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Caltrans

Corridor System Management Plan (CSMP)

Los Angeles County I-405 Corridor

Final Report

September 2010

I approve this Corridor System Management Plan (CSMP) for I-405 in Caltrans District 7 as the overall Policy Statement and Strategic Plan that will guide transportation decisions and investment for the I-405 Corridor from I-110 to the I-5 junction in Los Angeles County.

Approval

3/7/11

MICHAEL MILES — Date

District 7 Director

Table of Contents

List of Exhibits

1. INTRODUCTION

This document represents the Final Report for the Los Angeles Interstate 405 (I-405) Corridor System Management Plan (CSMP) developed by the California Department of Transportation (Caltrans). The Los Angeles County I-405 study corridor runs in a north-south direction from the I-110 (Harbor Freeway) Interchange in Torrance (post mile 12.5) to the end of the freeway at the I-5 (Golden State Freeway) Interchange in San Fernando (post mile 48.5).

This final report contains the results of a two-year study that included several key steps, including:

- Stakeholder Involvement (discussed below in this Section 1)
- Corridor Description and Performance Assessment (Sections 2 and 3)
- Bottleneck Identification and Causality Analysis (Section 4)
- Scenario Development and Evaluation (Section 5)
- Conclusions and Recommendations (Section 6).

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 deposited into a Corridor Mobility Improvement Account (CMIA). CMIA money is partially funding the northbound I-405 High Occupancy Vehicle (HOV) lane from I-10 in Los Angeles to US-101 in Sherman Oaks. Approximately, $730 million in CMIA funds have been adopted by the CTC for this project.

To receive CMIA funds, the California Transportation Commission (CTC) guidelines required that project sponsors describe in a CSMP how mobility gains from CMIA funded corridor improvements would be maintained over time. A CSMP therefore aims to define how corridors will be managed in the long term, focusing on operational strategies in addition to the already funded expansion projects. The goal is to get the most out of the existing system and maintain or improve corridor performance.

This report presents performance measurement findings, identifies bottlenecks that lead to less than optimal performance, and diagnoses the causes for these bottlenecks in detail. Alternative investment strategies were modeled using the year 2003 as the Base Year and 2020 as the Horizon Year.

This CSMP should be updated by Caltrans on a regular 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 current CSMP and the relative priorities in investments.

Therefore, it is recommended that updates occur no less than every two to three years. To the extent possible, this document has been organized to facilitate such updates.

The following discussion provides background to the system management approach in general and CSMPs in particular.

What is a Corridor System Management Plan (CSMP)?

In November 2006, voters approved Proposition 1B (The Highway Safety, Traffic Reduction, Air Quality, and Port Security Bond Act of 2006). This ballot measure included a funding program that to be deposited into a Corridor Mobility Improvement Account (CMIA). For a project to be nominated by a Caltrans district or regional agency, California Transportation Commission (CTC) CMIA guidelines require that the project nomination describe how mobility gains of urban corridor capacity improvements would be maintained over time.

The guidelines also stipulate that the CTC will give priority to project nominations that include a CSMP. A CSMP is a comprehensive plan for supporting the congestion reduction and productivity improvements achieved on a CMIA corridor. CSMPs incorporate all travel modes - including State highways and freeways, parallel and connecting roadways, public transit (bus, bus rapid transit, light rail, intercity rail), carpool/vanpool programs, and bikeways. CSMPs also include intelligent transportation technologies such as ramp metering, coordinated traffic signals, changeable message signs for traveler information, and improved incident management.

This CSMP is the first attempt to integrate the overall concept of system management into Caltrans' planning and decision-making processes for the I-405 study corridor. Traditional planning approaches identify localized freeway problem areas and then developed solutions to fix those problems often by building expensive capital improvement projects. The I-405 CSMP focuses on the system management approach with a greater emphasis on using on-going performance assessments to identify operational strategies that yield higher congestion reduction and productivity benefits relative to the amount of money spent.

Caltrans develops integrated multimodal projects in balance with community goals, plans, and values. Caltrans seeks and tries 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 CSMP, this report is focused more on reducing congestion and increasing mobility through capital and operational strategies. Future CSMP work will further address pedestrian, bicycle and transit components and seek to manage and improve the whole network as an interactive system.

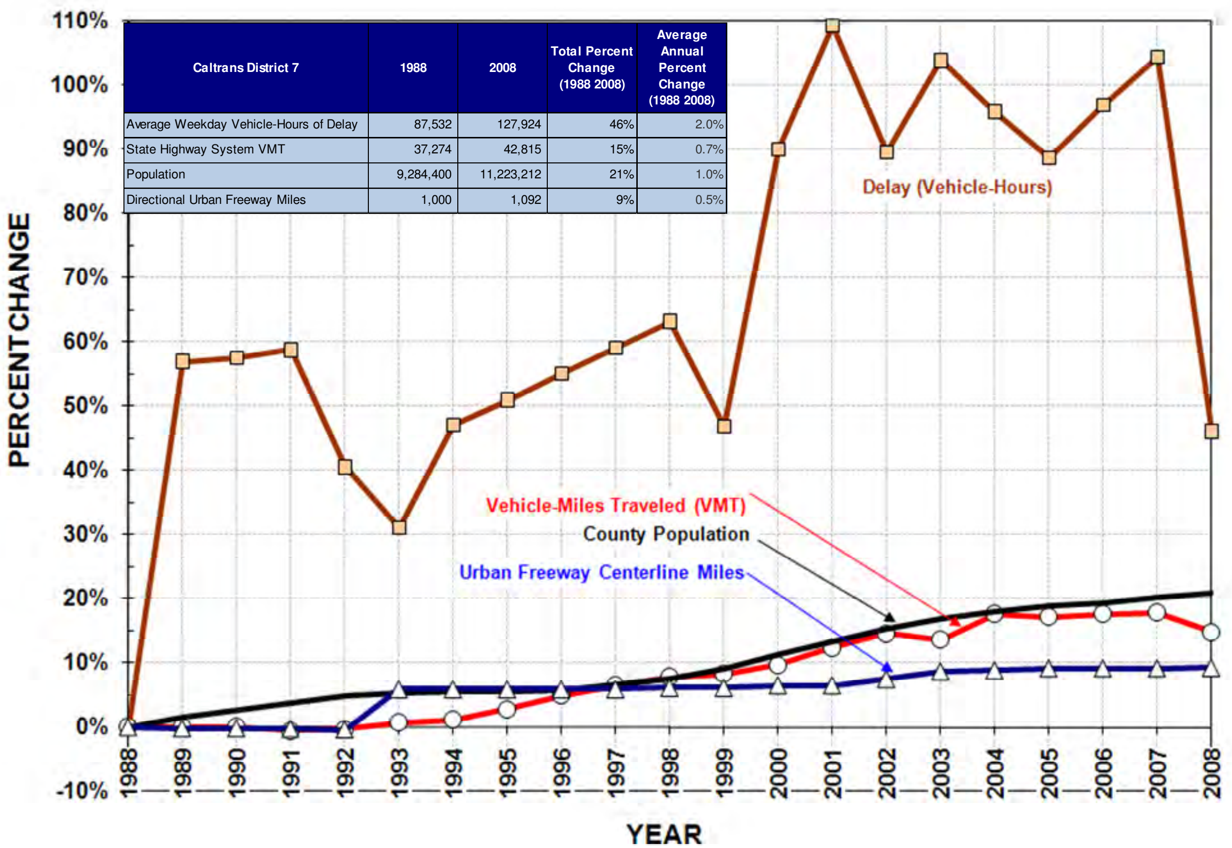
What is System Management?

With the rising cost and complexity of construction and right of way acquisition, the era of large-scale freeway construction is coming to an end. Compared to the growth of vehicle-miles traveled (VMT) and population, congestion is growing at a much higher rate.

Exhibit 1-1 shows District 7 congestion (measured by average weekday recurring vehicle-hours of delay), VMT, and population between 1988 and 2008. Over that 20-year period, congestion increased 50 percent from the 1988 congestion level (just under two percent per year). Over the same period, VMT and population rose by about 20 percent (one percent per year). However, urban freeway miles barely grew at less than one-half a percentage point per year.

Clearly, infrastructure expansion has not kept pace with demographic and travel 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.

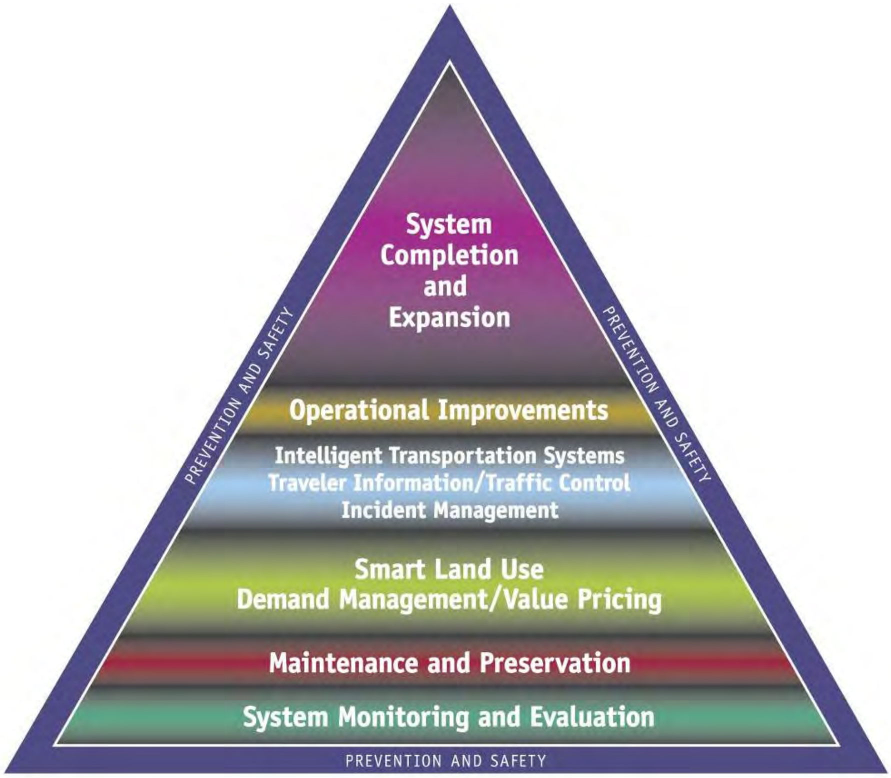
Exhibit 1-1: District 7 Growth Trends (1988-2008)



Caltrans District 7	1988	2008	Total Percent Change (1988 2008)	Average Annual Percent Change (1988 2008)
Average Weekday Vehicle-Hours of Delay	87,532	127,924	46%	2.0%
State Highway System VMT	37,274	42,815	15%	0.7%
Population	9,284,400	11,223,212	21%	1.0%
Directional Urban Freeway Miles	1,000	1,092	9%	0.5%

Caltrans and SCAG recognize this dilemma. Caltrans has adopted a mission statement that embraces the concept of system management. This mission and its goals are supported by the system management approach illustrated in the System Management pyramid shown in Exhibit 1-2.

Exhibit 1-2: System Management Pyramid



System Management is being touted at the federal, state, regional and local levels. It addresses both transportation demand and supply to get the best system performance possible. Ideally, Caltrans would develop a regional system management plan that addresses all components of the pyramid for an entire region comprehensively. However, because the system management approach is relatively new, it is prudent to apply it at the corridor level first.

The foundation of system management is monitoring and evaluation (shown as the base of the pyramid). This monitoring is done by comprehensive performance assessment and evaluation. Understanding how a corridor performs and why it performs the way it does is critical to crafting appropriate strategies. Section 3 is dedicated to performance assessment. It would be desirable for Caltrans to update this performance assessment every two or three years to ensure that future corridor issues can be identified and addressed before breakdown occurs on the corridor.

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 Los Angeles' urban freeways that have been experiencing growing 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-405 data from a non-holiday weekday in August 2008 from Caltrans detector data. It shows speeds (red line) and flow rates (blue line) on northbound I-405 at Santa Monica Boulevard.

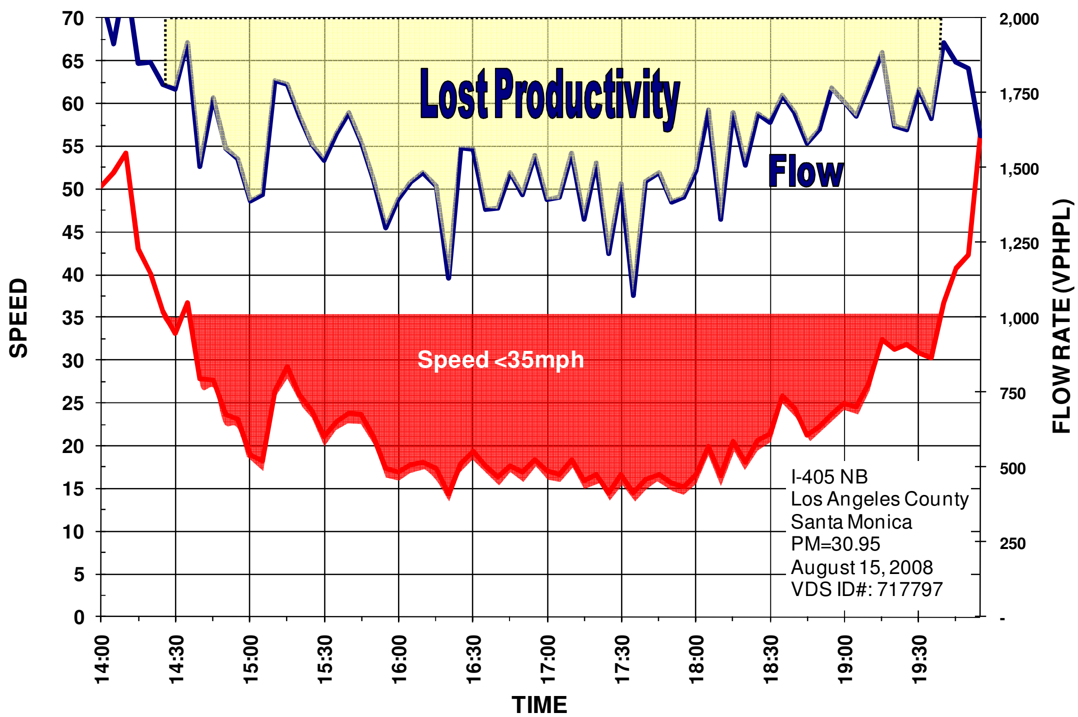
Flow rates (measured as vehicle-per-hour-per-lane or vphpl) at Santa Monica Boulevard average around 1,800 vphpl between 2:00 PM and 2:30 PM, which is slightly less than a typical peak period maximum flow rate. However, flow rates higher than this effective maximum flow cannot be sustained for a significant time.

Once volumes exceed this maximum rate, traffic breaks down and speeds plummet to below 35-45mph. Rather than being able to accommodate the same number of vehicles, flow rates also drop and vehicles back up creating what we know as congestion. In the example in Exhibit 1-3, throughput drops by over 20 percent to around 1,400 vphpl during the peak period. Just when the corridor needs the most capacity, it performs in the least productive manner, and effectively loses lanes. This is a major cost of congestion that is rarely discussed or understood.

This is lost productivity. Where there is sufficient automatic detection, this loss in throughput can be quantified and presented as "Equivalent Lost Lane-Miles". Discussed in more detail later in this report, the productivity losses on northbound I-405 were almost 13 lane-miles during the PM peak period in 2009. Caltrans works hard to recover this lost productivity by investing in improvements that utilize public funds in the most effective manner. By largely implementing operational strategies, Caltrans can leverage past investments and restore productivity.

Infrastructure expansion, although still an important strategy (at the top of the pyramid in Exhibit 1-2), cannot be the only strategy for addressing the mobility needs in Los Angeles. System management is needed to get the most out of the current system and must be an important consideration as we evaluate the need for facility expansion investments. Simply stated, the system management philosophy begins by defining how the system is performing, understanding why it is performing that way, and then evaluating different strategies, including operations centric strategies, to address deficiencies. These strategies can then be evaluated using various tools to assess potential benefits to determine if these benefits are worthy of the associated strategy costs.

Exhibit 1-3: Productivity Loss During Severe Congestion



Stakeholder Involvement

The I-405 CSMP involved corridor stakeholders in two ways. First, a technical committee was formed and met on an almost monthly basis to discuss progress, technical challenges, data needs, and preliminary conclusions. This technical committee comprised of Caltrans, SCAG, and Metro professionals as well as the consulting team members.

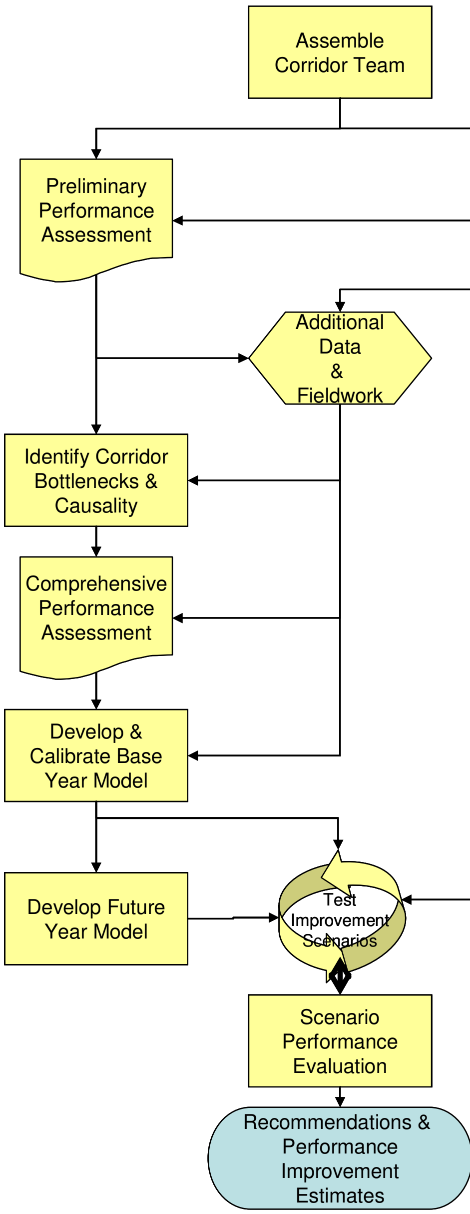
Other corridor stakeholders, including the South Bay Cities Council of Governments (SBCCOG) and the Los Angeles Department of Transportation (LADOT), were briefed at critical milestones. Feedback from these stakeholders helped solidify the findings of the performance assessment, bottleneck identification, and causality analysis given their intimate knowledge of local conditions. Moreover, various stakeholders have provided support and insight, and shared valuable field and project data without which this study would not have been possible.

Study Approach

The I-405 CSMP study approach follows system management principles by placing an emphasis on performance monitoring and evaluation (the base of the pyramid in Exhibit 1-2), and on using lower cost operational improvements to maintain system productivity.

Exhibit 1-4 is a flow chart that illustrates this approach. Each step of the approach is described in following the chart.

Exhibit 1-4: Study Approach



Assemble Corridor Team

The first task in this effort was undertaken by Caltrans with the creation of the I-405/I-210 Technical Advisory Committee (TAC). The TAC met most months to review project progress and to provide feedback to the study team.

In addition to the TAC, Caltrans also identified cities and other major stakeholders along the I-405 corridor whose input would be needed at critical project junctures (e.g., performance assessments, scenario reviews, and final report). The stakeholder group convened several times during the study period to receive local feedback on TAC issues and "buy off" at critical junctures.

Preliminary Performance Assessment

The Preliminary Performance Assessment Report presented a brief description of the corridor and existing projects along on or adjacent to I-405. It included a corridor-wide performance assessment for four key performance areas: mobility, reliability, safety, and productivity. The assessment also included a preliminary bottleneck location assessment based on readily available existing data and limited field observations.

The results of the Preliminary Performance Assessment were updated and included in the Comprehensive Performance Assessment described below. The results of these two assessments are presented in the Corridor Description and Corridor Performance sections - Sections 2 and 3 of this final report.

For future I-405 CSMP reporting, the Preliminary Performance Assessment should not be necessary, since its main purpose is to identify data gaps – particularly detection gaps. It is anticipated that these gaps will be addressed with improved automatic detection. Future updates to CSMPs can be made directly to this CSMP report.

Collect Data and Programmed/Planned Project Information

In conjunction with the Preliminary Performance Assessment, the study team reviewed existing studies, plans and other programming documents to assess additional data collection needs for modeling and scenario development. One of the key elements of this study was to identify projects that would be implemented in the short- and long-term timeframes to be included in the Paramics micro-simulation model developed by study team.

Details of the projects included in the scenario analysis are discussed in Section 5: Scenario Development and Evaluation.

Additional Data Collection and Fieldwork

The study team identified locations where additional manual traffic counts would be needed to calibrate the 2003 Base Year micro-simulation model and coordinated the collection of the traffic count data.

The study team conducted several field visits in 2007 and early 2008 to collect and observe field conditions during peak periods, and to videotape potential bottleneck locations. This fieldwork was used to identify bottlenecks and assess the causes of the major bottlenecks on the corridor. This fieldwork will be discussed in Section 4: Bottleneck Identification and Causality Analysis.

Identify Corridor Bottlenecks and Causality

Building on the Preliminary Performance Assessment and the fieldwork, the study team identified major AM and PM peak period bottlenecks along the corridor. These bottlenecks will be discussed in detail in Section 4 of this report.

Comprehensive Performance Assessment

Once the bottlenecks were identified and the causality of the bottlenecks determined, the study team prepared the Comprehensive Performance Assessment, which was delivered to Caltrans in May 2009. This report built on the Preliminary Performance Assessment and added a discussion of bottleneck causality findings – including performance results for each bottleneck area. It also included corridor-wide performance results updated to reflect 2008 conditions.

Develop and Calibrate Base Year Model

Using the bottleneck areas as the basis for calibration, the study team developed a calibrated base year model for the year 2003. This model was calibrated against California and Federal Highway Administration (FHWA) guidelines for model calibration. In addition, the model as evaluated to ensure that each bottleneck area was represented in the model and that travel times and speeds were consistent with observed data. This process required several review iterations by the study team and the TAC.

Discussion of the calibrated 2003 Base Year model can be found in Section 5: Scenario Development and Evaluation.

Develop Future Year Model

Following the approval of the 2003 Base Year model, the study team developed a 2020 Horizon Year model to be used to test the impacts of short-term programmed projects as well as future operational improvements including the impacts of improved incident management on the corridor.

Discussion of the 2020 Horizon Year model can be found in Section 5: Scenario Development and Evaluation.

Test Improvement Scenarios

The study team developed scenarios that were evaluated using the micro-simulation model. Short-term scenarios included programmed projects that would likely be completed within the next five years along with other operational improvements, such as improved ramp metering. In addition to the short-term evaluations, short-term projects were tested using the 2020 Horizon Year model to assess their long-term impacts.

The study team also developed and tested other scenarios using only the 2020 model. These scenarios included programmed and planned projects that would not be completed within five years of 2003 and likely experience benefits only in the long-term.

Scenario testing results are presented in Section 5: Scenario Development and Evaluation.

Scenario Performance Evaluations

Once scenarios were developed and fully tested, simulation results for each scenario were subjected to a benefit-cost evaluation to determine how much “bang for the buck” each scenario would deliver. The study team performed a detailed benefit-cost assessment using the California Benefit-Cost model (Cal-B/C).

The results of the Benefit-Cost analysis are presented in Section 5: Scenario Development and Evaluation.

Recommendations and Performance Improvement Estimates

The study team developed final recommendations for future operational improvements that could be reasonably expected to maintain the mobility gains achieved by existing programmed and planned projects. Section 6 summarizes these findings.

This report is organized into six sections (Section 1 is this introduction):

2. *Corridor Description* describes the corridor, including the roadway facility, recent improvements, major interchanges and relative demands at these interchanges, relevant transit services serving freeway travelers, major Intermodal facilities around the corridor, special event facilities/trip generators, and an I-405 origin-destination demand profile from the SCAG regional model.

3. *Corridor Performance Assessment* presents multiple years (2001-2003 and 2008-2009) of performance data for the freeway portion of the I-405 corridor. Statistics are included for the mobility, reliability, safety, and productivity performance measures.

4. *Bottleneck Identification and Causality Analysis* identifies bottlenecks, or choke points, on the I-405. It also diagnoses the bottlenecks and identifies the causes of each location through additional data analysis and field observations. This section has performance results for delay, productivity, and safety by major "bottleneck area", which allows for the relative prioritization of bottlenecks in terms of their contribution to corridor performance degradation. This section provides input to selecting projects to address the critical bottlenecks, and they provide the baseline against which the micro-simulation models were validated.

5. *Scenario Development and Evaluation* discusses the scenario development approach and summarizes the expected future performance based on the Paramics micro-simulation model.

6. *Conclusions and Recommended Improvements* describes the projects and scenarios that were evaluated and recommends a phased implementation of the most promising set of strategies.

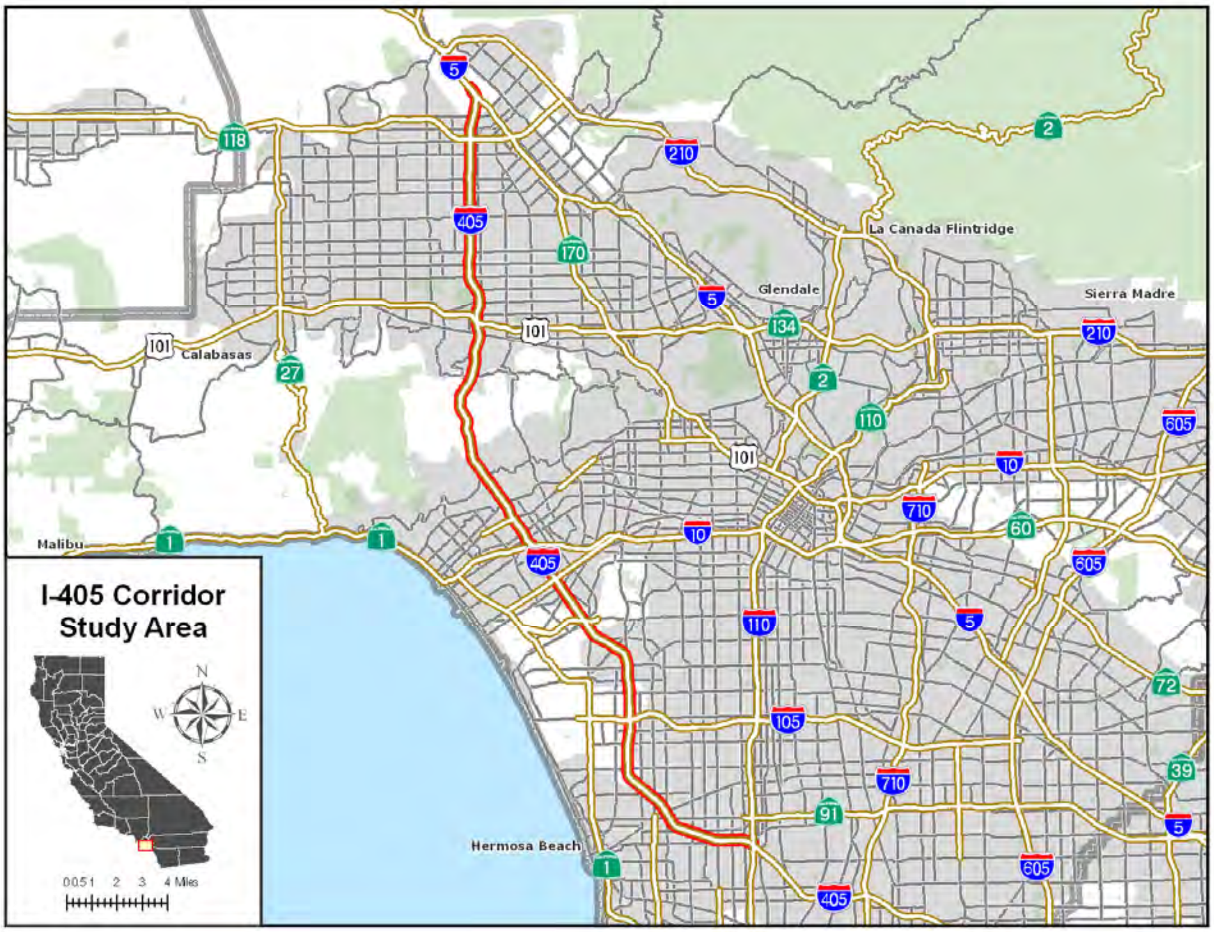
The appendices provide project lists for the micro-simulation scenarios and detailed benefit-cost results.

Note that at the end of each section and at other critical places in this final report, blank pages have been inserted to serve as placeholders for future updates.

2. CORRIDOR DESCRIPTION

The Los Angeles County I-405 Corridor begins at the I-110 (Harbor Freeway) Interchange in Torrance (post mile 12.5) to the end of the freeway at the I-5 (Golden State Freeway) Interchange in San Fernando (post mile 48.5). It extends approximately 36 miles and traverses through the cities in the South Bay such as Torrance, Carson, Lawndale, Hawthorne, and Inglewood. It also traverses through the cities of Santa Monica and Culver City, ending in San Fernando and Van Nuys.

Exhibit 2-1: Map of Study Area



Corridor Roadway Facility

The study corridor traverses a large portion of the northern section of Los Angeles County and connects several of the major communities. The corridor includes 36 miles of I-405 from its beginning at the I-110 junction to I-5. It intersects many of the key east-west corridors in Los Angeles County. The major interchanges in the I-405 study corridor include the following:

- I-110, which provides north-south access from Pasadena to San Pedro.
- Artesia Boulevard (SR-91), which provides east-west access from Riverside County to coastal cities such as Manhattan Beach and Hermosa Beach.
- Rosecrans Avenue, which provides east-west access from La Mirada on the east to El Segundo on the west.
- I-105 (Glenn Anderson Freeway), which provides east-west access from the I-605 interchange to the Los Angeles International Airport (LAX).
- SR-90 (Marina Freeway), which provides access to Marina Del Rey and Playa Vista.
- I-10 (Santa Monica Freeway), which provides east-west access from San Bernardino County to Culver City and Santa Monica.
- US-101 (Ventura Freeway), which provides interregional access from downtown Los Angeles to northern California.
- SR-118 (Ronald Reagan Freeway), which provides east-west access from the I-405 freeway/San Fernando to Ventura County.

High occupancy vehicle (HOV) lanes run throughout the majority of the corridor except for the northbound direction from the I-10 to the US-101, which is currently under construction. Ramp meters are active during both the morning and afternoon peak periods. Directions of travel are divided by a concrete median. Exhibit 2-2 shows the lane configurations along the I-405 corridor. Exhibit 2-3 identifies the ramp meters and traffic operation systems present throughout the corridor.

Exhibit 2-2: I-405 Corridor Lane Configuration

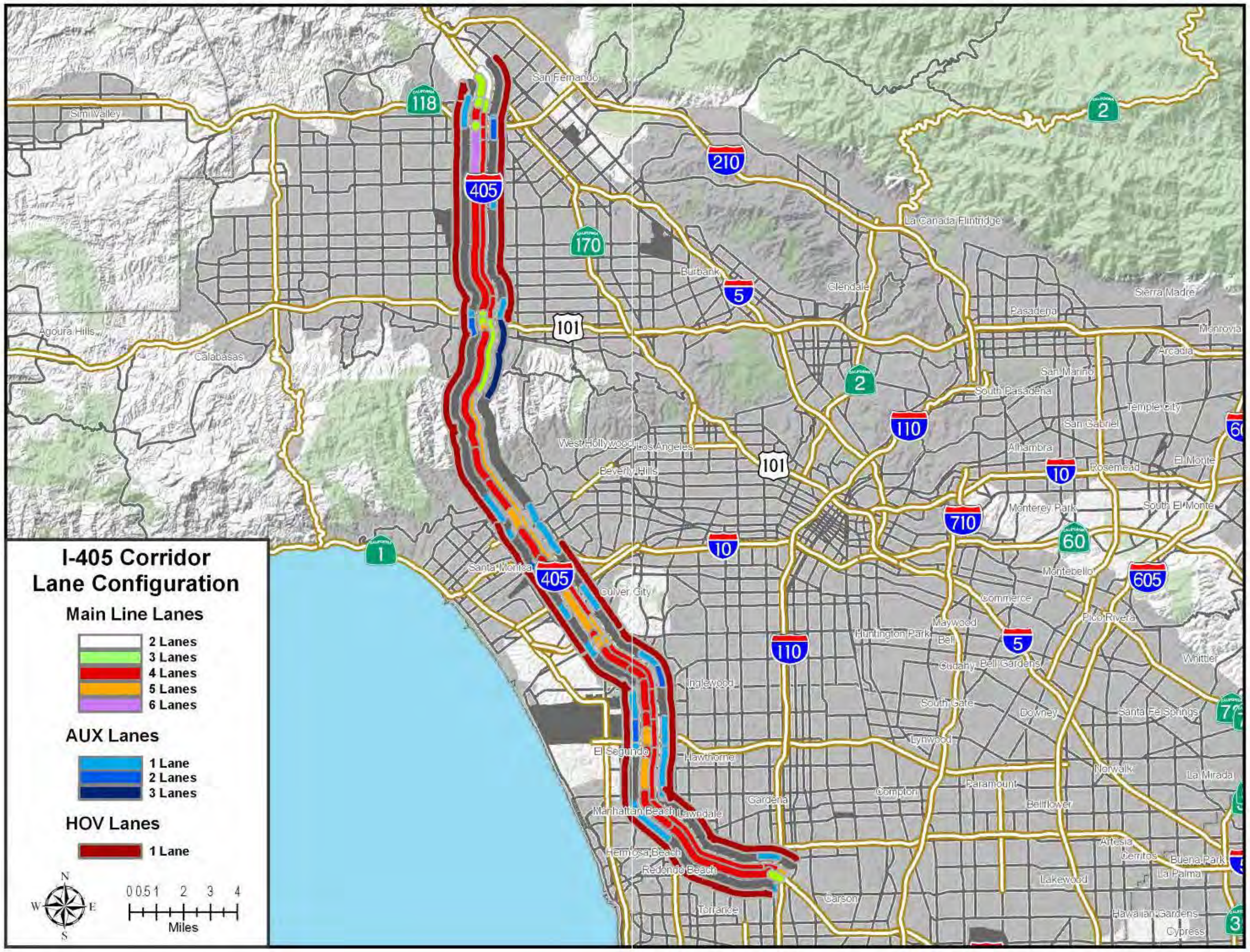
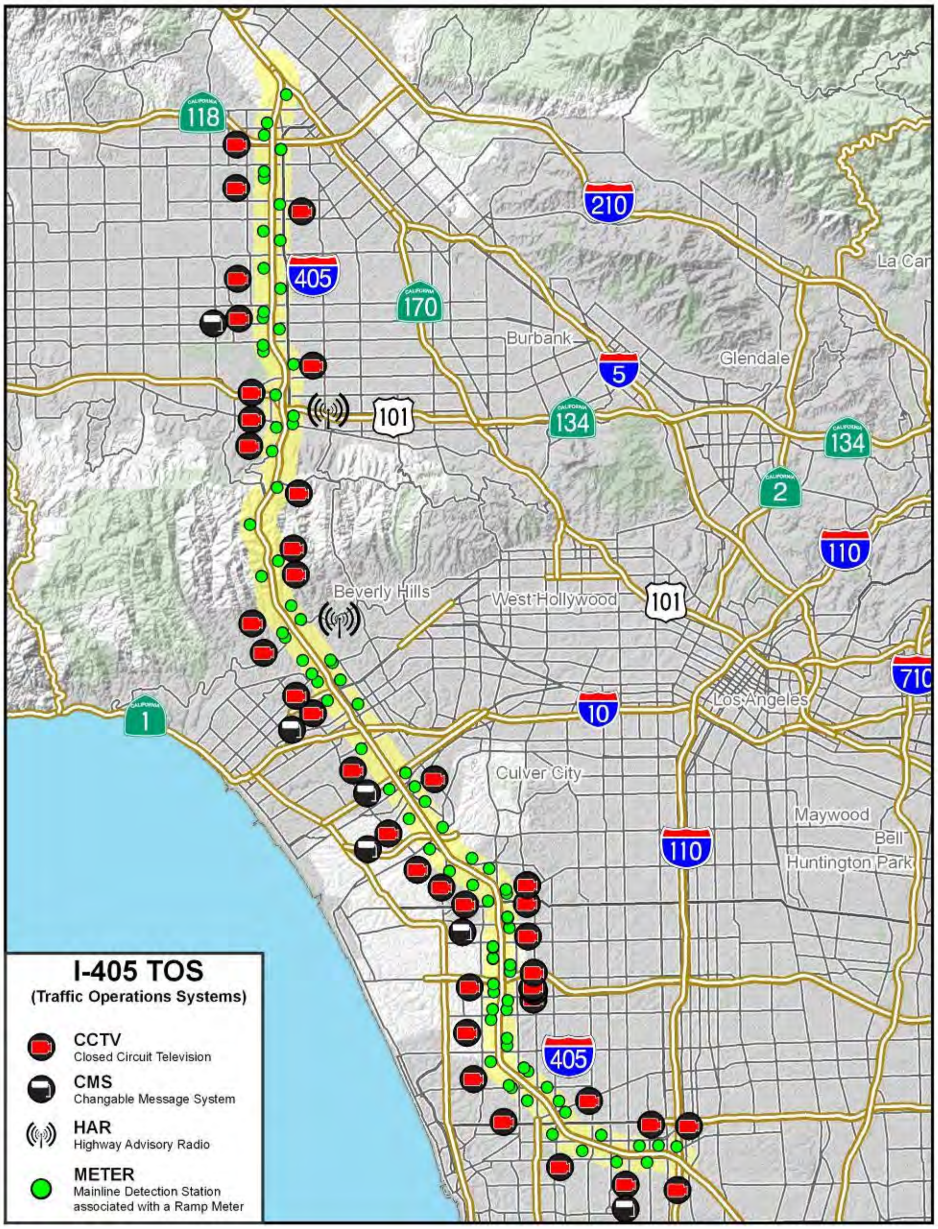


Exhibit 2-3: I-405 Traffic Operations and Management Systems

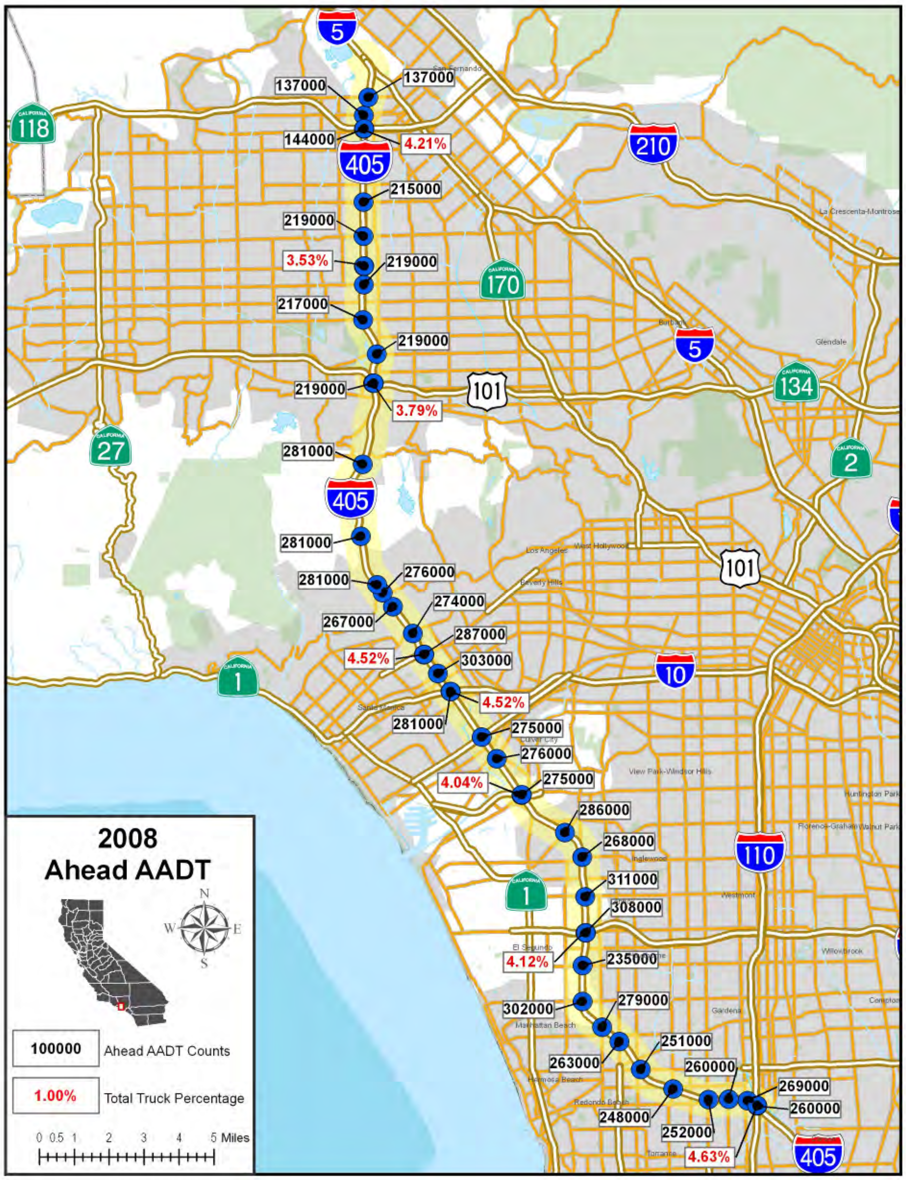


The 2008 Caltrans Traffic and Volume Data Systems indicate that the annual average daily traffic (AADT) ranges from 137,000 to 310,000 vehicles per day, as illustrated in Exhibit 2-4. The highest AADT was reported north of the I-105 Interchange and north of the I-10 Interchange.

I-405 is also a part of the Surface Transportation Assistance Act (STAA) National Truck Network as indicated in Exhibit 2-5. Exhibit 2-4 also identifies the total truck percentage at various locations throughout the corridor. According to the 2008 Annual Average

Daily Truck Traffic on the California State Highway System published by Caltrans in September 2009, the corridor's verified daily truck traffic comprises around 4 percent of the total daily traffic along the corridor, with the highest percentage (4.6 percent) near the I-110 Interchange.

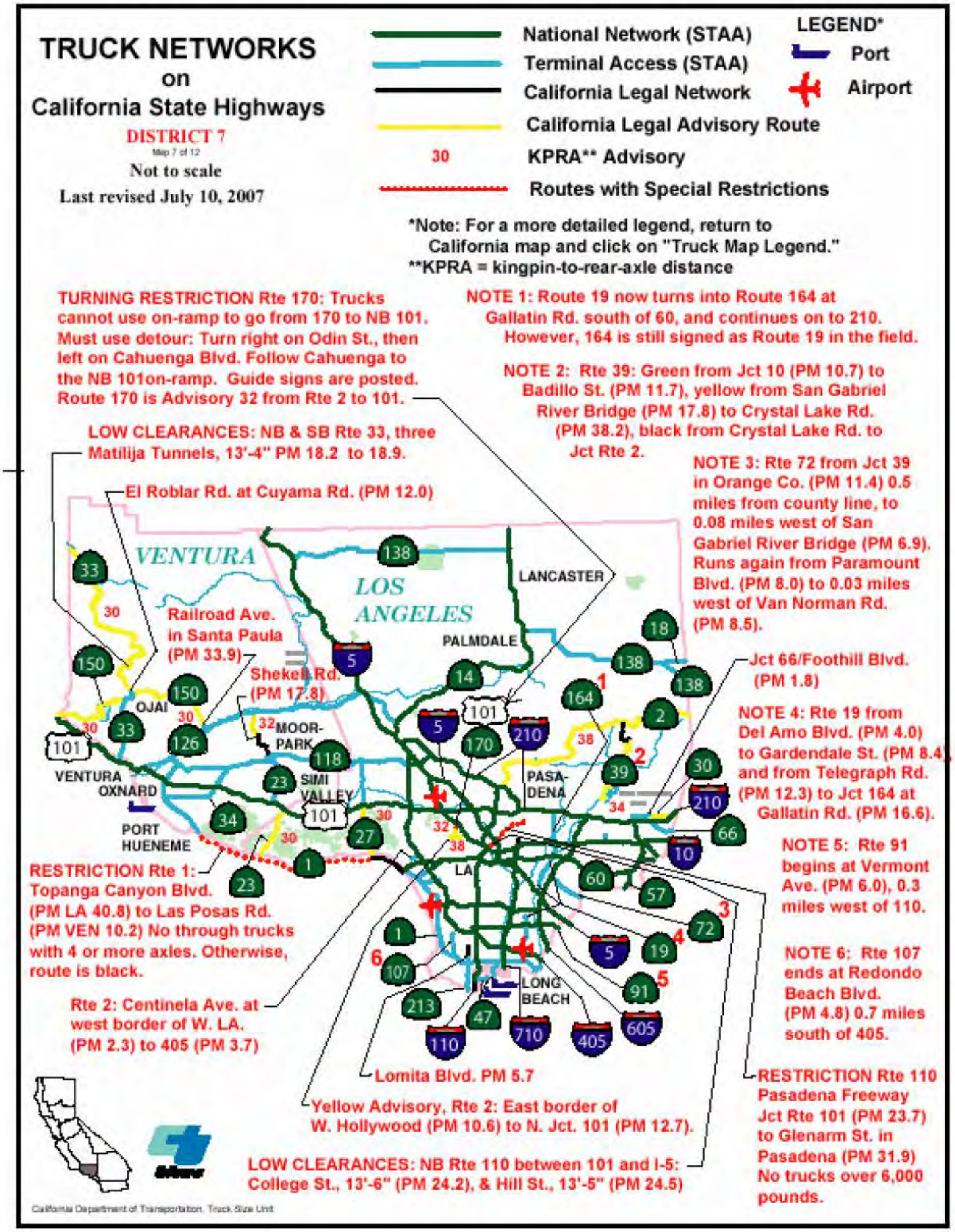
Exhibit 2-4: 2008 Annual Average Daily Traffic (AADT) along the I-405 Corridor



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

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

Exhibit 2-5: Los Angeles & Ventura County Truck Networks



Recent and Planned Roadway Improvements

There are several roadway improvements that have recently been completed and others that are underway along the corridor, including:

- HOV lanes in both directions from I-105 to SR-90 were completed and opened to traffic in 2009.
- An HOV lane extension from SR-90 to I-10 in both directions started in 2004 and was completed in 2009.
- A southbound HOV lane extension from Sunset Boulevard to I-10 was completed in 2009.
- Construction on a northbound HOV lane, as part of the Sepulveda Pass Widening Project, from I-10 to US-101 (partly funded by CMIA) began in May 2009 and is expected to be completed in 2016.
- Construction of a freeway connector from southbound I-405 to northbound and southbound US-101 is expected to be completed in 2016.
- Construction of the south half of a new interchange at Arbor Vitae Avenue is expected to be completed in 2013.

In summary, HOV related construction has been under way on the study corridor since 2000. Once all these activities are concluded, a new fresh look at corridor performance and problems will be needed to take into consideration likely shifting traffic patterns.

Transit

Major transit operators within the I-405 study corridor include:

- Los Angeles County Metropolitan Transportation Authority (Metro)
- Metrolink commuter rail service
- Antelope Valley Transit
- Santa Clarita Transit
- Culver City Transit
- Los Angeles City Department of Transportation Commuter Express
- Santa Monica's Big Blue Bus.

Metro operates local bus, rapid bus, and rail service along or parallel to the I-405 corridor. In the northerly portion of the corridor from the I-5 to the I-101, Metro operates Line 234, which runs south along Sepulveda Boulevard from the Sylmar/San Fernando

Metrolink Station southbound. Lines 233 and 237 run parallel to the study corridor along Van Nuys Boulevard.

In addition to these bus lines, Metro also operates Metro Rapid 734 along Sepulveda Boulevard and Metro Rapid 761 along Van Nuys Boulevard. Metro Orange Line crosses the study corridor south of Victory Boulevard. Exhibits 2-6 and 2-7 provide a close-up shot of the Metro transit lines servicing some of the cities within the northerly and middle portions of the study corridor.

In the southern portion of the study corridor, from the I-10 to the I-110, Metro operates Line 215, which runs along Inglewood Avenue parallel to the corridor. Metro Rapid Lines 740 and 940, local bus Line 40, and Express Line 442 run along Hawthorne Boulevard while Line 211 operates along Prairie Avenue. The Metro Rail Green Line crosses the freeway running along the I-105 freeway and terminates at the Redondo Beach Avenue Station. Finally, Metro Line 232 runs parallel to the study corridor along Sepulveda Blvd (SR-1). Exhibit 2-8 provides a close up shot of the Metro transit lines servicing some of the cities within the southerly portion of the I-405 corridor.

The Metrolink Ventura County Line crosses the northerly portion of the study corridor between Saticoy Street and Roscoe Boulevard while the Metrolink Antelope Valley Line runs southeast of the corridor to downtown Los Angeles. Exhibit 2-9 shows the Metrolink System Map for the southern California area.

Antelope Valley Transit operates Line 786, which runs on the I-405 corridor from the I-5 to the West Los Angeles area on Santa Monica Boulevard.

Santa Clarita Transit also operates many bus lines that run on the study corridor. They are Lines 792, 793, 797, and 798. These bus lines all terminate service at the northerly portion of the study corridor around Century City.

The Los Angeles Department of Transportation also operates two Commuter Express buses along this corridor. They are Lines 573 and 574.

The City of Santa Monica’s Big Blue Bus operates many bus lines within the proximity of the I-405 study corridor that provide transportation between residential neighborhoods and business centers.

Exhibit 2-10 illustrates the Park and Ride Lot facilities that are located in the vicinity of the corridor. Many of these facilities are located in the southern section of the corridor, near I-105. There are only a few facilities located north of I-10.

Exhibit 2-6: Metro Area Map Servicing North I-405 Corridor

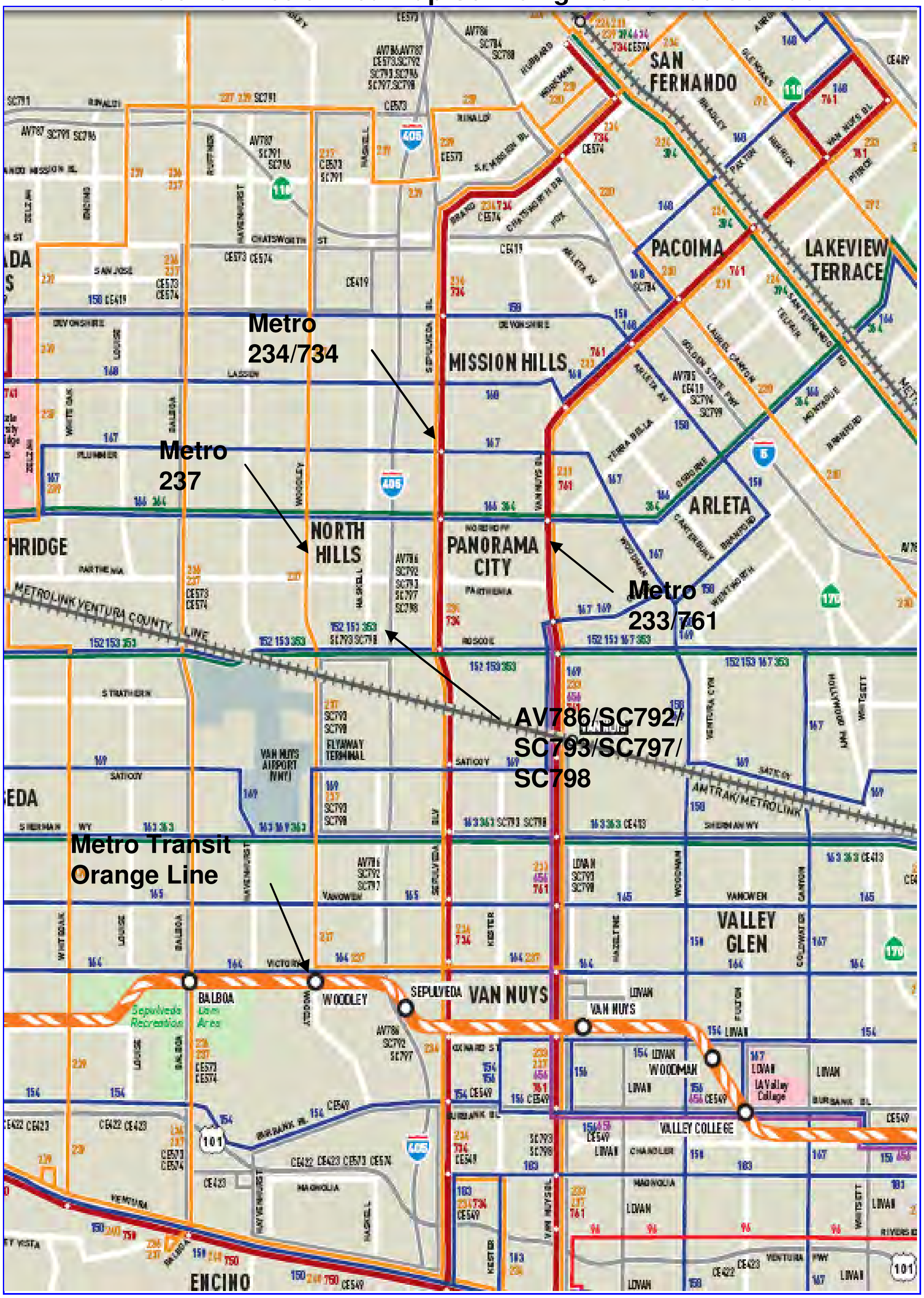


Exhibit 2-7: Metro Area Map Servicing Mid I-405 Corridor

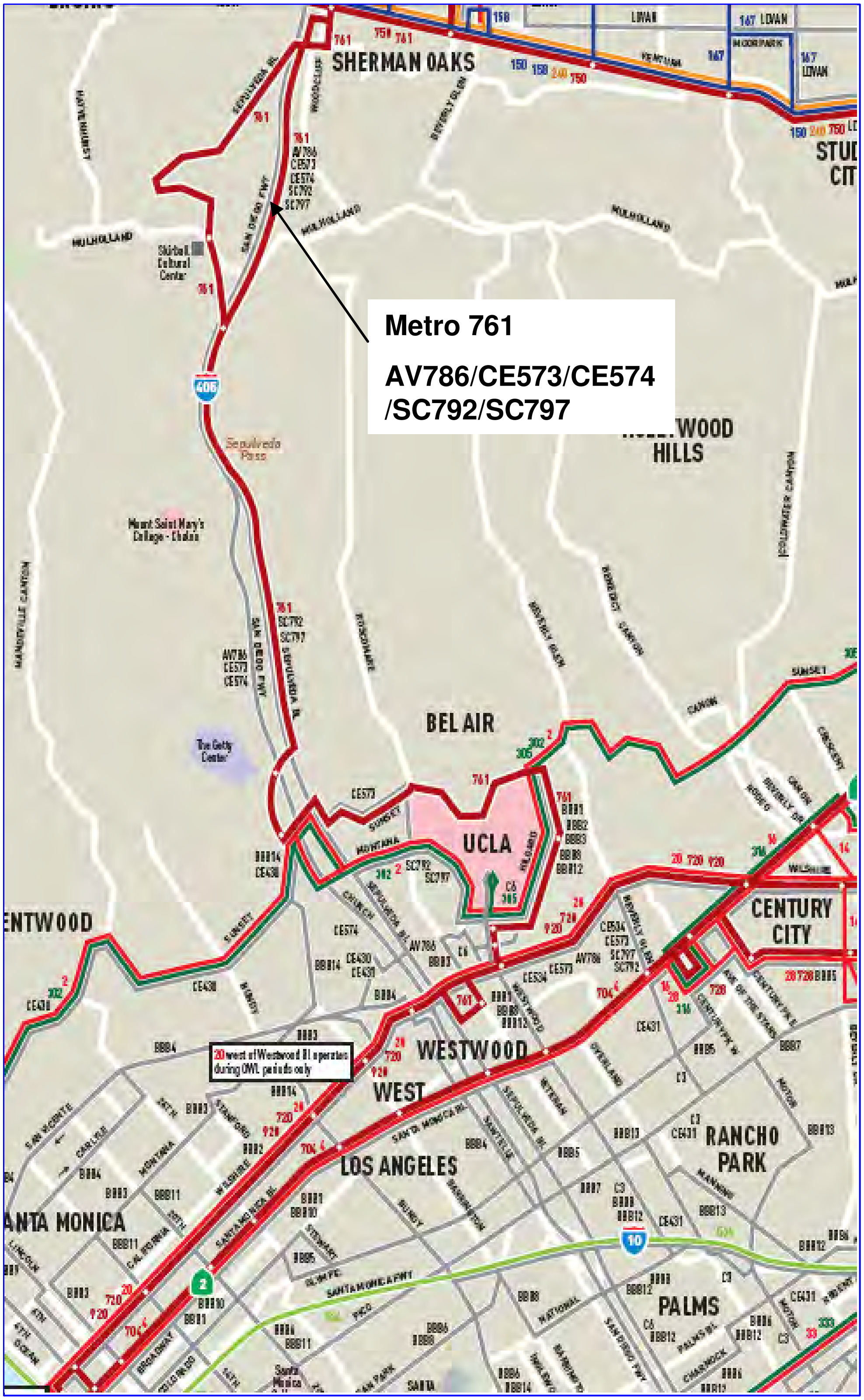


Exhibit 2-8: Metro Area Map Servicing South I-405 Corridor

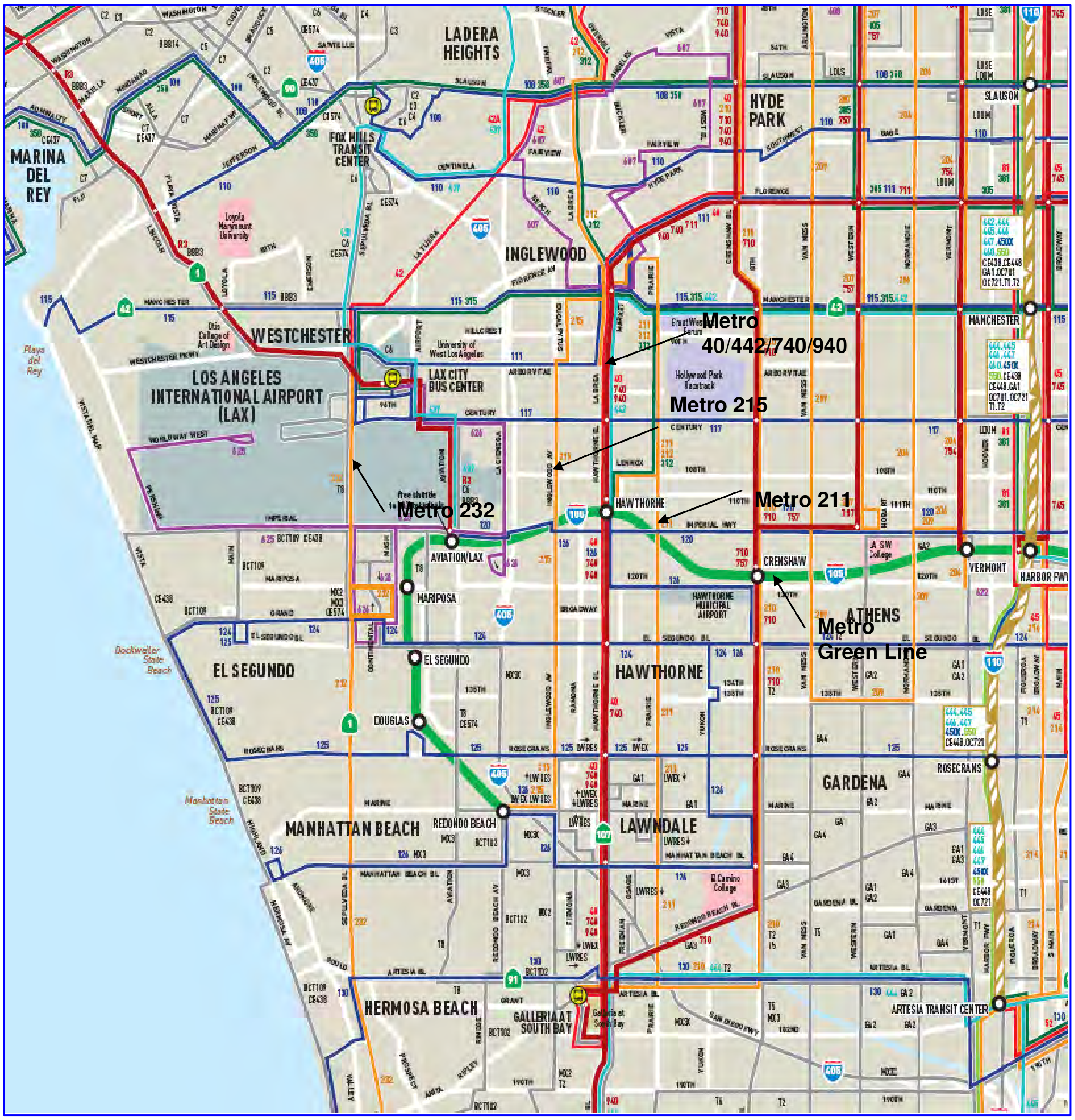
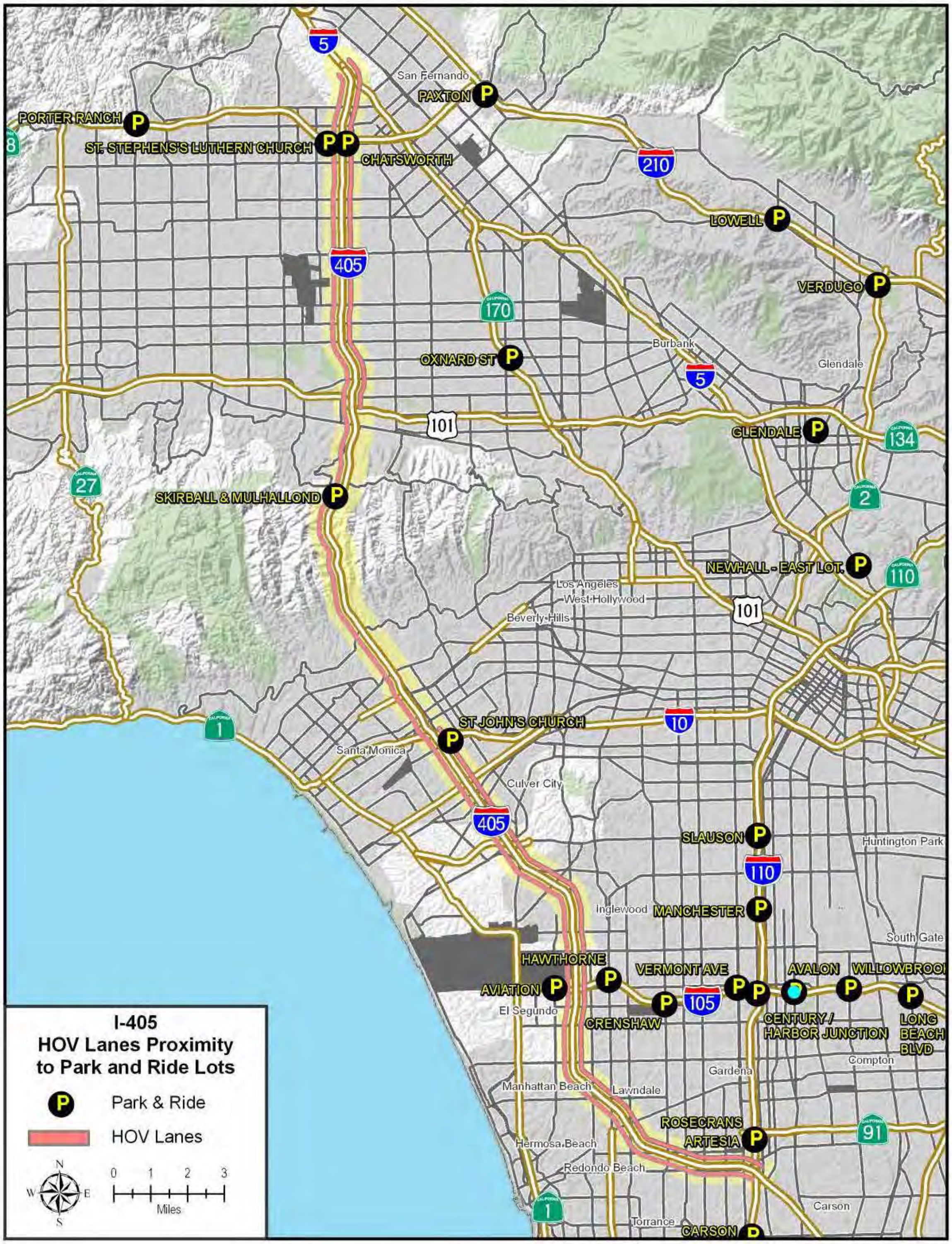


Exhibit 2-9: Metrolink System Map

Exhibit 2-10: Park and Ride Lots

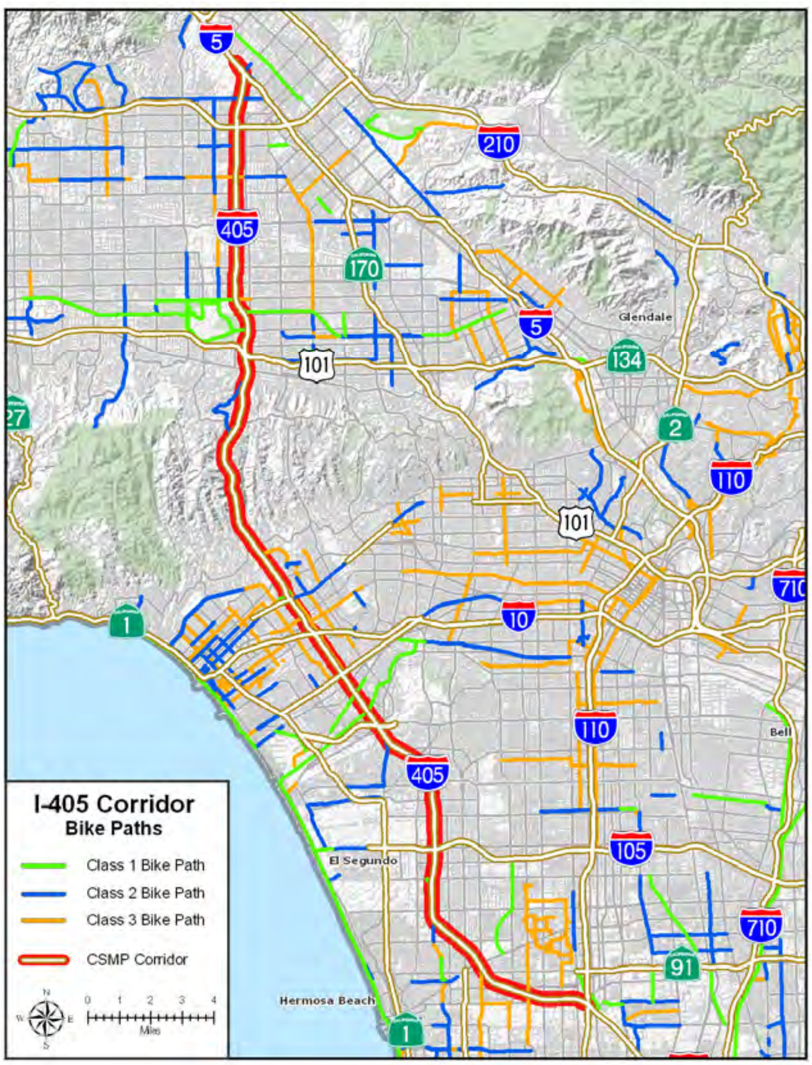


Bicycle Facilities

There are several bike paths near I-405, mainly concentrated in the southern section of the corridor near the ocean. The longest bike path that parallels the corridor travels along the Pacific Coast Highway from Hermosa Beach to Malibu. Exhibit 2-11 identifies the bike paths near the corridor and specifies the class of each path. There are three classes of bicycle facilities:

- Class I bike paths consist of a paved path within an exclusive right of way
- Class II bike lanes consist of signed and striped lanes within a street right of way,
- Class III bike routes are preferred routes on existing streets identified by signs only.

Exhibit 2-11: Bicycle Facilities Near I-405 Corridor



Intermodal Facilities

A number of airports operate within the vicinity of the I-405 study corridor. Among the smaller airports include the Van Nuys Airport and Santa Monica Airport located in the northerly portion of the study corridor, and Hawthorne Municipal Airport and Torrance Municipal Airport located within the southerly portion of the study corridor. The following exhibits show the location of the respective airports relative to its location to the I-405 study corridor.

