System Metrics Group, Inc.

in association with

Braidwood Associates

Corridor System Management Plan (CSMP)

Orange County SR-22 /I-405/I-605

Final Report

August 2010

State Route 22/Interstate 405/ Interstate 605

Corridor System Management Plan

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1. INTRODUCTION

This document represents the Final Report for the Orange County State Route 22/Interstate 405/Interstate 605 (SR-22/I-405/I-605) Corridor System Management Plan (CSMP) developed by the California Department of Transportation (Caltrans). This CSMP includes portions of three routes: SR-22, I-405, and I-605. The corridor begins at an interchange involving all three freeways at the Los Angeles County border. From there, the corridor runs east along SR-22 (Garden Grove Freeway) to SR-55. The corridor also runs southeast along I-405 (San Diego Freeway) until it reaches I-5 (Santa Ana Freeway) in Irvine. The corridor includes a short, one-mile section of I-605 (San Gabriel River Freeway) as it heads north from the Los Alamitos Curve (SR-22/I-405/I-605) interchange to the Los Angeles County border.

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 Bottleneck Area Performance (Section 4)
- Bottleneck Causality Analysis (Section 5)
- Scenario Development and Evaluation (Section 6)
- Conclusions and Recommendations (Section 7).

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). The CMIA will partially fund the construction of High Occupancy Vehicle (HOV) connectors between SR-22 and I-405 as well as I-405 and I-605.

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. Project proposals with CSMPs would be given a higher priority in the funding approval process. Hence, a CSMP aims to define how corridors will be managed over time, 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 a corridor performance assessment, identifies bottlenecks that lead to congestion, and diagnoses the causes for these bottlenecks. Alternative investment strategies were modeled using 2008 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.

The report references locations on the SR-22/I-405/I-605 using two types of postmiles: a California postmile (CA PM) and an absolute postmile (Abs PM). A California postmile is assigned to a geometric feature on the freeway when the freeway was built. The absolute postmile is the actual centerline distance down the freeway from the beginning of the route to the end of the route. Unless otherwise noted, all postmiles presented in this report are CA PM.

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 Reduction, Air Quality, and Port Security Bond Act of 2006). This ballot measure included a funding program to be deposited into the CMIA. For a project to be nominated by a Caltrans district or regional agency, the CMIA guidelines require that project nominations 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 maintaining 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 SR-22 corridor. Traditional planning approaches identify localized freeway problem areas and then develop solutions to fix those problems, often by building expensive capital improvement projects. The SR-22/I-405/I-605 CSMP focuses on the system management approach with 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 more focused on reducing congestion and increasing mobility through capital and operational strategies. The future CSMP work will further address pedestrian, bicycle and transit components and seek to manage and improve the whole network as an interactive system.

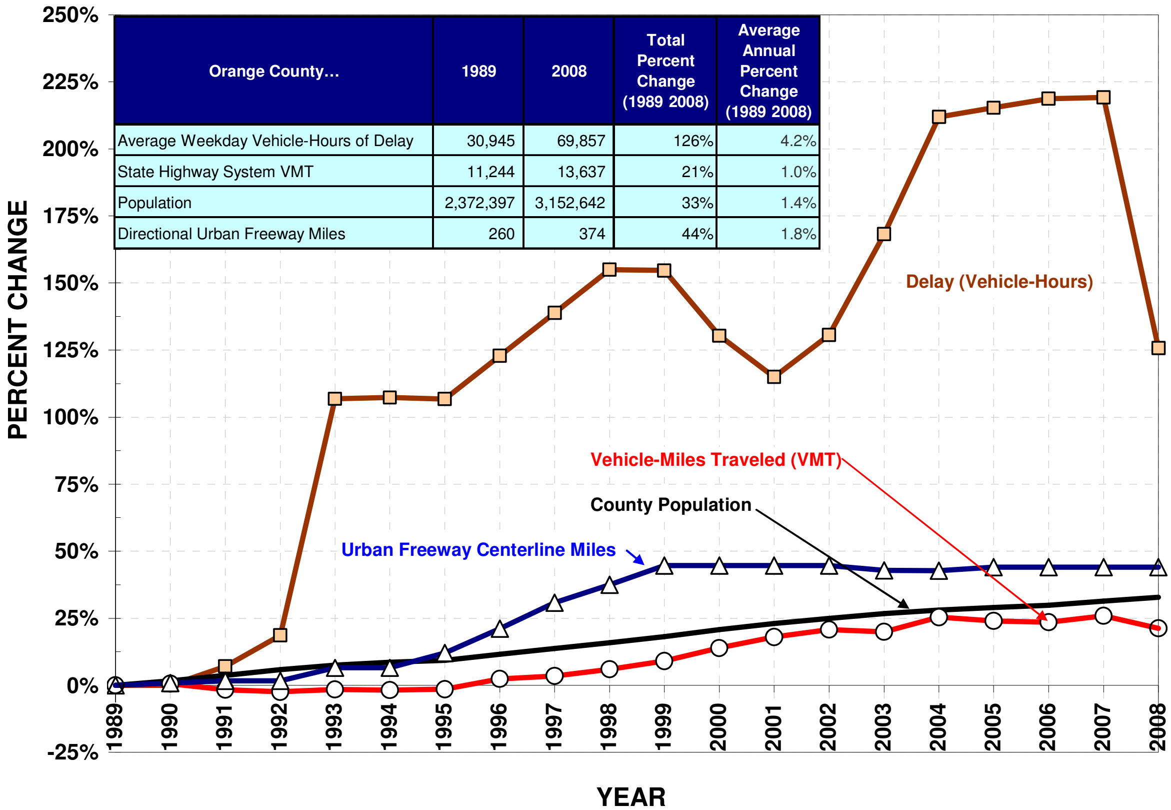
What is System Management?

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

Exhibit 1-1 shows Orange County congestion (measured by average weekday vehicle-hours of recurring delay), VMT, population, and urban freeway mileage between 1989 and 2008. Over that 20-year period, congestion grew by more than 125 percent from 1989 levels (just over four percent per year). Over the same period, VMT and population rose by 21 and 33 percent, respectively. Between 1989 and 1999, urban freeway miles grew dramatically, but since then virtually no miles have been added.

Clearly, infrastructure expansion is not keeping 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: Orange County Growth Trends (1989-2008)

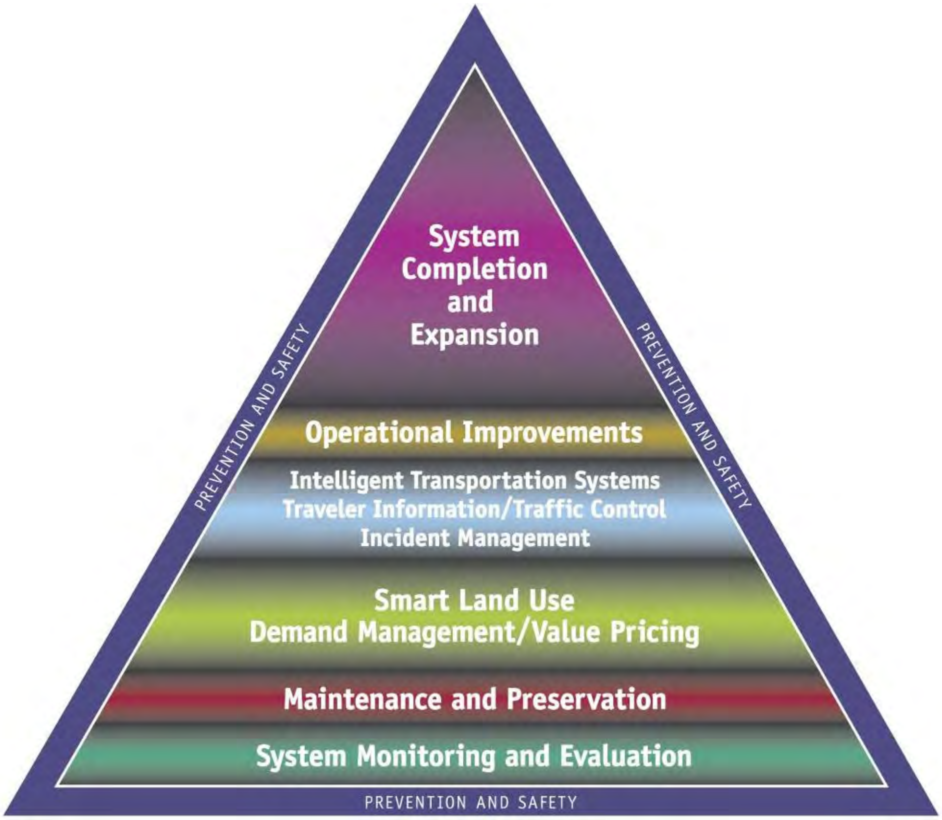


Orange County...	1989	2008	Total Percent Change (1989 2008)	Average Annual Percent Change (1989 2008)
Average Weekday Vehicle-Hours of Delay	30,945	69,857	126%	4.2%
State Highway System VMT	11,244	13,637	21%	1.0%
Population	2,372,397	3,152,642	33%	1.4%
Directional Urban Freeway Miles	260	374	44%	1.8%

Caltrans recognizes this dilemma, and 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.

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.

Exhibit 1-2: System Management Pyramid

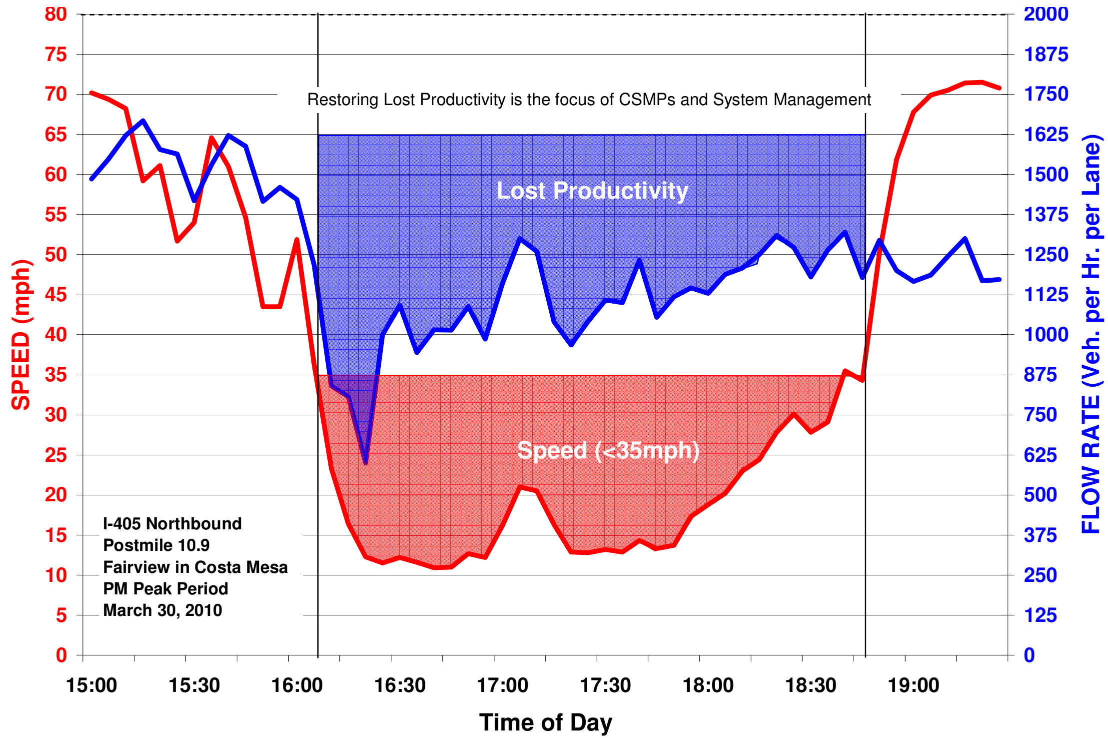


The foundation of system management is monitoring and evaluation (shown as the base of the pyramid). This monitoring is done by comprehensive performance assessment and evaluation. Understanding how a corridor performs and why it performs the way it does is critical to designing appropriate strategies. Section 2 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 Orange County's urban freeways experiencing congestion, the opposite is true. When demand is the highest, the flow breaks down and productivity declines.

Exhibit 1-3 illustrates how congestion leads to lost productivity. The exhibit was created using observed I-405 data from sensors for a typical spring 2010 afternoon peak period (March 30, 2010). It shows speeds (in red) and flow rates (in blue) on northbound I-405 at Fairview Road, one of the most congested locations on the corridor.

Exhibit 1-3: Lost Productivity Illustrated



Flow rates (measured as vehicle-per-hour-per-lane or "vphpl") at Fairview Avenue averaged around 1,600 vphpl between 3:00 PM and 4:00 PM, which is slightly less than a typical peak period maximum flow rate. Flow rates higher than approximately 2,000 vphpl cannot be sustained for a significant time.

Once volumes exceed this maximum flow rate, traffic breaks down and speeds plummet to below 35 to 45 miles per hour (mph). Rather than being able to accommodate the same number of vehicles, flow rates also drop and vehicles back up, creating what we know as congestion. At the location shown in Exhibit 1-3, throughput drops by nearly 30 percent on average during the peak period (from over 1,600 just over 1,000 vphpl). This six-lane segment therefore operates as if it were a four-lane road just when demand is at its highest. Stated differently, just when the corridor needed the most capacity, it performed in the least productive manner and effectively lost 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 exceeded 4.0 lane-miles during the AM peak period in 2009. This means that several hundred million dollars of previous investments on I-405 were idle when demand was at its highest. It is obvious that Caltrans needs to leverage these past investments to the extent possible and this can be done in large part by operational strategies.

Although still an important strategy, infrastructure expansion (at the top of the pyramid in Exhibit 1-2) cannot be the only strategy for addressing the mobility needs in Orange County. System management must be an important consideration as Caltrans and its partners evaluate the need for facility expansion investments. The system management philosophy begins by defining how the system is performing, understanding why it is performing that way, and then evaluating different strategies, including operations centric strategies, to address deficiencies. Various tools can be used to estimate potential benefits to determine if these benefits are worthy of the costs to implement the strategy.

Stakeholder Involvement

The SR-22/I-405/I-605 CSMP involved corridor stakeholders including representatives from cities bordering all three corridors; the Orange County Transportation Authority (OCTA); and the Southern California Association of Governments (SCAG). Caltrans briefed these stakeholders at critical milestones. Feedback from the stakeholders helped solidify the findings of the performance assessment, bottleneck identification, and causality analysis, given their intimate knowledge of local conditions. Moreover, the corridor stakeholders have provided support and insight, and shared valuable field and project data without which this study would not have been possible.

The stakeholders included representatives from the following organizations:

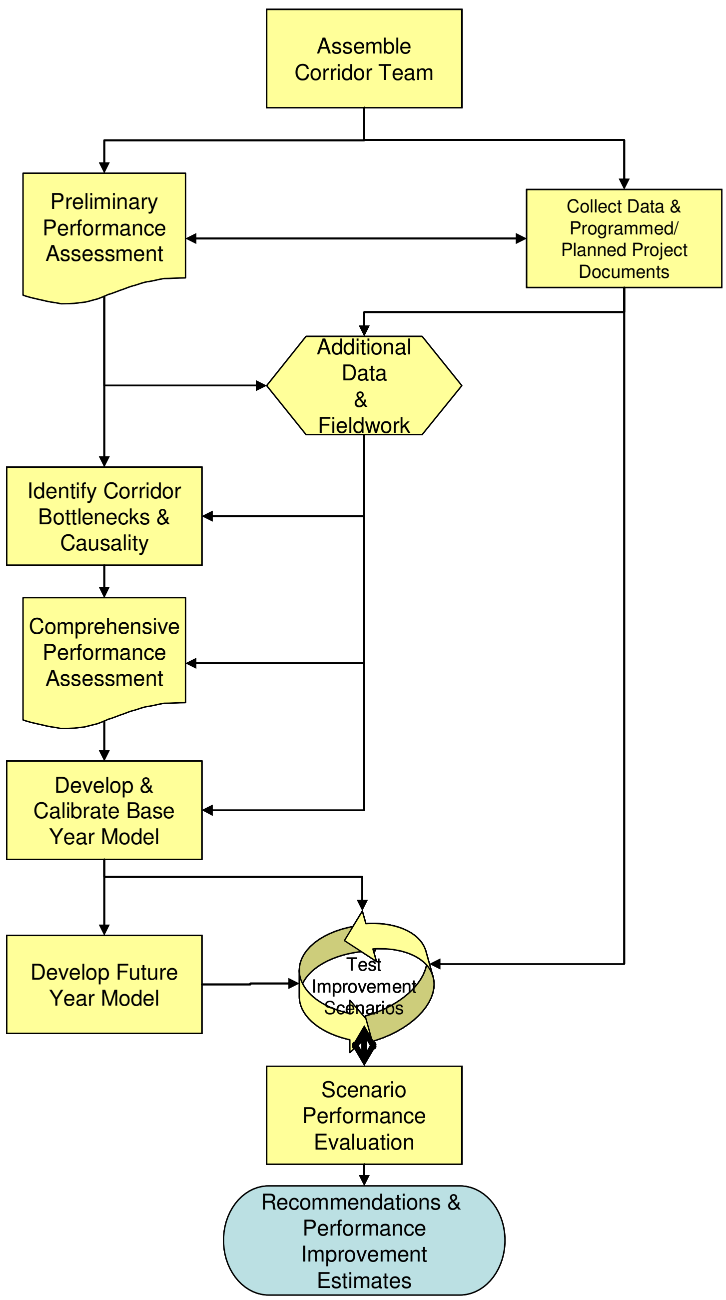
- OCTA
- SCAG
- City of Costa Mesa
- City of Fountain Valley
- City of Garden Grove
- City of Huntington Beach
- City of Irvine
- City of Los Alamitos
- City of Orange
- City of Santa Ana
- City of Seal Beach
- City of Stanton
- City of Westminster.

Caltrans would like to thank all of its partners for contributing to this CSMP development process. In addition, the CSMP development provided a venue for tighter coordination between Caltrans planning and operations professionals, which is critical to the success of the system management approach.

Study Approach

The 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 following the chart.

Exhibit 1-4: Study Approach



Assemble Corridor Team

Caltrans District 12 assembled a CSMP Project Development Team, which consists of members from various divisions within Caltrans (Planning, Traffic Operations, Maintenance, and Modeling) as well as representatives from OCTA and SCAG. The CSMP team reviewed project progress and provided continuous feedback throughout the study. Additionally, Caltrans identified along the SR-22/I-405/I-605 CSMP corridor, cities and other major stakeholders, whose input would be needed at critical project junctures (e.g., performance assessments, scenario reviews, and final report). The stakeholders group met several times during the study period to receive local feedback on project status updates and agree on project milestones.

Preliminary Performance Assessment

The Preliminary Performance Assessment Report delivered in 2007 presented a brief description of the corridor and existing projects along on or adjacent to SR-22 and 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 SR-22/I-405/I-605 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 to this final 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 time frames to be included in the Paramics micro-simulation model developed by the study team.

Details of the projects included in the scenario analysis are discussed in Section 6: Scenario Development and Evaluation.

Additional Data Collection and Fieldwork

The study team determined locations where additional manual traffic counts would be needed to calibrate the 2008 Base Year model and coordinated the collection of the traffic count data. Traffic data counts collected included peak period turning movement counts and 24-hour average daily traffic (ADT) counts. In addition, signal timing data were obtained from Caltrans and various cities for use in the model calibration.

The study team conducted several field visits in the fall of 2007 and throughout 2008 to observe peak period traffic conditions and to videotape potential bottleneck locations. This fieldwork will be discussed in Sections 4 and 5: 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 with a discussion of bottleneck causality findings – including performance results for each individual bottleneck area. It also included corridor-wide performance results updated to reflect 2009 conditions.

Develop and Calibrate Base Year Model

Using the bottleneck areas as the basis for calibration, the study team developed a calibrated 2008 Base Year model for the SR-22 and I-405 corridors. This model was calibrated against California and Federal Highway Administration (FHWA) guidelines for model calibration. In addition, the model was evaluated to ensure that each bottleneck area was represented and that travel times and speeds were consistent with observed data. This process required several review iterations by the study team and Caltrans.

Discussion of the calibrated 2008 Base Year model can be found in Section 6: Scenario Development and Evaluation.

Develop Future Year Model

Following the approval of the 2008 Base Year model, the modeling 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 6: 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 typically 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 also tested using the 2020 Horizon Year model to assess their long-term impacts.

In addition, the study team 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 2008 and that would likely only experience benefits in the long term.

Scenario testing results are presented in Section 6: Scenario Development and Evaluation.

Scenario Performance Evaluations

Once scenarios were developed and fully tested, the study team performed a detailed benefit-cost assessment using the California Benefit-Cost model (Cal-B/C). 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 results of the Benefit-Cost analysis are presented in Section 6: 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 7 summarizes these findings.

The remainder of this report is organized into seven 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 origin-destination demand profile from the SCAG regional model.

3. *Corridor Performance and Trends* presents multiple years of performance data for the freeway portion of the SR-22 CSMP corridor. Five years of data are presented for both SR-22 and I-405 corridors. Statistics are included for the mobility, reliability, safety, and productivity performance measures.

4. *Bottleneck Identification and Performance* identifies bottlenecks, or choke points, on SR-22 and I-405 using various sources. 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.

5. *Bottleneck Causality Analysis* diagnoses the bottlenecks and identifies the causes of each location through additional data analysis and field observations. 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.

6. *Scenario Development and Evaluation* discusses the scenario development approach and summarizes the expected future performance based on the Paramics micro-simulation model developed by the study team for the corridors.

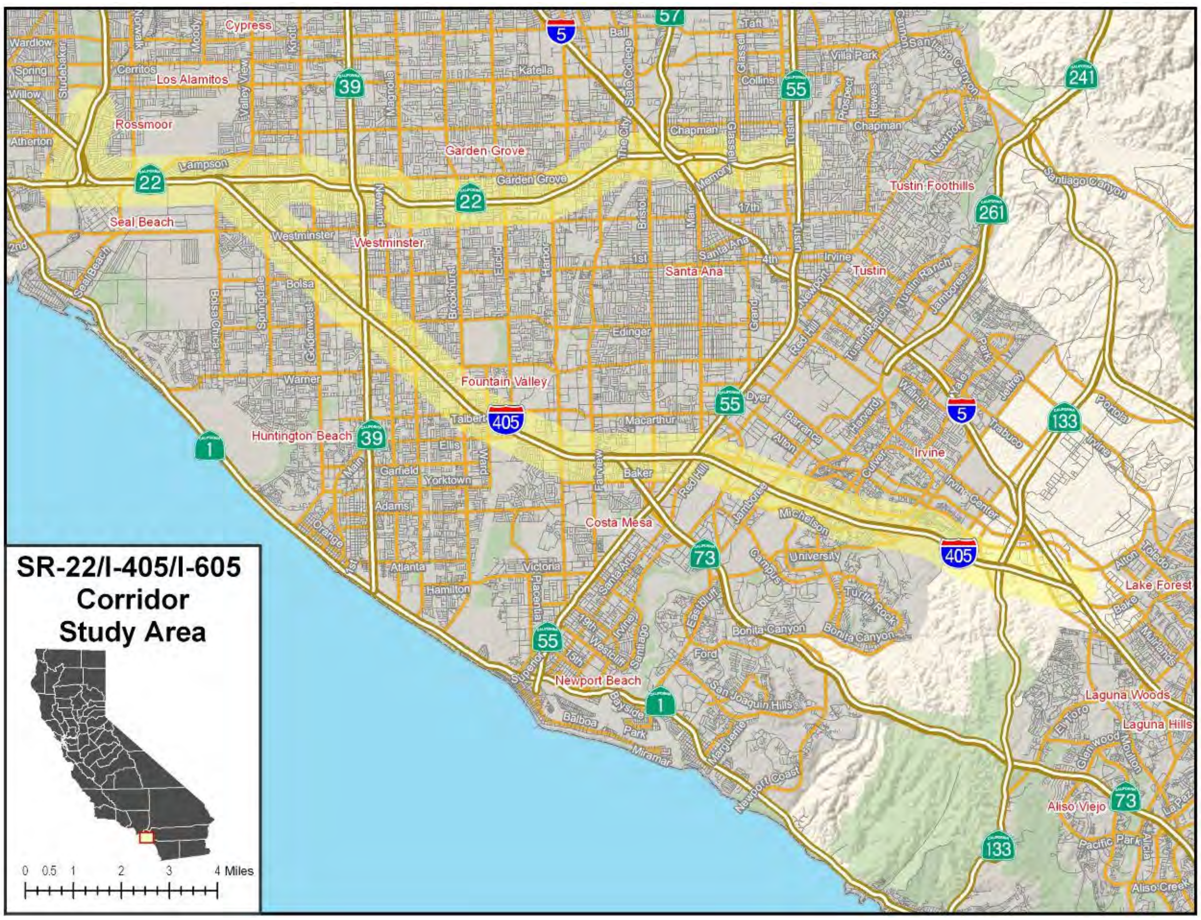
7. *Conclusions and Recommendations* describes the projects and scenarios that were evaluated and recommends a phased implementation of the most promising set of strategies.

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

2. CORRIDOR DESCRIPTION

The study corridor includes portions of three routes: SR-22, I-405, and I-605 in Orange County. The corridor begins at an interchange involving all three freeways at the Los Angeles County border. From there, the corridor runs east along SR-22 (Garden Grove Freeway) to SR-55. The corridor also runs southeast along I-405 (San Diego Freeway) until it reaches I-5 (Santa Ana Freeway) in Irvine. The corridor includes a short, one-mile section of I-605 (San Gabriel River Freeway) as it heads north from the Los Alamitos Curve (SR-22/I-405/I-605) interchange to the Los Angeles County border. The study corridor is highlighted in Exhibit 2-1.

Exhibit 2-1: SR-22/I-405/I-605 CSMP Study Area Map



Corridor Roadway Facility

The portion of SR-22 in the study corridor traverses a large part of Orange County and includes all 13 miles of the freeway from its beginning in Seal Beach (Post Mile R0.000) through Westminster, Garden Grove, and Santa Ana to SR-55 (Post Mile R13.164). SR-22 intersects most of the north-south corridors in Orange County. As Exhibit 2-1 shows, the SR-22 portion of the study corridor includes four major freeway-to-freeway interchanges:

- I-605 provides access to Bellflower, Norwalk, El Monte, Baldwin Park, and other communities in Los Angeles County, while I-405 provides access north to the coastal communities in Los Angeles County and the Los Angeles International Airport.
- I-405 also provides access south in Orange County and this portion is included in the corridor.
- I-5 runs north-to-south, connecting Orange County to Canada, Mexico, Washington State, Oregon, Los Angeles, and San Diego. SR-57 connects the area regionally to Anaheim and eastern Los Angeles County.
- SR-55 forms the north-south spine among Orange County freeways.

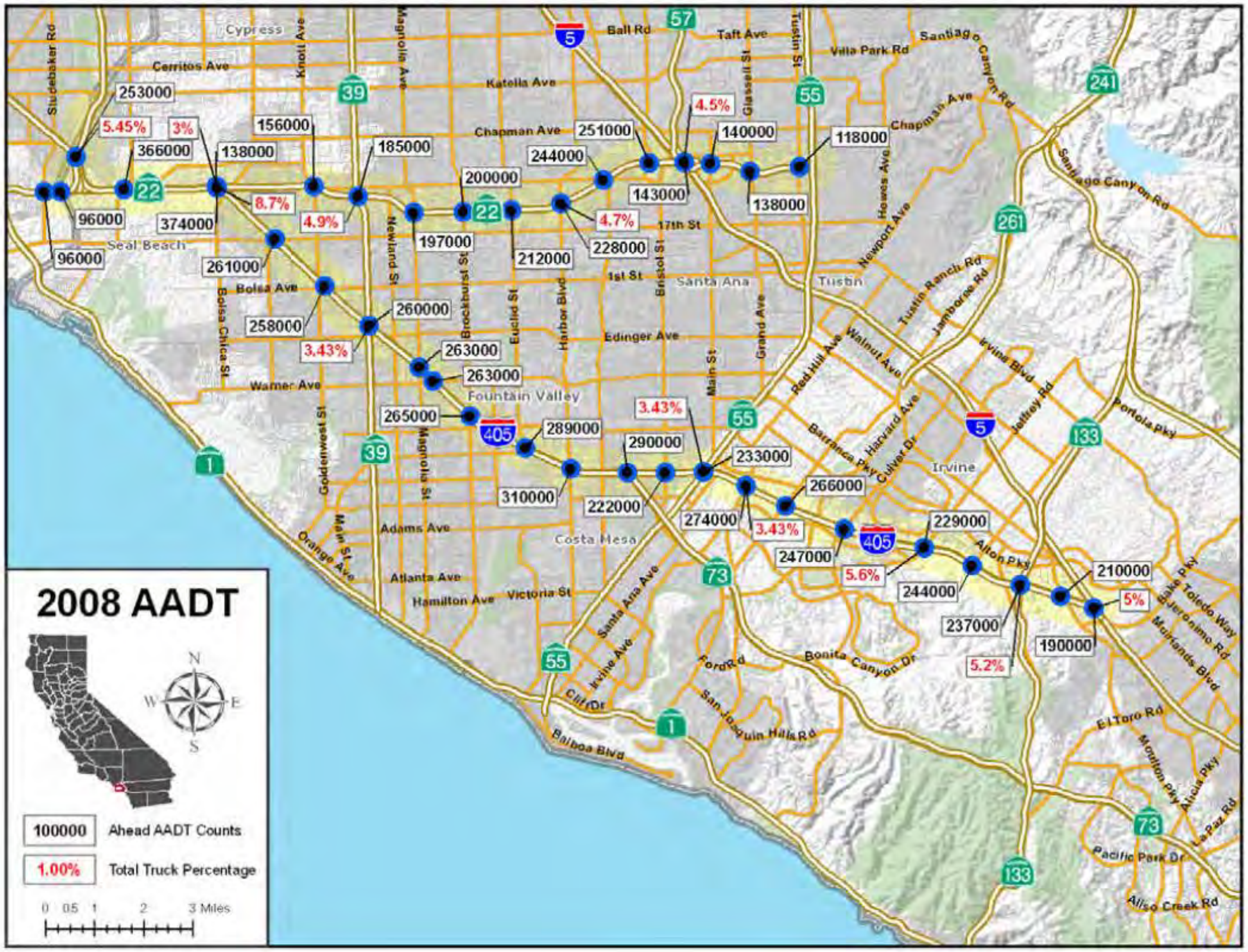
According to Caltrans traffic volumes reported for 2008, SR-22 carries between 96,000 and 251,000 annual average daily traffic (AADT)[1] as shown in Exhibit 2-2. The heaviest traffic occurs between the I-405 and I-605 interchanges. Traffic volumes are much less at the eastern ends of the corridor.

The portion of the study corridor along I-405 extends 24 miles (Post Mile 0.230 to Post Mile 24.178), paralleling the Orange County coastline from I-5 to SR-22. The I-405 Corridor includes four major freeway-to-freeway interchanges:

- I-5 provides interstate north-south access and continues south to San Diego.
- SR-133 provides access to the Eastern Transportation Corridor.
- SR-55 also connects with SR-22. According to the Orange County Transportation Authority (OCTA), this interchange handles more than 433,000 vehicles daily and is one of the ten busiest in the United States.[2]
- SR-73 runs near the coast and through the University of California at Irvine.

[1] AADT is the total annual volume of vehicles counted divided by 365 days.
[2] http://www.octa.net/I405.aspx

Exhibit 2-2: Major Interchanges, 2008 AADT and Truck Percent on SR-22, I-405, and I-605



Source: Caltrans Traffic and Vehicle Data Systems Unit (http://www.dot.ca.gov/hq/traffops/saferesr/trafdata/)

AADT along I-405 ranges from 190,000 at the I-5 interchange to 374,000 near the SR-22 interchange. Traffic steadily declines from north to south, with the exception of a slight increase near Fountain Valley.

The corridor also includes a one-mile section of I-605 (Post Mile R0.000 to Post Mile R0.879). AADT is about 253,000.

As illustrated in Exhibit 2-3, SR-22 and I-405 highways are Surface Transportation Assistance Act (STAA) routes, so large trucks are permitted to operate on them. According to the latest validated truck volumes from the 2008 Caltrans Annual Average Daily Truck Traffic data, trucks comprise the following percentages of total daily traffic along the corridor:

- Between 3.0 and 4.7 percent on SR-22 with the highest percentage near Harbor Boulevard
- Between 3.5 and 8.7 percent on I-405 with the highest percentages near the University of California at Irvine and at the SR-22 interchange
- Approximately 5.5 percent on I-605 near the SR-22/I-405/I-605 interchange.

Exhibit 2-3: Orange County Truck Network on California State Highways

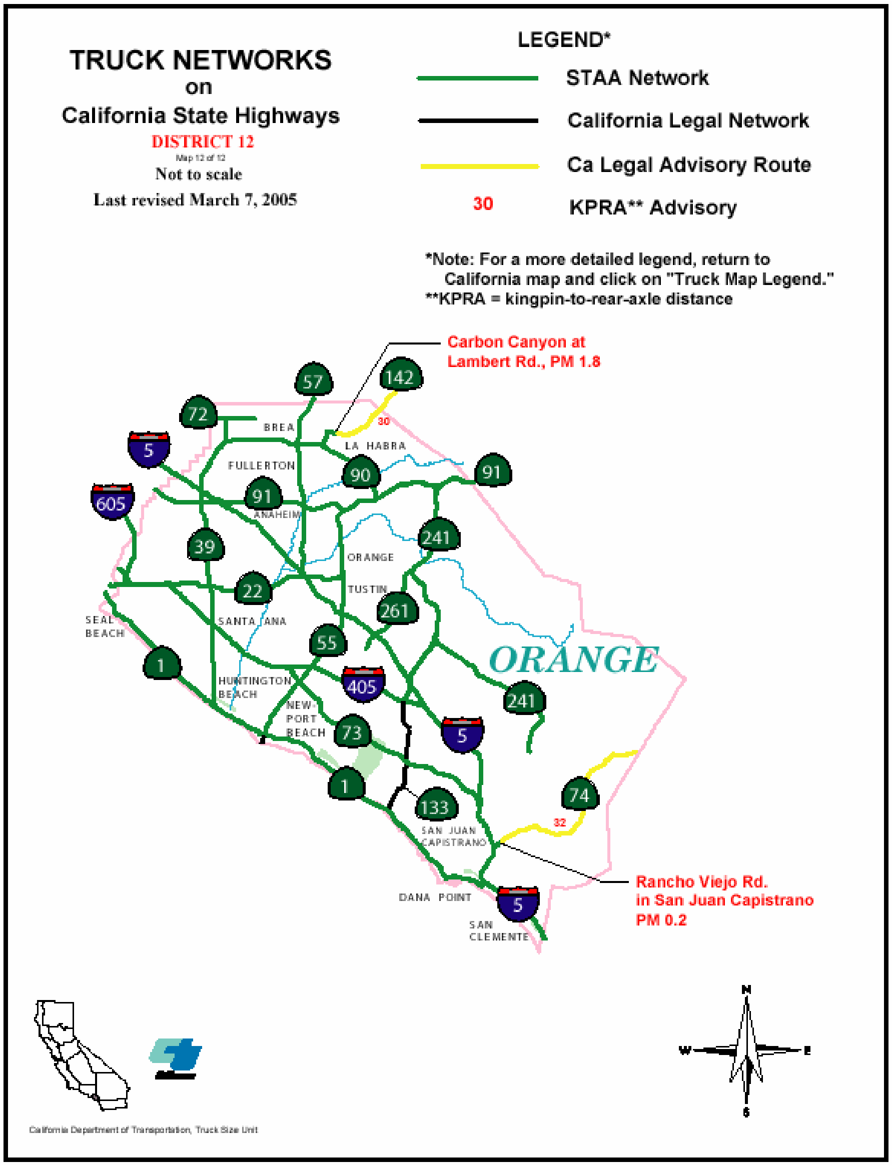


Exhibit 2-4 shows the lane configuration on SR-22, I-405, and I-605. In the spring of 2007, the SR-22 widening project was completed, resulting in an eight-lane freeway with a continuous HOV lane in both directions. The I-405 corridor is an eight to ten-lane freeway with a buffer-separated HOV lane in both directions. There are auxiliary lanes along many sections of both SR-22 and I-405 corridors, but they are not continuous nor are they always available for both sides of the freeway. Exhibit 2-5 shows the locations of traffic operations systems deployed on the three freeways. As shown in the exhibit, there are meters at every ramp and various traffic operation systems installed throughout the corridors.

Exhibit 2-4: Lane Configuration on SR-22, I-405, and I-605

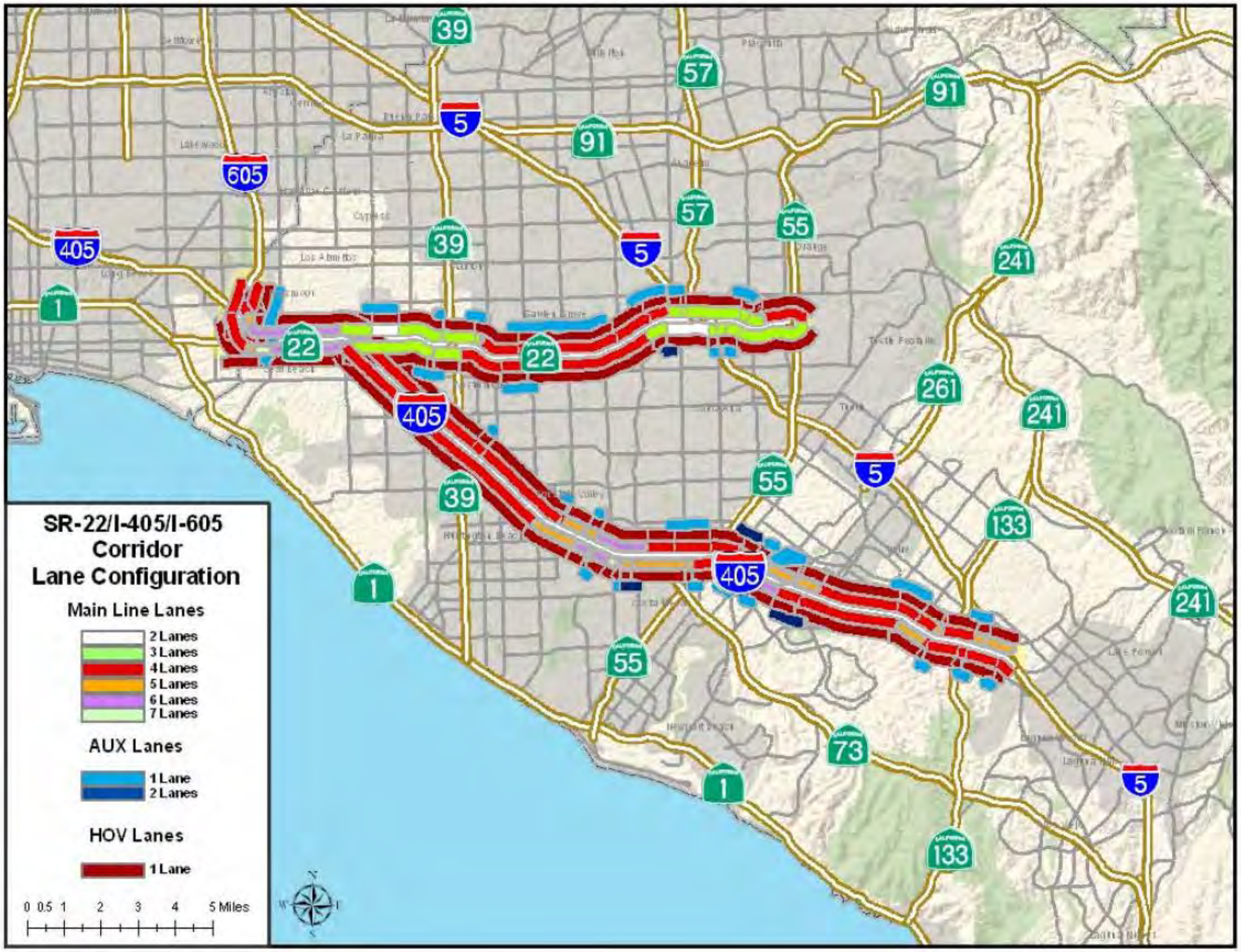
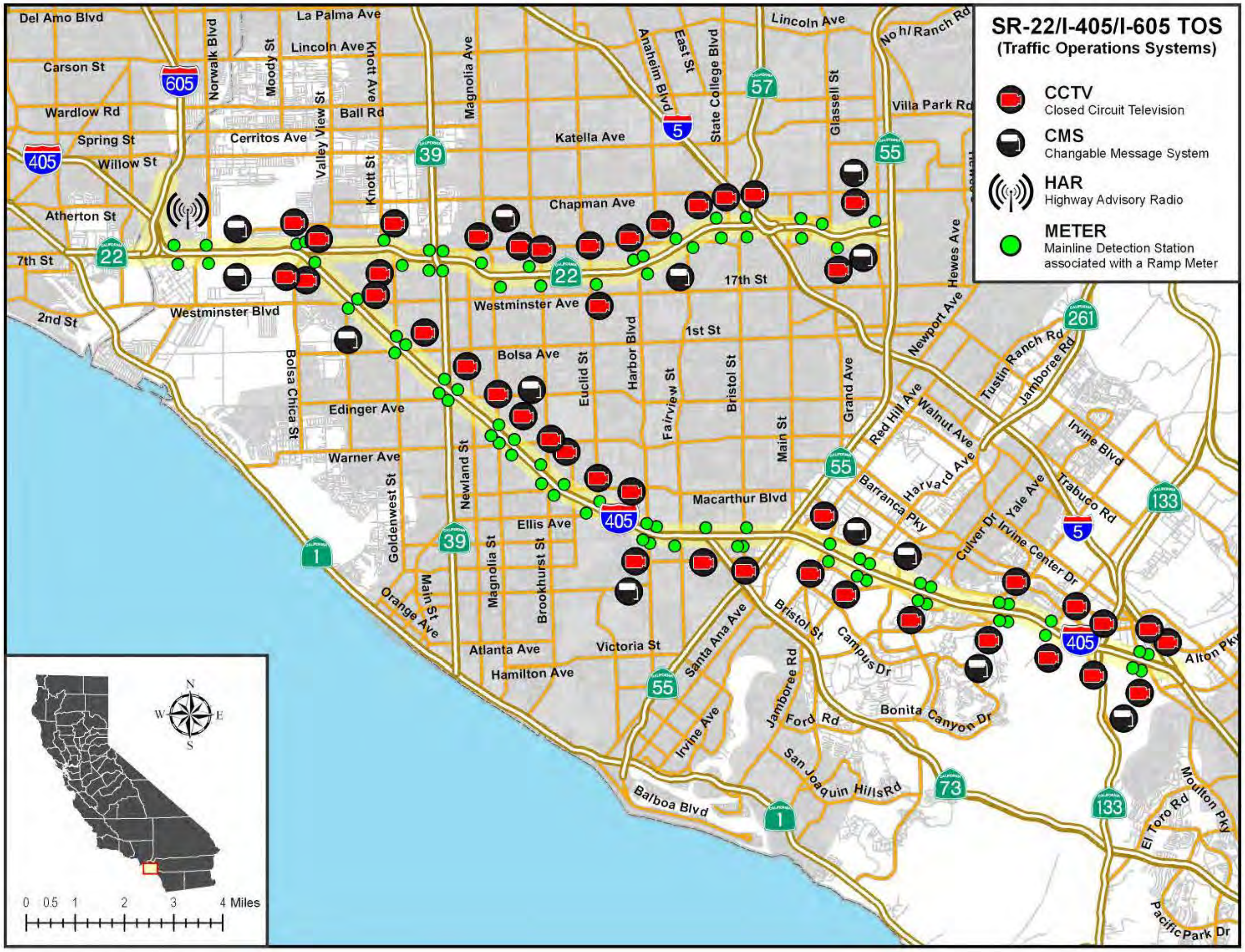


Exhibit 2-5: Traffic Operations Systems on SR-22, I-405, and I-605



Recent Roadway Improvements

Several roadway improvements have recently been completed along the state routes that comprise the SR-22/I-605/I-405 Corridors. The SR-22 Corridor underwent a project that improved several interchanges and widened the freeway to include an HOV lane in both directions. SR-22 project construction started in September 2004 and was completed during the spring of 2007. Along I-405, the Orange County Transportation Authority (OCTA) completed a $135.8 million project in July 2005 to improve the I-405/SR-55 Interchange in Costa Mesa. The interchange was reconfigured with braided connectors to eliminate weaving. HOV connectors were also added at this location. In addition, the neighboring interchange with SR-73 was reconfigured to eliminate a chokepoint. Work on this interchange was completed in July 2004.

Major Investment Study

In 2006, the Orange County Transportation Authority (OCTA) completed the San Diego Freeway (I-405) Major Investment Study (MIS), which examined the transportation needs of western Orange County and is part of OCTA's strategic effort to improve mobility on Orange County's corridors in the next 20 years. The MIS analyzed the existing conditions of the corridor in 2005, identified deficiencies along the corridor, and evaluated and recommended improvements for 2030. The MIS resulted in the adoption of a Locally Preferred Alternative, which proposes adding one general purpose lane in each direction between Brookhurst Street and I-605, and adding an auxiliary lane at selected locations. Following the completion of the MIS, a Project Study Report/Project Development Support (PSR/PDS) document was completed in 2008 by Caltrans and OCTA.

Corridor Transit Services

Three major public transportation operators provide service near the freeways in the SR-22 Corridor:

- Southern California Regional Rail Authority (SCCRA) - Metrolink
- Amtrak Pacific Surfliner train service
- Orange County Transportation Authority (OCTA).

SCCRA is a joint powers authority that operates the Metrolink regional rail service throughout Southern California. Metrolink commuter rail service stops at 11 stations in Orange County and provides 44 weekday round trips on three lines:

- The Orange County Line provides service from Los Angeles Union Station to Oceanside.

- The Inland Empire-Orange County Line provides service from San Bernardino to Oceanside.
- The 91 Line provides service Riverside to Los Angeles Union Station, via Fullerton and Buena Park.

While none of these lines operate directly parallel to SR-22 or the full length of I-405, the Orange County and Inland Empire-Orange County Lines run along Edinger Avenue within a mile of I-405 in Tustin and Irvine. Over 9,000 people (including riders on the Amtrak Pacific Surfliner) ride the 19 trains operated daily on the Orange County Line. Nearly 4,700 people ride 16 trains on the Inland Empire-Orange County Line.

Amtrak Pacific Surfliner

Amtrak offers Pacific Surfliner rail service along the same route as the Orange County Line. Service is provided 12 times daily in each direction. Metrolink riders can use Pacific Surfliner service as part of the Rail 2 Rail cooperative program.

Exhibit 2-6 shows the primary rail services offered by SCRRA and Amtrak near the study corridor.

Orange County Transportation Authority (OCTA)

As the primary bus transit provider in Orange County, OCTA provides fixed-route bus and paratransit services throughout Orange County. While none of these services operates on SR-22, two routes provide local bus service parallel to SR-22:

- *Route 56* runs approximately every 30 minutes from Garden Grove to Orange via Garden Grove Boulevard.
- *Route 60* provides service at about 10-minute frequency from Long Beach to Tustin via 7th Street, Westminster Avenue, and 17th Street.

Route 213A provides express weekday service between Fullerton and Irvine via SR-91, SR-55, and I-405 once in the morning and once in the afternoon. This line operates on I-405 between Jamboree Road and SR-55, where it uses the HOV connector.

Route 211 (Seal Beach to Irvine Express) operates along nearly the entire I-405 portion of the corridor. Three buses operate in the morning and four in the afternoon. In the northern end of the corridor, Route 701 provides express service from Huntington Beach to Los Angeles with three buses in the morning and three in the afternoon.

In the southern end, two express routes operate along I-405 near the I-5 Interchange:

- *Route 212* provides express service (two morning buses and two afternoon buses) from Irvine to San Juan Capistrano via I-405 and surface routes.
- *Route 216* provides express service (one morning and one afternoon bus) from San Juan Capistrano to Costa Mesa via I-405.

Exhibit 2-6: Rail Transit Services near SR-22, I-405, and I-605

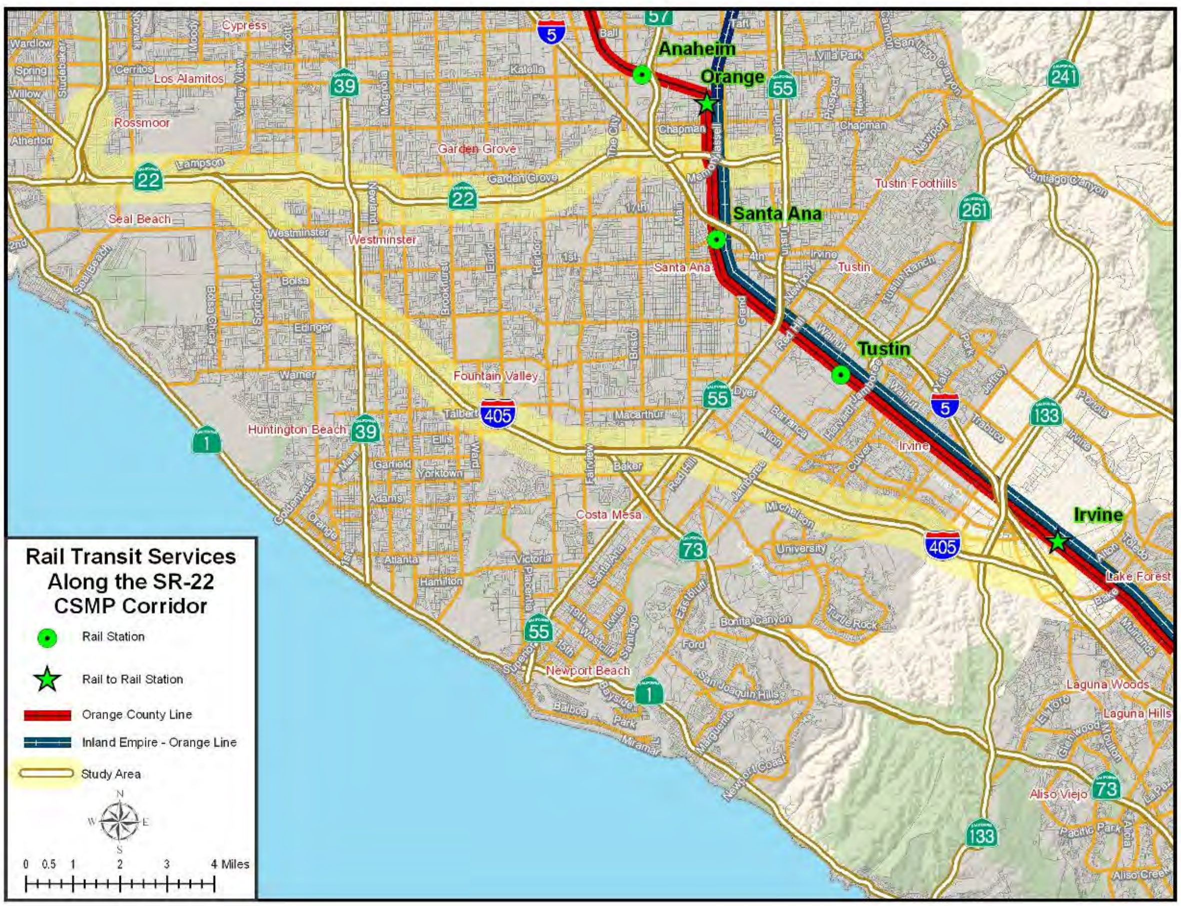
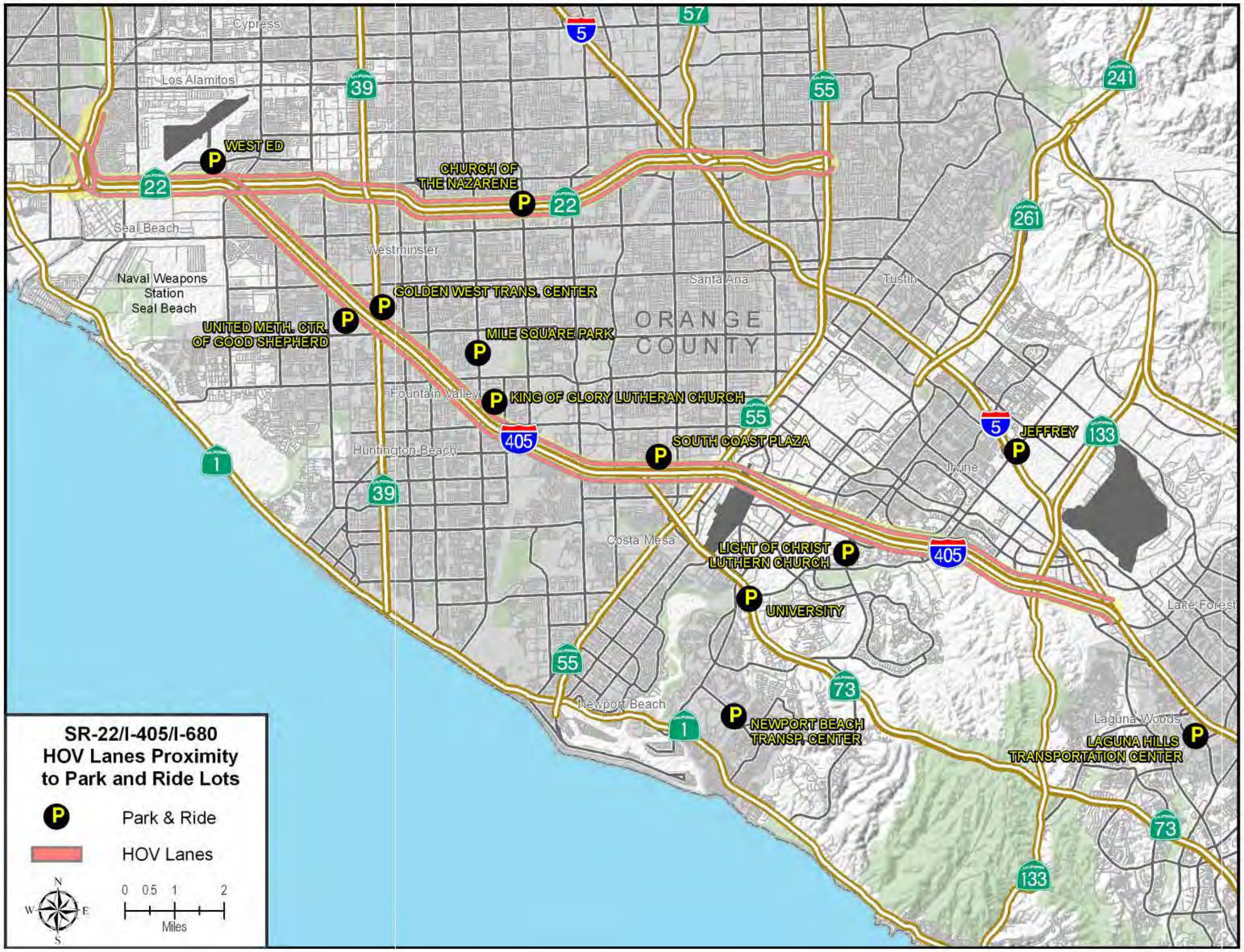


Exhibit 2-7 identifies the Park and Ride Facilities near the CSMP corridor. While there are two facilities near SR-22, there are many more along I-405, particularly near major trip generators such as South Coast Plaza in Costa Mesa, the University of California at Irvine, and the businesses in Newport Beach.

Exhibit 2-7: Park and Ride Facilities near SR-22, I-405, and I-605

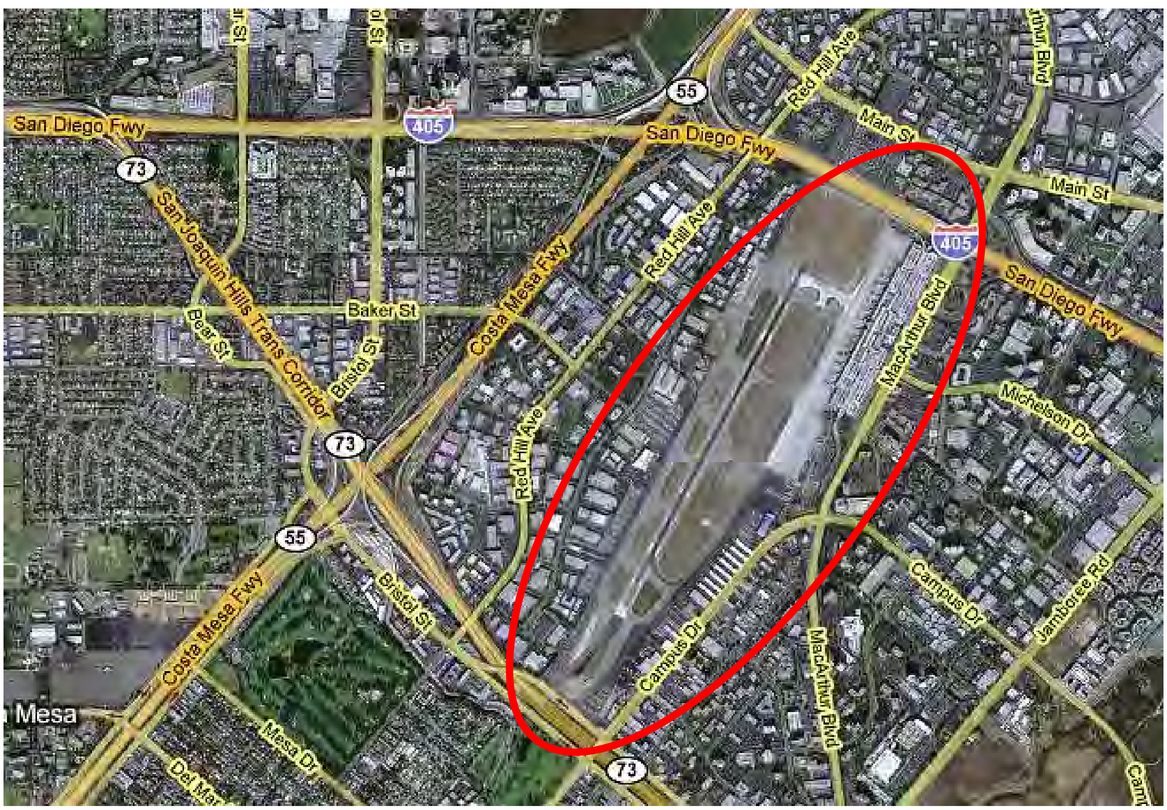


Intermodal Facilities

John Wayne Airport, also known as Santa Ana Airport (SNA), is situated in the southern portion of the corridor at the intersection of three freeways (i.e., I-405, SR-55, and SR-73), as shown in Exhibit 2-8. SNA hosts air carrier, general aviation, air taxi, military, and air cargo services. Fourteen commercial and commuter air carriers serve SNA. During September 2007, SNA recorded 782,896 total passengers, including 388,735 enplanements and 394,161 deplanements. In the same month, the airport served 1,967 air cargo tons, of which 1838 tons were carried by all-cargo carriers. Both FedEx and UPS serve SNA.[3]

As of 2006, SNA recorded the 42nd most enplanements in the United States and is ranked seventh in California, just ahead of Ontario International Airport (ONT).[4]

Exhibit 2-8: John Wayne Airport (SNA)



[3] Wedge, Jenny. "John Wayne Airport Posts September Statistics (Revised)." *John Wayne Airport News and Facts*. October 11, 2007. John Wayne Airport. 15 May 2008 <http://www.ocair.com/newsandfacts/newsreleases/2007/NR-2007-10-11.html>.
[4] "Passenger Boarding and All-Cargo Data." Federal Aviation Administration. May 2008. Air Carrier Activity Information System (ACAIS). <http://www.faa.gov/airports_airtraffic/airports/planning_capacity/passenger_allcargo_stats/passenger/>.

Special Event Facilities/Trip Generators

Several major special event facilities are located along SR-22 and I-405 that might contribute several trips to corridor traffic. Exhibit 2-9 shows the location of the most significant traffic generators.

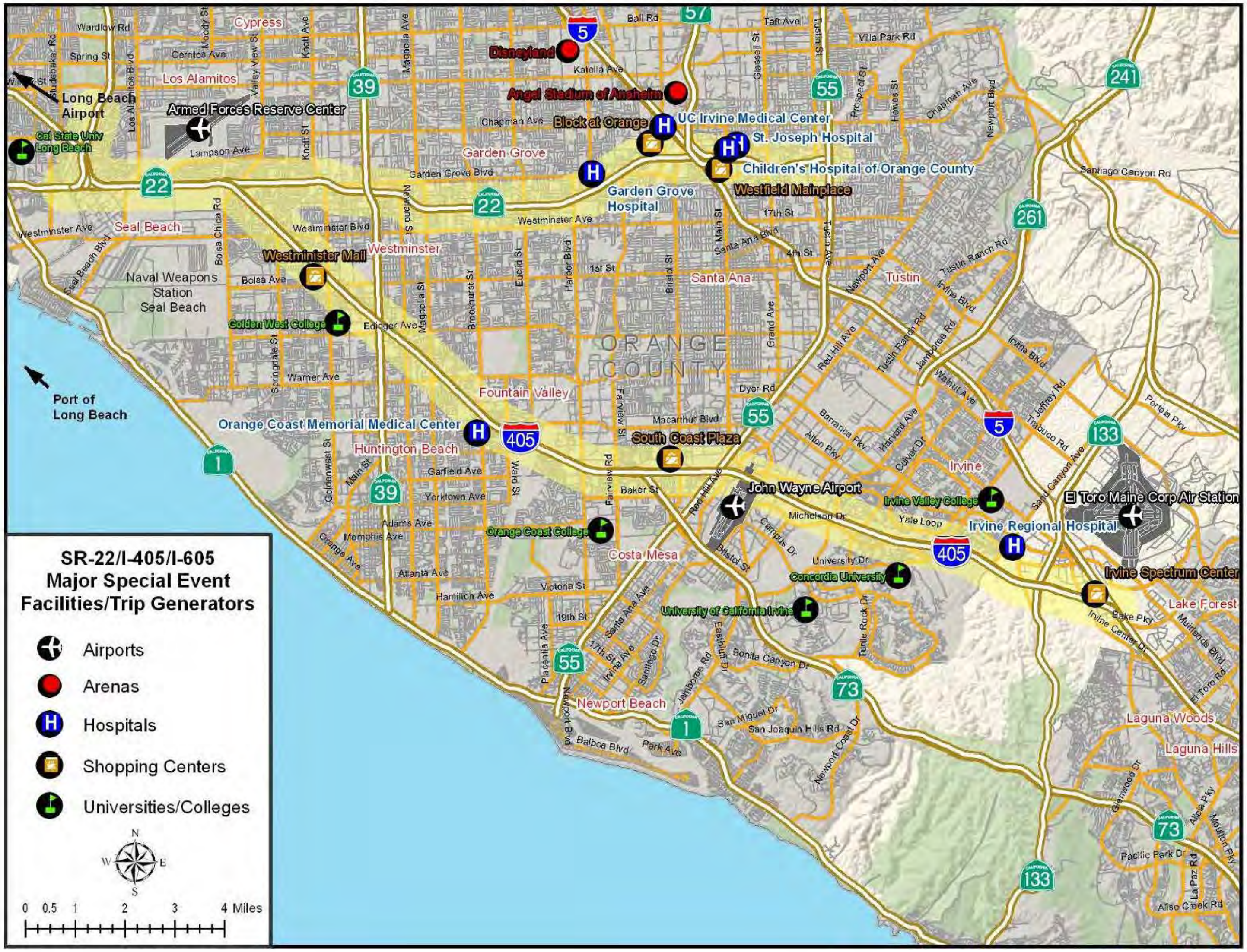
On SR-57 at East Katella Avenue is the Angel Stadium of Anaheim, home of the Los Angeles professional baseball team the Angels. The Honda Center arena, home to the professional hockey team the Anaheim Ducks, is co-located there. Other events such as concerts, rodeos, basketball tournaments, and other major performances take place at the Honda Center. Angel Stadium seats over 45,000 fans, and the Honda Center can accommodate between 17,000 and 19,000 people, depending on the event held. (Sporting or ice skating events accommodate between 17,000 and 17,700 people, while a concert can hold between 18,000 to 19,000.) Although these two facilities primarily impact SR-91 and SR-57, they also affect SR-22 and I-405.

The Disneyland Resort and Theme Park is another major trip generator along SR-22. It is located approximately three and a half miles north of SR-22 on Harbor Boulevard and is the second busiest amusement park in the world, with an average daily attendance of nearly 40,000 patrons. The Disneyland Resort directly employs over 20,000 people, making it Orange County's largest employer and one of the largest single-site private employers in the state.

Seven major universities/colleges near SR-22 and I-405 can also generate significant trips:

- California State University Long Beach (CSULB) is located approximately three miles west of the SR-22/I-405 junction. It is the second largest campus of the California State University system with an enrollment of over 35,000 students each year.
- Santa Ana College, a public community college with over 25,000 students enrolled, is located at the corner of Bristol and 17th Street in Santa Ana, approximately 1.5 miles south of SR-22.
- Golden West College is located further south on I-405 in the City of Huntington Beach. It is a medium-sized two-year college that serves 13,000 students.
- The University of California, Irvine (UCI) is located approximately four miles south of I-405 and north of SR-73. This four-year public university offers Bachelors, Masters, and Doctorates degree programs, and has an estimated enrollment of 24,500 students.
- Less than three miles east from UCI is Concordia University, a private Lutheran liberal arts institution located two miles south of I-405 off of University Drive It has an estimated enrollment of 2,300 students.

Exhibit 2-9: Major Special Event Facilities/Trip Generators near SR-22, I-405, and I-605



- Irvine Valley College is less than two miles north of I-405 off of Jeffrey Road. It is a public community college with over 13,000 students enrolled. In addition to these educational facilities, Orange County is comprised of 28 school districts. Near the SR-22 and I-405 freeways, ten school districts could affect the corridors in the mornings and afternoons.
- Orange Coast College, a public community college with over 28,000 students enrolled, is located on Fairview Road in Costa Mesa, approximately two miles south of I-405.

There are eight major medical facilities close to SR-22 and I-405, which can generate significant trips:

- The Garden Grove Hospital and Medical Center is a 167-bed acute care medical facility and is the largest employer in the City of Garden Grove. It is located less than a mile north of SR-22 on Garden Grove Boulevard.
- The UC Irvine Medical Center, the only university hospital in the County, is located north of SR-22 and immediately west of I-5 in the City of Orange. The facility has more than 400 specialty and primary care physicians and offers a full range of acute and general care services.
- St. Joseph Hospital is located north of SR-22 and east of I-5 on Main Street. It is the largest and one of the highest volume hospitals in the County with a 1,000-member medical staff.
- The Children's Hospital of Orange County (CHOC) is adjacent to St. Joseph Hospital and is the first hospital in Orange County to open an emergency room for children.
- The Orange Coast Memorial Medical Center is located less than a mile west of I-405 on Talbert Avenue in the City of Fountain Valley.
- The Fountain Valley Regional Hospital and Medical Center is a 400-bed, full-service, acute care facility located on Euclid Street in Fountain Valley, approximately two miles north of I-405. It provides a comprehensive range of health services including 24-hour emergency care, cardiology services, maternity care, advanced neonatal and pediatric intensive care, and a number of specialties. The hospital has a medical staff of approximately 1,100 and an employee base of 1,500 people.
- A new Kaiser Permanente Hospital in Irvine opened its doors in May 2008. This 434,000 square-foot medical facility is the county's largest HMO hospital and is located on Alton Parkway, north of I-405.

The five major shopping malls near SR-22 and I-405 that may generate significant trips include:

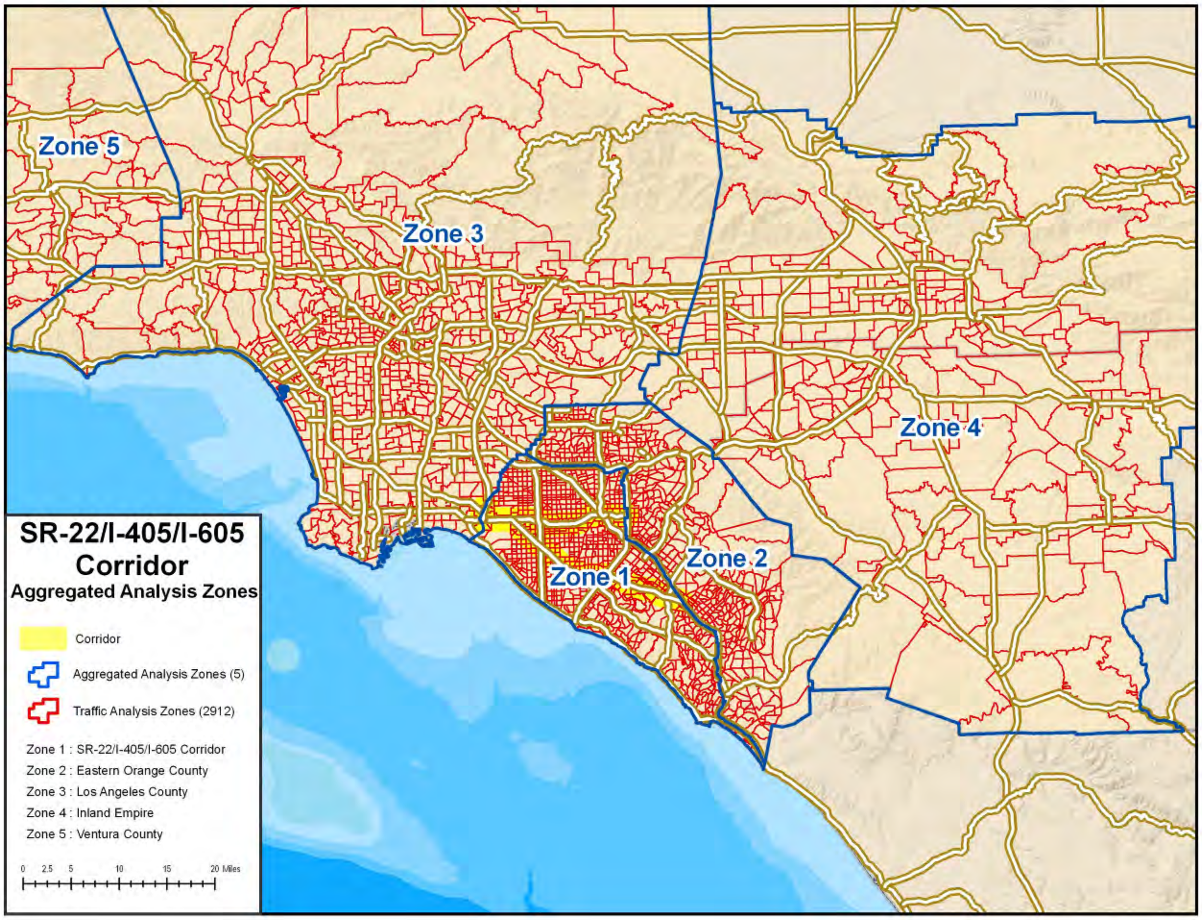
- Along SR-22 and west of I-5, in the City of Orange, is the outdoor shopping mall The Block at Orange. The Block is popular for its skateboarding facility and thriving nightlife.
- Further east along SR-22 and east of I-5 is Westfield MainPlace, a mall in the City of Santa Ana that features over 200 specialty shops.
- In the City of Westminster, along I-405 and Bolsa Avenue, is the Westminster Mall, which houses over 180 specialty shops.
- Further south along I-405 and west of SR-55 interchange, in the City of Costa Mesa, is South Coast Plaza, Orange County's largest shopping mall. South Coast Plaza is an upscale shopping center with over 280 stores and approximately 24 million visitors annually.
- Lastly, along the I-5/I-405 Interchange is the Irvine Spectrum Center. The Irvine Spectrum is an outdoor mall with a 21-multiplex cinema and IMAX, two major department stores and over 130 specialty stores.

The Seal Beach Naval Weapons Station has potential to be a large trip generator. Located near the SR-22/I-405 junction, the facility occupies 5,256 acres and has 230 buildings and 128 ammunition storage spaces.

Demand Profiles

An analysis of origins and destinations was conducted to determine the travel pattern of trips made on the SR-22 CSMP study corridor. Based on OCTA's travel demand model, this "select link analysis" isolated the three freeways that comprise the SR-22 CSMP study corridor (SR-22, I-405, I-605) and identified the origins and destinations of trips made on these corridors. The origins and destinations were identified by Traffic Analysis Zones (TAZ), which were grouped into seven aggregate analysis zones shown in Exhibit 2-10.

Exhibit 2-10: SR-22/I-405/I-605 Corridor Demand Profile Aggregated Analysis Zones



Based on this aggregation, demand on the corridor was summarized by aggregated origin-destination zones as shown on Exhibits 2-11 and 2-12 for the AM and PM peak periods. The analysis showed that a significant percentage of trips using the SR-22 Corridor involve inter-county trips.

During the AM peak period, only about 44 percent of all trips originate and terminate in Orange County (Zones 1 or 2). The remaining trips originate in Orange County and terminate in another county (26 percent), originate outside Orange County and terminate in Orange County (25 percent), or originate and terminate outside Orange County (6 percent).

Exhibit 2-11: SR-22 AM Peak Origin Destination by Aggregated Analysis Zone

	AM Trips	TO ZONE: SR-22/I-405/I-605	Eastern Orange County	LA County	Inland Empire	Ventura County	Outside Zones
FROM ZONE	SR-22/I-405/I-605	18,234	5,641	11,150	3,092	83	22
	Eastern OC	7,755	2,191	4,266	1,176	28	10
	LA County	10,719	3,140	2,417	770	7	40
	Inland Empire	3,729	1,129	940	309*	3	12
	Ventura County	168	48	11	8	0	2
	Outside Zones	104	29	149	39	7	1

Trips starting and ending in Orange County ~ 44%
Trips starting in Orange County and ending outside of Orange County ~ 26%
Trips starting outside of Orange County and ending in Orange County ~ 25%
Trips starting and ending outside of Orange County ~ 6%

* Note that travel demand models sometimes assign a small number of trips to unusual routing. The trips shown in the table to and from the Inland Empire, from LA County to Ventura County, and from Ventura County to LA County represent such an anomaly.

The picture is similar for the PM peak period, which experiences around 28 percent more demand than the AM. Around 44 percent of trips originate and terminate in Orange County. The remaining trips originate in Orange County and terminate in another county (25 percent), originate outside Orange County and terminate in Orange County (25 percent), or originate and terminate outside Orange County (7 percent).

Exhibit 2-12: SR-22 PM Peak Origin Destination by Aggregated Analysis Zone

	PM Trips	TO ZONE: SR-22/I-405/I-605	Eastern Orange County	LA County	Inland Empire	Ventura County	Outside Zones
FROM ZONE	SR-22/I-405/I-605	25,449	9,883	15,568	4,794	185	63
	Eastern OC	8,473	2,933	4,993	1,539	61	30
	LA County	14,994	5,234	4,076	1,311	46	135
	Inland Empire	4,319	1,510	1,145	392*	4	37
	Ventura County	192	54	38	10	0	4
	Outside Zones	62	15	81	24	3	0

Trips starting and ending in Orange County ~ 44%
Trips starting in Orange County and ending outside of Orange County ~ 25%
Trips starting outside of Orange County and ending in Orange County ~ 25%
Trips starting and ending outside of Orange County ~ 7%

* Note that travel demand models sometimes assign a small number of trips to unusual routing. The trips shown in the table to and from the Inland Empire, from LA County to Ventura County, and from Ventura County to LA County represent such an anomaly.

As shown in Exhibits 2-13 and 2-14, the origin-destination pattern for I-405 is similar to SR-22 with less than half of all trips occurring entirely within Orange County. During the AM peak period, about 46 percent of all trips originate and terminate in Orange County (Zones 1 or 2). The remaining trips originate in Orange County and terminate in another county (22 percent), originate outside Orange County and terminate in Orange County (26 percent), or originate and terminate outside Orange County (5 percent).

Exhibit 2-13: I-405 AM Peak Origin Destination by Aggregated Analysis Zone

		TO ZONE					
	AM Trips	SR-22/I-405/I-605	Eastern Orange County	LA County	Inland Empire	Ventura County	Outside Zones
FROM ZONE	SR-22/I-405/I-605	36,335	16,076	21,301	5,695	240	381
	Eastern OC	16,934	7,295	7,271	1,963	87	172
	LA County	23,266	6,982	4,746	1,308	89	163
	Inland Empire	7,377	2,329	1,400	363*	7	48
	Ventura County	571	170	72	14	0	8
	Outside Zones	1,497	625	538	155	23	2

Trips starting and ending in Orange County ~ 46%
Trips starting in Orange County and ending outside of Orange County ~ 22%
Trips starting outside of Orange County and ending in Orange County ~ 26%
Trips starting and ending outside of Orange County ~ 5%

* Note that travel demand models sometimes assign a small number of trips to unusual routing. The trips shown in the table to and from the Inland Empire, from LA County to Ventura County, and from Ventura County to LA County represent such an anomaly.

The pattern is again similar during the PM peak period, which experiences around 27 percent more demand than the AM peak period. Almost half of all trips (48 percent) originate and terminate in Orange County. The remaining trips originate in Orange County and terminate in another county (25 percent), originate outside Orange County and terminate in Orange County (21 percent), or originate and terminate outside Orange County (5 percent).

Exhibit 2-14: I-405 PM Peak Origin Destination by Aggregated Analysis Zone

		TO ZONE					
	PM Trips	SR-22/I-405/I-605	Eastern Orange County	LA County	Inland Empire	Ventura County	Outside Zones
FROM ZONE	SR-22/I-405/I-605	62,488	30,123	38,247	11,611	728	2,256
	Eastern OC	10,632	4,963	3,004	944	76	76
	LA County	34,298	11,029	4,641	1,500	0	696
	Inland Empire	915	401	261	62*	0	49
	Ventura County	192	82	76	3	0	15
	Outside Zones	1,908	585	2,867	638	199	3

Trips starting and ending in Orange County ~ 48% -
Trips starting in Orange County and ending outside of Orange County ~ 25% -
Trips starting outside of Orange County and ending in Orange County ~ 21% -
Trips starting and ending outside of Orange County ~ 5% -

* Note that travel demand models sometimes assign a small number of trips to unusual routing. The trips shown in the table to and from the Inland Empire, from LA County to Ventura County, and from Ventura County to LA County represent such an anomaly.

3. CORRIDOR PERFORMANCE AND TRENDS

This section summarizes the performance measures used to evaluate the existing conditions of the SR-22 and I-405 corridors. The measures provide a technical basis to describe traffic performance on these corridors and were used to calibrate the micro-simulation model. Data from mainline and high occupancy vehicle (HOV) facilities were analyzed separately.

Before discussing the performance measures, this section describes the quality of the data used in the analysis. This was done to ensure that the automatic sensor data used for the analysis was sufficiently reliable.

Following the data quality discussion, the following five key performance areas will be discussed in detail:

- *Mobility* describes how quickly people and freight move along the corridor.
- *Reliability* captures the relative predictability of travel time 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
- *Pavement Condition* describes the structural adequacy and ride quality of the pavement.

Data Sources and Detection

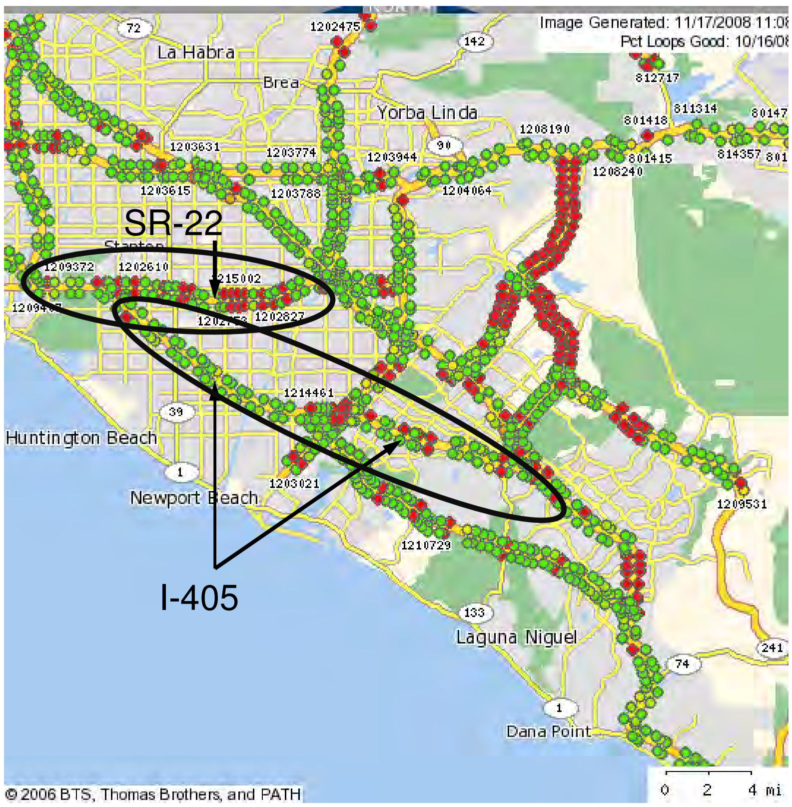
The existing available data analyzed for the SR-22 and I-405 corridors included the following sources:

- Caltrans Highway Congestion Monitoring Program (HICOMP) report and data files (2004 - 2007)
- Caltrans Freeway detection data
- Caltrans District 12 probe vehicle runs (electronic tachometer runs)
- Caltrans Traffic Accident Surveillance and Analysis System (TASAS) from PeMS
- Signal Timing Plans from the Cities of Garden Grove, Seal Beach, Costa Mesa, and Irvine
- Traffic study reports (various)
- Aerial photographs (Google Earth) and Caltrans photologs
- Internet (i.e., OCTA, Metrolink, SCAG websites, etc.).

Numerous documents describe these data sources, so they are not discussed in detail in this report. However, given the need for comprehensive and continuous monitoring and evaluation, detection coverage and quality are discussed in more detail.

Exhibit 3-1 depicts the detectors in place on SR-22 and I-405 as of October 16, 2008 (chosen randomly). The exhibit shows that there are many detectors on the mainline and most are functioning well (shown as the green color). Furthermore, it illustrates some seemingly small gaps between detectors at some locations.

Exhibit 3-1: Sensor Data Quality (October 16, 2008)

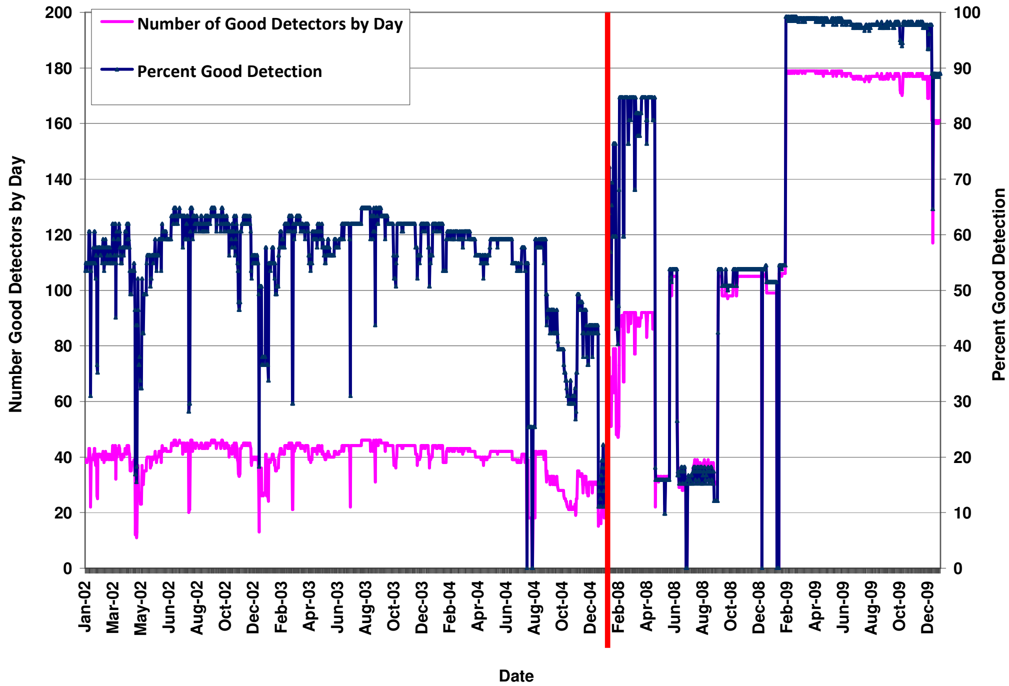


Source: Automatic detector data

To see how well detectors performed over a longer period of time, Exhibits 3-2 and 3-3 show the number and percentage of good detectors on the SR-22 mainline facility for the years analyzed, 2002-2004 (pre-construction), and 2008-2009 (post-construction). The exhibits report the number and percentage of "good" detectors each day during the period of analysis. These include mainline detectors as well as ramp detectors.

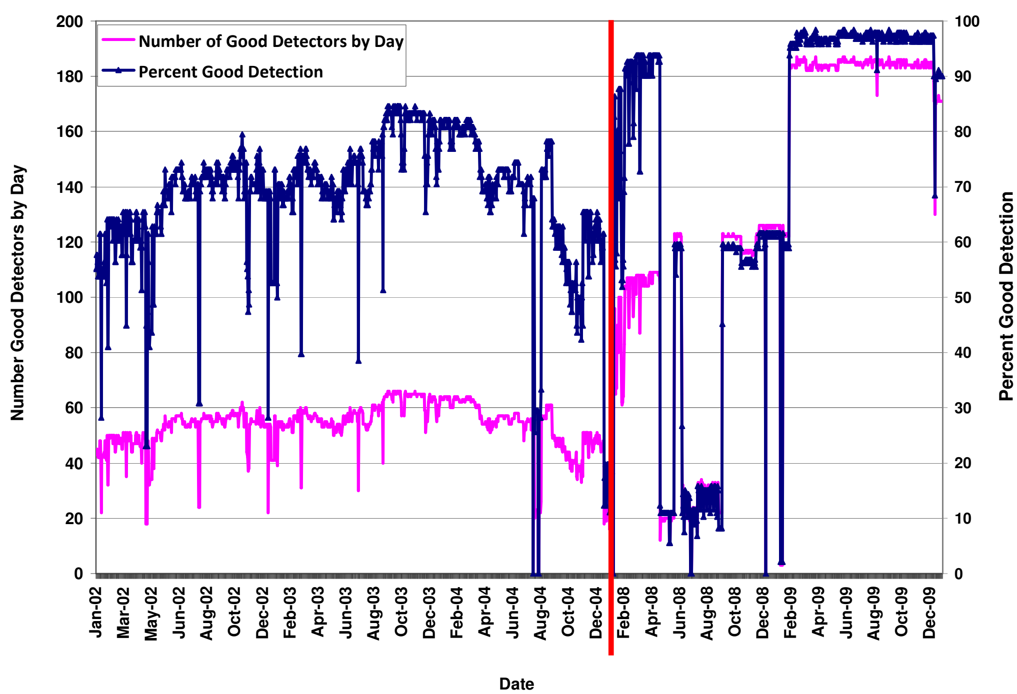
The left y-axis shows the scale used for the number of detectors, while the right y-axis shows the scale used for the percent good detectors. Exhibits 3-2 and 3-3 suggest that detection in the westbound direction was slightly better than the eastbound direction, particularly during the pre-construction years when the percentage of good detectors in the westbound direction reported roughly 70 percent compared to 60 percent in the eastbound direction. In 2008, Caltrans installed new and fixed existing detectors. Starting in February 2009, detection significantly improved, achieving close to 100 percent of good data in both directions.

Exhibit 3-2: Eastbound SR-22 Mainline Daily Good Detectors (2002-2009)



Source: Automatic detector data

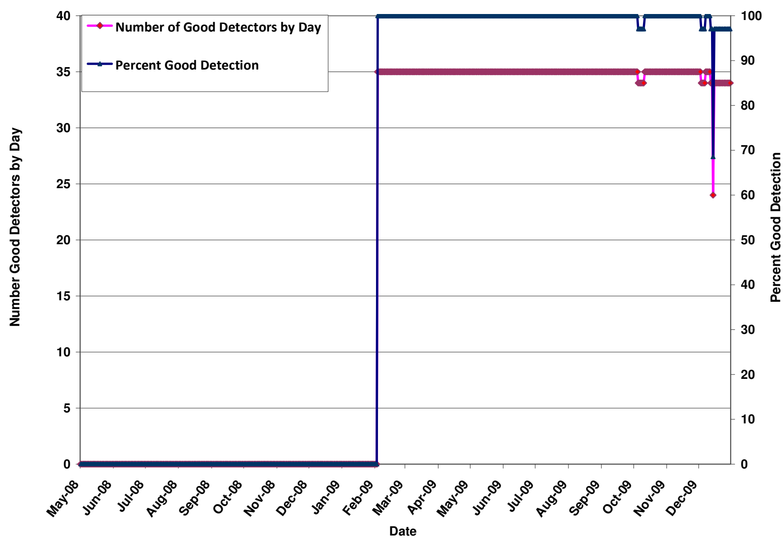
Exhibit 3-3: Westbound SR-22 Mainline Daily Good Detectors (2002-2009)



Source: Automatic detector data

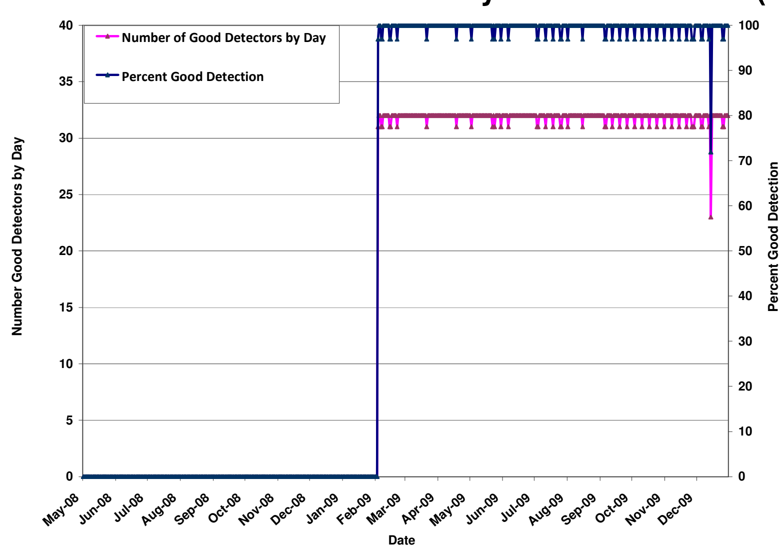
Exhibits 3-4 and 3-5 separately illustrates the number and percentage of good detection on the SR-22 HOV facility by direction. These exhibits clearly show that good detection for the HOV facility was not available until February 2009. In February 2009, both directions of the HOV facility reported almost 100 percent of good data. It is important to note that many detectors were added to SR-22 as part of a widening project that added an HOV lane in each direction. Project construction started in September 2004 and was completed during the spring of 2007. The detectors that were added to the mainline facility post construction are listed in Exhibit 3-6. Additionally, Exhibits 3-7 and 3-8 list all of the detectors added to the HOV facility during construction.

Exhibit 3-4: Eastbound SR-22 HOV Daily Good Detectors (2008-2009)



Source: Automatic detector data

Exhibit 3-5: Westbound SR-22 HOV Daily Good Detectors (2008-2009)



Source: Automatic detector data

Exhibit 3-6: SR-22 Mainline and Ramp Detection Added (2008)

VDS	Location	Type	CA PM	Abs PM	Date Online
EASTBOUND					
1215205	VALLEY V1	Off Ramp	R.89	2.347	5/2/2008
1214838	VALLEY V2	Off Ramp	R1.08	2.537	5/2/2008
1214853	VIA LOS ALISOS	Mainline	R1.41	2.867	5/2/2008
1214869	YUMA	Mainline	R2.07	3.527	5/2/2008
1215092	GARDEN GROV	Mainline	R3.27	4.727	5/2/2008
1214938	WILSON	Mainline	R4.03	5.487	5/2/2008
1214955	NEWLAND	Mainline	R4.34	5.797	5/2/2008
1215208	BROOKHURST 1	Off Ramp	R5.57	7.027	5/2/2008
1214988	HOPE	Mainline	R6.05	7.507	5/2/2008
1215003	WARD	Mainline	R6.34	7.797	5/2/2008
1214805	TAFT	Mainline	R6.61	8.067	5/2/2008
1214807	EUCLID	Off Ramp	R6.61	8.067	5/2/2008
1214894	HARBOR 1	Mainline	R7.72	9.177	5/2/2008
1215017	PEARCE	Mainline	R8.3	9.757	5/2/2008
1215109	22E CD AT CITY DRIVE	Fwy-Fwy	R9.7	11.261	5/2/2008
1214715	HESPERIAN	Mainline	R9.9	11.461	5/2/2008
1215043	LEWIS	Mainline	R10	11.561	5/2/2008
1214724	22E CD AT BRISTOL	Fwy-Fwy	R10.13	11.691	5/2/2008
1215111	22E CD ON AT 5	Fwy-Fwy	R10.53	12.091	5/2/2008
1214881	CONCORD	Mainline	R12.25	13.811	5/2/2008
1215026	TUSTIN	Mainline	R12.7	14.261	5/2/2008
VDS	Location	Type	CA PM	Abs PM	Date Online
WESTBOUND					
1214842	VALLEY V2	Off Ramp	R.89	2.347	5/2/2008
1214854	VIA LOS ALISOS	Mainline	R1.41	2.867	5/2/2008
1215248	SPRINGDALE CENSUS	Mainline	R1.74	3.197	5/2/2008
1214871	YUMA	Mainline	R2.07	3.527	5/2/2008
1215091	GARDEN GROV	Mainline	R3.27	4.727	5/2/2008
1214939	WILSON	Mainline	R4.03	5.487	5/2/2008
1214954	NEWLAND	Mainline	R4.34	5.797	5/2/2008
1214972	BROOKHURST 2	Mainline	R5.77	7.227	5/2/2008
1214987	HOPE	Mainline	R6.05	7.507	5/2/2008
1215002	WARD	Mainline	R6.34	7.797	5/2/2008
1214806	TAFT	Mainline	R6.61	8.067	5/2/2008
1215018	PEARCE	Mainline	R8.3	9.757	5/2/2008
1214743	5S/57S TO 22W	Fwy-Fwy	R9.69	11.251	5/2/2008
1215044	LEWIS	Mainline	R10	11.561	5/2/2008
1215122	22W to 5/57N	Fwy-Fwy	R10.53	12.091	5/2/2008
1215123	22E to 5/57N	Fwy-Fwy	R10.53	12.091	5/2/2008
1214882	CONCORD	Mainline	R12.25	13.811	5/2/2008

Source: Automatic detector data

Exhibit 3-7: Eastbound SR-22 HOV Detection Added (2008)

VDS	Location	Type	CA PM	Abs PM	Date Online
EASTBOUND					
1214852	VIA LOS ALISOS	HOV	R1.41	2.867	5/2/2008
1215235	SPRINGDALE CENSUS	HOV	R1.74	3.197	5/2/2008
1214857	SPRINGDALE	HOV	R1.75	3.207	5/2/2008
1214868	YUMA	HOV	R2.07	3.527	5/2/2008
1215078	KNOTT 1	HOV	R2.49	3.947	5/2/2008
1215096	KNOTT 2	HOV	R2.88	4.337	5/2/2008
1215090	GARDEN GROV	HOV	R3.27	4.727	5/2/2008
1214763	BEACH 1	HOV	R3.44	4.897	5/2/2008
1214821	BEACH 2	HOV	R3.73	5.187	5/2/2008
1214936	WILSON	HOV	R4.03	5.487	5/2/2008
1214953	NEWLAND	HOV	R4.34	5.797	5/2/2008
1214781	MAGNOLIA 1	HOV	R4.6	6.057	5/2/2008
1214826	MAGNOLIA 2	HOV	R4.99	6.447	5/2/2008
1215072	BROOKHUR1	HOV	R5.57	7.027	5/2/2008
1214970	BROOKHUR2	HOV	R5.77	7.227	5/2/2008
1214986	HOPE	HOV	R6.05	7.507	5/2/2008
1215001	WARD	HOV	R6.34	7.797	5/2/2008
1214803	TAFT	HOV	R6.61	8.067	5/2/2008
1214790	EUCLID	HOV	R6.94	8.397	5/2/2008
1215063	NEWHOPE	HOV	R7.29	8.747	5/2/2008
1215251	NEWHOPE CENSUS	HOV	7.3	8.757	5/2/2008
1214892	HARBOR 1	HOV	R7.72	9.177	5/2/2008
1215055	HARBOR 2	HOV	R8.02	9.477	5/2/2008
1215015	PEARCE	HOV	R8.3	9.757	5/2/2008
1214771	GARDEN G1	HOV	R8.68	10.137	5/2/2008
1215051	GARDEN G2	HOV	R9.04	10.497	5/2/2008
1215052	GARDEN G2	HOV	R9.04	10.497	5/2/2008
1215041	LEWIS	HOV	R9.44	10.897	5/2/2008
1215108	THE CITY DRIVE	HOV	R9.7	11.261	5/2/2008
1214714	HESPERIAN	HOV	R9.9	11.461	5/2/2008
1214723	BRISTOL	HOV	R10.13	11.691	5/2/2008
1215115	W OF 5	HOV	R10.35	11.911	5/2/2008
1215128	E OF 5	HOV	R10.71	12.271	5/2/2008
1214752	MAIN	HOV	R11.25	12.811	5/2/2008
1214729	GLASSELL1	HOV	R11.68	13.241	5/2/2008

Source: Automatic detector data

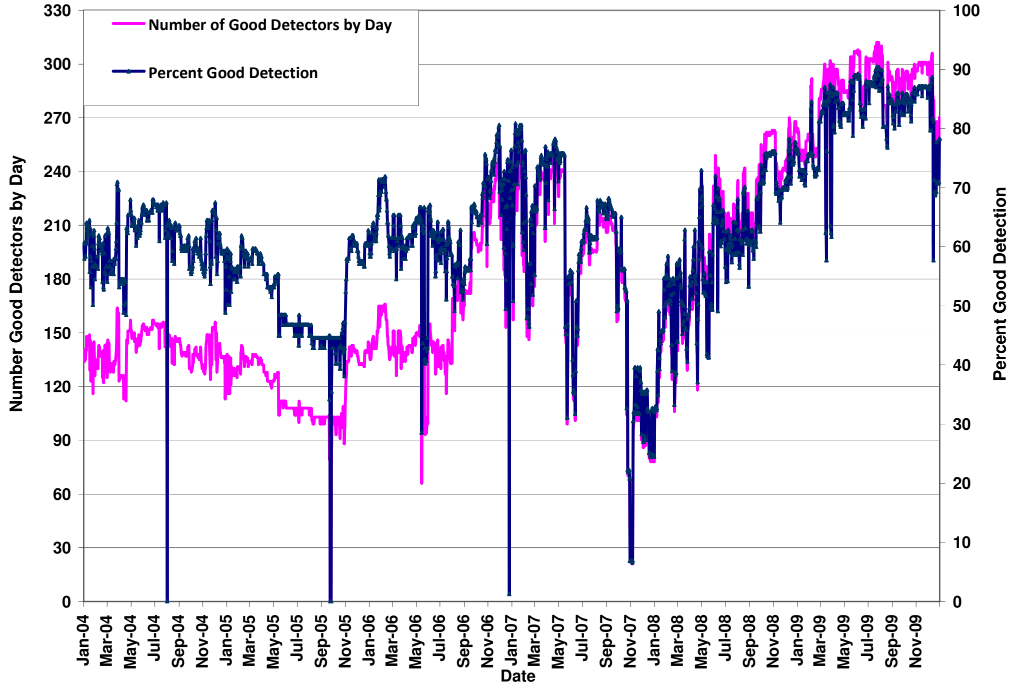
Exhibit 3-8: Westbound SR-22 HOV Detection Added (2008)

VDS	Location	Type	CA PM	Abs PM	Date Online
WESTBOUND					
1214870	YUMA	HOV	R2.07	3.527	5/2/2008
1215077	KNOTT 1	HOV	R2.49	3.947	5/2/2008
1215097	KNOTT 2	HOV	R2.88	4.337	5/2/2008
1215089	GARDEN GROV	HOV	R3.27	4.727	5/2/2008
1214816	BEACH 1	HOV	R3.45	4.907	5/2/2008
1214811	BEACH 2	HOV	R3.73	5.187	5/2/2008
1214937	WILSON	HOV	R4.03	5.487	5/2/2008
1214952	NEWLAND	HOV	R4.34	5.797	5/2/2008
1214780	MAGNOLIA 1	HOV	R4.6	6.057	5/2/2008
1214832	MAGNOLIA 2	HOV	R4.99	6.447	5/2/2008
1215071	BROOKHUR1	HOV	R5.57	7.027	5/2/2008
1214971	BROOKHUR2	HOV	R5.77	7.227	5/2/2008
1214985	HOPE	HOV	R6.05	7.507	5/2/2008
1215000	WARD	HOV	R6.34	7.797	5/2/2008
1214804	TAFT	HOV	R6.61	8.067	5/2/2008
1214785	EUCLID	HOV	R6.94	8.397	5/2/2008
1215062	NEWHOPE	HOV	R7.29	8.747	5/2/2008
1215249	NEWHOPE CENSUS	HOV	7	8.757	5/2/2008
1214893	HARBOR 1	HOV	R7.72	9.177	5/2/2008
1214899	HARBOR 2	HOV	R7.93	9.387	5/2/2008
1215016	PEARCE	HOV	R8.3	9.757	5/2/2008
1214770	GARDEN G1	HOV	R8.68	10.137	5/2/2008
1215042	LEWIS	HOV	R9.44	10.897	5/2/2008
1214742	CITY DRIVE	HOV	R9.69	11.251	5/2/2008
1214713	HESPERIAN	HOV	R9.9	11.461	5/2/2008
1214706	BRISTOL	HOV	R10.14	11.701	5/2/2008
1215114	W OF 5	HOV	R10.35	11.911	5/2/2008
1215129	E OF 5	HOV	R10.71	12.271	5/2/2008
1214746	MAIN	HOV	R11.23	12.791	5/2/2008
1214727	GLASSELL1	HOV	R11.68	13.241	5/2/2008
1214734	GLASSELL2	HOV	R12.01	13.571	5/2/2008
1215212	CONCORD	HOV	R12.25	13.811	5/2/2008

Source: Automatic detector data

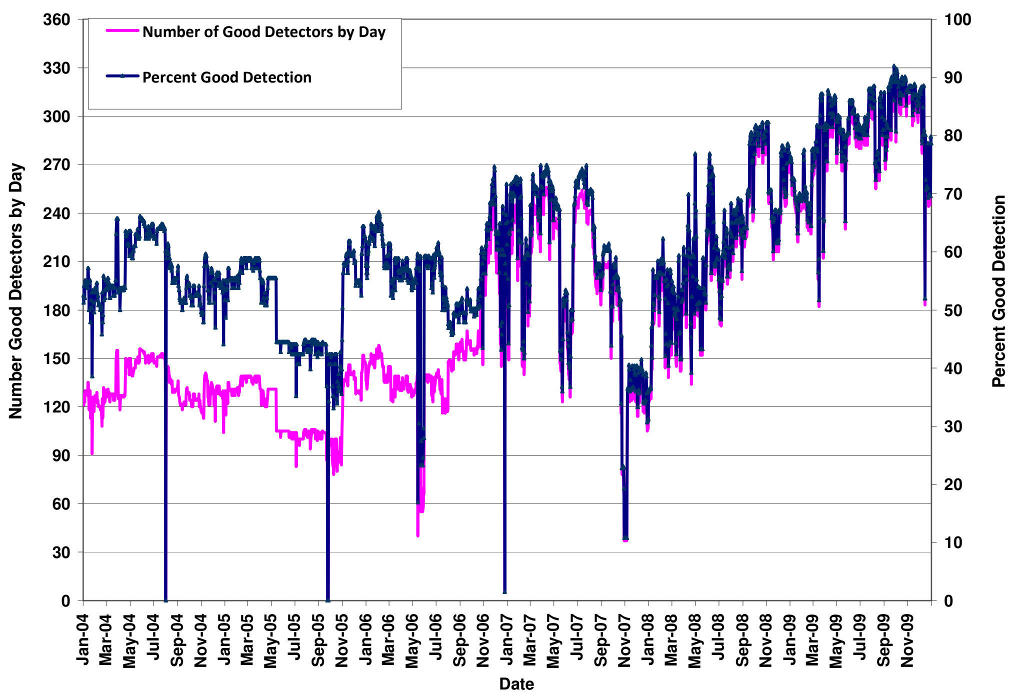
As of February 2009, the detection coverage on SR-22 is thorough with a detector station in at least every 0.75 miles of the corridor. Detection along the I-405 Corridor was overall more consistent than detection on the SR-22 Corridor. The I-405 mainline and HOV facilities experienced similar detection quality patterns. As shown in Exhibits 3-9 through 3-12, both directions of the mainline and HOV facilities experienced mediocre detection quality in 2004, 2005, and 2006 with the majority of detectors reporting around 60 percent “good” data. In the first half of 2007, detection improved, reaching 70-80 percent of good data, but declined significantly in the autumn months of 2007 to less than 40 percent of good data. However, in 2008, detection gradually improved throughout the months, climbing up to and reporting over 80 percent of good data by the end of 2009.

