Transportation Consortium of South-Central States

Tran-SET

Solving Emerging Transportation Resiliency, Sustainability, and Economic Challenges through the Use of Innovative Materials and Construction Methods: From Research to Implementation

Mitigating Traffic Congestion on I-10 in Baton Rouge, LA: Supply- and Demand-Oriented Strategies & Treatments

Project No. 17ITSLSU09

Lead University: Oklahoma State University

Collaborative University: Louisiana State University

Addressing Region 6 Transportation Needs

Final Report

December 2018

Disclaimer

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the information presented herein. This document is disseminated in the interest of information exchange. The report is funded, partially or entirely, by a grant from the U.S. Department of Transportation's University Transportation Centers Program. However, the U.S. Government assumes no liability for the contents or use thereof.

Acknowledgments

We would like to thank graduate students Peter Bakhit, Swapnil Singh, and Xuan Liao for their sincere and dedicated effort to perform all the required data collection, simulation calibration, and simulation modeling effort required in this project under the supervision of Dr. Osama Osman at Louisiana State University (LSU). All analyses and final report preparation were performed at Oklahoma State University (OSU) under the supervision of Dr. Samir Ahmed. The authors would like to sincerely thank Mr. Christopher Melson for his significant revisions and edits to the report.

TECHNICAL DOCUMENTATION PAGE

1. **Project No.**	2. **Government Accession No.**	3. **Recipient's Catalog No.**
17ITSLSU09		

4. Title and Subtitle	**5. Report Date**
Mitigating Traffic Congestion on I-10 in Baton Rouge, LA: Supply- and Demand-Oriented Strategies & Treatments	Dec. 2018
	6. Performing Organization Code
7. Author(s)	**8. Performing Organization Report No.**
PI: Dr. Samir Ahmed https://orcid.org/0000-0001-9530-7213 Co-PI: Dr. Osama A. Osman https://orcid.org/0000-0002-5157 2805 Co-PI: Dr. Julius Codjoe https://orcid.org/0000-0003-1958-8695	
9. Performing Organization Name and Address	**10. Work Unit No. (TRAIS)**
Transportation Consortium of South-Central States (Tran-SET) University Transportation Center for Region 6 3319 Patrick F. Taylor Hall, Louisiana State University, Baton Rouge, LA 70803	**11. Contract or Grant No.** 69A3551747106
12. Sponsoring Agency Name and Address	**13. Type of Report and Period Covered**
United States of America Department of Transportation Research and Innovative Technology Administration	Final Research Report May 2017 – May 2018
	14. Sponsoring Agency Code

15. Supplementary Notes

Report uploaded and accessible at: [Tran-SET's website (http://transet.lsu.edu/)](http://transet.lsu.edu/)

16. Abstract

The aim of this study is to develop a better understanding of the causes of traffic congestion on I-10 in the Baton Rouge, LA area, particularly at the I-10 Mississippi River Bridge, and to identify treatments and strategies to mitigate congestion at the bridge site. This study developed and calibrated a microsimulation model of I-10 (from Lobdell Highway in Port Allen to Highland Road, I-110 to Florida Street, and I-12 to Walker Road) and investigated several supply- and demand-oriented strategies. This includes: rehabilitation and utilization of the old Mississippi River Bridge on US-190 and the existing US-190/US-61 corridor, overall demand management of I-10 EB traffic, reduction in percent trucks traveling eastbound on I-10 during the A.M. peak period, and ramp metering at the on-ramp west of the I-10 Mississippi River Bridge. The majority of the tested strategies appear to be feasible and effective solutions; however, a combination of supply- and demand-oriented treatments must be implemented to fully relieve congestion on I-10 in Baton Rouge.

17. Key Words	**18. Distribution Statement**
Congestion Mitigation, Traffic Modeling, Traffic Simulation, Baton Rouge, LA	No restrictions.

19. Security Classif. (of this report)	**20. Security Classif. (of this page)**	**21. No. of Pages**	**22. Price**
Unclassified	Unclassified	85	

Form DOT F 1700.7 (8-72) **Reproduction of completed page authorized**

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
^oC	Celsius	1.8C+32	Fahrenheit	^oF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS, ABBREVIATIONS, AND SYMBOLS

ADT	Average Daily Traffic
ALPR	Automatic License Plate Readers
ATM	Active Traffic Management
BUMP	Baton Rouge Urban Renewal and Mobility Plan
CRPC	Capital Region Planning Commission
CRISIS	Capital Region Industry for Sustainable Infrastructure Solutions
EB	Eastbound
EIS	Environmental Impact Statement
FHWA	Federal Highway Administration
GIS	Geographic Information System
I-10	Interstate 10
I-110	Interstate 110
I-12	Interstate 12
ITS	Intelligent Transportation Systems
LA-1	Louisiana Highway 1
LA-415	Louisiana Highway 415
LADOTD	Louisiana Department of Transportation and Development
LIDAR	Light Detection and Ranging
LOS	Level of Service
MPO	Metropolitan Planning Organization
NPMRDS	National Performance Management Research Data Set
P3	Public-Private Partnerships
SIU	Segment of Independent Utility
TDM	Travel Demand Management
TTI	Texas Transportation Institute
US-190	U.S. Highway 190
US-61	U.S. Highway 61 (Airline Highway)

VISSIM	"Verkehr In Städten- SIMulationsmodell" (German for "Traffic in Cities - Simulation Model"); PTV Traffic Modeling Software
VMT	Vehicle-Miles of Travel
VPD	Vehicles per Day
VPH	Vehicles per Hour
WB	Westbound

EXECUTIVE SUMMARY

For more than two decades, Baton Rouge, LA has been suffering from severe traffic congestion that threatens the quality of life and economic development in the area. Travel demand in Baton Rouge has been increasing at a rapid rate due to the growth in population, growth in employment that is three times faster than the rest of the state, high freight demand associated with the petrochemical industry in the area, and lack of integrated transportation and land-use planning. Among mid-sized cities, Baton Rouge ranks third worst in terms of average annual commuter traffic delay and excess fuel consumption, amount of money congestion is costing the average commuter per year, the total congestion-related shipping costs per year, and freeway travel time unreliability.

The I-10 Mississippi River Bridge is an example of transportation facilities/locations suffering from severe breakdowns that affect the surrounding streets and intersections and extend over prolonged periods. Solving such an acute congestion problem is challenging especially considering that capacity expansion is an expensive solution. For instance, a recent study showed that a new Mississippi River Bridge could significantly solve the current bridge's congestion problem; however, such a bridge will cost around $1 billion *(7)*. Thus, other solutions related to traffic demand management (TDM), application of proven intelligent transportation system (ITS) techniques, and rehabilitation and utilization of the old Mississippi River Bridge on US-190 are of a dire need to be investigated. As such, this study undertook network simulation and analysis to identify the extent of and identify solutions to the congestion problem at the I-10 Mississippi River Bridge. A VISSIM simulation model was obtained from the Louisiana Department of Transportation and Development (LADOTD) for I-10 starting from Lobdell Highway in Port Allen to Highland Road, I-110 to Florida Street, and I-12 to Walker Road. The model was validated using limited data from several sources including LADOTD, Streetlytics database developed by CitiLabs, the National Performance Management Research Data Set (NPMRDS), and traffic signal schedules from the City of Baton Rouge.

The simulated scenarios represented several potential solutions for mitigating congestion on the I-10 Mississippi River Bridge. The solutions can be classified into either supply-oriented or demand-oriented. Supply-oriented solutions included: (a) rehabilitation and utilization of the old Mississippi River Bridge on US-190 and the existing US-190/US-61 corridor and (b) minimizing turbulence and queuing caused by excessive lane changes upstream of exit ramps. Demand oriented solutions included: (a) demand management strategies to reduce traffic demand and lessen the variability in demand over time, (b) implementing ramp metering/demand optimization at the Alexander Avenue on-ramp west of the I-10 Mississippi River Bridge during the P.M. peak period, and (c) reducing percent trucks on I-10 eastbound at the Alexander Avenue on-ramp during the A.M. peak period.

Based on the simulation results, a combination of both supply- and demand-oriented measures will be required to mitigate traffic congestion on the I-10 Mississippi River Bridge. Rehabilitation and utilization of the old Mississippi River Bridge on US-190 and the existing US-190/US-61 corridor, overall demand management of I-10 EB traffic, reduction in percent trucks traveling eastbound on I-10 during the A.M. peak period, and ramp metering at the on-ramp west of the I-10 Mississippi River Bridge appear to be feasible and effective solutions.

The results of this study should be considered with an important caveat in mind: the data available to the researchers for calibrating the simulation model were limited. As such, additional data on key traffic parameters (e.g., flow rate, average speed, and traffic density) as well as demand-related data (e.g., traveler preferences and perceptions, route choice, mode choice, etc.) are required to confirm the numerical values of the MOE's and metrics included in the report.

IMPLEMENTATION STATEMENT

Understanding the causes of traffic congestion on the I-10 Mississippi River Bridge (in Baton Rouge, LA) and the effectiveness of potential strategies/treatments helps planners, stakeholders, and policymakers decide what policies and investments are needed to improve transportation system performance. To this end, the implementation phase of this research project will focus on communicating the research findings to the policymakers and stakeholders in the Baton Rouge area and LADOTD. A project-specific technology transfer (T2) plan has been developed, and the following are the planned activities during the implementation phase:

- A stakeholder webinar to communicate project findings and recommendations (Oct. 2018);
- Local newspaper articles summarizing the study and findings (Nov. 2018); and
- Publication and journal submission to the Transportation Research Board Annual Meeting (Jan. 2019).

1. INTRODUCTION

Traffic congestion and the resulting unreliable transportation system performance are major impediment to sustainable economic growth, productivity and urban area vitality. Traffic congestion is caused by several factors including inadequate base capacity, increased demands, traffic control devices, traffic incidents, work zones, special events and weather *(9)*. Unreliable travel times and delays to region-wide commuters, late deliveries, limited skilled labor markets, increased stress levels, and air pollution are examples of the impacts of congestion on commuters, shippers, just-in-time manufacturing processes and complex supply-chain networks. A 2009 study entitled "Gridlock and Growth" found that a 10% reduction in travel times could boost production of goods and services by 1%, leading to tens of billions of dollars in higher income and output in urban areas *(1)*.

According to the Texas A&M Transportation Institute's (TTI) "2015 Annual Mobility Scoreboard" *(2)* and the Baton Rouge Area Capital Region Industry for Sustainable Infrastructure Solutions (CRISIS), the Baton Rouge area has been suffering from severe traffic congestion that threatens the economic development in the area. Baton Rouge is listed as the third worst for moderate- average-sized urban areas in the category of average commuter annual traffic delay. The Baton Rouge area also ranks second worst among mid-sized cities for the amount of annual excess fuel consumed per commuter, and number one on the list for the amount of money congestion is costing the average commuter per year, at $1,262. Baton Rouge also ranks third worst for cities its size both for freeway travel reliability, and for total truck congestion costs per year, at $189 million. Reasons for this congestion impediment in Baton Rouge include (a) the high freight demand imposed by the oil and gas industry in the area *(3)*, and (b) the high population density of 700,000 in Baton Rouge Metropolitan Area which generates around 3.2 million vehicle trips every day *(4)*. These high demands and daily trips impose severe delays, and long lasting and fast spreading breakdowns on the transportation infrastructures in Baton Rouge. One of the main facilities suffering from severe traffic conditions in Baton Rouge is the I-10 Mississippi River Bridge, possibly because of the chemical plants located on the west bank of the river.

The I-10 Mississippi River Bridge is a 4-lane facility that represents the main link between East and West Baton Rouge areas *(5)*. The only other link is an older bridge on US-190 located 4.5 miles upstream of the I-10 Mississippi River Bridge. Travelers choose to use the I-10 Mississippi River Bridge because of the ease of access to several significant locations in Baton Rouge, in addition to the extra travel time and discomfort travelers may experience when rerouting through the city network to use the older bridge. According to Louisiana Department of Transportation and Development (LADOTD), the annual average daily traffic (AADT) on and around the I-10 Mississippi River Bridge is higher than 108,000 based on estimates in 2014 with an increase of 13% compared to 2011's estimates *(6)*. Severe traffic congestion is a daily recurring occurrence on the bridge that affects the surrounding streets and intersections and extends over prolonged periods. Solving such an acute congestion problem is challenging especially that capacity expansion is an expensive solution. For instance, a recent study showed that a new Mississippi Bridge could significantly solve the current bridge's congestion problem; however, such bridge will cost around $1 billion *(7)*. Therefore, other congestion mitigation solutions such as Active Traffic Management (ATM), Intelligent Transportation Systems (ITS), and the application of travel demand management (TDM) techniques must be investigated. As such, this study is aiming to perform comprehensive comparative analysis between several supply-oriented and demand-oriented solutions to mitigate the congestion problem at the I-10 Mississippi River Bridge.

1.1. Review of Previous Studies

The Interstate I-10 corridor is the most highly traveled coast-to-coast interstate in the U.S. It is also a national freight corridor of significant importance to the economy. The portion of I-10 through Baton Rouge, LA was constructed in the 1960's as a four-lane freeway with two lanes per direction. Traffic demand in Baton Rouge has been growing steadily and currently exceeds the capacity of the corridor during much of the day. Severe traffic congestion is a daily occurrence in the morning and afternoon peak periods, particularly along the portion of I-10 from Louisiana Highway 415 (LA 415) across the Mississippi River Bridge to the I-10/I-12 merge. Capacity improvements to I-10 and I-12 in the eastern suburbs helped deliver more traffic to the core of the urban area, thus compounding the traffic congestion on I-10 and across the Mississippi River. Figure 1 illustrates the existing I-10 traffic issues in Baton Rouge while Figure 2 shows a picture of traffic congestion on the I-10 Mississippi River Bridge.

Several studies have been conducted in the past 20 years to address the 1-10 traffic congestion challenge in the Baton Rouge area. These studies focused primarily on adding capacity and eliminating bottlenecks. The studies can be grouped into two broad groups: 1) I-10 corridor projects, and 2) Off-corridor projects. Examples of the proposed I-10 corridor projects include:

- I-10 Baton Rouge Major Investment Study (Parsons Brinckerhoff Quade & Douglas), *(13)*;
- National I-10 Freight Corridor Study (Wilbur Smith Associates) *(15)*;
- I-10 Corridor Improvements Stage-0 Feasibility Study (Providence) *(7)*; and
- Baton Rouge Loop: Tier 1 Final Environmental Impact Statement *(16)*.

Figures 3 through 6 illustrate examples of proposed capacity improvements that involve widening of I-10 by adding a third lane in each direction and making major geometric changes to some of the exits along the 3.5-mile corridor between the Interstate 10/12 split interchange and the Mississippi River Bridge *(17)*.

Off-corridor projects that have been proposed were directed at rehabilitating the existing roadway network surrounding the I-10 corridor and reconstructing the US-190/US-61 corridor to shift some of the I-10 traffic demand to the old Mississippi River Bridge and link the regional interstate systems on each side of the Mississippi River. Examples of off-corridor proposed projects include:

- New Mississippi River Bridge to the south;
- Baton Rouge Urban Renewal and Mobility Plan (BUMP) – public private partnership;
- LA-1 to LA-415 Connector;
- Baton Rouge Loop as envisioned in the Tier-1 Environmental Impact Statement; and
- Northern Bypass as envisioned in a 2004 Feasibility Study.

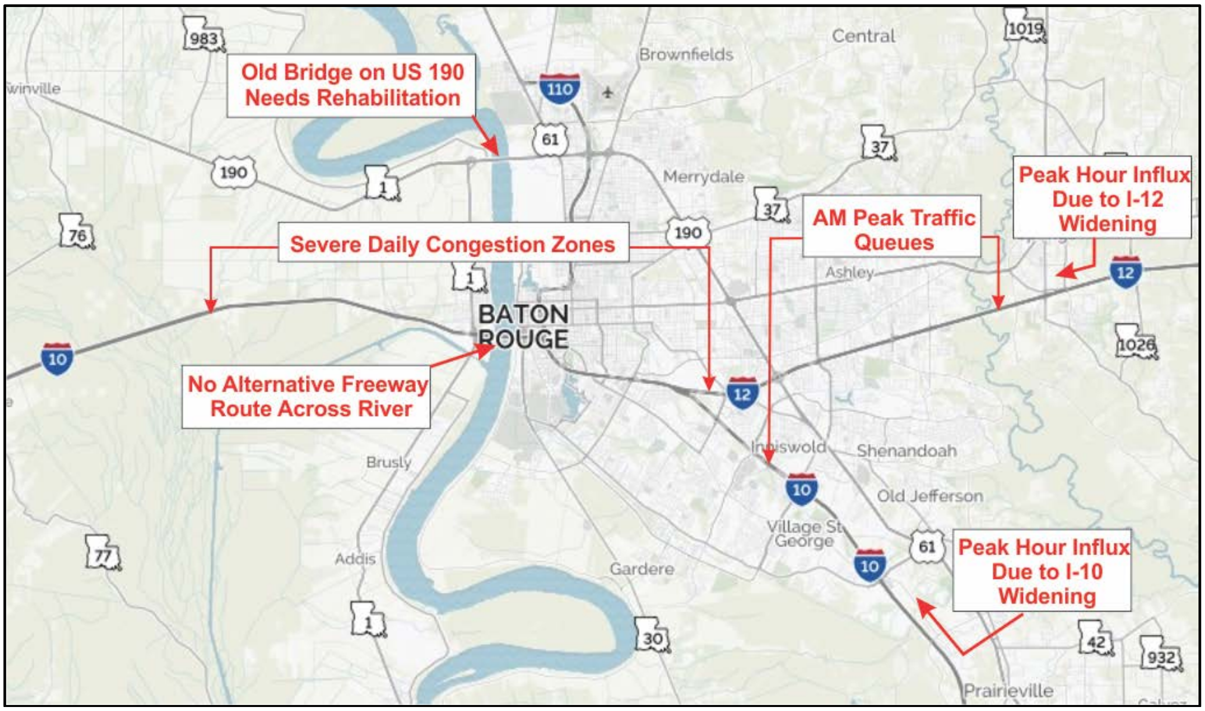


Figure 1. Existing I-10 Traffic Issues in Baton Rouge, LA.

Figure 2. I-10 Mississippi River Bridge.

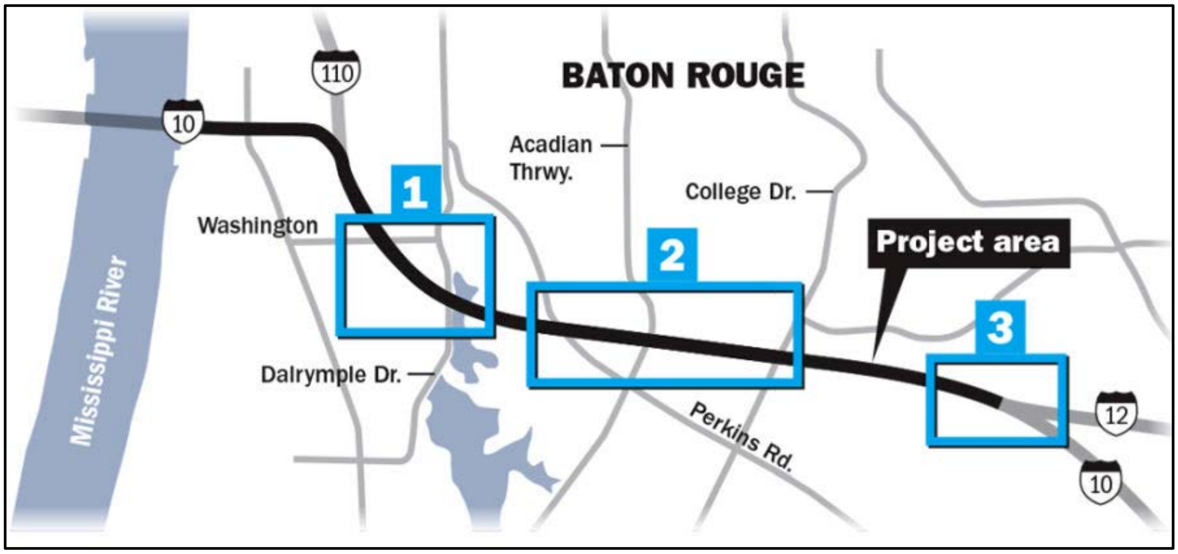


Figure 3. I-10 widening (4-lanes to 6-lanes) and changes to some ramps at six interchanges along the 3.5-mile Corridor *(17)*.

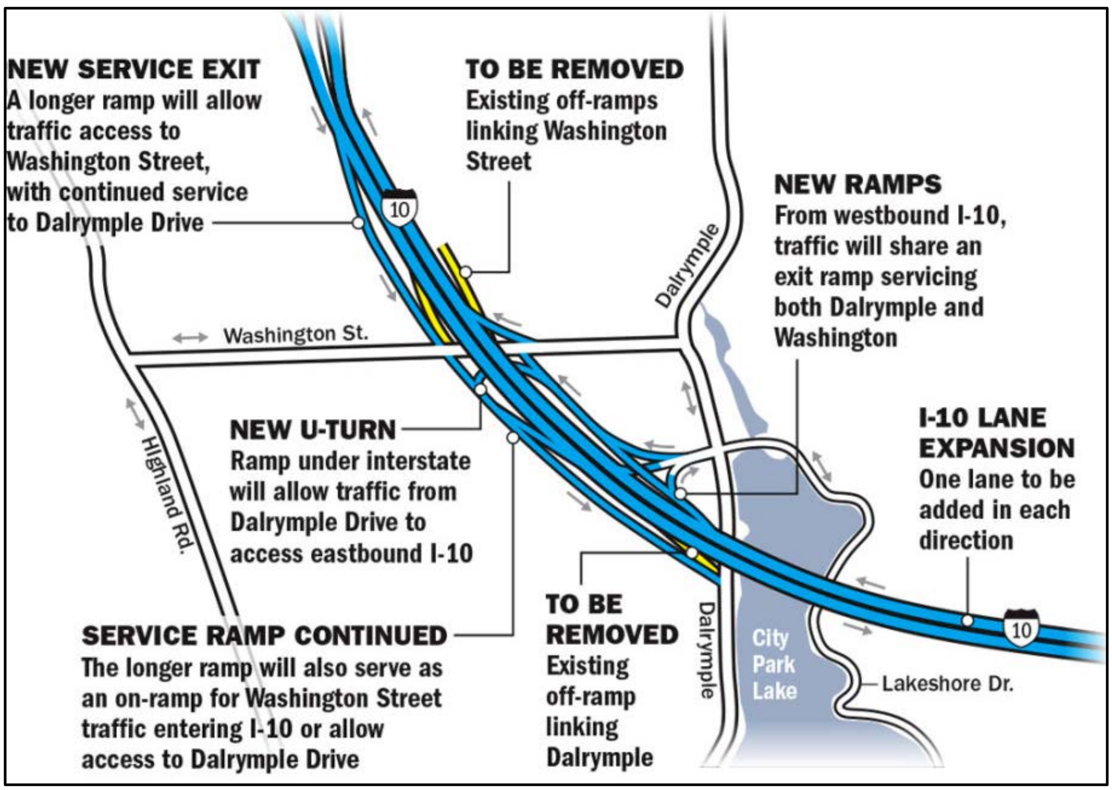


Figure 4. Stage-1: Redesign and construction of exits at Washington Street and Dalrymple Drive *(17)*.

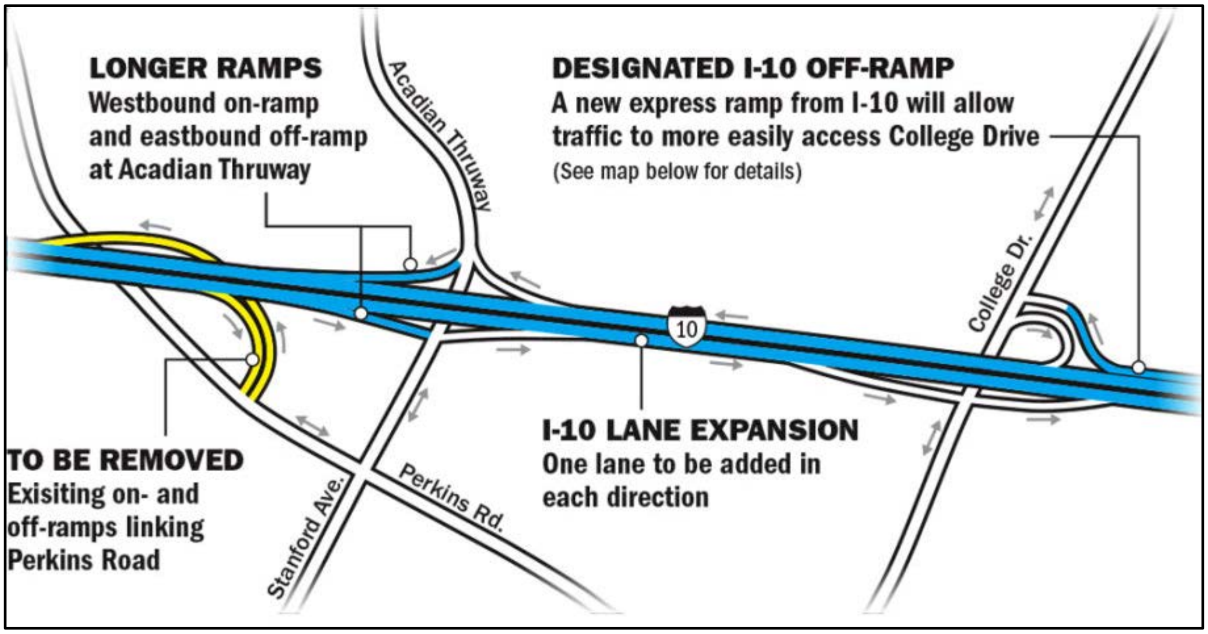


Figure 5. Stage-2: Redesign and reconstruction of exits and ramps at Perkins Road, Acadian Thruway, and College Drive *(17)*.

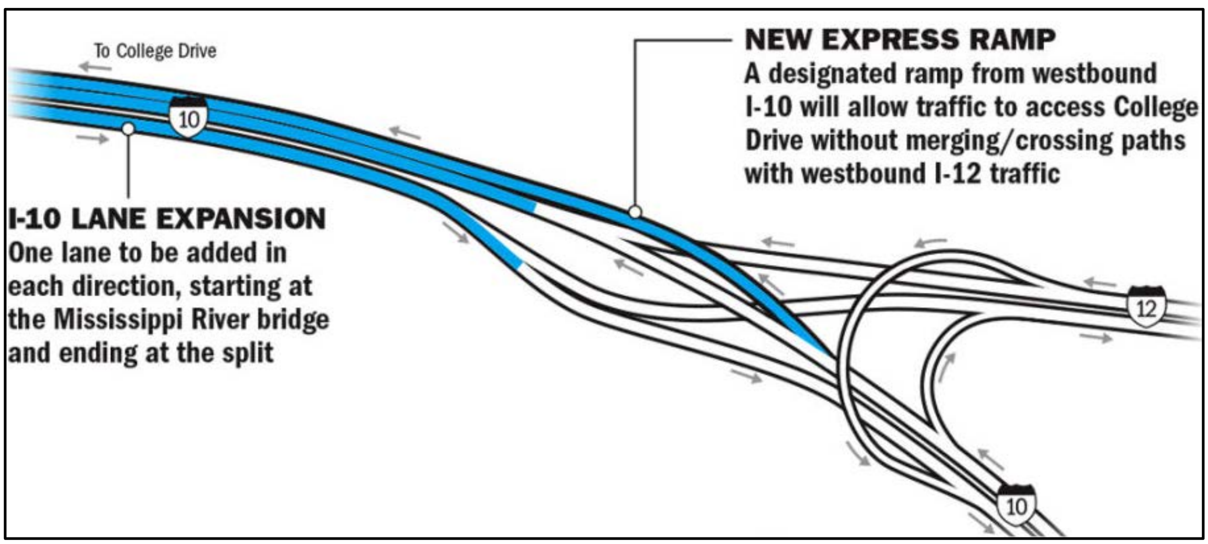


Figure 6. Stage-3: Redesign and reconstruction of I-10/I-12 Split Interchange *(17)*.

The Baton Rouge Urban Renewal and Mobility Plan (BUMP) project proposed by AECOM is particularly noteworthy because it can effectively reduce the demand on the I-10 corridor through the core urban area and across the I-10 Mississippi River Bridge. Figure 7 illustrates the proposed alignment of the BUMP project. Under the AECOM proposal, the existing US-190/US-61 corridor is utilized to construct a 60-70 mph toll-road connecting I-10 in West Baton Rouge Parish with I-12 and I-10 in East Baton Rouge Parish. Traffic demand will be shifted from the existing heavily congested I-10 Mississippi River Bridge to the existing underutilized old US-190 Mississippi River Bridge just 4.5 miles upstream. Access to existing business and other land-uses along the US190/US 61 corridor will be maintained through a toll-free system of frontage roads using existing right of way. In addition to improving regional mobility, the BUMP project was planned to provide an urban renewal stimulus for the older part of the US 61/US 190 corridor north of Florida Boulevard in East Baton Rouge Parish. This corridor, once a vibrant primary route in the area, has not kept pace since the I-10 system came on line in the 1960s and 1970s.

