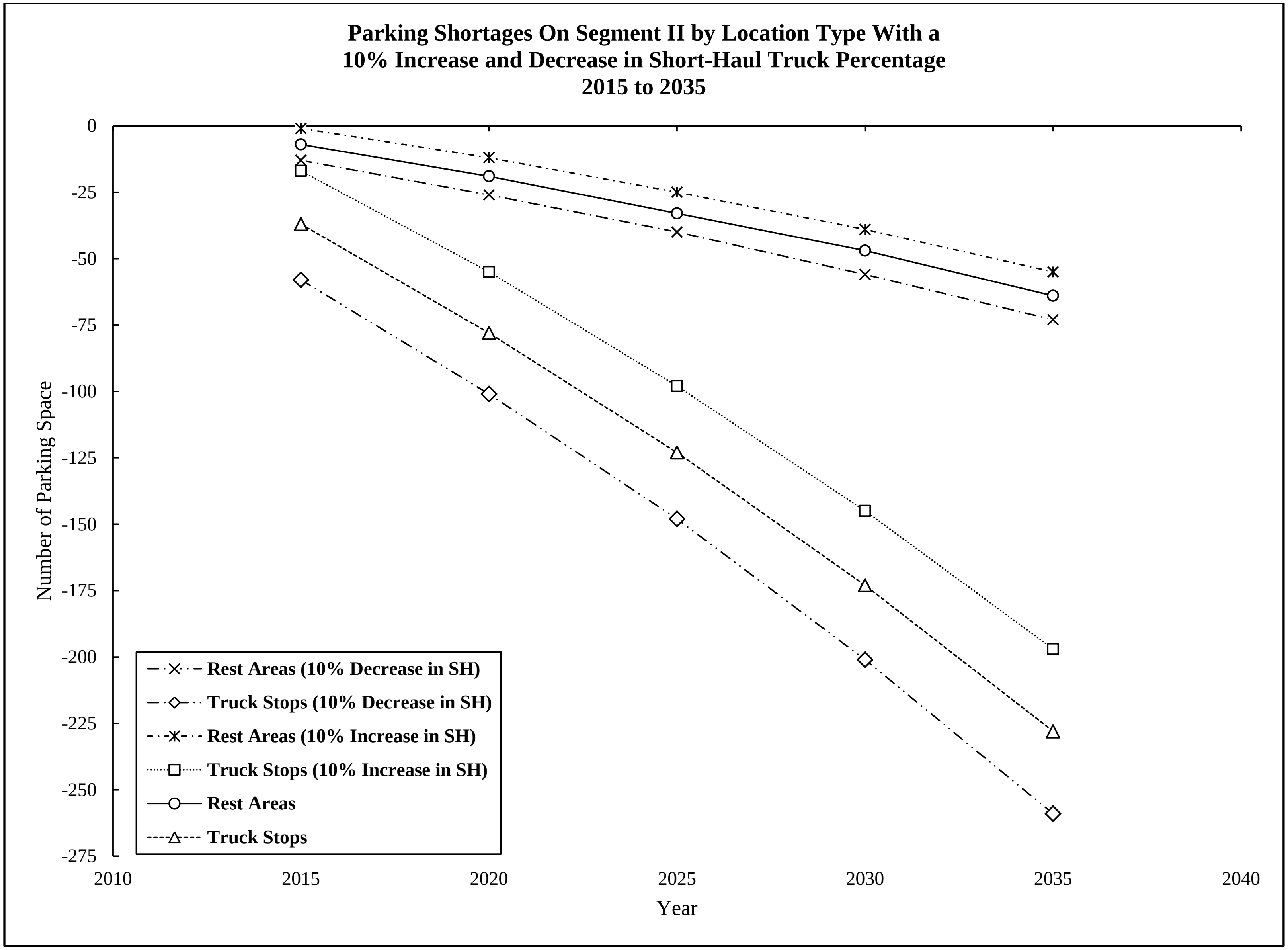

Figure 6.13: Parking Shortages on US-97 Analysis Segment II for All Short-Haul Percentages

Reducing the average truck speed to 50 miles per hour impacted truck parking more significantly than either a 10% increase or 10% decrease in the percentage of short-haul trucks. For example, the combined analysis that includes I-84 and US-97 Segment I experiences an approximate 11% increase in the number of parking space shortages at rest areas and 14% increase at truck stops. I-84 also experienced an increase in shortages, 16 to 18 at rest areas and zero to five at truck stops. In regard to US-97 Segment I, there is an increase in shortages at rest areas and a decrease in truck stop surplus for each forecasted year. US-97 Segment II has a significant increase in parking space shortages at rest areas and truck stops over the forecasted years.

By further reducing the average truck speed to 45 miles per hour, the impact on truck parking is affected more significantly. For the combined analysis, there is roughly a 21% increase in rest area shortages and a 28% increase in parking space shortages at truck stops. The I-84 segment now has an increase in shortages from 12 to 16 at rest areas and an increase of 12 parking space shortages at truck stops. In regard to US-97 Segment I, there is an increase in rest area shortages and a decrease in the parking space surplus at truck stops for each forecasted year. Likewise, US-97 Segment II experienced a significant increase in parking space shortages at rest areas and truck stops from 2015 to 2035.

Figure 6.14 shows the decrease in surplus at truck stops and increase in shortages at rest areas for Segment I. Particularly, if the average truck speed is equal to the posted speed limit of 55 miles per hour, a surplus of parking spaces at truck stops is observed for each forecasted year. However, if the average truck speed is 50 miles per hour or 45 miles per hour there becomes a shortage in parking spaces in 2030 and 2035, respectively. As for rest areas, Figure 6.14 shows that the number of parking space shortages increases as the average truck speed decreases. As for Segment II, each 5 miles per hour decrease in average truck speed increases the shortage in parking spaces at both truck stops and rest areas, as shown in Figure 6.15.

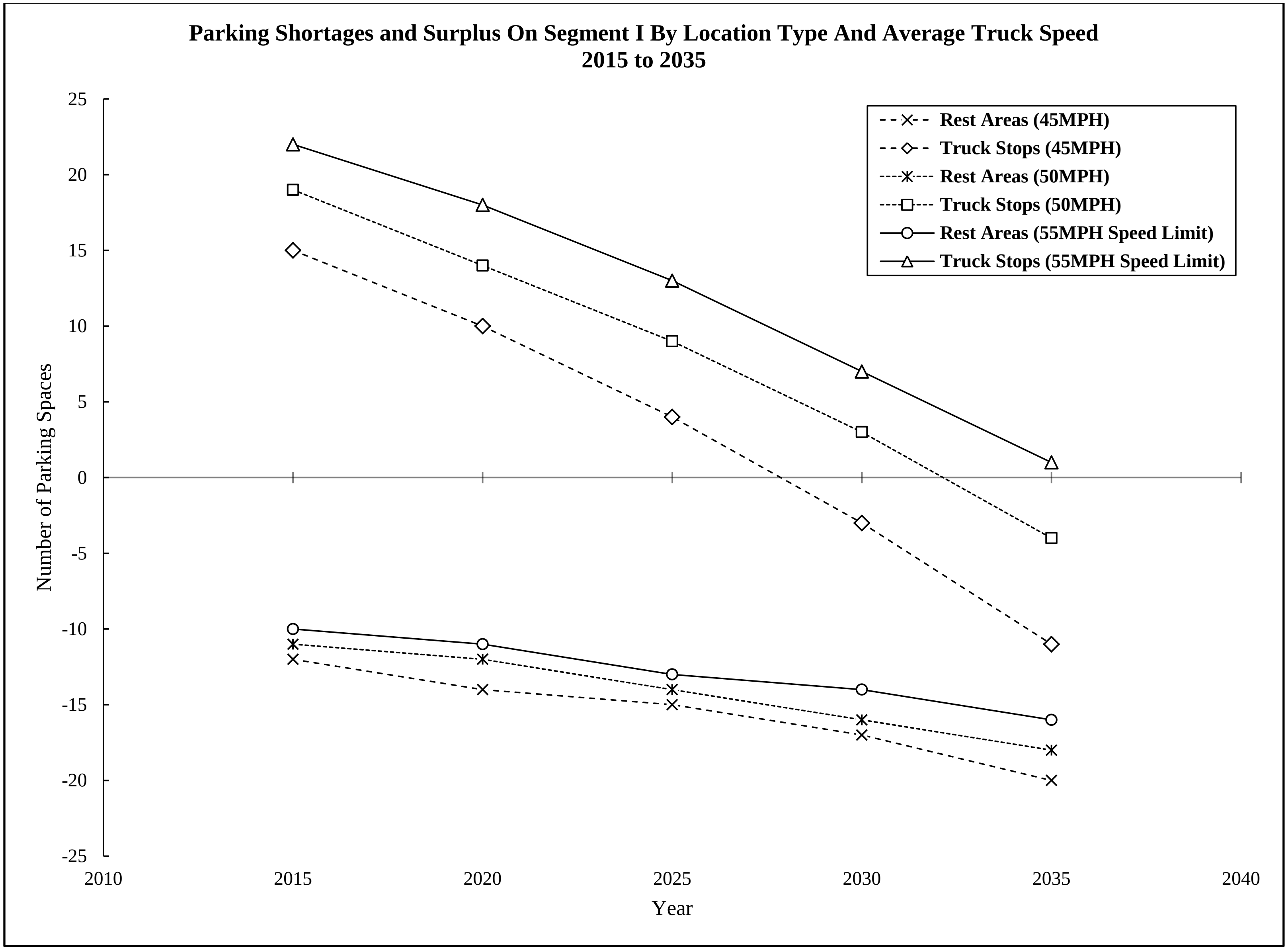

Figure 6.14: Parking Shortages and Surplus by Average Truck Speed on US-97 Analysis Segment I

