CORRIDOR SYSTEM MANAGEMENT PLAN (CSMP)
SAN BERNARDINO COUNTY I-10

FINAL REPORT

June 10, 2011

System Metrics Group, Inc.

Interstate 10

Corridor System Management Plan

APPROVED BY:

-for-

RAYMOND W. WOLFE, PhD
District 8 Director

July 1, 2011
Date

Approval Recommended by:

for.

WILLIAM A. MOSBY
District 8 Deputy District Director
Planning

June 23, 2011
Date

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EXECUTIVE SUMMARY

This is the San Bernardino/Riverside Interstate 10 (I-10) Final Corridor System Management Plan (CSMP) developed on behalf of the California Department of Transportation (Caltrans). This report analyzes the existing conditions of the I-10 corridor with the latest available data. It also analyzes improvement scenarios using a calibrated Vissim micro-simulation model and a benefit-cost analysis that would maintain the mobility gains achieved by implementing projects partially funded by Proposition 1B. This Final CSMP is a culmination of previous deliverables and represents the final milestone of developing a Corridor System Management Plan.

Background

This CSMP is the direct result of the November 2006 voter-approved Proposition 1B (The Highway Safety, Traffic Reduction, Air Quality, and Port Security Bond Act of 2006). This ballot measure included a funding program to be deposited into a Corridor Mobility Improvement Account (CMIA).

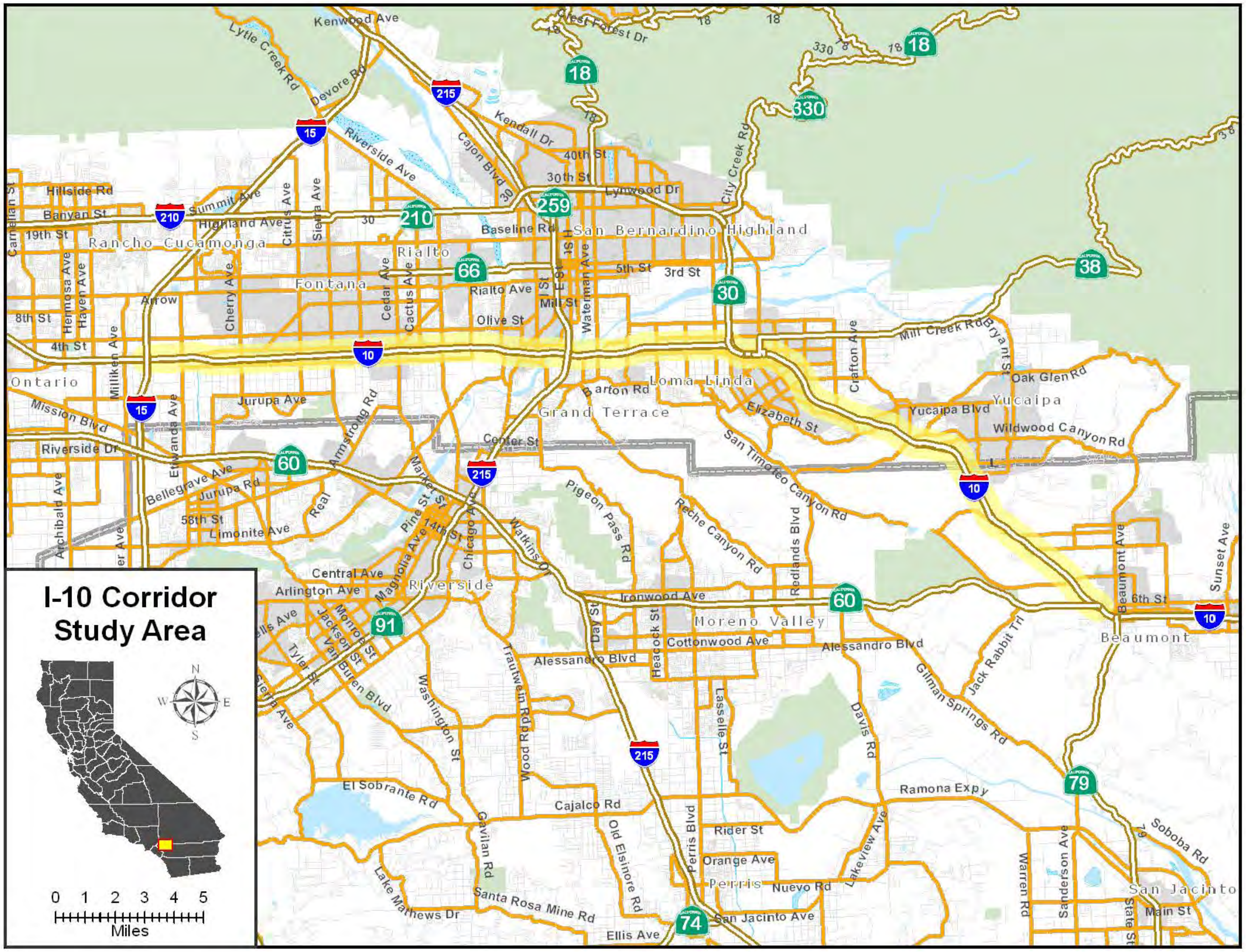
The CMIA will partially fund the construction of the westbound mixed flow lane from Live Oak Canyon Road to Ford Street, and the construction of auxiliary lanes at Cherry, Citrus, and Cedar interchanges.

As a requirement to obtain CMIA funding for this project, Caltrans District 8 is developing this I-10 CSMP to be submitted to the California Transportation Commission (CTC). This document assesses the existing conditions of the corridor and identifies the scenarios of projects that were determined to best maintain the mobility gains due to the implementation of these projects.

Corridor Description

Caltrans and the CTC defined the San Bernardino/Riverside I-10 study corridor as the 37 mile stretch from I-15 (Ontario Freeway) in San Bernardino County (CA PM 9.5) to SR-60 (Moreno Valley Freeway) in Riverside County (CA PM 6.8). The corridor passes through the cities of Ontario, Fontana, Rialto, Colton, San Bernardino, Loma Linda, Redlands, Yucaipa, Calimesa, and Beaumont.

Exhibit ES-1: Map of I-10 Study Corridor



Corridor-wide Performance and Trends

To identify how the corridor is performing, the existing conditions of the I-10 corridor were analyzed using performance measures for mobility, reliability, productivity, and safety. These measures are based on data from 2007 to 2009 with a focus on the 2008 base year used for the micro-simulation modeling effort.

Analyzing performance data on I-10 presents a unique challenge due to the limited availability of detector data. Automatic detector data is only available west of I-215. Since the many of the performance measures rely on vehicle detector data, these measures focus on the segment of the study corridor west of I-215. However, the safety and pavement condition measures analyze the entire length of the study corridor. The following briefly summarizes the results of each performance measure by the portion of the corridor analyzed. The detailed discussion can be found in Section 3 of this document, *Comprehensive Performance Assessment*.

- *Mobility* (west of I-215) – From 2007 to 2009, annual delay decreased significantly from about 960,000 vehicle-hours in 2007 to 300,000 vehicle-hours in 2008, and finally to 197,000 vehicle-hours in 2009. By far, the eastbound PM peak period was the most congested direction and time period on the corridor. In 2008, eastbound PM delay (136,000 vehicle-hours) was nearly three times greater than westbound PM delay (46,000 vehicle-hours). The AM peak period delays were much lower than PM peak period delays. Eastbound delay in the AM peak period was 22,000 vehicle-hours while westbound AM delay was 14,000 vehicle-hours. Delay in the eastbound direction was also greater than the westbound direction. In 2008, the eastbound direction experienced about 80 percent more delay than the westbound direction.
- *Reliability* (west of I-215) – this measure captures the degree of predictability in travel time and focuses on how travel time varies from day to day. The variability of travel time during peak periods declined from 2007 to 2009. In the eastbound direction, travel time variability decreased from eight minutes in 2007 to four minutes in 2008, and again to two minutes in 2009. In the westbound direction, travel time variability decreased from six minutes in 2007 to two minutes in 2008 and 2009.
- *Productivity* (west of I-215) – this measure reflects the reduction in effective capacity due to merging and weaving activities in equivalent lost lane-miles. Just as delay on the corridor decreased from 2007 to 2009, so did the unit of lost lane-miles, signifying an increase in corridor productivity. The trends in productivity losses are comparable to the delay trends. In 2008, the largest productivity losses occurred during the PM peak period in the eastbound (1.2 equivalent lost lane-miles) and westbound directions (0.8 equivalent lost lane-

miles), which correspond relatively to the time period and direction that experienced the most delay.

- *Safety* (entire study corridor) – the number of annual accidents declined from 2006 to 2008 and the number of accidents was similar in both directions, according to the latest available accident data from the Caltrans Traffic Accident Surveillance and Analysis System (TASAS). In 2006, both directions experienced about 1,450 accidents, which decreased to about 1,250 in 2007. In 2008, the eastbound direction experienced slightly more accidents at about 900, compared to the westbound direction at about 800. TASAS data are not yet available for 2009.

Exhibit ES-2: I-10 Corridor Analysis

MAINLINE FACILITY										
	Mobility				Reliability		Safety		Productivity	
	Total Annual Delay (Vehicle Hours)[1]		Average Peak Hour Travel Time (Minutes)[2]		Peak Hour Travel Time Variability (Percent)[2]		Annual Accidents[3]		Average Daily Lost Productivity (Lane-Miles)[1]	
	EB	WB	EB	WB	EB	WB	EB	WB	EB	WB
2007	500,226	460,091	17	15	42%	37%	1,259	1,258	4.3	5.1
2008	192,095	107,375	15	14	27%	14%	901	794	2.2	2.0
2009	137,848	58,583	14	13	19%	8%	n/a	n/a	2.0	1.6

[1] Accounts for weekdays during peak and non-peak periods

[2] Accounts for weekdays only

[3] Accounts for weekdays and weekends

Bottleneck Identification and Causality Analysis

Exhibits ES-3 and ES-4 show a map of the I-10 corridor with the bottleneck locations identified in this study for the AM and PM peak periods. In the eastbound direction, the nine bottlenecks during the PM peak period were identified and no bottlenecks during the AM peak period. In the westbound direction, two bottlenecks during the AM peak period were identified and no bottlenecks during the PM peak period.

Major bottlenecks are the primary cause of congestion and lost productivity. By definition (HCM2000), a bottleneck is a road element in which traffic demand exceeds the capacity of the roadway facility. In most cases, a bottleneck is caused by a sudden reduction in capacity (e.g., a lane drop), heavy merging and weaving, driver distractions, or a surge in demand that the road cannot accommodate. The cause of each bottleneck along the corridor was identified through numerous field visits in December 2008 and January 2009. These causes are summarized in Exhibit ES-5.

A detailed description of each bottleneck location is provided in Section 3 of this report.

Exhibit ES-3: AM Bottleneck Locations

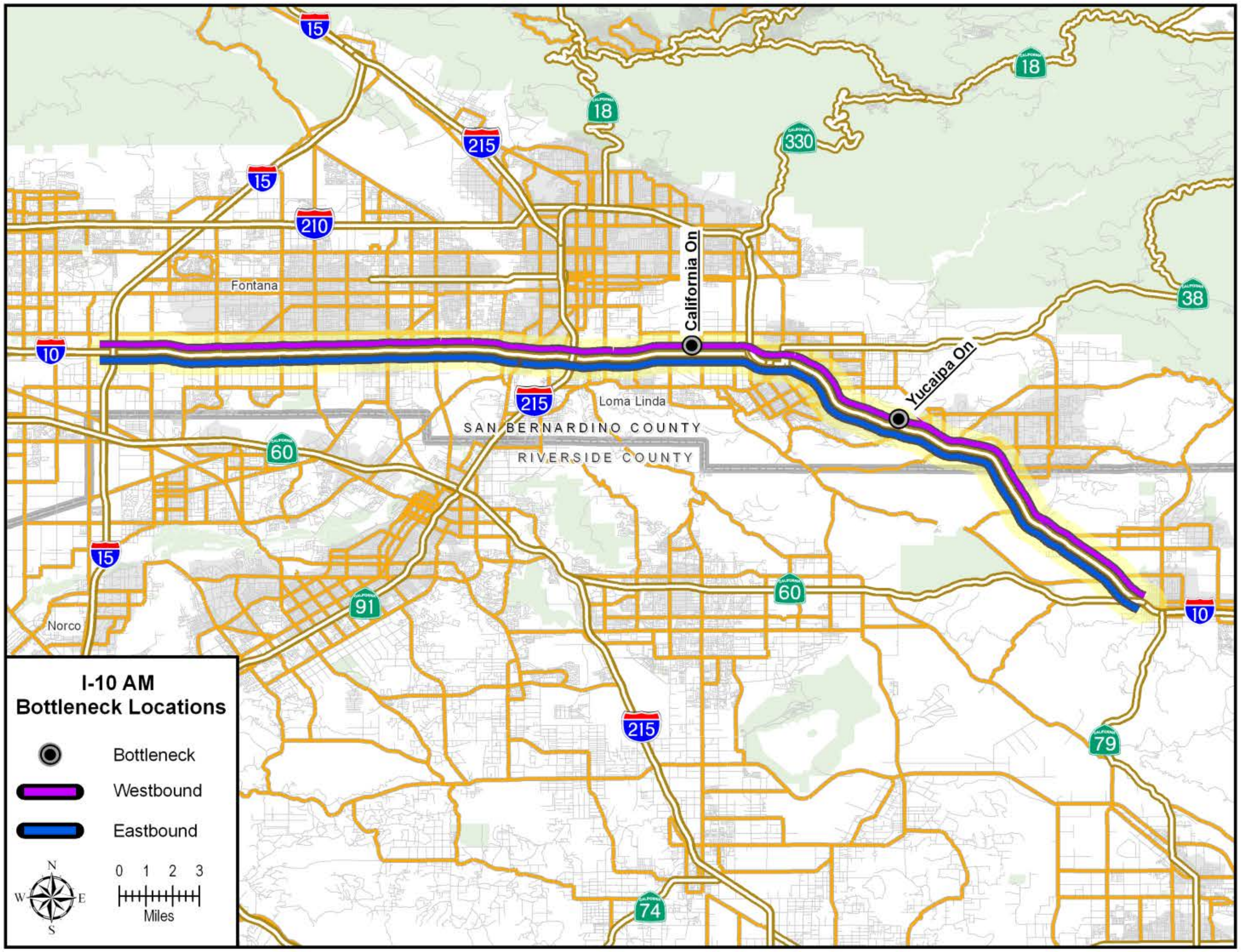


Exhibit ES-4: PM Bottleneck Locations

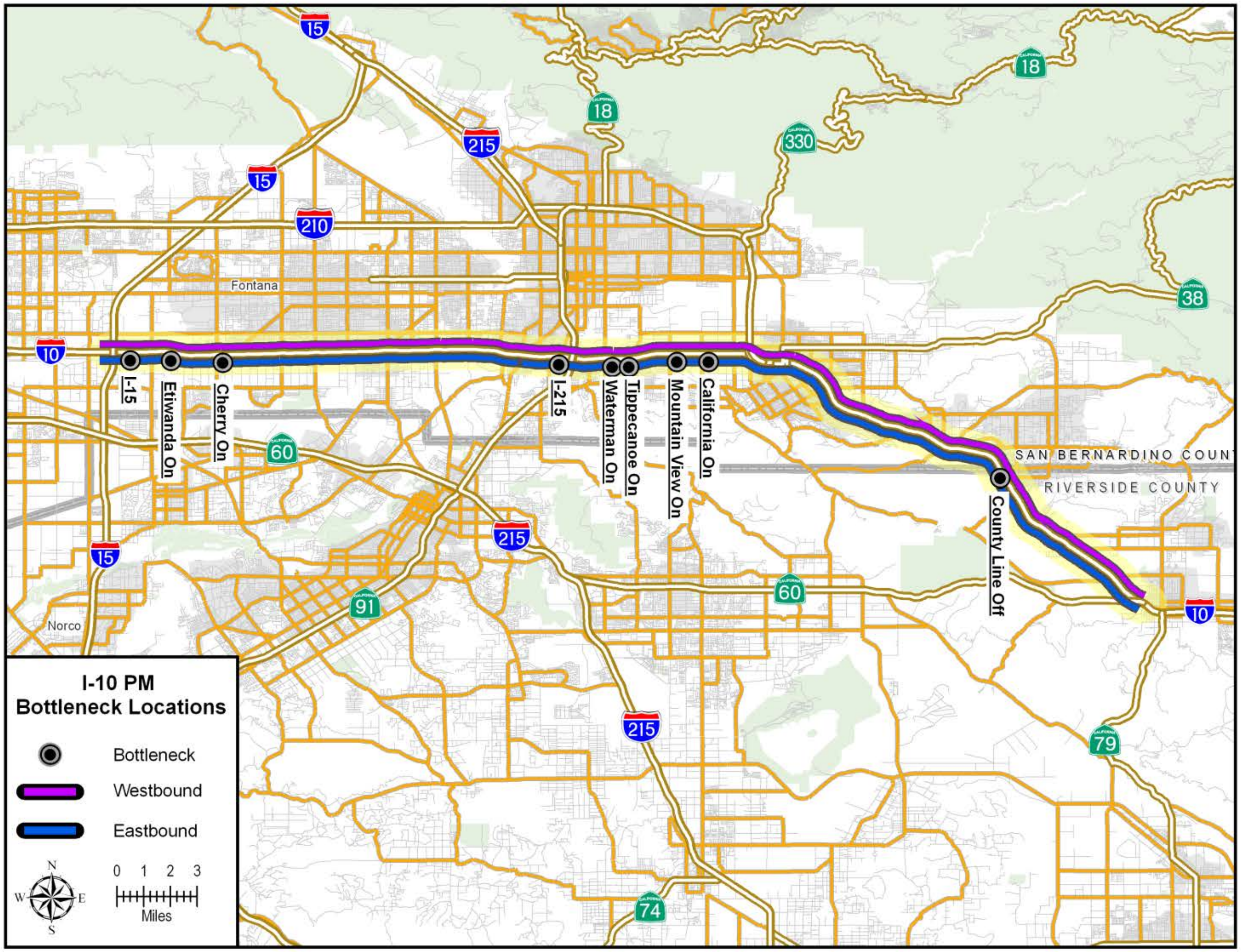


Exhibit ES-5: Summary of Bottleneck Causes

Eastbound Bottlenecks

Abs	CA	Bottleneck Location	Active Period AM	Active Period PM	Causality Summary
56.5	9.7	I-15[1]		✓	Traffic merging and weaving
58.5	11.7	Etiwanda On		✓	Surge of additional demand from the Etiwanda Avenue C-D road on-ramp
60.1	13.3	Cherry On		✓	Probe vehicle runs indicate a bottleneck at this location
70.6	R23.8	I-215		✓	Heavy volumes from I-215 connector ramps; cross-weaving with cars exiting Waterman
72.3	25.5	Waterman On		✓	Surge of additional demand from the Waterman Avenue C-D on-ramp
72.8	26	Tippecanoe On		✓	On-ramp demand and merging from Tippecanoe
74.3	27.5	Mountain View On		✓	On-ramp demand and merging from Mountain View
75.3	28.5	California On		✓	Probe vehicle runs indicate a bottleneck at this location
85.8	R39.0	County Line Off		✓	Traffic backing up on to the mainline from the off-ramp

[1] segment is not included in the bottleneck area analysis due to the short distance in length

Westbound Bottlenecks

Abs	CA	Bottleneck Location	Active Period AM	Active Period PM	Causality Summary
82.1	35.4	Yucaipa On	✓		Steep uphill grade; on-ramp demand and merging from Yucaipa
74.7	28.0	California On	✓		On-ramp demand and merging from California

Planned Corridor System Management Strategies

As one of the most congested corridors in Southern California, I-10 has been the focus of many efforts to identify potential alternatives for improving the corridor. Projects on the state highway system with funding are identified in the Southern California Association of Government's (SCAG) Regional Transportation Improvement Program (RTIP) and the State Highway Operations Protection Program (SHOPP). The RTIP is a listing of all capital transportation projects proposed over a six-year period for the SCAG region. Similarly, the SHOPP is a listing of all safety and operations projects that can be implemented in the short term. Along the I-10 corridor, projects with funding in the RTIP and SHOPP include:

- Reconfigure interchange and widen Live Oak Canyon Road in Yucaipa
- Install vehicle detection systems on I-10, SR-91, and I-215
- Install fiber communication backbone, ramp metering, and changeable message signs at Waterman Avenue, Tippecanoe Avenue, Mountain View Avenue, California Street, and Alabama Street on I-10 and at Iowa Avenue, Barton Road and Mount Vernon/Washington on I-215
- Add auxiliary lane from Waterman Avenue to Alabama Street (eastbound and westbound)
- Add auxiliary lanes and widen off-ramps from Etiwanda Avenue to Riverside Avenue
- Reconstruct interchange at Cedar Avenue between Slover Avenue and Valley Boulevard
- Modify interchange and add auxiliary lane at Pepper Avenue
- Modify interchange and add auxiliary lane at Riverside Avenue from Slover Avenue to Valley Boulevard
- Reconstruct interchange at Citrus Avenue
- Reconstruct interchange at Singleton Road and widen ramps
- Construct interchange at Beech Avenue in Fontana
- Construct interchange at Alder Avenue in Fontana
- Construct a westbound mixed-flow lane from Ford Street to Live Oak Canyon Road
- Construct an HOV lane in each direction from Haven Avenue to Ford Street; add auxiliary lanes and reconstruct ramps where needed
- Begin construction on a new Transportation Management Center in Fontana
- Widen ramps and add ramp metering at Cedar Avenue, Pepper Avenue, Rancho Avenue, 9^{th} Street, and Mount Vernon Avenue
- Signal and intersection improvement at Ford Street.

After planned corridor improvements were identified, a framework to combine projects into scenarios to test in a calibrated Vissim micro-simulation model was developed. Following the testing in the model, a benefit-cost analysis (BCA) was performed for each scenario to evaluate how well each scenario would maintain the mobility gains achieved by the CMIA funded project.

This framework combines projects using a number of rules, including:

- Operations projects were combined separately from expansion projects to distinguish their benefits. Operations projects improve mobility without expanding the capacity of the facility. These projects include auxiliary lanes, ramp metering, and interchange improvements.
- Projects that were fully programmed and funded were combined separately from projects that were not
- Short-term projects (delivered by 2015) were used to develop scenarios for testing in the 2008 model
- Medium-term projects (delivered by 2020) were used to develop scenarios for testing in the 2020 model

The Vissim model was developed based on the best data available at the time. After a thorough and careful review of each incremental step and analysis, it is believed that both the calibration and the scenario results are reasonable and allow for more informed decision-making.

However, caution should always be used when making decisions based on modeling alone. Engineering and professional judgment and experience, among other technical factors, should be taken into consideration in making the most effective project decisions that affect millions, if not billions, of dollars in investment. Project decisions are based on a combination of regional and inter-regional plans and needs, regional and local acceptance for the project, availability of funding, planning and engineering requirements.

Based on the results, the following conclusions and recommendations are offered:

- ♦ Although the costs of the completed projects and other programmed auxiliary lane and interchange improvement projects (including CMIA) in Scenarios 1 and 2 are high at almost $250 million combined, the model results indicate that benefits could outweigh costs by almost 4 to 1 with benefits reaching almost $1 billion over a 20-year lifecycle. These projects produce significant returns on investment.

- The benefit-cost ratios for Scenarios 3 and 4 are low to moderate. These medium-cost interchange improvement projects seem to show relatively reasonable investment results.
- With many of the major bottleneck areas already addressed by projects in Scenarios 1 to 4, the high-cost expansion projects, such as the general purpose lane and HOV lane additions, do not produce a significant return for the cost. Only a small increase in benefits is derived from traffic being diverted from the adjacent freeways and arterials.

There is very little congestion by 2020 after all of the scenarios are implemented. Only a small amount of congestion at Waterman Avenue remains in the eastbound direction in the PM peak period. Since the CSMP horizon year model is for 2020, further study or other methodology may be needed to assess the benefits of addressing demand beyond 2020.

This is the first-generation CSMP for the I-10 corridor. It is important to emphasize that CSMPs should be updated on a regular basis, if possible. This is particularly important since traffic conditions and patterns can differ from current projections. After projects are delivered, it is also useful to compare actual results with estimated ones in this document so that models can be further improved as appropriate.

CSMPs, or some variation, should become the normal course of business that includes detailed performance assessments, an in-depth understanding of the reasons for performance deterioration, and an analytical framework that allows for evaluating complementary operational strategies that maximize system productivity.

1. INTRODUCTION

This report is the San Bernardino Interstate 10 (I-10) Final Corridor System Management Plan (CSMP). The document is required by the California Transportation Commission (CTC) for corridors that received funding from the Corridor Mobility Improvement Account (CMIA) approved by voters in 2006. The CMIA will partially fund the construction of the westbound mixed-flow lane addition from Live Oak Canyon Road to Ford Street, and the construction of the auxiliary lanes at the Cherry Avenue, Citrus Avenue, and Cedar Avenue interchanges.

This report presents performance measurement findings, identifies bottlenecks leading to degraded freeway performance, and diagnoses the causes for these bottlenecks in detail. It also discusses recent and future improvements on the corridor as well as the scenarios of projects tested with the micro-simulation model and assessed using a benefit-cost analysis.

This report provides an assessment of corridor conditions using the latest available data. It also presents the projects tested using micro-simulation modeling and benefit-cost analysis (BCA).

This report and associated CSMP should be updated on a periodic basis since corridor performance can vary dramatically over time due to changes in demand patterns, economic conditions, and delivery of projects and strategies. Such changes could influence the conclusions of the CSMP and the relative priorities in investments. This document has been updated twice since the Preliminary Performance Assessment was written to reflect the most current corridor conditions.

What is a Corridor System Management Plan (CSMP)?

A CSMP is a comprehensive, integrated management plan for increasing transportation options, decreasing congestion, and improving travel times in a transportation corridor. The California Department of Transportation (Caltrans) is developing CSMPs for all major urban corridors in the state to improve mobility and optimize the use of taxpayer dollars. The document identifies the recommended system management strategies for a given State Highway System facility based on comprehensive performance assessment and evaluation. The strategies are phased and include both operations and long-range capital expansion strategies. The strategies take into account transit usage, projections, and interactions with the arterial network. This corridor system management plan serves as a "first cut" template that integrates the overall concept of system management into Caltrans' planning and decision-making processes. Moving away from the traditional approach that often focuses on expensive capital improvements to localized freeway problem areas; this plan follows a corridor management approach, which emphasizes performance assessments and operations strategies that yield higher benefit-cost results.

A CSMP includes all travel modes in a defined corridor -- highways and freeways, parallel and connecting roadways, and public transit. Although individual districts are ultimately responsible for completing each CSMP, these plans are developed and implemented in partnership with regional and local transportation agencies. Caltrans develops integrated multimodal projects in balance with community goals, plans, and values. Caltrans seeks to address the safety and mobility needs of bicyclists, pedestrians, and transit users in all projects, regardless of funding. Bicycle, pedestrian, and transit travel is facilitated by creating "complete streets," beginning early in system planning, and continuing through project delivery, maintenance, and operations. Developing a network of complete streets requires collaboration among all Caltrans functional units and stakeholders. As the first generation of CSMP, this report is more focused on reducing congestion and increasing mobility through capital and operations strategies. The future, more matured CSMP network will further address pedestrian, bicycle and transit components and seek to manage and improve the whole network as an interactive system.

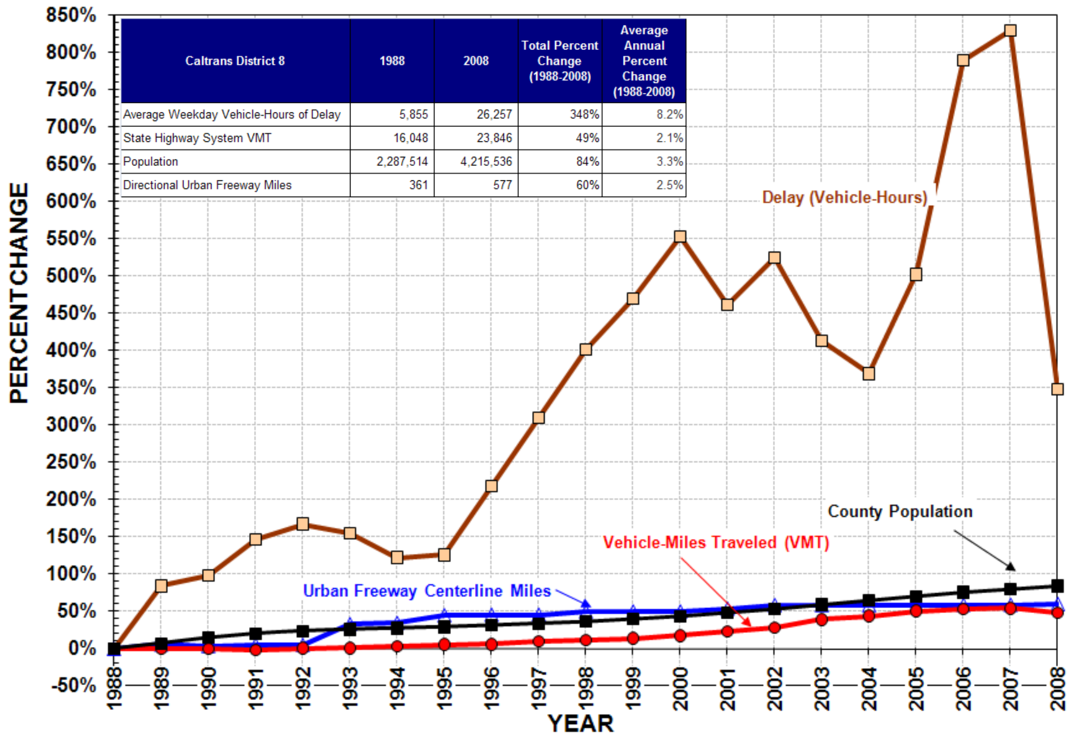
What is System Management?

The system management philosophy begins by defining how the system performs, understanding why it is performing that way, and then evaluating different strategies, including operations-oriented strategies, to address deficiencies.

Exhibit 1-1 shows Riverside and San Bernardino congestion (measured by average weekday recurring vehicle-hours of delay), VMT, population, and urban freeway mileage between 1988 and 2008. Over that 20-year period, congestion increased by more than 300 percent from 1988 levels (just over 8 percent per year). Over the same period, VMT and population rose by 49 percent and 84 percent, respectively. Between 1995 and 2004, urban freeway miles grew dramatically, but since then virtually no miles have been added.

Historically, regional infrastructure expansion has not kept pace with demographic and congestion trends and is not likely to keep pace in the future. Therefore, if conditions are to improve, or at least not deteriorate as fast, a new approach to transportation decision making and investment is needed.

Exhibit 1-1: District 8 Growth Trends (1988-2008)



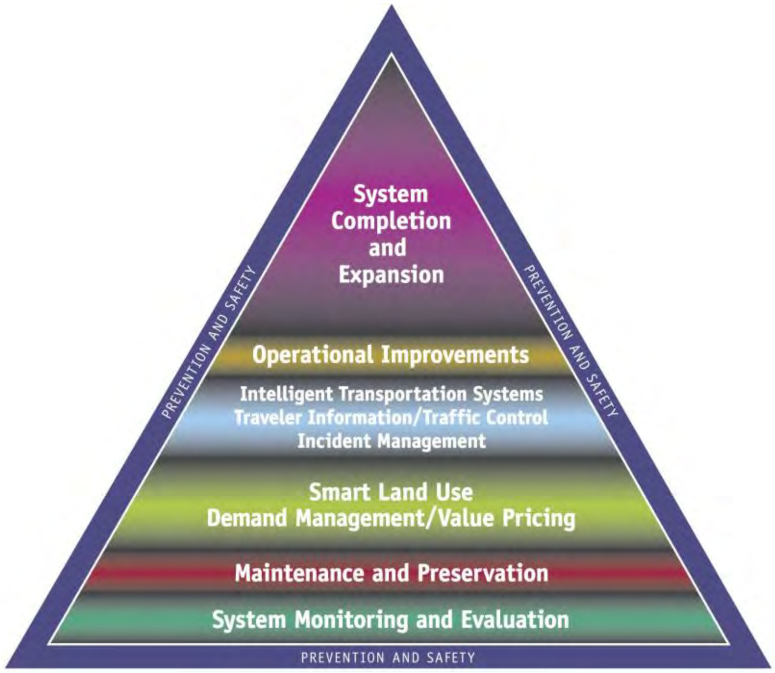
Caltrans District 8	1988	2008	Total Percent Change (1988-2008)	Average Annual Percent Change (1988-2008)
Average Weekday Vehicle-Hours of Delay	5,855	26,257	348%	8.2%
State Highway System VMT	16,048	23,846	49%	2.1%
Population	2,287,514	4,215,536	84%	3.3%
Directional Urban Freeway Miles	361	577	60%	2.5%

Sources: *HICOMP data*
Caltrans Traffic Operations
California Department of Finance
Caltrans Division of Transportation System Information (TSI)

Caltrans recognized this emerging need as it adopted a "One Vision/One Mission" statement to improve mobility across California. It specifies a revised set of goals to help guide the State towards that new approach: productivity, reliability, flexibility, safety, and performance. The first three goals are new and call for improving the efficiency of the transportation system, reducing traveler delays due to incidents and road work, and making transit a more practical travel option. The last two goals are traditional, but critical, ensuring the public's safety and delivering projects efficiently.

System Management (SM) is the wave of the future and is being touted at the federal, state, regional and local levels. The SM "pyramid" shown in Exhibit I-2 illustrates how Caltrans and its partners need to address both transportation demand and supply to maximize system performance. In the end, it is critical that the *productivity of our system increases* to make up with the past and likely future difference (deficiency) between supply and demand increases.

Exhibit 1-2: System Management Pyramid

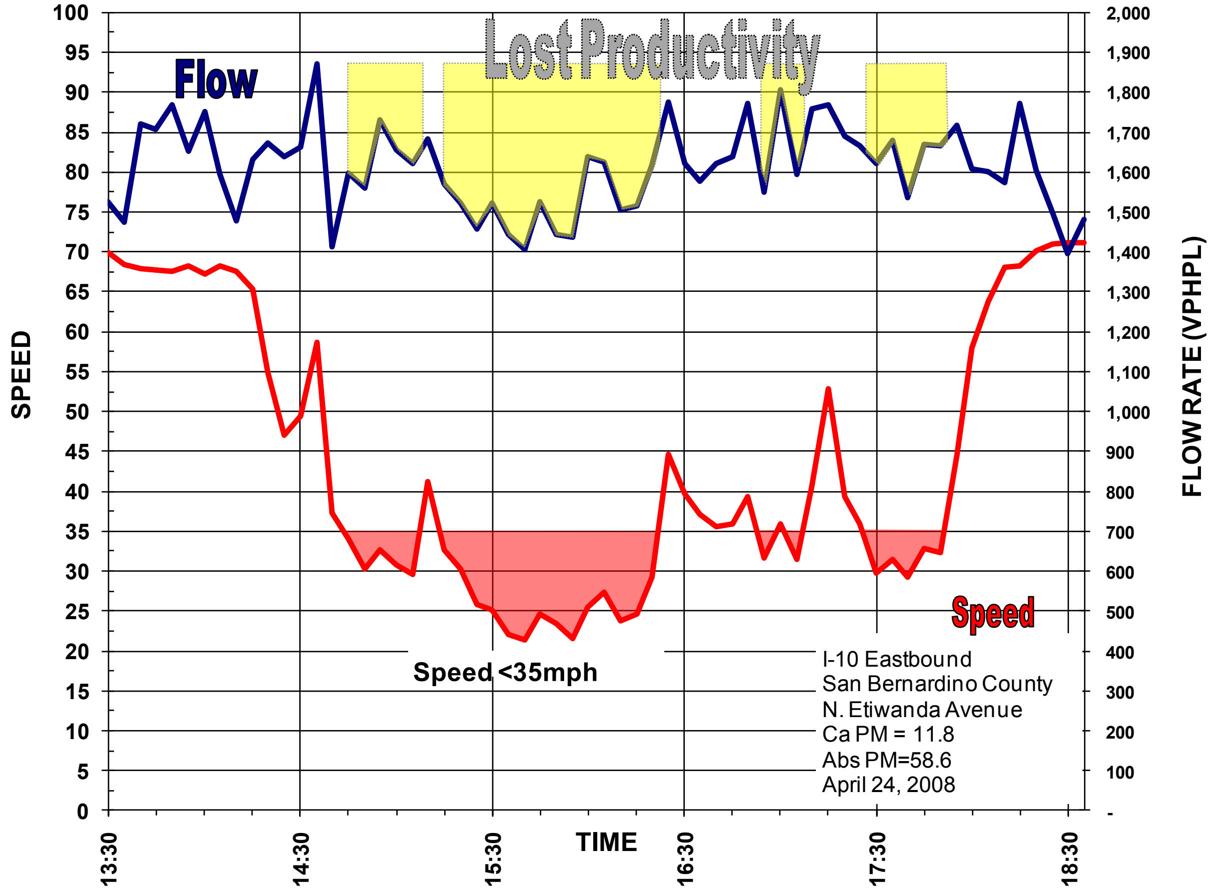


What is Productivity?

A critical goal of System Management is to "get the most out" of the existing system, or maximize system productivity. One would think that a given freeway is most productive during peak commute times. Yet, this is not true for heavy commute corridors. In fact, for San Bernardino and Riverside Counties' urban freeways experiencing congestion, the opposite is true. When demand is the highest, the flow breaks down and productivity declines.

Exhibit 1-3 illustrates how congestion leads to lost productivity. The exhibit was created using observed I-10 data from sensors for a typical April afternoon peak period (Thursday, April 24, 2008). It shows speeds (in red) and flow rates (in blue) on eastbound I-10 at Etiwanda Avenue, which is one of the most congested locations on the corridor.

Exhibit 1-3: Productivity Loss during Congestion



As shown in the exhibit, flow rates (measured as vehicles per hour per lane, or vphpl) averaged around 1,700 vphpl at Etiwanda Avenue between 1:30 PM and 2:30 PM. This is slightly less than a typical maximum flow rate for a peak period.

However, flow rates higher than approximately 2,000 vphpl cannot be sustained for a significant time. Once volumes exceed this maximum flow rate, traffic breaks down and speeds plummet to below 35 or 45 miles per hour (mph). Rather than being able to accommodate the same number of vehicles, flow rates also drop and vehicles back up, creating what most people know as recurrent congestion. Recurrent congestion occurs at regular times at a specific location and can be anticipated by road users that normally use the route during those times. At the location shown in Exhibit 1-3, throughput drops by nearly 20 percent (to 1,400 vphpl) at about 3:35 PM. Since this is a four-lane road, it is as if 20 percent (or almost one lane) were taken away during rush hour. Stated differently, just when the corridor needed the most capacity, it performed in the least productive manner and effectively lost lanes.

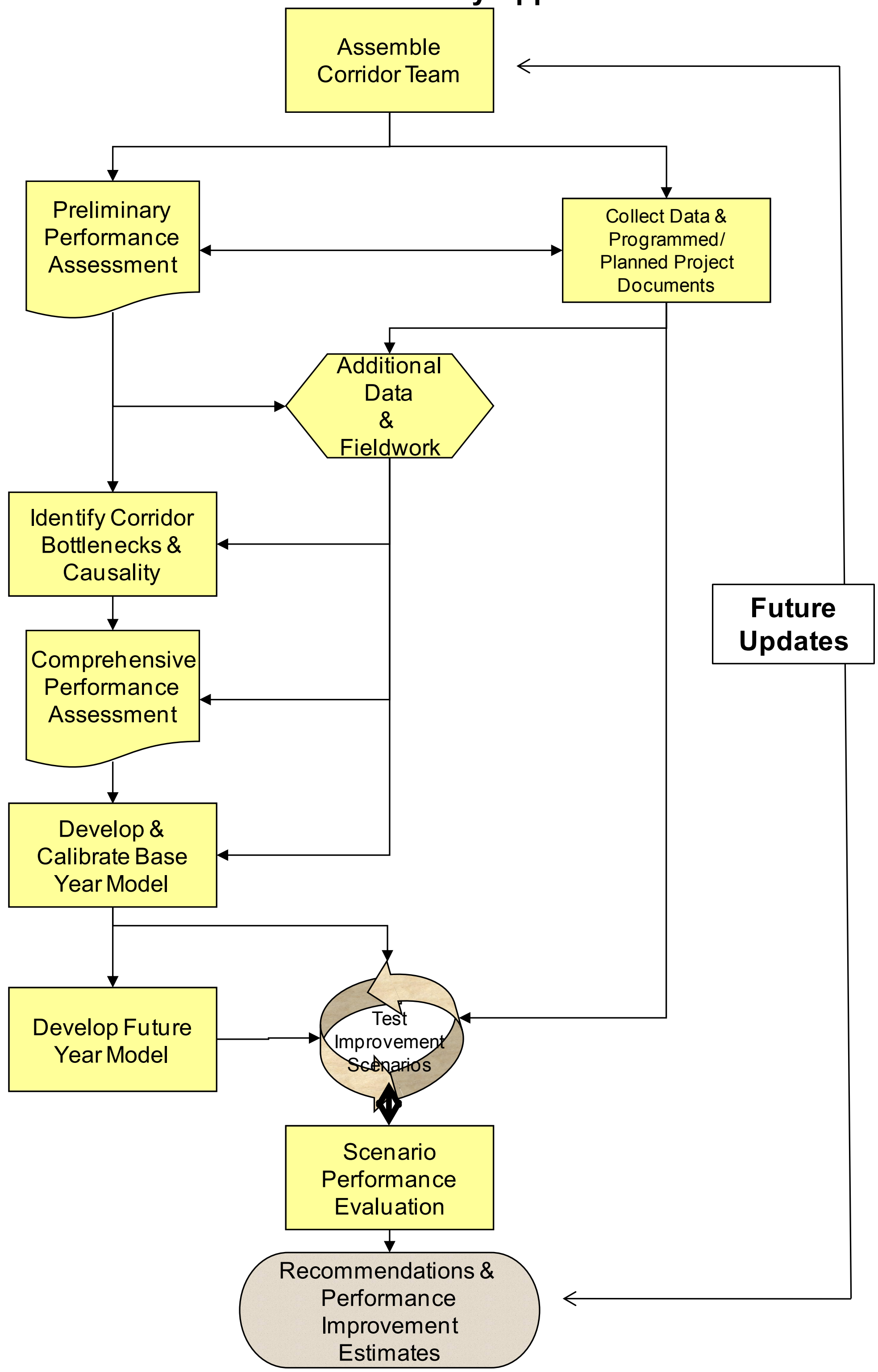
This lost productivity is a major cost of congestion that is rarely discussed or understood. Where there is sufficient automatic detection, the loss in throughput can be quantified and presented as "Equivalent Lost-Lane-Miles". As discussed in more detail later in the report, productivity losses on eastbound I-10 were about 0.75 lane-miles in 2009 during the PM peak period. This means that several hundred million dollars of previous investments on I-10 were idle when demand was at its highest.

Infrastructure expansion, although still an important strategy, cannot be the only strategy for addressing the mobility needs of Californians. System management is needed to get the most out of the current system and must be an important consideration as Caltrans and its partners evaluate the need for facility expansion investments. **The system management philosophy begins by defining how the system performs, understanding why it is performing that way, and then evaluating different strategies, including operations-oriented strategies, to address deficiencies.** These strategies can then be evaluated using different tools to estimate benefits and determine whether the benefits are worthy of the associated costs.

Study Approach

The I-10 study approach follows system management principles by emphasizing performance monitoring and evaluation (the base of the pyramid in Exhibit 1-2) and the use of lower cost operations improvements to maintain system productivity. The flow chart in Exhibit 1-4 illustrates this approach.

Exhibit 1-4: Study Approach



Document Organization

Subsequent to the introduction, this report is organized into four sections:

2. *Corridor Description*
   This section describes the corridor, including the roadway facility, major interchanges and relative demands at these interchanges, rail and transit services along the freeway facility, major intermodal facilities around the corridor, and special event facilities and trip generators. This section has been expanded since the Comprehensive Performance Assessment milestone to include a discussion on traffic operations systems.

3. *Comprehensive Performance Assessment*
   This section presents multiple years of performance data for the CSMP-defined freeway facility, including mobility, reliability, productivity, and safety performance measures. It has been updated to include performance through December 2009. This section also identifies the locations of bottlenecks, or choke points, on the freeway facility and reports performance results for delay, productivity, and safety by major "bottleneck area." This addition allows bottlenecks to be prioritized relative to their contribution to corridor performance degradation. A discussion diagnosing the causes of each bottleneck is included in this section.

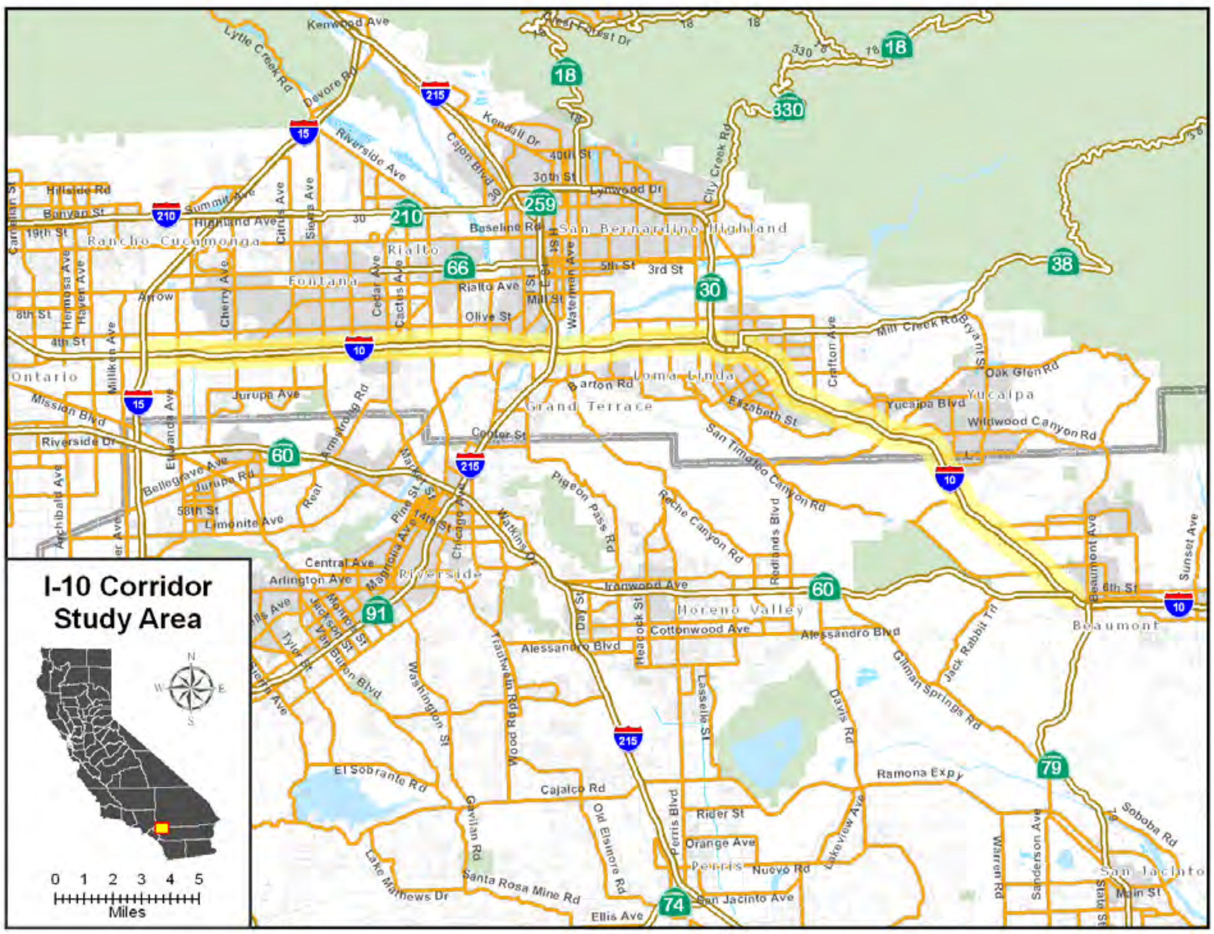
4. *Planned Corridor System Management Strategies*
   This section introduces various improvement projects planned for the corridor. It identifies bottlenecks that may improve with implementation of these projects. It also presents the framework that was developed for combining projects into scenarios.

5. *Next Steps and Expected Outcomes*
   The last section of this report discusses the expected outcomes of the current plan and strategies based on the analyses conducted.