The *supply-oriented* proposals discussed earlier (both I-10 corridor projects and off-corridor projects) have not been realized for various reasons including lack of political and/or community support, lack of funding, right of way issues, environmental impacts, etc. While the stakeholders and leadership in Baton Rouge and Louisiana may not have given up on these potential supply-oriented improvements, traffic demand keeps increasing and traffic congestion keeps getting worse.

Another class of solutions to traffic congestion problems is labeled *travel demand management* (TDM). The goal of TDM is to reduce the number of vehicles on a given road during a particular time of day. TDM may take the form of promoting alternative commute options and regulating heavy vehicle operating schedules. Examples of TDM strategies include:

- Employee telecommuting options;
- Flextime or staggered work hours;
- Expanding and/or improving the quality of transit services to make public transportation easier and more attractive to use;
- Adopting congestion pricing;
- Promoting integrated transportation and land-use planning;
- Preferential parking for carpools and vanpools, employee parking cash-out; and
- Bike lanes.

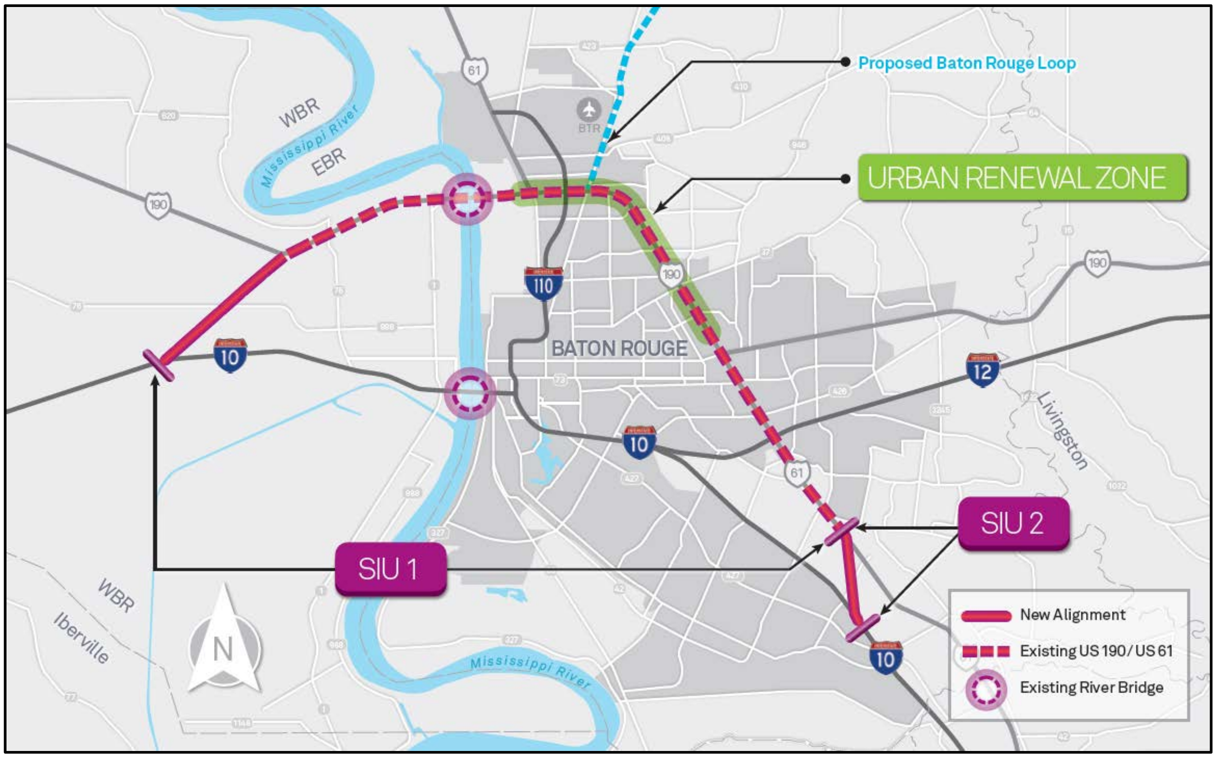


Figure 7. AECOM Baton Rouge Urban Renewal and Mobility Plan (BUMP).

2. OBJECTIVE

The main goal of this study is to examine the causes and impacts of traffic congestion at the I-10 Mississippi River Bridge in Baton Rouge, LA and to propose supply- and demand-oriented strategies/treatments to improve the transportation system performance. The specific research objectives include:

- Collecting traffic and geometric data from the I-10 Mississippi Bridge in the Baton Rouge area and some of its surrounding streets and intersections;
- Coding the transportation network in a simulation platform;
- Performing network analysis to identify the scope, causes and impacts of the congestion problem in each location;
- Identifying potential strategies/treatments to overcome the congestion problem (supply - and demand-oriented measures); and
- Performing high-level evaluation of the economic feasibility of the potential solutions.

3. SCOPE

This study focused on the I-10 corridor from Louisiana Highway 415 (LA 415) across the Mississippi River Bridge to the I-10/I-12 merge in Baton Rouge, LA. The study explored the effectiveness of several supply- and demand-oriented solutions to mitigate congestion on I-10 at the bridge location.

4. METHODOLOGY

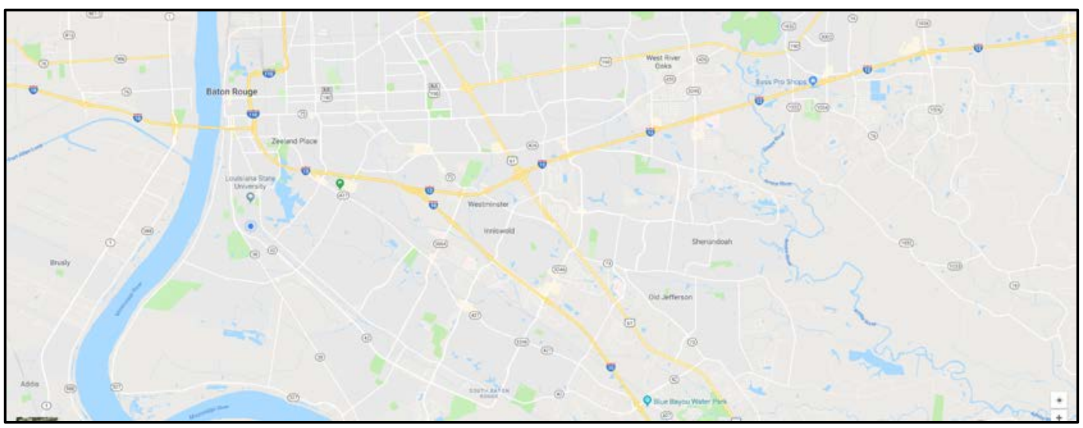
The research methodology started with identification of potential data sources to model the I-10 Mississippi River Bridge using microsimulation. This was followed by the development and calibration of the simulation platform required for the study. Then, the research team identified several solutions for testing in the simulation platform. Following is a discussion of the different steps of the research methodology:

4.1. Identification of Data Sources

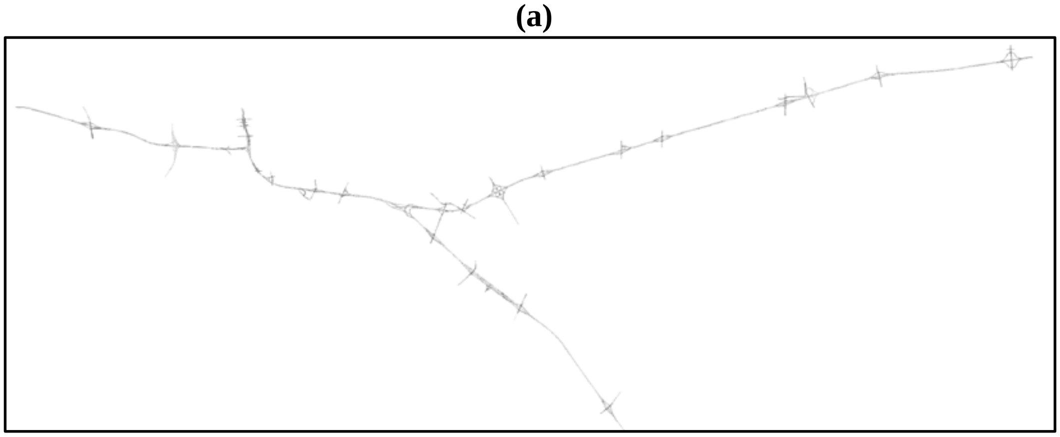
Upon several communications with various parties, the research team identified four main sources of data: LADOTD, the Streetlytics database developed by CitiLabs, the National Performance Management Research Data Set (NPMRDS), and traffic signal timing schedules from the City of Baton Rouge and LADOTD.

4.1.1. LADOTD Data

A VISSIM simulation model was obtained from LADOTD for I-10 starting from Lobdell Highway in Port Allen to Highland Road, I-110 to Florida Street, and I-12 to Walker Road. Figure 8 shows a snapshot of the acquired model. The simulation model included encoded hourly traffic volumes collected during three A.M. peak hours and four P.M. peak hours. This model and the encoded traffic volumes were the main data used in the study. For verification and validation purposed, other data sources were sought.



(a)



(b)

Figure 8. The study area in (a) Google Maps and (b) in the VISSIM Simulation Model.

4.1.2. Streetlytics Data

The research team also collected traffic volume data from Streetlytics database that is owned by Citilabs. The Streetlytics database contains three-hour aggregated traffic counts from the entire nation collected from billions of GPS points, cellular data, connected vehicles, and Bluetooth devices among other sources. In addition, the database contains other parameters in GIS-based form including daily traffic, off-peak vs. peak counts, and commute vs. non-commute traffic, among others. Figure 9 shows a sample snapshot of the Streetlytics database.

4.1.3. NPMRDS Data

The NPMRDS database is a comprehensive data collection effort sponsored by the Federal Highway Administration (FHWA). According to the NPMRDS website, this database contains "an archived travel time and speed dataset that covers the National Highway System (NHS) and additional roadways near 26 key border crossings with Canada (20 crossings) and Mexico (6 crossings)". The database has a user-friendly interface, shown in Figure 10, which allows selection of multiple filtering options such as date, day of week, and type of vehicle. The NPMRDS has nearly 400,000 road segments, and was being updated on a monthly basis starting from 2011 through the end of January 2017.

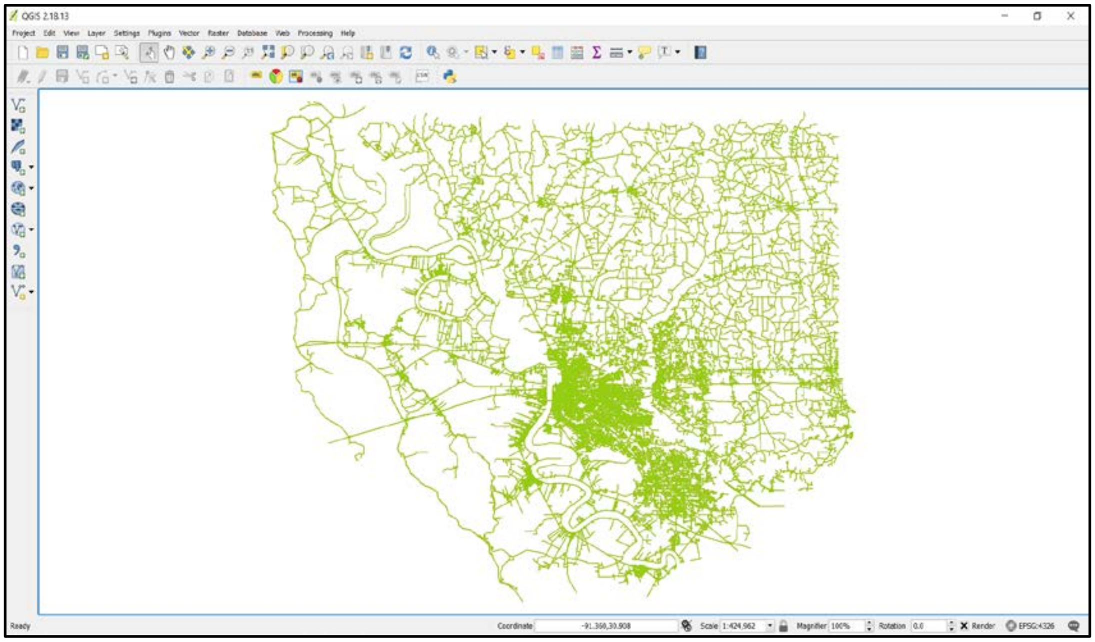
4.1.4. Traffic Signal Inventory (TSI)

The traffic signal inventory (TSI) data contained signal timing schedules for all signalized intersections in the simulation network obtained from the LADOTD. The research team obtained over a 100 TSI files for the traffic signals on the arterials around I-10, I-110, and I-12 from the City of Baton Rouge. As shown in Figure 11, each TSI files contained several signalization patterns depending on the time of day, whether the signal is coordinated with another upstream and/or downstream, and graphical demonstration for easier representation.

4.1.5. Extracted Data

The research team investigated the four data sources to decide which parameters to collect. Since simulation is the main tool used for the study, the VISSIM simulation model acquired from the LADOTD was used along with the encoded hourly volumes as the primary data source, while the other data sources (Streetlytics, NPMDRS, and TSI) were used for model calibration. Data were collected from the Streelytics and NPMDRS for the A.M. and P.M. peaks on typical weekdays in the year 2015 to match the encoded data in the simulation model.

For the Streetlytics data, the aggregated peak-period traffic volumes were extracted for all locations in the simulation model. As shown in Figure 12, the aggregated traffic volumes were obtained for every single link and for every direction on the I-10 Mississippi River Bridge, I-10, I-12, I-110 and all surrounding arterials encoded in the simulation model.



(a)

AMPKDIR	Maximum peak flow direction for two way road is AM peak period flow (1/0)
PMPKDIR	Maximum peak flow direction for two way road is PM peak period flow (1/0)
TOTDATAP	Total Daily Traffic
TOTAMTAP	Total AM peak period (3 hour) traffic
TOTPMTAP	Total PM peak period (3 hour) traffic
TOTOPTAP	Total Off Peak (18 hour rest of day) traffic
TOTDAFQ	Flow Quality index (0 to 1) for Daily Traffic
TOTAMFQ	Flow Quality index for AM peak period
TOTPMFQ	Flow Quality index for PM peak period
TOTOPFQ	Flow Quality index for Off peak period
PERDACMN	Percent of Daily Traffic that is commute traffic
PERDAEDN	Percent of Daily Traffic that is education related traffic
PERDALCN	Percent of Daily Traffic that is local traffic (both origin and destination inside model region)

(b)

Figure 9. Snapshot of Streetlytics database including (a) the GIS-based Streetlytics database and (b) the parameters provided in the database.

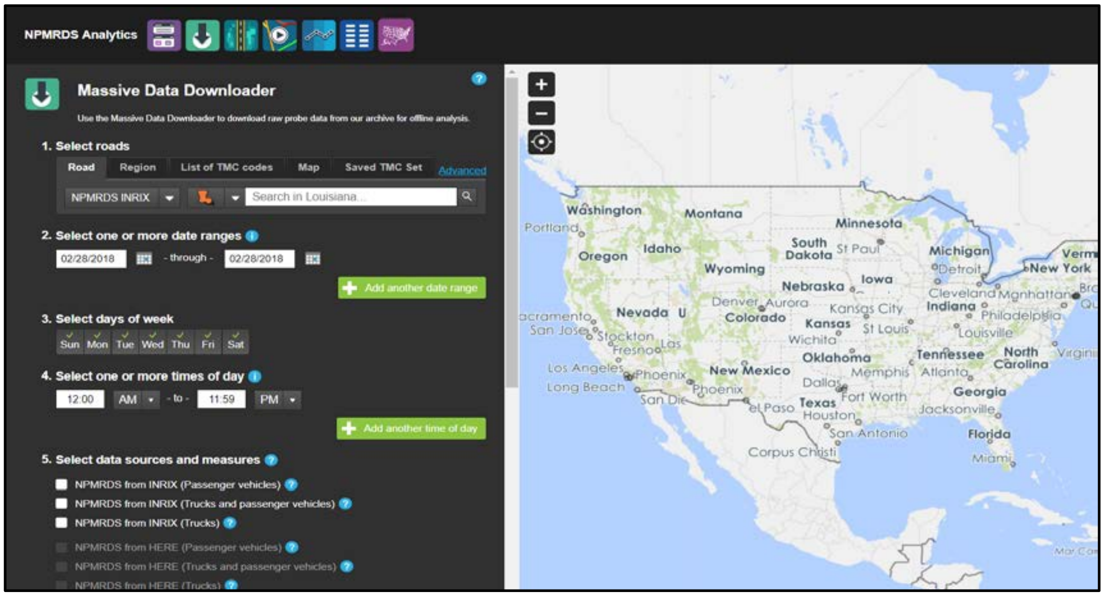


Figure 10. NPMRDS database.

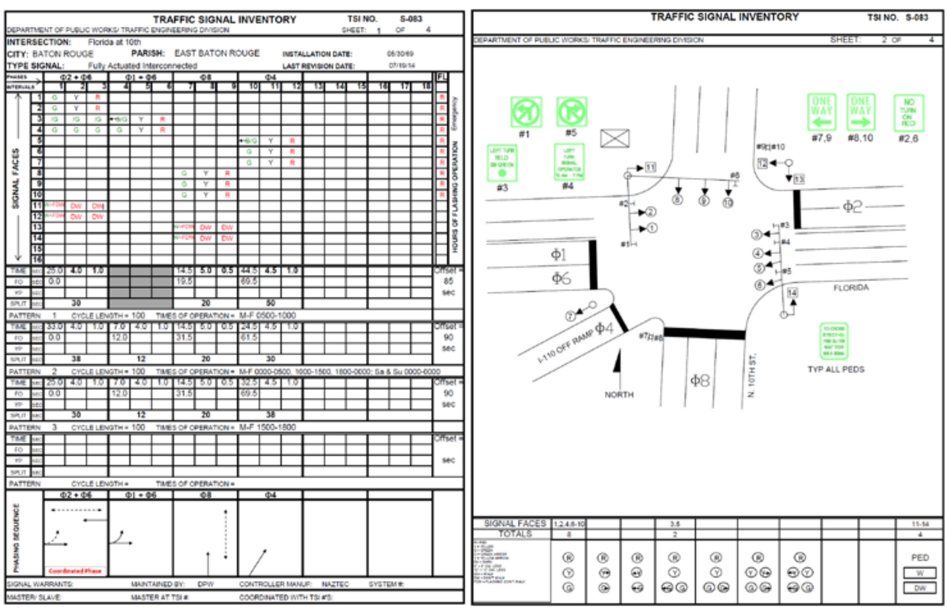


Figure 11. Sample TSI file.

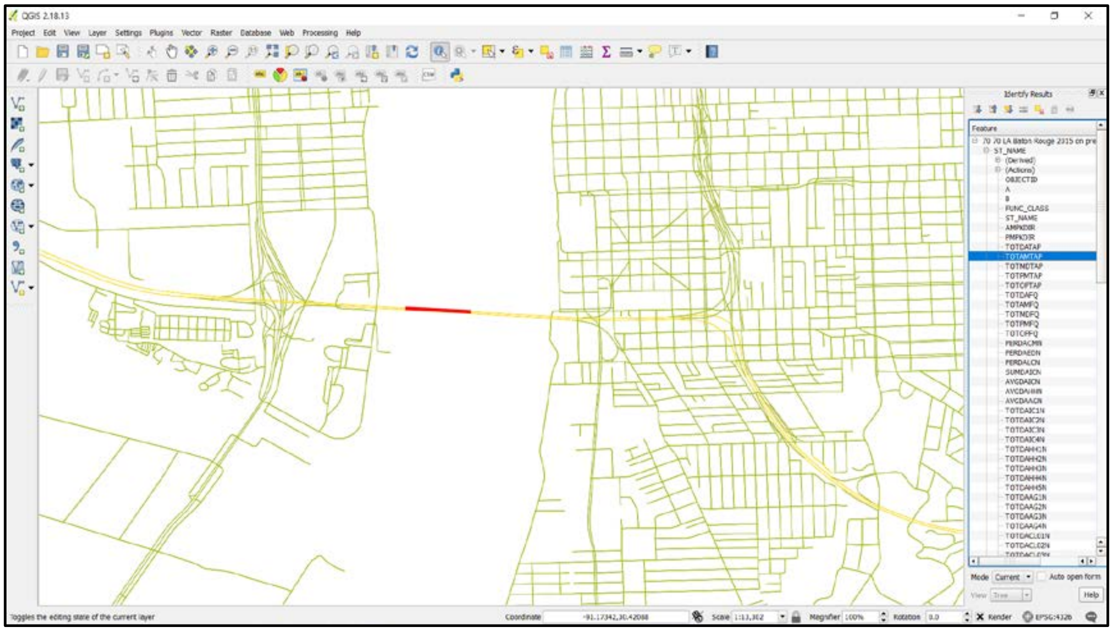


Figure 12. Link-based data extraction from the Streetlytics GIS files.

Since the Streetlytics data were available only for through movements in an aggregated form during the entire 3-hour A.M. peak period and the entire 3-hour P.M. peak period, the research team had to make several assumptions to convert the obtained traffic volumes into hourly volumes and to estimate turning movements. To obtain hourly values, uniform hourly distributions were assumed, hence the aggregated traffic volumes were divided by the number of hours. For the turning movements, the research team spent more than 200 hours working manually on every intersection individually. Figure 13 shows an example intersection where every merging or diverging point was labeled to help estimate the turning movements. It is worth pointing out that some turning movements were easy to estimate using simple calculations based on the Streetlytics hourly traffic volume data. Nevertheless, some turning movements were estimated based on several assumptions. The final routing scenario for those movements was determined after a comprehensive validation process using the NPMRDS database and the simulation model results.

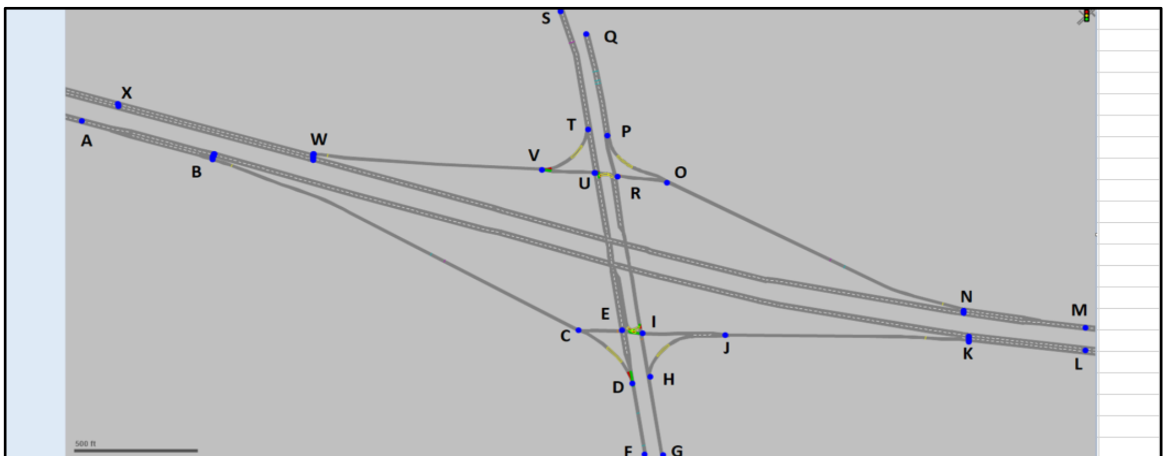
From the NPMRDS database, travel time data were extracted for the A.M. and P.M. peak hours that are known to be from 6:00 to 9:00 A.M. for the morning peak and from 3:00 to 7:00 P.M. for the evening peak. The travel time data were extracted for typical weekdays in 2015 to match the hourly traffic volume data encoded in the simulation model. Holidays and game days were avoided while extracting the travel time data. Figure 14 shows a snapshot of the data extraction process from the NPMRDS database.

4.2. Simulation Model Development and Calibration

After acquiring the required data for the study, the next step was to have a complete simulation model that can be used for testing of the alternative solutions. To this end, the research team validated the simulation model obtained from the LADOTD using the data collected from all other sources. The first step in this validation process was to encode the TSI data at the various signalized intersections in the simulation model. A total of 48 signalized intersections were encoded and verified using the TSI files obtained from the City of Baton Rouge. The main verification criteria included (a) green times are not higher or lower than the set maximum and minimum green times in the TSI files, (b) coordination is working wherever it applies, and (c) red times match the values given in the TSI files. Encoding the TSI files was one last step the research team had to perform to have a ready model for the calibration process that will be discussed thoroughly below.

4.2.1. Model Calibration

Simulation model calibration was a crucial step to have a working model with conditions that match real world traffic conditions. After several runs and investigation of all intersections and roadway segments in the model, it was clear that in addition to the regular calibration process which includes adjustment of car following and lane change parameters, routing decisions were another important parameter that needed to be tackled. This was based on comparison of travel time data between the model results and Streetlytics and NPMRDS data. As shown in Figure 15, there are significant differences between the travel time measurements obtained on the ground truth and the results from the simulation model that are as high as 500% for the A.M. peak model and 6000% for the P.M. peak model.



AB	wkt_geo	OBJECTI	A	B	FUNC_Cl	ST_NAM	AMPKDI	PMPKDI	TOTDAT	TOTAMT	TOTMDT	TOTPMT	TOTOPT	TOTDAF	TOTAMF	TOTMDF	TOTPMF	TOTOPF
	MultiLin	110476	201725	51612	1	I-10	1	1	12354	4535	1692	3456	2671	0.26	0.42	0.04	0.32	0.06
BC	wkt_geo	OBJECTI	A	B	FUNC_Cl	ST_NAM	AMPKDI	PMPKDI	TOTDAT	TOTAMT	TOTMDT	TOTPMT	TOTOPT	TOTDAF	TOTAMF	TOTMDF	TOTPMF	TOTOPF
	MultiLin	2199	51612	161336	4	151	1	1	2614	422	454	1125	614	0.09	0.06	0.02	0.17	0.02
BK	wkt_geo	OBJECTI	A	B	FUNC_Cl	ST_NAM	AMPKDI	PMPKDI	TOTDAT	TOTAMT	TOTMDT	TOTPMT	TOTOPT	TOTDAF	TOTAMF	TOTMDF	TOTPMF	TOTOPF
	MultiLin	2198	51612	151383	1	I-10	1	1	9740	4114	1239	2331	2057	0.22	0.38	0.03	0.22	0.05
CD	wkt_geo	OBJECTI	A	B	FUNC_Cl	ST_NAM	AMPKDI	PMPKDI	TOTDAT	TOTAMT	TOTMDT	TOTPMT	TOTOPT	TOTDAF	TOTAMF	TOTMDF	TOTPMF	TOTOPF
	MultiLin	87255	161336	161335	5		1	1	646	100	100	401	100	0.04	0.01	0	0.06	0
CE	wkt_geo	OBJECTI	A	B	FUNC_Cl	ST_NAM	AMPKDI	PMPKDI	TOTDAT	TOTAMT	TOTMDT	TOTPMT	TOTOPT	TOTDAF	TOTAMF	TOTMDF	TOTPMF	TOTOPF
	MultiLin	87254	161336	51617	4		1	1	1967	341	367	723	535	0.06	0.05	0.01	0.11	0.02
DF	wkt_geo	OBJECTI	A	B	FUNC_Cl	ST_NAM	AMPKDI	PMPKDI	TOTDAT	TOTAMT	TOTMDT	TOTPMT	TOTOPT	TOTDAF	TOTAMF	TOTMDF	TOTPMF	TOTOPF
	MultiLin	87253	161335	131901	5	S LOBDEI	1	1	2893	720	540	847	786	0.23	0.32	0.06	0.38	0.09
ED	wkt_geo	OBJECTI	A	B	FUNC_Cl	ST_NAM	AMPKDI	PMPKDI	TOTDAT	TOTAMT	TOTMDT	TOTPMT	TOTOPT	TOTDAF	TOTAMF	TOTMDF	TOTPMF	TOTOPF
	MultiLin	2210	51617	161335	5	LA-415	1	1	2246	639	454	445	708	0.16	0.29	0.05	0.2	0.08

Figure 13. Streetlytics data preparation and estimation of turning movements.