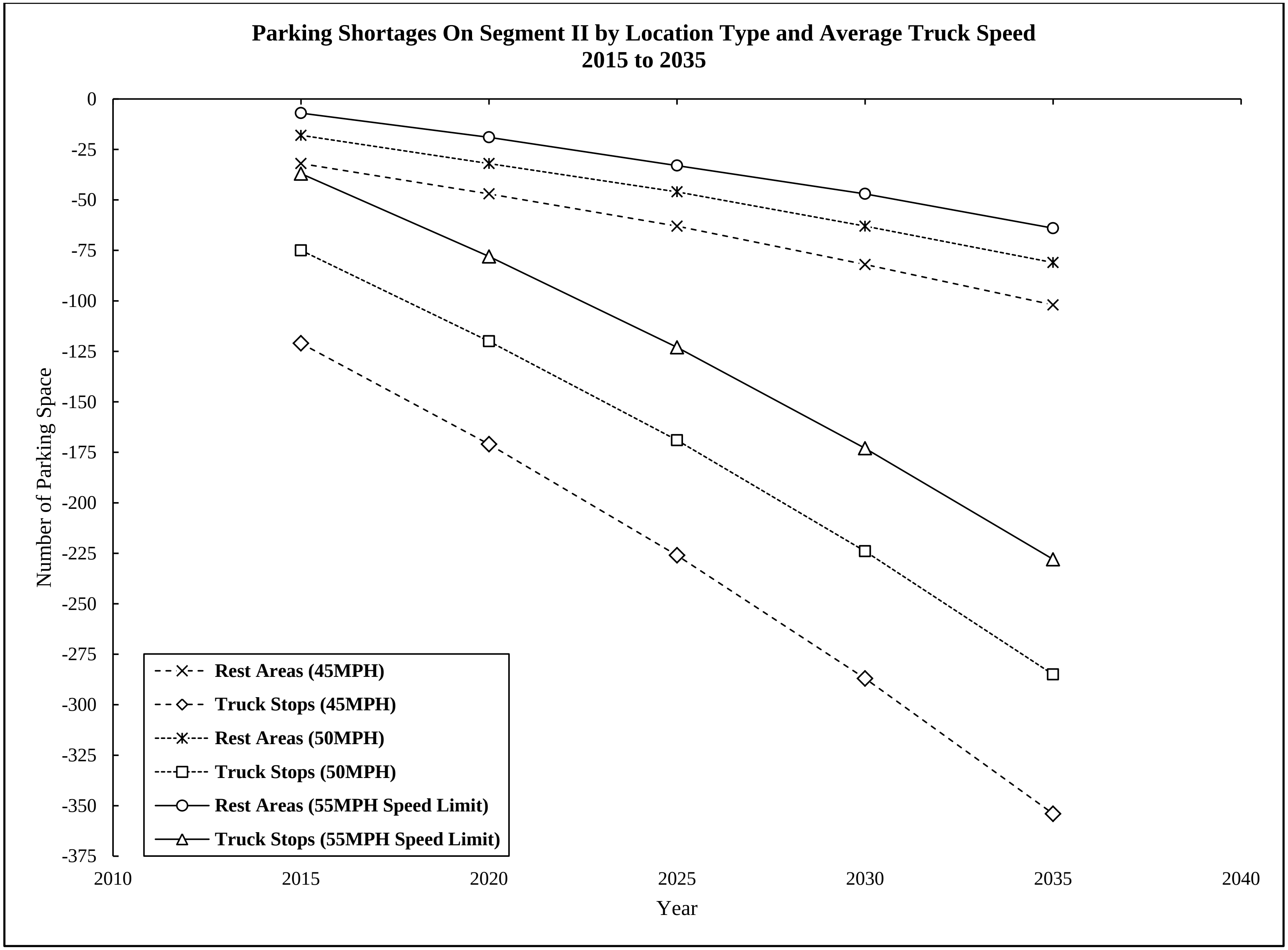

Figure 6.15: Parking Shortages by Average Truck Speed on US-97 Analysis Segment II

6.4 SUMMARY OF PARKING DEMAND ANALYSIS

Utilizing the FHWA's commercial motor vehicle parking assessment model, the current task investigated truck parking demand along US-97 in Oregon. AADT data was used to generate an average daily number of large trucks on the segments considered for analysis. Using growth rates provided by ODOT's SWIM model, the average daily number of large trucks along the analysis segments were forecast to years 2015, 2020, 2025, 2030 and 2035. Truck parking demand at rest areas and truck stops were then analyzed and presented.

Along Segment I, I-84 to Grass Valley, the forecast shows a surplus of truck parking spaces for each year (still the number of vacant spaces is reducing). With that in mind, the truck traffic along I-84 is not included and if included is going to result in a significant shortage at Biggs Junction. This was seen in 2014 when I-84 counts and US-97 Segment I counts were analyzed together. In addition, no rest areas are located along this segment of US-97; therefore, a shortage in rest area parking spaces was observed each year. Correspondingly, when including truck traffic from I-84, the rest area shortage is expected to increase considerably.

Regarding Segment II, the forecasts illustrate that Grass Valley to the California border, experiences a shortage of parking spaces at both rest areas and truck stops. Rest areas have an increase in shortages from 7 to 64, and truck stops have an increase in shortages from 37 to 228 from 2015 to 2035. There are six rest areas along this segment, but they do not offer an adequate number of parking spaces. Likewise, five truck stops are located along Segment II, yet based on the analysis, these do not provide an adequate number of parking spaces. A summary of truck parking shortages and surplus are presented in Table 6.4, where negative values indicate a shortage and positive values indicate a surplus.

Table 6.4: Summary of Truck Parking Shortage and Surplus On US-97

US-97 Segment I (Biggs Junction to Grass Valley)			US-97 Segment II (Grass Valley to California Border)		
Year	Rest Areas	Truck Stops	Year	Rest Areas	Truck Stops
2015	-10	22	2015	-7	-37
2020	-11	18	2020	-19	-78
2025	-13	13	2025	-33	-123
2030	-14	7	2030	-47	-173
2035	-16	1	2035	-64	-228

Through a sensitivity analysis, it was determined that a 10% increase in the percentage of short-haul trucks has a positive impact on truck parking demand. That is, as short-haul percentage increases, the parking shortages are decreased, and the parking surplus is increased. Conversely, a 10% decrease in short-haul percentage has a negative impact on truck parking demand. As the percentage of short-haul trucks decreases, the parking space shortages increase and parking space surplus decreases. These results suggest that parking demand is more affected by the percentage of long-haul trucks. In other words, as the percentage of long-haul trucks increases (decrease in short-haul), parking demand worsens and as the percentage of long-haul trucks decreases (increase in short-haul), parking demand improves.

In addition to the impact of short-haul percentage on truck parking demand, the effect of average truck speed was also investigated using a sensitivity analysis. Results from the sensitivity analysis indicate that as the average truck speed decreases, parking demand worsens. It was found that average truck speed impacts truck parking demand significantly more than an increase or decrease in the percent of short-haul trucks. The assessment model accounts for truck-hours of travel and includes HOS regulations. Therefore, these results suggest that as average truck speed decreases the truck-hours of travel increases and to meet HOS regulations more parking is required.

With this is mind, distinct limitations are present within the analysis. Although the method provides default values for short-haul to long-haul ratios, proportion of truck parking at rest areas and truck stops, and the amount of parking time per week, these values may differ in the Pacific Northwest. This methodology is preferred, as it includes HOS regulations when determining parking demand, but to perform a region-specific demand analysis (e.g., Pacific Northwest) a comprehensive survey of a similar sample size is recommended (roughly 2,000 drivers). Further, unique truck counts were not available and would increase the accuracy of the demand analysis. This would consist of manual counts, as well as overnight observations to observe peak-hour parking conditions at truck parking locations along the analysis segments. Another possible solution to address the data limitations is to implement the use of third-party data, such as EROAD,[11] American Transportation Research Institute,[12] FleetSeek,[13] or TRANSEARCH.[14] These datasets can provide detailed information on route, type of shipment, truck volumes, among other factors, and could be used to model truck parking demand. Ultimately, given the data available for the present study, the demand analysis offers parking demand estimates that have the potential to be improved with the recommendations for future studies.

[11] http://www.eroad.com/
[12] http://atri-online.org/
[13] http://www.fleetseek.com/
[14] https://www.ihs.com/products/transearch-freight-transportation-research.html

7.0 SAFETY IMPACT ANALYSIS

The final section of this report seeks to assess the safety impacts by utilizing the crash harm metric in the context of truck parking safety. Crash harm is defined as “a quantitative measure of the combined human and material losses from traffic crashes based on economic valuation” (*Knipling 2009*). Crash harm assessments are completed for costs occurred based on the maximum crash severity. As for truck parking enhancements, the scope of the current study did not include the implementation and observation of truck parking enhancements. As such, up-to-date enhancements implemented by states across the United States are presented and recommendations for the State of Oregon will be provided.

Due to considerable limitations within the crash data regarding if the crash occurred as a result of deficient truck parking, only at-fault truck crashes are considered for the crash harm assessment in an attempt to analyze only crashes that have the potential to be related to truck parking. Therefore, the estimations presented in this analysis represent crashes where inefficient truck parking may have been a contributing factor. For example, crashes due to fatigue may be linked with inefficient truck parking, but it cannot be stated for certain. Likewise, improper lane changing (e.g., driver attempts to abruptly exit the freeway/highway to park to meet HOS regulations) may stem from inefficient truck parking. See Section 7.3 and Section 8.6 for a full discussion on the crash data limitations and possible solutions.

