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I-15 EXPRESS LANES STUDY

Phase I: System Evaluation

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Final Report
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16. Abstract

The primary objectives of this research included an identification of literature in Utah and nationally on how changing toll rates, occupancies, and violation rates have had an effect on Express Lane use and an examination of the utilization of the Express Lanes under a limited number of congestion and pricing scenarios. The results of this study indicate that while the majority of the Express Lane corridor within the state of Utah is operating within acceptable ranges set by the Utah Department of Transportation (UDOT) and Federal Highway Administration (FHWA), there are several zones where 10^{th} percentile speeds have dropped below the 55 mph goal set by UDOT including Zones 140 and 145 in the AM peak and Zones 145, 250, and 260 in the PM peak. Additionally, the 10^{th} percentile speeds in Zone 255 in the PM peak have dropped below the FHWA requirement of 45 mph.

There are several methods to reduce the volume in the Express Lanes, which, if implemented, are anticipated to increase the speeds within these lanes. These methods include: 1) increase Express Lane tolls during peak periods; 2) increase the High Occupancy Vehicle (HOV) limits in the Express Lanes; 3) reduce violation rates along the corridor through methods such as improved enforcement, education, campaigns, etc. and 4) enforce current cap for “C” decal vehicles in the Express Lanes and consider options for increasing the number of “C” decals issued for off-peak travel and/or travel outside of the congested areas during peak periods.

To better understand the impacts of the alternatives additional research is necessary including a detailed analysis of average vehicle occupancy (AVO) in the Express Lanes and the GP lanes and a more detailed analysis of enforcement alternatives for the state. Additional research could also include a survey of travelers to better estimate their toll price elasticity, and a detailed analysis of the geometry of the Express Lane corridor.

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AASHTO	American Association of State Highway and Transportation Officials
AFV	Alternative Fuel Vehicle
AVI	Automatic Vehicle Identification
AVO	Average Vehicle Occupancy
BYU	Brigham Young University
"C" decal	Clean fuel vehicle decal permit
CMV	Commercial Motor Vehicle
CNG	Compressed Natural Gas
EB	Eastbound
EMS	Emergency Medical Services
EPA	Environmental Protection Agency
FHWA	Federal Highway Administration
GP	General Purpose
HOT	High Occupancy Toll
HOV	High Occupancy Vehicle
ILEV	Inherently Low-Emissions Vehicle
LEEEV	Low-Emission and Energy Efficient Vehicle
LEV	Low-Emissions Vehicle
LNG	Liquid Natural Gas
LPR	License Plate Reader
Metro	Houston Metropolitan Transit
MUTCD	Manual on Uniform Traffic Control Devices
NB	Northbound
NCHRP	National Cooperative Highway Research Program
NJDOT	New Jersey Department of Transportation
PANYNJ	Port Authority of New York and New Jersey
PeMS	Performance Measurement System
SAFETEA-LU	Safe Accountable Flexible and Efficient Transportation Act: A Legacy for Users
SB	Southbound
SOV	Single Occupancy Vehicle

SUV	Sport Utility Vehicle
TAC	Technical Advisory Committee
TxDOT	Texas Department of Transportation
UDOT	Utah Department of Transportation
ULI	Urban Land Institute
USDOE	United States Department of Energy
vphpl	Vehicles per Hour per Lane
VES	Violation Enforcement Systems
VTMS	Variable Toll Message Signs
WB	Westbound
WFRC	Wasatch Front Regional Council
WSDOT	Washington State Department of Transportation
XBL	Exclusive Bus Lane

EXECUTIVE SUMMARY

The primary objectives of this research included an identification of literature in Utah and nationally on how changing toll rates, occupancies, and violation rates have had an effect on managed lane (i.e., Express Lane or High Occupancy Toll (HOT) lane) use and an examination of the utilization of the I-15 Express Lanes under a limited number of congestion and pricing scenarios. The research analyzed the data for the Express Lanes in Utah including an analysis of speed, volume, and toll rates within the lanes and a detailed analysis of Express Pass transponder and "C" decal use within the Express Lanes. The results of this study indicate that the majority of the Express Lane corridor in the state of Utah is operating within the 10th percentile speed goal of 55 mph set by the Utah Department of Transportation (UDOT) and the 45 mph requirement set by the Federal Highway Administration (FHWA). There are; however, some zones where 10th percentile speeds have dropped below 55 mph. The zones where the speeds were reported to drop below 55 mph using either transponder data or the UDOT Performance Measurement System (PeMS) data include Zones 140 (North Utah County) and 145 (South Valley) in the AM Peak Period and Zones 145 (South Valley), 250 (Salt Lake), and 260 (North Utah County) in the PM Peak Period. Additionally, the 10th percentile speeds in Zone 255 (South Valley) in the PM Peak Period have dropped below 45 mph based on the analysis. While UDOT does report at the zone level, the Department does not require each zone to be above 55/45 mph for the system to meet the specific goal/requirement.

There are several methods to consider in an effort to reduce the volume in the Express Lanes and subsequently increase the speeds within the lanes. The primary methods identified in the research include:

1. Increase Express Lane tolls during peak periods, including an increase in the maximum allowable toll.
2. Increase the High Occupancy Vehicle (HOV) limits in the Express Lanes from 2+ to 3+ persons per vehicle during peak periods.
3. Reduce the violation rate along the corridor through methods such as improved enforcement, education campaigns regarding policies related to the proper use of the Express Lanes, and the consideration of a "HERO" program for public enforcement.

In an effort to increase the number of “C” decal vehicles in the state, the following was also identified as an important component of the Express Lane study:

4. Enforce current cap for “C” decal vehicles in the Express Lanes and consider options for increasing the number of “C” decals issued for off-peak travel and/or travel outside of the congested areas during peak periods.

In addition to the primary methods, several other alternatives to reduce the volume in the Express Lanes were brainstormed by the Technical Advisory Committee (TAC) to consider at a future date including:

5. Examine the lanes to see if there are specific locations where the speeds are degrading due to geometric design or weaving with the general purpose (GP) lanes and identify design changes to help improve performance and to address some or all of the speed degradation.
6. Add an additional HOV/HOT lane.
7. Remove some HOT lane access points to reduce the number of merge areas along the corridor.
8. Install rumble strips between the double white lines to discourage drivers from crossing the lines illegally.

To better understand the impacts of the alternatives additional research is necessary to address each of the primary methods outlined.

1.0 INTRODUCTION

1.1 Problem Statement

In September 2006, the Utah Department of Transportation (UDOT) developed a system of managed lanes when the existing High Occupancy Vehicle (HOV) lanes along the Wasatch Front were converted to Express Lanes, also known as High Occupancy Toll (HOT) or "managed" lanes, providing an opportunity for Single Occupancy Vehicles (SOVs) to travel in the HOV lanes for a fee. From the opening of these Express Lanes in September 2006 until August 2010, SOVs paid a flat monthly fee to use the lanes. UDOT allowed up to 2,200 vehicles to purchase a monthly pass for $50 per month. This pass allowed unlimited usage of the Express Lanes by the SOVs. Therefore, it masked the true cost of using the Express Lanes from the travelers. In effect, it encouraged use of the lanes so that travelers could "get their money's worth" from the monthly pass.

Beginning in August 2010, the Express Lanes began to charge SOVs for each trip taken on the lanes. In addition, the price per trip varied based on the amount of congestion experienced in the Express Lanes at that time. This new pricing system opened up the potential user base to many more travelers as it was no longer limited to 2,200 users and better aligned the cost of travel on the lanes to the true societal costs. As part of the requirements for the Express Lanes, UDOT has set specific speed values that must be met on the system. The goal set by UDOT is to maintain speeds at, or above, 55 mph 90% of the time (10^{th} percentile speed), while the Federal Highway Administration (FHWA) has required that the lanes operate at a minimum speed of 45 mph 90% of the time. As of 2013 there are 62 miles of Express Lanes along the Wasatch Front extending from Spanish Fork in the south to Layton in the north (UDOT 2013).

The purpose of this research is to examine the utilization of the Express Lanes and to provide guidance to UDOT on future use and policies with regards to the Express Lanes.

1.2 Objectives

The primary objectives of this research include:

- Examine the utilization of the Express Lanes under a limited number of congestion and pricing scenarios.
- Identify literature in Utah and nationally on how changing toll rates, occupancies, and violation rates have had an effect on managed lane use.
- Provide limited recommendations on Express Lanes use.
- Provide recommendations on needed additional data collection efforts to better quantify results and propose changes with respect to Express Lane policies and use.

It is anticipated that this will continue to be an ongoing effort. Future phases of the research will be developed to collect additional data that will aid in better defining issues and proposing solutions to address the use of the Express Lanes.

1.3 Scope

1.3.1 Kickoff Meeting

The first task for this project was a kickoff meeting with the research team and the Technical Advisory Committee (TAC) to discuss and evaluate the roadway inventory data, to review the scope and schedule, and to introduce all members of the research and UDOT team. This meeting was held on January 8, 2014 and included members of the Brigham Young University (BYU) research team, the UDOT Traffic Management team members, and the UDOT Research Division representatives. At this meeting, the BYU research team identified with UDOT and the TAC the most likely policy changes that should be evaluated for the Express Lanes. This was useful to help focus later tasks on what data are critical to obtain and what scenarios must be examined.

1.3.2 Literature Review

The second task for this project involved the completion of a comprehensive literature review to train and inform new research assistants regarding the general topic of managed lanes and to address specific topics in the research including, but not limited to: managed lane configuration, pricing alternatives for managed lanes (i.e., Express Lanes or HOT lanes), vehicle occupancy use, and enforcement techniques related to managed lanes. One of the byproducts of the research being conducted in the state is the transfer of knowledge and information to help develop the next generation of transportation engineers. This task was critical in the ongoing workforce development process.

1.3.3 Data Collection

To set the stage for any possible changes to the Express Lanes in Utah, data were collected in order to quantify the current usage of the lanes. Usage data collected include:

- Number of transponders (Express Lane passes) in circulation each month.
- Number of trips made by transponder owners each month – including an analysis of the frequency with which transponder owners use the facility.
- Number of "C" decals currently in circulation statewide.
- Number of trips made by "C" decal vehicles each month.
- Speed and volume data for both Express Lanes and General Purpose (GP) lanes to determine how travel time savings may have impacted usage statistics.
- Violator data as collected in previous studies.
- Summary of Express Lane users by type ("C" decal, SOV, HOV2, HOV3+, motorcycle, etc.) using existing data.

All of the above data were obtained from previous data collection efforts due to the tight timeframe of the study.

1.3.4 Data Analysis

The purpose of this task was to analyze the data collected and to perform a sensitivity analysis of speeds, toll rates, violators, etc. This provided a snapshot of the Express Lane usage and any trends that are occurring within the lanes. This task also included projections of future use based on expected (and calculated) growth factors and elasticity rates provided by UDOT, the Wasatch Front Regional Council (WFRC), and/or from national standards outlined in the literature. All of the analysis completed helped to form the basis for the conclusions and recommendations from the research.

1.3.5 Conclusions and Recommendations

In this task, the research team identified limited conclusions and recommendations based upon observations and analyses in each of the aforementioned tasks. The compilation of this project report documenting the results of the research tasks is provided as a culmination of the results of the study.

1.4 Outline of Report

This report is organized into the following chapters: Chapter 1 Introduction, Chapter 2 Literature Review, Chapter 3 Data Collection, Chapter 4 Data Analysis, and Chapter 5 Conclusions and Recommendations. A References section follows the indicated chapters.

2.0 LITERATURE REVIEW

2.1 Overview

A comprehensive literature review was performed to gain general knowledge on managed lanes and to address specific topics. The topics included: gathering information on managed lane configuration, pricing alternatives for managed lanes, vehicle occupancy use, various enforcement techniques related to managed lanes, and violation data. The research was performed by locating recent articles and publications from various transportation organizations and from previous research done on the subject.

2.2 Managed Lane Configuration

HOV lanes have been in operation since 1969, with the first lane opening in Virginia. HOV lanes restrict access to the lane to vehicles that meet certain occupancy requirements and are in operation to provide travel time savings and more predictable travel times for those high occupancy vehicles. According to the FHWA, there are 345 HOV facilities in the United States (FHWA 2008). There are three main types of HOV lanes in use in the nation to date which include: exclusive HOV lanes, concurrent flow HOV lanes (used in Utah), and contraflow HOV lanes. Each of these lanes uses different eligibility requirements depending on the time of day and volume (NCHRP 1998).

The following present the general statistics of the HOV lanes across the nation according to the FHWA (2008). It should be noted that these statistics are constantly changing; therefore, this represents only a snapshot in time for this information:

- 185 HOV facilities are purely HOV2+ facilities,
- 14 facilities are purely 3+, 2 facilities are 2+ or 3+ depending on the time of day,
- 12 facilities are 2+ with no toll and SOV with a toll,
- 2 facilities are 3+ with no toll and 2+ and SOV with a toll, and
- 4 facilities are 2+ HOT and 3+ HOT depending on the time of day.

The statistics on operation of the facilities across the nation are as follows:

- 140 of the HOV facilities operate 24 hours a day, seven days a week, and
- 156 operate on weekdays only during the AM peak, the PM peak, or both.

The statistics on access are as follows:

- 41 of the HOV facilities allow for continuous access,
- 180 facilities allow for intermediate access, and
- 26 facilities allow no intermediate access.

Figure 2.1 shows the typical geometry of the HOV lanes in Utah.

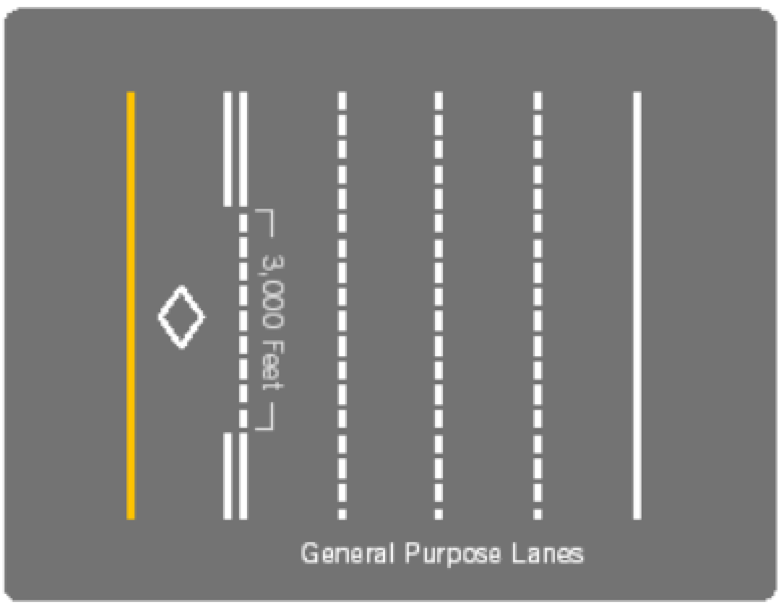

Figure 2.1 I-15 HOV Lane Configuration in Utah (Martin et al. 2009)

There are currently 22 HOT facilities across the United States as summarized in Table 2.1. The following sections will discuss HOT facilities in Miami, Denver, Minneapolis, Houston, and Seattle to highlight the variable use of HOT lanes across the nation.

Table 2.1 HOT Facilities in the United States

State	Facility Name	Length (mi)
California	El Monte Busway	11.0
California	I-15 Value Pricing Project	20.0
California	I-680 SMART Carpool Lanes	14.0
California	I-880/SR 237 Express Connector	4.0
California	SR 91 (Riverside Freeway)	10.0
California	I-110 Express Lanes	11.0
Colorado	I-25 HOV/Tolled Express Lanes	7.0
Florida	I-95 Express	21.0
Georgia	I-85	15.5
Maryland	I-95 Express	8.0
Minnesota	I-394 Express Lanes	11.0
Minnesota	I-35W Express Lanes	16.0
Texas	Katy I-10 Quick Ride	11.9
Texas	IH-45S	9.2
Texas	IH-45N	13.5
Texas	US 59S	18.2
Texas	US 59N	18.2
Texas	US-290	13.5
Utah	I-15 Express Lanes	61.9
Virginia	I-495	14.0
Virginia	SR 195 (Downtown Expressway)	3.4
Washington	SR 167	28.6

*Data listed are as of February 25, 2014

2.2.1 Miami

I-95 in Miami, FL has two Express Lanes in each direction that are only accessible at the beginning of the Express Lanes in either direction. The Express Lanes extend from SR-112 to the Golden Glades Interchange. The occupancy requirements for free travel on the Express Lanes are 3+ people per vehicle. Carpools and vanpools need to be registered in order to use the Express Lanes for free. The requirements for registering as a 3+ carpool are that participants must: live within a 3 mile radius of each other, work within a one mile radius of each other, and have a start/end work time within 30 minutes of each other. Following the opening of the Express Lanes on I-95 there was a 4.6% increase in person throughput (Goel and Burris 2011).

2.2.2 Denver

The I-25 Express Lanes in Denver, CO run for 7 miles and opened on June 2, 2006. There are two Express Lanes separated by a barrier that is reversible depending on the time of day. SOVs may use the lanes for a fee while HOV2+ vehicles and motorcycles may use the lanes for free. Fees for the toll lane vary by time of day. In 2008, 2000 permits were issued to hybrid vehicles for free access to Express Lanes (Goel and Burris 2011).

2.2.3 Minneapolis

The I-394 Express Lanes in Minneapolis, MN use a combination of barrier and non-barrier separated lanes along the 11 mile stretch of the corridor. Fees are only charged in the paint separated lanes during peak direction hours (6:00 a.m. to 10:00 a.m. eastbound (EB) and 2:00 p.m. to 7:00 p.m. westbound (WB)). Lanes are either open access or limited access depending on the location and time of day. Dynamic pricing is used on I-394 and I-35W to meet performance goals of free-flow speed of 50-55 mph. This goal is accomplished 98% of time. The dynamic pricing uses transponder technology and the Minnesota State Patrol uses transponder enforcement readers to make sure transponders are active (Buckeye 2012).

2.2.4 Houston

There are six corridors in the Houston, TX area that utilize HOT lanes. These corridors include: the Katy Freeway (IH 10W), North Freeway (IH 45N), Gulf Freeway (IH 45S), Northwest Freeway (US 290), Southwest Freeway (US 59S), and Eastex Freeway (US 59N). The overall Average Vehicle Occupancy (AVO) in the HOT lane of the Katy Freeway during peak hour is 1.36 and 1.44 during the off-peak period (Goodin et al. 2013a). The Katy Freeway features two pylon separated HOV/HOT lanes in the EB and WB directions. The HOV lane is designated on the right side during peak periods and the left lane is the designated as the SOV toll lane. The managed lanes feature three toll plazas in which SOVs may enter. At these plazas, there is sufficient space for enforcement vehicles (Goodin et al. 2013a).

2.2.5 Seattle

The HOT lanes on SR-167 in Seattle, WA began operation in May 2008. There is a single HOT lane running for approximately 9 miles in each direction between Renton and Auburn. SOVs can use the lane for a toll while HOV 2+, vanpools, transit and motorcycles can use the lanes for free. There are specific access points along the corridor separated by a 2 foot buffer with two solid white lines as separators (Goel and Burris 2011).

2.3 Pricing Alternatives for Managed Lanes

The concept of HOT lanes was first presented by Gordon J. Fielding and Daniel B. Klein as a hybrid HOV facility that enables SOVs to utilize the facilities for a fee. This was done to help alleviate congestion in the GP lanes as well as to sell unused capacities in the HOV lanes in the hope of generating revenue (Chaudhuri et al. 2010).

An important component of any HOT facility is the method in which the fees are imposed on drivers utilizing the facility. According to the Urban Land Institute (ULI), there are three primary methods utilized for pricing: cost pricing, value pricing, and congestion pricing. These can be simplified into the most common method, which is that of a combination value/congestion pricing. Congestion pricing is a specific type of value pricing imposed on users to reduce congestion in the travel corridor or to maintain free-flowing conditions. Congestion pricing is highly dependent on the overall conditions in the corridor and will change based on the density of vehicles throughout the corridor (ULI, 2013). In simple terms, the fee imposed on driver’s changes throughout the day as the corridor gets more congested and the demand on the HOT facilities fluctuates. These fees are backward calculated using a logit model (Chaudhuri et al. 2010). The most common use of congestion pricing in the United States is to provide free-flowing lanes on segments of urban highways.

An example of congestion pricing would be the Express Lanes along I-15 in Salt Lake and Utah Counties in Utah. This transit corridor consists of six different zones that run along the western slopes of the Wasatch Mountains as illustrated in Figure 2.2. As a SOV driver enters the zone, the fee to drive their car in the zone is charged. This fee is dependent on how congested the corridor is and may range from $0.25 to $1.00. As the corridor gets more congested, the fee to enter the corridor may increase. However, should a driver enter a zone before the fee is increased, the driver only needs pay the fee that was imposed when they entered the corridor even if the price were to fluctuate (UDOT 2013).

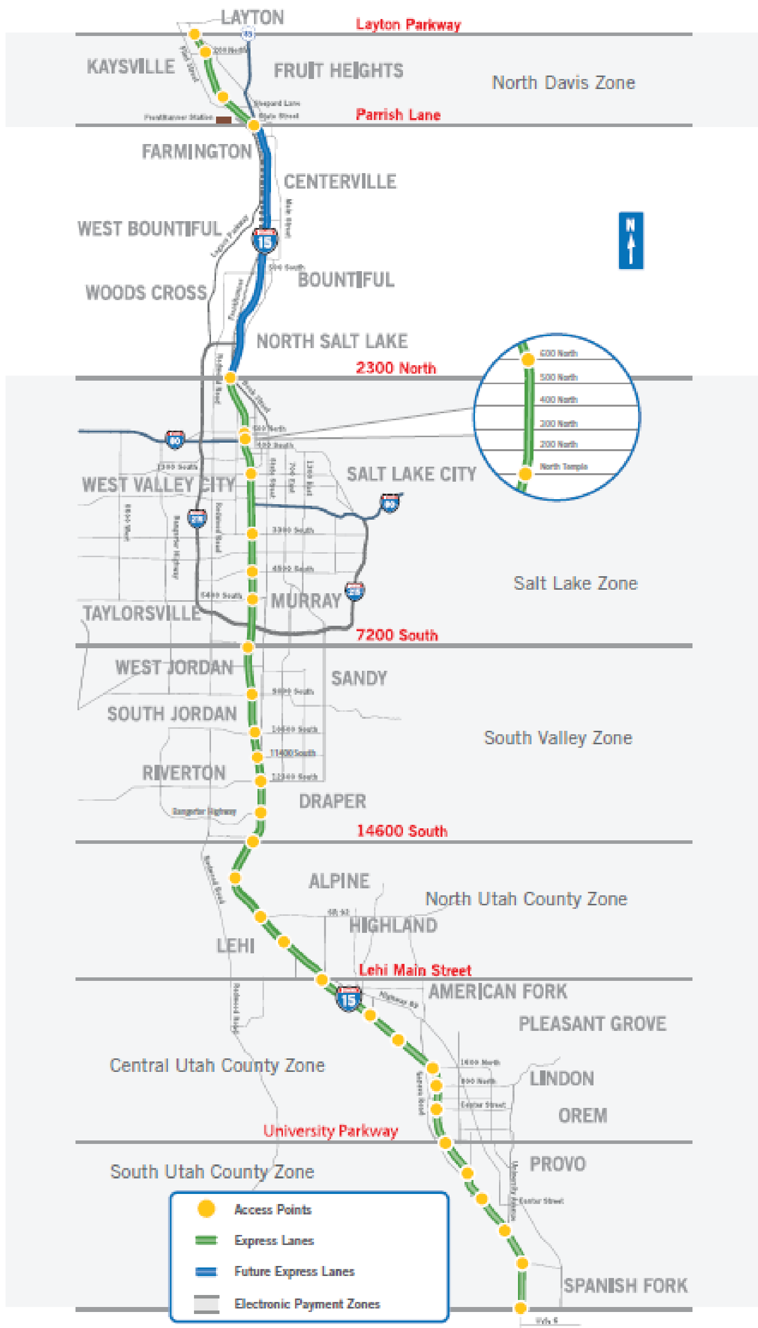

Figure 2.2 Express Lanes Map (UDOT 2013)

2.4 Vehicle Occupancy Use

According to the US Department of Energy (USDOE), the average number of people occupying a vehicle is 1.59 persons per vehicle, 2.35 persons per van, and 1.92 persons per sport utility vehicle (SUV) (USDOE 2010). Vehicle occupancy verification is important for more efficient HOV/HOT lane enforcement (Chan et al. 2011). Because no automated system has been developed, manual occupancy counts are suggested (Goodin et al. 2013b). The following provides a sample of vehicle occupancy in Salt Lake City, Miami, and Denver.

2.4.1 Salt Lake City Occupancy Use

In Salt Lake City, UT the following occupancy of the HOV lane was reported in the 2012 UDOT Express Lane Annual Report (UDOT 2012):

- 60% HOV2+
- 17% violators
- 18% Express Pass
- 4% “C” decal
- 1% Bus or motorcycle

2.4.2 I-95 Miami Occupancy Use

The HOV/HOT lanes in Miami, FL were opened in early December 2008. A comparison study was conducted for 2008 and 2009. The person throughput during the PM Peak period (4:00 p.m. – 5:00 p.m.) in the HOT lanes and GP lanes increased by 23% and 8%, respectively. The person throughput in Express Lanes increased even when the AVO dropped from 1.95 in 2008 to 1.39 in 2009 due to SOVs being allowed in Express Lanes. Overall, the person throughput increased by 1,325 or 12% in the facility after the Express Lanes were implemented (CTC 2013). It should be noted, however, that the capacity of the lanes doubled in this scenario from 1 lane to 2 lanes.

2.4.3 I-25 Denver Occupancy Use

Because Denver, CO utilizes a toll lane and an HOV lane, the trends of both lanes have been reported in the Special Report to the Board of Directors. Data have been collected since

July 2006, when SOVs were allowed to use the lanes for a fee, and show that there is an increase in toll lane usage and a decrease in HOV lane usage. The authors hypothesize that this decrease could possibly be due to the increased convenience of paying a toll instead of finding someone to carpool with. The report does not feature any data comparing the HOV/toll lanes and the GP lanes along the corridor.

2.5 Enforcement Techniques Related to Managed Lanes

The way an HOV or HOT facility is to be enforced is something that should be considered early on in the facility design process. All of the stakeholders in the project, including but not limited to the judiciary that are to enforce the laws along the facility and legislators who may have to change or enact new laws concerning the facility, should be involved.

2.5.1 Corridor Design

The FHWA *High-Occupancy Vehicle (HOV) Lane Enforcement Considerations Handbook*, the National Cooperative Highway Research Program (NCHRP) *HOV Systems Manual*, and the American Association of State Highway and Transportation Officials (AASHTO) *Guide for High-Occupancy Vehicle Facilities* recommend various design specifications for enforcement along HOV and HOT corridors. These specifications are illustrated in Table 2.2. Further, the FHWA, AASHTO, and the NCHRP have specific design considerations for various facility types. These facilities include: barrier-separated free HOV facilities, concurrent flow HOV lane facilities, contraflow HOV facilities, and queue bypass HOV facilities. An example of each of these facilities is shown in Table 2.3. Based on the type of facility, AASHTO, NCHRP, and the FHWA have various recommendations, these recommendations are summarized in Table 2.4.

Table 2.2 Recommendations for Enforcement Area (Wikander and Goodin 2006)

Design Feature	Recommendations for Enforcement Area	
	Low- Speed Enforcement	High-Speed Enforcement
Locations	Access points along barrier-separated HOV facilities, such as ramps, reversible lane entrances, and queue bypasses	Spaced every 3.2 – 4.8 km (2 – 3 miles) along mainline HOV facility
Length	30 – 60 m (100 – 200 ft.)	30 m (100 ft.) for monitoring only 394 m (1300 ft.) for monitoring and apprehension
Shoulder Width	3.6 – 4.3 m (12 – 14 ft.)	4.2 – 4.5 m (14 –15 ft.)
Approach Taper	2:1 or 9.1 m (30 ft.)	At least 20:1
Departure Taper	10:1 or 45.7 m (150 ft.)	At least 80:1

Table 2.3 Types of HOV Lane Facilities

Barrier Separated Houston, Texas (Turnbull 2003)	
Concurrent Flow Salt Lake City, Utah (Burke 2013)	
Contraflow Lincoln Tunnel, New York (PANYNJ 2013).	
Queue Bypass Washington D.C. (Jacobsen et al. 2006)	

Table 2.4 Recommended Enforcement Features for Different Types of HOV Facilities (Wikander and Goodin 2006)

Type of Facility	Preferred Enforcement Features	Minimum Enforcement Features
Barrier Separated (Two-way and reversible)	• Enforcement areas at entrances and exits • Continuous enforcement shoulder	• Enforcement areas at entrances or exits
Concurrent Flow	• Continuous median (left-side) enforcement shoulders with periodic barrier offsets • Continuous right-side buffers	• Periodic mainline enforcement areas • Monitoring areas • Continuous right-side buffers
Contraflow	• Enforcement area at entrance • Continuous inside shoulder	• Enforcement area at entrance
Queue Bypass Treatments	• Enforcement area on right-side shoulder • Continuous right-side shoulder • Duplicate signal head facing enforcement area at ramp meters	• Enforcement monitoring pad with continuous right-side shoulder downstream

2.5.1.1 Barrier Separated Facilities

As can be seen from Table 2.3, a barrier separated facility is an HOV facility that is physically separated from the GP lanes by a physical barrier. This type of facility may also be known as an exclusive facility. The barriers in this facility typically consist of a concrete wall or other physical barrier between the HOV lanes and the GP lanes. This type of facility is the easiest to enforce because there are only a select number of entrance and exit points into and out of the facility. This type of facility also deters violators because they are essentially trapped in the facility and can only exit at designated positions which make evasion impossible (Wikander and Goodin 2006). An added feature of a barrier separated facility is that the lanes can be reversible. For example, the lanes could be going into the city during peak morning rush and going away from the city in the evening as commuters travel home. According to AASHTO's *Guide for High-occupancy Vehicle (HOV) Facilities,* the minimum vehicle volume threshold for the barrier design is between 700 and 1,000 vehicles per hour per lane (vphpl) and the maximum is 1,200 to 1,600 vphpl (AASHTO 2004).

The most extensive network of barrier separated HOV lanes in the country is in Houston, TX. The system was first implemented in 1979 by the Houston Metropolitan Transit (Metro) as

Express Lanes for busses and vanpools that had registered with the state (Turnbull 2003). According to the *Twin Cities HOV Lanes Evaluation*, an interesting facet of the Houston system is that, "The Texas Department of Transportation (TxDOT) is only responsible for the maintenance of the HOV infrastructures" (CSI 2001). All of the HOV lanes in Houston operate on weekdays from 5:00 a.m. until 11:00 a.m. to coincide with morning peak travel and from 2:00 p.m. until 8:00 p.m. for afternoon travel. The facilities are closed the remainder of the day. Only some of the corridors are open on weekends. By doing this, the costs of the facility are decreased as the corridor only needs to be monitored during the times when the corridors are open. Because Metro is the caretaker of the facility, separate campaigns to promote transit and HOV lanes are not needed as both can be promoted simultaneously, and it has its own enforcement team that only needs to monitor the HOV facilities while the State Highway Patrol monitors the GP lanes (CSI 2001). One problem that is experienced along the Houston HOV facility is that the ridership requirements in the facility fluctuate from 2+ vehicle occupants to 3+ during peak periods. This presents a problem for enforcement when vehicles with only 2 occupants enter the facility before the occupancy restriction changes. Metro enforcement often gives these riders a benefit of a doubt, but this leads to facility abuse by some drivers. As a direct result, sometimes violation rates are as high as 44% (Turnbull 2003).

2.5.1.2 Concurrent Flow Facilities

Concurrent flow facilities provide minimal or no separation between the GP lanes and the HOV lanes. According to the FHWA, these facilities are the most difficult of all HOV facilities to enforce because SOVs can easily merge into the HOV lane and out at any time (Wikander and Goodin 2006). Because of this, a greater amount of effort is necessary to enforce the lanes and keep violation rates low. A disadvantage to a concurrent flow facility is that many perceive the HOV lanes as a passing lane or may not understand the divider markings and mistakenly use the lanes. As with other HOV facilities, it is imperative that the general public be educated on the correct use of the facility and corresponding markings. AASHTO recommends that concurrent flow facilities be designed with a minimum vehicle volume threshold of 700 to 1,000 vphpl and a maximum of 1,200 to 1,600 vphpl (AASHTO 2004).

An example of a concurrent flow facility is the Express Lanes in the Seattle, WA area. The HOV facilities were first constructed in the 1970s and as of 2001 were being converted into

HOT lanes (CSI 2001). As of December 2013, 310 miles of the 320 proposed miles had been constructed and were in operation (WSDOT 2013). According to the Washington State Department of Transportation (WSDOT) the HOV and HOT facilities are well utilized between 6:00 a.m. and 9:00 a.m. during morning peak travel times and between 3:00 p.m. and 7:00 p.m. during afternoon peak travel times. WSDOT is having a problem in the HOV lanes along I-5, I-405, and WB SR 520 because of utilization of the facilities during peak travel times when the HOV corridors are so congested that the 45 mph performance standard is no longer met (WSDOT 2013). As a result, WSDOT is currently reevaluating their transit system so new HOV facilities can be constructed to enable more unimpeded flow throughout the entire system.

2.5.1.3 Contraflow Facilities

A contraflow lane is a lane in which traffic can flow in the opposite direction of the surrounding lanes. Contraflow facilities include a single entrance and a single exit to the facility although several access points may be provided. According to the FHWA, two separation approaches are generally used for contraflow facilities. “The first [approach] uses plastic pylons that are manually inserted into holes in the pavement to separate the traffic lanes, while the other uses a moveable barrier to create the contraflow lane” (Wikander and Goodin 2006). AASHTO recommends that contraflow facilities be designed with a minimum vehicle volume threshold of 700 to 1,000 vphpl and maximum of 1,200 to 1,500 vphpl. AASHTO has also specified that contraflow facilities that operate with trained drivers, such as drivers of busses and vanpools, operate at a minimum 200 to 400 vphpl and maximum of 600 to 800 vphpl (AASHTO 2004).