Exhibit 3-9: Northbound I-405 Mainline Daily Good Detectors (2004-2009)



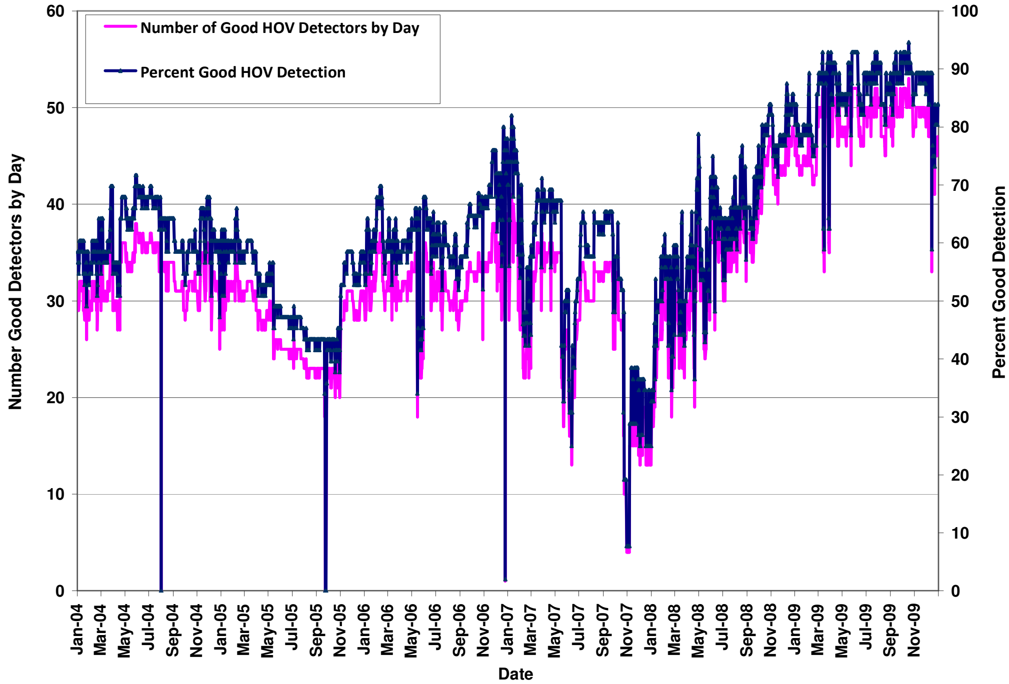
Source: Automatic detector data

Exhibit 3-10: Southbound I-405 Mainline Daily Good Detectors (2004-2009)



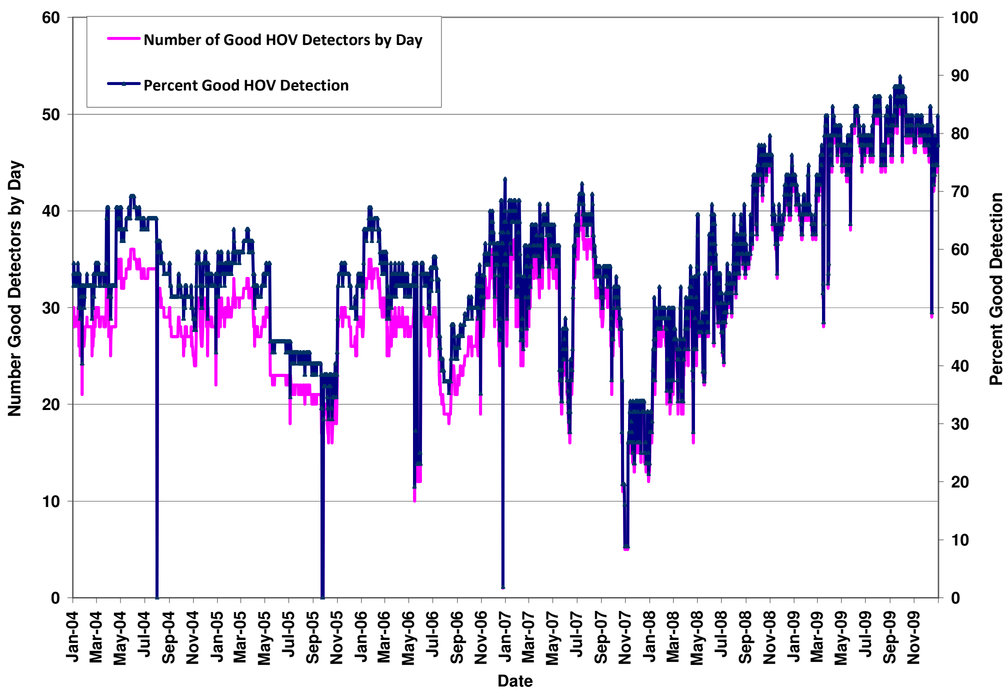
Source: Automatic detector data

Exhibit 3-11: Northbound I-405 HOV Daily Good Detectors (2004-2009)



Source: Automatic detector data

Exhibit 3-12: Southbound I-405 HOV Daily Good Detectors (2004-2009)



Source: Automatic detector data

Unlike SR-22, the I-405 freeway did not experience major construction. Exhibit 3-13 identifies the new detectors added to I-405 in 2007-2009, and Exhibit 3-14 identifies the new detectors added to the HOV facility.

Exhibit 3-13: I-405 Mainline and Ramp Detection Added (2007-2008)

VDS	Location	Type	CA PM	Abs PM	Date Online
NORTHBOUND					
1211066	N of 5	Mainline	0.6	0.37	5/2/2008
1213963	Sand Canyon 1	Mainline	2.66	2.89	2/14/2007
1213964	Sand Canyon 1	On Ramp	2.66	2.89	2/14/2007
1213965	Sand Canyon 1	Off Ramp	2.66	2.89	2/14/2007
1209076	Spruce	Mainline	5.05	4.82	5/2/2008
1214212	Anton	Mainline	8.7	8.47	5/2/2008
1214265	Anton	On Ramp	8.7	8.47	5/2/2008
1214268	Anton	Fwy-Fwy	8.7	8.47	5/2/2008
1214270	Anton	Off Ramp	8.7	8.47	5/2/2008
1214273	Anton	Fwy-Fwy	8.7	8.47	5/2/2008
1214274	Anton	Fwy-Fwy	8.7	8.47	5/2/2008
1209144	N of 55	Mainline	8.9	8.67	5/2/2008
1209483	N of 55	Fwy-Fwy	8.9	8.67	5/2/2008
1214238	Ave. of Art	Mainline	9.2	8.97	5/2/2008
1214241	Ave. of Art	On Ramp	9.2	8.97	5/2/2008
1214282	Ave. of Art	Off Ramp	9.2	8.97	5/2/2008
1214080	Bear	Mainline	9.9	9.67	2/14/2007
1214461	N of 73	Mainline	10.1	9.87	5/2/2008
SOUTHBOUND					
1201118	N of 5	Mainline	0.60	0.37	5/2/2008
1209070	Spruce	Mainline	5.05	4.82	5/2/2008
1201410	N of 55	Mainline	8.90	8.67	5/2/2008
1209482	N of 55	Fwy-Fwy	8.90	8.67	5/2/2008
1214209	Ave. of Art	Mainline	9.20	8.97	5/2/2008
1214237	Ave. of Art	Mainline	9.20	8.97	5/2/2008
1214240	Ave. of Art	Fwy-Fwy	9.20	8.97	5/2/2008
1214081	Bear	Mainline	9.90	9.67	2/14/2007

Source: Automatic detector data

Exhibit 3-14: I-405 HOV Detection Added (2007-2008)

VDS	Location	Type	CA PM	Abs PM	Date Online
NORTHBOUND					
1211067	N of 5	HOV	0.6	0.37	5/2/2008
1213966	Sand Canyon 1	HOV	2.66	2.89	2/14/2007
1209075	Spruce	HOV	5.05	4.82	5/2/2008
1214260	Anton	HOV	8.7	8.47	5/2/2008
1214243	Ave. of Art	HOV	9.2	8.97	5/2/2008
1214082	Bear	HOV	9.9	9.67	2/14/2007
SOUTHBOUND					
1211065	N of 5	HOV	0.60	0.37	5/2/2008
1213967	Sand Canyon 1	HOV	2.89	2.66	2/14/2007
1209068	Spruce	HOV	5.05	4.82	5/2/2008
1214242	Ave. of Art	HOV	9.20	8.97	5/2/2008
1214083	Bear	HOV	9.90	9.67	2/14/2007

Source: Automatic detector data

Exhibit 3-15 reveals that there are several segments extending over 0.75 miles without detection in each direction on I-405. These should be considered for deployment of additional detection when funding becomes available.

Exhibit 3-15: I-405 Detection Gaps (June 30, 2010)

Location	Abs PM		Length (Miles)
	From	To	
NORTHBOUND			
Jeffrey 2 (ML) to Yale (ML)	3.8	4.78	0.98
N of 73 (ML) to Fairview (ML)	9.87	10.67	0.8
SOUTHBOUND			
N of 22 (ML) to Bolsa Chica (ML)	21.33	20.46	0.87
McFadden (ML) to Beach 1 (ML)	17.22	16.37	0.85
Yale (ML) to Jeffrey 2 (ML)	4.78	3.8	0.98

Source: Automatic detector data

Mobility

Two primary measures quantify mobility in this report: delay and travel time. Each is estimated from field automatic detection data and forecasted using macro- or micro-simulation models. The Performance Measurement System (PeMS)[5] provides access to the historical freeway detection data needed to estimate the two mobility measures. PeMS collects detector volume and occupancy data on the freeway, which are used to estimate speed, 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 using the following formula:

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

In the formula above, the *Vehicles Affected per Hour* value depends on the methodology used. Some methods assume a fixed flow rate (e.g., 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 experienced below the threshold speed.

The threshold speed can also vary. In general, the threshold speed represents free-flow or some other pre-defined speed. In this CSMP analysis, 60 mph is considered free-flow speed for the corridor, and will be used to calculate delay.

Different reports and studies use other threshold speeds, typically 35 mph (e.g., HICOMP), which is defined here as the “severe congestion” speed threshold, and 45 mph (Federal Highway Administration threshold to define HOV degradation).

The HICOMP annual report discussed in the following section uses the 35 mph threshold speed and assumes 2,000 vehicles per hour per lane as the throughput threshold. Therefore, HICOMP reports on severe delay, while the automatic detector data uses 60 mph and the reported number of vehicles reported by the detectors. Each of these two sources is discussed separately since their results are extremely difficult to compare due to methodological and data collection differences.

[5] Developed and maintained by Caltrans and accessible at http://pems.dot.ca.gov.

Caltrans HICOMP

The HICOMP report has been published annually by Caltrans since 1987[6]. Delay is presented as average daily vehicle-hours of delay (DVHD). The HICOMP report defines delay as travel time in excess of free flow travel time when speeds dip below 35 mph for 15 minutes or longer.

District 12 collects data for HICOMP using probe vehicle runs for two to four days during the year (ideally, two days of data collection in the spring and two in the fall, though resource constraints often affect the number of runs performed). In addition to probe vehicles, Traffic Operations in District 12 uses ATMS and automatic detector data to calculate delay from the HICOMP Report. As discussed later in this section on automatic detector data, congestion levels vary from day to day and depend on any number of factors including accidents, weather, special events, the price of gasoline, and construction activities.

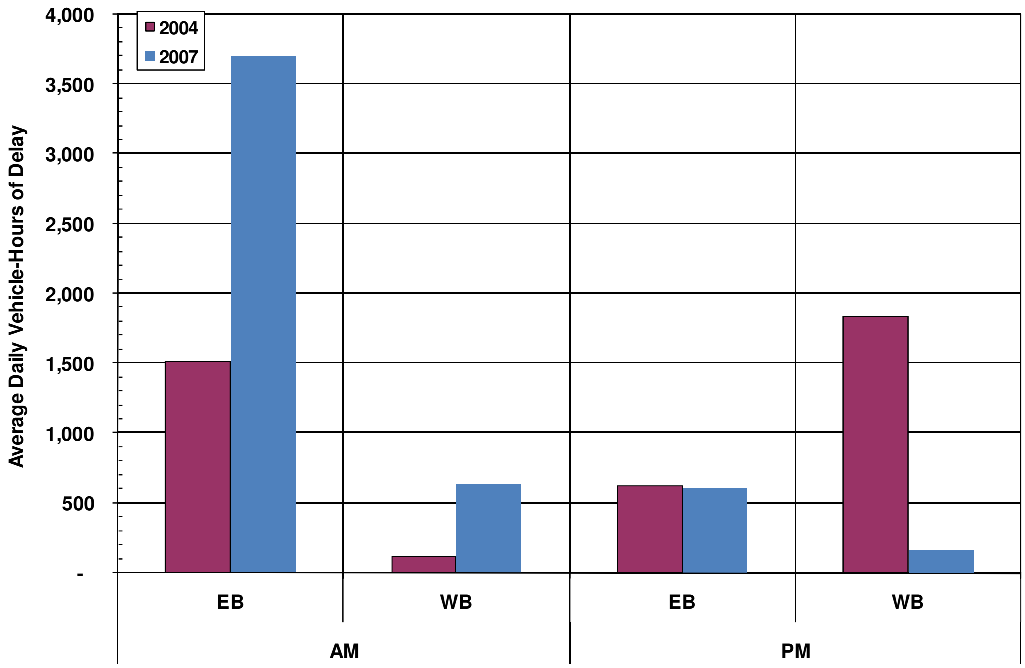
Exhibit 3-16 shows the yearly delay trend for SR-22 in 2004 and 2007 during the AM and PM peak periods for both directions. Data for 2005 and 2006 is not included in the exhibit because it was not available. From the year 2004 to 2007, congestion increased during the AM peak in both directions, and decreased during the PM peak. The eastbound direction experienced the heaviest congestion in 2004 and 2007 during the AM peak, while the westbound direction experienced the most congestion in 2004 during the PM peak.

Exhibit 3-17 illustrates the yearly delay trends for I-405 in 2006 and 2007 during the AM and PM peak periods. HICOMP information for 2005 was not available. The exhibit reveals that congestion increased in the northbound direction during both peak periods, but decreased in the southbound direction during both peak periods between 2006 and 2007.

It should be noted that changes in delay from one year to the next may not be significant given the limited number of days on which data is collected. Trends over several years can be deemed significant.

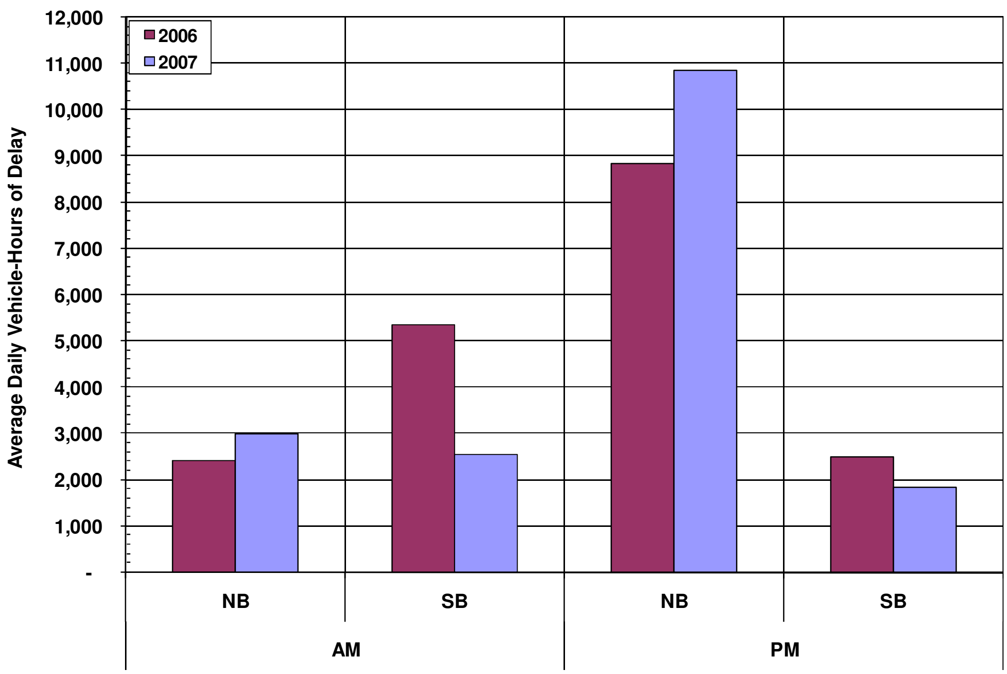
[6] Located at: http://www.dot.ca.gov/hq/traffops/sysmgtpl/HICOMP/index.htm

Exhibit 3-16: SR-22 Mainline Average Daily Vehicle-Hours of Delay (2004 & 2007)



Source: 2004 & 2007 HICOMP Reports

Exhibit 3-17: I-405 Mainline Average Daily Vehicle-Hours of Delay (2006-2007)



Source: 2006 & 2007 HICOMP Reports

Exhibit 3-18 identifies the complete list of congested segments reported by the HICOMP Report for SR-22. The most congested segment was in the eastbound direction from Newland Street to Main Street with 1,507 hours (in 2004) and 3,701 hours of delay (in 2007) during the AM peak. From 2004 to 2007, overall congestion increased on the freeway, most notably during the AM peak from 1,623 hours of delay in 2004 to 4,340 hours in 2007. This is an increase of more than 250 percent.

Exhibit 3-18: SR-22 Mainline HICOMP Congested Segments (2004 & 2007)

Period	Dir	Generalized Congested Area	Generalized Area Congested	
			2004	2007
AM	EB	Newland St to Main St	1,507	3,701
	WB	Goldenwest St to Valley View St	116	639
AM PEAK PERIOD SUMMARY			1,623	4,340
PM	EB	Garden Grove Bl to Springdale St	64	
		Newland St to Magnolia St	33	
		Magnolia St to Deodara Rd	59	
		Brookhurst St to Taft St	84	
		Euclid St to Garden Grove Bl	211	
		Town & Country to w/o Parker St	43	
		Parker St to Cambridge St	123	
		w/o Harbor Blvd to Parker St		609
	WB	e/o Blue Spruce Ave to Main St	826	168
		Tustin Ave to Lewis St	1,010	
PM PEAK PERIOD SUMMARY			2,453	777
TOTAL CORRIDOR CONGESTION			4,076	5,117

Note: 2005 and 2006 HICOMP not available for the SR-22.

Exhibit 3-19 identifies the list of congested segment for I-405. The most congested segment on the corridor was in the northbound direction from Harvard Avenue to Harbor Boulevard during the PM peak. Delay in this segment totaled 7,748 hours of delay in 2007. In 2006, the most congested segment occurred in a different location - Sand Canyon Avenue and Harbor Boulevard. In 2006, the most congested segment was also in the northbound direction during the PM peak. From 2006 to 2007, total corridor congestion decreased during the AM peak by approximately 30 percent and increased during the PM peak by about 12 percent.

Exhibit 3-19: I-405 Mainline HICOMP Congested Segments (2006 & 2007)

Period	Dir	Generalized Congested Area	Generalized Area Congested	
			2006	2007
AM	NB	Irvine Ctr Dr to Jamboree Bl	1,757	
		Harbor Bl to Jnct 605	656	
		Irvine Center Dr to s/o Macarthur Blvd		2,428
		Brookhurst St to LA County Line		569
	SB	Harbor Bl to Jeffrey Rd	257	
		Jnct 22 to Harbor Bl	5,088	
		n/o Bolsa Chica St to Brookhurst St		2,417
		Harbor Blvd to University Dr		112
AM PEAK PERIOD SUMMARY			7,758	5,526
PM	NB	Sand Canyon Av to Harbor Bl	5,765	
		Harbor Blvd to Jnct 605	3,066	
		Harvard Ave to Habor Blvd		7,748
		Harbor Blvd to LA County Line		3,092
	SB	LA County Line to Magnolia/Warner	363	
		SR-55 to Sand Canyon Av	2,113	
		LA County Line to Newland St		381
		Red Hill Ave to n/o Sand Cayon Ave		1,456
PM PEAK PERIOD SUMMARY			11,307	12,677
TOTAL CORRIDOR CONGESTION			**19,065**	**18,203**

Source: 2006 & 2007 HICOMP Reports

Exhibits 3-20 and 3-21 present the congestion information on maps for the AM and PM peak commute periods in 2007. The maps show the congestion on both freeways (SR-22 and I-405). The approximate locations of the congested segments, the duration of that congestion, and the reported recurrent daily delay are also shown. More "generalized" congested segments were created so that segment comparisons can be made from one year to the next.

Exhibit 3-20: HICOMP AM Peak Period Congested Segments Map (2007)

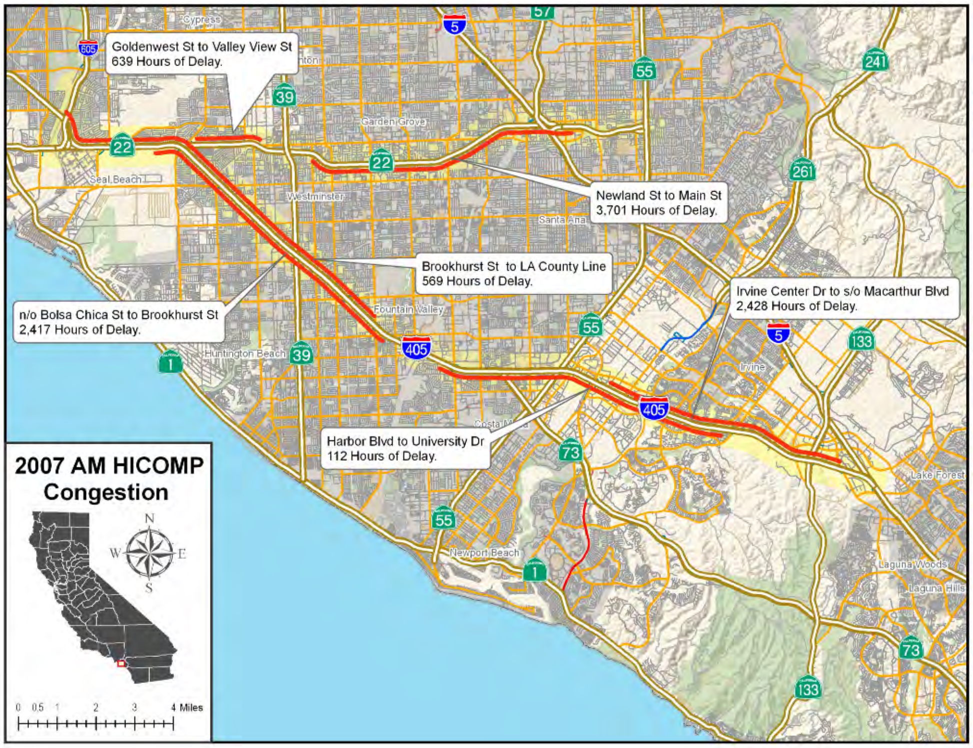
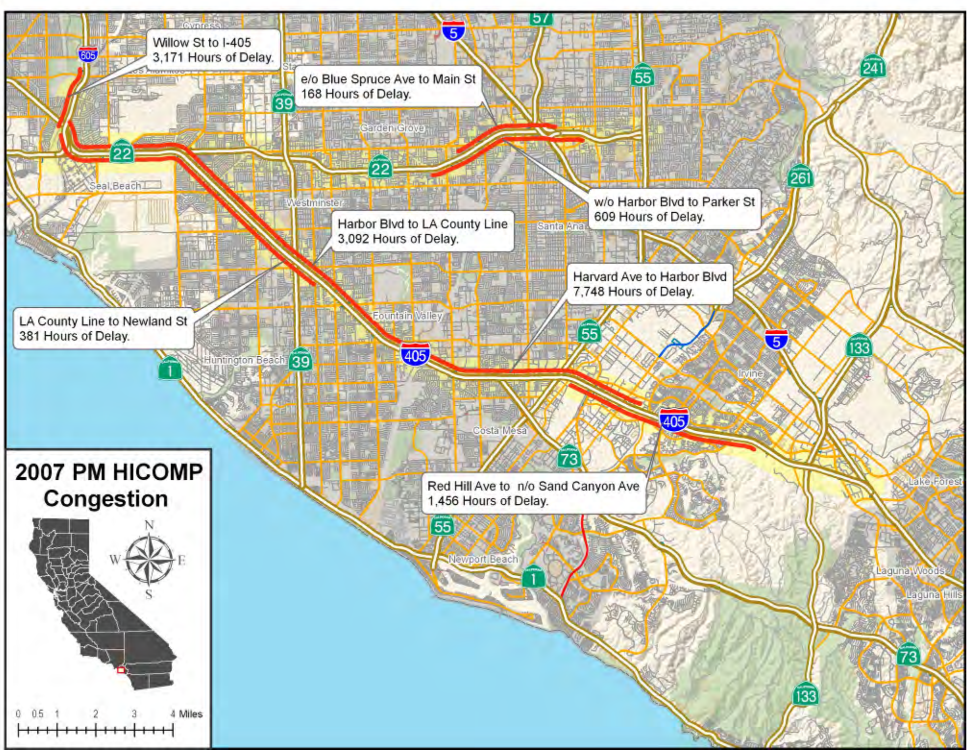


Exhibit 3-21: HICOMP PM Peak Period Congested Segments Map (2007)



Automatic Detector Data

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

For the SR-22 mainline facility, performance assessments were conducted for two time periods: 2002-2004 (pre-construction) and 2008-2009 (post-construction). The same performance assessment was conducted for the SR-22 HOV facility, but during the post-construction year of 2009 when detection quality was high. For the I-405 mainline and HOV facilities, performance assessments were conducted for the continuous five-year period of 2005 to 2009. HICOMP only estimates delay when speeds drop below 35 mph, and it assumes a capacity volume of 2,000 vehicles per hour per lane.

The automatically collected detector data presented here is based on the difference in travel time between reported conditions and the travel time at free-flow measured at 60 miles per hour, applied to the actual output flow volume collected from a vehicle detector station.

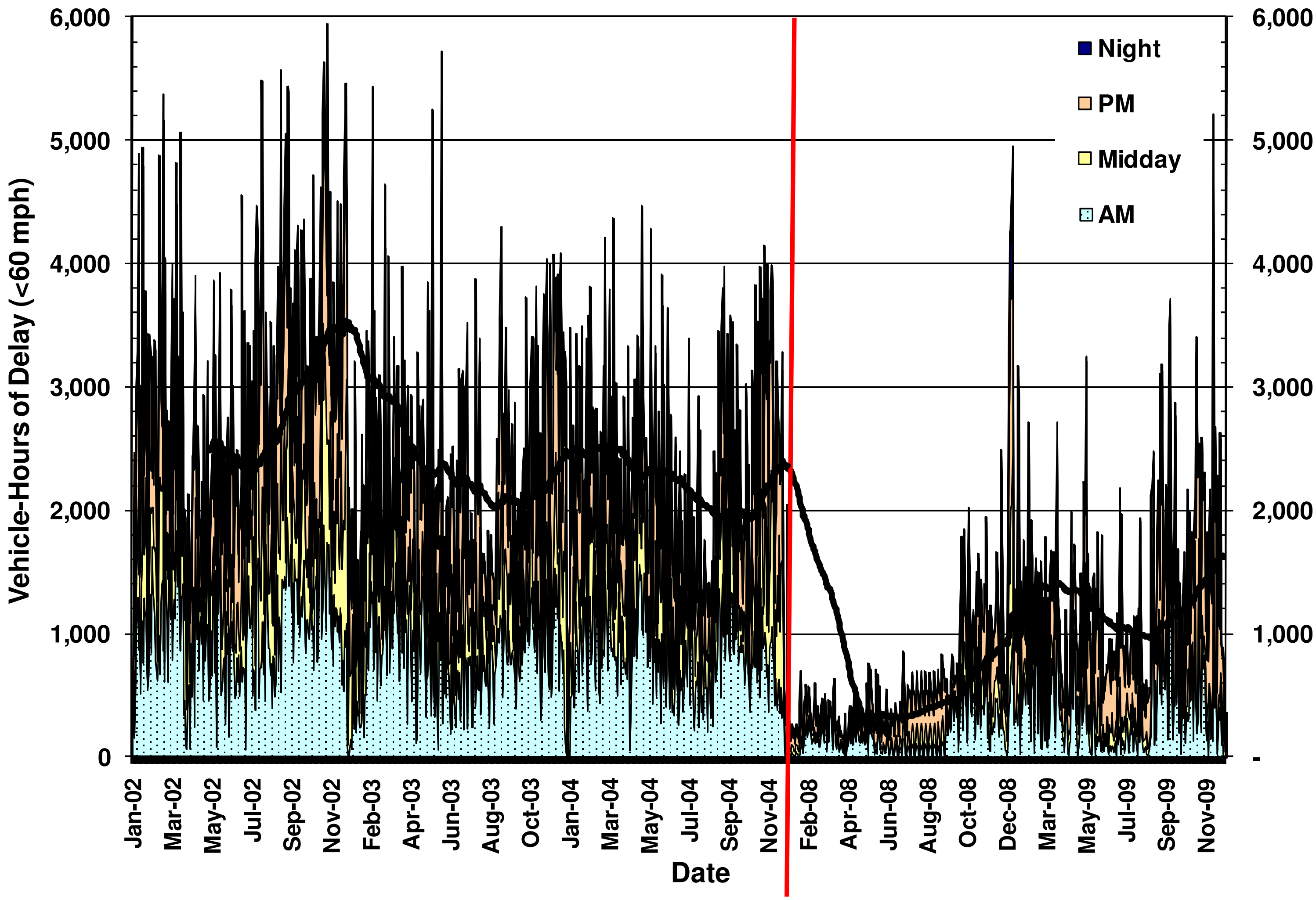
Total delay along the study corridor was computed for four time periods: AM peak (6:00 AM to 9:00 AM), Midday (9:00 AM to 3:00 PM), PM peak (3:00 PM to 7:00 PM), and evening/early AM (7:00 PM to 6:00 AM).

The following exhibits illustrate the delay experienced on the weekdays for the SR-22 Corridor. Exhibits 3-22 and 3-23 depict the mainline facility and Exhibits 3-24 and 3-25 depict the HOV facility. Mainline delay in the eastbound direction (Exhibit 3-22) was greatest during the AM peak period. Delay significantly declined between pre- and post-construction periods. The pre-construction period experienced an average delay that ranged between 2,000 and 3,000 vehicle-hours, whereas the post-construction period witnessed an average delay between 1,000 and 2,000 vehicle-hours. However, it is important to note that 2008 experienced limited detection quality, which may have resulted in underreported data during this year.

Mainline delay in the westbound direction (Exhibits 3-23) was overwhelmingly concentrated in the PM peak. The westbound mainline direction experienced the same levels of decline in delay as the eastbound mainline between pre- and post-construction periods. Total delay in the westbound mainline was lower than the eastbound mainline.

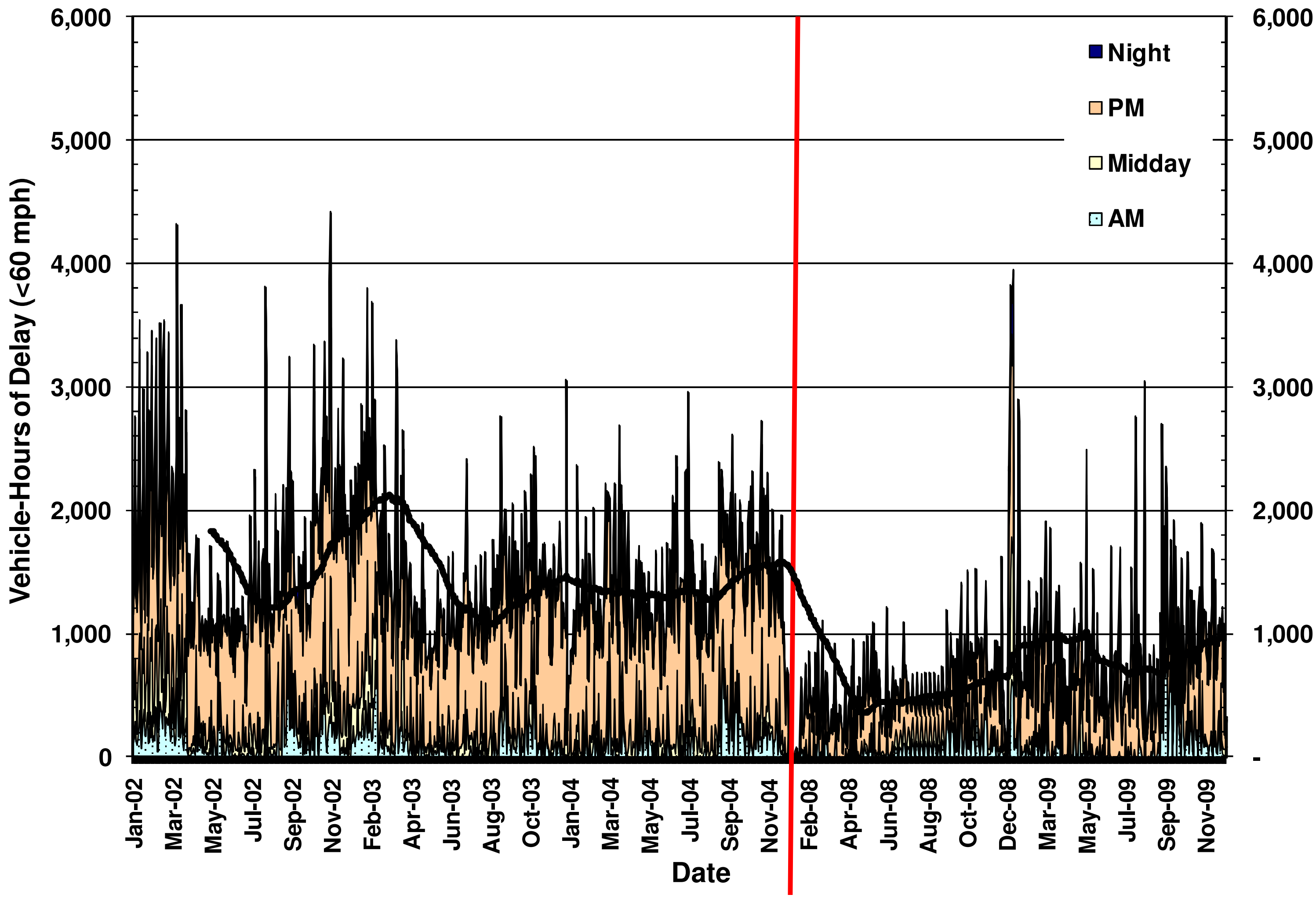
Delay on the SR-22 HOV facility is presented in Exhibits 3-24 and 3-25. The HOV facility was completed in spring of 2007 and reliable detection data on the HOV facility was not available until February 5, 2009. In 2009, delay on both directions of the HOV-lane was greater in the PM peak than the AM peak. However, in the westbound direction during the months of September and October, there was greater delay during the AM peak.

Exhibit 3-22: Eastbound SR-22 Mainline Average Daily Delay by Time Period (2002-2009)



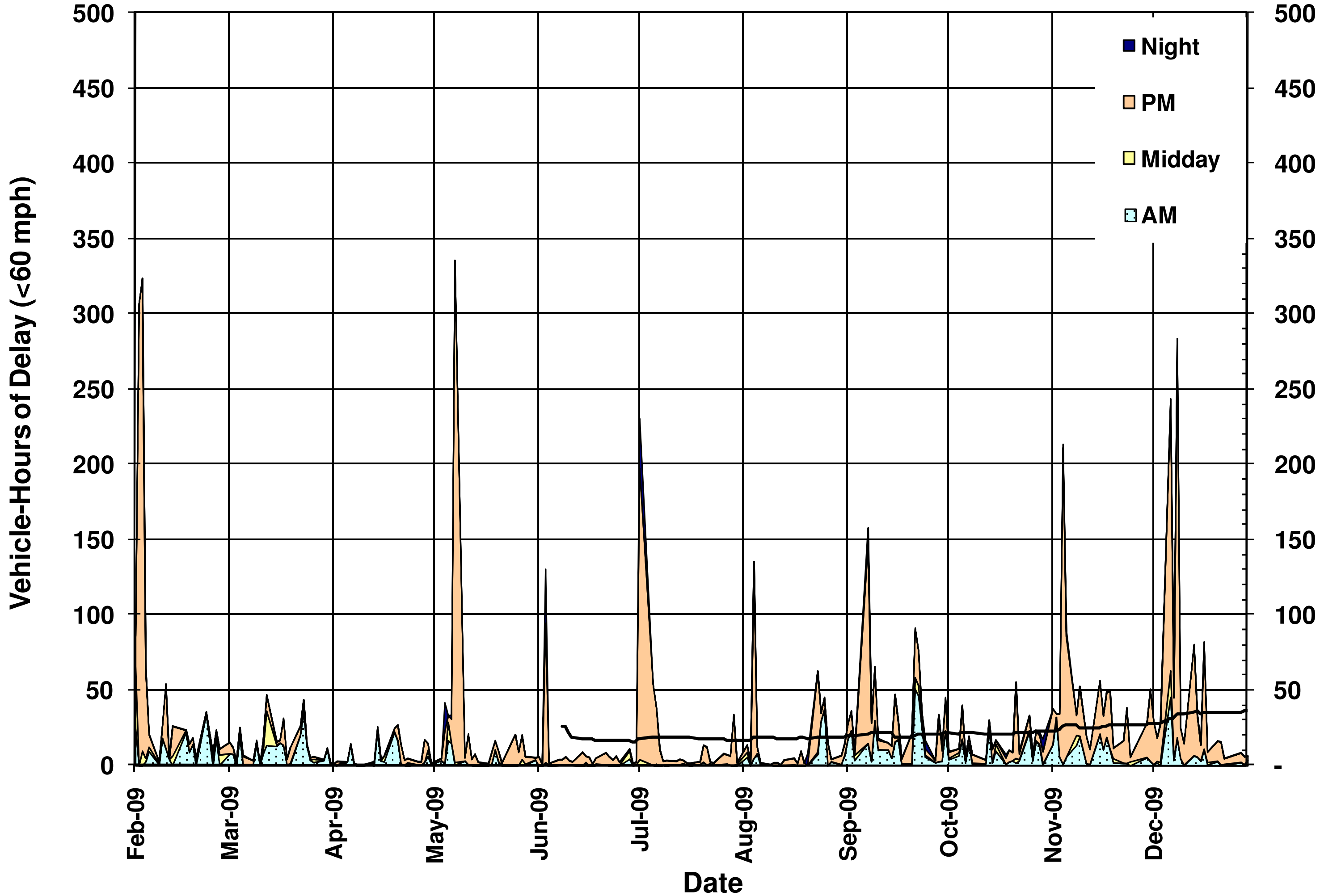
Source: Automatic detector data
Note: Due to limited detection on SR-22 in 2008, delay may be underreported for 2008.

Exhibit 3-23: Westbound SR-22 Mainline Average Daily Delay by Time Period (2002-2009)



Source: Automatic detector data
Note: Due to limited detection on SR-22 in 2008, delay may be underreported for 2008.

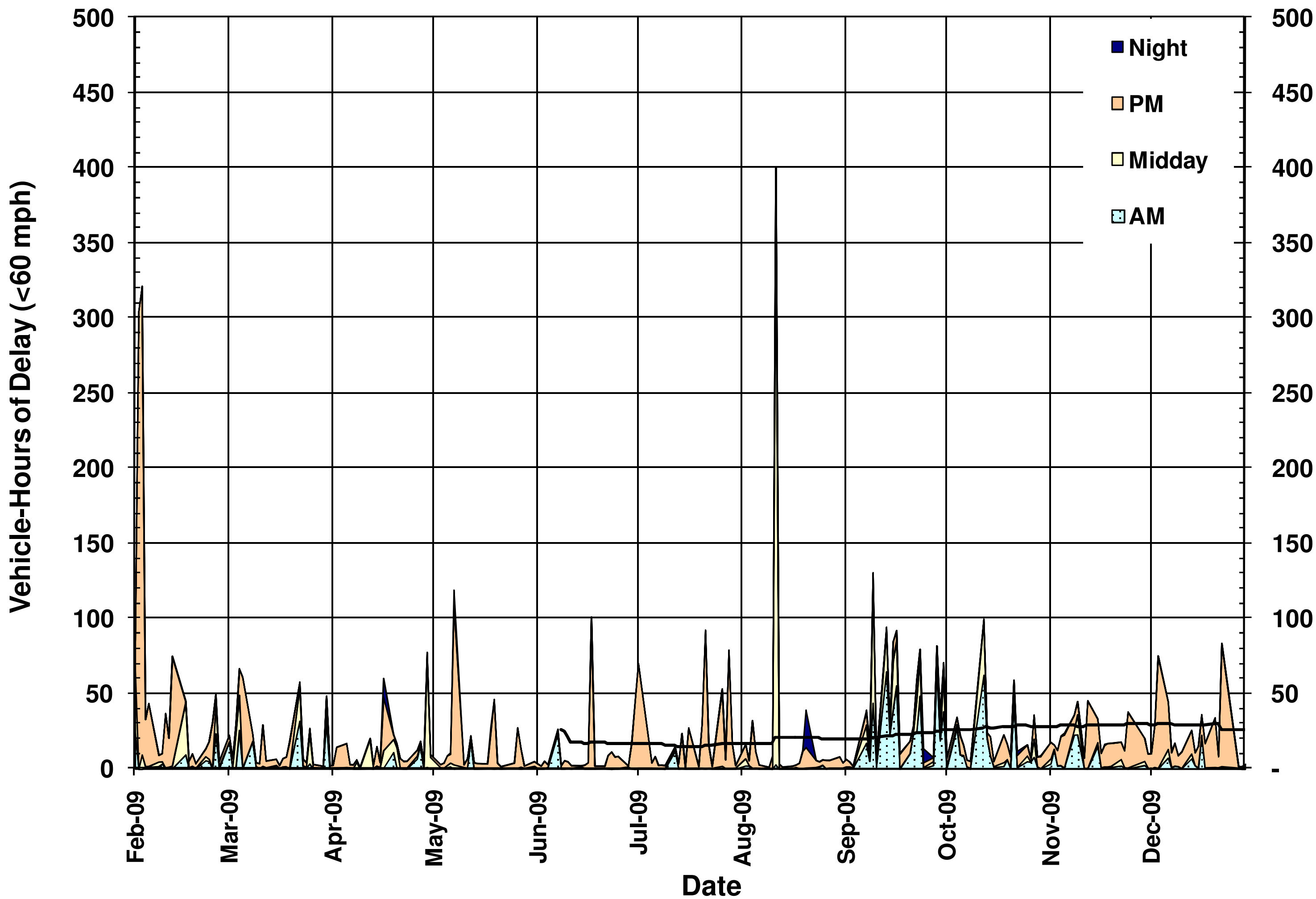
Exhibit 3-24: Eastbound SR-22 HOV Average Daily Delay by Time Period (2009)



Source: Automatic detector data

Note: Detection data for the SR-22 HOV facility was available starting on February 5, 2009.

Exhibit 3-25: Westbound SR-22 HOV Average Daily Delay by Time Period (2009)



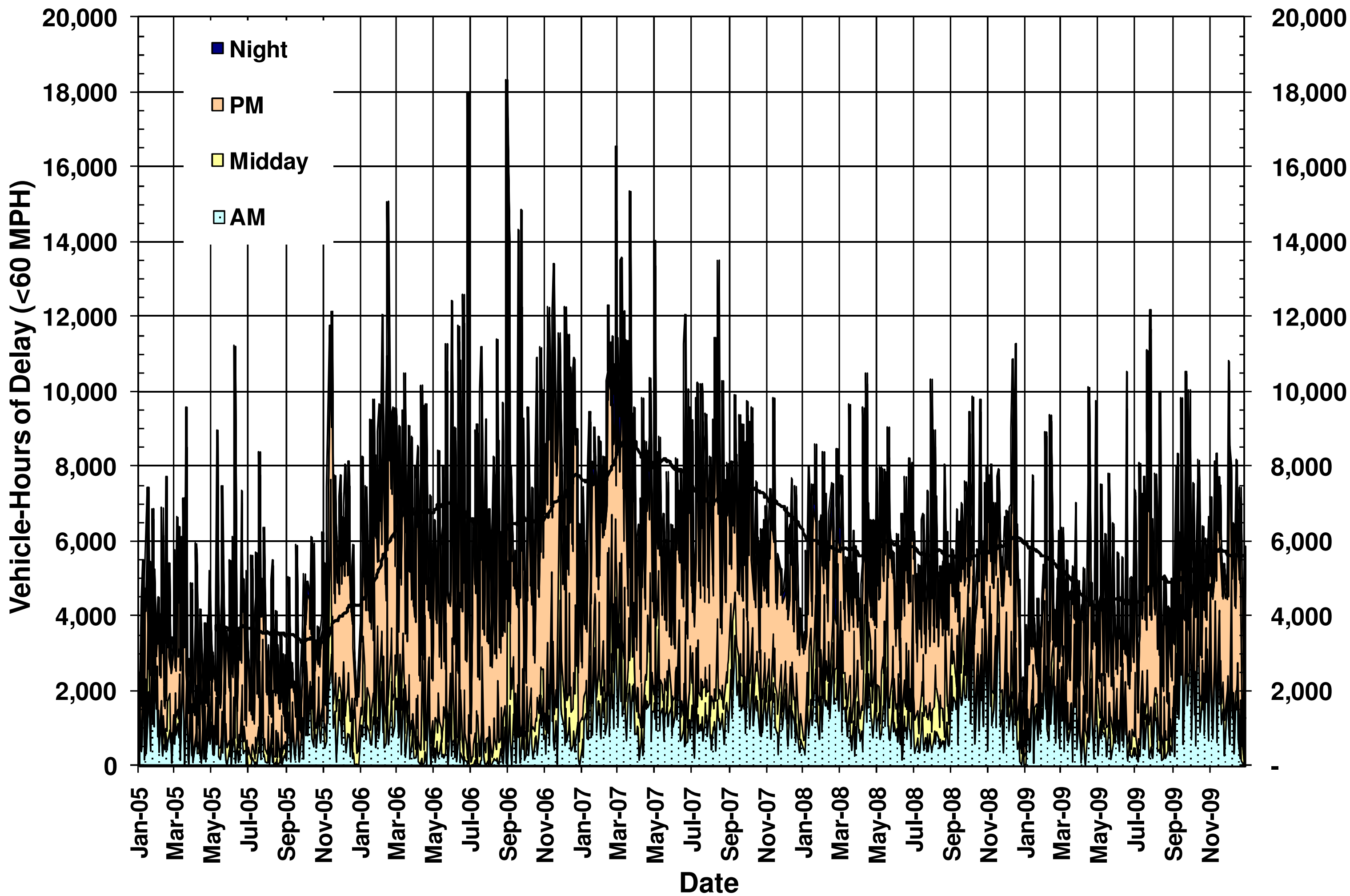
Source: Automatic detector data
Note: Detection data for the SR-22 HOV facility was available starting on February 5, 2009.

Delay on the I-405 Corridor is shown in Exhibits 3-26 through 3-29. Unlike the SR-22 delay exhibits, the I-405 exhibits cover the entire five-year period from 2005 through 2009 continuously without any breaks, since major construction did not take place on the corridor during this time.

For the mainline facility, Exhibit 3-26 shows that delay in the northbound direction increased significantly from 2006 to mid-2007 and decreased from mid-2007 to 2009. The southbound mainline facility (see Exhibit 3-27) shows the same trend with increased delay from 2006 to mid-2007 and decreased delay from mid-2007 to 2009. Delay in the northbound direction was concentrated in the PM peak while delay in the southbound direction was concentrated in the AM peak, suggesting a directional pattern of congestion.

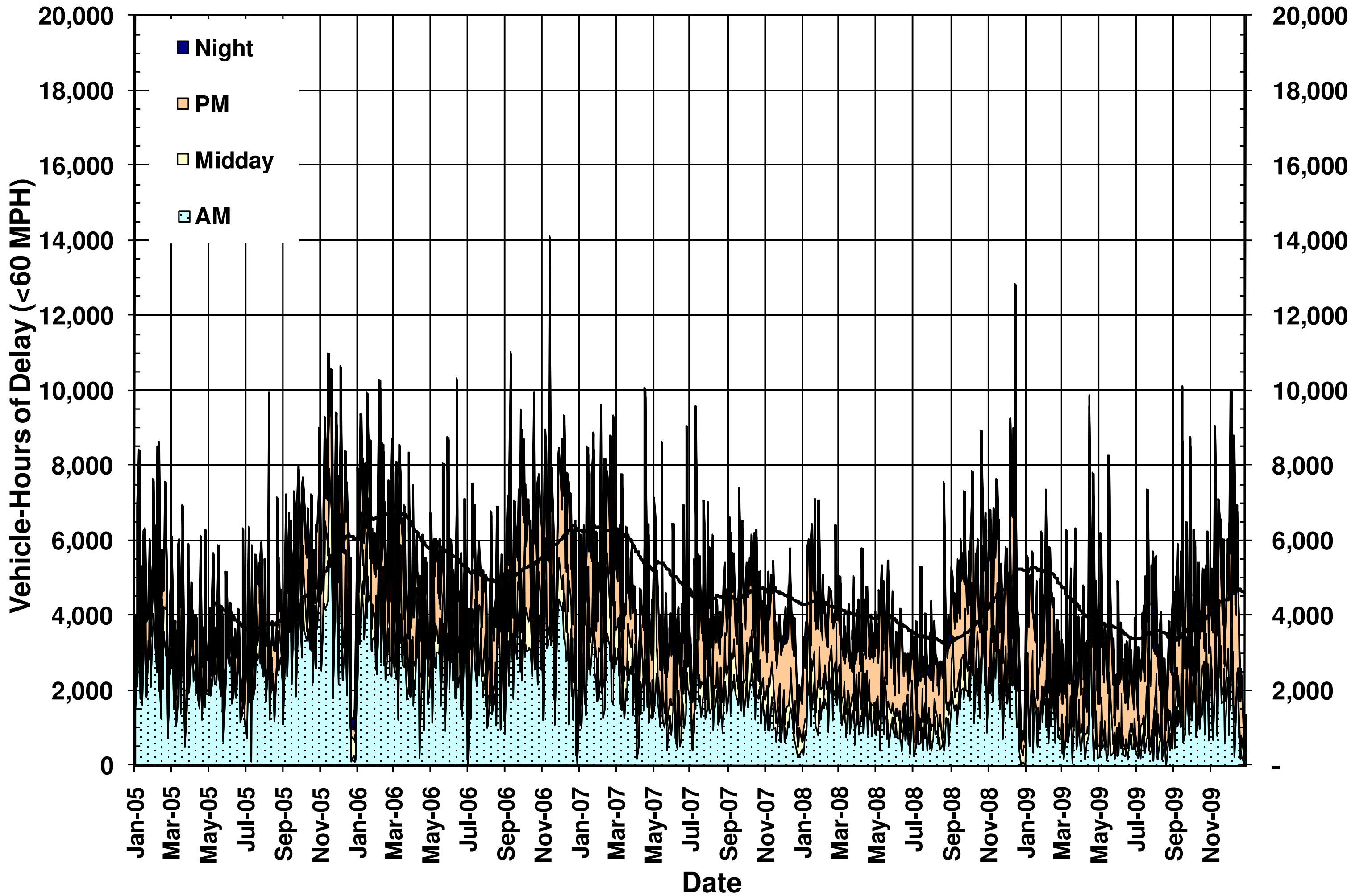
Delay on the I-405 HOV facility is depicted in Exhibits 3-28 and 3-29 for the same five-year period. Exhibit 3-28 shows that the northbound direction experienced significantly greater delay than the southbound direction, specifically in 2007 when the average vehicle hours of delay reached 2,000, compared to only 1,000 in the southbound direction during the same time period. Similar to the mainline, delay in the northbound direction was concentrated in the PM peak period while delay in the southbound direction was concentrated in the AM peak period. Unlike the mainline facility, the northbound HOV-lane witnessed an increase in congestion starting in 2008 until the autumn of 2009. Interestingly, in 2008 and 2009, the southbound direction experienced increased levels of delay during the PM peak compared to previous years.

Exhibit 3-26: Northbound I-405 Mainline Average Daily Delay by Time Period (2005-2009)



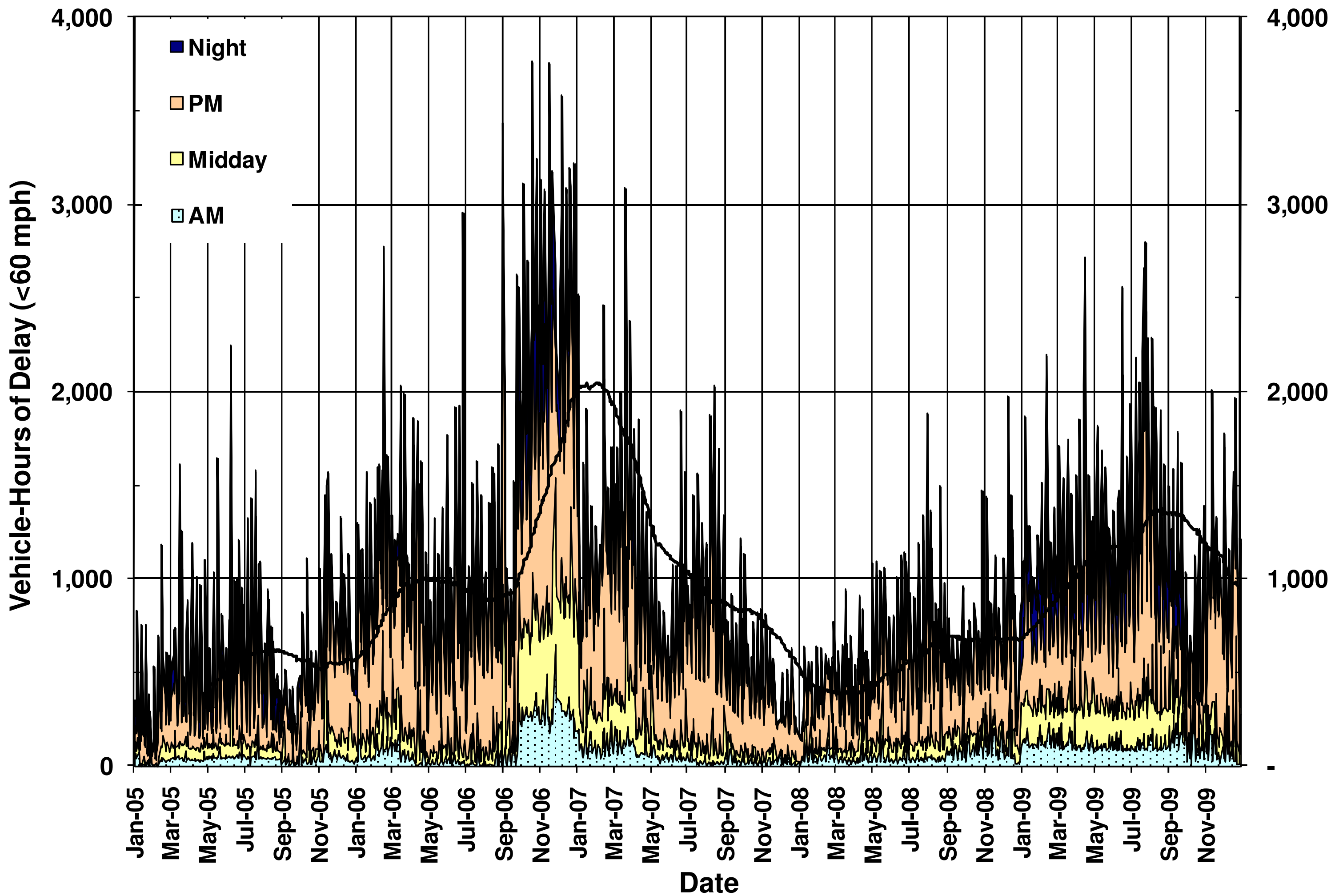
Source: Automatic detector data

Exhibit 3-27: Southbound I-405 Mainline Average Daily Delay by Time Period (2005-2009)



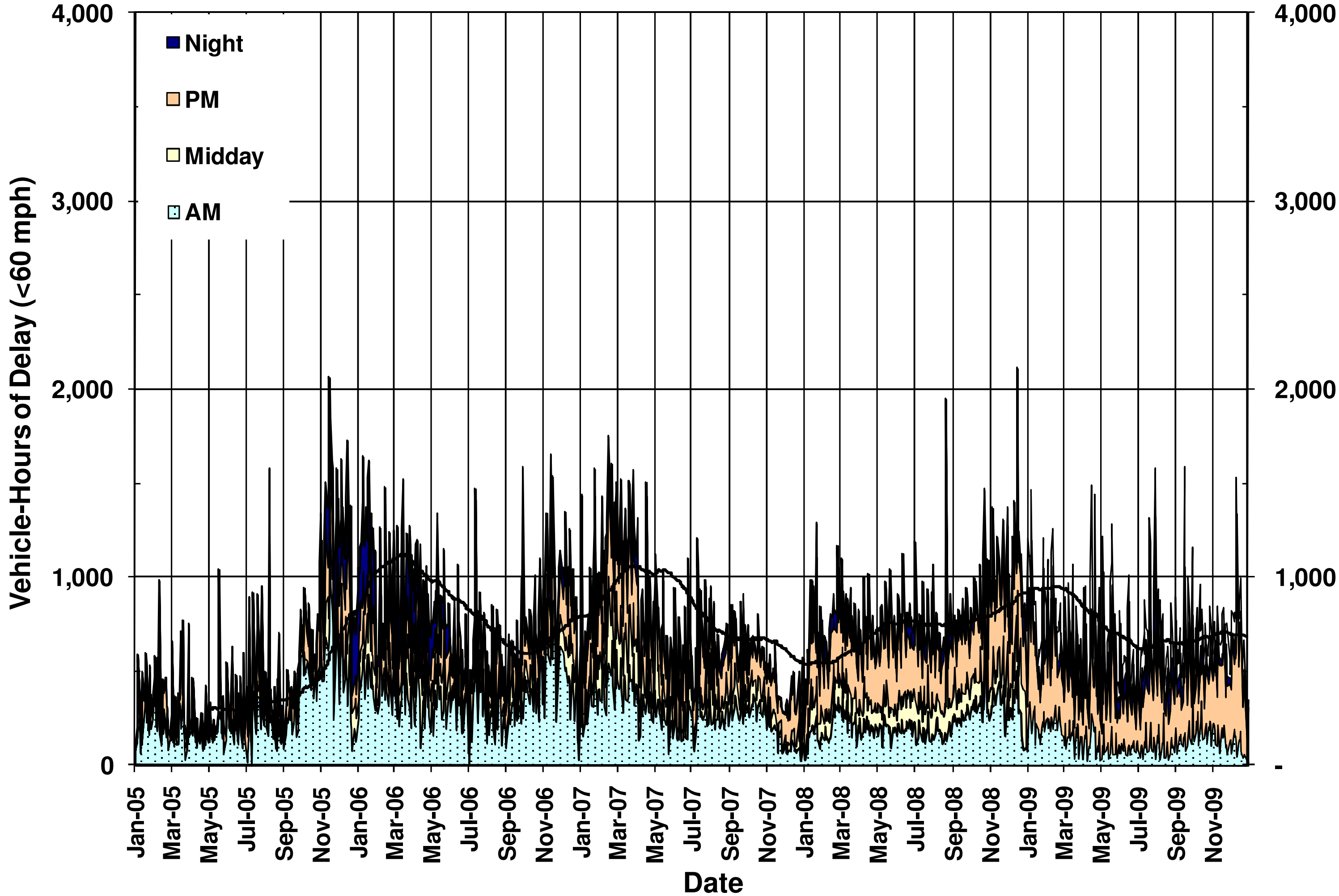
Source: Automatic detector data

Exhibit 3-28: Northbound I-405 HOV Average Daily Delay by Time Period (2005-2009)



Source: Automatic detector data

Exhibit 3-29: Southbound I-405 HOV Average Daily Delay by Time Period (2005-2009)

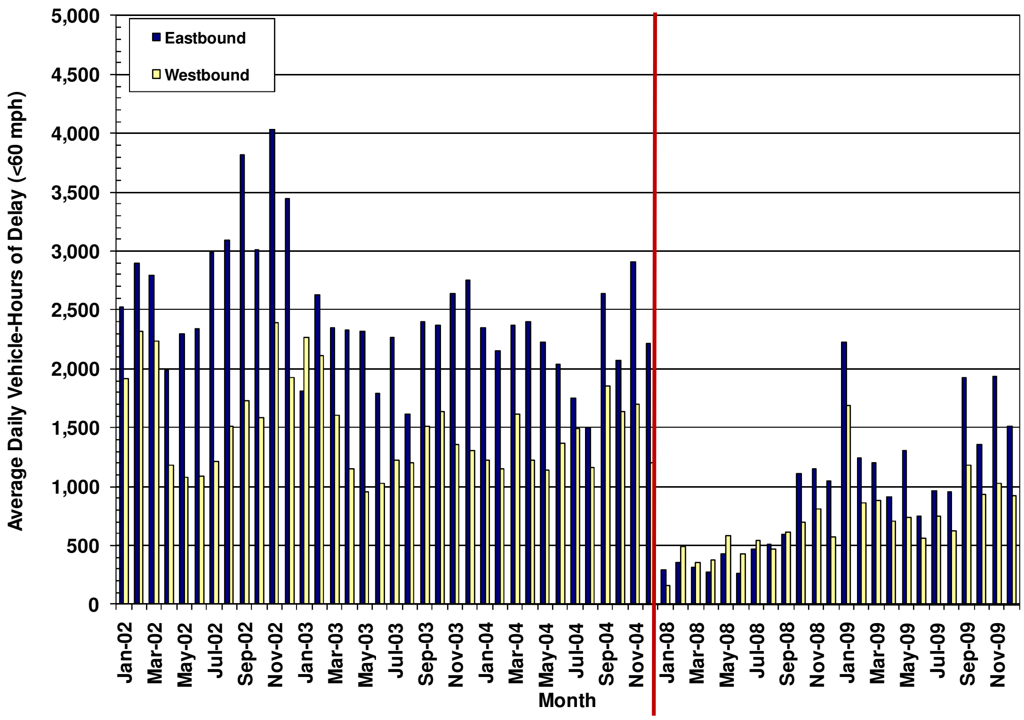


Source: Automatic detector data

Another way to look at delay trends is by monthly average. The average daily weekday delay by month and by direction is shown for the SR-22 corridor in Exhibits 3-30 and 3-31. For the mainline facility, the years 2005 and 2006 are omitted from the exhibits since traffic patterns change dramatically as a result of construction activity and the use of alternate routes. Although the project was completed in spring 2007, 2007 is also excluded from the exhibit since traffic patterns vary immediately after construction with motorists continuing to use alternate routes or motorists getting accustomed to the new facility. Exhibit 3-30 illustrates that the average weekday delay decreased significantly in 2008 and 2009 compared to the previous years, suggesting that the widening project improved mobility on SR-22. During the pre-construction years (2002-2004), the eastbound and westbound directions exceeded 2009 delay numbers by at least 30 percent.

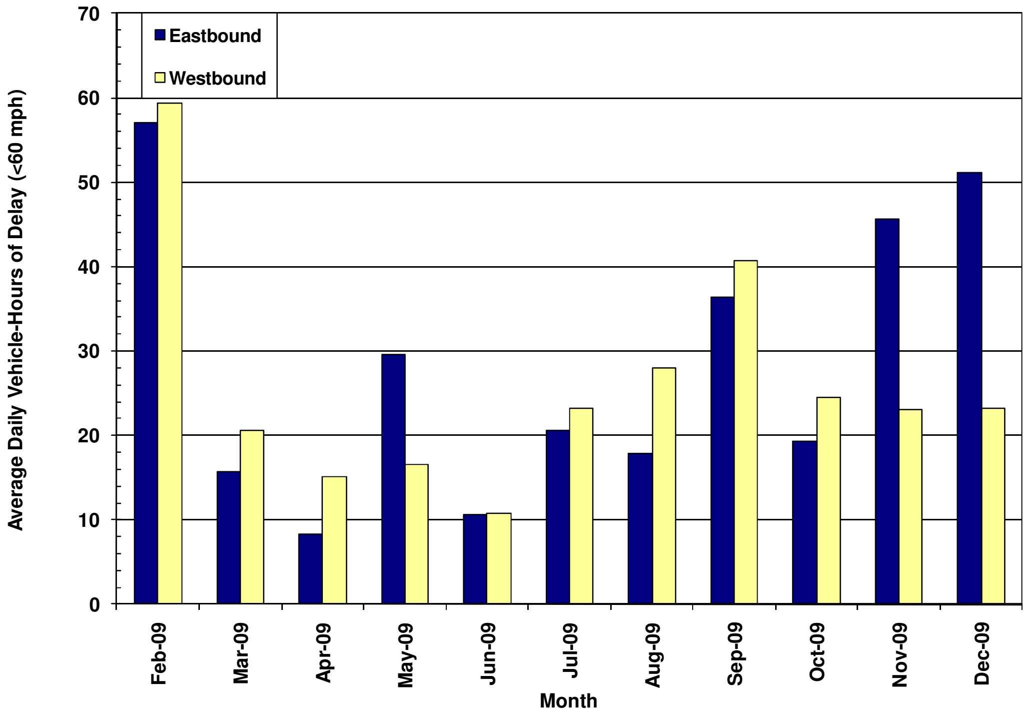
Exhibit 3-31 shows that each direction of the HOV facility experienced around 50 or fewer vehicle-hours of delay each month.

Exhibit 3-30: SR-22 Mainline Average Weekday Delay by Month (2002-2009)



Source: Automatic detector data
Note: Due to limited detection on SR-22 in 2008, delay may be underreported for 2008.

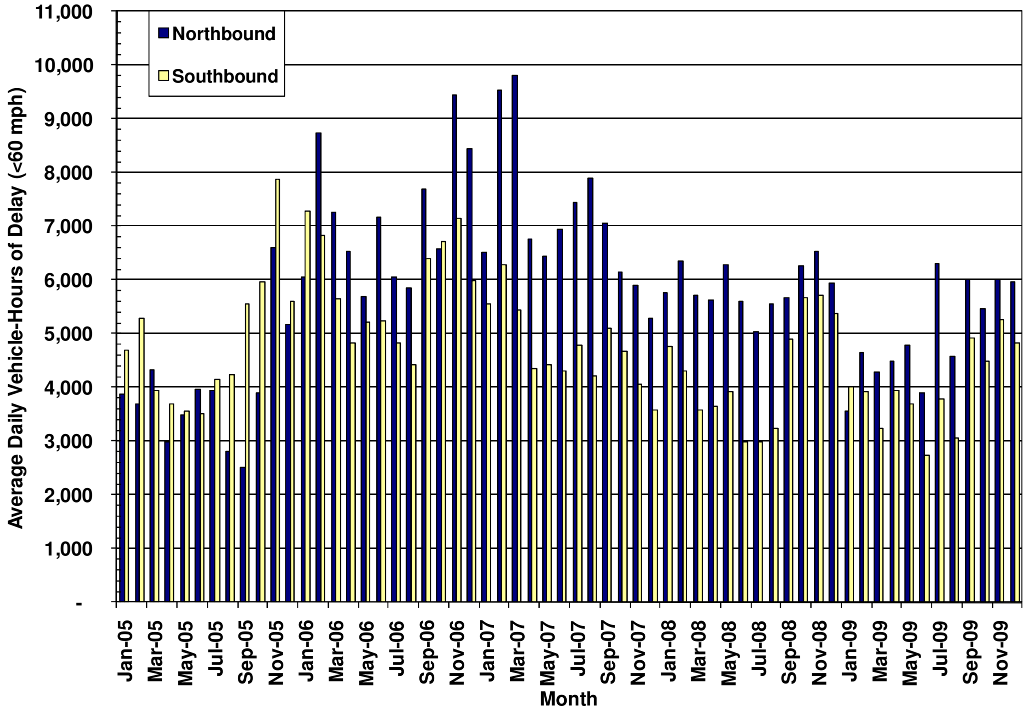
Exhibit 3-31: SR-22 HOV Average Weekday Delay by Month (2009)



Source: Automatic detector data
Note: Detection on the SR-22 HOV facility was not available until February 5, 2009.

On the I-405 Corridor, Exhibit 3-32 shows that delay increased from 2005 to mid-2007 and slowly decreased throughout 2008 and first half of 2009. However, delay in the last half of 2009 rebounded to early 2008 levels. In 2005, delay was greater in the southbound direction than the northbound. This trend reversed in the following years (2006-2009), when delay in the northbound direction exceeded the southbound by up to 30 percent in 2008.

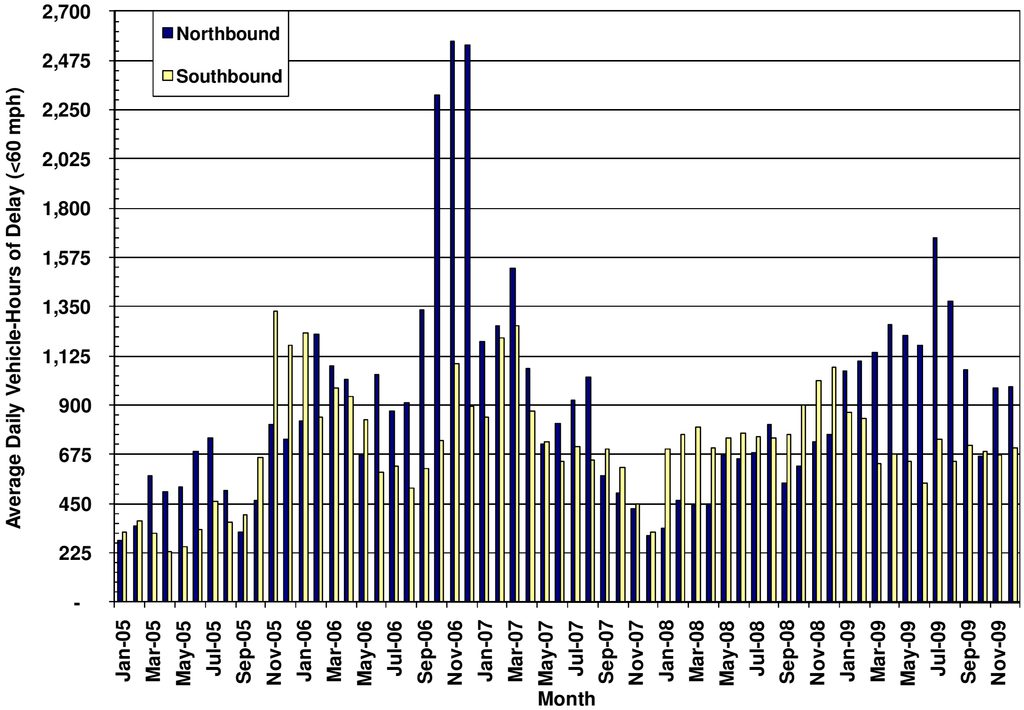
Exhibit 3-32: I-405 Mainline Average Weekday Delay by Month (2005-2009)



Source: Automatic detector data

Exhibit 3-33 illustrates the average daily vehicle-hours of delay experienced on the I-405 HOV facility. The HOV facility followed a similar trend as the mainline facility, with a peak in delay occurring in late 2006. Delay decreased throughout 2007 but rebounded gradually in 2008 and the first half of 2009. The last half of 2009 experienced a decline in delay.

Exhibit 3-33: I-405 HOV Average Weekday Delay by Month (2005-2009)



Source: Automatic 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 the following exhibits:

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

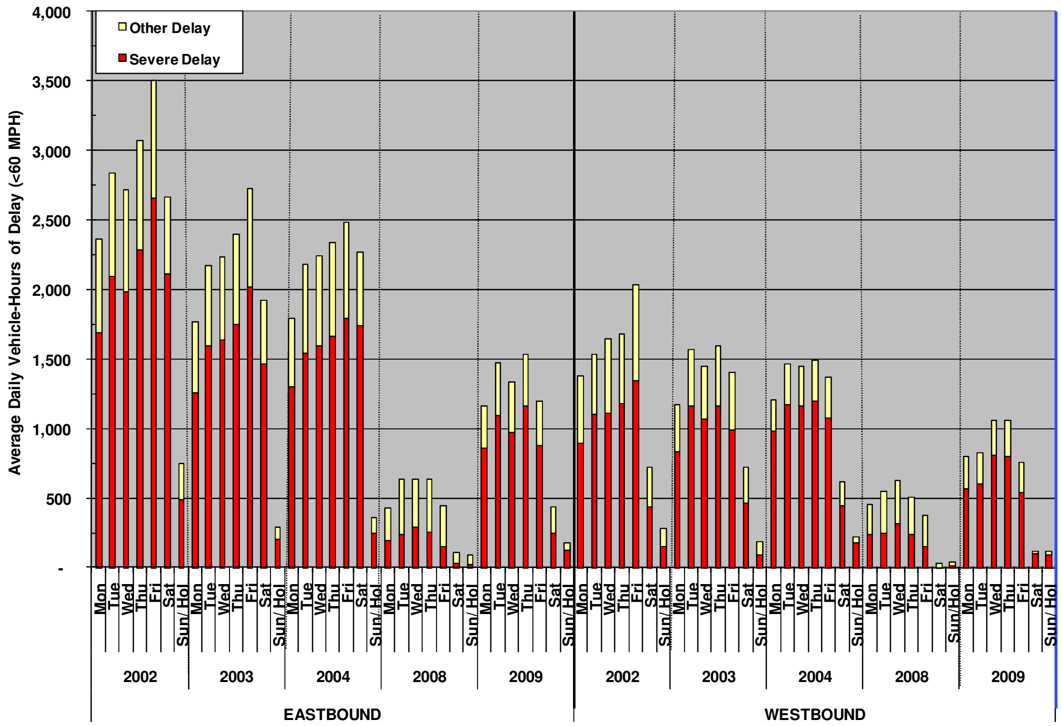
Severe delay as shown in Exhibit 3-34 represents breakdown conditions, which is the focus of most congestion mitigation strategies. "Other" delay represents conditions approaching the breakdown congestion, leaving the breakdown conditions, or areas that do not cause widespread breakdowns, but cause at 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.

Exhibit 3-34 shows that severe delay makes up approximately two-thirds of all weekday delay on the mainline facility. It also shows that severe delay was greater in the eastbound direction than the westbound direction during both pre and post-construction periods. In the eastbound direction of the mainline during the pre-construction period, the level of congestion grew during the workweek and peaked on Fridays (followed by

Thursday and Wednesday), whereas no consistent pattern emerged during the post-construction period.

A surprising finding is that Saturday delays in the eastbound direction were almost as high as weekday delays between 2002 and 2004. However, Saturday delays declined dramatically after construction of the HOV facility in 2007. The exhibit clearly shows the drop in delay experienced post-construction compared to pre-construction. Delays were minimal on weekends in both directions of the mainline.

Exhibit 3-34: SR-22 Mainline Average Delay by Day of Week by Severity (2002-2009)

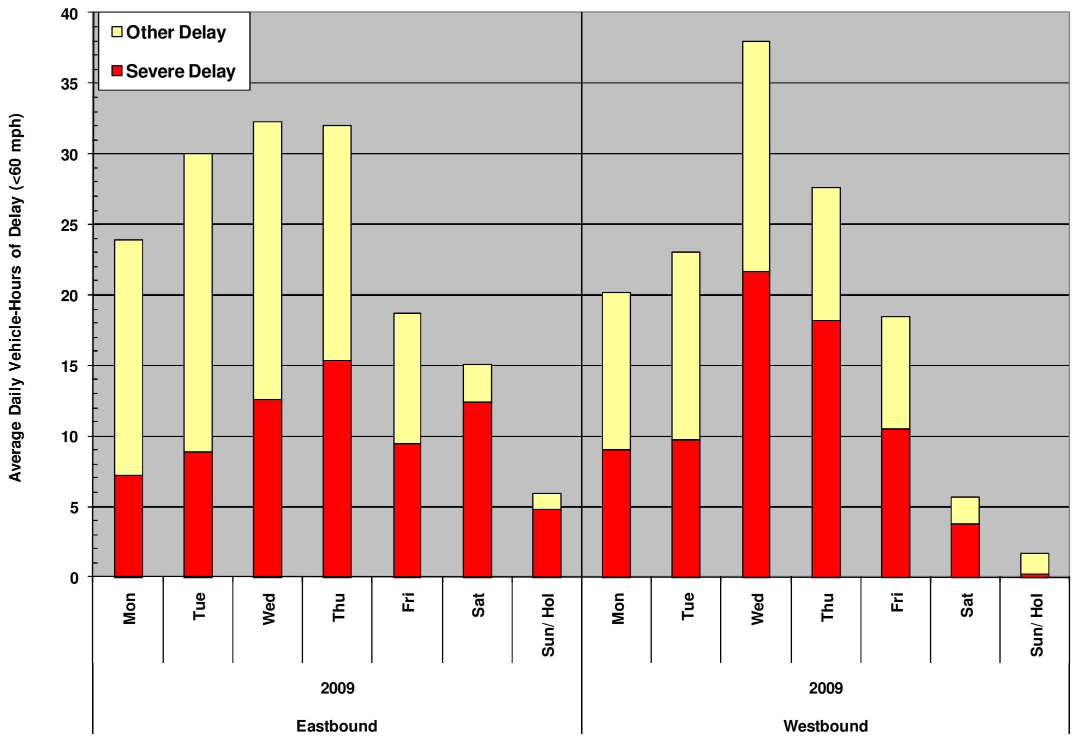


Source: Automatic detector data

Note: Due to limited detection on SR-22 in 2008, delay may be underreported for 2008.

On the HOV facility of the SR-22 Corridor (Exhibit 3-35), severe delay comprised between 30 and 70 percent of total weekday delay. Severe delay was greatest on Thursday in the eastbound direction (15 hours) and Wednesdays in the westbound direction (22 hours).

Exhibit 3-35: SR-22 HOV Average Delay by Day of Week by Severity (2009)

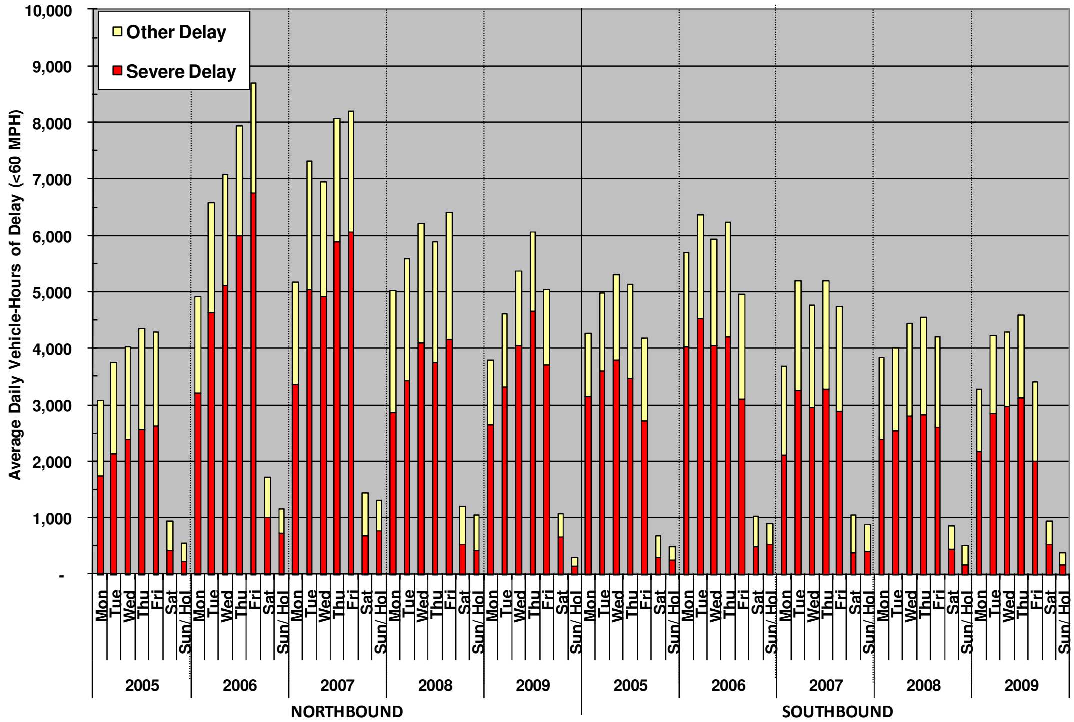


Source: Automatic detector data

Note: Detection on the SR-22 HOV facility was not available until February 5, 2009.

For the I-405 mainline, severe delay comprised approximately two-thirds of total delay (see Exhibit 3-36). Delay peaked on Fridays (followed by Thursday and Wednesday) in the northbound direction, but did not show a consistent peak day in the southbound direction. Delay reached its highest levels in 2006.

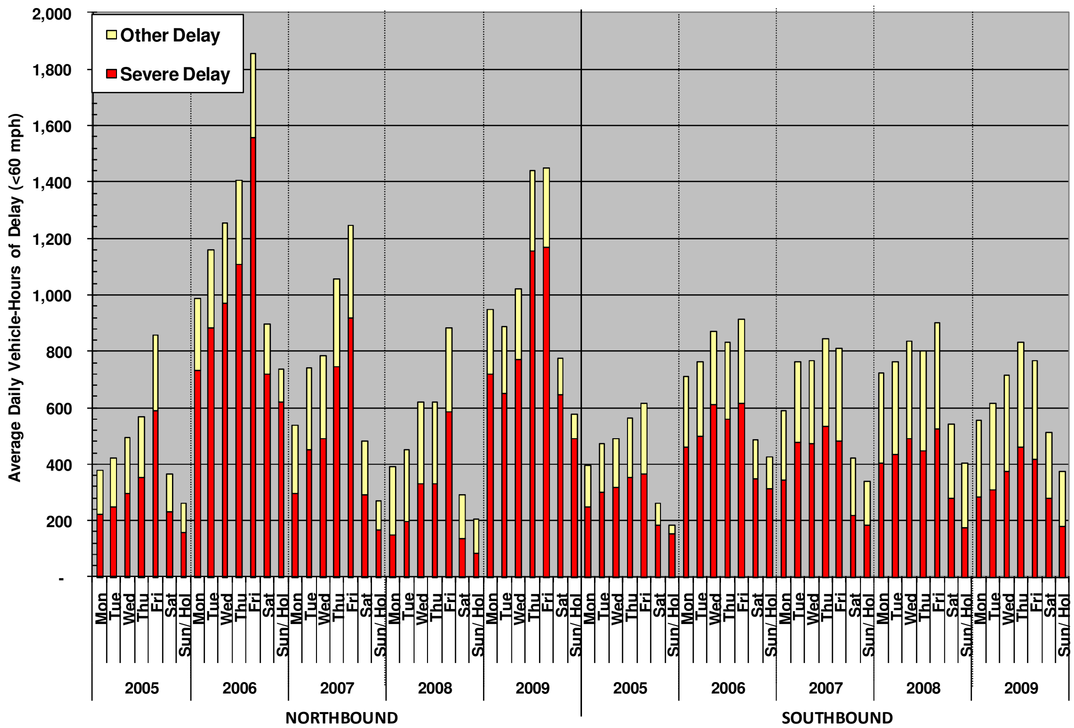
Exhibit 3-36: I-405 Mainline Average Delay by Day of Week by Severity (2005-2009)



Source: Automatic detector data

As shown in Exhibit 3-37, both directions of travel on the HOV facility experienced an increase in severe delay as the work week progressed, peaking on Fridays. Delay trends on the northbound HOV-lane fluctuated significantly more than the southbound direction. From 2006 to 2008, the northbound HOV-lane experienced a dramatic drop in severe delay from a high of about 1,550 hours to a low of about 600 hours on a Friday. This is in contrast to the southbound direction during the same period and same day when delay decreased from 600 hours to 520 hours.

Exhibit 3-37: I-405 HOV Average Delay by Day of Week by Severity (2005-2009)



Source: Automatic detector data

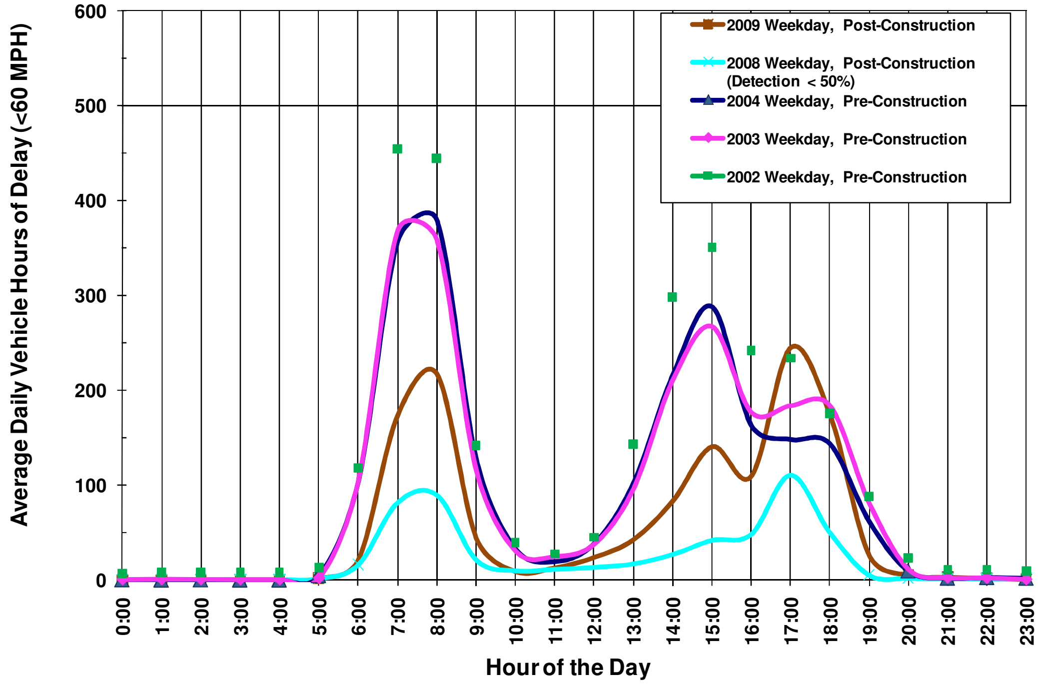
Another way to understand the characteristics of congestion and related delays is shown in Exhibits 3-38 and 3-39, which summarize average weekday hourly delay for the SR-22 mainline, and Exhibits 3-40 and 3-41, which summarize average weekday hourly delay for HOV facility. These exhibits allow planners and decision makers to understand the trend in peak period delay spiking and peak period spreading by comparing the intensity and duration of the peak congestion.

The exhibits highlight several trends on the mainline facility:

- During the 7:00 AM peak hour in the eastbound direction of the mainline facility (Exhibit 3-38), daily delay decreased significantly from approximately 470 vehicle-hours in 2002 to approximately 220 in 2009. Similarly, at the 3:00 PM peak hour, daily delay decreased from approximately 350 vehicle-hours in 2002 to 140 vehicle-hours in 2009. The exhibit suggests that delay improved in the eastbound direction of the mainline more than 50 percent from 2002 to 2009.
- The westbound direction of the mainline (Exhibit 3-39) also witnessed an improvement in delay from 2002 to 2009. At the 5:00 PM peak hour, daily delay decreased from approximately 420 vehicle-hours in 2002 to 325

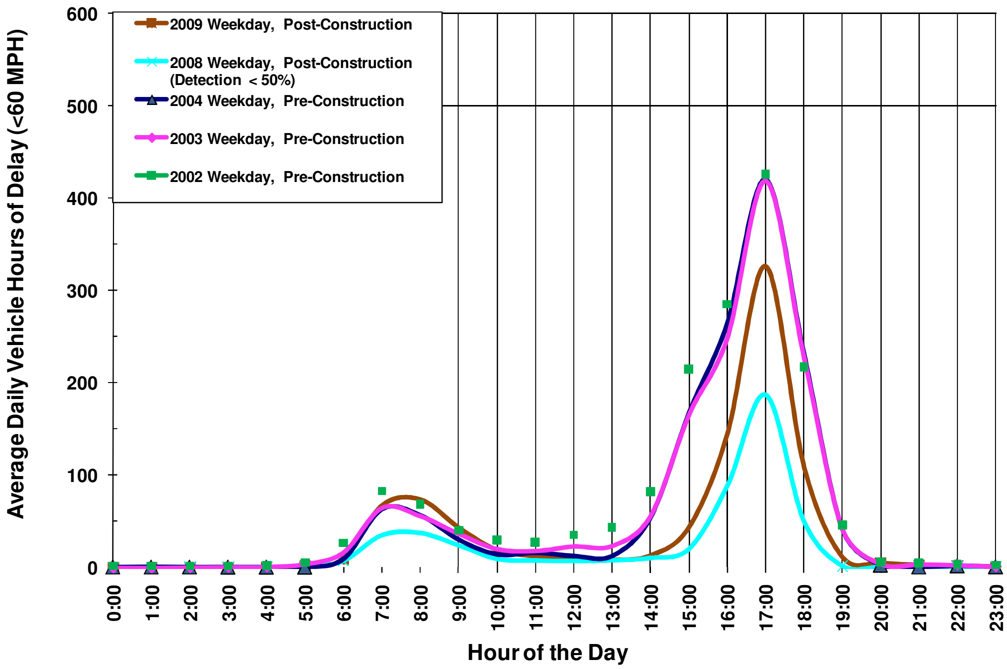
vehicle-hours in 2009. This represents a 20 percent decrease in delay from 2002 to 2009 at the 5:00 PM peak hour.

Exhibit 3-38: Eastbound SR-22 Mainline Lanes Hourly Delay (2002-2009)



Source: Automatic detector data
Note: Due to limited detection on SR-22 in 2008, delay may be underreported for 2008.

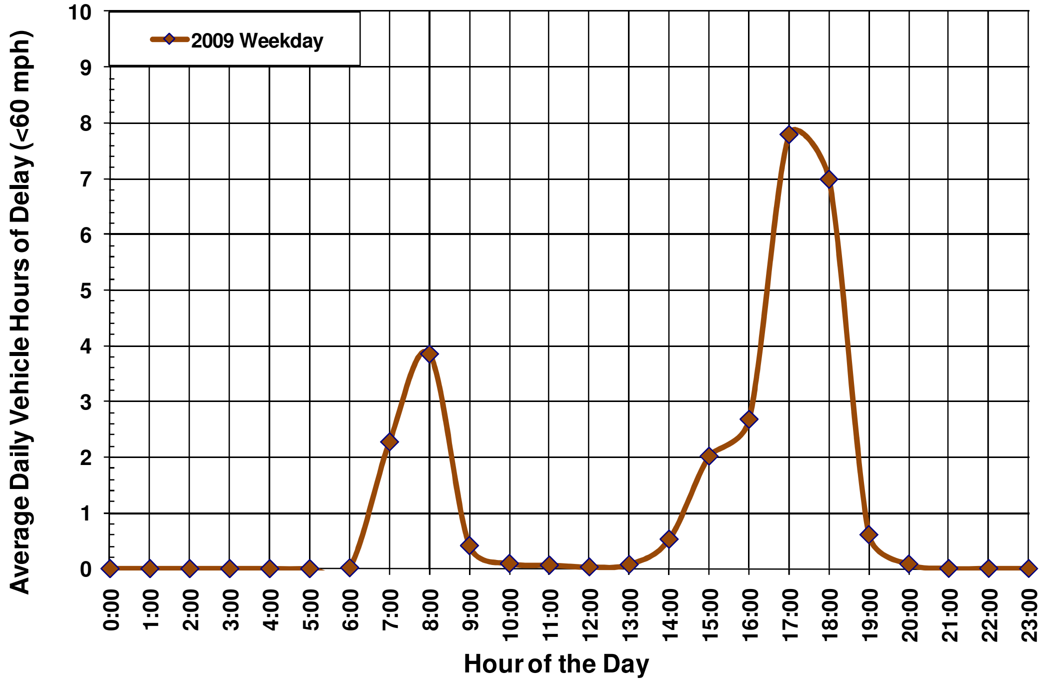
Exhibit 3-39: Westbound SR-22 Mainline Lanes Hourly Delay (2002-2009)



Source: Automatic detector data
Note: Due to limited detection on SR-22 in 2008, delay may be underreported for 2008.

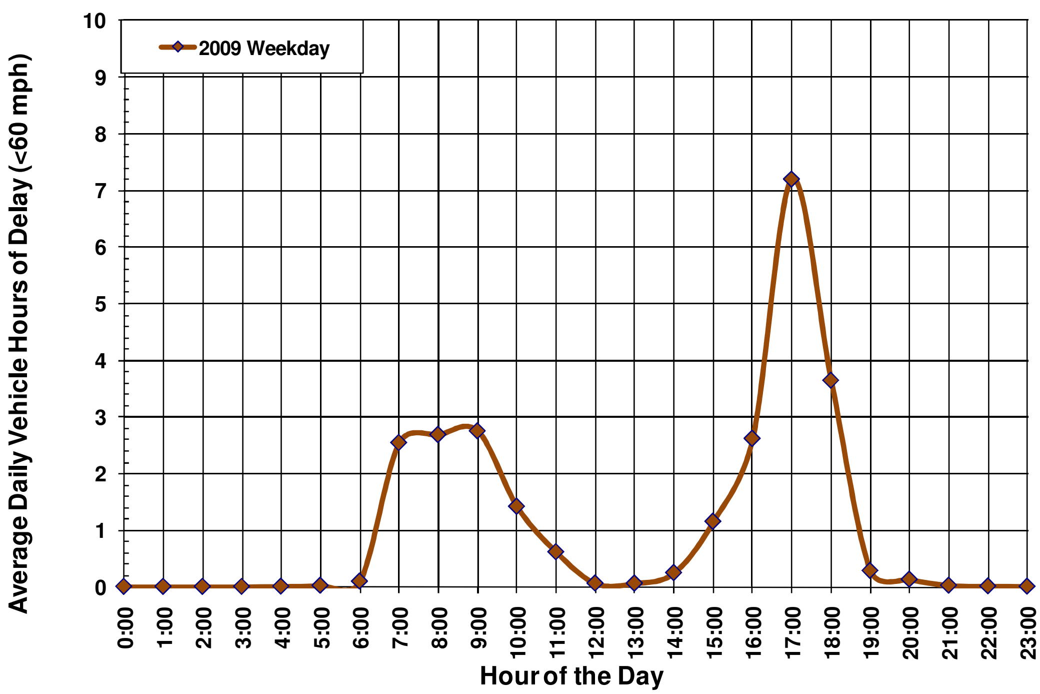
- During the 8:00 AM peak hour in the eastbound direction of the HOV facility (Exhibit 3-40), the average vehicle hour of delay was four hours in 2009. Delay during the 5:00 PM peak hour was slightly higher with about eight hours.
- During the 9:00 AM and 5:00 PM peak hours in the westbound direction of the HOV facility (Exhibit 3-41), the average vehicle hour of delay was around three hours and seven hours in 2009, respectively.

Exhibit 3-40: Eastbound SR-22 HOV Lanes Hourly Delay (2009)



Source: Automatic detector data
Note: Detection on the SR-22 HOV facility was not available until February 5, 2009.