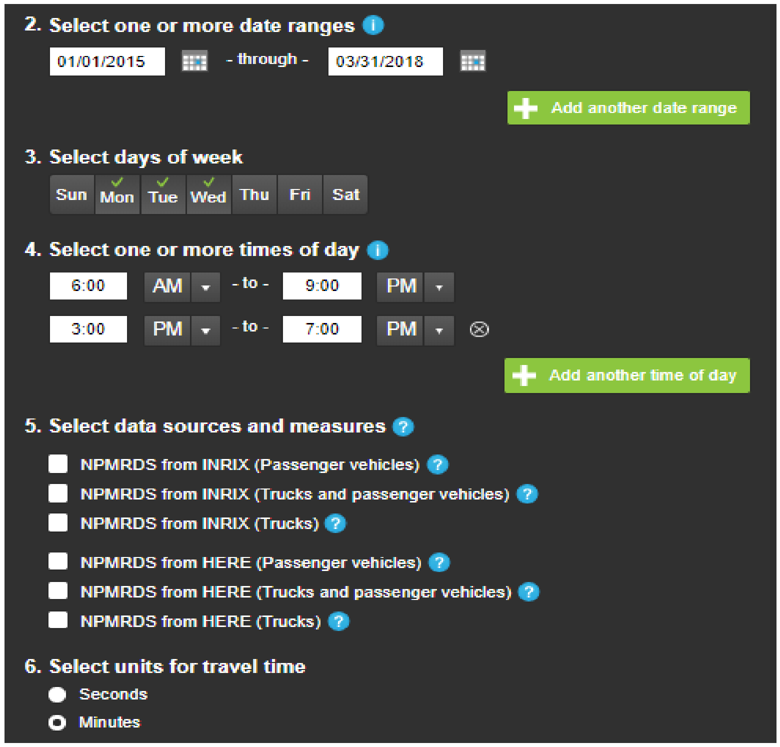
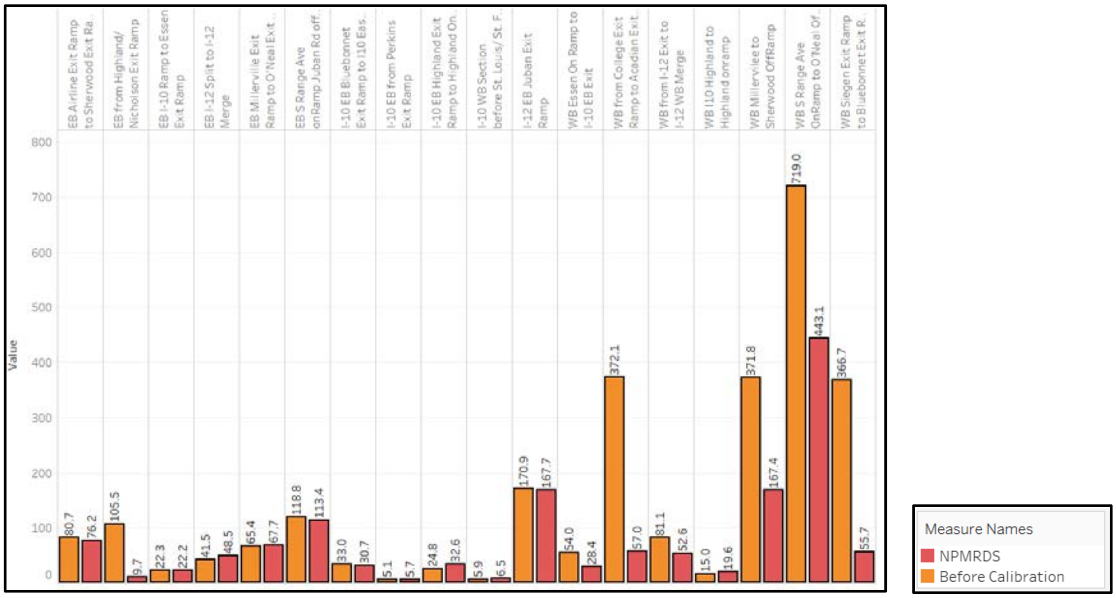
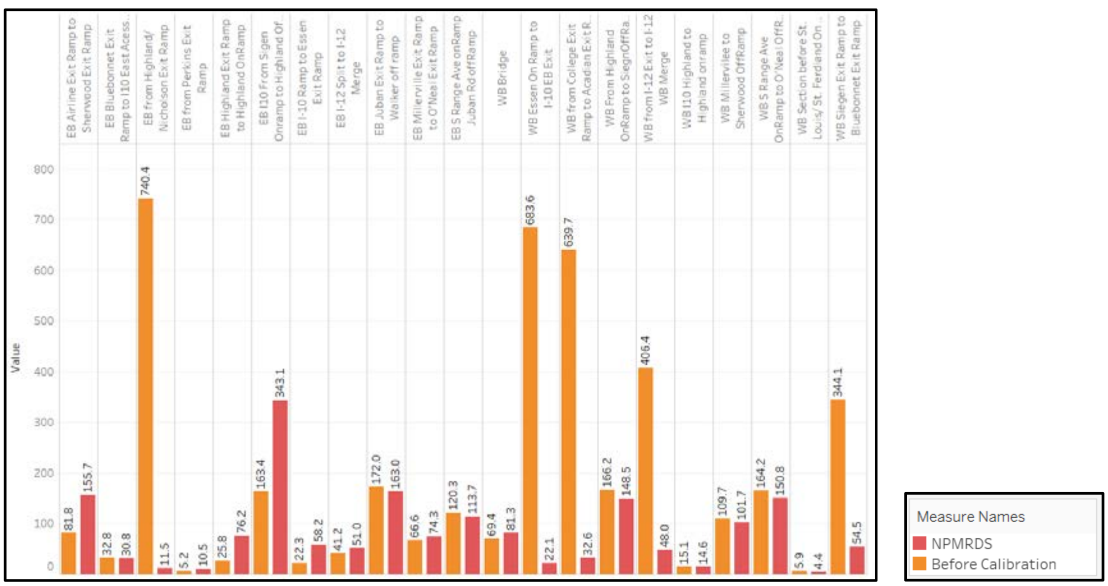


Figure 14. Travel time data extraction from NPMRDS database.



(a)



(b)

Figure 15. Comparison of travel time values (in seconds) before model calibration in the (a) A.M. peak model and (b) P.M. peak model.

Model calibration required tens of hours and tens of trials of simulation runs. To guarantee a robust process, several data collection points and travel time sections were added in the simulation model to collect traffic volume and travel time results. In each trial, these results were compared to the travel time data collected from the NPMRDS database and, when necessary, the turning-movements data estimated using the Streetlytics database. More specifically, each calibration trial included adjustment of the car following and lane change parameters first, as shown in Figure 16. After initial comparison of the simulation results to the collected data, routing decisions were only adjusted when significant differences in travel times were found. In such cases, the traffic volume results from the simulation model at each problematic location, where significant differences in travel times were obtained, were compared to the traffic volumes estimated from the Streetlytics database. Then, the routing decisions in the simulation model were adjusted at those locations several times until the counted traffic volumes in the simulation matched those estimated from Streetlytics database.

At some specific locations, other adjustments were made to reach travel time results that match the ground truth data. For instance, the on-ramps near the chemical plants west of the I-10 Mississippi River Bridge have high truck movement and hence speeds are not expected to be high. Similarly, speeds are not expected to be high at the end of the on-ramps on the Interstates. At these locations, reduced speed areas were added with lower speed values than the set speed limits. The final speed values used at every location was determined after several trials. Overall, several car-following parameters were used in the calibration, namely: headway time, 'following' variation, threshold for entering 'following', negative 'following' threshold, and positive 'following' threshold. The authors refer the reader to the VISSIM manual for parameter definitions *(19)*. Driver behavior was observed to be different on the interstate versus on the interstate at the Mississippi River Bridge (mainly due to the consolidated entrances and exits at the bridge); parameters of the car-following model were calibrated at these locations to match the observed differences in driver behavior.

Additionally, gridlocks were found to form at some merging locations on the interstates in an unrealistic way. At these locations, cooperative lane changes were set in addition to calibration of the routing decisions. After tens of trials, the research team was able to reach travel time results that match to a far extent the ground truth data with an average error value of as low as 0.1% for the A.M. model and 6% for the P.M. model, as shown in Figure 17. At the end of the calibration process, two working models (A.M. model and P.M. model) were ready to test several strategies and treatments to solve the congestion problem on the I-10 Mississippi River Bridge.

4.3. Proposed Solutions and Simulation Scenarios

After the model calibration, several simulation scenarios were created for testing. The simulation scenarios represented several proposed solutions for the congestion problem on the I-10 Mississippi River Bridge. The various solutions can be classified into either supply-oriented or demand-oriented solutions. The supply-oriented solutions included (a) minimizing turbulence and queuing caused by excessive lane changes upstream of exit ramps, and (b) Utilization of the old US-190 Mississippi River Bridge to connect I-10 in West Baton Rouge Parish with I-12 and I-10 in East Baton Rouge Parish. Whereas, the demand-oriented solutions included demand management and optimization strategies. All scenarios were determined through careful and substantial discussions among the research team, the sponsor, and LADOTD personnel. Likewise, several factors were considered in determining the solutions: feasibility of implementation, potential positive versus negative impacts of the solution, proximity of conflict points to an exit or an entrance, percentage of truck traffic, among others.

4.3.1. Supply-Oriented Solutions

Minimizing Turbulence and Queuing Caused by Excessive Lane Changes Upstream of Problem Exit Ramps: In this solution, new traffic controls/regulations are proposed at specific exit ramp locations to smooth traffic operations and reduce congestion. For instance, lane changes and traffic diverging from I-10 at the Washington Street exit can be redirected to the Dalrymple exit as shown in Figure 18-a. This may help reduce the congestion created by the high number of lane changes taking place in a short distance at that location as shown in Figure 18-b. This solution can also reduce the shockwaves of congestion that are initiated at the Washington Street exit and propagate upstream towards theI-10 Mississippi River Bridge. Since this shockwave problem is formed only during the A.M. peak, this solution is only tested in the A.M. model.

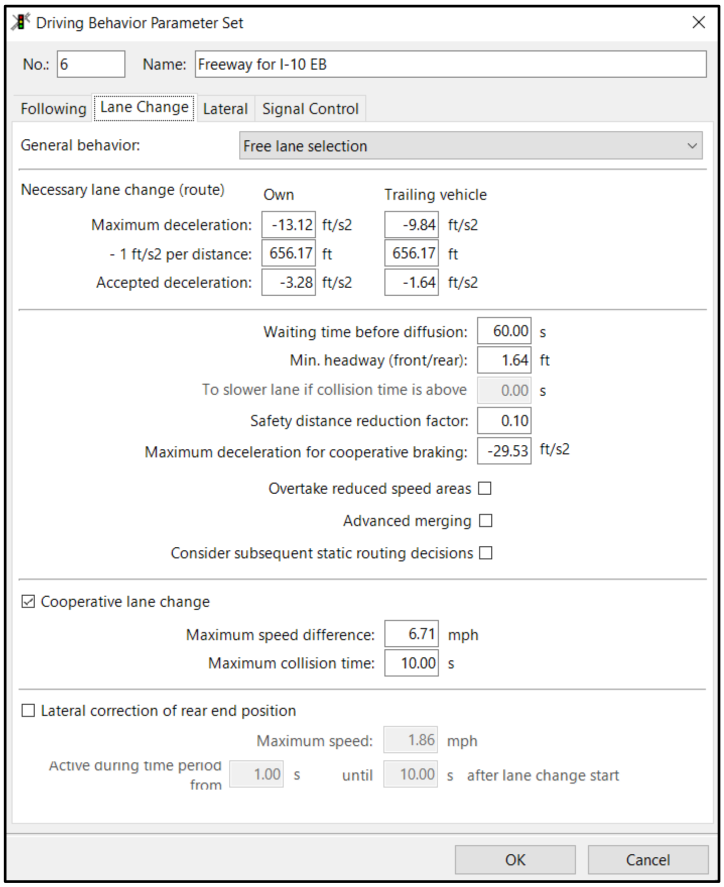
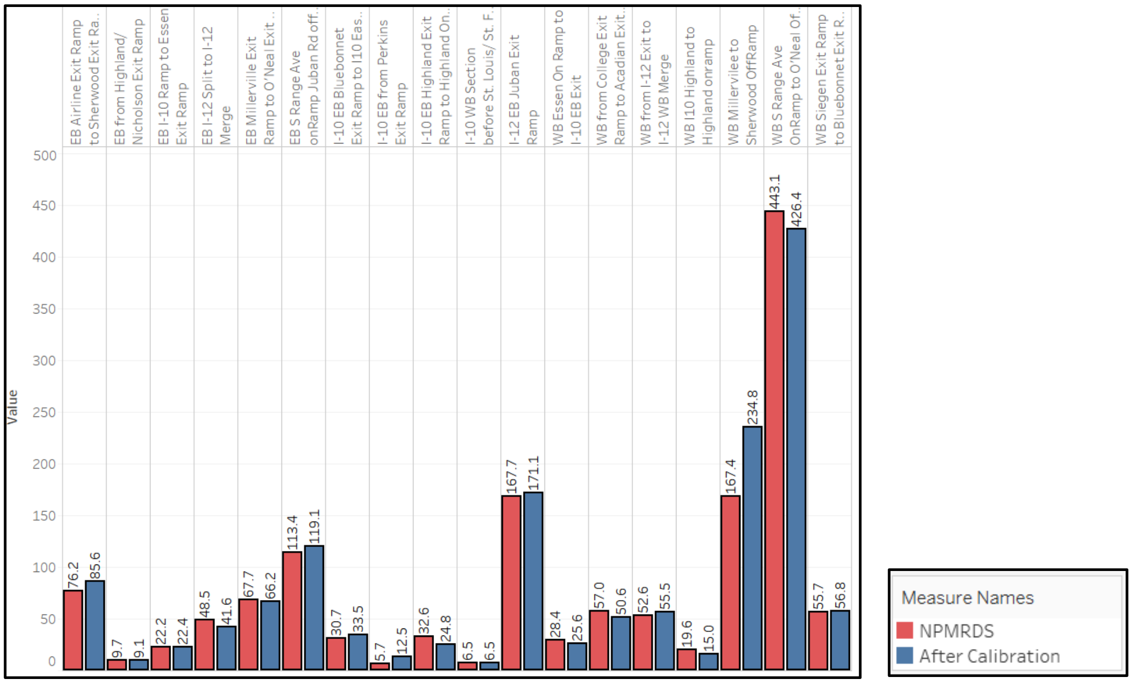
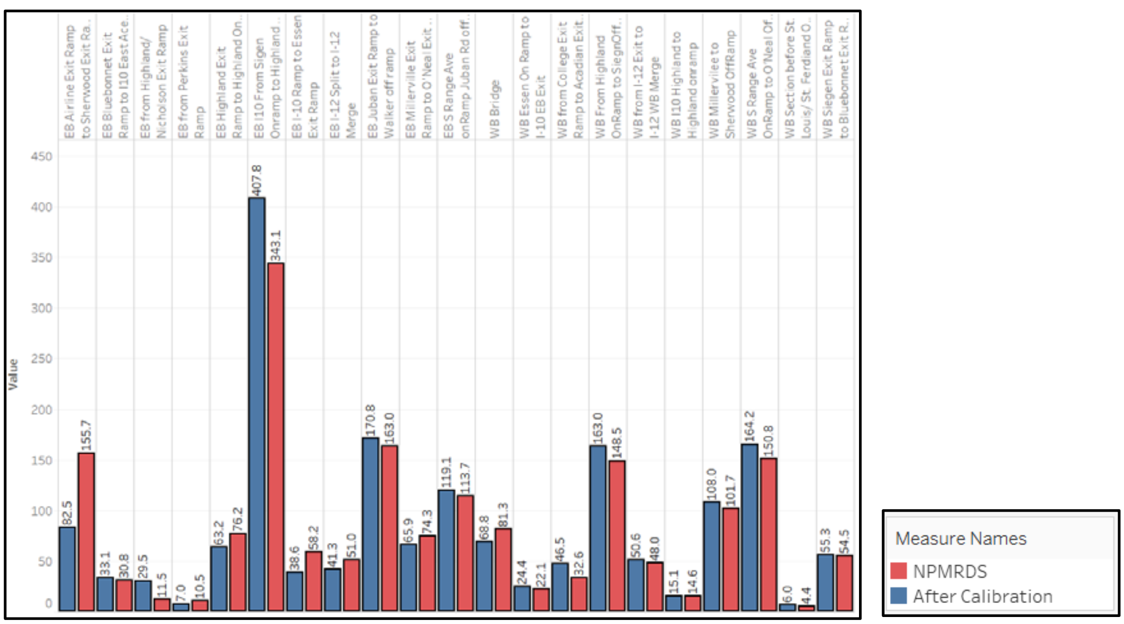


Figure 16. VISSIM driving behavior parameters (lane-change).



(a)



(b)

Figure 17. Comparison of travel time values after model calibration for the (a) A.M. peak model and (b) P.M. peak model.

Rehabilitation of the Old Mississippi River Bridge on US-190 and Resurfacing/Improvement of the Existing US-190/US-61 Corridor: This solution is similar in concept to the BUMP project proposed by AECOM *(11)*. It creates an alternate route connecting I-10 in West Baton Rouge with I-12 and I-10 in East Baton Rouge to shift some of the traffic demand on the I-10 Mississippi River Bridge to the underutilized old US-190 Mississippi River Bridge just 4.5 miles upstream.

To investigate the impact of this solution, the eastbound truck traffic on I-10 and the overall local traffic from Alexander Avenue on-ramp, as illustrated in Figure 19, were reduced by several percentages as depicted in Table 1. The reduction in traffic demand is accomplished by routing traffic to the rehabilitated old Mississippi River Bridge on US-190 using the improved US-190/US-61 Corridor. Several combinations were tested as shown in Table 1, which added nine simulation scenarios for each of the A.M. and P.M. peaks.

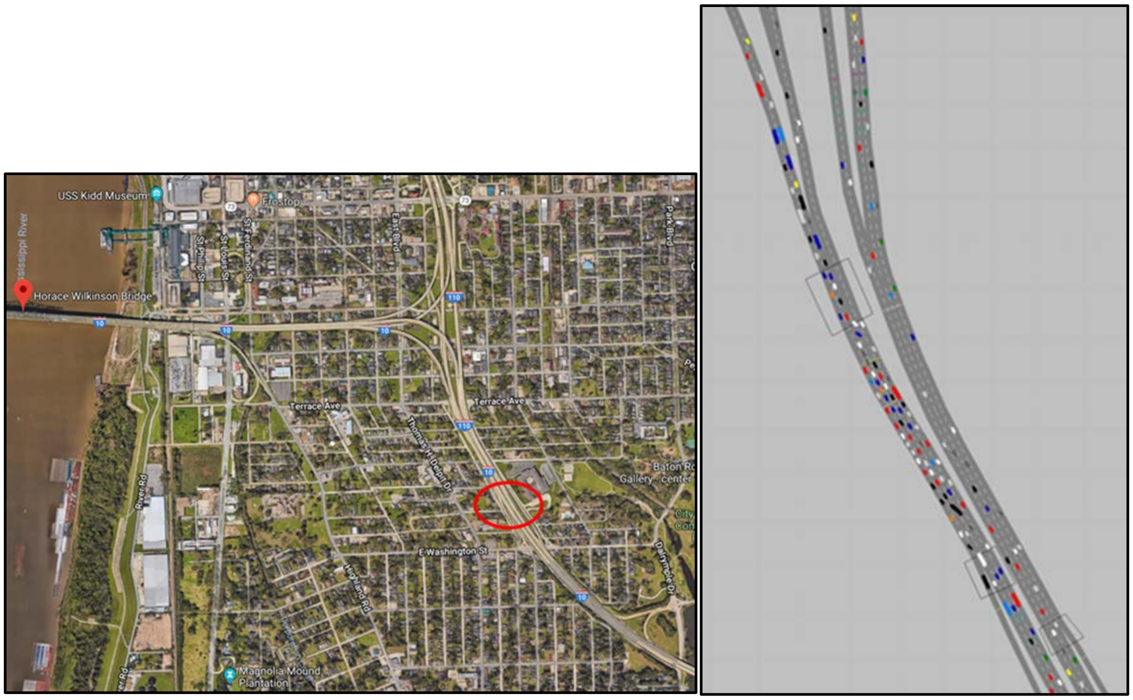
4.3.2. Demand-Oriented Solutions

The goal of demand-oriented solutions is to reduce the incoming traffic to the Eastbound and Westbound directions of the I-10 Mississippi River Bridge. Several strategies and treatments were proposed including ramp metering, reduction of truck traffic, reduction of the overall local demand, or a combination of both.

Ramp Metering: This solution involves active traffic management (ATM) during the P.M. peak period. Specifically, fixed ramp metering with a maximum flow rate of 600 vehicle/hour is proposed for eastbound traffic coming from the Alexander Avenue on-ramp west of the bridge, as shown in Figure 20. This on-ramp serves an hourly traffic flow of as high as 1340 vehicle/hour during the P.M. peak period.

Due to the importance of this on-ramp, as it is the main access for local traffic coming from the chemical plants to I-10, a queue override strategy is also proposed. In other words, as the queue reaches the beginning of the ramp because of the metering effect, the metering signal is set to turn green until the ramp queues are flushed.

Local Traffic Demand Management: This solution was tested during both the A.M. and P.M. peak periods. Specifically, the traffic demand from all the on-ramps surrounding the I-10 Mississippi River Bridge, shown in Figure 19, was reduced by 10%, 20%, and 30%. This potential solution added six simulation scenarios, three scenarios for each of the A.M. and P.M. peaks.



(a) (b)

Figure 18. (a) Routing of I-10 EB traffic from Washington Street Exit to Dalrymple Drive Exit and (b) Congestion created by lane changes at Washington Street.

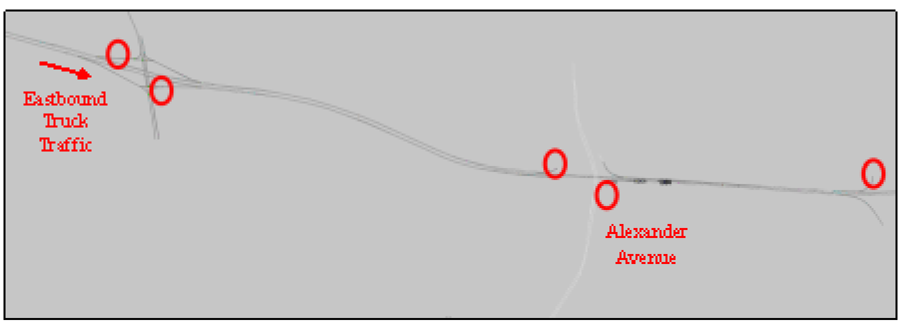
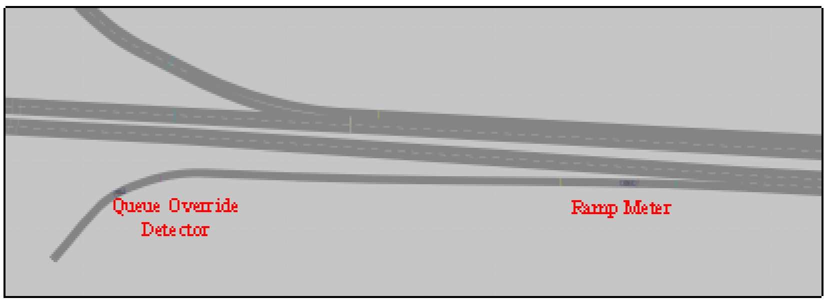


Figure 19. On-Ramp Locations with reduced traffic demand as a result of routing traffic to the old Mississippi River Bridge on US-190.

Table 1. Combined reduction in I-10 truck traffic and Alexander Avenue traffic demands.

Reduction in Demand at Alexander Avenue On-Ramp	0% Reduction in I-10 Eastbound Truck Traffic	25% Reduction in I-10 Eastbound Truck Traffic	50% Reduction in I-10 Eastbound Truck Traffic
30%	x	x	x
40%	x	x	x
50%	x	x	x

(a)



(b)

Figure 20. Ramp metering on Alexander Avenue on-ramp: (a) an over-head view and (b) in the VISSIM model.

Reduction in Truck Traffic: This solution was only tested during the P.M. period at the Alexander Avenue on-ramp shown in Figure 20. On this ramp, about 22% of the traffic demand is trucks. Therefore, the research team investigated the impact of reducing this percentage to 19%, 16%, and 13%. Accordingly, three simulation scenarios were tested for the P.M. period for this potential solution.

A total of 10 simulation runs were performed for every proposed solution. For every solution, several performance measures were collected including delay, travel time, throughput, and speed. The average values for the 10 simulation runs were obtained for every performance measure for further analysis and evaluation.

5. FINDINGS

Tables 2 and 3 present summary and comparison of key strategies and treatments included in this study. Results of the VISSIM simulations of these strategies and treatments are summarized in Appendices A-D in the form of tables and figures. To identify the strategies and treatments most likely to have the greatest impact on mitigating traffic congestion in Baton Rouge, LA, several measures of effectiveness (MOEs) and metrics were calculated including:

- Average Delay, seconds/vehicle;
- Throughput, vehicles;
- Total Delay, vehicle-hours;
- Vehicle-Miles Traveled (VMT);
- Delay Cost, $/hour;
- Annual Cost of Delay, $/year; and
- Annual Economic Savings, $/year compared to the baseline conditions (do-nothing alternative).

User delay cost was computed by multiplying the delay (vehicle-hours) times one-half of the average hourly wage in Baton Rouge (0.5 x $21.38/hour = $10.69/hour).

Appendices A and B present the results of the A.M. peak period analyses for an average hour and the three-hour peak, respectively. Appendices C and D present the results of the P.M. peak period analyses for an average hour and the three-hour peak, respectively.

5.1. A.M. Peak Strategies/Treatments

Effect of Rehabilitating the Old Mississippi River Bridge and Reconstructing the US-190/US-61 Corridor: The effects of shifting some of the I-10 eastbound traffic to the old bridge are illustrated in Figure A-3 and Tables A-8 through A-16 for the average A.M. peak hour. This solution produced notable reduction in the vehicle-hours of delay and annual user costs for the different demand-shift scenarios. The results for the entire three-hour A.M. peak-period are shown in Figure B-3 and Tables B-8 through B-16.

Effect of Closing the Washington Street Exit and Directing I-10 EB traffic to Use the Dalrymple Drive Exit: The impact of reducing the intensity of lane changing and the associated turbulence at the Washington Street exit is shown in Figure A-4 and Tables A-17 & A-18 for the average A.M. peak hour. This solution did not result in reduction in delay because of the proximity of the Dalrymple Drive exit to the Washington Street exit and the geometry of the exit ramps. A complete reconstruction of these ramps has been proposed as shown in Figure 4. The simulation results for the entire three-hour A.M. peak-period are shown in Figure B-4 and Tables B-17 & B-18.

Effect of Reducing Percent Trucks on I-10 Eastbound: The effects of reducing percent trucks on I-10 eastbound at the Alexander Avenue on-ramp are illustrated in Figure A-1 and Tables A-1 through A-4 for the average A.M. peak hour. Truck traffic was reduced from their current value of 22% to 19%, 16%, 13% and 10%. This solution produced notable reduction in the vehicle-hours of delay and annual user costs for the different percent trucks scenarios. The results for the entire three-hour A.M. peak-period are shown in Figure B-1 and Tables B-1 through B-4. This solution may be difficult to implement and requires close cooperation of local industries and businesses.

Table 2. Summary of strategies/treatments.

Category	Strategy/Treatment	Description or Application	Modes Affected
Supply-Oriented Strategies/Treatments	Minimize turbulence and queuing caused by excessive lane changes upstream of problem exit ramps	Traffic diverging from I-10 at the Washington Street exit is directed to the Dalrymple exit during the A.M. peak period.	Passenger vehicles and trucks
Supply-Oriented Strategies/Treatments	Infrastructure improvements, geometric design treatments, signal timing (Old US-190 Mississippi River Bridge and the US-190/US-61 Corridor)	• Rehabilitation of the old Mississippi River Bridge on US-190 • Reconstruction of the US-190/US-61 Corridor • Signal timing improvements	Passenger vehicles, trucks and transit
Demand-Oriented Strategies/Treatments	Ramp Metering	Demand optimization to keep demand and capacity in balance. Ramp metering for eastbound traffic coming from the Alexander Avenue on-ramp west of the I-10 bridge during the P.M. peak period	Passenger vehicles and trucks
Demand-Oriented Strategies/Treatments	Local Traffic Demand Management	• Employee telecommuting options • Expanding and improving transit services to make public transportation easier and more attractive to use • Bike lanes • Flextime or staggered work hours. • Adopting congestion pricing • Promoting integrated transportation and land-use planning • Preferential parking for carpools and vanpools, employee parking cash-out	Passenger vehicles and transit
Demand-Oriented Strategies/Treatments	Reduction in Truck Traffic	Reduction in truck volume at the Alexander Avenue on-ramp during the A.M. peak period	Trucks

Table 3. Comparison of strategies/treatments.

Strategy/Treatment	Relative Impact	Impact	Cost	Barriers to Implementation
Minimize turbulence and queuing caused by excessive lane changes upstream of problem exit ramps	Low	• Improve traffic flow and safety	Low	• Public Acceptance • Difficult to implement
Infrastructure improvements, geometric design treatments, signal timing (Old US-190 Mississippi River Bridge and the US-190/US-61 Corridor)	High	• Improved mobility and traffic flow • Improved capacity • Reduced congestion • Reduced delays to travelers and shippers	Medium	• Limited elected leader support • Lack of funding
Ramp Metering	Medium	• Improve traffic flow and safety • Reduced congestion	Low	• Public Acceptance
Local Traffic Demand Management	High	• Improved mobility and traffic flow • Reduced congestion • Reduced delays to travelers and shippers	Low	• Public Acceptance • Employer/agency buy-in
Reduction in Truck Traffic	Medium	• Reduced congestion • Reduced delays to travelers and shippers	Low	• Cooperation of local Industries and businesses • Difficult to implement

Effect of Local Traffic Demand Management: The benefits of implementing local traffic demand management (telecommuting, improved transit service, promoting integrated land-use and transportation planning, etc.) are illustrated in Figure A-2 and Tables A-5 through A-7 for the average A.M. peak hour. Local traffic demand on I-10 EB was reduced by 10%, 20% and 30%. This solution produced notable reduction in the vehicle-hours of delay and annual user costs for the different percent demand reduction scenarios. The results for the entire three-hour A.M. peak-period are shown in Figure B-2 and Tables B-5 through B-7. This solution requires public acceptance and employer/business buy-in to produce the desired results.