7.1 CRASH HARM ASSESSMENT BY CRASH SEVERITY

Due to lack of sufficient data (collecting such data was beyond the scope of this project), the current study adopts the crash harm metrics presented by Zaloshnja & Miller (2007). These metrics have been chosen based on their comprehensiveness; that is, they are the most recent metrics that include medically related costs, emergency services costs, property damage costs, costs due to lost productivity, monetized value of pain, monetized value of suffering, and monetized value of quality of life that the family loses due to death or injury. These crash harm metrics are the average cost per heavy vehicle crash by crash severity[15]; namely, no injury crashes, non-fatal injury crashes, and fatal crashes. However, the dollar amount shown by Zaloshnja & Miller (2007) is presented in 2005 dollars as follows:

[15] The crash severity is based on the maximum severity sustained during the crash (e.g., if an occupant was killed, the crash severity is classified as fatal).

Table 7.1: Average Cost per Heavy Vehicle Crash by Maximum Crash Severity (2005)

Crash Severity	Average Cost in 2005 Dollars
No Injury (Property-Damage-Only)	\$15,114
Non-Fatal Injury	\$195,258
Fatal	\$3,604,518

Therefore, to properly estimate the crash harm in 2015 dollars (the most current year available and consistent between at least two sources), consumer price index (CPI) inflation conversion factors provided by the Bureau of Labor Statistics and Oregon State University's Political Science department were applied (*Bureau of Labor Statistics 2016*; *Sahr 2016*). The objective is to convert the 2005 dollars shown in Table 7.1 to 2015 dollars, and is accomplished by the following equation:

$$C_{2015_i} = \frac{C_i}{CF} \tag{7.1}$$

Where C_{2015_i} is the average cost per heavy vehicle for crash severity i in 2015 dollars, C_i is the average cost per heavy vehicle crash for crash severity i in 2005 dollars (shown in Table 7.1), and CF is a conversion factor equal to 0.824 used to convert 2005 dollars to 2015 dollars.[16] Applying Eq. (7.1), Table 7.1 can now be written as follows:

Table 7.2: Average Cost per Heavy Vehicle Crash by Maximum Crash Severity (2015)

Crash Severity	Average Cost in 2015 Dollars	Percent Change
No Injury (Property-Damage-Only)	\$18,342	
Non-Fatal Injury	\$236,964	+ 21.4%
Fatal	\$4,374,415	

To present the crash harm assessment for each hot spot location on the same page, crash harm assessment results begin on the following page.

7.1.1 Biggs Junction

As seen from Figure 7.1, no fatal crashes occurred in the vicinity of Biggs Junction during the years 2007 to 2014. However, 9 non-fatal injury crashes occurred, and at an average of \$236,964, these totaled \$2,132,676. As for no injury crashes, there were 13 crashes that took place near Biggs Junction. At an average of \$18,342, no injury crashes totaled \$110,052. For a summary of crash harm at Biggs Junction, see Table 7.3.

[16] Conversion factors are based on the final annual CPI average for 2015.

Table 7.3: Summary of Crash Harm at Biggs Junction

Crash Severity	Number of Crashes	Crash Harm
No Injury (Property-Damage-Only)	13	$110,052
Non-Fatal Injury	9	$2,132,676
Fatal	0	-
Total		**$2,242,728**

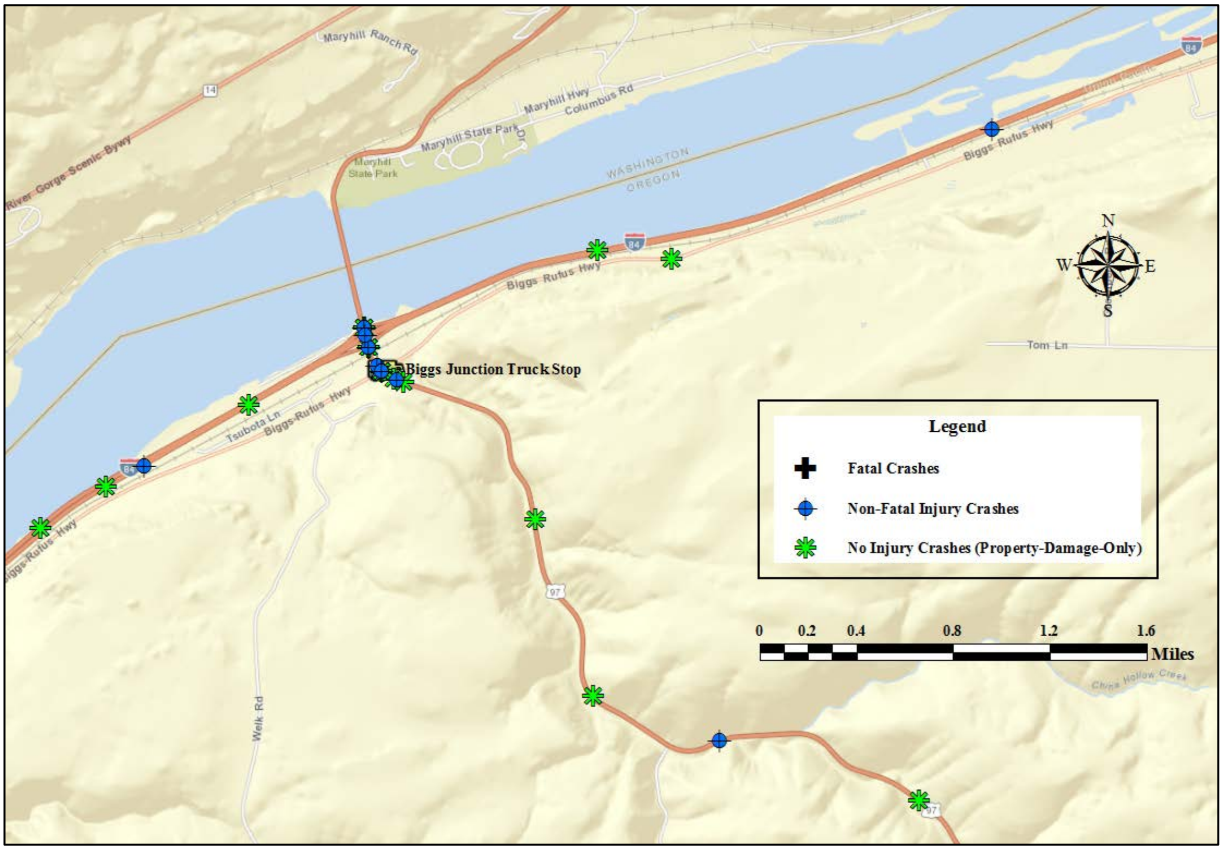

Figure 7.1: Large Truck Crashes Near Biggs Junction by Crash Severity

7.1.2 Peter Skene Ogden Wayside

Figure 7.2 shows crashes, by crash severity, near Peter Skene Ogden Wayside. In terms of non-fatal injury crashes, 13 occurred near Peter Skene Ogden Wayside. At an average of $236,964, non-fatal injury crashes culminated to $3,080,532, while no injury crashes totaled $385,182 based on 21 no injury crashes at an average of $18,342 per crash. A possible explanation for the high number of crashes here may be attributed to this segment of US-97 passing through a town where traffic volumes are higher with changing speed limits. For a summary of crash harm near Peter Skene Ogden Wayside, see Table 7.4.

Table 7.4: Summary of Crash Harm Near Peter Skene Ogden Wayside

Crash Severity	Number of Crashes	Crash Harm
No Injury (Property-Damage-Only)	21	$385,182
Non-Fatal Injury	13	$3,080,532
Fatal	0	-
Total		**$3,465,714**

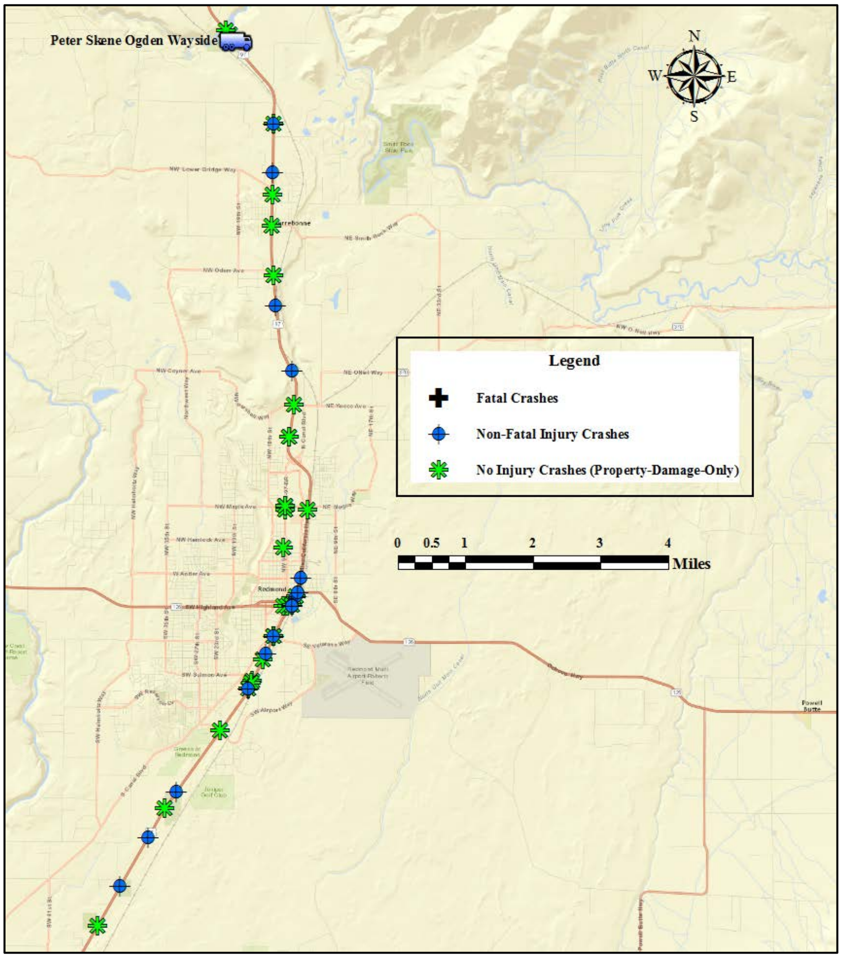

Figure 7.2: Large Truck Crashes Near Peter Skene Ogden Wayside by Crash Severity

7.1.3 Bend

Large truck crashes in Bend, by crash severity, are shown in Figure 7.3. Although several crashes took place on this segment of US-97, there was just one fatal crash ($4,374,415). In regard to non-fatal injury crashes, 14 happened here and amounted to $3,317,496. 17 no injury crashes occurred, and at $18,342 per crash, these amounted to $311,814. For a summary of crash harm in Bend, refer to Table 7.5.

