Caltrans

FINAL

CORRIDOR SYSTEM MANAGEMENT PLAN (CSMP)
LOS ANGELES COUNTY I-5
FROM ORANGE COUNTY LINE TO I-710
COMPREHENSIVE PERFORMANCE ASSESSMENT
AND
CAUSALITY ANALYSIS

May 8, 2009

System Metrics Group, Inc.

Table of Contents

List of Exhibits

1. INTRODUCTION

This document represents the final for the fifth and sixth milestones of the Los Angeles County Interstate 5 (I-5) Corridor System Management Plan (CSMP) development process, which is required by the California Transportation Commission (CTC) for corridors that received funding from the Corridor Mobility Improvement Account (CMIA) approved by the voters in 2006. The CMIA will partially fund the construction of High Occupancy Vehicle (HOV) lanes from the Los Angeles/Orange County line to the I-710.

These two milestones 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 long 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 and updated 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*
This section presents multiple years of performance data for the freeway portion of the defined CSMP corridor. Statistics are included for the mobility, reliability, safety, and productivity performance measures. Wherever possible, this section has been expanded from the preliminary performance assessment by adding performance results through December 2008. A new section on pavement conditions on the freeway was also added.

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 terms of 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 to selecting projects to address the critical bottlenecks. Moreover, they provide the baseline against which micro-simulation models will be validated. Finally, this section represents the sixth milestone of the CSMP development process.

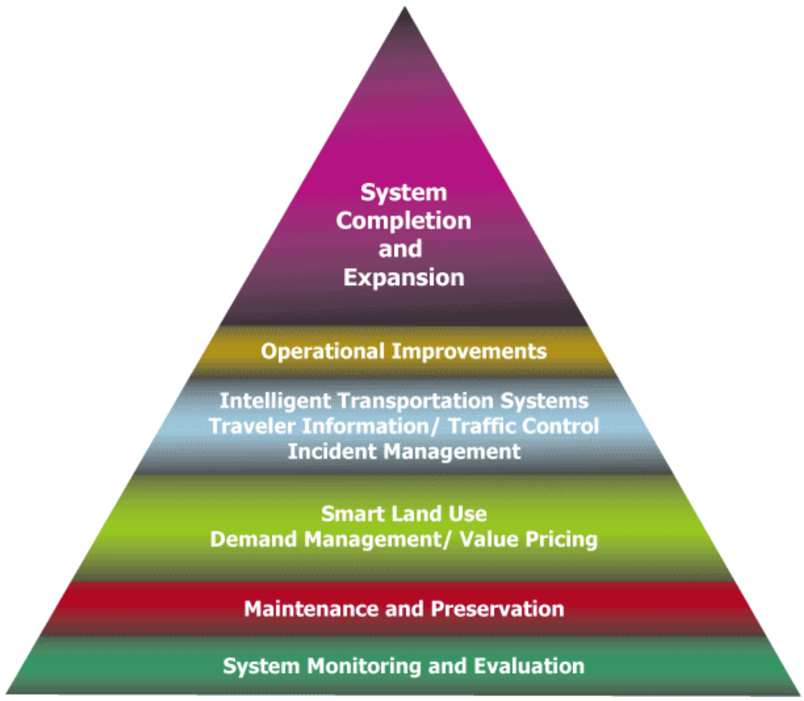
The remainder of this introduction provides some background on system management, a framework that eventually led to the CSMP requirement. It also includes a discussion on data sources and the state of detection on the I-5 freeway facility.

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 current California Administration as part of its 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 defined I-5 Corridor.

Existing Data Sources

The available data analyzed for the comprehensive 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 Traffic Accident Surveillance and Analysis System (TASAS) from PeMS
- Traffic study reports (various)

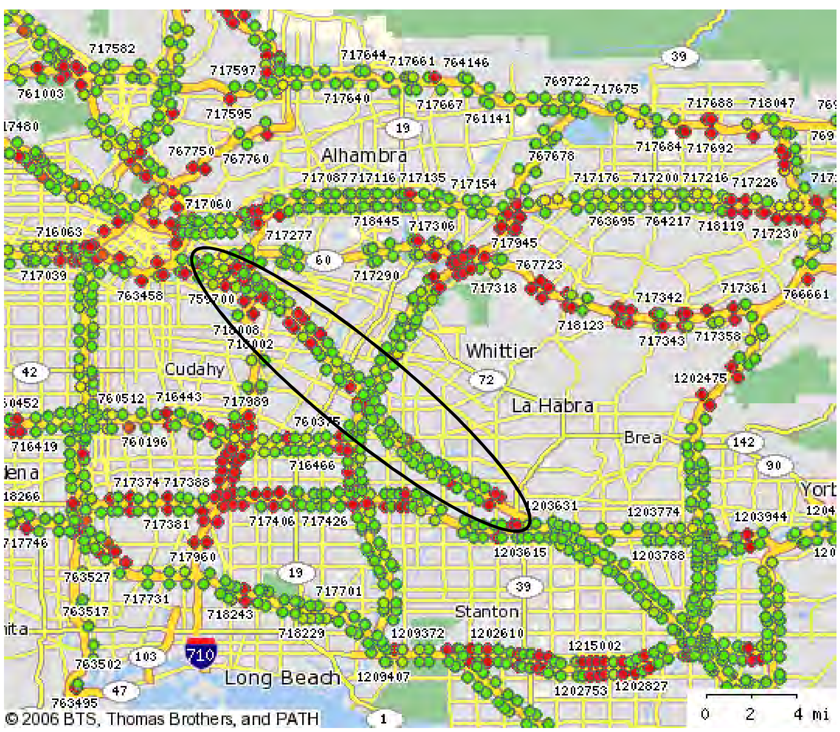
- Aerial photographs (Microsoft Virtual Earth and Google Earth) and Caltrans photologs
- Internet (i.e. Metro website, Metrolink website, etc.).

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 depicts the corridor freeway facility with the detectors in place as of November 25, 2008. This date was chosen randomly to provide a snapshot of the detection status. The exhibit shows that there are many detectors on the mainline, almost all functioning well (based on the green color). Furthermore, it illustrates some seemingly small gaps between detectors at some locations.

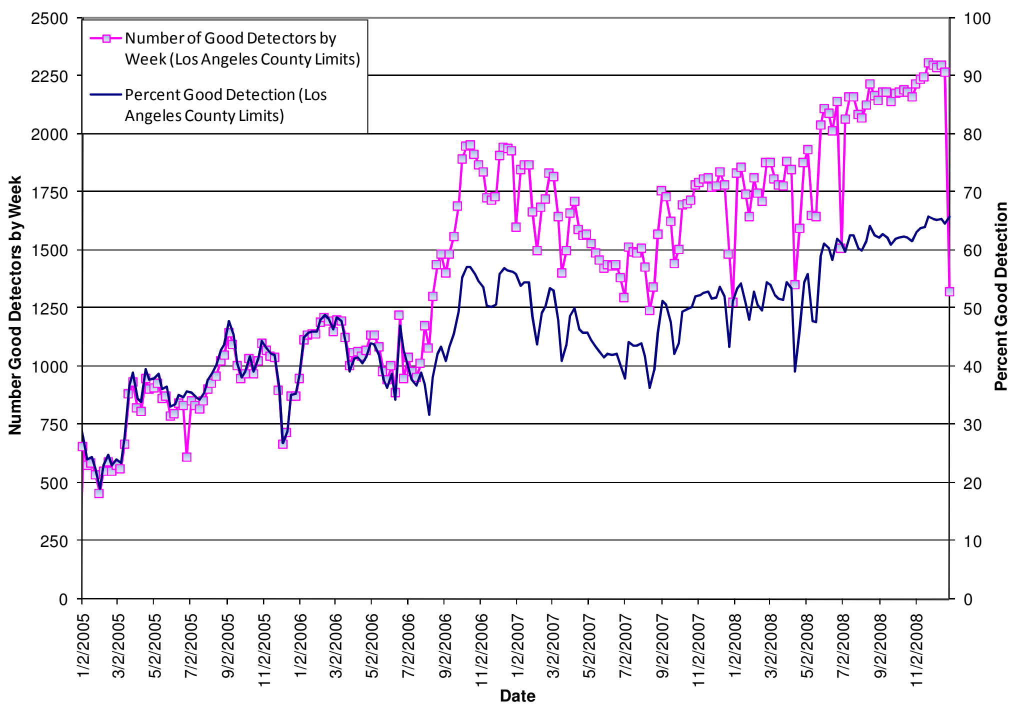
Exhibit 1-2: I-5 Sensor Status (November 25, 2008)



Source: PeMS data

The following exhibits provide a better picture of how the detectors on the corridor performed over a longer period of time. Exhibits 1-3 and 1-4 report the number and percentage of "good" detectors by week for the entire I-5 in Los Angeles County from 2005 to 2008. The left y-axis shows the scale used for the number of detectors, while the right y-axis shows the scale used for the percent good detectors. These exhibits suggest that detection in the northbound direction (Exhibit 1-3) was slightly better than the southbound direction (Exhibit 1-4), particularly in 2007 and 2008 when the percentage of good detectors in the northbound direction reported around 50 percent compared to 40 percent in the southbound direction. The difference appears to be due to the addition of a large number of operating detectors at the end of 2006 in the northbound direction.

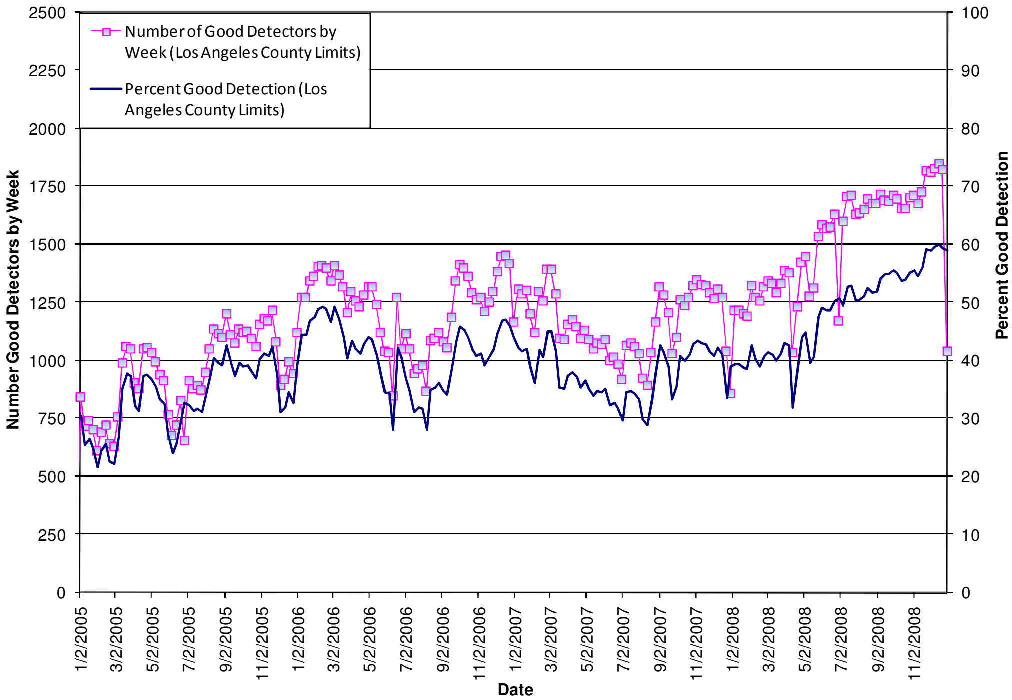
Exhibit 1-3: Number and Percentage of Good Detection on Northbound I-5 (Los Angeles County Limits)



Source: SMG analysis of PeMS data
Note: Number of Good Detectors by Week can be divided by seven (7) to estimate total number of good detectors in the field

Exhibits 1-3 and 1-4 also show that detection on the entire I-5 Los Angeles corridor experienced a general improvement from 2005 to 2008, reaching or exceeding 60 percent of good detection in 2008.

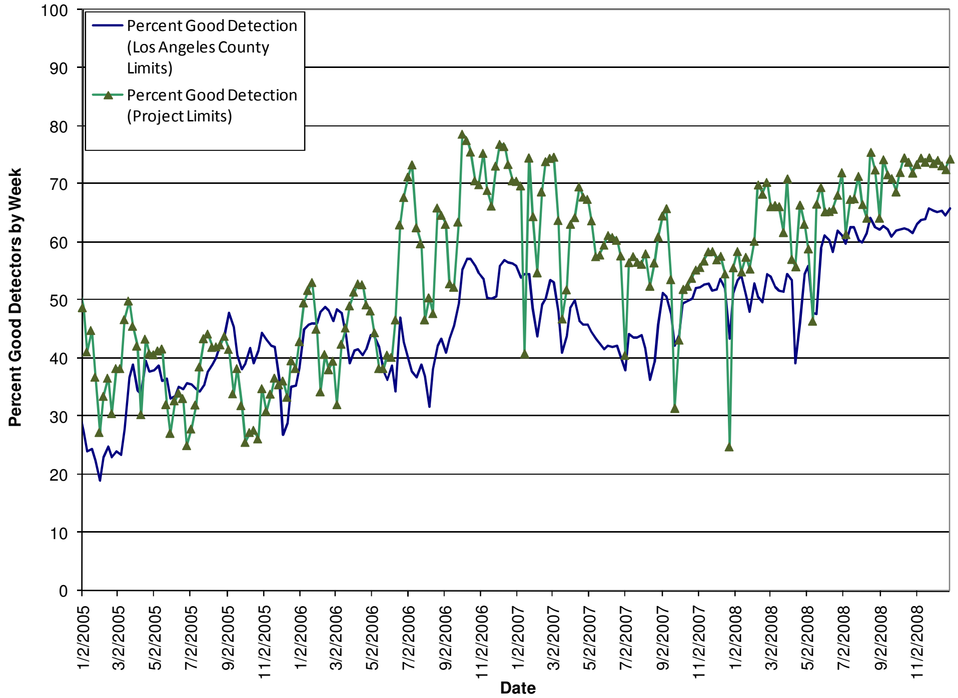
Exhibit 1-4: Number and Percentage of Good Detection on Southbound I-5 (Los Angeles County Limits)



Source: SMG analysis of PeMS data
Note: Number of Good Detectors by Week can be divided by seven (7) to estimate total number of good detectors in the field

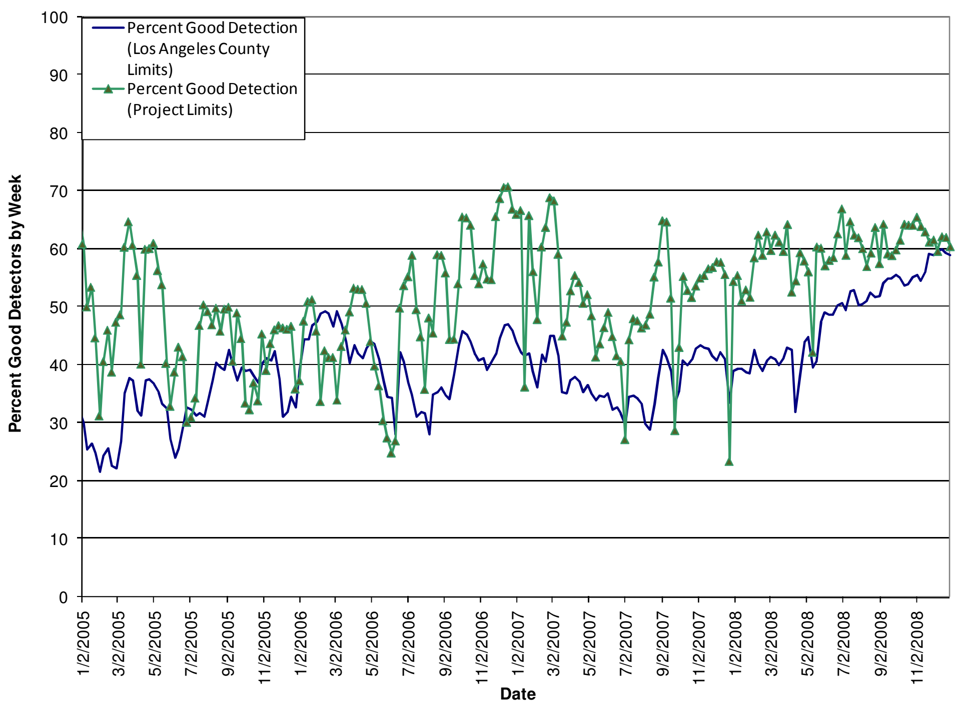
Exhibits 1-5 and 1-6 isolate the I-5 study corridor (in green) and reports the percentage of good detectors within the I-5 corridor limits compared to all of LA County (in blue). As the exhibits illustrate, the I-5 corridor has better detection in both directions relative to the freeway as a whole (in LA County). As for the countywide statistics reported in the previous exhibits, the northbound direction (Exhibit 1-5) of the study corridor exhibited greater detection compared to the southbound direction (Exhibit 1-6). The detection on the study corridor generally improved between 2005 and 2008, reaching 75 percent in the northbound direction and 65 percent in the southbound direction.

Exhibit 1-5: Percentage of Good Detection on Northbound I-5 (Project Limits)



Source: SMG analysis of PeMS data

Exhibit 1-6: Percentage of Good Detection on Southbound I-5 (Project Limits)



Source: SMG analysis of PeMS data

Part of the increased detection quality in 2008 may be attributed to improved maintenance of the existing detection. Regardless of the reason, this trend is very encouraging and should allow for detailed analysis capabilities now and in the future. By comparing detectors in detail, we identified three detectors that were added in 2008. These are shown in Exhibit 1-7.

Exhibit 1-7: I-5 Detection Added (2008)

VDS	Location	Type	CA PM	Abs PM	Date Online
NORTHBOUND					
769625	Rosecrans	ML	3.28	119.91	2/14/2008
769626	Rosecrans	Off-Ramp	3.28	119.91	2/14/2008
771209	Atlantic	Off-Ramp	12.68	129.31	9/11/2008
SOUTHBOUND					
	None				

Source: SMG analysis of PeMS data

Finally, an analysis of gaps without detection is shown in Exhibit 1-8. Note that there is one segment in each direction extending over 0.75 miles without detection. These should be considered for deployment of additional detection when funding becomes available.

Exhibit 1-8: I-5 Gaps In Detection (November 25, 2008)

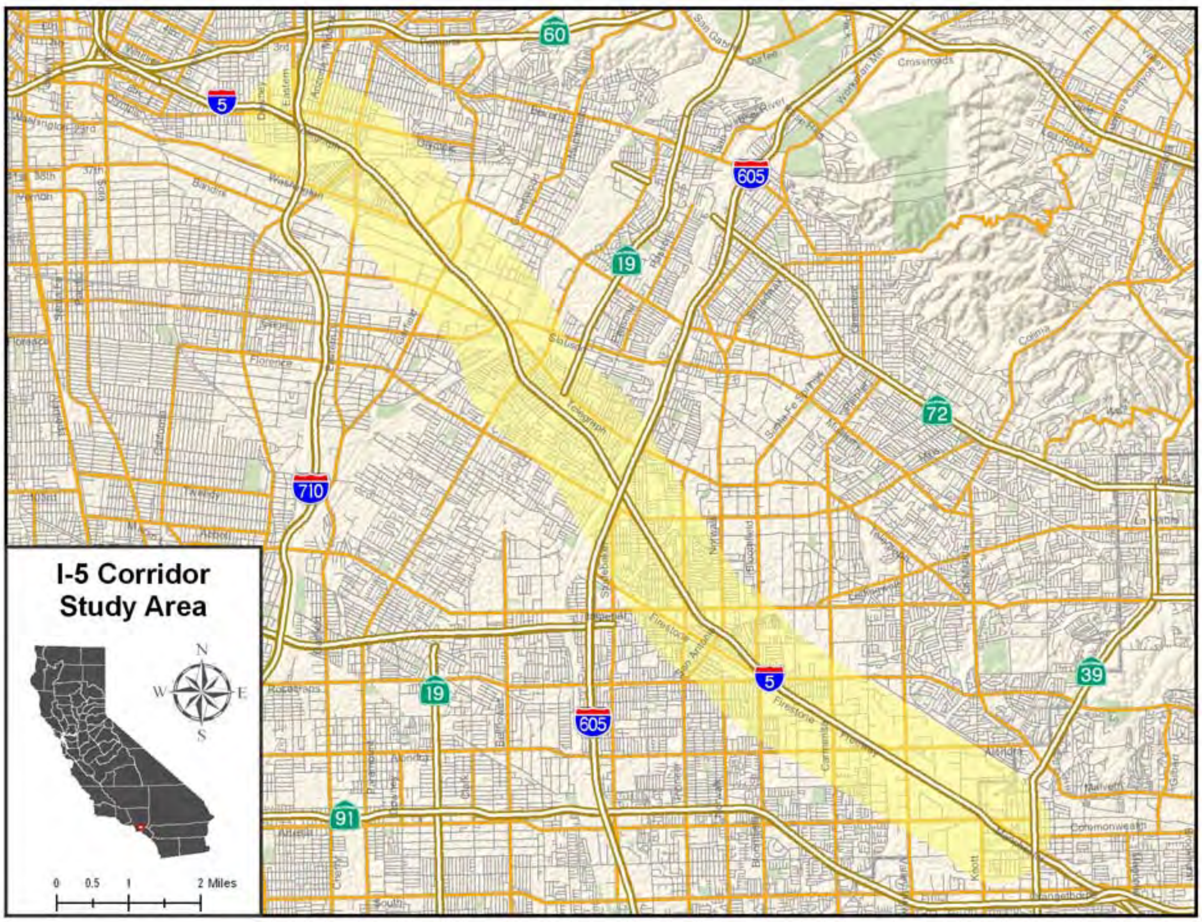
Location	Abs PM		Length (Miles)
	From	To	
NORTHBOUND			
SB 605 to NB 5 (Fwy-Fwy) to Garnish (ML)	123.633	124.433	0.80
SOUTHBOUND			
SB 605 to NB 5 (Fwy-Fwy) to Garnish (ML)	123.6	124.37	0.77

Source: SMG analysis of PeMS data

2. CORRIDOR DESCRIPTION

The Golden State Freeway (I-5) study corridor begins at the Orange County/Los Angeles County border and runs in a northwesterly direction to the I-710 (Long Beach Freeway) interchange. The freeway corridor, as defined by Caltrans District 7, extends approximately 14 miles from the Orange County (OC)/Los Angeles (LA) County Line at Post Mile (PM) 0.000 to the I-710 interchange at PM 13.784. It traverses through the cities of La Mirada, Norwalk, Santa Fe Springs, Downey, Pico Rivera, Bell Gardens, and Commerce.

Exhibit 2-1: Map of I-5 Study Area



Corridor Roadway Facility

The study corridor crosses through Los Angeles County and includes the following major freeway-to-freeway and arterial interchanges:

- Artesia Boulevard runs east-to-west connecting Orange County at Beach Boulevard (SR-39) to the South Bay and the coastal cities of Hermosa Beach and Manhattan Beach.

- Valley View Avenue runs north-to-south connecting Imperial Highway to the Garden Grove Freeway (SR-22) in Orange County.

- Rosecrans Avenue runs east-to-west connecting the city of Fullerton in Orange County to the South Bay and the coastal cities of Manhattan Beach and El Segundo.

- Imperial Highway runs east-to-west and connects the Riverside Freeway (SR-91) in the city of Anaheim to the Los Angeles World Airports.

- The San Gabriel River Freeway (I-605) runs north-to-south and provides access to the cities of Norwalk, Downey, Pico Rivera, and Santa Fe Springs. It also provides access to Orange County and the I-105 freeway connecting to the Los Angeles World Airports.

- Lakewood Boulevard/Rosemead Boulevard (SR-19) runs north-to-south paralleling the I-605, connecting the I-210 and San Gabriel Valley to the Long Beach Airport and the I-405 Freeway.

- The Long Beach Freeway (I-710) runs north-to-south and connects the San Gabriel Valley to the Port of Long Beach. It provides access to the cities of East Los Angeles and Commerce.

According to annual traffic reports from the Caltrans Traffic and Vehicle Data Systems Unit, the I-5 Corridor carries between 165,000 and 255,000 annual average daily traffic (AADT)[1] as shown in Exhibit 2-2. The highest traffic occurs near the junction of the I-710 interchange. Traffic volumes decrease as travel approaches the southern end of the corridor.

[1] AADT is the total annual volume of vehicles counted divided by 365 days.

Exhibit 2-2: Major Interchanges and AADT on the I-5 Corridor

Source: AADT is from the Caltrans Traffic and Vehicle Data Systems Unit[2]

As illustrated in Exhibit 2-3, the I-5 Corridor is a Surface Transportation Assistance Act (STAA) route, which permits large trucks to operate on them. According to the validated truck volumes from the 2006 Caltrans Annual Average Daily Truck Traffic data, trucks comprise between 7.2 and 10 percent of the total daily traffic along the corridor with the highest percentage at the Firestone interchange in the city of Norwalk.

The current Transportation Systems Network (TSN) records and latest available aerial photos and photologs indicate that the I-5 generally has three to five lanes in each direction of travel. Exhibit 2-4 shows the lane configurations on the corridor according to the latest available aerial photos and field visit visits conducted.

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

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

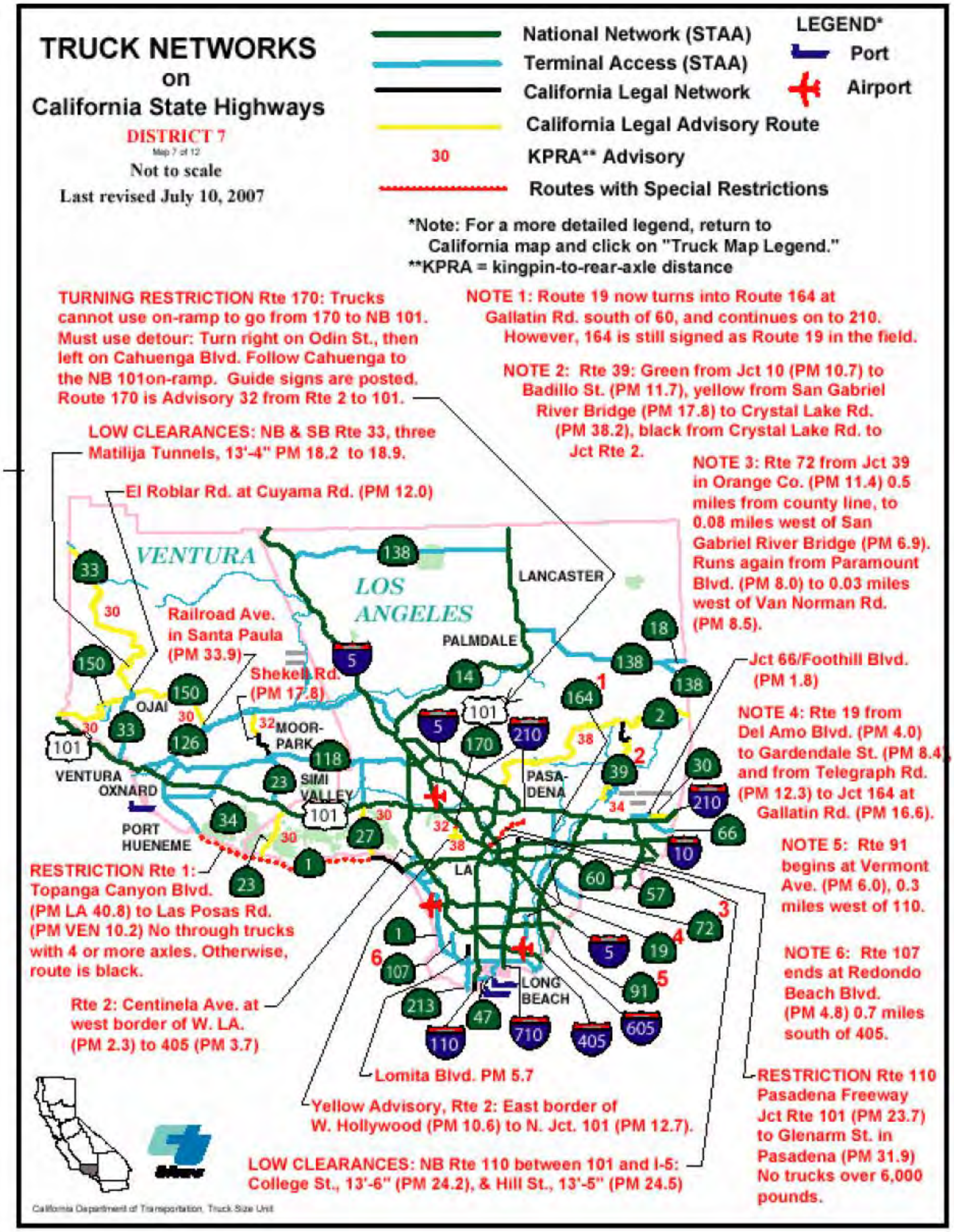
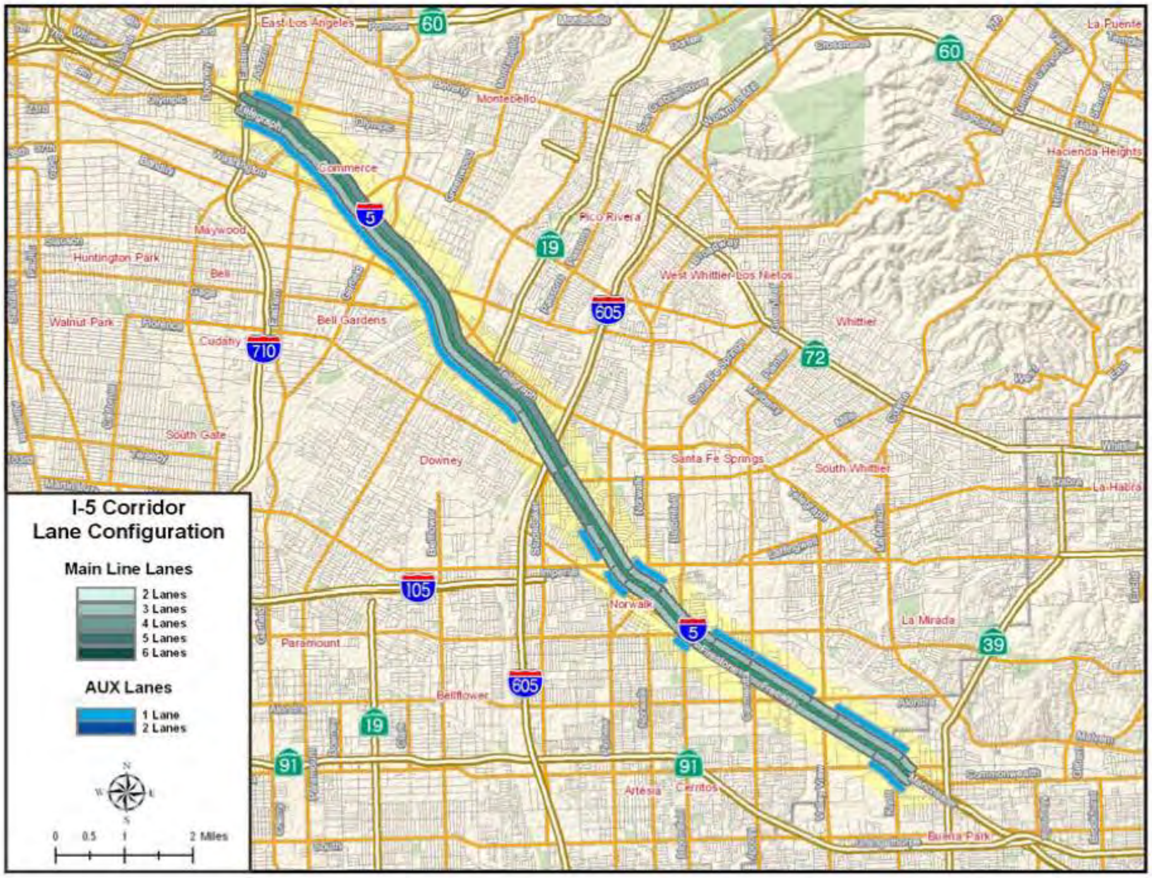


Exhibit 2-4: Lane Configurations on the I-5 Corridor



Page Intentionally Left Blank for Future Updates on Corridor Roadway Facility Statistics

Corridor Transit Services

The following major public transportation operators provide service near the I-5 CSMP corridor:

- Southern California Regional Rail Authority (SCCRA) - Metrolink
- Amtrak
- Los Angeles County Metropolitan Transportation Authority (Metro).

As of early 2007, overall Metrolink weekday ridership was slightly above 44,000 per day. This reflects a growth of 4 percent from 2006 boardings. Both the Metrolink Orange County Line and 91 Line offer rail service from downtown Los Angeles to Orange County. The Orange County Line terminates in Oceanside in San Diego County with an average weekday ridership of 2,315, while the 91 Line terminates in downtown Riverside with an average weekday ridership of 7,841.

Amtrak offers the Coast Starlight and Pacific Surfliner rail services that operate parallel to the I-5 study corridor. The Coast Starlight offers daily service from Los Angeles to Oakland and Seattle. The Pacific Surfliner provides high-frequency service from San Diego to San Luis Obispo, via Los Angeles. The Pacific Surfliner is the second busiest corridor in the country with 2,898,859 riders in fiscal year (FY) 2008. According to the FY 2008 Amtrak Fact Sheet on the State of California, California has the highest Amtrak usage of any state in the country.

Metro services 1,433 square miles in Los Angeles County with over 190 bus lines and an average weekday passenger boarding of 1.2 million. Metro Line 62 runs along Telegraph Road paralleling the entire segment of the I-5 Corridor.

Exhibit 2-5 shows the Metrolink system map for Southern California while Exhibit 2-6 shows Metro service in the vicinity of the I-5 Corridor.

Exhibit 2-5: Metrolink System Map

Source: Metrolink

Exhibit 2-6: Metro Area Map Servicing of the I-5 Corridor

Source: Metro

Page Intentionally Left Blank for Future Updates on Corridor Transit Service Information

Special Event Facilities/Trip Generators

There are various facilities and institutions located along I-5 that may generate significant trips on the corridor. Downtown Los Angeles, other employment centers, and industrial warehouses are found along the corridor, as are the ports of Los Angeles and Long Beach further south. Exhibit 2-7 identifies the location of the most significant traffic generators.

