UPDATED FINAL

CORRIDOR SYSTEM MANAGEMENT PLAN (CSMP)
LOS ANGELES COUNTY I-405 CORRIDOR
COMPREHENSIVE PERFORMANCE ASSESSMENT
AND
CAUSALITY ANALYSIS

August 3, 2009

System Metrics Group, Inc.

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1. INTRODUCTION

This document represents the draft for the sixth and seventh milestones of the Los Angeles Interstate (I-405) Corridor System Management Plan (CSMP) development process, which is required by the California Transportation Commission (CTC) for corridors that have received funding from the Corridor Mobility Improvement Account (CMIA) approved by the voters in 2006. The CMIA will partially fund the construction of the northbound High Occupancy Vehicle (HOV) lane from the I-10 to the US-101.

The two milestones reached in this document are called the Comprehensive Performance Assessment and the Causality of Performance Degradation. They build on the third milestone, the "Preliminary Performance Assessment" (already developed), and the fourth milestone, "Ensure Adequate Corridor Detection." The milestones, eight in total, were documented in the CSMP guidelines distributed by Caltrans Headquarters.

The main purpose of the Comprehensive Performance Assessment is to detail the performance of the corridor so that future investment decisions can build on its findings and conclusions, and investment alternatives are tested to ensure reasonable returns on investment for public funds.

This report is lengthy and presents performance measurement findings, identifies bottlenecks that lead to less than optimal performance, and diagnoses the causes for these bottlenecks in detail. Once this report has been finalized, alternative investment strategies will be modeled and evaluated to understand their relative benefits and eventually develop a recommended implementation plan for existing and potential future funding.

This report and the associated CSMP (eighth milestone in the CSMP guidelines) should be updated 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 among others. Such changes could influence the conclusions of the CSMP and the relative priorities in investments.

Therefore, updates should probably occur no less than every two to three years. To the extent possible, this document has been organized to facilitate such updates so that Caltrans can insert new update sections without re-writing the entire document.

The remainder of this report is organized into four sections (Section 1 is this introduction):

2. *Corridor Description*
   This section describes the corridor, including the roadway facility, major interchanges and relative demands at these interchanges, rail and transit services along the freeway facility, major Intermodal facilities around the corridor, and special event facilities/trip generators. This section has been expanded

since the Preliminary Performance Assessment milestone to include a subsection on corridor demand profiles.

3. *Corridor-Wide Performance and Trends*
   The section presents multiple years of performance data for the defined CSMP freeway facility of the corridor, including mobility, reliability, safety, and productivity performance measures. The section has also been augmented to include the performance of the HOV facility and the pavement condition of the freeway. When available, the performance data has been updated to reflect conditions up to December 2008.

4. *Bottleneck Identification and Analysis*
   This section identifies the locations of bottlenecks, or choke points, on the freeway facility. These bottlenecks are generally the major cause for mobility and productivity performance degradations and are often related to safety degradations as well. This section has also been augmented. It now has performance results for delay, productivity, and safety by major "bottleneck area." This addition allows for the relative prioritization of bottlenecks in regards to their contribution to corridor performance degradation.

5. *Bottleneck Causality Analysis*
   This section diagnoses the bottlenecks identified in Section 4 and identifies the causes of each bottleneck through additional data analysis and significant field observations. Electronic videos were taken for many of the major bottlenecks (to the extent possible) to verify our conclusions. Sections 4 and 5 provide valuable input in selecting projects to address the critical bottlenecks. Moreover, they provide the baseline against which the micro-simulation models will be validated. Finally, this section represents the sixth milestone of the CSMP development process.

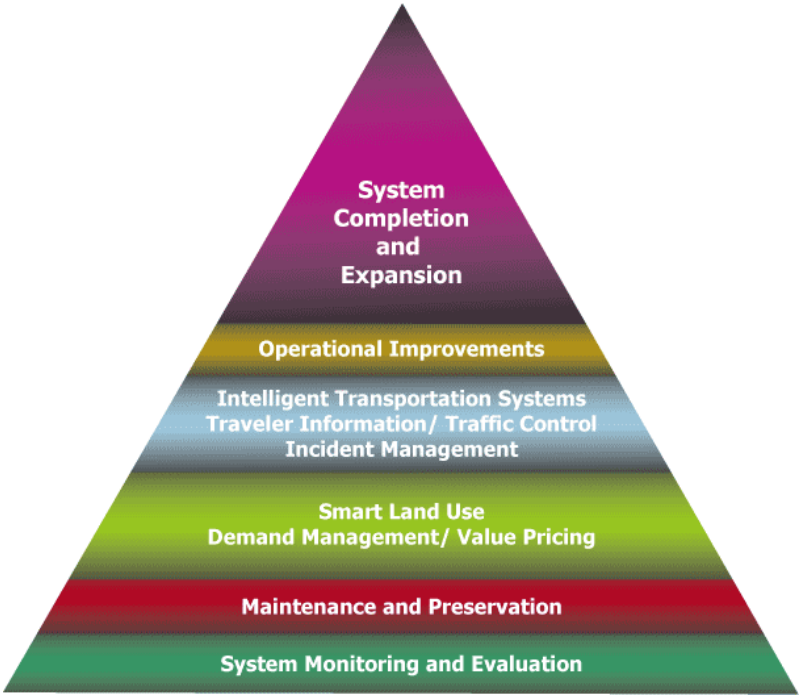
The remainder of this introduction provides some background on system management, a framework that eventually led to the CSMP requirement. It also includes a discussion on data sources and the state of detection on the I-405 freeway.

Background

Over the last few years, Caltrans and its stakeholders and partner agencies have been developing and committing to a framework called "System Management" which is depicted in Exhibit 1-1. This framework aims to get the most of our transportation infrastructure through a variety of strategies, not just through the traditional and increasingly expensive expansion projects. System Management has been embraced by the Administration as part of their Strategic Growth Plan and by the Southern California Association of Governments (SCAG), the Metropolitan Planning Organization for Southern California and Los Angeles County.

One major new aspect of system management is an increased focus on operational strategies and investments. Operational solutions are generally less expensive, can often be implemented much faster, and can produce results that, when compared to traditional expansion projects, often provide much higher returns on the scarce transportation funding available. Partly because of the focus on operational strategies, system management relies on much more detailed data.

Exhibit 1-1: System Management Pyramid



The base of the system management "pyramid" is titled "System Monitoring and Evaluation." It is the foundation of all other decisions, and it includes identifying problems, evaluating solutions (and combinations thereof), and eventually funding the most promising strategies. This document represents the first version of this foundation for the I-405 CSMP corridor.

One of the main purposes of this corridor-wide performance assessment is to collect and analyze all information necessary to understand the existing traffic conditions. This report details findings of the causes of traffic congestion along the corridor and identifies freeway bottlenecks and the likely causes for the bottlenecks. Ideally, the freeway assessment component of this report would rely on comprehensive and continuous data collected over the years from automatic freeway detection systems (generally inductive loops located below the pavement, radar, or other electronic devices) and other field data collected for special studies or annual reports. Unfortunately that was not possible for the study corridor for a variety of reasons, including:

- Corridor construction – Caltrans often has to disconnect detectors during construction activities. The study corridor has been under some degree of construction for almost eight years. Construction included the southbound HOV lane from the US-101 to the I-10, HOV lanes in both directions from the I-105 to SR-90, and current project extending the HOV lane from SR-90 to the I-10 in both directions. As a result, detection data is sporadic and reflects the impacts of the construction activities.

- Detector reliability – Over the years, detection systems fail. When funding is scarce and needs are high, it is usually impossible to keep all detectors in good working conditions. As a result, the data used in this report has many "holes".

- Available data collected in the field using probe vehicles that record speeds during peak commute periods were very useful and complemented the detection data. However, they represented a very small sample of traffic conditions throughout the years.

- Field observations conducted by the study team to evaluate bottlenecks occurred primarily in 2007 and early 2008, which represent more recent data and likely reflect different traffic conditions than detection and probe data analyzed.

As a result, four sets of different data were used: (1) detection data from 2001-2003, which represents the pre-construction period, and 2008 data, which reflects current conditions; (2) Highway Congestion Monitoring data from 2004 through 2007; (3) probe vehicle data from 2002/2003, and field observations from 2007/2008. *Although the study team believes that the conclusions of these reports are reasonably accurate and defensible, it believes it is prudent to keep updating the findings and conclusions on a regular basis once more consistent data is available and current construction is completed.*

Note that the performance measures used in this report are consistent with the adopted measurement framework at SCAG and at Caltrans and include: mobility, reliability, safety, and productivity.

Existing Data Sources

The existing available data analyzed for the preliminary performance assessment includes the following sources:

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

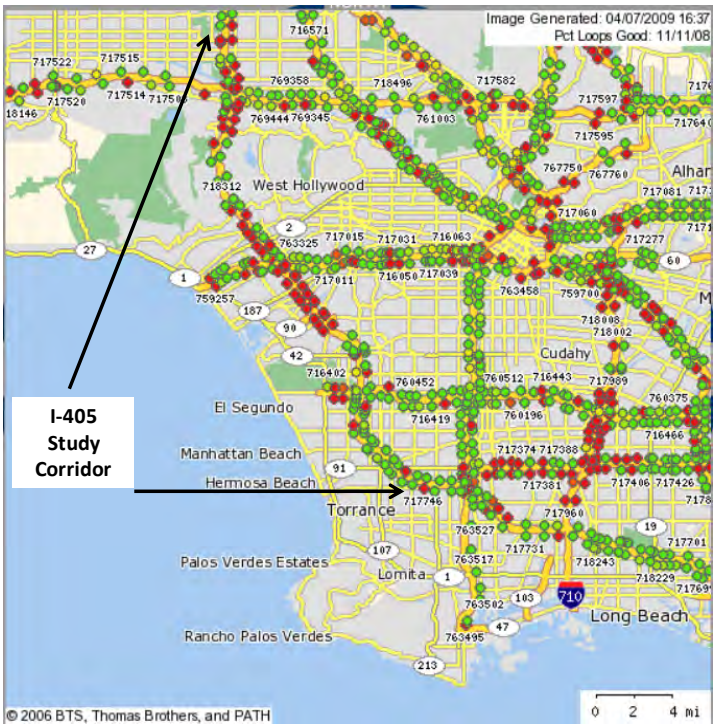
There are numerous documents that describe these data sources, so they are not discussed in detail here. However, given the need for comprehensive and continuous monitoring and evaluation, detection coverage and quality are discussed in more detail below.

Freeway Detection Status

Exhibit 1-2 is a graphic from PeMS showing the I-405 corridor vehicle detection stations (VDS) and the “good” (green) and “bad” (red) VDS data available for November 11, 2008. As illustrated in the exhibit, detection on this day was relatively good along the corridor except for the segments between the SR-90 and the West Hollywood area and south of the US-101 Interchange. This is due to the construction activity in that area where the detection system is rendered inoperable. This is the case since construction started in late 2003.

The analysis of the corridor is based on two time periods: one that reflects pre-construction conditions and another that reflects present conditions. The pre-construction period refers to the three years of 2001-2003, before the heavy construction of the HOV-lane commenced. The present conditions period refers to the year 2008, which continued to experience construction of the HOV-lane but on a different portion of the corridor. As of 2009, construction of the HOV-lane continues, on the segment between SR-90 and US-101.

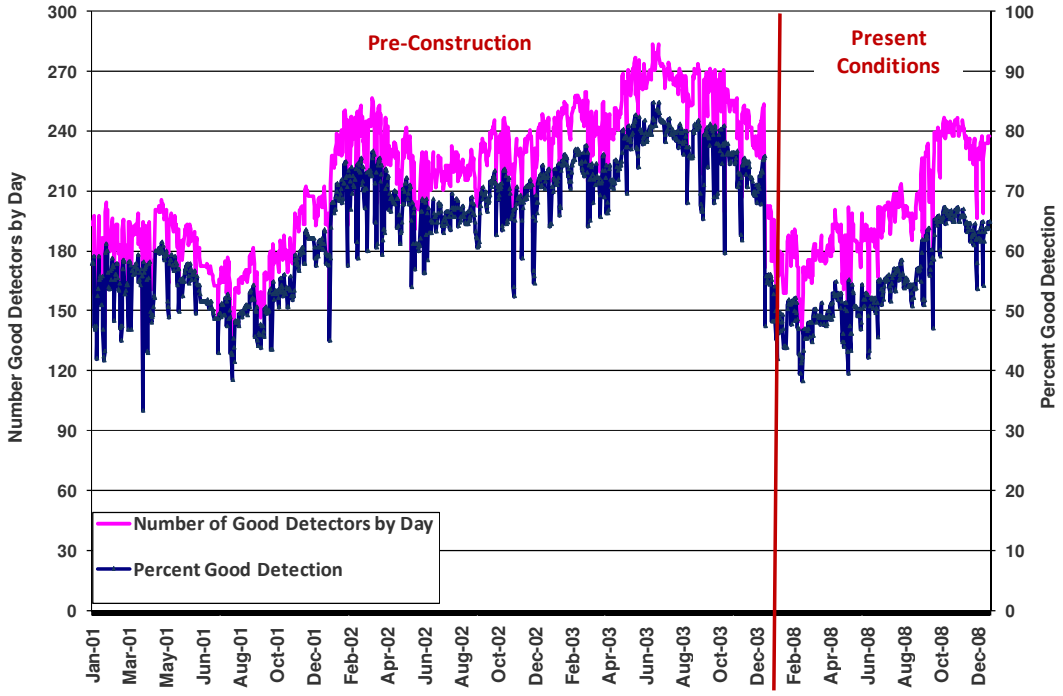
Exhibit 1-2: PeMS Sensor Data Quality (November 2008)



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

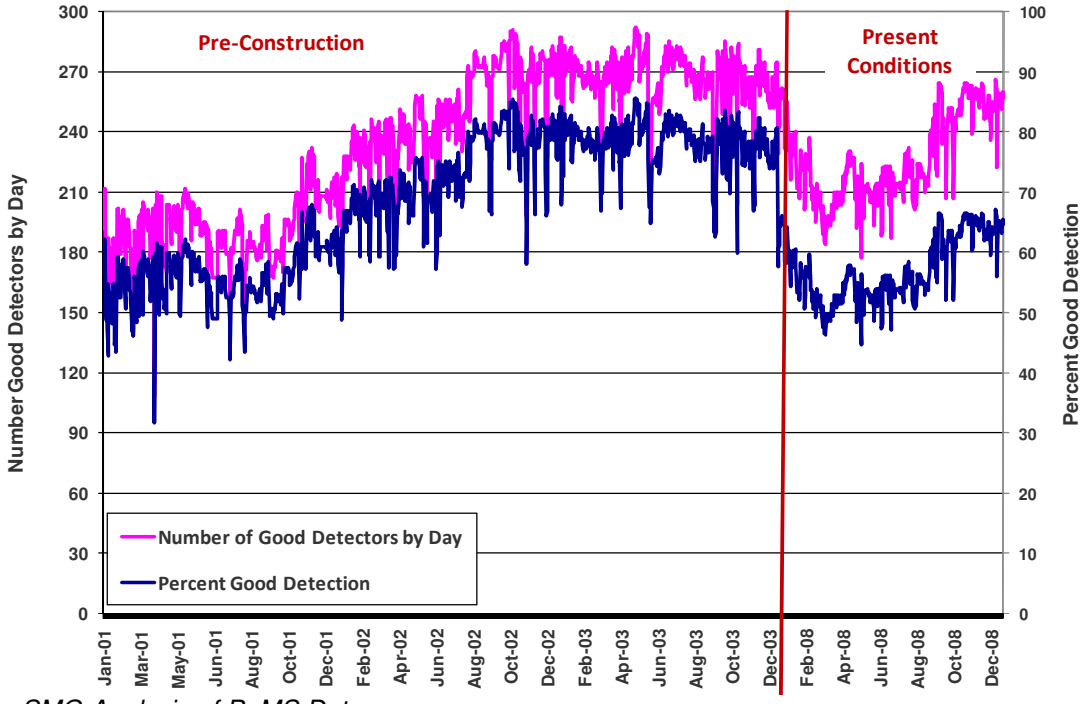
To see how well the detectors performed over the years covered in the analysis, Exhibits 1-3 and 1-4 show the percentage of good detection on the I-405 mainline facility for the pre-construction (2001-2003) and present conditions (2008) time frames. The exhibits report the percentage of daily "good detectors" during the period of analysis for the entire Los Angeles I-405 corridor. These include mainline detectors as well as ramp detectors. The left y-axis shows the scale used for the number of detectors, while the right y-axis shows the scale used for the percent good detectors. In both directions of the mainline facility, detection during the pre-construction years increased from 2001 to 2002 with the addition of new "good" detectors, and further improved in 2003, reaching above 80 percent good detection. However, in 2008, detection on the mainline dropped to about 50 percent in the beginning of the year, and slowly climbed to about 70 percent good detection towards the end of the year. These fluctuations in detection are likely attributed to the construction activities along the corridor that require the disabling of detectors.

Exhibit 1-3: Northbound I-405 Mainline
Number and Percentage of Daily Good Detectors (2001-2003 & 2008)



Source: SMG Analysis of PeMS Data

Exhibit 1-4: Southbound I-405 Mainline
Number and Percentage of Daily Good Detectors (2001-2003 & 2008)

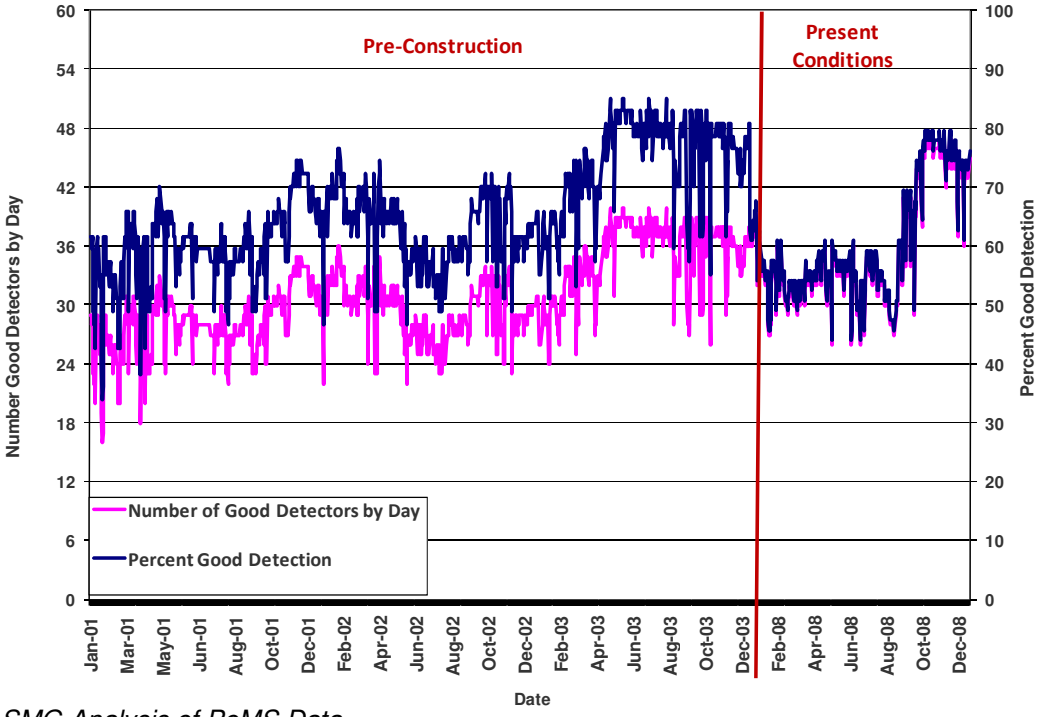


Source: SMG Analysis of PeMS Data

It is important to emphasize that the HOV facility is not the same length in distance as the mainline facility because the HOV-lane remains under construction along the study corridor. Exhibits 1-5 and 1-6 illustrate the percentage of good detection on the I-405 HOV facility by direction. Similar to the detection pattern along the mainline, the HOV facility also experienced an improvement in detection throughout the pre-construction period from 2001-2003, and a decline in detection in 2008. Exhibit 1-6 shows that the number of good detectors in the southbound direction in 2008 exceeded the number of good detectors in the northbound direction. However, the percentage of good detectors in both directions remained about the same in 2008, indicating that the southbound direction also had many other detectors which were either not operating or operating inadequately.

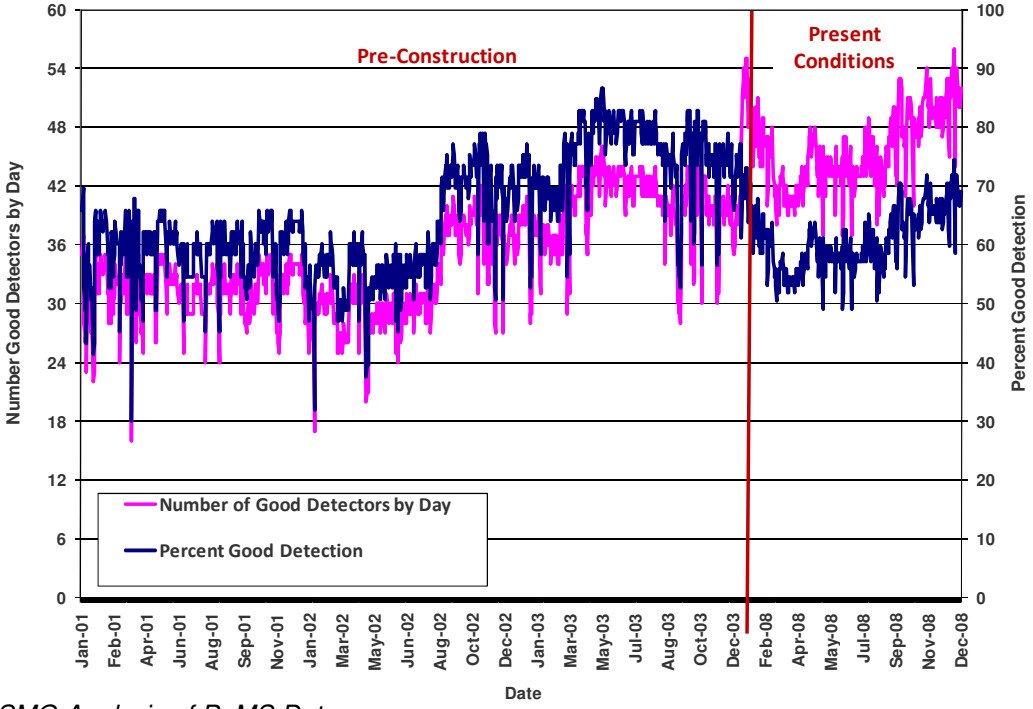
Exhibits 1-7 and 1-8 identify the detectors which were added to the mainline facility between 2003 and 2008. Similarly, Exhibits 1-9 and 1-10 identify the detectors added to the HOV-facility during the same period. The southbound direction of both the mainline and HOV facilities had more detectors added than the northbound.

Exhibit 1-5: Northbound I-405 HOVL
Number and Percentage of Daily Good Detectors (2001-2003 & 2008)



Source: SMG Analysis of PeMS Data

Exhibit 1-6: Southbound I-405 HOVL
Number and Percentage of Daily Good Detectors (2001-2003 & 2008)



Source: SMG Analysis of PeMS Data

Exhibit 1-7: Northbound I-405 ML & Ramp Detectors Added (2003-2008)

VDS	CA PM	Abs PM	Name	Type	Date Online
766505	12.05	35.822	TRUCK SCALE 2	Mainline	9/16/2005
766268	12.57	36.342	MAIN	Off Ramp	9/16/2005
769228	22.34	46.112	OLIVE / MANCHESTER	Mainline	2/21/2007
769496	26	49.772	JEFFERSON	Mainline	2/14/2008
769506	26	49.772	JEFFERSON	Off Ramp	2/14/2008
769507	26	49.772	JEFFERSON	On Ramp	2/14/2008
768643	26.84	50.612	BRADDOCK	Mainline	9/16/2005
768969	28.4	52.172	S OF 10	Mainline	11/1/2005
768971	28.4	52.172	NB 405 TO WB 10	Fwy-Fwy	11/1/2005
768636	38.74	62.512	GREENLEAF/SEPULVEDA	Off Ramp	9/16/2005
767351	40.9	64.672	OXNARD ST	Mainline	9/16/2005
767367	43.2	66.972	STAGG ST	Mainline	9/16/2005

Exhibit 1-8: Southbound I-405 ML & Ramp Detectors Added (2003-2008)

VDS	CA PM	Abs PM	Name	Type	Date Online
769248	13.18	36.952	N OF 110	Mainline	2/21/2007
769251	13.181	36.953	SB 405 to SB 110 #1	Fwy-Fwy	2/21/2007
769198	13.31	37.082	VERMONT	Off Ramp	2/21/2007
769195	13.31	37.082	VERMONT	Mainline	2/21/2007
767827	R21.365	45.137	FM 105 WB	Mainline	9/16/2005
769077	27.81	51.582	VENICE	Mainline	3/17/2006
768970	28.4	52.172	EB 10 TO SB 405	Fwy-Fwy	11/1/2005
768968	28.4	52.172	S OF 10	Mainline	11/1/2005
768619	33.42	57.192	MORAGA	Mainline	9/16/2005
768634	38.74	62.512	GREENLEAF/SEPULVEDA	Mainline	9/16/2005
767056	40.08	63.852	BURBANK 2	Off Ramp	9/16/2005
767055	40.08	63.852	BURBANK 2	On Ramp	9/16/2005
767053	40.08	63.852	BURBANK 2	Mainline	9/16/2005
767350	40.9	64.672	OXNARD ST	Mainline	9/16/2005
767366	43.2	66.972	STAGG ST	Mainline	9/16/2005
768626	44.87	68.642	NORDHOFF OFF	Mainline	9/16/2005

Exhibit 1-9: Northbound I-405 Added to HOV Facility (2005-2008)

VDS	CA PM	Abs PM	Name	Type	Date Online
766506	12.05	35.822	TRUCK SCALE 2	HOV	9/16/2005
769249	13.18	36.952	N OF 110	HOV	2/21/2007
769232	22.34	46.112	OLIVE	HOV	2/21/2007
769255	22.68	46.452	CENTURY 1	HOV	2/21/2007
769259	22.7	46.472	CENTURY 2	HOV	2/21/2007
769260	23.36	47.132	MANCHESTER 1	HOV	2/21/2007
769263	23.47	47.242	MANCHESTER 2	HOV	2/21/2007
769236	23.61	47.382	LA CIENEGA	HOV	2/21/2007
769265	24.25	48.022	LA TIJERA	HOV	2/21/2007
769242	25.41	49.182	CENTINELA	HOV	2/21/2007
767353	40.9	64.672	OXNARD ST	HOV	9/16/2005
767369	43.2	66.972	STAGG ST	HOV	9/16/2005

Exhibit 1-10: Southbound I-405 Added to HOV Facility (2003-2008)

VDS	CA PM	Abs PM	Name	Type	Date Online
769250	13.18	36.952	N OF 110	HOV	2/21/2007
767847	R20.9	44.672	FM RT 105	HOV	9/16/2005
769219	22	45.772	102ND / CENTURY	HOV	2/21/2007
769231	22.34	46.112	OLIVE	HOV	2/21/2007
769221	22.4	46.172	98TH / WB CENTURY	HOV	2/21/2007
769235	23.61	47.382	LA CIENEGA	HOV	2/21/2007
769238	24.25	48.022	LA TIJERA	HOV	2/21/2007
769241	25.41	49.182	CENTINELA	HOV	2/21/2007
766956	33.04	56.812	SUNSET WB / CHURCH	HOV	9/16/2005
768618	33.42	57.192	MORAGA	HOV	9/16/2005
766954	35.8	59.572	BEL AIR CR	HOV	9/16/2005
766952	36.55	60.322	SKIRBALL/MULHOLLAND	HOV	9/16/2005
767264	37.57	61.342	ROYAL RIDGE	HOV	9/16/2005
767258	38.09	61.862	VENTURA	HOV	9/16/2005
767262	38.14	61.912	WOODCREST	HOV	9/16/2005
767260	38.42	62.192	VALLEY VISTA	HOV	9/16/2005
768633	38.74	62.512	GREENLEAF/SEPULVEDA	HOV	9/16/2005
767054	40.08	63.852	BURBANK 2	HOV	9/16/2005
767352	40.9	64.672	OXNARD ST	HOV	9/16/2005
767368	43.2	66.972	STAGG ST	HOV	9/16/2005
768625	44.87	68.642	NORDHOFF OFF	HOV	9/16/2005

An analysis of gaps without detection on I-405 is shown in Exhibit 1-11. There are various segments extending over 0.75 miles without detection in each direction. These gaps should be considered for deployment of additional detection when funding becomes available.

Exhibit 1-11: I-405 Gaps In Detection (as of June 2008)

Location	Abs PM		Length (Miles)
	From	To	
NORTHBOUND			
Inglewood to Rosecrans	42.122	42.932	0.81
122nd to FM 105WB	44.372	45.137	0.77
FM 105WB to Olive/Manchester	45.137	46.112	0.98
La Tijera to Centinela	48.022	49.182	1.16
National to Pico/Olympic	52.932	53.902	0.97
Wilshire2 to Montana	55.342	56.172	0.83
Moraga to Getty/Sepulveda	57.192	58.482	1.29
Getty/Sepulveda to Bel Air Cr	58.482	59.572	1.09
Bel Air Cr to Skirball/Mulholland	59.572	60.702	1.13
Ventura to Burbank1	62.742	63.772	1.03
Victory to Sherman Way	65.252	66.232	0.98
Roscoe to Nordhoff	67.642	68.642	1.00
SOUTHBOUND			
Devonshire 1 to Nordhoff Off	69.872	68.642	1.23
Nordhoff On to Roscoe	68.432	67.452	0.98
Shermany Way 1 to Victory 2	66.032	65.252	0.78
Oxnard St to Burbank 2	64.672	63.852	0.82
Burbank 1 to Ventura	63.772	62.862	0.91
Royal Ridge to Skirball/Mulholland	61.342	60.322	1.02
Bel Air Cr to Getty/Sepulveda	59.572	58.502	1.07
Getty/Sepulveda to Moraga	58.502	57.192	1.31
Sunset WB/Church to Waterford	56.812	55.882	0.93
Pico to National	53.902	52.932	0.97
National to S of 10	52.932	52.172	0.76
Centinela to La Tijera	49.182	48.022	1.16
Olive/Manchester to 98th/WB Century	47.062	46.172	0.89
Rosecrans 1 to Inglewood 2	42.932	42.072	0.86

NOTE: The next page is intentionally left blank so that Caltrans can insert updates to the detection analysis results presented in the last four exhibits (Exhibits 1-3 through 1-6) and discuss the ramifications of its findings (e.g., have the gaps been filled, is detector reliability improving or diminishing). Similar place holder pages have been inserted throughout the document to insert future updates.

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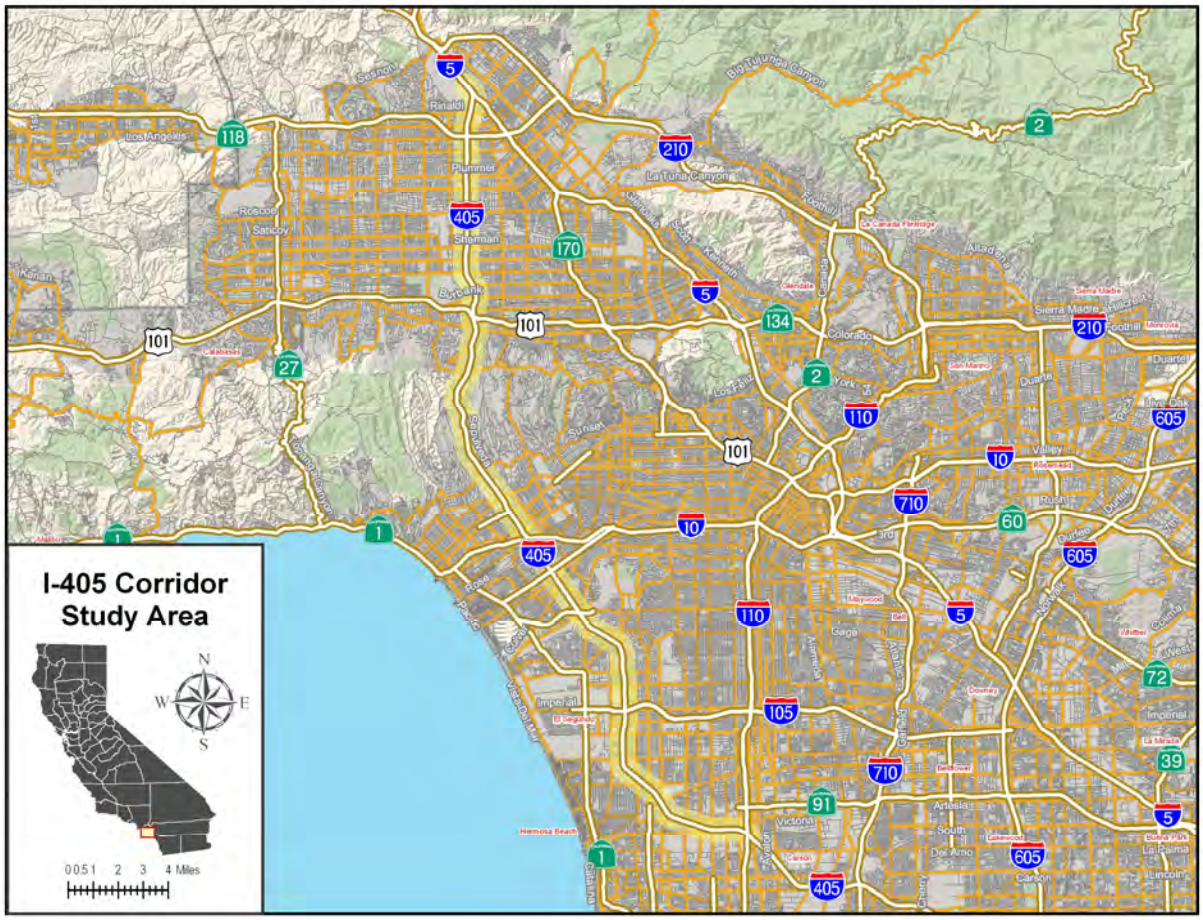
2. CORRIDOR DESCRIPTION

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

Exhibit 2-1: Map of I-405 Corridor Study Area



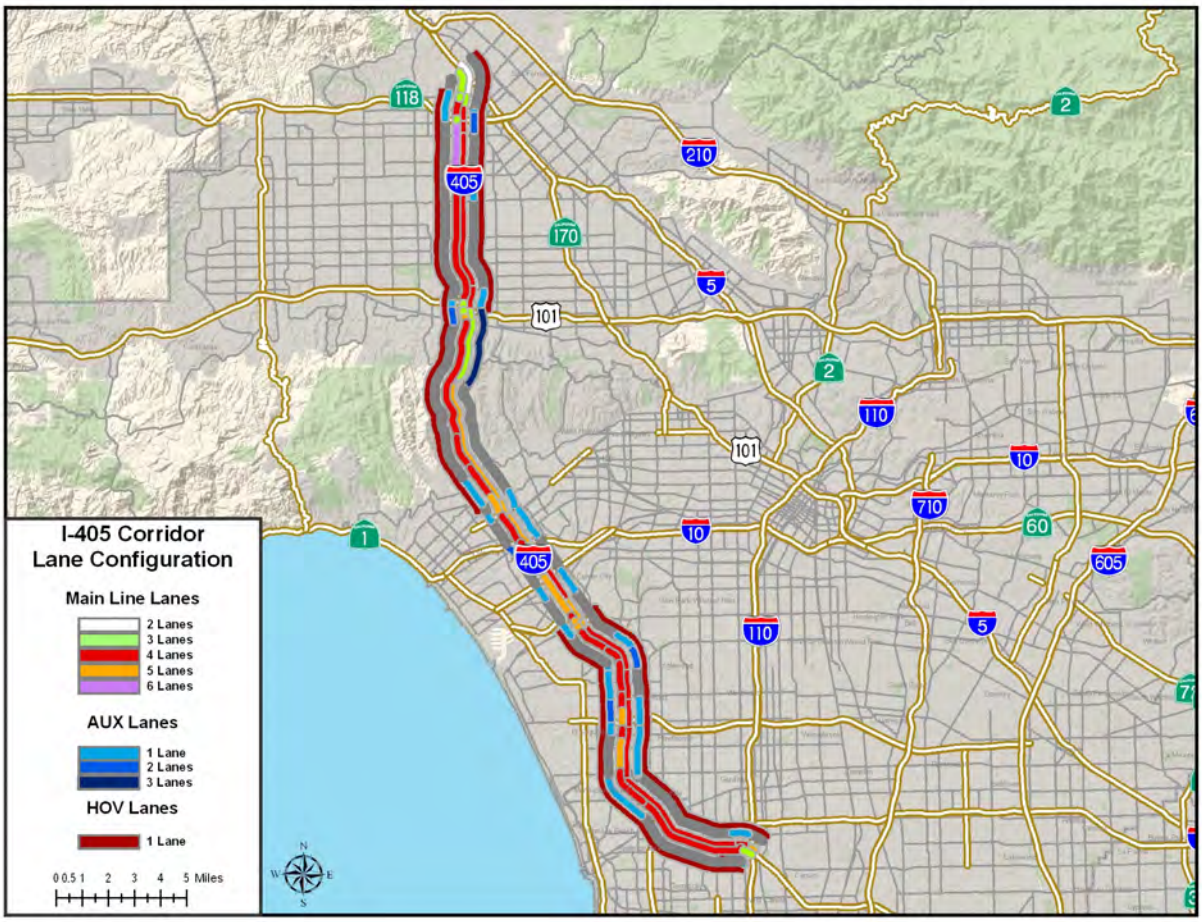
Corridor Roadway Facility

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

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

HOV lanes are available throughout the majority of the corridor except for both directions from the SR-90 (Marina Freeway) to the I-10 (Santa Monica Freeway) and in the northbound direction from the I-10 to the US-101. Ramp meters are active during both the morning and afternoon peak periods. Directions of travel are divided by a concrete median. Exhibit 2-2 shows the lane configurations along the I-405 corridor.

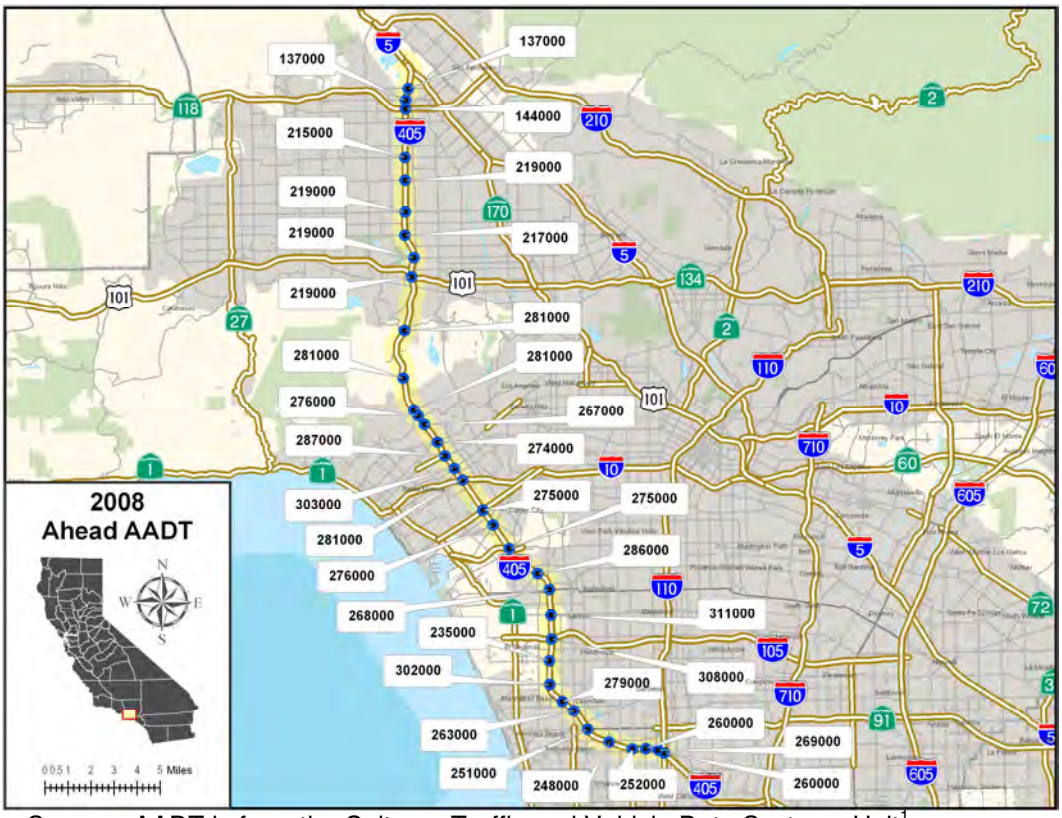
Exhibit 2-2: I-405 Corridor Lane Configuration



The 2008 Caltrans Traffic and Volume Data Systems indicate that the annual average daily traffic (AADT) ranges from 137,000 to 310,000 vehicles per day, as illustrated in Exhibit 2-2. The highest AADT was reported at or around the I-405/I-105 Interchange.

I-405 is also a part of the STAA National Truck Network. According to the 2007 Annual Average Daily Truck Traffic on the California State Highway System published by Caltrans in September 2008, this corridor's daily truck traffic ranges from 3.4 percent to 5.5 percent of the total daily traffic.