Table 7.5: Summary of Crash Harm in Bend

Crash Severity	Number of Crashes	Crash Harm
No Injury (Property-Damage-Only)	17	$311,814
Non-Fatal Injury	14	$3,317,496
Fatal	1	$4,374,415
Total		**$8,003,725**

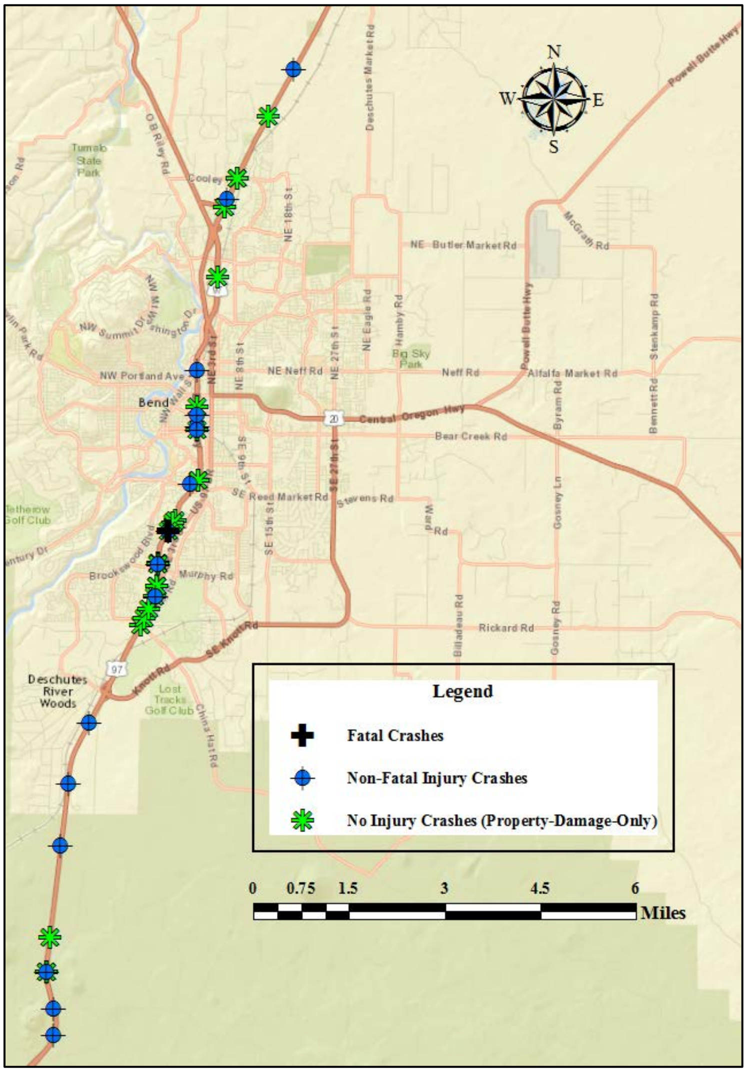

Figure 7.3: Large Truck Crashes in Bend by Crash Severity

7.1.4 Gordy's Truck Stop

Figure 7.4 displays large truck crashes near Gordy's Truck Stop by crash severity. This segment of US-97 has two fatal crashes, which consisted of a cost of $8,748,830. Compared to the previous hot spot locations, the number of non-fatal injury crashes near Gordy's Truck Stop was relatively low at nine crashes; however, these crashes still totaled $2,132,676. Once more, the largest number of crashes were no injury crashes at 17. With an average cost of $18,342, no injury crashes resulted in a cost of $311,814. Table 7.6 shows a summary of crash harm near Gordy's Truck Stop.

Table 7.6: Summary of Crash Harm Near Gordy's Truck Stop

Crash Severity	Number of Crashes	Crash Harm
No Injury (Property-Damage-Only)	17	$311,814
Non-Fatal Injury	9	$2,132,676
Fatal	2	$8,748,830
Total		**$11,193,320**

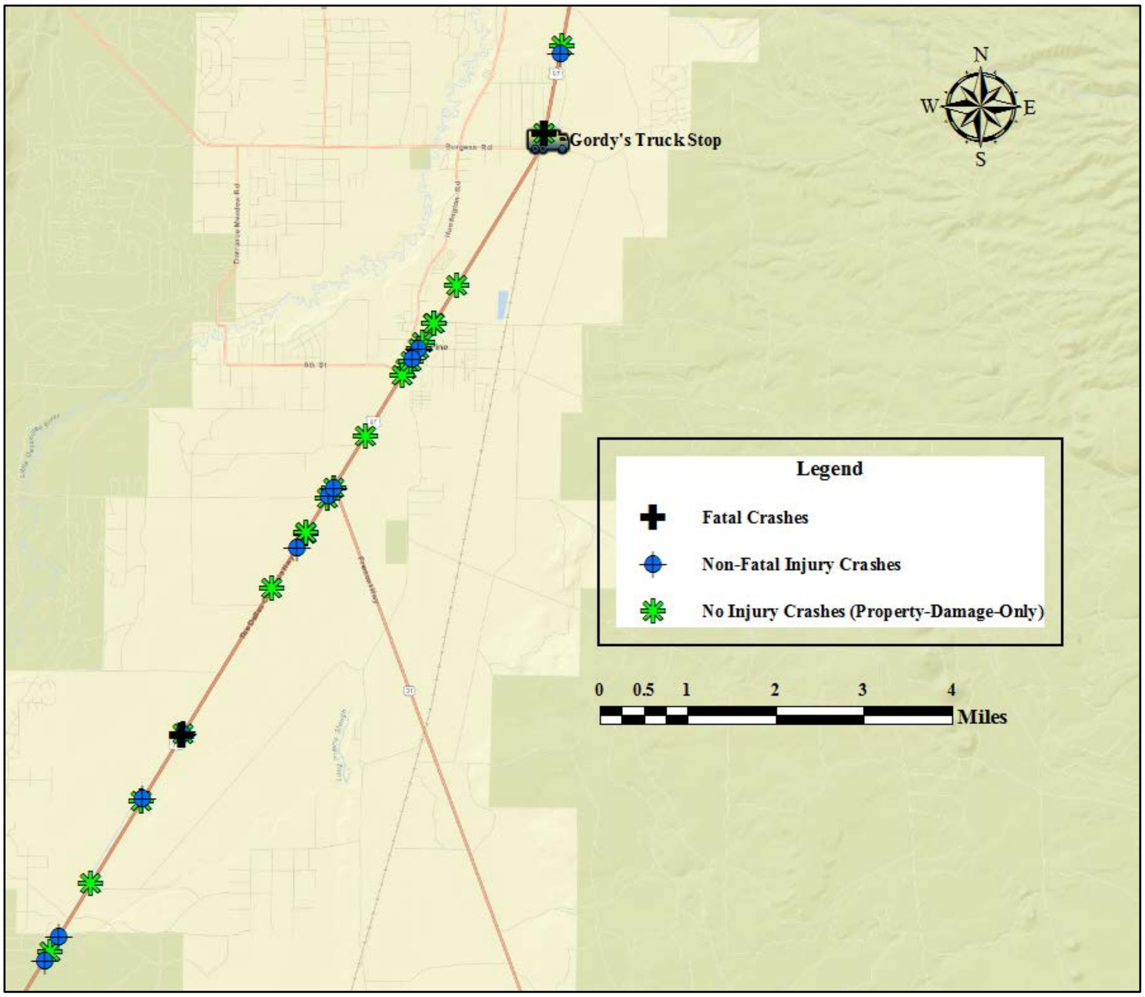

Figure 7.4: Large Truck Crashes Near Gordy's Truck Stop by Crash Severity

7.1.5 Chiloquin

Large truck crashes near the Chiloquin rest area by crash severity are displayed in Figure 7.5. This crash hot spot had three fatal crashes that, based on an average of $4,374,415 per fatal crash, amounted to $13,123,245. Regarding non-fatal injury crashes, 23 occurred along this segment of US-97 with an associated cost of $5,450,172. For no injury crashes, at an average cost of $18,342, the corresponding cost for the 34 crashes that happened here is $623,628. A summary of crash harm is shown in Table 7.7.