2. CORRIDOR DESCRIPTION

The San Bernardino/Riverside County I-10 corridor begins from I-15 (Ontario Freeway) in San Bernardino County (post mile 9.5) to SR-60 (Moreno Valley Freeway) in Riverside County (post mile 6.8). It extends approximately 30 miles in San Bernardino County and 7 miles in Riverside County. This study corridor traverses through the cities of Ontario, Fontana, Rialto, Colton, San Bernardino, Loma Linda, Redlands, Yucaipa, Calimesa, and Beaumont.

Exhibit 2-1: Map of Study Area



Corridor Roadway Facility

Major interchanges along the I-10 study corridor include the following:

- I-15, which provides north-south access from the San Bernardino Mountains to San Diego.
- Sierra Avenue, which provides north-south connection from I-15 up by the San Bernardino Mountains to SR-60.
- I-215 (Riverside Freeway), which provides north-south access from San Bernardino County to Riverside County.
- SR-210, which connects the end of the I-210 freeway to the I-10 freeway.
- Live Oak Canyon Road/Oak Glen Road, which provides northeasterly access from the San Bernardino Mountains to mountains south of Redlands.
- SR-60, which provides east-west access from Los Angeles County to Riverside County.

The I-10 Corridor generally has three to five through lanes in each direction of travel with intermittent auxiliary lanes. Directions of travel are divided by a concrete median or metal beam guard rails. Exhibit 2-2 shows the lane configurations along the I-10 Corridor.

Exhibit 2-2: I-10 Corridor Lane Configuration

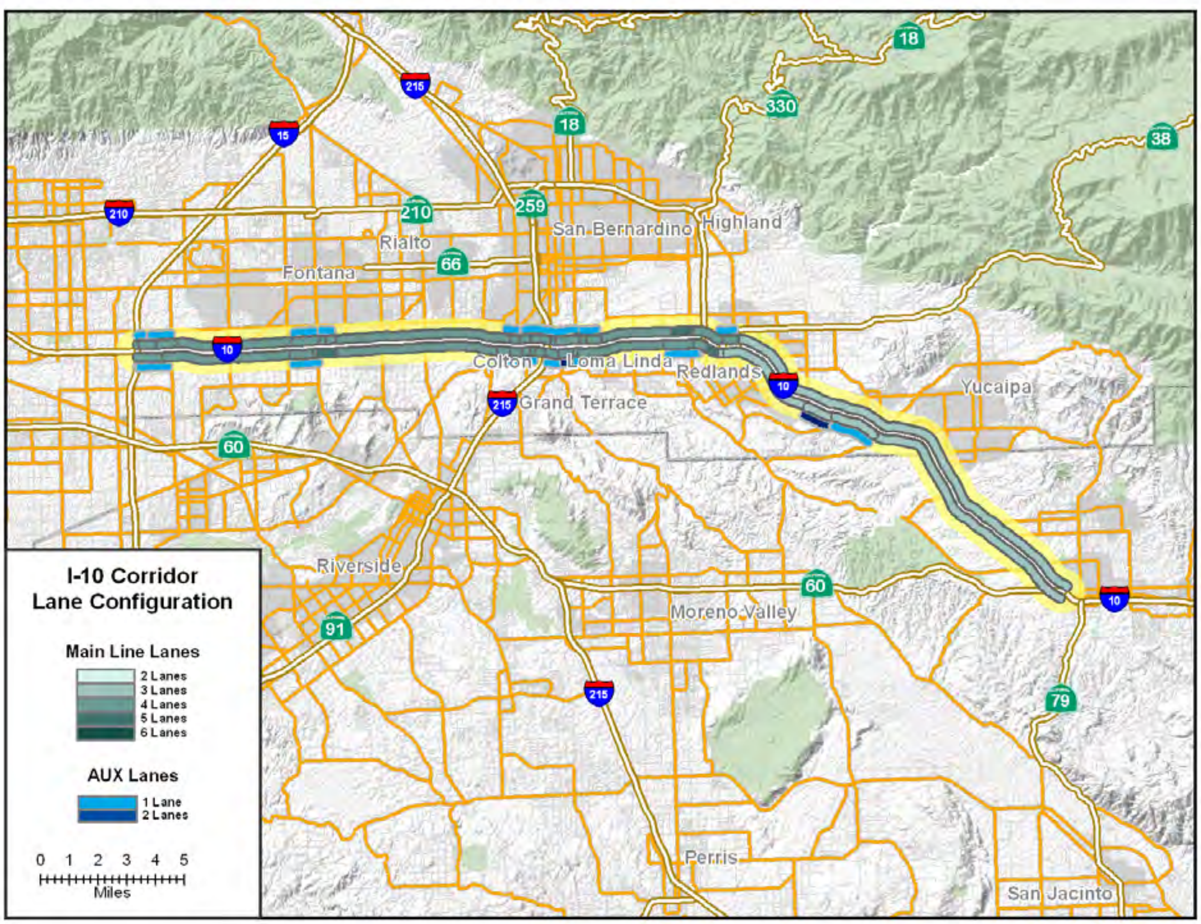
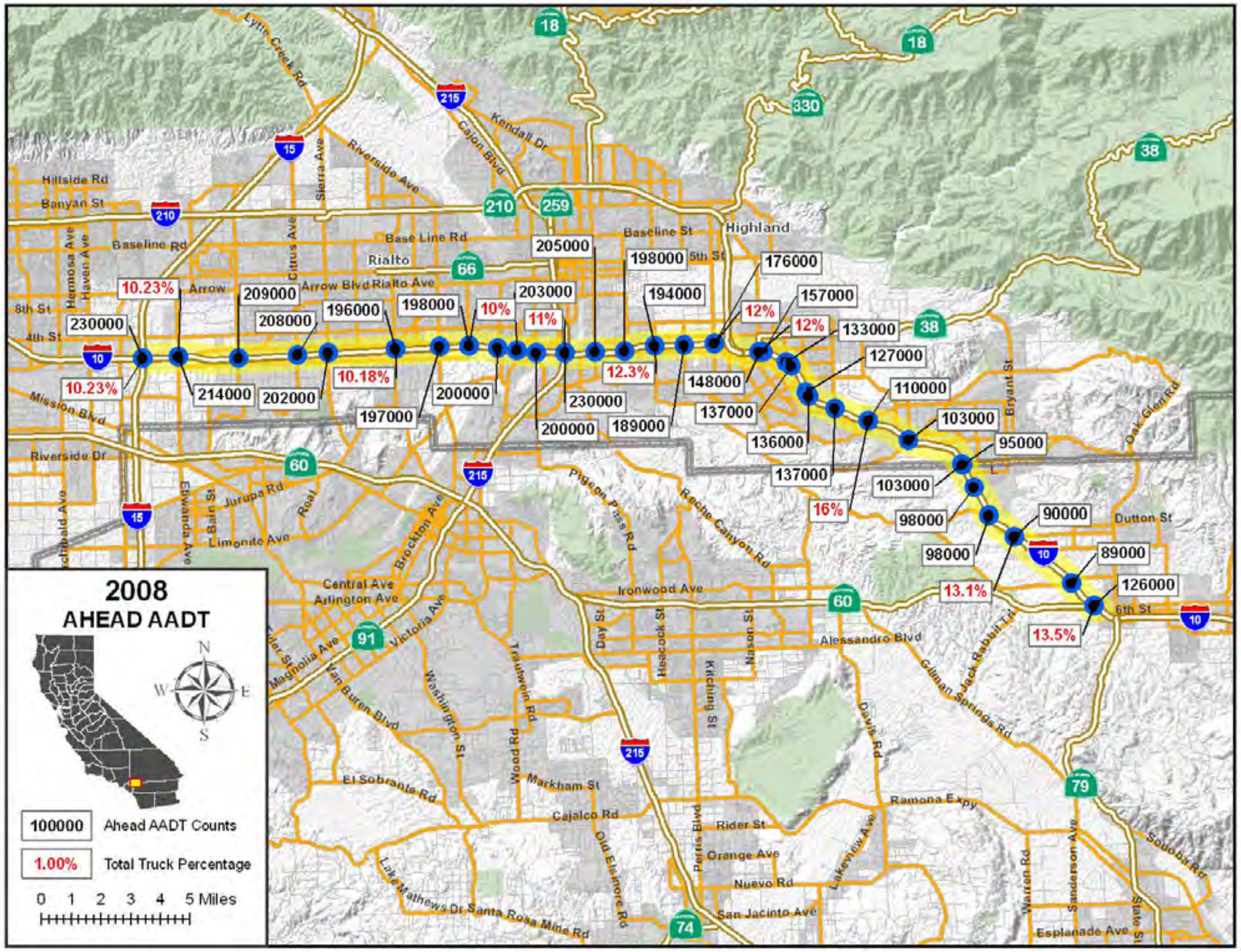


Exhibit 2-3: Major Interchanges and AADT along the I-10 Corridor



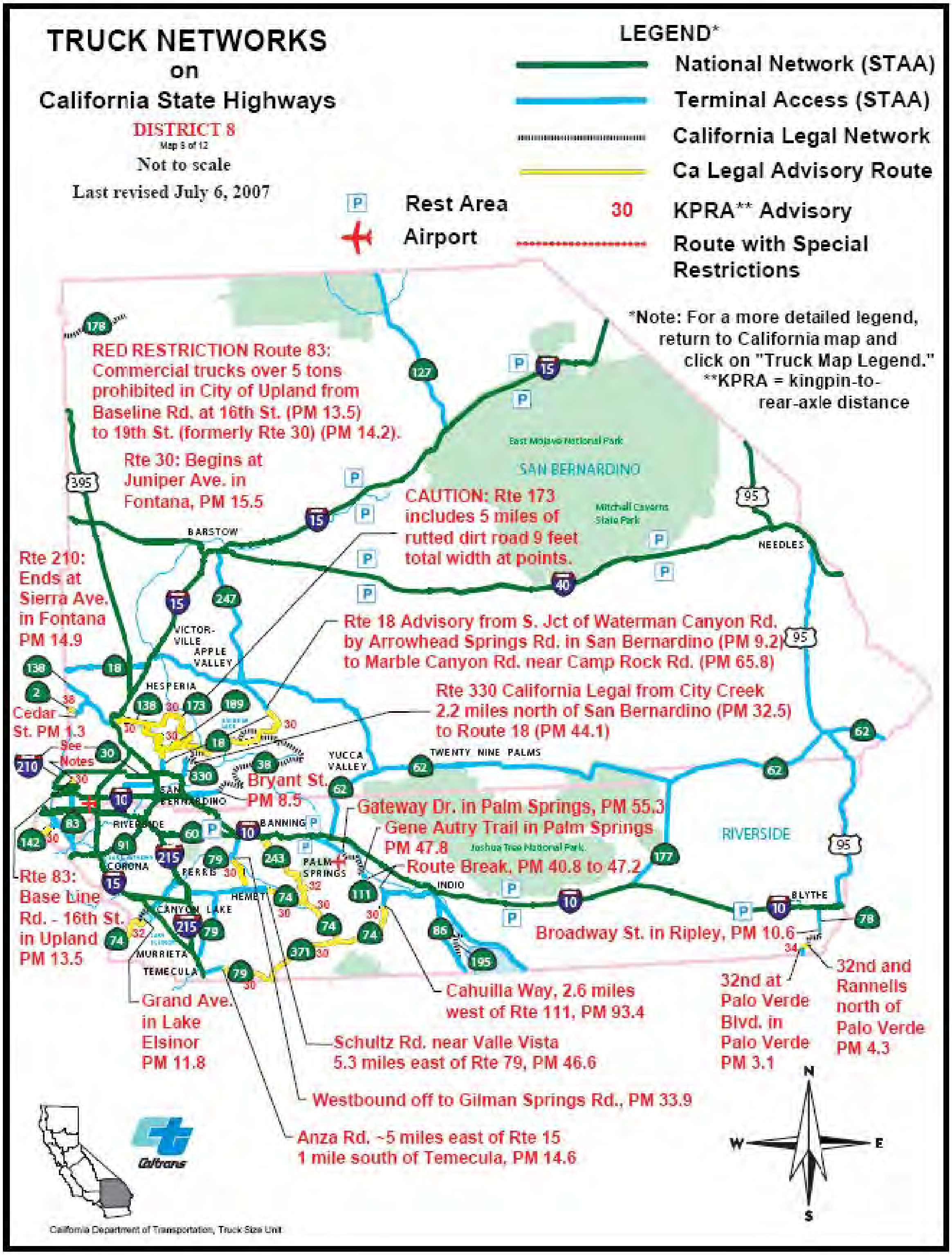
Source: AADT is from the Caltrans Traffic and Vehicle Data Systems Unit[1]

[1] http://www.dot.ca.gov/hq/traffops/saferesr/trafdata/

The 2008 Caltrans Annual Traffic Volumes Report indicates that the annual average daily traffic (AADT) for the I-10 corridor ranges from 89,000 to 230,000 vehicles per day, as illustrated in Exhibit 2-3. The highest AADT was reported at the I-15 and I-215 interchanges with roughly 230,000 vehicles per day at each location.

I-10 is designated as a Surface Transportation Assistance Act (STAA) route, which means that trucks may operate on the corridor as shown in Exhibit 2-4. According to the 2008 Annual Average Daily Truck Traffic on the California State Highway System published by Caltrans in September 2009, the corridor's daily truck traffic ranges from 10 to 16.0 percent of the total daily traffic. Exhibit 2-3 also shows the truck percentages throughout the I-10 study corridor.

Exhibit 2-4: San Bernardino/Riverside County Truck Networks



Recent Roadway Improvements

In review of the major recent roadway improvements completed by Caltrans along the I-10 corridor, there were six projects recently implemented and open to traffic that may have significantly impacted the I-10 corridor traffic conditions. These include:

- The 2.5-mile widening of I-10 from six to eight lanes between Orange Street and Ford Street in the City of Redlands. These two lanes opened in November and December of 2007.
- The SR-210 extension, a 7.25-mile segment between Rialto and San Bernardino that connects to Highway 30, opened in July 2007.
- The Live Oak Canyon Road interchange reconfiguration and widening from two to five lanes was completed in September 2009.
- The installation of vehicle detection systems (VDS) in Riverside and San Bernardino Counties on Routes 10, 91, and 215 was completed in June 2009.
- The installation of fiber communication backbone, ramp metering, and changeable message signs on I-10 at Waterman Avenue, Tippecanoe Avenue, Mountain View Avenue, California Street, and Alabama Avenue and on I-215 at Iowa Avenue, Barton Road, and Mount Vernon/Washington were completed in September 2009.
- The eastbound I-10 auxiliary lane re-striping project from Waterman Avenue to Alabama Street was completed in October 2009.

Transit

Major transit operators within the I-10 study corridor include Riverside Transit Agency (RTA), Metrolink commuter rail service, and Omnitrans. RTA was established in 1975 and provides 38 fixed routes, 5 commuter routes, and Dial-A-Ride services in western Riverside County. It provides transit services linking communities in San Bernardino County and Riverside County along I-10. Exhibit 2-5 shows the transit lines servicing the I-10 study corridor area. Route 35 travels along SR-60, south of I-10 from the Moreno Valley Mall to the cities of Beaumont and Banning just east of the I-10/SR-60 interchange. Route 36 travels along I-10 from Sun Lakes just east of the I-10/SR-60 interchange to the city of Yucaipa.

Southern California Regional Rail Authority (SCRRA) is a joint powers authority that operates the Metrolink regional rail service throughout Southern California. Two lines service the areas along the study corridor. The Riverside Line provides service from Los Angeles Union Station to Riverside Downtown running parallel to south of the I-10 corridor with stops in Montebello/Commerce, Industry, Pomona, Pedley, and Ontario. This line operates 12 trains on the weekdays and averages nearly 5,200 riders per day, which reflects an increase of approximately 9 percent from 2006. The San Bernardino Line provides service from Los Angeles Union Station to San Bernardino running parallel to north of the I-10 corridor with stops at Cal State Los Angeles, Baldwin Park, Claremont, Montclair, Rancho Cucamonga, Fontana, Rialto, and San Bernardino. This line operates 34 trains on the weekdays and averages over 12,000 riders per day, which reflects an increase of approximately 2 percent from 2006.

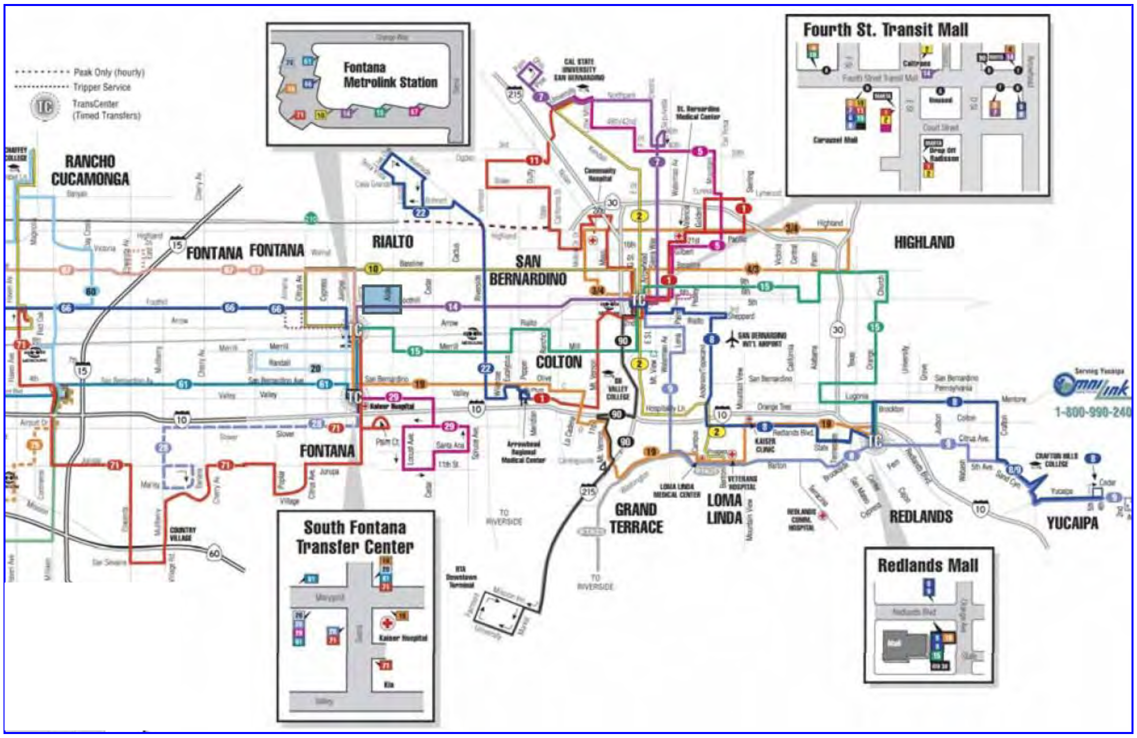
Omnitrans is a joint powers authority representing the County of San Bernardino and the 15 cities served by Omnitrans. There are many routes that operate within the proximity of the I-10 study corridor. These routes include: 1, 2, 8, 9, 15, 19, 20, 22, 29, 61, 66, 67, 82, and 215. System-wide ridership for Omnitrans routes was down slightly by 1 percent from 2006 to 2007. Estimated ridership for 2007-2008 is projected to decrease by more than 6 percent from approximately 15.5 million to 14.5 million.

Exhibit 2-5: Riverside Transit Authority Map Servicing the I-10 Corridor

Exhibit 2-6: Metrolink System Map

Source: Metrolink

Exhibit 2-7: Omnitrans Area Map Servicing the I-10 Corridor

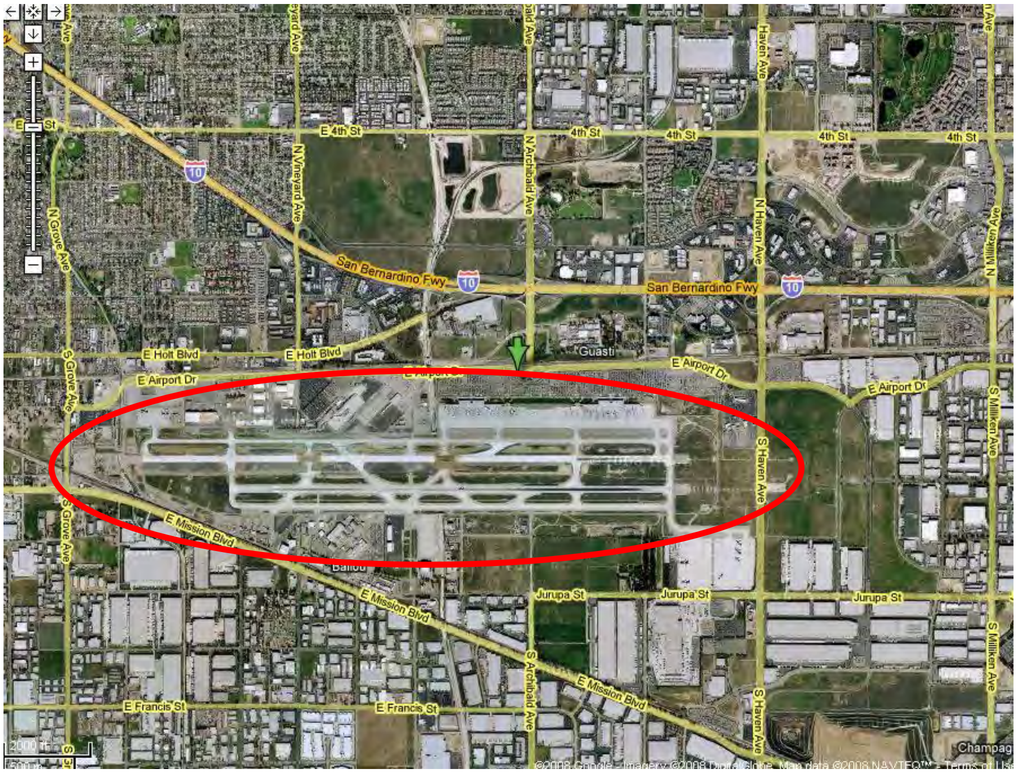


Intermodal Facilities

Several airports operate within the vicinity of the I-10 study corridor. The Ontario International Airport is a full-service airport with commercial jet service to major U.S. cities and through service to many international destinations. It is located in the city of Ontario, approximately 35 miles east of downtown Los Angeles, just west of the I-10/I-15 interchange. This airport provides air passenger service with the following airlines: Aeromexico, Alaska, American, Continental, Delta, ExpressJet, Jet Blue, Southwest, United, United Express, and US Airways. It also operates freight services with cargo airlines such as DHL, UPS and FedEx. This airport serves as a convenient alternative to the Los Angeles International Airport (LAX). Exhibit 2-8 shows the location of the airport in relation to the I-10 study corridor. Exhibit 2-9 shows the airport's historical passenger counts from 1992 to 2006.

The San Bernardino International Airport is a full-service airport providing regional air traffic for domestic and international service, both commercial and cargo. This airport serves flights for charter, corporate, and general aviation users. Exhibit 2-10 shows the location of the airport in relation to the I-10 study corridor. The Redlands Municipal Airport, as shown in Exhibit 2-11 is owned by the City of Redlands and is located two miles northeast of downtown Redlands. This is a general aviation services airport with one runway and an average of 120 aircraft operations per day.

Exhibit 2-8: Ontario International Airport



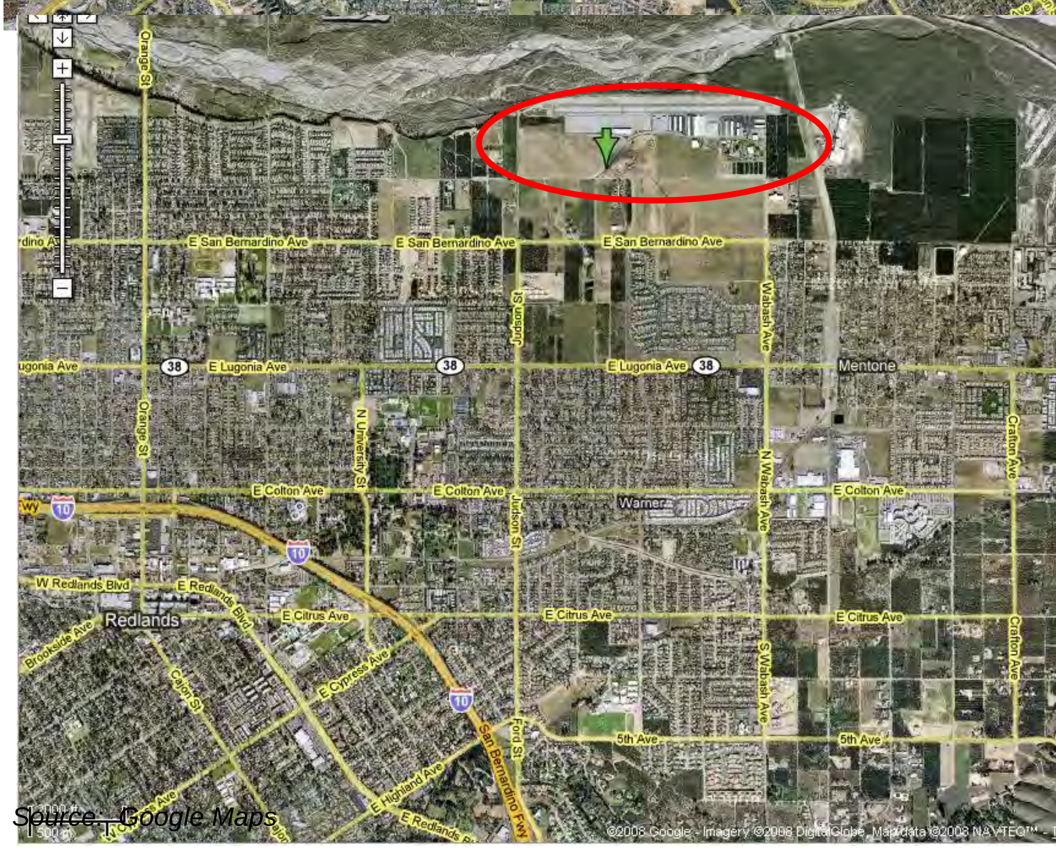
Source: Google Maps

Exhibit 2-9: Ontario International Airport Passenger Count

PASSENGER COUNT				FREIGHT	ANNUAL OPERATIONS
Year	Departures	Arrivals	Total	Freight is listed per year in TONS. Totals include U.S. mail.	Includes all commercial aircraft, air taxi, alternates, military, and general aviation.
1992	3,067,671	3,053,952	6,121,623	306,973	151,836
1993	3,105,181	3,086,854	6,192,035	353,302	154,944
1994	3,200,836	3,185,164	6,386,000	379,911	159,895
1995	3,210,582	3,194,515	6,405,097	386,953	156,283
1996	3,132,803	3,120,035	6,252,838	437,139	154,314
1997	3,153,825	3,147,037	6,300,862	461,747	154,332
1998	3,212,487	3,222,371	6,434,858	454,231	144,949
1999	3,268,661	3,309,344	6,578,005	488,774	156,607
2000	3,359,978	3,396,108	6,756,086	511,758	155,501
2001	3,354,400	3,348,000	6,702,400	462,758	154,715
2002	3,259,866	3,257,184	6,516,858	547,461	149,292
2003	3,285,577	3,262,300	6,547,877	571,892	146,413
2004	3,473,284	3,464,053	6,937,337	605,132	152,870
2005	3,611,978	3,601,550	7,213,528	575,369	143,249
2006	3,533,858	3,516,046	7,049,904	544,600	136,261
2007	3,607,184	3,599,966	7,207,150	532,865	147,678
2008	3,112,112	3,120,649	6,232,761	481,284	124,242
2009	2,444,643	2,442,052	4,886,695	390,932	98,332

Exhibit 2-10: San Bernardino International Airport

Source: Google Maps



Source: Google Maps

Trip Generators

Major special event facilities can generate significant trips along the I-10 corridor. A number of the major facilities are shown in Exhibit 2-12. A trip generator is a venue that produces substantial trips to and from the site. Although the list of trip generators identified in this report is not comprehensive, it provides an indication of the types of businesses and facilities near the study corridor.

One category of trip generators is educational institutions. These include:

- Crafton Hills College is located one mile northeast of I-10 off Sand Canyon Road. It is part of the California community college system with an enrollment of 5,100 students. It offers two-year Associate degrees in 32 programs and 25 occupational certificate plans.
- The University of Redlands is located just south of I-10 off Colton Avenue. It is a private, liberal arts university with the College of Arts and Sciences offering 42 programs to undergraduate students. It also offers advanced degrees in the School of Education and School of Business. The College of Arts and Sciences has approximately 2,500 students while the Schools of Education and Business have approximately 500 and 1,000 students, respectively.
- Loma Linda University is a Seventh-day Adventist educational health-sciences institution with 3,000 students. It is located south of I-10 off Tippecanoe/Anderson and north of Barton Road. There are more than 55 programs that are offered by the various schools within the university. Loma Linda University is a part of the Loma Linda University Adventist Health Sciences Center, which comprises the Loma Linda University Medical Center and its various affiliates.
- San Bernardino Valley College is located one and a half mile north of I-10, just west of I-215 off Mount Vernon Avenue. It is part of the California community college system with an enrollment of over 25,000 students. It offers over 100 Associate degrees and certificate programs.

In addition to educational institutions, hospital facilities can also be a major trip generator.

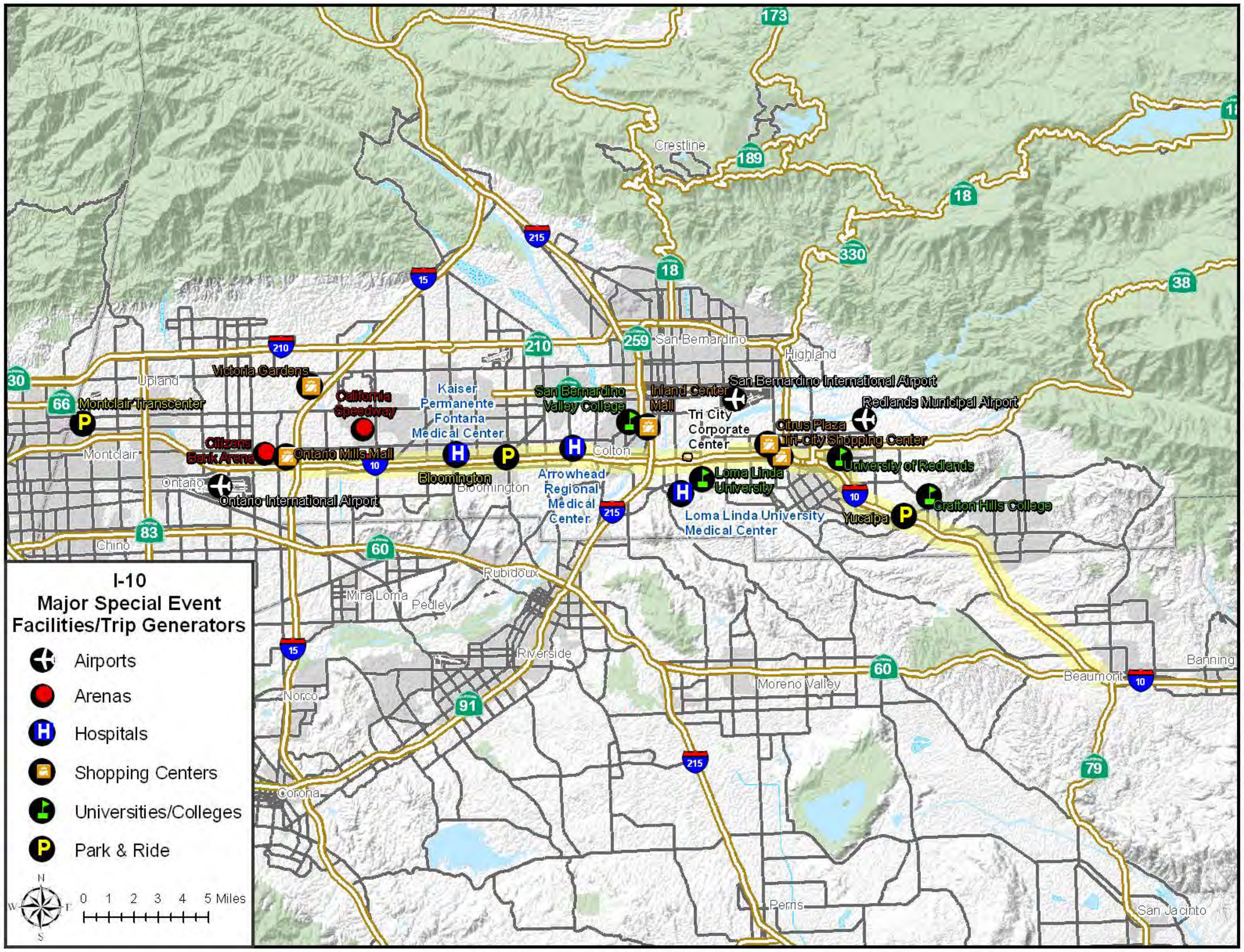
- The Loma Linda University Medical Center is a 900-bed hospital located adjacent to the Loma Linda University south of I-10 off Tippecanoe/Anderson. It includes a Children's Hospital, a Medical Center East Campus, and a Behavioral Medicine Center. This hospital serves more than 33,000 inpatients and half a million outpatients each year. It is the only level one regional trauma center for the Inyo, Mono, Riverside, and San Bernardino counties.

- Kaiser Permanente Fontana Medical Center is located north of I-10 at the corner of Sierra Avenue and Valley Boulevard. It is a full service hospital offering preventive care, prenatal care, emergency services, screening diagnostics, and pharmacy services. It serves part of Kaiser Permanente's 6.5 million members in California.
- Arrowhead Regional Medical Center is located just north of I-10 at Pepper Avenue. It is a 373-bed teaching facility with a Level II trauma center, an emergency department and other specialty services serving the San Bernardino, Riverside, Inyo, and Mono counties.

Other facilities that may generate significant trips include:

- California Speedway, which is located just one mile north of I-10 off Cherry Avenue. It provides over 92,000 grandstand seating and is accessible by car as well as Metrolink train services during race event weekends. It is the site of various racing events including the American Motorcyclist Association (AMA) and the National Association for Stock Car Auto Racing (NASCAR) races.
- The San Bernardino Stadium is located approximately two miles north of I-10, east of I-215. It is home to the Inland Empire 66ers, San Bernardino's single-A minor league baseball team in the California League.
- The Citizens Bank Arena, formerly the Ontario Community Events Center, hosts local events and concerts. The arena's capacity is approximately 11,000. It is located less than a mile north of I-10 and west of I-15.
- Victoria Gardens is a large shopping mall in Rancho Cucamonga, located approximately four miles north of the I-10/I-15 interchange.
- Ontario Mills Mall is located just west of the I-10/I-15 interchange and is the largest outlet mall in California with over 200 discount stores and entertainment venues.
- The Inland Center Mall, approximately two miles north of I-10, just east of I-215, has over 100 specialty shops.
- Citrus Plaza is an open-air shopping center in Redlands located off Alabama Street north of I-10 and east of SR-210 off Lugonia Avenue.
- Tri-City Shopping Center is located just south of I-10 between Alabama Street and Tennessee Street. It has over 60 specialty shops.

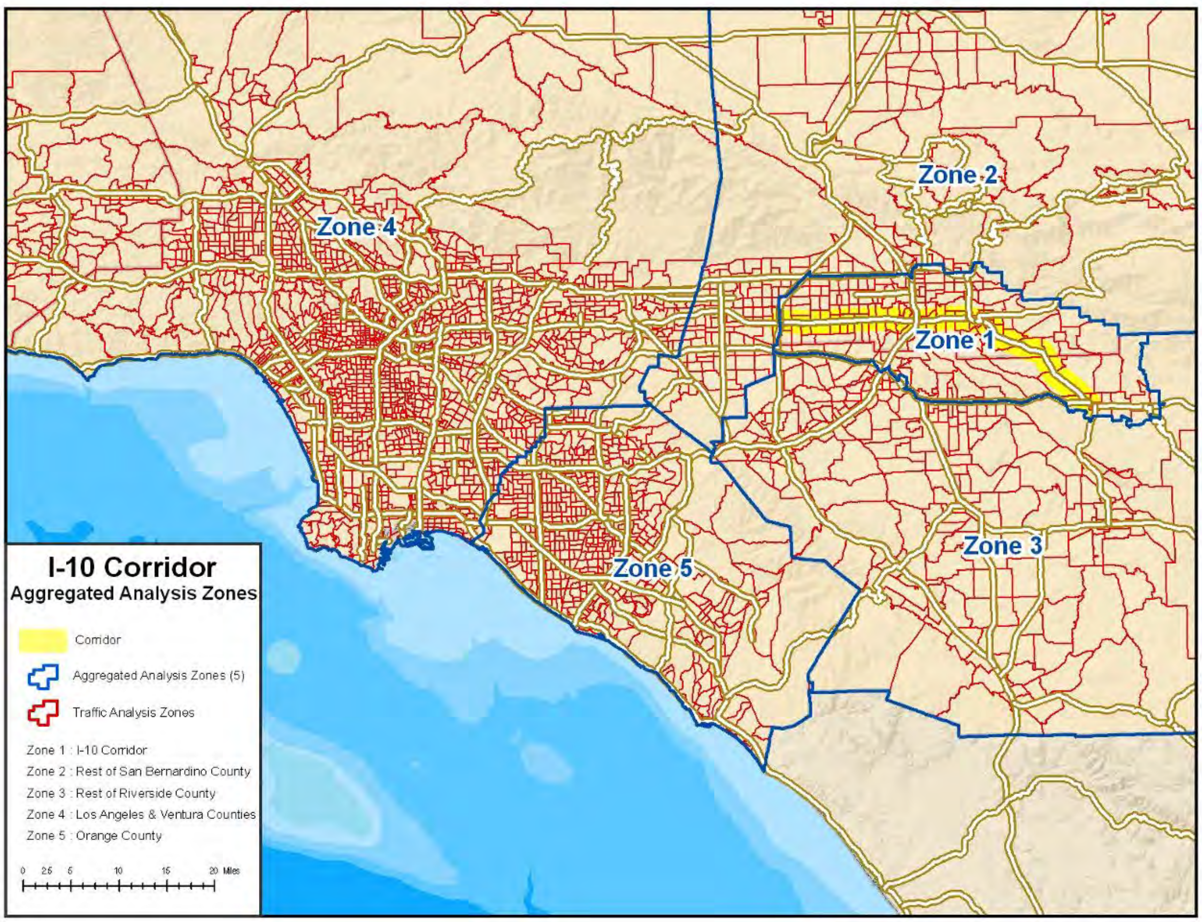
Exhibit 2-12: Trip Generators



Demand Profiles

An analysis of origins and destinations was conducted to determine the travel pattern of trips made on the I-10 CSMP study corridor. Based on the Southern California Association of Governments' (SCAG) travel demand model, this "select link analysis" isolated the I-10 study corridor and identified the origins and destinations of trips made on the corridor. The origins and destinations were identified by Traffic Analysis Zone (TAZ), which were grouped into four aggregate analysis zones shown in Exhibit 2-13.

Exhibit 2-13: Aggregate Analysis Zones for Demand Profile Analysis



Based on this aggregation, demand on the corridor was summarized by aggregated origin-destination zone as shown on Exhibits 2-14 and 2-15 for the AM and PM peak periods. This analysis shows that the majority of trips using the I-10 CSMP study corridor represent travel within San Bernardino and Riverside Counties.

During the AM peak period, about 76 percent of all trips originate and terminate in San Bernardino or Riverside Counties (Zones 1, 2, or 3). The remaining trips originate in San Bernardino or Riverside Counties and terminate in another county (16 percent); originate outside San Bernardino and Riverside Counties and terminate in San Bernardino or Riverside Counties (6 percent); or originate and terminate outside San Bernardino and Riverside Counties (2 percent).

Exhibit 2-14: AM Peak Origin Destination by Aggregated Analysis Zone

		TO ZONE					
	AM Trips	**I-10 CSMP Corridor**	**Rest of SBD Co**	**Rest of RIV Co**	**LA & Ventura Co**	**Orange Co**	**Outside Zones**
FROM ZONE	**I-10 CSMP Corridor**	38,790	13,689	10,800	9,960	2,980	187
	Rest of SBD Co	14,828	3,634	3,781	4,506	668	133
	Rest of RIV Co	9,334	3,753	4,463	2,547	420	347
	LA & Ventura Co	4,393	984	1,019	43	0	1,040
	Orange Co	881	148	131	1	0	167
	Outside Zones	134	86	259	1,093	167	315

76.0%	Trips starting and ending in SBD and RIV Counties
16.0%	Trips starting in SBD or RIV Counties and ending outside of SBD and RIV Counties
5.9%	Trips starting outside of SBD and RIV Counties and ending in SBD or RIV Counties
2.1%	Trips starting and ending outside of SBD and RIV Counties

During the PM peak period (which experiences around 64 percent more demand than the AM peak period), the picture is similar. Roughly 75 percent of trips originate and terminate in San Bernardino and Riverside Counties. The remaining trips originate in San Bernardino or Riverside Counties and terminate in another county (8 percent); originate outside San Bernardino and Riverside Counties and terminate in San Bernardino or Riverside Counties (14 percent); or originate and terminate outside San Bernardino and Riverside Counties (3 percent).

Exhibit 2-15: PM Peak Origin Destination by Aggregated Analysis Zone

		TO ZONE					
	PM Trips	**I-10 CSMP Corridor**	**Rest of SBD Co**	**Rest of RIV Co**	**LA & Ventura Co**	**Orange Co.**	**Outside Zones**
FROM ZONE	**I-10 CSMP Corridor**	60,715	21,230	15,014	8,857	1,714	222
	Rest of SBD Co	21,768	5,119	6,376	2,553	490	132
	Rest of RIV Co	16,540	6,232	6,063	1,843	222	464
	LA & Ventura Co	13,564	5,530	3,940	66	3	1,297
	Orange Co	3,454	806	495	3	0	283
	Outside Zones	462	271	1,009	2,760	331	1,500

75.3%	Trips starting and ending in SBD and RIV Counties
7.8%	Trips starting in SBD or RIV Counties and ending outside of SBD or RIV Counties
14.0%	Trips starting outside of SBD or RIV Counties and ending in SBD or RIV Counties
3.0%	Trips starting and ending outside of SBD and RIV Counties

3. COMPREHENSIVE PERFORMANCE ASSESSMENT

A. Data Sources and Freeway Detection Status

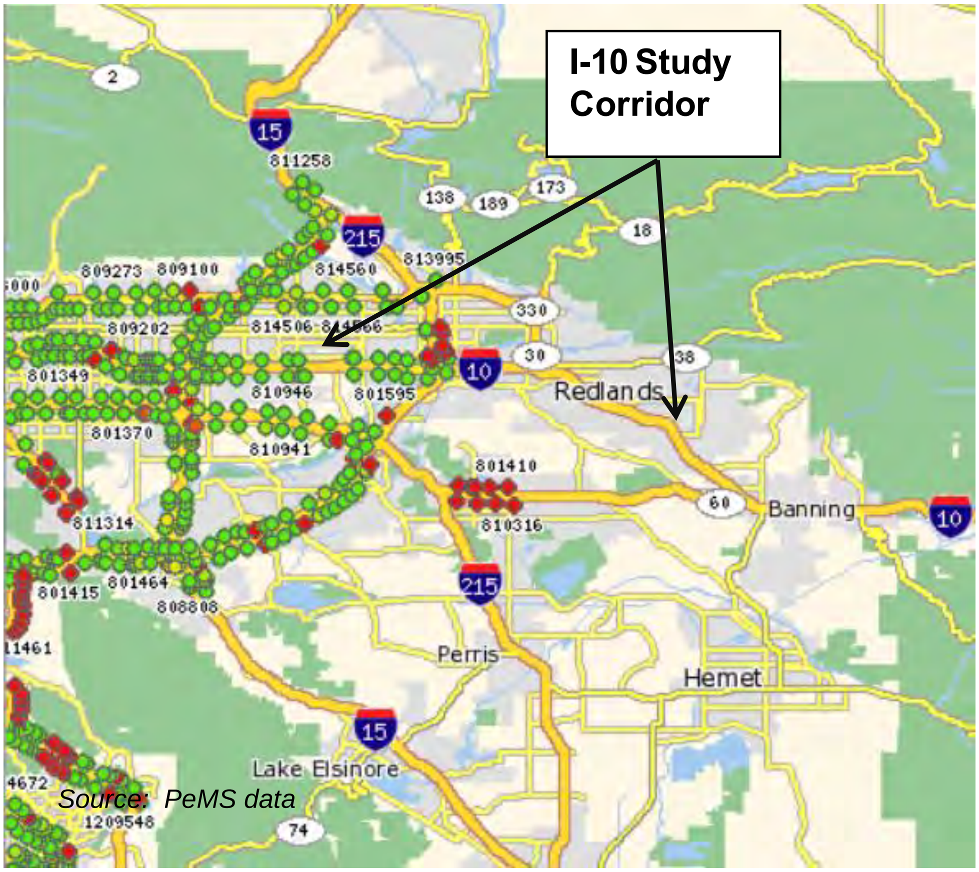
Numerous data sources were used to analyze the existing conditions of the corridor. They were also used to identify bottlenecks. These sources include:

- Caltrans Highway Congestion Monitoring Program (HICOMP) report and data files (2006 – 2008)
- Caltrans Freeway Performance Measurement System (PeMS) detector data
- Caltrans Traffic Accident Surveillance and Analysis System (TASAS) from PeMS
- Various traffic study reports
- Aerial photographs (Microsoft Virtual Earth and Google Earth) and Caltrans photologs
- Internet (i.e., Omnitrans, Metrolink websites).

Details for each data source are provided in the applicable sections of this report. However, given the need for comprehensive and continuous monitoring and evaluation, detection coverage and quality are discussed in more detail here.

Exhibit 3A-1 depicts the corridor freeway facility with the detectors in place as of December 23, 2008. This data was chosen randomly to provide a snapshot of the detection status. The exhibit illustrates the availability of detectors west of I-215 and the absence of detectors east of I-215. As noted by the green color, the majority of existing detectors west of I-215 were functioning well on this specific date. However, among these detectors, there are some seemingly large gaps that exist.