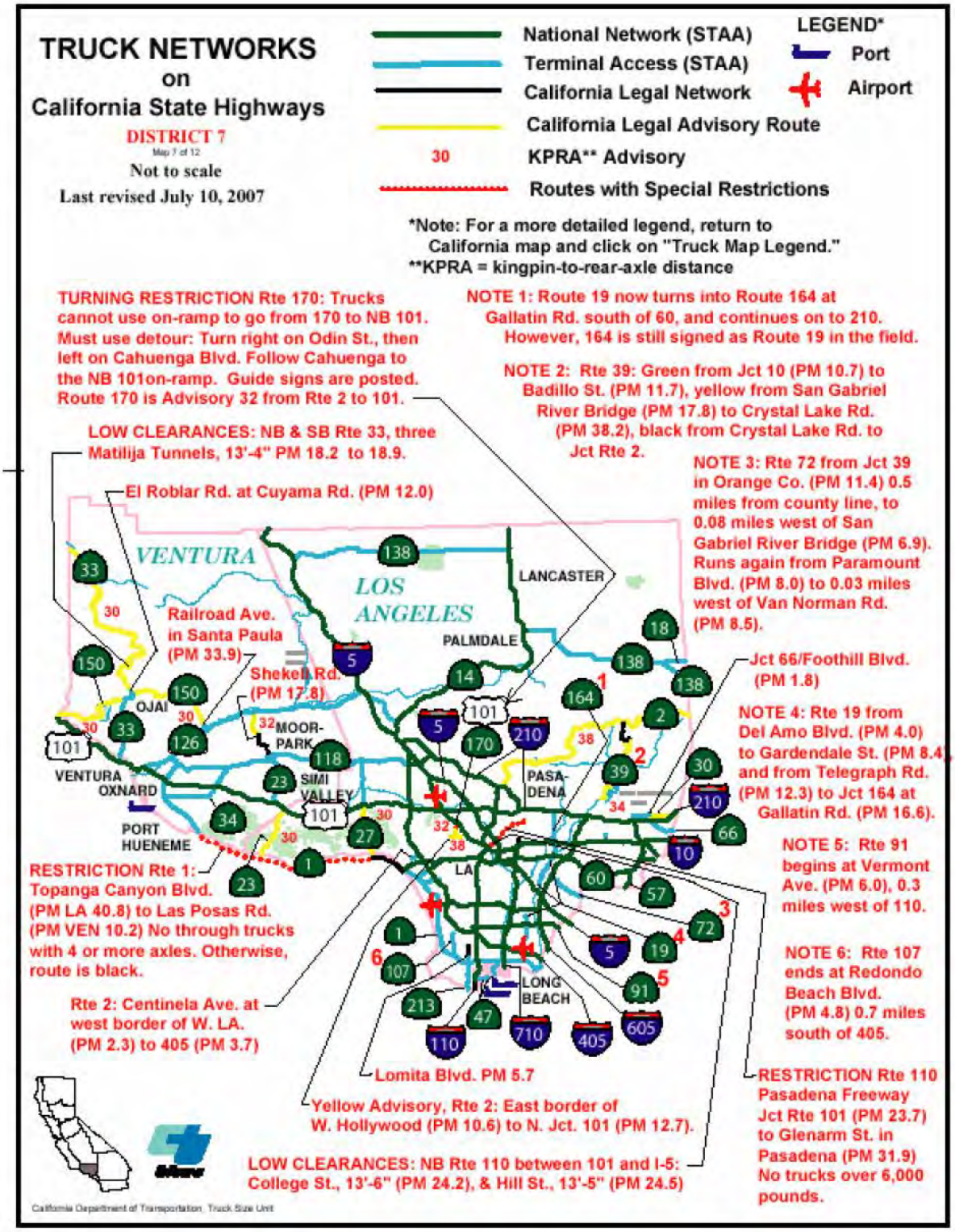
Exhibit 2-2: Major Interchanges and AADT along the I-405 Corridor (2008)



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

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

Exhibit 2-3: Los Angeles & Ventura County Truck Networks



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Recent and Planned Roadway Improvements

Several roadway improvements have recently been completed and others are currently under construction along the corridor:

- HOV lanes in both directions from I-105 to SR-90 were completed and open to traffic in 2004.
- An HOV lane extension from SR-90 to I-10 in both directions started in 2004 and is scheduled to be completed in 2009.
- A southbound only HOV lane extension from Sunset Boulevard to I-10 is under construction and also scheduled to be completed in 2009.
- Construction on a northbound HOV lane from I-10 to US-101 (partly funded by CMIA) began in May 2009 and is expected to take four years.

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

Corridor Transit Services

Major transit operators within the I-405 study corridor include

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

Metro operates local bus, rapid bus, and rail service along or parallel to the I-405 corridor. In the northerly portion of the corridor from the I-5 to the I-101, Metro operates Line 234, which runs southern along Sepulveda Boulevard from the Sylmar/San Fernando Metrolink Station southbound. Lines 233 and 237 run parallel to the study corridor along Van Nuys Boulevard.

In addition to these bus lines, Metro also operates Metro Rapid 734 along Sepulveda Boulevard and Metro Rapid 761 along Van Nuys Boulevard. Metro Orange Line crosses the study corridor south of Victory Boulevard. Exhibits 2-4 and 2-5 provide a close-up shot of the Metro transit lines servicing some of the cities within the northerly and middle portions of the study corridor.

In the southern portion of the study corridor, from the I-10 to the I-110, Metro operates Line 215, which runs along Inglewood Avenue parallel to the corridor. Metro Rapid Lines 740 and 940, local bus Line 40, and Express Line 442 run along Hawthorne Boulevard while Line 211 operates along Prairie Avenue. The Metro Rail Green Line crosses the freeway running along the I-105 freeway and terminates at the Redondo Beach Avenue Station. Finally, Metro Line 232 runs parallel to the study corridor along Sepulveda Blvd (SR-1). Exhibit 2-6 provides a close up shot of the Metro transit lines servicing some of the cities within the southerly portion of the I-405 corridor.

The Metrolink Ventura County Line crosses the northerly portion of the study corridor between Saticoy Street and Roscoe Boulevard while the Metrolink Antelope Valley Line runs southeast of the corridor to downtown Los Angeles. Exhibit 2-7 shows the Metrolink System Map for the southern California area.

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

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

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

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

Exhibit 2-4: Metro Area Map Servicing North I-405 Corridor

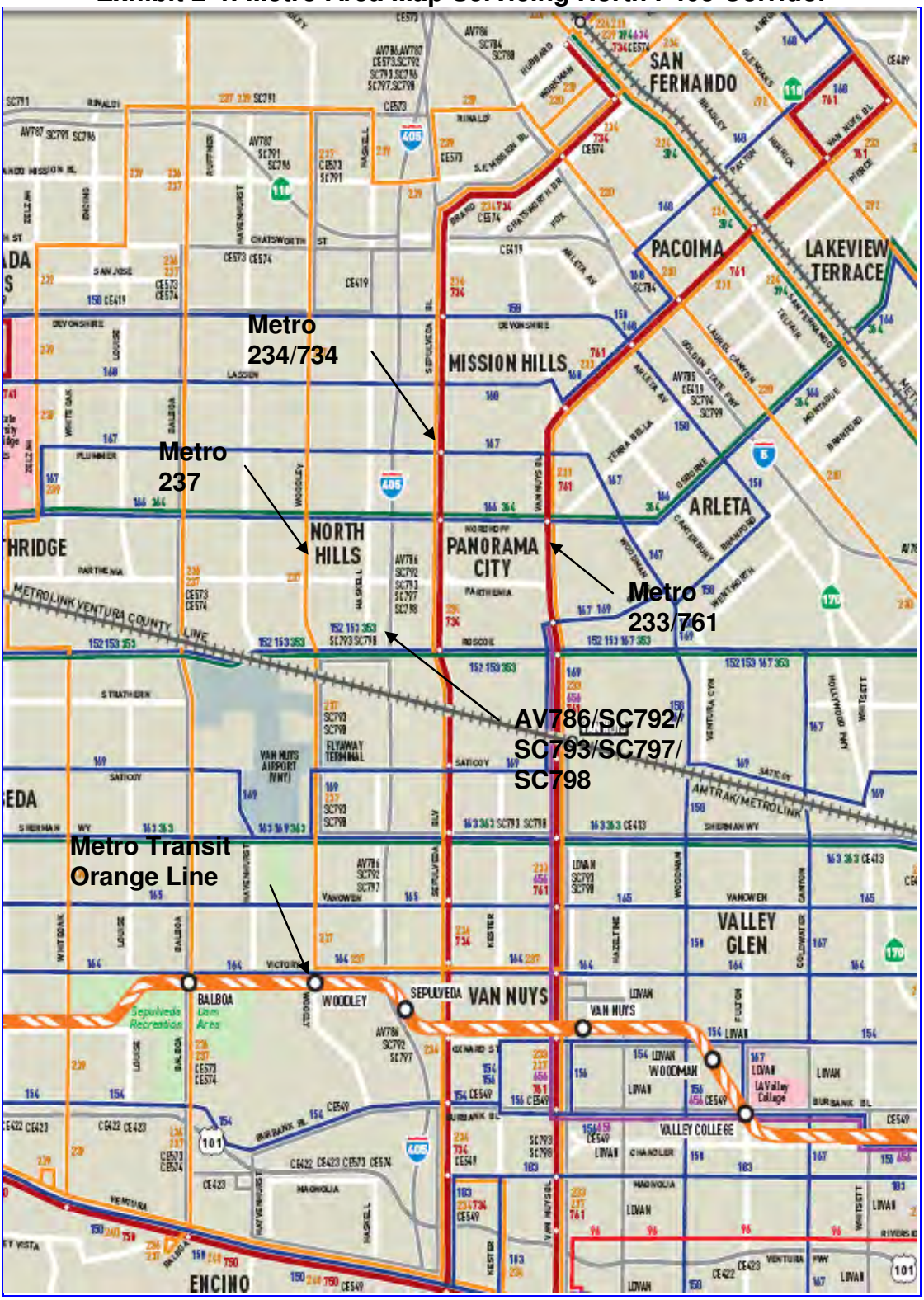

Exhibit 2-5: Metro Area Map Servicing Mid I-405 Corridor

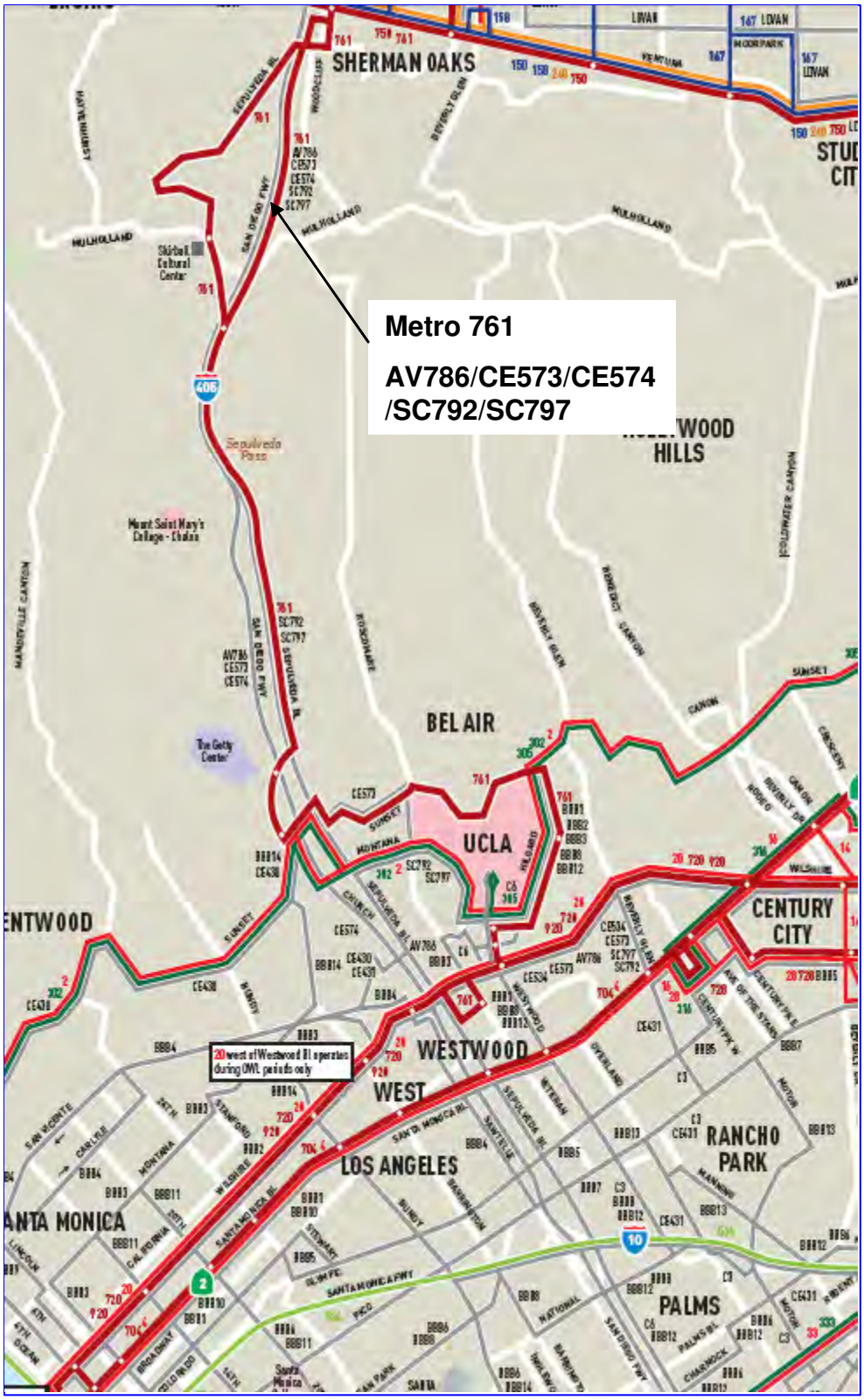

Exhibit 2-6: Metro Area Map Servicing South I-405 Corridor

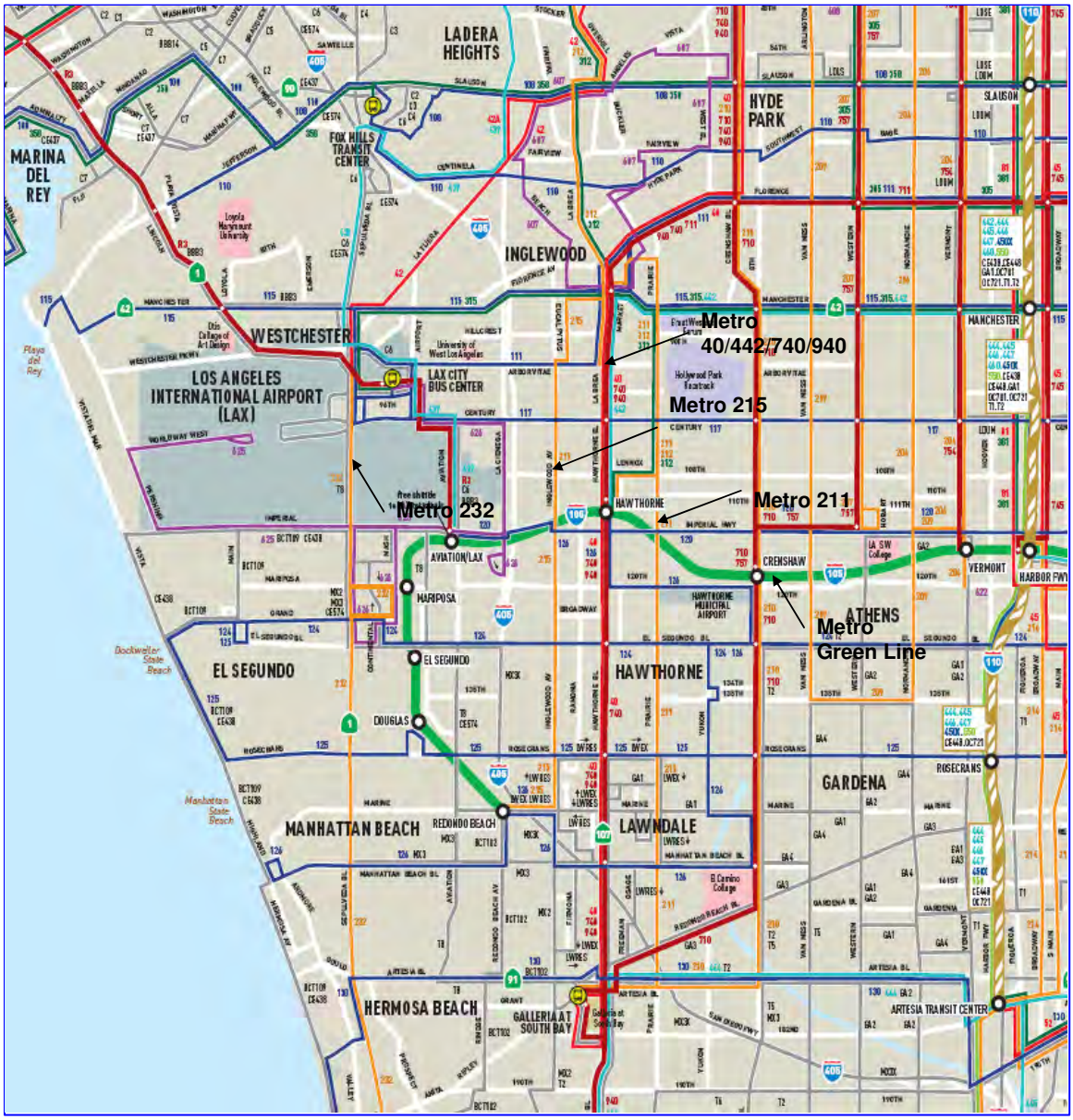

Exhibit 2-7 Metrolink System Map

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Intermodal Facilities

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

Exhibit 2-8 Santa Monica Airport

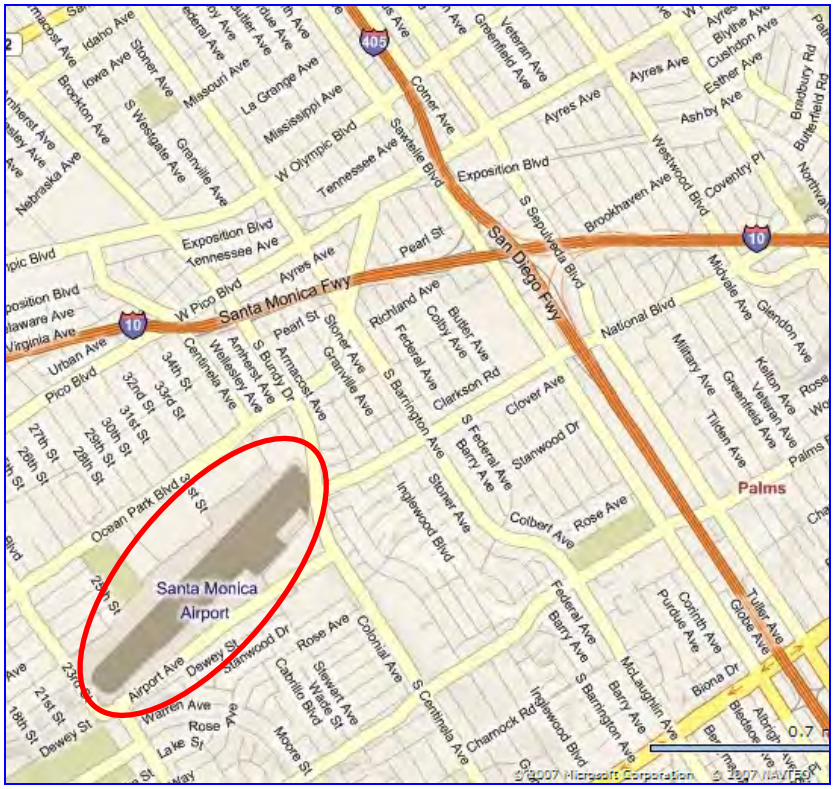


Exhibit 2-9 Van Nuys Airport

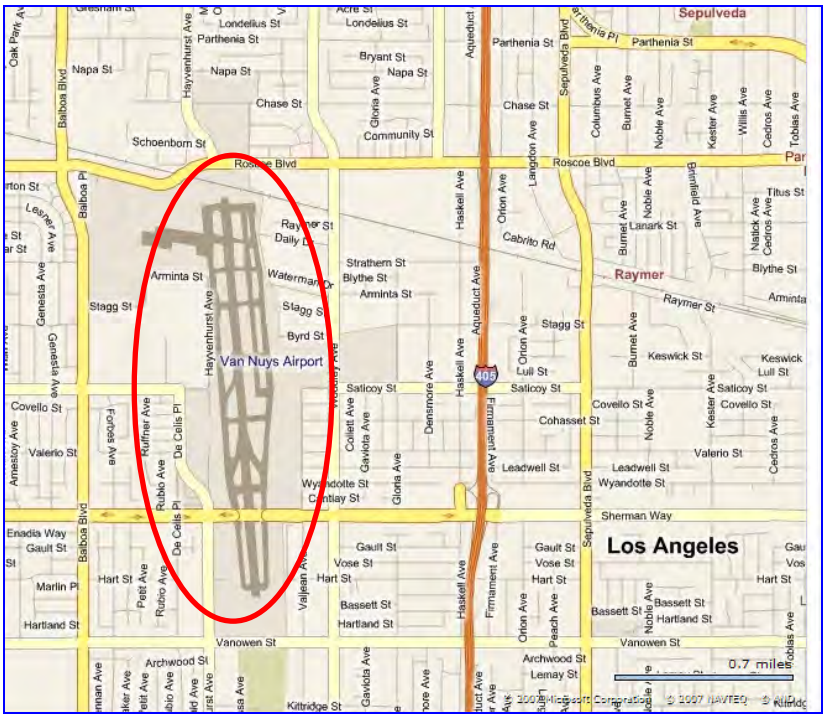


Exhibit 2-10 Hawthorne Municipal Airport

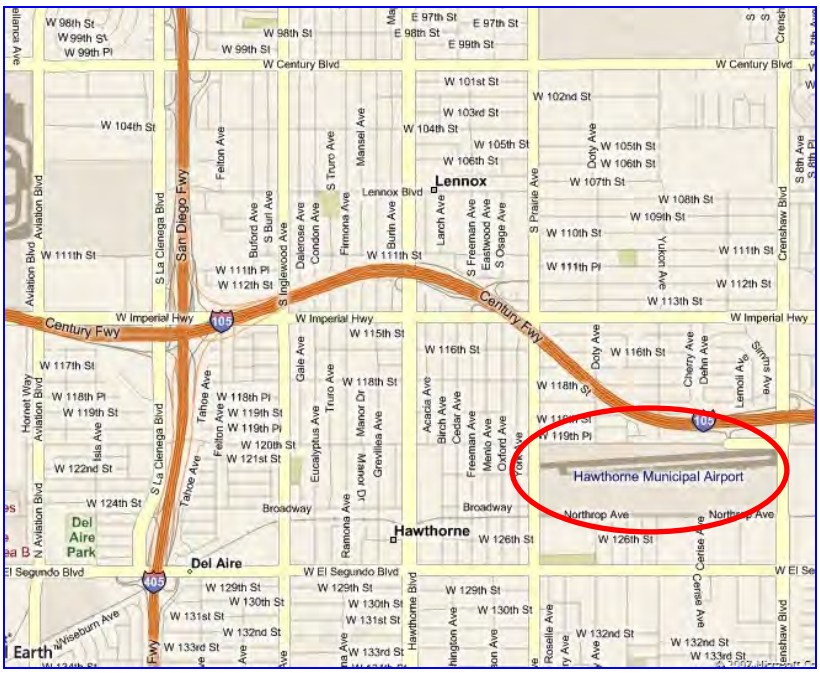


Exhibit 2-11 Torrance Municipal Airport

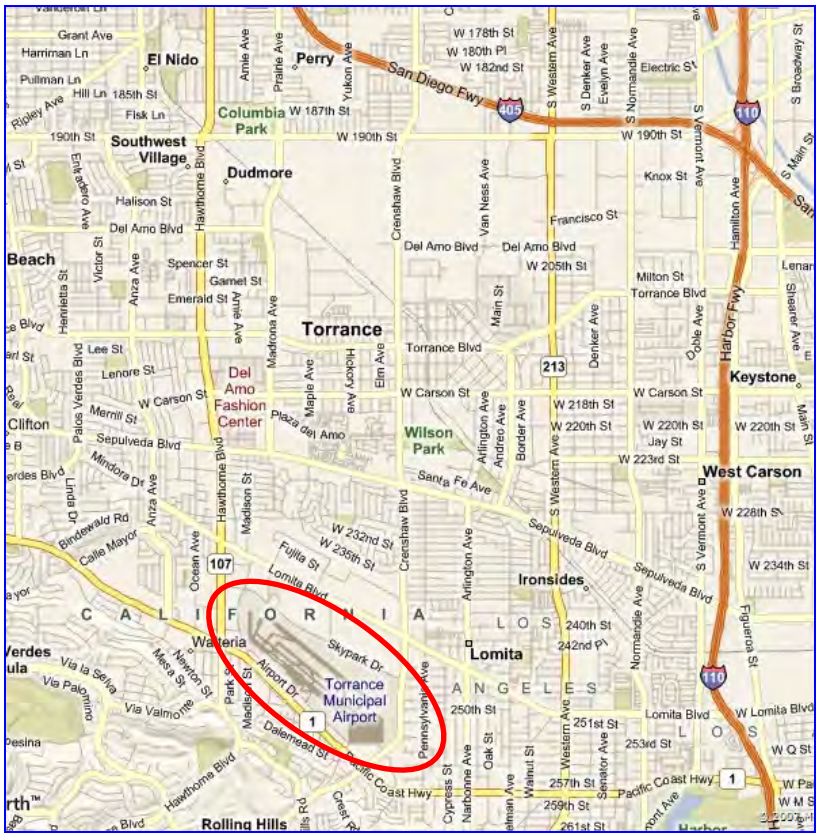
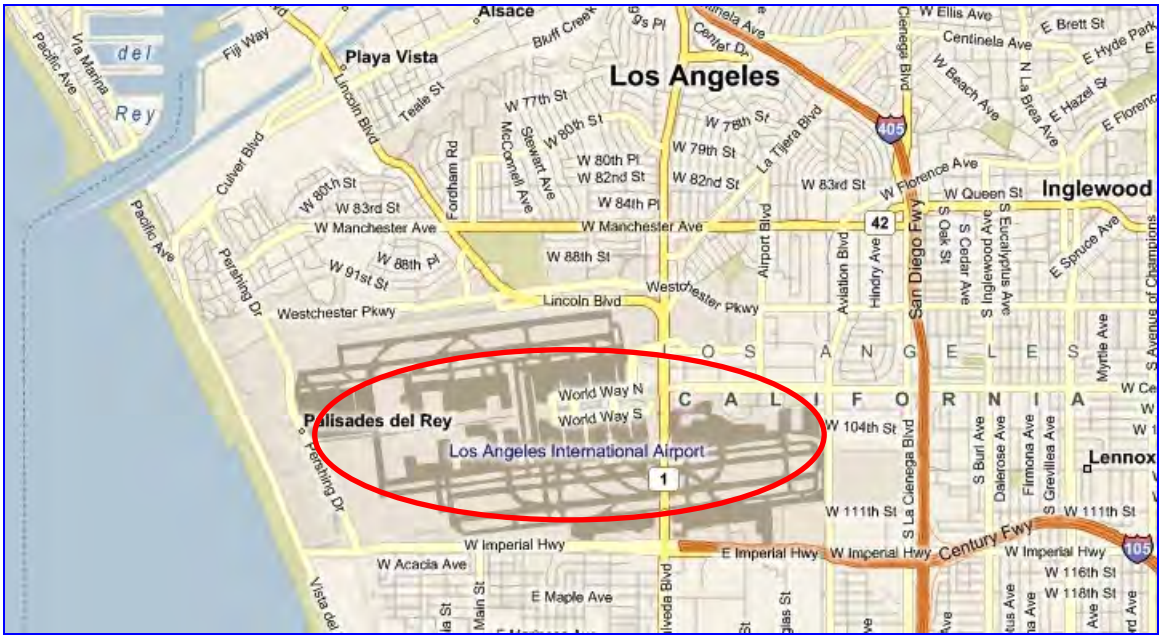


Exhibit 2-12: Los Angeles International Airport



Los Angeles International Airport (LAX), shown in Exhibit 2-11, is located off of the I-405 and I-105 Freeways. LAX is the world's fifth busiest passenger airport and ranks eleventh in air cargo tonnage handled.

In 2006, more than 61 million people traveled through LAX. A commerce leader, its ever-expanding air cargo system handled more than 2.1 million tons of goods. International freight is more than 50 percent of this total. LAX handled 70 percent of the passengers, 75 percent of the air cargo, and 95 percent of the international passengers and cargo traffic in the five-county Southern California region. Exhibit 2-13 shows the Los Angeles International Airports (LAX) Passenger Traffic Comparison by Terminal.

Exhibit 2-13: LA International Airports (LAX) Passenger Traffic Comparison by Terminal

Terminal	Type	Passenger Count January to December		
		2005	2006	% Change
Imperial Terminal	Arrival	2,221	2,697	21.43%
	Departure	2,154	2,882	33.80%
LAX T1	Arrival	5,049,887	4,828,195	-4.39%
	Departure	5,092,235	4,828,409	-5.18%
LAX T2	Arrival	2,945,327	2,992,262	1.59%
	Departure	2,942,103	3,005,327	2.15%
LAX T3	Arrival	2,019,833	2,048,725	1.43%
	Departure	2,380,991	2,465,245	3.54%
LAX T4	Arrival	5,687,870	5,636,517	-0.90%
	Departure	5,392,125	5,445,036	0.98%
LAX T5	Arrival	2,485,780	2,215,130	-10.89%
	Departure	2,462,723	2,261,503	-8.17%
LAX T6	Arrival	2,450,915	2,712,916	10.69%
	Departure	2,514,849	2,737,386	8.85%
LAX T7	Arrival	3,562,576	3,579,788	0.48%
	Departure	3,609,407	3,707,096	2.71%
LAX T8	Arrival	1,326,878	1,377,466	3.81%
	Departure	1,318,915	1,348,936	2.28%
Miscellaneous Terminal	Arrival	3,691	4,679	26.77%
	Departure	3,298	4,034	22.32%
TBIT	Arrival	4,760,825	4,670,204	-1.90%
	Departure	4,386,128	4,221,919	-3.74%

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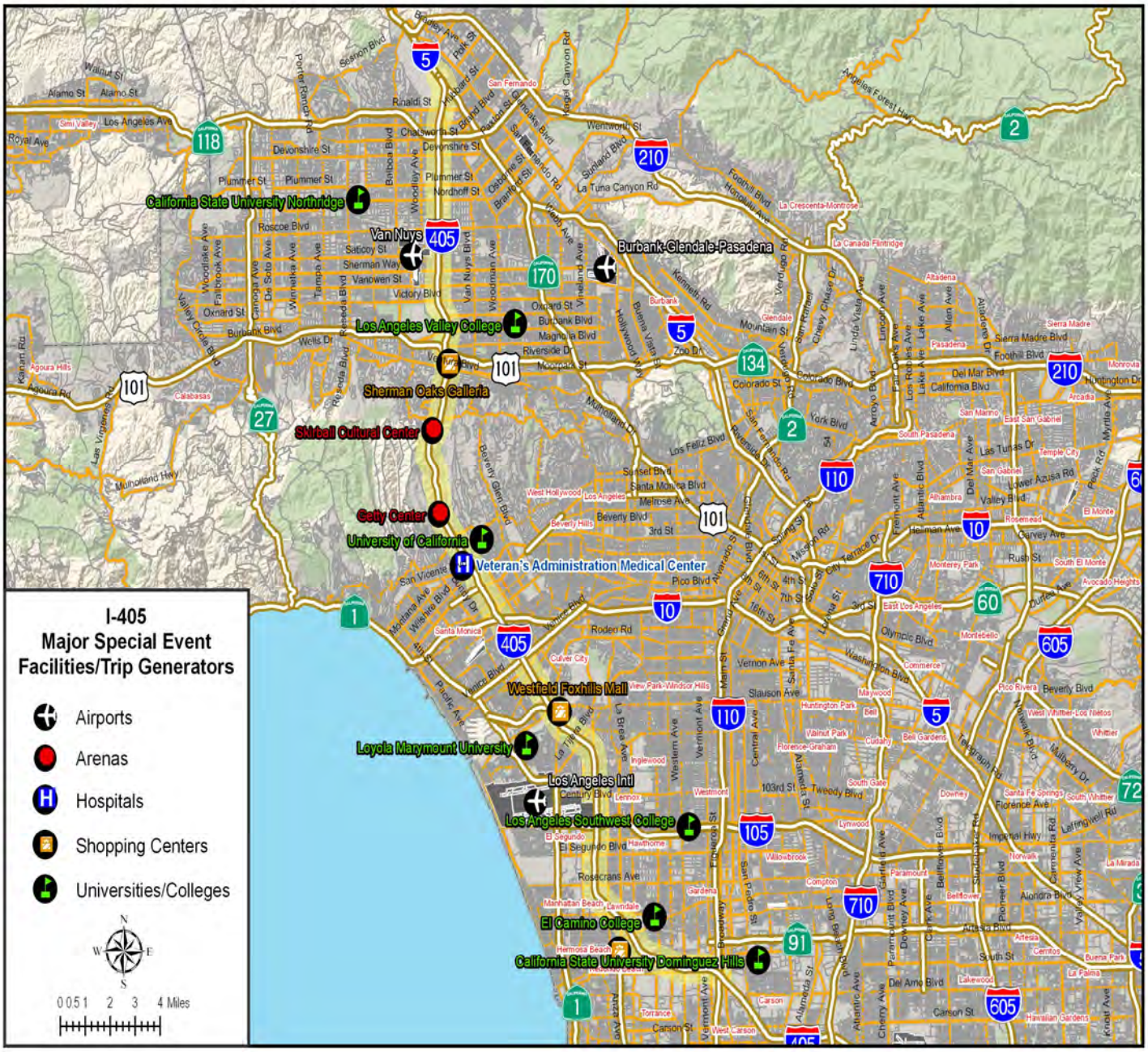
Special Event Facilities/Trip Generators

In addition to the Los Angeles International Airport and the major employment centers along the corridor, particularly the Westside and South Bay, there are major special event facilities that may generate significant trips along the I-405 corridor. A number of the most significant ones are shown in Exhibit 2-14. There are seven major colleges/universities near the I-405 corridor. California State University Northridge is located approximately three miles west of the study corridor and near the SR-118 (Simi Valley) Freeway. It is a public university with an estimated enrollment of 35,000 students. It offers Bachelors, Masters and Doctorate Degrees. Loyola Marymount University (LMU) is located one mile west of the study corridor and south of the SR-90 Freeway. LMU is a private Catholic university, offering Bachelors, Masters, Doctorate and Law degrees. It has an estimated enrollment of approximately 9,000 students. El Camino College is located one mile east of the I-405 and west of the I-110 freeway. It is a two-year undergraduate college with an estimated student enrollment of 24,000. The University of California, Los Angeles (UCLA) is located in Westwood approximately one mile east of the 405 freeway. It is a public university offering Bachelors, Masters, and Doctorate degrees. It has an estimate enrollment of 40,000 students. Los Angeles Valley College is located three miles east of the study corridor and north of the US-101 freeway in the San Fernando Valley. The school is a part of the Los Angeles Community College District. It is a public two-year college with an estimated enrollment of 16,200 students. Los Angeles Southwest College is approximately three miles from the I-405 freeway and off the I-105 freeway. It is also part of the Los Angeles Community College District. It is a public two-year college with an estimated enrollment of 6,000 students. California State University Dominguez Hills is located approximately one mile from the I-405 freeway and east of the I-110 freeway. It is a four-year university offering undergraduate and graduate degrees. It has an estimated enrollment of 12,800 students. Approximately 40% of the students are enrolled in graduate programs. The majority of students are part-time evening students with an average course load of six units.

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

In addition to these facilities, other major trip generators within the proximity of the I-405 study corridor include the Sherman Oaks Galleria off the US-101 interchange, the Skirball Cultural Center off Mulholland Drive, the Getty Center off Sunset Boulevard, the Westfield Foxhills Mall off the SR-90 interchange, and the South Bay Galleria off o Hawthorne Boulevard.

Exhibit 2-14: Major Special Event Facilities or Trip Generators



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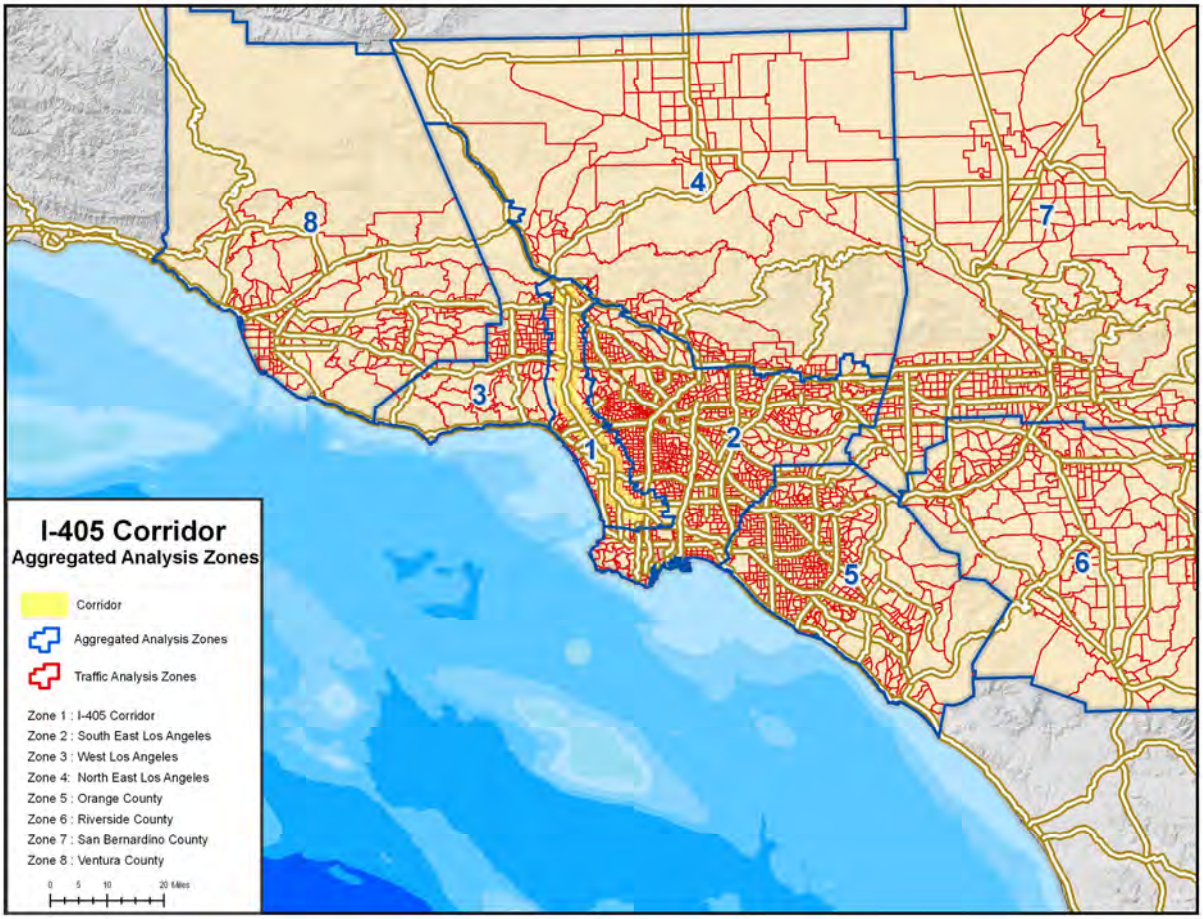
Demand Profiles

An analysis of origins and destinations was conducted to determine the travel pattern of trips made on the I-405 CSMP study corridor. Based on SCAG's travel demand model, this "select link analysis" isolated the I-405 study corridor and identified the origins and destinations of trips made on the corridor. The origins and destinations were identified by Traffic Analysis Zones (TAZ), which were grouped into eight aggregate analysis zones shown in Exhibit 2-15.

Exhibit 2-15: Aggregate Analysis Zones for Demand Profile Analysis



Based on this aggregation, demand on the corridor was summarized by aggregated origin-destination zones as shown on Exhibits 2-16 and 2-17 for the AM and PM peak periods. The analysis showed that a significant percentage of trips using the I-405 Corridor involve trips within Los Angeles County.

During the AM peak period, 86 percent of all trips originate <u>and</u> terminate in Los Angeles County (Zones 1, 2, 3, 4). Of these trips, a significant portion travel within close proximity to the corridor (Zone 1) or to and from Southeast Los Angeles (Zone 2).

The remaining trips depicted in Exhibit 2-16 originate in Los Angeles County and terminate in another county (5 percent); originate outside Los Angeles County and terminate in Los Angeles County (8 percent); or originate and terminate outside of Los Angeles County (1 percent).

Exhibit 2-16: I-405 AM Peak Origin Destination by Aggregated Analysis Zone

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

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

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

Exhibit 2-17: I-405 PM Peak Origin Destination by Aggregated Analysis Zone

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

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

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3. CORRIDOR-WIDE PERFORMANCE AND TRENDS

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

The performance measures focus on four key areas:

- **Mobility** describes how well the corridor moves people and freight
- **Reliability** captures the relative predictability of the public's travel time
- **Safety** captures the safety characteristics in the corridor such as collisions
- **Productivity** describes the productivity loss due to inefficiencies in the corridor
- **Pavement Condition** describes the structural adequacy and ride quality of the pavement.

MOBILITY

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

Delay

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

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

In the formula above, the *Vehicles Affected per Hour* value depends on the methodology used. Some methods assume a fixed flow rate (e.g., 2,000 vehicles per hour per lane), while others use a measured or estimated flow rate. The distance is the length under which the congested speed prevails and the duration is the hours of congestion experience below the threshold speed. The threshold speed is the speed

under which congestion is considered to occur. Any speed can be used, but two commonly used threshold speeds are 35 mph and 60 mph. Caltrans defines the threshold speed as 35 mph and assumes a fixed 2,000 vehicles per hour per lane are experiencing the delay to estimate severe delay for reporting congestion for the statewide Highway Congestion Monitoring Report (HICOMP).

