ADAPTIVE VERSUS TRADITIONAL

TRAFFIC CONTROL SYSTEMS

A FIELD-BASED COMPARATIVE ASSESSMENT

PINELLAS COUNTYWIDE ATMS PROJECT

US 19 Corridor – from Enterprise Road to Beckett Way
SR 60 Corridor - from Ft. Harrison Avenue to Bayshore Boulevard

FINANCIAL PROJECT ID: 408419-1-32-01

PREPARED FOR:

PREPARED BY

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1.0 EXECUTIVE SUMMARY

The Florida Department of Transportation (FDOT) has retained consulting services to design, procure, install, and integrate an Advanced Traffic Management System (ATMS) along two major corridors (US 19 and SR 60) in Pinellas County, Florida. Though the overall project, herein referred to as the Pinellas Countywide ATMS project, can be operated from the Pinellas County Regional Traffic Management Center (RTMC), currently the SR 60 corridor is controlled by the City of Clearwater's Traffic Operations Center. In the long run, the RTMC may be staffed with representatives from each local agency though each agency will continue to maintain its own traffic control center for management of respective jurisdictional control resources.

The Pinellas Countywide ATMS project is being designed and implemented in three deployment stages using the System Manager approach. The Stage I deployment, which is nearing completion, encompassed a diverse set of technologies including central control system, controller firmware, adaptive control software, video imaging detection, closed circuit television cameras, dynamic message signs, dynamic trailblazer signs, and fiber optic communications backbone. A primary goal of the project was to leverage incident management strategies and enabling technologies to improve real-time control, management, monitoring, verification, response, data storage and retrieval during periods of recurrent congestion and incidents.

In addition to other tasks, the Pinellas Countywide ATMS project required a comprehensive evaluation of two adaptive traffic control system deployed along portions of US 19 and SR 60 corridors in Pinellas County. The study corridors are presented in Figures 2-1 and 2-2. The US 19 and SR 60 study corridors encompassed 9 and 16 signalized intersections, respectively, segregated into three operational sections. In addition, the study considered three critical intersections, selected along each study corridor in consultation with the Pinellas County, to serve as benchmarks in differentiating traffic operations between the main corridor and associated side streets. The assessment considered field-based Before-After comparative analysis of operational measures of effectiveness such as travel times, speeds, control delay, fuel consumption, traffic crashes, etc. The Before Scenario was represented by historical time-of-day plans, which were fine-tuned over time as deemed appropriate by the maintaining agency whereas the After Scenario was represented by different adaptive traffic control systems deployed along US 19 (MIST and OPAC) and SR 60 (I2TMS and RHODS), respectively.

This paper, developed by Gord & Associates, Inc., presents the study approach, findings, conclusions, and recommendations. The focus of this study is on addressing the Evaluation Goal 2 (Assess Transportation System Impacts) during peak and off-peak periods and at system boundaries. The paper is organized as follows:

- Background
- Approach
- US 19 Findings
- SR 60 Findings
- Conclusions and Recommendations.

This Executive Summary focuses on the study conclusions and recommendations.

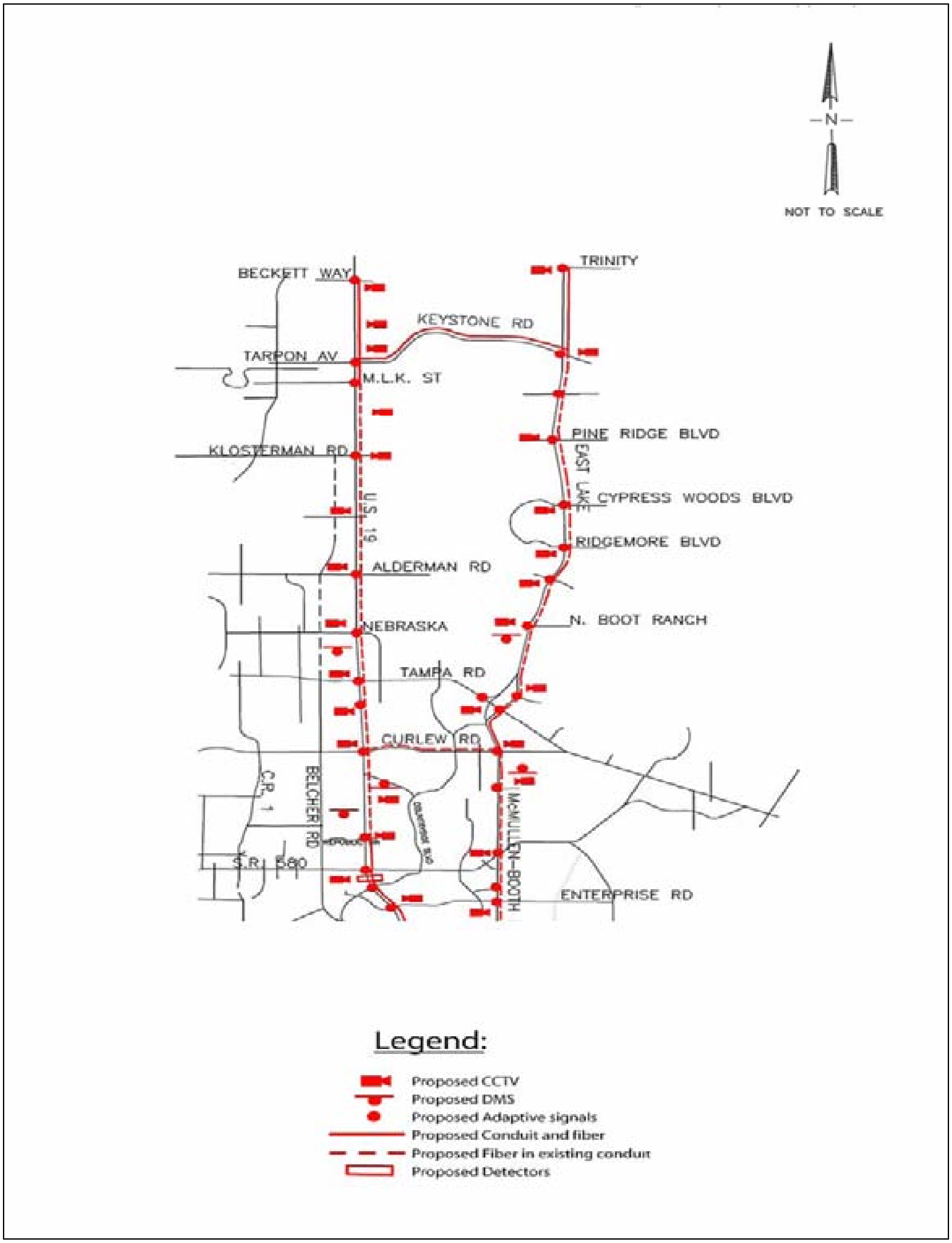

Figure ES1-1: Pinellas Countywide ATMS System Corridors – US 19

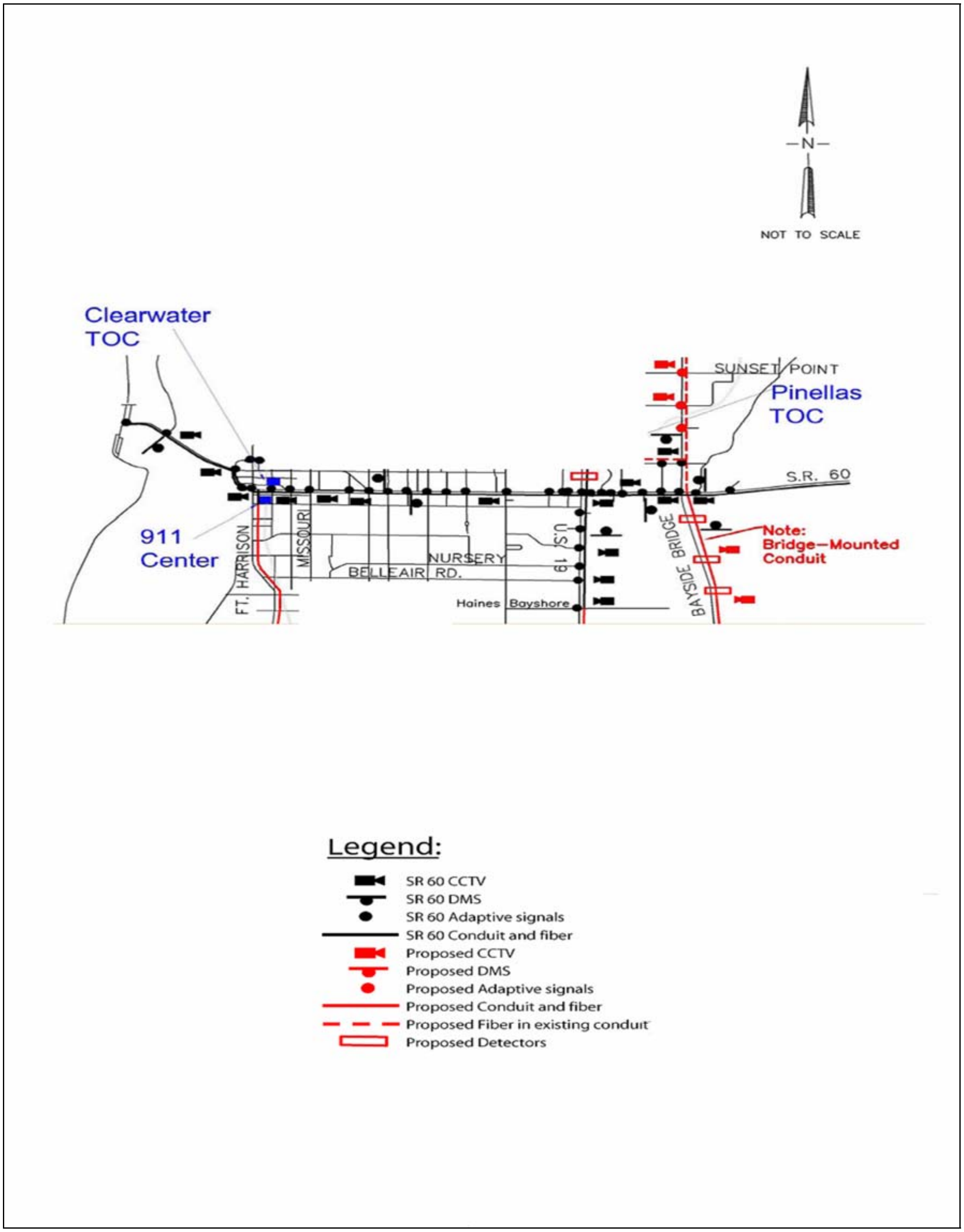

Figure ES 1-2: Pinellas Countywide ATMS System Corridors – SR 60

1.1 CONCLUSIONS

Table ES1-1 and Figure ES1-3 present the total lifecycle cost, savings, and associated benefit/cost ratios for US 19 and SR 60 corridors. The present value of the savings attributed to each adaptive system was estimated using a 10-year life cycle and a 6-percent compounding interest rate. The cost of the adaptive system reflects a portion of the deployment cost for the Pinellas Countywide ATMS project. The required elements for adaptive control included advanced traffic controller and associated cabinet, central control software, local control firmware, adaptive control hardware and software, etc.

Table ES1-1: Total Lifecycle Benefits for Adaptive Control

Corridor	Life-Cycle Savings (Present Value)	System Cost (Adaptive)	Benefit/Cost Ratio
US 19	$6,144,239	$1,020,000	6.0
SR 60	$10,620,861	$1,370,000	7.75
Total Project	$16,765,101	$2,390,000	7.0

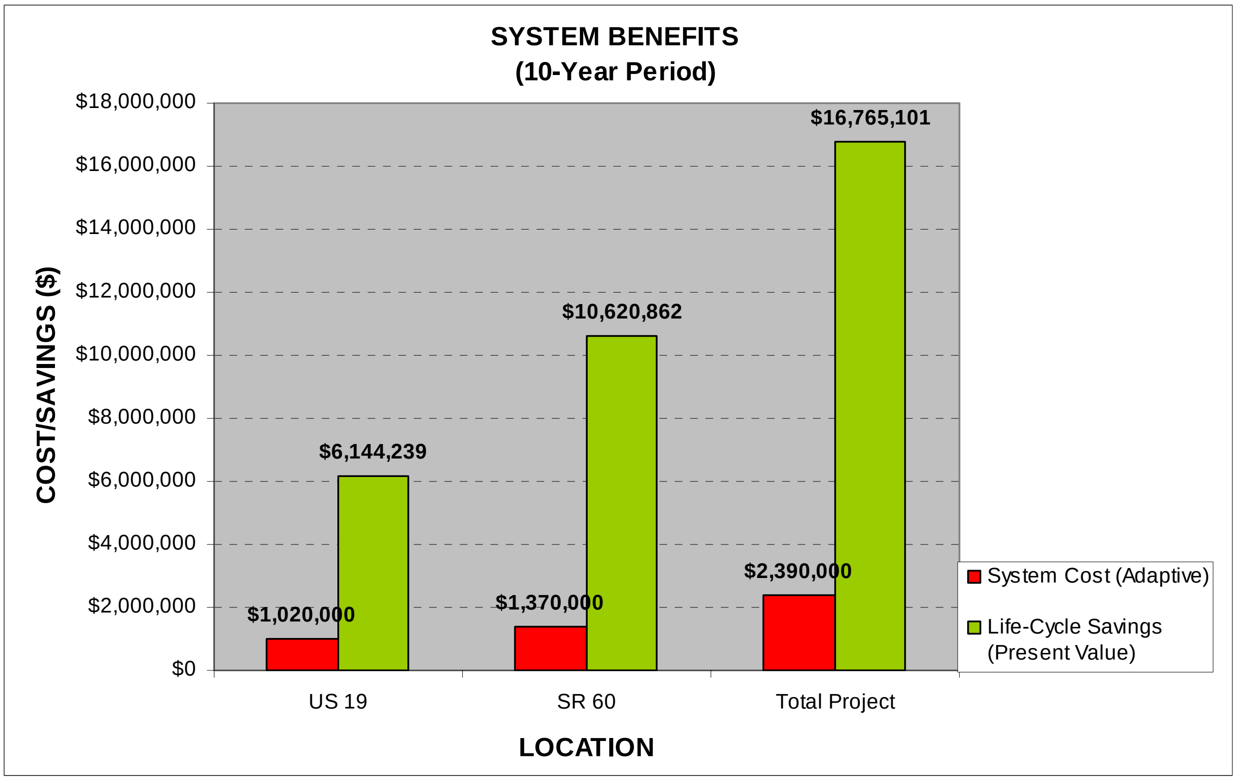

Figure ES1-3: Adaptive system implementation benefits over 10 years

The total deployment cost ($9 million) for the Pinellas Countywide ATMS project encompassed other improvements. These improvements included:

- ❑ Video wall, consoles, servers, electronic devices, communications equipment, etc. in the County's regional traffic management center

- CCTV cameras, dynamic message signs, inductive loops, video image detectors, etc. along US 19 and SR 60 corridors
- Communications infrastructure, fiber optic media, and end equipment for center-to-field devices connectivity.

The overarching conclusion of this assessment study, derived from Table 6-1 findings, is that both adaptive traffic control systems represent great value for each invested dollar, considering the high benefit/cost ratios of 6.0 for US 19 and 7.75 for SR 60 corridors. The present value of the combined total lifecycle savings over a 10-year period for the two adaptive systems is $16.7 million compared to the total adaptive system deployment cost of $2.3 million. This signifies an overall benefit/cost ratio of 7.0, which is significantly higher than return on investments derived from roadway capacity improvement projects. The deployed adaptive traffic control systems are prudent investment choices considering the significant operational benefits measured as savings in labor, consumed fuel, and environmental pollutants.

The following conclusions are pertinent to the operational impacts of the adaptive traffic control systems deployed along US 19 and SR 60 corridors, respectively.

1.1.1 US 19 Corridor

The overarching conclusion for the US 19 corridor is that the adaptive traffic control system represents a great value for each invested dollar, considering the high benefit/cost ratio for the US 19 corridor. The total lifecycle savings over a 10-year period at present value for the adaptive system are $6.14 million. Compared to the system total cost, the benefit/cost ratio is 6.0. Other pertinent conclusions include:

- The main corridor of US 19 experienced significant operational improvements. However, this success was achieved, at least in part, via degradation of traffic operations on side streets. Travel times and other MOEs improved in the direction of peak traffic flow along US 19 for all study periods, however, in certain cases, travel times worsened in the non-peak direction (e.g., northbound flow during AM Peak period). Typically, peak direction volumes were observed to be twice as much as the non-peak direction thus making the associated operational benefits far exceeding the operational disbenefits in the non-peak direction.
- The side streets were penalized along the US 19 corridor to accommodate the traffic flow along the main corridor. The total delay at side streets increased under adaptive traffic control system compared to the traditional control system. However, the US 19 corridor, as whole (including both main corridor and associated side streets), exhibited overall operational improvements attributed to deployment of adaptive traffic control system.
- The study team members perceived traffic operations along the US 19 corridor to be better under adaptive traffic control system than traditional control system as supported by documented statements reflecting fewer stops, higher speeds, lesser braking/delay, and lower drivers’ stress/fatigue.
- The adaptive traffic control system resulted in a net annual savings of $2,187,493 in labor and $409,597 in fuel consumed for the northbound direction on US 19 for a total annual savings of $2,597,090.

- The adaptive traffic control system resulted in a net annual savings of $2,037,037 in labor and $191,016 in fuel consumed for the southbound direction on US 19 for a total annual savings of $2,228,053.
- The adaptive traffic control system resulted in a net savings of $4,224,530 in labor and $600,613 in fuel consumed for the combined northbound and southbound directions on US 19 for a total annual savings of $4,825,143. The corridorwide findings represent significant savings.
- The adaptive traffic control system resulted in a net annual loss of $3,391,661 in labor for all side streets along US 19.
- The adaptive traffic control system resulted in a net annual savings of $834,815 in labor for the overall US 19 corridor comprised of both the main corridor and associated side streets.

1.1.2 SR 60 Corridor

The overarching conclusion for the SR 60 corridor is that the adaptive traffic control system represents a great value for each invested dollar, considering the high benefit / cost ratio for the SR 60 corridor. The total lifecycle savings over a 10-year period at present value for the adaptive system are $10.6 million. Compared to the system total cost, the benefit/cost ratio is 7.75. Other pertinent conclusions include:

- The main corridor of SR 60 experienced significant operational improvements. However, this success was achieved, at least in part, via degradation of traffic operations on side streets. Travel times and other MOEs improved in the direction of peak traffic flow for all study periods, however, in certain cases, travel times and other MOEs worsened in the non-peak direction (e.g., eastbound flow during PM Peak period). Typically, peak direction volumes were observed to be twice as much as the non-peak direction thus making the associated operational benefits far exceeding the operational disbenefits in the non-peak direction.
- The side streets were marginally penalized along the SR 60 corridor to accommodate the traffic flow along the main corridor by the adaptive control system. The total delay at side streets increased under adaptive traffic control system compared to the traditional control system. However, the majority of side streets' delay was attributable to the intersection of US 19 and SR 60, which is an atypical intersection within the study corridor, both in terms of traffic demand intensity and intersection geometry and lane configuration. The overall benefits derived from improved operational performance along the main corridor far exceeded the operational disbenefits imposed on side streets. In addition, the SR 60 corridor, as whole (including both main corridor and associated side streets), exhibited overall operational improvements attributed to deployment of adaptive traffic control system.
- The study team members perceived traffic operations along the SR 60 corridor to be better under adaptive traffic control system than traditional control system as supported by documented statements reflecting fewer stops, higher speeds, lesser braking/delay, and lower drivers' stress/fatigue.
- The adaptive traffic control system resulted in a net annual savings of $622,597 in labor and $305,790 in fuel consumed for the eastbound direction on SR 60 for a total annual savings of $928,388.

- The adaptive traffic control system resulted in a net annual savings of $1,139,670 in labor and $449,239 in fuel consumed for the westbound direction on SR 60 for a total annual savings of $1,588,909.
- The adaptive traffic control system resulted in a net annual savings of $1,762,268 in labor and $755,030 in fuel consumed for the combined eastbound and westbound directions on SR 60 for a total annual savings of $2,517,297. The corridorwide findings represent significant savings.
- The adaptive traffic control system resulted in a net annual savings of $1,443,052 in labor for the overall SR 60 corridor comprised of both the main corridor and associated side streets.

1.2 RECOMMENDATIONS

The assessment of the adaptive traffic control elements of the Pinellas Countywide ATMS project has yielded significant findings and conclusions in the form of tables and charts that could be of value in further fine-tuning and calibrating the systems. Of particular importance is the conclusion that the adaptive traffic control system should not attain its operational improvements along the main corridor by penalizing side streets traffic flow. Further system calibration will be needed by the system providers and engineers to help reduce delays on side streets while continuing to optimize traffic flow on the main corridor. In addition, the reach and effectiveness of the adaptive traffic control system is constrained by intersections and movements where demand consistently exceed available capacity. To further enhance the value of adaptive traffic control in optimizing corridor operations, there is a need for the owner agency to continue its investment program in traditional capacity improvements projects (i.e., auxiliary lanes) at signalized intersections where demand exceeds available capacity. Advanced technologies, including adaptive traffic control system, augment (not replace) the traditional roadway/intersection capacity improvement strategies.

2.0 BACKGROUND

The Florida Department of Transportation (FDOT) has retained consulting services to design, procure, install, and integrate an Advanced Traffic Management System (ATMS) along two major corridors (US 19 and SR 60) in Pinellas County, Florida. Though the overall project, herein referred to as the Pinellas Countywide ATMS project, can be operated from the Pinellas County Regional Traffic Management Center (RTMC), currently the SR 60 corridor is controlled by the City of Clearwater's Traffic Operations Center. In the long run, the RTMC may be staffed with representatives from each local agency though each agency will continue to maintain its own traffic control center for management of respective jurisdictional control resources.