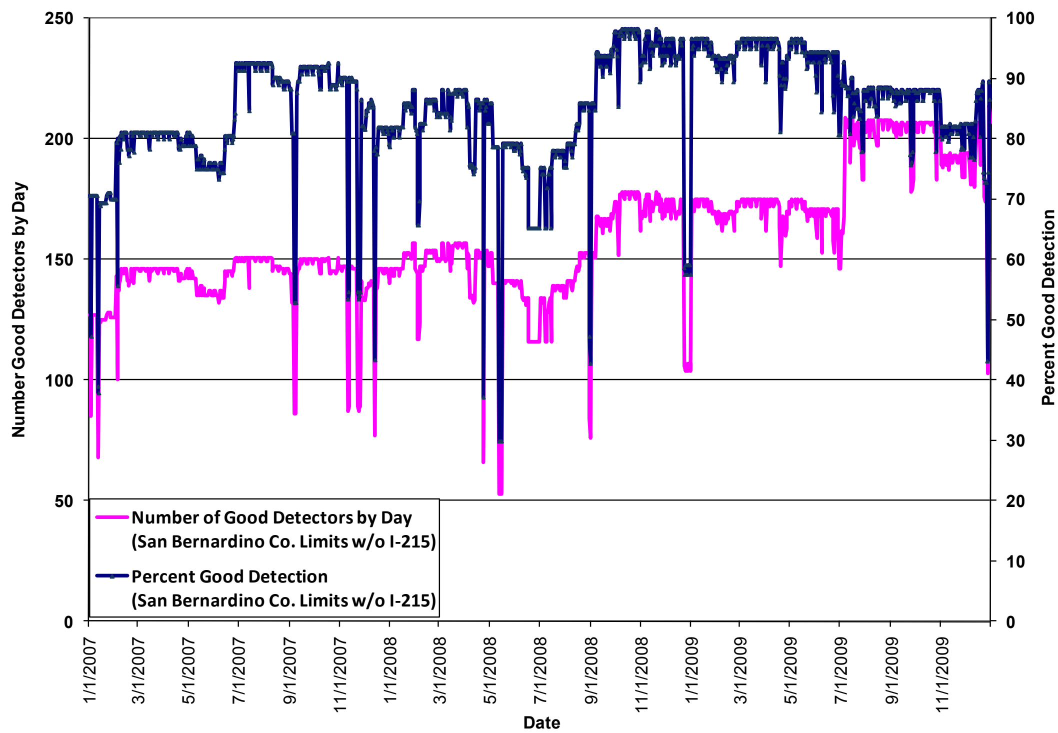
Exhibit 3A-1: Detector Data Quality (December 23, 2008)



Source: PeMS data

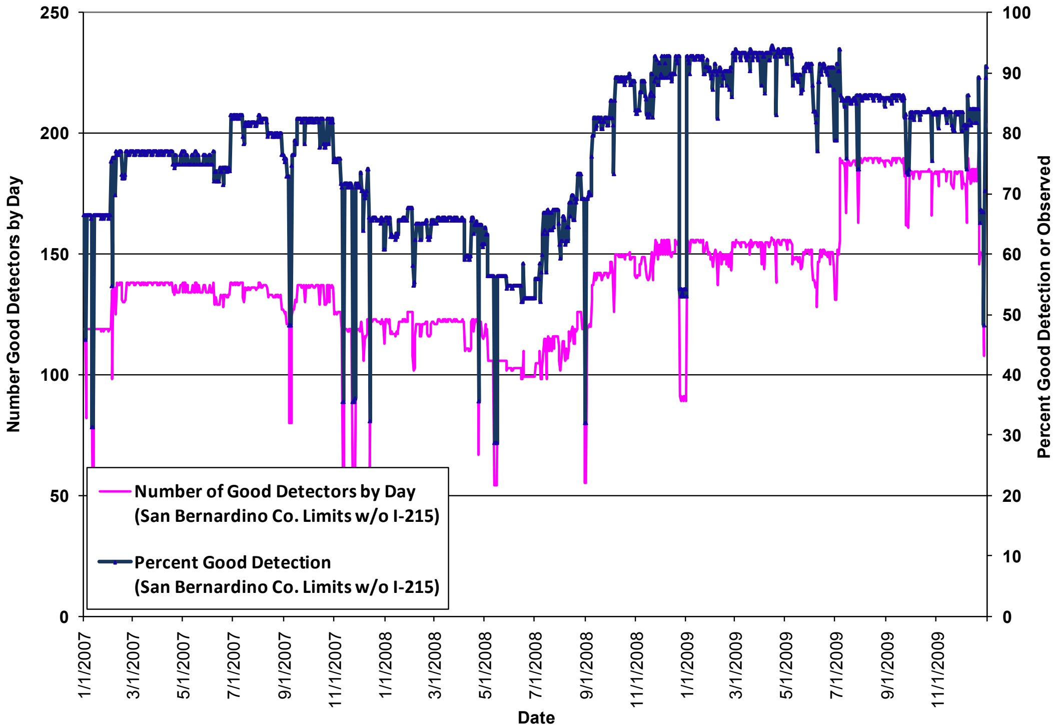
The following exhibits provide a better picture of how the detectors on the corridor performed over a longer period of time. Exhibits 3A-2 and 3A-3 report the number and percentage of "good" detectors by day for the entire I-10 corridor in San Bernardino County (west of I-215) from 2007 to 2009. The left y-axis shows the scale used for the number of detectors, while the right y-axis shows the scale used for the percent good detectors. These exhibits suggest that detection in the eastbound direction (Exhibit 3A-2) was slightly better than the westbound direction (Exhibit 3A-3), particularly in the last months of 2008 when the percentage of good detectors in the eastbound direction reported almost 100 percent compared to 90 percent in the westbound direction. The difference appears to be due to the addition of a large number of operating detectors during the summer months of 2008 in the eastbound direction.

Exhibit 3A-2: Good Detectors on Eastbound I-10 (SB Co. Limits w/o I-215)



Source: SMG analysis of PeMS data

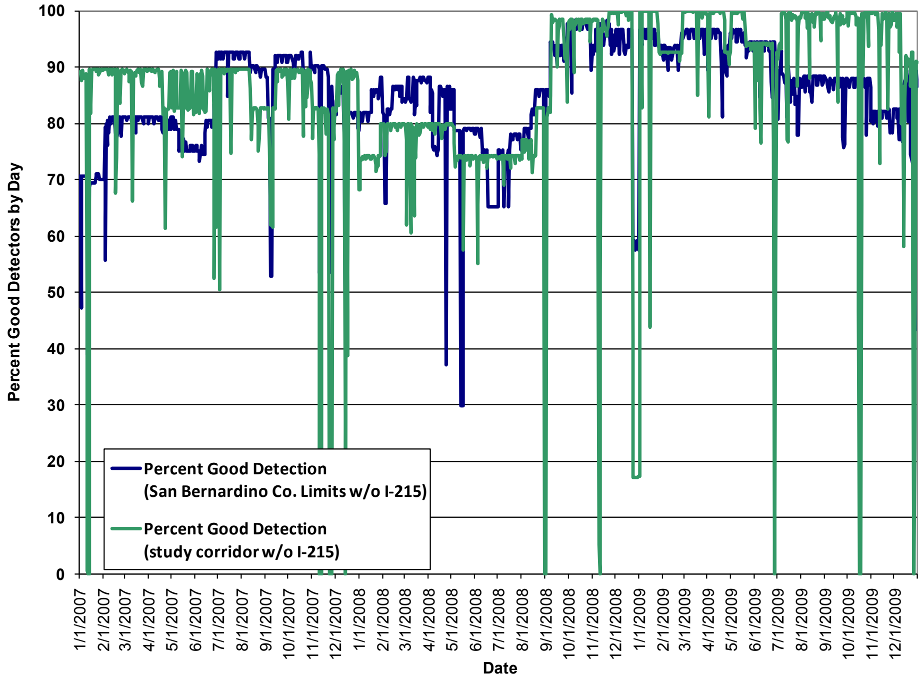
Exhibit 3A-3: Good Detectors on Westbound I-10 (SB Co. Limits w/o I-215)



Source: Caltrans detector data

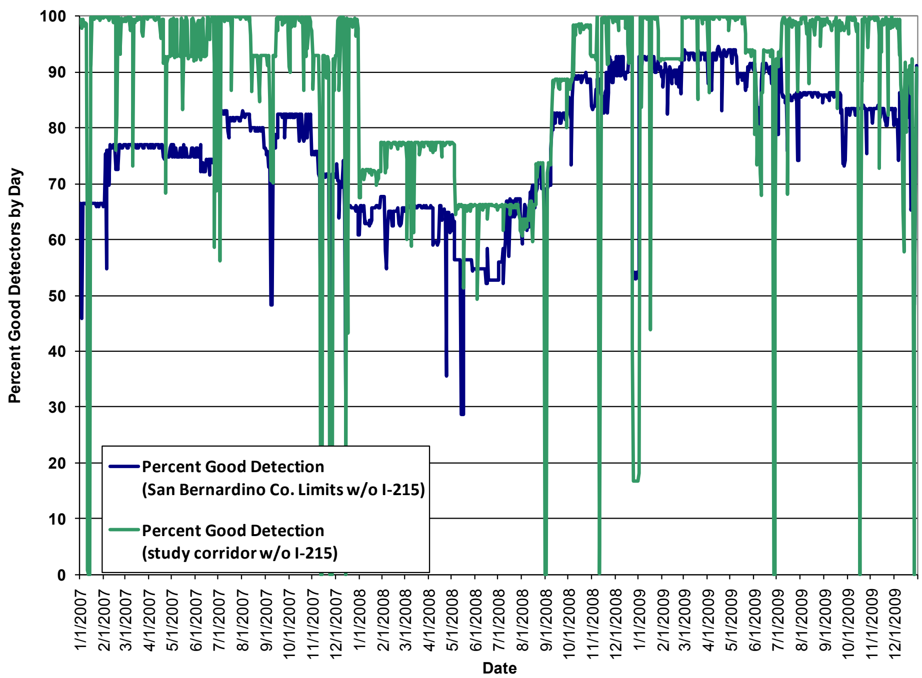
Exhibits 3A-4 and 3A-5 isolate the I-10 study corridor west of I-215 (in green) and reports the percentage of good detectors within the I-10 corridor limits compared to all of San Bernardino County west of I-215 (in blue). As the exhibits illustrate, both directions of the corridor have better detection relative to the freeway as a whole (in San Bernardino County west of I-215).

Exhibit 3A-4: Percentage of Good Detectors on Eastbound I-10 (Project Limits w/o I-215)



Source: Caltrans detector data

Exhibit 3A-5: Percentage of Good Detectors on Westbound I-10 (Project Limits w/o I-215)



Source: Caltrans detector data

Overall, the detection on the I-10 study corridor (west of I-215) during 2008-2009 is considered excellent with the majority of detectors reporting over 80 percent good data in both directions. In both directions, detection improved significantly starting in July 2008. Part of the increased detector quality in 2008 may be attributed to improved maintenance of the existing detectors. In 2009 and 2010, numerous detectors were added to the study corridor, notably east of I-215. These detectors are listed in Exhibits 3A-6 and 3A-7.

Exhibit 3A-6: Eastbound Detectors Added (2009-2010)

VDS	Name	Type	CA PM	Abs PM	Date Online	VDS	Name	Type	CA PM	Abs PM	Date Online
EASTBOUND											
818158	RTE 15 JUNCTION E/O	Mainline	10.20	56.97	2/19/2010	818176	TENNESSEE AVE	Mainline	29.90	76.66	2/19/2010
818159	MULBERRY CREEK	Mainline	12.60	59.37	6/18/2010	819038	ORANGE ST W/O	Mainline	30.70	77.46	6/18/2010
818548	CHERRY AVE	Mainline	13.00	59.77	6/18/2010	819047	ORANGE ST E/O	Mainline	30.90	77.66	6/18/2010
818161	FONTANA REST	Mainline	14.40	61.17	2/19/2010	818178	6th STREET	Mainline	31.10	77.86	2/19/2010
818556	CITRUS AVE	Mainline	15.10	61.87	2/19/2010	818202	CYPRESS AVE	Mainline	32.20	78.96	2/19/2010
818170	CITRUS AVE	Mainline	15.30	62.07	2/19/2010	818582	FORD STREET	Mainline	33.00	79.76	2/19/2010
818190	SIERRA AVE	Mainline	17.00	63.77	2/19/2010	818204	REDLANDS BLVD UC	Mainline	33.40	80.16	2/19/2010
818163	CEDAR AVE	Mainline	17.70	64.47	2/19/2010	818584	WABASH AVE W/O	Mainline	34.00	80.76	2/19/2010
818567	CEDAR AVE	Mainline	R18.8	65.57	2/19/2010	818200	WABASH AVE	Mainline	34.40	81.16	2/19/2010
818172	CEDAR AVE	Mainline	19.30	66.07	2/19/2010	818579	WABASH AVE W/O	Mainline	34.80	81.56	2/19/2010
818192	RIVERSIDE AVE	Mainline	20.10	66.87	6/18/2010	818586	YUCAIPA BLVD	Mainline	35.30	82.06	6/18/2010
818175	PEPPER AVE	Mainline	20.80	67.57	2/19/2010	818206	YUCAIPA BLVD	Mainline	35.60	82.36	6/18/2010
818560	RANCHO AVE	Mainline	R21.8	68.57	2/19/2010	818576	16th STREET W/O	Mainline	36.30	83.06	2/19/2010
818166	RANCHO AVE	Mainline	R22	68.77	2/19/2010	818197	LIVE OAK CANYON RD	Mainline	36.90	83.66	2/19/2010
818563	9TH STREET	Mainline	R22.8	69.57	6/18/2010	818577	LIVE OAK CANYON RD	Mainline	R37.1	83.86	2/19/2010
818169	MT. VERNON AVE	Mainline	R23.1	69.87	6/18/2010	818573	WILDWOOD REST W/O	Mainline	R37.8	84.56	2/19/2010
818565	MT. VERNON AVE	Mainline	R23.4	70.17	6/18/2010	818194	COUNTY LINE RD	Mainline	R38.5	85.26	2/19/2010
816966	10/215 UC	Mainline	R24.25	71.02	7/7/2009	819051	COUNTY LINE RD	Mainline	R39.1	85.86	6/18/2010
816450	HUNTS LANE WB ON	Mainline	R24.54	71.31	7/7/2009	819048	COUNTY LINE RD	Mainline	0.20	86.12	6/18/2010
816463	WATERMAN AVE	On Ramp	25.40	72.17	7/7/2009	819053	SANDALWOOD DR OC	Mainline	R.75	86.67	6/18/2010
816464	WATERMAN AVE	Mainline	25.40	72.17	7/7/2009	819054	SANDALWOOD DR OC	Mainline	R1.00	86.92	6/18/2010
816419	TIPPECANOE AVE	Mainline	26.15	72.91	7/7/2009	819186	SINGLETON RD	Mainline	R2	87.92	6/18/2010
816479	TIPPECANOE AVE	On Ramp	26.43	73.19	7/7/2009	819059	CHERRY VALLEY BLVD	Mainline	R3.03	88.96	6/18/2010
816480	TIPPECANOE AVE	Mainline	26.43	73.19	7/7/2009	819056	CHERRY VALLEY BLVD	Mainline	R3.15	89.08	6/18/2010
816401	MT. VIEW AVE	Mainline	27.15	73.91	7/7/2009	819183	BROOKSIDE OC E/O	Mainline	R3.9	89.82	6/18/2010
816493	MT. VIEW AVE	On Ramp	27.42	74.19	7/7/2009	819185	OAK VALLEY PKWY W/O	Mainline	R4.6	90.52	6/18/2010
816494	MT. VIEW AVE	Mainline	27.42	74.19	7/7/2009	819063	OAK VALLEY PKWY W/O	Mainline	R5.4	91.32	6/18/2010
816382	CALIFORNIA ST.	Mainline	28.18	74.94	7/7/2009	819060	OAK VALLEY RD	Mainline	R5.6	91.52	6/18/2010
816508	CALIFORNIA ST.	On Ramp	28.43	75.20	7/7/2009	819178	RTE 10/60 SEP E/O	Mainline	6.80	92.68	6/18/2010
816509	CALIFORNIA ST.	Mainline	28.43	75.20	7/7/2009						

Exhibit 3A-7: Westbound Detectors Added (2009-2010)

VDS	Name	Type	CA PM	Abs PM	Date Online	VDS	Name	Type	CA PM	Abs PM	Date Online
WESTBOUND											
818157	RTE 15 JUNCTION E/O	Mainline	10.20	56.97	2/19/2010	816363	ALABAMA ST WB ON	On Ramp	29.16	75.93	7/7/2009
818160	MULBERRY CREEK	Mainline	12.60	59.37	6/18/2010	816364	ALABAMA ST WB ON	Mainline	29.16	75.93	7/7/2009
818547	CHERRY AVE	Mainline	13.00	59.77	6/18/2010	818177	TENNESSEE AVE	Mainline	29.90	76.66	2/19/2010
818162	FONTANA REST	Mainline	14.40	61.17	2/19/2010	819045	ORANGE ST	Mainline	30.70	77.46	6/18/2010
818555	CITRUS AVE	Mainline	15.10	61.87	2/19/2010	819046	ORANGE ST E/O	Mainline	30.90	77.66	6/18/2010
818171	CITRUS AVE	Mainline	15.30	62.07	2/19/2010	818179	6th STREET	Mainline	31.10	77.86	2/19/2010
818191	SIERRA AVE	Mainline	17.00	63.77	2/19/2010	818203	CYPRESS AVE	Mainline	32.20	78.96	2/19/2010
818165	CEDAR AVE	Mainline	17.70	64.47	2/19/2010	818581	FORD STREET	Mainline	33.00	79.76	2/19/2010
818568	CEDAR AVE	Mainline	R18.8	65.57	2/19/2010	818205	REDLANDS BLVD UC	Mainline	33.40	80.16	2/19/2010
818173	CEDAR AVE	Mainline	19.30	66.07	2/19/2010	818583	WABASH AVE W/O	Mainline	34.00	80.76	2/19/2010
818193	RIVERSIDE AVE	Mainline	20.10	66.87	6/18/2010	818201	WABASH AVE	Mainline	34.40	81.16	2/19/2010
818174	PEPPER AVE	Mainline	20.80	67.57	2/19/2010	818580	WABASH AVE W/O	Mainline	34.80	81.56	2/19/2010
818559	RANCHO AVE	Mainline	R21.8	68.57	2/19/2010	818585	YUCAIPA BLVD	Mainline	35.30	82.06	6/18/2010
818167	RANCHO AVE	Mainline	R22	68.77	2/19/2010	818207	YUCAIPA BLVD	Mainline	35.60	82.36	6/18/2010
818564	9TH STREET	Mainline	R22.8	69.57	6/18/2010	818575	16th STREET W/O	Mainline	36.30	83.06	2/19/2010
818168	MT. VERNON AVE	Mainline	R23.1	69.87	6/18/2010	818196	LIVE OAK CANYON RD	Mainline	36.90	83.66	2/19/2010
818566	MT. VERNON AVE	Mainline	R23.4	70.17	6/18/2010	818578	LIVE OAK CANYON RD	Mainline	R37.1	83.86	2/19/2010
816967	10/215 UC WB OS	Mainline	R24.25	71.02	7/7/2009	818574	WILDWOOD REST W/O	Mainline	R37.8	84.56	2/19/2010
816445	HUNTS LANE WB ON	On Ramp	R24.54	71.31	7/7/2009	818195	COUNTY LINE RD	Mainline	R38.5	85.26	2/19/2010
816446	HUNTS LANE WB ON	Mainline	R24.54	71.31	7/7/2009	819050	COUNTY LINE RD	Mainline	R39.1	85.86	2/19/2010
816431	HOSPITALITY DR WB ON	On Ramp	25.45	72.21	7/7/2009	819049	COUNTY LINE RD	Mainline	0.20	86.12	2/19/2010
816432	HOSPITALITY DR WB ON	Mainline	25.45	72.21	7/7/2009	819052	SANDALWOOD DR OC	Mainline	R.749	86.67	6/18/2010
816417	TIPPECANOE AVE	On Ramp	26.15	72.91	7/7/2009	819055	SANDALWOOD DR OC	Mainline	R1.002	86.92	6/18/2010
816418	TIPPECANOE AVE	Mainline	26.15	72.91	7/7/2009	819187	SINGLETON RD	Mainline	R2	87.92	6/18/2010
816481	TIPPECANOE AVE	Mainline	26.43	73.19	7/7/2009	819058	CHERRY VALLEY BLVD	Mainline	R3.03	88.96	6/18/2010
816399	MT. VIEW AVE	On Ramp	27.15	73.91	7/7/2009	819057	CHERRY VALLEY BLVD	Mainline	R3.15	89.08	6/18/2010
816400	MT. VIEW AVE	Mainline	27.15	73.91	7/7/2009	819182	BROOKSIDE OC E/O	Mainline	R3.9	89.82	6/18/2010
816495	MT. VIEW AVE	Mainline	27.42	74.19	7/7/2009	819184	OAK VALLEY PKWY W/O	Mainline	R4.6	90.52	6/18/2010
816381	CALIFORNIA ST.	On Ramp	28.18	74.94	7/7/2009	819062	OAK VALLEY PKWY W/O	Mainline	R5.4	91.32	6/18/2010
816383	CALIFORNIA ST.	Mainline	28.18	74.94	7/7/2009	819061	OAK VALLEY RD	Mainline	R5.6	91.52	6/18/2010
816510	CALIFORNIA ST.	Mainline	28.43	75.20	7/7/2009						

Finally, an analysis of gaps without detection is shown in Exhibit 3A-8.

Exhibit 3A-8: I-10 Gaps in Detection (as of September 2010)

Location		Abs PM		Length (Miles)
From	To	From	To	
EASTBOUND				
RTE 15 JUNCTION E/O	MULBERRY CREEK	56.97	59.37	2.41
CHERRY AVE	FONTANA REST	59.77	61.17	1.40
CITRUS AVE	SIERRA AVE	62.07	63.77	1.70
PEPPER AVE	RANCHO AVE	67.57	68.57	1.00
MT. VERNON AVE	10/215 UC	70.17	71.02	0.85
HUNTS LANE WB ON	WATERMAN AVE	71.31	72.17	0.85
MT. VIEW AVE	CALIFORNIA ST.	74.19	74.94	0.75
CALIFORNIA ST.	TENNESSEE AVE	75.20	76.66	1.47
TENNESSEE AVE	ORANGE ST W/O	76.66	77.46	0.80
6th STREET	CYPRESS AVE	77.86	78.96	1.10
CYPRESS AVE	FORD STREET	78.96	79.76	0.80
SANDALWOOD DR OC	SINGLETON RD	86.92	87.92	1.00
SINGLETON RD	CHERRY VALLEY BLVD	87.92	88.96	1.04
OAK VALLEY RD	RTE 10/60 SEP E/O	91.52	92.68	1.16
WESTBOUND				
RTE 15 JUNCTION E/O	MULBERRY CREEK	56.97	59.37	2.41
CHERRY AVE	FONTANA REST	59.77	61.17	1.40
CITRUS AVE	SIERRA AVE	62.07	63.77	1.70
CEDAR AVE	RIVERSIDE AVE	66.07	66.87	0.80
PEPPER AVE	RANCHO AVE	67.57	68.57	1.00
RANCHO AVE	9TH STREET	68.77	69.57	0.80
MT. VERNON AVE	10/215 UC WB OS	70.17	71.02	0.85
HUNTS LANE WB ON	HOSPITALITY DR WB ON	71.31	72.21	0.89
MT. VIEW AVE	CALIFORNIA ST.	74.19	74.94	0.75
TENNESSEE AVE	ORANGE ST	76.66	77.46	0.80
6th STREET	CYPRESS AVE	77.86	78.96	1.10
CYPRESS AVE	FORD STREET	78.96	79.76	0.80

Source: Caltrans detector data

B. Corridor-Wide Performance and Trends

This section summarizes the analysis results of the performance measures used to evaluate the existing conditions of the I-10 Corridor. The primary objective for having the measures is to provide a sound technical basis for describing traffic performance on the corridor. The base year for the analysis and modeling of the I-10 study corridor is 2008.

The performance measures focus on four key areas:

- **Mobility** describes how well people and freight move along the corridor
- **Reliability** captures the relative predictability of travel along the corridor
- **Productivity** describes the productivity loss due to traffic inefficiencies
- **Safety** provides an overview of collisions along the corridor

Mobility

The mobility performance measures are both measurable and straightforward for documenting current conditions. They can be forecasted, which makes them useful for future comparisons. Two primary measures are typically used to quantify mobility: delay and travel time.

Delay

Delay is defined as the observed travel time less the travel time under non-congested conditions, and is reported as vehicle-hours of delay. Delay can be computed for severe congested conditions using the following formula:

$$(\text{Vehicles Affected per Hour}) \times (\text{Segment Length}) \times (\text{Duration}) \times \left[\frac{1}{(\text{Congested Speed})} - \frac{1}{(\text{Threshold Speed})}\right]$$

In the formula above, the *Vehicles Affected per Hour* value depends on the methodology used. Some methods assume a fixed flow rate (e.g., 2000 vehicles per hour per lane), while others use a measured or estimated flow rate. The segment length is the distance under which the congested speed prevails. The duration is how long the congested period lasts (measured in hours), with the congested period being the amount of time spent below the threshold speed. The threshold speed is the speed under which congestion is considered to occur. Any speed can be used, but two commonly used threshold speeds are 35 mph and 60 mph.

Caltrans defines the threshold speed as 35 mph and assumes a fixed 2,000 vehicles per hour per lane are experiencing the delay to estimate severe delay for reporting congestion for the statewide Highway Congestion Monitoring Report (HICOMP).

In calculating total delay, Caltrans automatic detectors use the 60 mph threshold speed and the observed number of vehicles reported. The congestion results of HICOMP and automatic detectors are difficult to compare due to these methodological differences, so they are discussed separately in this assessment.

Caltrans HICOMP

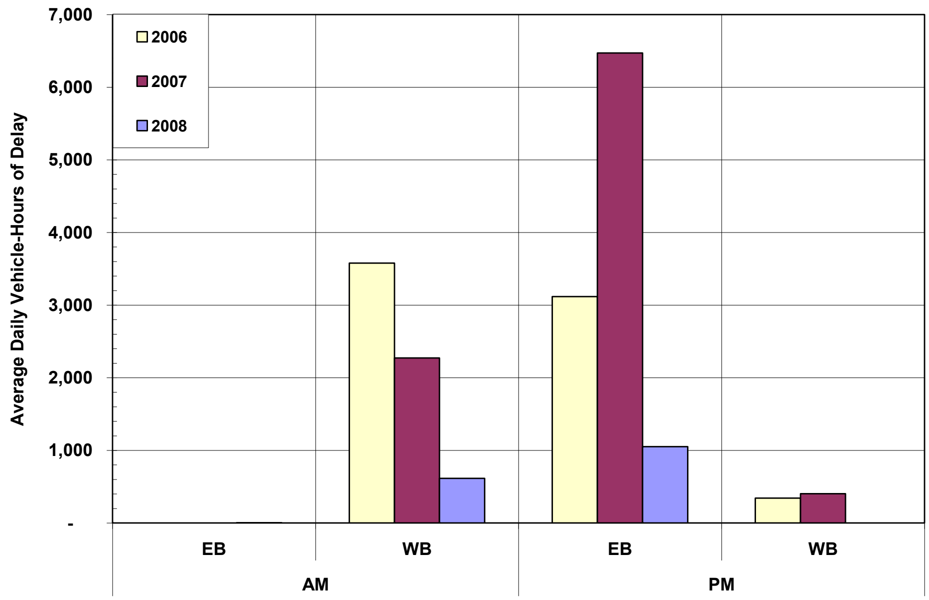
The HICOMP report has been published annually by Caltrans since 1987.[2] Delay is presented as average daily vehicle-hours of delay (DVHD). In HICOMP, Caltrans attempts to capture recurrent congestion during "typical" incident-free weekday peak periods. Recurrent delay is defined in HICOMP as a condition where speeds drop below 35 mph for a period of 15-minutes or longer during weekday AM or PM commute periods.

For the HICOMP report, probe vehicle runs are performed at most only two to four days during the entire year (ideally, two days of data collection in the spring and two in the fall of the year, but resource constraints may affect the number of runs performed during a given year).

Exhibit 3B-1 summarizes HICOMP delay trends from 2006 to 2008 for the AM and PM peak travel period for both directions along the I-10 corridor. As indicated, the westbound corridor had the most significant congestion during the AM peak period while the eastbound corridor experienced the most congestion during the PM peak period. The pattern of congestion differs by direction. In the westbound direction, congestion decreased yearly from 2006 to 2007 and 2008. In the eastbound direction, congestion increased by almost 100 percent from 2006 to 2007, but then decreased by almost 85 percent in 2008.

[2] Located at: http://www.dot.ca.gov/hq/traffops/sysmgtpl/HICOMP/index.htm

Exhibit 3B-1: Average Daily Vehicle-Hours of Delay (2006-2008)



Source: Caltrans HICOMP Reports for 2006-2008

Exhibit 3B-2 shows a complete list of congested segments reported by the HICOMP report for the I-10 corridor. A congested segment may vary in distance or size from one year to the next as well as from day-to-day.

Exhibit 3B-2 shows that the most congested segment on the corridor varied from year to year (most likely due to construction and detection availability). The highest delays were reported for the westbound segment during the AM peak period, between Live Oak Canyon Road and 6th Street. Delay in this segment totaled roughly 2,371 hours in 2006. However, congestion at almost the same location decreased in 2007 to 1,997 hours. The eastbound direction also experienced high levels of congestion around the same location but during the PM peak period. In 2007, the segment from SR-210 (formerly SR-30) to Ford Street recorded the highest delay of any segment on the corridor during the three-year period with 2,206 hours of delay. Congestion levels in 2008 declined significantly in both directions of travel.

Exhibit 3B-2: HICOMP Congested Segments (2006-2008)

Period	Dir	Potential Bottleneck: Location (approx)	Potential Bottleneck: Ca PM (approx)	Approximate Queue End: Location (approx)	Approximate Queue End: Ca PM (approx)	Hours of Delay: 2006	Hours of Delay: 2007	Hours of Delay: 2008
AM	WB	Wabash St	33.9	Live Oak Canyon Rd	37			171
		6th St	31.4	Live Oak Canyon Rd	37	2,371	1,997	
		Mountain View	27.5	SR-210	29.8	223		165
		Etiwanda Ave	11.7	I-215	23.8	984	275	
		I-15	9.9	Sierra Ave	16.5			277
					AM PEAK PERIOD CONGESTION	3,578	2,272	613
PM	EB	Cherry Ave	13.4	I-15	10	918	2,143	338
		b/n Sierra Ave & Cedar Ave	17.8	Cherry Ave	13.8	240		
		Rancho Ave	21.5	Cherry Ave	13.2		1,151	
				Cedar Ave	18.3	175		
		I-215	24.4	Mt Vernon Ave	23.3			104
		Tippecanoe Ave	25.9	I-215	24.3			
		SR-210	29.1	I-215	24.4		971	610
				Mt Vernon Ave	23.5	573		
				Alabama St	29			
		University St	31.7	SR-210	29.9	1,210		
		Ford St	33.2	SR-210	29.8		2,206	
	WB	Rancho Ave	21.8	I-215	24.2	343		
		Citrus Ave	15.3	I-215	23.7		402	
					PM PEAK PERIOD CONGESTION	3,459	6,873	1,052
					TOTAL CORRIDOR CONGESTION	7,037	9,145	1,665

Exhibits 3B-3 and 3B-4 provide maps illustrating the 2008 congested segments during the AM and PM peak commute periods for I-10. The approximate locations of the congested segments and the reported recurrent daily delay are identified in the exhibit.

Exhibit 3B-3: HICOMP Congested Segments Map - AM Peak Period (2008)

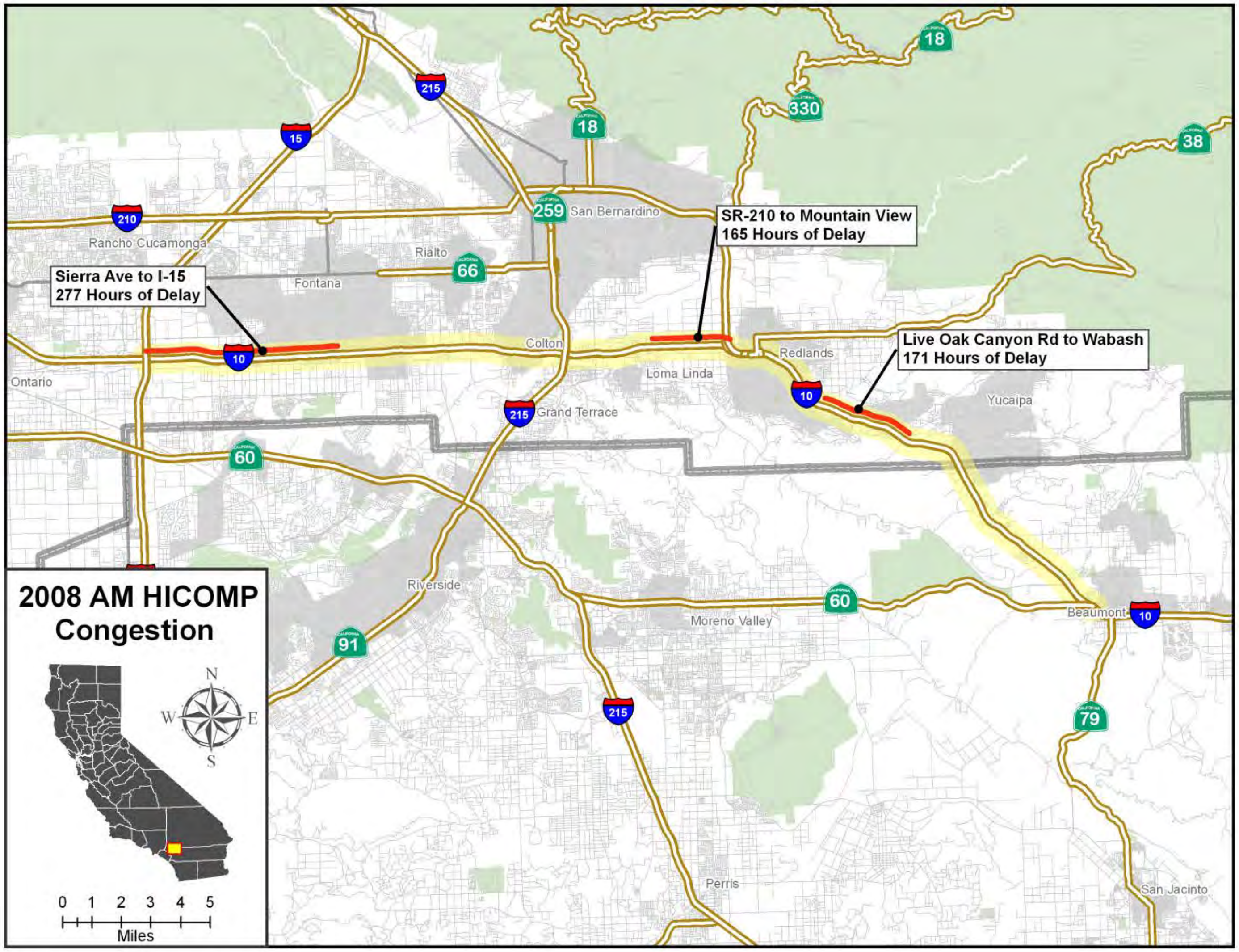
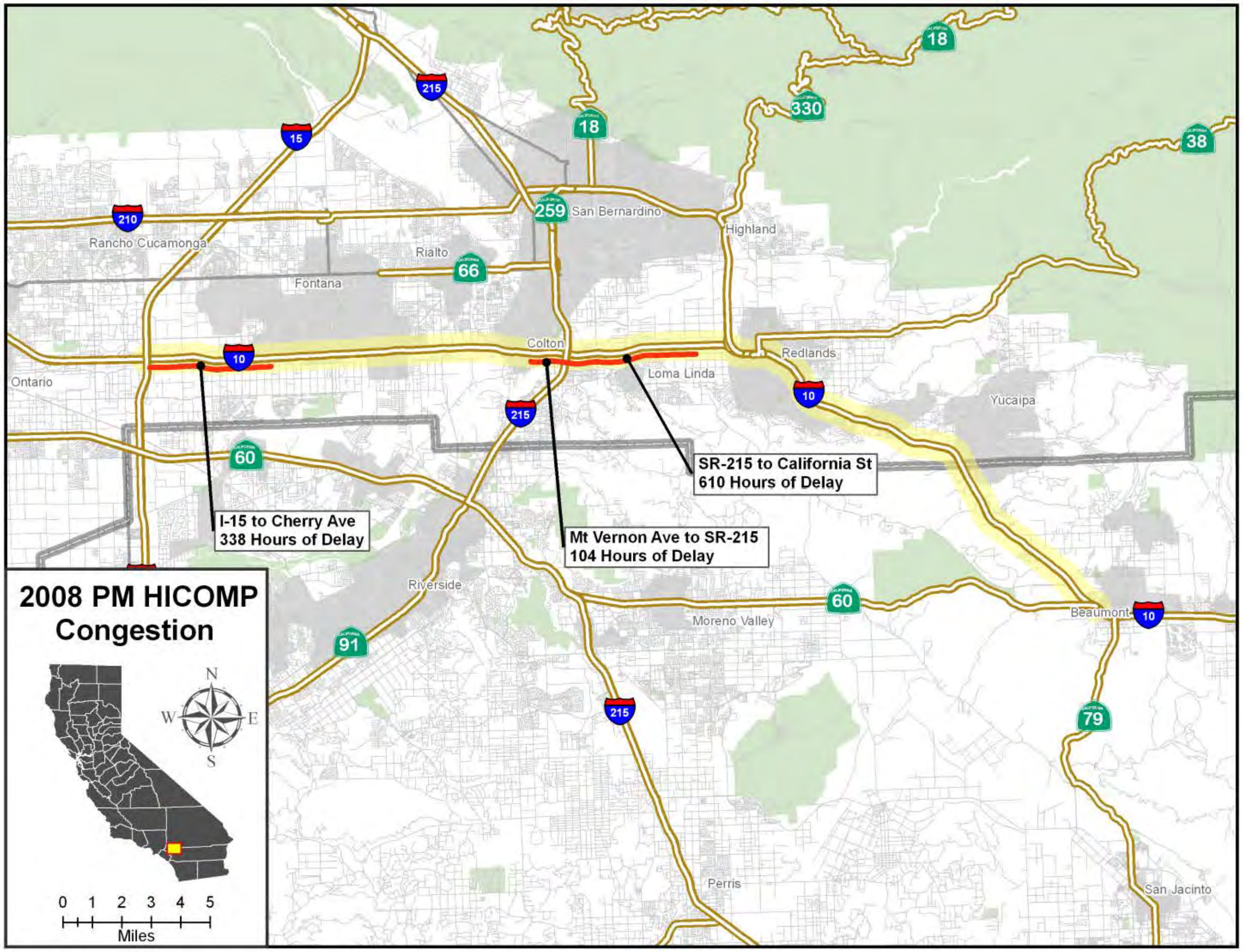


Exhibit 3B-4: HICOMP Congested Segments Map - PM Peak Period (2008)



Vehicle Detector Data

Freeway detector data can be used to calculate daily delay, which is not possible when using probe vehicle data. For the I-10 study corridor, detector data was only available from I-15 to I-215 starting in October 2006. Therefore, the performance assessments include only analysis for the complete years of 2007, 2008, and 2009 and only for the portion of the corridor west of I-215.

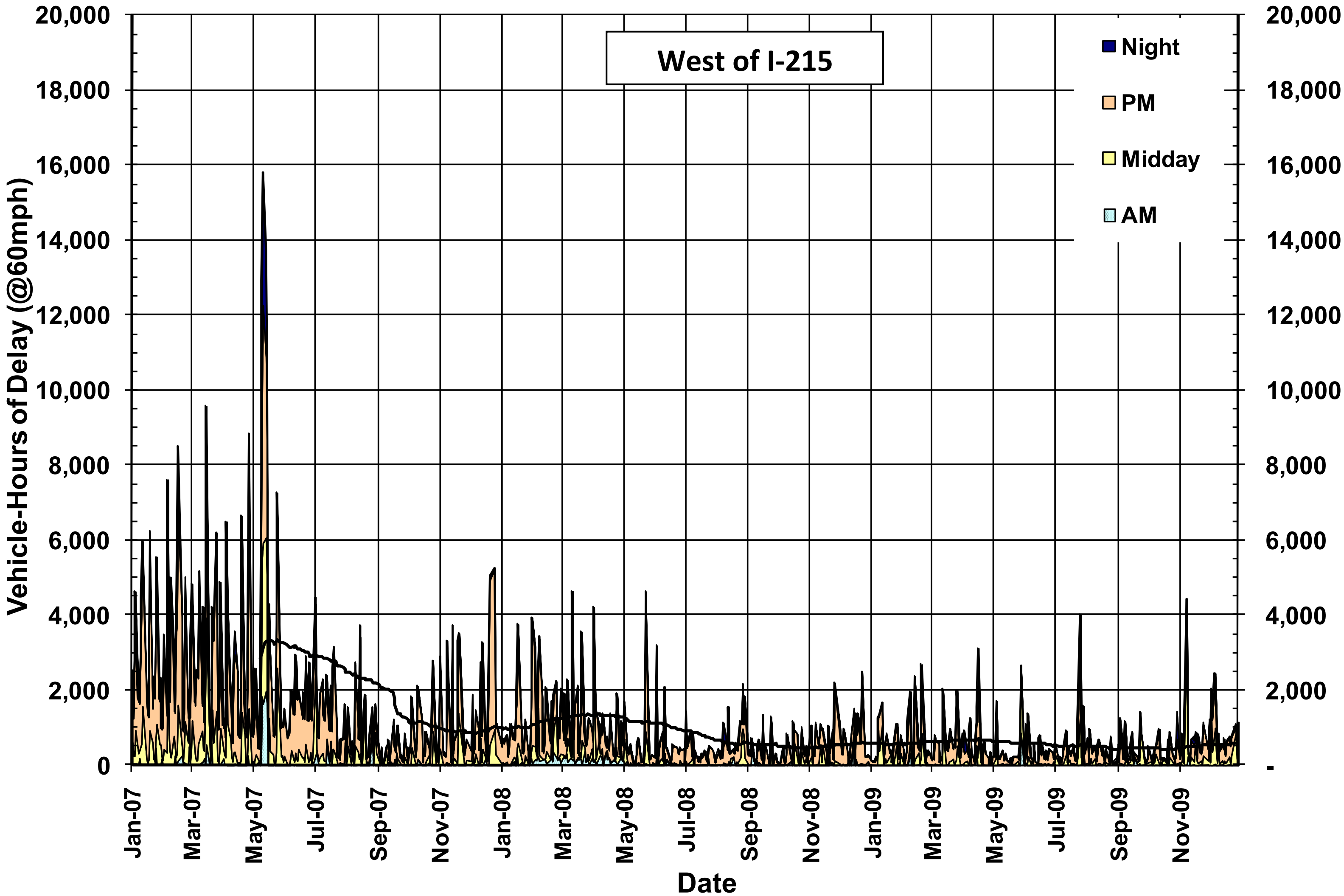
Unlike HICOMP where delay is only considered and captured for speeds below 35 miles per hour and applied to an assumed output or capacity volume of 2,000 vehicles per hour, delays presented in this section represent the difference in travel time between actual conditions and free-flow conditions at 60 miles per hour, applied to the actual output flow collected from a vehicle detector station. The total delay by time period for I-10 west of I-215 for each direction is shown in Exhibits 3B-5 to 3B-6.

Exhibits 3B-5 and 3B-6 show the 36-month trend in weekday (i.e., excluding weekends and holidays) delay for the I-10 corridor west of I-215 in the eastbound and westbound directions respectively. The exhibits also show a 90-day moving average that reduces the day-to-day variations and more easily illustrates the seasonal and annual changes in congestion over time.

As indicated in Exhibit 3B-5, the highest daily congestion occurred during the PM peak period in the eastbound direction. Total eastbound delay decreased significantly during the last half of 2007 through 2009 with a spike of delay experienced in May 2007.

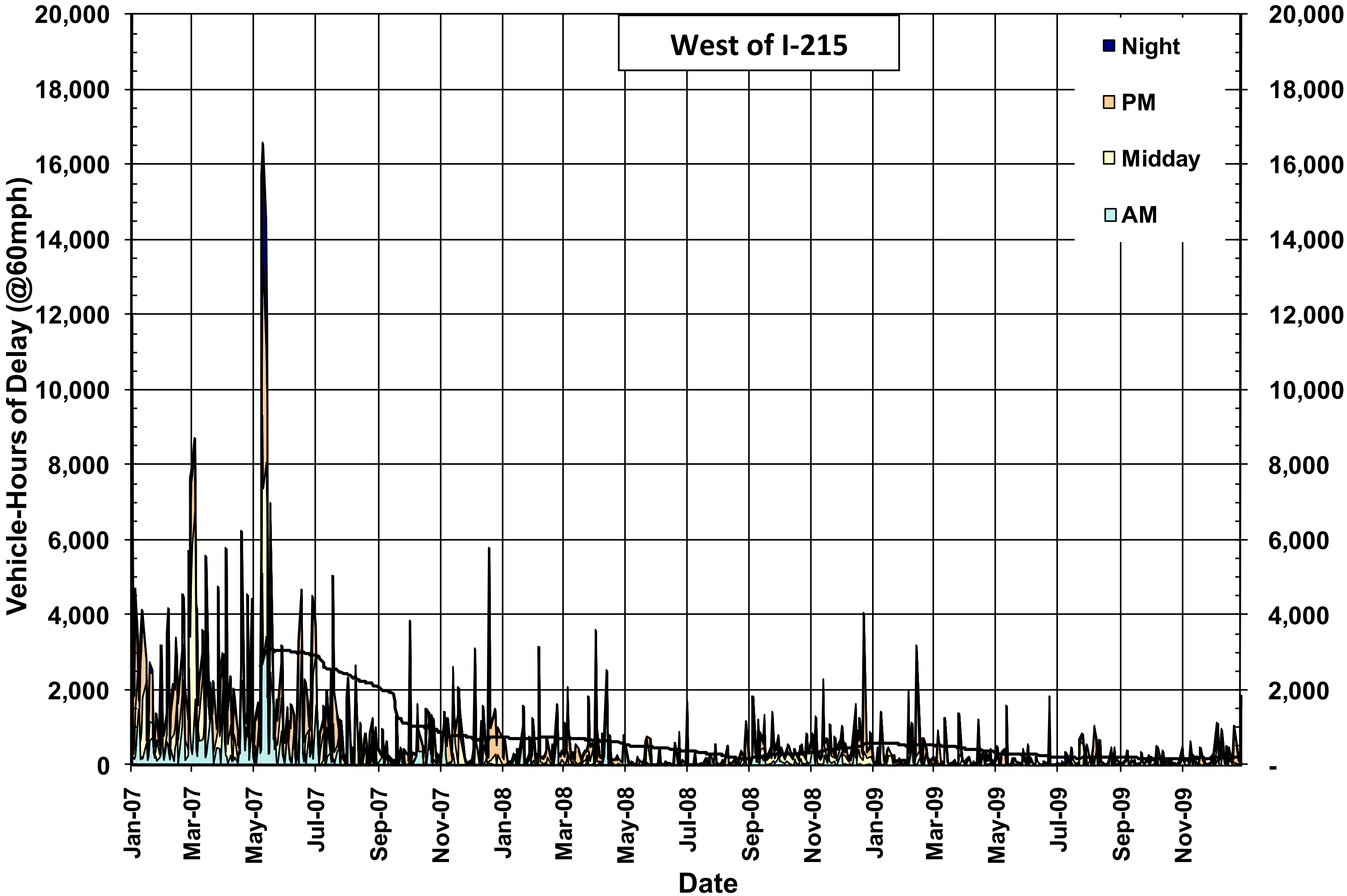
Similarly in the westbound direction, Exhibit 3B-6 shows that the highest daily congestion also occurred during the PM peak period with some delay in the AM peak period. The pattern of delay in the westbound direction is similar to the eastbound direction with delay having decreased during the last half of 2007 through 2009 with a spike in delay having occurred in May 2007. Over the entire study area, the decline in delay in both directions is likely attributed to the opening of the SR-210 extension in July 2007, which may have diverted vehicles from I-10.

Exhibit 3B-5: Eastbound I-10 Average Daily Delay by Time Period (2007-2009)



Source: Caltrans detector data

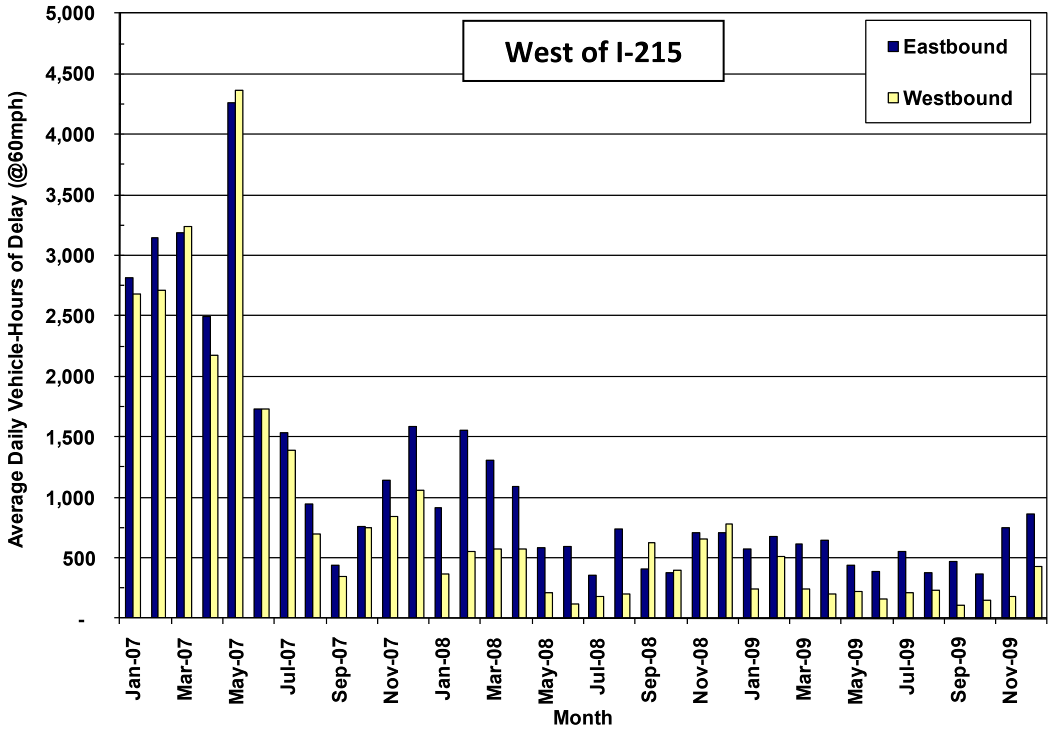
Exhibit 3B-6: Westbound I-10 Average Daily Delay by Time Period (2007-2009)



Source: Caltrans detector data

Exhibit 3B-7 shows the average daily weekday delay for the I-10 Corridor west of I-215 by month and direction. As indicated in this exhibit, the average weekday delay varies month to month. The total of the delay in both directions ranges from approximately 500 vehicle-hours in October 2009 to almost 9,000 vehicle-hours in May 2007. The eastbound corridor consistently experienced more congestion than the westbound corridor. Again, May 2007 experienced the highest levels of congestion during the three-year period with over 4,250 vehicle-hours of delay in each direction. As illustrated, average delay decreased annually from 2007 to 2009.