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

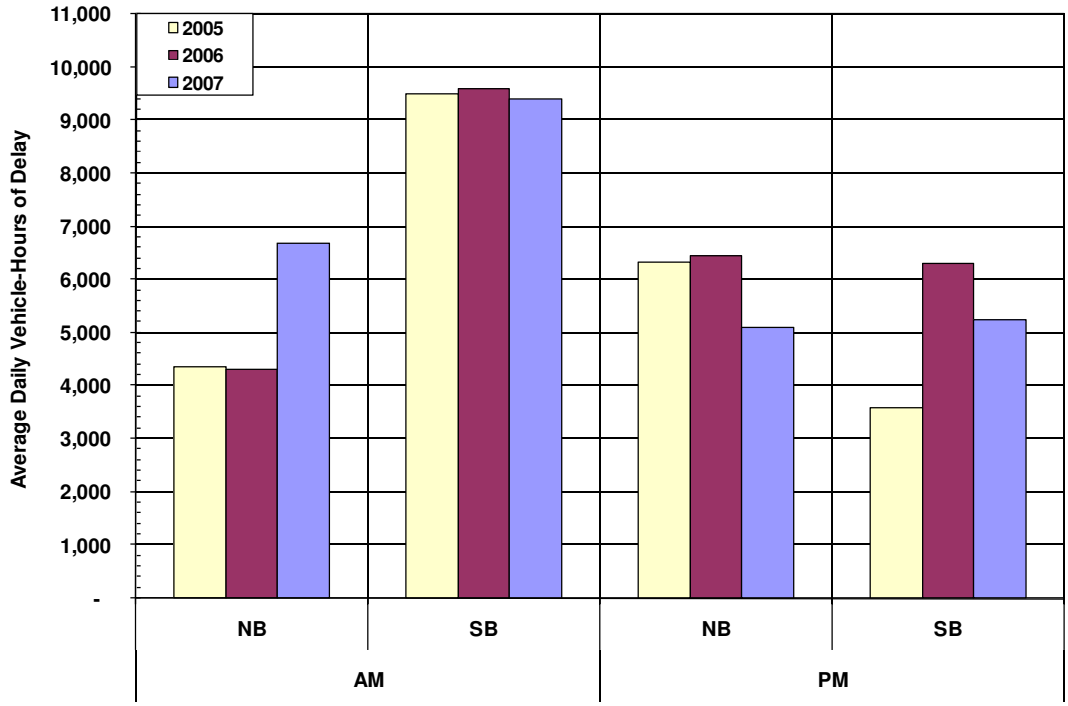
Caltrans HICOMP

The HICOMP report has been published annually by Caltrans since 1987.[2] Delay is presented as average daily vehicle-hours of delay (DVHD) and attempts to represent the sum of all the delay experienced by commuters on the corridor. For the Los Angeles HICOMP analysis, delay is calculated only for the mainline facility using detection data. Two sample days are identified and used to compute delay to reflect "normal conditions". Days with much higher or lower delays are not included in the analysis and only severe delays (i.e., using 35 mph in the aforementioned formula) are reported. The average delay per vehicle per hour computed for the sample days is multiplied by 2,000 to maintain consistency among the different Caltrans districts. As mentioned in the introduction section, parts of the corridor where detection equipment was disconnected or where detection systems failed are not included the overall delay results.

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

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

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



Source: 2005-2007 HICOMP data

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

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

Based on the HICOMP results, the most congested segment on the corridor varied from year to year (most likely due to construction and detection availability). The highest delays were reported for the southbound segment during the AM peak period between San Fernando Mission and US-101. Delay in this segment totaled 6,774 hours in 2007.

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

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

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

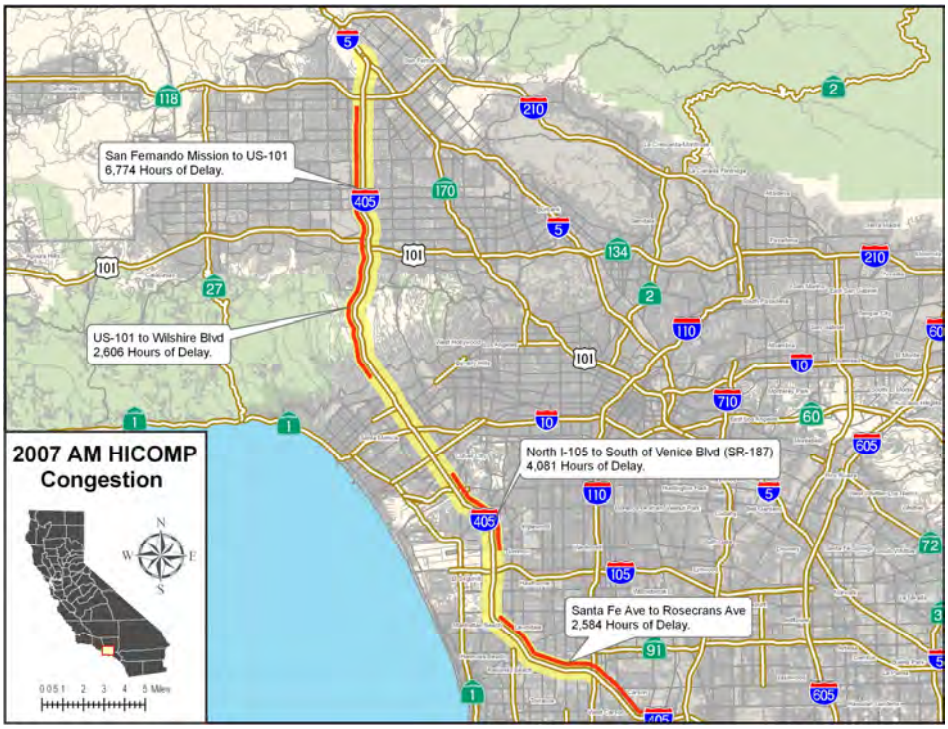
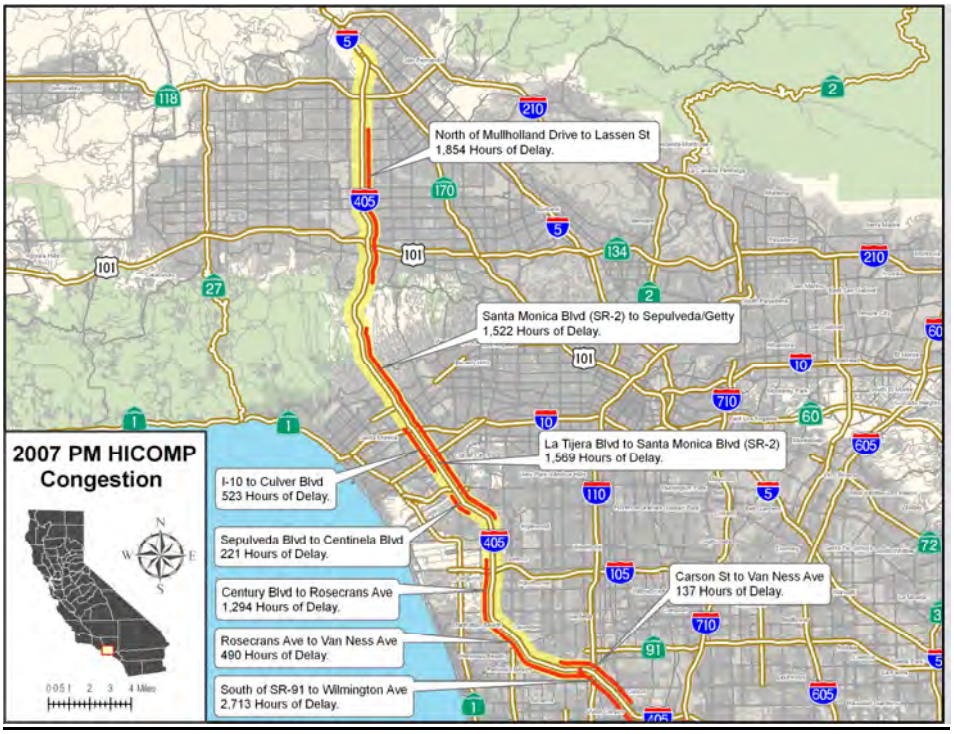


Exhibit 3-4: 2007 PM Peak Period HICOMP Congested Segments Map



Page Intentionally Left Blank for Future Updates from HICOMP

Freeway Performance Measurement System (PeMS)

Using freeways detector data discussed in Section 1 and accessed via PeMS, delay is computed for every day and summarized in various ways, which is not possible when using probe vehicle data.

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

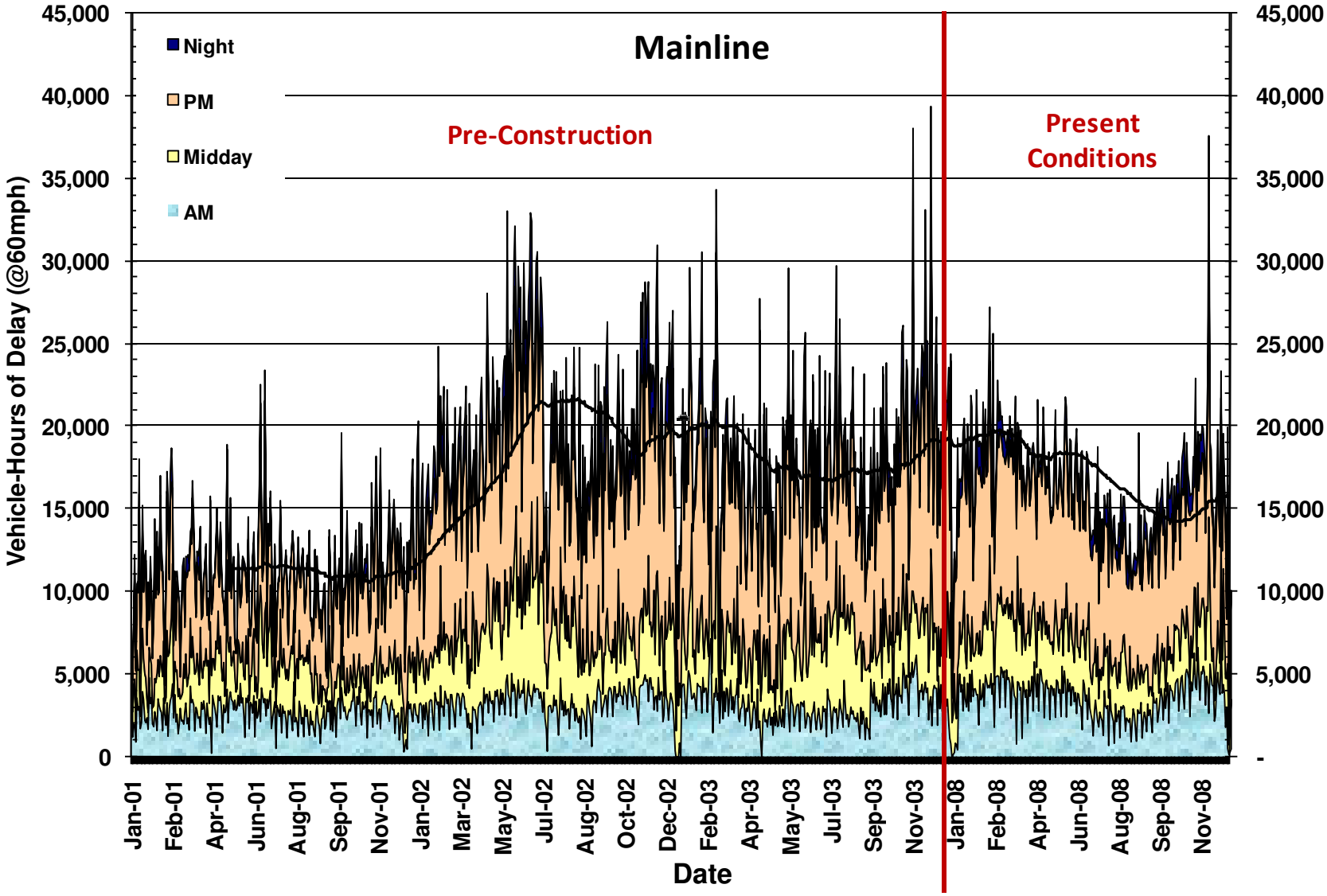
Unlike HICOMP where delay is captured only for speeds below 35 miles per hour and applied to an assumed output or capacity volume of 2,000 vehicles per hour, delays presented in this section represent the difference in travel time between actual conditions and free-flow conditions at 60 miles per hour,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

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

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

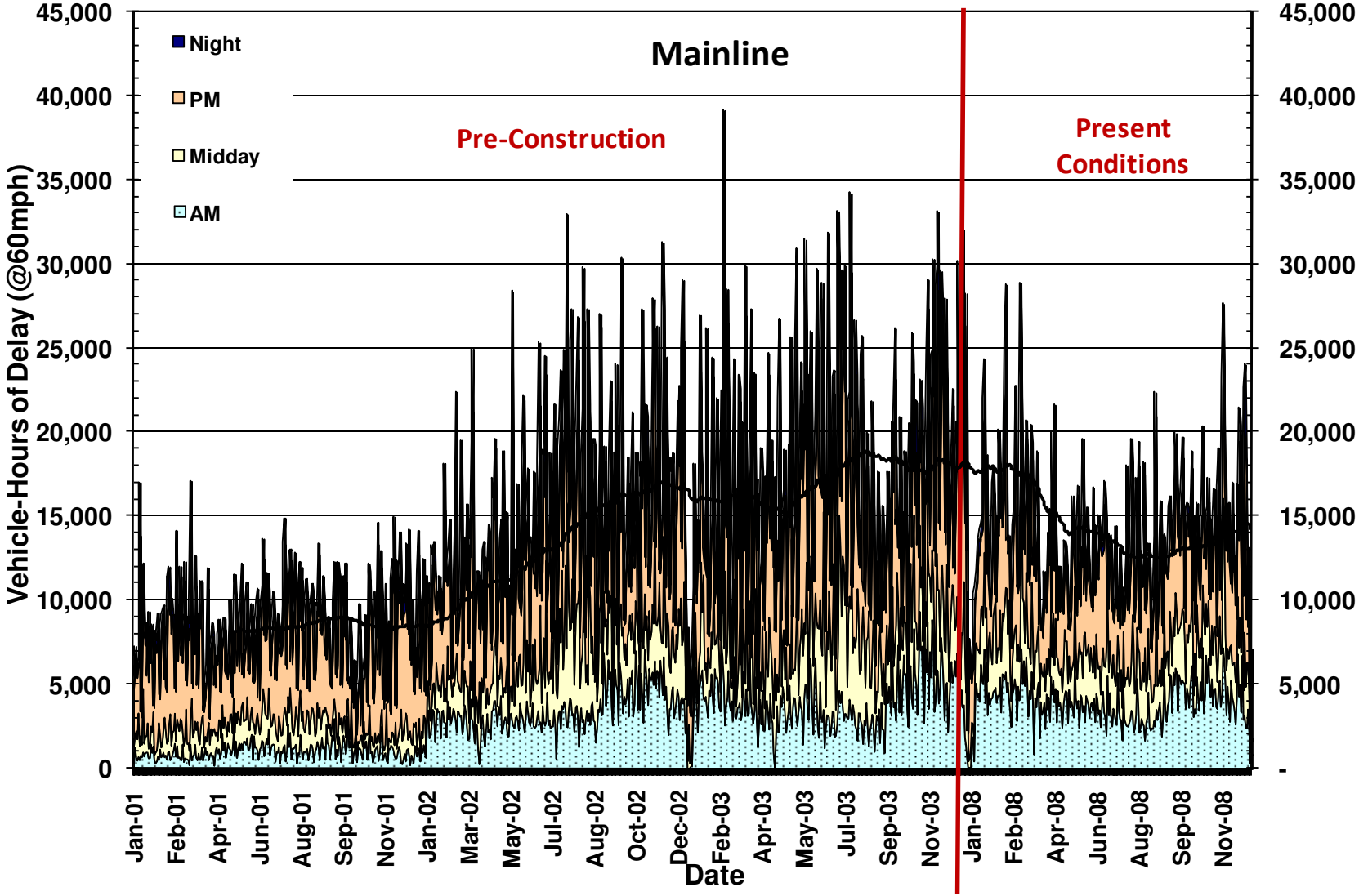
Exhibits 3-7 and 3-8 show the pattern of delay on the HOV facility. Since the HOV-lane does not currently extend throughout the entire study corridor, it is inappropriate to compare the mainline with the HOV-lane. Delay on both directions of the HOV-facility was evenly split between AM and PM peaks.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

Exhibit 3-5: Northbound I-405 ML Average Daily Delay by Time Period (2001-2003 & 2008)



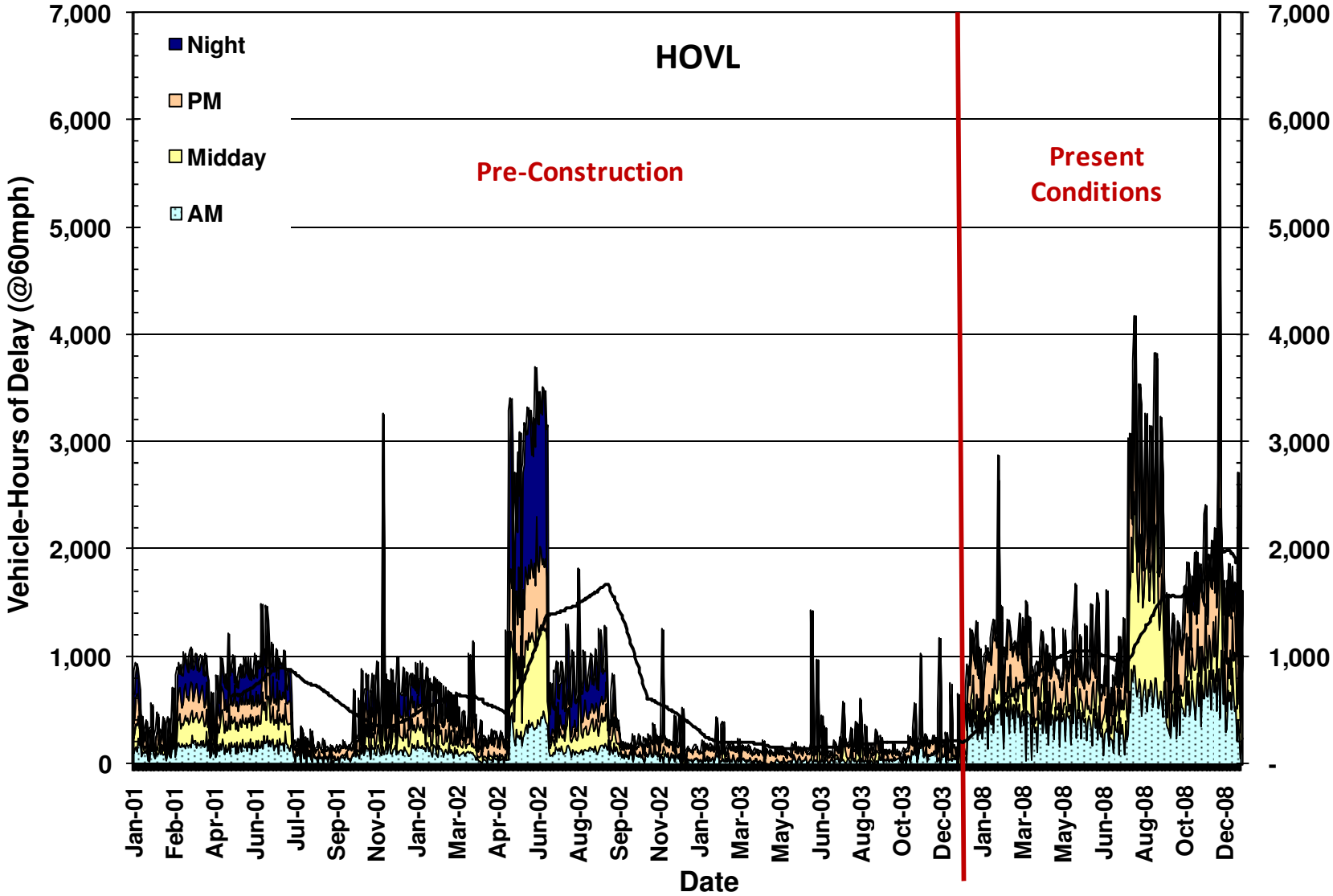
Source: SMG Analysis of PeMS Data

Exhibit 3-6: Southbound I-405 ML Average Daily Delay by Time Period (2001-2003 & 2008)



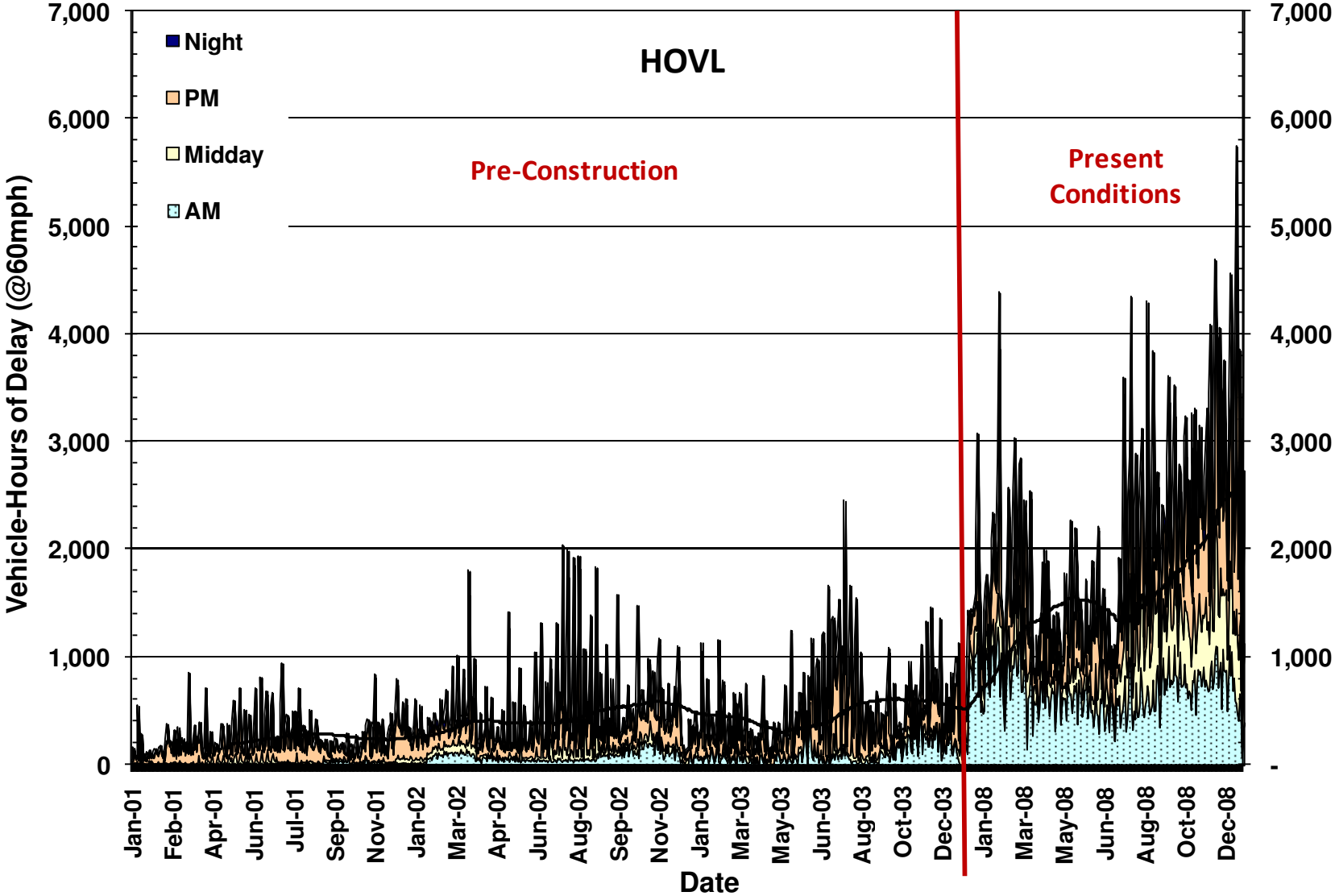
Source: SMG Analysis of PeMS Data

Exhibit 3-7: Northbound I-405 HOVL Average Daily Delay by Time Period (2001-2003 & 2008)



Source: SMG Analysis of PeMS Data

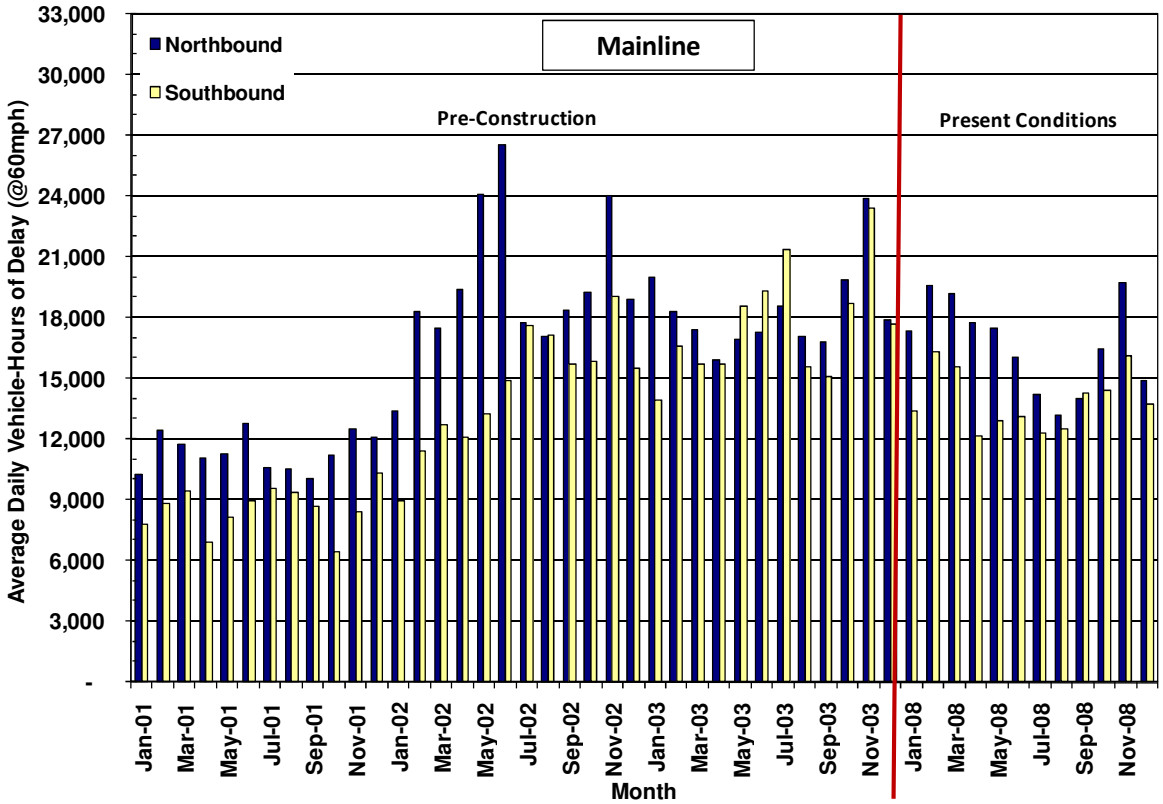
Exhibit 3-8: Southbound I-405 HOVL Average Daily Delay by Time Period (2001-2003 & 2008)



Source: SMG Analysis of PeMS Data

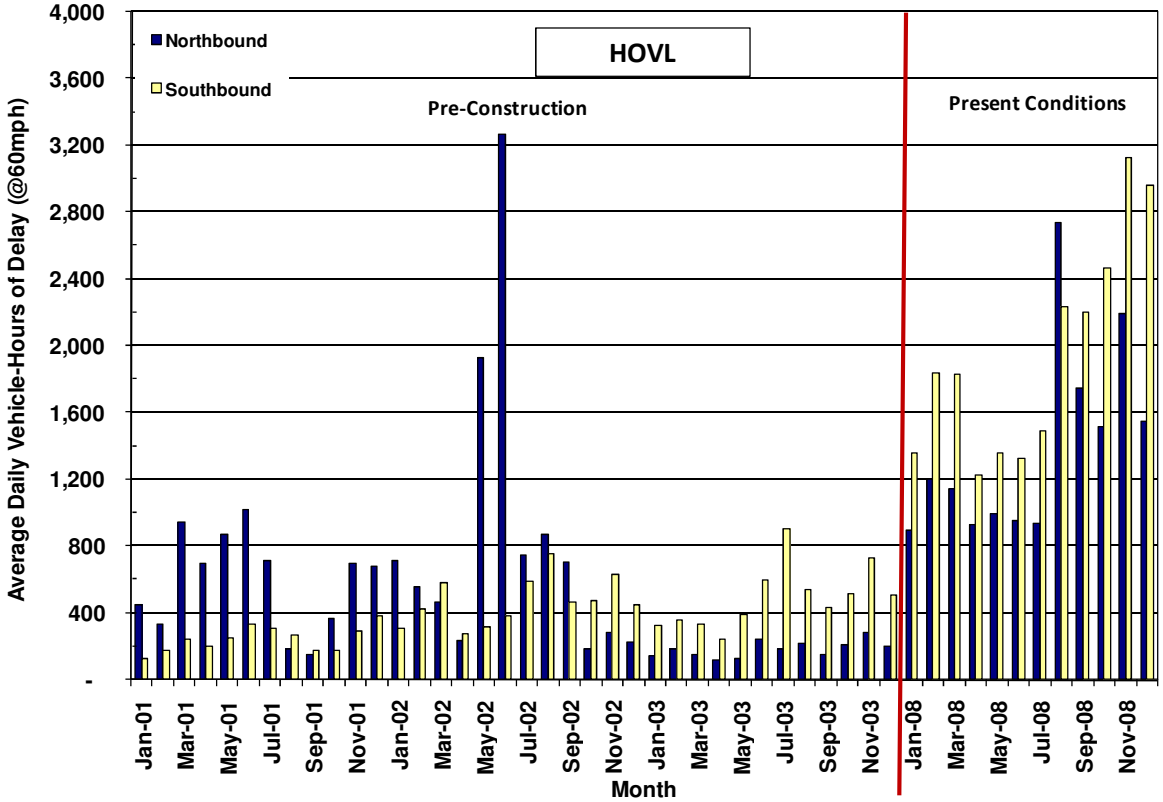
The following set of exhibits provides additional delay characteristics and trends. Exhibit 3-9 illustrates the average daily weekday delay by month for the mainline facility and Exhibit 3-10 shows the HOV facility. On the mainline facility (Exhibit 3-9), the northbound direction experienced greater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

Exhibit 3-9: I-405 ML Average Weekday Delay by Month (2001-2003 & 2008)



Source: SMG Analysis of PeMS Data

Exhibit 3-10: I-405 HOVL Average Weekday Delay by Month (2001-2003 & 2008)



Source: SMG Analysis of PeMS Data

Delay presented to this point represents the difference in travel time between "actual" conditions and free-flow conditions at 60 miles per hour. This delay can be segmented into two components as shown in Exhibits 3-11 and 3-12:

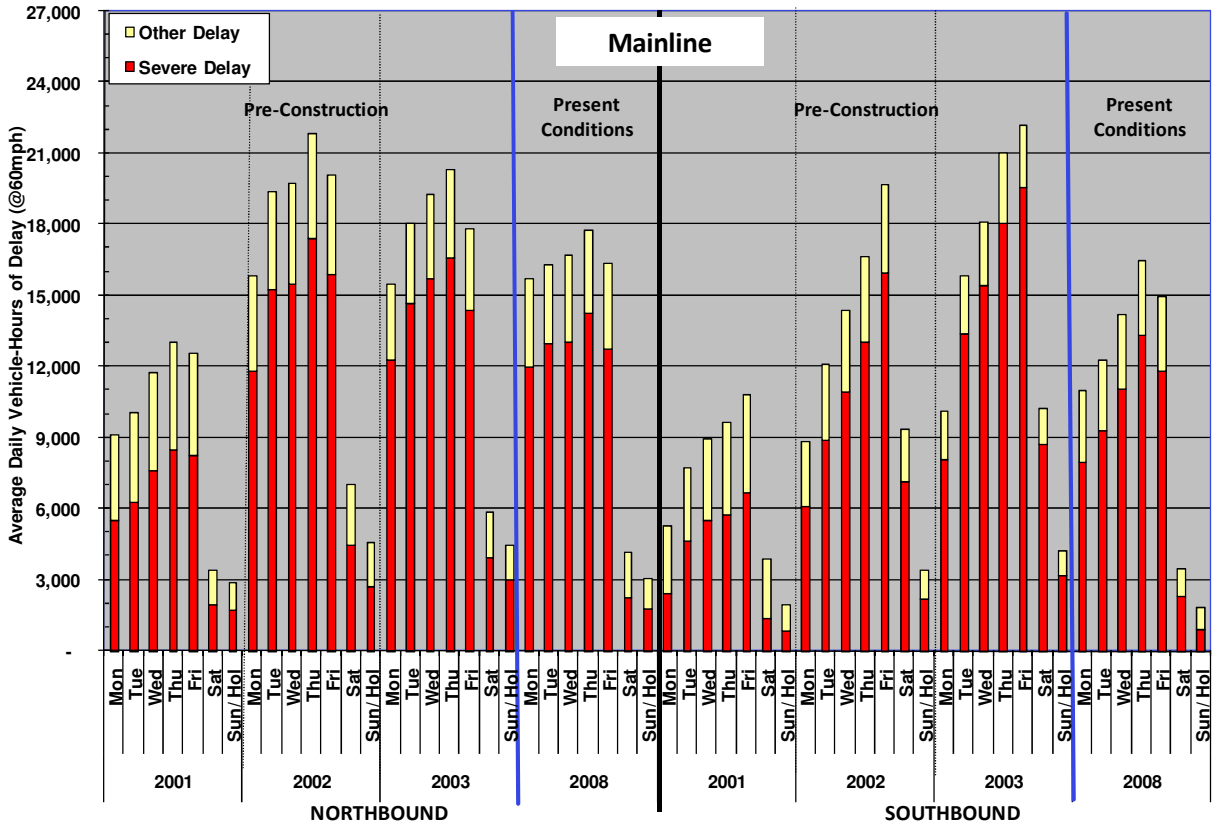
- Severe delay – delay that occurs when speeds are below 35 miles per hour; and
- Other delay – delay that occurs when speeds are between 35 miles per hour and 60 miles per hour.

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

On the mainline facility (Exhibit 3-11), the northbound direction on Thursdays experienced the highest "severe" delay during all four years analyzed. Thursdays in 2002 experienced the highest "severe" delay, slightly below 18,000 vehicle-hours. In

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

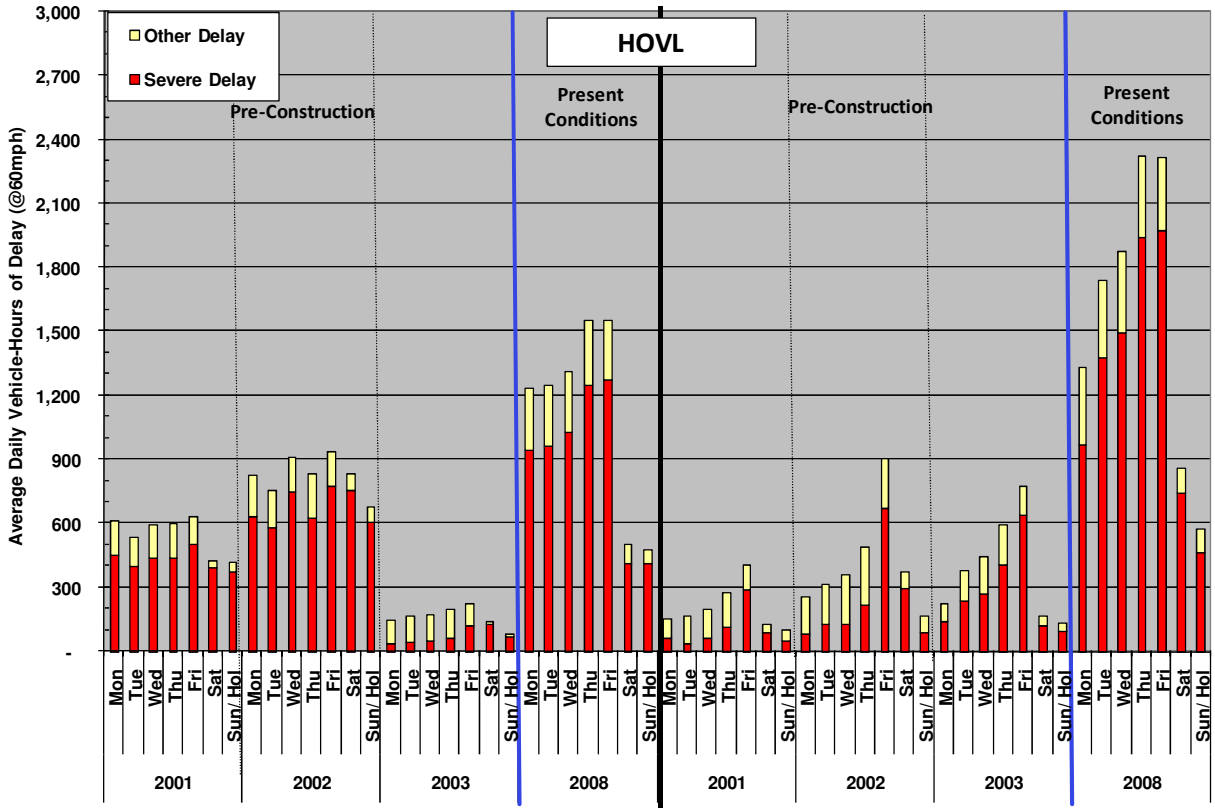
Exhibit 3-11: I-405 ML Average Delay by Day of Week by Severity (2001-2003 & 2008)



Source: SMG Analysis of PeMS Data

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

Exhibit 3-12: I-405 HOVL Average Delay by Day of Week by Severity (2001-2003 & 2008)



Source: SMG Analysis of PeMS Data

Another way to understand the characteristics of congestion and related delays is to examine average weekday delays by hour. For the mainline facility of I-405, Exhibit 3-13 illustrates the average weekday delay by hour for the northbound direction, while Exhibit 3-14 shows the southbound direction. Delay on the HOV facility is depicted in Exhibits 3-15 and 3-16. Each point represents the total delay for the hour. For example, the 7:00 AM point is the sum of delay from 7:00 AM to 8:00 AM. The exhibits show the peaking characteristics of congestion and how the peak period changes over time.

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

- On the northbound mainline facility (Exhibit 3-13), the greatest delay occurred during the 8:00 AM and 5:00 PM peak hours. In 2003, delay during the 8:00 AM peak hour was approximately 1,500 vehicle-hours and the 5:00 PM peak hour delay was about 2,800 vehicle-hours. In 2008, delay increased slightly above

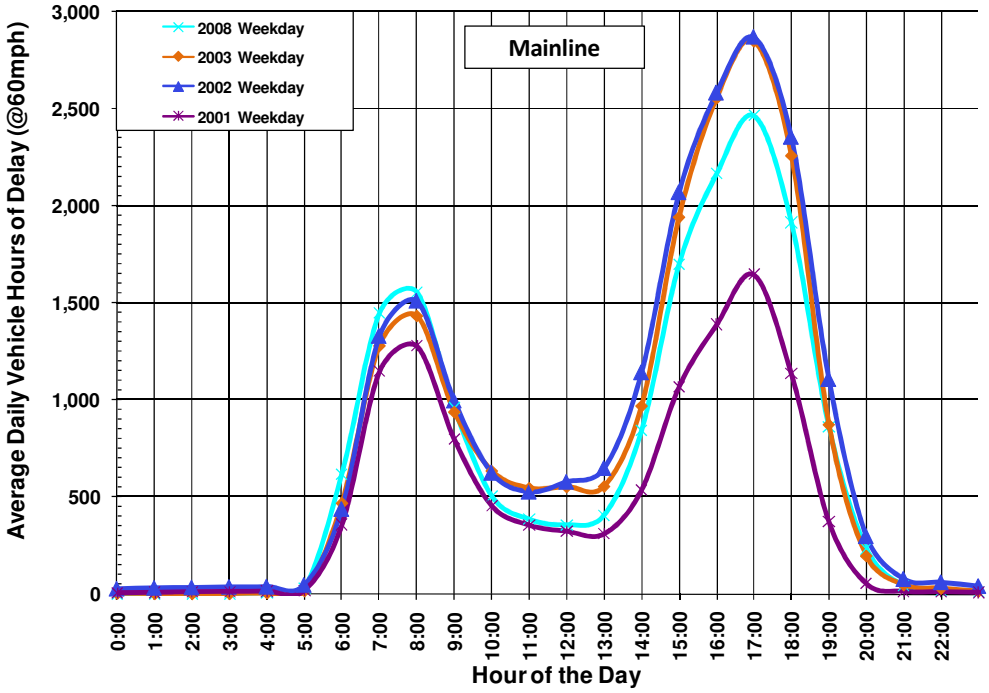
2003 levels during the AM peak hour, but decreased during the PM peak hour to under 2,500 vehicle-hours. The northbound direction also experienced overall more delay than the southbound on the mainline facility.