Sports and Entertainment Facilities

- Dodger Stadium is the home of the Los Angeles Dodgers Major League Baseball team. The stadium has a seating capacity of approximately 56,000 and is adjacent to downtown Los Angeles, northwest of the I-5/SR-110 Interchange.
- The Staples Center is a multi-purpose sports arena in Downtown Los Angeles. It is home to several professional sports franchises - the NBA's Los Angeles Lakers and Los Angeles Clippers, the NHL's Los Angeles Kings and the WNBA's Los Angeles Sparks. The arena is host to 250 events and nearly 4,000,000 visitors a year. It can seat up to 20,000 patrons for concerts and roughly 18,000 for sporting events. Staples Center is located approximately six miles northwest of the I-5/I-710 Interchange.

Universities/Colleges

- Biola University is a private Christian university offering Bachelors, Masters, and Doctorate degrees. It is located in the City of La Mirada, 1.5 miles east of I-5.
- Cerritos College is a two-year community college located in the City of Norwalk, approximately three miles west of the I-5 and within the southern portion of the corridor.
- Many elementary, middle, and high schools near the I-5 Corridor may also influence morning and afternoon traffic.

Retail Centers

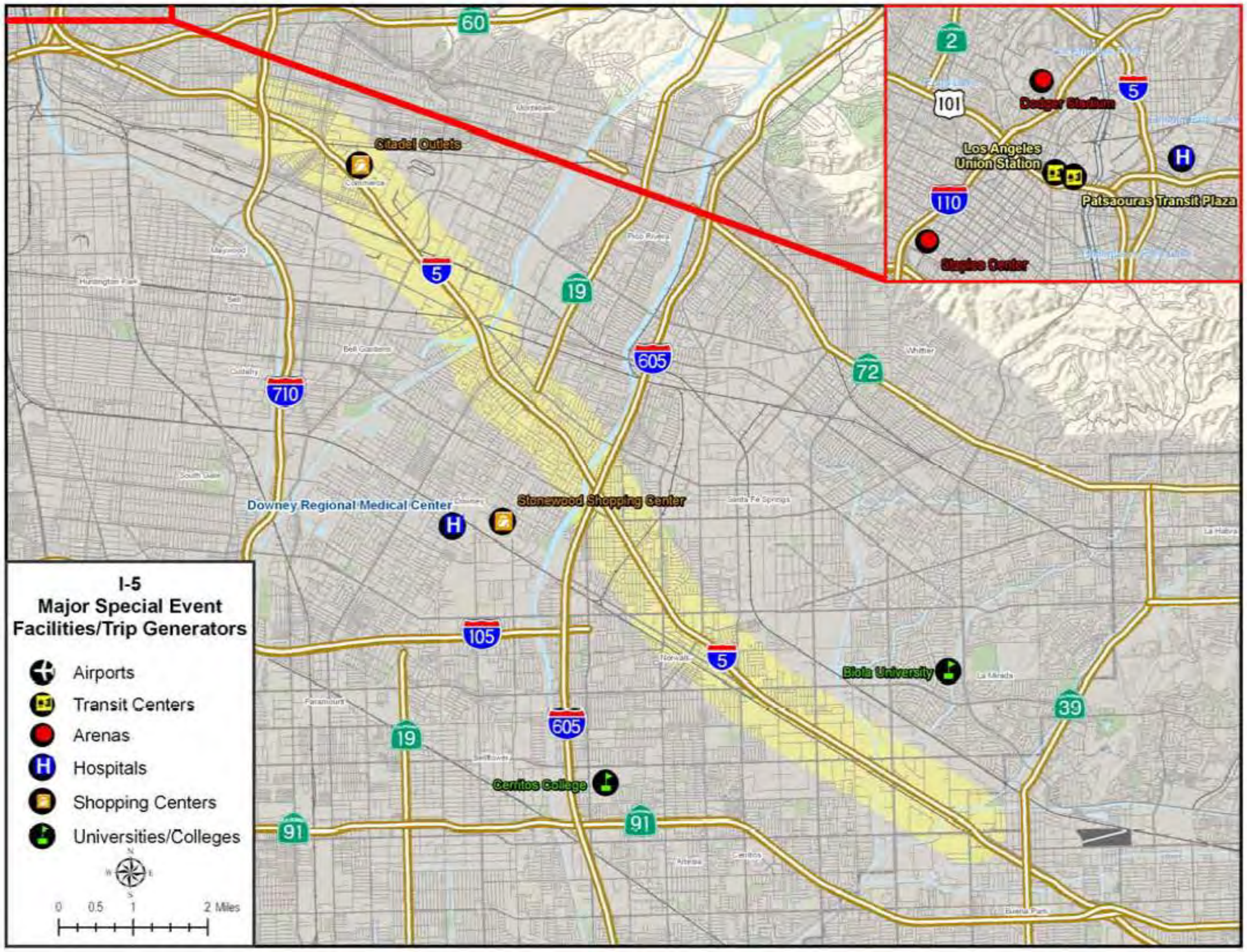
- The Citadel Outlets, Los Angeles' only outlet center opened in November 1990 as a mixed-use project which includes a retail outlet center, a food court, five office buildings, and a 201-room Double Tree Hotel. It is located immediately west of I-5 in the City of Commerce.
- Stonewood Shopping Center is located in the City of Downey on Firestone Boulevard, west of I-5. It is comprises more than 170 shops, eateries, and department stores.

A medical facility within close proximity to I-5 is the Downey Regional Medical Center. It is a 199-bed facility located approximately 1.5 miles west of the I-5 in Downey.

In addition to the facilities listed above, Los Angeles Union Station, located in downtown Los Angeles approximately one mile west of the I-5, is the terminus for four long-distance Amtrak trains. Union Station serves as the hub for Metrolink's passenger trains and provides connections to the Metro Red, Purple, and Gold light-rail lines. The Patsaouras Transit Plaza is attached to Union Station. It provides many bus services including regular Metro and Metro Rapid bus lines, downtown DASH shuttles, FlyAway express service to Los Angeles World Airports, and several other municipal bus lines.

A major generator for truck traffic is the Union Pacific and Burlington Northern Santa Fe Railway (BNSF) railroad yard near the I-710 and I-5 junction. Much of the freight traffic destined for the rail yard originates at the Ports of Long Beach and Los Angeles.

Exhibit 2-7: Major Special Event Facilities/Trip Generators



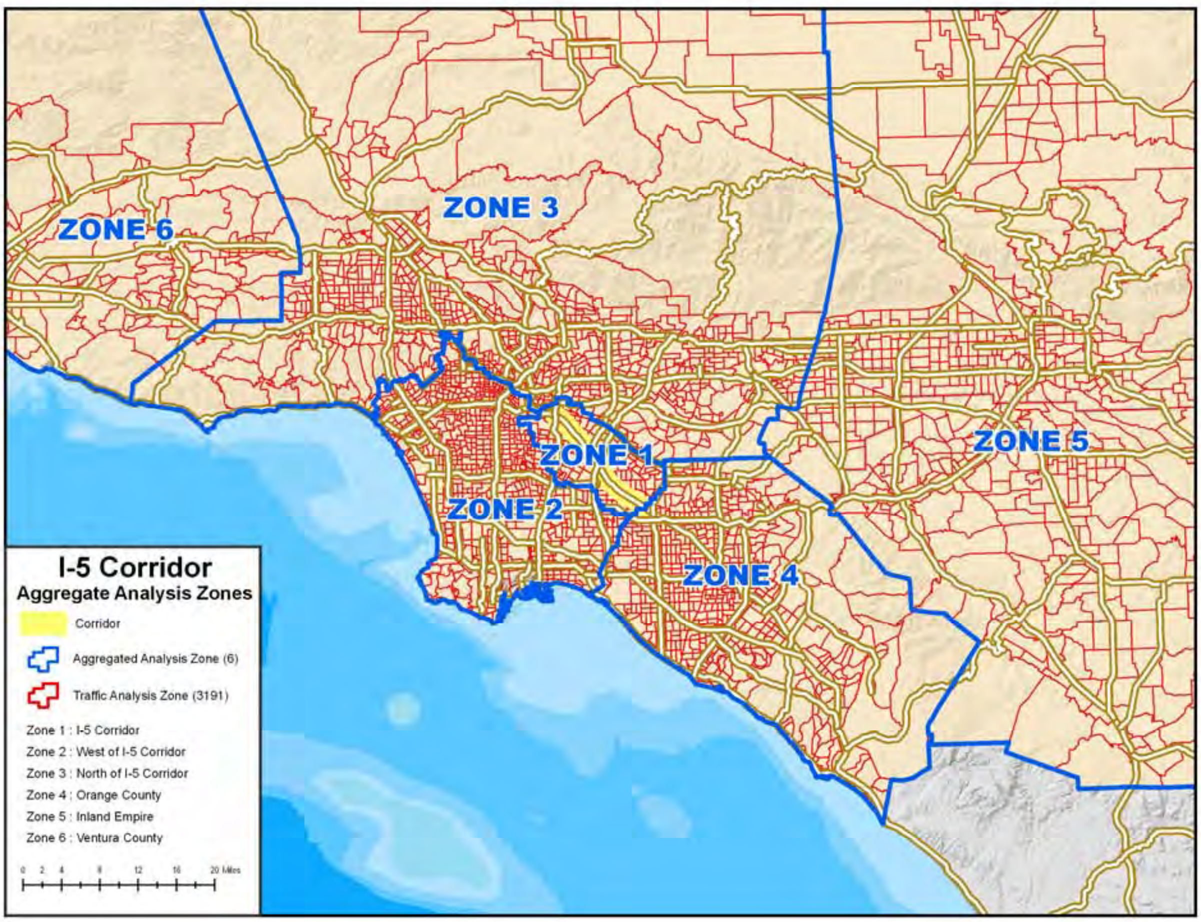
Source: SMG mapping of trip generators

Page Intentionally Left Blank for Future Updates on Corridor Special Event/Trip Generators

Demand Profiles

An analysis of origins and destinations was conducted to determine the travel pattern of trips made on the I-5 study corridor. Based on SCAG's 2000 travel demand model, this "select link analysis" isolated the I-5 study corridor and identified the origins and destinations of trips made on the corridor. The origins and destinations were identified by Traffic Analysis Zone (TAZ), which were grouped into six aggregate analysis zones as shown in Exhibit 2-8. These zones were determined by county line and proximity to the corridor.

Exhibit 2-8: Aggregate Analysis Zones for Demand Profile Analysis



Based on this aggregation, demand on the corridor was summarized by aggregated origin-destination zone as shown on Exhibits 2-9 and 2-10 for the AM and PM peak periods. This analysis shows that a significant percentage of trips using the I-5 represent inter-county trips.

During the AM peak period, about 40 percent of all trips originate and terminate in Los Angeles County (Zones 1, 2, or 3). The remaining trips originate in Los Angeles County and terminate in another county (23 percent), originate outside Los Angeles County and terminate in Los Angeles County (24 percent), or originate and terminate outside Los Angeles County (13 percent).

Exhibit 2-9: AM Peak Origin Destination by Aggregated Analysis Zone

	AM Trips	To Zone: I-5 Corridor (South)	West of I-5 Corridor	North of I-5 Corridor	Orange County	Inland Empire	Ventura County	Outsize Zones
From Zone	I-5 Corridor (South)	57	1,414	718	552	677	18	28
	West of I-5 Corridor	987	14,804	10,427	4,137	8,429	914	901
	North of I-5 Corridor	573	10,449	7,089	4,180	6,245	529	408
	Orange County	411	5,891	4,289	178	3,361	391	564
	Inland Empire	451	8,352	6,348	2,361	4,823	591	464
	Ventura County	6	943	582	398	591	0	61
	Outsize Zones	11	401	194	175	190	30	840

~ 40%	Trips starting and ending in Los Angeles County
~ 23%	Trips starting in Los Angeles County and ending outside of Los Angeles County
~ 24%	Trips starting outside of Los Angeles County and ending in Los Angeles County
~ 13%	Trips starting and ending outside of Los Angeles County

During the PM peak period (which experiences around 32 percent more demand for travel on I-5 than the AM peak), the picture is similar. Around 39 percent of trips originate and terminate in Los Angeles County. The remaining trips originate in Los Angeles County and terminate in another county (24 percent), originate outside Los Angeles County and terminate in Los Angeles County (24 percent), or originate and terminate outside Los Angeles County (14 percent).

Exhibit 2-10: PM Peak Origin Destination by Aggregated Analysis Zone

	PM Trips	To Zone: I-5 Corridor (South)	West of I-5 Corridor	North of I-5 Corridor	Orange County	Inland Empire	Ventura County	Outsize Zones
From Zone	I-5 Corridor (South)	101	1,535	835	663	730	21	29
	West of I-5 Corridor	1,819	21,173	15,096	7,897	12,137	1,411	947
	North of I-5 Corridor	1,061	14,587	10,206	6,805	9,029	880	463
	Orange County	716	7,179	6,251	432	4,116	651	501
	Inland Empire	913	12,006	8,917	4,969	7,146	945	501
	Ventura County	26	1,416	849	699	850	0	78
	Outsize Zones	34	1,587	550	1,104	775	55	1,265

~ 39%	Trips starting and ending in Los Angeles County
~ 24%	Trips starting in Los Angeles County and ending outside of Los Angeles County
~ 24%	Trips starting outside of Los Angeles County and ending in Los Angeles County
~ 14%	Trips starting and ending outside of Los Angeles County

Page Intentionally Left Blank for Future Updates on Demand Profiles

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-5 Corridor. The primary objective of the measures is to provide a sound technical basis for describing traffic performance on the corridor. The base year for the analysis and modeling is 2007 for the I-5 Corridor.

The performance measures in this section focus on five 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:

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

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

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

In calculating total delay, 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

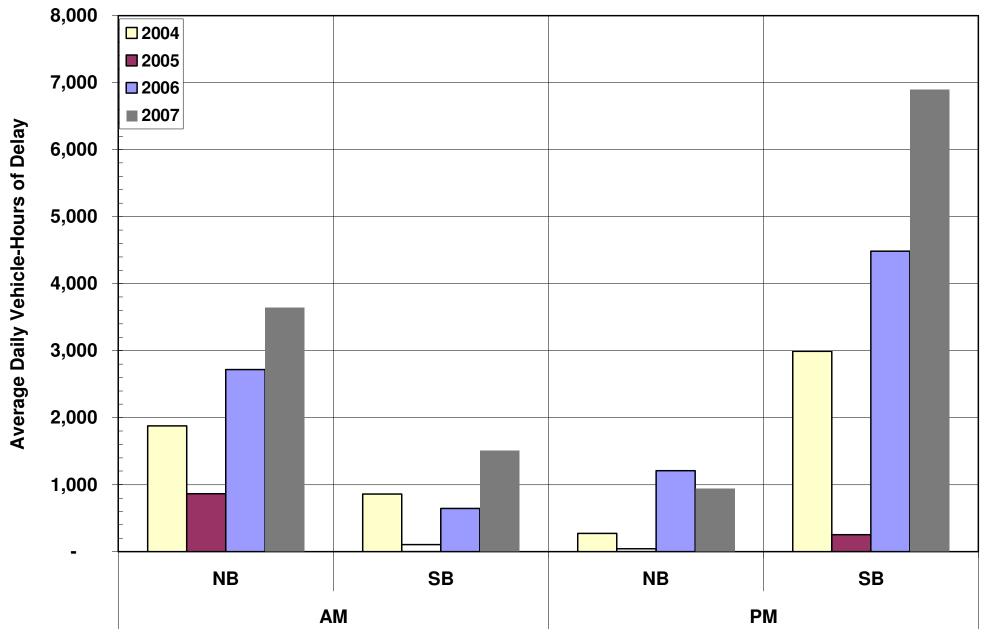
The HICOMP report has been published annually by Caltrans since 1987.[3] Delay is presented as average daily vehicle-hours of delay (DVHD). The HICOMP defines delay as travel time in excess of free-flow travel time when speeds dip below 35 mph for 15 minutes or longer.

For the HICOMP report, probe vehicle runs are performed only one to four days during the entire year for the mainline facility only. Ideally, two days of data collection in the spring and two in the fall of the year are desired, but resource constraints may affect the number of runs performed during a given year. As will be discussed later in this section when discussing the PeMS data, congestion levels vary from day to day and depend on any number of factors including accidents, weather, and special events, the price of gasoline, and construction activities.

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

Exhibit 3-1 shows yearly delay trends from 2004 through 2007 for the AM and PM peak travel period along the I-5 Corridor in both directions. As shown in Exhibit 3-1, northbound traffic experienced the most significant congestion during the AM peak period, while southbound traffic experienced the most congestion during the PM peak period. Delay during these peak periods increased sizably from 2006 to 2007. The significant drop in delay shown for 2005 may reflect limited data available due to poor detection, rather than an actual decrease in congestion.

Exhibit 3-1: Average Daily Vehicle-Hours of Delay (2004-2007)



Source: 2004-2007 HICOMP Reports

Exhibit 3-2 lists all of the congested segments shown in the last four HICOMP reports for the I-5 Corridor. As the exhibit illustrates, the length of the congested segments vary from one year to the next.

Exhibit 3-2: HICOMP Congested Segments (2004-2007)

Period	Dir	CA PM From/To	Generalized Congested Area	Generalized Area Congested Average Vehicle Hours of Delay			
				2004	2005	2006	2007
AM	NB	0.0/1.5	LA/Orange County Line to Alondra Bl		80	86	
		0.4/2.4	n/o Artesia Blvd to Carmentia Blvd				112
		2.4/5.4	Carmentia Rd to Pioneer Blvd				1,533
		2.4/5.9	Carmenita Rd to Orr and Day Rd			1,827	
		3.5/10.5	Rosecrans Ave to Telegraph/Garfield		787		
		3.5/11.5	Rosecrans Ave to Washington Bl	1,877			
		5.4/10.4	Pioneer Blvd to s/o Slauson Ave				1,208
		5.9/10.4	Orr and Day Rd to Greenwood			803	
		12.4/15.4	s/o Lorena St to s/o Atlantic Blvd				793
	SB	10.0/2.5	Slauson Av/Gage Av Ave to Carmenita Rd	859			
		6.9/4.4	I-605 to Norwalk Blvd				346
		6.4/0.0	Florence Ave to Los Angeles/Orange County Line			645	
		6.0/2.0	Florence Ave to Carmenita Dr		105		
		4.4/0.4	Norwalk Blvd to Artesia Blvd				1,161
AM PEAK PERIOD SUMMARY				2,736	972	3,360	5,153
PM	NB	0.0/1.5	LA/Orange County Line to Alondra Bl		40	149	
		0/2.4	Commonwealth Ave to Carmenita Rd				300
		2.4/5.4	Carmenita Rd to Pioneer Blvd				638
		2.4/5.9	Carmenita Rd to Orr and Day Rd			1,057	
		3.5/9.5	Rosecrans Ave to Rio Hondo River	103			
		9.5/18.5	Rio Hondo River to north of State St	167			
	SB	18.0/9.5	Brooklyn Ave to Rio Hondo River	2,553			
		17.9/10.9	Cesar E Chavez Ave to Garfield Ave				3,375
		17.9/9.4	Brooklyn Ave to Rio Hondo River			2,591	
		10.4/7.4	s/o Garfield Ave to n/o I-605				357
		9.5/2.5	Rio Hondo River to Carmenita Dr	436			
		9.4/7.4	Rio Hondo to Lemoran Ave			132	
		6.9/2.4	I-605 to Carmenita Rd			1,130	
		6.9/0	I-605 to Commonwealth Ave				3,159
		5.5/1.5	Pioneer Bl to Alondra Bl		254		
		2.4/0.4	Carmenita Rd to Artesia Ave			631	
PM PEAK PERIOD SUMMARY				3,261	294	5,689	7,829
TOTAL CORRIDOR CONGESTION				**5,996**	**1,266**	**9,048**	**12,982**

According to Exhibit 3-2, the most congested segment during the AM peak period was from Rosecrans Avenue to Washington Boulevard. While delay on this segment decreased in 2005, it increased slightly to above 2004 levels in 2006 (when both portions are considered). Congestion is slightly lower in 2007. During the PM peak period, the most congested segment was from Brooklyn Avenue to the Rio Hondo River. Delay dropped significantly in 2005, while in 2006 it was similar to the delay experienced in 2004. In 2007, the delay was even greater, while the congested area was a mile shorter. The decrease in delay in 2005 may have been due to a lack of good detector data in 2005 as well as decreases in the number of accidents.

Exhibits 3-3 and 3-4 present the congestion information in map form for the AM and PM peak commute periods in 2007. The approximate locations of the congested segments, the duration of that congestion, and the reported recurrent daily delay are also shown. More "generalized" congested segments were created so that segment comparisons can be made from one year to the next.

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

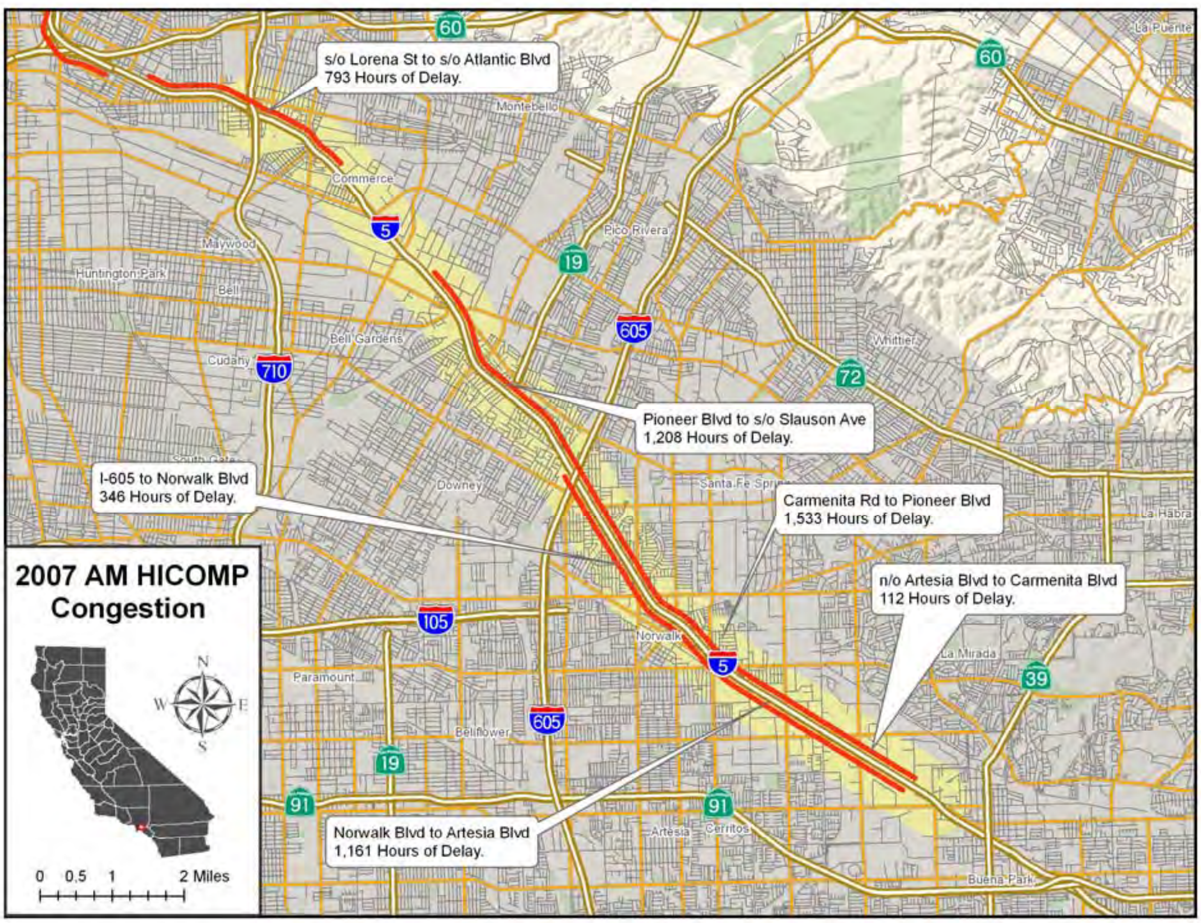
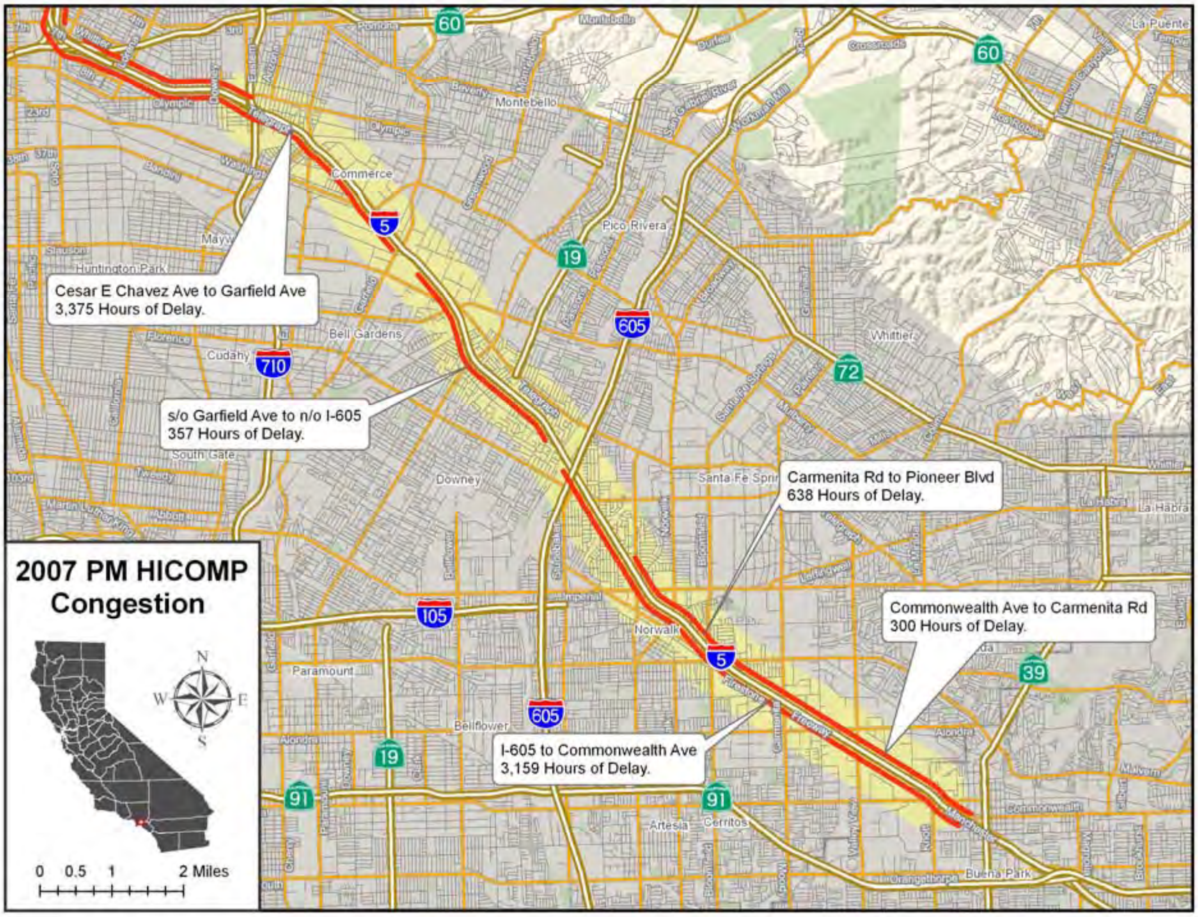


Exhibit 3-4: HICOMP Congested Segments Map - PM Peak Period (2007)



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 different ways, which is not possible when using probe vehicle data.

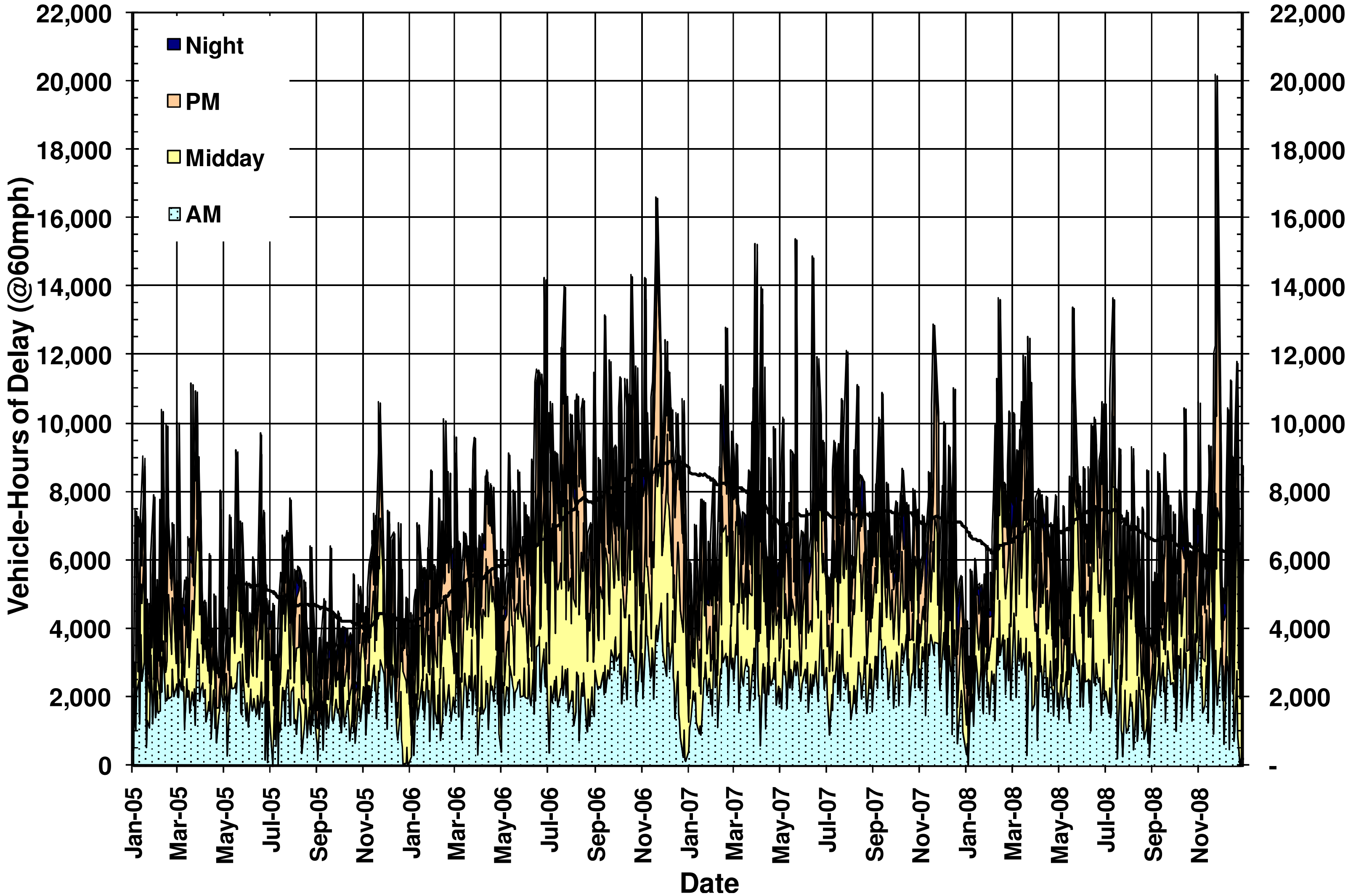
Performance assessments were initially conducted for the three-year period between 2005 and 2007. These assessments were recently updated through December 2008. The performance assessment includes four years of PeMS data. Unlike HICOMP where delay is only considered and captured for speeds below 35 miles per hour and applied to an assumed output or capacity volume of 2,000 vehicles per hour, delays presented here on using PeMS 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.

Exhibits 3-5 and 3-6 show the four-year trend in weekday (i.e., excluding weekends and holidays) delay for the entire corridor in the northbound and southbound directions respectively. The exhibits also show a 90-day moving average that reduces the day-to-day variations and more easily illustrates the seasonal and annual changes in congestion over time.

As illustrated in Exhibit 3-5, delay in the northbound direction was concentrated in the AM peak period, followed by the Midday period. The exhibit shows a trend consistent with the HICOMP report table – delay levels decreased in 2005 and increased in 2006. As described earlier, the drop in 2005 could be due to less detection data available. In 2007 and 2008, total delay remained steady between 6,000 and 8,000 vehicle-hours.

