DRAFT FINAL

CORRIDOR SYSTEM MANAGEMENT PLAN (CSMP)
ORANGE COUNTY SR-57
COMPREHENSIVE PERFORMANCE ASSESSMENT
AND
CAUSALITY ANALYSIS

May 22, 2009

System Metrics Group, Inc.

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1. INTRODUCTION

This document represents the draft for the sixth and seventh milestones of the Orange County State Route 57 (SR-57) Corridor System Management Plan (CSMP) development process which is required by the California Transportation Commission (CTC) for corridors that have received funding from the Corridor Mobility Improvement Account (CMIA) approved by voters in 2006. The CMIA will fund the construction of the northbound widening projects from 0.3 mile south of Katella to 0.3 mile north of Lincoln and from 0.4 mile north of SR-91 to 0.1 mile north of Lambert.

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

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

This report is 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 should be updated on a regular basis since corridor performance can vary dramatically over time due to changes in demand patterns, economic conditions, and delivery of projects and strategies among others. Such changes could influence the conclusions of the CSMP and the relative priorities in investments.

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

The remainder of this report is organized into five main sections as follows:

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. A subsection on corridor demand profiles has been added.

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

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

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

6. *Environmental Elements*
   Provided by Caltrans District 12, this section summarizes the environmental elements that may be impacted by the SR-57 widening effort, a project which is currently in design.

The remainder of this section provides a 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 SR-57 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 Administration as part of their Strategic Growth Plan and by the Southern California Association of Governments (SCAG), the Metropolitan Planning Organization for Southern California, including Orange 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. Therefore 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 SR-57 Corridor.

Exhibit 1-1: System Management Pyramid

Existing Data Sources

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

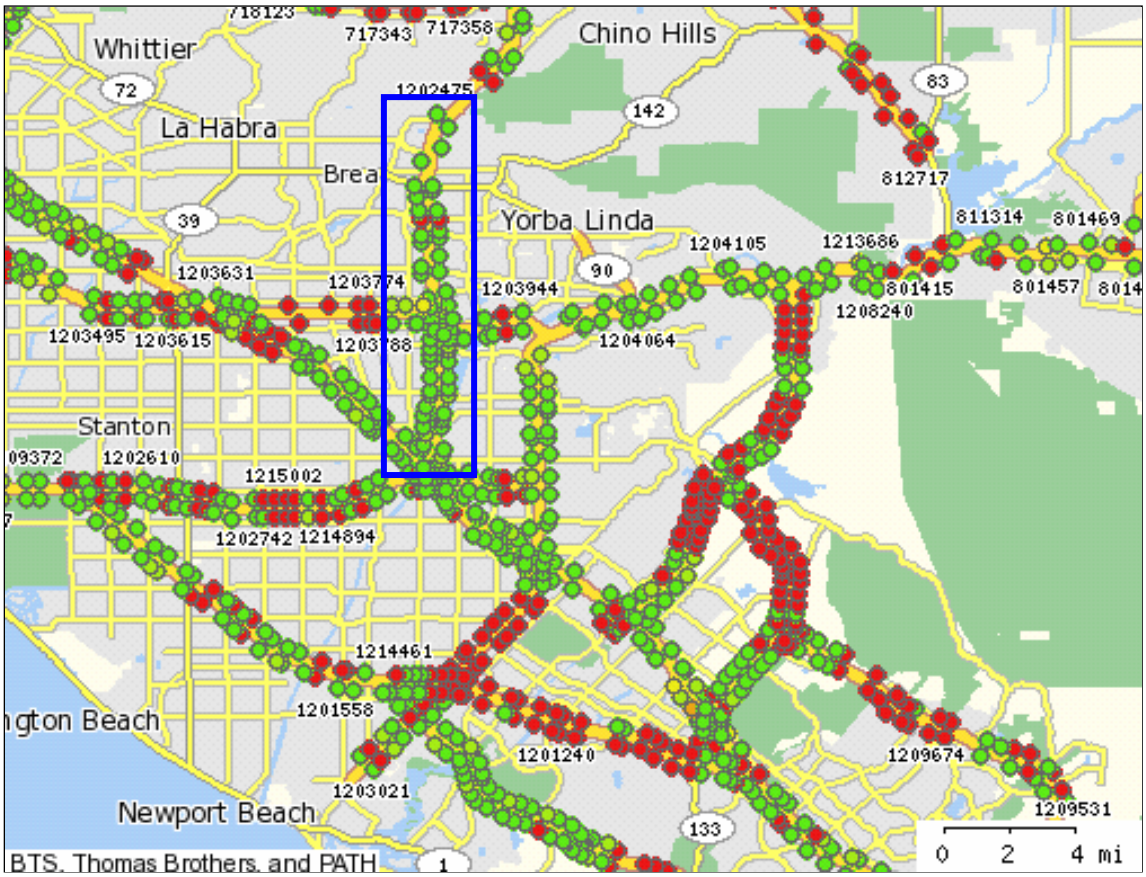
- Caltrans Highway Congestion Monitoring Program (HICOMP) report and data files (2006 – 2007)
- Caltrans Freeway Performance Measurement System (PeMS)
- Caltrans District 12 probe vehicle runs (electronic tachometer runs)
- Caltrans Traffic Accident Surveillance and Analysis System (TASAS) from PeMS
- Signal Timing Plans from the Cities of Brea, Fullerton, Placentia, Anaheim, and Orange
- Various studies
- Aerial photographs (Google Earth) and Caltrans photologs
- Internet (i.e. OCTA website, Metrolink website, SCAG website, etc)

There are numerous documents that describe these data sources. Therefore, they are not discussed in this document in detail. 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 May 30, 2008 (chosen randomly). The exhibit shows that there are many detectors on the mainline, almost all functioning well on that date (based on the green color). Furthermore, it illustrates some seemingly small gaps between detectors at some locations.

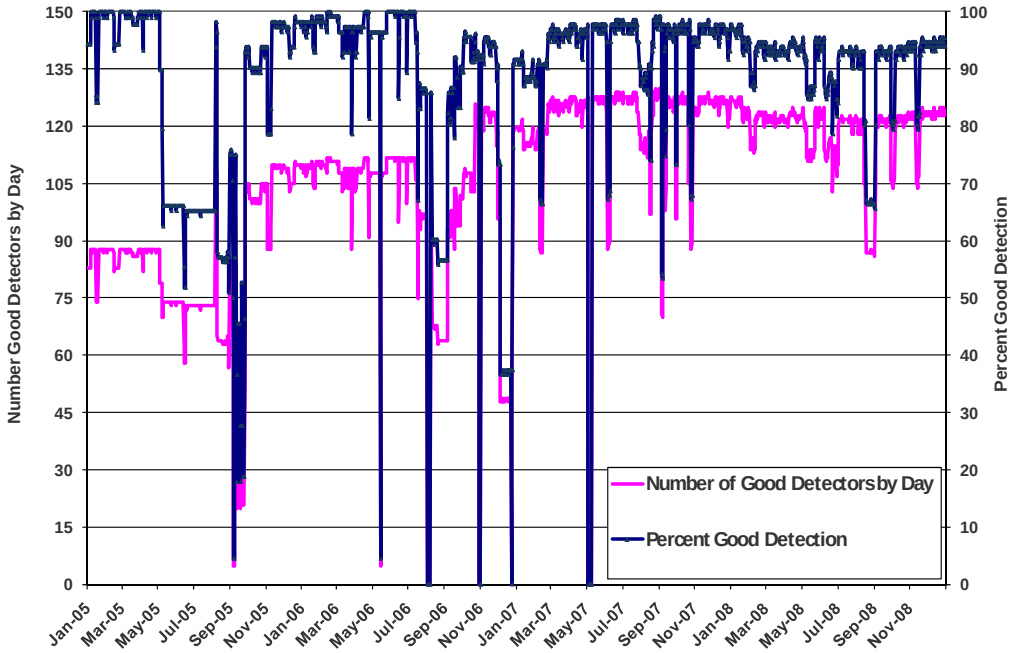
Exhibit 1-2: SR-57 Detection Status for May 28, 2008



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 daily "good" detectors on the mainline facility of the SR-57 study corridor from 2005 to 2008. Exhibits 1-5 and 1-6 report the same information for the HOV facility. 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 of good detectors. These exhibits suggest that detection on the mainline facility was solid with both directions reporting consistently over 90 percent of good data throughout most of the four-year period. In both directions of the mainline, it is clear that a large number of good detectors emerged

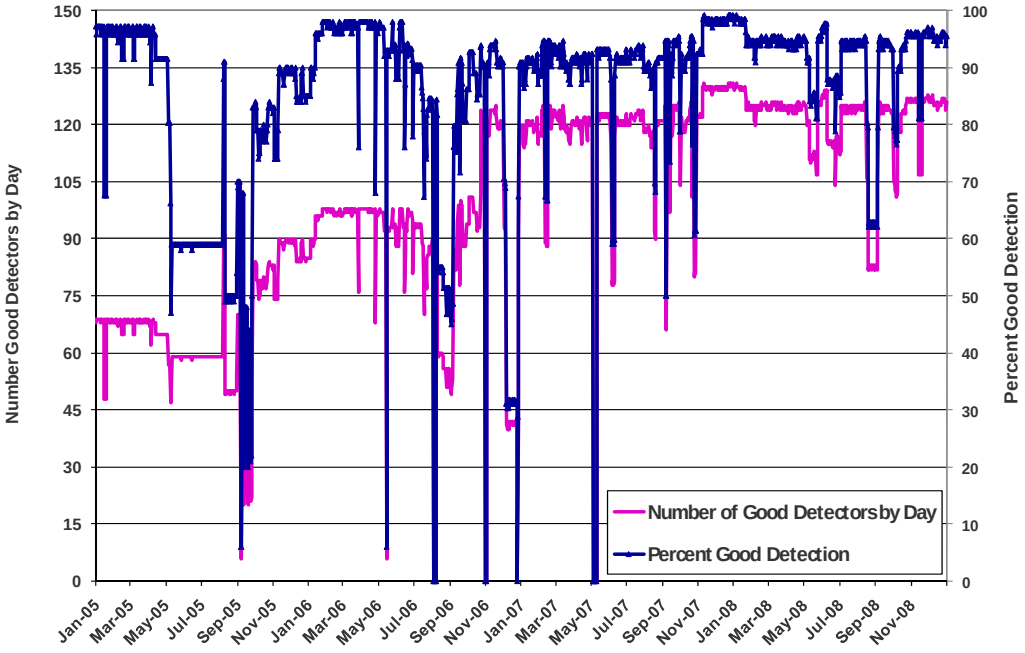
in the fall of 2006, when the number of good detectors jumped from around 50-60 to over 120 by the end of the year.

Exhibit 1-3: Northbound SR-57 ML Number & Percentage of Daily Good Detectors



Source: System Metrics Group (using PeMS data)

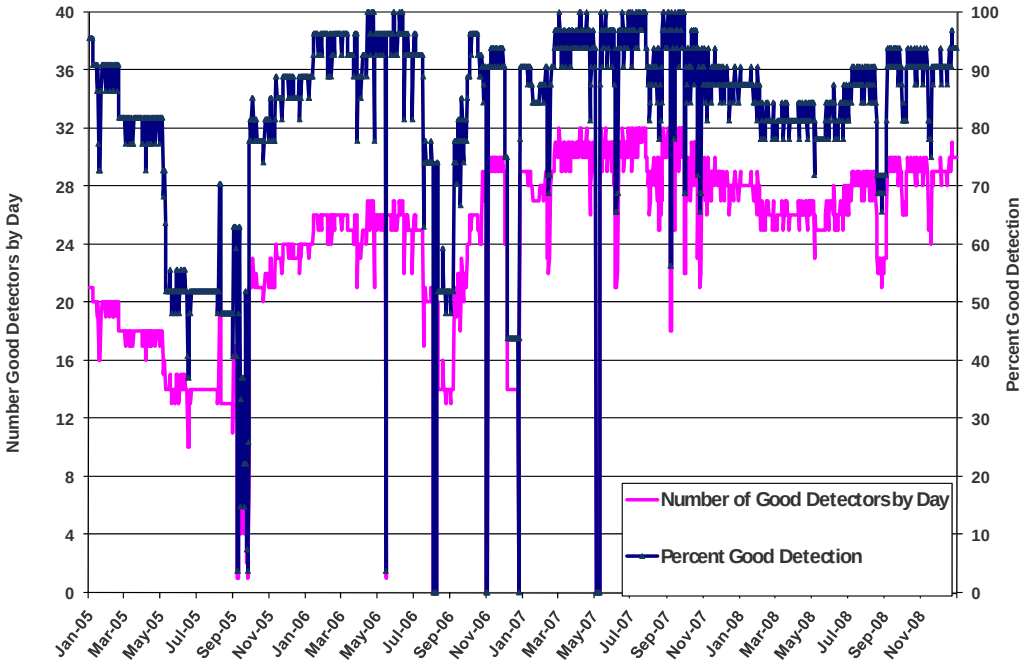
Exhibit 1-4: Southbound SR-57 ML Number & Percentage of Daily Good Detectors



Source: System Metrics Group (using PeMS data)

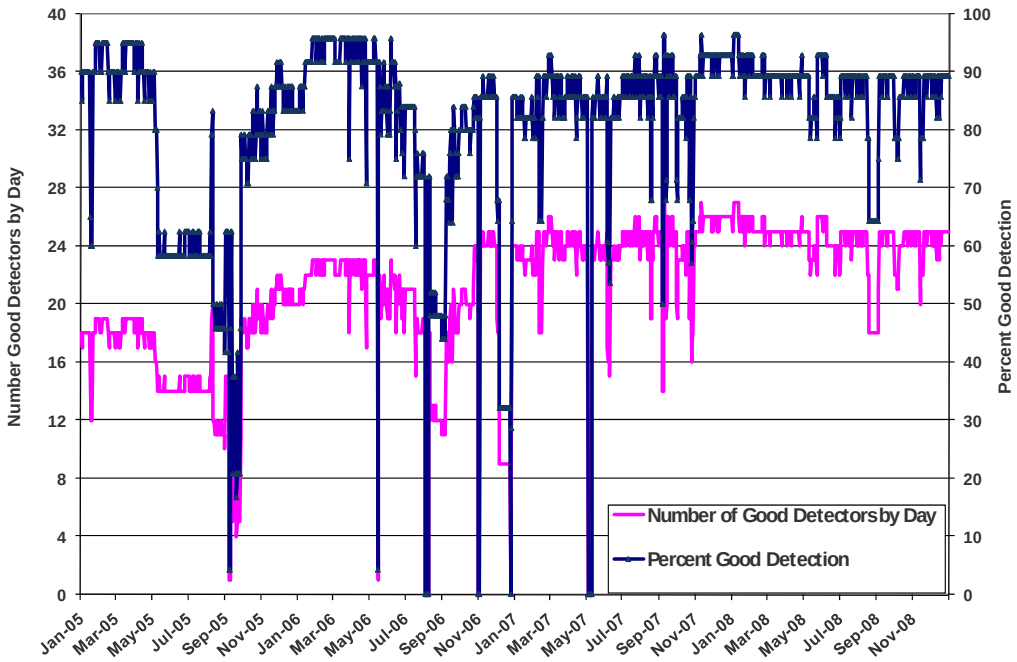
The quality of detection on the HOV facility was as almost as healthy as the mainline facility, as shown in Exhibits 1-5 and 1-6. In 2007 and 2008, the northbound HOV lane reported a greater number of good detectors (around 28-32) compared to the southbound HOV lane (around 24). Overall, detection on both directions of the HOV facility was healthy with both directions consistently reporting over 80 percent of good data, notably in 2007 and 2008.