5.2. P.M. Peak Strategies/Treatments

Effect of Rehabilitating the Old Mississippi River Bridge and Reconstructing the US-190/US-61 Corridor: The effects of shifting some of the I-10 eastbound traffic to the old bridge are illustrated in Figure C-2 and Tables C-4 through C-12 for the average P.M. peak hour. This solution produced notable reduction in the vehicle-hours of delay and annual user costs for the different demand-shift scenarios. The results for the entire three-hour P.M. peak-period are shown in Figure D-2 and Tables D-1 through D-9.

Effect of Local Traffic Demand Management: The benefits of implementing local traffic demand management are illustrated in Figure C-1 and Tables C-1 through C-3 for the average P.M. peak hour. Local traffic demand on I-10 EB was reduced by 10%, 20% and 30%. This solution produced notable reduction in the vehicle-hours of delay and annual user costs for the different percent demand reduction scenarios. The results for the entire three-hour P.M. peak-period are shown in Figure D-1 and Tables D-10 through D-12. As in the A.M. Peak, this solution requires public acceptance and employer/business buy-in to produce the desired results.

Effect of Ramp Metering/Local Demand Optimization: The impact of metering traffic demand at the Alexander Avenue on-ramp west of theI-10 Mississippi River Bridge during the P.M. peak period is illustrated in Figure C-3 and Table C-13 for the average P.M. peak hour. A maximum metering rate of 600 veh/hr with a queue override feature was used in the VISSIM simulations. This solution produced notable reduction in the vehicle-hours of delay and annual user costs. The results for the entire three-hour P.M. peak-period are shown in Figure D-3 and Table D-13. This solution requires public acceptance.

The results of this study should be considered with an important caveat in mind: the data available to the researchers for calibrating the simulation model were very limited. As such, additional data on key traffic parameters (e.g., flow rate, average speed, and traffic density) as well as demand-related data (e.g., traveler preferences and perceptions, route choice, mode choice, etc.) are required to confirm the numerical values of the MOE’s and metrics included in the report.

6. CONCLUSIONS

Baton Rouge, LA has been suffering from severe traffic congestion for more than two decades – threatening the quality of life and economic development in the area. One of the most troublesome congestion sections is at the I-10 Mississippi River Bridge. This study modeled several supply-oriented and demand-oriented strategies to mitigate congestion at the bridge site. Supply-oriented solutions included: (a) rehabilitation and utilization of the old Mississippi River Bridge on US-190 and the existing US-190/US-61 corridor and (b) minimizing turbulence and queuing caused by excessive lane changes upstream of exit ramps. Demand oriented solutions included: (a) demand management strategies to reduce traffic demand and lessen the variability in demand over time, (b) implementing ramp metering/demand optimization at the Alexander Avenue on-ramp west of the I-10 Mississippi River Bridge during the P.M. peak period, and (c) reducing percent trucks on I-10 eastbound at the Alexander Avenue on-ramp during the A.M. peak period.

Based on the simulation results, a combination of both supply-oriented and demand-oriented measures will be required to mitigate traffic congestion on the I-10 Mississippi River Bridge. Rehabilitation and utilization of the old Mississippi River Bridge on US-190 and the existing US-190/US-61 corridor, overall demand management of I-10 EB traffic, reduction in percent trucks traveling eastbound on I-10 during the A.M. peak period, and ramp metering at the on-ramp west of the I-10 Mississippi River Bridge appear to be feasible and effective solutions.

7. RECOMMENDATIONS

Based on the findings of the VISSIM simulations presented earlier in this report, the following recommendations have been reached:

1. During the course of this study, there were very limited data available on key traffic parameters (e.g., flow rate, average speed, and traffic density) as well as demand-related data (e.g., traveler preferences and perceptions, route choice, mode choice, etc.). These data are required for knowing how the transportation system is performing, calibrating the computer simulation models, and planning/design of infrastructure improvements and ITS applications to mitigate congestion. It is recommended that the LADOTD and the Baton Rouge MPO establish an ongoing program for collecting such data. Available technology makes it feasible to collect the required data in real-time at low cost. Point detection technologies such as in-pavement inductive loop detectors, video detection, radar/microwave/LIDAR detectors, Bluetooth MAC Readers, GPS and probe vehicles can be used to collect traffic data economically. Likewise demand-related data can be obtained easily using automatic license plate readers (ALPR), crowdsourcing, and travel surveys.
2. A combination of supply-oriented and demand-oriented strategies/treatments must be implemented to relieve congestion on I-10 in Baton Rouge.
3. Rehabilitating the old Mississippi River Bridge and reconstructing the US-190/US-61 Corridor will shift some of the I-10 eastbound traffic to the old bridge. This will improve traffic flow on the I-10 Mississippi River Bridge and produce notable reduction in the vehicle-hours of delay and annual user costs during the A.M. and P.M. peak periods.
4. Implementation of local traffic demand management strategies (telecommuting, improved transit service, promoting integrated land-use and transportation planning, etc.) can produce immediate reduction in traffic delays on I-10 during the A.M. and P.M. peak periods.
5. Ramp metering/local demand optimization at the Alexander Avenue on-ramp west of the I-10 Mississippi River Bridge during the P.M. peak period can result in notable reduction in delays and user costs.
6. Reducing percent trucks on I-10 eastbound during the A.M. peak period at the Alexander Avenue on-ramp can result in notable improvement in traffic operations. This solution may be difficult to implement and requires close cooperation of local industries and businesses.

REFERENCES

1. Hartgen, D.T., M.G. Fields, and A.T. Moore. *Gridlock and growth: the effect of traffic congestion on regional economic performance*. The Reason Foundation, Los Angeles, CA, 2009.

2. Schrank, D., et al. *2015 urban mobility scorecard*, 2015.

3. West Baton Rouge Parish Council. *LA 1/ LA 415 Connector*. Available from: http://www.wbrcouncil.org/Images/Interior/wbr%20presentation-lr%20%28rev%207-19%29.pdf

4. Capital Region Planning Commission. *Congestion Management Process*. CRPC: Baton Rouge, Louisiana, 2013.

5. LADOTD. Frequently Asked Questions, 2007 [cited 2017; Available from: http://wayback.archive.org/web/20070808151948/http://www.dotd.state.la.us/press/faq.asp#bridges

6. LADOTD. [cited 2017; Available from: http://wwwapps.dotd.la.gov/engineering/tatv/.

7. LADOTD. I-10 Corridor Improvements Stage-0 Feasibility Study, 2016. Available from: https://i10br.com/wp-content/uploads/2016/08/Feasibility-Study_I-10-Corridor-Report-Only_July-2016.pdf.

8. Urban Systems, Inc. Traffic Study for I-10 Stage-0 Feasibility Study, 2016. Available from: https://filestogeaux.lsu.edu/public/download.php?FILE=jcodjo1/24163ezgxlf.

9. Cambridge Systematics, Inc., and Texas Transportation Institute. *Traffic Congestion and Reliability: Trends and Advanced Strategies for Congestion Mitigation*. Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., 2005.

10. Cambridge Systematics, Inc., Texas A&M Transportation Institute, University of Washington, Dowling Associates, Street Smarts, H. Levinson, and H. Rakha. *Analytical Procedures for Determining the Impacts of Reliability Mitigation Strategies*. SHRP-2 Report S2-L03-RR-1, Transportation Research Board of the National Academies, Washington, D.C., 2013.

11. AECOM, t*he Baton Rouge Renewal and Mobility Plan (BUMP).* December 2014. Available from: http://wwwsp.dotd.la.gov/Inside_LaDOTD/Divisions/Administration/LTA/Misc%20Documents/AECOM%20Unsoliticed%20Proposal%20BUMP.pdf

12. Capital Area Expressway Authority, *Baton Rouge Loop Tier 1 Environmental Impact Statement*, 2011.

13. LADOTD. *I-10 Baton Rouge Major Investment Study*, 2000.

14. LADOTD. *Northern Bypass Feasibility Study*, 2004.

15. Wilbur Smith Associates. *The National I-10 Freight Corridor Study,* 2004. Available from: http://web.archive.org/web/20040827004852/http://www.i10freightstudy.org/assets/Technical%20Memorandum%205.pdf.

16. Ascension, East Baton Rouge, Iberville, Livingston, and West Baton Rouge Parishes, Louisiana. Baton Rouge Loop: Tier 1 Final Environmental Impact Statement, 2015. Available from:

http://brloop.com/pdf/01_Baton%20Rouge%20Loop%20Tier%201%20FEIS%20Volume%201.pdf.

17. Will Sentell. I-10 Widening Plan in Baton Rouge includes Major Changes to these exists; Here's What Comes Next. The Advocate, February 17, 2018. Available from: http://www.theadvocate.com/baton_rouge/news/politics/article_5d266efc-0126-11e8-88a3-7b74351f722a.html.

18. Will Sentell. Bill Advances, would Require Rush-Hour Restrictions on Trucks Traveling Baton Rouge Interstates. The Advocate, April 16, 2018. Available from: http://www.theadvocate.com/baton_rouge/news/politics/legislature/article_1070c55a-3f5e-11e8-81b4-cb53c55da67b.html

19. PTV Group, 2014. Vissim 7 User Manual. Germany: PTV Group.

APPENDIX-A: A.M. PEAK, HOURLY AVERAGE

Table A-1. Reducing Percent Local trucks on I-10 EB to 10%.

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	117.70	6.16	18.89	6.03
Throughput	2931	1560	3101	1603
Total Delay (veh.sec)	333251	8357	56720	8413
Total Delay (veh.hour)	92.57	2.32	15.76	2.34
Travelled Distance	5215	7077	5215	7077
VMT	2895	2091	3063	2149
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$989.57	$24.82	$168.43	$24.98
Annual Delay Cost	$257,288	$6,452	$43,791	$6,495
Annual Economic Savings	$0	$0	$213,497	($43)

Table A-2. Reducing percent local trucks on I-10 EB to 13%.

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	117.70	6.16	29.57	6.16
Throughput	2931	1560	3106	1623
Total Delay (veh.sec)	333251	8357	87737	8683
Total Delay (veh.hour)	92.57	2.32	24.37	2.41
Travelled Distance	5215	7077	5215	7077
VMT	2895	2091	3067	2176
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$989.57	$24.82	$260.53	$25.78
Annual Delay Cost	$257,288	$6,452	$67,738	$6,704
Annual Economic Savings	$0	$0	$189,550	($252)

Table A-3 Reducing percent local trucks on I-10 EB to 16%.

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	117.70	6.16	51.87	6.11
Throughput	2931	1560	3088	1600
Total Delay (veh.sec)	333251	8357	152853	8509
Total Delay (veh.hour)	92.57	2.32	42.46	2.36
Travelled Distance	5215	7077	5215	7077
VMT	2895	2091	3050	2144
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$989.57	$24.82	$453.89	$25.27
Annual Delay Cost	$257,288	$6,452	$118,011	$6,570
Annual Economic Savings	$0	$0	$139,277	($118)

Table A-4. Reducing percent local trucks on I-10 EB to 19%.

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	117.70	6.16	83.04	5.97
Throughput	2931	1560	3062	1603
Total Delay (veh.sec)	333251	8357	244410	8337
Total Delay (veh.hour)	92.57	2.32	67.89	2.32
Travelled Distance	5215	7077	5215	7077
VMT	2895	2091	3024	2148
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$989.57	$24.82	$725.76	$24.76
Annual Delay Cost	$257,288	$6,452	$188,698	$6,437
Annual Economic Savings	$0	$0	$68,590	$15

Table A-5. 10% reduction in demand using demand management.

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	117.70	6.16	54.51	5.86
Throughput	2931	1560	2938	1602
Total Delay (veh.sec)	333251	8357	159461	8189
Total Delay (veh.hour)	92.57	2.32	44.29	2.27
Travelled Distance	5215	7077	5215	7077
VMT	2895	2091	2901	2147
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$989.57	$24.82	$473.51	$24.32
Annual Delay Cost	$257,288	$6,452	$123,113	$6,323
Annual Economic Savings	$0	$0	$134,175	$129

Table A-6. 20% reduction in demand using demand management.

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	117.70	6.16	37.90	5.83
Throughput	2931	1560	2806	1604
Total Delay (veh.sec)	333251	8357	108581	8154
Total Delay (veh.hour)	92.57	2.32	30.16	2.27
Travelled Distance	5215	7077	5215	7077
VMT	2895	2091	2772	2150
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$989.57	$24.82	$322.42	$24.21
Annual Delay Cost	$257,288	$6,452	$83,830	$6,296
Annual Economic Savings	$0	$0	$173,458	$156

Table A-7. 30% reduction in demand using demand management.

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	117.70	6.16	26.12	5.57
Throughput	2931	1560	2664	1605
Total Delay (veh.sec)	333251	8357	72039	7806
Total Delay (veh.hour)	92.57	2.32	20.01	2.17
Travelled Distance	5215	7077	5215	7077
VMT	2895	2091	2631	2151
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$989.57	$24.82	$213.92	$23.18
Annual Delay Cost	$257,288	$6,452	$55,618	$6,026
Annual Economic Savings	$0	$0	$201,670	$426

Table A-8. Shifting 50% on-ramp + 50% trucks from I-10 EB (BUMP project).

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	117.70	6.16	6.15	5.95
Throughput	2931	1560	1928	1604
Total Delay (veh.sec)	333251	8357	12301	8321
Total Delay (veh.hour)	92.57	2.32	3.42	2.31
Travelled Distance	5215	7077	5215	7077
VMT	2895	2091	1905	2149
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$989.57	$24.82	$36.53	$24.71
Annual Delay Cost	$257,288	$6,452	$9,497	$6,424
Annual Economic Savings	$0	$0	$247,791	$28

Table A-9. Shifting 50% on-ramp + 25% trucks from I-10 EB (BUMP project).

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	117.70	6.16	9.39	6.05
Throughput	2931	1560	2019	1595
Total Delay (veh.sec)	333251	8357	19799	8400
Total Delay (veh.hour)	92.57	2.32	5.50	2.33
Travelled Distance	5215	7077	5215	7077
VMT	2895	2091	1994	2137
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$989.57	$24.82	$58.79	$24.94
Annual Delay Cost	$257,288	$6,452	$15,286	$6,485
Annual Economic Savings	$0	$0	$242,002	($33)

Table A-10. Shifting 50% on-ramp + 0% trucks from I-10 EB (BUMP project).

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	117.70	6.16	15.04	6.01
Throughput	2931	1560	2111	1608
Total Delay (veh.sec)	333251	8357	33455	8405
Total Delay (veh.hour)	92.57	2.32	9.29	2.33
Travelled Distance	5215	7077	5215	7077
VMT	2895	2091	2085	2154
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$989.57	$24.82	$99.34	$24.96
Annual Delay Cost	$257,288	$6,452	$25,829	$6,489
Annual Economic Savings	$0	$0	$231,459	($37)

Table A-11. Shifting 40% on-ramp + 50% trucks from I-10 EB (BUMP project).

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	117.70	6.16	6.30	6.06
Throughput	2931	1560	1991	1607
Total Delay (veh.sec)	333251	8357	12690	8460
Total Delay (veh.hour)	92.57	2.32	3.53	2.35
Travelled Distance	5215	7077	5215	7077
VMT	2895	2091	1966	2154
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$989.57	$24.82	$37.68	$25.12
Annual Delay Cost	$257,288	$6,452	$9,798	$6,532
Annual Economic Savings	$0	$0	$247,491	($80)

Table A-12. Shifting 40% on-ramp + 25% trucks from I-10 EB (BUMP project).

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	117.70	6.16	9.58	6.03
Throughput	2931	1560	2042	1571
Total Delay (veh.sec)	333251	8357	19905	8236
Total Delay (veh.hour)	92.57	2.32	5.53	2.29
Travelled Distance	5215	7077	5215	7077
VMT	2895	2091	2017	2105
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$989.57	$24.82	$59.11	$24.46
Annual Delay Cost	$257,288	$6,452	$15,368	$6,358
Annual Economic Savings	$0	$0	$241,920	$94

Table A-13. Shifting 40% on-ramp + 0% trucks from I-10 EB (BUMP project).

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	117.70	6.16	15.42	5.98
Throughput	2931	1560	2174	1610
Total Delay (veh.sec)	333251	8357	34424	8394
Total Delay (veh.hour)	92.57	2.32	9.56	2.33
Travelled Distance	5215	7077	5215	7077
VMT	2895	2091	2148	2158
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$989.57	$24.82	$102.22	$24.92
Annual Delay Cost	$257,288	$6,452	$26,577	$6,480
Annual Economic Savings	$0	$0	$230,711	($28)

Table A-14. Shifting 30% on-ramp + 50% trucks from I-10 EB (BUMP project).

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	117.70	6.16	6.52	6.12
Throughput	2931	1560	2056	1607
Total Delay (veh.sec)	333251	8357	13219	8560
Total Delay (veh.hour)	92.57	2.32	3.67	2.38
Travelled Distance	5215	7077	5215	7077
VMT	2895	2091	2030	2153
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$989.57	$24.82	$39.25	$25.42
Annual Delay Cost	$257,288	$6,452	$10,205	$6,609
Annual Economic Savings	$0	$0	$247,083	($157)

Table A-15. Shifting 30% on-ramp + 25% trucks from I-10 EB (BUMP project).

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	117.70	6.16	9.84	5.92
Throughput	2931	1560	2148	1578
Total Delay (veh.sec)	333251	8357	21026	8125
Total Delay (veh.hour)	92.57	2.32	5.84	2.26
Travelled Distance	5215	7077	5215	7077
VMT	2895	2091	2121	2115
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$989.57	$24.82	$62.43	$24.13
Annual Delay Cost	$257,288	$6,452	$16,233	$6,273
Annual Economic Savings	$0	$0	$241,055	$179

Table A-16. Shifting 30% on-ramp + 0% trucks from I-10 EB (BUMP project).

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	117.70	6.16	15.78	6.03
Throughput	2931	1560	2239	1613
Total Delay (veh.sec)	333251	8357	35444	8470
Total Delay (veh.hour)	92.57	2.32	9.85	2.35
Travelled Distance	5215	7077	5215	7077
VMT	2895	2091	2211	2162
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$989.57	$24.82	$105.25	$25.15
Annual Delay Cost	$257,288	$6,452	$27,364	$6,539
Annual Economic Savings	$0	$0	$229,924	($87)

Table A-17. Routing I-10 EB traffic at Washington Street.

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	117.70	6.16	164.89	5.99
Throughput	2931	1560	2924	1604
Total Delay (veh.sec)	333251	8357	465471	8363
Total Delay (veh.hour)	92.57	2.32	129.30	2.32
Travelled Distance	5215	7077	5215	7077
VMT	2895	2091	2887	2149
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$989.57	$24.82	$1,382.19	$24.83
Annual Delay Cost	$257,288	$6,452	$359,370	$6,457
Annual Economic Savings	$0	$0	($102,082)	($5)

Table A-18. Routing I-10 EB traffic at Washington Street and reducing percent trucks to 10%.

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	117.70	6.16	58.43	6.08
Throughput	2931	1560	3086	1604
Total Delay (veh.sec)	333251	8357	170150	8475
Total Delay (veh.hour)	92.57	2.32	47.26	2.35
Travelled Distance	5215	7077	5215	7077
VMT	2895	2091	3048	2149
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$989.57	$24.82	$505.25	$25.17
Annual Delay Cost	$257,288	$6,452	$131,365	$6,543
Annual Economic Savings	$0	$0	$125,923	($91)

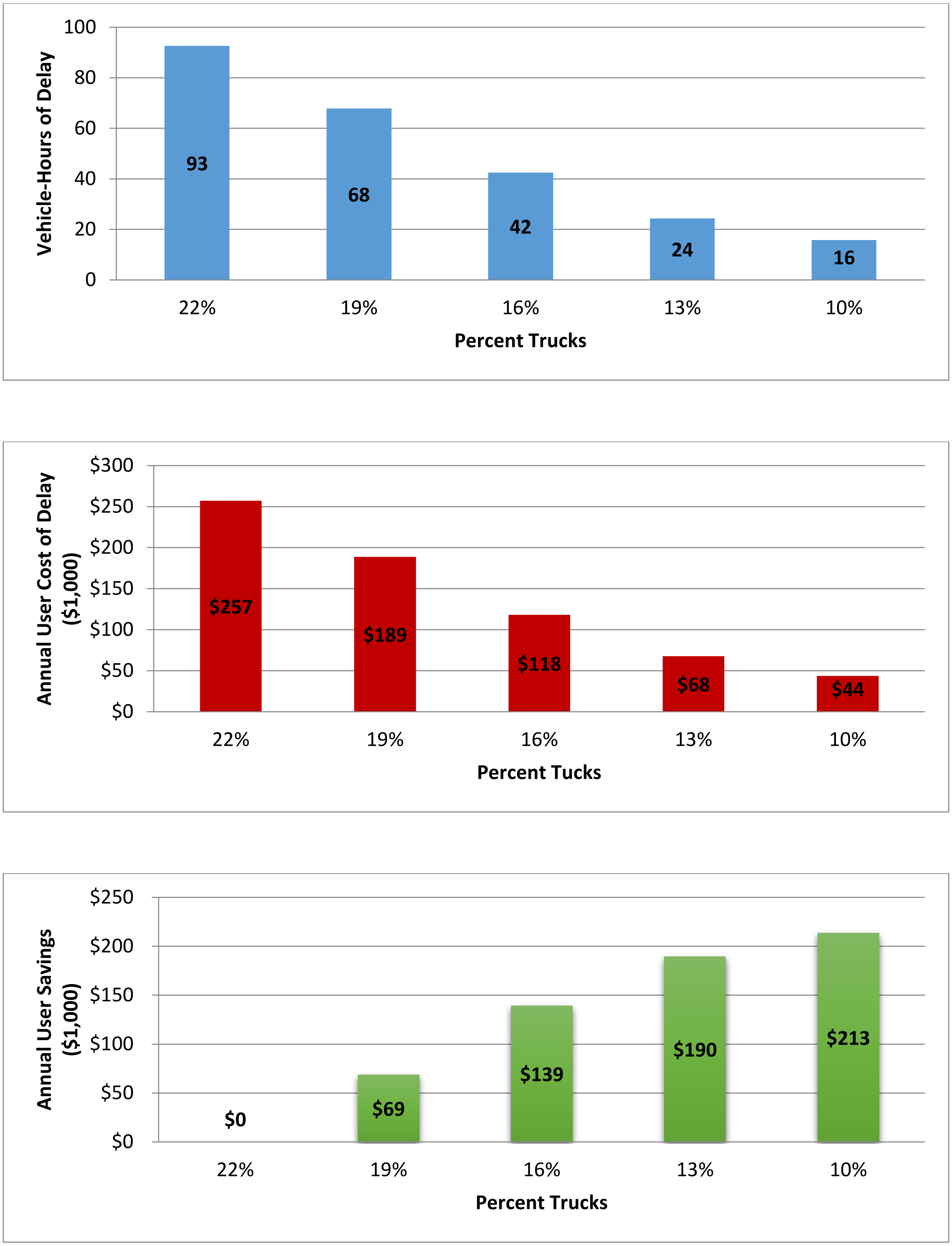


Figure A-1. Effect of reducing percent local trucks on I-10 EB.

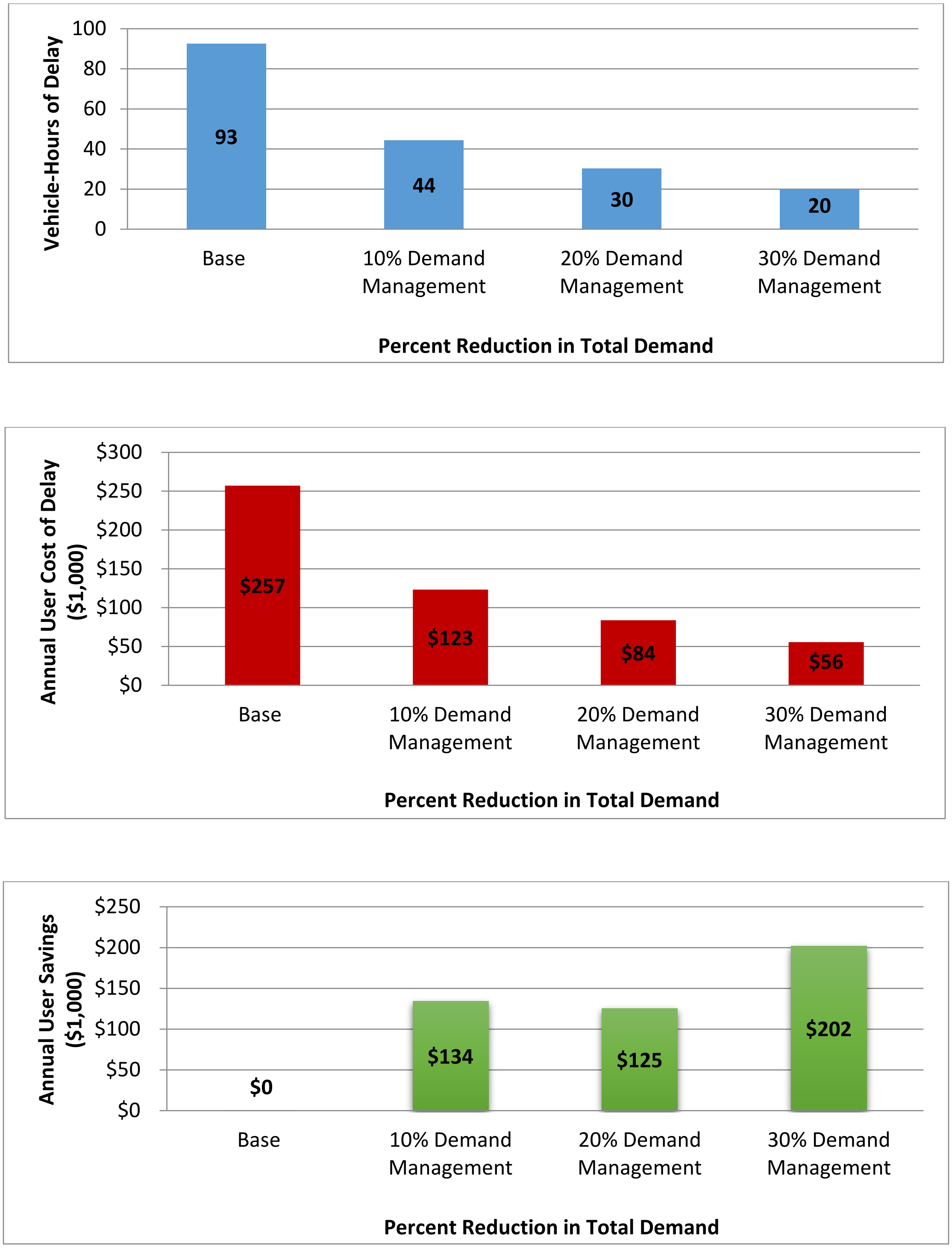


Figure A-2. Effect of implementing demand management techniques to reduce total traffic on I-10 EB.

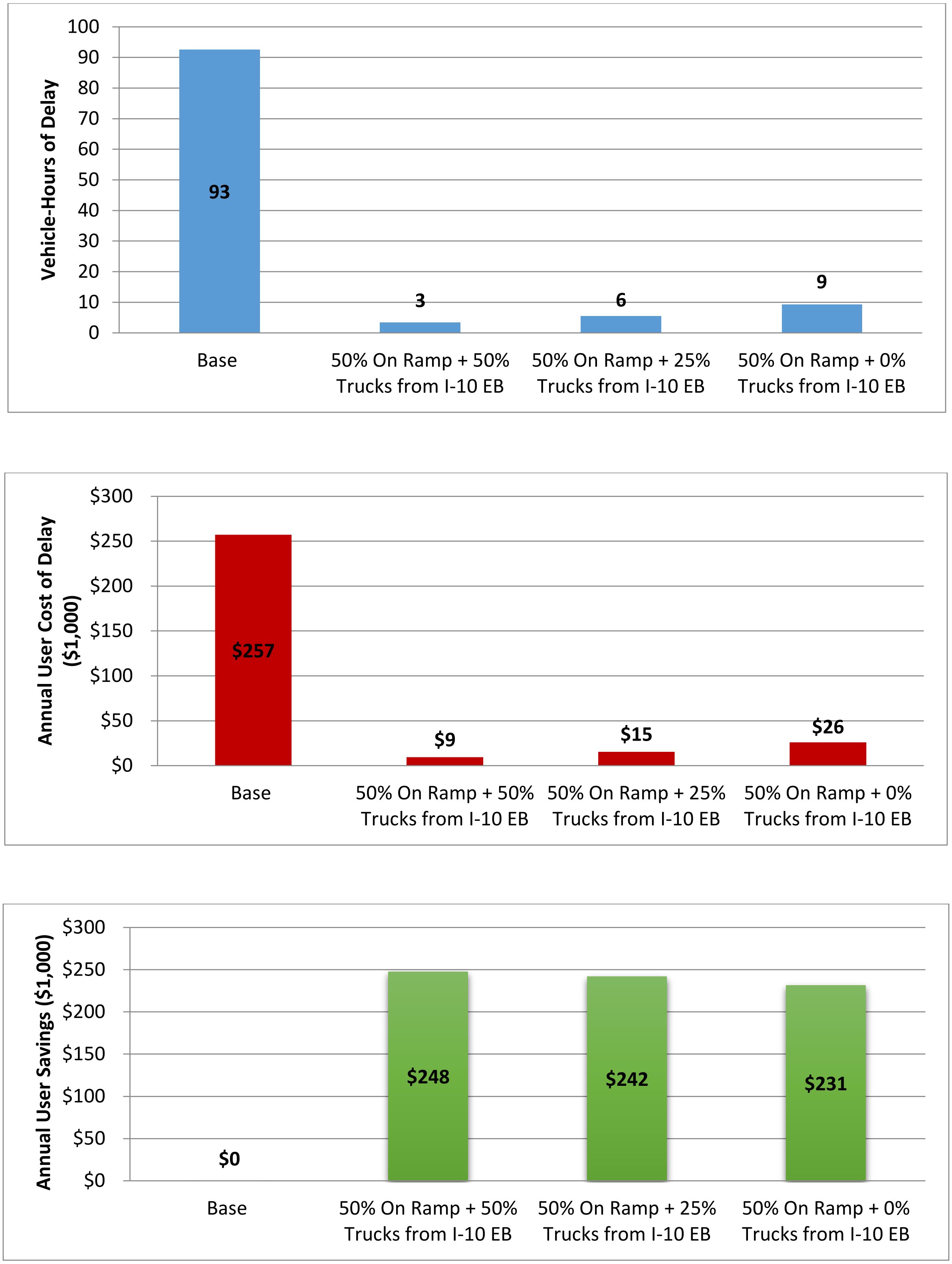


Figure A-3. Effect of shifting I-10 EB traffic through Old Bridge and surface street network (BUMP) project.