Exhibit 2-12: Santa Monica Airport

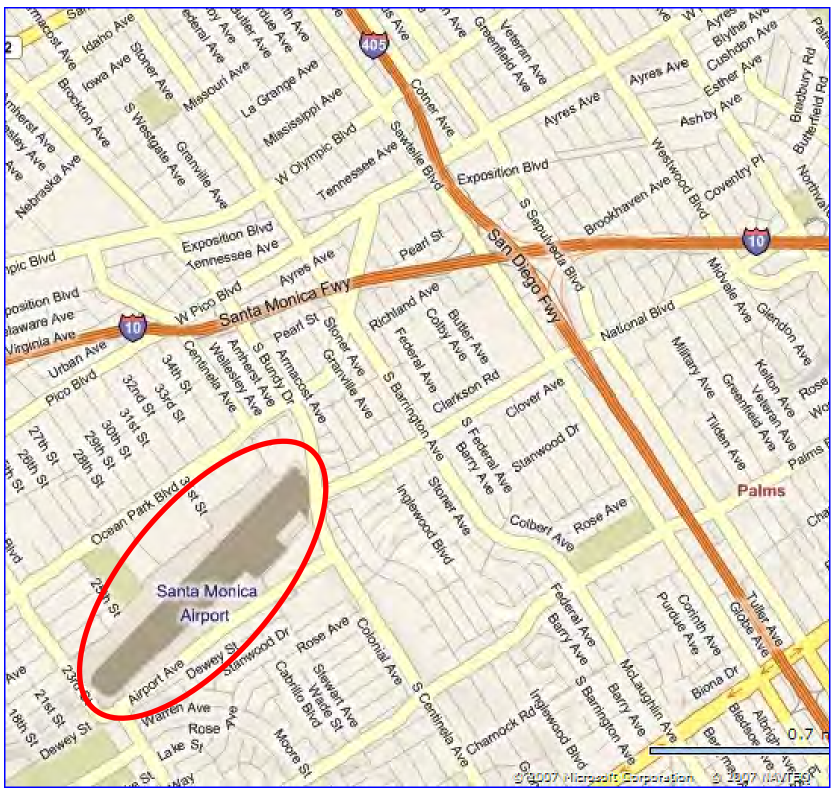


Exhibit 2-13: Van Nuys Airport

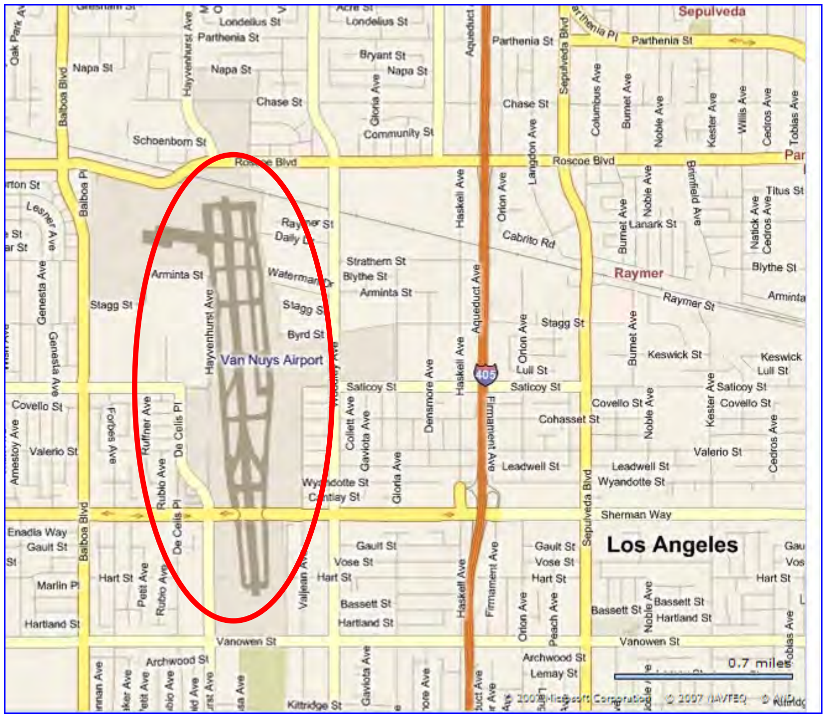


Exhibit 2-14: Hawthorne Municipal Airport

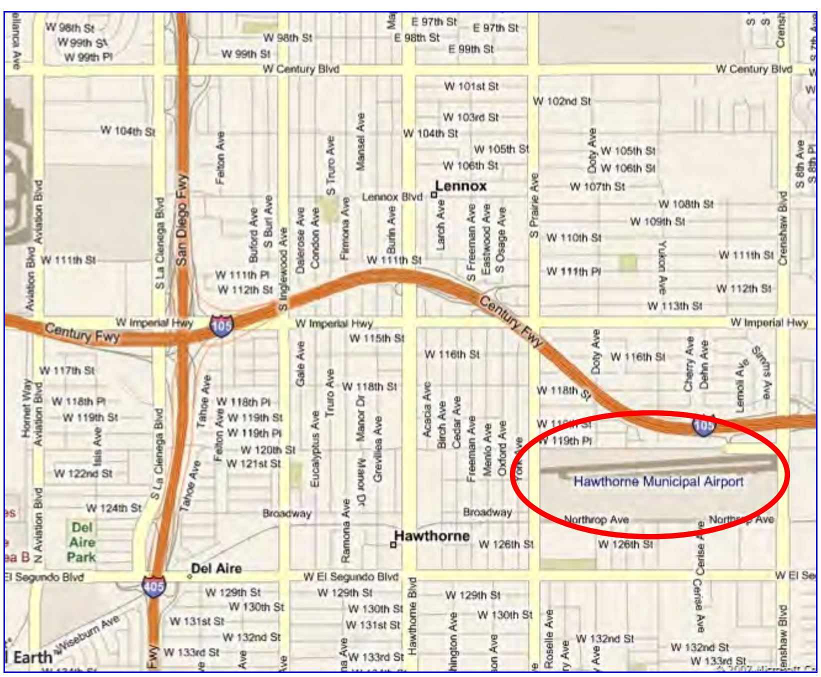


Exhibit 2-15: Torrance Municipal Airport

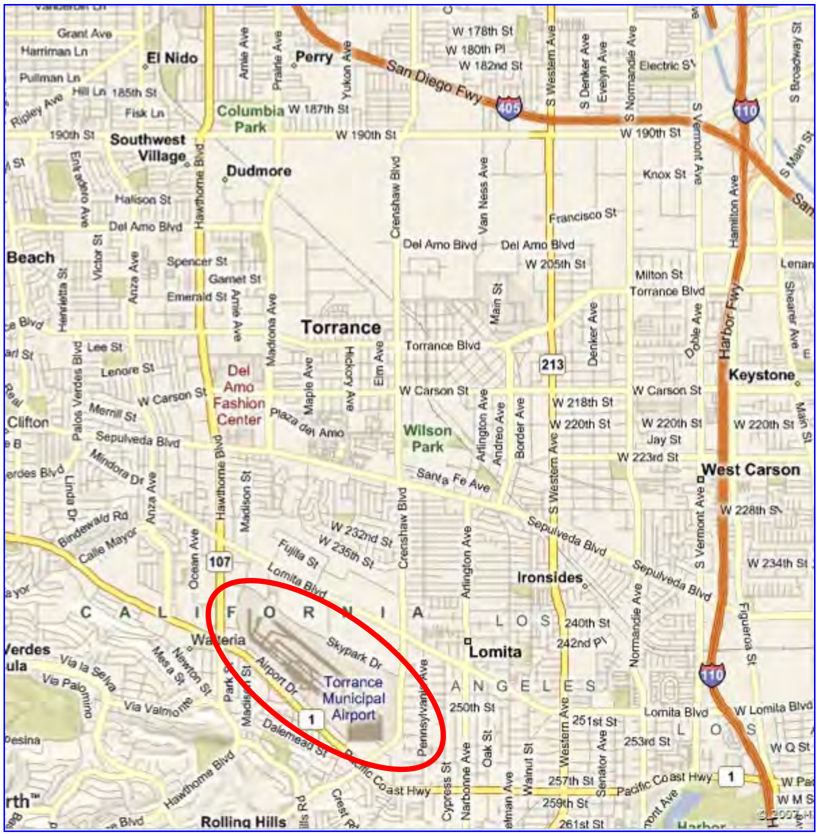
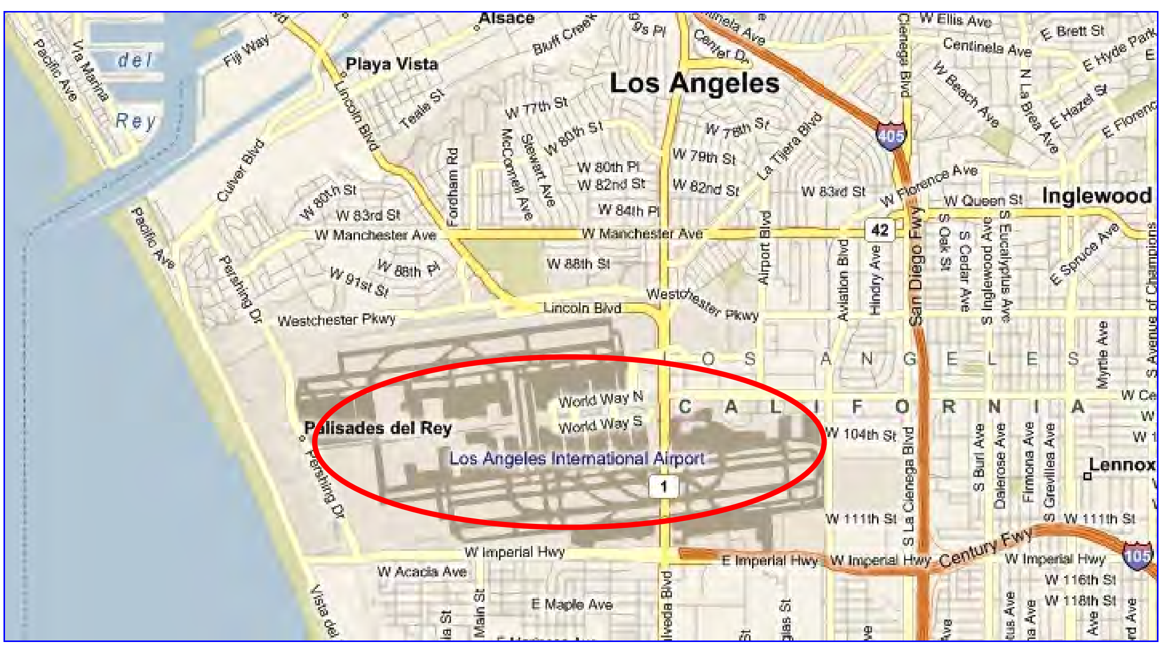


Exhibit 2-16: Los Angeles International Airport



Los Angeles International Airport (LAX), shown in Exhibit 2-16, is located off of the I-405 and I-105 Freeways. LAX is the world's fifth busiest passenger airport and ranks eleventh in air cargo tonnage handled.

In 2009, more than 56 million people traveled through LAX. A commerce leader, its ever-expanding air cargo system handled more than 2.1 million tons of goods. International freight is more than 50 percent of this total. LAX handled 70 percent of the passengers, 75 percent of the air cargo, and 95 percent of the international passengers and cargo traffic in the five-county Southern California region. Exhibit 2-17 shows the Los Angeles International Airports (LAX) Passenger Traffic Comparison by Terminal.

Exhibit 2-17: LA International Airports (LAX) Passenger Traffic Comparison by Terminal

		Passenger Count (January to December)		
Terminal	**Type**	**2008**	**2009**	**% Change**
Imperial Terminal	Arrival	437	289	-33.9%
	Departure	1,208	241	-80.0%
LAX T1	Arrival	4,604,914	4,396,178	-4.5%
	Departure	4,580,246	4,418,326	-3.5%
LAX T2	Arrival	2,903,589	2,206,383	-24.0%
	Departure	3,073,196	2,376,896	-22.7%
LAX T3	Arrival	2,006,047	2,080,289	3.7%
	Departure	2,418,177	2,539,043	5.0%
LAX T4	Arrival	5,370,325	4,826,023	-10.1%
	Departure	5,154,467	4,893,872	-5.1%
LAX T5	Arrival	2,496,619	2,543,300	1.9%
	Departure	2,646,837	2,740,045	3.5%
LAX T6	Arrival	2,784,713	2,441,639	-12.3%
	Departure	2,846,687	2,393,846	-15.9%
LAX T7	Arrival	3,138,797	3,298,110	5.1%
	Departure	3,316,982	3,472,813	4.7%
LAX T8	Arrival	1,320,472	1,382,480	4.7%
	Departure	1,309,406	1,405,155	7.3%
Miscellaneous Terminal	Arrival	3,369	2,600	-22.8%
	Departure	3,053	2,732	-10.5%
TBIT	Arrival	4,821,638	4,825,889	0.1%
	Departure	4,147,073	3,815,790	-8.0%

Source: Los Angeles World Airports Statistics

Special Event Facilities and Trip Generators

In addition to the Los Angeles International Airport and the major employment centers along the corridor, particularly in the Westside and South Bay, there are major special event facilities that generate significant trips along the I-405 corridor. A number of the most significant ones are shown in Exhibit 2-18. However, flow on I-405 can and is impacted by parallel facilities (for example I-5) as well as facilities not in the immediate proximity of the freeway in Los Angeles County, such as a number of hospitals and recreational areas.

There are a number of major colleges/universities near the I-405 corridor:

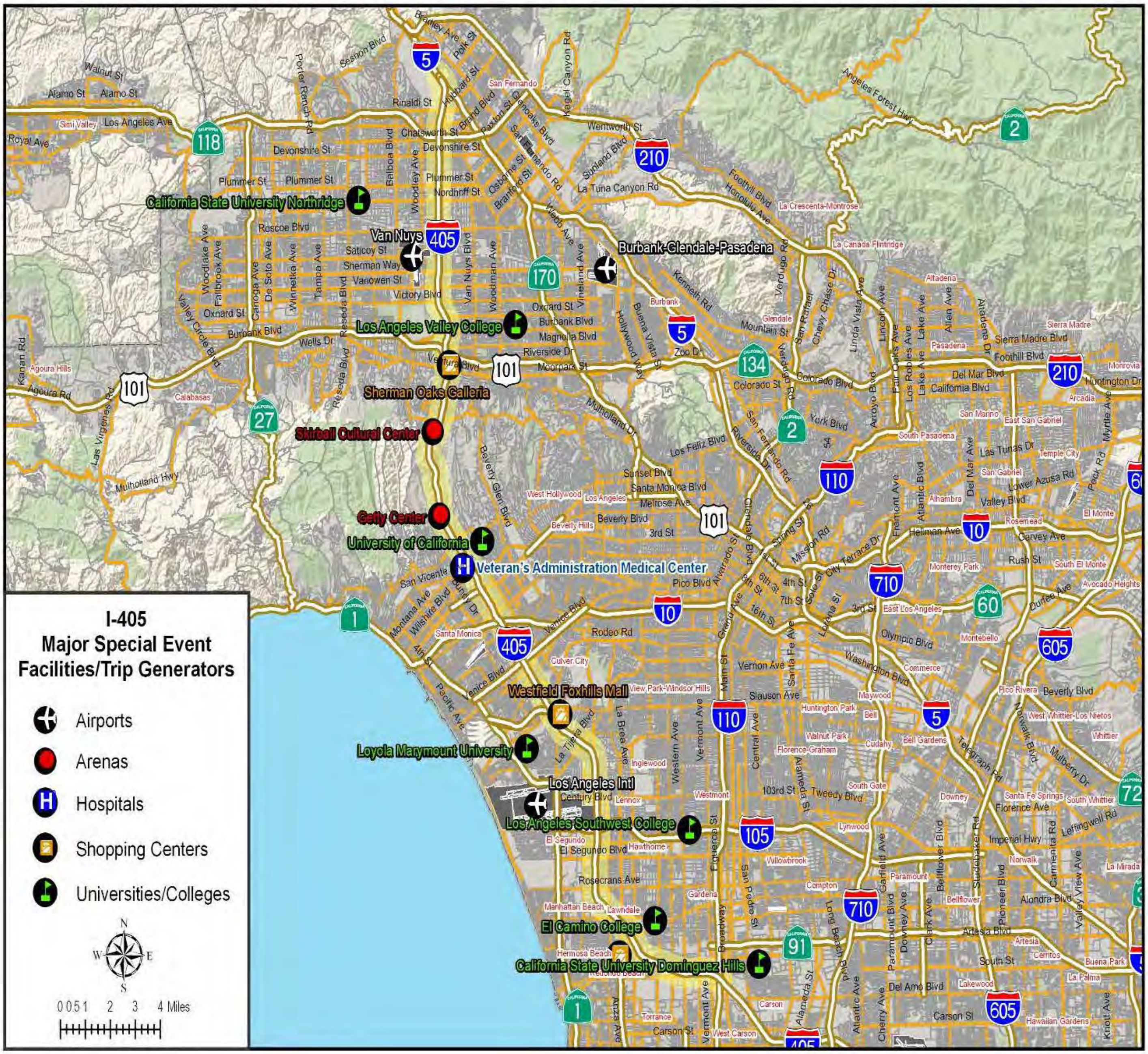
- California State University Northridge is located approximately three miles west of the study corridor and near the SR-118 (Simi Valley) Freeway. It is a public university with an estimated enrollment of 35,000 students. It offers Bachelors, Masters and Doctorate Degrees.
- Loyola Marymount University (LMU) is located one mile west of the study corridor and south of the SR-90 Freeway. LMU is a private Catholic university, offering Bachelors, Masters, Doctorate and Law degrees. It has an estimated enrollment of approximately 9,000 students.
- El Camino College is located one mile east of the I-405 and west of the I-110 freeway. It is a two-year undergraduate college with an estimated student enrollment of 24,000.
- The University of California, Los Angeles (UCLA) is located in Westwood approximately one mile east of the I-405 freeway. It is a public university offering Bachelors, Masters, and Doctorate degrees. It has an estimate enrollment of 40,000 students.
- Los Angeles Valley College is located three miles east of the study corridor and north of the US-101 freeway in the San Fernando Valley. The school is a part of the Los Angeles Community College District. It is a public two-year college with an estimated enrollment of 16,200 students.
- Los Angeles Southwest College is approximately three miles from the I-405 freeway and off the I-105 freeway. It is also part of the Los Angeles Community College District. It is a public two-year college with an estimated enrollment of 6,000 students.
- California State University Dominguez Hills is located approximately one mile from the I-405 freeway and east of the I-110 freeway. It is a four-year university offering undergraduate and graduate degrees. It has an estimated enrollment of 12,800 students. Approximately 40% of the students are enrolled in graduate programs. The majority of students are part-time evening students with an average course load of six units.

The I-405 Corridor has two major medical facilities within its vicinity, the Veteran's Administration Medical Center and the UCLA Medical Center. The Veteran's Administration Medical Center is located less than one mile from the I-405 freeway and north of the I-10 freeway. It provides a full spectrum of inpatient and ambulatory care to over one million veterans residing in the primary service area of Los Angeles County, which has the largest concentration of veterans of any county in the United States. The Healthcare Center operates a 321-bed domiciliary that provides medical care in a therapeutic institutional environment to prepare veterans for re-entry into a community setting. It also contains two 120-bed nursing home care units located on the grounds and an active community nursing home program. The UCLA Medical Center is about one mile east of the I-405 freeway on the UCLA campus. It has over 600 beds and offers comprehensive care to all ages. More than 300,000 people come to the UCLA Medical Center each year to receive care from the world's most renowned providers.

In addition to these facilities, other major trip generators within the proximity of the I-405 study corridor include:

- The Sherman Oaks Galleria off the US-101 interchange
- Skirball Cultural Center off Mulholland Drive
- The Getty Center off Sunset Boulevard
- The Westfield Foxhills Mall off the SR-90 interchange
- The South Bay Galleria off of Hawthorne Boulevard.

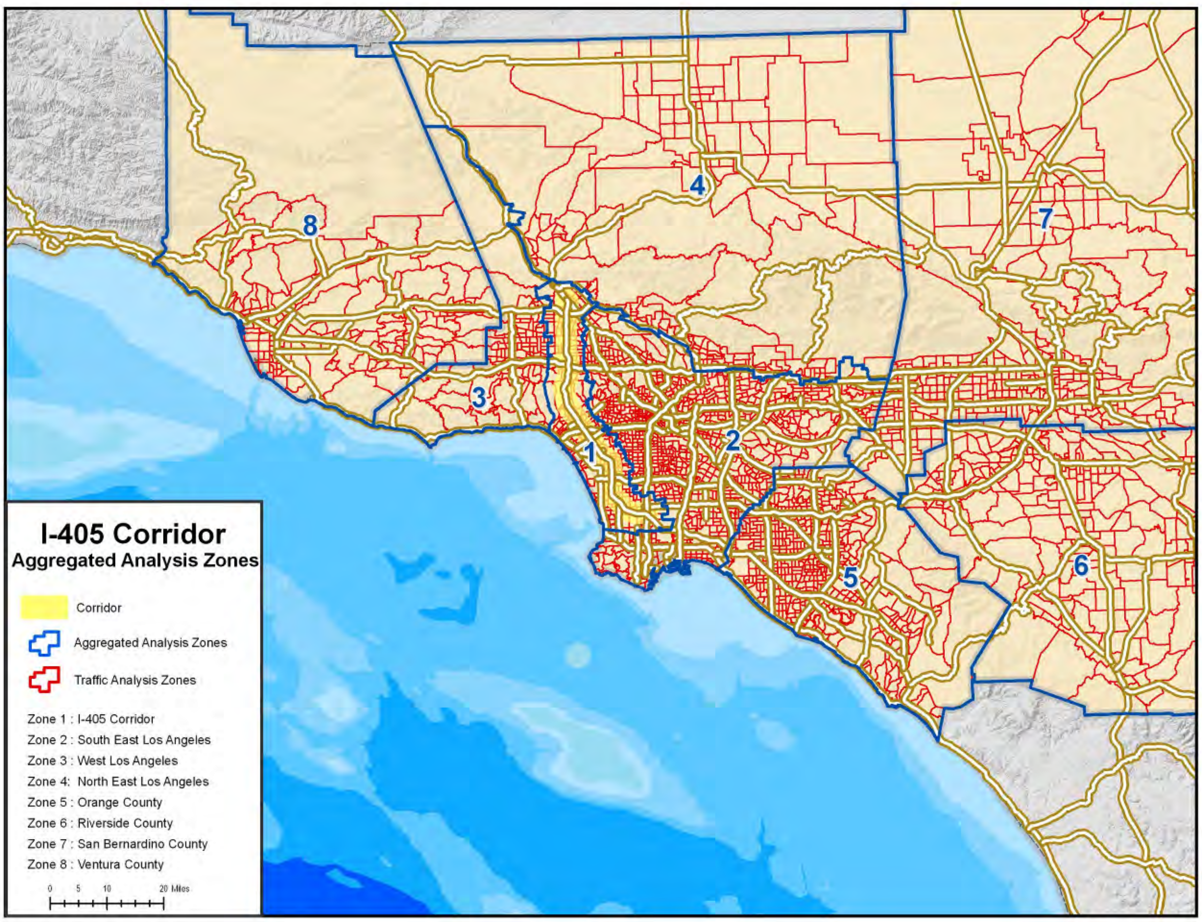
Exhibit 2-18: Major Special Event Facilities or Trip Generators



Demand Profiles

An analysis of origins and destinations was conducted to determine the travel pattern of trips made on the I-405 CSMP study corridor. Based on SCAG's 2000 travel demand model, this "select link analysis" isolated the I-405 study corridor and identified the origins and destinations of trips made on the corridor. The origins and destinations were identified by Traffic Analysis Zones (TAZ), which were grouped into eight aggregate analysis zones shown in Exhibit 2-19.

Exhibit 2-19: Aggregate Analysis Zones for Demand Profile Analysis



Based on this aggregation, demand on the corridor was summarized by aggregated origin-destination zones as shown on Exhibits 2-20 and 2-21 for the AM and PM peak periods. The analysis showed that a significant percentage of trips using the I-405 Corridor involve trips within Los Angeles County.

During the AM peak period, 86 percent of all trips originate <u>and</u> terminate in Los Angeles County (Zones 1, 2, 3, 4). Of these trips, a significant portion travel within close proximity to the corridor (Zone 1) or to and from Southeast Los Angeles (Zone 2). The remaining trips depicted in Exhibit 2-20 originate in Los Angeles County and terminate in another county (5 percent); originate outside Los Angeles County and terminate in Los Angeles County (8 percent); or originate and terminate outside of Los Angeles County (1 percent).

Exhibit 2-20: I-405 AM Peak Origin Destination by Aggregated Analysis Zone

		TO ZONE								
	AM Trips	I-405 Corridor	Southeast Los Angeles	West Los Angeles	Northeast Los Angeles	Orange County	Riverside County	San Bernardino Co.	Ventura County	Outside Zones
FROM ZONE	I-405 Corridor	80,602	49,319	13,681	6,689	6,345	97	189	2,866	1,378
	Southeast LA	67,611	9,155	4,190	4,707	1,219	1	6	424	2,103
	West LA	16,891	5,502	889	2,589	203	3	10	137	298
	Northeast LA	14,723	13,526	5,686	4	243	1	0	999	60
	Orange Co.	12,108	3,293	198	63	0	0	0	20	1,532
	Riverside Co.	528	2	4	0	0	0	0	0	6
	San Bernardino Co.	765	23	45	0	0	0	0	8	0
	Ventura Co.	7,232	1,232	110	1,016	85	0	3	3	362
	Outsize Zones	564	1,074	127	24	418	4	1	84	1,006

85.9%	Trips starting and ending in Los Angeles County
4.8%	Trips starting in Los Angles County and ending outside of Los Angeles County
8.3%	Trips starting outside of Los Angeles County and ending in Los Angeles County
1.0%	Trips starting and ending outside of Los Angeles County

The picture is similar for the PM peak period, which experiences around 33 percent more demand than the AM. Approximately 84 percent of trips originate and terminate in Los Angeles County. The remaining trips originate in Los Angeles County and terminate in another county (8 percent); originate outside Los Angeles County and terminate in Los Angeles County (7 percent); or originate and terminate outside Los Angeles County (2 percent).

Exhibit 2-21: I-405 PM Peak Origin Destination by Aggregated Analysis Zone

		TO ZONE								
	PM Trips	I-405 Corridor	Southeast Los Angeles	West Los Angeles	Northeast Los Angeles	Orange County	Riverside County	San Bernardino Co.	Ventura County	Outside Zones
FROM ZONE	I-405 Corridor	118,279	93,088	24,814	20,225	17,430	615	949	9,569	1,312
	Southeast LA	76,544	12,526	8,503	17,856	2,922	4	41	1,716	2,046
	West LA	18,442	6,118	1,468	7,991	431	6	76	191	290
	Northeast LA	12,228	10,045	5,078	21	245	1	0	1,730	64
	Orange Co.	12,592	3,583	426	336	0	0	0	114	1,388
	Riverside Co.	257	4	5	1	0	0	0	0	5
	San Bernardino Co.	428	8	35	0	0	0	0	3	0
	Ventura Co.	5,565	1,000	202	1,731	111	0	30	2	380
	Outsize Zones	2,878	4,891	737	100	3,213	8	4	764	1,772

84.1%	Trips starting and ending in Los Angeles County
7.7%	Trips starting in Los Angles County and ending outside of Los Angeles County
6.7%	Trips starting outside of Los Angeles County and ending in Los Angeles County
1.5%	Trips starting and ending outside of Los Angeles County

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3. CORRIDOR PERFORMANCE ASSESSMENT

This section summarizes existing conditions on the I-405 corridor. The primary objectives of the performance measures are to provide a sound technical basis for describing traffic performance on the corridor.

A. Data Sources and Detection

Various data sources were used to analyze the performance of the corridor, including:

- Caltrans Highway Congestion Monitoring Program (HICOMP) report and data files (2004-2007)
- Caltrans Freeway detector data
- Caltrans District 7 probe vehicle runs (electronic tachometer runs)
- Caltrans Traffic Accident Surveillance and Analysis System (TASAS)
- Signal Timing Plans
- Traffic study reports (various)
- Aerial photographs (Google Earth) and Caltrans photologs
- Internet (i.e. Metro website, Metrolink website, SCAG website, etc).

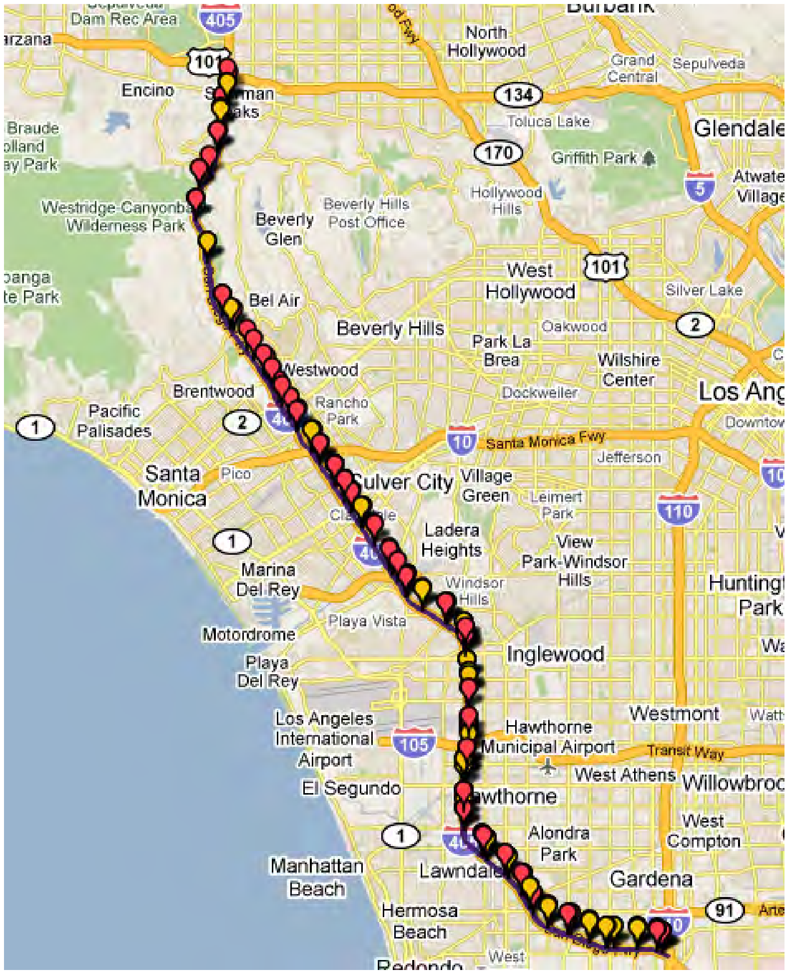
Details for each data source are provided in applicable sections of this report. However, given the need for comprehensive and continuous monitoring and evaluation, detection coverage and quality are discussed in more detail below.

Freeway Detection Status

Exhibit 3A-1 depicts the I-405 corridor freeway facility with detectors in place and their status in June 2010. The red bubbles represent detectors that are reporting good data while the yellow represent detectors that are not fully functioning. As illustrated in the exhibit, detection on this day was relatively good along the corridor except for the segment north of the I-110 Interchange.

The analysis of the corridor is based on two time periods: one that reflects pre-construction conditions and another that reflects present conditions. The pre-construction period refers to the three years of 2001-2003, before the heavy construction of the HOV-lane commenced. The present conditions period refers to the years 2008 and 2009, which continued to experience construction of the HOV-lane but on a different portion of the corridor. As of 2010, construction of the HOV-lane continues, on the northbound segment between I-10 and US-101.

Exhibit 3A-1: I-405 Detection Status in June 2010

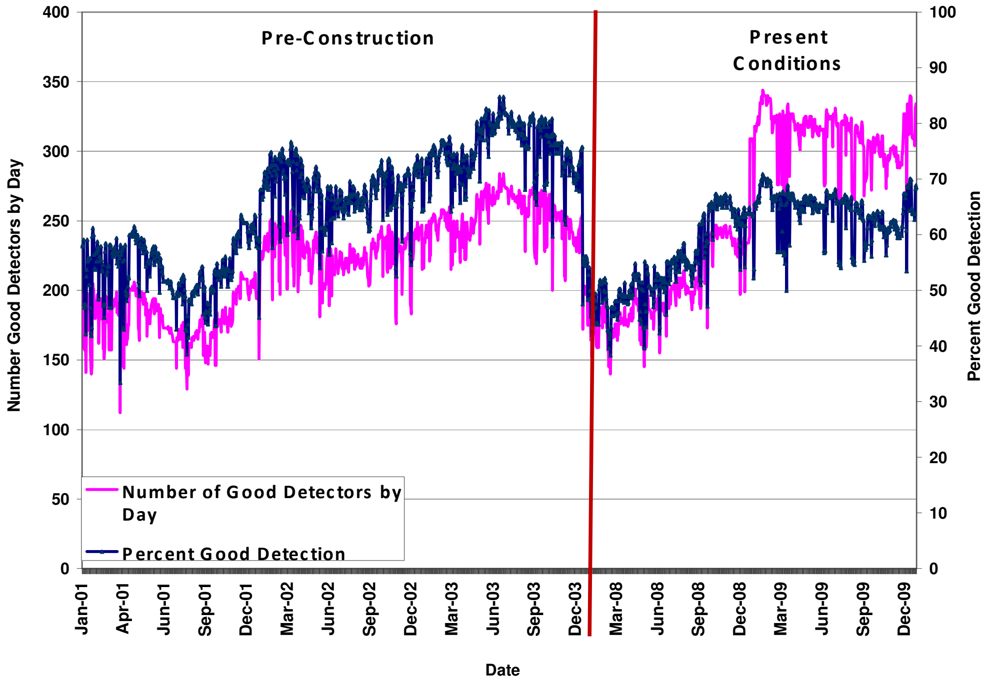


Source: Caltrans detector data

The study team, in coordination with SCAG, Caltrans and other stakeholders, selected 2003 as the baseline year for micro-simulation model development and calibration since 2003 was the year with the best detection data observed. Again, this decision is not ideal. The model can be updated in the future as more data becomes available for more recent years.

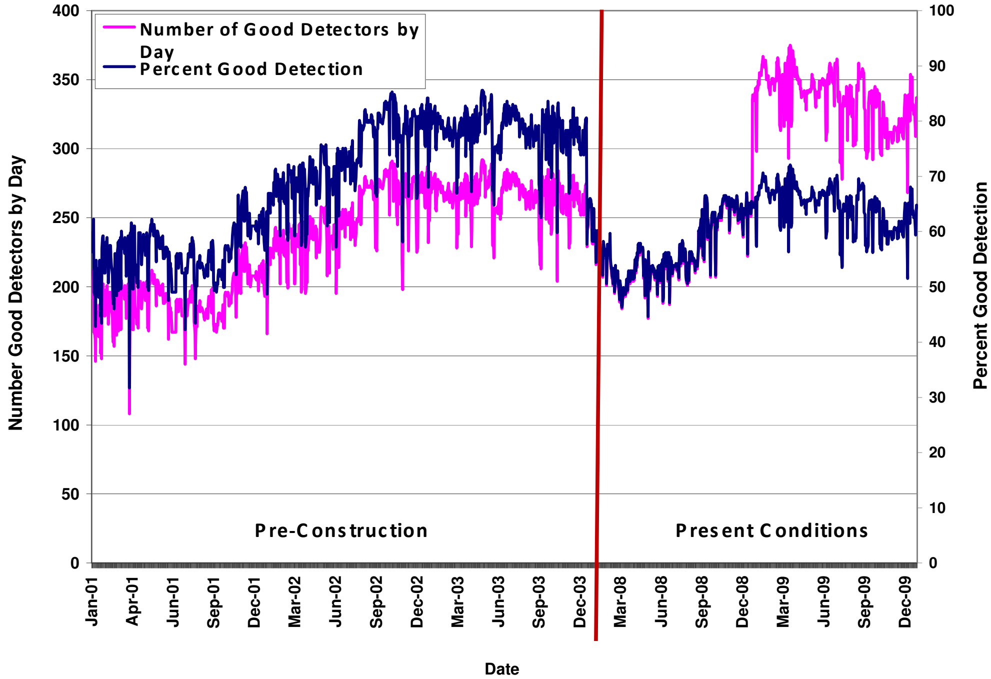
To see how well the detectors performed over the years covered in the analysis, Exhibits 3A-2 and 3A-3 show the percentage of good detection on the I-405 mainline facility for the pre-construction (2001-2003) and present conditions (2008-2009) time frames. The exhibits report the percentage of daily “good detectors” during the period of analysis for the entire Los Angeles I-405 corridor. These include mainline detectors as well as ramp detectors. 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. In both directions of the mainline facility, detection during the pre-construction years increased from 2001 to 2002 with the addition of new “good” detectors, and further improved in 2003, reaching above 80 percent good detection. However, in 2008, detection on the mainline dropped to about 50 percent in the beginning of the year, and slowly climbed to about 70 percent good detection towards the end of 2009. These fluctuations in detection are likely attributed to the construction activities along the corridor that require the disabling of detectors.

Exhibit 3A-2: Northbound I-405 ML Daily Good Detectors (2001-03, 2008-09)



Source: Caltrans detector data

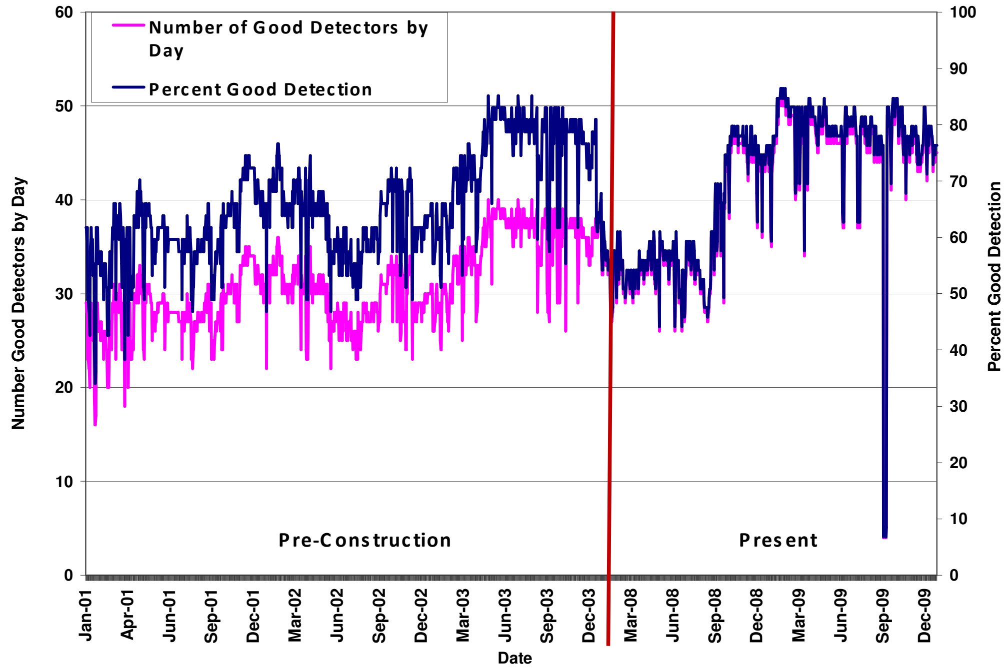
**Exhibit 3A-3: Southbound I-405 ML
Daily Good Detectors (2001-03, 2008-09)**



Source: Caltrans detector data

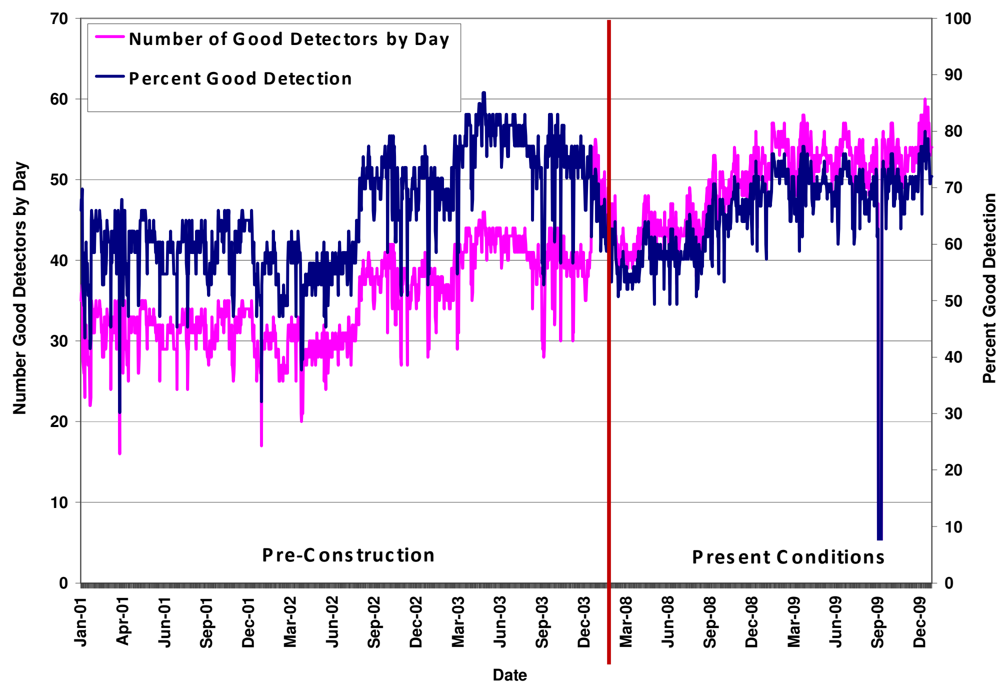
It is important to emphasize that the HOV facility is not the same length in distance as the mainline facility because the HOV-lane remains under construction along the study corridor. Exhibits 3A-4 and 3A-5 illustrate the percentage of good detection on the I-405 HOV facility by direction. Similar to the detection pattern along the mainline, the HOV facility also experienced an improvement in detection throughout the pre-construction period from 2001-2003, and a decline in detection in 2008. Exhibit 3A-5 shows that the number of good detectors in the southbound direction in 2008 exceeded the number of good detectors in the northbound direction. However, the percentage of good detectors in both directions remained about the same in 2008, indicating that the southbound direction also had many other detectors that were either not operating or operating inadequately. In 2009, the northbound direction experienced an increase in the number of good detectors as well as percent of good detection, which was between 70 and 80 percent by the end of the year.

Exhibit 3A-4: Northbound I-405 HOV Daily Good Detectors (2001-03, 2008-09)



Source: Caltrans detector data

Exhibit 3A-5: Southbound I-405 HOV Daily Good Detectors (2001-03, 2008-09)



Source: Caltrans detector data

Exhibits 3A-6 and 3A-7 identify the detectors that were added to the mainline facility between 2003 and 2010. Similarly, Exhibits 3A-8 and 3A-9 identify the detectors added to the HOV-facility during the same period. As indicated, many of these detectors were added in 2010, particularly on the HOV facility.

Exhibit 3A-6: Northbound I-405 ML & Ramp Detectors Added (2003-2010)

VDS	CA PM	Abs PM	Name	Type	Date Online
772473	13.0	36.8	N/B 405 TO S/B 110	Fwy-Fwy	1/8/2010
772474	13.0	36.8	N/B 405 TO N/B 110	Fwy-Fwy	1/8/2010
772475	13.0	36.8	N/B 405 TO N/B 110	Fwy-Fwy	1/8/2010
769228	22.3	46.1	OLIVE / MANCHESTER	Mainline	2/21/2007
771969	24.9	48.7	HOWARD HUGHES PKWY	Mainline	1/12/2010
771970	24.9	48.7	HOWARD HUGHES PKWY	On Ramp	1/12/2010
769496	26.0	49.8	JEFFERSON	Mainline	2/14/2008
769506	26.0	49.8	JEFFERSON	Off Ramp	2/14/2008
769507	26.0	49.8	JEFFERSON	On Ramp	2/14/2008
768643	26.8	50.6	BRADDOCK	Mainline	9/16/2005
772437	28.1	51.9	N/O VENICE	Mainline	1/8/2010
768969	28.4	52.2	S OF 10	Mainline	11/1/2005
768971	28.4	52.2	NB 405 TO WB 10	Fwy-Fwy	11/1/2005
772455	28.5	52.3	PALMS BLVD	Mainline	1/8/2010
768636	38.7	62.5	GREENLEAF/SEPULVEDA	Off Ramp	9/16/2005
767351	40.9	64.7	OXNARD ST	Mainline	9/16/2005
767367	43.2	67.0	STAGG ST	Mainline	9/16/2005
771808	45.7	69.5	LASSEN	Mainline	1/8/2010
771767	46.2	70.0	DEVONSHIRE 1	Mainline	1/8/2010
771768	46.2	70.0	DEVONSHIRE 1	On Ramp	1/8/2010
771770	46.2	70.0	DEVONSHIRE 1	Off Ramp	1/8/2010
771778	46.4	70.2	DEVONSHIRE 2	On Ramp	1/8/2010
772011	47.9	71.7	RINALDI	Mainline	1/12/2010
772013	47.9	71.7	RINALDI	On Ramp	1/12/2010
772024	48.3	72.1	FM 5 to 405	Mainline	1/12/2010

Exhibit 3A-7: Southbound I-405 ML & Ramp Detectors Added (2003-2010)

VDS	CA PM	Abs PM	Name	Type	Date Online
769248	13.2	37.0	N OF 110	Mainline	2/21/2007
769251	13.2	37.0	SB 405 to SB 110 #1	Fwy-Fwy	2/21/2007
769198	13.3	37.1	VERMONT	Off Ramp	2/21/2007
769195	13.3	37.1	VERMONT	Mainline	2/21/2007
767827	R21.4	45.1	FM 105 WB	Mainline	9/16/2005
771954	24.9	48.7	HOWARD HUGHES PKWY	Mainline	1/12/2010
771956	24.9	48.7	HOWARD HUGHES PKWY	On Ramp	1/12/2010
771957	24.9	48.7	HOWARD HUGHES PKWY	Off Ramp	1/12/2010
769077	27.8	51.6	VENICE	Mainline	3/17/2006
772438	28.1	51.9	N/O VENICE	Mainline	1/8/2010
768970	28.4	52.2	EB 10 TO SB 405	Fwy-Fwy	11/1/2005
768968	28.4	52.2	S OF 10	Mainline	11/1/2005
772527	28.5	52.3	WESTMINSTER	Mainline	1/8/2010
772454	28.5	52.3	PALMS BLVD	Mainline	1/8/2010
768619	33.4	57.2	MORAGA	Mainline	9/16/2005
768634	38.7	62.5	GREENLEAF/SEPULVEDA	Mainline	9/16/2005
767056	40.1	63.9	BURBANK 2	Off Ramp	9/16/2005
767055	40.1	63.9	BURBANK 2	On Ramp	9/16/2005
767053	40.1	63.9	BURBANK 2	Mainline	9/16/2005
767350	40.9	64.7	OXNARD ST	Mainline	9/16/2005
767366	43.2	67.0	STAGG ST	Mainline	9/16/2005
768626	44.9	68.6	NORDHOFF OFF	Mainline	9/16/2005
771807	45.7	69.5	LASSEN	Mainline	1/8/2010
771981	47.6	71.4	RINALDI	Mainline	1/12/2010
771982	47.6	71.4	RINALDI	On Ramp	1/12/2010
771983	47.6	71.4	RINALDI	Off Ramp	1/12/2010
771997	47.6	71.4	SAN FERNANDO	Mainline	1/12/2010
771999	47.6	71.4	SAN FERNANDO	On Ramp	1/12/2010
772025	48.3	72.1	FM 5 to 405	Mainline	1/12/2010

Exhibit 3A-8: Northbound I-405 Added to HOV Facility (2003-2010)

VDS	CA PM	Abs PM	Name	Type	Date Online
769249	13.2	37.0	N OF 110	HOV	2/21/2007
769232	22.3	46.1	OLIVE	HOV	2/21/2007
769255	22.7	46.5	CENTURY 1	HOV	2/21/2007
769259	22.7	46.5	CENTURY 2	HOV	2/21/2007
769260	23.4	47.1	MANCHESTER 1	HOV	2/21/2007
769263	23.5	47.2	MANCHESTER 2	HOV	2/21/2007
769236	23.6	47.4	LA CIENEGA	HOV	2/21/2007
769265	24.3	48.0	LA TIJERA	HOV	2/21/2007
769242	25.4	49.2	CENTINELA	HOV	2/21/2007
772518	27.4	51.1	CULVER	HOV	1/8/2010
772439	28.1	51.9	N/O VENICE	HOV	1/8/2010
772528	28.5	52.3	WESTMINSTER	HOV	1/8/2010
772457	28.5	52.3	PALMS BLVD	HOV	1/8/2010
772533	29.2	52.9	NATIONAL	HOV	1/8/2010
767353	40.9	64.7	OXNARD ST	HOV	9/16/2005
767369	43.2	67.0	STAGG ST	HOV	9/16/2005
771810	45.7	69.5	LASSEN	HOV	1/8/2010
771769	46.2	70.0	DEVONSHIRE 1	HOV	1/8/2010
772012	47.9	71.7	RINALDI	HOV	1/12/2010

Exhibit 3A-9: Southbound I-405 Added to HOV Facility (2003-2010)

VDS	CA PM	Abs PM	Name	Type	Date Online
769250	13.2	37.0	N OF 110	HOV	2/21/2007
767847	R20.9	44.7	FM RT 105	HOV	9/16/2005
769219	22.0	45.8	102ND / CENTURY	HOV	2/21/2007
769231	22.3	46.1	OLIVE	HOV	2/21/2007
769221	22.4	46.2	98TH / WB CENTURY	HOV	2/21/2007
769235	23.6	47.4	LA CIENEGA	HOV	2/21/2007
769238	24.3	48.0	LA TIJERA	HOV	2/21/2007
771955	24.9	48.7	HOWARD HUGHES PKWY	HOV	1/12/2010
769241	25.4	49.2	CENTINELA	HOV	2/21/2007
772519	27.4	51.1	CULVER	HOV	1/8/2010
772440	28.1	51.9	N/O VENICE	HOV	1/8/2010
772529	28.5	52.3	WESTMINSTER	HOV	1/8/2010
772456	28.5	52.3	PALMS BLVD	HOV	1/8/2010
772532	29.2	52.9	NATIONAL	HOV	1/8/2010
772538	29.5	53.3	S OF 10	HOV	1/8/2010
766956	33.0	56.8	SUNSET WB / CHURCH	HOV	9/16/2005
768618	33.4	57.2	MORAGA	HOV	9/16/2005
766954	35.8	59.6	BEL AIR CR	HOV	9/16/2005
766952	36.6	60.3	SKIRBALL/MULHOLLAND	HOV	9/16/2005
767264	37.6	61.3	ROYAL RIDGE	HOV	9/16/2005
767258	38.1	61.9	VENTURA	HOV	9/16/2005
767262	38.1	61.9	WOODCREST	HOV	9/16/2005
767260	38.4	62.2	VALLEY VISTA	HOV	9/16/2005
768633	38.7	62.5	GREENLEAF/SEPULVEDA	HOV	9/16/2005
767054	40.1	63.9	BURBANK 2	HOV	9/16/2005
767352	40.9	64.7	OXNARD ST	HOV	9/16/2005
767368	43.2	67.0	STAGG ST	HOV	9/16/2005
768625	44.9	68.6	NORDHOFF OFF	HOV	9/16/2005
771809	45.7	69.5	LASSEN	HOV	1/8/2010
771998	47.6	71.4	SAN FERNANDO	HOV	1/12/2010

An analysis of gaps without detection on I-405 is shown in Exhibit 3A-10. There are various segments extending over 0.75 miles without detection in each direction. These gaps should be considered for deployment of additional detection when funding becomes available.

Exhibit 3A-10: I-405 Gaps In Detection (as of May 2010)

Location	Abs PM		Length (Miles)
	From	To	
NORTHBOUND			
Inglewood 2 to Rosecrans 1	42.12	42.93	0.81
122nd to FM 105 WB	44.37	45.14	0.77
FM 105 WB to Olive/Manchester	45.14	46.11	0.98
Wilshire 2 to Montana	55.34	56.17	0.83
Moraga to Getty/Sepulveda	57.19	58.48	1.29
Getty/Sepulveda to Bel Air CR	58.48	59.57	1.09
Bel Air CR to Skirball/Mulholland	59.57	60.70	1.13
Ventura to Burbank 1	62.74	63.77	1.03
Victory to Sherman Way	65.25	66.23	0.98
Roscoe to Nordhoff	67.64	68.64	1.00
Nordhoff to Lassen	68.64	69.47	0.83
Devonshire 1 to Rinaldi	69.97	71.71	1.74
SOUTHBOUND			
Inglewood 2 to Rosecrans 1	42.07	42.93	0.86
98th/WB Century to Olive/Manchester	46.17	47.06	0.89
Waterford to Sunset WB/Church	55.88	56.81	0.93
Moraga to Getty/Sepulveda	57.19	58.50	1.31
Getty/Sepulveda to Bel Air CR	58.50	59.57	1.07
Skirball/Mulholland to Royal Ridge	60.32	61.34	1.02
Ventura to Burbank 1	62.86	63.77	0.91
Burbank 2 to Oxnard st	63.85	64.67	0.82
Victory 2 to Sherman Way 1	65.25	66.03	0.78
Roscoe to Nordhoff on	67.45	68.43	0.98
Nordhoff off to Lassen	68.64	69.47	0.83
Devonshire 2 to Rinaldi	69.98	71.37	1.39

B. Corridor Performance Assessment

This section summarizes the analysis results of the performance measures used to evaluate the existing conditions of the I-405 CSMP Corridor. The primary objective of the measures is to provide a sound technical basis for describing traffic performance on the corridor. Data from the mainline (ML) and high-occupancy vehicle (HOV) facilities were analyzed separately under each performance measure. The base year of analysis and modeling for I-405 is 2003, the year when the best detection data was observed.

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
- *Safety* provides an overview of collisions along the corridor
- *Productivity* quantifies the degree to which traffic inefficiencies at bottlenecks or hot spots reduce flow rates along the corridor.

MOBILITY

Mobility describes how well the corridor moves people and freight. The mobility performance measures are both readily measurable and straightforward for documenting current conditions and are readily forecasted making them useful for future comparisons. Two primary measures are typically used to quantify mobility: delay and travel time.

Delay

Delay is defined as the total 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:

$$(\text{Vehicles Affected per Hour}) \times (Dis\tan ce) \times (Duration) \times \left[\frac{1}{(\text{Congested Speed})} - \frac{1}{\text{35mph}} \right]$$

In the formula above, the *Vehicles Affected per Hour* value depends on the methodology used. Some methods assume a fixed flow rate (e.g., 2,000 vehicles per hour per lane), while others use a measured or estimated flow rate. The distance is the length under which the congested speed prevails and the duration is the hours of congestion experience 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 detector data uses the 60 mph threshold speed and the observed number of vehicles reported by detection systems. The congestion results of HICOMP and Caltrans detector data are difficult to compare due to these methodological differences, so they are discussed separately in this assessment.

Caltrans HICOMP

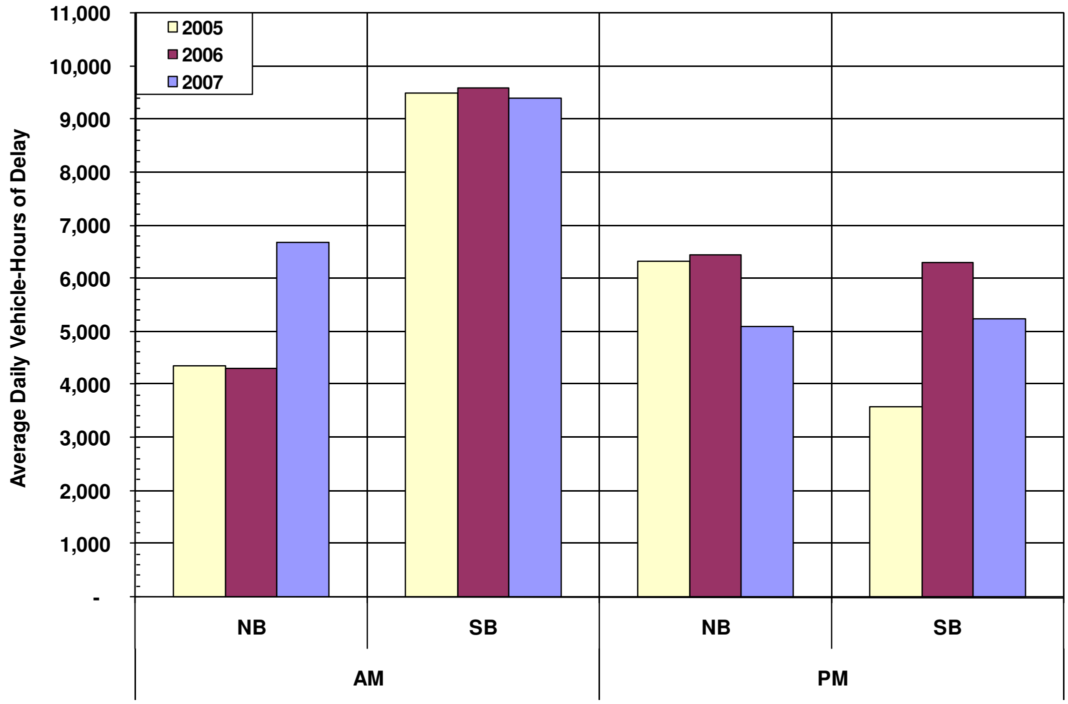
The HICOMP report has been published annually by Caltrans since 1987.[2] Delay is presented as average daily vehicle-hours of delay (DVHD). In HICOMP, Caltrans attempts to capture recurrent congestion during "typical" incident-free weekday peak periods. Recurrent delay is defined in HICOMP as a condition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

For the Los Angeles HICOMP analysis, delay is calculated only for the mainline facility using detector data As discussed later in this section when using automatic detector data, congestion levels vary from day to day and depend on any number of factors including accidents, weather, and special events.

Exhibit 3B-1 shows the HICOMP delay results from 2005 to 2007 for the AM and PM peak travel period for both directions of I-405. Although construction activities occurred in 2005 through 2007, these were the most recent years which HICOMP data was available. As shown in Exhibit 3B-1, the southbound corridor had the most significant congestion during the AM peak period while the northbound experienced the most congestion during the PM peak period. The exhibit shows a sharp decline in the northbound PM peak period congestion from 2006 to 2007.

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

Exhibit 3B-1: Average Daily Vehicle-Hours of Delay (2005-2007)



Source: 2005-2007 HICOMP data

Exhibit 3B-2 shows the complete list of congested segments reported by the HICOMP report for the I-405 corridor. "Generalized" congested segments are presented so that segment comparisons can be made from one year to the next since a given congested segment may vary in distance or size from one year to the next as well as from day-to-day. However, it is important to reiterate that these trends are affected by the lack of detection data in construction areas and the overall reliability of detection equipment.

Exhibits 3B-3 and 3B-4 provide maps illustrating the 2007 congested segments during the AM and PM peak commute periods for the I-405. The approximate locations of the congested segments, the duration of that congestion, and the reported recurrent daily delay are also shown.

Based on the HICOMP results, 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 southbound segment during the AM peak period between San Fernando Mission and US-101. Delay in this segment totaled 6,774 hours in 2007.

Exhibit 3B-2: HICOMP Hours of Delay for Congested Segments (2005-2007)

Period	Dir	Generalized Congested Area	Generalized Area Congested Hours of Delay 2005	2006	2007
AM	NB	East of I-110 to South of Rosecrans Ave	1,875		
		Carson St to Rosecrans Ave		1,186	
		Santa Fe Ave to Rosecrans Ave			2,584
		North I-105 to South of Venice Blvd (SR-187)	2,467	3,113	4,081
	SB	San Fernando Mission to US-101	6,104	5,715	6,774
		US-101 to Wilshire Blvd	3,132	3,788	2,606
		Oylimpic Blvd to Venice Blvd (SR-187)	148		
		I-105 to Normandie Ave	93		
		I-105 to North of Rosecrans Ave		85	
AM PEAK PERIOD SUMMARY			13,819	13,887	16,045
PM	NB	Carson St to Van Ness Ave			137
		La Tijera Blvd to Sepulveda/Getty	4,405	5,145	
		La Tijera Blvd to Santa Monica Blvd (SR-2)			1,569
		Santa Monica Blvd (SR-2) to Sepulveda/Getty			1,521
		Sepulveda/Getty To US-101	584		
		US-101 to Lassen St	1,319		
		North of Mullholland Drive to Lassen St		1,302	1,854
	SB	Santa Fe Ave to Sepulveda Blvd	1,169	961	
		I-10 to Culver Blvd			523
		Sepulveda Blvd to Centinela Blvd			221
		Century Blvd to Rosecrans Ave	922	2,152	1,294
		Rosecrans Ave to Van Ness Ave	242	972	490
		Van Ness Ave to Wilmington Ave	1,235		
		North of Van Ness Ave to Carson St		2,213	
		South of SR-91 to Wilmington Ave			2,714
PM PEAK PERIOD SUMMARY			9,876	12,745	10,323
TOTAL CORRIDOR CONGESTION			**23,695**	**26,632**	**26,368**

Exhibit 3B-3: 2007 AM Peak Period HICOMP Congested Segments Map

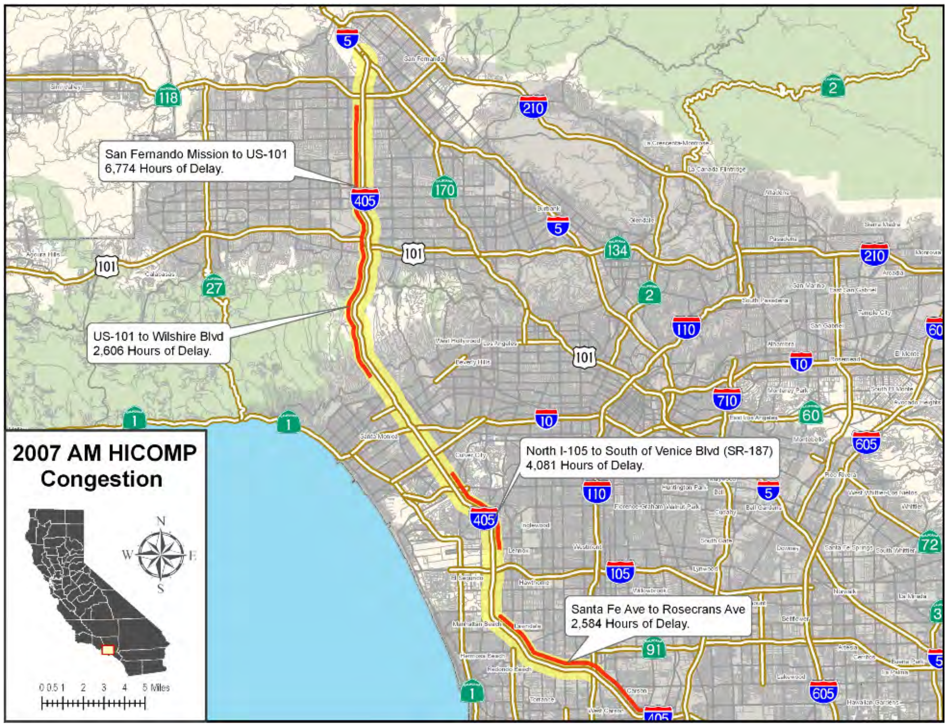
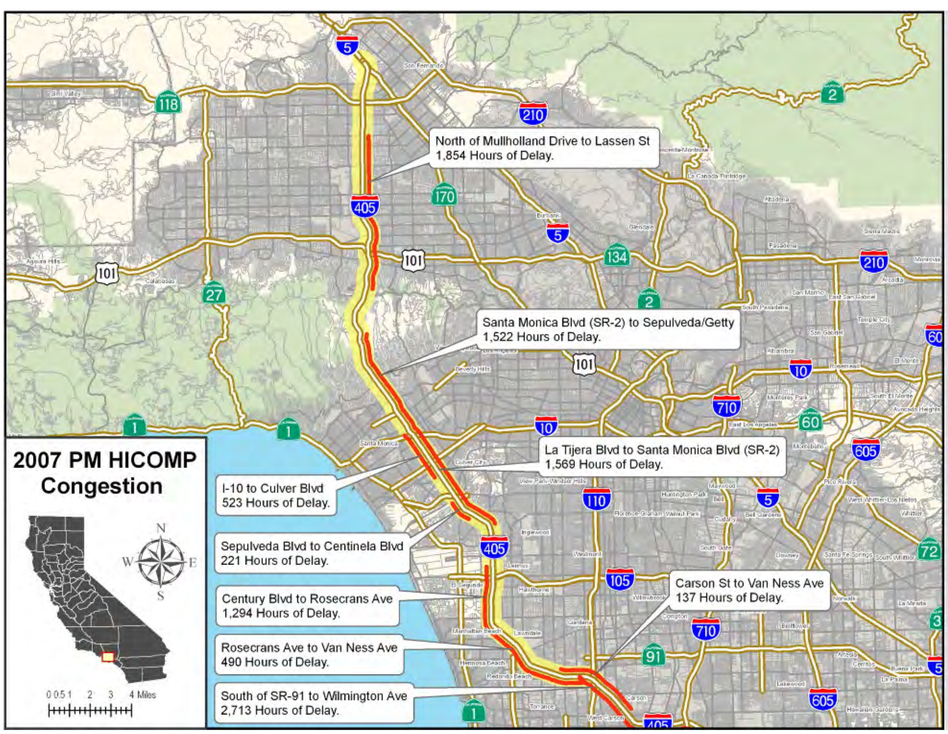


Exhibit 3B-4: 2007 PM Peak Period HICOMP Congested Segments Map



Automatic Detector Data

Using freeway detector data in the previous section, delay is computed for every day and summarized in different ways, which is not possible when using probe vehicle data.

Performance assessments were initially conducted during the three-year period between 2001 and 2003. These assessments were recently updated to include 2008 and 2009 data, which shows the current conditions of the corridor. Data for years between 2003 and 2008 are not analyzed due to heavy construction activity that required the disconnection of many detectors.

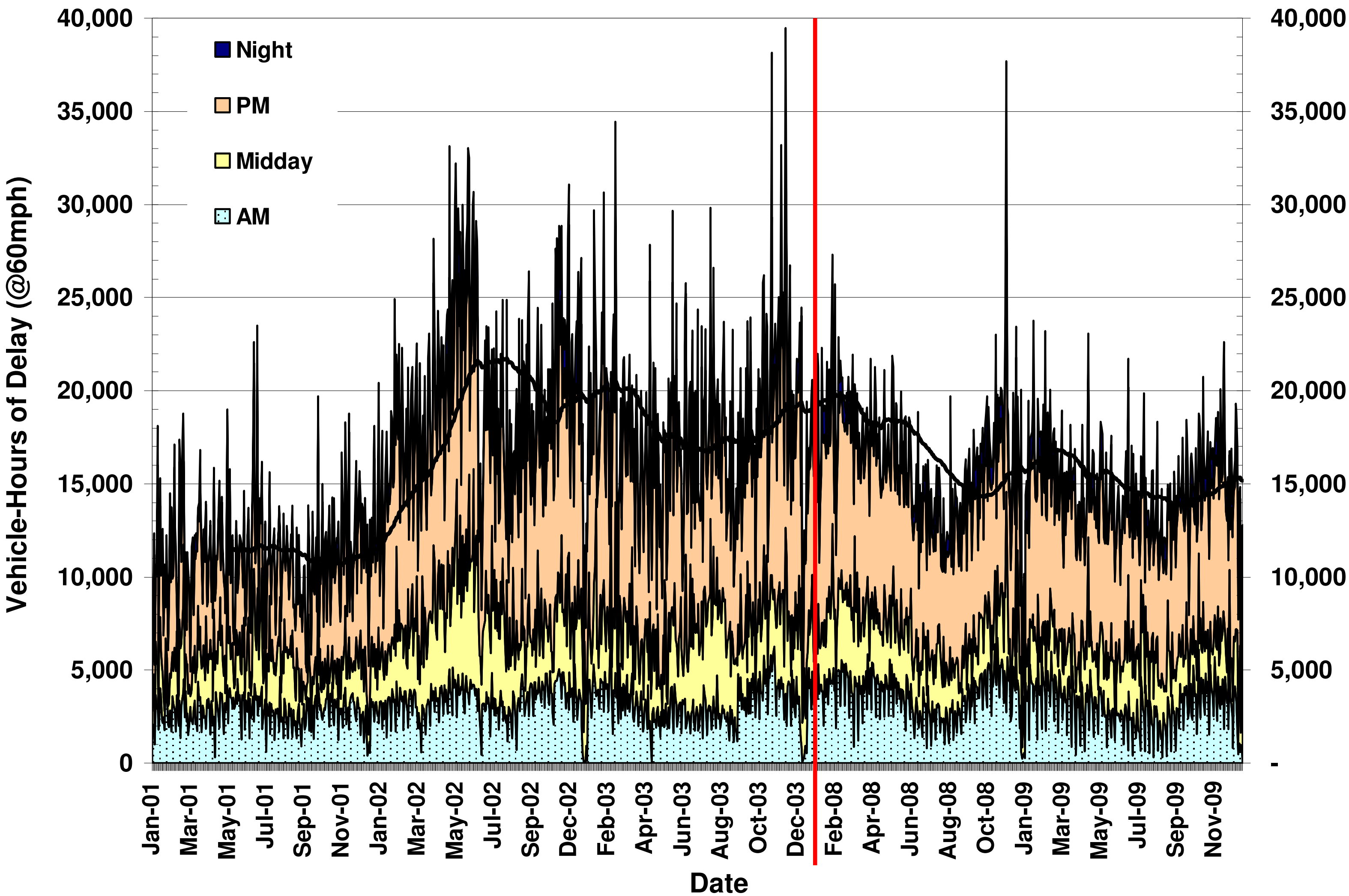
Unlike HICOMP where delay is captured only for speeds below 35 miles per hour and applied to an assumed output or capacity volume of 2,000 vehicles per hour, delays presented in this section represent the difference in travel time between actual conditions and free-flow conditions at 60 miles per hour, applied to the actual output flow volume collected from a vehicle detector station.

Total delay was computed during four time periods: AM peak (6:00 AM to 9:00 AM), Midday (9:00 AM to 3:00 PM), PM peak (3:00 PM to 7:00 PM), and evening/early AM (7:00 PM to 6:00 AM). The total delay by time period is shown in Exhibits 3B-5 through 3B-8. The exhibits include a 90-day moving average that reduces the day-to-day variations, which illustrates the seasonal and annual changes in congestion over time more easily.

Weekday delay on the mainline facility is presented in Exhibits 3B-5 and 3B-6 for each direction during the pre-construction (2001-2003) and present conditions (2008-2009) periods. Within the exhibit, there is a 90-day moving average to "smooth" out the day-to-day variations and illustrate the seasonal and annual changes in congestion over time. As indicated in these exhibits, delay in both directions followed a similar pattern with an increase in total delay from 2001 to 2002, a leveling off in 2003, followed by a decline in the middle of 2008 to 2009 with approximately 15,000 daily vehicle-hours of delay. Both directions also experienced the highest levels of delay during the PM peak period for all of the years analyzed.

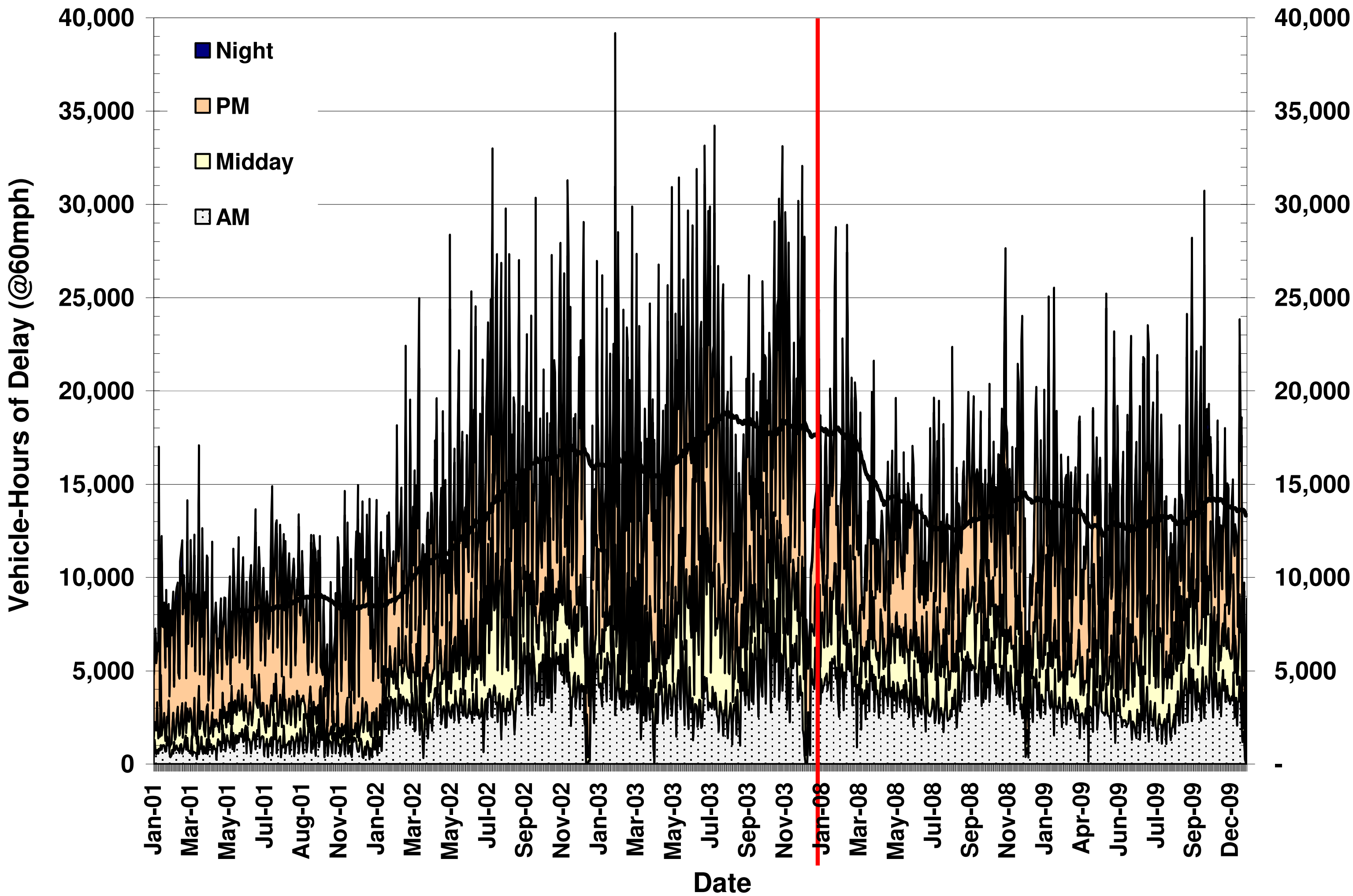
Exhibits 3B-7 and 3B-8 show the pattern of delay on the HOV facility. Since the HOV-lane does not currently extend throughout the entire study corridor, it is inappropriate to compare the mainline with the HOV-lane. Delay on both directions of the HOV-facility was evenly split between AM and PM peaks. Delay on both directions of the HOV-lane also increased in 2008 from 2001-2003 levels.