Exhibit 3B-7: I-10 Average Weekday Delay by Month (2007-2009)



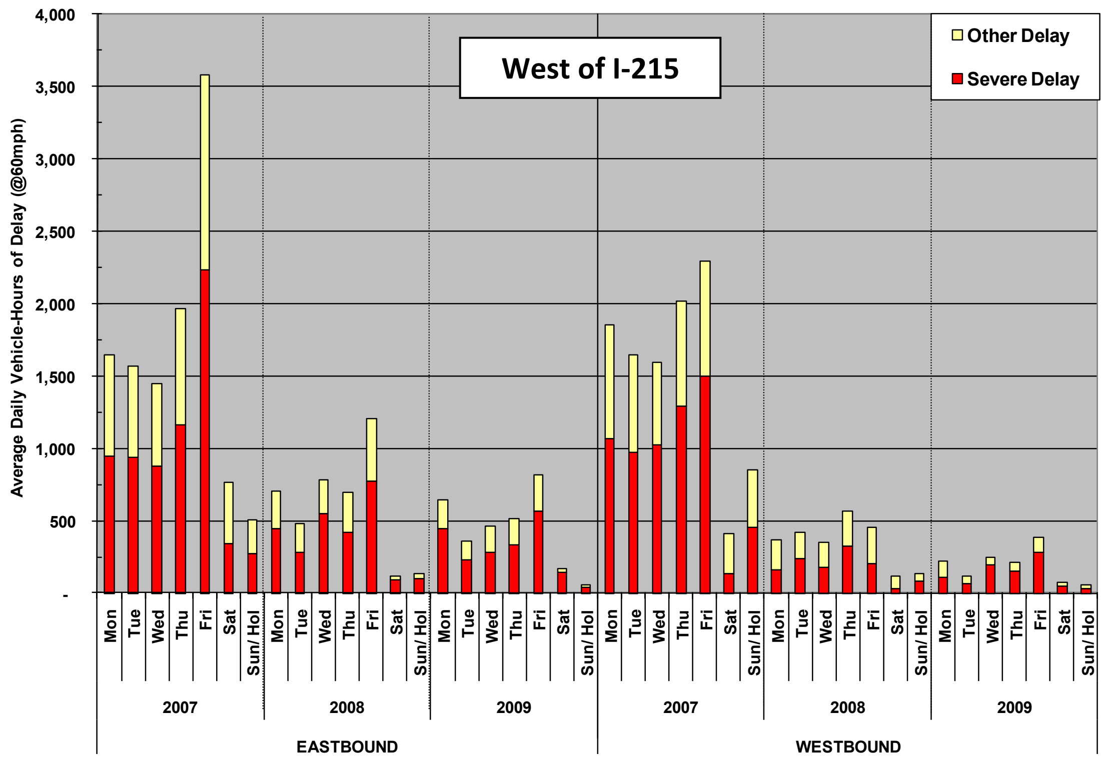
Source: Caltrans detector data

Delay presented to this point represents the difference in travel time between "actual" conditions and free-flow conditions at 60 miles per hour. This delay can be separated into two components as shown in Exhibit 3B-8:

- Severe delay – delay occurring when speeds are below 35 miles per hour
- Other delay – delay occurring when speeds are between 35 and 60 miles per hour.

Severe delay, as depicted in Exhibit 3B-8 represents breakdown conditions and is generally the focus of congestion mitigation strategies. "Other" delay represents conditions approaching breakdown conditions, vehicles leaving breakdown conditions, or areas that cause temporary slowdowns rather than widespread breakdowns. As depicted in Exhibit 3B-8, the eastbound direction on Fridays in 2007 experienced the highest "severe" delay at about 2,250. Similarly, in the westbound direction, Fridays in 2007 experienced the highest "severe" delay with 1,500 vehicle-hours. Overall, delay in both directions decreased annually from 2007 to 2009, most notably on Fridays.

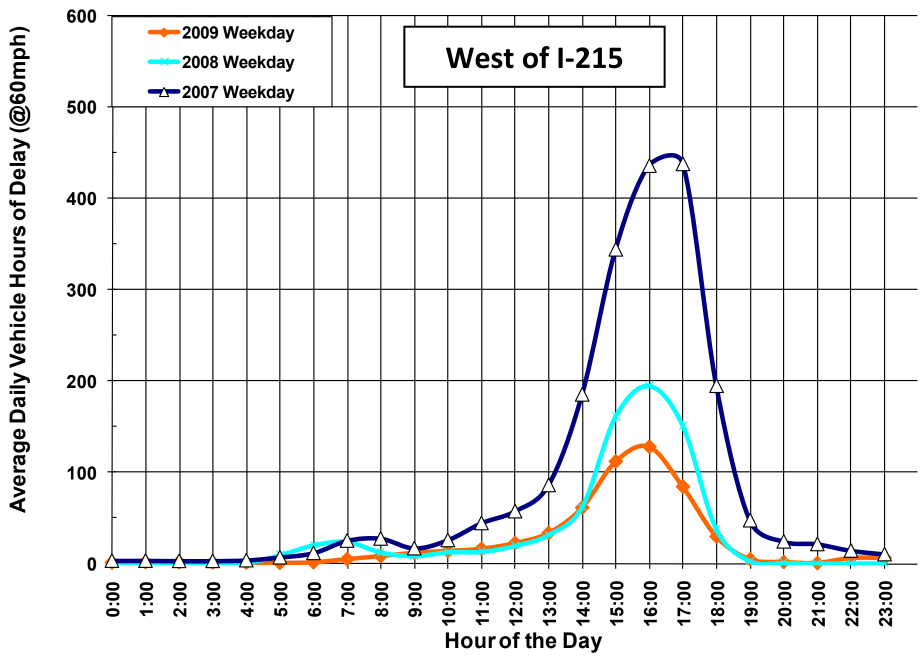
Exhibit 3B-8: I-10 Average Delay by Day of Week by Severity (2007-2009)



Source: Caltrans detector data

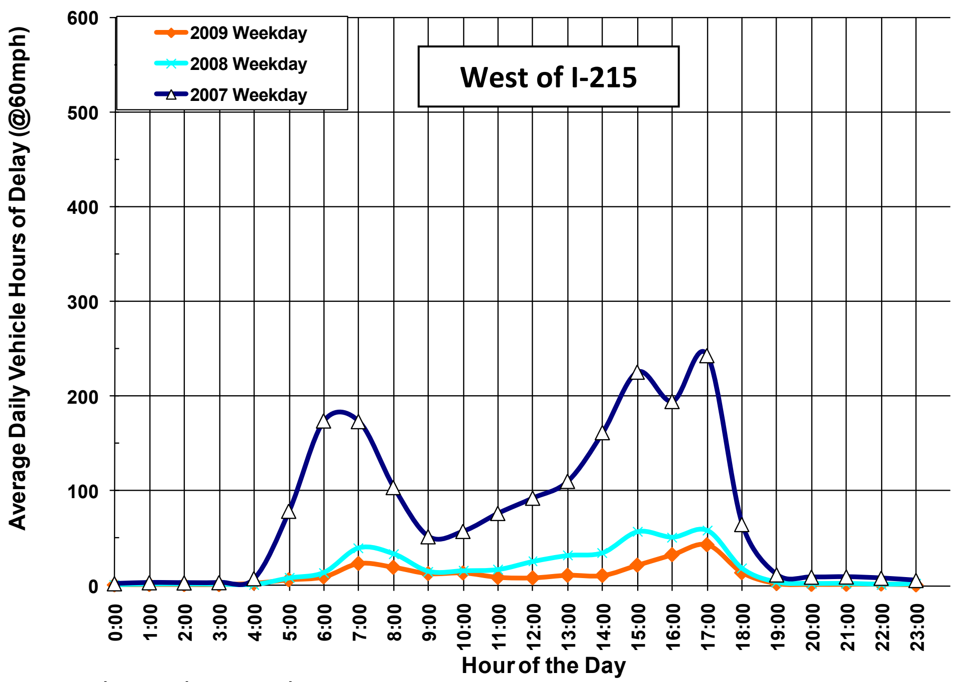
Another way to understand the characteristics of congestion and related delays is to examine average weekday delays by hour. Exhibits 3B-9 and 3B-10 summarize average weekday hourly delay for the three-year period from 2007 to 2009. Each point represents the total delay for the hour. For example, the 7:00 AM point is the sum of delay from 7:00 AM to 8:00 AM. The exhibits show the peaking characteristics of congestion and how the peak period changes over time. The exhibits highlight the highly directional aspects of travel on the I-10 Corridor, west of I-215. Exhibit 3B-9 shows that peak hourly delay in the eastbound direction (at 4:00 PM) was approximately 440 vehicle-hours in 2007 and decreased to 200 vehicle-hours in 2008, and again to 130 vehicle-hours in 2009. In the westbound direction, Exhibit 3B-10 reveals the peak hourly delay (at 5:00 PM) was approximately 250 vehicle-hours in 2007, which decreased to 60 vehicle-hours in 2008, and again to 50 vehicle-hours in 2009. As previously noted, the decline in delay in both directions is likely attributed to the decrease in demand from the opening of the SR-210 extension in July 2007 and the economic downturn.

Exhibit 3B-9: Eastbound I-10 Average Weekday Hourly Delay (2007-2009)



Source: Caltrans detector data

Exhibit 3B-10: Westbound I-10 Average Weekday Hourly Delay (2007-2009)



Source: Caltrans detector data

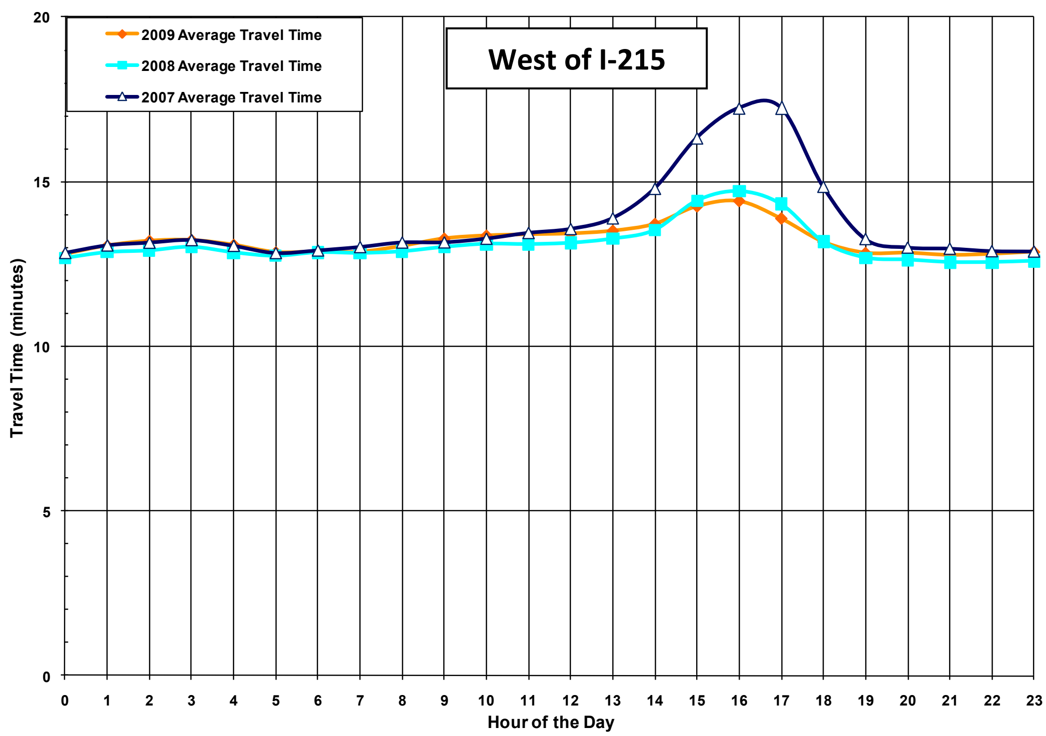
Travel Time

Travel time is reported as the time it takes for a vehicle to travel between two points on the corridor as estimated using automatic detector data. For the travel time analysis, PeMS data was analyzed for the 14-mile corridor from I-15 to I-215. The performance measure is reported in terms of time to travel from one end of the corridor to the other along the freeway. Travel time on parallel arterials is not included in the analysis.

Exhibits 3B-11 and 3B-12 depict the travel times calculated for the I-10 Corridor, west of I-215 from 2007 to 2009. Both Exhibits 3B-11 and 3B-12 show that travel times decreased from 2007 to 2009. Again, the decline in travel times is likely attributed to the decline in demand caused by the opening of the SR-210 extension in July 2007.

At the 4:00 PM peak hour, the eastbound direction experienced a travel time of about 17 minutes in 2007, which declined to 15 minutes in 2008 and 2009.

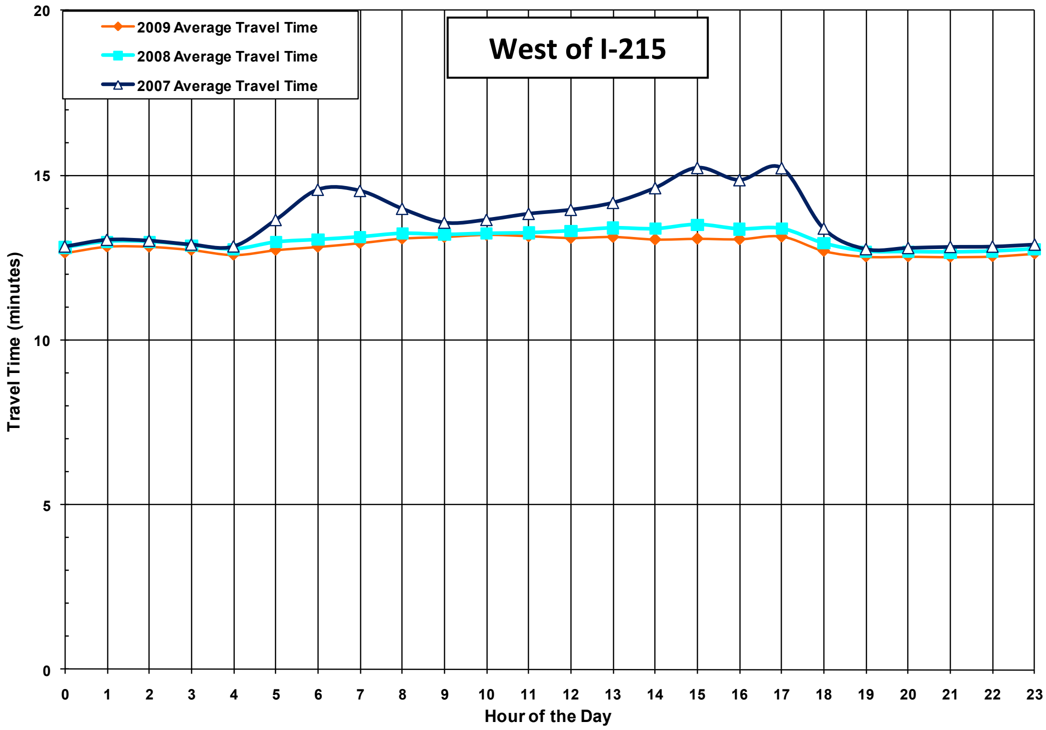
Exhibit 3B-11: Eastbound I-10 Travel Time by Time of Day (2007-2008)



Source: Caltrans detector data

Similarly, the westbound corridor had an average travel time of approximately 15 minutes during the PM peak hour (4:00-5:00 PM) in 2007, which declined to approximately 14 minutes in 2008 and 2009. Travel time variability throughout the three year- period is consistent with the delay trends observed for this corridor west of I-215. As delay improves, travel time also improves.

Exhibit 3B-12: Westbound I-10 Travel Time by Time of Day (2007-2008)



Source: Caltrans detector data

Reliability

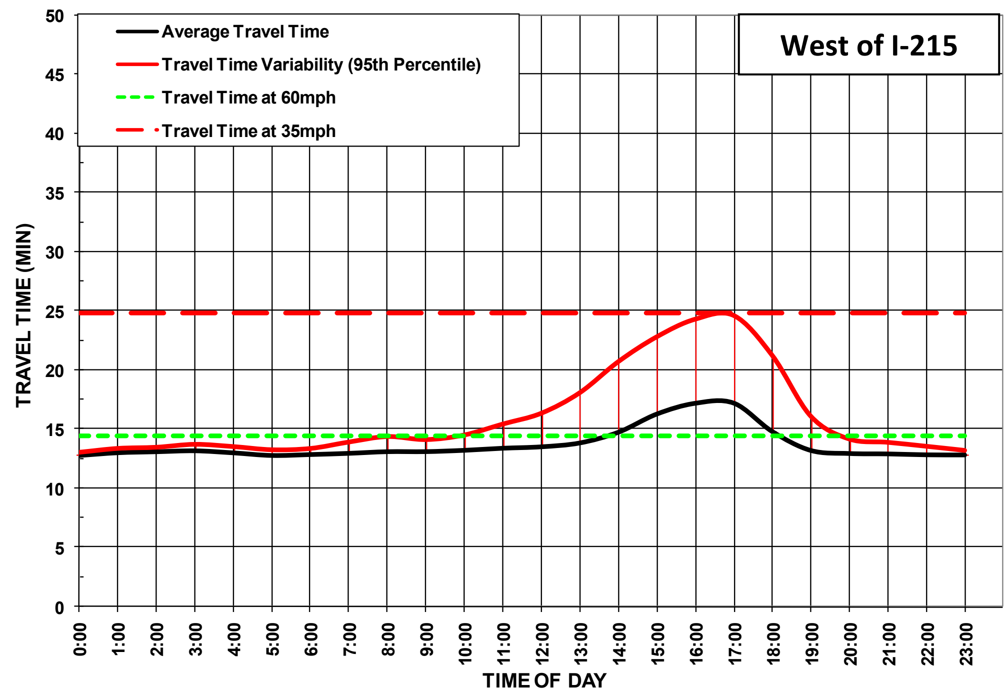
Reliability captures the degree of predictability in the public's travel time. Unlike mobility, which measures the rate of travel, the reliability measure focuses on how travel time varies from day to day. To measure reliability, statistical measures of variability on the travel times estimated from automatic detector data were used. The 95^{th} percentile was chosen to represent the maximum time it would take most people to travel the corridor. Severe events, such as fatal collisions, could cause longer travel times, but the 95^{th} percentile was chosen as a balance between extreme events and a "typical" day.

Exhibits 3B-13 to 3B-16 on the following pages illustrate the variability of travel time along the I-10 Corridor (west of I-215) on weekdays for 2007 through 2009. Exhibits 3B-13 through 3B-15 show travel time variability for the eastbound direction for the years 2007 through 2009. Similarly, Exhibits 3-16 through 3-18 show the travel time variability for the westbound direction for 2007 through 2009.

For the eastbound direction, the 4:00 PM peak hour was the most unreliable hour in addition to being the slowest. In 2007 (shown in Exhibit 3B-13), motorists driving the entire length of the corridor had to add 8 minutes to an average travel time of 17 minutes (for a total travel time of 25 minutes) to ensure that they arrived on time 95 percent of the time. This is 10 minutes longer than the 15-minute travel time at 60 mph. In 2008 (Exhibit 3B-14), a driver needs to add 4 minutes to an average travel time of 14 minutes (for a total travel time of 18 minutes) to arrive on time 95 percent of the time. In 2009 (Exhibit 3B-15), a driver only needs to add 2 minutes to an average travel time of 14 minutes to arrive on time. Travel time variability decreased by 4 minutes from 2007 to 2008, and by 2 minutes from 2008 to 2009 in the eastbound direction.

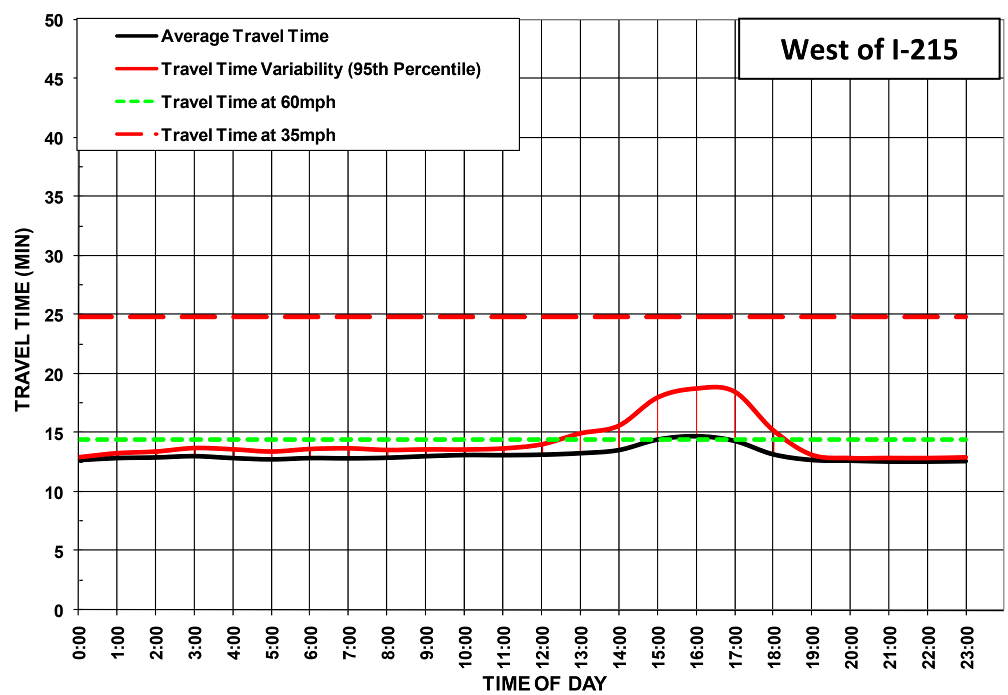
Unlike the eastbound direction, the westbound direction does not have as distinct of a peak hour. During the 7:00 AM and 5:00 PM peak hours (Exhibit 3B-16 through 3B-18), a driver needs to add 6 minutes to an average travel time of 15 minutes to ensure an on-time arrival 95 percent of the time in 2007. This corresponds to a total travel time of 21 minutes. In 2008 and 2009, a driver needs to add about 2 minutes to an average travel time of 13 minutes to ensure an on-time arrival 95 percent of the time (for a total travel time of 15 minutes).

Exhibit 3B-13: Eastbound I-10 Travel Time Variation (2007)



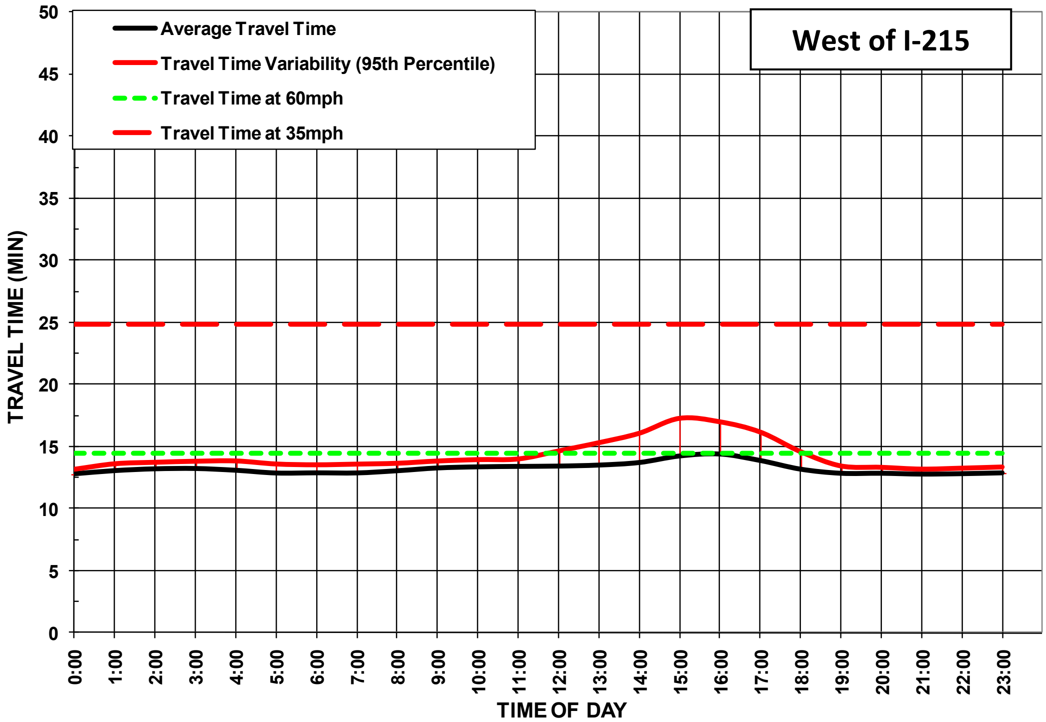
Source: Caltrans detector data

Exhibit 3B-14: Eastbound I-10 Travel Time Variation (2008)



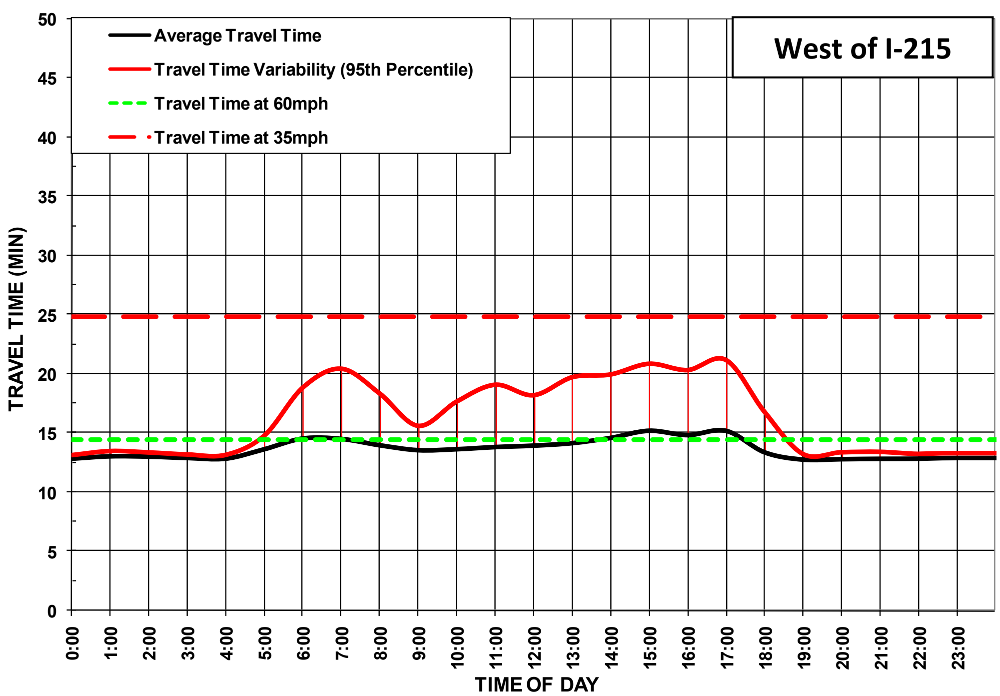
Source: Caltrans detector data

Exhibit 3B-15: Eastbound I-10 Travel Time Variation (2009)



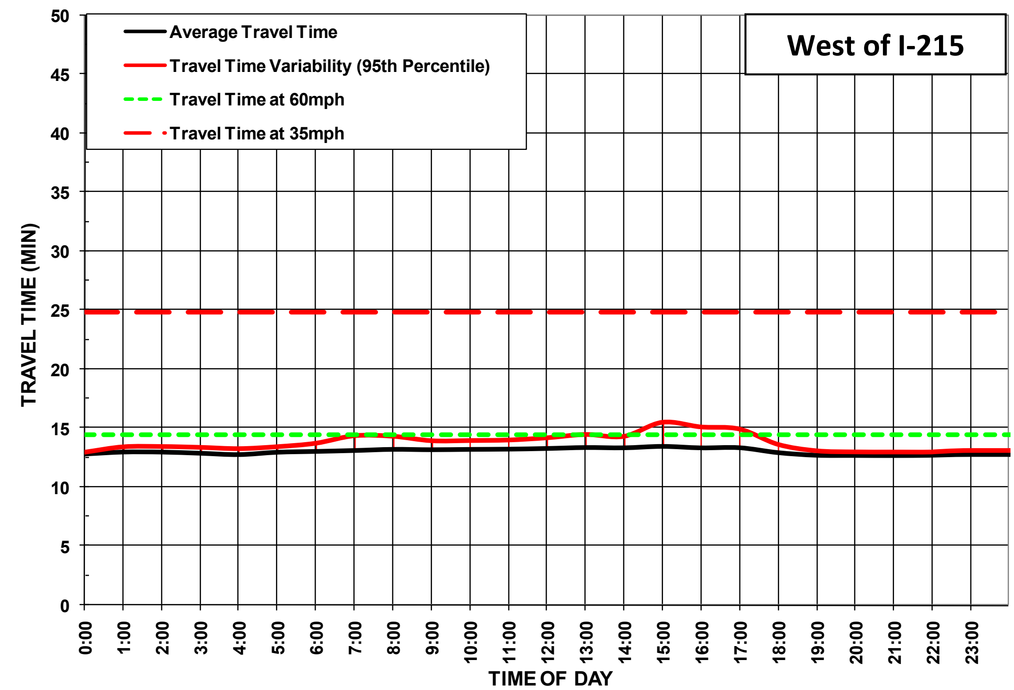
Source: Caltrans detector data

Exhibit 3B-16: Westbound I-10 Travel Time Variation (2007)



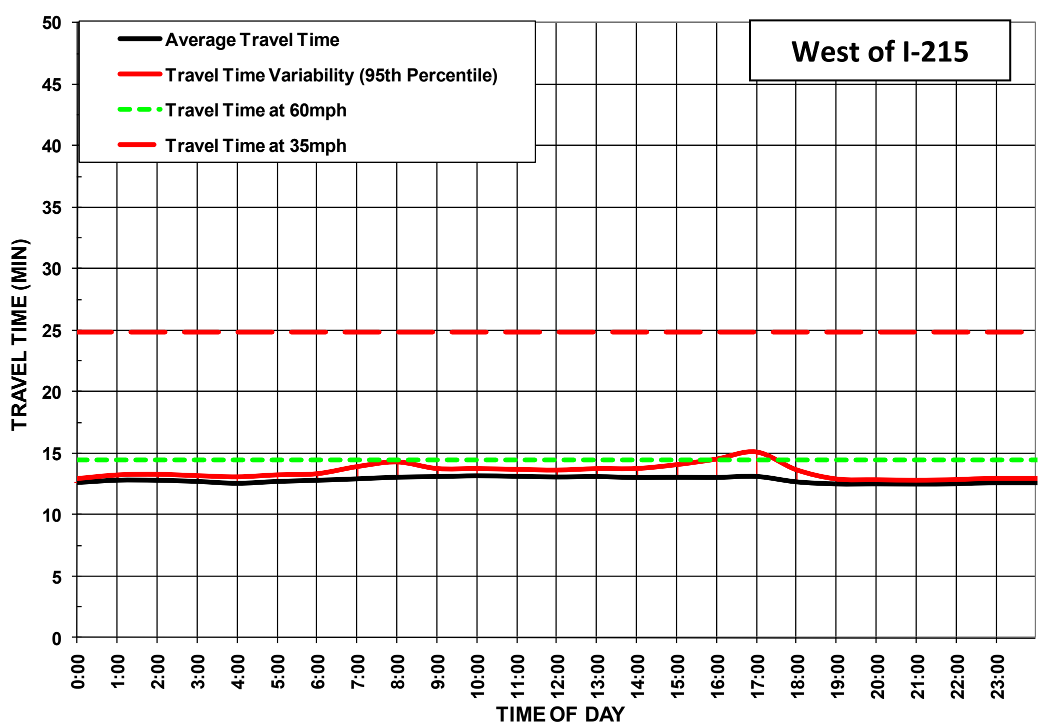
Source: Caltrans detector data

Exhibit 3B-17: Westbound I-10 Travel Time Variation (2008)



Source: Caltrans detector data

Exhibit 3B-18: Westbound I-10 Travel Time Variation (2009)



Source: Caltrans detector data

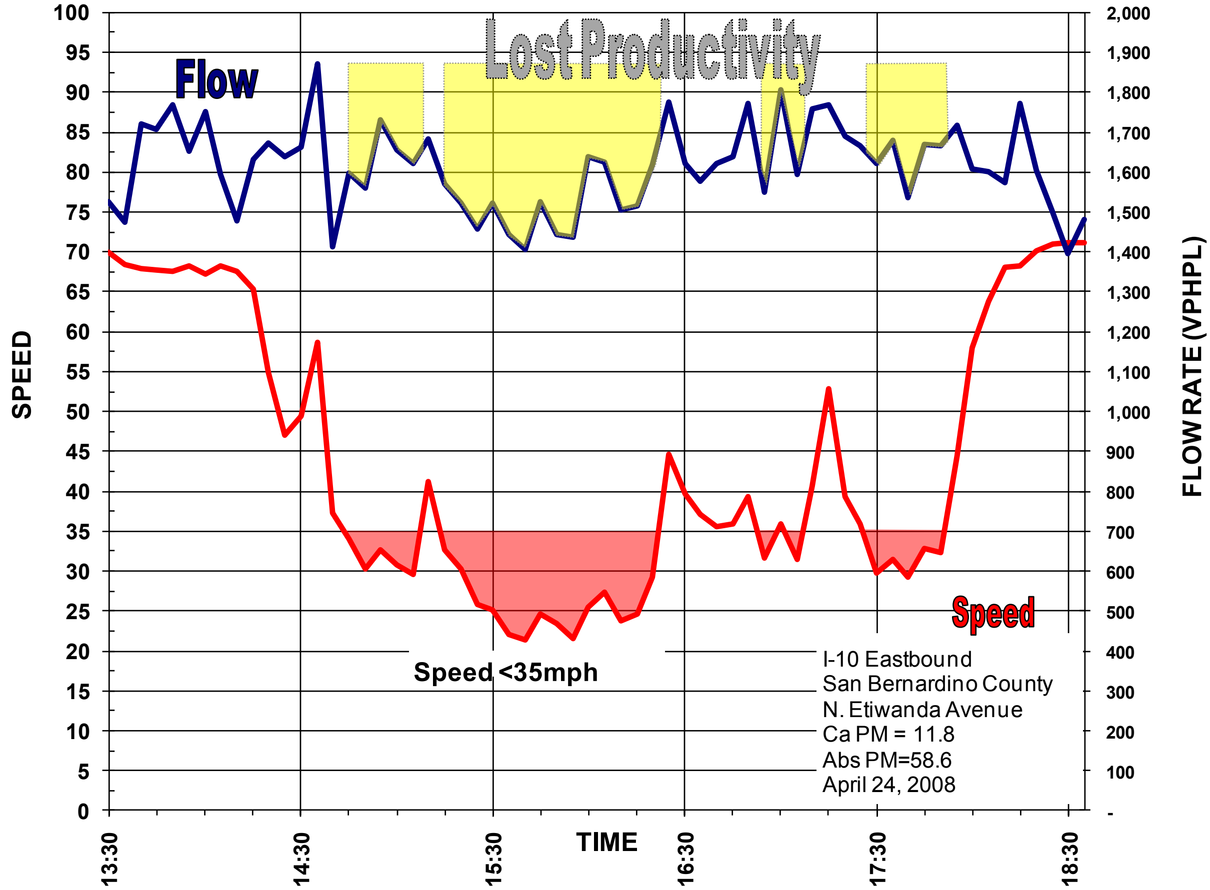
Productivity

Productivity is a measure of system efficiency that captures the capacity of the corridor and is defined as the ratio of output (or service) per unit of input. In the case of transportation, productivity is the number of people served divided by the level of service provided. For highways, it is the number of vehicles compared to the capacity of the roadways.

For the corridor analysis, productivity is defined as the percent utilization of the facility or mode under peak conditions. The highway productivity performance measure is calculated as actual volume divided by the capacity of the highway. Travel demand models generally do not project capacity loss for highways, but detailed micro-simulation tools can forecast productivity. For highways, productivity is particularly important because the lowest "production" from the transportation system occurs often when capacity is needed the most.

Exhibit 3B-19 provides an example of this loss in productivity for the I-10 corridor. As traffic flow increases to the capacity limits of a roadway, speeds decline rapidly and throughput drops dramatically. This loss in throughput is the lost productivity of the system. There are a few ways to estimate productivity losses. Regardless of the approach, productivity calculations require good detection or significant field data collection at congested locations. One approach is to convert this lost productivity into "equivalent lost lane-miles." These lost lane-miles represent a theoretical level of capacity that would need to be added in order to achieve maximum productivity. For example, losing six lane-miles implies that congestion has caused a loss in capacity roughly equivalent to one lane along a six-mile section of freeway.

Exhibit 3B-19: Lost Productivity Illustrated



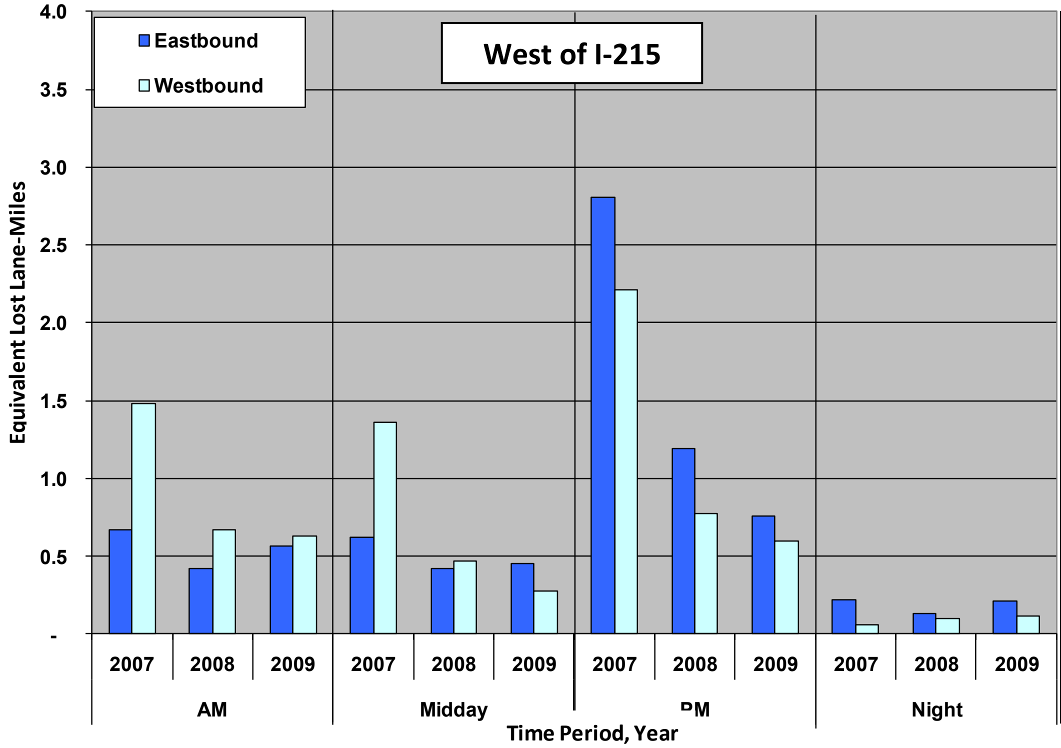
Equivalent lost lane-miles is computed as follows (for congested locations only):

$$LostLaneMiles = \left(1 - \frac{ObservedLaneThroughput}{2000vphpl}\right) \times Lanes \times CongestedDistance$$

Exhibit 3-20 summarizes the productivity losses on the I-10 Corridor (west of I-215) for the three years analyzed for the respective directions of travel. The trends in the productivity losses are comparable to the delay trends. The largest productivity losses (measured in equivalent lost-lane miles) occurred during the PM peak period in the eastbound direction, which is the time period and direction that experienced the most congestion. Productivity during the AM and PM peak periods in both directions improved annually from 2007 to 2009.

Strategies to combat such productivity losses are primarily related to operations. These strategies include: building new or extending auxiliary lanes, developing more aggressive ramp metering strategies without negatively influencing the arterial network, and improving incident clearance times.

Exhibit 3B-20: I-10 Average Lost Lane-Miles by Direction, Time Period, and Year



Source: Caltrans detector data

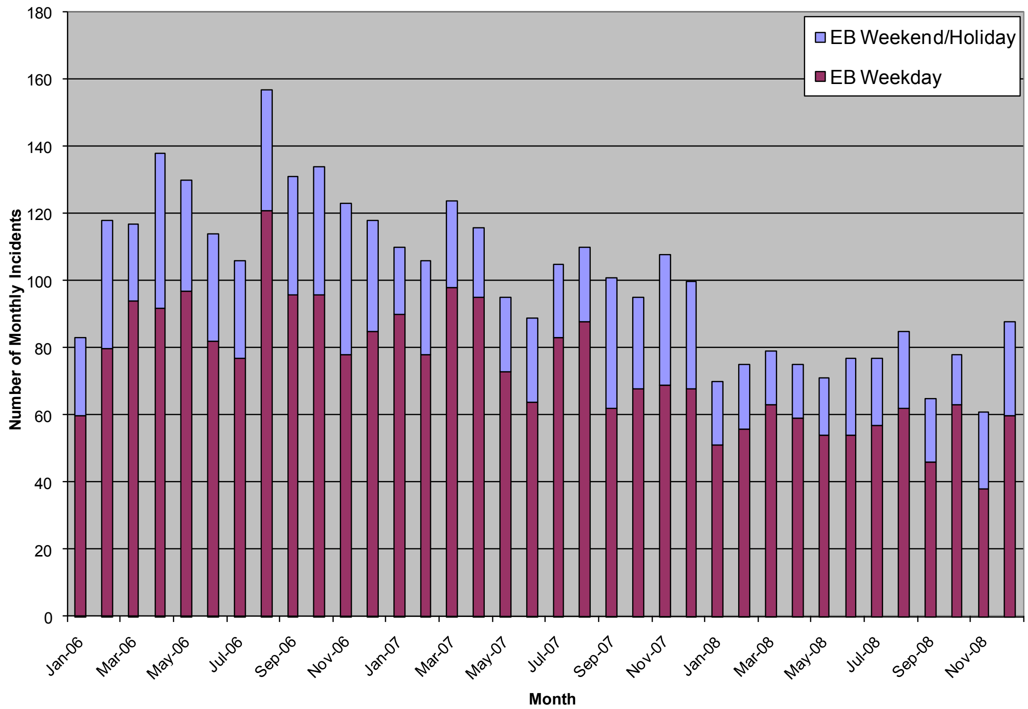
Safety

The adopted performance measures to assess safety are: the number of accidents and accident rates computed from the Caltrans Traffic Accident Surveillance and Analysis System (TASAS). TASAS is a traffic records system containing an accident database linked to a highway database. The highway database contains description elements of highway segments, intersections and ramps, access control, traffic volumes and other data. TASAS contains specific data for accidents on State Highways. Accidents on non-State Highways are not included (e.g., local streets and roads).

The safety assessment in this report is intended to characterize the overall accident history and trends in the corridor, and to highlight notable accident concentration locations or patterns that are readily apparent. This report is not intended to supplant more detailed safety investigations routinely performed by Caltrans staff.

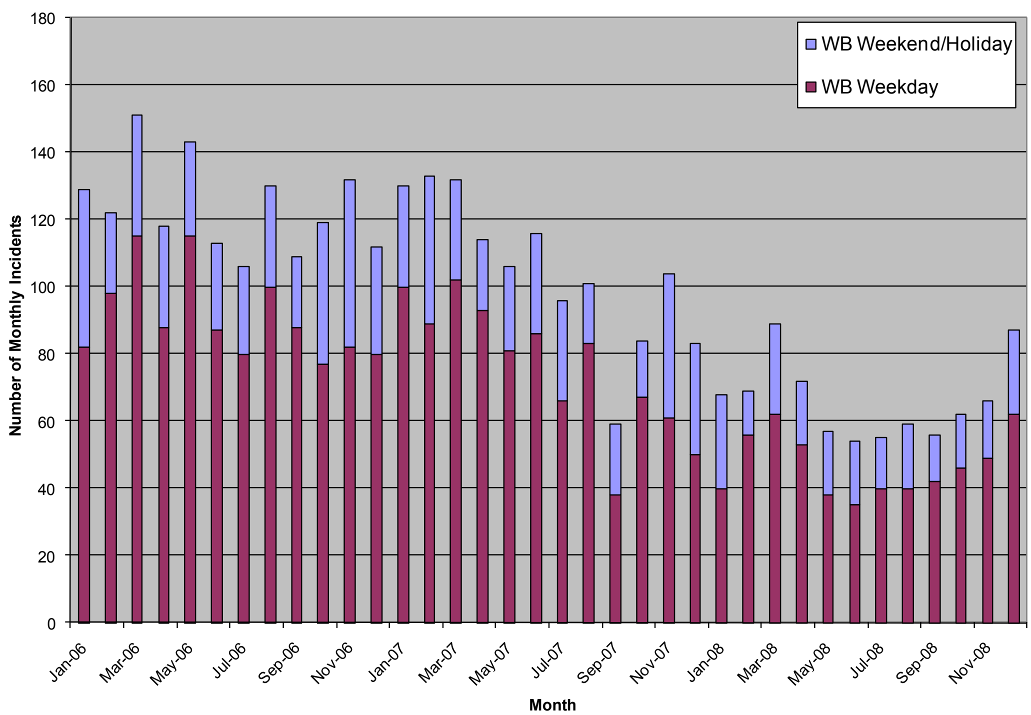
Exhibits 3B-21 and 3B-22 show accidents on the I-10 Corridor (from I-15 to SR-60) by direction and by month, respectively. The monthly accidents are broken down by weekdays and weekends. Caltrans typically analyzes the latest three-year safety data. The latest available data for the three-year period from January 1, 2006 through December 31, 2008 were analyzed. Note that these are comprehensive and do not rely on automatic detection systems. As indicated, both the eastbound and westbound corridor experienced similar numbers of annual accidents. In 2006, both directions experienced about 1,450 accidents, which decreased to about 1,250 in 2007. In 2008, the eastbound direction experienced slightly more accidents at about 900, compared to the westbound direction at about 800.

Exhibit 3B-21: Eastbound I-10 Monthly Accidents (2006-2008)



Source: TASAS

Exhibit 3B-22: Westbound I-10 Monthly Accidents (2006-2008)



Source: TASAS

C. Bottlenecks and Causality

Bottlenecks, or locations of significant mobility constraints, were preliminarily identified as “potential” bottlenecks based on readily available, existing data sources, including the 2008 State Highway Congestion Monitoring Program (HICOMP) Annual Report, Caltrans District 8 2008 probe vehicle runs, and Caltrans vehicle detector station data. Actual bottlenecks were verified from extensive field observations. These efforts resulted in confirming consistent sets of bottlenecks for both freeway directions. This section summarizes the findings of that analysis.

Exhibits 3C-1 and 3C-2 summarize the bottleneck locations identified in this analysis by direction. The exhibits also show “bottleneck areas”, which are defined for reporting performance in this report and used to evaluate the effectiveness of project scenarios during the modeling and benefit-cost analysis (BCA). They represent the area from one bottleneck to the one upstream. Exhibits 3C-1 and 3C-2 include an extra row at the end to cover the remainder of the corridor after the last bottleneck. The actual queues formed at the bottlenecks may have a different length than the bottleneck area. This concept is described in detail later in the report and illustrated in Exhibit 3C-15.

Exhibits 3C-3 and 3C-4 are maps that identify the bottleneck locations by AM and PM peak periods.