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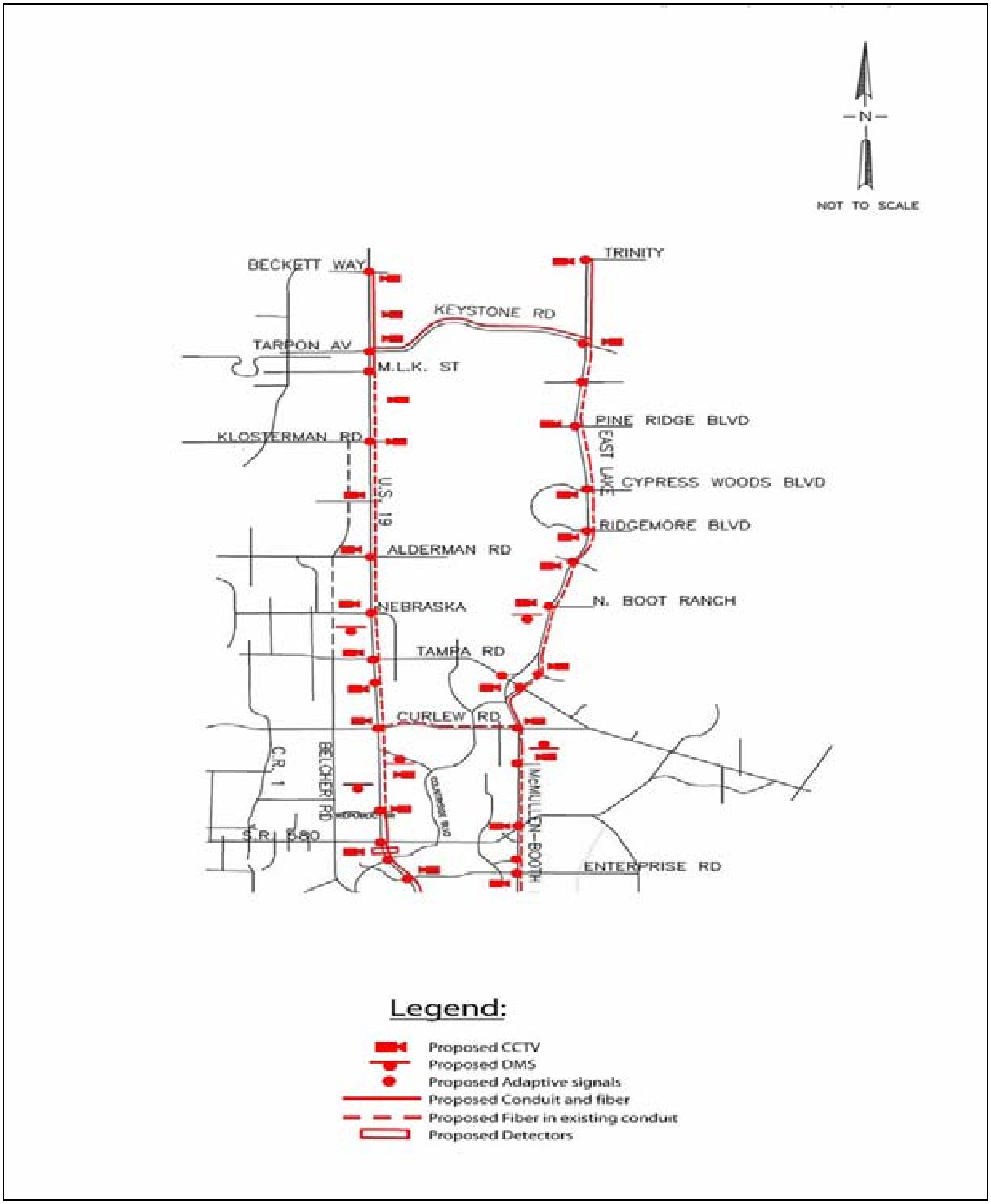

Figure 2-1: Pinellas Countywide ATMS System Corridors – US 19

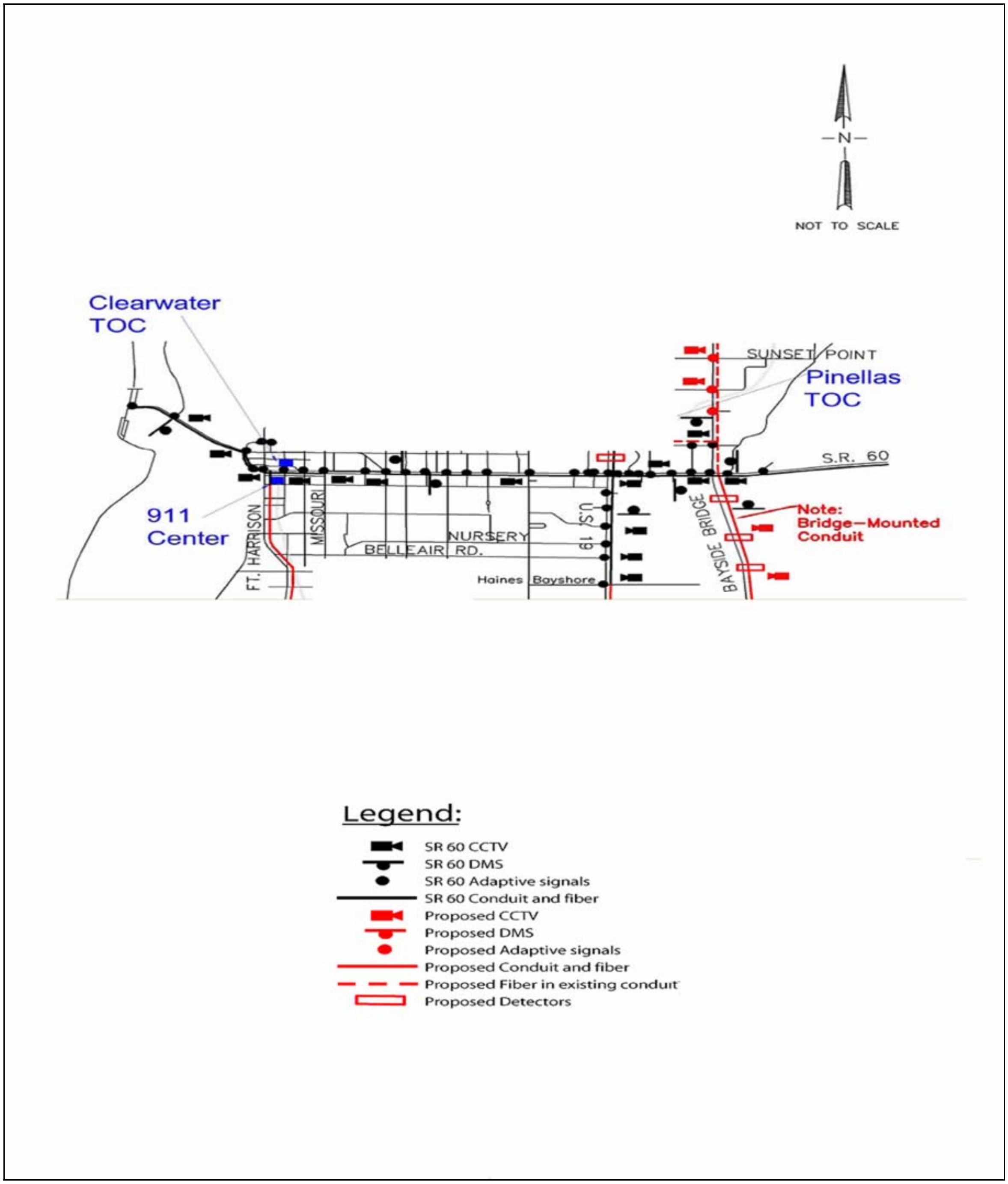

Figure 2-2: Pinellas Countywide ATMS System Corridors – SR 60

3.0 APPROACH

The overall ATMS evaluation plan is segregated into four focus areas or evaluation goals. To better align the evaluation budget to project issues and concerns, the project stakeholders prioritized the evaluation goals and associated objectives and measures of effectiveness as presented in Table 3-1.

Table 3-1: Prioritized Goals and Objectives

Priority	Goals	Objectives	Rank
1	Goal 2 – Assess Transportation System Impacts	Objective 2.1 – Assess Traffic Operations Impacts During Normal Peak Periods and Off-peak Periods	1
		Objective 2.3 – Assess Traffic Operations Impacts during Incidents and Special Events	2
		Objective 2.2 – Assess Traffic Operations Impacts at the System Boundaries	3
2	Goal 1 – Assess System Performance Characteristics	Objective 1.1 – Assess System Performance	4
		Objective 1.2 – Assess System Capabilities	5
3	Goal 3 – Document Cost Impacts	Objective 3.1 – Document Adaptive Signal Control System Costs by System Components	6
		Objective 3.2 – Document Adaptive Signal Control System Personnel Training Costs	7
		Objective 3.3 – Document All Partner Contributions	8
4	Goal 4 – Identify Deployment Issues	Objective 4.2 – Identify Methods for Effective Maintenance and Operations	9
		Objective 4.1 – Identify Deployment Technical Issues	10
		Objective 4.3 – Identify Institutional Issues	11
		Objective 4.4 – Identify Effectiveness of System Manager Approach for Procurement	12
		Objective 4.5 – Define Transferability Issues	13

Specifically, the focus of this paper is on the Evaluation Objectives 2.1 and 2.2, which consider the transportation system impacts of the Pinellas Countywide ATMS during normal peak periods and off-peak periods and at system boundaries. The Evaluation Objectives 2.3 (transportation system impacts during incidents and special events) will be addressed qualitatively based on the perceived value; by system operators, engineers, and managers, of applied technology tools for managing incidents, special events, and system boundaries. The remaining evaluation goals and objectives will be addressed as part of the Final Evaluation Report subject to availability of pertinent data and funding.

3.1 MEASURES OF EFFECTIVENESS

Various measures of effectiveness (MOEs) were used to validate the Evaluation Objectives 2.1 and 2.2 including safety, mobility, efficiency, energy/environment, and productivity as briefly described below.

3.1.1 Safety

The original vision for safely assessment called for leveraging such MOEs as total crash rates, injury crash rates and fatal crash rates. These rates were to be expressed in terms of the number of crashes per million-vehicles entering each study intersection, or traveling along each study corridor. However, for the safety study to be statistically significant there is a need for three years of crash data for each analysis scenario (Before-After). Since the adaptive systems along US 19 and SR 60 became fully operational in late September 2006, sufficient time period was not available to perform a statistically significant crash analysis. Crash data, however, was available for a Before-After comparative crash assessment using descriptive (rather than inferential) statistics. This assessment compared corridorwide traffic crashes segregated by severity and type along the study corridor and associated side streets. The available crash data pertained to Before-After time periods in October 2006 when travel time runs were conducted for representative Before-After scenarios for both US 19 and SR 60 corridors.

3.1.2 Mobility

The MOEs used to quantify impacts on mobility included travel time, number of stops, speed, and control delay along each study corridor on a section-by-section basis as well as level of service and control delay at three critical intersections along each study corridor.

3.1.3 Efficiency

The MOE used to quantify impacts on operational efficiency was throughput at the three critical intersections along each study corridor.

3.1.4 Energy and Environment

The MOEs used to quantify impacts on energy/environments included consumed fuel and concentrations of primary exhaust pollutants such as hydrocarbons (HC), carbon monoxide (CO), and nitrogen oxides (NOx). Fuel consumption and emissions were outputs of the travel time runs under Before-After Scenarios. The model governing the fuel consumption and environment MOEs is an older model, which is based on instantaneous values (second-by-second) of vehicles' speed and acceleration during each travel time run. The model parameters governing the environmental MOEs may be updated in the future to become more representative of motoring vehicles that presently populate the roadway system. Since the improved environmental model will not be available in time for this study, the study used the older model. The fuel and environmental MOEs generated by the older model may not completely represent actual field experience; however, they do serve as a good base for comparing Before-After scenarios.

3.1.5 Productivity

The MOE used to quantify impacts on productivity was savings/losses attributed to vehicular operation (fuel) and travelers' time (control delay). The adaptive traffic control system is hypothesized to improve fuel consumption and travelers' time corridorwide, which translate into associated cost savings. In addition, the improvement in the central system monitoring and data management capabilities would enhance productivity resulting from synergistic benefits

attributed to the value of automation in traffic operations and maintenance. This latter aspect of system benefits will be addressed as part of the final evaluation reporting.

The Before-After travel time runs provided findings regarding savings or loss in average delay (seconds per vehicle) and average fuel (gallons per vehicle). To quantify these findings to monetary savings or losses on an annual basis, the analysis assumed the following average values:

- $2.5 for a gallon of fuel
- $10 for a person-hour
- 1.2 persons per vehicle (vehicle occupancy).

To derive the annual savings or cost, the savings/losses in delay and consumed fuel during each study period were multiplied by the representative number of annual hours for each study period as shown below.

- Study period for AM Peak (7–9 AM) – with each day containing two representative hours for a total of 520 representative hours in a year
- Study period for AM Off-Peak (10–11:30 AM) – with each day containing three representative hours (9 AM–12 PM) for a total of 780 representative hours in a year
- Study period for PM Off-Peak (1:30–3 PM) – with each day containing three representative hours (1–4 PM) for a total of 780 representative hours in a year
- Study period for PM Peak (4–6 PM) – with each day containing three representative hours (4–7 PM) for a total of 780 representative hours in a year.

3.2 STUDY CORRIDORS AND CRITICAL INTERSECTIONS

The two study corridors included US 19 and SR 60 as shown in Figures 2-1 and 2-2, respectively. For each study corridor, three “critical intersections” were selected in consultation with Pinellas County stakeholders. These critical intersections were used to serve as benchmarks in differentiating traffic operations between the main corridor and associated side streets. The assessment considered field-based Before-After comparative analysis of operational measures of effectiveness such as travel times, speeds, control delay, fuel consumption, etc. The differentiation between the main corridor and its side streets provided the opportunity to consider main corridor’s operational impacts in the context of operational impacts to side streets approaches. Level of Service (LOS) runs were conducted at each critical intersection to identify operational impacts to side streets. Each study corridor and associated critical intersections are briefly discussed below. The critical intersections selected for the US 19 and SR 60 corridors included:

- US 19 and Curlew Road (Section 4)
- US 19 and Alderman Road (Section 4)
- US 19 and Tarpon Road.(Section 7)
- SR 60 and US 19 (Section 3)
- SR 60 and Belcher Road (Section 2)
- SR 60 and Highland Avenue.(Section 1)

3.2.1 US 19 Corridor

The US 19 study corridor is almost 11 miles long and comprised of 11 signalized intersections situated between Enterprise Road on the south and Beckett Way on the north. The corridor is divided into three operational sections as shown in Figure 2-1.

- Section 1 is comprised of the segment of US 19 between Enterprise Road and Republic Drive
- Section 4 is comprised of the segment of US 19 between Curlew Road and Old Post Road
- Section 7 is comprised of the segment of US 19 between Klosterman Road and Beckett Way.

Two separate operational scenarios were considered:

- Before Scenario – US 19 corridor running under historical time-of-day plans for all three sections (1, 4, and 7)
- After Scenario – US 19 corridor running under adaptive traffic control for the entire corridor.

Each section was governed by an operational mode that was independent of the other two sections under the Before Scenario. All three sections operated under independent time-based coordination with pre-developed time-of-day plans, which signified operational interdependence between sections resulting from random traffic arrivals and operations at system boundaries.

Upon completion of field-based data collection and data reduction, Pinellas County indicated that the intersections of Enterprise Road and Republic Drive (Section 1) and Beckett Way (Section 7) were running free throughout the data collection period representing Before-After Scenarios. This finding required all pertinent data collected for these intersections to be discarded from further consideration. In addition, the travel time runs, conducted for the US 19 corridor, were adjusted to reflect new boundaries for Sections 4 and 7. Labeled as "adjusted runs," these runs served as the basis for assessing Sections 4 and 7 along the US 19 corridor.

3.2.2 SR 60 Corridor

The SR 60 study corridor is 4.6 miles long and comprised of 17 signalized intersections situated between Damascus Road on the east and Hillcrest Road on the west. The corridor is divided into three operational sections as shown in Figures 2-2.

- Section 1 is comprised of the segment of SR 60 between Hillcrest Avenue and Hercules Avenue
- Section 2 includes the intersection of Belcher Road and SR 60
- Section 3 is comprised of the segment of SR 60 between Old Coachman Road and Damascus Road.

Three separate operational scenarios were considered:

- Before Case – SR 60 corridor running under time-of-day plans (Sections 1 and 3) or free operations (Section 2)
- After Case 1 – SR 60 corridor running under adaptive traffic control excepting Belcher Road, which ran under free mode of operations. This scenario enables statistically significant comparative assessment of Sections 1 and 3 separately and independently since SR 60 and Belcher Road (Section 2) was running under free mode of operations under both Before-After Scenarios. This approach eliminated the impacts of random traffic arrivals and operations on Sections 1 and 3 that could be attributed to SR 60 and Belcher Road running free.
- After Case 2 – SR 60 corridor running in its entirety under adaptive traffic control, including Belcher Road, to allow comparative assessment of boundary conditions associated with Sections 1 and 3 during Before-After Scenarios.

Each section was governed by an operational mode that was independent of the other two sections under the Before Scenario. Sections 1 and 3 operated under independent time-based coordination with pre-developed time-of-day plans whereas Section 2 operated under free mode of operations, which signified operational independence among sections resulting from random traffic arrivals and operations at system boundaries.

3.3 Data Sources

A variety of quantitative data sources were used:

- Travel time runs along study corridor
- Level of service runs at each critical intersection within each study corridor
- System generated data pertaining to side street approaches at three critical intersections along each study corridor.

The validation of the applicable evaluation goals and objectives required collection of pertinent data. The data directly supported the respective evaluation measures of effectiveness. The sections below present the data collection methods used for this assessment.

3.4 Before – After Data Collection Schedule

The Before Scenario was represented by predetermined traditional time of day plans (i.e., background cycles, splits, and offsets). The After Scenario was represented by adaptive traffic control system, capable of assigning in real-time minimum delay cycles, splits, and relative offsets at consecutive set (i.e., peer-to-peer) of signalized intersections. The traditional and adaptive control systems are founded on entirely different operational concepts. Adaptive traffic control's use of potentially different minimum delay cycle length at adjoining signalized intersections is envisioned to contribute to lowering the control delay for all applicable signalized intersections and overall corridor compared with time of day plans.

Table 3-2 presents the schedule for conducting the travel time and level of service runs for Before and After Scenarios for each study corridor:

Table 3-2: Travel Time and Level of Service Runs Schedule

Scenario	SR 60	US 19
Before (Time Base Coordination)	❑ October 10,11,12	❑ October 10,11,12,17,18
After Scenario (Adaptive)	❑ October 3,4,5 (Belcher running under adaptive) ❑ October 17,18,19 (Belcher running free operation)	❑ October 3,4,5,24,25,26

3.5 SYSTEM GENERATED DATA

As part of the Pinellas Countywide ATMS deployment, detectors were installed upstream of all approaches to signalized intersections, where practical. System generated data such as throughput and spot speed was collected during the study periods when travel time runs were collected to represent Before-After Scenarios. Throughput data was recorded by the system in one-minute increments for each critical intersection approach during each study period. This data was extracted for each study period, converted to hourly values, and used to estimate annual savings and costs attributable to delay and fuel consumptions.

3.6 TRAVEL TIME AND LEVEL OF SERVICE RUNS

The "floating car" method was used to validate the MOEs associated with travel time runs and level of service runs. For the travel time runs, probe vehicles were used to measure travel time, speed, number of stops, control delay, fuel consumption, and environmental parameters. The probe vehicles traverse the study corridor as “an average” vehicles during each applicable study period. For the level of service runs, probe vehicles were used to measure control delay. The probe vehicles traverse all approaches and movements of the critical intersections within each study corridor as “an average” vehicles during each applicable study period. The study periods included:

- ❑ AM Peak (7:00 - 9:00 AM)
- ❑ AM Off-Peak (10:00 - 11:30 AM)
- ❑ PM Off-Peak (1:30 - 3:00 PM)
- ❑ PM Peak (4:00 – 6:00 PM).

A team of two drivers conducted preliminary travel time runs along each study corridor. Data derived from the preliminary runs was used to measure the mean and standard deviation of travel times as the basis for identifying the number of runs (sample size) required to achieve a 95% confidence level with a 10% tolerance of error. Any travel time run affected by external influences was discarded during both the preliminary and final travel time runs. These external influences constituted aberrations from “normal traffic flow” such as inclement weather, incidents causing lane blockage, crashes, signal preemption, or distractions (rubbernecking) that would adversely impact typical traffic operations along the study corridor.

After conducting preliminary travel time runs and determining required sample size for 95% confidence level, a team of six drivers was mobilized for four weeks in October, 2006 to

collect Before-After operational data. Two drivers were assigned to each corridor to conduct travel time runs for each study period. Travel time runs were conducted for both Before-After Scenarios. The remaining two drivers conducted exclusively the level of service runs as described in the Field Procedure subsection below. Each team was assigned a team leader who maintained continuous contact with system operators of the Pinellas County Regional Traffic Management Center and the City of Clearwater Traffic Control Center. The team members received real-time information about the state of the traffic flow along each study corridor documented on daily worksheets. In addition to run information, the worksheets summarized notes about field conditions (e.g., incidents, crashes, signal preemptions, vehicle break-downs, unusually large queues, inclement weather, etc.) as well as personal observations and perspectives regarding overall traffic operations (e.g., level of congestion, driving comfort, aggressive drivers' behavior, etc.).

3.6.1 Field Procedure

Each probe vehicle was equipped with a GPS receiver and a laptop PC to use in conducting travel time and level of service runs. The GPS units were manufactured by Haicom Electronics Corp., model number 204E. The GPS receiver provided position and velocity information at a rate of once every second processed on each laptop using a program developed by Jamar Technologies called GPS2LT, Version 1.5.1. GPS receivers were mounted on the roof of the probe vehicle and connected to the onboard laptops.

The procedure for travel time runs included launching the laptops and GPS2LT software and monitoring proper receipt of the GPS data. The probe vehicle drivers would subsequently press a key to initiate data collection. The driver would initiate the run by entering traffic flow a predetermined distance before the starting point of the study corridor to maintain random arrival into the traffic stream. As the probe vehicle passed through the first intersection of the study corridor, the driver would press the space bar to mark the opposing traffic flow's stop bar of that intersection. At the end of the run, the driver would press the space bar again to mark the opposing traffic flow's stop bar of the final intersection of the study corridor. The driver would subsequently conclude the run and initiate a new run in the opposing direction. All drivers were instructed to use the "floating car" technique, which required maintaining an average speed during each run. During data collection, drivers would maintain communications, via cell phones, with the team leader for each study corridor and respective Traffic Management/Control Center as needed to identify/confirm/document external influences impacting the corridor's traffic operations. Examples of external influences were signal preemptions, crashes, signal malfunctions, and inclement weather. The impacted runs were flagged to be discarded prior to data analysis.

The procedure for level of service runs was similar to the travel time runs. The same equipment and software were used as described above. The level of service data allows for evaluation of the "control delay" experienced by the probe vehicle as it enters and leaves a given intersection. For the level of service runs, the driver would press a key to begin data collection, enter traffic flow prior to the intersection, match speeds with the flow of traffic, press the space bar to mark the stop bar of the intersection, drive through the intersection, and end the run once average flow speeds were achieved again after clearing the intersection. This process was repeated for all intersection movements at each critical intersection within the study corridor. The same drivers were used for travel time/level of service runs during Before-After Scenarios to maintain consistent driving behavior. In addition, drivers represented diversity

in terms of ethnic groups, gender, and age, which yielded a broad representation of driver behavior/perception as prevalent in typical traffic flow.

3.6.2 Data Reduction and Analysis

Data collected through travel time/level of service runs was stored in electronic files and backed up on a daily basis during data collection period. Travel time data files were processed using Jamar Technologies' travel time software, PC-Travel for Windows Version 1.11.1. This version of PC-Travel included a new feature that automatically calculated the number (sample size) of runs needed to achieve statistical significance using the Institute of Transportation Engineers specified procedures. This feature ensured that the number of viable runs were sufficient to attain statistical significance at a 95% confidence level.

The level of service data files were processed using a program from Jamar Technologies called PC-LOS, Version 1.1.1. The PC-LOS program provided the opportunity to view the speed profile associated with each run, identify the point where the probe vehicle was forced to slow down as it was approaching the critical intersection, and mark the point where the probe vehicle regained the running speed of the traffic stream after crossing the study intersection. Once these two "control points" were established, the software would calculate the overall control delay experienced by the probe vehicle for that movement and associated run. The value of the control delay was used by the software to assign a level of service "letter grade" for the run in accordance with the Highway Capacity Manual. PC-LOS averaged the control delay associated with many runs for applicable movements to calculate the control delay for the approach or intersection as appropriate. Specific runs, impacted by external influences, were discarded prior to undertaking data reduction and analysis.

4.0 US 19 FINDINGS

This section presents the study findings attributed to the US 19 corridor derived from many data sources including system generated data (throughput and spot speed), travel time runs, and level of service runs. The findings reflect the results of the “adjusted runs” described in section 3.2.1 of this paper. The findings of the Before-After Scenarios are presented in various tables representing the Before Scenario, the After Scenario, and the difference between the Before and After Scenarios. This difference is color-coded for each applicable MOE to better discern the impact of adaptive traffic control system operationally:

- Green is used to indicate the adaptive traffic control improved the applicable MOE relative to the traditional time-of-day system
- Red is used to indicate the traditional traffic control system performed better relative to the adaptive traffic control system for the applicable MOE
- Yellow is used to indicate no measurable difference between the performance of the adaptive and traditional control systems relative to the applicable MOE.

4.1 MAIN US 19 CORRIDOR FINDINGS

The US 19 corridor’s operational findings are segregated into two elements: 1) the main US 19 corridor irrespective of side streets; and 2) the side streets. This segregation is essential to differentiate how each corridor element performed operational independent of the other and as a whole (corridorwide). The findings represent Before-After MOEs, which were quantified into monetary values to identify the annualized impacts associated with deployment of adaptive traffic control system.