Exhibit 3-41: Westbound SR-22 HOV Lanes Hourly Delay (2009)

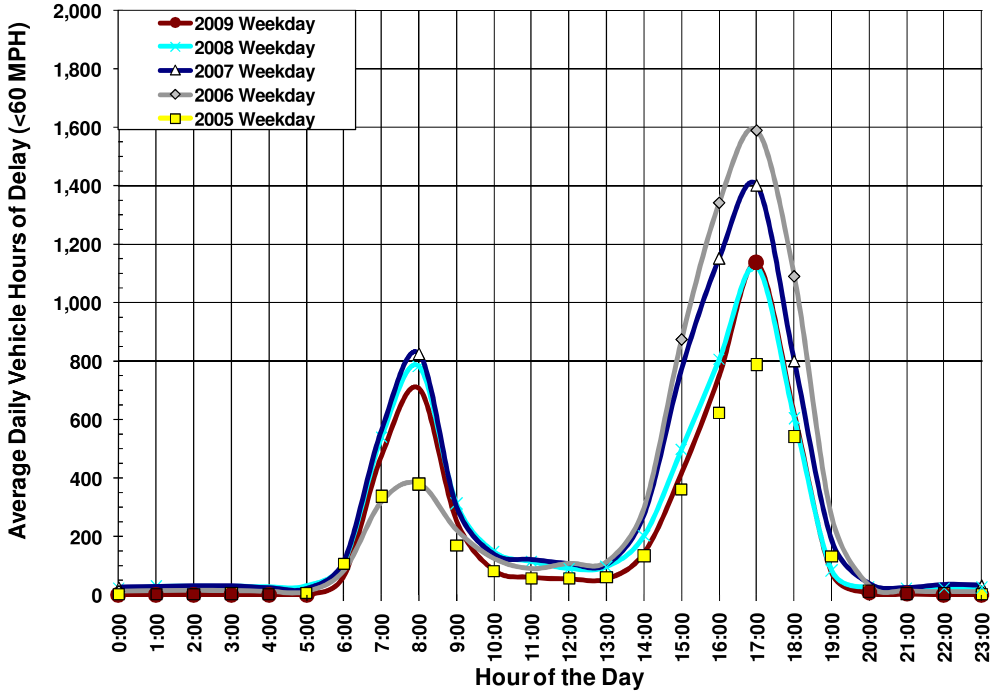


Source: Automatic detector data
Note: Detection on the SR-22 HOV facility was not available until February 5, 2009.

Exhibits 3-42 through 3-45 show the average daily vehicle hours of delay for the I-405 corridor for each year during the 2005-2009 period. The following observations can be made about time-of-day patterns on I-405:

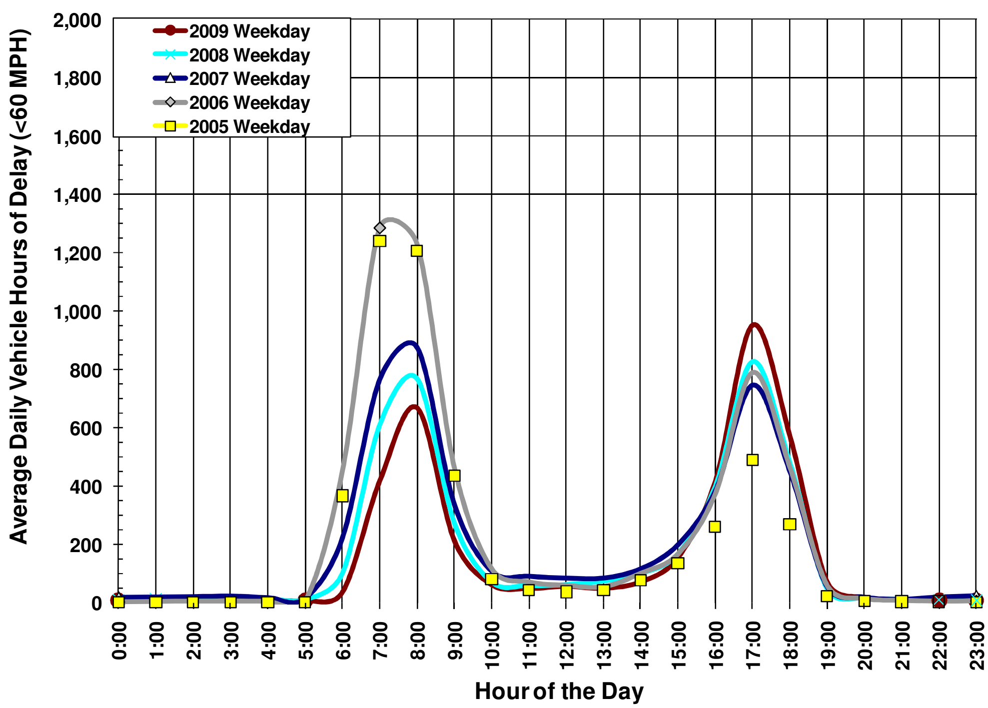
- Delay in the northbound direction of the mainline facility (Exhibit 3-42) decreased overall since 2006. During the 8:00 AM peak hour, delay in 2009 (just over 700 vehicle-hours) was greater than delay in 2005 and 2006, but less than delay in 2007 and 2008. During the 5:00 PM peak hour, delay in 2009 (at around 1,100 vehicle-hours) was less than the delay in 2006 and 2007, and near the same levels as 2008.
- Delay in the southbound direction of the mainline facility (Exhibit 3-43) was the lowest in 2009 during the 8:00 AM peak hour at around 670 vehicle-hours, and highest in 2009 during the 5:00 PM peak hour also at about 950 vehicle-hours.
- Delay in the northbound direction of the HOV facility (Exhibit 3-44) followed a similar pattern as the mainline. During the 5:00 PM peak hour, delay in 2009 was greater than the delay in 2005, 2007, and 2008 (at roughly 200 vehicle-hours), but less than the delay in 2006.
- Delay in the southbound direction of the HOV facility (Exhibit 3-45) also followed the same pattern as the mainline. During the 7:00 AM peak hour, delay in 2009 (60 hours) was the lowest compared to the previous years, but highest during the 5:00 PM peak hour at around 130 hours.

Exhibit 3-42: Northbound I-405 Mainline Lanes Hourly Delay (2005-2009)



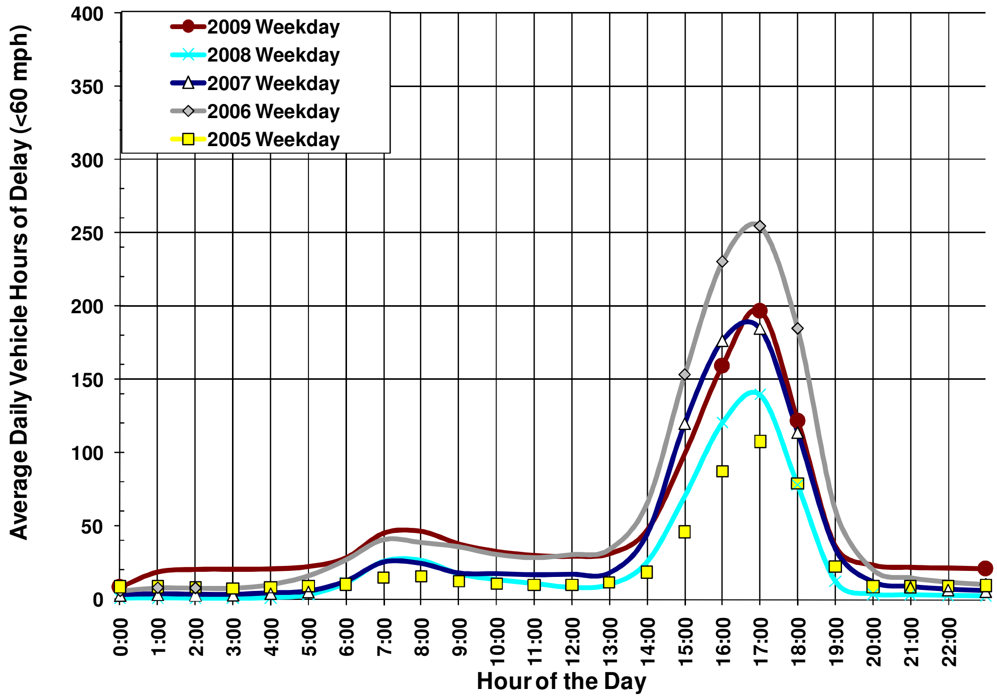
Source: Automatic detector data

Exhibit 3-43: Southbound I-405 Mainline Lanes Hourly Delay (2005-2009)



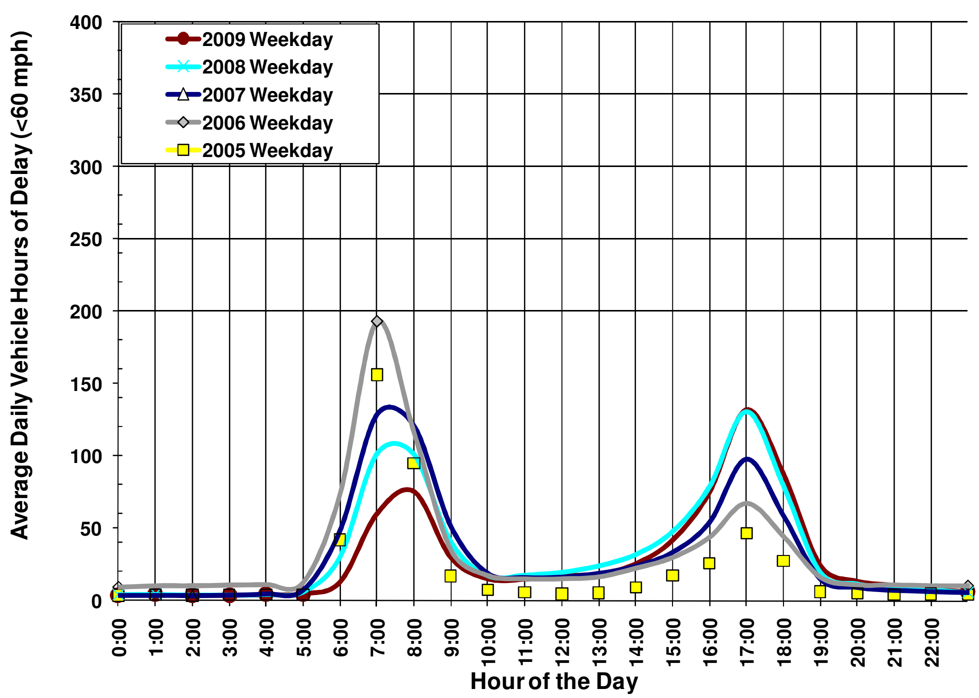
Source: Automatic detector data

Exhibit 3-44: Northbound I-405 HOV Lanes Hourly Delay (2005-2009)



Source: Automatic detector data

Exhibit 3-45: Southbound I-405 HOV Lanes Hourly Delay (2005-2009)



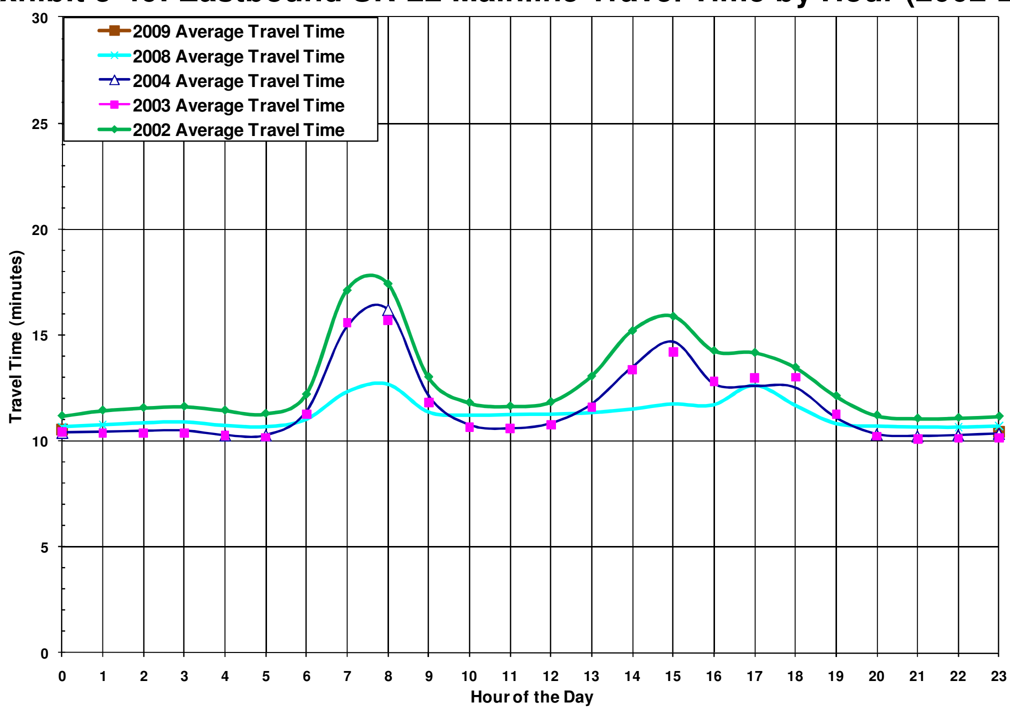
Source: Automatic detector data

Travel Time

Travel time is reported as the amount of time for a vehicle to travel the distance between two points on a corridor. For the travel time analysis, automatic detector data was analyzed for the entire 13-mile segment of SR-22 and the entire 24-mile segment of I-405. Travel time on parallel arterials is not included for this analysis.

Exhibits 3-46 and 3-47 illustrate the travel times assessed for the mainline facility of SR-22. As indicated in Exhibit 3-46, the eastbound direction of the mainline had typical travel times of 15 to 17 minutes in the AM peak period during the pre-construction period from 2002 to 2004. However, post construction in 2008 and 2009, travel times decreased (as shown by the brown line) to roughly 14 minutes. The westbound direction of the mainline facility also experienced an improvement in travel times as depicted in Exhibit 3-47. Between 2002 and 2004, the westbound direction experienced typical travel times of approximately 17 minutes during the PM peak hour and about 11 to 12 minutes during the off-peak hours. In 2009, travel times during the PM peak period decreased to less than 15 minutes.

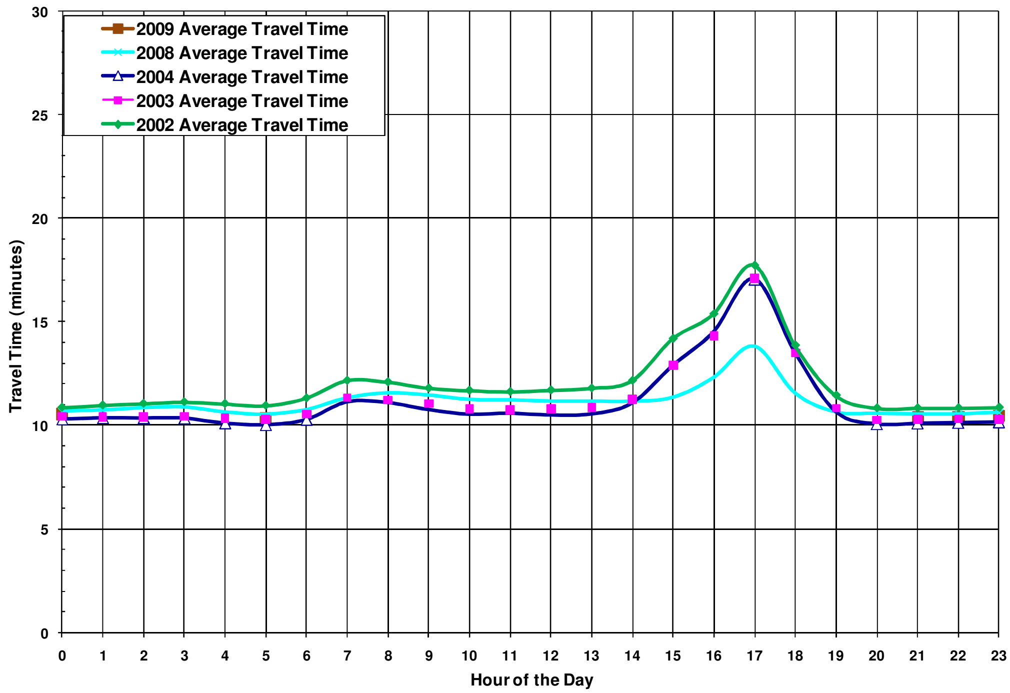
Exhibit 3-46: Eastbound SR-22 Mainline Travel Time by Hour (2002-2009)



Source: Automatic detector data

Note: Due to limited detection on SR-22 in 2008, travel times may be underreported for 2008.

Exhibit 3-47: Westbound SR-22 Mainline Travel Time by Hour (2002-2009)

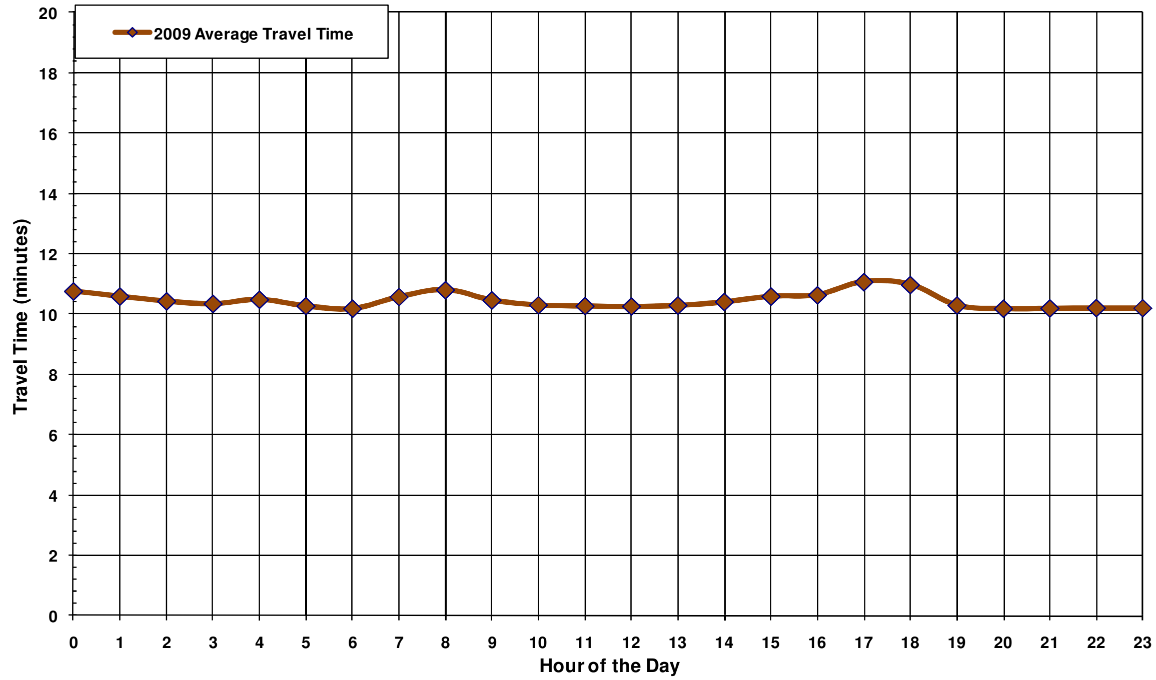


Source: Automatic detector data

Note: Due to limited detection on SR-22 in 2008, travel times may be underreported for 2008.

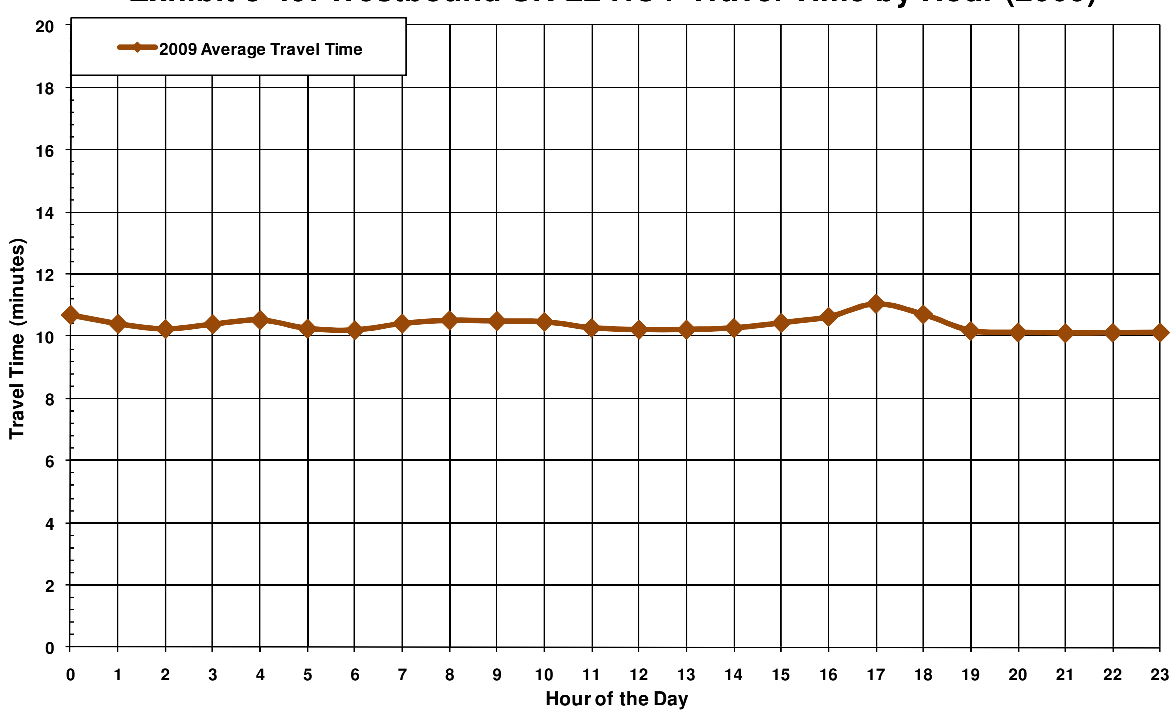
Travel times for the SR-22 HOV facility are illustrated in Exhibits 3-48 and 3-49. For both directions of the HOV facility, travel times during the peak periods in 2009 were extremely close to travel times during the off-peak periods, at around 10 minutes. Travel times during the peak period were only one minute greater (at 11 minutes) than during the off-peak periods. Again, 2008 results are not discussed in the analysis given the limited detection.

Exhibit 3-48: Eastbound SR-22 HOV Travel Time by Hour (2009)



Source: Automatic detector data
Note: Detection on the SR-22 HOV facility was not available until February 5, 2009.

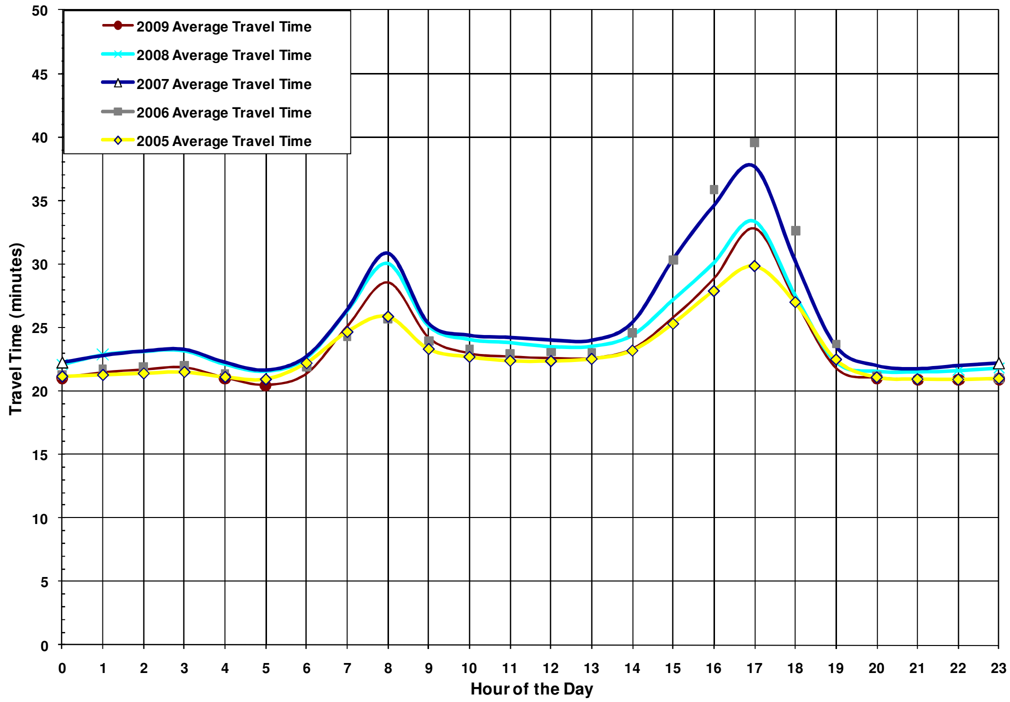
Exhibit 3-49: Westbound SR-22 HOV Travel Time by Hour (2009)



Source: Automatic detector data
Note: Detection on the SR-22 HOV facility was not available until February 5, 2009.

Exhibits 3-50 through 3-53 reveal the travel times for the I-405 Corridor for each year between 2005 and 2009. In the northbound direction of the mainline, travel times were highest during the PM peak period. Travel times in 2009 were less than in 2006 and 2007 during the PM peak period. In 2009 during the PM peak, it took a vehicle about 33 minutes to drive the corridor, which is seven minutes faster than it took to drive it in 2006.

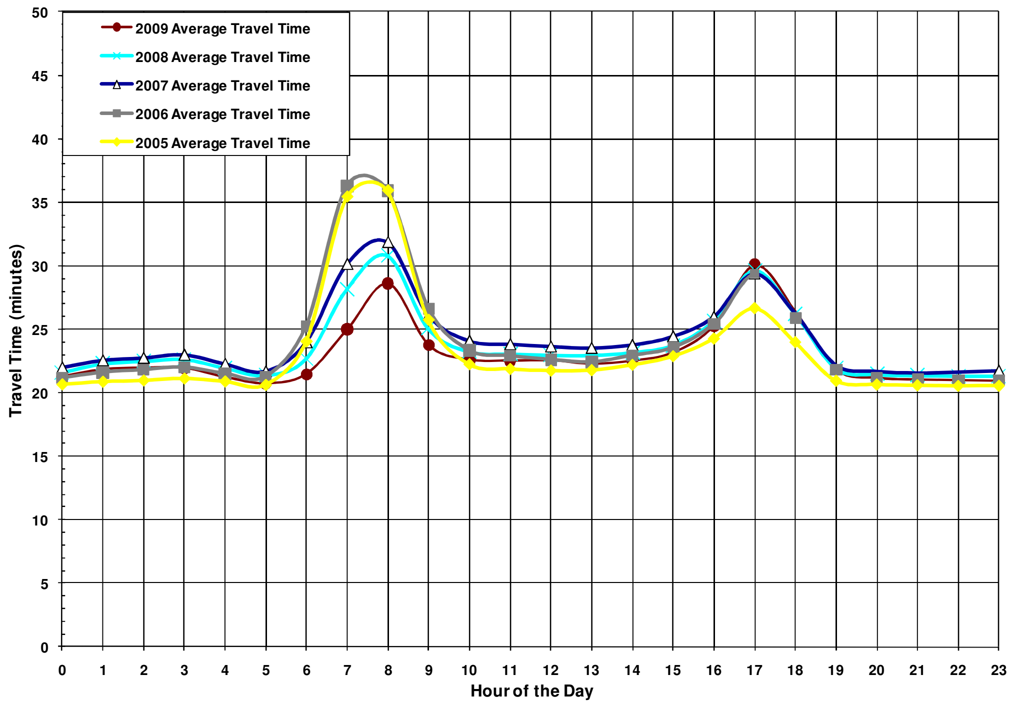
Exhibit 3-50: Northbound I-405 Mainline Travel Time by Hour (2005-2009)



Source: Automatic detector data

Exhibit 3-51 illustrates travel time for the southbound direction of the I-405 mainline facility. In the southbound direction of the mainline, travel times were highest during the AM peak period. During the AM peak hour, the southbound direction experienced an overall decline in delay, reaching its lowest level in 2009 at about 28 minutes. However, during the PM peak hour, the southbound direction in 2009 also experienced the greatest delay at 30 minutes.

Exhibit 3-51: Southbound I-405 Mainline Travel Time by Hour (2005-2009)

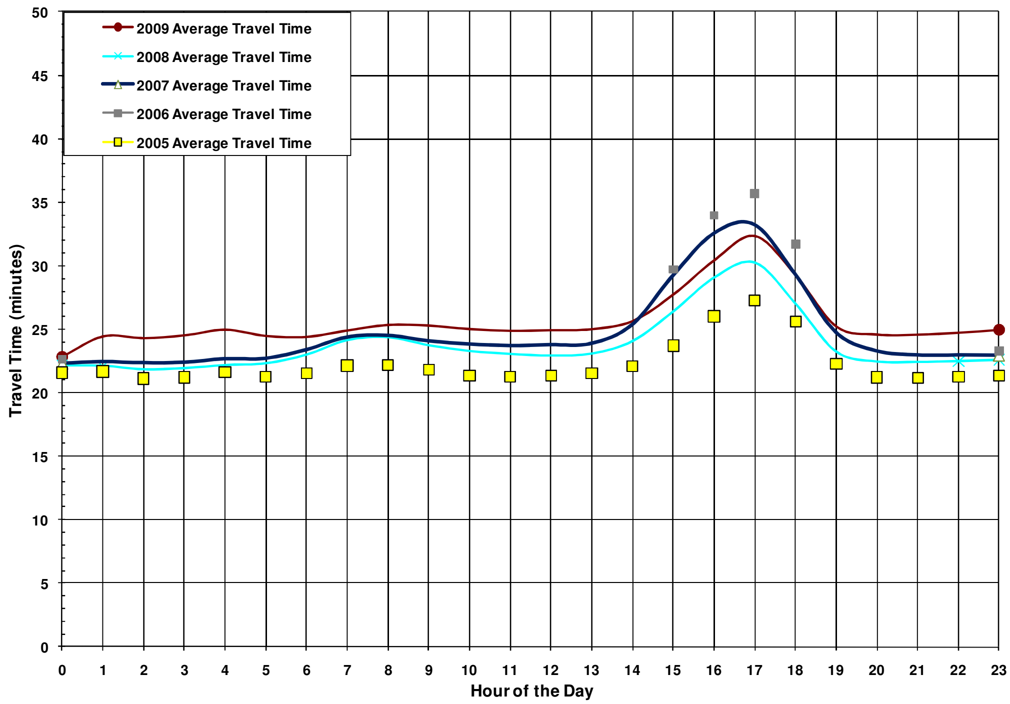


Source: Automatic detector data

Travel times for both directions of the I-405 HOV facility are lower than the mainline facility. In the northbound direction of the HOV facility, travel times ranged from 27 to 35 minutes at the 5:00 PM peak hour, which is less than the travel time range of 30-40 minutes on the mainline facility. The travel time in 2009 for the northbound direction of the HOV facility (Exhibit 3-52) at 5:00 PM was 32 minutes, which an improvement over 2006 and 2007 travel times.

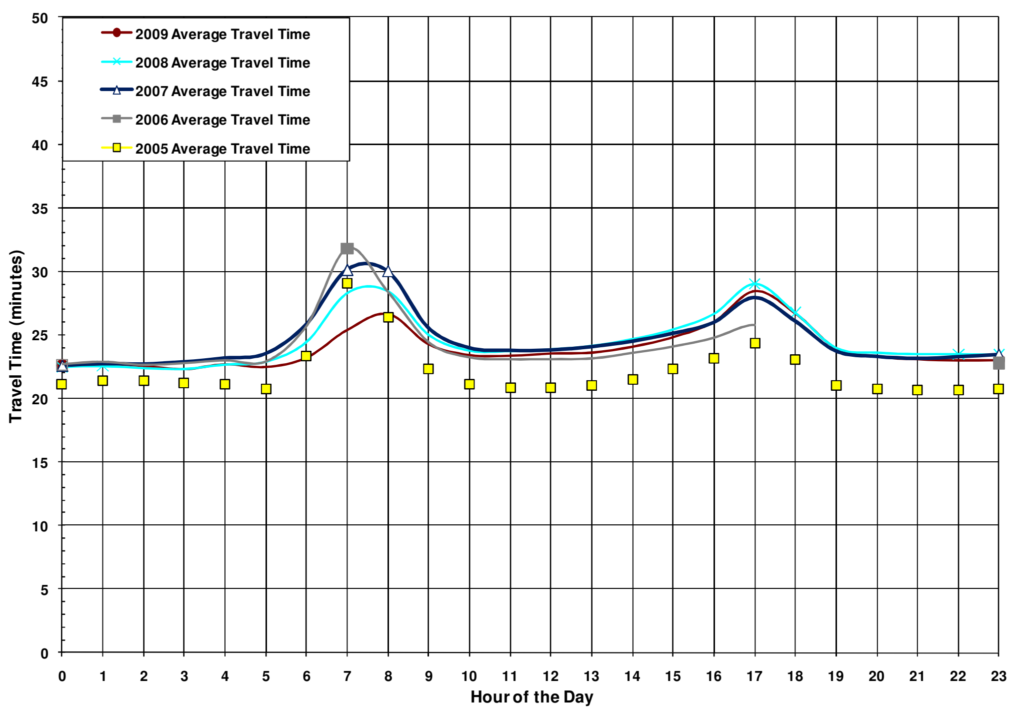
The travel time for the southbound direction of the HOV facility (Exhibit 3-53) was also an improvement over the mainline facility. Southbound travel times ranged between 25-33 minutes on the HOV lane, which is less than the mainline travel time range of 28-36 minutes. During the AM peak period, the southbound HOV travel time in 2009 was about 25 minutes, which is the lowest in comparison to the previous four years. However, during the PM peak period, the southbound HOV travel time in 2009 was the second highest (after 2008 with 29 minutes) compared to the previous years at about 28 minutes.

Exhibit 3-52: Northbound I-405 HOV Travel Time by Hour (2005-2009)



Source: Automatic detector data

Exhibit 3-53: Southbound I-405 HOV Travel Time by Hour (2005-2009)



Source: Automatic detector data

Reliability

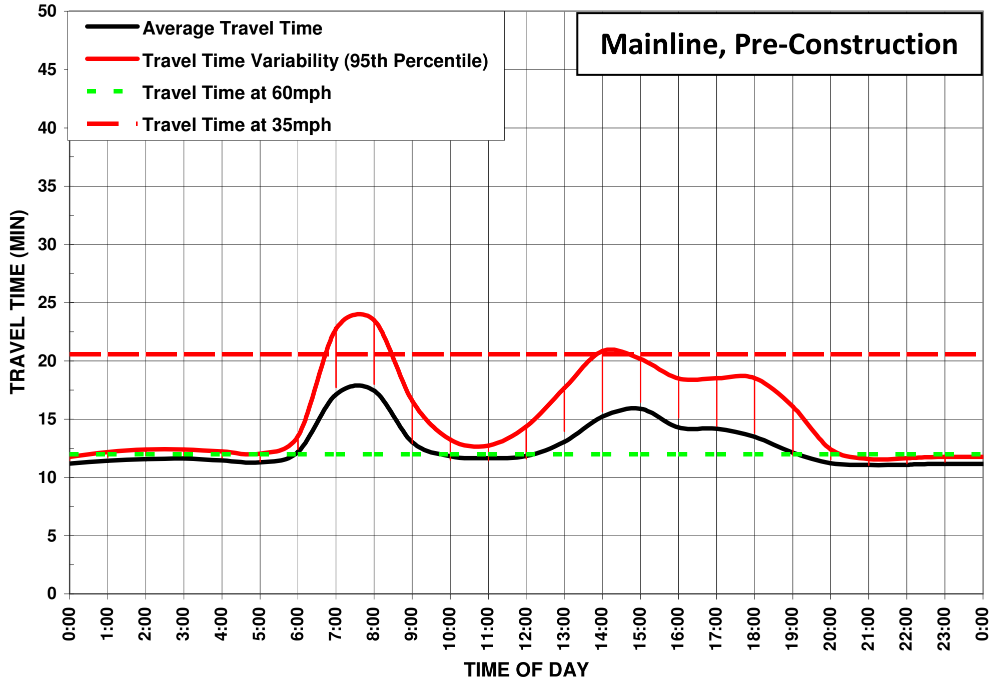
Reliability captures the relative predictability of the public's travel time. Unlike mobility, which measures the rate of travel, the reliability measure focuses on how travel time varies from day to day. To measure reliability, the study team estimated travel time variability using automatic detector data. The 95th percentile was chosen as a reasonable representation of the maximum peak travel time that could be experienced along the corridor. Severe incidents, such as fatal accidents, could cause travel times longer than the 95th percentile, but this statistic is a balance between extreme outliers and the "typical" travel day.

Exhibits 3-54 through 3-63 on the following pages illustrate the variability of travel time for the SR-22 Corridor on weekdays for 2002 to 2004 (pre-construction) and 2008 and 2009 (post-construction). Exhibits 3-54 through 3-63 present travel time variability for the mainline in the eastbound direction followed by the westbound. Similarly, Exhibits 3-64 and 3-65 show travel time variability for the HOV facility beginning with the eastbound and followed by the westbound direction.

For the mainline facility of SR-22, the AM peak hour was the most unreliable in addition to being the slowest hour in the eastbound direction. In 2002 (shown in Exhibit 3-54), motorists driving the entire length of the corridor had to add 7 minutes to an average travel time of 17 minutes (for a total travel time of 24 minutes) to ensure that they arrived on time 95 percent of the time. This is 12 minutes longer than the 12-minute travel time at 60 mph. In 2003 (Exhibit 3-55), the time needed to arrive on time 95 percent of the time decreased to 21 minutes; remained the same in 2004 (Exhibit 3-56); and declined significantly in 2009 to 15 minutes (Exhibit 3-58). The westbound direction of the mainline facility experienced a similar decline in travel time variability. In 2002 (Exhibit 3-59), the time needed to arrive on time 95 percent of the time was 25 minutes, which declined in 2003 and 2004 to 21 minutes, and further declined in 2009 to 16 minutes (Exhibit 3-63).

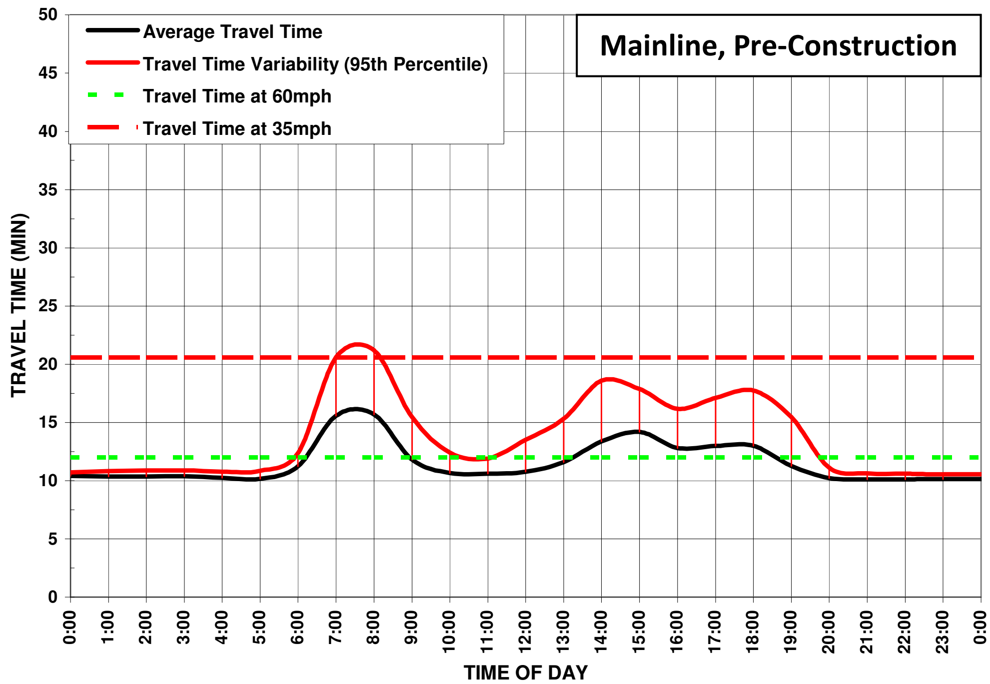
The SR-22 HOV facility experienced lower levels of travel time variability. In the eastbound direction in 2009 (Exhibit 3-64), the driving time needed to arrive on time 95 percent of the time was below 12 minutes, the same as the travel time at 60 mph, even during the AM peak period. In the westbound direction (Exhibit 3-65), the time needed to arrive on time during the 5:00 PM peak hour was about 13 minutes, which is 2 minutes greater than the 11-minute average travel time, and 1 minute greater than the travel time at 60 mph. Given the limited detection on the corridor in 2008, the results are not discussed.

Exhibit 3-54: Eastbound SR-22 Mainline Travel Time Variation (2002)



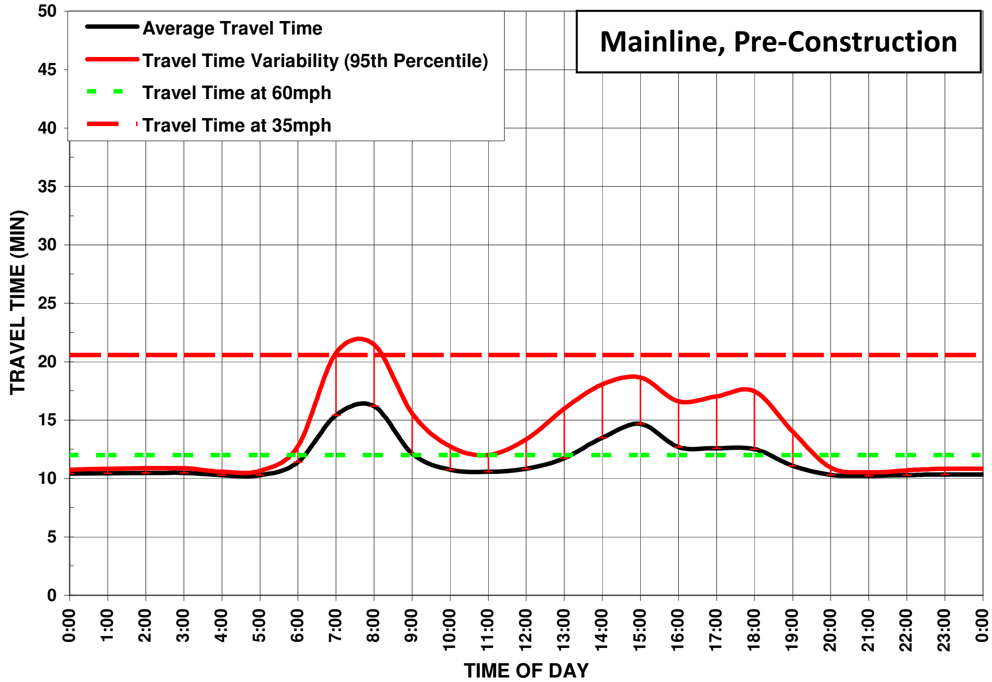
Source: Automatic detector data

Exhibit 3-55: Eastbound SR-22 Mainline Travel Time Variation (2003)



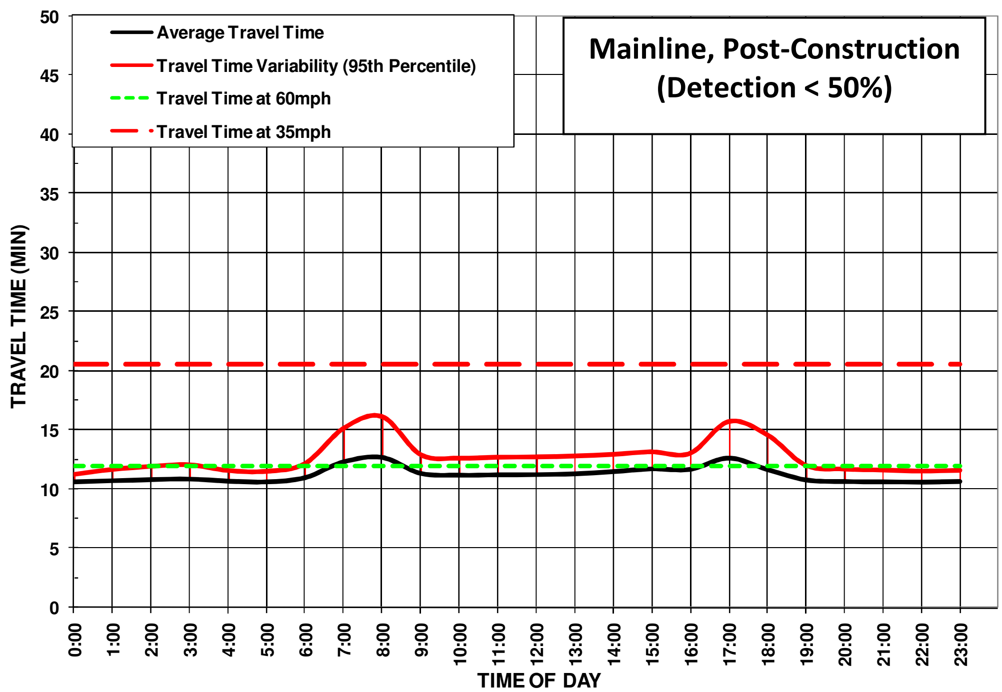
Source: Automatic detector data

Exhibit 3-56: Eastbound SR-22 Mainline Travel Time Variation (2004)



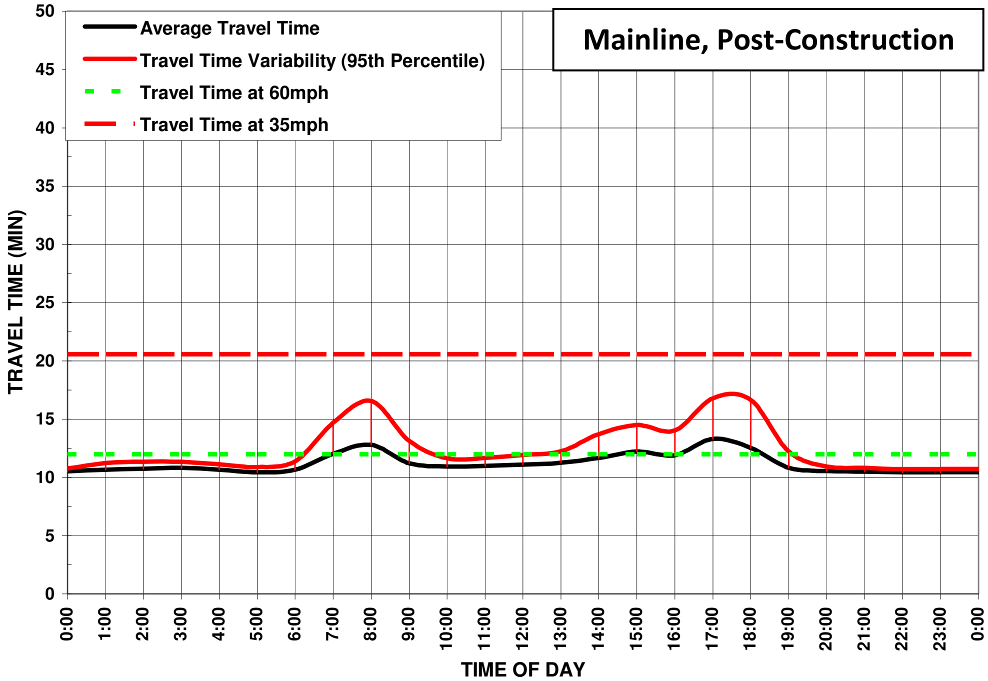
Source: Automatic detector data

Exhibit 3-57: Eastbound SR-22 Mainline Travel Time Variation (2008)



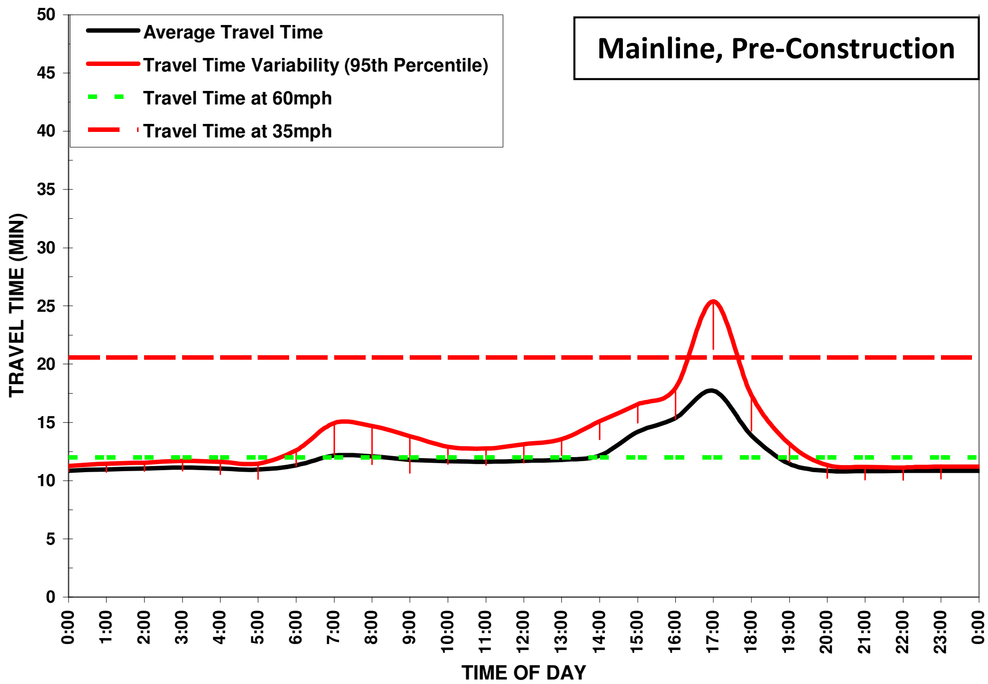
Source: Automatic detector data
Note: Due to limited detection on SR-22 in 2008, travel time variation may be underreported for 2008.

Exhibit 3-58: Eastbound SR-22 Mainline Travel Time Variation (2009)



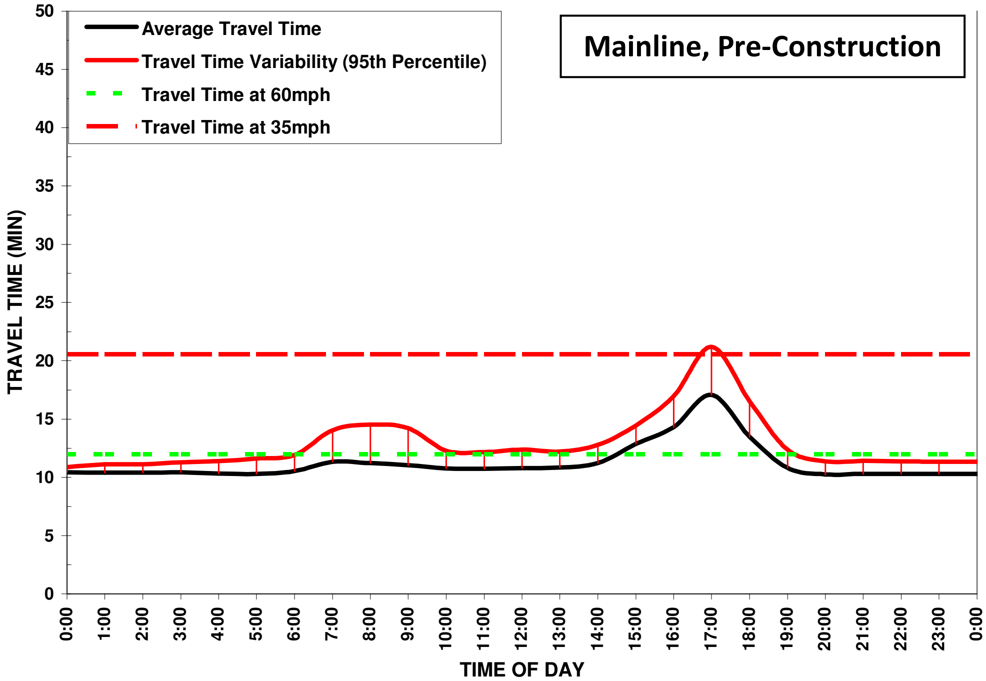
Source: Automatic detector data

Exhibit 3-59: Westbound SR-22 Mainline Travel Time Variation (2002)



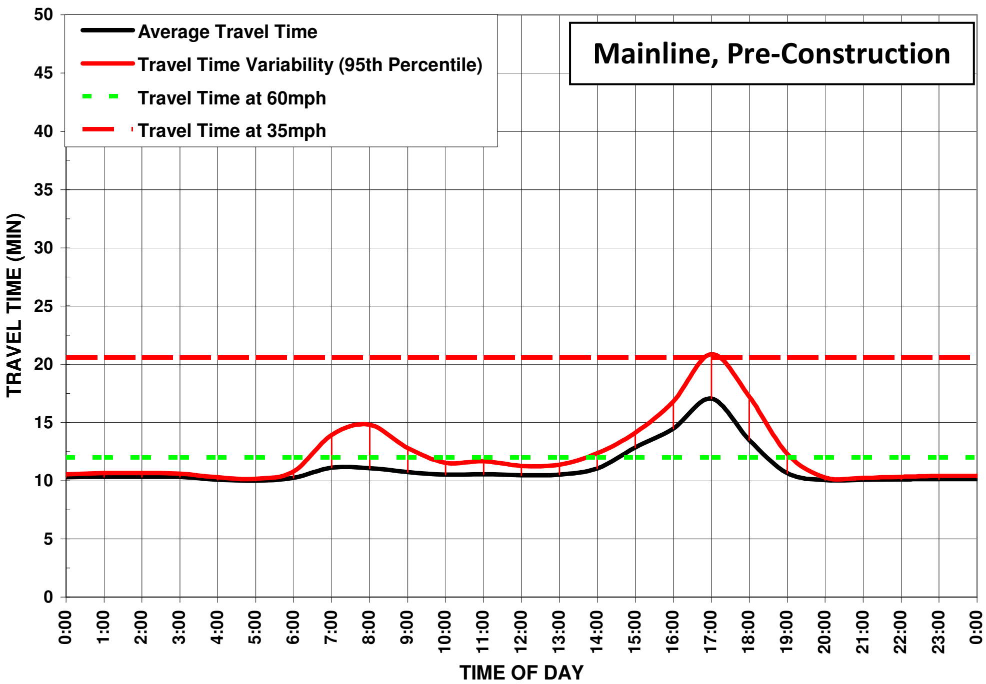
Source: Automatic detector data

Exhibit 3-60: Westbound SR-22 Mainline Travel Time Variation (2003)



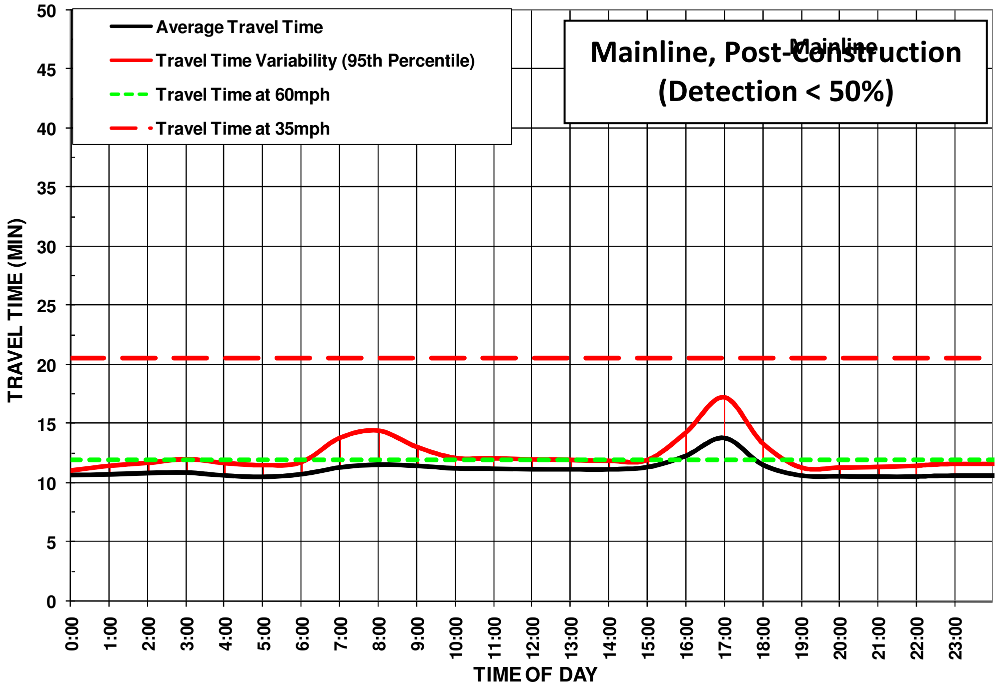
Source: Automatic detector data

Exhibit 3-61: Westbound SR-22 Mainline Travel Time Variation (2004)



Source: Automatic detector data

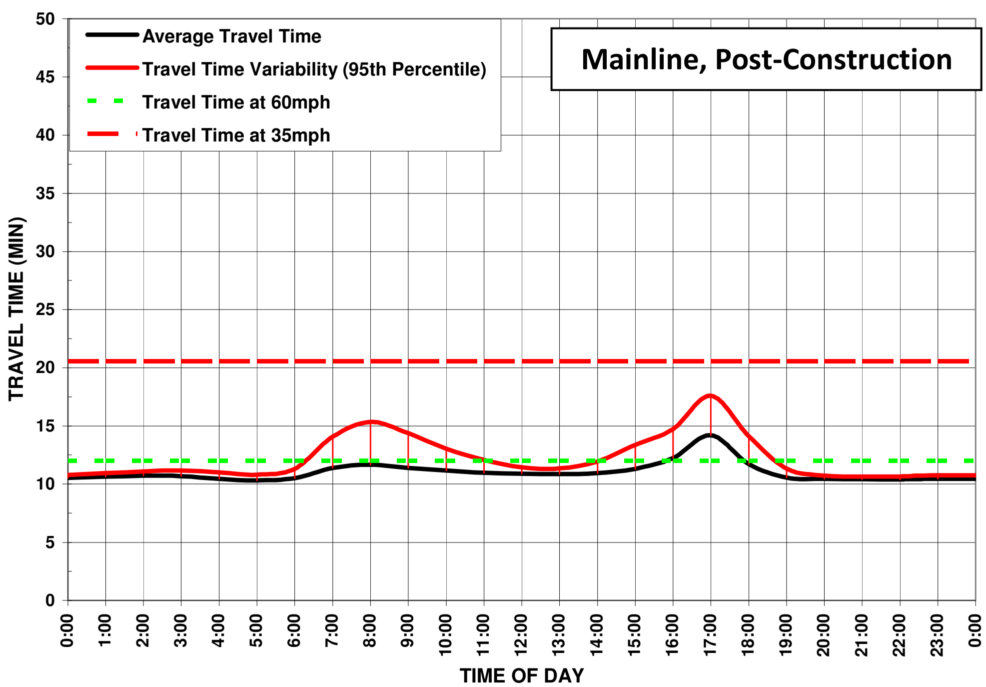
Exhibit 3-62: Westbound SR-22 Mainline Travel Time Variation (2008)



Source: Automatic detector data

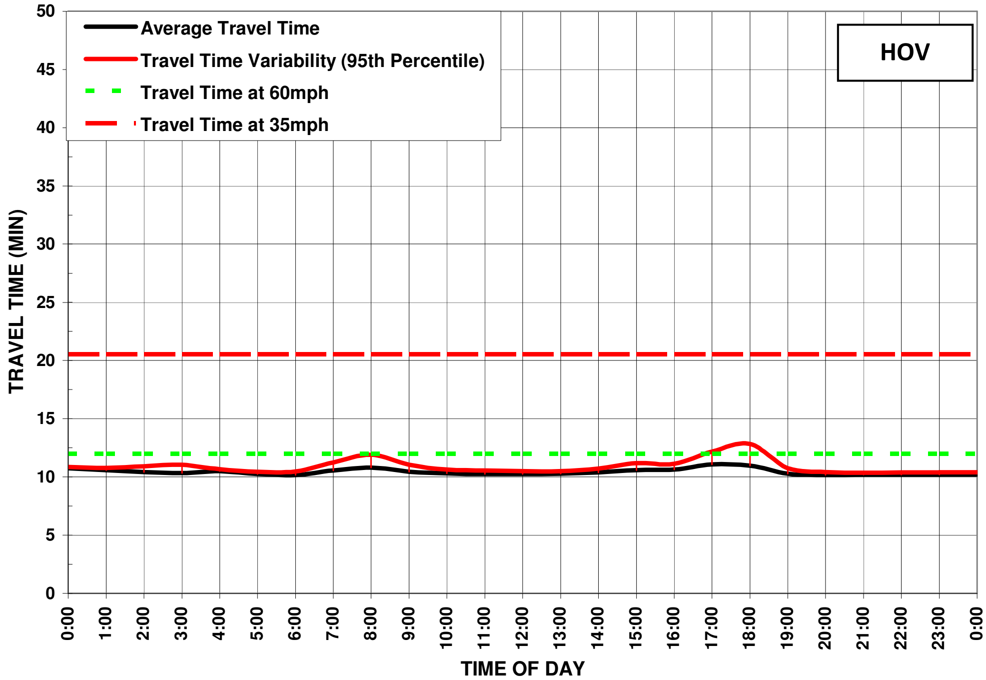
Note: Due to limited detection on SR-22 in 2008, travel time variation may be underreported for 2008.

Exhibit 3-63: Westbound SR-22 Mainline Travel Time Variation (2009)



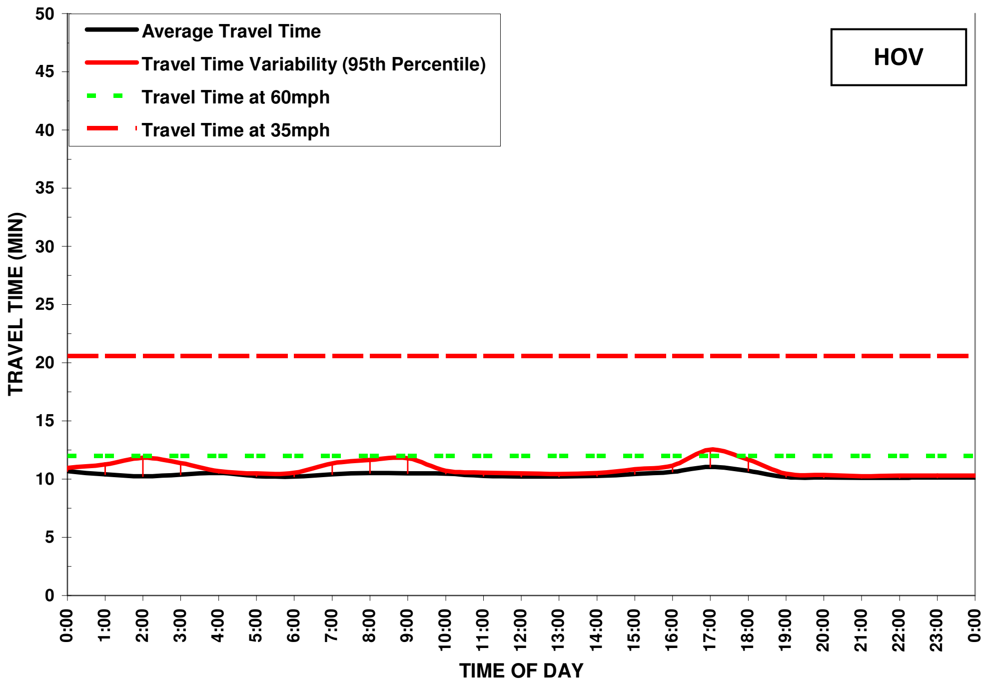
Source: Automatic detector data

Exhibit 3-64: Eastbound SR-22 HOV Travel Time Variation (2009)



Source: Automatic detector data
Note: Detection on the SR-22 HOV facility was not available until February 5, 2009.

Exhibit 3-65: Westbound SR-22 HOV Travel Time Variation (2009)



Source: Automatic detector data
Note: Detection on the SR-22 HOV facility was not available until February 5, 2009.

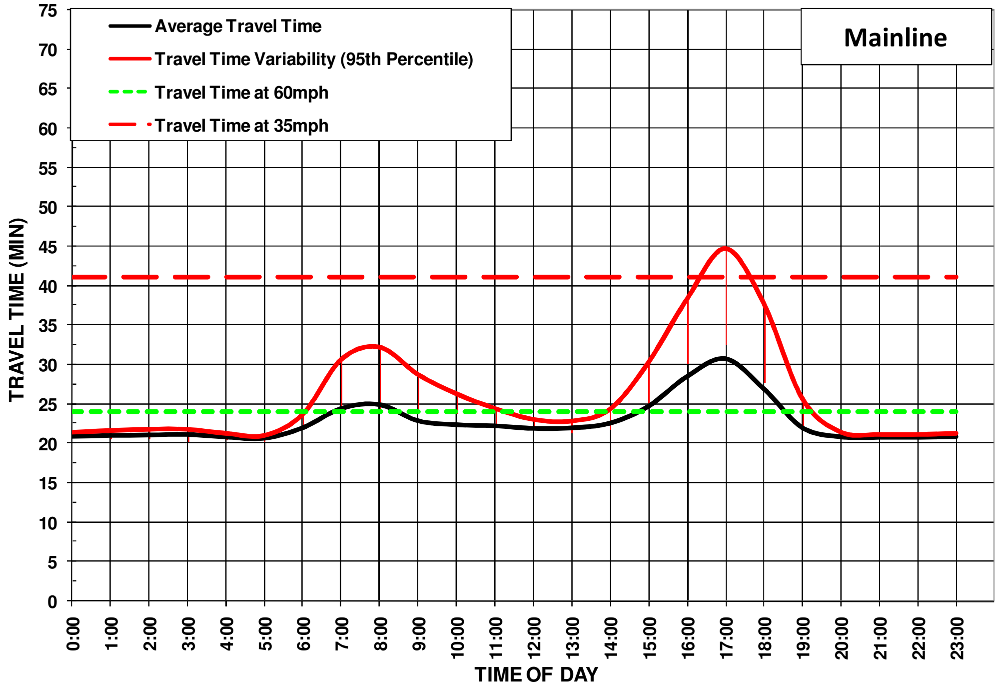
Exhibits 3-66 to 3-89 on the proceeding pages illustrate the variability of travel time for the I-405 Corridor on weekdays for the years 2004-2009. Exhibits 3-66 to 3-77 present travel time variability for the mainline facility. Exhibits 3-78 through 3-89 show travel time variability for the HOV facility 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 the northbound direction. In 2004 (shown in Exhibit 3-66), motorists driving the entire length of the corridor had to add 15 minutes to an average travel time of 30 minutes (for a total travel time of 45 minutes) to ensure that they arrived on time 95 percent of the time. This is 20 minutes longer than the 25-minute travel time at 60 mph. In 2005 (Exhibit 3-67), the time needed to arrive on time 95 percent of the time decreased to 41 minutes; but increased dramatically to 55 minutes in 2006 (Exhibit 3-68); declined to 50 minutes in 2007 (Exhibit 3-69); and further declined to 40 minutes in 2008 (Exhibit 3-70). In 2009 this number slightly increased to 46 minutes (Exhibit 3-71). The southbound direction of the mainline facility experienced a gradual decline in travel time variability between 2004 and 2009. In 2004 (Exhibit 3-72) at the 8:00 AM peak hour, the time needed to arrive on time 95 percent of the time was 46 minutes; which increased to 50 minutes in 2005 (Exhibit 3-73); but declined to 48 minutes in 2006 (Exhibit 3-74); and declined further to 41 minutes in 2007 and 2008 (Exhibits 3-75 and 3-76). Moreover, 2009 experienced a further decline at the 8:00 AM peak hour to 37 minutes (Exhibit 3-77).

Travel times for the I-405 HOV facility are illustrated in Exhibits 3-78 through 3-89. During the 5:00 PM peak hour in the northbound direction of the HOV facility, 2006 experienced the highest travel time at about 49 minutes (Exhibit 3-80), which declined in the following two years to 41 minutes in 2007 (Exhibit 3-81) and 37 minutes in 2008 (Exhibit 3-82). Travel time slightly increased in 2009 to 40 minutes (Exhibit 3-83). The same trend occurred in the southbound direction. In 2006 during the 7:00 AM peak hour, the southbound HOV lane experienced the highest travel time at slightly under 40 minutes (Exhibit 3-86), which declined to 38 minutes in 2007 (Exhibit 3-87), 35 minutes in 2008 (Exhibit 3-88), and further declined to 32 minutes in 2009 (Exhibit 3-89).

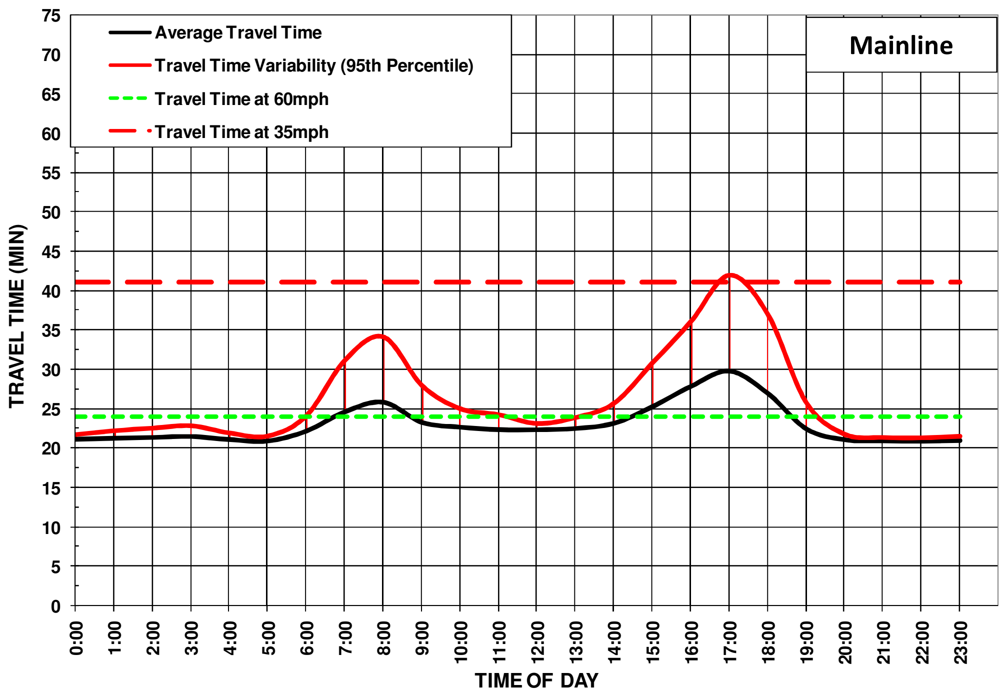
Traveling on the HOV facility saved motorists an average of almost 6 minutes in the northbound direction and 8 minutes in the southbound direction during their respective peak hours in 2004-2009. In 2009, the savings in travel time was less than the average at about 3 minutes in the northbound direction and 8 minutes in the southbound direction during their peak hours.

Exhibit 3-66: Northbound I-405 Mainline Travel Time Variation (2004)



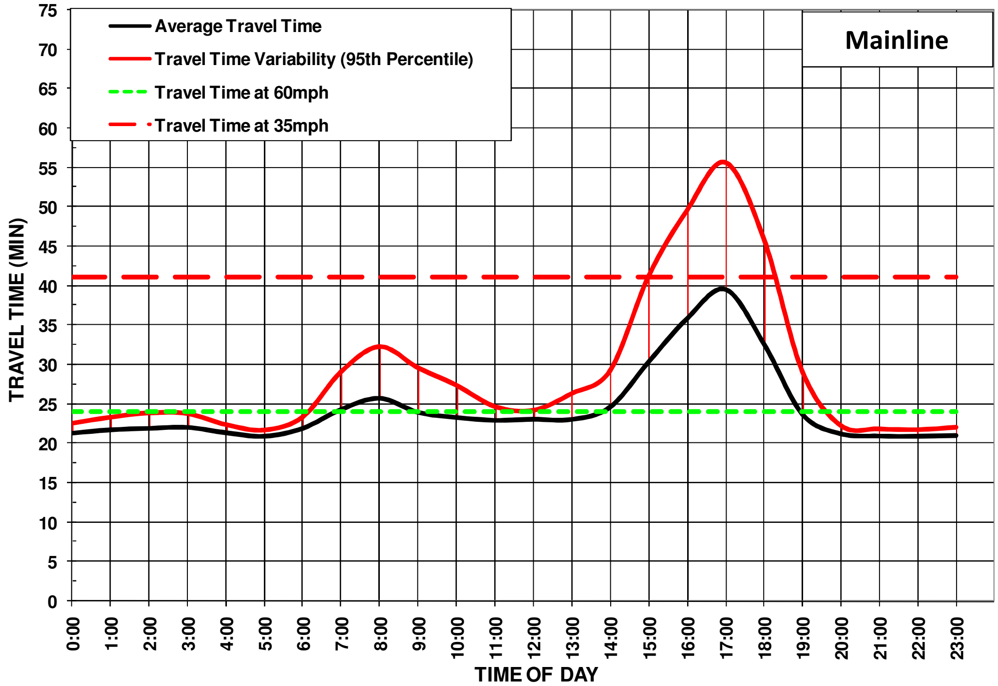
Source: Automatic detector data

Exhibit 3-67: Northbound I-405 Mainline Travel Time Variation (2005)



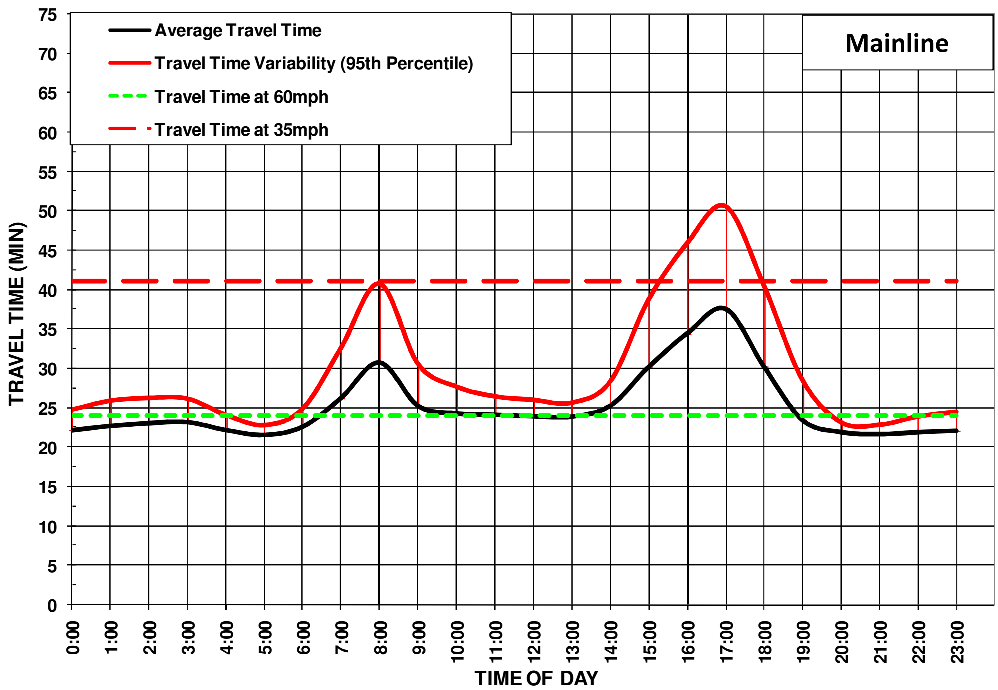
Source: Automatic detector data

Exhibit 3-68: Northbound I-405 Mainline Travel Time Variation (2006)



Source: Automatic detector data

Exhibit 3-69: Northbound I-405 Mainline Travel Time Variation (2007)



Source: Automatic detector data

Exhibit 3-70: Northbound I-405 Mainline Travel Time Variation (2008)

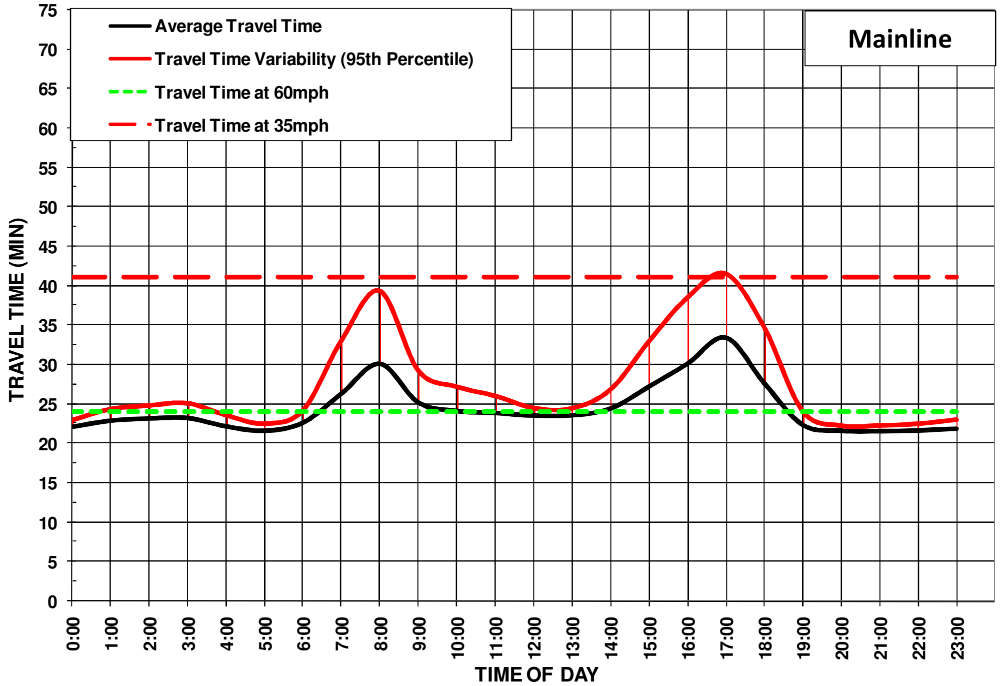
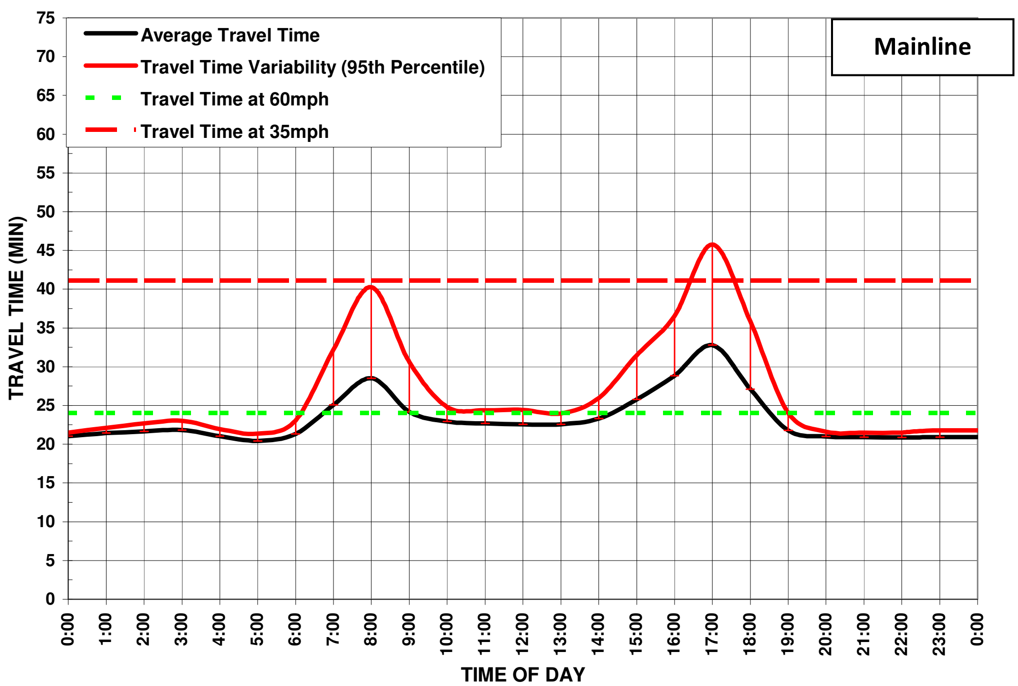
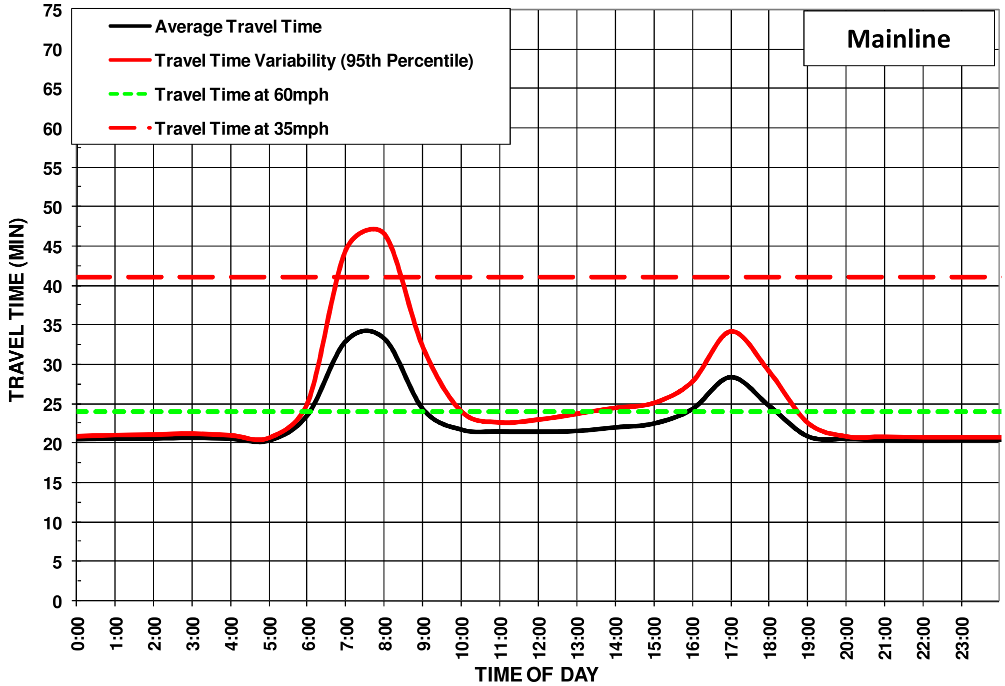


Exhibit 3-71: Northbound I-405 Mainline Travel Time Variation (2009)



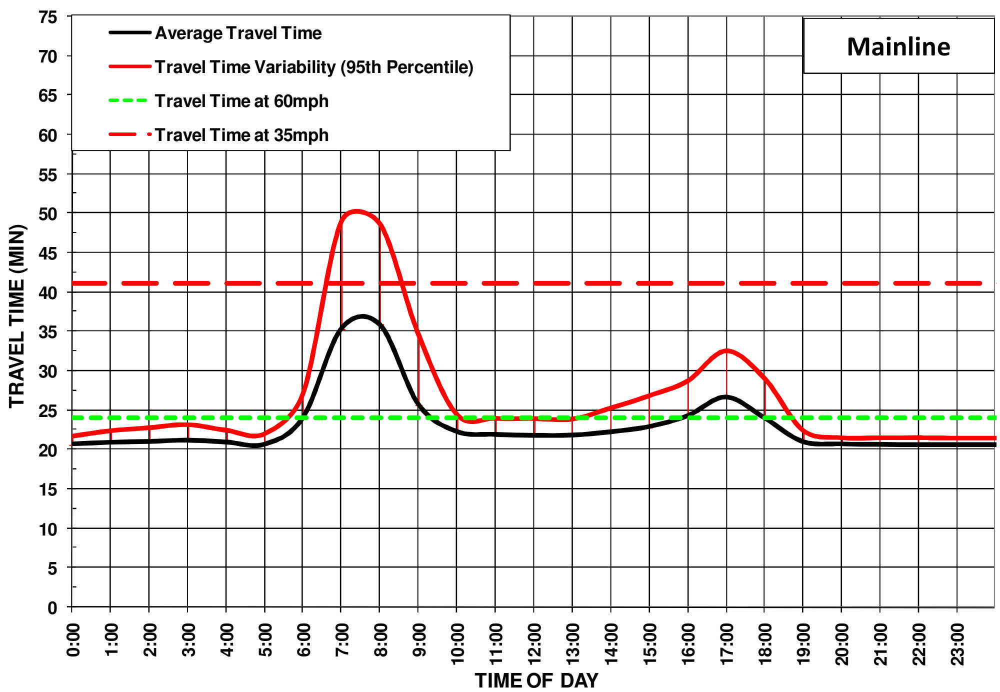
Source: Automatic detector data

Exhibit 3-72: Southbound I-405 Mainline Travel Time Variation (2004)



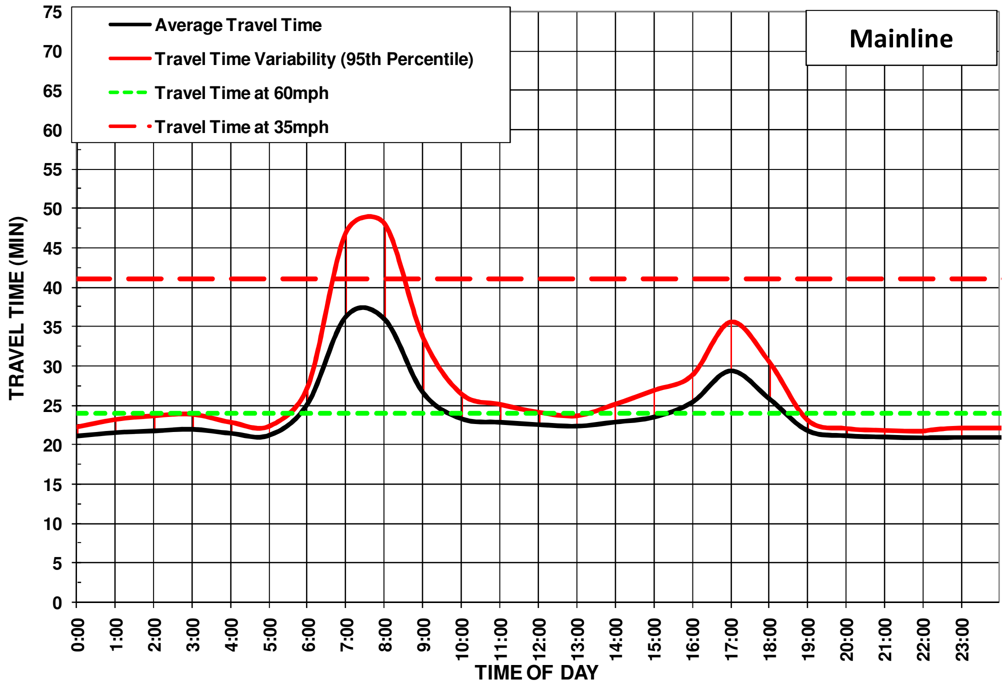
Source: Automatic detector data

Exhibit 3-73: Southbound I-405 Mainline Travel Time Variation (2005)



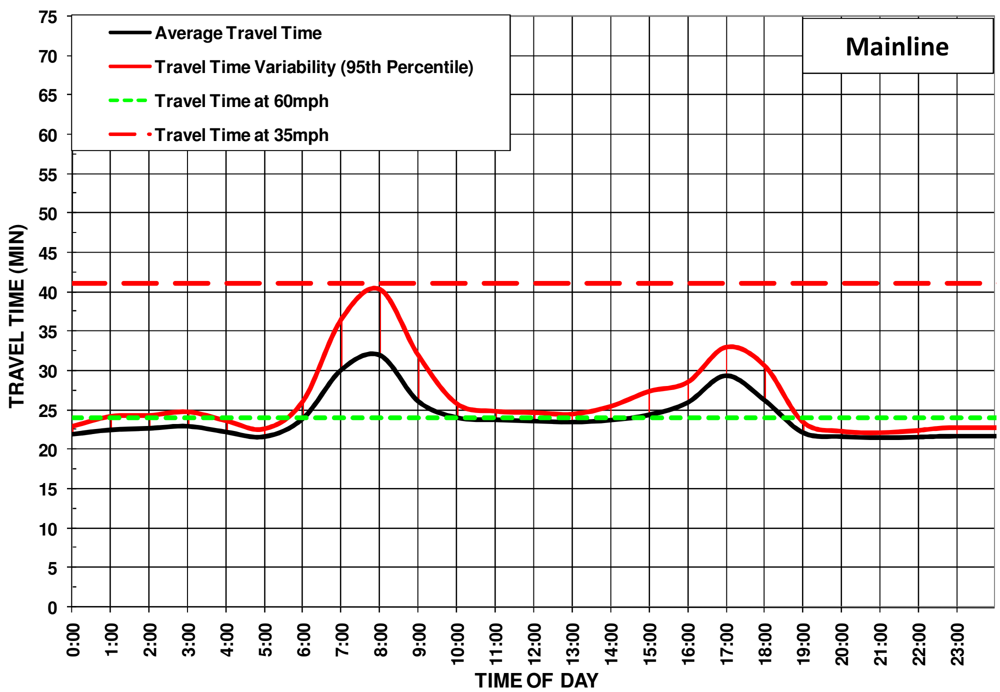
Source: Automatic detector data

Exhibit 3-74: Southbound I-405 Mainline Travel Time Variation (2006)



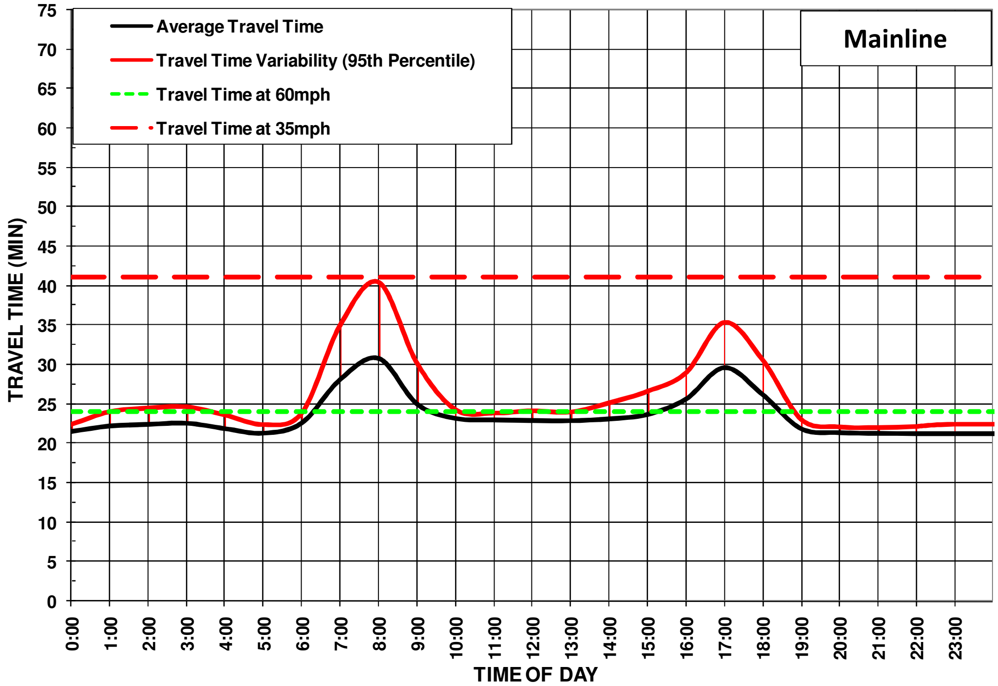
Source: Automatic detector data

Exhibit 3-75: Southbound I-405 Mainline Travel Time Variation (2007)



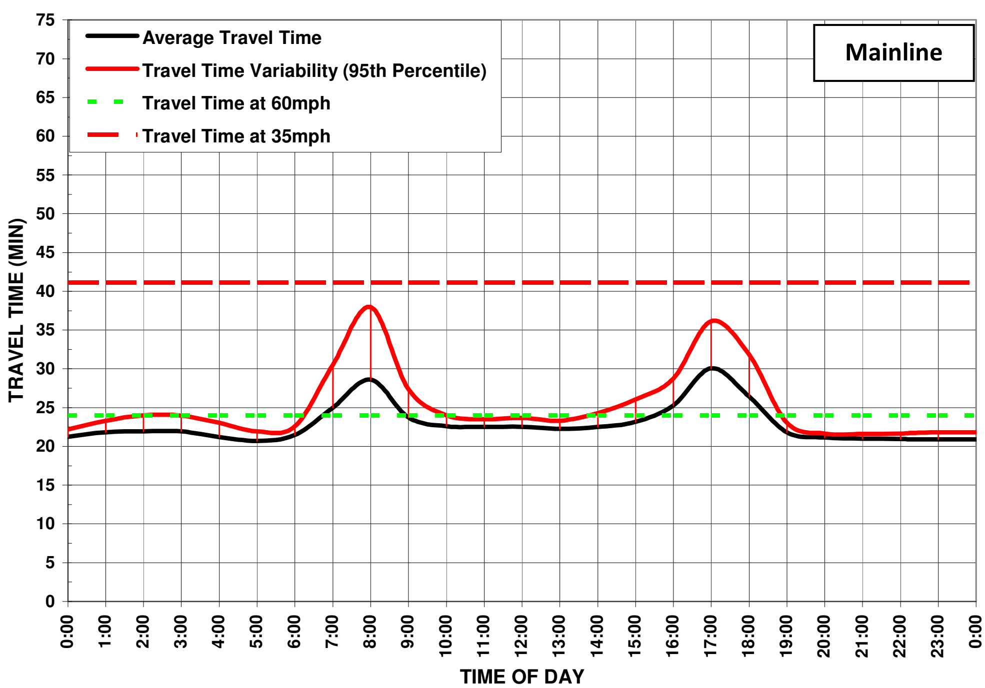
Source: Automatic detector data

Exhibit 3-76: Southbound I-405 Mainline Travel Time Variation (2008)



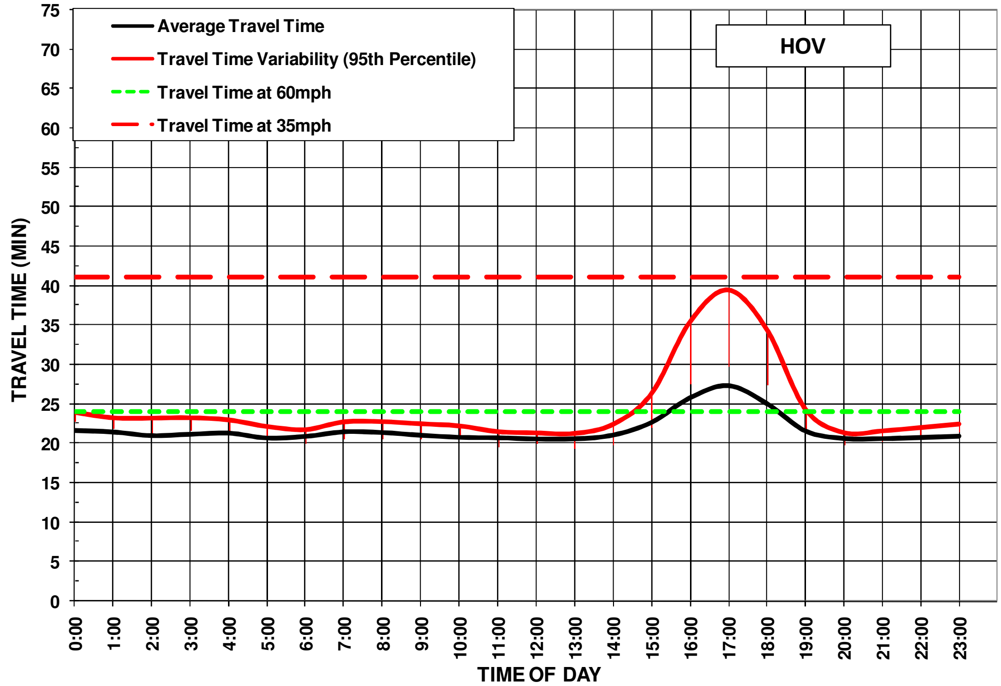
Source: Automatic detector data

Exhibit 3-77: Southbound I-405 Mainline Travel Time Variation (2009)



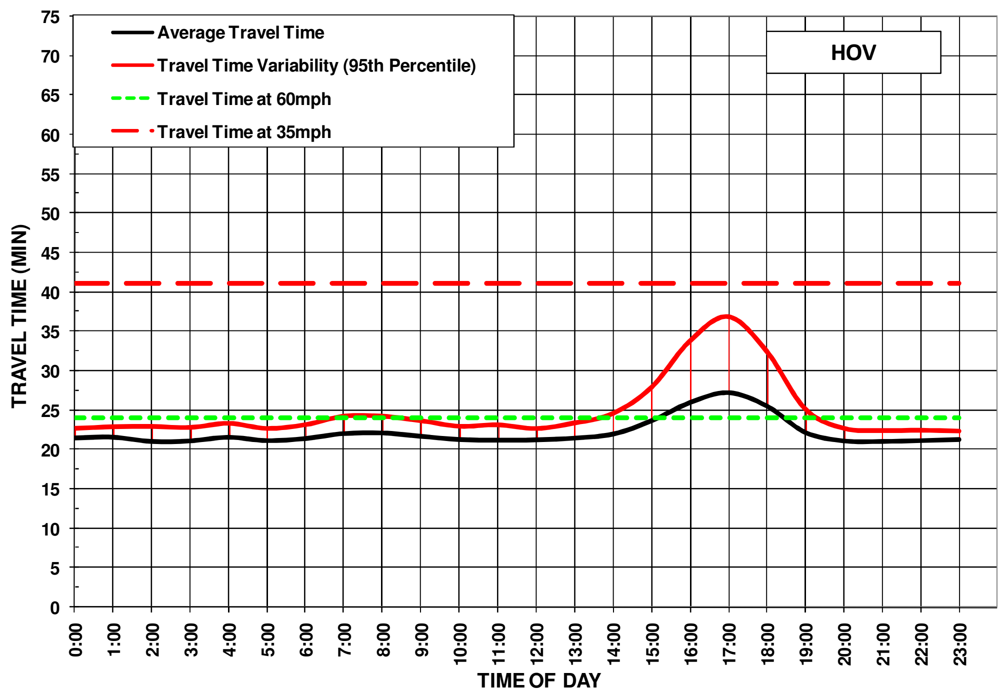
Source: Automatic detector data

Exhibit 3-78: Northbound I-405 HOV Travel Time Variation (2004)



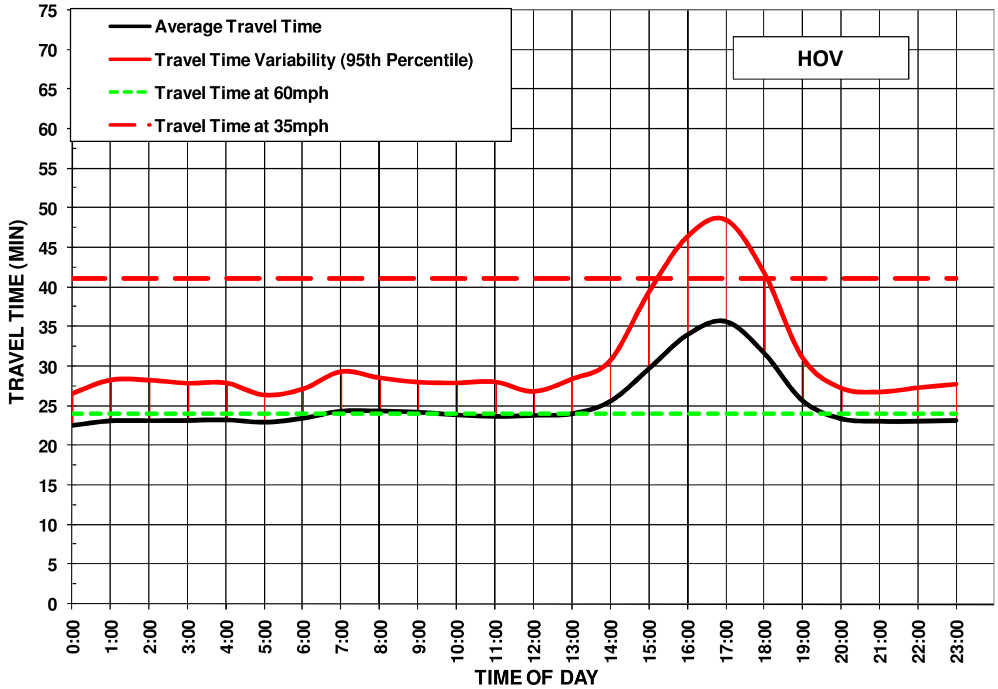
Source: Automatic detector data

Exhibit 3-79: Northbound I-405 HOV Travel Time Variation (2005)