Exhibit 1-5: Northbound SR-57 HOVL Number & Percentage of Daily Good Detectors



Source: System Metrics Group (using PeMS data)

Exhibit 1-6: Southbound SR-57 HOVL Number & Percentage of Daily Good Detectors



Source: System Metrics Group (using PeMS data)

A more detailed look at all the detectors along the corridor revealed that the latest detectors were placed in October 2006. Although no new detectors were added in 2007 or 2008, the SR-57 Corridor generally has very good detector density and quality. Exhibit 1-5 shows an analysis of the gaps without detection. Note that there are several segments with lengths of over 0.75 miles without detection. These should be considered for deployment of additional detection when funding becomes available.

Exhibit 1-7: SR-57 Gaps Without Detection (December 2008)

Location	Abs PM		Length
	From	To	
NORTHBOUND			
Imperial Hwy to Lambert Rd	9.377	10.427	1.05
Lambert Rd to Tonner Canyon Rd	10.487	11.327	0.84
SOUTHBOUND			
Tonner Canyon Rd to Lambert Rd	11.458	10.158	1.30
Lambert Rd to Imperial Hwy	10.158	9.398	0.76
Yorba Linda Blvd to Nutwood Ave	7.638	6.868	0.77

Source: System Metrics Group (using PeMS data)

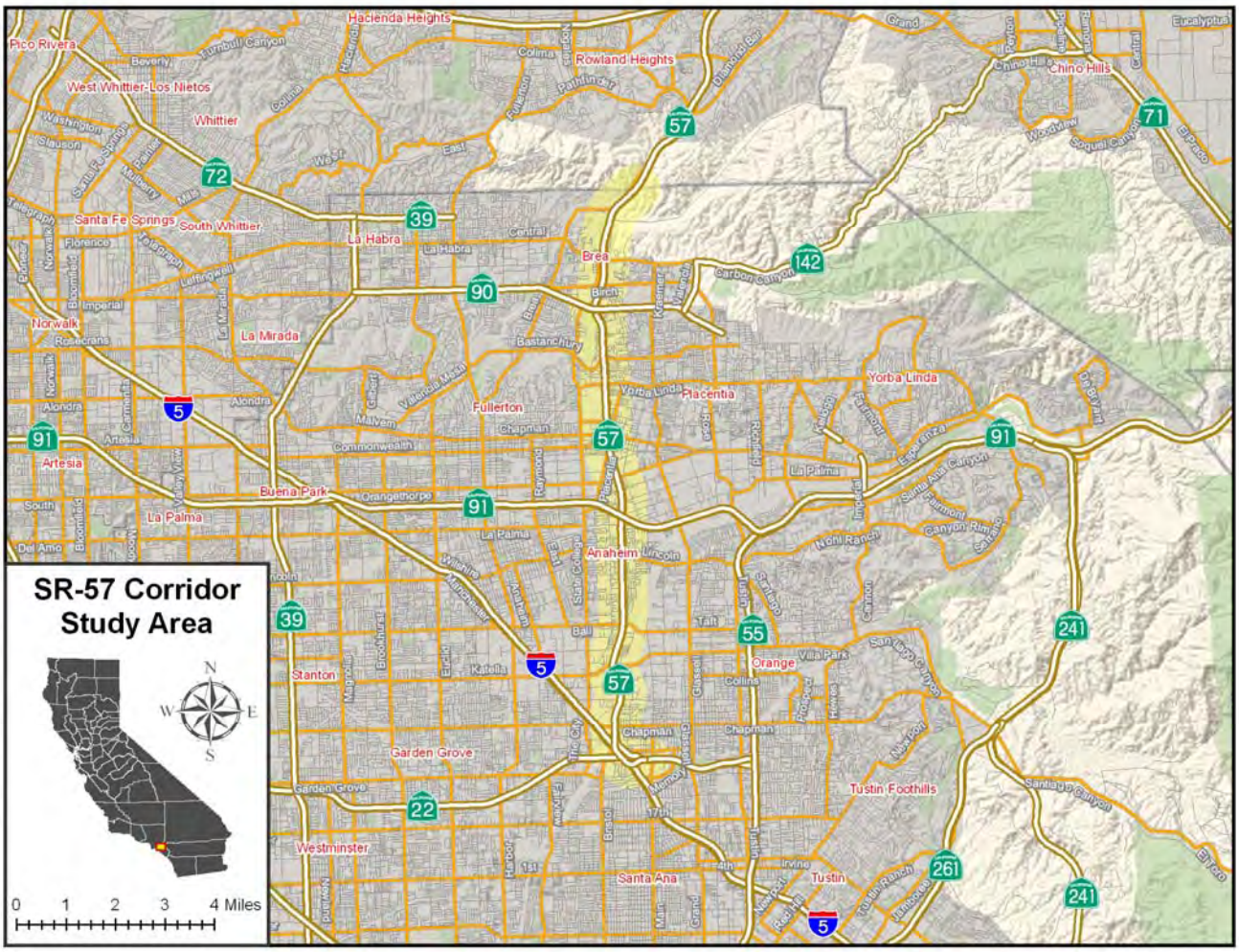
NOTE: This page is intentionally left blank so that Caltrans can insert updates to the detection analysis results presented in the last six exhibits (Exhibits 1-2 through 1-7) and discuss the ramifications of its findings (e.g., have the gaps been filled, is detector reliability improving or diminishing). Similar place holder pages have been inserted throughout the document to insert future updates.

Page Intentionally Left Blank for Future Freeway
Detection Reliability and Coverage Updates

2. CORRIDOR DESCRIPTION

The Orange County SR-57 study corridor, known as the Orange Freeway, runs in a north-south direction from the I-5/SR-22 Interchange (the "Orange Crush") at Postmile R10.7 in the City of Orange to the Orange/Los Angeles County Line at Postmile R22.6.

Exhibit 2-1: Map of Study Area



Corridor Roadway Facility

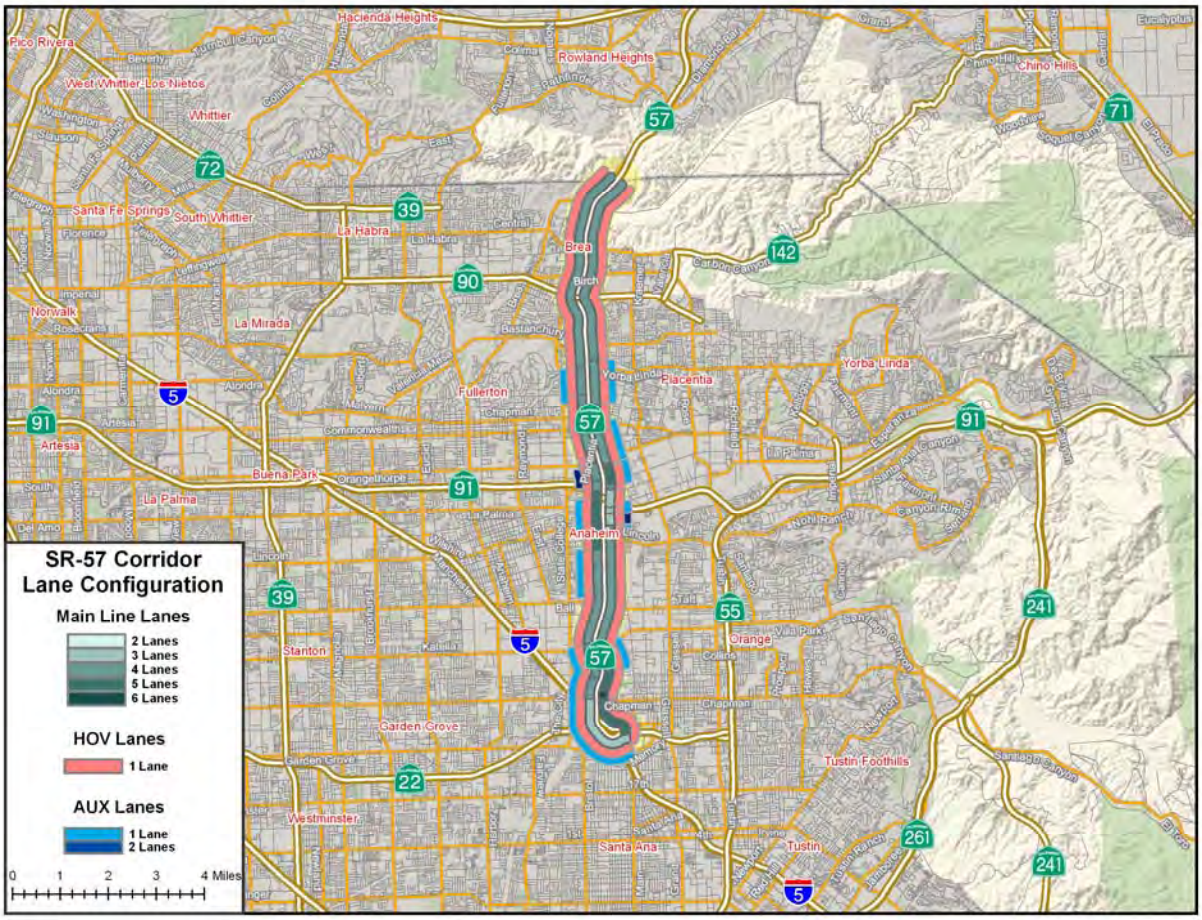
As shown in Exhibit 2-1, the approximately 12-mile SR-57 Corridor passes through the cities of Orange, Anaheim, Fullerton, Placentia, and Brea, and includes two major freeway-to-freeway interchanges that involve three other state highways:

- I-5 is a north-south interstate serving California from Mexico to Oregon. Regionally, it connects Orange County to Los Angeles and San Diego.

- SR-22 is an east-west state highway intersecting most of the major north/south corridors in Orange County, including the I-405 and SR-55 corridors. SR-22 is a vital link for residents, businesses, employees and visitors.
- SR-91 is an east-west state highway connecting Riverside and San Bernardino counties to Orange County.

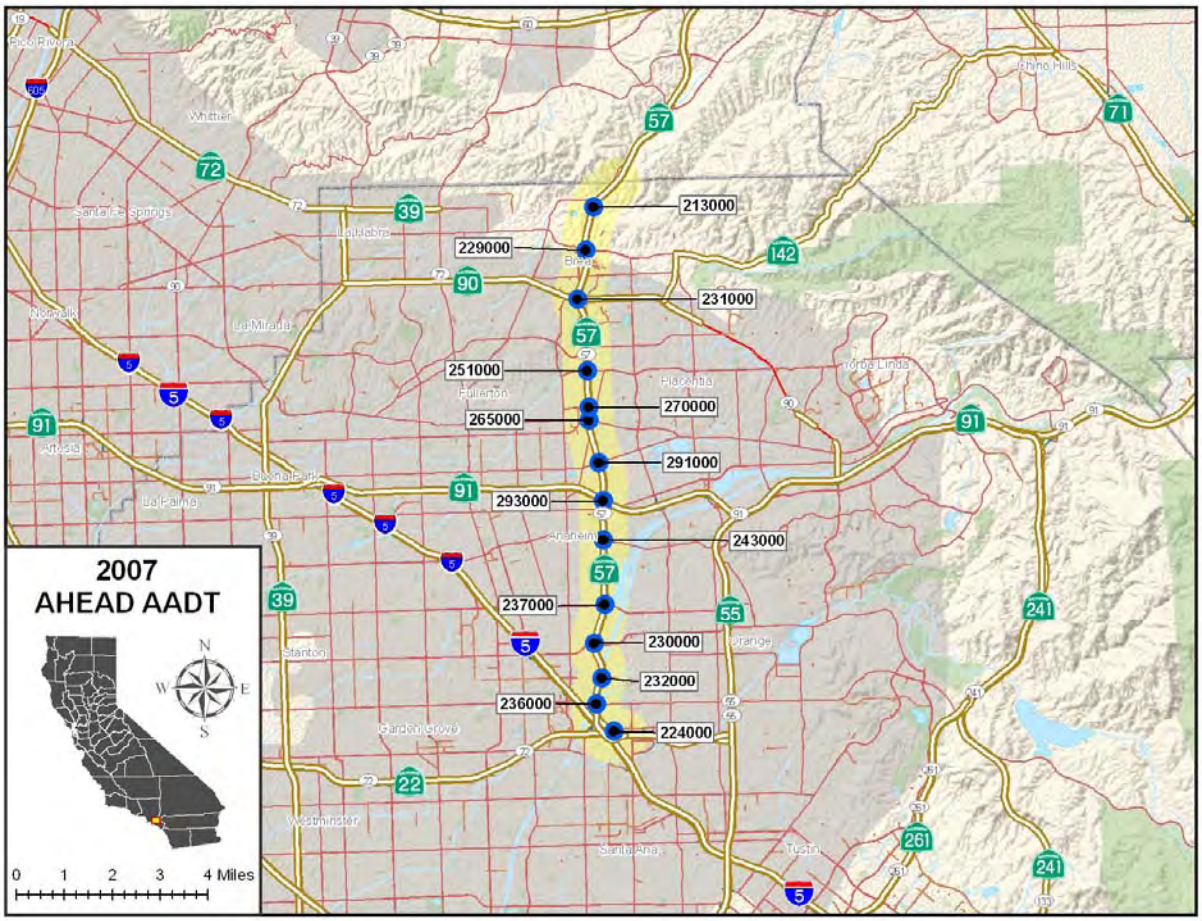
As depicted in Exhibit 2-2, SR-57 is an eight to ten-lane freeway with a concrete median barrier that separates northbound and southbound traffic for most of the corridor. There are auxiliary lanes along many sections of the corridor, but they are not continuous and not necessarily available on both sides of the freeway in a given highway section. There are HOV lanes on both directions of the study corridor, which operate as a 2+ facility, 24 hours a day. There is a direct HOV connector between the southbound SR-57 and westbound SR-91 and between the SR-91 and northbound SR-57. There is also a direct HOV connector (transitway) from the northbound I-5 to northbound SR-57.

Exhibit 2-2: SR-57 Corridor Lane Configuration



According to the Caltrans Traffic and Vehicle Data Systems annual traffic volumes reports for 2007, the SR-57 study corridor carries between 213,000 and 293,000 annual average daily traffic (AADT)[1] as shown in Exhibit 2-2. The highest average daily traffic volume on the corridor occurs between SR-91 and Orangethorpe Avenue and the lowest volume occurs between Lambert Road and Tonner Canyon Road.