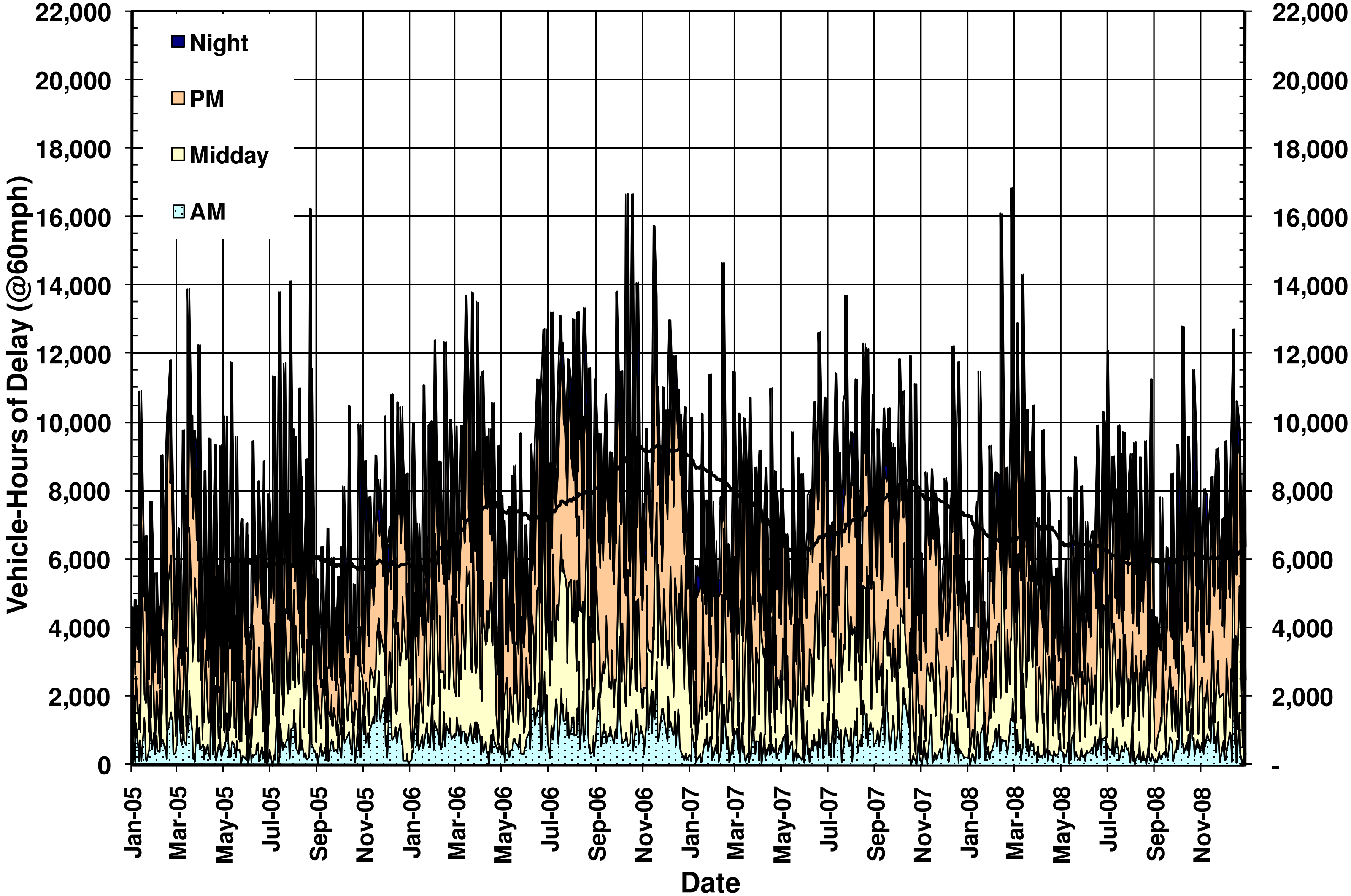
Delay in the southbound direction revealed an opposite trend from the northbound direction with delay concentrated in the PM peak instead of the AM peak. This suggests a directional commute patterns towards downtown Los Angeles. As shown in Exhibit 3-6, the majority of delay in the southbound direction occurred during the PM peak. Delay in the southbound direction followed the same pattern as the northbound direction with an increase in delay in 2006, followed by a decline in early 2007, and a steady flattening in 2008. In 2008, total delay in the southbound direction hovered between 6,000 and 8,000 vehicle-hours.

Exhibit 3-5: Northbound I-5 Average Daily Delay by Time Period (2005-2008)



Source: SMG analysis of PeMS data

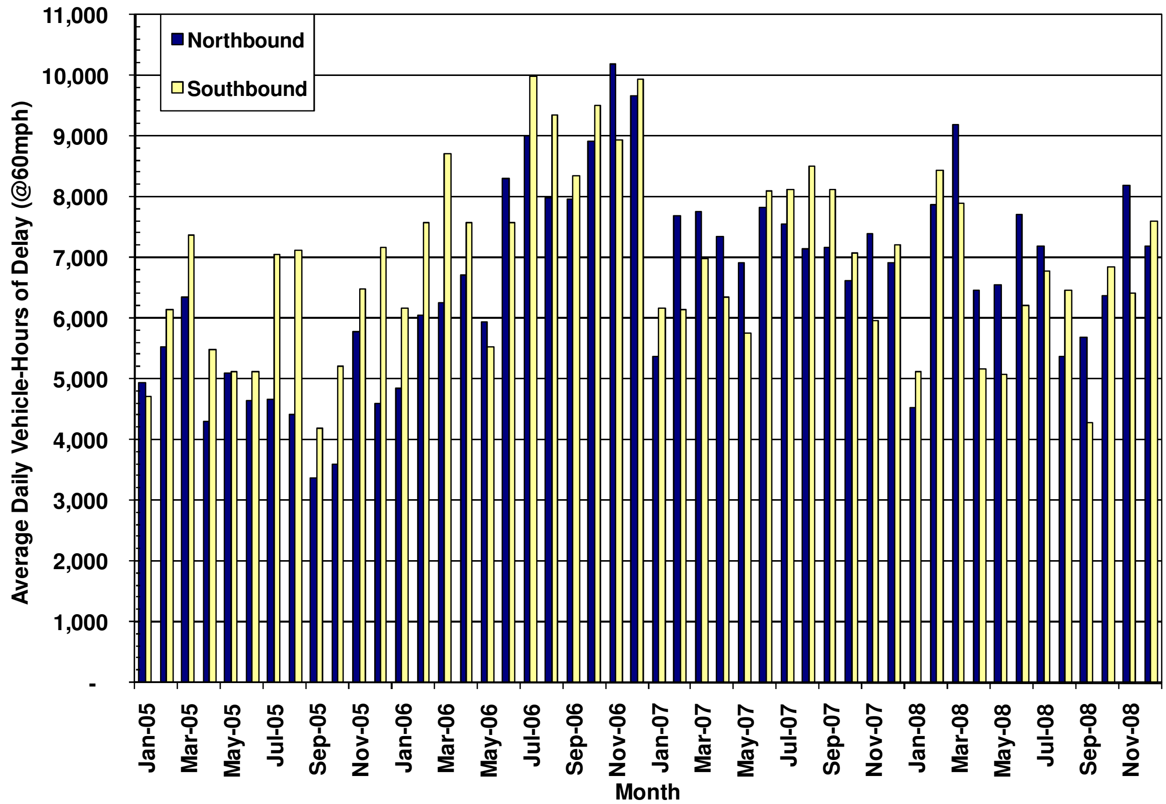
Exhibit 3-6: Southbound I-5 Average Daily Delay by Time Period (2005-2008)



Source: SMG analysis of PeMS data

Exhibit 3-7 shows the average daily weekday delay for the I-5 Corridor by month and direction. This exhibit shows that the highest months of delay in both directions of travel occurred during the last half of 2006. The trends for the two directions are very similar with some variations in the absolute level of delay, particularly in the 2005 and the first half of 2006.

Exhibit 3-7: I-5 Average Weekday Delay by Month (2005-2008)



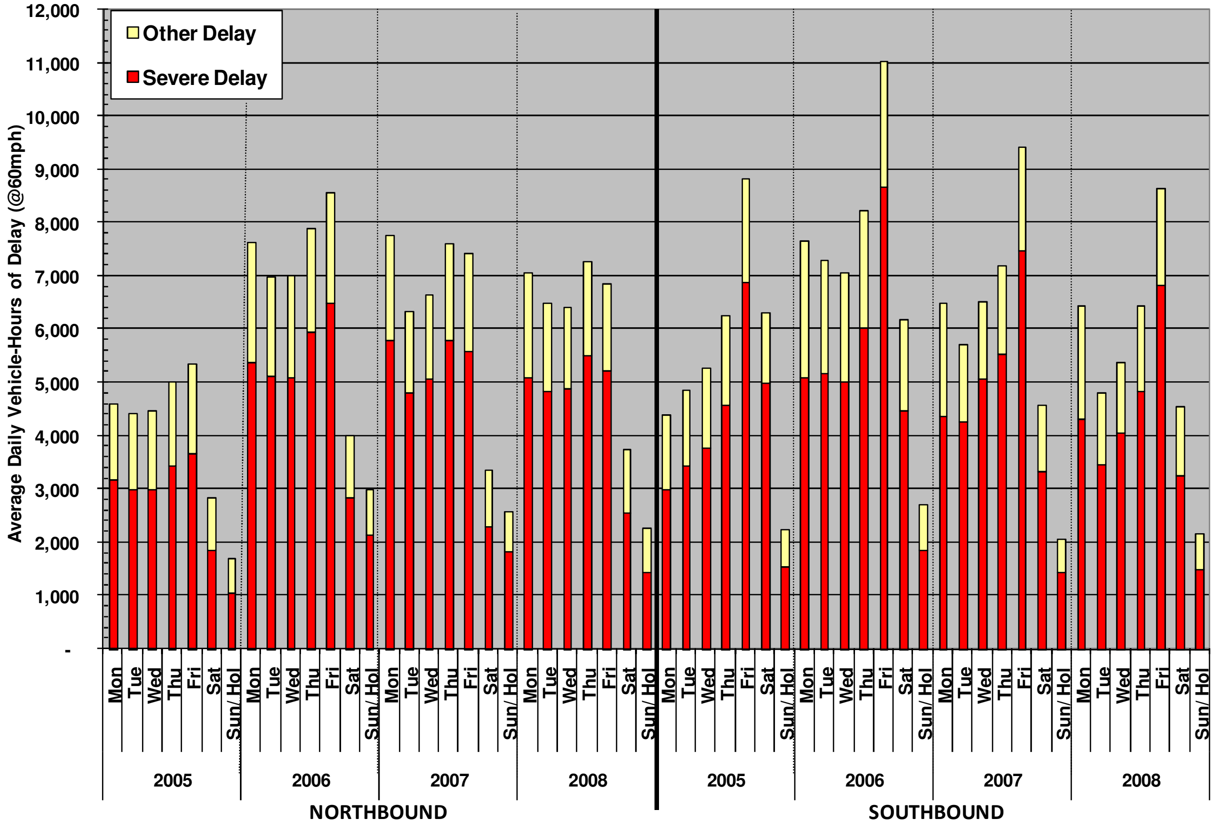
Source: SMG analysis of PeMS data

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 Exhibit 3-8:

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

Severe delay in Exhibit 3-8 represents breakdown conditions and is the focus of most congestion mitigation strategies. “Other” delay represents conditions approaching the breakdown congestion, leaving the breakdown conditions, or areas that cause temporary slowdowns rather than widespread breakdowns. As depicted in Exhibit 3-8, the magnitude of daily delay typically increased throughout the week with the highest delay occurring on Fridays. Delays were generally higher in 2006 and southbound delays were greater in magnitude than northbound delays (especially on Fridays).

Exhibit 3-8: I-5 Average Delay by Day of Week by Severity (2005-2008)

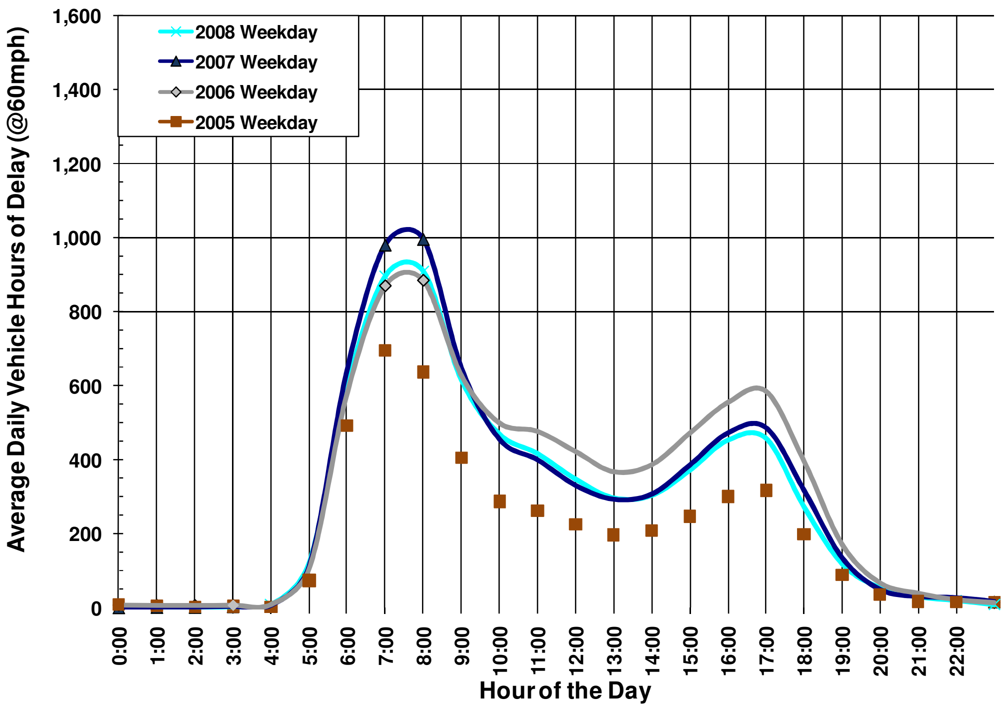


Source: SMG analysis of PeMS data

Although combating congestion requires the focus on severe congestion, it is important to review “other” congestion and understand its trends. This could allow for proactive intervention before the “other” congestion turns into severe congestion.

Another way to understand the characteristics of congestion and related delays is to examine average weekday delays by hour. Exhibits 3-9 and 3-10 summarize average weekday hourly for each year within the 2005-2008 period. Each point represents the total delay for the hour. For example, the 7:00 AM point is the sum of delay from 7:00 AM to 8:00 AM. The exhibits show the peaking characteristics of congestion and how the peak period changes over time. The exhibits highlight the highly directional aspects of travel on the I-5 Corridor. The biggest delays in the northbound direction occur during the AM peak hours centered at 7:00 AM. At the 7:00 AM peak hour, Exhibit 3-9 reveals that 2007 experienced the greatest delay with over 1,000 vehicle-hours, followed by 2008 with slightly above 900 vehicle-hours. The PM peak hours also show sizeable delays from 4:00 PM to 6:00 PM (16:00 to 18:00), ranging from 370 to 600 vehicle-hours of delay at the 5:00 PM peak hour.

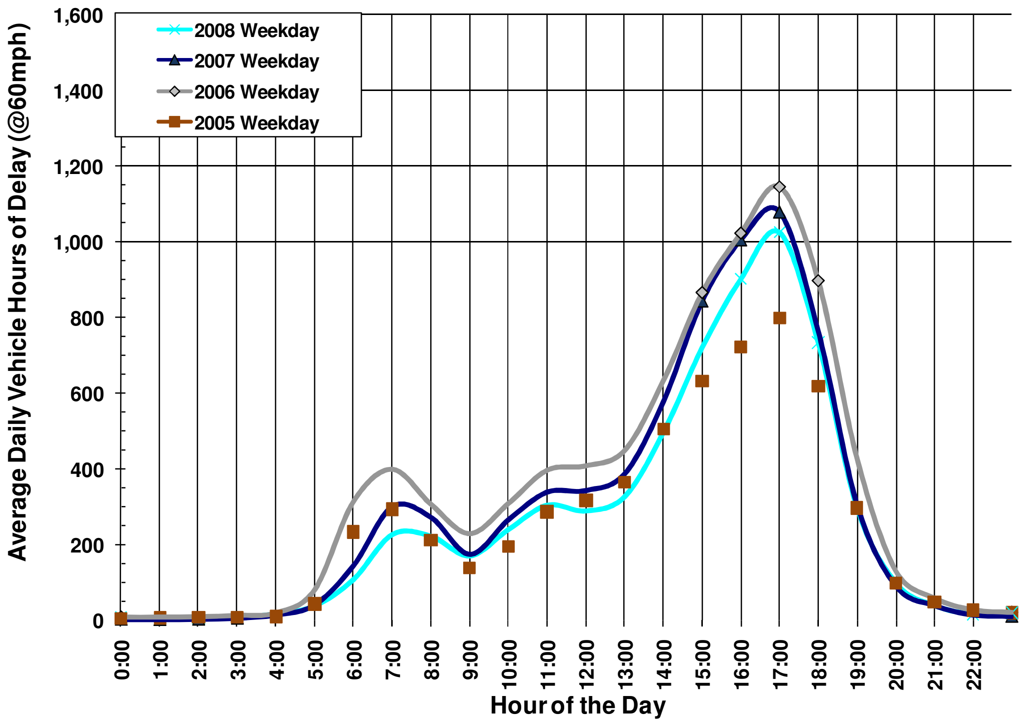
Exhibit 3-9: Northbound I-5 Average Weekday Hourly Delay (2005-2008)



Source: SMG analysis of PeMS data

In the southbound direction, Exhibit 3-10 shows that the hourly delay profile is the reverse with delay concentrated in the PM peak. The biggest delay occurred during the PM peak hour of 5:00 PM (17:00). At the 5:00 PM peak hour, 2006 and 2007 experienced the highest average daily vehicle-hours of delay with roughly 1,100. This number declined slightly in 2008. The AM peak hours show significantly less delay from 6:00 AM to 8:00 AM.

Exhibit 3-10: Southbound I-5 Average Weekday Hourly Delay (2005-2008)



Source: SMG analysis of PeMS data

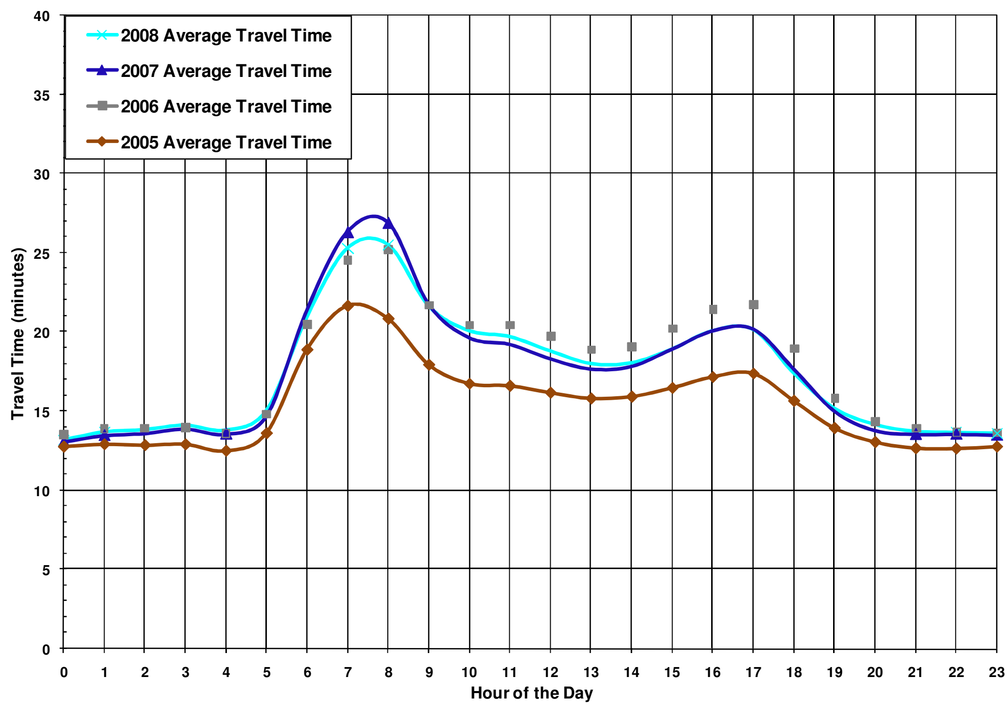
Page Intentionally Left Blank for Future Updates on Detector Based Corridor Delays

Travel Time

Travel time is reported as the amount of time it takes a vehicle to travel between two points on a corridor, as estimated using PeMS data in this analysis. In the case of the I-5 Corridor, the time it takes to travel 14 miles of the corridor from the Orange/LA County line to the I-710 Interchange is 14 minutes traveling at 60 mph. Travel time on parallel arterials is not included in the analysis.

Exhibits 3-11 and 3-12 depict the travel times calculated for the I-5 Corridor. As shown, the northbound direction had typical travel times of approximately 22 to 28 minutes during the peak congested periods and about 16 to 20 minutes during the middle of the day. At the 7:00 AM peak hour, travel times were highest in 2007, followed by 2008. However, during the PM and off-peak hours, 2006 experienced the highest travel times.

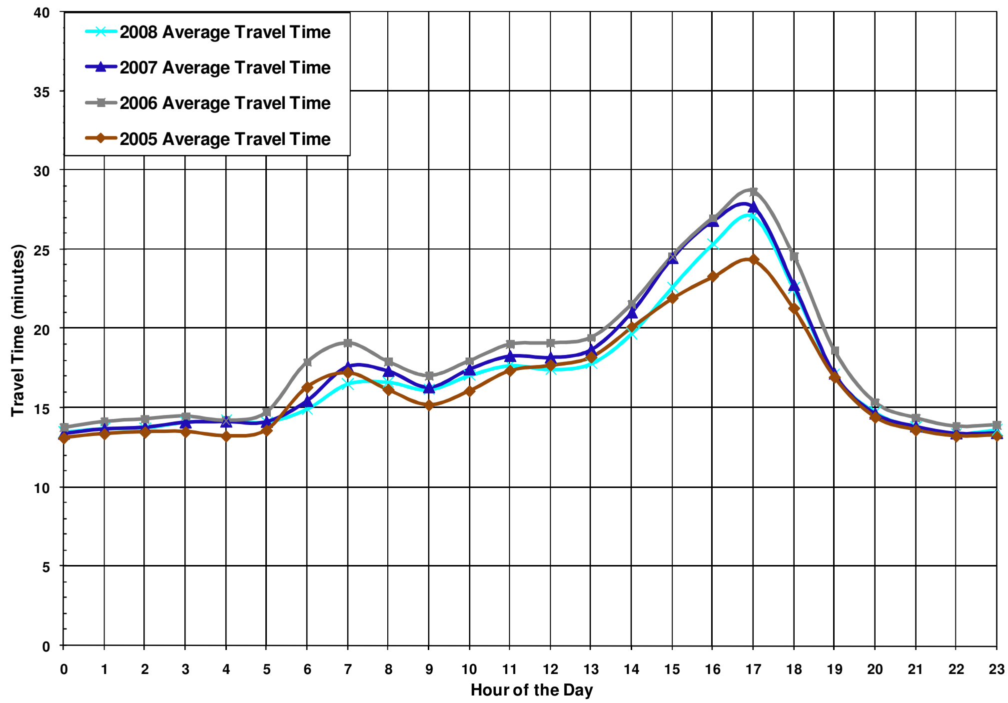
Exhibit 3-11: Northbound I-5 Travel Time by Time of Day (2005-2008)



Source: SMG analysis of PeMS data

In the southbound direction, typical travel times range from approximately 24 to 29 minutes during the PM peak hour and from about 16 to 18 minutes during the midday. During both peak and non-peak hours, 2006 experienced the highest travel times, followed by 2007 and 2008. Travel time variability throughout this four-year period is consistent with the delay trends observed for this corridor. As delay improves, travel time also improves.

Exhibit 3-12: Southbound I-5 Travel Time by Time of Day (2005-2008)



Source: SMG analysis of PeMS data

Page Intentionally Left Blank for Future Updates on Detection Based Travel Time

RELIABILITY

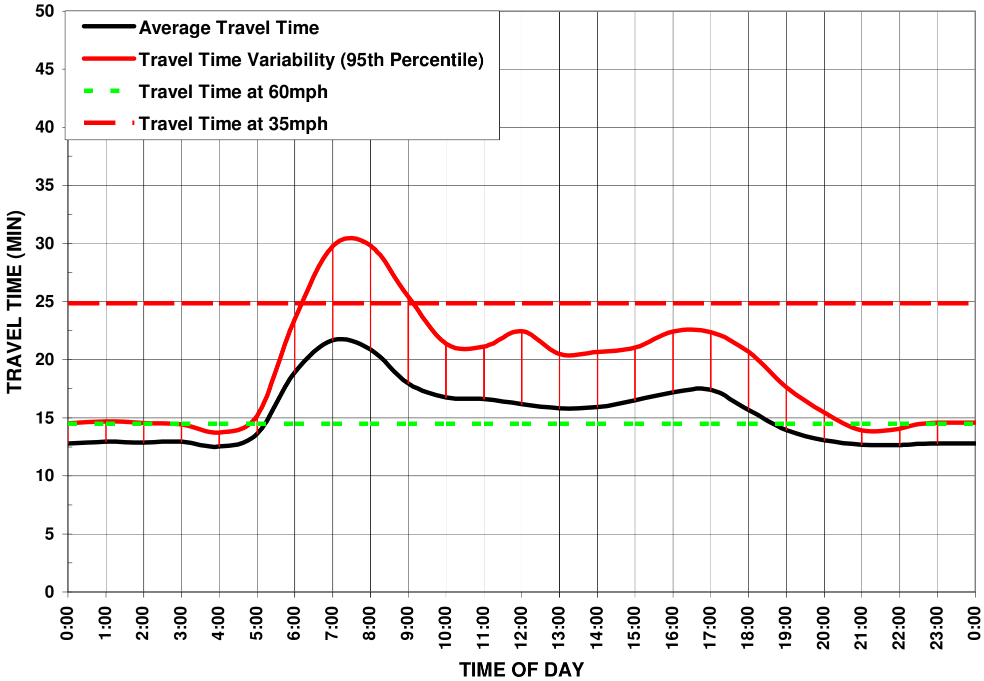
Reliability captures the relative predictability of the public's travel time. Unlike mobility, which measures the rate of travel, the reliability measure focuses on how travel time varies from day to day. To measure reliability, the study team estimated travel time variability using PeMS data. The 95^{th} 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 95^{th} percentile, but this statistic is a balance between extreme outliers and the "typical" travel day.

Exhibits 3-13 through 3-20 on the following pages illustrate the variability of travel time along the I-5 Corridor on weekdays for the years 2005, 2006, 2007, and 2008. Exhibits 3-13 through 3-16 present travel time variability for the northbound direction, and Exhibits 3-17 through 20 present travel time variability for the southbound direction.

In the northbound direction, the 8:00 AM peak hour was the most unreliable in addition to being the slowest hour. In 2005 (shown in Exhibit 3-13), motorists driving the entire length of the corridor had to add 9 minutes to an average travel time of 21 minutes (for a total travel time of 30 minutes) to ensure that they arrived on time 95 percent of the time. This is 15 minutes longer than the 15-minute travel time at 60 mph. In the following three years (Exhibits 3-14 through 3-16), the time needed to arrive on time 95 percent increased by 7 minutes to 37 minutes.

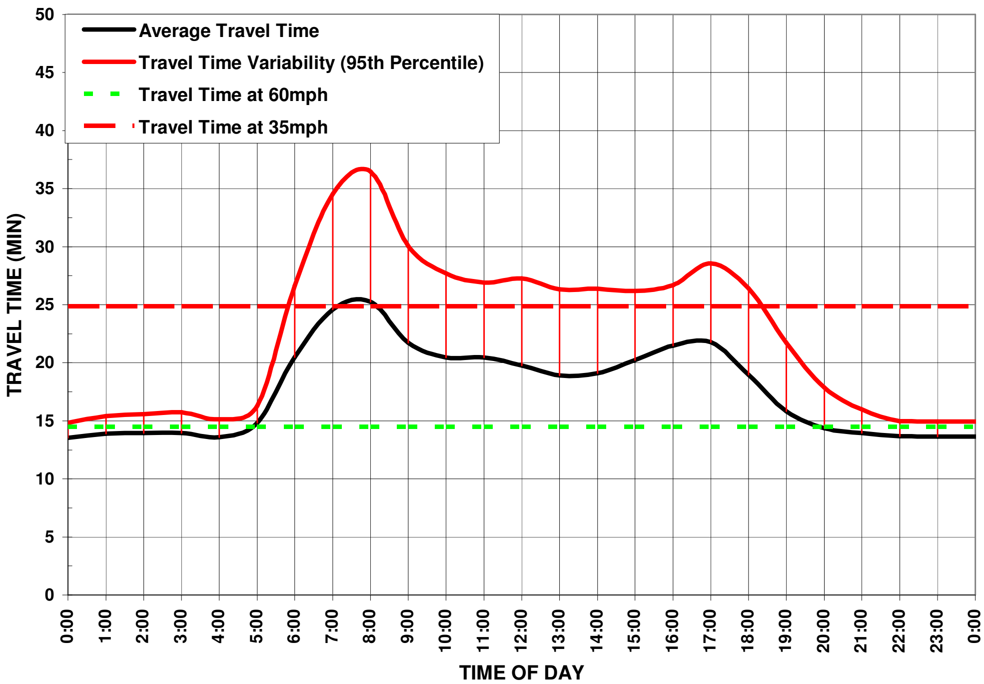
In the southbound direction, the most unreliable hour was 5:00 PM. Unlike the northbound direction which experienced the highest travel times during the AM peak period, the southbound direction experienced higher travel times during the PM peak period. In 2006 (Exhibit 3-17), the time needed to arrive on time 95 percent of the time was 31 minutes during the 5:00 PM peak hour. In 2006 (Exhibit 3-18), travel time variability increased slightly to 32 minutes, and increased again in 2007 (Exhibit 3-19) and 2008 (Exhibit 3-20) to 35 minutes.

Exhibit 3-13: Northbound I-5 Travel Time Variation (2005)



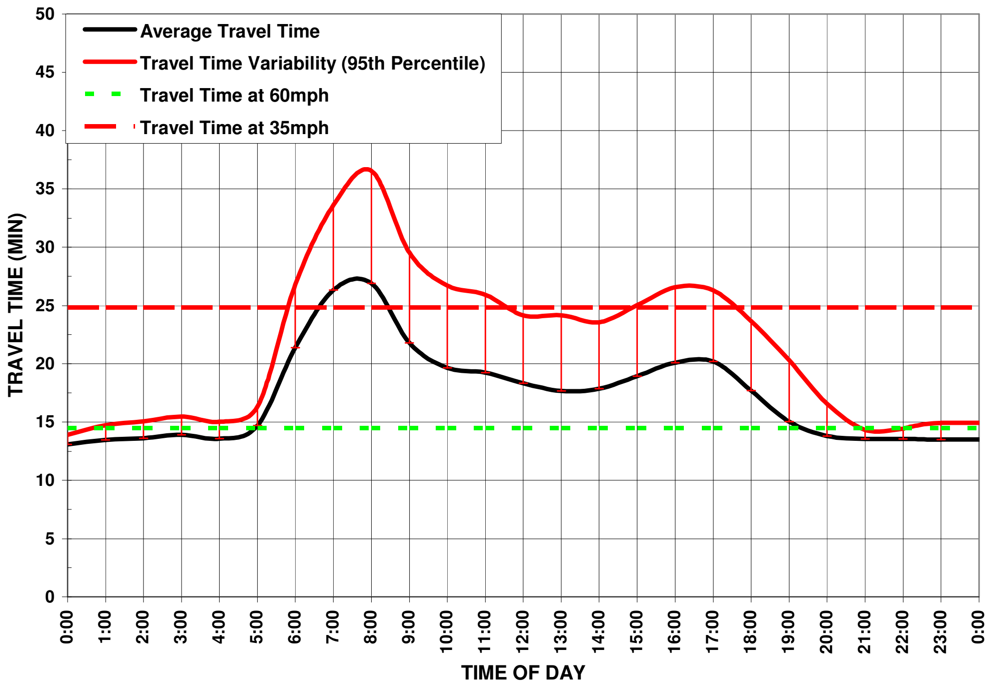
Source: SMG analysis of PeMS data

Exhibit 3-14: Northbound I-5 Travel Time Variation (2006)



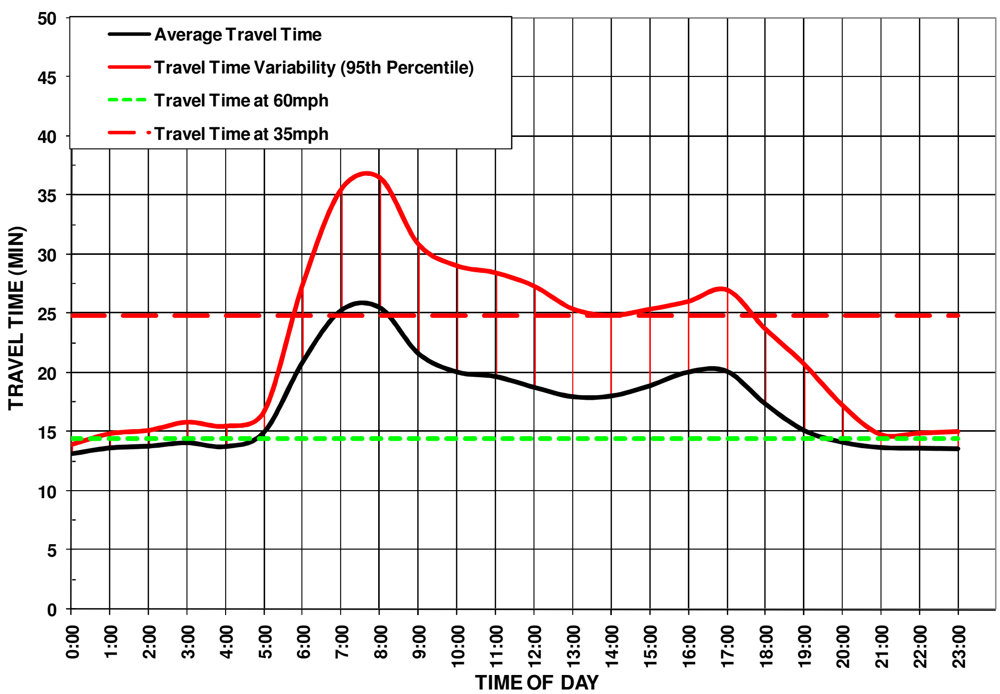
Source: SMG analysis of PeMS data

Exhibit 3-15: Northbound I-5 Travel Time Variation (2007)



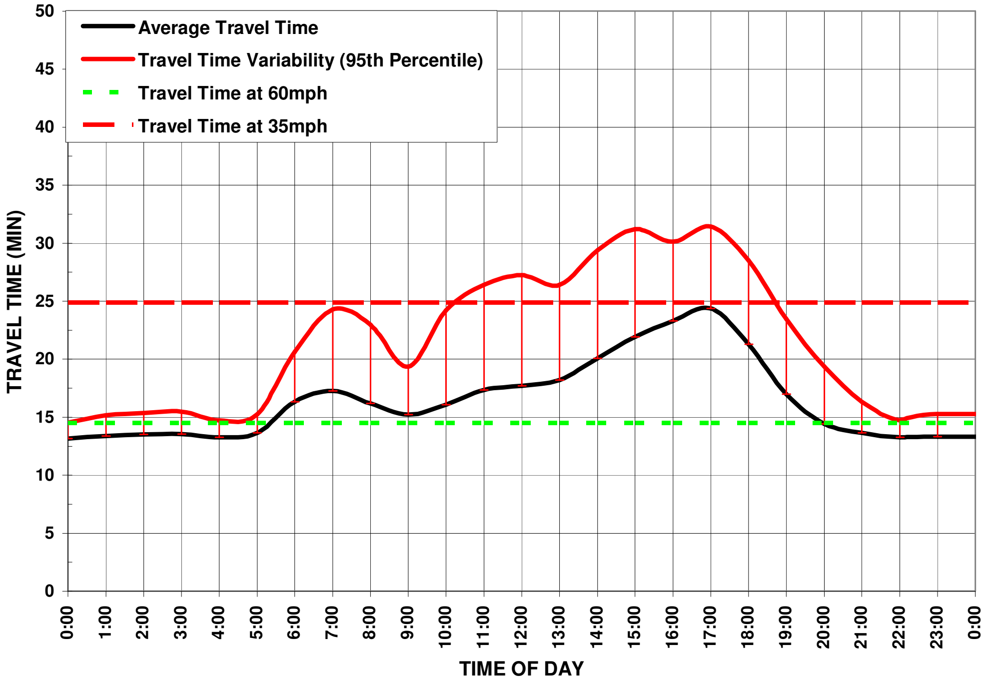
Source: SMG analysis of PeMS data

Exhibit 3-16: Northbound I-5 Travel Time Variation (2008)