4.1.1 US 19 Throughput and Spot Speed Study

Table 4-1 and Figure 4-1 present the study findings for throughput and spot speed attributed to system generated data on all approaches to the three critical intersections. To quantify the degree of difference between Before-After MOEs, percentage change values are included in Table 4-1 for both throughput and spot speed. The associated findings are summarized as follows:

- Throughput and spot speed for the northbound and southbound directions along US 19 mostly improved for all three intersections during all study periods. The only exception was Alderman Road, where throughput decreased during the PM off-peak and PM peak periods. Overall, there was improvement in operational performance on the main US 19 corridor.
- Throughput and spot speed for the side streets of the three critical intersections mostly worsened for all study periods excepting the westbound approach of Tarpon Avenue during the three study periods. Throughput and spot speed for the eastbound side street approaches to the critical intersections mostly worsened for all study periods with a significant reduction in throughput (-35%) observed at Tarpon Avenue during the AM peak period. The throughput and spot speed, for the

westbound side street approaches to the critical intersections mostly worsened for all study periods excepting Tarpon Avenue, which indicated improvements under adaptive traffic control during three study periods.

4.1.2 US 19 Travel Time Study

Tables 4-2, 4-3, and 4-4 and Figures 4-2 and 4-3 present the findings for the travel time runs associated with the northbound direction, southbound direction, and overall corridor (combined). The travel time tables are organized as follows:

- ❑ The far left column of each table presents the average volume (vehicles/study period) for each study period over the entire study duration.
- ❑ Columns represent the difference between Before and After values for such MOEs as travel time (seconds); speed (mph); number of stops; total delay (seconds); fuel consumption (gallons); and hydrocarbons (grams), carbon monoxide (grams), and nitrogen oxide (grams) emissions, respectively.

The associated findings for the US 19 corridor are summarized as follows:

- ❑ The adaptive traffic control system performed better than the traditional system in improving the northbound traffic operations during the PM Off-Peak and PM Peak periods for Section 2 and during the AM Off-Peak, PM Off-Peak, and PM Peak periods for Section 7.
- ❑ The adaptive traffic control system performed better than the traditional system in improving the southbound traffic operations during the AM Peak, PM Off-Peak, and PM Peak periods for Section 2 and during the AM peak, AM Off-Peak, and PM Off-Peak periods for Section 7.
- ❑ The adaptive traffic control system improved the overall corridor's traffic operations (northbound and southbound directions combined) during most of the study periods. Compared with the traditional system, the adaptive traffic control system seems to improve the corridor's traffic operations in the peak direction (southbound in the AM Peak and northbound in the PM Peak periods) during the AM Peak and PM Peak periods by favoring the peak direction of flow and compromising traffic flow in the non-peak direction.
- ❑ During the PM Off-Peak, all MOEs indicated performance improvements for all sections in the northbound and southbound directions. Corresponding combined values for the entire corridor in Table 4-4 also indicated performance improvements for all the MOEs.

Tables 4-5 and 4-6 present the travel time MOEs in terms of percentages for the northbound and southbound directions. These tables offer an overarching comparison between the Before-After Scenarios. The presented MOEs are travel time, speed, number of stops, delay and fuel consumption.

4.1.3 US 19 Corridor Cost/Savings Analysis

Tables 4-7, 4-8, 4-9, and 4-10 present the impact of adaptive traffic control system on control delay and fuel consumption quantified into daily and annual monetary savings/loss for northbound direction, southbound direction, and overall corridor (combined).

The associated findings for the US 19 corridor are summarized as follows:

- ❑ The adaptive traffic control system resulted in a net annual savings of $2,187,493 in labor and $409,597 in fuel consumed for the northbound direction on US 19 for a total annual savings of $2,597,090.
- ❑ The adaptive traffic control system resulted in a net annual savings of $2,037,037 in labor and $191,016 in fuel consumed for the southbound direction on US 19 for a total annual savings of $2,228,053.
- ❑ The adaptive traffic control system resulted in a net annual savings of $4,224,530 in labor and $600,613 in fuel consumed for the combined northbound and southbound directions on US 19 for a total annual savings of $4,825,143. The corridorwide findings represent significant savings.

4.2 US 19 Side Street Findings

The side street findings are comprised of intersection level of service and control delay for each critical intersection and study period. These findings are based on level of service runs conducted at each critical intersection. Tables 4-11 and 4-12 present the findings from the level of service study. The associated findings for US 19 side streets are summarized as follows:

- ❑ The side streets' approaches to the US 19 corridor, as represented by the three critical intersections, experienced degradation in traffic operations during most of the study periods under adaptive traffic control when compared to the traditional system.
- ❑ The adaptive traffic control system resulted in a net annual loss of $1,271,873 in labor associated with the side streets of the three representative critical intersections along the US 19 corridor or $423,957 average net annual loss per intersection.
- ❑ Considering the average annual loss of $423,957 per intersection, the adaptive traffic control system resulted in a net annual loss of $3,391,661 in labor associated with the side streets of all signalized intersections along the US 19 corridor.

4.3 US 19 Corridorwide Summary of Benefits

Tables 4-10 and 4-12 and Figure 4-4 present a high-level summary of the overall monetary impact of adaptive traffic control system in improving the traffic operations along US 19 corridor and associated side streets. The savings or losses in average delay (seconds per vehicle) and average fuel (gallons per vehicle) were quantified to monetary values on an annual basis using the methodology previously described. The findings pertain to the northbound direction, southbound direction, overall corridor (combined), and side streets' approaches.

The average labor cost for the three critical intersections was applied to each of the remaining eight intersections on the US 19 corridor to arrive at a total intersection labor cost.

Since the critical intersections selected for this study are typically the busiest and most congested along the US 19 corridor, the total side street cost represents the worst case scenario. The total side street cost was subsequently subtracted from the labor savings along the US 19 corridor to arrive at the total net savings/year. The total net savings along the US 19 corridor was $834,815 annually attributed to deployment of adaptive traffic control system.

4.3.1 Descriptive Crash Assessment

Crash data was collected for Before-After Scenarios in October 2006. This data provided the opportunity to assess Before-After traffic crashes using descriptive (rather than inferential) statistics. This assessment compared corridorwide traffic crashes segregated by severity and type along the study corridor and side streets' approaches. Tables 4-13 and 4-14 and Figures 4-5 and 4-6 present the traffic crash findings for the US 19 corridor segregated by severity and type. The MOE is color coded, as previously defined to discern increase or decrease in the number of crashes. The following findings are observed:

- The frequency of traffic crashes, in terms of both severity and type, reduced under adaptive traffic control system when compared with the traditional system. This finding applied to the overall US 19 corridor (which included side streets) as well as the main US 19 corridor (which excluded side streets). In addition, there was no change in frequency of traffic crashes on side streets under adaptive traffic control.

The frequency of rear-end crashes was especially reduced (7 of 8 or 87.5% of all crashes corridorwide) under adaptive traffic control system when compared with the traditional system. This finding applied to the overall US 19 corridor (which included side streets) as well as the main US 19 corridor (which excluded side streets). In addition, there was no change in frequency of rear-end crashes on side streets under adaptive traffic control. This finding reflects lowers levels of congestion and traffic queues on the main US 19 corridor.

4.4 PERCEPTION STUDY

In addition to performing descriptive crash analysis, the study team members also documented, during each data collection day, personal observations and perceptions of the corridor's traffic operations during each assessment scenario. The following findings are representative of the overall observations and perceptions of the study team members who conducted travel time or level of service runs applicable to Before-After Scenarios:

- During the AM Peak study period, team members experienced no significant changes in traffic speed or levels of congestion in the northbound direction when comparing traffic operations under the adaptive and traditional control systems. However, for the southbound direction, the overall observation was a sizeable increase in the levels of congestion when traffic operations were controlled by the traditional control system. This increase was characterized by such statements as "having twice more congestion than adaptive mode of operations" or "extreme traffic southbound north of Tarpon Avenue."
- Minor improvements in traffic flows were perceived by team members under adaptive traffic control system compared with the traditional control system during the AM Off-

Peak and PM Off Peak periods. Traffic conditions were described as “higher volumes but smooth and efficient flow” under the adaptive control system.

- For the PM Peak period, team members found that the southbound runs were “smooth and quick” with fewer red lights under the adaptive traffic control system. Furthermore, the northbound runs encountered longer red lights during traditional control system when compare with the adaptive control system with approximately 25% higher congestion levels. Heavy traffic “jams” were observed at Tarpon Ave for the northbound runs, “extending over a quarter mile” beyond Martin Luther King Avenue. The delays “were up to 20 minutes, twice as long as” the adaptive traffic control system.
- The overall impression of the team members was that the adaptive control system performed better than the traditional control system by providing smoother traffic flow, less delay, and higher speeds.

US 19 Corridor Findings

Table 4-1: US 19 Throughput Study

INTERSECTION	TIME PERIOD	EB Volume (veh/Time Period) After	EB Volume (veh/Time Period) Before	EB Volume (After-Before) Volume	EB Percent Change (%)	EB Speed (mph) After	EB Speed (mph) Before	EB Speed (After - Before) Speed	EB Percent Change (%)	NB Volume (veh/Time Period) After	NB Volume (veh/Time Period) Before	NB Volume (After-Before) Volume	NB Percent Change (%)	NB Speed (mph) After	NB Speed (mph) Before	NB Speed (After - Before) Speed	NB Percent Change (%)
Section 4 Alderman	AMO Period	1425	1532	-107	-6.98%	28.3	30.1	-1.8	-5.84%	3064	2937	127	4.31%	48.8	45.7	3.2	6.93%
	AMP Period	2073	2261	-188	-8.32%	26.1	28.0	-1.9	-6.84%	3701	3485	216	6.20%	52.2	51.6	0.5	1.05%
	PMO Period	1939	1884	55	2.92%	24.6	28.9	-4.3	-14.89%	3926	4676	-750	-16.04%	34.5	36.6	-2.1	-5.73%
	PMP Period	2640	2650	-9	-0.35%	12.1	17.2	-5.1	-29.87%	7040	8198	-1158	-14.13%	30.4	22.7	7.7	34.01%
Section 4 Curlew	AMO Period	1816	1942	-126	-6.46%	41.2	40.1	1.1	2.70%	2522	2493	29	1.18%	50.9	42.1	8.7	20.76%
	AMP Period	2771	2983	-211	-7.09%	41.9	43.6	-1.7	-3.92%	3060	3358	-298	-8.86%	53.7	45.6	8.1	17.73%
	PMO Period	2111	2311	-200	-8.65%	41.8	44.7	-3.0	-6.66%	3413	3168	245	7.74%	43.2	33.3	9.8	29.50%
	PMP Period	3278	3470	-192	-5.54%	42.3	46.0	-3.7	-8.04%	6299	5718	581	10.16%	33.9	25.9	8.0	31.00%
Section 7 Tarpon	AMO Period	751	839	-88	-10.48%	37.1	38.5	-1.3	-3.50%	2367	2302	65	2.83%	47.6	43.0	4.6	10.70%
	AMP Period	689	1061	-372	-35.07%	35.2	39.3	-4.0	-10.30%	2973	2774	199	7.17%	52.0	44.4	7.6	17.09%
	PMO Period	1026	1072	-45	-4.22%	35.4	38.3	-2.9	-7.68%	3134	2935	199	6.77%	42.6	35.1	7.5	21.26%
	PMP Period	1324	1602	-278	-17.36%	24.3	38.2	-13.9	-36.34%	6125	5327	798	14.97%	36.2	12.6	23.7	188.24%

INTERSECTION	TIME PERIOD	SB Volume (veh/Time Period) After	SB Volume (veh/Time Period) Before	SB Volume (After-Before) Volume	SB Percent Change (%)	SB Speed (mph) After	SB Speed (mph) Before	SB Speed (After - Before) Speed	SB Percent Change (%)	WB Volume (veh/Time Period) After	WB Volume (veh/Time Period) Before	WB Volume (After-Before) Volume	WB Percent Change (%)	WB Speed (mph) After	WB Speed (mph) Before	WB Speed (After - Before) Speed	WB Percent Change (%)
Section 4 Alderman	AMO Period	3149	3243	-94	-2.91%	43.3	36.7	6.6	17.98%	620	1066	-447	-41.89%	26.2	26.5	-0.3	-1.26%
	AMP Period	7170	7010	160	2.29%	40.1	24.0	16.1	66.92%	857	1381	-524	-37.96%	28.5	23.0	5.5	23.96%
	PMO Period	3413	3548	-136	-3.82%	37.9	33.3	4.6	13.67%	759	1312	-552	-42.11%	25.4	27.3	-1.9	-6.97%
	PMP Period	4157	5788	-1631	-28.18%	52.1	39.8	12.4	31.06%	1302	2357	-1055	-44.77%	21.0	25.1	-4.1	-16.17%
Section 4 Curlew	AMO Period	3490	3206	284	8.85%	52.1	42.4	9.8	23.06%	1625	2195	-570	-25.98%	46.9	43.1	3.8	8.90%
	AMP Period	7107	5899	1208	20.48%	43.7	39.7	3.9	9.93%	2598	3920	-1323	-33.74%	44.5	47.9	-3.4	-7.14%
	PMO Period	3766	3398	369	10.85%	51.4	41.8	9.7	23.13%	1828	2491	-664	-26.64%	44.3	44.9	-0.5	-1.21%
	PMP Period	4757	4530	228	5.02%	45.2	51.6	-6.5	-12.51%	2740	3708	-968	-26.11%	40.6	40.4	0.3	0.73%
Section 7 Tarpon	AMO Period	3166	2925	241	8.25%	45.0	45.1	-0.1	-0.17%	1833	1628	205	12.57%	35.8	37.0	-1.3	-3.41%
	AMP Period	6976	5689	1288	22.64%	29.2	27.8	1.4	5.09%	2850	2270	579	25.52%	18.9	29.7	-10.8	-36.47%
	PMO Period	3272	3195	77	2.41%	47.2	43.0	4.2	9.78%	1912	1800	112	6.24%	34.1	35.2	-1.1	-3.00%
	PMP Period	4427	4779	-352	-7.36%	51.4	49.7	1.7	3.42%	2721	2782	-62	-2.21%	28.0	30.5	-2.5	-8.18%

Table 4-2: US 19 Northbound Travel Time Study

Scenario	Study	Section 4 - Northbound									Section 7 - Northbound									Overall US 19 Corridor - Northbound (Section 4 + Section 7)							
		Avg Throughput (veh/Study Period)	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)	Avg Throughput (veh/Study Period)	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)
After-Before	AMP	3593	80.6	-6.8	0.8	60.7	0.0217	1.7445	17.3018	0.2999	2874	7.8	-1.5	0.2	6.1	0.0032	-0.0764	-0.8026	-0.2447	88.4	-8.3	1	66.8	0.0249	1.6681	16.4992	0.0552
After-Before	AMO	3000	4.4	-0.4	0.3	-1.1	0.0068	0.6248	9.8821	0.5132	2334	-20	3.2	-0.5	-14.9	-0.0002	0.7239	19.1857	0.8832	-15.6	2.8	-0.2	-16	0.0066	1.3487	29.0678	1.3964
After-Before	PMO	4301	-19.7	1.4	-0.1	-19.8	-0.0042	-0.2099	-0.1187	0.098	3035	-3	0.4	0.2	-2.7	0.0114	1.1645	20.7411	1.0865	-22.7	1.8	0.1	-22.5	0.0072	0.9546	20.6224	1.1845
After-Before	PMP	7619	-64.8	3.3	-0.3	-64.9	-0.0115	-0.977	-3.2566	0.0246	5726	-214.8	15.8	-5	-212	-0.0379	-4.7442	-17.303	-1.8384	-279.6	19.1	-5.3	-276.9	-0.0494	-5.7212	-20.5596	-1.8138

Table 4-3: US 19 Southbound Travel Time Study

Scenario	Study	Section 4 - Southbound									Section 7 - Southbound									Overall US 19 Corridor - Southbound (Section 4 + Section 7)							
		Avg Throughput (veh/Study Period)	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)	Avg Throughput (veh/Study Period)	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)
After-Before	AMP	7090	-162.5	12	-2.9	-155.9	-0.0159	-3.7286	-8.2442	-1.6827	6332	-106.9	7.3	-1.2	-94.4	-0.0113	-3.6389	-14.0694	-2.4827	-269.4	19.3	-4.1	-250.3	-0.0272	-7.3675	-22.3136	-4.1654
After-Before	AMO	3196	5	-0.7	0.4	3	0.0107	1.146	20.4425	0.891	3045	-49.8	3.9	-0.4	-45.7	0.008	-0.5124	13.445	-0.0588	-44.8	3.2	0	-42.7	0.0187	0.6336	33.8875	0.8322
After-Before	PMO	3481	-64.5	8	-1	-54.4	-0.0117	-1.9478	-14.7407	-1.0058	3234	-64.3	4.3	-0.8	-62.8	-0.0114	-2.3426	-18.3934	-1.4316	-128.8	12.3	-1.8	-117.2	-0.0231	-4.2904	-33.1341	-2.4374
After-Before	PMP	4271	-11.9	1.7	0	-9.1	0.0077	0.254	10.0966	0.2813	4603	28.5	-2	0.2	28.1	0.0024	-0.2955	-10.6493	-0.6735	16.6	-0.3	0.2	19	0.0101	-0.0415	-0.5527	-0.3922

Table 4-4: US 19 Combined Travel Time Study

Scenario	Study	Section 4 - Northbound + Southbound									Section 7 - Northbound + Southbound									Overall US 19 Corridor - Northbound + Southbound (Section 4 + Section 7)							
		Avg Throughput (veh/Study Period)	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)	Avg Throughput (veh/Study Period)	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)
After-Before	AMP	10683	-81.9	5.2	-2.1	-95.2	0.0058	-1.9841	9.0576	-1.3828	9206	-99.1	5.8	-1	-88.3	-0.0081	-3.7153	-14.872	-2.7274	-181	11	-3.1	-183.5	-0.0023	-5.6994	-5.8144	-4.1102
After-Before	AMO	6196	9.4	-1.1	0.7	1.9	0.0175	1.7708	30.3246	1.4042	5380	-69.8	7.1	-0.9	-60.6	0.0078	0.2115	32.6307	0.8244	-60.4	6	-0.2	-58.7	0.0253	1.9823	62.9553	2.2286
After-Before	PMO	7781	-84.2	9.4	-1.1	-74.2	-0.0159	-2.1577	-14.8594	-0.9078	6268	-67.3	4.7	-0.6	-65.5	0	-1.1781	2.3477	-0.3451	-151.5	14.1	-1.7	-139.7	-0.0159	-3.3358	-12.5117	-1.2529
After-Before	PMP	11890	-76.7	5	-0.3	-74	-0.0038	-0.723	6.84	0.3059	10329	-186.3	13.8	-4.8	-183.9	-0.0355	-5.0397	-27.9523	-2.5119	-263	18.8	-5.1	-257.9	-0.0393	-5.7627	-21.1123	-2.206

LEGEND:	
(green)	Improvement
(yellow)	No significant change
(pink)	Decreased performance