An example of a contraflow facility is Route 495 in the Newark, NJ and New York City, NY area which was constructed in 1971. Route 495 utilizes an exclusive bus lane (XBL) which extends two and a half miles between the New Jersey Turnpike, Route 3, and the Lincoln Tunnel. The XBL allows EB traffic to travel in a WB lane. According to The Port Authority of New York and New Jersey’s (PANYNJ), report entitled, *Lincoln Tunnel Exclusive Bus Lane Enhancement Study*, “The XBL is separated from the other lanes by 560 cylindrical traffic delineators that are manually inserted into predrilled holes along the length of the bus lane every morning” (Quelch 2005). There are also overhead signs and directional signals which notify drivers of the status of the lane and instruct them accordingly to who can use the lane. The XBL is a cooperative effort of three agencies: PANYNJ, the New Jersey Department of Transportation

(NJDOT), and the New Jersey Turnpike Authority. The lane is operated under an agreement between these agencies, which assigns responsibility to PANYNJ, for the daily operation of the lane, the maintenance of all the electronic signs pertaining to the facility, and emergency response to incidents that occur during its operation (Quelch 2005). The XBL is the most productive and busiest lane of its kind in the nation. It operates between 6:15 a.m. and 10:00 a.m. and accommodates roughly 1,700 busses and 62,000 commuters on a daily basis (PANYNJ 2013). The XBL handles more daily trans-Hudson commuter trips to downtown New York City than any other mode of transportation. The XBL however is a victim of its own success. Users of the XBL save approximately 15 to 20 minutes on their overall commute over users of the other GP lanes (Quelch 2005). As a result, the XBL facility is utilized to the design capacity and can no longer accommodate more busses during peak travel times. Another problem with the XBL is that if there is a crash in the corridor, the corridor is forced to shut down and traffic is diverted to peripheral corridors (PANYNJ 2013).

2.5.1.4 Queue Bypass Facilities

Queue bypass lanes are unique in that they are only used for HOVs at freeway ramps, toll plazas, and some ferry landings. These lanes allow HOVs to bypass other vehicles waiting in line to either enter or exit a freeway, ferry, toll plazas, or other HOV facilities. According to AASHTO, queue bypass facilities ought to be designed with a minimum vehicle volume threshold of 100 to 200 vphpl minimum and 300 to 500 vphpl maximum (AASHTO 2004). It should be noted that enforcement is a difficult problem in queue bypasses because motorists have a clear view of the entire facility. As such, violators can see if there is anyone monitoring the facility and thereby use the facility because there is no-one enforcing the queue bypass policies. The FHWA recommends that screens be provided to obscure enforcement vehicles from the view of motorists. To aid in enforcement, the FHWA also recommends that queue bypasses be physically separated from GP onramps and exits (Wikander and Goodin 2006).

2.5.2 General Enforcement Strategies

While enforcement strategies are unique for each individual HOV or HOT facility, there are some basic principles and techniques that can be applied across the board. The FHWA has identified four main types of enforcement techniques that can be used for HOT and HOV facilities. The techniques identified by the FHWA are: routine enforcement, special enforcement, selective enforcement, and self-enforcement (Wikander and Goodin 2006).

2.5.2.1 Routine Enforcement

Routine enforcement is the normal everyday enforcement conducted by municipal police entities and the Highway Patrol. This enforcement scenario is appropriate when the HOV facility is well established as violation rates will be low or at an accepted level. Routine enforcement is also appropriate when the design of the facility makes it simple to monitor (Wikander and Goodin 2006). Finally, routine enforcement is perhaps the only option when there are no funds available for other enforcement options.

2.5.2.2 Special Enforcement

On page 17 of the *High-Occupancy Vehicle (HOV) Lane Enforcement Considerations Handbook*, the FHWA states, “Special enforcement is characterized by continuing, systematic manpower allocations and enforcement tactics specifically dedicated to enforce HOV violations” (Wikander and Goodin 2006). This type of an enforcement strategy is best applied when the facility is new, and when the need for enforcement is great and cannot be sufficiently managed using a routine enforcement technique. Special enforcement is generally done by assigning an enforcement vehicle to monitor solely the HOV and HOT lanes or by adding extra patrols to monitor an HOV or HOT facility.

2.5.2.3 Selective Enforcement

Selective enforcement is a combination of the routine enforcement techniques and the special enforcement techniques with the added facet that they are not scheduled. This ensures that motorists are unable to predict when enforcement operations will occur. Selective enforcement is best applied periodically to specific sites along a corridor where violations are known to occur. It is also best to operate a selective enforcement scenario whenever a facility is new or changes to HOV or HOT policies have been made. Such changes may include but are not limited to: increasing vehicle occupancy requirements, extending or decreasing operating times, changing requirements on exempt vehicles, or any other significant change (Wikander and Goodin 2006).

2.5.2.4 Self-Enforcement

A self-enforcement strategy involves regulation of the HOV or HOT facility by individual users in the facility or by people passing by in the GP lanes. It should be said however that self-enforcement should not be the only strategy used to monitor any HOV or HOT facility. Rather, it is a tool to be used in direct correlation with highway patrols and local law enforcement (Wikander and Goodin 2006).

One of the major success stories for self-enforcement is WSDOT's HERO program. The HERO program began in 1984 as a way to encourage drivers to self-enforce the HOV lane rules. It was so successful that it is currently a nationally recognized program used as a role model in several areas across the country (WSDOT 2014). Riders in either the HOV lanes or in the adjacent GP lanes are able to report HOV violators either by phone or using the WSDOT website. Upon the first violation, the violator is sent educational materials concerning how the HOV facility works and qualification requirements. If the violator proceeds to a second violation WSDOT sends a personalized letter to the offender emphasizing correct HOV lane use. Upon a third violation, or more, the Washington State Highway Patrol sends a personalized warning by mail containing the date, time, and location of violation to the violator (WSDOT 2014). In 2000, there were 43,879 reported violations during the year. Approximately 6% of those violations were repeat offenders and less than 1% were third time offenders (Martin et al. 2004).

2.5.3 Enforcement Strategies and Techniques for HOV Facilities

While no enforcement strategy is guaranteed to work for every HOV facility, as each enforcement strategy has its own unique advantages and disadvantages, the FHWA has identified several things that have been effective in HOV facilities throughout the country. The FHWA four principle enforcement techniques identified are: stationary enforcement patrols, roving enforcement patrols, team patrols, and citations or warnings by mail.

2.5.3.1 Stationary Enforcement Patrols

Stationary patrols involve the assignment of enforcement personnel at discrete known locations along an HOV corridor. According to the FHWA, *High-Occupancy Vehicle (HOV) Lane Enforcement Considerations Handbook*, "These [stationary] enforcement locations may be dedicated enforcement locations or locations that provide the necessary vantage points and space for enforcement personnel [to effectively monitor the HOV facility]" (Wikander and Goodin 2006).

Stationary enforcement patrols are advantageous in that it is very time efficient for enforcement as no pursuits of the violators are necessary. This technique also has a high degree of safety for the enforcement personnel as they are usually off to the side of the road and out of the lane. It also lets facility users know the lanes are being monitored as users can immediately see enforcement throughout the facility (Wikander and Goodin 2006).

Some of the disadvantages of the stationary enforcement patrol technique in HOV facilities include: rubbernecking as vehicles slow down before passing the enforcement vehicles, limited locations along most corridors to station enforcement vehicles, violators may know of set enforcement locations and circumvent them, and having a stationary enforcement presence requires a diversion of enforcement personnel and resources (Wikander and Goodin 2006).

2.5.3.2 Roving Enforcement Patrols

Roving enforcement patrols involve enforcement patrolling the length of the HOV facility looking for violators. This may be done in the HOV lane or in adjacent GP lanes. Roving patrols also offer the option of allowing enforcement vehicles to only patrol a certain segment while other enforcement vehicles enforce other segments. Nevertheless, the entire corridor is covered by a team of enforcement vehicles (Wikander and Goodin 2006).

A roving patrol enforcement method is advantageous because vehicles can operate along the entire length of the corridor provided that there is a safe area for vehicle apprehension and citation. Further, having roving patrols does not require a reallocation of enforcement personnel (Wikander and Goodin 2006).

Roving patrols may be discouraged if a shoulder or other refuge area is not available in which an enforcement vehicle can safely stop a violator and issue a citation. It is also not favorable because the vantage points of enforcement officers may be obscured by moving vehicles or their full attention may not be on the HOV facility while they are driving (Wikander and Goodin 2006).

2.5.3.3 Team Patrols

Team patrols are a combination of roving and stationary patrols that work in unison to monitor the HOV facility and to apprehend and cite HOV violators. This option is most generally used when it is impossible or deemed unsafe for a single enforcement officer to detect, apprehend, and cite a violator. In a team scenario, one officer is stationary and detects the violator and reports it to one of the roving officers downstream for the purpose of apprehension (Wikander and Goodin 2006).

Team patrols are advantageous because it divides the task of monitoring and apprehension among enforcement personnel. It also offers greater flexibility for facilities that do not have safe areas where enforcement officers can apprehend violators (Wikander and Goodin 2006).

A team patrol is unfavorable because it puts a drain on enforcement resources as twice the number of enforcement personnel are needed along the corridor. This enforcement scenario may also not be legal in jurisdictions where the law states that the apprehending officer must be the one who witnessed the violation (Wikander and Goodin 2006).

2.5.3.4 Citations or Warnings by Mail

Citations or warnings issued through the mail may be used by enforcement agencies only if they have been granted the legal authority to do so. This enforcement technique eliminates the need to stop HOV violators. The violators may be observed by police officers on the spot or with the aid of high powered cameras that are capable of seeing inside vehicles and also simultaneously recording driver information so that a ticket or warning may be issued (Wikander and Goodin 2006). As of December 2013, no provisions for issuing citations by mail are currently in effect for any HOV facility in the country due to successful legal challenges.

This enforcement scenario is preferable to others because violators do not have to be apprehended, it requires a minimal refuge area for enforcement personnel, and it is highly time efficient (Wikander and Goodin 2006).

One of the principal disadvantages to this enforcement technique is that it is not currently supported by law in any municipality without apprehension of the violator (Wikander and

Goodin 2006). Further, this technique requires the use of high-powered and complex cameras that are able to verify with surety vehicle occupancy and take a clear high resolution photograph. There is also a concern about keeping the system secure so that the pictures cannot be tampered with or made available to the general public at large.

2.5.4 Enforcement Technologies

Most attempts at developing enforcement technologies specific to HOV facilities have focused on determining the number of occupants in a vehicle or on determining vehicle eligibility. Having exempt vehicles or toll users in an HOV facility adds increased complexity to effective enforcement. According to the FHWA, "Regular toll lanes are amenable to automated enforcement techniques, such as [license plate reader] LPR in combination with [automatic vehicle identification] AVI [readers]. However, usage of toll transponders on HOT lanes is not required for HOVs while additional verification of vehicle occupancy is needed" (Wikander and Goodin 2006). Alas, no automated occupancy verification system has yet been developed that has been able to demonstrate a high accuracy rate.

The two main categories of enforcement technologies are either video systems or infrared and multi-band infrared systems. Additionally, vehicle transponders and a universal tag can be used as a method of enforcement for HOT facilities. These four technologies are briefly discussed in the following sections.

2.5.4.1 Video Systems

Video systems have been deployed in the past for vehicle occupancy detection. While these systems have proven useful in monitoring HOV facilities, they have not yet been proven accurate for vehicle occupancy detection. It is the common consensus based on several studies that have been sponsored by the FHWA that video methods are not as reliable as live visual inspection of HOVs (Wikander and Goodin 2006).

2.5.4.2 Infrared and Multi-band Infrared Systems

No infrared and multi-band infrared systems have ever been implemented on any HOV facility, although a few field tests were conducted in 2006. The primary benefit of infrared and multi-band infrared systems in that they can operate regardless of the amount of ambient light, meaning they can operate either during the day or at night. A primary flaw with infrared systems is that the data can be skewed by heat blocking materials or the metallic tint typical of tinted windows (Wikander and Goodin 2006).

2.5.4.3 Vehicle Transponders

Those vehicles that fail to meet the occupancy or eligibility requirements for an HOT facility are often the only ones required to have a toll transponder if they expect to use the HOT facility, although some facilities require all users (HOV and SOV) to have a transponder. At stationary enforcement locations, or through roving patrols, the occupancy requirement of a vehicle is checked. If the vehicle occupancy is below that specified along the HOT corridor, enforcement would then look for a transponder which is normally located near the rear view mirror and below the AS-1 line on the windshield (UDOT 2013). The AS-1 line is a small tinted strip installed at the top of most windshields. This line usually doesn't extend more than 5 inches past the top of the windshield. If the driver fails to meet both the occupancy and the active transponder requirement, they would be apprehended and cited. The FHWA has noted that automated violation enforcement systems (VES) have not yet been implemented as all vehicles are not yet required to have transponders, although all HOT facilities in the country use transponders in their HOT facilities (Wikander and Goodin 2006).

2.5.4.4 Universal Tag or Decal on all HOT Vehicles

Having a transponder in all vehicles that are using the HOT facility is what is currently being done along California State Route 91 in the Los Angeles area. This requires that all vehicles in an HOT facility, including HOVs, low-emission vehicles (LEVs), and emergency personnel, have a transponder on the front windshield. The facility is then monitored with a VES using high definition photographs to enforce toll payment (Wikander and Goodin 2006). For those drivers that are exempt from toll because of vehicle occupancy requirements or other legislation, a special lane is generally used for this purpose where vehicle occupancy is visually verified.

2.5.5 Enforcement Strategies and Techniques for HOT Facilities

Many of the enforcement strategies that are listed for HOV facilities can be adapted for use in HOT facilities. For barrier separated HOT facilities which use a universal tag or transponder, a separate tolling lane is often used at the tolling area to travel under the electronic toll readers. As such, enforcement personnel would only need to monitor traffic in the toll exempt lane to look for violators. Enforcement in the non-HOV lane would be handled using automatic photo cameras or video cameras.

For HOT facilities that tag only HOV ineligible vehicles, the presence of HOV and toll traffic along the HOT facility requires enforcement officers to pay special attention and differentiate not only between HOV and non-HOV vehicles, but also between toll paying and non-toll paying HOV violators. The FHWA advises to "…locate some of observation and/or enforcement areas slightly downstream from tolling areas on a facility so that officers observe transponder status (as shown by a roadside indicator beacon) as well as vehicle occupancy in the tolling zone" (Wikander and Goodin 2006).

Concurrent flow HOT facilities impede many of the aforementioned enforcement techniques because toll evaders can essentially enter and exit the HOT facility at will by illegally crossing the painted lines on the road. As a result, there doesn't exist an optimal location for enforcement along this type of HOT corridor where apprehending all the violators is a possibility. However, this may be overcome through VES readers or AVI readers mounted throughout the facility or with roving enforcement patrols (Wikander and Goodin 2006).

One of the most important enforcement techniques for an HOT facility is to have adequate and easy to understand signage spread throughout the facility. An informed driver is less likely to commit unsafe last-minute maneuvers to enter or exit any HOT facility. Or a driver may inadvertently violate the policies of an HOT lane as they cross a double white line or some other barrier. It is imperative to have good signage when tolls vary along a corridor or if there are multiple lanes (Wikander and Goodin 2006). All signage for HOT facilities should be in general accordance with the standards and policies for HOV facilities found in the *Manual on Uniform Traffic Control Devices* (MUTCD) (FHWA 2009).

2.5.6 Enforcement Considerations for Exempt Vehicles

An exempt vehicle is any vehicle that qualifies to use HOV without regard to occupancy requirements. The Safe Accountable Flexible and Efficient Transportation Act: A Legacy for Users (SAFETEA-LU) defines two types of exempt vehicles: an Inherently Low-Emission Vehicle (ILEV) and a Low-Emission and Energy Efficient Vehicle (LEEEV). However, SAFETEA-LU contains various provisions written into the law that must be followed to ensure that exempt vehicles do not seriously degrade the operation of the HOV lane (Wikander and Goodin 2006).

To qualify as an ILEV, the vehicle must be manufactured to use solely a dedicated non-gasoline federally recognized clean fuel. The Environmental Protection Agency (EPA) has certified the following fuels as being clean fuels: compressed natural gas (CNG), liquid natural gas (LNG), hydrogen, ethane, methane, or other liquefied petroleum-based gasses (Wikander and Goodin 2006). However, it must be stated that vehicles that have converted to using a clean fuel after their initial manufacture do not qualify as a ILEVs, according to the EPA (EPA 2011).

According to the FHWA, “LEEEVs include gas/electric hybrid vehicles meeting EPA Tier II emission standards and achieving a 50 percent increase in city fuel economy or not less than a 25 percent increase in combined city-highway fuel economy relative to a comparable vehicle that is an internal combustion gasoline fueled vehicle” (Wikander and Goodin 2006). Additionally, alternative fuel vehicles (AFVs) meeting EPA Tier II emission standards also qualify. EPA Tier II emission standards can be found on the EPA website (EPA 2013).

In many states some kind of decal is affixed by the state on specific fuel exempt vehicles that alert enforcement officers that minimum occupancy requirements during travel along HOV corridors do not apply. These decals may be a sticker that is on the windshield, or a special license plate that is affixed to the vehicle. However, the decal should be clearly visible to enforcement personnel (Wikander and Goodin 2006). More details concerning exempt vehicles and the “C” decal used in Utah will be provided later in this report.

Federal law also allows the use of HOV facilities by emergency personnel provided that the vehicle is clearly marked and is equipped with rooftop emergency lights and a siren. These vehicles include ambulances, Emergency Medical Services (EMS) vehicles, fire engines, law enforcement, and tow trucks. However, FHWA guidelines do not include an HOV exemption for unmarked agency vehicles or the personnel vehicles of enforcement or EMS personnel (Wikander and Goodin 2006).

2.5.7 Legislative and Judicial Issues in Enforcement

The FHWA advises in their *High-Occupancy Vehicle (HOV) Lane Enforcement Considerations Handbook*, that legislatures have considerable influence in HOV and HOT enforcement. The principal areas of influence that legislative bodies have is the capacity to create legislation that grants authority to conduct necessary enforcement in transportation corridors, as well as granting authority to issue citations to violators. The judiciary is an important aspect in the enforcement of HOV and HOT facilities in that they must be able to interpret the laws and impose the corresponding consequences to those that violate the rules (Wikander and Goodin 2006).

The authorization and allocation of powers for enforcement of freeway HOV facilities is conducted through a correlation of state regulations and local ordinances in as much as they do not conflict with federal laws and guidelines. Traditionally, legislation denotes who has primary responsibility for constructing, operating, and maintaining HOV corridors. Further, the legislation denotes who has jurisdiction concerning enforcement of the HOV lanes. For HOT facilities laws may be in effect concerning the enforcement and expenditures of revenue generated by tolls (Wikander and Goodin 2006).

Title 23 of the United States Code directs state departments of transportation or other responsible local entities to establish minimum occupancy requirements for vehicles operating in HOV lanes and defines specific exceptions to these requirements for vehicles operating in HOV facilities, and further defines exceptions to these regulations for certain classes of vehicles (Wikander and Goodin 2006).

2.6 Violation Data

In the AASHTO *Guide for High-Occupancy Vehicle Facilities* it states that "the enforcement policies and programs should be followed to maintain the integrity of the facility by deterring possible violators and to promote the safe and efficient use of the lane" (AASHTO 2004). This section examines reported violation rates on HOV lanes in Utah and nationally.

2.6.1 Violation Data in Utah

Utah reports a violation rate of 17% according to the Utah State 2012 Annual Report (UDOT 2012).

2.6.2 Violation Data Nationally

Table 2.5 summarizes violator data collected on facilities around the country. It can also be noted that the Texas law states that the top HOV lane violator's names can be reported on the internet in an effort to collect all toll violations (TxDOT 2013).

Table 2.5 HOV Violation Rate Summary

Freeway, Location	Violation Rate (%)
SR-167, Washington	1-7
Northwest Freeway, Houston	37 (AM), 11 (PM)
Southwest Freeway, Houston	3.39 (AM), 7.84 (PM)
North Freeway, Houston	8.83 (AM), 9.40 (PM)
Gulf Freeway, Houston	2.90 (AM), 8.19 (PM)
Katy Freeway, Houston	38 (AM), 30 (PM)
Eastex Freeway, Houston	3.82 (AM), 7.66 (PM)
Dallas, IH-30	1-6
I-66, Virginia	27
I-395, Virginia	20
I-25, Colorado	<1
I-394, Minnesota	10
I-15, San Diego	5-15
SR-91, Orange County	8

Sources: CDOT 2013, FHWA 2007, Smith and Yook 2009, TTI 2009, TTI 2004, WSDOT 2013, Wikander and Goodin 2006

3.0 DATA COLLECTION

3.1 Overview

The data are a key component of this analysis and were collected in an effort to quantify the current usage of the Express Lanes in Utah. The data collected for this analysis included data on Express Pass circulation and trip frequency, “C” decal circulation and trip frequency, violators, speed and volume data, and a summary of the Express Lane users by user type. The data collection was conducted in some instances for the entire Express Lane corridor, while other data were collected for specific zones within the corridor. Figure 3.1 provides a representation of the corridor, while more details for each of the zones are provided in Figure 3.2. A summary of the zones by number and name is provided in Table 3.1 for both northbound (NB) and southbound (SB) zones.

Table 3.1 Express Lanes Zone Summary

Northbound		
Zone	Name	Extents
130	South Utah County	U.S. 6 to University Parkway
135	Central Utah County	University Parkway to Lehi Main Street
140	North Utah County	Lehi Main Street to 14600 South
145	South Valley	14600 South to 7200 South
150	Salt Lake	7200 South to 2300 North
160	North Davis County	Parrish Lane to Layton Parkway
Southbound		
Zone	Name	Extents
240	North Davis County	Layton Parkway to Parrish Lane
250	Salt Lake	2300 North to 7200 South
255	South Valley	7200 South to 14600 South
260	North Utah County	14600 South to Lehi Main Street
265	Central Utah County	Lehi Main Street to University Parkway
270	South Utah County	University Parkway to U.S. 6

Figure 3.1 I-15 Express Lane Zones

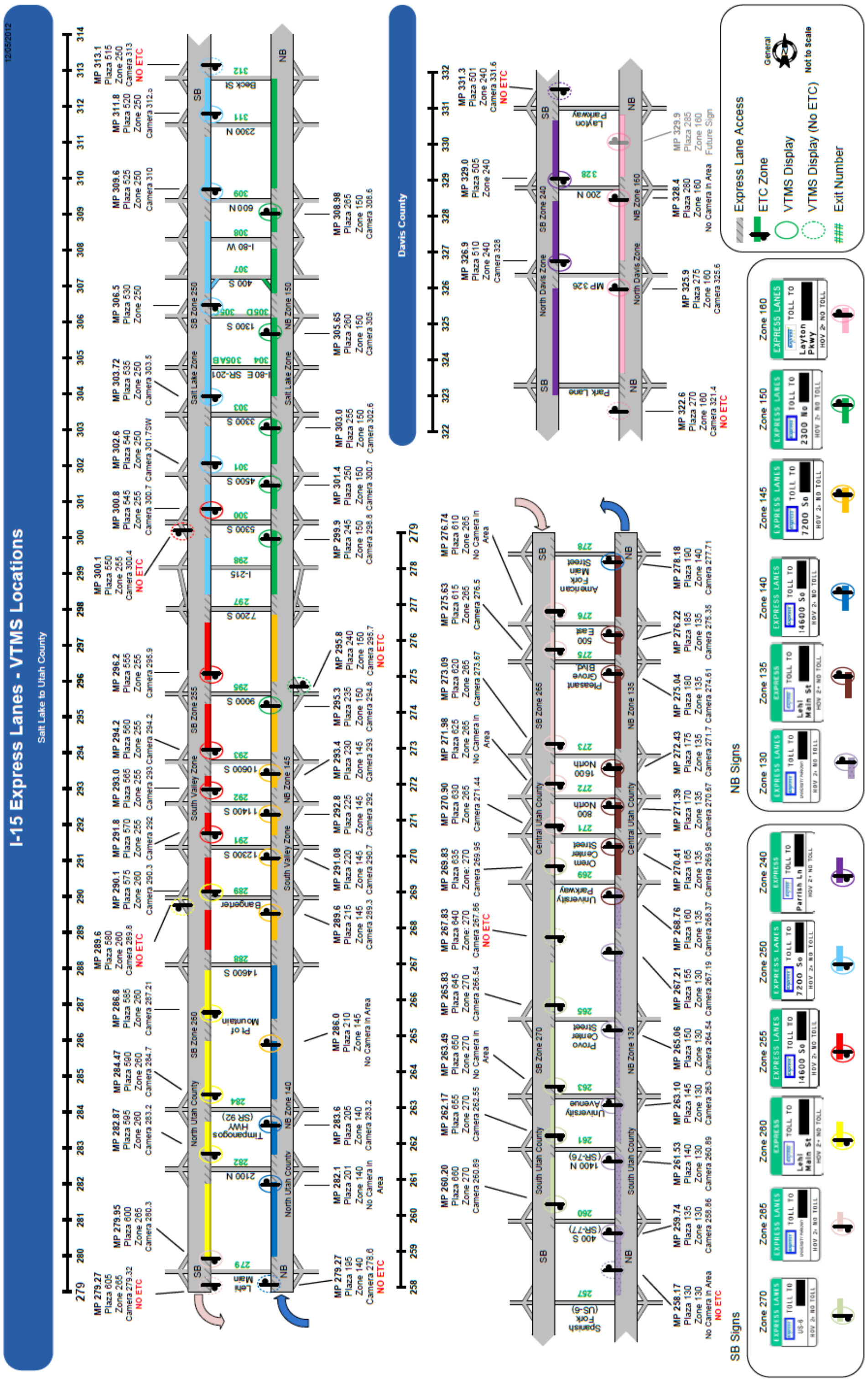

Figure 3.2 I-15 Express Lanes – VTMS Locations

3.2 Express Pass Data

Express Pass data were collected for the number of Express Pass transponders in circulation over time, the number of trips made by transponder owners each month, and the variability of tolls paid by time of day. The results of this analysis are provided in the following sections.

3.2.1 Express Pass Transponder Circulation Data

The number of Express Pass transponders has grown steadily over the past three years, while the number of transponders used at least once each month has remained relatively steady at approximately 8,000 as summarized in Table 3.2 and illustrated in Figure 3.3. Although there is a $2.85 fee assessed to UDOT to maintain these transponder accounts, there is no account or transponder maintenance fee assessed to the transponder user.

Table 3.2 Express Pass Transponder Summary Data

Year	Month	Express Pass Customer Accounts	Express Pass Transponders	Transponders Used At Least Once
2011	January	6,996	8,567	
	February	7,121	8,736	
	March	7,323	8,963	
	April	7,455	9,125	
	May	7,586	9,271	
	June	7,753	9,466	
	July	8,012	9,611	
	August	8,059	9,831	
	September	8,225	10,032	5,860
	October	8,371	10,200	5,759
	November	8,532	10,390	6,166
	December	8,657	10,540	6,178
2012	January	8,802	10,715	5,936
	February	8,956	10,877	6,459
	March	9,065	11,138	6,888
	April	9,207	11,215	6,820
	May	9,392	11,555	7,131
	June	9,567	11,833	7,128
	July	9,687	12,010	6,788
	August	9,990	12,097	7,504
	September	10,180	12,807	7,271
	October	10,385	12,555	7,540
	November	10,564	12,771	7,386
	December	10,721	12,961	7,128
2013	January	10,932	13,205	7,384
	February	11,099	13,387	7,465
	March	11,235	13,548	7,697
	April	11,390	13,734	7,959
	May	11,569	13,938	8,244
	June	11,673	14,072	7,955
	July	11,775	14,198	7,648
	August	11,909	14,344	8,189
	September	12,115	14,577	7,845
	October	12,315	14,800	8,501
	November	12,548	15,057	7,399
	December	12,742	15,300	8,293

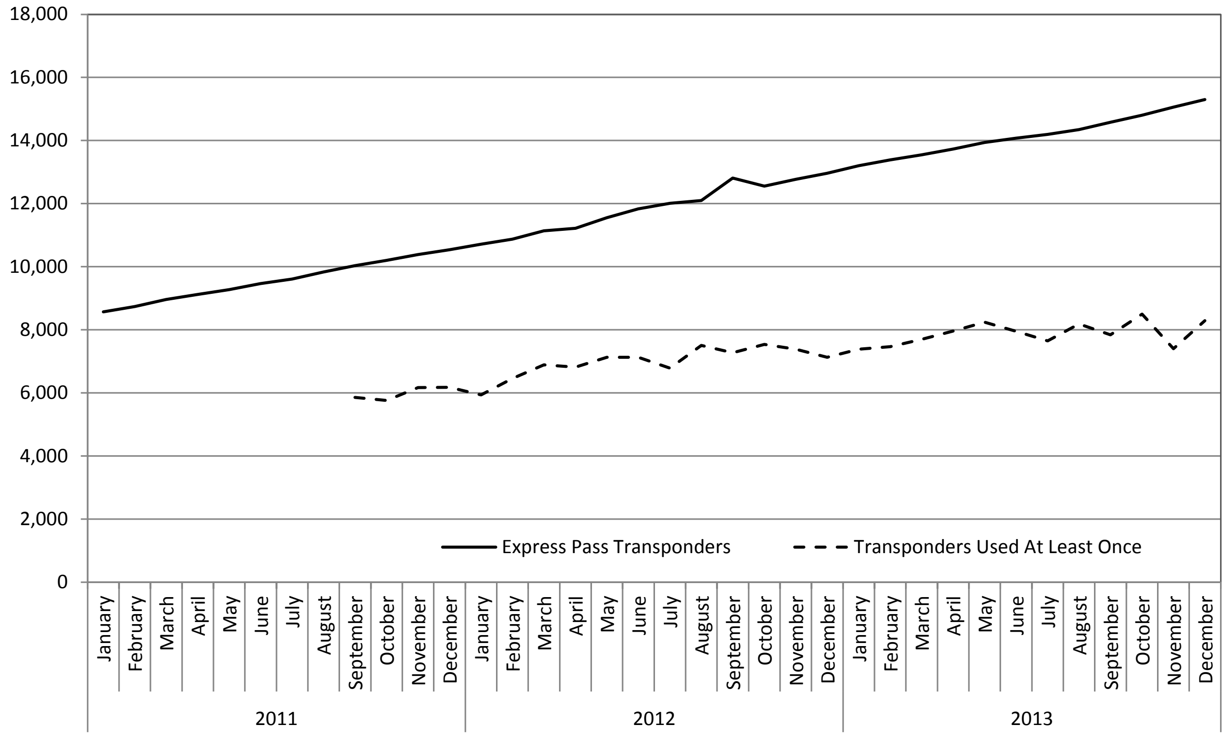

Figure 3.3 Express Pass Transponder Use

3.2.2 Express Pass Trip Data

General Express Pass trip data were generated from the monthly report data provided by UDOT. While the maximum number of trips for a single Express Pass has grown (with a high degree of variability) over the past three years, the average number of trips per Express Pass has remained relatively constant at approximately 10 trips per Express Pass per month with the average number of zones per trip steady at approximately 1.6 zones per trip as shown in Table 3.3. A graphical representation of this data and the variability in maximum trips for a single Express Pass is shown in Figure 3.4.

Table 3.3 Monthly Express Pass Trip Data

Year	Month	Maximum Trips/Month for a Single Express Pass	Average Number of Trips/Month per Express Pass	Average Number of Zones per Trip
2011	January	87	10.3	1.6
	February	75	9.7	1.6
	March	88	10.8	1.6
	April	88	9.8	1.5
	May	78	9.9	1.5
	June	78	9.6	1.5
	July	76	9.3	1.5
	August	108	12.25	1.5
	September	72	9.8	1.4
	October	86	9.8	1.4
	November	80	10.1	1.5
	December	86	9.3	1.6
2012	January	129	10.8	1.6
	February	129	10.7	1.6
	March	85	11.4	1.6
	April	101	10.5	1.5
	May	88	11	1.6
	June	77	10.2	1.5
	July	77	9.3	1.5
	August	146	10.9	1.5
	September	146	10	1.5
	October	115	11.1	1.5
	November	115	10.3	1.6
	December	109	9	1.6
2013	January	129	10.4	1.6
	February	107	10	1.6
	March	119	10.4	1.6
	April	141	10.7	1.6
	May	155	10.9	1.6
	June	144	10	1.6
	July	144	9.9	1.6
	August	162	10.6	1.6
	September	129	10.3	1.6
	October	154	11.3	1.6
	November	127	9.8	1.6
	December	124	9.2	1.6

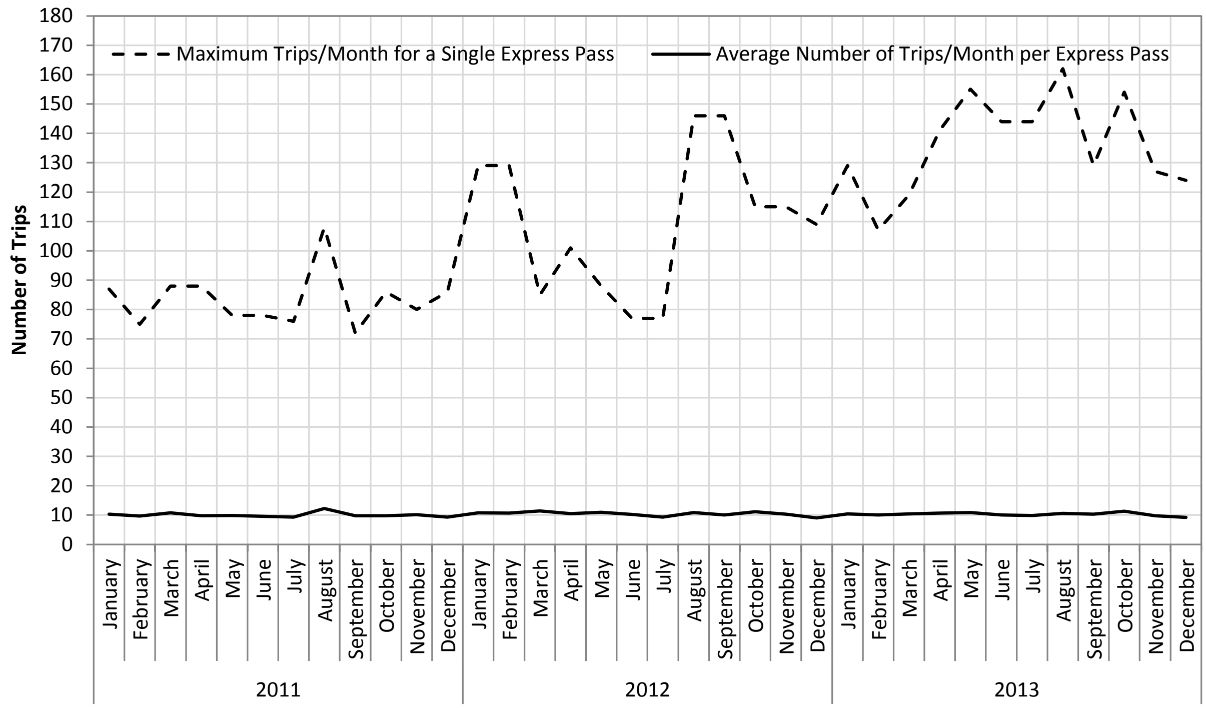

Figure 3.4 Monthly Express Pass Trip Summary

Specific Express Pass trip data were generated from detailed reports of transponder data for the period from April 1, 2013 through September 30, 2013. The data included trips at several zones for both AM and PM Peak periods. A summary of the number of transponder trips by zone from the data received is provided in Table 3.4 for the AM Peak Period (7:00 a.m. – 8:00 a.m.) and in Table 3.5 for the PM Peak Period (5:00 p.m. – 6:00 p.m.). The tables include minimum, 10^{th} percentile, average, 90^{th} percentile, and maximum speeds, as well as the standard deviation of the speeds within the zone reported. For all zones, the average speeds during the AM Peak Period are above 55 mph. However, the 10^{th} percentile speeds have dropped below the UDOT goal of 55 mph in Zone 145 and are exactly at 55 mph in Zone 140 (see Table 3.4).