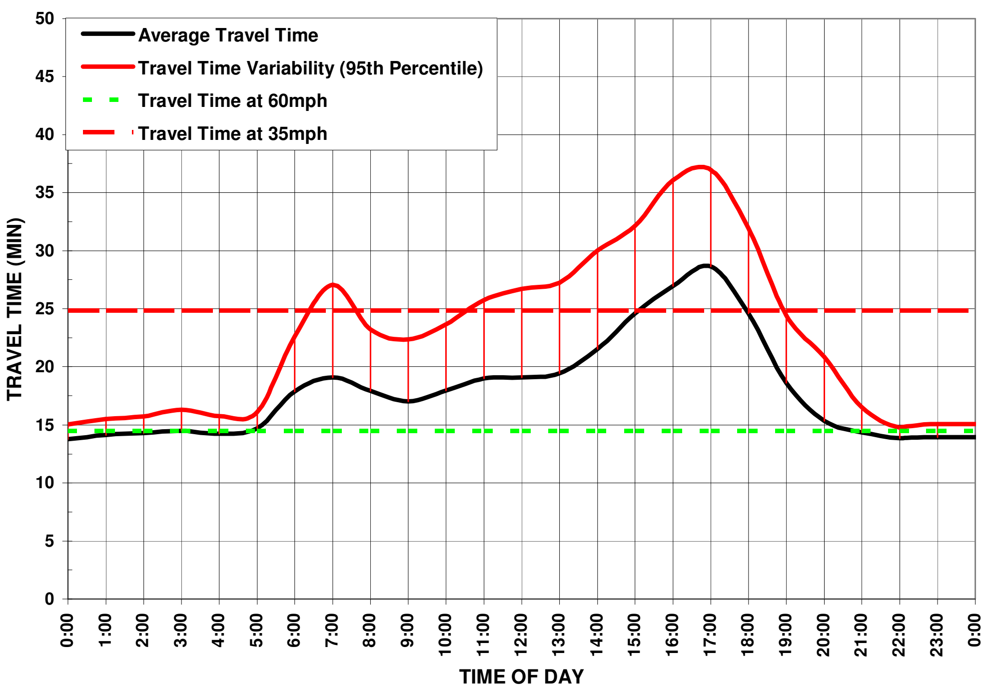
Source: SMG analysis of PeMS data

Exhibit 3-17: Southbound I-5 Travel Time Variation (2005)



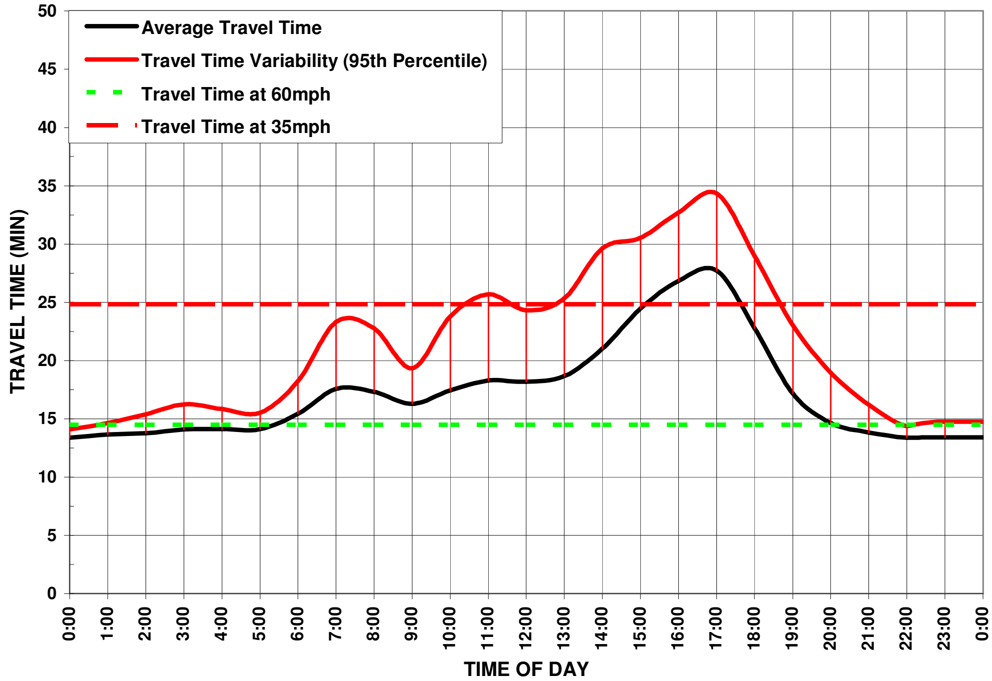
Source: SMG analysis of PeMS data

Exhibit 3-18: Southbound I-5 Travel Time Variation (2006)



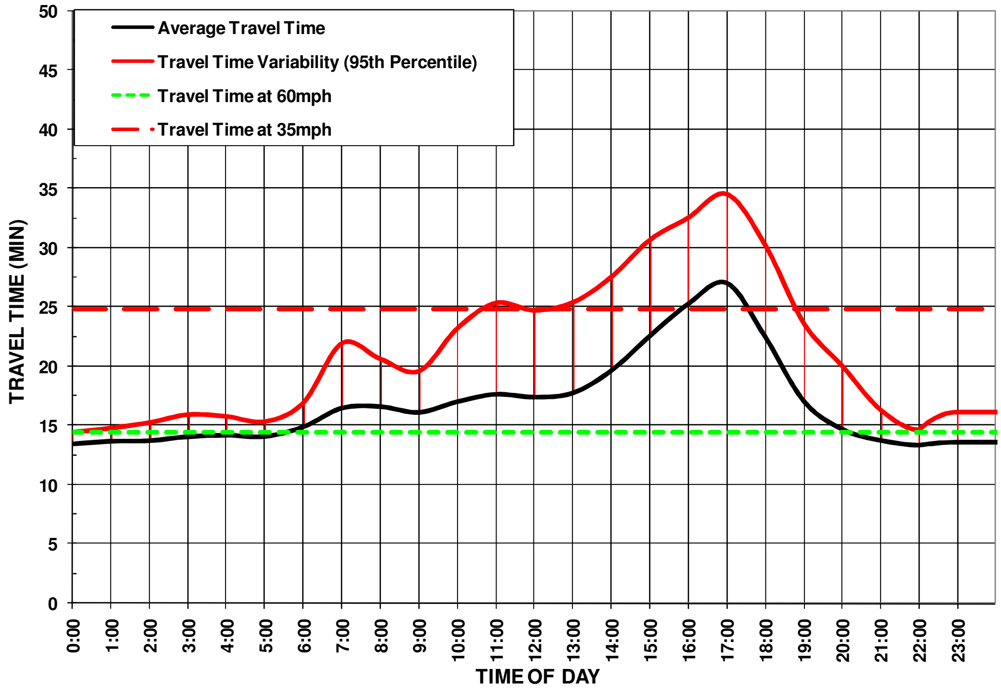
Source: SMG analysis of PeMS data

Exhibit 3-19: Southbound I-5 Travel Time Variation (2007)



Source: SMG analysis of PeMS data

Exhibit 3-20: Southbound I-5 Travel Time Variation (2008)



Source: SMG analysis of PeMS data

Page Intentionally Left Blank for Future Updates on Detection Based Reliability

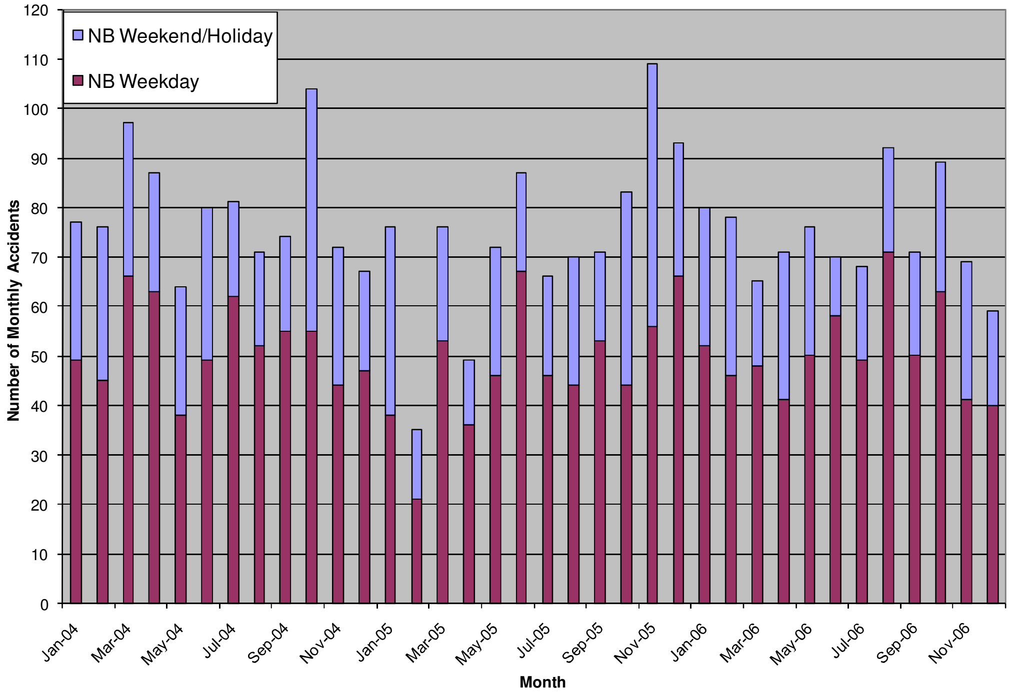
SAFETY

Collision data in terms of the number of accidents and accident rates from the Caltrans Traffic Accident Surveillance and Analysis System (TASAS) were used for the safety measure. TASAS is a traffic records system containing an accident database linked to a highway database. The highway database contains description elements of highway segments, intersections and ramps, access control, traffic volumes and other data. TASAS contains specific data for accidents on state highways. Accidents on non-state highways are not included (e.g., local streets and roads).

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

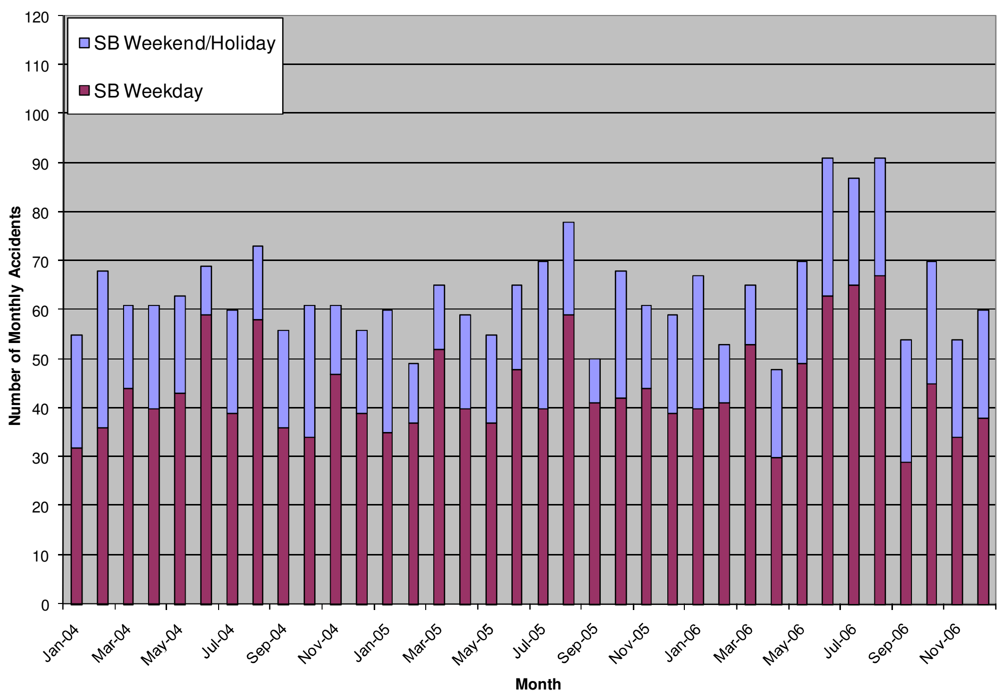
Exhibits 3-21 and 3-22 show the number of accidents experienced on I-5 for both directions of travel by month. The monthly accidents are broken down by weekdays and weekends. Caltrans typically analyzes the latest three-year safety data. TASAS data is currently available only through December 31, 2006. Therefore, monthly data for the three-year period from January 1, 2004 through December 31, 2006 were analyzed. Total monthly accidents were similar for all three years in the northbound direction with the exception of February 2005, which decreased significantly. In the southbound direction, total monthly accidents were similar in 2004 and 2006 with increases during the third quarter of 2006. Overall, the northbound direction experienced more accidents than the southbound direction.

Exhibit 3-21: Northbound I-5 Monthly Accidents (2004-2006)



Source: SMG analysis of TASAS data

Exhibit 3-22: Southbound I-5 Monthly Accidents (2004-2006)



Source: SMG analysis of TASAS data

Page Intentionally Left Blank for Future Updates on Traffic Safety

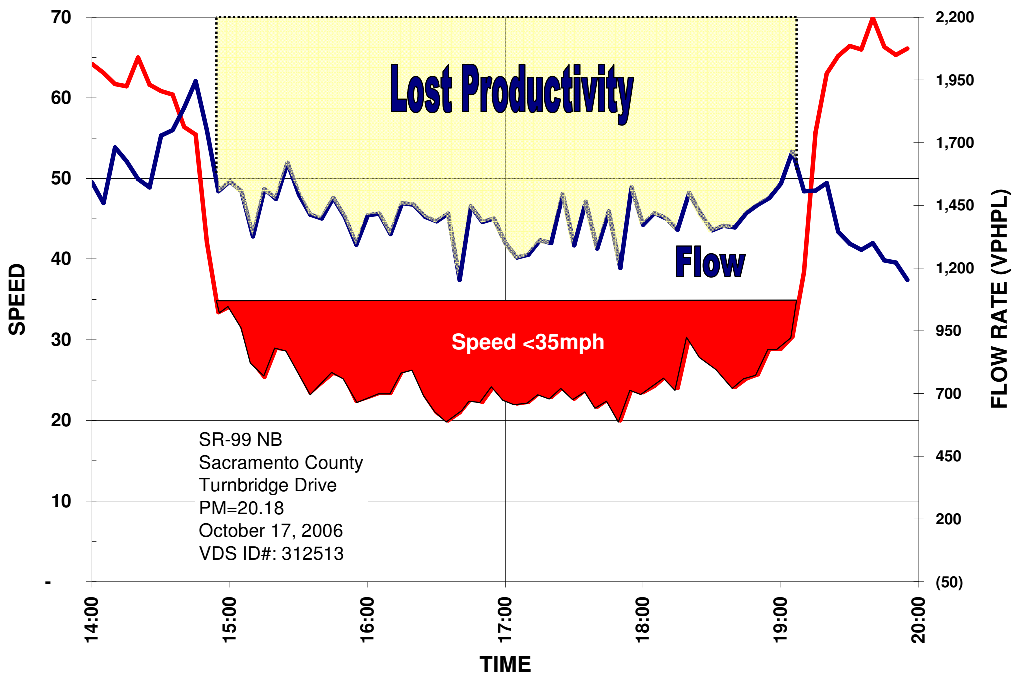
PRODUCTIVITY

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

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 do not generally project capacity loss for highways, but detailed micro-simulation tools can forecast productivity. For highways, productivity is particularly important because where capacity is needed the most, the lowest "production" from the transportation system often occurs.

This loss in productivity example is illustrated in Exhibit 3-23. 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 would improve productivity.

Exhibit 3-23: Lost Productivity Illustrated



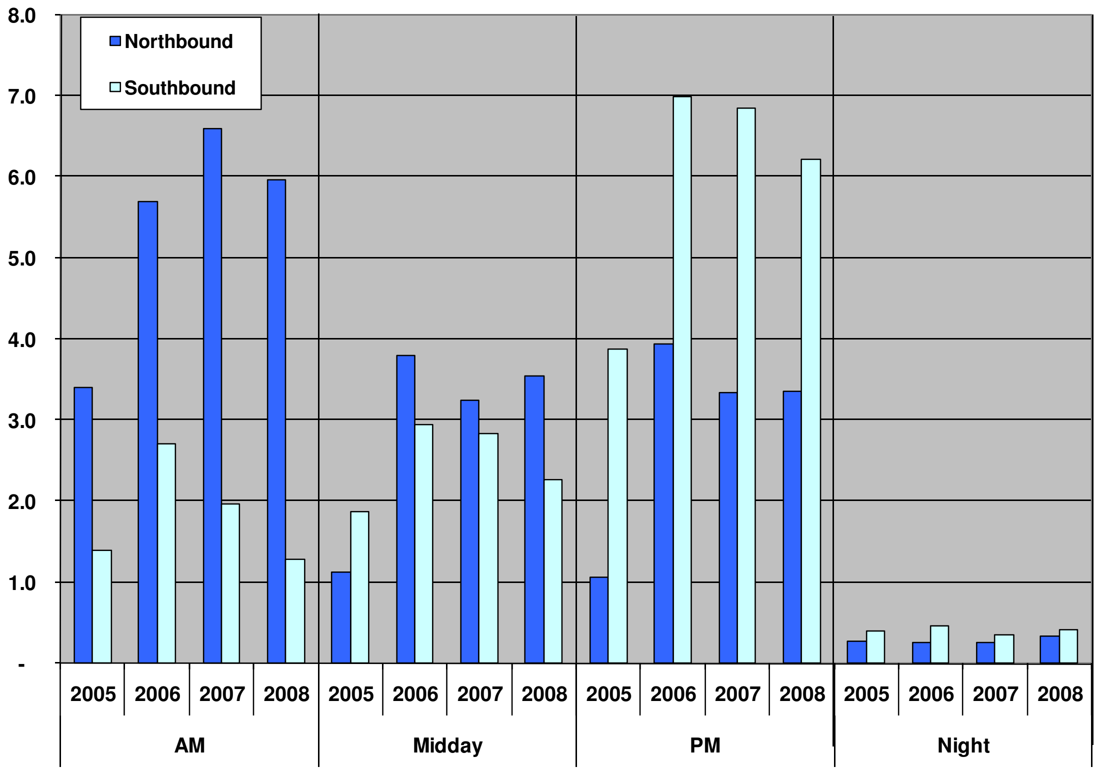
Equivalent lost lane-miles is computed as follows (for congested locations only):

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

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

Exhibit 3-24 summarizes the productivity losses on the I-5 Corridor for the 2005-2008 period. The trends in the productivity losses are comparable to the delay trends. The largest productivity losses occurred during the AM peak hours in the northbound direction (as noted by the blue-colored bars) and during the PM peak hours in the southbound direction (as noted by the aqua-colored bars), which correspond to the same time period and direction that experienced the most congestion, or delay.

Exhibit 3-24: I-5 Average Lost Lane-Miles by Direction, Time Period, and Year



Source: SMG analysis of PeMS data

Page Intentionally Left Blank for Future Updates on Detection Based Productivity

PAVEMENT CONDITION

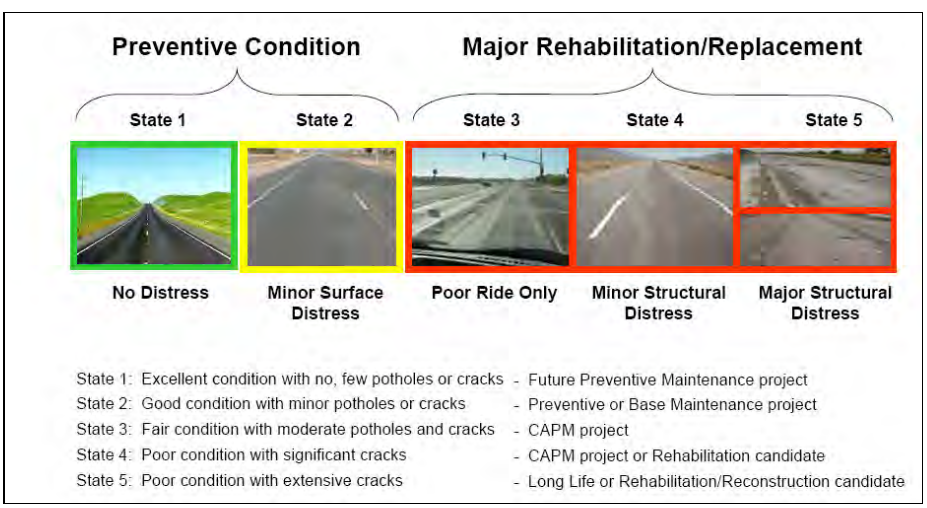
The condition of the roadway pavement (or ride quality) on the corridor can influence its traffic performance. Rough or poor pavement conditions can decrease the mobility, reliability, safety, and productivity of the corridor, whereas smooth pavement can have the opposite effect. Pavement preservation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

Pavement Performance Measures

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

Using distressed lane-miles allows us to distinguish among pavement segments that require only preventive maintenance at relatively low costs and segments that require major rehabilitation or replacement at significantly higher costs. All segments that require major rehabilitation or replacement are considered to be distressed. Segments with poor ride quality are also considered to be distressed. Exhibit 3-25 provides an illustration of this distinction. The first two pavement conditions include roadways that provide adequate ride quality and is structurally adequate. The remaining three conditions are included in the calculation of distressed lane-miles.

Exhibit 3-25: Pavement Condition States Illustrated



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

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

Existing Pavement Condition

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

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

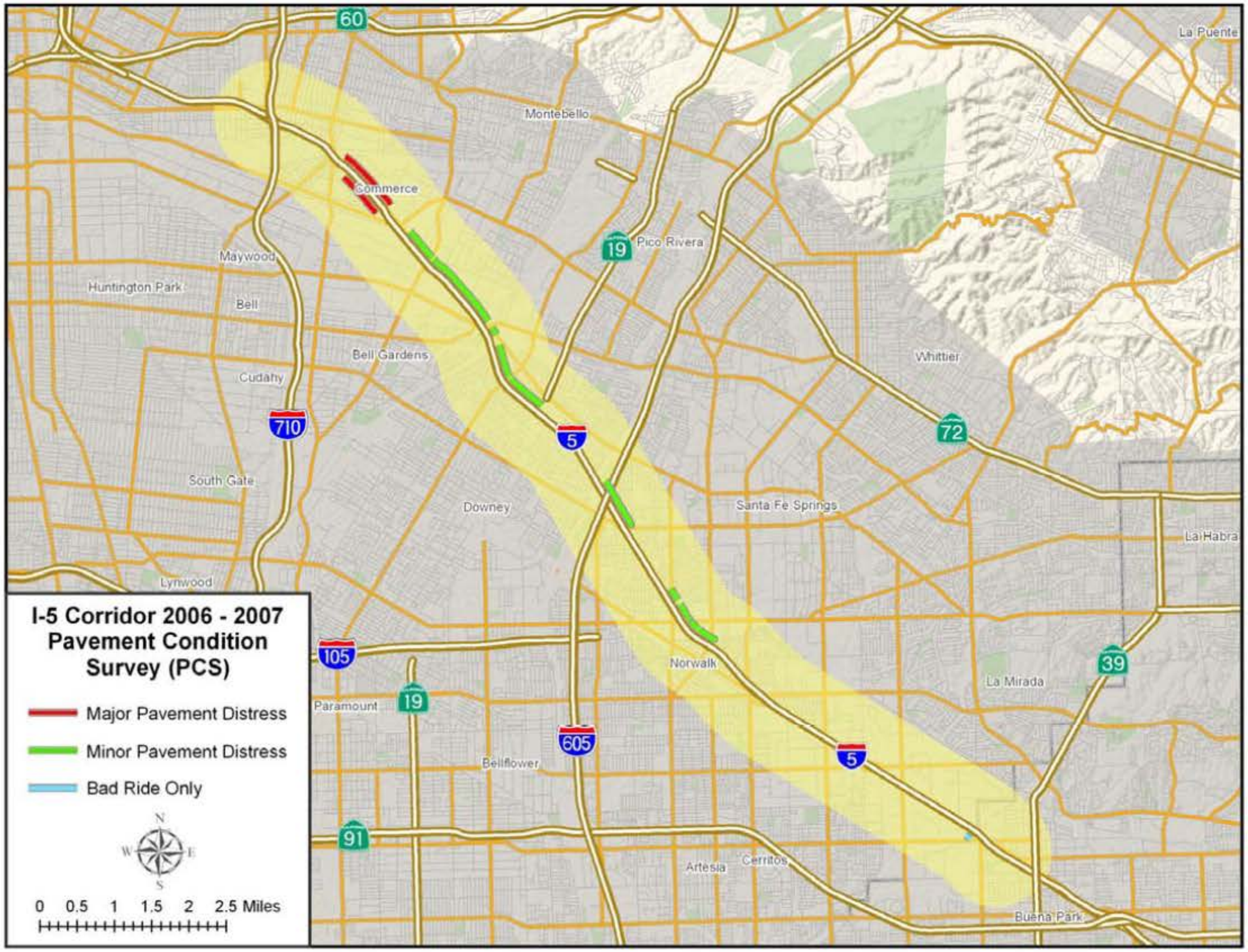
Exhibit 3-26 shows pavement distress along the I-5 Corridor according to the 2007 PCS data. The three categories shown in this exhibit represent the three distressed conditions that require major rehabilitation or replacement and were presented earlier in Exhibit 3-25.

The I-5 Corridor has considerably less pavement distress than does a typical freeway in District 7. As seen in Exhibit 3-26, some portions of northbound I-5 have minor pavement distress, but comparable distress is not found in the southbound direction. There is also a small section (less than a mile) with major pavement distress in the City of Commerce. A very minor section in the southern portion of the corridor has ride only issues.

Exhibit 3-27 shows results from prior pavement condition surveys along the I-5 Corridor. Pavement quality along the corridor has improved steadily since 2004. Most of the major distress has been eliminated.

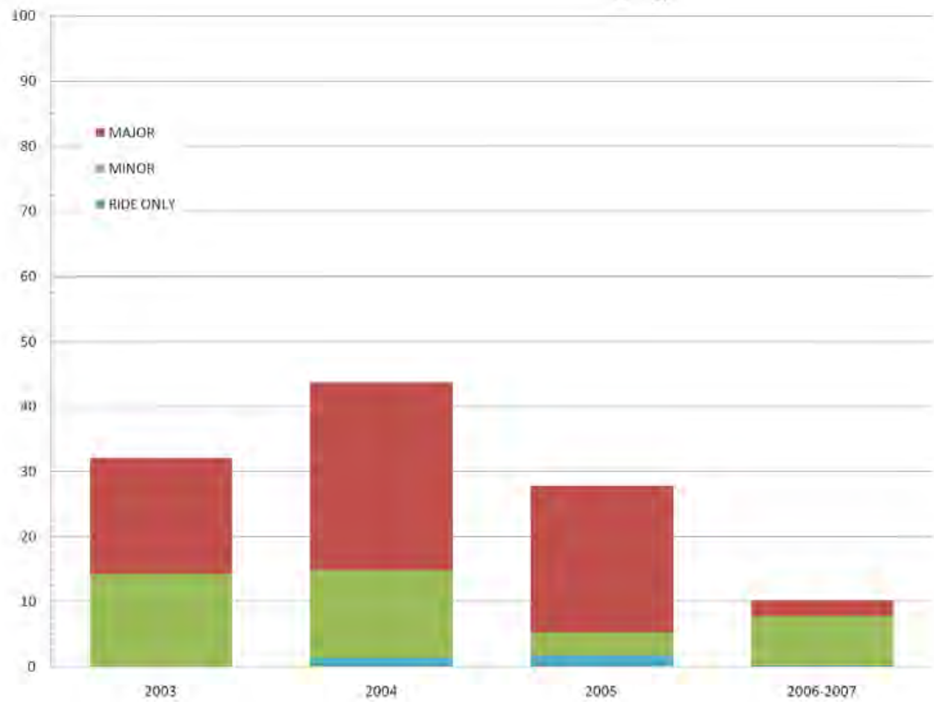
The change in the percent mix of distressed lane-miles is shown more clearly in Exhibit 3-28. Minor pavement distress makes up roughly 75 percent of the issues along the corridor.

Exhibit 3-26: Distressed Lane-Miles on I-5 Corridor (2006–2007)



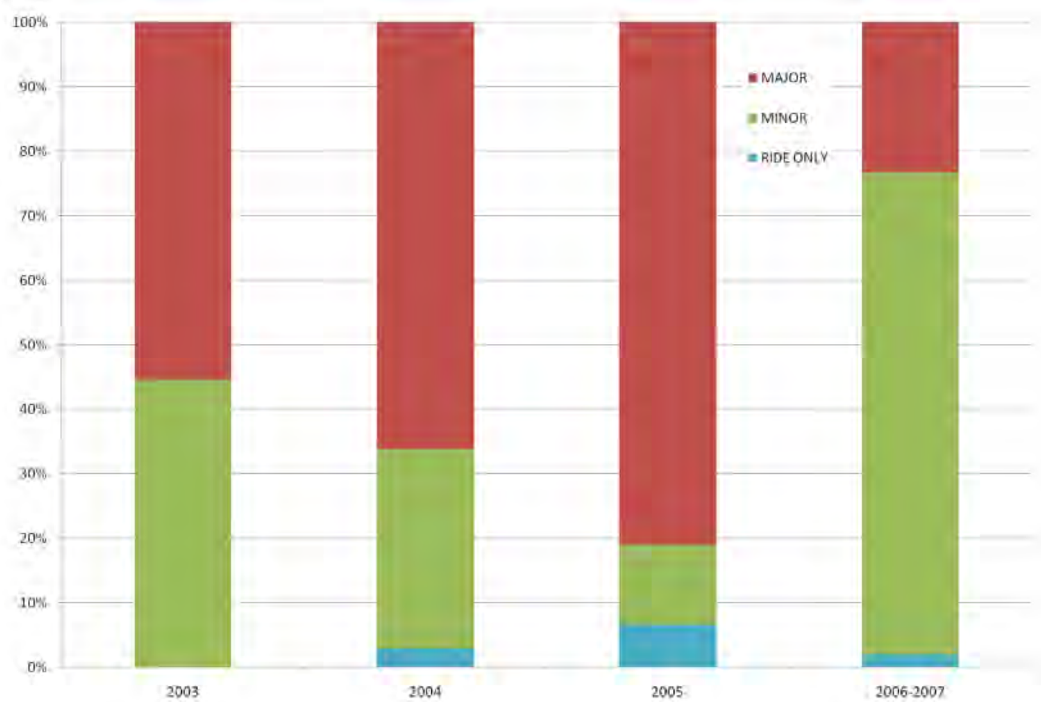
Source: SMG mapping of 2007 Pavement Condition Survey data

Exhibit 3-27: I-5 Distressed Lane-Miles Trends



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

Exhibit 3-28: I-5 Distressed Lane-Miles by Type



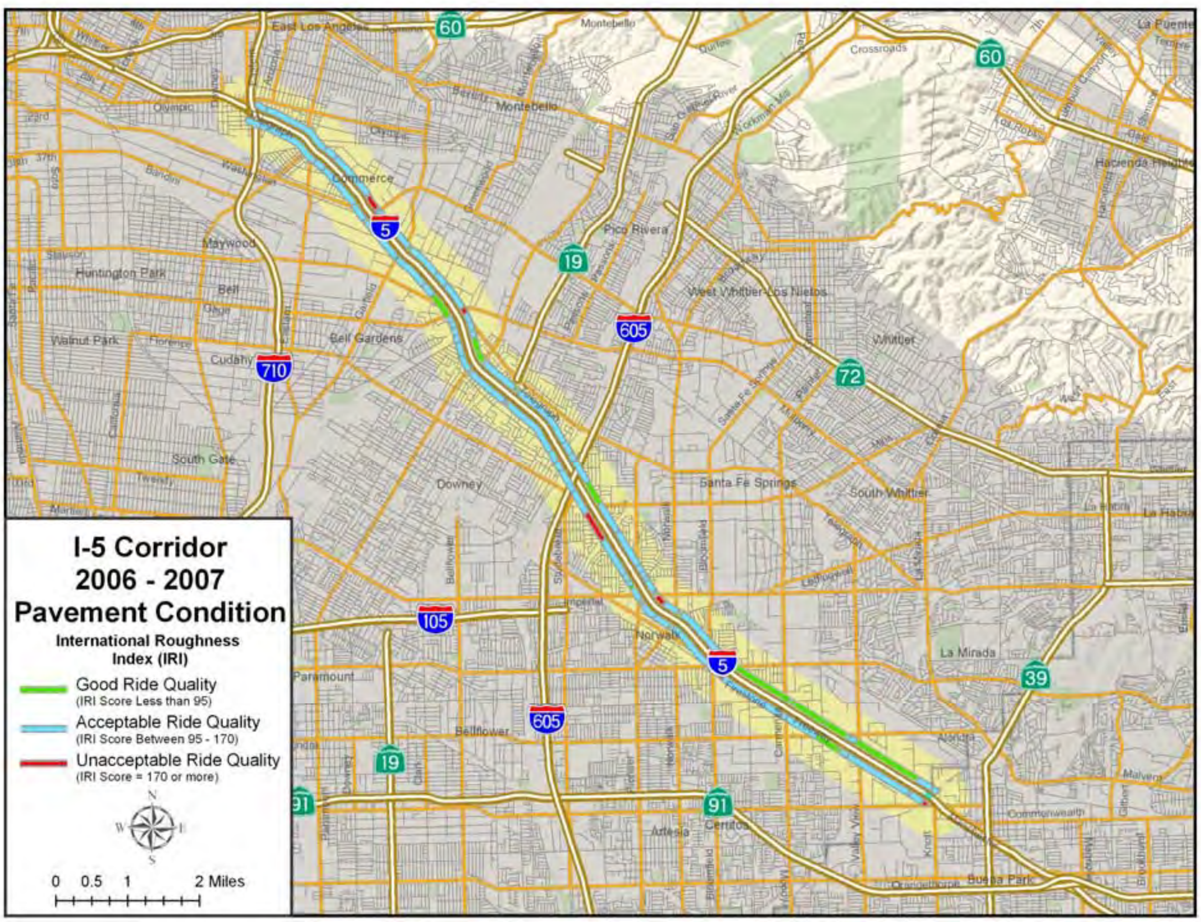
Source: SMG analysis of 2003 to 2007 Pavement Condition Survey data

Exhibit 3-29 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. As the exhibit shows, very little of the corridor has ride quality in the unacceptable range. However, much of the corridor exhibits only acceptable ride quality, which means that ride quality could drop to the unacceptable range in future years.