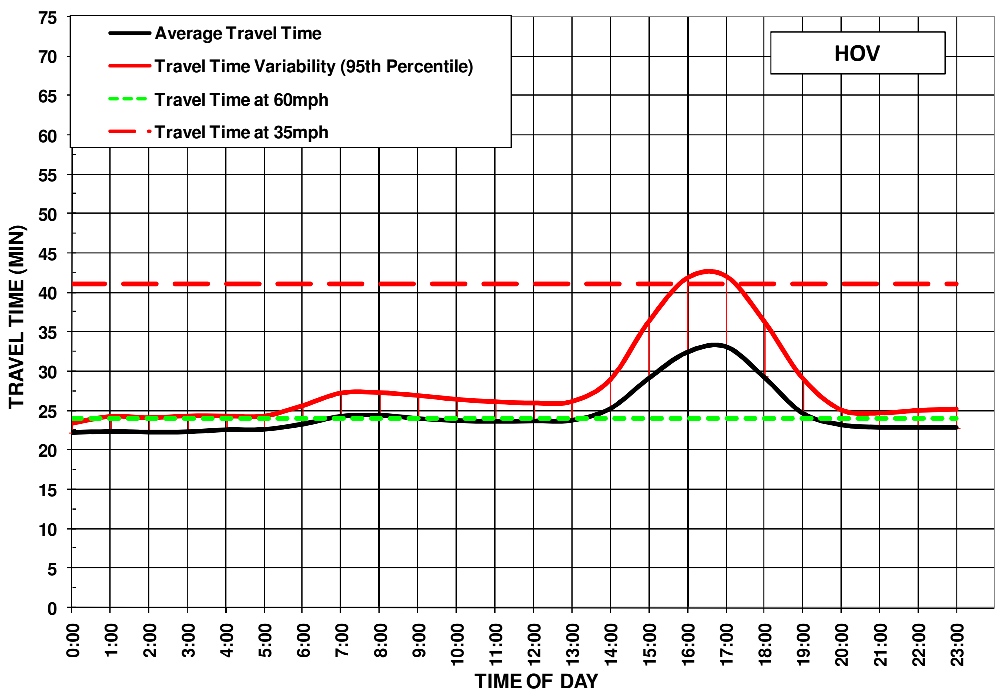
Source: Automatic detector data

Exhibit 3-80: Northbound I-405 HOV Travel Time Variation (2006)



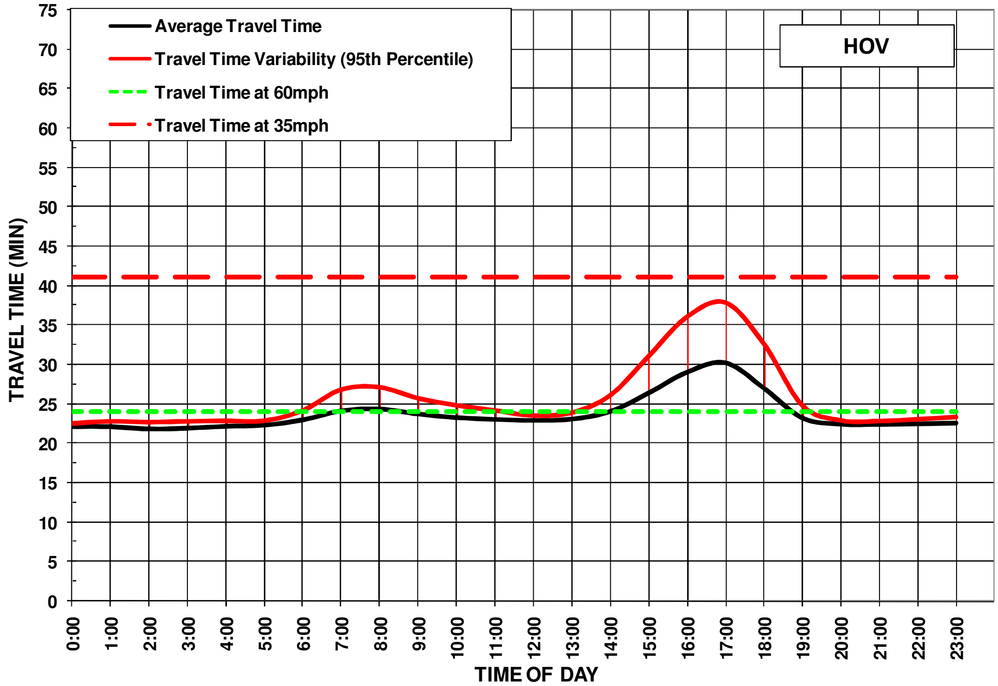
Source: Automatic detector data

Exhibit 3-81: Northbound I-405 HOV Travel Time Variation (2007)



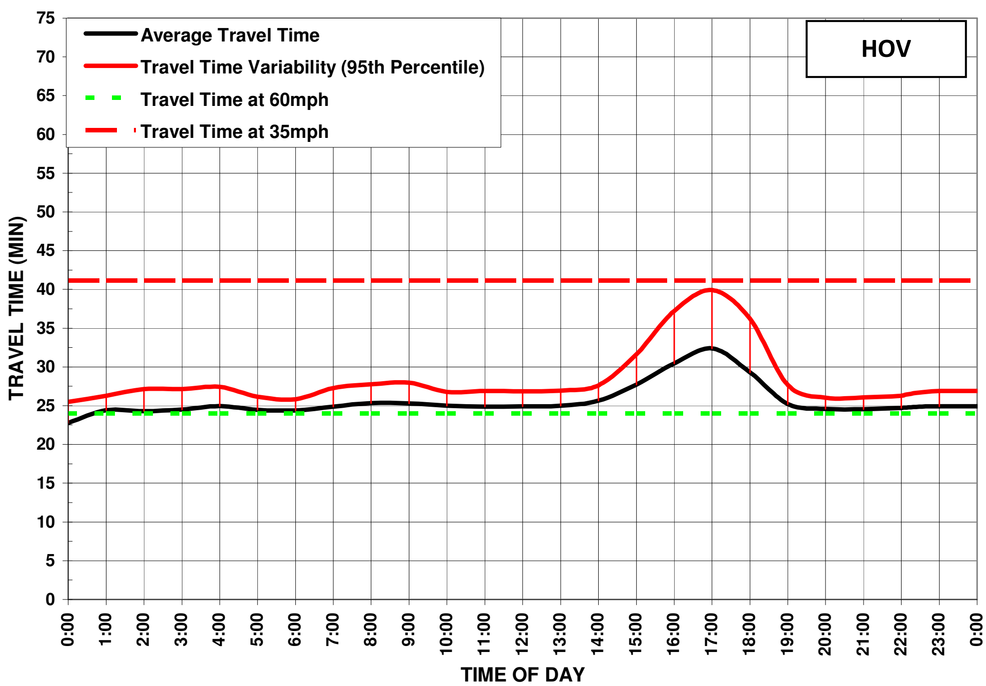
Source: Automatic detector data

Exhibit 3-82: Northbound I-405 HOV Travel Time Variation (2008)



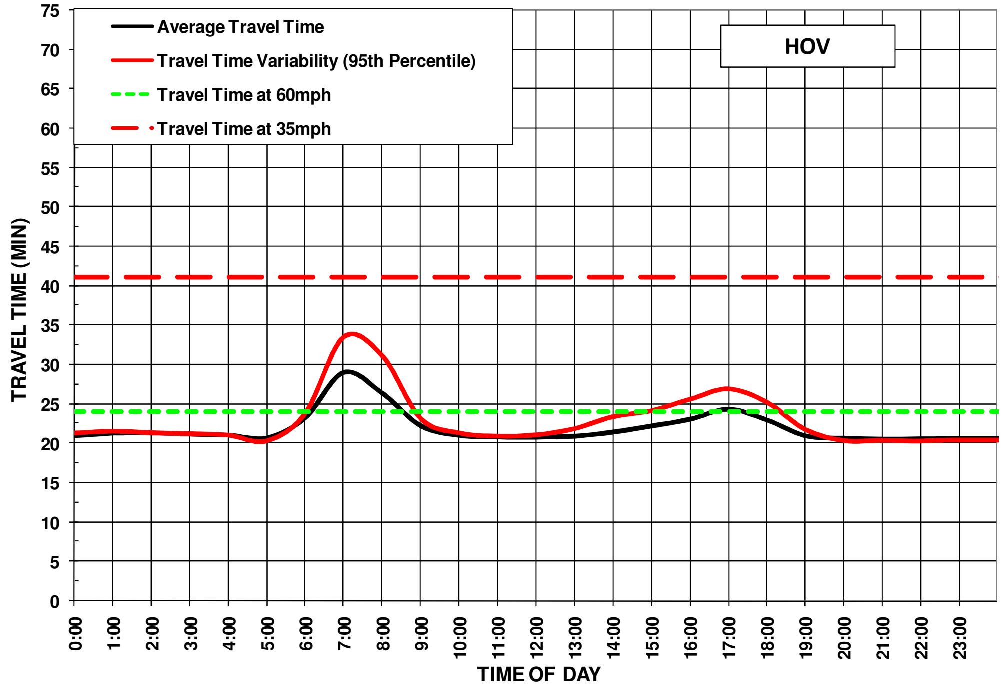
Source: Automatic detector data

Exhibit 3-83: Northbound I-405 HOV Travel Time Variation (2009)



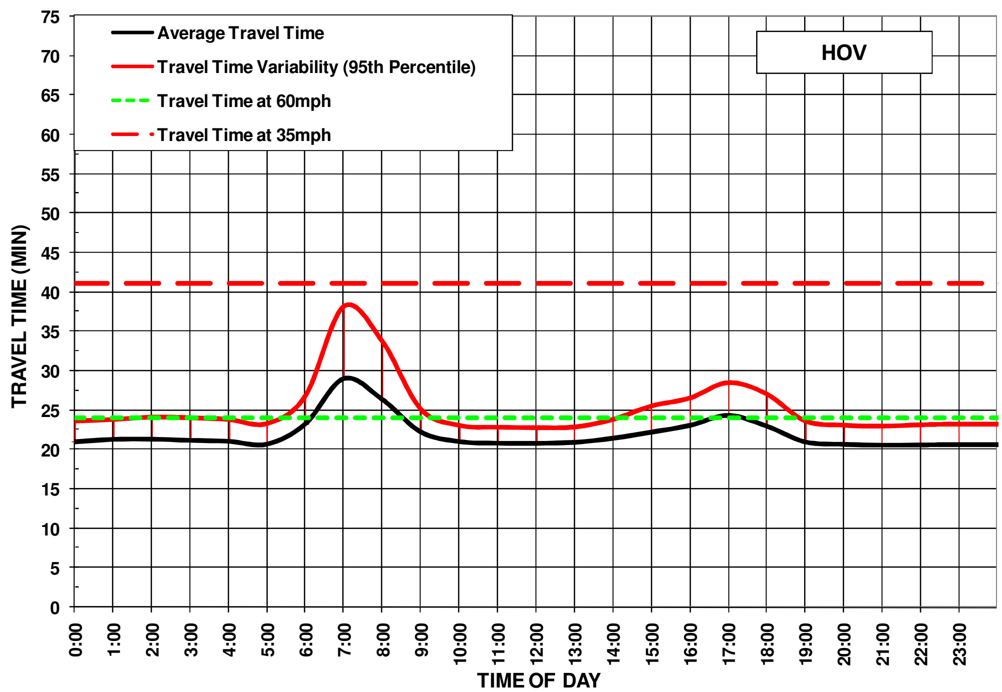
Source: Automatic detector data

Exhibit 3-84: Southbound I-405 HOV Travel Time Variation (2004)



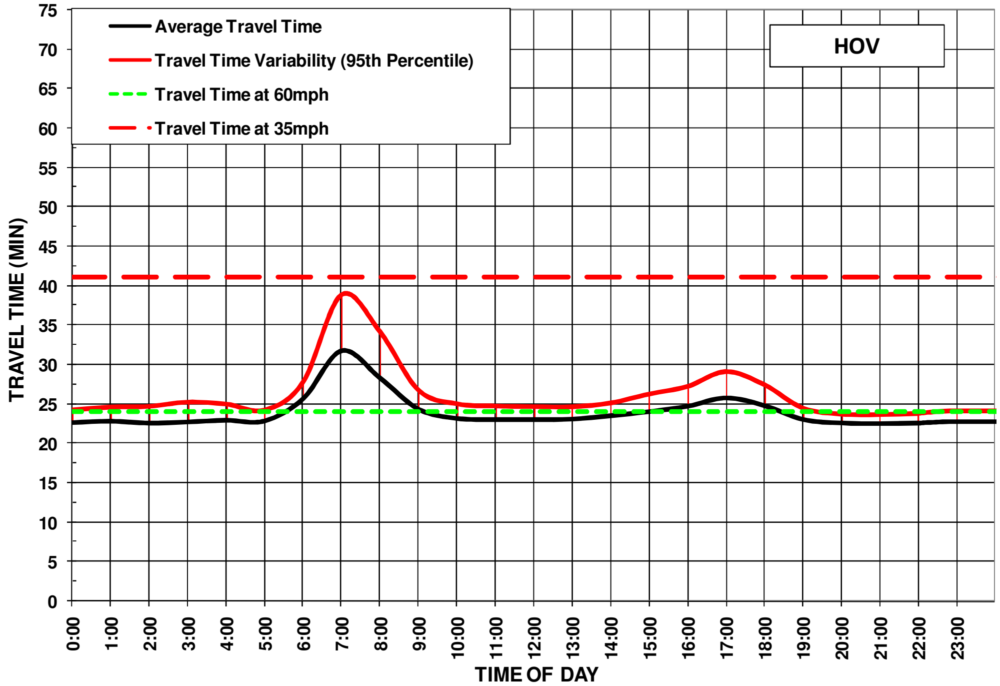
Source: Automatic detector data

Exhibit 3-85: Southbound I-405 HOV Travel Time Variation (2005)



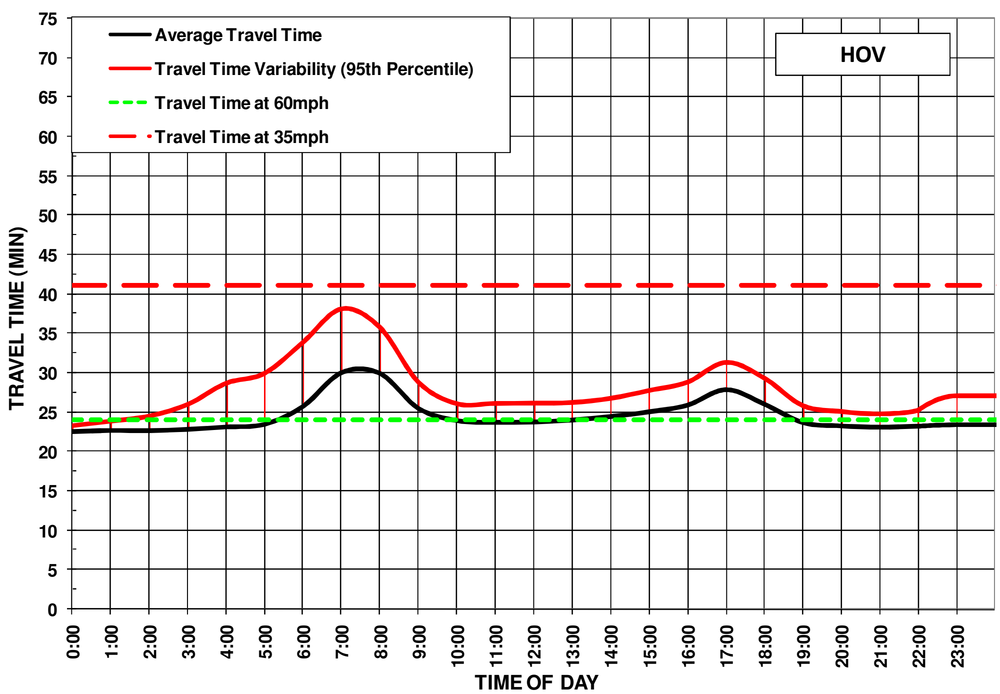
Source: Automatic detector data

Exhibit 3-86: Southbound I-405 HOV Travel Time Variation (2006)



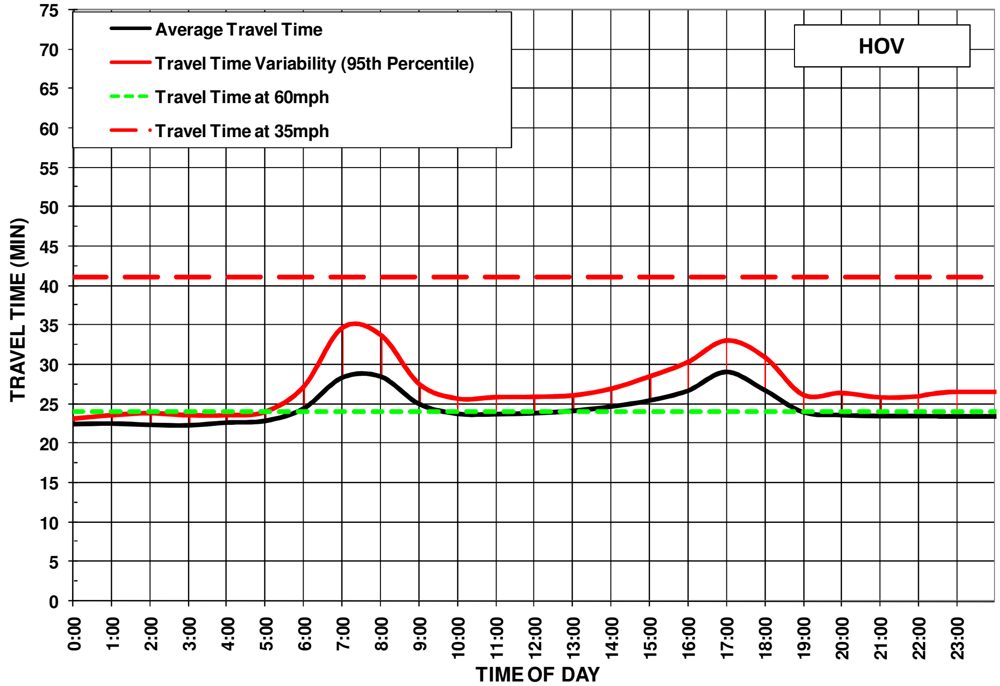
Source: Automatic detector data

Exhibit 3-87: Southbound I-405 HOV Travel Time Variation (2007)



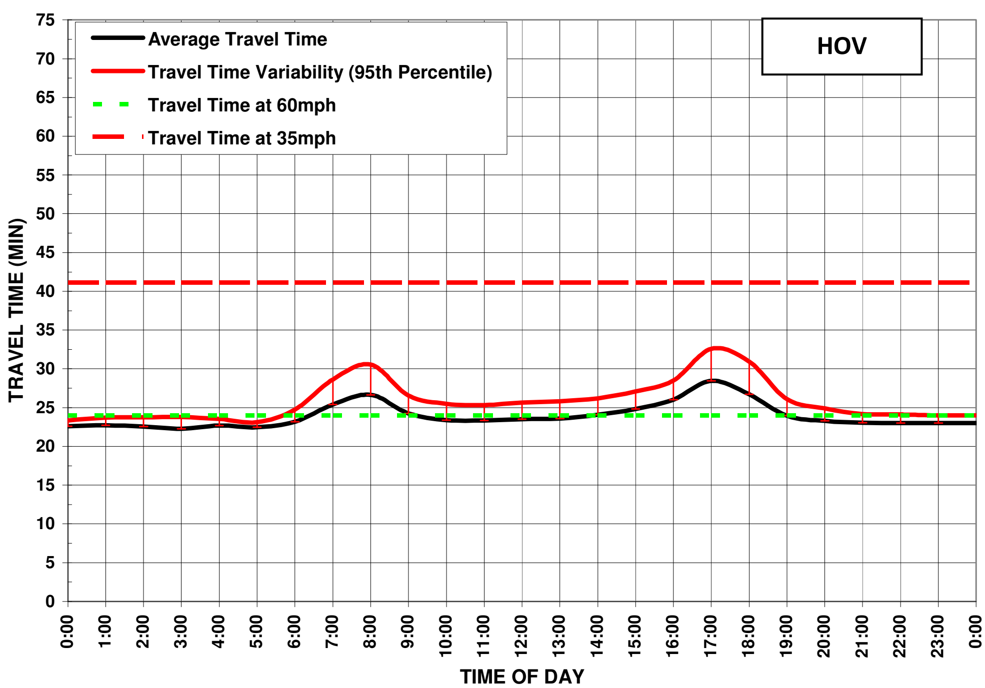
Source: Automatic detector data

Exhibit 3-88: Southbound I-405 HOV Travel Time Variation (2008)



Source: Automatic detector data

Exhibit 3-89: Southbound I-405 HOV Travel Time Variation (2009)



Source: Automatic detector data

Safety

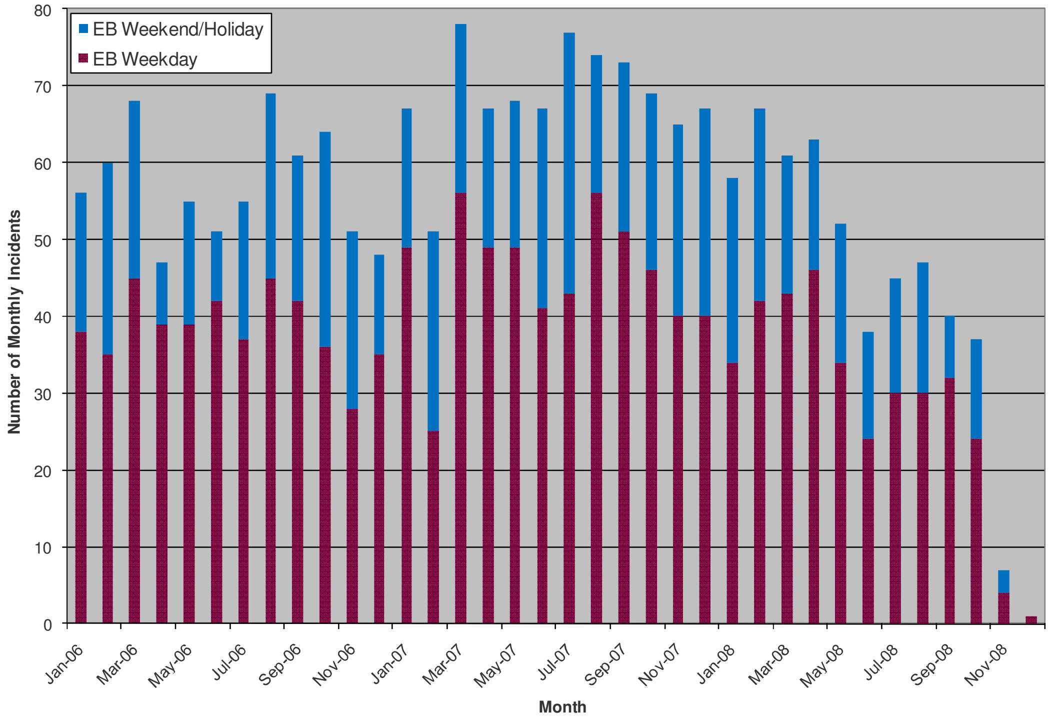
The adopted performance measures to assess safety involve the number of accidents and the accident rates computed from the Caltrans Traffic Accident Surveillance and Analysis System (TASAS). TASAS is a traffic records system containing an accident database linked to a highway database. The highway database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

The safety assessment in this report intends to characterize the overall accident history and trends in the corridor. It also highlights notable accident concentration locations or readily apparent patterns. This report is not intended to replace more detailed safety investigations routinely performed by Caltrans staff.

The safety analysis conducted for the SR-22 Corridor is based on data provided by Caltrans District 12. The safety assessment analyzes the three-year period from January 1, 2006 through December 31, 2008. Prior to 2008, the corridor was undergoing construction.

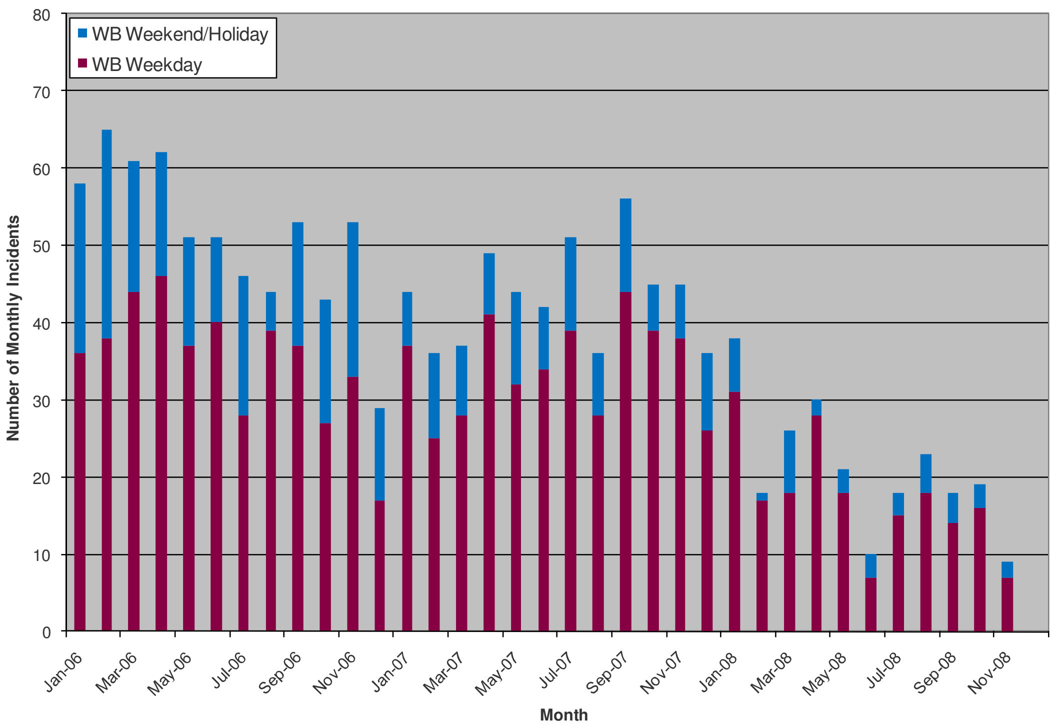
Exhibits 3-90 and 3-91 summarize the number of accidents on the SR-22 Corridor by month, respectively. From 2006 to 2008, the eastbound corridor experienced as much as 80 collisions per month, while the westbound experienced as much as 65 collisions per month. This is consistent with the corridor having experienced greater congestion in the eastbound direction than the westbound. In the eastbound direction, the number of accidents increased from 2006 to 2007, but sharply decreased in 2008. In the westbound direction, the corridor experienced a steady decrease in accidents throughout the three year period. The decrease in accidents from 2007 to 2008 in both directions may be attributed to the widening and improvements made to the corridor.

Exhibit 3-90: Eastbound SR-22 Monthly Accidents (2006-2008)



Source: Caltrans TASAS Selective Accident Retrieval Report

Exhibit 3-91: Westbound SR-22 Monthly Accidents (2006-2008)

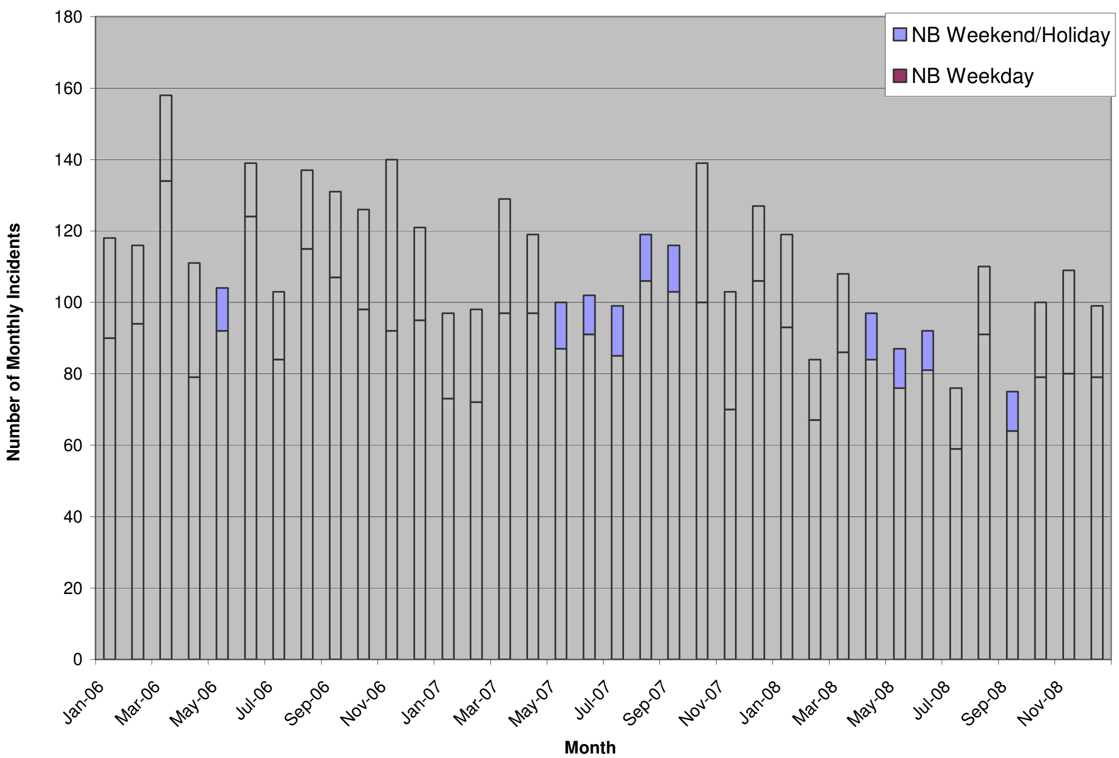


Source: Caltrans TASAS Selective Accident Retrieval Report

The number of accidents which occurred on I-405 from 2006 to 2008 is depicted in the following two charts. Exhibits 3-92 and 3-93 summarize the number of accidents by month during the three-year period.

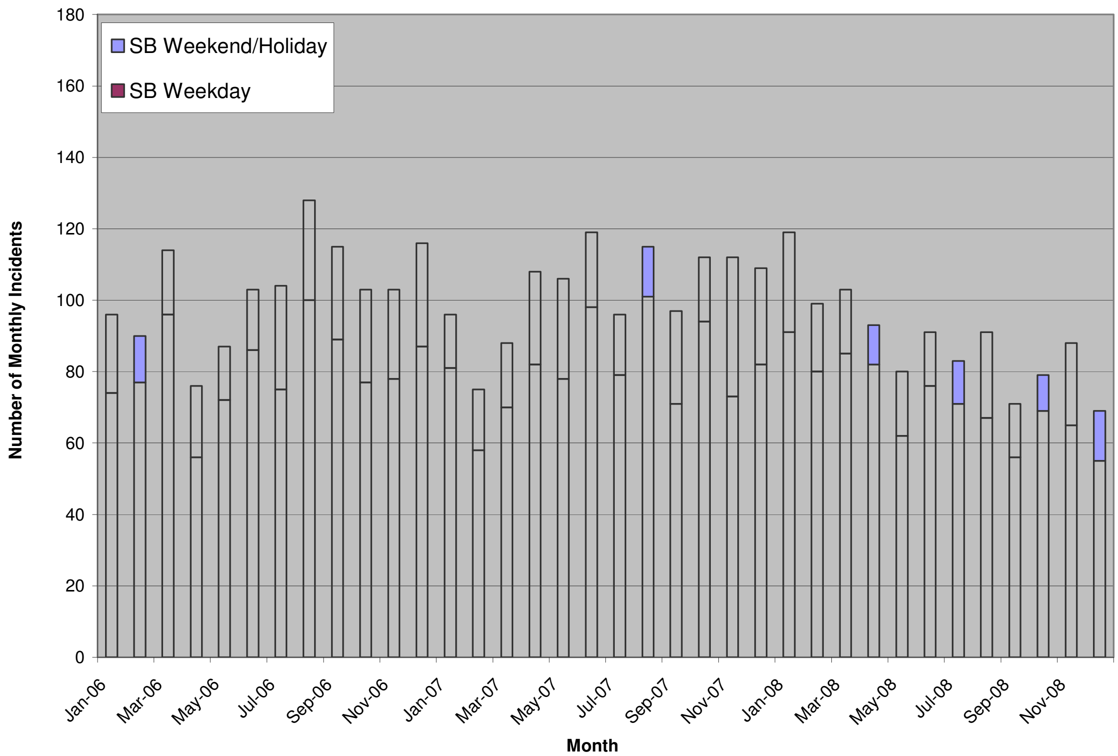
From 2006 to 2008, the northbound corridor experienced as many as 160 collisions per month (over 5 per day), while the southbound experienced as many as 125 collisions per month (4 per day). This is consistent with the corridor having experienced greater congestion in the northbound direction than the southbound. In both directions of the corridor, the vast majority of accidents occurred on the weekdays (80 percent) compared to the weekend. Overall, both directions of the corridor experienced a decrease in accidents from 2006 to 2008.

Exhibit 3-92: Northbound I-405 Monthly Accidents (2006-2008)



Source: Caltrans TASAS Selective Accident Retrieval Report

Exhibit 3-93: Southbound I-405 Monthly Accidents (2006-2008)



Source: Caltrans TASAS Selective Accident Retrieval Report

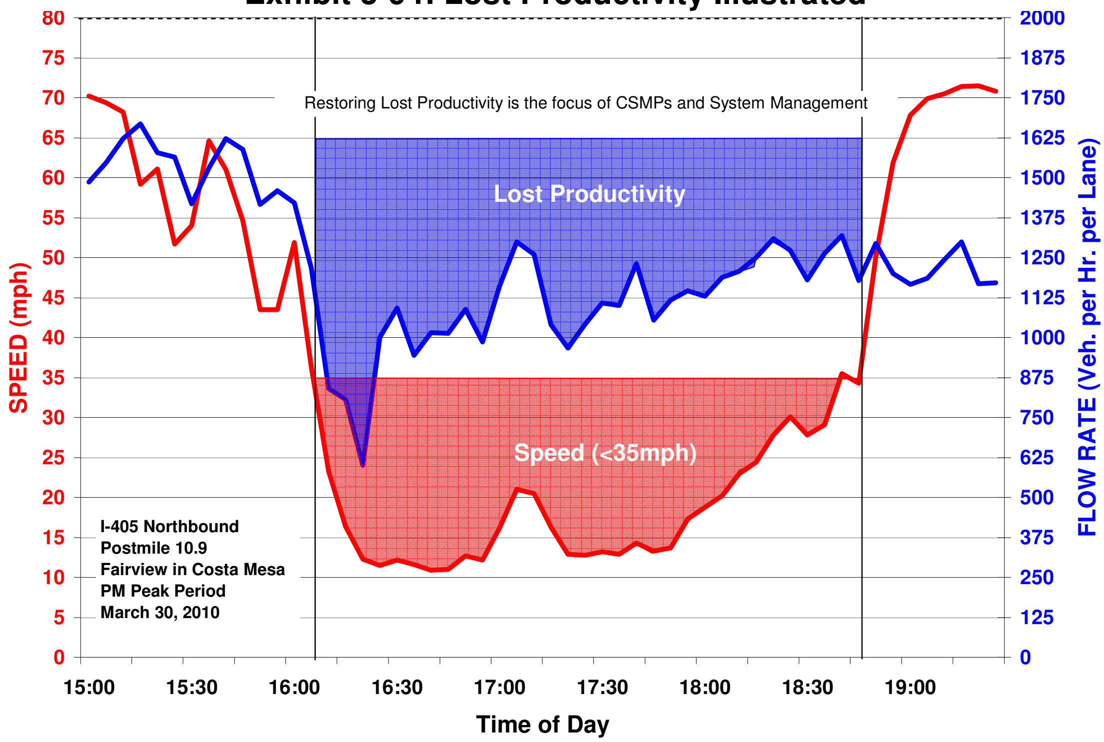
Productivity

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, it is the number of people served divided by the level of service provided, or the percent utilization of a facility or mode under peak congested conditions.

For highways, the input to the system is the capacity of the roadway and the output is the number of people or vehicles that can pass through that roadway, and is calculated as the actual volume divided by the theoretical capacity of the highway. Highway productivity is particularly important because where capacity is needed the most, the lowest "production" from the transportation system often occurs.

This loss in productivity example is illustrated in Exhibit 3-94, which is similar to the productivity chart presented in Section 1. 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.

Exhibit 3-94: Lost Productivity Illustrated



There are a few ways to estimate productivity losses. Regardless of the approach, highway 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 have to be added in order to achieve maximum productivity. For example, losing six lane-miles implies that adding a new lane along a six-mile section of freeway would regain lost productivity.

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

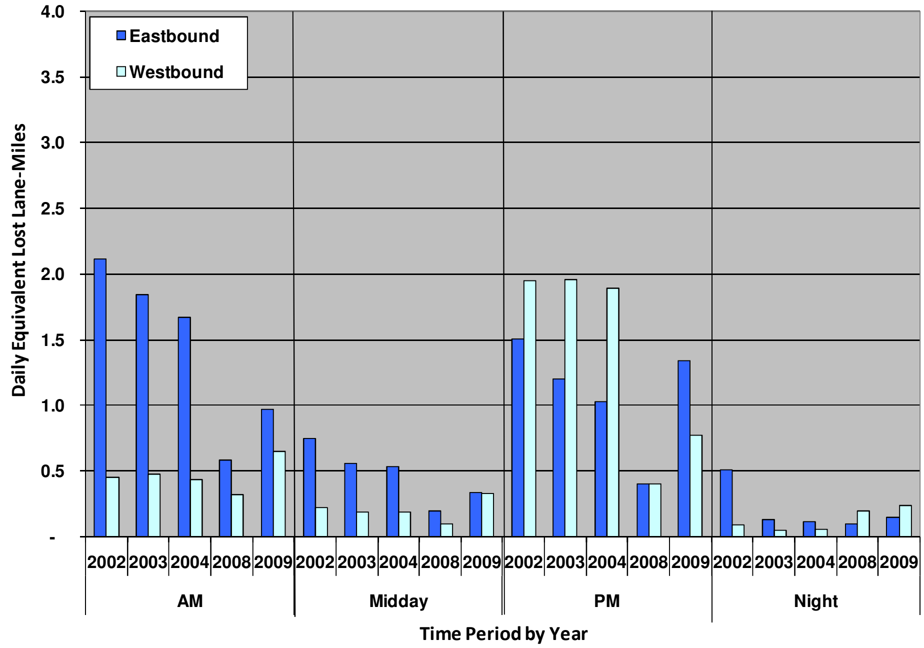
$$LostLaneMiles = \left(1 - \frac{ObservedLaneThroughput}{2200vphpl}\right) \times Lanes \times CongestedDis\tan ce$$

Exhibit 3-95 summarizes the productivity losses on the SR-22 mainline facility during both pre-construction and post-construction periods. The trends in the productivity losses are comparable to the delay trends. The largest productivity losses occurred in the eastbound direction during the AM peak and in the westbound direction during the PM peak.

The exhibit shows that productivity improved during the post-construction period (2008-2009) as compared to the pre-construction period. In the eastbound direction during the AM peak period, lost-lane miles decreased from 1.7 in 2004 to 1.0 in 2009. Similarly, in the westbound direction during the PM peak, lost-lane miles declined from 1.9 in 2004 to 0.8 in 2009. Again, data from 2008 were not discussed in this section given the limited detection during that year. The same analysis was performed for the SR-22 HOV facility (Exhibit 3-96), which shows that productivity losses were minimal and less than 0.12 equivalent lost lane-miles during any particular time and direction.

Strategies to combat such productivity losses are related primarily 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.

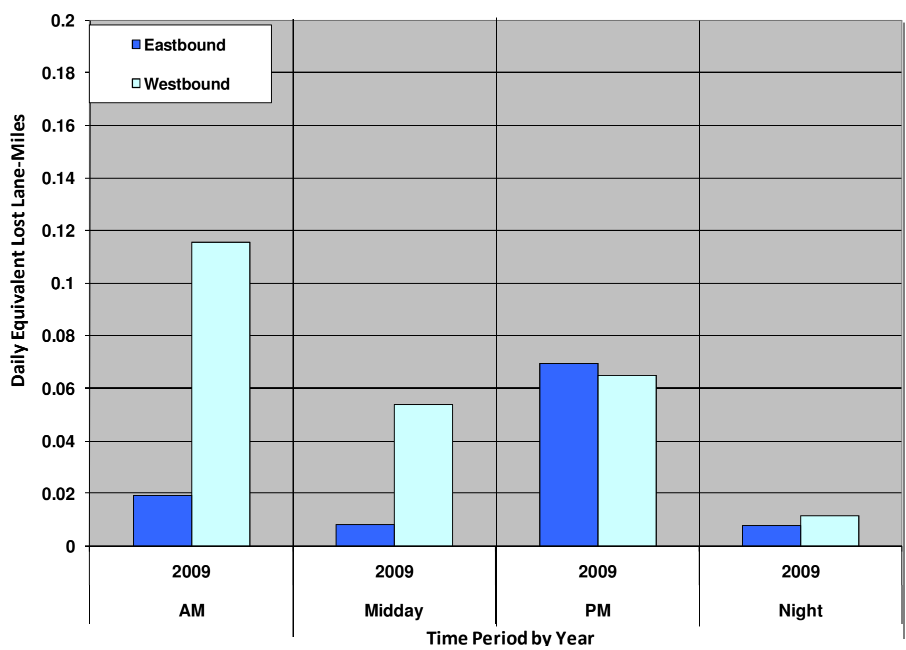
Exhibit 3-95: SR-22 Mainline Average Daily Equivalent Lost Lane-Miles by Direction and Period (2002-2009)



Source: Automatic detector data

Note: Due to limited detection on SR-22 in 2008, productivity may be underreported for 2008.

Exhibit 3-96: SR-22 HOV Average Daily Equivalent Lost Lane-Miles by Direction and Period (2009)

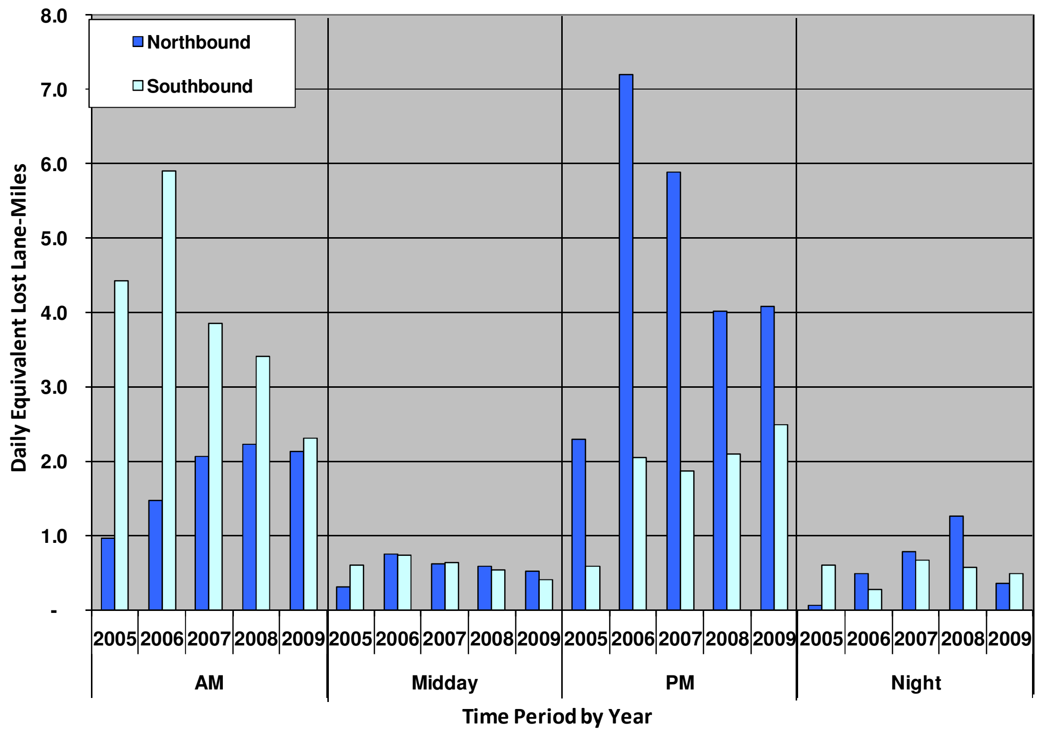


Source: Automatic detector data

Note: Detection on the SR-22 HOV facility was not available until February 5, 2009.

Exhibits 3-97 and 3-98 summarize the productivity losses on the I-405 mainline and HOV facilities for the 2005-2009 period. Again, the trends in the productivity losses are comparable to the delay trends. On the mainline facility, the largest productivity losses occurred during the AM peak period in the southbound direction and during the PM peak period in the northbound direction, which is the time period and direction that experienced the most congestion. From 2005 to 2009, productivity gains were made in both directions of the mainline. The most notable occurred during the AM in the southbound direction from 2006 to 2007 when lost-lane miles decreased from 6.0 to 3.9. In the northbound direction, a significant improvement was evident during the PM peak from 2007 to 2008 when lost-lane miles declined from 6.0 to 4.0.

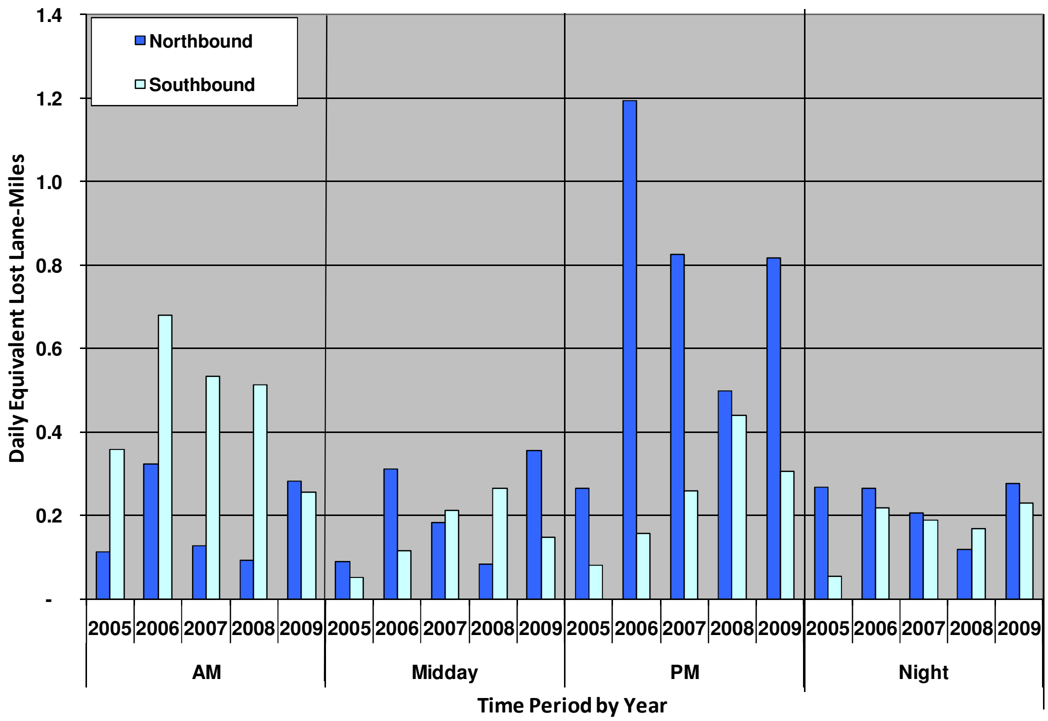
Exhibit 3-97: I-405 Mainline Average Daily Equivalent Lost Lane-Miles by Direction and Period (2005-2009)



Source: Automatic detector data

Exhibit 3-98 also shows that on the HOV facility, the productivity losses are comparable to the delay trends at a smaller scale. Like the mainline, the highest productivity also occurred in the southbound direction during the AM peak and in the northbound direction during the PM peak. Exhibit 3-98 also identified 2006 as the year with the highest lost-lane miles, which is consistent with the delay results presented earlier that showed 2006 had the highest delay of any year of analysis.

Exhibit 3-98: I-405 HOV Average Daily Equivalent Lost Lane-Miles by Direction and Period (2005-2009)



Source: Automatic detector data

Pavement Condition

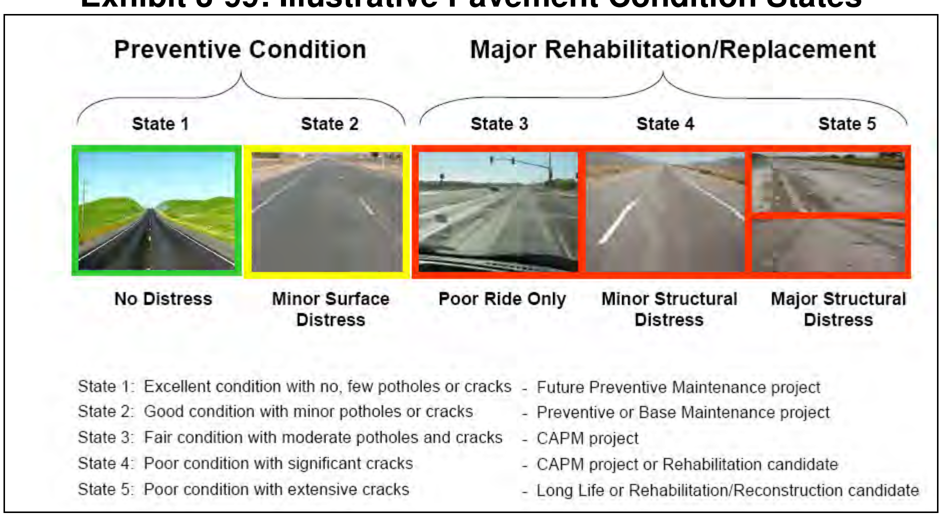
The condition of the roadway pavement (or ride quality) on the corridor can influence its traffic performance. Rough or poor pavement conditions can decrease the mobility, reliability, safety, and productivity of the corridor, whereas smooth pavement can have the opposite effect. Pavement preservation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

Pavement 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 3-99 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 3-99: Illustrative 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 at 95 inches per mile or less, the pavement is considered good or smooth-riding. When movements are between 95 and 170 inches per mile, the pavement is considered acceptable. Measurements above 170 inches per mile reflect unacceptable or rough-riding conditions.

Existing Pavement Conditions

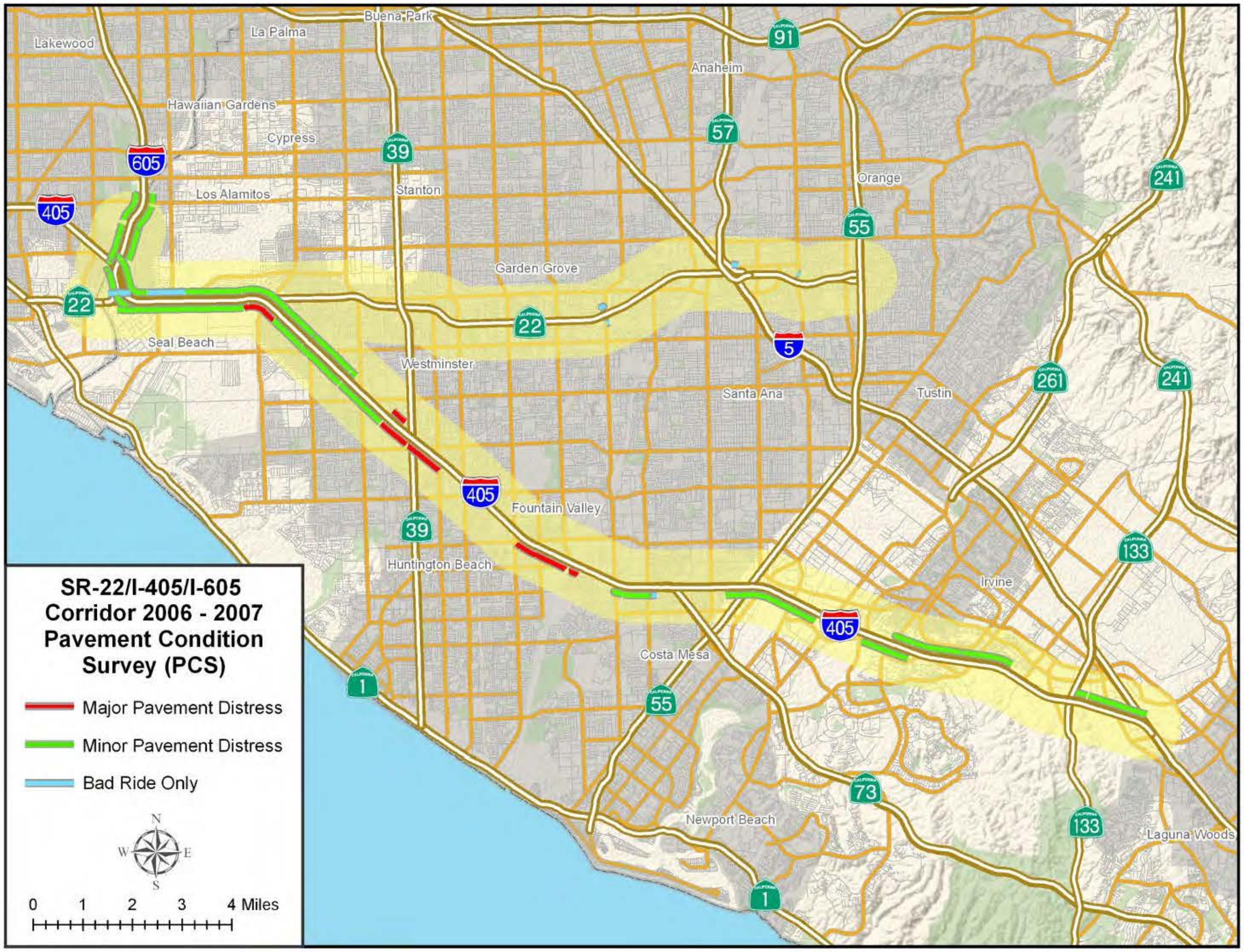
The most recent pavement condition survey, completed in November 2007, recorded 12,998 distressed lane-miles statewide. Unlike prior surveys, the 2007 PCS included pavement field studies for a period longer than a year, due to an update in the data collection methodology. The survey includes data for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

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

Exhibit 3-100 uses 2007 PCS data to show pavement distress along all three freeways (SR-22, I-405, and I-605) that comprise the SR-22 CSMP corridor in Orange County. The three categories shown in this exhibit represent the distressed conditions that require major rehabilitation or replacement and were presented earlier in Exhibit 3-99.

The three freeways in the corridor provide a fairly representative sample of conditions for freeways in Orange County. SR-22 has almost no distress as a result of the recent roadway work on the freeway. About half of I-405 and the small section of I-605 included in the corridors have portions of minor pavement distress. There are small one-mile sections with major pavement distress near Huntington Beach as well as some areas with only ride quality issues near the SR-22, I-405, and I-605 interchanges. However, in December 2007, 40 lane-miles of distressed pavement from Beach Boulevard to the LA County Line were repaired. This project is not reflected in the most current PCS since it was completed after the PCS reporting date of December 14, 2006.

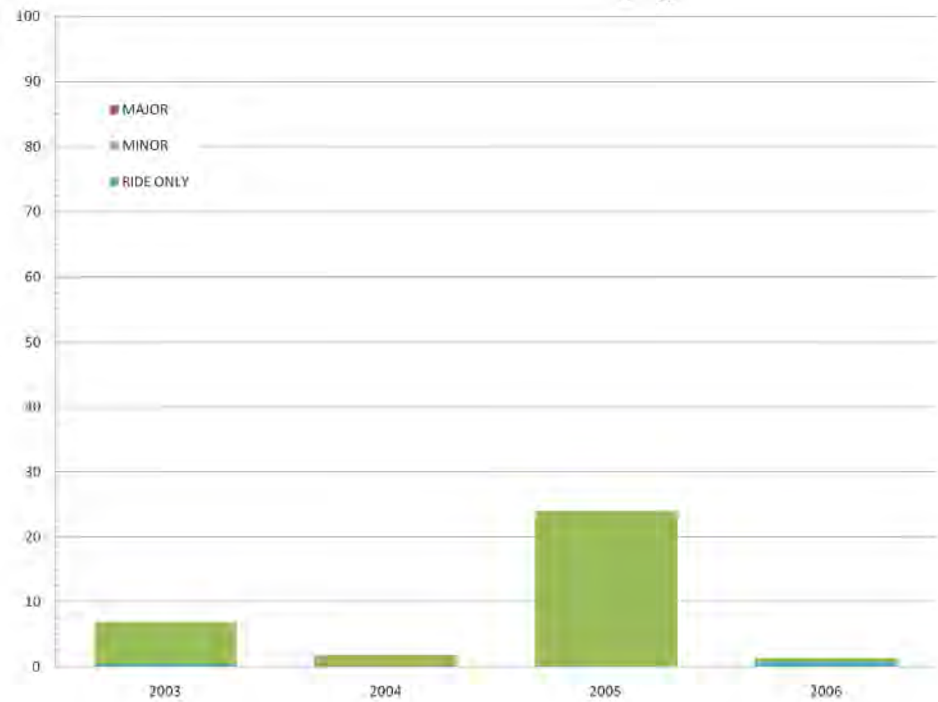
Exhibit 3-100: Distressed Lane-Miles for SR-22, I-405, and I-605 (2006-2007)



Source: 2007 Pavement Condition Survey data

Exhibit 3-101 compares results from prior pavement condition surveys along SR-22. As the exhibit shows, the freeway typically has very few distressed lane-miles with the exception of the roadway construction during 2005. Exhibit 3-102 presents the percent mix of distressed lane-miles along SR-22. In most years, the distressed lane-miles represent minor pavement distress. In the most recent survey, the distressed lane-miles were compressed of roughly half minor pavement distress and half ride quality issues.

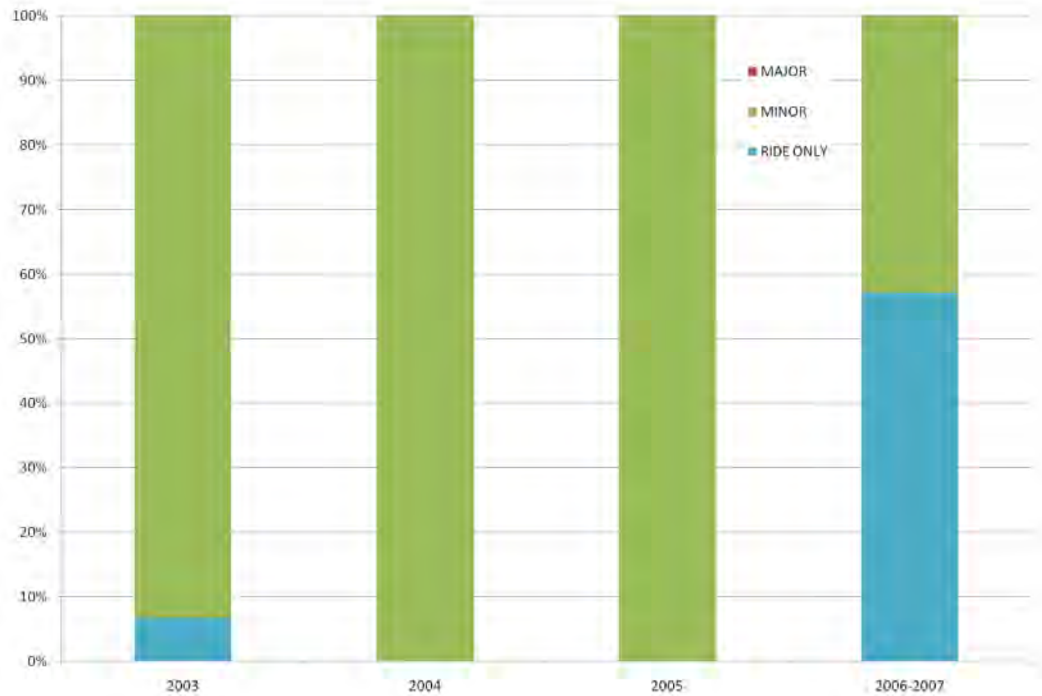
Exhibit 3-101: SR-22 Distressed Lane-Mile Trends (2003-2007)



Source: 2003 to 2007 Pavement Condition Survey data

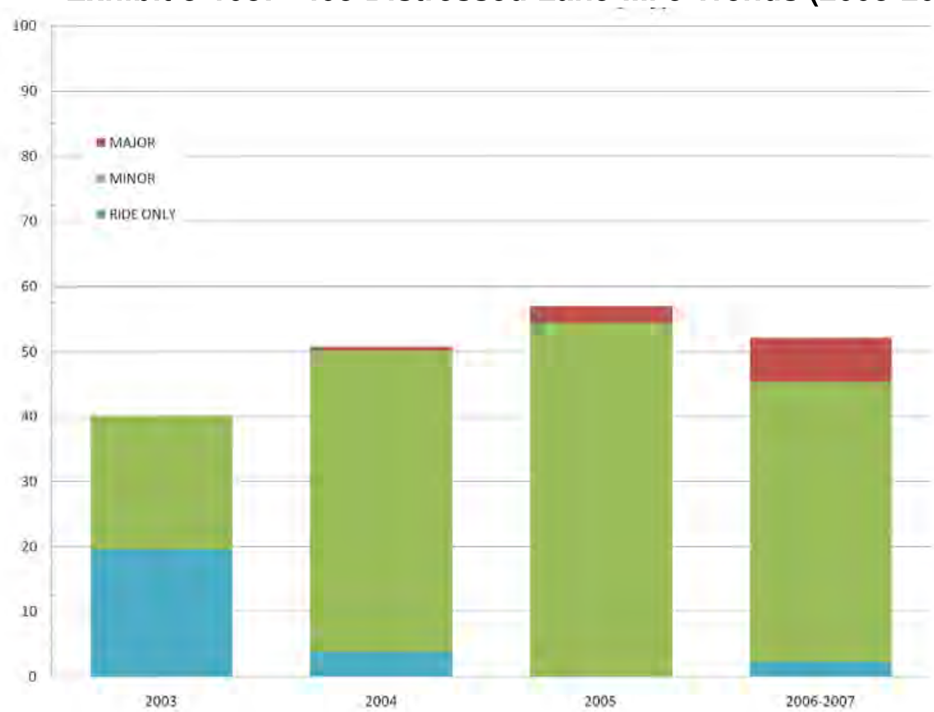
Exhibit 3-103 shows pavement conditions along I-405 for the last several years. The number of distressed lane-miles increased from 2003 to 2005, but the trend has reversed in the most recent PCS. Sections with only ride quality issues have been addressed in the last few years and the remaining issues involve major and minor pavement distress. This change in the mix of distressed-lane miles can be seen more clearly in Exhibit 3-104.

Exhibit 3-102: SR-22 Distressed Lane-Miles by Type (2003-2007)



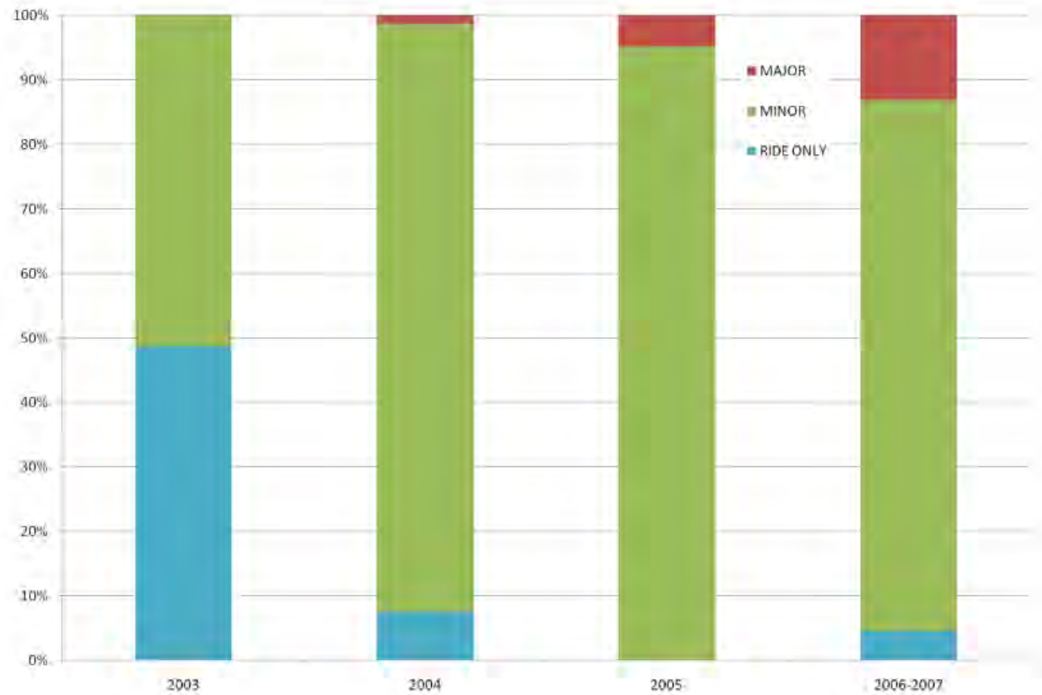
Source: 2003 to 2007 Pavement Condition Survey data

Exhibit 3-103: I-405 Distressed Lane-Mile Trends (2003-2007)



Source: 2003 to 2007 Pavement Condition Survey data

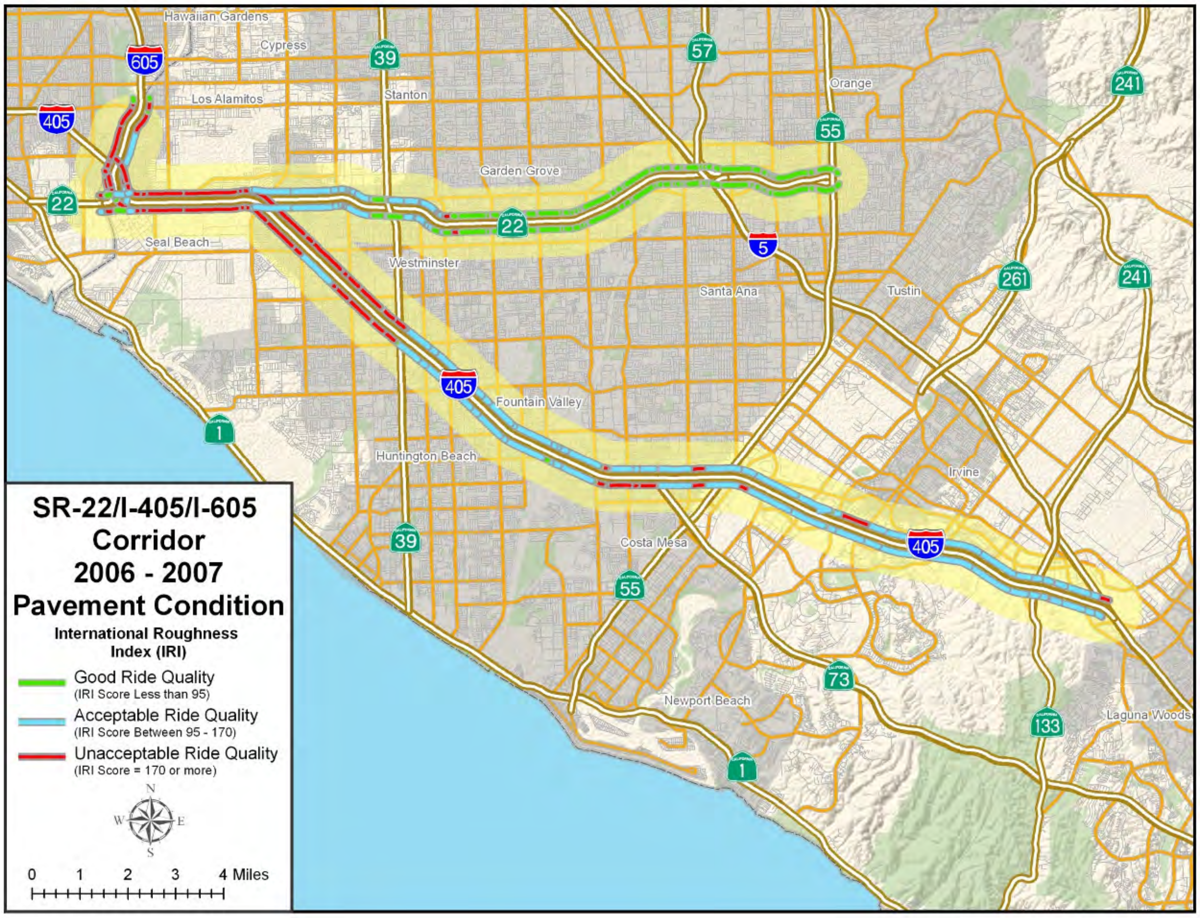
Exhibit 3-104: I-405 Distressed Lane-Miles by Type (2003-2007)



Source: 2003 to 2007 Pavement Condition Survey data

Exhibit 3-105 shows IRI along all three freeways in the study corridor for the lane with the poorest pavement condition in each freeway segment. The poorest condition is shown because investment decisions are made on this basis. As the exhibit demonstrates, the majority of the corridor has either good or acceptable ride quality. Most of the sections with unacceptable ride quality are where I-405, SR-22, and I-605 converge. Good ride quality is found along SR-22 as a result of the recent road construction.

Exhibit 3-105: Road Roughness for SR-22, I-405, and I-605 (2006-2007)



Source: 2007 Pavement Condition Survey data

The portion of the study corridor along SR-22 comprises roughly 95 lane-miles, when the conditions of all lanes are considered. Of these lanes:

- 36 lane-miles, or 38 percent, are considered to have good ride quality (IRI ≤ 95)
- 54 lane-miles, or 56 percent, are considered to have acceptable ride quality (95 < IRI ≤ 170)
- 6 lane miles, or 6 percent, are considered to have unacceptable ride quality (IRI > 170).

The portion along I-405 includes 261 lane-miles, of which:

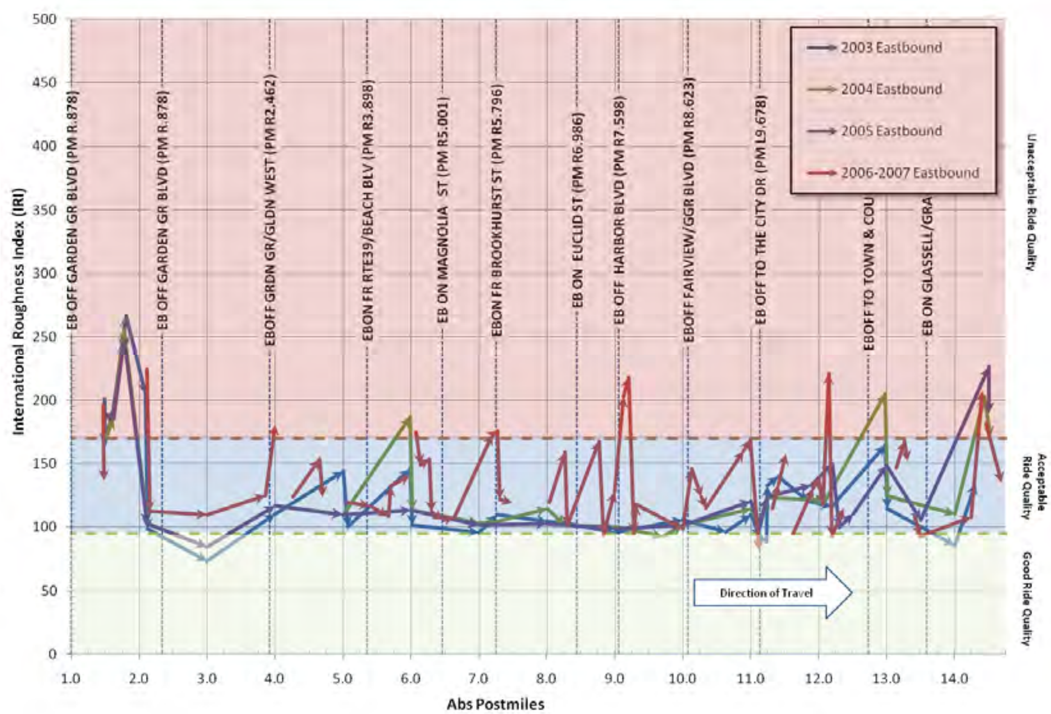
- 110 lane-miles, or 42 percent, are considered to have good ride quality (IRI ≤ 95)
- 95 lane-miles, or 37 percent, are considered to have acceptable ride quality (95 < IRI ≤ 170)

- 55 lane miles, or 21 percent, are considered to have unacceptable ride quality (IRI > 170).

I-605 includes only 15 lane-miles of the study corridor. Of these lane-miles, just over 50 percent are considered to have unacceptable ride quality. The remaining lane-miles on I-605 are split fairly evenly between good and acceptable ride quality.

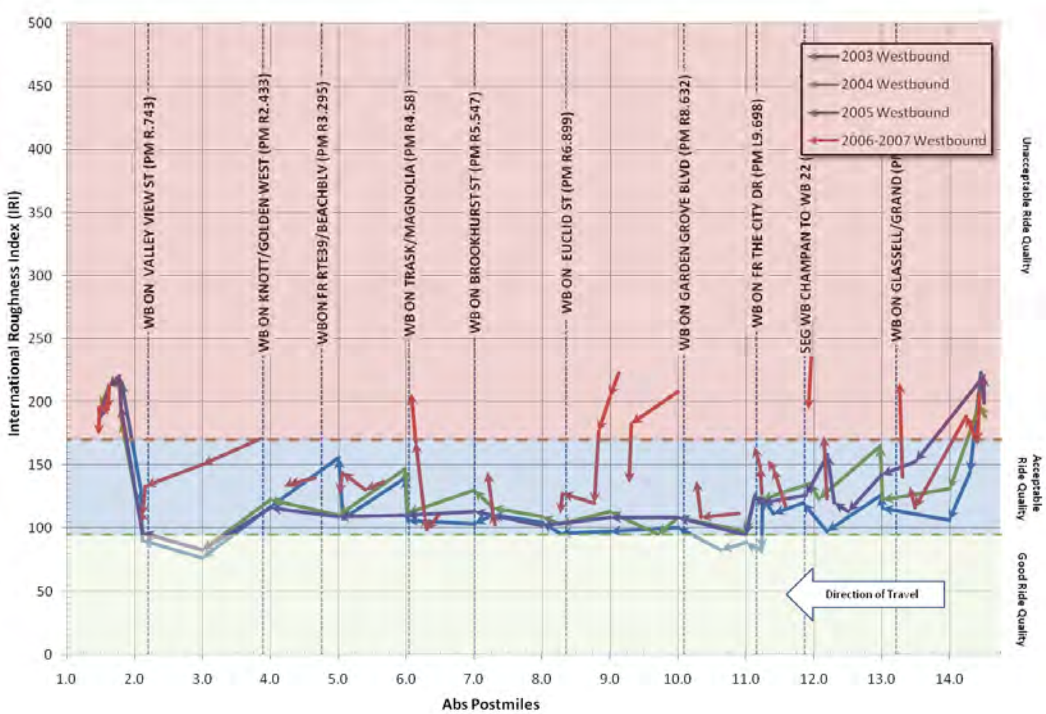
Exhibits 3-106 through 3-109 present ride conditions for the study corridor using IRI from the last four pavement surveys. The first two exhibits cover SR-22, while the last two exhibits show data for I-405. The information is presented by postmile and direction in all four exhibits. The exhibits include color-coded bands to indicate the three ride quality categories defined by Caltrans: good ride quality (green), acceptable ride quality (blue), and unacceptable ride quality (red). The surveys show fairly consistent patterns of good, acceptable, and unacceptable ride quality. Unlike many freeways in the state, the freeways in the study corridor have had fairly steady ride quality over the last few surveys. The exhibits exclude a number of sections that were not measured or had calibration issues (i.e., IRI = 0) in the 2006-07 period.

Exhibit 3-106: Eastbound SR-22 Road Roughness (2003-2007)



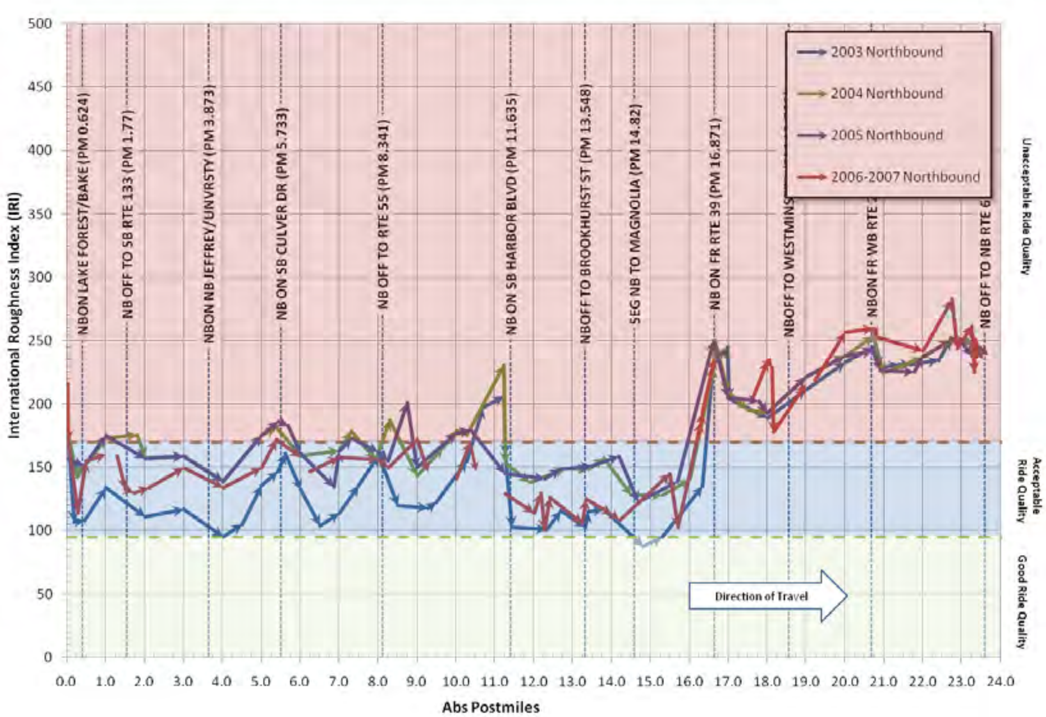
Source: 2003 to 2007 Pavement Condition Survey data

Exhibit 3-107: Westbound SR-22 Road Roughness (2003-2007)



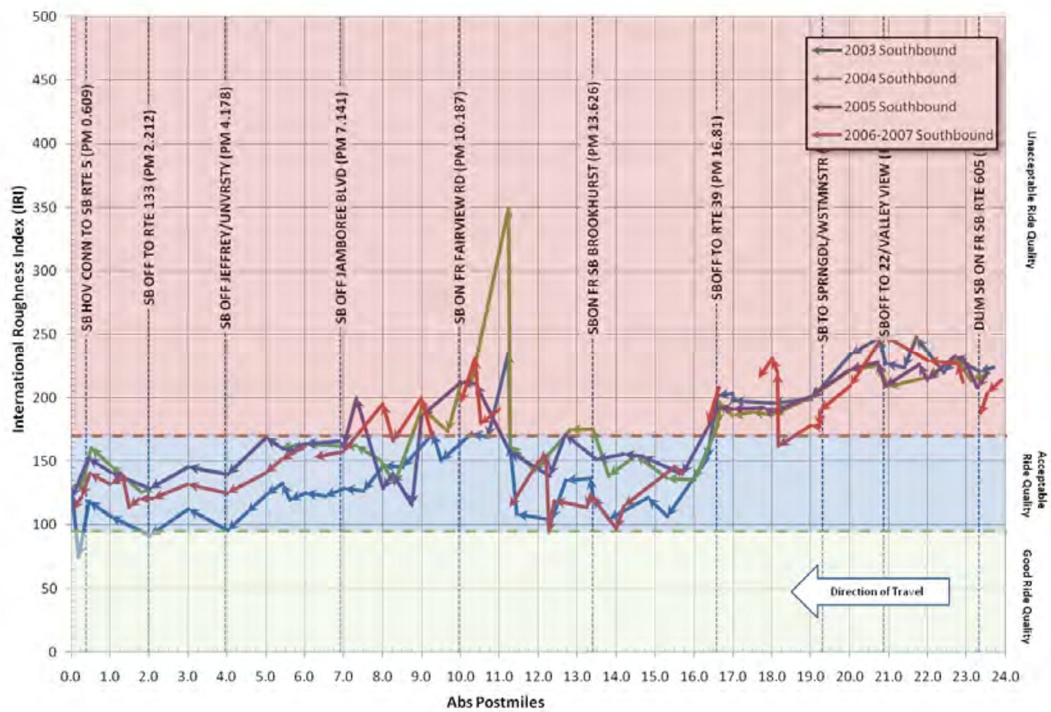
Source: 2003 to 2007 Pavement Condition Survey data

Exhibit 3-108: Northbound I-405 Road Roughness (2003-2007)



Source: 2003 to 2007 Pavement Condition Survey data

Exhibit 3-109: Southbound I-405 Road Roughness (2003-2007)



Source: 2003 to 2007 Pavement Condition Survey data

4. BOTTLENECK IDENTIFICATION AND PERFORMANCE

SR-22 and I-405 bottleneck locations were identified and verified during 2008 and 2009 based on a variety of data sources, including State Highway Congestion Monitoring Program (HICOMP) data, Caltrans District 12 probe vehicle runs, automatic detector data, and extensive consultant team field observations and video-taping.

Potential bottleneck locations were initially identified in the Preliminary Performance Assessment report delivered in May 2008. The Comprehensive Performance Assessment delivered in May 2009 presented the results of additional analysis and extensive field observations.

The study team conducted the field observations, videotaping major bottlenecks to document the locations and potential causes of the bottlenecks. These efforts resulted in confirming consistent sets of bottlenecks for both directions of the freeway. Exhibits 4-1, 4-2, and 4-3 summarize the bottleneck locations identified for the SR-22, I-405 and I-605 corridors, respectively. Exhibits 4-4 and 4-5 are maps showing these locations.

Exhibit 4-1: SR-22 Bottleneck Locations

Dir	Bottleneck Location	Active Period	
		AM	PM
Eastbound	Euclid On	✓	✓
	Harbor On	✓	✓
	Fairview On	✓	✓
	I-5 Off/City Drive IC	✓	✓
	I-5 On/Town and Country Off		✓
Dir	**Bottleneck Location**	**Active Period**	
		AM	**PM**
Westbound	NB I-5 On		✓
	Garden Grove On		✓
	Valley View Off		✓
	I-405 On		✓

Exhibit 4-2: I-405 Bottleneck Locations

Dir	Bottleneck Location	Active Period	
		AM	PM
Northbound	Sand Canyon Off	✓	
	Jeffrey/University On	✓	✓
	SR-73/Fairview On		✓
	Euclid On		✓
	Brookhurst On		✓
	SR-39 On	✓	✓
	SR-22 On	✓	✓
Dir	**Bottleneck Location**	**Active Period**	
		AM	**PM**
Southbound	I-605 On	✓	✓
	Seal Beach On	✓	✓
	Valley View/SR-22	✓	✓
	SR-39 On	✓	✓
	Warner On	✓	✓
	Talbert On	✓	
	Bristol Off	✓	
	MacArthur Off	✓	✓
	Culver On	✓	✓
	Jeffrey/University On	✓	✓
	Sand/Shady Canyon On	✓	✓

Caltrans staff indicated that additional bottleneck locations on I-405 likely exist at the following locations:

- Jamboree On-ramp (northbound)
- SR-55 Interchange (northbound)
- Irvine Center Drive (southbound)
- SR-133 Interchange (southbound)
- I-5 Interchange (southbound)

Exhibit 4-3: I-605 Bottleneck Locations

Dir	Bottleneck Location	Active Period	
		AM	PM
NB	None		
SB	Southbound I-405 On		✓

Exhibit 4-4: Map of SR-22/I-405/I-605 AM Existing Bottlenecks

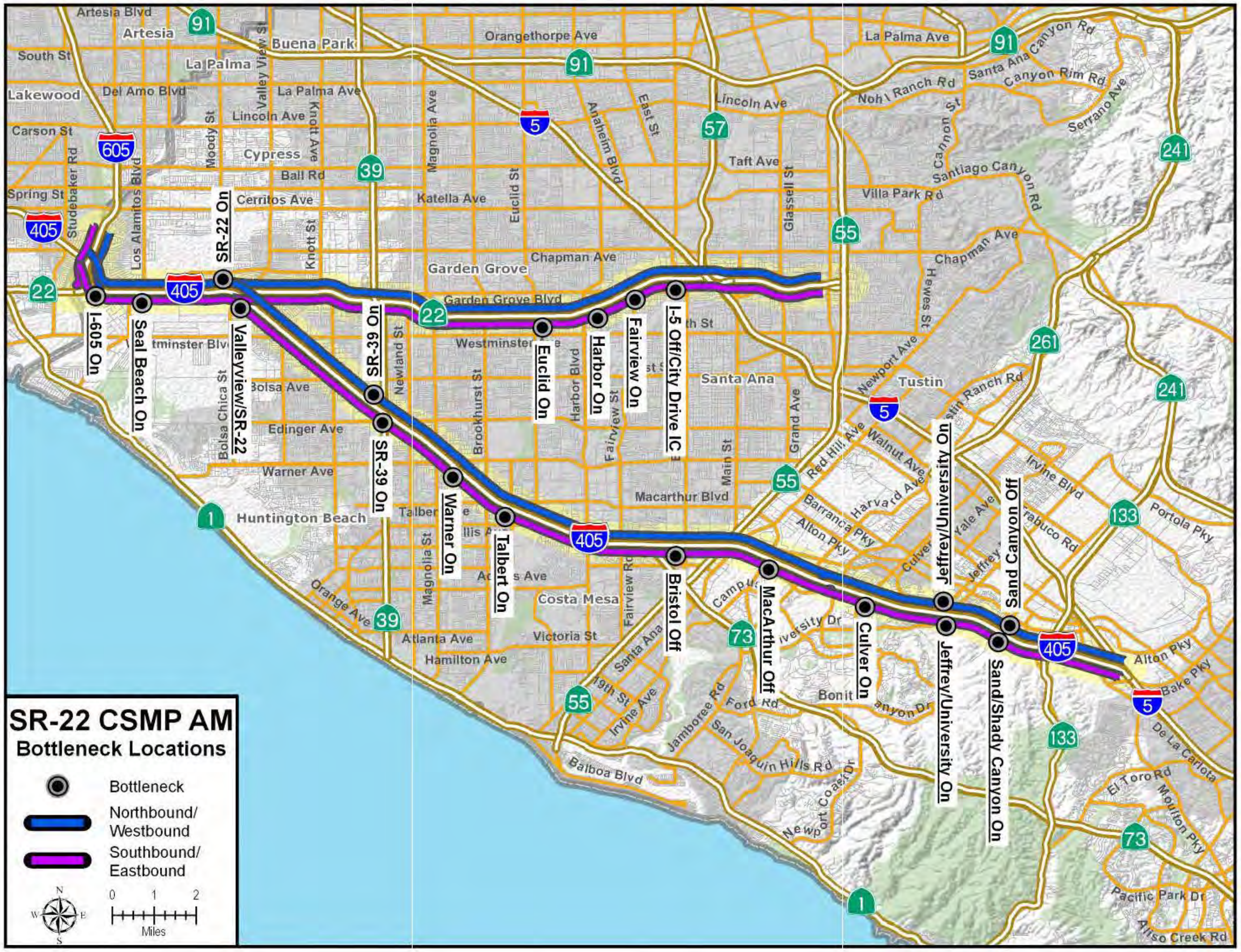
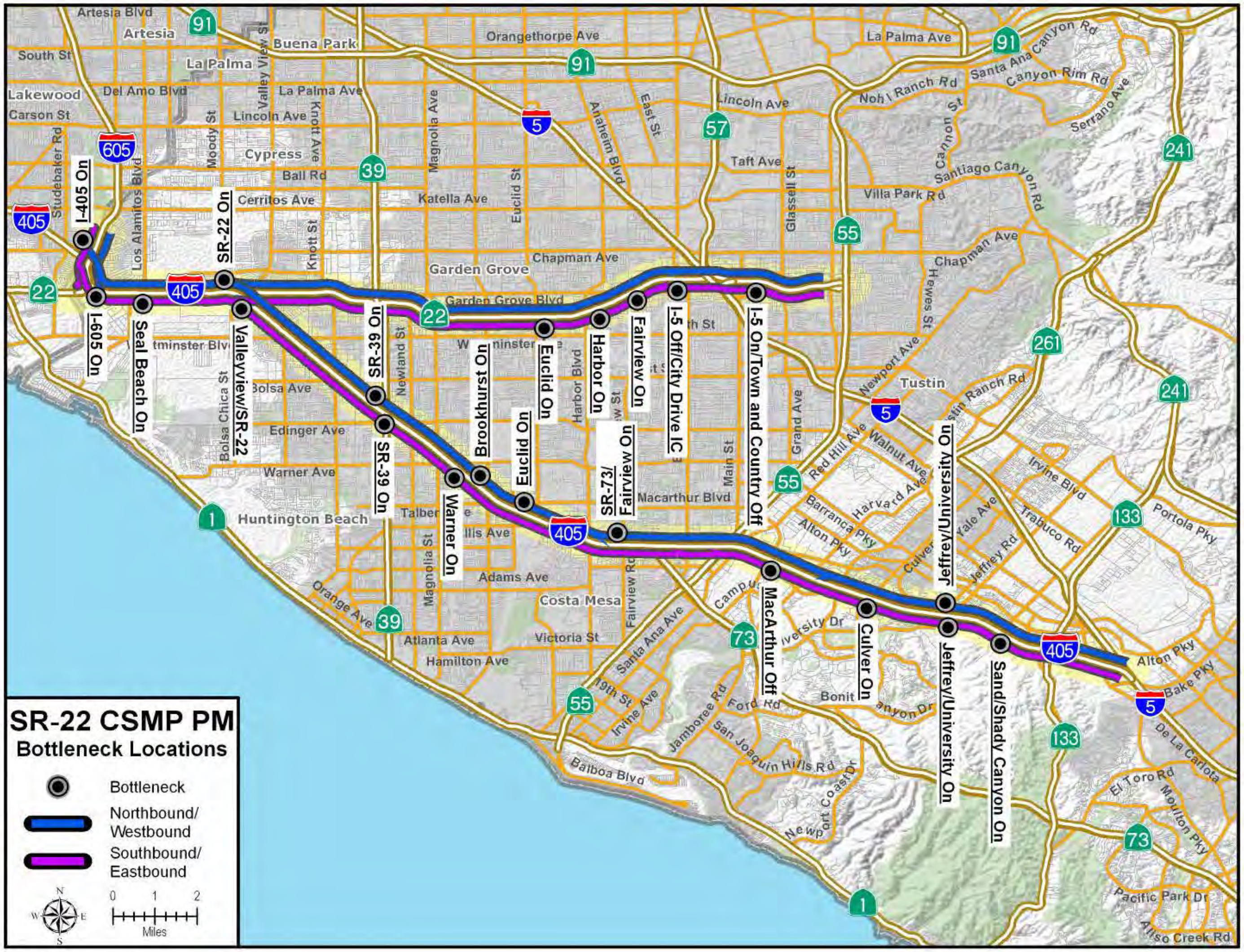


Exhibit 4-5: Map of SR-22/I-405/I-605 PM Existing Bottlenecks



Bottleneck Identification

This section presents the initial bottleneck identification analysis performed as part of the Preliminary Performance Assessment. Findings from further analysis and subsequent field visits were reported in the Comprehensive Performance Assessment.

A variety of sources were used to initially identify bottlenecks. They included:

- Caltrans 2006 State Highway Congestion Monitoring Program report
- Caltrans District 12 probe vehicle runs (electronic tachometer runs)
- Automatic freeway detector data
- Aerial photos (Google Earth) and Caltrans photologs.

State Highway Congestion Monitoring Program

The Caltrans Highway Congestion Monitoring Program (HICOMP) annual report was the first tool used by the study team to identify problem areas. Published annually since 1987, HICOMP attempts to measure "typical" peak period, weekday, and recurring traffic congestion on urban area freeways. HICOMP does not include congestion on other State highways or local surface streets. Non-recurrent congestion such as holiday, maintenance, construction or special-event generated traffic congestion is also not included. HICOMP data is useful for finding general trends and making regional comparisons of freeway performance, but some estimates presented in the report are based on a limited number of observations. Furthermore, HICOMP does not attempt to capture bottleneck locations, but simply report on locations of likely recurrent congestion.

Using the 2006 HICOMP data, potential problem areas were initially identified. As illustrated in Exhibits 4-6 and 4-7, the downstream end of congested segments could potentially be problem areas in the northbound direction, as outlined in red circles, and in the southbound direction, as outlined in blue circles.

- In the AM peak, the location near Jamboree Road showed congestion in the northbound direction and the location near University Drive showed congestion in the southbound direction.
- The I-605 corridor showed congestion at the I-405 Interchange in both peak periods.
- For SR-22, no congestion or bottleneck was indicated in the 2006 HICOMP report.

Exhibit 4-6: HICOMP AM Congestion Map with Potential Bottlenecks (2006)

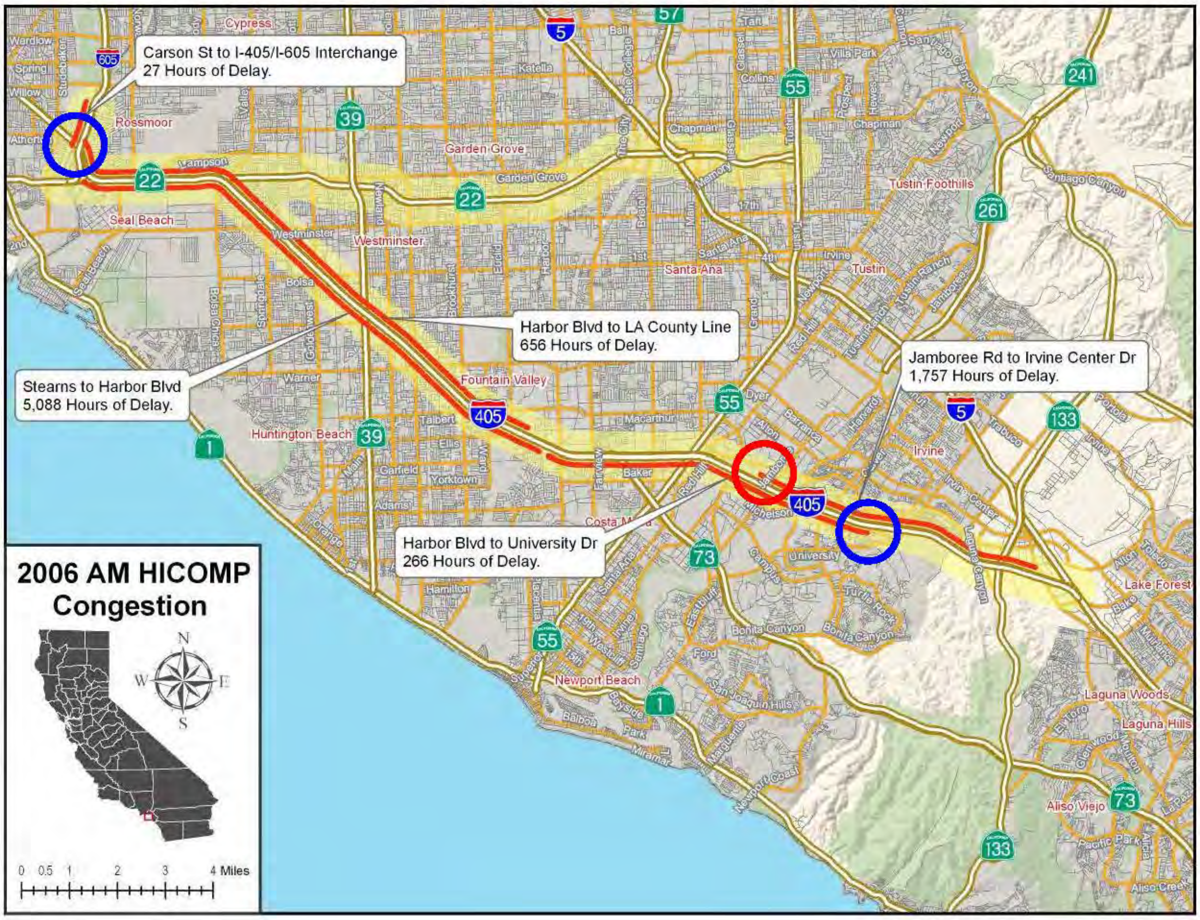
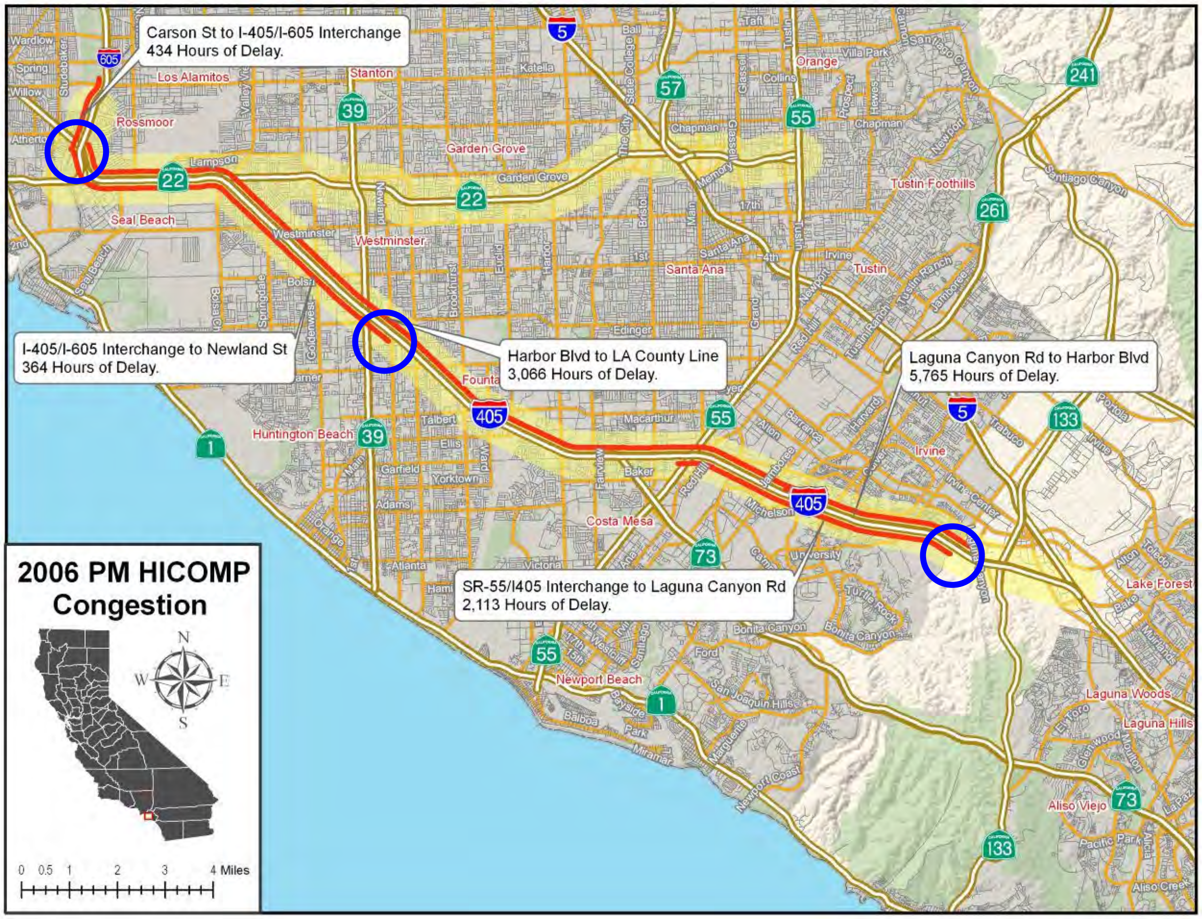


Exhibit 4-7: HICOMP PM Congestion Map with Potential Bottlenecks (2006)



Probe Vehicle Runs

The probe vehicle runs (electronic tachometer runs) provide speed plots across the corridor at various departure times. A vehicle equipped with an electronic (GPS or tachograph) device is driven along the corridor at various departure times, typically in a middle lane, during the peak period, at regular, 20- to 30-minute intervals. Actual speeds are recorded as the vehicle traverses the corridor length. Bottlenecks can be found at the end of a slow congested speed location where speeds pick up to 30 mph to 50 mph.

Caltrans collected probe vehicle run data in December 13, 2006 for the SR-22 Corridor from Tustin to Brookhurst. No data was available for I-405 or I-605.

Exhibit 4-8 illustrates the SR-22 westbound probe vehicle run at 8 AM and 5:20 PM conducted on December 13, 2006. As indicated, there is no congestion or bottleneck evident in the AM peak hours; however, there is some slowing in the PM peak hours from Euclid to west of Brookhurst. The likely bottleneck would be west of Brookhurst, beyond the limit of the probe vehicle runs. No data is available west of Brookhurst. As such, potential bottleneck cannot be determined from these runs.