For the PM Peak Period, the average speeds are above 55 mph in all but Zone 250. However, for the PM Peak Period, the 10^{th} percentile speeds have dropped below the UDOT goal of 55 mph in Zones 140, 250, 255, and 260 and are exactly at 55 mph in Zone 145. The 10^{th} percentile speeds have also degraded below the FHWA requirement of 45 mph for zones 250 and

255 (see Table 3.5). The zones where the 10th percentile speeds have dropped below 55 mph will be considered as primary areas of focus for the analysis in Chapter 4.

Table 3.4 AM Peak Period Express Pass Trip Statistics

Zone 130 AM	[Spanish Fork (US 6) - University Parkway]					
	Min.	**10th** Percentile	**Avg.**	**90th** Percentile	**Max.**	**Std. Dev.**
Travelled Miles	1.6	5.2	20.5	39.9	49.2	13.8
Trip Time	1.1	3.7	17.6	36.1	58.8	12.6
Trip Speed	34.0	68.0	72.9	79.0	92.0	7.0
Zone 135 AM	[University Parkway - Lehi Main]					
	Min.	**10th** Percentile	**Avg.**	**90th** Percentile	**Max.**	**Std. Dev.**
Travelled Miles	1.0	9.7	23.8	36.9	49.2	10.4
Trip Time	0.7	7.6	20.6	32.7	59.9	9.6
Trip Speed	27.0	63.0	71.0	78.0	94.0	6.9
Zone 140 AM	[Lehi Main - 14600 South]					
	Min.	**10th** Percentile	**Avg.**	**90th** Percentile	**Max.**	**Std. Dev.**
Travelled Miles	1.5	6.3	15.9	26.9	49.2	8.5
Trip Time	1.1	5.4	14.7	25.2	59.9	7.8
Trip Speed	10.0	55.0	66.1	75.0	94.0	8.8
Zone 145 AM	[14600 South - 7200 South]					
	Min.	**10th** Percentile	**Avg.**	**90th** Percentile	**Max.**	**Std. Dev.**
Travelled Miles	1.1	3.0	11.5	19.6	49.2	6.9
Trip Time	0.8	3.4	10.8	18.7	66.0	6.3
Trip Speed	9.0	51.0	63.9	74.0	90.0	9.6
Zone 150 AM	[7200 South - Beck Street]					
	Min.	**10th** Percentile	**Avg.**	**90th** Percentile	**Max.**	**Std. Dev.**
Travelled Miles	1.5	4.2	11.8	19.6	49.2	6.5
Trip Time	1.1	3.5	10.7	18.4	66.0	6.2
Trip Speed	12.0	59.0	67.6	74.0	95.0	6.9
Zone 240 AM	[Layton Parkway - Park Lane]					
	Min.	**10th** Percentile	**Avg.**	**90th** Percentile	**Max.**	**Std. Dev.**
Travelled Miles	2.3	2.3	2.3	2.3	2.3	0.0
Trip Time	1.6	1.8	1.9	2.1	13.8	0.2
Trip Speed	10.0	65.0	71.5	77.0	87.0	5.3

Table 3.5 PM Peak Period Express Pass Trip Statistics

Zone 130 PM	[Spanish Fork (US 6) - University Parkway]					
	Min.	**10th** Percentile	**Avg.**	**90th** Percentile	**Max.**	**Std. Dev.**
Travelled Miles	1.6	3.7	18.4	32.2	49.2	11.5
Trip Time	1.1	3.0	15.4	28.2	51.7	10.1
Trip Speed	32.0	69.0	73.5	79.0	91.0	6.0
Zone 135 PM	**[University Parkway - Lehi Main]**					
	Min.	**10th** Percentile	**Avg.**	**90th** Percentile	**Max.**	**Std. Dev.**
Travelled Miles	1.0	5.9	18.3	32.8	49.2	9.8
Trip Time	0.7	4.8	15.8	28.5	51.7	9.0
Trip Speed	15.0	63.0	71.5	78.0	97.0	7.9
Zone 140 PM	**[Lehi Main - 14600 South]**					
	Min.	**10th** Percentile	**Avg.**	**90th** Percentile	**Max.**	**Std. Dev.**
Travelled Miles	1.5	3.9	14.8	26.9	49.2	8.8
Trip Time	1.2	3.6	13.3	24.9	72.5	8.1
Trip Speed	14.0	53.0	67.7	76.0	97.0	10.8
Zone 145 PM	**[14600 South - 7200 South]**					
	Min.	**10th** Percentile	**Avg.**	**90th** Percentile	**Max.**	**Std. Dev.**
Travelled Miles	1.1	3.8	14.1	25.7	49.2	8.6
Trip Time	0.8	3.2	12.7	23.7	72.5	8.0
Trip Speed	9.0	55.0	68.2	76.0	94.0	10.3
Zone 150 PM	**[7200 South - Beck Street]**					
	Min.	**10th** Percentile	**Avg.**	**90th** Percentile	**Max.**	**Std. Dev.**
Travelled Miles	1.5	3.4	11.1	20.9	49.2	7.6
Trip Time	1.1	3.0	9.8	19.1	72.5	7.1
Trip Speed	9.0	62.0	69.3	76.0	90.0	7.8
Zone 160 PM	**[Layton Parkway - Park Lane]**					
	Min.	**10th** Percentile	**Avg.**	**90th** Percentile	**Max.**	**Std. Dev.**
Travelled Miles	2.5	2.5	2.5	2.5	2.5	0.0
Trip Time	1.7	2.0	2.3	2.6	5.8	0.3
Trip Speed	26.0	56.0	66.5	76.0	89.0	8.1
Zone 250 PM	**[Beck Street - 7200 South]**					
	Min.	**10th** Percentile	**Avg.**	**90th** Percentile	**Max.**	**Std. Dev.**
Travelled Miles	1.3	5.0	12.5	22.0	51.7	7.4
Trip Time	0.9	4.9	14.5	26.0	80.6	8.6
Trip Speed	7.0	**37.0**	53.6	70.0	91.0	12.8
Zone 255 PM	**[7200 South - 14600 South]**					
	Min.	**10th** Percentile	**Avg.**	**90th** Percentile	**Max.**	**Std. Dev.**
Travelled Miles	1.0	3.8	13.1	23.1	51.7	7.7
Trip Time	0.7	4.1	14.7	26.2	80.6	8.8
Trip Speed	8.0	**41.0**	55.6	69.0	88.0	11.2
Zone 260 PM	**[14600 South - Lehi Main]**					
	Min.	**10th** Percentile	**Avg.**	**90th** Percentile	**Max.**	**Std. Dev.**
Travelled Miles	1.6	5.7	16.8	28.8	51.7	8.9
Trip Time	1.1	5.5	17.2	30.2	80.6	9.9
Trip Speed	10.0	47.0	61.3	72.0	90.0	10.0
Zone 265 PM	**[Lehi Main - University Parkway]**					
	Min.	**10th** Percentile	**Avg.**	**90th** Percentile	**Max.**	**Std. Dev.**
Travelled Miles	1.1	8.8	23.4	38.6	51.7	11.0
Trip Time	0.8	7.0	21.9	38.0	72.7	11.7
Trip Speed	24.0	56.0	67.1	76.0	88.0	8.4
Zone 270 PM	**[University Parkway - Spanish Fork (Us 6)]**					
	Min.	**10th** Percentile	**Avg.**	**90th** Percentile	**Max.**	**Std. Dev.**
Travelled Miles	1.3	4.3	22.3	41.9	51.7	14.4
Trip Time	0.9	3.3	20.0	40.6	72.5	14.4
Trip Speed	26.0	61.0	71.1	79.0	91.0	7.4

3.2.3 Express Pass Toll Data

Express Pass toll data were generated from a sample of transponder data for tolls collected between April 1, 2013 and September 30, 2013 (with weekends and holidays removed). The data were evaluated by zone, with data collected NB for Zone 130 (South Utah County), Zone 135 (Central Utah County), Zone 140 (North Utah County), Zone 145 (South Valley), Zone 150 (Salt Lake), and Zone 160 (North Davis). Data were collected SB for Zone 240 (North Davis), Zone 250 (Salt Lake), Zone 255 (South Valley), Zone 260 (North Utah County), Zone 265 (Central Utah County), and Zone 270 (South Utah County). Details on the zone locations were provided previously in Figure 2.2, Figure 3.1, Figure 3.2, and Table 3.1.

The results of the Express Pass toll data collected are summarized in the following figures. Figure 3.5 provides a summary of toll data for the NB direction, while Figure 3.6 through Figure 3.11 provides detailed information on the six NB zones. Figure 3.12 provides a summary of toll data for the SB direction, while Figure 3.13 through Figure 3.18 provides detailed information on the six SB zones. The figures show the range of toll rates as well as average, median, 10th percentile, and 90th percentile toll rates during the study period. The average toll is calculated from the transponder data by connecting the toll data to each transponder use. The toll data are organized by zone and then by time of day using the PivotTable function in Microsoft Excel to take an average of each one minute interval. The PivotTable uses an arithmetic mean, not a weighted mean for the calculation. It should be noted that the median, 10th percentile, and 90th percentile data are not included for locations with little variability in the toll. It is important to recall that the minimum toll per zone allowed by Administrative Rule R940-1-3 is $0.25, while the maximum toll is $1.00 (Utah Administrative Code 2014).

The results of the Express Pass toll data analysis for the NB direction show that although the toll does reach the maximum value of $1.00 regularly in both the AM Peak and the PM Peak Periods and the 90th percentile toll also approaches $1.00 during the AM Peak and PM Peak Periods, the average toll does not surpass $0.70 for any of the zones during either the AM Peak or PM Peak Periods, other than for Zone 145 (South Valley Zone), which extends from 14600 South to 7200 South, during the AM Peak Period. As a result of this and the fact that the 10th percentile speed in this zone has dropped below 55 mph, Zone 145 will be a focus area for the AM Peak Period.

The results of the Express Pass toll data analysis for the SB direction show that the 90th percentile toll does reach the maximum value of $1.00 regularly in the PM Peak Period; however, for the AM Peak Period, the maximum value is rarely reached. The average toll does not surpass $0.45 for any zone during the AM Peak Period; however, during the PM Peak Period the 90th percentile toll reaches the maximum of $1.00 for the northern zones (North Utah County through Salt Lake), while the average toll exceeds $0.85 for these three zones as well, Zone 250 (Salt Lake), Zone 255 (South Valley), and Zone 260 (North Utah County). As a result of this and the fact that these three zones have 10th percentile speeds below 55 mph, these will be focus areas for the PM Peak Period.

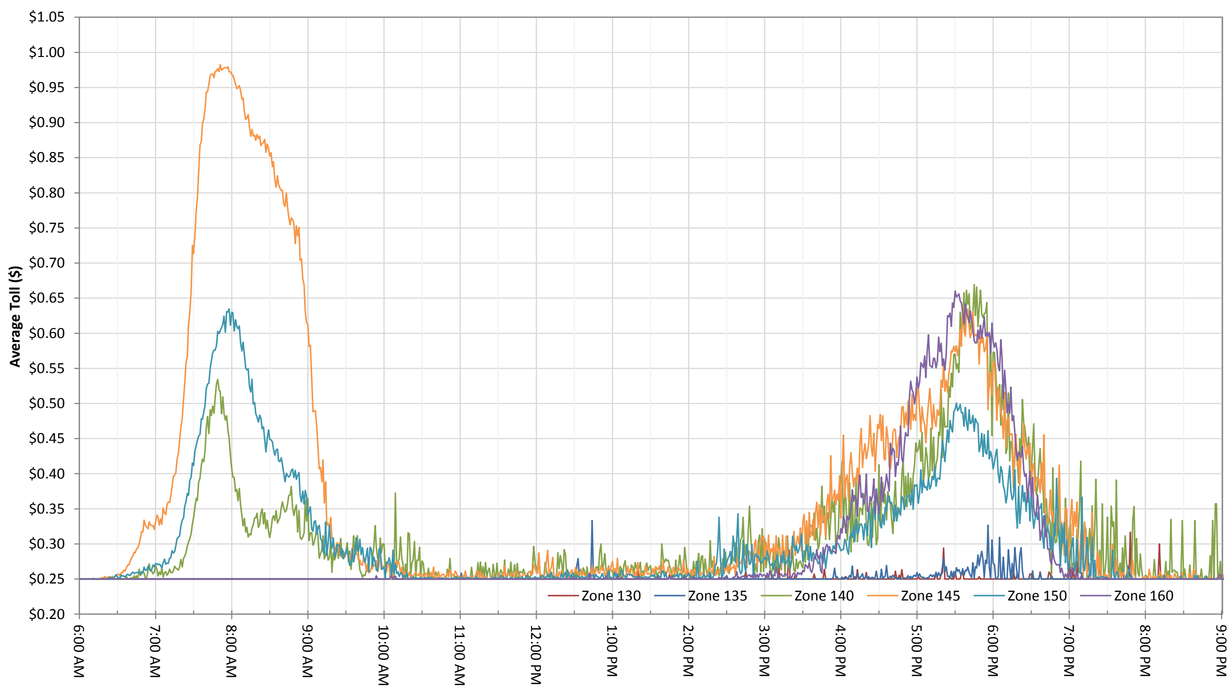

Figure 3.5 Express Lane Average Toll by Time of Day (NB, Entire Corridor)

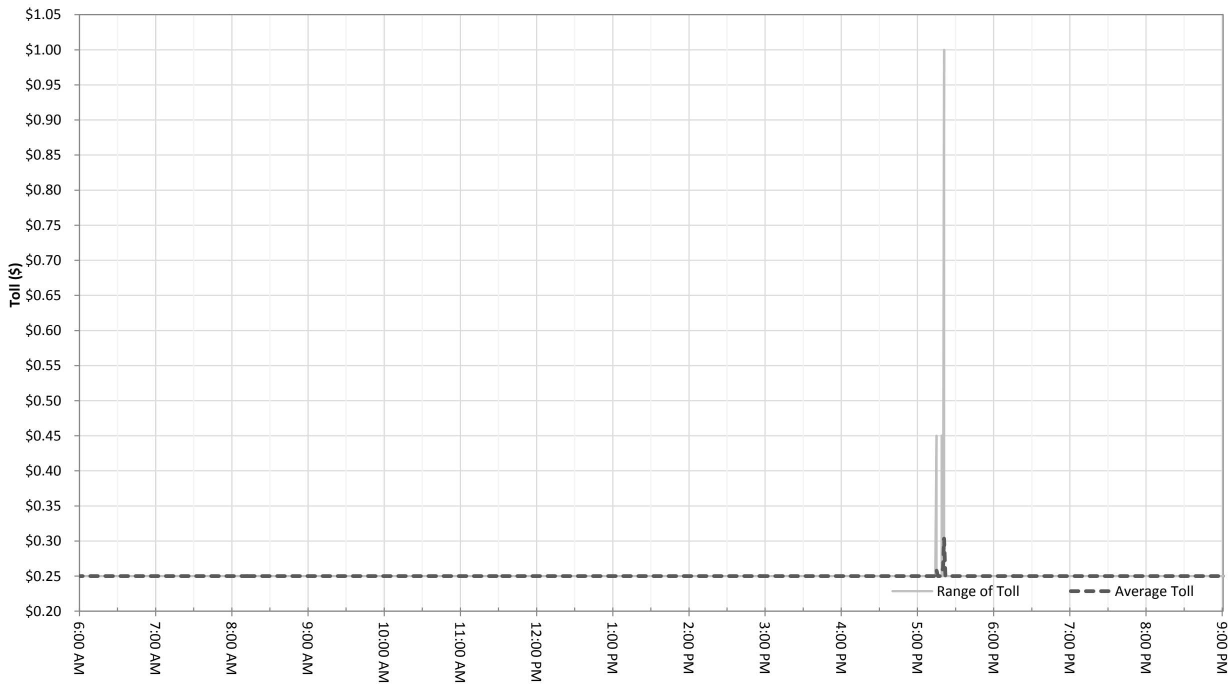

Figure 3.6 Express Lane Toll by Time of Day (NB, Zone 130)

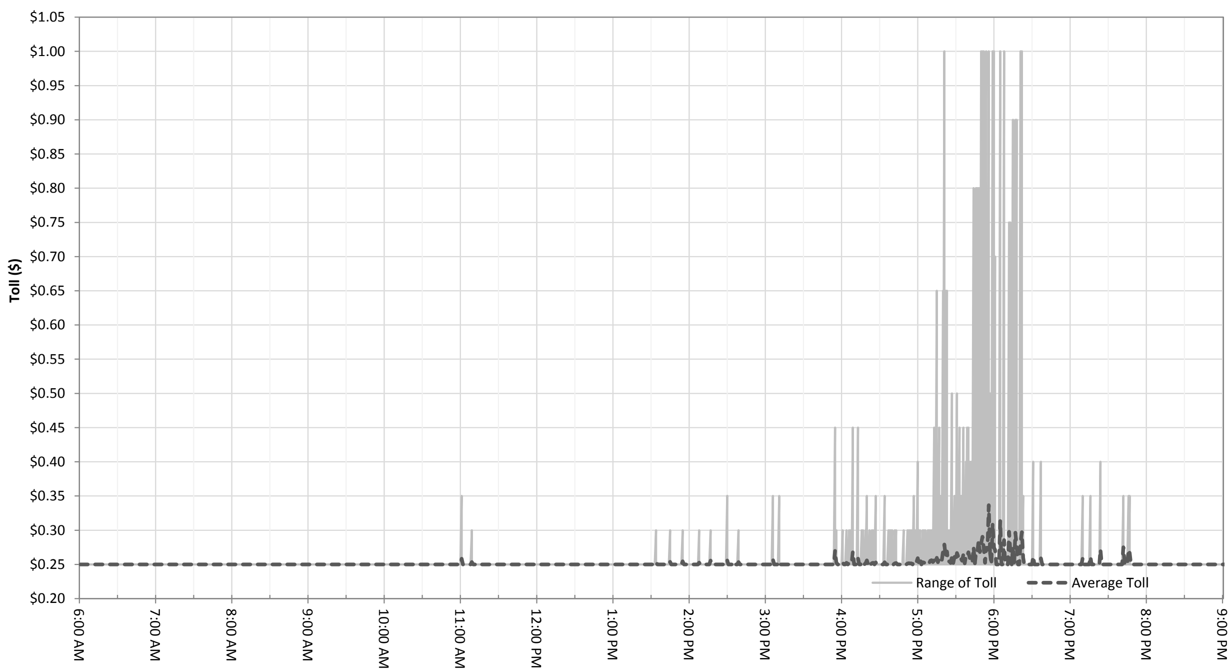

Figure 3.7 Express Lane Toll by Time of Day (NB, Zone 135)

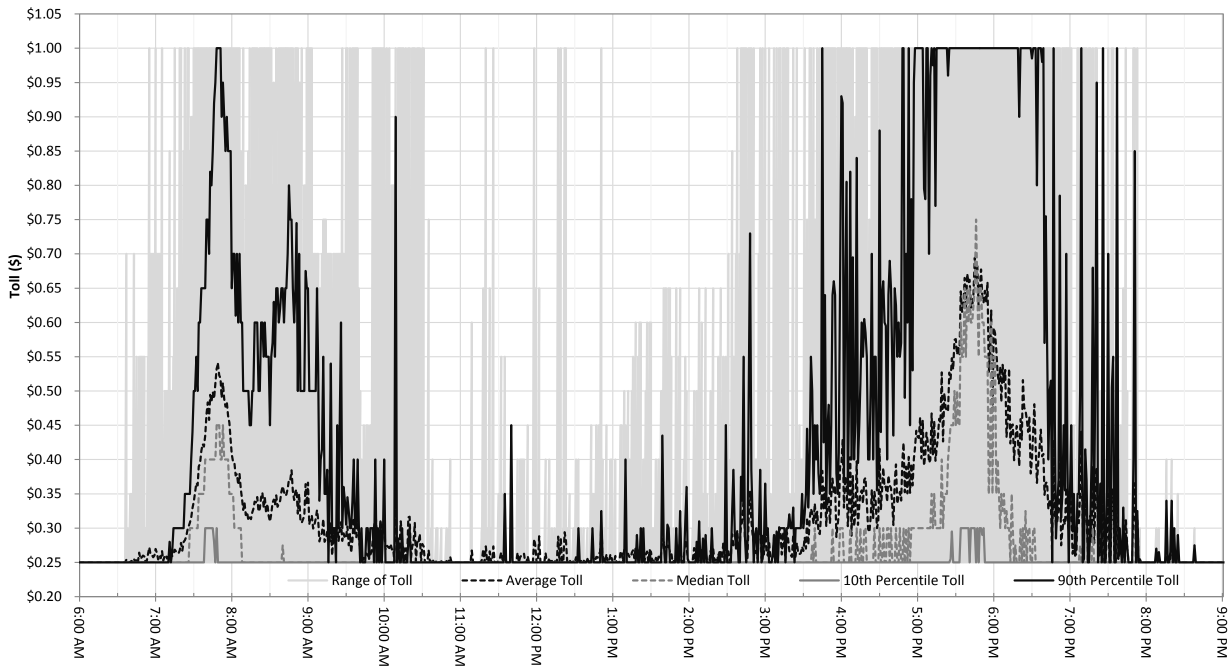

Figure 3.8 Express Lane Toll by Time of Day (NB, Zone 140)

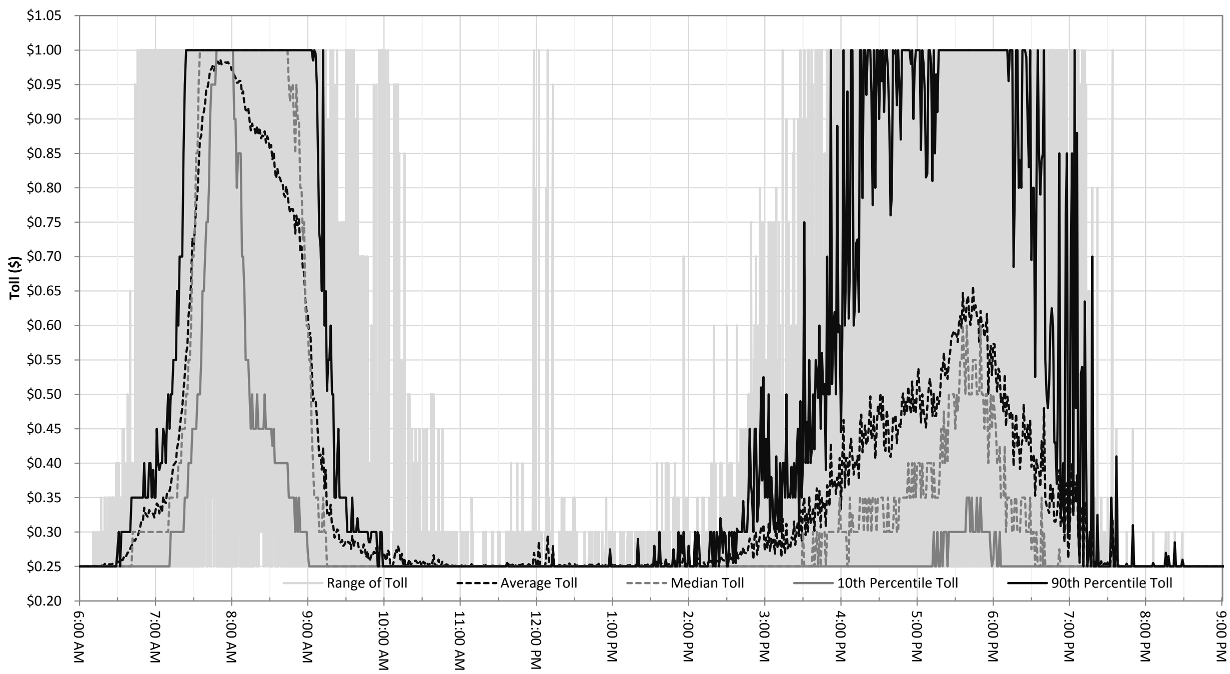

Figure 3.9 Express Lane Toll by Time of Day (NB, Zone 145)

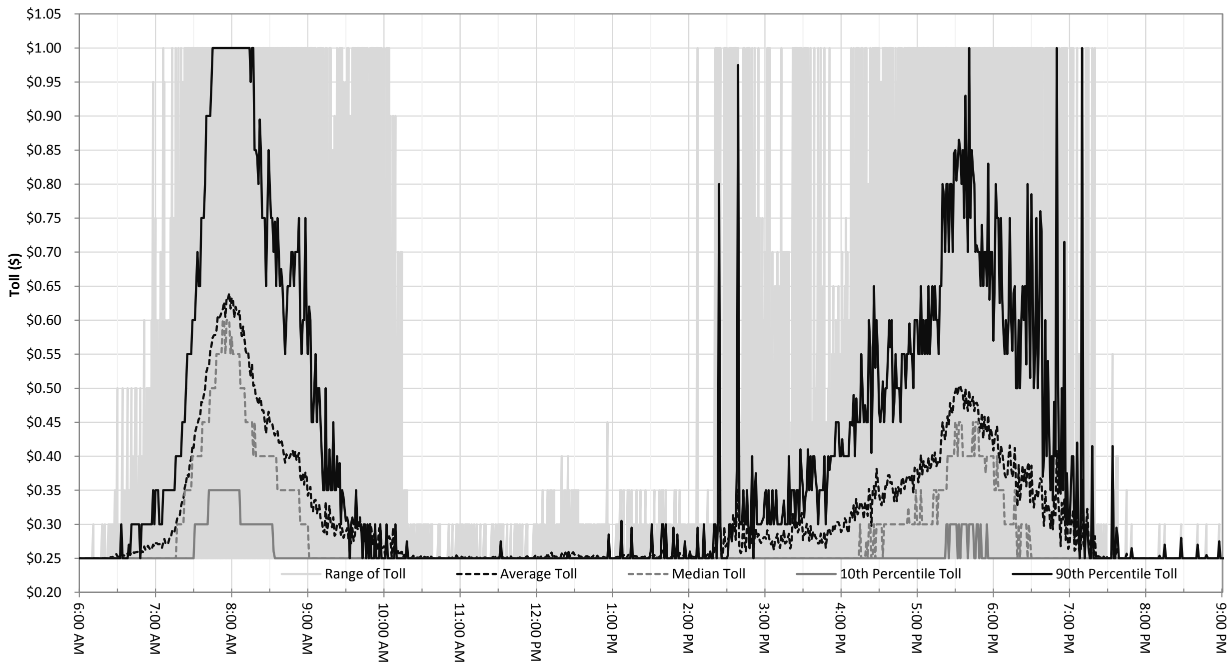

Figure 3.10 Express Lane Toll by Time of Day (NB, Zone 150)

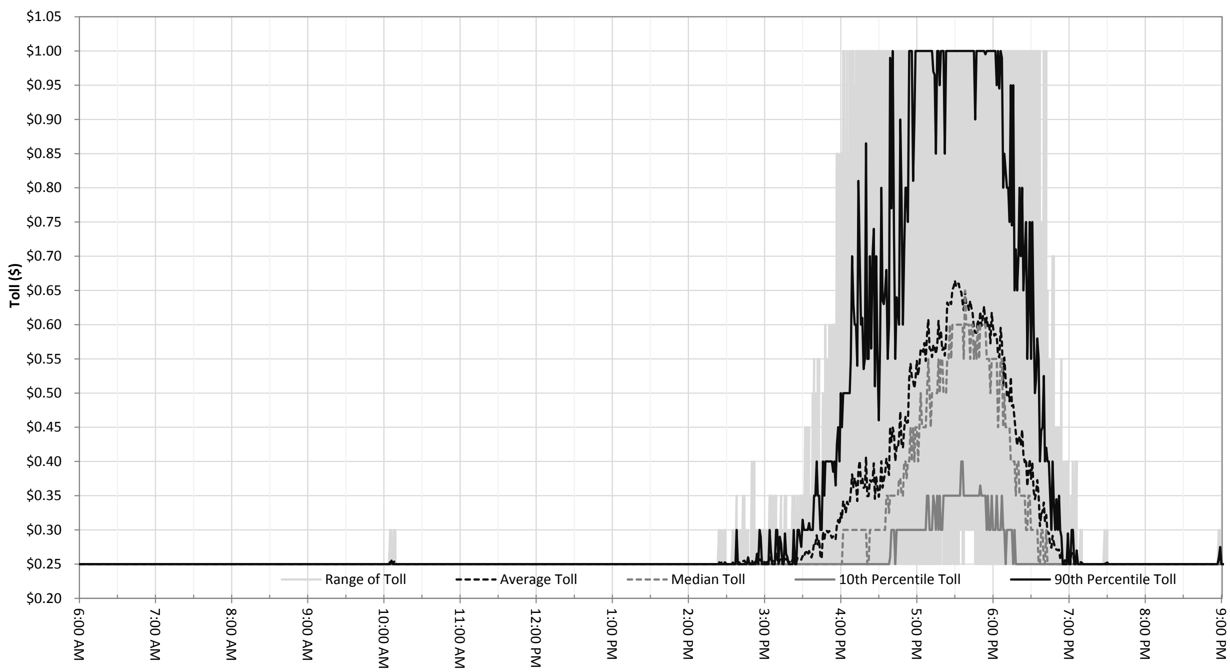

Figure 3.11 Express Lane Toll by Time of Day (NB, Zone 160)

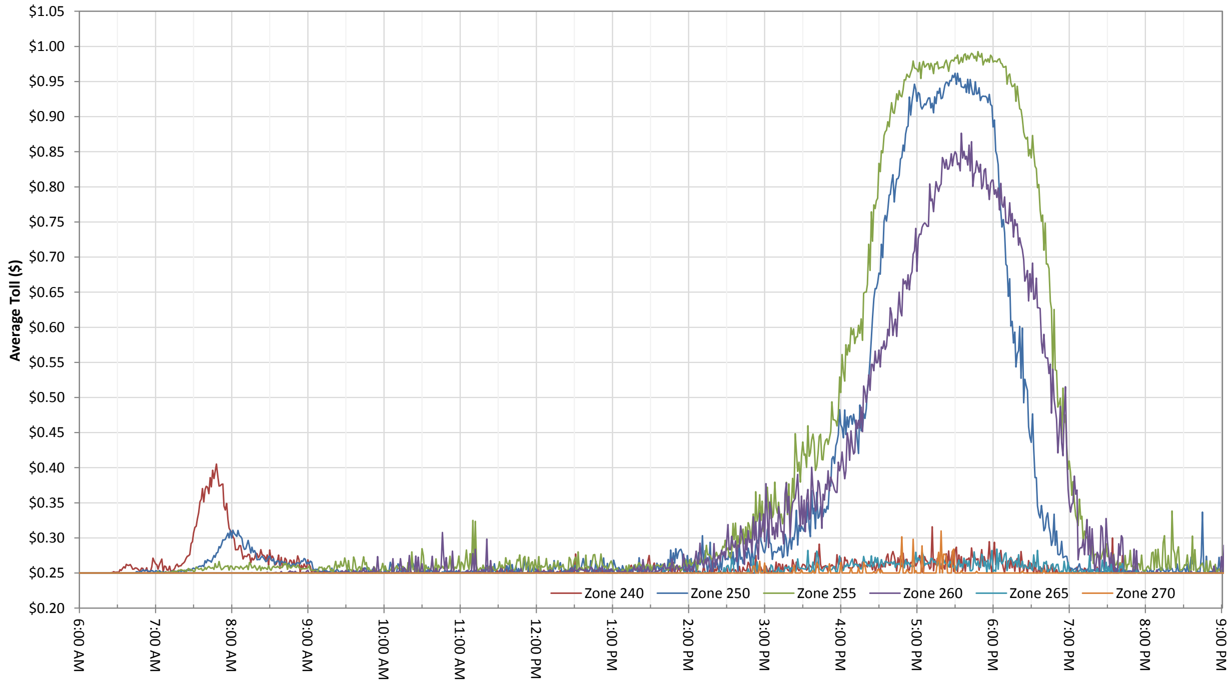

Figure 3.12 Express Lane Average Toll by Time of Day (SB, Entire Corridor)