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

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

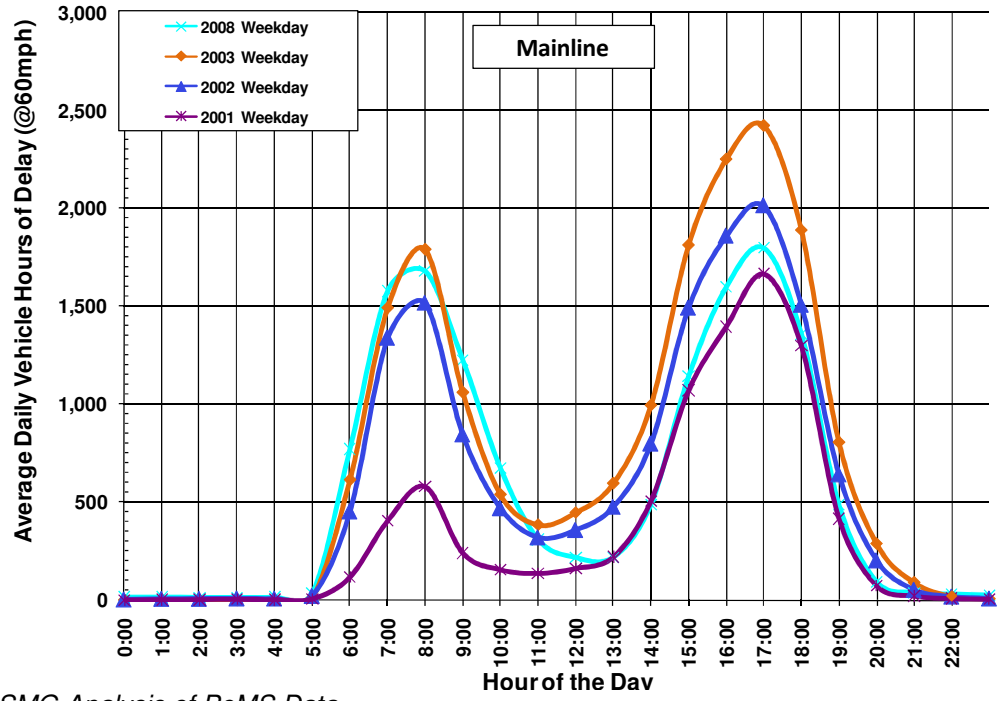
- In the northbound direction of the HOV-lane (Exhibit 3-15), delay was fairly even between both peak periods in 2001-2003 at around 50 vehicle-hours of delay. However, in 2008, delay increased significantly during the 7:00 AM peak hour to over 200 vehicle-hours, and to about 150 vehicle-hours during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

Exhibit 3-13: Northbound I-405 ML Average Weekday Hourly Delay (2001-2003 & 2008)



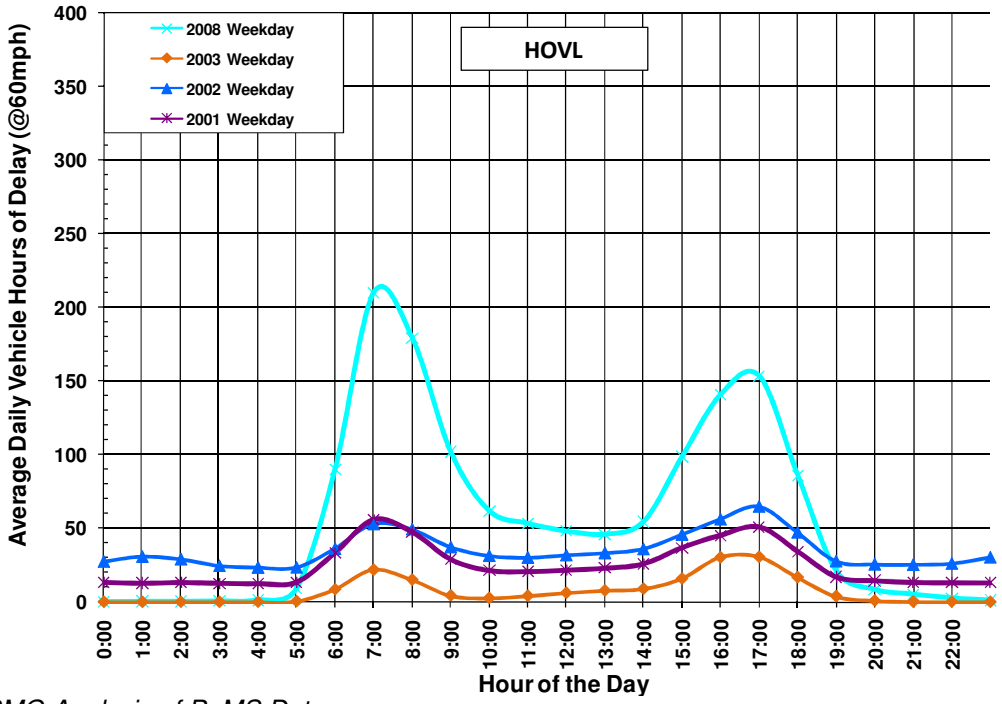
Source: SMG Analysis of PeMS Data

Exhibit 3-14: Southbound I-405 ML Average Weekday Hourly Delay (2001-2003 & 2008)



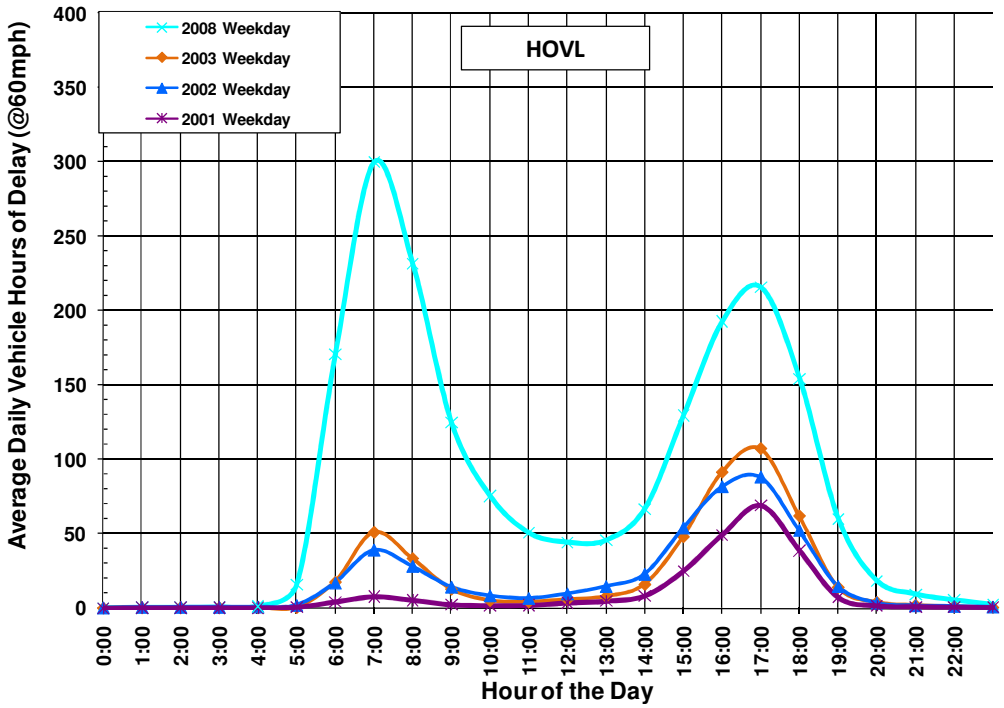
Source: SMG Analysis of PeMS Data

Exhibit 3-15: Northbound I-405 HOVL Average Weekday Hourly Delay (2001-2003 & 2008)



Source: SMG Analysis of PeMS Data

Exhibit 3-16: Southbound I-405 HOVL Average Weekday Hourly Delay (2001-2003 & 2008)



Source: SMG Analysis of PeMS Data

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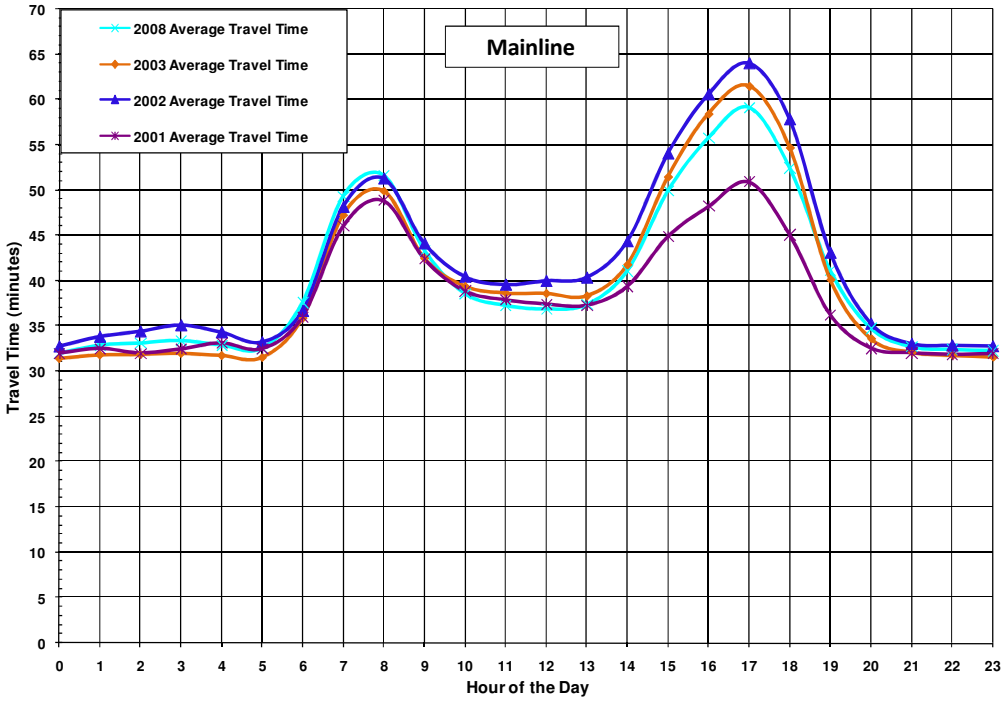
Travel Time

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

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

Exhibit 3-17: Northbound I-405 ML Travel Time by Time of Day (2001-2003 & 2008)



Source: SMG Analysis of PeMS Data

Exhibit 3-18: Southbound I-405 ML Travel Time by Time of Day (2001-2003 & 2008)

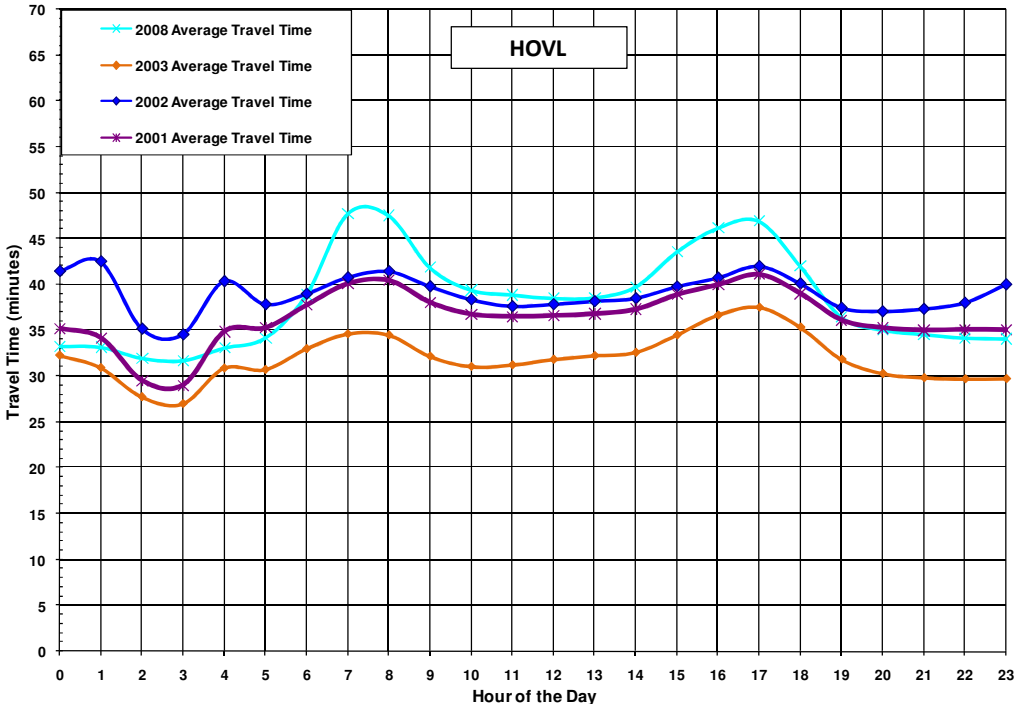
Mainline

Source: SMG Analysis of PeMS Data

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

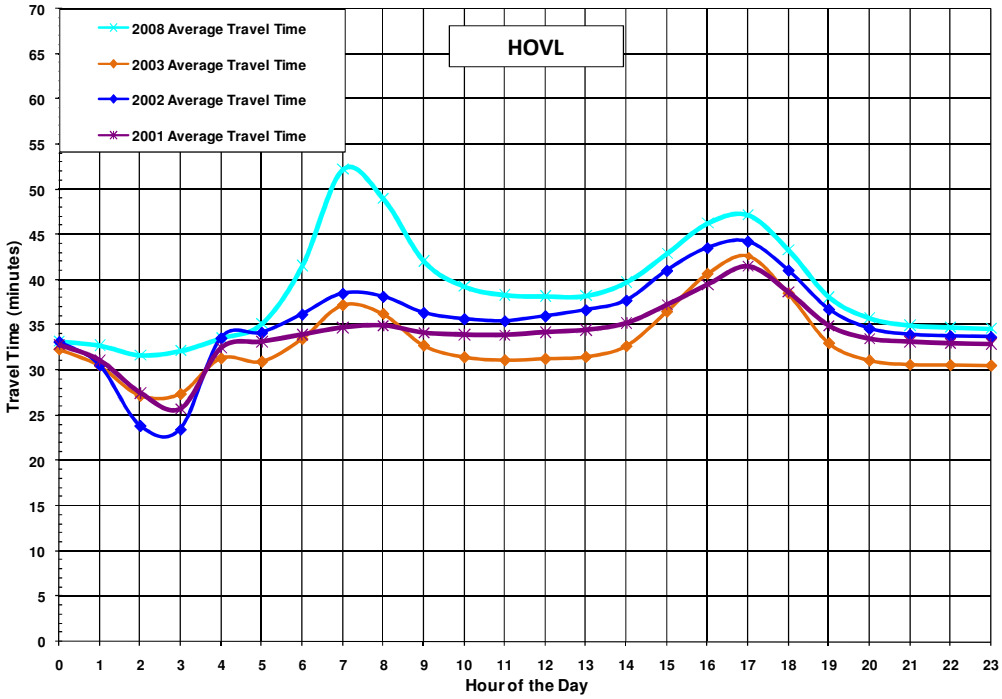
In the southbound direction of the HOV-lane (Exhibit 3-20), travel times were generally higher in the PM than the AM peak period. In 2001-2003, the 5:00 PM peak hour experienced travel times ranging between 42 and 44 minutes, which exceeded the 8:00 AM peak hour travel times of 35-39 minutes. However,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

Exhibit 3-19: Northbound I-405 HOVL Travel Time by Time of Day (2001-2003 & 2008)



Source: SMG Analysis of PeMS Data

Exhibit 3-20: Southbound I-405 HOVL Travel Time by Time of Day (2001-2003 & 2008)



Source: SMG Analysis of PeMS Data

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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 PeMS 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.

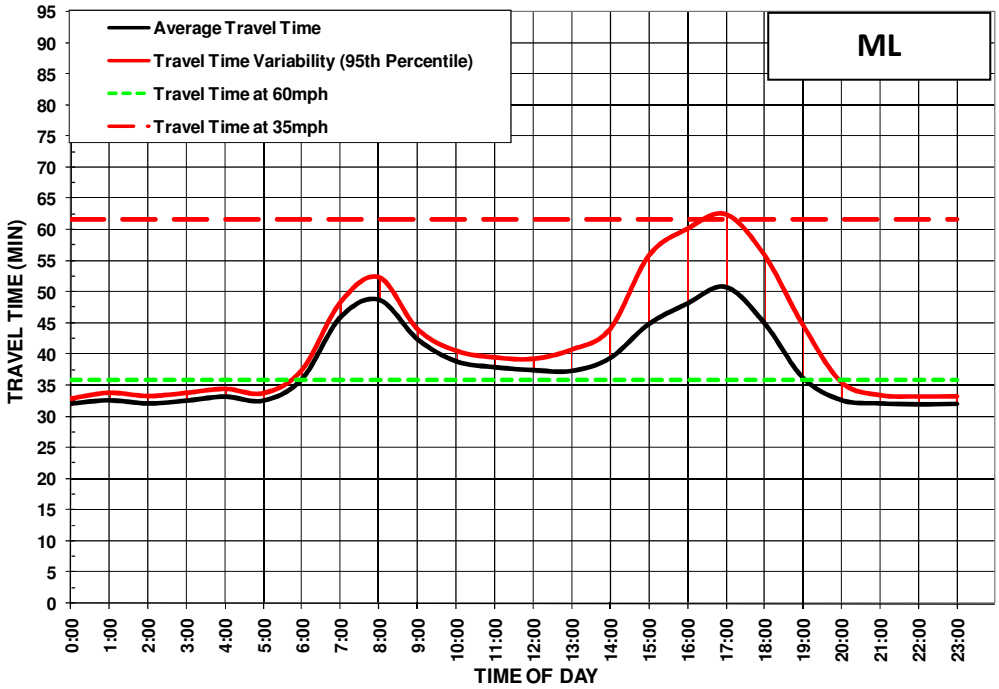
Exhibits 3-21 through 3-36 on the following pages illustrate the variability of travel time for the I-405 Corridor on weekdays for the years 2001-2003 (pre-construction) and 2008 (present conditions). Exhibits 3-21 through 3-28 present travel time variability for the mainline in the northbound direction followed by the southbound. Similarly, Exhibits 3-29 and 3-36 show travel time variability for the HOV facility beginning with the northbound and followed by the southbound direction.

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

In the southbound direction of the mainline, the 5:00 PM peak hour was also the slowest and most unreliable. In 2001 (Exhibit 3-25) at the 5:00 PM peak hour, travel time variability was 11 percent; which remained the same at 12 percent in 2002 (Exhibit 3-26); but significantly increased to 52 percent in 2003 (Exhibit 3-27); and declined to 15 percent in 2008 (Exhibit 3-28).

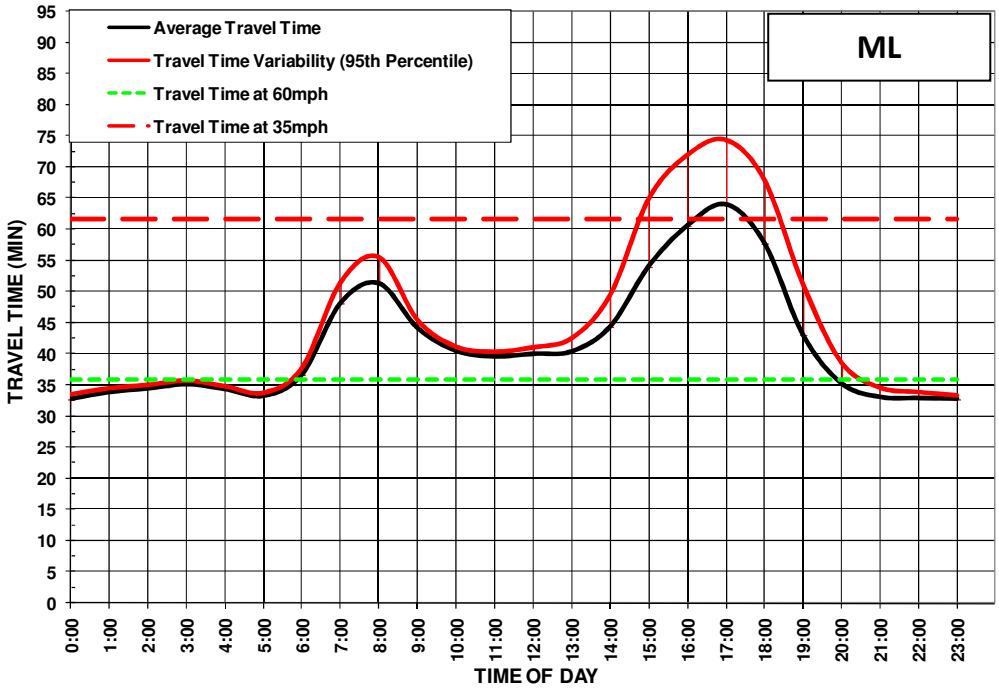
Overall, reliability improved on the mainline from the years 2003 to 2008 as evident by the decrease in travel time variability in both directions during those years.

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



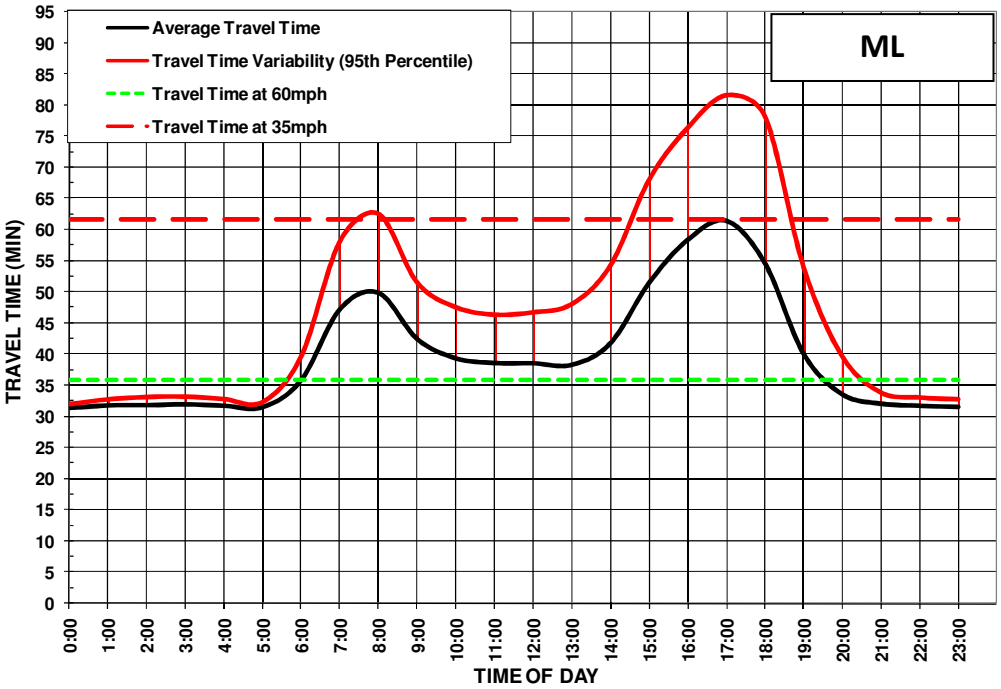
Source: SMG Analysis of PeMS Data

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



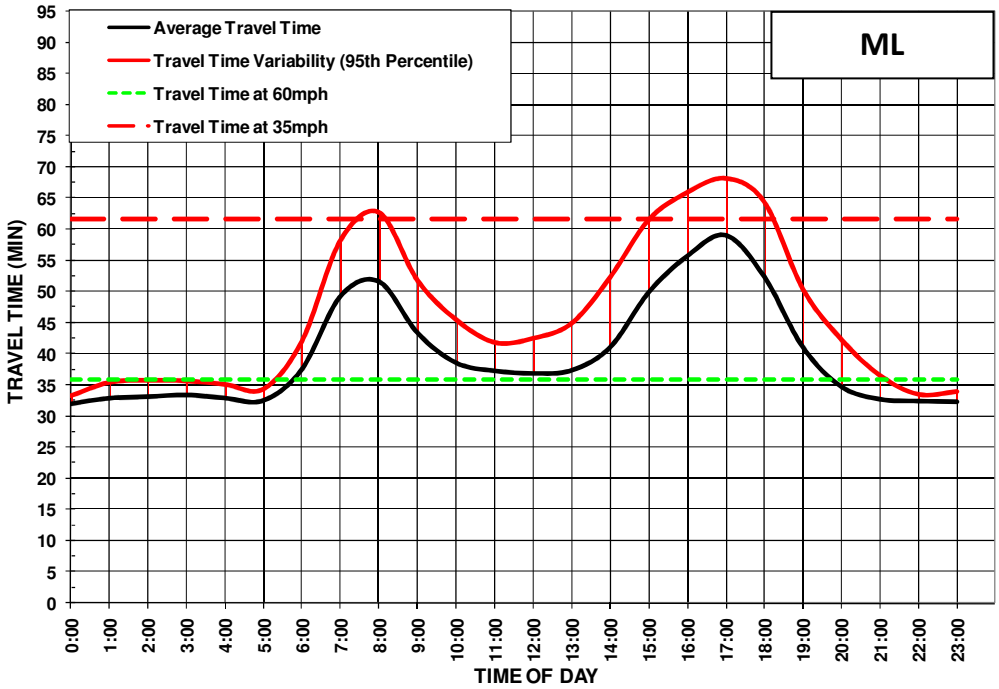
Source: SMG Analysis of PeMS Data

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



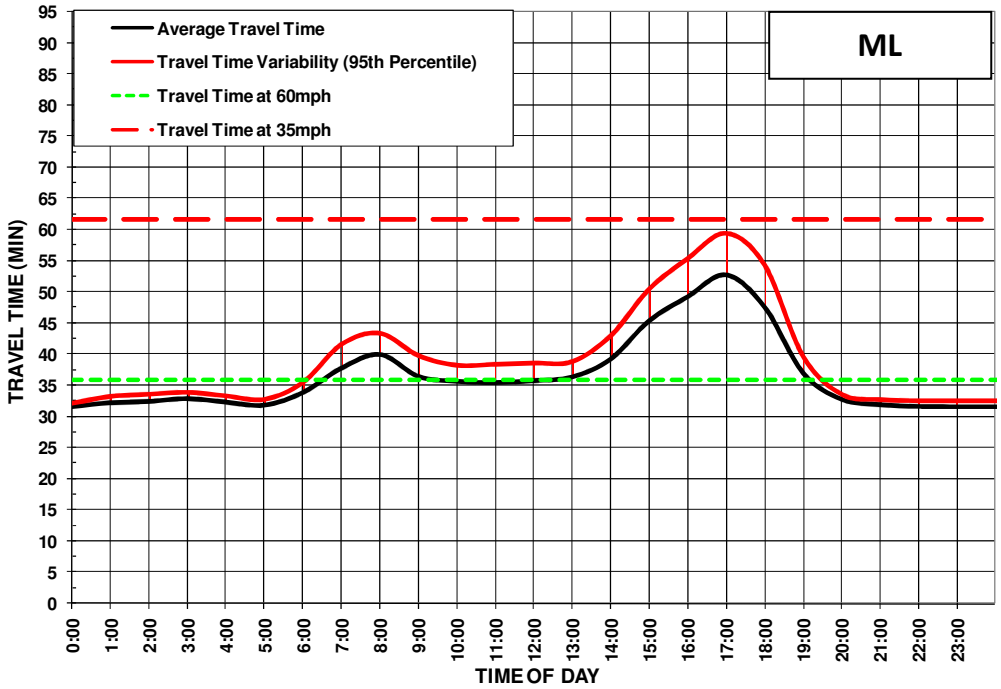
Source: SMG Analysis of PeMS Data

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



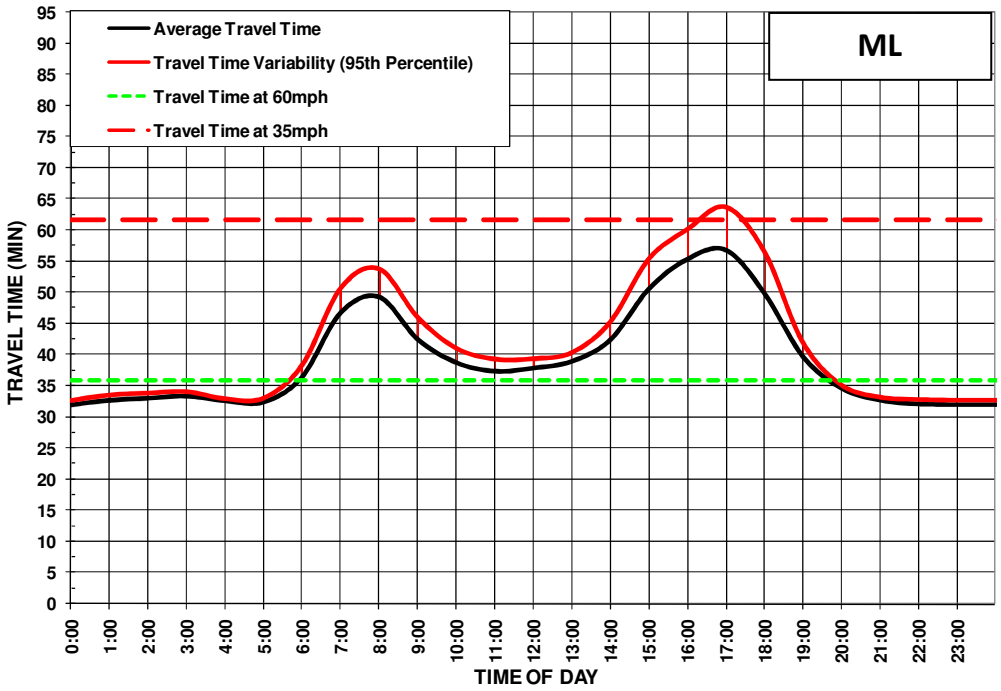
Source: SMG Analysis of PeMS Data

Exhibit 3-25: Southbound I-405 ML Travel Time Variation (2001)



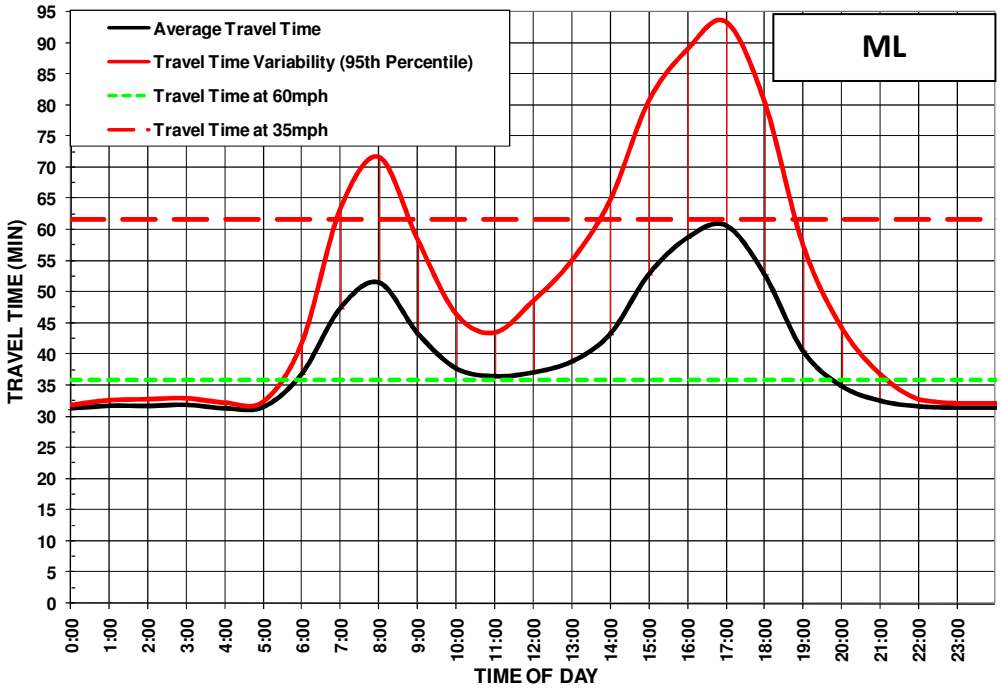
Source: SMG Analysis of PeMS Data

Exhibit 3-26: Southbound I-405 ML Travel Time Variation (2002)



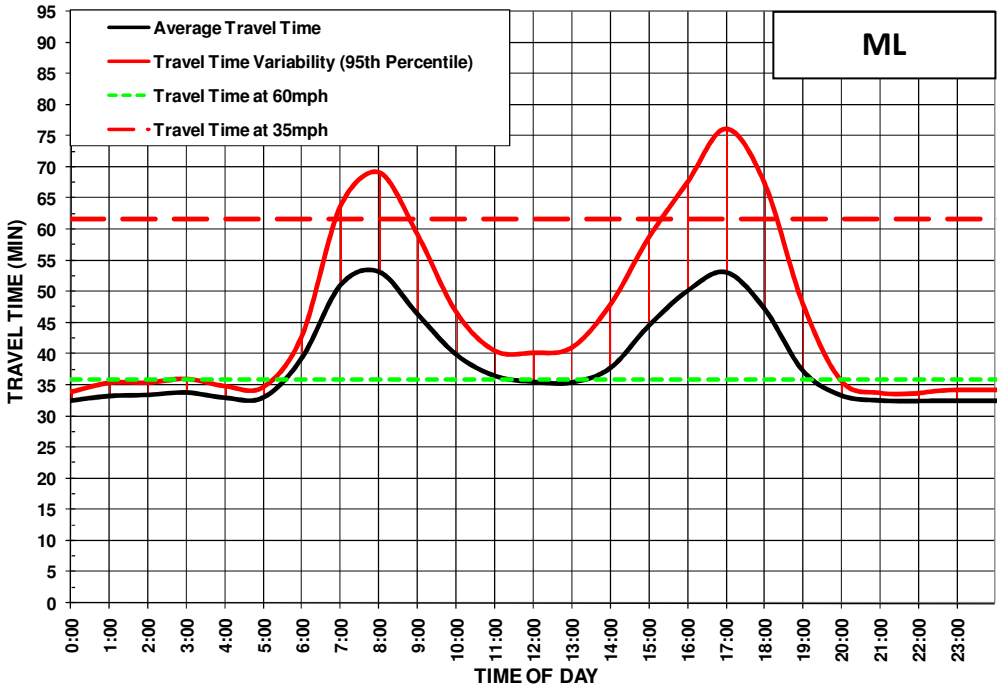
Source: SMG Analysis of PeMS Data

Exhibit 3-27: Southbound I-405 ML Travel Time Variation (2003)



Source: SMG Analysis of PeMS Data

Exhibit 3-28: Southbound I-405 ML Travel Time Variation (2008)

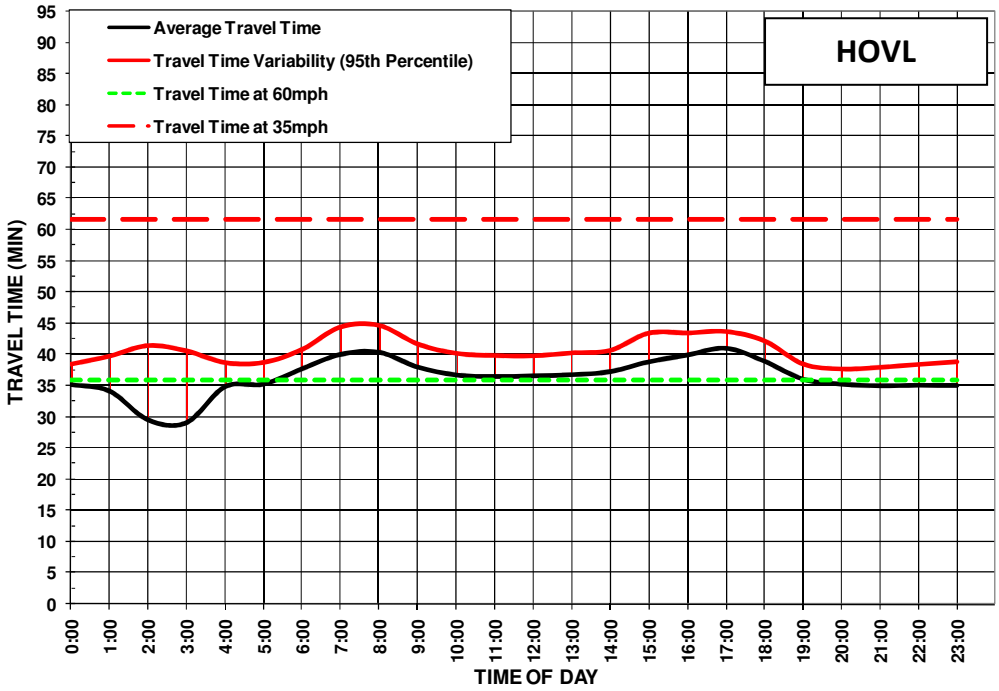


Source: SMG Analysis of PeMS Data

Travel times for the I-405 HOV facility are illustrated in Exhibits 3-29 through 3-36. Travel time variability in both directions of the HOV facility are considered high and volatile. In the northbound direction, there was not a distinct peak hour as peak periods displayed similar levels of travel times. In 2001-2003 (Exhibits 3-29 through 3-31) in the northbound direction of the HOV facility, travel times during the peak periods ranged up to 20 percent (or 9 minutes) of the mean travel time. However, in 2008, the variability in travel time dramatically increased to 48 percent (or 22 minutes) of the mean travel time.

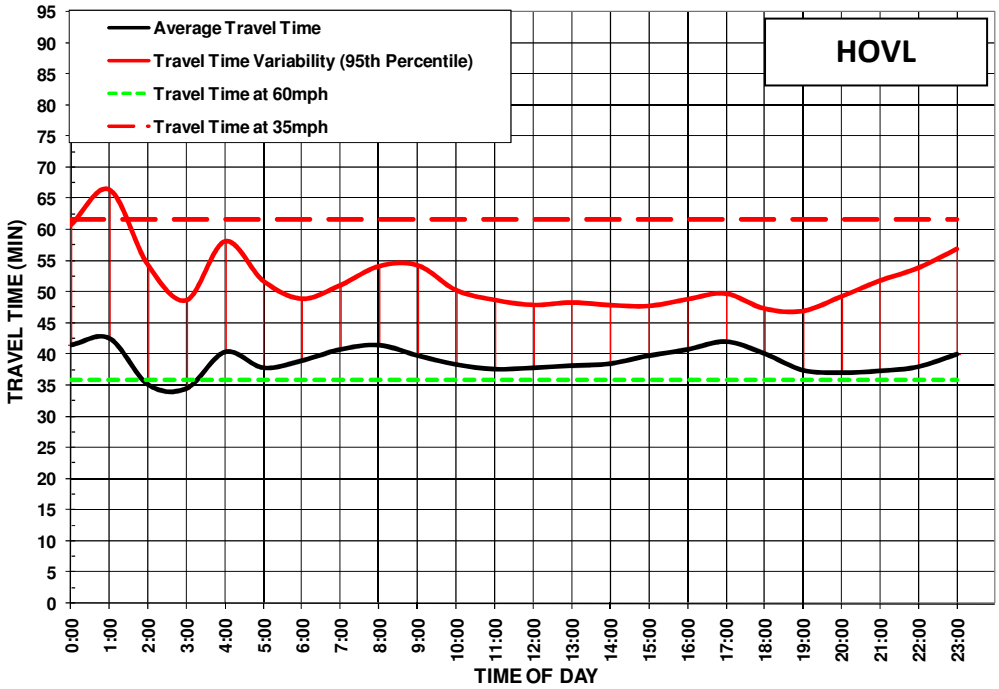
In the southbound direction of the HOV facility, the slowest and most unreliable hour occurred at 5:00 PM. During this hour, travel time variability was higher than the northbound HOV-lane. In 2001 (Exhibit 3-33), travel time variability in the southbound HOV-lane was 19 percent, which increased to 57 percent in 2002 (Exhibit 3-34), decreased to 47 percent in 2003 (Exhibit 3-35), and declined again to 40 percent in 2008 (Exhibit 3-36).