Exhibit 2-3: Major Interchanges and AADT along the SR-57 Corridor

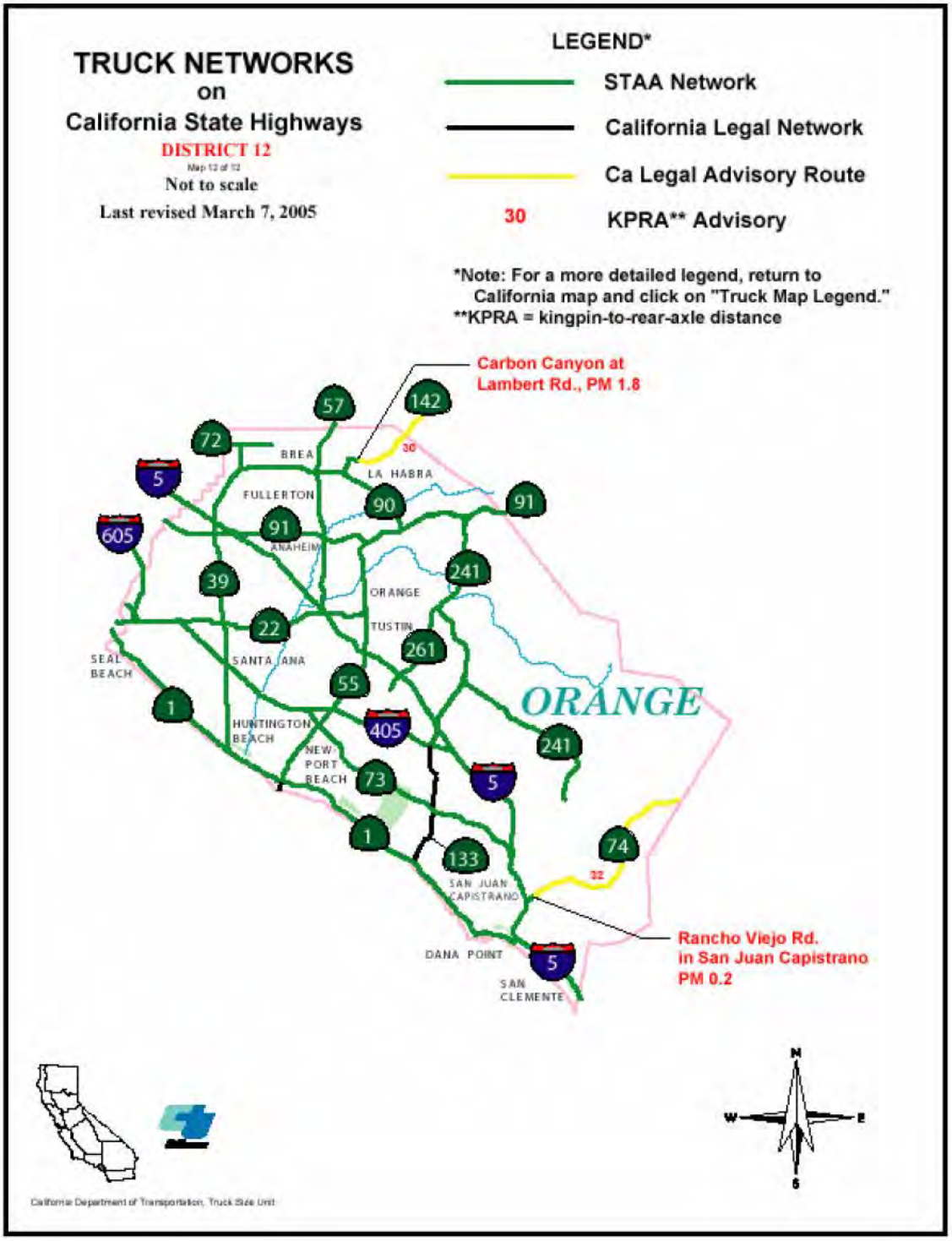


Source: AADT is from the Caltrans Traffic and Vehicle Data Systems Unit[2]

Similar to most highways in Orange County, SR-57 is a Surface Transportation Assistance Act (STAA) route, which means that trucks are allowed to operate on the corridor (see Exhibit 2-4). According to the 2007 Caltrans Annual Average Daily Truck Traffic data, trucks comprise 8 percent of total daily traffic along the corridor. This data is the latest available from the Caltrans Traffic Census unit and was published September 2008.

[1] AADT is the total annual volume of vehicles counted divided by 365 days.
[2] Located at <www.dot.ca.gov/hq/traffops/saferesr/trafdata>

Exhibit 2-4: Orange County Truck Network on California State Highways



Source: Caltrans

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

Corridor Transit Services

The following public transportation operators provide service on or near the SR-57 study corridor:

- Orange County Transportation Authority (OCTA)
- Foothill Transit
- Southern California Regional Rail Authority (SCRRA) – Metrolink
- Amtrak

Orange County Transportation Authority (OCTA)

Established in 1991, OCTA provides fixed-route bus and paratransit services throughout Orange County. In addition to several local and express routes that run in the vicinity of the SR-57 Corridor as shown in Exhibit 2-5, the following routes operate on or parallel to SR-57:

- *Route 53* operates parallel to SR-57, providing frequent service between the cities of Brea and Irvine via Associated Road, Placentia Avenue, and Sunkist Street. The route stops in the cities of Fullerton, Placentia, Anaheim, Orange, and Santa Ana.

- *Route 57* operates daily between the cities of Brea and Newport Beach via State College Boulevard. State College Boulevard is a four to six-lane arterial that runs parallel to SR-57, directly west of the corridor. The route begins at the Brea Mall and terminates at the Newport Transportation Center/Park-and-Ride facility, with various stops in the cities of Fullerton, Anaheim, Orange, Santa Ana, Costa Mesa, and Newport Beach.

- *Route 59* provides weekday service between the Brea Mall and the University of California at Irvine with limited weekend service between the cities of Brea and Santa Ana. The route runs parallel to and less than a mile east of SR-57 on Kraemer Boulevard and Glassell Street. The arterial has two to three lanes in each direction and is known as Kraemer Boulevard in the segment north of SR-91, and Glassell Street in the segment south of SR-91.

- *Route 757* provides weekday express bus service between the City of Pomona in Los Angeles County, and the City of Santa Ana in Orange County, with a number of stops, including Brea Mall, Anaheim Stadium, the UCI Medical Center, and MainPlace Mall. This route operates on SR-57 between Imperial Highway and Katella Avenue, and northbound between Lambert Road and Tonner Canyon Road.

- *Route 758* provides weekday express service between the Cities of Irvine and Chino (San Bernardino County), with stops in Diamond Bar and Brea. The route operates on SR-57 between Lambert Road and Tonner Canyon Road.

Exhibit 2-5: OCTA Bus Services along the SR-57 Corridor

Source: Orange County Transportation Authority (OCTA).

<u>Foothill Transit</u>

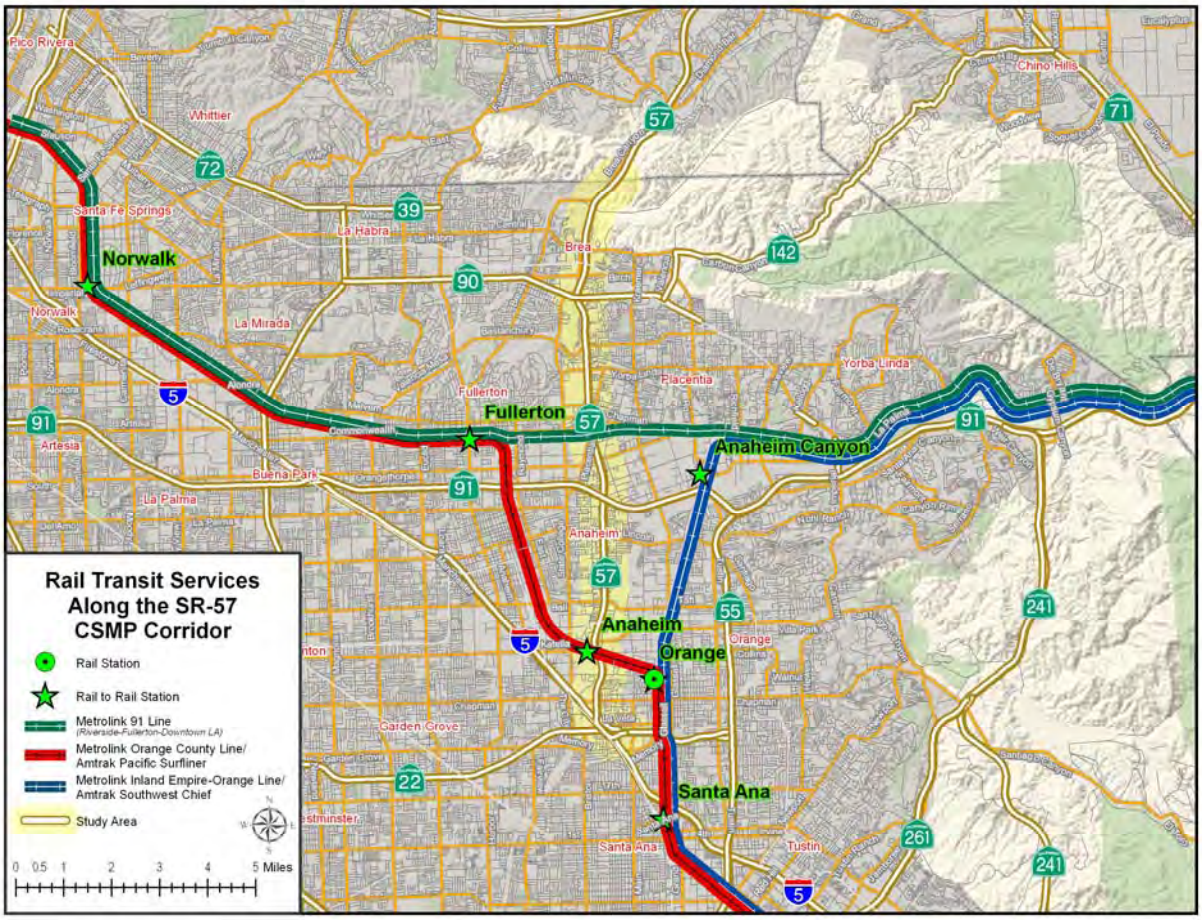
Foothill Transit has operated fixed-route bus public transit in the San Gabriel Valley since 1998. Foothill Transit *Route 286* operates directly on the study corridor. It provides daily inter-county service between the cities of Pomona in Los Angeles County

and Brea in Orange County. The route operates on SR-57 between Brea Canyon Road and Lambert Road.

Southern California Regional Rail Authority (SCRRA) – Metrolink

SCCRA is a joint powers authority that operates the Metrolink regional rail service throughout Southern California. Metrolink commuter rail trains stop at 11 stations in Orange County. As shown in Exhibit 2-6, there are four stations near the SR-57 Corridor: Fullerton, Anaheim Canyon, Anaheim, and Orange. However, as the exhibit also shows, Metrolink service is available in only the southern portion of the corridor and does not provide a direct alternative to travel on SR-57.

Exhibit 2-6: Rail Services along the SR-57 Corridor



Three lines provide daily service to Orange County:

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

- Orange County Line: service from Los Angeles Union Station to Oceanside

Inland Empire-Orange County Line connects the City of San Bernardino in San Bernardino County to the City of Oceanside in San Diego County. This line can be accessed by two stations along the SR-57 study corridor – the Anaheim Canyon Metrolink Station located at 1039 North Pacificenter Drive in Anaheim near the intersection of Tustin Avenue and La Palma Avenue (two miles east of SR-57), and the Orange Metrolink station located two miles east of SR-57 near Chapman Avenue at 100 North Atchison Street in the City of Orange. According to the latest ridership statistics provided by SCRRA, this line carries just under 4,800 weekday passengers with most AM peak period boardings occurring in Riverside County with destinations in Orange County. Ridership between 2006 and 2007 has grown by two percent. Over 90 percent of all riders are commuters.

The *91 Line* connects the City of Riverside to Union Station in downtown Los Angeles. The line does not offer service parallel to the SR-57 Corridor, but it has a station at the joint Amtrak/Metrolink station located in the Fullerton Transportation Center on 120 East Santa Fe Avenue. This station is less than three miles west of SR-57. According to the latest ridership statistics provided by SCRRA, this line carries just over 2,300 weekday passengers with most AM peak period boardings occurring in Riverside County. However, a significant percentage of passengers board in Fullerton. Ridership has declined by 14 percent between 2006 and 2007. Over 85 percent of riders are commuters.

The *Orange County Line* connects Oceanside to Union Station in downtown Los Angeles. Over 9,000 people ride the 19 trains that operate daily on this line. This line can be accessed at three stations near the SR-57 Corridor. The first is the Fullerton Transportation Center. The second is at the joint Anaheim Amtrak/Metrolink station located on 2150 East Katella Avenue, adjacent to the Angel Stadium parking lot. The station is less than a quarter mile west of SR-57 on Katella Avenue. The third is the Orange Metrolink station.

<u>Amtrak</u>

While Metrolink provides intra-regional service throughout Southern California, Amtrak provides interregional service. Two Amtrak trains use the same route as Metrolink's trains. Amtrak's Pacific Surfliner, which offers service from San Diego to San Luis Obispo, travels along the same route as Metrolink's Orange County Line; and Amtrak's Southwest Chief, which offers service from Los Angeles to Chicago, travels along the same route as Metrolink's Inland Empire-Orange County Line. Similarly, Amtrak shares station locations with Metrolink at the Fullerton, Santa Ana, Anaheim, and Orange stations.

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Intermodal Facilities

There are various intermodal facilities throughout the SR-57 study area, including a large commercial airport, three park and ride lots, and several bike lane paths.

John Wayne Airport (SNA) lies approximately 10 miles south of the I-5/SR-22/SR-57 Interchange and is linked to the SR-57 Corridor by I-5 and SR-55, as shown in Exhibit 2-7. SNA hosts air carrier, general aviation, air taxi, military, and air cargo services. Fourteen commercial and commuter air carriers operate from SNA.

As of 2006, SNA ranked 42nd in United States airports in terms of enplanements seventh in California just ahead of Ontario International Airport (ONT).[3] Exhibit 2-8 lists passenger boardings in recent years. Over the five-year period between 2002 and 2006, the number of passenger boardings grew from just under four million annually to nearly 4.8 million in 2006 with most of the growth occurring in the first two years. In one month alone (September 2007), SNA recorded 782,896 total passengers, including 388,735 enplanements and 394,161 deplanements. In the same month, the airport served 1,967 air cargo tons, including 1,838 tons carried by all-cargo carriers. Both FedEx and UPS serve SNA.[4]

Park and ride lots are also available along the SR-57 Corridor providing parking and access to local, regional and interregional transit. There are three park and ride lots in proximity:

- In Brea, the park and ride lot is located on Lambert Road and the SR-57 southbound off-ramp.
- In Anaheim, one mile from SR-57, the park and ride lot is located at the Church of Christ on 311 N. State College Boulevard below Lincoln Avenue.
- In Orange, the park and ride lot is located a little over two miles from SR-57 on Lincoln Avenue and SR-55/SR-91.