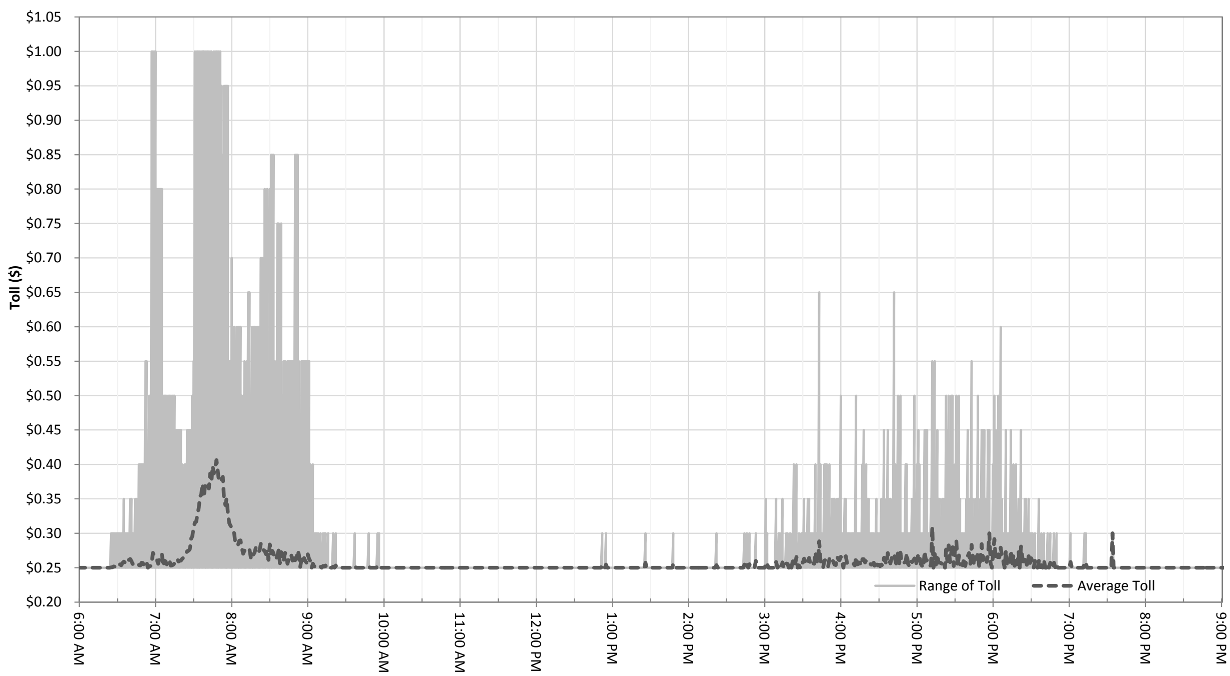

Figure 3.13 Express Lane Toll by Time of Day (SB, Zone 240)

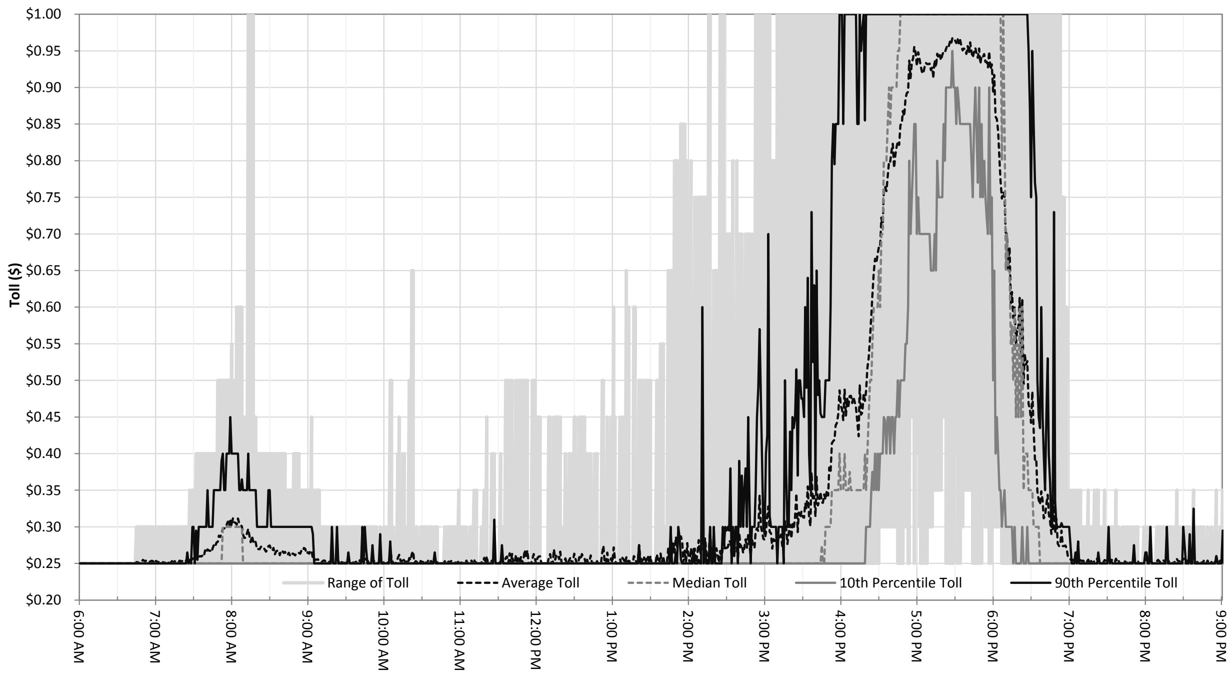

Figure 3.14 Express Lane Toll by Time of Day (SB, Zone 250)

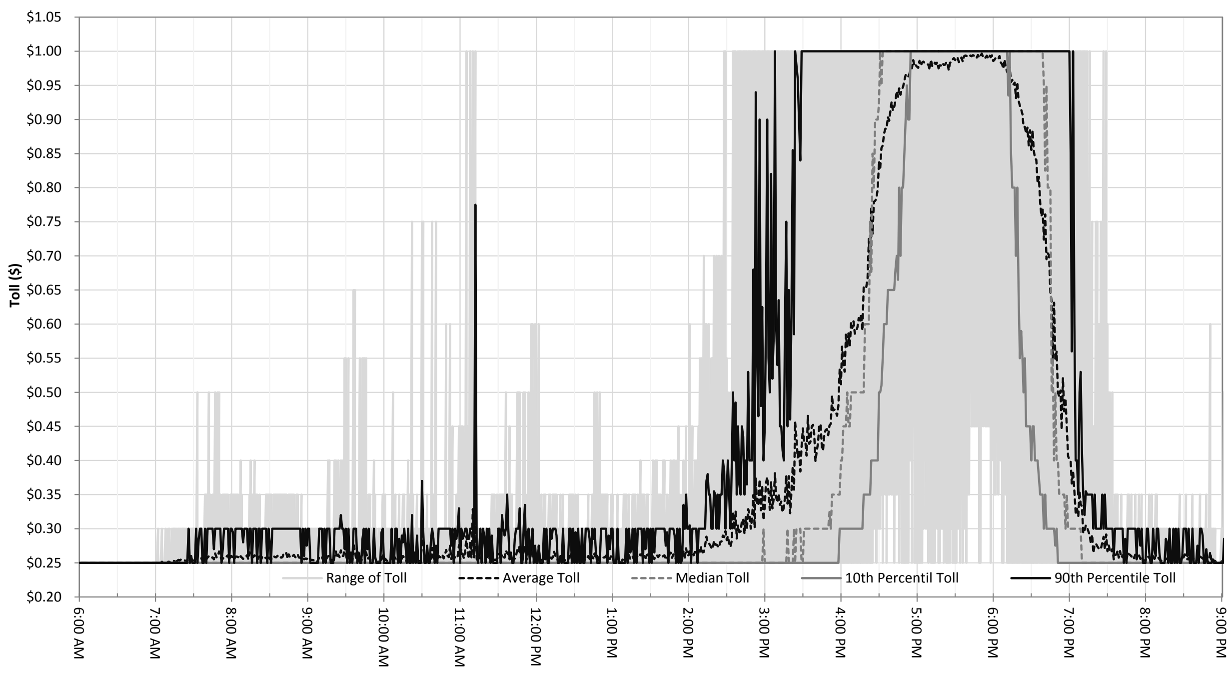

Figure 3.15 Express Lane Toll by Time of Day (SB, Zone 255)

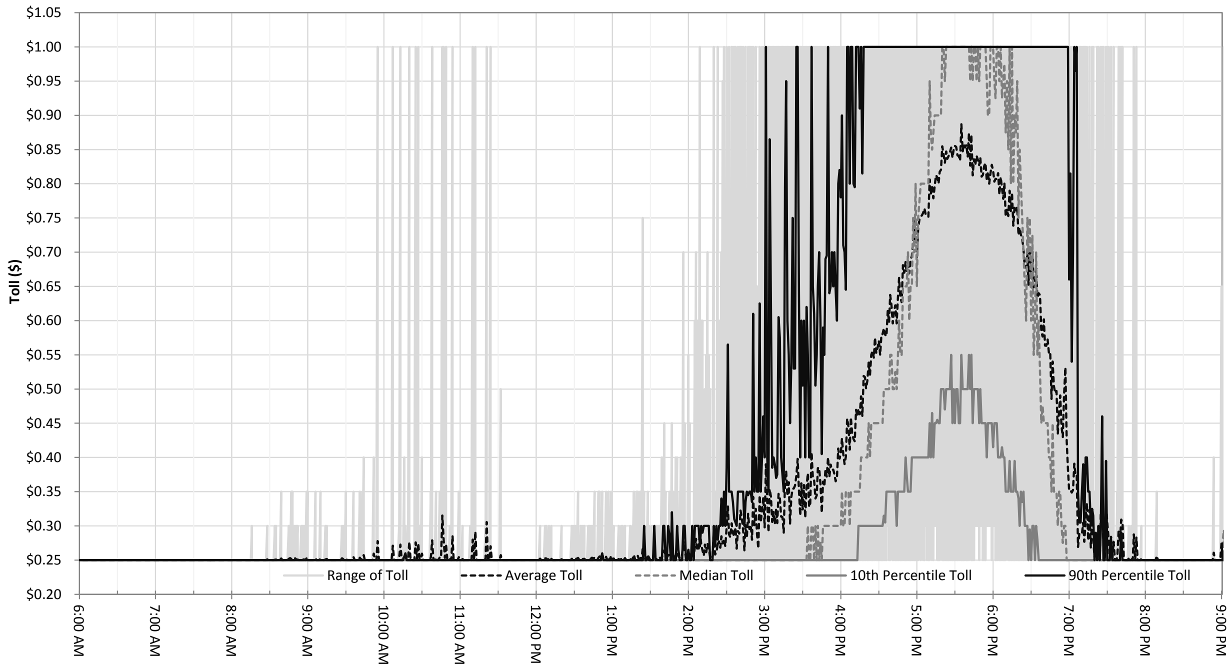

Figure 3.16 Express Lane Toll by Time of Day (SB, Zone 260)

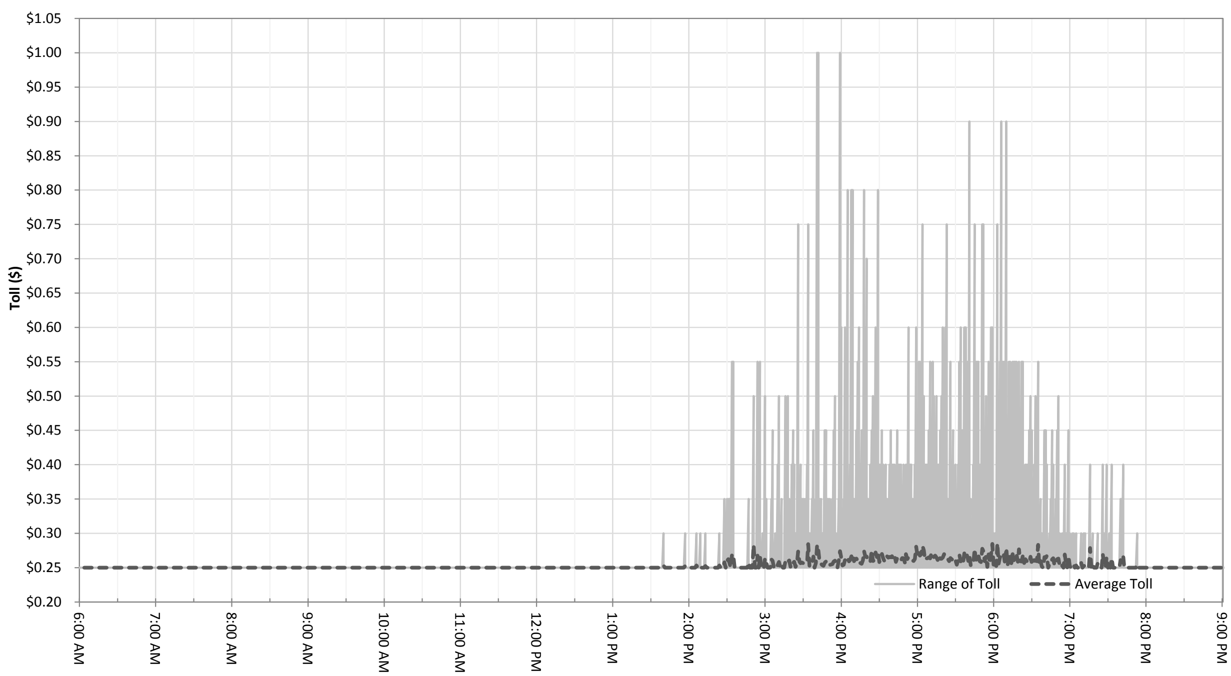

Figure 3.17 Express Lane Toll by Time of Day (SB, Zone 265)

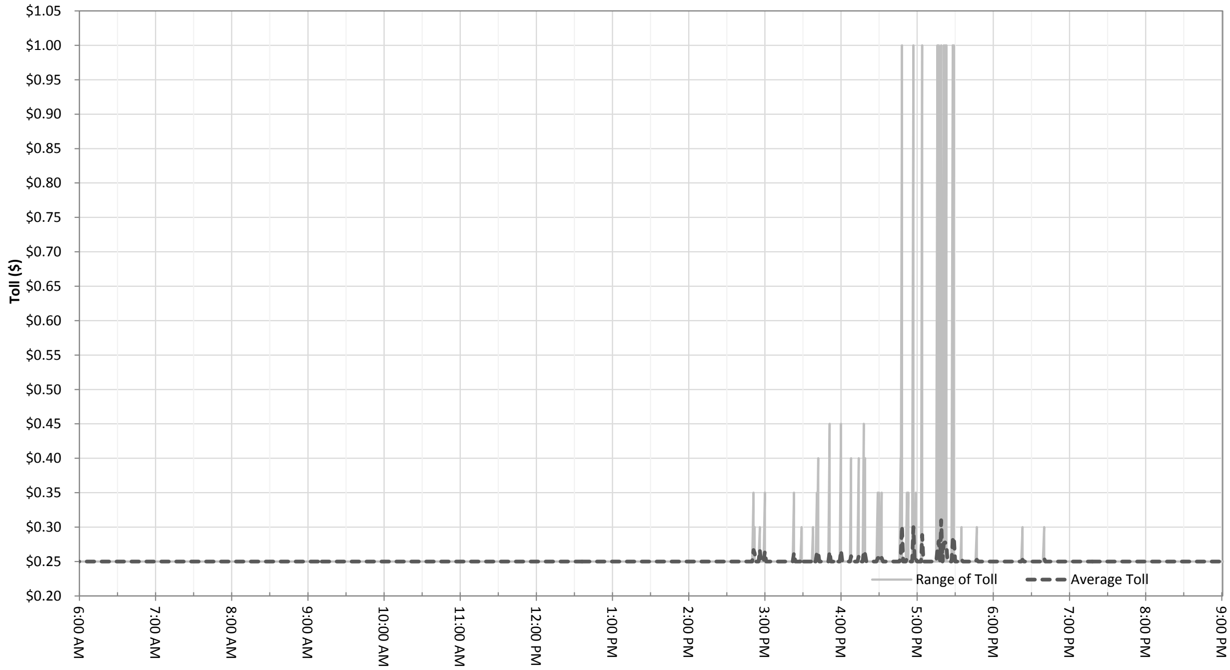

Figure 3.18 Express Lane Toll by Time of Day (SB, Zone 270)

3.3 "C" Decal Data

"C" decals are utilized for clean fuel vehicles in the state. "C" decal data were collected on the number of "C" decals in circulation statewide and the number of trips made by "C" decal vehicle owners each month. The results of this analysis are provided in the following sections.

3.3.1 "C" Decal Circulation Data

According to Title 72, Chapter 6, Section 121 (72-6-121) of the Utah State Code (2014b), beginning on July 1, 2011, UDOT began issuing a clean fuel vehicle decal permit ("C" decal) to applicants who own vehicles powered by clean fuel as set forth by the state. The number of "C" decals in circulation across the state has grown steadily since that time as summarized in Table 3.6 and illustrated in Figure 3.19. As noted in the table and figure, the state has placed a cap on the total number of "C" decals issued at 6,000 vehicles. This cap is formalized in Title 41, Chapter 6a, Section 702 (41-6a-702) of Utah State Code (2014a) and was expected to be reached in March 2014 according to discussion by the TAC.

3.3.2 "C" Decal Trip Data

Trip data for the "C" decal vehicles was not available for this study based on privacy policies associated with the data.

Table 3.6 "C" Decal Summary Data

Year	Month	"C" Decals in Circulation	"C" Decal Limit as per 41-6a-702
2011	September	3,002	6,000
	October	3,053	6,000
	November	3,083	6,000
	December	3,089	6,000
2012	January	3,620	6,000
	February	3,692	6,000
	March	3,760	6,000
	April	3,837	6,000
	May	3,942	6,000
	June	4,015	6,000
	July	4,087	6,000
	August	4,194	6,000
	September	4,277	6,000
	October	4,378	6,000
	November	4,459	6,000
	December	4,519	6,000
2013	January	4,615	6,000
	February	4,702	6,000
	March	4,796	6,000
	April	4,758	6,000
	May	4,761	6,000
	June	4,762	6,000
	July	5,033	6,000
	August	5,160	6,000
	September	5,308	6,000
	October	5,427	6,000
	November	5,536	6,000
	December	5,663	6,000

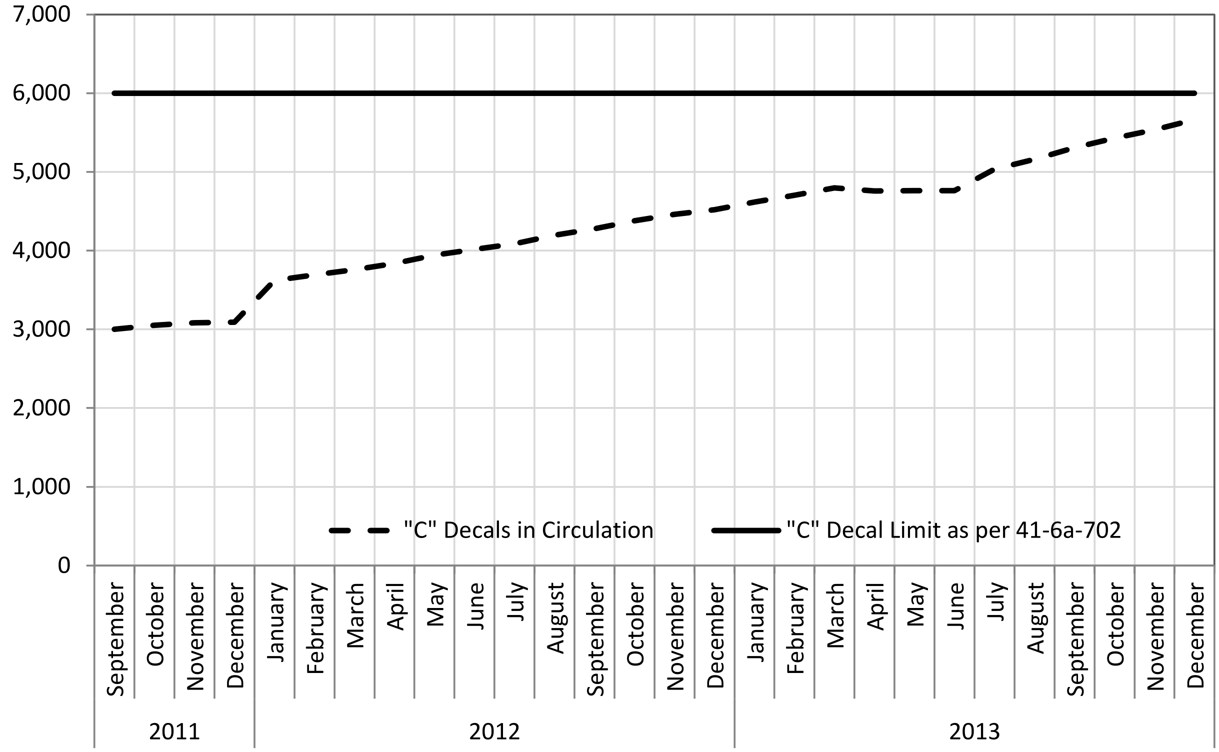

Figure 3.19 "C" Decal Use Summary

3.4 Violator Data

Violator data collected include both a summary of the enforcement reports as well as average occupancy data from previous studies. The results of this analysis are provided in the following sections.

3.4.1 Enforcement Data Reports

Enforcement data are collected monthly across the entire Express Lane corridor. Data include total contacts made, total citations written, and total warnings given. The citations include a variety of infractions including improper use of the lane, crossing the double white line, toll violation, Commercial Motor Vehicle (CMV) left lane violation, HOV on and off ramp lane violation, operating restricted vehicles in the left lane, and left lane restricted vehicles over 12,000 pounds. The results of the enforcement data are provided in Table 3.7 and Figure 3.20. As illustrated in the table and figure, a large increase in contacts and citations occurred during the summer of 2013. It was initially thought that these increases corresponded to an enforcement blitz; however, it was determined that enforcement blitzes occurred in April and October, thus the reason for the increase is unknown.

Table 3.7 Express Lanes Enforcement Data (Entire Corridor)

Year	Month	Total Contact	Total Citation	Total Warning
2011	January	153	110	43
	February	208	145	63
	March	260	183	77
	April	225	149	76
	May	219	120	99
	June	191	108	83
	July	144	78	66
	August	191		
	September	182	91	91
	October	160	85	75
	November	147	71	76
	December			
2012	January	42		
	February	37		
	March	256		
	April	256	148	108
	May	186	97	89
	June	200	96	104
	July	192	101	91
	August	288	153	135
	September	237	123	114
	October	233	118	115
	November	305	160	145
	December	176	91	85
2013	January	194	109	85
	February	241	118	123
	March	378	177	201
	April	645	377	268
	May	528	195	333
	June	909	431	477
	July	954	430	524
	August	934	424	506
	September	278	146	132
	October	450	239	211
	November	408	198	237
	December	169	88	89

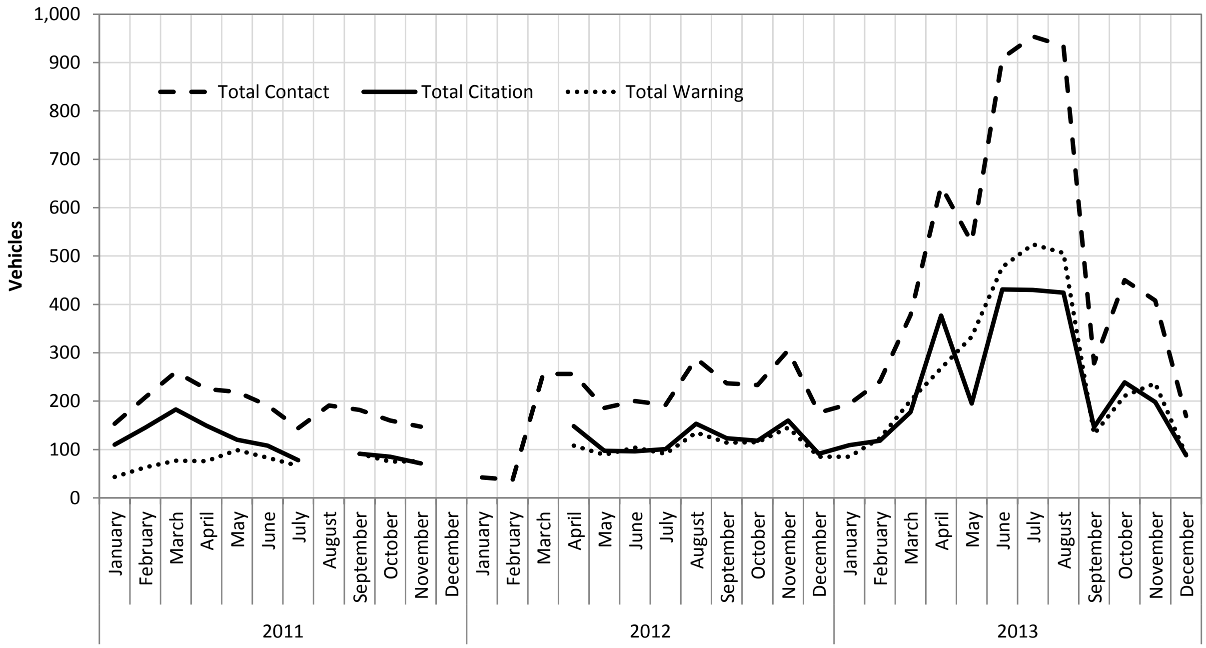

Figure 3.20 Express Lanes Enforcement (Entire Corridor)

3.4.2 Vehicle Occupancy Data

The most current occupancy field study that has been completed was from a University of Utah report by Martin et al. (2005). The results of this study indicated that the overall HOV (the lanes were still HOV only lanes at the time of the study) AVO during the peak period was 2.31, while the GP lane AVO was 1.05. The data for this analysis was completed during the AM and PM Peak Periods. The overall AVO on I-15 using the average of averages method was calculated to be 1.37. This is the most current comprehensive study that has been completed. No new data have been collected on vehicle occupancy as the current scope of work does not include detailed field studies. More detailed field studies would be more appropriate during a future phase of the project.

3.5 Speed and Volume Data

Speed and volume data were collected for both the Express Lanes and the GP lanes throughout the corridor. The results of the speed data and volume data analyses are provided in the following sections.

3.5.1 Speed Data

Speed data were collected using loop detectors along both the Express Lanes and the GP lanes throughout the corridor from monthly data summaries provided by UDOT. Data were collected from the UDOT monthly reports for the entire length of the Express Lane project as well as in the South Valley zone (Zone 145 NB and Zone 255 SB) of the corridor. Results of average weekday speed data for the AM Peak period (7:00 – 8:00 a.m.) for the entire corridor are provided in Figure 3.21. Results of the average weekday speed data for the PM Peak period (5:00 – 6:00 p.m.) for the corridor are provided in Figure 3.22. Results of the average weekday speed data for the NB AM Peak period in Zone 145 are provided in Figure 3.23. Results of the average weekday speed data for the SB PM Peak period in Zone 255 are provided in Figure 3.24.

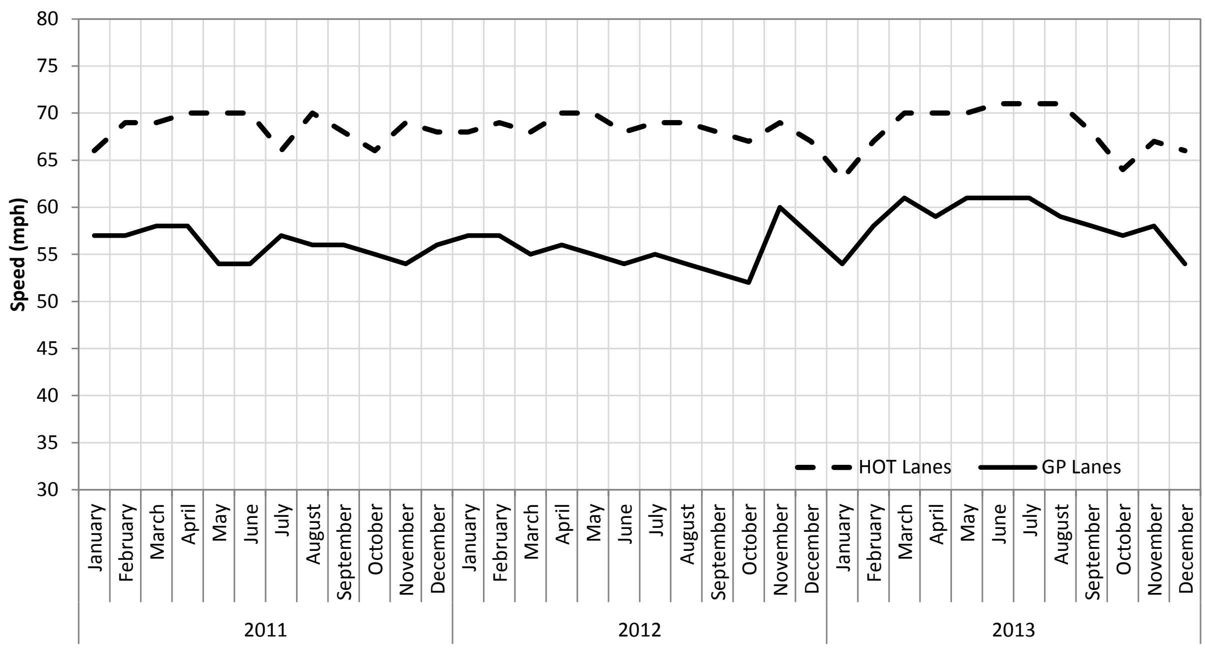

Figure 3.21 Average Weekday AM Peak (7:00 – 8:00 a.m.) Speeds (Entire Corridor)

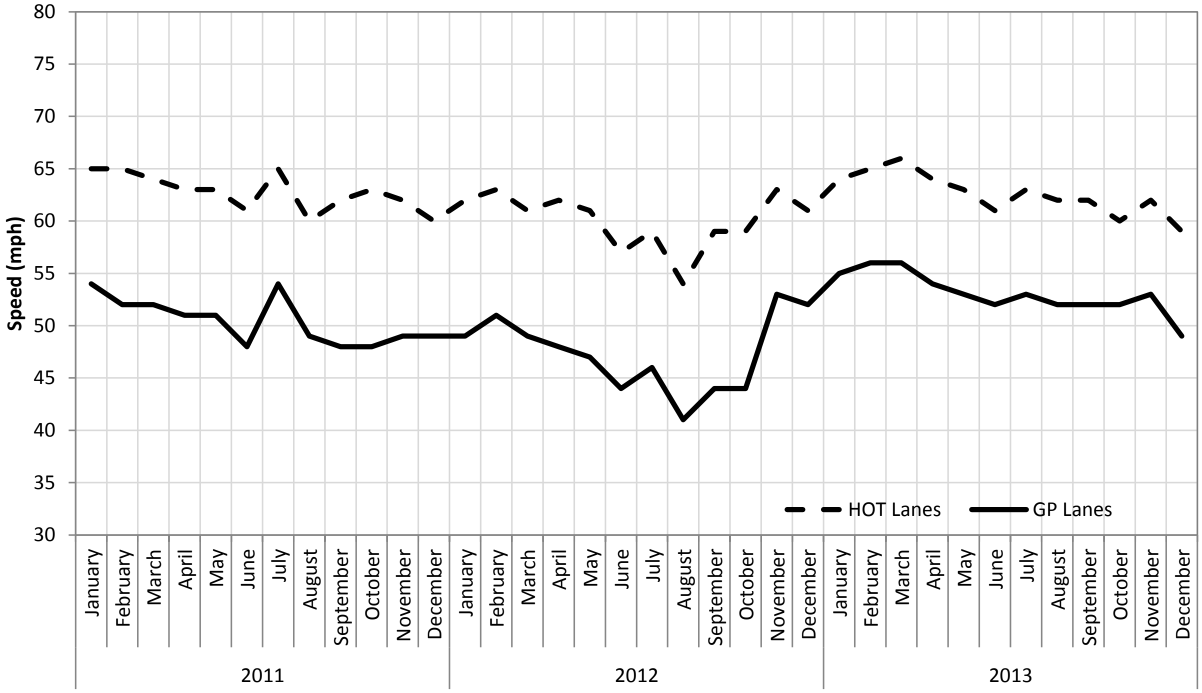

Figure 3.22 Average Weekday PM Peak (5:00 – 6:00 p.m.) Speeds (Entire Corridor)

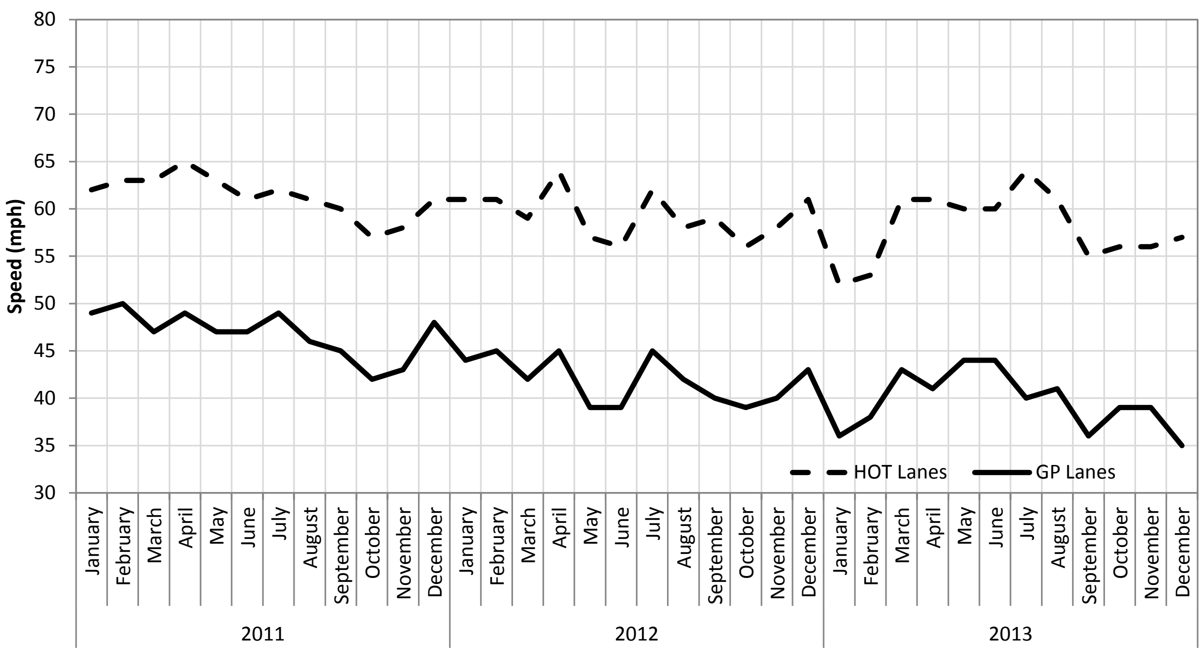

Figure 3.23 Average Weekday AM Peak (7:00 – 8:00 a.m.) Speeds (NB, Zone 145)