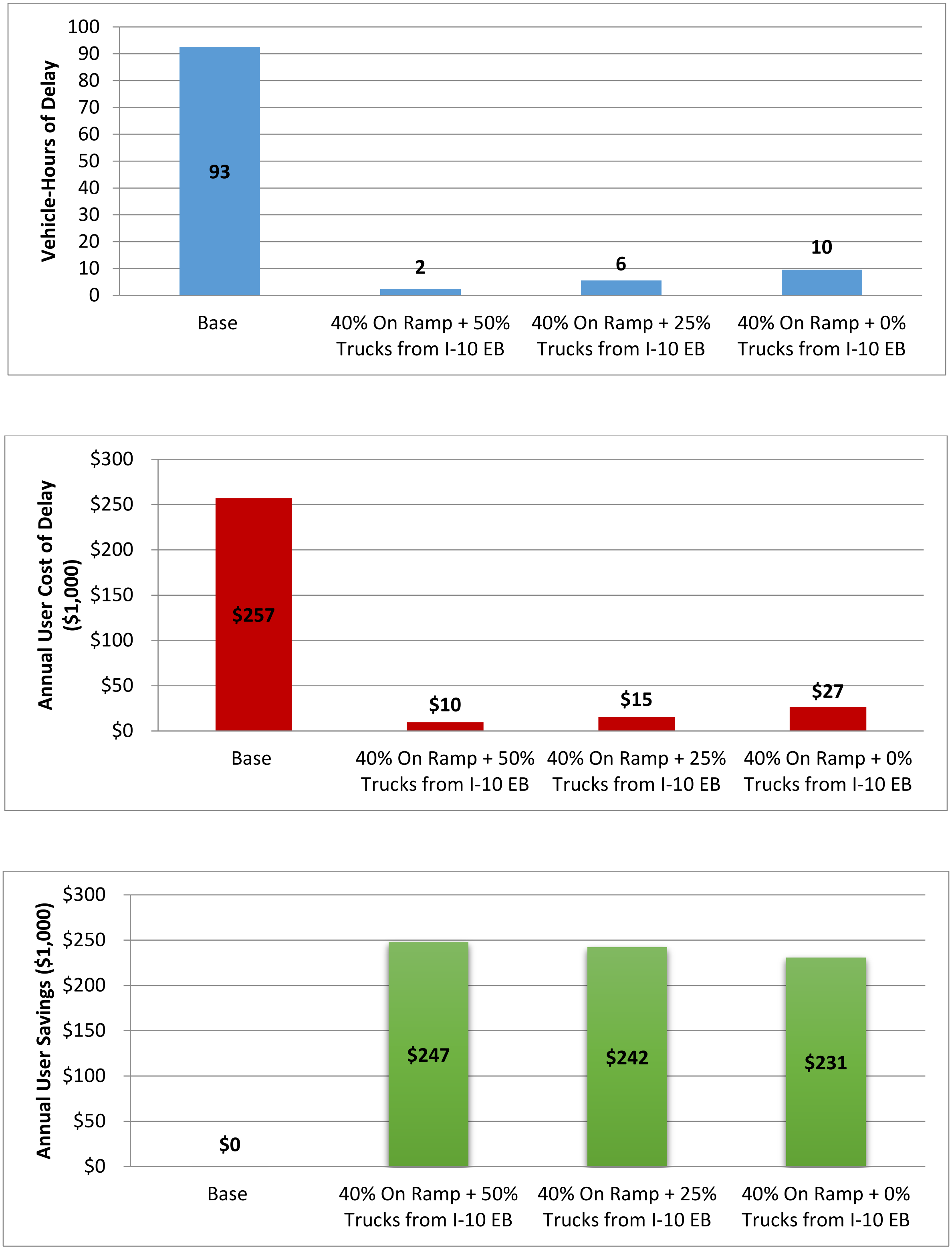
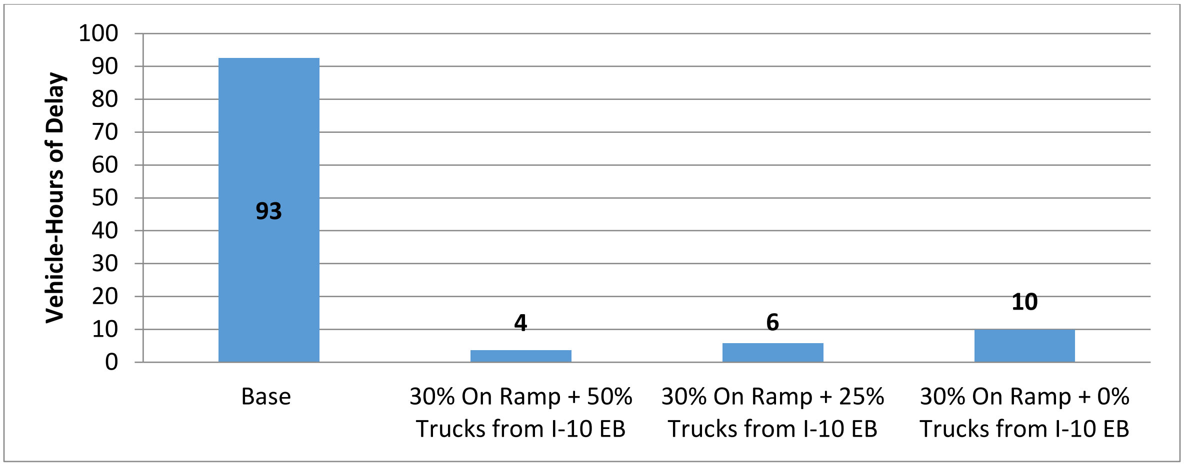
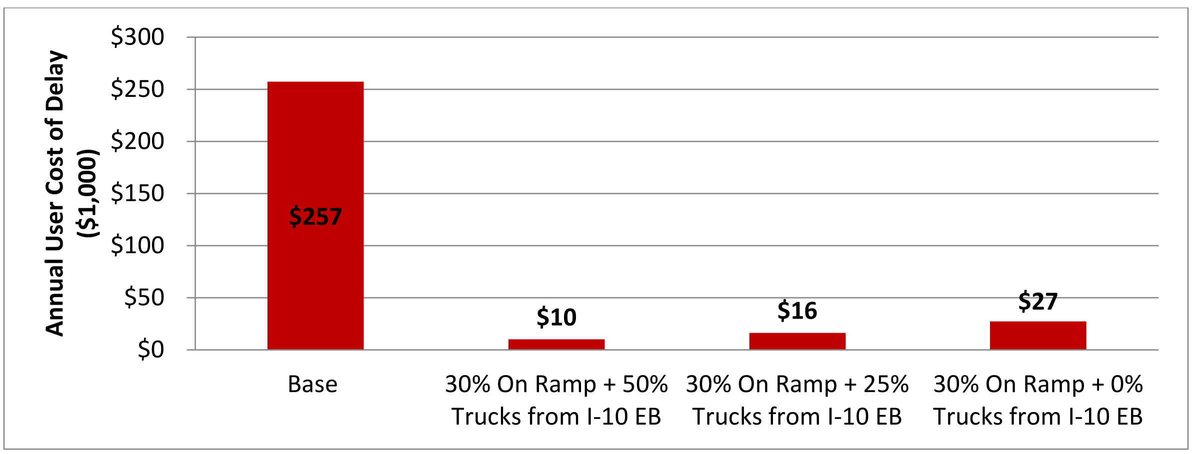


Figure A-3 (continued). Effect of shifting I-10 EB traffic through Old Bridge and surface street network (BUMP project).





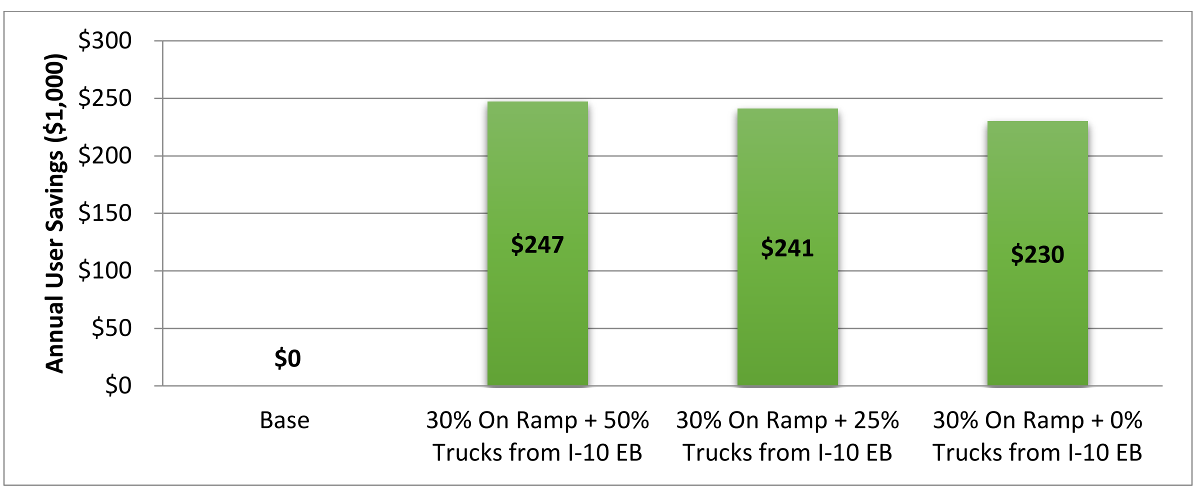


Figure A-3 (continued). Effect of shifting I-10 EB traffic through Old Bridge and surface street network (BUMP project).

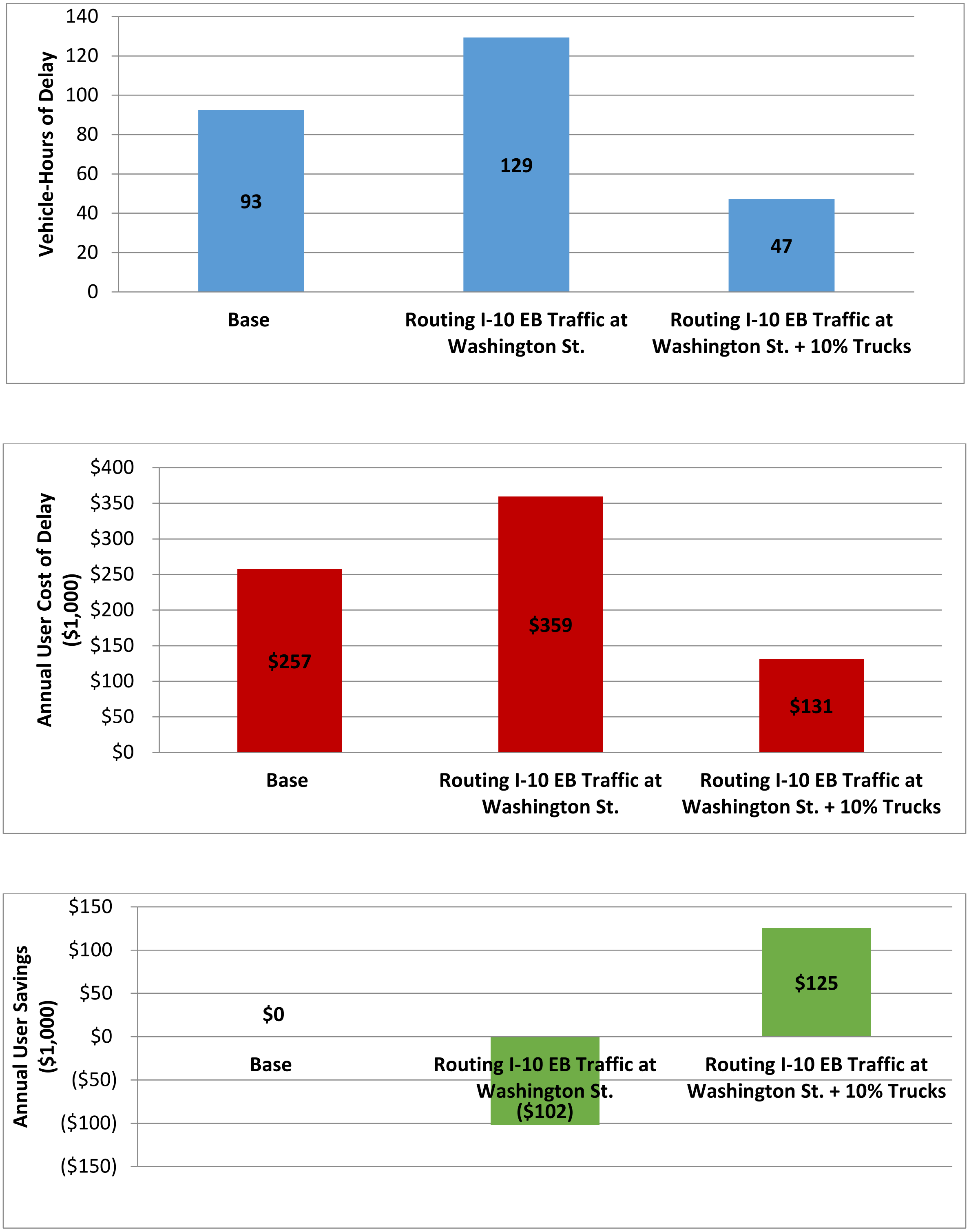


Figure A-4. Effect of routing I-10 EB traffic at Washington Street.

APPENDIX-B: A.M. PEAK, 3-HOURS

Table B-1. Reducing percent local trucks on I-10 EB to 10%.

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	117.70	6.16	18.89	6.03
Throughput	8793	4680	9304	4810
Total Delay (veh.sec)	999752	25071	170159	25240
Total Delay (veh.hour)	277.71	6.96	47.27	7.01
Travelled Distance	5215	7077	5215	7077
VMT	8685	6272	9189	6447
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$2,968.71	$74.45	$505.28	$74.95
Annual Delay Cost	$771,864	$19,356	$131,372	$19,486
Annual Economic Savings	$0	$0	$640,492	($130)

Table B-2. Reducing percent local trucks on I-10 EB to 13%.

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	117.70	6.16	29.57	6.16
Throughput	8793	4680	9317	4870
Total Delay (veh.sec)	999752	25071	263211	26049
Total Delay (veh.hour)	277.71	6.96	73.11	7.24
Travelled Distance	5215	7077	5215	7077
VMT	8685	6272	9202	6527
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$2,968.71	$74.45	$781.59	$77.35
Annual Delay Cost	$771,864	$19,356	$203,214	$20,111
Annual Economic Savings	$0	$0	$568,651	($755)

Table B-3. Reducing percent local trucks on I-10 EB to 16%.

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	117.70	6.16	51.87	6.11
Throughput	8793	4680	9264	4800
Total Delay (veh.sec)	999752	25071	458560	25528
Total Delay (veh.hour)	277.71	6.96	127.38	7.09
Travelled Distance	5215	7077	5215	7077
VMT	8685	6272	9150	6433
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$2,968.71	$74.45	$1,361.67	$75.80
Annual Delay Cost	$771,864	$19,356	$354,034	$19,709
Annual Economic Savings	$0	$0	$417,830	($353)

Table B-4. Reducing percent local trucks on I-10 EB to 19%.

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	117.70	6.16	83.04	5.97
Throughput	8793	4680	9186	4808
Total Delay (veh.sec)	999752	25071	733230	25012
Total Delay (veh.hour)	277.71	6.96	203.67	6.95
Travelled Distance	5215	7077	5215	7077
VMT	8685	6272	9073	6444
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$2,968.71	$74.45	$2,177.29	$74.27
Annual Delay Cost	$771,864	$19,356	$566,094	$19,311
Annual Economic Savings	$0	$0	$205,770	$45

Table B-5. 10% reduction in demand using demand management.

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	117.70	6.16	54.51	5.86
Throughput	8793	4680	8813	4806
Total Delay (veh.sec)	999752	25071	478384	24568
Total Delay (veh.hour)	277.71	6.96	132.88	6.82
Travelled Distance	5215	7077	5215	7077
VMT	8685	6272	8704	6441
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$2,968.71	$74.45	$1,420.53	$72.95
Annual Delay Cost	$771,864	$19,356	$369,339	$18,968
Annual Economic Savings	$0	$0	$402,525	$388

Table B-6. 20% reduction in demand using demand management.

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	117.70	6.16	37.90	5.83
Throughput	8793	4680	8419	4812
Total Delay (veh.sec)	999752	25071	325743	24463
Total Delay (veh.hour)	277.71	6.96	90.48	6.80
Travelled Distance	5215	7077	5215	7077
VMT	8685	6272	8315	6449
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$2,968.71	$74.45	$967.27	$72.64
Annual Delay Cost	$771,864	$19,356	$251,491	$18,887
Annual Economic Savings	$0	$0	$520,373	$469

Table B-7. 30% reduction in demand using demand management.

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	117.70	6.16	26.12	5.57
Throughput	8793	4680	7993	4815
Total Delay (veh.sec)	999752	25071	216117	23417
Total Delay (veh.hour)	277.71	6.96	60.03	6.50
Travelled Distance	5215	7077	5215	7077
VMT	8685	6272	7894	6453
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$2,968.71	$74.45	$641.75	$69.53
Annual Delay Cost	$771,864	$19,356	$166,854	$18,079
Annual Economic Savings	$0	$0	$605,010	$1,277

Table B-8. Shifting 50% on-ramp + 50% trucks from I-10 EB (BUMP project).

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	117.70	6.16	6.15	5.95
Throughput	8793	4680	5785	4811
Total Delay (veh.sec)	999752	25071	36903	24963
Total Delay (veh.hour)	277.71	6.96	10.25	6.93
Travelled Distance	5215	7077	5215	7077
VMT	8685	6272	5714	6448
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$2,968.71	$74.45	$109.58	$74.13
Annual Delay Cost	$771,864	$19,356	$28,491	$19,273
Annual Economic Savings	$0	$0	$743,373	$83

Table B-9. Shifting 50% on-ramp + 25% trucks from I-10 EB (BUMP project).

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	117.70	6.16	9.39	6.05
Throughput	8793	4680	6057	4784
Total Delay (veh.sec)	999752	25071	59397	25200
Total Delay (veh.hour)	277.71	6.96	16.50	7.00
Travelled Distance	5215	7077	5215	7077
VMT	8685	6272	5982	6411
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$2,968.71	$74.45	$176.38	$74.83
Annual Delay Cost	$771,864	$19,356	$45,858	$19,456
Annual Economic Savings	$0	$0	$726,006	($100)

Table B-10. Shifting 50% on-ramp + 0% trucks from I-10 EB (BUMP project).

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	117.70	6.16	15.04	6.01
Throughput	8793	4680	6333	4823
Total Delay (veh.sec)	999752	25071	100365	25216
Total Delay (veh.hour)	277.71	6.96	27.88	7.00
Travelled Distance	5215	7077	5215	7077
VMT	8685	6272	6255	6463
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$2,968.71	$74.45	$298.03	$74.88
Annual Delay Cost	$771,864	$19,356	$77,487	$19,468
Annual Economic Savings	$0	$0	$694,377	($112)

Table B-11. Shifting 40% on-ramp + 50% trucks from I-10 EB (BUMP project).

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	117.70	6.16	6.30	6.06
Throughput	8793	4680	5973	4822
Total Delay (veh.sec)	999752	25071	38071	25381
Total Delay (veh.hour)	277.71	6.96	10.58	7.05
Travelled Distance	5215	7077	5215	7077
VMT	8685	6272	5899	6462
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$2,968.71	$74.45	$113.05	$75.37
Annual Delay Cost	$771,864	$19,356	$29,393	$19,596
Annual Economic Savings	$0	$0	$742,472	($240)

Table B-12. Shifting 40% on-ramp + 25% trucks from I-10 EB (BUMP project).

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	117.70	6.16	9.58	6.03
Throughput	8793	4680	6127	4713
Total Delay (veh.sec)	999752	25071	59715	24707
Total Delay (veh.hour)	277.71	6.96	16.59	6.86
Travelled Distance	5215	7077	5215	7077
VMT	8685	6272	6052	6316
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$2,968.71	$74.45	$177.32	$73.37
Annual Delay Cost	$771,864	$19,356	$46,103	$19,075
Annual Economic Savings	$0	$0	$725,761	$281

Table B-13. Shifting 40% on-ramp + 0% Trucks from I-10 EB (BUMP project).

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	117.70	6.16	15.42	5.98
Throughput	8793	4680	6523	4831
Total Delay (veh.sec)	999752	25071	103273	25181
Total Delay (veh.hour)	277.71	6.96	28.69	6.99
Travelled Distance	5215	7077	5215	7077
VMT	8685	6272	6443	6474
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$2,968.71	$74.45	$306.66	$74.77
Annual Delay Cost	$771,864	$19,356	$79,732	$19,441
Annual Economic Savings	$0	$0	$692,132	($85)

Table B-14. Shifting 30% on-ramp + 50% trucks from I-10 EB (BUMP project).

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	117.70	6.16	6.52	6.12
Throughput	8793	4680	6168	4820
Total Delay (veh.sec)	999752	25071	39656	25681
Total Delay (veh.hour)	277.71	6.96	11.02	7.13
Travelled Distance	5215	7077	5215	7077
VMT	8685	6272	6091	6460
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$2,968.71	$74.45	$117.75	$76.26
Annual Delay Cost	$771,864	$19,356	$30,616	$19,827
Annual Economic Savings	$0	$0	$741,248	($471)

Table B-15. Shifting 30% on-ramp + 25% trucks from I-10 EB (BUMP project).

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	117.70	6.16	9.84	5.92
Throughput	8793	4680	6443	4733
Total Delay (veh.sec)	999752	25071	63077	24375
Total Delay (veh.hour)	277.71	6.96	17.52	6.77
Travelled Distance	5215	7077	5215	7077
VMT	8685	6272	6363	6344
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$2,968.71	$74.45	$187.30	$72.38
Annual Delay Cost	$771,864	$19,356	$48,699	$18,819
Annual Economic Savings	$0	$0	$723,165	$537

Table B-16. Shifting 30% on-ramp + 0% trucks from I-10 EB (BUMP project).

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	117.70	6.16	15.78	6.03
Throughput	8793	4680	6716	4839
Total Delay (veh.sec)	999752	25071	106331	25410
Total Delay (veh.hour)	277.71	6.96	29.54	7.06
Travelled Distance	5215	7077	5215	7077
VMT	8685	6272	6633	6486
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$2,968.71	$74.45	$315.74	$75.45
Annual Delay Cost	$771,864	$19,356	$82,093	$19,618
Annual Economic Savings	$0	$0	$689,771	($262)

Table B-17. Routing I-10 EB traffic at Washington Street.

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	117.70	6.16	164.89	5.99
Throughput	8793	4680	8771	4811
Total Delay (veh.sec)	999752	25071	1396413	25089
Total Delay (veh.hour)	277.71	6.96	387.89	6.97
Travelled Distance	5215	7077	5215	7077
VMT	8685	6272	8662	6447
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$2,968.71	$74.45	$4,146.57	$74.50
Annual Delay Cost	$771,864	$19,356	$1,078,109	$19,370
Annual Economic Savings	$0	$0	($306,245)	($14)

Table B-18. Routing I-10 EB traffic at Washington Street and reducing percent trucks to 10%.

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	117.70	6.16	58.43	6.08
Throughput	8793	4680	9259	4811
Total Delay (veh.sec)	999752	25071	510450	25426
Total Delay (veh.hour)	277.71	6.96	141.79	7.06
Travelled Distance	5215	7077	5215	7077
VMT	8685	6272	9145	6447
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$2,968.71	$74.45	$1,515.75	$75.50
Annual Delay Cost	$771,864	$19,356	$394,096	$19,630
Annual Economic Savings	$0	$0	$377,769	($274)

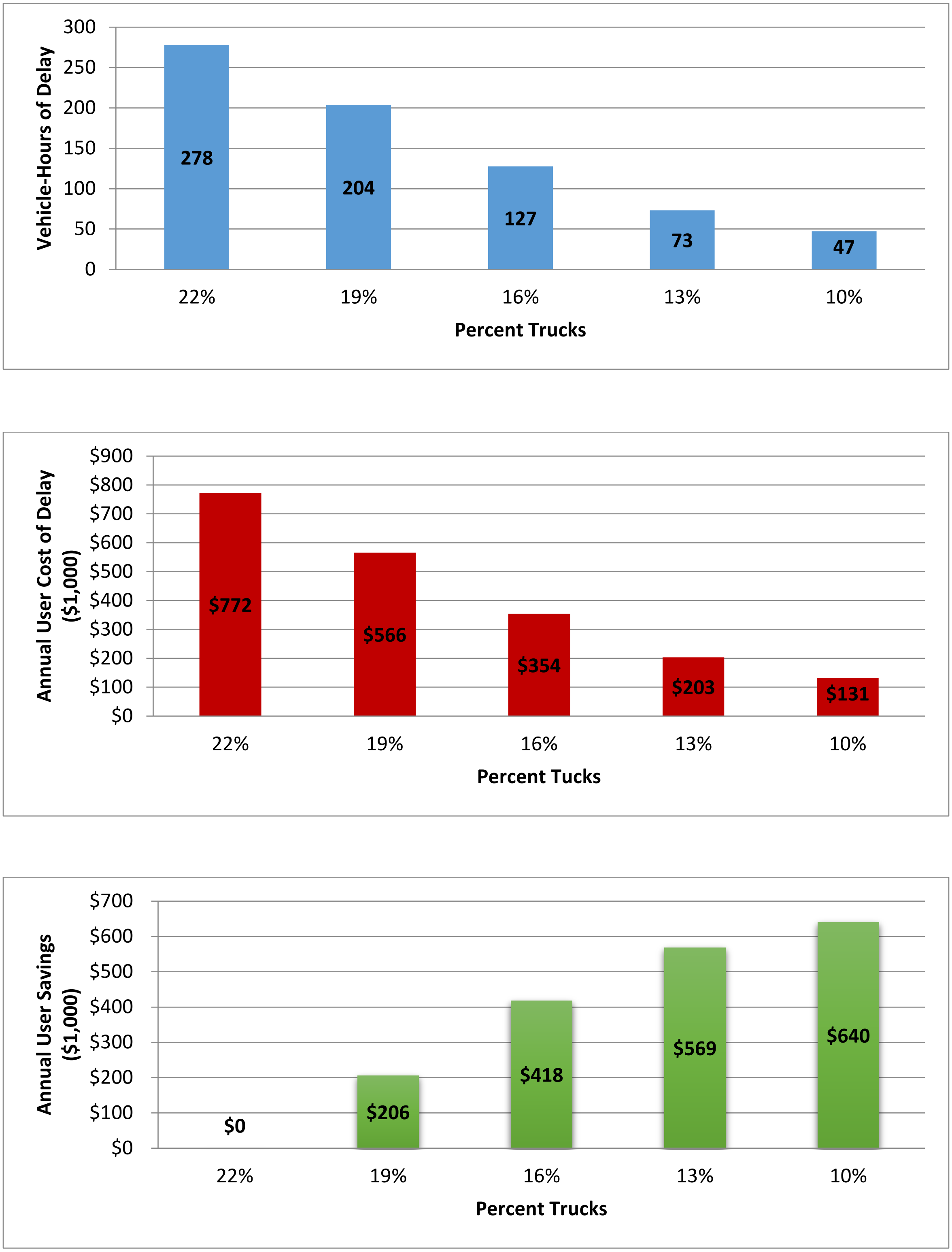


Figure B-1. Effect of reducing percent local trucks on I-10 EB.