When the conditions on all lanes are considered, the study corridor comprises roughly 97 lane-miles, of which:

- 48 lane-miles, or 50 percent, are considered to have good ride quality (IRI ≤ 95)
- 48 lane-miles, or 49 percent, are considered to have acceptable ride quality (95 < IRI ≤ 170)
- Just over 1 lane-mile, or about 1 percent, is considered to have unacceptable ride quality (IRI > 170)

Exhibit 3-29: I-5 Road Roughness (2006-2007)

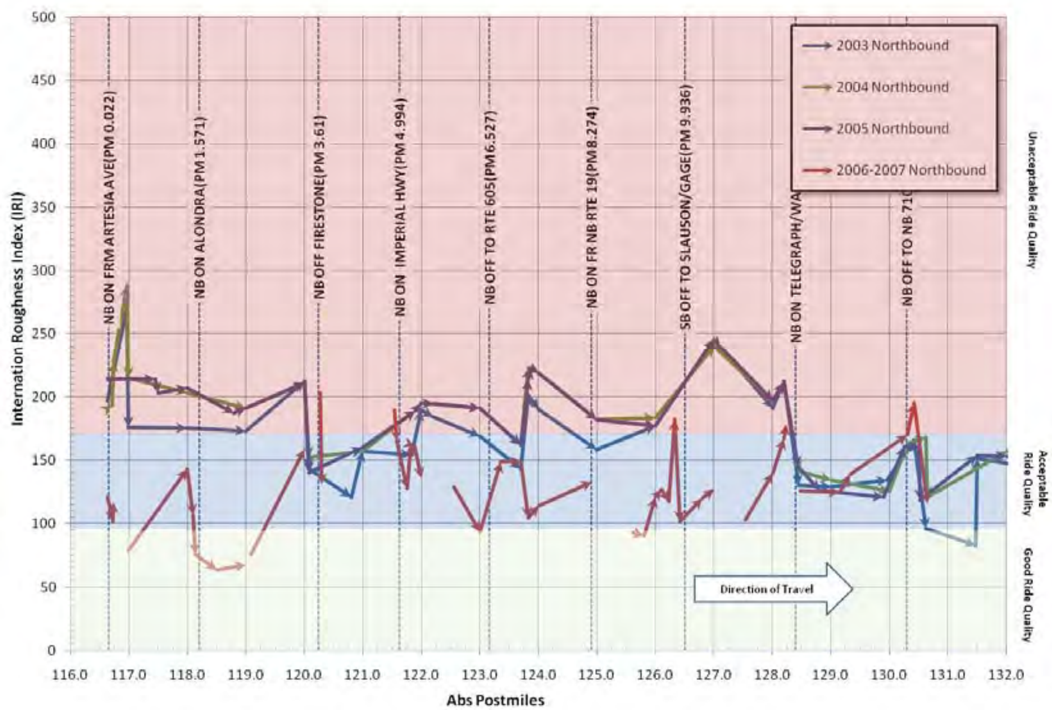


Source: SMG mapping of 2007 Pavement Condition Survey data

Exhibits 3-30 and 3-31 present ride conditions for the I-5 Corridor using IRI from the last four pavement surveys. The information is presented by Post Mile and direction. The exhibits include color-coded bands to indicate the three ride quality categories defined by Caltrans: good ride quality (green), acceptable ride quality (blue), and unacceptable ride quality (red). The IRI conditions reported in the latest PCS are considerably better than those in prior years and reflect an eleven-mile pavement rehabilitation and improvement project from Buena Park to the City of Commerce completed in 2005.

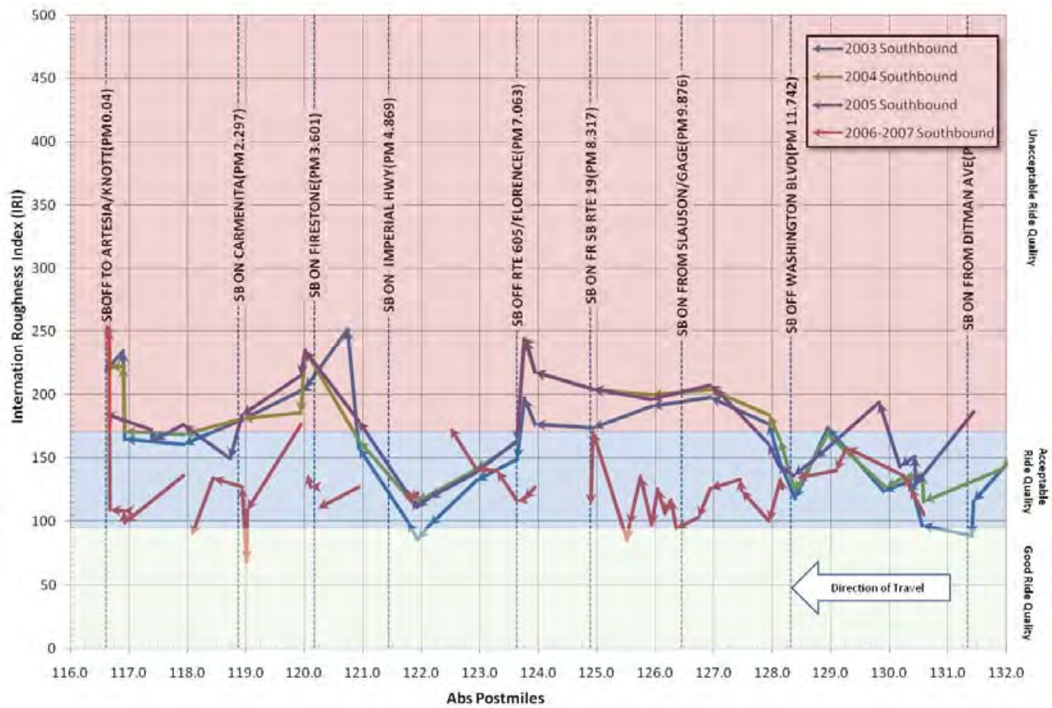
The exhibits exclude a number of sections that were not measured or had calibration issues (i.e., IRI = 0) in the 2006-07 Period.

Exhibit 3-30: Northbound I-5 Road Roughness (2003-2007)



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

Exhibit 3-31: Southbound I-5 Road Roughness (2003-2007)



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

Page Intentionally Left Blank for Future Updates on Pavement Conditions

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 the Orange/Los Angeles County Line and moving northbound, the following bottlenecks were found:

- Carmenita Road Interchange – Inadequate capacity on the mainline contributes to this bottleneck.
- Pioneer Boulevard On-ramp: High truck volume on the mainline and a short merge taper at the on-ramp contribute to this bottleneck.
- I-605 On-ramp: This bottleneck relates to cross-weaving and queuing of vehicles destined for the I-605.
- Paramount Boulevard On-ramp: The congestion and queuing extends for many miles behind this bottleneck during the AM as a platoon of vehicles merge on to the mainline.
- Telegraph Road Off-ramp: An uphill grade and roadway curvature contributes to this bottleneck.
- I-710 On-ramp: The bottleneck relates to cross-weaving and queuing of vehicles destined for the US-101 or I-10.

Southbound Bottlenecks

Starting from the I-710 and moving southbound, the following bottlenecks were found:

- I-710 On-ramp: Although this location is not one of the major bottlenecks, congestion on I-5 caused by the traffic entering from the I-710 connector on-ramp was noticed on numerous site visits.
- Washington Boulevard Interchange: This bottleneck can extend to Atlantic Boulevard or downstream to Bandini Boulevard/Slauson Avenue.
- Paramount On-ramp: This bottleneck frequently extends to the Slauson Avenue Interchange.
- I-605 Off-ramp: This bottleneck occurs during peak periods when a queue forms from the I-605 off ramp on to the I-5 mainline.
- Carmenita Road Interchange – The absence of an auxiliary lane at the ramps contribute to this bottleneck location.

- Valley View Interchange: poor geometric configuration similar to the Carmenita Interchange contribute to this bottleneck location
- OC/LA County Line (Artesia Boulevard Construction): the construction elements such as alignment shifts, changing pavement conditions, or concrete rails, affects traffic flow at this 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, some performance statistics that presented earlier for the entire corridor can be segmented by bottleneck area. This way, the relative contribution of each bottleneck area to the degradation of the corridor performance can be gauged. The performance statistics that lend themselves to such segmentation include:

- Mobility
- Productivity
- Safety

The analysis of bottleneck areas is based on 2007 data (when available). 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 the northbound direction of I-5. 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

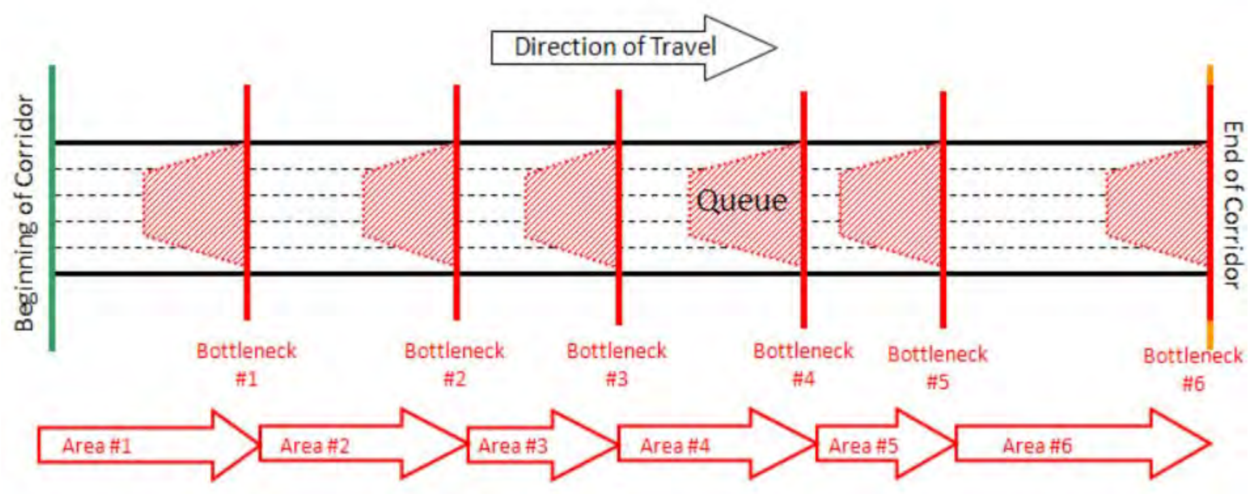
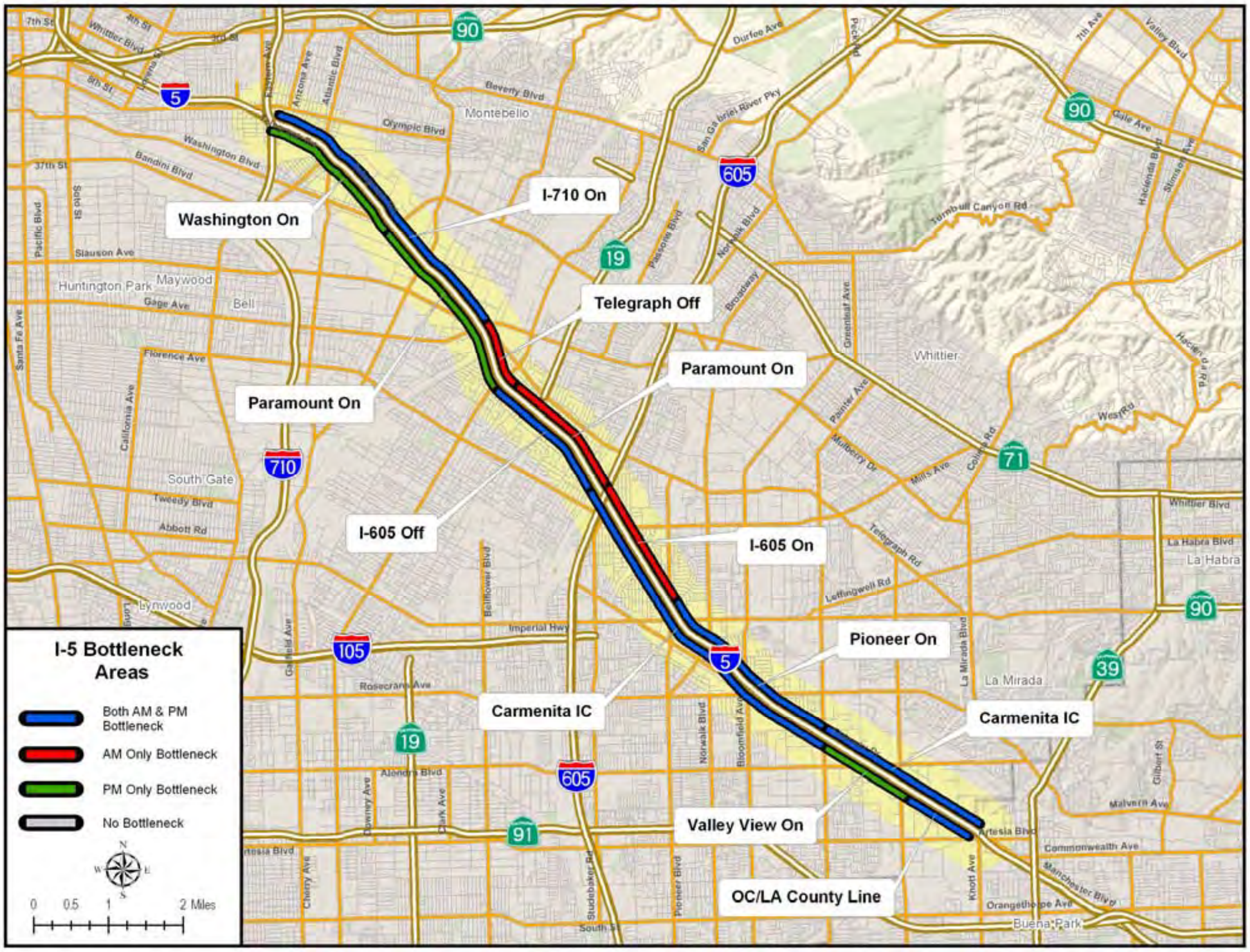


Exhibit 4-2 graphically illustrates the location of each of the bottleneck locations and areas for the I-5 Corridor. Exhibit 4-3 and 4-4 provide a summary of each bottleneck location and corresponding bottleneck area.

Exhibit 4-2: I-5 Bottleneck Locations and Bottleneck Areas



Source: SMG mapping of bottleneck locations and 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, productivity, and pavement condition to evaluate each bottleneck area. The results from this bottleneck analysis will reveal which segments of the corridor should be prioritized for improvements.

For the southern portion of the I-5 Corridor, field observations were conducted by the project consultant team on multiple days (midweek) in September, October, and November 2008 during the AM and PM peak hours. The most recent field reviews were conducted during November 18-20, 2008. During these field visits, photos and electronic videos were taken (to the extent possible) to verify each bottleneck location.

Exhibit 4-3: Northbound I-5 Identified Bottleneck Areas

Bottleneck Location	Bottleneck Area	Active Period		From		To		Distance (miles)
		AM	PM	Abs	CA	Abs	CA	
Carmenita IC	OC/LA County line to Carmenita IC	✓	✓	116.0	0.0	119.1	2.5	3.1
Pioneer On	Carmenita IC to Pioneer On	✓	✓	119.1	2.5	121.9	5.2	2.8
I-605 On	Pioneer On to I-605 On	✓		121.9	5.2	123.6	7.0	1.7
Paramount On	I-605 On to Paramount On	✓		123.6	7.0	125.5	8.8	1.9
Telegraph Off	Paramount On to Telegraph Off/Slauson	✓		125.5	8.8	126.5	9.8	1.0
I-710 On	Telegraph Off/Slauson to I-710 On	✓	✓	126.5	9.8	130.5	13.7	4.0

Exhibit 4-4: Southbound I-5 Identified Bottleneck Areas

Bottleneck Location	Bottleneck Area	Active Period		From		To		Distance (miles)
		AM	PM	Abs	CA	Abs	CA	
Washington On	I-710 to Washington On		✓	130.5	13.7	128.0	11.5	2.5
Paramount On	Washington On to Paramount On		✓	128.0	11.5	125.5	8.9	2.5
I-605 Off	Paramount On to I-605 Off	✓	✓	125.5	8.9	123.6	7.0	1.9
Carmenita IC	I-605 Off to Carmenita IC	✓	✓	123.6	7.0	118.8	2.3	4.8
Valley View IC	Carmenita IC to Valley View On		✓	118.8	2.3	117.6	1.0	1.2
OC/LA County Line	Valley View On to OC/LA County line	✓	✓	117.6	1.0	116.0	0.0	1.6

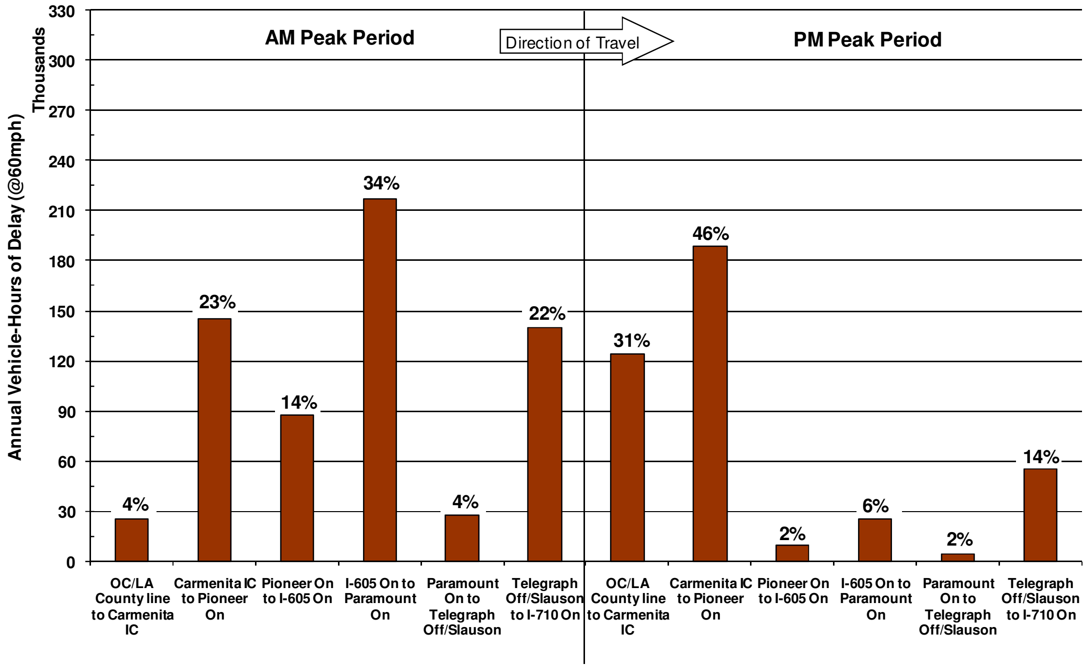
Mobility by Bottleneck Area

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.

Exhibits 4-5 and 4-7 illustrate the vehicle-hours of delay experienced by each bottleneck area. As depicted in Exhibit 4-5, delay in the northbound direction is slightly higher in the AM peak compared to the PM peak. The segment between I-605 to Paramount experienced the greatest delay during the AM peak with 34 percent of the corridor's delay, or over 210,000 annual vehicle-hours of delay. During the PM peak, the segment between Carmenita and Pioneer experienced the greatest delay.

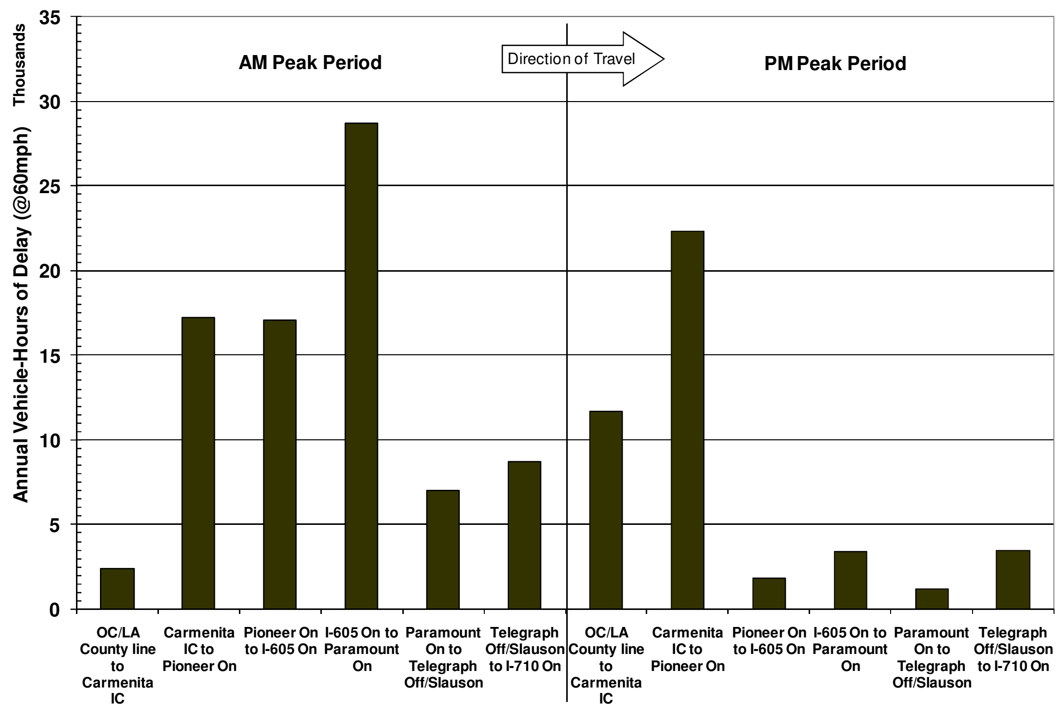
Delay in the southbound direction varied significantly between AM and PM peak periods. Exhibit 4-7 shows that during the PM peak, the two combined segments of I-710 to Washington and I-605 to Carmenita experienced over 60 percent of the delay on the corridor, or about 270,000 annual vehicle-hours of delay each. In the AM peak, the segment between I-605 and Carmenita experienced the most delay with 61 percent of the delay on the corridor, or nearly 110,000 annual vehicle-hours of delay.

Exhibit 4-5: Northbound I-5 Annual Vehicle-Hours of Delay (2007)



Source: SMG analysis of PeMS data

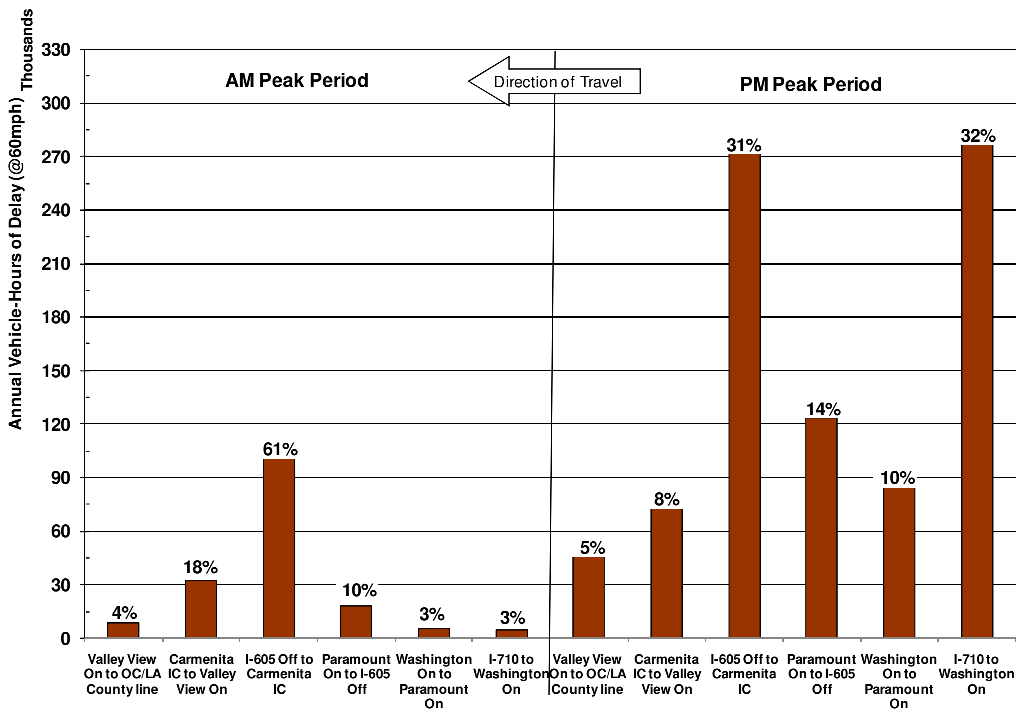
Exhibit 4-6: Northbound I-5 Delay per Lane-Mile (2007)



Source: SMG analysis of PeMS data

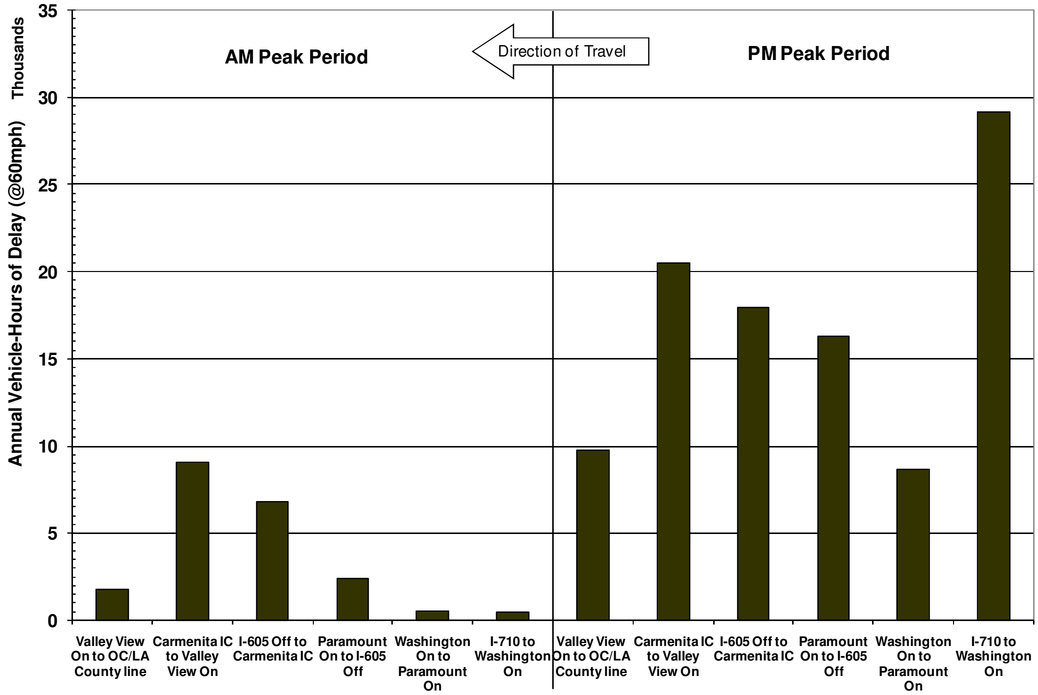
Exhibits 4-6 and 4-8 have been normalized to reflect delay per lane-mile. The delay calculated for each bottleneck area was divided by the total lane-miles for each bottleneck area to obtain delay per lane-mile. In both directions, the results were similar to the delay shown in Exhibits 4-5 and 4-7. However, in the southbound direction (Exhibit 4-8), normalizing lane-miles resulted in more evenly distributed delay among the bottleneck areas during the PM peak period.

Exhibit 4-7: Southbound I-5 Annual Vehicle-Hours of Delay (2007)



Source: SMG analysis of PeMS data

Exhibit 4-8: Southbound I-5 Delay per Lane-Mile (2007)



Source: SMG analysis of PeMS data

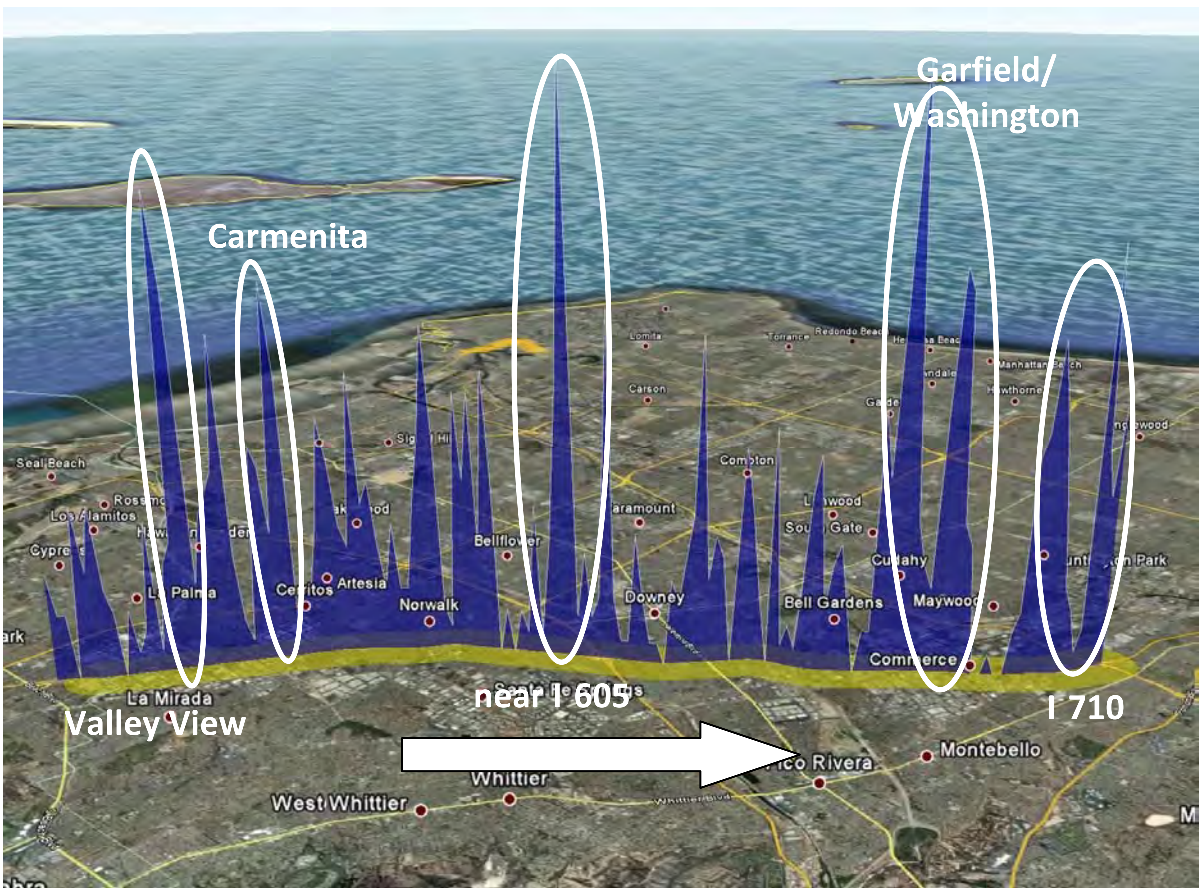
Safety by Bottleneck Area

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 areas.

Exhibit 4-9 shows the location of all collisions plotted along the I-5 Corridor in the northbound direction. The spikes show the total number of collisions (fatality, injury, and property damage only) occurring within 0.1 mile segments during 2006. The highest spike corresponds to roughly 26 collisions in a single 0.1 mile location. The size of the spikes is a function of how collisions are grouped. If the data were grouped in 0.2 mile segments, the spikes would be higher.

As evident in Exhibit 4-9, the study corridor has a high concentration of collisions at many locations. Therefore, it is relevant to identify the locations that have disproportionately high collision rates. Starting from the Orange/Los Angeles County Line and moving northbound, a large number of collisions occurred around Valley View and Carmenita, near the I-605 Interchange, between Garfield and Washington, and at the I-710 Interchange. In many cases, a spike in the number of collisions occurs in the same location as a bottleneck. For example, a spike occurred at Carmenita and the I-605 Interchange, which are also bottleneck locations.