Exhibit 3B-5: Northbound I-405 ML Avg Daily Delay by Time Period (2001-03, 2008-09)



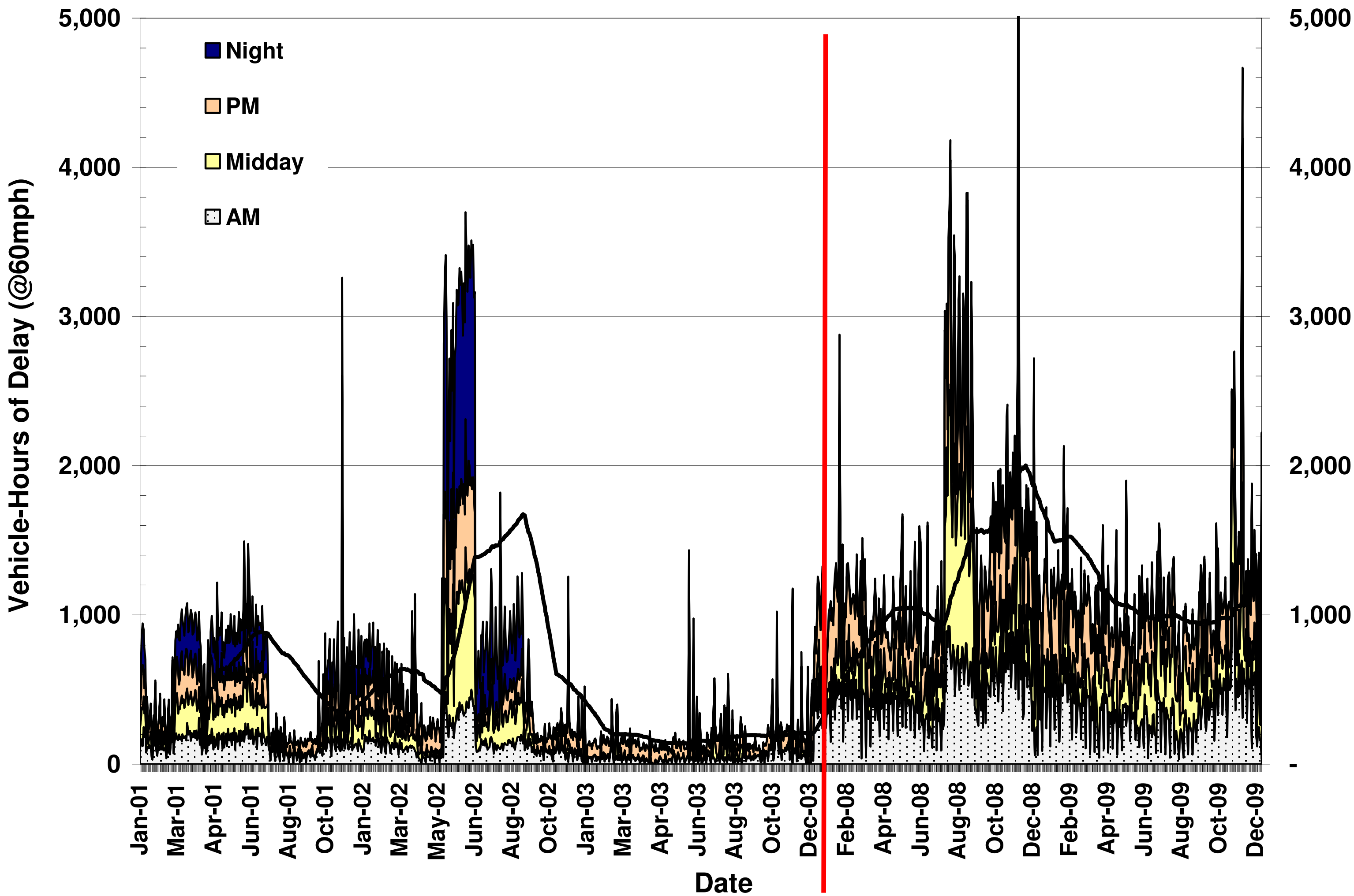
Source: Caltrans detector data

Exhibit 3B-6: Southbound I-405 ML Avg Daily Delay by Time Period (2001-03, 2008-09)



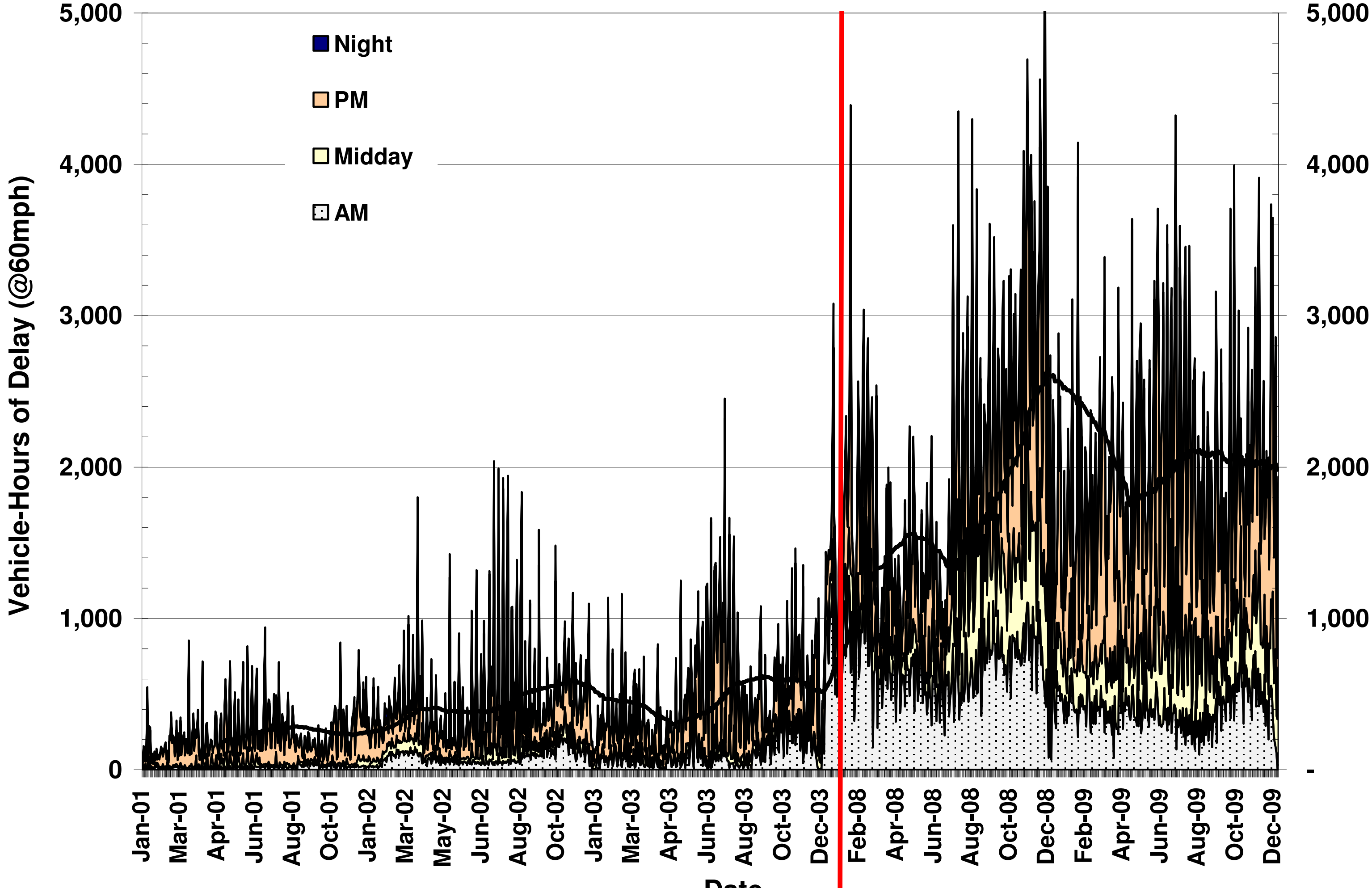
Source: Caltrans detector data

Exhibit 3B-7: Northbound I-405 HOV Avg Daily Delay by Time Period (2001-03, 2008-09)



Source: Caltrans detector data

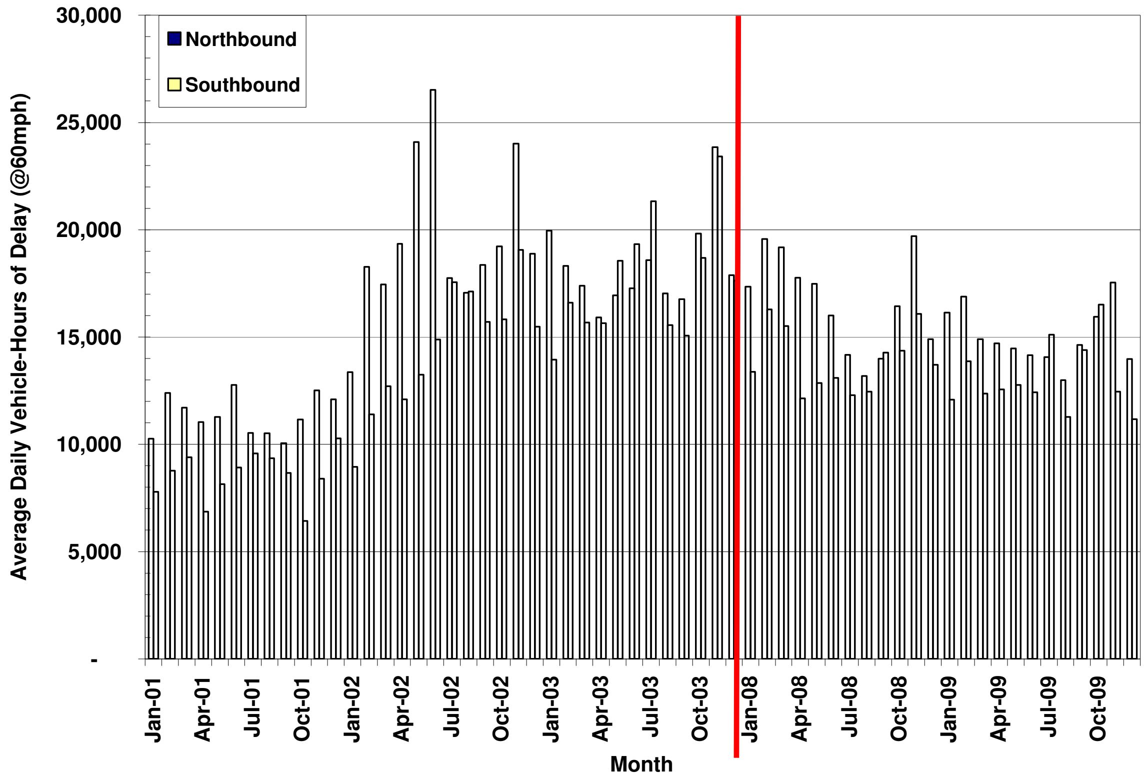
Exhibit 3B-8: Southbound I-405 HOV Avg Daily Delay by Time Period (2001-03, 2008-09)



Source: Caltrans detector data

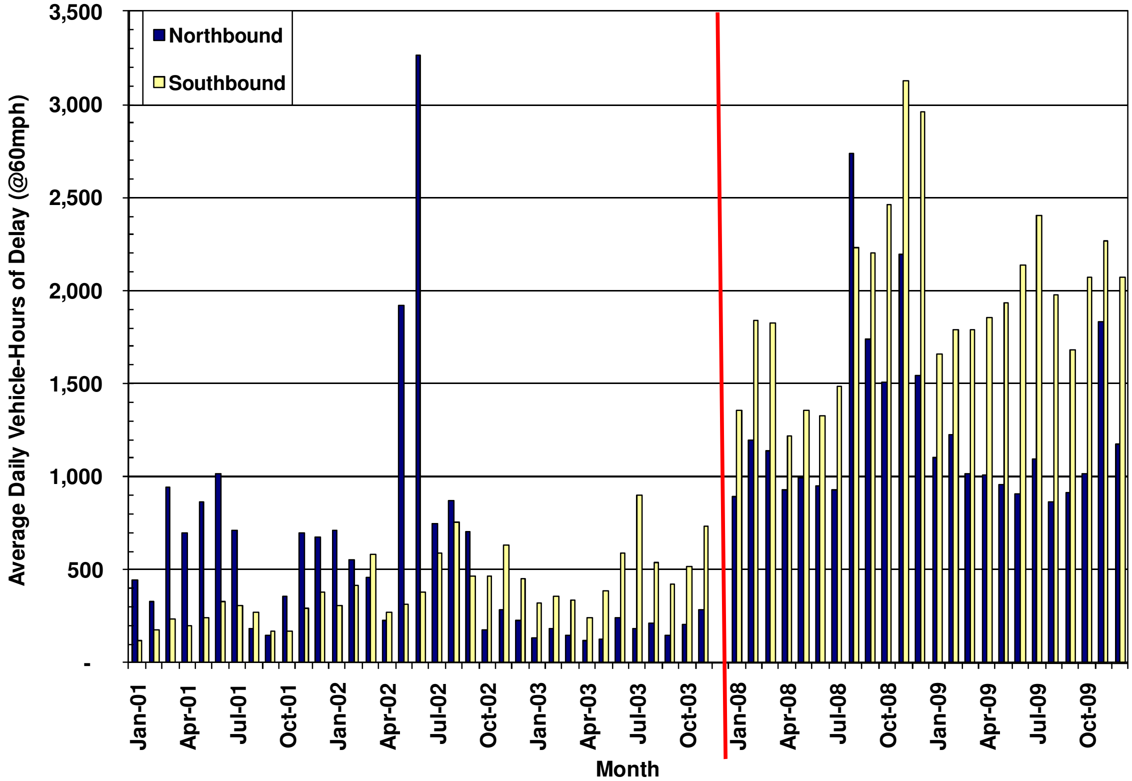
The following set of exhibits provides additional delay characteristics and trends. Exhibit 3B-9 illustrates the average daily weekday delay by month for the mainline facility and Exhibit 3B-10 shows the HOV facility. On the mainline facility (Exhibit 3B-9), the northbound direction experienced greater overall congestion compared to the southbound for the years analyzed. However, on the HOV facility (Exhibit 3B-10), the southbound direction exceeded delay in the northbound direction in 2003 and 2008-2009. Both exhibits, particularly Exhibit 3B-10, highlight the extreme delay that occurred in June 2002 in the northbound direction.

Exhibit 3B-9: I-405 ML Avg Weekday Delay by Month (2001-03, 2008-09)



Source: Caltrans detector data

Exhibit 3B-10: I-405 HOV Avg Weekday Delay by Month (2001-03, 2008-09)



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 segmented into two components as shown in Exhibits 3B-11 and 3B-12:

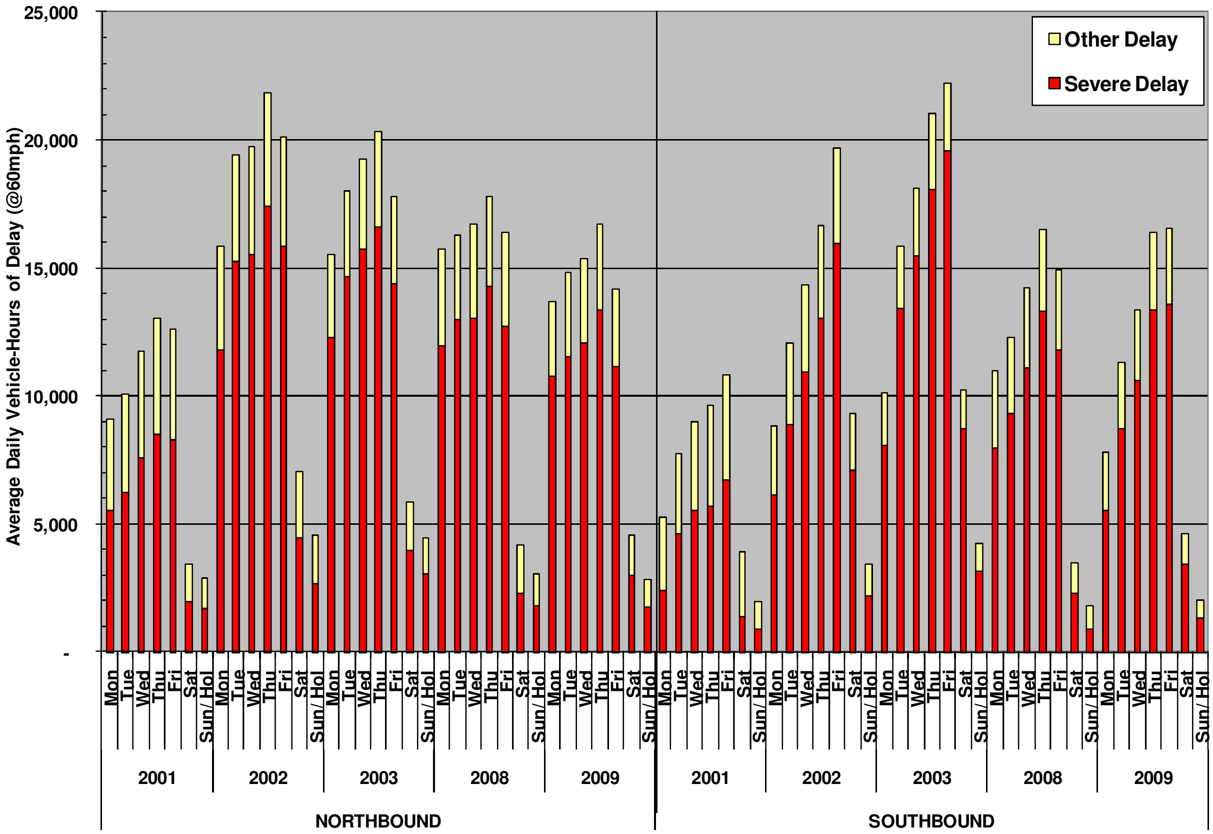
- Severe delay – delay that occurs when speeds are below 35 miles per hour; and
- Other delay – delay that occurs when speeds are between 35 miles per hour and 60 miles per hour.

Severe delay, as depicted in Exhibits 3B-11 through 3B-12 in red, represents breakdown conditions and is generally the focus of congestion mitigation strategies. "Other" delay represents conditions approaching breakdown congestion, leaving the breakdown conditions, or areas that do not cause widespread breakdowns, but cause at least temporary slowdowns. Although combating congestion requires the focus on severe congestion, it is important to review "other" congestion and understand its trends. This could allow for pro-active intervention before the "other" congestion turns into severe congestion.

On the mainline facility (Exhibit 3B-11), the northbound direction on Thursdays experienced the highest "severe" delay during all five years analyzed. Thursdays in

2002 experienced the highest "severe" delay, slightly below 18,000 vehicle-hours. In the southbound direction of the mainline, the level of congestion grew during the weekday and peaked on Fridays from 2001-2003. Fridays in 2003 experienced the highest "severe" delay, at about 20,000 vehicle-hours. However, in 2008 and 2009, Thursdays experienced the highest "severe" delay in the southbound direction at approximately 13,000 vehicle-hours. Delays were minimal on weekends in both directions of the mainline.

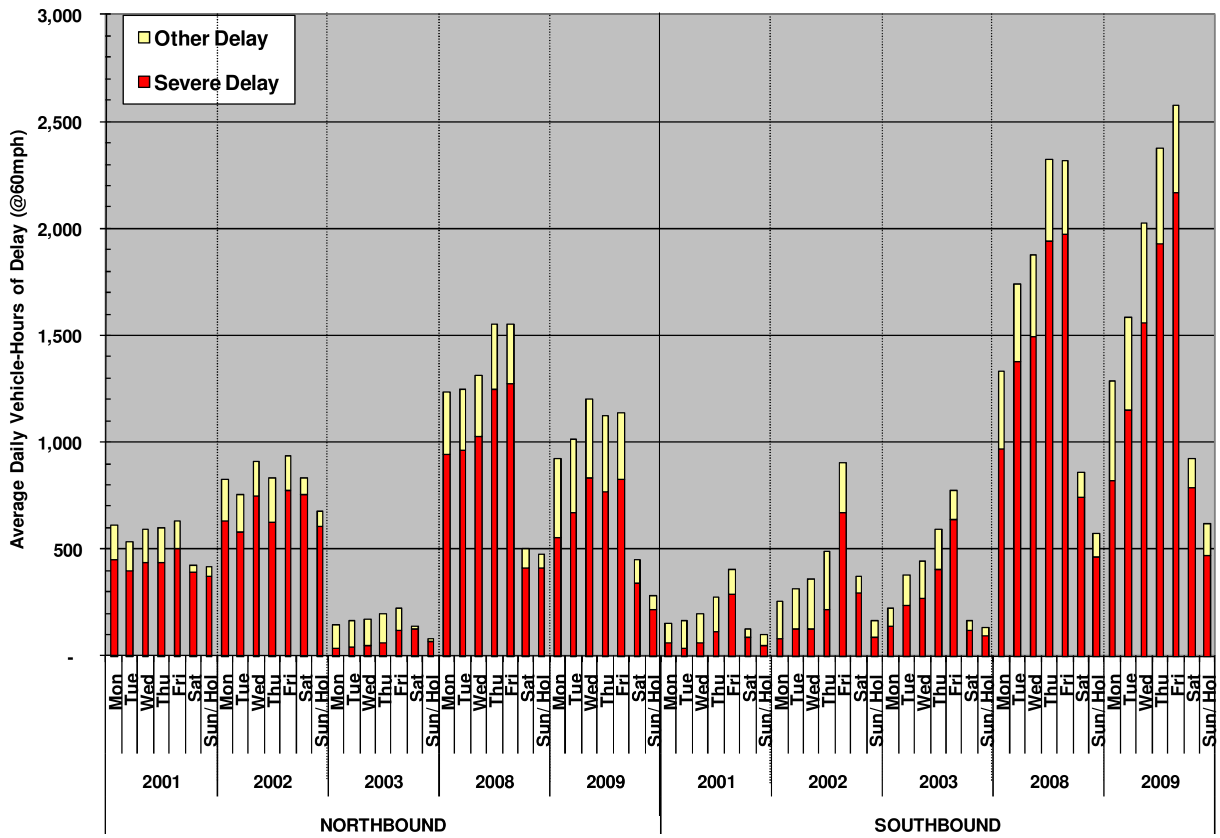
Exhibit 3B-11: I-405 ML Avg Delay by Day of Week by Severity (2001-03, 2008-09)



Source: Caltrans detector data

On the HOV facility (Exhibit 3B-12), delay peaked on Fridays in both directions. In 2008 and 2009, Fridays in the southbound direction experienced the greatest "severe" delay at approximately 2,000 vehicle-hours. Unlike the mainline facility (Exhibit 3B-11) which experienced a decrease in delay in 2008 from prior years, the HOV facility (Exhibit 3B-12) experienced a notable increase in delay in 2008 and 2009 compared to pre-construction levels.

Exhibit 3B-12: I-405 HOV Avg Delay by Day of Week by Severity (2001-03, 2008-09)



Source: Caltrans detector data

Another way to understand the characteristics of congestion and related delays is to examine average weekday delays by hour. For the mainline facility of I-405, Exhibit 3B-13 illustrates the average weekday delay by hour for the northbound direction, while Exhibit 3B-14 shows the southbound direction. Delay on the HOV facility is depicted in Exhibits 3B-15 and 3B-16. 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.

A number of observations can be made about the time-of day patterns shown in Exhibits 3B-13 and 3B-14 for the mainline facility and Exhibits 3B-15 and 3B-16 for the HOV facility:

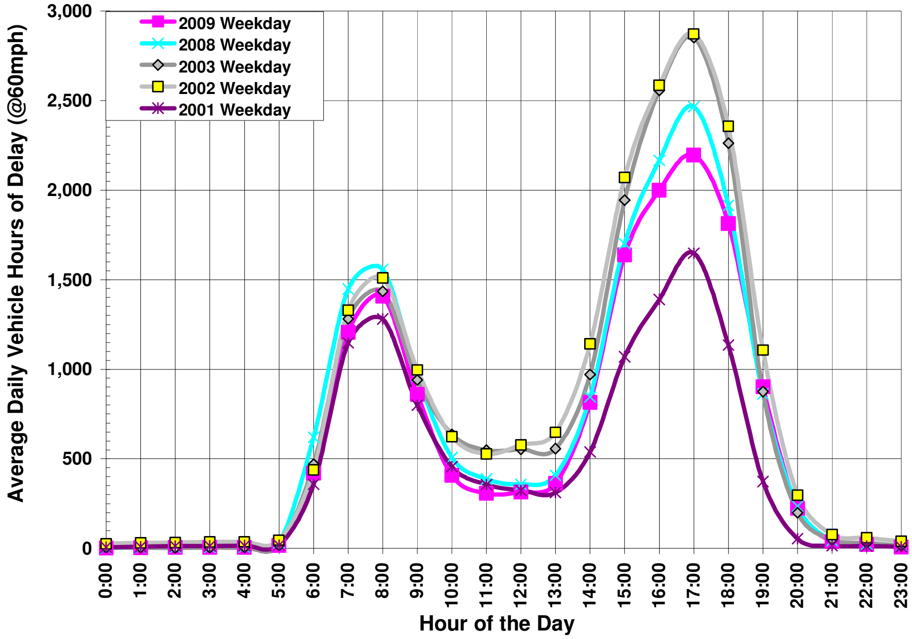
- On the northbound mainline facility (Exhibit 3B-13), the greatest delay occurred during the 8:00 AM and 5:00 PM peak hours. In 2003, delay during the 8:00 AM peak hour was approximately 1,500 vehicle-hours and the 5:00 PM peak hour delay was about 2,800 vehicle-hours. In 2008, delay increased slightly above 2003 levels during the AM peak hour, but decreased during the PM peak hour to under 2,500 vehicle-hours. These numbers further declined in 2009 during both AM and PM peak hours. The northbound direction also experienced overall more delay than the southbound on the mainline facility.

- On the southbound mainline facility, the greatest delay also occurred during the 8:00 AM and 5:00 PM peak hours. Exhibit 3B-14 shows that 2003 experienced the highest delays compared to the other years analyzed. In 2003, the 8:00 AM peak hour experienced over 1,700 vehicle-hours of delay, while the 5:00 PM peak hour experienced about 2,500 vehicle-hours of delay. 2008 and 2009 experienced further decline during both peak hours. Both years reported around 1,500 vehicle-hours of delay during the 8:00 AM peak hour, and approximately 1,700 vehicle hours during the 5:00 PM peak hour.

- The duration of congestion on the mainline (Exhibits 3B-13 and 3B-14) is much longer during the PM peak period, starting around 2:00 PM and lasting until 7:00 PM. In contrast, the AM peak period lasts about 3 hours, from approximately 6:30 AM until 9:30 AM. Over time, it is important to evaluate the peak "spreading" trends and whether projects delivered not only reduce total delay, but also reduce the peak congested periods.

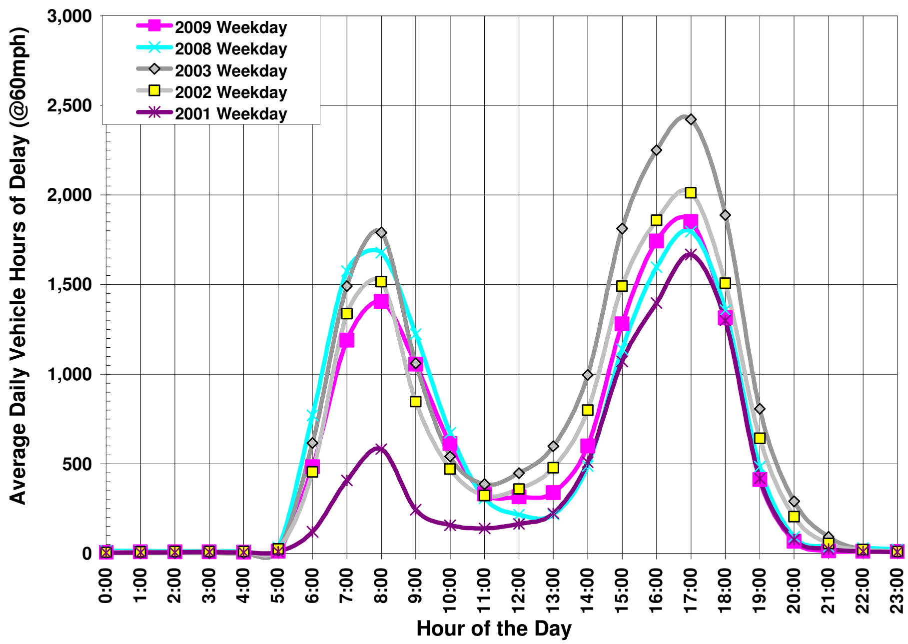
- In the northbound direction of the HOV-lane (Exhibit 3B-15), delay was fairly even between both peak periods in 2001-2003 at around 50 vehicle-hours of delay. However, in 2008, delay increased significantly during the 7:00 AM peak hour to over 200 vehicle-hours, and to about 150 vehicle-hours during the 5:00 PM peak hour. In 2009, delay decreased during both peak hours with 180 vehicle-hours during the 7:00 AM peak hour and 120 vehicle-hours during the 5:00 PM peak hour. In the southbound direction of the HOV facility (Exhibit 3B-16), delay was greatest during the PM peak in 2001-2003, which was not the case in 2008. In 2008, the southbound direction, delay jumped to 300 vehicle-hours at the 7:00 AM peak hour, and to over 200 vehicle-hours at the 5:00 PM peak hour. However, in 2009 delay during the 7:00 AM peak hour decreased to 180 vehicle-hours and significantly increased to 320 vehicle-hours during the 5:00 PM peak hour.

Exhibit 3B-13: Northbound I-405 ML Avg Weekday Hourly Delay (2001-03, 2008-09)



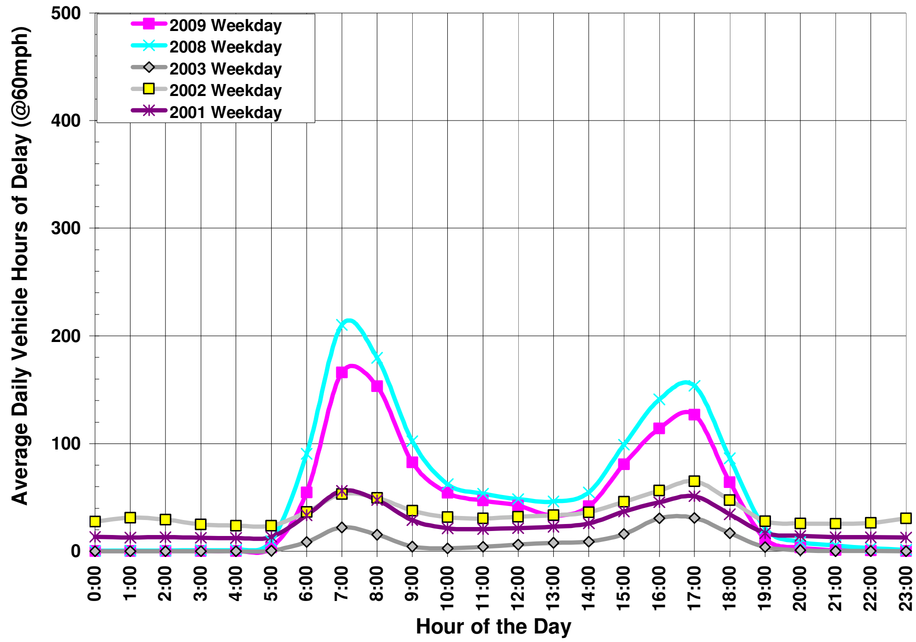
Source: Caltrans detector data

Exhibit 3B-14: Southbound I-405 ML Avg Weekday Hourly Delay (2001-03, 2008-09)



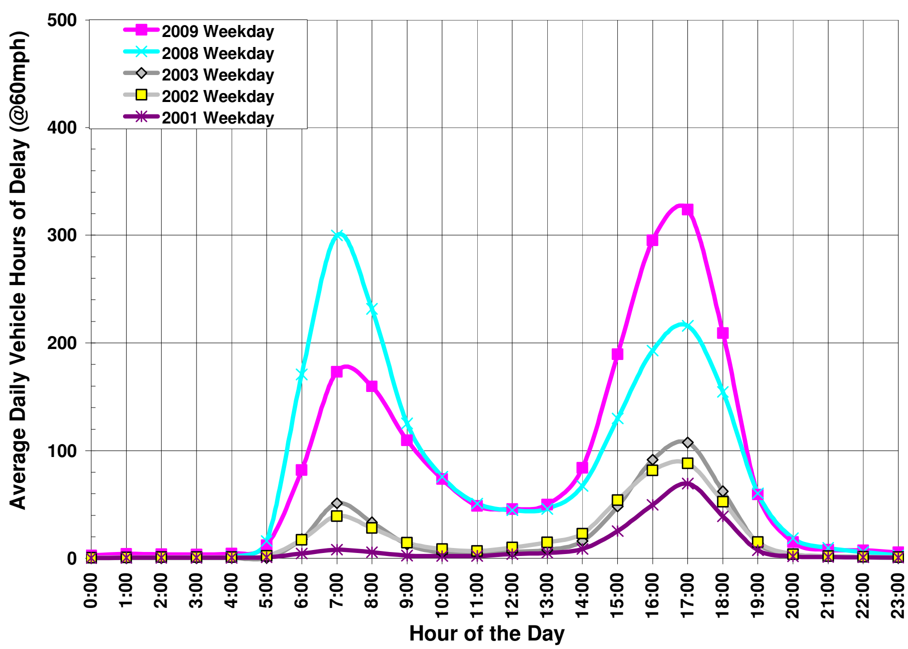
Source: Caltrans detector data

Exhibit 3B-15: Northbound I-405 HOV Avg Weekday Hourly Delay (2001-03, 2008-09)



Source: Caltrans detector data

Exhibit 3B-16: Southbound I-405 HOV Avg Weekday Hourly Delay (2001-03, 2008-09)



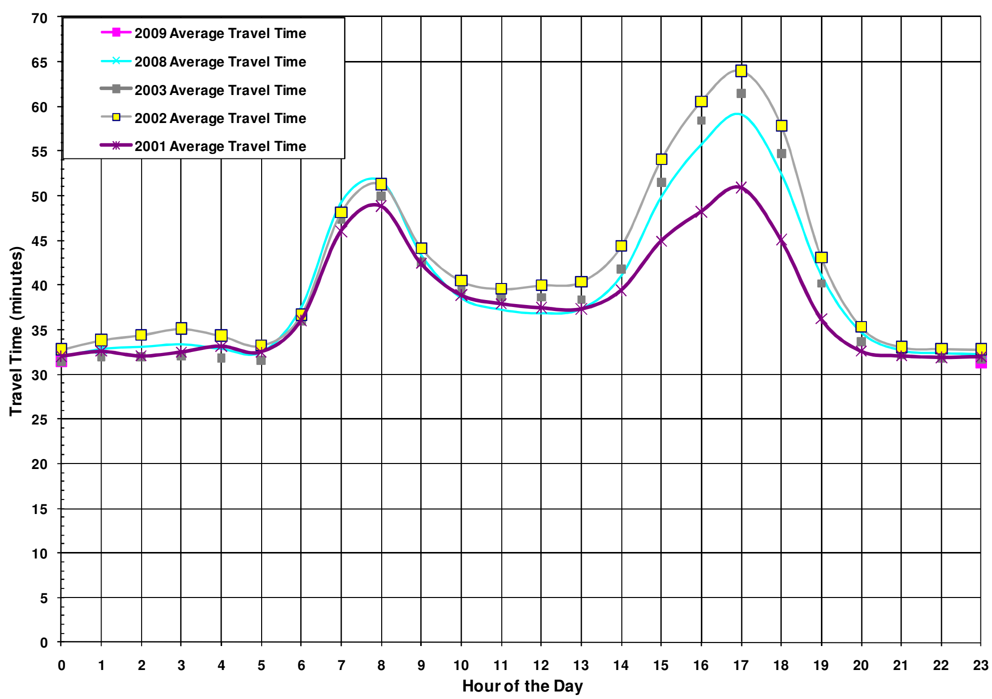
Source: Caltrans detector data

Travel Time

Travel time is reported as the amount of time it takes for a vehicle to travel the distance of the study corridor. Automatic detector data was used to calculate the travel time of the corridor from I-110 to I-5, a distance of approximately 36 miles. Travel time on parallel arterials was not included for this analysis.

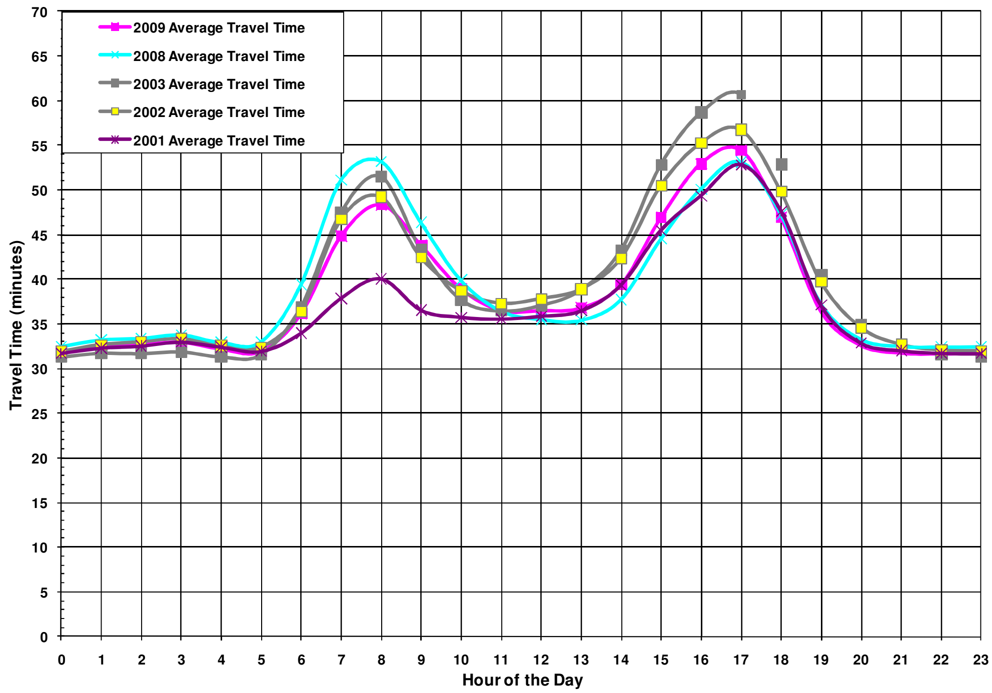
Exhibits 3B-17 and 3B-18 illustrate the travel times calculated for the mainline facility by direction. In 2003, the northbound and southbound directions experienced an average travel time of approximately 51 minutes during the AM peak hour (7AM-8AM) and approximately 61 minutes during the PM peak hour (4PM-5PM). Unlike most other corridors that experience a directional pattern of congestion, the I-405 has the same pattern of congestion irrespective of direction with the highest travel time occurring in the PM peak. In both directions of the mainline, travel times in 2008 improved from 2002-2003 levels. At the 5:00 PM peak hour in the northbound direction, it took a vehicle an average of 56 minutes to travel the corridor in 2009, compared to 64 minutes in 2002, 61 minutes in 2003, and 59 minutes in 2008. Similarly, in the southbound direction at the 5:00 PM peak hour, it took a vehicle an average of 54 minutes to travel the corridor in 2009, compared to 57 minutes in 2002, 61 minutes in 2003, and 53 minutes in 2008.

Exhibit 3B-17: Northbound I-405 ML Travel Time by Hour (2001-03, 2008-09)



Source: Caltrans detector data

Exhibit 3B-18: Southbound I-405 ML Travel Time by Hour (2001-03, 2008-09)

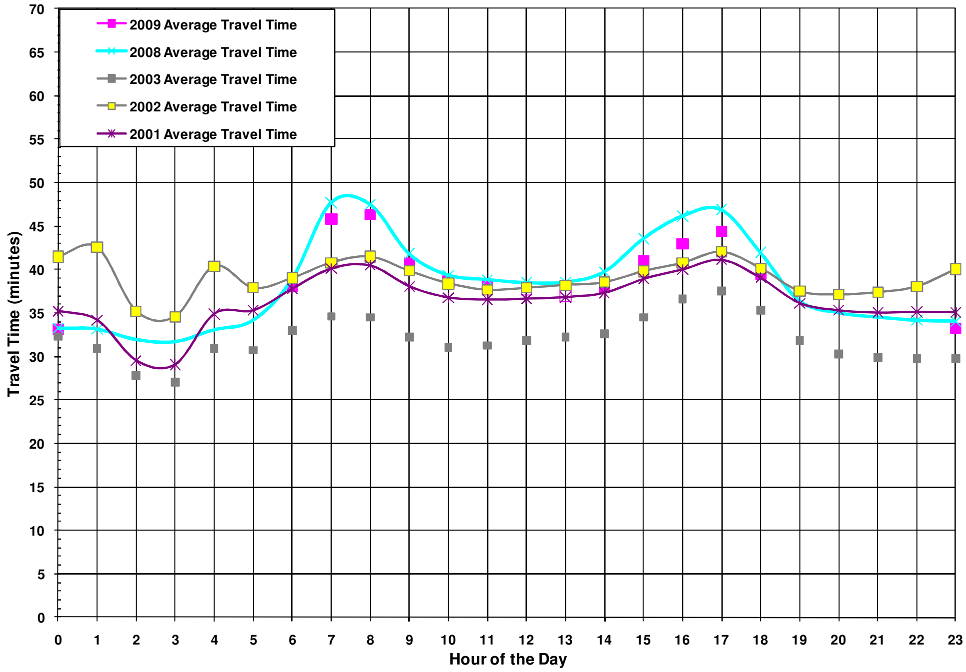


Source: Caltrans detector data

Exhibits 3B-19 and 3B-20 illustrate the travel times calculated for the HOV facility by direction. Since the HOV lane does not currently extend throughout the entire study corridor, it is inappropriate to compare travel times between the mainline and HOV facilities. In the northbound direction of the HOV lane, travel times between the AM and PM peak hours were similar, at approximately 35-37 minutes in 2003. Travel times were highest in 2008 when it reached 48 minutes at the 7:00 AM peak hour and 47 minutes at the 5:00 PM peak hour. This is primarily attributed to the extension of the HOV-lane since 2003. However, travel time declined in 2009 to 45 minutes at the 7:00 AM peak hour and 44 minutes at the 5:00 PM peak hour.

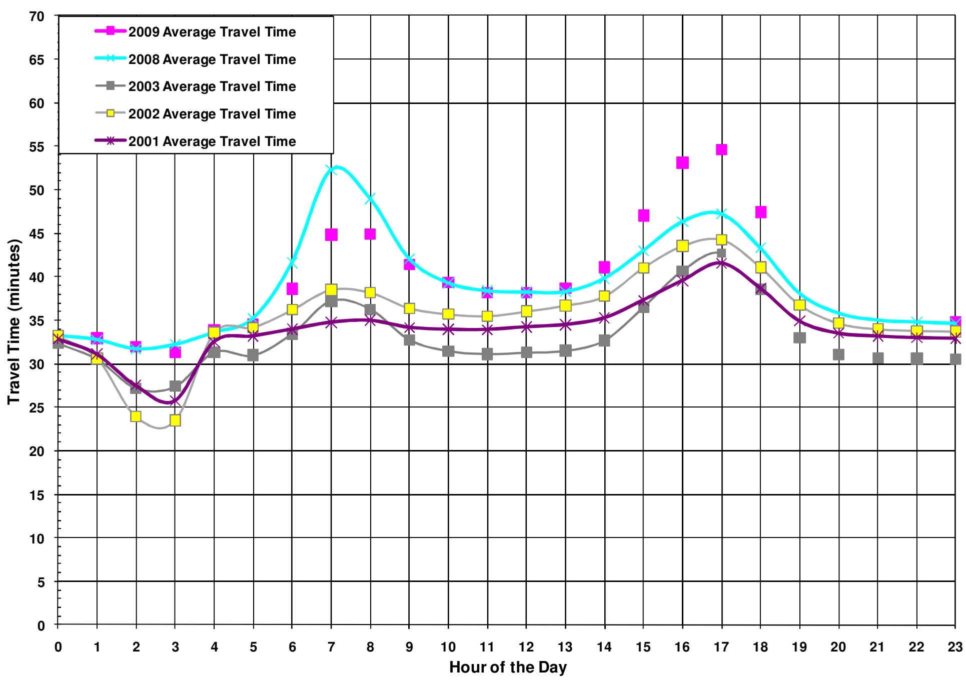
In the southbound direction of the HOV-lane (Exhibit 3B-20), travel times were generally higher in the PM than the AM peak period. In 2001-2003, the 5:00 PM peak hour experienced travel times ranging between 42 and 44 minutes, which exceeded the 8:00 AM peak hour travel times of 35-39 minutes. However, in 2008, travel times were greater than the prior years analyzed at 47 minutes during the 5:00 PM peak hour and 52 minutes during the 7:00 AM peak hour. Moreover, 2009 experienced an increase in travel time during the PM peak hour with 55 minutes and a decrease in the AM peak hour with 45 minutes. Again, the extension of the HOV-lane from 2003 and 2008 is a factor that contributed to the increased travel times.

Exhibit 3B-19: Northbound I-405 HOV Travel Time by Hour (2001-03, 2008-09)



Source: Caltrans detector data

Exhibit 3B-20: Southbound I-405 HOV Travel Time by Hour (2001-03, 2008-09)



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, the CSMP used the "buffer index", which reflects the additional time required (over and beyond the average) to ensure an on-time arrival 95 percent of the time. In other words, if a person must be on time 95 days out of 100 (or 19 out of 20 workdays per month), then that person must add additional time to their average expected travel time to ensure an on-time arrival. That additional time is the buffer time. Severe incidents, such as fatal accidents, could cause travel times longer than the 95^{th} percentile, but this statistic is a balance between extreme events and the "typical" travel day.

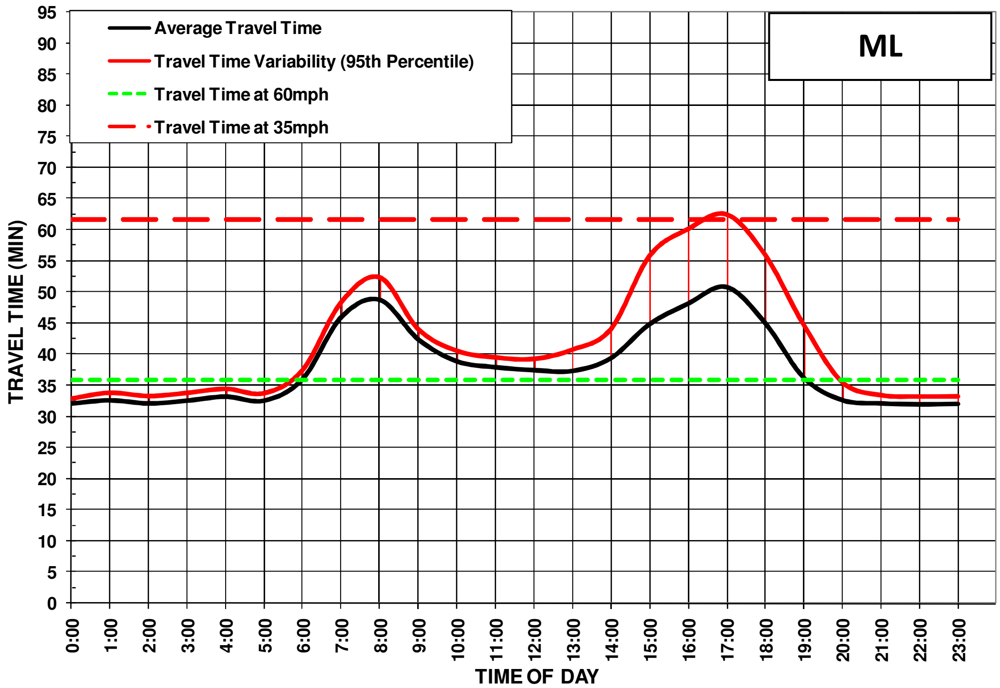
Exhibits 3B-21 through 3B-40 on the following pages illustrate the variability of travel time for the I-405 Corridor on weekdays for the years 2001-2003 (pre-construction) and 2008-2009 (present conditions). Exhibits 3B-21 through 3B-30 present travel time variability for the mainline in the northbound direction followed by the southbound. Similarly, Exhibits 3B-31 and 3B-40 show travel time variability for the HOV facility beginning with the northbound and followed by the southbound direction.

For the mainline facility of I-405, the 5:00 PM peak hour was the most unreliable in addition to being the slowest hour in both directions. In the northbound direction in 2001 (shown in Exhibit 3B-21), motorists driving the entire length of the corridor had to add 12 minutes to an average travel time of 51 minutes (for a total travel time of 63 minutes) to ensure that they arrived on time 95 percent of the time. This is 27 minutes longer than the 36-minute travel time at 60 mph. In 2002 (Exhibit 3B-22), the time needed to arrive on time 95 percent of the time increased to 75 minutes; increased again in 2003 to 82 minutes (Exhibit 3B-23); and declined to 68 minutes in 2008 (Exhibit 3B-24). In 2009, this number further decreased to 65 minutes (Exhibit 3B-25). In the northbound direction of the mainline, travel times ranged as much as 32 percent (about 20 minutes) longer of the mean travel time during the peak 5:00 PM hour.

In the southbound direction of the mainline, the 5:00 PM peak hour was also the slowest and most unreliable. In 2001 (Exhibit 3B-26) at the 5:00 PM peak hour, the time needed to arrive on time 95 percent of the time travel was 59 minutes, which increased to 64 in 2002 (Exhibit 3B-27). The time then increased to 94 minutes in 2003 (Exhibit 3B-28), decreased to 76 minutes in 2008 (Exhibit 3B-29), and slightly increased again to 77 minutes in 2009 (Exhibit 3B-30).

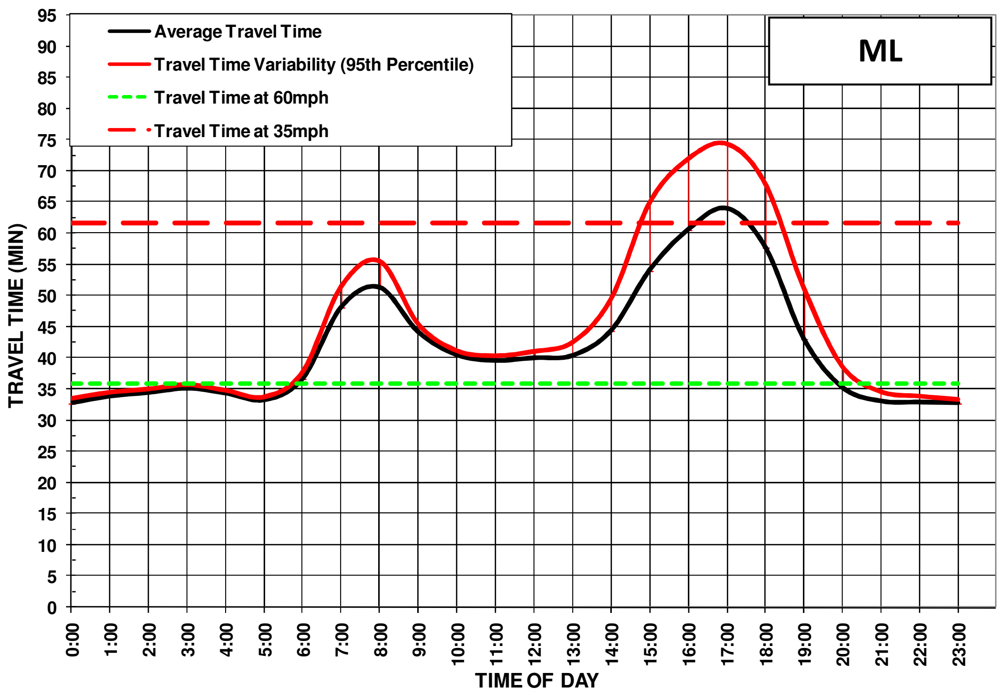
Overall, reliability improved on the mainline in 2008 and 2009 as compared to 2003 as evident by the decrease in travel time variability in both directions during those years.

Exhibit 3B-21: Northbound I-405 ML Travel Time Variation (2001)



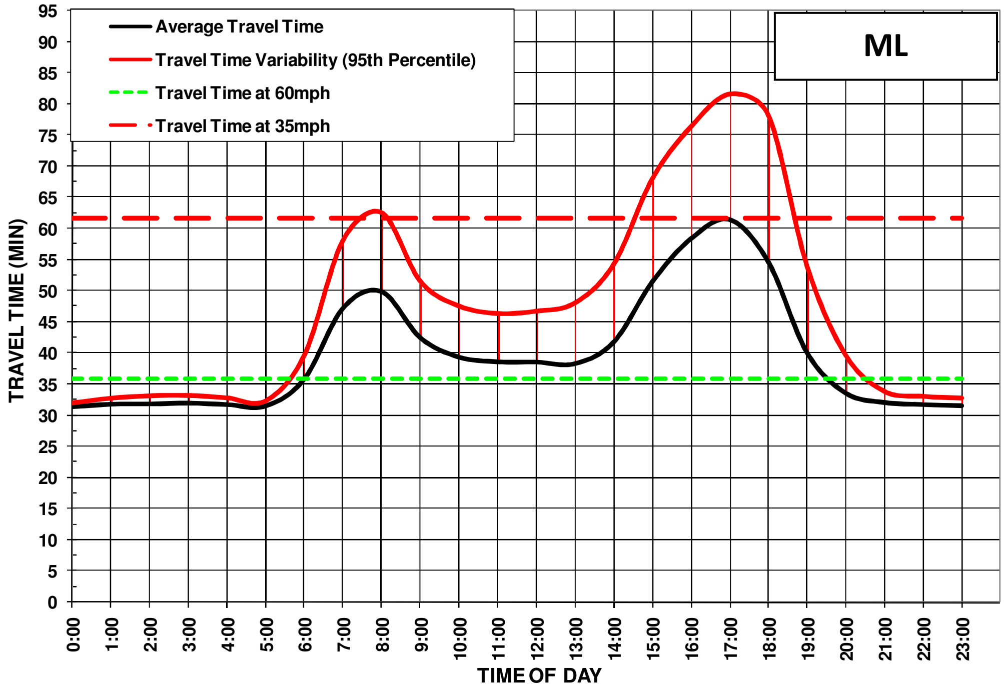
Source: Caltrans detector data

Exhibit 3B-22: Northbound I-405 ML Travel Time Variation (2002)



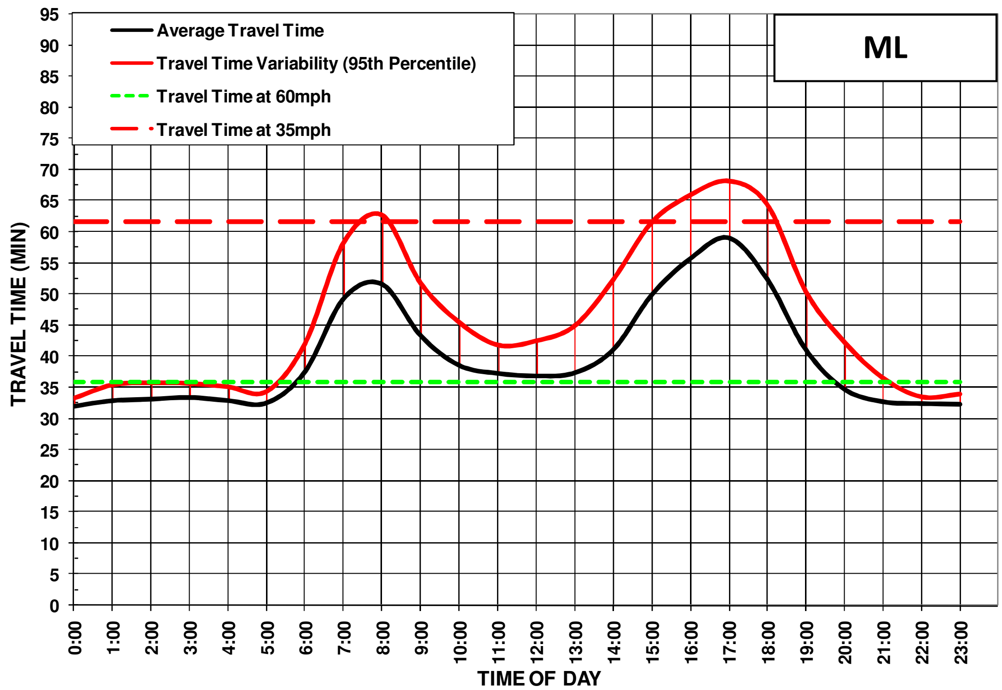
Source: Caltrans detector data

Exhibit 3B-23: Northbound I-405 ML Travel Time Variation (2003)



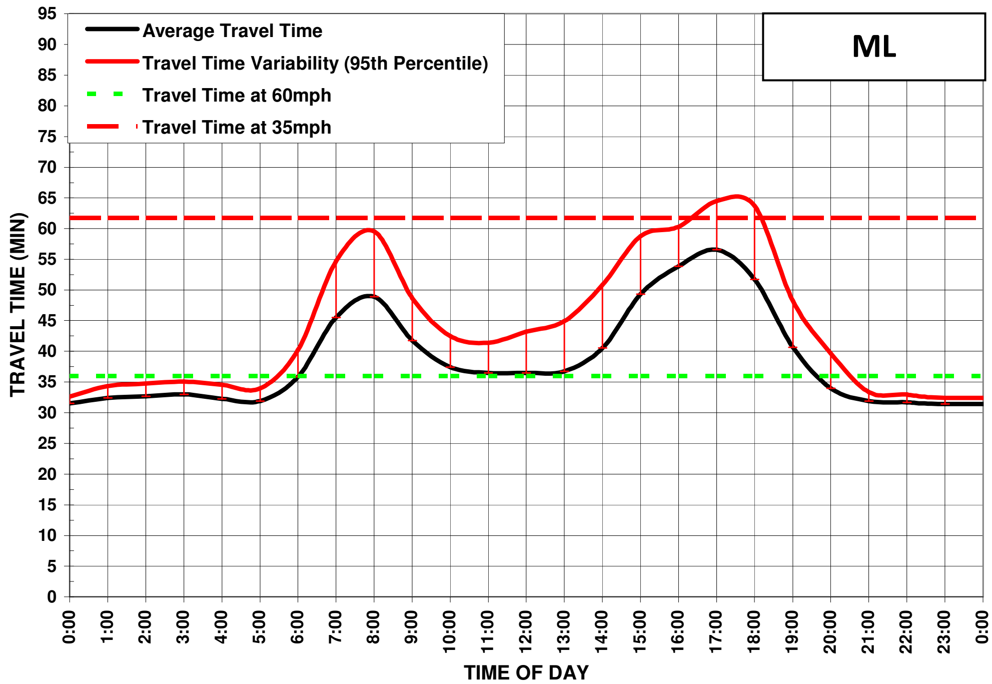
Source: Caltrans detector data

Exhibit 3B-24: Northbound I-405 ML Travel Time Variation (2008)



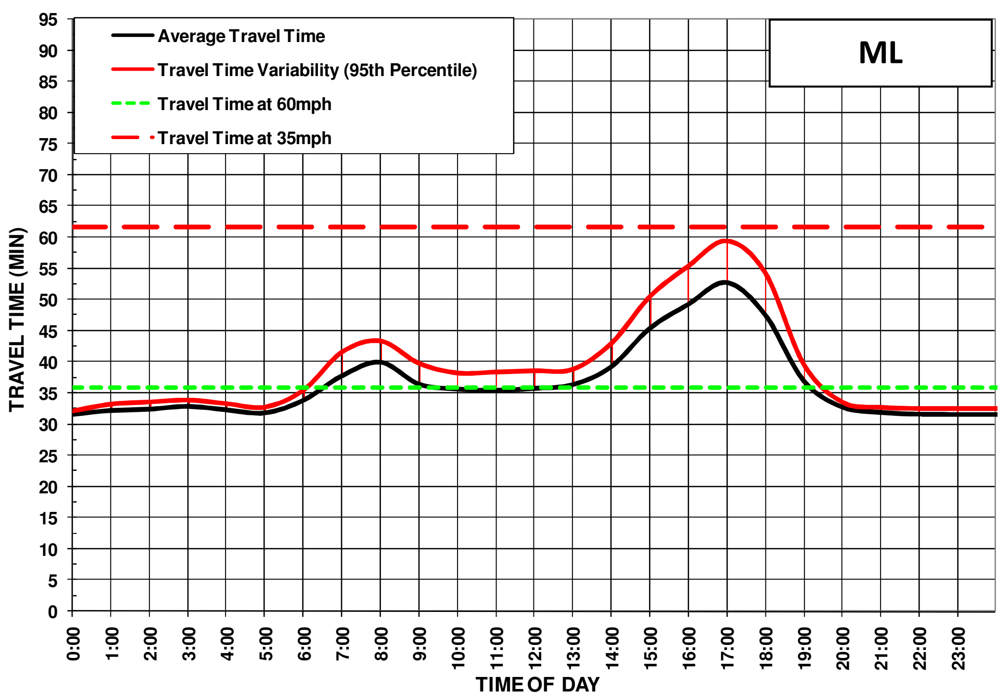
Source: Caltrans detector data

Exhibit 3B-25: Northbound I-405 ML Travel Time Variation (2009)



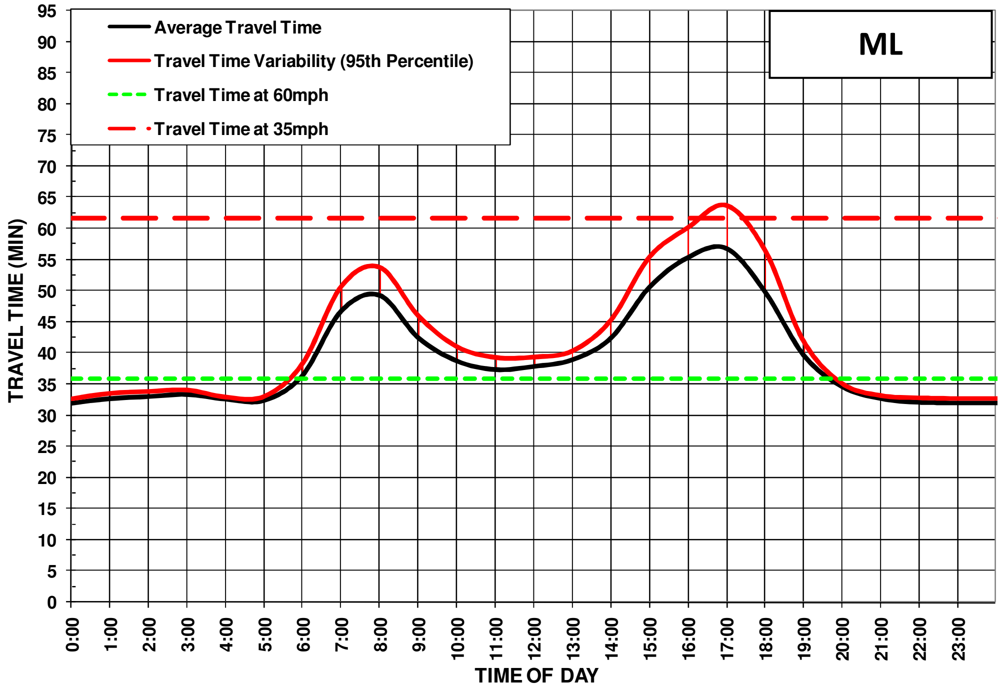
Source: Caltrans detector data

Exhibit 3B-26: Southbound I-405 ML Travel Time Variation (2001)



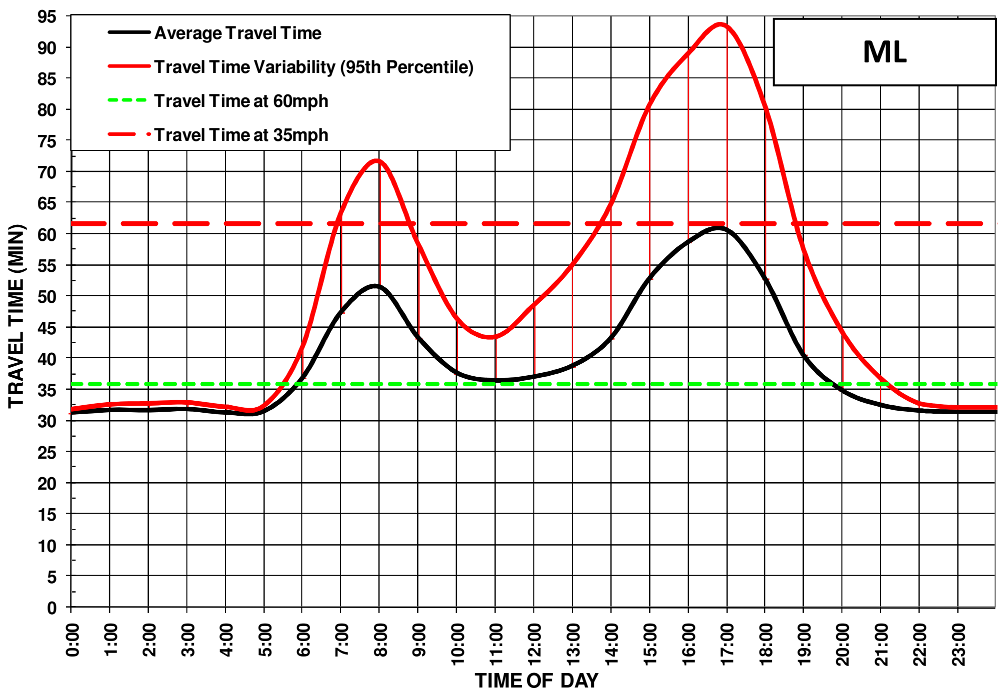
Source: Caltrans detector data

Exhibit 3B-27: Southbound I-405 ML Travel Time Variation (2002)



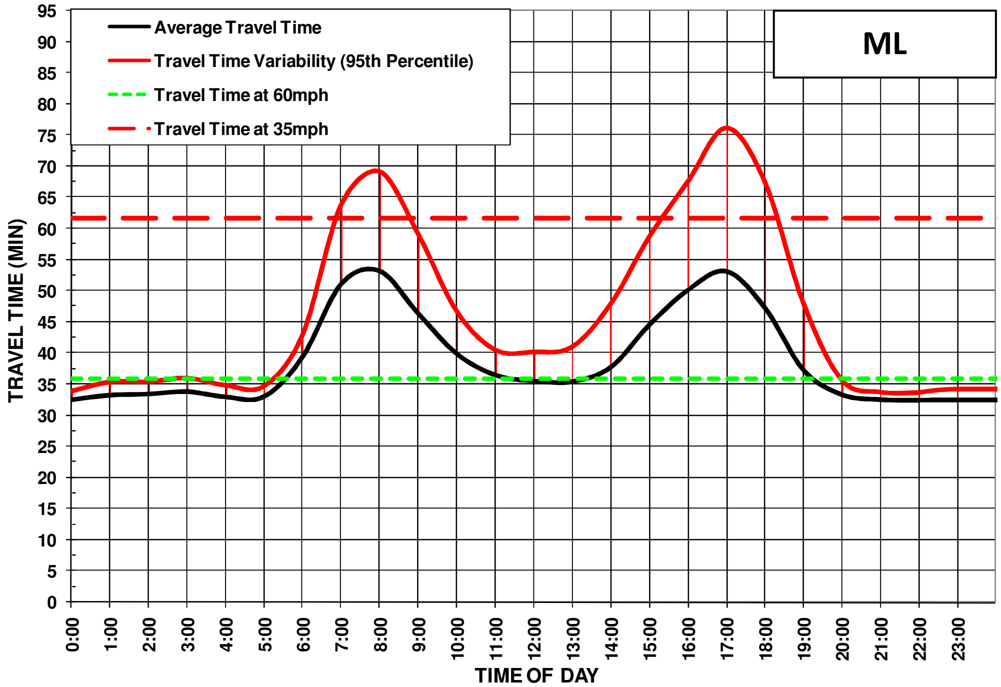
Source: Caltrans detector data

Exhibit 3B-28: Southbound I-405 ML Travel Time Variation (2003)



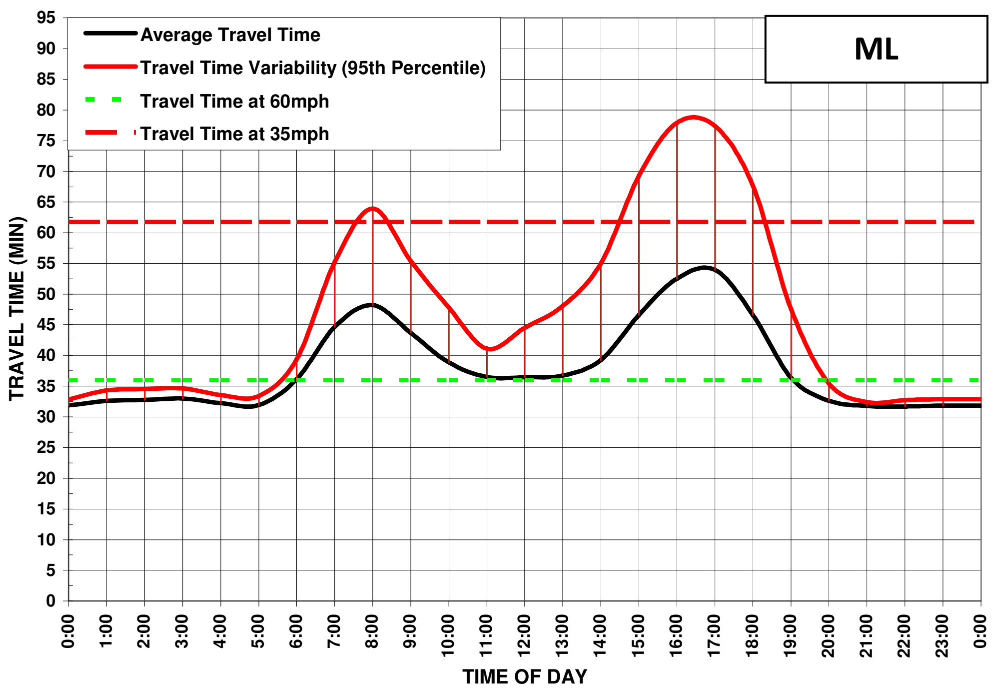
Source: Caltrans detector data

Exhibit 3B-29: Southbound I-405 ML Travel Time Variation (2008)



Source: Caltrans detector data

Exhibit 3B-30: Southbound I-405 ML Travel Time Variation (2009)

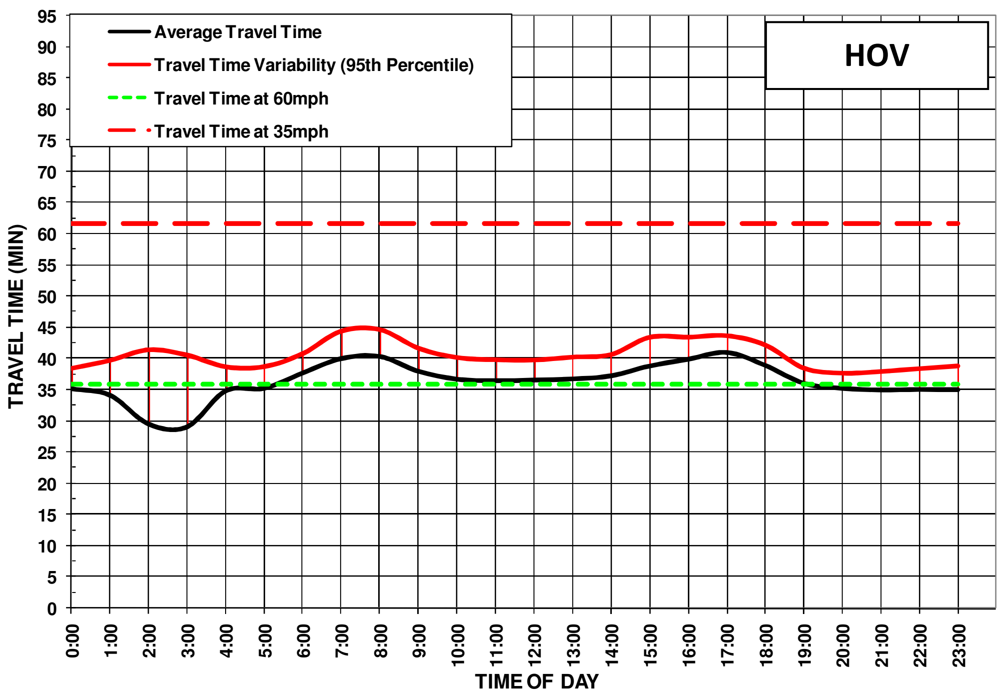


Source: Caltrans detector data

Travel times for the I-405 HOV facility are illustrated in Exhibits 3B-31 through 3B-40. Travel time variability in both directions of the HOV facility is considered high and volatile. In the northbound direction, there was not a distinct peak hour as peak periods displayed similar levels of travel times. In 2001-2003 (Exhibits 3B-31 through 3B-33) in the northbound direction of the HOV facility, travel times during the peak periods ranged between 40 and 50 minutes, which was five to 15 minutes more than the mean travel time. However, in 2008, the variability in travel time dramatically increased to 69 minutes (or 22 minutes) of the mean travel time (Exhibit 3B-34). Variability decreased in 2009 to 50 minutes (or six minutes) of the mean travel time (Exhibit 3B-35).