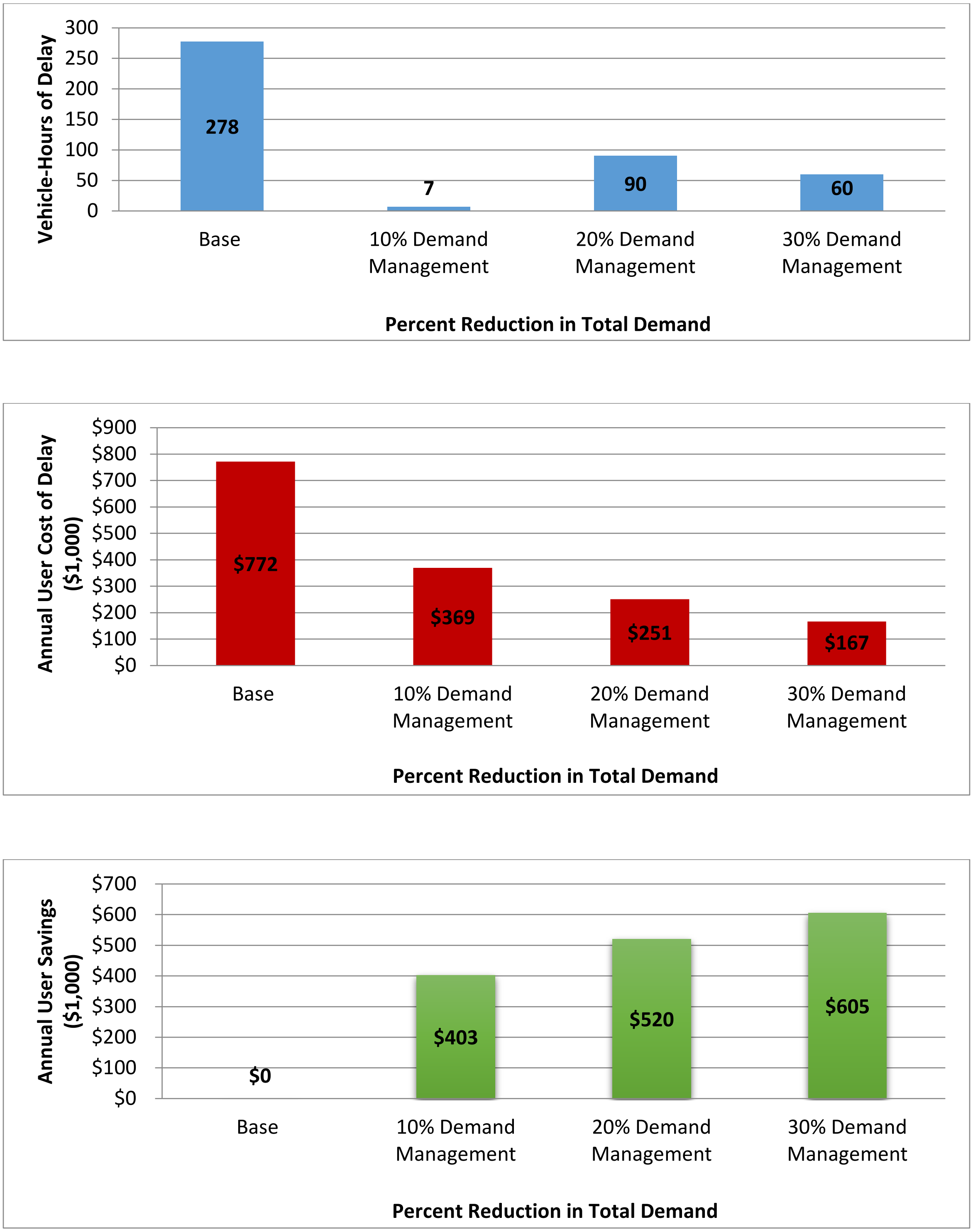
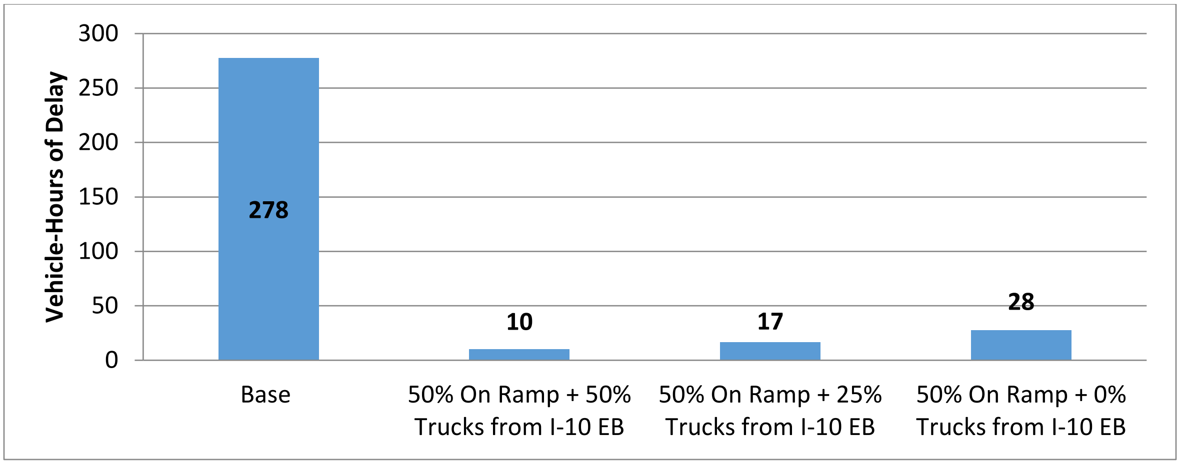
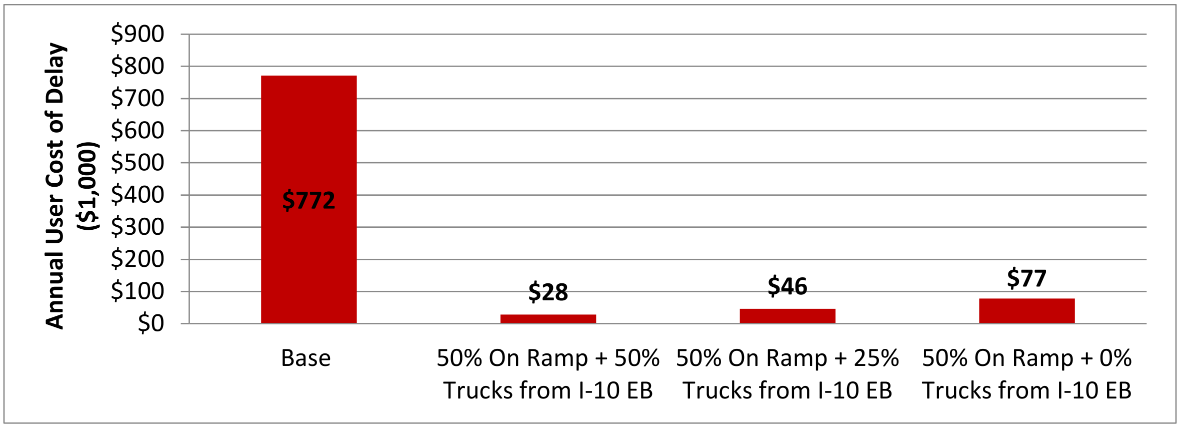


Figure B-2. Effect of implementing demand management techniques to reduce total traffic on I-10 EB.





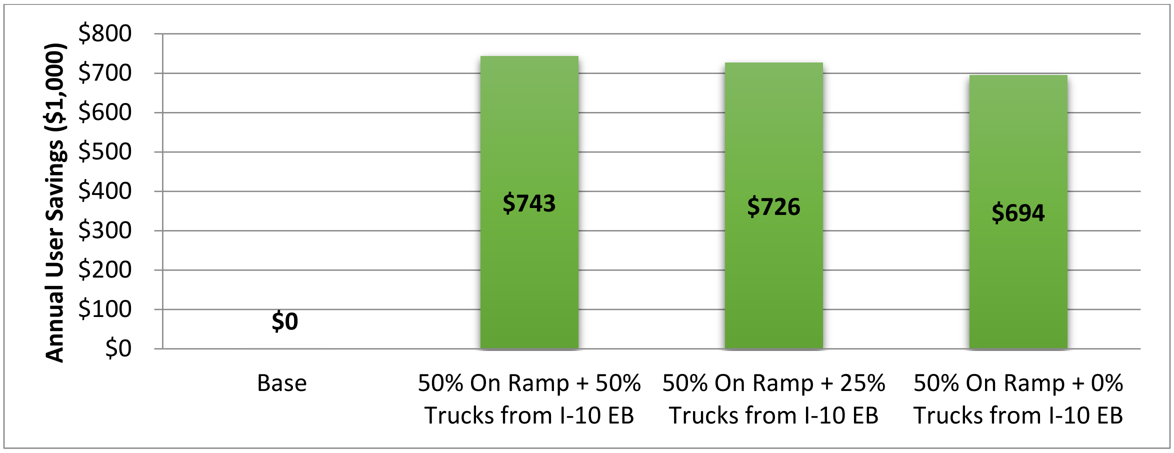
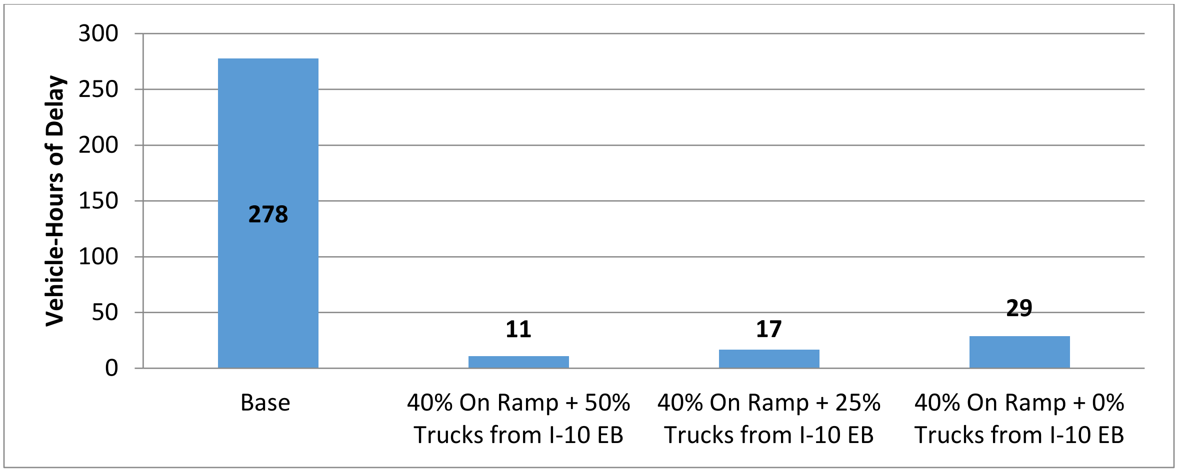
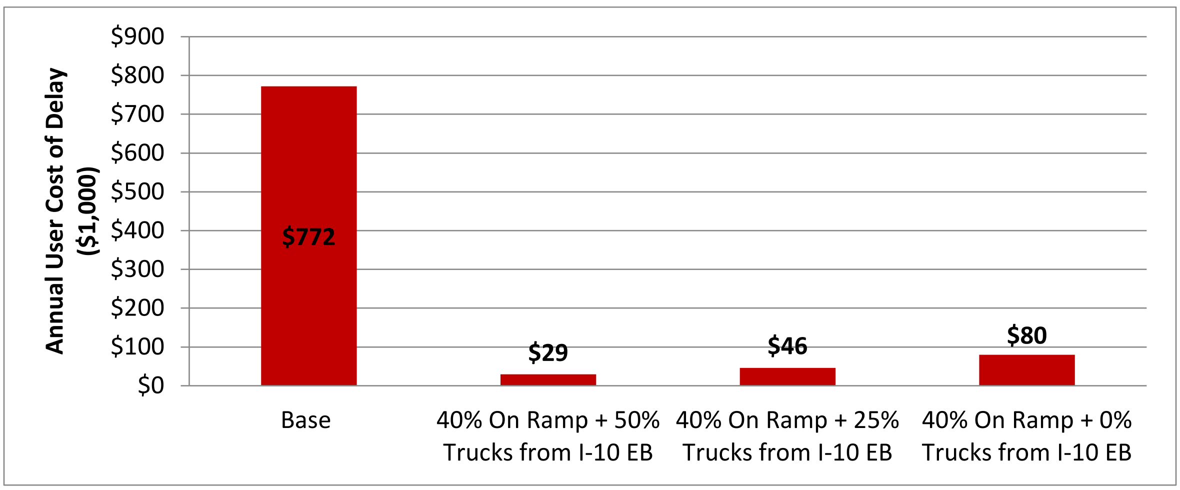


Figure B-3. Effect of shifting I-10 EB traffic through Old Bridge and surface street network (BUMP project).





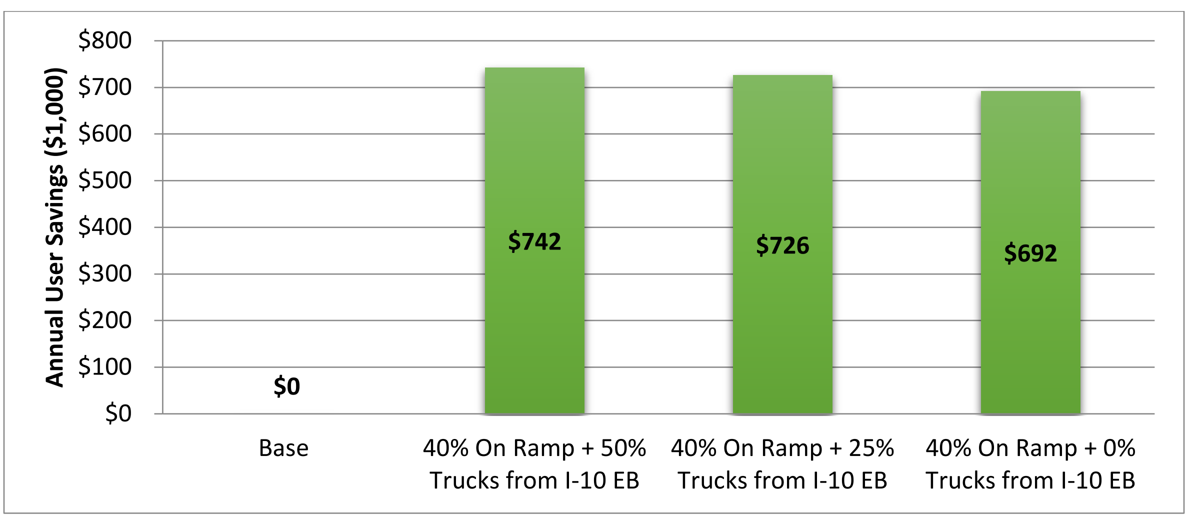
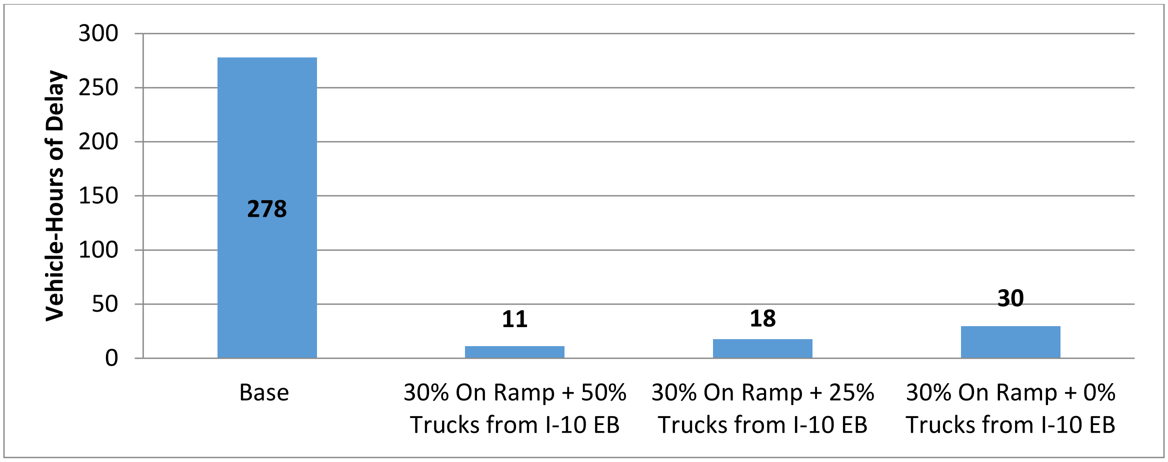
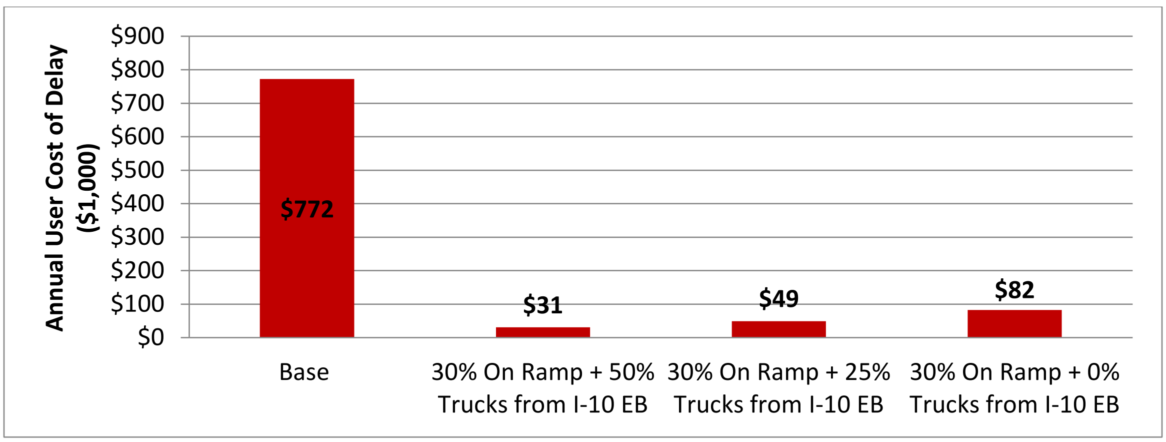


Figure B-3 (continued). Effect of shifting I-10 EB Traffic through Old Bridge and surface street network (BUMP project).





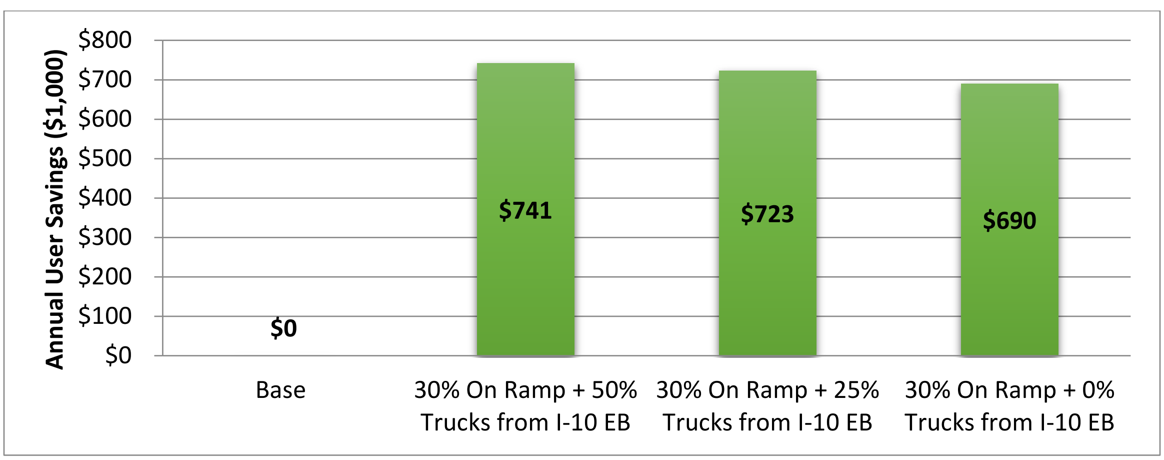


Figure B-3 (continued). Effect of shifting I-10 EB Traffic through Old Bridge and surface street network (BUMP project).

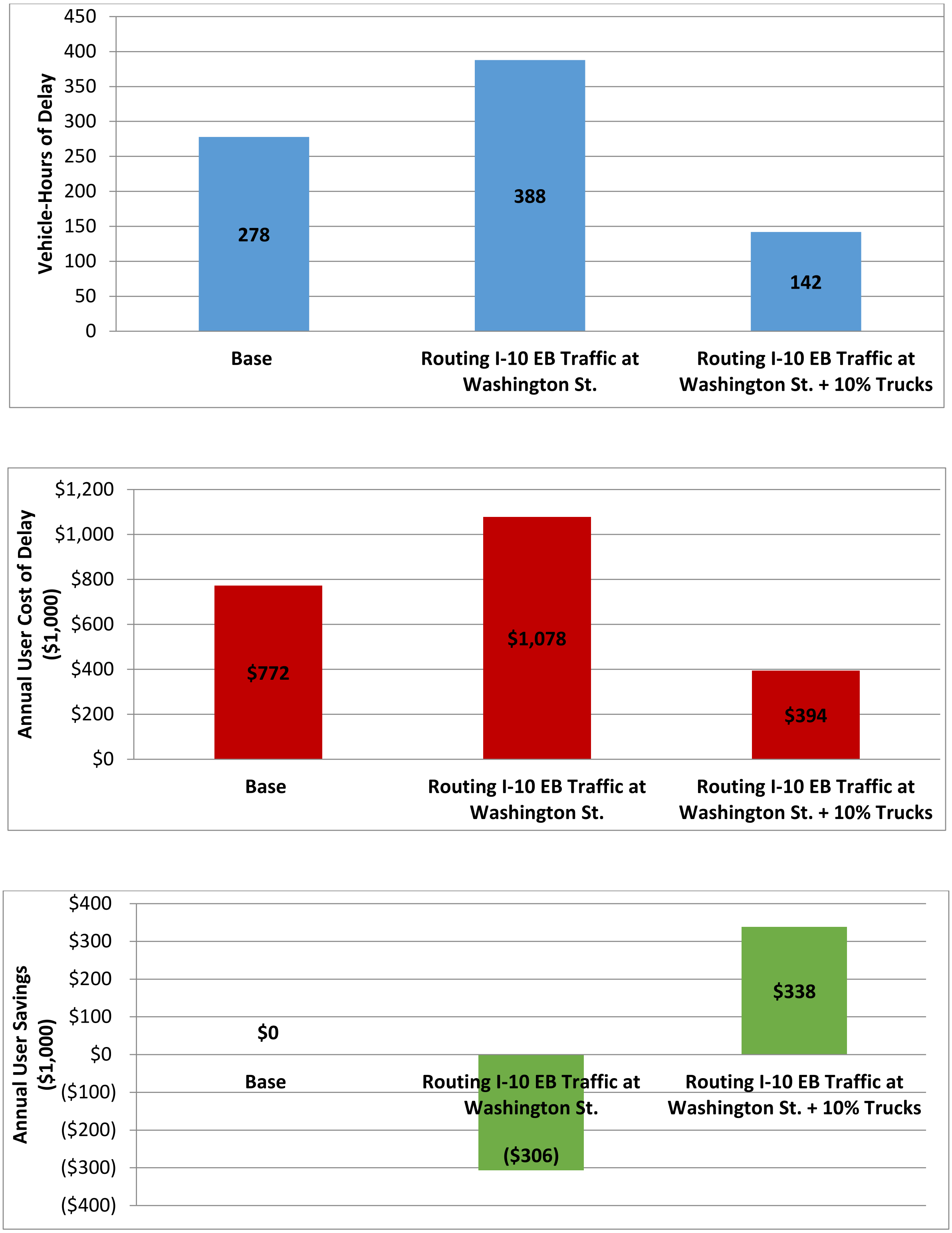


Figure B-4. Effect of routing I-10 EB traffic at Washington Street.

APPENDIX-C: P.M. PEAK, HOURLY AVERAGE

Table C-1. 10% reduction in demand using demand management.

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	171.55	3.52	150.17	3.51
Throughput	1745	1295	1657	1299
Total Delay (veh.sec)	329472	4192	292231	4199
Total Delay (veh.hour)	91.52	1.16	81.18	1.17
Travelled Distance	5215	7077	5215	7077
VMT	1723	1735	1636	1741
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$978.35	$12.45	$867.76	$12.47
Annual Delay Cost	$254,371	$3,236	$225,619	$3,242
Annual Economic Savings	$0	$0	$28,752	($6)

Table C-2. 20% reduction in demand using demand management.

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	171.55	3.52	129.85	3.54
Throughput	1745	1295	1570	1299
Total Delay (veh.sec)	329472	4192	257925	4225
Total Delay (veh.hour)	91.52	1.16	71.65	1.17
Travelled Distance	5215	7077	5215	7077
VMT	1723	1735	1550	1741
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$978.35	$12.45	$765.89	$12.55
Annual Delay Cost	$254,371	$3,236	$199,133	$3,262
Annual Economic Savings	$0	$0	$55,238	($26)

Table C-3. 30% reduction in demand using demand management.

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	171.55	3.52	93.38	3.45
Throughput	1745	1295	1481	1297
Total Delay (veh.sec)	329472	4192	184503	4126
Total Delay (veh.hour)	91.52	1.16	51.25	1.15
Travelled Distance	5215	7077	5215	7077
VMT	1723	1735	1463	1739
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$978.35	$12.45	$547.87	$12.25
Annual Delay Cost	$254,371	$3,236	$142,447	$3,186
Annual Economic Savings	$0	$0	$111,924	$50

Table C-4. Shifting 50% on-ramp + 50% trucks from I-10 EB (BUMP project).

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	171.55	3.52	13.19	3.70
Throughput	1745	1295	1360	1299
Total Delay (veh.sec)	329472	4192	24391	4437
Total Delay (veh.hour)	91.52	1.16	6.78	1.23
Travelled Distance	5215	7077	5215	7077
VMT	1723	1735	1343	1741
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$978.35	$12.45	$72.43	$13.17
Annual Delay Cost	$254,371	$3,236	$18,831	$3,425
Annual Economic Savings	$0	$0	$235,540	($189)

Table C-5. Shifting 50% on-ramp + 25% trucks from I-10 EB (BUMP project).

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	171.55	3.52	31.21	3.65
Throughput	1745	1295	1406	1299
Total Delay (veh.sec)	329472	4192	65763	4360
Total Delay (veh.hour)	91.52	1.16	18.27	1.21
Travelled Distance	5215	7077	5215	7077
VMT	1723	1735	1389	1741
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$978.35	$12.45	$195.28	$12.95
Annual Delay Cost	$254,371	$3,236	$50,773	$3,366
Annual Economic Savings	$0	$0	$203,598	($130)

Table C-6. Shifting 50% on-ramp + 0% trucks from I-10 EB (BUMP project).

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	171.55	3.52	56.32	3.54
Throughput	1745	1295	1457	1300
Total Delay (veh.sec)	329472	4192	123835	4242
Total Delay (veh.hour)	91.52	1.16	34.40	1.18
Travelled Distance	5215	7077	5215	7077
VMT	1723	1735	1439	1742
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$978.35	$12.45	$367.72	$12.60
Annual Delay Cost	$254,371	$3,236	$95,608	$3,275
Annual Economic Savings	$0	$0	$158,763	($39)

Table C-7. Shifting 40% on-ramp + 50% trucks from I-10 EB (BUMP project).

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	171.55	3.52	43.16	3.68
Throughput	1745	1295	1411	1300
Total Delay (veh.sec)	329472	4192	88895	4444
Total Delay (veh.hour)	91.52	1.16	24.69	1.23
Travelled Distance	5215	7077	5215	7077
VMT	1723	1735	1393	1742
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$978.35	$12.45	$263.97	$13.19
Annual Delay Cost	$254,371	$3,236	$68,632	$3,431
Annual Economic Savings	$0	$0	$185,739	($194)

Table C-8. Shifting 40% on-ramp + 25% trucks from I-10 EB (BUMP project).

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	171.55	3.52	71.40	3.53
Throughput	1745	1295	1461	1299
Total Delay (veh.sec)	329472	4192	149104	4228
Total Delay (veh.hour)	91.52	1.16	41.42	1.17
Travelled Distance	5215	7077	5215	7077
VMT	1723	1735	1443	1741
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$978.35	$12.45	$442.76	$12.55
Annual Delay Cost	$254,371	$3,236	$115,117	$3,264
Annual Economic Savings	$0	$0	$139,254	($28)

Table C-9. Shifting 40% on-ramp + 0% trucks from I-10 EB (BUMP project).

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	171.55	3.52	93.97	3.66
Throughput	1745	1295	1520	1300
Total Delay (veh.sec)	329472	4192	196798	4381
Total Delay (veh.hour)	91.52	1.16	54.67	1.22
Travelled Distance	5215	7077	5215	7077
VMT	1723	1735	1501	1743
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$978.35	$12.45	$584.38	$13.01
Annual Delay Cost	$254,371	$3,236	$151,939	$3,382
Annual Economic Savings	$0	$0	$102,432	($146)

Table C-10. Shifting 30% on-ramp + 50% trucks from I-10 EB (BUMP project).

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	171.55	3.52	94.95	3.48
Throughput	1745	1295	1474	1299
Total Delay (veh.sec)	329472	4192	187273	4141
Total Delay (veh.hour)	91.52	1.16	52.02	1.15
Travelled Distance	5215	7077	5215	7077
VMT	1723	1735	1456	1741
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$978.35	$12.45	$556.10	$12.30
Annual Delay Cost	$254,371	$3,236	$144,585	$3,197
Annual Economic Savings	$0	$0	$109,785	$39

Table C-11. Shifting 30% on-ramp + 25% trucks from I-10 EB (BUMP project).