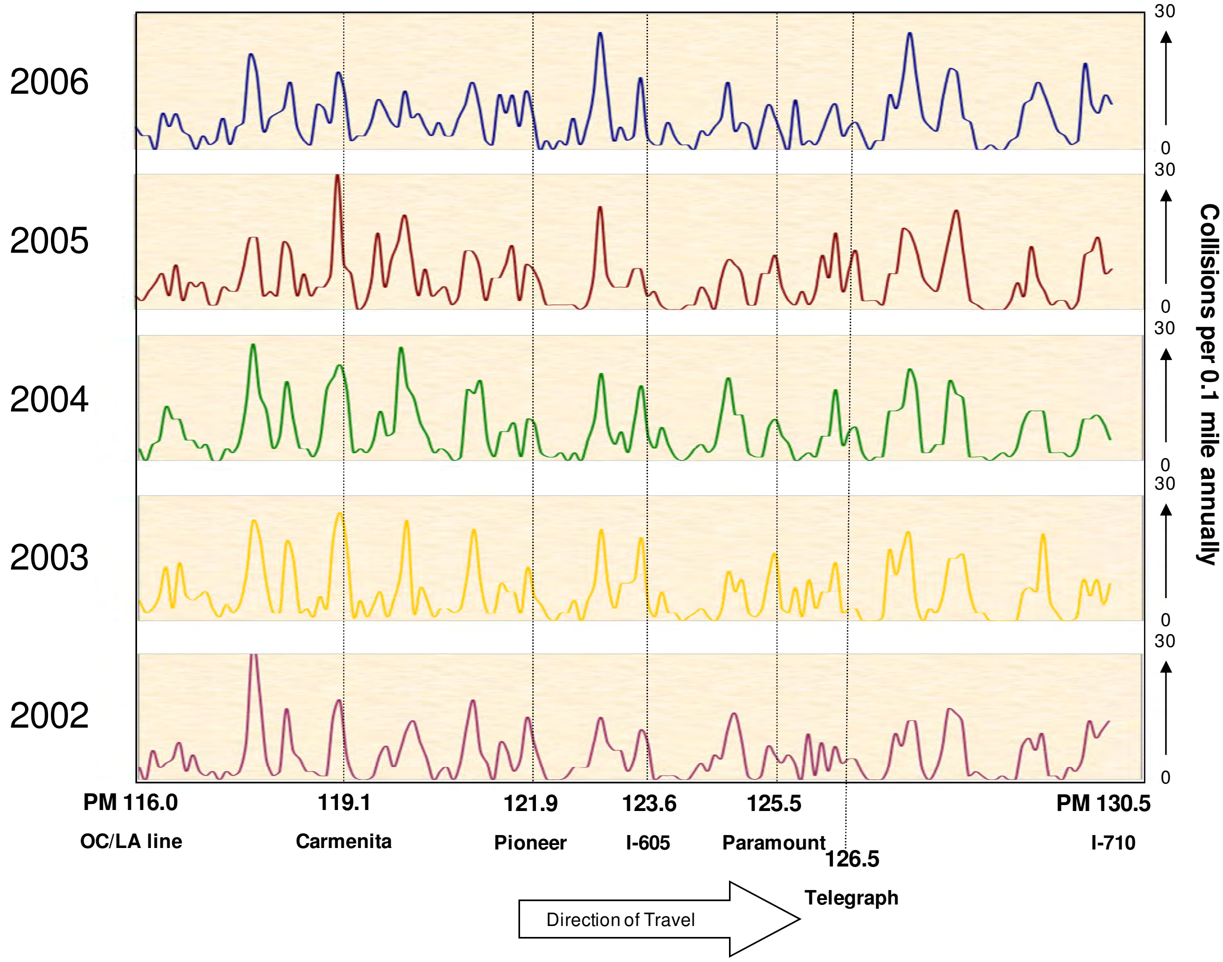
Exhibit 4-9: Northbound I-5 Collision Locations (2006)



Source: SMG mapping of 2006 TASAS data obtained through PeMS

Exhibit 4-10 illustrates the same data for the five-year period from 2002 to 2006. The vertical lines in the exhibit separate the corridor by bottleneck area. This exhibit is an extension of Exhibit 4-9 as it includes collision data from the years preceding 2006. As indicated in Exhibit 4-9 and as shown in Exhibit 4-10, a high number of collisions occurred at Carmenita (PM 119.1) and the I-605 Interchange (PM 123.6). Exhibit 4-10 shows that the pattern of collisions has stayed fairly consistent from one year to the next. However, the group of collisions south of Carmenita, around PM 117.7 has decreased overall since 2002.

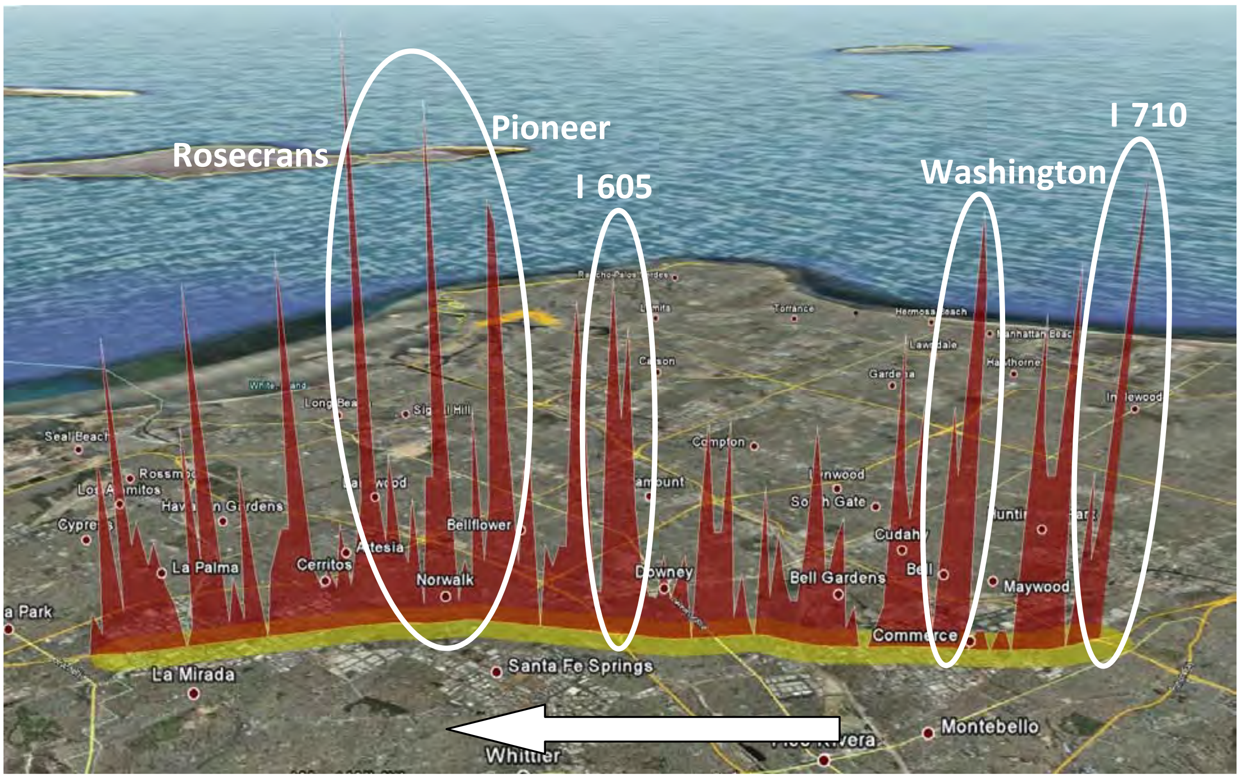
Exhibit 4-10: Northbound I-5 Collision Locations (2002-2006)



Source: SMG analysis of TASAS data obtained through PeMS

Exhibit 4-11 shows the same 2006 collision data for the I-5 in the southbound direction. The largest spike in this exhibit corresponds roughly to 26 collisions per 0.1 miles. The pattern in the southbound direction is similar to that in the northbound direction but with greater variance in spike lengths. Moving in the southbound direction from I-710, spikes are most notable at the I-710 Interchange, near Washington, at the I-605 Interchange, and between Pioneer and Rosecrans. The locations at Washington and I-605 are also bottleneck locations.

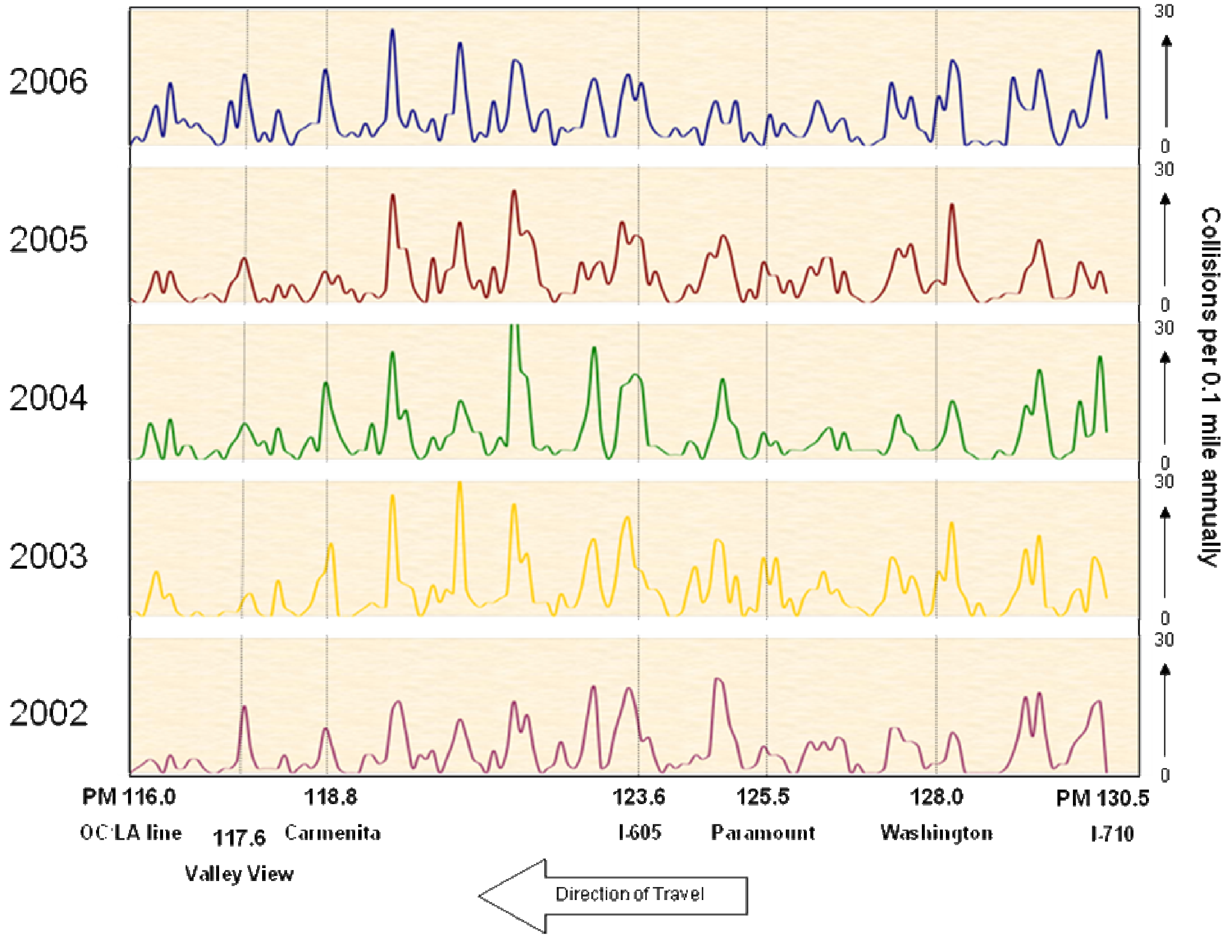
Exhibit 4-11: Southbound I-5 Collision Locations (2006)



Source: SMG mapping of 2006 TASAS data obtained through PeMS

Exhibit 4-12 shows the trend of collisions for the southbound direction during the 2002-2006 period by bottleneck area. As the exhibit shows, the pattern of collisions has been fairly steady from one year to the next. The bottleneck area with the highest spikes or largest number of collisions is located between the I-605 Interchange (PM 123.6) and Carmenita (PM 118.8). Collisions which occurred in this bottleneck area have decreased since 2003.

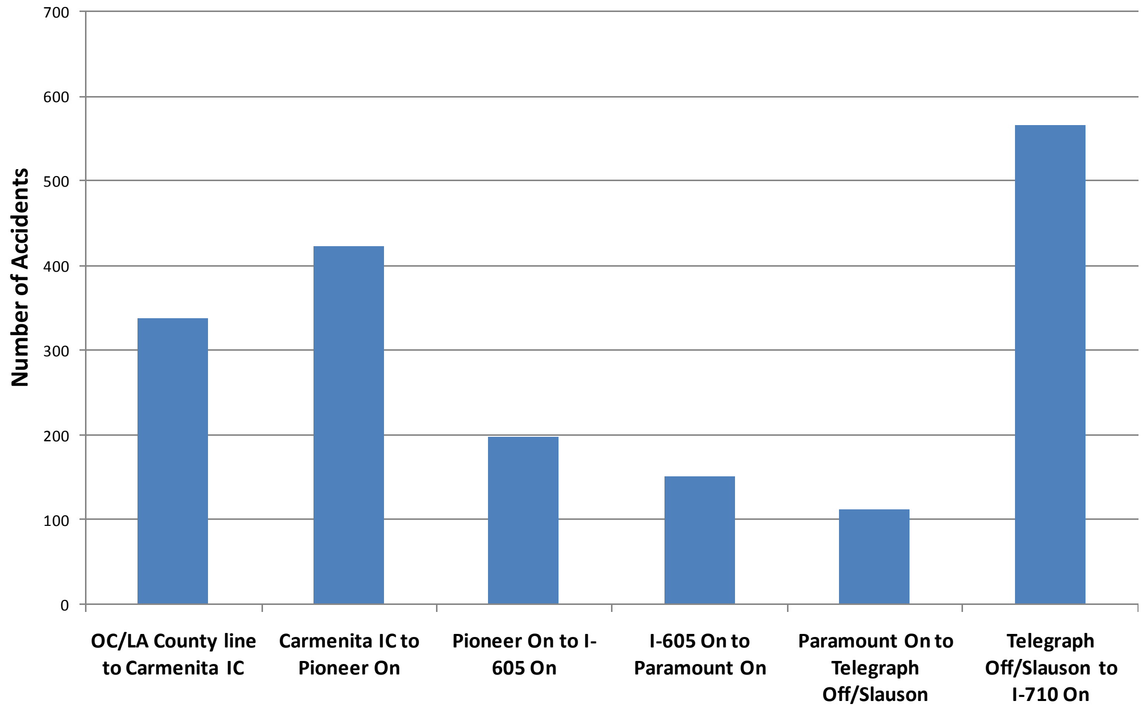
Exhibit 4-12: Southbound I-5 Collision Locations (2002-2006)



Source: SMG analysis of TASAS data obtained through PeMS

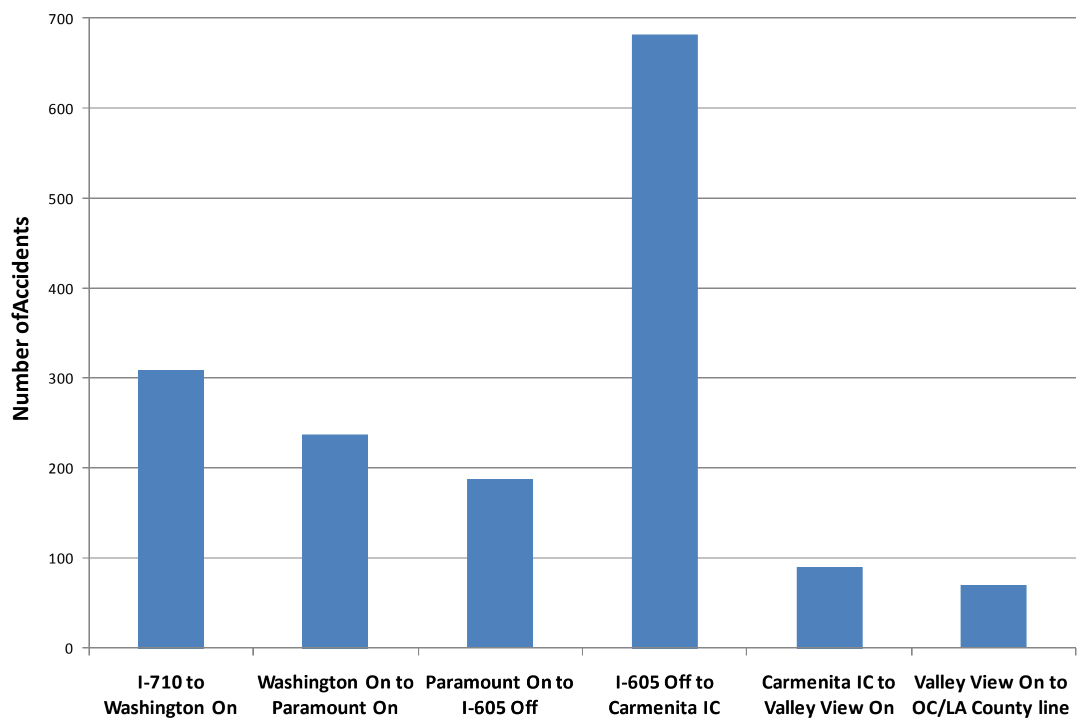
Exhibits 4-13 and 4-14 present the total number of accidents reported in TASAS by bottleneck area. The bars show the total of accidents that occurred in 2005 and 2006, the latest two years available in TASAS. In the southbound direction, the segment between the I-605 and Carmenita exceeded every other segment in accidents in both directions with nearly 700. This bottleneck area is also the longest in distance at nearly five miles.

Exhibit 4-13: Northbound I-5 Total Accidents (2005-2006)



Source: SMG analysis of TASAS data

Exhibit 4-14: Southbound I-5 Total Accidents (2005-2006)



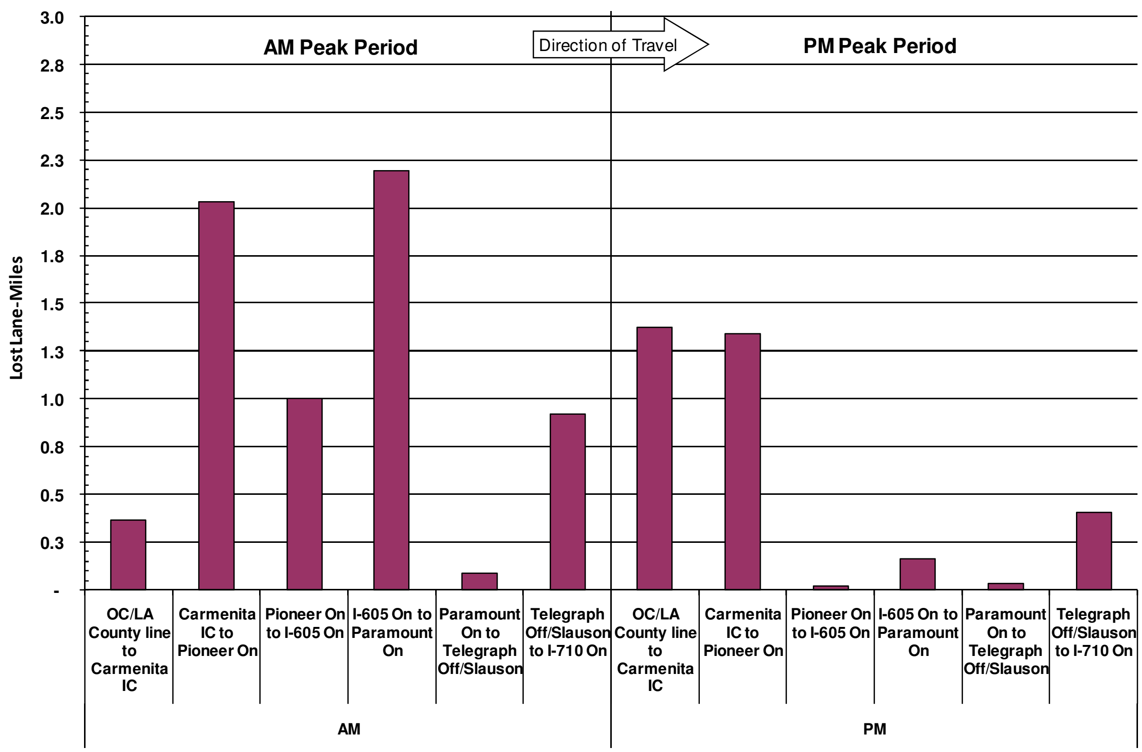
Source: SMG analysis of TASAS data

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.

Exhibits 4-15 and 4-16 show the productivity losses for both directions of the corridor. In the northbound direction, the segment from I-605 to Paramount had the worst productivity of any other segment with just under 2.2 lost lane-miles in the AM peak. The section from Carmenita to Pioneer had similar productivity losses of about 2.0 lane-miles. During the PM peak, the segments from the County line to Carmenita, and from Carmenita to Pioneer had productivity losses of approximately 1.4 lost lane-miles.

Exhibit 4-15: Northbound I-5 Lost Lane-Miles (2007)

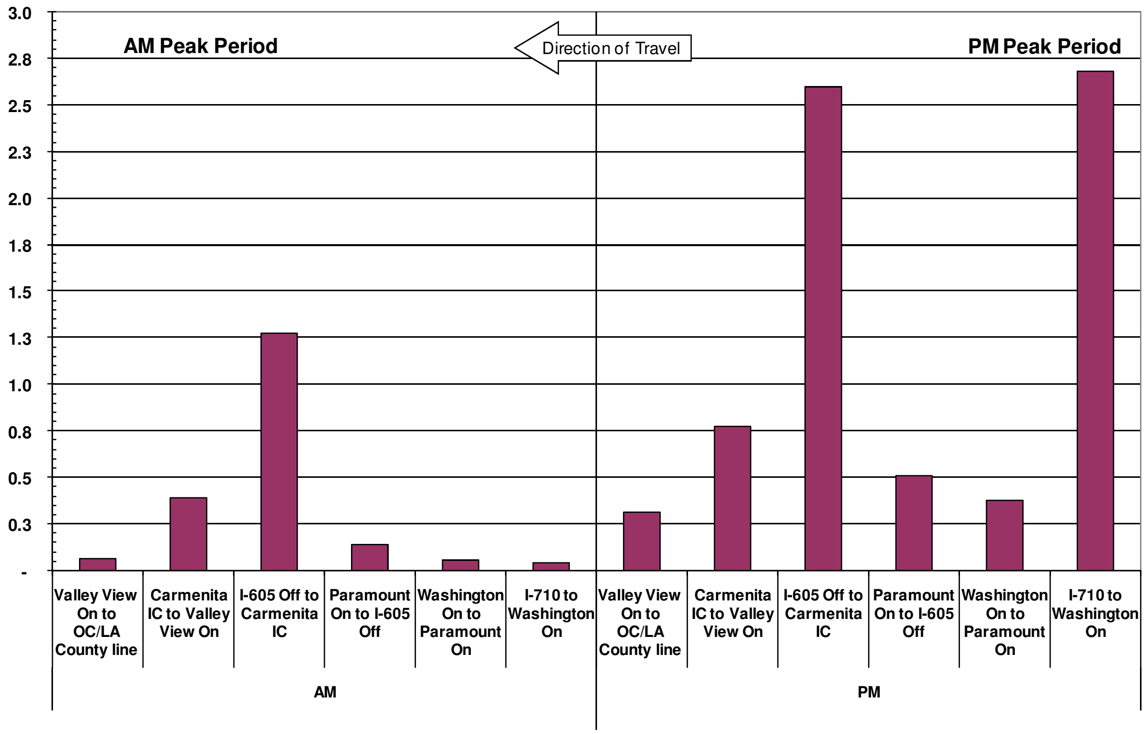


Source: SMG analysis of PeMS data

In the southbound direction, the segment from the I-710 to Washington had the worst productivity of any segment on the study corridor with 2.7 lost lane-miles in the PM peak. The segment from the I-605 to Carmenita was just as unproductive with over 2.5 lost lane-miles during the PM peak. During the AM peak, the segment from the I-605 to Carmenita suffered the worst productivity at about 1.3 lane-miles, while the rest of the segments experienced relatively high levels of productivity with under 0.5 lost lane-miles.

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

Exhibit 4-16: Southbound I-5 Lost Lane-Miles (2007)



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-5 Corridor, field observations were conducted by the project consultant team on multiple days (midweek) in September, October, and November 2008 during the AM and PM peak hours. The recent field reviews were conducted November 18 through 20, 2008.

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.

Northbound Bottlenecks and Causes

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

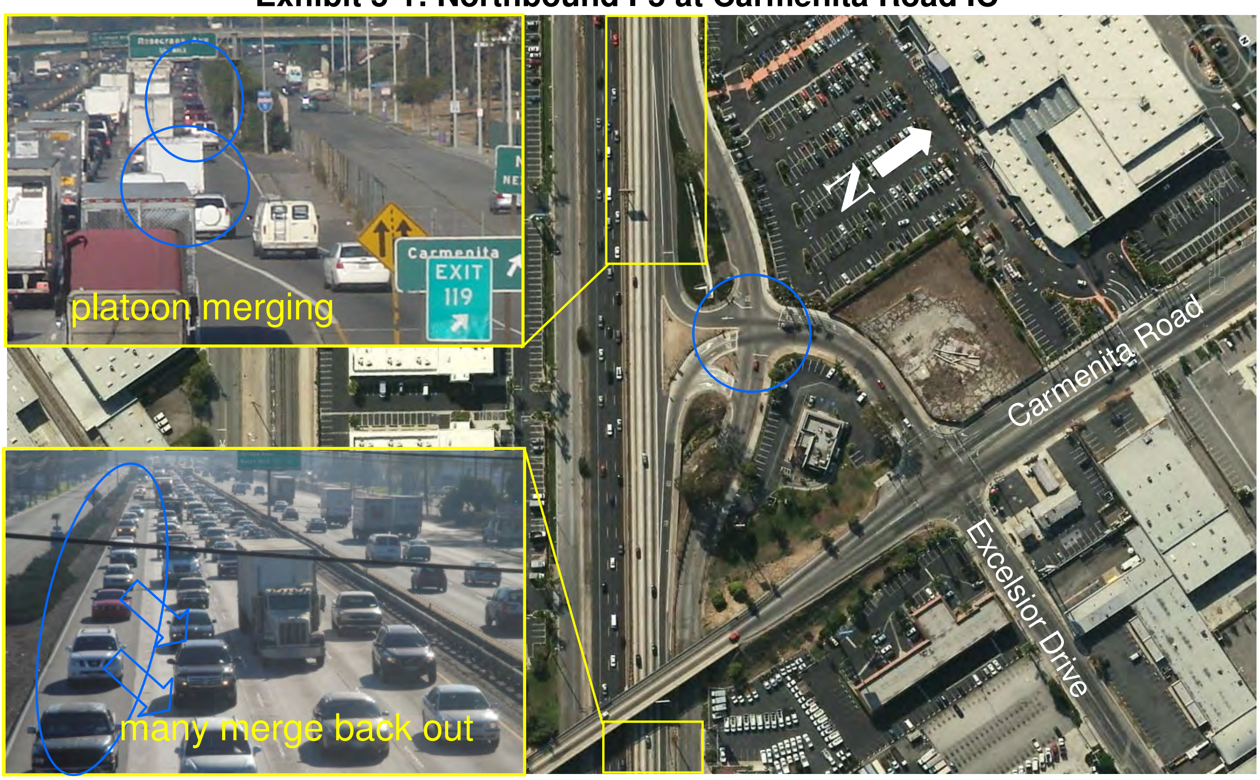
Carmenita Road Interchange

Exhibit 5-1 is an aerial photograph of the northbound I-5 mainline at the Carmenita Road Interchange. As shown, the on- and off-ramps are slip ramps that no longer meet the current demand. The poor geometric configuration of this interchange results in inefficient traffic operations. The primary cause of this bottleneck is the traffic merging from both the off-ramp and the on-ramp.

As the lower inset digital photograph indicates, much of the heavy traffic in the auxiliary lane merges back into the mainline, rather than exiting at the off-ramp. The mainline at capacity cannot absorb the additional demand, resulting in a bottleneck. Also, as the upper inset photograph indicates, the traffic from the on-ramp merges onto the mainline as the auxiliary lane ends at Rosecrans Avenue, also resulting in a bottleneck condition. The ramp metering at the on-ramp is ineffective due to the lack of storage capacity on the ramp.

Additionally, the intersection at the base of the ramps is a stop-controlled intersection. During heavy peak periods, the off-ramp traffic queues onto the mainline from the intersection.

Exhibit 5-1: Northbound I-5 at Carmenita Road IC



Imperial Highway On/Pioneer Boulevard On

Exhibit 5-2 is an aerial photograph of the northbound I-5 mainline between Imperial Highway and Pioneer Boulevard. As shown, there are two on-ramps in close proximity, one from Imperial Highway and another from Pioneer Boulevard.

As indicated from the inset photographs, the configuration of both ramps includes a very short taper, making for a difficult merge transition particularly with heavy truck traffic present on the mainline. In addition, there is a short but noticeable vertical grade as the freeway crosses over the two interchanges, slowing vehicles down, especially heavy trucks. This is also evident in the photographs.

Although the ramp volumes are not heavy (even during peak hours), it is enough to disrupt the mainline flow and create the bottleneck condition. Just past the Pioneer Boulevard on-ramp, traffic flow returns to free-flow speeds.

Exhibit 5-2: Northbound I-5 at Imperial Highway and Pioneer Blvd Interchanges

Florence Avenue/I-605 On

Exhibit 5-3 is an aerial photograph of the northbound I-5 mainline at the I-605 Interchange. As indicated in the top blue oval, the two connector on-ramps from the I-605 merge together into a new (fourth) lane. Just upstream of the connector on-ramp to the I-5 is the Florence Avenue on-ramp merge, as indicated in the bottom blue oval.

Although this location does not always form a bottleneck, it does occur, whenever the ramp or mainline traffic volumes are heavy. With traffic growth, it is likely to be a major bottleneck in the future.

Exhibit 5-3: Northbound I-5 at Florence Avenue and I-605 On

Paramount Boulevard On

Exhibit 5-4 is an aerial photograph of the northbound I-5 at Paramount Boulevard. The bottleneck condition at this location is caused by the platoon of vehicles merging onto the freeway mainline as the mainline traffic makes the turn (see the inset photograph). The photograph illustrates the mainline queuing behind the merge point and the free-flow conditions just past it.

The platoon is due to the ramp metering location too far back the ramp as indicated by the blue circle, releasing two vehicles at a time. By the time they reach the merge point, a platoon of four to six vehicles already are formed as they merge onto the freeway. The congestion and queuing extends for many miles behind this bottleneck during the AM peak hours. Some congestion also forms behind this bottleneck during the PM peak hours.

Exhibit 5-4: Northbound I-5 at Paramount Boulevard On

Telegraph Road/Slauson Avenue Off

Exhibit 5-5 is an aerial photograph of the northbound I-5 approaching the Telegraph Road/Slauson Avenue off-ramp. The bottleneck condition at this location is caused by the combination of uphill grade, roadway curvature, and slow speeds coming out of the Paramount Boulevard bottleneck, as evident in the inset photograph. As the traffic travels over the hill and around the curve, speeds increase to free-flow speeds and the queue begins to dissipate.

Exhibit 5-5: Northbound I-5 Approaching Telegraph Road/Slauson Avenue Off

I-710 On

The last bottleneck in the northbound direction is at the I-710 connector on-ramp. Exhibit 5-6 is an aerial photograph of the northbound I-5 at the I-710 on-ramp merge point. About a mile and a half further downstream, the freeway separates into the US-101 in the left lanes, the I-5 in the middle lanes, and the I-10 in the right lanes. Traffic from the I-710 merges from the left. As a result, there is a significant amount of cross-weaving at this junction as some of the I-5 vehicles are shifting to the left to use US-101 and some of the I-710 vehicles are shifting to the right to use I-10.

Exhibit 5-6: Northbound I-5 at I-710 On

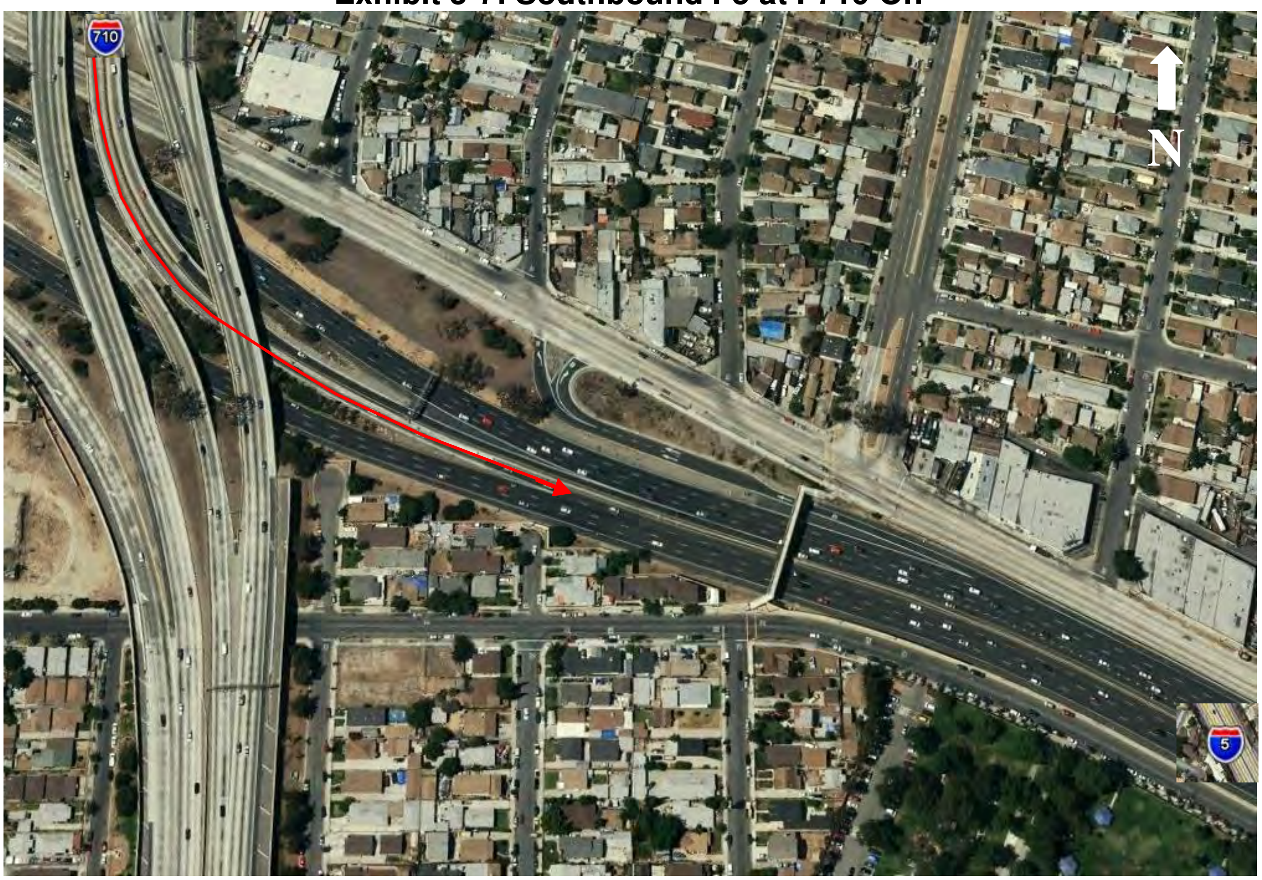
Southbound Bottlenecks and Causes

The southbound bottlenecks occur mostly in the PM peak hours although the same bottlenecks occur to a lesser degree in the AM peak hours. Below is a summary of the causes of the bottleneck locations.