Exhibit 3C-1: Eastbound I-10 Identified Bottleneck Areas

Bottleneck Location	Bottleneck Area	Active Period		From			To		
		AM	PM	Abs	CA	County	Abs	CA	County
I-15[1]	I-15 Connectors[1]		✓	56.3	9.5	SBD	56.5	9.7	SBD
Etiwanda On	I-15 to Etiwanda On		✓	56.5	9.7	SBD	58.5	11.7	SBD
Cherry On	Etiwanda On to Cherry On		✓	58.5	11.7	SBD	60.1	13.3	SBD
I-215	Cherry On to I-215		✓	60.1	13.3	SBD	70.6	R23.8	SBD
Waterman On	I-215 to Waterman On		✓	70.6	R23.8	SBD	72.3	25.5	SBD
Tippecanoe On	Waterman On to Tippecanoe On		✓	72.3	25.5	SBD	72.8	26	SBD
Mountain View On	Tippecanoe On to Mountain View On		✓	72.8	26	SBD	74.3	27.5	SBD
California On	Mountain View On to California On		✓	74.3	27.5	SBD	75.3	28.5	SBD
County Line Off	California On to County Line Off		✓	75.3	28.5	SBD	85.8	R39.0	SBD
Not a bottleneck location	County Line Off to SR-60	N/A		85.8	R39.0	SBD	92.7	6.8	RIV

[1] segment is not included in the bottleneck area analysis due to the short distance in length

Exhibit 3C-2: Westbound I-10 Identified Bottleneck Areas

Bottleneck Location	Bottleneck Area	Active Period		From			To		
		AM	PM	Abs	CA	County	Abs	CA	County
Yucaipa On	SR-60 to Yucaipa On	✓		92.7	6.8	RIV	82.1	35.4	SBD
California On	Yucaipa On to California On	✓		82.1	35.4	SBD	74.7	28.0	SBD
Not a bottleneck location	California On to I-15	N/A		74.7	28.0	SBD	56.3	9.5	SBD

Exhibit 3C-3: I-10 AM Bottleneck Locations

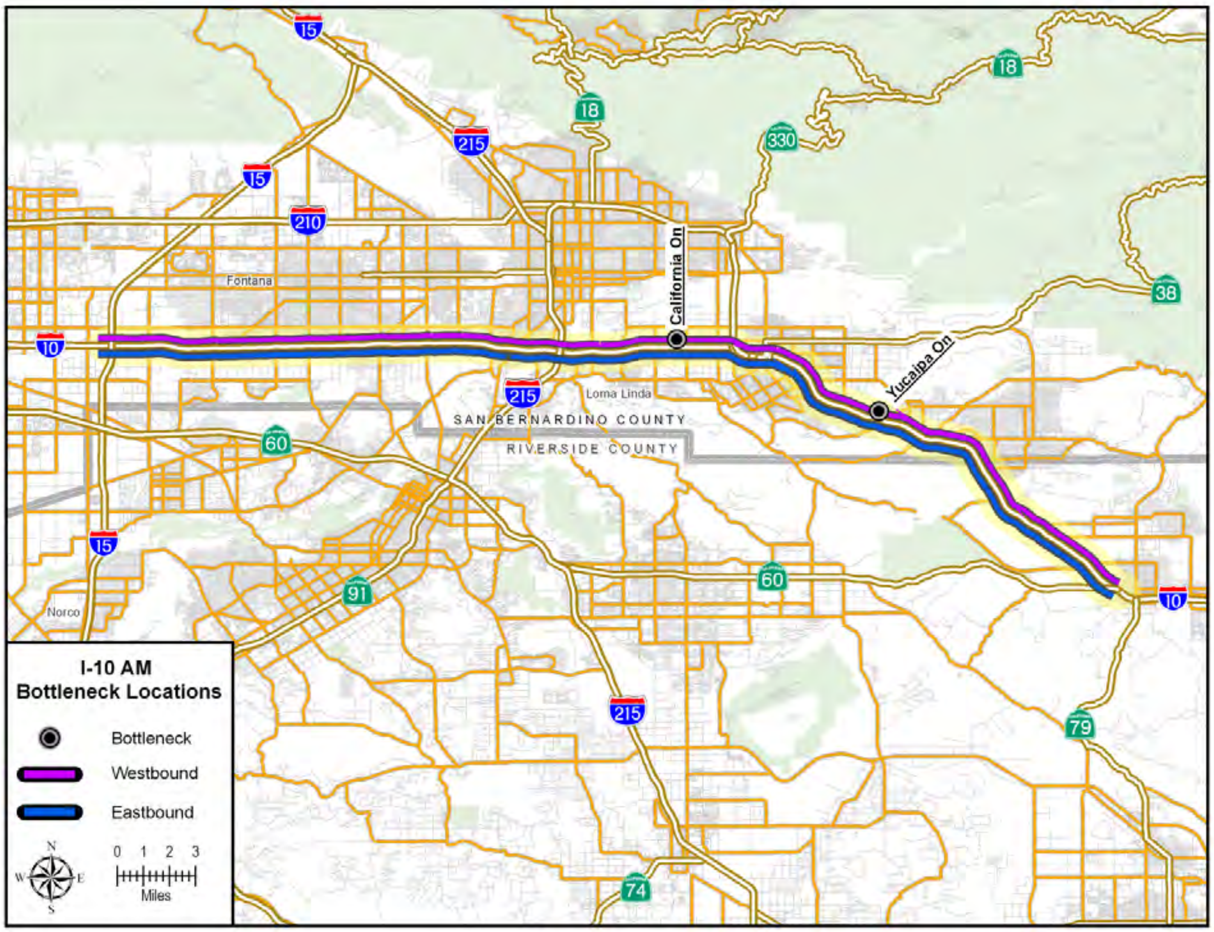
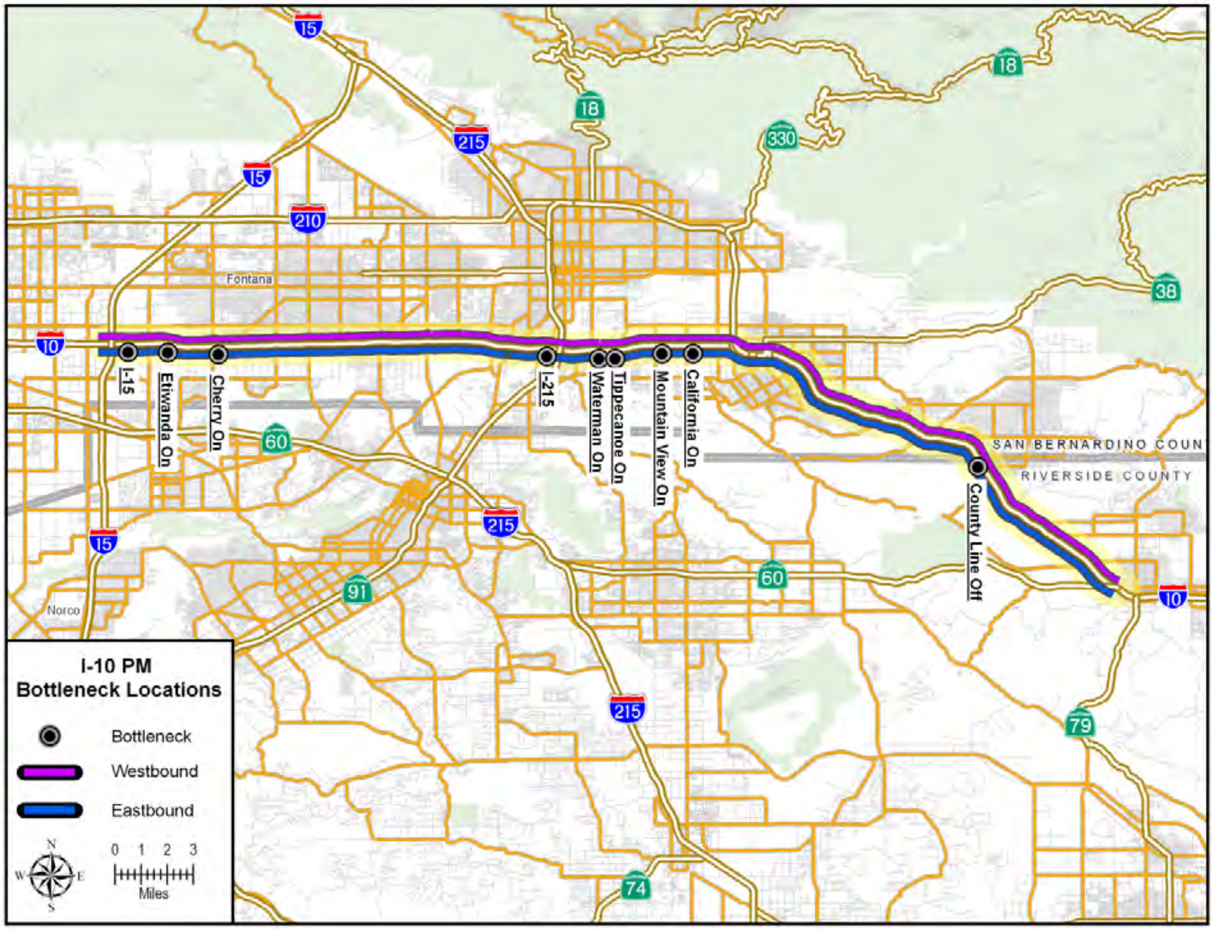


Exhibit 3C-4: I-10 PM Bottleneck Locations



Eastbound Bottlenecks

Starting from I-15 and moving eastbound, the following bottlenecks were identified during the PM peak period only:

- I-15
- Etiwanda On-ramp
- Cherry On-ramp
- I-215
- Waterman On-ramp
- Tippecanoe On-ramp
- Mountain View On-ramp
- California On-ramp
- County Line Off-ramp

Westbound Bottlenecks

Starting from SR-60 and moving westbound, the following bottlenecks were identified from data based on Caltrans detector data and probe vehicle runs:

- Yucaipa On-ramp
- California On-ramp

Bottleneck Identification

As stated earlier, bottlenecks were initially identified (as “potential” bottlenecks) based on a variety of data sources. Data from the following sources were reviewed to identify potential bottlenecks:

- State Highway Congestion Monitoring Program (HICOMP) report
- Vehicle detector data
- Aerial photos.

HICOMP and vehicle detector data were used to identify congestion issues. Aerial photos were used to visually confirm the geometrics that may contribute to a bottleneck condition.

HICOMP

The State Highway Congestion Monitoring Program (HICOMP) Annual Report was the first tool used to initially identify mobility constrained areas. Published annually since 1987, HICOMP attempts to measure “typical” peak period, weekday, and recurring traffic congestion on urban area freeways. HICOMP does not include congestion on other state highways or local surface streets. Non-recurrent congestion such as holiday, maintenance, construction or special-event generated traffic congestion is also not included. HICOMP data is useful for finding general trends and making regional comparisons of freeway performance, but some estimates presented in the report are based on a limited number of observations.

An initial identification of bottleneck locations was performed by reviewing the 2008 Caltrans HICOMP report, which was the most recent data available at the time of the data analysis. Congested queues form upstream from bottlenecks, which are located “at the front” of the congested segment. Exhibits 3C-5 and 3C-6 show the HICOMP congestion maps with circles overlaid to indicate potential bottleneck locations, or locations with mobility constraints. Bottleneck areas are identified with blue circles in the eastbound direction and red circles in the westbound direction.

For the AM peak period in 2008 (Exhibit 3C-5), three potential bottlenecks were reported for the westbound direction (at I-15, Mountain View Avenue, and Wabash Avenue). There were no potential bottlenecks reported for the eastbound direction.

Exhibit 3C-6 shows PM peak period bottlenecks using data from the 2008 HICOMP report. The PM peak period tends to be more congested than the AM peak period, which is shown in both HICOMP and sensor data.

Exhibit 3C-5: 2008 HICOMP AM Congestion Map with Potential Bottlenecks

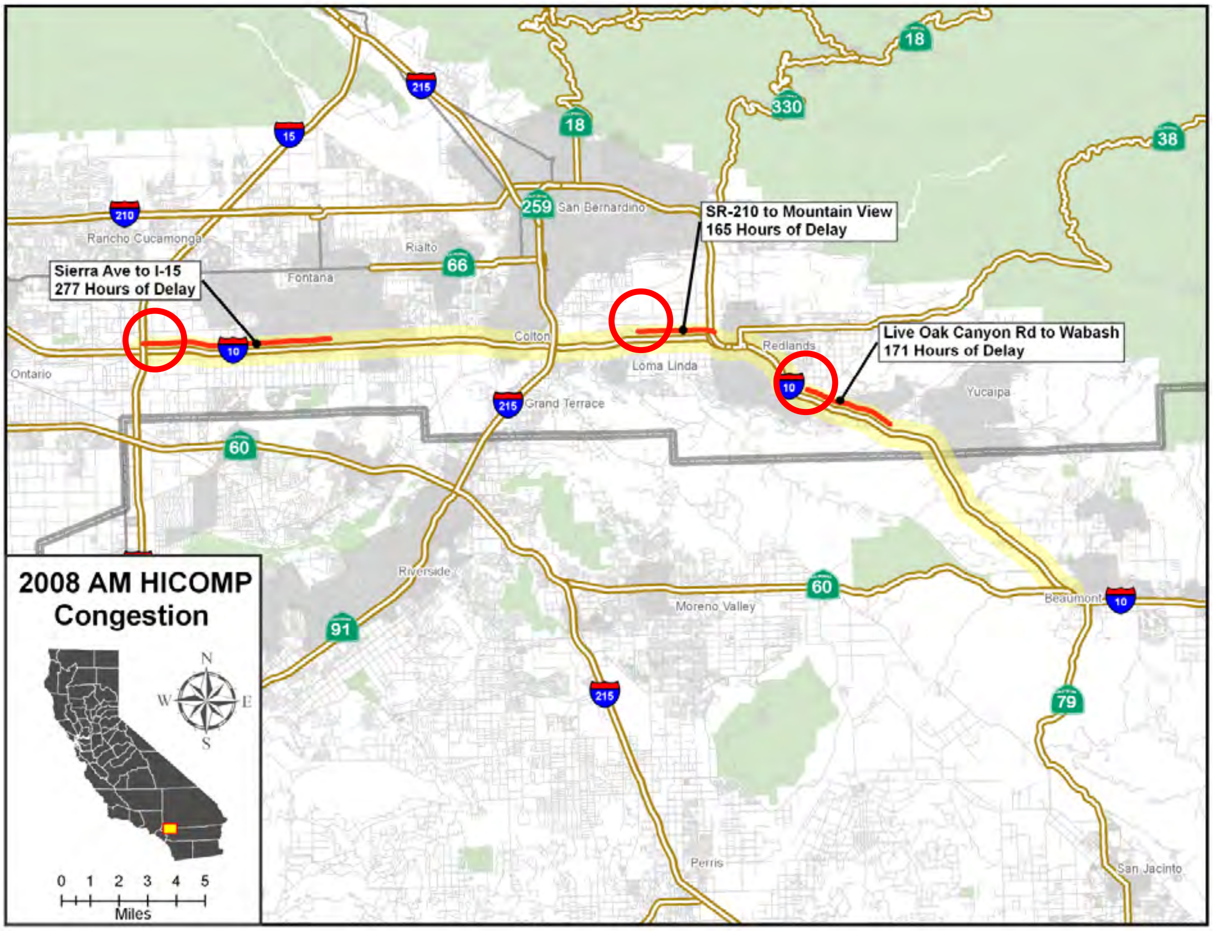
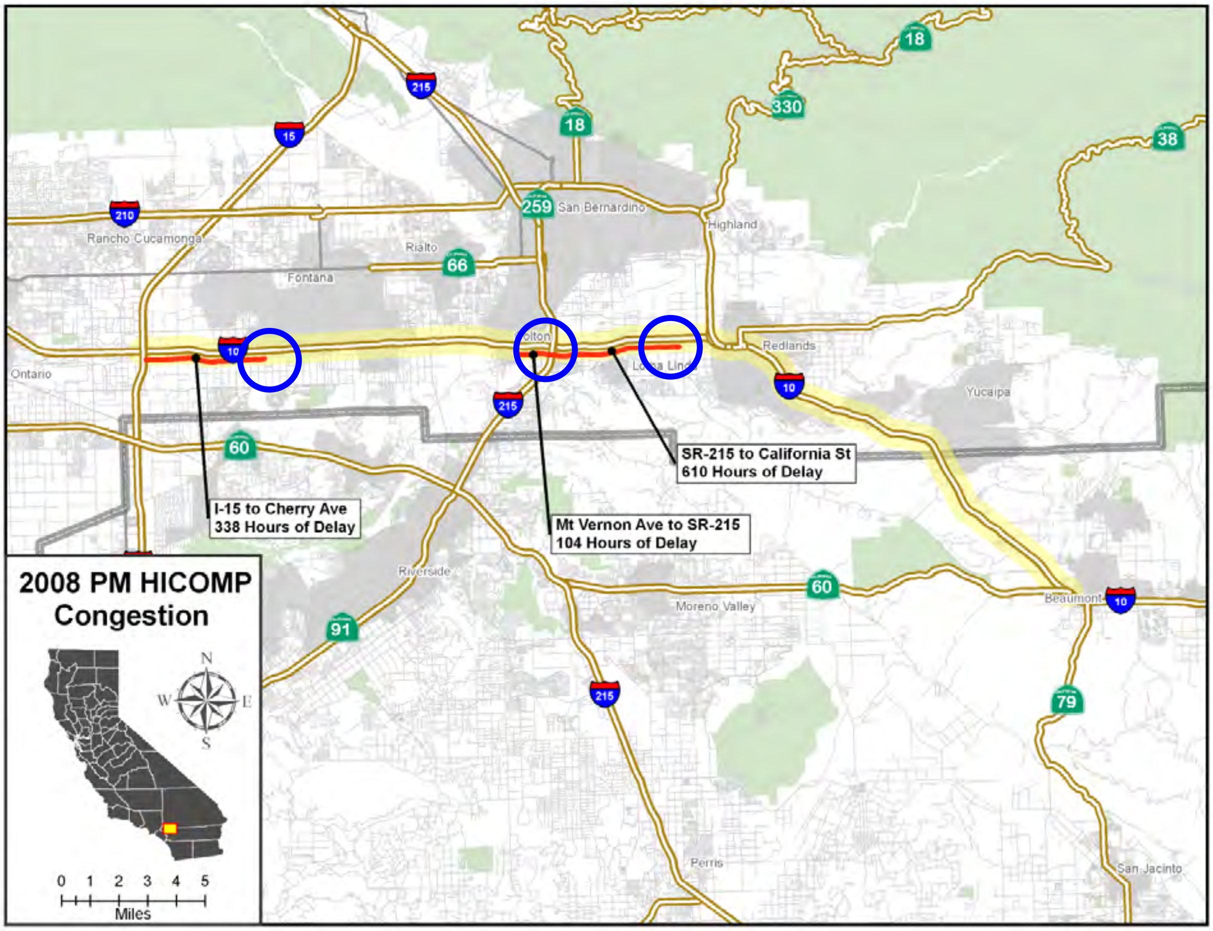


Exhibit 3C-6: 2008 HICOMP PM Congestion Map with Potential Bottlenecks

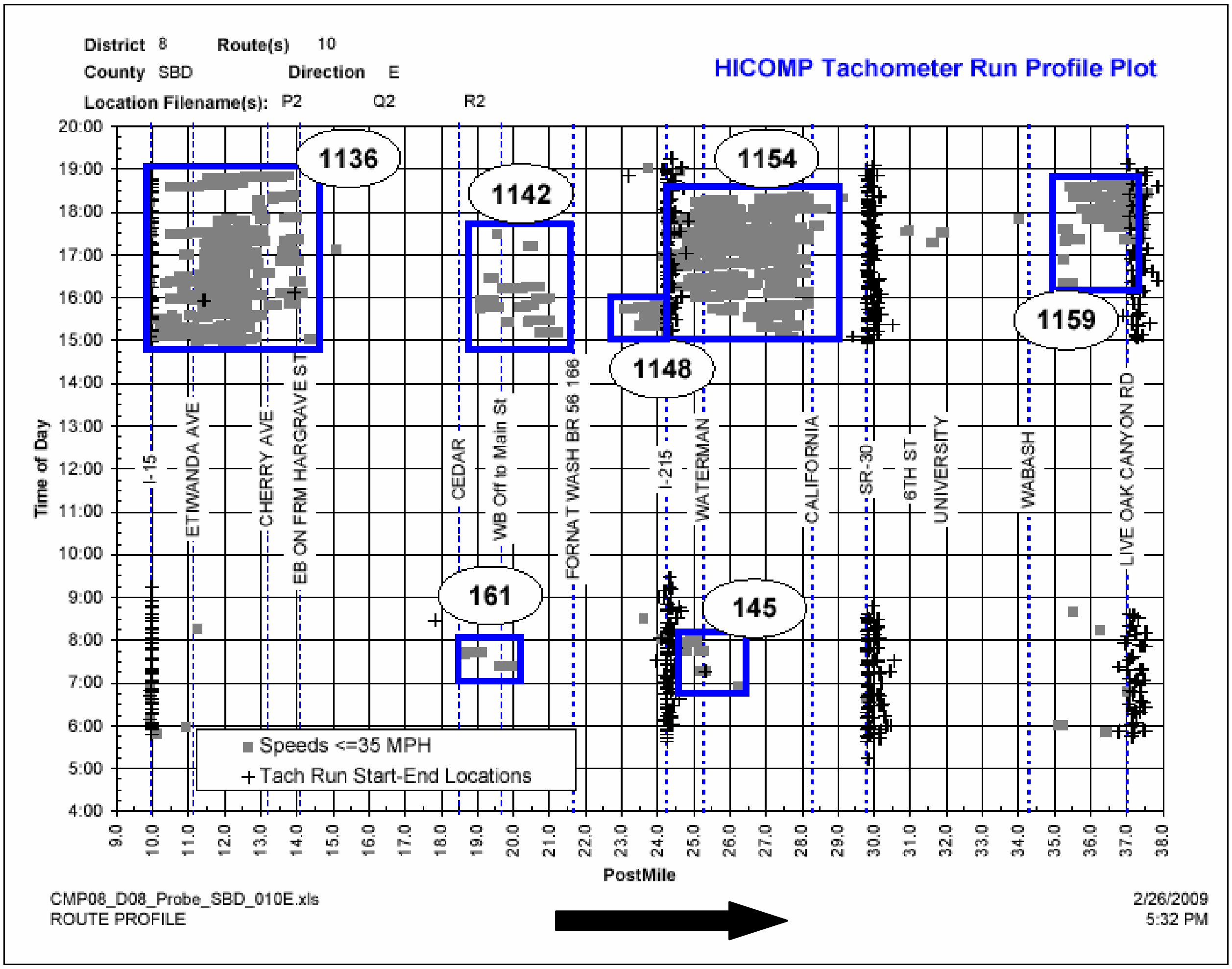


Probe Vehicle Runs

Probe vehicle data collected by Caltrans District 8 in 2008 was also used to conduct additional analyses to confirm the potential bottlenecks identified in the HICOMP data. Probe vehicle runs provide speed plots across the corridor for various departure times. Caltrans collects the data by driving a vehicle equipped with various electronic devices (e.g., tachograph and global positioning system) along the corridor at various departure times (usually at 10 to 20 minute intervals). The vehicles are driven in a middle lane to capture "typical" conditions during the peak periods. Actual speeds are recorded as the vehicle travels the corridor. Bottlenecks can be found downstream of a congested location where vehicles accelerate from congested speeds (e.g., below 35 mph) to a higher speed within a very short distance.

Caltrans District 8 collected probe vehicle run data on mid-week days in February to May and in October to November of 2008 for each segment of the I-10 freeway from the I-15 interchange to the Riverside County Line. Exhibit 3C-7 illustrates the eastbound and Exhibit 3C-8 illustrates the westbound probe vehicle runs presented in speed contour diagram from 4AM to 8PM. Note that not all of these bottleneck locations were confirmed by other sources or field visits.

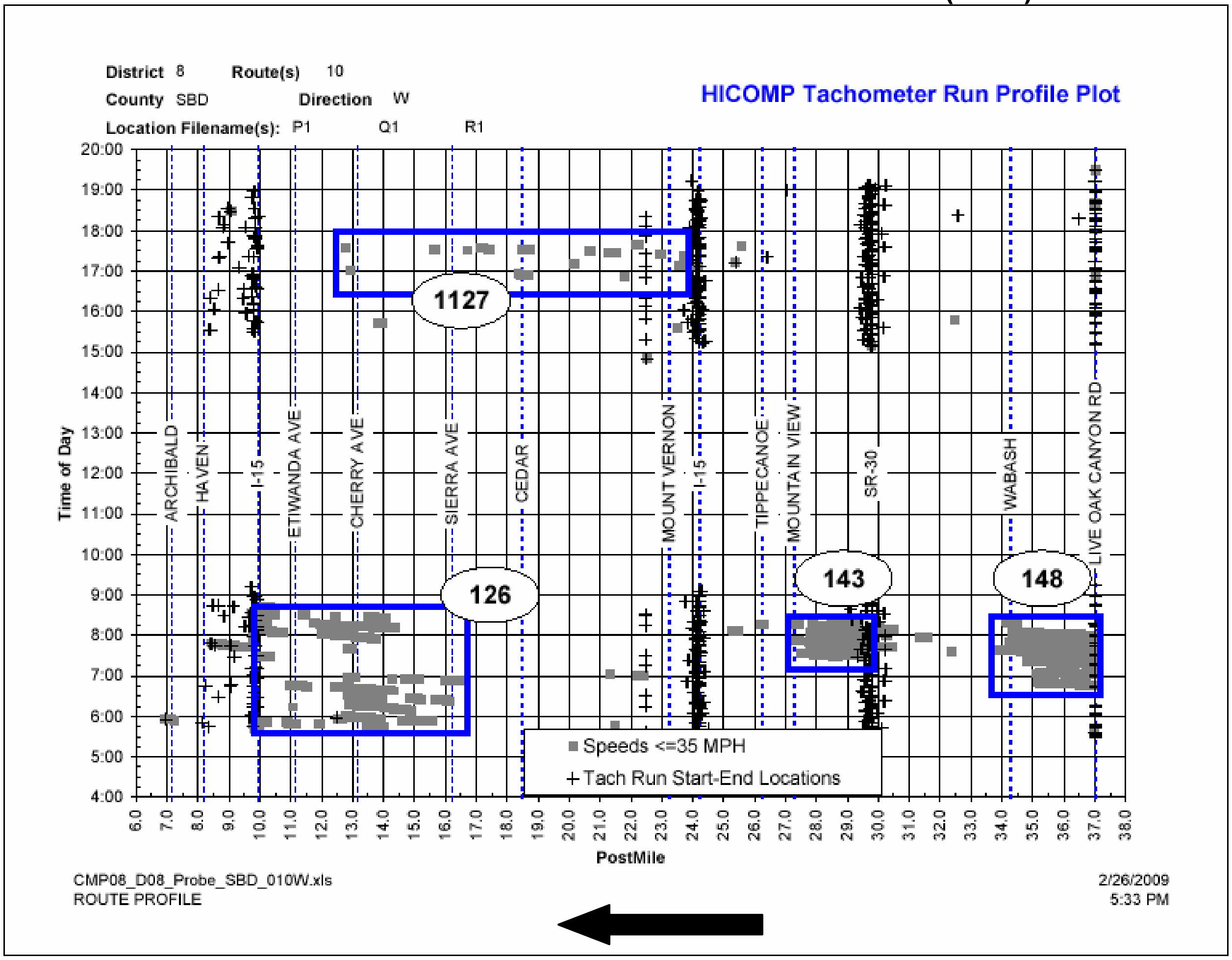
Exhibit 3C-7: Eastbound I-10 Probe Vehicle Runs (2008)



As indicated, potential major <u>eastbound</u> bottlenecks were identified from probe vehicle runs at:

- Cherry Avenue (PM)
- I-215 (PM)
- California Street (PM)
- Live Oak Canyon Road (PM)

Exhibit 3C-8: Westbound I-10 Probe Vehicle Runs (2008)



As indicated, potential major <u>westbound</u> bottlenecks were identified from probe vehicle runs at:

- I-15 (AM)
- Mountain View Avenue (AM)
- Wabash Avenue (AM)

Vehicle Detector Data

The third source used to identify potential bottlenecks was to review speed contour plots from 2008 vehicle detector data. Detector data from the Caltrans Freeway Performance Measurement System (PeMS) was downloaded to conduct this analysis.

Speed contour plots show speeds across the corridor for every detector location for every five-minute period throughout the day. The resulting plot shows the location, extent, and duration of congestion

<u>Eastbound Detector Analysis</u>

Speed contour plots for sample days in April 2008 as well as 2008 quarterly weekday averages were analyzed for the eastbound direction. Exhibits 3C-9 and Exhibit 3C-10 present speed contour and speed profile plots for the I-10 freeway corridor in the eastbound direction (traffic moving left to right on the plot). Along the vertical axis is the time period from 4AM to 9PM. Along the horizontal axis is the corridor segment from the I-15 interchange to the I-215 interchange. The various colors represent the average speeds corresponding to the color speed chart shown below the diagram. As shown, the dark blue blotches represent congested areas where speeds are reduced. The ends of each dark blotches represent bottleneck areas, where speeds pickup after congestion, typically to 30 to 50 miles per hour. The horizontal length of each plot is the congested segment, queue lengths. The vertical length is the congested time period. The eastbound speed contour data analysis results indicated recurring bottleneck locations across multiple weekdays and quarterly averages.

In addition to multiple days, larger averages were also analyzed. Exhibit 3C-11 illustrates the weekday averages by each quarter of 2008. Again, the same bottleneck locations are identified.

As indicated in Exhibits 3C-9 through 3C-11, potential major <u>eastbound</u> bottlenecks were identified from the PeMS data plots at:

- I-15 (AM)
- Etiwanda Off (PM)
- Etiwanda On (PM)

Exhibit 3C-9: PeMS Eastbound I-10 Speed Contour Plots (April 2008)

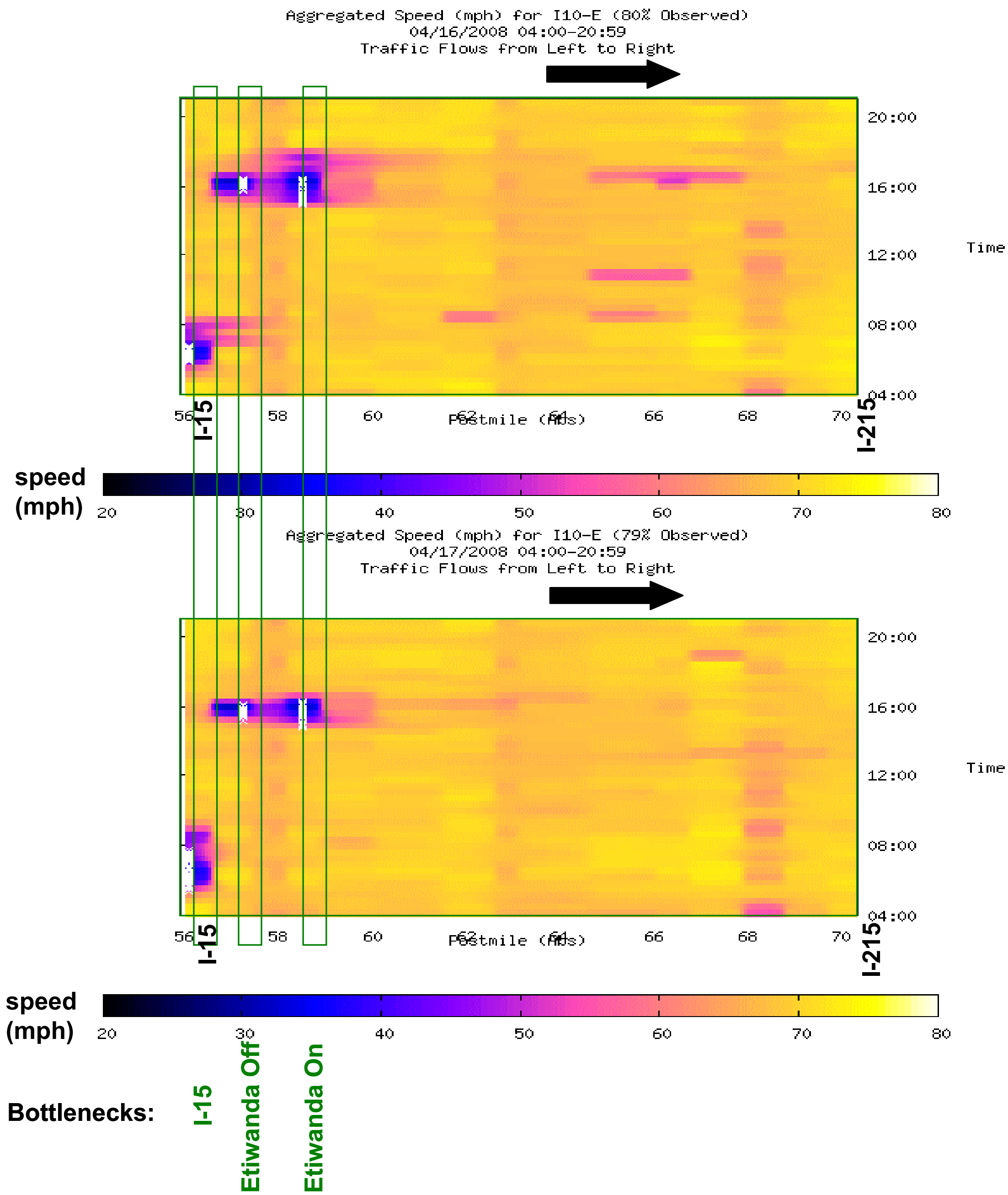


Exhibit 3C-10: PeMS Eastbound I-10 Speed Profile Plots (April 16, 2008)

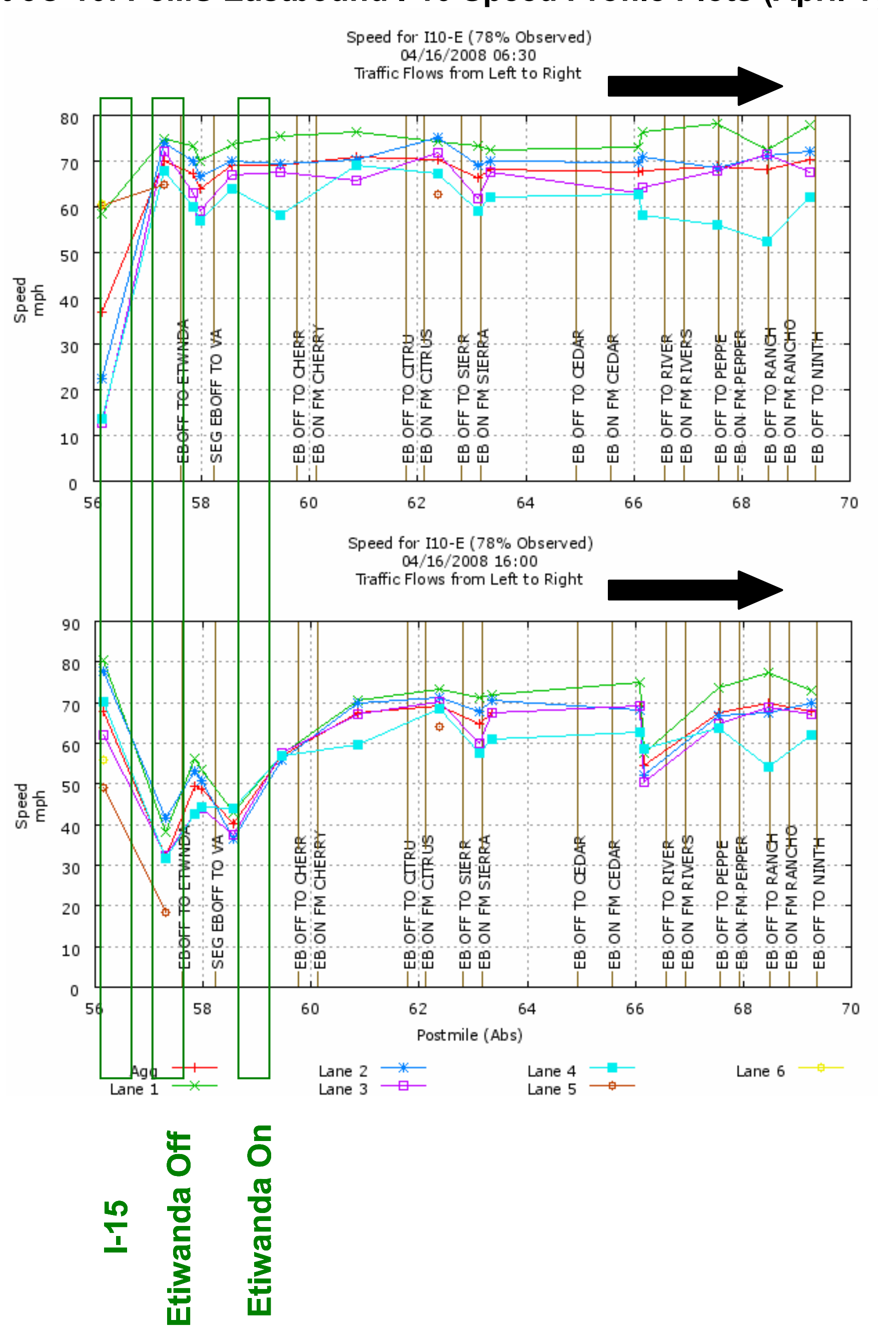
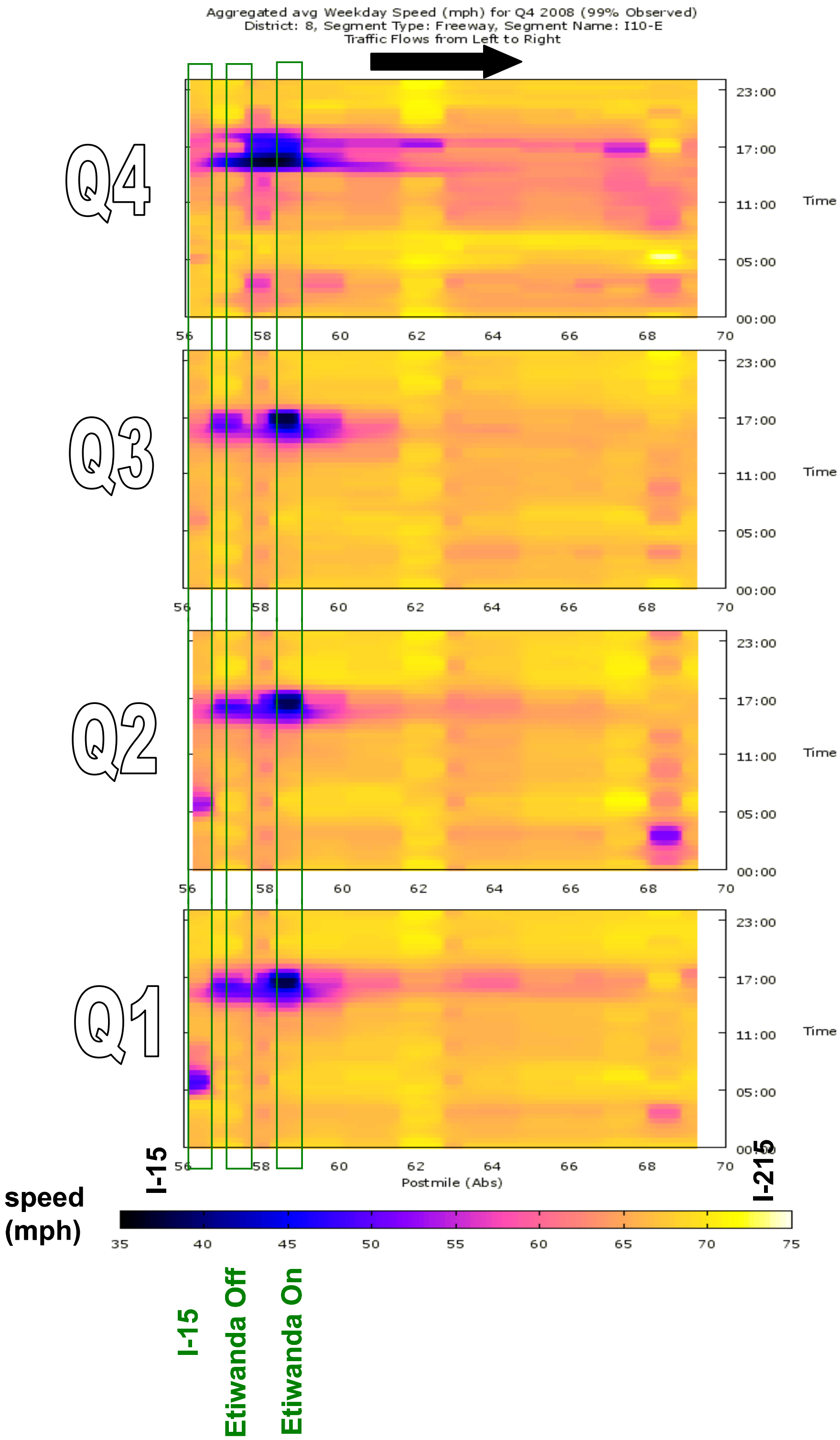


Exhibit 3C-11: PeMS Eastbound I-10 Long (Speed) Contours (2008 Avg by Qtr)

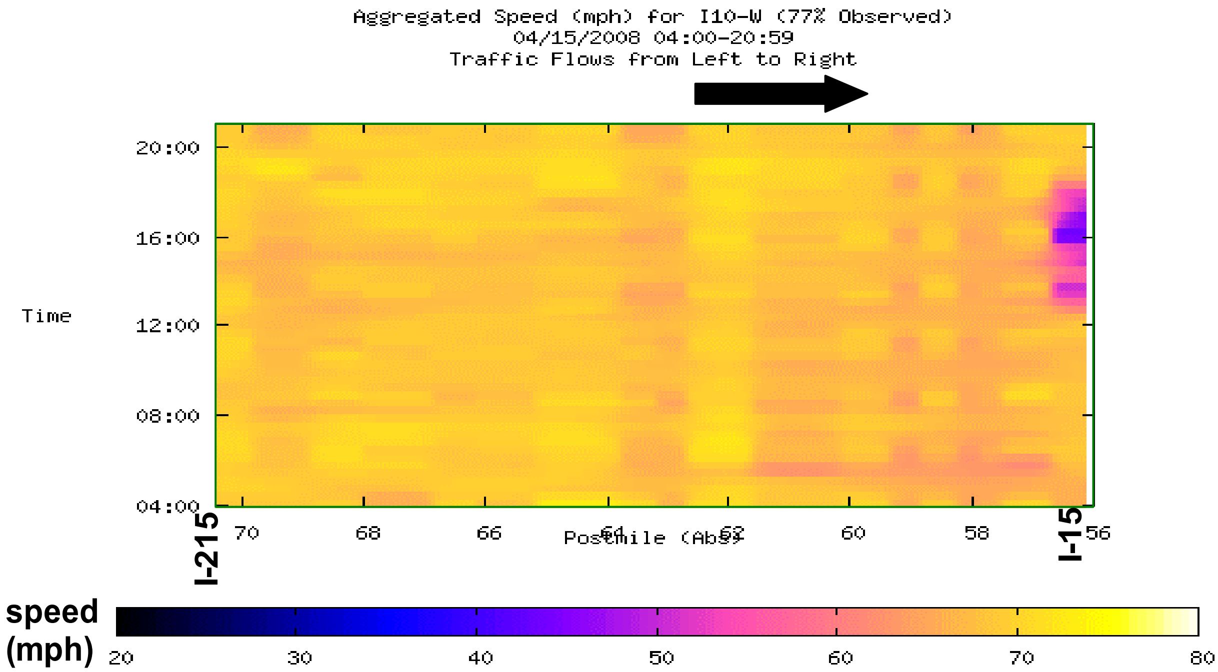


Westbound Detector Analysis

Exhibit 3C-12 provides speed contour plots from Tuesday, April 15, 2008 and Wednesday, April 16, 2008 for westbound I-10. These plots represent typical weekdays in order to highlight bottleneck locations and the resulting congestion. The vertical axis is the time period from 4AM to 9PM, while the horizontal axis shows the corridor segment from the I-215 interchange to the I-15 interchange. There is no detection data to the east of the I-215 interchange. As illustrated in Exhibits 3C-12 and 3C-13, there were no bottlenecks evident on April 15, 2008 or April 16, 2008.

Exhibit 3C-14 illustrates the weekday averages by each quarter of 2008. Again, no potential bottleneck locations were evident.