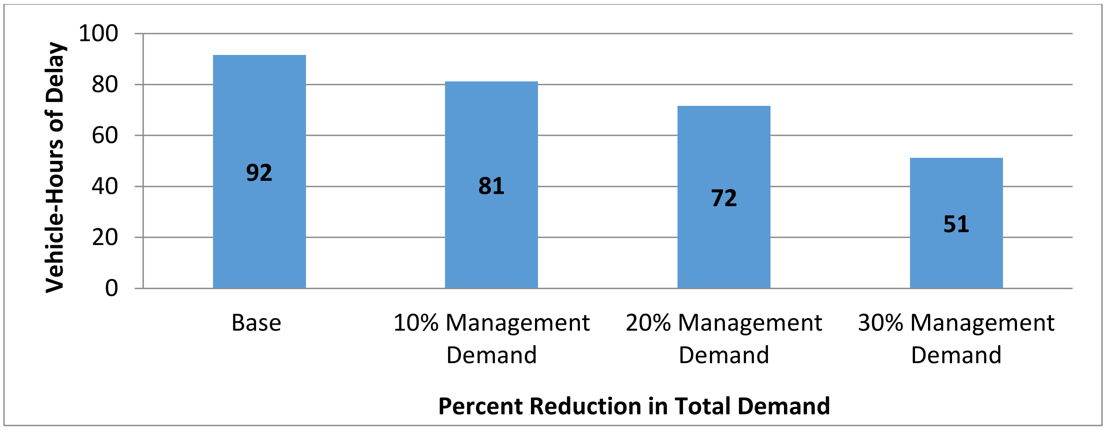
Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	171.55	3.52	102.09	3.51
Throughput	1745	1295	1525	1300
Total Delay (veh.sec)	329472	4192	205284	4208
Total Delay (veh.hour)	91.52	1.16	57.02	1.17
Travelled Distance	5215	7077	5215	7077
VMT	1723	1735	1506	1742
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$978.35	$12.45	$609.58	$12.49
Annual Delay Cost	$254,371	$3,236	$158,491	$3,249
Annual Economic Savings	$0	$0	$95,880	($12)

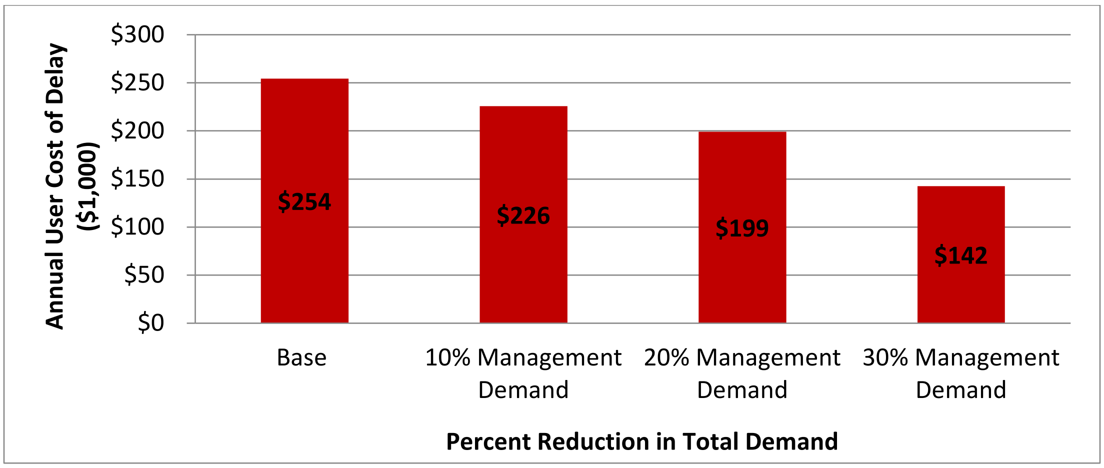
Table C-12. Shifting 30% on-ramp + 0% trucks from I-10 EB (BUMP project).

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	171.55	3.52	117.96	3.60
Throughput	1745	1295	1579	1300
Total Delay (veh.sec)	329472	4192	244567	4303
Total Delay (veh.hour)	91.52	1.16	67.94	1.20
Travelled Distance	5215	7077	5215	7077
VMT	1723	1735	1559	1743
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$978.35	$12.45	$726.23	$12.78
Annual Delay Cost	$254,371	$3,236	$188,819	$3,322
Annual Economic Savings	$0	$0	$65,551	($86)

Table C-13. Fixed-rate ramp metering.

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	171.55	3.52	26.23	3.59
Throughput	1745	1295	1467	1299
Total Delay (veh.sec)	329472	4192	53821	4298
Total Delay (veh.hour)	91.52	1.16	14.95	1.19
Travelled Distance	5215	7077	5215	7077
VMT	1723	1735	1449	1741
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$978.35	$12.45	$159.82	$12.76
Annual Delay Cost	$254,371	$3,236	$41,553	$3,318
Annual Economic Savings	$0	$0	$212,818	($82)





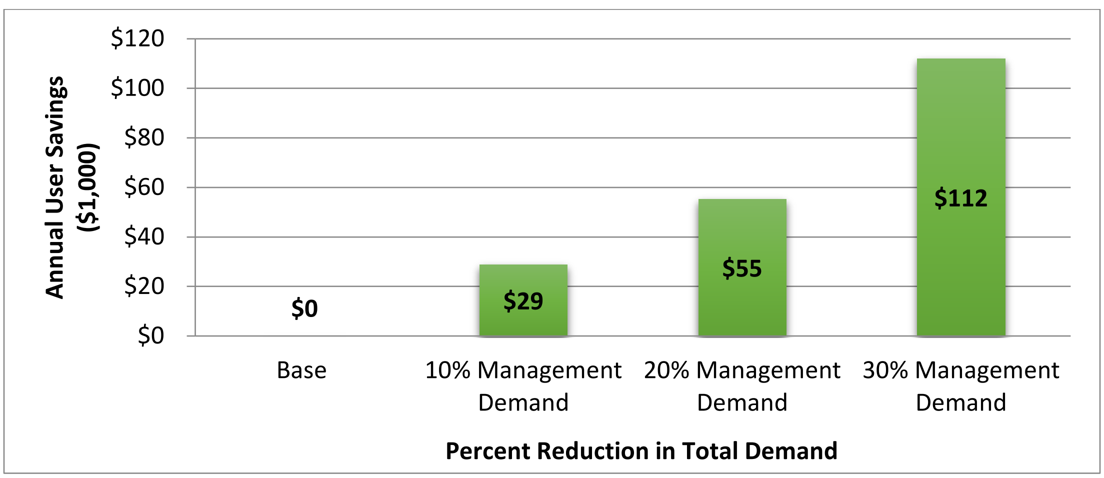


Figure C-1. Effect of implementing demand management techniques to reduce total traffic on I-10 EB.

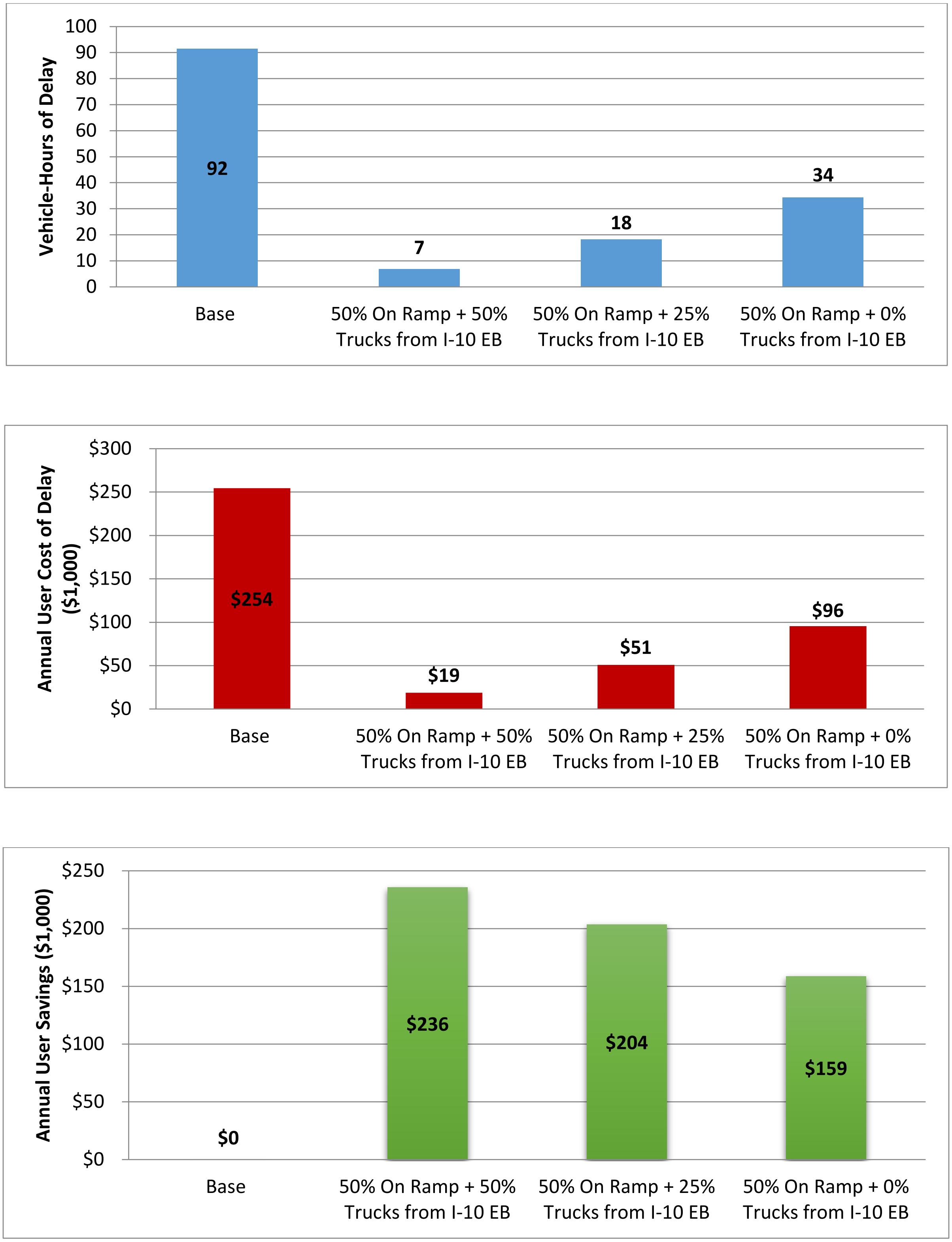
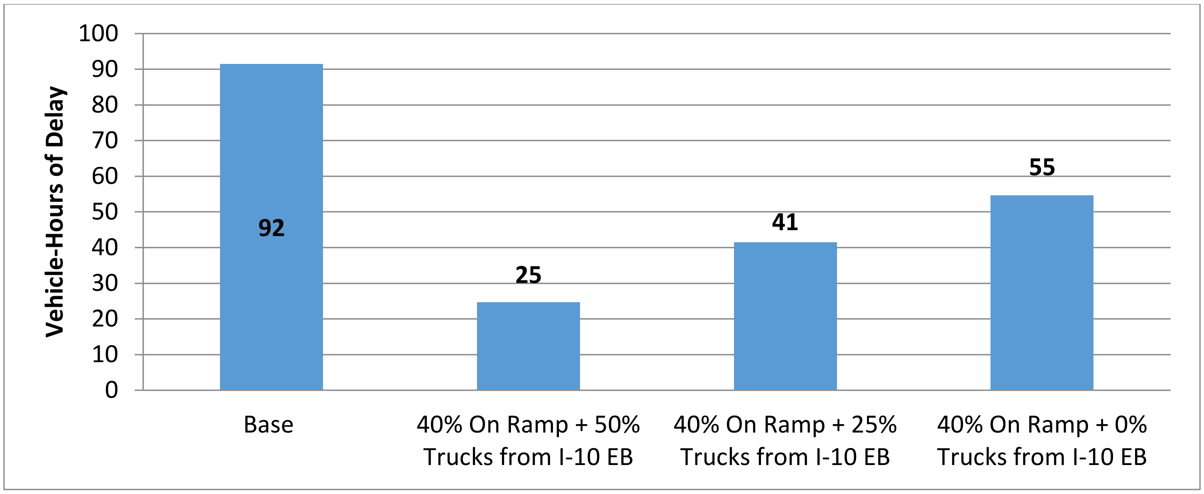
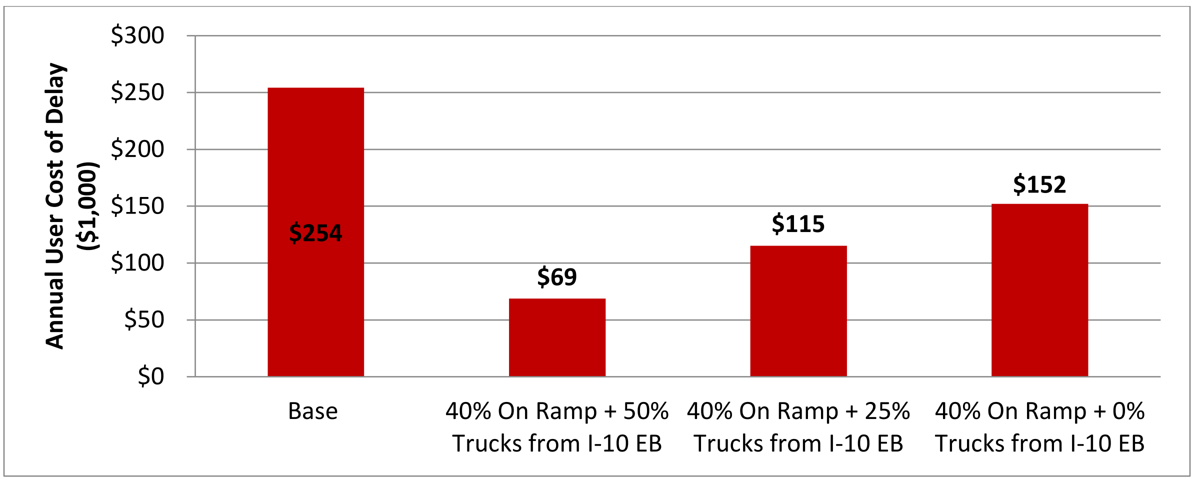


Figure C-2. Effect of shifting I-10 EB traffic through Old Bridge and surface street network (BUMP project).





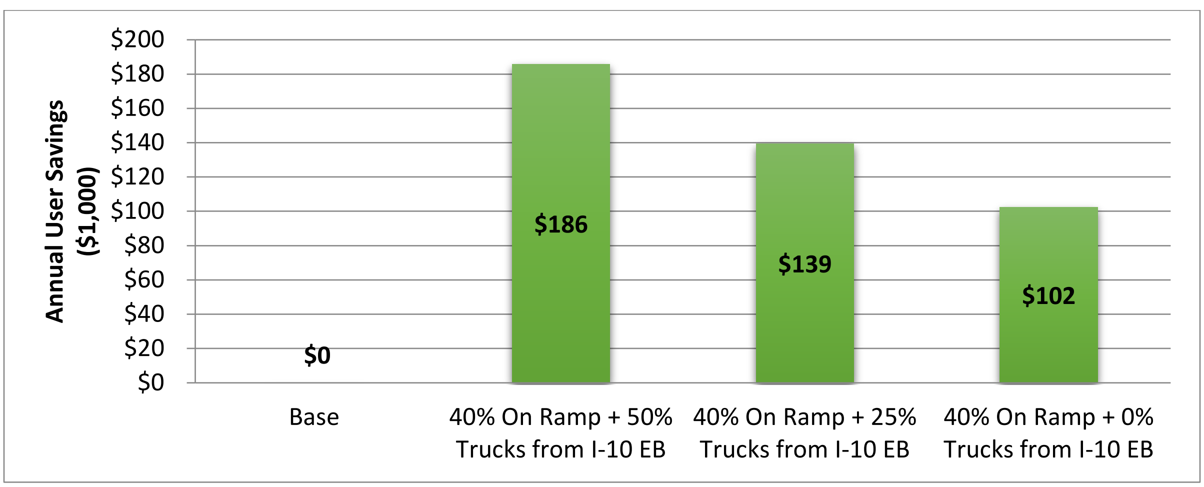
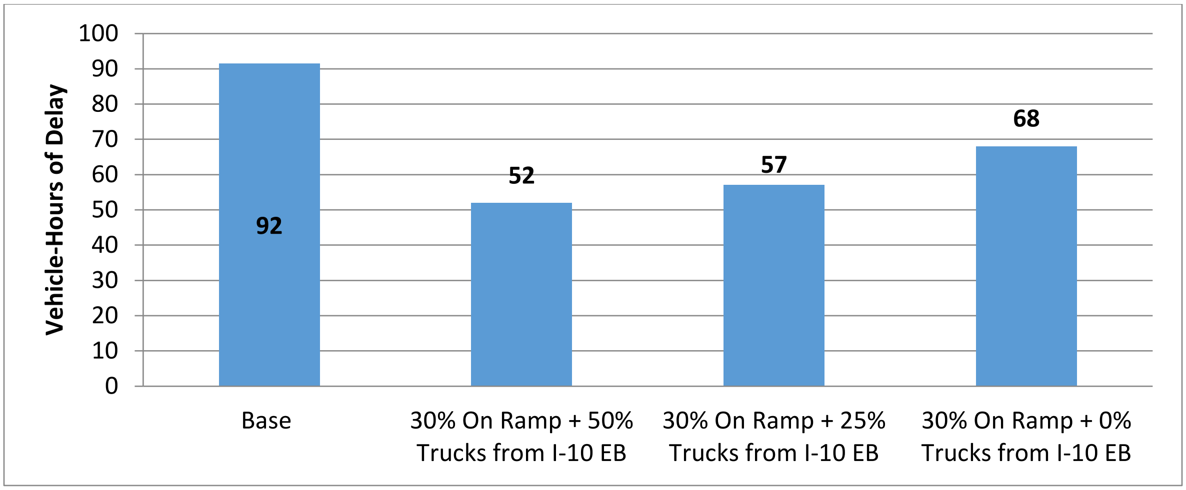
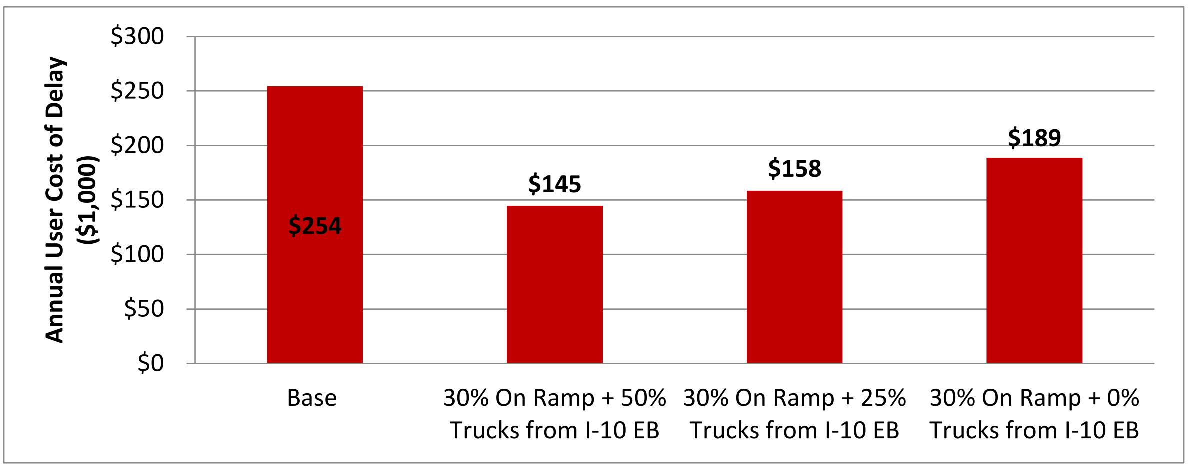


Figure C-2 (continued). Effect of shifting I-10 EB traffic through Old Bridge and surface street network (BUMP project).





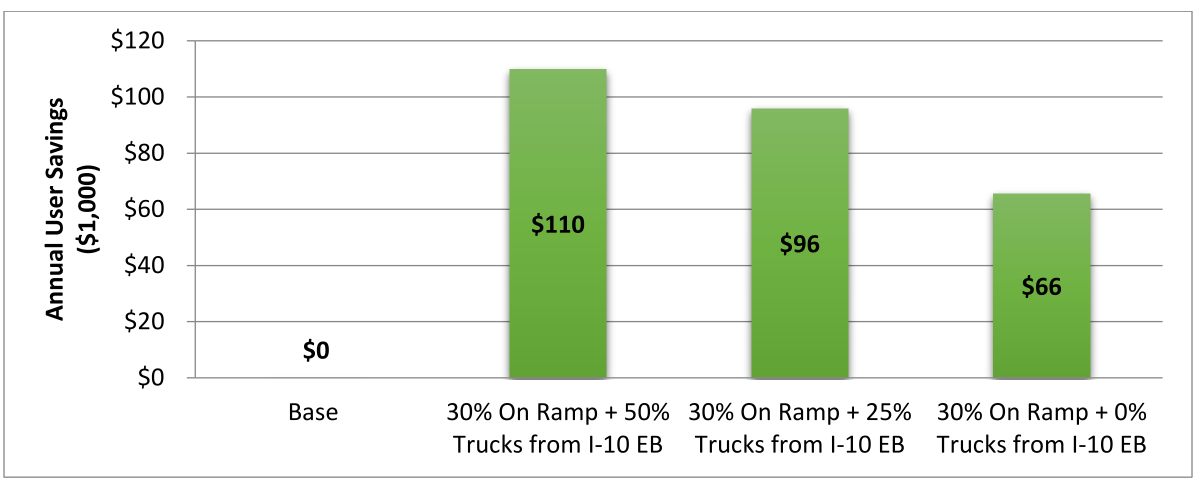
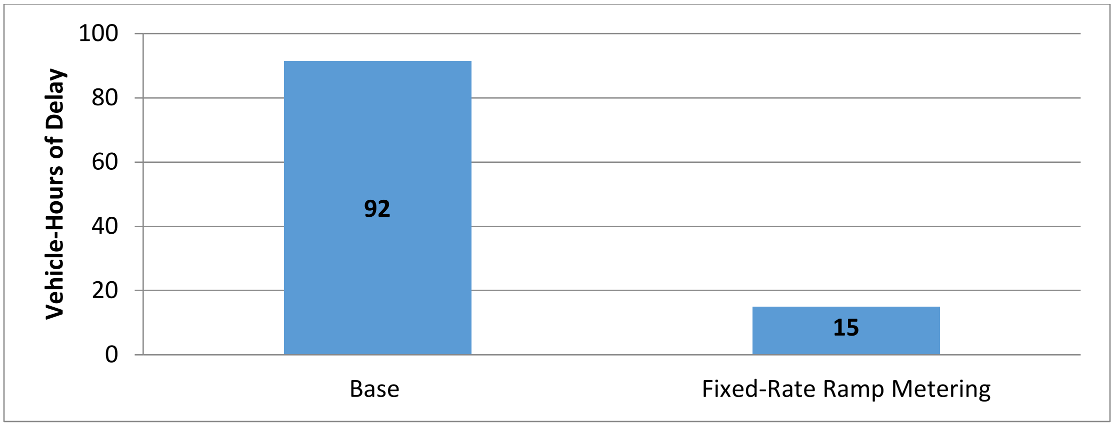
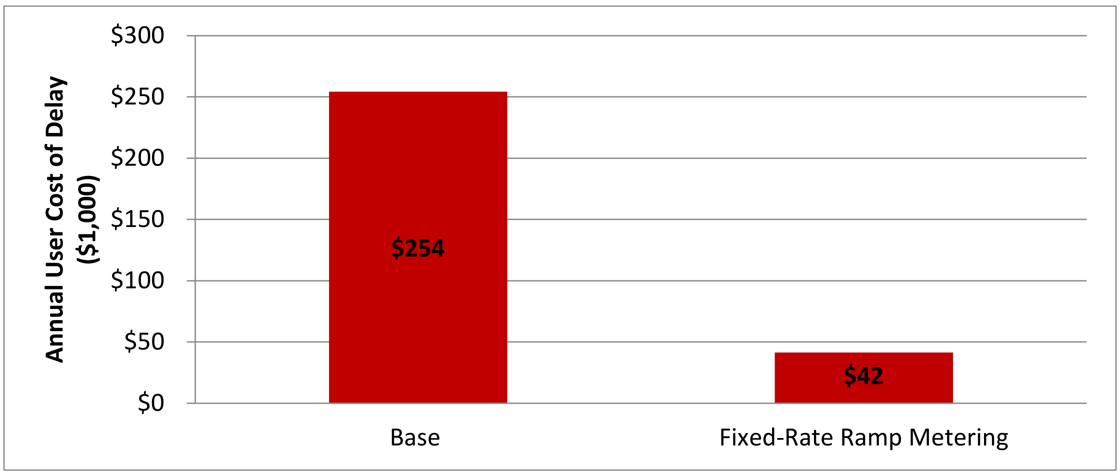


Figure C-2 (continued). Effect of shifting I-10 EB traffic through Old Bridge and surface street network (BUMP project).





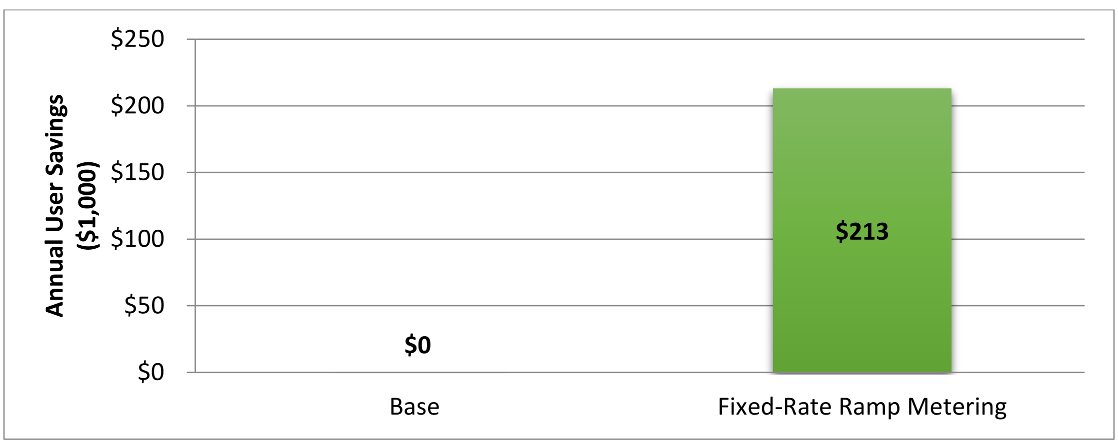


Figure C-3. Effect of fixed-rate, on-ramp metering west of I-10 Bridge.

APPENDIX-D: P.M. PEAK, 3-HOURS

Table D-1. Shifting 50% on-ramp + 50% trucks from I-10 EB (BUMP project).

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	171.55	3.52	13.19	3.70
Throughput	5235	3884	4079	3897
Total Delay (veh.sec)	988416	12575	73173	13310
Total Delay (veh.hour)	274.56	3.49	20.33	3.70
Travelled Distance	5215	7077	5215	7077
VMT	5170	5206	4029	5223
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$2,935.05	$37.34	$217.28	$39.52
Annual Delay Cost	$763,112	$9,709	$56,494	$10,276
Annual Economic Savings	$0	$0	$706,619	($568)

Table D-2. Shifting 50% on-ramp + 25% trucks from I-10 EB (BUMP project).

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	171.55	3.52	31.21	3.65
Throughput	5235	3884	4218	3898
Total Delay (veh.sec)	988416	12575	197290	13081
Total Delay (veh.hour)	274.56	3.49	54.80	3.63
Travelled Distance	5215	7077	5215	7077
VMT	5170	5206	4166	5224
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$2,935.05	$37.34	$585.84	$38.84
Annual Delay Cost	$763,112	$9,709	$152,319	$10,099
Annual Economic Savings	$0	$0	$610,794	($391)

Table D-3. Shifting 50% on-ramp + 0% trucks from I-10 EB (BUMP project).

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	171.55	3.52	56.32	3.54
Throughput	5235	3884	4372	3899
Total Delay (veh.sec)	988416	12575	371506	12726
Total Delay (veh.hour)	274.56	3.49	103.20	3.54
Travelled Distance	5215	7077	5215	7077
VMT	5170	5206	4318	5225
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$2,935.05	$37.34	$1,103.17	$37.79
Annual Delay Cost	$763,112	$9,709	$286,824	$9,826
Annual Economic Savings	$0	$0	$476,289	($117)

Table D-4. Shifting 40% on-ramp + 50% trucks from I-10 EB (BUMP project).

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	171.55	3.52	43.16	3.68
Throughput	5235	3884	4232	3899
Total Delay (veh.sec)	988416	12575	266684	13331
Total Delay (veh.hour)	274.56	3.49	74.08	3.70
Travelled Distance	5215	7077	5215	7077
VMT	5170	5206	4179	5226
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$2,935.05	$37.34	$791.90	$39.58
Annual Delay Cost	$763,112	$9,709	$205,895	$10,292
Annual Economic Savings	$0	$0	$557,218	($583)

Table D-5. Shifting 40% on-ramp + 25% trucks from I-10 EB (BUMP project).