Exhibit 3-29: Northbound I-405 HOVL Travel Time Variation (2001)



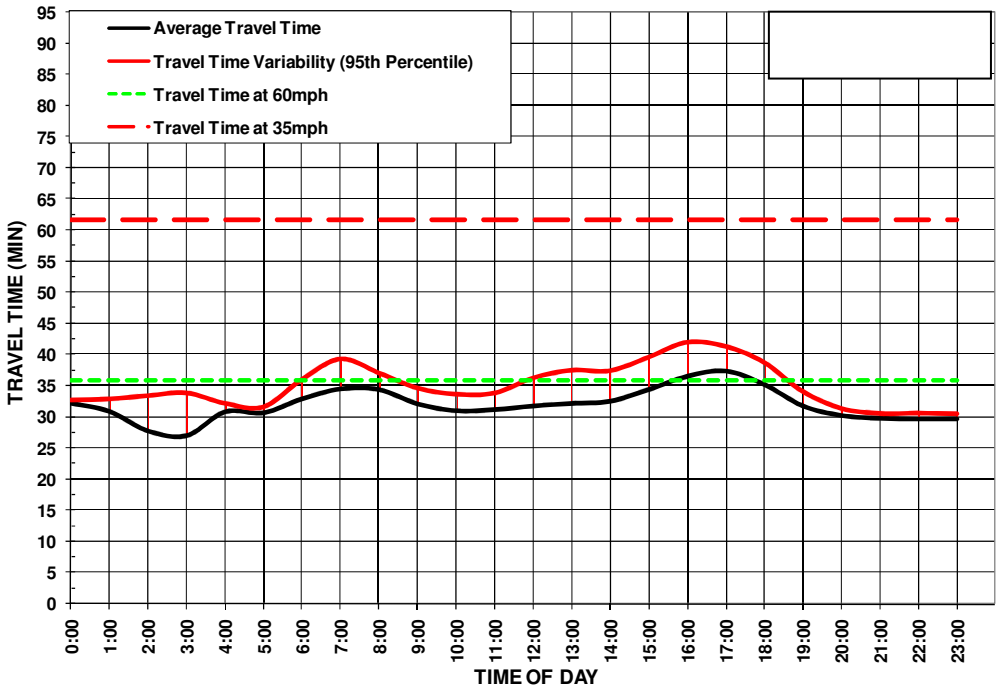
Source: SMG Analysis of PeMS Data

Exhibit 3-30: Northbound I-405 HOVL Travel Time Variation (2002)



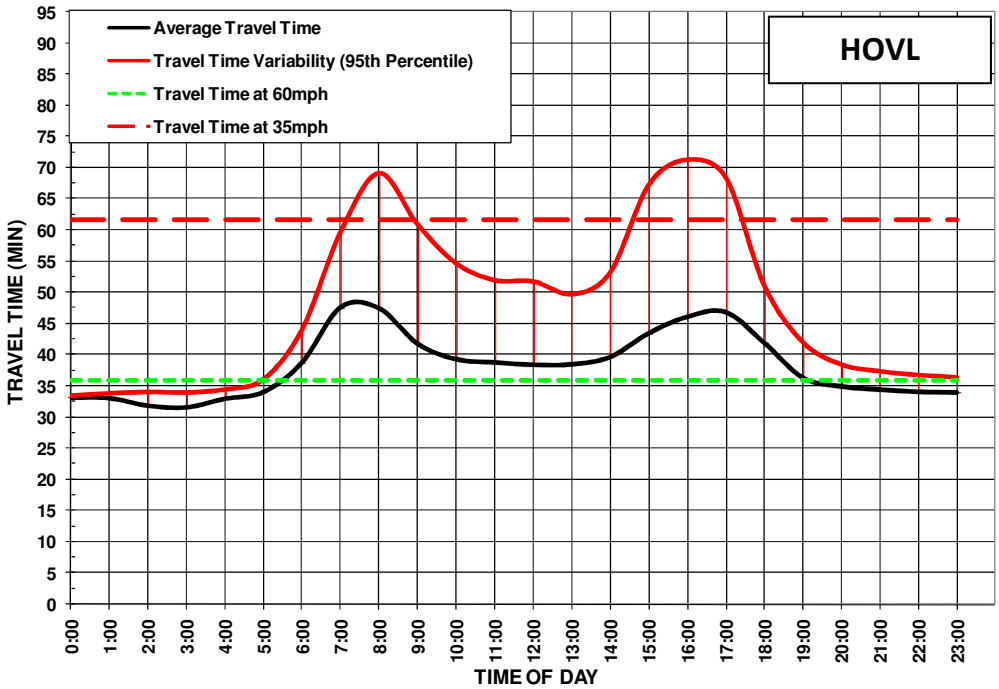
Source: SMG Analysis of PeMS Data

Exhibit 3-31: Northbound I-405 HOVL Travel Time Variation (2003)



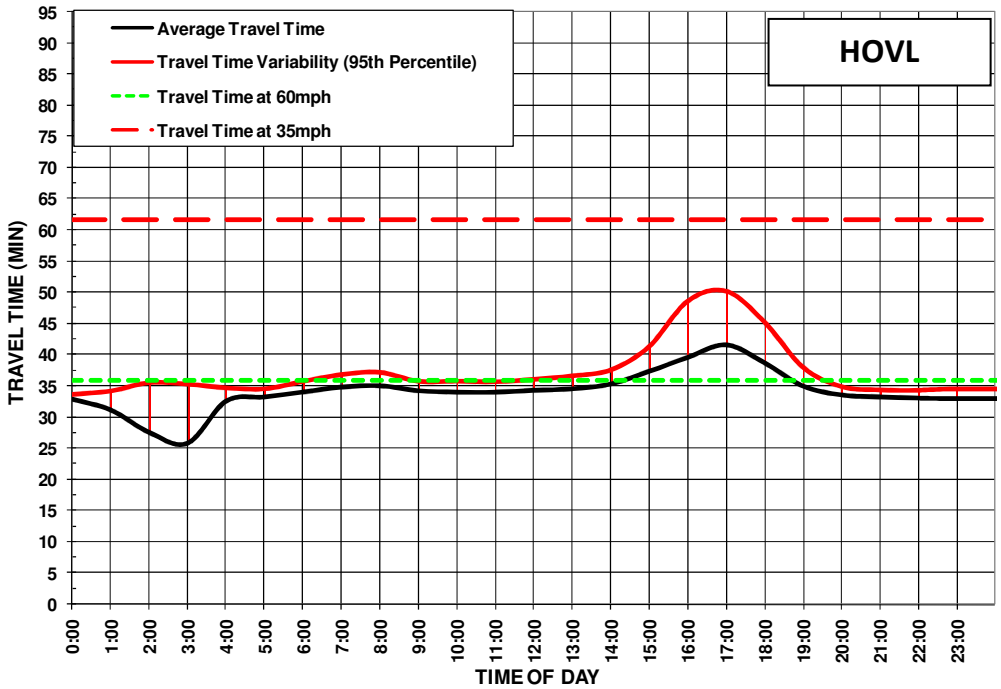
Source: SMG Analysis of PeMS Data

Exhibit 3-32: Northbound I-405 HOVL Travel Time Variation (2008)



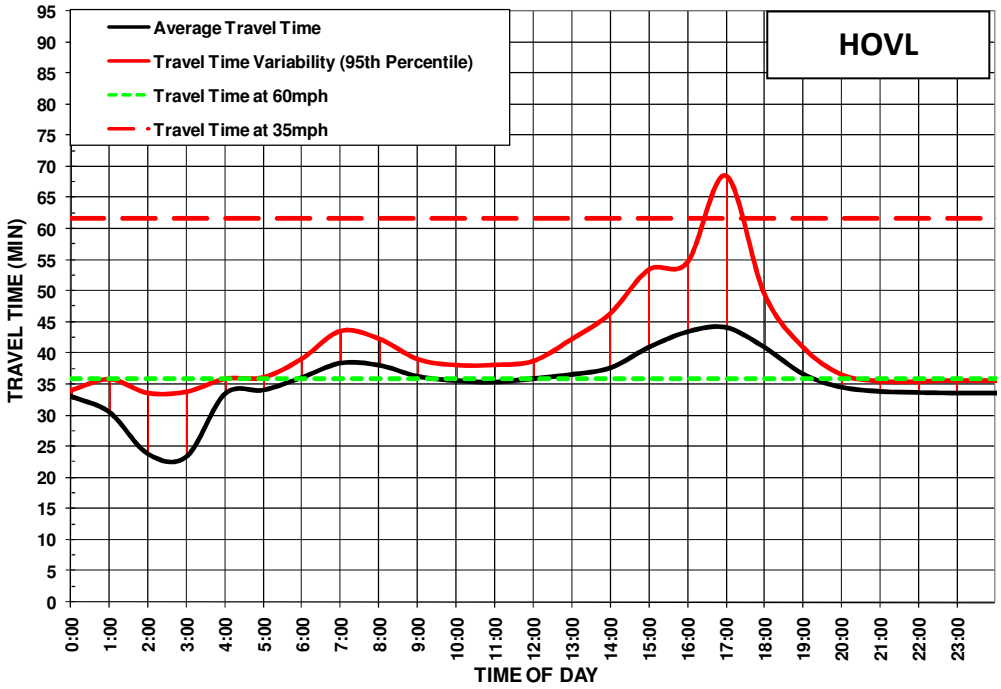
Source: SMG Analysis of PeMS Data

Exhibit 3-33: Southbound I-405 HOVL Travel Time Variation (2001)



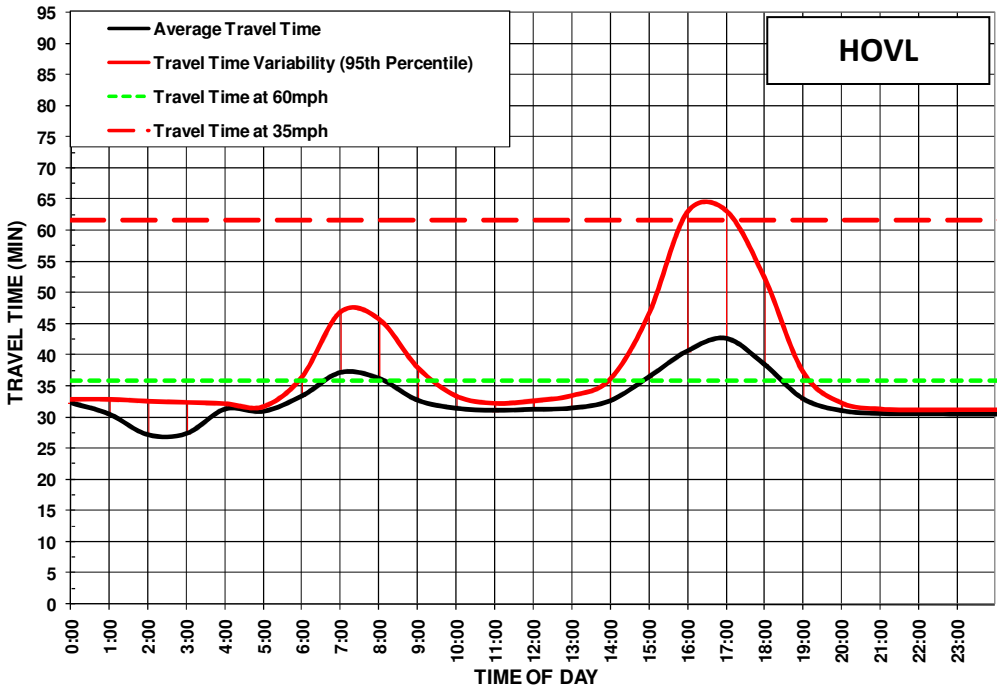
Source: SMG Analysis of PeMS Data

Exhibit 3-34: Southbound I-405 HOVL Travel Time Variation (2002)



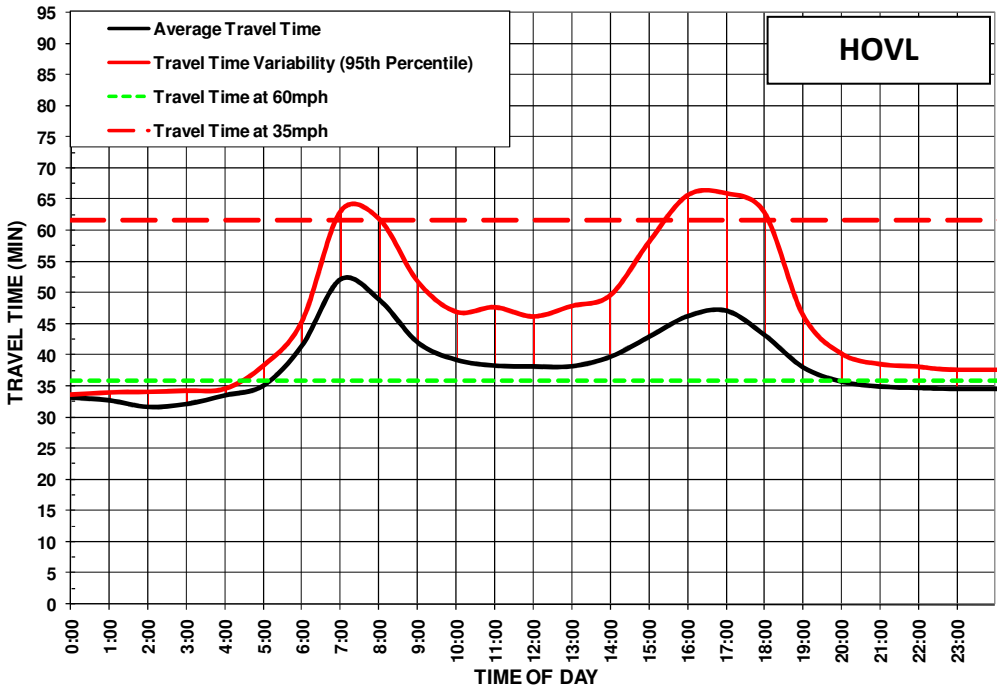
Source: SMG Analysis of PeMS Data

Exhibit 3-35: Southbound I-405 HOVL Travel Time Variation (2003)



Source: SMG Analysis of PeMS Data

Exhibit 3-36: Southbound I-405 HOVL Travel Time Variation (2008)



Source: SMG Analysis of PeMS Data

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SAFETY

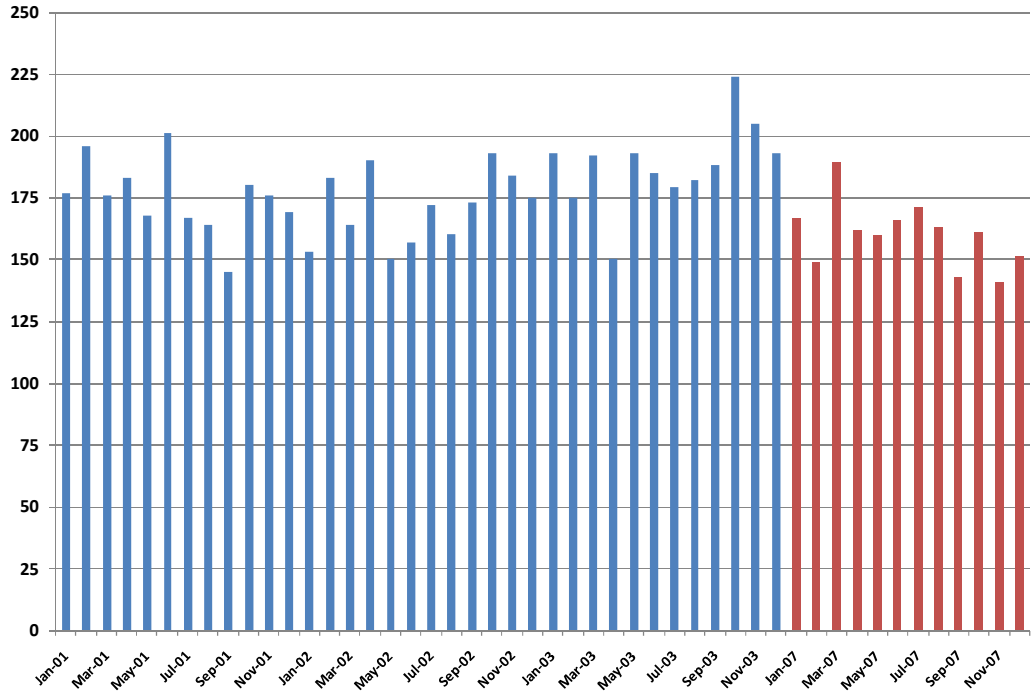
The adopted performance measures to assess safety include the number of accidents and accident rates computed from the Caltrans Traffic Accident Surveillance and Analysis System (TASAS). TASAS is a traffic records system containing an accident database linked to a highway database. The highway database contains description elements of highway segments, intersections and ramps, access control, traffic volumes, and other data. TASAS contains specific data for accidents on State highways, but not other roads (e.g., local streets and roads). The TASAS information presented in this analysis does not distinguish between mainline and HOV facilities.

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

The safety analysis conducted for the I-405 Corridor is based on TASAS data obtained through PeMS. Since safety data for the 2008 year is unavailable, data for 2007 is presented in addition to 2001-2003 data. When the 2008 safety data is made available, it is expected to show a decrease in accidents compared to the prior years.

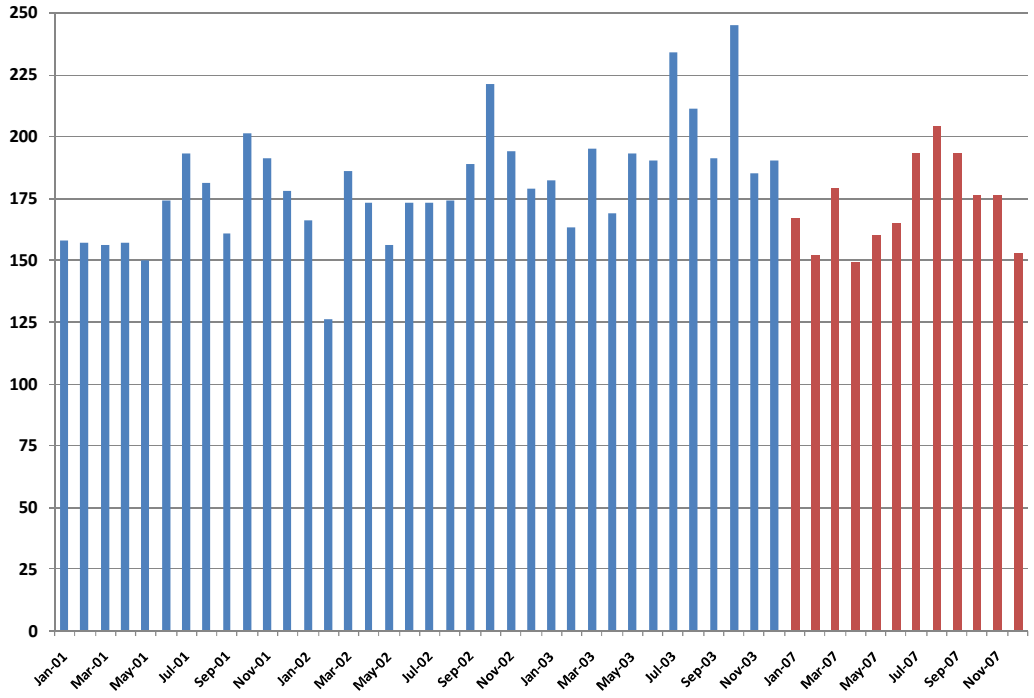
Exhibits 3-37 and 3-38 show that both directions of travel experienced similar levels of accidents with an average of about 175 accidents per month. Both directions also show a decrease in the number of accidents in 2007 from 2001-2003 levels.

Exhibit 3-37: Northbound Monthly Accidents (2001-2003 & 2007)



Source: Caltrans TASAS Selective Accident Retrieval Report

Exhibit 3-38: Southbound Monthly Accidents (2001-2003 & 2007)



Source: Caltrans TASAS Selective Accident Retrieval Report

Exhibit 3-39 presents the latest TASAS three year accident data for April 1, 2004 through March 31, 2007 for the I-405 corridor. Total number of accidents by type (fatality, injury, and property damage only (PDO), vehicle miles of travel, and the accident rate by type are provided. As indicated in this exhibit, the I-405 corridor experienced lower accident rates in both fatalities and injuries as compared to the average rates experienced by similar roadway facilities.

Exhibit 3-39: Total Number of Accidents by Type and Accident Rate (2005-2007)

							Accident Rates					
		Number of Accidents on I-405					Actual Rates on I-405			Average Rates on Similar Facilities		
From	***To***	***Fat***	***Inj***	***PDO***	***Total***	***MVM***	***Fat***	***F+I***	***Total***	***Fat***	***F+I***	***Total***
Northbound												
I-110 (Harbor Freeway)	I-5 (Golden State Freeway)	12	1561	3708	5281	5110.89	0.002	0.31	1.03	0.006	0.36	1.16
Southbound												
I-5 (Golden State Freeway)	I-110 (Harbor Freeway)	11	1804	4056	5871	5110.89	0.002	0.36	1.15	0.006	0.36	1.16

Note: Accident rates expressed as # of accidents/Million Vehicle Miles (MVM)

Source: Caltrans, TASAS, Table B.

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PRODUCTIVITY

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

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

This loss in productivity example is illustrated in Exhibit 3-40. As traffic flows increase to the capacity limits of a roadway, speeds decline rapidly and throughput drops dramatically. This loss in throughput is the lost productivity of the system. There are a few ways to estimate productivity losses. Regardless of the approach, productivity calculations require good detection or significant field data collection at congested locations. One approach is to convert this lost productivity into "equivalent lost lane-miles." These lost lane-miles represent a theoretical level of capacity that would need to be added in order to achieve maximum productivity. For example, losing six lane-miles implies that adding a new lane along a six-mile section of freeway to improve 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 3-40: Lost Productivity Illustrated

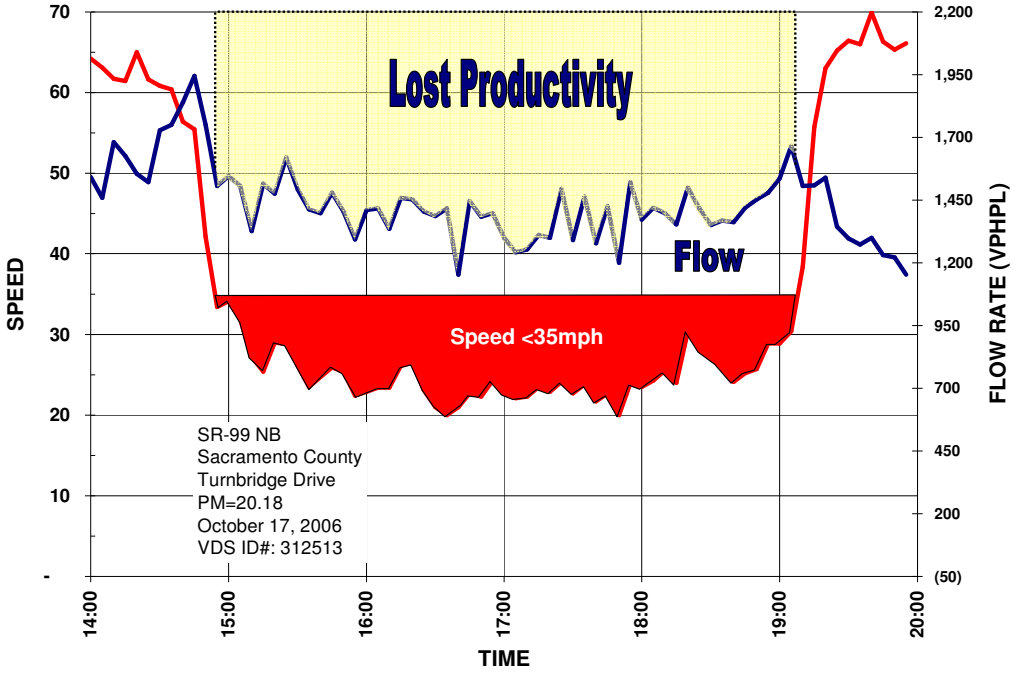
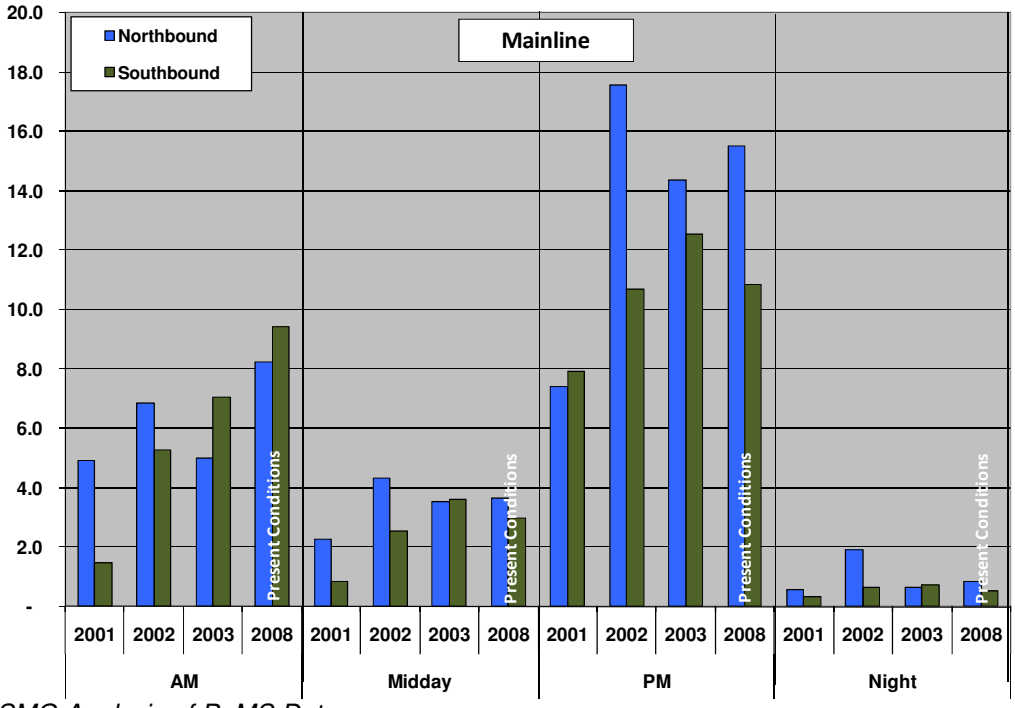


Exhibit 3-41 summarizes the productivity losses on the I-405 mainline facility for the four years analyzed in each direction. As indicated, the largest productivity losses occurred in the PM peak hours. The trends in the productivity losses are comparable to the delay trends. The largest productivity losses occurred in the PM peak hours in both directions, which is the time period and direction that experienced the most congestion. From 2003 to 2008, the northbound direction experienced a decline in productivity from 5.0 to 8.2 lost-lane miles in the AM peak and from 14.3 to 15.5 lost-lane miles in the PM peak. The southbound direction of the mainline experienced an improvement in productivity from 2003 to 2008 only in the PM peak period when lost-lane miles decreased from 12.5 to 10.8.

The same analysis was performed for the I-405 HOV facility (Exhibit 3-42), which shows that the southbound direction, particularly in 2008 experienced the greatest losses in productivity during both peak periods. From 2003 to 2008, productivity on both directions of the HOV-lane declined as lost-lane miles significantly increased.

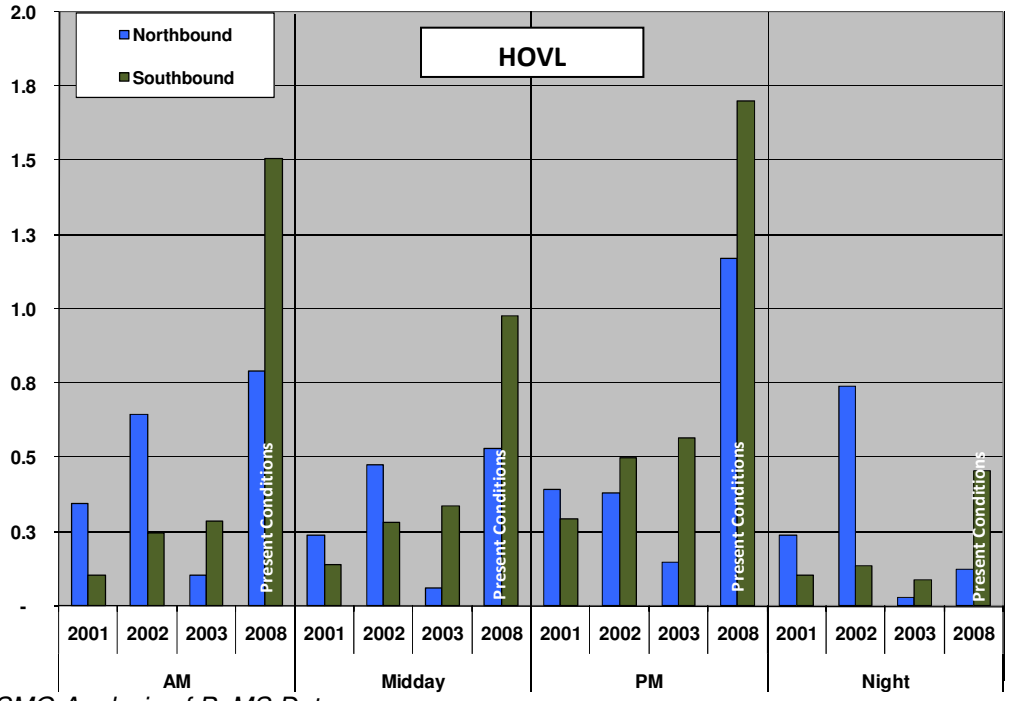
Strategies to combat productivity losses are primarily related to operations and include building new or extending auxiliary lanes, developing more aggressive ramp metering strategies without negatively influencing the arterial network, and improvements in incident clearance times.

Exhibit 3-41: I-405 ML Lost Lane-Miles by Direction, Time Period (2001-2003 & 2008)



Source: SMG Analysis of PeMS Data

Exhibit 3-42: I-405 HOVL Lost Lane-Miles by Direction, Time Period (2001-2003 & 2008)



Source: SMG Analysis of PeMS Data

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PAVEMENT CONDITION

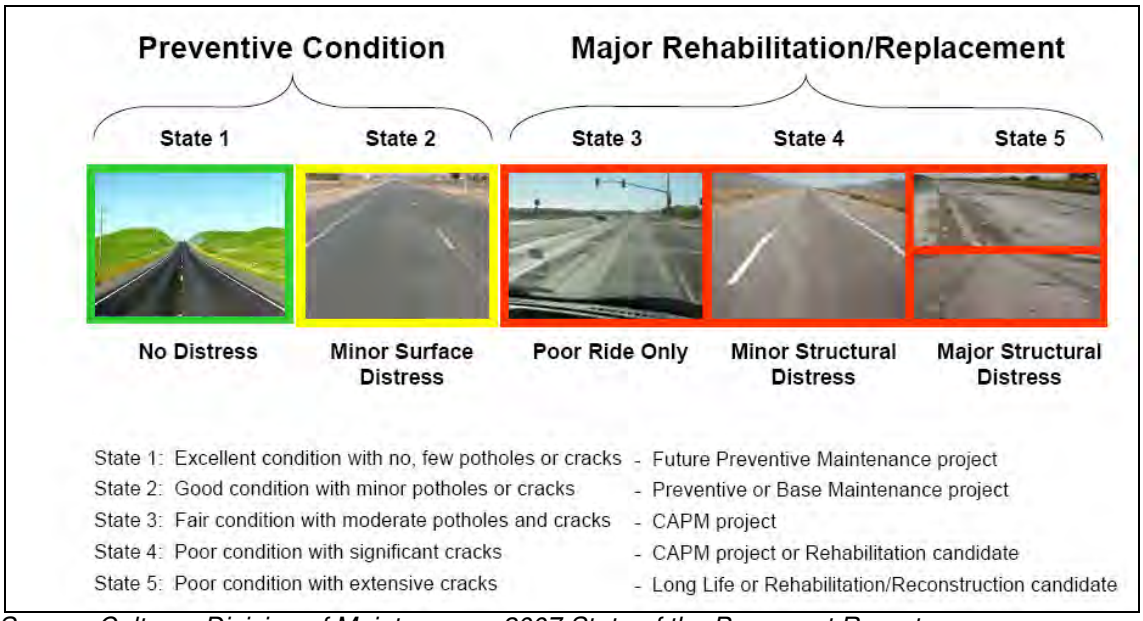
The condition of the roadway pavement (or ride quality) on the corridor can influence its traffic performance. Rough or poor pavement conditions can decrease the mobility, reliability, safety, and productivity of the corridor, whereas smooth pavement can have the opposite effect. Pavement preservation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

Performance Measures

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

Using distressed lane miles allows us to distinguish among pavement segments that require only preventive maintenance at relatively low costs and segments that require major rehabilitation or replacement at significantly higher costs. All segments that require major rehabilitation or replacement are considered to be distressed. Segments with poor ride quality are also considered to be distressed. Exhibit 3-43 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 3-43: Pavement Condition States



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

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

Existing Pavement Condition

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

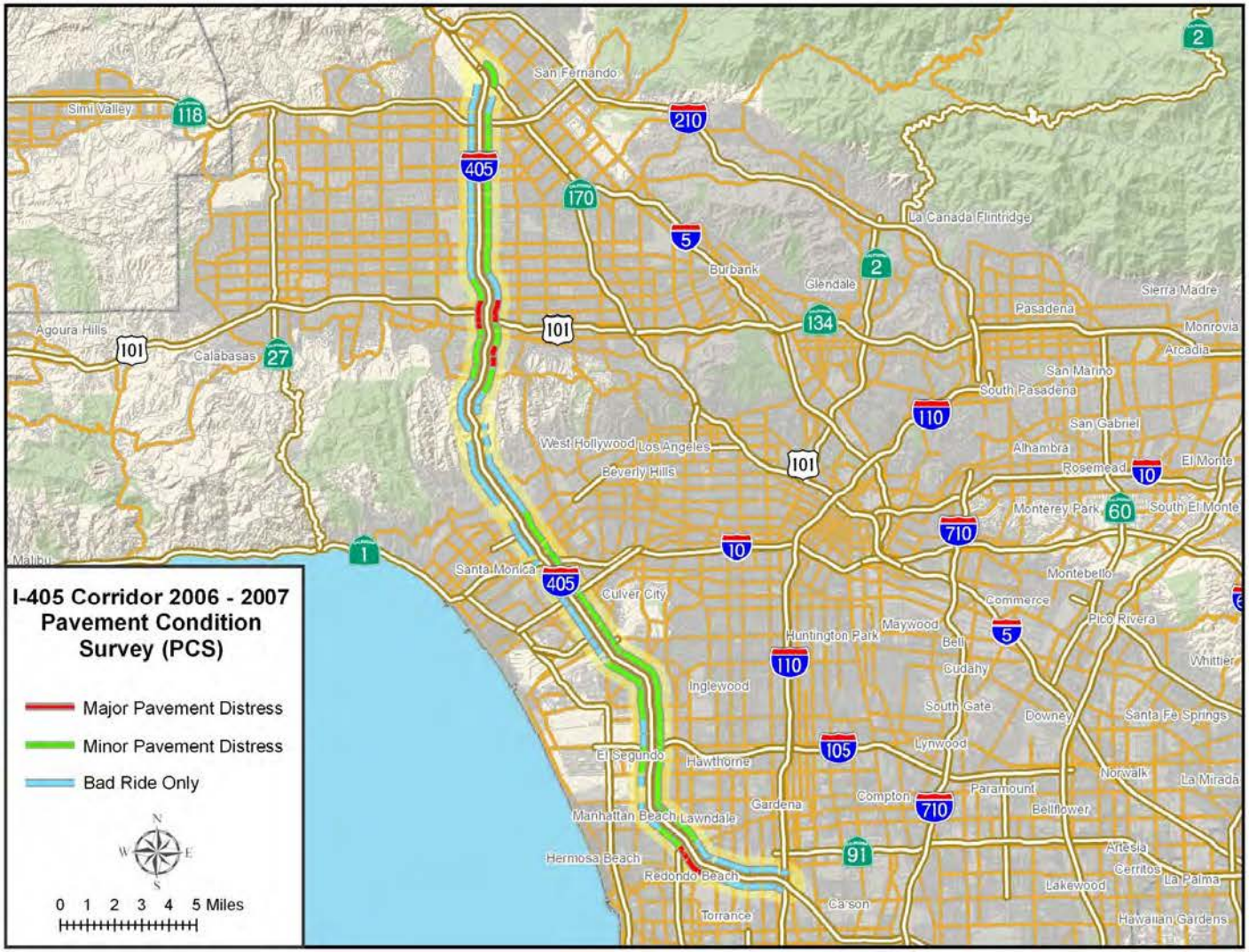
The field work consists of two parts. In the first part, pavement raters visually inspect the pavement surface to assess structural adequacy. In the second part, field staff uses vans with automated profilers to measure ride quality. The 2007 PCS revealed that the majority of distressed pavement was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

Exhibit 3-44 shows pavement distress along the I-405 Corridor according to the 2007 PCS data. The three categories shown in this exhibit represent the three distressed conditions that require major rehabilitation or replacement and were presented earlier in Exhibit 3-43.

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

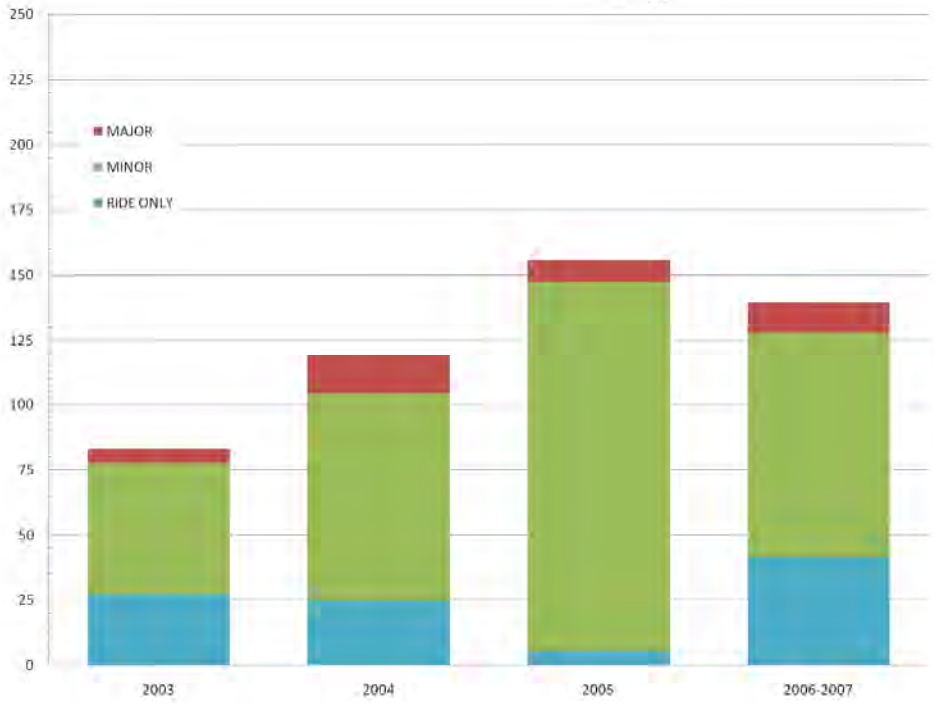
Exhibit 3-45 shows results from prior pavement condition surveys for the I-405 Corridor. The total number of distressed lane-miles increased between 2003 and 2005. From 2005 to the 2006-07 period, the number of distressed lane-miles decreased. The exhibit also splits the distressed lane miles by classification. The exhibit shows that not only has the number of distressed-lane miles declined, but so has the level of distress. Minor pavement distress declined more than 30 percent and was replaced primarily by ride quality issues, which can be addressed by less costly treatments. This shift is shown more clearly in Exhibit 3-46, which shows the percent mix.

Exhibit 3-44: Distressed Lane-Miles on I-405 Corridor for 2006-07 Period



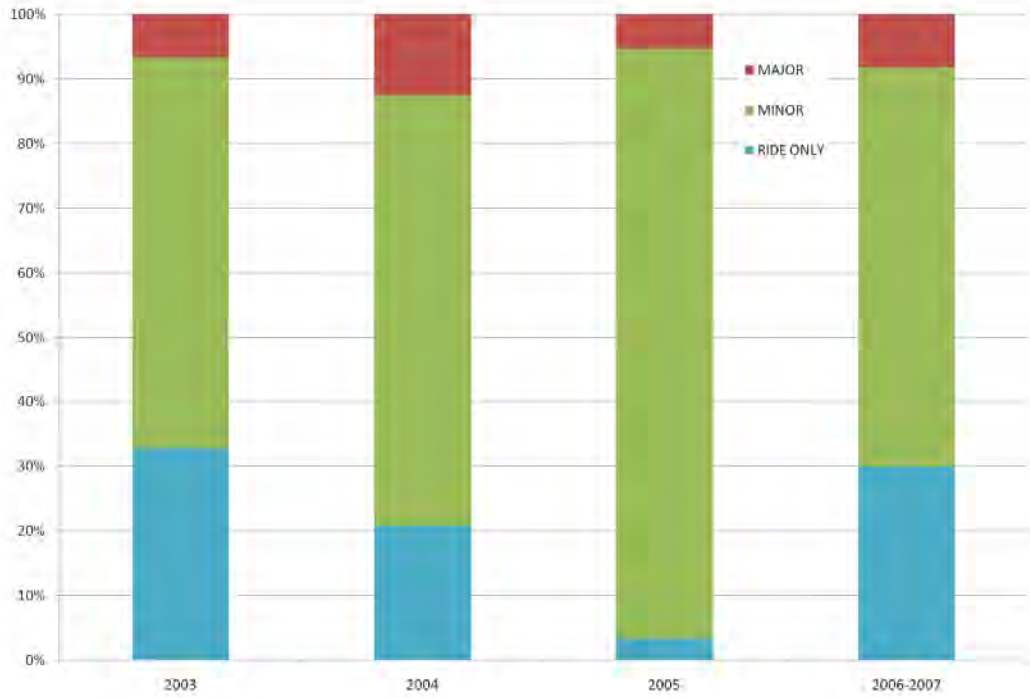
Source: SMG mapping of 2007 Pavement Condition Survey data

Exhibit 3-45: Distressed Lane-Miles Trends on the I-405 Corridor



Source: SMG analysis of 2003 to 2007 Pavement Condition Survey data

Exhibit 3-46: Distressed Lane-Miles by Type on the I-405 Corridor



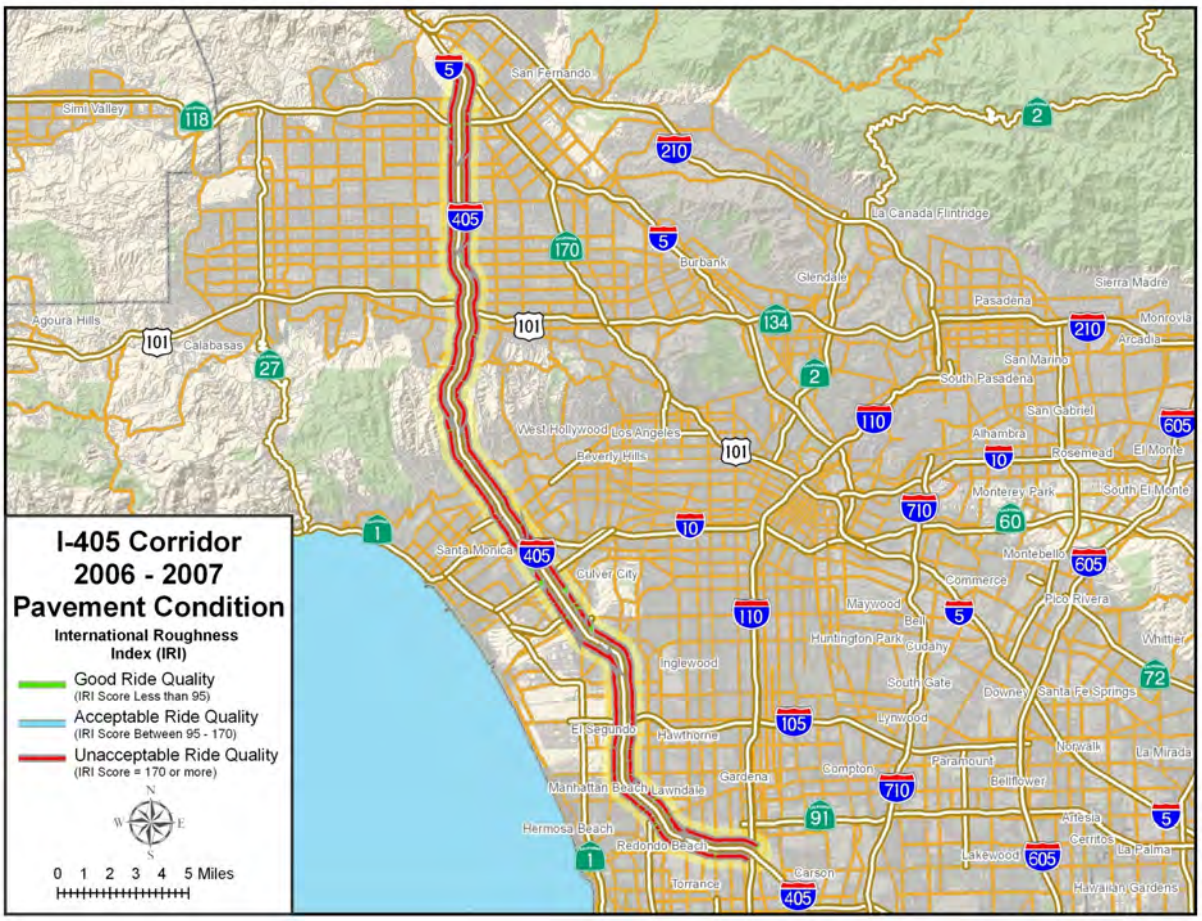
Source: SMG analysis of 2003 to 2007 Pavement Condition Survey data

Exhibit 3-47 shows IRI along the study corridor for the lane with the poorest pavement condition in each freeway segment. The poorest pavement conditions are shown in the exhibit because pavement investment decisions are made on this basis. Although the exhibit suggests that nearly the entire corridor has unacceptable ride quality, there are also lanes with good ride quality in many sections. The study corridor comprises roughly 339 lane-miles, of which:

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

Note that the percentages do not add due to rounding.