Several major arterials adjacent to the SR-57 Corridor also provide bike lanes. Parallel to and west of SR-57, there are Class II lanes on Sunkist Avenue from Cerritos to Lincoln Avenue, and on Acacia Street from SR-91 to the CSUF campus at State College Boulevard and Nutwood Avenue. Classes I and II lanes exist from Commonwealth and Chapman Avenues (City of Fullerton) north to Central Avenue in Brea. East of SR-57, there is a network of Class III routes in Placentia as well as a Class II facility on Kraemer Boulevard between Yorba Linda Boulevard and Birch Street.

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

Class II facilities exist at these freeway crossings: Bastanchury Road, Rolling Hills Road, and Associated Road in Fullerton; Birch Street and Lambert Road in Brea.

Exhibit 2-7: John Wayne Airport

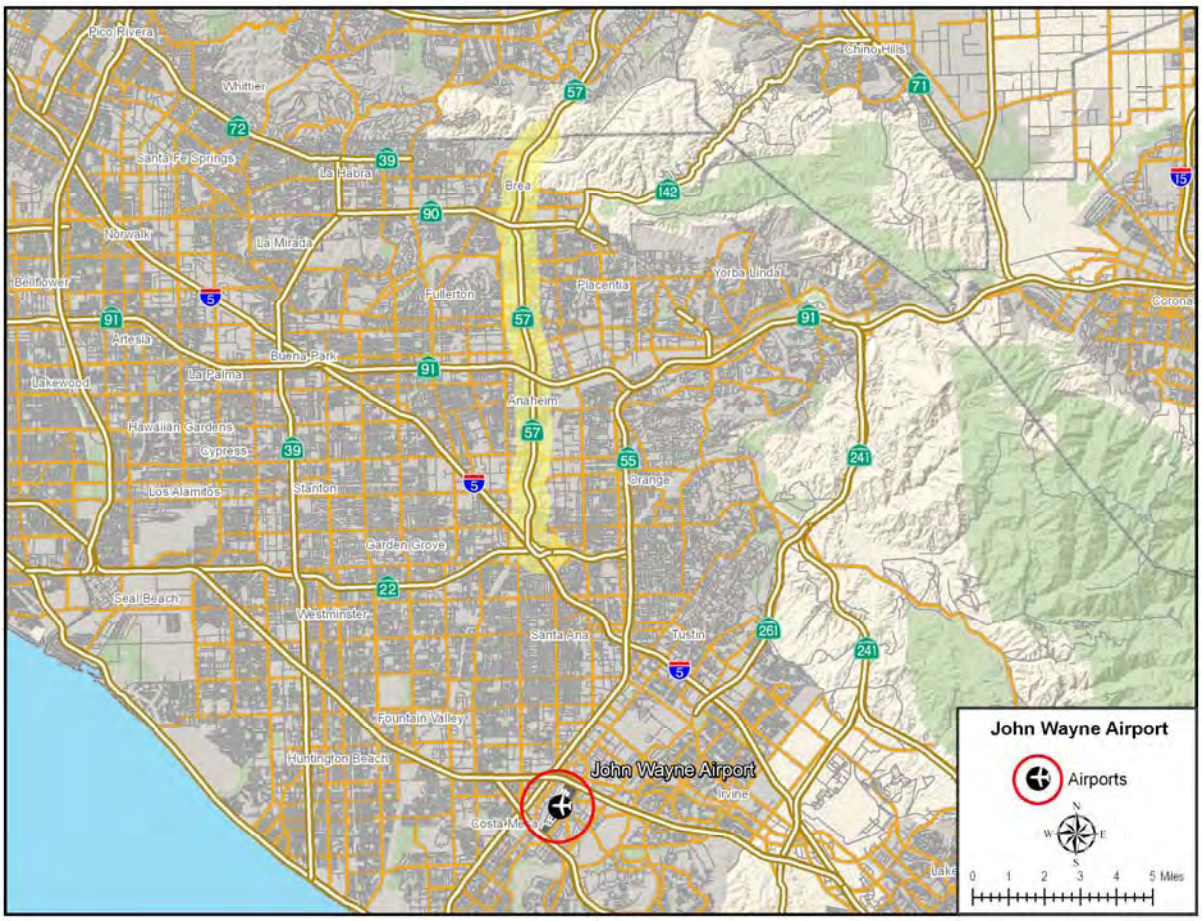

Exhibit 2-8: SNA Passenger Boarding Statistics

	2002	2003	2004	2005	2006
Passenger Boardings	3,968,978	4,266,083	4,621,107	4,791,786	4,777,896
Difference		297,105	355,024	170,679	-13,890
Percent Difference		7%	8%	4%	0%

Source: Federal Aviation Administration (FAA) Air Carrier Activity Information System (ACAIS).[5]

[5] "Passenger Boarding and All-Cargo Data." Federal Aviation Administration. May 2008. Air Carrier Activity Information System (ACAIS). <www.faa.gov/airports_airtraffic/airports/planning_capacity/passenger_allcargo_stats/passenger>.

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Special Event Facilities/Trip Generators

There are various facilities and institutions located along SR-57 that could generate significant trips on the corridor. Exhibit 2-9 shows the location of the most significant traffic generators.

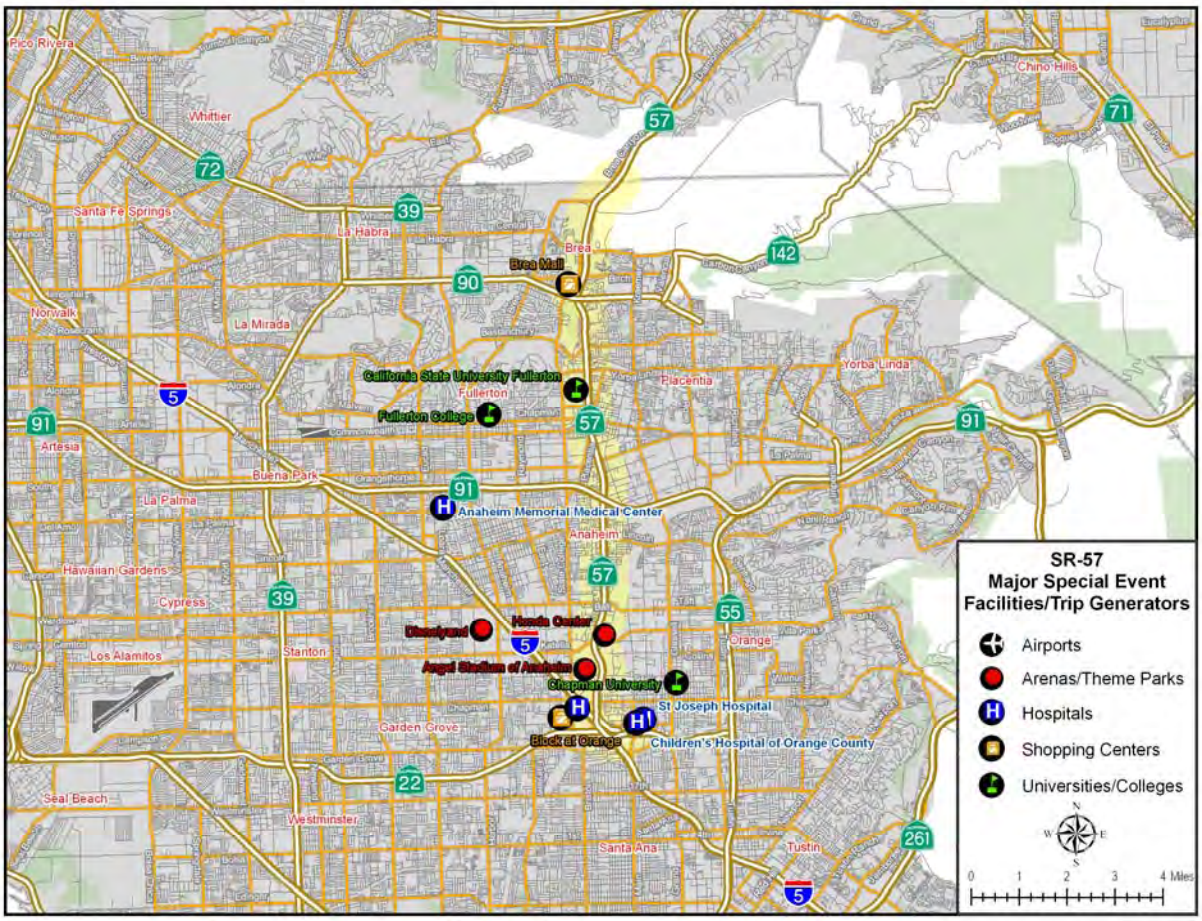
The special event facilities located within several miles of the SR-57 Corridor include Disneyland Resort and Theme Park, Angel Stadium, and the Honda Center. The Disneyland Resort and Theme Park is located three miles west of SR-57 on Katella Avenue and is the second busiest amusement park in the world with an average daily attendance of nearly 40,000 patrons. The Disneyland Resort directly employs over 20,000 people, making it Orange County's largest employer and one of the largest single-site private employers in the state. Adjacent to SR-57 on Katella Avenue is the "Angels Stadium of Anaheim," home of the Los Angeles Angels' professional baseball team. Across the street from Angels Stadium on Katella Avenue and east of SR-57, is the "Honda Center" arena, home to the professional hockey team, the Anaheim Ducks. Other events, such as concerts, rodeos, basketball tournaments, and other major performances, take place at the Honda Center. Angel Stadium seats over 45,000 people and the Honda Center can accommodate between 17,000 and 19,000 guests depending on the event and seating configuration.

Two major universities and a college are located near the SR-57 Corridor. The two universities are California State University Fullerton (CSUF) and Chapman University. CSUF is situated directly west of SR-57 on Yorba Linda Boulevard and is a four-year public university offering Bachelor and Masters Degree programs to nearly 36,000 students. Chapman University, a private institution built around a liberal arts core with an enrollment of over 5,000 students, is located less than two miles east of SR-57 on Glassell Street in the City of Orange. Approximately two miles west from Cal State Fullerton on Chapman Avenue is Fullerton College, a two-year institution with an enrollment of almost 20,000 students. There are also several secondary, middle, and elementary schools within a few miles of the corridor.

There are four major medical facilities within a few miles of the SR-57 Corridor. The first is the Anaheim Memorial Medical Center. This facility has served North Orange County since 1958 and is ranked among the nation's top 100 hospitals for heart attack, heart failure and pneumonia care. It is located about four miles west of SR-57 on LaPalma Avenue. The second major medical facility is UCI Medical Center, which is located less than a mile west of SR-57 on Chapman Avenue in the City of Orange. This facility is the only university hospital in Orange County and boasts more than 400 specialty and primary care physicians who offer a full range of acute and general care services. The third and fourth major medical facilities are St Joseph Hospital and Children's Hospital of Orange County (CHOC), located in the City of Orange. St. Joseph Hospital is the largest and one of the highest volume hospitals in the County

with a 1,000-member medical staff, and CHOC is the first hospital in Orange County to open an emergency room for children.

Exhibit 2-9: Major Special Event Facilities/Trip Generators



Two major shopping malls are located near the SR-57 Corridor. Brea Mall is directly west of SR-57 on Imperial Highway and State College Boulevard. It houses five major department stores and over 175 specialty shops and boutiques. The Block at Orange is located less than two miles west of SR-57 on Chapman Avenue and The City Drive in the City of Orange. The Block is an outdoor mall popular for its skateboarding facility and thriving nightlife.

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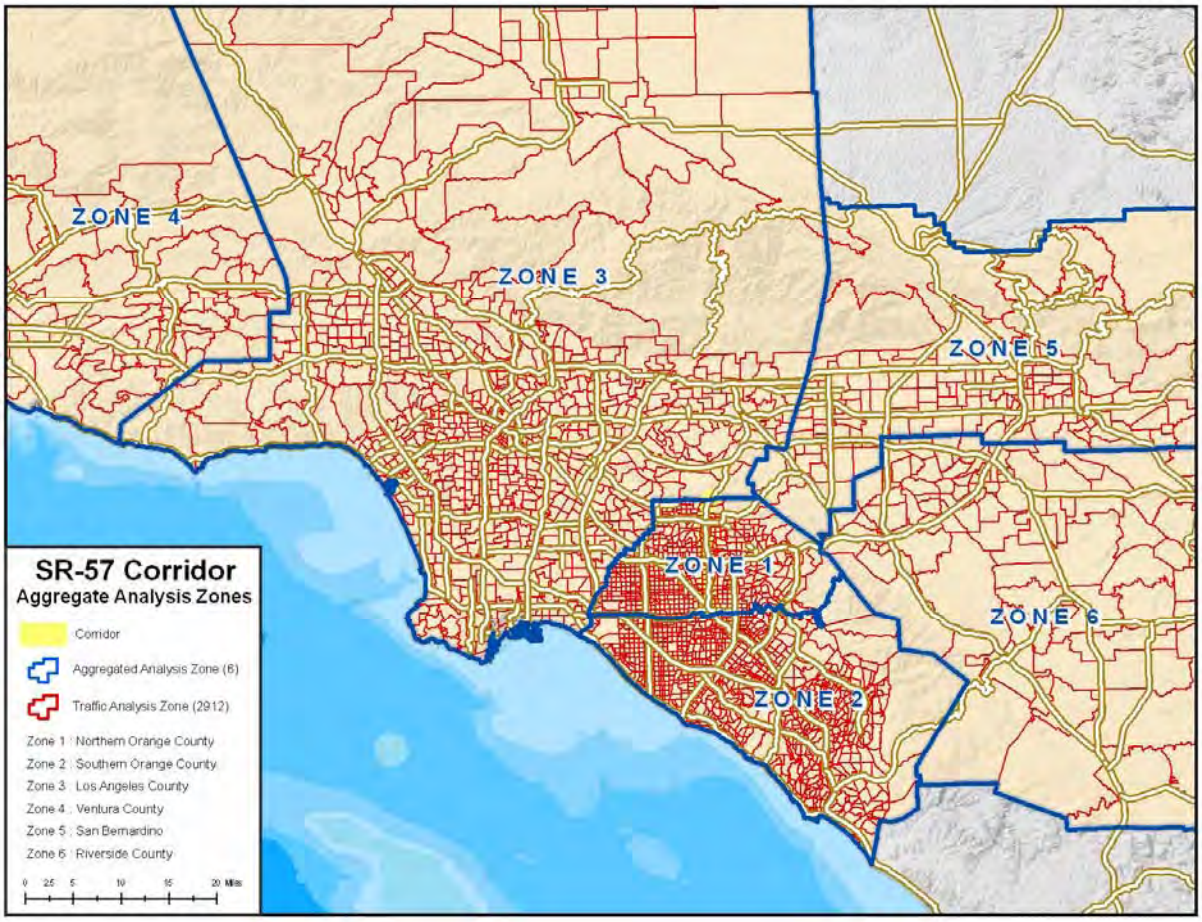
Demand Profiles

An analysis of origins and destinations was conducted to determine the travel pattern of trips made on the SR-57 study corridor. Based on Caltrans' travel demand model, this "select link analysis" isolated the SR-57 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 shown in Exhibit 2-10.

Exhibit 2-10: Aggregate Analysis Zones for Demand Profile Analysis



Based on this aggregation, demand on the corridor was summarized by aggregated origin-destination zone as depicted in Exhibits 2-11 and 2-12 for the AM and PM peak periods. This analysis shows that the majority of trips using the SR-57 study corridor represent travel within Orange County. However, a significant number of trips also originated or terminated in Los Angeles County.