Exhibit 4-8: Westbound SR-22 Sample Probe Vehicle Runs (2006)

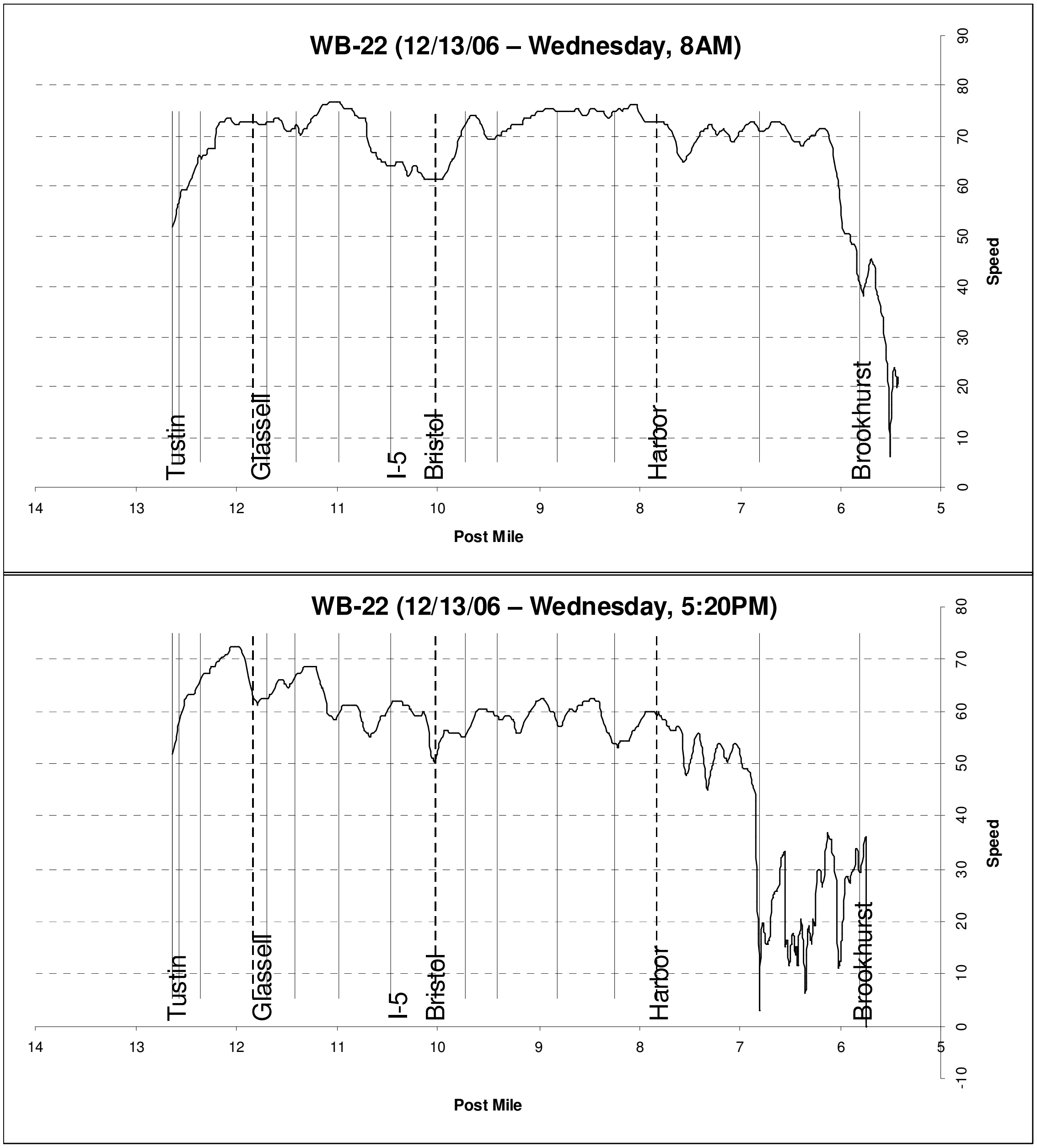
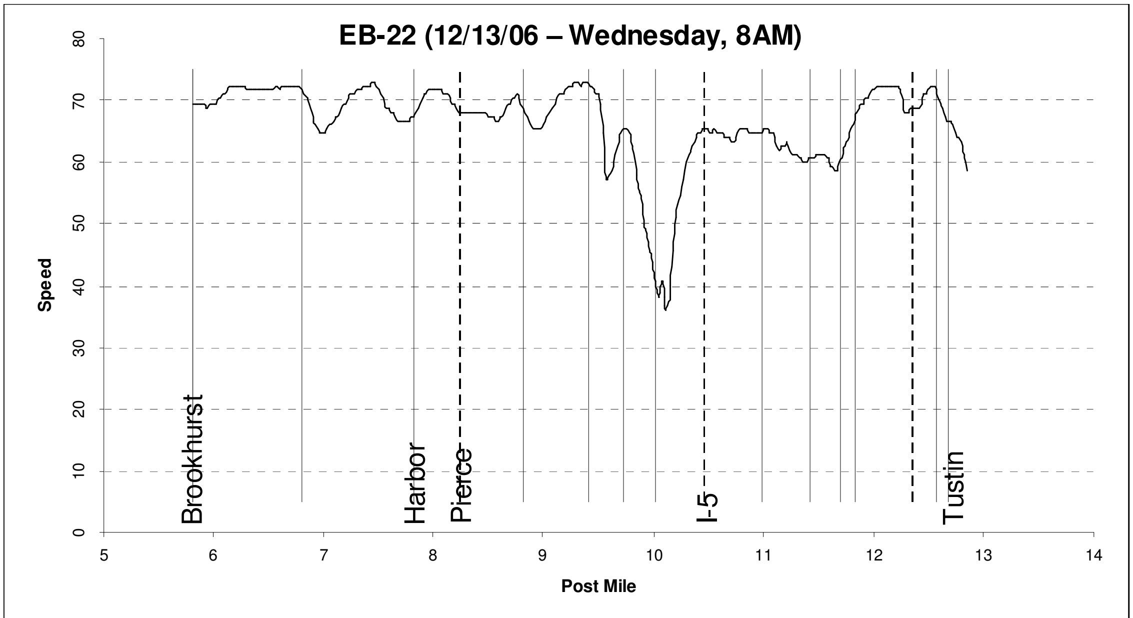
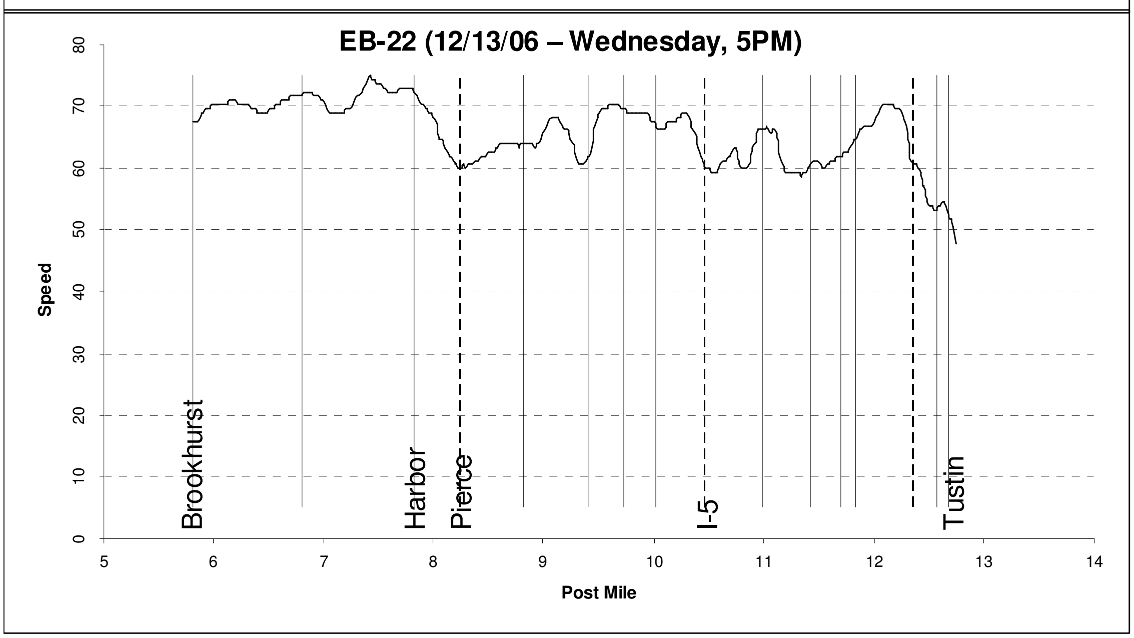


Exhibit 4-9 illustrates the SR-22 eastbound probe vehicle run at 8 AM and 5 PM conducted on December 13, 2006. As indicated, there is very little congestion or slowing evident in the AM or PM peak hours; however, there is some slowing in the AM peak hours approaching the I-5 junction.

The potential bottleneck location based on the 8 AM run is from Bristol On-ramp to I-5 Off-Ramp. The amount of congestion and queuing would vary from day to day. With only one day sample run, the level of impact or extent of this potential bottleneck cannot be determined.

Exhibit 4-9: Eastbound SR-22 Sample Probe Vehicle Runs (2006)





Automatic Detector Data

The third source used to identify potential bottlenecks prior to the in-depth field visits was to review speed contour and speed profile plots from automatic detectors. The study team downloaded detector data to conduct this analysis.

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

Speed profile plots are very similar to probe vehicle run graphs. Unlike the probe vehicle runs, however, each speed plot has the same time across the corridor. For example, an 8:00 AM plot includes the speed at one end of the corridor at 8:00 AM and the speed at the other end of the corridor at 8:00 AM. 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 similar problem areas. These speed plots are then compiled at every five minutes and presented in speed contour plots.

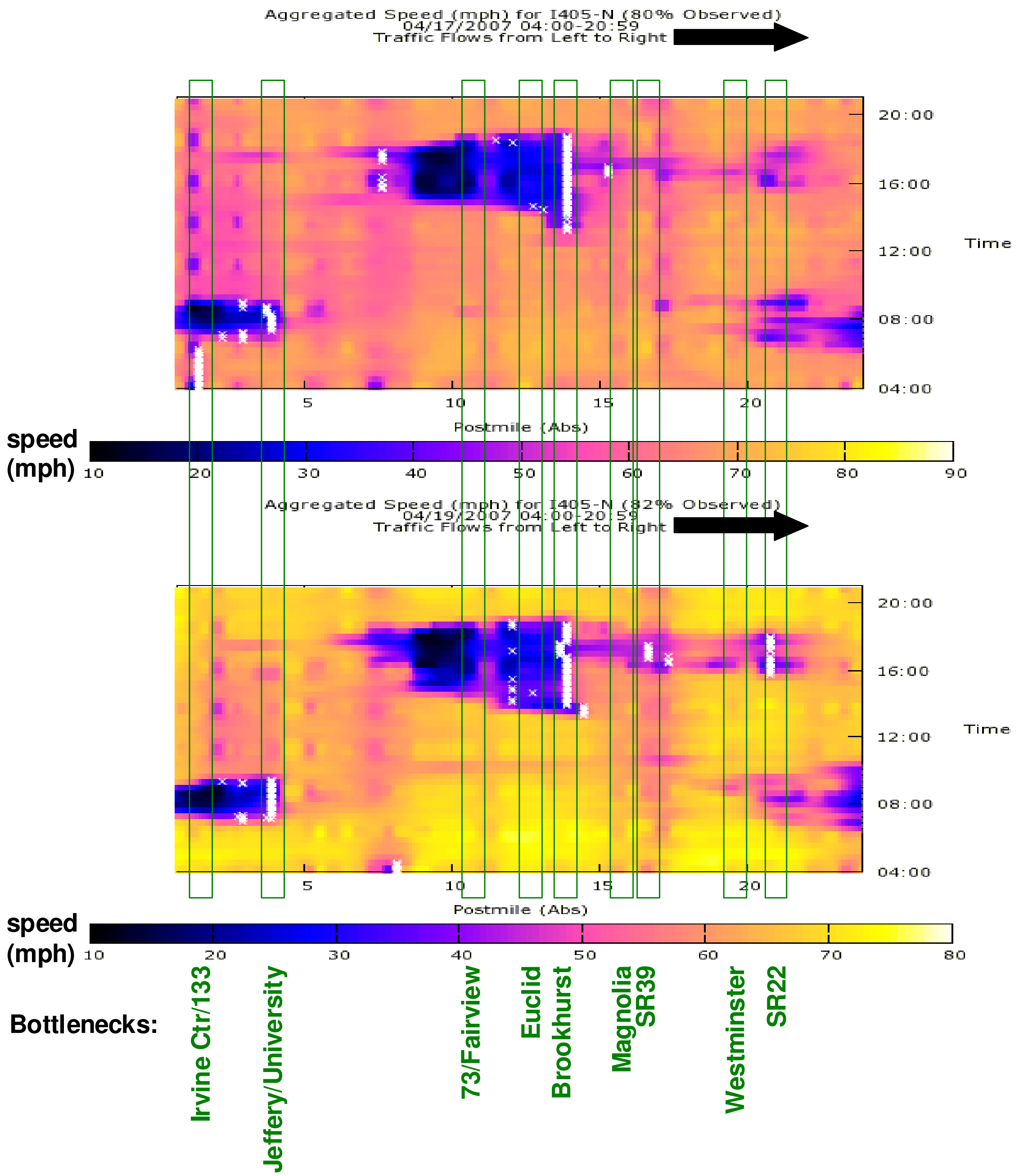
Several items to note:

- ♦ Due to construction and inoperable vehicle detection on SR-22, automatic detector data was not available beyond 2004. With the widening in 2007, results from the 2004 data cannot be applied, as conditions have significantly changed.
- ♦ Detector data for 2006 and 2007 is available on I-405. The results of the data analysis are presented.
- ♦ Only two vehicle detection stations are available for the I-605 and as such provide very limited results, which are presented.

<u>Northbound I-405 Detector Analysis</u>

Speed contour and profile plots were analyzed for different weekdays in April 2007 (see Exhibit 4-10). “Long-contour” weekday plots for each quarter of 2007 were also reviewed to identify “typical” conditions. Along the vertical axis is the time period from 4 AM to 8 PM. Along the horizontal axis is the corridor segment from the I-5 junction to the County line. 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 the dark blotches represent bottleneck areas, where speeds pickup after congestion, typically 30 to 50 mph in a very short stretch. The horizontal length of each plot is the congested segment, queue lengths. The vertical length is the congested time period.

Exhibit 4-10: NB I-405 Speed Contour Plots (April 2007)



Based on these contour plots of typical weekday samples in April 2007 and November 2006, the following northbound bottlenecks were identified:

- Irvine Center to SR133
- Jeffery/University to Culver

- SR73/Fairview to Harbor
- Harbor to Euclid
- Brookhurst to Warner
- Magnolia to SR-39
- SR-39 to Bolsa
- Westminster to SR22
- SR22 to Seal Beach

In addition to multiple days, larger averages were also analyzed. Exhibits 4-11 and 4-12 illustrate weekday averages by each quarter of each year from 2006 to 2007. The same bottleneck locations are identified. From the long contours, we see the same bottlenecks.

Exhibit 4-11: NB I-405 Speed Long Contours (2006 Quarterly Averages)

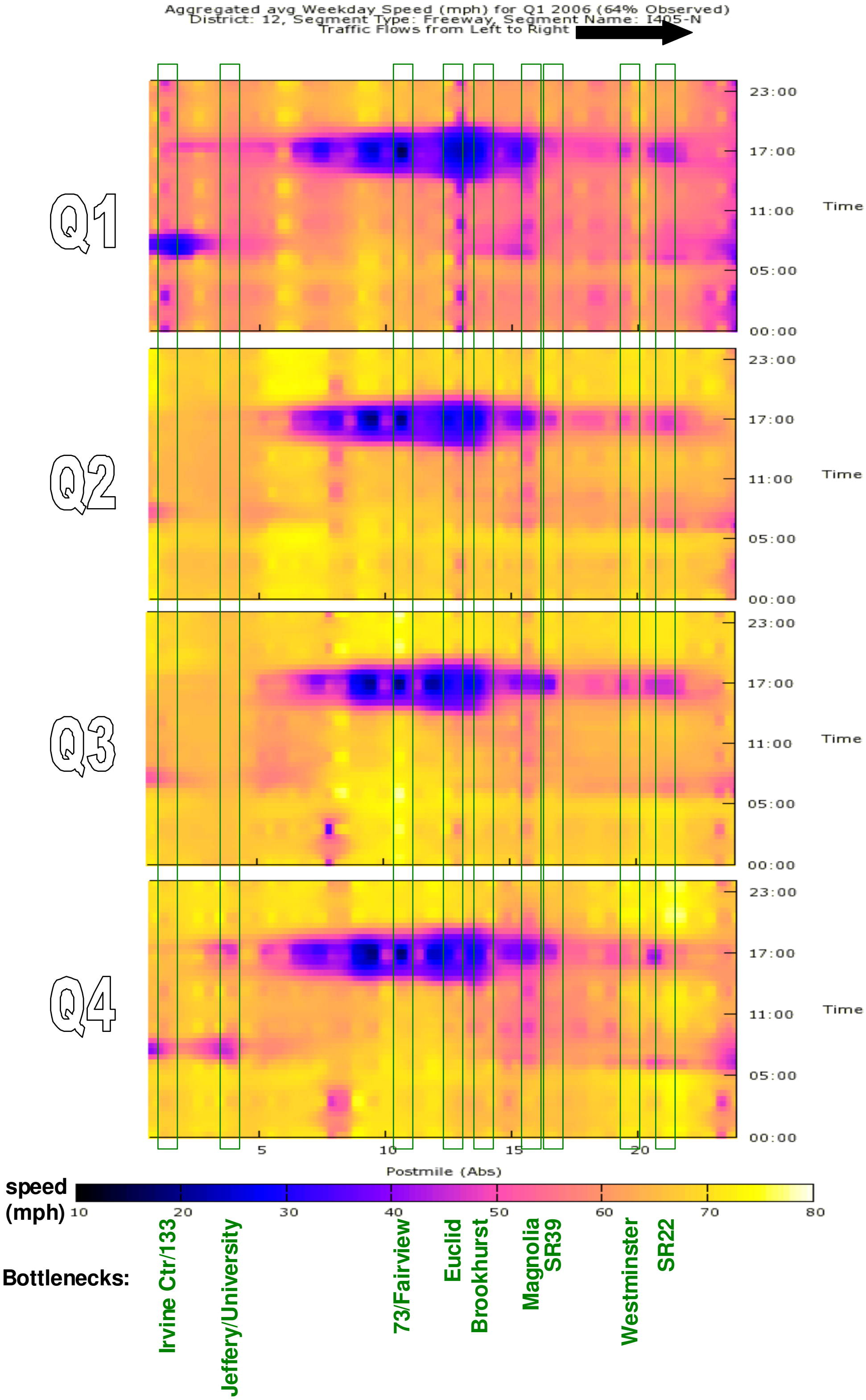
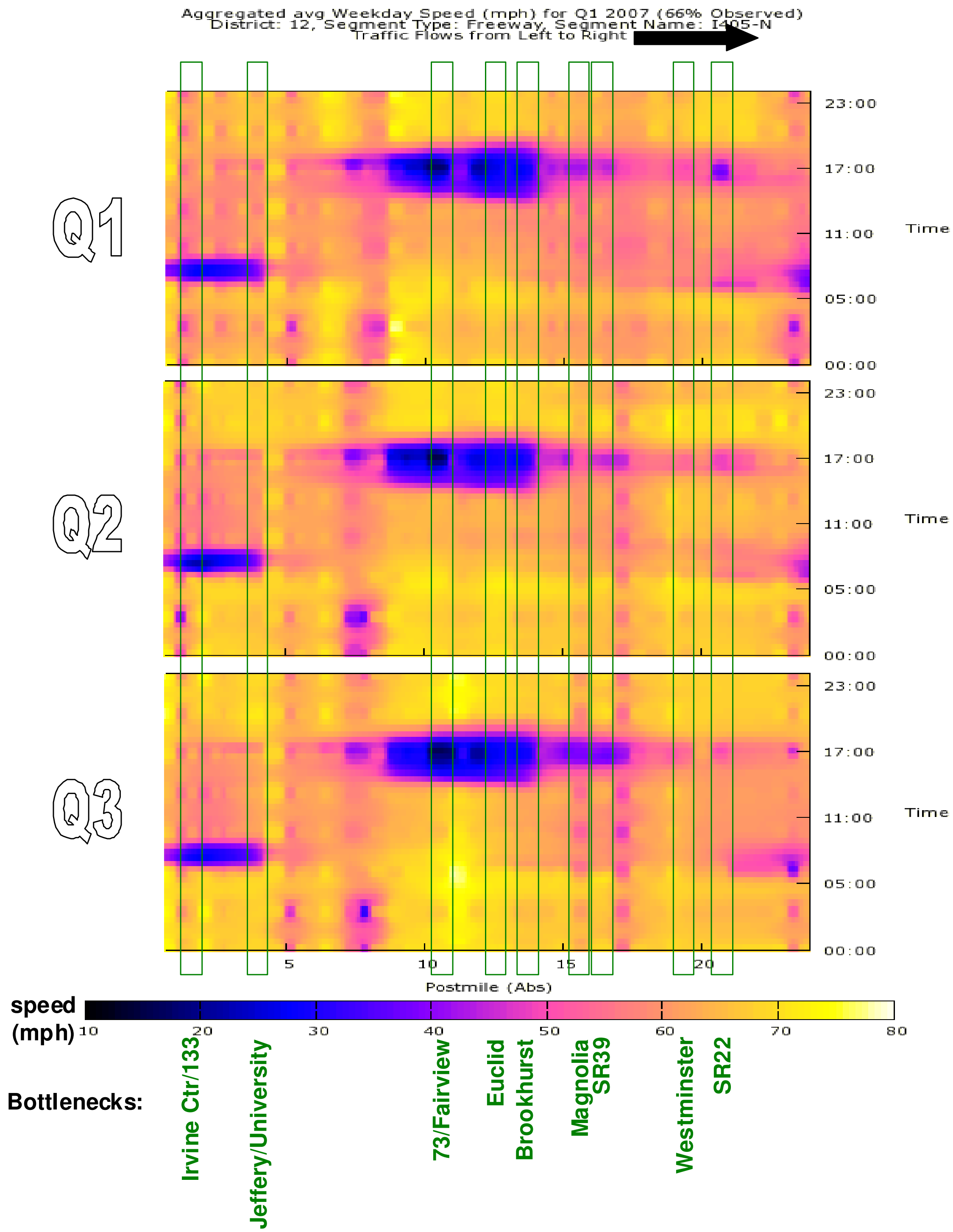


Exhibit 4-12: NB I-405 Speed Long Contours (2007 Quarterly Averages)



Southbound I-405 Detector Analysis

Similarly, speed contour plots for the same sample days and quarterly weekday average long contours were analyzed for the southbound direction. Exhibit 4-13 to Exhibit 4-15 illustrate speed contour plots for the I-405 freeway corridor in the southbound direction (traffic moves left to right on the plot) on two typical weekdays in April 2007 and November 2006 and 2006/2007 quarterly weekday average long contours. Along the vertical axis is the time period from 4 AM to 8 PM. Along the horizontal axis is the corridor segment from the I-5 junction to the County line.

Exhibit 4-13: SB I-405 Speed Contour Plots (April 2007)

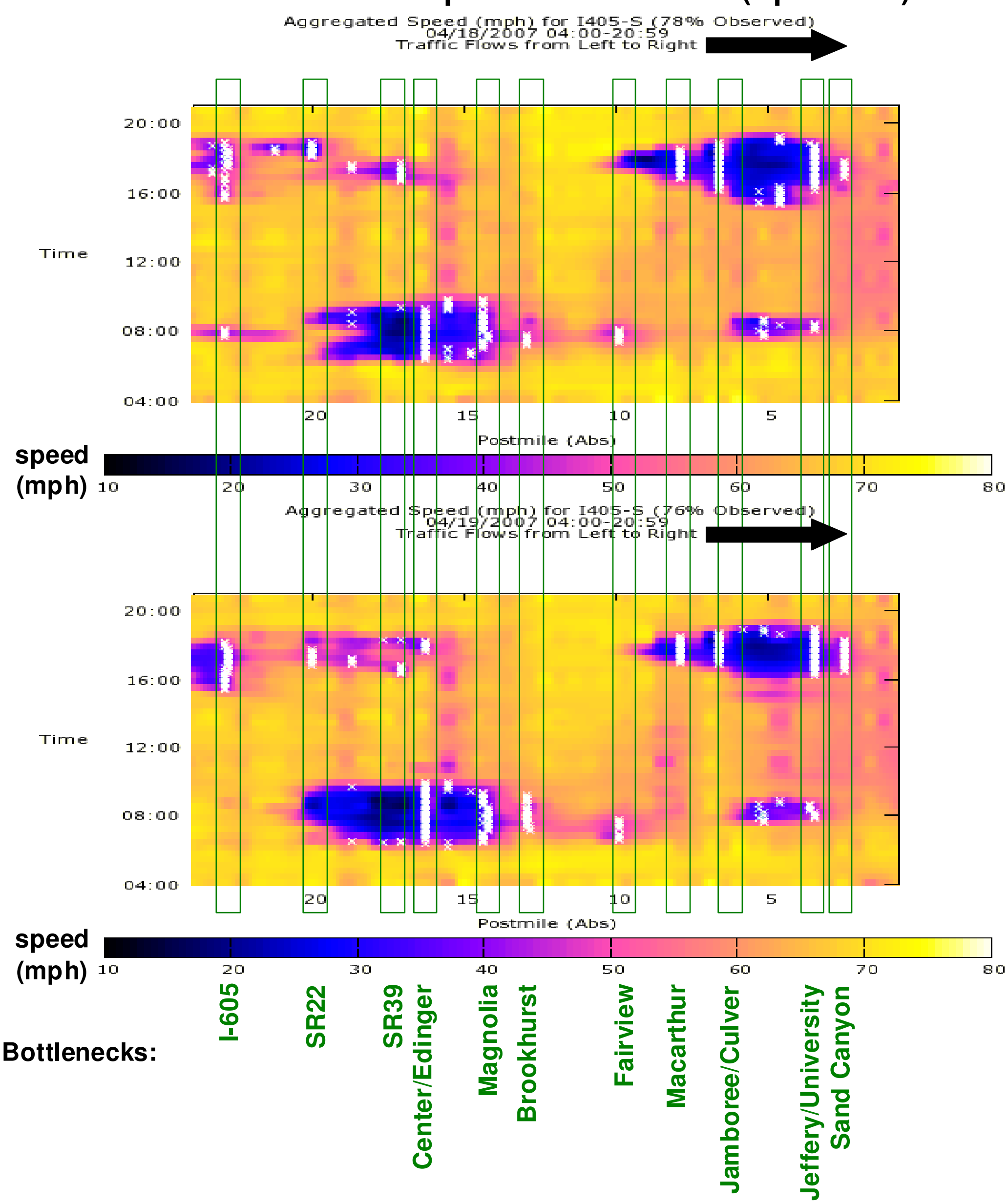


Exhibit 4-14: SB I-405 Speed Long Contours (2006 Quarterly Averages)

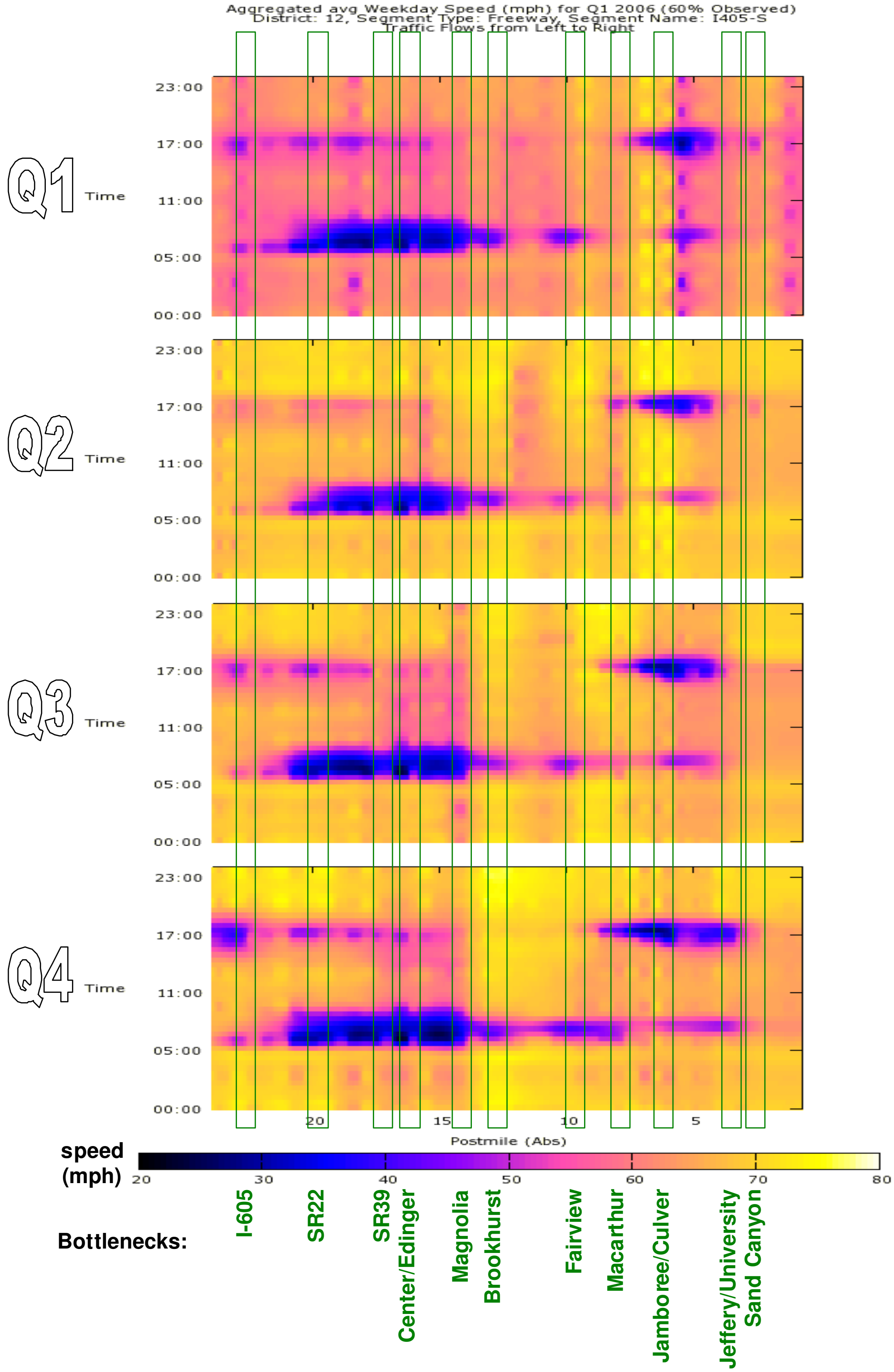
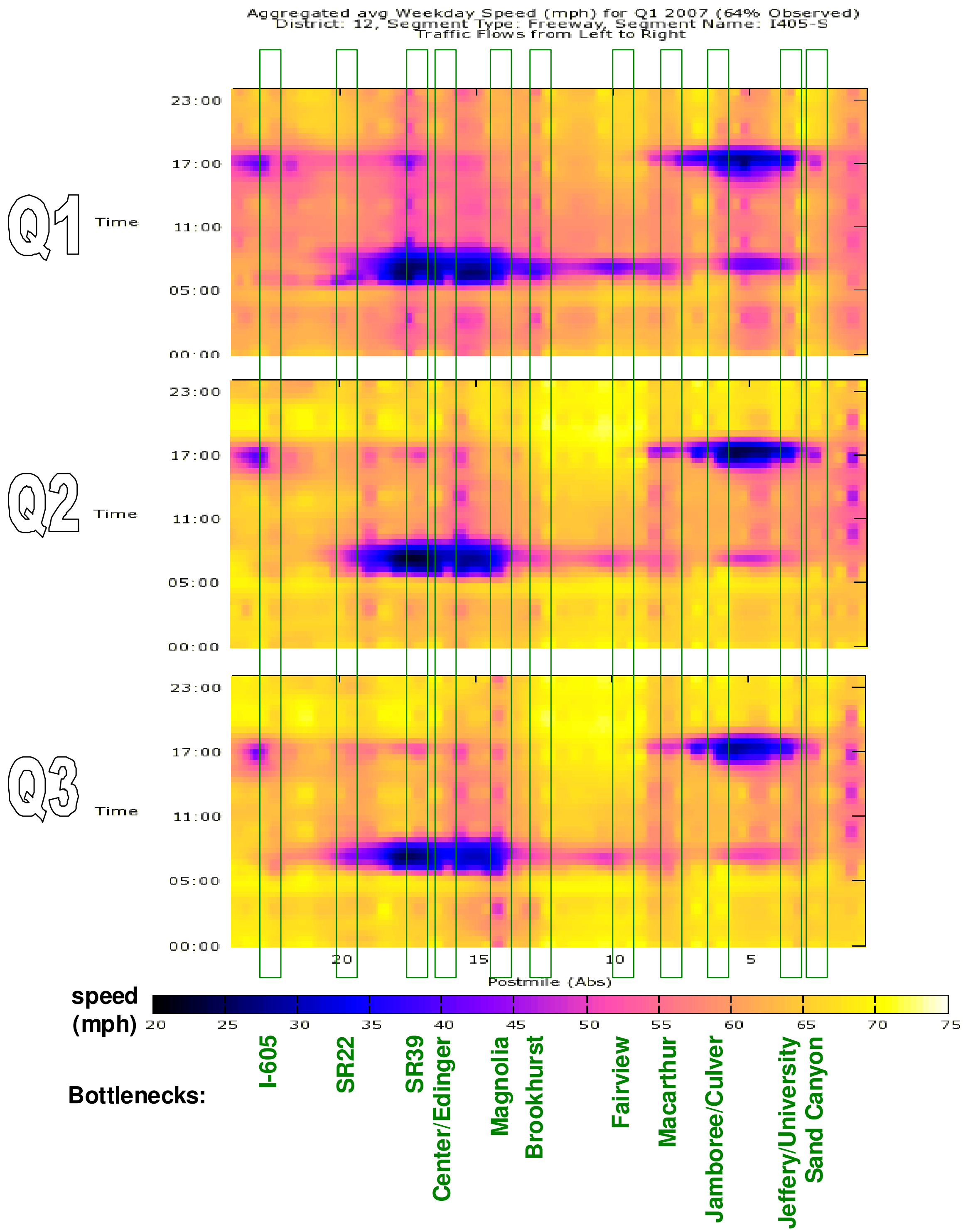


Exhibit 4-15: SB I-405 Speed Long Contours (2007 Quarterly Averages)



Based on these contour plots of typical weekday samples in April 2007 and November 2006 and 2006/2007 quarterly weekday average long contours, the following southbound bottlenecks were identified:

- I-605/SR-22 to Seal Beach
- Valley View/SR22 to Spring Dale/Westminster
- Bolsa to SR-39
- Edinger to Magnolia
- SR39 to Magnolia
- Magnolia to Warner
- Brookhurst to Euclid
- Fairview to Bristol
- SR55 to MacArthur
- Jamboree to Culver
- Jeffrey/University to Sand Canyon
- Sand Canyon to SR-133

I-605 Detector Analysis

Much like the analysis for I-405, automatic detector data was also analyzed for the I-605 freeway section. Unlike I-405, I-605 only had two vehicle detector stations within the corridor, and as such, it provided limited results. Exhibits 4-16 to 4-18 illustrate the typical AM and PM speed profiles and typical weekday speed contour diagram from Thursday, April 19, 2007. As indicated, the entire section is congested during the PM peak hours, with the bottleneck stemming from the I-405 junction.

Exhibit 4-16: SB I-605 Speed Plot (April 19, 2007 at 8 AM)

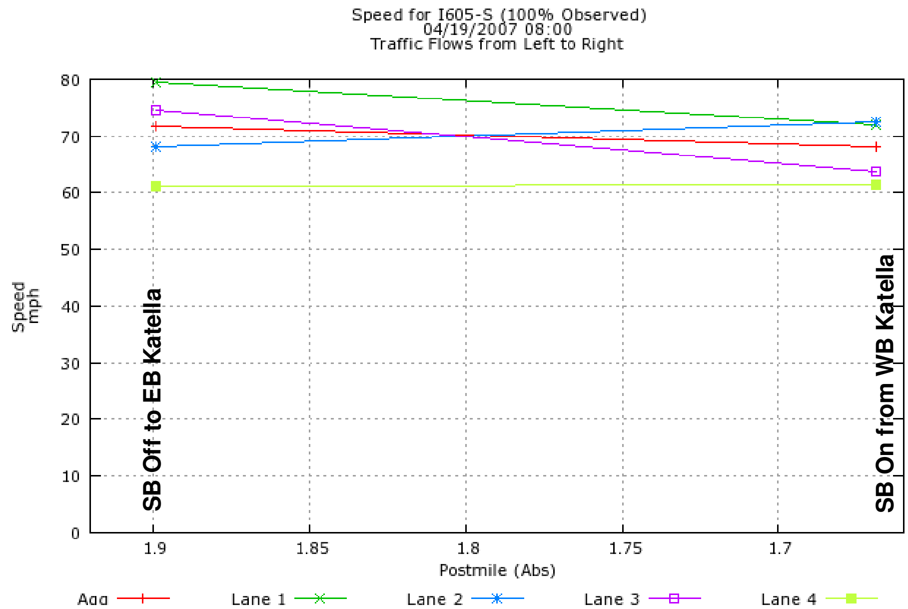


Exhibit 4-17: SB I-605 Speed Plot (April 19, 2007 at 5 PM)

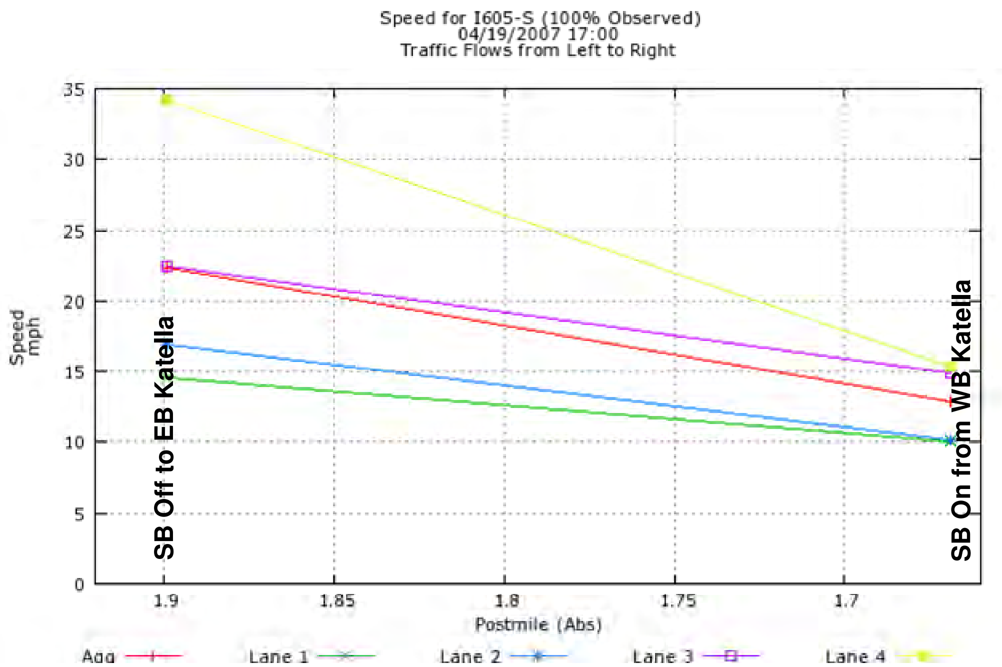
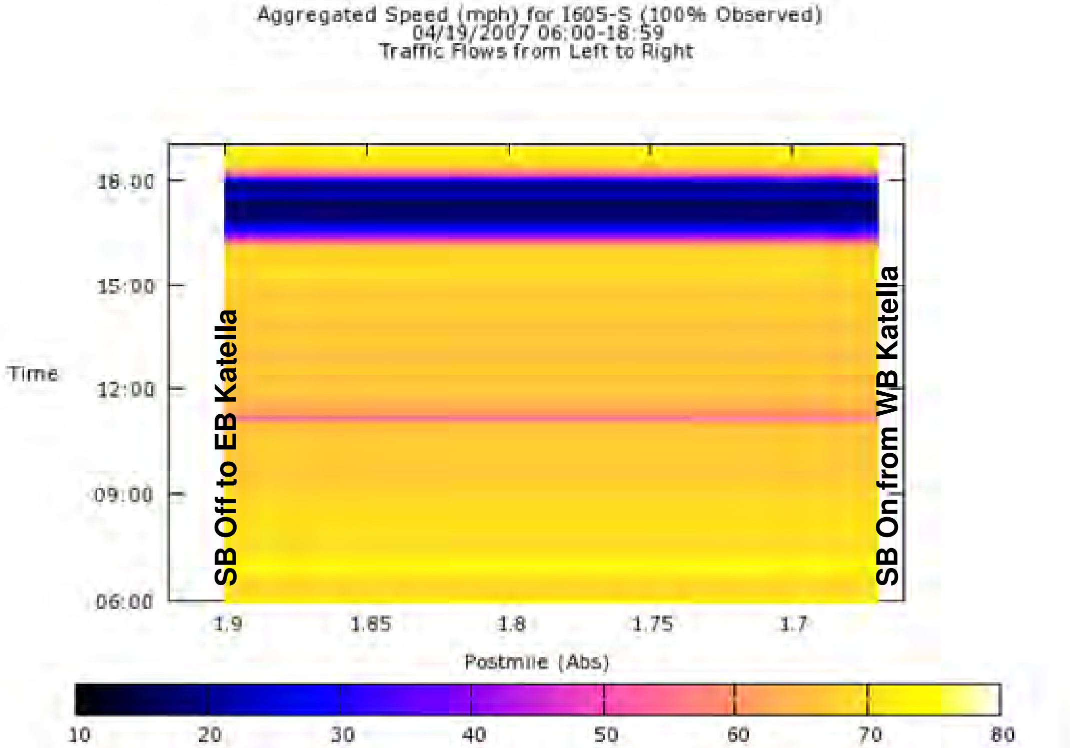


Exhibit 4-18: SB I-605 Speed Contour Plot (April 19, 2007)



Bottleneck Area Analysis

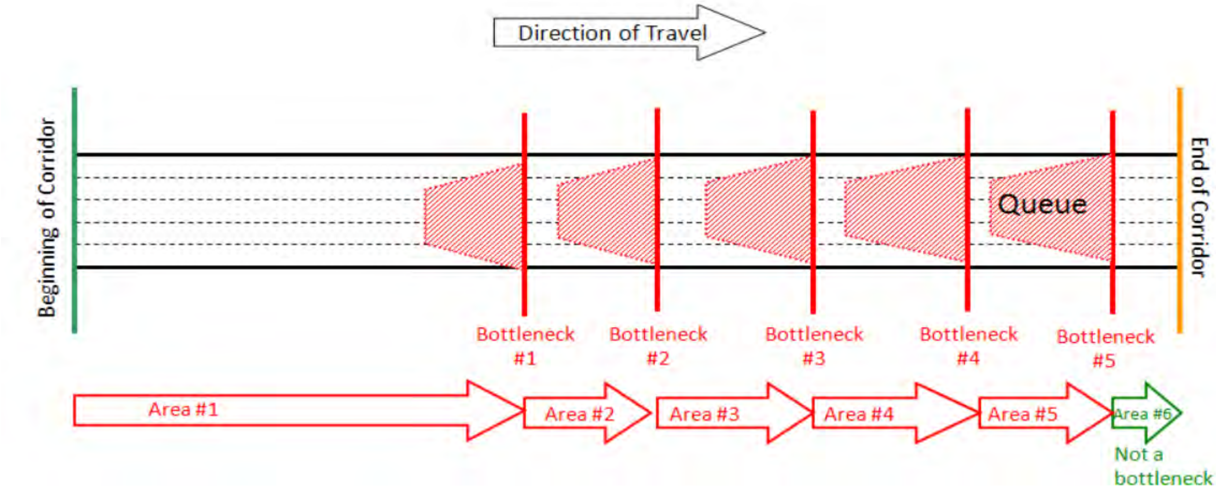
Once the bottlenecks were identified, the corridor was divided into “bottleneck areas.” Bottleneck areas represent segments that are defined by one major bottleneck (or a number of smaller ones). By segmenting the corridor into these bottleneck areas, the performance statistics presented earlier for the entire corridor in Section 3 of this report can be segmented by bottleneck area. This way, the relative contribution of each bottleneck area to the degradation of the corridor performance can be gauged. Performance statistics that lend themselves to such segmentation include:

- Delay
- Productivity
- Safety.

The analysis of bottleneck areas is based on 2008 data for SR-22 and I-405, and is limited to the mainline facility since the mainline has greater detection coverage than the HOV facility. Based on this segmentation approach, the study corridor comprises several bottleneck areas, which differ by direction. Exhibit 4-19 illustrates the general concept of bottleneck areas in one direction. The red lines in the exhibit represent the bottleneck locations and the arrows represent the bottleneck areas. Given that the I-

605 study corridor is less than a mile long, a bottleneck area analysis was not conducted for this corridor.

Exhibit 4-19: Bottleneck Areas Illustrated



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 Exhibits 4-1 and 4-2 are shown again in Exhibits 4-20 and 4-21 with the associated bottleneck areas.

Exhibit 4-20: SR-22 Bottleneck Locations and Areas

Eastbound

Bottleneck Location	Bottleneck Area	Active Period		From		To		Distance (miles)
		AM	PM	Abs	CA	Abs	CA	
Euclid On	I-405 to Euclid On	✓	✓	2.1	R0.7	8.4	R7.0	6.3
Harbor On	Euclid On to Harbor On	✓	✓	8.4	R7.0	9.5	R8.1	1.1
Fairview On	Harbor On to Fairview On	✓	✓	9.5	R8.1	10.4	R9.0	0.9
I-5 Off/City Drive IC	Fairview On to I-5 Off/City Drive IC	✓	✓	10.4	R9.0	11.3	R9.7	0.9
I-5 On/Town and Country Off	I-5 Off/City Drive IC to I-5 On/Town and Country Off		✓	11.3	R9.7	12.8	R11.3	1.5
None	I-5 On/Town and Country Off to SR-55	N/A		12.8	R11.3	14.3	R12.7	1.5

Westbound

Bottleneck Location	Bottleneck Area	Active Period		From		To		Distance (miles)
		AM	PM	Abs	CA	Abs	CA	
NB I-5 On	SR-55 to NB I-5 On		✓	14.3	R12.7	12.1	R10.5	2.2
Garden Grove On	NB I-5 On to Garden Grove On		✓	12.1	R10.5	10.1	R8.6	2.0
Valley View Off	Garden Grove On to Valley View Off		✓	10.1	R8.6	2.5	R1.1	7.6
I-405 On	Valley View Off to I-405		✓	2.5	R1.1	2.1	R0.7	0.4

Exhibit 4-21: I-405 Bottleneck Locations and Areas

Northbound

Bottleneck Location	Bottleneck Area	Active Period		From		To		Distance (miles)
		AM	PM	Abs	CA	Abs	CA	
Sand Canyon Off	I-5 to Sand Canyon Off	✓		0.0	0.2	2.4	2.6	2.4
Jeffrey/University On	Sand Canyon Off to Jeffrey/University On	✓	✓	2.4	2.6	3.9	4.1	1.5
SR-73/Fairview On	Jeffrey/University On to SR-73/Fairview On		✓	3.9	4.1	10.7	10.9	6.9
Euclid On	SR-73/Fairview On to Euclid On		✓	10.7	10.9	12.6	12.9	1.9
Brookhurst On	Euclid On to Brookhurst On		✓	12.6	12.9	13.8	14.0	1.2
SR-39 On	Brookhurst On to SR-39 On	✓	✓	13.8	14.0	16.6	16.8	2.8
SR-22 On	SR-39 On to SR-22 On	✓	✓	16.6	16.8	20.7	20.9	4.1
None	SR-22 On to LA County Line	N/A		20.7	20.9	24.0	24.2	3.3

Southbound

Bottleneck Location	Bottleneck Area	Active Period		From		To		Distance (miles)
		AM	PM	Abs	CA	Abs	CA	
I-605 On	LA County Line to I-605 On	✓	✓	24.0	24.2	23.3	23.5	0.7
Seal Beach On	I-605 On to Seal Beach On	✓	✓	23.3	23.5	22.3	22.5	1.0
Valley View/SR-22	Seal Beach On to Valley View/SR-22	✓	✓	22.3	22.5	20.3	20.5	2.0
SR-39 On	Valley View/SR-22 On to SR-39 On	✓	✓	20.3	20.5	16.4	16.6	3.9
Warner On	SR-39 On to Warner On	✓	✓	16.4	16.6	14.5	14.7	1.9
Talbert On	Warner On to Talbert On	✓		14.5	14.7	13.1	13.3	1.4
Bristol Off	Talbert On to Bristol Off	✓		13.1	13.3	9.5	9.7	3.6
MacArthur Off	Bristol Off to MacArthur Off	✓	✓	9.5	9.7	7.6	7.8	1.9
Culver On	MacArthur Off to Culver On	✓	✓	7.6	7.8	5.4	5.7	2.2
Jeffrey/University On	Culver On to Jeffrey/University On	✓	✓	5.4	5.7	3.8	4.0	1.6
Sand/Shady Canyon On	Jeffrey/University On to Sand/Shady Canyon On	✓	✓	3.8	4.0	2.7	2.9	1.1
None	Sand/Shady Canyon On to I-5	N/A		2.7	2.9	0.0	0.0	2.7

Mobility by Bottleneck Area

Mobility describes how efficiently the corridor moves vehicles. Vehicle-hours of delay measured at 60 mph were calculated for each segment. The results reveal the areas of the corridor that experience the worst mobility.

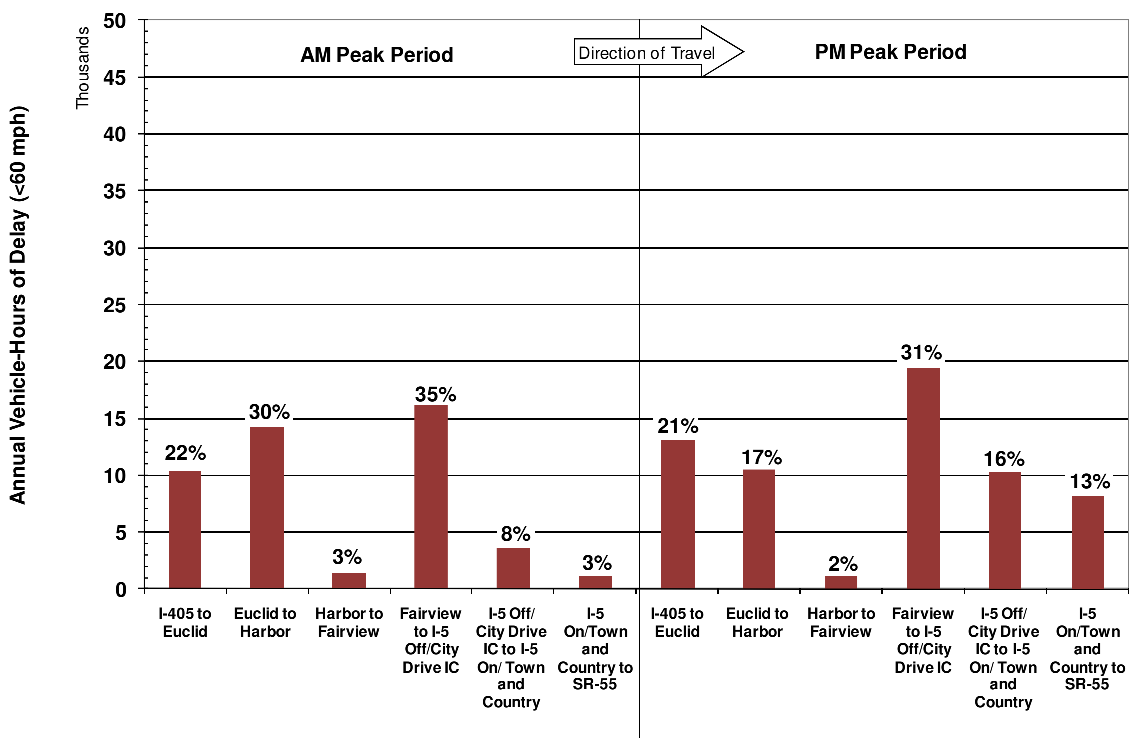
SR-22 Mobility

This mobility analysis is based on 2008 automatic detector data for the mainline facility. Exhibits 4-22 and 4-24 illustrate the vehicle-hours of delay experienced by each bottleneck area on SR-22. As depicted in Exhibit 4-22, eastbound delay in 2008 is slightly greater during the PM peak than the AM peak period. During both the AM and

PM peaks, the bottleneck area between Fairview and I-5 Off-Ramp/City Drive experienced the most delay with over 15,000 vehicle-hours in the AM and about 20,000 annual vehicle-hours in the PM. In the westbound direction (Exhibit 4-24), delay was overwhelmingly concentrated in the PM peak with four times more delay in the PM peak than the AM peak period. The bottleneck area between Northbound I-5 and Garden Grove experienced the highest delay of any other segment, followed closely by the area from Garden Grove Boulevard to Valley View. Both of these segments experienced over 35,000 vehicle-hours of delay each during the PM peak.

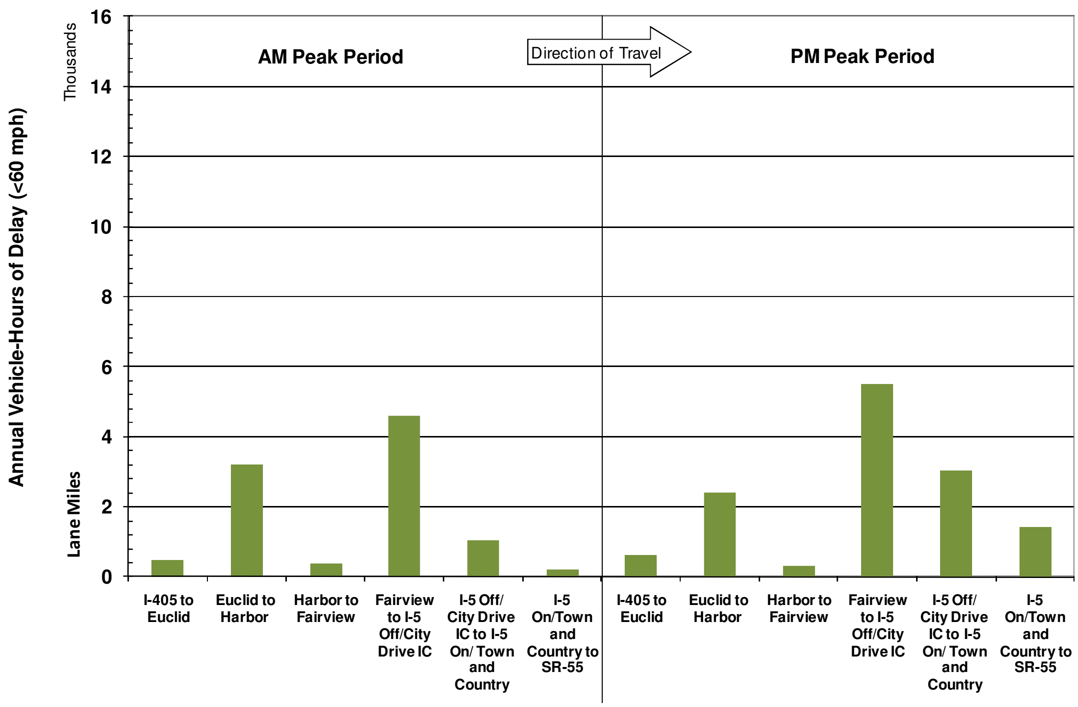
Exhibits 4-23 and 4-25 have been normalized to reflect delay per lane-mile. The delay calculated for each bottleneck area was divided by the total lane-miles for each bottleneck area to obtain delay per lane-mile. In the eastbound direction, normalizing lane-miles resulted in similar delay results as Exhibit 4-22, but in the westbound direction, the results were different. In the westbound direction, the segment from Valley View to I-405 experienced the highest levels of delay per lane-mile, which contrasts the delay results in Exhibit 4-24. In Exhibit 4-24, Valley View to I-405 experienced lower levels of delay during both peak periods compared to the other bottleneck areas along the corridor, specifically the segments from Northbound I-5 to Garden Grove and from Garden Grove to Valley View.

Exhibit 4-22: Eastbound SR-22 Annual Vehicle-Hours of Delay (2008)



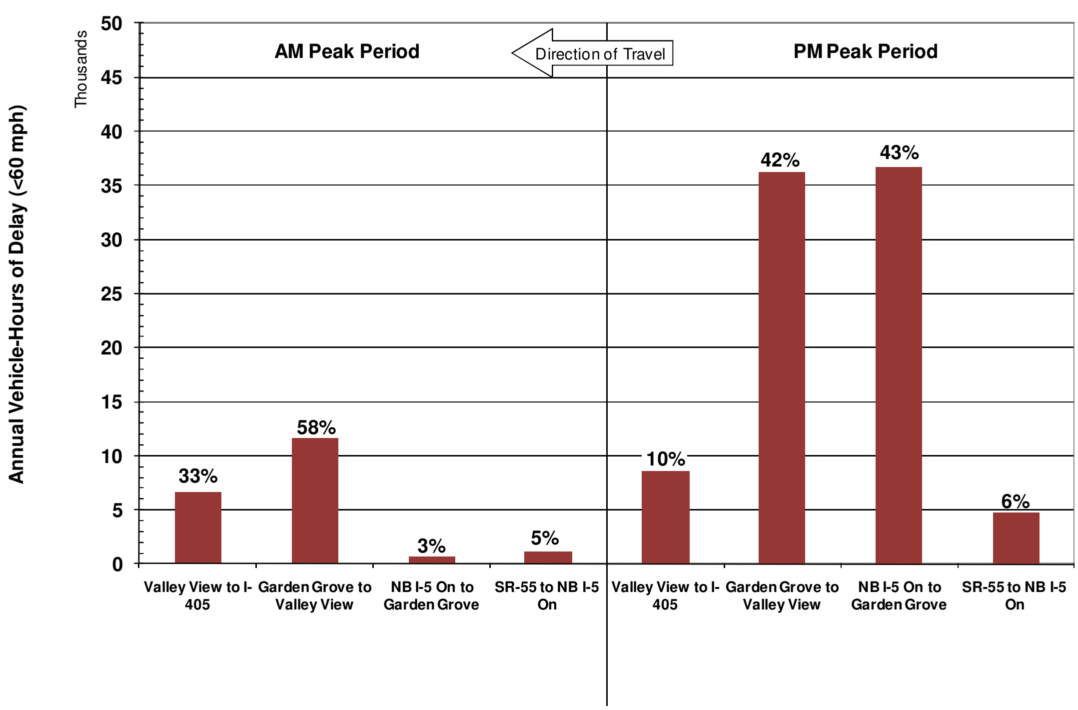
Source: Automatic detector data

Exhibit 4-23: Eastbound SR-22 Delay per Lane-Mile (2008)



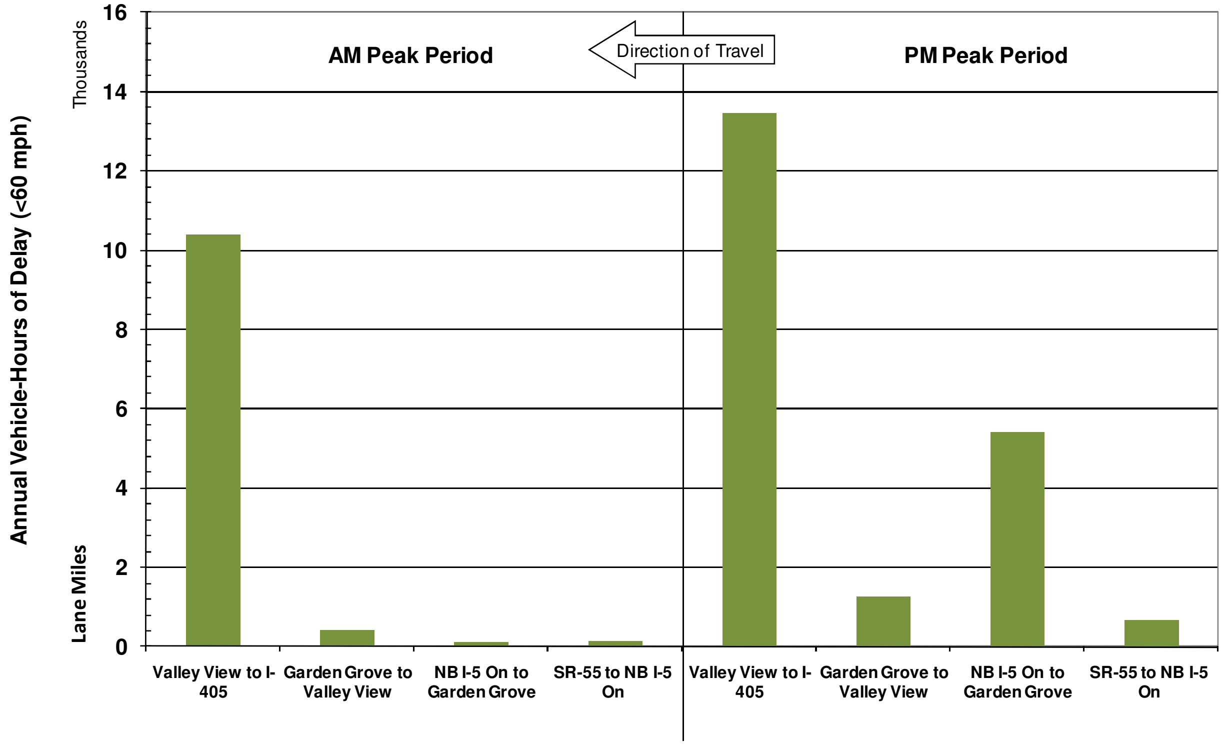
Source: Automatic detector data

Exhibit 4-24: Westbound SR-22 Annual Vehicle-Hours of Delay (2008)



Source: Automatic detector data

Exhibit 4-25: Westbound SR-22 Delay per Lane-Mile (2008)



Source: Automatic detector data

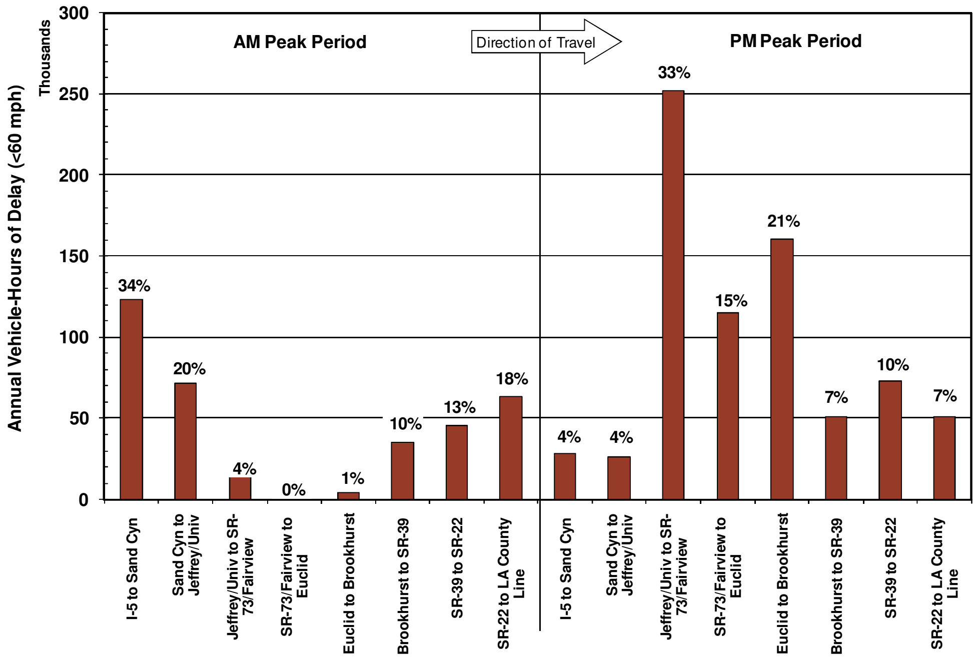
I-405 Mobility

Delay on I-405 is illustrated in Exhibits 4-26 through 4-29. As depicted in Exhibits 4-26 and 4-28, delay is greater during the PM in the northbound direction and during the AM in the southbound direction, indicating a directional pattern of travel. In the northbound direction (Exhibit 4-26), the segment between Jeffrey/University to SR-73 experienced the greatest delay of any segment on the corridor with over 250,000 annual vehicle-hours accrued during the PM peak. During the AM peak, the segment between SR-22 to the Los Angeles County line experienced the greatest delay. In the southbound direction (Exhibit 4-28), the segment between Valley View/SR-22 and SR-39 (Beach Boulevard), and the segment from MacArthur to Culver, experienced the heaviest delay during the AM and PM peaks, respectively.

Exhibits 4-27 and 4-29 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 both directions, the results were similar to the delay shown in Exhibits 4-26 and 4-28 with a clear directional pattern of travel. However, in the northbound direction during the PM peak, the segment which experienced the heaviest delay per lane mile was Euclid to Brookhurst, rather than Jeffrey/University to SR-73. Similarly, in the southbound direction during the AM peak

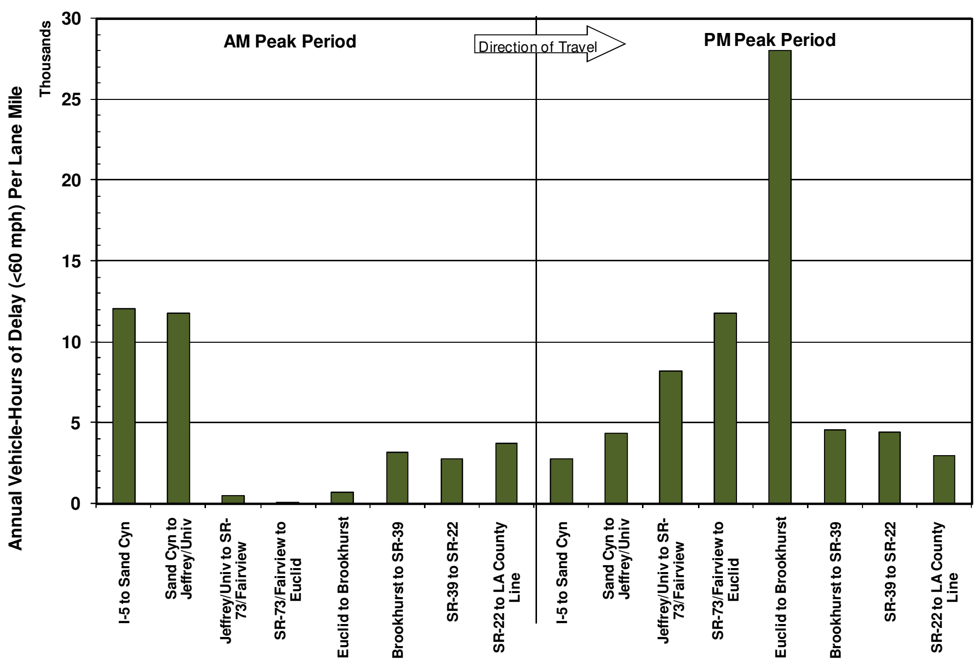
(Exhibit 4-29), the segment with the highest delay per lane mile was SR-39 to Warner rather than Valley View/SR-22 to SR-39.

Exhibit 4-26: Northbound I-405 Annual Vehicle-Hours of Delay (2008)



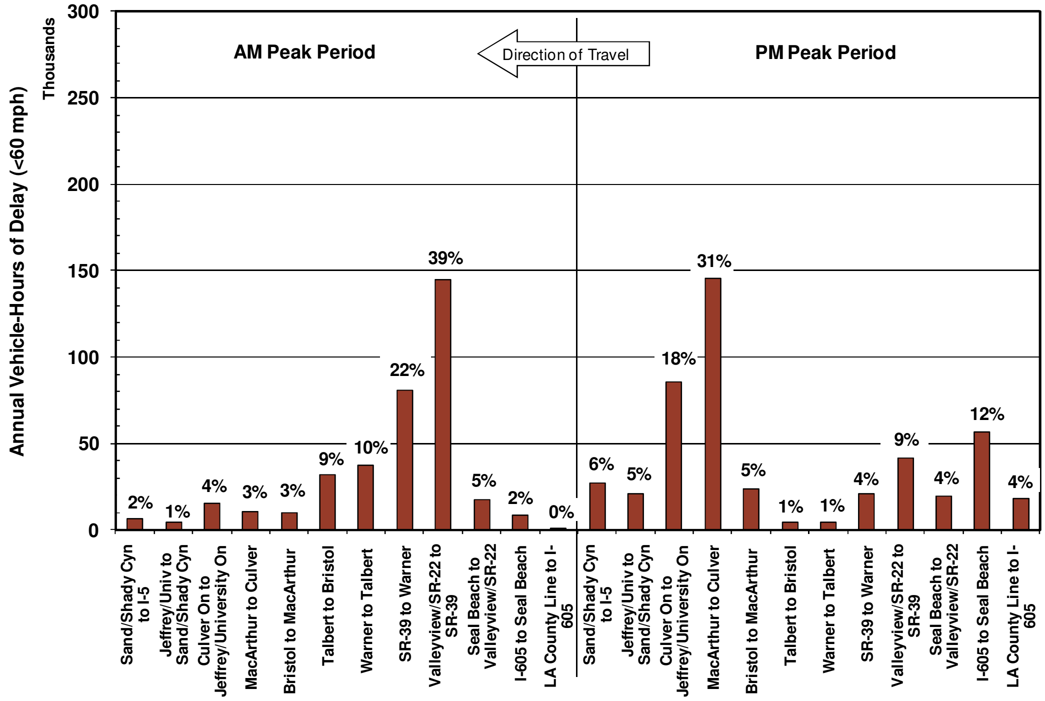
Source: Automatic detector data

Exhibit 4-27: Northbound I-405 Delay per Lane-Mile (2006)



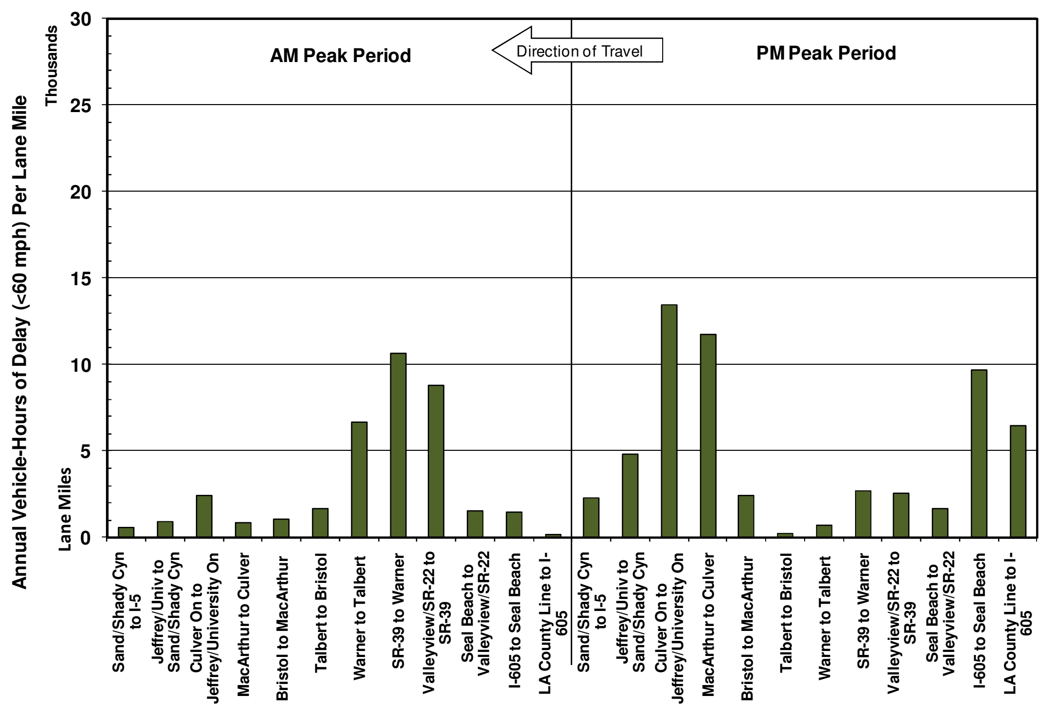
Source: Automatic detector data

Exhibit 4-28: Southbound I-405 Annual Vehicle-Hours of Delay (2008)



Source: Automatic detector data

Exhibit 4-29: Southbound I-405 Delay per Lane-Mile (2008)



Source: Automatic detector data

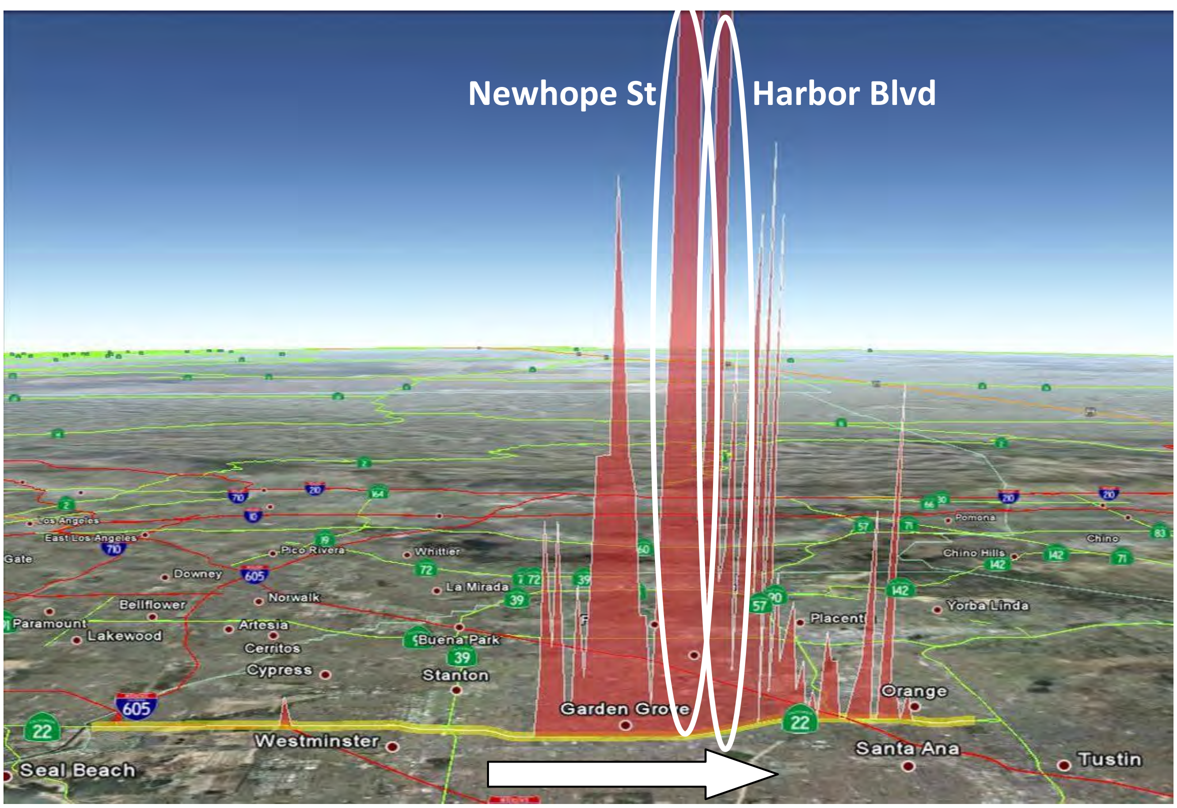
Safety by Bottleneck Area

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 SR-22 and I-405 corridors.

SR-22 Safety

The safety analysis in this section conducted for the SR-22 Corridor is based on PeMS. Exhibit 4-30 shows the location of all collisions plotted along SR-22 in the eastbound direction. The spikes show the total number of collisions (fatality, injury, and property damage only) occurring within a 0.1 mile segments in 2008. The highest spike corresponds to roughly 55 collisions in a single 0.1 mile location. 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 4-30: Eastbound SR-22 Collision Locations (2008)

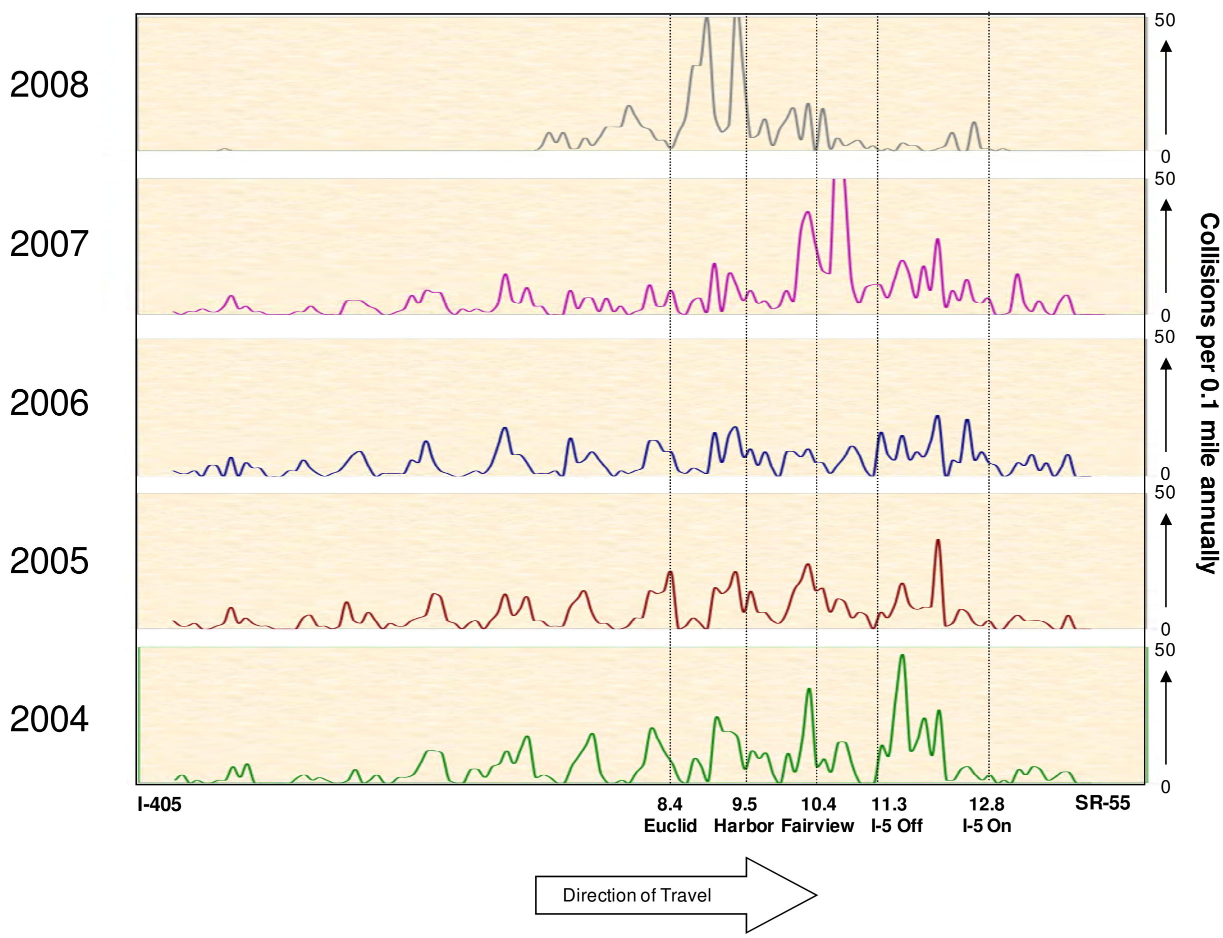


Source: TASAS data

As evident in Exhibit 4-30, the study corridor had a high concentration of collisions at two main locations in 2008. Starting from I-405 and moving eastbound, the largest number of collisions occurred around New Hope Street and Harbor Boulevard. A spike in the number of collisions occurred in the same location as the bottleneck at Harbor Boulevard.

Exhibit 4-31 illustrates the same collision data as the previous exhibit, but for the entire five-year period from 2004 to 2008. Each column within Exhibit 4-31 represents one year with the spikes indicating the number of collisions which occurred at a specific post mile 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 indicate bottleneck locations. Exhibit 4-30 showed that in 2008, the highest number of collisions occurred near Harbor Boulevard. This is illustrated in Exhibit 4-31 as the bottleneck location at PM 9.5. Exhibit 4-31 also shows that the pattern of collisions has stayed consistent from 2004 through 2006, with an increase in collisions in 2007 near Fairview, but a corridor-wide decrease in collisions in 2008.

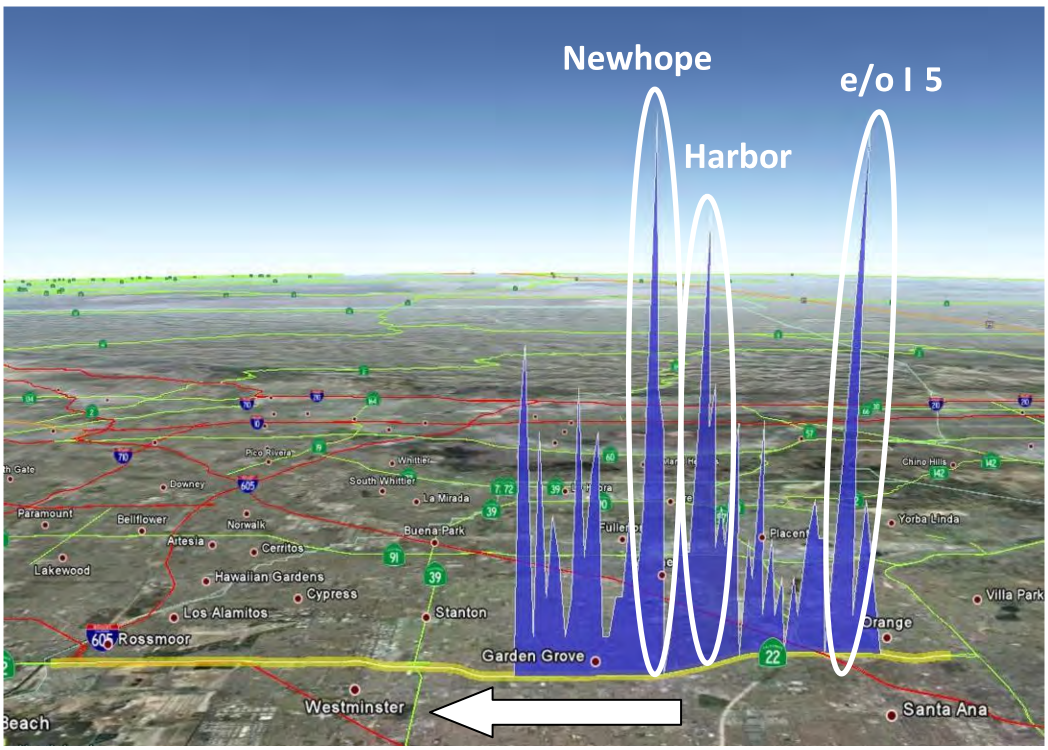
Exhibit 4-31: Eastbound SR-22 Collision Locations (2004-2008)



Source: TASAS data

For the westbound direction of SR-22, Exhibit 4-32 maps similar 2008 collision data. The largest spike in this exhibit corresponds roughly to 15 collisions per 0.1 mile. Although the pattern in the westbound direction is similar to that in the eastbound direction, the spikes in the westbound are thinner than those in the eastbound direction, suggesting that a high number of accidents occurred at very specific locations along the corridor. Moving in the westbound direction from SR-55, spikes are most notable just east of the I-5 Interchange, around Harbor Boulevard, and near Newhope Street. Two out of these three locations (Harbor Boulevard and Newhope Street) are the same as those identified in the eastbound direction (Exhibit 4-30).

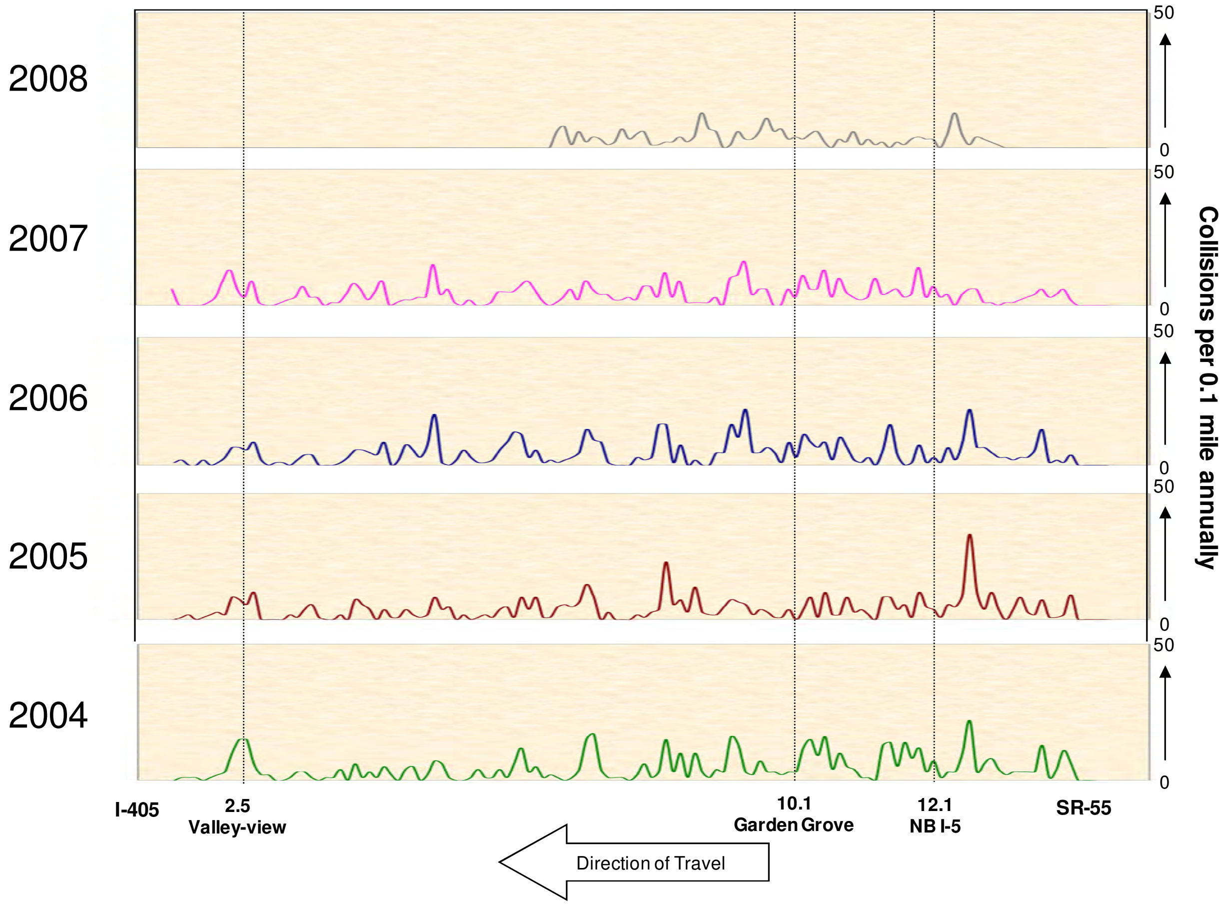
Exhibit 4-32: Westbound SR-22 Collision Locations (2008)



Source: TASAS data

As demonstrated previously for the eastbound direction, Exhibit 4-33 shows the trend of collisions in the westbound direction from 2004 to 2008. Again, the vertical lines in the exhibit indicate bottleneck locations. As the exhibit shows, the pattern of collisions has been fairly steady from one year to the next with an overall decrease of accidents from 2007 to 2008. Unlike the eastbound direction where a high number of accidents clustered around the bottleneck locations, the westbound direction experienced relatively fewer accidents near its respective bottleneck locations.

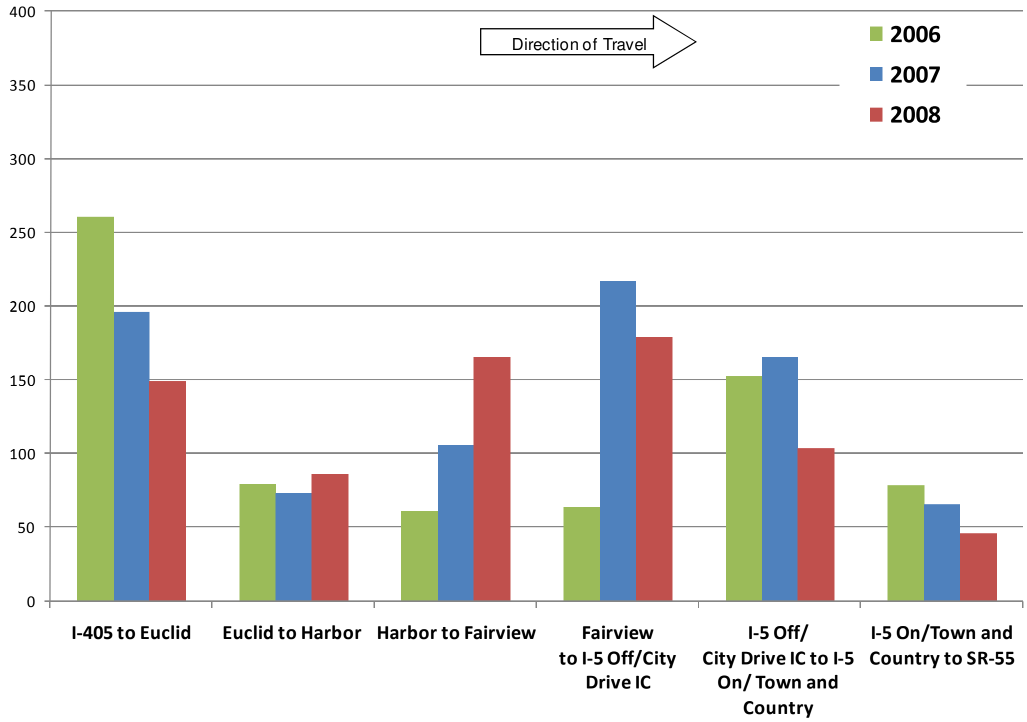
Exhibit 4-33: Westbound SR-22 Collision Locations (2004-2008)



Source: TASAS data

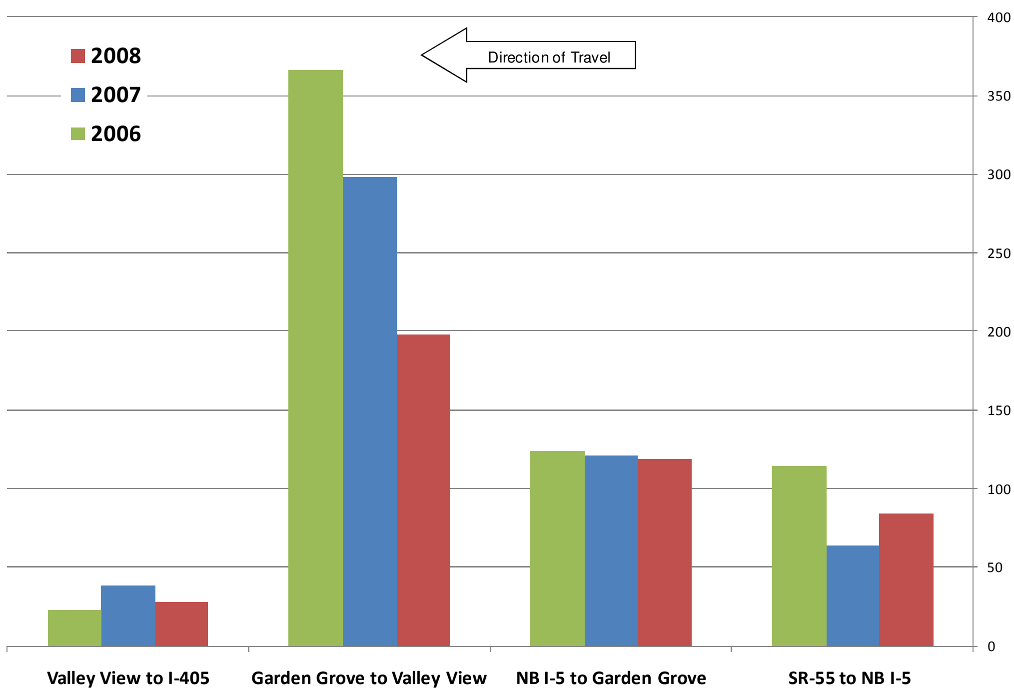
Exhibits 4-34 and 4-35 present the total number of accidents reported from 2006 to 2008 by TASAS for the eastbound and westbound directions. In the eastbound direction, the segment from Fairview to I-5 experienced the greatest number of accidents in 2007 and 2008 with, respectively, 220 and 180. In the westbound direction, the segment between Garden Grove and Valley View reported the greatest number of accidents in 2007 with about 300. In the westbound direction, the segment from Garden Grove to Valley View experienced the most accidents in 2007 and 2008 with approximately 300 and 200, respectively.

Exhibit 4-34: Eastbound SR-22 Accidents by Bottleneck Area (2006-2008)



Source: TASAS data

Exhibit 4-35: Westbound SR-22 Accidents by Bottleneck Area (2006-2008)



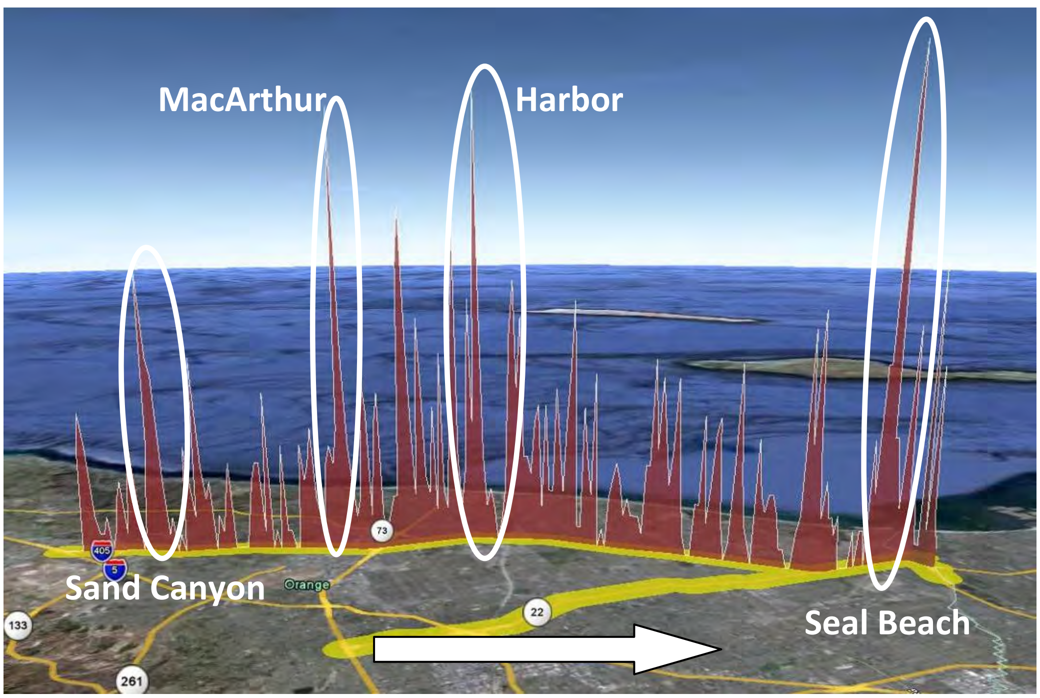
Source: TASAS data

I-405 Safety

Exhibit 4-36 identifies the location of all collisions plotted along the I-405 Corridor in the northbound direction. The spikes show the total number of collisions (fatality, injury, and property damage only) that occurred within a 0.1 mile segment in 2008. The highest spike in Exhibit 4-36 corresponds to roughly 31 collisions in a single 0.1 mile location.

As evident in Exhibit 4-36, I-405 has a high concentration of collisions at many locations. Starting from I-5 and moving northbound, a large number of collisions occurred around Sand Canyon, at MacArthur, near Harbor, and around Seal Beach and the SR-22 Interchange. In many cases, a spike in the number of collisions occurred in the same location as a bottleneck. For example, a spike occurred at the Sand Canyon interchange, which is also a bottleneck location.

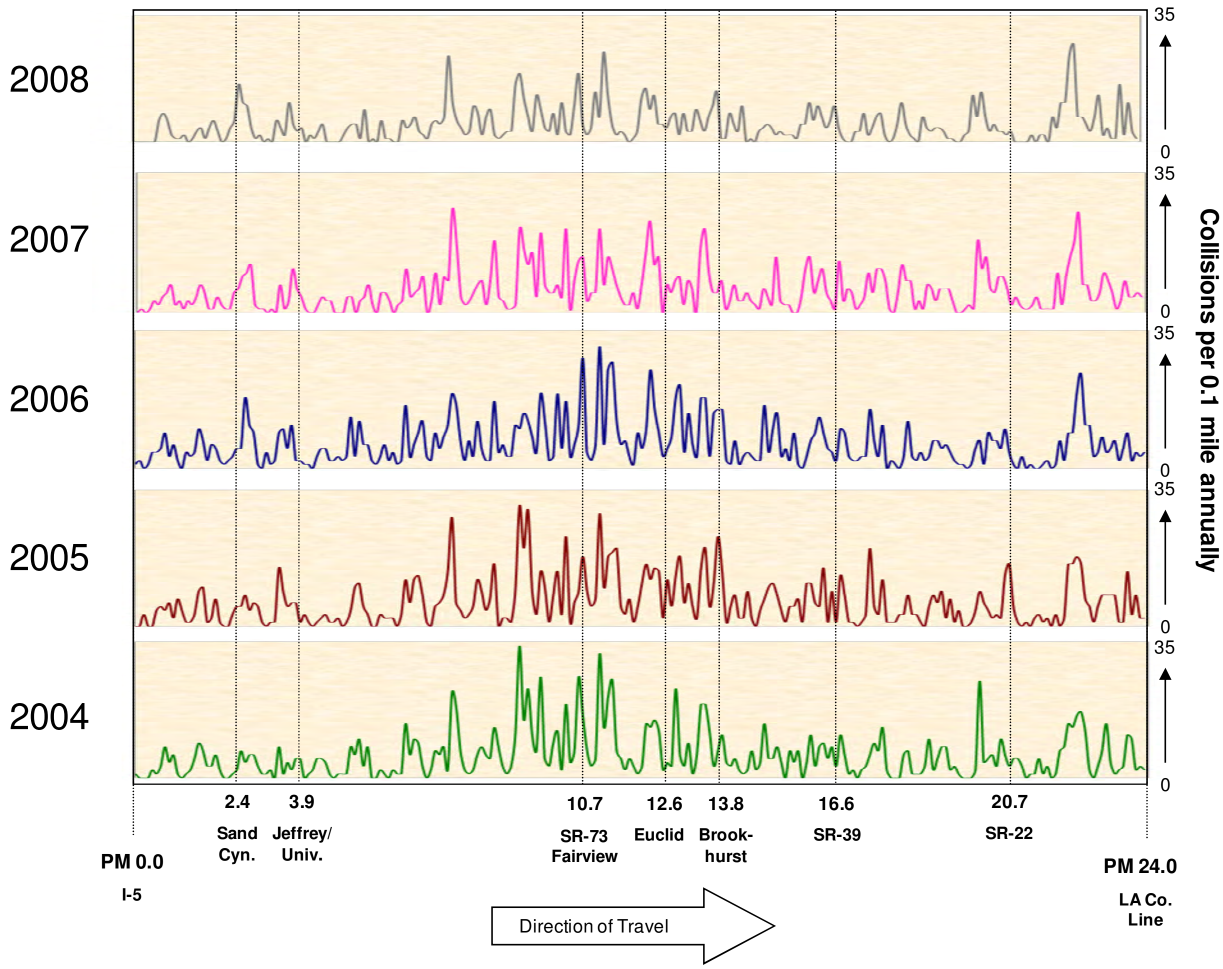
Exhibit 4-36: Northbound I-405 Collision Locations (2008)



Source: TASAS data

Exhibit 4-37 illustrates the same safety data as the previous exhibit, but for the entire five-year period from 2004 to 2008. Each graph represents one year and the spikes indicate the number of collisions that occurred at a specific post mile location. The collisions range anywhere between zero (the minimum) and 35 (the maximum) on the y-axis. The vertical lines in the exhibit separate the corridor by bottleneck area. As indicated in this exhibit, a high number of collisions occurred between SR-73/Fairview (PM 10.7) and Brookhurst (PM 13.8). Exhibit 4-37 also shows that the pattern of collisions has stayed fairly consistent from one year to the next. However, the number of accidents (or spikes) that occurred between SR-73/Fairview and Brookhurst Avenue appeared to have increased in 2007 compared to prior years.