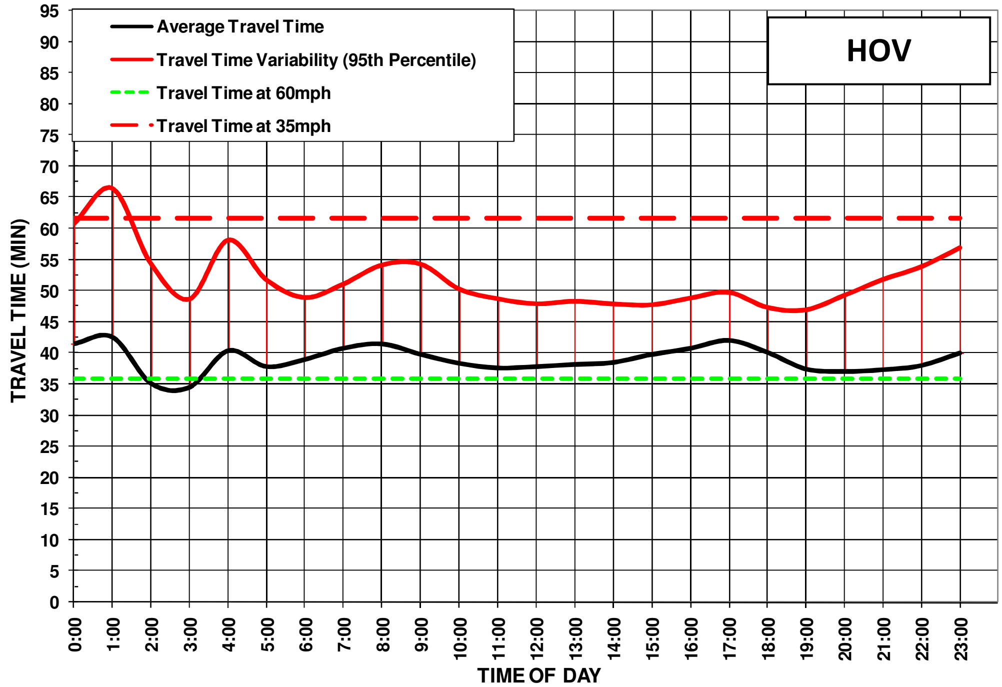
In the southbound direction of the HOV facility, the slowest and most unreliable hour occurred at 5:00 PM. During this hour, travel time variability was higher than the northbound HOV-lane. In 2001 (Exhibit 3B-36), travel time variability in the southbound HOV-lane was 50 minutes, which increased to 69 minutes in 2002 (Exhibit 3B-37), decreased to 63 minutes in 2003 (Exhibit 3B-38), and slightly increased again to 66 minutes in 2008 (Exhibit 3B-39). Moreover, 2009 experienced a further increase in variability to 70 minutes (Exhibit 3B-40).

Exhibit 3B-31: Northbound I-405 HOV Travel Time Variation (2001)



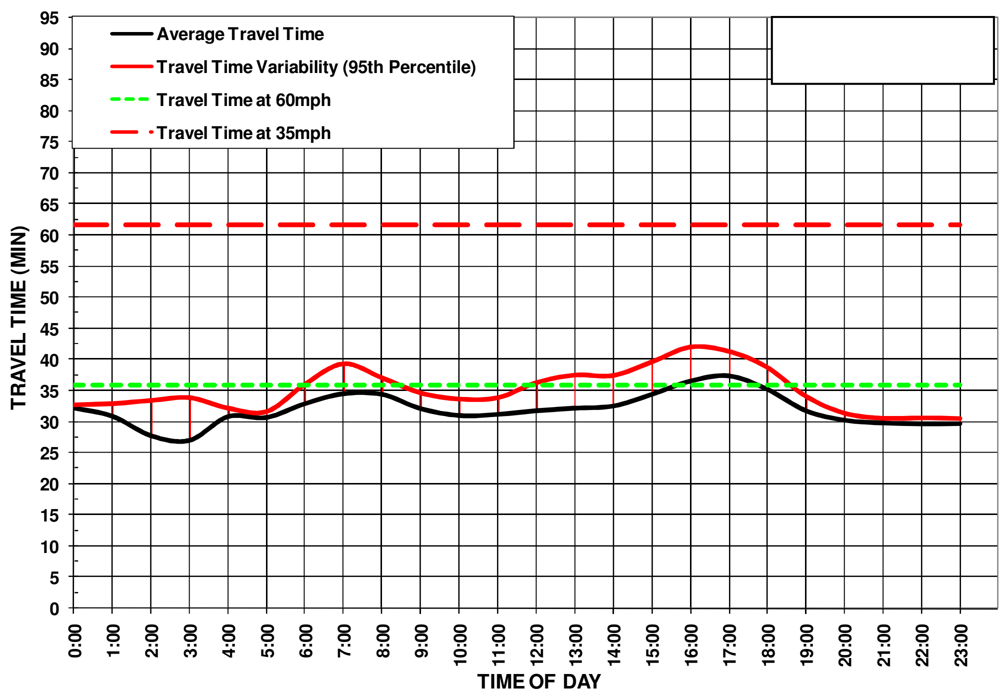
Source: Caltrans detector data

Exhibit 3B-32: Northbound I-405 HOV Travel Time Variation (2002)



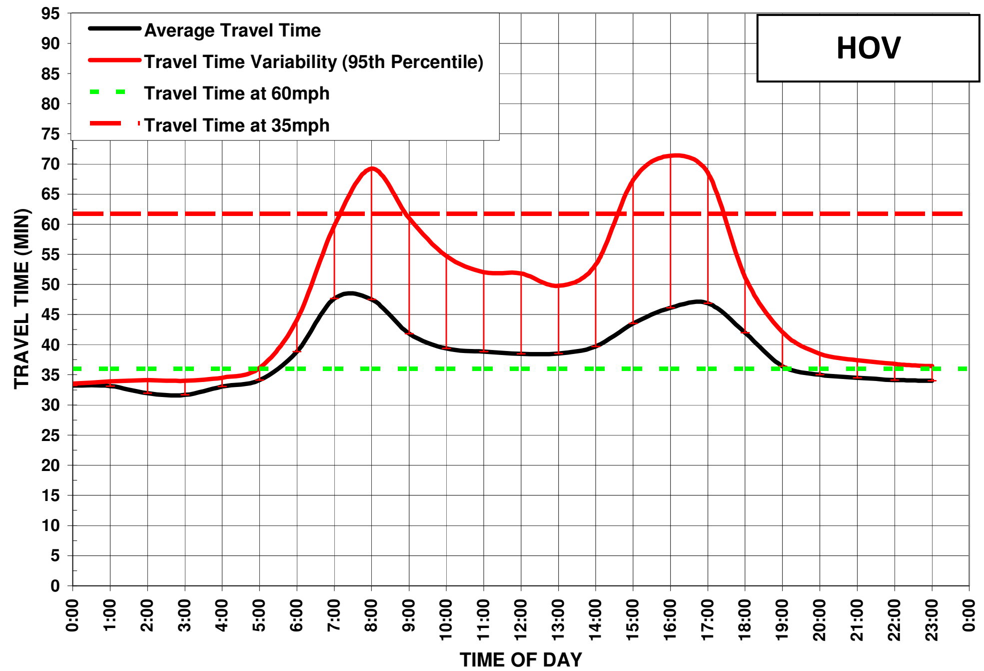
Source: Caltrans detector data

Exhibit 3B-33: Northbound I-405 HOV Travel Time Variation (2003)



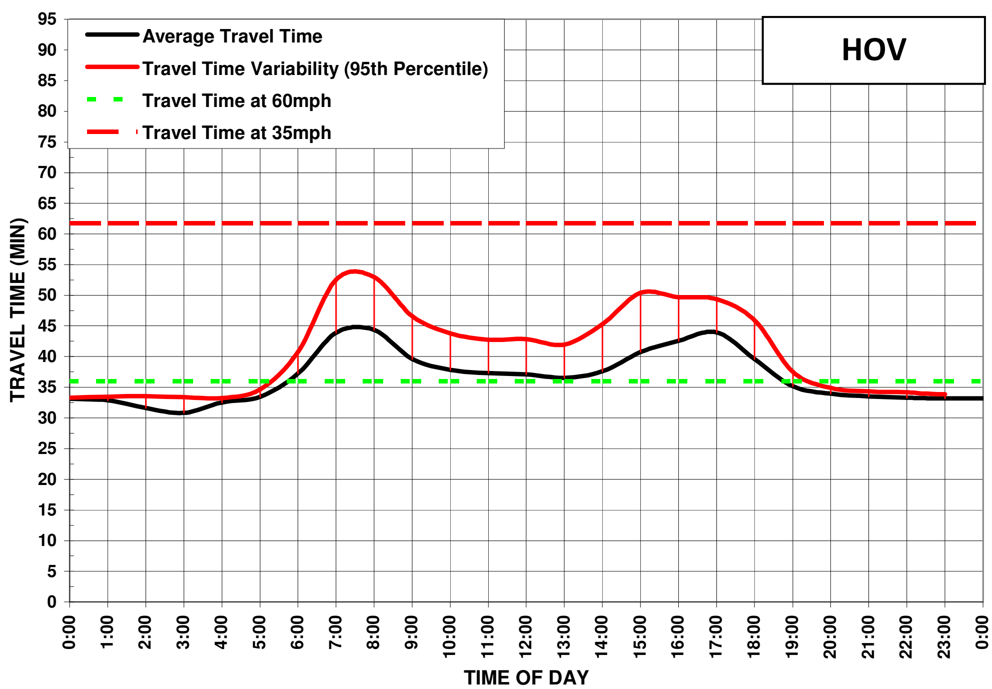
Source: Caltrans detector data

Exhibit 3B-34: Northbound I-405 HOV Travel Time Variation (2008)



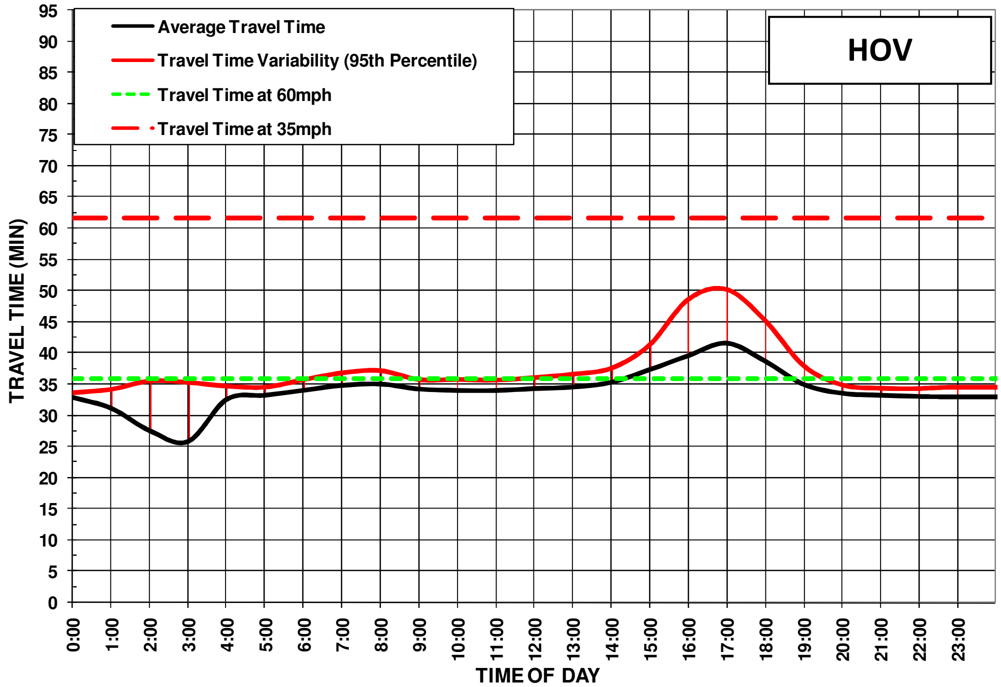
Source: Caltrans detector data

Exhibit 3B-35: Northbound I-405 HOV Travel Time Variation (2009)



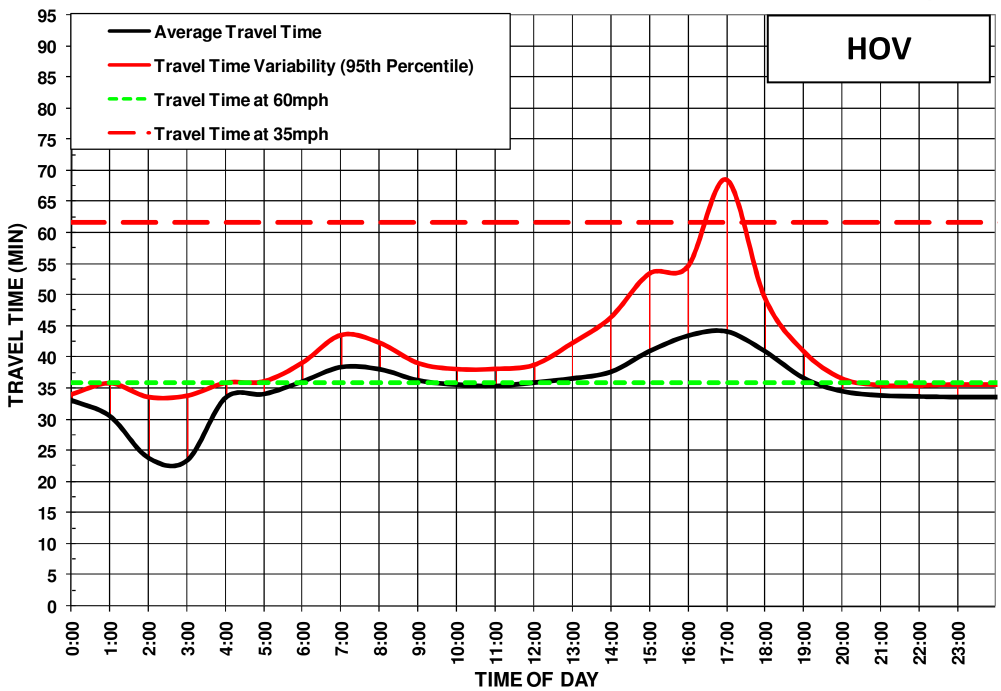
Source: Caltrans detector data

Exhibit 3B-36: Southbound I-405 HOV Travel Time Variation (2001)



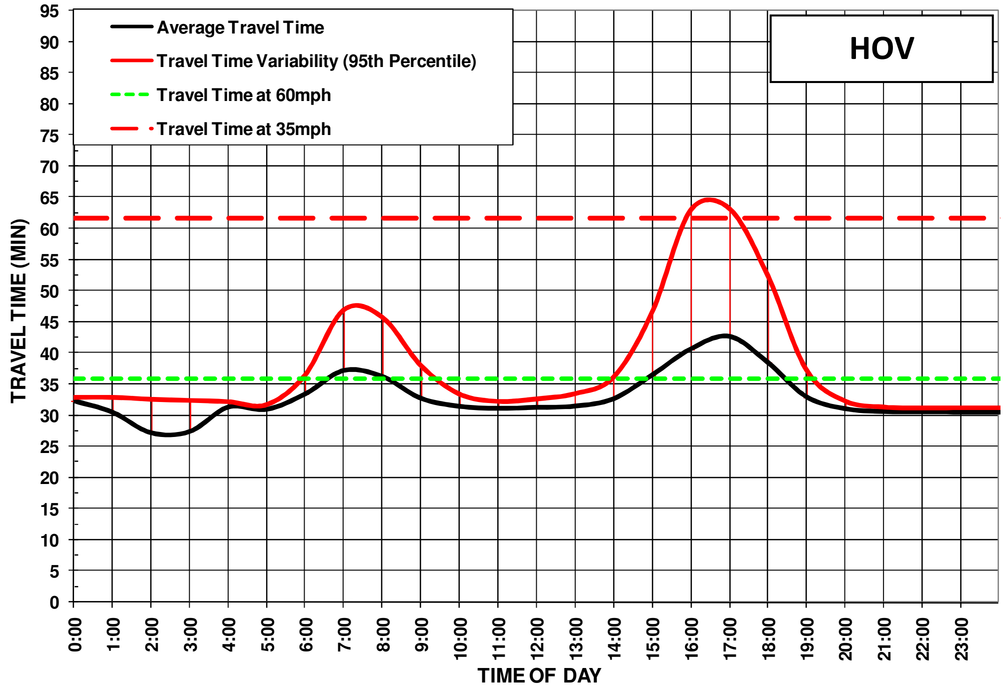
Source: Caltrans detector data

Exhibit 3B-37: Southbound I-405 HOV Travel Time Variation (2002)



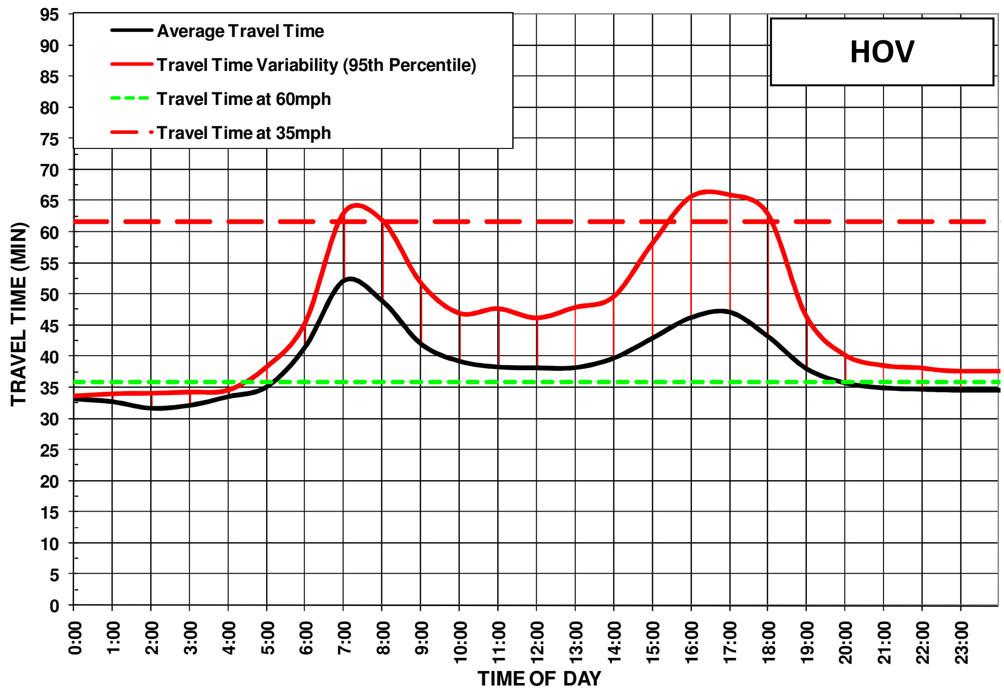
Source: Caltrans detector data

Exhibit 3B-38: Southbound I-405 HOV Travel Time Variation (2003)



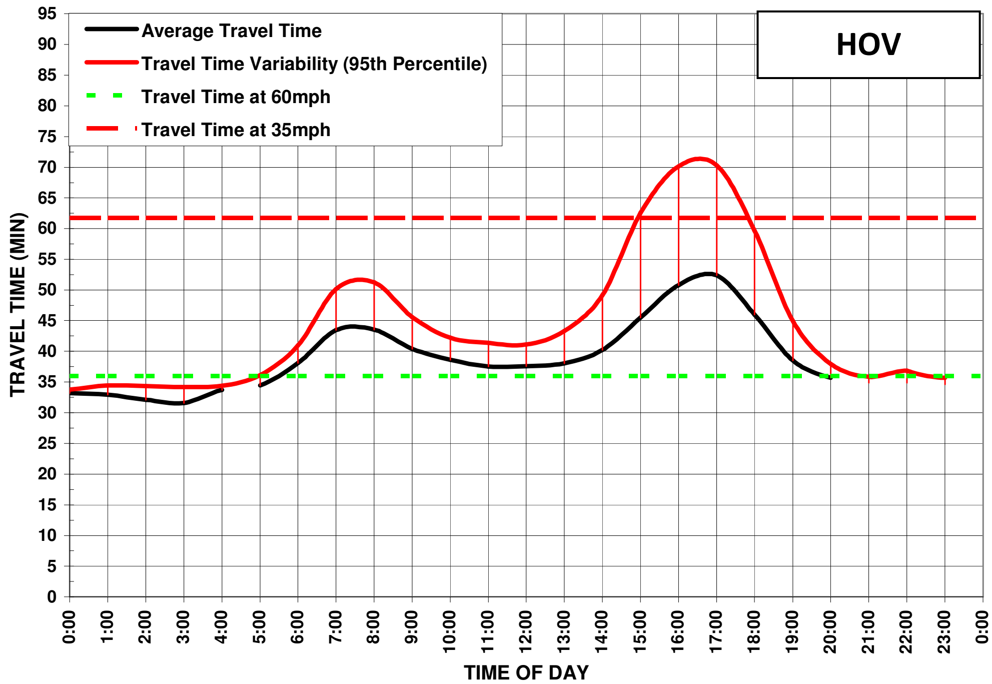
Source: Caltrans detector data

Exhibit 3B-39: Southbound I-405 HOV Travel Time Variation (2008)



Source: Caltrans detector data

Exhibit 3B-40: Southbound I-405 HOV Travel Time Variation (2009)



Source: Caltrans detector data

SAFETY

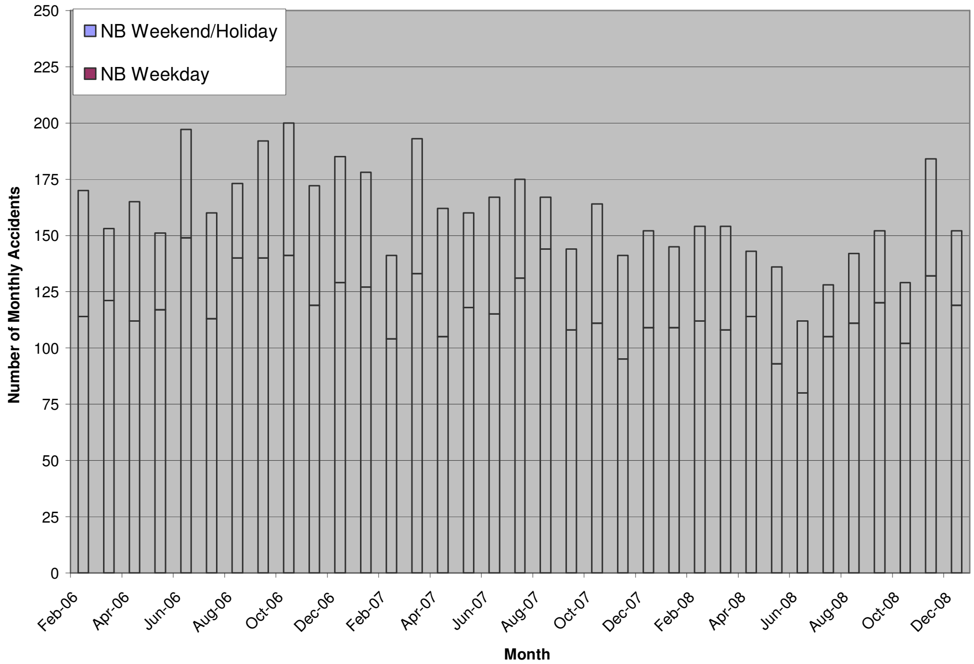
The adopted performance measures to assess safety include the number of accidents and accident rates computed from the Caltrans Traffic Accident Surveillance and Analysis System (TASAS). TASAS is a traffic records system containing an accident database linked to a highway database. The highway database 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, but not other roads (e.g., local streets and roads). The TASAS information presented in this analysis does not distinguish between mainline and HOV facilities.

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

The safety analysis conducted for the I-405 Corridor is based on TASAS data obtained through the Caltrans Performance Measurement System (PeMS). Since safety data for the 2009 year is unavailable, data for 2006-2008 is presented. When the 2009 safety data is made available, it is expected to show a decrease in accidents compared to the prior years.

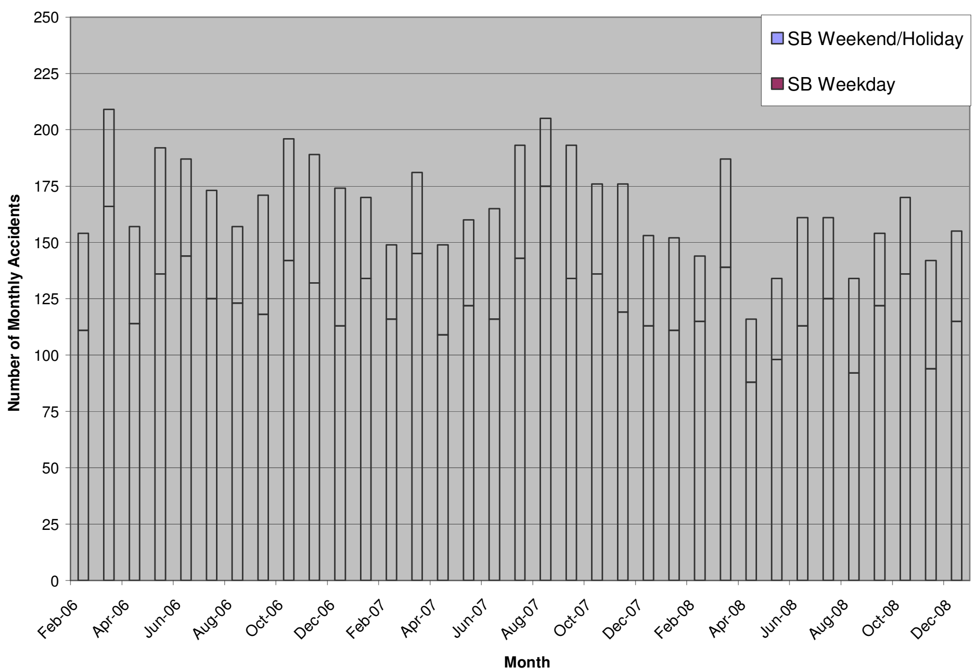
Exhibits 3B-41 and 3B-42 show that both directions of travel experienced similar levels of accidents with an average of about 175 accidents per month. Both directions also show an overall decrease in the number of accidents from 2006 to 2008.

Exhibit 3B-41: Northbound Monthly Accidents (2006-2008)



Source: Caltrans TASAS Selective Accident Retrieval Report

Exhibit 3B-42: Southbound Monthly Accidents (2006-2008)



Source: Caltrans TASAS Selective Accident Retrieval Report

PRODUCTIVITY

Productivity is a system efficiency measure used to analyze 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 a 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.

This loss in productivity example is illustrated in Exhibit 3B-43. As traffic flows increase 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.

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

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

Exhibit 3B-43: Lost Productivity Illustrated

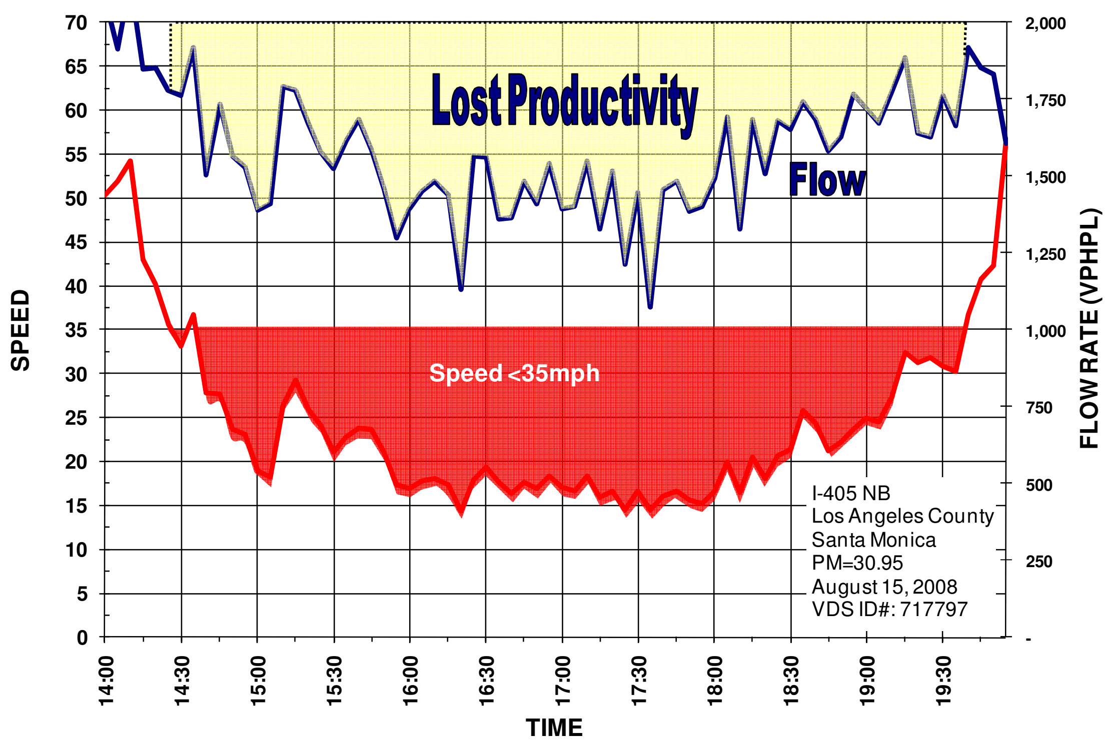
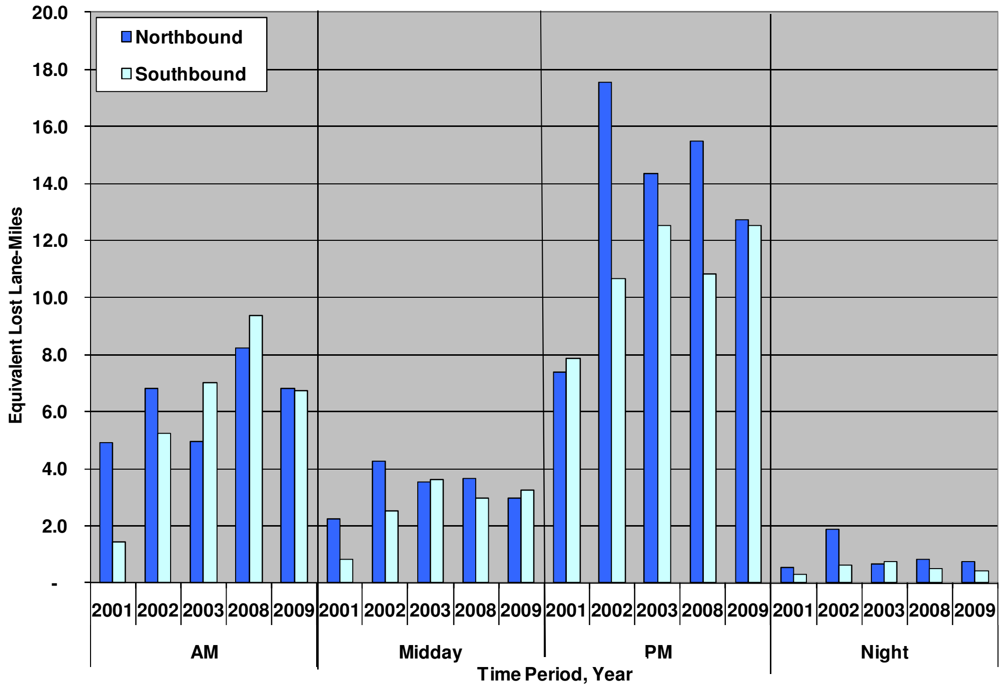


Exhibit 3B-44 summarizes the productivity losses on the I-405 mainline facility for the five years (2001-2003, 2008-2009) analyzed in each direction. As indicated, the largest productivity losses occurred in the PM peak hours. The trends in the productivity losses are comparable to the delay trends. The largest productivity losses occurred in the PM peak hours in both directions, which is the time period and direction that experienced the most congestion. From 2008-2009 an increase in productivity in the AM (8.2 to 6.9) and PM (15.5 to 12.8) peak was reported. The southbound direction of the mainline experienced an improvement in productivity from 2003 to 2008 in the PM peak period when lost-lane miles decreased from 12.5 to 10.8.

The same analysis was performed for the I-405 HOV facility (Exhibit 3B-45), which shows that the southbound direction, particularly in 2008 experienced the greatest losses in productivity during both peak periods. From 2003 to 2008, productivity on both directions of the HOV-lane declined as lost-lane miles significantly increased. From 2008 to 2009, productivity increased in the northbound direction during both the AM and PM peak periods.

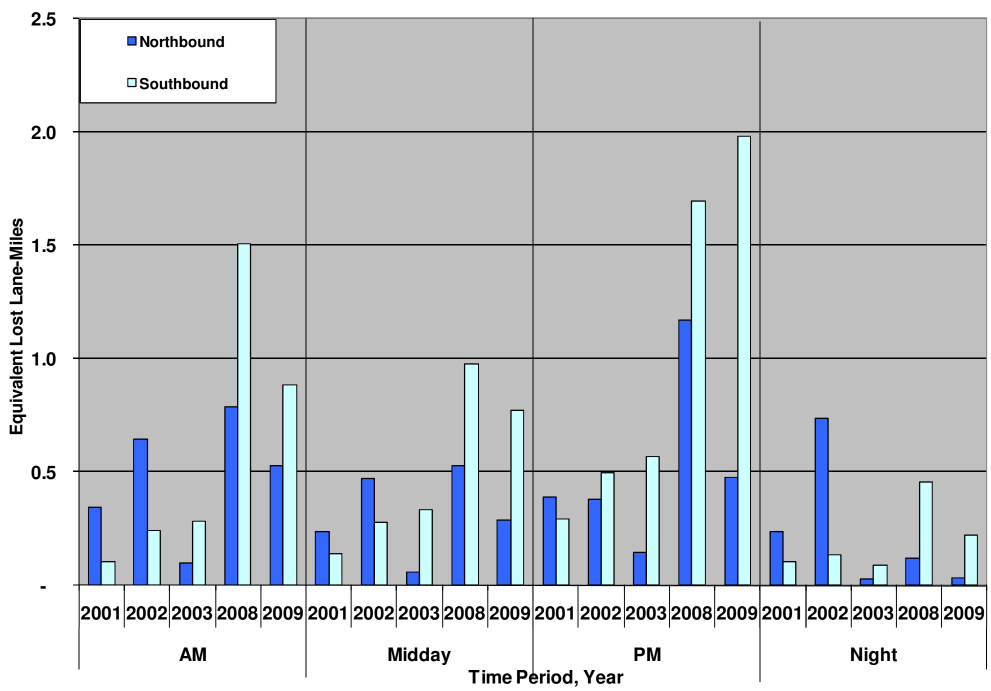
Strategies to combat productivity losses are primarily related to operations and include building new or extending auxiliary lanes, developing more aggressive ramp metering strategies without negatively influencing the arterial network, and improvements in incident clearance times.

Exhibit 3B-44: I-405 ML Avg Equivalent Lost Ln-Mi by Time Period (2001-03, 2008-09)



Source: Caltrans detector data

Exhibit 3B-45: I-405 HOV Avg Equivalent Lost Ln-Mi by Time Period (2001-03, 2008-09)



Source: Caltrans detector data

C. Corridor-wide Pavement Condition

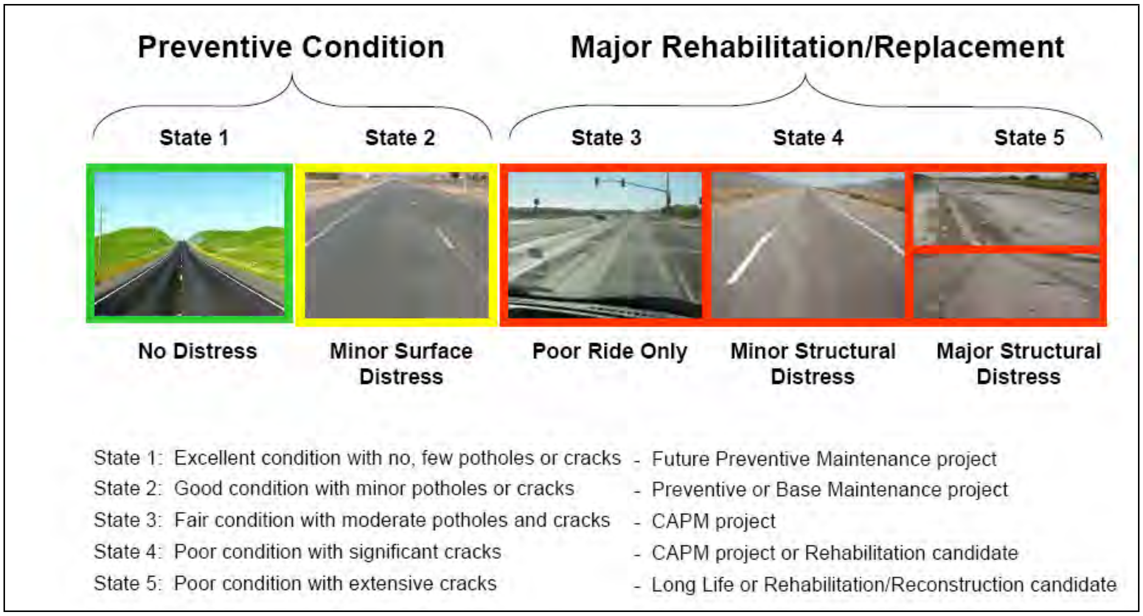
The condition of the roadway pavement (or ride quality) on the corridor can influence its traffic performance. Rough or poor pavement conditions can decrease the mobility, reliability, safety, and productivity of the corridor, whereas smooth pavement can have the opposite effect. Pavement preservation 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: 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 3C-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 3C-1: Pavement Condition States



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 to be 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, identified 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.

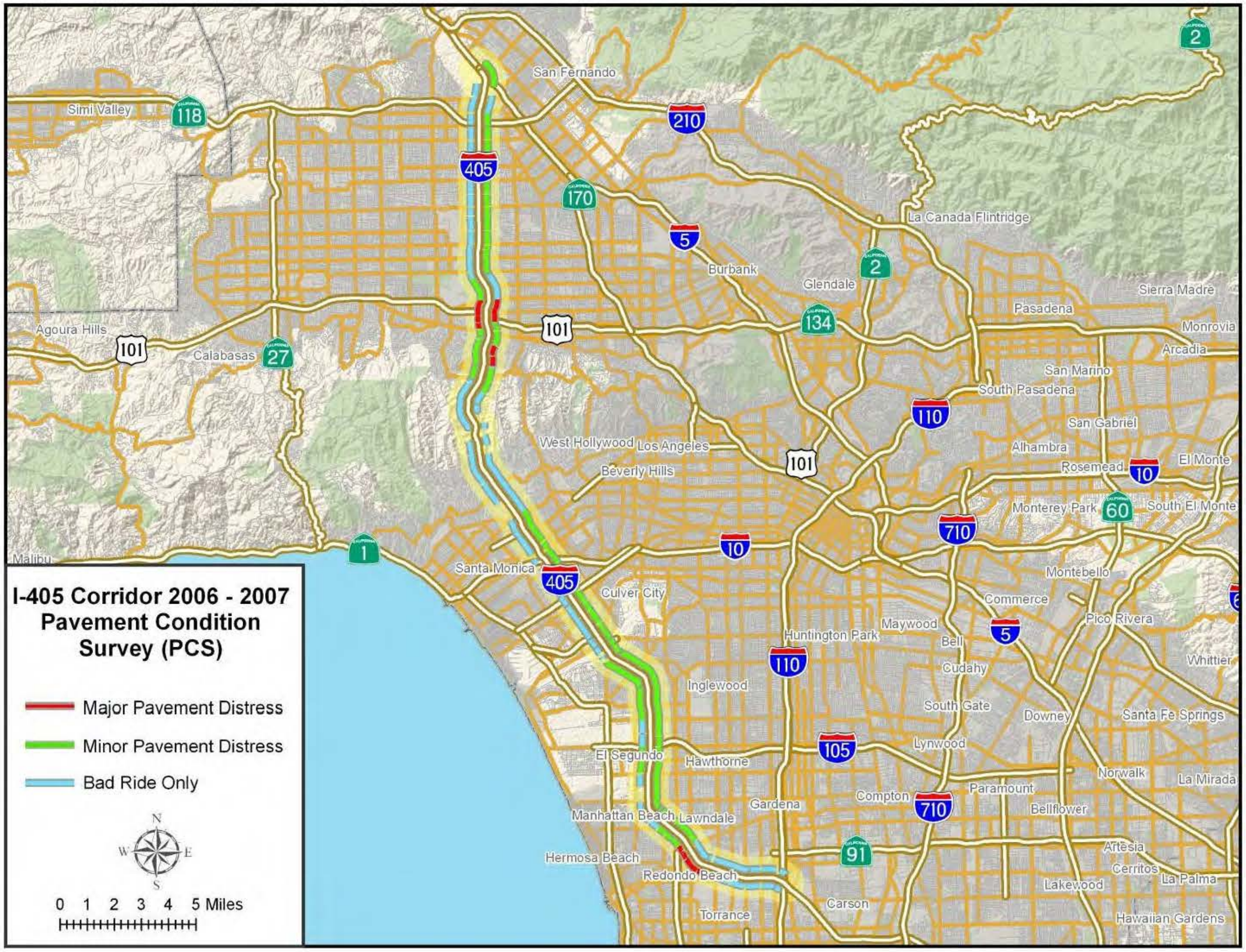
The field work consists of two parts. In the first part, pavement raters visually inspect the pavement surface to assess structural adequacy. In the second part, field staff uses vans with automated profilers to measure ride quality. The 2007 PCS revealed that the majority of distressed pavement was 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 3C-2 shows pavement distress along the I-405 Corridor according to 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 3C-1.

In general, pavement on the I-405 Corridor is in better condition than the District 7 as a whole. While most of the corridor represents conditions that reflect distressed conditions, very few sections (primarily around the US-101 interchange) show major pavement distress. The majority of distressed lane-miles are split fairly evenly between minor pavement distress and bad ride quality only.

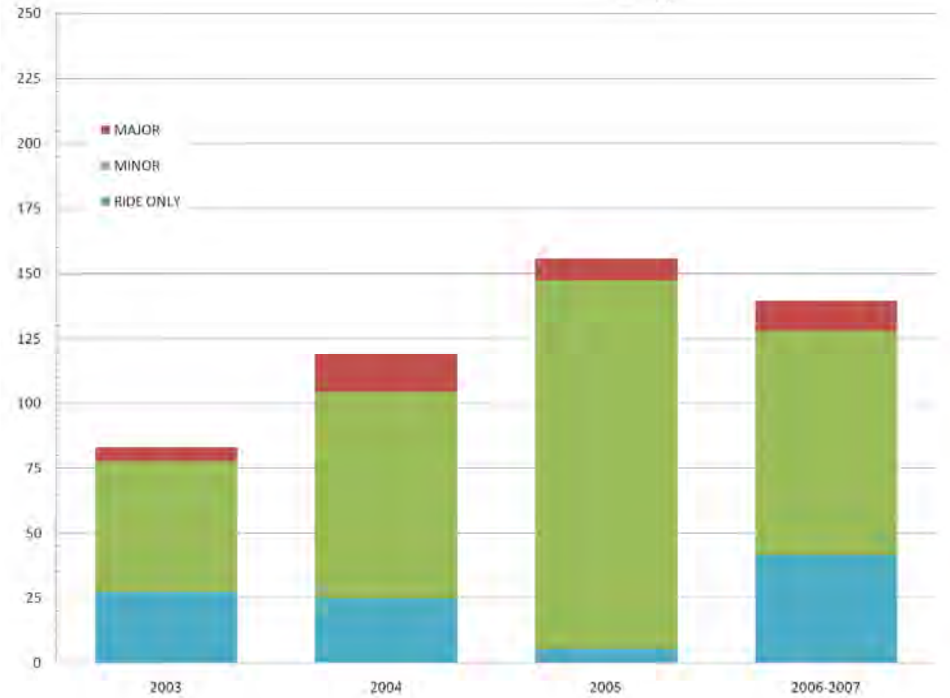
Exhibit 3C-3 shows results from prior pavement condition surveys for the I-405 Corridor. The total number of distressed lane-miles increased between 2003 and 2005. From 2005 to the 2006-2007 period, the number of distressed lane-miles decreased. The exhibit also splits the distressed lane miles by classification. The exhibit shows that not only has the number of distressed-lane miles declined, but so has the level of distress. Minor pavement distress declined more than 30 percent and was replaced primarily by ride quality issues, which can be addressed by less costly treatments. This shift is shown more clearly in Exhibit 3C-4, which shows the percent mix.

Exhibit 3C-2: Distressed Lane-Miles on I-405 Corridor for 2006-07 Period



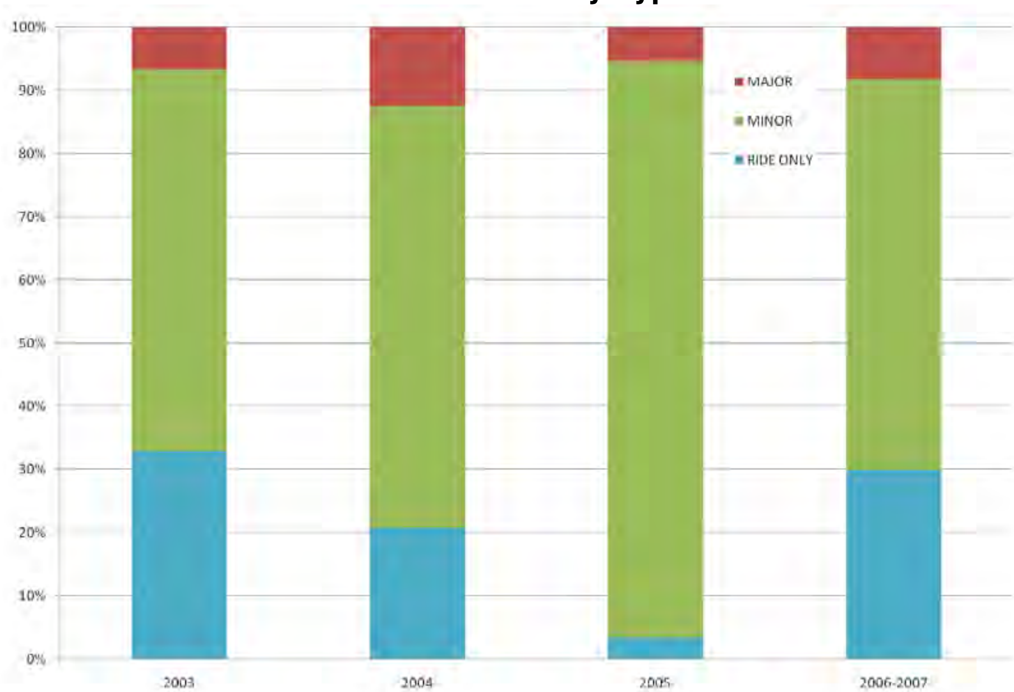
Source: Mapping of 2007 Pavement Condition Survey data

Exhibit 3C-3: Distressed Lane-Miles Trends on the I-405 Corridor



Source: 2003 to 2007 Pavement Condition Survey data

Exhibit 3C-4: Distressed Lane-Miles by Type on the I-405 Corridor



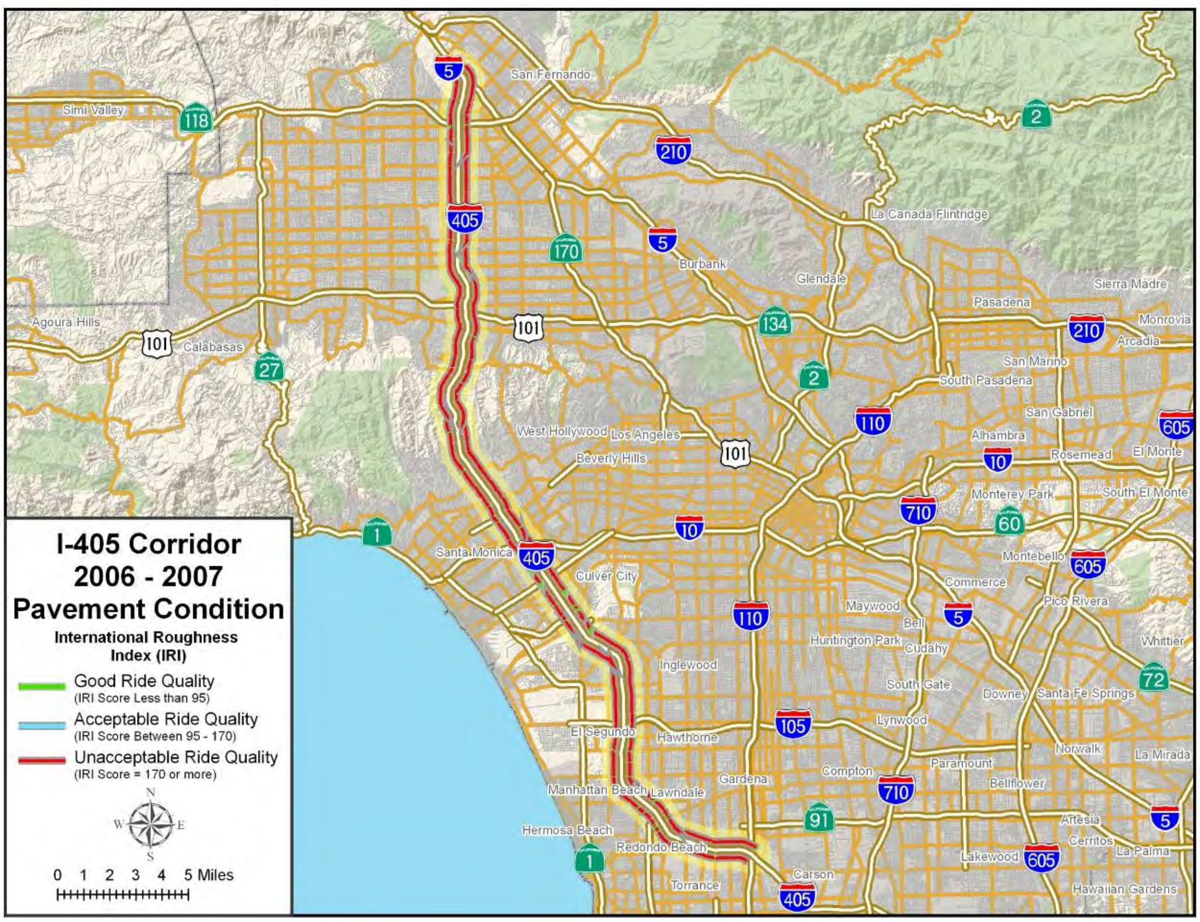
Source: 2003 to 2007 Pavement Condition Survey data

Exhibit 3C-5 shows IRI along the study corridor for the lane with the poorest pavement condition in each freeway segment. The poorest pavement conditions are shown in the exhibit because pavement investment decisions are made on this basis. Although the exhibit suggests that nearly the entire corridor has unacceptable ride quality, there are also lanes with good ride quality in many sections. The study corridor comprises roughly 339 lane-miles, of which:

- 53 lane-miles, or 16 percent, are considered to have good ride quality (IRI ≤ 95)
- 67 lane-miles, or 20 percent, are considered to have acceptable ride quality (95 < IRI ≤ 170)
- 219 lane miles, or 65 percent, are considered to have unacceptable ride quality (IRI > 170)

Note that the percentages do not add due to rounding.

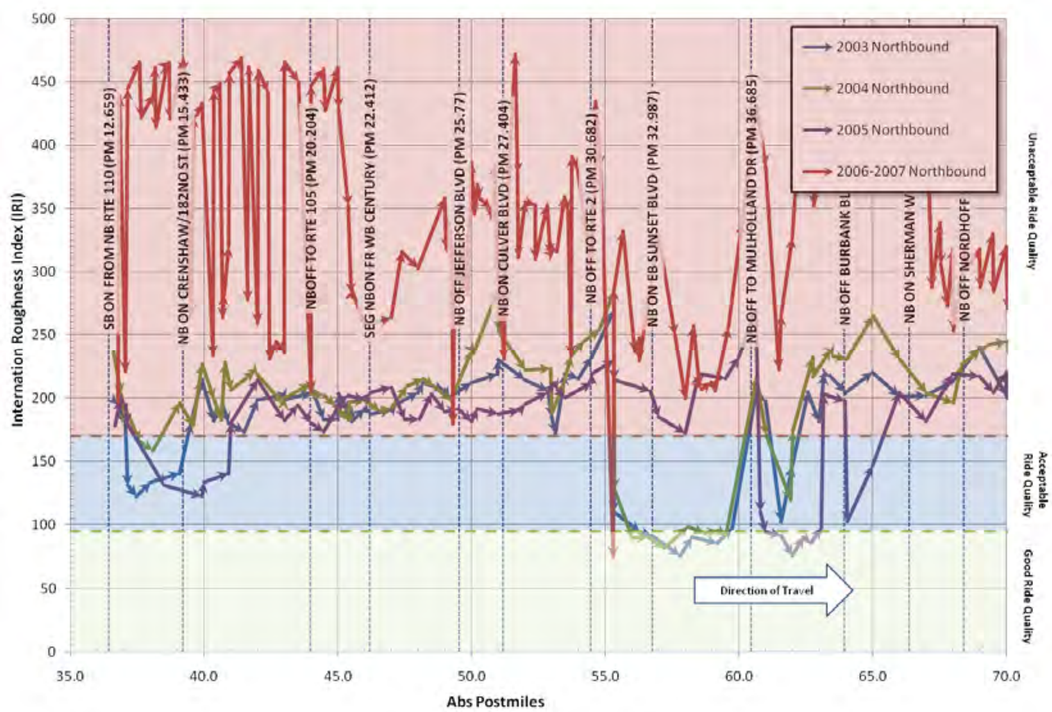
Exhibit 3C-5: I-405 Corridor IRI for the (2006-2007 Period)



Source: Mapping of 2007 Pavement Condition Survey data

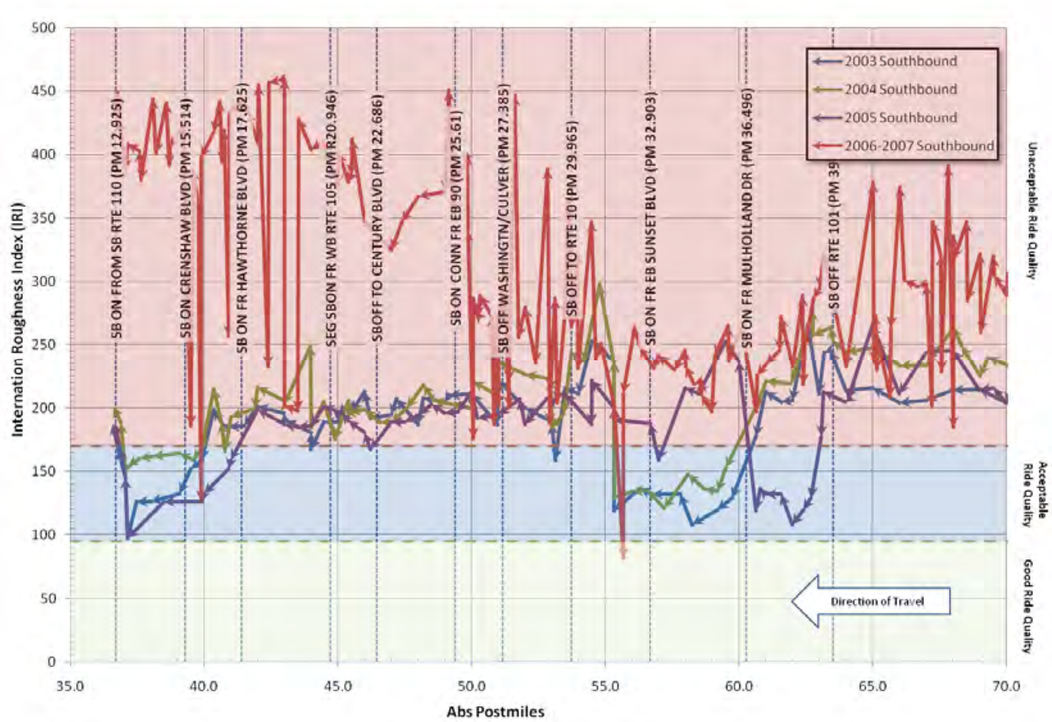
Exhibits 3C-6 and 3C-7 present ride conditions based on the IRI measure for the I-405 Corridor over the last four pavement surveys. The information is presented by postmile and direction. The exhibits include color-coded bands to indicate the three ride quality categories defined by Caltrans: good ride quality (green), acceptable ride quality (blue), and unacceptable ride quality (red). Ride quality worsened considerably between 2005 and the 2006-2007 period, but this may be due to the 2006-07 change in data collection methodology. The exhibits exclude sections that were not measured or have calibration issues (i.e., IRI = 0).

Exhibit 3C-6: Northbound I-405 Corridor IRI (2003-2007)



Source: 2003 to 2007 Pavement Condition Survey data

Exhibit 3C-7: Southbound I-405 Corridor IRI (2003-2007)



Source: 2003 to 2007 Pavement Condition Survey data

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4. BOTTLENECK IDENTIFICATION & CAUSALITY ANALYSIS

A. Bottleneck Identification

Bottlenecks were identified and verified based on a variety of data sources, including HICOMP, probe vehicle runs, Caltrans detector data, and consultant team field reviews. The study team conducted numerous field observations and videotaped major bottlenecks to further document the bottleneck locations. These efforts resulted in confirming consistent sets of bottlenecks for both directions of the freeway. This section summarizes the findings of that analysis. Exhibits 4A-1 and 4A-2 summarize the bottleneck locations identified in this analysis by direction. Exhibits 4A-3 and 4A-4 are maps that identify the bottleneck locations by AM and PM peak period.

In this section of the report, the results of the bottleneck analysis are presented. The bottleneck analysis was conducted to identify potential bottleneck locations. Potential freeway bottleneck locations that create mobility constraints are identified and documented, and their relative contribution to corridor-wide congestion is reported.

Exhibit 4A-1: Northbound I-405 Identified Bottleneck Locations

Abs	CA	Bottleneck Location	Active Period	
			AM	PM
37.4	13.7	Normandie Off	✓	✓
39.1	15.3	Crenshaw Off	✓	✓
41.2	17.5	Hawthorne On	✓	
42.2	18.4	Inglewood On	✓	✓
49.2	25.4	Sepulveda Off	✓	✓
51.2	27.4	Culver On	✓	✓
52.6	28.9	National Off	✓	✓
53.7	29.9	I-10 On	✓	✓
55.4	31.6	Wilshire On		✓
58.5	34.7	Getty On		✓
60.4	36.7	Mulholland Drive		✓
62.7	38.9	US-101 Off		✓
65.2	41.5	Victory On		✓

Exhibit 4A-2: Southbound I-405 Identified Bottleneck Locations

Abs	CA	Bottleneck Location	Active Period	
			AM	PM
70.1	46.2	Devonshire On	✓	
68.7	44.9	Nordhoff Street Off	✓	
65.1	41.3	Victory On	✓	
62.9	39.2	US-101 Off	✓	
60.3	36.5	Mulholland	✓	
56.7	32.9	Sunset	✓	
55.2	31.5	Wilshire	✓	
52.9	29.1	I-10 On		✓
51.1	27.4	Culver On	✓	✓
48.9	25.1	Howard Hughes Off	✓	✓
44.1	20.3	El Segundo On	✓	✓
41.9	18.1	Inglewood	✓	✓
36.0	12.5	I-110 Fwy	✓	✓

Exhibit 4A-3: I-405 AM Bottleneck Locations

Exhibit 4A-4: I-405 PM Bottleneck Locations

Data Sources

The study team used data analysis and extensive field verification to identify potential bottleneck locations (i.e., places with mobility constraints). All bottleneck locations were photographed to both document the field visits as well as to assist the modeling team in calibrating the micro-simulation model used in the study. The field visits were conducted initially in 2006 and subsequently in the proceeding years.

The study team consulted a variety of data sources to identify bottlenecks:

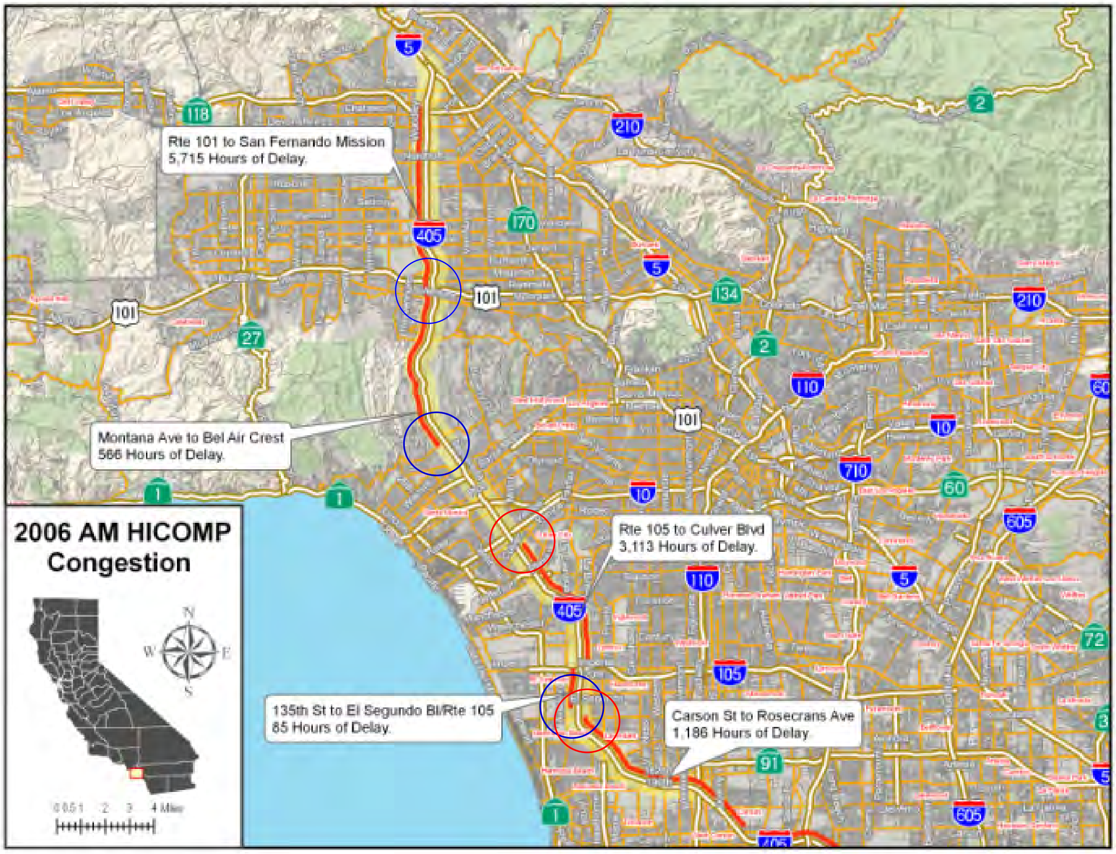
- 2006 Highway Congestion Monitoring Program (HICOMP) report
- probe vehicle data (electronic tach runs)
- Caltrans District 7 tach runs
- Freeway detector data
- aerial photos
- field observations.

HICOMP

The study team began the problem area identification by reviewing the 2006 Caltrans HICOMP report. Congested queues form upstream from bottlenecks, which are located "at the front" of the congested segment. Exhibits 4A-5 and 4A-6 show the HICOMP congestion maps with circles overlaid to indicate potential bottleneck locations. Bottleneck areas are identified with red circles in the northbound direction and blue circles in the southbound direction.

- As indicated by the 2006 HICOMP, in the AM peak there are two major bottlenecks in the northbound direction and three major bottlenecks in the southbound direction:
    - Rosecrans Avenue (Northbound)
    - El Segundo Boulevard (Southbound)
    - Culver Boulevard (Northbound)
    - Montana Avenue (Southbound)
    - US-101 Interchange (Southbound)

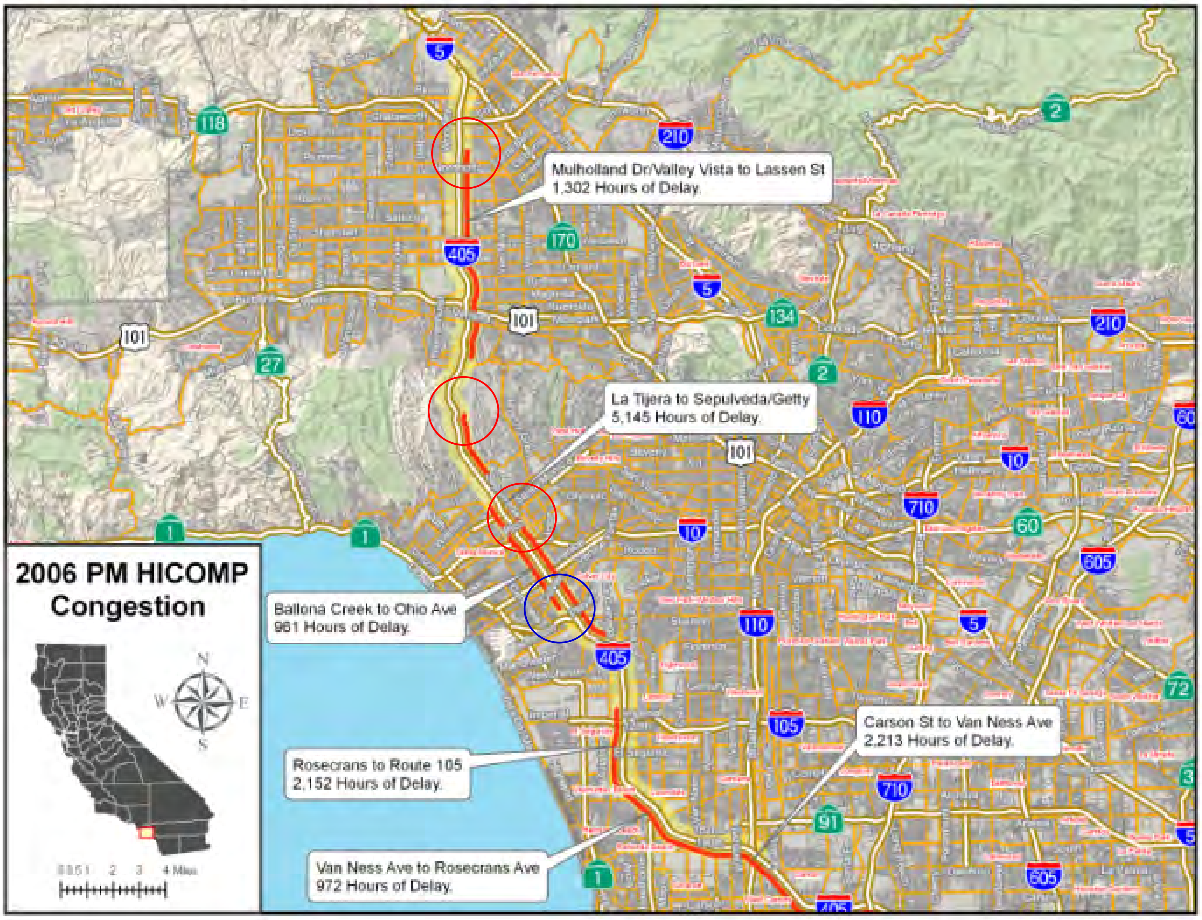
Exhibit 4A-5: 2006 HICOMP AM Congestion Map with Potential Bottlenecks



- In the PM peak, the 2006 HICOMP identified three major bottlenecks in the northbound direction and three in the southbound direction:
  - Van Ness Avenue/I-110 Interchange (Southbound)
  - Rosecrans Avenue (Southbound)
  - Ballona Creek, south of Culver Boulevard (Southbound)
  - Getty Center Drive (Northbound)
  - Mulholland Drive (Northbound)
  - Lassen Street, north of Nordhoff Street (Northbound)

Further analysis was done to determine the actual location of these bottlenecks and possibly any other bottlenecks along the corridor not identified in the HICOMP. The review of the HICOMP provided a good starting point to identify the congested areas and possible bottleneck locations as more detailed analysis was conducted.

Exhibit 4A-6: 2006 HICOMP PM Congestion Map with Potential Bottlenecks

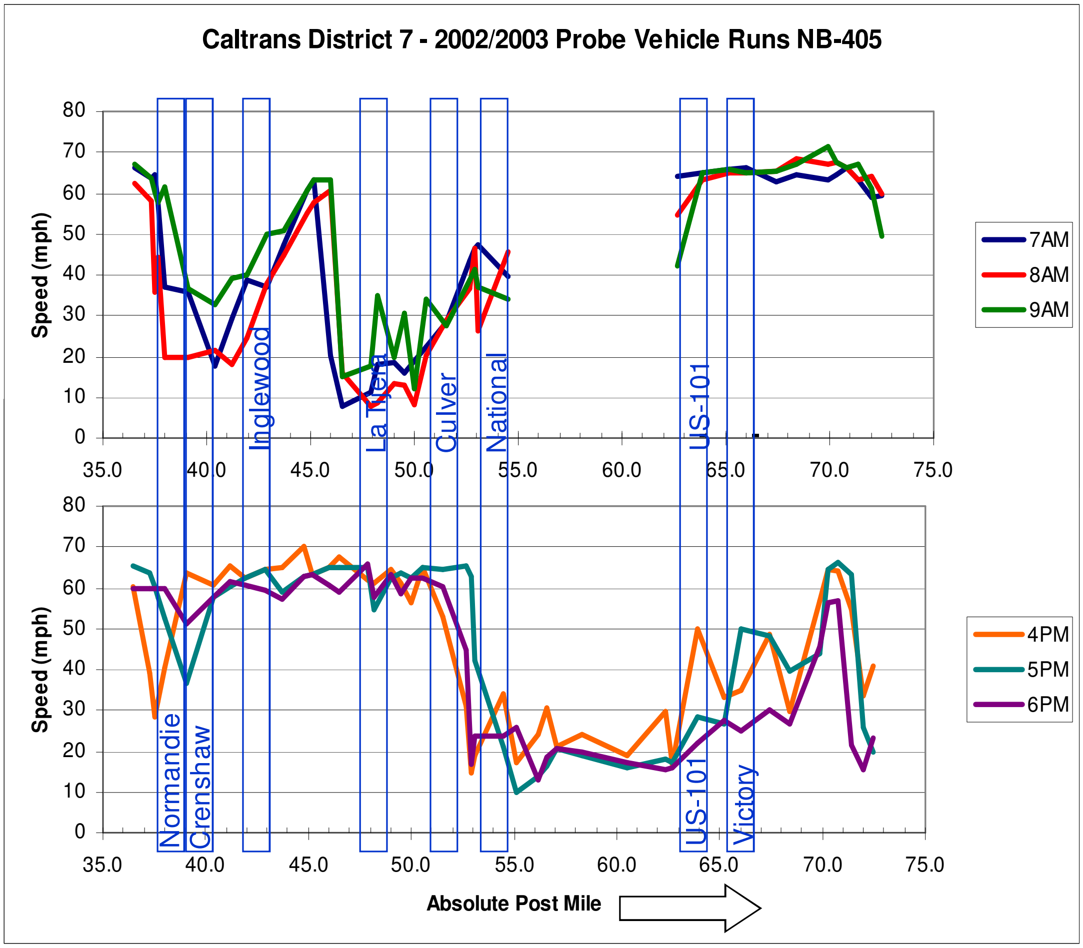


Probe Vehicle Runs

The study team used probe vehicle data collected by Caltrans District 7 and conducted additional analyses to verify the 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 traverses the corridor. Bottlenecks can be found at the downstream end of a congested location where vehicles accelerate from congested speeds (e.g., below 35 mph) to a higher speed within a very short distance.