During the AM peak period, about 36 percent of all trips originate and terminate in Orange County (Zones 1, 2). The remaining trips originate in Orange County and terminate in another county (22 percent); originate outside Orange County and terminate in Orange County (33 percent); or originate and terminate outside Orange County (8 percent).

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

		TO ZONE						
	AM Trips	Northern Orange County	Southern Orange County	Los Angeles County	Ventura County	San Bernardino County	Riverside County	Outside Zones
FROM ZONE	Northern Orange County	12.2%	12.3%	9.3%	0.1%	0.5%	3.3%	0.1%
	Southern Orange County	10.4%	1.0%	6.4%	0.0%	0.2%	2.6%	0.0%
	Los Angeles County	13.6%	9.8%	4.3%	0.0%	0.2%	1.5%	0.0%
	Ventura County	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
	San Bernardino County	0.8%	0.3%	0.2%	0.0%	0.0%	0.1%	0.0%
	Riverside County	4.7%	3.7%	1.3%	0.0%	0.1%	0.5%	0.0%
	Outside Zones	0.2%	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%

35.8%	Trips starting and ending in Orange County
22.4%	Trips starting in Orange County and ending outside of Orange County
33.4%	Trips starting outside of Orange County and ending in Orange County
8.4%	Trips starting outside of Orange County and ending outside of Orange County

During the PM peak period (which experiences over 30 percent more demand for travel than the AM), the picture is similar. Roughly 35 percent of trips originate and terminate in Orange County. The remaining trips originate in Orange County and terminate in another county (31 percent); originate outside Orange County and terminate in Orange County (25 percent); or originate and terminate outside Orange County (9 percent).

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

		TO ZONE						
	PM Trips	Northern Orange County	Southern Orange County	Los Angeles County	Ventura County	San Bernardino County	Riverside County	Outside Zones
FROM ZONE	Northern Orange County	12.1%	10.7%	12.6%	0.1%	0.6%	4.5%	0.2%
	Southern Orange County	10.6%	1.1%	9.2%	0.1%	0.3%	3.6%	0.0%
	Los Angeles County	10.5%	7.3%	4.6%	0.0%	0.2%	1.4%	0.2%
	Ventura County	0.2%	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%
	San Bernardino County	0.7%	0.3%	0.2%	0.0%	0.0%	0.1%	0.0%
	Riverside County	3.4%	2.7%	1.5%	0.0%	0.1%	0.4%	0.1%
	Outside Zones	0.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%

34.6%	Trips starting and ending in Orange County
31.2%	Trips starting in Orange County and ending outside of Orange County
25.3%	Trips starting outside of Orange County and ending in Orange County
8.9%	Trips starting outside of Orange County and ending outside of Orange County

3. CORRIDOR-WIDE PERFORMANCE AND TRENDS

This section summarizes the analysis results of the performance measures used to evaluate the existing conditions of the SR-57 Corridor. The primary objective of the measures is to provide a sound technical basis for describing traffic performance on the corridor. Data from the mainline (ML) and high-occupancy vehicle (HOV) facilities are analyzed separately under each performance measure. The base year for the analysis and modeling is 2007 for the SR-57 study corridor.

The performance measures focus on five key areas:

- **Mobility** describes how well people and freight move along the corridor
- **Reliability** captures the relative predictability of travel along the corridor
- **Safety** provides an overview of collisions along the corridor
- **Productivity** describes the productivity loss due to traffic inefficiencies
- **Pavement Condition** describes the structural adequacy and the ride quality of the pavement.

MOBILITY

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

Delay

Delay is defined as the 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 Caltrans Highway Congestion Monitoring Program (HICOMP) report has been published annually by Caltrans since 1987.[6] 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.

Exhibit 3-1 shows the yearly delay trends from 2006 to 2007 for the AM and PM peak travel period for both directions along the study corridor. As indicated in the exhibit, the most significant congestion occurs during the PM peak period in the northbound direction for both years. While the northbound delay showed an increase in the PM peak period, the southbound delay decreased significantly from 2006 to 2007 for both the AM and PM peak periods.

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

Exhibit 3-1: Average Daily Vehicle-Hours of Delay

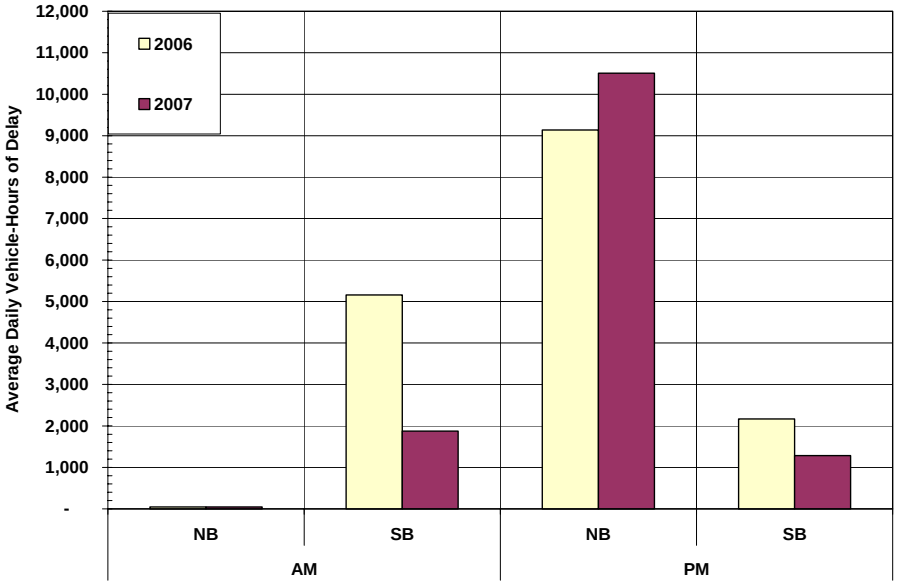


Exhibit 3-2 shows the complete list of congested segments reported by the HICOMP report for the corridor. A congested segment may vary in distance or size from one year to the next as well as from day-to-day. Exhibit 3-2 standardizes the list of congested segments (i.e., "generalized" segments) so comparisons can be made from one year to the next. It should be noted that the trends are affected by the quality of the data available in individual years. As the exhibit and other measures presented throughout this report show, travel along the SR-57 Corridor exhibits directional demand. Congestion occurs during the AM and PM peak periods in the southbound direction and during the PM peak period in the northbound direction.

The maps in Exhibits 3-3 and 3-4 show the 2007 delays from Exhibit 3-2 during each of the two peak periods. The approximate locations of the congested segments, the duration of that congestion, and the reported recurrent daily delay are also shown on the maps.

The most congested segment on the corridor was in the northbound direction during the PM peak period between Chapman Avenue (City of Fullerton) and Tonner Canyon Road. Delay experienced in this segment increased from 9,138 hours in 2006 to 10,507 hours in 2007. Delay in the southbound direction decreased during both the AM and PM peak periods, thus the overall delay experienced on the corridor from 2006 to 2007 showed a decrease in total delay of 2,800 vehicle-hours or approximately 17 percent.

Exhibit 3-2: HICOMP Hours of Delay for Congested Segments (2006-2007)

Period	Dir	Generalized Congested Area	Generalized Area Congested Average Vehicle-Hours of Delay	
			2006	2007
AM	NB	Chapman Ave to s/o Orangewood Ave	5	
		Lincoln Ave to Orangethorpe Ave	39	47
	SB	Tonner Canyon Rd to Chapman Ave	5,157	1,874
AM PEAK PERIOD SUMMARY			5,201	1,921
PM	NB	Chapman Ave to Tonner Canyon Rd	9,138	10,507
	SB	Tonner Canyon Rd to Chapman Ave	2,170	1,280
PM PEAK PERIOD SUMMARY			11,308	11,787
TOTAL CORRIDOR CONGESTION			16,508	13,708

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

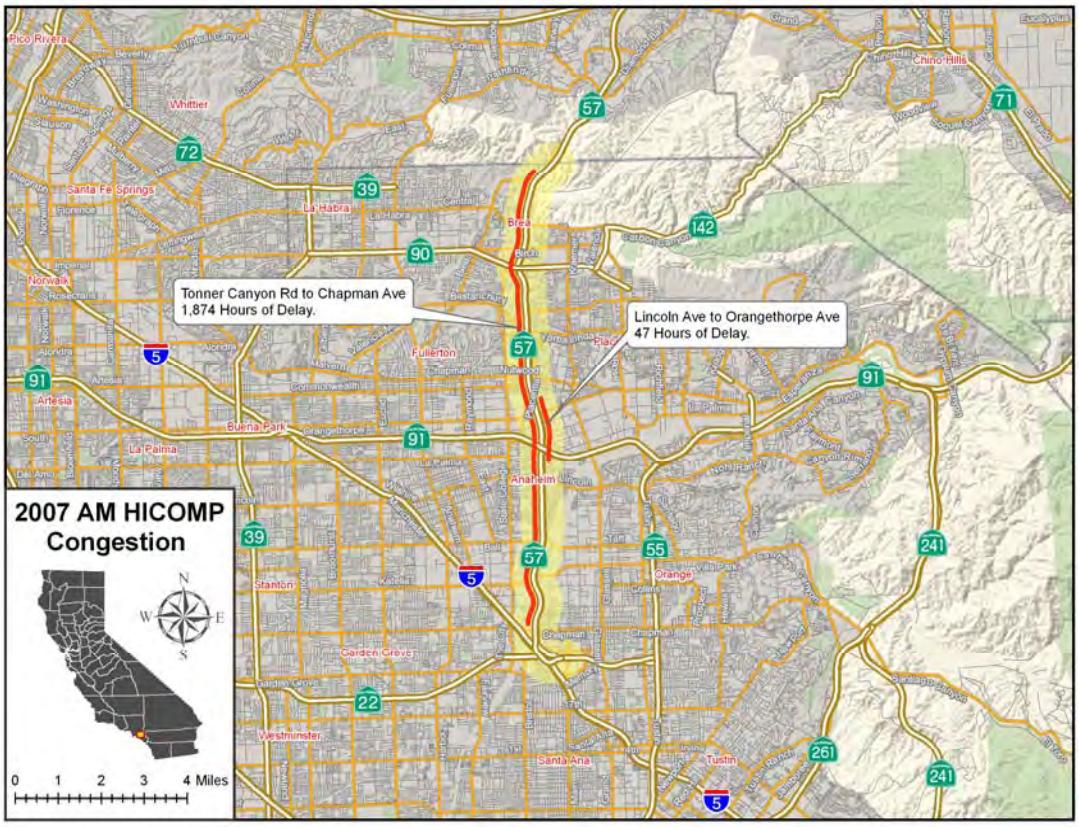
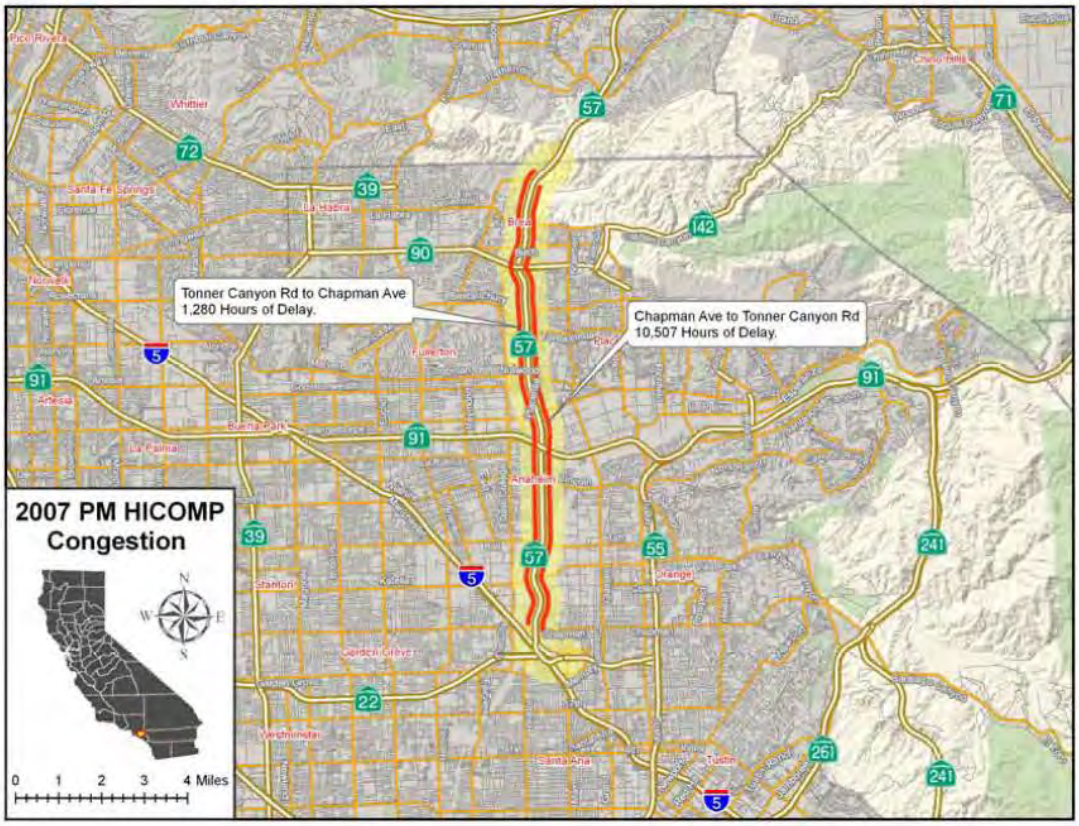


Exhibit 3-4: 2007 PM Peak Period HICOMP Congested Segments Map



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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.

Initially, performance assessments were conducted during the three-year period between 2005 and 2007. Updates were recently conducted to December 2008. Unlike HICOMP where delay is only considered and captured for speeds below 35 miles per hour and applied to an assumed output or capacity volume of 2,000 vehicles per hour, delays presented in this section represent the difference in travel time between actual conditions and free flow conditions at 60 miles per hour, applied to the actual output flow volume collected from a vehicle detector station.