<u>I-710 On</u>

Exhibit 5-7 is an aerial photograph of the southbound I-5 mainline at the I-710 connector on-ramp. Although this location is not one of the major bottlenecks, congestion on I-5 caused by the traffic entering from the I-710 connector on-ramp was noticed on numerous site visits. The I-710 traffic enters I-5 using a new fourth lane on the left. This left entering traffic causes the next lane to slow down and disrupt traffic flow.

Exhibit 5-7: Southbound I-5 at I-710 On

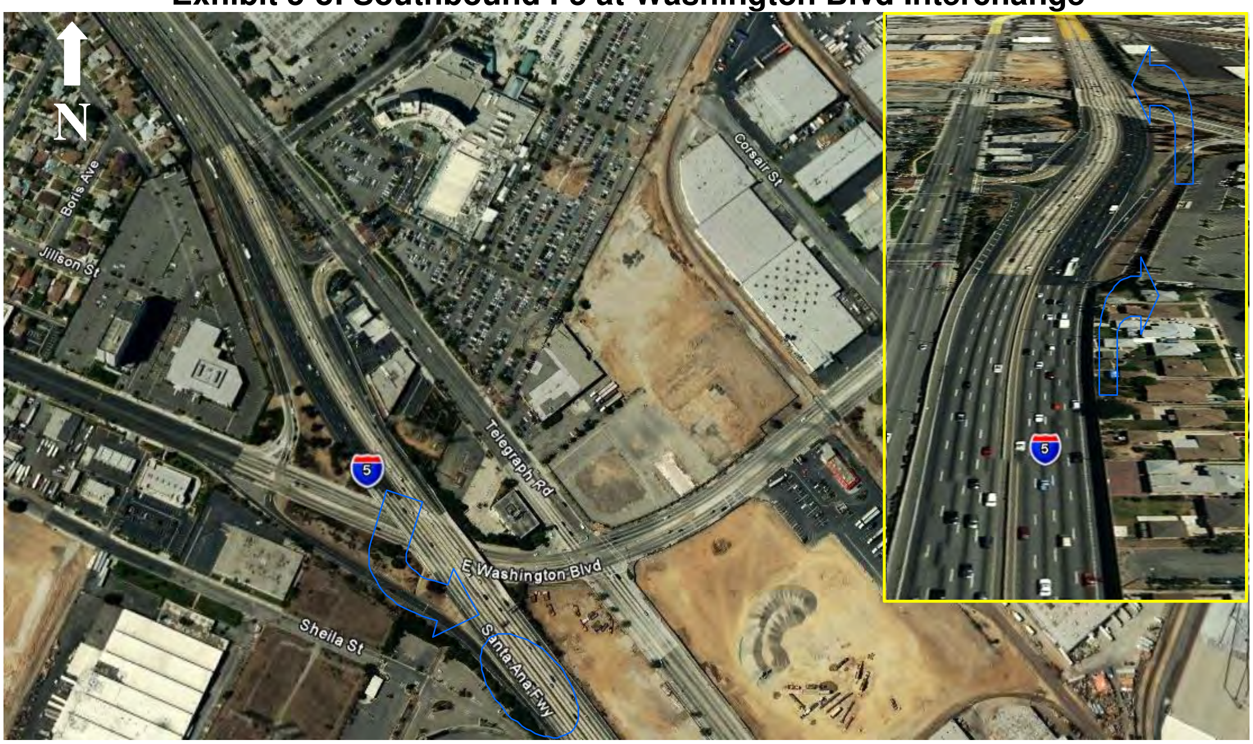


Washington Boulevard Interchange

Exhibit 5-8 is an aerial photograph of the southbound I-5 mainline at the Washington Boulevard Interchange. Although substantial congestion was not observed in any of the field visits at this location, vehicles did slow down to below 35 miles per hour on many occasions during the PM peak hours. It is likely that the primary cause of the bottleneck at this location is the presence of an on-ramp merge beyond the crest of a vertical grade.

Although this location appears to be the primary bottleneck location, sometimes the bottleneck occurs at Atlantic Boulevard interchange further upstream or at Bandini Boulevard/Slauson Avenue interchange further downstream. Similar to the Washington Boulevard interchange, geometric configurations at both locations appear to affect traffic flow and reduce travel speed during the PM peak hours.

Exhibit 5-8: Southbound I-5 at Washington Blvd Interchange



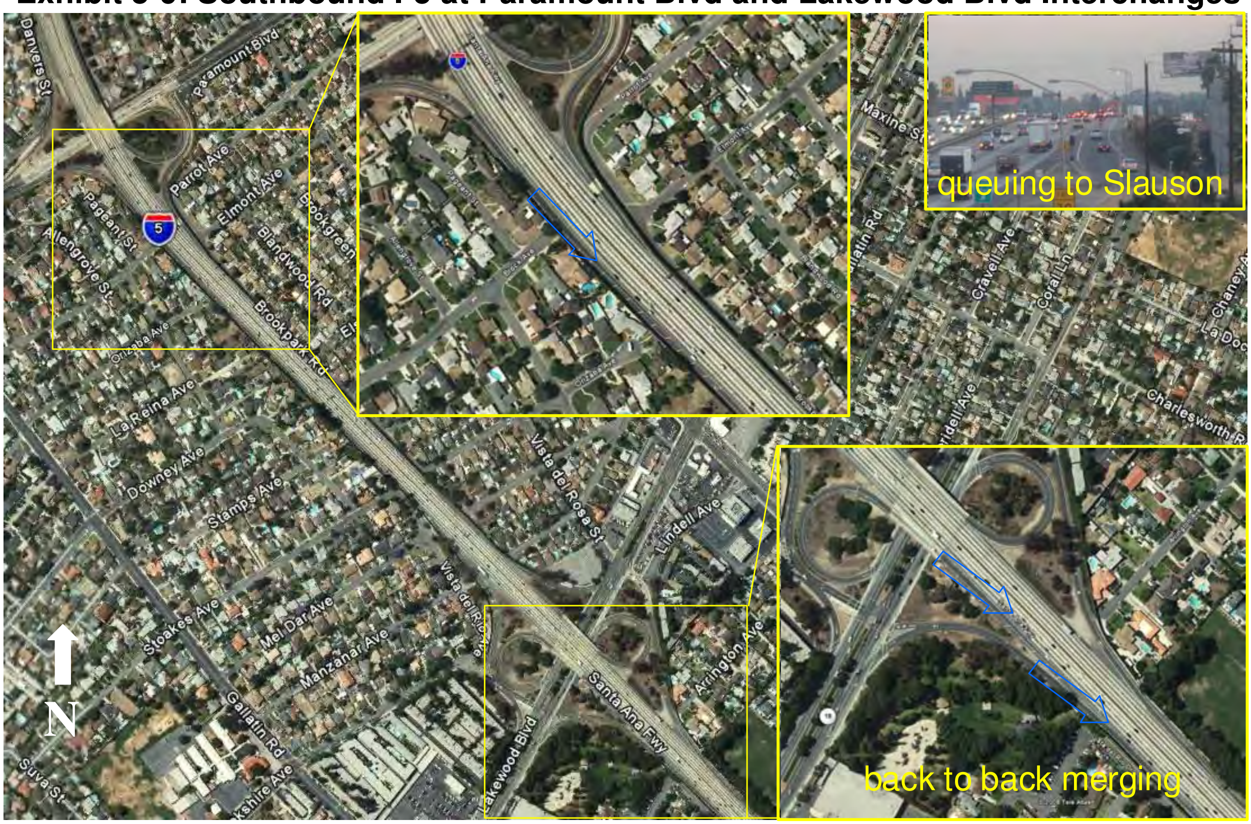
<u>Paramount Boulevard On/Lakewood Boulevard On</u>

Exhibit 5-9 is an aerial photograph of the southbound I-5 at the Paramount Boulevard and Lakewood Boulevard interchanges. The primary location of the bottleneck is at the Paramount Boulevard on-ramp merge. However, bottlenecks also form on frequent occasions at the Lakewood Boulevard on-ramps as well.

The primary cause of the bottleneck at Paramount Boulevard on-ramp is its location affecting the merge. As the inset photograph illustrates, queues often extends to the Slauson Avenue interchange. It also illustrates the geometric configuration of the vertical grade over the crest and dropping down (past Paramount Boulevard, while moving in a turn to the left). The on-ramp merge point is at the peak of the roadway curve to the left and descent, causing vehicles to slow down suddenly to allow for the slow moving on-ramp traffic to merge.

The cause of the bottleneck at the Lakewood Boulevard on-ramp is due to the consecutive on-ramps merging, not allowing the mainline traffic to recover from the merging. When ramp traffic is heavy during the peak hours, the mainline cannot accommodate the additional demand and merging effects.

Exhibit 5-9: Southbound I-5 at Paramount Blvd and Lakewood Blvd Interchanges



I-605 Off

Exhibit 5-10 is an aerial photograph of the southbound I-5 at the I-605 connector off-ramp. As shown, the mainline roadway loses one lane to the I-605 off, going from four lanes to three. Based on the field reviews, it does not appear to be the lane drop that causes the bottleneck at this location but rather the queuing of the I-605 off-ramp traffic backing up onto the I-5 mainline. As a result, the third lane is sometimes blocked as well since the third lane is an option lane for I-5 and I-605 exit. This bottleneck condition only occurs when the exiting traffic at the I-605 off-ramp is heavy during the peak hours.

Exhibit 5-10: Southbound I-5 at I-605 Off

Carmenita Road Interchange

Exhibit 5-11 is an aerial photograph of the southbound I-5 mainline at Carmenita Road Interchange. As shown, like the northbound, the on and off-ramps are slip ramps that no longer meet the current demand, but unlike the northbound, these ramps do not connect to an auxiliary lane. The poor geometric configuration of this interchange results in inefficient traffic operations.

The upper inset photograph shows the significant congestion and queues approaching the interchange. The next photograph below shows the congestion loosening up at the off-ramp location. Passing the on-ramp, the speeds return to free-flow conditions.

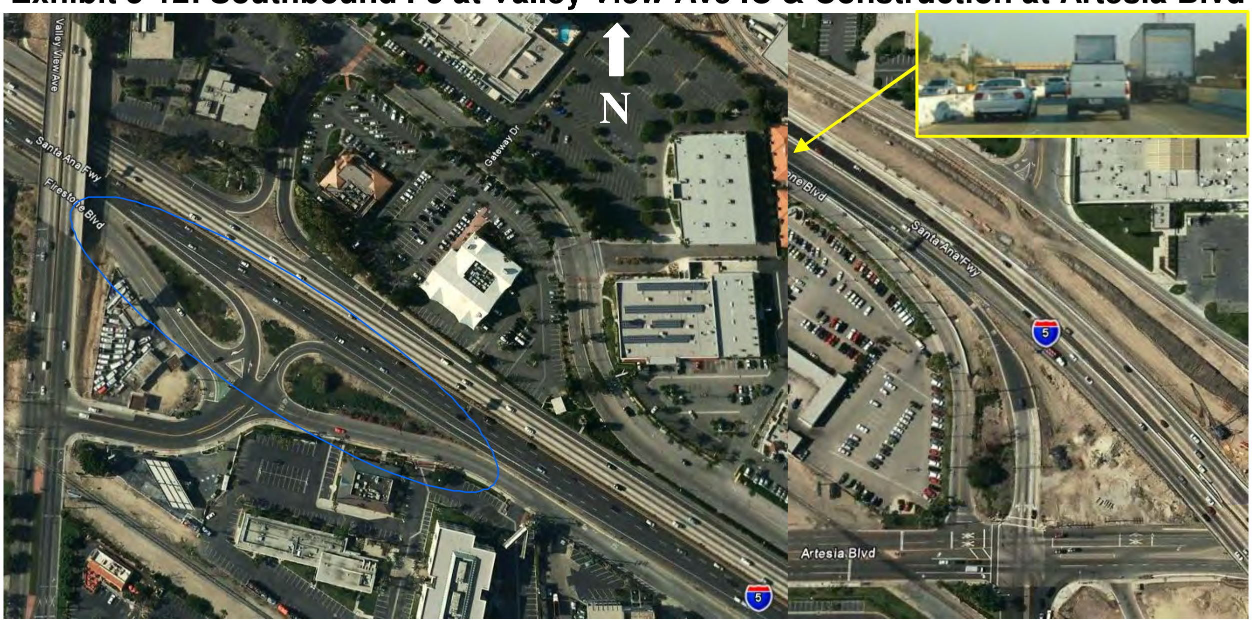
From the field observations it was noticed that the ramp traffic itself does not seem to directly cause the bottleneck condition, unlike the northbound direction. The bottleneck is likely due to the poor geometric configuration of the interchange causing the slow down at this junction. The on-ramp traffic is just below 500 vehicles per hour during the peak hours.

Exhibit 5-11: Southbound I-5 at Carmenita Road IC

Valley View Avenue Interchange/Artesia Boulevard Construction

Exhibit 5-12 is an aerial photograph of the southbound I-5 mainline at Valley View Avenue Interchange. The traffic effects are very similar to Carmenita Road as the interchange is also very similar in configuration. Just past this interchange is the beginning of the mainline construction approaching Artesia Boulevard. The construction elements with alignment shift, changing pavement conditions, concrete rails on both sides, little or no shoulder width, and construction activities causes the traffic to breakdown since the reduced capacity associated with construction cannot accommodate the constant demand.

Exhibit 5-12: Southbound I-5 at Valley View Ave IC & Construction at Artesia Blvd



Page Intentionally Left Blank for Future Updates on Bottleneck Causality

APPENDIX

This appendix is an exact copy of Section 4 of the Preliminary Performance Assessment document developed and submitted to Caltrans in April 2008. 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.

A. BOTTLENECK ANALYSIS

This section presents the results of the bottleneck analysis. The goal is to identify potential locations that create mobility constraints. Potential freeway bottleneck locations are identified and documented, and their relative contribution to corridor-wide congestion is reported.

A variety of sources were used to identify bottlenecks:

- Caltrans Highway Congestion Monitoring Program (HICOMP) 2006 report
- Freeway Performance Measurement System (PeMS)
- Aerial photos (Google Earth) and Caltrans photologs.

HICOMP

Potential problem areas are initially identified by reviewing the Caltrans Highway Congestion Monitoring (HICOMP) Report. The results of the analysis are in Exhibits 4-1 and 4-2. The downstream end of congested segments indicate potential bottleneck areas, which are indicated by blue circles in the northbound direction and red circles in the southbound direction.

- In the **AM peak**, there are potentially two major bottlenecks in the northbound direction and one major bottleneck in the southbound direction, as identified in the 2006 HICOMP:
    - Artesia Boulevard (southbound)
    - Alondra Boulevard (northbound)
    - Telegraph Road/Garfield Avenue/Greenwood Avenue (northbound).
- In the **PM peak**, there are potentially two major bottleneck in the northbound direction and two major bottlenecks in the southbound direction, as identified in the 2006 HICOMP:
    - Artesia Boulevard (southbound)
    - Alondra Boulevard (northbound)
    - I-605 Off-ramp/Orr and Day Road (northbound)
    - I-605 Off-ramp/Lemoran Avenue (southbound).

Further analysis is needed to determine their actual locations and other possible 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 A4-1: 2006 HICOMP AM Congestion Map with Potential Bottlenecks

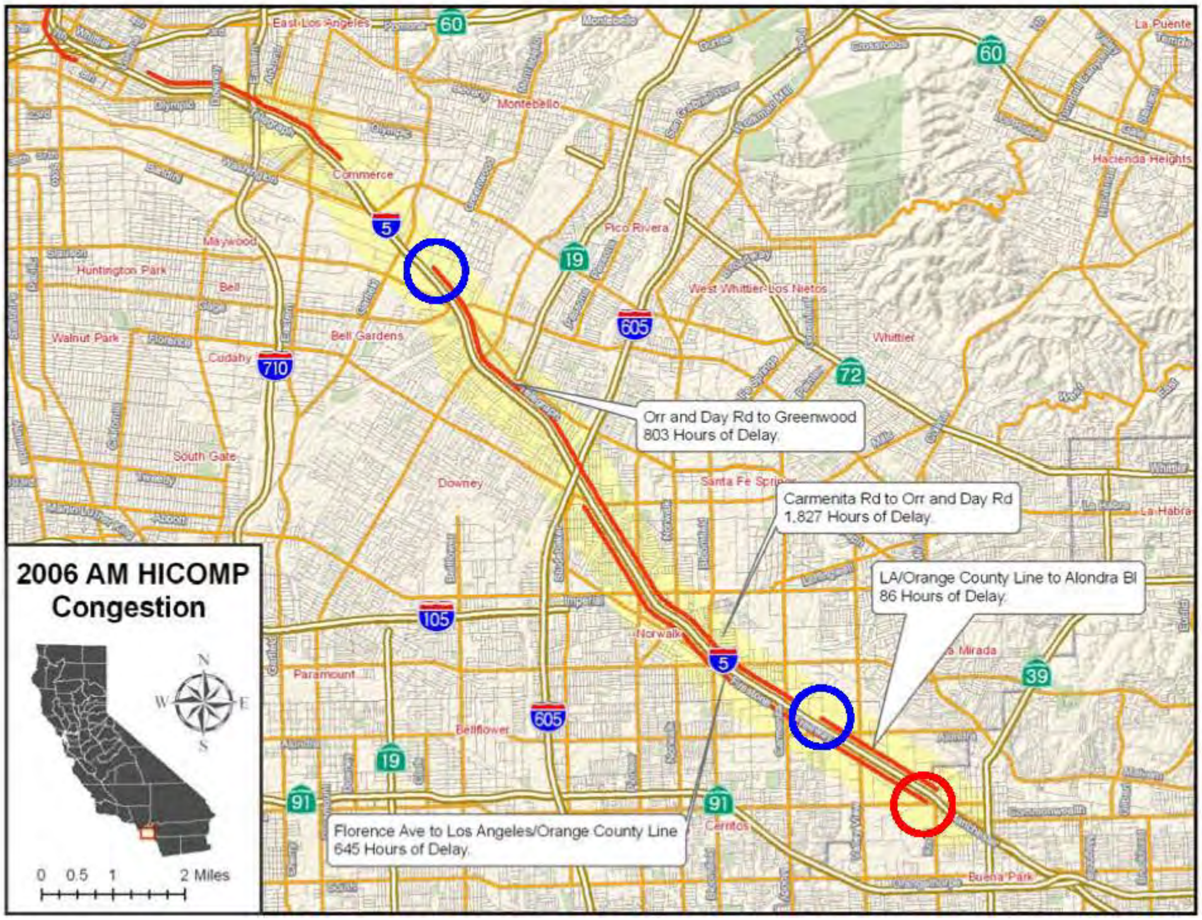
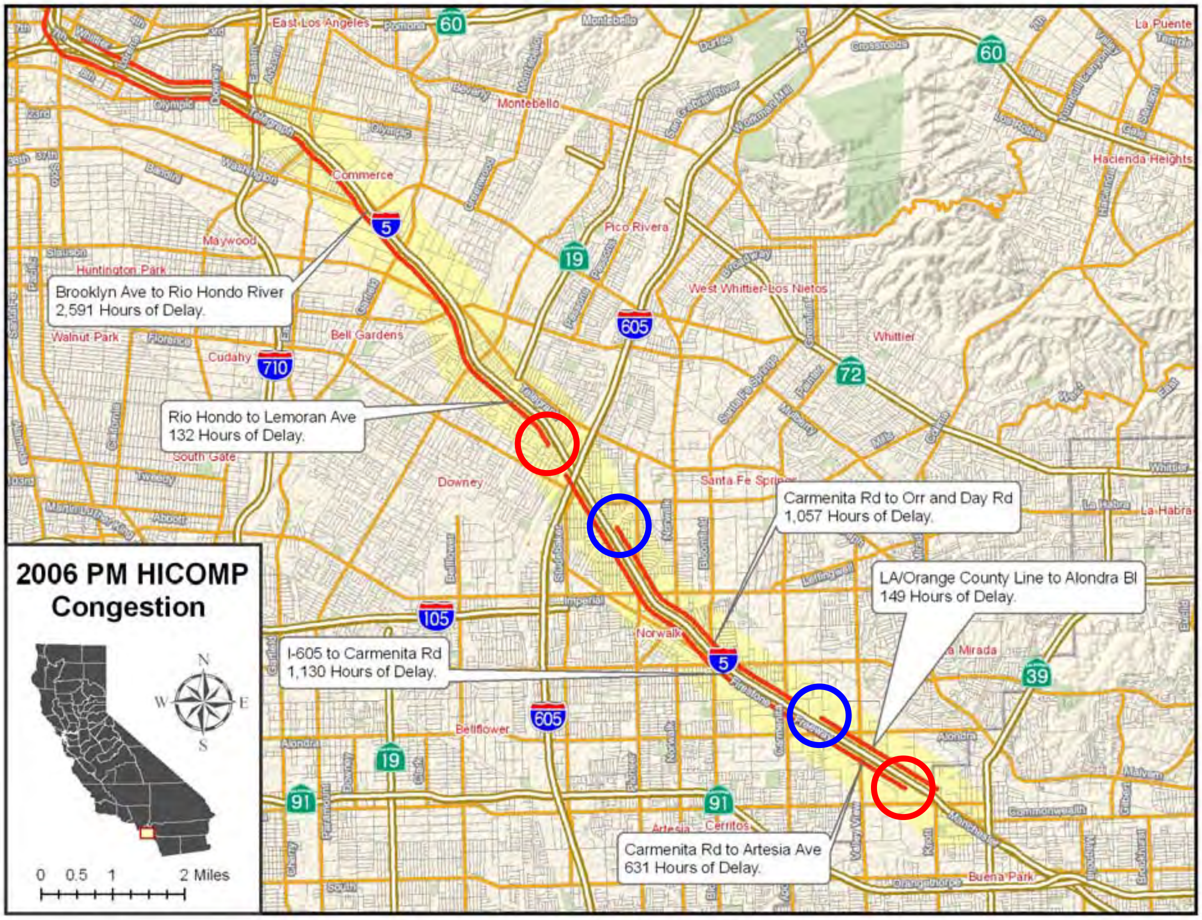


Exhibit A4-2: 2006 HICOMP PM Congestion Map with Potential Bottlenecks

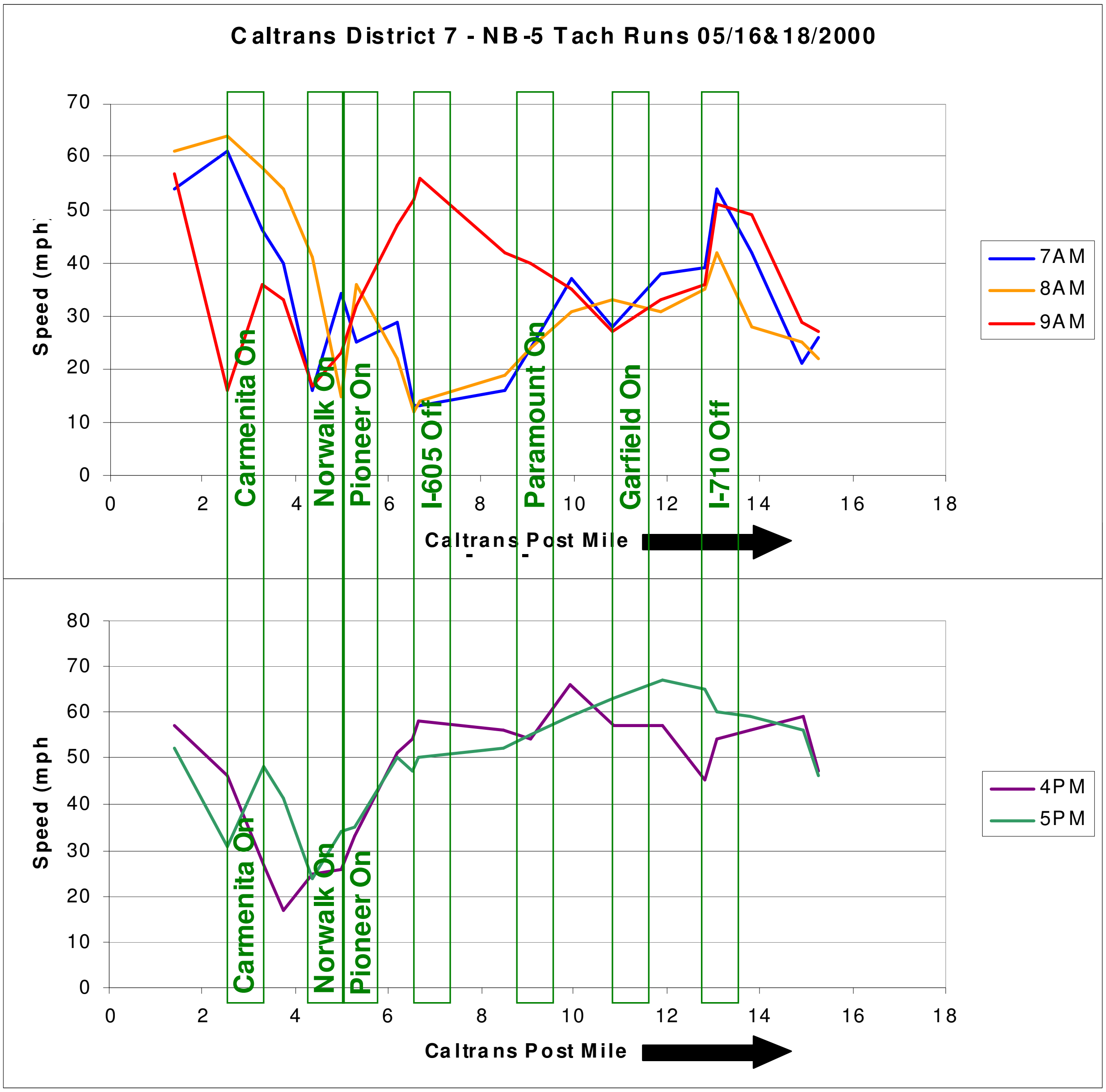


Probe Vehicle Runs

The probe vehicle runs (electronic tachometer runs) provide speed plots across the corridor at various departure times. A vehicle equipped with an electronic (GPS or tachometer) 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. Bottlenecks can be found at the end of congested segment, where speeds generally increase from about 30 miles per hour to 50 miles per hour.

Caltrans District 7 collected probe vehicle run data in May 2000 for the I-5 freeway from the Orange County Line to the Calzona Street interchange. The freeway corridor runs were broken into two separate segments from the Orange County Line (Artesia Avenue) to Rosemead Boulevard and Rosemead Boulevard to the Calzona Street interchange. For each segment, the runs were conducted from 5:30 AM to 11:00 AM and from 2:30 PM to 7:30 PM. Exhibit 4-3 illustrates the I-5 northbound probe vehicle runs conducted on separate days in May 2000 at specific time intervals: 7:00 AM, 8:00 AM, 9:00 AM, 4:00 PM, and 5:00 PM. As indicated, there are slow speeds (congestion) and bottlenecks evident in both the AM and PM peak hours in the northbound direction.

Exhibit A4-3: Northbound I-5 Sample Probe Vehicle Runs (May 2000)



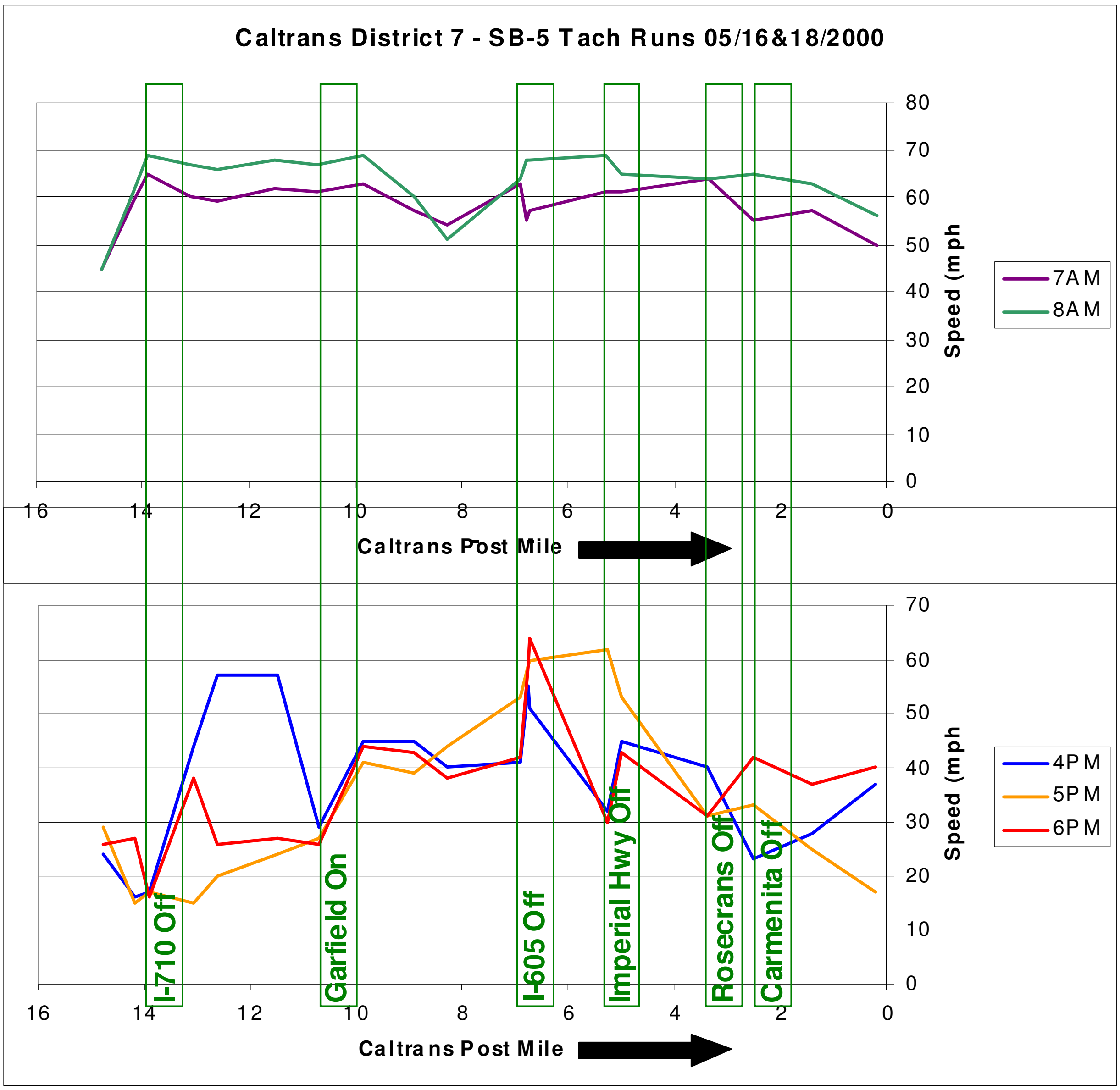
The major northbound bottlenecks identified from the probe vehicle runs occur at:

- Carmenita on (AM/PM)
- Norwalk on (AM/PM)
- Pioneer on (AM/PM)
- I-605 off (AM)

- Paramount on (AM)
- Garfield on (AM)
- I-710 off (AM)

Exhibit 4-4 shows the I-5 southbound probe vehicle runs, which were conducted on separated days in May 2000, for five specific times: 7:00 AM, 8:00 AM, 4:00 PM, 5:00 PM, and 6:00 PM. There are slow speeds (congestion) and bottleneck evident only in the PM peak hours in the southbound direction.

Exhibit A4-4: Southbound I-5 Sample Probe Vehicle Runs (May 2000)



The major southbound bottlenecks identified from the probe vehicle runs occur at:

- I-710 off (PM)
- Garfield on (PM)
- I-605 off (PM)
- Imperial Highway off (PM)
- Rosecrans off (PM)
- Carmenita off (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 graphs. Unlike the probe vehicle runs, each speed plot has the same time across the corridor. For example, an 8:00 AM plot includes the speed at one end of the corridor at 8:00 AM and the speed at the other end of the corridor also at 8:00 AM. With probe vehicle runs, the end time, or time at the end of the corridor is the departure time plus the actual travel time. Despite this difference, the two sets of graphs identify similar problem areas. These speed plots are then compiled at five minute intervals and presented in speed contour plots.

NORTHBOUND

Exhibit 4-5 shows the speed contour plots for Wednesday, February 28, 2007 and Thursday, March 1, 2007. The speed contour plots represent a typical weekday sample to illustrate the bottleneck locations and the resulting congestion. The sample days had observed or "good" detection data of 74 and 80 percent, providing reasonably accurate results. The speed contour plots are typical speed contour diagrams for the I-5 freeway in the northbound direction (traffic moving left to right on the plot). Along the vertical axis is the time period from 4:00 AM to 8:00 PM. Along the horizontal axis is the corridor segment from the Orange County Line to the I-710 interchange. The various colors indicate the average speeds corresponding to the color speed chart shown below the diagram. The dark blue blotches represent congested areas where speeds are reduced. The end of each dark blotch represents a bottleneck area, 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 or queue lengths. The vertical length is the congested time period.

Exhibit 4-6 shows the speed profile plots for Thursday, March 1, 2007. The speed profile plots represent a typical weekday sample to illustrate the bottleneck locations and congestion formed at a particular time in the day, in this case 8:00 AM and 5:00 PM. The speed profile plots illustrate the typical speed profile diagram for the I-5 freeway in the northbound direction (traffic moving left to right on the plot).