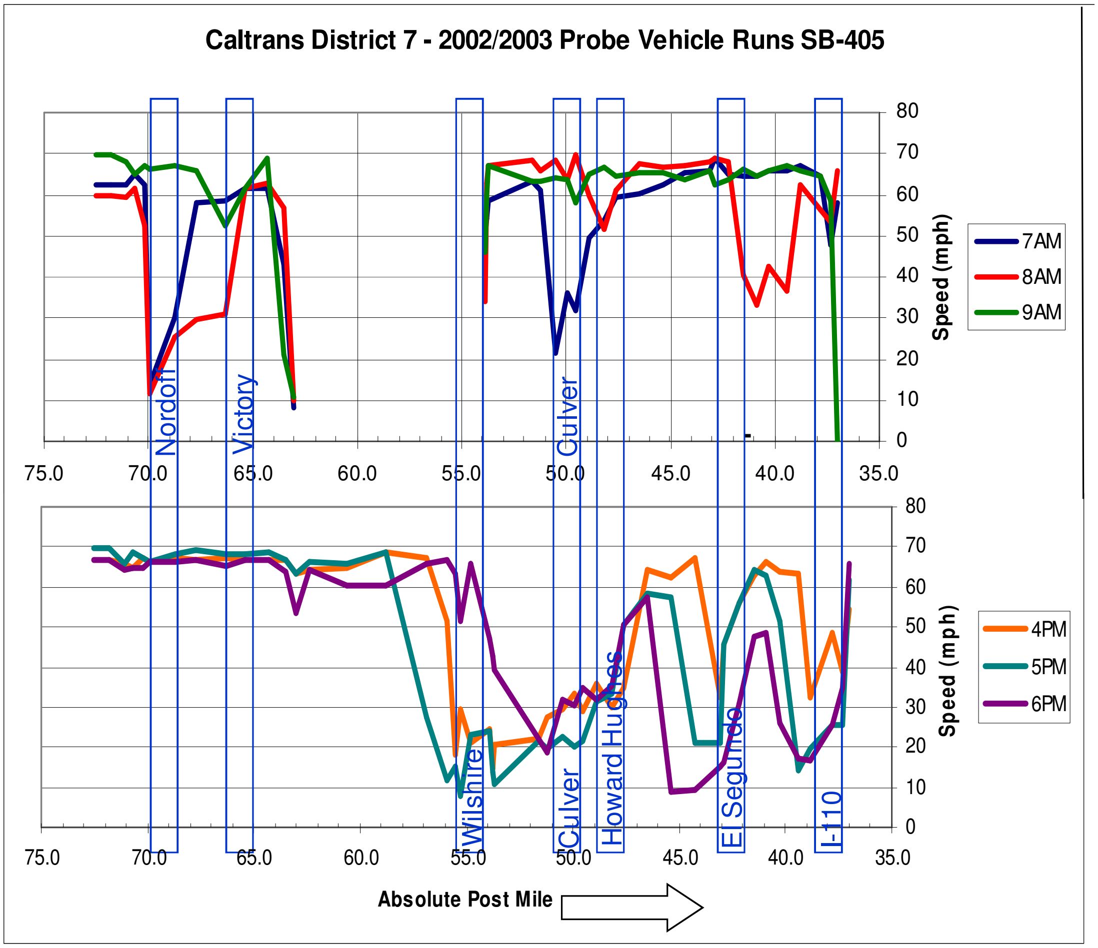
Caltrans District 7 collected probe vehicle run data in March and April 2002 and March 2003, their most recent data available, for the I-405 freeway from I-605 junction to the I-5 junction. The freeway corridor runs were broken into five separate segments from I-605 to I-110, I-110 to I-105, I-105 to I-10, I-10 to US-101, and US-101 to I-5. For each segment, the runs were conducted from approximately 6AM to 10AM and from 2:30PM to 7:30PM, except for Segment 3 (I-10 to US-101), which did not include AM runs. Exhibit 4A-7 illustrates the compiled northbound probe vehicle runs and Exhibit 4A-8 illustrates the compiled southbound probe vehicle runs at 7AM, 8AM, 9AM, 4PM, 5PM, and 6PM.

Exhibit A4-7: Northbound I-405 Probe Vehicle Runs



- As indicated, major <u>northbound</u> bottlenecks from the probe vehicle runs were identified at:
    - Normandie Avenue Off (PM)
    - Crenshaw Boulevard Off (PM)
    - Hawthorne Boulevard On (AM)
    - Culver Boulevard On (AM)
    - US-101 Off (AM/PM)
    - Victory Boulevard On (PM)

Exhibit 4A-8: Southbound I-405 Probe Vehicle Runs



- As indicated, major <u>southbound</u> bottlenecks from the probe vehicle runs were identified at:
  - Devonshire Street On (AM)
  - Victory Boulevard On (AM)
  - Wilshire Boulevard Off (PM)
  - Culver Boulevard On (AM/PM)
  - Howard Hughes (AM/PM)
  - El Segundo (AM/PM)
  - I-110 (AM/PM)

Automatic Detector Data

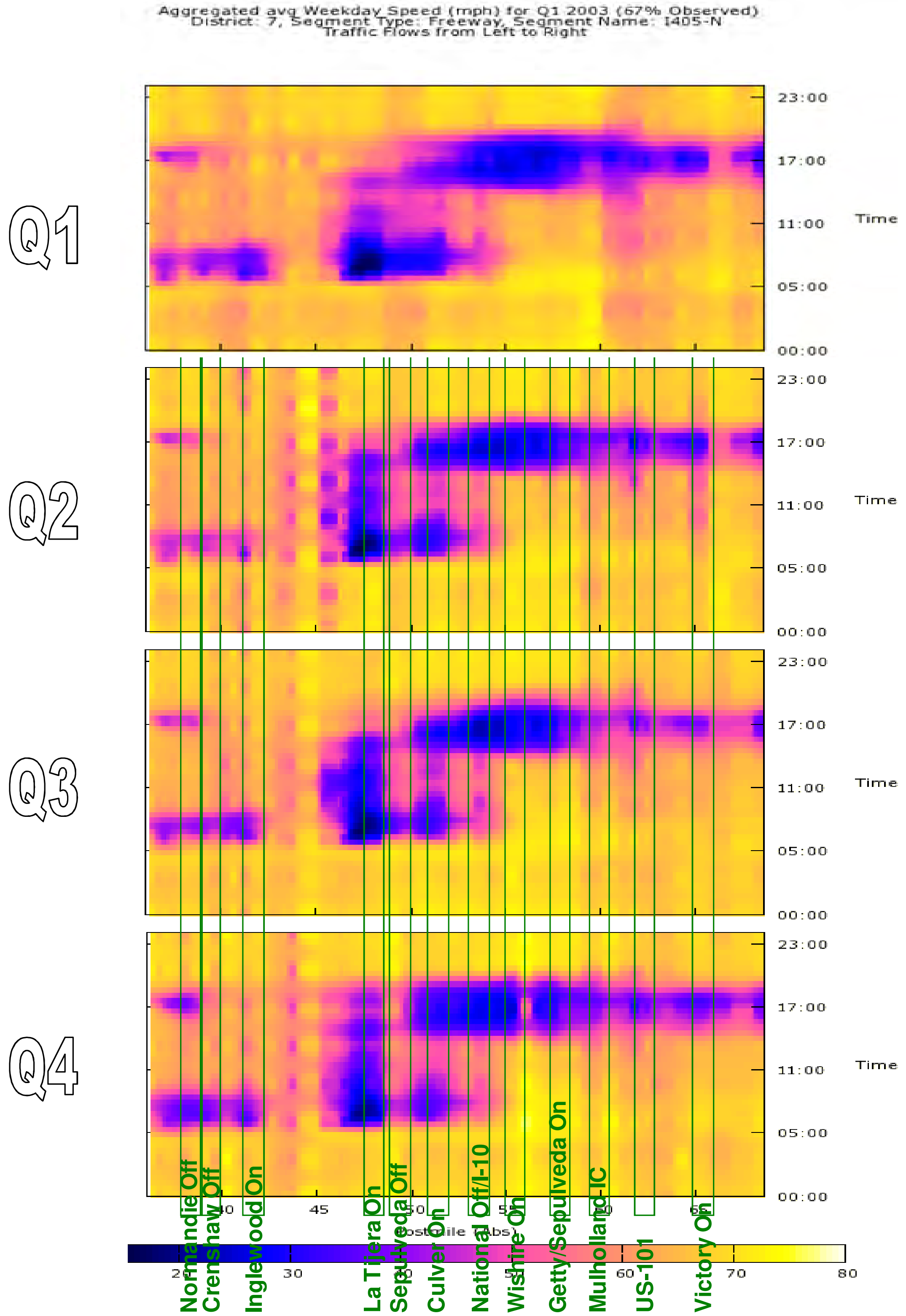
Using automatic detector data, speed plots are also used to identify potential bottleneck locations. Speed plots are very similar to probe vehicle run graphs. Unlike the probe vehicle runs, however, each speed plot has universally the same time across the corridor. For example, an 8AM plot includes the speed at one end of the corridor at 8AM and the speed at the other end of the corridor also at 8AM. With probe vehicle runs, the end time, or time at the end of the corridor is the departure time plus the actual travel time. Despite this difference, they both identify the same problem areas. These speed plots are then compiled at every five minutes and presented in speed contour plots.

Northbound I-405 Detector Analysis

Exhibit 4A-9 illustrates the speed contour plots that are averaged quarterly in 2003. The speed contour plot represents a typical weekday sample to illustrate the bottleneck locations and congestion formed from them. The sample day had observed or "good" detection data of 67 percent, providing reasonably accurate results. The speed contour plot illustrates the typical speed contour diagram for the I-405 freeway in the northbound direction (traffic moving left to right on the plot). Along the vertical axis is the time period from 4AM to 8PM. Along the horizontal axis is the corridor segment from south of I-110 to I-5. 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 blotch represent bottleneck areas, where speeds pickup after congestion, typically to 30 to 50 miles per hour in a relatively short distance. The horizontal length of each plot is the congested segment, queue lengths. The vertical length is the congested time period.

- Based on the contour plot of a typical weekday sample averaged quarterly in 2003, the following bottlenecks were identified in the northbound direction:
  - Normandie Off (AM/PM)
  - Crenshaw Boulevard Off (AM/PM)
  - Inglewood On (AM)
  - Sepulveda Off (AM/PM)
  - Culver On (AM/PM)
  - National Off/I-10 (AM/PM)
  - Wilshire Boulevard On (PM)
  - Getty On (PM)
  - Mulholland Drive (PM)
  - US-101 Off (PM)
  - Victory Boulevard On (PM)

Exhibit 4A-9: Northbound I-405 Long (Speed) Contours – 2003 by Qtr Avg

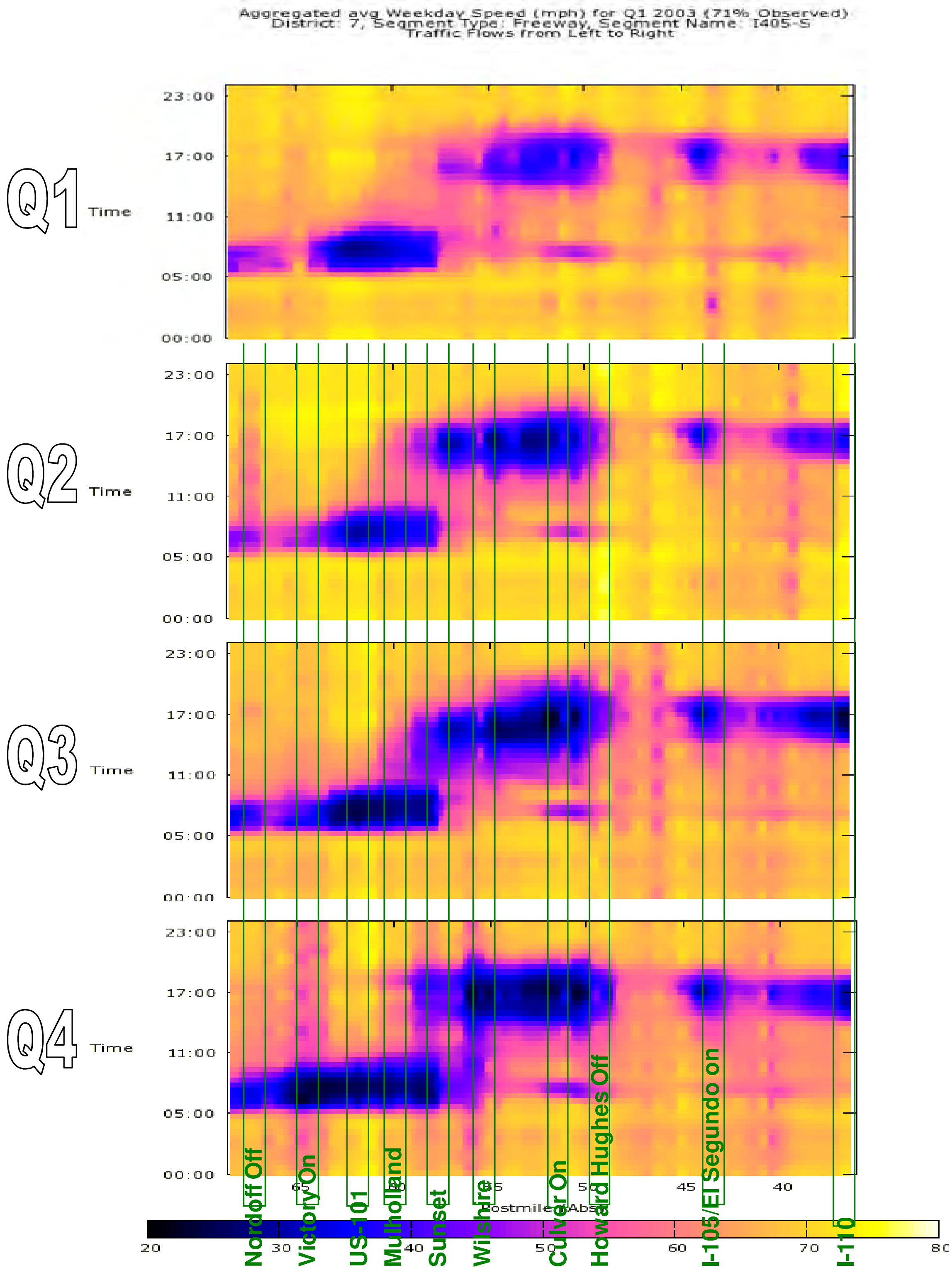


Southbound I-405 Detector Analysis

Similarly, speed contour plots for the quarterly weekday average long contours in 2003 were analyzed for the southbound direction. Exhibits 4A-10 illustrates the speed contour plots for the I-405 freeway corridor in the southbound direction (traffic moving left to right on the plot) for each quarter in 2003. Along the vertical axis is the time period from 4AM to 8PM. Along the horizontal axis is the corridor segment from south of I-110 to I-5. Similar to the northbound speed contour analysis results, the southbound speed contour analysis results indicate reoccurring bottleneck locations across multiple weekdays and quarterly averages.

- Based on the quarterly averages of weekdays, the following bottlenecks were identified in the southbound direction:
    - I-110 (PM)
    - I-105/El Segundo On (PM)
    - Howard Hughes Off (AM/PM)
    - Culver On (AM/PM)
    - Wilshire (AM)
    - Sunset On (AM)
    - Victory On (AM)
    - Nordhoff Off (AM)

Exhibit 4A-10: Southbound I-405 Long (Speed) Contours – 2003 by Qtr Avg



B. Bottleneck Causality Analysis

Major bottlenecks are the primary cause 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 operational problems.

Field observations not only help in identifying bottleneck locations, but they also help in identifying the causes of these bottlenecks. For the I-405 Corridor, field observations were conducted by the project team on multiple days (midweek) in 2007 and in the beginning of 2008 during the AM and PM peak hours.

By definition, a bottleneck is a condition where traffic demand exceeds the capacity of the roadway facility. 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 that the facility cannot accommodate. Due to the limited vehicle detector stations along this corridor, traffic volume data was not readily available for consideration. Nevertheless, major bottleneck conditions were verified and their causes identified. Below is a summary of the causes of the bottleneck locations.

Mainline (ML) Facility

Northbound I-405 Mainline Bottlenecks and Causes

Normandie Avenue Off

Exhibit 4B-1 shows the aerial photograph of the northbound I-405 mainline from the Vermont Avenue on-ramp to the Normandie Avenue off-ramp. The mainline fifth lane mostly carries heavy traffic from I-110 onto I-405, as shown in the lower right photograph and indicated by the first blue arrow (note that the actual I-110 connector ramp is not shown on the aerial view). In addition, the Vermont Avenue on-ramp traffic merges with this lane, as indicated by the second blue arrow. The cross weaving of the Normandie Avenue off-ramp traffic and the lane drop results in the bottleneck condition at this location. Just past the lane drop, speeds begin to pick up and vehicles begin to separate as shown in the inset photograph.

Exhibit 4B-1: Northbound I-405 at Vermont Avenue On to Normandie Avenue Off

<u>Crenshaw Boulevard Off</u>

Exhibit 4B-2 is an aerial photograph of the northbound I-405 mainline at the Crenshaw Boulevard Interchange. As shown in the photograph below, the off-ramp traffic queues onto the mainline, in this case along the mainline shoulder. The primary cause of this bottleneck is from intersection 1, indicated on the exhibit. In order to provide left-turn access at this intersection, the heavy southbound Crenshaw Boulevard traffic cannot clear the intersection and queues back to intersection 2 and back along 182nd Street to intersection 3 and onto the freeway mainline.

Exhibit 4B-2: Northbound I-405 at Crenshaw Boulevard Off-ramp

Hawthorne Boulevard On

Exhibit 4B-3 is an aerial photograph of the northbound I-405 at the Hawthorne Boulevard Interchange. As the inset digital photograph shows, platoon of vehicles merge onto the freeway mainline, creating the bottleneck condition at this location. This is due to the geometry of the ramp with the ramp metering location too far back on the ramp. The slow speeds up the ramp and the merge of the three lanes into one lane result in the platoon of the vehicles. During the peak hours about 900 vehicles per hour enters the freeway from this on-ramp.

Exhibit 4B-3: Northbound I-405 at Hawthorne Boulevard

Inglewood Avenue/Rosecrans Avenue

The primary cause of this bottleneck is likely due to the roadway geometry. The large horizontal curve and vertical grade reduces sight distance and affects travel speed, adversely impacting capacity. The analysis of the probe vehicle runs and speed contours indicates that the bottleneck occurs at the crest of the horizontal curve in both directions as indicated by the blue arrows and outlined by the white circles.

Exhibit 4B-4: Northbound I-405 at Inglewood Avenue/Rosecrans Avenue

La Tijera Boulevard On

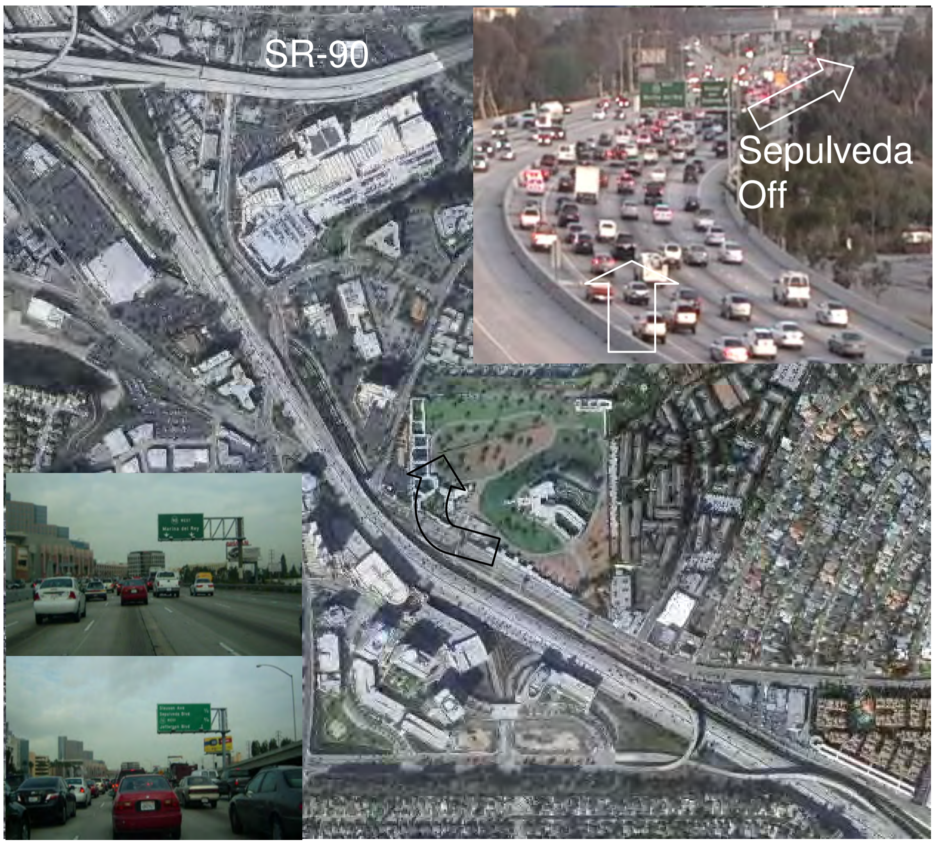
This bottleneck location is due to the roadway geometry and on-ramp merging. As shown in the aerial photograph shown in Exhibit 4B-5, increased density is caused by the narrow curve to the left preceding and approaching the on-ramp. At the La Tijera on-ramp, platoon of vehicles merging with the freeway mainline traffic causes the bottleneck to occur at this location. The platoon of vehicles is created by the HOV bypass lane at the ramp metering.

Exhibit 4B-5: Northbound I-405 at La Tijera Boulevard

Sepulveda Boulevard Off

This bottleneck location is mainly due to the roadway geometry. As indicated in the aerial photograph shown in Exhibit 4B-6, the uphill grade and roadway curve slows vehicles creating the bottleneck condition at this location.

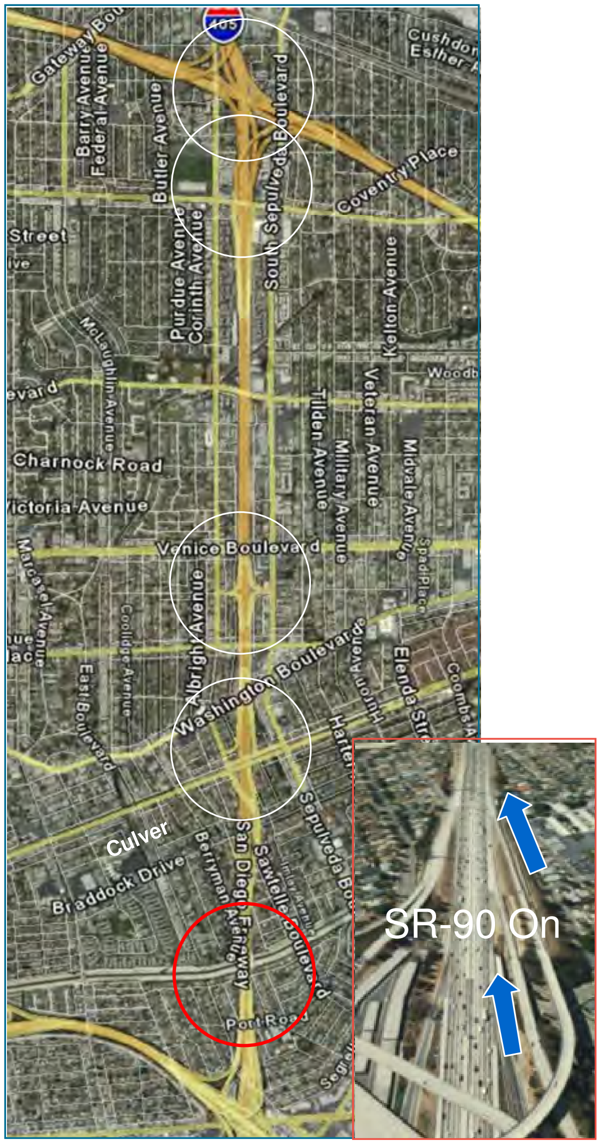
Exhibit 4B-6: Northbound I-405 at La Tijera Boulevard/Howard Hughes Parkway



Culver Boulevard On/Venice Boulevard (Matteson Avenue) On

The bottleneck conditions at the Culver Boulevard and Venice Boulevard locations are caused primarily by the merging of the on-ramp traffic. Exhibit 4B-7 shows the aerial photograph of this area with highlighted bottleneck areas noted by white circles. With the high density of traffic on the freeway mainline stemming from the increased volume of traffic from SR-90, the traffic stream cannot absorb the on-ramp traffic from the merging, and breaks down. These bottlenecks are more pronounced during the AM peak hours.

Exhibit 4B-7: Northbound I-405 from SR-90 to I-10



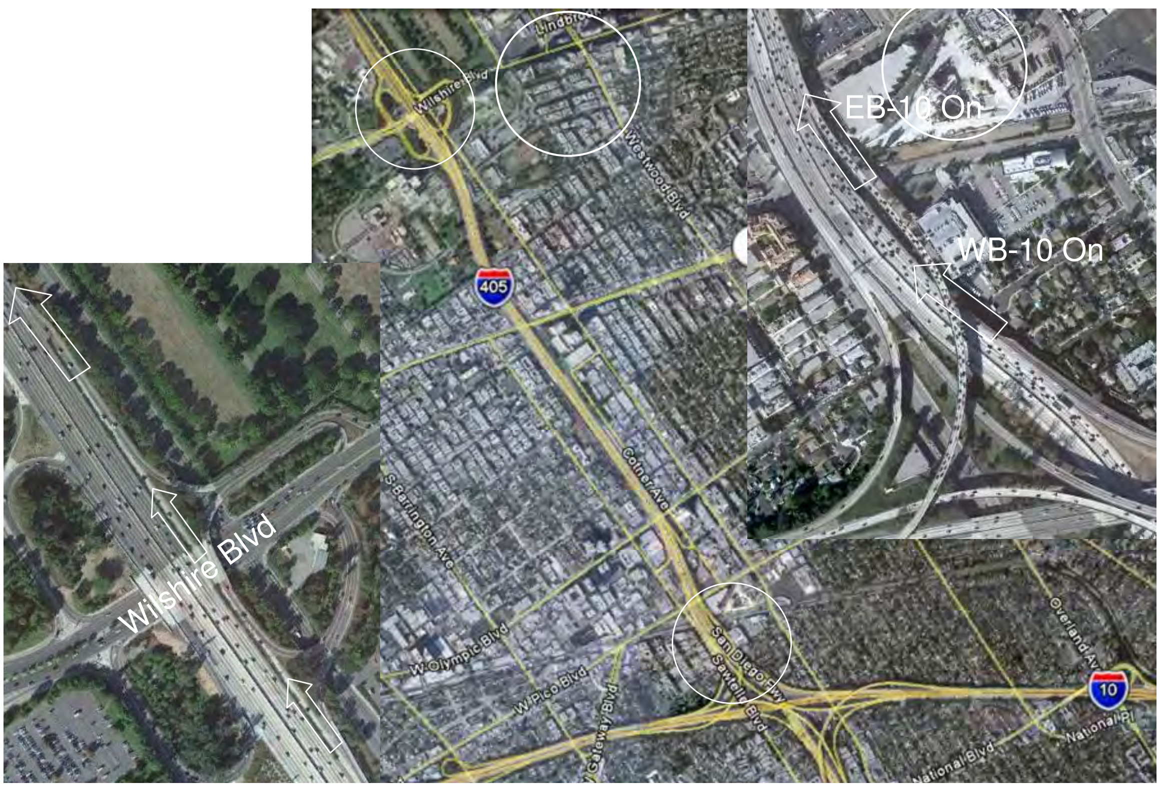
<u>National Boulevard/I-10 Off</u>

The bottleneck condition at the National Boulevard and I-10 interchange locations are caused primarily by the weaving of the off-ramp traffic and the loss of a mainline lane to the connectors. As such, the northbound mainline traffic is squeezed into the remaining lanes, resulting in the bottleneck condition. Exhibit 4B-7 shows the aerial photograph of this area.

I-10 On and Wilshire Boulevard On

These two bottleneck locations are shown in Exhibit 4B-8. The freeway mainline cannot handle the platoon merging from the I-10 connector on-ramps, resulting in the bottleneck condition. The exhibit also shows the Wilshire Boulevard with the collector distributor (C/D) configuration. The collector distributor allows for vehicle platoons to form before merging with the freeway mainline traffic, also resulting in a bottleneck condition. The C/D on-ramp adds over 1,500 vehicles/hour on to the mainline during the peak hours.

Exhibit 4B-8: Northbound I-405 at I-10 and Wilshire Boulevard



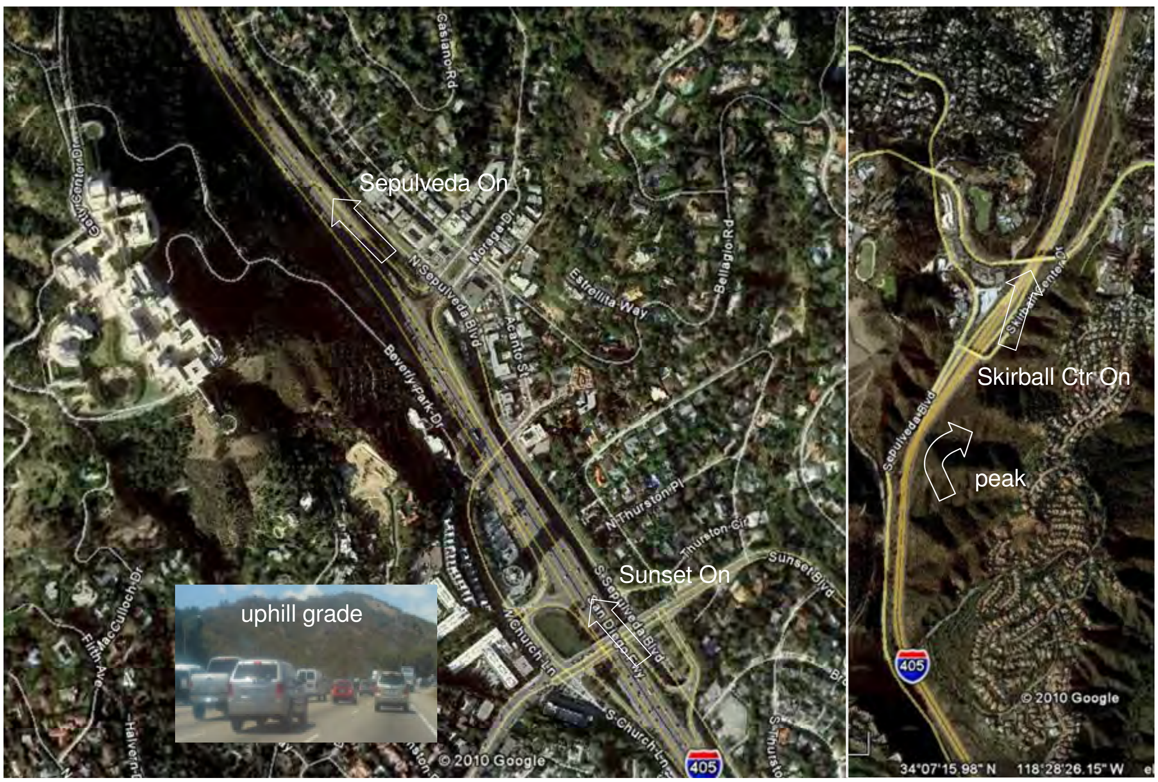
Sunset Boulevard On/Getty Drive IC

The long uphill grade and the heavy traffic merging from Sunset Boulevard and Sepulveda Boulevard (Moraga Drive) on-ramps during the PM peak hours causes the bottleneck condition to occur approaching the Getty Drive interchange. With the slowed traffic from the uphill grade, the mainline traffic stream cannot handle the merging of the ramp volumes, causing it to break down. Exhibit 4B-9 illustrates this location.

Mulholland Drive Overcrossing

At the crest of the very long uphill grade is the Mulholland Drive overcrossing. This uphill grade, compounded by the merging of the Skirball Center Drive on-ramp on to the mainline traffic during the PM peak hours, causes the bottleneck condition to occur. Once past this bottleneck location, traffic flows in a downhill grade and picks up speed. Exhibit 4B-9 illustrates this location with an aerial photograph.

Exhibit 4B-9: Northbound I-405 at Sunset Blvd, Getty Center Dr, and Mulholland Dr



US-101 Off

The bottleneck condition at the US-101 interchange is caused by the heavy off-ramp traffic backing up onto the freeway mainline. Several lanes are stopped trying to weave into the US-101 connector ramp. Compounding this location is the on-ramp traffic from Ventura Boulevard/Sepulveda Boulevard trying to merge on to the freeway mainline.

Victory Boulevard On and Nordhoff Street On

The bottleneck at the Victory Boulevard on-ramp is caused by the platoon of vehicles merging with the mainline traffic. As shown in Exhibit 4B-10, the ramp metering location is too far back on the ramp. The heavy demand of the ramp traffic, long ramp distance, and slow speeds up the ramp creates the platoon of the vehicles. At the Nordhoff Street interchange, the on-ramp traffic merging on to the northbound I-405 mainline traffic is likely to cause the bottleneck condition.

Exhibit 4B-10: Northbound I-405 at Victory Boulevard

Southbound I-405 Mainline Bottlenecks and Causes

Devonshire Street On to Nordhoff Street Off

Exhibit 4B-11 shows the aerial photograph of the southbound (top down) I-405 at Devonshire Street. As indicated, traffic from SR-118 and two consecutive on ramps from Devonshire Street merges with the mainline traffic, while dropping a lane on the mainline approaching Nordhoff Street, creating the bottleneck condition at this location.

Exhibit 4B-11: Southbound I-405 at Devonshire Street

<u>US-101</u>

As shown in Exhibit 4B-12 inset photographs, traffic is heavily congested approaching US-101. The primary cause of this bottleneck is the heavy traffic destined to continue southbound on I-405 and the lane drop, lost to the US-101 connector, from 4- lanes to 3-lanes. The lower photograph shows the stream of traffic on the fourth lane that must merge to the left before the split. As shown on the upper photograph, very little of the I-405 mainline traffic is headed to the US-101 during the AM peak hours.

Exhibit 4B-12: Southbound I-405 approaching US-101

Exhibit 4B-13 shows the next bottleneck at the US-101 merge with the southbound I-405. The bottleneck is located at the northbound US-101 to southbound I-405 connector ramp merge point, as illustrated by the white oval. Traffic congestion from this location queues traffic back onto the US-101 mainline to SR-134. The bottleneck condition at this location is created by the heavy demand from the ramp, compounded by the very tight loop of the ramp, resulting in a platoon of vehicles merging with the southbound I-405 traffic at an uphill grade. The lower inset photograph shows the traffic congested approaching the merge and the upper photograph illustrates speeds picking up and traffic beginning to separate just past the merge. This bottleneck was also observed in the field on multiple occasions during the AM peak hours. As traffic continues southward into the long steep uphill grade through Mulholland pass, more congestion is formed throughout this section of the corridor.

Exhibit 4B-13: Southbound I-405 at US-101 Merge

Mulholland Drive Overcrossing

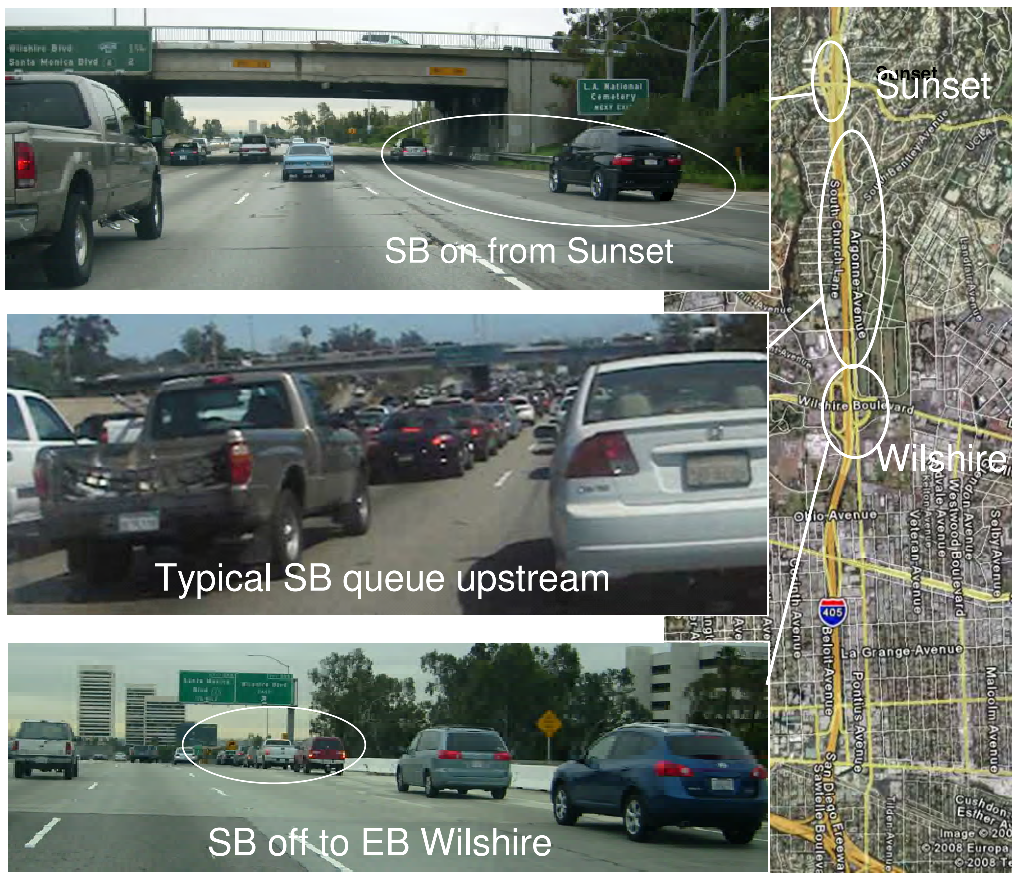
As traffic travels through the Mulholland pass, the steep vertical grade and the lane drop just past the Skirball off-ramp create the bottleneck condition and traffic congestion, as shown in the Exhibit 4B-14 inset right photograph.

Exhibit 4B-14: Southbound I-405 at Mulholland Drive

Sunset Boulevard On and Wilshire Boulevard Off

Another significant bottleneck is at the Sunset Boulevard on-ramp merge. With the very short merge taper, as shown in the left above photograph in Exhibit 4B-15, a small platoon of ramp traffic will cause the mainline traffic flow to breakdown, creating the bottleneck condition. Just past this location, traffic normally picks up speed to the Wilshire Boulevard off-ramp, where traffic is again congested. The cause of the bottleneck at Wilshire Boulevard off-ramp is the off-ramp traffic backing up onto the mainline, as shown in the lower photograph, highlighted by the white oval. During the PM peak hours, traffic along Wilshire Boulevard is heavily congested, resulting in the queuing to the freeway mainline.

Exhibit 4B-15: Southbound I-405 at Sunset and Wilshire Boulevard



I-10 On

At the I-10 interchange, the merging from the consecutive I-10 connector ramps overloads the freeway causing the bottleneck condition to occur. The connectors are not metered.

Culver Boulevard (Braddock Drive) On

At the Culver Boulevard interchange, the merging from the Braddock Drive on-ramp causes the bottleneck to occur at this location. With the dense mainline flow during both the AM and PM peak hours, the freeway cannot absorb the demand from the ramp and the merging effects cause the bottleneck to form.

SR-90/Howard Hughes Parkway

The primary cause of this bottleneck is the platoon merging from the heavy traffic demand from the SR-90 on-ramp. The southbound I-405 mainline traffic demand during the peak hours is very heavy. Added to that is the heavy stream of traffic from SR-90 merging with the I-405 traffic, as shown in the Exhibit 4B-16 inset photograph, highlighted by the white oval. The connector ramp is not metered. The roadway geometry with the downhill grade and horizontal curves affecting sight distance contributes to the bottleneck condition.

Exhibit 4B-16: Southbound I-405 at SR-90 On/Howard Hughes Parkway

El Segundo Boulevard to Rosecrans Avenue

Exhibit 4B-17 shows the aerial photograph of the southbound I-405 mainline at El Segundo Boulevard. As shown, the connector ramp traffic from the I-105 is very heavy, even with ramp metering, at over 1500 vehicles per hour during the PM peak hours. Added to this traffic, the El Segundo Boulevard on-ramp traffic exceeds 900 vehicles per hour, which results in over 2400 vehicles per hour of traffic merging with the I-405 southbound mainline traffic. The primary cause of the bottleneck is this demand plus the lane drop that occurs downstream, as highlighted by white ovals in the exhibit. The multiple lane drops that occur cause the bottleneck and the severe congestion that follows.

Exhibit 4B-17: Southbound I-405 at El Segundo Boulevard/Rosecrans Avenue

Inglewood Avenue/Rosecrans Avenue

As described in the northbound bottleneck at this location, the primary cause of this bottleneck is likely due to the roadway geometry. The large horizontal curve and vertical grade reduces sight distance and affects travel speed, adversely impacting capacity. The analysis of the probe vehicle runs and speed contours indicates that the bottleneck occurs at the crest of the horizontal curve in both directions as indicated by the blue arrows and outlined by the white circles.

Exhibit 4B-18: Southbound I-405 at Inglewood Avenue/Rosecrans Avenue

<u>I-110 Interchange</u>

Similar to the US-101 approach, the lane drop from 4-lanes to 3-lanes at the I-110 split causes the bottleneck and congestion to occur regularly during the weekday PM peak hours at this location. As traffic speeds begin to pick up after the split and bottleneck, another bottleneck is created from the merge of the I-110 traffic and Main Street traffic from three consecutive on-ramps and multiple lane drops. The I-110 connector ramps are not metered. Exhibit 4B-19 illustrates this location.

Exhibit 4B-19: Southbound I-405 at-110

High-Occupancy Vehicle (HOV) Facility

A bottleneck causality analysis was also conducted for the HOV facility of the I-405 Corridor. Automatic detector data and field observations were primarily used to conduct the HOV analysis. HOV lanes along the I-405 Corridor operate on a full-time basis separated by a buffer with varying widths. It has a vehicle occupancy requirement of two plus (2+) in both directions.

Northbound I-405 HOV Bottlenecks and Causes

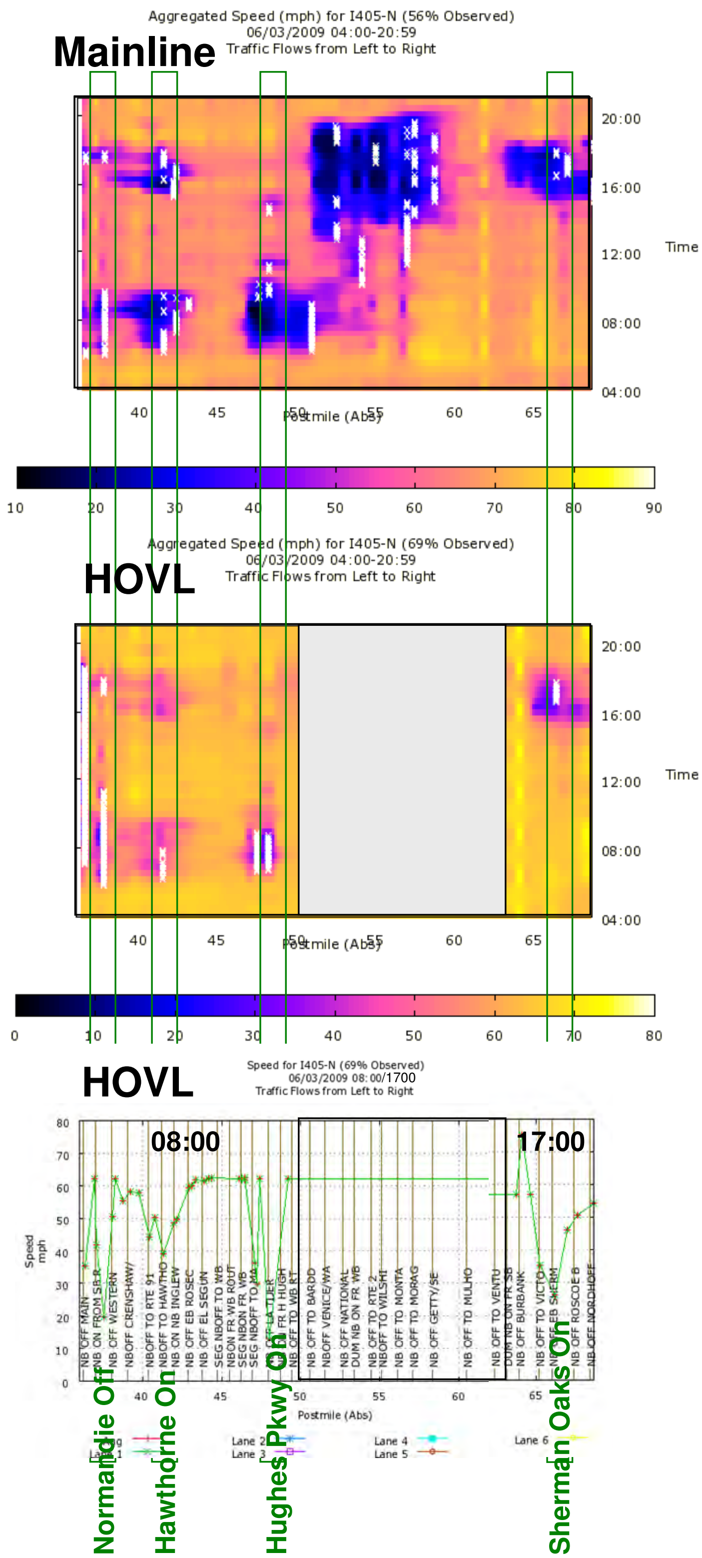
In the northbound direction, four major HOV bottlenecks were identified based on data analysis at the following locations:

- Normandie Off-ramp (mainline lane drop)
- Hawthorne Boulevard On-ramp
- Howard Hughes Parkway On-ramp
- Sherman Oaks On-ramp

Exhibit 4B-20 presents speed contour and profile diagrams of the northbound mainline and HOV facilities during a typical weekday in June 2009. The diagram identifies the four locations of congestion with dark shaded plots. The review of multiple 2008 sample days and monthly averages consistently revealed the same bottleneck locations at these four locations. The HOV-lane remains under construction and does not extend throughout the entire length of the mainline facility of the study corridor, as noted by the gaps on the HOV diagrams.

As illustrated in the exhibit, the HOV bottleneck locations coincide exactly with the mainline bottleneck locations. This is primarily due to the close proximity of the HOV-lane to the mainline lane. Currently, the HOV-lane is separated from the mainline by a double-yellow and white stripe buffer (about 2-feet in width) and has little to no inside shoulder. When the mainline is congested and speeds are at stop and go, the HOV traffic will also slow down out of caution, breaking down the flow of vehicles, particularly near the HOV-lane ingress/egress locations and at roadway curves.

Exhibit 4B-20: Northbound I-405 ML & HOV Speed Contours (June 2009)



Southbound I-405 HOV Bottlenecks and Causes

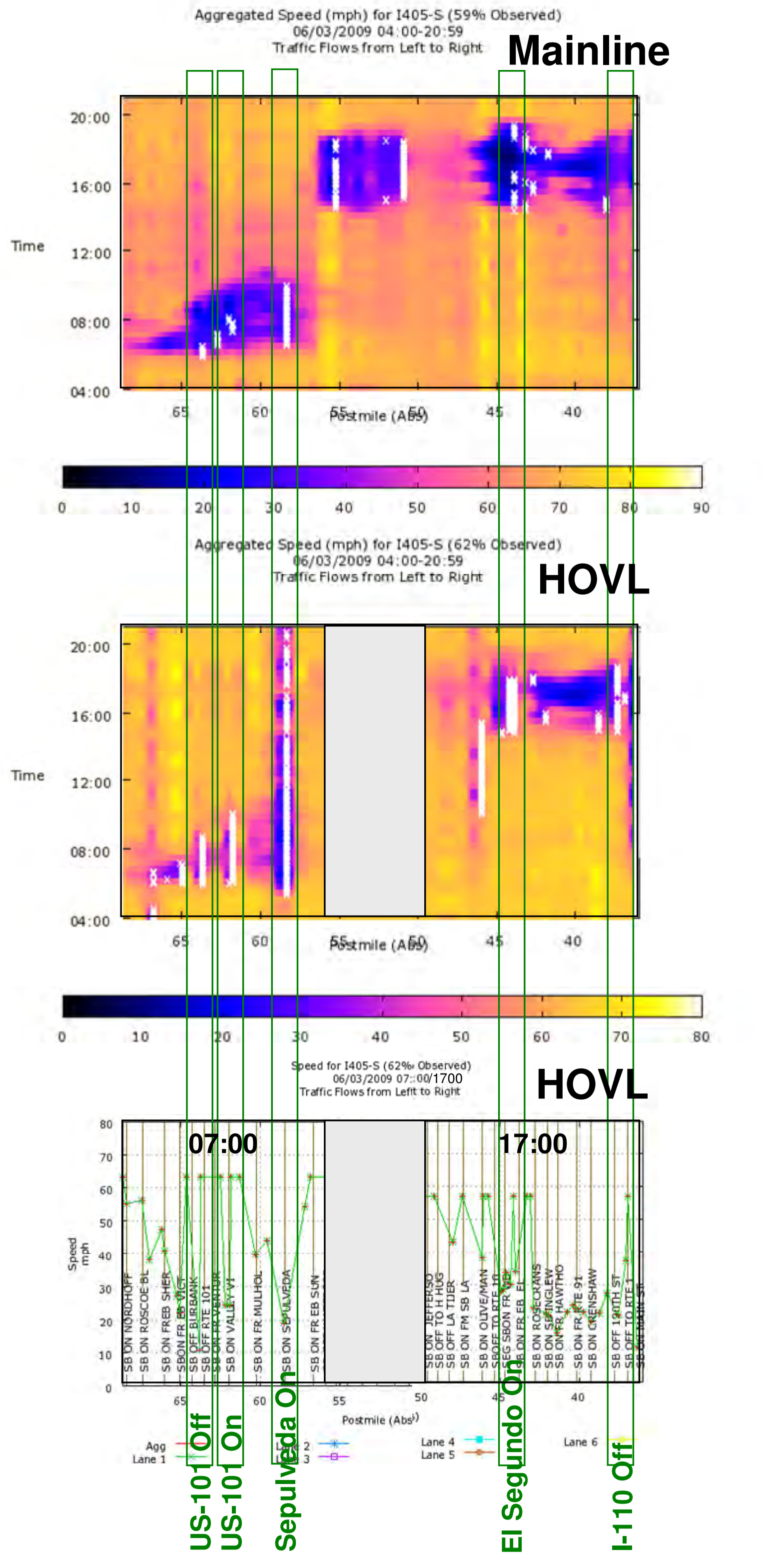
In the southbound direction, six bottlenecks were identified based on data analysis, at the following locations:

- US-101 Connector Off-ramp
- US-101 Connector On-ramp
- Sepulveda Boulevard On-ramp
- Santa Monica Boulevard (HOV terminus)
- I-110 Connector Off-ramp

Exhibit 4B-21 presents speed contour and profile diagrams of the southbound mainline and HOV facilities during a weekday in June 2009. The diagram identifies the six locations of congestion with dark shaded plots. The review of multiple 2008 sample days and monthly averages consistently revealed the same bottleneck locations at these six locations. The HOV-lane remains under construction and does not extend throughout the entire length of the mainline facility of the study corridor, as noted by the gaps on the HOV diagrams.

Similar to the northbound direction, the southbound HOV bottleneck locations also coincide with the mainline bottleneck locations. Again, this is primarily due to the close proximity of the HOV-lane to the mainline lane. Currently, the HOV-lane is separated from the mainline by a double yellow and white stripe separation (about 2 feet in width) and has little to no inside shoulder. When the mainline is congested and speeds are at stop and go, the HOV traffic will also slow down out of caution, breaking down the flow of vehicles, particularly near the HOV-lane ingress/egress locations and at roadway curves. It was further observed in the field that the location where the HOV-lane terminates (near Santa Monica Boulevard) is heavily congested during the PM peak hours. Significant queuing was observed in the HOV-lane stemming from its terminus and onto the congested mainline freeway.

Exhibit 4B-21: Southbound I-405 ML & HOV Speed Contour (June 2009)



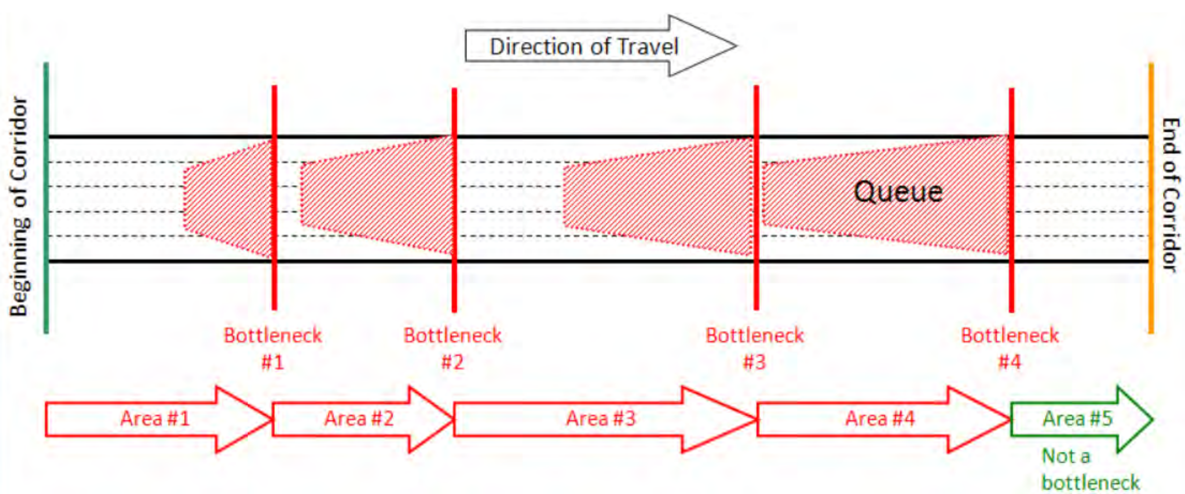
C. Bottleneck Area Performance

Once the bottlenecks were identified, the corridor is divided into "bottleneck areas." Bottleneck areas represent segments that are defined by one major bottleneck (or a number of smaller ones). By segmenting the corridors into these bottleneck areas, specific performance statistics that were presented for the entire corridor can now be broken down by bottleneck area. This way, the relative contribution of each bottleneck area to the degradation of the corridor performance can be gauged. The performance statistics that lend themselves to such segmentation include:

- Delay
- Safety
- Productivity

The analysis of bottleneck areas is based on 2003 data for I-405 and is limited to the mainline facility since the mainline has greater detection coverage than the HOV facility. Again, the year 2003 was selected as the base year for modeling. Based on this segmentation approach, the study corridor comprises several bottleneck areas, which differ by direction. Exhibit 4C-1 illustrates the general concept of bottleneck areas for a corridor. The red lines in the exhibit represent the bottleneck locations and the arrows represent the bottleneck areas.

Exhibit 4C-1: Dividing a Corridor into Bottleneck Areas



Dividing the corridor into bottleneck areas makes it easier to compare the various segments of the freeway with each other. Dividing the corridor into bottleneck areas makes it easier to compare the various segments of the freeway with each other. Based on the above, the bottlenecks previously identified in Exhibit 4A-1 and 4A-2 are shown again in Exhibit 4C-2 and 4C-3 with the associated bottleneck areas.

Exhibit 4C-2: Northbound I-405 Bottleneck Areas

Bottleneck Location	Bottleneck Area	Active Period		From		To		Distance (miles)
		AM	PM	Abs	CA	Abs	CA	
Normandie Off	From I-110 (Harbor Fwy) to Normandie Off	✓	✓	36.0	12.5	37.4	13.7	1.4
Crenshaw Off	From Normandie Off to Crenshaw Off	✓	✓	37.4	13.7	39.1	15.3	1.7
Hawthorne On	From Crenshaw Off to Hawthorne On	✓		39.1	15.3	41.2	17.5	2.1
Inglewood On	From Hawthorne On to Inglewood On	✓	✓	41.2	17.5	42.2	18.4	1.0
Sepulveda Off	From Inglewood On to Sepulveda Off	✓	✓	42.2	18.4	49.2	25.4	7.0
Culver On	From Sepulveda Off to Culver On	✓	✓	49.2	25.4	51.2	27.4	2.0
National Off	From Culver On to National Off	✓	✓	51.2	27.4	52.6	28.9	1.4
I-10 On	From National Off to I-10 On	✓	✓	52.6	28.9	53.7	29.9	1.1
Wilshire On	From I-10 On to Wilshire On		✓	53.7	29.9	55.4	31.6	1.7
Getty On	From Wilshire On to Getty On		✓	55.4	31.6	58.5	34.7	3.1
Mulholland Drive	From Getty On to Mulholland Drive		✓	58.5	34.7	60.4	36.7	1.9
US-101 Off	From Mulholland Drive to US-101 Off		✓	60.4	36.7	62.7	38.9	2.3
Victory On	From US-101 Off to Victory On		✓	62.7	38.9	65.2	41.5	2.5
Not a bottleneck location	From Victory On to I-5	N/A		65.2	41.5	72.0	48.5	6.8

Exhibit 4C-3: Southbound I-405 Bottleneck Areas

Bottleneck Location	Bottleneck Area	Active Period		From		To		Distance (miles)
		AM	PM	Abs	CA	Abs	CA	
Devonshire On	From I-5 to Devonshire On	✓		72.0	48.5	70.1	46.2	1.9
Nordhoff Street Off	From Devonshire On to Nordhoff Street Off	✓		70.1	46.2	68.7	44.9	1.4
Victory On	From Nordhoff Street Off to Victory On	✓		68.7	44.9	65.1	41.3	3.6
US-101 Off	From Victory On to US-101 I/C	✓		65.1	41.3	62.9	39.2	2.2
Mulholland	From US-101 I/C to Mulholland	✓		62.9	39.2	60.3	36.5	2.6
Sunset	From Mulholland to Sunset	✓		60.3	36.5	56.7	32.9	3.6
Wilshire	From Sunset to Wilshire	✓		56.7	32.9	55.2	31.5	1.5
I-10 On	From Wilshire to I-10 On		✓	55.2	31.5	52.9	29.1	2.3
Culver On	From I-10 On to Culver On	✓	✓	52.9	29.1	51.1	27.4	1.8
Howard Hughes Pkwy Off	From Culver On to Howard Hughes Pkwy Off	✓	✓	51.1	27.4	48.9	25.1	2.2
El Segundo On	From Howard Hughes Pkwy Off to El Segundo On	✓	✓	48.9	25.1	44.1	20.3	4.8
Inglewood	From El Segundo On to Inglewood	✓	✓	44.1	20.3	41.9	18.1	2.2
I-110 Fwy	From Inglewood to I-110 (Harbor Fwy)	✓	✓	41.9	18.1	36.0	12.5	5.9

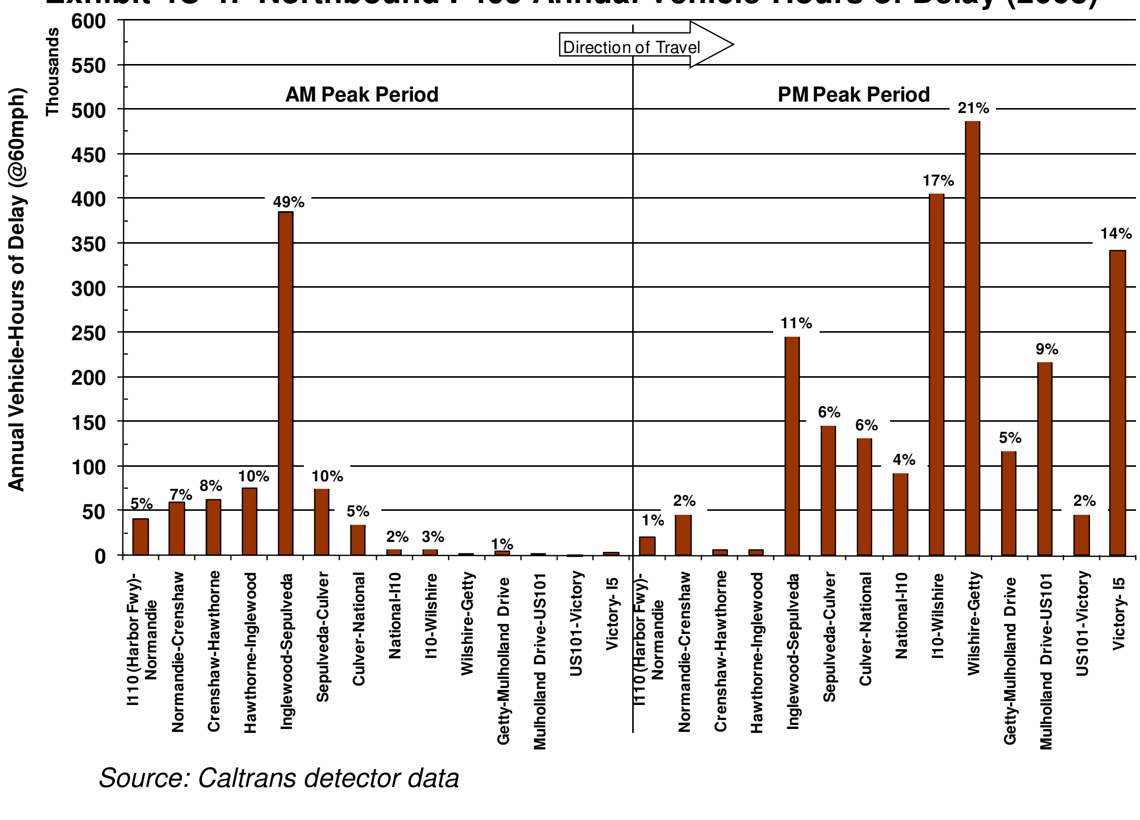
Mobility by Bottleneck Area

Mobility describes how efficiently the corridor moves vehicles. To evaluate how well (or poorly) each bottleneck area moves vehicles, vehicle-hours of delay were calculated for each segment. The results reveal the areas of the corridor that experience the worst mobility.

Mobility on I-405

This mobility analysis is based on 2003 automatic detector data for the mainline facility. Exhibits 4C-4 and 4C-6 illustrate the vehicle-hours of delay experienced by each bottleneck area on I-405. As depicted in Exhibit 4C-4, delay in the northbound direction is greater during the PM peak than the AM peak period. During the PM peak, there are bottleneck areas which experience significant congestion, notably between I-10 and Wilshire (410,000 annual vehicle-hours), Wilshire and Getty (500,000 annual vehicle-hours), and Victory and I-5 (340,000 annual vehicle-hours). During the AM peak, the bottleneck area between Inglewood and Sepulveda experienced about half (385,000 annual vehicle-hours) of the corridor's delay.

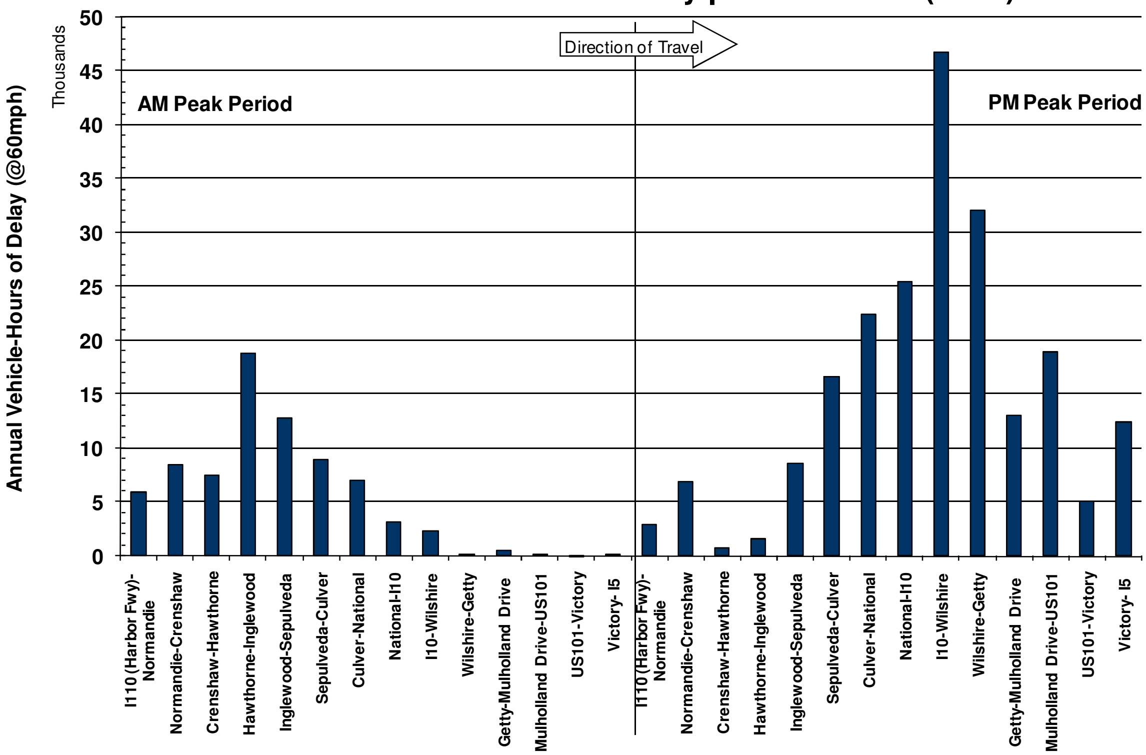
Exhibit 4C-4: Northbound I-405 Annual Vehicle-Hours of Delay (2003)



Source: Caltrans detector data

In the southbound direction (Exhibit 4C-6), delay was twice as high in the PM peak as the AM peak period. During the PM peak in the southbound direction, the bottleneck area between Inglewood and I-110 experienced the highest delay of any other segment in this direction, followed closely by the segment from Wilshire to I-10. Combined, both of these segments comprise approximately 43 percent of the corridor's delay, or 900,000 annual vehicle-hours of delay.

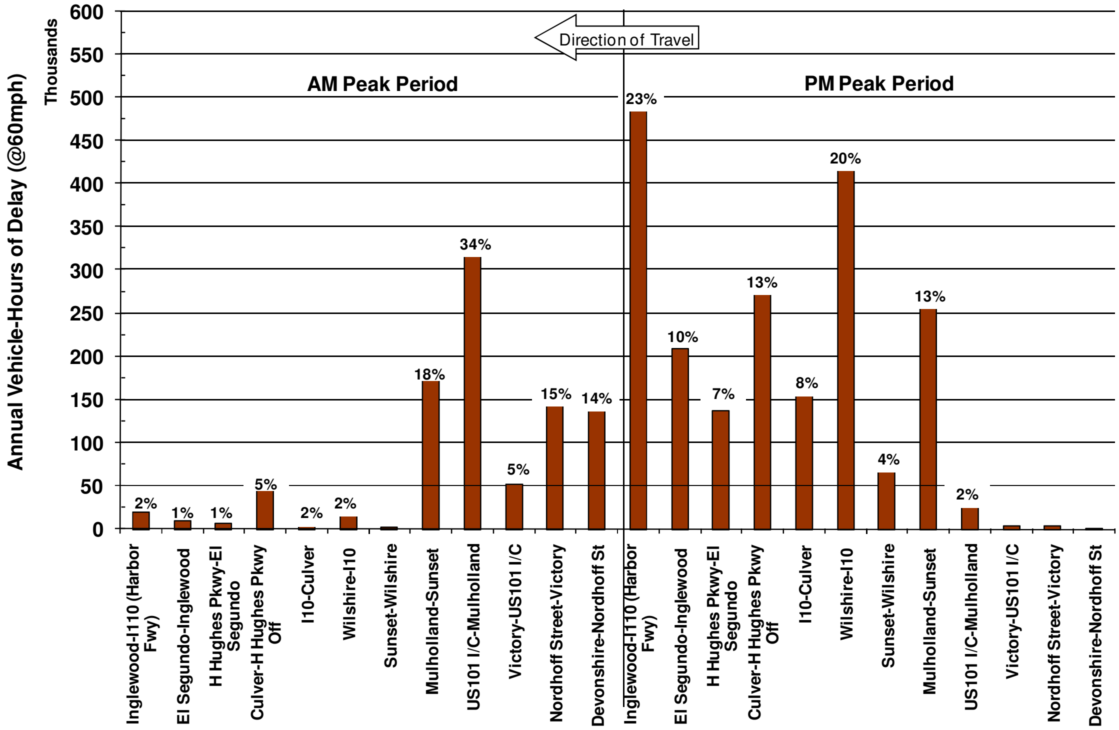
Exhibit 4C-5: Northbound I-405 Delay per Lane-Mile (2003)



Source: Caltrans detector data

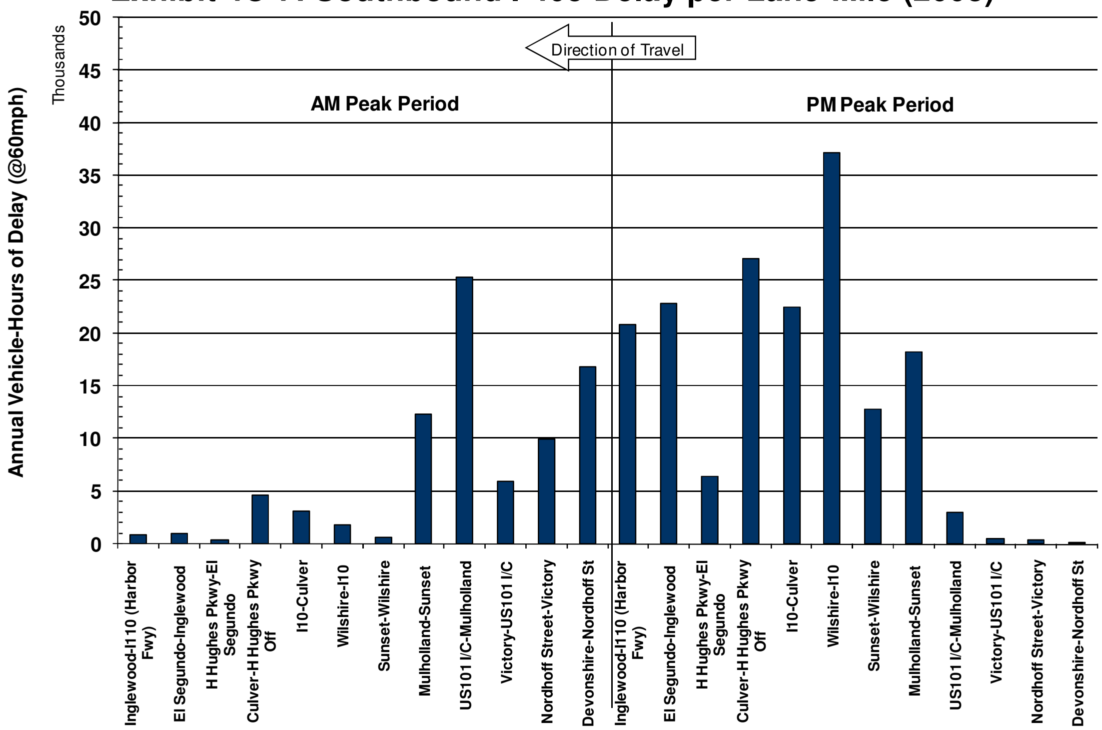
Exhibits 4C-5 and 4C-7 have been normalized to reflect delay per lane-mile. The delay calculated for each bottleneck area was divided by the total lane-miles for each bottleneck area to obtain delay per lane-mile. In the northbound direction, normalizing lane-miles resulted in similar delay results as Exhibit 4C-4 with slight differences. Exhibit 4C-5 reveals that the segment from Wilshire to I-10 experienced overwhelmingly greater delay (per lane-mile) than any other segment on the corridor, which is not the case in Exhibit 4C-4, which shows the segment from Wilshire to Getty experiencing the greatest delay. In the southbound direction, normalizing lane-miles resulted in the same delay results as shown in Exhibit 4C-6.