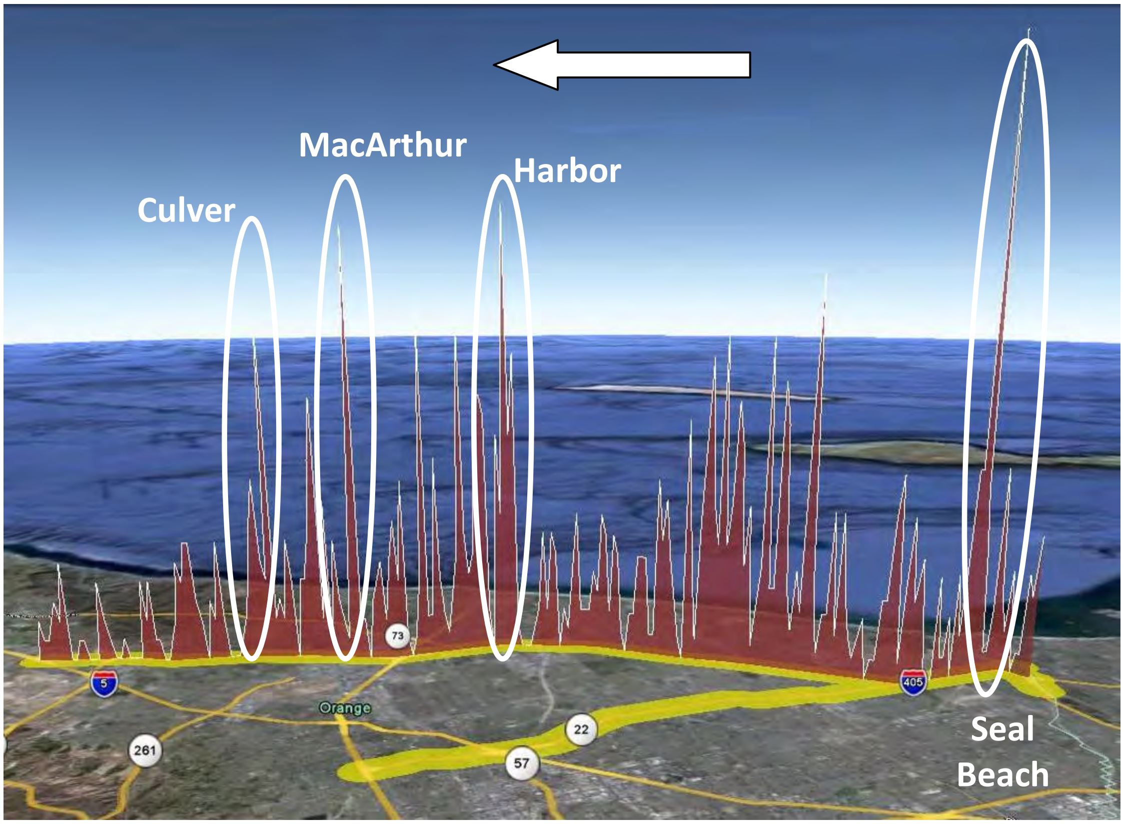
Exhibit 4-37: Northbound I-405 Collision Locations (2004-2008)



Source: TASAS data

Exhibit 4-38 suggests that the southbound direction experienced similar spikes in collisions compared to the northbound. The largest spike in this exhibit corresponds to 26 collisions per 0.1 miles, which occurred at Seal Beach Boulevard. Moving in the southbound direction from the LA County Line, spikes are most notable near Seal Beach, Harbor, MacArthur, and Culver. The locations at Seal Beach, Harbor, and MacArthur were also identified as high collision locations in the northbound direction.

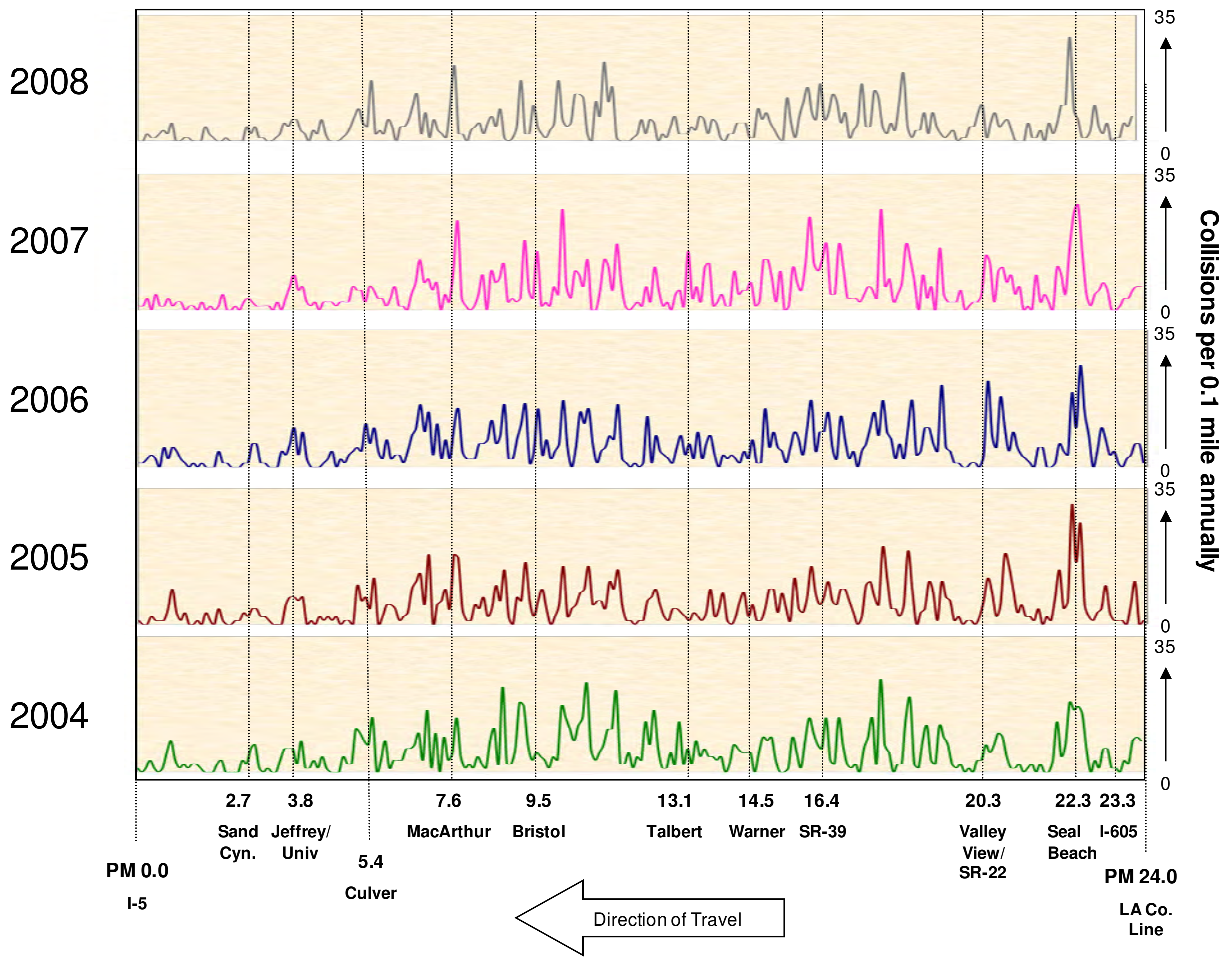
Exhibit 4-38: Southbound I-405 Collision Locations (2008)



Source: TASAS data

The trend of collisions for the southbound direction during the 2004-2008 period by bottleneck area is depicted in Exhibit 4-39. As the exhibit shows, the number of collisions that occurred at MacArthur and SR-22 remain significant throughout the five-year period.

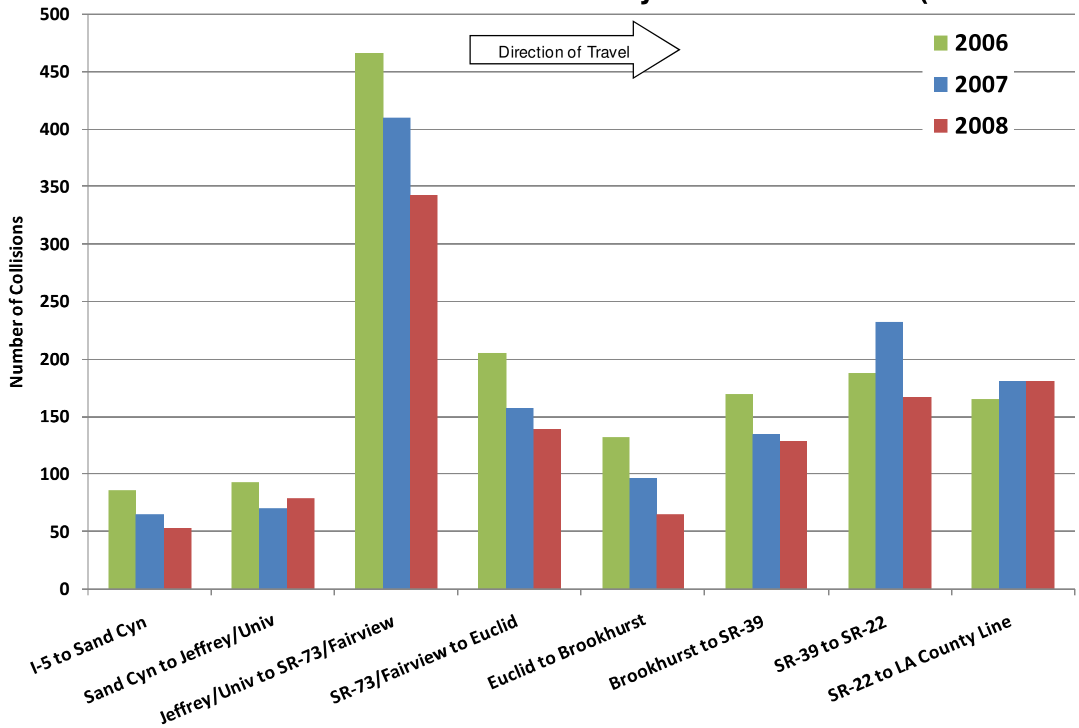
Exhibit 4-39: Southbound I-405 Collision Locations (2004-2008)



Source: TASAS data

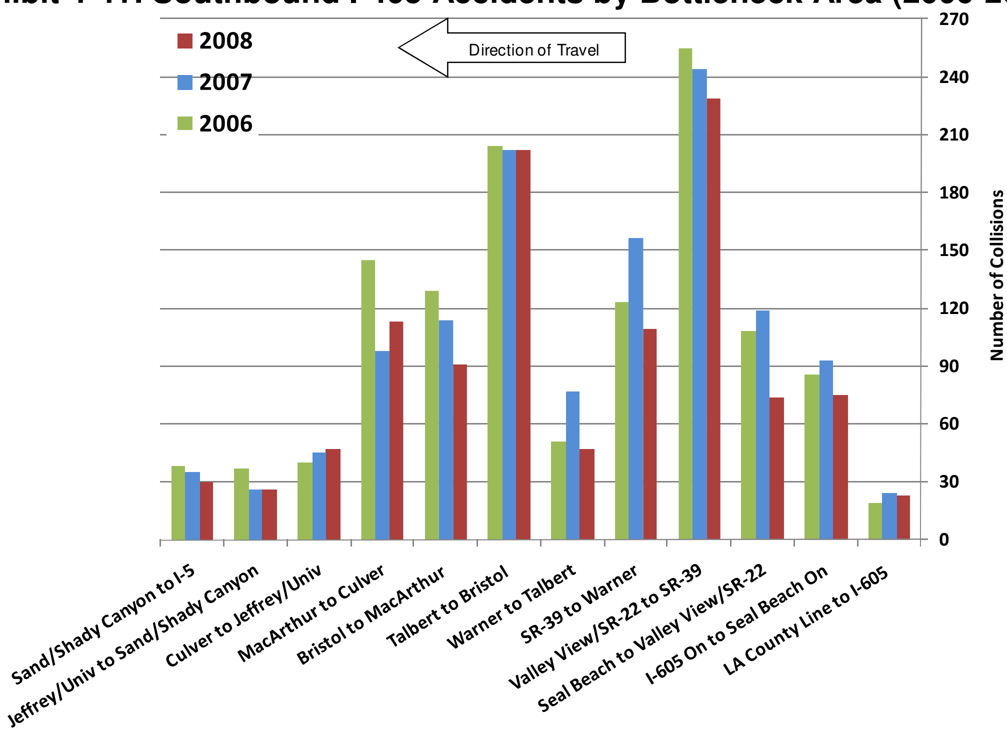
Exhibits 4-40 and 4-41 present the number of accidents reported in TASAS by bottleneck area. The bars show the total of accidents that occurred from 2006 to 2008. In the northbound direction, the segment from Jeffrey/University to SR-73/Fairview experienced the greatest number of accidents with over 400 in 2007 and almost 350 in 2008. In the southbound direction, the segment from Valley View/SR-22 to SR-39 experienced the most accidents with around 220-250 during each year.

Exhibit 4-40: Northbound I-405 Accidents by Bottleneck Area (2006-2008)



Source: TASAS data

Exhibit 4-41: Southbound I-405 Accidents by Bottleneck Area (2006-2008)



Source: TASAS data

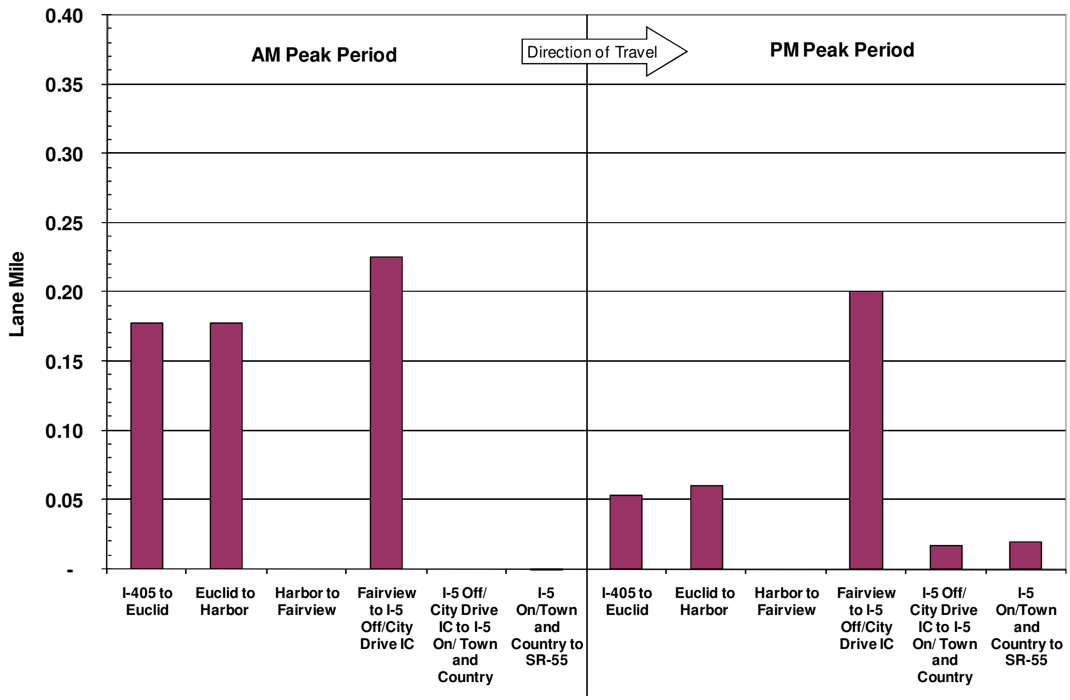
Productivity by Bottleneck Area

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 "equivalent 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.

SR-22 Productivity

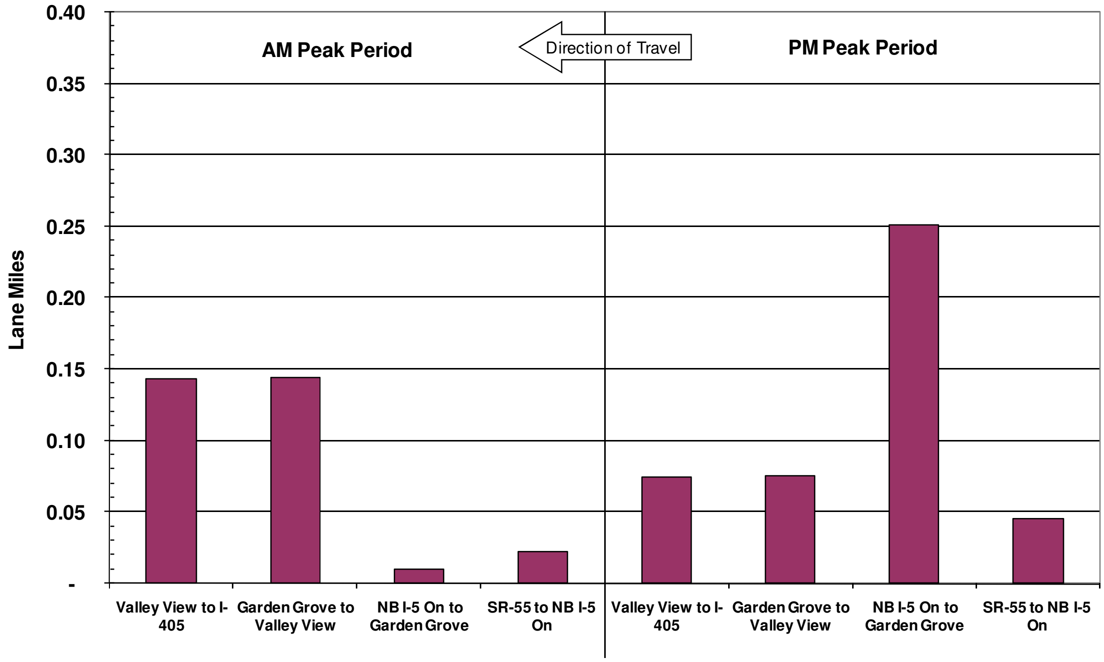
Similar to the mobility analysis, the productivity analysis is also based on 2008 automatic detector data. Exhibits 4-42 and 4-43 show the productivity losses for both directions of the SR-22 Corridor. In the eastbound direction, the segment from Fairview to I-5 Off-Ramp/City Drive suffered the highest productivity loss during both the AM and PM peak periods with over 0.20 lost-lane miles. In the westbound direction, Northbound I-5 On-ramp to Garden Grove had the worst productivity loss during the PM peak (0.25 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 4-42: Eastbound SR-22 Average Daily Equivalent Lost Lane-Miles (2008)



Source: Automatic detector data

Exhibit 4-43: Westbound SR-22 Average Daily Equivalent Lost Lane-Miles (2008)



Source: Automatic detector data

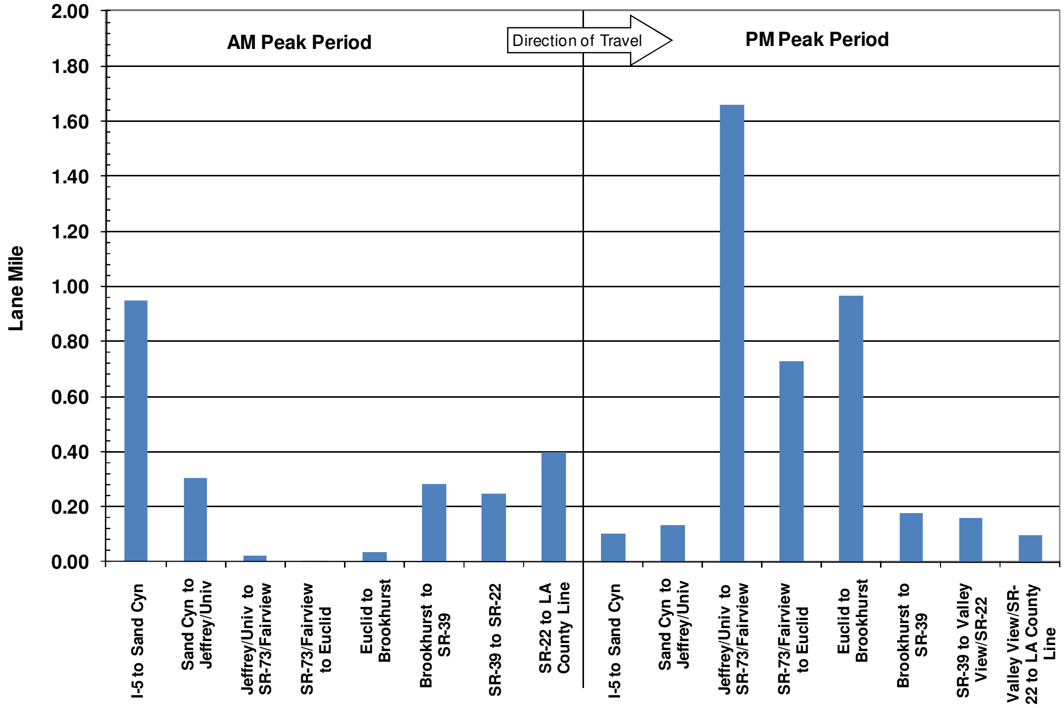
I-405 Productivity

Exhibits 4-44 and 4-45 show the productivity losses for both directions of I-405. In the northbound direction, the segment from Jeffrey/University to SR-73 had the worst productivity of any segment on the corridor with over 1.6 lost lane-miles during the PM peak. During the AM peak, the segments from I-5 to Sand Canyon suffered the worst productivity at around 1.0 lost lane-miles, while the rest of the segments experienced relatively higher levels of productivity with under 0.4 lost lane-miles.

In the southbound direction, the segment from Valley View/SR-22 to SR-39 had the highest productivity loss during the AM peak, while the segment from MacArthur to Culver had the highest productivity loss during the PM peak.

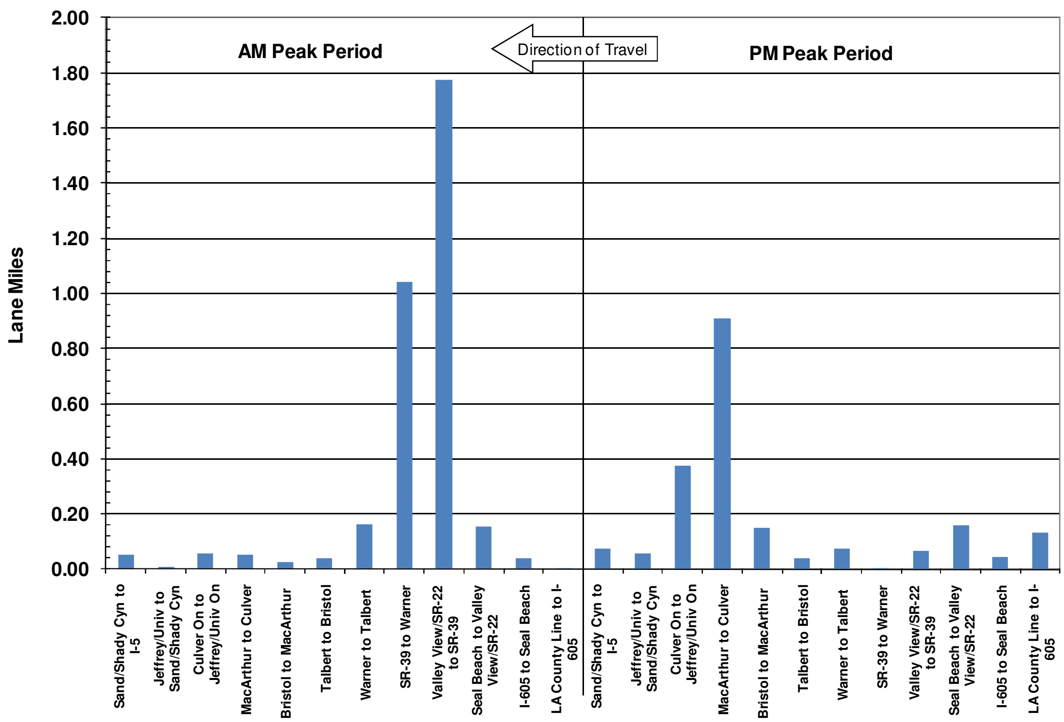
The segments of the corridor with the highest productivity losses coincide with the segments that experienced the greatest annual vehicle-hours of delay.

Exhibit 4-44: Northbound I-405 Average Daily Equivalent Lost Lane-Miles (2008)



Source: Automatic detector data

Exhibit 4-45: Southbound I-405 Average Daily Equivalent Lost Lane-Miles (2008)



Source: Automatic detector data

5. BOTTLENECK CAUSALITY ANALYSIS

This section details the causes of the major bottlenecks identified in Section 4 of this report (see Exhibits 4-1 to 4-3 for reference).

Major bottlenecks are the primary cause of traffic congestion and lost productivity. It is important to verify the precise location and causes of each major bottleneck to develop appropriate, low cost, operational improvements to maintain corridor mobility.

The location of each major bottleneck was verified by multiple field observations on separate days as discussed in Section 4 of this final report. The causes of each major bottleneck were also identified by field observations and additional traffic data analysis. For the SR-22 and I-405 mainline facilities, field observations were conducted by the project consultant team on multiple days (midweek) in October, November, and December 2008 during the AM and PM peak hours. The most recent field reviews were conducted on December 11 and 18, 2008.

By definition, a bottleneck is a location where traffic demand exceeds the capacity of the roadway facility. The cause of a bottleneck is typically related to a sudden reduction in capacity, such as a physical loss when a lane drop occurs or when heavy merging and weaving take place at major on- and off-ramps. Other variables that can cause reductions in capacity include weather or driver distractions. On the demand side, surges in demand can be larger than a roadway can accommodate. In many cases, it is a combination of increased demand and capacity reductions.

Mainline Facility

Eastbound SR-22 Mainline Bottlenecks and Causes

Major eastbound bottlenecks and congestion often occur during both the AM and the PM peak hours. The following is a summary of the eastbound bottlenecks and the identified causes.

Brookhurst Street, Euclid Street and Harbor Boulevard On-Ramp

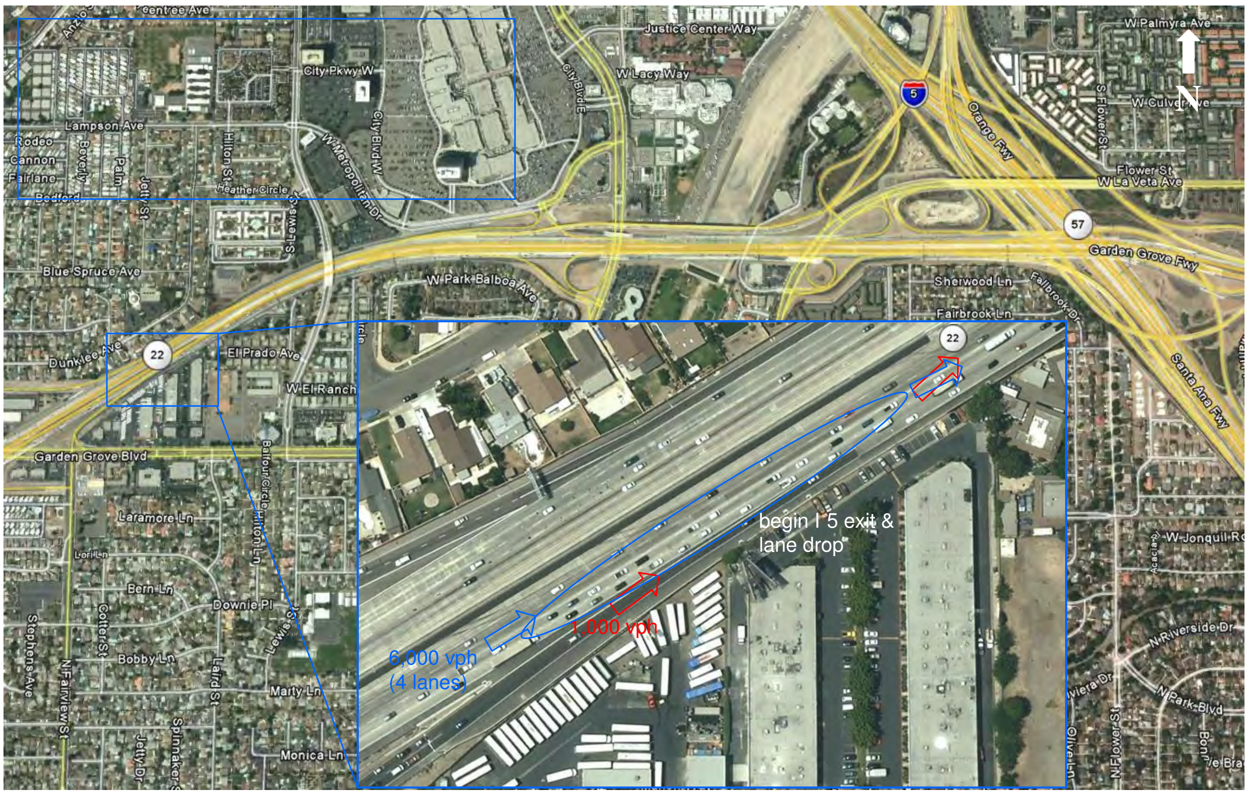
Exhibit 5-1 contains an aerial photograph of the eastbound SR-22 mainline at Brookhurst Street, Euclid Street, and Harbor Boulevard interchanges. As indicated in the exhibit, the on-ramp at each of the three locations carries about 700 to 800 vehicles per hour (vph). When the mainline traffic demand is high (e.g., 7,000 vph), a bottleneck condition and traffic congestion typically forms. Although this condition was not observed at Brookhurst Street or Euclid Street on any of the field visits during either peak hours, it was observed on several occasions at Harbor Boulevard, as evident in the inset pictures. Data analysis suggests that bottleneck and congestion occurred at all three locations at various times throughout 2008.

Exhibit 5-1: Eastbound SR-22 Mainline at Brookhurst St, Euclid St, and Harbor Blvd On-Ramp

<u>Fairview Street On-Ramp (Mainline Lane Drop)</u>

Exhibit 5-2 is an aerial photograph of the eastbound SR-22 mainline at the Fairview Street on-ramp leading on to the I-5 freeway interchange. As indicated, the mainline begins to drop a lane from four lanes to three with auxiliary lane markings (elephant tracks) signifying the lane drop and approaching exit. As a result, cross weaving occurs between the Fairview Street on-ramp traffic and mainline traffic bound for City Drive or I-5. As a result, the freeway mainline breaks down and results in the bottleneck condition and traffic congestion, as evident in the inset picture.

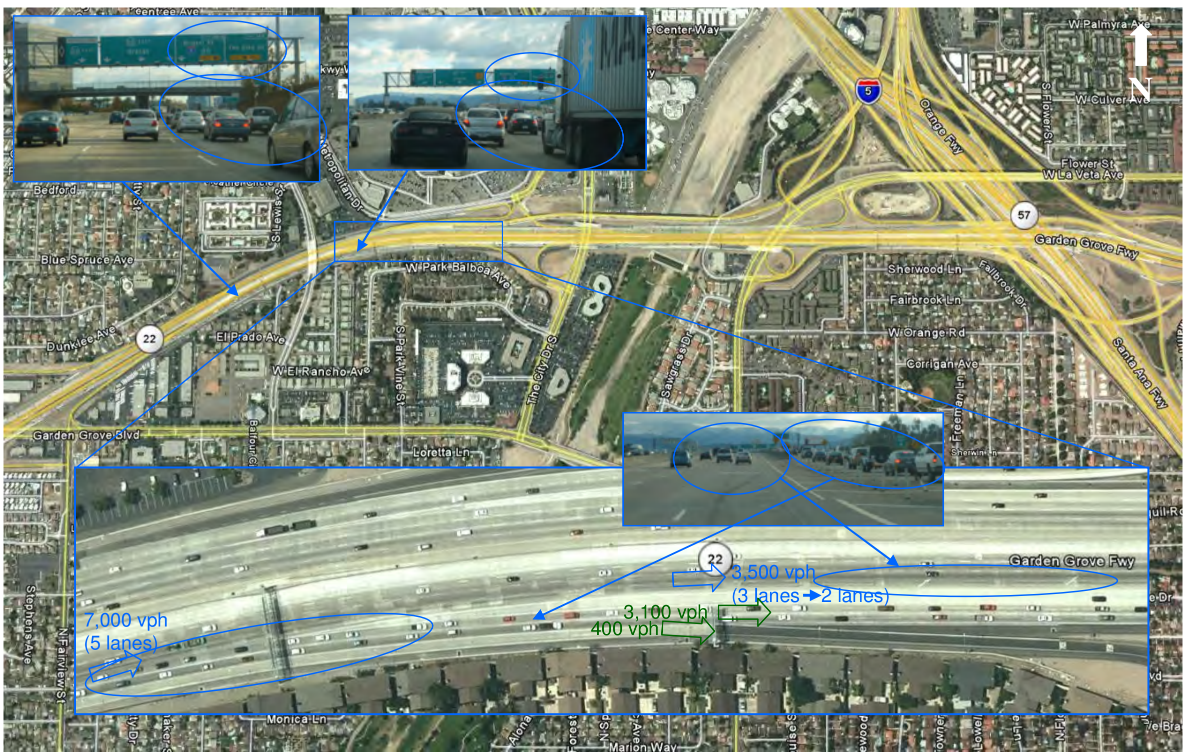
Exhibit 5-2: Eastbound SR-22 Mainline at Fairview Street and I-5 Interchange



City Drive/I-5 (Mainline Lane Drop)

Exhibit 5-3 is an aerial photograph of eastbound SR-22 at the City Drive Interchange and approaching to the I-5 connector exits. As the exhibit illustrates, two lanes are separated from the mainline for the City Drive and I-5 bound traffic with an optional third lane. In addition, the outside lane is dropped on the mainline shortly past the separation from three lanes to two. The primary cause of the bottleneck, however, is the inability of the exit facility to accommodate the demand that exceeds 3,500 vph in two lanes, resulting in the congestion and queuing as evident in the inset pictures.

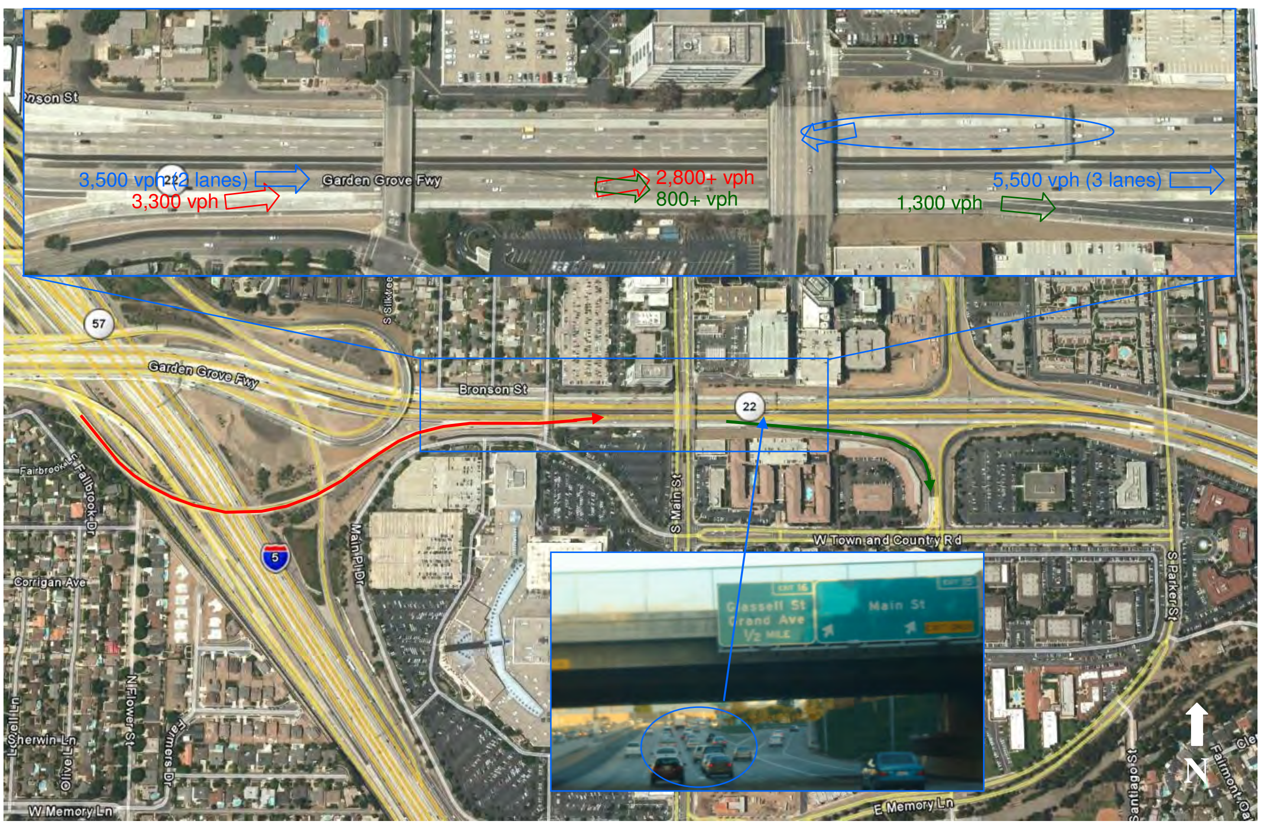
Exhibit 5-3: Eastbound SR-22 Mainline at City Drive and I-5 Interchange



<u>Southbound I-5 On-Ramp/Town and Country Road (Main Street) Off-Ramp</u>

Exhibit 5-4 is an aerial photograph of eastbound SR-22 between the southbound I-5 connector on-ramp and Town and Country Road off-ramp. As shown, the I-5 connector on-ramp adds over 3,300 vph onto the eastbound SR-22 mainline. Of the two lanes, the outer lane is an auxiliary lane to the Town and Country Road exit. As a result, much of the connector on-ramp traffic must weave left, while the Town and Country exit traffic (nearly 1,300 vph) must weave right. This heavy cross-weaving of over 3,500 vehicles causes the mainline traffic to break down, creating the bottleneck condition and resulting traffic congestion, as evident in the inset picture. Just past the Town and Country exit, the mainline flow is about 5,500 vph across 3 lanes. This equals 1,800 vphpl, which is near the threshold level.

Exhibit 5-4: Eastbound SR-22 Mainline at Southbound I-5 On-Ramp /Town and Country Road Off-Ramp



Westbound SR-22 Mainline Bottlenecks and Causes

Unlike the eastbound bottlenecks, which occur during both the AM and PM peaks, westbound bottlenecks and congestion typically occurs during the PM peak hours. The following is a summary of the westbound bottlenecks and the identified causes.

Northbound I-5 On-Ramp

Exhibit 5-5 is an aerial photograph of the northbound I-5 mainline connector on-ramp to westbound SR-22. During the PM peak hours, the volume of traffic from SR-22 mainline is at about 4,500 vehicles per hour (vph) in 3 lanes or 1,500 vph per lane (vphpl). The northbound I-5 connector on-ramp adds typically about 500 vph during the peak hours, resulting in fairly heavy mainline traffic demand (nearly 1700 vphpl). Additionally, a downstream on-ramp from La Veta Avenue adds an additional 700 vph, resulting in a total of 5,700 vph on the mainline in 3 lanes or 1,900 vphpl, at the threshold level, often creating bottleneck conditions and traffic congestion.

Exhibit 5-5: Westbound SR-22 Mainline at Northbound I-5 On-Ramp

Garden Grove Boulevard/Southbound I-5 On-Ramp

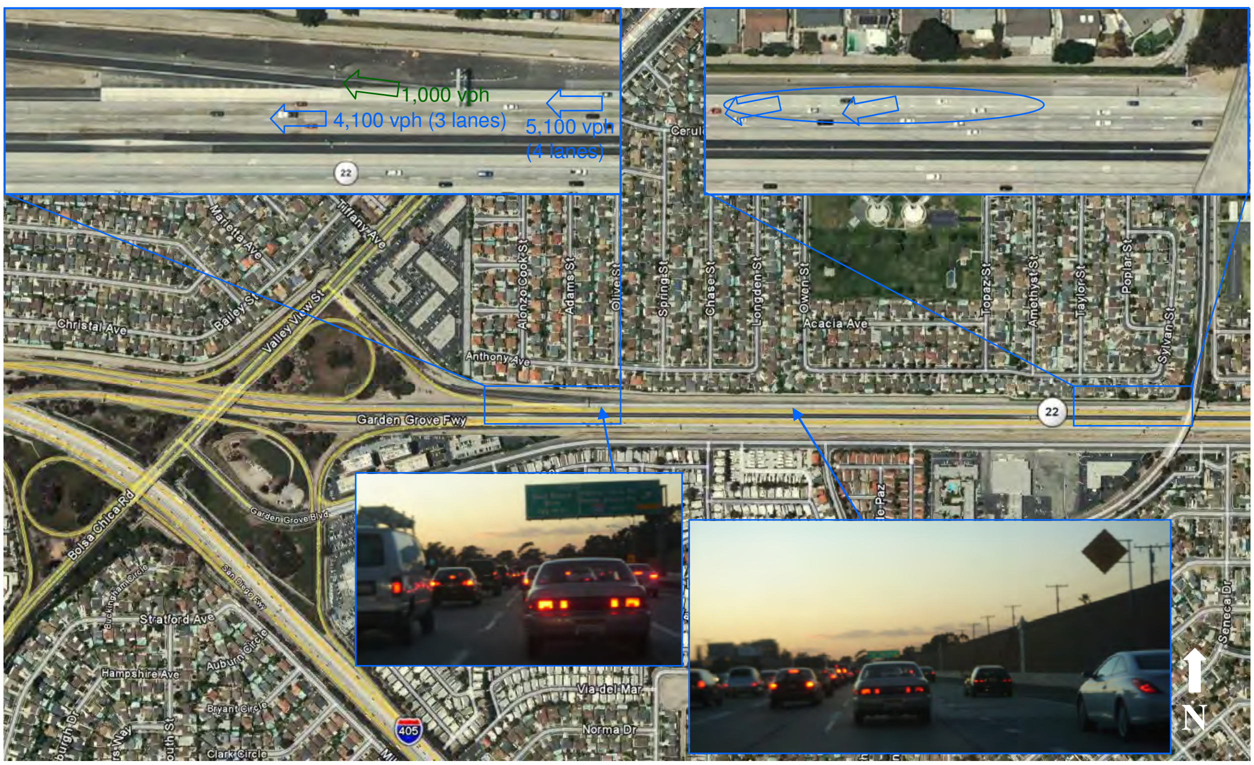
Exhibit 5-6 is an aerial photograph of the Garden Grove Boulevard on-ramp to the westbound SR-22 mainline. As shown in the inset digital picture, significant congestion and queuing is evident from the southbound I-5 connector on-ramp. The mainline traffic cannot accommodate the additional demand from the two ramps. As indicated, with the I-5 connector ramp (over 1,300 vph) traffic the mainline currently carries over 7,000 vph during the PM peak hours. The on-ramp from Garden Grove Boulevard adds over 800 vph to this total, resulting in over 7,800 vph in four mainline lanes or over 1,900 vphpl at the threshold levels, often resulting in bottleneck conditions and traffic congestion.

Exhibit 5-6: Westbound SR-22 Mainline at Garden Grove Blvd/Southbound I-5 On-Ramp

<u>Valley View Street (access to Southbound I-405) Off-Ramp</u>

Exhibit 5-7 is an aerial photograph of the Valley View Street off-ramp from westbound SR-22. Because of a missing freeway to freeway connector between westbound SR-22 and southbound I-405, traffic bound for southbound I-405 must exit at Valley View Street from westbound SR-22 freeway and re-enter the southbound I-405 freeway at the Bolsa Chica Road on-ramp. To accommodate this, the westbound SR-22 mainline dedicates the fourth lane to the Valley View Street exit, resulting in a lane drop from four lanes to three lanes. As a result, weaving occurs from the outer lanes to the inside lanes, creating the bottleneck condition and traffic congestion, as evident in the inset pictures.

Exhibit 5-7: Westbound SR-22 Mainline at Valley View Street Off-Ramp



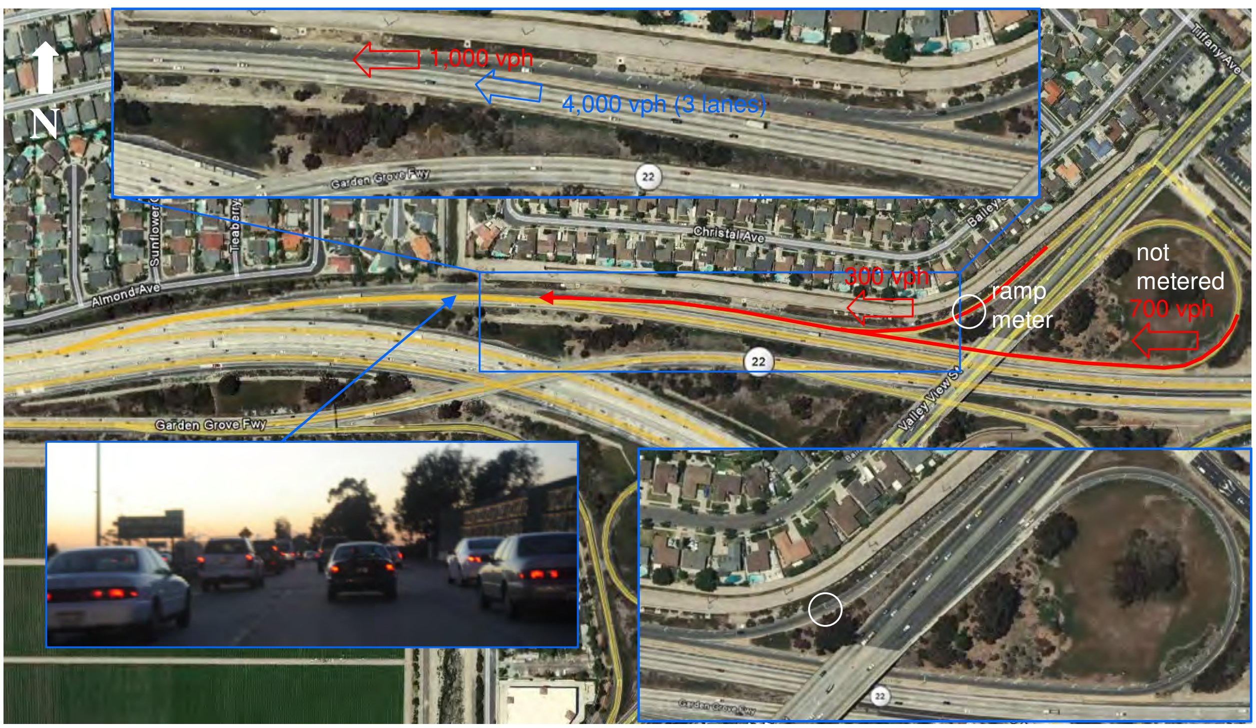
<u>Valley View Street On-Ramp</u>

Exhibit 5-8 is an aerial photograph of the Valley View Street on-ramp to westbound SR-22. As illustrated traffic from two Valley View Street on-ramps merges into one before merging with the westbound SR-22 mainline. As indicated, combined, over 1,000 vph ramp traffic merges with the mainline. Also, the combined ramp lane and the loop ramp are not metered, often resulting in platoon merging at the mainline, creating the bottleneck condition and resulting in traffic congestion.

In total, the mainline traffic with the ramp traffic is over 5,000 vph in 3 lanes or nearly 1,700 vphpl, approaching the threshold level. Platoon merging at this level is likely to result in a breakdown of the mainline traffic flow.

Since the Valley View on- and off-ramps are located so close to each other, with detectors that are less than 0.2 miles apart, the previous bottleneck analysis did not analyze the bottleneck area between the Valley View off-ramp and on-ramp.

Exhibit 5-8: Westbound SR-22 Mainline at Valley View Street On-Ramp



Northbound I-405 On-Ramp

Exhibit 5-9 is an aerial photograph of the westbound SR-22 mainline merge with the northbound I-405 mainline. As indicated, the westbound SR-22 mainline carries approximately 5,000 vph in three lanes while the northbound I-405 mainline carries approximately 8,000 vph in five lanes typically on most heavy weekdays.

The westbound SR-22, however, drops a lane from three lanes to two. Two lanes cannot accommodate 5,000 vph, resulting in the bottleneck condition and traffic congestion. Moreover, the traffic from the westbound SR-22 begins actively weaving into the northbound I-405 lanes, also impacting the I-405 traffic and thereby also creating congestion there. Just past the lane drop, the combined freeways reach a total traffic flow of over 13,000 vph across seven lanes. This is nearly 1,900 vphpl, which is near the threshold level.

Exhibit 5-9: Westbound SR-22 Mainline at Northbound I-405

Northbound I-405 Mainline Bottlenecks and Causes

Major northbound bottlenecks and congestion often occur during both AM and PM peak hours. The following is a summary of the northbound bottlenecks and the identified causes.

Sand Canyon Off-Ramp

Exhibit 5-10 is an aerial photograph of the northbound I-405 mainline at the Sand Canyon Avenue interchange. During the AM peak hours, the mainline traffic can reach 9,000 vph in five lanes. Immediately past the off-ramp to Sand Canyon Avenue (with about 400 vph), a lane drop occurs, from five to four lanes for the mainline traffic of over 8,600 vph. Four lanes cannot accommodate this amount of traffic. As a result, bottleneck and congestion occurs at this location, as evident in the inset pictures.

Exhibit 5-10: Northbound I-405 Mainline at Sand Canyon Avenue

Jeffrey Road On-Ramp

Exhibit 5-11 is an aerial photograph of the northbound I-405 mainline at the Jeffrey Road interchange. As shown, there are back-to-back on-ramp merges with a combined flow of over 1,500 vph during the AM peak hours. While both ramps are metered, the westbound ramp allows over 1,200 vph (via two metered lanes), resulting in a platoon of vehicles merging onto the mainline, causing the bottleneck condition and traffic congestion, as evident in the inset picture. The mainline flow is near 7,700 vph in four lanes. The mainline cannot accommodate the additional 1,500 vph of traffic.

Exhibit 5-11: Northbound I-405 Mainline at Jeffrey Road On-Ramp

SR-73/Fairview Road On-Ramp

Exhibit 5-12 is an aerial photograph of the northbound I-405 mainline at the SR-73 connector on-ramp and Fairview Road on-ramp. As illustrated, the SR-73 connector ramp adds to the mainline approximately 3,300 vph in three lanes that reduces into two lanes further downstream. In addition, the Fairview Road on-ramp near the crest of the uphill grade adds another 500 vph to the mainline, bringing the total to 11,000 vph in six lanes or over 1,800 vphpl on an uphill grade, often resulting in the bottleneck condition and traffic congestion, as evident in the inset picture.

Exhibit 5-12: Northbound I-405 Mainline at SR-73/Fairview Road On-Ramp

Caltrans

Euclid Street On-Ramp /Brookhurst Street Off-Ramp

Exhibit 5-13 is an aerial photograph of the northbound I-405 at Euclid Street and Brookhurst Street interchanges. At the Euclid Street off-ramp, one of the lane additions from the SR-73 connector is dropped at the exit, going from six lanes to five, with heavy off-ramp traffic often exceeding 1,400 vph. Between the Euclid Street on-ramp and the Brookhurst Street off-ramp, another lane is dropped from five lanes to four, forcing about 6,500 cars to be squeezed in. Although the mainline flow has not reached the threshold level (existing level is 8,000 vph in five lanes or 1,600 vphpl), the weaving results in the bottleneck condition and traffic congestion, as evident in the inset pictures. This condition is more pronounced when the mainline demand is higher.

Exhibit 5-13: Northbound I-405 Mainline at Euclid Street On-Ramp /Brookhurst Street Off-Ramp

Caltrans

Brookhurst Street On-Ramp

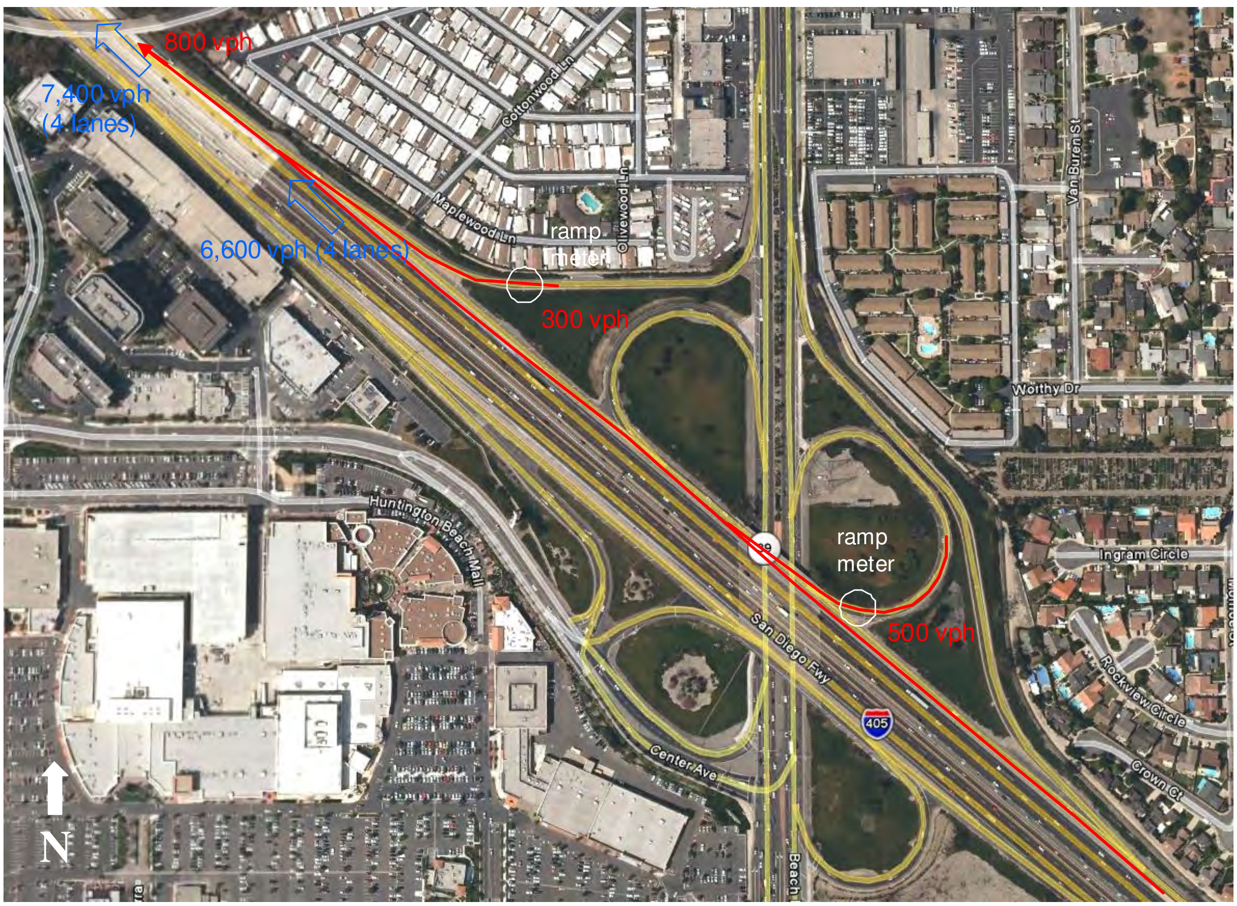
Exhibit 5-14 is an aerial photograph of the northbound I-405 at the Brookhurst Street on-ramp. As illustrated, this interchange includes a collector/distributor. While both on-ramps from Brookhurst Street are metered, the collector/distributor is not. As a result, platoons of vehicles merge onto the freeway mainline, causing mainline traffic flow to breakdown. This creates bottleneck conditions and traffic congestion. For much of the time during the PM peak hours, the steady stream of vehicles (platoons) merges onto the freeway, as shown on the inset pictures. With the added ramp traffic, the mainline facility cannot accommodate a total demand of over 7,800 vph, or 1,950.

Exhibit 5-14: Northbound I-405 Mainline at Brookhurst Street On-Ramp

Beach Boulevard (SR-39) On-Ramp

Exhibit 5-15 is an aerial photograph of the northbound I-405 at the Beach Boulevard interchange. Although the operational issues are not as significant, the condition at this interchange is similar to the Brookhurst Street interchange with the collector/distributor. The flow from the ramps is less at about 800 vph combined. The extent and magnitude of the bottleneck condition and congestion are also less at this location than at Brookhurst Street, mainly because the bottleneck at Brookhurst Street reduces the traffic demand at Beach Boulevard. If the bottleneck at Brookhurst Street were eliminated, the Beach Boulevard bottleneck would be exacerbated.

Exhibit 5-15: Northbound I-405 Mainline at Beach Boulevard (SR-39) On-Ramp



SR-22 On-Ramp

Exhibit 5-16 is an aerial photograph of the northbound I-405 at the SR-22 on-ramp. As the exhibit illustrates, the SR-22 ramp drops a lane, just as it merges, from three lanes to two for 5,000 vph of traffic. Since the two lanes cannot accommodate the 5,000 vph of traffic, congestion builds quickly and traffic moves over onto the I-405 mainline, causing I-405 to break down also. After the lane drop, the total flow on the freeway is over 13,000 vph in seven lanes or over 1,850 vphpl. This is near the breaking point or threshold level. With the merging and weaving, the bottleneck condition is created and congestion results.

Exhibit 5-16: Northbound I-405 Mainline at SR-22 On-Ramp

Caltrans

Southbound I-405 Mainline Bottlenecks and Causes

Major southbound bottlenecks and accompanying congestion often occur during both the AM and PM peak hours. The following is a summary of the southbound bottlenecks and the identified causes.

<u>I-605 On-Ramp</u>

Exhibit 5-17 is an aerial photograph of the southbound I-405 mainline at the I-605 connector on-ramp. As shown in the inset photos, significant congestion is evident on both the I-605 connector and the I-405 mainline at the merge. The main cause of this bottleneck is the lane drop that occurs at the merge reducing the total lanes from six lanes to five. As the ramp traffic merges over to the left, the mainline flow breaks down and results in the bottleneck condition at this location.

Exhibit 5-17: Southbound I-405 Mainline at I-605 On-Ramp

Seal Beach On-Ramp

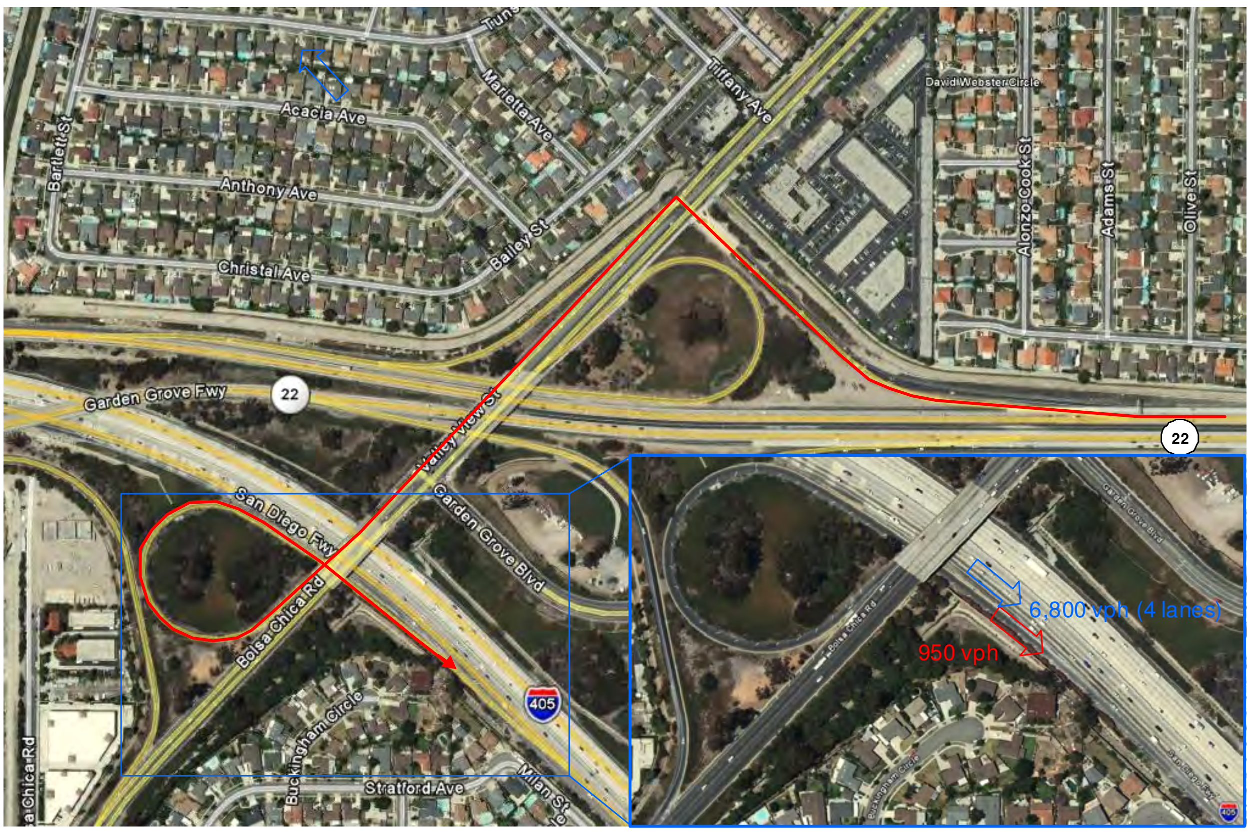
Exhibit 5-18 is an aerial photograph of the southbound I-405 mainline at the Seal Beach Boulevard interchange and SR-22 interchange. Although this is not a major bottleneck location and congestion was not observed on any of the field visits, data analysis indicates existing bottleneck conditions and traffic congestion. It is likely that the main cause of this bottleneck is due to the cross-weaving of the Seal Beach Boulevard on-ramp traffic and SR-22 off-ramp traffic.

Exhibit 5-18: Southbound I-405 Mainline at Seal Beach On-Ramp

Bolsa Chica/Valley View Road (SR-22) On-Ramp

Exhibit 5-19 is an aerial photograph of the southbound I-405 mainline at the Bolsa Chica Road interchange. Traffic from the westbound SR-22 typically exits at Valley View Street and re-enters the I-405 freeway at Bolsa Chica Road interchange. Nearly 1,000 vph enters the freeway at this location. This is also not a major bottleneck location and congestion was not observed on any of the field visits, but data analysis indicates existing bottleneck conditions and traffic congestion. Depending on the mainline demand, it is likely that the bottleneck condition occurs when the mainline demand is high (near or above 7,000 vph).

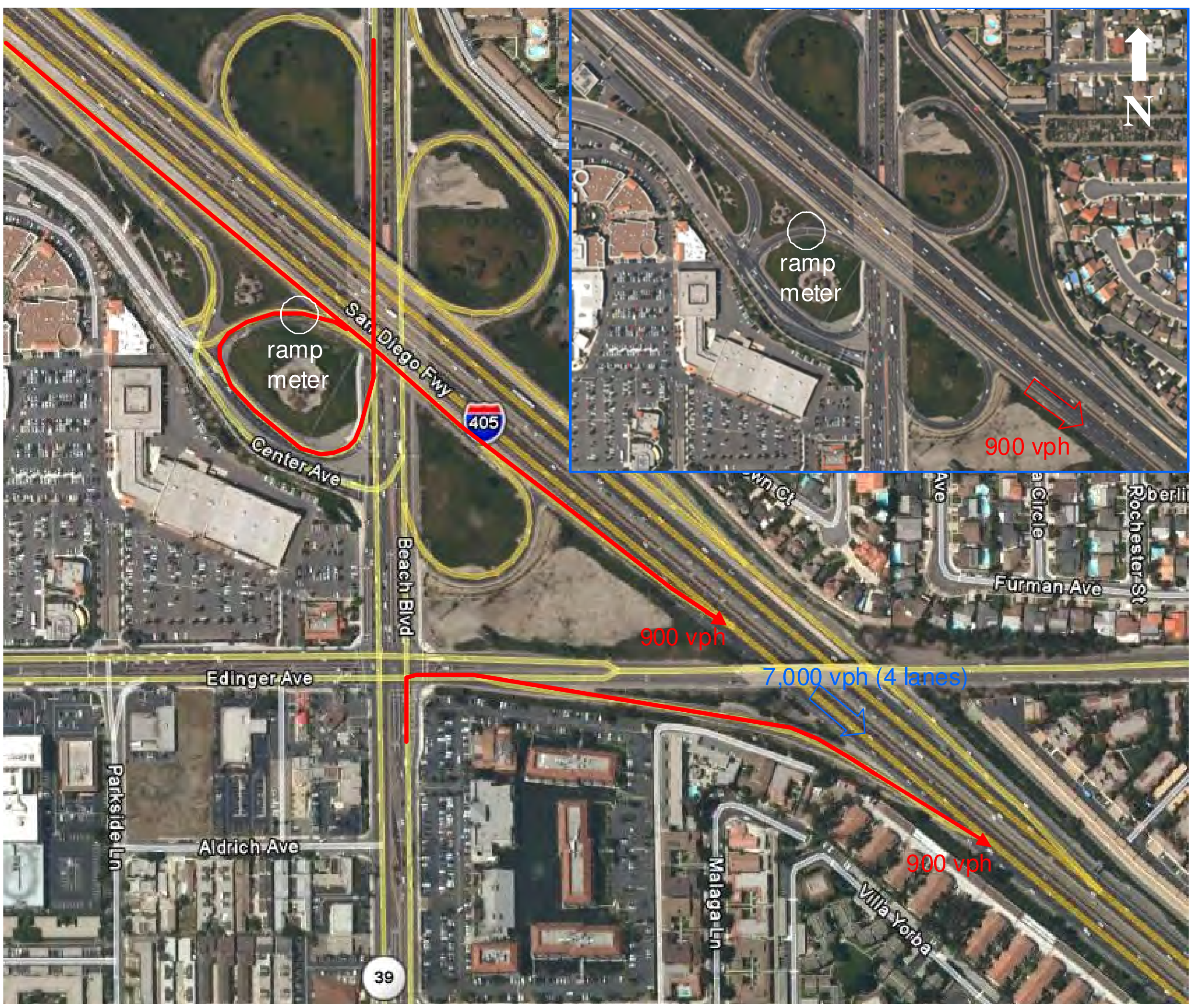
Exhibit 5-19: Southbound I-405 Mainline at Bolsa Chica Road (SR-22) On-Ramp



Beach Boulevard (SR-39)/Edinger Avenue On-Ramp

Exhibit 5-20 is an aerial photograph of the southbound I-405 at the Beach Boulevard (SR-39) on-ramp and Edinger Avenue on-ramp. As shown, the Beach Boulevard interchange has a collector/distributor. Although the westbound (southbound) Beach Boulevard loop on-ramp is metered, the collector/distributor is not. Over 900 vph are added to the mainline from this ramp. Shortly past this merge point, another on-ramp merge occurs from Edinger Avenue. Additional 900 vph metered traffic are also added to the freeway mainline, resulting in nearly 7,900 vph in four lanes. This is very close to threshold traffic and results a bottleneck condition.

Exhibit 5-20: Southbound I-405 Mainline at Beach Boulevard (SR-39)/ Edinger Avenue On-Ramp



Warner Avenue On-Ramp

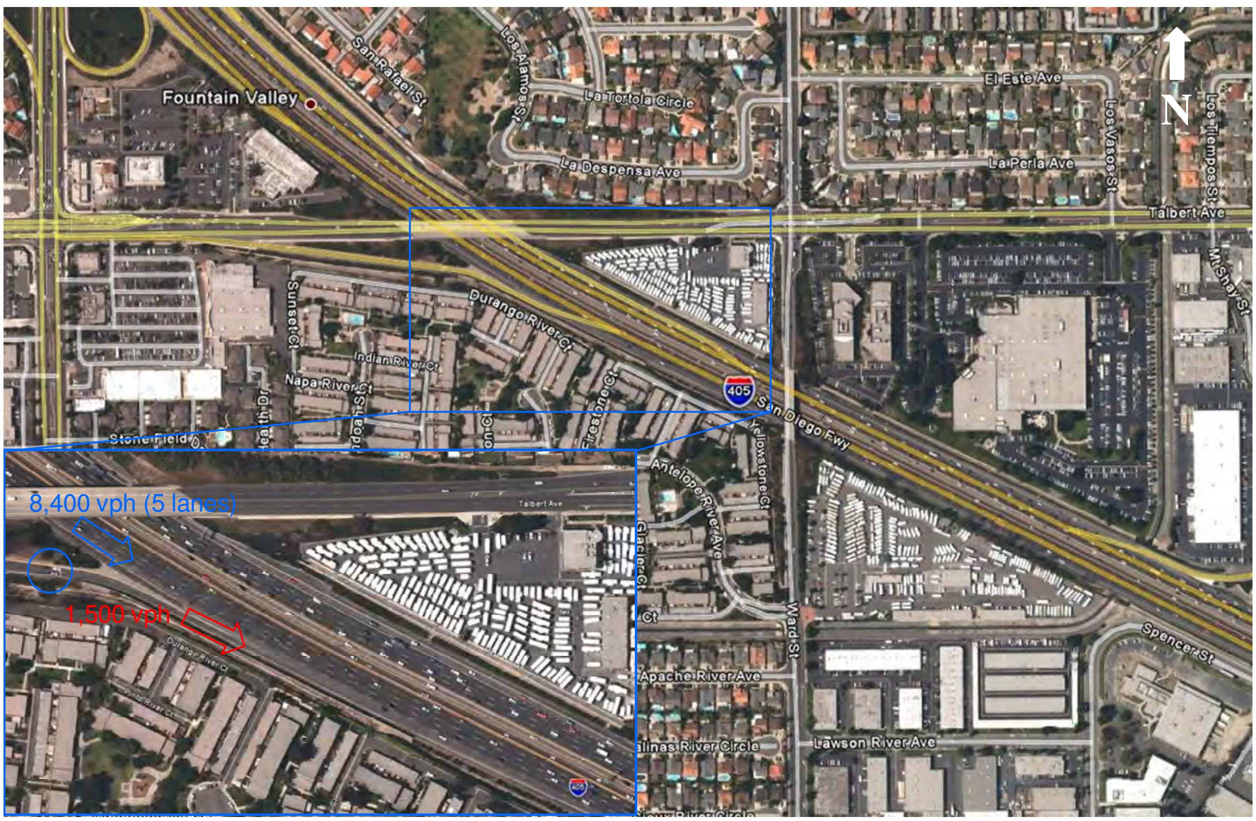
Exhibit 5-21 is an aerial photograph of the southbound I-405 mainline at the Warner Avenue on-ramp. As shown in the inset picture, there is a surge of demand (over 1,000 vph) from the on-ramp, which enters the freeway as platoons. This location is the most significant bottleneck on this corridor, with queues extending for many miles. Also indicated in the inset picture are higher speeds and separation of vehicles just past the on-ramp merge point. With mainline flow exceeding 7,400 vph in four lanes, the mainline cannot accommodate additional 1,000 vehicles of traffic.

Exhibit 5-21: Southbound I-405 Mainline at Warner Avenue On-Ramp

Talbert Avenue On-Ramp

Exhibit 5-22 is an aerial photograph of the southbound I-405 mainline at the Talbert Avenue on-ramp. With two lanes metered, the on-ramp flow merging onto the freeway often reaches 1,500 vph during the peak hours. With the mainline already at 8,400 vph approaching the ramp, the five freeway lanes cannot accommodate the total combined flow of nearly 10,000 vph.

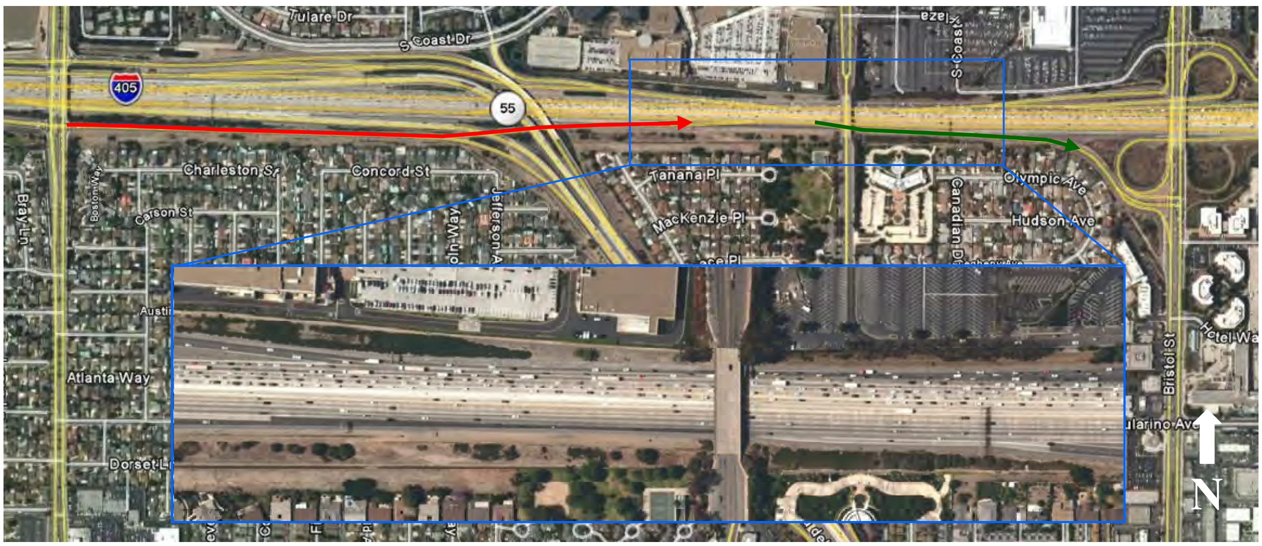
Exhibit 5-22: Southbound I-405 Mainline at Talbert Avenue On-Ramp



Fairview Road On-Ramp /Bristol Street Off-Ramp

Exhibit 5-23 is an aerial photograph of the southbound I-405 mainline between the Fairview Road on-ramp and Bristol Street off-ramp. As indicated, over 2,500 vph cross-weaves along the 1,000-foot stretch of freeway segment between the two ramps. This condition often results in a bottleneck and ensuing traffic congestion.

Exhibit 5-23: Southbound I-405 Mainline at Fairview Road On-Ramp /Bristol Street Off-Ramp



SR-55 On-Ramp /MacArthur Boulevard Off-Ramp

Exhibit 5-24 is an aerial photograph of the southbound I-405 mainline between the SR-55 connector on-ramps and MacArthur Boulevard off-ramp. As indicated in the picture, consecutive SR-55 connector ramps add over 2,300 vph. The MacArthur Boulevard off-ramp carries as much as 2,500 vph during the AM peak hours. As a result, significant cross-weaving occurs at this location and often causes a bottleneck condition to occur resulting in traffic congestion.

Exhibit 5-24: Southbound I-405 Mainline at SR-55 On-Ramp /MacArthur Boulevard Off-Ramp

Culver Drive On-Ramp

Exhibit 5-25 is an aerial photograph of the southbound I-405 mainline at the Culver Drive interchange. With back-to-back on-ramp merges for a combined flow of over 1,100 vph, the mainline cannot accommodate the nearly 8,000 vph in four lanes, creating the bottleneck condition at this location and resulting in traffic congestion.

Exhibit 5-25: Southbound I-405 Mainline at Culver Drive On-Ramp

Jeffrey Road/University Drive On-Ramp

Exhibit 5-26 is an aerial photograph of the southbound I-405 mainline at the University Drive interchange. A series of on-ramp merges produce a combined flow of over 1,300 vph. The mainline cannot accommodate the over 8,200 vph in four lanes, creating the bottleneck condition at this location and resulting in traffic congestion. The two metered lanes that allow over 1,100 vph to merge onto the freeway results in a platoon of vehicles merging and traffic congestion on the mainline, as evident in the inset picture.

Exhibit 5-26: Southbound I-405 Mainline at University Drive On-Ramp

Sand Canyon/Shady Canyon Avenue On-Ramp

Exhibit 5-27 is an aerial photograph of the southbound I-405 mainline at the Shady Canyon Avenue interchange. When the mainline demand is heavy at over 7,500 vph in four lanes, the mainline cannot accommodate the additional demand of over 500 vph from the Shady Canyon Avenue on-ramp, resulting in the bottleneck condition.

Exhibit 5-27: Southbound I-405 Mainline at Sand/Shady Canyon Avenue On-Ramp

Southbound I-605 Mainline Bottleneck and Cause

Congestion and bottleneck conditions occur on the I-605 study corridor during the PM peak only. Although northbound congestion also exists on I-605, it is beyond the limits of the study.

<u>Southbound I-405 On-Ramp</u>

Exhibit 5-28 is an aerial photograph of the southbound I-605 mainline connector on-ramp to the southbound I-405 freeway. During the PM peak hours, the traffic from the I-605 at about 3,100 vph merges with the southbound I-405 traffic carrying about 6,500 vph in 4 lanes, for a total of over 9,600 vph in five lanes, as the outer lane is dropped. This lane drop results in the mainline traffic over the threshold level creating the bottleneck condition and resulting traffic congestion, as evident in the inset pictures.

Exhibit 5-28: Southbound I-605 Mainline at Southbound I-405

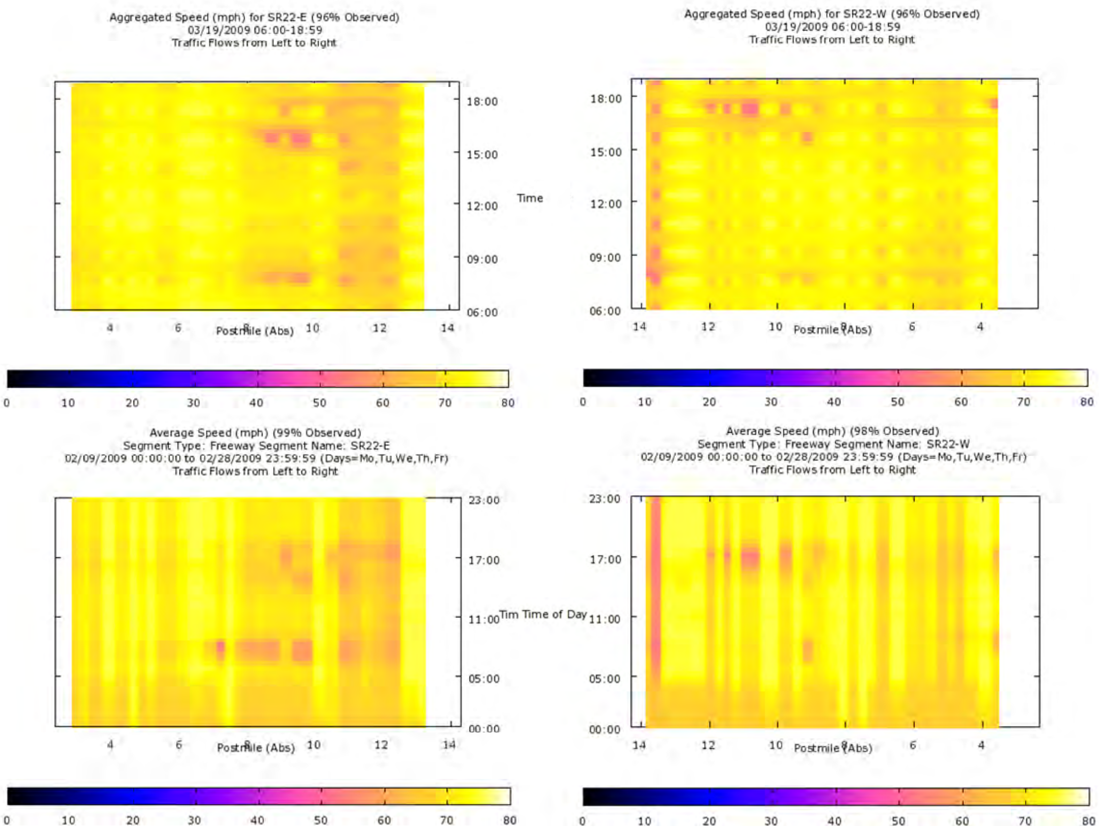
High-Occupancy Vehicle (HOV) Facility

Bottleneck and causality analyses were also conducted for the HOV facilities on SR-22 and I-405. The bottleneck locations on the HOV facility were initially determined based on automatic detector data analysis and later verified by multiple field reviews that confirmed the actual bottleneck locations and identified the causes. The HOV facility along the SR-22 Corridor is contiguous and operates on a full-time basis with a vehicle occupancy requirement of two plus in both directions. Similarly, the HOV facility along I-405 operates on a full-time basis with a vehicle occupancy requirement of two plus in both directions, but is buffer-separated from the mainline facility in varying widths. The I-605 Corridor in Orange County does not comprise an HOV facility. The proceeding section describes the bottleneck locations and the causes for the bottlenecks that were verified on the SR-22 and I-405 HOV facilities.

SR-22 HOV Facility Bottlenecks and Causes

The analysis of automatic detector data, and multiple field reviews conducted in February and March 2009 during the weekday peak period, confirm that there are no bottlenecks or traffic congestion on SR-22 in either direction of the HOV facility. Exhibit 5-29 shows the speed contours of the HOV lanes in both directions. These speed contours indicate speeds well above 50 miles per hour during all hours of the day for the sample day in March 2009 and the average of multiple weekdays in the last three weeks of February 2009. This sample period is based on excellent data quality.

Exhibit 5-29: Eastbound and Westbound SR-22 HOV Speed Contours



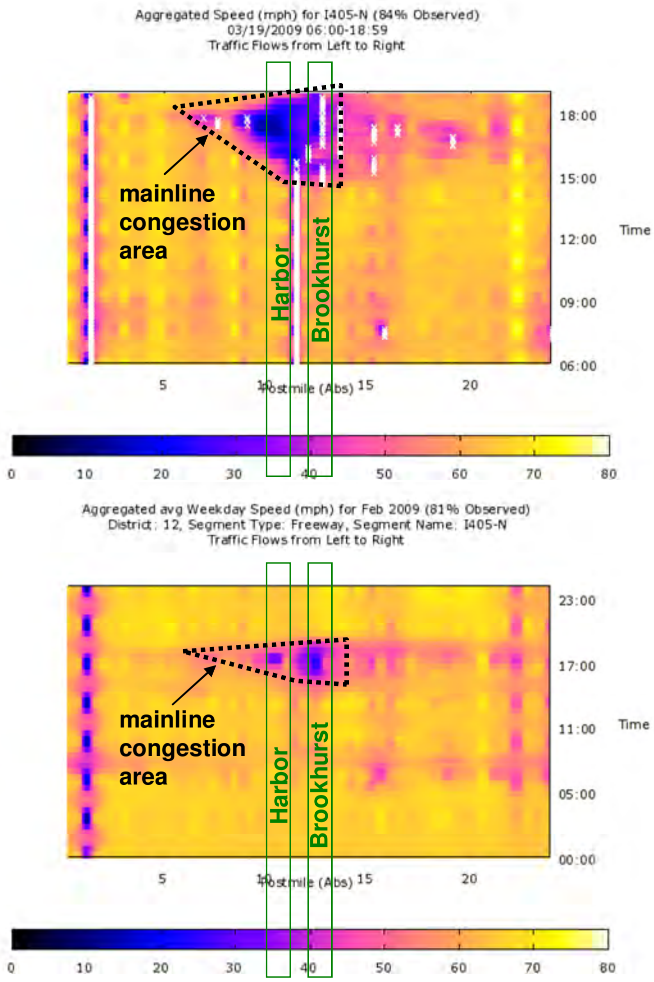
Northbound I-405 HOV Facility Bottlenecks and Causes

Automatic detector data analysis and multiple field reviews conducted in February and March 2009 during the weekday peak period confirm two major bottlenecks in the northbound direction at the following locations:

- Brookhurst Street ingress/egress (Caltrans postmile 13.5)
- Harbor Boulevard ingress/egress (Caltrans postmile 11.0).

These two bottleneck locations are caused by weaving traffic entering and exiting at the HOV lane ingress/egress areas during the peak hours. Exhibit 5-30 presents the speed contour diagram of the northbound I-405 HOV lane for a sample day in March 2009 and for an average of all weekdays in the month of February 2009. As indicated in the exhibit, the two bottleneck locations at the Brookhurst Street ingress/egress and at the Harbor Boulevard ingress/egress coincide within the mainline congestion area. As a result, the vehicles on the HOV lane that intend to exit the corridor must stop to squeeze into the mainline congested traffic stream. Similarly, the vehicles on the mainline which intend to enter the HOV lane must do so from a very low speed, disrupting the HOV lane flow. The HOV volume at these two locations exceeds 1,600 vehicles per hour (vph) during the PM peak hours, which is near the threshold or capacity level of 1,800 vph.

Exhibit 5-30: Northbound I-405 HOV Speed Contours (2009)



Exhibits 5-31 and 5-32 are aerial photographs of the HOV lane ingress/egress areas of the Brookhurst Street and Harbor Boulevard bottleneck locations. When the mainline freeway is congested, vehicles have a difficult time entering and exiting the HOV lane. As a result, a bottleneck condition occurs and vehicles queue behind this location, as far back as five miles.

Exhibit 5-31: Northbound I-405 HOV Ingress/Egress at Brookhurst Street

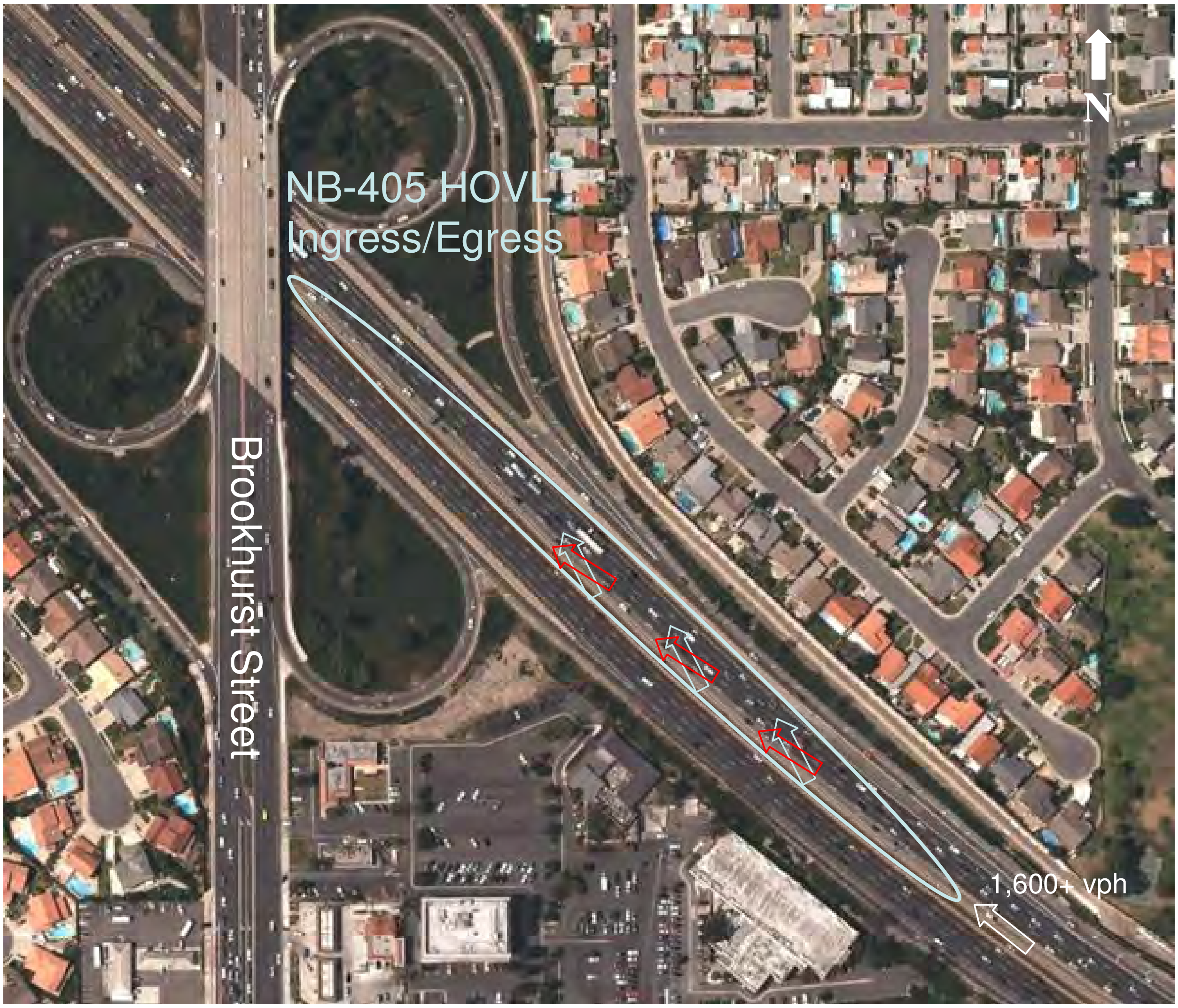


Exhibit 5-32: Northbound I-405 HOV Ingress/Egress at Harbor Blvd

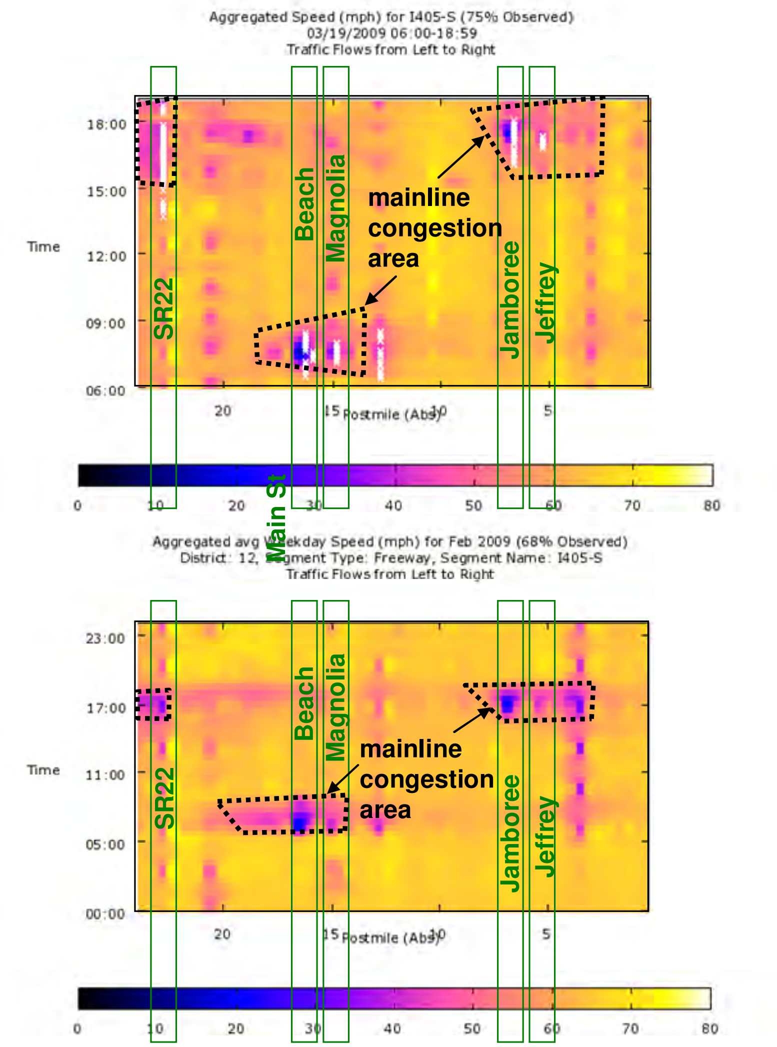
Southbound I-405 HOV Facility Bottlenecks and Causes

Automatic detector data analysis and multiple field reviews conducted in February and March 2009 during the weekday peak period confirm five major bottlenecks in the southbound direction at the following locations:

- Seal Beach Boulevard ingress/egress (Caltrans postmile 22.0)
- North of Beach Boulevard ingress/egress (Caltrans postmile 17.0)
- Magnolia Street ingress/egress (Caltrans postmile 15.0)
- South of Jamboree Road ingress/egress (Caltrans postmile 6.0)
- South of Culver Drive ingress/egress (Caltrans postmile 5.0).

These five bottleneck locations are caused by weaving traffic entering and exiting at the HOV lane ingress/egress areas during the peak hours. Exhibit 5-33 presents the speed contour diagram of the southbound I-405 HOV lane for a sample day in March 2009 and for an average of all weekdays in the month of February 2009. As indicated in the exhibit, all five bottleneck locations are within the mainline congestion area. As a result, the vehicles on the HOV lane that intend to exit the corridor must stop to squeeze into the mainline congested traffic stream. Similarly, the vehicles on the mainline which intend to enter the HOV lane must do so from a very low speed, disrupting the HOV lane flow. The HOV volumes at these locations vary from 1,500 vph to 2,100 vph during the peak hours, near or over the threshold capacity level of 1,800 vph. Also as indicated, the bottlenecks at Beach Boulevard and Magnolia Street occur during the AM peak hours, whereas the other three bottlenecks occur during the PM peak hours.

Exhibit 5-33: Southbound I-405 HOV Speed Contours (2009)



Exhibits 5-34 to 5-38 are the aerial photographs of the bottleneck locations of the HOV lane ingress/egress areas at: Seal Beach Boulevard; north of Beach Boulevard; Magnolia Avenue; south of Jamboree Road; and south of Culver Drive. When the mainline freeway is congested, vehicles have a difficult time entering and exiting the HOV lane. As a result, bottleneck conditions occur and vehicles queue behind these locations. Peak hour volumes are near or exceed threshold capacity levels at all of these locations.

Exhibit 5-34: Southbound I-405 HOV Ingress/Egress at Seal Beach Blvd.

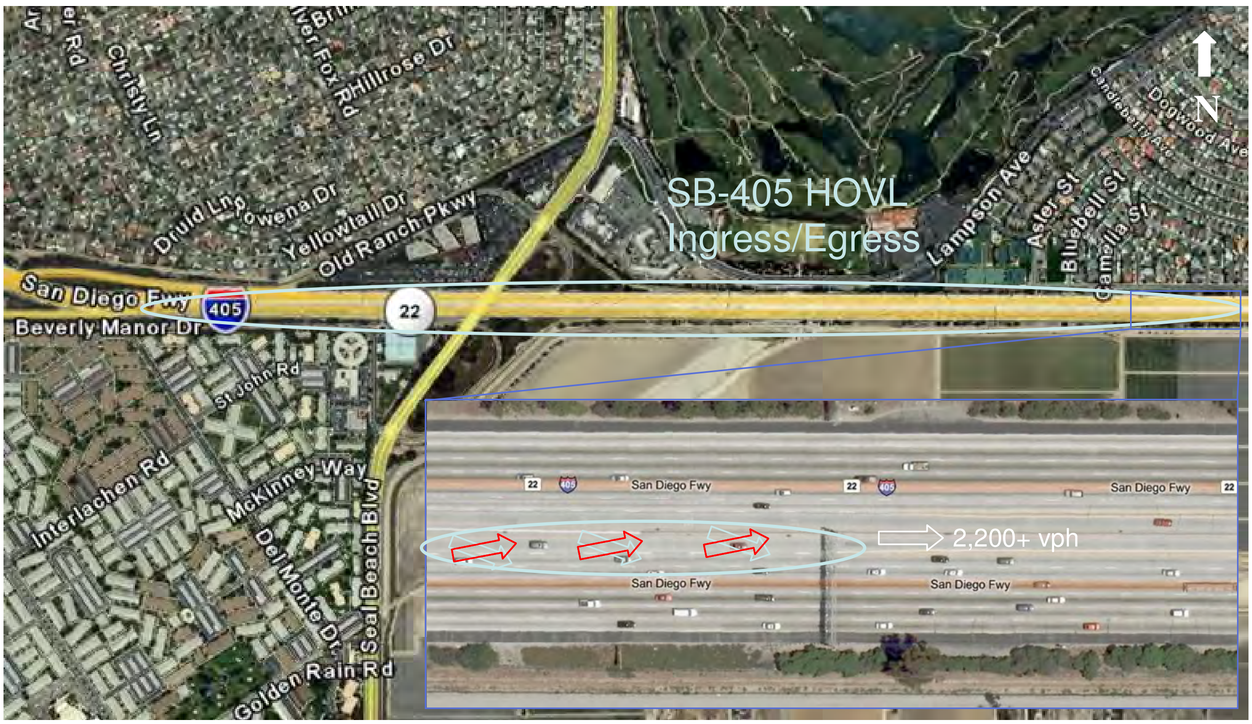


Exhibit 5-35: Southbound I-405 HOV Ingress/Egress at Beach Blvd.

Caltrans

Exhibit 5-36: Southbound I-405 HOV Ingress/Egress at Magnolia Street

Exhibit 5-37: Southbound I-405 HOV Ingress/Egress at South of Jamboree Road

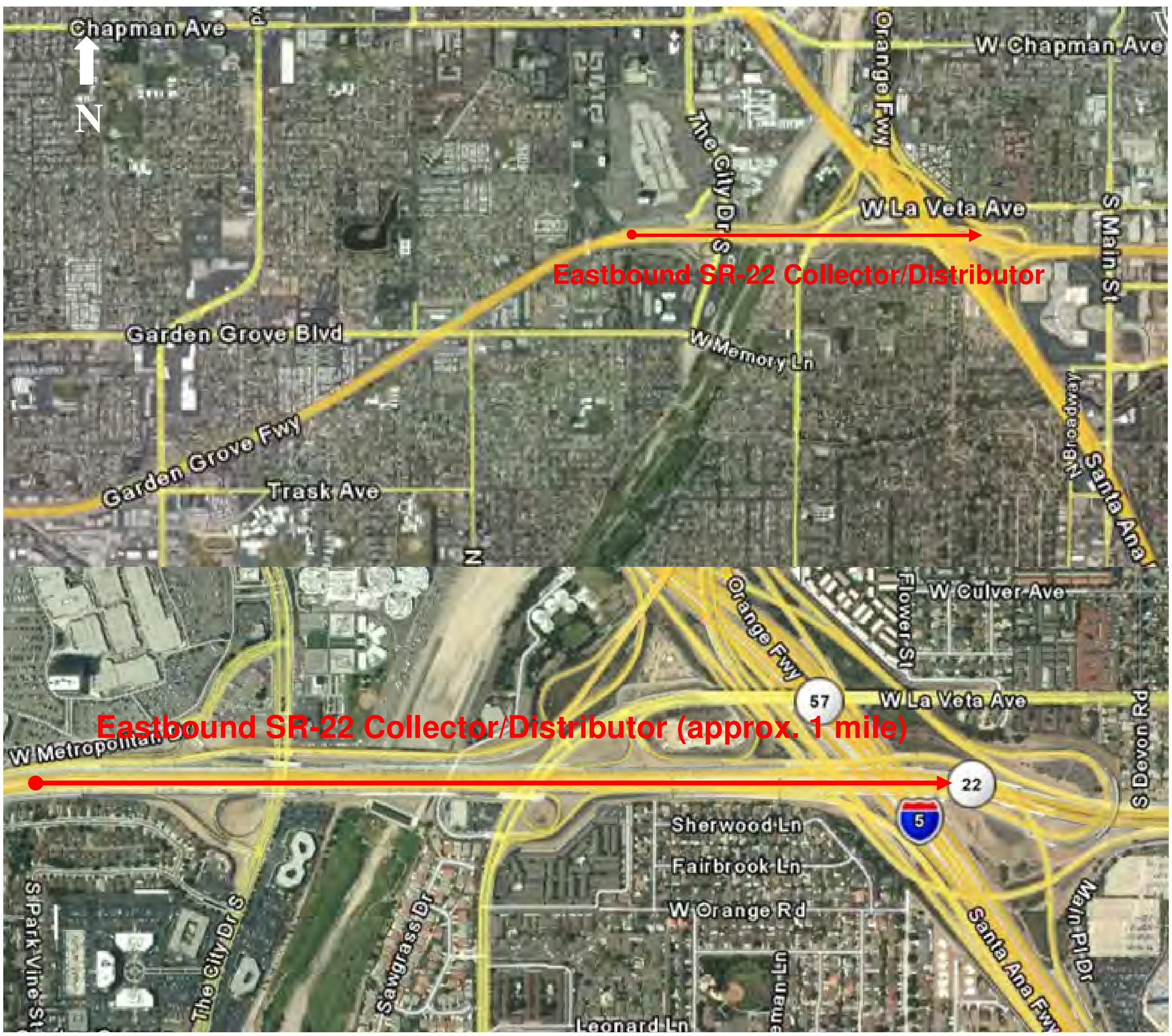
Exhibit 5-38: Southbound I-405 HOV Ingress/Egress at South of Culver Drive

Collector/Distributor (C/D) Facility

Eastbound SR-22 C/D Facility Bottlenecks and Causes

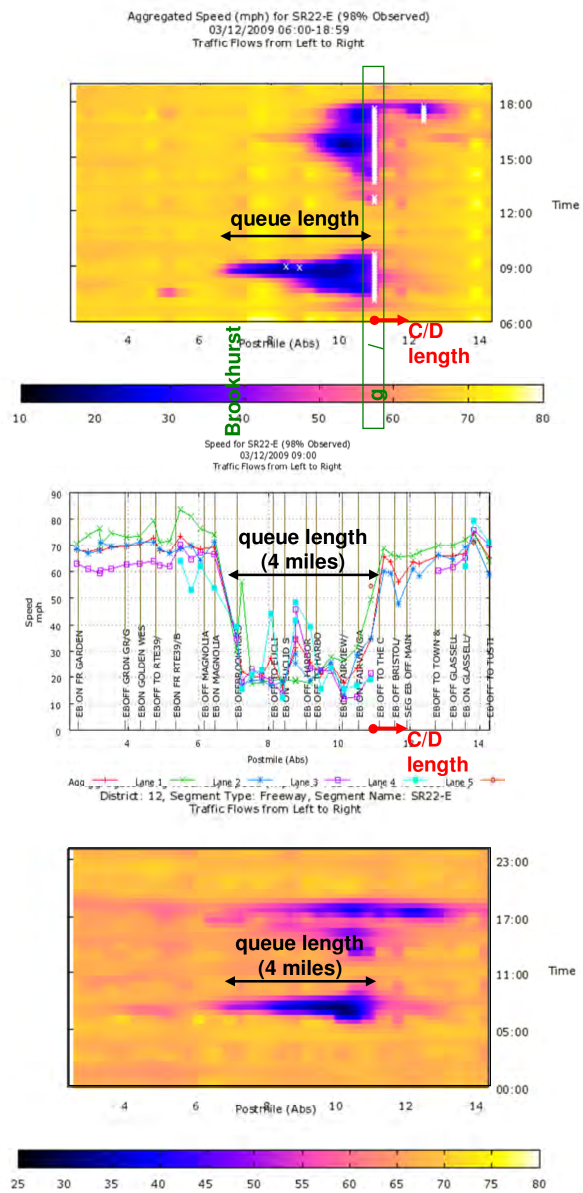
Bottleneck and causality analyses were also conducted for the collector/distributor (C/D) facility of SR-22 in the eastbound direction from City Drive to the SR-57 connector ramp. Exhibit 5-39 is an aerial photograph of the SR-22 C/D facility. The two-lane C/D is approximately one mile in length and runs from slightly west of the City Drive off-ramp to slightly east of the SR-57 connector off-ramp. Within the C/D, there are two interchanges , City Drive and Bristol Street, which interact with the C/D.