Exhibit A4-5: PeMS Northbound I-5 Speed Contour Plots (Feb/Mar 2007)

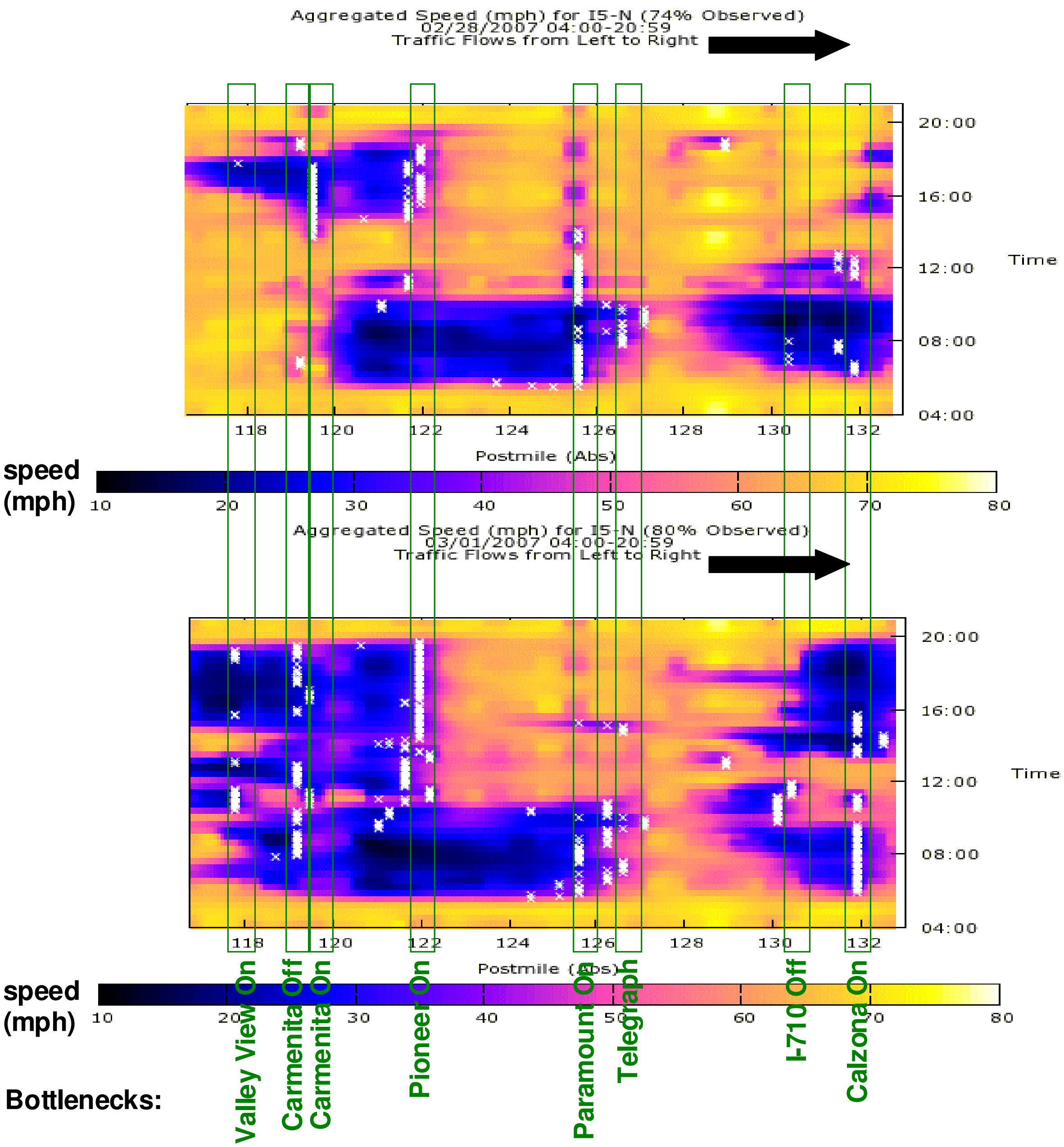
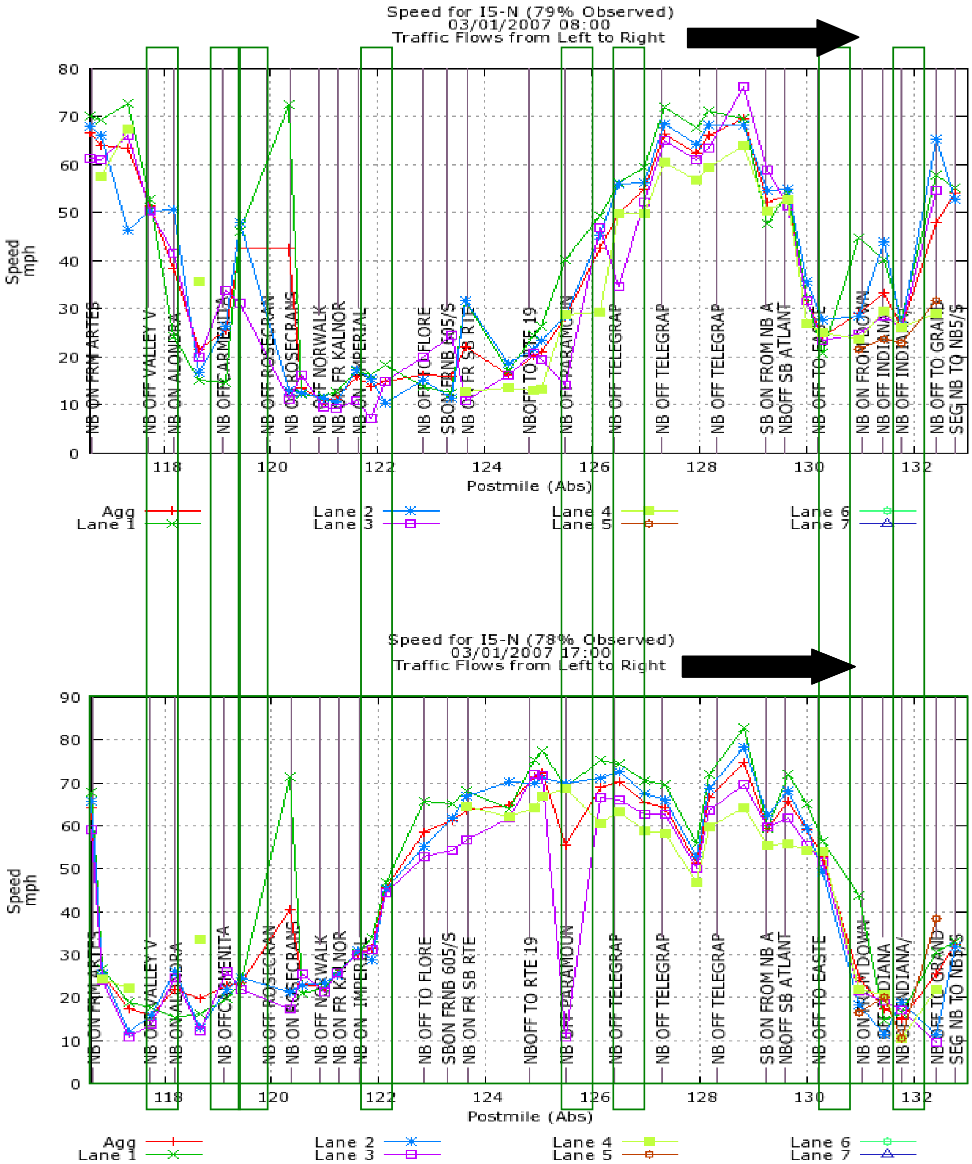


Exhibit A4-6: PeMS Northbound I-5 Speed Profile Plots (March 2007)

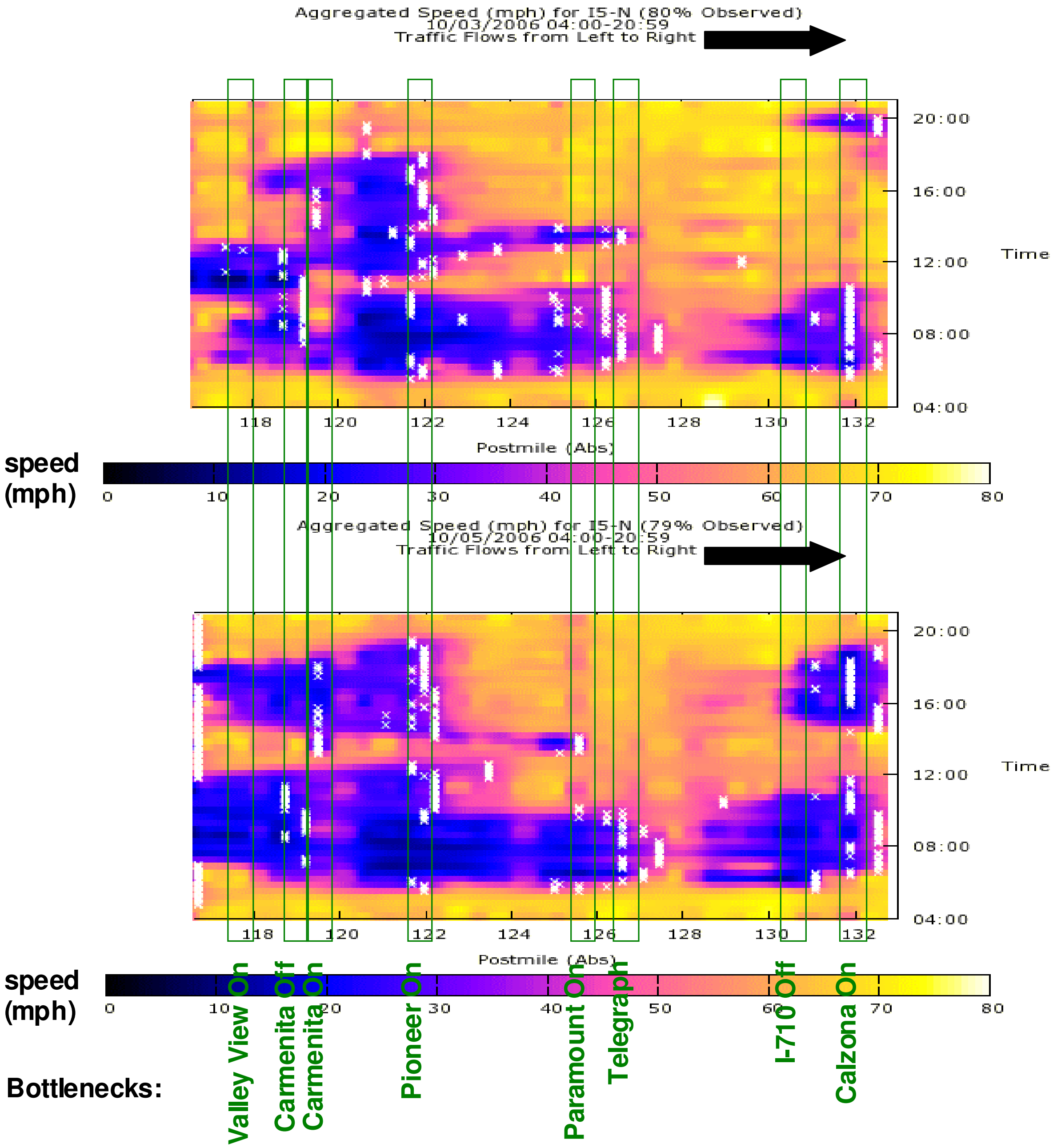


Based on the contour plots of a typical weekday sample in February and March 2007, the following bottlenecks were identified in the northbound direction:

- Valley View on (AM/PM)
- Carmenita off (AM/PM)
- Carmenita on (AM/PM)
- Pioneer on (AM/PM)
- Paramount on (AM/PM)
- Telegraph (AM)
- I-710 off (AM)
- Calzona on (AM/PM)

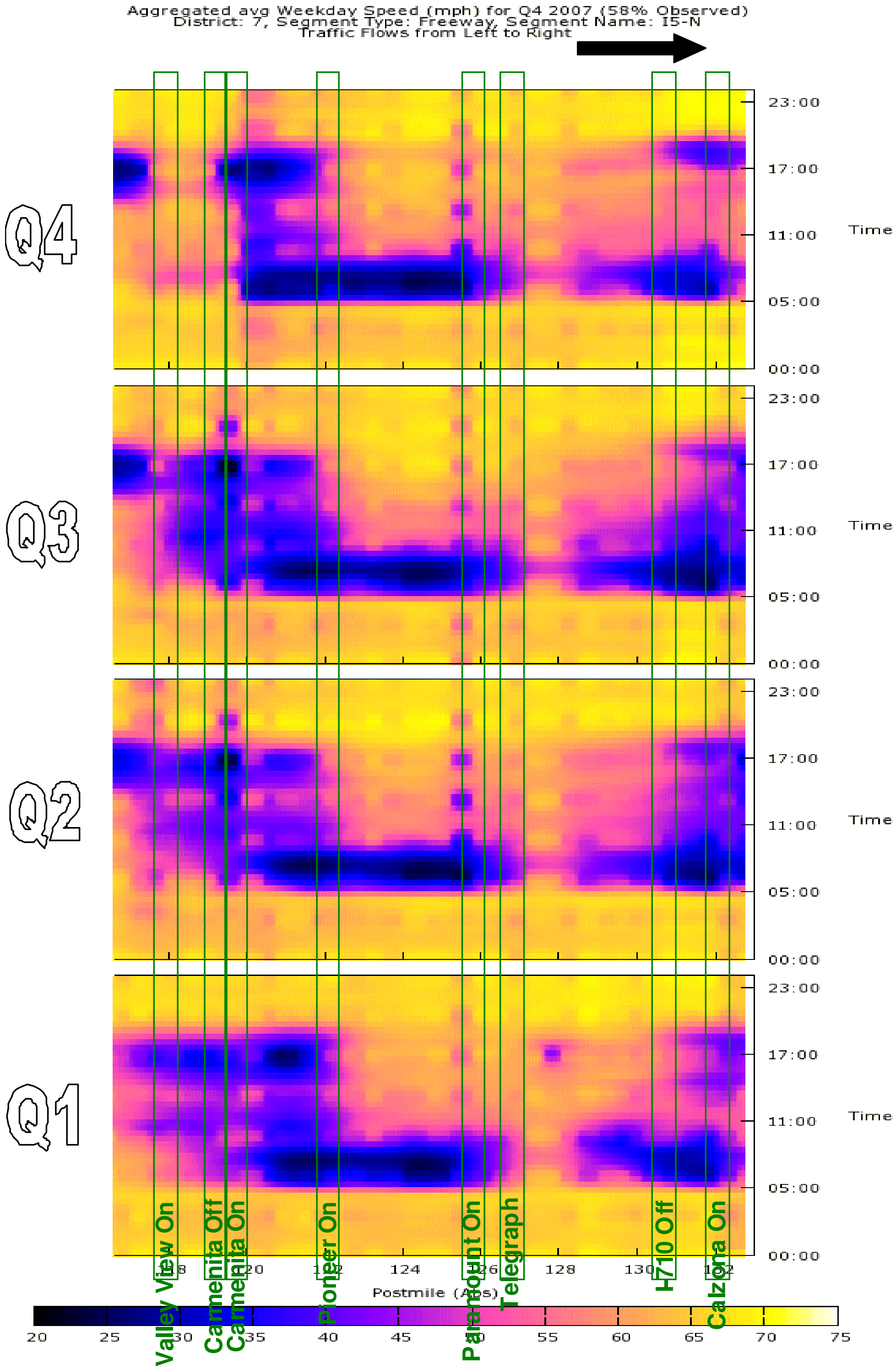
Other sample days were reviewed to validate the analysis. Exhibit 4-7 illustrates the speed contours of the additional weekday samples in October 2006. The same bottleneck locations are identified on the new sample days, indicating a reoccurring pattern of the bottleneck locations.

Exhibit A4-7: PeMS Northbound I-5 Speed Contour Plots (October 2006)



In addition to multiple days, averages over longer periods were also considered. Exhibit 4-8 shows weekday averages by each quarter of 2007. 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-5 Long (Speed) Contours (2007 Avg. by Qtr.)



<u>SOUTHBOUND</u>

Similarly, speed contour and profile plots were analyzed in the southbound direction for probe vehicle sample days in February and March 2007. The results were validated by examining additional days in October 2006 and quarterly averages for 2007. Exhibits 4-9 to Exhibit 4-12 illustrate the speed contour and profile plots for the I-5 freeway corridor in the southbound direction (traffic moving left to right on the plot) for sample weekdays in February and March 2007, additional typical weekdays in October 2006, and 2007 quarterly weekday average long contours. Along the vertical axis is the time period from 4:00 AM to 8:00 PM. Along the horizontal axis is the corridor segment from the Orange County Line to the I-710 interchange. Similar to the northbound PeMS speed contour analysis results, the PeMS southbound speed contour analysis results indicated reoccurring bottleneck locations across multiple weekdays and quarterly averages.

Exhibit A4-9: PeMS Southbound I-5 Speed Contour Plots (Feb/Mar 2007)

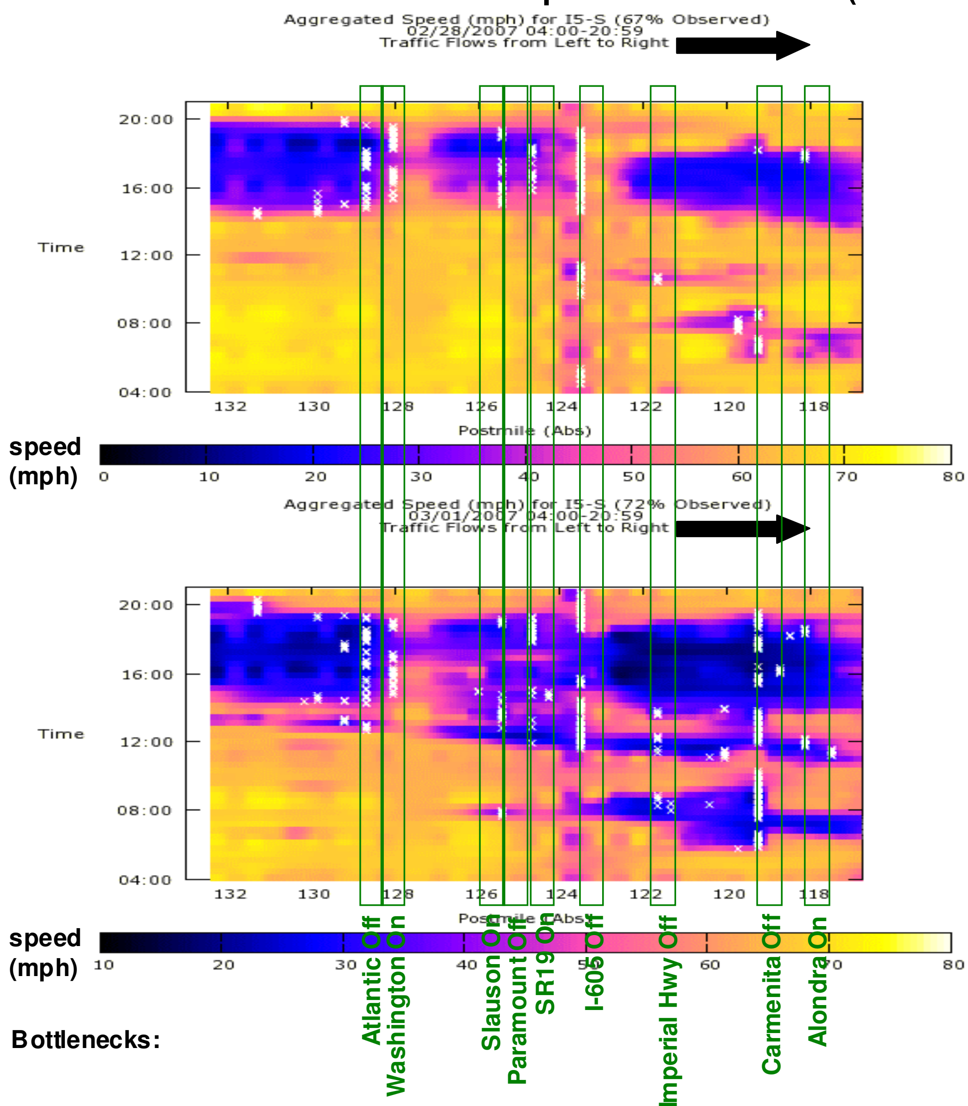


Exhibit A4-10: PeMS Southbound I-5 Speed Profile Plots (March 2007)

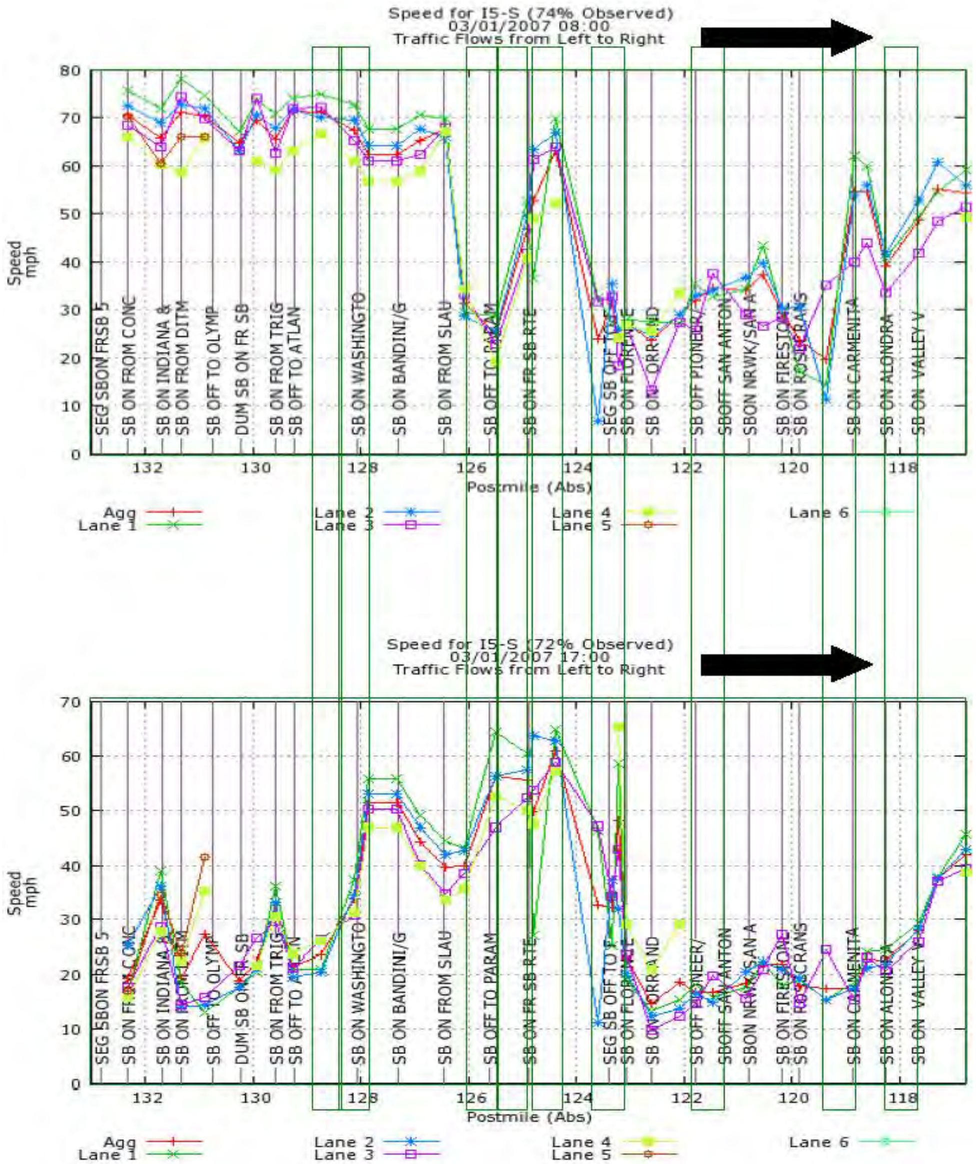


Exhibit A4-11: PeMS Southbound I-5 Speed Contour Plots (October 2006)

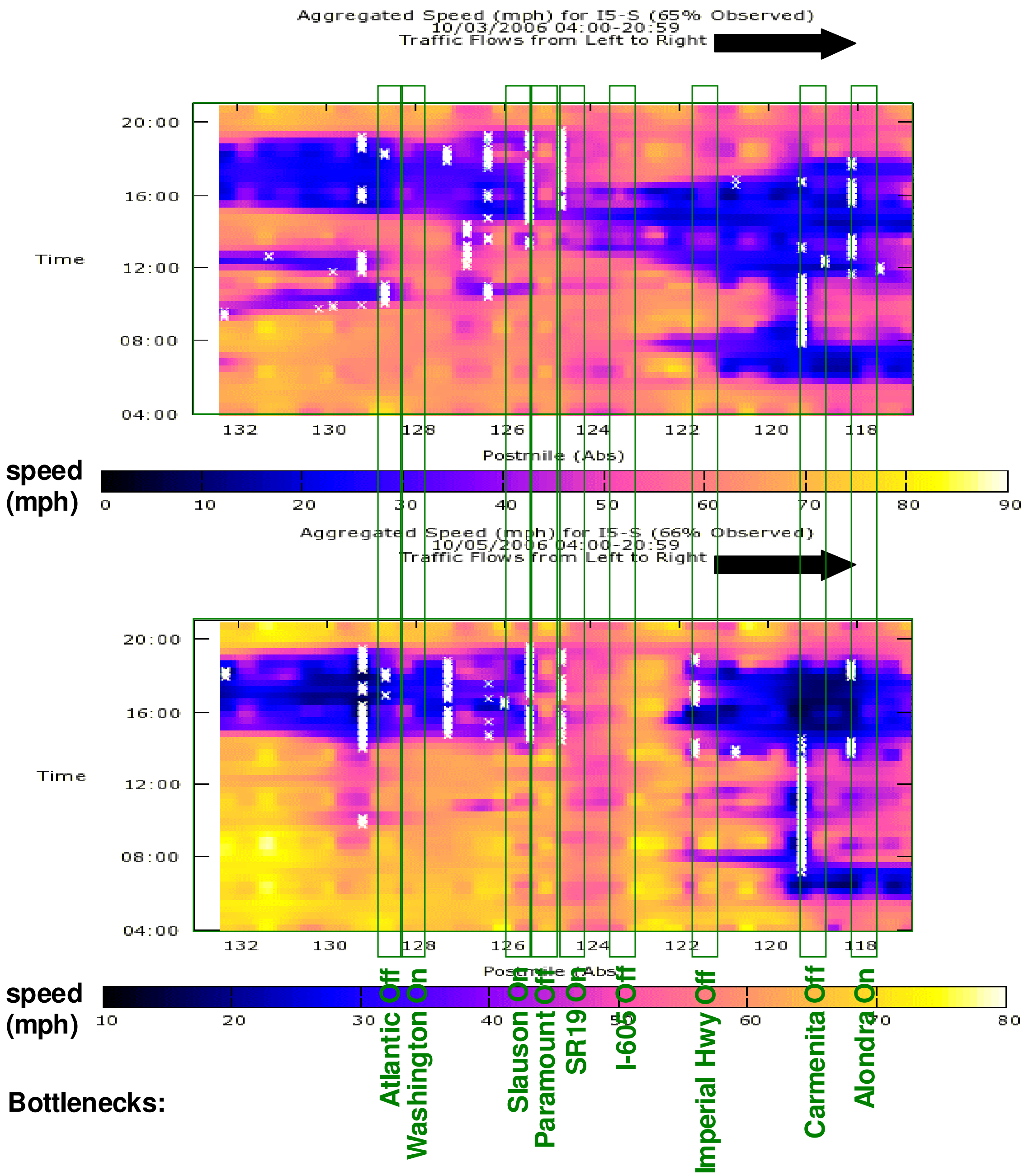
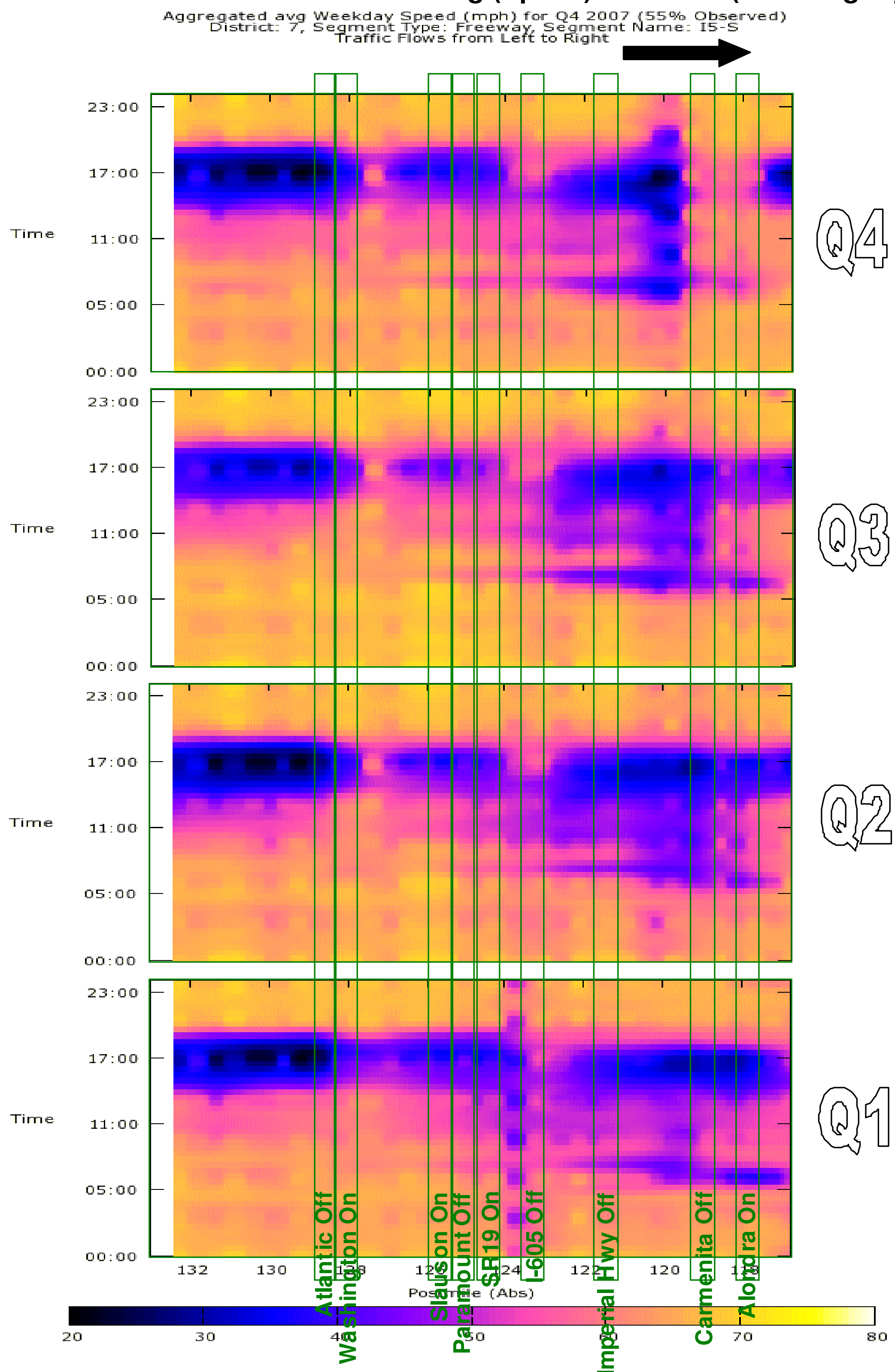


Exhibit A4-12: PeMS Southbound I-5 Long (Speed) Contours (2007 Avg. by Qtr.)



Based on these contour and profile plots of typical weekday samples, the following bottlenecks were identified in the southbound direction:

- Atlantic off (PM)
- Washington on (PM)
- Slauson on (PM)
- Paramount off (AM/PM)
- SR-19 on (AM/PM)
- I-605 off (AM/PM)
- Imperial Highway off (AM/PM)
- Carmenita off (AM/PM)
- Alondra on (AM/PM).

Bottleneck Summary

Exhibit 4-13 provides a summary of the potential bottleneck locations based on the various sources: 2006 HICOMP report, Caltrans District 7 probe vehicle runs, and PeMS speed profile and speed contour plots. The rows in bold indicate bottlenecks identified in multiple sources. These are likely to be major reoccurring bottlenecks.

The locations have not been field verified. Additional data and/or extensive field reviews will be necessary to confirm their actual locations and identify causes of the bottlenecks.

Exhibit A4-13: I-5 Identified Bottlenecks Summary Table

BOTTLENECK LOCATION	Bottleneck Area Post Mile Range		HICOMP [a] Report		Caltrans [b] Probe Veh. Runs		PeMS [a] Speed Contours	
	Absolute	Caltrans	AM	PM	AM	PM	AM	PM
NORTHBOUND								
Valley View on	117.77	1.14	-	-	-	-	✓	✓
Alondra on	118.20	1.57	✓	✓	-	-	-	-
Carmenita off	119.11	2.48	-	-	-	-	✓	✓
Carmenita on	119.15	2.52	-	-	✓	✓	✓	✓
Norwalk on	120.99	4.36	-	-	✓	✓	-	-
Pioneer on	121.91	5.28	-	-	✓	✓	✓	✓
I-605 off	123.16	6.53	-	✓	✓	-	-	-
Paramount on	125.57	8.94	-	-	✓	-	✓	✓
Telegraph/Garfield on	127.35	10.72	✓	-	✓	-	✓	-
I-710 off	130.30	13.67	-	-	✓	-	✓	-
Calzona on	131.79	16.16	-	-	-	-	✓	✓
SOUTHBOUND								
I-710 off	130.46	13.89	-	-	-	✓	-	-
Atlantic off	129.24	12.67	-	-	-	-	-	✓
Washington on	128.07	11.5	-	-	-	-	-	✓
Garfield on	127.31	10.74	-	-	-	✓	-	-
Slauson on	126.45	9.88	-	-	-	-	-	✓
Paramount off	125.6	9.03	-	-	-	-	✓	✓
SR-19 on	124.89	8.32	-	-	-	-	✓	✓
I-605 off	123.63	7.06	-	✓	-	✓	✓	✓
Imperial Highway off	121.79	5.22	-	-	-	✓	✓	✓
Rosecrans off	119.95	3.38	-	-	-	✓	-	-
Carmenita off	118.91	2.34	-	-	-	✓	✓	✓
Alondra on	118.25	1.68	-	-	-	-	✓	✓
Artesia off	116.61	0.04	✓	✓	-	-	-	-

NOTES:

[a] Based on 2006 HICOMP report.
[b] Based on Caltrans District 7 tach runs conducted on May 16 and May 18, 2000.
[c] Based on Performance Measurement System (PeMS) sample speed contours and profiles taken from October 2006, February and March 2007, and 2007 quarterly weekday averages data.

na Data not available
\- No indication of bottleneck from this source.
✓ Bottleneck identified from this source.
bold Bottleneck identified from multiple sources.