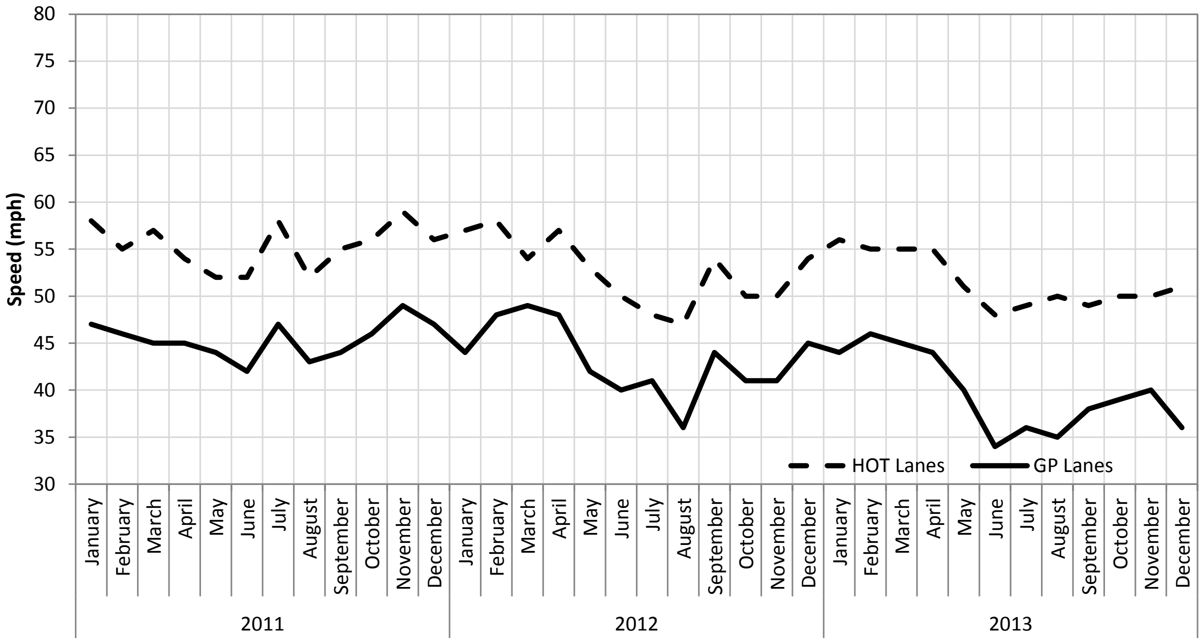

Figure 3.24 Average Weekday PM Peak (5:00 – 6:00 p.m.) Speeds (SB, Zone 255)

Table 3.8 Speed Data Summary

		Express Lane Speed (mph)						General Purpose Lane Speed (mph)					
		All Zones				*South Valley*		*All Zones*				*South Valley*	
		Weekend Average	**Weekday Average**	**HOT Average Weekday AM Peak**	**Average Weekday PM Peak**	**NB AM Peak**	**SB PM Peak**	**Weekend Average**	**Weekday Average**	**GP Average Weekday AM Peak**	**Average Weekday PM Peak**	**NB AM Peak**	**SB PM Peak**
2011	January	69	68	66	65	62	58	61	59	57	54	49	47
	February	69	69	69	65	63	55	59	58	57	52	50	46
	March	69	69	69	64	63	57	59	57	58	52	47	45
	April	69	69	70	63	65	54	58	57	58	51	49	45
	May	70	69	70	63	63	52	56	56	54	51	47	44
	June	70	69	70	61	61	52	56	56	54	48	47	42
	July	69	68	66	65	62	58	61	59	57	54	49	47
	August	69	69	70	60	61	52	57	56	56	49	46	43
	September	68	68	68	62	60	55	55	54	56	48	45	44
	October	68	67	66	63	57	56	52	53	55	48	42	46
	November	70	69	69	62	58	59	54	54	54	49	43	49
	December	70	69	68	60	61	56	57	56	56	49	48	47
2012	January	69	69	68	62	61	57	60	58	57	49	44	44
	February	69	69	69	63	61	58	60	58	57	51	45	48
	March	69	68	68	61	59	54	56	55	55	49	42	49
	April	70	69	70	62	64	57	55	55	56	48	45	48
	May	70	69	70	61	57	53	56	54	55	47	39	42
	June	69	68	68	57	56	50	55	54	54	44	39	40
	July	70	68	69	59	62	48	55	54	55	46	45	41
	August	69	68	69	54	58	47	55	53	54	41	42	36
	September	69	68	68	59	59	54	54	53	53	44	40	44
	October	70	69	67	59	56	50	55	54	52	44	39	41
	November	69	69	69	63	58	50	61	60	60	53	40	41
	December	69	67	67	61	61	54	61	59	57	52	43	45
2013	January	68	67	63	64	52	56	60	58	54	55	36	44
	February	68	69	67	65	53	55	59	60	58	56	38	46
	March	70	70	70	66	61	55	60	61	61	56	43	45
	April	70	69	70	64	61	55	60	59	59	54	41	44
	May	70	70	70	63	60	51	62	61	61	53	44	40
	June	70	69	71	61	60	48	63	61	61	52	44	34
	July	70	70	71	63	64	49	60	60	61	53	40	36
	August	69	69	71	62	61	50	58	60	59	52	41	35
	September	67	68	68	62	55	49	60	60	58	52	36	38
	October	66	65	64	60	56	50	59	59	57	52	39	39
	November	69	68	67	62	56	50	61	60	58	53	39	40
	December	67	67	66	59	57	51	58	58	54	49	35	36

In addition to the monthly summary report data provided by UDOT, data were collected by the research team using the UDOT Performance Measurement System (PeMS) data system for the zones identified as focus areas based on the results of the previous analysis and input from the TAC. This included NB AM Peak Period (7:30 – 8:30 a.m.) data for Zone 140 (North Utah County), Zone 145 (South Valley), and Zone 150 (Salt Lake). The results of this analysis are provided in Figure 3.25 through Figure 3.27. Note that the hourly data for this analysis are slightly different than the data reported previously from the UDOT monthly reports as the 7:30 – 8:30 a.m. time period was identified by the research team as the highest volume for the AM Peak Period. SB PM Peak Period (5:00 – 6:00 p.m.) data were collected for Zone 250 (Salt Lake), Zone 255 (South Valley), and Zone 260 (North Utah County). The results of this analysis are provided in Figure 3.28 through Figure 3.30. Not all areas of each zone were utilized in the data collection due to missing or incomplete data in the PeMS system.

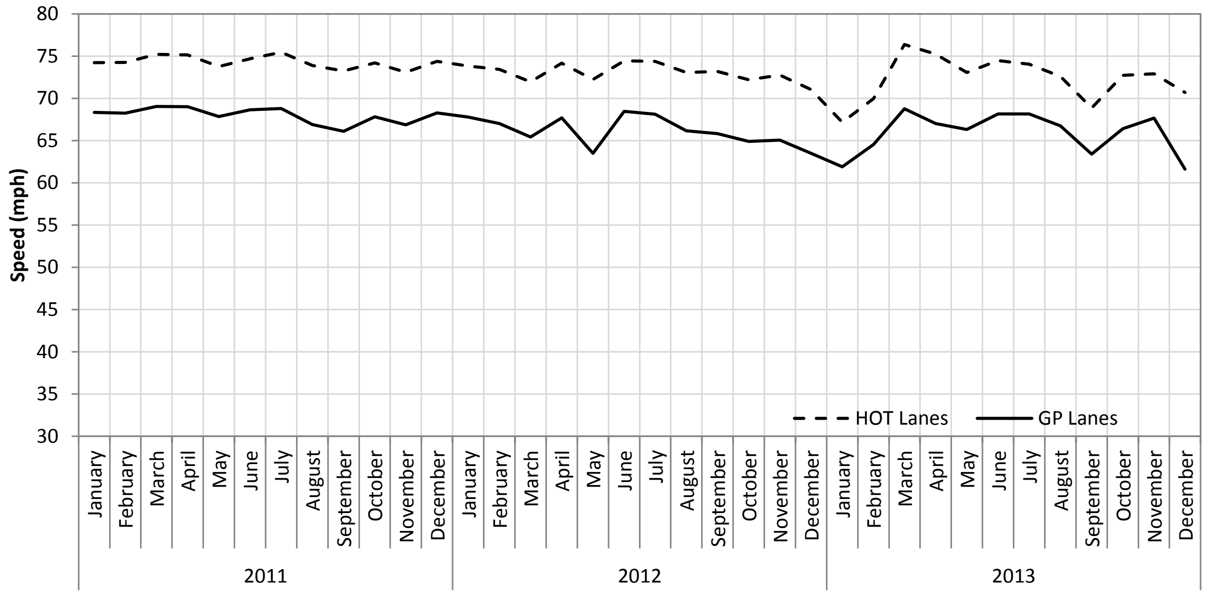

Figure 3.25 Average Weekday AM Peak (7:30 – 8:30 a.m.) Speeds (NB, Zone 140)

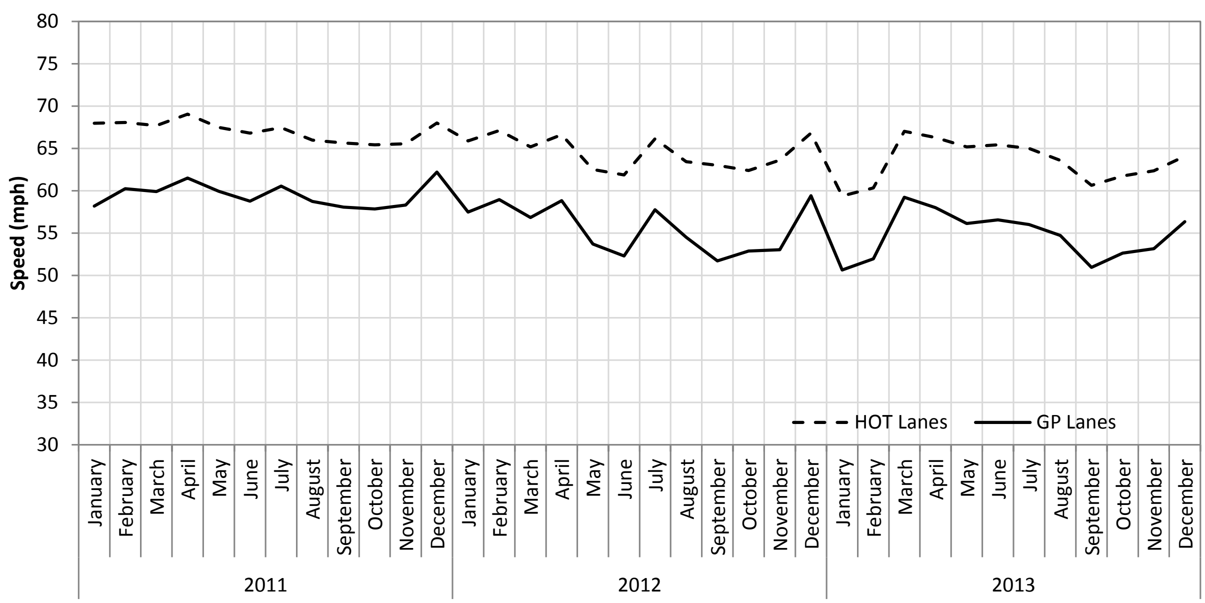

Figure 3.26 Average Weekday AM Peak (7:30 – 8:30 a.m.) Speeds (NB, Zone 145)

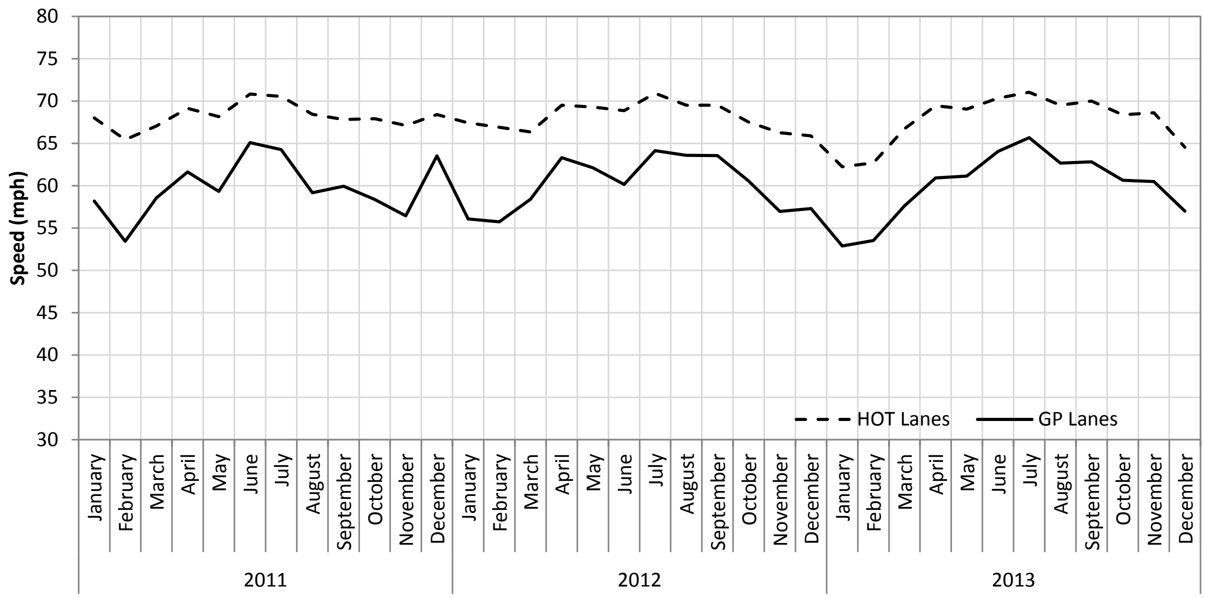

Figure 3.27 Average Weekday AM Peak (7:30 – 8:30 a.m.) Speeds (NB, Zone 150)

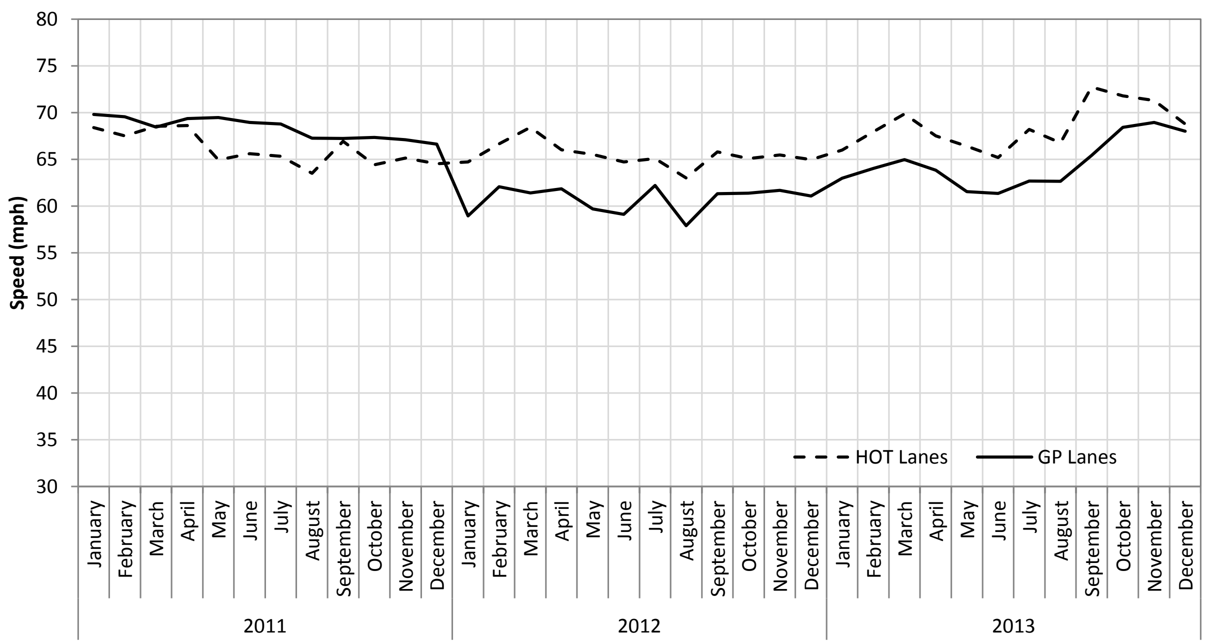

Figure 3.28 Average Weekday PM Peak (5:00 – 6:00 p.m.) Speeds (SB, Zone 250)

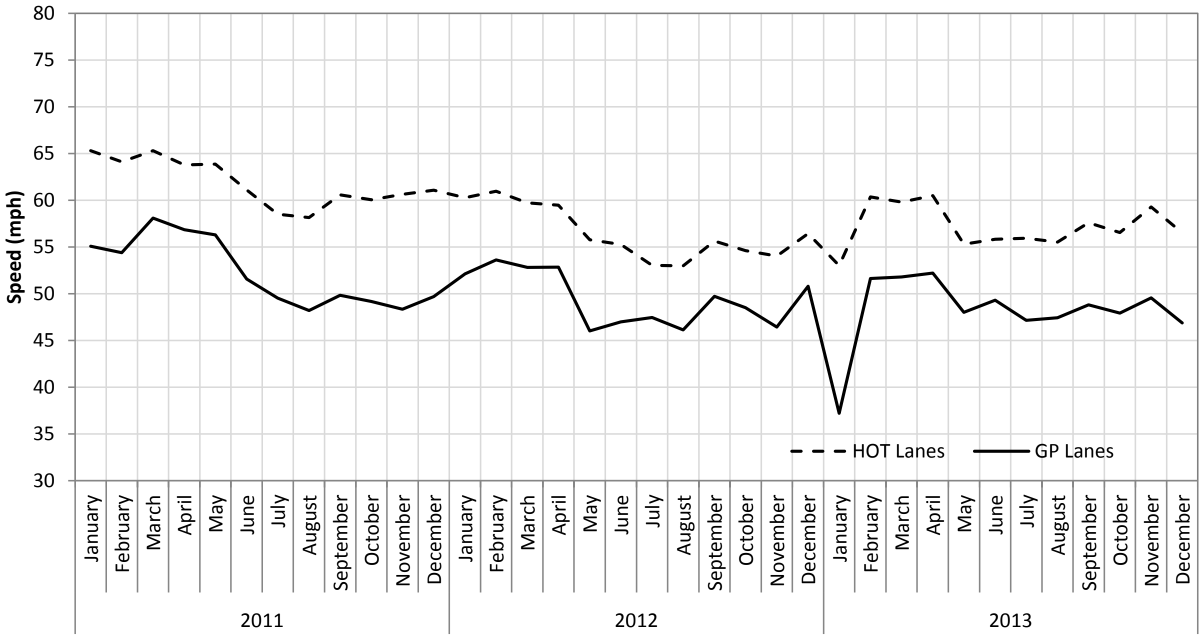

Figure 3.29 Average Weekday PM Peak (5:00 – 6:00 p.m.) Speeds (SB, Zone 255)

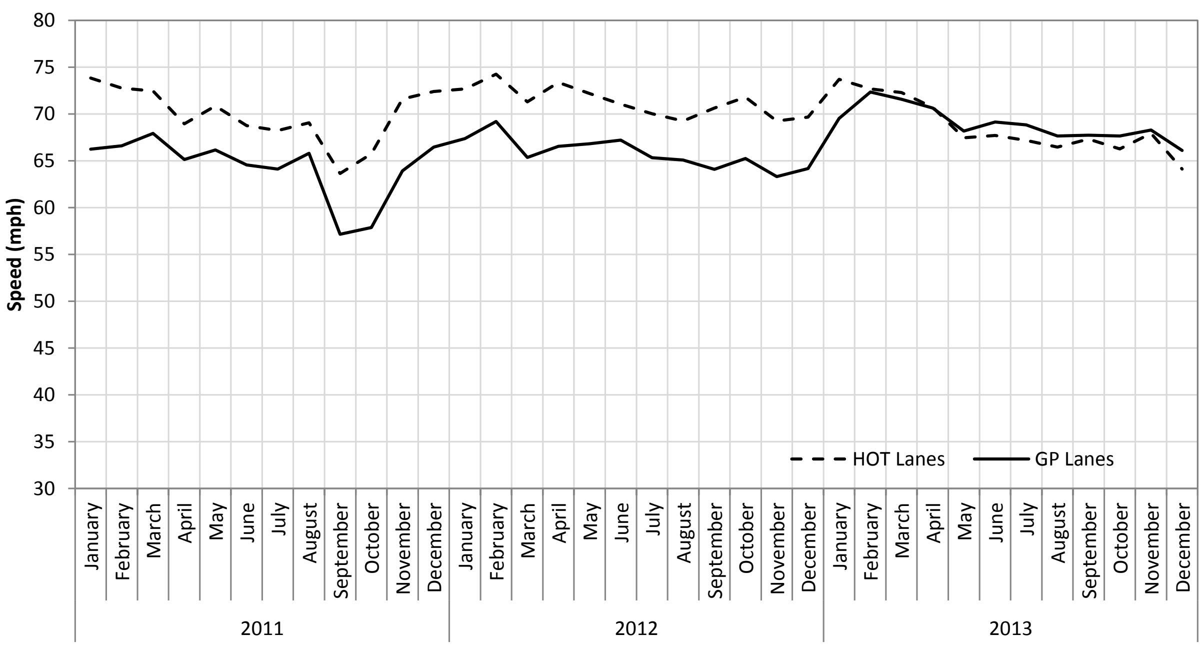

Figure 3.30 Average Weekday PM Peak (5:00 – 6:00 p.m.) Speeds (SB, Zone 260)

As illustrated in the figures, average speeds fluctuate throughout the year and may be affected by a variety of factors including weather, incidents, and seasonal demand. Some fluctuation in the reporting of results may also be a factor of missing or incomplete data in the data analysis process.

The results of this analysis indicated that average speeds on much of the Express Lanes and GP lanes are within acceptable ranges. Note that in several sections the 10th percentile speeds drop below UDOT's goal of 55 mph. The results cover a large area, specifically entire zones for the Express Lanes system. If specific problem spots are pulled from these zones, the results show that there are specific areas within the zones where speeds are considerably slower than those in the entire zone. One example of this is the section of I-15 SB during the PM Peak Period from 4800 South to I-215. The results of this analysis are shown in Figure 3.31. It can be seen from the figure that the Express Lanes speeds in this section have been operating on average below 55 mph since the middle of 2011. The speeds in the GP lane have been very low, at times operating on average below 35 mph. This is one segment of the system that the research team was able to identify through the analysis that should include special consideration; however, it may not be the only segment that falls below expected ranges. Other segments may exist, but were not identified in the original data collection.

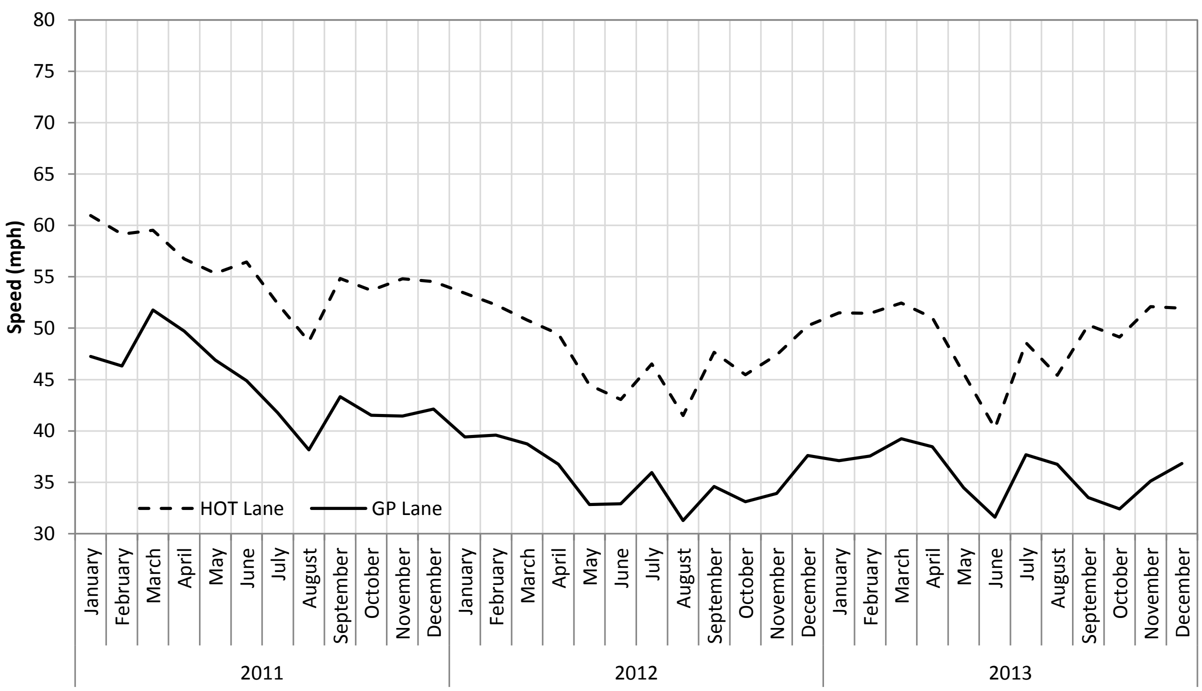

Figure 3.31 Average Weekday PM Peak (5:00 – 6:00 p.m.) Speeds (SB, 4800 S. to I-215)

3.5.2 Volume Data

Volume data were collected on both the Express Lanes and the GP lanes throughout the corridor using the UDOT PeMS data system for the zones identified as focus areas based on the results of the previous analysis and input from the TAC. This included NB AM Peak Period (7:30 – 8:30 a.m.) data for Zone 140 (North Utah County), Zone 145 (South Valley), and Zone 150 (Salt Lake). The results of this analysis are provided in Figure 3.32 through Figure 3.34. SB PM Peak Period (5:00 – 6:00 p.m.) data were collected for Zone 250 (Salt Lake), Zone 255 (South Valley), and Zone 260 (North Utah County). The results of this analysis are provided in Figure 3.35 through Figure 3.37. Not all areas of each zone were utilized in the data collection due to missing or incomplete data in the PeMS system.

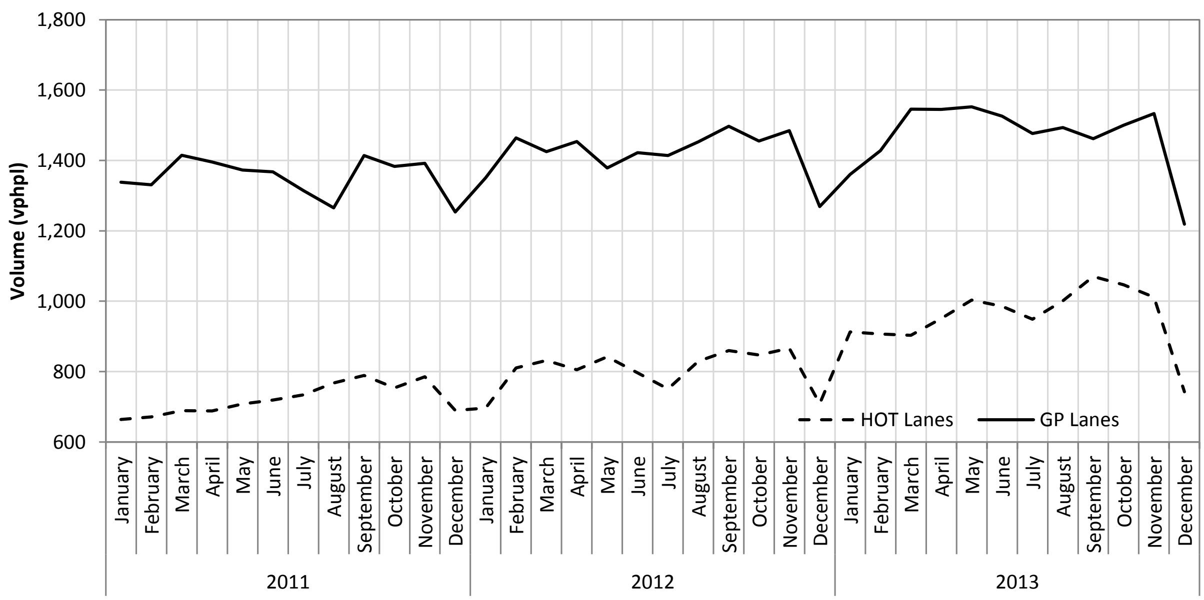

Figure 3.32 Average Weekday AM Peak (7:30 – 8:30 a.m.) Volume (NB, Zone 140)

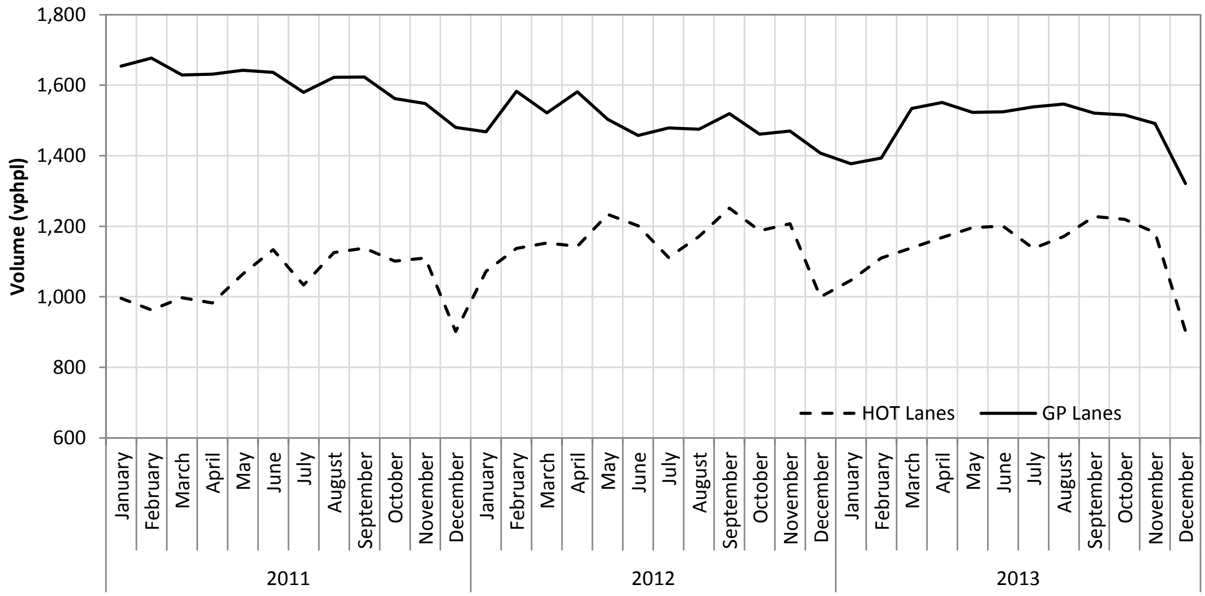

Figure 3.33 Average Weekday AM Peak (7:30 – 8:30 a.m.) Volume (NB, Zone 145)

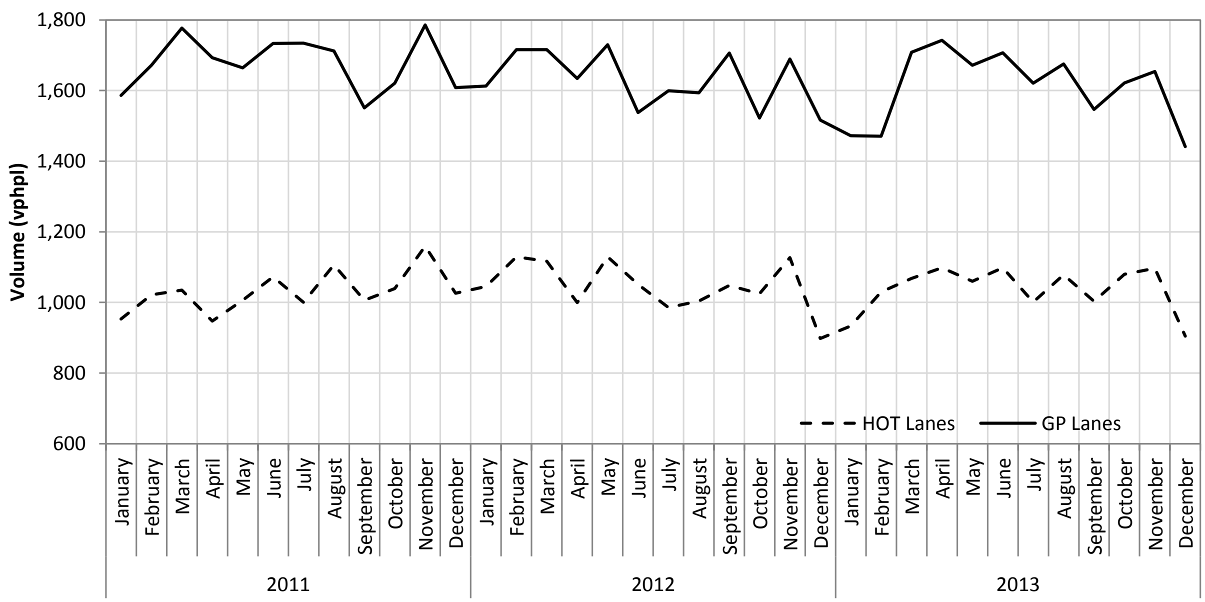

Figure 3.34 Average Weekday AM Peak (7:30 – 8:30 a.m.) Volume (NB, Zone 150)