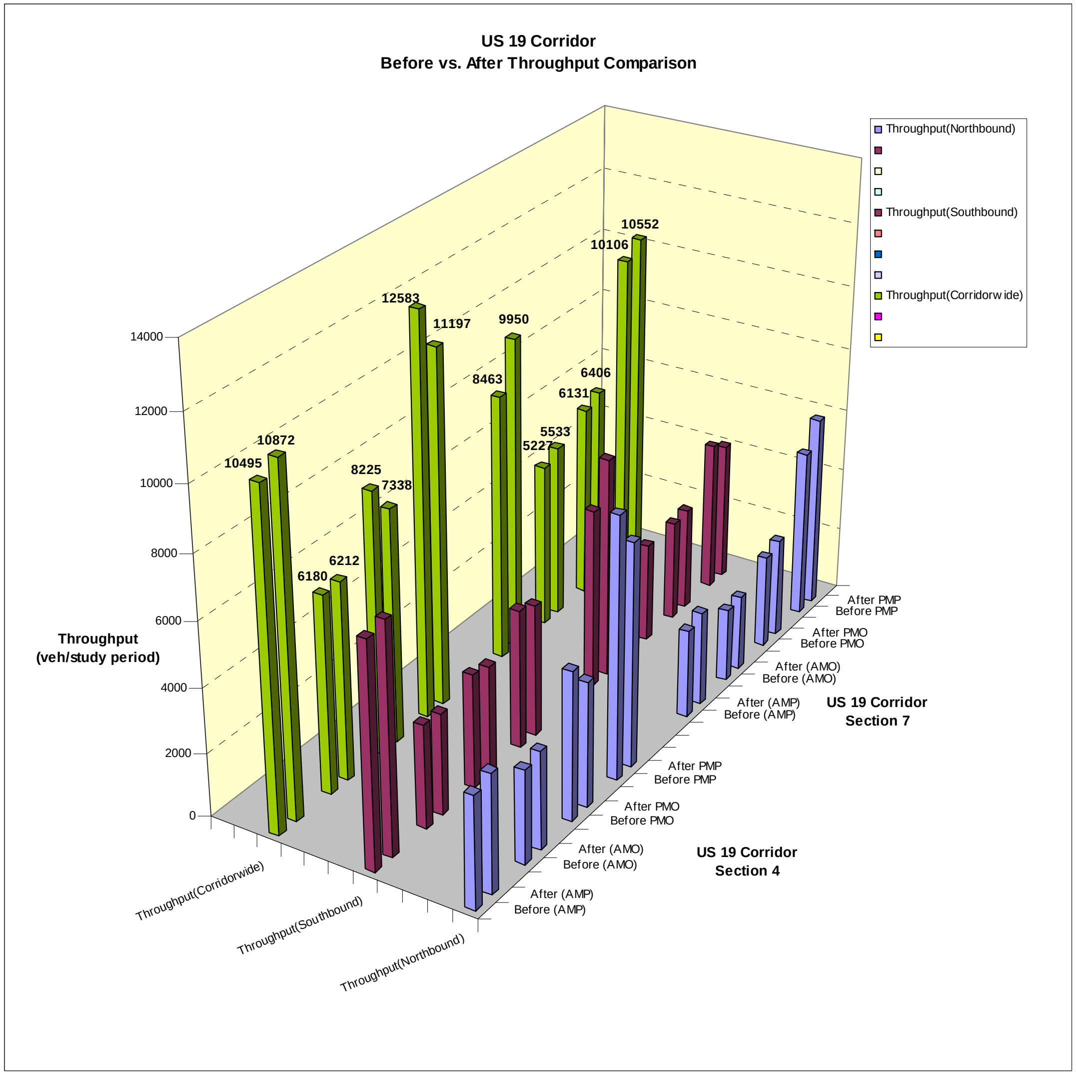

Figure 4-1: Comparison of Before vs. After Throughput on US 19 Corridor

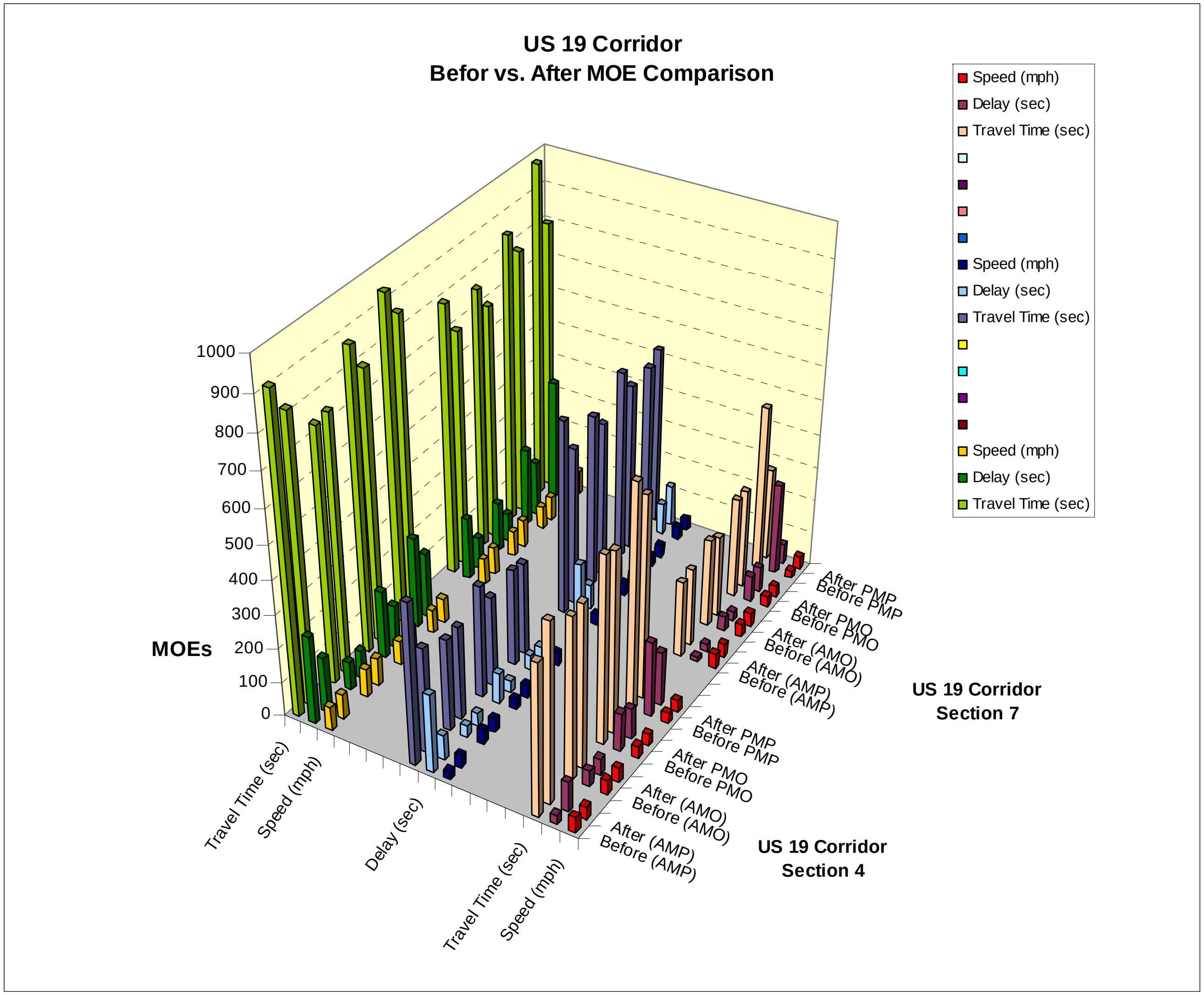

Figure 4-2: Comparison of Before vs. After MOEs on US 19 Corridor

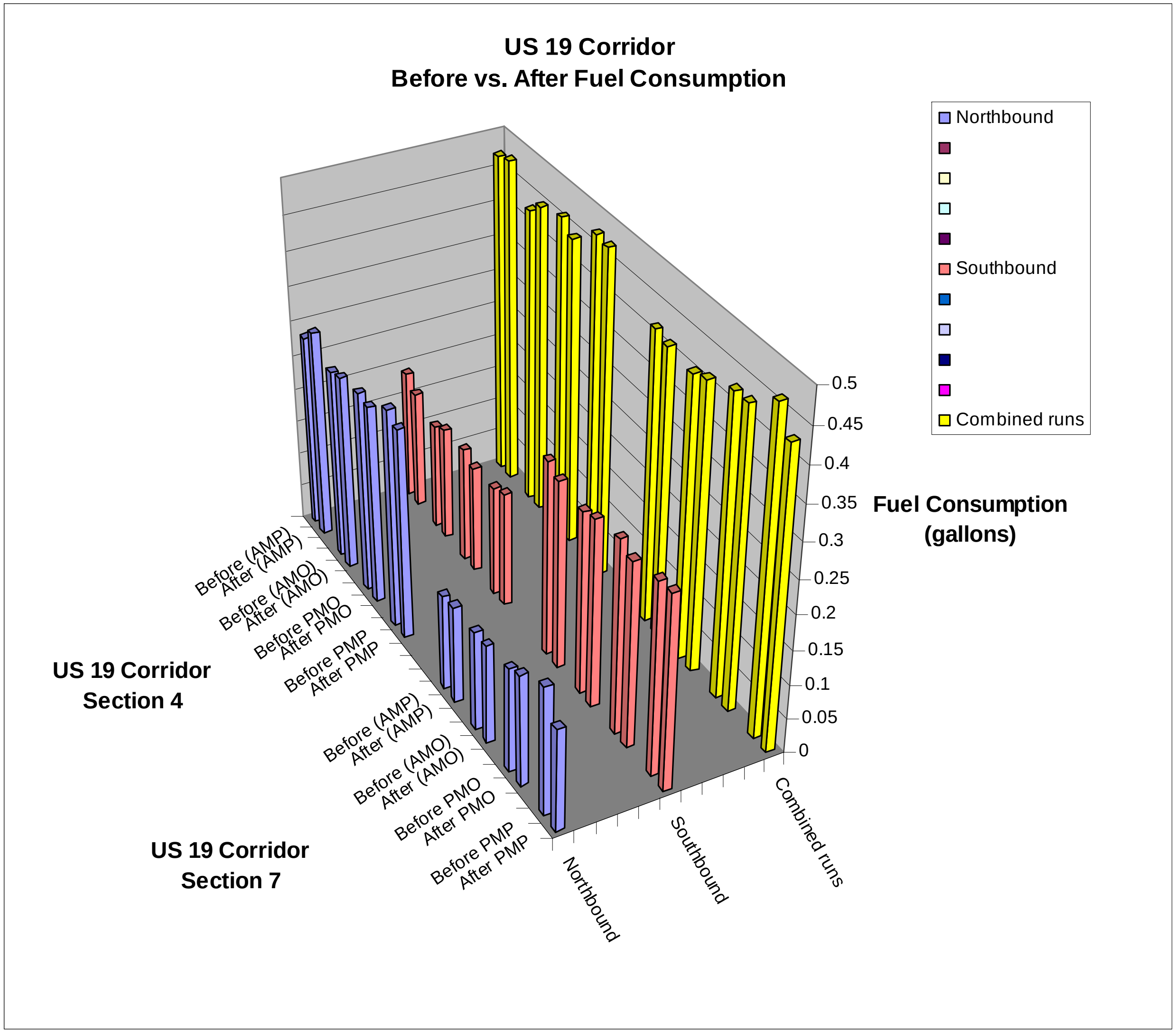

Figure 4-3: Comparison of Before vs. After Fuel Consumption on US 19 Corridor

Table 4-5: US 19 Northbound Before-After MOE Percentage Change

Scenario	Study	Section 4 - Northbound											Section 7 - Northbound										
		Avg Throughput (veh/Study Period)	TT (sec)	TT (%)	Speed (mph)	Speed (%)	Stops	Stops (%)	Delay (sec)	Delay (%)	Fuel (gal)	Fuel (%)	Avg Throughput (veh/Study Period)	TT (sec)	TT (%)	Speed (mph)	Speed (%)	Stops	Stops (%)	Delay (sec)	Delay (%)	Fuel (gal)	Fuel (%)
Before	AMP	3485	443.9	18.2%	44.1	-15.4%	1.5	53.3%	27.9	217.6%	0.2828	7.7%	2775	222.6	3.5%	44	-3.4%	0.9	22.2%	15.7	38.9%	0.138	2.3%
After	AMP	3701	524.5		37.3		2.3		88.6		0.3045		2973	230.4		42.5		1.1		21.8		0.1412	
Before	AMO	2937	472.2	0.9%	41.5	-1.0%	1.6	18.8%	47.8	-2.3%	0.2779	2.4%	2302	258.3	-7.7%	37.9	8.4%	1.4	-35.7%	42.5	-35.1%	0.1432	-0.1%
After	AMO	3064	476.6		41.1		1.9		46.7		0.2847		2367	238.3		41.1		0.9		27.6		0.143	
Before	PMO	4676	546.9	-3.6%	35.8	3.9%	2.4	-4.2%	111.2	-17.8%	0.2939	-1.4%	2935	294.6	-1.0%	33.2	1.2%	1.9	10.5%	76.6	-3.5%	0.1506	7.6%
After	PMO	3926	527.2		37.2		2.3		91.4		0.2897		3134	291.6		33.6		2.1		73.9		0.162	
Before	PMP	8198	658.4	-9.8%	29.7	11.1%	3.8	-7.9%	222.6	-29.2%	0.318	-3.6%	5327	487.2	-44.1%	20.1	78.6%	6.8	-73.5%	269.3	-78.7%	0.1864	-20.3%
After	PMP	7040	593.6		33		3.5		157.7		0.3065		6125	272.4		35.9		1.8		57.3		0.1485	

Table 4-6: US 19 Southbound Before-After MOE Percentage Change

Scenario	Study	Section 4 - Southbound											Section 7 - Southbound										
		Avg Throughput (veh/Study Period)	TT (sec)	TT (%)	Speed (mph)	Speed (%)	Stops	Stops (%)	Delay (sec)	Delay (%)	Fuel (gal)	Fuel (%)	Avg Throughput (veh/Study Period)	TT (sec)	TT (%)	Speed (mph)	Speed (%)	Stops	Stops (%)	Delay (sec)	Delay (%)	Fuel (gal)	Fuel (%)
Before	AMP	7010	472.6	-34.4%	23	52.2%	4.7	-61.7%	230.6	-67.6%	0.1892	-8.4%	5689	574.3	-18.6%	31.9	22.9%	3.2	-37.5%	167.9	-56.2%	0.2847	-4.0%
After	AMP	7171	310.1		35		1.8		74.7		0.1733		6976	467.4		39.2		2		73.5		0.2734	
Before	AMO	3243	269.6	1.9%	40.3	-1.7%	0.9	44.4%	34.4	8.7%	0.1554	6.9%	2925	509.2	-9.8%	36	10.8%	2.5	-16.0%	103.1	-44.3%	0.2651	3.0%
After	AMO	3149	274.6		39.6		1.3		37.4		0.1661		3166	459.4		39.9		2.1		57.4		0.2731	
Before	PMO	3549	330.2	-19.5%	32.9	24.3%	1.9	-52.6%	88.2	-61.7%	0.1687	-6.9%	3195	558.6	-11.5%	32.8	13.1%	3.3	-24.2%	152.4	-41.2%	0.2812	-4.1%
After	PMO	3413	265.7		40.9		0.9		33.8		0.157		3272	494.3		37.1		2.5		89.6		0.2698	
Before	PMP	4385	284.4	-4.2%	38.2	4.5%	1.1	0.0%	46.2	-19.7%	0.1607	4.8%	4779	499.3	5.7%	36.7	-5.4%	2.2	9.1%	93.1	30.2%	0.2793	0.9%
After	PMP	4157	272.5		39.9		1.1		37.1		0.1684		4428	527.8		34.7		2.4		121.2		0.2817	

LEGEND:	
(green)	Improvement
(yellow)	No significant change
(pink)	Decreased performance

Table 4-7: US 19 Northbound Cost/Savings Analysis

		Section 4 - Northbound							Section 7 - Northbound							Overall US 19 Corridor - Northbound					
			Cost/Savings per Hour			Cost/Savings Per Year				Cost/Savings per Hour			Cost/Savings Per Year			Cost/Savings per Hour			Cost/Savings Per Year		
Scenario	Study	Avg Volume (veh/Study Period)	Labor ($/hr)	Fuel ($/hr)	Total ($/hr)	Labor ($/Yr)	Fuel ($/Yr)	Total ($/Yr)	Avg Volume (veh/Study Period)	Labor ($/hr)	Fuel ($/hr)	Total ($/hr)	Labor ($/Yr)	Fuel ($/Yr)	Total ($/Yr)	Labor ($/hr)	Fuel ($/hr)	Total ($/hr)	Labor ($/Yr)	Fuel ($/Yr)	Total ($/Yr)
After-Before	AMP	3593	$363	$195	$558	$189,016	$101,359	$290,374	2874	$29	$23	$52	$15,193	$11,955	$27,149	$393	$218	$611	$204,209	$113,314	$317,523
After-Before	AMO	3000	-$6	$51	$46	-$4,290	$39,783	$35,493	2334	-$58	-$1	-$59	-$45,217	-$910	-$46,127	-$63	$50	-$14	-$49,507	$38,873	-$10,634
After-Before	PMO	4301	-$142	-$45	-$187	-$110,701	-$35,223	-$145,924	3035	-$14	$86	$73	-$10,652	$67,460	$56,808	-$156	$41	-$114	-$121,353	$32,237	-$89,116
After-Before	PMP	7619	-$824	-$219	-$1,043	-$642,826	-$170,859	-$813,684	5726	-$2,023	-$543	-$2,566	-$1,578,017	-$423,162	-$2,001,178	-$2,847	-$762	-$3,609	-$2,220,842	-$594,020	-$2,814,863
						-$568,801	-$64,940	-$633,742					-$1,618,692	-$344,657	-$1,963,349				-$2,187,493	-$409,597	-$2,597,090

Table 4-8: US 19 Southbound Cost/Savings Analysis

		Section 4 - Southbound							Section 7 - Southbound							Overall US 19 Corridor - Southbound					
			Cost/Savings per Hour			Cost/Savings Per Year				Cost/Savings per Hour			Cost/Savings Per Year			Cost/Savings per Hour			Cost/Savings Per Year		
Scenario	Study	Avg Volume (veh/Study Period)	Labor ($/hr)	Fuel ($/hr)	Total ($/hr)	Labor ($/Yr)	Fuel ($/Yr)	Total ($/Yr)	Avg Volume (veh/Study Period)	Labor ($/hr)	Fuel ($/hr)	Total ($/hr)	Labor ($/Yr)	Fuel ($/Yr)	Total ($/Yr)	Labor ($/hr)	Fuel ($/hr)	Total ($/hr)	Labor ($/Yr)	Fuel ($/Yr)	Total ($/Yr)
After-Before	AMP	7090	-$1,842	-$282	-$2,124	-$957,987	-$146,555	-$1,104,543	6332	-$996	-$179	-$1,175	-$518,073	-$93,023	-$611,095	-$2,839	-$461	-$3,299	-$1,476,060	-$239,578	-$1,715,638
After-Before	AMO	3196	$16	$85	$101	$12,464	$66,682	$79,146	3045	-$232	$61	-$171	-$180,926	$47,508	-$133,418	-$216	$146	-$70	-$168,462	$114,190	-$54,272
After-Before	PMO	3481	-$316	-$102	-$417	-$246,150	-$79,410	-$325,560	3234	-$338	-$92	-$431	-$264,003	-$71,886	-$335,890	-$654	-$194	-$848	-$510,153	-$151,297	-$661,450
After-Before	PMP	4271	-$65	$82	$17	-$50,523	$64,125	$13,602	4603	$216	$28	$243	$168,161	$21,544	$189,705	$151	$110	$261	$117,638	$85,669	$203,307
						-$1,242,196	-$95,159	-$1,337,355					-$794,840	-$95,857	-$890,698				-$2,037,037	-$191,016	-$2,228,053

Table 4-9: US 19 Combined Cost/Savings Analysis

		Section 4 - Northbound + Southbound							Section 7 - Northbound + Southbound							Overall US 19 Corridor - Northbound + Southbound					
			Cost/Savings per Hour			Cost/Savings Per Year				Cost/Savings per Hour			Cost/Savings Per Year			Cost/Savings per Hour			Cost/Savings Per Year		
Scenario	Study	Avg Volume (veh/Study Period)	Labor ($/hr)	Fuel ($/hr)	Total ($/hr)	Labor ($/Yr)	Fuel ($/Yr)	Total ($/Yr)	Avg Volume (veh/Study Period)	Labor ($/hr)	Fuel ($/hr)	Total ($/hr)	Labor ($/Yr)	Fuel ($/Yr)	Total ($/Yr)	Labor ($/hr)	Fuel ($/hr)	Total ($/hr)	Labor ($/Yr)	Fuel ($/Yr)	Total ($/Yr)
After-Before	AMP	10683	-$1,479	-$87	-$1,566	-$768,972	-$45,197	-$814,168	9206	-$967	-$156	-$1,123	-$502,879	-$81,067	-$583,947	-$2,446	-$243	-$2,689	-$1,271,851	-$126,264	-$1,398,115
After-Before	AMO	6196	$10	$136	$147	$8,174	$106,465	$114,639	5380	-$290	$60	-$230	-$226,143	$46,597	-$179,545	-$279	$196	-$83	-$217,969	$153,063	-$64,906
After-Before	PMO	7781	-$458	-$147	-$604	-$356,851	-$114,634	-$471,485	6268	-$352	-$6	-$358	-$274,655	-$4,427	-$279,081	-$810	-$153	-$962	-$631,506	-$119,060	-$750,566
After-Before	PMP	11890	-$889	-$137	-$1,026	-$693,349	-$106,734	-$800,082	10329	-$1,808	-$515	-$2,322	-$1,409,855	-$401,618	-$1,811,473	-$2,696	-$652	-$3,348	-$2,103,204	-$508,351	-$2,611,555
						-$1,810,998	-$160,099	-$1,971,097					-$2,413,532	-$440,514	-$2,854,046				-$4,224,530	-$600,613	-$4,825,143

LEGEND:		
	(green)	Improvement
	(yellow)	No significant change
	(pink)	Decreased performance

Table 4-10: Main US 19 Corridor Summary of Benefits

Scenario	Study	Cost/Savings Per Year - Northbound		
		Labor ($/Yr)	Fuel ($/Yr)	Total ($/Yr)
Adaptive vs. Traditional	AM Peak Period	$204,209	$113,314	$317,523
Adaptive vs. Traditional	AM Off-Peak Period	-$49,507	$38,873	-$10,634
Adaptive vs. Traditional	PM Off-Peak Period	-$121,353	$32,237	-$89,116
Adaptive vs. Traditional	PM Peak Period	-$2,220,842	-$594,020	-$2,814,863
Total Annual Savings – US 19 Northbound		-$2,187,493	-$409,597	-$2,597,090
Scenario	**Study**	**Cost/Savings Per Year - Southbound**		
		Labor ($/Yr)	Fuel ($/Yr)	Total ($/Yr)
Adaptive vs. Traditional	AM Peak Period	-$1,476,060	-$239,578	-$1,715,638
Adaptive vs. Traditional	AM Off-Peak Period	-$168,462	$114,190	-$54,272
Adaptive vs. Traditional	PM Off-Peak Period	-$510,153	-$151,297	-$661,450
Adaptive vs. Traditional	PM Peak Period	$117,638	$85,669	$203,307
Total Annual Savings – US 19 Southbound		-$2,037,037	-$191,016	-$2,228,053
Scenario	**Study**	**Cost/Savings Per Year – Northbound + Southbound**		
		Labor ($/Yr)	Fuel ($/Yr)	Total ($/Yr)
Adaptive vs. Traditional	AM Peak Period	-$1,271,851	-$126,264	-$1,398,115
Adaptive vs. Traditional	AM Off-Peak Period	-$217,969	$153,063	-$64,906
Adaptive vs. Traditional	PM Off-Peak Period	-$631,506	-$119,060	-$750,566
Adaptive vs. Traditional	PM Peak Period	-$2,103,204	-$508,351	-$2,611,555
Total Annual Savings – US 19 Northbound + Southbound		**-$4,224,530**	**-$600,613**	**-$4,825,143**

LEGEND:		
	(green)	Improvement
	(yellow)	No significant change
	(pink)	Decreased performance

US 19 Side Street Findings

Table 4-11: US 19 Level of Service Study

Study Period	Critical Intersection	Intersection Movements	BEFORE SCENARIO				AFTER SCENARIO				DIFFERENCE	
			Avg. Control Delay (sec)	Stop Delay (sec)	Control Delay/Stop Delay	LOS	Avg. Control Delay (sec)	Stop Delay (sec)	Control Delay/Stop Delay	LOS	Avg. Control Delay (sec)	Stop Delay (sec)
AM Peak	US 19 at Curlew Rd.	All Movements	68	51	1.33	E	72	56	1.29	E	4	5
		Curlew & Major Left	89	70	1.27	F	98	79	1.24	F	9	9
		Side Street Only	82	61	1.34	F	77	59	1.31	E	-5	-2
		Side Street EB	75	56	1.34	E	101	84	1.20	F	26	28
		Side Street WB	90	67	1.34	F	56	38	1.47	E	-34	-29
	US 19 at Alderman Rd.	All Movements	66	49	1.35	E	71	53	1.34	E	5	4
		Alderman & Major Left	89	69	1.29	F	91	74	1.23	F	2	5
		Side Street Only	73	55	1.33	E	83	67	1.24	F	10	12
		Side Street EB	74	56	1.32	E	70	53	1.32	E	-4	-3
		Side Street WB	72	55	1.31	E	96	81	1.19	F	24	26
	US 19 at Tarpon Ave.	All Movements	75	58	1.29	E	102	71	1.44	F	27	13
		Tarpon & Major Left	91	72	1.26	F	135	100	1.35	F	44	28
		Side Street Only	98	77	1.27	F	126	92	1.37	F	28	15
		Side Street EB	60	44	1.36	E	108	92	1.17	F	48	48
		Side Street WB	141	115	1.23	F	140	92	1.52	F	-1	-23
AM Off-Peak	US 19 at Curlew Rd.	All Movements	55	39	1.41	E	36	21	1.71	D	-19	-18
		Curlew & Major Left	64	47	1.36	E	45	28	1.61	D	-19	-19
		Side Street Only	52	35	1.49	D	33	17	1.94	C	-19	-18
		Side Street EB	40	23	1.74	D	33	16	2.06	C	-7	-7
		Side Street WB	65	49	1.33	E	33	17	1.94	C	-32	-32
	US 19 at Alderman Rd.	All Movements	55	39	1.41	E	49	36	1.36	D	-6	-3
		Alderman & Major Left	67	49	1.37	E	62	46	1.35	E	-5	-3
		Side Street Only	53	36	1.47	D	53	38	1.39	D	0	2
		Side Street EB	50	32	1.56	D	58	43	1.35	E	8	11
		Side Street WB	56	38	1.47	E	44	31	1.42	D	-12	-7
	US 19 at Tarpon Ave.	All Movements	39	24	1.63	D	47	31	1.52	D	8	7
		Tarpon & Major Left	43	28	1.54	D	59	41	1.44	E	16	13
		Side Street Only	47	31	1.52	D	59	40	1.48	E	12	9
		Side Street EB	38	23	1.65	D	66	48	1.38	E	28	25
		Side Street WB	57	39	1.46	E	51	31	1.65	D	-6	-8
PM Off-Peak	US 19 at Curlew Rd.	All Movements	53	36	1.47	D	65	50	1.30	E	12	14
		Curlew & Major Left	62	44	1.41	E	87	71	1.23	F	25	27
		Side Street Only	44	26	1.69	D	89	71	1.25	F	45	45
		Side Street EB	42	25	1.68	D	100	82	1.22	F	58	57
		Side Street WB	45	28	1.61	D	76	60	1.27	E	31	32
	US 19 at Alderman Rd.	All Movements	44	30	1.47	D	84	68	1.24	F	40	38
		Alderman & Major Left	89	69	1.29	F	110	93	1.18	F	21	24
		Side Street Only	50	34	1.47	D	91	75	1.21	F	41	41
		Side Street EB	57	41	1.39	E	84	67	1.25	F	27	26
		Side Street WB	43	26	1.65	D	99	84	1.18	F	56	58
	US 19 at Tarpon Ave.	All Movements	44	30	1.47	D	75	59	1.27	E	31	29
		Tarpon & Major Left	51	36	1.42	D	89	73	1.22	F	38	37
		Side Street Only	54	39	1.38	D	78	63	1.24	E	24	24
		Side Street EB	46	34	1.35	D	108	90	1.20	F	62	56
		Side Street WB	61	44	1.39	E	48	35	1.37	D	-13	-9
PM Peak	US 19 at Curlew Rd.	All Movements	76	57	1.33	E	119	98	1.21	F	43	41
		Curlew & Major Left	97	75	1.29	F	157	132	1.19	F	60	57
		Side Street Only	92	69	1.33	F	125	103	1.21	F	33	34
		Side Street EB	80	60	1.33	F	134	111	1.21	F	54	51
		Side Street WB	103	77	1.34	F	117	93	1.26	F	14	16
	US 19 at Alderman Rd.	All Movements	93	72	1.29	F	114	92	1.24	F	21	20
		Alderman & Major Left	117	94	1.24	F	146	122	1.20	F	29	28
		Side Street Only	120	96	1.25	F	139	115	1.21	F	19	19
		Side Street EB	164	135	1.21	F	199	168	1.18	F	35	33
		Side Street WB	88	69	1.28	F	79	61	1.30	E	-9	-8
	US 19 at Tarpon Ave.	All Movements	53	36	1.47	D	86	65	1.32	F	33	29
		Tarpon & Major Left	64	46	1.39	E	107	83	1.29	F	43	37
		Side Street Only	58	42	1.38	E	110	86	1.28	F	52	44
		Side Street EB	84	65	1.29	F	168	137	1.23	F	84	72
		Side Street WB	34	21	1.62	C	51	34	1.50	D	17	13