Exhibit 4C-6: Southbound I-405 Annual Vehicle-Hours of Delay (2003)



Source: Caltrans detector data

Exhibit 4C-7: Southbound I-405 Delay per Lane-Mile (2003)



Source: Caltrans detector data

Safety by Bottleneck Area

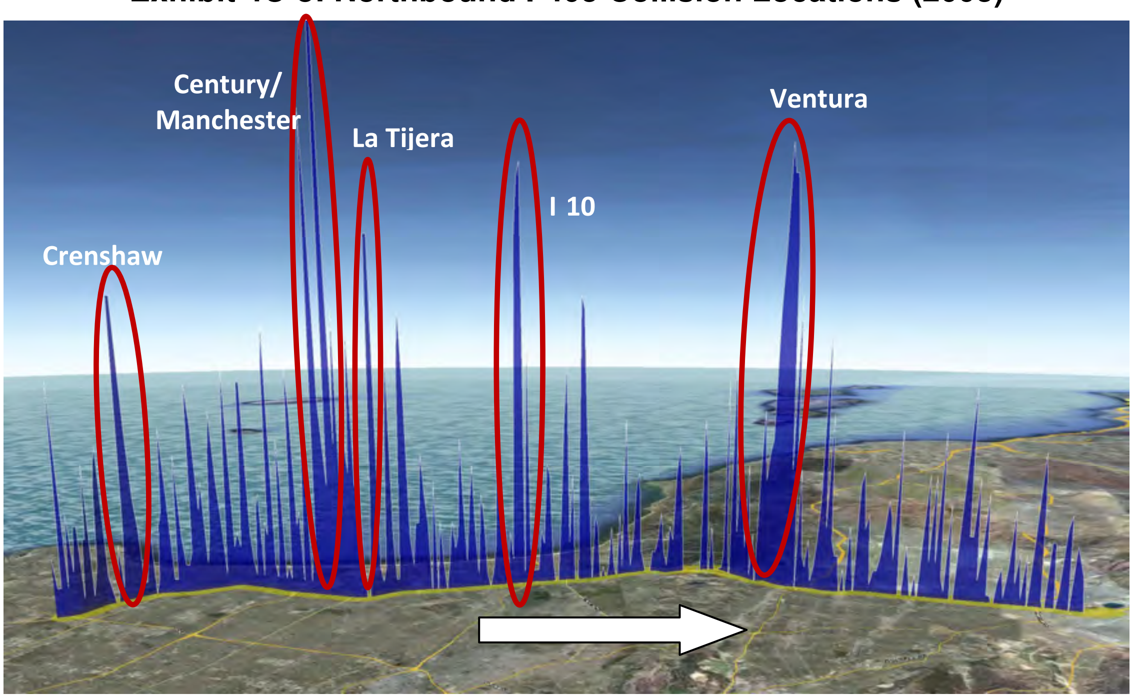
As previously indicated in Section 3, the safety assessment in this report is intended to characterize the overall accident history and trends in the corridor, and to highlight notable accident concentration locations or patterns that are readily apparent. The following discussion examines the pattern of collisions by bottleneck area for the I-405 Corridor.

Safety on I-405

The safety analysis in this section conducted for the I-405 Corridor is based on a combination of safety data obtained through PeMS and data provided by Caltrans District 7.

Exhibit 4C-8 shows the location of all collisions plotted along I-405 in the northbound direction. The spikes show the total number of collisions (fatality, injury, and property damage only) occurring within a 0.1 mile segments in 2003. The highest spike corresponds to roughly 60 collisions in a single 0.1-mile location, which happens to be near Century and Manchester. The size of the spikes is a function of how collisions are grouped. If the data were grouped in 0.2-mile segments, the spikes would be higher.

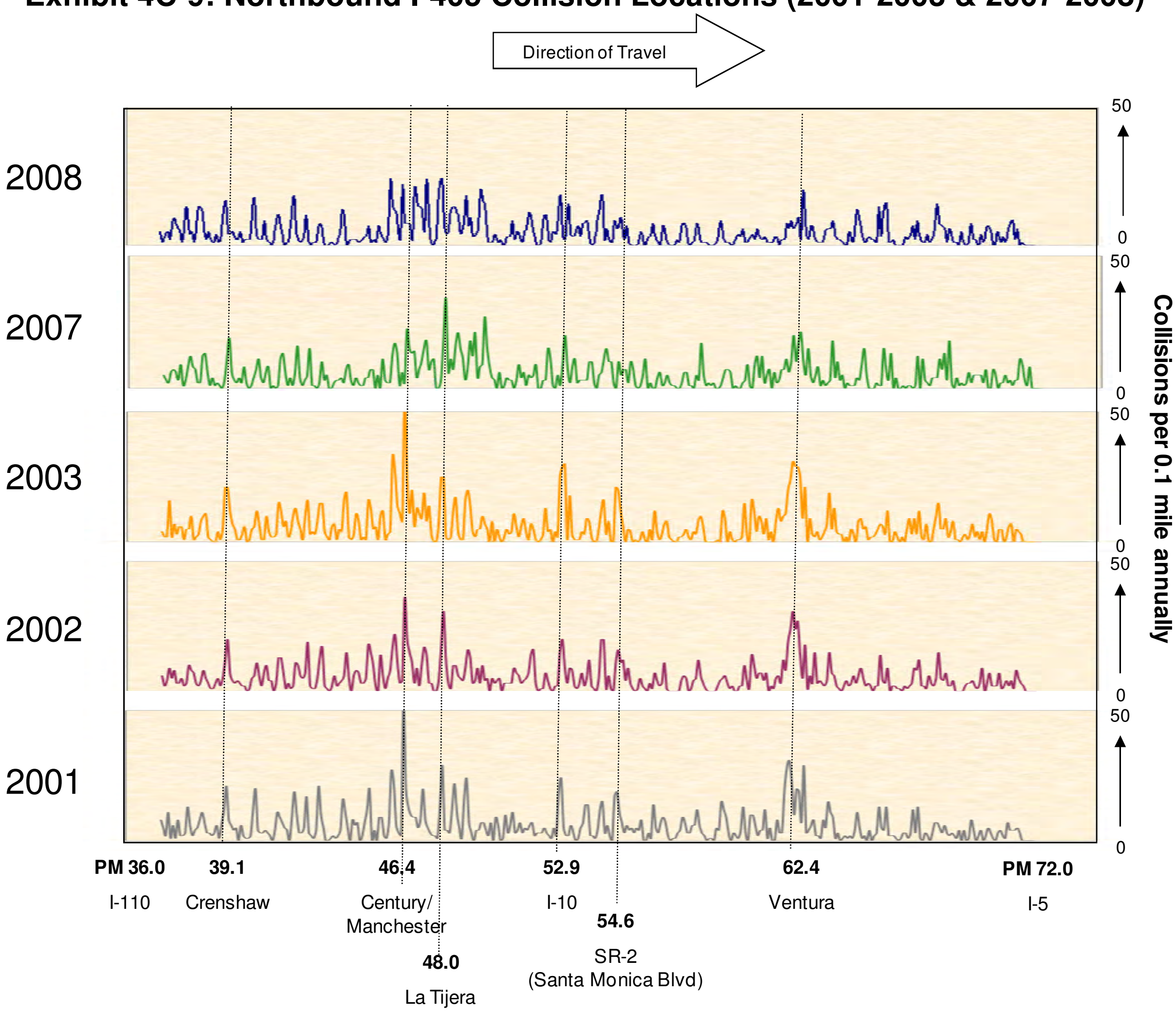
Exhibit 4C-8: Northbound I-405 Collision Locations (2003)



Source: TASAS data

Exhibit 4C-9 illustrates the same collision data as the previous exhibit, but for additional years. Each graph in Exhibit 4C-9 represents one year, with the spikes indicating the number of collisions occuring at a specific postmile location. The collisions range anywhere between zero (the minimum) and 50 (the maximum) as reflected on the y-axis. The vertical lines in the exhibit separate the corridor by bottleneck area. Due to the large number of bottleneck locations, not all of them are graphically represented in the exhibit. Starting from I-405 and moving northbound, the largest number of collisions occurred around Crenshaw, at Century/Manchester, at the I-10 Interchange, and around Ventura Boulevard. It is notable that the five high-collision locations identified in Exhibit 4C-8 are also bottleneck locations, as shown in Exhibit 4C-9. Exhibit 4C-9 further shows that the pattern of collisions has stayed fairly the same with an overall decrease of collisions between 2003 and 2008.

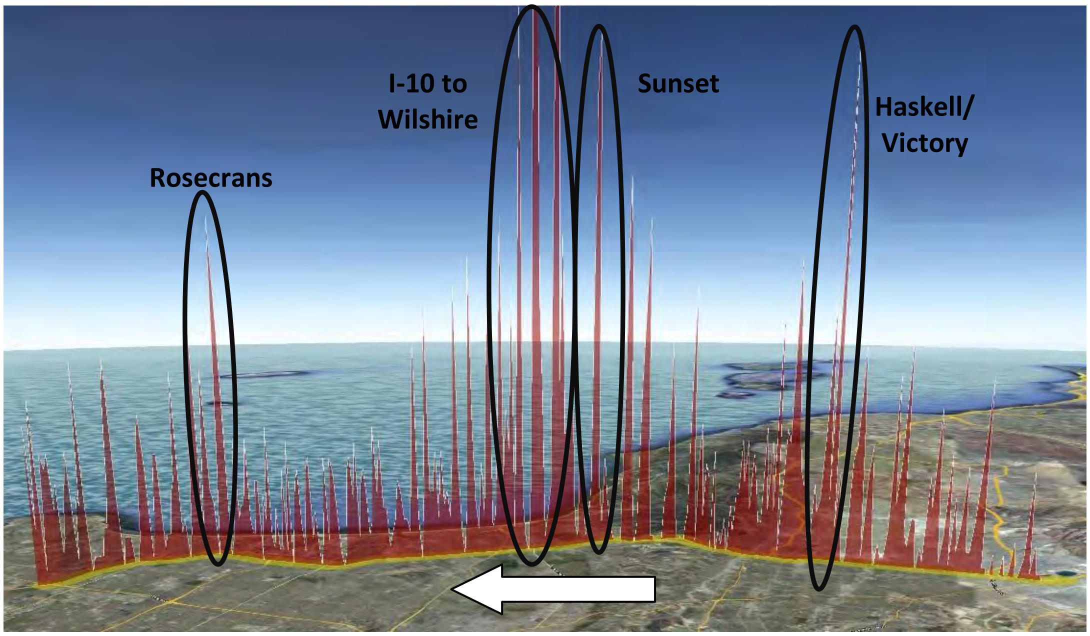
Exhibit 4C-9: Northbound I-405 Collision Locations (2001-2003 & 2007-2008)



Source: TASAS data

For the southbound direction of I-405, Exhibit 4C-10 maps the same 2003 collision data. The largest spike in this exhibit corresponds roughly to 55 collisions per 0.1 mile. Moving in the southbound direction from I-5, spikes are most notable around Haskell/Victory, at Sunset Boulevard, between Wilshire Boulevard and the I-10 Interchange, and at Rosecrans Avenue. Like the northbound direction, all of the high-collision locations identified are also bottleneck locations.

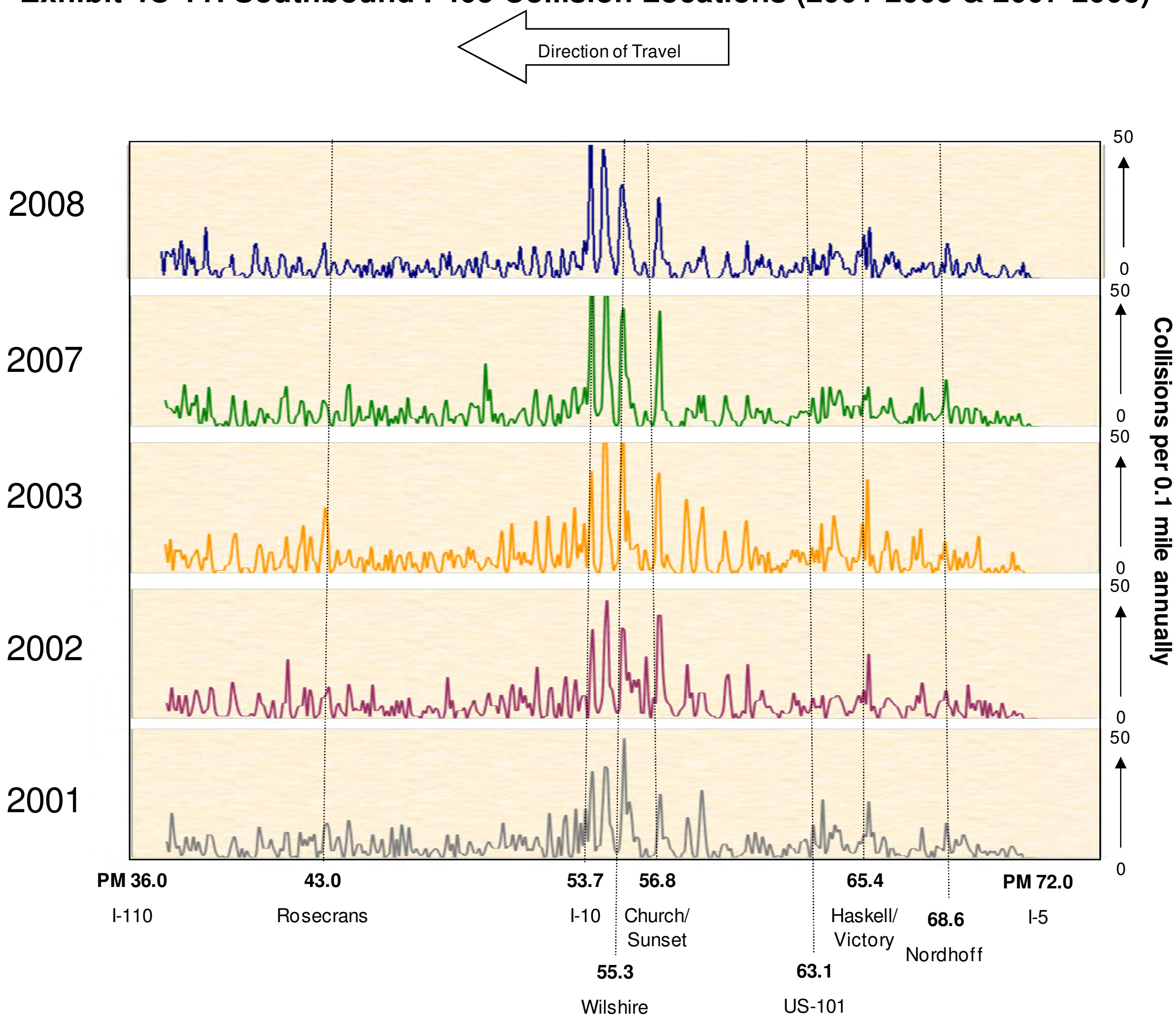
Exhibit 4C-10: Southbound I-405 Collision Locations (2003)



Source: TASAS data

As done previously for the northbound direction, Exhibit 4C-11 shows the trend of collisions in the southbound direction during the 2001-2003 and 2007-2008 period by select bottleneck areas. As the exhibit shows, the pattern of collisions has been fairly steady from one year to the next with an overall increase of accidents between 2001 and 2008.

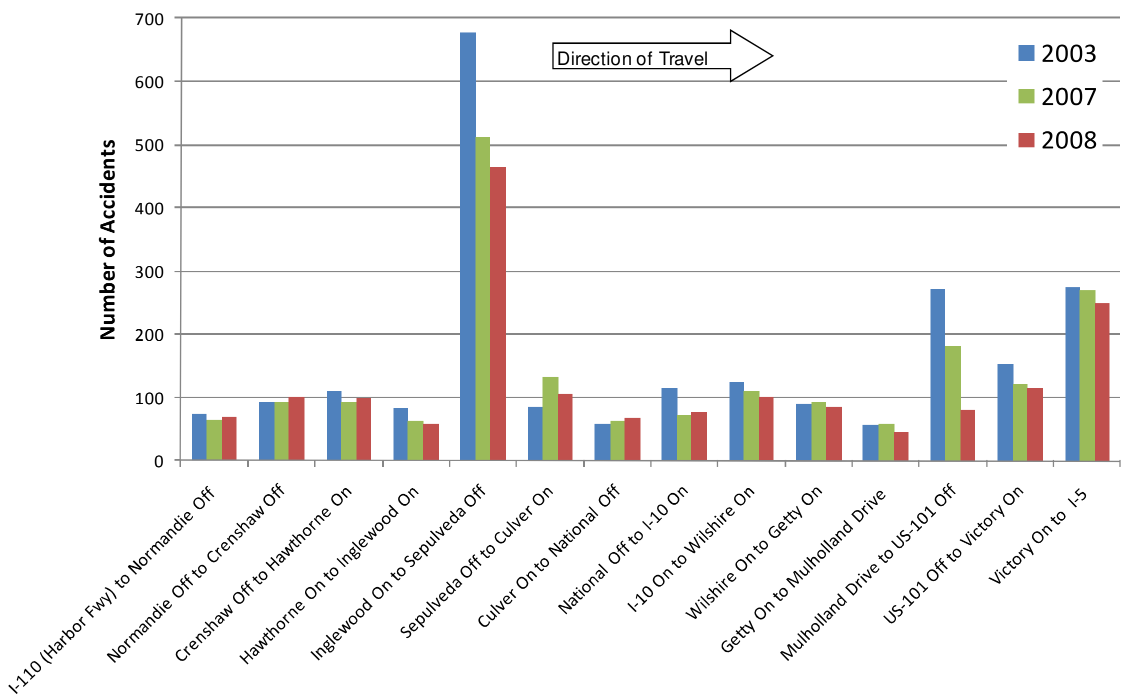
Exhibit 4C-11: Southbound I-405 Collision Locations (2001-2003 & 2007-2008)



Source: TASAS data

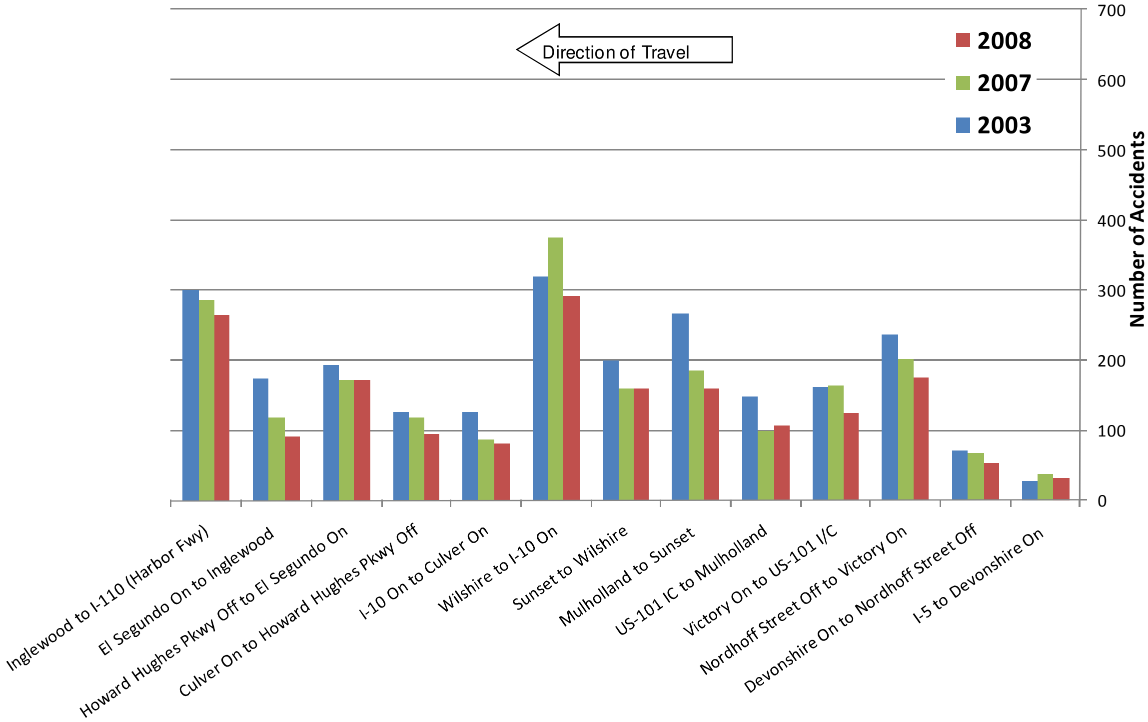
Exhibits 4C-12 and 4C-13 present the total number of accidents reported in TASAS by bottleneck area. The bars show the total of accidents that occurred in 2003 (base year of analysis) and 2007 and 2008. The last two years are the latest data available. In the northbound direction, the segment from Inglewood to Sepulveda exceeded every other segment in accidents in all three years. From 2003 to 2008, the number of accidents at this location significantly decreased from 680 in 2003 to 510 in 2007 and again to 465 in 2008. In the southbound direction, the segment between Wilshire and I-10 experienced the highest number of accidents in 2003 and 2007 with respectively 320 and 380. These locations also experienced high levels of delay as previously illustrated.

Exhibit 4C-12: Northbound I-405 Total Accidents (2003, 2007-2008)



Source: TASAS data

Exhibit 4C-13: Southbound I-405 Total Accidents (2003, 2007-2008)



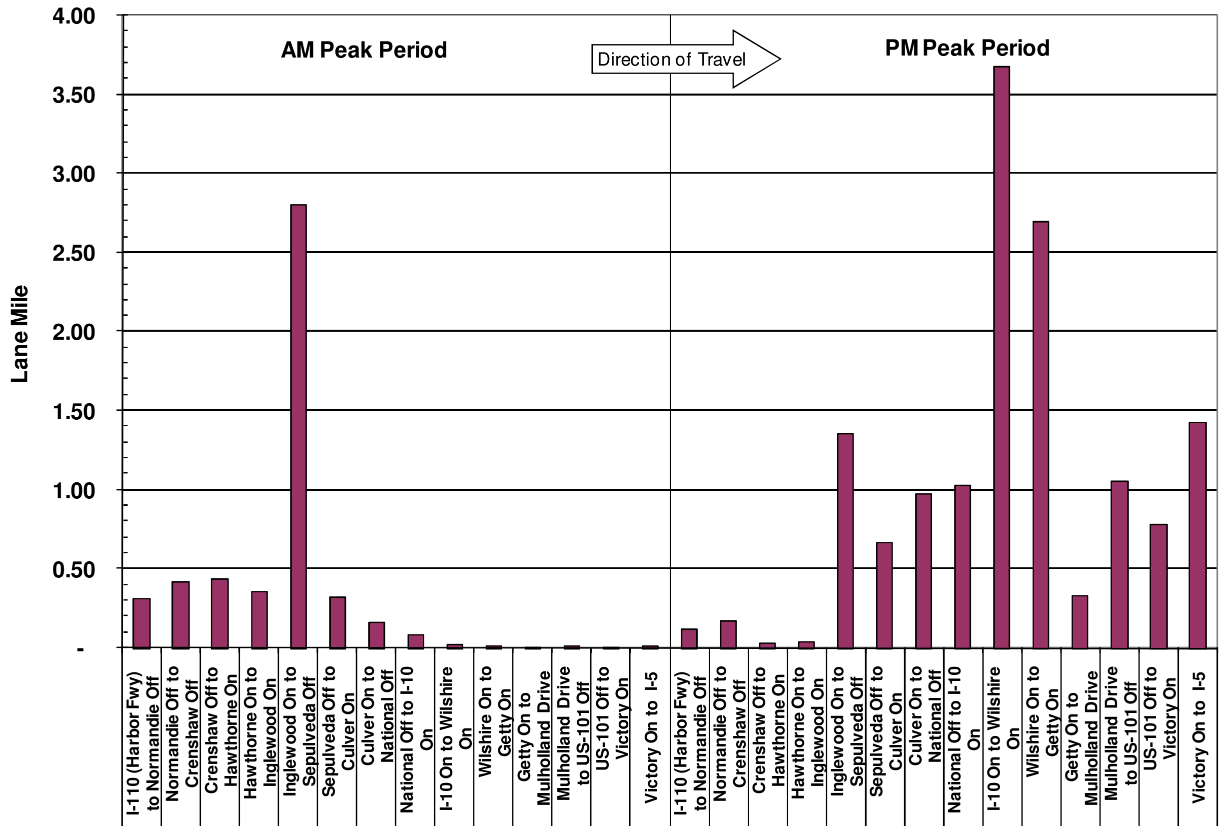
Source: TASAS data

Productivity by Bottleneck Area

As previously discussed in Section 3, the productivity of a corridor is defined as the percent utilization of a facility or mode under peak conditions. Productivity is measured by calculating the lost productivity of the corridor and converting it into “lost lane-miles.” These lost lane-miles represent a theoretical level of capacity that would have to be added in order to achieve maximum productivity.

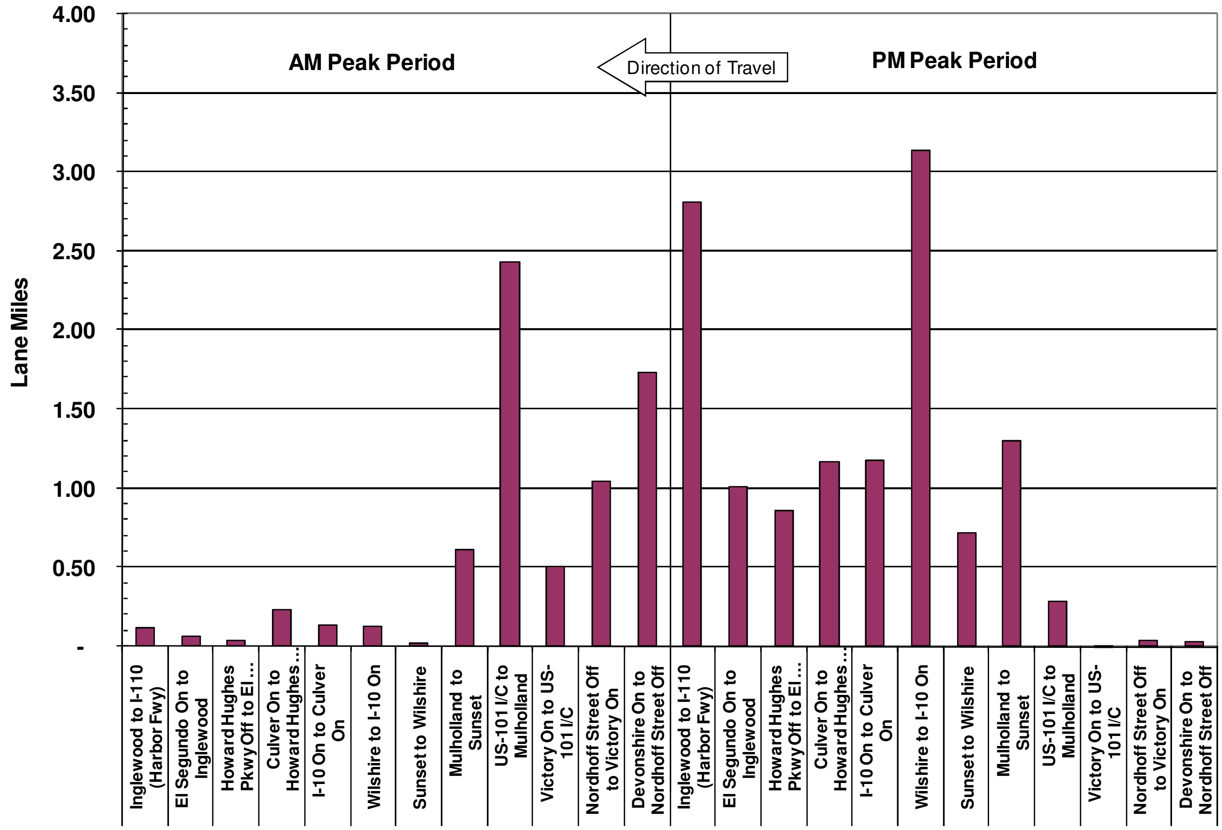
Similar to the mobility analysis, the productivity analysis is also based on 2003 automatic detector data. Exhibits 4C-14 and 4C-15 show the productivity losses for both directions of the I-405 Corridor. In the northbound direction (Exhibit 4C-14), the segment from Inglewood to Sepulveda and from I-10 to Wilshire experienced the highest productivity losses during the AM and PM peak periods, respectively, with about 2.8 and 3.7 lost-lane miles. In the southbound direction (Exhibit 4C-15), the segment from US-101 and Mulholland (AM) and from Wilshire to I-10 (PM) had the worst productivity losses at around 2.5 and 3.2 lost-lane miles. These segments of the corridor also coincide with the segments that experienced the highest levels of annual vehicle-hours of delay.

Exhibit 4C-14: Northbound I-405 Equivalent Lost Lane-Miles (2003)



Source: Caltrans detector data

Exhibit 4C-15: Southbound I-405 Equivalent Lost Lane-Miles (2003)



Source: Caltrans detector data

Page Intentionally Left Blank for Future Updates on Bottleneck Identification, Bottleneck Area Definition, and Performance Measures by Bottleneck Area

5. SCENARIO DEVELOPMENT AND EVALUATION

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

- Developing traffic models for 2003 base year and 2020 long-term demand
- Combining projects in a logical manner for modeling and testing
- Evaluating model outputs and summarizing results
- Conducting a benefit cost assessment of scenarios.

Traffic Model Development

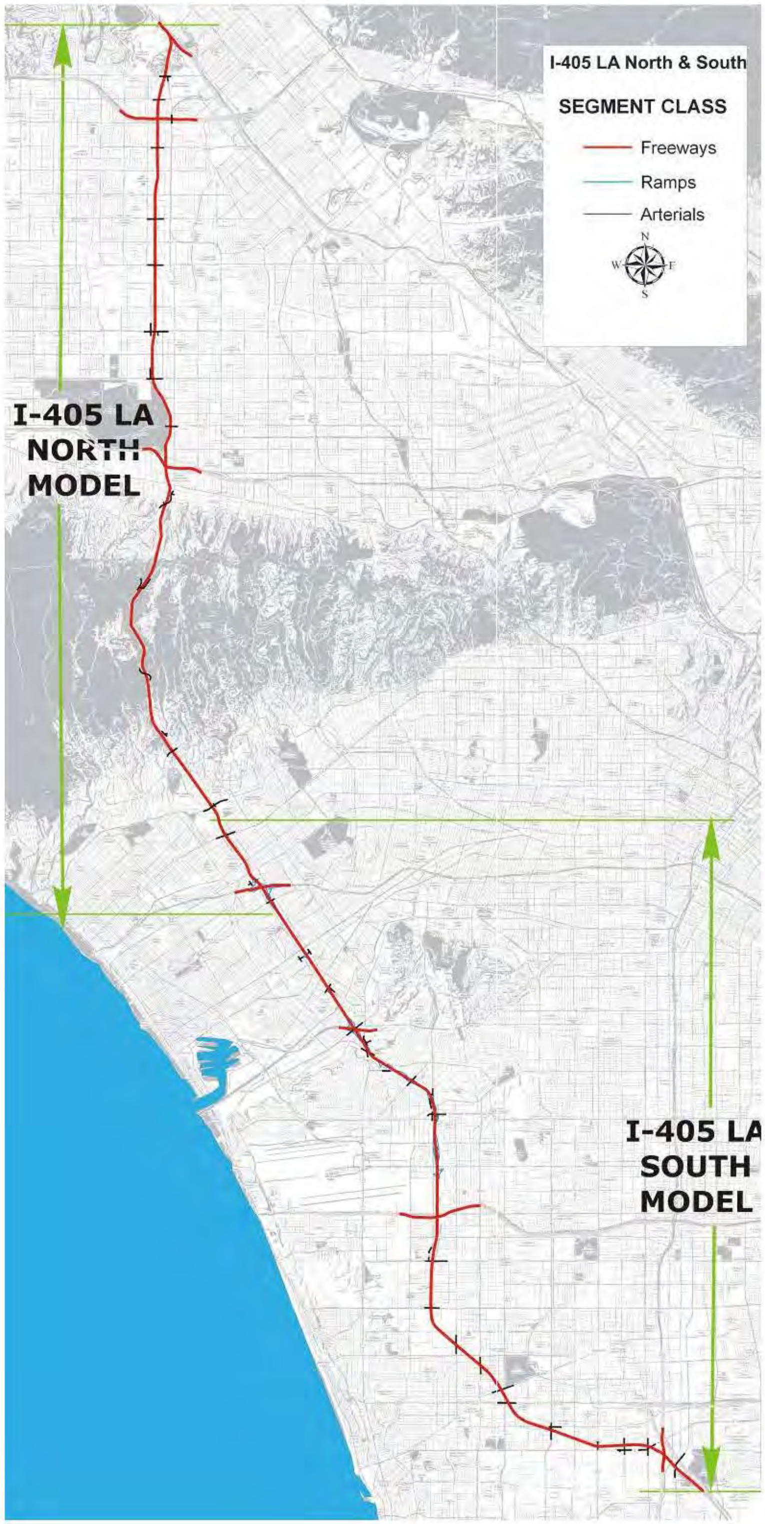
The study team developed a traffic model using the Paramics micro-simulation software. It is important to note that micro-simulation models are complex to develop and calibrate for a large urban corridor. However, it is one of the only tools capable of providing a reasonable approximation of bottleneck formation and queue development. Therefore, such tools help quantify the impacts of operational strategies, which traditional travel demand models cannot.

Due to the extensive length of the study corridor, Caltrans and SCAG agreed to divide the corridor into two models. The North Model extends from I-10 to I-5 and the South Model extends from I-110 to I-10. There is a small overlap section at the I-10 junction in order to accurately capture the congestion at this interchange. Exhibit 5-1 shows the roadway network included in both models. Note that only certain arterials were included. Adding more arterials would have challenged the calibration process and delayed the overall project. However, all freeway interchanges were included as well as on and off-ramps.

The models were calibrated against 2003 conditions. As previously mentioned in the report, the base year was chosen due to the construction activities from 2003 to 2009 and the availability of detector data in 2003. Following 2003, the construction activities associated with the addition of the HOV lane prevented a large number of detectors from reporting data. Calibrating against 2003 conditions was a resource intensive effort, requiring multiple iterations until the models reasonably matched bottleneck locations and relative severity. Once the 2003 base year calibration was approved, future 2020 baseline models were also developed based on SCAG's travel demand model projections.

These two models were then used to evaluate different scenarios (combinations of projects) to quantify the associated congestion relief benefits and to compare total project costs against their benefits.

Exhibit 5-1: Micro-Simulation Model Network



Scenario Development Framework

The study team developed a framework for combining projects into scenarios. It would be desirable to evaluate every possible combination of projects. However, this would have entailed thousands of model runs. Instead, the team combined projects based on a number of factors, including:

- Projects that were fully constructed and open to traffic from 2003 base year to current year 2010 and tested with both the 2003 and 2020 models
- Projects that were fully programmed and funded were combined separately from projects that were not and tested with both the 2003 and 2020 models
- Short and medium range operational projects were grouped into scenarios and tested with the both the 2003 and 2020 models
- Longer range projects to be delivered by 2020 and beyond were used to develop scenarios to be tested with the 2020 model only.

The study assumes that projects delivered before 2016 could reasonably be evaluated using the 2003 base year model. The 2020 forecast year for the I-405 study was consistent with the SCAG 2020 regional travel demand model origin-destination matrices used to develop the 2008 Regional Transportation Plan (RTP). When SCAG updates its travel demand model and Regional Transportation Plan (RTP), it may wish to update the micro-simulation model with revised demand projections.

Project lists used to develop scenarios were part from the Regional Transportation Improvement Program (RTIP), the Regional Transportation Plan (RTP), and other sources (e.g., special studies). Projects that do not directly affect mobility were eliminated. For instance, sound wall, landscaping, or minor arterial improvement projects were not evaluated since micro-simulation models cannot evaluate them.

Scenario testing performed for the I-405 CSMP differed from traditional “alternatives evaluations” done for Major Investment Studies (MIS) or Environmental Impact Reports (EIRs). An MIS or EIR focuses on identifying alternative solutions to address current or projected corridor problems, so each alternative is evaluated separately and results among competing alternatives are compared resulting in a locally preferred alternative. In contrast, for the I-405 CSMP, scenarios build on each other in that a scenario contains the projects from the previous scenario plus one or more projects as long as the incremental scenario results showed an acceptable level of performance improvement. This incremental scenario evaluation approach is important since CSMPs are new and are often confused with alternatives studies.

Since I-405 was divided into two separate models, the North Corridor and the South Corridor, separate scenario lists were developed for each corridor. The results of the North Corridor will be presented first followed by the South Corridor.

North Corridor Model Results

The North Corridor Model covers the section of the corridor from I-10 to I-5, which is approximately 20 miles in distance. The travel pattern on this stretch of the corridor is somewhat directional with the southbound direction experiencing greater delay in the AM peak and the northbound direction experiencing greater delay in the PM peak.

Exhibit 5-2 summarizes the approach used and scenarios tested, and provides a general description of the projects included in the 2003 and 2020 micro-simulation runs.

Exhibits 5-3 and 5-4 show the delay results for all the 2003 scenarios evaluated for the AM and PM peak periods, respectively. Exhibits 5-5 and 5-6 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.

Exhibits 5-7 through 5-10 summarize the delay results of the 2003 base year model by bottleneck area for the northbound and southbound directions and for each peak period. The delay results of the 2020 horizon year model are summarized in Exhibits 5-11 through 5-14.

For each scenario, the modeling team produced results by facility type (i.e., mainline, HOV, arterials, and ramps) and vehicle type (SOV, HOV, trucks) as well as speed contour diagrams. The study team scrutinized the results to ensure that they were consistent with general traffic engineering principles.

A traffic report with all the model output details is available under separate cover.

Exhibit 5-2: Micro-Simulation Modeling Approach for the North Corridor

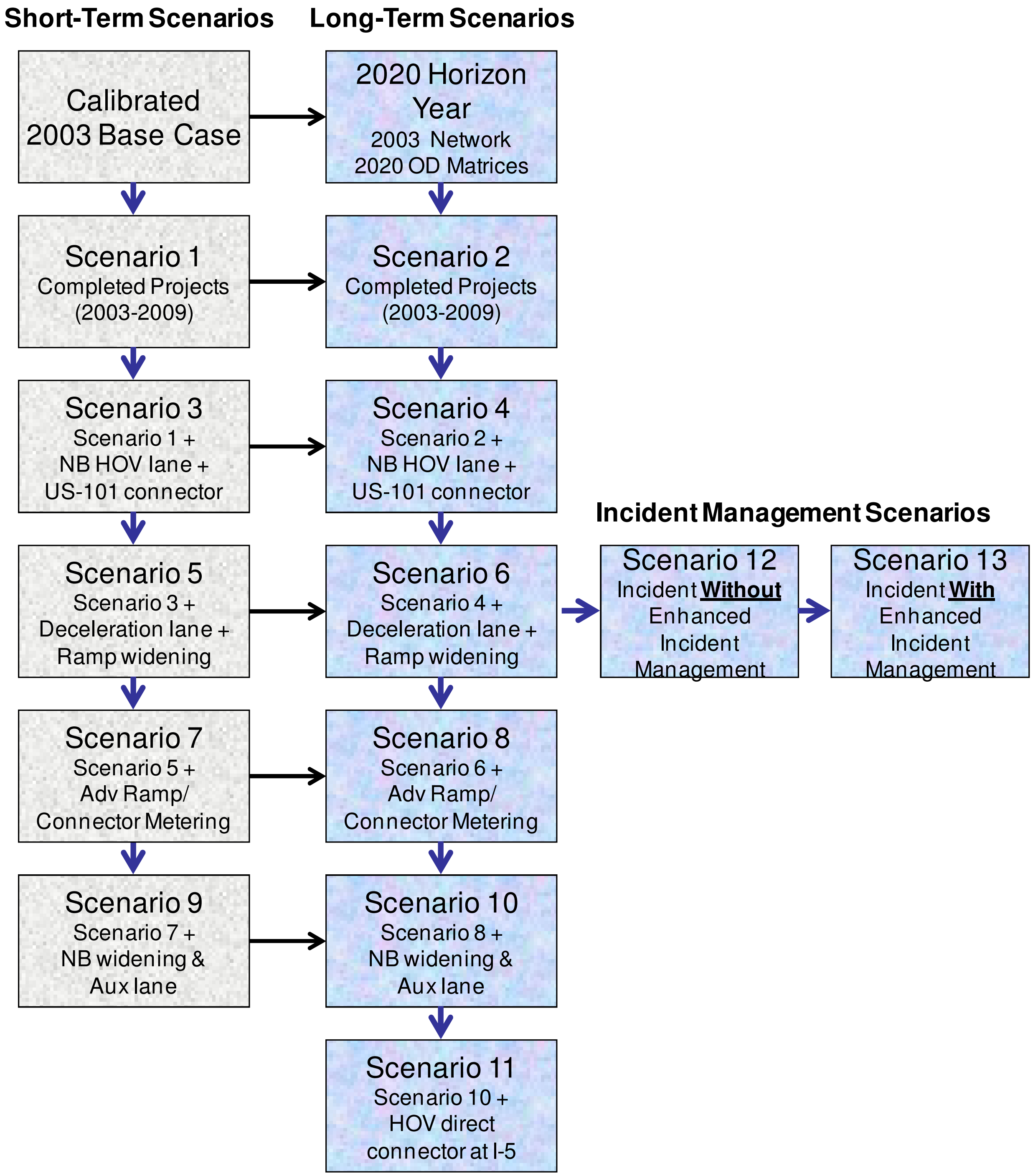


Exhibit 5-3: North Corridor – 2003 AM Peak Micro-Simulation Delay Results

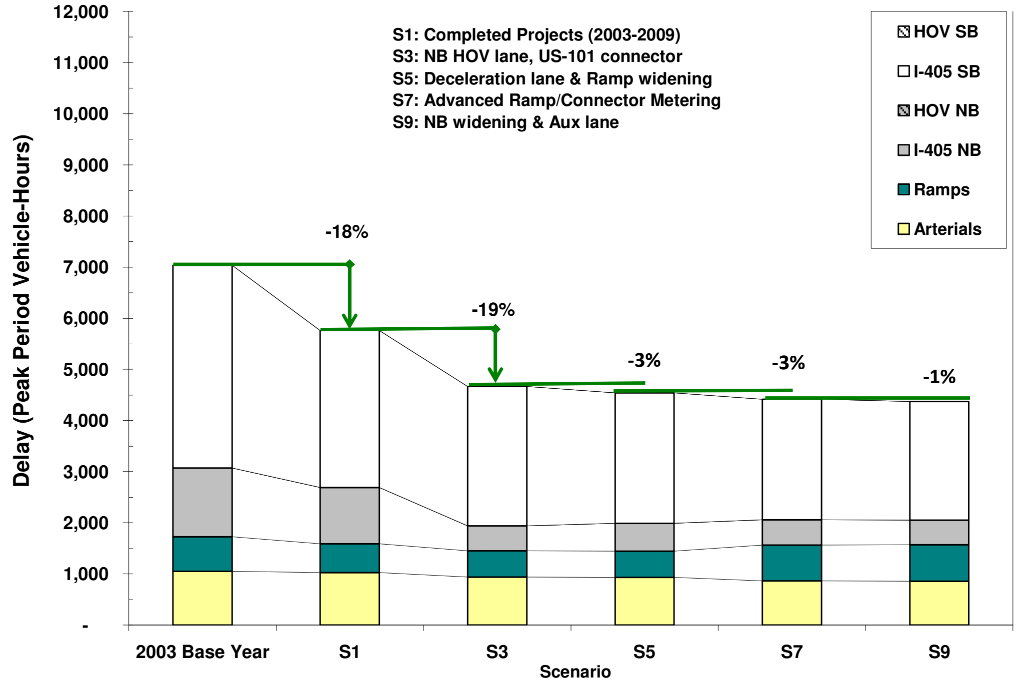


Exhibit 5-4: North Corridor – 2003 PM Peak Micro-Simulation Delay Results

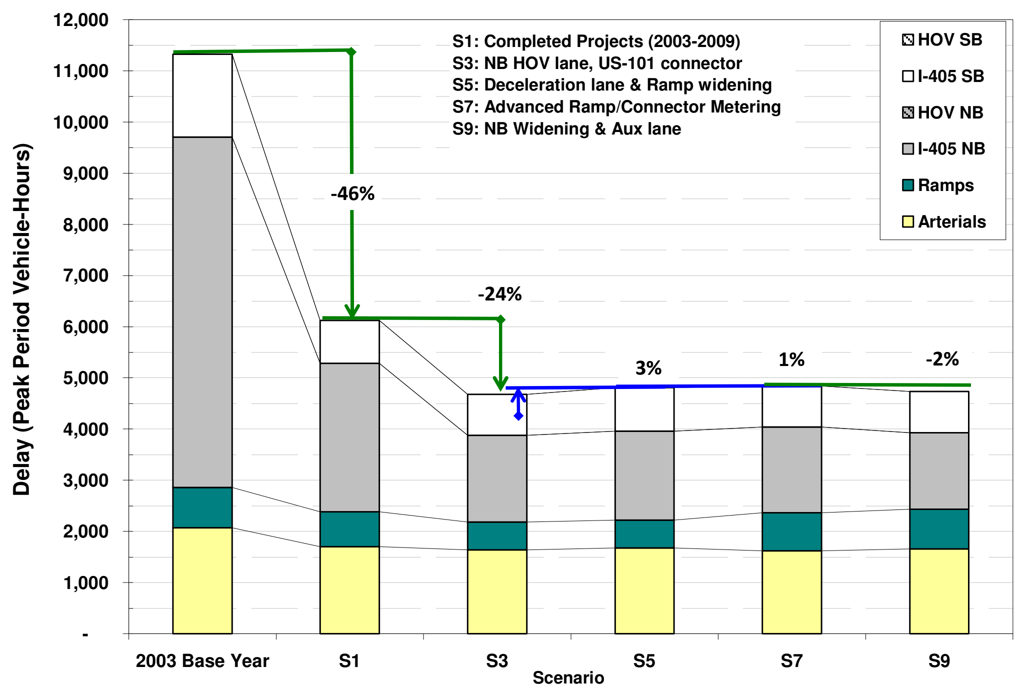


Exhibit 5-5: North Corridor – 2020 AM Peak Micro- Simulation Delay Results

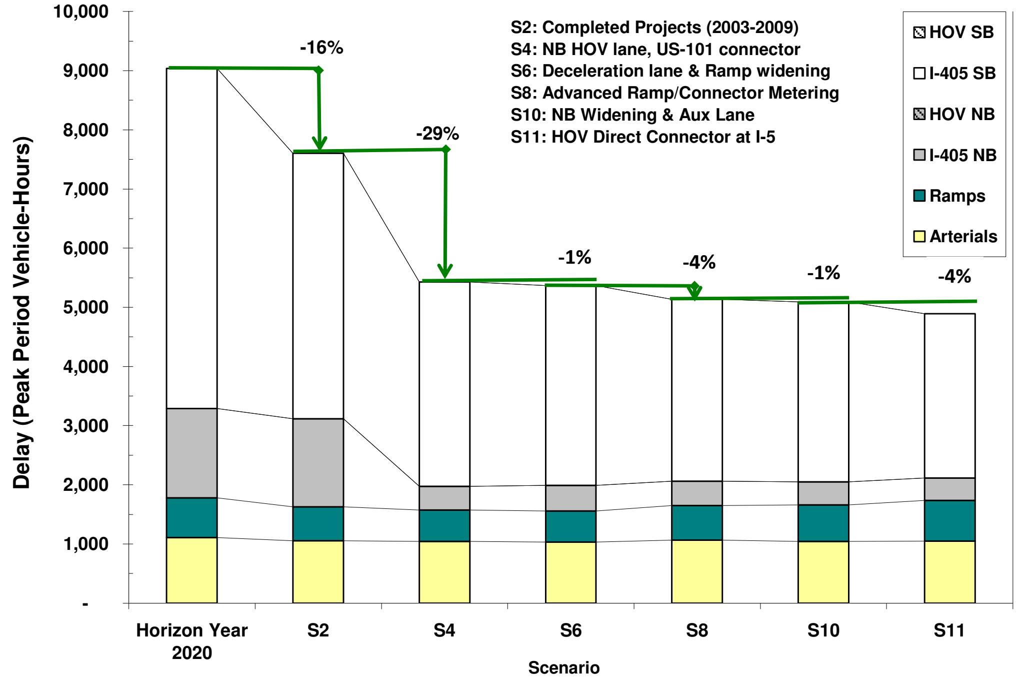


Exhibit 5-6: North Corridor – 2020 PM Peak Micro- Simulation Delay Results

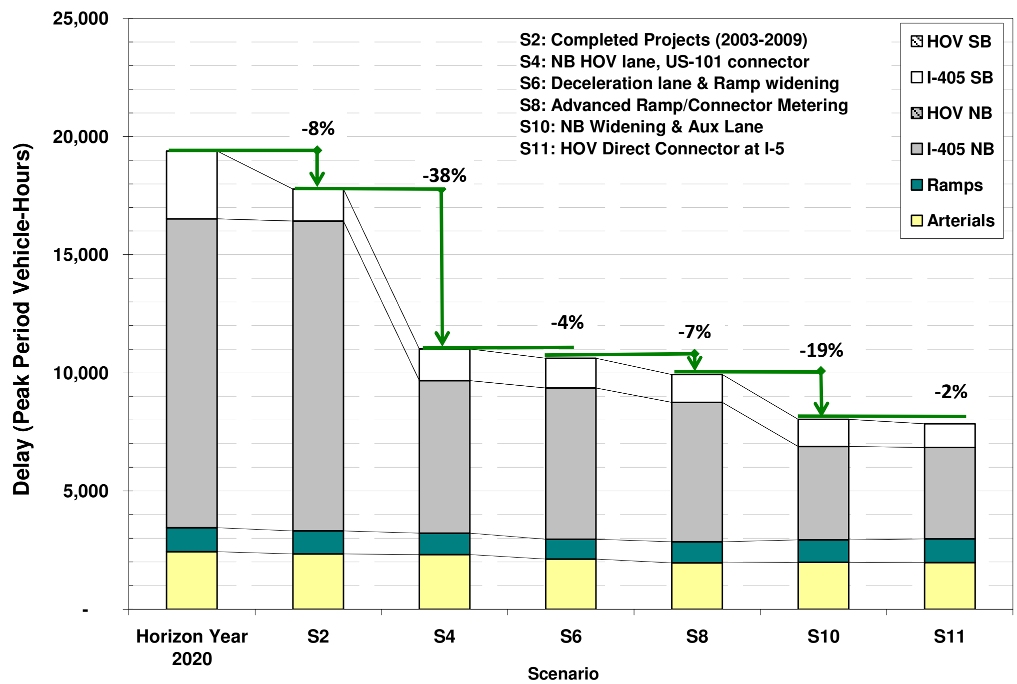


Exhibit 5-7: North Corridor – 2003 Northbound AM Delay by Scenario and Bottleneck Area

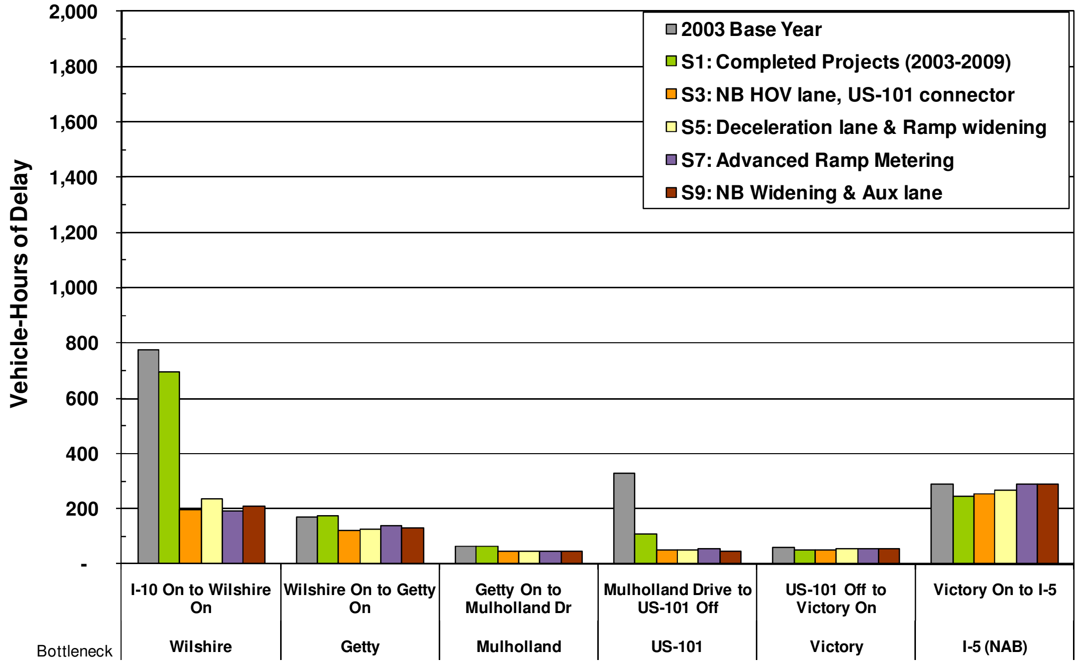


Exhibit 5-8: North Corridor – 2003 Northbound PM Delay by Scenario and Bottleneck Area

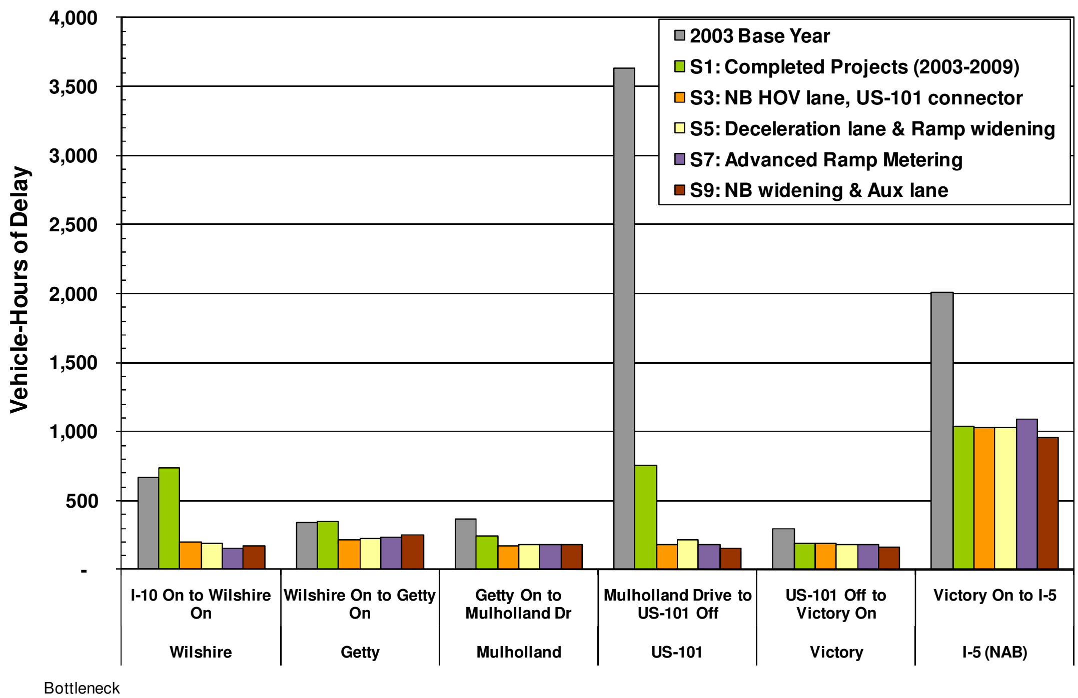


Exhibit 5-9: North Corridor – 2003 Southbound AM Delay by Scenario and Bottleneck Area

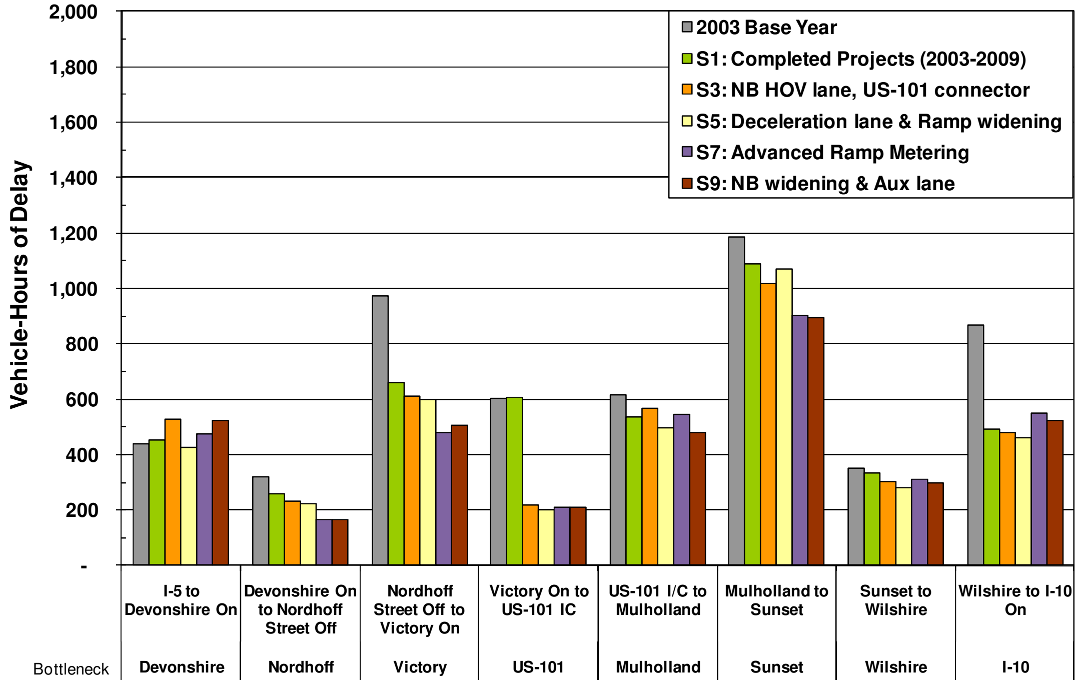


Exhibit 5-10: North Corridor – 2003 Southbound PM Delay by Scenario and Bottleneck Area

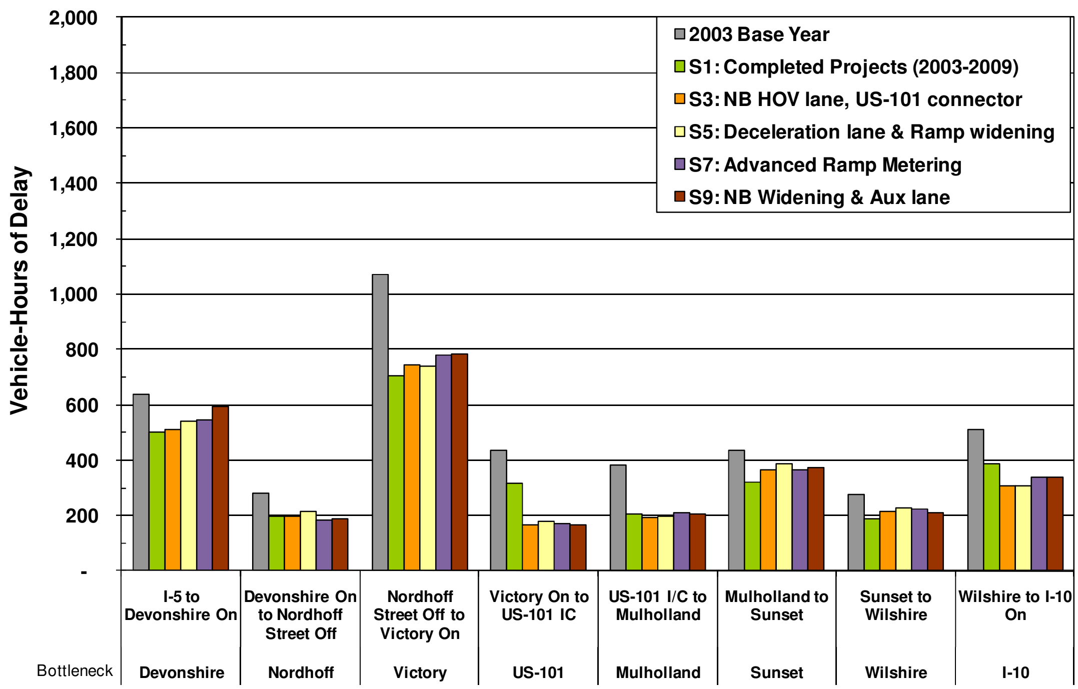


Exhibit 5-11: North Corridor – 2020 Northbound AM Delay by Scenario and Bottleneck Area

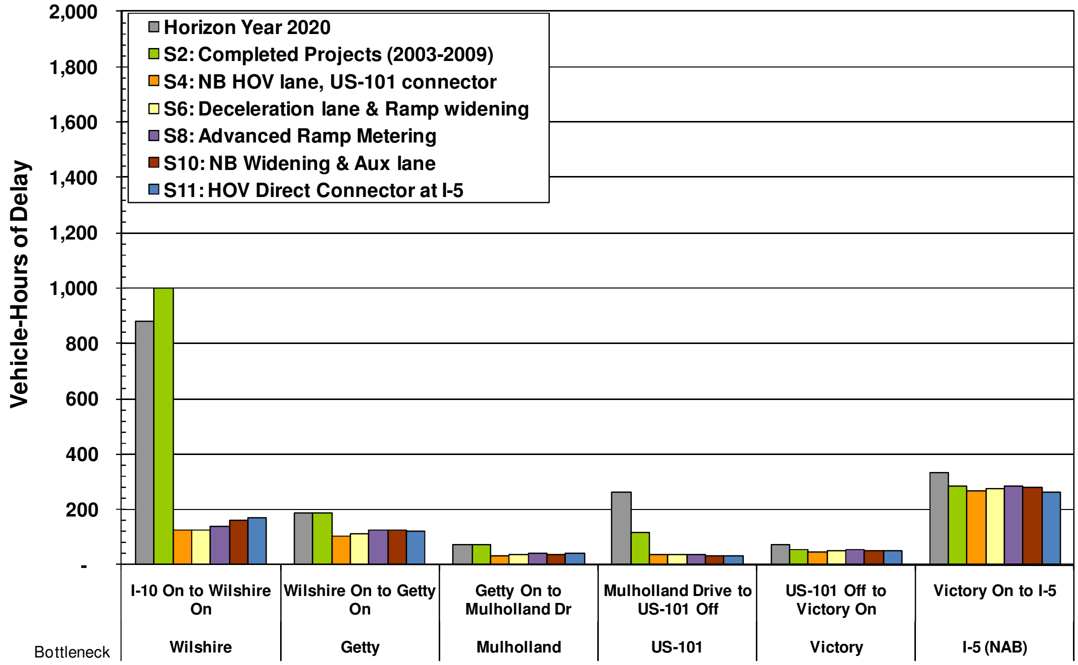


Exhibit 5-12: North Corridor – 2020 Northbound PM Delay by Scenario and Bottleneck Area

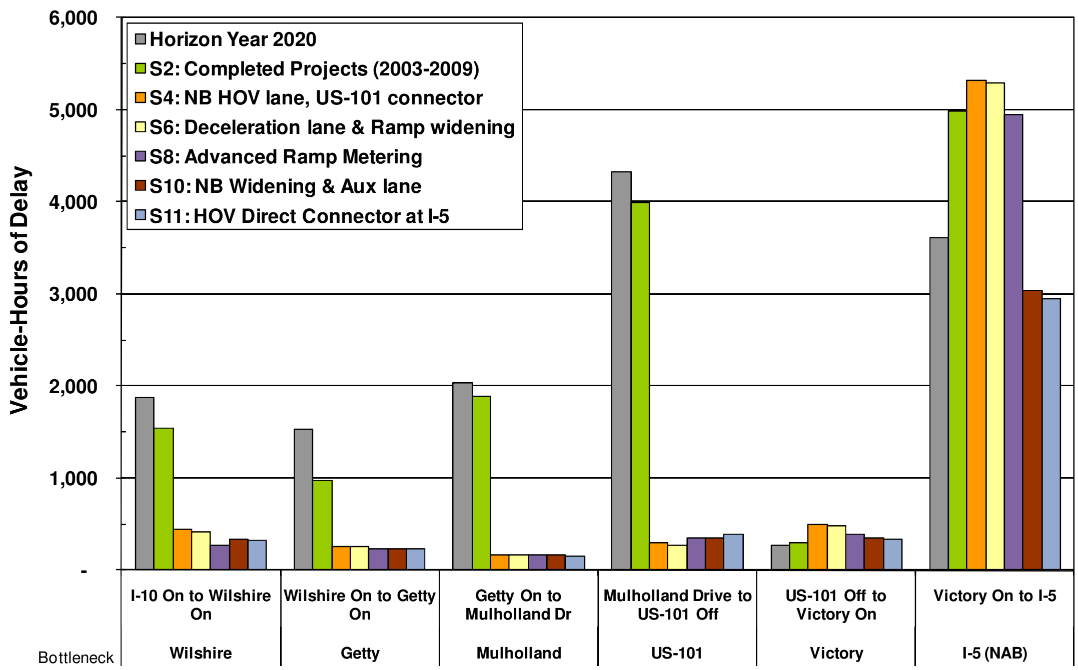


Exhibit 5-13: North Corridor – 2020 Southbound AM Delay by Scenario and Bottleneck Area

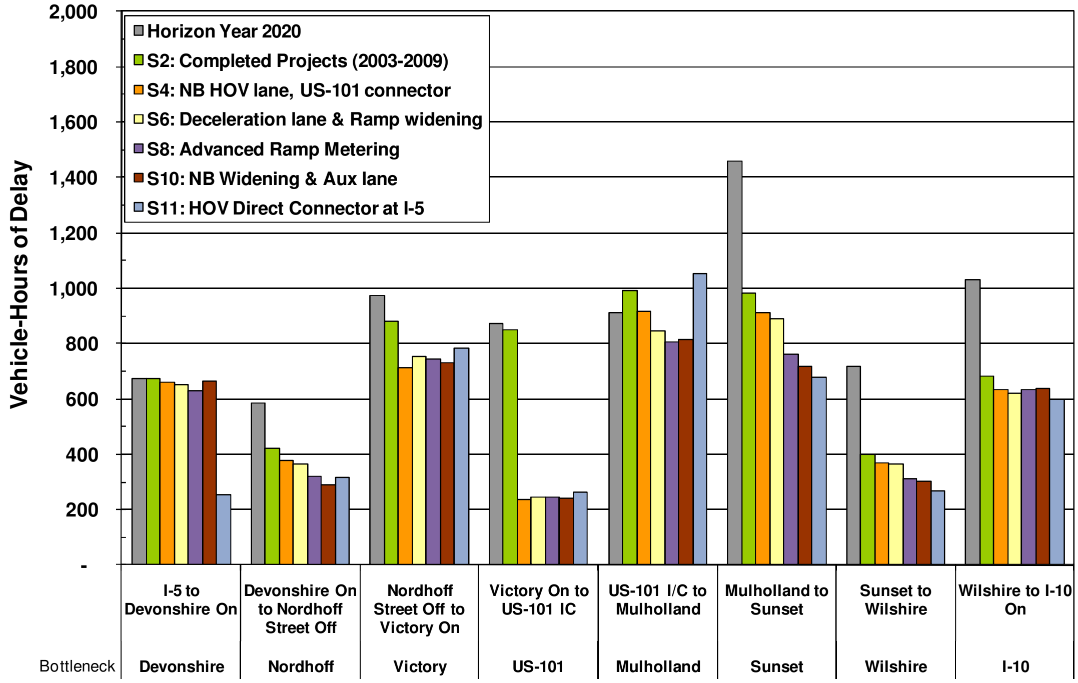
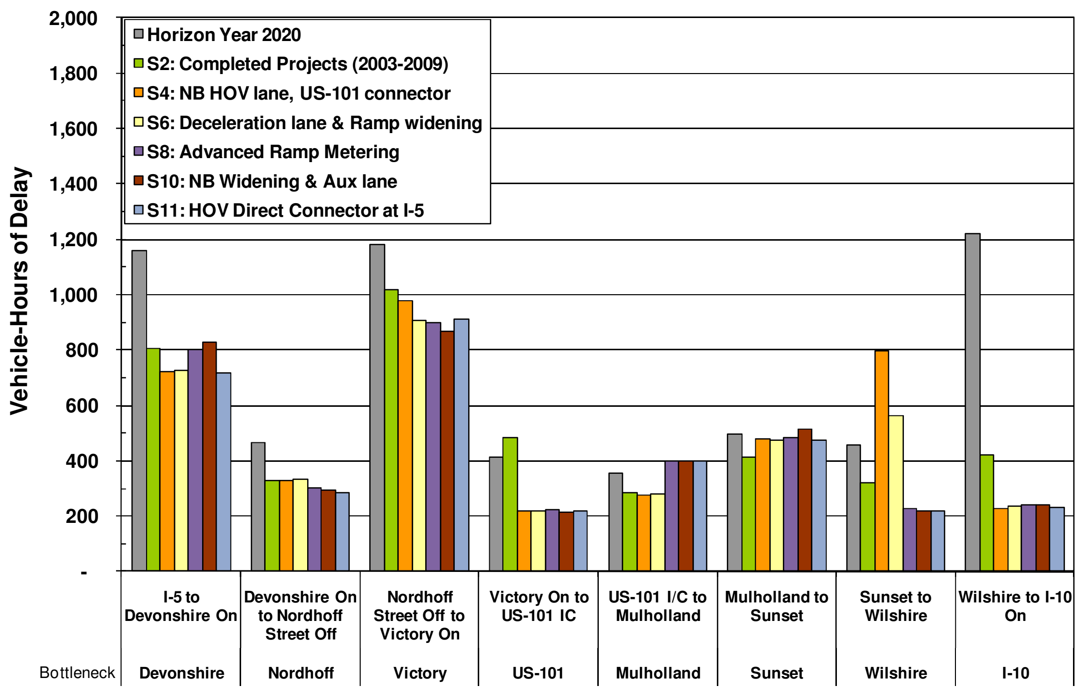


Exhibit 5-14: North Corridor – 2020 Southbound PM Delay by Scenario and Bottleneck Area



North Corridor Model: 2003 Base Year and 2020 "Do Minimum" Horizon Year

Absent any physical improvements, the model estimates that total delay on the north corridor (mainline, HOV, ramps, and arterials) increases by over 55 percent by 2020 compared to 2003 (from a total of around 18,000 vehicle-hours to over than 28,000 vehicle-hours) in the AM and PM peak hours combined. As described below, the completed improvements and programmed projects lead to significant decreases and improved mobility on the corridor.

North Corridor Model: Scenarios 1 and 2 (Completed Projects 2003-2009)

Scenarios 1 and 2 include all projects that were completed between 2003 and 2009. Results from this scenario were compared to the existing conditions of the corridor in 2009 to determine the reasonableness of the model. Scenario 1 and 2 projects included:

- Adding a northbound auxiliary lane from Mulholland to Ventura Boulevard
- Widening the northbound I-405 connector to southbound US-101 to add a lane
- Extending the northbound I-405 HOV lane from south of Ventura Boulevard to south of Burbank Boulevard where it joins the existing HOV lane
- Closing the gap at the I-405/US-101 connector
- Constructing the southbound auxiliary lane and HOV lane from Waterford Avenue to I-10.

The 2003 model estimates that Scenario 1 would reduce overall delay on the corridor by nearly 35 percent over the base model (from around 18,000 vehicle-hours to 12,000 vehicle-hours), most of which occurs in the PM peak period. The delay reduction in the PM peak (5,000 vehicle-hours) can be largely attributed to the improvements in the northbound direction at the US-101 Interchange, which experienced an 80 percent drop in delay, which is equivalent to a reduction of 2,800 vehicle-hours. At this location, a northbound auxiliary lane was constructed and the US-101 connector was widened and modified. The southbound direction in the PM also experienced a significant delay reduction of over 750 vehicle-hours, largely from the auxiliary lane construction.

The 2020 model estimates that Scenario 2 will reduce corridor delay by 16 percent in the AM and eight percent in the PM. In total, this scenario will reduce daily delay by more than 3,000 vehicle-hours over the horizon year.

North Corridor Model: Scenarios 3 and 4 (Northbound HOV Lane, US-101 Connector)

Scenarios 3 and 4 include two fully funded projects that are expected to be delivered in 2016. One is the Sepulveda Pass Widening Project, which will extend the northbound HOV lane from I-10 to US-101 with several interchange modifications. The other is the construction of the freeway connector from southbound I-405 to northbound and southbound US-101.

The 2003 model shows that Scenario 3 will improve overall delay on the corridor by about 19 percent in the AM and 24 percent in the PM, which is equivalent to a total reduction of 2,500 vehicle-hours. In the northbound direction, the addition of the HOV lane resulted in a delay reduction of 600 vehicle-hours (or 55 percent) in the AM peak and 1,200 vehicle-hours (or 40 percent) in the PM peak. The northbound segment from I-10 to Wilshire experienced a notable improvement in delay during both peak periods with a reduction of over 1,000 vehicle-hours. In the southbound direction, the corridor experienced a moderate reduction of over 400 vehicle-hours of delay. The southbound segment from Victory to US-101 during the AM experienced the most significant delay in this direction, a reduction of over 350 vehicle-hours, which can be attributed to the construction of the US-101 connector.