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	171.55	3.52	71.40	3.53
Throughput	5235	3884	4382	3896
Total Delay (veh.sec)	988416	12575	447312	12684
Total Delay (veh.hour)	274.56	3.49	124.25	3.52
Travelled Distance	5215	7077	5215	7077
VMT	5170	5206	4328	5222
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$2,935.05	$37.34	$1,328.27	$37.66
Annual Delay Cost	$763,112	$9,709	$345,350	$9,793
Annual Economic Savings	$0	$0	$417,762	($84)

Table D-6. Shifting 40% on-ramp + 0% trucks from I-10 EB (BUMP project).

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	171.55	3.52	93.97	3.66
Throughput	5235	3884	4560	3901
Total Delay (veh.sec)	988416	12575	590395	13142
Total Delay (veh.hour)	274.56	3.49	164.00	3.65
Travelled Distance	5215	7077	5215	7077
VMT	5170	5206	4504	5228
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$2,935.05	$37.34	$1,753.14	$39.03
Annual Delay Cost	$763,112	$9,709	$455,818	$10,147
Annual Economic Savings	$0	$0	$307,295	($438)

Table D-7. Shifting 30% on-ramp + 50% trucks from I-10 EB (BUMP project).

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	171.55	3.52	94.95	3.48
Throughput	5235	3884	4423	3897
Total Delay (veh.sec)	988416	12575	561820	12422
Total Delay (veh.hour)	274.56	3.49	156.06	3.45
Travelled Distance	5215	7077	5215	7077
VMT	5170	5206	4368	5222
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$2,935.05	$37.34	$1,668.29	$36.89
Annual Delay Cost	$763,112	$9,709	$433,756	$9,591
Annual Economic Savings	$0	$0	$329,356	$118

Table D-8. Shifting 30% on-ramp + 25% trucks from I-10 EB (BUMP project).

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	171.55	3.52	102.09	3.51
Throughput	5235	3884	4576	3900
Total Delay (veh.sec)	988416	12575	615852	12623
Total Delay (veh.hour)	274.56	3.49	171.07	3.51
Travelled Distance	5215	7077	5215	7077
VMT	5170	5206	4519	5227
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$2,935.05	$37.34	$1,828.74	$37.48
Annual Delay Cost	$763,112	$9,709	$475,472	$9,746
Annual Economic Savings	$0	$0	$287,641	($37)

Table D-9. Shifting 30% on-ramp + 0% trucks from I-10 EB (BUMP project).

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	171.55	3.52	117.96	3.60
Throughput	5235	3884	4737	3901
Total Delay (veh.sec)	988416	12575	733701	12910
Total Delay (veh.hour)	274.56	3.49	203.81	3.59
Travelled Distance	5215	7077	5215	7077
VMT	5170	5206	4678	5228
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$2,935.05	$37.34	$2,178.69	$38.34
Annual Delay Cost	$763,112	$9,709	$566,458	$9,967
Annual Economic Savings	$0	$0	$196,654	($259)

Table D-10. 10% reduction in demand using demand management.

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	171.55	3.52	150.17	3.51
Throughput	5235	3884	4970	3897
Total Delay (veh.sec)	988416	12575	876694	12596
Total Delay (veh.hour)	274.56	3.49	243.53	3.50
Travelled Distance	5215	7077	5215	7077
VMT	5170	5206	4908	5222
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$2,935.05	$37.34	$2,603.29	$37.40
Annual Delay Cost	$763,112	$9,709	$676,856	$9,725
Annual Economic Savings	$0	$0	$86,256	($17)

Table D-11. 20% reduction in demand using demand management.

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	171.55	3.52	129.85	3.54
Throughput	5235	3884	4709	3896
Total Delay (veh.sec)	988416	12575	773776	12675
Total Delay (veh.hour)	274.56	3.49	214.94	3.52
Travelled Distance	5215	7077	5215	7077
VMT	5170	5206	4651	5222
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$2,935.05	$37.34	$2,297.68	$37.64
Annual Delay Cost	$763,112	$9,709	$597,398	$9,786
Annual Economic Savings	$0	$0	$165,714	($77)

Table D-12. 30% reduction in demand using demand management.

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	171.55	3.52	93.38	3.45
Throughput	5235	3884	4444	3892
Total Delay (veh.sec)	988416	12575	553510	12379
Total Delay (veh.hour)	274.56	3.49	153.75	3.44
Travelled Distance	5215	7077	5215	7077
VMT	5170	5206	4389	5216
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$2,935.05	$37.34	$1,643.62	$36.76
Annual Delay Cost	$763,112	$9,709	$427,341	$9,557
Annual Economic Savings	$0	$0	$335,772	$151

Table D-13. Fixed-rate ramp metering.

Metric	Base EB	Base WB	Treatment EB	Treatment WB
Average Delay (sec/veh)	171.55	3.52	26.23	3.59
Throughput	5235	3884	4400	3897
Total Delay (veh.sec)	988416	12575	161463	12894
Total Delay (veh.hour)	274.56	3.49	44.85	3.58
Travelled Distance	5215	7077	5215	7077
VMT	5170	5206	4346	5223
Average hourly wages/2	10.69	10.69	10.69	10.69
Delay Cost/hour	$2,935.05	$37.34	$479.45	$38.29
Annual Delay Cost	$763,112	$9,709	$124,658	$9,955
Annual Economic Savings	$0	$0	$638,454	($246)

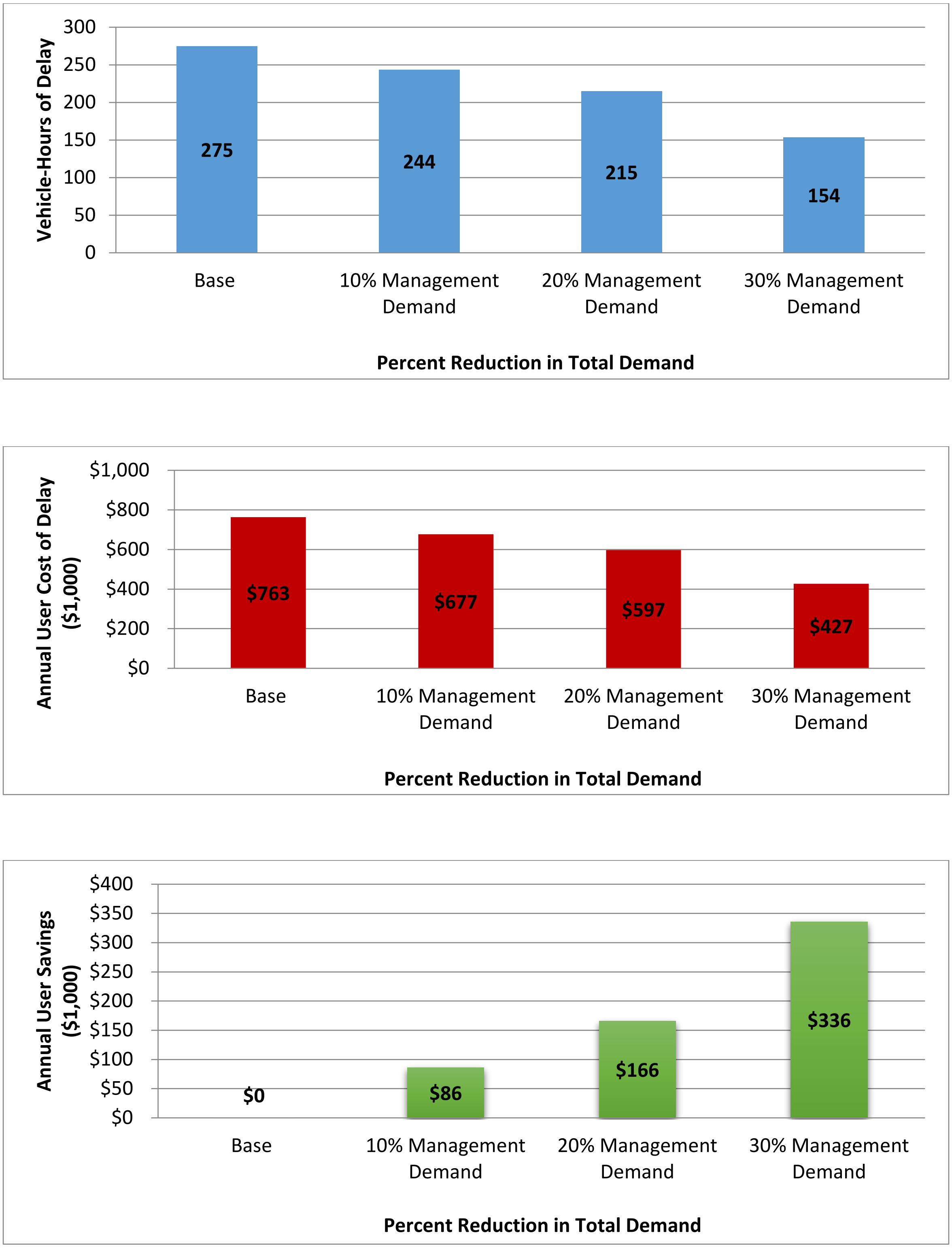
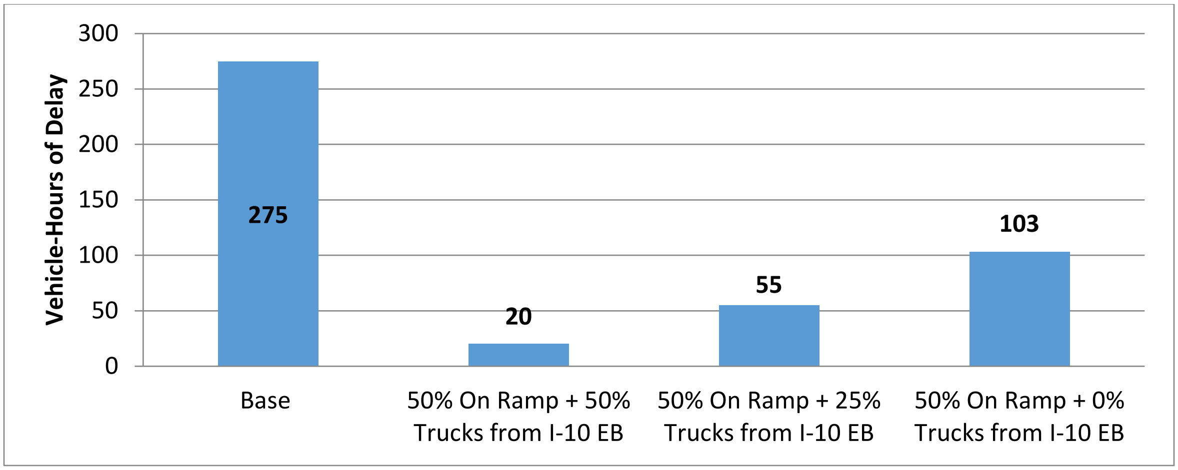
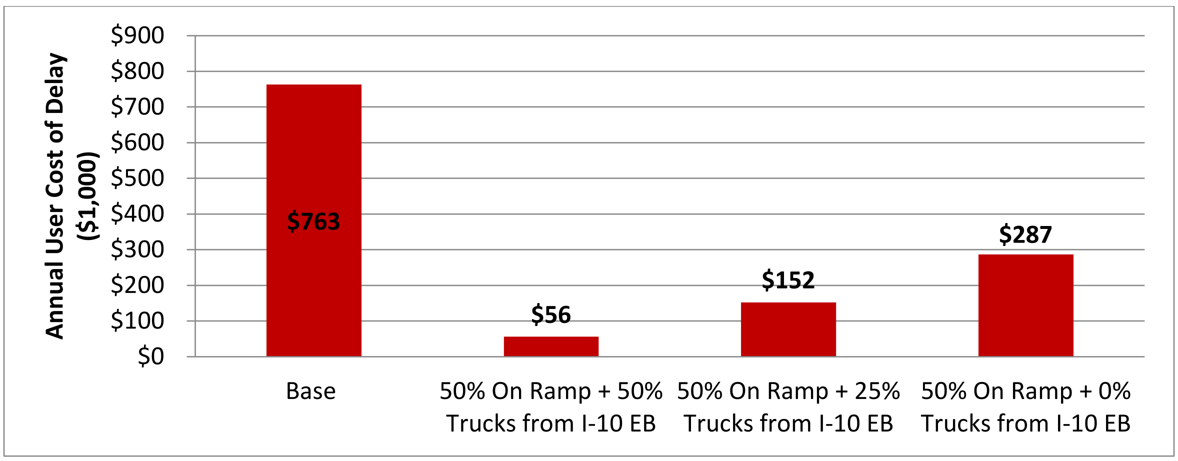


Figure D-1. Effect of implementing demand management techniques to reduce total traffic on I-10 EB.





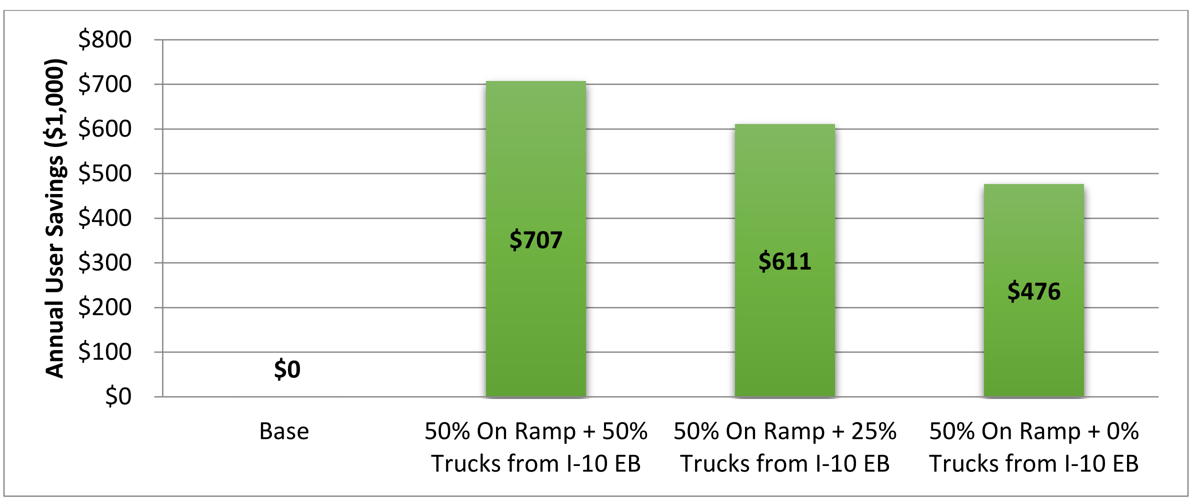
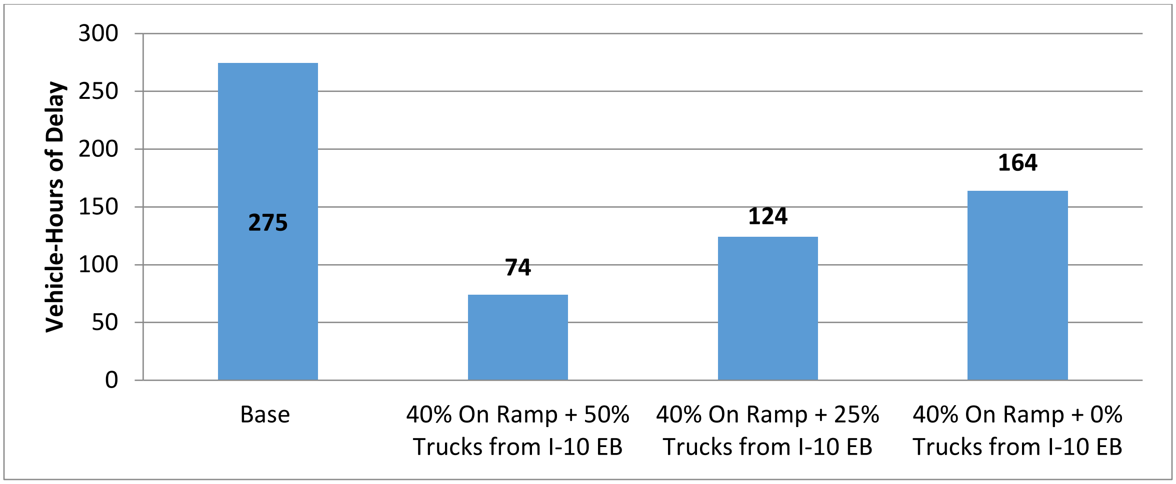
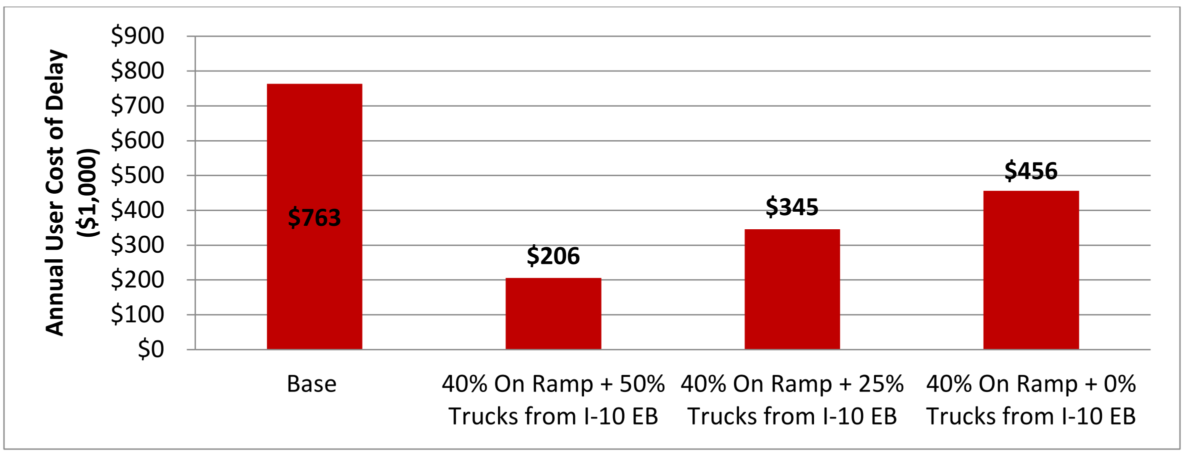


Figure D-2. Effect of Shifting I-10 EB traffic through Old Bridge and surface street network (BUMP project).





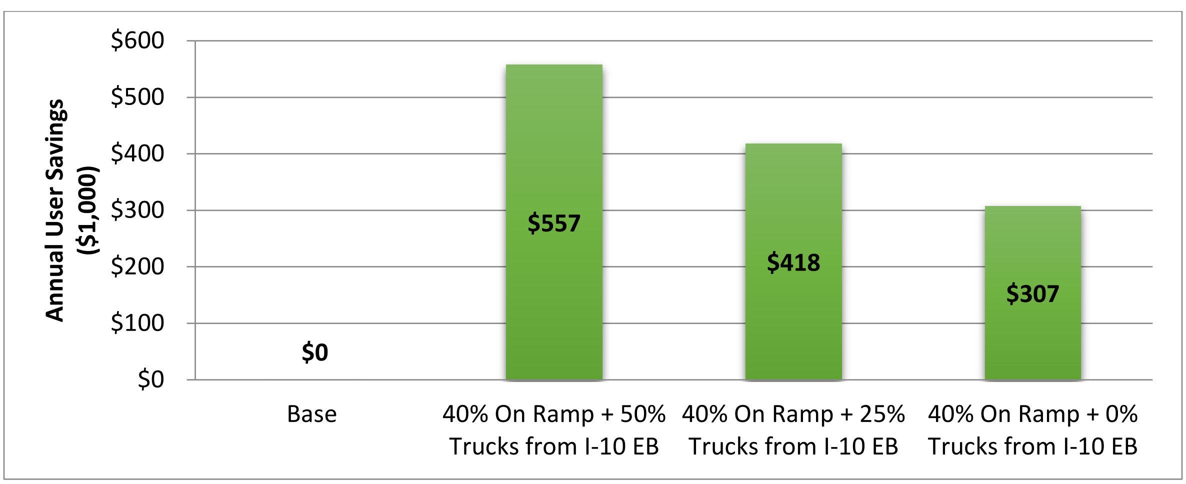
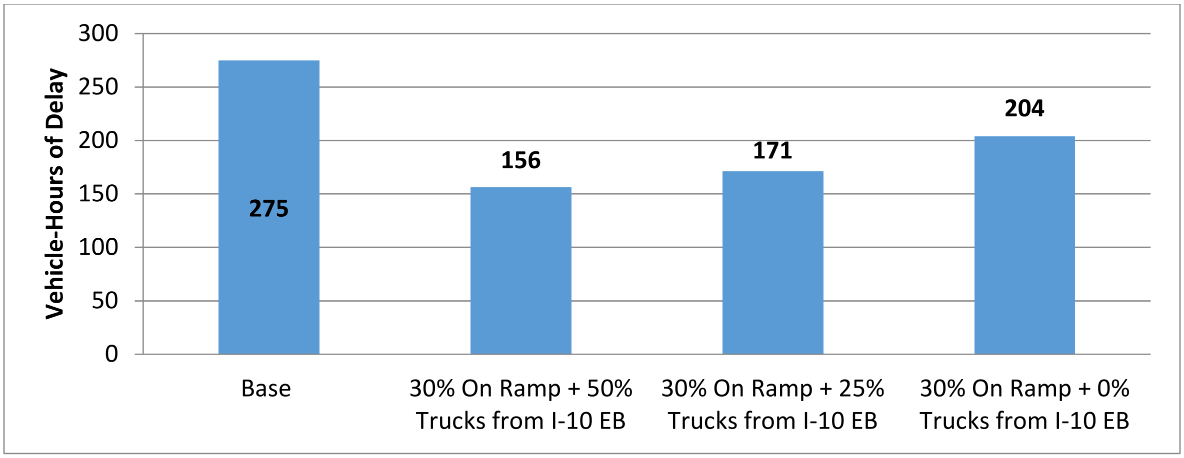
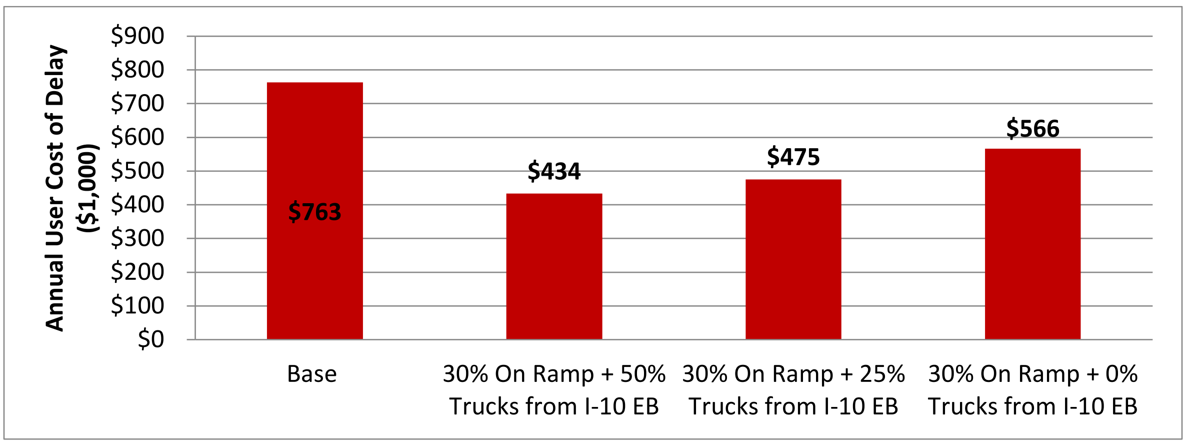


Figure D-2 (continued). Effect of Shifting I-10 EB traffic through Old Bridge and surface street network (BUMP project).





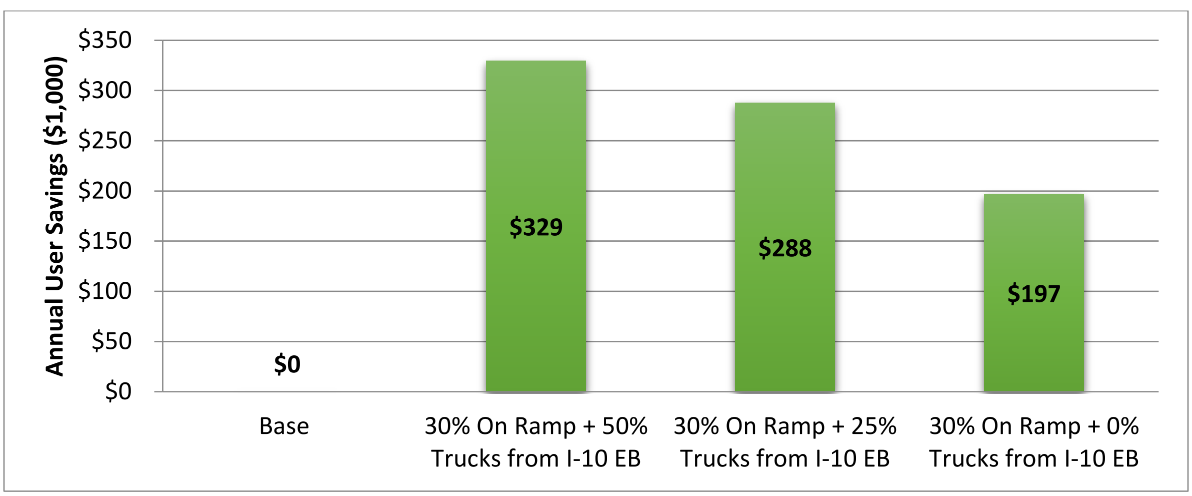


Figure D-2 (continued). Effect of Shifting I-10 EB traffic through Old Bridge and surface street network (BUMP project).

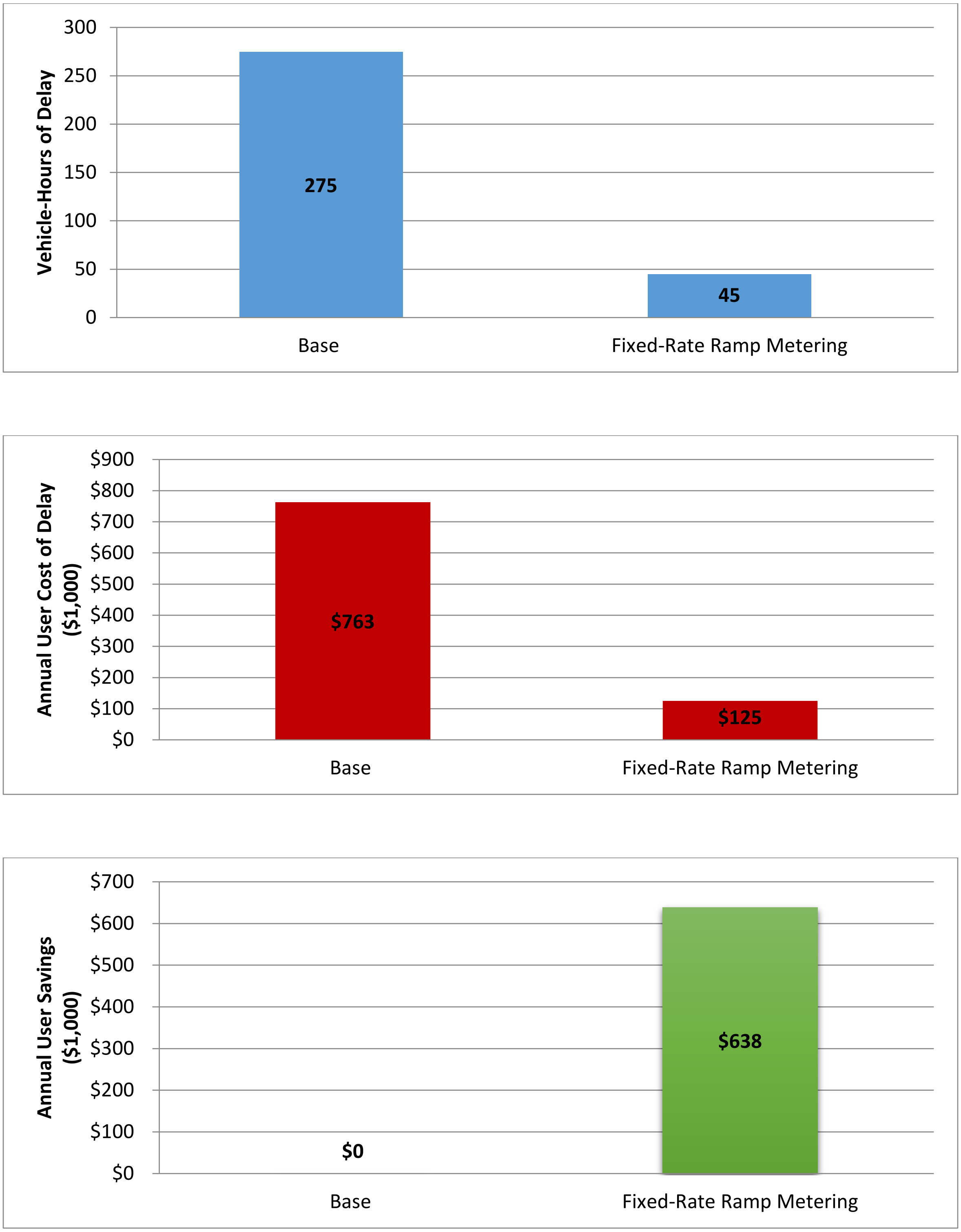


Figure D-3. Effect of fixed-rate, on-ramp metering west of I-10 Bridge.