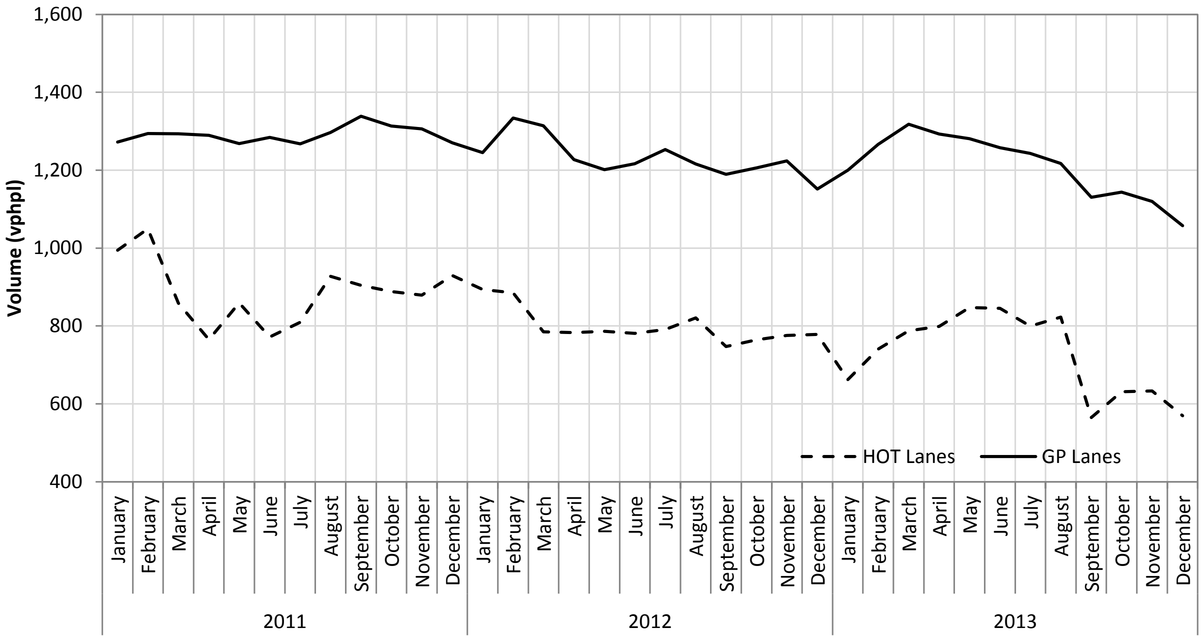

Figure 3.35 Average Weekday PM Peak (5:00 – 6:00 p.m.) Volume (SB, Zone 250)

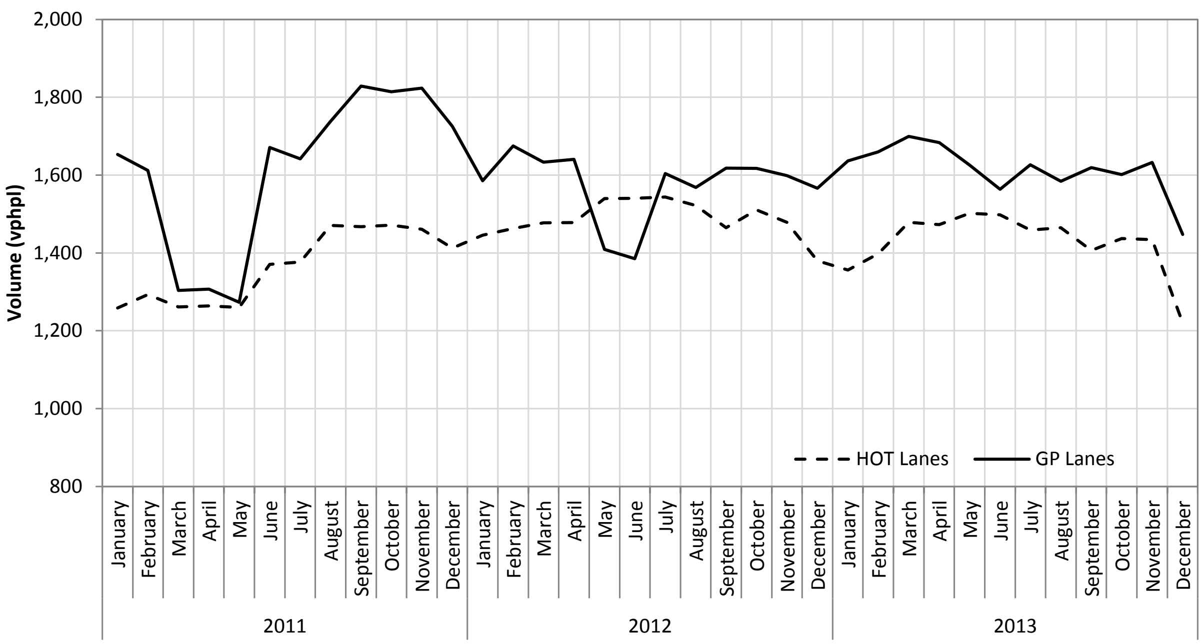

Figure 3.36 Average Weekday PM Peak (5:00 – 6:00 p.m.) Volume (SB, Zone 255)

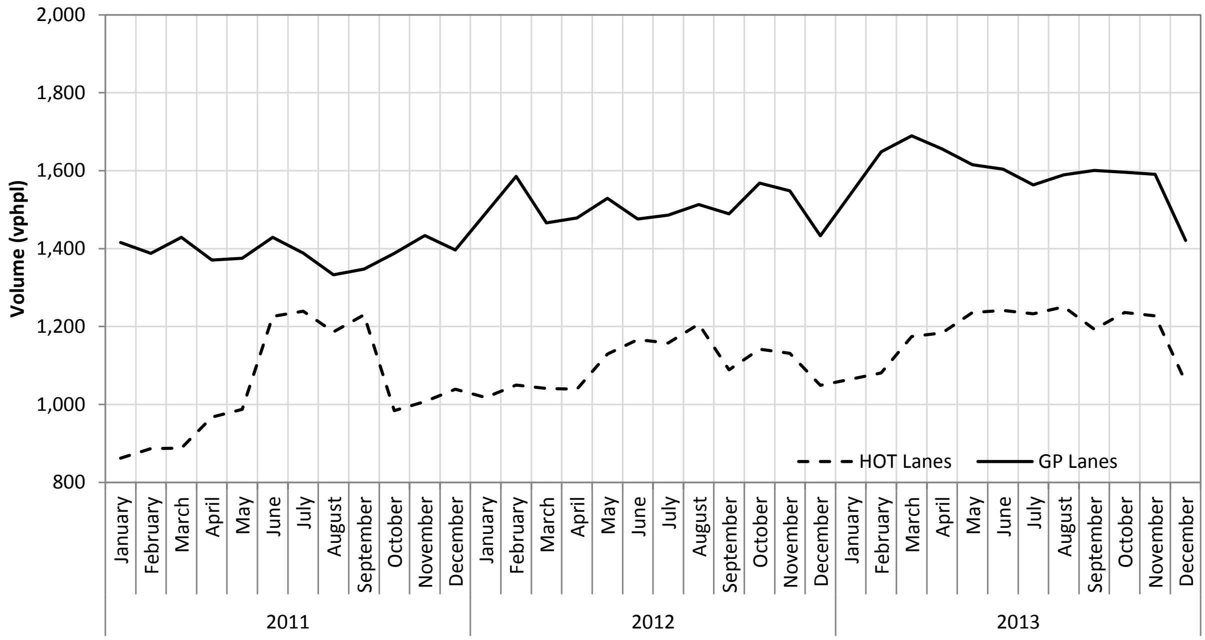

Figure 3.37 Average Weekday PM Peak (5:00 – 6:00 p.m.) Volume (SB, Zone 260)

As with the speed data, the average volumes also fluctuate throughout the year and may be affected by a variety of factors including weather, incidents, and seasonal demand. As noted also, some data may be incomplete, which may have an impact on areas where large fluctuations appear (e.g., March through May in Figure 3.36). It is unclear the exact reasoning for large fluctuations such as these.

The results of the volume analysis indicated that, on average, the volume for both the Express Lanes and GP lanes are operating within acceptable ranges.

3.6 Summary of Express Lane User Data

Express Lanes are used primarily by a variety of users including Express Pass users, "C" decal users, HOV users, buses, motorcycles, and violators. Based on the information currently available, monthly averages by user type have been prepared for a combination of AM Peak and PM Peak, and for AM Peak and PM Peak separately. The results of this summary is provided in Table 3.9 for AM Peak and PM Peak combined, in Table 3.10 for NB AM Peak users, and in Table 3.11 for SB PM Peak users. The HOV, bus, motorcycle, and violator data are combined in one column as the current data do not differentiate between these users (as noted previously in Section 3.4.2). The results of Table 3.9 show that on average for the weekday period the number of “C” decals using the Express Lanes has decreased since late 2012. This is anticipated to be as a result of the completion of the I-15 CORE project in Utah County and the opening of the lanes in that area.

Table 3.9 Express Pass User Summary (Weekday)

Year	Month	Express Pass	"C" Decal	Other (Carpool, Bus, Motorcycle, and Violators)
2011	September	3.40%	1.50%	95.10%
	October	4.10%	2.10%	93.90%
	November	4.10%	2.00%	93.90%
	December	3.10%	1.80%	95.10%
2012	January	4.80%	2.50%	92.70%
	February	4.70%	2.50%	92.80%
	March	4.80%	2.50%	92.70%
	April	3.90%	2.20%	93.90%
	May	4.00%	2.40%	93.60%
	June	3.40%	2.30%	94.30%
	July	3.10%	1.80%	95.10%
	August	4.10%	1.60%	94.30%
	September	4.80%	0.90%	94.20%
	October	5.50%	1.20%	93.40%
	November	4.88%	0.65%	94.48%
	December	4.02%	0.41%	95.57%
2013	January	5.82%	0.89%	93.28%
	February	5.85%	0.54%	93.60%
	March	4.88%	0.43%	94.70%
	April	5.36%	0.45%	94.19%
	May	5.04%	1.16%	93.80%
	June	4.47%	0.81%	94.72%
	July	4.29%	0.35%	95.36%
	August	4.92%	0.35%	94.72%
	September	5.87%	0.43%	93.70%
	October	6.07%	0.47%	93.45%
	November	5.63%	0.45%	93.92%
	December	5.08%	0.47%	94.45%

Table 3.10 Express Pass User Summary (NB AM Peak)

Year	Month	Express Pass	"C" Decal	Other (Carpool, Bus, Motorcycle, and Violators)
2011	September	20.20%	3.60%	76.20%
	October	11.70%	1.90%	86.40%
	November	10.30%	1.60%	88.20%
	December	9.20%	1.80%	88.90%
2012	January	11.70%	2.10%	86.20%
	February	12.00%	1.80%	86.20%
	March	12.40%	2.00%	85.60%
	April	10.60%	2.10%	87.30%
	May	9.30%	2.60%	88.10%
	June	9.20%	2.30%	88.60%
	July	8.50%	2.10%	89.40%
	August	9.80%	2.10%	88.10%
	September	11.20%	2.70%	86.10%
	October	12.10%	2.90%	85.00%
	November	9.90%	2.50%	87.70%
	December	9.50%	2.60%	87.90%
2013	January	14.20%	2.90%	82.90%
	February	12.30%	3.20%	84.50%
	March	10.90%	3.50%	85.60%
	April	10.40%	3.40%	85.30%
	May	9.20%	3.30%	87.50%
	June	8.40%	3.30%	88.30%
	July	7.70%	3.10%	89.20%
	August	9.20%	3.20%	87.50%
	September	10.40%	4.20%	85.40%
	October	10.70%	4.40%	84.90%
	November	9.70%	4.10%	86.20%
	December	9.80%	4.80%	85.30%

Table 3.11 Express Pass User Summary (SB PM Peak)

Year	Month	Express Pass	"C" Decal	Other (Carpool, Bus, Motorcycle, and Violators)
2011	September	10.40%	2.70%	86.90%
	October	10.10%	3.00%	86.90%
	November	9.00%	2.80%	88.20%
	December	7.40%	2.50%	90.20%
2012	January	11.00%	3.40%	85.50%
	February	10.20%	3.70%	86.10%
	March	10.10%	2.90%	87.00%
	April	9.50%	2.40%	88.10%
	May	9.60%	2.20%	88.20%
	June	8.60%	2.20%	89.20%
	July	7.30%	2.10%	90.60%
	August	8.00%	2.30%	89.70%
	September	9.20%	2.70%	88.10%
	October	9.20%	3.00%	87.80%
	November	8.00%	2.80%	89.20%
	December	7.00%	2.40%	90.50%
2013	January	10.00%	3.50%	86.40%
	February	9.70%	3.30%	87.00%
	March	8.60%	2.90%	88.50%
	April	9.10%	2.90%	88.30%
	May	8.10%	2.50%	89.40%
	June	8.50%	2.70%	88.90%
	July	7.00%	2.70%	90.30%
	August	7.20%	3.17%	89.80%
	September	8.20%	3.80%	88.00%
	October	8.10%	4.20%	87.60%
	November	6.90%	4.00%	89.10%
	December	6.40%	4.30%	89.30%

4.0 DATA ANALYSIS

4.1 Overview

The data collected in Chapter 3 were analyzed to better understand travelers' speeds, toll rates, and violations. This analysis will provide UDOT with a concise picture of current travel on, and use of, the Express Lanes. It also forms the basis for future analysis examining the impact of potential changes to the Express Lanes. The analysis evaluates the relationship between speed, volume, and toll rates and the future demand for the Express Lanes.

4.2 Speed, Volume, and Toll Rate Analysis

Speed, volume, and toll data were analyzed to determine trends in the data. The results of this analysis for NB and SB directions are provided in the following sections.

4.2.1 Northbound

To provide a comparison of speed, volume, and toll rate, the NB data for Zone 145 (South Valley) between April 1, 2013 and September 30, 2013 were plotted to identify relationships and anomalies in the data. The toll data presented here are those illustrated previously in Chapter 3 and were obtained from a sample of transponder data. The speed and volume data (including the 10^{th} and 90^{th} percentile speeds) presented in this section are data collected by the research team from the UDOT PeMS system for the time period between April 1, 2013 and September 30, 2013. As a result, the 10^{th} and 90^{th} percentile speeds are different than those recorded previously in Table 3.4 and Table 3.5 (the source of the data for those tables was a sample of transponder data for the same time period). Although the results show similar trends in the data, the exact values are not expected to be the same due to the differences in data collection methods.

The results of the speed comparison are provided in Figure 4.1 for average speeds on both the Express Lane and the GP lane and in Figure 4.2 for the 10^{th} and 90^{th} percentile speeds, while the result of the volume comparison is provided in Figure 4.3. As illustrated in the speed comparison, GP lane speeds are higher than Express Lanes in the off-peak. Average Express

Lane speeds dropped during the peak period corresponding to increases in the average toll; however, neither average speeds nor the 10th percentile speeds drop below 55 mph. The volume data analysis shows that the number of vehicles in the Express Lanes increases during the peak periods (i.e., periods with a higher toll); however, the increase is consistent with the increase of vehicles in the GP lanes. To better understand the consistency of these increases, the volume data were plotted as a percent so that the proportion of the vehicles could be evaluated. The percent of vehicles was calculated on a per lane basis. In this way, the average volume per lane for the Express Lanes and the average volume per lane for the GP lanes is totaled and the percent taken for the two vphpl results. The results of this analysis are provided in Figure 4.4. As illustrated in the figure, the percent of total vehicles in the Express Lanes increases slightly during the AM Peak period, however, overall the volumes remain relatively steady as a percentage.

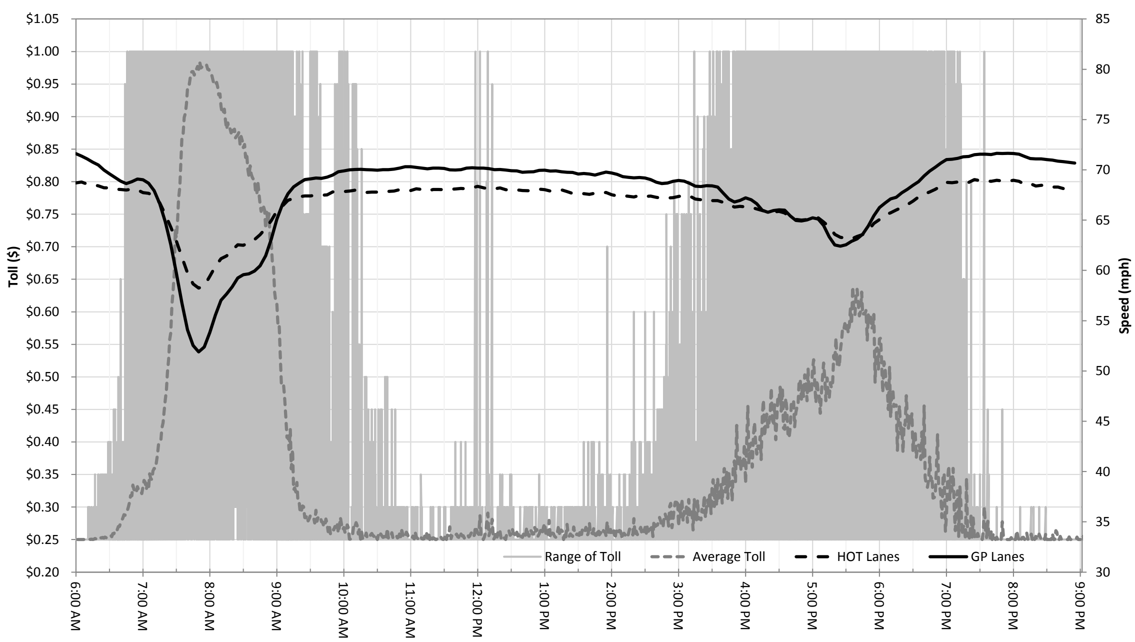

Figure 4.1 Express Lane Toll and Speed by Time of Day (NB, Zone 145)

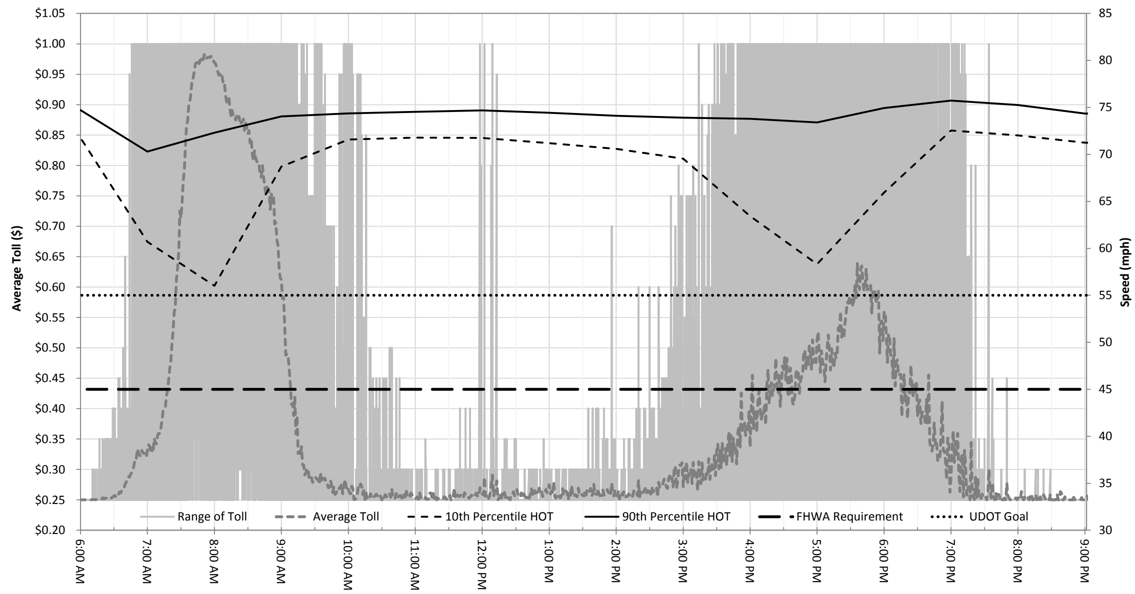

Figure 4.2 Express Lane Toll vs. 10th and 90th Percentile Speed by Time of Day (NB, Zone 145)

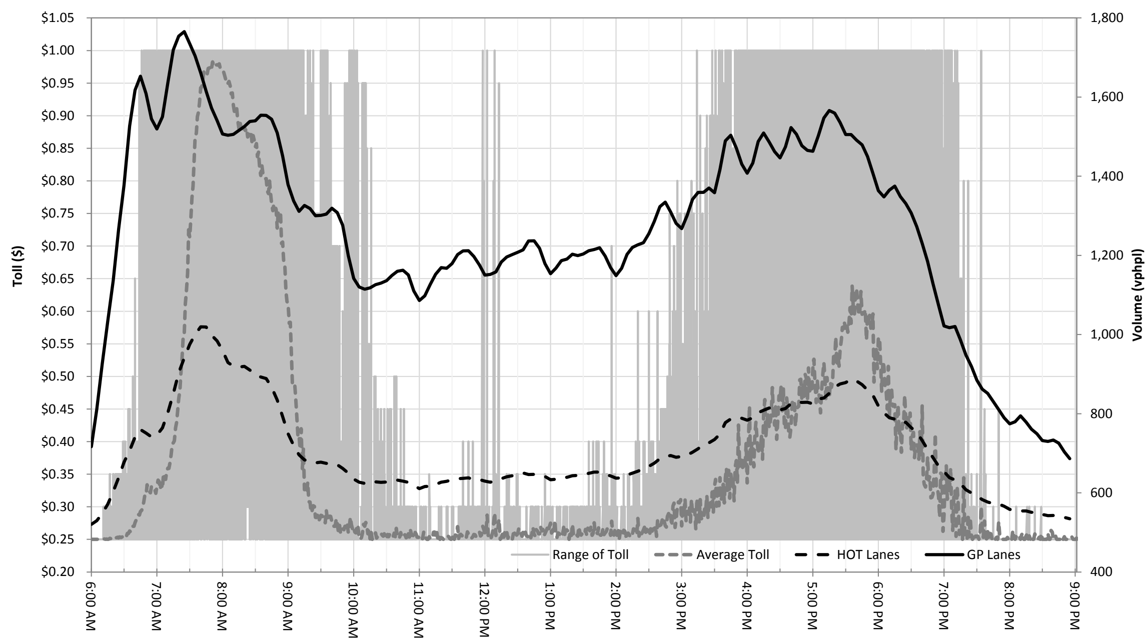

Figure 4.3 Express Lane Toll and Volume by Time of Day (NB, Zone 145)

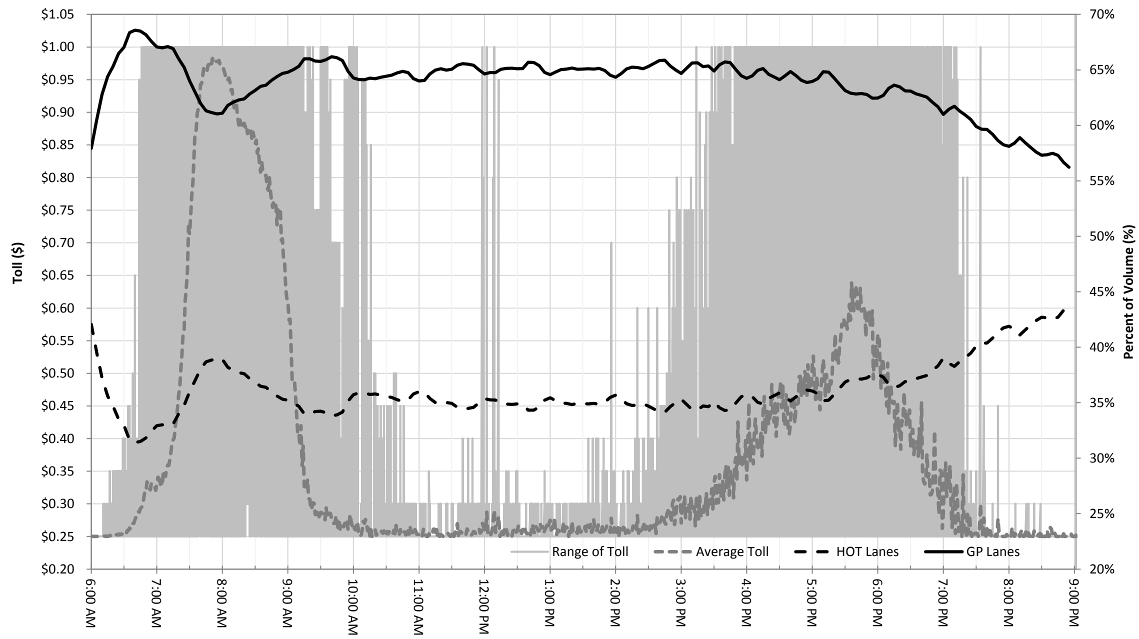

Figure 4.4 Express Lane Toll and Percent of Volume by Time of Day (NB, Zone 145)

4.2.2 Southbound

A similar analysis of speed, volume, and toll rate was conducted for the SB PM Peak Period data for Zone 250 (Salt Lake), Zone 255 (South Valley), and Zone 260 (North Utah County) between April 1, 2013 and September 30, 2013. The data were plotted to identify relationships and anomalies in the data. Again, as with the NB direction analysis, the toll data presented here are those illustrated previously in Chapter 3 and were obtained from a sample of transponder data. The speed and volume data (including the 10^{th} and 90^{th} percentile speeds) presented in this section are data collected by the research team from the UDOT PeMS system for the time period between April 1, 2013 and September 30, 2013. As a result, the 10^{th} and 90^{th} percentile speeds are different than those recorded previously in Table 3.4 and Table 3.5. Although the results show similar trends in the data, the exact values are not expected to be the same due to the differences in data collection methods.

The results of the speed, volume, and percent of volume comparisons are provided in Figure 4.5 through Figure 4.8 for Zone 250, Figure 4.9 through Figure 4.12 for Zone 255, and Figure 4.13 through Figure 4.16 for Zone 260. Similar to the results in the NB direction, average speeds dropped during the peak period corresponding to increases in the average toll. The 10^{th}

percentile speeds drop below 55 mph for Zone 250 and Zone 255, with 10th percentile speeds in Zone 255 approaching 45 mph. The volume data analysis shows that the number of vehicles in the Express Lanes increases during the peak periods (i.e., periods with a higher toll), corresponding to the decreases in speeds; however, the increase is consistent with the increase of vehicles in the GP lanes. Based on the results of the plot of the proportion of vehicles, the percent of total vehicles in the Express Lanes increases slightly during the AM Peak period; however, overall the volumes remain relatively steady as a percentage.

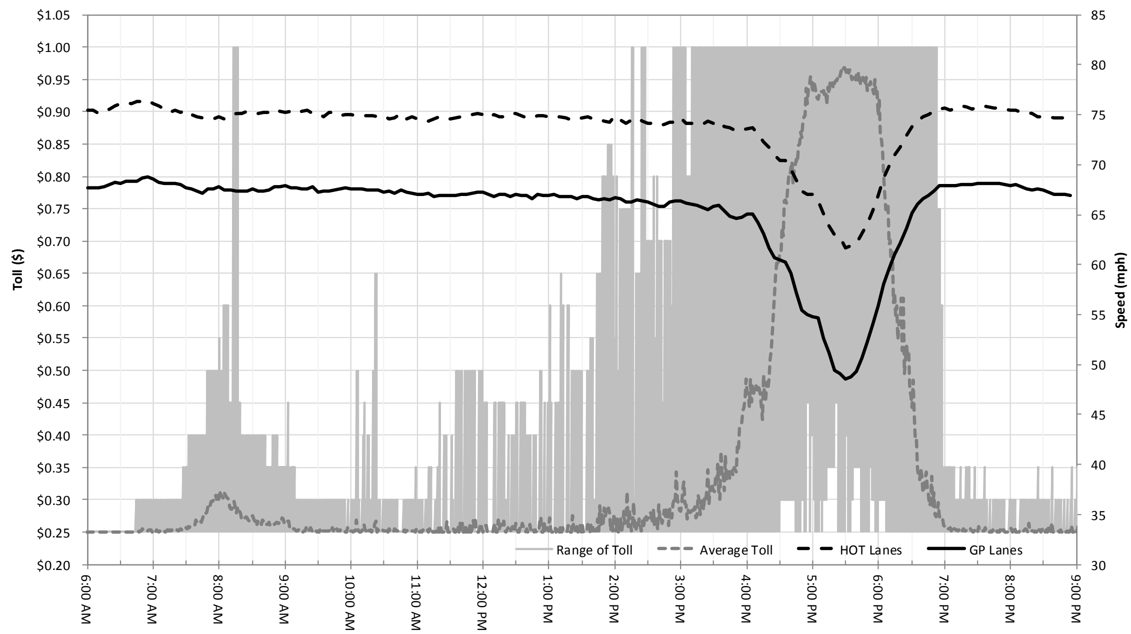

Figure 4.5 Express Lane Toll and Speed by Time of Day (SB, Zone 250)

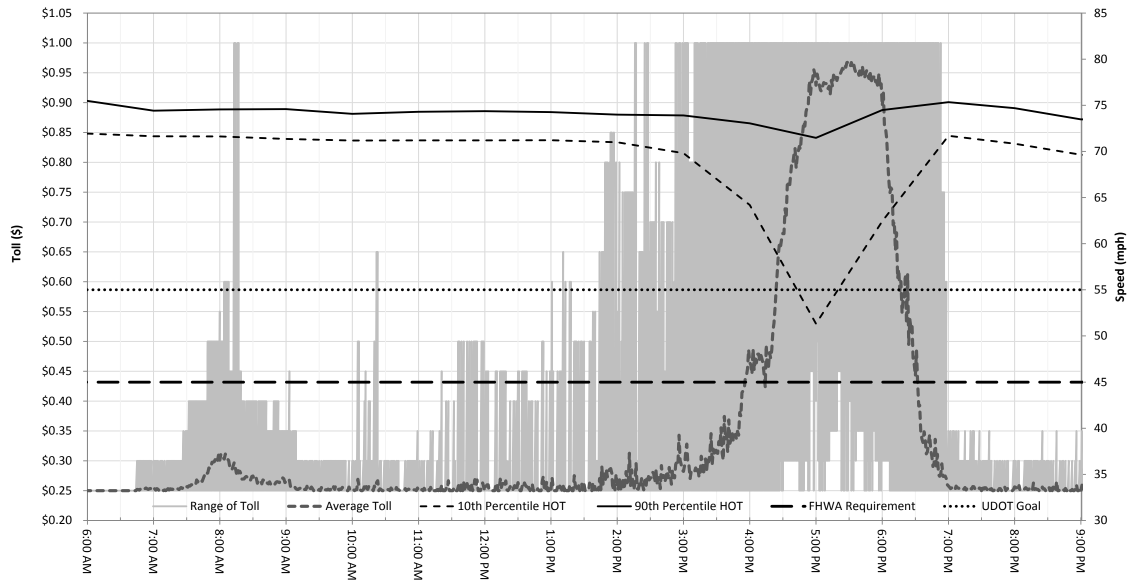

Figure 4.6 Express Lane Toll vs. 10^{th} and 90^{th} Percentile Speed by Time of Day (SB, Zone 250)

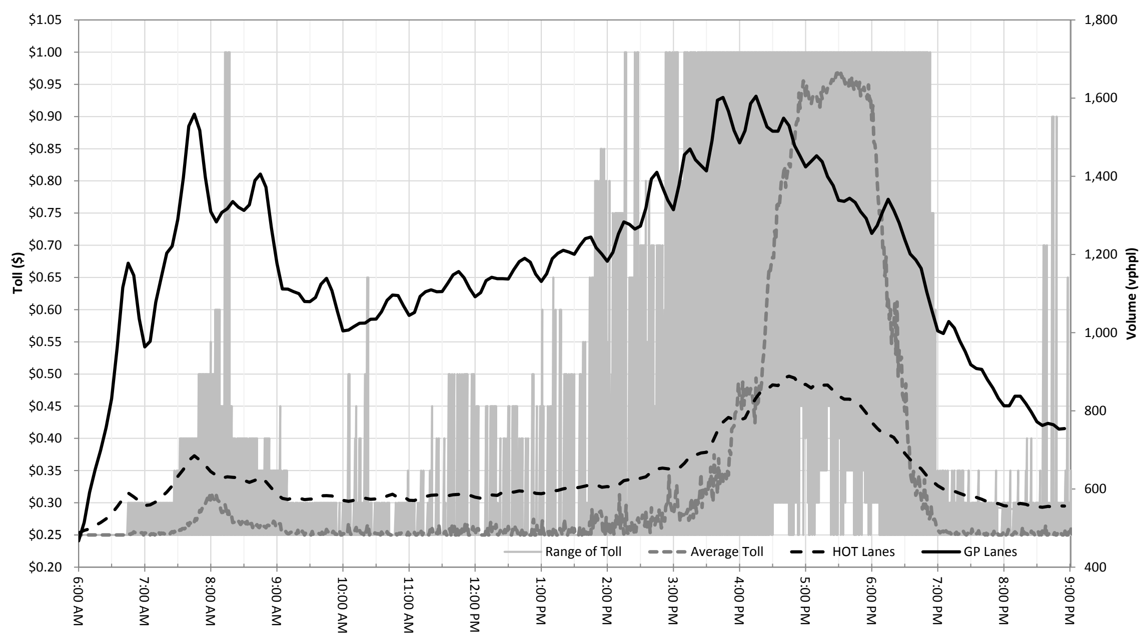

Figure 4.7 Express Lane Toll and Volume by Time of Day (SB, Zone 250)

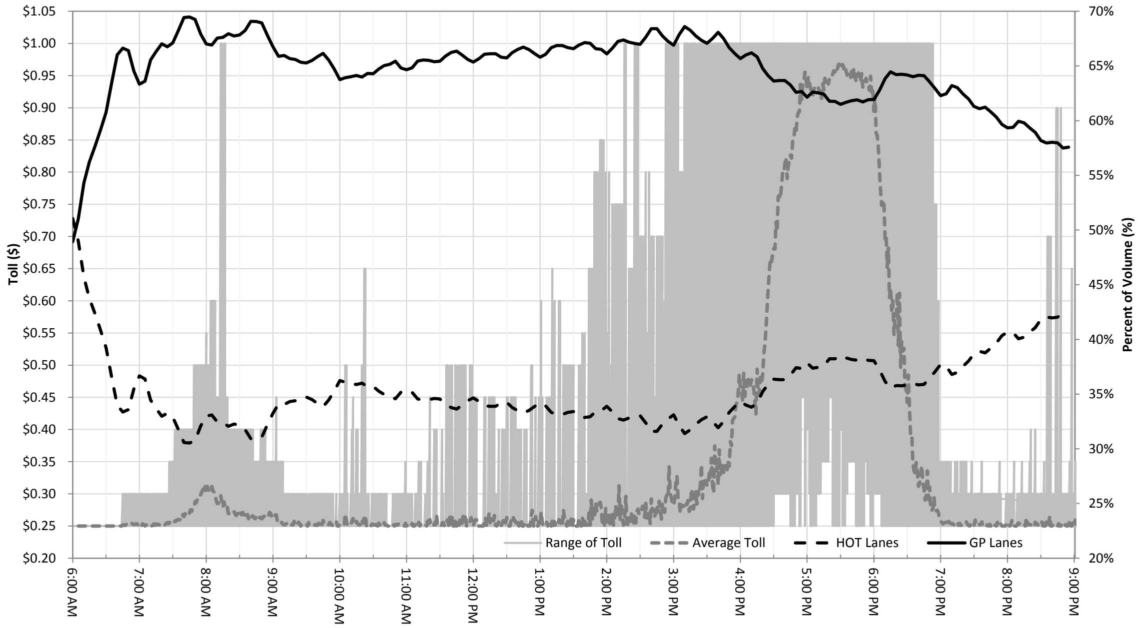

Figure 4.8 Express Lane Toll and Percent of Volume by Time of Day (SB, Zone 250)