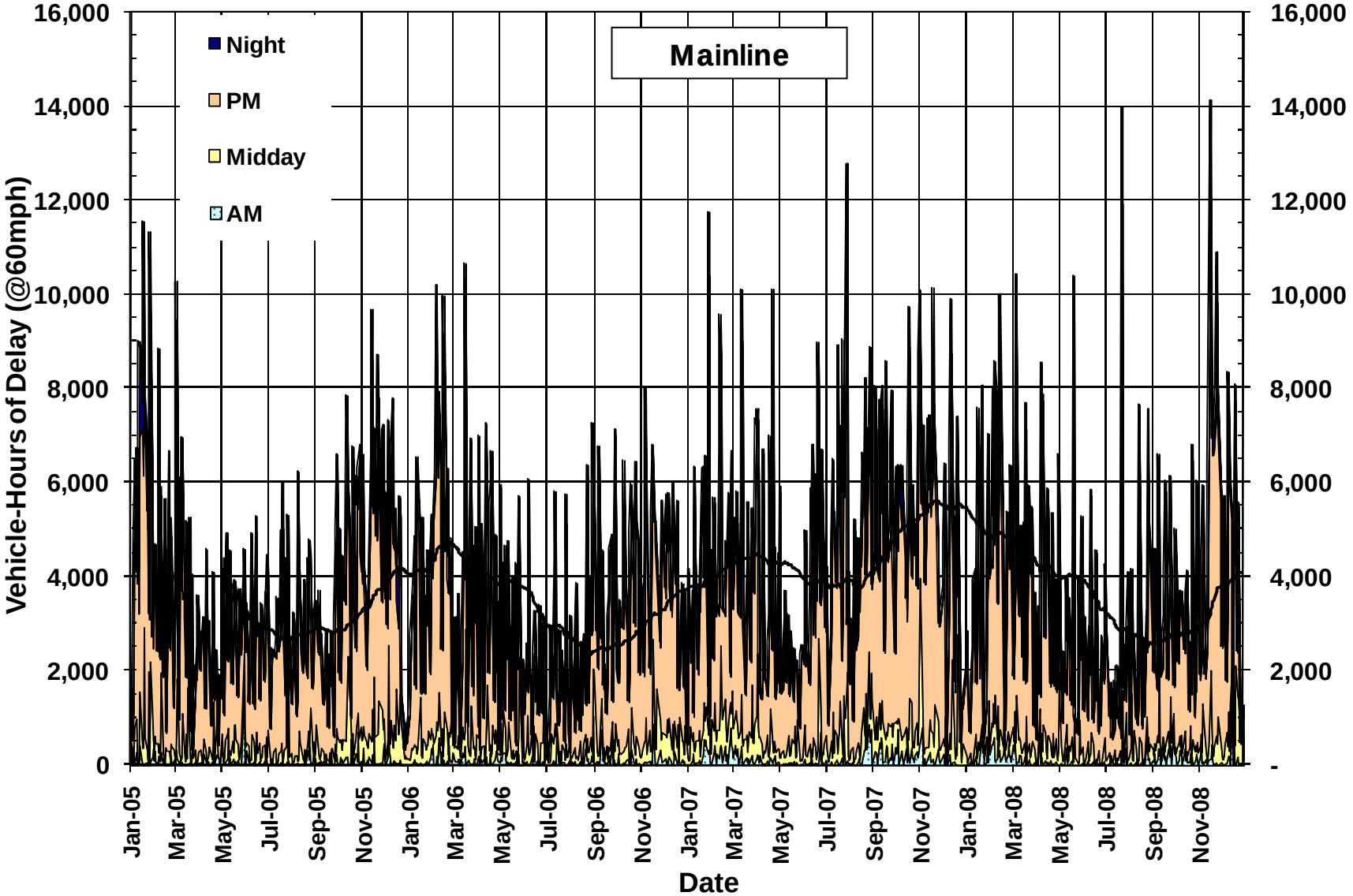
The HICOMP results presented earlier cover the years 2006 through 2007, while the PeMS data covers the period from 2005 through 2008. Therefore, only the two-year period between 2006 and 2007 is comparable. Another difference that exists between HICOMP and PeMS is that PeMS estimates speeds across all lanes for all days of the year while probe vehicle runs for HICOMP are conducted only one day of the year. Probe vehicle runs also measure traffic conditions in one lane of traffic while PeMS covers multiple lanes.

Total delay for the SR-57 mainline and HOV facilities in each direction are illustrated in Exhibits 3-5, 3-6, 3-7, and 3-8. Delay along the study corridor was computed for four time periods: AM peak (6:00 AM to 9:00 AM), Midday (9:00 AM to 3:00 PM), PM peak (3:00 PM to 7:00 PM), and evening/early AM (7:00 PM to 6:00 AM).

Weekday delay for the mainline facility is presented in Exhibits 3-5 and 3-6 during the four-year period of 2005-2008. Within the exhibit, there is a 90-day moving average to “smooth” out the day-to-day variations and illustrate the seasonal and annual changes in congestion over time. Consistent with the HICOMP data, the highest daily congestion occurred during the PM peak period in the northbound direction (Exhibit 3-5). Total northbound delay fluctuated during this four-year period with the highest delay having occurred around December 2007. This was followed by a steep decline in delay from January to September 2008. The southbound direction is also consistent with the HICOMP data, which shows that the highest daily congestion occurred during the AM peak period (Exhibit 3-6). Similar to the northbound, delay in the southbound direction also fluctuated during the 2005-2008 period, but peaked around January 2006 and January 2008.

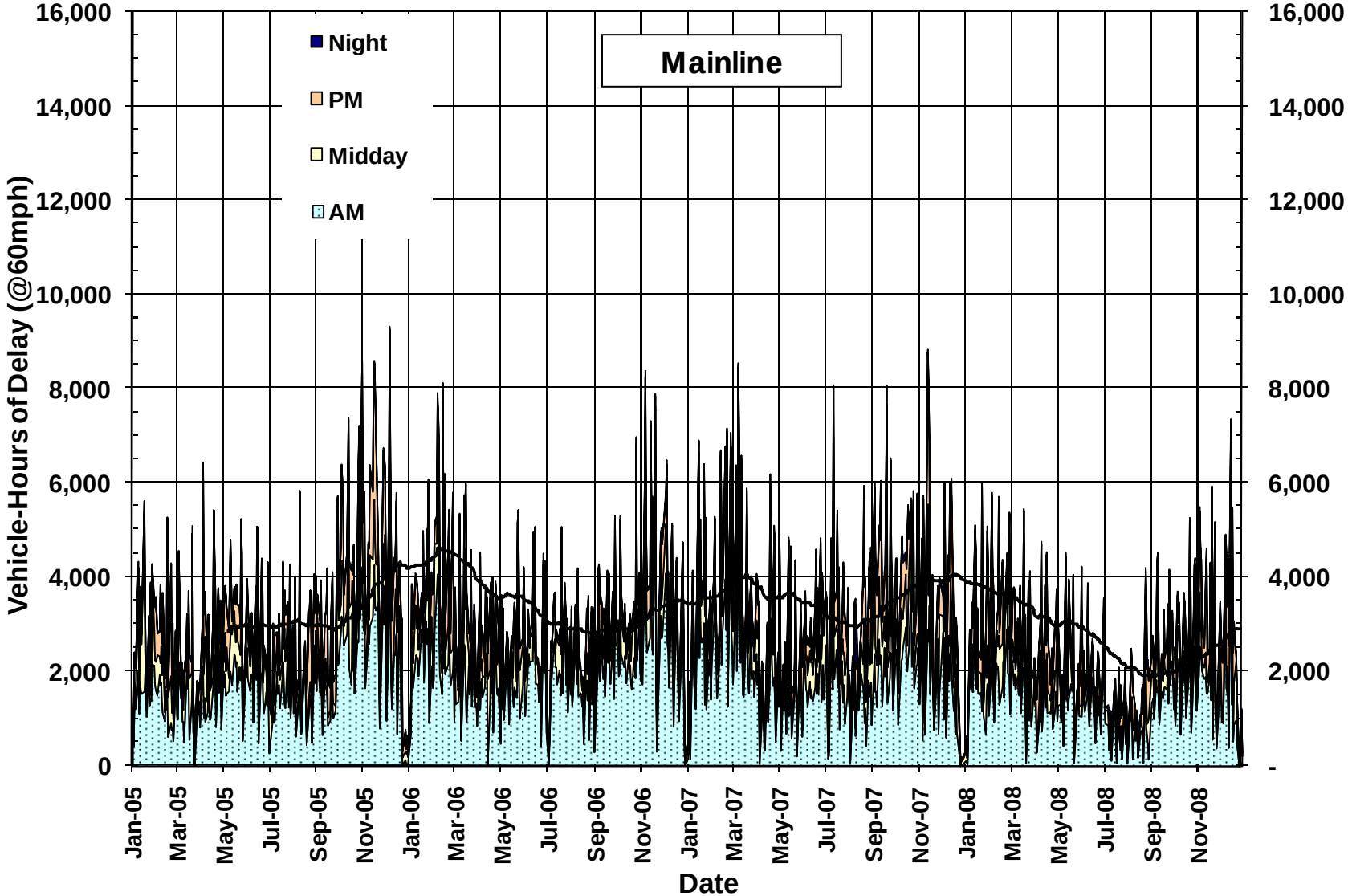
Exhibits 3-7 and 3-8 show that delay on the HOV facility followed the same pattern as the mainline facility with more congestion having occurred in the PM for the northbound direction and in the AM for the southbound direction. Similar to the mainline trend, the northbound HOV facility experienced significantly more delay than the southbound HOV.

Exhibit 3-5: Northbound SR-57 Mainline Average Daily Delay by Time Period (2005-2008)



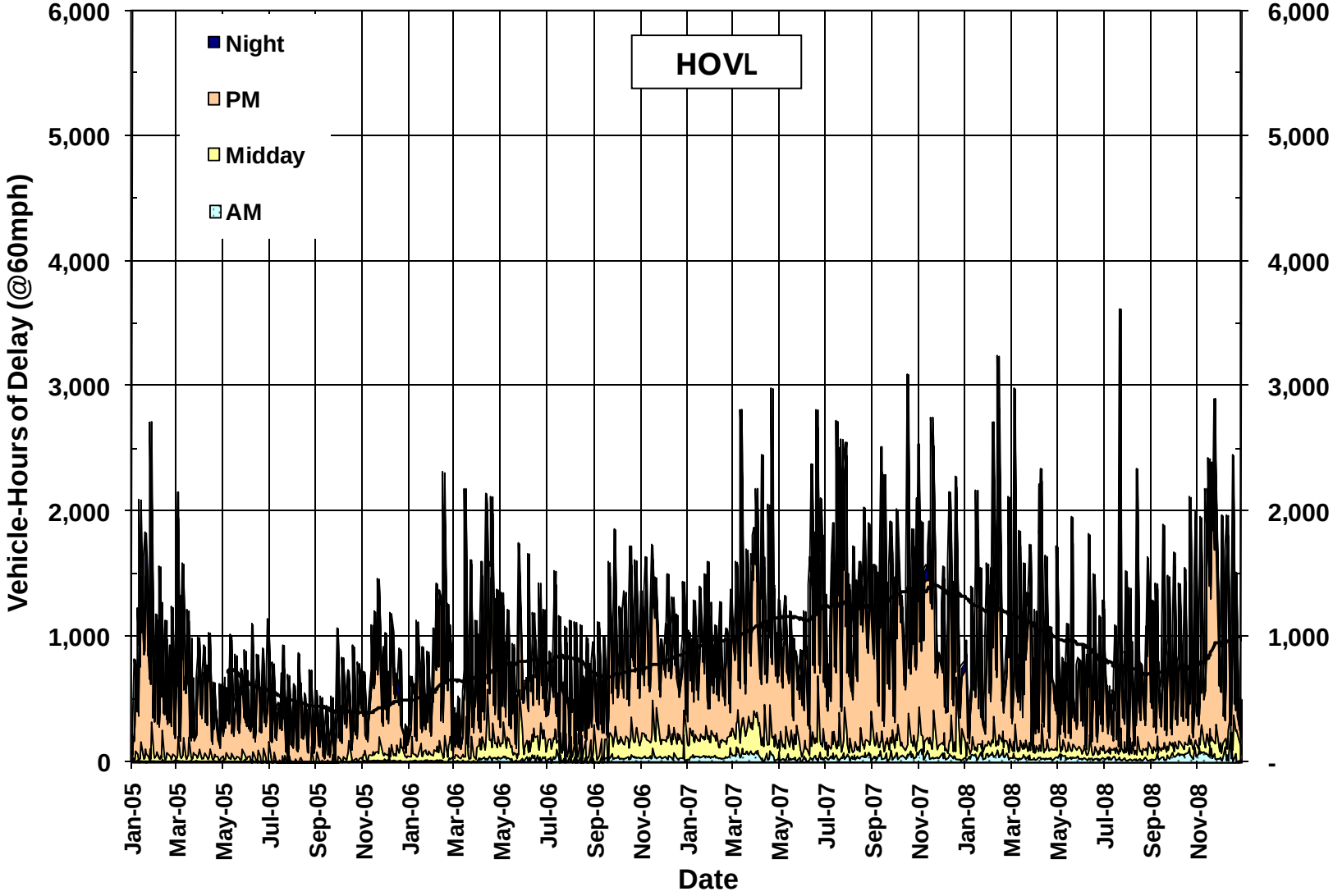
Source: SMG analysis of PeMS data

Exhibit 3-6: Southbound SR-57 Mainline Average Daily Delay by Time Period (2005-2008)



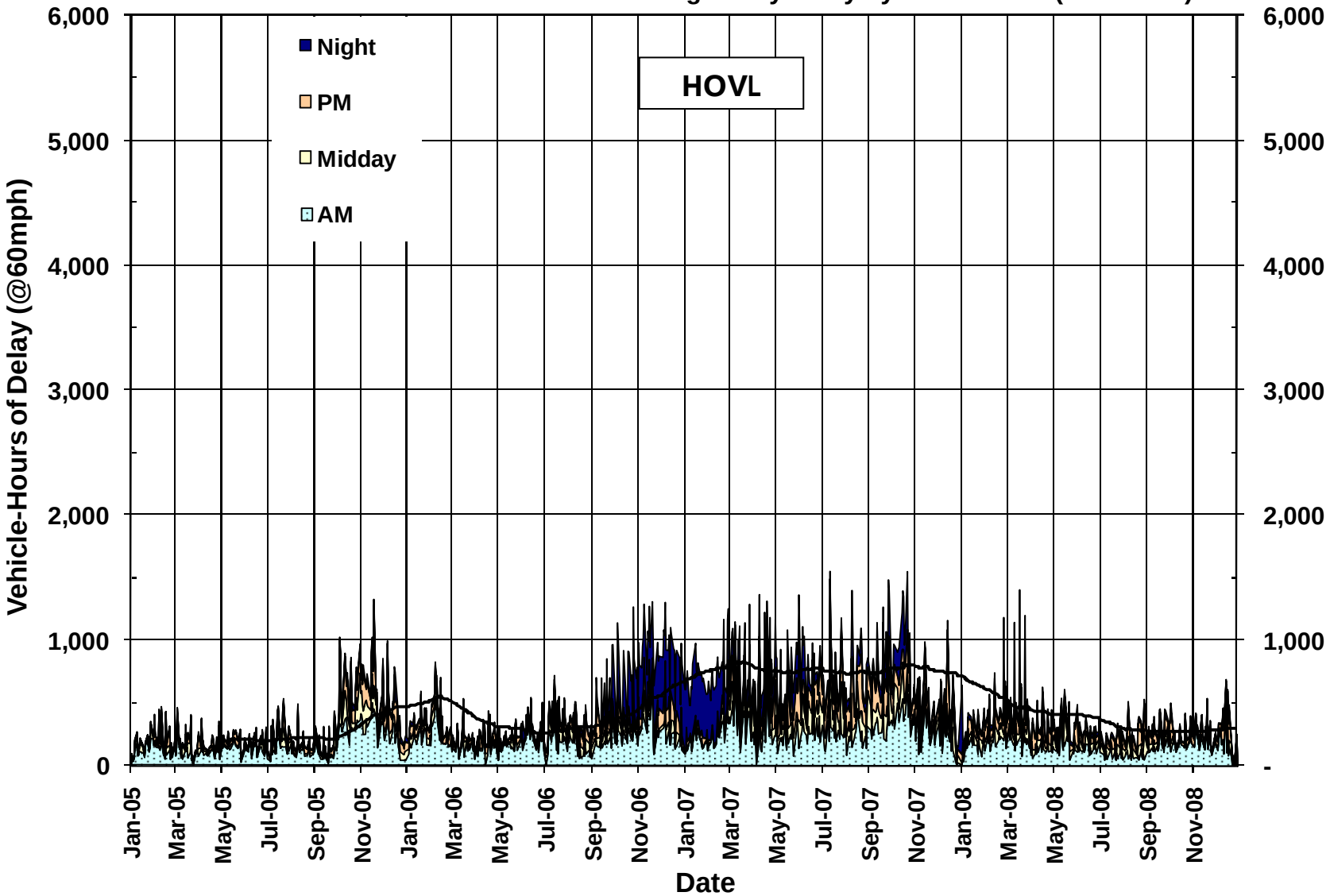
Source: SMG analysis of PeMS data

Exhibit 3-7: Northbound SR-57 HOVL Average Daily Delay by Time Period (2005-2008)