LEGEND:
- (green) Improvement
- (yellow) No significant change
- (pink) Decreased performance

Table 4-12: US 19 Side Street Summary of Benefits

Section	Critical Intersection	Time Period	Side Street Delay ($/Yr)
Section 4	Curlew	AM Peak Period	-$37,444
		AM Off-Peak Period	-$154,570
		PM Off-Peak Period	$406,134
		PM Peak Period	$315,389
	Alderman	AM Peak Period	$18,921
		AM Off-Peak Period	$3,561
		PM Off-Peak Period	$228,076
		PM Peak Period	$105,591
Section 7	Tarpon	AM Peak Period	$41,001
		AM Off-Peak Period	$24,736
		PM Off-Peak Period	$85,120
		PM Peak Period	$235,357
Total Side Street Cost (Sections 4 and 7) @ Three Critical Intersections			$1,271,873
US 19 Northbound and Southbound Labor Savings			-$4,224,530
Total Net Savings for US 19 Corridorwide -$4,224,530 + 8 X ($1,271,143 / 3) (Worst Case Scenario)			-$834,815

LEGEND:
- Improvement (green)
- No significant change (yellow)
- Decreased performance (pink)

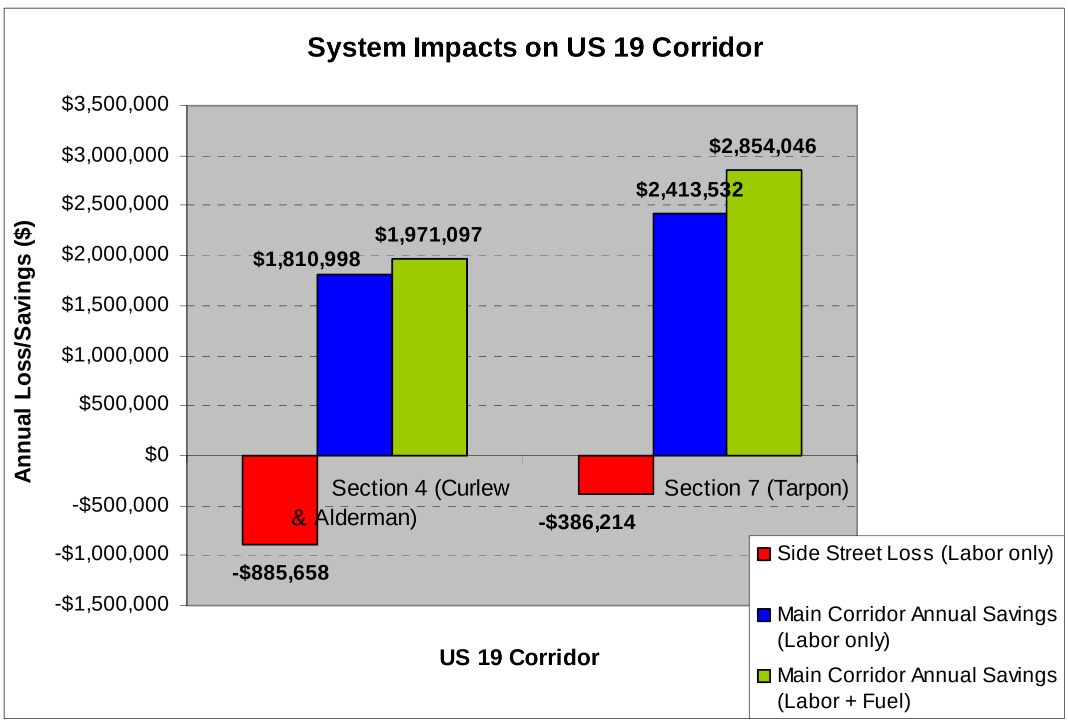

Figure 4-4: System Impacts on US 19 Corridor

Table 4-13: US 19 Descriptive Corridorwide Crash Assessment

Crash Severity	US 19 Crashes (After Scenario)															
	US 19 Main Corridor (After)								US 19 Side Streets (After)							
	Rear End	Head On	Angle	Left Turn	Right Turn	Side Swipe	Hit Other Fixed Object	Total	Rear End	Head On	Angle	Left Turn	Right Turn	Side Swipe	Hit Other Fixed Object	Total
Property Damage	5	0	3	1	1	0	0	**10**	0	0	1	0	0	0	0	**1**
Injuries	1	1	1	1	0	0	0	**4**	1	1	0	0	0	0	0	**2**
Total Crashes	**6**	**1**	**4**	**2**	**1**	**0**	**0**	**14**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**3**

Crash Severity	US 19 Crashes (Before Scenario)															
	US 19 Main Corridor (Before)								US 19 Side Streets (Before)							
	Rear End	Head On	Angle	Left Turn	Right Turn	Side Swipe	Hit Other Fixed Object	Total	Rear End	Head On	Angle	Left Turn	Right Turn	Side Swipe	Hit Other Fixed Object	Total
Property Damage	5	1	3	1	1	1	0	**12**	0	0	0	0	0	0	0	**0**
Injuries	8	0	3	1	0	0	1	**13**	1	0	0	0	0	0	0	**1**
Total Crashes	**13**	**1**	**6**	**2**	**1**	**1**	**1**	**25**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**1**

Table 4-14: US 19 Corridorwide Before/After Crash Assessment

Crash Severity	After - Before																				
	All Crashes (US 19 After - Before Analysis)							Corridor (US 19 After - Before Analysis)							Side Street (US 19 After - Before Analysis)						
	Rear End	Head On	Angle	Left Turn	Right Turn	Side Swipe	Hit Other Fixed Object	Rear End	Head On	Angle	Left Turn	Right Turn	Side Swipe	Hit Other Fixed Object	Rear End	Head On	Angle	Left Turn	Right Turn	Side Swipe	Hit Other Fixed Object
Property Damage	0	-1	1	0	0	-1	0	0	-1	0	0	0	-1	0	0	0	1	0	0	0	0
Injuries	-7	2	-2	0	0	0	-1	-7	1	-2	0	0	0	-1	0	1	0	0	0	0	0

LEGEND:	
(green)	Improvement
(yellow)	No significant change
(pink)	Decreased performance

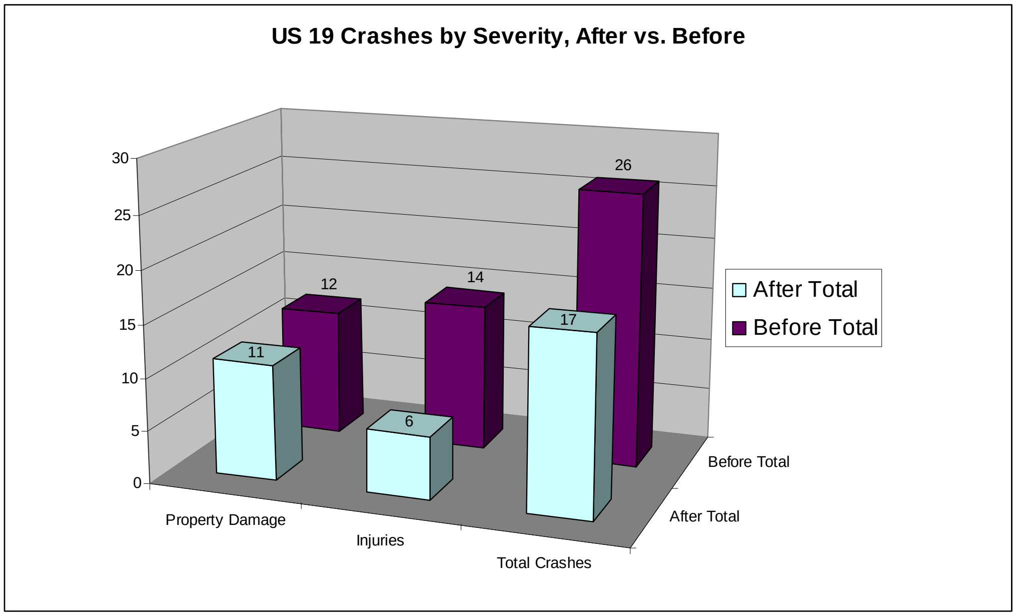

Figure 4-5: US 19 Corridor Before vs. After Crashes by Severity

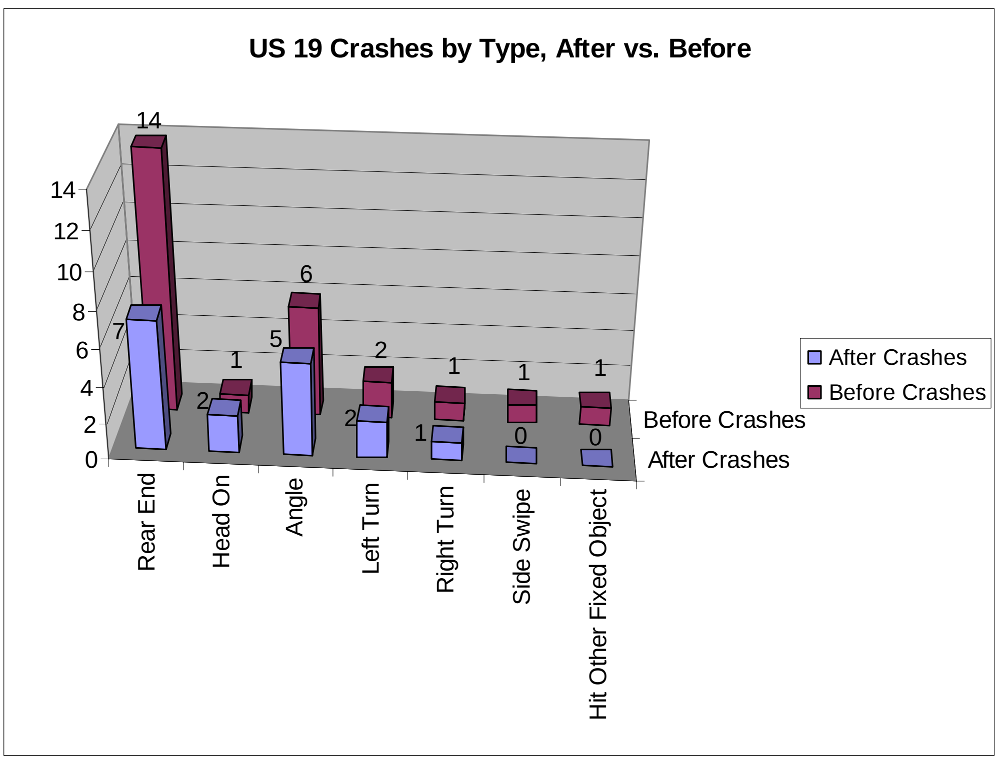

Figure 4-6: US 19 Corridor Before vs. After Crashes by Type

5.0 SR 60 FINDINGS

This section presents the study findings attributed to the SR 60 corridor derived from many data sources including system generated data (throughput and spot speed), travel time runs, and level of service runs. The findings reflect the results of two operational cases:

- Case 1 represents the intersection of SR 60 and Belcher Road running under fully-actuated mode of operations (i.e., free from coordinated operations) during both Before and After Scenarios. The other two sections (i.e., 1 and 3) run under traditional time of day operations during Before Scenario and adaptive during After Scenario. This case provides the opportunity to compare the coordinated Sections 1 and 3 independent of each other since they are physically separated by Section 2 (Belcher Road), which is not considered in the analysis. The fully-actuated mode of operations at Belcher Road results in random platoon arrival and signal operations. The effects of this randomness will be eliminated by omitting Section 2 from consideration.
- Case 2 represents the intersection of SR 60 and Belcher Road running under fully-actuated mode of operations during Before Scenario and adaptive during the After Scenario. The other two sections (i.e., 1 and 3) of the SR 60 corridor run under traditional time of day operations during Before Scenario and adaptive during After Scenario. This case, when compared with the corridorwide MOEs of Case 1, provides the opportunity to identify adaptive traffic control impacts on system boundaries.

The findings of the Before-After Scenarios are presented in various tables representing the Before Scenario, the After Scenario, and the difference between the After and Before Scenarios. This difference is color-coded for each applicable MOE to better discern the impact of adaptive traffic control system operationally:

- Green is used to indicate the adaptive traffic control improved the applicable MOE relative to the traditional time-of-day system
- Red is used to indicate the traditional traffic control system performed better relative to the adaptive traffic control system for the applicable MOE
- Yellow is used to indicate no measurable difference between the performance of the adaptive and traditional control systems relative to the applicable MOE.

5.1 MAIN SR 60 CORRIDOR FINDINGS

The SR 60 corridor's operational findings are segregated into two elements: 1) the main US SR 60 corridor irrespective of side streets; and 2) the side streets. This segregation is essential to differentiate how each corridor element performed operational independent of the other and as a whole (corridorwide). The findings represent Before-After MOEs, which were quantified into monetary values to identify the annualized impacts associated with deployment of adaptive traffic control system.

5.1.1 SR 60 Throughput and Spot Speed Study

Table 5-1 and Figure 5-1 present the study findings for throughput and spot speed attributed to system generated data on all approaches to the three critical intersections. To quantify the degree of difference between After-Before MOEs, percentage change values are included in Table 5-1 for both throughput and spot speed. The associated findings are summarized as follows:

- ❑ Throughput and spot speed for the eastbound and westbound directions along SR 60 significantly improved for all three intersections during all study periods. Overall, there was improvement in operational performance on the main SR 60 corridor.
- ❑ Throughput and spot speed for the side streets of the three critical intersections worsened for all study periods.

5.1.2 SR 60 Travel Time Study

The travel time tables are organized as follows:

- ❑ The far left column of each table presents the average volume (vehicles/study period) for each study period over the entire study duration.
- ❑ Columns represent the difference between Before and After values for such MOEs as travel time (seconds); speed (mph); number of stops; total delay (seconds); fuel consumption (gallons); and hydrocarbons (grams), carbon monoxide (grams), and nitrogen oxide (grams) emissions, respectively.

5.1.2.1 Travel Time Study for Case 1

Tables 5-2, 5-3, and 5-4 present the Case 1 findings for the travel time runs associated with the eastbound direction, westbound direction, and overall corridor (combined). The associated findings for the SR 60 corridor are summarized as follows:

- ❑ The adaptive traffic control system performed better than the traditional system in improving the eastbound traffic operations during all study periods excepting PM Peak study period for Section 1.
- ❑ The adaptive traffic control system performed better than the traditional system in improving the westbound traffic operations during all study periods excepting PM Peak study period for Section 3.
- ❑ The adaptive traffic control system improved the overall corridor's traffic operations (eastbound and westbound directions combined) during all study periods.

Tables 5-5 and 5-6 present the travel time MOEs in terms of percentage of change values for the eastbound and westbound directions on SR 60. These tables offer an overarching comparison between the Before-After Scenarios. The presented MOEs are travel time, speed, number of stops, delay and fuel consumption.

5.1.2.2 Travel Time Study for Case 2

Tables 5-7, 5-8 and 5-9 present the Case 2 findings for the travel time runs associated with the eastbound direction, westbound direction, and overall corridor (combined). The associated findings for the SR 60 corridor are summarized as follows:

- ❑ The adaptive traffic control system performed better than the traditional system in improving the eastbound traffic operations during all study periods excepting PM Peak study period for Section 3.
- ❑ The adaptive traffic control system performed better than the traditional system in improving the westbound traffic operations during all study periods.
- ❑ The adaptive traffic control system improved the overall corridor's traffic operations (eastbound and westbound directions combined) during all study periods.

5.1.3 Boundary Conditions

The Evaluation Objective 2.2 considers traffic operations at system boundaries, for example, in-between two coordinated operational corridors (i.e., Sections 4 and 7 along US 19) and between two coordinated sections (i.e., Sections 1 an 3) demarcated by an isolated traffic signal running under free mode of operations (Section 2 or Belcher Road). A comparative Before-After assessment of the MOEs across the overall corridor, versus section-by-section comparison, highlights the potential value of running adaptive traffic control operations along the overall corridor as compared with segmented roadway sections governed by different operational modes. Comparisons of applicable MOEs associated with Case 1 and Case 2 reveal the system boundary impacts associated with Section 2, which borders Sections 1 and 3. The overall finding, as observed from Tables 5-10, 5-11, and 5-12, was that the adaptive traffic control system improved travel times and fuel consumption at the system boundaries.

5.1.4 SR 60 Corridor Cost/Savings Analysis

Tables 5-13, 5-14, 5-15, and 5-16 present the impact of adaptive traffic control system under Case 1 on control delay and fuel consumption quantified into daily and annual monetary savings/loss for northbound direction, southbound direction, and overall corridor (combined).

The associated findings for the SR 60 corridor are summarized as follows:

- ❑ The adaptive traffic control system resulted in a net annual savings of $622,597 in labor and $305,790 in fuel consumed for the eastbound direction on SR 60 for a total annual savings of $928,388.
- ❑ The adaptive traffic control system resulted in a net annual savings of $1,139,670 in labor and $449,239 in fuel consumed for the westbound direction on SR 60 for a total annual savings of $1,588,909.
- ❑ The adaptive traffic control system resulted in to a net annual savings of $1,762,268 in labor and $755,030 in fuel consumed for the combined eastbound and westbound directions on SR 60 for a total annual savings of $2,517,297. The corridorwide findings represent significant savings.

5.2 SR 60 SIDE STREET FINDINGS

This section presents all findings related to the main SR 60 side streets for Case 1. The side street findings are comprised of intersection level of service and control delay for each critical intersection and study period. These findings are based on level of service runs conducted at each critical intersection and are presented in Tables 5-17 and 5-18. The associated findings for the SR 60 corridor are summarized as follows:

- ❑ The side streets' approaches to the SR 60 corridor, as represented by the two critical intersections located within coordinated Sections 1 and 3, experienced both operational improvements and degradation depending on the study period and side street direction. For example, traffic operations on Highland Avenue improved during AM Off-Peak and PM Off-Peak periods and worsened during AM Peak and PM peak periods under adaptive traffic control. However, the overall net impact on the traffic operations associated with side streets at SR 60 and Highland Avenue was a net annual savings of $16,372.
- ❑ Traffic operations at side streets at SR 60 and US 19 improved during the PM Off-Peak and degraded during the remaining study periods for a net annual loss of $564,796. The intersection of SR 60 and US 19, however, is atypical within the SR 60 corridor, as differentiated by its demand intensity attributed to regional significance of the intersecting corridors and intersection geometry and lane configuration (i.e., single-point urban interchange). Highland Avenue represents a more typical intersection within the SR 60 corridor and a better representation of the other 15 signalized intersections within the study corridor.
- ❑ The adaptive traffic control system resulted in a net annual savings of $319,261 in labor on the corridor's side streets when considering all 16 signalized intersections within the SR 60 study corridor.

5.3 SR 60 CORRIDORWIDE SUMMARY OF BENEFITS

Tables 5-16 and 5-18 and Figure 5-4 present a high-level summary of the overall monetary impact of adaptive traffic control system under Case 1 resulting from operational changes along SR 60 corridor and associated side streets. The savings or losses in average delay (seconds per vehicle) and average fuel (gallons per vehicle) were quantified to monetary values on an annual basis using the methodology previously described. The findings pertain to the eastbound direction, westbound direction, overall corridor (combined), and side streets' approaches.

The average annual savings in labor associated with the side streets at SR 60 and Highland Avenue were applied to the remaining 15 signalized intersections within the study corridor and subtracted from the average annual loss in labor for the side streets at SR 60 and US 19 to SR 60 to arrive at the net impact of adaptive traffic control system on SR 60 corridor. The total net savings along the SR 60 corridor was $1,443,052 annually attributed to deployment of adaptive traffic control system.

5.3.1 Descriptive Crash Assessment

Crash data was collected for Before-After Scenarios in October 2006. This data provided the opportunity to assess Before-After traffic crashes using descriptive (rather than inferential) statistics. This assessment compared corridorwide traffic crashes segregated by severity and type along the study corridor and side streets' approaches. Tables 5-19 and 5-20 and Figures 5-5 and 5-6 present the traffic crash findings for the SR 60 corridor under Case 2 where the entire corridor operates under adaptive traffic control system. The findings are comprised of the difference in crashes by severity and type between After and Before Scenarios. The findings are color coded, as previously defined to discern increase or decrease in the number of crashes. The overall findings is that the frequency of traffic crashes, in terms of both severity and type, reduced under adaptive traffic control system when compared with the traditional system. This finding applied to the overall SR 60 corridor (which included side streets) as well as the main SR 60 corridor (which excluded side streets). In addition, there was no change in frequency of traffic crashes on side streets under adaptive traffic control.

5.4 PERCEPTION STUDY

In addition to performing descriptive crash analysis, the study team members also documented, during each data collection day, personal observations and perceptions of the corridor's traffic operations during each assessment scenario. The overall impression of the team members was that the adaptive control system performed better and provided smoother traffic flow, fewer stops, and higher speeds.