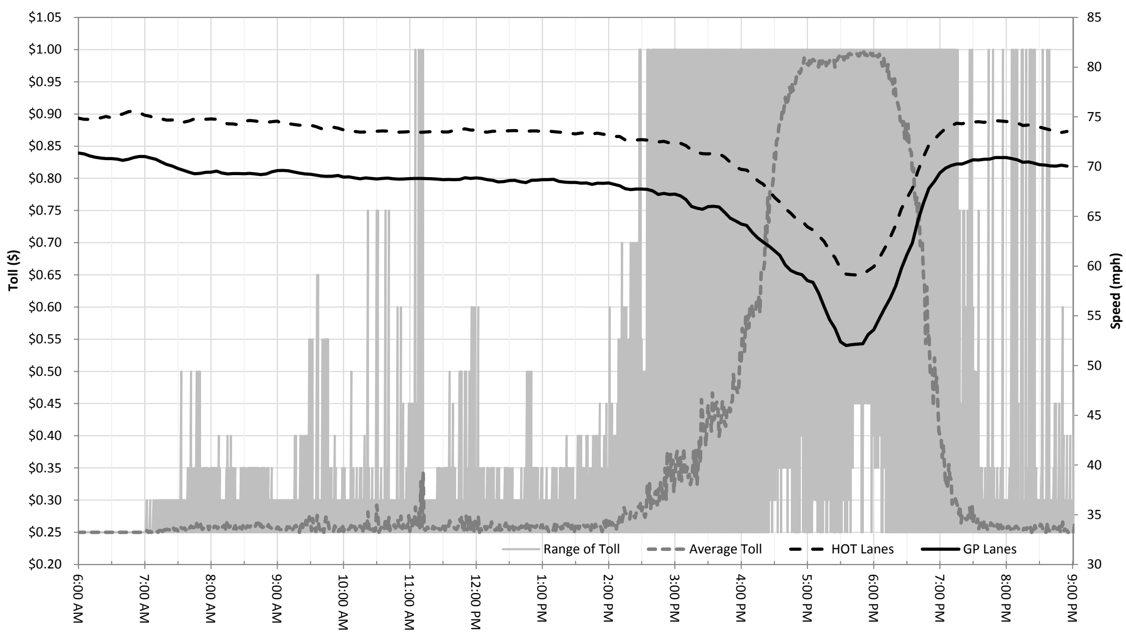

Figure 4.9 Express Lane Toll and Speed by Time of Day (SB, Zone 255)

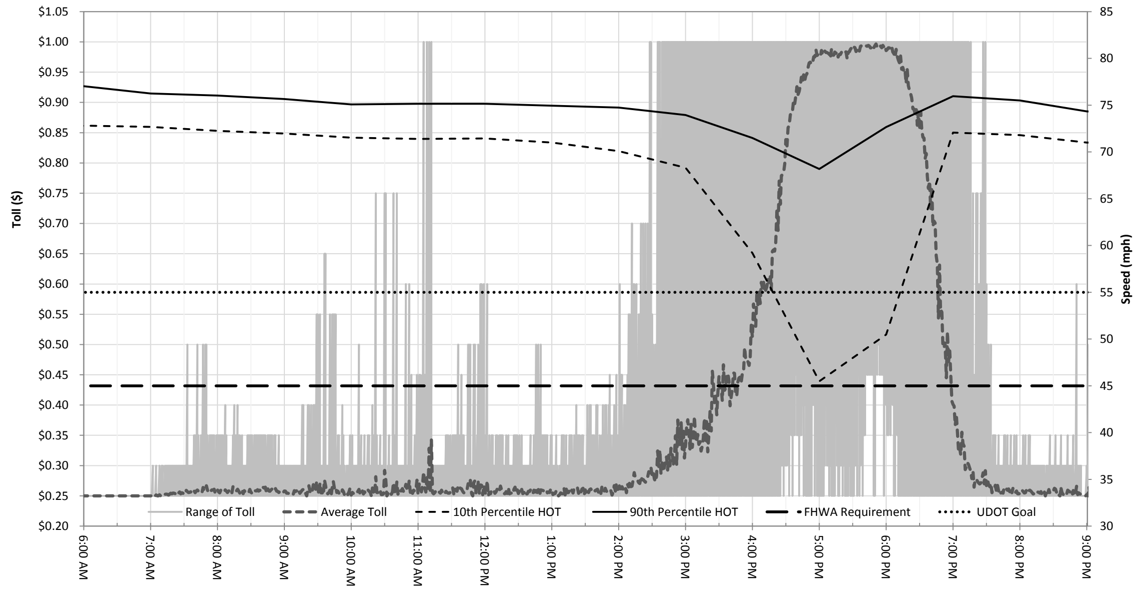

Figure 4.10 Express Lane Toll vs. 10th and 90th Percentile Speed by Time of Day (SB, Zone 255)

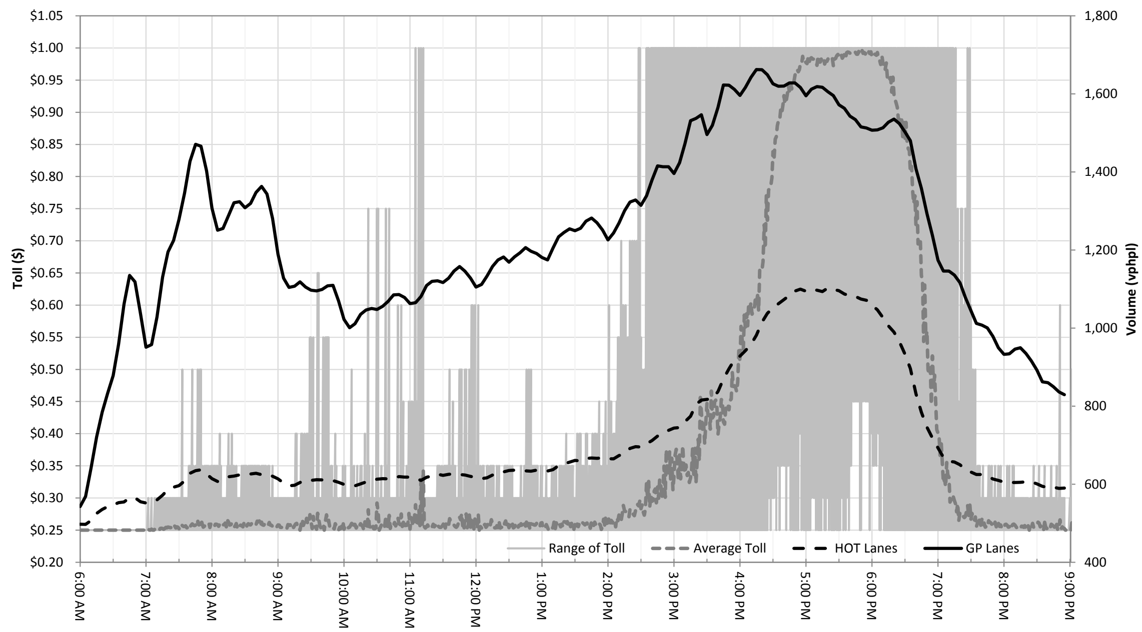

Figure 4.11 Express Lane Toll and Volume by Time of Day (SB, Zone 255)

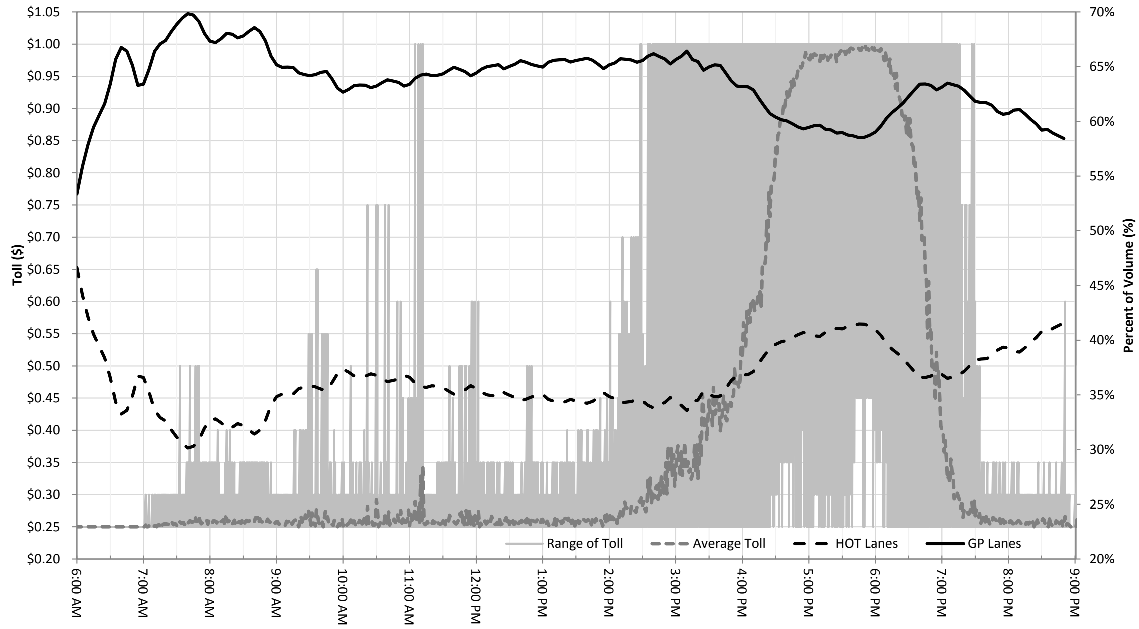

Figure 4.12 Express Lane Toll and Percent of Volume by Time of Day (SB, Zone 255)

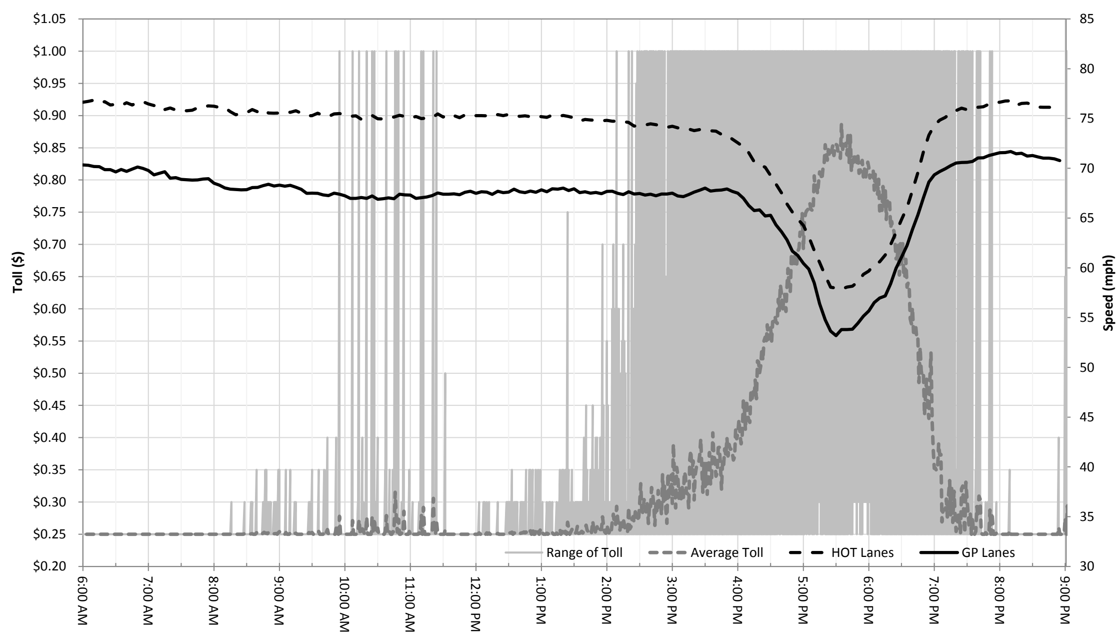

Figure 4.13 Express Lane Toll and Speed by Time of Day (SB, Zone 260)

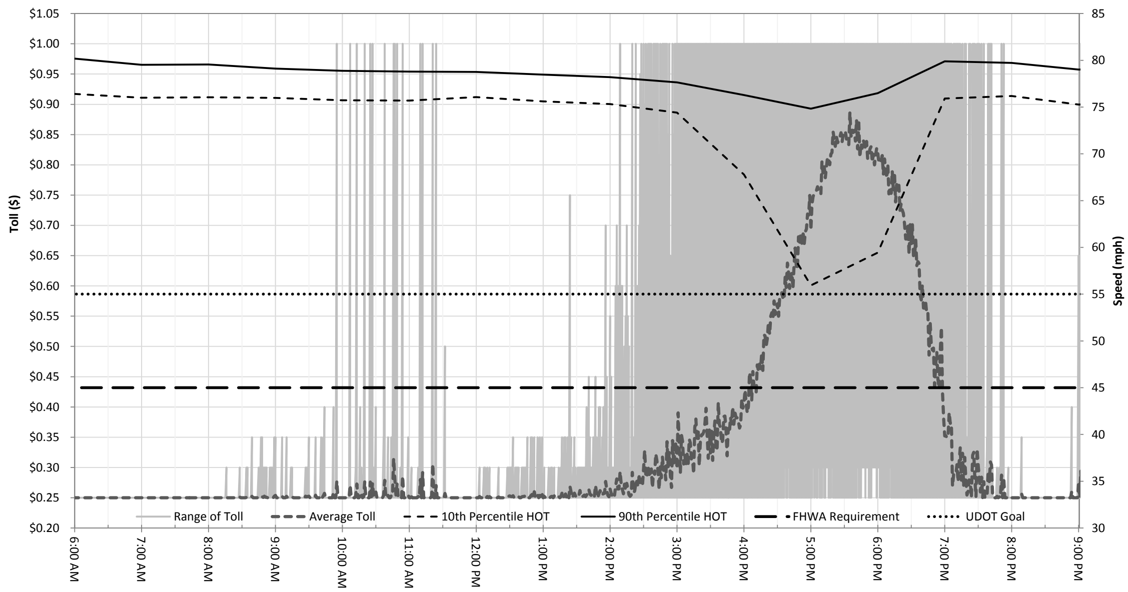

Figure 4.14 Express Lane Toll vs. 10^{th} and 90^{th} Percentile Speed by Time of Day (SB, Zone 260)

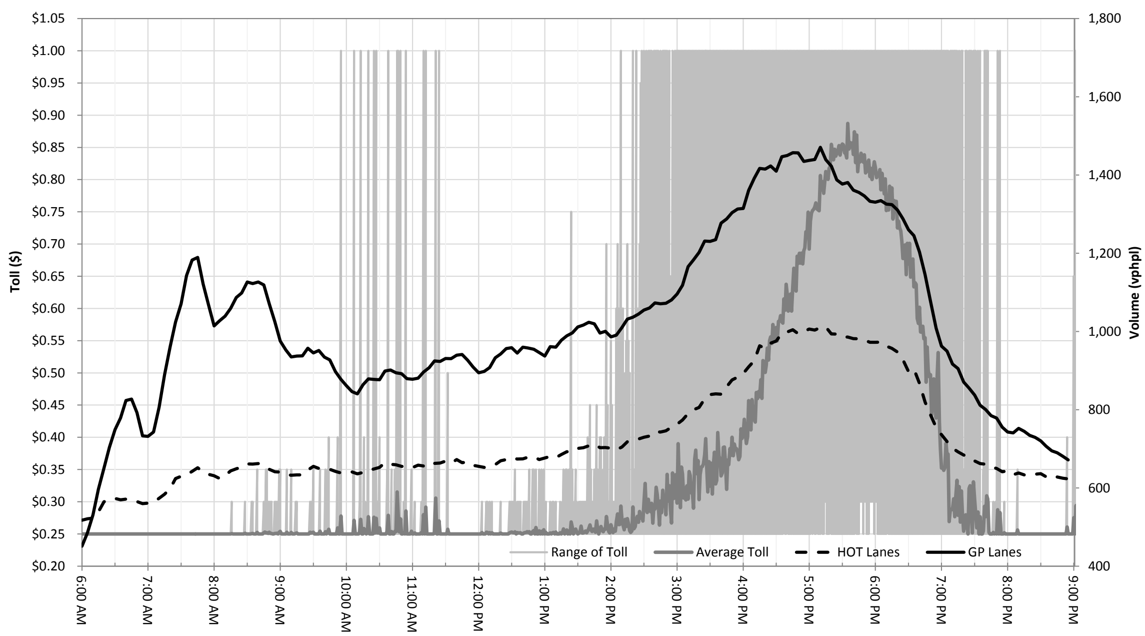

Figure 4.15 Express Lane Toll and Volume by Time of Day (SB, Zone 260)

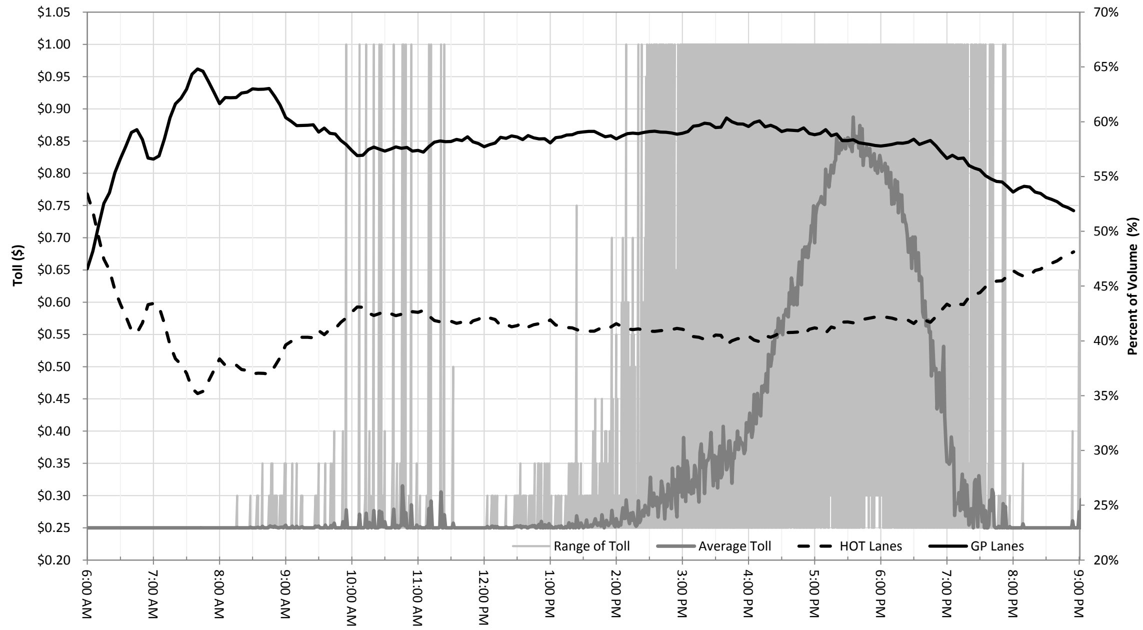

Figure 4.16 Express Lane Toll and Percent of Volume by Time of Day (SB, Zone 260)

During the peak period the 10th percentile speeds in several zones drop below UDOT's goal of 55 mph. In Zone 255 during the PM Peak Period the 10th percentile speeds even drop below the FHWA requirement of 45 mph. During these times the average toll rate for those zones is nearly $1.00 and is thus at the maximum allowable toll. These zones warrant additional examination to determine potential solutions to this problem. For example, investigation of the number of violators in these areas may point to additional enforcement (or other methods to reduce violators) being sufficient to decrease the volume, and thus congestion, in the short term, while knowing the AVO and volume of HOV2 and HOV3+ vehicles would help to determine what impact raising the minimum occupancy to HOV3+ for free travel might have on the lane.

4.3 Future Demand

Data needed to predict future demand data were collected for Express Pass transponder use, "C" decal data, and HOV utilization. The results of this analysis are provided in the following sections.

4.3.1 Express Pass Transponder Use

Predicting future traffic and revenue for a toll facility is normally a complex analysis that takes into consideration predicted future traffic based on origin-destination surveys, development along the corridor, employment predictions, and other detailed and specific data analysis. However, for short term estimates for this Express Lane, a much more simplified approach has been utilized, one in which the most recent years of data and the trends associated with those years are used to predict the near future impacts of the system. Several aspects of the traffic and revenue on the Express Lanes in the state of Utah have been either consistent or changing at a fairly uniform rate giving more confidence to short-term predictions of future demand. To illustrate the consistency in the data, projections are provided for volume, speed, Express Passes in circulation, and revenue as summarized in the following sections.

4.3.1.1 Volume and Speed Data Projections

Projections for speed and volume data were calculated based on the data presented in Chapter 3. In reviewing the speed and volume results from Chapter 3, it is apparent that the speeds depend on the volume as a function of a typical speed, volume, density relationship. In general, as the volumes increase, the speeds decrease, while maintaining similar density values throughout the corridor. The results of the speed and volume projection analysis are provided for each analysis zone, the volume projection is plotted first, followed by the speed projection. AM Peak Period (7:30 – 8:30 a.m.) data NB for Zone 140 (North Utah County), Zone 145 (South Valley), and Zone 150 (Salt Lake) are illustrated in Figure 4.17 through Figure 4.22.

Projections were also calculated for the PM Peak Period (5:00 – 6:00 p.m.) SB for Zone 250 (Salt Lake), Zone 255 (South Valley), and Zone 260 (North Utah County), shown in Figure 4.23 through Figure 4.28. The results of the volume and speed projections indicate that, in general, volumes and speeds are relatively steady for both GP and Express Lanes; however, they do vary primarily as a function of volume (speed depends on volume). It is important to note that there are some projections that show a predicted decrease in volume along with a predicted decrease in speed. While this is technically possible, it is not probable that this will occur. When the volume decreases, speeds will likely increase; when volumes increase, speeds will likely decrease. It is theorized that the condition contrary to what is expected may be due to incomplete data from the PeMS database. To provide a more detailed analysis of the projections would require a more complex speed-flow model that was not developed using the current data.

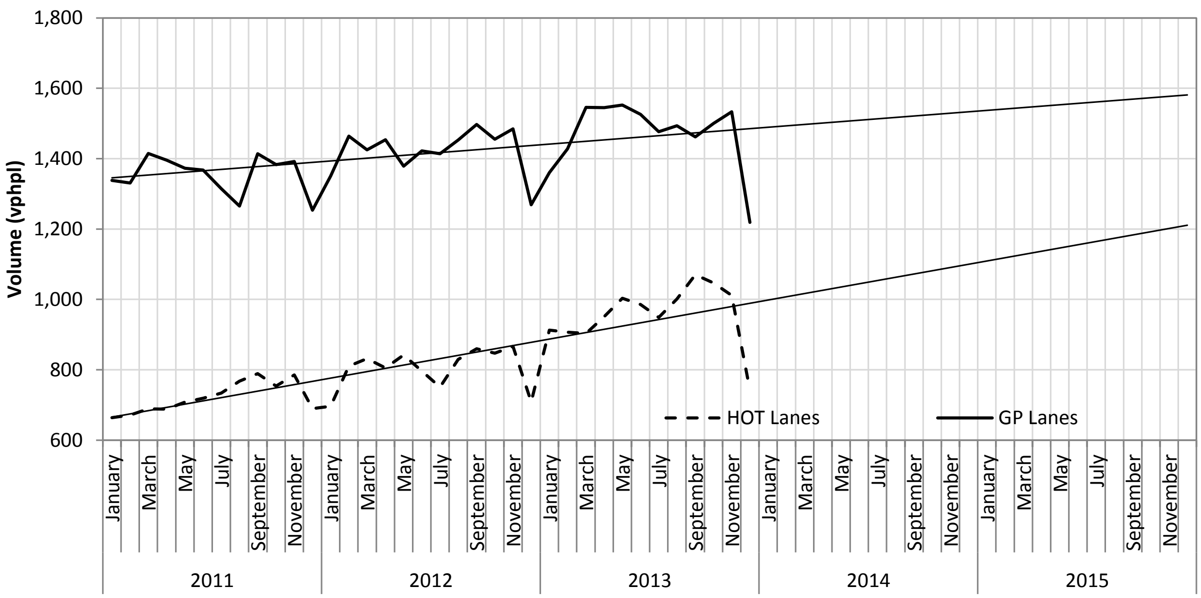

Figure 4.17 Average Weekday AM Peak (7:30 – 8:30 a.m.) Volume Projections (NB, Zone 140)

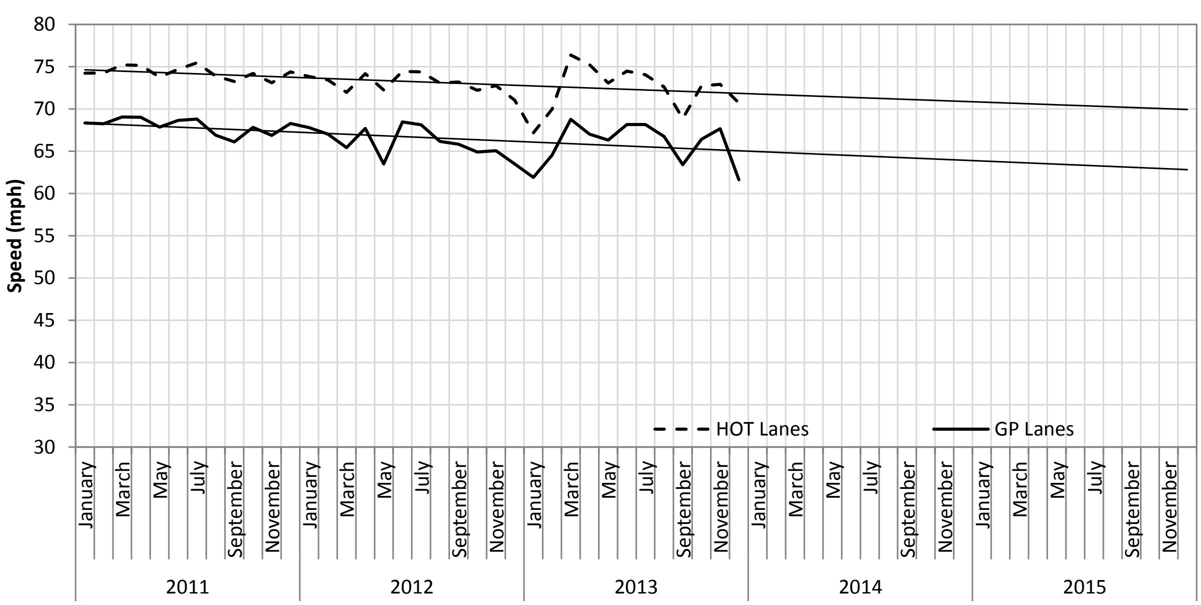

Figure 4.18 Average Weekday AM Peak (7:30 – 8:30 a.m.) Speed Projections (NB, Zone 140)

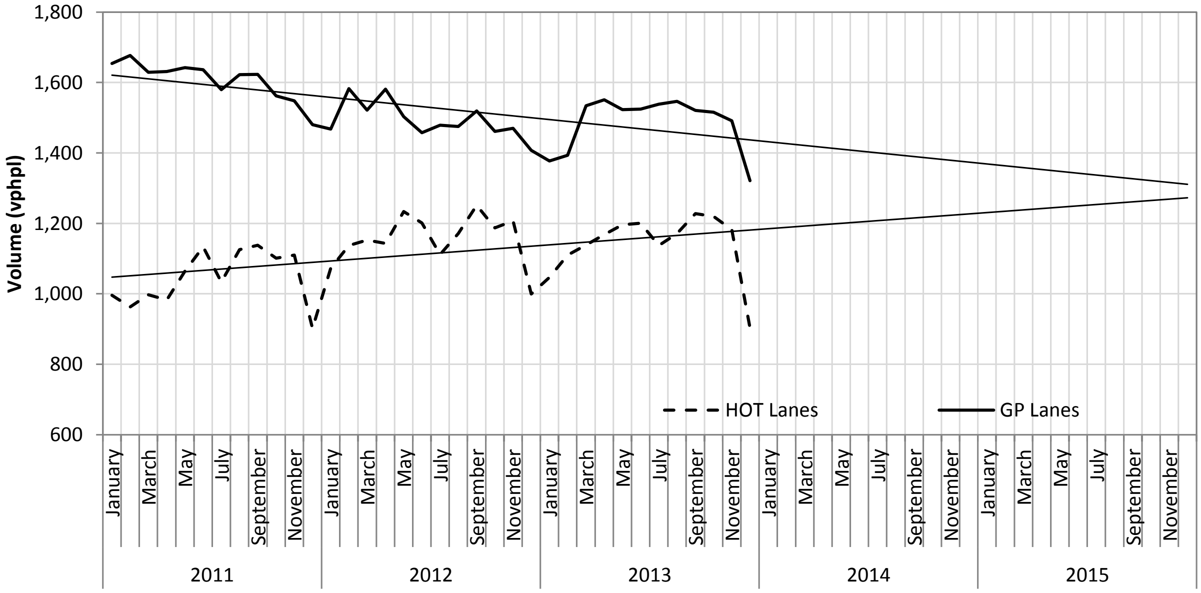

Figure 4.19 Average Weekday AM Peak (7:30 – 8:30 a.m.) Volume Projections (NB, Zone 145)

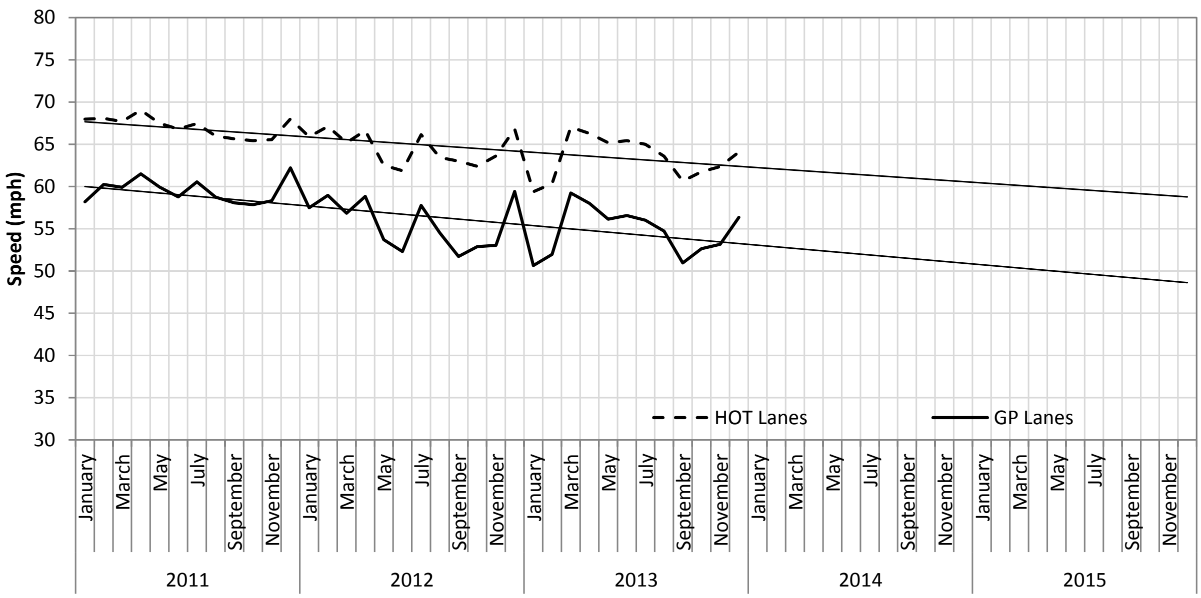

Figure 4.20 Average Weekday AM Peak (7:30 – 8:30 a.m.) Speed Projections (NB, Zone 145)

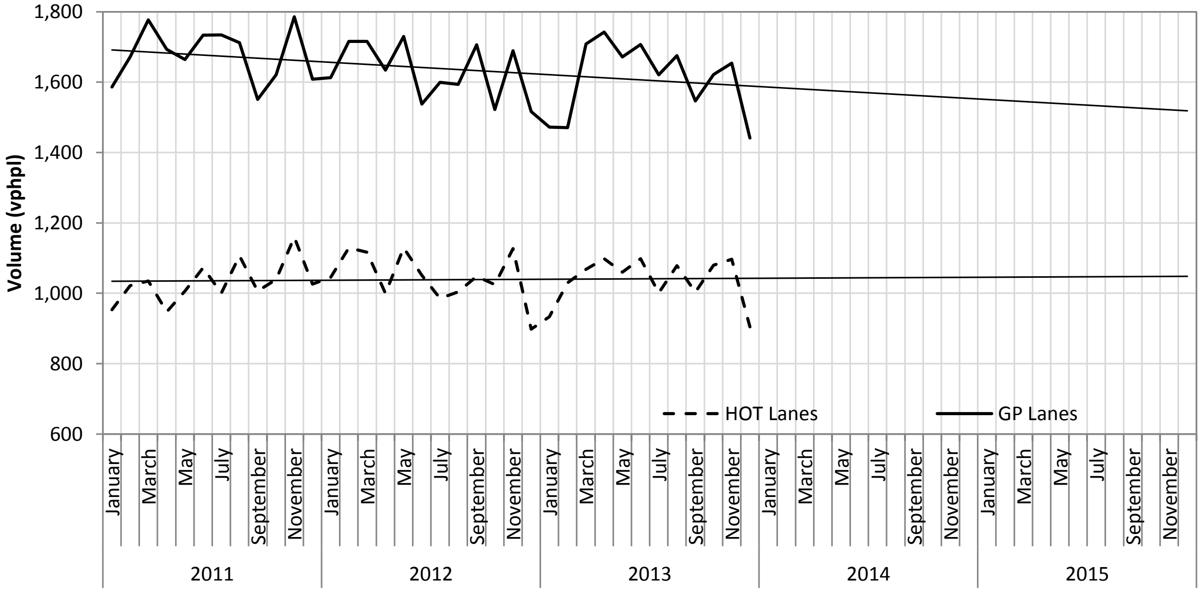

Figure 4.21 Average Weekday AM Peak (7:30 – 8:30 a.m.) Volume Projections (NB, Zone 150)