Exhibit 3C-12: PeMS Westbound I-10 Speed Contour Plots (April 2008)



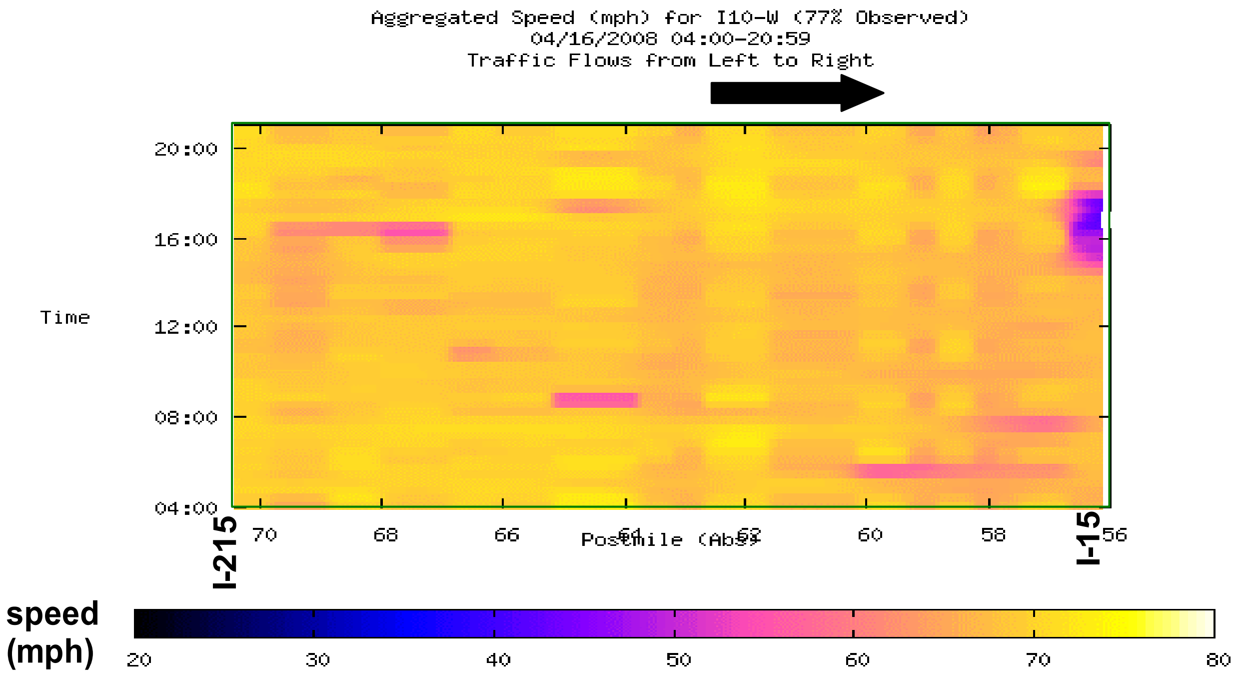


Exhibit 3C-13: PeMS Westbound I-10 Speed Profile Plots (April 15, 2008)

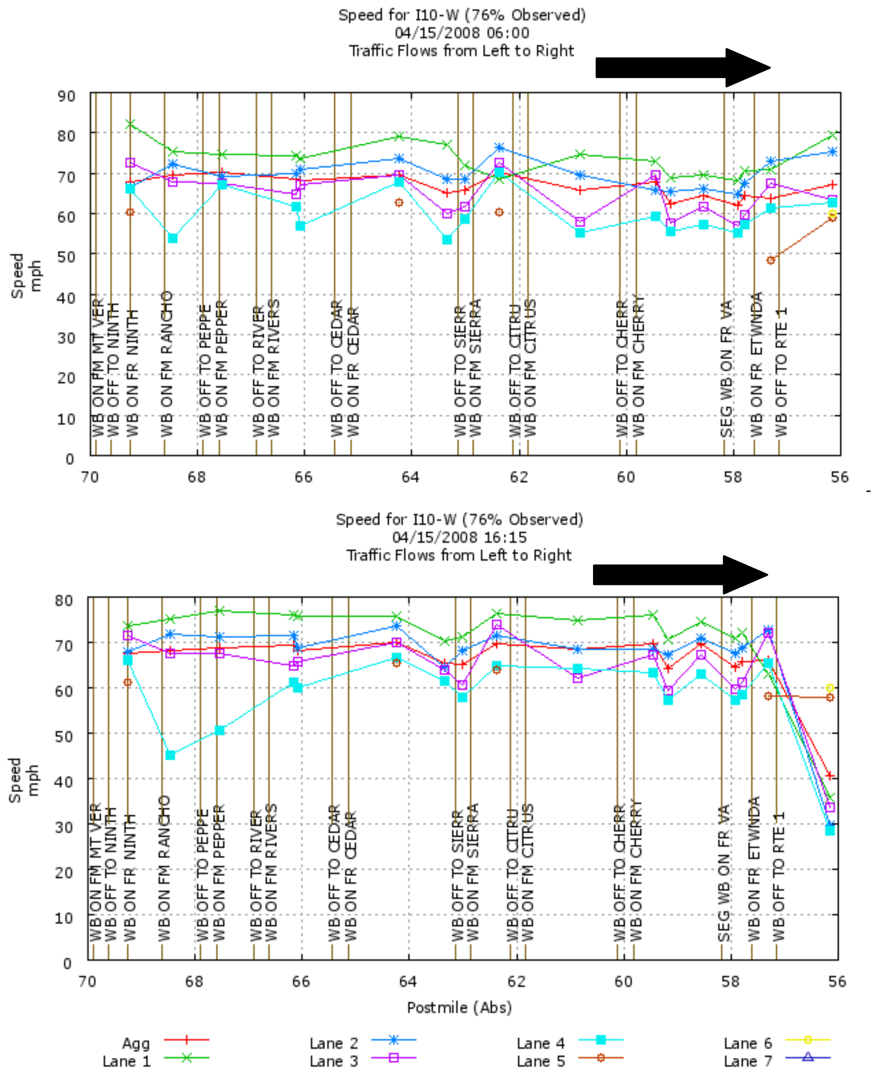
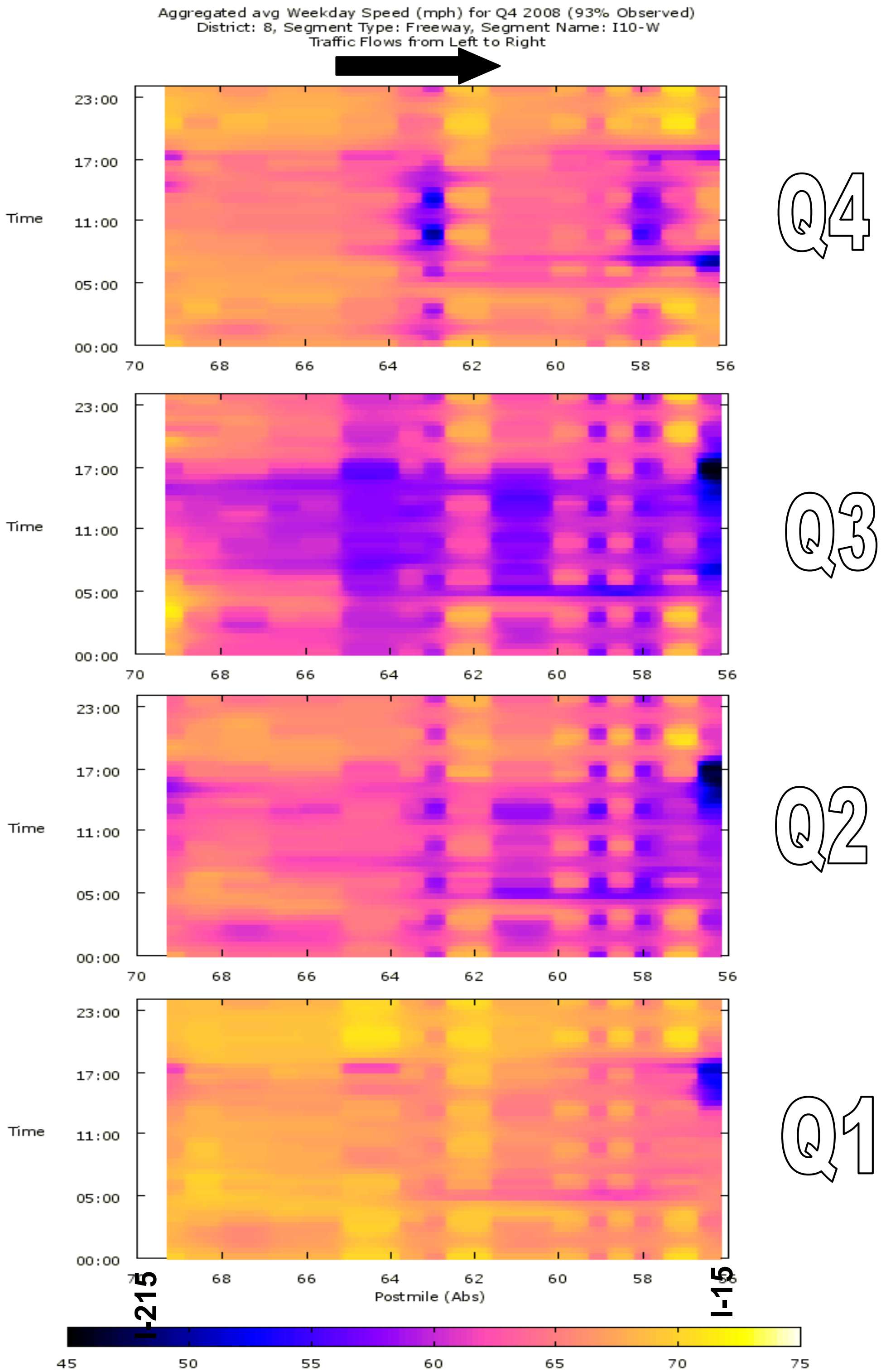


Exhibit 3C-14: PeMS Westbound I-10 Long (Speed) Contours (2008 Avg by Qtr)



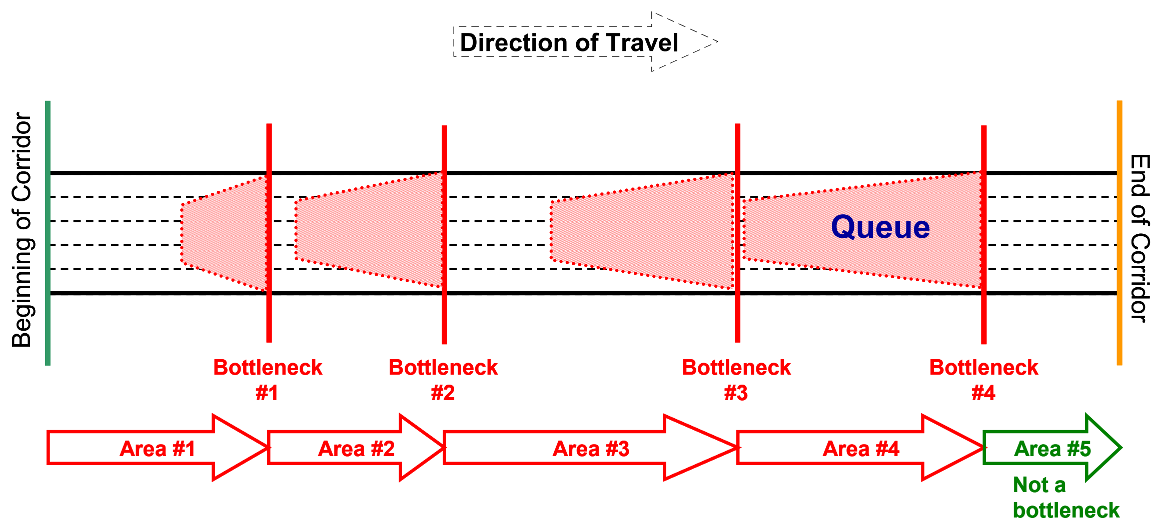
Bottleneck Area Performance

Once the bottlenecks were identified, the corridor is divided into "bottleneck areas." Bottleneck areas represent segments defined by one major bottleneck (or a number of smaller ones). By segmenting the corridors into these bottleneck areas, the performance statistics that were presented for the entire corridor can be segmented by bottleneck area. This way, the relative contribution of each bottleneck area to the degradation of the corridor performance can be gauged. Due to limited detection available on the corridor, the reliability and productivity performance measures could not be analyzed by segment. Nevertheless, the performance statistics that lend themselves to such segmentation include:

- Mobility
- Safety

The study corridor comprises several bottleneck areas, which are different by direction. Exhibit 3C-15 illustrates the concept of bottleneck areas. They represent the area from one bottleneck to the one upstream. The actual queues formed at the bottlenecks may have a different length than the bottleneck area. The red vertical lines represent the bottleneck locations and the arrows identify the bottleneck areas.

Exhibit 3C-15: Dividing a Corridor into Bottleneck Areas



Mobility by Bottleneck Area

Mobility describes how efficiently the corridor moves vehicles. To evaluate how well (or poorly) vehicles move in each bottleneck area, vehicle-hours of delay were calculated by segment. The results reveal the areas of the corridor that experience the worst mobility. Two different sources of data were used to calculate delay for the corridor since automatic detection data is limited to west of I-215. For each direction of travel, there are two sides of the chart that express delay; one side illustrates the bottleneck areas west of I-215 where automatic detection data exists and is used to calculate delay, while the other side depicts bottleneck areas east of I-215, where detector data is unavailable and probe vehicle run data is used to calculate delay. Since the travel pattern on I-10 is highly directional and probe vehicle run data exists only during peak periods, delay is presented by peak period in the following charts. It should be noted that delay quantities calculated from the two separate data sources are different and are not compatible. Caution should be exercised when comparing them.

Exhibit 3C-16 illustrates the vehicle-hours of delay experienced by each bottleneck area during the PM peak on I-10. As depicted in Exhibit 3C-16, the segment from Tippecanoe to Mountain View experienced the most delay east of I-215 with over 105,000 vehicle-hours of delay. Delay in the westbound direction during the AM peak is shown in Exhibit 3C-17. The bottleneck area from Yucaipa to California exhibited the most delay with about 85,000 vehicle-hours.

Exhibits 3C-18 and 3C-19 have been normalized to reflect delay per lane-mile. The delay calculated for each bottleneck area was divided by the total lane-miles for each area. In the eastbound direction (Exhibit 3C-18), the bottleneck area from Waterman Avenue to Tippecanoe Avenue was the segment that experienced the highest delay per lane mile during the PM peak. This is different from the delay illustrated in Exhibit 3C-16, which shows the highest delay experienced between Tippecanoe Avenue and Mountain View Avenue. In the westbound direction (Exhibit 3C-19), the county line to Yucaipa segment experienced the highest delay per lane mile during the AM peak.

Exhibit 3C-16: Eastbound I-10 Annual Vehicle-Hours of Delay (2008)

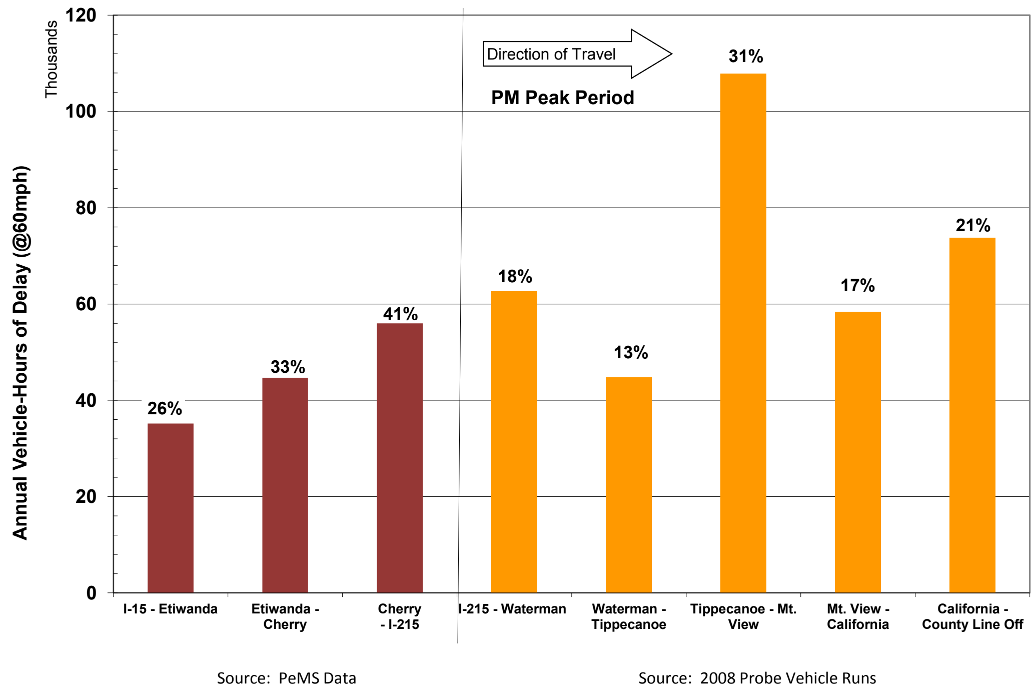


Exhibit 3C-17: Westbound I-10 Annual Vehicle-Hours of Delay (2008)

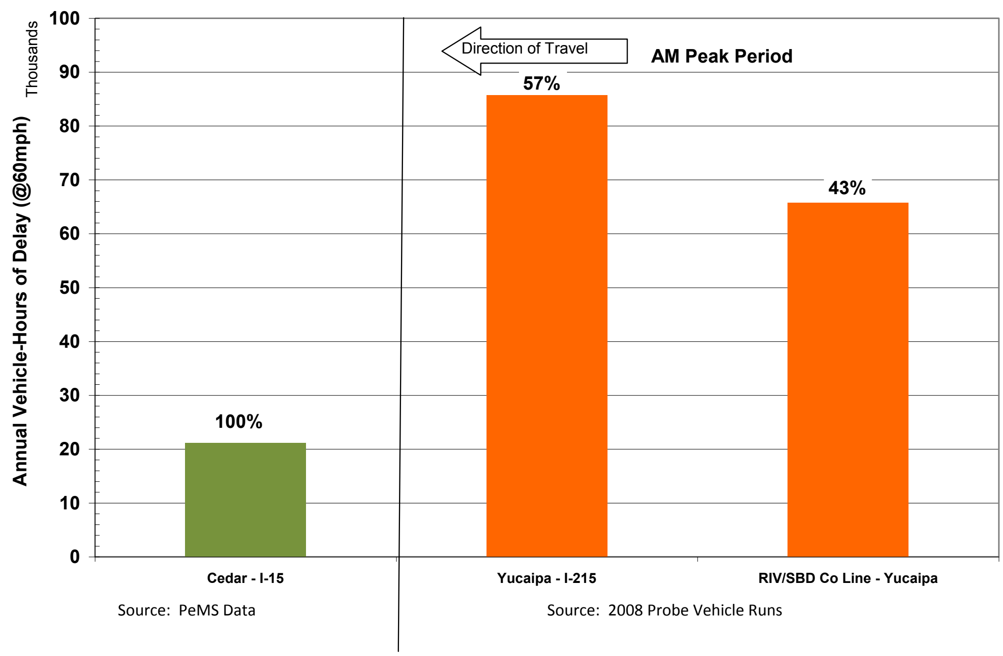


Exhibit 3C-18: Eastbound I-10 Delay per Lane-Mile (2008)

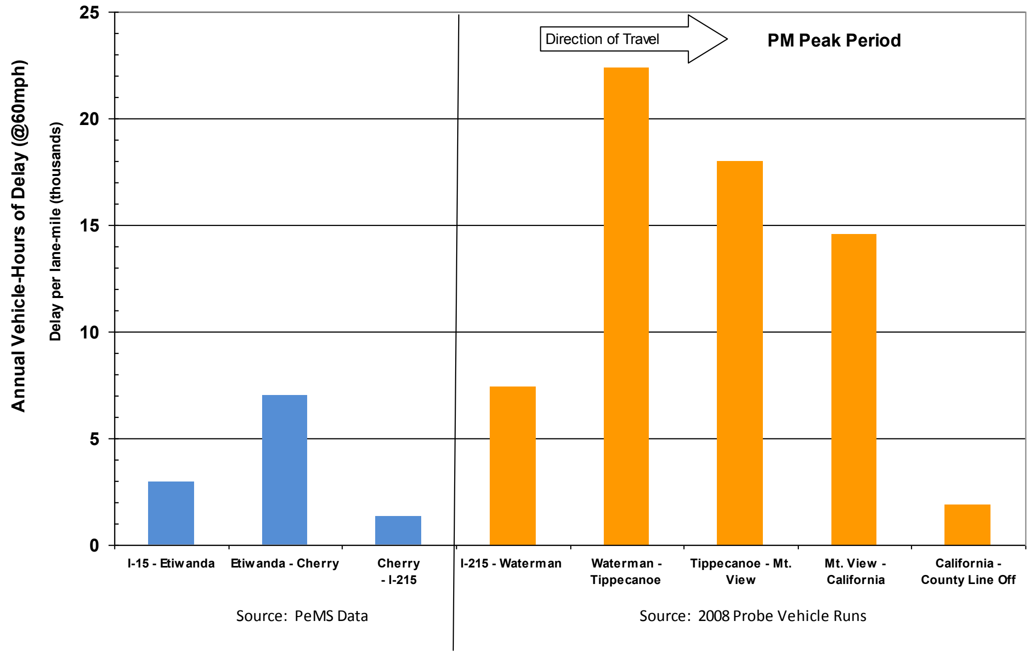
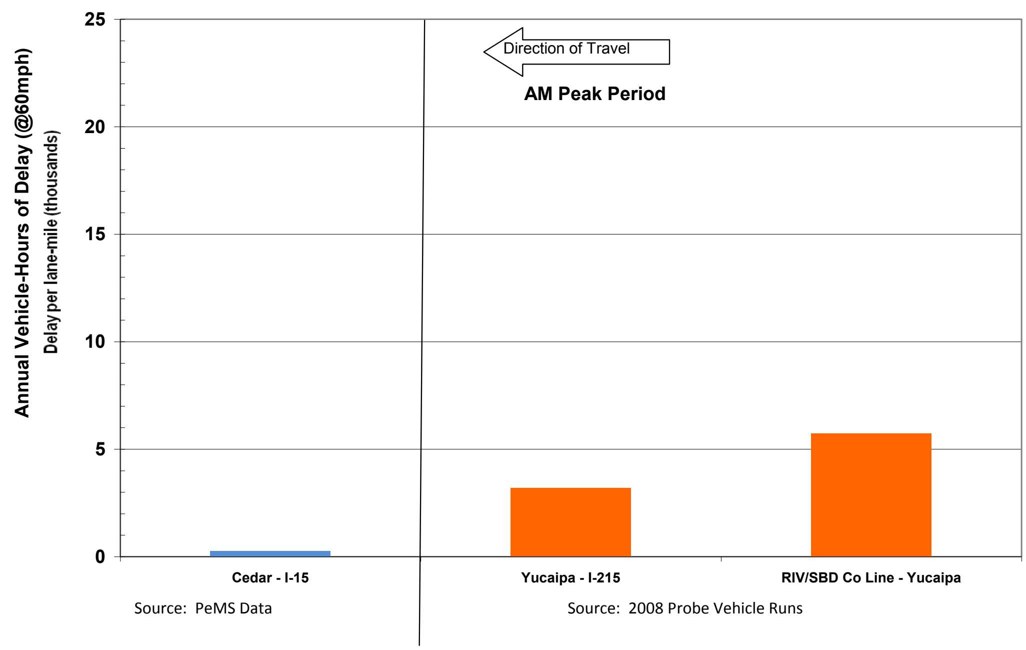


Exhibit 3C-19: Westbound I-10 Delay per Lane-Mile (2008)



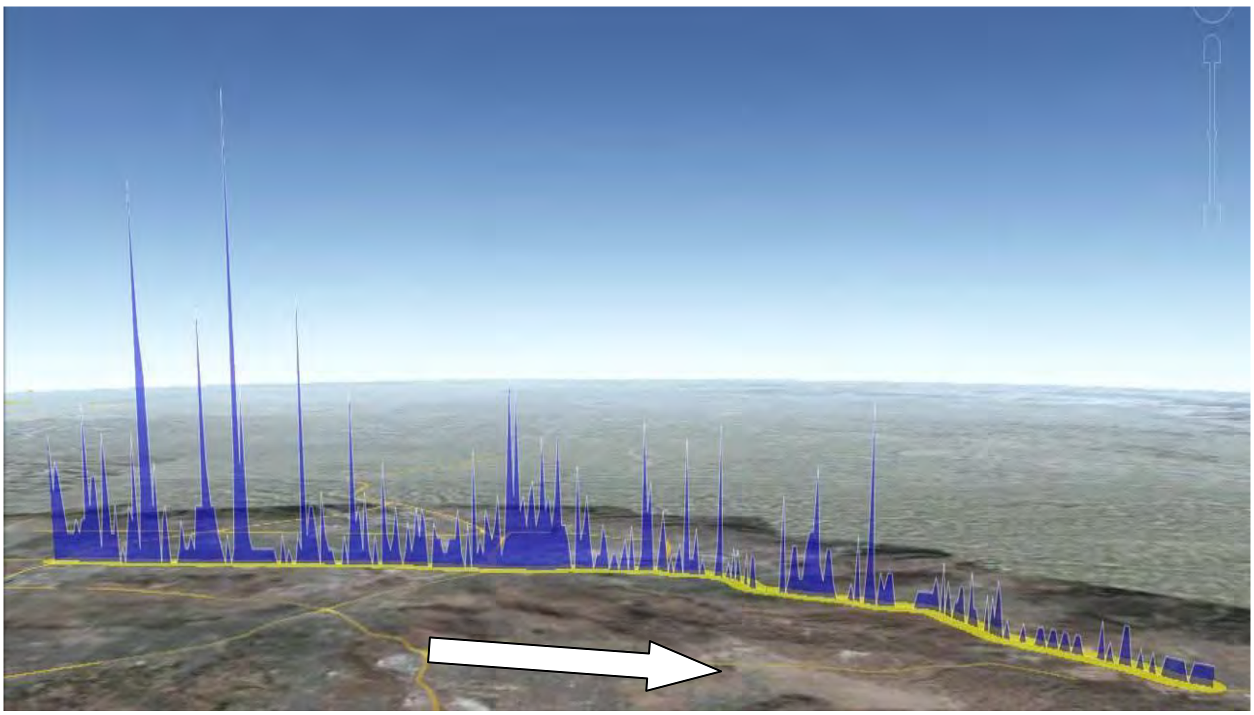
Safety by Bottleneck Area

As previously indicated in Section 3, the safety assessment in this report is intended to characterize the overall accident history and trends in the corridor, and to highlight notable accident concentration locations or patterns that are readily apparent. The following discussion examines the pattern of collisions by bottleneck areas.

Exhibit 3C-20 shows the location of all collisions plotted along the I-10 Corridor in the eastbound direction. The spikes show the total number of collisions (fatality, injury, and property damage only) that occurred within 0.1-mile segments in 2008. The highest spike corresponds to roughly 30 collisions in a single 0.1-mile location. The size of the spikes is a function of how collisions are grouped.

As Exhibit 3C-20 shows, more collisions occurred on the west part of the corridor compared to the east. In many cases, a spike in the number of collisions occurred in the same location as a bottleneck.

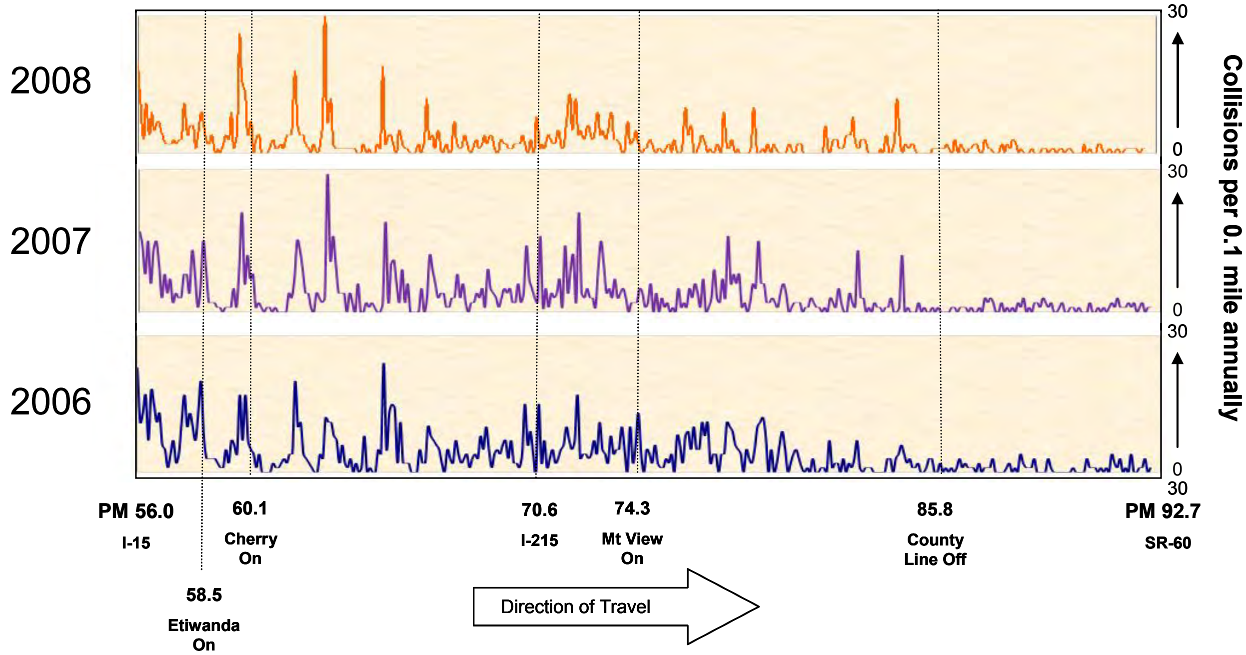
Exhibit 3C-20: Eastbound I-10 Collision Locations (2008)



Source: TASAS data

Exhibit 3C-21 illustrates the same collision data for the three-year period between 2006 and 2008. The vertical lines in the exhibit separate the corridor by bottleneck area. Since the eastbound direction comprised a large number of bottleneck locations, not all of them are depicted in the exhibit below. Exhibit 3C-21 suggests that the pattern of collisions remained consistent during the three-year period between 2006 and 2008. The exhibit also suggests that the high accident locations identified in 2008 (Exhibit 3C-20) were the same as the preceding years: around Cherry Avenue (PM 60.1).

Exhibit 3C-21: Eastbound I-10 Collision Locations (2006-2008)



Source: TASAS data

Westbound collision data for 2008 is illustrated in Exhibit 3C-22. The largest spike in this exhibit corresponds roughly to 30 collisions per 0.1-miles. Comparing the spikes in the westbound direction to the eastbound (Exhibit 3C-20) reveals that no one direction experienced significantly more collisions than the other.

Exhibit 3C-22: Westbound I-10 Collision Locations (2008)

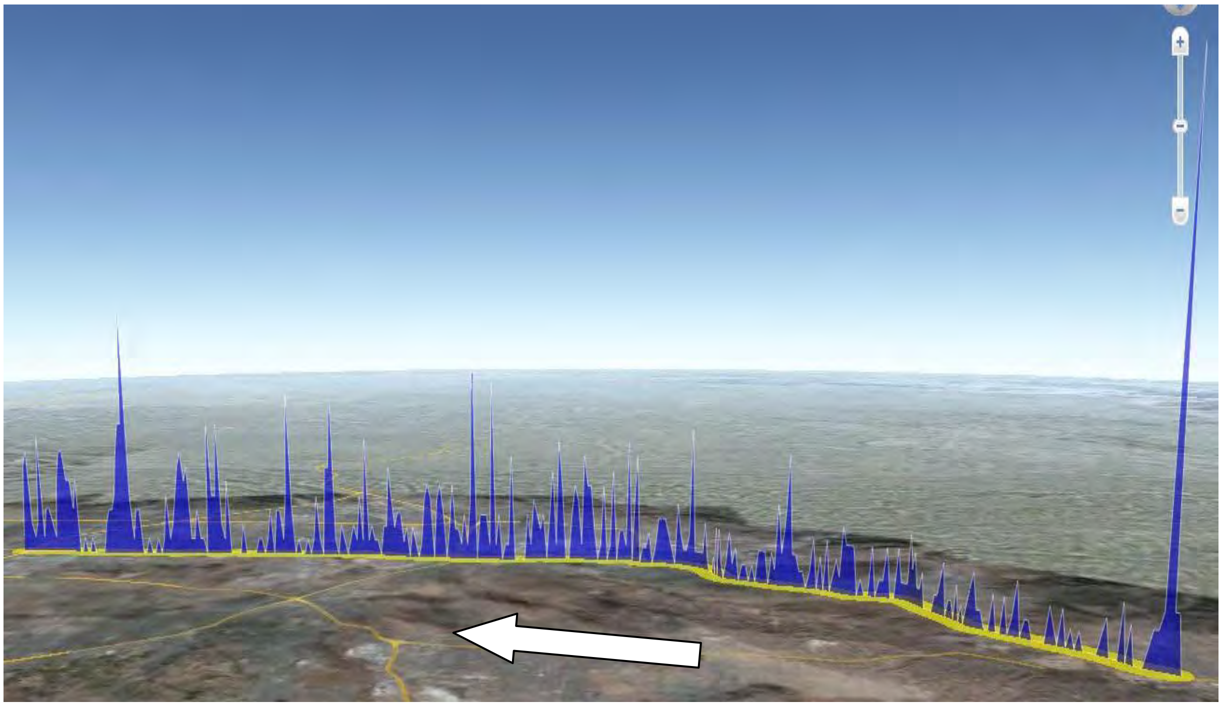
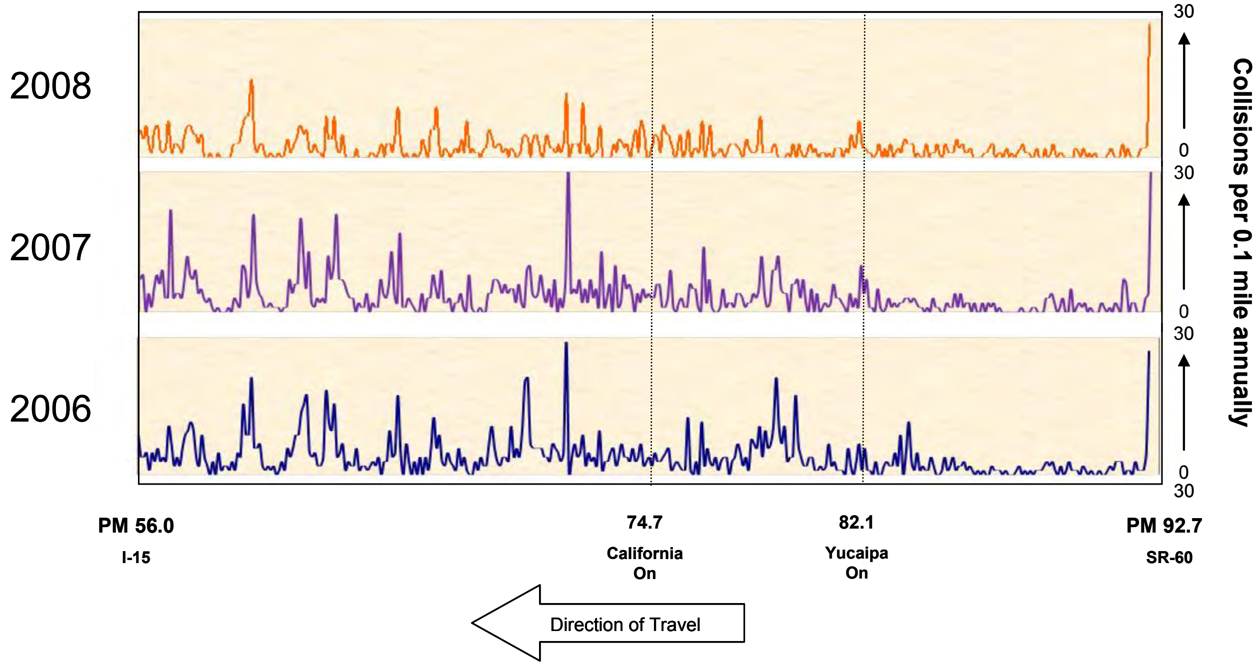


Exhibit 3C-23 shows the trend of collisions for the westbound direction from the 2006 to 2008 period. The pattern of collisions has been fairly steady from one year to the next. The high accident locations depicted in Exhibit 3C-22 reappear in the preceding years.

Exhibit 3C-23: Westbound I-10 Collision Locations (2006-2008)



Source: TASAS data

Bottleneck Causality

Bottlenecks are the location of corridor performance degradation and resulting congestion and lost productivity. It is important to verify the specific location and cause of each major bottleneck to determine appropriate solutions to traffic operations problems. By definition (HCM2000), a bottleneck is a road element in which traffic demand exceeds the capacity of the roadway facility. In other words, a location where traffic demand able to reach a section of roadway is greater than the section can handle, because there are too many vehicles or not enough road, or both (*Caltrans Freeway Operations Academy Manual*). In most cases, the cause of bottlenecks is related to a sudden reduction in capacity (such as roadway geometry, heavy merging and weaving, and driver distractions) or a surge in demand (from ramps or connectors) that the facility cannot accommodate.

Major eastbound bottlenecks and congestion occurs mostly during the PM peak period. In fact, no significant amount of congestion was observed during the AM peak period during field site visits in the eastbound direction. The following is a summary of the eastbound bottlenecks and their identified causes.

<u>I-15</u>

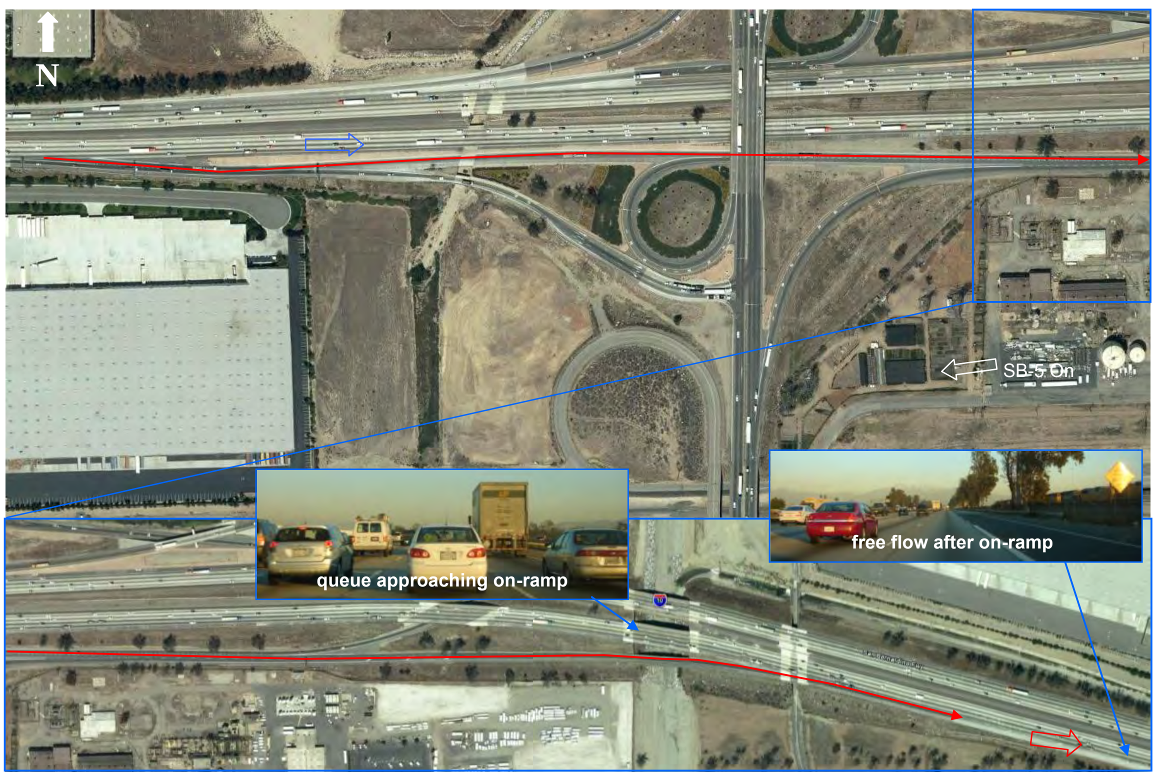
Exhibit 3C-24 is an aerial photograph of the I-15 mainline connectors to the eastbound I-10. When the mainline traffic is heavy, it cannot accommodate the additional demand merging from the I-15 connectors. In addition, downstream off-ramp traffic to Etiwanda Avenue creates cross weaving with the I-15 traffic. Although not substantial, bottleneck and traffic congestion was observed at this location during the field reviews. The high volume of traffic merging and weaving at this location is likely to be the cause of this bottleneck.

Exhibit 3C-24: Eastbound I-10 at I-15

Etiwanda Avenue On

Exhibit 3C-25 is an aerial photograph of the Etiwanda Avenue interchange. As shown, this interchange includes a collector-distributor (C-D). Both northbound and southbound on-ramp traffic to the eastbound I-10 mainline occur via the C-D road. Although both ramps have ramp metering systems, active application was not observed during any of the field reviews regardless of the mainline roadway conditions. During several field visits, heavy platoon merging from the C-D road (on-ramp to freeway) was observed to affect the mainline flow. This bottleneck condition is likely to be caused by the inability of the mainline facility to accommodate the merging from the Etiwanda Avenue C-D road on-ramp. Because of the C-D road, active metering of the two on-ramps is not likely to break up the platoon merging of the C-D road traffic entering the freeway mainline.

Exhibit 3C-25: Eastbound I-10 at Etiwanda Avenue Interchange



Cherry Avenue On

Exhibit 3C-26 is an aerial photograph of the Cherry Avenue on-ramp to eastbound I-10. Although a bottleneck condition at this location was not observed during any of the field visits in 2008, vehicle detector data from PeMS and travel data from District 8 probe vehicle runs indicated that bottleneck and congestion conditions occurred at this location in 2008. The reduction in the overall mainline demand as a result of the SR-210 extension completed in 2007 is likely to have impacted conditions at this location since mid-2007.

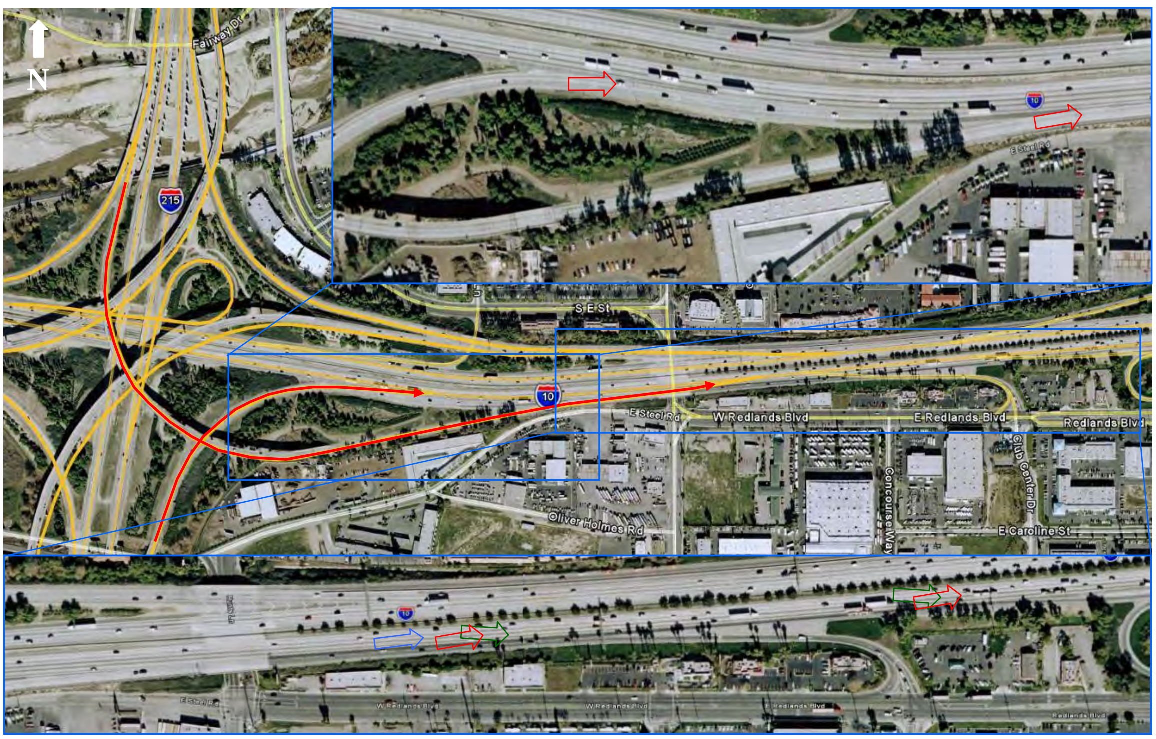
When the mainline traffic is heavy, it cannot accommodate additional demand from the Cherry on-ramp merging traffic. Platoon vehicle merging at this on-ramp was observed, however, due to the lack of density on the mainline, the merges did not appear to have had any adverse impact to the mainline flow.

Exhibit 3C-26: Eastbound I-10 at Cherry On

I-215

Exhibit 3C-27 is an aerial photograph of the I-215 connectors to eastbound I-10. During the PM peak period, heavy traffic volume is added to the mainline with the consecutive I-215 connectors. When the mainline traffic is heavy and dense, it cannot accommodate this additional demand merging. In addition, downstream off-ramp traffic to Waterman Avenue creates cross weaving with the I-215 traffic. Although not substantial, bottleneck and traffic congestion were observed at this location during the field visits.

Exhibit 3C-27: Eastbound I-10 at I-215



Waterman Avenue On

Exhibit 3C-28 is an aerial photograph of the eastbound I-10 at the Waterman Avenue interchange. As shown, this interchange includes a collector-distributor. Both northbound and southbound on-ramp traffic to the eastbound I-10 mainline occur via the C-D road. Also shown in the inset photographs are heavy platoon ramp traffic merging with the mainline traffic, breaking down the freeway mainline flow. This bottleneck condition is likely to be caused by the inability of the mainline facility to accommodate the surge of additional demand from the Waterman Avenue C-D road on-ramp with the heavy platoon merging. The roadway geometrics here are also likely to adversely affect the effective capacity of the mainline, exacerbating the condition.

Exhibit 3C-28: Eastbound I-10 at Waterman Avenue On

<u>Tippecanoe Avenue On</u>

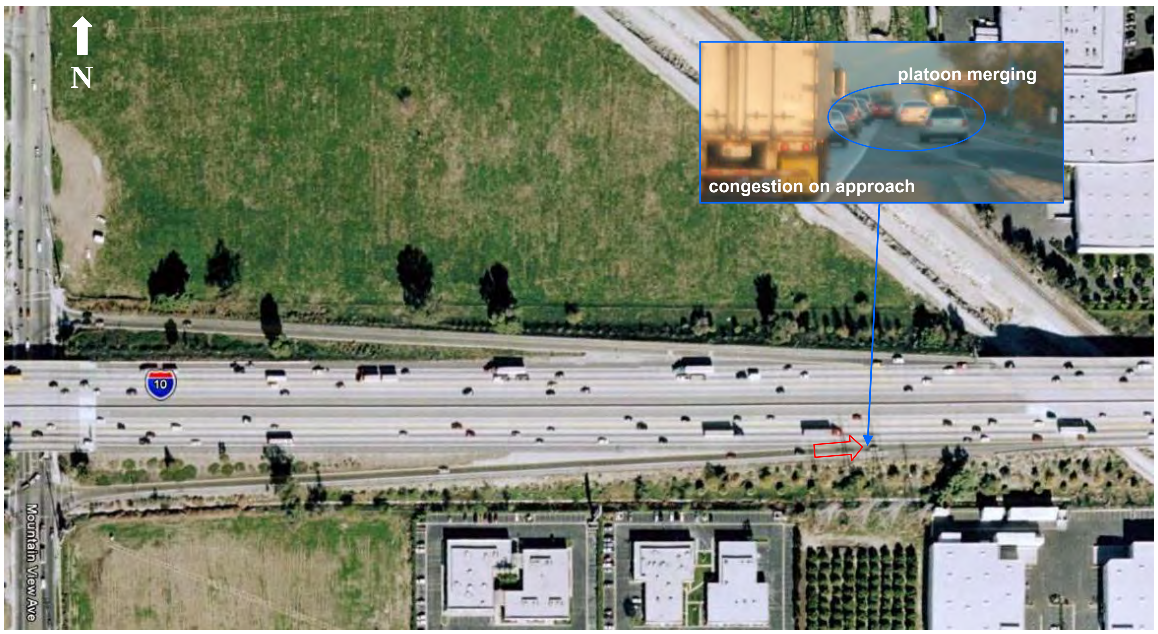
Exhibit 3C-29 is an aerial photograph of the eastbound I-10 at the Tippecanoe Avenue on-ramp. When the mainline demand is high, near the threshold level, the freeway facility cannot accommodate the on-ramp merging, particularly with platoon merging from the ramp.

Exhibit 3C-29: Eastbound I-10 at Tippecanoe Avenue On

Mountain View Avenue On

Exhibit 3C-30 is an aerial photograph of the eastbound I-10 at the Mountain View Avenue on-ramp. From the field visits, this is a major bottleneck location that results in significant traffic congestion and queuing. When the mainline demand is high, near the threshold level, the freeway mainline facility cannot accommodate this surge in demand merging, as shown in the inset photograph.

Exhibit 3C-30: Eastbound I-10 at Mountain Avenue On



California Street On

Exhibit 3C-31 is an aerial photograph of the eastbound I-10 at the California Street on-ramp. When the mainline demand is high, it is likely that the freeway facility cannot accommodate the additional demand merging from the ramp.

Exhibit 3C-31: Eastbound I-10 at California Street On

County Line Road Off

Exhibit 3C-32 is an aerial photograph of the eastbound I-10 at the County Line Lane off-ramp. When the mainline and off-ramp demands are high, it is likely that traffic backing up onto the mainline from the off-ramp, blocking the outside lane would result in a bottleneck condition, as indicated on the probe vehicle run data.

Exhibit 3C-32: Eastbound I-10 at County Line Road Off

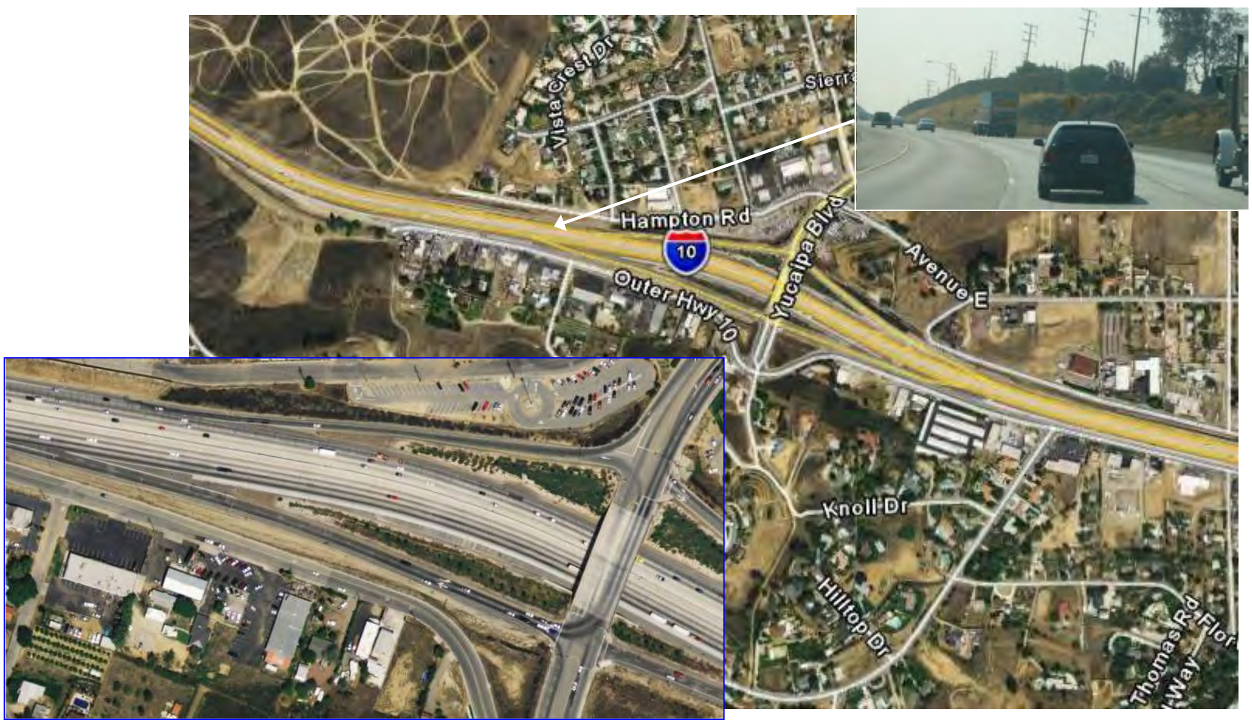
Westbound Bottlenecks and Causes

The following is a summary of the westbound bottlenecks and their causes.

<u>Yucaipa Boulevard On</u>

Exhibit 3C-33 is an aerial photograph of the westbound I-10 mainline at the Yucaipa Boulevard on-ramp. As shown in the aerial and inset photographs, there is a steep uphill grade on the westbound mainline through the interchange. When the mainline demand is high with slow climbing trucks on the outer lanes, a bottleneck condition is likely to occur with the merging on-ramp traffic from Yucaipa Boulevard.