Table 7.7: Summary of Crash Harm Near the Chiloquin Rest Area

Crash Severity	Number of Crashes	Crash Harm
No Injury (Property-Damage-Only)	34	$623,628
Non-Fatal Injury	23	$5,450,172
Fatal	3	$13,123,245
Total		**$19,197,045**

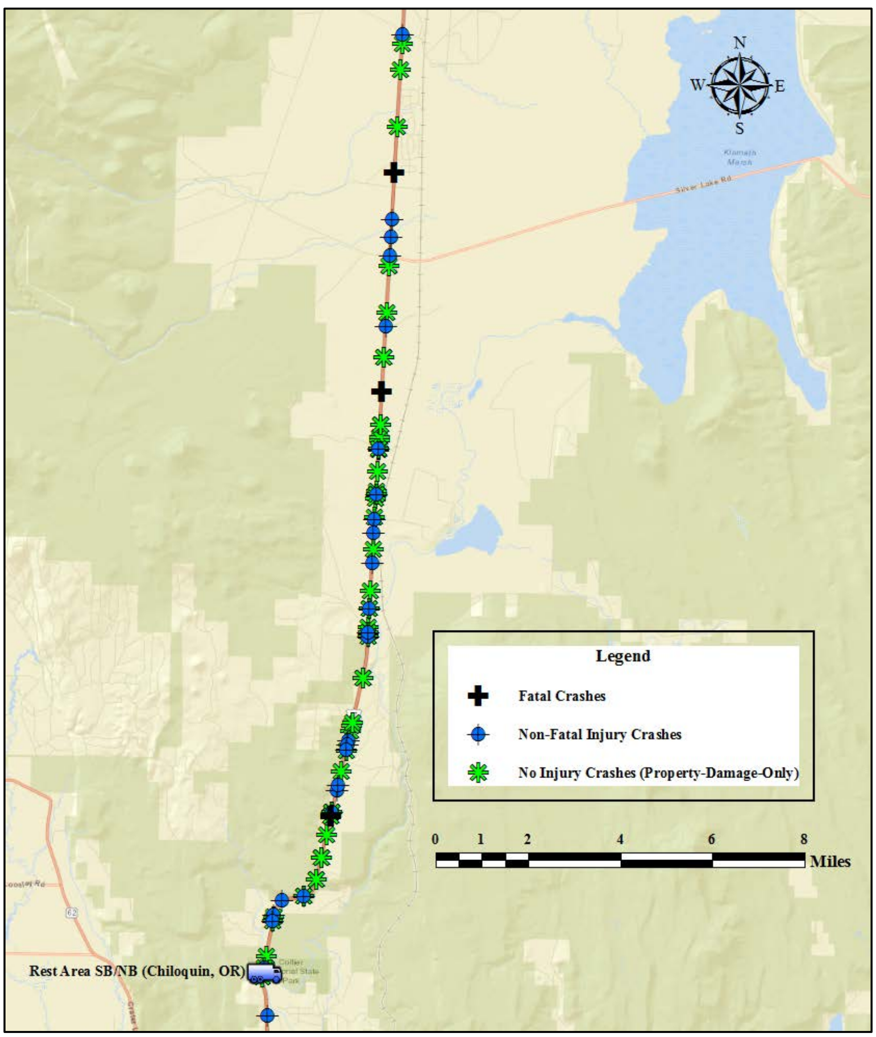

Figure 7.5: Large Truck Crashes Near Chiloquin Rest Area by Crash Severity

7.1.6 Klamath Falls

The final hot spot location for large truck crashes was near Klamath Falls and is shown in Figure 7.6. This location had the largest number of fatal crashes, six, totaling $26,246,490. In terms of non-fatal injury crashes, 18 non-fatal injury crashes occurred and had an associated cost of $4,265,352. For no injury crashes, the corresponding cost was $330,156 based on 23 no injury crashes that happened along this segment of US-97. For a summary of crash harm, see Table 7.8.

Table 7.8: Summary of Crash Harm at Klamath Falls

Crash Severity	Number of Crashes	Crash Harm
No Injury (Property-Damage-Only)	18	$330,156
Non-Fatal Injury	18	$4,265,352
Fatal	6	$26,246,490
Total		**$30,841,998**

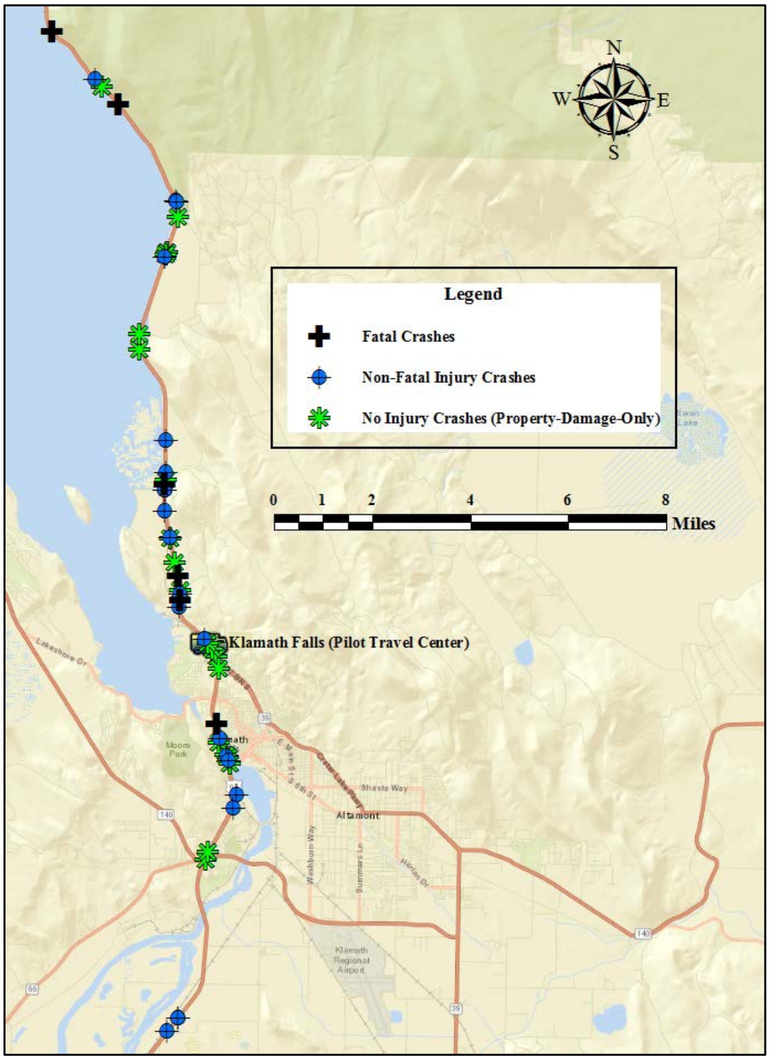

Figure 7.6: Large Truck Crash in Klamath Falls by Crash Severity

7.2 SAFETY IMPACTS OF TRUCK PARKING ENHANCEMENTS

As previously described, implementing truck parking enhancements and observing the impacts in terms of safety was not within the scope of the current study. Taking that into consideration, this section will present truck parking enhancements that have been implemented in other states and provide recommendations for the State of Oregon.

Florida conducted a truck parking study that included the assessment of technology to improve parking management by selecting one parking facility as a test location for a "smart parking system" (Bayraktar et al. 2012). In particular, the idea for the study was built on the premise that providing better information for large truck drivers can reduce the number of trucks that park on freeway shoulders/ramps and reduce the number of crashes due to driver fatigue. Bayraktar et al. (2012) implemented a "smart parking management system" to investigate this, and was based on three specific aspects (Bayraktar et al. 2012; Smith et al. 2005):

1. The "smart parking management system" **must** accurately and reliably know if a parking area is full, and if there are available spaces, it must know the exact number (*Smith et al. 2005*).

2. The "smart parking management system" **must** have the ability to archive data to ensure that historical parking occupancy data can be assembled and monitored.

3. The "smart parking management system" **must** forecast parking space availability for drivers that are approahing a given parking facility. (This must be done at a microscopic level by combining real-time parking space occupancy and the historical parking data described above.)

Following the guidelines set forth by Smith et al. (2005), Bayraktar et al. (2012) selected a wireless ground sensor that detects the presence of a vehicle as it approaches a parking facility as the intelligent transporation system (ITS) for their pilot facility; the selected ITS has the ability to differentiate between large trucks and other vehicles. The sensors collect the data and deliver the data to a central database through an internet connection, where users (e.g., truck drivers) can access the informational maps, historical reports, and various other applications that include shared databases and smart phone devices.

Upon identification of the ITS to be used, Bayraktar et al. (2012) chose rest areas in Leon County as pilot facilties to examine the effect of the "smart parking management system." Using the collected data, a GIS web mapping platform was created that dissinated specific information based on a report generation module:

1. Average occupancy by location, time-of-day, and day of the week

2. Average occupancy by location and time-of-day

3. Turnover by location

4. Turnover by location and day of the week

5. Average daily occupancy
6. Parking event details
7. Occupancy details
8. Occupancy prediction (a Kalman filter method is used)

Bayraktar et al. (2012) concluded that the proposed ITS has several benefits, such as significantly lower capital and maintence costs, high accuracy of real-time occupancy prediction, and a reliabile source for parking information. Implementing a system that can accurately predict the availability of parking spaces for drivers in real-time can reduce the number of crashes related to fatigue (drivers are not exceeding their HOS limits to find parking) and reduce the safety concerns regarding large trucks parking on freeway ramps and shoulders (drivers are not parking at unsafe locations to meet HOS requirements).

Although not directly related to safety, Felsburg Holt and Ullevig (2014) generated a list of minimum investments regarding truck parking in South Dakota Improving truck parking facilities and capacity is likely to have a positive impact on safety concerns related to truck parking (e.g., fatigued drivers due to no parking vacancies, parking on freeway shoulders, etc.). Investments in South Dakota to improve truck parking include expanding parking capacity for both large trucks and passenger vehicles, improve restroom capacity, preserve functionality of facility structures (plumbing mechanical, electrical, etc.), preserve facility conditions (pavement, lighting, etc.), and provide routine maintence and upkeep.