SR 60 Corridor Findings

Table 5-1: SR 60 Throughput Study (Case 1)

EB

Intersection (Belcher Free)	Time Period	Throughput (veh/Time Period) After	Throughput (veh/Time Period) Before	Throughput (After-Before) Volume	Percent Change (%)	Speed (mph) After	Speed (mph) Before	Speed (After - Before) Speed	Percent Change (%)
Highland (Section 1)	AMO Period	2000	1941	60	3.07%	32.8	30.0	2.8	9.25%
	AMP Period	2638	2697	-59	-2.20%	32.7	32.5	0.2	0.55%
	PMO Period	2288	2237	51	2.27%	30.1	27.7	2.5	8.94%
	PMP Period	3668	3578	91	2.53%	30.5	27.8	2.6	9.44%
Belcher (Section 2)	AMO Period	2278	2283	-5	-0.21%	23.5	21.8	1.7	7.58%
	AMP Period	3663	3631	32	0.89%	17.4	18.8	-1.4	-7.49%
	PMO Period	2645	2362	284	12.00%	14.6	19.6	-5.1	-25.77%
	PMP Period	3898	3754	144	3.84%	11.9	16.0	-4.0	-25.33%
US 19 (Section 3)	AMO Period	2661	2512	149	5.94%	37.6	33.1	4.5	13.70%
	AMP Period	4323	4259	64	1.49%	31.3	25.9	5.4	20.76%
	PMO Period	2986	2724	263	9.64%	35.2	33.4	1.8	5.43%
	PMP Period	4275	4040	235	5.83%	31.5	33.7	-2.2	-6.44%

NB

Intersection (Belcher Free)	Time Period	Throughput (veh/Time Period) After	Throughput (veh/Time Period) Before	Throughput (After-Before) Volume	Percent Change (%)	Speed (mph) After	Speed (mph) Before	Speed (After - Before) Speed	Percent Change (%)
Highland (Section 1)	AMO Period	490	528	-38	-7.23%	30.3	31.7	-1.4	-4.20%
	AMP Period	786	820	-34	-4.11%	27.8	26.9	0.9	3.32%
	PMO Period	608	638	-30	-4.71%	25.9	31.6	-5.7	-18.17%
	PMP Period	1127	1137	-10	-0.91%	19.5	25.6	-6.0	-23.66%
Belcher (Section 2)	AMO Period	944	958	-14	-1.43%	14.5	15.1	-0.6	-4.13%
	AMP Period	1316	1326	-9	-0.70%	15.9	16.3	-0.4	-2.43%
	PMO Period	1129	1139	-10	-0.83%	12.3	10.5	1.9	17.74%
	PMP Period	1816	1798	18	1.02%	5.6	7.7	-2.1	-27.34%
US 19 (Section 3)	AMO Period	569	619	-50	-8.05%	24.7	24.8	0.0	-0.03%
	AMP Period	818	1003	-185	-18.40%	18.4	22.6	-4.2	-18.74%
	PMO Period	676	747	-71	-9.55%	19.8	22.7	-2.9	-12.58%
	PMP Period	1076	1106	-31	-2.79%	9.2	20.6	-11.4	-55.21%

SB

Intersection (Belcher Free)	Time Period	Throughput (veh/Time Period) After	Throughput (veh/Time Period) Before	Throughput (After-Before) Volume	Percent Change (%)	Speed (mph) After	Speed (mph) Before	Speed (After - Before) Speed	Percent Change (%)
Highland (Section 1)	AMO Period	420	465	-45	-9.71%	27.9	31.7	-3.8	-11.95%
	AMP Period	897	906	-8	-0.90%	25.5	25.5	0.0	0.02%
	PMO Period	535	539	-4	-0.74%	28.0	36.3	-8.3	-22.94%
	PMP Period	786	810	-24	-2.94%	29.0	29.1	-0.1	-0.38%
Belcher (Section 2)	AMO Period	1245	1241	4	0.34%	16.3	16.8	-0.5	-3.16%
	AMP Period	2086	2056	30	1.48%	12.8	13.4	-0.5	-4.04%
	PMO Period	1345	1353	-8	-0.59%	13.3	12.0	1.4	11.27%
	PMP Period	1861	1886	-26	-1.35%	13.5	13.6	-0.1	-0.86%
US 19 (Section 3)	AMO Period	799	1321	-522	-39.48%	22.4	26.5	-4.1	-15.53%
	AMP Period	1376	1843	-467	-25.35%	7.6	22.9	-15.3	-66.87%
	PMO Period	831	1455	-624	-42.87%	20.9	21.6	-0.7	-3.19%
	PMP Period	1073	2290	-1217	-53.13%	20.1	19.5	0.6	2.89%

WB

Intersection (Belcher Free)	Time Period	Throughput (veh/Time Period) After	Throughput (veh/Time Period) Before	Throughput (After-Before) Volume	Percent Change (%)	Speed (mph) After	Speed (mph) Before	Speed (After - Before) Speed	Percent Change (%)
Highland (Section 1)	AMO Period	2006	1960	45	2.30%	39.7	27.6	12.1	43.74%
	AMP Period	3263	3265	-2	-0.06%	31.9	31.3	0.5	1.73%
	PMO Period	2351	2182	170	7.78%	31.7	30.0	1.7	5.74%
	PMP Period	2970	2878	92	3.20%	30.6	28.3	2.4	8.32%
Belcher (Section 2)	AMO Period	2197	2142	55	2.57%	14.4	14.5	-0.1	-0.84%
	AMP Period	2911	2854	58	2.02%	14.4	15.5	-1.1	-7.26%
	PMO Period	2704	2614	90	3.44%	12.1	13.0	-0.9	-7.15%
	PMP Period	4006	3909	97	2.49%	11.4	11.1	0.3	2.39%
US 19 (Section 3)	AMO Period	2684	2630	54	2.07%	35.1	29.7	5.6	18.44%
	AMP Period	3488	3281	207	6.30%	37.9	27.3	10.6	38.73%
	PMO Period	3368	3125	243	7.78%	30.1	18.5	11.5	62.21%
	PMP Period	5496	5026	470	9.34%	29.3	17.6	11.7	66.59%

Table 5-2: SR 60 Eastbound Travel Time Study (Case 1)

Section 1 - Eastbound

Scenario	Study	Avg Throughput (veh/Study Period	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)
After-Before	AMP	2668	-32.5	3.6	-0.5	-31.3	-0.0105	-1.2052	-12.4714	-0.668
After-Before	AMO	1971	-5	0.5	0	-4.5	0	-0.028	0.8045	0.0226
After-Before	PMO	2262	-32.8	3.5	-0.2	-33	-0.0021	-0.0188	2.4992	0.5316
After-Before	PMP	3623	-32.9	2.7	-0.6	-33	-0.0079	-1.1799	-7.9937	-0.7575

Section 3 - Eastbound

Scenario	Study	Avg Throughput (veh/Study Period	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)
After-Before	AMP	4291	-68.6	5.3	-1.4	-58.7	-0.02	-2.9784	-27.0613	-1.9855
After-Before	AMO	2587	-24.2	2.7	-1	-24.1	-0.0062	-0.5349	1.4799	-0.2854
After-Before	PMO	2855	-46.7	4.7	-1.4	-30.4	-0.0141	-2.5452	-24.7852	-1.9129
After-Before	PMP	4157	29.9	-2.7	0	23.3	0.0021	0.4283	-0.9447	0.0351

Overall SR 60 Corridor - Eastbound (Section 1 + Section 3)

Scenario	Study	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)
After-Before	AMP	-101.1	8.9	-1.9	-90	-0.0305	-4.1836	-39.5327	-2.6535
After-Before	AMO	-29.2	3.2	-1	-28.6	-0.0062	-0.5629	2.2844	-0.2628
After-Before	PMO	-79.5	8.2	-1.6	-63.4	-0.0162	-2.564	-22.286	-1.3813
After-Before	PMP	-3	0	-0.6	-9.7	-0.0058	-0.7516	-8.9384	-0.7224

Table 5-3: SR 60 Westbound Travel Time Study (Case 1)

Section 1 - Westbound

Scenario	Study	Avg Throughput (veh/Study Period	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)
After-Before	AMP	3264	-20.7	2.1	-0.7	-20.8	-0.0069	-1.3238	-9.3675	-1.1464
After-Before	AMO	1983	-26.9	2.9	-0.7	-27.1	-0.0112	-1.0453	-9.5171	-0.6205
After-Before	PMO	2267	-11.2	1	0.3	-11	0.002	0.8142	10.5512	1.013
After-Before	PMP	2924	0.2	0	0.4	0.2	-0.0025	0.2726	-1.725	0.413

Section 3 - Westbound

Scenario	Study	Avg Throughput (veh/Study Period	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)
After-Before	AMP	3385	-44.5	4.8	-1	-44.2	-0.0133	-1.9754	-18.9433	-1.3151
After-Before	AMO	2657	-44.6	4.6	-1.2	-44.4	-0.0129	-2.3581	-15.5757	-1.9178
After-Before	PMO	3246	-77.2	7.3	-1.2	-77	-0.0181	-2.9362	-24.6215	-1.843
After-Before	PMP	5261	-54.3	5.1	-0.9	-54.3	-0.0128	-1.4807	-13.5922	-0.5942

Overall SR 60 Corridor - Westbound (Section 1 + Section 3)

Scenario	Study	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)
After-Before	AMP	-65.2	6.9	-1.7	-65	-0.0202	-3.2992	-28.3108	-2.4615
After-Before	AMO	-71.5	7.5	-1.9	-71.5	-0.0241	-3.4034	-25.0928	-2.5383
After-Before	PMO	-88.4	8.3	-0.9	-88	-0.0161	-2.122	-14.0703	-0.83
After-Before	PMP	-54.1	5.1	-0.5	-54.1	-0.0153	-1.2081	-15.3172	-0.1812

Table 5-4: SR 60 Combined Travel Time Study (Case 1)

Section 1 - Eastbound + Westbound

Scenario	Study	Avg Throughput (veh/Study Period	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)
After-Before	AMP	5932	-53.2	5.7	-1.2	-52.1	-0.0174	-2.529	-21.8389	-1.8144
After-Before	AMO	3954	-31.9	3.4	-0.7	-31.6	-0.0112	-1.0733	-8.7126	-0.5979
After-Before	PMO	4529	-44	4.5	0.1	-44	-0.0001	0.7954	13.0504	1.5446
After-Before	PMP	6547	-32.7	2.7	-0.2	-32.8	-0.0104	-0.9073	-9.7187	-0.3445

Section 3 - Eastbound + Westbound

Scenario	Study	Avg Throughput (veh/Study Period	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)
After-Before	AMP	7675	-113.1	10.1	-2.4	-102.9	-0.0333	-4.9538	-46.0046	-3.3006
After-Before	AMO	5243	-68.8	7.3	-2.2	-68.5	-0.0191	-2.893	-14.0958	-2.2032
After-Before	PMO	6101	-123.9	12	-2.6	-107.4	-0.0322	-5.4814	-49.4067	-3.7559
After-Before	PMP	9418	-24.4	2.4	-0.9	-31	-0.0107	-1.0524	-14.5369	-0.5591

Overall SR 60 Corridor - Eastbound + Westbound (Section 1 + Section 3)

Scenario	Study	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)
After-Before	AMP	-166.3	15.8	-3.6	-155	-0.0507	-7.4828	-67.8435	-5.115
After-Before	AMO	-100.7	10.7	-2.9	-100.1	-0.0303	-3.9663	-22.8084	-2.8011
After-Before	PMO	-167.9	16.5	-2.5	-151.4	-0.0323	-4.686	-36.3563	-2.2113
After-Before	PMP	-57.1	5.1	-1.1	-63.8	-0.0211	-1.9597	-24.2556	-0.9036

LEGEND:
- Improvement
- No significant change
- Decreased performance

Table 5-5: SR 60 Eastbound Before-After MOE Percentage Change (Case 1)

Scenario	Study	Section 1 - Eastbound: Avg Throughput (veh/Study Period)	TT (sec)	TT (%)	Speed (mph)	Speed (%)	Stops	Stops (%)	Delay (sec)	Delay (%)	Fuel (gal)	Fuel (%)
Before	AMP	2697	238.1	-13.6%	23	15.7%	2.1	-23.8%	81.1	-38.6%	0.0955	-11.0%
After	AMP	2638	205.6		26.6		1.6		49.8		0.085	
Before	AMO	1941	214	-2.3%	25.6	2.0%	1.8	0.0%	92	-4.9%	0.0848	0.0%
After	AMO	2000	209		26.1		1.8		87.5		0.0848	
Before	PMO	2237	243.1	-13.5%	22.5	15.6%	1.9	-10.5%	86.3	-38.2%	0.0874	-2.4%
After	PMO	2288	210.3		26		1.7		53.3		0.0853	
Before	PMP	3578	274.7	-12.0%	19.9	13.6%	2.8	-21.4%	117.8	-28.0%	0.0996	-7.9%
After	PMP	3668	241.8		22.6		2.2		84.8		0.0917	

Scenario	Study	Section 3 - Eastbound: Avg Throughput	TT (sec)	TT (%)	Speed (mph)	Speed (%)	Stops	Stops (%)	Delay (sec)	Delay (%)	Fuel (gal)	Fuel (%)
Before	AMP	4259	402.5	-17.0%	26	20.4%	3.3	-42.4%	103	-57.0%	0.1759	-11.4%
After	AMP	4323	333.9		31.3		1.9		44.3		0.1559	
Before	AMO	2512	323.3	-7.5%	32.3	8.4%	2.6	-38.5%	90.6	-26.6%	0.1575	-3.9%
After	AMO	2661	299.1		35		1.6		66.5		0.1513	
Before	PMO	2724	345.4	-13.5%	30.3	15.5%	2.7	-51.9%	45.9	-66.2%	0.1596	-8.8%
After	PMO	2986	298.7		35		1.3		15.5		0.1455	
Before	PMP	4040	325.2	9.2%	32.1	-8.4%	2.2	0.0%	34	68.5%	0.1561	1.3%
After	PMP	4275	355.1		29.4		2.2		57.3		0.1582	

Table 5-6: SR 60 Westbound Before-After MOE Percentage Change (Case 1)

Scenario	Study	Section 1 - Westbound: Avg Throughput (veh/Study Period)	TT (sec)	TT (%)	Speed (mph)	Speed (%)	Stops	Stops (%)	Delay (sec)	Delay (%)	Fuel (gal)	Fuel (%)
Before	AMP	3265	288.7	-7.2%	27.2	7.7%	2.8	-25.0%	114	-18.2%	0.1275	-5.4%
After	AMP	3263	268		29.3		2.1		93.2		0.1206	
Before	AMO	1960	282.4	-9.5%	27.8	10.4%	2.6	-26.9%	107.9	-25.1%	0.1258	-8.9%
After	AMO	2006	255.5		30.7		1.9		80.8		0.1146	
Before	PMO	2182	302	-3.7%	26	3.8%	2.3	13.0%	127.1	-8.7%	0.1235	1.6%
After	PMO	2351	290.8		27		2.6		116.1		0.1255	
Before	PMP	2878	358.4	0.1%	21.9	0.0%	3.2	12.5%	183.6	0.1%	0.1377	-1.8%
After	PMP	2970	358.6		21.9		3.6		183.8		0.1352	

Scenario	Study	Section 3 - Westbound: Avg Throughput	TT (sec)	TT (%)	Speed (mph)	Speed (%)	Stops	Stops (%)	Delay (sec)	Delay (%)	Fuel (gal)	Fuel (%)
Before	AMP	3281	281	-15.8%	25.8	18.6%	2.2	-45.5%	119.4	-37.0%	0.1173	-11.3%
After	AMP	3488	236.5		30.6		1.2		75.2		0.104	
Before	AMO	2630	287.6	-15.5%	25.2	18.3%	2.6	-46.2%	126.1	-35.2%	0.1174	-11.0%
After	AMO	2684	243		29.8		1.4		81.7		0.1045	
Before	PMO	3125	319.8	-24.1%	22.6	32.3%	2.9	-41.4%	158.5	-48.6%	0.1236	-14.6%
After	PMO	3368	242.6		29.9		1.7		81.5		0.1055	
Before	PMP	5026	306	-17.7%	23.7	21.5%	2.5	-36.0%	144.6	-37.6%	0.1189	-10.8%
After	PMP	5496	251.7		28.8		1.6		90.3		0.1061	

LEGEND:
- Improvement
- No significant change
- Decreased performance

Table 5-7: SR 60 Eastbound Travel Time Study (Case 2)

Scenario	Study	Section 1 - Eastbound: Avg Throughput (veh/Study Period	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)	Section 2 - Eastbound: Avg Throughput (veh/Study Period	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)
After-Before	AMP	2683	-22	2.2	-0.2	-20.7	-0.0054	-0.6636	-6.5523	-0.3145	3689	-2.5	0.7	-0.1	-2.3	-0.0021	-0.3967	-5.1042	-0.3496
After-Before	AMO	1952	-8.4	-8.4	0	-8.4	0.0037	0.328	8.2028	0.3604	2295	-9.4	2.2	0.2	-9.8	-0.0004	-0.0122	-0.4727	0.1806
After-Before	PMO	2249	-53.1	6.3	-0.5	-50.3	0.0006	0.0575	10.2545	0.8238	2526	16.1	-3.7	0.3	15.1	0.0046	0.4095	3.1934	0.1649
After-Before	PMP	3596	-48.8	4.3	-0.7	-48.9	-0.0076	-0.8442	-1.1964	-0.1791	3784	-10.1	1.9	0	-10.4	-0.0024	-0.3551	-4.5738	-0.1668

Scenario	Study	Section 3 - Eastbound: Avg Throughput (veh/Study Period	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)	Overall SR 60 Corridor - Eastbound (All Sections): TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)
After-Before	AMP	4360	-18.4	1.37	-0.4	-16.9	-0.0072	-0.9518	-12.2917	-0.6042	-43.9	4.27	-0.7	-39.8	-0.0147	-2.0121	-23.9482	-1.2683
After-Before	AMO	2565	-33.9	3.8	-0.5	-21.1	-0.01	-1.2562	-5.0486	-0.8019	-51.7	-3.4	-0.3	-39.3	-0.0067	-0.9404	2.6816	-0.3609
After-Before	PMO	2947	-24.5	2.3	-0.7	-10.7	0.0014	0.2895	13.7922	0.4826	-61.5	4.9	-0.9	-45.9	0.0066	0.7565	27.2401	1.4713
After-Before	PMP	4097	41.2	-3.6	0.4	35.9	0.0102	1.3071	11.1827	0.6651	-17.7	2.6	-0.3	-23.4	0.0002	0.1078	5.4125	0.3102

Table 5-8: SR 60 Westbound Travel Time Study (Case 2)

Scenario	Study	Section 1 - Westbound: Avg Throughput (veh/Study Period	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)	Section 2 - Westbound: Avg Throughput (veh/Study Period	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)
After-Before	AMP	3324	-22	0.9	-0.3	-6.4	0.0031	0.2353	9.043	0.2428	2848	3.7	-1.1	-0.1	6.2	-0.0002	-0.3888	-3.3908	-0.5041
After-Before	AMO	1991	-31.8	3.5	-0.8	-23.8	-0.0028	-0.2404	9.6791	0.0388	2155	15.3	-5.1	0.1	13.7	0.0031	0.1681	1.6529	-0.1101
After-Before	PMO	2251	-28.2	2.7	0.2	-27.9	0.0028	1.5667	25.7967	1.982	2641	-15.2	4.7	-0.3	-10	-0.0016	-0.4155	-1.1112	-0.2428
After-Before	PMP	2855	-33.6	2.2	0.2	-33.6	0.0029	0.6248	14.3085	1.0799	3913	-29.6	6.2	-0.2	-27.9	-0.0041	-0.4467	-1.8954	0.0187

Scenario	Study	Section 3 - Westbound: Avg Throughput (veh/Study Period	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)	Overall SR 60 Corridor - Westbound (All Sections): TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)
After-Before	AMP	3380	-13.9	1.3	-0.2	-14.7	-0.0013	0.01	0.4969	0.2638	-32.2	1.1	-0.6	-14.9	0.0016	-0.1436	6.1481	0.0026
After-Before	AMO	2636	-55.5	6	-1.3	-52.4	-0.0126	-1.9819	-10.3186	-1.3315	-72	4.4	-2	-62.5	-0.0122	-2.0542	1.0134	-1.4031
After-Before	PMO	3203	-79.4	7.5	-1.2	-75	-0.0165	-3.2222	-13.1287	-1.1102	-122.8	14.9	-1.3	-112.9	-0.0153	-1.072	11.5588	0.629
After-Before	PMP	5154	-61.7	6	-1.2	-67.8	-0.0103	-1.2068	-4.4781	-0.3192	-124.8	14.4	-1.2	-119.3	-0.0115	-1.0277	7.935	0.7794

Table 5-9: SR 60 Combined Travel Time Study (Case 2)

Scenario	Study	Section 1 - Eastbound + Westbound: Avg Throughput (veh/Study Period	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)	Section 2 - Eastbound + Westbound: Avg Throughput (veh/Study Period	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)
After-Before	AMP	6007	-44	3.1	-0.5	-27.1	-0.0023	-0.4283	2.4907	-0.0717	6537	1.2	0.4	-0.2	3.9	-0.0023	-0.7865	-8.496	-0.8537
After-Before	AMO	3943	-40.2	-5.9	-0.8	-32.2	0.0008	0.0876	17.8819	0.3989	4450	6.9	2.9	0.3	3.9	0.0027	0.1569	1.1802	0.0706
After-Before	PMO	4500	-81.3	9	-0.3	-78.2	0.0034	1.6232	36.0512	2.8058	5169	0.9	1	0	5.1	0.003	-0.006	2.0822	-0.0779
After-Before	PMP	6451	-82.3	6.5	-0.5	-82.5	-0.0047	-0.2194	13.1121	0.9008	7697	-39.7	8.1	-0.2	-38.3	-0.0065	-0.8016	-6.4692	-0.1471

Scenario	Study	Section 3 - Eastbound + Westbound: Avg Throughput (veh/Study Period	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)	Overall SR 60 Corridor - Eastbound + Westbound (All Sections): TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)
After-Before	AMP	7740	-33.3	2.67	-0.6	-31.6	-0.0085	-0.9418	-11.7958	-0.3403	-76.1	5.37	-1.3	-54.8	-0.0131	-2.1566	-17.8301	-1.2657
After-Before	AMO	5201	-89.4	9.8	-1.8	-73.5	-0.0226	-3.2301	-15.3671	-2.2334	-123.7	1	-2.3	-101.8	-0.0189	-2.9946	3.695	-1.764
After-Before	PMO	6050	-103.9	9.8	-1.9	-85.7	-0.0151	-1.9337	0.6635	-0.6276	-184.3	19.8	-2.2	-158.8	-0.0087	-0.3165	38.7969	2.1003
After-Before	PMP	9251	-20.5	2.4	-0.8	-21.9	-0.0001	0.1013	6.7046	0.3359	-142.5	17	-1.5	-142.7	-0.0113	-0.9199	13.3475	1.0896

LEGEND:	
(green)	Improvement
(yellow)	No significant change
(pink)	Decreased performance