The 2020 model shows that Scenario 4 will decrease delay by 29 percent in the AM peak and 38 percent in the PM peak or almost 9,000 vehicle-hours of daily delay. The additional capacity from the HOV lane will provide greater delay reductions in 2020.

North Corridor Model: Scenarios 5 and 6 (Deceleration Lane, Ramp Widening)

Scenarios 5 and 6 include two operational projects that have been proposed by Caltrans and can be implemented within a short period of time. Both of these projects affect the southbound direction of the corridor: the construction of a southbound deceleration lane from Mulholland to Sunset, and the widening of the southbound Ventura Boulevard on-ramp.

The 2003 model estimates that Scenario 5 will reduce delay in the AM by three percent (or 130 vehicle-hours) and insignificantly increase delay by three percent in the PM peak. These results are expected since both projects in this scenario are minor operational improvements.

The 2020 model estimates a one percent improvement in delay in the AM peak and a four percent improvement in the PM peak, or a combined total reduction of 450 daily vehicle-hours.

North Corridor Model: Scenarios 7 and 8 (Advanced Ramp/Connector Metering)

Scenarios 7 and 8 build on Scenarios 5 and 6 by adding an advanced ramp metering system such as dynamic or adaptive ramp metering system with connector metering with queue control (to ensure that queuing does not exceed the capacity of the connector) at the following locations:

- Eastbound and westbound I-10 connectors to I-405
- Eastbound and westbound SR-118 connectors to I-405.

The 2003 model estimates that advanced ramp metering will improve delay slightly by three percent in the AM peak, or 120 vehicle-hours, and increase delay insignificantly in the PM peak. The 2020 model estimates greater gains with a four percent delay reduction in the AM and a seven percent delay reduction in the PM peak, or a combined total of 900 daily vehicle-hours. Although the mainline facility experienced an improvement in delay during both the AM and PM peak hours, the ramps experienced an overall delay increase, thereby resulting in only a small improvement for the overall corridor.

Note that there are various types of advanced ramp metering systems deployed around the world, including System-wide Adaptive Ramp Metering System or SWARM tested in Los Angeles I-210 freeway corridor. For the I-405 modeling purposes, the ALINEA system was tested as a proxy for any advanced ramp metering system, as its algorithm for the model was readily available (and SWARM is not). However, it is not necessarily recommended that ALINEA be deployed but rather some type of advanced ramp metering system that would produce similar, if not better results.

North Corridor Model: Scenarios 9 and 10 (Northbound Widening and Auxiliary Lane)

Scenarios 9 and 10 build on Scenarios 7 and 8 by including two short-range operational improvement projects proposed by the study team. Both of these projects affect the northbound direction of the corridor: the construction of an auxiliary lane from Victory Boulevard to Sherman Way, and widening to add new lane from SR-118 off-ramp to Devonshire on-ramp. Both of these improvements could be implemented within Caltrans right-of-way and with roadway modification.

The 2003 model estimates that Scenario 9 will reduce delay in the AM and PM peak period modestly by only one to two percent, or a combined total of around 150 vehicle-hours of delay. The 2020 model estimates a greater reduction in delay by nearly 1,900 vehicle-hours (or 19 percent) in the PM peak. This is expected since most of the congestion is in the northbound direction during the PM peak.

North Corridor Model: Scenario 11 (HOV Direct Connector at I-5)

Scenario 11 (long-range planned improvement) is tested with only the 2020 model and builds on Scenarios 10 by adding the HOV direct connectors at the I-5 interchange. The estimated completion date for this project is 2029.

The 2020 model estimates that Scenario 11 will reduce delay by 200 vehicle-hours in both peak periods, for a combined total of 400 vehicle-hours on the corridor (four percent reduction in the AM and two percent reduction in the PM). This improvement did not show a significant delay reduction, which is likely due to the congested conditions along the I-5 mainline corridor. Should the I-5 corridor from the I-405 to SR-14 be improved, this project could yield significantly better results.

North Corridor Model: Scenarios 12 and 13 (Enhanced Incident Management)

Two incident scenarios were tested on top of Scenario 6 to evaluate the non-recurrent delay reductions resulting from enhanced incident management strategies. In the first scenario, Scenario 12, one collision incident with one outside lane closure was simulated in the southbound direction in the AM peak period model and in the northbound direction in the PM peak period model. The incident simulation location and duration was selected based on review of the 2010 actual incident data, at one of the high incident frequency locations. The following are the Scenario details:

- Southbound AM peak period starting at 7:00 AM, close outermost mainline lane for 35 minutes at absolute post mile 54.1 (at Olympic)
- Northbound PM peak period starting at 3:00 PM, close outermost mainline lane for 35 minutes at absolute post mile 69.7 (at Devonshire).

In the second scenario, Scenario 13, the same collision incident was simulated with a reduction in duration by 10 minutes in both the southbound and the northbound direction. It is estimated, based on recent actual incident management data analysis results provided by Caltrans, that an enhanced incident management system could reduce a 35-minute incident by about 10 minutes. This scenario represents a typical moderate level incident at one location during the peak period direction.

An enhanced incident management system would entail upgrading or enhancing the current Caltrans incident management system that includes deployment of intelligent transportation system (ITS) field devices, central control/communications software, communications medium (i.e. fiber optic lines), advanced traveler information system, and/or freeway service patrol (FSP) program to reduce incident detection, verification, response, and clearance times. Data suggest that incidents vary significantly in terms of impact and duration. Some incidents last hundreds of minutes, some close multiple lanes, and some occur at multiple locations simultaneously. There are also numerous minor incidents without lane closures that last only a few minutes that also result in congestion. There are also many incidents that occur during off-peak hours.

As illustrated in Exhibits 5-15 and 5-16, without enhanced incident management, the first scenario (Scenario 12) produced a six percent increase in congestion in the AM and a 43 percent increase in the PM over Scenario 6 - an increase of about 5,000 vehicle-hours delay. With enhanced incident management, the model results indicated a two percent reduction in delay in the AM and eight percent in the PM peak periods, which is a decrease in delay of over 1,200 vehicle-hours for both incidents.

Exhibit 5-15: North Corridor – 2020 AM Delay for Enhanced Incident Management

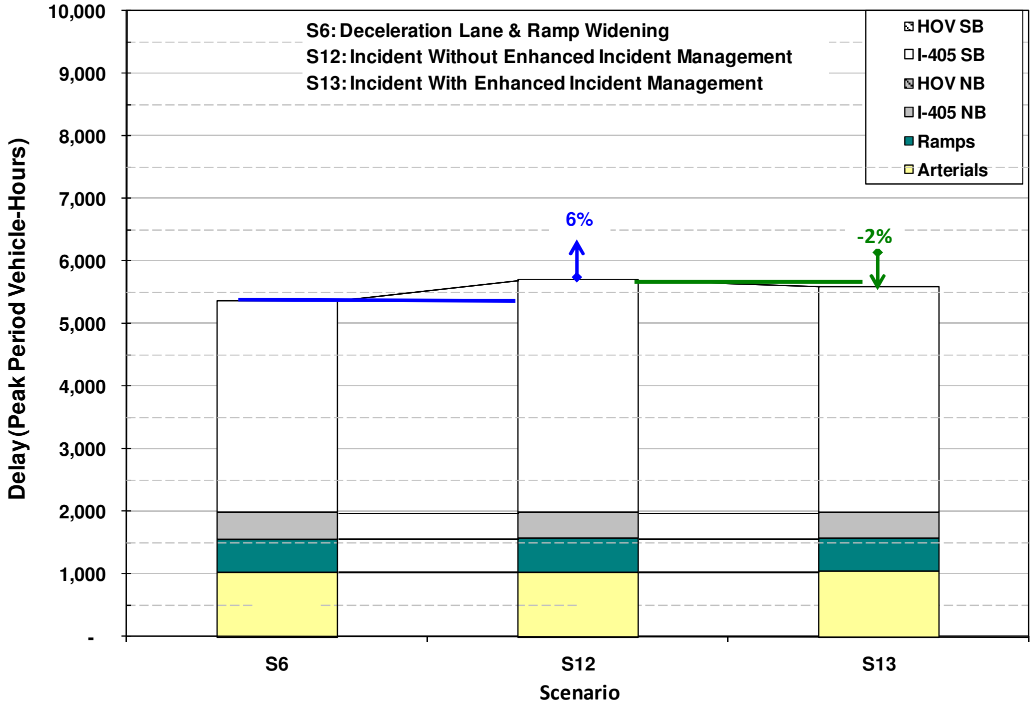
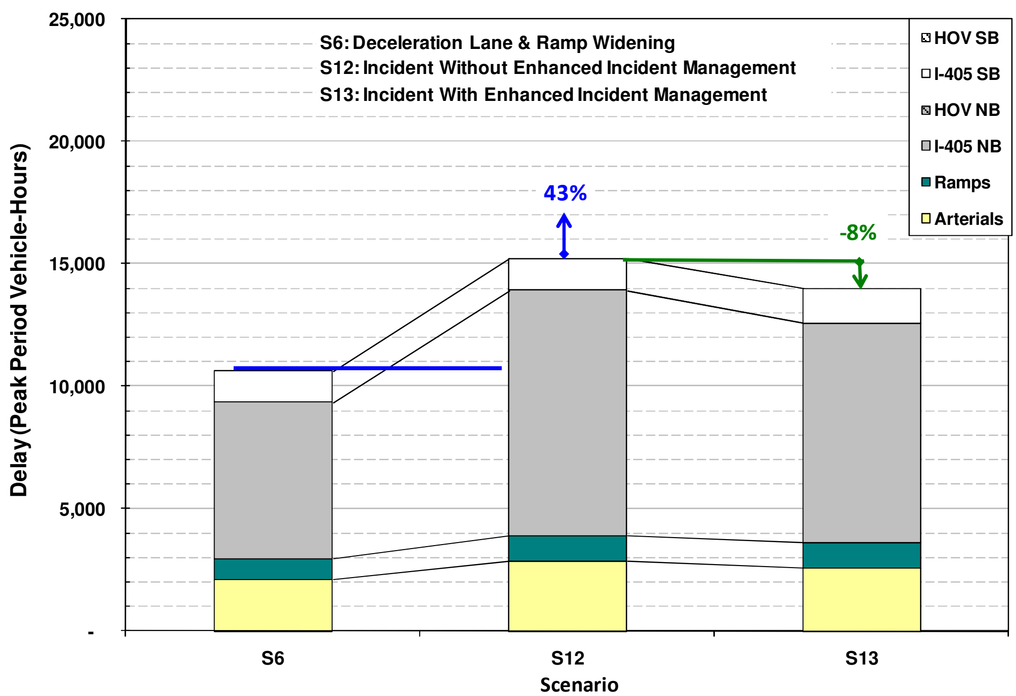


Exhibit 5-16: North Corridor – 2020 PM Delay for Enhanced Incident Management



South Corridor Model Results

The South Corridor Model covers the section of the corridor from I-110 to I-10, which is approximately 18 miles in distance. There is no clear directional pattern of travel on this section of the corridor.

Exhibit 5-17 summarizes the approach for scenario testing. It also provides a general description of the projects included in the 2003 and 2020 micro-simulation runs.

Exhibits 5-18 and 5-19 show the delay results for all the 2003 scenarios evaluated for the AM and PM peak periods, respectively. Exhibits 5-20 and 5-21 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.

Exhibits 5-22 through 5-25 summarize the delay results of the 2003 base year model by bottleneck area for the northbound and southbound directions and for each peak period. The delay results of the 2020 horizon year model are summarized in Exhibits 5-26 through 5-29.

For each scenario, the modeling team produced results by facility type (i.e., mainline, HOV, arterials, and ramps) and vehicle type (SOV, HOV, trucks) as well as speed contour diagrams. The study team scrutinized the results to ensure that they were consistent with general traffic engineering principles.

A traffic report with all the model output details is available under separate cover.

Exhibit 5-17: I-405 Micro-Simulation Modeling Approach for the South Corridor

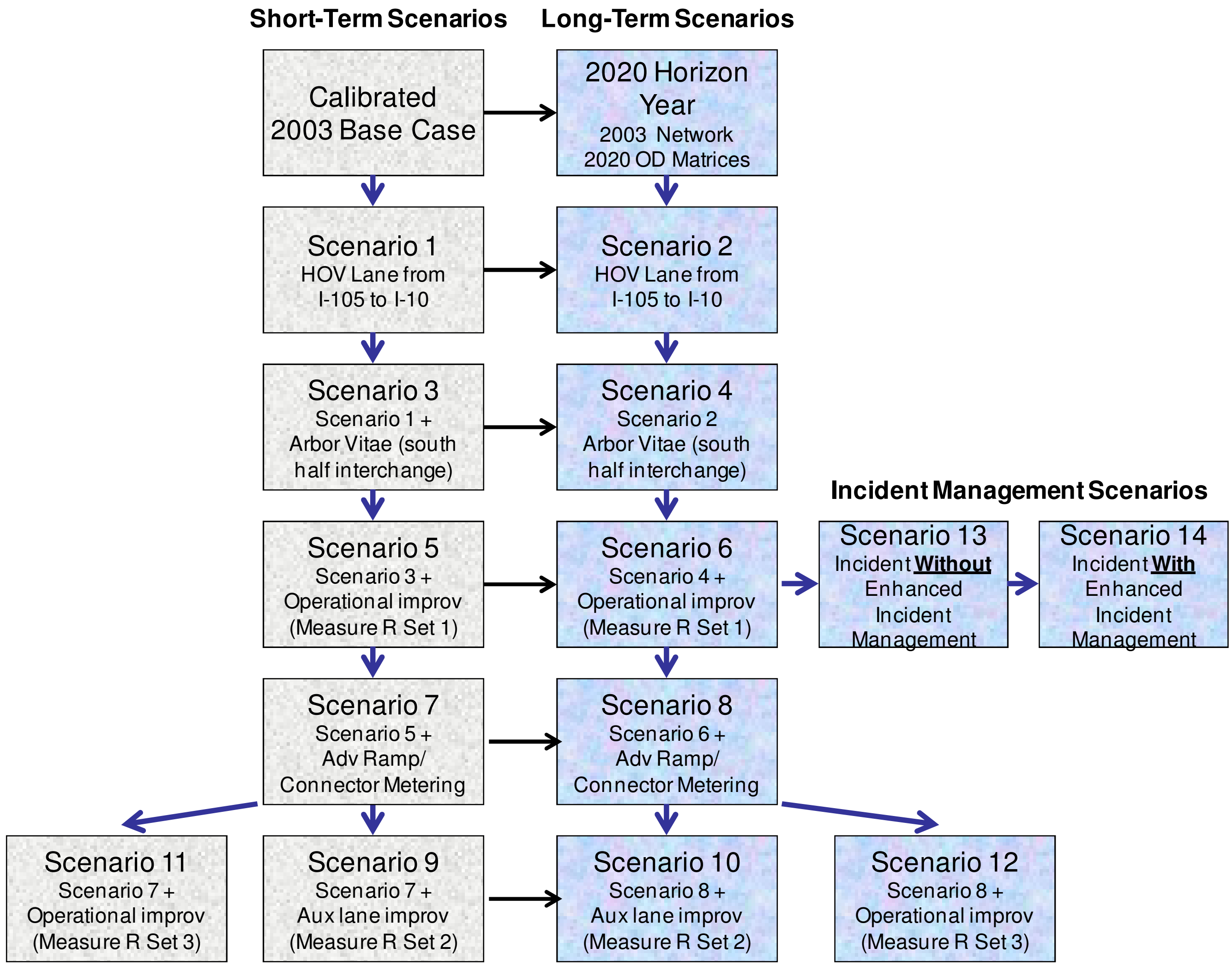


Exhibit 5-18: South Corridor – 2003 AM Peak Micro- Simulation Delay Results by Scenario

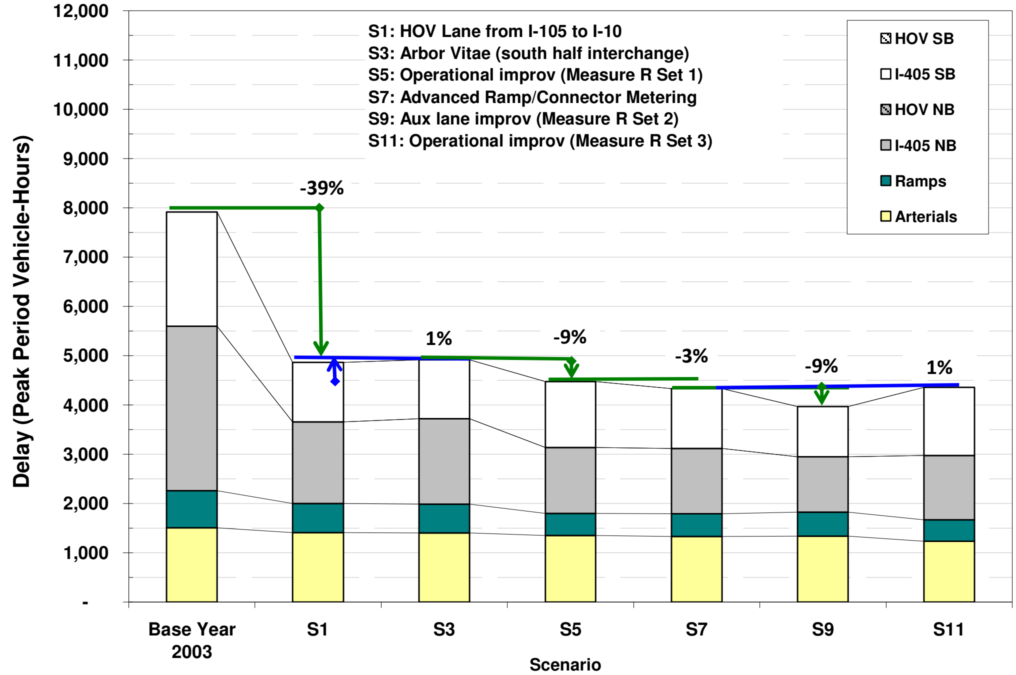


Exhibit 5-19: South Corridor – 2003 PM Peak Micro-Simulation Delay Results by Scenario

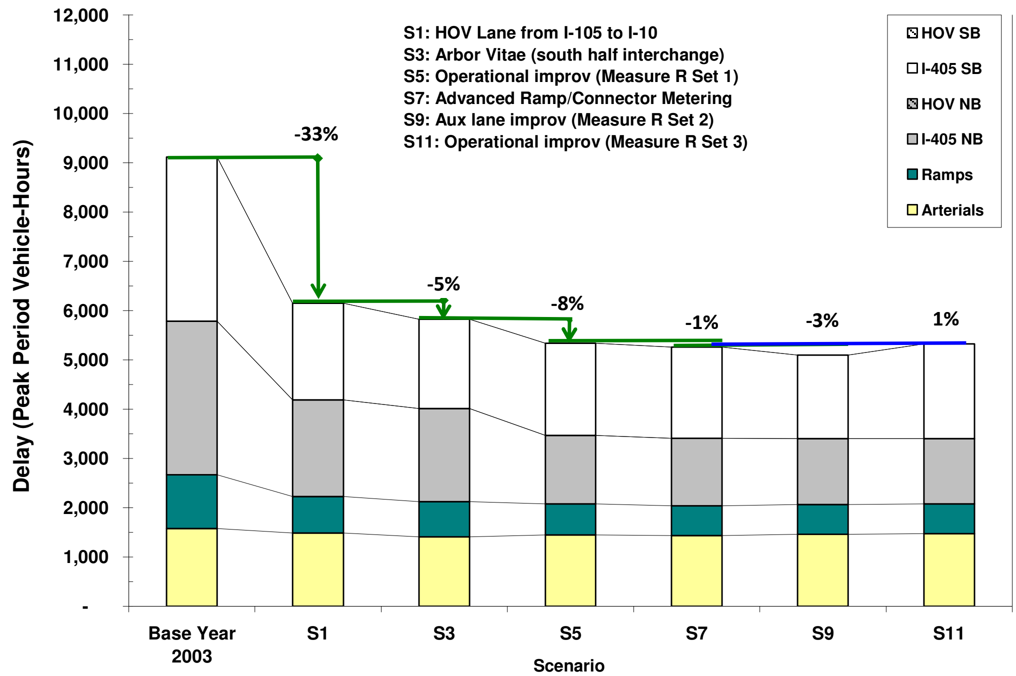


Exhibit 5-20: South Corridor – 2020 AM Peak Micro-Simulation Delay Results by Scenario

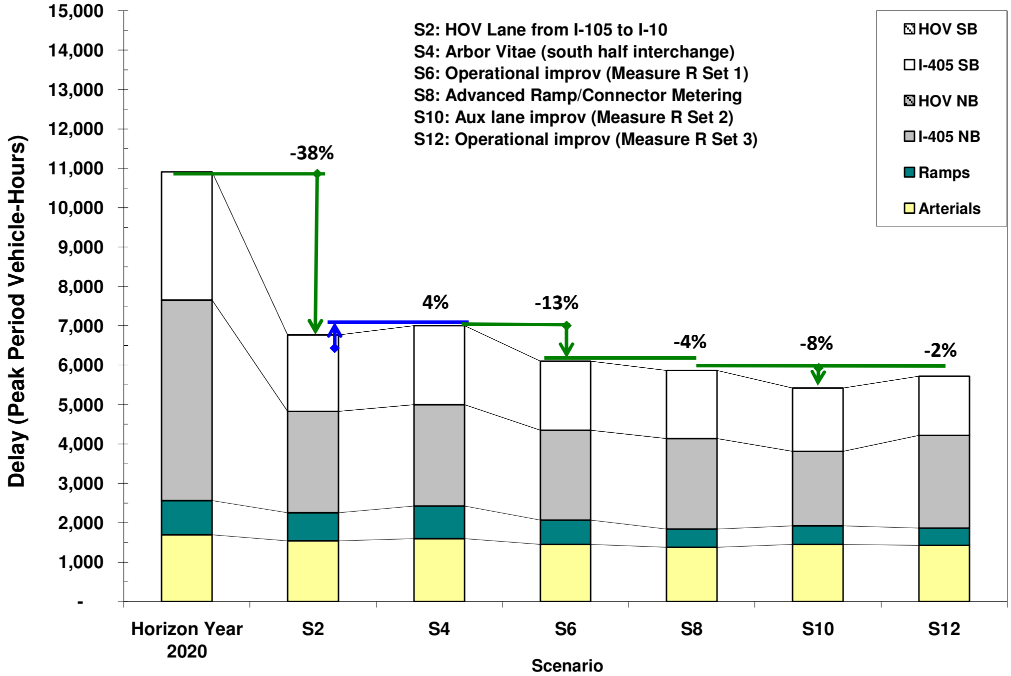


Exhibit 5-21: South Corridor – 2020 PM Peak Micro-Simulation Delay Results by Scenario

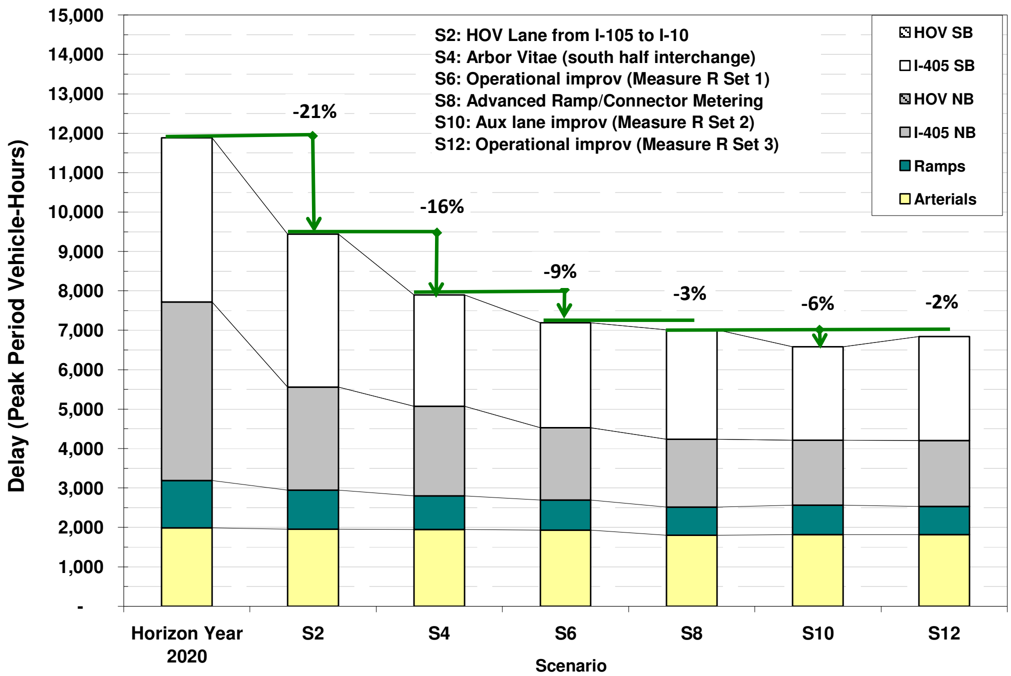


Exhibit 5-22: South Corridor – 2003 Northbound AM Delay by Scenario and Bottleneck Area

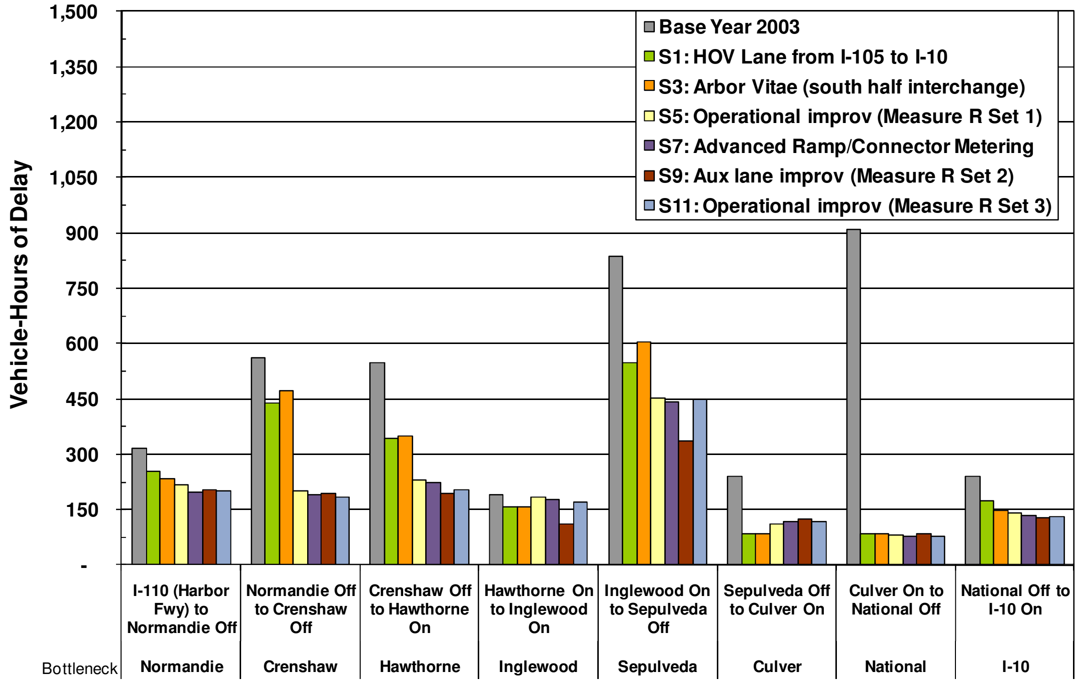


Exhibit 5-23: South Corridor – 2003 Northbound PM Delay by Scenario and Bottleneck Area

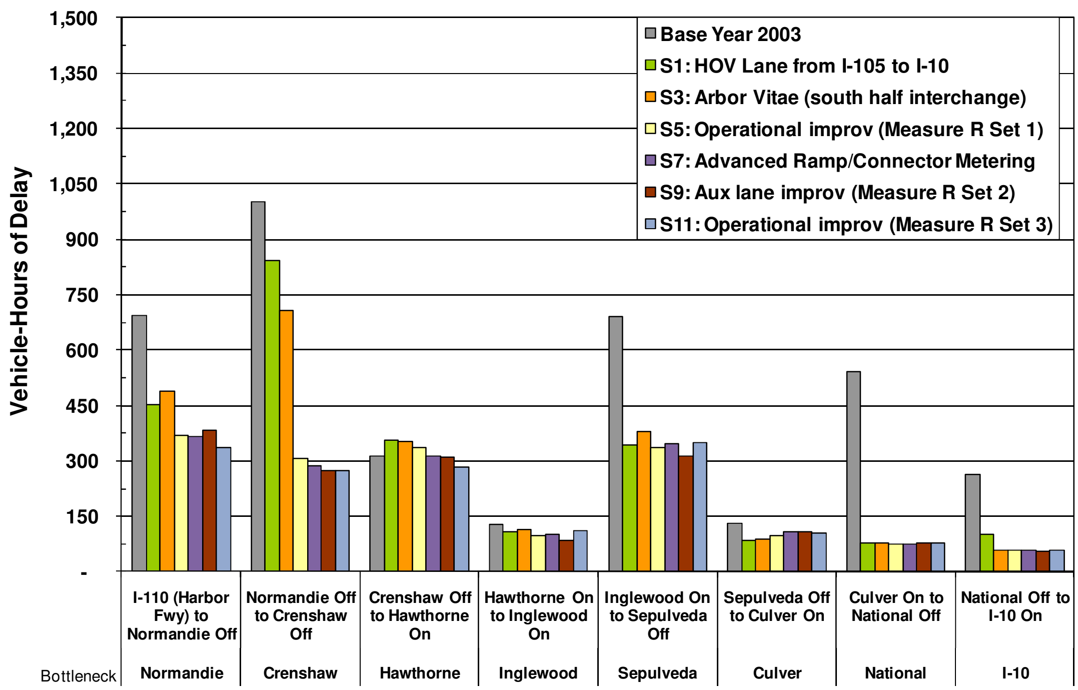


Exhibit 5-24: South Corridor – 2003 Southbound AM Delay by Scenario and Bottleneck Area

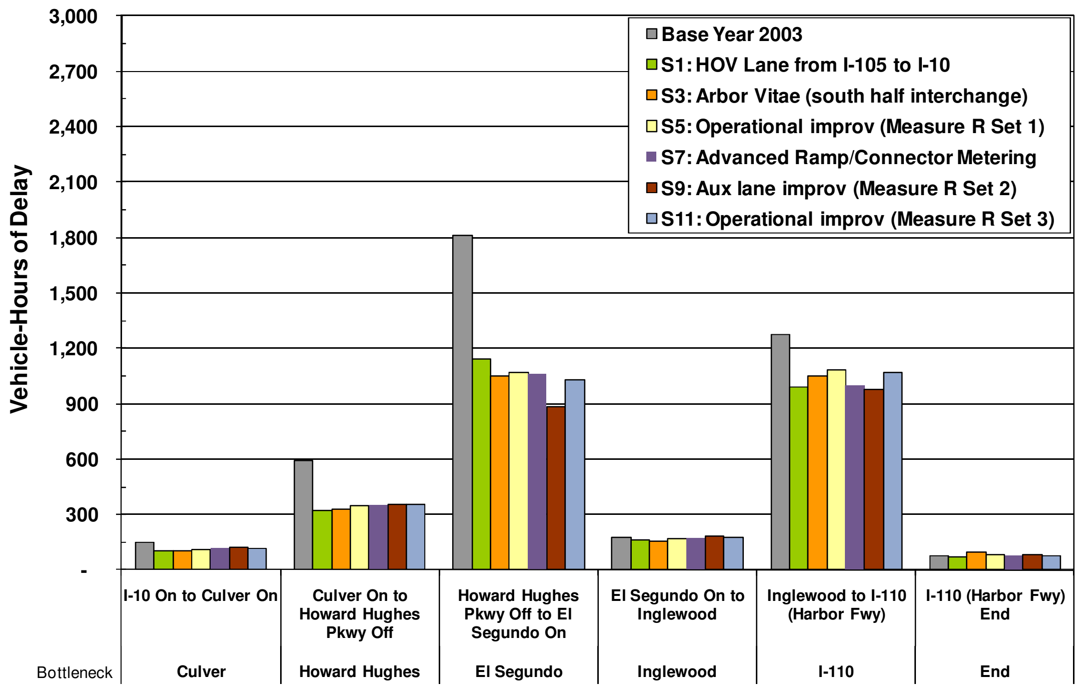


Exhibit 5-25: South Corridor – 2003 Southbound PM Delay by Scenario and Bottleneck Area

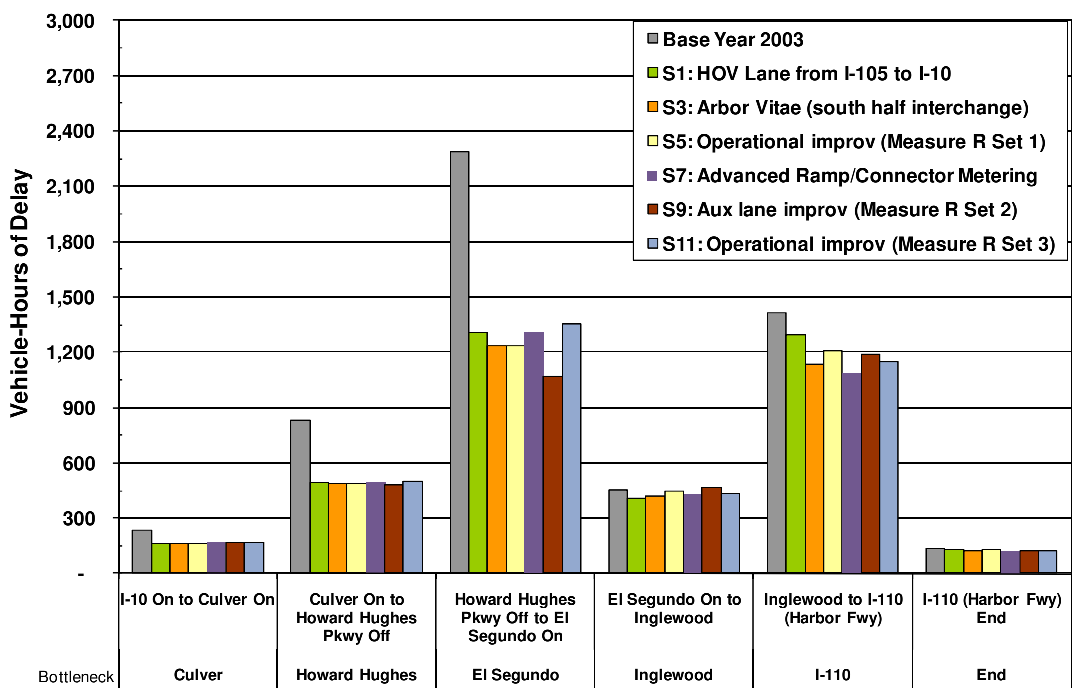


Exhibit 5-26: South Corridor – 2020 Northbound AM Delay by Scenario and Bottleneck Area

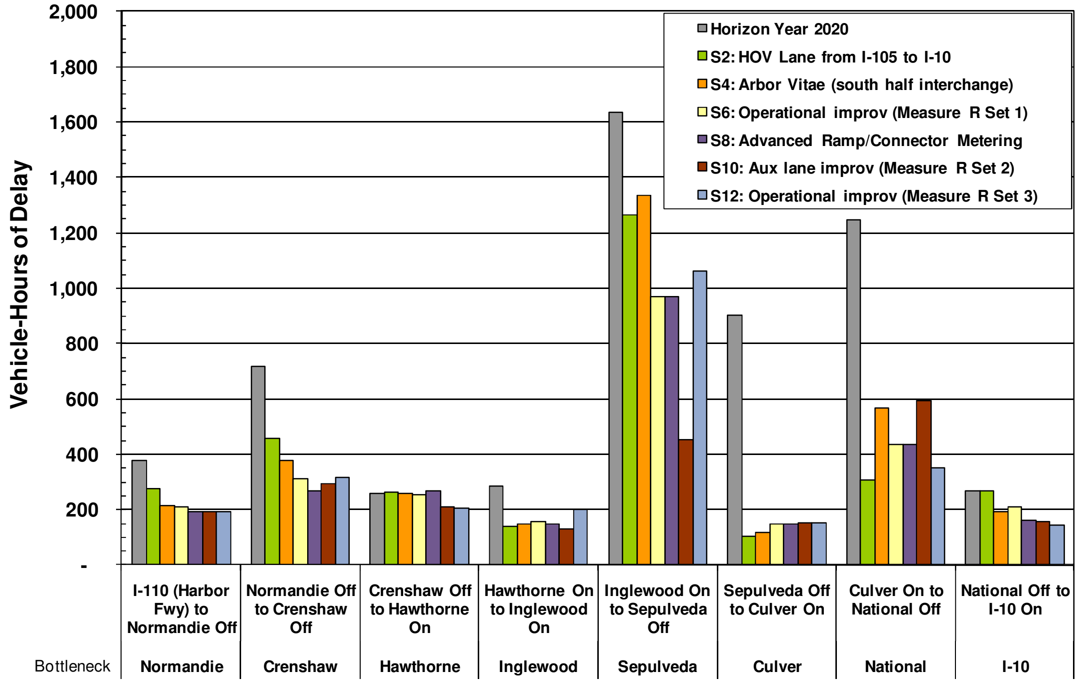


Exhibit 5-27: South Corridor – 2020 Northbound PM Delay by Scenario and Bottleneck Area

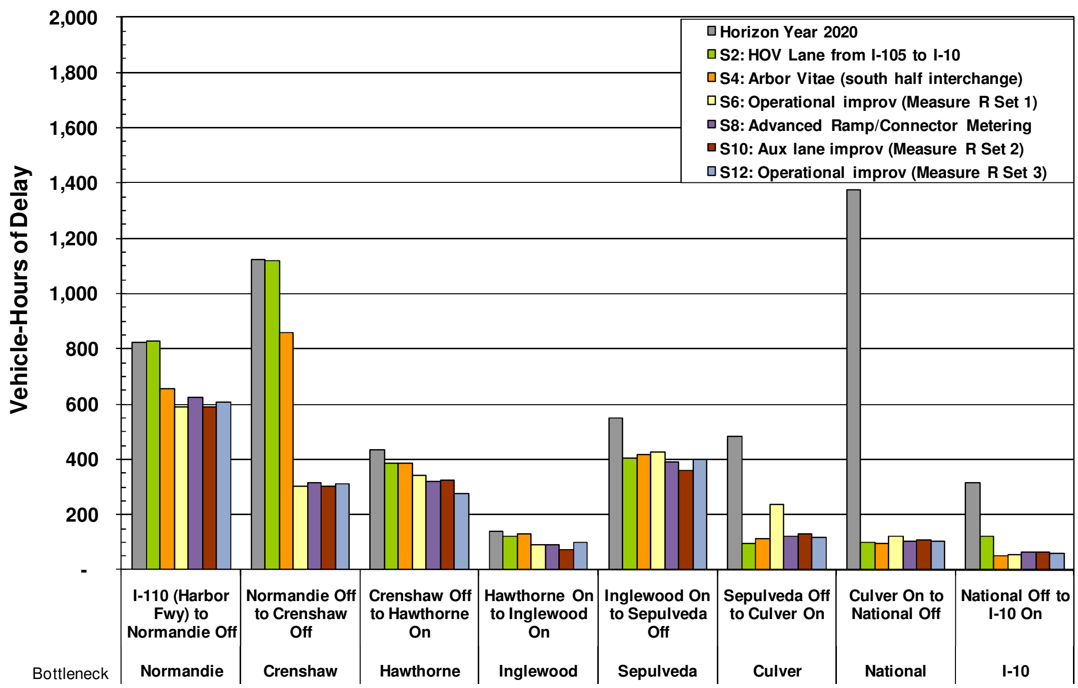


Exhibit 5-28: South Corridor – 2020 Southbound AM Delay by Scenario and Bottleneck Area

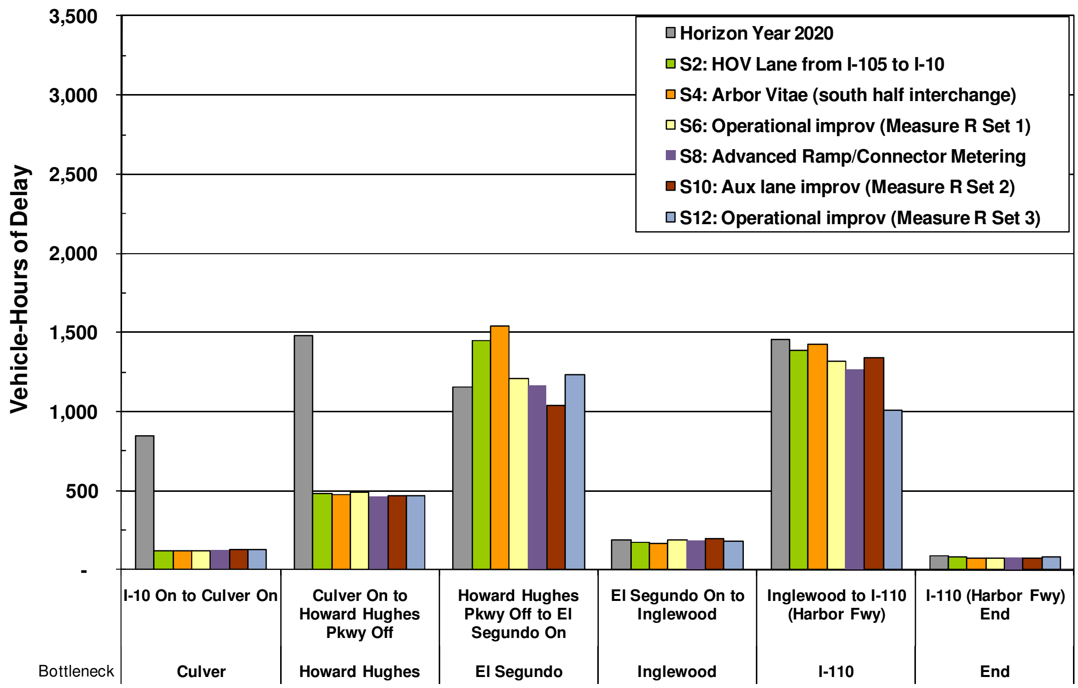
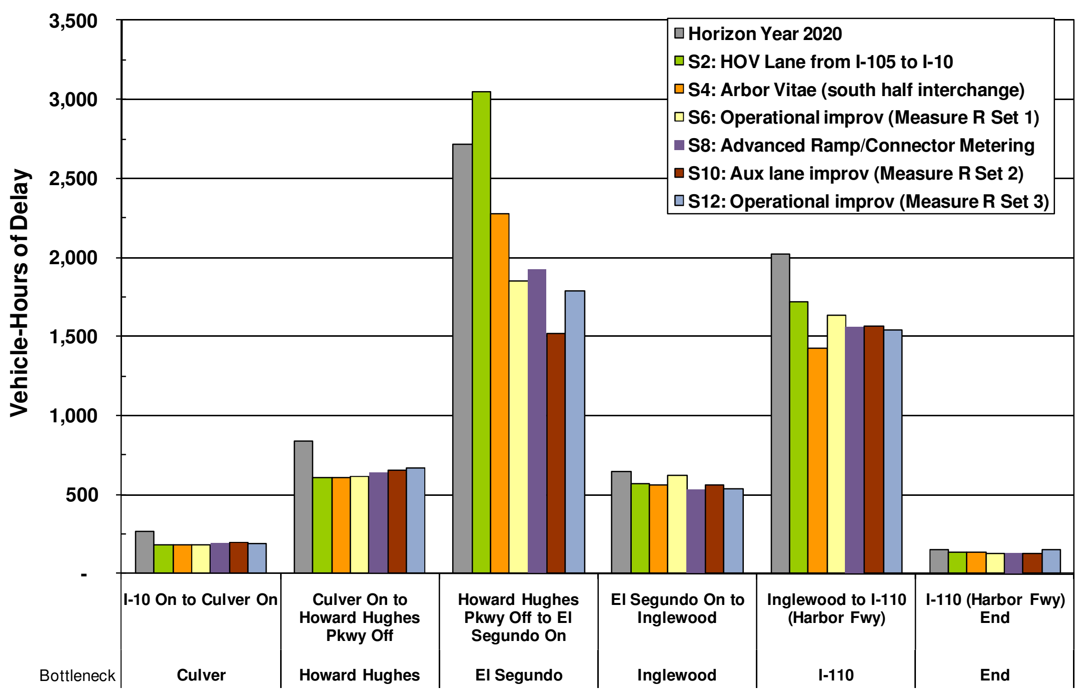


Exhibit 5-29: South Corridor – 2020 Southbound PM Delay by Scenario and Bottleneck Area



South Corridor Model: Base Year and "Do Minimum" Horizon Year

Absent any physical improvements, the model estimates that total delay on the south corridor (mainline, HOV, ramps, and arterials) increases about 35 percent from around 17,000 vehicle-hours in 2003 to nearly 23,000 by 2020, in the AM and PM peak hours combined. As described below, the completed HOV lanes and programmed projects lead to significant decreases and improved mobility on the corridor.

South Corridor Model: Scenarios 1 and 2 (HOV Lane from I-105 to I-10)

Scenarios 1 and 2 include all projects that were completed between 2003 and 2010. Results from this scenario were compared to the existing conditions of the corridor in 2010 to determine the reasonableness of the model. The project that was included in Scenarios 1 and 2 is the HOV lane addition in both directions from I-105 to SR-90 and from SR-90 to I-10. The HOV lane from I-105 to SR-90 opened in 2008 while the section from SR-90 to I-10 opened in late 2009.

The 2003 model estimates that Scenario 1 reduces delay on the corridor by about 39 percent in the AM peak and 33 percent in the PM peak, for a combined total reduction of 6,000 daily vehicle-hours of delay. Although the entire corridor experienced a decline in delay due to the HOV widening, one location stood out in particular. The northbound bottleneck at National experienced a 90 percent decrease during the AM peak compared to the base year from around 900 daily vehicle-hours of delay to 85.

The 2020 model estimates that Scenario 2 reduces delay on the corridor by about 4,100 vehicle-hours (38 percent) in the AM peak and 2,500 vehicle-hours (21 percent) in the PM peak. Similar to the 2003 model, the 2020 model shows a significant improvement at the northbound National bottleneck location during the PM peak from 1,375 vehicle-hours of delay to 100 vehicle-hours, an improvement of about 93 percent.

South Corridor Model: Scenarios 3 and 4 (Arbor Vitae – South Half Interchange)

Scenarios 3 and 4 build upon Scenarios 1 and 2 and test one project that is fully funded and is expected to be delivered in 2013. This project constructs the south half of an interchange at Arbor Vitae Avenue in Inglewood. This south half of the interchange comprises a new northbound off-ramp at Arbor Vitae and a southbound Arbor Vitae on-ramp.

The 2003 model shows that Scenario 3 slightly improves PM peak delay on the corridor by over 300 vehicle-hours (five percent) with minimal effect on the AM peak.

The 2020 model estimates greater gains with the Arbor Vitae Interchange during the PM peak with a delay reduction of over 1,500 vehicle-hours, or a 16 percent reduction. The southbound segment from Howard Hughes to El Segundo improved about 25 percent from over 3,000 vehicle-hours of delay in Scenario 2 to 2,230 vehicle-hours in Scenario 4. For this scenario, the model assumes distribution of the demand from other nearby interchanges and redirects them to the new Arbor Vitae interchange.

South Corridor Model: Scenarios 5 and 6 (Operational Improvements – Measure R Set 1)

Scenarios 5 and 6 build upon Scenarios 3 and 4 and include operational projects that are either fully funded or expected to be funded with local funds in the near term. These projects include:

- Adding a northbound auxiliary lane from La Tijera to Jefferson
- At 182nd Street/Crenshaw – widening the northbound off-ramp to 182nd Street and modifying the signal at the terminus
- At Hawthorne – constructing a new on-ramp for the southbound Hawthorne Boulevard onto northbound I-405 with upgraded signals at southbound and northbound ramps
- At Rosecrans/Hindry – widening the southbound I-405 off-ramp onto Hindry Avenue and install a signal
- Eliminating the lane drop on northbound I-405 at Normandie by adding an auxiliary lane to the Western Avenue off-ramp.

The 2003 model estimates that Scenario 5 reduces overall delay on the corridor by over 400 vehicle-hours (nine percent) in the AM and by almost 500 vehicle-hours (eight percent) in the PM peak. The northbound segment from Normandie to Crenshaw experienced a combined decrease of 600 vehicle-hours of delay during both AM and PM peaks. This improvement can be attributed to the elimination of the lane drop at the northbound Normandie interchange.

The 2020 model shows a similar trend as the 2003 model. Scenario 6 reduces delay on the corridor by 13 percent in the AM peak (a reduction of 900 vehicle-hours) and nine percent in the PM peak period (a reduction of 700 vehicle-hours). This scenario shows a reduction of 350 vehicle-hours (27 percent) of delay in the northbound direction from Inglewood to Sepulveda during the AM peak. This can be attributed to the addition of the northbound auxiliary lane at La Tijera, which improves merging.

South Corridor Model: Scenarios 7 and 8 (Advanced Ramp/Connector Metering)

Scenarios 7 and 8 build on Scenarios 5 and 6 by adding an advanced ramp metering system such as dynamic or adaptive ramp metering system with connector metering with queue control (to ensure that queuing does not exceed the capacity of the connector) at the following locations:

- Eastbound and westbound I-10 connectors to I-405
- Eastbound and westbound SR-90 connectors to I-405.

The 2003 model estimates that advanced ramp metering will modestly reduce delay by one percent in the AM peak and four percent in the PM peak, for a combined reduction of 200 daily vehicle-hours of delay.

The 2020 model estimates a similar modest improvement with Scenario 8 – a four percent reduction in delay in the AM peak and three percent in the PM peak, for a combined reduction of 400 daily vehicle-hours of delay.

South Corridor Model: Scenarios 9 and 10 (Auxiliary Lane Improvements – Measure R Set 2)

Scenarios 9 and 10 build upon Scenarios 7 and 8 and include local planned operational projects with potential funding availability. These projects include:

- Adding a northbound auxiliary lane from Hawthorne Boulevard to Inglewood Avenue
- Adding a northbound auxiliary lane from Inglewood Avenue to Rosecrans Avenue
- Adding a northbound lane from south of El Segundo to I-105
- Adding a southbound auxiliary lane from Howard Hughes Parkway to Century Boulevard.

The third and fourth projects on the list above were modified by the study team from the original project description for increased viability.

The 2003 model estimates that the proposed improvements would reduce delay by nine percent in the AM peak (or 370 vehicle-hours) and three percent in the PM peak (or 160 vehicle-hours). The 2020 model estimates similar results with a reduction in delay of eight percent in the AM peak (440 vehicle-hours) and six percent in the PM peak (430 vehicle-hours). Since significant delay reductions were experienced as a result of the previous scenarios, these auxiliary lane projects produced only a moderate reduction in delay.

South Corridor Model: Scenarios 11 and 12 (Operational Improvements – Measure R Set 3)

Scenarios 11 and 12, represents an alternate to Scenarios 9 and 10, and build upon Scenarios 7 and 8. They also include local planned operational projects with potential funding availability. These projects include:

- At Crenshaw Boulevard, constructing a new southbound on-ramp from northbound Crenshaw Boulevard
- Adding a northbound auxiliary lane from Redondo Beach Boulevard to Hawthorne Boulevard
- Widening the northbound off-ramp at Rosecrans Avenue
- At Crenshaw Boulevard at 182nd Street – widening 182nd Street and the east side of Crenshaw Boulevard (3 northbound through) and modifying signal. Modifying the northbound on-ramp from 182nd Street to provide 2 lanes and modify signal.

The 2003 model estimates that the proposed improvements would have little or no impact in reducing delay in either the AM or PM peak period.

The 2020 model estimates nominal results with a reduction in delay of about two percent in the AM peak and two percent in the PM peak, for a combined total of less than 500 vehicle-hours delay reduction. By comparison, these improvements would be less effective than those of Scenarios 9 and 10, in part due to the increased congestion in the southbound direction approaching the I-110 interchange. Should there be improvements in the future at the I-110 interchange, these improvements could yield much better results.

South Corridor Model: Scenarios 13 and 14 (Enhanced Incident Management)

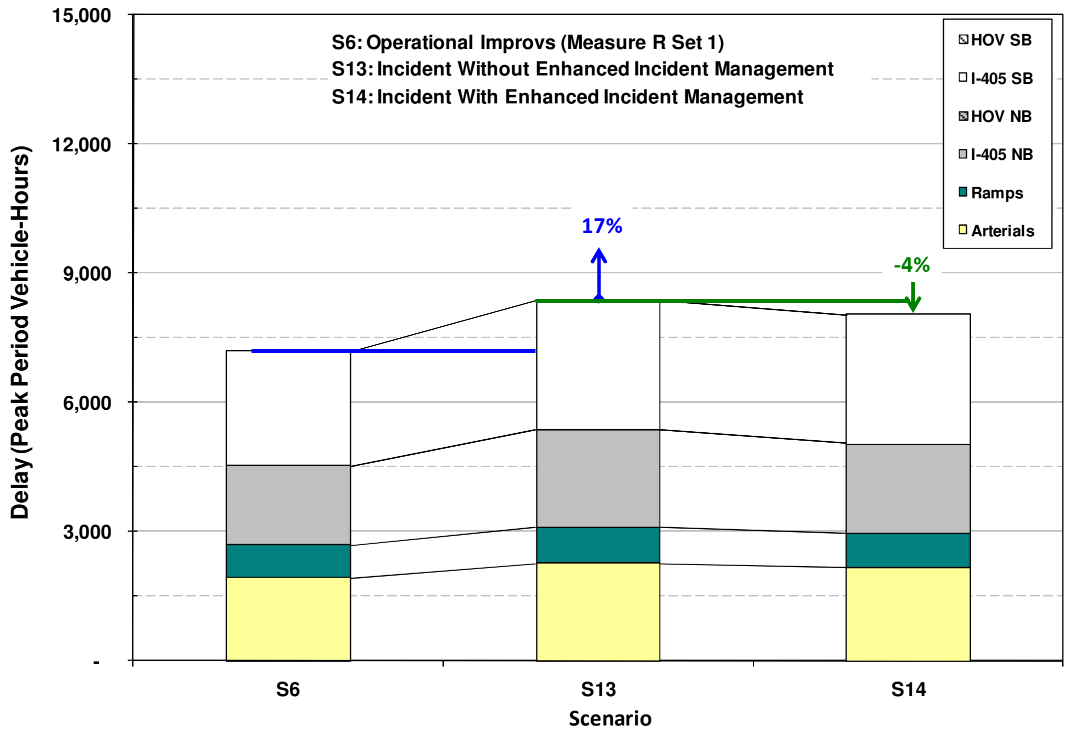
Two incident scenarios were tested on top of Scenario 6 to evaluate the non-recurrent delay reductions resulting from enhanced incident management strategies. In the first scenario, Scenario 13, one collision incident with one outside lane closure was simulated in the northbound and one in the southbound direction in the PM peak period models. The incident simulation location and duration was selected based on review of the 2010 actual incident data, at one of the high incident frequency locations. The following are the Scenario details:

- Southbound PM peak period starting at 3:30 PM, close outermost mainline lane for 35 minutes at absolute post mile 41.6 (at Inglewood)
- Northbound PM peak period starting at 4:00 PM, close outermost mainline lane for 35 minutes at absolute post mile 42.0 (at Inglewood)

In the second scenario, Scenario 14, the same collision incident was simulated with a reduction in duration by 10 minutes for each of the incidents. It is estimated, based on actual incident management data analysis results provided by Caltrans, that an enhanced incident management system could reduce a 35-minute incident by about 10 minutes. This scenario represents a typical moderate level incident at one location during the peak period direction.

The 2020 model shows that without enhanced incident management, the first scenario (Scenario 13) produced a 17 percent increase in congestion in the PM peak period for both incidents combined, an increase of over 1,000 vehicle-hours delay. With enhanced incident management, there was a decrease in delay of about four percent combined or about 400 vehicle-hours for improving the incident detection, verification, response, and clearance time of two moderate level incidents in the PM peak period, in each direction.

Exhibit 5-30: South Corridor – 2020 PM Delay for Enhanced Incident Management



Benefit-Cost Analysis

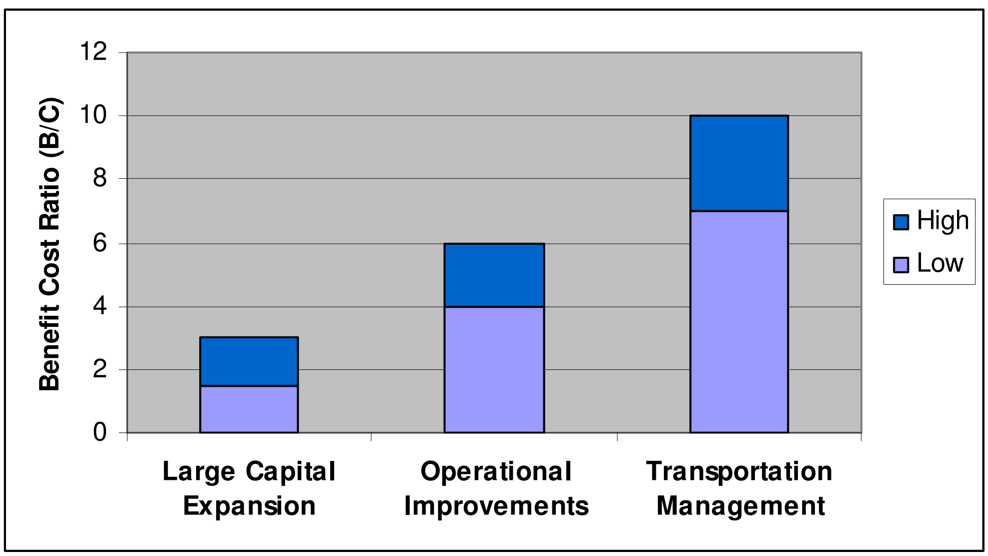
Following an in-depth review of the model results, the study team developed a benefit-cost analysis for each scenario. The benefit-cost results represent the incremental benefits over the incremental costs of a given scenario.

The study team used the California Life-Cycle Benefit/Cost Analysis Model (Cal-B/C) developed by Caltrans 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 other benefits, such as the reduction in congestion beyond the peak periods and improvement in transit travel times.

Project costs were developed from SCAG and Caltrans project planning and programming documents. These costs include construction and support costs in current dollars. The study team estimated costs for projects that did not have cost estimates by reviewing similar completed projects. A B/C ratio greater than one means that a scenario's projects return greater benefits than the costs to construct or implement. It is important to consider the total benefits that a project brings. For example, a large capital expansion project, such as adding major lane additions, can have a high cost and a low B/C ratio, but it would bring much higher absolute benefits to I-405 users.

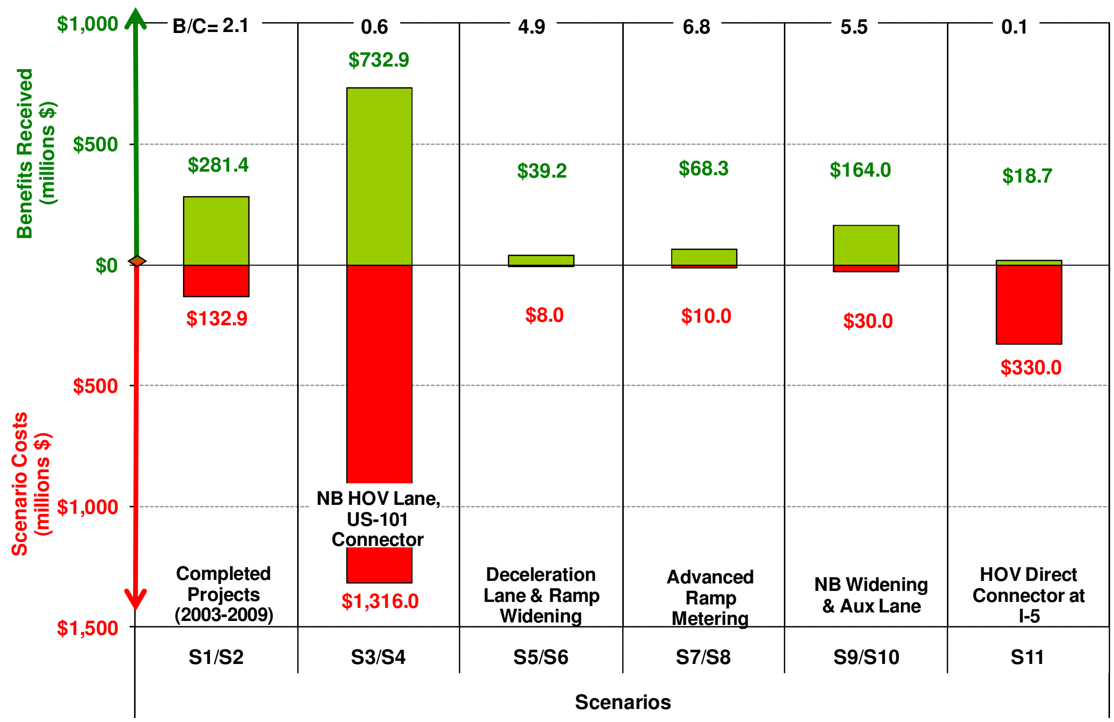
Exhibit 5-31 illustrates typical benefit-cost ratios for different project types. Large capital expansion improvements generally produce low benefit-cost ratios because the costs are so high. Conversely, transportation management strategies such as ramp metering produce high benefit-cost ratios given their low costs.

Exhibit 5-31: Benefit-Cost Ratios for Typical Projects



The benefit-cost results for the North Corridor scenarios are shown in Exhibit 5-32.

Exhibit 5-32: North Corridor – Scenario Benefit/Cost (B/C) Results



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

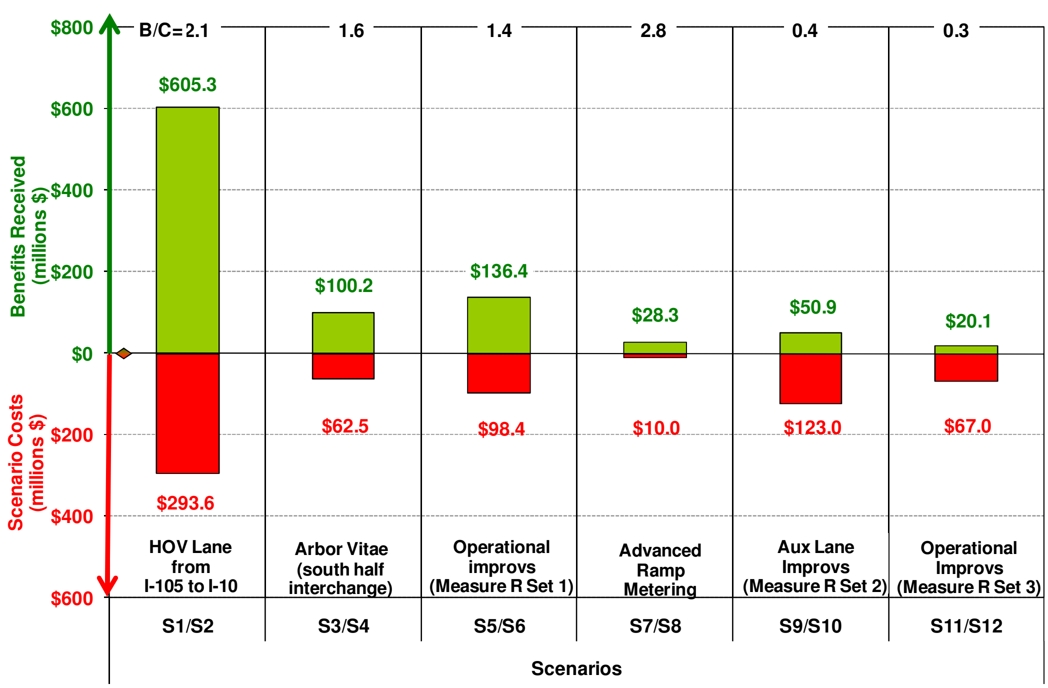
- Scenarios 1 and 2 (Completed Projects – 2003 to 2009) produce a benefit-cost ratio of over 2:1. This result is consistent with typical capacity enhancement projects with high costs – the cost of this improvement exceeds $130 million. The benefits are substantial at over $280 million.
- Scenarios 3 and 4 (Northbound HOV Lane, US-101 Connector) produce a benefit-cost ratio below one due to the high cost of construction at over $1.3 billion. The benefits are substantial, however, at over $730 million.
- Scenarios 5 and 6 (Deceleration Lane and Ramp Widening) produce a relatively high benefit-cost ratio of nearly 5:1. This is primarily due to the low cost of the construction at below $10 million.
- Scenarios 7 and 8 (Advanced Ramp Metering with Connector Metering) produce benefit-cost ratio of nearly 7:1, which is consistent with typical transportation management projects.
- Scenarios 9 and 10 (Northbound Widening and Auxiliary Lane) produce a benefit-cost ratio of 5.5 to 1, again consistent with typical operational improvement projects. Benefits of over $160 million could be realized.

- Scenario 11 (HOV Direct Connectors) produce a relatively low benefit-cost ratio of 0.1, which is unexpected. This is likely due to the over-saturated and congested conditions along the I-5 mainline corridor. Should the I-5 corridor from the I-405 to SR-14 be improved, this project could yield significantly better results.
- Implementation of enhanced incident management would result in over 600 vehicle-hours of delay savings for each incident. With approximately 1,800 collisions per year experienced on this corridor, that would translate to a delay savings of over one million vehicle-hours.
- The benefit-cost ratio of all scenarios combined is just under 1 to 1 due to the high cost of the HOV widening project at over $1.3 billion. However, the total combined benefits could well exceed $1 billion, substantially reducing congestion and delay, improving mobility, and improving air quality.
- The projects also reduce greenhouse gas (GHG) emissions by over 850 thousand tons over 20 years, averaging over 40,000-ton reduction per year.

I-405 South Corridor Benefit-Cost Results

Exhibit 5-33 summarizes the benefit-cost results for the South corridor scenarios.

Exhibit 5-33: South Corridor – Scenario Benefit/Cost (B/C) Results



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

- Scenarios 1 and 2 (Completed HOV Lane from I-105 to I-10) produce a relatively high benefit-cost ratio of over 2:1, considering the high cost at nearly $300 million. This result is consistent with typical capital expansion projects in the State but higher than typical of Southern California freeways with higher costs.
- Scenarios 3 and 4 (Arbor Vitae Interchange) produce a benefit-cost ratio of 1.6 to 1 with benefits of over $100 million, which is unexpected considering that it is only a half interchange improvement.
- Scenarios 5 and 6 (Operational Projects – Measure R Set 1) produce a relatively low benefit-cost ratio of 1.4 to 1, despite the over $130 million in benefits. This is much lower than the typical operational improvement projects, primarily due to the high cost of construction at nearly $100 million, common for Southern California.
- Scenarios 7 and 8 (Advanced Ramp Metering with Connector Metering) produce a benefit-cost ratio of nearly 3:1, which is relatively lower than the typical transportation management projects, unlike the North Corridor.
- Scenarios 9 and 10 (Auxiliary Lanes – Measure R Set 2) produce a relatively low benefit-cost ratio of less than one, again due to the high cost of construction and significant reduction in delay on the corridor by Scenario 7 and 8 with previous scenario improvements. Modest benefits of over $50 million could be realized at the cost of well over $100 million.
- Scenarios 11 and 12 (Operational Improvements – Measure R Set 3) that build upon Scenarios 7 and 8 and tested as an alternative to the Measure R Set 2, also produce a relatively low benefit-cost ratio of less than one for the same reasons, despite the comparatively lower construction cost at an estimated $67 million. By comparison, they yield significantly less benefits than those of Scenario 9 and 10.
- Implementation of enhanced incident management would result in about 200 vehicle-hours of delay savings for each incident. With approximately 1,750 collisions per year experienced on this corridor, that would translate to a delay savings of up to 350,000 vehicle-hours.
- The benefit-cost ratio of all scenarios combined is over 1.5 to 1. If all projects were delivered at current costs, the public would get a dollar and a half of benefits for each dollar expended. In current dollars, costs add up to around $600 million whereas the benefits are estimated to be over $920 million.
- The projects also reduce greenhouse gas (GHG) emissions by about 560 thousand tons over 20 years. This reduction averages nearly 30,000 tons per year.

6. CONCLUSIONS AND RECOMMENDATIONS

This section presents the overall conclusions and recommendations based on the micro-simulation analyses presented in the previous section. After a thorough review of the calibrated base year and forecast year models of each scenario developed and analyzed, the study team believes that the scenario results are reasonable and allow for more informed decision-making. Caution is advised in making decisions based on modeling alone. There are other technical factors to be considered using engineering and professional judgment and experience in order to make the most effective project decisions that affect millions if not billions of dollars of investments.

Based on the results, the study team offers the following conclusions and recommendations:

North Corridor Improvements

- The combination of all scenarios significantly reduces overall congestion on the corridor. Projected 2020 congestion after implementation of all scenarios is below 2003 levels in both the AM and PM peak period. In the AM peak period, the model projects total delay in 2020 after delivering all projects to be less than 5,000 hours compared to the 2003 base year delay of 7,000 hours. This represents a reduction of almost 30 percent. In the PM peak period, the model projects total delay in 2020 after delivering all projects to be around 8,000 hours compared to the 2003 base year delay of almost 11,500 hours. This represents a reduction of over 30 percent. Clearly, the scenarios deliver significant mobility benefits to the corridor. Despite the growth in demand, future 2020 congestion will be less than experienced in 2003.
- Completing the northbound HOV lane from I-10 to US-101 and closing the HOV lane system gap are expected to result in substantial improvements - a 50 percent reduction in delay and more than $1 billion in net benefits by future year 2020. The results of recently completed programmed projects (Scenarios 1 and 2) and the programmed CMIA project (Scenarios 3 and 4) were included in the model to make this determination. However, due to the high costs of these HOV projects, the benefit cost of these projects (i.e., combining scenarios 1 through 4) is less than one. This is not uncommon for major expansion projects on an urban corridor.
- Operational improvement projects associated with Scenarios 5, 6, 9, and 10 that complement the HOV widening and CMIA projects could result in net mobility improvements of over $200 million in benefits over the 20-year planning period. With benefit to cost ratio of over 5 to 1, these improvements are strongly recommended for funding and implementation.

- Advanced ramp metering with connector metering (Scenarios 7 and 8) could be very cost effective with nearly 7 to 1 benefit-cost results. The district should continue to research and evaluate the deployment of advanced ramp metering given the high potential for mobility improvement.
- Although the HOV direct connector at the I-5 interchange is not expected to produce any significant congestion relief and the investment yields a benefit to cost ratio of significantly less than one. The benefits may be more significant should the stretch of northbound I-5, north of I-405, be improved in the future. However, until further analysis is conducted to evaluate this extension, this project is not recommended for funding or implementation.
- Enhanced incident management system associated with Scenarios 12 and 13 to address non-recurrent congestion could be proven effective with daily delay reduction of over 1,200 vehicle-hours during the AM and PM peak hours over the non-incident management scenario. Over the course of a year, the delay savings would add up to more than one million vehicle-hours (given 1,800 collisions per year per TASAS).

South Corridor Improvements

- Similar to the North Corridor results, the combination of all scenarios significantly reduces overall congestion on the corridor. Projected 2020 congestion after implementation of all scenarios is below 2003 levels in both the AM and PM peak period. In the AM peak period, the model projects total delay in 2020 after delivering all projects to be less than 6,000 hours compared to the 2003 base year delay of around 8,000 hours. This represents a reduction of 25 percent. In the PM peak period, the model projects total delay in 2020 after delivering all projects to be around 7,000 hours compared to the 2003 base year delay of almost 9,000 hours. This represents a reduction of over 20 percent. Clearly, the scenarios deliver significant mobility benefits to the corridor. Despite the growth in demand, future 2020 congestion will be less than experienced in 2003.
- The completed HOV widening improvements from 2003 to 2009 associated with Scenarios 1 and 2 are estimated to account for over $600 million in benefits, representing a benefit to cost ratio of over 2.
- Advanced ramp metering with connector metering are expected to produce modest results on this corridor with a 3 to 1 benefit-cost ratio. Despite the relatively lower benefit to cost ratio in comparison to other typical demand management projects, it may be a necessary project to moderate the high demand merge from the SR-90 interchange on-ramps.
- Operational improvement projects that complement the recently completed HOV widening project could result in net mobility improvements of well over $300 million in benefits over 20 year period. Despite the relatively low benefit to cost

ratio of slightly over 1 to 1, these improvements increase corridor-wide productivity and efficiency.