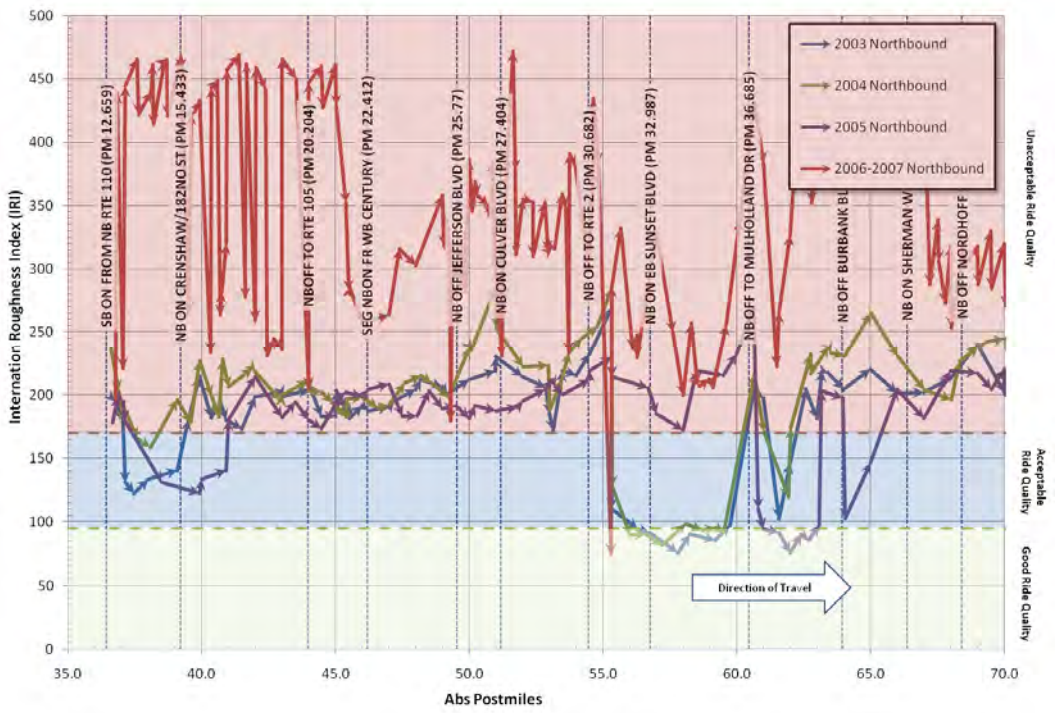
Exhibit 3-47: I-405 Corridor IRI for the 2006-07 Period



Source: SMG mapping of 2007 Pavement Condition Survey data

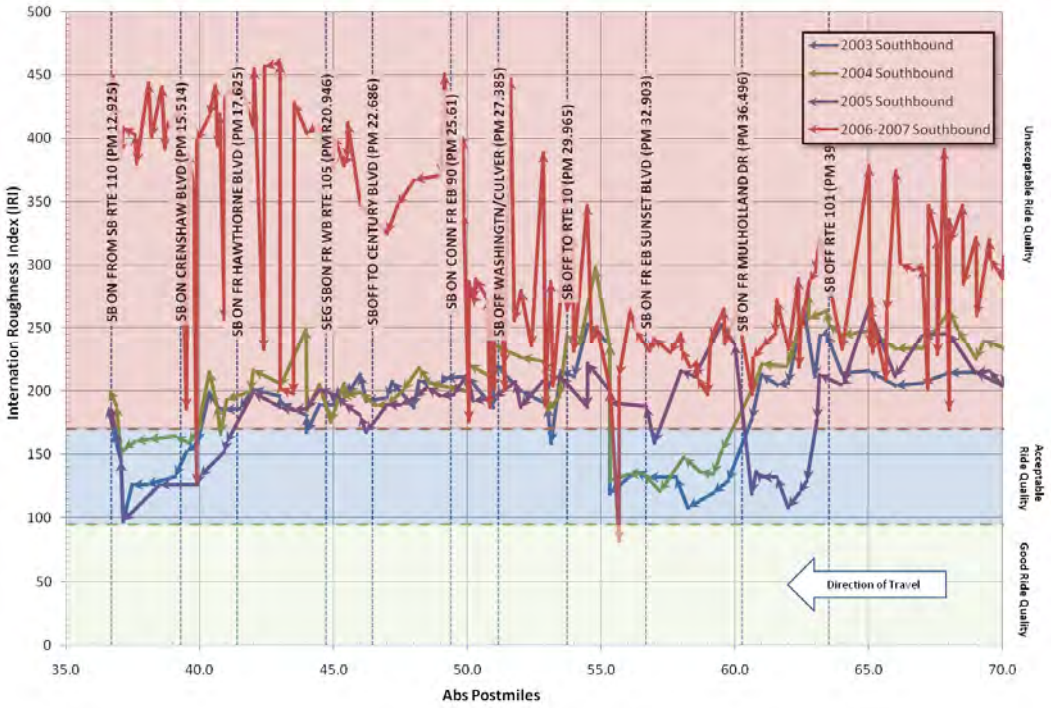
Exhibits 3-48 and 3-49 present ride conditions based on the IRI measure for the I-405 Corridor over the last four pavement surveys. The information is presented by postmile and direction. The exhibits include color-coded bands to indicate the three ride quality categories defined by Caltrans: good ride quality (green), acceptable ride quality (blue), and unacceptable ride quality (red). Ride quality worsened considerably between 2005 and the 2006-07 period, but this may be due to the 2006-07 change in data collection methodology. The exhibits exclude sections that were not measured or have calibration issues (i.e., IRI = 0).

Exhibit 3-48: Northbound I-405 Corridor IRI 2003-2007



Source: SMG analysis of 2003 to 2007 Pavement Condition Survey data

Exhibit 3-49: Southbound I-405 Corridor IRI 2003-2007



Source: SMG analysis of 2003 to 2007 Pavement Condition Survey data

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4. BOTTLENECK IDENTIFICATION AND ANALYSIS

Potential bottlenecks were identified in the Preliminary Performance Assessment document in May 2008. They were identified based on a variety of data sources, including HICOMP, probe vehicle runs, and PeMS. Limited field observations were conducted as well, but not enough to verify each bottleneck. Since the Preliminary Performance Assessment, significant field observations as well as additional analysis of PeMS data have been conducted. As a result of these additional efforts, the consistent bottlenecks are identified for both directions. The initial analysis from the Preliminary Performance Assessment is found in the Appendix.

Northbound Bottlenecks

Starting from I-110 northbound, the following bottlenecks were identified:

- Normandie Off-ramp: Cross-weaving traffic at the Normandie off-ramp and a lane drop results in a bottleneck condition.
- Crenshaw Off-ramp: Excessive queuing at the off-ramp causes heavy congestion at this location.
- Hawthorne On-ramp: Platoon merging at the on-ramp contributes to the bottleneck condition.
- Inglewood On-ramp: The large horizontal curve and vertical grade contributes to this bottleneck location.
- Sepulveda Off – Roadway geometry & heavy demand from ramp result in congestion at this location.
- Culver On-ramp: Heavy traffic merging from the SR-90 on-ramps results in a bottleneck.
- National Off-ramp: The heavy off-ramp traffic destined for I-10 and National Boulevard contributes to this bottleneck location.
- I-10 On-ramp: Heavy demand from I-10 contributes to congestion at this location.
- Wilshire On – The surge of demand from the on-ramp which the mainline cannot accommodate results in a bottleneck condition.
- Getty On-ramp: The long steep uphill grade slows vehicle speeds, resulting in heavy congestion.
- Mulholland Drive: The long steep uphill climb significantly impacts vehicle speeds, contributing to this bottleneck location.
- US-101 Off-ramp: The queue from the off-ramp causes heavy congestion at this location.
- Victory On-ramp: Platoon merging at the on-ramp contributes to the bottleneck condition.

Southbound Bottlenecks

Starting from I-5 and moving southbound, the following bottlenecks were identified:

- Devonshire On-ramp: Two consecutive on-ramps cause this bottleneck.
- Nordhoff Off-ramp: A lane drop occurs before approaching Nordhoff, causing congestion.
- Victory On-ramp: Platoon merging at the on-ramp contributes to this bottleneck location.
- US-101 Off-ramp: the loss of a lane to the US-101 connector reduces capacity at this location.
- Mulholland Drive: a long steep uphill grade contributes to this bottleneck
- Sunset: A short merge taper contributes to a bottleneck condition.
- Wilshire: heavy traffic on the off-ramp backs up onto the mainline creating heavy congestion.
- I-10 On-ramp: Heavy demand from I-10 contributes to congestion at this location.
- Culver On-ramp: Weaving traffic and heavy demand from the on-ramp causes congestion at this location.
- Howard Hughes Parkway Off-ramp: The primary cause of this bottleneck is the lane drop that occurs at the La Tijera Boulevard off-ramp and the heavy traffic demand from the SR-90 on-ramp.
- El Segundo On-ramp: heavy demand from the I-105 and El Segundo on-ramps causes severe congestion at this location.
- Inglewood On-ramp: the large horizontal curve and vertical grade reduces sight distance and affects travel speed at this location.
- I-110 Freeway: the lane drop from 4 lanes to 3 lanes at the I-110 split and heavy demand from three consecutive on-ramps cause this bottleneck location.

ANALYSIS OF BOTTLENECK AREAS

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

- Delay
- Safety
- Productivity

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

Exhibit 4-1: Dividing a Corridor into Bottleneck Areas

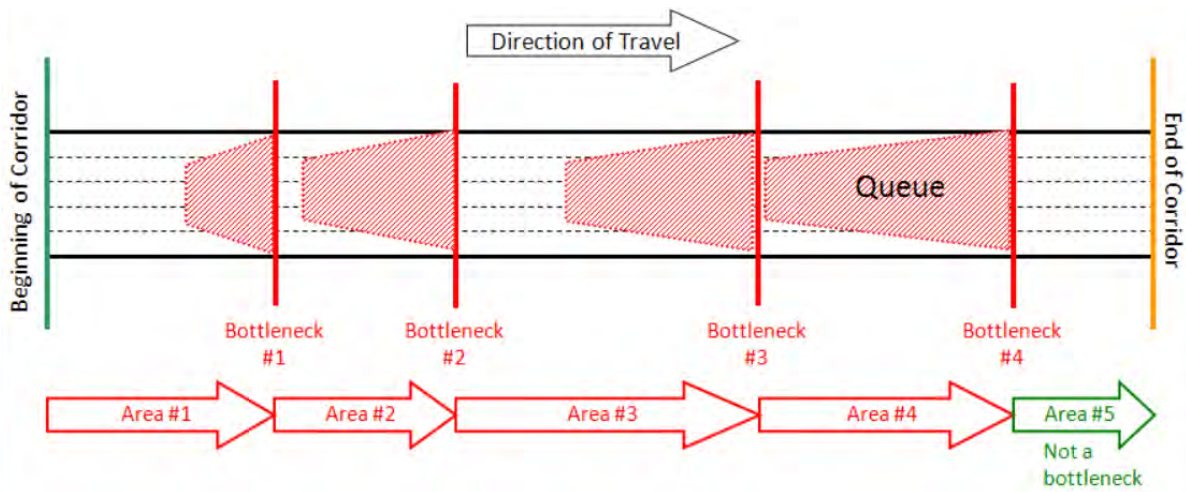


Exhibit 4-2 graphically illustrates the location of each of the bottleneck locations and areas for the I-405 Corridor. Exhibits 4-3 and 4-4 provide details of each bottleneck location and area.

Exhibit 4-2: I-405 Bottleneck Locations and Bottleneck Areas

Dividing the corridor into bottleneck areas makes it easier to compare the various segments of the freeway with each other. This section will use the previously discussed performance measures of mobility, safety, and productivity to evaluate each bottleneck area. The results from this bottleneck analysis will reveal which segments of the corridor should be prioritized for improvements.

Exhibit 4-3: Northbound I-405 Identified Bottleneck Areas

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

Exhibit 4-4: Southbound I-405 Identified Bottleneck Areas

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

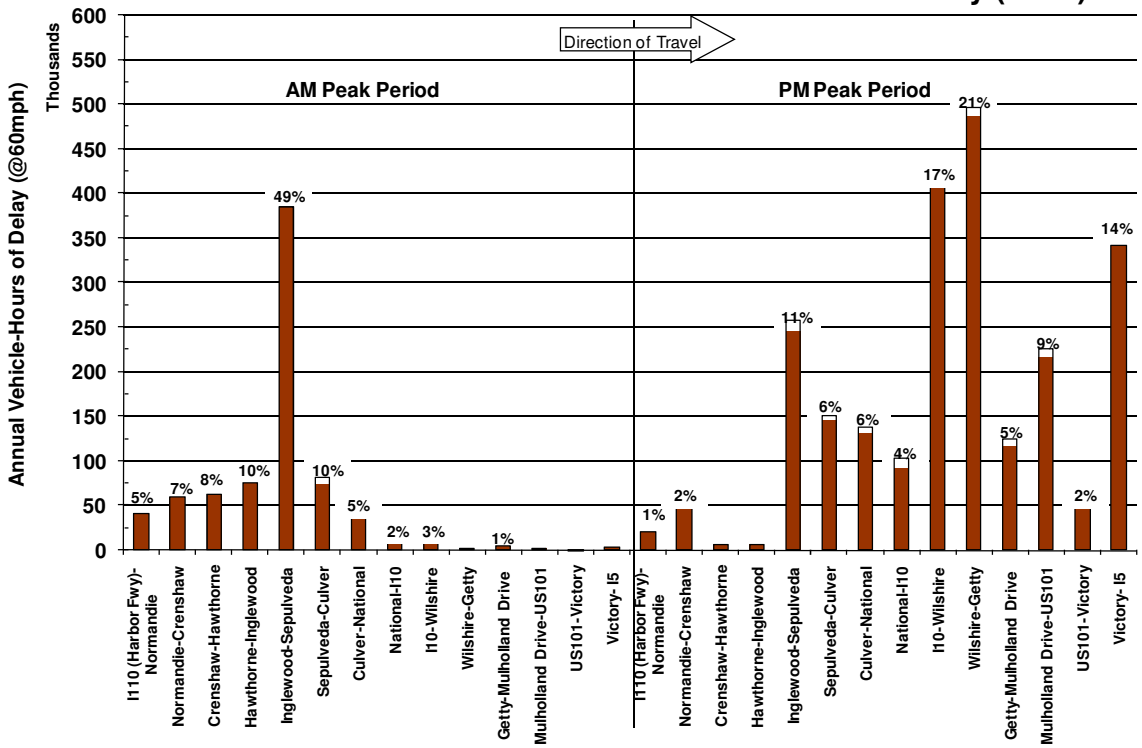
Mobility by Bottleneck Area

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

Mobility on I-405

This mobility analysis is based on 2003 PeMS data for the mainline facility. Exhibits 4-5 and 4-7 illustrate the vehicle-hours of delay experienced by each bottleneck area on I-405. As depicted in Exhibit 4-5, delay in the northbound direction is greater during the PM peak than the AM peak period. During the PM peak, there are bottleneck areas which experience significant congestion, notably between I-10 and Wilshire (410,000 annual vehicle-hours); Wilshire and Getty (500,000 annual vehicle-hours); and Victory and I-5 (340,000 annual vehicle-hours). During the AM peak, the bottleneck area between Inglewood and Sepulveda experienced about half (385,000 annual vehicle-hours) of the corridor's delay.

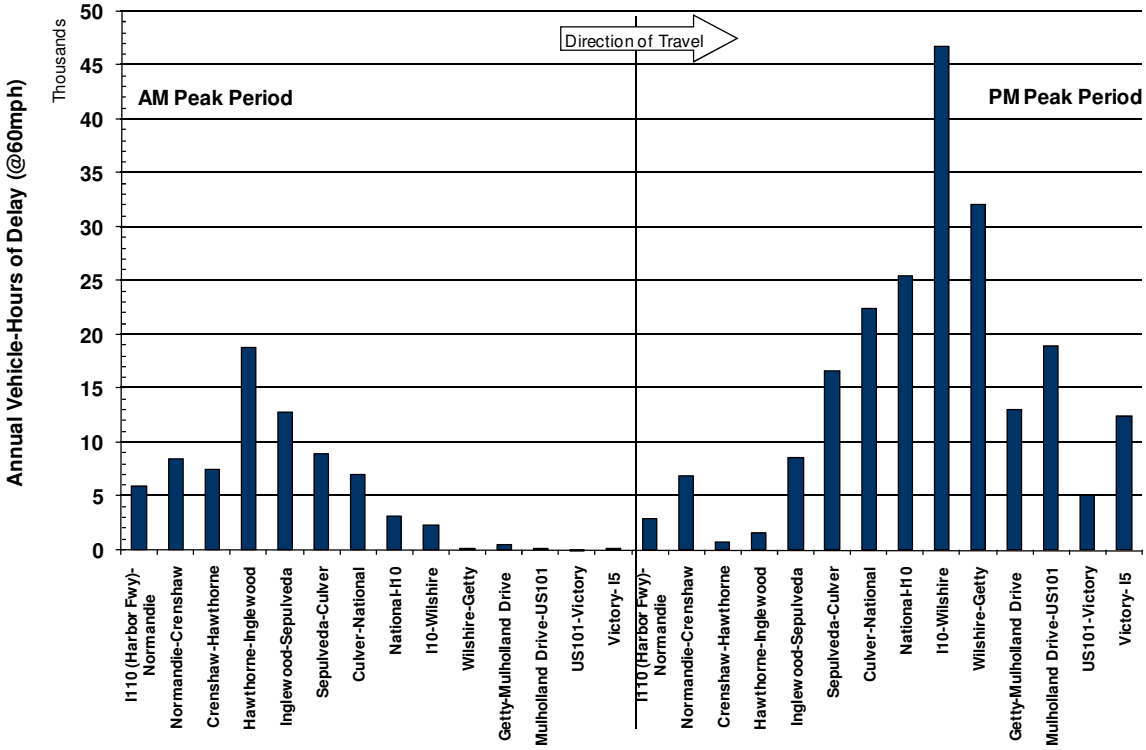
Exhibit 4-5: Northbound I-405 Annual Vehicle-Hours of Delay (2003)



Source: SMG analysis of PeMS data

In the southbound direction (Exhibit 4-7), delay was twice as high in the PM peak as the AM peak period. During the PM peak in the southbound direction, the bottleneck area between Inglewood and I-110 experienced the highest delay of any other segment in this direction, followed closely by the segment from Wilshire to I-10. Combined, both of these segments comprise approximately 43 percent of the corridor's delay, or 900,000 annual vehicle-hours of delay.

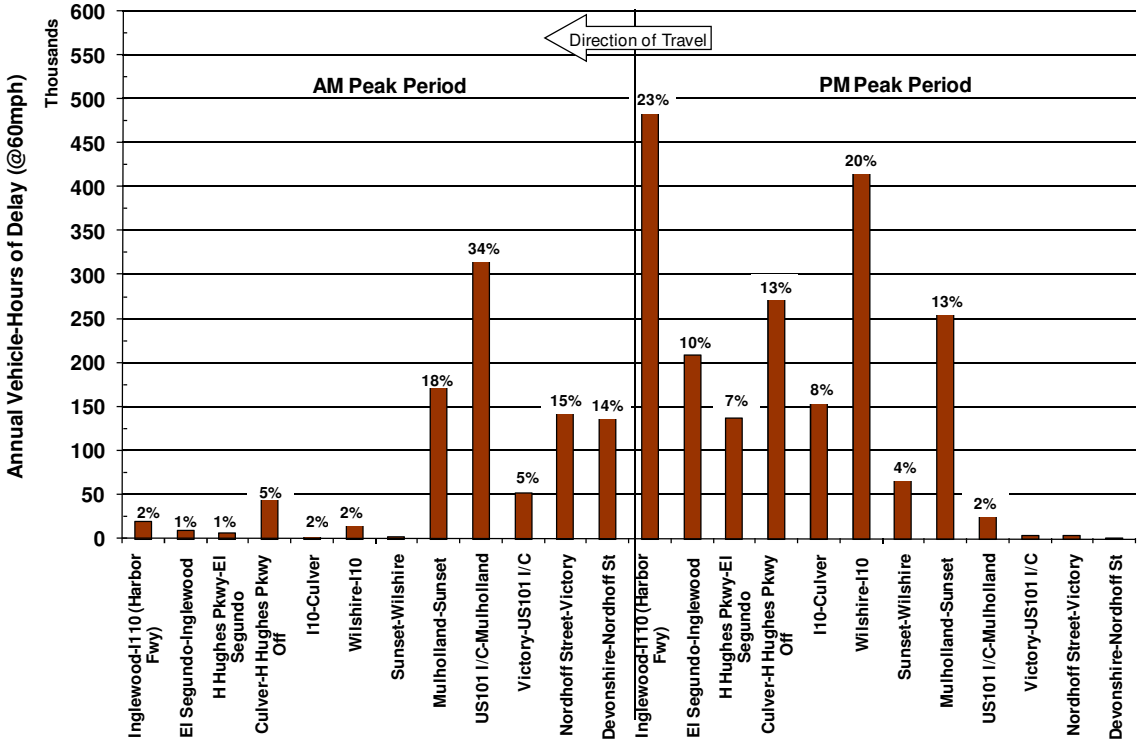
Exhibit 4-6: Northbound I-405 Delay per Lane-Mile (2003)



Source: SMG analysis of PeMS data

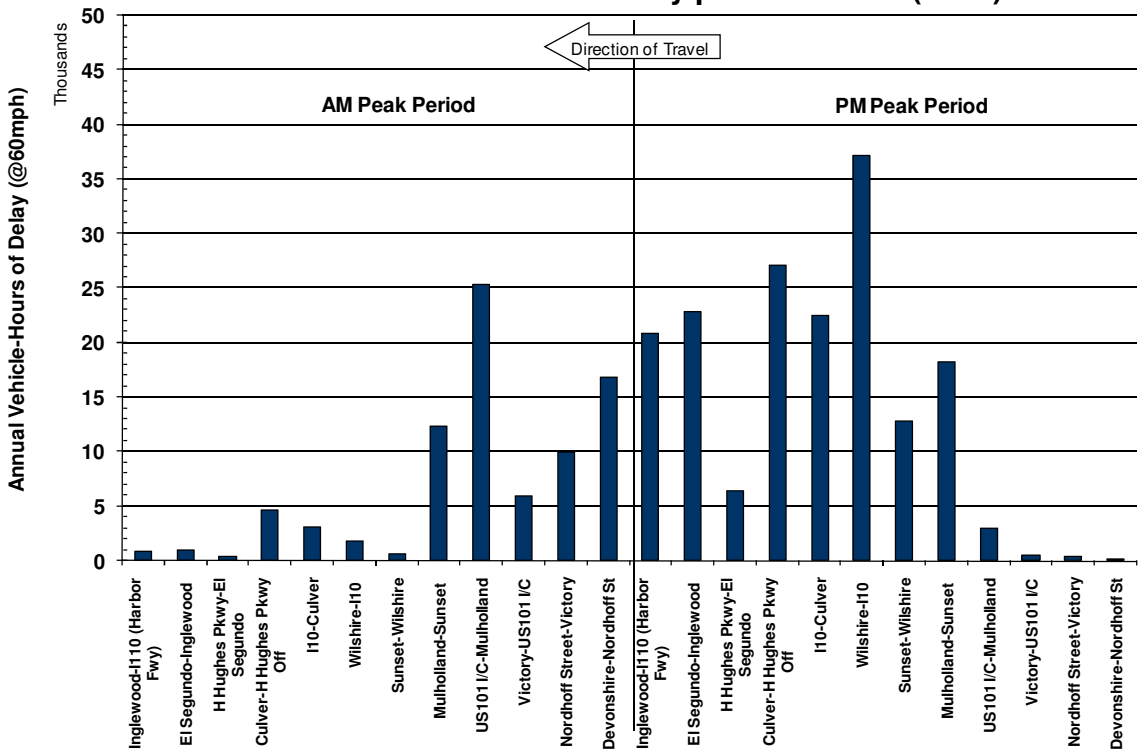
Exhibits 4-6 and 4-8 have been normalized to reflect delay per lane-mile. The delay calculated for each bottleneck area was divided by the total lane-miles for each bottleneck area to obtain delay per lane-mile. In the northbound direction, normalizing lane-miles resulted in similar delay results as Exhibit 4-5 with slight differences. Exhibit 4-6 reveals that the segment from Wilshire to I-10 experienced overwhelmingly greater delay (per lane-mile) than any other segment on the corridor, which is not the case in Exhibit 4-5, which shows the segment from Wilshire to Getty experiencing the greatest delay. In the southbound direction, normalizing lane-miles resulted in the same delay results as shown in Exhibit 4-7.

Exhibit 4-7: Southbound I-405 Annual Vehicle-Hours of Delay (2003)



Source: SMG analysis of PeMS data

Exhibit 4-8: Southbound I-405 Delay per Lane-Mile (2003)



Source: SMG analysis of PeMS data

Safety by Bottleneck Area

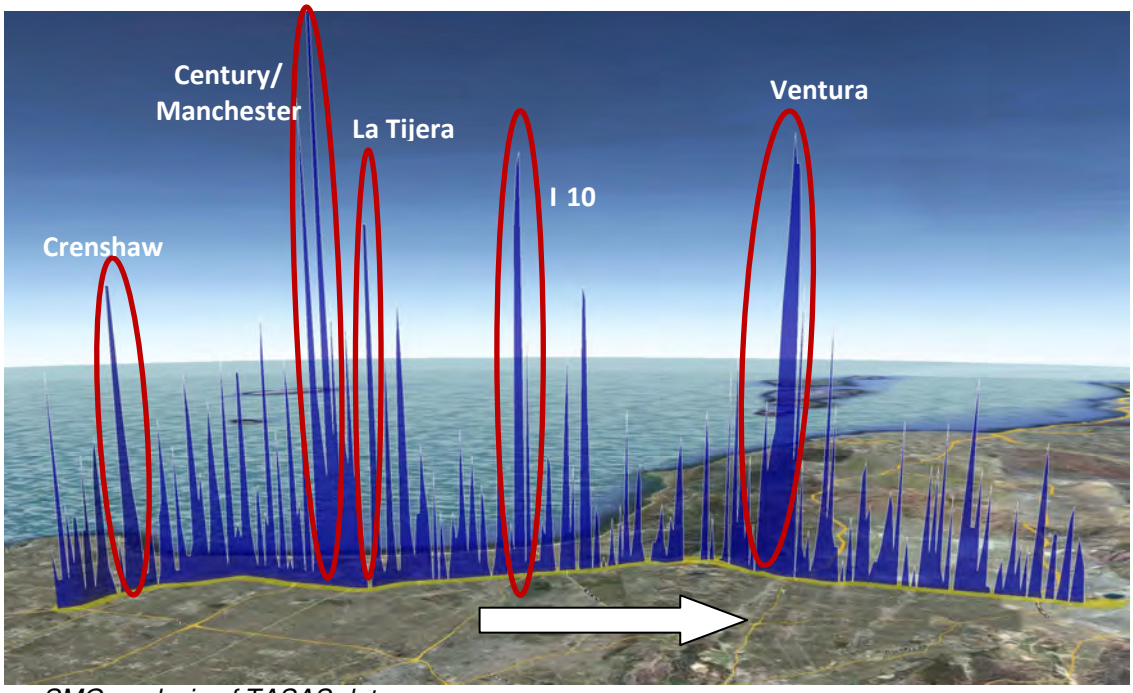
As previously indicated in Section 3, the safety assessment in this report is intended to characterize the overall accident history and trends in the corridor, and to highlight notable accident concentration locations or patterns that are readily apparent. The following discussion examines the pattern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

Safety on I-405

The safety analysis in this section conducted for the I-405 Corridor is based on a combination of PeMS data and data provided by Caltrans District 7. Unfortunately, safety data for the 2008 base year is not yet available from these two sources. Therefore, in addition to analyzing 2001-2003 data (pre-construction), the most recent available year data from 2007 is also analyzed.

Exhibit 4-9 shows the location of all collisions plotted along I-405 in the northbound direction. The spikes show the total number of collisions (fatality, injury, and property damage only) occurring within a 0.1 mile segments in 2003. The highest spike corresponds to roughly 60 collisions in a single 0.1 mile location, which happens to be near Century and Manchester in 2003. 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.

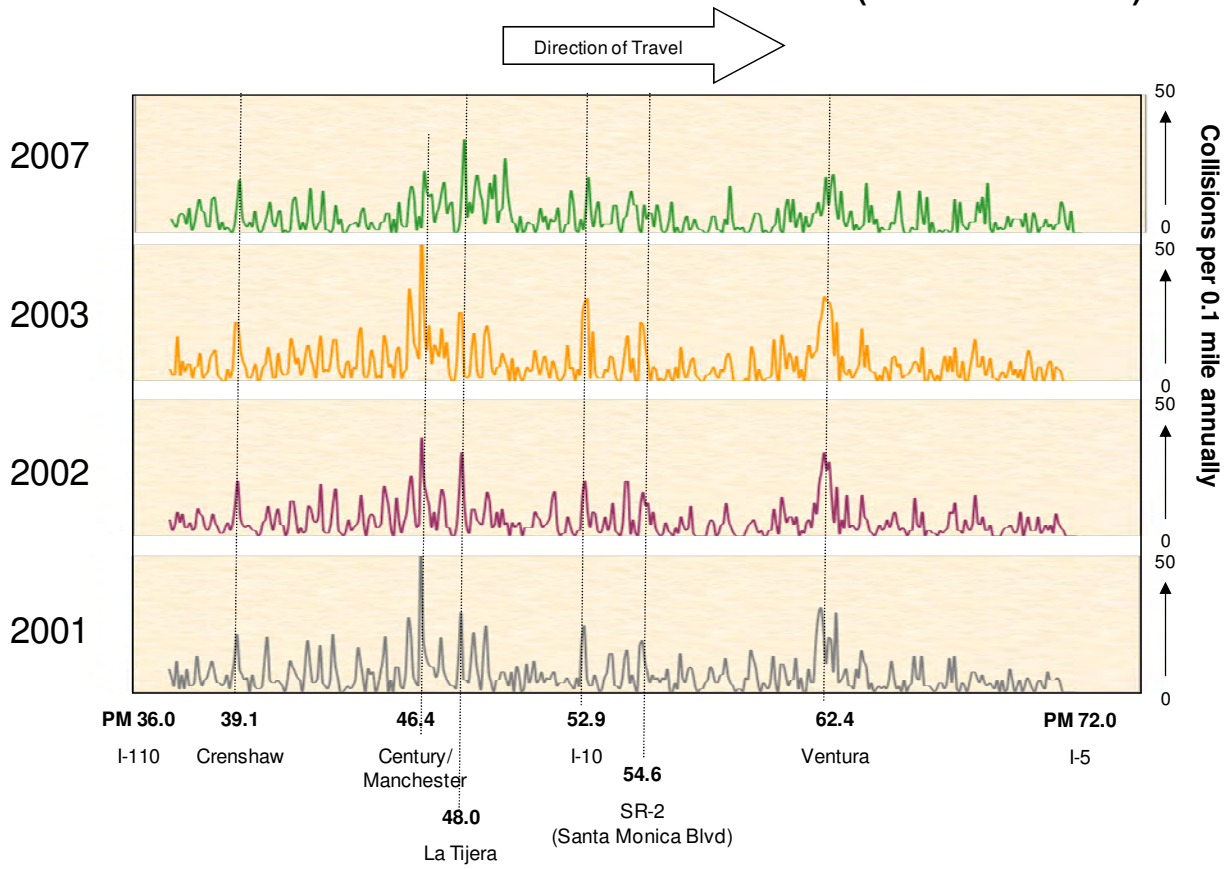
Exhibit 4-9: Northbound I-405 Collision Locations (2003)



Source: SMG analysis of TASAS data

Exhibit 4-10 illustrates the same collision data as the previous exhibit, but for additional years. Each graph in Exhibit 4-10 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 separate the corridor by bottleneck area. Due to the large number of bottleneck locations, not all of them are graphically represented in the exhibit. Starting from I-405 and moving northbound, the largest number of collisions occurred around Crenshaw, at Century/Manchester, at the I-10 Interchange, and around Ventura Boulevard. It is notable that the five high-collision locations identified in Exhibit 4-9 are also bottleneck locations, as shown in Exhibit 4-10. Exhibit 4-10 further shows that the pattern of collisions has stayed fairly the same with an overall decrease of collisions between 2003 and 2007.

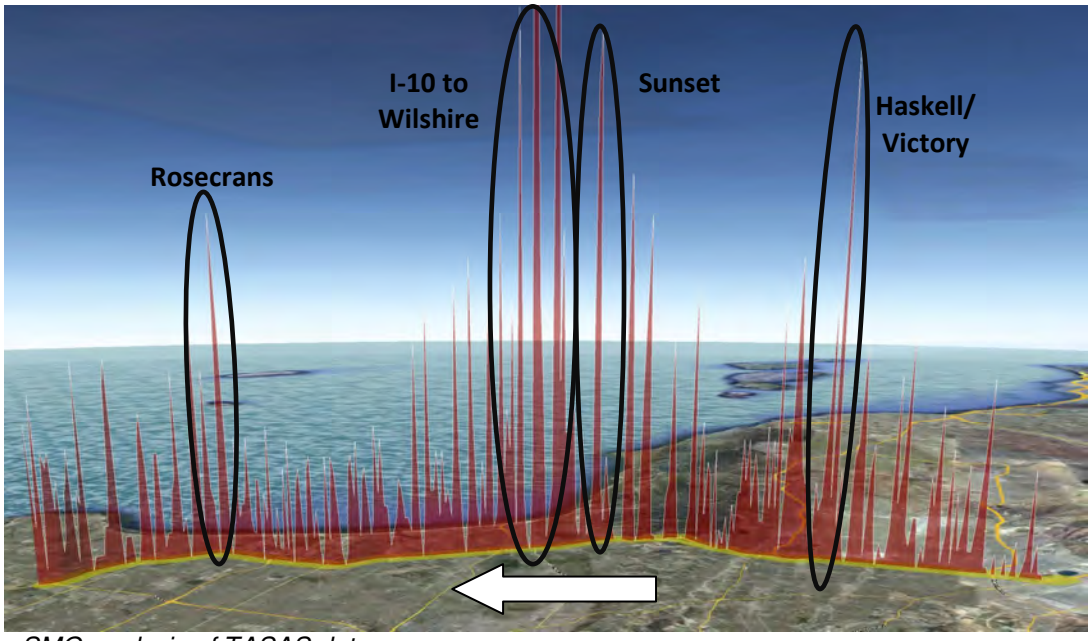
Exhibit 4-10: Northbound I-405 Collision Locations (2001-2003 & 2007)



Source: SMG analysis of TASAS data

For the southbound direction of I-405, Exhibit 4-11 maps the same 2003 collision data. The largest spike in this exhibit corresponds roughly to 55 collisions per 0.1 mile. Moving in the southbound direction from I-5, spikes are most notable around Haskell/Victory, at Sunset Boulevard, between Wilshire Boulevard and the I-10 Interchange, and at Rosecrans Avenue. Like the northbound direction, all of the high-collision locations identified are also bottleneck locations.

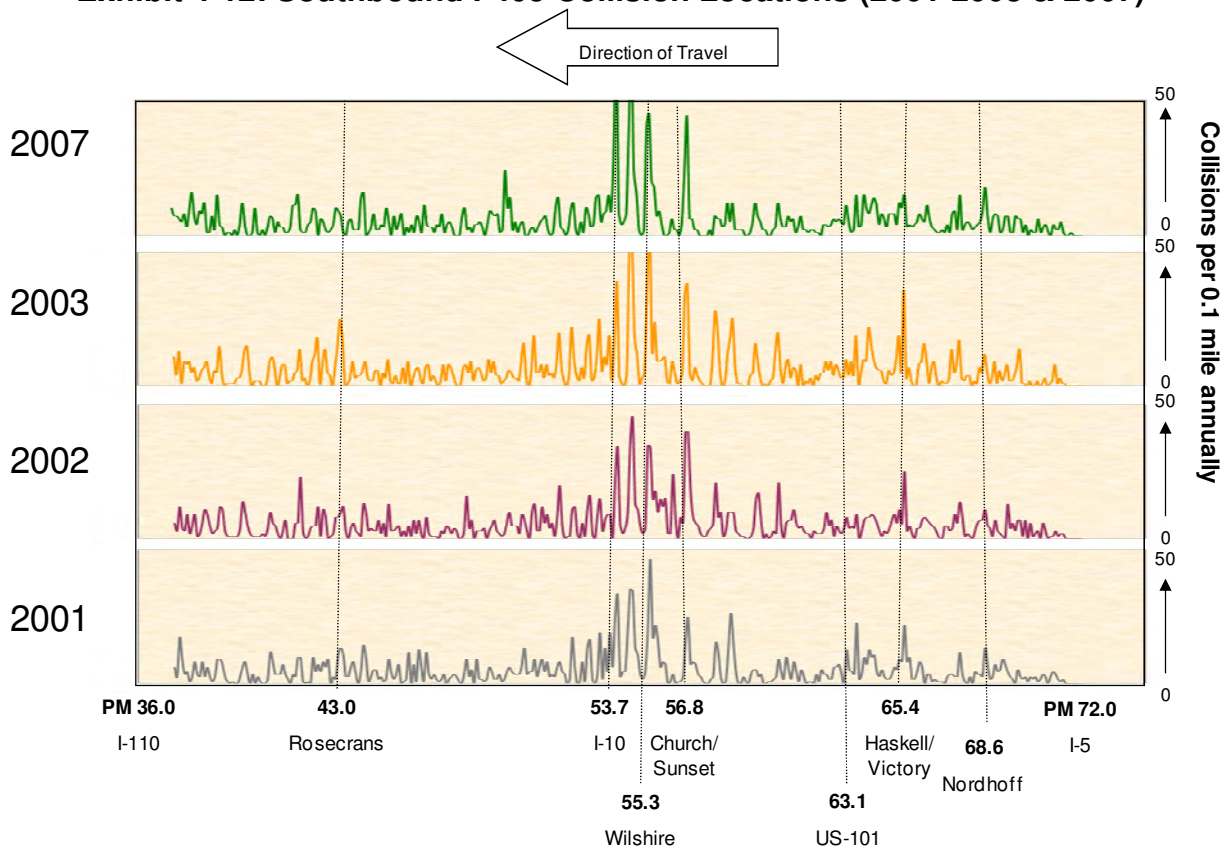
Exhibit 4-11: Southbound I-405 Collision Locations (2003)



Source: SMG analysis of TASAS data

As done previously for the northbound direction, Exhibit 4-12 shows the trend of collisions in the southbound direction during the 2001-2003 and 2007 period by select bottleneck areas. As the exhibit shows, the pattern of collisions has been fairly steady from one year to the next with an overall increase of accidents between 2001 and 2007.

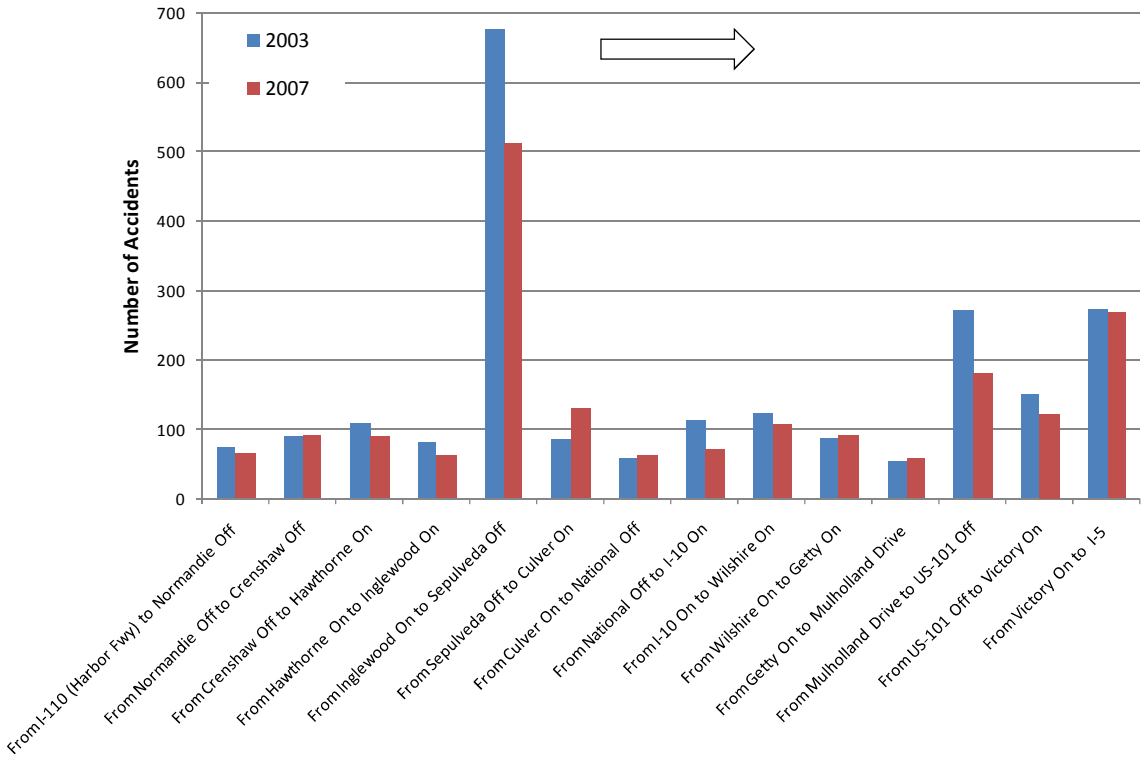
Exhibit 4-12: Southbound I-405 Collision Locations (2001-2003 & 2007)



Source: SMG analysis of TASAS data

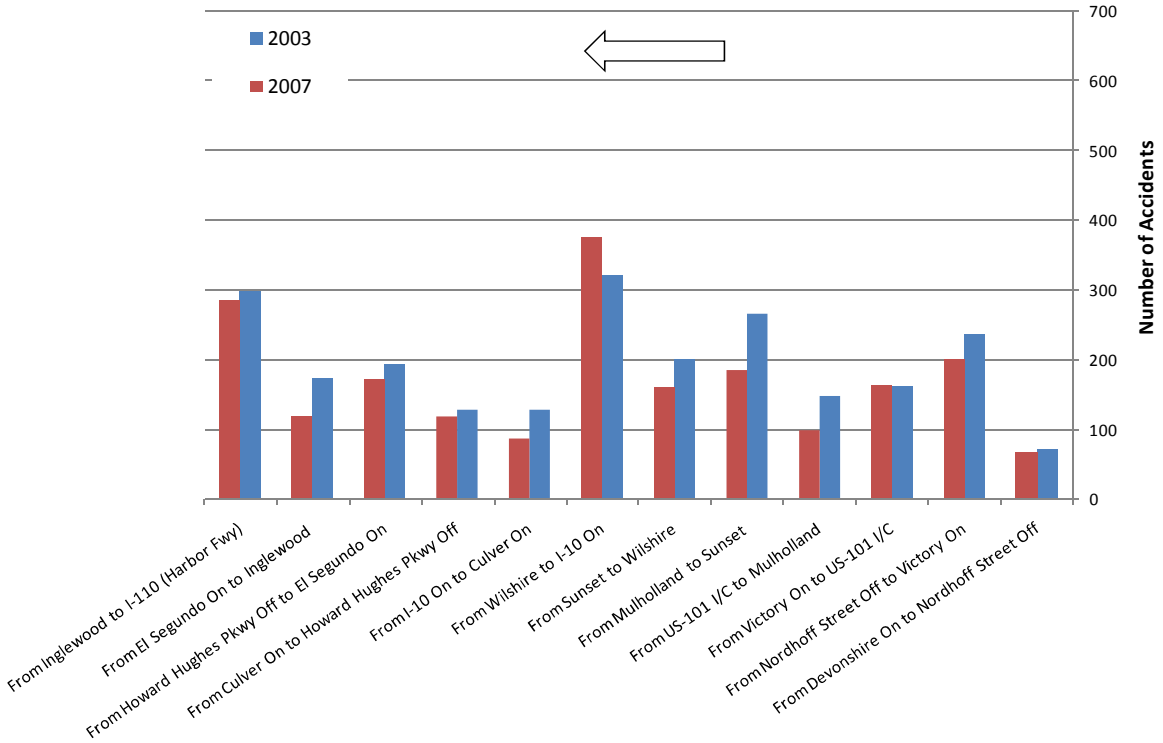
Exhibits 4-13 and 4-14 present the total number of accidents reported in TASAS by bottleneck area. The bars show the total of accidents that occurred in 2003 (base year of analysis) and 2007 (the most recent TASAS data available). In the northbound direction, the segment from Inglewood to Sepulveda exceeded every other segment in accidents in both 2003 and 2007 with about 680 and 510, respectively. In the southbound direction, the segment between Wilshire and I-10 experienced the highest number of accidents in 2003 and 2007 with respectively 320 and 380. These locations also experienced high levels of delay as previously illustrated in Exhibits 4-5 through 4-8.