Exhibit 5-39: Eastbound SR-22 Collector/Distributor Section



During the AM and PM peak hours, the demand for the C/D so heavy that that the entrance of the C/D does not have enough capacity to accommodate the demand. As a result, bottleneck conditions occur and significant congestion and queuing forms. Exhibit 5-40 presents the speed contour diagram and speed profile of the eastbound SR-22 mainline (not including C/D) for a sample day in March 2009 and for an average of all weekdays in the month of February 2009. As indicated the bottleneck causes over four miles of queuing to Brookhurst Street that lasts three hours, from 7 AM to 10 AM, in the AM peak and four hours, from 2 PM to 6 PM, in the PM peak, with speeds below 20 miles per hour.

Exhibit 5-40: Eastbound SR-22 Speed Contours (2009)



Exhibits 5-41 and 5-42 are aerial photographs of the C/D facility. The bottleneck section is from the C/D entrance to the southbound I-5 connector off-ramp. As shown, the bottleneck volume is around 3,900 vehicles per hour (vph) in two lanes and the output (C/D capacity) volume is over 4,100 vph in two lanes. The key bottleneck segment is the Bristol Street auxiliary lane that runs from the on-ramp to the southbound I-5 off-ramp. As indicated in Exhibit 5-42, the auxiliary lane that services the Bristol Street on-ramp volume of over 1,500 vph and the I-5 off-ramp of over 1,500 during the AM peak hours, is extremely short(500 feet).. In addition to this 3,000 vehicles of cross-weaving, the I-5 connector off-ramp often queues back onto the C/D, in the AM peak. Traffic bound for the northbound I-5 and northbound SR-57, over 4,000 vph, must endure and pass through the congestion of the C/D, adding and contributing to the overall demand of the C/D. Without the C/D, this traffic could bypass the bottleneck stemming from the southbound I-5 connector off-ramp.

Exhibit 5-41: Eastbound SR-22 Collector/Distributor

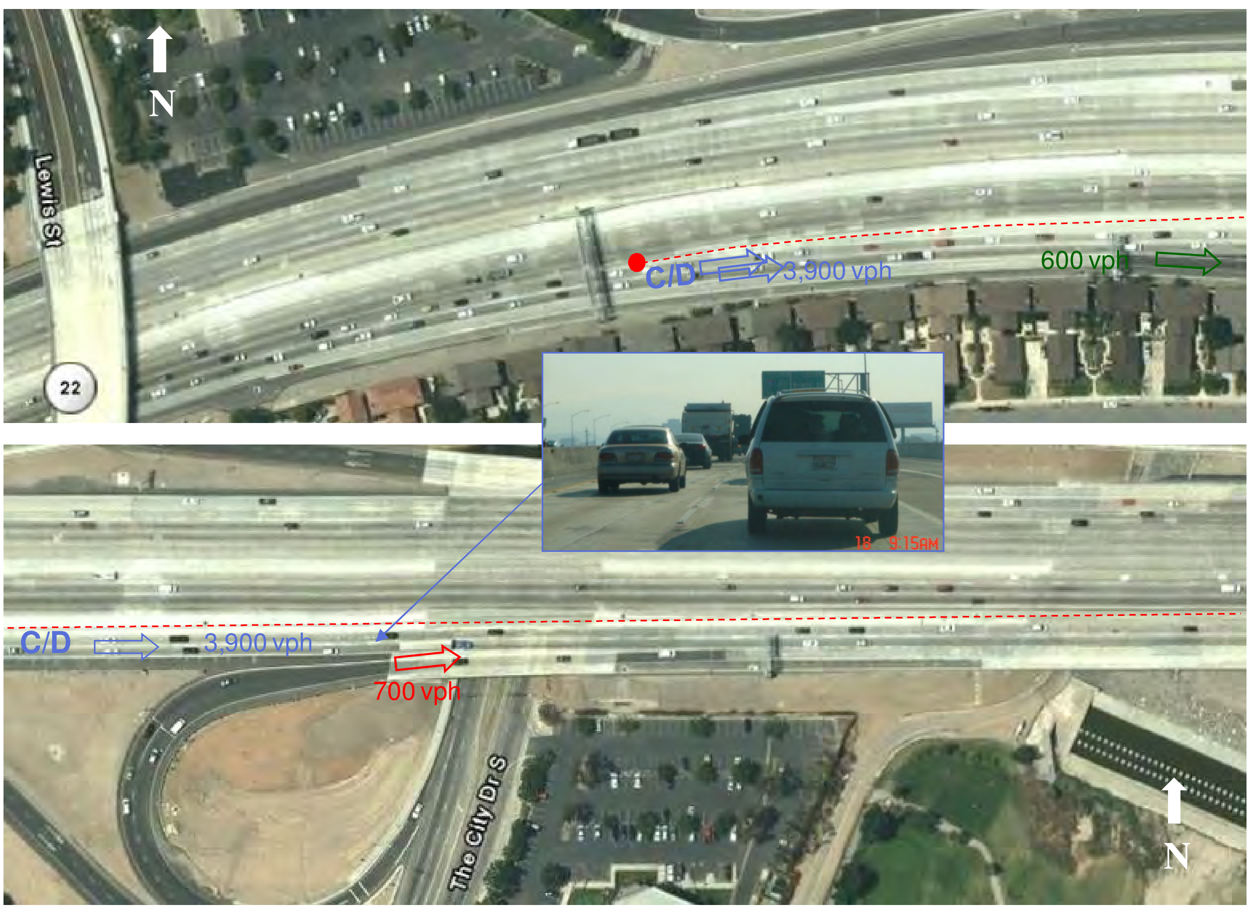
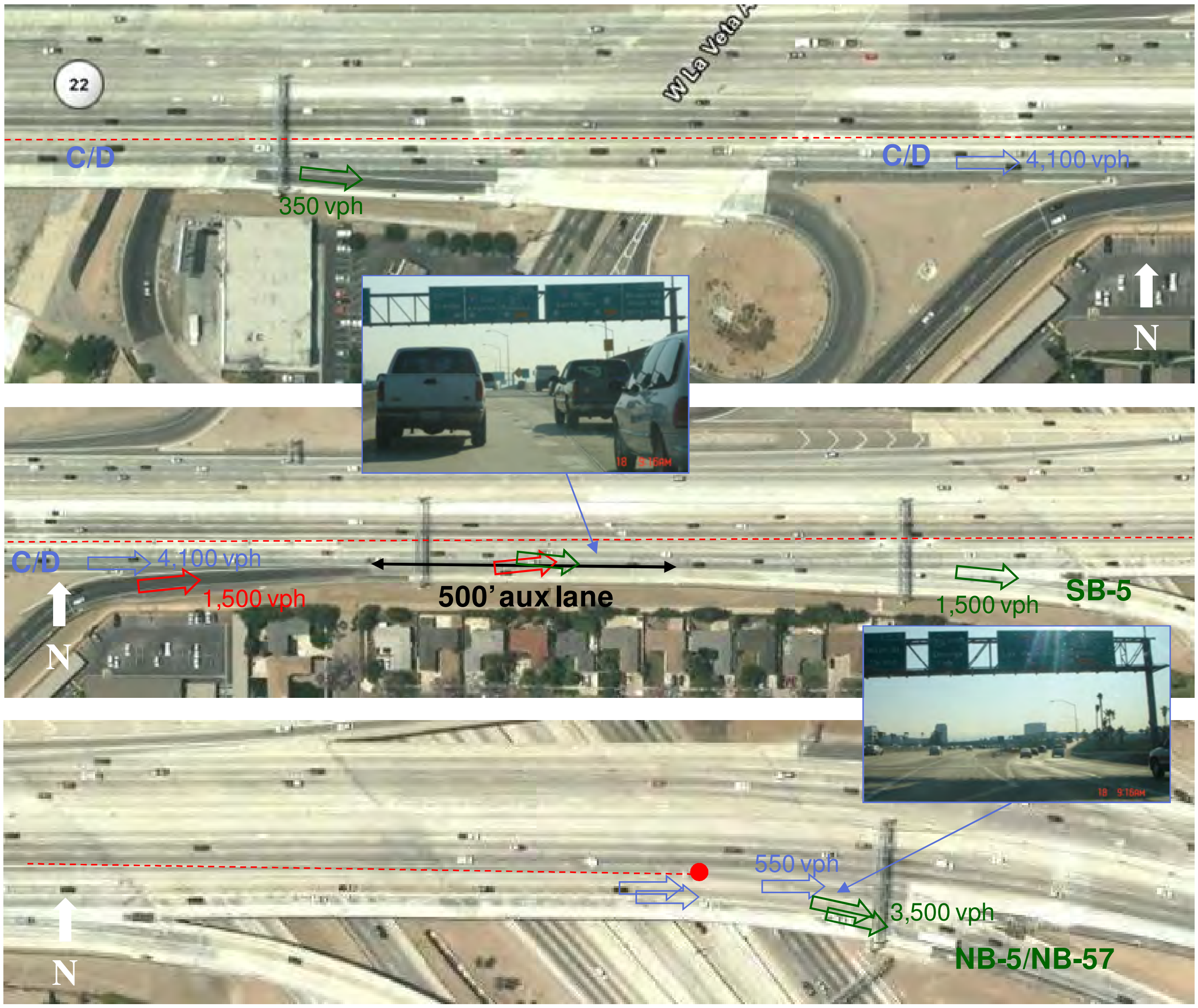


Exhibit 5-42: Eastbound SR-22 Collector/Distributor (continued)



6. SCENARIO DEVELOPMENT AND EVALUATION

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

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

Traffic Model Development

The study team developed separate traffic models for SR-22 and I-405 using 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, they are one of few 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.

Exhibit 6-1 shows the SR-22/I-405 road network included in the models. All freeway interchanges were included as well as on- and off-ramps. Note that only certain arterials were included. Adding more arterials would have challenged the calibration process and delayed the overall project. The study team calibrated the two base year models against 2008 conditions presented earlier. This was a resource-intensive effort, requiring several submittal and review cycles until the model reasonably matched bottleneck locations and relative congestion levels. After acceptance of the base year model, the team also developed a model with 2020 demands extrapolated from the OCTA 2030 travel demand model. Caltrans and the study team agreed to 2020 as the Horizon Year since micro-simulation modeling captures operational strategies, but is typically suited for the short- to medium-term forecasting. Note that latent demand over and beyond the OCTA forecast demand was not accounted for in the analysis.

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

Exhibit 6-1: SR-22/I-405 Micro-Simulation Model Networks

Scenario Development Framework

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

- Projects already completed since the 2008 base year or fully programmed and funded were combined and separated from projects that were not, and tested with both the 2008 and 2020 models.
- Corridor Mobility Improvement Account (CMIA) projects were separately from the others and tested with both the 2008 and 2020 models.
- Short-term operational projects (delivered typically by 2015) were grouped into scenarios to be tested with both the 2008 and 2020 models.
- Long-term projects (delivered after 2015, but before or by 2020) were used to develop scenarios to be tested with the 2020 model only.

The study team assumed that projects developed before 2015 could reasonably be evaluated using the 2008 base year model. The 2020 forecast year for the corridor was consistent with the OCTA regional travel demand model origin-destination matrices.

When OCTA updates its travel demand model and SCAG updates its Regional Transportation Plan (RTP), Caltrans may wish to update the micro-simulation model with revised demand projections.

Project lists used to develop scenarios were from the Regional Transportation Improvement Program (RTIP), the RTP, Measure M2, SR-91 Implementation Plan, Transportation Corridor Agencies (TCA) improvements, and other sources (such as special studies). The study team eliminated projects that do not directly affect mobility. For instance, sound wall, landscaping, or minor arterial improvement projects were eliminated because micro-simulation models cannot evaluate them. Appendix A provides project lists used in developing the micro-simulation scenarios.

Scenario testing performed for the SR-22/I-405/I-605 CSMP differs from traditional alternatives evaluations or Environmental Impact Reports (EIRs). Traditional alternatives evaluations or EIRs focus 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 SR-22/I-405/I-605 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 show an acceptable level of performance improvement.

Exhibits 6-2 and 6-3 summarize the approaches used and scenarios tested for the SR-22 and I-405 corridors, respectively. It also provides a general description of the projects included in the 2008 and 2020 micro-simulation runs.

Exhibit 6-2: SR-22 Micro-Simulation Modeling Approach

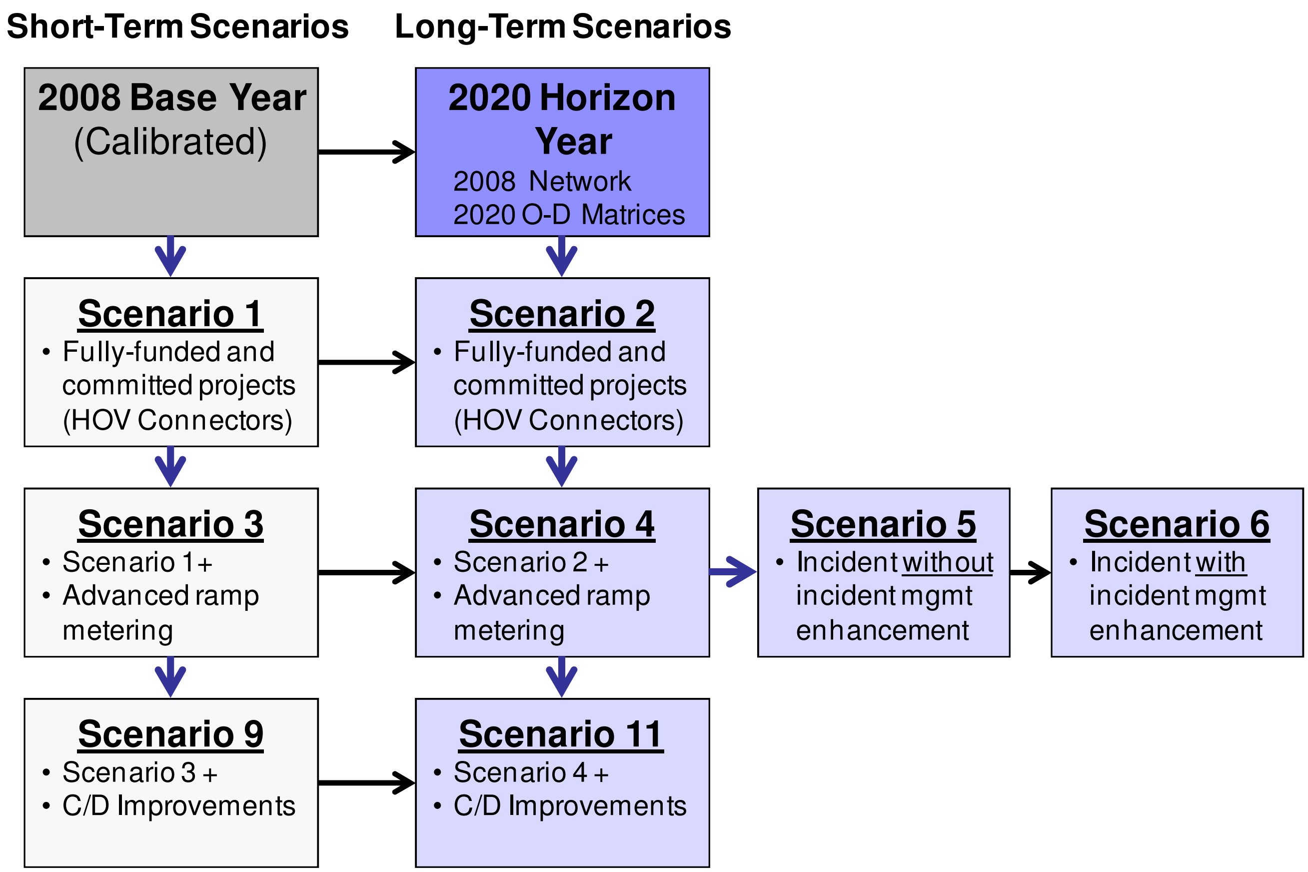
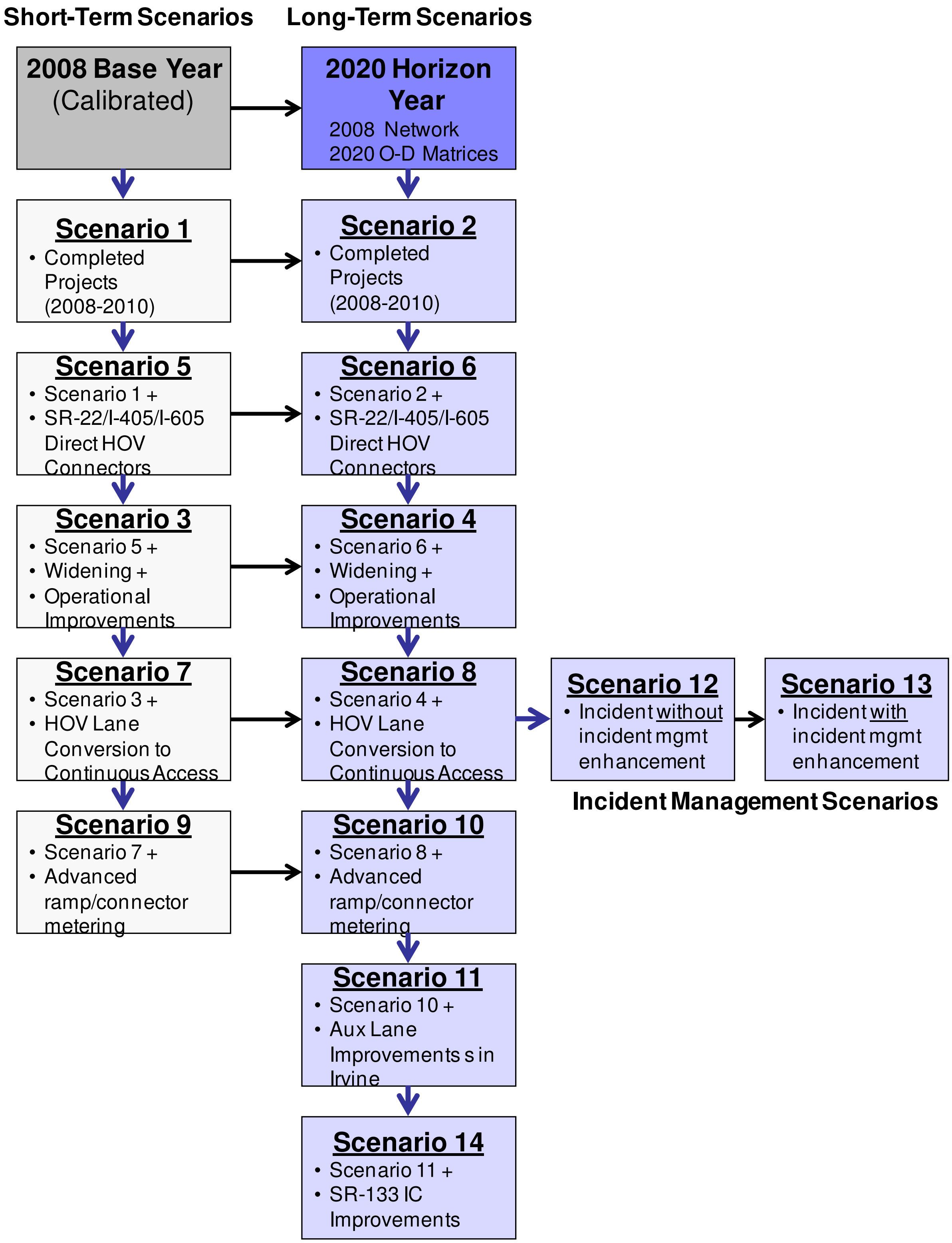


Exhibit 6-3: I-405 Micro-Simulation Modeling Approach



Scenario Evaluation Results

This section discusses the separate micro-simulation results for the SR-22 and I-405 freeways.

SR-22 Corridor Model Results

Exhibits 6-4 and 6-5 show the SR-22 corridor delay results for all the 2008 scenarios in the AM and PM peak periods, respectively. Exhibits 6-6 and 6-7 show results for all 2020 scenarios in the AM and PM peak periods, respectively. The percentages shown in the exhibits indicate the difference in delay between the current scenario and the previous scenario (i.e., 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.

For each scenario, the modeling team added the proposed improvements, conducted multiple model runs, and produced composite results by facility type (i.e., mainline, HOV, arterials, and ramps) and vehicle type (SOV, HOV, and trucks) as well as speed contour diagrams. The study team reviewed incremental steps in detail to ensure they were consistent with general traffic engineering principles.

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

Exhibit 6-4: SR-22 AM Peak Micro-Simulation Delay Results by Scenario (2008)

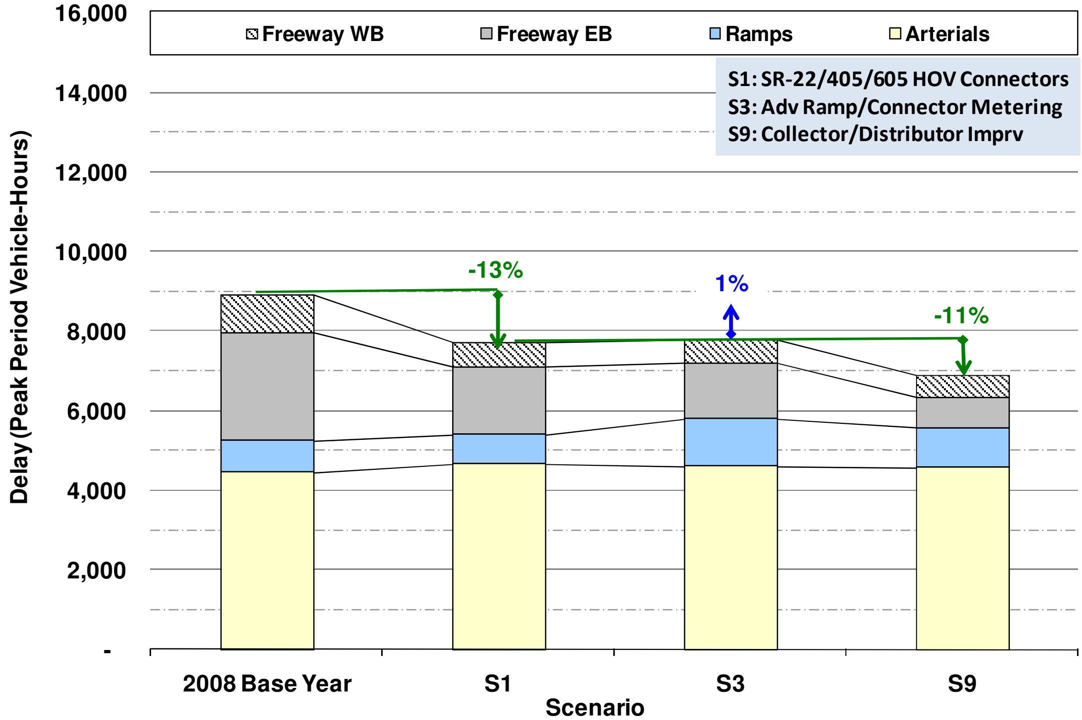


Exhibit 6-5: SR-22 PM Peak Micro-Simulation Delay Results by Scenario (2008)

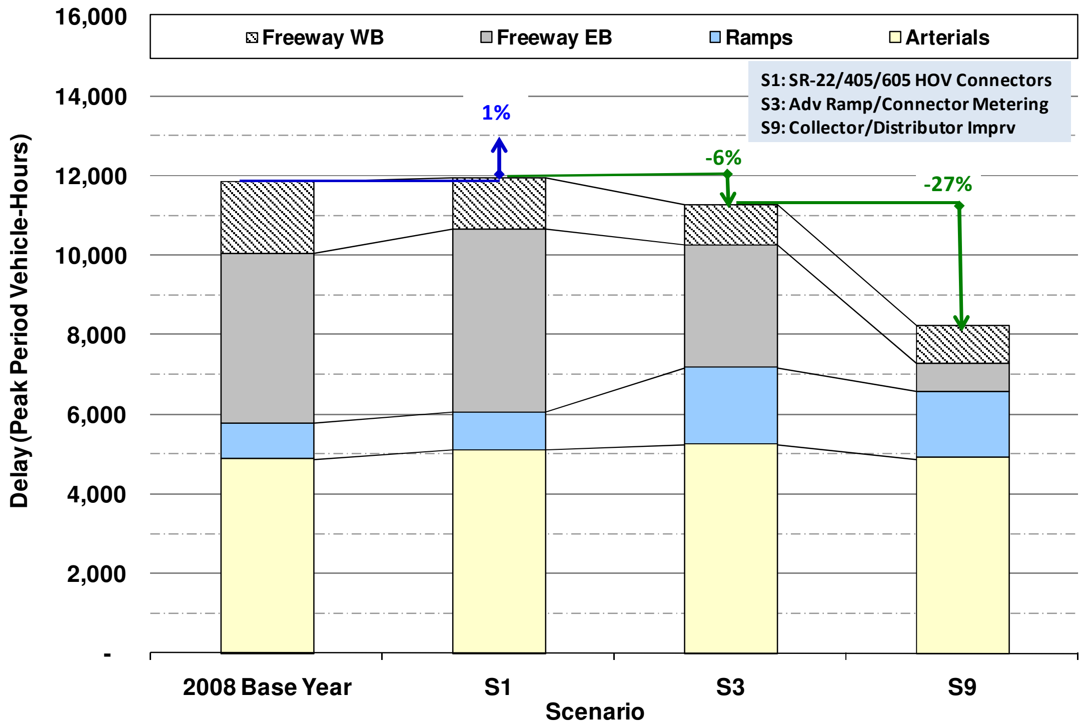


Exhibit 6-6: SR-22 AM Peak Micro-Simulation Delay by Scenario (2020)

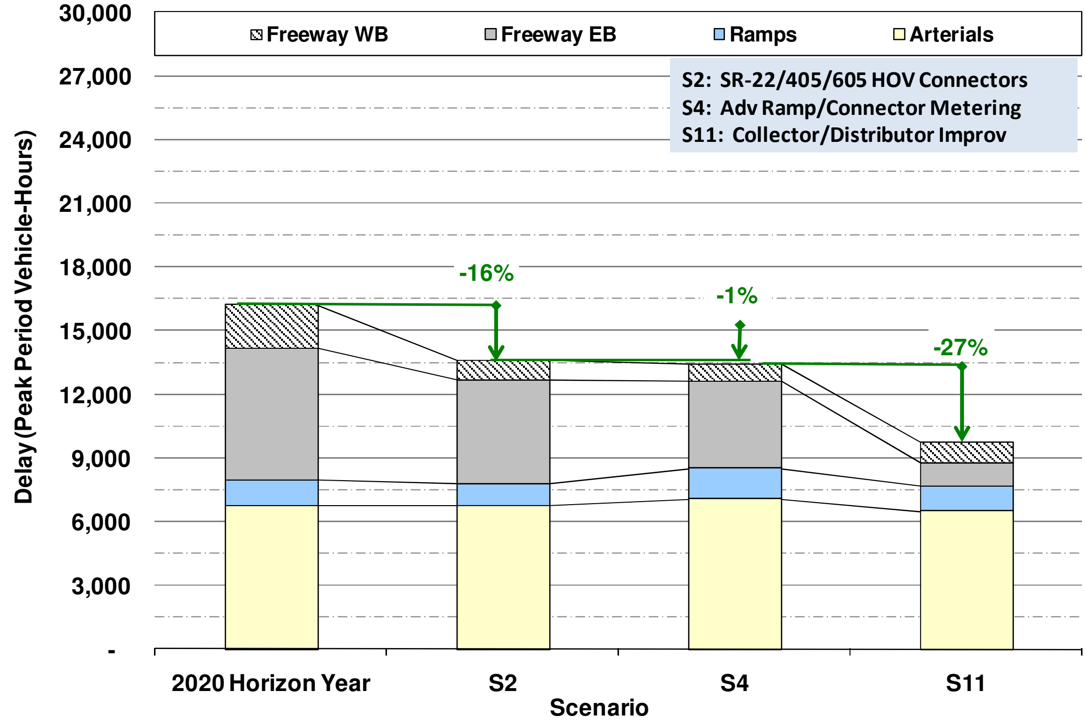
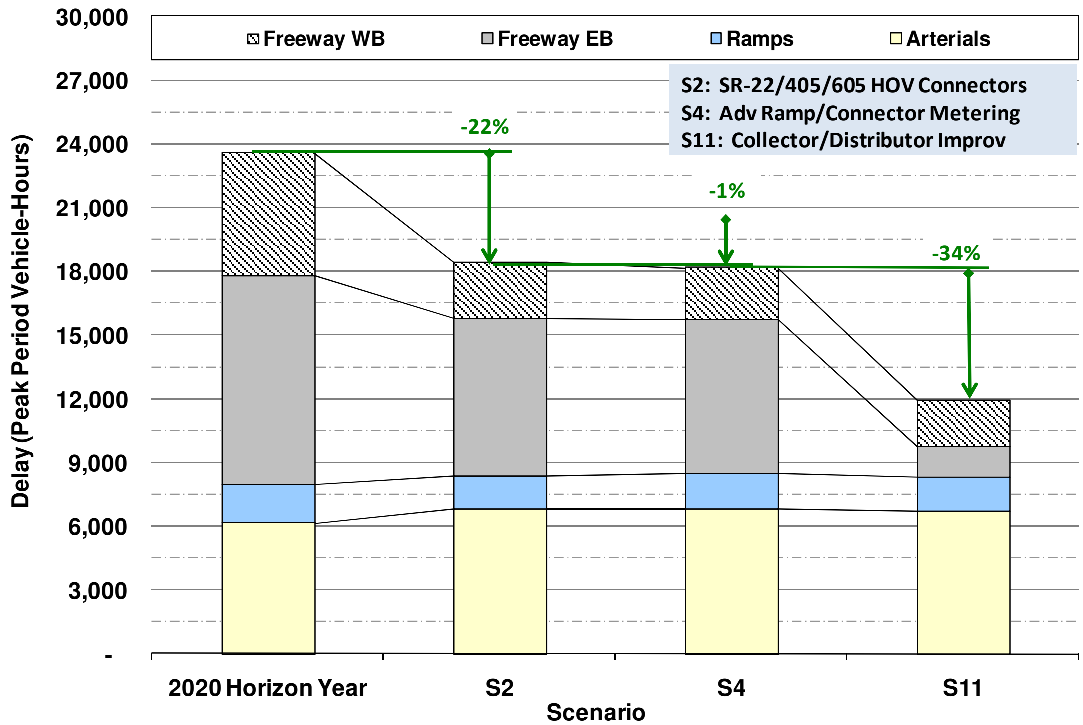


Exhibit 6-7: SR-22 PM Peak Micro-Simulation Delay by Scenario (2020)



Exhibits 6-8 through 6-11 summarize the delay results of the 2008 base year model by bottleneck area for the eastbound and westbound directions and for each peak period. The delay results of the 2020 horizon year model are summarized in Exhibits 6-12 through 6-15.

Exhibit 6-8: SR-22 Eastbound AM Delay Results by Scenario and Bottleneck Area (2008)

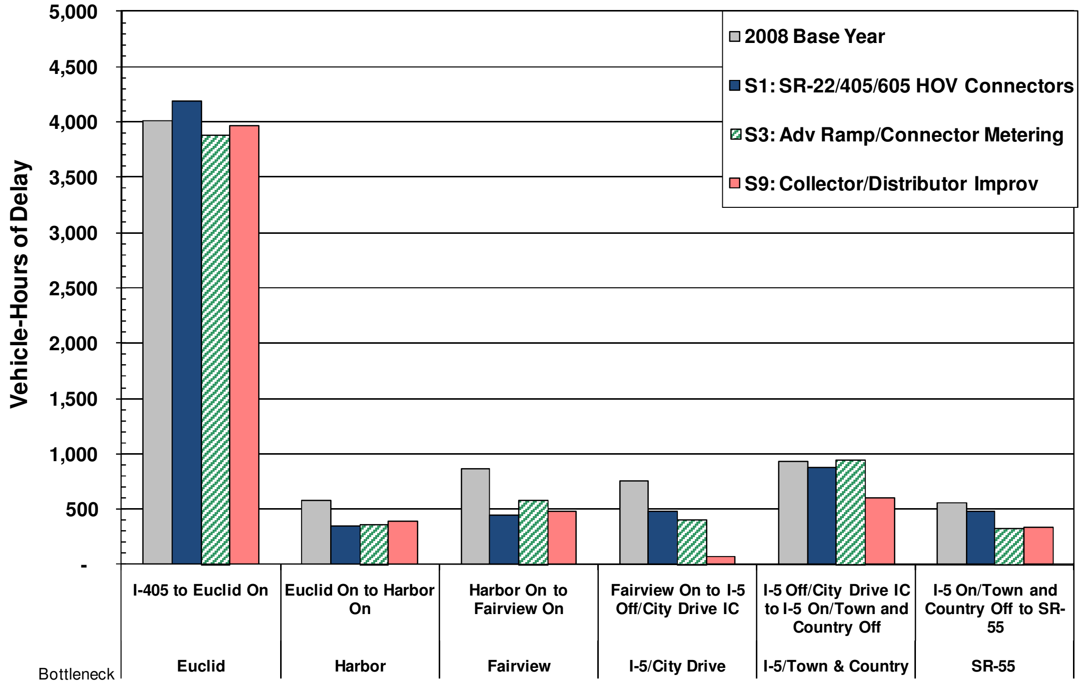


Exhibit 6-9: SR-22 Eastbound PM Delay Results by Scenario and Bottleneck Area (2008)

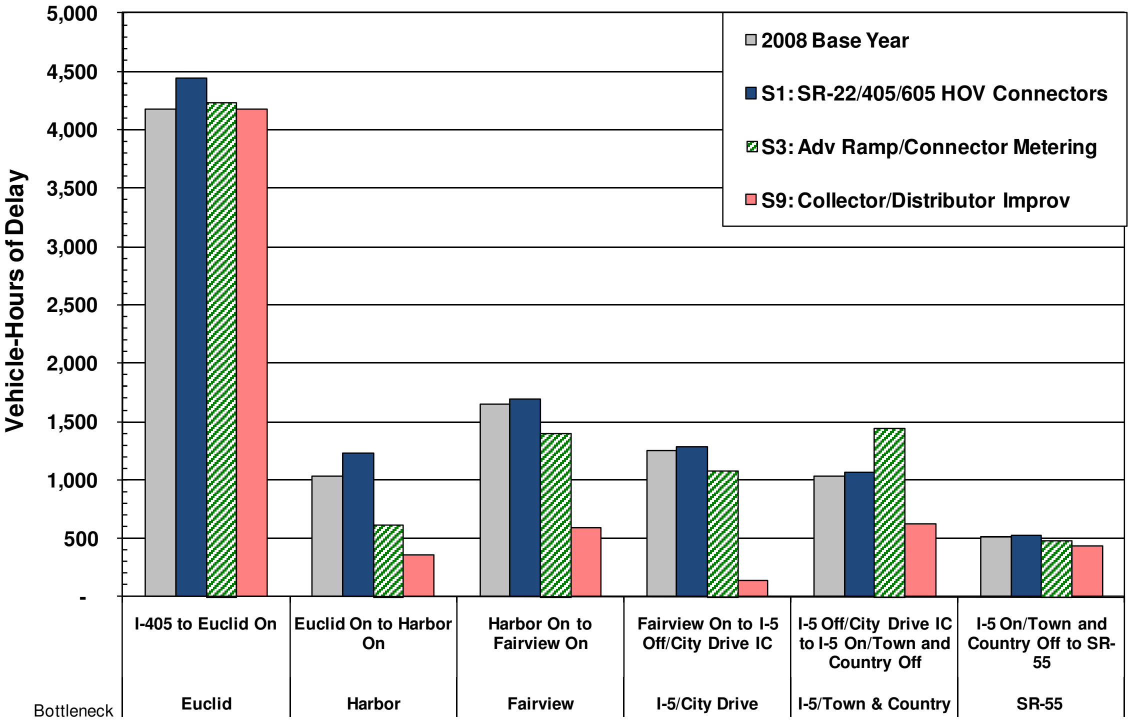


Exhibit 6-10: SR-22 Westbound AM Delay Results by Scenario and Bottleneck Area (2008)

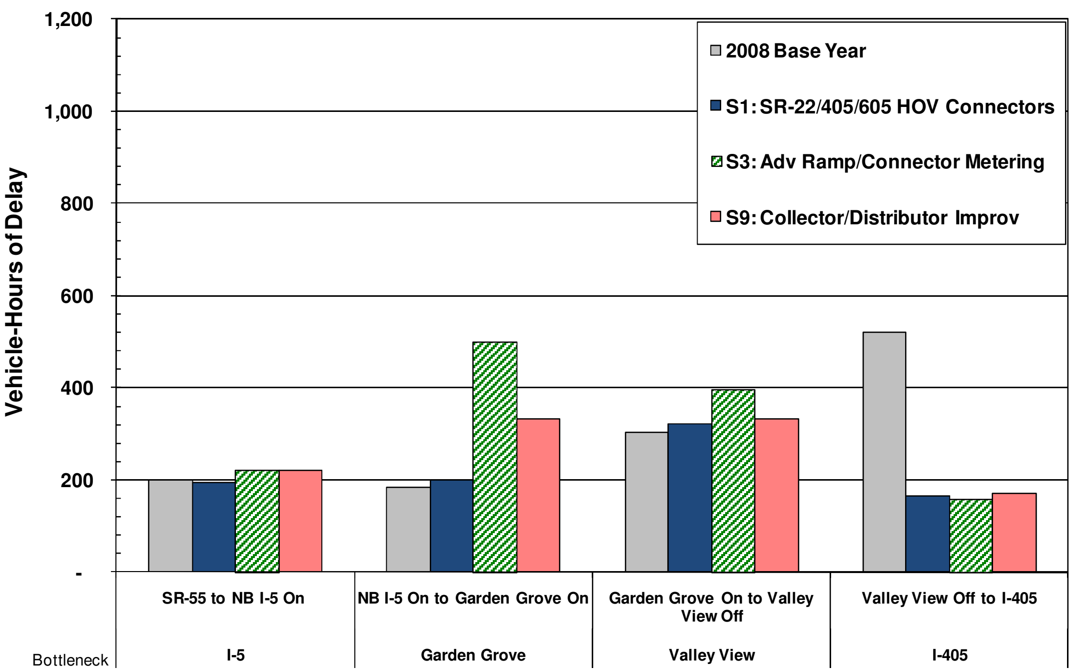


Exhibit 6-11: SR-22 Westbound PM Delay Results by Scenario and Bottleneck Area (2008)

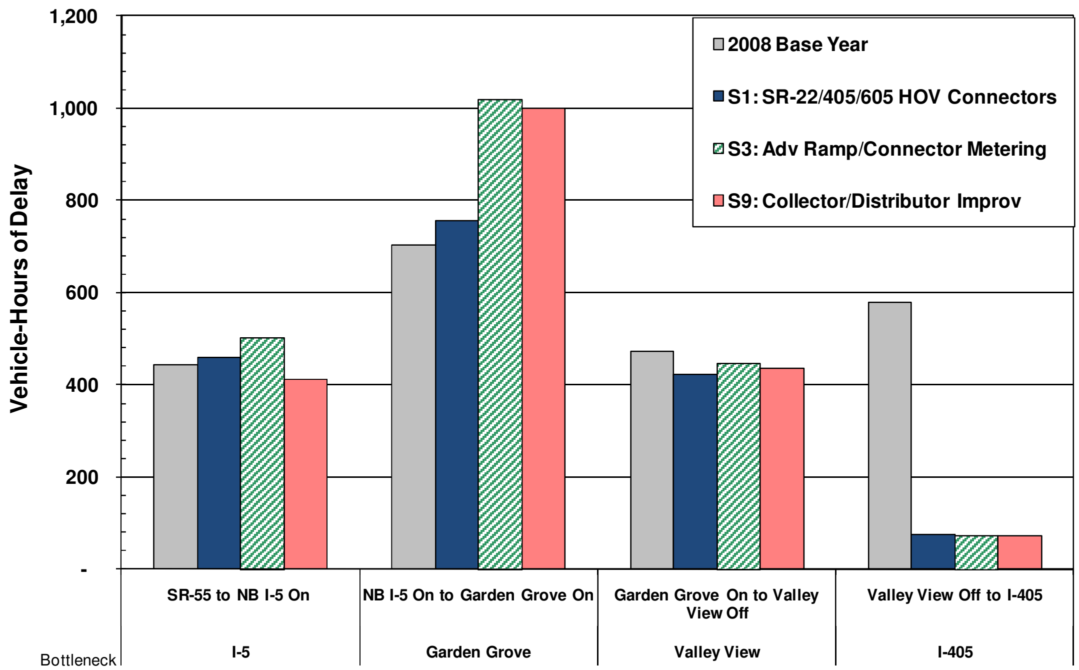


Exhibit 6-12: SR-22 Eastbound AM Delay Results by Scenario and Bottleneck Area (2020)

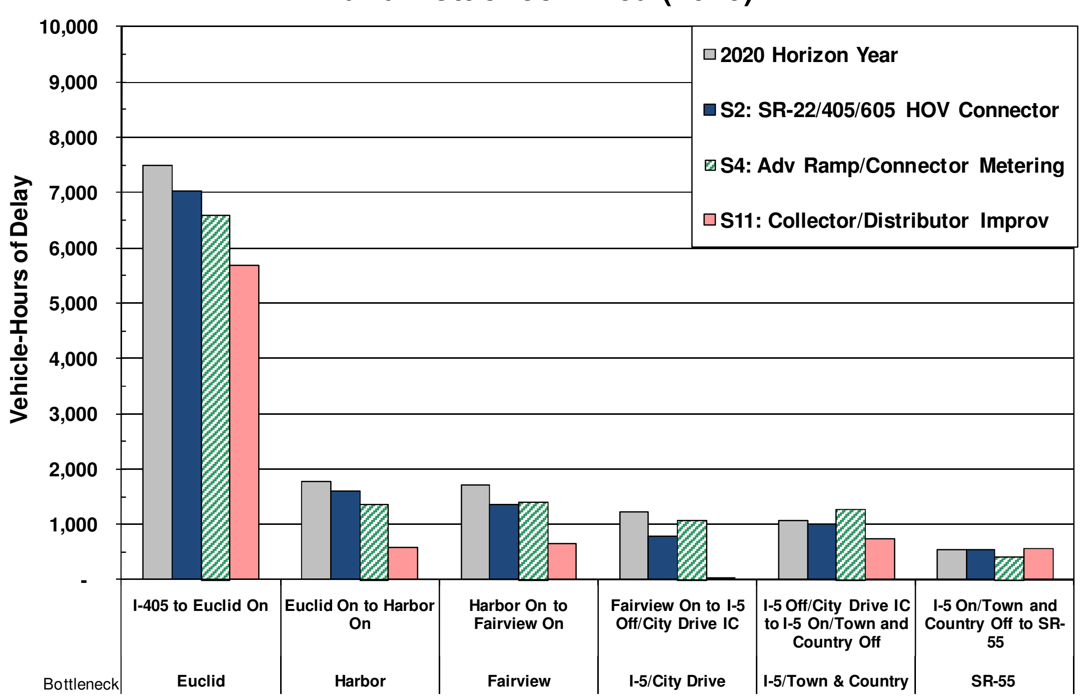


Exhibit 6-13: SR-22 Eastbound PM Delay Results by Scenario and Bottleneck Area (2020)

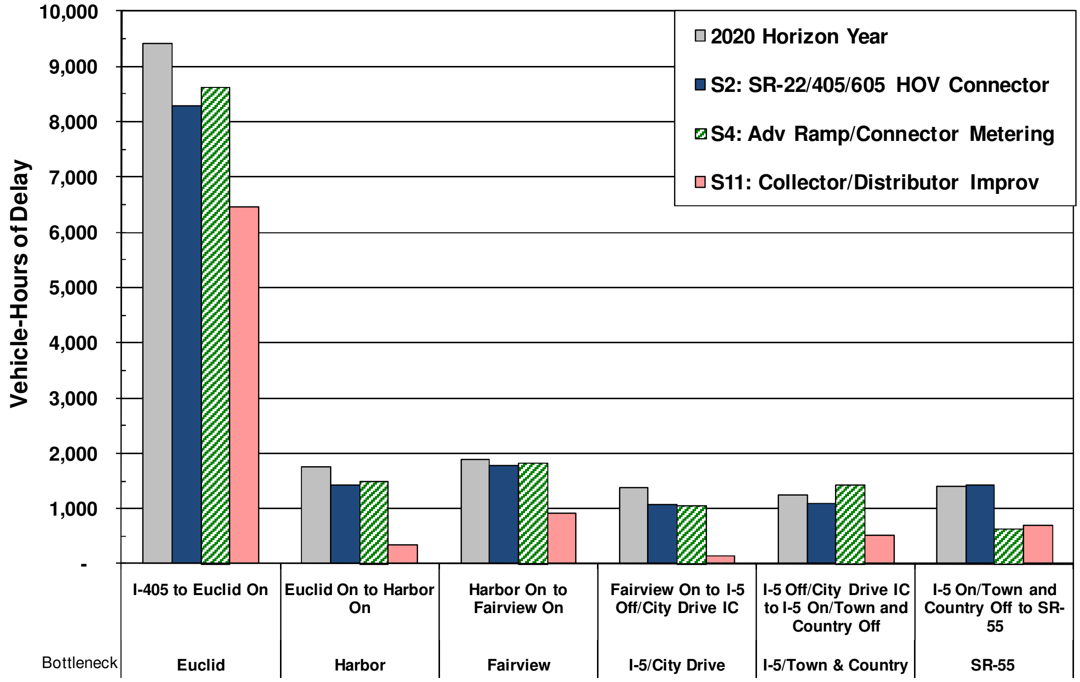


Exhibit 6-14: SR-22 Westbound AM Delay Results by Scenario and Bottleneck Area (2020)

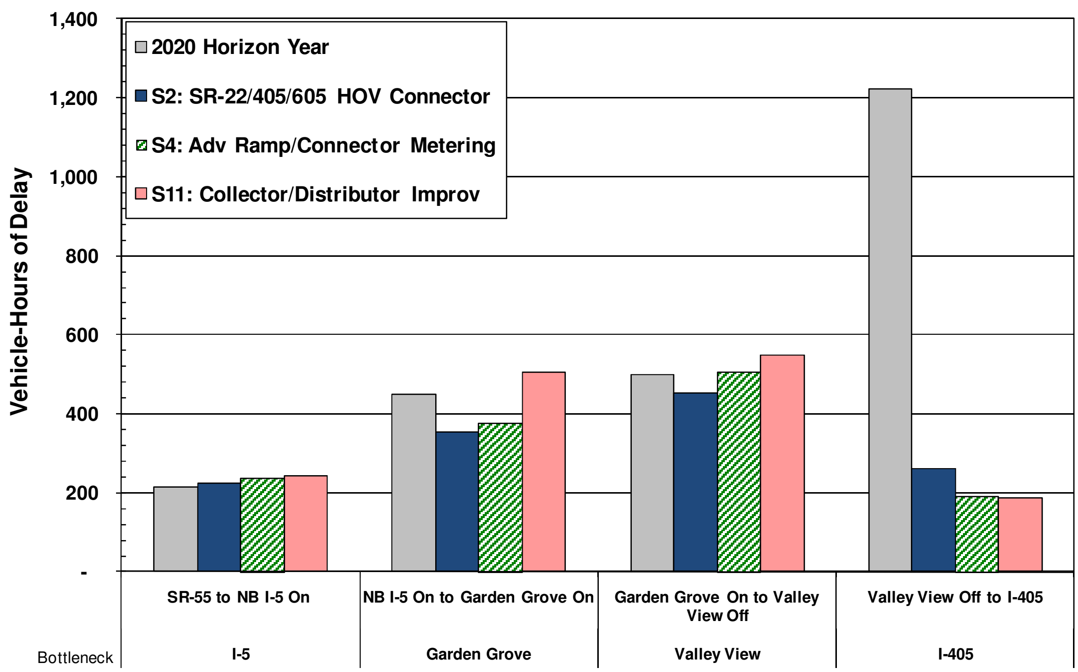
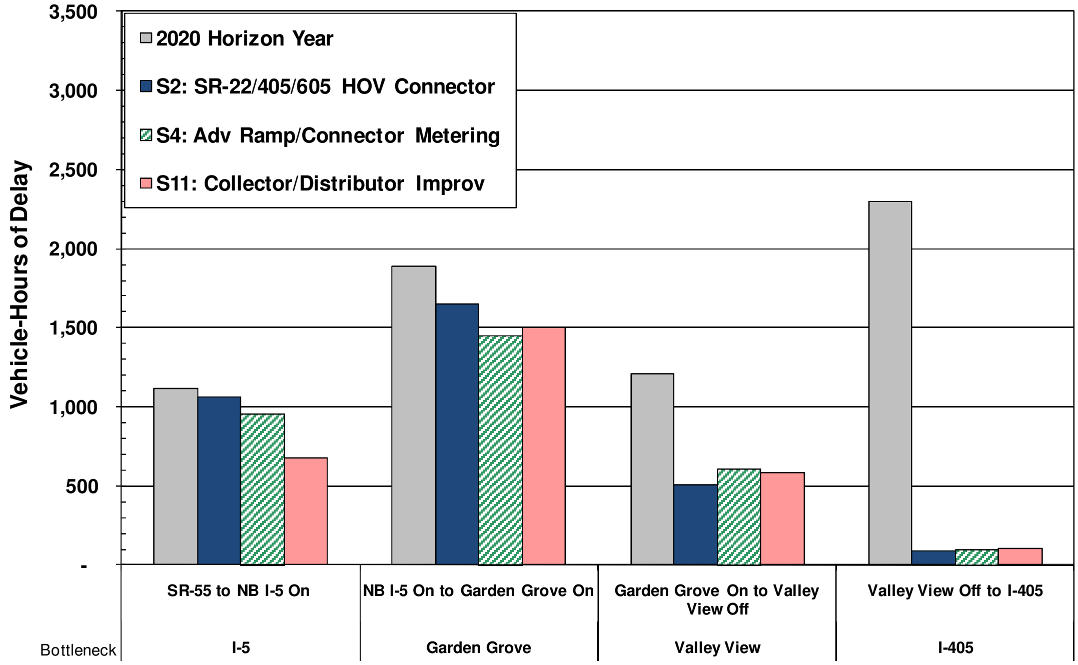


Exhibit 6-15: SR-22 Westbound PM Delay Results by Scenario and Bottleneck (2020)



Base Year and "Do Minimum" Horizon Year

Absent any physical improvements, the modeling team estimates that by 2020, total delay (mainline, HOV, ramps, and arterials) will nearly double compared to 2008 (from a total of around 21,000 vehicle-hours daily to just fewer than 40,000 vehicle-hours) in the combined AM and PM peak. Demand may continue to increase beyond 2020 and may require further study.

Scenarios 1 and 2 (SR-22/I-405/I-605 HOV Direct Connectors)

Scenarios 1 and 2 test the only fully funded project on SR-22. The project links HOV lanes on I-405 with HOV lanes on SR-22 and I-605 to create a seamless HOV connection. The eastern segment of the project directly connects the westbound SR-22 HOV lane at Valley View Street to the HOV lane on northbound I-405, and reconstructs the southbound I-405 to eastbound SR-22 HOV direct connector.

The 2008 model shows that the new HOV connectors improve overall corridor delay in the AM peak period by 13 percent (1,200 vehicle-hours) and minimally effect the PM peak period. In the last segment of the westbound direction, from Valley View to I-405, the corridor experienced a 68-percent delay reduction (350 vehicle-hours) during the AM peak period and almost a 90-percent delay reduction (500 vehicle-hours) during the PM peak period with the proposed project.

The 2020 model results indicate more impressive gains with the HOV direct connectors as corridor delay is reduced by 16 percent in the AM peak and 22 percent in the PM peak. In total, this scenario estimates a reduction of around 7,800 vehicle-hours of daily delay. Most of the reduction occurred in the westbound direction from Valley View to the I-405 Interchange, near the location of the project. The mobility improvements are likely attributable to better access to other freeways and reduced weaving (i.e., between the HOV lanes and general purpose lanes).

Scenarios 3 and 4 (Advanced Ramp Metering, Connector Metering)

Scenarios 3 and 4 build on Scenarios 1 and 2 by adding an advanced ramp metering system, such as a dynamic or adaptive ramp metering system with connector metering and queue control (to ensure queuing does not exceed the capacity of the connector) at the northbound and southbound I-5/SR-57 connectors to SR-22. The scenarios also add an HOV direct connector from southbound SR-57/I-5 to westbound SR-22.

The 2008 model indicates that advanced ramp and connector metering modestly improves delay by one percent in the AM peak and by six percent in the PM peak, or a total of 600 vehicle-hours. The 2020 model results show a similar improvement of only one percent during each peak period, or a total of 400 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 a modest improvement for the overall corridor. Overall, the two models estimate that advanced ramp and connector metering would reduce congestion along the corridor by more than 1,000 vehicle hours of delay. It appears that advanced ramp metering and connector metering may not be very effective on this corridor, especially in the westbound direction where most congestion occurs in the upstream segments.

There are various types of advanced ramp metering systems deployed around the world, including the System-wide Adaptive Ramp Metering System (SWARM) tested on Los Angeles I-210 freeway corridor. For modeling on SR-22, the Asservissement Lineaire d'Entrée Autoroutiere (ALINEA) system was tested as a proxy for an advanced ramp metering system, since its algorithm was readily available. The study team is not necessarily recommending deployment of ALINEA. Rather, some type of advanced ramp metering system would produce similar, if not better results.

Scenarios 5 and 6 (Enhanced Incident Management)

Two incident scenarios were built upon on Scenario 4 to evaluate the non-recurrent delay reductions resulting from enhanced incident management strategies. In the first scenario, Scenario 5, a collision incident with the closure of one outside lane was simulated westbound in the AM peak period model and eastbound in the PM peak period model. The incident simulation location and duration were selected based on a review of actual 2010 incident data, at one of the highest incident frequency locations.

The following are the scenario details:

- Eastbound AM Peak starting at 8:00 AM, close mainline lane 3 for 50 minutes at post mile 9.48 (at the collector/distributor entrance)
- Westbound PM Peak starting at 5:00 PM, close mainline lane 4 for 80 minutes at post mile 9.49 (at Harbor).

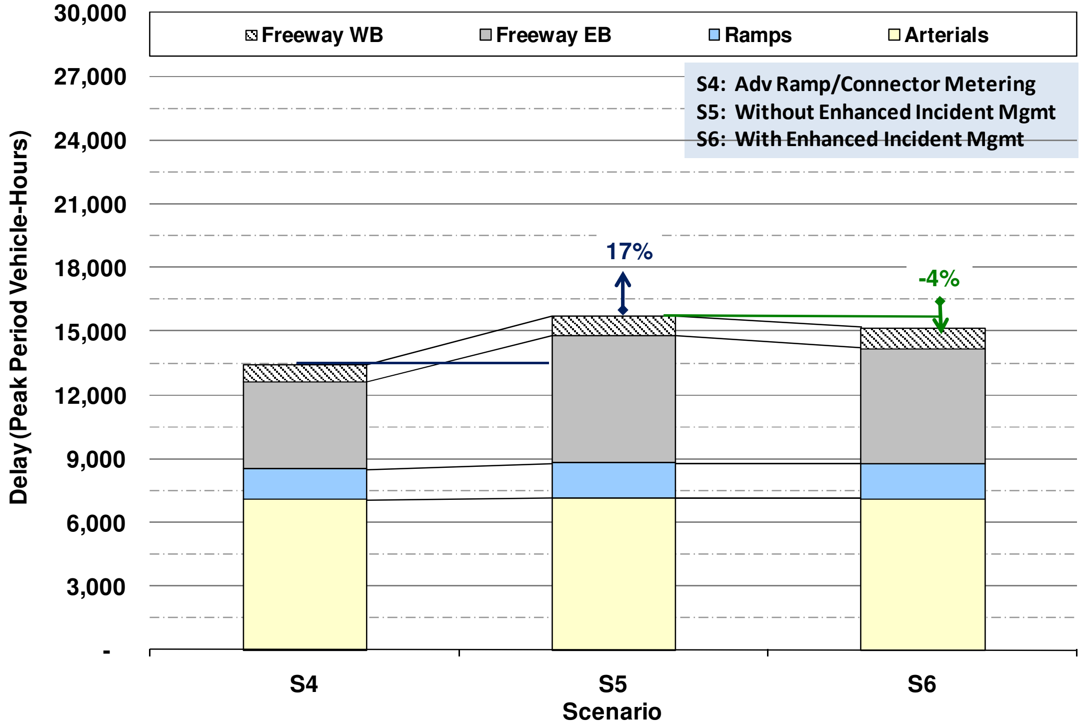
This scenario represents a typical, moderate incident at one location during each peak direction period. Data suggest that incidents vary significantly in terms of impact and duration. Some incidents last hundreds of minutes, some close multiple lanes, and some occur at multiple locations simultaneously. Numerous minor incidents last only a few minutes without lane closures and still result in congestion. In addition, many incidents occur during off-peak hours.

An enhanced incident management system would entail upgrading or enhancing the current Caltrans incident management system to include 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.

In the second scenario, Scenario 6, the same collisions were simulated with a reduction in duration by 13 minutes in the eastbound direction and by 14 minutes in the westbound direction. Based on actual Caltrans incident management data, it is estimated at that an enhanced incident management system could reduce a 35-minute incident by about 10 minutes.

As depicted in Exhibit 6-16, with the deployment of an enhanced incident management system (Scenario 6), the 2020 model estimates that approximately 600 vehicle-hours delay are eliminated in the eastbound direction with minimal impact in the westbound direction. These results reflect benefits realized during the peak direction period. However, significant additional benefits may also be realized during the off-peak direction and hours.

Exhibit 6-16: SR-22 AM Delay Results for Enhanced Incident Management (2020)



Scenarios 9 and 11 (Collector-Distributor Improvements)

Scenario 9 and 11 build on Scenarios 3 and 4 by adding a proposed project to reconstruct the eastbound collector-distributor facility and add new connectors to the I-5 and SR-57. The eastbound SR-22 collector distributor has significant congestion before the entrance and through the entire collector distributor facility. Traffic volumes exceed capacity resulting in queuing and delay to motorists accessing the local interchanges and freeway connectors to I-5, SR-57 and SR-22 freeways. Results indicate operational delay is directly attributed to traffic demand exceeding capacity, geometric and capacity constraints of the collector-distributor facility and freeway to freeway connectors. Significant weaving within the collector-distributor facility also contributes to the bottleneck severity.

The 2008 model estimates that the proposed project reduces delay by 11 percent in the AM peak and 27 percent in the PM peak, or a total of 4,000 vehicle-hours overall on the corridor. Delay at the eastbound segment from Fairview to I-5/City Drive decreases by over 85 percent from about 1,000 vehicle-hours without the project to 150 vehicle-hours with the interchange improvement. The 2020 model estimates a delay reduction of 27 percent in the AM peak and 34 percent in the PM peak. In total, this scenario estimates a reduction of over nearly 10,000 vehicle-hours of delay in 2020.

Benefits would result from widening the collector-distributor, widening of the I-5/SR-22 separation structure (horseshoe) and the braiding of SR-22 connectors to both I-5 and SR-57. The CSMP model results for 2020 traffic shows that short-term operational benefits for collector-distributor facility improvements may be achieved in a Minimum Operating Segment (MOS) by phasing construction. Outside the scope of the CSMP, Caltrans has analyzed future traffic conditions beyond the 2020 model year used in this study. This analysis estimates that year 2035 traffic volumes show that both braiding the connectors and modifications to the collector distributor facilities will be required to accommodate the future traffic demand and provide long-term benefits. Further study of the developing MOS strategies is recommended during the project report phase.

Post Scenario 11 Conditions

By 2020, with the inclusion of all the improvements tested, the model reveals some residual congestion that remains to be addressed with future improvements. The total remaining delay for the corridor as according to the model results is around 20,000 daily vehicle-hours of delay.

I-405 Corridor Model Results

This section presents the modeling results for the I-405 freeway.

Exhibits 6-17 and 6-18 show the delay results by facility type and peak period for all scenarios evaluated using the 2008 base year model. Exhibits 6-19 and 6-20 show similar results for scenarios evaluated using 2020 horizon year model. The percentages shown in the exhibits indicate the difference in delay between the current scenario and the previous scenario (i.e., 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.

For each scenario, the modeling team added the proposed improvements, conducted multiple model runs, and produced composite 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 reviewed incremental steps in detail of each modeling analysis to ensure that they were consistent with general traffic engineering principles.

Exhibits 6-21 through 6-24 summarize the delay results of the 2008 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 6-25 through 6-28.

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

Exhibit 6-17: I-405 AM Peak Micro-Simulation Delay Results by Scenario (2008)

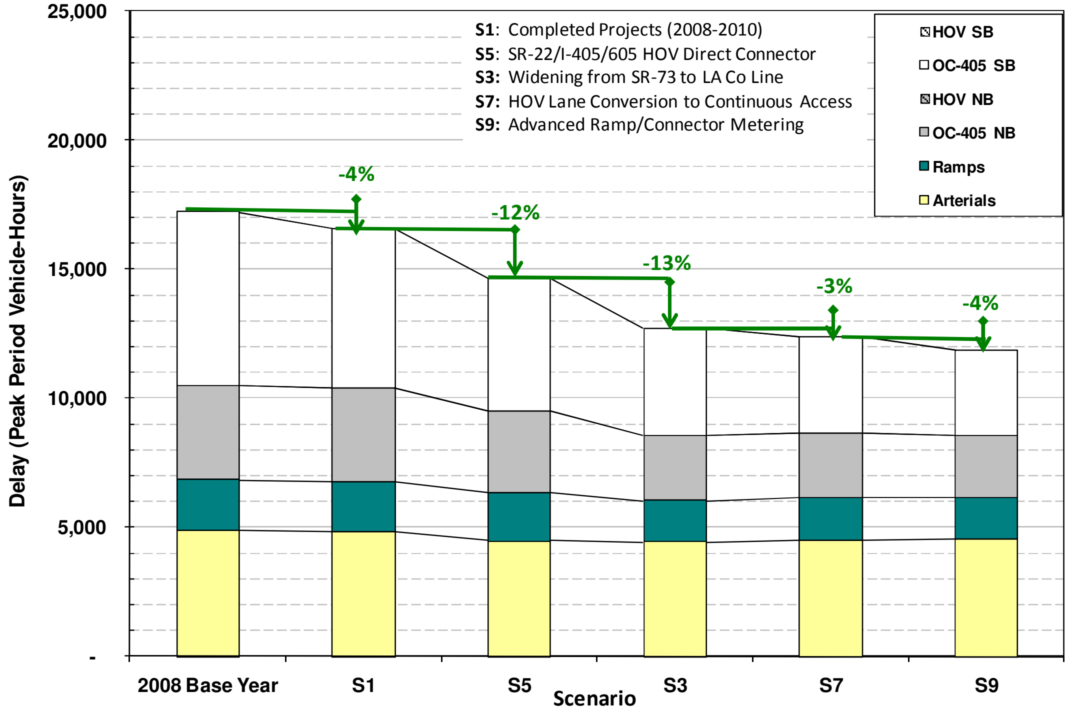


Exhibit 6-18: I-405 PM Peak Micro-Simulation Delay Results by Scenario (2008)

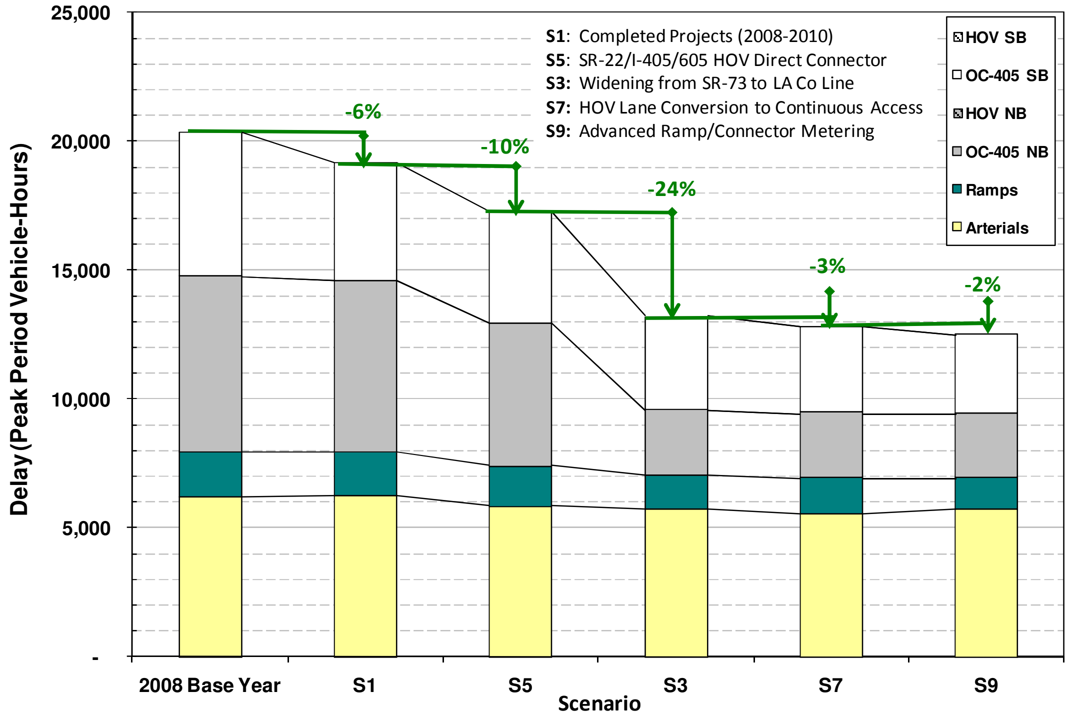


Exhibit 6-19: I-405 AM Peak Micro-Simulation Delay by Scenario (2020)

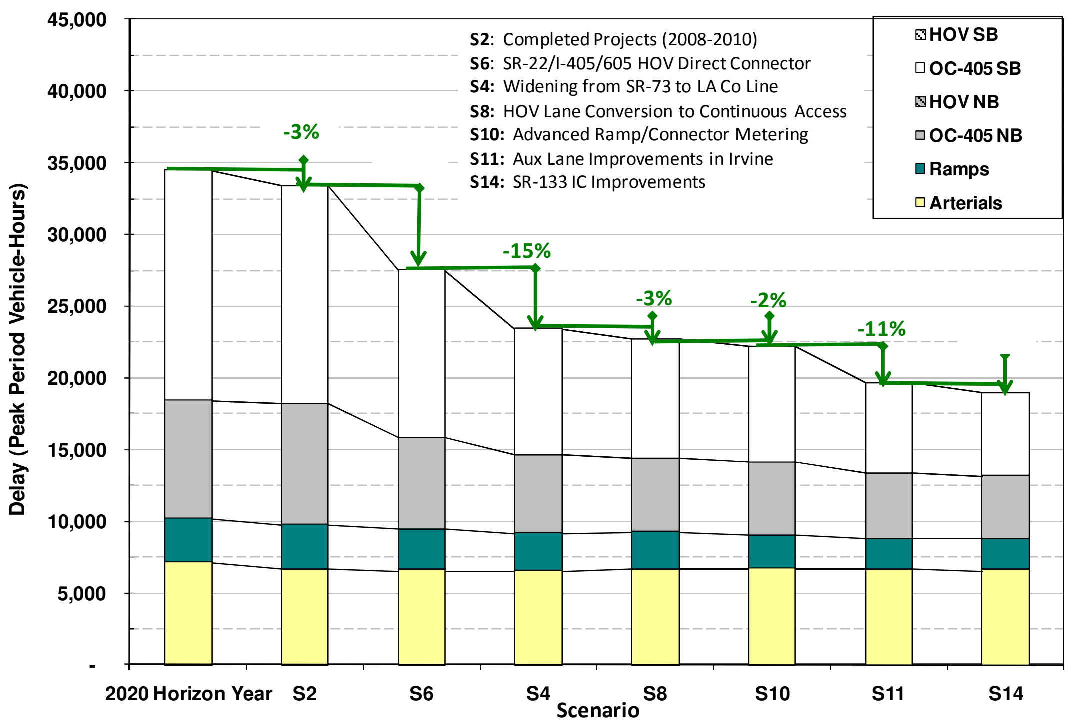


Exhibit 6-20: I-405 PM Peak Micro-Simulation Delay by Scenario (2020)

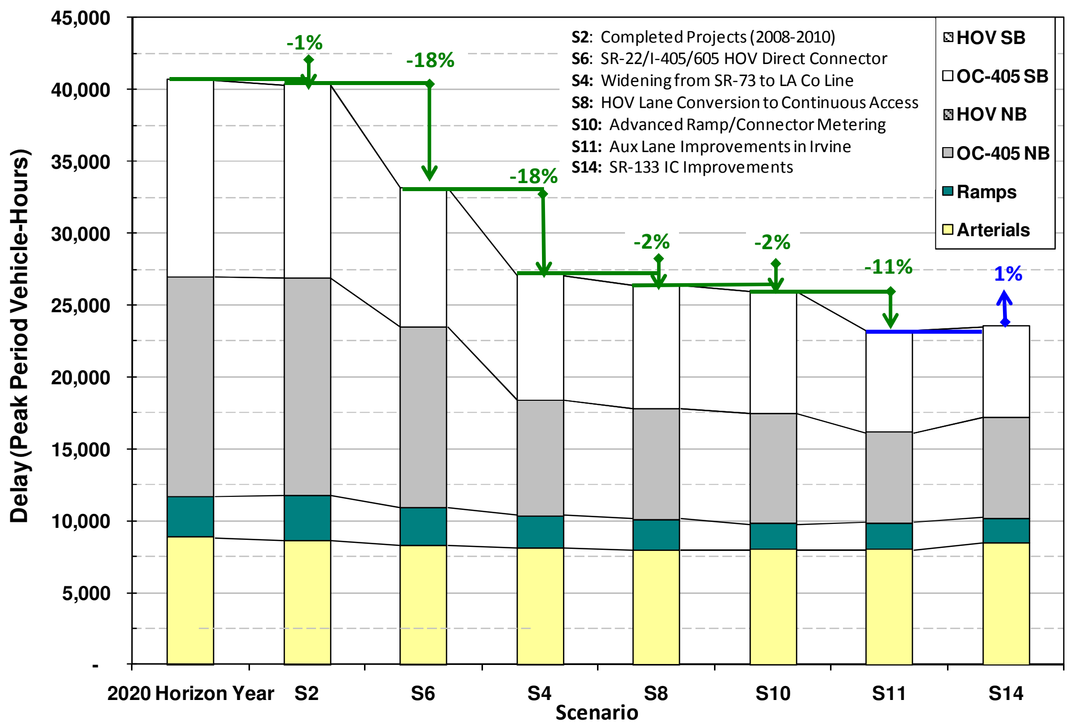


Exhibit 6-21: I-405 Northbound AM Delay Results by Scenario and Bottleneck Area (2008)

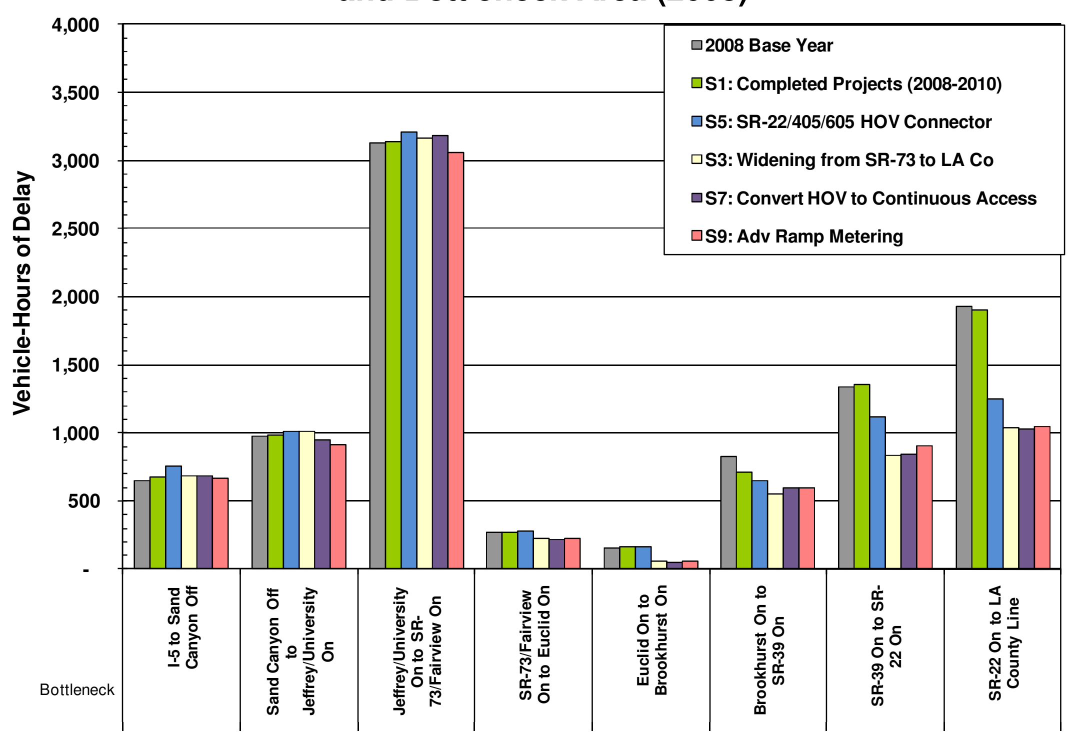


Exhibit 6-22: I-405 Northbound PM Delay Results by Scenario and Bottleneck Area (2008)

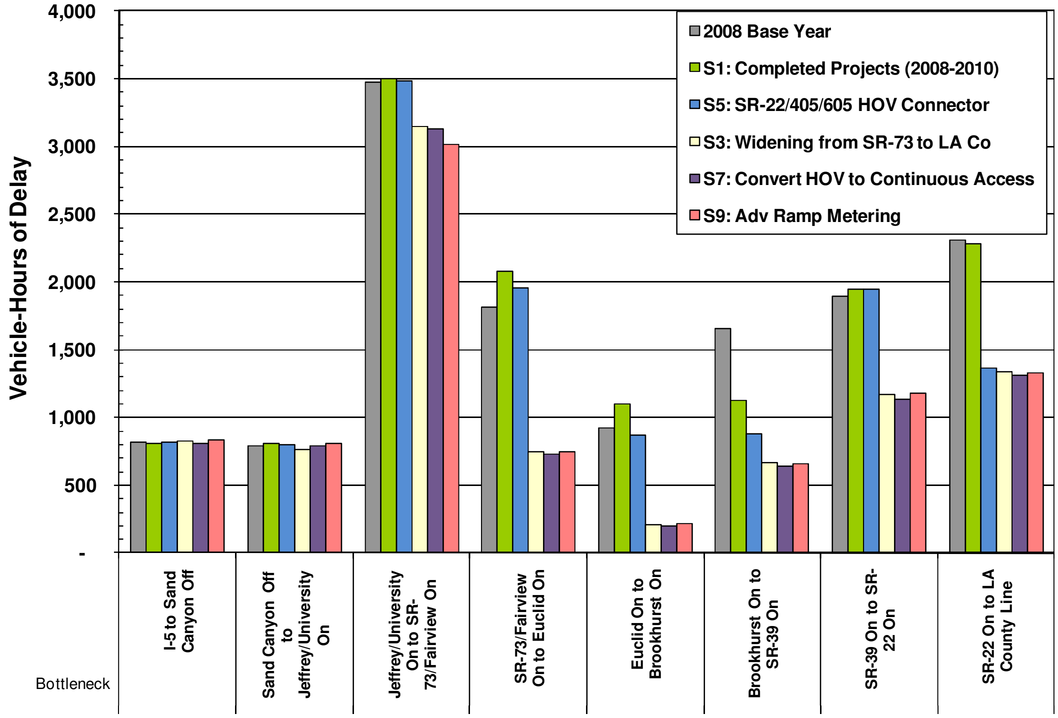


Exhibit 6-23: I-405 Southbound AM Delay Results by Scenario and Bottleneck Area (2008)

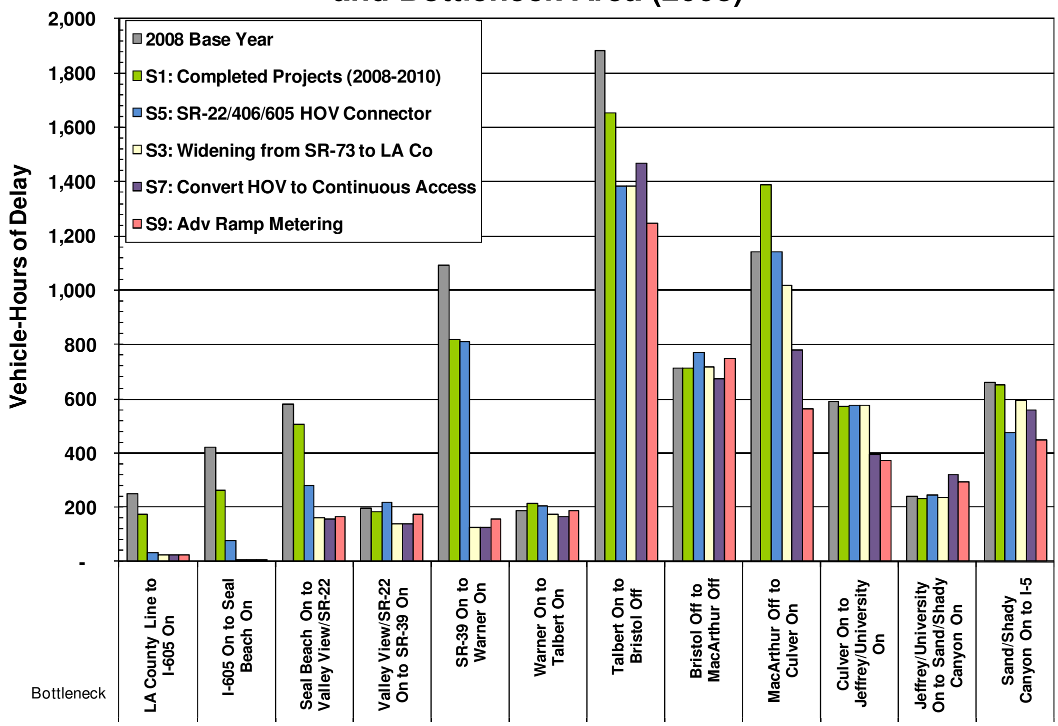


Exhibit 6-24: I-405 Southbound PM Delay Results by Scenario and Bottleneck Area (2008)

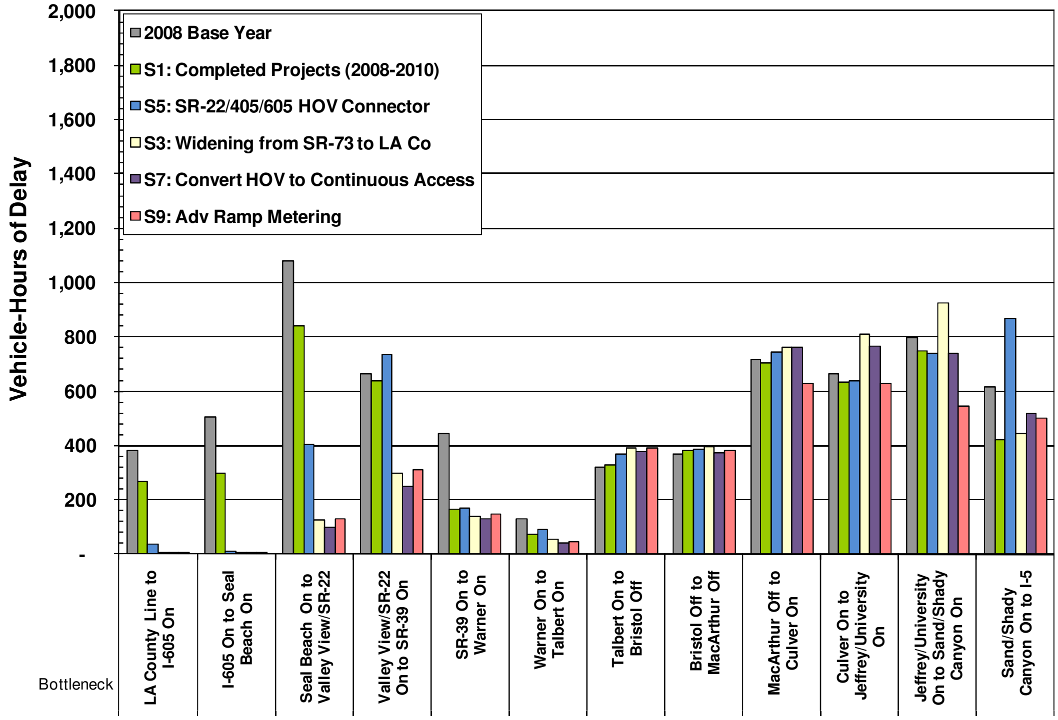


Exhibit 6-25: I-405 Northbound AM Delay Results by Scenario and Bottleneck Area (2020)

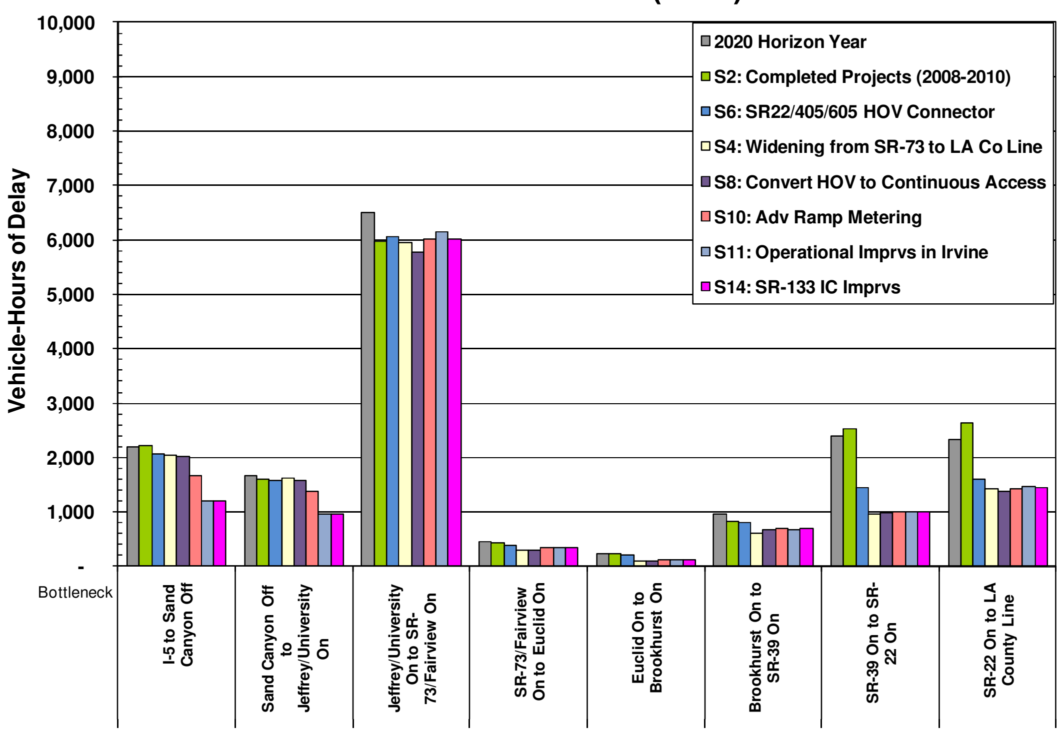


Exhibit 6-26: I-405 Northbound PM Delay Results by Scenario and Bottleneck Area (2020)

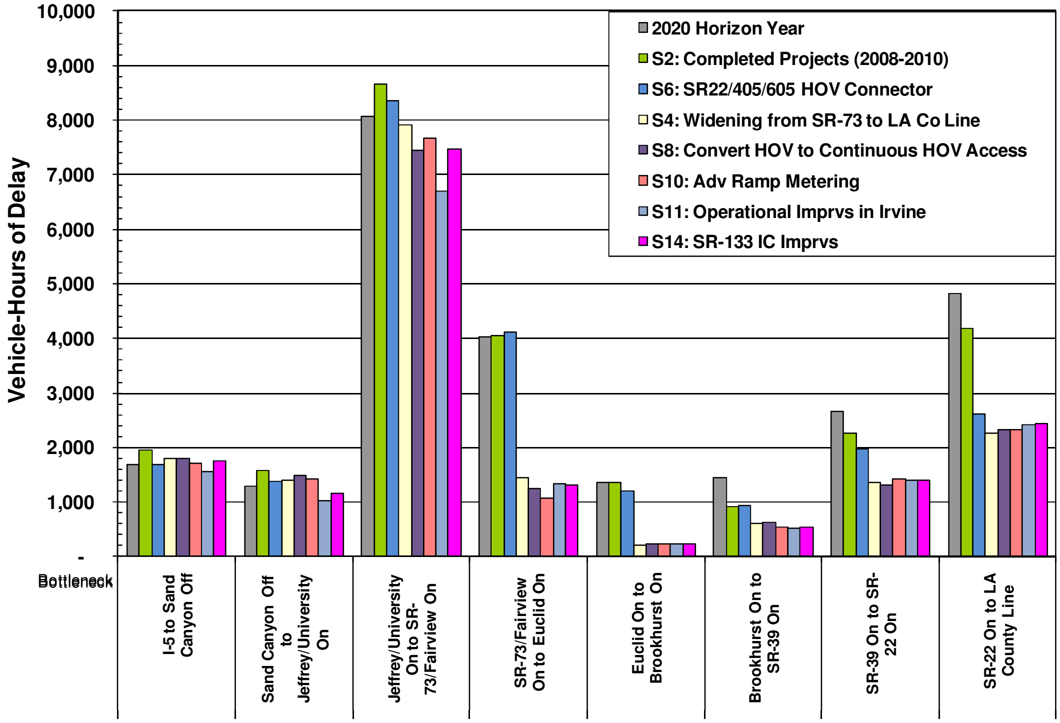


Exhibit 6-27: I-405 Southbound AM Delay Results by Scenario and Bottleneck Area (2020)

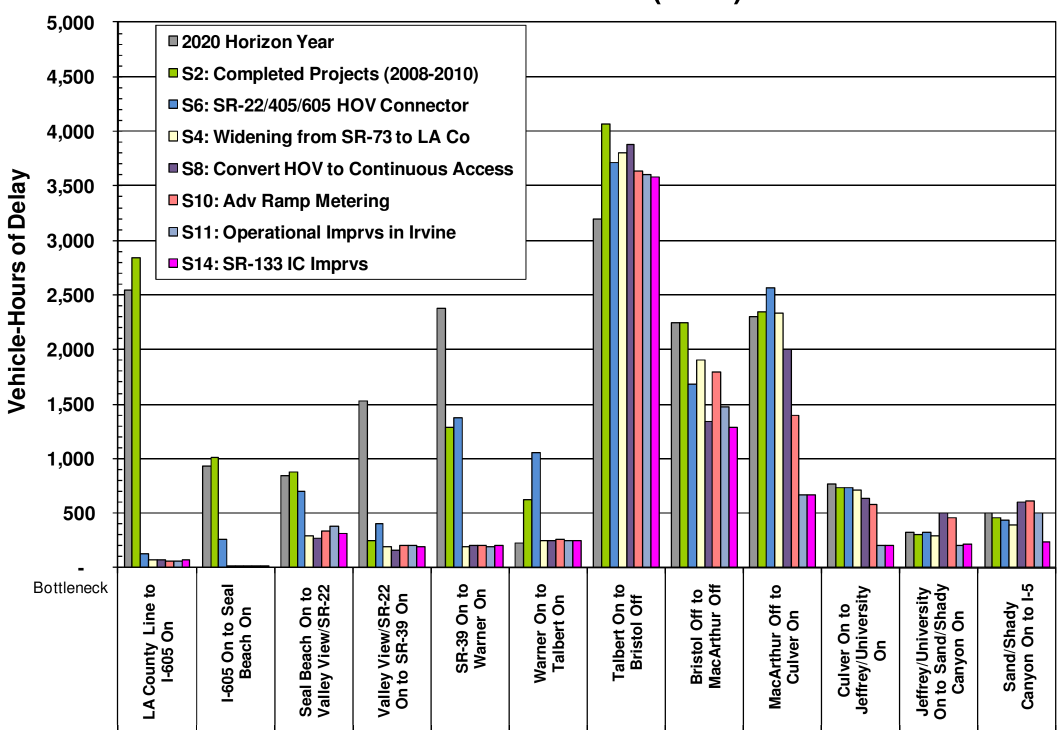
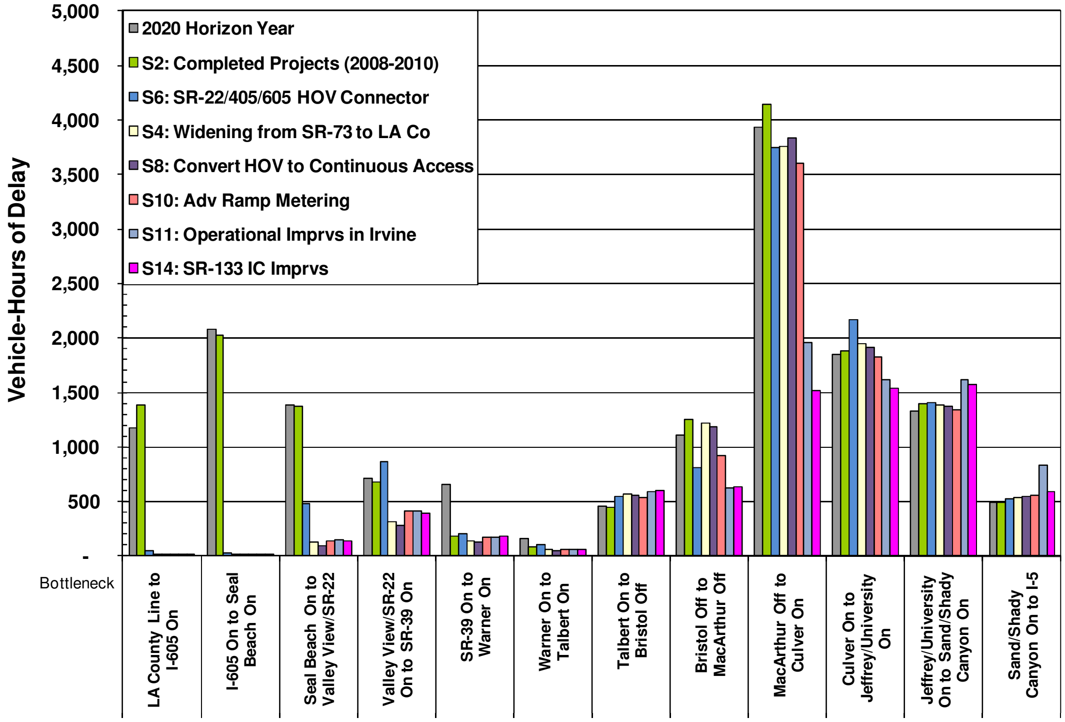


Exhibit 6-28: I-405 Southbound PM Delay Results by Scenario and Bottleneck Area (2020)



Base Year and "Do Minimum" Horizon Year

Absent any physical improvements, the model estimates that total delay on I-405 (mainline, HOV, ramps, and arterials) doubles in 2020 compared to 2008 (from a total of around 38,000 hours daily to just less than 75,000 hours). Demand may continue to increase beyond 2020 and may require further study.

Scenarios 1 and 2 (Completed Projects from 2008 to 2010)

Scenarios 1 and 2 consist of projects completed from the model base year to 2010. These projects include:

- Adding a northbound and southbound auxiliary lane from Magnolia to Beach
- Adding a third southbound left-turn lane and third southbound I-405 on-ramp lane at Fairview Road
- Adding a direct on-ramp at northbound Sand Canyon Avenue and converting the HOV preferential lane to a second metered general purpose lane
- Widening northbound Harbor Boulevard from three lanes to four lanes between the southbound I-405 off-ramp and the northbound I-405 on-ramp, and modifying the northbound I-405 on-ramp.

The 2008 model results show modest mobility improvements with the implementation of these projects. Delay improves by four percent in the AM peak period (650 vehicle-hours) and six percent in the PM peak period (1,200 vehicle-hours). The majority of the delay reduction occurs in the southbound direction (eight percent in the AM peak and 19 percent in the PM peak). During the AM peak in the southbound direction, the segment from SR-39 (Beach Boulevard) to Warner experiences a 25-percent improvement in delay (reduction from 1,100 to 800 vehicle-hours of delay). This is likely attributable to the auxiliary lane constructed between Beach and Magnolia.

The 2020 model results show that these projects are expected to provide a marginal reduction in delay (three percent in AM peak and one percent in the PM peak) when travel volumes increase. This scenario is expected to reduce overall corridor delay by over 1,300 vehicle-hours. The southbound section from SR-39 (Beach Boulevard) to Warner experiences a notable decrease in delay, particularly in the AM, from 2,400 to 1,300 vehicle-hours, a decline of about 40 percent.

Scenarios 5 and 6 (SR-22/I-405/I-605 HOV Direct Connectors)

Note that Scenarios 5 and 6 come before Scenarios 3 and 4. Scenarios 5 and 6 build on Scenarios 1 and 2 and test the SR-22/I-405/I-605 HOV direct connectors partially funded by the CMIA. The project links HOV lanes on I-405 with those on SR-22 and I-605 to create a seamless HOV connection among the three freeways.

The 2008 model results suggest that the project improves delay by an additional 12 percent in the AM peak and 10 percent in the PM peak over the previous scenario. This scenario is estimated to reduce overall corridor delay by nearly 3,800 vehicle-hours. The northbound segment from SR-22 to the LA County line has a notable reduction in delay—over 650 vehicle-hours in the AM peak and 920 vehicle-hours in the PM peak, which is at least a 35 percent reduction over the previous scenario.

The 2020 model estimates a greater reduction in delay from the project. Delay is estimated to decrease by 18 percent in both peak periods, or a total of 13,000 vehicle-hours. With the project, delay in the two southbound segments from the LA County line to SR-39 (Beach Boulevard) is reduced to minimal levels.

These significant mobility improvements are likely due to better access to the other freeways and reduced weaving between the HOV lanes and the general purpose lanes.

Scenarios 3 and 4 (Widening from SR-73 to LA County Line)

Scenarios 3 and 4 build on Scenarios 5 and 6 and test a project to add new lanes and incorporate operational improvements. These scenarios were tested out of sequence; hence, Scenarios 3 and 4 follow Scenarios 5 and 6 instead of preceding them. These projects include:

- Adding a general purpose lane in each direction from SR-73 to the LA County line and adding operational improvements and auxiliary lanes
- Widening Bolsa Avenue interchange bridge from four to six lanes from Chestnut to Golden West
- Constructing a fourth northbound through lane on Beach Boulevard at the I-405 interchange.

The 2008 model results indicate that mobility improves with the implementation of these projects. Delay drops 13 percent in the AM peak period (2,000 vehicle-hours) and 24 percent (4,000 vehicle-hours) in the PM peak period. The 2020 model results show that these projects reduce delay by 15 percent in AM peak (4,000 vehicle-hours) and 18 percent in the PM peak (6,000 vehicle-hours).

As expected, the largest reductions in delay occur in the lane-widening segments, most notably in the northbound direction from SR-73 to Brookhurst Street and Beach Boulevard to SR-22 during the PM peak period, and in the southbound direction from Beach Boulevard to Warner Avenue during the AM peak period. According to the model results, this project eliminates the southbound Warner Avenue bottleneck.

Scenarios 7 and 8 (HOV Lane Conversion to Continuous Access)

Scenarios 7 and 8 build on the previous scenarios (Scenarios 3 and 4) and include a planned project to convert the existing buffer-separated HOV facility to a continuous access HOV facility. Caltrans may revisit the modeling once the full details of the continuous access design are finalized.

The 2008 model shows that converting the HOV lane to continuous access reduces delay on the corridor by about three percent during each peak period. Similarly, the 2020 model estimates that the continuous HOV lane reduces delay on the corridor by three percent in the AM peak and two percent in the PM peak. In total, the project reduces daily delay by 750 vehicle-hours in the 2008 model and about 1,400 vehicle-hours in the 2020 model.

Scenarios 9 and 10 (Advanced Ramp Metering and Connector Metering)

Scenarios 9 and 10 build on Scenarios 7 and 8 and include implementation of advanced ramp metering and connector metering on the SR-73, SR-133, and SR-55 connectors to I-405.

The 2008 model estimates that advanced ramp metering and connector metering reduce delay modestly by four percent in the AM peak and two percent in the PM peak, or a total of 800 vehicle-hours. The southbound direction experienced a greater reduction in delay (690 vehicle-hours compared to 80 vehicle-hours in the northbound direction). The northbound direction has minimal reductions. The 2020 model estimates that this strategy reduces delay by two percent in both peak periods, or a total of 950 vehicle-hours.

For modeling purposes, the Asservissement Lineaire d'Entrée Autoroutiere (ALINEA) system was tested as a proxy for any advanced ramp metering system since its algorithm for the model was readily available. However, it is not necessarily recommended that ALINEA be deployed, but rather, some type of advanced ramp metering system that produces similar, if not better results.