New Jersey began working to address their truck parking issues and the safety concerns associated with such issues in 2008 *(North Jersey Transportation Planning Authority 2008)*. This publication strongly urged New Jersey to secure parking locations as a necessary land-use, while further suggesting that both private and public entities must provide truck parking as a necessary service. In the same context, it was recommended that New Jersey advance their federal legislations to promote innovation and public-private partnerships, being that at the time of the publication federal polocies addressing the truck parking issues were neither sufficient nor comprehensive (*North Jersey Transportation Planning Authority 2008*)—specifically, provide a framework for multistate initiatives, update decades old restrictions on public versus private facilities, encourage private investments to expand parking capacity, implement ITS technology, and find new funding sources. As a result of such a partnership, there can be an equitable approach in regard to providing public benefits (e.g., increase safety) while still maintaining the interests of private industries (North Jersey Transportation Planning Authority 2008).

Planning and finance were among the recommendations presented, such as giving incentives for private industries to develop truck parking facilities or remodel existing ones (North Jersey Transportation Planning Authority 2008). Another option is to incorporate truck parking as a future design parameter for facility improvement projects, such as including truck parking for highway improvement projects. Ultimately, enhancing the manner in which truck parking facilities are considered for design and planning, promoting cooperation between public and private sectors, and promoting multistate projects can have a residual impact on safety while addressing all aspects associated with truck parking issues.

A study in Minnesota identified low-cost solutions to enhance truck parking and, as a result, address the safety concerns that stem from truck parking inefficiencies (*Maze et al. 2010*). For instance, low-cost solutions may consist of identifying abandoned or available hard-surface facilities and convert them to sleeping-mode facilities for commercial motor vehicle operators (*Maze et al. 2010*). Maze et al. (2010) further suggest that redesigning existing parking layouts or restriping would be a low-cost solution to enhance parking capacity. In terms of long-term enhancements, surveyed drivers in Minnesota have indicated they would like real-time information regarding availability of parking spaces at upcoming parking facilities through the use of electronic roadside signs or smart phone applications. To enhance this aspect, Minnesota has embraced the comments from the drivers and are working the idea of real-time information into future funding plans. Since the conclusion of this study, Minnesota has developed a system to assist drivers in finding safe and legal parking. Specifically, images taken by networks of digital cameras are used to count the number of open parking spaces and then fed to drivers in real-time (*Tompkins et al. 2014*). Early demontrations at the time of implementation resulted in approximately 60% of drivers saying the system helped in finding safe and legal parking (*Coss 2016*).

A recent American Transportation Research Institute study suggested avenues for future enhancements in terms of three areas (*Boris and Brewster 2016*):

1. Public Sector
2. Truck Stop Operators
3. Driver Behavior

With regard to the public sector, some states are already creating and implementing real-time information systems. However, several states have not adopted this technology. Therefore, an alternative solution could consist of increasing the time limits at rest areas, in addition to allowing trucks to park at public works facilities and weigh stations. Another manageable enhancement to address truck parking issues and associated safety concerns, in terms of the public sector, would be to reopen facilities that have closed or expand existing facilities (*Boris and Brewster 2016*). Developing new facilities is also an option, but may not be feasible due to land-use and cost. For that reason, Boris and Brewster (2016) suggest that legal obstacles met by private truck stops when opening a new facility or expanding an existing facility be reduced.

As for truck stop operators, there are currently two truck stop chains that offer parking reservations that begin at 4:00 p.m. (also the peak parking hour *[Boris and Brewster 2016]*). Enforcement of truck stop “parking manners” is another viable solution to maximize existing capacity (e.g., drivers would not be able to use multiple parking spaces for just one truck), therefore reducing the number of trucks that park in illegal and unsafe locations. Providing parking dedicated strictly for bobtails would also increase capacity being that bobtails would not have to park in locations designated for tractor trailers.

Lastly, turning to driver behavior, Boris and Brewster (2016) suggest this is the primary factor that can impact parking issues (e.g., comprehensive planning that is crucial to maximize revenue-earning miles). Drivers can improve productivity and safety by shifting their hours of operations to weekends, as driver diaries indicated that fewer parking issues are encountered on the weekends.

In Wisconsin, parking management systems are being considered for implementation (*Adams et al. 2009a*). Many drivers have indicated that real-time information regarding available parking spaces would be useful due to their usual stopping locations being unavailable as a result of the number of trucks and volume of freight continuously increasing. In particular, Adams et al. (2009a) suggest that parking availability can be integrated into the decision software used by drivers and carriers to select refueling locations. Further, the authors state that Maryland publishes a truck map and motor carrier handbook that is available online and lists private truck stops, Park-N-Ride lots, and weigh stations with overnight parking (*Adams et al. 2009a*)—this is similar to the Trucker Path app currently used by drivers, yet it does not provide recent updates on available parking spaces. With that in mind, usage of mobile device while driving to obtain real-time information can have a negative impact on safety due to driver distraction.

Adams et al. (2009a) further suggest that radio broadcasting real-time parking availability could be an economically viable solution to reduce freeway shoulder parking and fatigued driving. Lastly, cellular phone based solutions that do not contribute to driver distraction (e.g., use of a hands-free device, such as Bluetooth) can be a solution. For instance, the use of traveler information systems can be used to disimenate parking availability. These sysetms already report traffic delays, weather, transit information, tourist information, etc. Therefore, incorporating truck parking availability by working with local departments of transportation can help to mitigate parking issues and the associated safety concerns; roughly 70% of the United States population has access to this system.

Since the conclusion of the above study, Wisconsin has implemented a new system designed to monitor truck parking and relay information regarding open spaces through intelligent transportation system signage (*Delozier 2016*; *Wisconsin Department of Transportation 2016*). Currently, four rest areas are being served with this technology, but Wisconsin plans to implement this technology at seven additional rest areas by the end of 2017. Through this implementation, Wisconsin seeks to improve efficiency, as well as save lives by getting fatigued truck drivers off the road quicker, although safety metrics since the implementation of this technology are not yet available.

7.3 SUMMARY OF CRASH HARM AND SAFETY IMPLICATIONS

A crash harm assessment by maximum crash severity was determined for each identified large truck crash hot spot. To provide the most current crash harm in terms of dollar amount, an inflation factor based on CPI was used to convert 2005 dollars to 2015 dollars. For each hot spot location, crash harm was given by severity; therefore, the following table summarizes the total crash harm by crash hot spot. The total harm along US-97 amounted to $74,944,530 in 2015 dollars. For a summary of crash harm, see Table 7.9.

It should be noted again, however, that the values presented in Table 7.9 are based on at-fault truck crashes where truck parking deficiency could have been a contributing factor. This is a major shortcoming, as there is no efficient method to estimate the cost of truck parking related crashes without crash records that indicate if a crash occurred as a result of truck parking. To address this, the primary solution would be to update crash data collection forms, both for police reporting and self-reporting, to include information regarding if the crash was related to truck parking (i.e., driver that has exceeded HOS regulations due to inadequate parking and a crash occurred due to fatigue). Unless addressed, this will remain an obstacle in determining the link between crashes and deficient truck parking. Therefore, these estimates are likely quite more than actual values and inferences from these estimates need to consider such.

Table 7.9: Crash Harm by Hot Spot and Crash Severity

Hot Spot Location	No Injury	Non-Fatal Injury	Fatal	Total
Biggs Junction	$110,052	$2,132,676	-	**$2,242,728**
Peter Skene Ogden Wayside	$385,182	$3,080,532	-	**$3,465,714**
Bend	$311,814	$3,317,496	$4,374,415	**$8,003,725**
Gordy's Truck Stop	$311,814	$2,132,676	$8,748,830	**$11,193,320**
Chiloquin Rest Area	$623,628	$5,450,172	$13,123,245	**$19,197,045**
Klamath Falls	$330,156	$4,265,352	$26,246,490	**$30,841,998**
Total	**$2,072,646**	**$20,378,904**	**$52,492,980**	**$74,944,530**