- Similar to the North Corridor, enhanced incident management also shows promise for the South Corridor. Over the course of a year, the delay savings would add up to 350,000 vehicle-hours for the total number of collisions (1,750) that typically occur on the south segment of I-405.

Speed Contour Maps

I-405 North Corridor Speed Contour Maps

Exhibits 6-1 and 6-2 show the northbound I-405 corridor speed contour maps produced by the model at the future horizon baseline. This represents the condition of the future 2020 with only minimal improvements such as signal improvements at intersections. As shown, by 2020 there is still noticeable congestion between the I-10 and Wilshire Boulevard in the AM peak and significant congestion throughout the corridor in the PM peak. Exhibits 6-3 and 6-4 illustrate the southbound I-405 corridor speed contour maps produced by the model at the future horizon baseline with only minimal improvements. As indicated, by 2020 there is noticeable congestion throughout the corridor in the AM peak and congestion approaching the I-10 in the PM peak.

Exhibit 6-5 and 6-6 show the northbound I-405 corridor speed contour maps produced by the model at the conclusion of Scenario 11, the final scenario tested in this direction on recurrent congestion. These maps indicate the last remaining residual congestion and bottleneck locations. As shown, by 2020 there is still noticeable congestion approaching the SR-118 in the PM peak even after all of the scenario improvements are implemented. Exhibits 6-7 and 6-8 illustrate the southbound I-405 corridor speed contour maps produced by the model at the conclusion of Scenario 11. As indicated, by 2020 there is still some residual congestion over the Mulholland pass and near Olympic Boulevard in the AM peak, and only minor congestion in the PM peak.

Exhibit 6-1: 2020 Northbound I-405 AM Model Speed Contours at Baseline

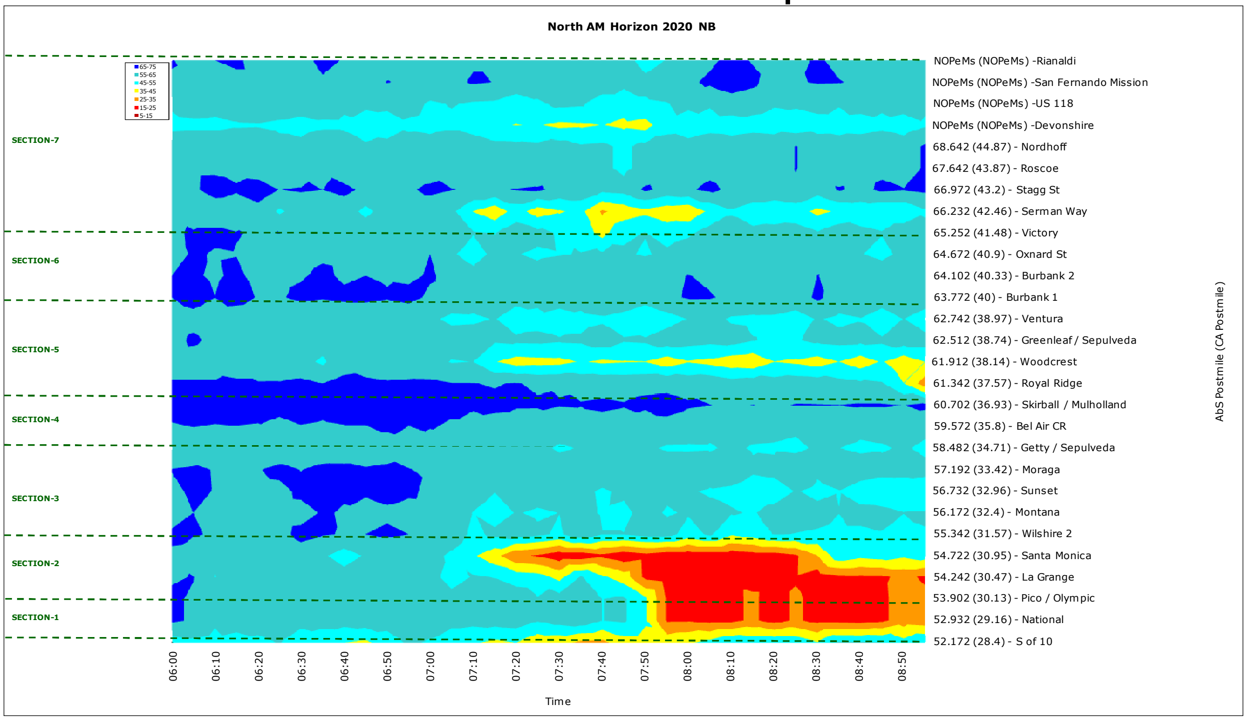


Exhibit 6-2: 2020 Northbound I-405 PM Model Speed Contours at Baseline

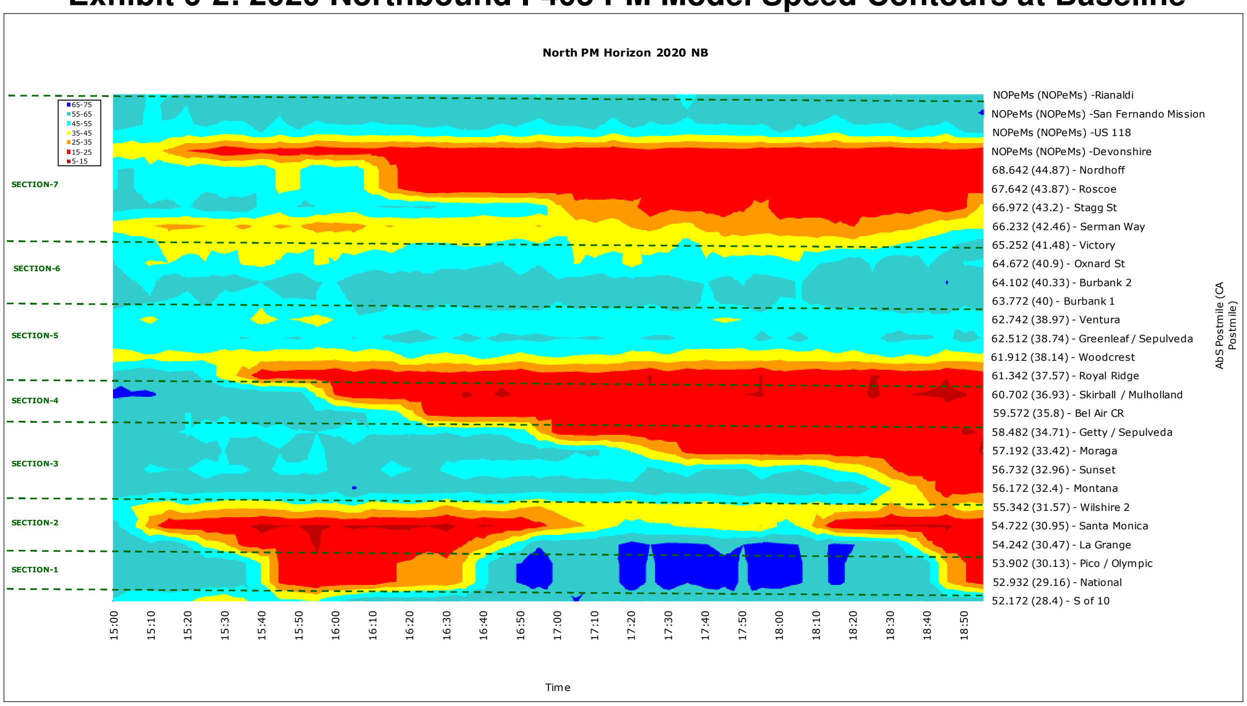


Exhibit 6-3: 2020 Southbound I-405 AM Model Speed Contours at Baseline

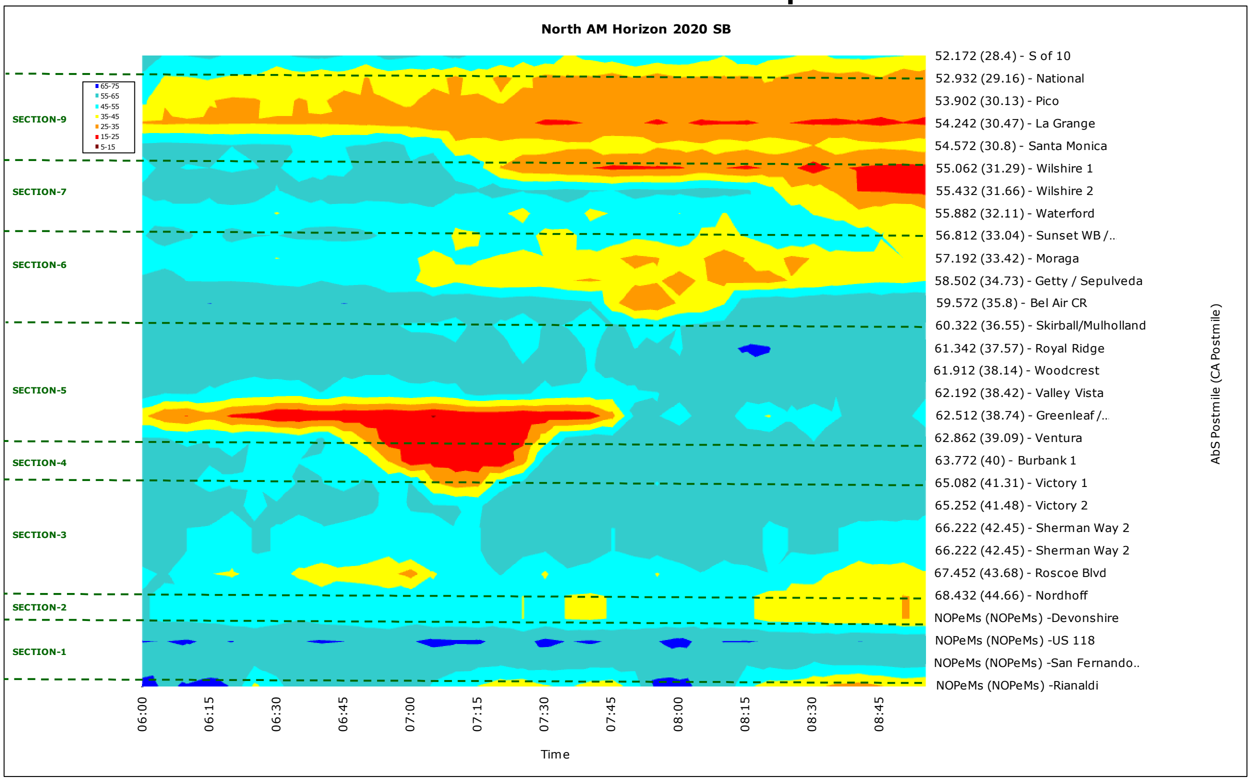


Exhibit 6-4: 2020 Southbound I-405 PM Model Speed Contours at Baseline

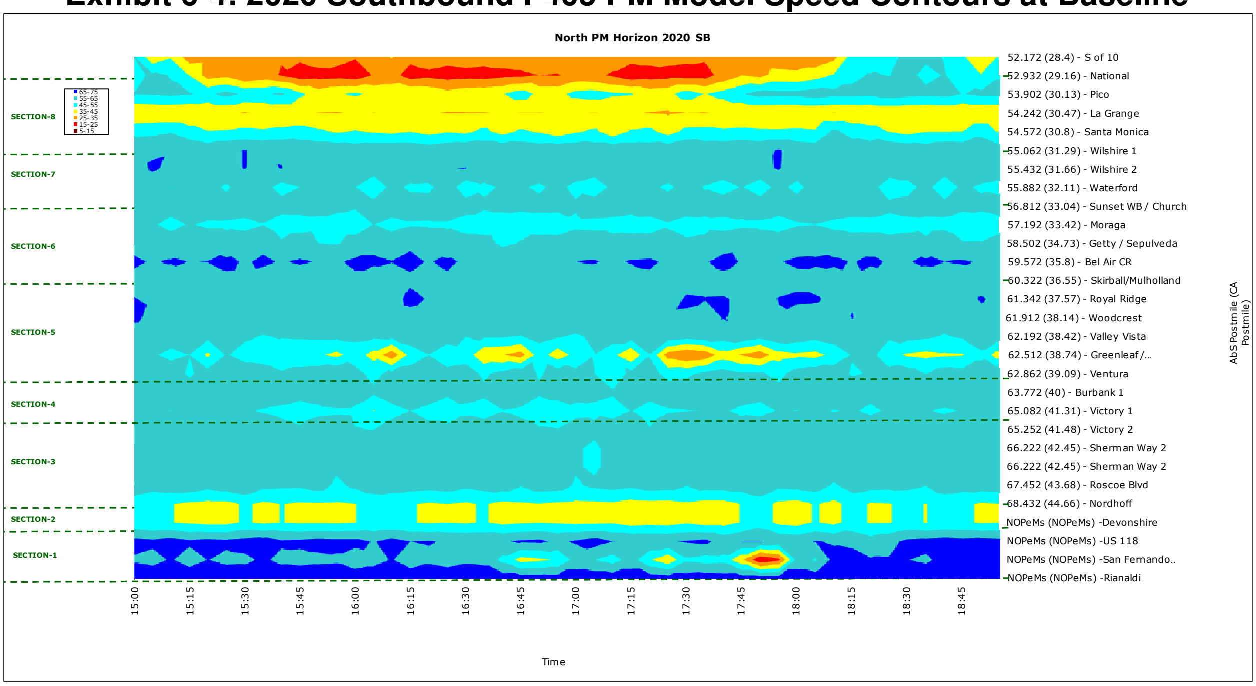


Exhibit 6-5: 2020 Northbound I-405 AM Model Speed Contours after Scenario 11

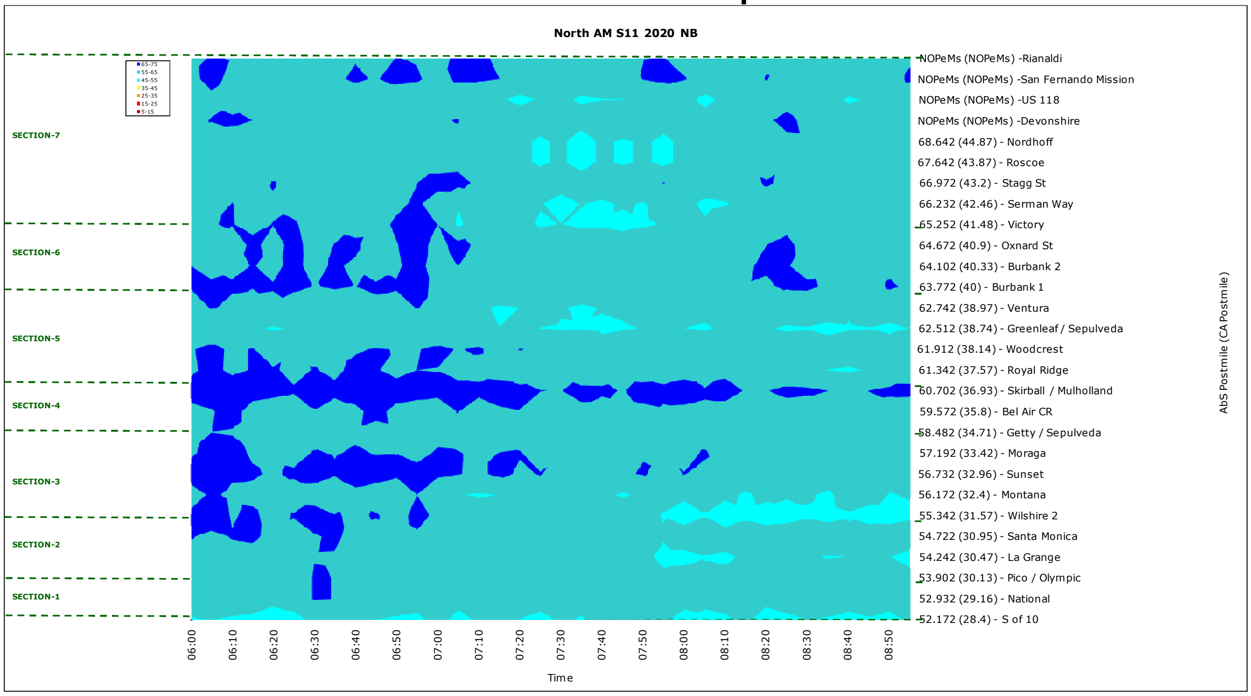


Exhibit 6-6: 2020 Northbound I-405 PM Model Speed Contours after Scenario 11

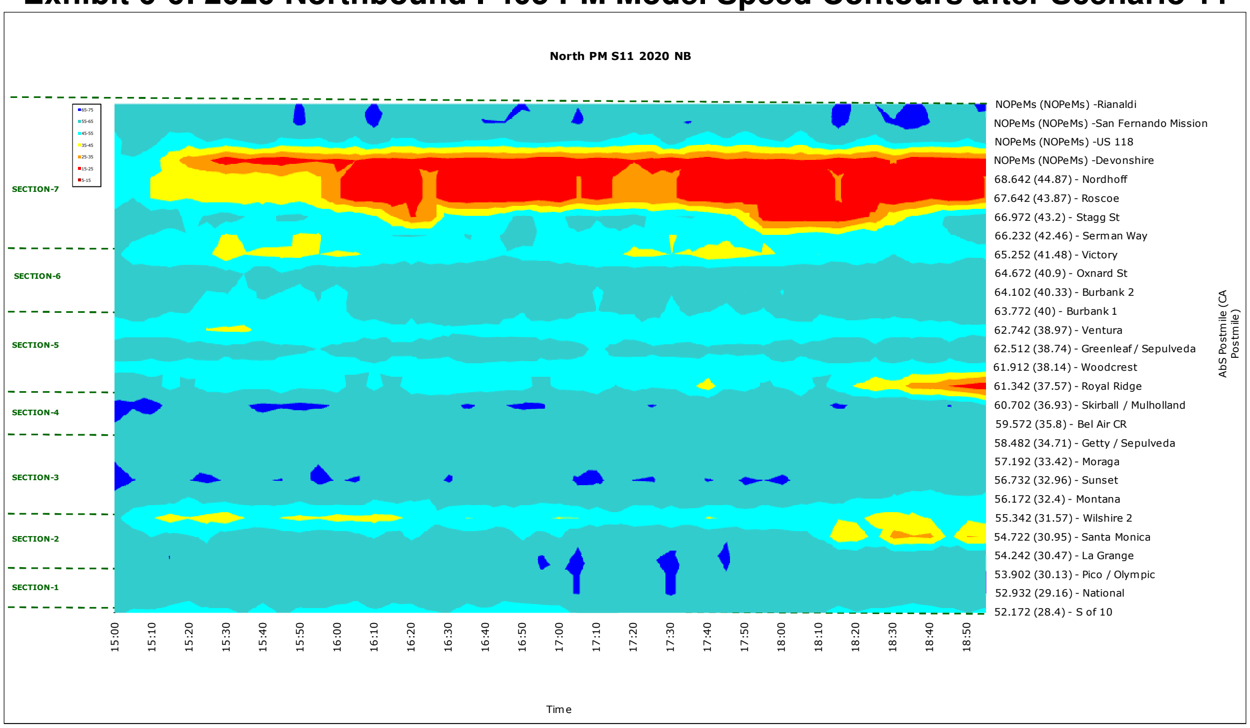


Exhibit 6-7: 2020 Southbound I-405 AM Model Speed Contours after Scenario 11

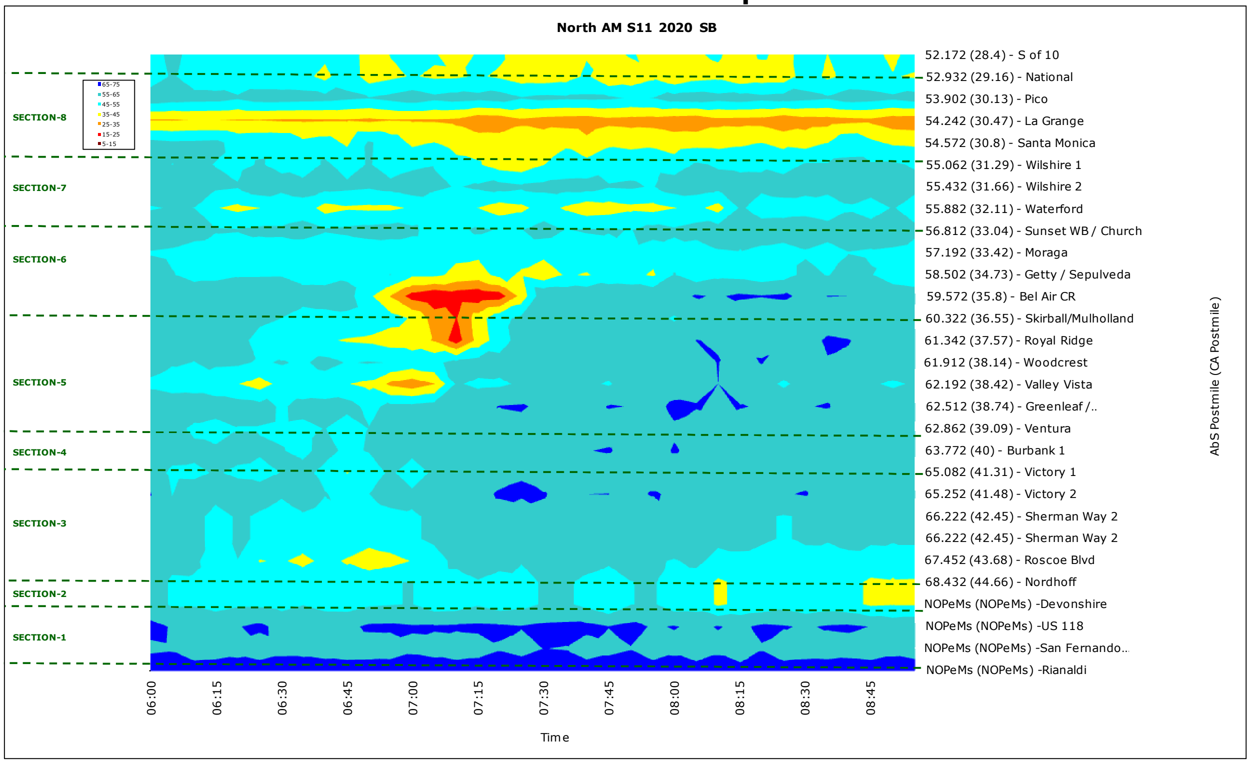
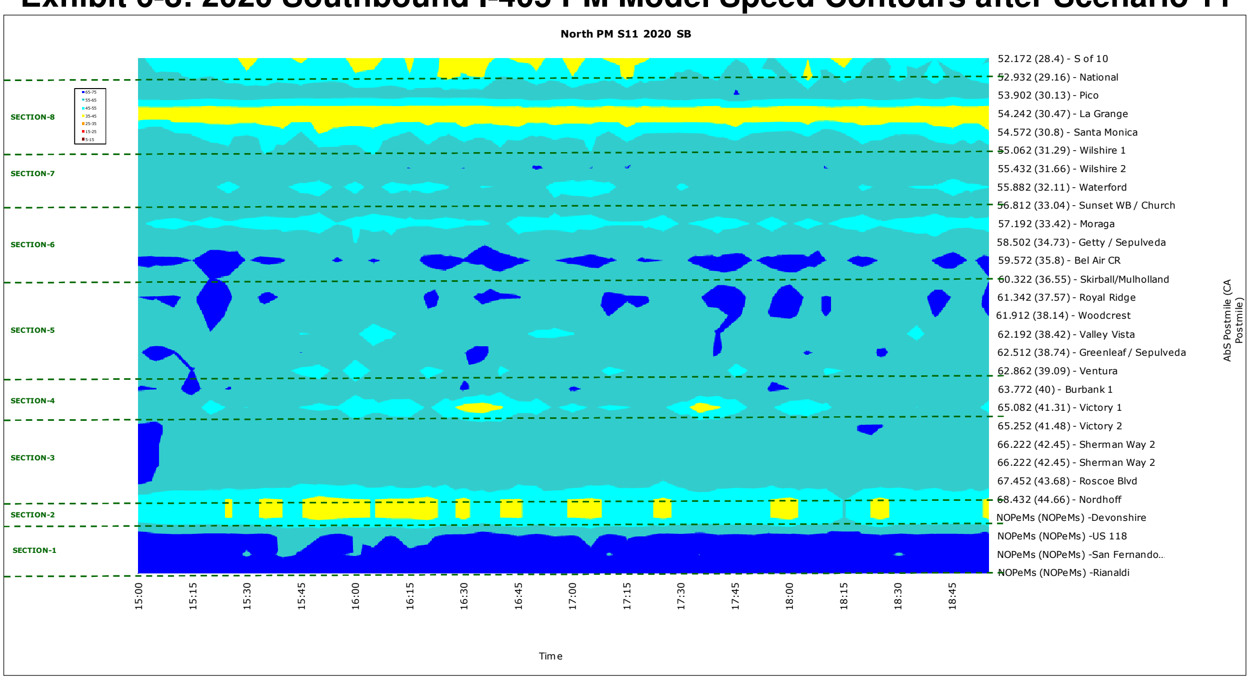


Exhibit 6-8: 2020 Southbound I-405 PM Model Speed Contours after Scenario 11



I-405 South Corridor Speed Contour Maps

Exhibit 6-9 and 6-10 show the northbound I-405 corridor speed contour maps produced by the model at the future horizon baseline. This represents the condition of the future 2020 with only minimal improvements such as signal improvements at intersections. As shown, by 2020 there is significant congestion throughout the corridor in the AM peak and at the Normandie Avenue and the I-10 in the PM peak. Exhibits 6-11 and 6-12 illustrate the southbound I-405 corridor speed contour maps produced by the model at the future horizon baseline with only minimal improvements. As indicated, by 2020 there is noticeable congestion from I-10 to Howard Hughes and at I-110 in the AM peak and significant congestion throughout the corridor in the PM peak.

Exhibit 6-13 and 6-14 show the northbound I-405 corridor speed contour maps produced by the model at the conclusion of Scenario 10, final alternative scenario tested in this direction on recurrent congestion. Scenario 12 is the last alternative tested; however, the results are not as positive as Scenario 10. These maps indicate the last remaining residual congestion and bottleneck locations. As shown, by 2020, there is only a modest amount of congestion at I-10 in the AM peak and minimal congestion in the PM peak, after all of the scenario improvements to Scenario 10 are implemented. Exhibits 6-15 and 6-16 illustrate the southbound I-405 corridor speed contour maps produced by the model at the conclusion of Scenario 10. As indicated, by 2020 there still some residual congestion approaching I-110 in the AM and PM peak, and also at El Segundo Boulevard in the PM peak.

Exhibit 6-9: 2020 Northbound I-405 AM Model Speed Contours at Baseline

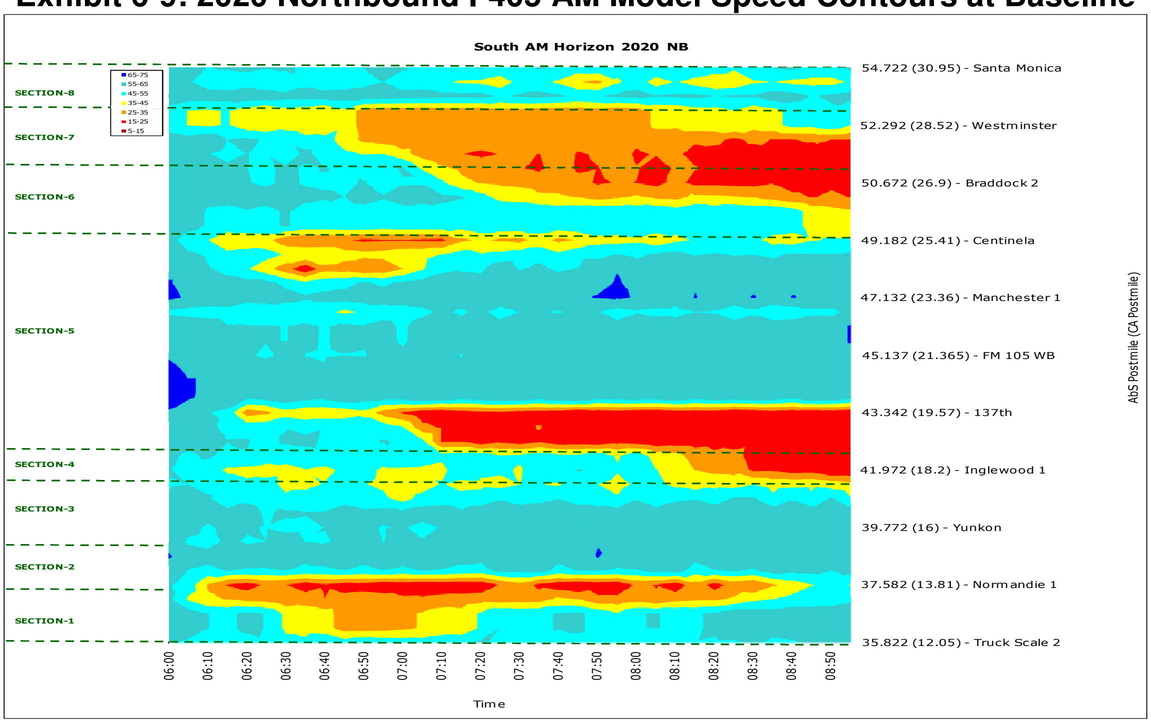


Exhibit 6-10: 2020 Northbound I-405 PM Model Speed Contours at Baseline

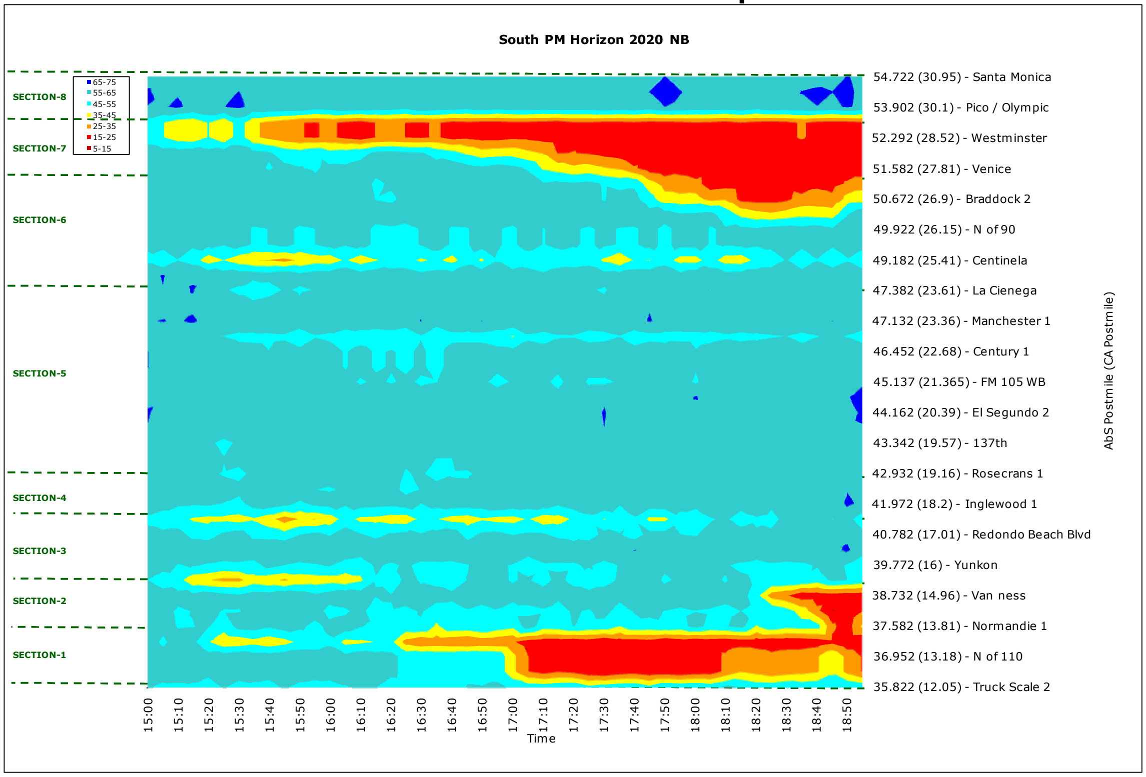


Exhibit 6-11: 2020 Southbound I-405 AM Model Speed Contours at Baseline

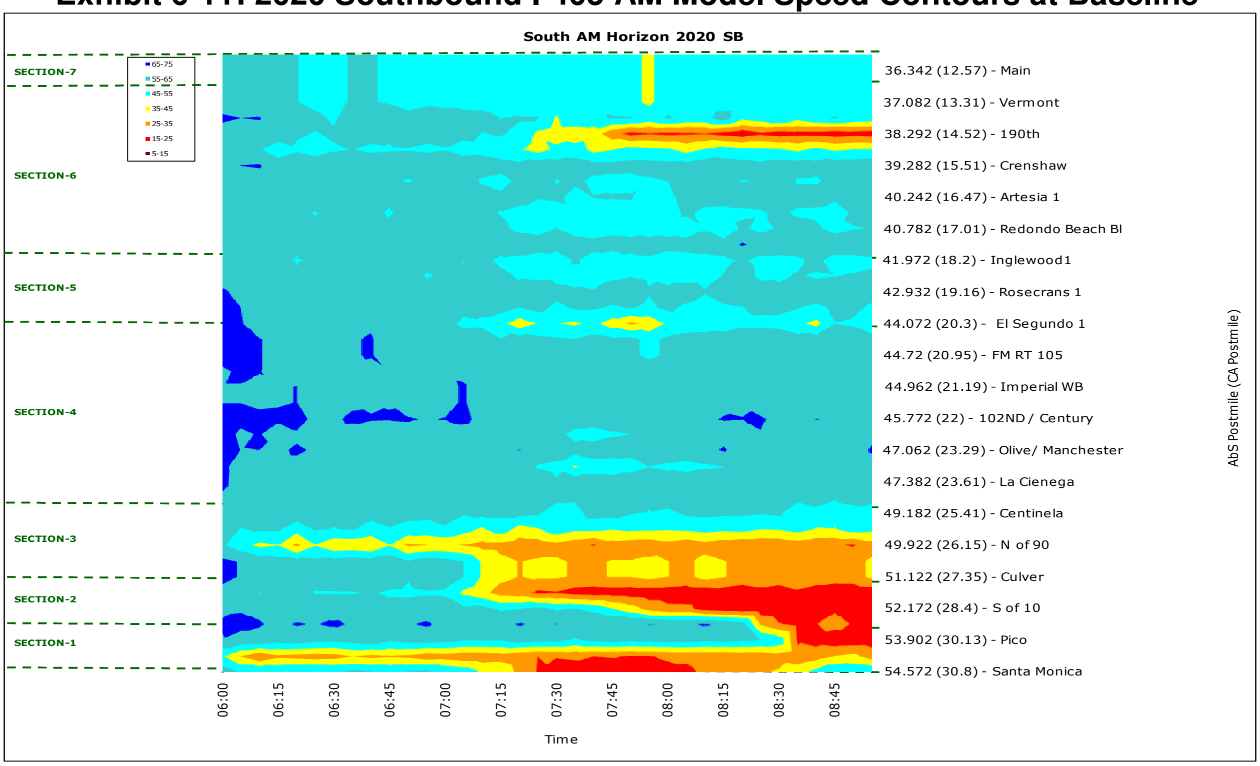


Exhibit 6-12: 2020 Southbound I-405 PM Model Speed Contours at Baseline

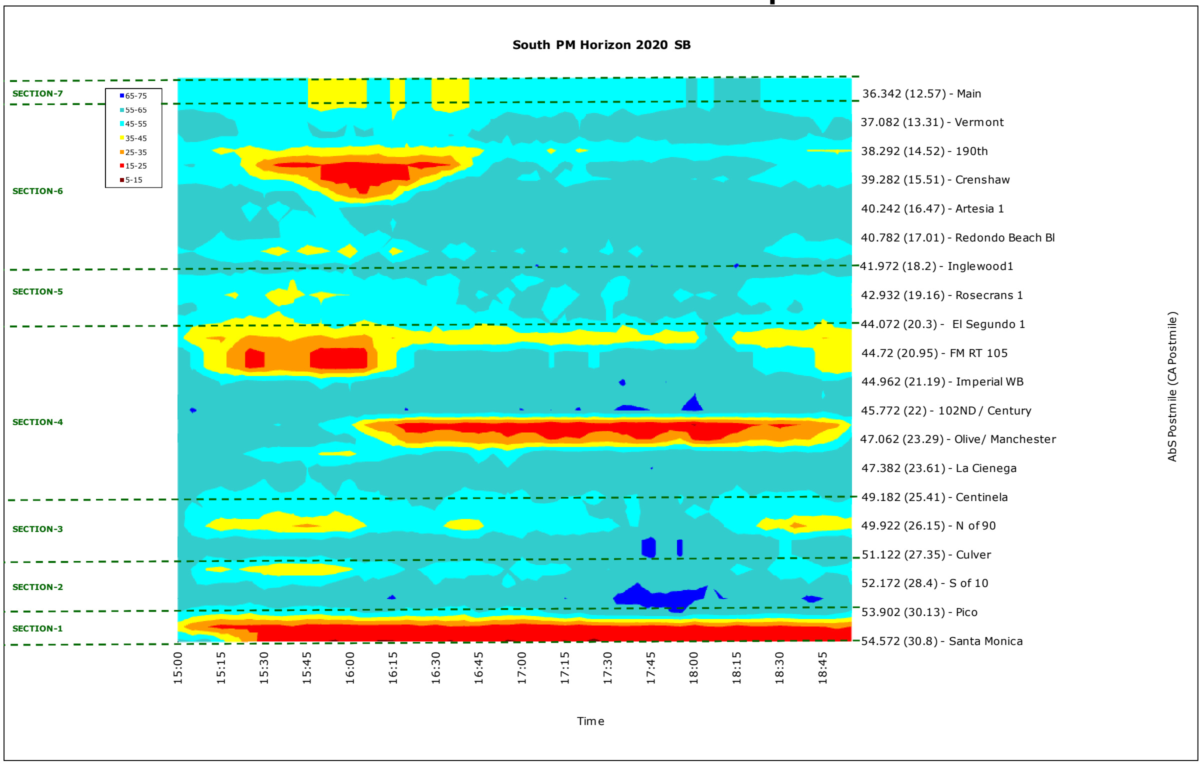


Exhibit 6-13: 2020 Northbound I-405 AM Model Speed Contours after Scenario 10

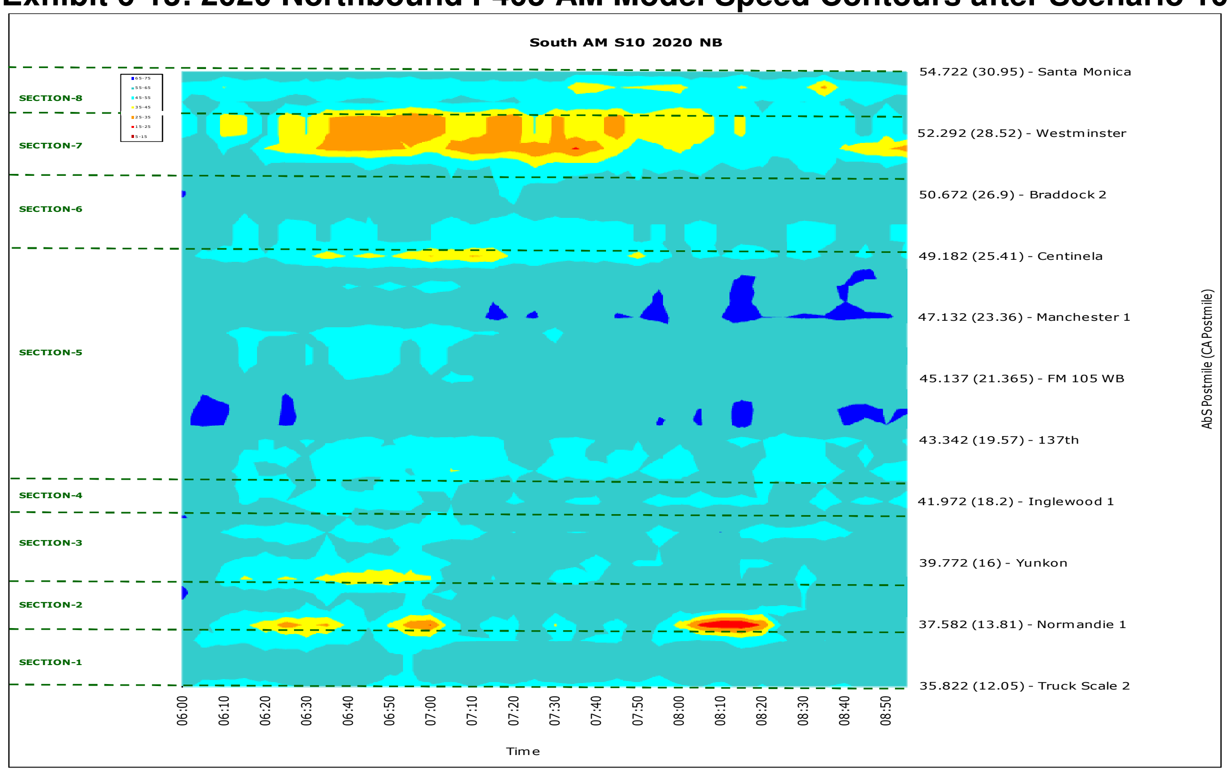


Exhibit 6-14: 2020 Northbound I-405 PM Model Speed Contours after Scenario 10

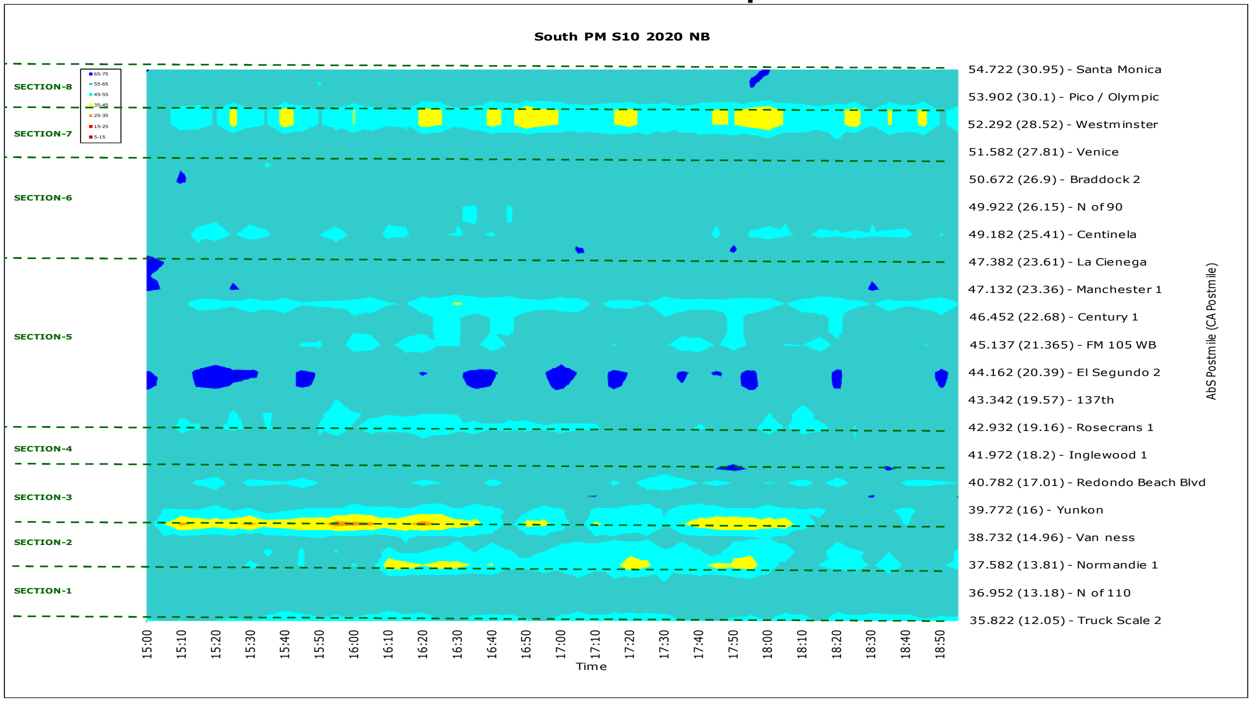


Exhibit 6-15: 2020 Southbound I-405 AM Model Speed Contours after Scenario 10

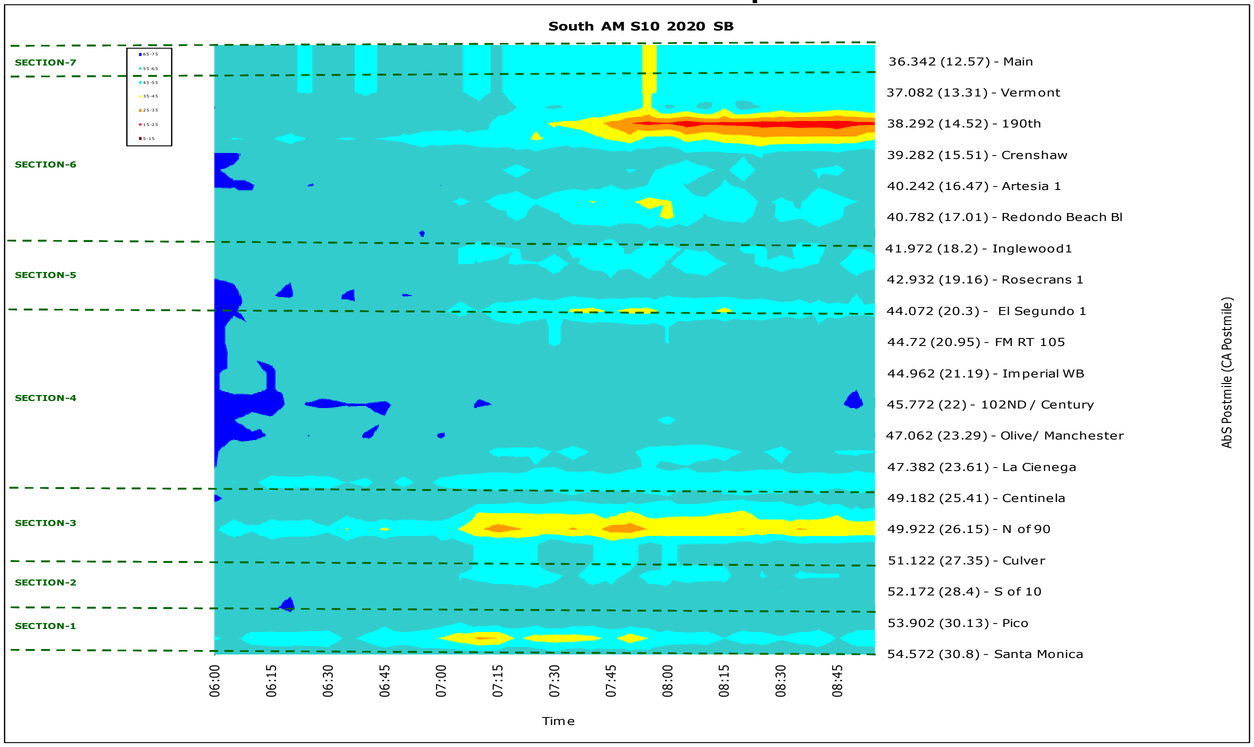
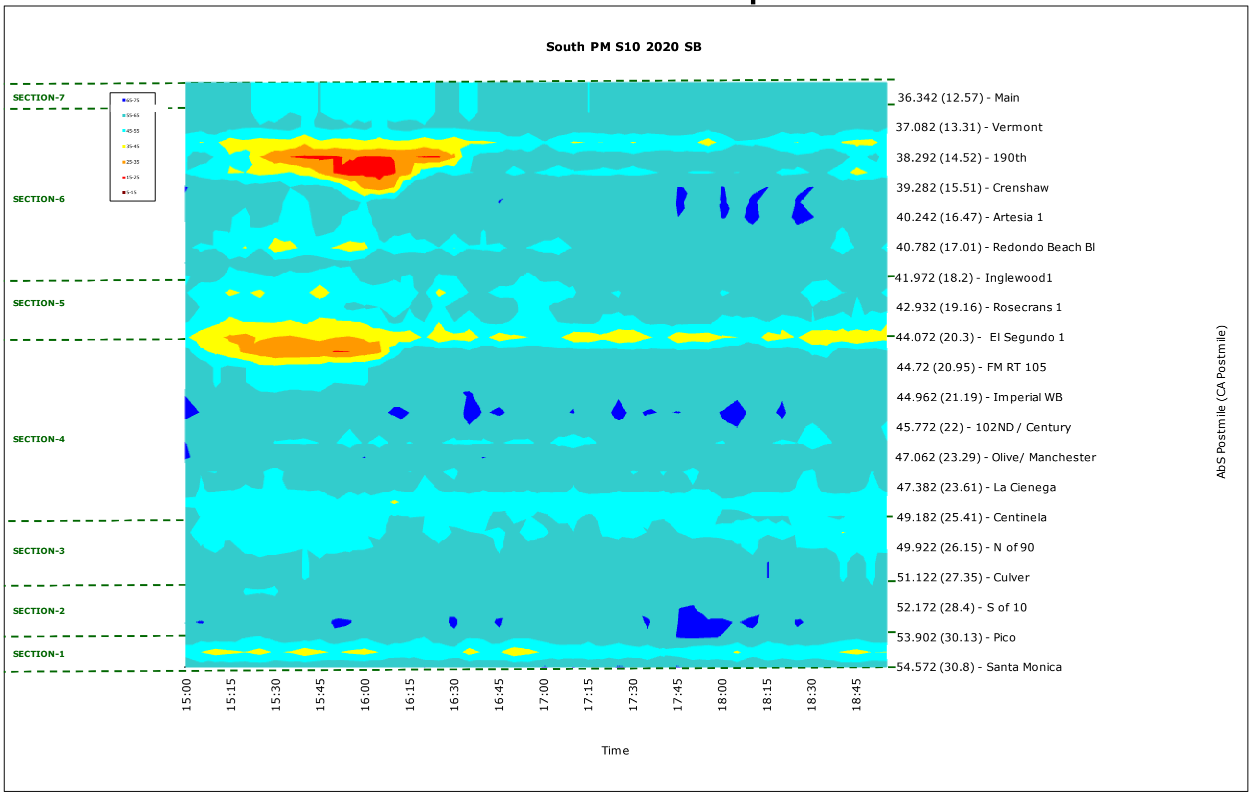


Exhibit 6-16: 2020 Southbound I-405 PM Model Speed Contours after Scenario 10



This is the first generation CSMP for the I-405 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 a variation thereof, should become the normal course of business that is based on 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 the productivity of the current system.

Appendix A: Project Lists for Micro-Simulation Scenarios

North I-405 Corridor

Scenario	RTIP ID/EA	Improvement	Lead Agency	Expected Compl Date	Source	Est Total Proj Cost (in 1,000s)*
1 (2003-1) 2 (2020-1)	LA996135 EA 19100	NB Mulholland to Ventura Blvd - aux lane NB	Caltrans	COMPL 03/2003	02 TIP	$ 9,676
	LA996136 EA 19130	NB from Ventura Blvd to SB-101 Kesler Ave connector widening (widen ramp to add lane)	Caltrans	COMPL 06/2004	02 TIP	$ 9,856
	LA0C8344 EA 19962	Extension of N/B I-405 HOV lane-to extend the HOV lane on N/B I-405 from south of Ventura Bl to so. Burbank Blvd where it will join the existing HOV lane.	Caltrans	COMPL 07/2008	02, 04, 06, 08 TIP	$ 7,780
	LA0D194 EA 20120K	Rte 405/101 connector gap closure	Caltrans	COMPL 08/2008	02, 04, 06, 08 TIP	$ 52,071
	LA195900 LA0D193	Waterford Ave. to Rte 10 - aux lane: Waterford Av. to Rte 10 - construct SB aux lane & SB HOV lane	Caltrans	COMPL 04/2009	02, 04, 06, 08 TIP	$ 53,484
3 (2003-2) 4 (2020-2)	LA0B408 EA 12030	From Rte 10 to Rte 101 widen for HOV lane & modify ramps, add new WB on ramp at Sunset & HOV ingress/egress at Santa Monica Blvd	Metro	2016	02, 04, 06, 08 TIP CMIA	$ 1,034,000
	LA0D77 EA 19961	At Rte 405 & US 101 IC. Construct freeway connector from SB Rte 405 to NB & SB US 101 & add aux lane from Burbank to NB 101 connector	Caltrans	2016	02, 04, 06, 08 TIP	$ 281,962
5 (2003-3) 6 (2020-3)	EA 26520	SB 405 between Sunset Blvd and Muholland Dr - Construct deceleration lane	Caltrans	2014	SHOPP proposed	$ 4,114
	EA 20490K	Widening of Ventura Blvd on-ramp to SB 405 from 2 lanes to 3 lanes	Caltrans	2013	SPSR	$ 3,888
7 (2003-4) 8 (2020-4)	Proposed (SMG)	Advanced Ramp Metering with queue control. Connector metering at SR-90, I-10 and SR-118 with possibly widening for more storage.			Proposed	$ 10,000
9 (2003-5) 10 (2020-5)	Proposed (SMG)	NB-405: Add NB aux lane from Victory on to Sherman Way off				$ 30,000
		NB-405: Widen to add NB lane from SR-118 off to Devonshire on-ramp				
11 (2020-6)	1H0103 EA 17610K	HOV direct connector with I-5 (Alternative 2, July 2006 PSR)	Caltrans	2029	08 RTP Metro LRTP	$ 330,000
12 (2020-7) 13 (2020-8) -Builds on	Proposed	Enhanced Incident Management System (incident clearance time reduction from current and with improvements)				$ 10,000

* Total cost includes construction and support costs in current dollars

South I-405 Corridor

Scenario	RTIP ID/EA	Improvement	Lead Agency	Expected Compl Date	Source	Est Total Proj Cost (in 1,000s)*
1 (2003-1) 2 (2020-1)	11985 EA 1198U	From Rte 105 to Rte 90 - 6 lane freeway, add 2 HOV lanes and soundwalls.	Caltrans	COMPL 04/2008	02, 04, 06 TIP	$ 67,372
	1178A EA 1178U	From Rte 90 to Rte 10 - HOV lanes (sb 5+0 to 5+1; nb 5+0 to 5+1 HOV)	Caltrans	COMPL 11/2009	02, 06, 08 TIP	$ 226,233
3 (2003-2) 4 (2020-2)	49160	In Inglewood at Arbor Vitae Ave-construct south half of Interchange	Caltrans	2013	02, 04, 06, 08 TIP	$ 62,495
5 (2003-3) 6 (2020-3)	LA0D332 EA 24130	From La Tijera Blvd to Jefferson Blvd; add NB auxiliary lane	Caltrans	2011	04, 06, 08 TIP; 04 & 06 SHOPP	$ 39,358
	Measure R (Set 1)	I-405 at 182nd Street/Crenshaw Blvd: widen NB off-ramp to 182nd St; modify the signal at terminus	Torrance Caltrans		Measure R (#2)	$ 13,000
		I-405 at Hawthorne Blvd: Construct new on-ramp for SB Hawthorne Blvd onto NB I-405. Upgrade signals at SB & NB ramps	Lawndale Caltrans		Measure R (#10)	$13,000 (SMG est)
		I-405 at Rosecrans/Hindry Ave: Widen SB I-405 off-ramp onto Hindry Ave & install signal	Hawthorne Caltrans		Measure R (#12)	$ 13,000
		Eliminate lane drop on NB I-405 at Normandie by adding an auxiliary lane to the Western Ave off-ramp	Caltrans		Measure R (SMG-proposed)	$20,000 (SMG est)
7 (2003-4) 8 (2020-4)	Proposed (SMG)	Advanced Ramp Metering with queue control. Connector metering at SR-90, I-10 and SR-118 with possibly widening for more storage.			Proposed	$ 10,000
9 (2003-5) 10 (2020-5)	Measure R (Set 2)	Add N/B auxiliary lane from Hawthorne Bl to Inglewood Ave			Measure R (#6)	$ 52,000
		Add N/B auxiliary lane from Inglewood Ave to Rosecrans Ave			Measure R (#9)	$ 51,000
		Add N/B Lane from ~~Hawthorne Bl~~ south of El Segundo to I-105			Measure R (#13)	$ 10,000
		Add S/B auxiliary lane from Howard Hughes Pkwy to ~~Florence Ave~~ Century			Measure R (#17)	$ 10,000

* Total cost includes construction and support costs in current dollars

South I-405 Corridor (continued)

Scenario	RTIP ID/EA	Improvement	Lead Agency	Expected Compl Date	Source	Est Total Proj Cost (in 1,000s)*
11 (2003-6) 12 (2020-6) -Build on Sc 7/8	Measure R (Set 3)	I-405 @ Crenshaw Bl: construct new S/B On-Ramp from N/B Crenshaw Bl			Measure R (#3)	$ 13,000
		Add N/B auxiliary lane from Redondo Beach Bl to Hawthorne Bl			Measure R (#5)	$ 31,000
		I-405 @ Rosecrans Ave: Widen N/B off-ramp			Measure R (#11)	$ 13,000
		~~Realign south of SR-90 at bend north of Manchester Bl~~			Measure R (#18)	
		Crenshaw Bl @ 182nd St: Widen 182nd Street and east side of Crenshaw Bl (3 N/B through), modify signal. Modify N/B on-ramp from 182nd St to provide 2 lanes, modify signal.			Measure R (#20)	$ 10,000
13 (2020-7) 14 (2020-8) -Builds on Sc 6	Proposed	Enhanced Incident Management System (incident clearance time reduction from current and with improvements)				$ 10,000

* Total cost includes construction and support costs in current dollars

Appendix B: Benefit-Cost Analysis Results

This appendix provides more detailed Benefit-Cost Analysis (BCA) results than found in Section 5 of the I-405 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* developed for Caltrans by System Metrics Group, Inc. (SMG).

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 CO2 Emissions (tons)** -additional CO2 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 CO2 emissions.
- **Additional CO2 Emissions (in millions of dollars)** - valued CO2 emissions 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: I-405 North Corridor Scenarios 1 & 2 (Completed Projects between 2003-2009) Benefit-Cost Analysis Results
- Exhibit B-2: I-405 North Corridor Scenarios 3 & 4 (Northbound HOV Lane, US-101 Connector) Benefit-Cost Analysis Results
- Exhibit B-3: I-405 North Corridor Scenarios 5 & 6 (Deceleration Lane & Ramp Widening) Benefit-Cost Analysis Results
- Exhibit B-4: I-405 North Corridor Scenarios 7 & 8 (Advanced Ramp Metering) Benefit-Cost Analysis Results
- Exhibit B-5: I-405 North Corridor Scenarios 9 & 10 (Northbound Widening & Aux Lane) Benefit-Cost Analysis Results
- Exhibit B-6: I-405 North Corridor Scenario 11 (HOV Direct Connector at I-5) Benefit-Cost Analysis Results
- Exhibit B-7: I-405 North Corridor Cumulative Benefit-Cost Analysis Results

- Exhibit B-8: I-405 South Corridor Scenarios 1 & 2 (HOV Lane from I-105 to I-10) Benefit-Cost Analysis Results
- Exhibit B-9: I-405 South Corridor Scenarios 3 & 4 (Arbor Vitae south half of interchange) Benefit-Cost Analysis Results
- Exhibit B-10: I-405 South Corridor Scenarios 5 & 6 (Operational Improvements – Measure R Set 1) Benefit-Cost Analysis Results
- Exhibit B-11: I-405 South Corridor Scenarios 7 & 8 (Advanced Ramp Metering) Benefit-Cost Analysis Results
- Exhibit B-12: I-405 South Corridor Scenarios 9 & 10 (Aux Lane Improvements – Measure R Set 2) Benefit-Cost Analysis Results
- Exhibit B-13: I-405 South Corridor Scenarios 11 & 12 (Operational Improvements – Measure R Set 3) Benefit-Cost Analysis Results
- Exhibit B-14: I-405 South Corridor Cumulative Benefit-Cost Analysis Results

Exhibit B-1: I-405 North Corridor Scenarios 1 & 2 (Completed Projects between from 2003 to 2010) Benefit-Cost Analysis Results

3

INVESTMENT ANALYSIS

SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$132.9
Life-Cycle Benefits (mil. $)	$281.4
Net Present Value (mil. $)	$148.5
Benefit / Cost Ratio:	2.1
Rate of Return on Investment:	18.8%
Payback Period:	5 years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$12.0	$240.4
Veh. Op. Cost Savings	$1.4	$28.9
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$0.6	$12.1
TOTAL BENEFITS	$14.1	$281.4
Person-Hours of Time Saved	1,300,590	26,011,807
Additional CO_2 Emissions (tons)	-5,971	-119,413
Additional CO_2 Emissions (mil. $	-$0.2	-$3.8

Incremental Costs (mil. $)	$132.9
Incremental Benefits (mil. $)	$281.4
Incremental Benefit / Cost Ratio	2.1

Exhibit B-2: I-405 North Corridor Scenarios 3 & 4 (Northbound HOV Lane, US-101 Connector) Benefit-Cost Analysis Results

3

INVESTMENT ANALYSIS

SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$1,448.8
Life-Cycle Benefits (mil. $)	$1,014.2
Net Present Value (mil. $)	-$434.6
Benefit / Cost Ratio:	0.7
Rate of Return on Investment:	0.5%
Payback Period:	20 years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$41.7	$834.7
Veh. Op. Cost Savings	$6.6	$132.8
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$2.3	$46.8
TOTAL BENEFITS	$50.7	$1,014.2
Person-Hours of Time Saved	5,014,651	100,293,022
Additional CO_2 Emissions (tons)	-31,693	-633,862
Additional CO_2 Emissions (mil. $)	-$0.9	-$18.9

Incremental Costs (mil. $)	$1,316.0
Incremental Benefits (mil. $)	$732.9
Incremental Benefit / Cost Ratio	0.6

Exhibit B-3: I-405 North Corridor Scenarios 5 & 6 (Deceleration Lane & Ramp Widening) Benefit-Cost Analysis Results

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INVESTMENT ANALYSIS

SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$1,456.8
Life-Cycle Benefits (mil. $)	$1,053.5
Net Present Value (mil. $)	-$403.4
Benefit / Cost Ratio:	0.7
Rate of Return on Investment:	0.8%
Payback Period:	19 years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$43.2	$864.8
Veh. Op. Cost Savings	$7.0	$139.3
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$2.5	$49.4
TOTAL BENEFITS	$52.7	$1,053.5
Person-Hours of Time Saved	5,208,779	104,175,574
Additional CO_2 Emissions (tons)	-33,303	-666,067
Additional CO_2 Emissions (mil. $)	-$1.0	-$19.9

Incremental Costs (mil. $)	$8.0
Incremental Benefits (mil. $)	$39.2
Incremental Benefit / Cost Ratio	4.9

Exhibit B-4: I-405 North Corridor Scenarios 7 & 8 (Advanced Ramp Metering) Benefit-Cost Analysis Results

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INVESTMENT ANALYSIS
SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$1,466.8
Life-Cycle Benefits (mil. $)	$1,121.8
Net Present Value (mil. $)	-$345.1
Benefit / Cost Ratio:	0.8
Rate of Return on Investment:	1.3%
Payback Period:	18 years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$46.1	$921.5
Veh. Op. Cost Savings	$7.4	$148.2
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$2.6	$52.0
TOTAL BENEFITS	$56.1	$1,121.8
Person-Hours of Time Saved	5,573,137	111,462,748
Additional CO_2 Emissions (tons)	-35,775	-715,494
Additional CO_2 Emissions (mil. $)	-$1.1	-$21.2

Incremental Costs (mil. $)	$10.0
Incremental Benefits (mil. $)	$68.3
Incremental Benefit / Cost Ratio	6.8

Exhibit B-5: I-405 North Corridor Scenarios 9 & 10 (Northbound Widening & Aux Lane) Benefit-Cost Analysis Results

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INVESTMENT ANALYSIS
SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$1,496.8
Life-Cycle Benefits (mil. $)	$1,285.8
Net Present Value (mil. $)	-$211.1
Benefit / Cost Ratio:	0.9
Rate of Return on Investment:	2.5%
Payback Period:	17 years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$52.3	$1,046.1
Veh. Op. Cost Savings	$8.9	$177.8
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$3.1	$61.9
TOTAL BENEFITS	$64.3	$1,285.8
Person-Hours of Time Saved	6,368,446	127,368,929
Additional CO_2 Emissions (tons)	-43,221	-864,420
Additional CO_2 Emissions (mil. $)	-$1.3	-$25.6

Incremental Costs (mil. $)	$30.0
Incremental Benefits (mil. $)	$164.0
Incremental Benefit / Cost Ratio	5.5

Exhibit B-6: I-405 North Corridor Scenario 11 (HOV Direct Connector at I-5) Benefit-Cost Analysis Results

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INVESTMENT ANALYSIS
SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$330.0
Life-Cycle Benefits (mil. $)	$18.7
Net Present Value (mil. $)	-$311.3
Benefit / Cost Ratio:	0.1
Rate of Return on Investment:	#DIV/0!
Payback Period:	20+ years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$1.1	$21.0
Veh. Op. Cost Savings	-$0.1	-$1.4
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	-$0.0	-$0.9
TOTAL BENEFITS	$0.9	$18.7
Person-Hours of Time Saved	124,249	2,484,974
Additional CO_2 Emissions (tons)	286	5,721
Additional CO_2 Emissions (mil. $)	$0.0	$0.2

Exhibit B-7: I-405 North Corridor Cumulative Benefit-Cost Analysis Results

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INVESTMENT ANALYSIS
SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$1,826.8
Life-Cycle Benefits (mil. $)	$1,304.5
Net Present Value (mil. $)	-$522.3
Benefit / Cost Ratio:	0.7
Rate of Return on Investment:	n/a
Payback Period:	n/a

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$53.4	$1,067.2
Veh. Op. Cost Savings	$8.8	$176.4
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$3.0	$61.0
TOTAL BENEFITS	$65.2	$1,304.5
Person-Hours of Time Saved	6,492,695	129,853,903
Additional CO_2 Emissions (tons)	-42,935	-858,698
Additional CO_2 Emissions (mil. $)	-$1.3	-$25.4

Exhibit B-8: I-405 South Corridor Scenarios 1 & 2 (HOV Lane from I-105 to I-10) Benefit-Cost Analysis Results

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INVESTMENT ANALYSIS

SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$293.6
Life-Cycle Benefits (mil. $)	$605.3
Net Present Value (mil. $)	$311.7
Benefit / Cost Ratio:	2.1
Rate of Return on Investment:	13.5%
Payback Period:	8 years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$24.8	$496.5
Veh. Op. Cost Savings	$4.1	$82.0
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$1.3	$26.8
TOTAL BENEFITS	$30.3	$605.3
Person-Hours of Time Saved	2,932,145	58,642,894
Additional CO_2 Emissions (tons)	-19,966	-399,316
Additional CO_2 Emissions (mil. $)	-$0.6	-$11.8

Incremental Costs (mil. $)	$293.6
Incremental Benefits (mil. $)	$605.3
Incremental Benefit / Cost Ratio	2.1

Exhibit B-9: I-405 South Corridor Scenarios 3 & 4 (Arbor Vitae south half of interchange) Benefit-Cost Analysis Results

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INVESTMENT ANALYSIS

SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$356.1
Life-Cycle Benefits (mil. $)	$705.5
Net Present Value (mil. $)	$349.4
Benefit / Cost Ratio:	2.0
Rate of Return on Investment:	12.7%
Payback Period:	8 years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$28.9	$578.6
Veh. Op. Cost Savings	$4.8	$95.6
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$1.6	$31.3
TOTAL BENEFITS	$35.3	$705.5
Person-Hours of Time Saved	3,443,202	68,864,039
Additional CO_2 Emissions (tons)	-23,342	-466,841
Additional CO_2 Emissions (mil. $)	-$0.7	-$13.8

Incremental Costs (mil. $)	$62.5
Incremental Benefits (mil. $)	$100.2
Incremental Benefit / Cost Ratio	1.6

Exhibit B-10: I-405 South Corridor Scenarios 5 & 6 (Operational Improvements – Measure R Set 1) Benefit-Cost Analysis Results

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INVESTMENT ANALYSIS
SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$454.5
Life-Cycle Benefits (mil. $)	$841.8
Net Present Value (mil. $)	$387.4
Benefit / Cost Ratio:	1.9
Rate of Return on Investment:	11.6%
Payback Period:	9 years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$34.3	$686.9
Veh. Op. Cost Savings	$5.8	$116.5
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$1.9	$38.5
TOTAL BENEFITS	$42.1	$841.8
Person-Hours of Time Saved	4,096,836	81,936,718
Additional CO_2 Emissions (tons)	-28,518	-570,361
Additional CO_2 Emissions (mil. $	-$0.8	-$16.8

Incremental Costs (mil. $)	$98.4
Incremental Benefits (mil. $)	$136.4
Incremental Benefit / Cost Ratio	1.4

Exhibit B-11: I-405 South Corridor Scenarios 7 & 8 (Advanced Ramp Metering) Benefit-Cost Analysis Results

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INVESTMENT ANALYSIS
SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$464.5
Life-Cycle Benefits (mil. $)	$870.1
Net Present Value (mil. $)	$405.7
Benefit / Cost Ratio:	1.9
Rate of Return on Investment:	11.7%
Payback Period:	9 years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$35.6	$711.1
Veh. Op. Cost Savings	$6.0	$119.5
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$2.0	$39.5
TOTAL BENEFITS	$43.5	$870.1
Person-Hours of Time Saved	4,246,676	84,933,511
Additional CO_2 Emissions (tons)	-29,233	-584,653
Additional CO_2 Emissions (mil. $	-$0.9	-$17.3

Incremental Costs (mil. $)	$10.0
Incremental Benefits (mil. $)	$28.3
Incremental Benefit / Cost Ratio	2.8

Exhibit B-12: I-405 South Corridor Scenarios 9 & 10 (Aux Lane Improvements – Measure R Set 2) Benefit-Cost Analysis Results

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INVESTMENT ANALYSIS
SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$587.5
Life-Cycle Benefits (mil. $)	$921.0
Net Present Value (mil. $)	$333.6
Benefit / Cost Ratio:	1.6
Rate of Return on Investment:	9.3%
Payback Period:	10 years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$38.5	$769.4
Veh. Op. Cost Savings	$5.7	$114.9
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$1.8	$36.7
TOTAL BENEFITS	$46.1	$921.0
Person-Hours of Time Saved	4,596,716	91,934,313
Additional CO_2 Emissions (tons)	-28,166	-563,320
Additional CO_2 Emissions (mil. $	-$0.8	-$16.6

Incremental Costs (mil. $)	$123.0
Incremental Benefits (mil. $)	$50.9
Incremental Benefit / Cost Ratio	0.4

Exhibit B-13: I-405 South Corridor Scenarios 11 & 12 (Operational Improvements – Measure R Set 3) Benefit-Cost Analysis Results

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INVESTMENT ANALYSIS
SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$531.5
Life-Cycle Benefits (mil. $)	$890.2
Net Present Value (mil. $)	$358.8
Benefit / Cost Ratio:	1.7
Rate of Return on Investment:	10.1%
Payback Period:	9 years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$36.5	$730.8
Veh. Op. Cost Savings	$6.0	$119.9
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$2.0	$39.5
TOTAL BENEFITS	$44.5	$890.2
Person-Hours of Time Saved	4,373,606	87,472,118
Additional CO_2 Emissions (tons)	-29,338	-586,766
Additional CO_2 Emissions (mil. $	-$0.9	-$17.3

Incremental Costs (mil. $)	$67.0
Incremental Benefits (mil. $)	$20.1
Incremental Benefit / Cost Ratio	0.3

Exhibit B-14: I-405 South Corridor Cumulative Benefit-Cost Analysis Results

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INVESTMENT ANALYSIS

SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$587.5
Life-Cycle Benefits (mil. $)	$921.0
Net Present Value (mil. $)	$333.6
Benefit / Cost Ratio:	1.6
Rate of Return on Investment:	9.3%
Payback Period:	10 years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$38.5	$769.4
Veh. Op. Cost Savings	$5.7	$114.9
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$1.8	$36.7
TOTAL BENEFITS	$46.1	$921.0
Person-Hours of Time Saved	4,596,716	91,934,313
Additional CO_2 Emissions (tons)	-28,166	-563,320
Additional CO_2 Emissions (mil. $	-$0.8	-$16.6