Source: SMG analysis of PeMS data

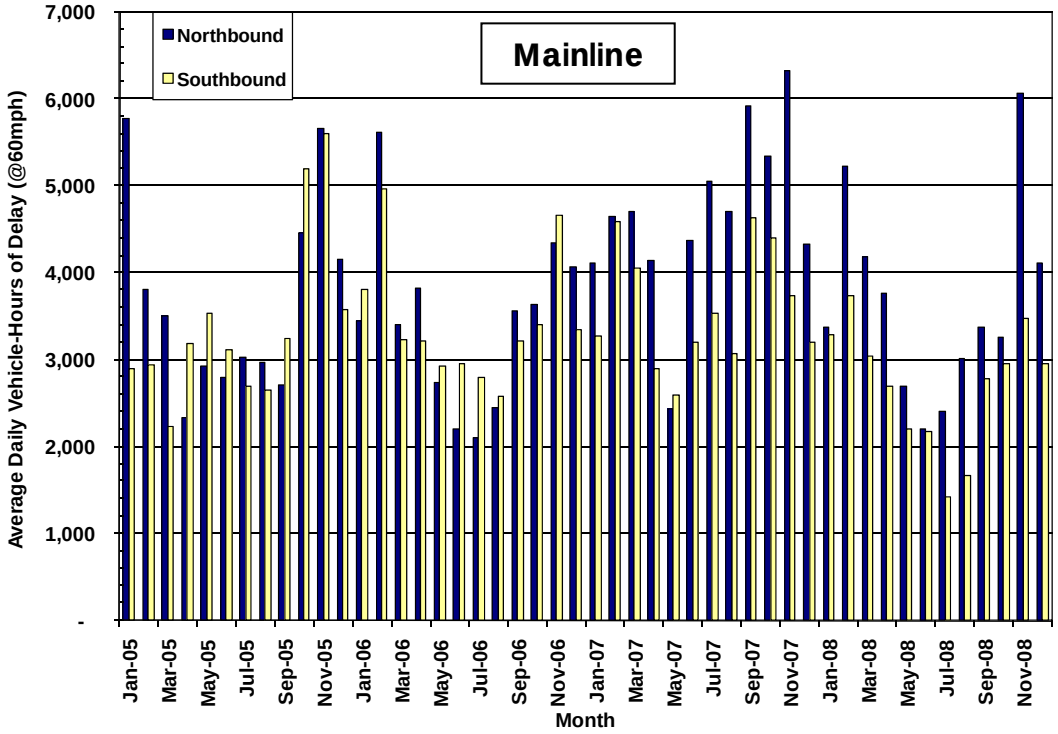
Exhibit 3-8: Southbound SR-57 HOVL Average Daily Delay by Time Period (2005-2008)



Source: SMG analysis of PeMS data

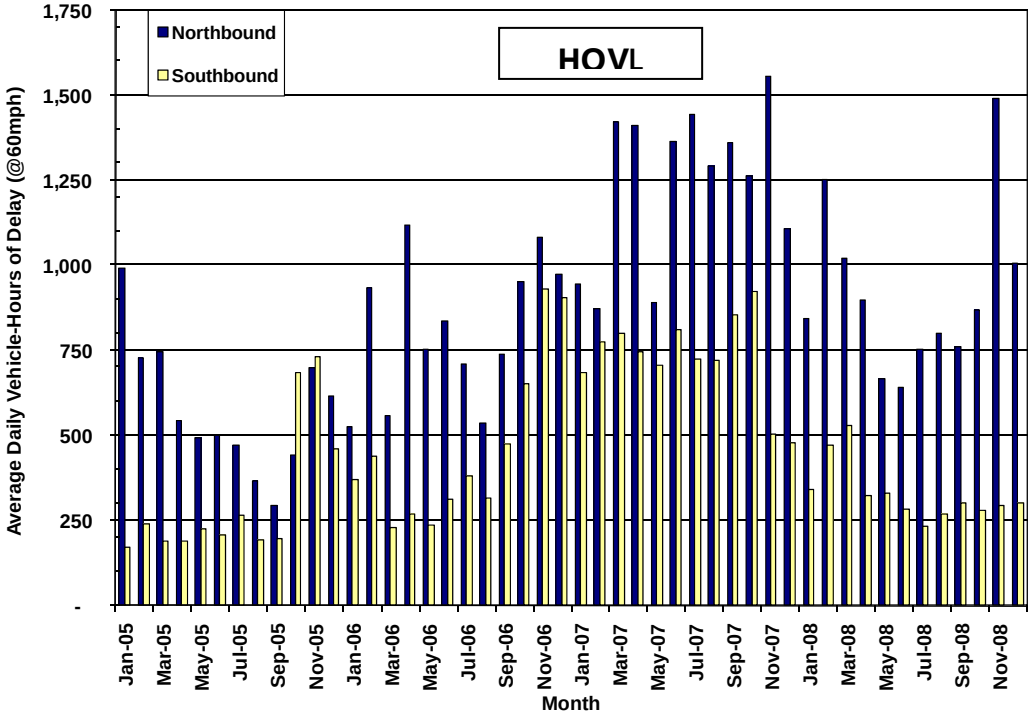
The average daily weekday delay by month for the mainline and HOVL facilities are depicted in Exhibits 3-9 and 3-10. On the mainline facility, the average weekday delay ranged from approximately 2,000 to 6,000 vehicle-hours, in each direction. For the HOV facility, delay was significantly less, ranging from roughly 250 to 1,500 vehicle-hours (Exhibit 3-10). Overall, the northbound direction on both the mainline and HOV facilities experienced more congestion than the southbound during this four-year period. The northbound direction also experienced a wider variation in delays from month to month.

Exhibit 3-9: Mainline Average Weekday Delay by Month 2005-2008



Source: SMG analysis of PeMS data

Exhibit 3-10: HOVL Average Weekday Delay by Month 2005-2008



Source: SMG analysis of PeMS data

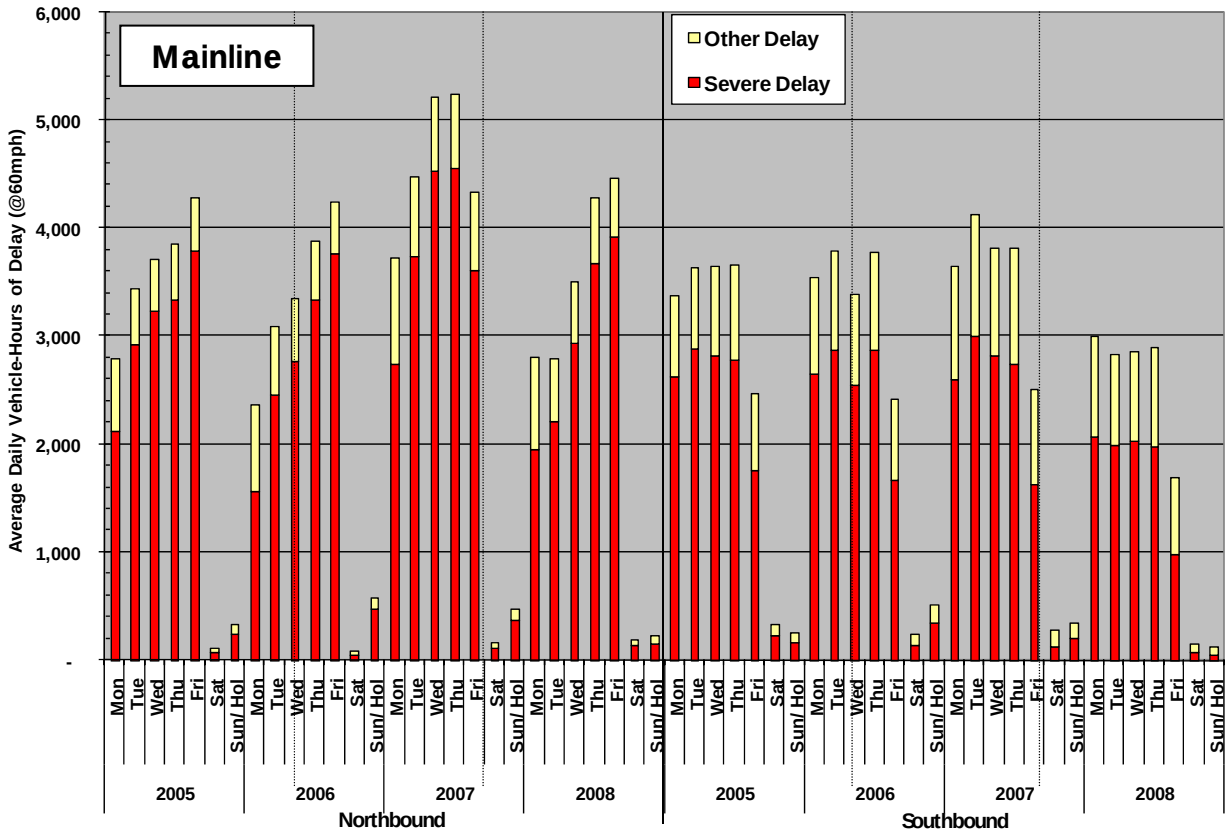
Delays presented to this point represent the difference in travel time between "actual" conditions and free flow conditions at 60 mph. This delay can be segmented into two components as shown in Exhibits 3-11:

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

Severe delay in Exhibit 3-11 represents breakdown conditions and is generally the focus of congestion mitigation strategies. "Other" delay represents conditions approaching breakdown congestion, but cause temporary slowdowns rather than long-lasting congestion queues. 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.

As indicated in Exhibit 3-11, the northbound mainline experienced the highest "severe" delay on Thursdays, with a delay of about 4,500 vehicle-hours in 2007. In the southbound direction, Tuesdays experienced the highest "severe" delays during all four years at around 2,800 vehicle-hours.

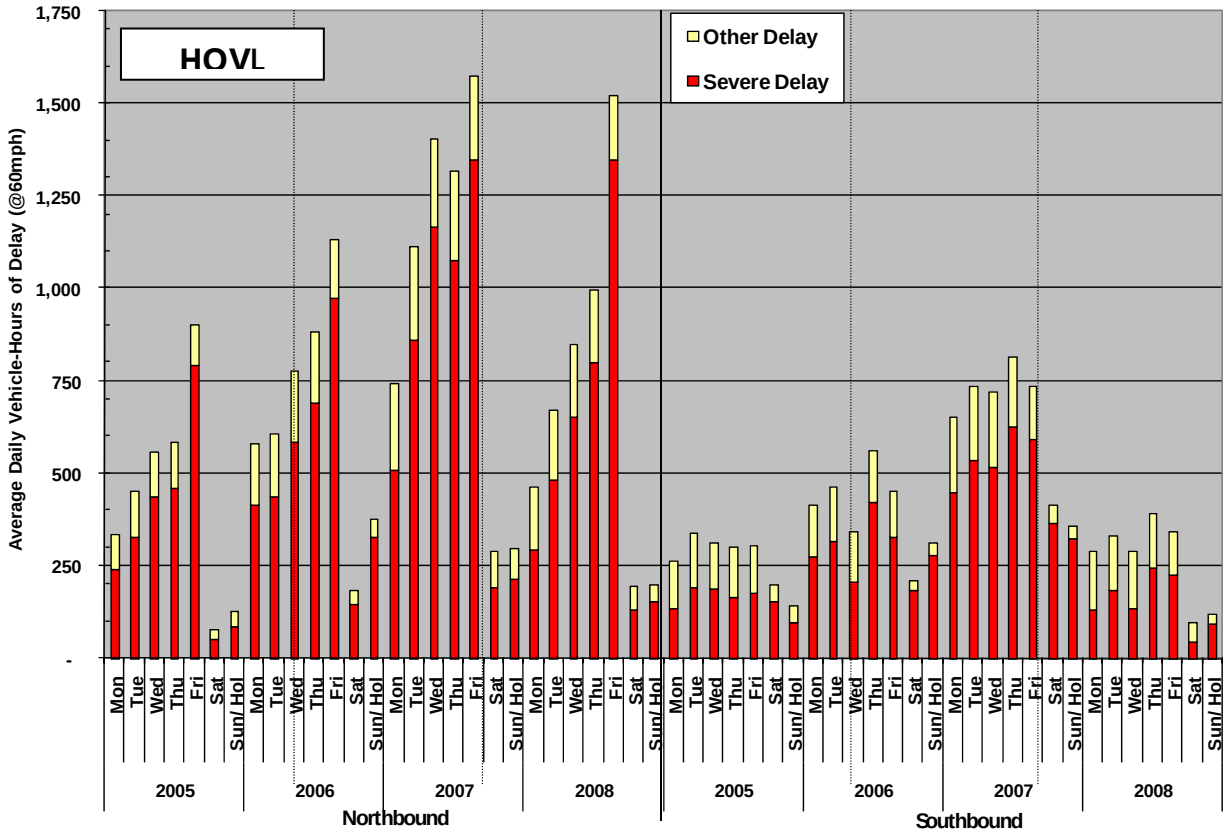
Exhibit 3-11: Mainline Average Delay by Day of Week by Severity (2005-2008)



Source: SMG analysis of PeMS data

On the HOV facility, "severe" delay was highest on Fridays in the northbound direction and Thursdays in the southbound direction. In 2008, the northbound HOV facility experienced about 1,300 vehicle-hours of "severe" delay on Friday, and the southbound HOV facility experienced about 240 vehicle-hours of "severe" delay on Thursday.