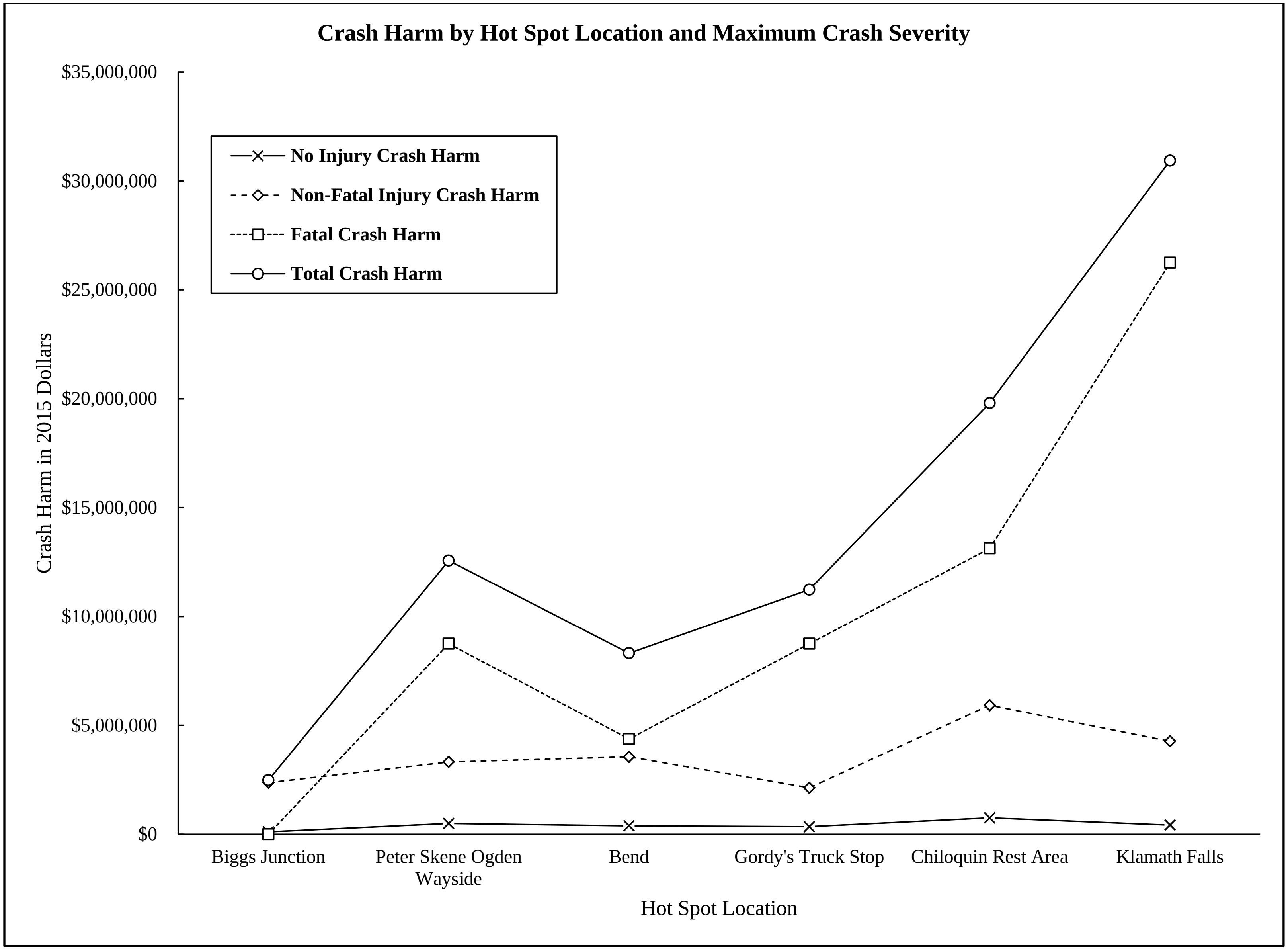

Figure 7.7: Crash Harm by Hot Spot Location and Maximum Crash Severity

Figure 7.7 shows that the large truck crash harm increases closer to the California border (more crashes are occurring). This may be a result of encountering troubles finding safe and adequate parking in Southern Oregon, as well as other factors (e.g., the change in speed limits, pavement condition, signage, etc.).

In regard to potential truck parking enhancements, it was not within the scope of the current study to implement enhancements and observe the effects of said enhancements. As such, enhancements implemented or recommended by other states were discussed. The most common takeaway consisted of the dissemination of real-time parking information through radio broadcasting, smart phone applications, or ITS (e.g., electronic roadway signs). One particular enhancement that could be immediately implemented in the State of Oregon is the 511 traveler information system and it reporting truck parking availability. Oregon's TripCheck[17] currently reports road closures, delays, weather hazards, construction locations, and is linked with the smart phone application Waze[18]. Therefore, incorporating data from an application, such as Trucker Path, could assist with parking issues while mitigating the associated safety concerns. Further, the drivers could dial the traveler information system and hear real-time information regarding available parking. Figure 7.8 shows that US-97 has the adequate cellular coverage to implement this right away.

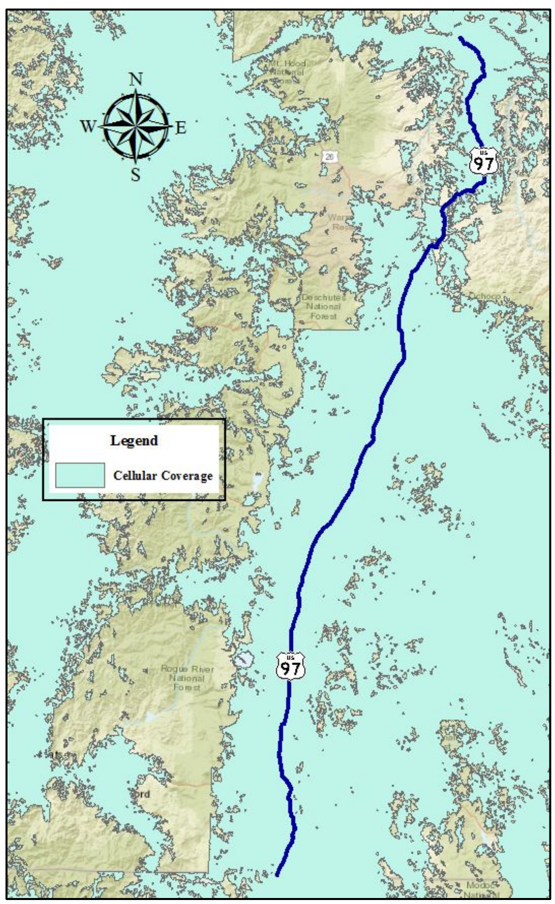

Figure 7.8: Cellular Coverage Along US-97

[17] https://tripcheck.com/Pages/RCMap.asp
[18] https://www.waze.com/

8.0 SUMMARY AND RECOMMENDATIONS

The current study surveyed county, state, and federal agencies to gain a better understanding of truck parking issues in the Pacific Northwest. In addition, 201 large truck drivers that deliver goods in the Pacific Northwest were surveyed to shed light on truck parking issues from a driver's perspective. To assess current conditions in a safety context, large truck involved crashes within the study area from 2007 to 2014 were examined. In addition to crash trends, a hot spot analysis was conducted to identify crash hot spots and their locations relative to truck parking facilities. Upon a current conditions assessment, a current parking demand and future parking demand assessment were completed utilizing available traffic data and a method provided by FHWA. Lastly, a safety impact analysis was presented in terms of crash harm (a comprehensive cost of each large truck crash based on maximum crash severity). The remainder of this section will summarize each of the above-mentioned analyses.

8.1 SUMMARY OF AGENCY SURVEYS

Survey results indicated that the surveyed agency representatives are moderately to extremely concerned with truck parking. However, the majority of representatives stated that truck parking at private truck stops was not a concern. On the other hand, truck parking on freeway shoulders, at designated pullouts/vista points, interchange ramps, and on highway roadsides are of grave concern to the surveyed agency representatives. Survey results suggest that agencies, based on the responses of their representatives, are not concerned with private facilities (e.g., private truck stops), but are vastly concerned with county, state, and federally owned areas (e.g., freeway shoulders, designated pullouts/vista points, etc.). These findings suggest that public and private agencies need to work together to resolve truck parking issues, which was also a common thread in the various reports completed by other State Departments of Transportation.

The current study had agency representatives from six states, with a total of 20 usable responses; therefore, a more comprehensive survey in terms of states represented would provide a more holistic view of truck parking issues.

8.2 SUMMARY OF DRIVER SURVEYS

As a requirement of the survey, all 201 drivers surveyed deliver goods within the Pacific Northwest. In terms of age and the number of years the surveyed drivers have been driving a truck, survey results indicated that nearly 77% (154) of drivers were younger than 49 years of age and 64% (129) of drivers have been driving a truck for less than 10 years. As for type of shipment and parking decisions, roughly 78% (156) of drivers surveyed indicated that their trips consist of truckload shipments, and 85% (171) of drivers make parking decisions themselves (i.e., their company does not make parking decisions for them). Of the 201 surveyed drivers, approximately 39% (78) stated that they encounter trouble when finding a safe and adequate location to park. With regard to the time of day when drivers most often experience parking troubles, 12:00 a.m. to 5:59 a.m. and 4:00 p.m. to 11:59 p.m. are of most concern to drivers. The majority of drivers stated that parking troubles were experienced the most on Fridays; still, at least 25% (50) of the surveyed drivers indicated they encountered parking troubles each day of the week (i.e., each day of the week had at least 25% of the drivers state they encountered parking issues). For months of the year, drivers indicated that the winter months (November, December, and January), and the summer months of June and July were the most difficult months to find safe and adequate parking.

Parking on freeway ramps and shoulders, according to the surveyed drivers, is most likely due to no nearby parking facilities being present and nearby truck stops and/or rest areas being at capacity. Regarding the importance of features at a truck stop or rest area, the surveyed drivers stated that convenience to the highway, fuel, well-lit parking lots, and restrooms are the most essential features when selecting a place to park; travel information and entertainment were least important. Drivers suggested that the most useful information is real-time information regarding parking availability and is consistent with previous parking studies discussed in Section 7.2. Improvements that would increase the effectiveness of truck parking, based on driver responses, include expanding parking capacity; separate parking for trucks, cars, and RVs; improved parking layouts; and providing real-time information.

8.3 SUMMARY OF CURRENT CONDITIONS

Based on historical crash data, the time-of-day periods with the largest number of crashes were 5:00 a.m. to 10:00 a.m. at 23%, 10:00 a.m. to 3:00 p.m. at 28%, and 3:00 p.m. to 8:00 p.m. at 24%. 50% took place on Wednesday, Friday, or Saturday, and 50% happened during the winter months (November, December, January, and February). In general, these trends correspond to the times that drivers encounter problems when finding for a safe and adequate location to park. Large truck VMT on the pilot corridor of US-97 accounts for 19% of the total VMT on US-97, where large truck VMT accounts for just 9% of total VMT statewide. In terms of total injury severity, the large truck proportion on US-97 is significantly higher than the large truck proportion for the entire State of Oregon. However, US-97 did not have any “Serious” injury crashes in 2013. Ultimately, when looking only at large truck crash trends on US-97, the proportion of crashes, injury severity, and rates are much higher than when looking at Oregon holistically.