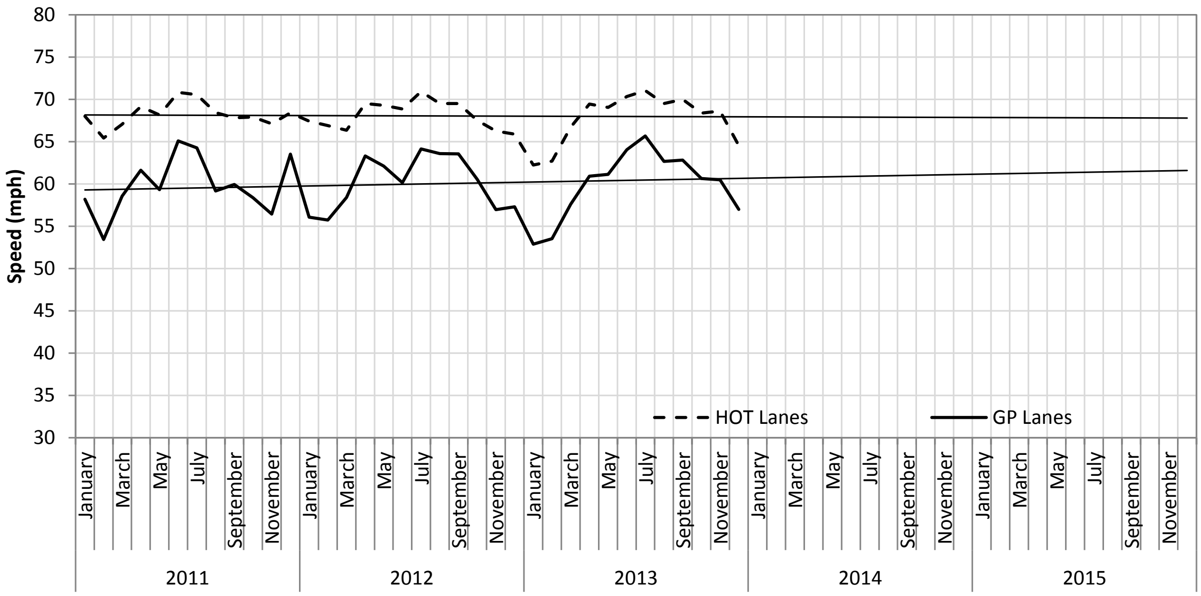

Figure 4.22 Average Weekday AM Peak (7:30 – 8:30 a.m.) Speed Projections (NB, Zone 150)

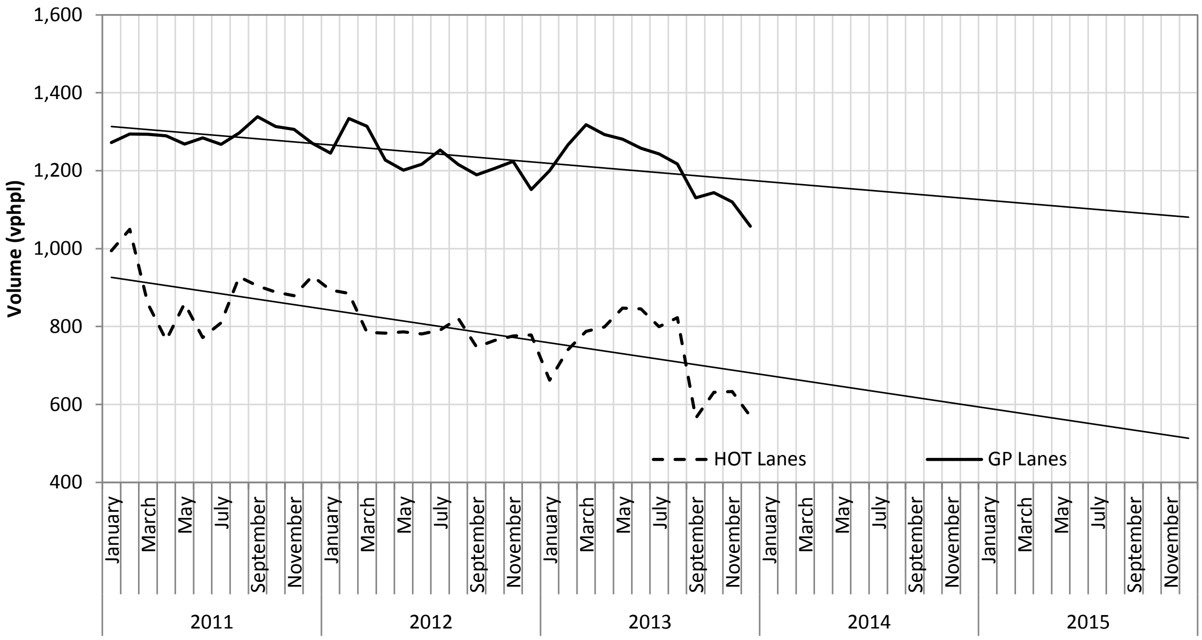

Figure 4.23 Average Weekday PM Peak (5:00 – 6:00 p.m.) Volume Projections (SB, Zone 250)

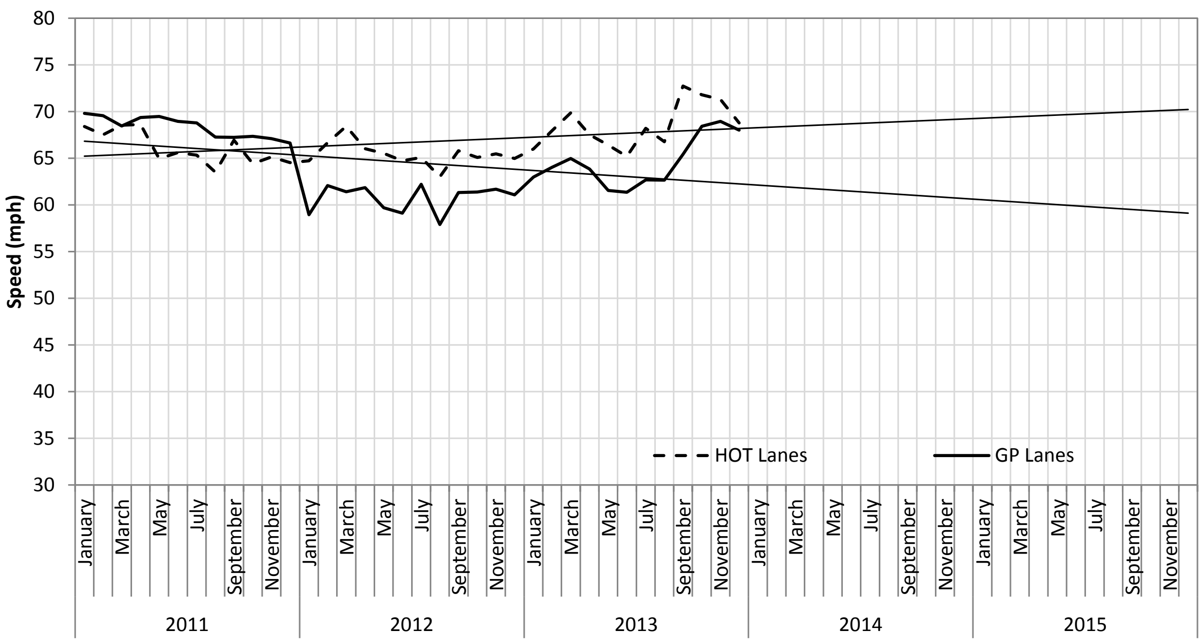

Figure 4.24 Average Weekday PM Peak (5:00 – 6:00 p.m.) Speed Projections (SB, Zone 250)

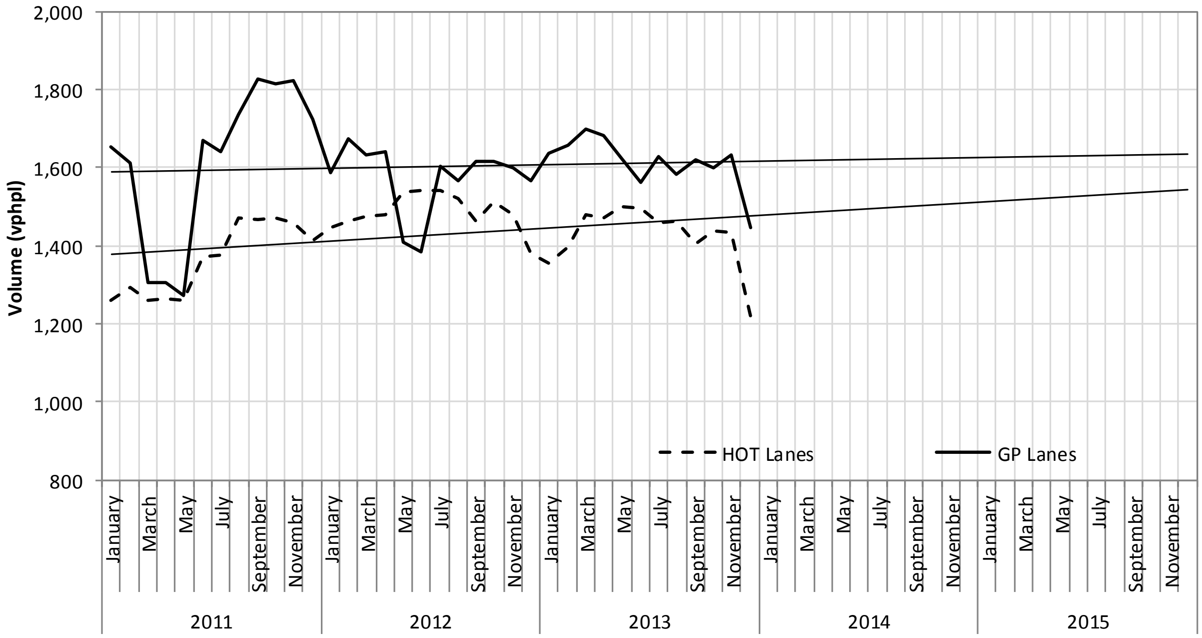

Figure 4.25 Average Weekday PM Peak (5:00 – 6:00 p.m.) Volume Projections (SB, Zone 255)

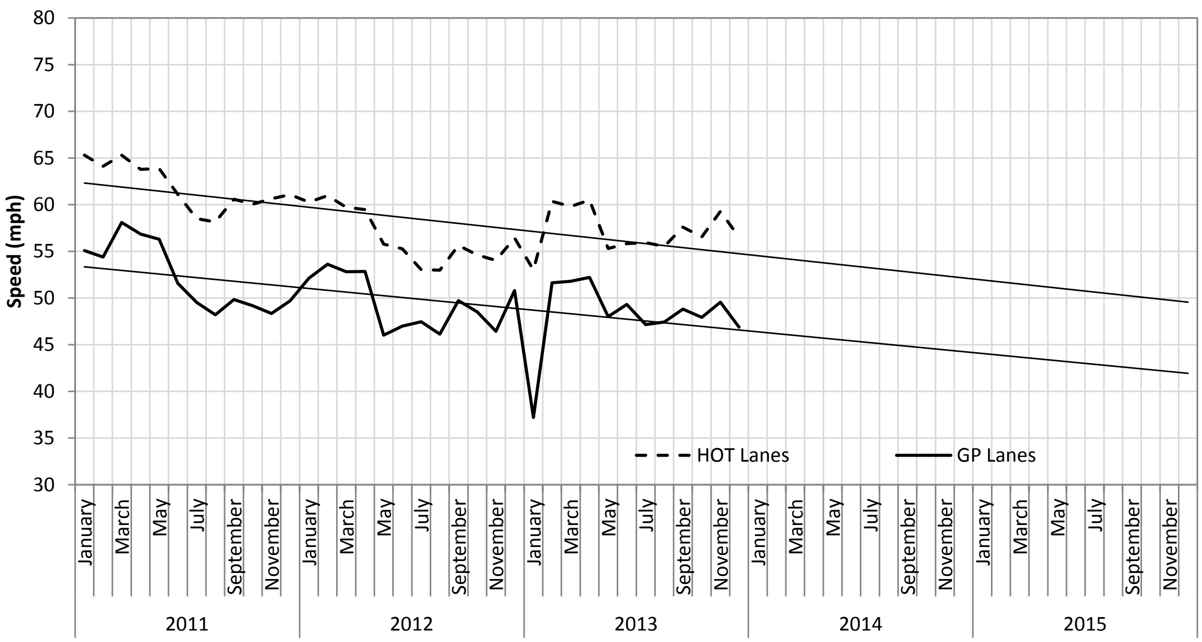

Figure 4.26 Average Weekday PM Peak (5:00 – 6:00 p.m.) Speed Projections (SB, Zone 255)

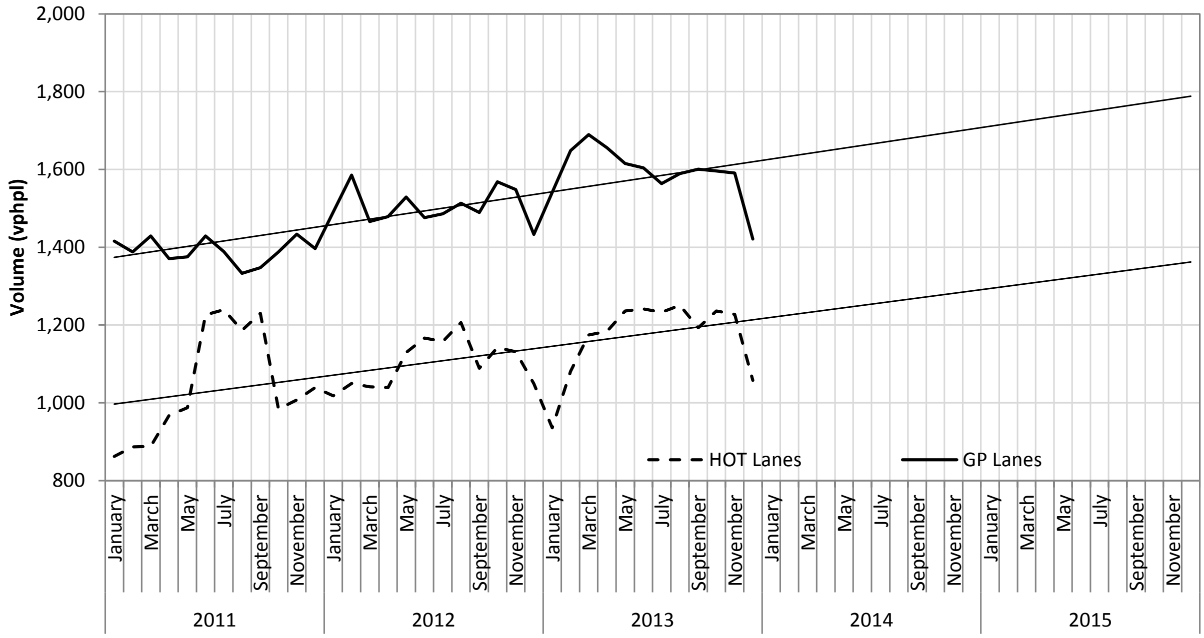

Figure 4.27 Average Weekday PM Peak (5:00 – 6:00 p.m.) Volume Projections (SB, Zone 260)

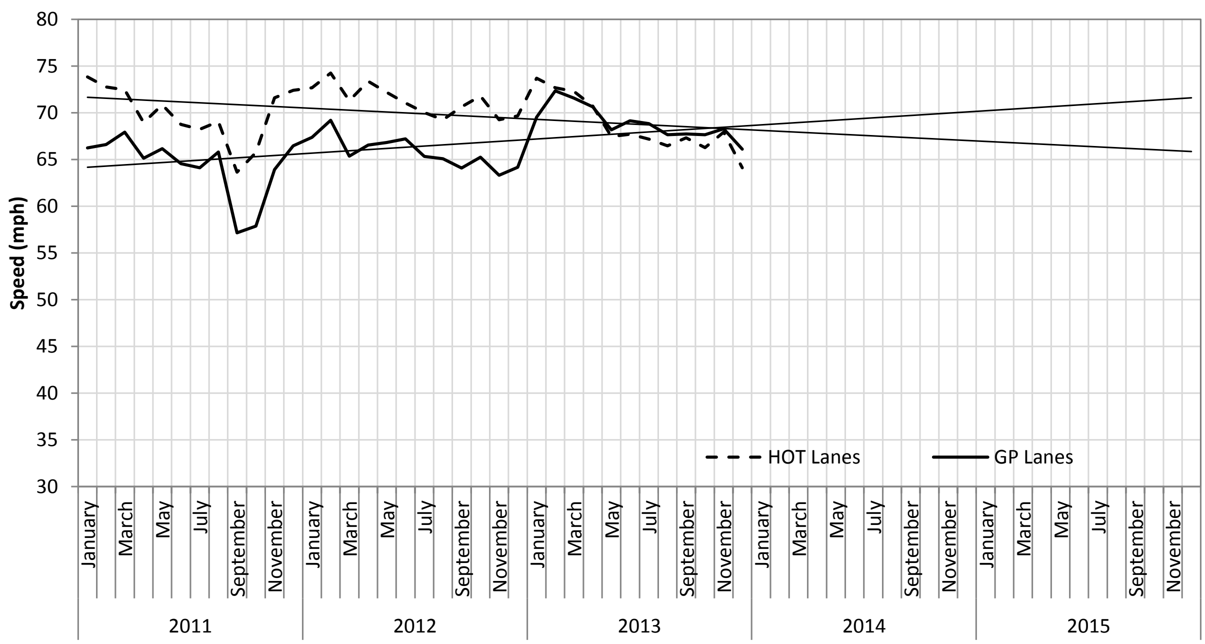

Figure 4.28 Average Weekday PM Peak (5:00 – 6:00 p.m.) Speed Projections (SB, Zone 260)

4.3.1.2 Express Passes in Circulation Projections

To better understand the numbers of Express Passes in circulation in the coming years, a projection was developed for the Express Transponders, Express Pass Transponders used at least once during a given month, and the future projections for each. The projections were developed both using a trendline and through a more detailed analysis of the historic trends and the possible fluctuations that could occur within these trends. The results of this analysis are provided in Figure 4.29. The results of the figure indicate that the overall trend is relatively consistent with an estimated increase in transponders of nearly 5,000 over the next two years, with a much smaller increase in the number of transponders used at least once. To obtain more accurate results, additional analyses, including surveys and detailed studies on the socioeconomic conditions surrounding the transponder users would be necessary.

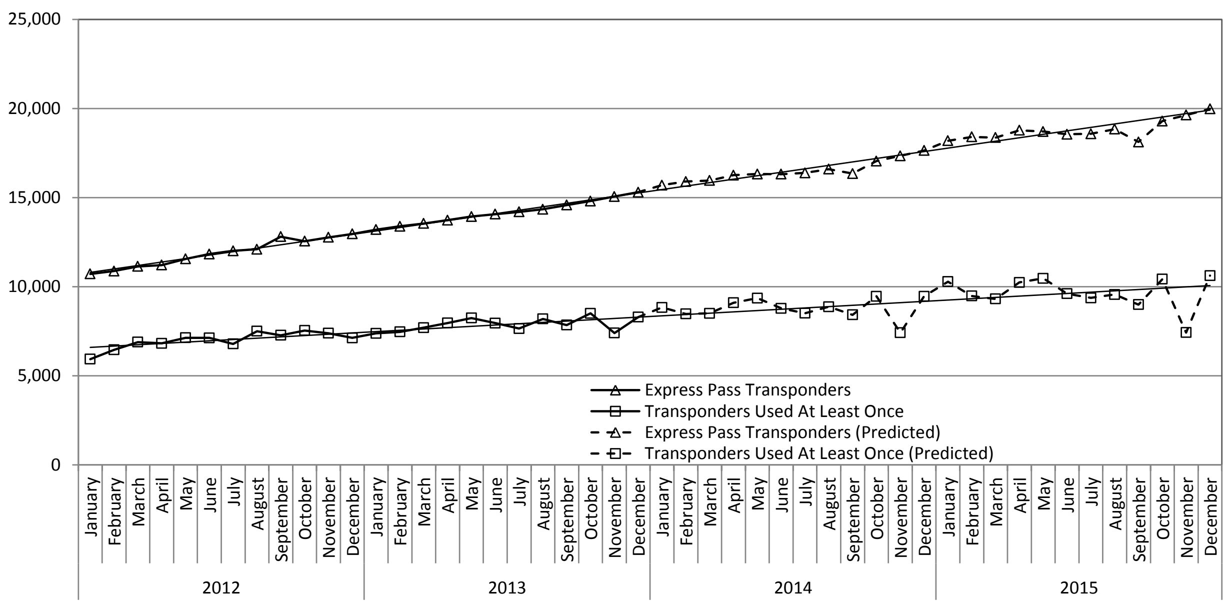

Figure 4.29 Express Lane Passes in Circulation Projections

4.3.1.3 Revenue Projections

The final projection made was that of revenue for the Express Pass use. The results of the revenue analysis are provided in Figure 4.30, which shows the expected revenue, the posted revenue, the uncollected revenue, and the average weekday (holidays excluded) revenue collected. Again, the results are relatively consistent and include both a trendline of the growth as well as an estimate of the fluctuation that occurs throughout the year based on past history. The results of this data will be utilized further to discuss impacts of changes in toll rates in this section.

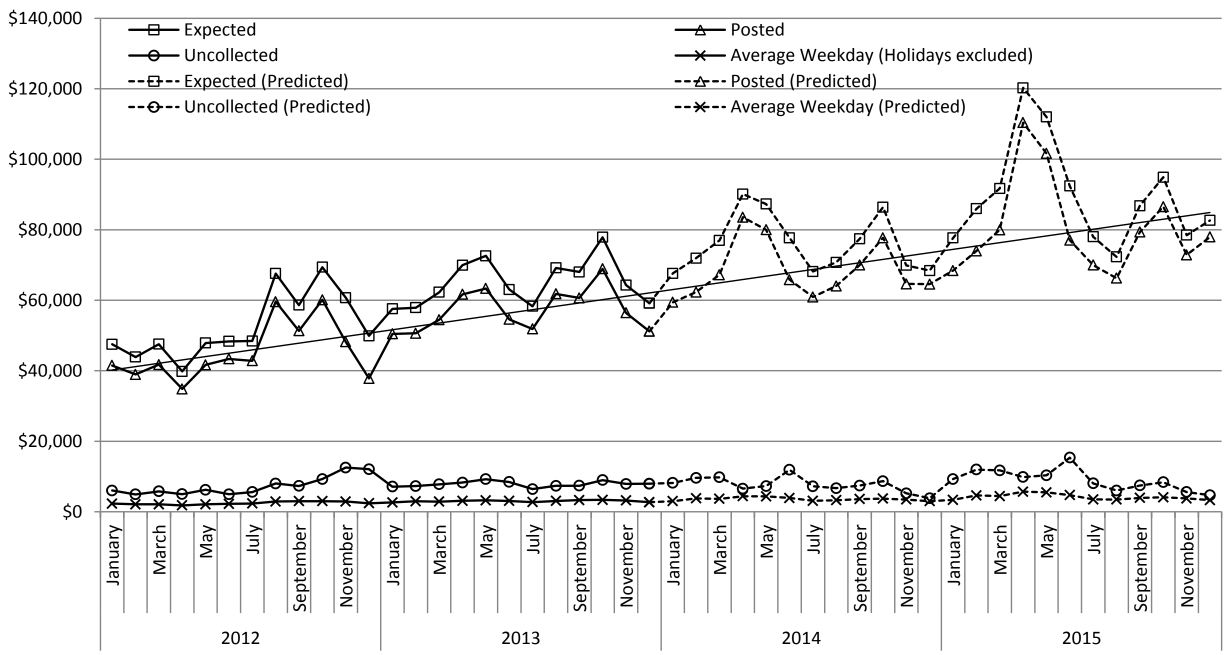

Figure 4.30 Express Lane Revenue Projections

A summary of the average values of all key indicators for traffic and revenue for calendar years 2011 to 2013 are included in Table 4.1. The first prediction assumes no change in toll rate, which will be used as a baseline for all of the analysis completed in this section. Using the information presented in the table to predict 2014 revenues and beyond, either with or without changes in the toll rate, it is necessary to make several assumptions. The first assumption is that the number of active transponders (transponders used at least one time during the year) will continue to increase at a rate similar to that of the previous year. This is an increase of 883 active transponders bringing the total predicted number of active transponders for 2014 to 8,765. It is assumed that the new accounts would join throughout the year and, on average, only make half as many total trips as the accounts that were already being utilized.

Table 4.1 Traffic and Revenue from 2011 to 2013 (Calendar Years)

Key Indicator	Value in Year		
	2011	2012	2013
Expected revenue	$591,873	$629,586	$780,081
Posted (actual) collections	$535,344	$541,803	$685,963
Number of accounts*	7,841	9,710	11,775
Number of transponders*	9,561	11,878	14,180
Number of active transponders*	5,991	6,998	7,882
Trips per transponder per month	10.05	10.43	10.29
Zones per trip	1.52	1.55	1.60
Expected revenue per transponder	$98.80	$89.96	$98.98
Expected revenue per trip	$0.82	$0.72	$0.80
Transactions per year	722,784	876,181	973,376
Transactions per active transponder	120.65	125.20	123.50

* Average value during the year

The next assumption is that the number of transactions per account and the average toll paid will remain at 2013 levels for the 2014 analysis. With this assumption, the expected revenue for 2014 would be $98.98 x 7,882 + $98.98 x 883 / 2 = $823,795. As a comparison, expected revenues in 2013 were $780,081, while actual revenues in 2013 were 12% lower, at $685,963.

Using the assumptions outlined in the previous paragraph, the data can be evaluated to estimate what may happen if the price of the Express Lanes were to increase. Unfortunately, without surveying travelers, it is not possible to know exactly how a toll increase will impact traffic. Based on Express Lane facilities and toll facilities from around the country; however, it can be assumed that the toll-price elasticity of demand is approximately -0.3. This means that for every 10% increase in toll rate, a 3% decrease in traffic would be expected. It is assumed that a toll price increase may also reduce the demand for new accounts and, while the potential change in demand is unknown, it is assumed to occur at the same rate as the elasticity level of -0.3.

The results of this analysis, including a limited sensitivity analysis with elasticity rates ranging from -0.2 to -0.4 and an estimated increase in toll of 25%, is shown in Table 4.2. The 25% increase in toll is not recommended at this time, it is simply used as an example for this analysis. The results indicate that a 25% increase in toll could reasonably be expected to yield a revenue increase of 12% to 18%. However, more work needs to be done to determine if there are any traffic impediments to continued growth in traffic on the lane and to determine the true price-elasticity of demand.

Table 4.2 Predicted Traffic and Revenue for 2014

Input	No Toll Change	Increase Toll by 25% Elasticity -0.20	Elasticity -0.30	Elasticity -0.40
Current (2013) accounts				
Reduced number of transactions/account	0	-6.2	-9.3	-12.4
Number of transactions/account	123.5	117.3	114.2	111.2
Revised revenue/account	$98.98	$117.53	$114.44	$111.35
Revised revenue	$780,081	$926,346	$901,968	$877,591
New (2014) accounts				
Assumed new active accounts w/o price increase	883			
Assume price increase dampens demand for new accounts similar to elasticity of demand	883	839	817	795
New number of transactions/new account	61.75	58.7	57.1	55.6
Revenue/new account	$49.49	$58.77	$57.22	$55.67
Revenue from new accounts	$43,714	$49,315	$46,754	$44,260
Totals				
Total Expected Revenue	$823,795	$975,661	$948,722	$921,851
Change from baseline	0	18.4%	15.2%	11.9%

4.3.2 "C" Decal Use

The results of the analysis of the data presented in Chapter 3 indicate that the maximum volume in the Express Lanes is approximately 1,700 vphpl. The "C" decal results indicate that the number of "C" decals during the peak periods is steady at approximately 4.5%, or 75 vehicles. Because the number of "C" decals has currently been capped at 6,000 as noted previously and that number was expected to be reached in early 2014 based on input from the TAC, the number of "C" decal vehicles does not appear to be a limiting factor in the operation of the lanes. If the cap on the number of "C" decals were increased, it would be expected (based on current trends) that the total percentage of "C" decals in the lane may not change considerably. As the total number of vehicles has increased, the percentage of "C" decals has not changed proportionately. If a considerable increase were recommended, additional analysis would be warranted, including an analysis of origin and destination data for the "C" decal vehicles to determine where the trips are focused proportionate to the most congested sections of the corridor. It is not anticipated that off-peak use would be an issue.

4.3.3 HOV Utilization

Given the current utilization of HOVs in the Express Lanes, it is not possible to determine the impacts of increasing the HOV limits as there is not sufficient data to understand the makeup of the current vehicles in the lane. Assuming that the majority of the HOV users in the lane are HOV2, increasing the limits of the lane to HOV3+ would require additional information to perform a sensitivity analysis of what proportion of those vehicles currently at HOV2 would split up to HOV3+ or go to the GP lanes. Improved data on the utilization of the lanes and AVO is necessary to complete this analysis.

4.4 Data Analysis Summary

A variety of analyses were conducted to evaluate speed and volume trends as a function of toll rate, and to evaluate overall effectiveness and future conditions related to transponder use, "C" decal use, and HOV utilization. The results of this analysis indicate that while the majority of the system is operating within acceptable speeds, two zones (Zone 250 and Zone 255) have reported 10^{th} percentile speeds that are lower than the goal set by UDOT (55 mph) and are approaching, or exceeding, minimum requirements set by FHWA (45 mph). This necessitates consideration of ways to improve speeds within these lanes to be able to maintain acceptable speeds.

It is important to note again that the toll data presented in this chapter are those illustrated previously in Chapter 3 and were obtained from a sample of transponder data. The speed and volume data (including the 10^{th} and 90^{th} percentile speeds) presented in this section are data collected by the research team from the UDOT PeMS system for the time period between April 1, 2013 and September 30, 2013. As a result, the 10^{th} and 90^{th} percentile speeds are different than those recorded previously in Table 3.4 and Table 3.5 (the source of the data for these tables was a sample of transponder data for the same time period). Although the results show similar trends in the data, the exact values are not expected to be the same due to the differences in data collection methods.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The primary objectives of this research included an identification of literature in Utah and nationally on how changing toll rates, occupancies, and violation rates have had an effect on managed lane (i.e., Express Lane or HOT lane) use and an examination of the utilization of the I-15 Express Lanes under a limited number of congestion and pricing scenarios. The preceding chapters have carefully analyzed the data for the Express Lanes in Utah including an analysis of speed, volume, and toll rates within the lanes and a detailed analysis of Express Pass transponder and "C" decal use within the Express Lanes. The results of this study indicate that the majority of the Express Lane corridor in the state of Utah is operating within the 10^{th} percentile speed goal of 55 mph set by UDOT and the 45 mph requirement set by the FHWA. There are; however, several zones where 10^{th} percentile speeds have dropped below 55 mph. The extent to which the speeds drop below the goal is somewhat variable, depending upon the data source utilized. The zones where the speeds were reported to drop below 55 mph using either transponder data or PeMS data include Zones 140 (North Utah County) and 145 (South Valley) in the AM Peak Period and Zones 145 (South Valley), 250 (Salt Lake), and 260 (North Utah County) in the PM Peak Period. Additionally, the 10^{th} percentile speeds in Zone 255 (South Valley) in the PM Peak Period have dropped below 45 mph based on the analysis. In each case the average toll is already near the $1.00 per zone maximum, so simply raising the toll rate within the current pricing paradigm to reduce volume and improve speeds is not a viable option unless the maximum rate is increased. This chapter provides conclusions based on the research and recommendations on next steps to address the degradation in speed and to propose changes with respect to Express Lane policies and use.

5.2 Recommendations

Although the majority of the Express Lane corridor within the state of Utah is operating within the goal/requirement set by UDOT and FHWA, there are several zones where speeds are approaching, or have dropped below these values, and where changes are necessary to address this degradation. There are several methods to consider in an effort to reduce the volume in the Express Lanes, which is anticipated to increase the speeds within these lanes. The primary methods identified in the research include:

1. Increase Express Lane tolls during peak periods, including an increase in the maximum allowable toll.
2. Increase the HOV limits in the Express Lanes from 2+ to 3+ persons per vehicle during peak periods.
3. Reduce violation rate along the corridor through methods such as improved enforcement, education campaigns regarding policies related to the proper use of the Express Lanes, and the consideration of a "HERO" program for public enforcement.

In an effort to increase the number of "C" decal vehicles in the state, the following was also identified as an important component of the Express Lane study:

4. Enforce current cap for "C" decal vehicles in the Express Lanes and consider options for increasing the number of "C" decals issued for off-peak travel and/or travel outside of the congested areas during peak periods.

In addition to the primary methods, several other alternatives were brainstormed by the TAC to consider at a future date including:

5. Examine the lanes to see if there are specific locations where the speeds are degrading due to geometric design or weaving with the GP lanes. If so, determine if there are design changes that will address some or all of the speed degradation.
6. Add an additional HOV/HOT lane.
7. Remove some HOT lane access points to reduce the number of merge areas along the corridor.
8. Install rumble strips between the double white lines to discourage drivers from crossing the lines illegally.

The background data surrounding each of these alternatives has been addressed in this report; however, the details necessary to make a final recommendations on which method(s) to implement is not available as a result of this study. To better understand the impacts of the alternatives additional research is necessary including primarily a detailed analysis of AVO both in the Express Lanes and the GP lanes and a more detailed analysis of enforcement alternatives for the state. Additional research could also include a survey of travelers to better estimate their toll price elasticity, and a detailed analysis of the geometry of the Express Lane corridor.

5.3 Implementation Plan

To make a recommendation on ways to increase the 10^{th} percentile speeds within the Express Lanes, additional research must be conducted as outlined in the Recommendations section. In addition to the work outlined in the Recommendations section, future efforts could include an analysis of the safety issues associated with the use of the Express Lanes and a comprehensive survey of travelers along with detailed traffic and revenue analysis to determine the impacts of potential toll price changes. The survey could also examine the current and past policies related to the Express Lanes including pricing and number of occupants needed for free travel.

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