Exhibit 4-13: Northbound I-405 Total Accidents (2003 & 2007)



Source: SMG analysis of TASAS data

Exhibit 4-14: Southbound I-405 Total Accidents (2003 & 2007)



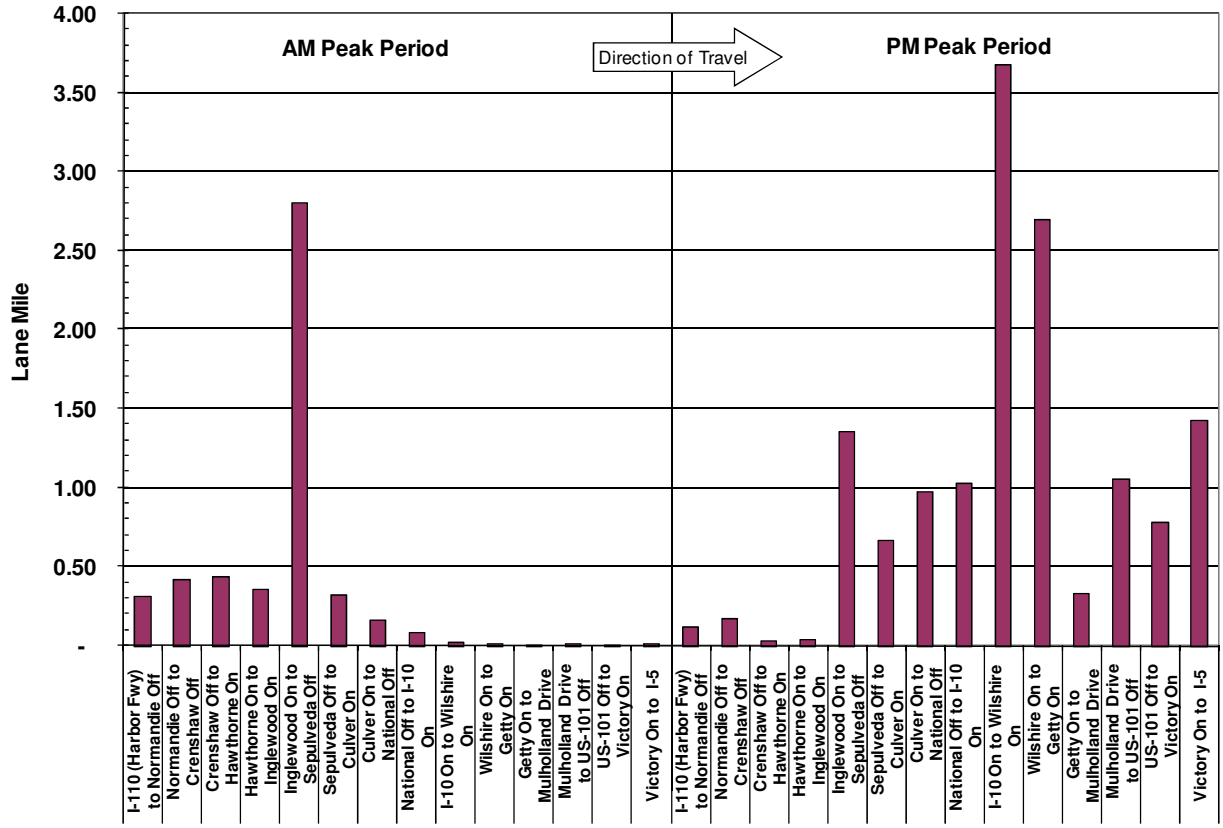
Source: SMG analysis of TASAS data

Productivity by Bottleneck Area

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

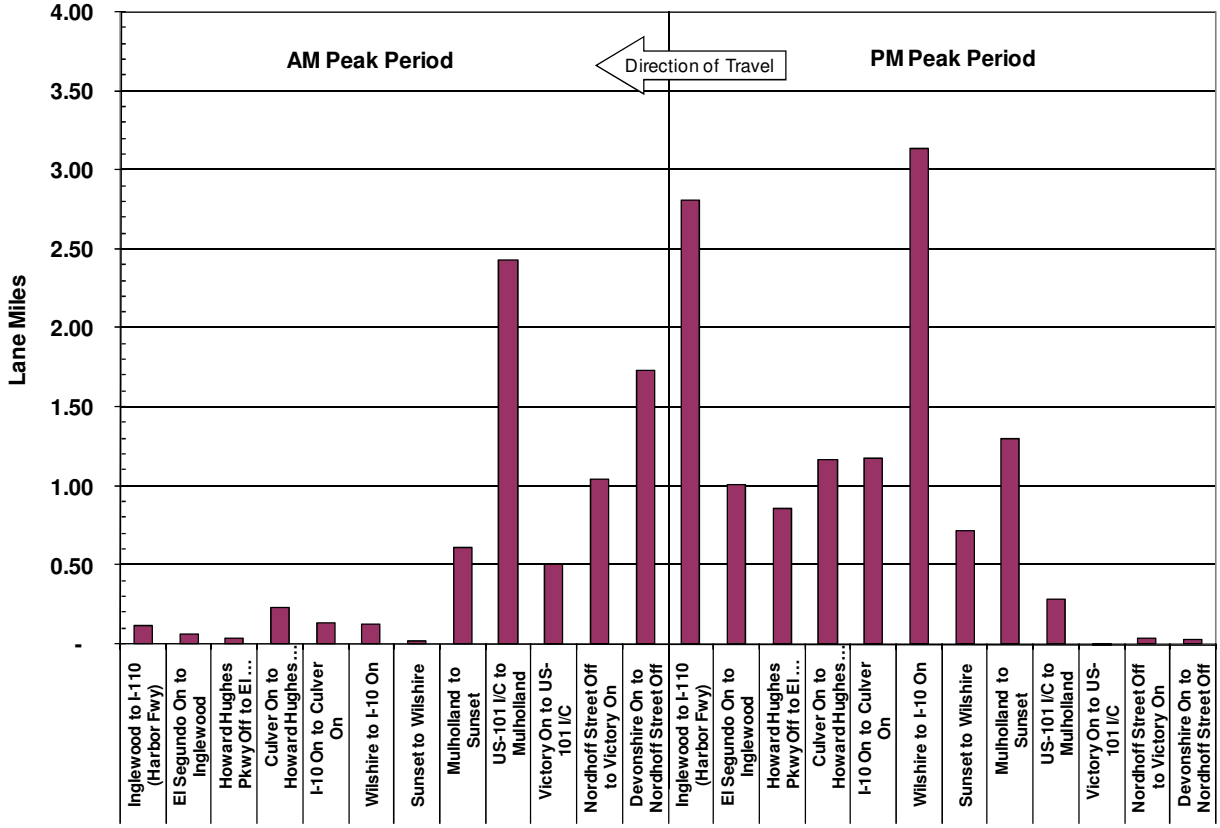
Similar to the mobility analysis, the productivity analysis is also based on 2003 PeMS data. Exhibits 4-15 and 4-16 show the productivity losses for both directions of the I-405 Corridor. In the northbound direction (Exhibit 4-15), the segment from Inglewood to Sepulveda and I-10 to Wilshire experienced the highest productivity losses during the AM and PM peak periods, respectively, with about 2.8 and 3.7 lost-lane miles. In the southbound direction (Exhibit 4-16), the segment from US-101 and Mulholland (AM) and from Wilshire to I-10 (PM) had the worst productivity losses at around 2.5 and 3.2 lost-lane miles. These segments of the corridor also coincide with the segments that experienced the highest levels of annual vehicle-hours of delay.

Exhibit 4-15: Northbound I-405 Lost Lane-Miles (2003)



Source: SMG analysis of PeMS data

Exhibit 4-16: Southbound I-405 Lost Lane-Miles (2003)



Source: SMG analysis of PeMS data

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

5. BOTTLENECK CAUSALITY ANALYSIS

Major bottlenecks are the primary cause of corridor performance degradation and the resulting congestion and lost productivity. It is important to verify the actual location and cause(s) of each major bottleneck to determine traffic operational problems.

The actual location of each major bottleneck is verified by multiple field observations on separate days. The cause(s) of each major bottleneck is also identified by field observations and additional traffic data analysis. For the I-405 mainline facility, 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 in the spring and summer of 2009.

By definition, a bottleneck is a condition where traffic demand exceeds the capacity of the roadway facility. In most cases, the cause of bottlenecks is related to a sudden reduction in capacity, such as roadway geometry, heavy merging and weaving, and driver distractions; or a surge in demand that the facility cannot accommodate. In many cases, it is a combination of increased demand and capacity reductions. Below is a summary of the causes of the bottleneck locations.

MAINLINE (ML) FACILITY

Northbound I-405 ML Bottlenecks and Causes

Vermont Avenue On to Normandie Avenue Off

Exhibit 5-1 shows the aerial photograph of the northbound I-405 mainline from the Vermont Avenue on-ramp to the Normandie Avenue off-ramp. The mainline fifth lane mostly carries heavy traffic from I-110 onto I-405, as shown in the lower right photograph and indicated by the first blue arrow (note that the actual I-110 connector ramp is not shown on the aerial view). In addition, the Vermont Avenue on-ramp traffic merges with this lane, as indicated by the second blue arrow. The cross weaving of the Normandie Avenue off-ramp traffic and the lane drop results in the bottleneck condition at this location. Just past the lane drop, speeds begin to pick up and vehicles begin to separate as shown in the inset photograph.

Exhibit 5-1: Northbound I-405 at Vermont Avenue On to Normandie Avenue Off

Crenshaw Boulevard Off

Exhibit 5-2 is an aerial photograph of the northbound I-405 mainline at the Crenshaw Boulevard Interchange. As shown in the photograph below, the off-ramp traffic queues onto the mainline, in this case along the mainline shoulder. The primary cause of this bottleneck is from the intersection 1, indicated on the exhibit. In order to provide left-turn access at this intersection, the heavy southbound Crenshaw Boulevard traffic cannot clear the intersection and queues back to intersection 2 and back along 182nd Street to intersection 3 and onto the freeway mainline.

Exhibit 5-2: Northbound I-405 at Crenshaw Boulevard Off-ramp

Hawthorne Boulevard On

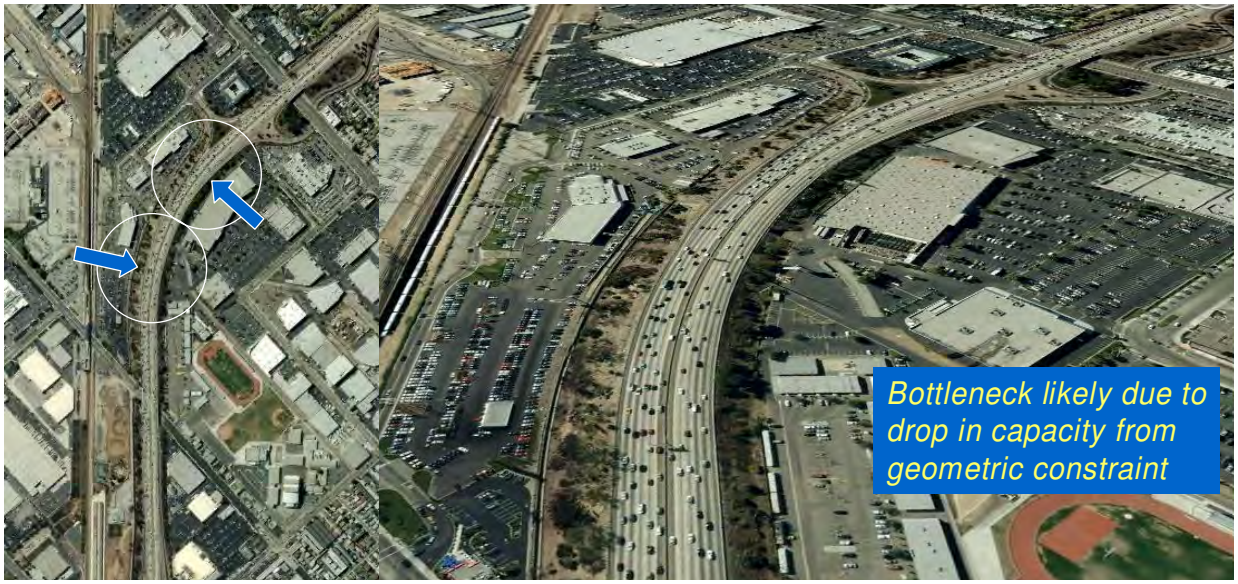
Exhibit 5-3 is an aerial photograph of the northbound I-405 at the Hawthorne Boulevard Interchange. As the inset digital photograph shows, platoon of vehicles merge onto the freeway mainline, creating the bottleneck condition at this location. This is due to the ramp metering location that is too far back on the ramp. The slow speeds up the ramp and the merge of the three lanes into one result in the platoon of the vehicles.

Exhibit 5-3: Northbound I-405 at Hawthorne Boulevard

Inglewood Avenue/Rosecrans Avenue

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

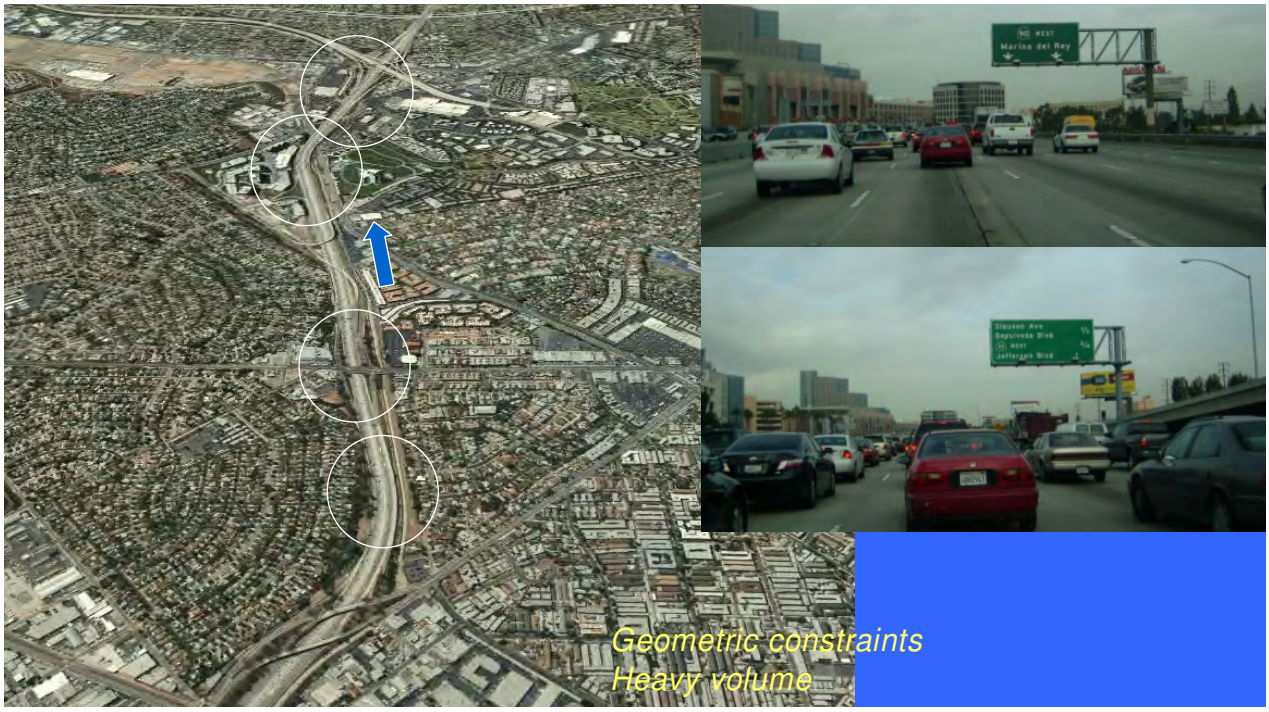
Exhibit 5-4: Northbound I-405 at Inglewood Avenue/Rosecrans Avenue



La Tijera Boulevard/Howard Hughes Parkway

This bottleneck location is also likely due to the roadway geometry. As indicated in the aerial photograph shown in Exhibit 5-5, an "s" curve is evident with a tight curve to the left approaching La Tijera Boulevard and to the right just past Howard Hughes Parkway, reducing sight distance and travel speeds. Additionally, a steady uphill grade also results in reduced speeds, as indicated by the inset photographs. During heavy traffic demand conditions in the peak hours, the adverse impact to the roadway effective capacity, however small, results in the bottleneck condition at this location.

Exhibit 5-5: Northbound I-405 at La Tijera Boulevard/Howard Hughes Parkway



West Los Angeles (SR-90 to US-101)

There are multiple bottlenecks along this section of the corridor from SR-90 to the US-101 interchanges, mostly due to surge of demand from the ramps that the mainline facility cannot accommodate, particularly from SR-90 with significant traffic growth in recent years. Exhibit 5-6 shows the aerial photograph of this area with highlighted bottleneck areas by white circles. One of the more significant bottlenecks is at the Culver Boulevard approach due to the heavy traffic merging from the SR-90 on-ramps, as shown by the inset photograph. Combined, they exceed 2,000 vehicles per hour during the peak hours. These ramps are currently not metered. Another significant bottleneck is at the Mulholland pass. The long steep uphill climb significantly impacts vehicle speeds reducing the effective capacity. With heavy demand, a bottleneck is formed.

Exhibit 5-6: Northbound I-405 at West Los Angeles (SR-90 to US-101)

Victory Boulevard On and Nordhoff Street On

Similar to the Hawthorne Boulevard on-ramp bottleneck, the bottleneck at the Victory Boulevard on-ramp is caused by the platoon of vehicles merging with the mainline traffic. As shown in Exhibit 5-7, the ramp metering location is too far back on the ramp. The heavy demand of the ramp traffic at over 900 vehicles per hour, long ramp distance, and slow speeds up the ramp creates the platoon of the vehicles.

At the Nordhoff Street interchange, the heavy on-ramp traffic merging onto the northbound I-405 mainline traffic is likely to cause the bottleneck condition. The on-ramp volume often exceeds 1,000 vehicles per hour during the peak hours. Currently there are two lanes metered that merges into one lane before merging with the mainline traffic.

Exhibit 5-7: Northbound I-405 at Victory Boulevard

Southbound I-405 ML Bottlenecks and Causes

Devonshire Street On to Nordhoff Street Off

Exhibit 5-8 shows the aerial photograph of the southbound (top down) I-405 at Devonshire Street. As indicated, traffic from SR-118 and two consecutive on ramps from Devonshire Street merges with the mainline traffic, while dropping a lane on the mainline approaching Nordhoff Street, creating the bottleneck condition at this location.

Exhibit 5-8: Southbound I-405 at Devonshire Street

US-101

As shown in Exhibit 5-9 inset photographs, traffic is heavily congested approaching US-101. The primary causes of this bottleneck are the heavy traffic destined to continue southbound on I-405 and the lane drop, lost to the US-101 connector, from 4 lanes to 3 lanes. The lower photograph shows the stream of traffic on the fourth lane that must merge to the left before the split. As shown on the upper photograph, very little of the I-405 mainline traffic is headed to US-101 during the AM peak hours.

Exhibit 5-9: Southbound I-405 approaching US-101

Exhibit 5-10 shows the next bottleneck at the US-101 merge with the southbound I-405. The bottleneck is located at the northbound US-101 to southbound I-405 connector ramp merge point, as illustrated by the white oval. Traffic congestion from this location queues traffic back onto the US-101 mainline to SR-134. The heavy demand from this ramp, compounded by the very tight loop of the ramp, result in a dense platoon of vehicles merging with the southbound I-405 traffic at an uphill grade, creating the bottleneck condition at this location. The lower inset photograph shows the traffic congested approaching the merge and the upper photograph illustrates speeds picking up and traffic beginning to separate just past the merge. This bottleneck was also observed in the field on multiple occasions during the AM peak hours. As traffic continues southward into the long steep uphill grade through Mulholland pass, more congestion is formed throughout this section of the corridor. Caltrans is currently conducting a study to reconfigure and reconstruct the southbound I-405/US-101 connectors to address some of these congestion problems.

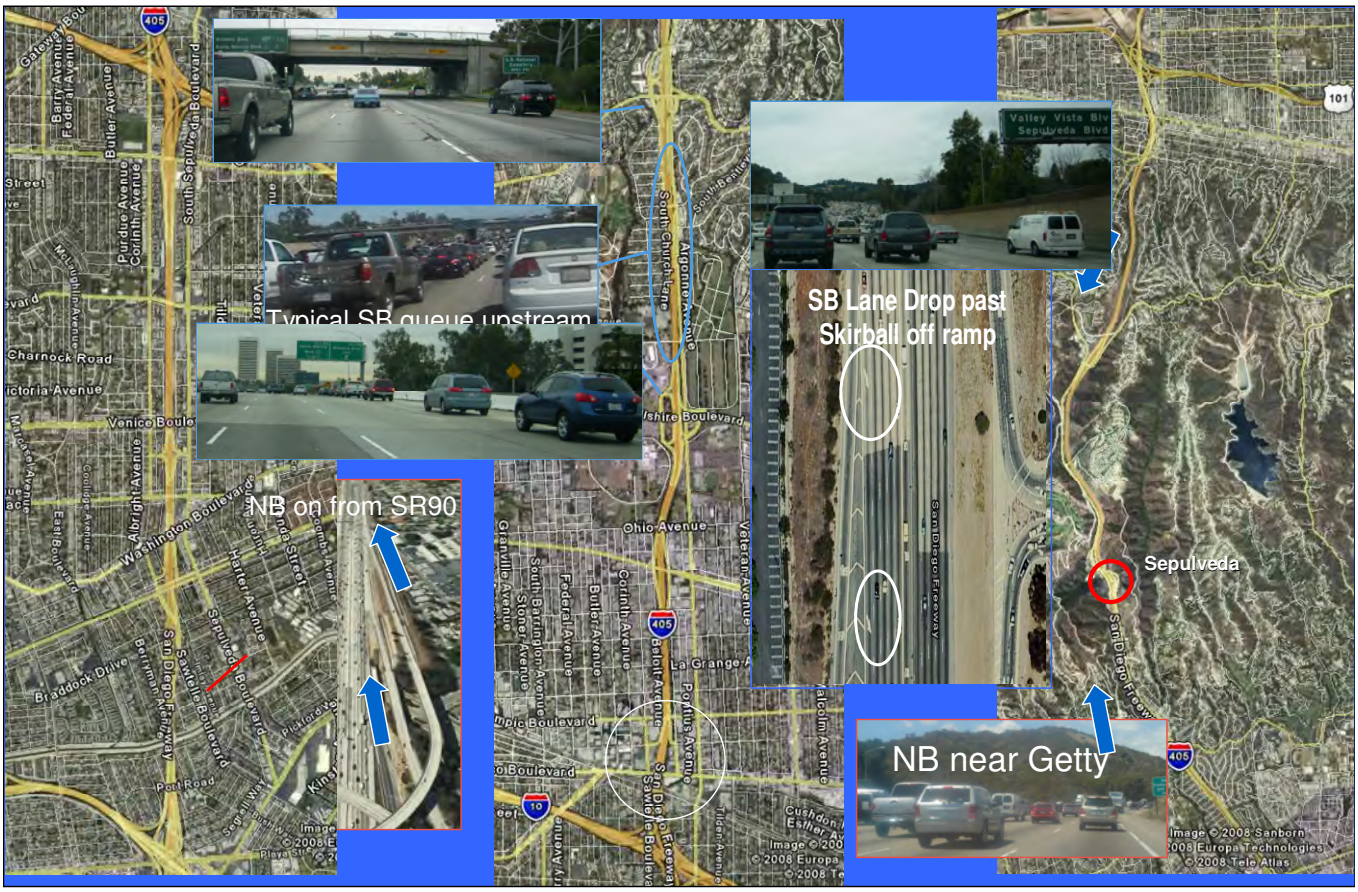
Exhibit 5-10: Southbound I-405 at US-101 merge

West Los Angeles (US-101 to SR-90)

There are multiple bottleneck locations within this section of the corridor. As traffic travels through the Mulholland pass, the steep vertical grade and the lane drop just past the Skirball off-ramp create the bottleneck condition and traffic congestion, as shown in the right inset photograph in Exhibit 5-11. For this reason, a lane gap closure from Skirball to Waterford Street is currently being considered and studied under the Sepulveda Pass Project. Another significant bottleneck is at the Sunset Boulevard on-ramp merge. This ramp is not metered. With a very short merge taper, as shown in the top left photograph in Exhibit 5-11, a small platoon of ramp traffic will cause the mainline traffic flow to breakdown, creating the bottleneck condition. Just past this location, traffic normally picks up speed to the Wilshire Boulevard off-ramp, where traffic is again congested. The cause of the bottleneck at Wilshire Boulvard off-ramp is the off-ramp traffic backing up onto the mainline, as shown in the lower photograph, highlighted by the white oval. During the PM peak hours, traffic along Wilshire Boulevard is heavily congested, resulting in the queuing to the freeway mainline.

Traveling past the I-10 interchange, multiple bottlenecks are evident from National Boulevard to the Culver Boulevard, due to on-ramp ramps merging into heavy traffic on the roadway facility.

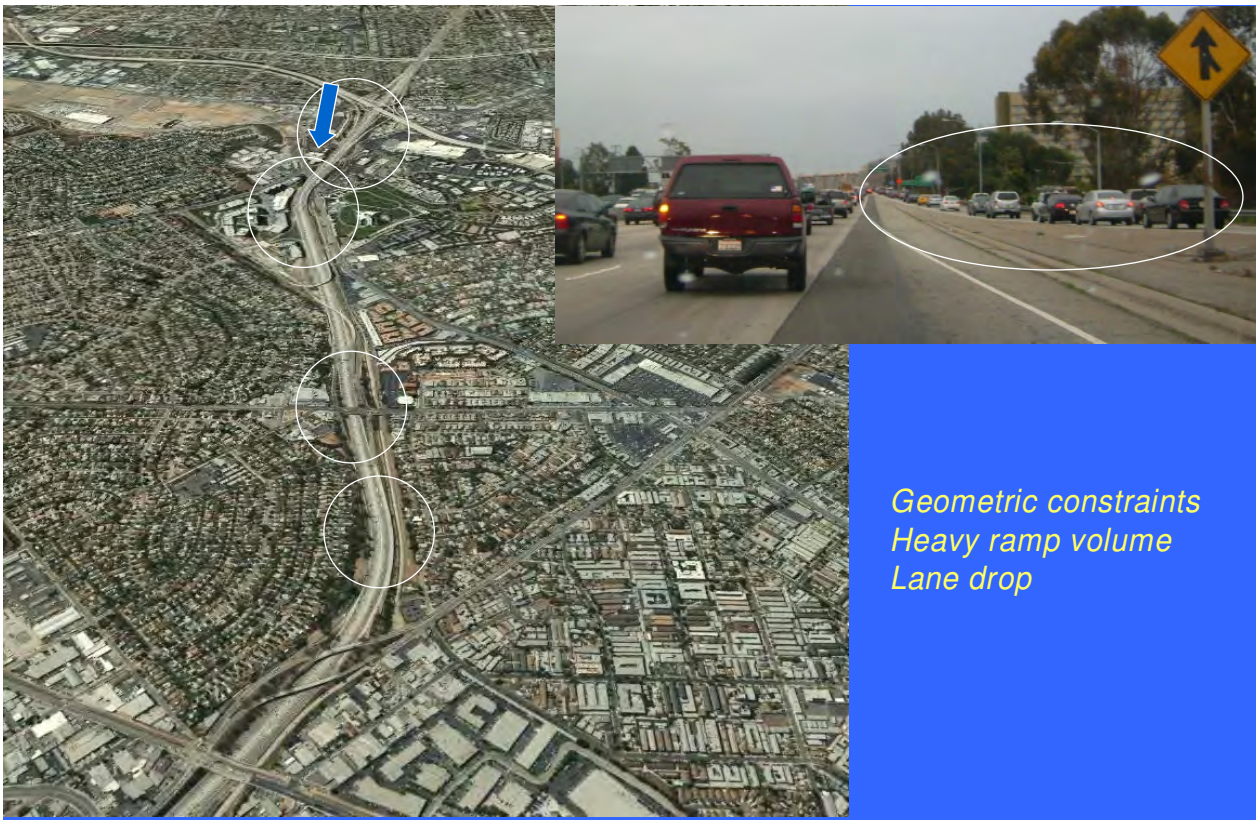
Exhibit 5-11: Southbound I-405 at West Los Angeles (US-101 to SR-90)



La Tijera Boulevard/Howard Hughes Parkway

The primary cause of this bottleneck is the lane drop that occurs at the La Tijera Boulevard off-ramp and the heavy traffic demand from the SR-90 on-ramp. The southbound I-405 mainline traffic demand during the peak hours is very heavy. Add to that the heavy stream of traffic from SR-90 merging with the I-405 traffic, as shown in the Exhibit 5-12 inset photograph, highlighted by the white oval. The connector ramp is not metered. The roadway geometry with the downhill grade and horizontal curves affecting sight distance, particularly at La Tijera Boulevard, contributes to the bottleneck condition.

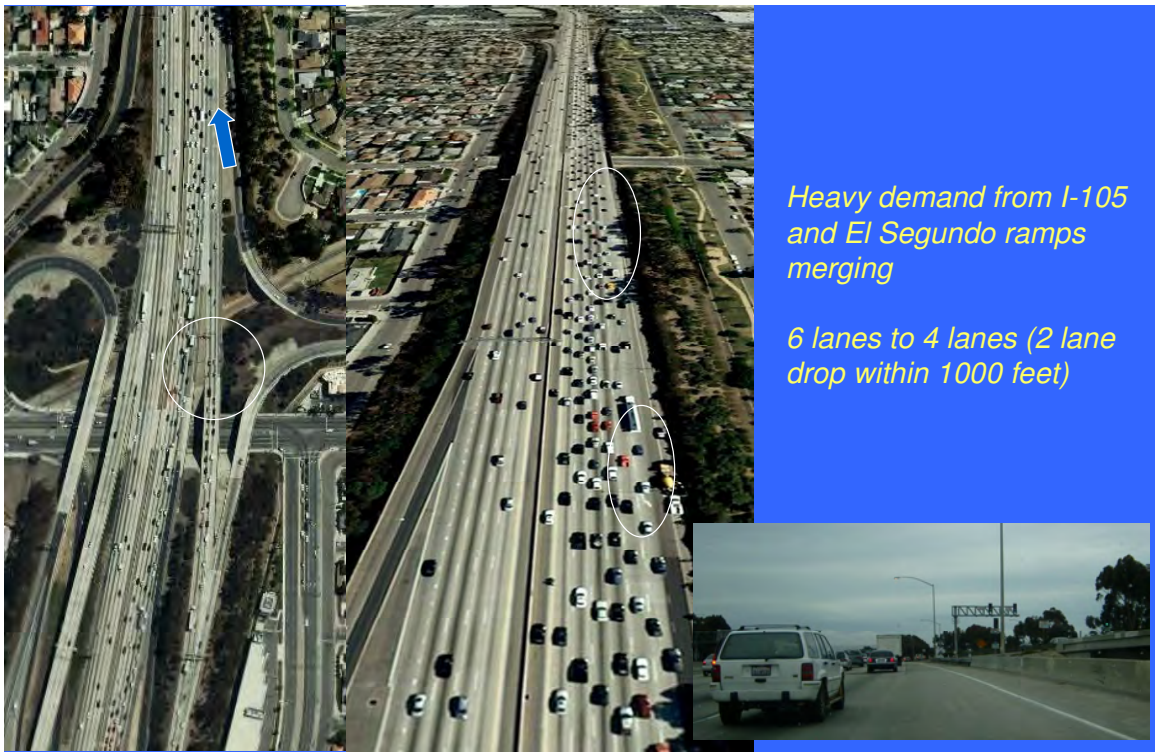
Exhibit 5-12: Southbound I-405 at La Tijera Boulevard/Howard Hughes Parkway



El Segundo Boulevard to Rosecrans Avenue

Exhibit 5-13 shows the aerial photograph of the southbound I-405 mainline at El Segundo Boulevard. As shown, the connector ramp traffic from I-105 is very heavy, even with ramp metering, at over 1,500 vehicles per hour during the PM peak hours. Additionally, the El Segundo Boulevard on-ramp traffic exceeds over 900 vehicles per hour, resulting in over 2,400 vehicles per hour of traffic merging with the I-405 southbound mainline traffic at one time. The primary cause of the bottleneck is this demand plus the lane drop that occurs downstream, as highlighted by white ovals in the exhibit. The multiple lane drops that occur cause the bottleneck and the severe congestion that follows.

Exhibit 5-13: Southbound I-405 at El Segundo Boulevard/Rosecrans Avenue



Inglewood Avenue/Rosecrans Avenue

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

Exhibit 5-14: Southbound I-405 at Inglewood Avenue/Rosecrans Avenue

Crenshaw Boulevard and I-110 Interchange

At the Crenshaw Boulevard Interchange, the on-ramp traffic merging onto the southbound mainline traffic is likely to cause the bottleneck at this location. During the PM peak hours, the on-ramp volume exceeds 600 vehicles per hour. The ramp is currently metered.

Much like the US-101 approach, the lane drop from 4 lanes to 3 lanes at the I-110 split, causes the bottleneck and congestion to occur regularly during the weekday PM peak hours at this location. As traffic speeds begin to pickup after the split and bottleneck, another bottleneck is created from the merge of the I-110 traffic and Figuroa Boulevard traffic in three consecutive on-ramps and multiple lane drops. The I-110 connector ramps are not metered. Exhibit 5-15 illustrates this location.

Exhibit 5-15: Southbound I-405 approaching I-110

HIGH-OCCUPANCY VEHICLE (HOV) FACILITY

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

Northbound I-405 HOV Bottlenecks and Causes

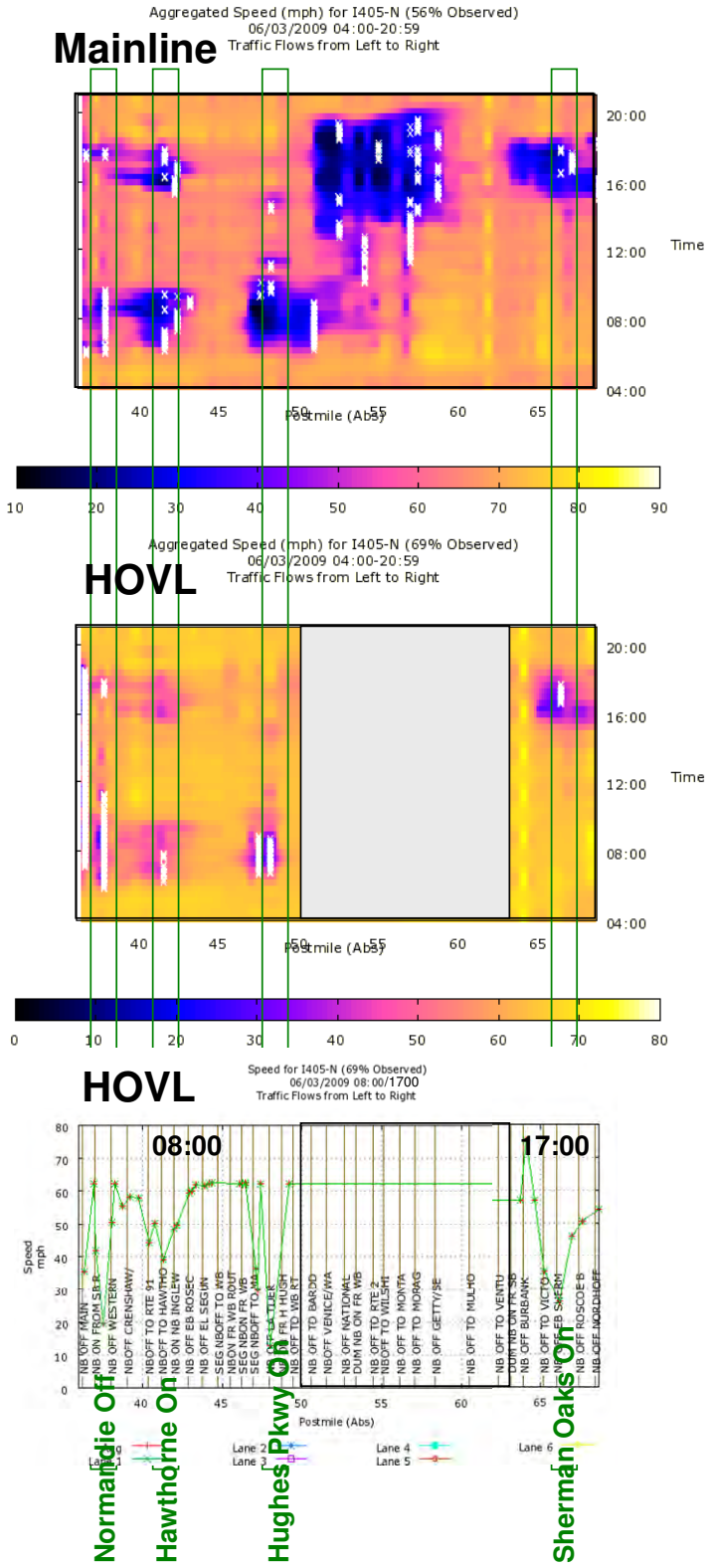
In the northbound direction, four major HOV bottlenecks were identified based on data analysis at the following locations:

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

Exhibit 5-16 presents the PeMS speed contour and profile diagrams of the northbound mainline and HOV facilities during a typical weekday in June 2009. The diagram identifies the four locations of congestion with dark shaded plots. The review of multiple 2008 sample days and monthly averages consistently revealed the same bottleneck locations at these four locations. The HOV-lane remains under construction and does not extend throughout the entire length of the mainline facility of the study corridor, as noted by the gaps on the HOV diagrams.

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

Exhibit 5-16: Northbound I-405 ML & HOVL PeMS Speed Contour (June 2009)



Southbound I-405 HOV Bottlenecks and Causes

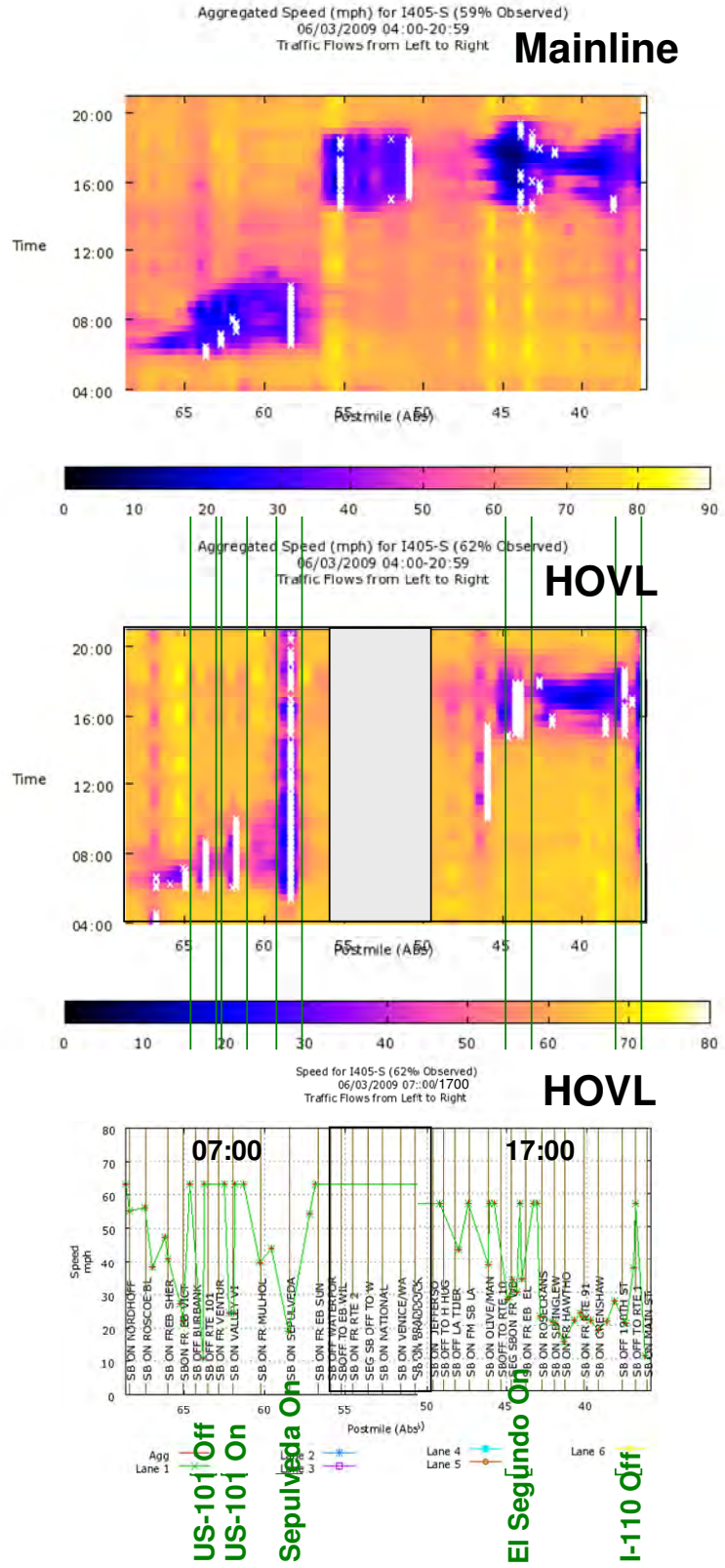
In the southbound direction, six bottlenecks were identified based on data analysis, at the following locations:

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

Exhibit 5-17 presents the PeMS speed contour and profile diagrams of the southbound mainline and HOV facilities during a weekday in June 2009. The diagram identifies the six locations of congestion with dark shaded plots. The review of multiple 2008 sample days and monthly averages consistently revealed the same bottleneck locations at these six locations. The HOV-lane remains under construction and does not extend throughout the entire length of the mainline facility of the study corridor, as noted by the gaps on the HOV diagrams.

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

Exhibit 5-17: Southbound I-405 ML & HOVL PeMS Speed Contour (June 2009)



APPENDIX

Appendix A is an exact copy of Section 4 from the Preliminary Performance Assessment document submitted to Caltrans in May 2008 (with the exception that an "A" has been added to the exhibit numbers). It is included for reference purposes and also to allow future updates to this analysis. The analysis identified potential bottlenecks based on a number of data sources and very limited field observations. However, it represented the foundation for the conclusions in Section 4 of this Comprehensive Performance Assessment report, which built on the original findings and then revised and/or confirmed these conclusions with significant field observations and additional data analysis.