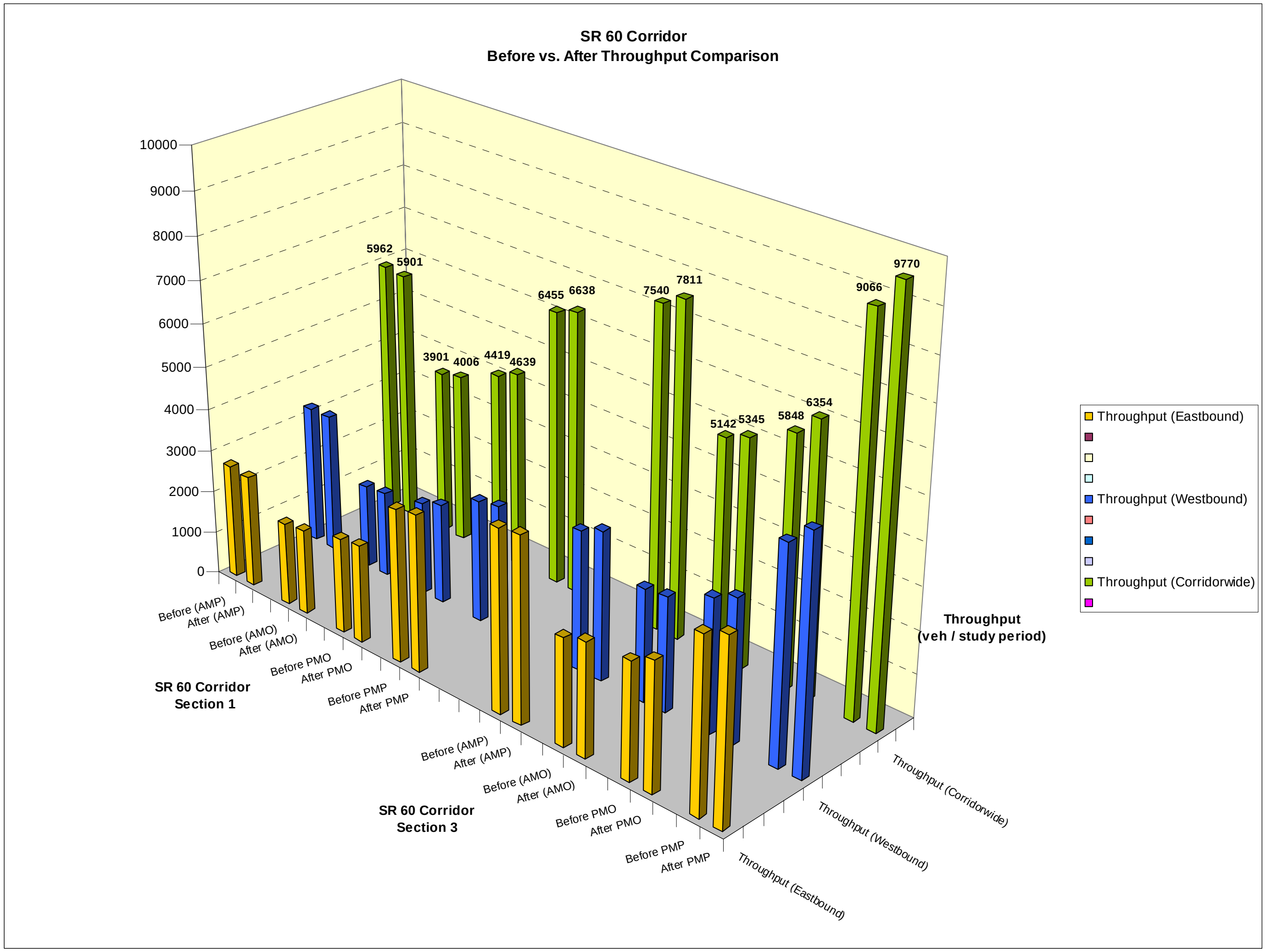

Figure 5-1: Comparison of Before vs. After Throughput on SR 60 Corridor

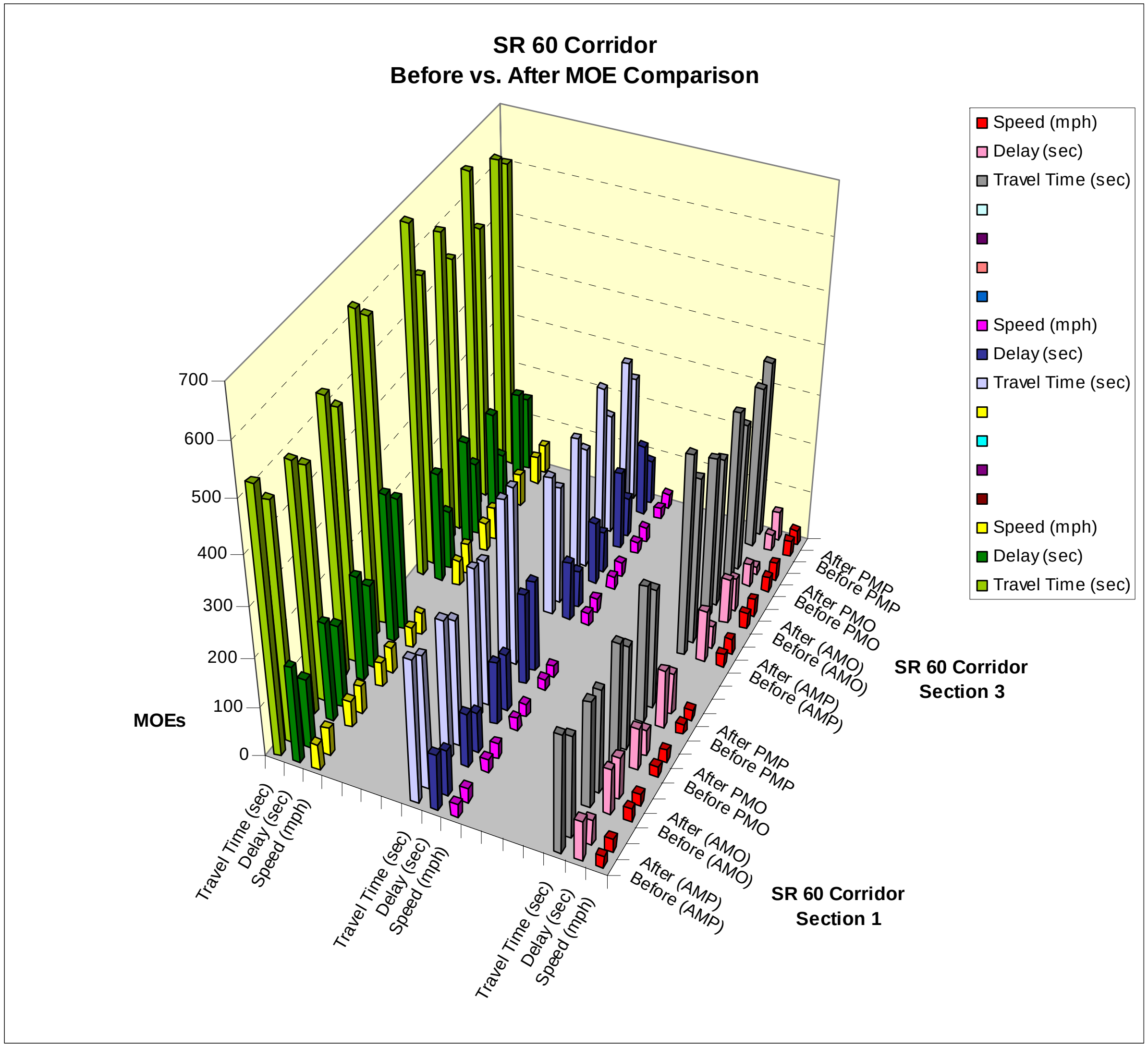

Figure 5-2: Comparison of Before vs. After MOEs on SR 60 Corridor

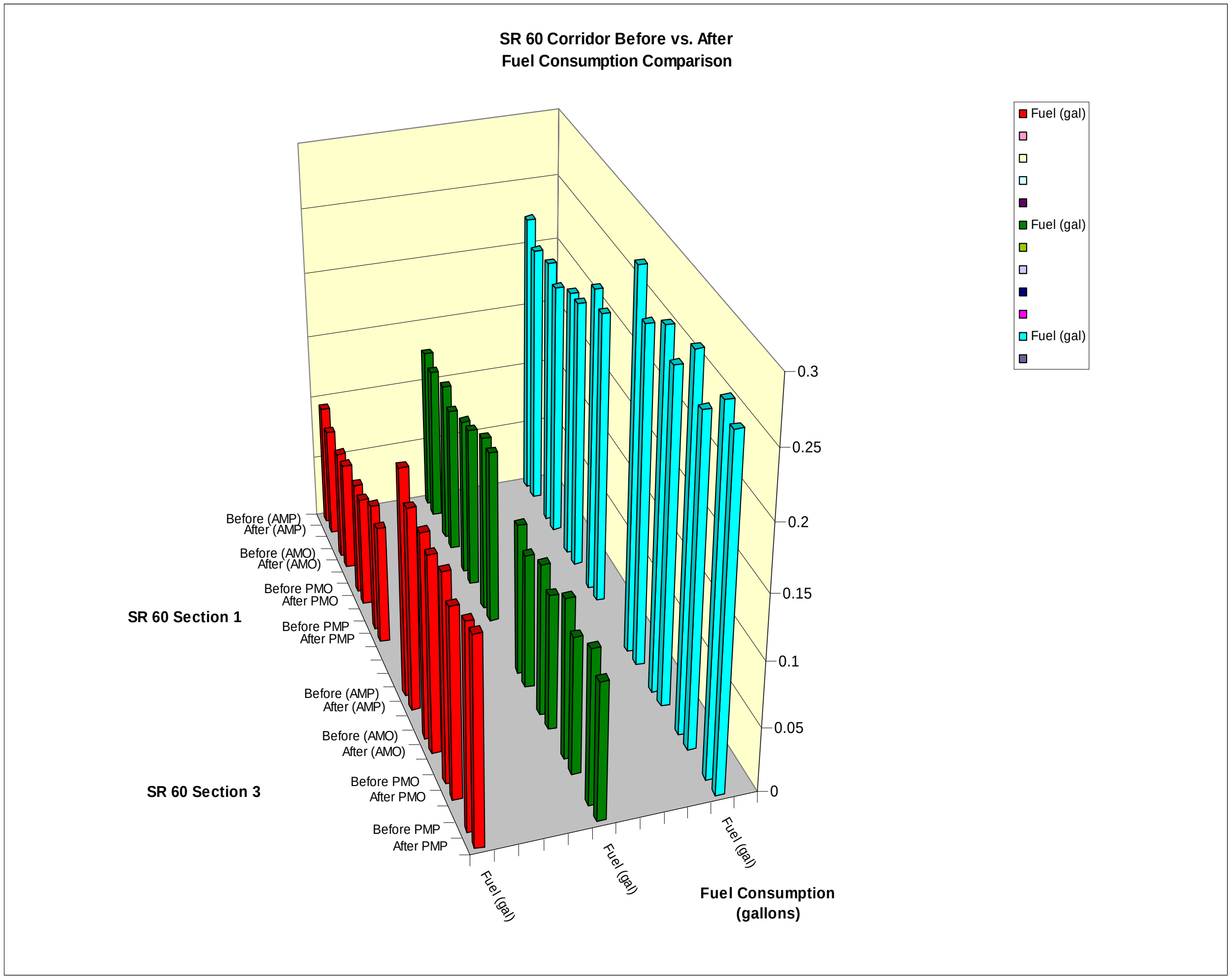

Figure 5-3: Comparison of Before vs. After Fuel Consumption on SR 60 Corridor

SR 60 Boundary Conditions

Table 5-10: SR 60 Eastbound Corridor Boundary Conditions

Section 1 - Eastbound boundary condition

Scenario	Study	Throughput (Case 2 - Case 1)	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)
After-Before	AMP	16	10.5	-1.4	0.3	10.6	0.0051	0.5416	5.9191	0.3535
After-Before	AMO	-18	-3.4	-9.9	0	-3.9	0.0037	0.366	7.3983	0.3378
After-Before	PMO	-14	-20.3	2.8	-0.3	-17.3	0.0027	0.0763	7.7553	0.2922
After-Before	PMP	-27	-15.9	1.6	-0.1	-15.9	0.0003	0.3357	6.7973	0.5784

Section 2 - Eastbound boundary condition

Scenario	Study	Throughput (Case 2 - Case 1)	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)
After-Before	AMP	41	-0.3	0.1	0	-0.8	-0.0003	-0.0575	-1.5315	-0.0321
After-Before	AMO	14	-9.9	2.3	0.1	-10.3	-0.0008	-0.0169	0.1727	0.1742
After-Before	PMO	24	-20.4	3.2	0	-20.7	-0.0028	-0.2461	-1.9662	0.1174
After-Before	PMP	-42	-10	1.9	0.2	-10.8	-0.0013	-0.1936	-2.8439	0.0082

Section 3 - Eastbound boundary condition

Scenario	Study	Throughput (Case 2 - Case 1)	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)
After-Before	AMP	69	49.2	-3.93	1	41.8	0.0128	2.0266	14.7696	1.3813
After-Before	AMO	-22	-9.7	1.1	0.5	3	-0.0038	-0.7213	-6.5284	-0.6165
After-Before	PMO	-8	22.2	-2.4	0.7	19.7	0.0155	2.8337	38.5774	2.3955
After-Before	PMP	-60	11.3	-0.9	0.4	12.6	0.0081	0.8788	12.1274	0.62

SR 60 Corridor Eastbound - All Sections boundary condition

Scenario	Study	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)
After-Before	AMP	59.4	-5.23	1.3	51.6	0.0176	2.5107	19.1572	1.7027
After-Before	AMO	-23	-6.5	0.6	-11.2	-0.0009	-0.3822	1.0426	-0.1045
After-Before	PMO	-18.5	3.6	0.4	-18.3	0.0154	2.6639	44.3665	2.8051
After-Before	PMP	-14.6	2.6	0.5	-14.1	0.0071	1.0209	16.0008	1.2066

Table 5-11: SR 60 Westbound Corridor Boundary Conditions

Section 1 - Westbound boundary condition

Scenario	Study	Throughput (Case 2 - Case 1)	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)
After-Before	AMP	60	-1.3	-1.2	0.4	14.4	0.01	1.5591	18.4105	1.3892
After-Before	AMO	8	-4.9	0.6	-0.1	3.3	0.0084	0.8049	19.1962	0.659
After-Before	PMO	-15	-17	1.7	-0.1	-16.9	0.0008	0.7515	15.2455	0.969
After-Before	PMP	-69	-33.7	2.2	-0.2	-33.8	0.0054	0.3622	16.0335	0.6669

Section 2 - Westbound boundary condition

Scenario	Study	Throughput (Case 2 - Case 1)	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)
After-Before	AMP	-34	-10.4	2.8	-0.2	-7.7	-0.0016	-0.2402	1.2558	-0.1558
After-Before	AMO	-15	-7	1.8	0	-8.5	0.0013	0.2688	5.331	0.3475
After-Before	PMO	-19	-18.5	5.5	-0.1	-13.3	-0.0013	-0.1696	0.9161	0.0724
After-Before	PMP	-45	-28.6	6	-0.2	-26.9	-0.0034	-0.2771	0.5354	0.1556

Section 3 - Westbound boundary condition

Scenario	Study	Throughput (Case 2 - Case 1)	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)
After-Before	AMP	-4	30.6	-3.5	0.8	29.5	0.012	1.9854	19.4392	1.579
After-Before	AMO	-21	-10.9	1.4	-0.1	-8	0.0004	0.3762	5.2571	0.5863
After-Before	PMO	-43	-2.2	0.2	0	2	0.0016	0.714	11.4928	0.7328
After-Before	PMP	-106	-7.4	0.9	-0.3	-3.5	0.0025	0.2749	9.1141	0.275

Overall SR 60 Corridor - Westbound All Sections boundary condition

Scenario	Study	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)
After-Before	AMP	18.9	-1.9	1	36.2	0.0204	3.3043	39.1055	2.8124
After-Before	AMO	-22.8	3.8	-0.2	-13.2	0.0101	1.4499	29.7843	1.5928
After-Before	PMO	-37.7	7.4	-0.2	-28.2	0.0011	1.2759	27.6544	1.7742
After-Before	PMP	-69.7	9.1	-0.7	-64.2	0.0045	0.35	25.683	1.0975

Table 5-12: SR 60 Overall Corridor Boundary Conditions

Section 1 - Eastbound + Westbound boundary condition

Scenario	Study	Throughput (Case 2 - Case 1)	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)
After-Before	AMP	76	9.2	-2.6	0.7	25	0.0151	2.1007	24.3296	1.7427
After-Before	AMO	-10	-8.3	-9.3	-0.1	-0.6	0.0121	1.1609	26.5945	0.9968
After-Before	PMO	-29	-37.3	4.5	-0.4	-34.2	0.0035	0.8278	23.0008	1.2612
After-Before	PMP	-96	-49.6	3.8	-0.3	-49.7	0.0057	0.6979	22.8308	1.2453

Section 2 - Eastbound + Westbound boundary condition

Scenario	Study	Throughput (Case 2 - Case 1)	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)
After-Before	AMP	7	-10.7	2.9	-0.2	-8.5	-0.0019	-0.2977	-0.2757	-0.1879
After-Before	AMO	-1	-16.9	4.1	0.1	-18.8	0.0005	0.2519	5.5037	0.5217
After-Before	PMO	6	-38.9	8.7	-0.1	-34	-0.0041	-0.4357	-1.0501	0.1898
After-Before	PMP	-86	-38.6	7.9	0	-37.7	-0.0047	-0.4707	-2.3085	0.1638

Section 3 - Eastbound + Westbound boundary condition

Scenario	Study	Throughput (Case 2 - Case 1)	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)
After-Before	AMP	65	79.8	-7.43	1.8	71.3	0.0248	4.012	34.2088	2.9603
After-Before	AMO	-43	-20.6	2.5	0.4	-5	-0.0034	-0.3451	-1.2713	-0.0302
After-Before	PMO	-51	20	-2.2	0.7	21.7	0.0171	3.5477	50.0702	3.1283
After-Before	PMP	-167	3.9	0	0.1	9.1	0.0106	1.1537	21.2415	0.895

Overall SR 60 Corridor - Eastbound + Westbound (All Sections) boundary condition

Scenario	Study	TT (sec)	Speed (mph)	Stops	Delay (sec)	Fuel (gal)	HC (grams)	CO (grams)	Nox (grams)
After-Before	AMP	78.3	-7.13	2.3	87.8	0.038	5.815	58.2627	4.5151
After-Before	AMO	-45.8	-2.7	0.4	-24.4	0.0092	1.0677	30.8269	1.4883
After-Before	PMO	-56.2	11	0.2	-46.5	0.0165	3.9398	72.0209	4.5793
After-Before	PMP	-84.3	11.7	-0.2	-78.3	0.0116	1.3709	41.7638	2.3041

LEGEND:

- Improvement
- No significant change
- Decreased performance

Table 5-13: SR 60 Eastbound Cost/Savings Analysis (Case 1)

Scenario	Study	Section 1 - Eastbound							Section 3 - Eastbound							Overall SR 60 Corridor - Eastbound (Section 1 + Section 3)					
			Cost/Savings per Hour			Cost/Savings Per Year				Cost/Savings per Hour			Cost/Savings Per Year			Cost/Savings per Hour			Cost/Savings Per Year		
		Avg Throughput (veh/Study Period)	Labor ($/hr)	Fuel ($/hr)	Total ($/hr)	Labor ($/Yr)	Fuel ($/Yr)	Total ($/Yr)	Avg Throughput (veh/Study Period)	Labor ($/hr)	Fuel ($/hr)	Total ($/hr)	Labor ($/Yr)	Fuel ($/Yr)	Total ($/Yr)	Labor ($/hr)	Fuel ($/hr)	Total ($/hr)	Labor ($/Yr)	Fuel ($/Yr)	Total ($/Yr)
After-Before	AMP	2668	-$139	-$70	-$209	-$72,365	-$36,414	-$108,779	4291	-$420	-$215	-$634	-$218,285	-$111,560	-$329,844	-$559	-$285	-$844	-$290,650	-$147,973	-$438,623
After-Before	AMO	1971	-$15	$0	-$15	-$11,528	$0	-$11,528	2587	-$104	-$40	-$144	-$81,040	-$31,273	-$112,313	-$119	-$40	-$159	-$92,568	-$31,273	-$123,841
After-Before	PMO	2262	-$124	-$12	-$136	-$97,058	-$9,265	-$106,322	2855	-$145	-$101	-$245	-$112,823	-$78,494	-$191,317	-$269	-$113	-$382	-$209,881	-$87,758	-$297,639
After-Before	PMP	3623	-$199	-$72	-$271	-$155,420	-$55,810	-$211,229	4157	$161	$22	$183	$125,921	$17,024	$142,944	-$38	-$50	-$88	-$29,499	-$38,786	-$68,285
						-$336,370	-$101,488	-$437,858					-$286,227	-$204,302	-$490,530				-$622,597	-$305,790	-$928,388

Table 5-14: SR 60 Westbound Cost/Savings Analysis (Case 1)

Scenario	Study	Section 1 - Westbound							Section 3 - Westbound							Overall SR 60 Corridor - Westbound (Section 1 + Section 3)					
			Cost/Savings per Hour			Cost/Savings Per Year				Cost/Savings per Hour			Cost/Savings Per Year			Cost/Savings per Hour			Cost/Savings Per Year		
		Avg Throughput (veh/Study Period)	Labor ($/hr)	Fuel ($/hr)	Total ($/hr)	Labor ($/Yr)	Fuel ($/Yr)	Total ($/Yr)	Avg Throughput (veh/Study Period)	Labor ($/hr)	Fuel ($/hr)	Total ($/hr)	Labor ($/Yr)	Fuel ($/Yr)	Total ($/Yr)	Labor ($/hr)	Fuel ($/hr)	Total ($/hr)	Labor ($/Yr)	Fuel ($/Yr)	Total ($/Yr)
After-Before	AMP	3264	-$113	-$56	-$169	-$58,841	-$29,279	-$88,119	3385	-$249	-$113	-$362	-$129,655	-$58,521	-$188,176	-$362	-$169	-$531	-$188,496	-$87,800	-$276,296
After-Before	AMO	1983	-$90	-$56	-$145	-$69,858	-$43,307	-$113,165	2657	-$197	-$86	-$282	-$153,343	-$66,828	-$220,171	-$286	-$141	-$427	-$223,201	-$110,135	-$333,336
After-Before	PMO	2267	-$42	$11	-$30	-$32,411	$8,839	-$23,572	3246	-$417	-$147	-$564	-$324,966	-$114,582	-$439,549	-$458	-$136	-$594	-$357,377	-$105,743	-$463,120
After-Before	PMP	2924	$1	-$18	-$17	$760	-$14,253	-$13,493	5261	-$476	-$168	-$644	-$371,356	-$131,308	-$502,665	-$475	-$187	-$662	-$370,596	-$145,561	-$516,157
						-$160,349	-$77,999	-$238,349					-$979,321	-$371,240	-$1,350,561				-$1,139,670	-$449,239	-$1,588,909

Table 5-15: SR 60 Combined Cost/Savings Analysis (Case 1)

Scenario	Study	Section 1 - Eastbound + Westbound							Section 3 - Eastbound + Westbound							Overall SR 60 Corridor - Eastbound + Westbound (Section 1 + Section 3)					
			Cost/Savings per Hour			Cost/Savings Per Year				Cost/Savings per Hour			Cost/Savings Per Year			Cost/Savings per Hour			Cost/Savings Per Year		
		Avg Throughput (veh/Study Period)	Labor ($/hr)	Fuel ($/hr)	Total ($/hr)	Labor ($/Yr)	Fuel ($/Yr)	Total ($/Yr)	Avg Throughput (veh/Study Period)	Labor ($/hr)	Fuel ($/hr)	Total ($/hr)	Labor ($/Yr)	Fuel ($/Yr)	Total ($/Yr)	Labor ($/hr)	Fuel ($/hr)	Total ($/hr)	Labor ($/Yr)	Fuel ($/Yr)	Total ($/Yr)
After-Before	AMP	5932	-$252	-$126	-$379	-$131,205	-$65,692	-$196,898	7675	-$669	-$327	-$996	-$347,940	-$170,080	-$518,020	-$921	-$453	-$1,375	-$479,145	-$235,773	-$714,918
After-Before	AMO	3954	-$104	-$56	-$160	-$81,386	-$43,307	-$124,693	5243	-$300	-$126	-$426	-$234,383	-$98,101	-$332,484	-$405	-$181	-$586	-$315,769	-$141,408	-$457,177
After-Before	PMO	4529	-$166	-$1	-$167	-$129,469	-$425	-$129,894	6101	-$561	-$248	-$809	-$437,789	-$193,076	-$630,865	-$727	-$248	-$975	-$567,258	-$193,501	-$760,759
After-Before	PMP	6547	-$198	-$90	-$288	-$154,659	-$70,063	-$224,722	9418	-$315	-$147	-$461	-$245,436	-$114,285	-$359,720	-$513	-$236	-$749	-$400,095	-$184,347	-$584,443
						-$496,720	-$179,487	-$676,207					-$1,265,548	-$575,542	-$1,841,090				-$1,762,268	-$755,030	-$2,517,297

LEGEND:
- Improvement
- No significant change
- Decreased performance

Table 5-16: SR 60 Main Corridor Summary of Benefits

Scenario	Study	Cost/Savings Per Year – Eastbound		
		Labor ($/Yr)	Fuel ($/Yr)	Total ($/Yr)
Adaptive vs. Traditional	AM Peak Period	-$290,650	-$147,973	-$438,623
Adaptive vs. Traditional	AM Off-Peak Period	-$92,568	-$31,273	-$123,841
Adaptive vs. Traditional	PM Off-Peak Period	-$209,881	-$87,758	-$297,639
Adaptive vs. Traditional	PM Peak Period	-$29,499	-$38,786	-$68,285
Total Annual Savings – SR 60 Eastbound		-$622,597	-$305,790	-$928,388
Scenario	Study	Cost/Savings Per Year – Westbound		
		Labor ($/Yr)	Fuel ($/Yr)	Total ($/Yr)
Adaptive vs. Traditional	AM Peak Period	-$188,496	-$87,800	-$276,296
Adaptive vs. Traditional	AM Off-Peak Period	-$223,201	-$110,135	-$333,336
Adaptive vs. Traditional	PM Off-Peak Period	-$357,377	-$105,743	-$463,120
Adaptive vs. Traditional	PM Peak Period	-$370,596	-$145,561	-$516,157
Total Annual Savings – SR 60 Westbound		-$1,139,670	-$449,239	-$1,588,909
Scenario	Study	Cost/Savings Per Year - Eastbound + Westbound		
		Labor ($/Yr)	Fuel ($/Yr)	Total ($/Yr)
Adaptive vs. Traditional	AM Peak Period	-$479,145	-$235,773	-$714,918
Adaptive vs. Traditional	AM Off-Peak Period	-$315,769	-$141,408	-$457,177
Adaptive vs. Traditional	PM Off-Peak Period	-$567,258	-$193,501	-$760,759
Adaptive vs. Traditional	PM Peak Period	-$400,095	-$184,347	-$584,443
Total Annual Savings – SR 60 Eastbound + Westbound		**-$1,762,268**	**-$755,030**	**-$2,517,298**

LEGEND:		
	(green)	Improvement
	(yellow)	No significant change
	(pink)	Decreased performance