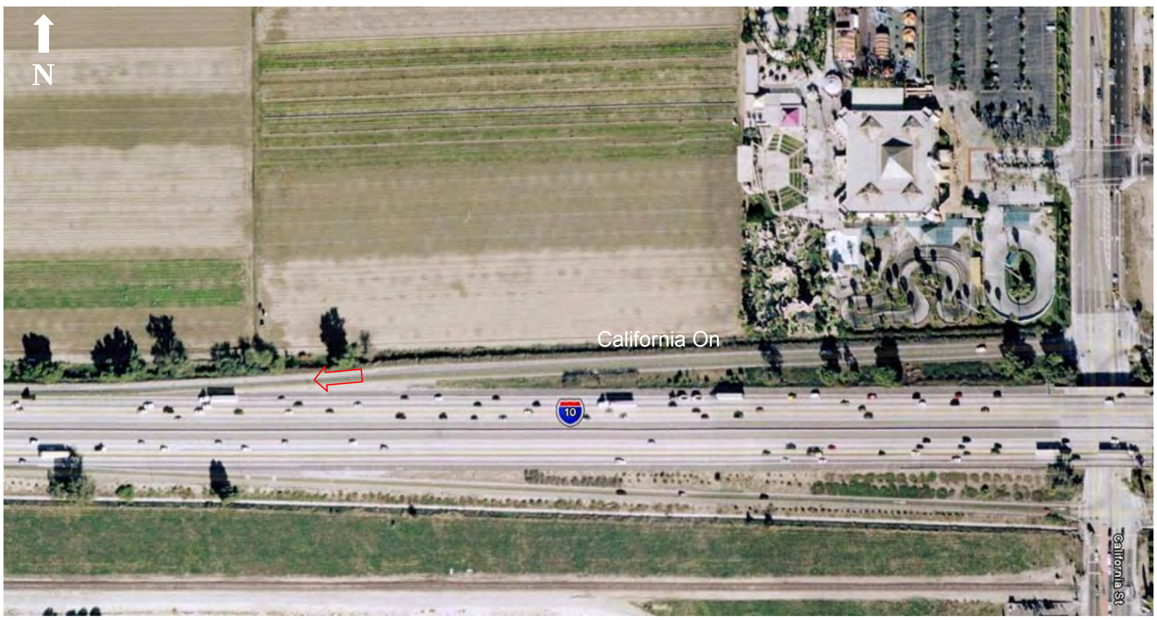
Exhibit 3C-33: Westbound I-10 at Yucaipa Boulevard On



California Street On

Exhibit 3C-34 is an aerial photograph of the westbound I-10 mainline at the California Street on-ramp. It is likely that bottleneck conditions and traffic congestion form when the mainline traffic demand is high with the addition of on-ramp traffic. A bottleneck condition, small amounts of congestion, and brief queuing were observed at this location during the field visits.

Exhibit 3C-34: Westbound I-10 at California Street On



D. Pavement Condition

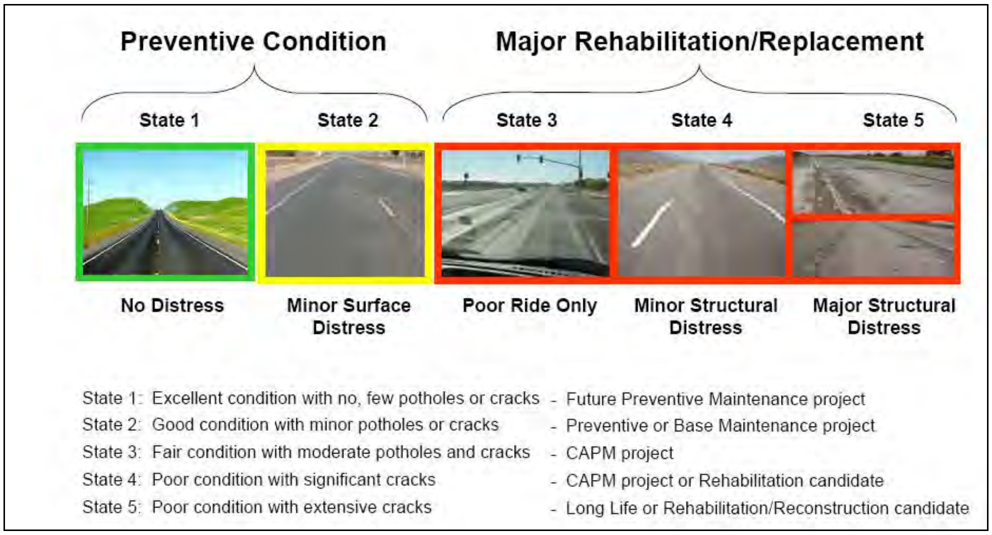
The condition of the roadway pavement (or ride quality) on the corridor can influence its traffic performance. Rough or poor pavement conditions can decrease the mobility, reliability, safety, and productivity of the corridor, whereas smooth pavement can have the opposite effect. Pavement preservation refers to maintaining the structural adequacy and ride quality of the pavement. It is possible for a roadway section to have structural distress without affecting ride quality. Likewise, a roadway section may exhibit poor ride quality, while the pavement remains structurally adequate.

Performance Measures

Caltrans conducts an annual Pavement Condition Survey (PCS) that can be used to compute two performance measures commonly estimated by Caltrans: distressed lane miles and International Roughness Index (IRI). Although Caltrans generally uses distressed lane miles for external reporting, this report uses the Caltrans data to present results for both measures.

Using distressed lane miles allows us to distinguish among pavement segments that require only preventive maintenance at relatively low costs and segments that require major rehabilitation or replacement at significantly higher costs. All segments that require major rehabilitation or replacement are considered to be distressed. Segments with poor ride quality are also considered to be distressed. Exhibit 3D-1 provides an illustration of this distinction. The first two pavement conditions include roadway that provides adequate ride quality and is structurally adequate. The remaining three conditions are included in the calculation of distressed lane-miles.

Exhibit 3D-1: Pavement Condition States Illustrated



Source: Caltrans Division of Maintenance, 2007 State of the Pavement Report

IRI distinguishes between smooth-riding and rough-riding pavement. The distinction is based on measuring the up and down movement of a vehicle over pavement. When such movement is measured at 95 inches per mile or less, the pavement is considered good or smooth-riding. When movements are between 95 and 170 inches per mile, the pavement is considered acceptable. Measurements above 170 inches per mile reflect unacceptable or rough-riding conditions.

Existing Pavement Condition

The most recent pavement condition survey, completed in November 2007, recorded 12,998 distressed lane-miles statewide. Unlike prior surveys, the 2007 PCS included pavement field studies for a period longer than a year, due to an update in the data collection methodology. The survey includes data for 23 months from January 2006 to November 2007.

The field work consists of two parts. In the first part, pavement raters visually inspect the pavement surface to assess structural adequacy. In the second part, field staff uses vans with automated profilers to measure ride quality. The 2007 PCS revealed that the majority of distressed pavement was on freeways and expressways (Class 1 roads). This is the result of approximately 56 percent of the State Highway System falling into this road class. As a percentage of total lane miles for each class, collectors and local roads (Class 3 roads) had the highest amount of distress.

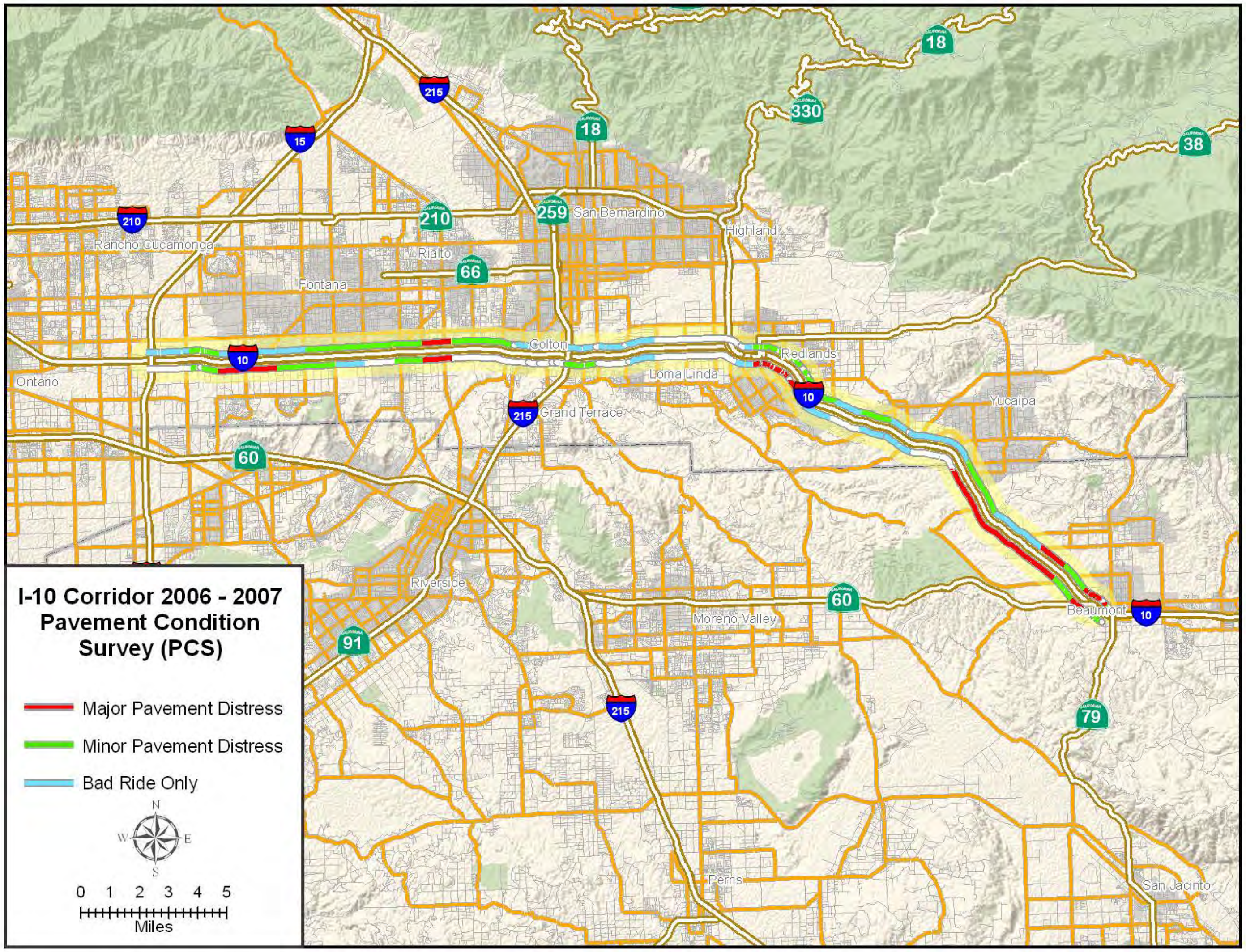
Exhibit 3D-2 shows the pavement distress recorded along the I-10 Corridor for the 2007 PCS data. The three categories shown in this exhibit represent the three distressed conditions that require major rehabilitation or replacement and were presented earlier in Exhibit 3D-1.

The I-10 Corridor is in better condition than many freeways in the Inland Empire. Major pavement distress is found primarily in the western portion of the corridor, although there are small sections with major pavement distress near Fontana and Redlands. The rest of the corridor exhibits mostly either minor pavement distress or poor ride quality only. There are some sections with no distress of any kind.

Exhibit 3D-3 compares results from prior pavement condition surveys along the I-10 Corridor. The total number of distressed lane-miles has generally increased since 2003 (with the exception of a decline in 2005). From 2003 to 2004, the growth was due to an increase in minor pavement distress, while major pavement distress became more prominent in 2005. In 2006-2007, pavement distress issues were replaced by ride quality issues.

The change in the percent mix of distressed lane-miles is presented more clearly in Exhibit 3D-4. As the exhibit shows, major pavement distress has been reduced since 2005. In 2006-2007, roughly half of the distressed lane-miles represented minor pavement distress while only a third was due to ride quality issues.

Exhibit 3D-2: Distressed Lane-Miles on I-10 Corridor (2006-2007)

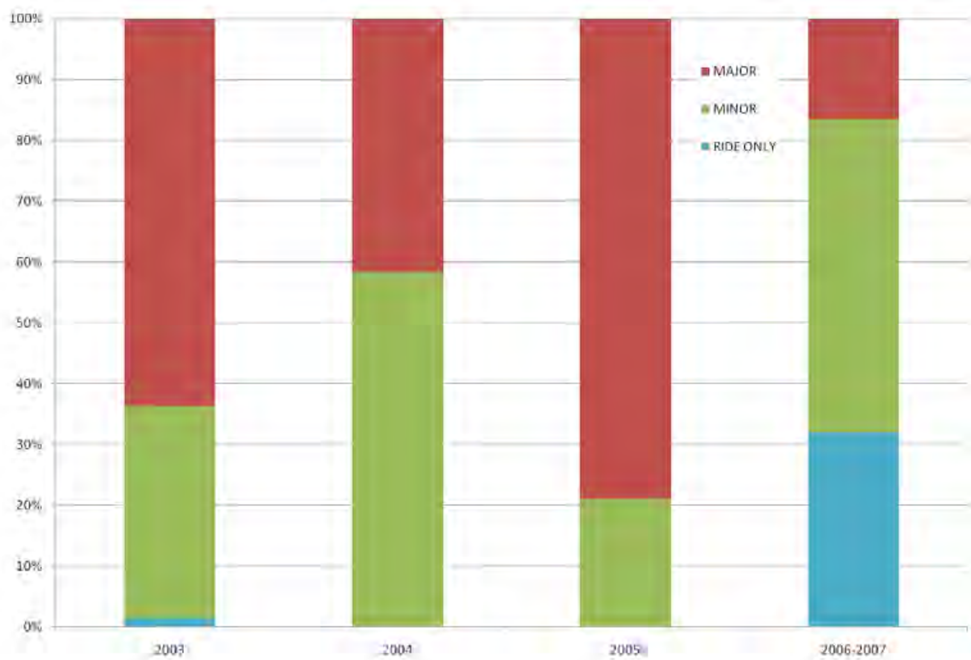


Source: 2007 Pavement Condition Survey data

Exhibit 3D-3: I-10 Distressed Lane-Miles Trends

Source: 2003 to 2007 Pavement Condition Survey data

Exhibit 3D-4: I-10 Distressed Lane-Miles by Type



Source: 2003 to 2007 Pavement Condition Survey data

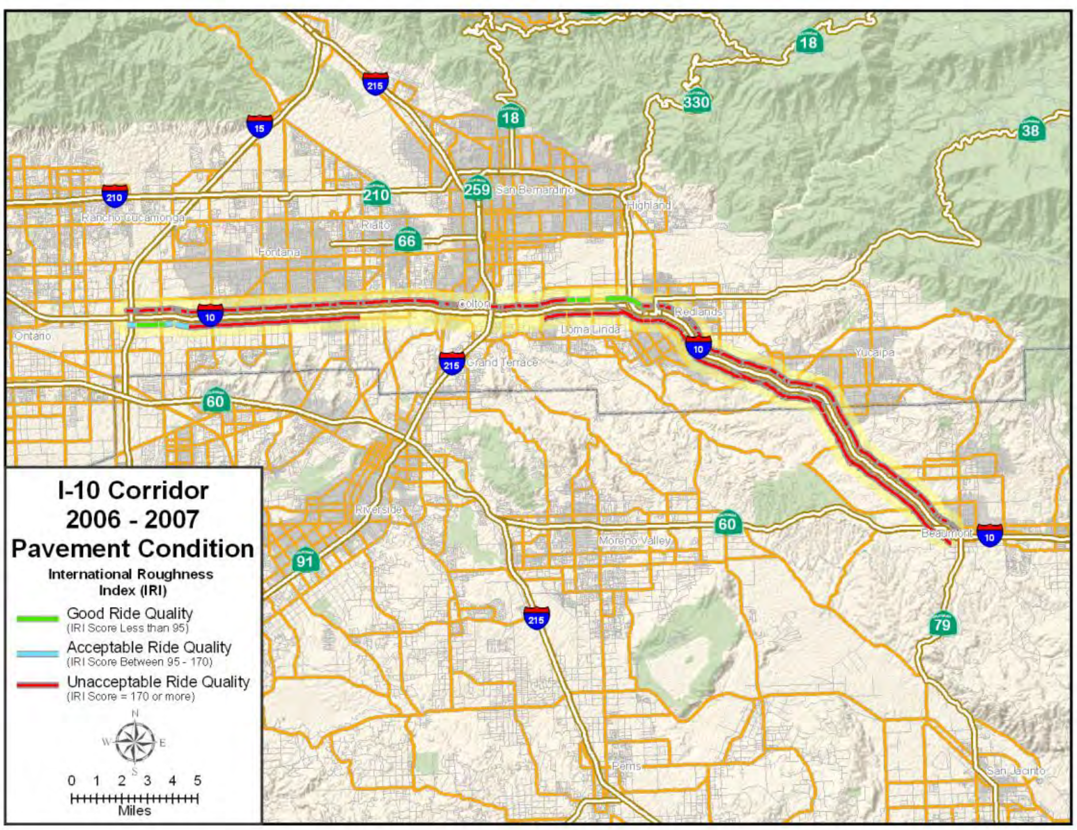
Exhibit 3D-5 shows IRI along the study corridor for the lane with the poorest pavement condition in each freeway segment. The worst pavement quality is shown because pavement investment decisions are made on this basis. As seen in the exhibit, over half of the corridor has ride quality issues (IRI greater than 170). However, large sections between Ontario and Redlands have at least one direction in which the worst lane has good or acceptable ride quality. In addition, some lanes have better quality than others within the same roadway section.

The relatively good ride quality is more apparent when the conditions on all lanes are considered. The study corridor is comprised of roughly 166 lane-miles, of which:

- 93 lane-miles, or 56 percent, are considered to have good ride quality (IRI ≤ 95)
- 2 lane-miles, or 1 percent, are considered to have acceptable ride quality (95 < IRI ≤ 170)
- 70 lane miles, or 42 percent, are considered to have unacceptable ride quality (IRI > 170)

Note: the lane-miles do not add due to rounding.

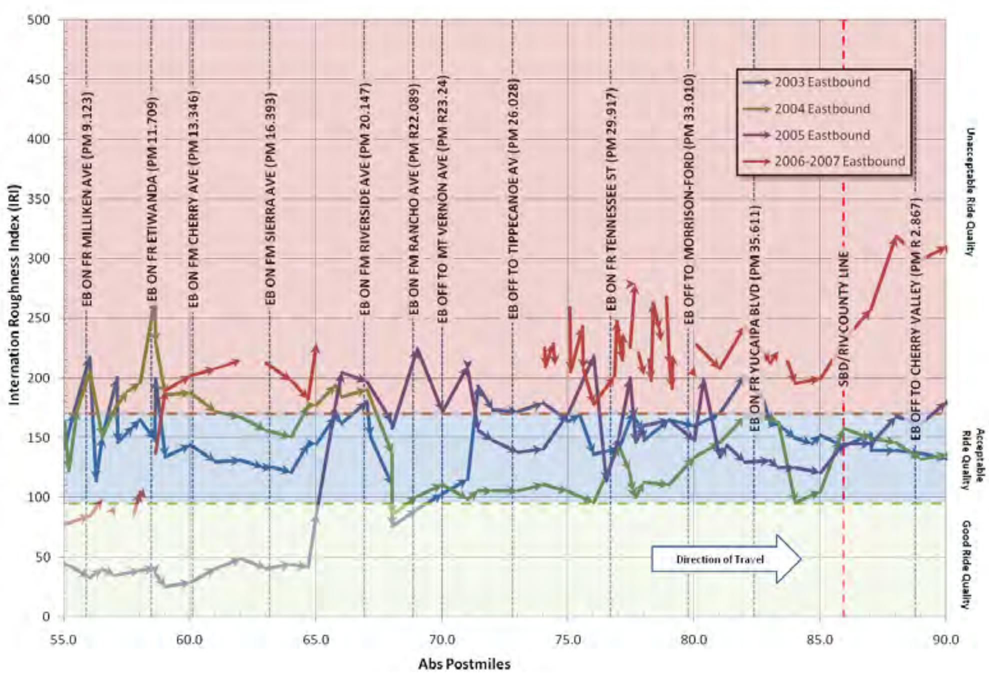
Exhibit 3D-5: I-10 Road Roughness (2006-2007)



Source: 2007 Pavement Condition Survey data

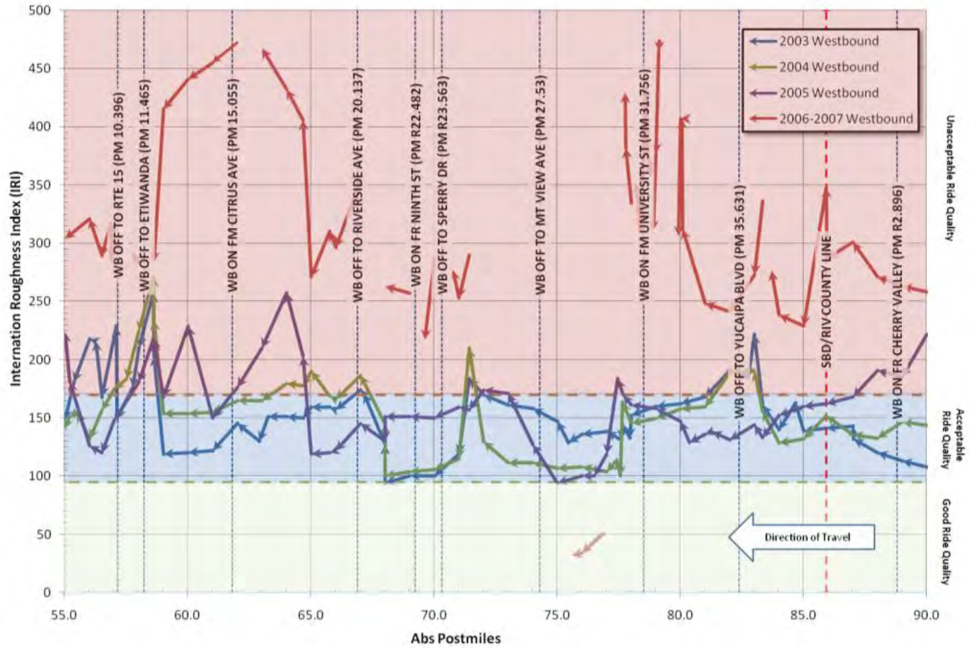
Exhibits 3D-6 and 3D-7 present ride conditions for the worst lane in each section on the I-10 Corridor using IRI from the last four pavement surveys. The information is presented by postmile and direction. The exhibits include color-coded bands to indicate the three ride quality categories defined by Caltrans: good ride quality (green), acceptable ride quality (blue), and unacceptable ride quality (red). The surveys show consistent patterns of good, acceptable, and unacceptable ride quality. Ride quality has worsened over the last few surveys, but this is expected with the aging of the freeway. The exhibits exclude a number of sections that were not measured or had calibration issues (i.e., IRI = 0) during the 2006-2007 PCS survey.

Exhibit 3D-6: Eastbound I-10 Road Roughness (2003-2007)



Source: 2003 to 2007 Pavement Condition Survey data

Exhibit 3D-7: Westbound I-10 Road Roughness (2003-2007)



Source: 2003 to 2007 Pavement Condition Survey data

4. SCENARIO DEVELOPMENT AND EVALUATION

Fully understanding how a corridor performs and why it performs that way is the foundation for evaluating potential solutions. Several steps were required to develop and evaluate improvements, including:

- Developing traffic models for 2008 base year and 2020 horizon year
- Combining projects in a logical manner for modeling and testing
- Evaluating model outputs and summarizing results
- Conducting benefit-cost assessments of scenarios.

Traffic Model Development

A traffic model was developed for I-10 using Vissim micro-simulation software. Micro-simulation models are among the few tools capable of providing a reasonable approximation of bottleneck formation and queue development. Although they require extensive calibration, simulation models help quantify the impacts of operational strategies that traditional travel demand models cannot.

Exhibit 4-1 shows the corridor roadway network included in the micro-simulation model. All freeway interchanges and on- and off-ramps are included. However, only arterial intersections adjacent to ramp intersections are included. Adding a more complete arterial network would have challenged the calibration process and delayed the overall project. A VISUM macroscopic model was developed to capture potential traffic diversion from I-210 and SR-60 as well as the following arterials: San Bernardino Avenue, Mill Street, Foothill Boulevard, and Baseline Avenue north of the corridor as well as Jurupa Street, Santa Ana Avenue, Center Street, and Barton Road south of the corridor. As described later, the VISUM model was used to assess diversion for Scenarios 5 and 6, which test the addition of HOV and general purpose lanes on I-10.

The base year model was calibrated against the 2008 conditions presented earlier. After the base year model met acceptance tests, a model with 2020 demands was interpolated from the Southern California Association of Government's (SCAG) 2030 travel demand model. Micro-simulation modeling captures the benefits of operational strategies, but can be calibrated to only short- and medium-term forecasts. Due to these modeling limitations, a 2020 Horizon Year was chosen to capture medium-term benefits.

The base and horizon year models were then used to evaluate different scenarios (combinations of projects) to quantify the associated mobility benefits and to compare the project costs against their benefits.

Exhibit 4-1: I-10 Micro-Simulation Model Network

Scenario Development Framework

A framework was developed for combining projects into scenarios for evaluation. It would be desirable to evaluate every possible combination of projects, but this would have entailed thousands of model runs. Instead, projects were combined based on a number of factors:

- Projects that could be delivered in the short-term (before 2015) were tested using both the 2008 and 2020 models to capture the short-term (2008) and long-term (2020) benefits. Total benefits were based generally on a 20-year useful life assumption.
- For horizon year 2020, a “do minimum” model was developed that does not include improvements scheduled for delivery before 2020 so the expected benefits from fully programmed improvements can also be evaluated. This is different from other studies that simply look for additional projects beyond those

programmed. These types of studies start with a "baseline" horizon year and include only projects completed before the horizon year.

- Projects with no programmed funds were tested separately from projects with programmed activities.
- Projects focusing on operational improvements were tested separately from projects that include combinations of operational and expansion strategies.

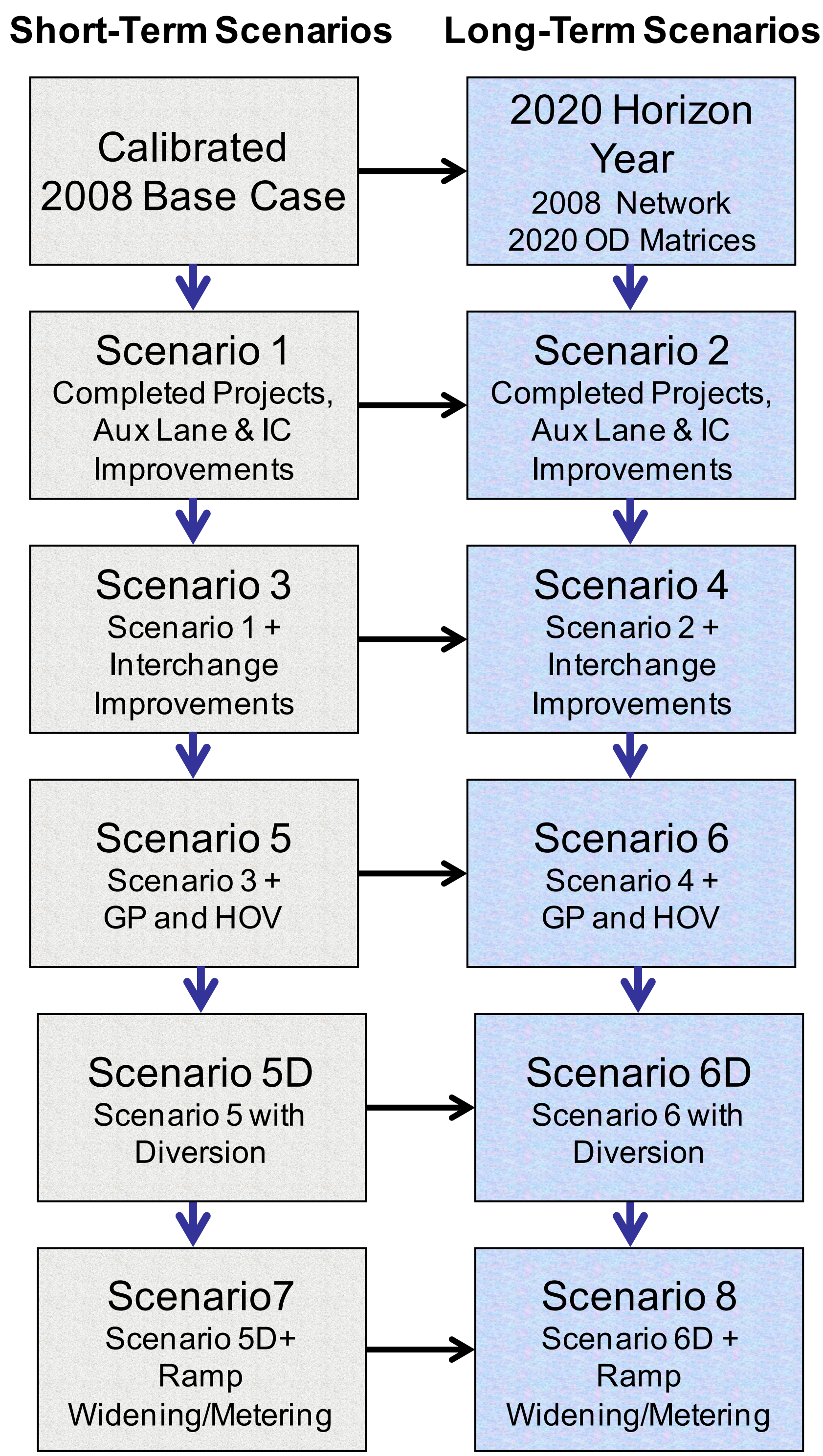
It was assumed that projects developed before 2015 could reasonably be evaluated using the 2008 base year model. The 2020 forecast year for the I-10 CSMP corridor was consistent with the origin-destination matrices in the SCAG regional travel demand model.

Project lists used to develop scenarios were obtained from the Regional Transportation Improvement Program (RTIP), the Regional Transportation Plan (RTP), and the State Highway Operation and Protection Program (SHOPP). Projects that do not directly affect mobility were eliminated. For instance, sound wall and landscaping projects were eliminated because micro-simulation models cannot evaluate them. Appendix A provides project lists used in developing the micro-simulation scenarios.

Scenario testing performed for the I-10 CSMP differs from traditional alternatives evaluations included in MIS or Environmental Impact Reports (EIRs). Traditional alternatives evaluations or EIRs focus on identifying alternative solutions to addressing current or projected corridor problems, so each alternative is evaluated separately and results are compared. At the end, a locally preferred alternative is defined. In contrast, the CSMP scenarios build on each other. A given scenario generally equates to a previous one plus one or more projects. This difference is important since corridor management studies are new and often confused with alternative studies.

Exhibit 4-2 summarizes the approach used and scenarios tested. It also provides a general description of the projects included in the 2008 and 2020 micro-simulation runs.

Exhibit 4-2: Micro-Simulation Modeling Approach



Exhibits 4-3 and 4-4 show the delay results for all the 2008 scenarios evaluated for the AM and PM peak periods, respectively. Exhibits 4-5 and 4-6 show similar results for scenarios evaluated using the 2020 horizon year model. The percentages shown in the exhibits indicate the difference in delay between the current scenario and the previous scenario (e.g., Percent Change = (Current Scenario – Previous Scenario)/Previous Scenario). Impacts of strategies differ based on a number of factors such as traffic flow conditions, ramp storage, bottleneck locations, and levels of congestion. Note that the results for the arterial intersections adjacent to ramps are reported as "arterials" in the exhibits. The delay calculated was based on the simulation and was not field verified.

For each scenario, proposed improvements were added to the model, multiple model runs were conducted, and composite results by facility type (i.e., mainline, HOV, ramps, and adjacent arterial intersections) and vehicle type (SOV, HOV, and trucks) as well as speed contour diagrams were produced. The results of each scenario were reviewed in detail to ensure they made sense before testing the next scenario of proposed improvements.

Exhibits 4-7 to 4-10 show the delay results by corridor segments (current bottleneck areas) and peak period for all 2008 scenarios. Exhibits 4-11 to 4-14 show similar results for all 2020 scenarios. A traffic report with all the model output details is available under separate cover.

Exhibit 4-3: AM Peak Micro-Simulation Delay Results by Scenario (2008)

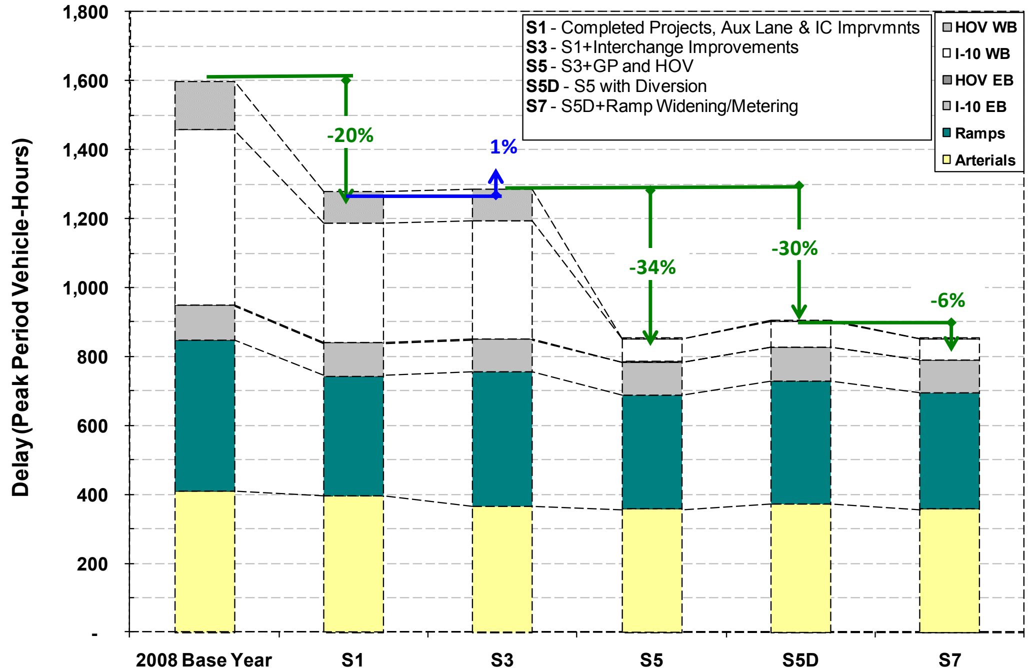


Exhibit 4-4: PM Peak Micro-Simulation Delay Results by Scenario (2008)

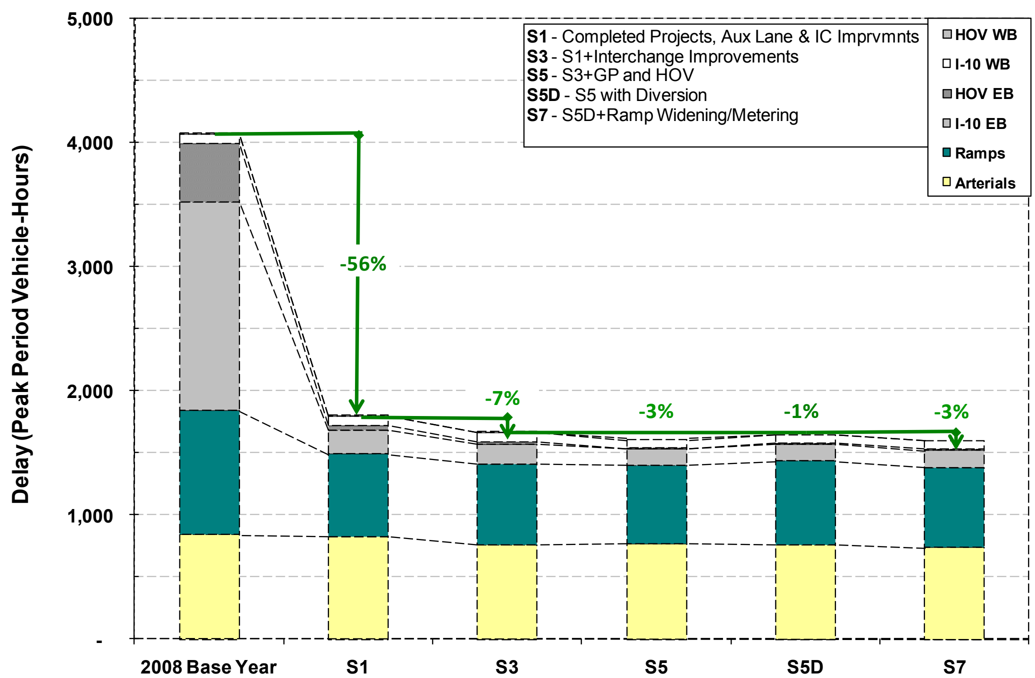


Exhibit 4-5: AM Peak Micro-Simulation Delay Results by Scenario (2020)

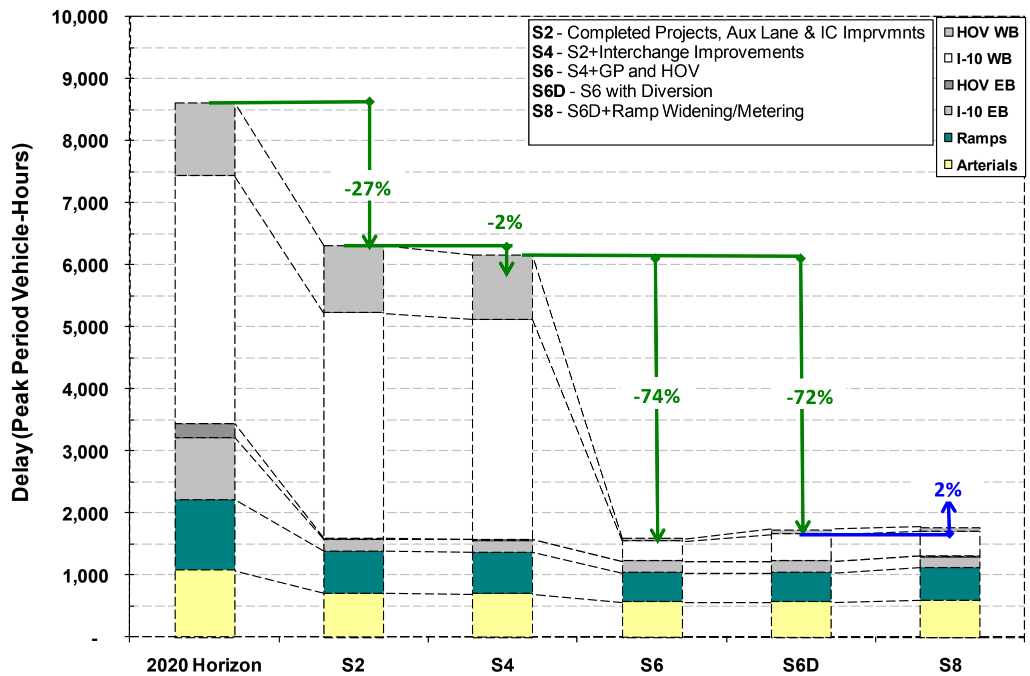


Exhibit 4-6: PM Peak Micro-Simulation Delay Results by Scenario (2020)

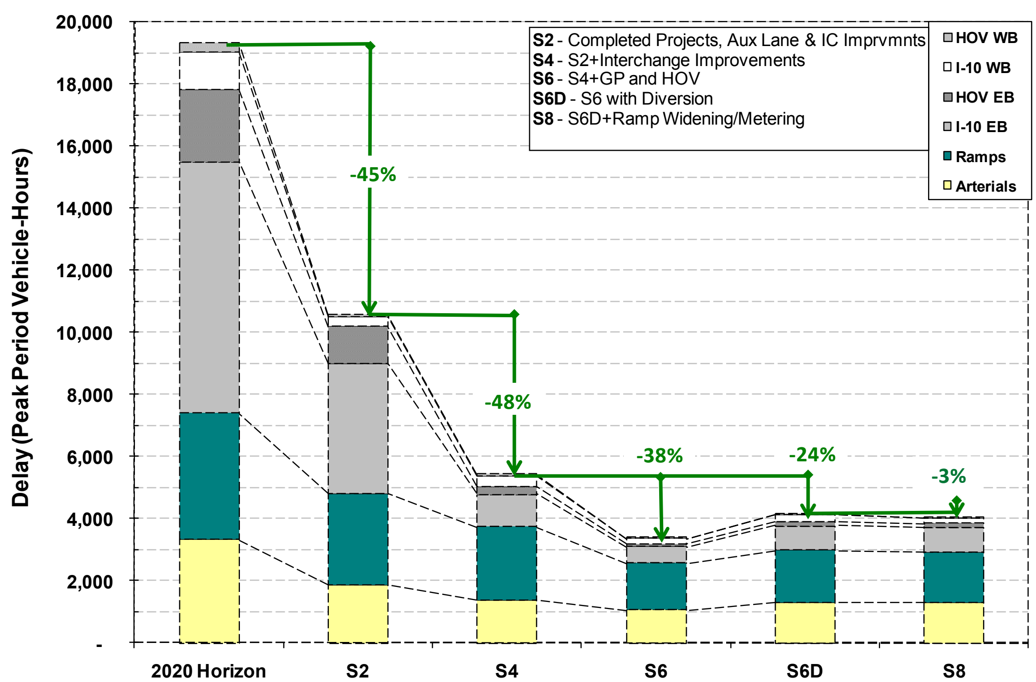


Exhibit 4-7: Eastbound AM Delay Results by Scenario and Bottleneck Area (2008)

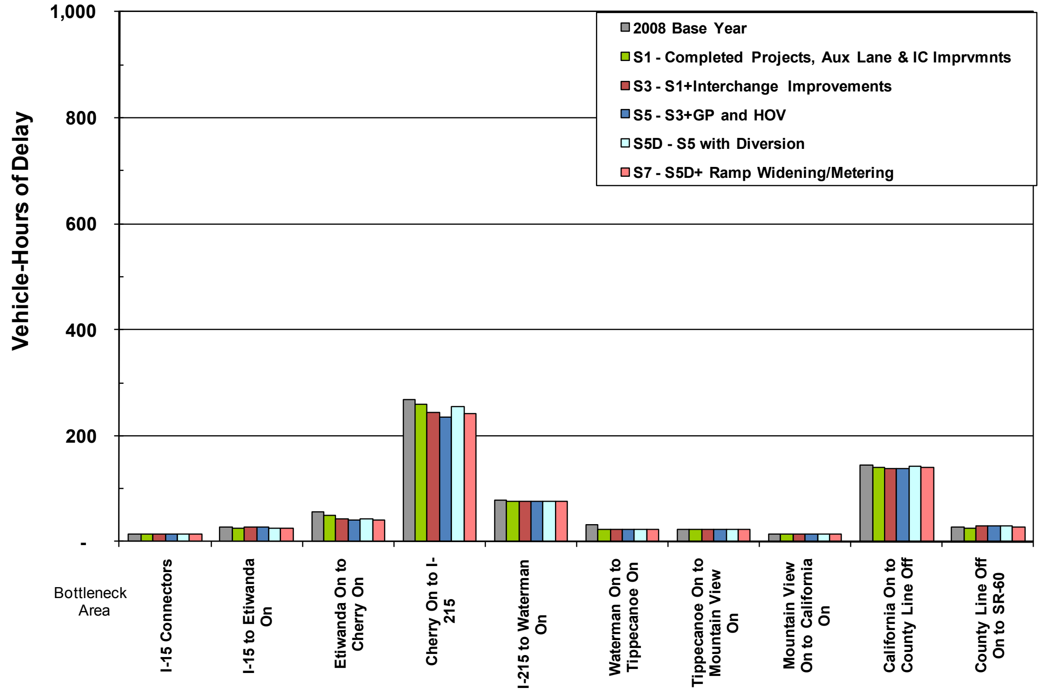


Exhibit 4-8: Eastbound PM Delay Results by Scenario and Bottleneck Area (2008)

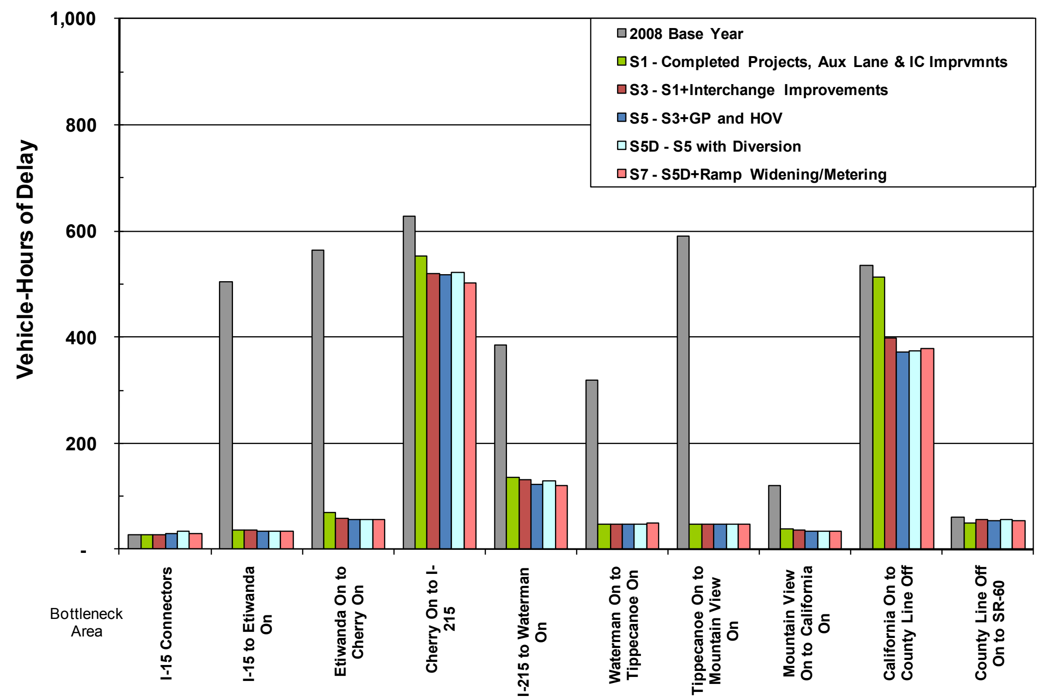


Exhibit 4-9: Westbound AM Delay Results by Scenario and Bottleneck Area (2008)

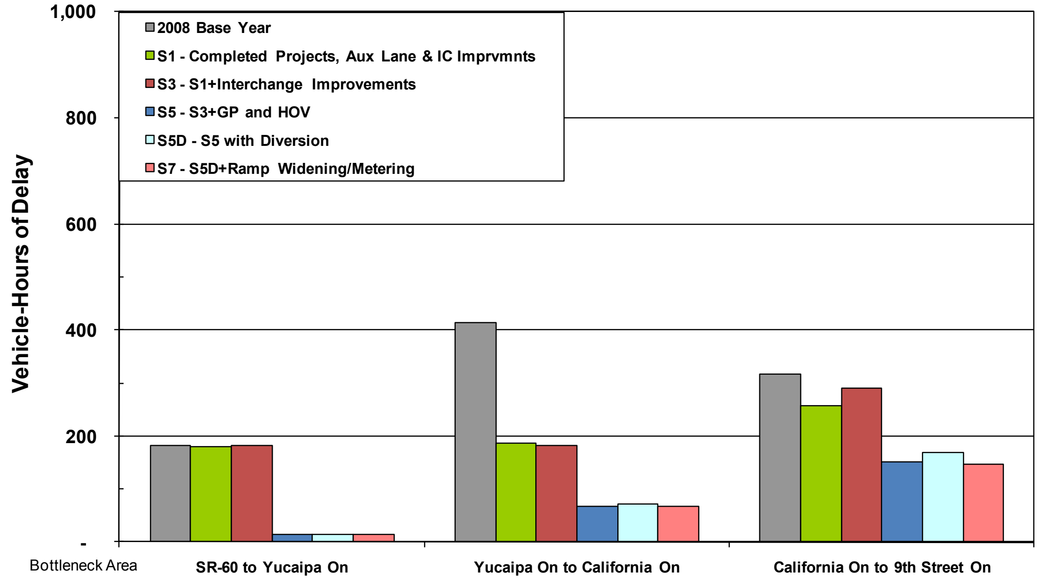


Exhibit 4-10: Westbound PM Delay Results by Scenario and Bottleneck Area (2008)