Scenario 11 (Auxiliary Lane Improvements in Irvine)

Scenario 11 consists of seven operational projects tested using the 2020 horizon year model. These projects build on Scenario 10 and include the following:

- At southbound Irvine Center Drive off-ramp, adding a second auxiliary lane from I-405 to the off-ramp
- At southbound Sand Canyon Avenue, adding a second drop lane from I-405 to the off-ramp
- Constructing southbound auxiliary lanes from SR-133 to Sand Canyon Road
- Adding a 400-meter southbound auxiliary lane and widening the off-ramp to provide a two-lane exit at Jeffrey/University
- Adding a second southbound auxiliary lane from SR-133 to Irvine Center Drive
- Adding a northbound auxiliary lane from Jeffrey to Culver
- Adding a northbound auxiliary lane at Culver Drive off-ramp.

The 2020 model estimates that the auxiliary lane improvements reduce delay by 11 percent in both peak periods. This totals to a reduction of over 5,000 vehicle-hours. Most notably, the reductions occur in the southbound direction in both the AM and PM peak period, from McArthur Boulevard to Jeffrey Road.

Scenarios 12 and 13 (Enhanced Incident Management)

Two incident scenarios were built upon on Scenario 8 to evaluate enhanced incident management strategies. In the first scenario, Scenario 12, a collision incident with one outside lane closure, was simulated in the northbound direction in the PM peak model and in the southbound direction in the AM peak model. The incident simulation location and duration were selected based on a review of the 2010 actual incident data, at one of the high-incident frequency locations. The following are the scenario details:

- Northbound PM Peak starting at 5:00 PM, close mainline outermost lane for 35 minutes at post mile 9.3 (north of Bristol)

- Southbound AM Peak starting at 7:30 AM, close mainline outermost lane for 35 minutes at post mile 8.1 (at Bristol).

In the second scenario, Scenario 13, the same incidents were simulated with the duration reduced by 10 minutes for both. Based on Caltrans incident management data, the study team estimated 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 in the peak period direction.

An enhanced incident management system would entail upgrading or enhancing the current Caltrans incident management system to include 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.

As shown in Exhibits 6-29 and 6-30, the 2020 model estimates that non-recurrent delay is reduced by two percent (approximately 1,000 vehicle-hours delay) for both directions with deployment of enhanced incident management. Similar to the SR-22 incident management results, these results reflect benefits that can be realized during the peak direction period. Additional benefits could be realized during off-peak hours and in the off-peak direction.

Exhibit 6-29: I-405 AM Delay Results for Enhanced Incident Management (2020)

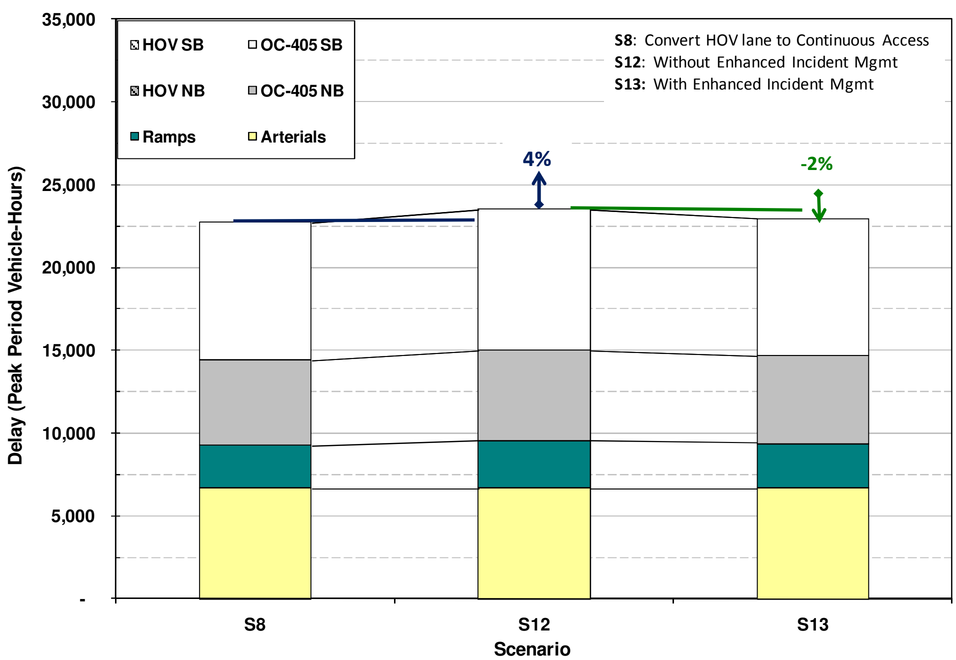
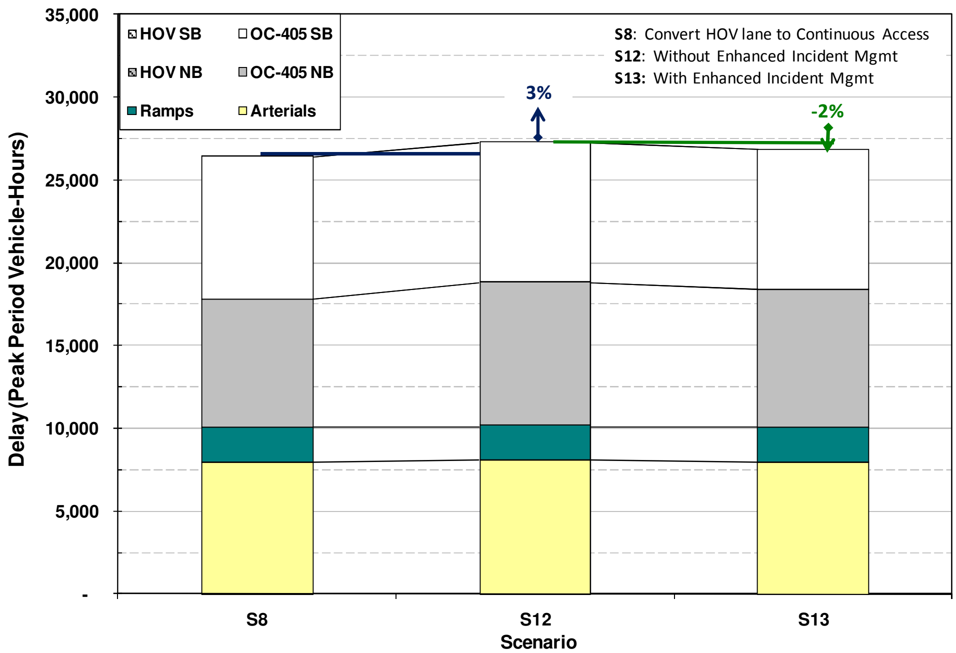


Exhibit 6-30: I-405 PM Delay Results for Enhanced Incident Management (2020)



Scenario 14 (SR-133 Interchange Improvements)

Scenario 14 builds on Scenario 11 and tests the interchange improvements at SR-133 proposed by the South Orange County Major Investment Study (SOCMIS) with the 2020 model. This project involves the construction of connectors from southbound I-405 to northbound and southbound SR-133. It also involves a new southbound I-405 off-ramp to the vicinity of Alton Parkway.

The 2020 model estimates that the project reduces delay by three percent in the AM peak period with minimal impact during the PM peak period. The new southbound connector to SR-133 contributes to the delay reduction of over 650 vehicle-hours in the AM peak. The northbound direction experiences slightly heavier congestion (of about 280 vehicle-hours) as the connector allows SR-133 vehicles to reach northbound I-405 more quickly. However, the model does not capture the additional benefits that may occur on the SR-133 corridor. The nominal impact of the project on I-405 is due to the limited, spot improvements rather than improvements across longer segments of the corridor.

Demand at this location may continue to increase beyond 2020 such that long-term operational benefits could be anticipated well into 2035 and beyond. Further study may be required to quantify the long-term benefits beyond 2020.

Post Scenario 14 Conditions

By 2020, with the inclusion of projects from Scenario 1 to Scenario 14, the model reveals some residual congestion remains to be addressed with future improvements. The total remaining delay for the corridor as according to the model results is around 40,000 daily vehicle-hours of delay.

Benefit-Cost Analysis

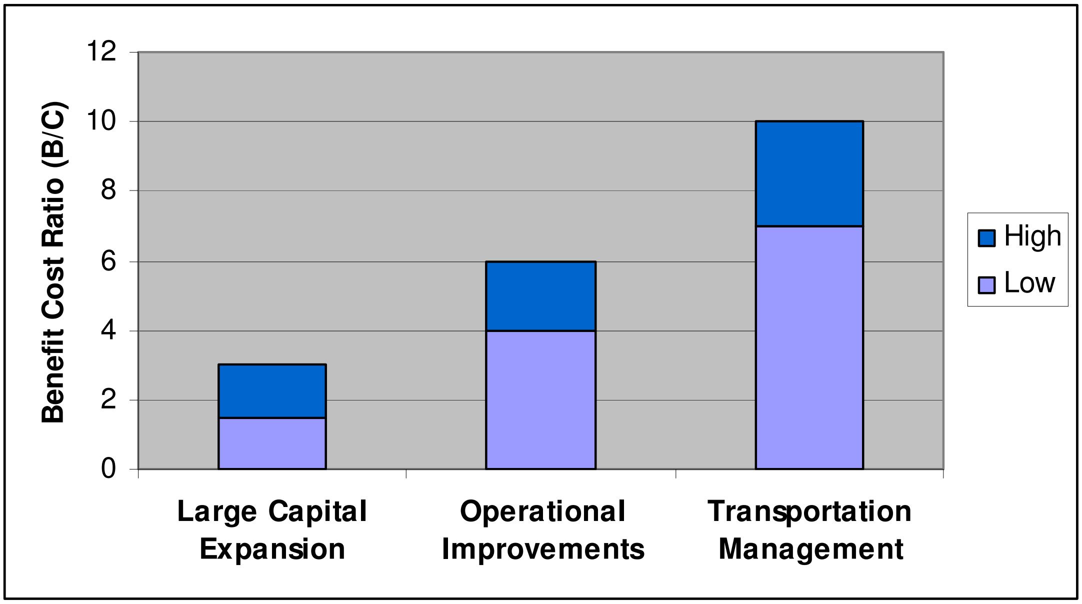
Following an in-depth review of the model results, the study team developed a benefit-cost analysis for each scenario. The benefit-cost results represent the incremental benefits over the incremental costs of a given scenario.

The study team used the California Benefit-Cost 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 the benefits after the 20-year lifecycle or other benefits, such as the reduction of congestion beyond the peak periods and improvement in transit travel times.

Project costs were obtained from various sources, including the RTIP, OCTA's Long Range Plan (LRP), and Caltrans project planning. Costs for the advanced ramp and connector ramp metering include widening to accommodate the connector meters within the State's right-of-way, but not the acquisition of new right-of-way. A benefit-cost ratio (B/C) greater than one means that a scenario's projects return benefits greater than they cost to construct or implement. It is important to consider the total benefits that 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 users.

Exhibit 6-31 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.

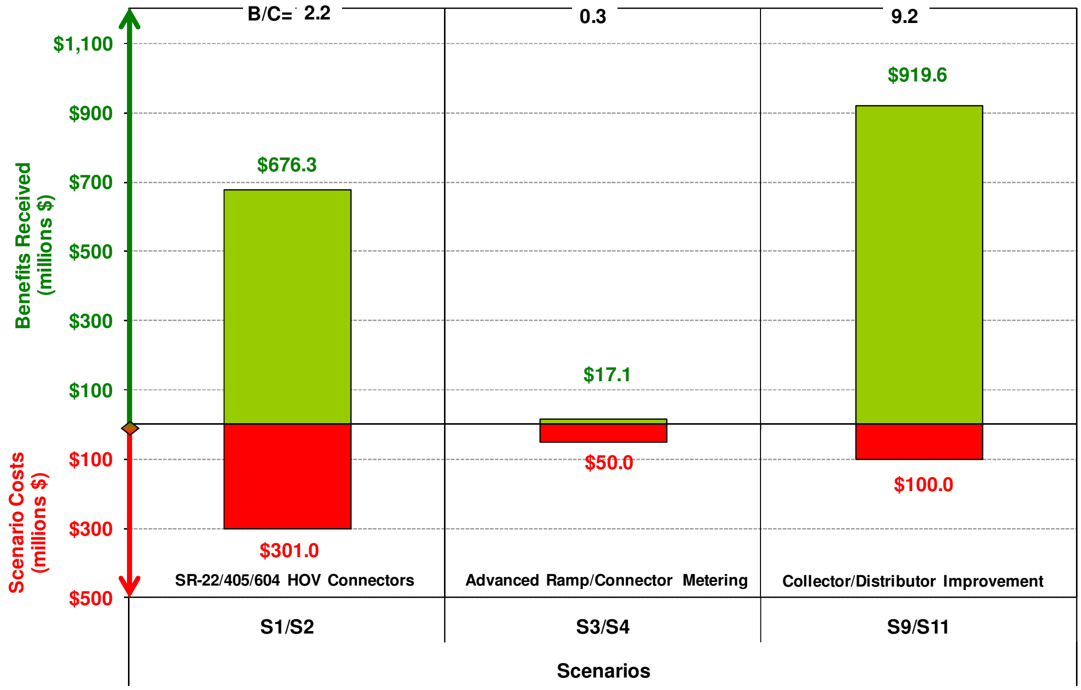
Exhibit 6-31: Benefit-Cost Ratios for Typical Projects



SR-22 Benefit-Cost Results

The benefit-cost results for the SR-22 scenarios are shown in Exhibit 6-32. Detailed benefit-cost results can be found in Appendix B.

Exhibit 6-32: SR-22 Scenario Benefit/Cost (B/C) Results



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

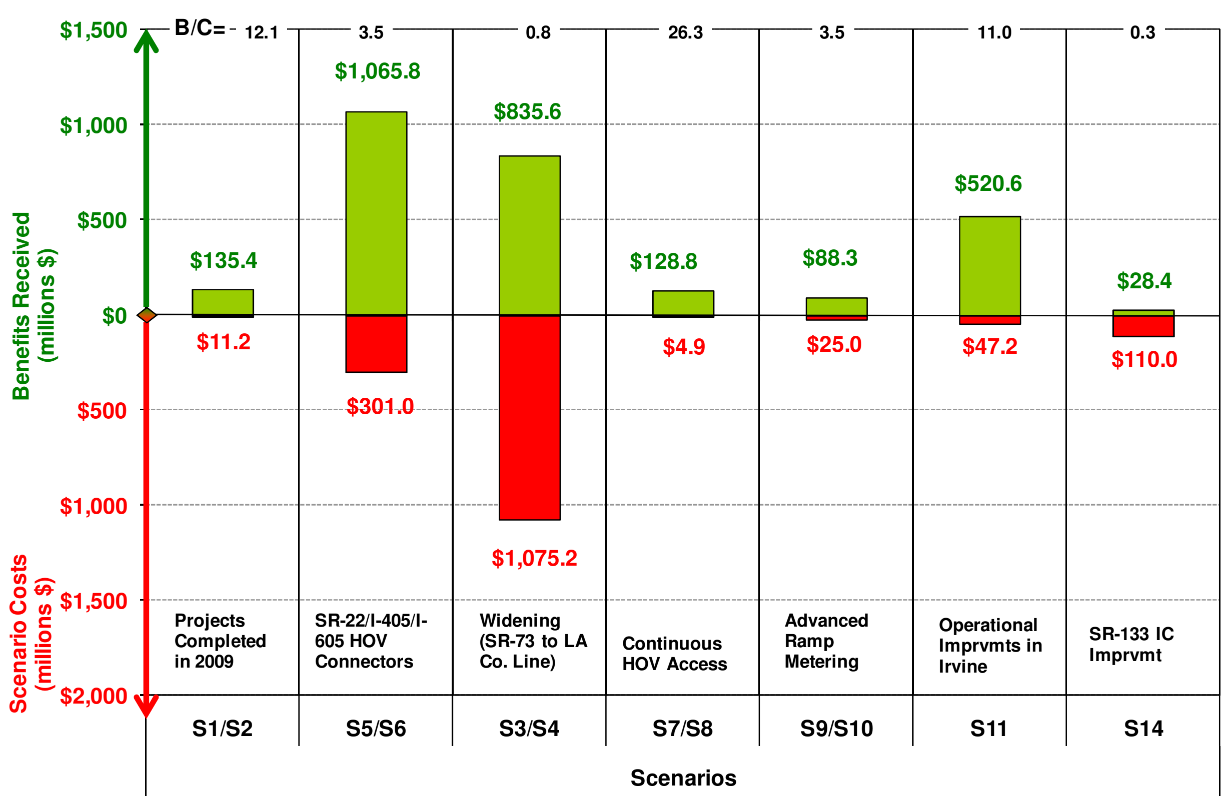
- Scenarios 1 and 2 (programmed SR-22/I-405/I-605 HOV direct connectors) produce a benefit-cost ratio of over 2:1. This result is consistent with typical operational projects with high costs (the cost of this improvement exceeds $300 million). The benefits are substantial at over $670 million.
- Scenarios 3 and 4 (advanced ramp metering with connector metering) produce a benefit-cost ratio below one, due to the limited effect of advanced ramp and connector metering on corridor mobility. The benefit-cost ratio is likely to be higher with minimal connector metering implementation (i.e. no widening). In addition, advanced ramp metering can be optimized further to provide additional benefits. The model can be used to test different variable settings to optimize flow and minimize delay further.
- Scenarios 9 and 11 (eastbound collector-distributor facility improvement) produce a relatively high benefit-cost ratio of over 9:1 because of high expected mobility improvements. Reconstruction of the eastbound collector-distributor facility (with braided access improvements to the I-5 and SR-57 freeways) would be cost-effective and produce a significant benefit. Staged improvement could be considered to capture mobility benefits earlier if there is a significant funding constraint. Additional analysis is recommended to evaluate MOS strategies.

- The benefit-cost ratio of all scenarios combined is about 3.5 to 1. If all projects were delivered at current cost estimates, the public would get over three dollars of benefits for each dollar expended. In current dollars, costs total to around $450 million whereas the benefits are estimated to be almost $1.6 billion.
- The projects also alleviate greenhouse gas emissions by over 1.1 million tons over 20 years, averaging nearly a 55,000-ton reduction per year. The emissions are estimated using data from the California Air Resources Board (CARB) EMFAC model.

I-405 Benefit-Cost Results

Exhibit 6-33 summarizes the benefit-cost results for the I-405 scenarios. Detailed benefit-cost results can be found in Appendix B.

Exhibit 6-33: I-405 Scenario Benefit/Cost (B/C) Results



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

- Scenarios 1 and 2 (completed projects from 2008 base year to current year 2010) produce a relatively high benefit-cost ratio of over 12:1. This is primarily the result of beneficial improvements costing only $11.2 million. This result is consistent with other effective operational improvement projects.
- Scenarios 5 and 6 (CMIA project – SR-22/I-405/I-605 HOV direct connectors) produce a benefit-cost ratio above 3:1. This is consistent with other typical capital improvement projects.
- Scenarios 3 and 4 (mainline widening, auxiliary lanes, and operational improvements) produce a benefit-cost ratio below one. This relatively modest B/C is due to the high cost of widening at over $1.07 billion. However, the benefits are substantial at over $830 million.
- Scenarios 7 and 8 (HOV conversion to continuous access) produce a benefit-cost ratio of over 26:1. Although the benefits are relatively modest at $130 million, the low cost makes this project a cost-effective investment.
- Scenarios 9 and 10 (advanced ramp metering and connector metering) produces a benefit-cost ratio above 3:1, which is in an appropriate range considering the added cost of connector metering. The cost related to connector metering is based on existing conditions and does not consider widening of connectors.
- Scenario 11 (operational improvements at the south end of the corridor) produces a relatively high B/C of over 10:1, again due to the relatively low cost of construction. The high benefit-cost ratio is consistent with other effective operational improvement projects.
- Scenario 14 (capital improvement with SR-133 interchange modification) produces a benefit-cost ratio below one, due to the high cost of construction and nominal benefits to the corridor. However, the model may not capture all of the benefits, since SR-133 may also experience improvements.
- The benefit-cost ratio of all scenarios combined is about 2:1. If all projects were delivered at current costs, the public would get two dollars of benefits for each dollar expended. In current dollars, costs add up to around $1.6 billion whereas the benefits are estimated to be almost $2.8 billion.
- The projects also alleviate greenhouse gas (GHG) emissions by about 1.7 million tons over 20 years. This reduction averages nearly 85,000 tons per year. The emissions are estimated using data from the California Air Resources Board (CARB) EMFAC model.

7. CONCLUSIONS AND RECOMMENDATIONS

This section summarizes the conclusions and recommendations based on the analysis presented. Many of these conclusions are based on the micro-simulation model results. The model was developed based on the best data available at the time. After a thorough and careful review of each incremental step and analysis, the study team believes that both the calibration and the scenario results are reasonable and allow for more informed decision-making.

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

SR-22 Corridor Improvements

Based on the results, the study team offers the following conclusions and recommendations for the SR-22 Corridor:

- The programmed CMIA project, which constructs the SR-22/I-405/I-605 HOV direct connectors, is expected to produce a benefit-cost ratio of over 2:1. This result is consistent with typical capital expansion projects. Benefits are substantial at over $670 million.
- Advanced ramp metering with connector metering results in only modest mobility improvements on this corridor. This result should be revisited with additional analyses in the future.
- Reconstruction of the eastbound collector-distributor facility (with access improvements to the I-5 and SR-57 freeways) would be very cost-effective, producing a benefit-cost ratio of over 9:1. The CSMP model results for 2020 traffic shows that short-term operational benefits for collector-distributor facility improvements may be achieved in a Minimum Operating Segment (MOS) by phasing construction. The study team recommends additional analysis to evaluate such staging properly.
- Finally, improved incident management shows promise. The SR-22 corridor experienced up to 750 accidents in 2008. With an average delay savings of nearly 300 vehicle-hours per incident, that would amount to a total annual delay savings of over 225,000 vehicle-hours for the corridor.

I-405 Corridor Improvements

Based on the results, the study team offers the following conclusions and recommendations for the I-405 Corridor:

- The analysis results indicate that the operational projects completed in the last two years have produced immediate results and are very cost-effective (benefit-cost ratio of 12 to 1). The benefits of these projects may decline somewhat in future years.
- The CMIA project (SR-22/I-405/I-605 HOV direct connectors) is expected to produce a benefit-cost ratio of 3.5 to 1 on I-405. This project produces large benefits for a low cost.
- An HOV conversion to continuous access (Scenarios 7 and 8) would produce large benefits for a low cost on I-405.
- Auxiliary lane improvements at the south end of the corridor (Scenario 11) are also very cost-effective (B/C ratio of over 10:1). In 2020, these improvements may reduce delay by over 5,000 vehicle hours.
- Other scenarios range from low to moderate cost-effectiveness. Low-cost improvements, such as advanced ramp metering with connector metering, seem to show relatively reasonable investment. Caltrans needs to consider other factors, including intangibles, for the high-cost investments.
- Enhanced incident management shows promise. The I-405 study corridor experienced around 1,200 accidents in 2008. With an average delay savings of nearly 500 vehicle-hours per incident, that would amount to a total annual delay savings of over 600,000 vehicle-hours for the corridor.

Speed Contour Maps

Exhibits 7-1 through 7-4 show speed contour maps for the eastbound SR-22 mainline in the 2020 “Do Minimum” horizon year with the growth in congestion before and at the conclusion of the final scenario. Exhibits 7-5 through 7-8 show the speed contour maps for the westbound SR-22 mainline before and at the conclusion of the final scenario tested. A separate modeling report is available that provides speed contour diagrams for each scenario tested.

Exhibits 7-2 and 7-4 are speed contour maps of the eastbound SR-22 corridor produced by the model at the conclusion of Scenario 11 (collector-distributor improvement), the final scenario with improvements in this direction. There is very little noticeable congestion after all of the scenarios are implemented. However, there is some congestion near Harbor and approaching the new SR-57 access ramp, in the AM peak, and minor congestion and bottleneck residual at Beach, Euclid, Harbor, and SR-55 interchanges in the PM peak.

Exhibits 7-3 and 7-5 show speed contour maps of the westbound SR-22 corridor produced by the model at the conclusion of Scenario 4 (advanced ramp/connector metering), the final scenario with improvements in this direction. These maps indicate the last remaining residual congestion and bottleneck locations. As shown, there is still noticeable congestion in 2020 near Beach Boulevard in the AM peak and from SR-55 to Euclid in the PM peak even after all of the improvements are implemented.

Since the CSMP horizon year model is for 2020, further study or other methodology may be needed to assess the benefits of addressing demand beyond 2020.

Exhibit 7-1: Eastbound SR-22 AM Peak Model Speed Contours Before Improvements (2020)

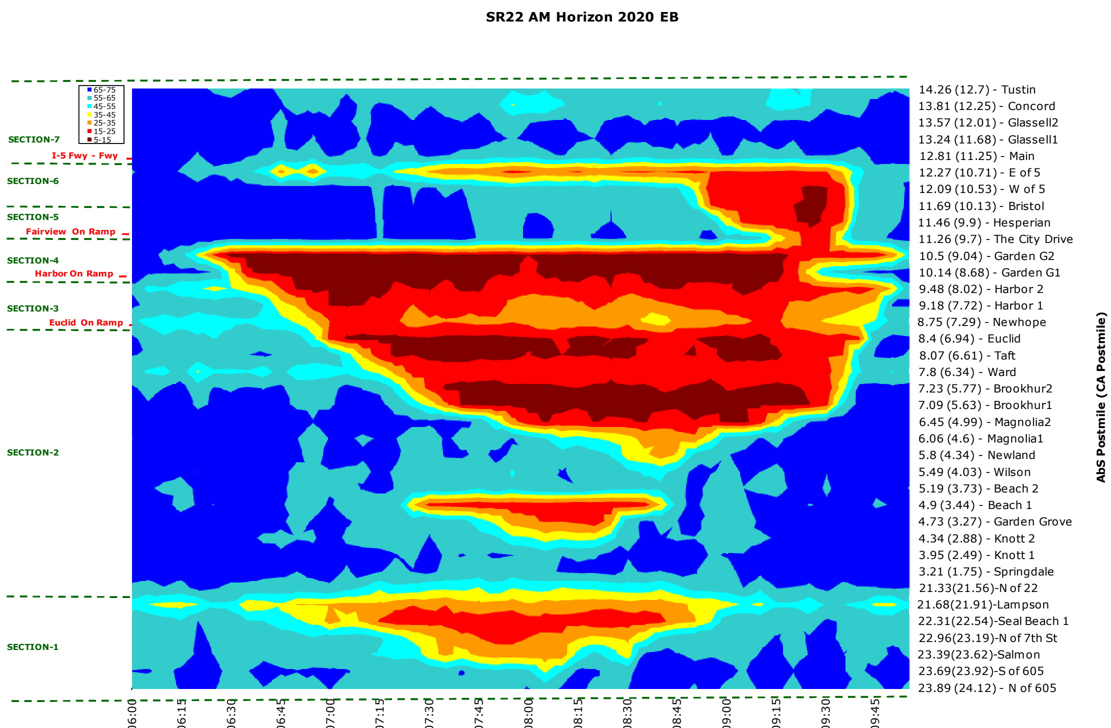


Exhibit 7-2: Eastbound SR-22 AM Peak Model Speed Contours After Improvements (2020)

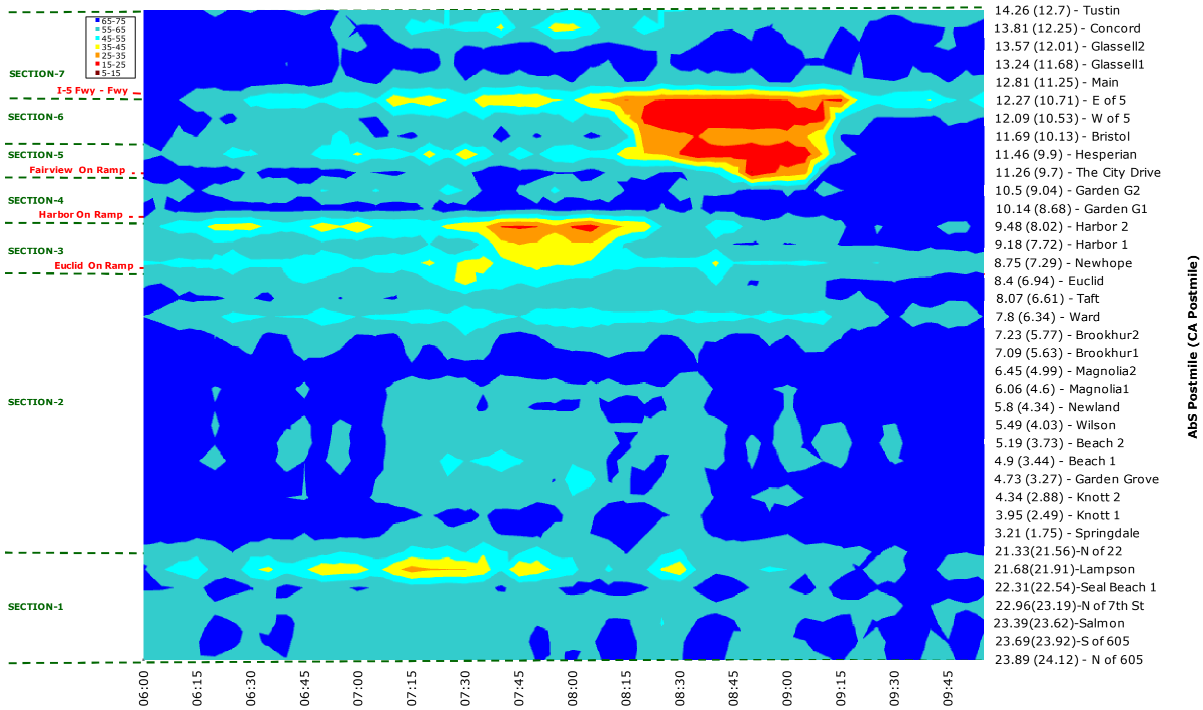


Exhibit 7-3: Eastbound SR-22 PM Peak Model Speed Contours Before Improvements (2020)

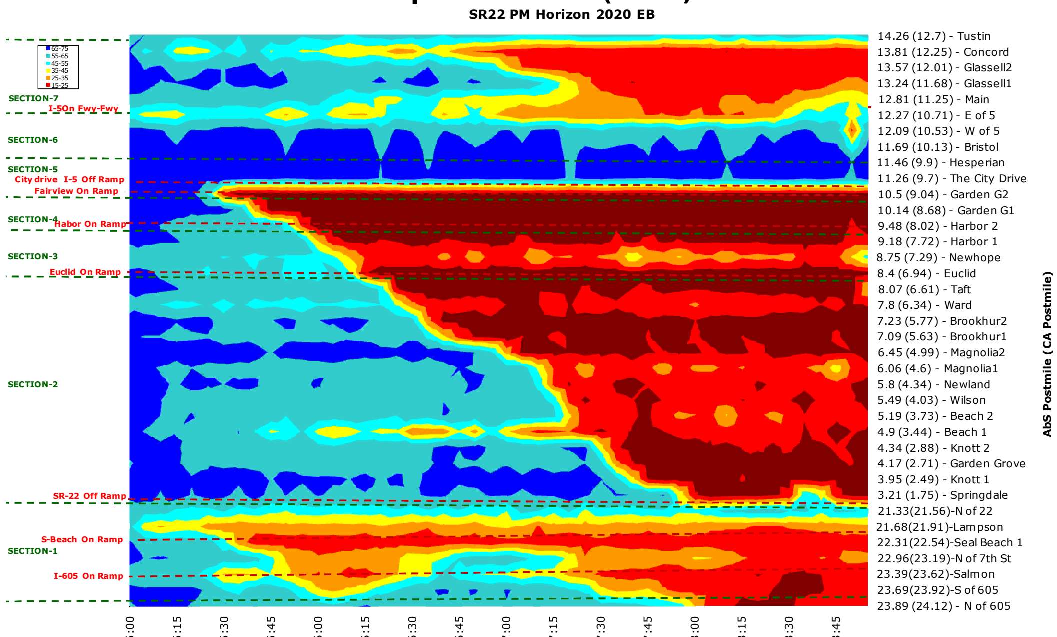


Exhibit 7-4: Eastbound SR-22 PM Peak Model Speed Contours After Improvements (2020)

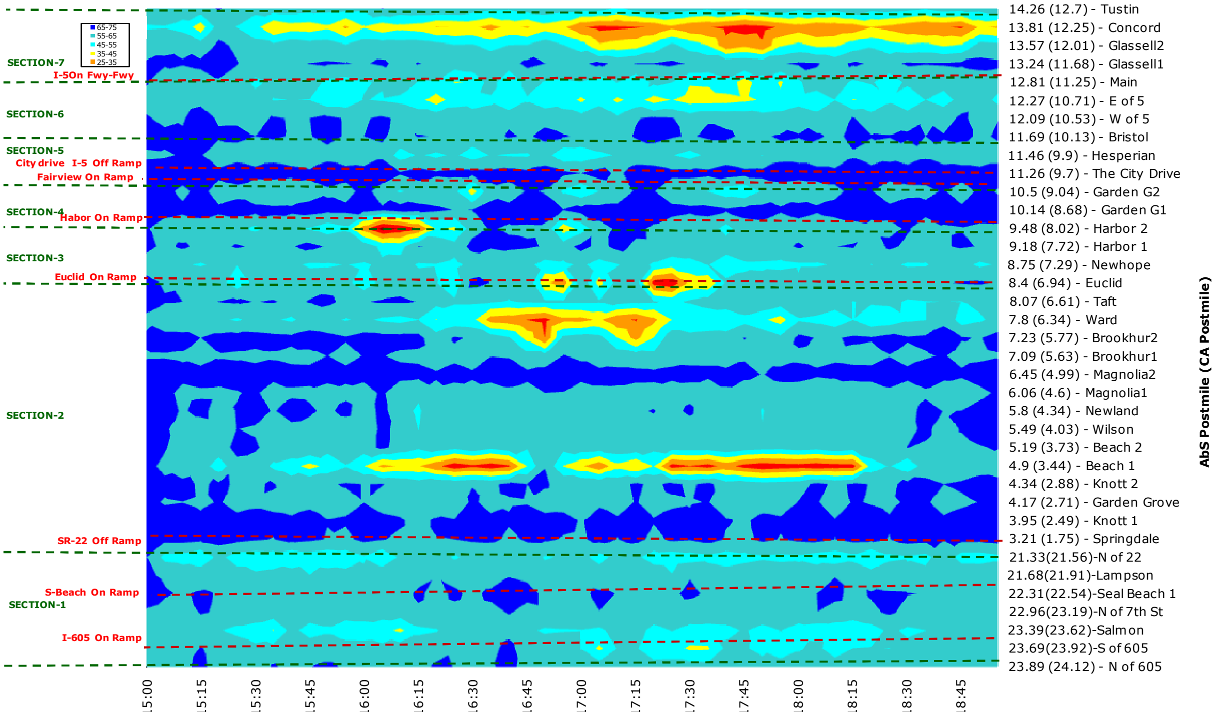


Exhibit 7-5: Westbound SR-22 AM Peak Model Speed Contours Before Improvements (2020)

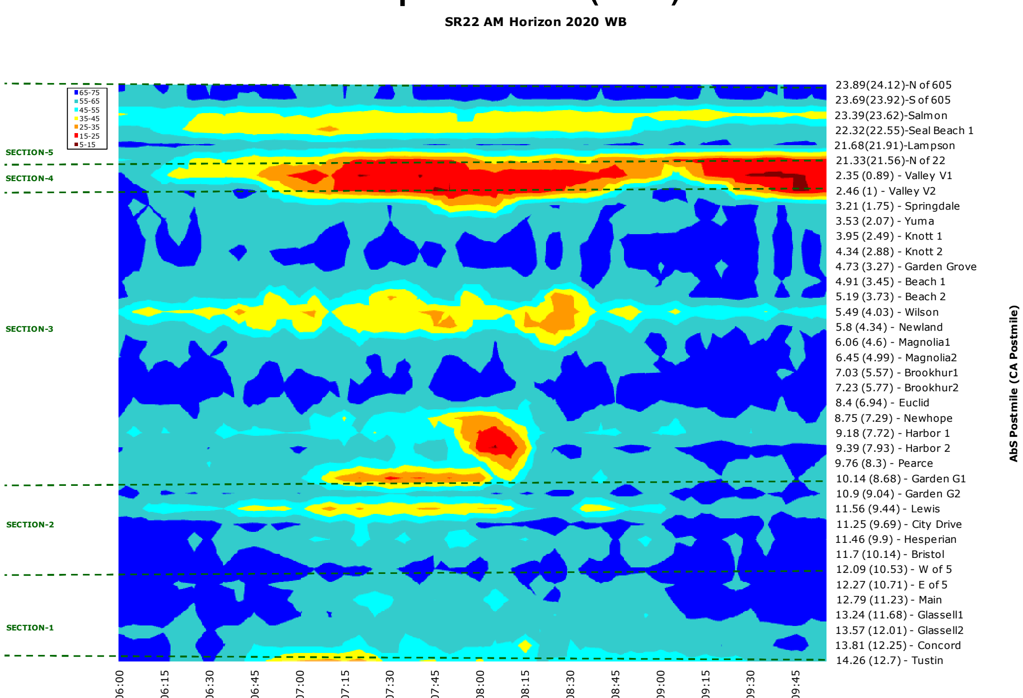


Exhibit 7-6: Westbound SR-22 AM Peak Model Speed Contours After Improvements (2020)

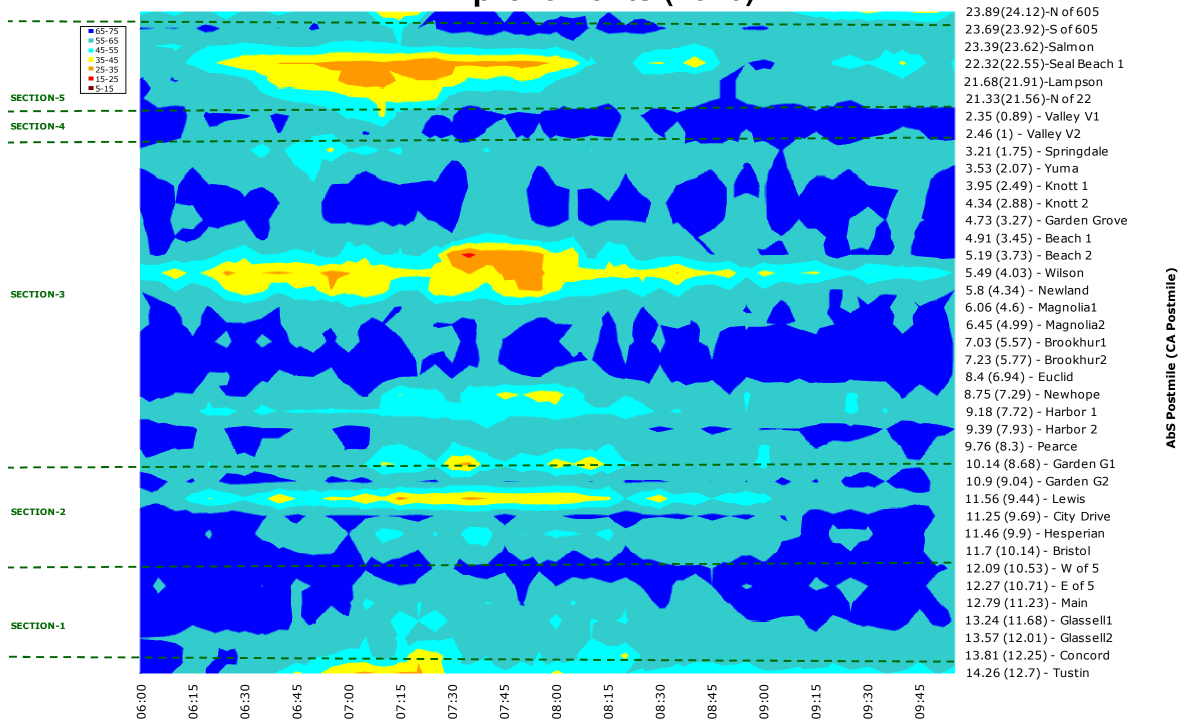


Exhibit 7-7: Westbound SR-22 PM Peak Model Speed Contours Before Improvements (2020)

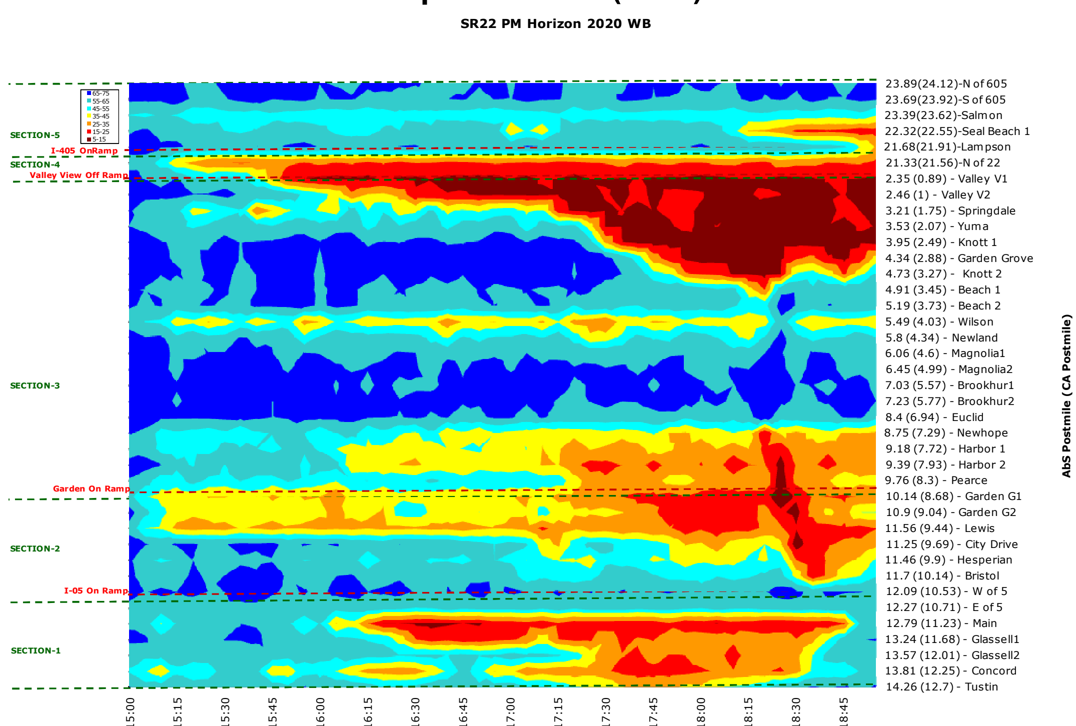
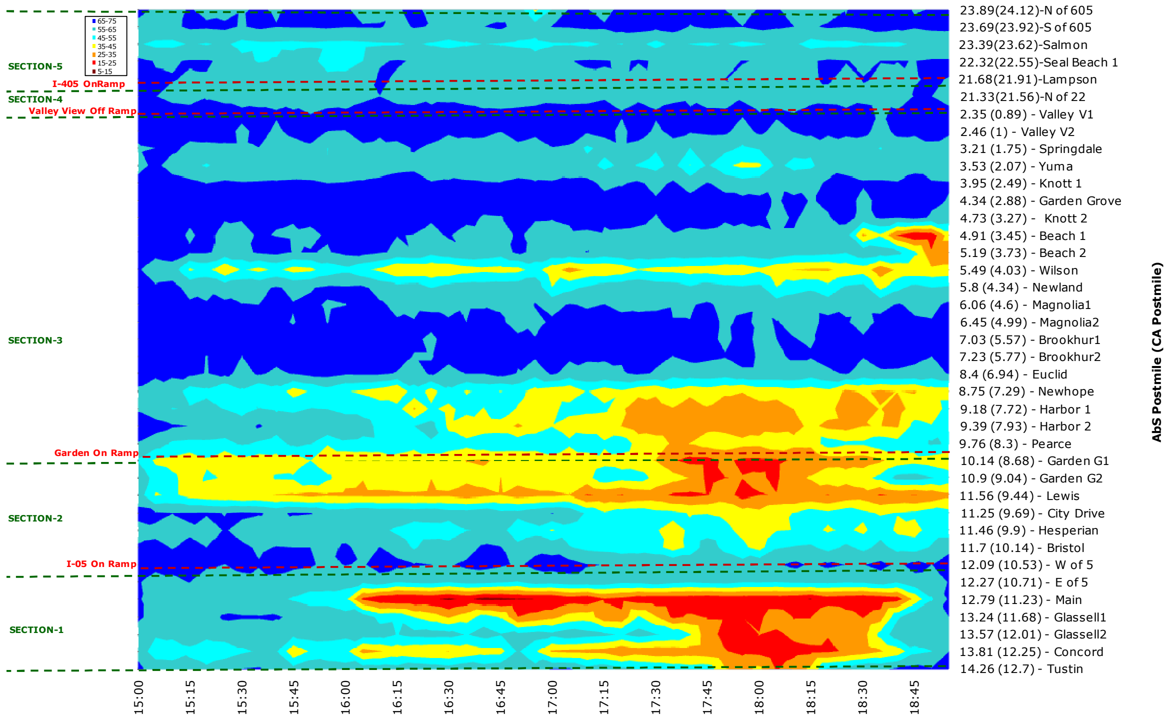


Exhibit 7-8: Westbound SR-22 PM Peak Model Speed Contours After Improvements (2020)



Exhibits 7-9 through 7-12 show the eastbound SR-22 collector-distributor and SR-57 connector “horseshoe” segments speed contour maps produced by the model before and at the conclusion of the collector-distributor improvement, the final scenario tested. With the implementation of all the improvements, there is still noticeable congestion within the connector horseshoe, as the expected demand would still be high, particularly in the AM peak period. Only modest congestion remains even in the horseshoe in the PM peak period.

Exhibit 7-9: Eastbound SR-22 C/D AM Peak Model Speed Contours Before Improvements (2020)

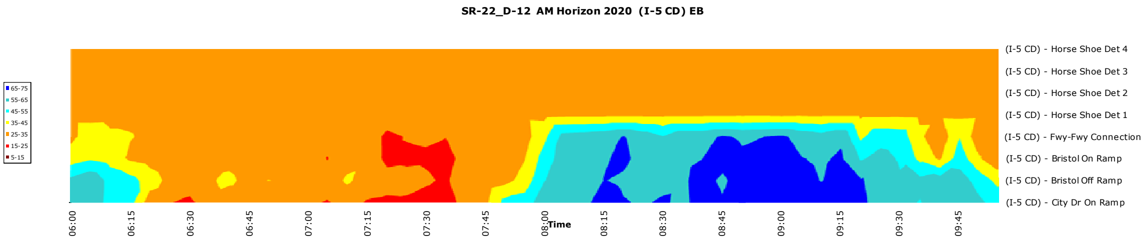


Exhibit 7-10: Eastbound SR-22 C/D AM Peak Model Speed Contours After Improvements (2020)

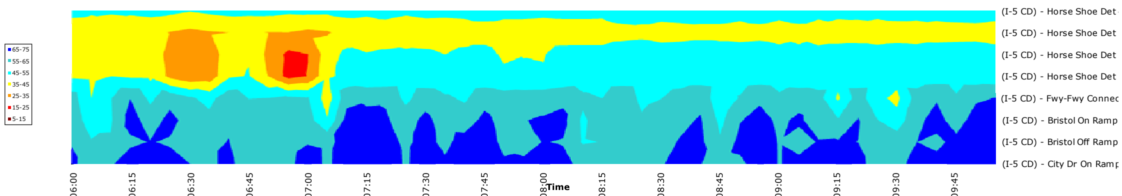


Exhibit 7-11: 2020 Eastbound SR-22 C/D PM Peak Model Speed Contours Before Improvements (2020)

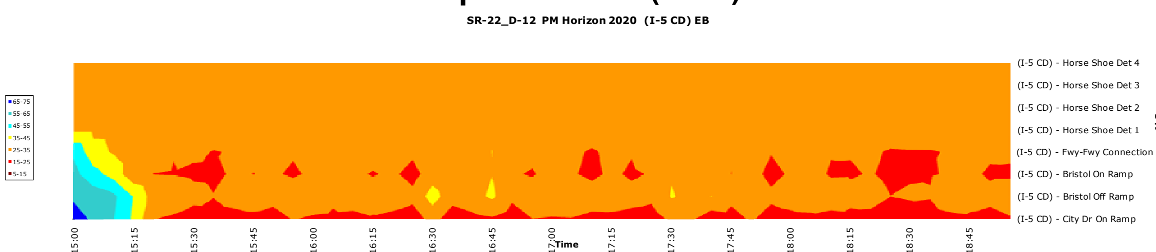


Exhibit 7-12: Eastbound SR-22 C/D PM Peak Model Speed Contours After Improvements (2020)

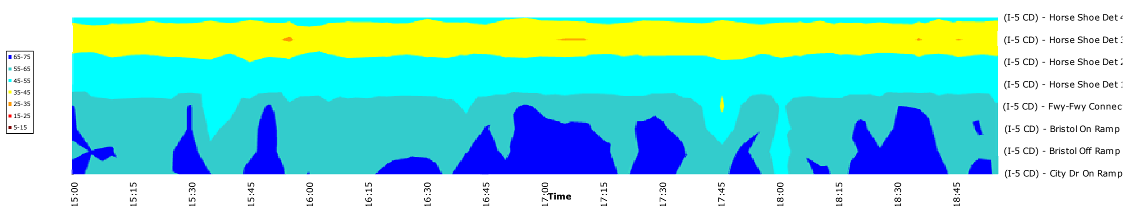


Exhibit 7-13 through 7-16 are speed contour maps of the northbound I-405 produced by the model before and at the conclusion of Scenario 14 (SR-133 Interchange improvements), the final scenario tested on the corridor. These maps indicate the last remaining residual congestion and bottleneck locations. With the implementation of all the improvements, there is still noticeable congestion from SR-133 to Jamboree in the AM peak with major bottlenecks at Sand Canyon and Jamboree and between SR-133 and SR-73 in the PM peak with major bottleneck at SR-73, even after all of the scenarios are implemented. To reduce or address these congestion areas in the future, widening or other capital expansion projects may be necessary in the southern segments south of SR-73.

Exhibits 7-17 through 7-20 show the southbound I-405 corridor speed contour maps produced by the model before and at the conclusion of Scenario 14 (SR-133 Interchange improvements), the final scenario tested on the corridor. These maps illustrate the last remaining residual congestion and bottleneck locations. With the implementation of all the improvements, there is still noticeable congestion from Euclid to MacArthur in the AM peak with major bottlenecks at Harbor, Bristol, and SR-55, and between Jamboree and SR-133 in the PM peak. In the southbound direction, widening or major improvements may be needed in the southern segments south of SR-73 to relieve these congestion areas.

Exhibit 7-13: Northbound I-405 AM Peak Model Speed Contours Before Improvements (2020)

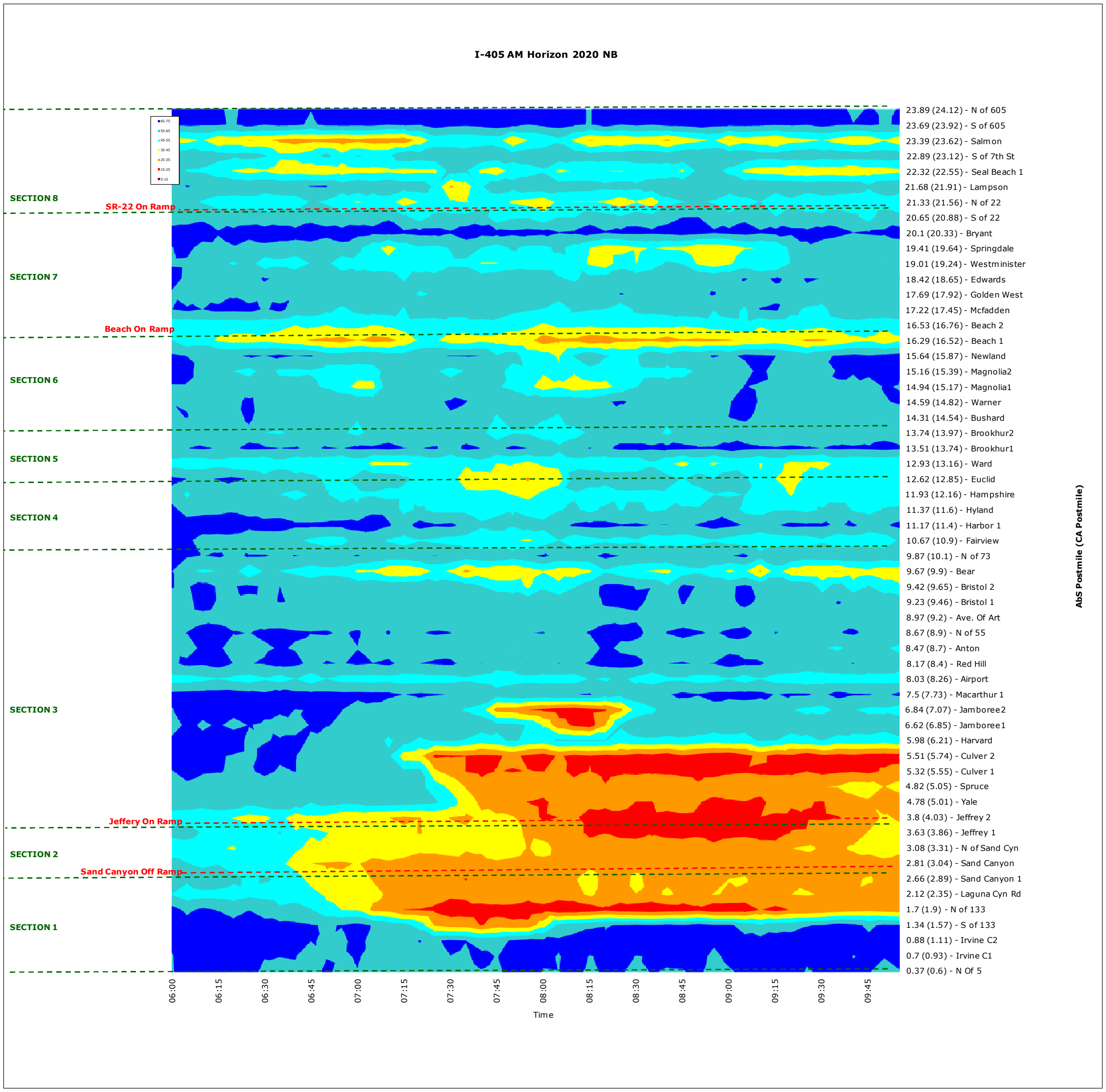


Exhibit 7-14: Northbound I-405 AM Peak Model Speed Contours After Improvements (2020)

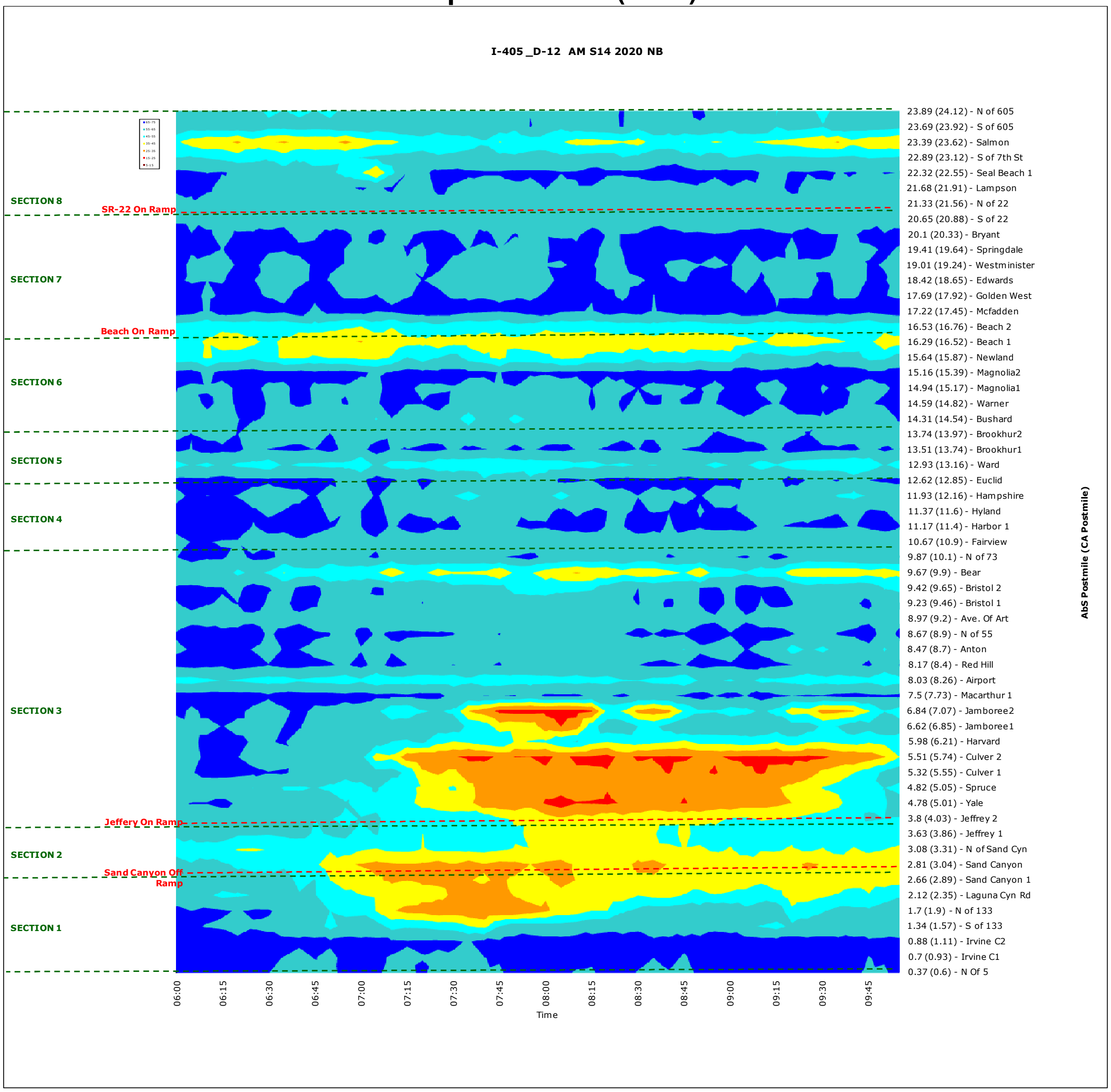


Exhibit 7-15: Northbound I-405 PM Peak Model Speed Contours Before Improvements (2020)

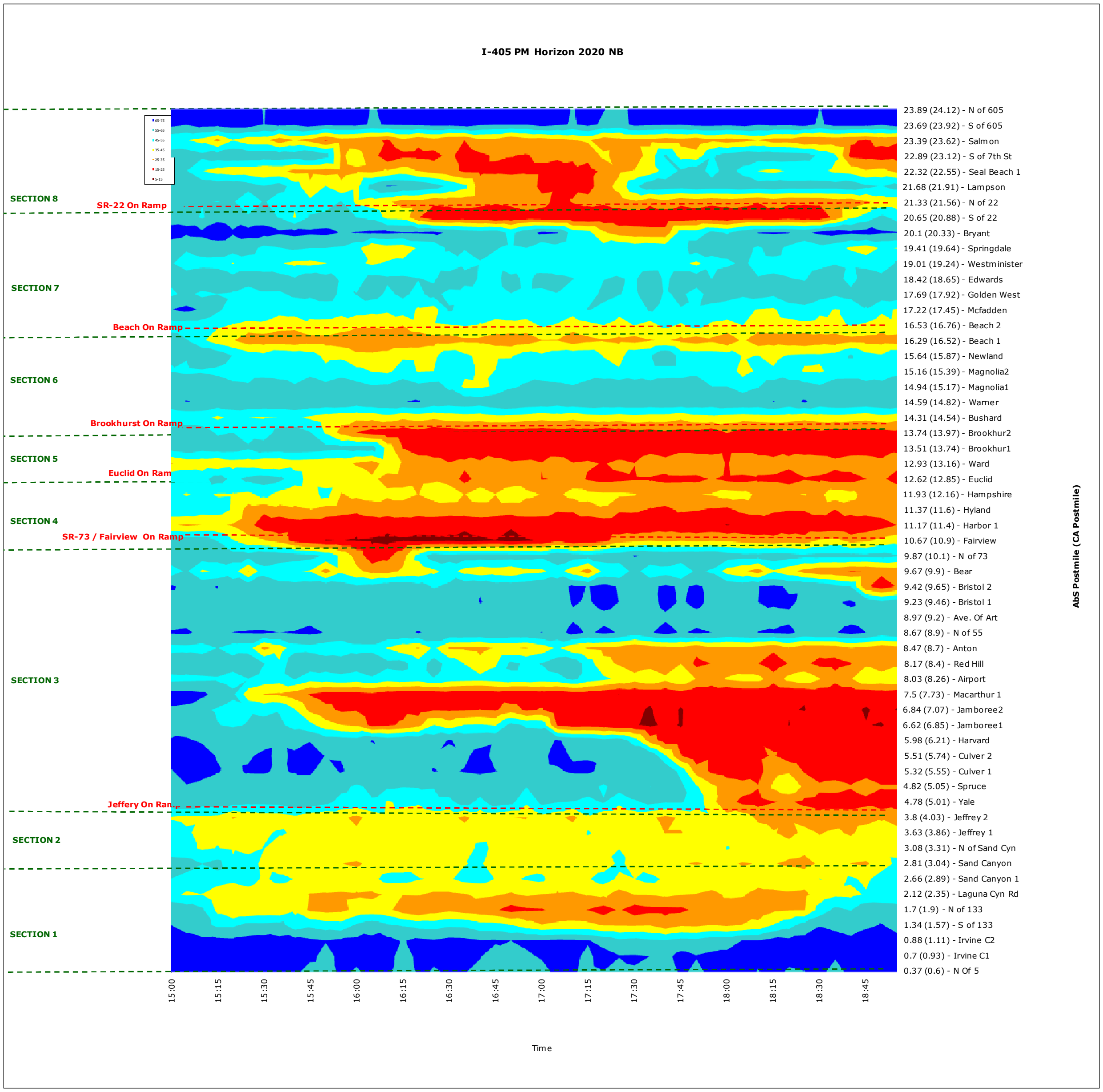


Exhibit 7-16: Northbound I-405 PM Peak Model Speed Contours After Improvements (2020)

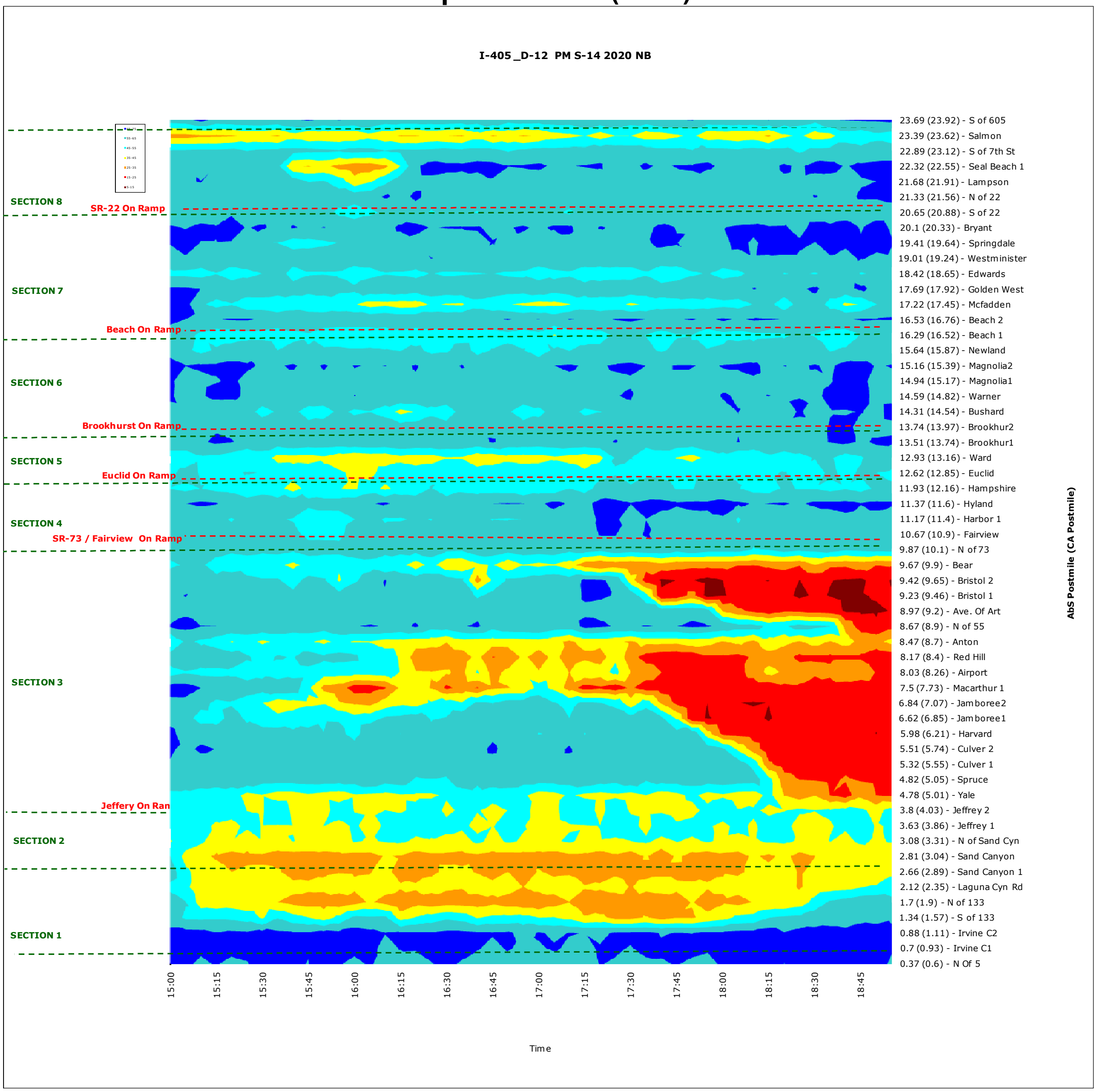


Exhibit 7-17: Southbound I-405 AM Peak Model Speed Contours Before Improvements (2020)

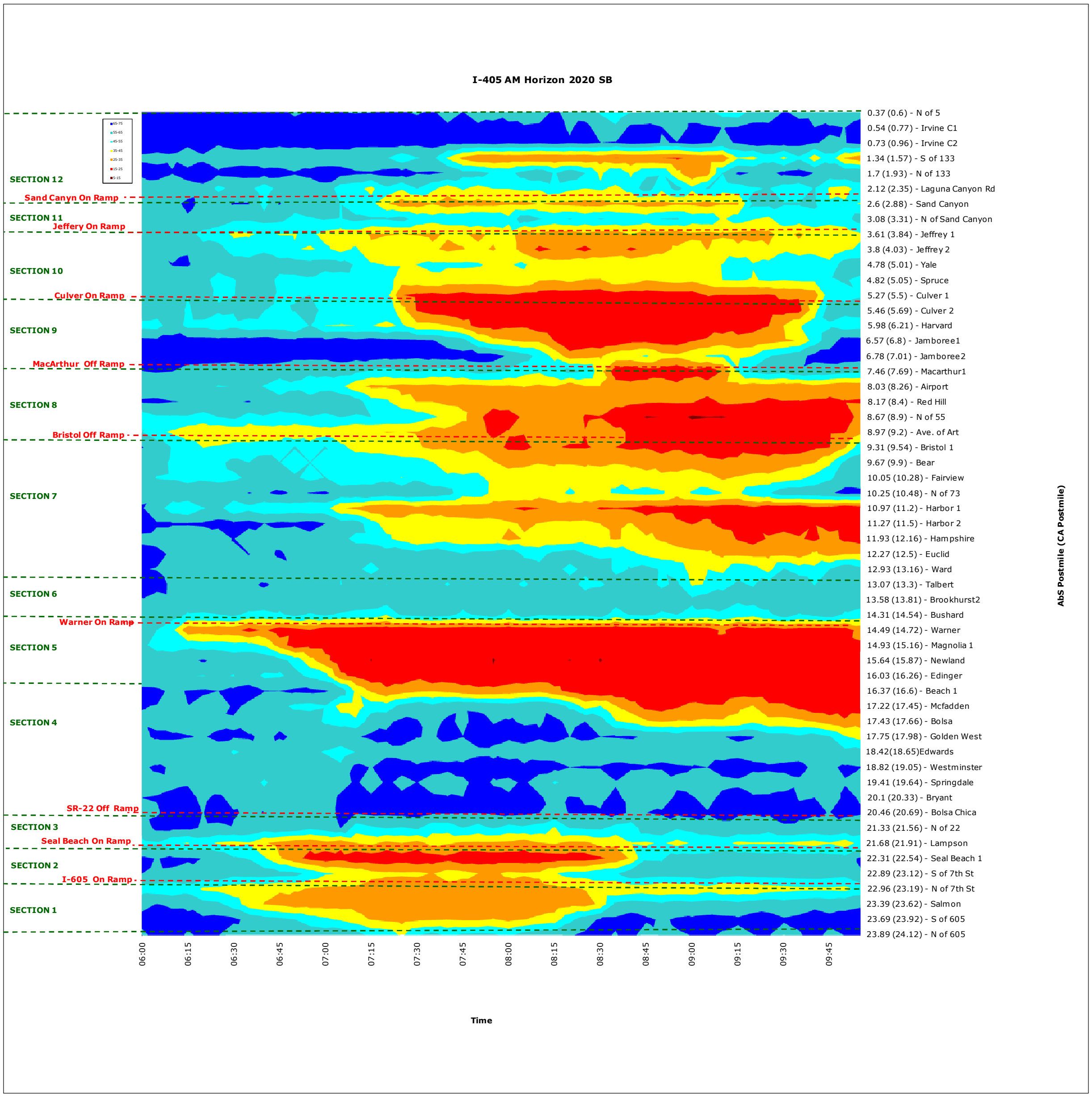


Exhibit 7-18: Southbound I-405 AM Peak Model Speed Contours After Improvements (2020)

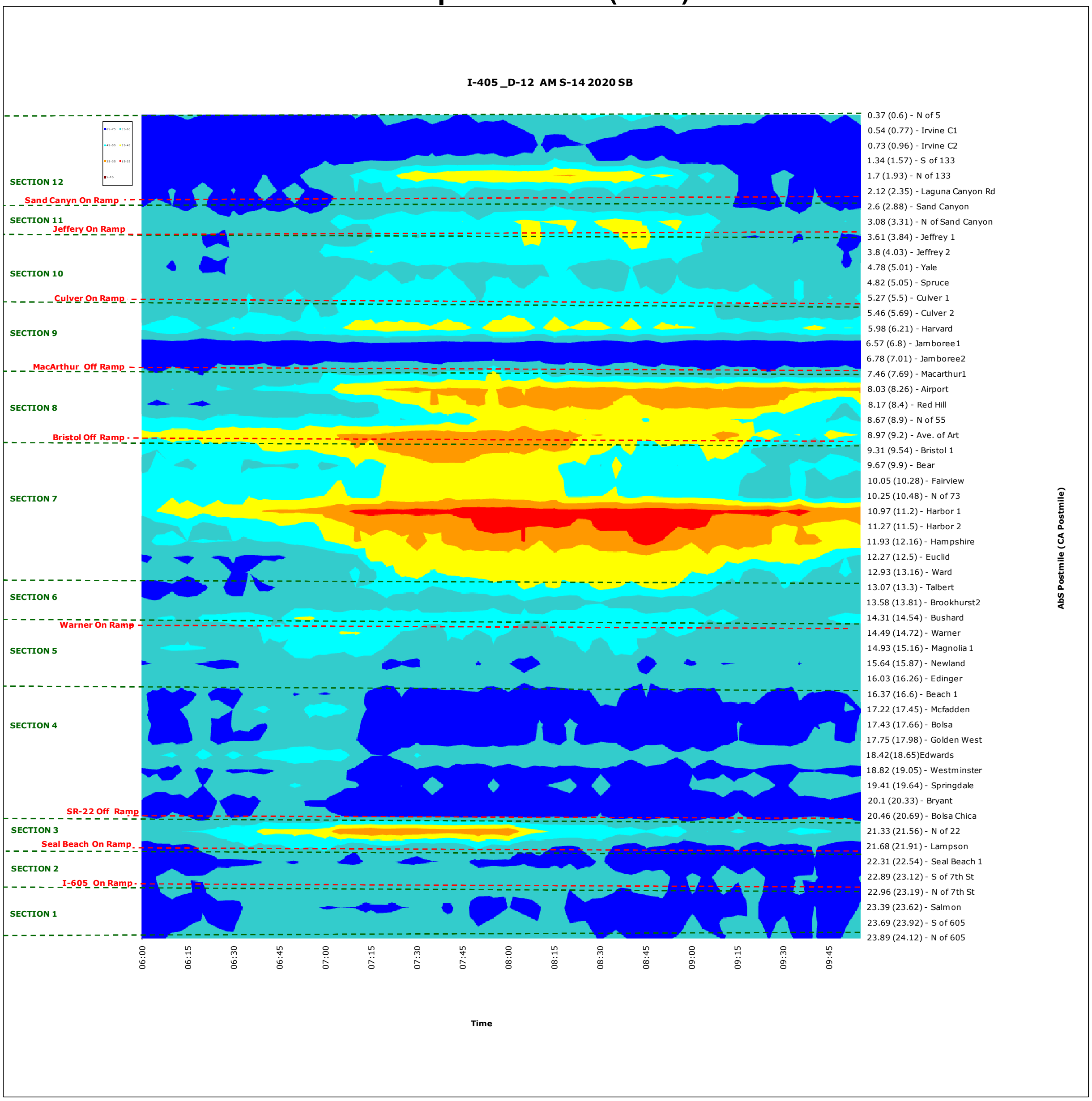


Exhibit 7-19: Southbound I-405 PM Peak Model Speed Contours Before Improvements (2020)

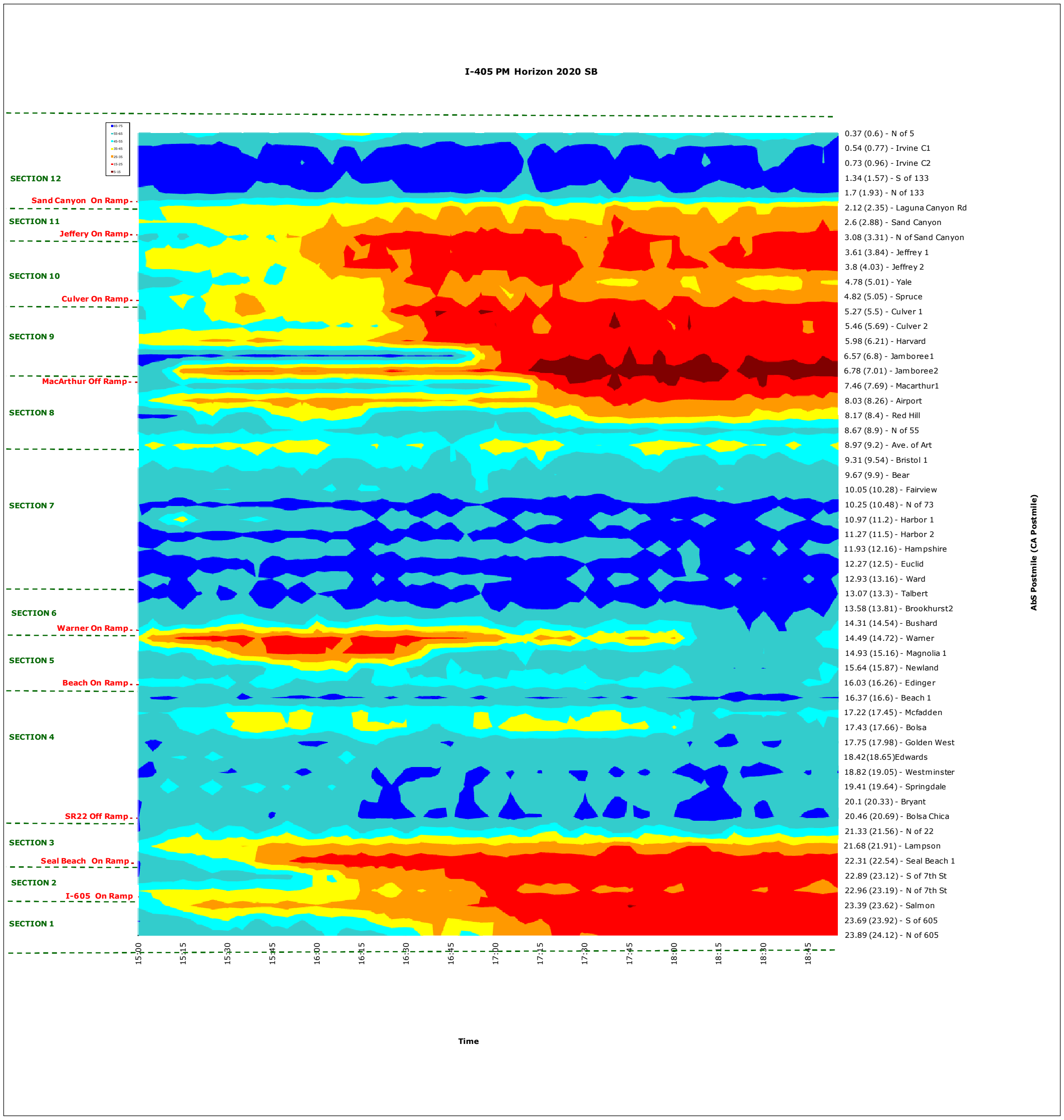
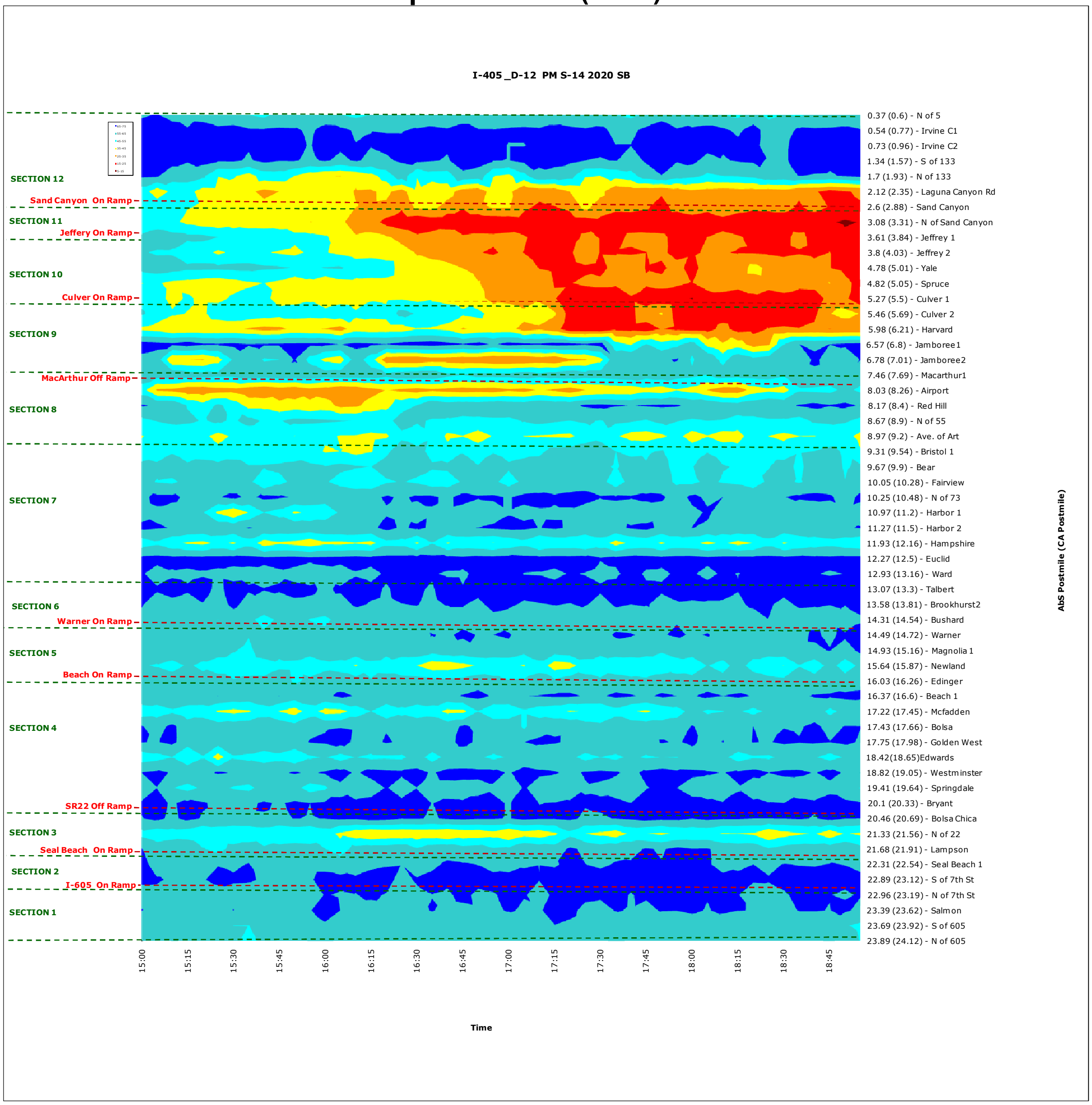


Exhibit 7-20: Southbound I-405 PM Peak Model Speed Contours After Improvements (2020)



This is the first-generation CSMP for the SR-22 corridor. It is important to emphasize that CSMPs should be updated, on a regular basis, if possible. This is particularly important since traffic conditions and patterns can differ from current projections. After projects are delivered, it is also useful to compare actual results with estimated ones in this document so that models can be further improved as appropriate.

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

Appendix A: Project Lists for Micro-Simulation Scenarios

State Route 22

Scenario	Proj ID	Improvement	Lead Agency	Expected Compl Date	Source	Est Total Proj Cost (in 1,000s)
1 (2008-1) 2 (2020-1)	ORA000193 EA 07163 EA 07162 (EA 071600)	SR-22/I-405/I-605 HOV Connectors , SR-22, PM 0.66/0.92. I-405, PM 20.64/24.07. I-605, PM 0.00/1.00 in the cities of Seal Beach & Los Alamitos. Total length of project is 4.7 miles.	CALTRANS	2014	06 & 08 TIP; CMIA	$ 174,503
		Widen IC & construct connector on SR-22 PM .66/.92 & Rte 405 PM 20.56/22.64, IN GGR WTM & Seal Beach from JCT 405/22 sep to Seal Beach Blvd	CALTRANS	2014		$ 126,500
3 (2008-2) 4 (2020-2)	Proposed (SMG)	Adaptive ramp metering with queue control				$ 50,000
	Proposed (SMG)	Meter the NB and SB I-5/SR-57 connectors				
	Proposed (SMG)	Add HOV direct connector from SB-57/I-5 to WB-22.				
5 (2020-3) 6 (2020-4)	Proposed (SMG)	Enhanced Incident Management System (incident clearance time reduction from current and with no improvements). **Tested with 2020 model only**				
9 (2008-5) Builds on Sc 3	Proposed (CT)	Collector-Distributor **Alt #4** presented to OCTA Board: Major interchange reconstruction and widening of NB I-5 connector. **Tested with 2008 model**	CALTRANS			$70-$100,000
11 (2020-6) Builds on Sc 4	Proposed (CT)	Collector-Distributor **Alt #4** presented to OCTA Board: Major interchange reconstruction and widening of NB I-5 connector. **Tested with 2020 model**	CALTRANS			$70-$100,000

Interstate 405

Scenario	Proj ID	Improvement	Agency	Expected Compl Date	Source	Est Total Proj Cost (in 1,000s)
1 (2008-1) 2 (2020-1)	ORA020110 EA 0A762	I-405 NB & SB auxiliary lane (Magnolia to Beach Blvd) -- from 5 to 6 lanes in each direction.	OCTA	Completed 2009	2006 RTIP	$ 5,129
	ORA020103 EA 0F930	Costa Mesa (Fairview Rd @ I-405 IC) Add 3rd SB left-turn lane and 3rd SB I-405 onramp lane	COSTA MESA	Completed 10/2009	06 & 08 RTIP	$ 3,344
	EA 0K040	At NB Sand Canyon Ave direct on-ramp: convert HOV preferential lane to a second metered GP lane	IRVINE	Completed 12/2009	NITM	$ 34
	ORA020104 EA 0G500	Costa Mesa - Widen northbound Harbor Blvd from 3 to 4 lanes between SB-405 off-ramp and NB-405 on-ramp and modify NB-405 on-ramp	COSTA MESA	In Const 5/2010	2006 RTIP	$ 2,718
5 (2008-2) 6 (2020-2)	ORA000194 EA 07160 EA07163 EA 07162	HOV connectors from I-405 to I-605, between Katella Ave. (I-605 PM R001.104) and Seal Beach Blvd. (I-405 PM 022.643), with a second HOV lane in each direction on I-405 between the two direct connectors	CALTRANS	2014	2008 RTIP CMIA	$ 174,503
		Widen interchange & construct connector on SR-22 PM .66/.92 & Rte 405 PM 20.56/22.64 in GGR WTM & Seal Beach from Jct 405/22 sep to Seal Beach Blvd	CALTRANS	2014	2009 RTIP CMIA	$ 126,500
3 (2008-3) 4 (2020-3)	EA 0H100	I-405 widening & operational improvements (SR-73 to LA County line; add one GP lane in ea dir (73 - Beach) & add aux lns & ops impvs.	OCTA	2020	06 & 08 RTIP	$1,071,690 (CT)
		Bolsa Ave (Chestnut to Goldenwest) Widen Bolsa Ave Bridge from 4 to 6 lanes	WESTMINSTER	2011	06 & 08 RTIP	$ 2,200
		Construct fourth NB through lane on Beach Blvd at the I-405 interchange. Co-lead with Westminster	OCTA WESTMINSTER	2012	06 & 08 RTIP	$ 1,300
7 (2008-4) 8 (2020-4)	EA OJ440K	Convert existing buffer-separated HOV facility to a continuous HOV facility	CALTRANS	2012	2007 PSR	$4,934 (2007 PSR, Alt 3)

Interstate 405 (continued)

Scenario	Proj ID	Improvement	Agency	Expected Compl Date	Source	Est Total Proj Cost (in 1,000s)
9 (2008-5) 10 (2020-5)	Proposed (SMG)	Adaptive Ramp Metering with queue control				$ 10,000
	Proposed (SMG)	Meter the connectors at SR-73, SR-133, SR-55				$ 15,000
11 (2020-6)	NITM (proposed)	At SB Irvine Center Drive off-ramp: Add second aux lane from I-405 to the off-ramp	IRVINE		NITM	$ 7,348
	NITM (proposed)	At SB Sand Canyon Ave: add second drop lane from I-405 to the off-ramp	IRVINE	2012	NITM	$ 6,041
	EA 0H320	In Irvine - Route 133 to Sand Canyon Road - construct SB auxiliary lanes	CALTRANS	2016	2004/2005 SHOPP	$ 4,293
	EA 0H770	Add 400 meter aux lane on SB I-405 & widen the off-ramp to provide a two lane exit at Jeffrey/University	CALTRANS	2016	STIP not programmed	$ 2,770
	EA 0F240K 2M04130	SB I-405: Add 2nd aux lane from SR-133 to Irvine Center Dr.	OCTA	2020	2008 RTP	$ 10,892
	2M04131 (EA 09320)	NB I-405: add aux lane from Jeffrey to Culver	CALTRANS	2020	2008 RTP	$ 13,927
	12-ORA-405NB	NB I-405: add an aux lane at Culver Drive off-ramp	CALTRANS		Proposed minor project	$ 1,900
12 (2020-7) 13 (2020-8) -Builds on Sc 8	Proposed (SMG)	**Enhanced Incident Management System** (incident clearance time reduction from current and with improvements)				
14 (2020-9)	SOCMIS	Provide Interchange improvements at SR-133. Ramp connector to southbound I-405 to northbound SR-133	OCTA		SOCMIS	$ 110,000

Appendix B: Benefit-Cost Analysis Results

This appendix provides more detailed Benefit-Cost Analysis (BCA) results than found in Section 6 of the SR-22 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 CO_2 Emissions (tons)** -additional CO_2 emissions that occur because of the project. The emissions are estimated using average speed categories using data from the California Air Resources Board (CARB) EMFAC model. This is a gross calculation because the emissions factors do not take into account changes in speed cycling or driver behavior. A negative value indicates a project benefit. Projects in areas with severe congestion will generally lower CO_2 emissions.
- **Additional CO_2 Emissions (in millions of dollars)** - valued CO_2 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: SR-22 Scenarios 1 & 2 (SR-22/405/605 Direct HOV Connector) Benefit-Cost Analysis Results
- Exhibit B-2: SR-22 Scenarios 3 & 4 (Advanced Ramp/Connector Metering) Benefit-Cost Analysis Results
- Exhibit B-3: SR-22 Scenarios 9 & 11 (Collector/Distributor Improvement) Benefit-Cost Analysis Results
- Exhibit B-4: SR-22 Cumulative Benefit-Cost Analysis Results
- Exhibit B-5: I-405 Scenarios 1 & 2 (Completed Projects in 2008-2010) Benefit-Cost Analysis Results
- Exhibit B-6: I-405 Scenarios 5 & 6 (SR-22/405/605 HOV Direct Connectors) Benefit-Cost Analysis Results
- Exhibit B-7: I-405 Scenarios 3 & 4 (Widening from SR-73 to LA County Line) Benefit-Cost Analysis Results

- Exhibit B-8: I-405 Scenarios 7 & 8 (Convert HOV to Continuous Access) Benefit-Cost Analysis Results
- Exhibit B-9: I-405 Scenarios 9 & 10 (Advanced Ramp/Connector Metering) Benefit-Cost Analysis Results
- Exhibit B-10: I-405 Scenario 11 (Auxiliary Lane Improvements in Irvine) Benefit-Cost Analysis Results – Incremental
- Exhibit B-11: I-405 Scenario 14 (SR-133 Interchange Improvements) Benefit-Cost Analysis Results – Incremental
- Exhibit B-12: I-405 Cumulative Benefit-Cost Analysis Results

Exhibit B-1: SR-22 Scenarios 1 & 2 (SR-22/405/605 Direct HOV Connector) Benefit-Cost Analysis Results

3

INVESTMENT ANALYSIS

SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$301.0
Life-Cycle Benefits (mil. $)	$676.3
Net Present Value (mil. $)	$375.3
Benefit / Cost Ratio:	2.2
Rate of Return on Investment:	11.8%
Payback Period:	10 years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$28.0	$560.5
Veh. Op. Cost Savings	$4.4	$88.0
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$1.4	$27.8
TOTAL BENEFITS	$33.8	$676.3
Person-Hours of Time Saved	3,673,183	73,463,669
Additional CO_2 Emissions (tons)	-23,630	-472,591
Additional CO_2 Emissions (mil. $)	-$0.7	-$13.3

Incremental Costs (mil. $)	$301.0
Incremental Benefits (mil. $)	$676.3
Incremental Benefit / Cost Ratio	2.2

Exhibit B-2: SR-22 Scenarios 3 & 4 (Advanced Ramp/Connector Metering) Benefit-Cost Analysis Results

3

INVESTMENT ANALYSIS
SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$351.0
Life-Cycle Benefits (mil. $)	$693.5
Net Present Value (mil. $)	$342.5
Benefit / Cost Ratio:	2.0
Rate of Return on Investment:	10.4%
Payback Period:	11 years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$29.7	$594.6
Veh. Op. Cost Savings	$3.9	$77.4
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$1.1	$21.5
TOTAL BENEFITS	$34.7	$693.5
Person-Hours of Time Saved	3,867,830	77,356,604
Additional CO_2 Emissions (tons)	-21,397	-427,933
Additional CO_2 Emissions (mil. $)	-$0.6	-$11.9

Incremental Costs (mil. $)	$50.0
Incremental Benefits (mil. $)	$17.1
Incremental Benefit / Cost Ratio	0.3

Exhibit B-3: SR-22 Scenarios 9 & 11 (Collector/Distributor Improvement) Benefit-Cost Analysis Results

3

INVESTMENT ANALYSIS
SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$451.0
Life-Cycle Benefits (mil. $)	$1,613.0
Net Present Value (mil. $)	$1,162.0
Benefit / Cost Ratio:	3.6
Rate of Return on Investment:	19.1%
Payback Period:	7 years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$66.5	$1,330.3
Veh. Op. Cost Savings	$10.6	$212.8
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$3.5	$69.9
TOTAL BENEFITS	$80.7	$1,613.0
Person-Hours of Time Saved	8,493,458	169,869,167
Additional CO_2 Emissions (tons)	-55,128	-1,102,553
Additional CO_2 Emissions (mil. $)	-$1.6	-$31.6

Incremental Costs (mil. $)	$100.0
Incremental Benefits (mil. $)	$919.6
Incremental Benefit / Cost Ratio	9.2

Exhibit B-4: SR-22 Cumulative Benefit-Cost Analysis Results

3

INVESTMENT ANALYSIS

SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$451.0
Life-Cycle Benefits (mil. $)	$1,613.0
Net Present Value (mil. $)	$1,162.0
Benefit / Cost Ratio:	3.6
Rate of Return on Investment:	19.1%
Payback Period:	7 years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$66.5	$1,330.3
Veh. Op. Cost Savings	$10.6	$212.8
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$3.5	$69.9
TOTAL BENEFITS	$80.7	$1,613.0
Person-Hours of Time Saved	8,493,458	169,869,167
Additional CO_2 Emissions (tons)	-55,128	-1,102,553
Additional CO_2 Emissions (mil. $)	-$1.6	-$31.6

Exhibit B-5: I-405 Scenarios 1 & 2 (Completed Projects in 2008-2010) Benefit-Cost Analysis Results

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INVESTMENT ANALYSIS

SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$11.2
Life-Cycle Benefits (mil. $)	$135.4
Net Present Value (mil. $)	$124.2
Benefit / Cost Ratio:	12.1
Rate of Return on Investment:	94.0%
Payback Period:	2 years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$6.7	$134.1
Veh. Op. Cost Savings	$0.1	$1.3
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$0.0	$0.0
TOTAL BENEFITS	$6.8	$135.4
Person-Hours of Time Saved	806,877	16,137,532
Additional CO_2 Emissions (tons)	-322	-6,448
Additional CO_2 Emissions (mil. $)	-$0.0	-$0.2

Incremental Costs (mil. $)	$11.2
Incremental Benefits (mil. $)	$135.4
Incremental Benefit / Cost Ratio	12.1

Exhibit B-6: I-405 Scenarios 5 & 6 (SR-22/405/605 HOV Direct Connectors) Benefit-Cost Analysis Results

3

INVESTMENT ANALYSIS

SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$312.2
Life-Cycle Benefits (mil. $)	$1,201.3
Net Present Value (mil. $)	$889.0
Benefit / Cost Ratio:	3.8
Rate of Return on Investment:	20.6%
Payback Period:	6 years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$50.2	$1,004.5
Veh. Op. Cost Savings	$7.5	$149.9
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$2.3	$46.9
TOTAL BENEFITS	$60.1	$1,201.3
Person-Hours of Time Saved	6,544,756	130,895,130
Additional CO_2 Emissions (tons)	-38,910	-778,198
Additional CO_2 Emissions (mil. $	-$1.1	-$22.3

Incremental Costs (mil. $)	$301.0
Incremental Benefits (mil. $)	$1,065.8
Incremental Benefit / Cost Ratio	3.5

Exhibit B-7: I-405 Scenarios 3 & 4 (Widening from SR-73 to LA County Line) Benefit-Cost Analysis Results

3

INVESTMENT ANALYSIS

SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$1,387.4
Life-Cycle Benefits (mil. $)	$2,036.9
Net Present Value (mil. $)	$649.5
Benefit / Cost Ratio:	1.5
Rate of Return on Investment:	7.9%
Payback Period:	12 years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$88.2	$1,764.9
Veh. Op. Cost Savings	$10.4	$208.6
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$3.2	$63.3
TOTAL BENEFITS	$101.8	$2,036.9
Person-Hours of Time Saved	11,329,925	226,598,506
Additional CO_2 Emissions (tons)	-54,095	-1,081,902
Additional CO_2 Emissions (mil. $	-$1.5	-$31.0

Incremental Costs (mil. $)	$1,075.2
Incremental Benefits (mil. $)	$835.6
Incremental Benefit / Cost Ratio	0.8

Exhibit B-8: I-405 Scenarios 7 & 8 (Convert HOV to Continuous Access) Benefit-Cost Analysis Results

3

INVESTMENT ANALYSIS
SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$1,392.4
Life-Cycle Benefits (mil. $)	$2,165.7
Net Present Value (mil. $)	$773.4
Benefit / Cost Ratio:	1.6
Rate of Return on Investment:	8.6%
Payback Period:	11 years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$93.9	$1,878.7
Veh. Op. Cost Savings	$11.0	$220.3
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$3.3	$66.8
TOTAL BENEFITS	$108.3	$2,165.7
Person-Hours of Time Saved	12,049,934	240,998,679
Additional CO_2 Emissions (tons)	-57,170	-1,143,407
Additional CO_2 Emissions (mil. $)	-$1.6	-$32.8

Incremental Costs (mil. $)	$4.9
Incremental Benefits (mil. $)	$128.8
Incremental Benefit / Cost Ratio	26.1

Exhibit B-9: I-405 Scenarios 9 & 10 (Advanced Ramp/Connector Metering) Benefit-Cost Analysis Results

3

INVESTMENT ANALYSIS
SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$1,417.4
Life-Cycle Benefits (mil. $)	$2,254.0
Net Present Value (mil. $)	$836.7
Benefit / Cost Ratio:	1.6
Rate of Return on Investment:	8.8%
Payback Period:	11 years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$95.9	$1,918.1
Veh. Op. Cost Savings	$12.8	$256.6
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$4.0	$79.4
TOTAL BENEFITS	$112.7	$2,254.0
Person-Hours of Time Saved	12,294,987	245,899,735
Additional CO_2 Emissions (tons)	-65,818	-1,316,369
Additional CO_2 Emissions (mil. $)	-$1.9	-$37.9

Incremental Costs (mil. $)	$25.0
Incremental Benefits (mil. $)	$88.3
Incremental Benefit / Cost Ratio	3.5

Exhibit B-10: I-405 Scenario 11 (Auxiliary Lane Improvements in Irvine) Benefit-Cost Analysis Results - Incremental

3

INVESTMENT ANALYSIS
SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$47.2
Life-Cycle Benefits (mil. $)	$520.6
Net Present Value (mil. $)	$473.4
Benefit / Cost Ratio:	11.0
Rate of Return on Investment:	81.7%
Payback Period:	2 years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$20.3	$407.0
Veh. Op. Cost Savings	$4.2	$84.9
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$1.4	$28.7
TOTAL BENEFITS	$26.0	$520.6
Person-Hours of Time Saved	2,458,459	49,169,190
Additional CO_2 Emissions (tons)	-19,623	-392,450
Additional CO_2 Emissions (mil. $	-$0.6	-$11.9

Exhibit B-11: I-405 Scenario 14 (SR-133 Interchange Improvements) Benefit-Cost Analysis Results – Incremental

3

INVESTMENT ANALYSIS
SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$110.0
Life-Cycle Benefits (mil. $)	$28.4
Net Present Value (mil. $)	-$81.6
Benefit / Cost Ratio:	0.3
Rate of Return on Investment:	#NUM!
Payback Period:	20+ years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$1.6	$31.5
Veh. Op. Cost Savings	-$0.1	-$2.0
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	-$0.1	-$1.1
TOTAL BENEFITS	$1.4	$28.4
Person-Hours of Time Saved	190,475	3,809,492
Additional CO_2 Emissions (tons)	483	9,654
Additional CO_2 Emissions (mil. $	$0.0	$0.3

Exhibit B-12: I-405 Cumulative Benefit-Cost Analysis Results

3

INVESTMENT ANALYSIS

SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$1,574.5
Life-Cycle Benefits (mil. $)	$2,803.0
Net Present Value (mil. $)	$1,228.5
Benefit / Cost Ratio:	1.8
Rate of Return on Investment:	n/a
Payback Period:	n/a

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$117.8	$2,356.6
Veh. Op. Cost Savings	$17.0	$339.5
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$5.3	$107.0
TOTAL BENEFITS	$140.2	$2,803.0
Person-Hours of Time Saved	14,943,921	298,878,417
Additional CO_2 Emissions (tons)	-84,958	-1,699,165
Additional CO_2 Emissions (mil. $	-$2.5	-$49.5

District 12 CSMP Team Organization Chart