Appendix A: Preliminary Bottleneck Analysis

In this section of the report, the results of the bottleneck analysis are presented. The bottleneck analysis was conducted to identify potential bottleneck locations. Potential freeway bottleneck locations that create mobility constraints are identified and documented, and their relative contribution to corridor-wide congestion is reported. A variety of sources were used to identify bottlenecks. They include the following:

- Caltrans Highway Congestion Monitoring Program (HICOMP) 2006 report;
- Probe vehicle runs (electronic tach runs)
- Freeway Performance Measurement System (PeMS)
- Aerial photos (Google Earth) and Caltrans photologs
- Field observations

Exhibit 4-1 provides a summary of the bottlenecks identified from the analysis of the various sources. Each bottleneck was verified in separate field observations made on a normal weekday in November and December 2007 and February 2008. The rows in bold represent bottlenecks that have been verified by multiple sources and are most likely recurrent bottlenecks that exist today. The others should be revisited and verified when more data becomes available.

Exhibit A4-1: Summary of Bottlenecks Identified and Verified

BOTTLENECK LOCATION	HICOMP [a] Report		Caltrans [b] Probe Veh. Runs		PeMS [c] Speed Contours	
	AM	PM	AM	PM	AM	PM
NORTHBOUND						
Normandie off	-	-	-	✓	✓	✓
Crenshaw off	-	-	-	✓	✓	✓
Hawthorne on	-	-	✓	-	✓	-
Inglewood on to Rosecrans off	✓	-	-	-	✓	-
La Tijera/Hughes on to Sepulveda	-	-	-	-	✓	✓
Culver on	✓	-	✓	-	✓	✓
Wilshire on	-	-	-	-	-	✓
Getty on	-	✓	-	-	-	✓
Mulholland Drive	-	✓	-	-	-	✓
US-101 off	-	-	✓	✓	-	✓
Victory on	-	-	-	✓	-	✓
Nordhoff on	-	✓	-	✓	-	-
SOUTHBOUND						
Devonshire on	-	-	✓	-	✓	-
Victory on	-	-	✓	-	✓	-
US-101 on	✓	-	-	-	-	-
Montana on	✓	-	-	-	-	-
Sunset on	-	-	-	-	✓	-
Wilshire off	-	-	-	✓	✓	-
I-10 on	-	✓	-	-	-	-
Culver on	-	-	✓	✓	✓	✓
La Tijera/Hughes Pkwy off	-	-	-	✓	✓	✓
El Segundo on to Rosecrans off	✓	✓	-	✓	✓	✓
Inglewood	-	-	-	-	✓	✓
Crenshaw on	-	-	✓	✓	-	-
I-110 off/on	-	✓	-	-	✓	✓

NOTES:
[a] Based on 2006 HICOMP report.
[b] Based on Caltrans District 7 sample probe vehicle runs, taken in March/April 2002 and 2003.
[c] Based on Performance Measurement System (PeMS) sample daily speed contours taken from April & October 2003, and 2003 quarterly weekday averages.
- No indication of bottleneck from this source.
✓ Bottleneck identified from this source.

ANALYSIS DETAILS

HICOMP

In review of the Caltrans Highway Congestion Monitoring (HICOMP) 2006 report, potential problem areas are initially identified. As illustrated in Exhibits 4-2 and 4-3, the downstream end of congested segments could potentially be bottleneck areas in the southbound direction, as outlined in blue circles, and in the northbound direction, as outlined in red circles.

- As indicated, in the **AM peak** there are potentially two major bottlenecks in the northbound direction and three major bottlenecks in the southbound direction, as identified in the 2006 HICOMP:
    - Rosecrans Avenue (NB)
    - 135th Street, south of El Segundo Boulevard (SB)
    - Culver Boulevard (NB)
    - Montana Avenue (SB)
    - US-101 Interchange (SB)
- In the **PM peak**, there are potentially three major bottlenecks in the northbound direction and three in the southbound direction:
    - Van Ness Avenue/I-110 Interchange (SB)
    - Rosecrans Avenue (SB)
    - Ballona Creek, south of Culver Boulevard (SB)
    - Getty Center Drive (NB)
    - Mulholland Drive (NB)
    - Lassen Street, north of Nordhoff Street (NB)

Further analysis would be needed, however, to determine their actual locations and possibly any other bottlenecks along the corridor not identified in the HICOMP. The review of the HICOMP provides a good starting point to keep in mind of the congested areas and possible bottleneck locations as more detailed analysis is conducted.

Exhibit A4-2: 2006 HICOMP AM Congestion Map with Potential Bottlenecks

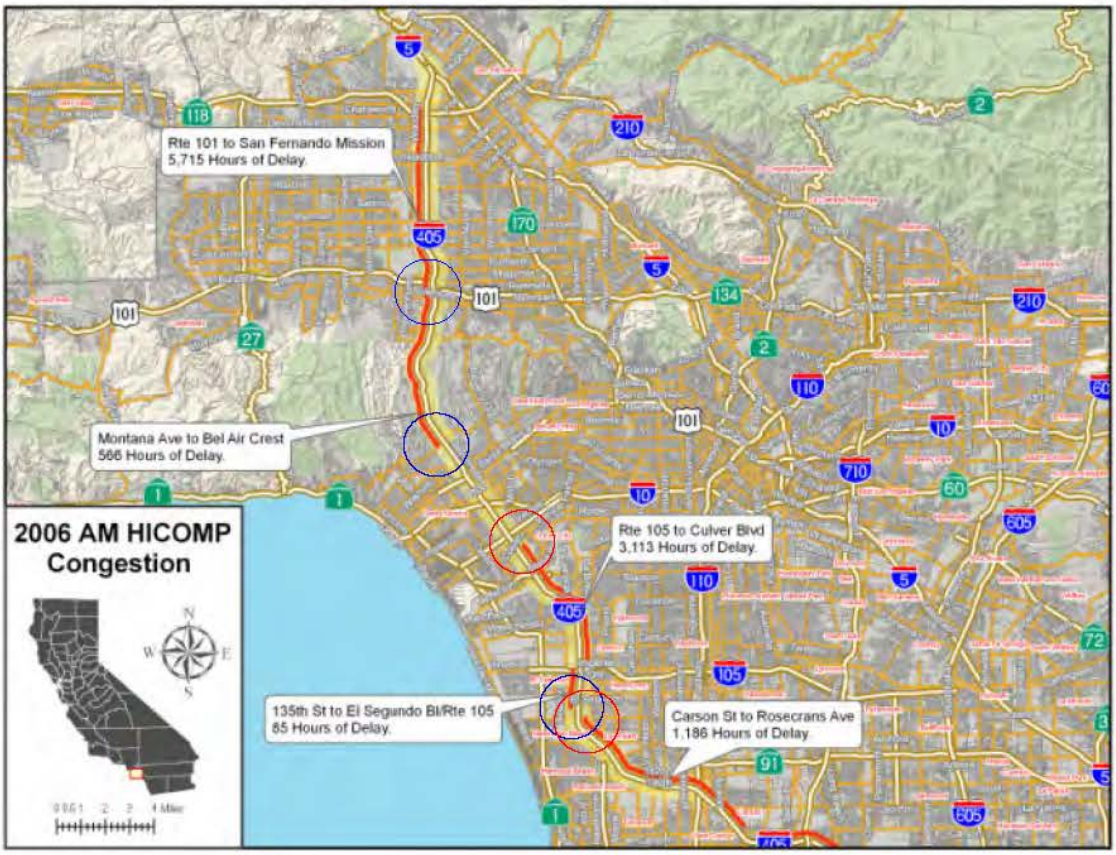
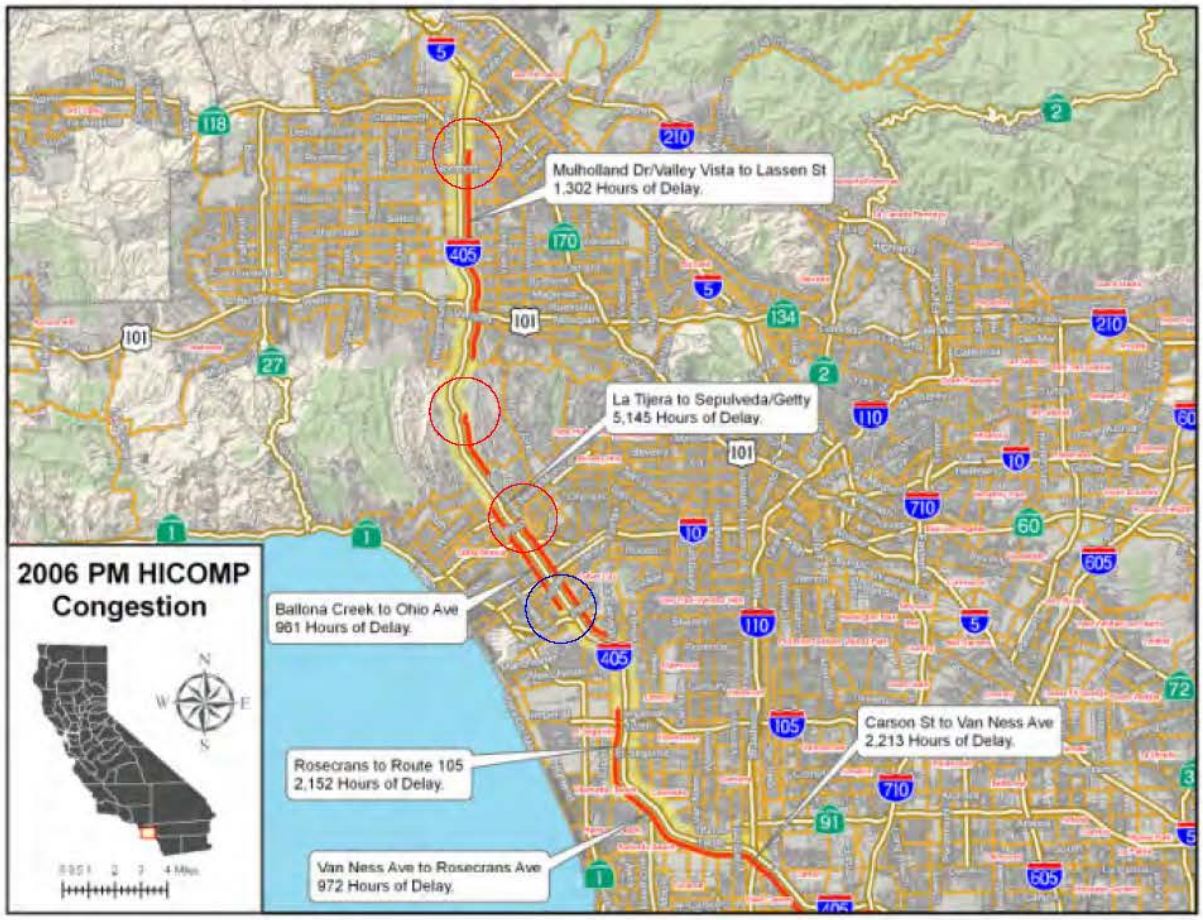


Exhibit A4-3: 2006 HICOMP PM Congestion Map with Potential Bottlenecks

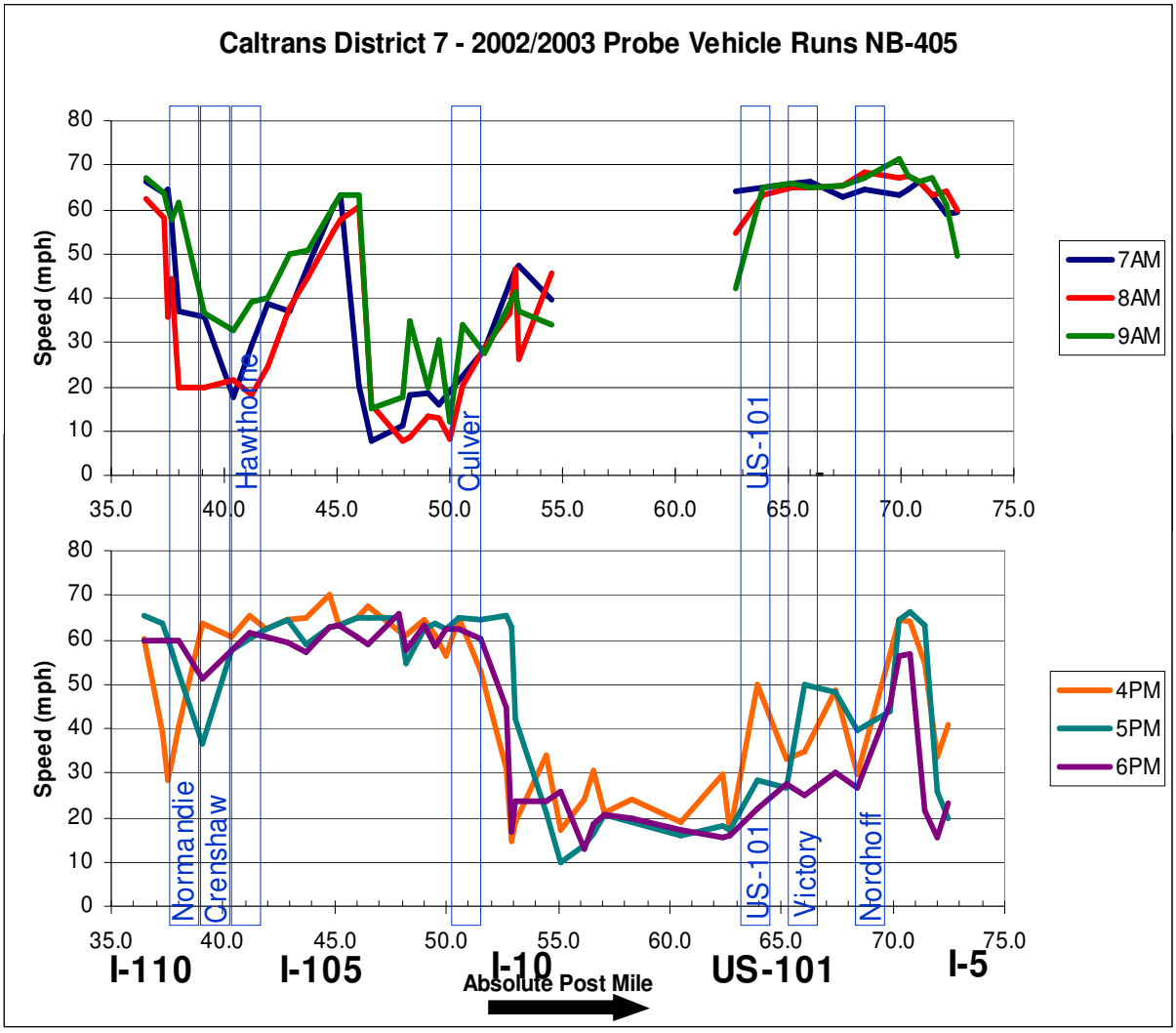


Probe Vehicle Runs

The probe vehicle runs (electronic tach 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 miles per hour to 50 miles per hour.

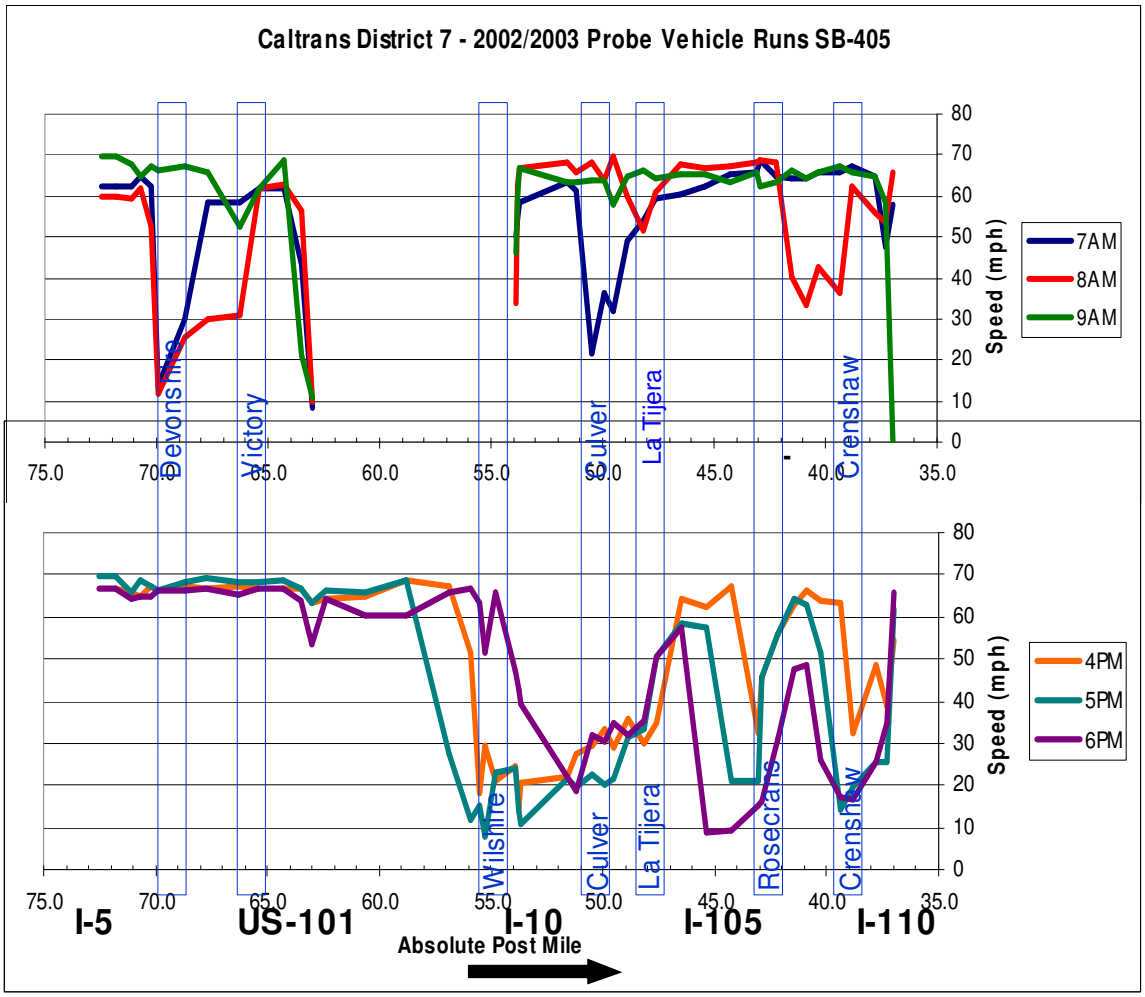
Caltrans District 7 collected probe vehicle run data in March and April 2002 and March 2003, their most recent data available, for the I-405 freeway from I-605 junction to the I-5 junction. The freeway corridor runs were broken into five separate segments from I-605 to I-110, I-110 to I-105, I-105 to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

Exhibit A4-4: Northbound I-405 Probe Vehicle Runs



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

Exhibit A4-5: Southbound I-405 Probe Vehicle Runs



- As indicated, major southbound bottlenecks from the probe vehicle runs were identified at:
    - Devonshire Street on (AM)
    - Victory Boulevard on (AM)
    - Wilshire Boulevard off (PM)
    - Culver Boulevard on (AM/PM)
    - La Tijera Boulevard off (AM/PM)
    - Rosecrans Avenue off (PM)
    - Crenshaw Boulevard on (AM/PM)

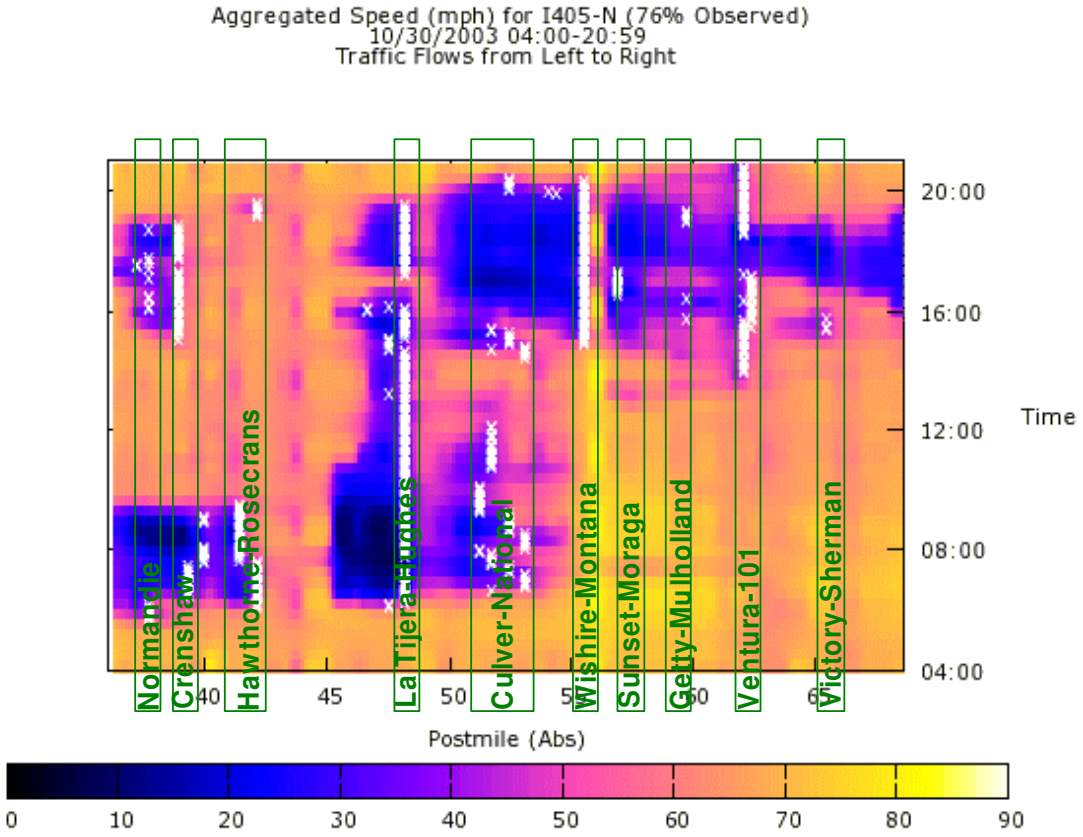
Freeway Performance Measurement System (PeMS)

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

NORTHBOUND

Exhibit 4-6 illustrates the speed contour plot on Thursday, October 30, 2003. The speed contour plot represents a typical weekday sample to illustrate the bottleneck locations and congestion formed from them. The sample day had observed or “good” detection data of 76%, providing reasonably accurate results. The speed contour plot illustrates the typical speed contour diagram for the I-405 freeway in the northbound direction (traffic moving left to right on the plot). Along the vertical axis is the time period from 4AM to 8PM. Along the horizontal axis is the corridor segment from south of I-110 to I-5. The various colors represent the average speeds corresponding to the color speed chart shown below the diagram. As shown, the dark blue blotches represent congested areas where speeds are reduced. The ends of each dark blotch represent bottleneck areas, where speeds pickup after congestion, typically to 30 to 50 miles per hour in a relatively short distance. The horizontal length of each plot is the congested segment, queue lengths. The vertical length is the congested time period.

Exhibit A4-6: PeMS Northbound I-405 Speed Contour Plot – October 2003

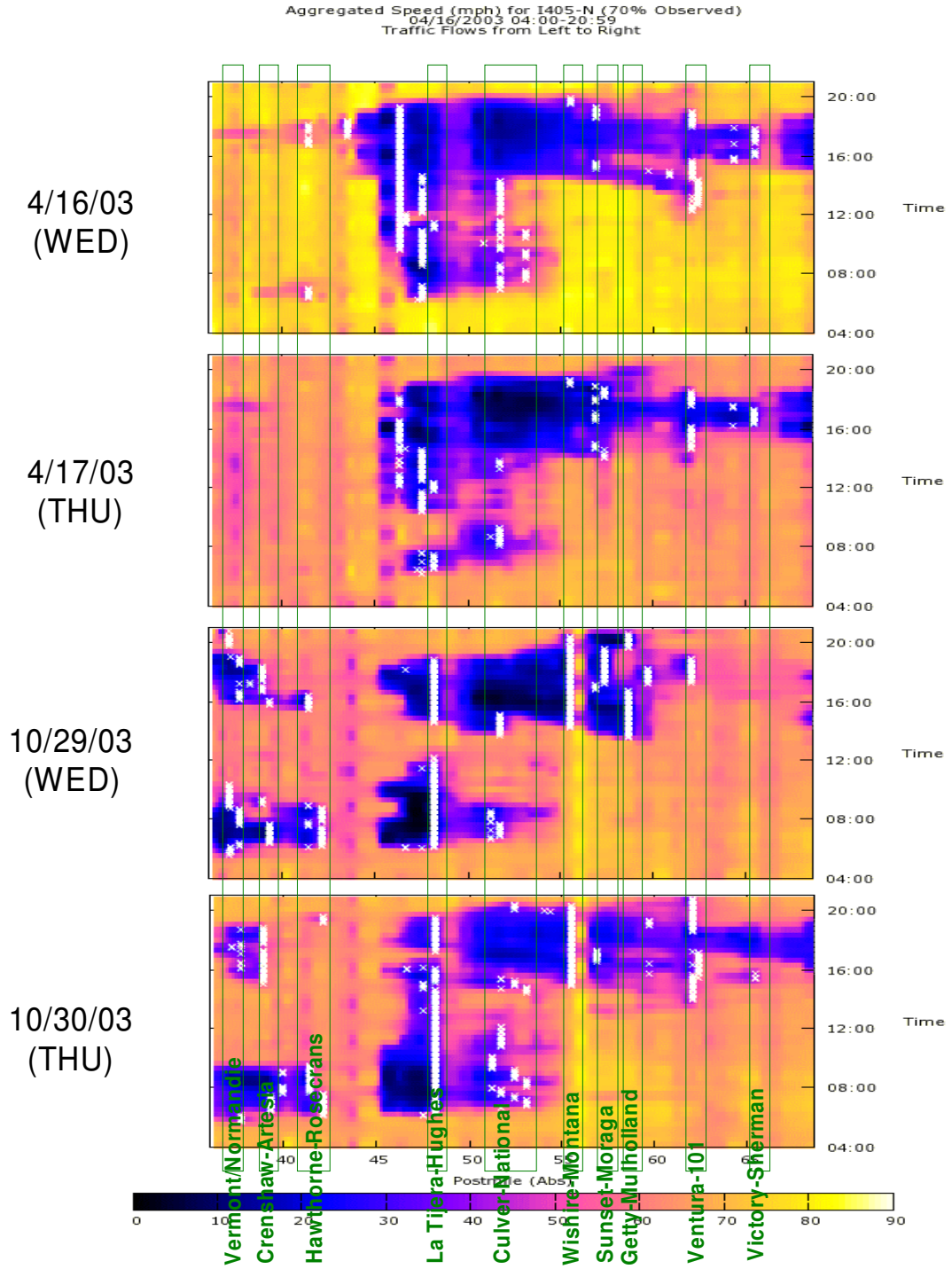


- Based on the contour plot of a typical weekday sample in October 2003, the following bottlenecks were identified in the <u>northbound</u> direction:

  - Normandie Avenue off (AM/PM)
  - Crenshaw Boulevard off (AM/PM)
  - Hawthorne Boulevard on (AM)
  - Rosecrans Avenue off (AM)
  - Howard Hughes Parkway on (AM/PM)
  - Various from Culver Boulevard to National Boulevard (AM/PM)
  - Wilshire Boulevard on (PM)
  - Sunset Boulevard on (PM)
  - Getty Center Drive to Mulholland Drive (PM)
  - US-101 off (PM)
  - Victory Boulevard on (PM)

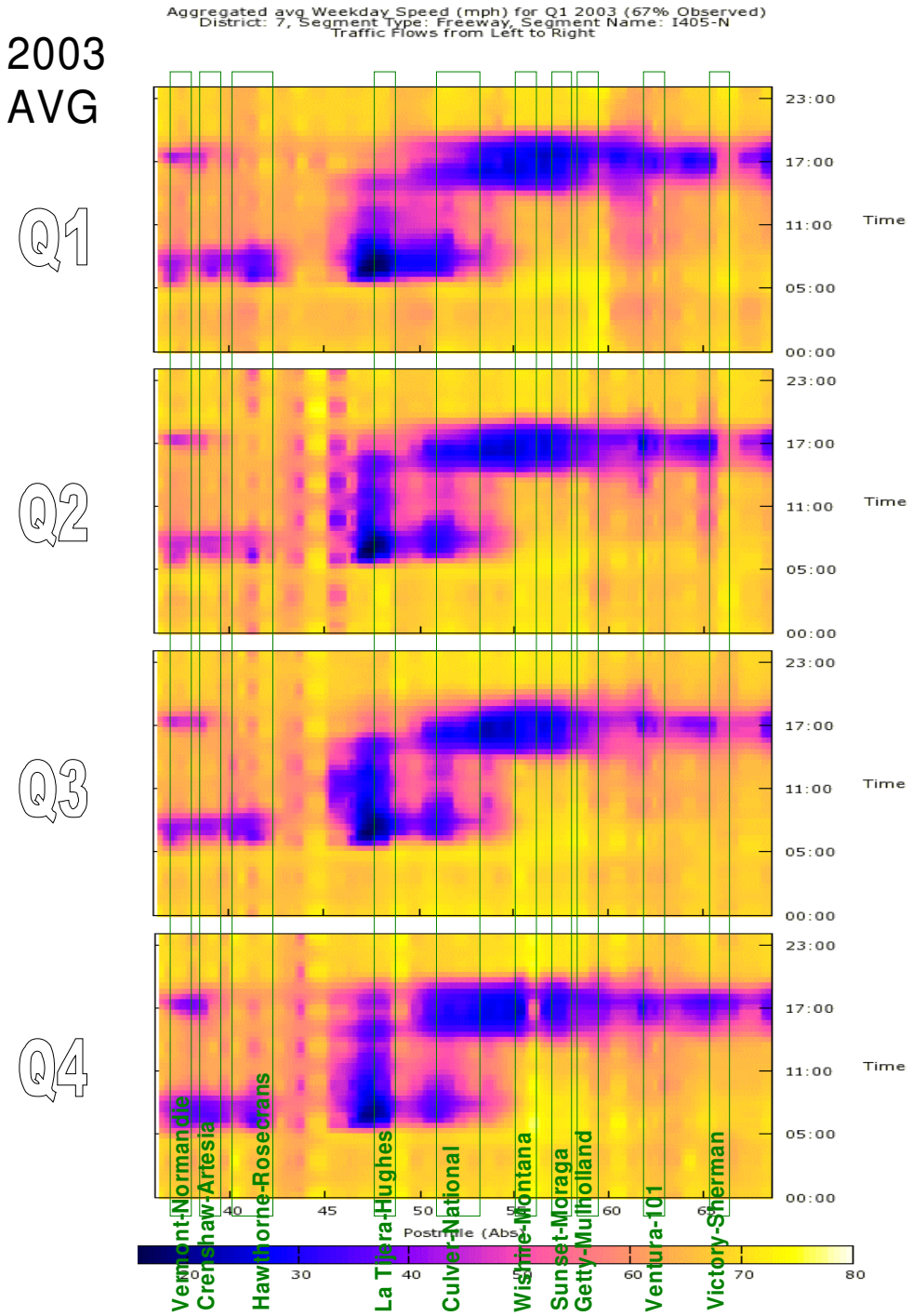
In addition to a sample day in 2003, additional sample days were also analyzed. Exhibit 4-7 illustrates the speed contours of additional weekday samples in April and October 2003. The same bottleneck locations are identified on each of the four different sample days, indicating a reoccurring pattern of the bottleneck locations.

Exhibit A4-7: PeMS Northbound I-405 Speed Contour Plots – April/October 2003



In addition to multiple days, larger averages were also analyzed. Exhibit 4-8 illustrates the weekday averages by each quarter of 2003. Again, the same bottleneck locations are identified. From the long contours, the same bottlenecks are evident, further validating the reoccurring pattern of the bottleneck locations.

Exhibit A4-8: PeMS Northbound I-405 Long (Speed) Contours – 2003 by Qtr Avg



SOUTHBOUND

Similarly, speed contour plots for the same sample days and 2003 quarterly weekday average long contours were analyzed for the southbound direction. Exhibits 4-9 to 4-11 illustrate the speed contour plots for the I-405 freeway corridor in the southbound direction (traffic moving left to right on the plot) for a sample weekday in October 2003, four typical weekdays in April and October 2003, and 2003 quarterly weekday average long contours. Along the vertical axis is the time period from 4AM to 8PM. Along the horizontal axis is the corridor segment from south of I-110 to I-5. Similar to the northbound PeMS speed contour analysis results, the PeMS southbound speed contour analysis results indicate reoccurring bottleneck locations across multiple weekdays and quarterly averages.

- Based on these contour plots of typical weekday samples in April and October 2003 and quarterly averages of weekdays, the following bottlenecks were identified in the southbound direction:
    - I-110 (PM)
    - Inglewood Avenue off (AM/PM)
    - El Segundo Boulevard on to Rosecrans Avenue off (AM/PM)
    - La Tijera Boulevard off (AM/PM)
    - Culver Boulevard on (AM/PM)
    - Wilshire Boulevard off (AM)
    - Sunset Boulevard on (AM)
    - Victory Boulevard on (AM)
    - Devonshire Street on to Nordhoff Street off (AM)

Exhibit A4-9: PeMS Southbound I-405 Speed Contour Plot – October 2003

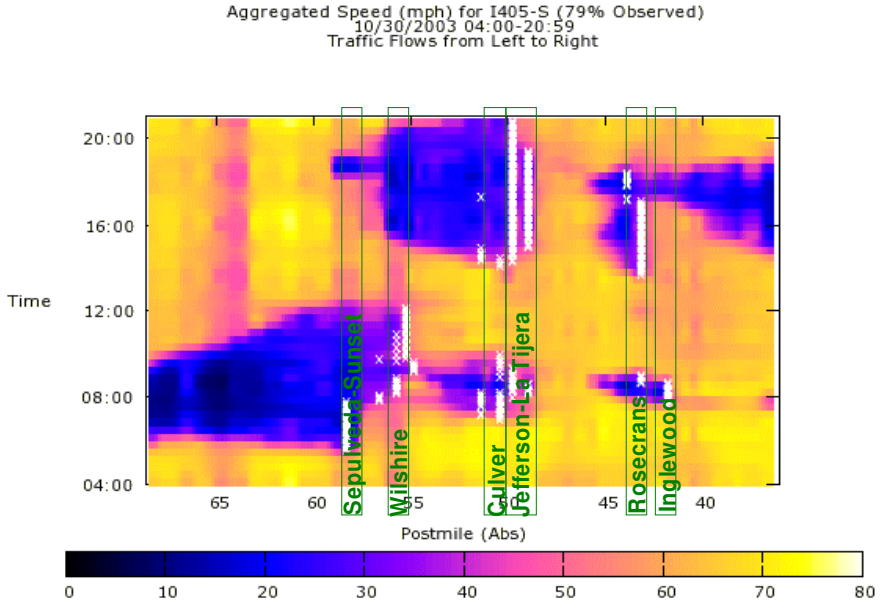


Exhibit A4-10: PeMS Southbound I-405 Speed Contour Plots – April/October 2003

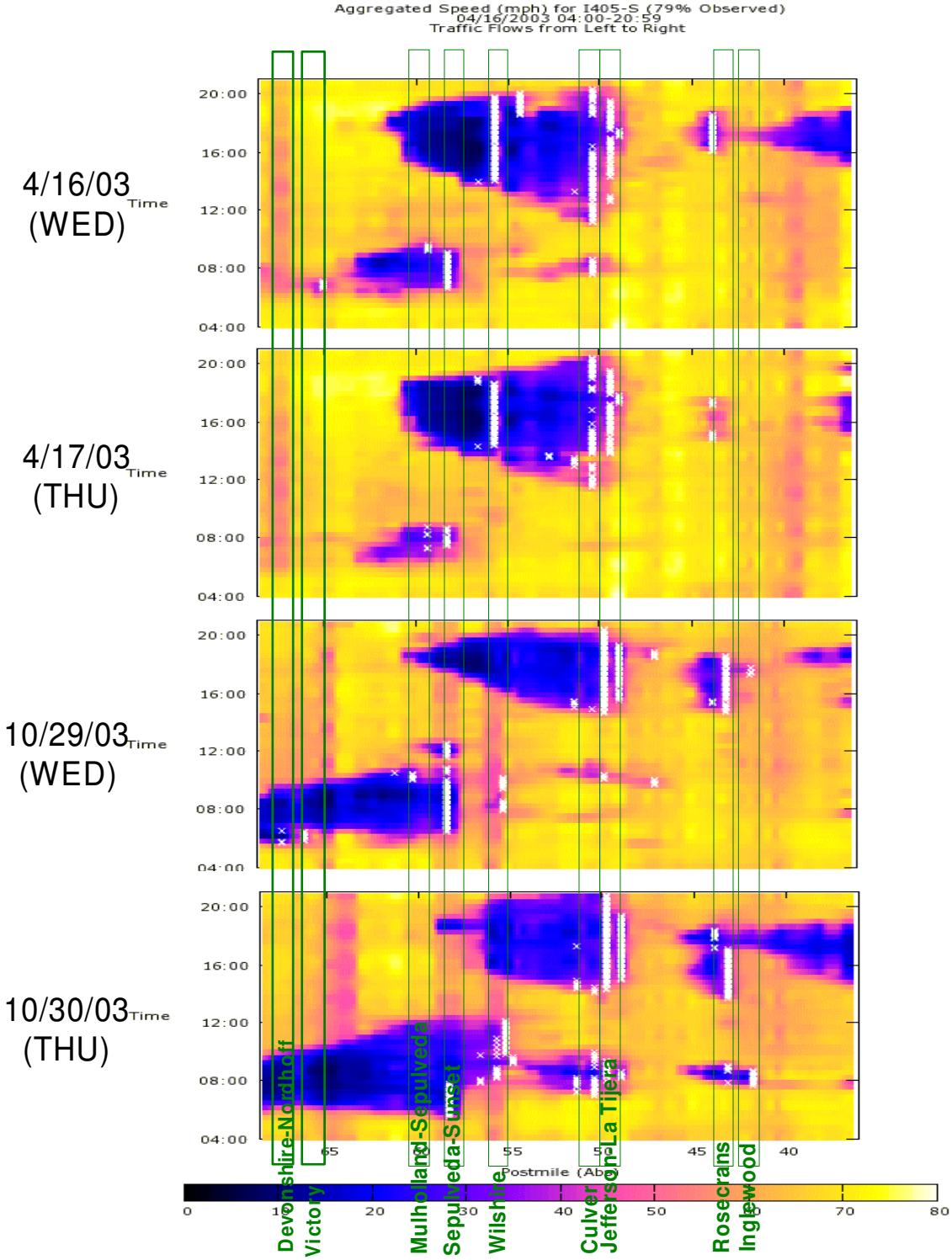
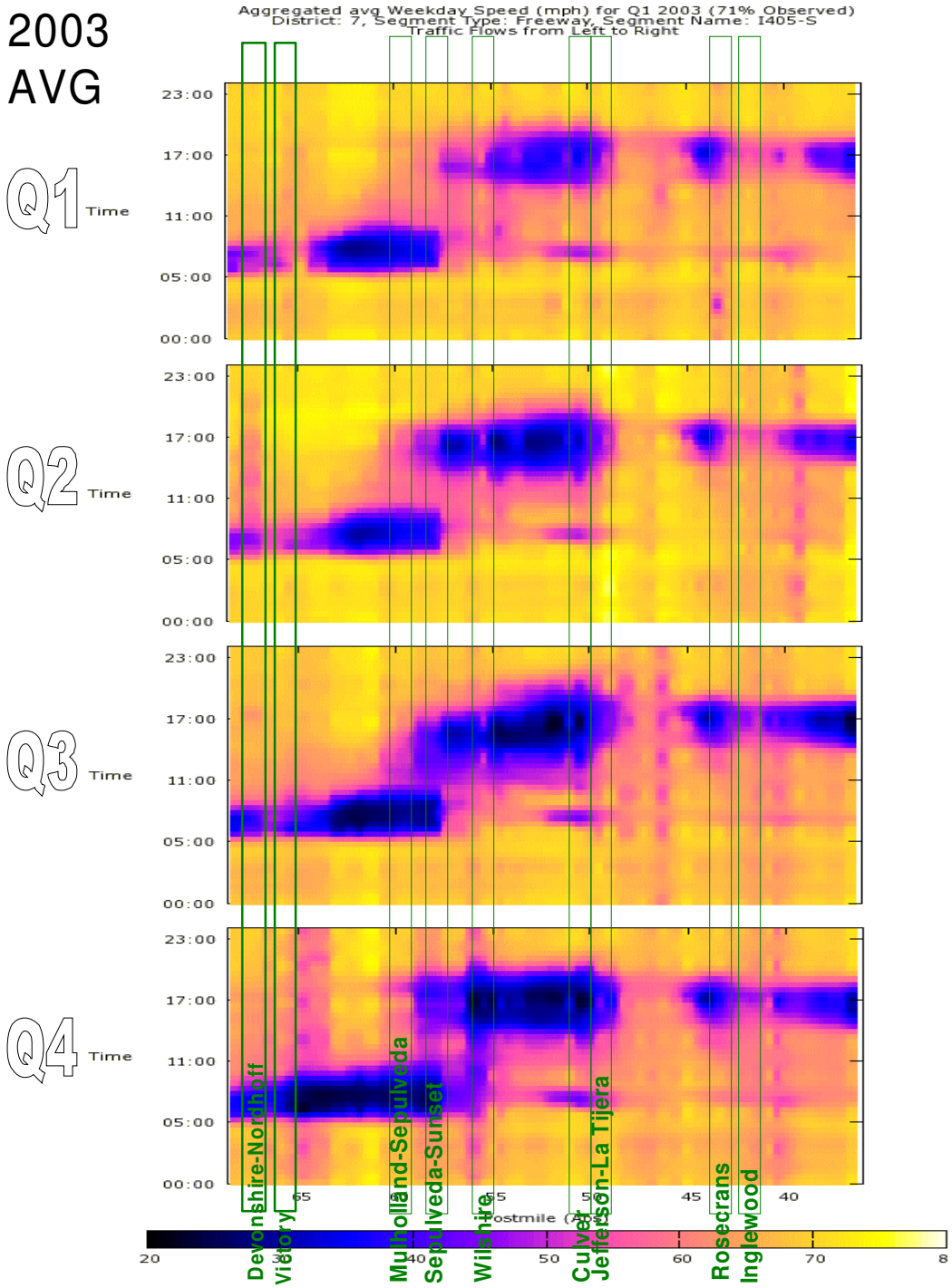



Exhibit A4-11: PeMS Southbound I-405 Long (Speed) Contours – 2003 by Qtr Avg