SR 60 Side Street Findings

Table 5-17: SR 60 Level of Service Study

Study Period	Critical Intersection	Intersection Movements	BEFORE SCENARIO				AFTER (Belcher Free) SCENARIO				DIFFERENCE	
			Avg. Control Delay (sec)	Stop Delay (sec)	Control Delay/Stop Delay	LOS	Avg. Control Delay (sec)	Stop Delay (sec)	Control Delay/Stop Delay	LOS	Avg. Control Delay (sec)	Stop Delay (sec)
AM Peak	SR 60 at US19	All Movements	38	23	1.65	D	68	44	1.55	E	30	21
		US 19 & Major Left	49	32	1.53	D	98	65	1.51	F	49	33
		Side Street Only	51	32	1.59	D	126	84	1.50	F	75	52
		Side Street NB	56	34	1.65	E	69	42	1.64	E	13	8
		Side Street SB	45	30	1.50	D	191	132	1.45	F	146	102
	SR 60 at Belcher Rd.	All Movements	56	41	1.37	E	42	29	1.45	D	-14	-12
		Belcher & Major Left	63	48	1.31	E	44	30	1.47	D	-19	-18
		Side Street Only	61	44	1.39	E	45	31	1.45	D	-16	-13
		Side Street NB	59	45	1.31	E	39	28	1.39	D	-20	-17
		Side Street SB	62	43	1.44	E	51	34	1.50	D	-11	-9
	SR 60 at Highland Ave.	All Movements	23	14	1.64	C	31	20	1.55	C	8	6
		Side Street Only	34	23	1.48	C	45	32	1.41	D	11	9
		Side Street NB	34	25	1.36	C	43	31	1.39	D	9	6
		Side Street SB	46	36	1.28	D	47	33	1.42	D	1	-3
AM Off-Peak	SR 60 at US19	All Movements	26	11	2.36	C	28	17	1.65	C	2	6
		US 19 & Major Left	33	16	2.06	C	40	26	1.54	D	7	10
		Side Street Only	29	13	2.23	C	43	30	1.43	D	14	17
		Side Street NB	47	28	1.68	D	37	23	1.61	D	-10	-5
		Side Street SB	14	1	14	B	50	37	1.35	D	36	36
	SR 60 at Belcher Rd.	All Movements	43	30	1.43	D	38	26	1.46	D	-5	-4
		Belcher & Major Left	51	37	1.38	D	40	26	1.54	D	-11	-11
		Side Street Only	51	37	1.38	D	38	23	1.65	D	-13	-14
		Side Street NB	56	41	1.37	E	46	34	1.35	D	-10	-7
		Side Street SB	47	33	1.42	D	29	12	2.42	C	-18	-21
	SR 60 at Highland Ave.	All Movements	33	22	1.50	C	23	13	1.77	C	-10	-9
		Side Street Only	44	34	1.29	D	33	21	1.57	C	-11	-13
		Side Street NB	43	31	1.39	D	31	22	1.41	C	-12	-9
		Side Street SB	46	36	1.28	D	35	21	1.67	D	-11	-15
PM Off-Peak	SR 60 at US19	All Movements	36	24	1.50	D	42	35	1.20	D	6	11
		US 19 & Major Left	44	31	1.42	D	63	53	1.19	E	19	22
		Side Street Only	38	25	1.52	D	41	31	1.32	D	3	6
		Side Street NB	38	26	1.46	D	68	58	1.17	E	30	32
		Side Street SB	38	25	1.52	D	18	9	2.00	B	-20	-16
	SR 60 at Belcher Rd.	All Movements	59	43	1.37	E	50	34	1.47	D	-9	-9
		Belcher & Major Left	61	46	1.33	E	50	36	1.39	D	-11	-10
		Side Street Only	57	43	1.33	E	47	32	1.47	D	-10	-11
		Side Street NB	43	29	1.48	D	48	32	1.50	D	5	3
		Side Street SB	73	59	1.24	E	46	32	1.44	D	-27	-27
	SR 60 at Highland Ave.	All Movements	33	22	1.50	C	26	17	1.53	C	-7	-5
		Side Street Only	44	32	1.38	D	36	25	1.44	D	-8	-7
		Side Street NB	55	42	1.31	E	35	24	1.46	D	-20	-18
		Side Street SB	32	21	1.52	C	38	25	1.52	D	6	4
PM Peak	SR 60 at US19	All Movements	46	30	1.53	D	79	55	1.44	E	33	25
		US 19 & Major Left	53	37	1.43	D	106	75	1.41	F	53	38
		Side Street Only	52	35	1.49	D	106	75	1.41	F	54	40
		Side Street NB	80	58	1.38	F	152	104	1.46	F	72	46
		Side Street SB	26	16	1.63	C	84	62	1.35	F	58	46
	SR 60 at Belcher Rd.	All Movements	70	52	1.35	E	72	55	1.31	E	2	3
		Belcher & Major Left	76	56	1.36	E	79	61	1.30	E	3	5
		Side Street Only	72	57	1.26	E	78	59	1.32	E	6	2
		Side Street NB	84	68	1.24	F	100	80	1.25	F	16	12
		Side Street SB	61	45	1.36	E	56	38	1.47	E	-5	-7
	SR 60 at Highland Ave.	All Movements	34	22	1.55	C	34	23	1.48	C	0	1
		Side Street Only	43	31	1.39	D	46	33	1.39	D	3	2
		Side Street NB	49	37	1.32	D	67	50	1.34	E	18	13
		Side Street SB	36	25	1.44	D	26	17	1.53	C	-10	-8

LEGEND:	
(green)	Improvement
(yellow)	No significant change
(pink)	Decreased performance

Table 5-18: SR 60 Side Street Summary of Benefits

Section	Critical Intersection	Time Period	Side Street Delay ($/Yr)
Section 1	SR 60 at Highland	AM Peak Period	$8,452
		AM Off-Peak Period	-$22,832
		PM Off-Peak Period	-$19,200
		PM Peak Period	$17,208
	Total Side Street Cost (Highland Only)		**-$16,372**
Section 3	SR 60 at US 19	AM Peak Period	$256,619
		AM Off-Peak Period	$67,059
		PM Off-Peak Period	-$3,153
		PM Peak Period	$244,270
	Total Side Street Cost (US 19)		**$564,796**
SR 60 Eastbound and Westbound Labor Savings			**-$1,762,268**
Total Net Cost for SR 60 Corridorwide	**-$1,762,268 + (15 X - $16,372) + $564,796**		**-$1,443,052**

LEGEND:	
(green)	Improvement
(yellow)	No significant change
(pink)	Decreased performance

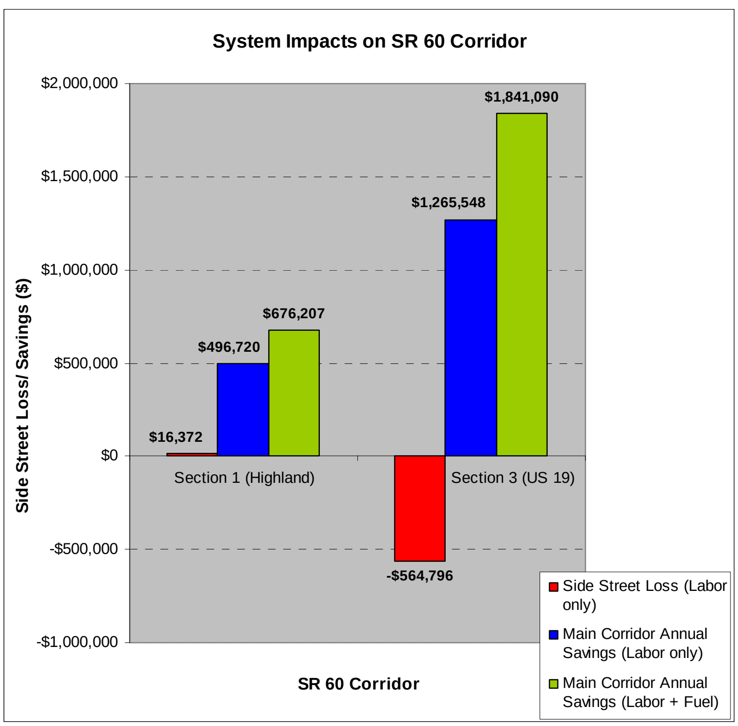

Figure 5-4: System Impacts on SR 60 Corridor

SR 60 Descriptive Corridorwide Crash Assessment

Table 5-19: SR 60 Corridorwide Crash Assessment (Case 2)

Crash Severity	SR 60 Crashes (After Scenario)															
	SR 60 Main Corridor (After with Belcher Adaptive)								SR 60 Side Streets (After with Belcher Adaptive)							
	Rear End	Head On	Angle	Left Turn	Right Turn	Side Swipe	Hit Other Fixed Object	Total	Rear End	Head On	Angle	Left Turn	Right Turn	Side Swipe	Hit Other Fixed Object	Total
Property Damage	2	0	1	0	0	0	0	**3**	0	0	0	0	0	0	0	**0**
Injuries	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	**0**
Total Crashes	**2**	**0**	**1**	**0**	**0**	**0**	**0**	3	**0**	**0**	**0**	**0**	**0**	**0**	**0**	0

Crash Severity	SR 60 Crashes (Before Scenario)															
	SR 60 Main Corridor (Before)								SR 60 Side Streets (Before)							
	Rear End	Head On	Angle	Left Turn	Right Turn	Side Swipe	Hit Other Fixed Object	Total	Rear End	Head On	Angle	Left Turn	Right Turn	Side Swipe	Hit Other Fixed Object	Total
Property Damage	3	0	2	1	0	1	0	**7**	0	0	0	0	0	0	0	**0**
Injuries	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	**0**
Total Crashes	**3**	**0**	**2**	**1**	**0**	**1**	**0**	7	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Table 5-20: SR 60 Corridorwide Before/After Crash Assessment (Case 2)

Crash Severity	After - Before																				
	All Crashes (SR 60 After - Before Analysis)							Corridor (SR 60 After - Before Analysis)							Side Street (SR 60 After - Before Analysis)						
	Rear End	Head On	Angle	Left Turn	Right Turn	Side Swipe	Hit Other Fixed Object	Rear End	Head On	Angle	Left Turn	Right Turn	Side Swipe	Hit Other Fixed Object	Rear End	Head On	Angle	Left Turn	Right Turn	Side Swipe	Hit Other Fixed Object
Property Damage	-1	0	-1	-1	0	-1	0	-1	0	-1	-1	0	-1	0	0	0	0	0	0	0	0
Injuries	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LEGEND:	
(green)	Improvement
(yellow)	No significant change
(pink)	Decreased performance

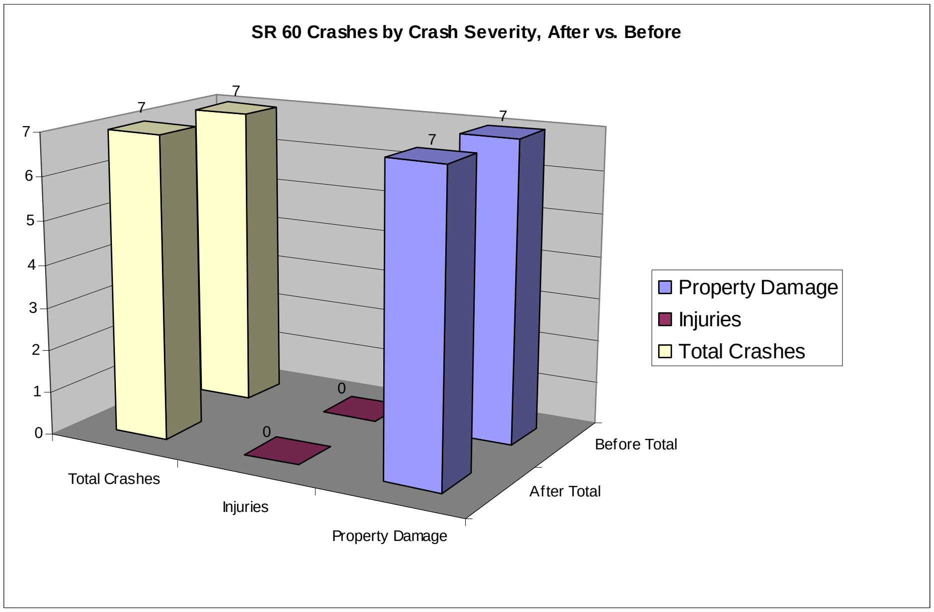

Figure 5-5: SR 60 Before vs. After Crashes by Severity

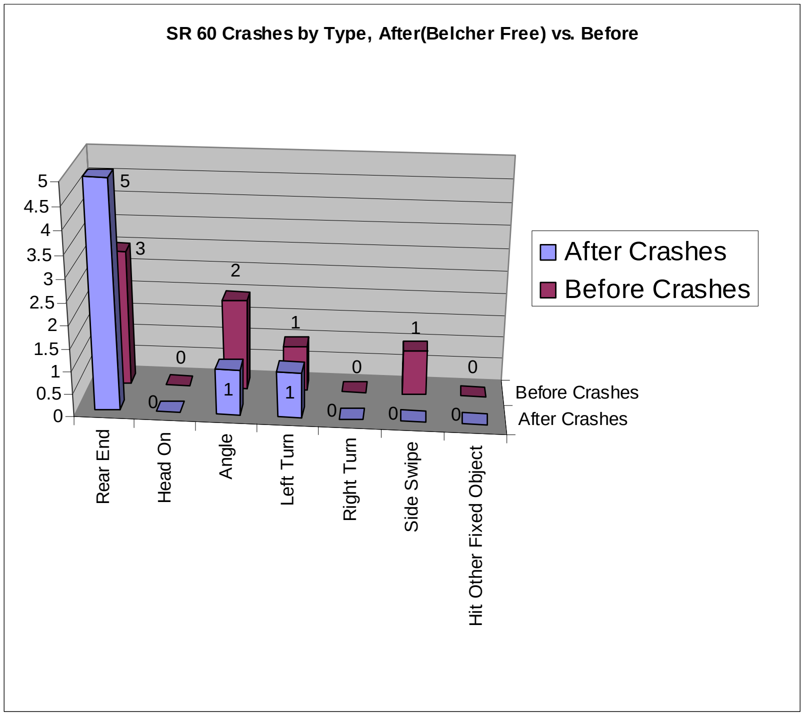

Figure 5-6: SR 60 Before vs. After Crashes by Severity

6.0 CONCLUSIONS AND RECOMMENDATIONS

Table 6-1 and Figure 6-1 present the total lifecycle cost, savings, and associated benefit/cost ratios for US 19 and SR 60 corridors. The present value of the savings attributed to each adaptive system was estimated using a 10-year life cycle and a 6-percent compounding interest rate. The cost of the adaptive system reflects a portion of the deployment cost for the Pinellas Countywide ATMS project. The required elements for adaptive control included advanced traffic controller and associated cabinet, central control software, local control firmware, adaptive control hardware and software, detection, etc.

Table 6-1: Total Lifecycle Benefits for Adaptive Control

Corridor	Life-Cycle Savings (Present Value)	System Cost (Adaptive)	Benefit/Cost Ratio
US 19	$6,144,239	$1,020,000	6.0
SR 60	$10,620,861	$1,370,000	7.75
Total Project	$16,765,101	$2,390,000	7.0

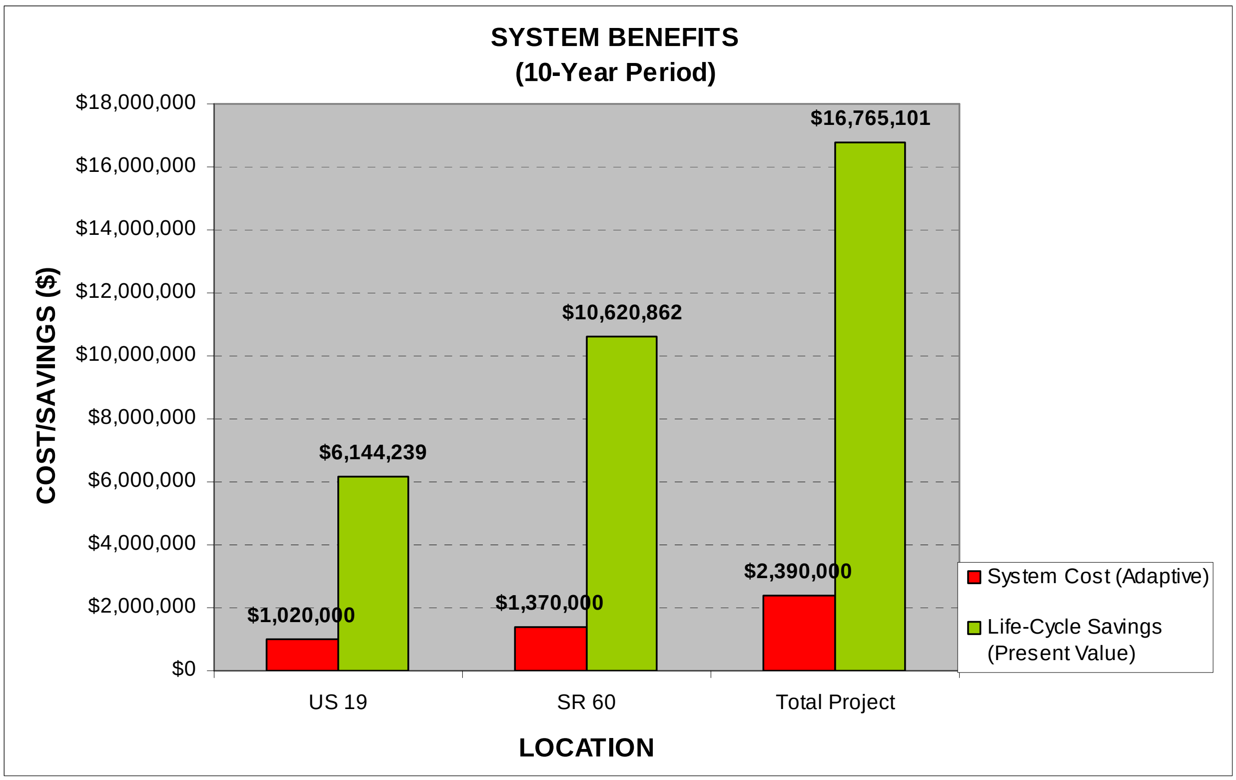

Figure 6-1: Adaptive system implementation benefits over 10 years

The total deployment cost ($9 million) for the Pinellas Countywide ATMS project encompassed other improvements. These improvements included:

- ❑ Video wall, consoles, servers, electronic devices, communications equipment, etc. in the County's regional traffic management center

- CCTV cameras, dynamic message signs, inductive loops, video image detectors, etc. along US 19 and SR 60 corridors
- Communications infrastructure, fiber optic media, and end equipment for center-to-field devices connectivity.

The overarching conclusion of this assessment study, derived from Table 6-1 findings, is that both adaptive traffic control systems represent great value for each invested dollar, considering the high benefit/cost ratios of 6.0 for US 19 and 7.75 for SR 60 corridors. The present value of the combined total lifecycle savings over a 10-year period for the two adaptive systems is $16.7 million compared to the total adaptive system deployment cost of $2.3 million. This signifies an overall benefit/cost ratio of 7.0, which is significantly higher than return on investments derived from roadway capacity improvement projects. The deployed adaptive traffic control systems are prudent investment choices considering the significant operational benefits measured as savings in labor, consumed fuel, and environmental pollutants.

The following conclusions are pertinent to the operational impacts of the adaptive traffic control systems deployed along US 19 and SR 60 corridors, respectively.

6.1.1 US 19 Corridor

The overarching conclusion for the US 19 corridor is that the adaptive traffic control system represents a great value for each invested dollar, considering the high benefit/cost ratio for the US 19 corridor. The total lifecycle savings over a 10-year period at present value for the adaptive system are $6.14 million. Compared to the system total cost, the benefit/cost ratio is 6.0. Other pertinent conclusions include:

- The main corridor of US 19 experienced significant operational improvements. However, this success was achieved, at least in part, via degradation of traffic operations on side streets. Travel times and other MOEs improved in the direction of peak traffic flow along US 19 for all study periods, however, in certain cases, travel times worsened in the non-peak direction (e.g., northbound flow during AM Peak period). Typically, peak direction volumes were observed to be twice as much as the non-peak direction thus making the associated operational benefits far exceeding the operational disbenefits in the non-peak direction.
- The side streets were penalized along the US 19 corridor to accommodate the traffic flow along the main corridor. The total delay at side streets increased under adaptive traffic control system compared to the traditional control system. However, the US 19 corridor, as whole (including both main corridor and associated side streets), exhibited overall operational improvements attributed to deployment of adaptive traffic control system.
- The study team members perceived traffic operations along the US 19 corridor to be better under adaptive traffic control system than traditional control system as supported by documented statements reflecting fewer stops, higher speeds, lesser braking/delay, and lower drivers' stress/fatigue.
- The adaptive traffic control system resulted in a net annual savings of $2,187,493 in labor and $409,597 in fuel consumed for the northbound direction on US 19 for a total annual savings of $2,597,090.

- ❑ The adaptive traffic control system resulted in a net annual savings of $2,037,037 in labor and $191,016 in fuel consumed for the southbound direction on US 19 for a total annual savings of $2,228,053.
- ❑ The adaptive traffic control system resulted in a net savings of $4,224,530 in labor and $600,613 in fuel consumed for the combined northbound and southbound directions on US 19 for a total annual savings of $4,825,143. The corridorwide findings represent significant savings.
- ❑ The adaptive traffic control system resulted in a net annual loss of $3,391,661 in labor for all side streets along US 19.
- ❑ The adaptive traffic control system resulted in a net annual savings of $834,815 in labor for the overall US 19 corridor comprised of both the main corridor and associated side streets.

6.1.2 SR 60 Corridor

The overarching conclusion for the SR 60 corridor is that the adaptive traffic control system represents a great value for each invested dollar, considering the high benefit / cost ratio for the SR 60 corridor. The total lifecycle savings over a 10-year period at present value for the adaptive system are $10.6 million. Compared to the system total cost, the benefit/cost ratio is 7.75. Other pertinent conclusions include:

- ❑ The main corridor of SR 60 experienced significant operational improvements. However, this success was achieved, at least in part, via degradation of traffic operations on side streets. Travel times and other MOEs improved in the direction of peak traffic flow for all study periods, however, in certain cases, travel times and other MOEs worsened in the non-peak direction (e.g., eastbound flow during PM Peak period). Typically, peak direction volumes were observed to be twice as much as the non-peak direction thus making the associated operational benefits far exceeding the operational disbenefits in the non-peak direction.
- ❑ The side streets were marginally penalized along the SR 60 corridor to accommodate the traffic flow along the main corridor by the adaptive control system. The total delay at side streets increased under adaptive traffic control system compared to the traditional control system. However, the majority of side streets' delay was attributable to the intersection of US 19 and SR 60, which is an atypical intersection within the study corridor, both in terms of traffic demand intensity and intersection geometry and lane configuration. The overall benefits derived from improved operational performance along the main corridor far exceeded the operational disbenefits imposed on side streets. In addition, the SR 60 corridor, as whole (including both main corridor and associated side streets), exhibited overall operational improvements attributed to deployment of adaptive traffic control system.
- ❑ The study team members perceived traffic operations along the SR 60 corridor to be better under adaptive traffic control system than traditional control system as supported by documented statements reflecting fewer stops, higher speeds, lesser braking/delay, and lower drivers' stress/fatigue.
- ❑ The adaptive traffic control system resulted in a net annual savings of $622,597 in labor and $305,790 in fuel consumed for the eastbound direction on SR 60 for a total annual savings of $928,388.

- The adaptive traffic control system resulted in a net annual savings of $1,139,670 in labor and $449,239 in fuel consumed for the westbound direction on SR 60 for a total annual savings of $1,588,909.
- The adaptive traffic control system resulted in a net annual savings of $1,762,268 in labor and $755,030 in fuel consumed for the combined eastbound and westbound directions on SR 60 for a total annual savings of $2,517,297. The corridorwide findings represent significant savings.
- The adaptive traffic control system resulted in a net annual savings of $1,443,052 in labor for the overall SR 60 corridor comprised of both the main corridor and associated side streets.

6.2 RECOMMENDATIONS

The assessment of the adaptive traffic control elements of the Pinellas Countywide ATMS project has yielded significant findings and conclusions in the form of tables and charts that could be of value in further fine-tuning and calibrating the systems. Of particular importance is the conclusion that the adaptive traffic control system should not attain its operational improvements along the main corridor by penalizing side streets traffic flow. Further system calibration will be needed by the system providers and engineers to help reduce delays on side streets while continuing to optimize traffic flow on the main corridor. In addition, the reach and effectiveness of the adaptive traffic control system is constrained by intersections and movements where demand consistently exceed available capacity. To further enhance the value of adaptive traffic control in optimizing corridor operations, there is a need for the owner agency to continue its investment program in traditional capacity improvements projects (i.e., auxiliary lanes) at signalized intersections where demand exceeds available capacity. Advanced technologies, including adaptive traffic control system, augment (not replace) the traditional roadway/intersection capacity improvement strategies.