As for large truck crash hot spots, Biggs Junction, just south of Peter Skene Ogden Wayside, just south of Bend, Gordy’s Truck Stop, near Chiloquin rest area, and Klamath Falls were crash hot spot locations with at least 95% confidence. Therefore, results from this analysis suggest a correlation between truck parking facilities and crash hot spots. Although unable to state for certain if these crash hot spots are related to truck parking, the statistical and geospatial crash hot spot analysis provides evidence that there is an association. Due to crash data limitations, however, further work is needed to investigate these crash hot spots and assess any safety concerns that are directly related to truck parking issues.

8.4 SUMMARY OF PARKING DEMAND ASSESSMENT

Using the parking assessment model developed by FHWA, this study applied the most recent AADT data to determine parking shortages or surplus along the pilot corridor of US-97. Current demand exceeds current capacity on along the I-84 segment, as no rest areas are present. Similarly, current demand along Segment I of US-97 exceeds capacity due to no rest areas being located along this segment. Biggs Junction, however, has a surplus of spaces based on the proposed assessment model. As for Segment II, current demand marginally exceeds capacity at rest areas (5 spaces) and significantly exceeds capacity at truck stops (30 spaces).

In regard to the forecasted demand, Segment I maintains a surplus of parking spaces until 2035. (This does not include truck traffic from I-84.) On Segment II, there is a substantial increase in shortages at both rest areas and truck stops, 7 spaces in 2015 to 64 spaces in 2035 at rest areas and 37 spaces in 2015 to 228 spaces in 2035 at truck stops. In addition, a sensitivity analysis was conducted to determine the impact of the short-haul to long-haul ratio and the average truck speed presented in the FHWA assessment model. With respect to the short-haul to long-haul ratio, the demand based on a 10% increase and 10% decrease in the number of short-haul trucks was identified. With an increase in the percentage of short-haul trucks, shortages were decreased and surplus was increased; a higher percentage of short-haul trucks has a positive impact on parking demand. On the other hand, a decrease in short-haul trucks has a negative impact on parking demand being that it increases the shortages at rest areas and truck stops. Average truck speed had a more significant impact on parking demand. In particular, as average truck speed decreases, parking demand worsens and shortages have a significant increase.

8.5 SUMMARY OF SAFETY IMPACTS

Converting 2005 dollars to 2015 dollars using CPI, the total crash harm on the pilot corridor of US-97 was estimated to be $74,944,530. In addition, crash harm estimates increased closer to the California border. The increase in crash harm near the California border may be attributed to the higher speeds seen in Southern Oregon, in which drivers headed south often increase speed to make-up for time lost when traveling on the northern segment of US-97. (This is generally a result of the topology in Northern Oregon.) Once more, however, this crash harm estimate has been determined for at-fault truck crashes in which trucking deficiency may have been a contributing factor. As described previously, until crash data collection forms have an explicit section for truck parking related crashes, crash harm and other safety assessments must operate under the assumption that specific at-fault truck crashes (e.g., due to fatigue) may have been a result of inadequate truck parking. With regard to truck parking enhancements, others states have either implemented systems or plan to implement a system based on previous research (e.g., radio broadcasting, smart phone applications, and electronic roadway signs). In general, real-time information is the most preferred method to enhance truck parking and improve safety.

8.6 LIMITATIONS AND FUTURE WORK

Although the parking assessment model presented in this work was recently used in 2015 (*Higgins et al. 2015*), the model and its corresponding parameters were established in 2002 (*Pécheux et al. 2002*). Using this assessment framework, the current study was able to produce demand estimates, yet the development of a region-specific assessment model is recommended. Key parameters, such as the long-haul to short-haul ratio, may be different by geographic region. A survey that consists of questions designed for a parking assessment model and a large number of observations, as well as in-the-field observations, would provide the needed data to generate an up-to-date parking assessment model for the Pacific Northwest. This also presents an opportunity to utilize third-party data, such as EROAD, to secure the necessary data for modeling truck parking demand. In addition, the proposed assessment model is designed to assess a single corridor, yet a method to model demand at a junction (e.g., Biggs Junction) is preferred; this could also be accomplished with the necessary data.

Related to the above recommendation, unique truck counts for the segment of interest would better the demand estimates. As is, the available traffic count data differs from segment to segment (sometimes in two- to five-mile segments); therefore, to assess parking an average truck count based on large truck AADT must be used. This too would involve field observations or the use of third-party data for the study corridor. With regard to crash harm, the most recent values are in 2005 dollars. Despite the fact that the current study converted the crash harm metrics to 2015 dollars, a more recent metric is preferred. This would, however, involve the collection of data that is often difficult to attain (e.g., medical data, insurance data, monetary values related to pain and suffering, etc.).

With regard to crash data, there is room for significant improvement. As is currently the case, crash data does not contain information regarding if a crash was related to truck parking deficiencies. As a result, crash harm assessments (or any other safety assessment) with regard to crashes that occurred as a result of inefficient truck parking must be estimated under the assumption that the crash may have occurred due to truck parking shortages. For example, crashes that happened due to driver fatigue may be a result of drivers exceeding HOS regulations due to inefficient truck parking, but no exact correlation can be made. Therefore, to better the safety assessment, associated costs, and potential project investments, future studies need to analyze truck parking related crashes with more certainty. This can be achieved by adding a box on crash data collection forms that allows police-reporting or self-reporting to indicate if the crash occurred as a result of inefficient truck parking. Another option, although costly, could include conducting a study along a corridor where all crashes are investigated to determine if it was related to truck parking shortages. Ultimately, until researchers and transportation agencies are able to fully identify the crashes that are directly related to truck parking deficiencies, there will remain a distinct challenge.

In terms of parking enhancements, there is considerable room for future work. For instance, Oregon has the platform for implementing real-time information through the traveler information system and/or TripCheck. A future study could implement this technology for a given corridor in Oregon and evaluate its impact (e.g., determine if there is a significant difference in the number of trucks parked in illegal and/or unsafe location, such as freeway shoulders, interchange ramps, etc.). Selecting a corridor to implement electronic signage that reports vacancies for upcoming parking facilities can be another option, as similar signage and work is being done in the context of work zones in Oregon. In addition, a method to evaluate safety implications of specific truck parking enhancements would help transportation agencies select the most efficient truck parking enhancements to meet their needs. This could be accomplished through a multi-partner project, such as federal agencies, state agencies, and the trucking industry, in which a single corridor is selected and examined; depending on the size of the project, multiple corridors could be examined based on functional class of road. The goal of the project would be to develop crash modification factors for each truck parking enhancement examined to assist decision makers.

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APPENDIX A

SAMPLE CALCULATION OF TRUCK PARKING DEMAND

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A.1 TRUCK PARKING DEMAND

1. Determine the average-truck-travel-time (TT):

$$\mathrm{TT} = \frac{\mathrm{L}_i}{\mathrm{S}_i} = \frac{(261\ \text{miles})}{\left(55\ {}^{\text{miles}}\!/_{\text{hour}}\right)} = 4.75$$

$$\mathrm{TT} = 4.75$$

2. Determine the daily truck-hours of travel for short-haul and long-haul:

$$\mathrm{THT_{SH}} = \mathrm{P_{SH}} \times \mathrm{V}_i \times \mathrm{TT} = (0.36)(2{,}507)(4.75) = 4{,}283$$

$$\mathrm{THT_{LH}} = \mathrm{P_{LH}} \times \mathrm{V}_i \times \mathrm{TT} = (0.64)(2{,}507)(4.75) = 7{,}614$$

$$\mathrm{THT_{SH}} = 4{,}283 \qquad \mathrm{THT_{LH}} = 7{,}614$$

3. Determine the daily short-haul hours of parking demand:

$$\mathrm{THP_{SH}} = \frac{\mathrm{D_{ST}THT_{SH}}}{60} = \frac{(5)(4{,}283)}{60} = 357$$

$$\mathrm{THP_{SH}} = 357$$

4. Determine the daily long-haul hours of parking demand:

$$\mathrm{THP_{LH}} = \frac{{}^{\text{Parking Time}}\!/_{\text{Week}}}{{}^{\text{Driving Time}}\!/_{\text{Week}}} \times \mathrm{THT_{LH}} \times \frac{\mathrm{D_{ST}THT_{LH}}}{60} = \frac{(49)}{(70)} \times (7{,}614) \times \frac{(5)(7{,}614)}{60}$$

$$\mathrm{THP_{LH}} = 5{,}964$$

5. Determine the truck parking demand for short-haul and long-haul trucks:

$$\text{PHP}_{\text{SH}} = \text{PPF}_{\text{SH}} \times \text{THP}_{\text{SH}} = (0.02)(357) = 7$$

$$\text{PHP}_{\text{LH}} = \text{PPF}_{\text{LH}} \times \text{THP}_{\text{LH}} = (0.09)(5{,}964) = 537$$

6. Determine parking demand at truck stops and rest areas:

$$\text{PHP}_{\text{SH/RA}} = \text{P}_{\text{RA}} \times \text{PHP}_{\text{SH}} = (0.23)(7) = 2$$

$$\text{PHP}_{\text{SH/TS}} = \text{P}_{\text{TS}} \times \text{PHP}_{\text{SH}} = (0.77)(7) = 5$$

$$\text{PHP}_{\text{LH/RA}} = \text{P}_{\text{RA}} \times \text{PHP}_{\text{LH}} = (0.23)(537) = 123$$

$$\text{PHP}_{\text{LH/TS}} = \text{P}_{\text{TS}} \times \text{PHP}_{\text{LH}} = (0.77)(537) = 413$$

7. Assess truck parking demand:

Parking Facility	Available Spaces	Required Spaces	Shortage
Rest Area	106	125	-19
Truck Stop	341	419	-78