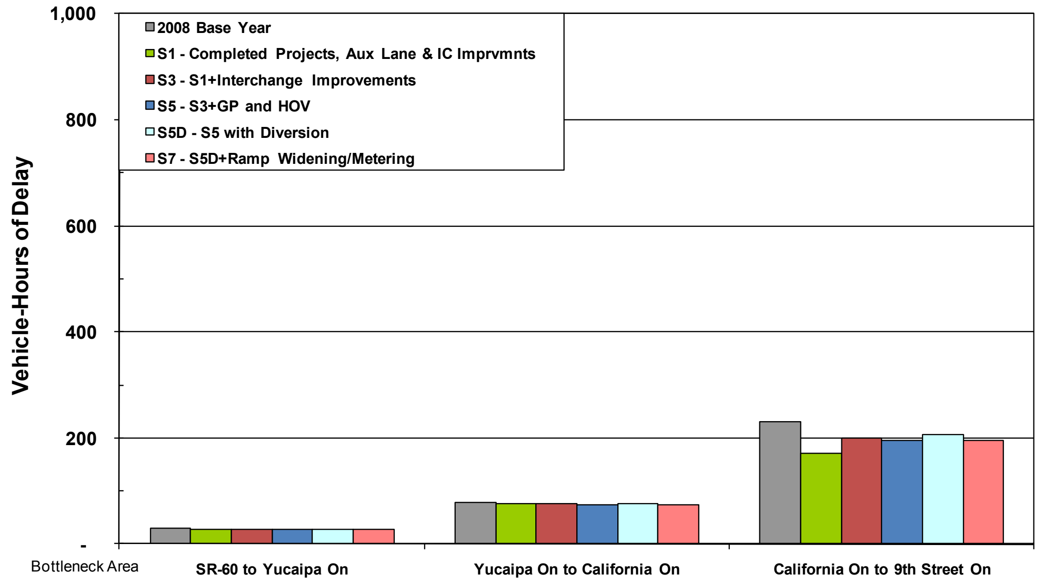


Exhibit 4-11: Eastbound AM Delay Results by Scenario and Bottleneck Area (2020)

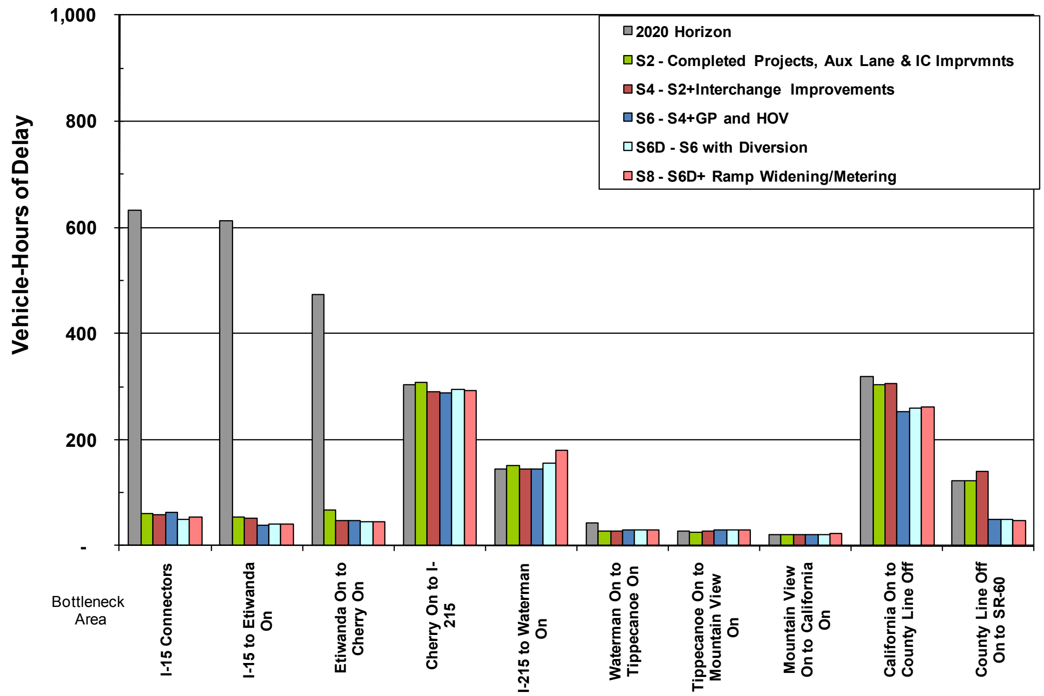


Exhibit 4-12: Eastbound PM Delay Results by Scenario and Bottleneck Area (2020)

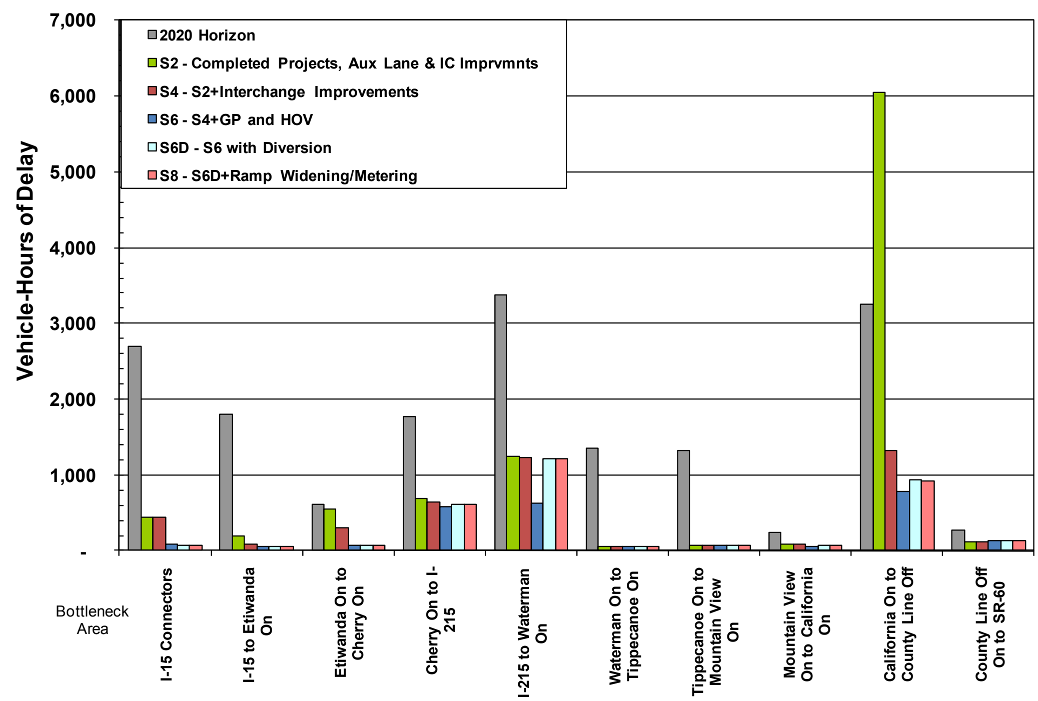


Exhibit 4-13: Westbound AM Delay Results by Scenario and Bottleneck Area (2020)

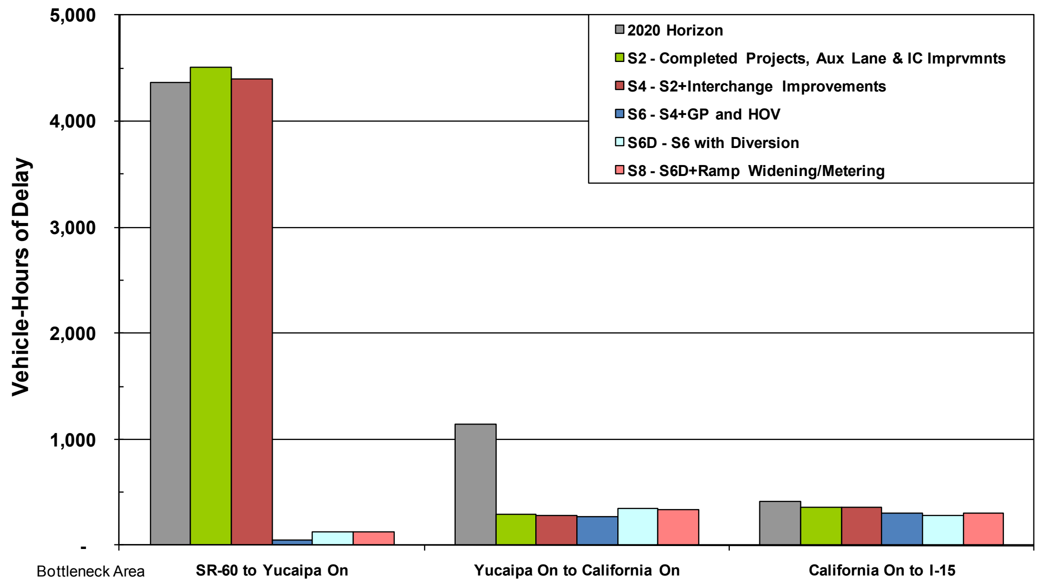
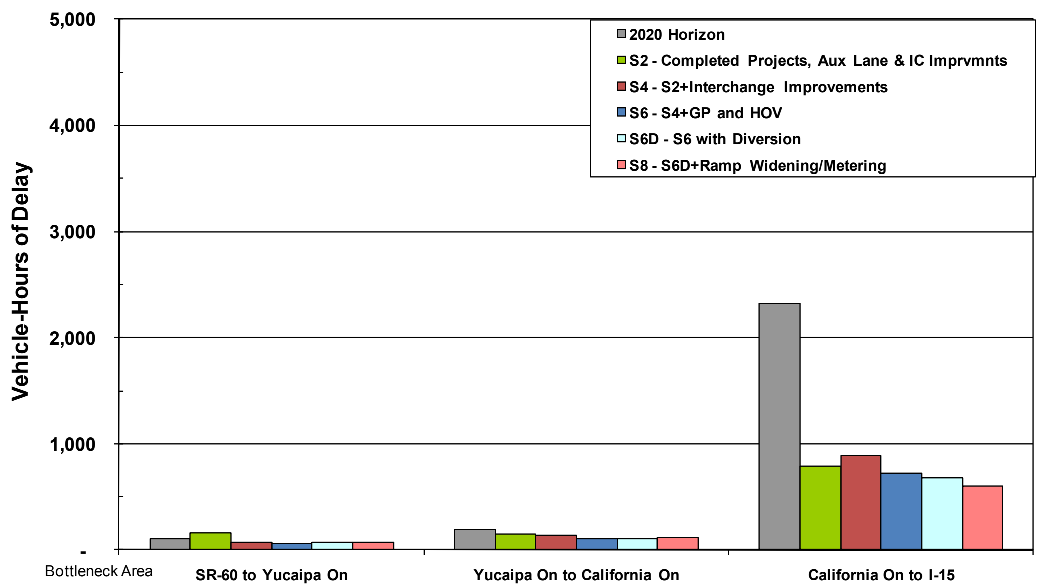


Exhibit 4-14: Westbound PM Delay Results by Scenario and Bottleneck Area (2020)



The following describes the findings for each scenario tested and reviewed.

2008 Base Year and 2020 "Do Minimum" Horizon Year

Without any improvements, it is estimated that by 2020, total delay (mainline, ramps, and arterial intersections adjacent to ramps) will increase by almost 400 percent compared to 2008 (from a total of around 5,700 daily vehicle-hours of delay to nearly 28,000 daily vehicle-hours of delay). Demand may continue to increase beyond 2020 and may require further study. As described in the results for Scenarios 1 and 2, projects with already programmed activities will lead to significant decreases in congestion.

Scenarios 1 and 2 (Completed Projects, Auxiliary Lane, Interchange Improvements)

The first two scenarios include completed projects and projects slated for completion by 2015 that involve addition of auxiliary lanes and interchange improvements. They include:

- Reconfiguring and widening Live Oak Canyon Road in Yucaipa from 2 to 5 through lanes
- Installing vehicle detection systems (VDS) on I-10, SR-91, and I-215
- Installing fiber communication backbone, ramp metering, and changeable message signs at Waterman Avenue, Tippecanoe Avenue, Mountain View Avenue, California Street, and Alabama Street on I-10 and at Iowa Avenue, Barton Road and Mount Vernon/Washington on I-215
- Restriping roadbed to add an eastbound auxiliary lane from Waterman Avenue to Alabama Street
- Widening exit ramps and constructing auxiliary lanes from Etiwanda Avenue to Riverside Avenue
- Reconfiguring Tippecanoe Avenue interchange and adding eastbound off-ramp; adding auxiliary lane from Waterman Avenue to Tippecanoe Avenue; modifying and improving local roads
- Reconstructing Cedar Avenue interchange and widening from 4 to 6 lanes between Slover Avenue and Valley Boulevard
- Modifying Pepper Avenue interchange; widening from 5 to 7 lanes; adding auxiliary lanes

The 2008 model estimates that the combination of projects in Scenario 1 will reduce delay on the corridor by 20 percent in the AM peak period and by 56 percent in the PM peak period. In total, this scenario produces a reduction of over 2,600 vehicle-hours of daily (AM and PM peak period) delay. In the westbound direction, the majority of the delay reduction occurs during the AM peak period from Yucaipa Boulevard to California Street. In the eastbound direction, the greatest mobility improvements occur during the

PM peak period from Tippecanoe Avenue to Mountain View Avenue. The bottleneck areas from I-15 to Cherry Avenue also experience large delay reductions.

The 2020 model estimates that the same projects will reduce delay on the corridor by approximately 27 percent in the AM peak period and 45 percent in the PM peak period, for a total daily reduction of over 11,000 vehicle-hours of delay.

Scenarios 3 and 4 (Interchange Improvements)

Scenarios 3 and 4 build on Scenarios 1 and 2 by adding interchange improvement projects at Riverside Avenue, Citrus Avenue, Cherry Avenue, and Singleton Road. The scenarios also include constructing new interchanges at Beech Avenue and Alder Avenue in Fontana and signalizing County Line Road and University Street.

The 2008 model estimates that Scenario 3 delay results would be similar to those for Scenario 1 during the AM peak period, while a seven-percent reduction in delay would occur in the PM peak period. The delay reductions are much larger in 2020. The 2020 model estimates that Scenario 4 would result in delay reductions of over two percent during the AM peak period and 48 percent in the PM peak period compared to Scenario 2. The majority of the delay reductions experienced during the PM peak period occurs from California Street to County Line Road. Overall, the 2020 model estimates a total daily delay reduction (AM and PM peak periods) of almost 5,300 vehicle-hours.

Scenarios 5 and 6 (General Purpose and HOV)

Scenarios 5 and 6 build on Scenarios 3 and 4 by adding a general purpose (mixed-use) lane to westbound I-10 from Ford Street to Live Oak Canyon Road and an HOV facility in both directions with auxiliary lanes from Haven Avenue and Ford Street.

The 2008 model estimates that with these capacity enhancing projects, Scenario 5 would result in delay reductions of 34 percent in the AM peak period and three percent in the PM peak period. In Scenario 6, the 2020 model estimates large delay reductions of 74 percent during the AM peak period and 38 percent during the PM peak period for a total daily delay reduction of over 6,600 vehicle-hours.

Scenarios 5D and 6D (Scenarios 5 and 6 with Diversion)

Scenarios 5D and 6D are the same as Scenarios 5 and 6 except they take into account the traffic diverted from parallel freeways and arterials. The parallel freeways include SR-210 and SR-60 with major arterials north and south of the I-10 corridor. The 2008 model estimates that the I-10 corridor would experience slight delay increases when compared to the scenario without diversion. However, Scenario 5D is still estimated to have a small delay reduction of almost one percent during the AM peak period and 13 percent during the PM peak period compared to the Scenario 3 model results.

The 2020 model estimates that Scenario 6D would result in delay reduction of almost 72 percent during the AM peak period and approximately 24 percent during the PM peak period compared to the Scenario 4 model results. The total daily delay is still significantly reduced at over 5,700 vehicle-hours.

Scenarios 7 and 8 (Ramp Widening and Metering)

Scenarios 7 and 8 build on Scenarios 5D and 6D by testing ramp widening and metering at Cedar Avenue, Pepper Avenue, Rancho Avenue, 9th Street, and Mount Vernon Avenue.

The 2008 model estimates slight delay reductions for both the AM and PM peak periods. Scenario 7 would result in a total reduction of less than 100 vehicle-hours during the AM and PM peak periods since most of the congestion on the corridor is gone. Likewise, the 2020 model estimates that Scenario 8 would result in a net change of less than 100 vehicle-hours of delay for the AM and PM peak periods.

Post Scenarios 7 and 8 Conditions

With the inclusion of projects from Scenarios 1 to 8, the 2020 model reveals that there is very little residual congestion remaining to be addressed with future improvements. According to the model results, the total remaining delay on the corridor is less than 5,600 vehicle-hours of daily delay in 2020. Only the eastbound Waterman Avenue bottleneck area during the PM peak period has daily delay exceeding 1,000 vehicle-hours with approximately 400 vehicle-hours of delay each for the mainline, ramps, and adjacent arterial intersections. Initially additional scenarios had been identified, but the modeling demonstrated that they are not needed until additional demand occurs on the corridor.

Benefit-Cost Analysis

Following an in-depth review of the model results, a benefit-cost analysis (BCA) was developed for each scenario. The benefit-cost results represent the incremental benefits over the incremental costs of a given scenario.

The California Life-Cycle Benefit/Cost Analysis Model (Cal-B/C) was used to estimate benefits in three key areas: travel time savings, vehicle operating cost savings, and emission reduction savings. The results are conservative since this analysis does not capture benefits after the 20-year lifecycle or other benefits, such as the reduction in congestion beyond the peak periods and improvement in transit travel times.

Project costs were obtained from various sources, including the RTIP and RTP. A benefit-cost ratio (B/C) greater than "1" means that a scenario's projects return benefits greater than they cost to construct or implement. It is important to consider the total benefits that projects bring.

Exhibit 4-15 illustrates typical benefit-cost ratios for different types of projects. Large capital expansion improvements generally produce low benefit-cost ratios because the costs are so high. Conversely, transportation management strategies such as ramp metering produce high benefit-cost ratios given their low costs. The benefit-cost analysis for the I-10 CSMP Corridor is summarized in Exhibit 4-16.

Exhibit 4-15: Benefit-Cost Ratios for Typical Projects

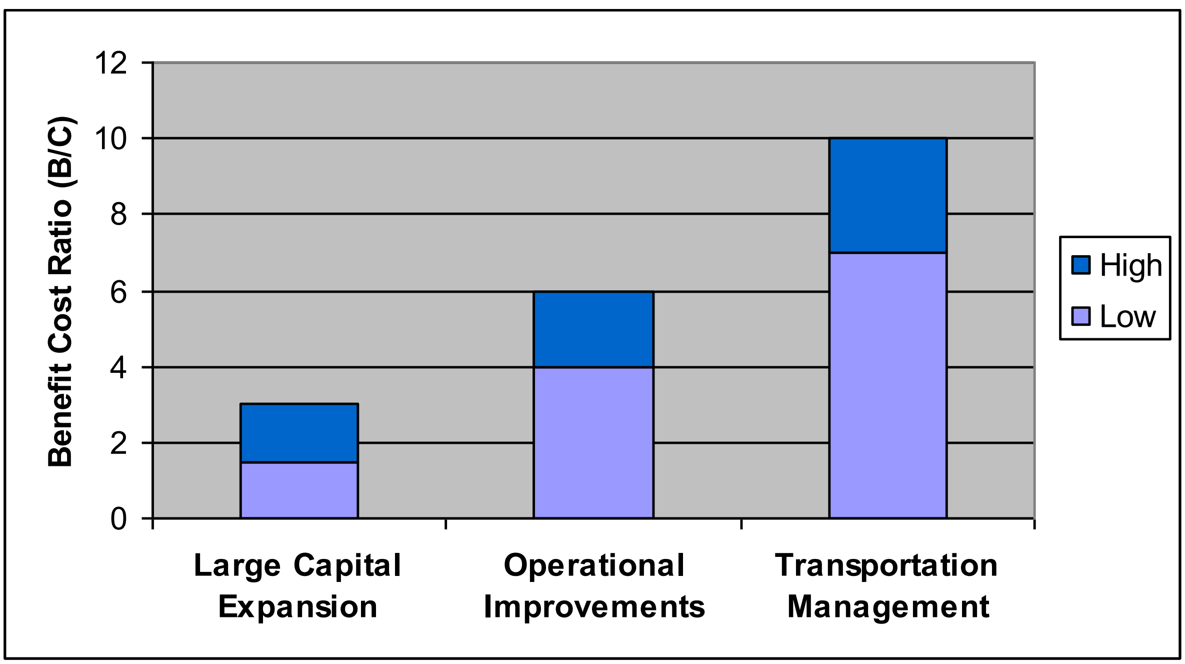
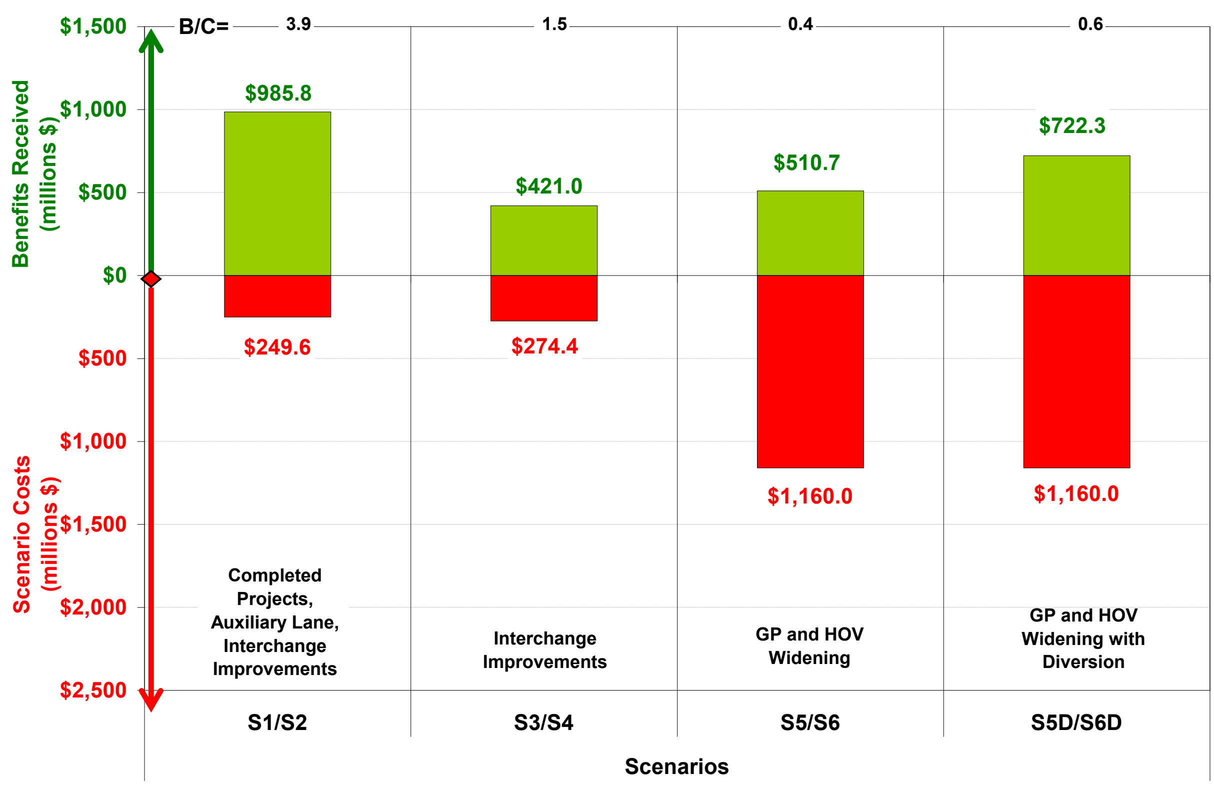


Exhibit 4-16: Scenario Benefit/Cost (B/C) Results



The benefit-cost findings for each scenario are as follows:

- Scenarios 1 and 2 (completed projects including auxiliary lanes and interchange improvements) produce a high benefit-cost ratio of almost 4 to 1.
- Scenarios 3 and 4 (interchange improvements) produce a benefit-cost ratio of 1.5 to 1.
- Scenarios 5 and 6 (general purpose lane and HOV lane additions) produce a low benefit-cost ratio of less than 1. The benefit-cost ratio is lowered by the high cost expansion projects.
- Scenarios 5D and 6D (general purpose lane and HOV lane additions with diversion from adjacent freeways and arterials benefits) also produce a benefit-cost ratio of less than 1.
- Scenarios 7 and 8 (ramp widening and metering) were also tested but did not produce any benefits.
- The benefit-cost ratio of all the scenarios combined is about 1.8 to 1. This means that, if all the projects are delivered at current cost estimates, the public

will get almost two dollars of benefits for each dollar expended. In current dollars, costs add to around $2.5 billion whereas the benefits are estimated to be almost $4.5 billion.

- The projects also alleviate greenhouse gas (GHG) emissions by over 2.5 million tons over 20 years, averaging nearly 124,000 tons reduced per year. The emissions reductions are estimated in Cal-B/C using data from the California Air Resources Board (CARB) Emissions Factors (EMFAC) model.

Detailed benefit-cost results can be found in Appendix B.

5. CONCLUSIONS AND RECOMMENDATIONS

This section summarizes conclusions and recommendations based on the analysis presented. Many of these conclusions are based on the micro-simulation model results using the best data available at the time of the analysis.

However, caution should always be used when making decisions based on modeling alone. Engineering and professional judgment and experience, among other technical factors should be taken into consideration in making the most effective project decisions that affect millions, if not billions, of dollars in investment. Project decisions are based on a combination of regional and inter-regional plans and needs, regional and local acceptance for the project, availability of funding, planning and engineering requirements.

Based on the results, the following conclusions and recommendations are offered:

- Although the costs of the completed projects and other auxiliary lane and interchange improvement projects (including CMIA) in Scenarios 1 and 2 total almost $250 million combined, the model results indicate that benefits could outweigh costs by almost 4 to 1 with benefits reaching almost $1 billion over a 20-year lifecycle. These projects produce significant returns on investment.
- The benefit-cost ratio for Scenarios 3 and 4 is just slightly above 1 to 1. These investment results are reasonable given the types of projects and associated improvement costs.
- With many of the major bottleneck areas already addressed by projects in Scenarios 1 to 4, the expansion projects, such as the general purpose lane and HOV lane additions, do not produce a significant return for the cost. Only a small increase in benefits is derived from traffic being diverted from the adjacent freeways and arterials.

Exhibits 5-1 and 5-2 show speed contour maps for the I-10 mainline in the 2020 "Do Minimum" Horizon Year with the growth in congestion before any improvements. Exhibits 5-3 and 5-4 show the speed contour maps produced by the model for the mainline at the conclusion of Scenarios 7 and 8, the final scenarios tested. Other speed contour maps can be found in the traffic report. Exhibits 5-3 and 5-4 show the residual congestion and bottleneck locations. There is very little congestion by 2020 after all of the scenarios are implemented. Only a small amount of congestion at Waterman Avenue remains in the eastbound direction in the PM peak period. Since the CSMP horizon year model is for 2020, further study or other methodology may be needed to assess the benefits of addressing demand beyond 2020.

Exhibit 5-1: Eastbound PM Peak Model Speed Contours Before Improvements (2020)

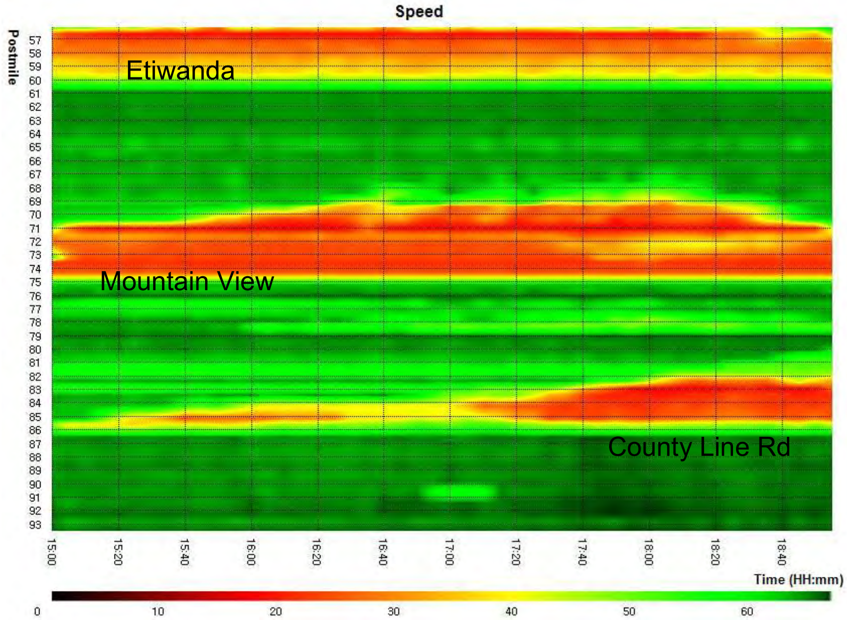


Exhibit 5-2: Westbound AM Peak Model Speed Contours Before Improvements (2020)

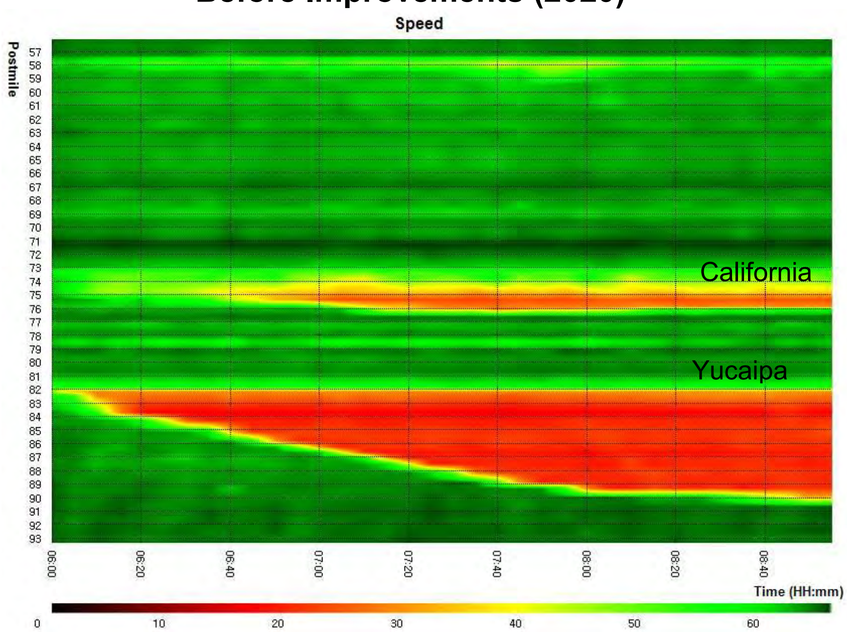


Exhibit 5-3: Eastbound PM Peak Model Speed Contours After Improvements (2020)

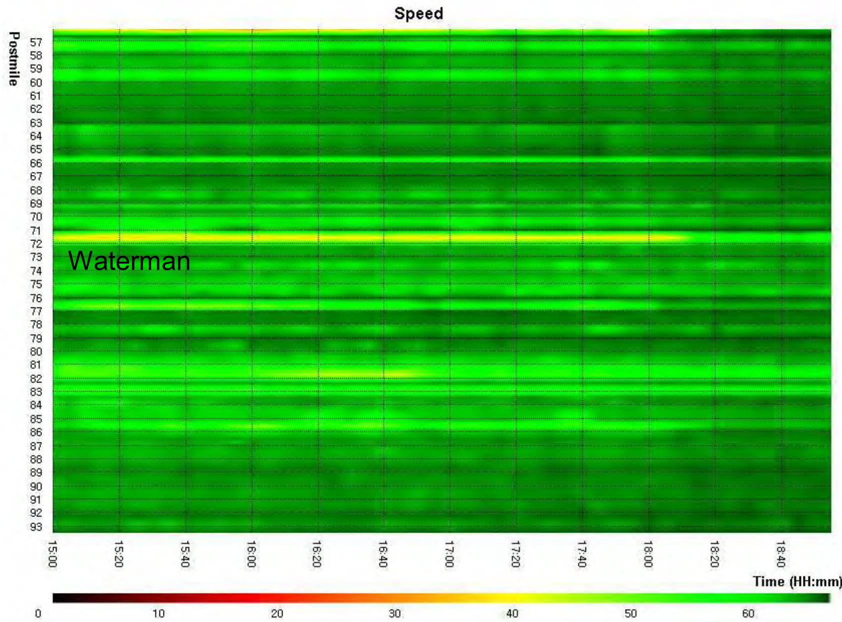
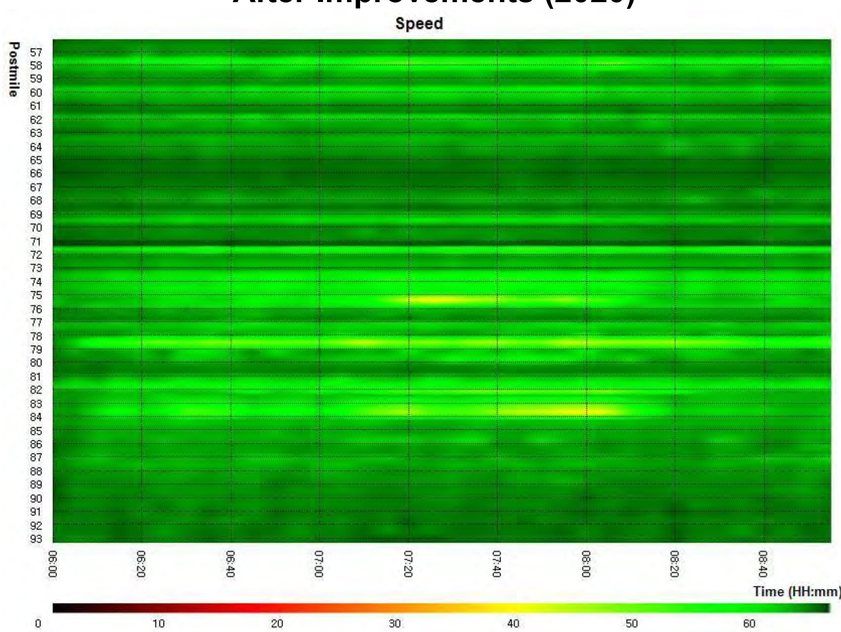


Exhibit 5-4: Westbound AM Peak Model Speed Contours After Improvements (2020)



This is the first-generation CSMP for the I-10 corridor. It is important to emphasize that CSMPs should be updated on a regular basis, if possible. This is particularly important since future travel patterns and traffic conditions can differ from current projections. After projects are delivered it is useful to compare the resulting performance, realized benefits, and the actual costs to the current estimates in order to improve future models as appropriate.

CSMPs, or some variation, should become the normal course of business that includes detailed performance assessments, an in-depth understanding of the reasons for performance deterioration, and an analytical framework that allows for evaluating complementary operations strategies that maximize system productivity.

Appendix A: Project List for Micro-Simulation Scenarios

Scenario	Proj ID	Improvement	Lead Agency	Beg PM	End PM	Expected Compl Date	Source	Est Total Proj Cost (in 1,000s)
	43320	In Yucaipa @ Live Oak Canyon road IC **reconfigure IC** and widen Live Oak Canyon Road from 2 to 5 thru lanes (I-10/Live Oak Canyon) (TCRP #59)	YUCAIPA	35.5	39.2	Completed 09/2009	06 & 08 RTIP	$ 18,634
	EA 0K500	In Riverside and San Bernardino Counties on Routes 10, 91 and 215 (portion also in Los Angeles County on Route 5). **Install Vehicle Detection Systems (VDS)**. (**Prop 1B Bond Funded**)	CALTRANS			Completed 06/2009	07 & 08 SHOPP	$ 4,907
	EA 38420	Install fiber communication backbone, ramp metering, and changeable message signs at Waterman, Tippecanoe, Mt View, California and Alabama ramps on I-10 and at Iowa Avenue, Barton Road and Mt Vernon/Washington on I-215	CALTRANS	23.6	33.4	Completed 9/2009	06 & 08 RTIP 06 SHOPP	$11,177 (SHOPP) $16,855 (RTIP)
	OH760	From Waterman Ave UC to Alabama St OC - restripe roadbed to add eastbound **aux lane** (**Caltrans Minor A**)	CALTRANS	25	29.5	Completed 10/2009	06 & 08 RTIP	$ 1,550
1 (2008-1) 2 (2020-1)	0H930	from Waterman Ave UC to Alabama St OC - restripe roadbed to add a westbound **auxiliary lane** (**Minor A**)	CALTRANS	25	29.5	10/2010	06 & 08 RTIP	$928 (CT)
	49750	From 0.8 km e/of Etiwanda Ave OVC to 1.5 km w/o Riverside Ave o/c-widen exit ramps and construct **aux lanes**	CALTRANS	12	19.8	11/2011	06 & 08 RTIP CMIA	$ 32,693
	44810 EA 1A490	I-10 Tippecanoe **reconfigure IC** & add eastbound off-ramp **auxiliary ln** from Waterman on-ramp to Tippecanoe off-ramp , widen bridge (non-capacity), & local rd imp/mod	SANBAG	25.3	27.3	2013	06 & 08 RTIP	$ 85,000
	1830	I-10 at Cedar Ave. between Slover and Valley- **reconstruct IC**-widen from 4-6 lanes with left and right turn lanes.	VARIOUS	17.8	19.3	2015	06 & 08 RTIP	$ 56,948
	SBD41339 EA 40830	Pepper Ave. at I-10 **IC modification** of Pepper Ave. widen bridge from 5-7 lanes and add **auxiliary lanes** to freeway	SB COUNTY	20.1	22	2015	06 & 08 RTIP	$ 33,000
	SBD31808 EA 42230	I-10 at Riverside Ave - 2.1 km w/o Riverside ave to 1.3 km e/o Riverside Ave. **modify IC** 4 to 9 lns (incl turn lns) from Slover to Valley & add aux lanes & oper imprv	RIALTO	19.4	20.4	2011	06 & 08 RTIP	$ 33,937
	SBD45000 EA 46810	I-10 at Citrus Ave IC **reconstruct IC** with 6 thru lanes; & replace bridge overcrossing (o/c widen from 2-6 lns) and widen Citrus from Slover to Valley 4-6 lns.	SANBAG	14.8	15.5	2014	06 & 08 RTIP	$ 54,697
	20020812 EA 46800	I-10/Cherry Ave. IC - **IC reconstruct** from Slover to Valley from 4-6 lanes & 1 aux ln ea. dir. w/ double left turns to ramps	VARIOUS	12.3	14.1	2014	06 & 08 RTIP	$ 77,806
3 (2008-2) 4 (2020-2)	RIV060117 EA 0F980	I-10/Singleton Rd **IC: reconstruct**/widen 2 to 4 through lanes (Woodhouse to Calimesa blvd), **Reconstruct/widen ramps** – EB entry 1 to 2 lns w/ HOV preferential ln, WB exit 1 to 3 lns, add EB exit ramp (3 lns), WB entry ramp (2 lns w/ HOV preferential ln)	CALIMESA	1.5	2.3	2018	06 & 08 RTIP	$ 38,400
	SBD031269 EA 0J120K	in Fontana at Beech Ave. Construct 4 **lane IC** (2 lanes in each direction).	FONTANA	13.7	14.6	2016	06 & 08 RTIP	$ 42,400
	34090	In Fontana at Alder Ave. **Construct IC**	FONTANA	16.9	17.9	2016	06 & 08 RTIP	$ 26,674
		Signalize County Line Road and University St					Added to improve model calibration	$ 500
5/5D (2008-3) 6/6D (2020-3)	200434 EA 0F1500	In Redlands and Yucaipa from Ford St. O/C to Live Oak Canyon Rd. Construct 1 WB **mixed-flow lane**	SANBAG	33.3	36.9	2011	06 & 08 RTIP CMIA	$ 70,001
	0C2500	I-10 **HOV lane** addition - from Haven (Ontario to Ford St (Redlands)-widening from 8-10 lanes, **aux lanes** widening UC and OC and reconstruction of ramps where needed	SANBAG	8.2	33.43	2018	2008 RTIP	$ 1,090,014
	EA 37004 EA 37701 EA 37700	In Fontana, SE quadrant of Rte 15/210 IC - construct new Transportation Management Center (L5506). In Fontana, SE quadrant of Rte 15/210 IC - stage 2 working drawings for Transportation Management Center (FCO to DGS) (Status: partially constructed, not complete)	CALTRANS	23.6	33.4	2011 (EA 37004) Completed EA 37701, EA 37700	06 SHOPP	$22,822 $2,346
7 (2008-4) 8 (2020-4)	EA 38434 EA 38430	Ramp widening and metering on I-10 at Cedar Ave, Pepper Ave, Rancho Ave, 9th Street and Mt Vernon Avenue. (**Prop 1B Bond Funded**) - Phase 2 of EA 38420	CALTRANS	9.9	R24.5	2012	09 & 10 SHOPP	$ 19,100
	200432	At I-10 and Ford St, on- ramp to the freeway - **signal and intersections** improvements	REDLANDS	33.3	33.5	2014	06 & 08 RTIP	$ 700

Appendix B: Benefit-Cost Analysis Results

This appendix provides more detailed benefit-cost analysis (BCA) results than found in Section 4 of the I-10 Corridor System Management Plan (CSMP) Final Report. The BCA results for this CSMP were estimated by using the *California Life-Cycle Benefit/Cost Analysis Model (Cal-B/C) Version 4.0*.

Caltrans uses Cal-B/C to conduct investment analyses of projects proposed for the interregional portion of the State Transportation Improvement Program (STIP), the State Highway Operations and Protection Program (SHOPP), and other ad hoc analyses requiring BCA. Cal-B/C is a spreadsheet-based tool that can prepare analyses of highway, transit, and passenger rail projects. Users input data defining the type, scope, and cost of projects. The model calculates life-cycle costs, net present values, benefit-cost ratios, internal rates of return, payback periods, annual benefits, and life-cycle benefits. Cal-B/C can be used to evaluate capacity expansion projects, transportation management systems (TMS), and operational improvements.

Cal-B/C measures, in constant dollars, four categories of benefits:

- Travel time savings (reduced travel time and new trips)
- Vehicle operating cost savings (fuel and non-fuel operating cost reductions)
- Accident cost savings (safety benefits)
- Emission reductions (air quality and greenhouse gas benefits).

Each of these benefits was estimated for the peak period for the following categories:

- **Life-Cycle Costs** - present values of all net project costs, including initial and subsequent costs in real current dollars.
- **Life-Cycle Benefits** - sum of the present value benefits for the project.
- **Net Present Value** - life-cycle benefits minus the life-cycle costs. The value of benefits exceeds the value of costs for a project with a positive net present value.
- **Benefit/Cost Ratio** - benefits relative to the costs of a project. A project with a benefit-cost ratio greater than one has a positive economic value.
- **Rate of Return on Investment** - discount rate at which benefits and costs are equal. For a project with a rate of return greater than the discount rate, the benefits are greater than costs and the project has a positive economic value. The user can use rate of return to compare projects with different costs and different benefit flows over different time periods. This is particularly useful for project staging.

- **Payback Period** - number of years it takes for the net benefits (life-cycle benefits minus life-cycle costs) to equal the initial construction costs. For a project with a payback period longer than the life-cycle of the project, initial construction costs are not recovered. The payback period varies inversely with the benefit-cost ratio. A shorter payback period yields a higher benefit-cost ratio.

The model calculates these results over a standard 20-year project life-cycle, itemizes each user benefit, and displays the annualized and life-cycle user benefits. Below the itemized project benefits, Cal-B/C displays three additional benefit measures:

- **Person-Hours of Time Saved** - reduction in person-hours of travel time due to the project. A positive value indicates a net benefit.
- **Additional CO_2 Emissions (tons)** - additional CO_2 emissions that occur because of the project. The emissions are estimated using average speed categories using data from the California Air Resources Board (CARB) EMFAC model. This is a gross calculation because the emissions factors do not take into account changes in speed cycling or driver behavior. A negative value indicates a project benefit. Projects in areas with severe congestion will generally lower CO_2 emissions.
- **Additional CO_2 Emissions (in millions of dollars)** - CO_2 emissions valued using a recent economic valuing methodology.

A copy of Cal-B/C v4.0, the User's Guide, and detailed technical documentation can be found at the Caltrans' Division of Transportation Planning, Office of Transportation Economics website at http://www.dot.ca.gov/hq/tpp/offices/ote/benefit.html.

The exhibits in this appendix are listed as follows:

- Exhibit B-1: Scenarios 1 & 2 Benefit-Cost Analysis Results
- Exhibit B-2: Scenarios 3 & 4 Benefit-Cost Analysis Results
- Exhibit B-3: Scenarios 5 & 6 Benefit-Cost Analysis Results
- Exhibit B-4: Scenarios 5D & 6D Benefit-Cost Analysis Results
- Exhibit B-5: Cumulative Benefit-Cost Analysis Results

Exhibit B-1: Scenarios 1 & 2 Benefit-Cost Analysis Results

3

INVESTMENT ANALYSIS
SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$249.6
Life-Cycle Benefits (mil. $)	$985.8
Net Present Value (mil. $)	$736.2
Benefit / Cost Ratio:	3.9
Rate of Return on Investment:	20.1%
Payback Period:	7 years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$41.6	$831.1
Veh. Op. Cost Savings	$5.4	$108.6
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$2.3	$46.0
TOTAL BENEFITS	$49.3	$985.8
Person-Hours of Time Saved	5,184,530	103,690,597
Additional CO_2 Emissions (tons)	-29,351	-587,023
Additional CO_2 Emissions (mil. $)	-$0.8	-$16.6

Exhibit B-2: Scenarios 3 & 4 Benefit-Cost Analysis Results

3

INVESTMENT ANALYSIS
SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$524.0
Life-Cycle Benefits (mil. $)	$1,406.7
Net Present Value (mil. $)	$882.7
Benefit / Cost Ratio:	2.7
Rate of Return on Investment:	14.2%
Payback Period:	9 years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$59.7	$1,193.7
Veh. Op. Cost Savings	$7.5	$149.8
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$3.2	$63.3
TOTAL BENEFITS	$70.3	$1,406.7
Person-Hours of Time Saved	7,557,197	151,143,944
Additional CO_2 Emissions (tons)	-41,175	-823,496
Additional CO_2 Emissions (mil. $)	-$1.2	-$23.1

Incremental Costs (mil. $)	$274.4
Incremental Benefits (mil. $)	$421.0
Incremental Benefit / Cost Ratio:	1.5

Exhibit B-3: Scenarios 5 & 6 Benefit-Cost Analysis Results

3

INVESTMENT ANALYSIS
SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$1,684.0
Life-Cycle Benefits (mil. $)	$1,917.4
Net Present Value (mil. $)	$233.4
Benefit / Cost Ratio:	1.1
Rate of Return on Investment:	5.1%
Payback Period:	15 years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$83.8	$1,675.5
Veh. Op. Cost Savings	$8.5	$170.2
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$3.6	$71.8
TOTAL BENEFITS	$95.9	$1,917.4
Person-Hours of Time Saved	10,702,924	214,058,483
Additional CO_2 Emissions (tons)	-48,695	-973,907
Additional CO_2 Emissions (mil. $)	-$1.3	-$26.9

Incremental Costs (mil. $)	$1,160.0
Incremental Benefits (mil. $)	$510.7
Incremental Benefit / Cost Ratio:	0.4

Exhibit B-4: Scenarios 5D & 6D Benefit-Cost Analysis Results

3

INVESTMENT ANALYSIS
SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$1,684.0
Life-Cycle Benefits (mil. $)	$2,129.0
Net Present Value (mil. $)	$445.0
Benefit / Cost Ratio:	1.3
Rate of Return on Investment:	n/a
Payback Period:	n/a

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$92.2	$1,843.5
Veh. Op. Cost Savings	$9.7	$193.3
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$4.6	$92.2
TOTAL BENEFITS	$106.5	$2,129.0
Person-Hours of Time Saved	11,642,614	232,852,285
Additional CO_2 Emissions (tons)	-53,307	-1,066,131
Additional CO_2 Emissions (mil. $)	-$1.5	-$29.7

Incremental Costs (mil. $)	$1,160.0
Incremental Benefits (mil. $)	$722.3
Incremental Benefit / Cost Ratio:	0.6

Exhibit B-5: Cumulative Benefit-Cost Analysis Results

3

INVESTMENT ANALYSIS
SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$2,457.6
Life-Cycle Benefits (mil. $)	$4,521.6
Net Present Value (mil. $)	$2,064.0
Benefit / Cost Ratio:	1.8
Rate of Return on Investment:	
Payback Period:	

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$193.4	$3,868.3
Veh. Op. Cost Savings	$22.6	$451.7
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$10.1	$201.6
TOTAL BENEFITS	$226.1	$4,521.6
Person-Hours of Time Saved	24,384,341	487,686,825
Additional CO_2 Emissions (tons)	-123,833	-2,476,650
Additional CO_2 Emissions (mil. $)	-$3.5	-$69.5