Exhibit 3-12: HOVL Average Delay by Day of Week by Severity (2005-2008)

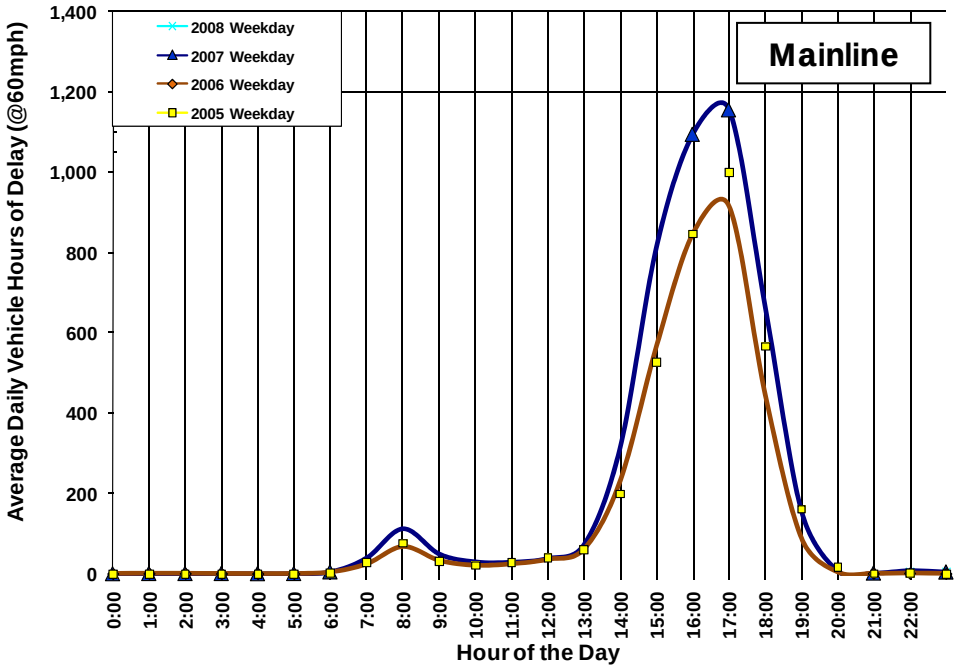


Source: SMG analysis of PeMS data

Another way to understand the characteristics of congestion and related delays is shown in Exhibits 3-13 through 3-16, which summarize average weekday hourly delays by time of day for the four-year period of 2005-2008. For the mainline facility, Exhibit 3-13 shows that the peak hourly delay in the northbound direction is approximately 1,000 vehicle-hours at around 5:00 PM. Conversely, Exhibit 3-14 shows that the peak hourly delay in the southbound mainline is roughly 800 vehicle-hours at around 7:00 AM. The pattern of delay for all four years is similar to each other with a couple of exceptions: in 2007, the northbound delay was the highest and the duration of the peak period widened; and in 2008, southbound delay declined significantly during the AM peak.

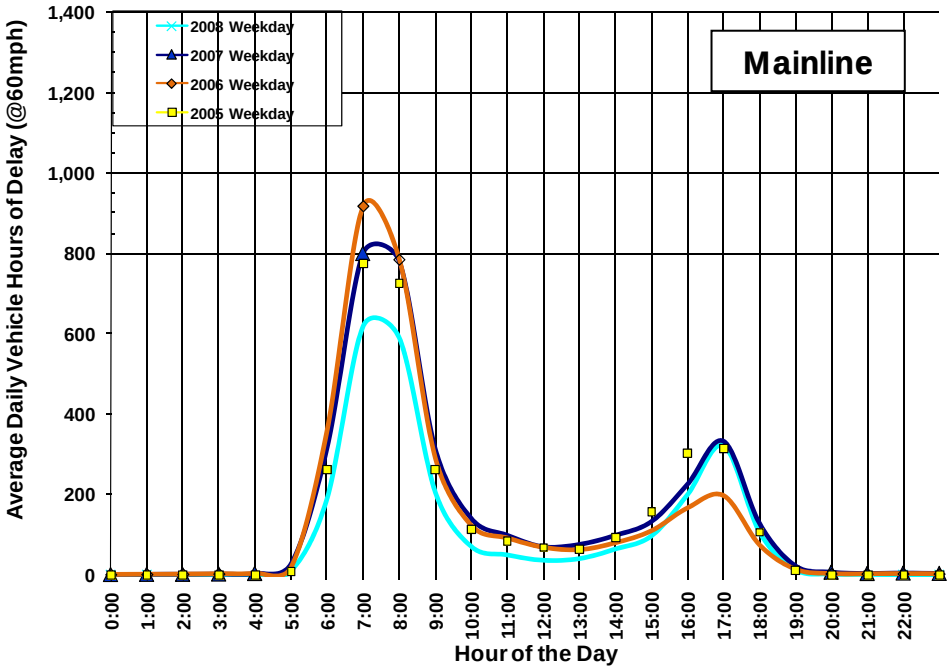
Delay on the HOV facility in Exhibits 3-15 and 3-16 illustrate the same pattern as the mainline facility. In 2007, the northbound HOV facility also experienced a longer PM peak period and had the highest delay compared to the other years. Delay in the southbound HOV facility remained constant.

Exhibit 3-13: Northbound Mainline Average Weekday Hourly Delay (2005-2008)



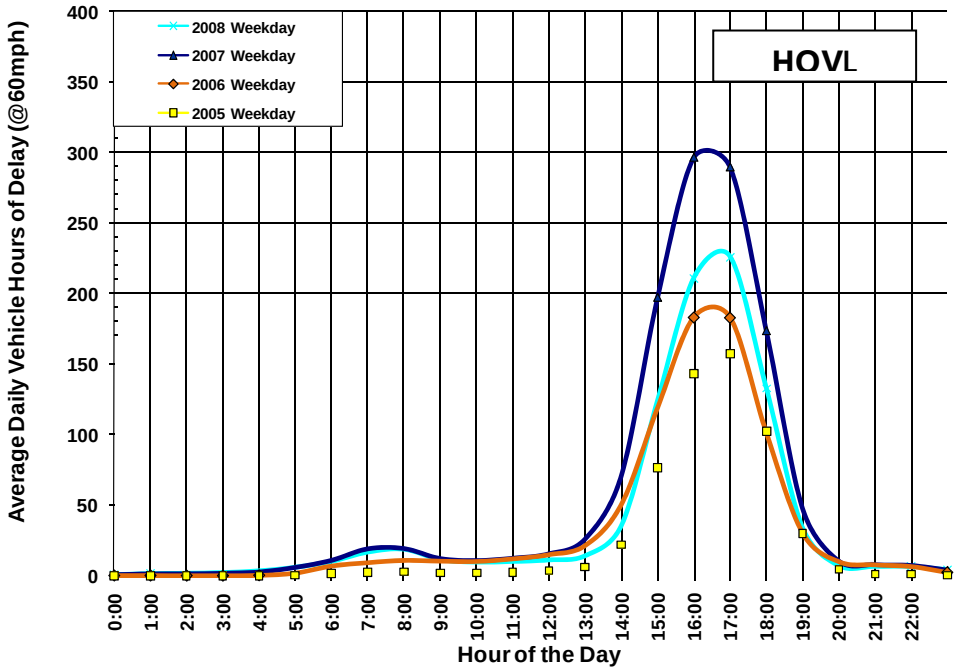
Source: SMG analysis of PeMS data

Exhibit 3-14: Southbound Mainline Average Weekday Hourly Delay (2005-2008)



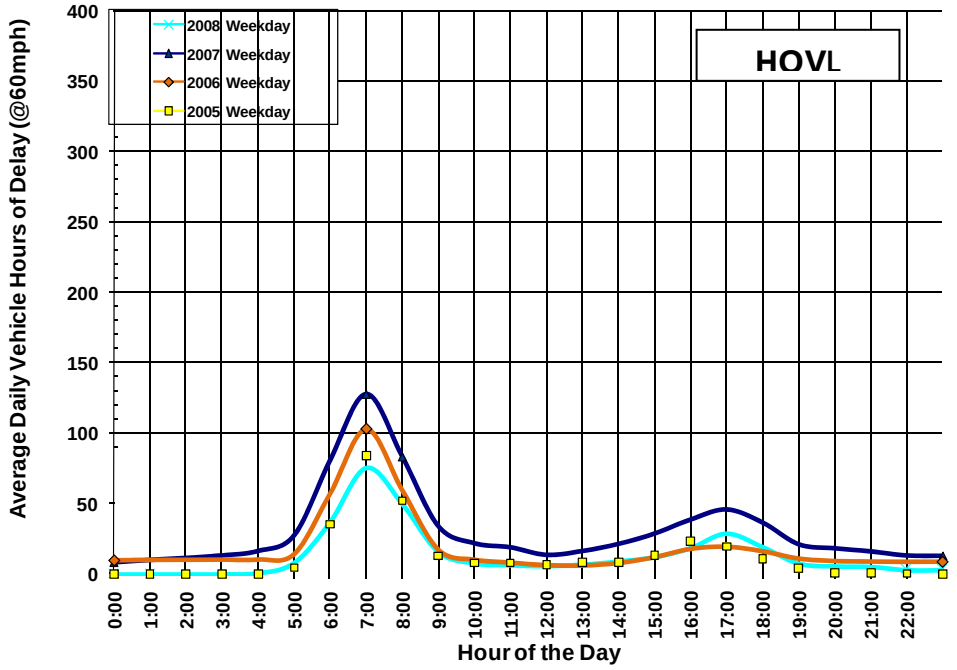
Source: SMG analysis of PeMS data

Exhibit 3-15: Northbound HOVL Average Weekday Hourly Delay (2005-2008)



Source: SMG analysis of PeMS data

Exhibit 3-16: Southbound HOVL Average Weekday Hourly Delay (2005-2008)



Source: SMG analysis of PeMS data

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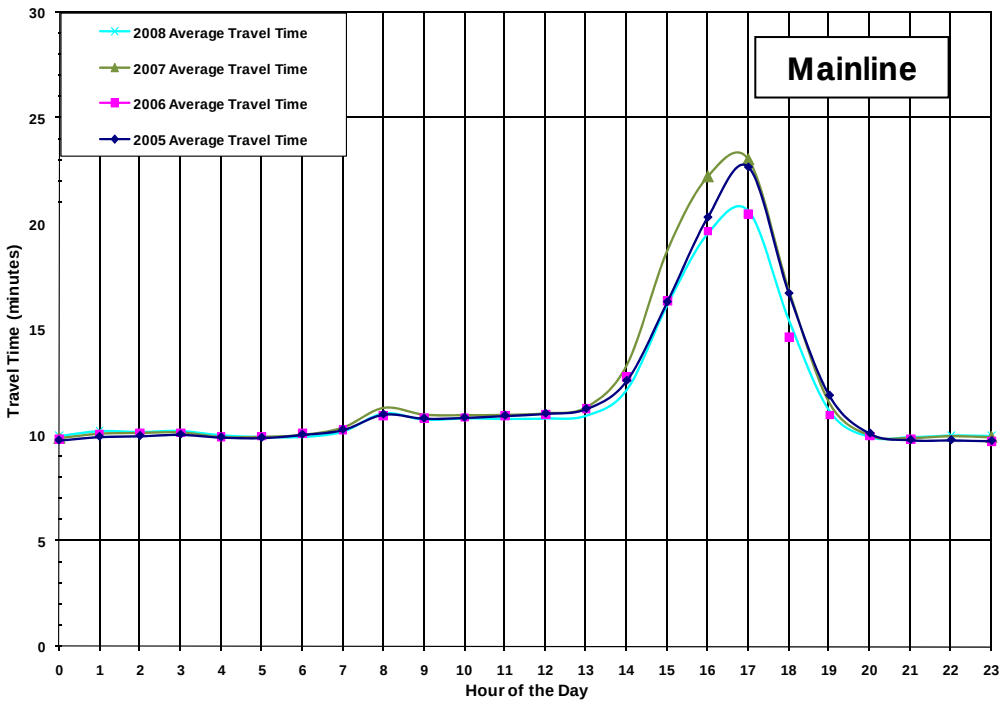
Travel Time

Travel time is the amount of time it takes for a vehicle to traverse between two points on a corridor as estimated using PeMS data. In the case of the SR-57 Corridor, the time it takes to travel 12 miles of the corridor from the Los Angeles County/Orange County line to the I-5/SR-22/SR-57 Interchange, is 12 minutes traveling at 60 mph. Travel time on parallel arterials is not included in the analysis.

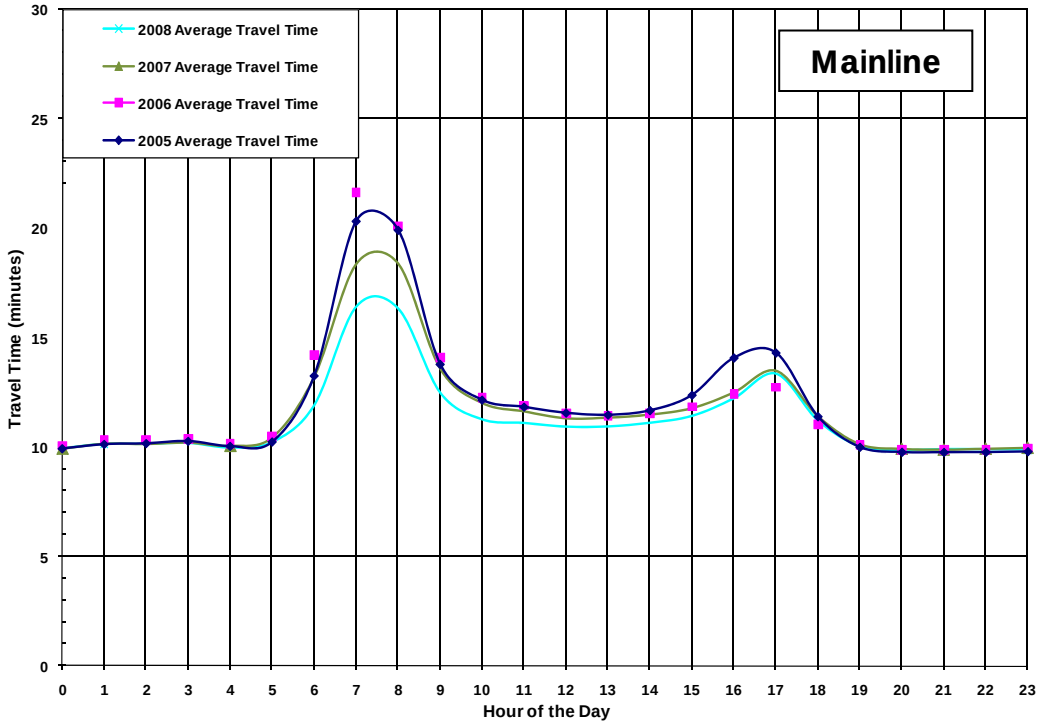
Exhibits 3-17 and 3-20 summarize the travel times estimated for the mainline and HOV facilities. As shown in Exhibits 3-17 and 3-18, travel along the mainline takes about 10 minutes in the off-peak periods. This corresponds to a speed of just over 60 mph. Peak period travel times are roughly double the free-flow travel times. The northbound mainline had an average travel time of approximately 22 minutes during the PM peak hour (4:00-5:00 PM) while the southbound mainline had an average travel time of approximately 19 minutes during the AM peak hour (6:30-7:30 AM). Once again, these statistics indicate the directionality of travel along the corridor – southbound in the morning and northbound in the afternoon.

Exhibit 3-17: Northbound Mainline Travel Time by Time of Day (2005-2008)



Source: SMG analysis of PeMS data

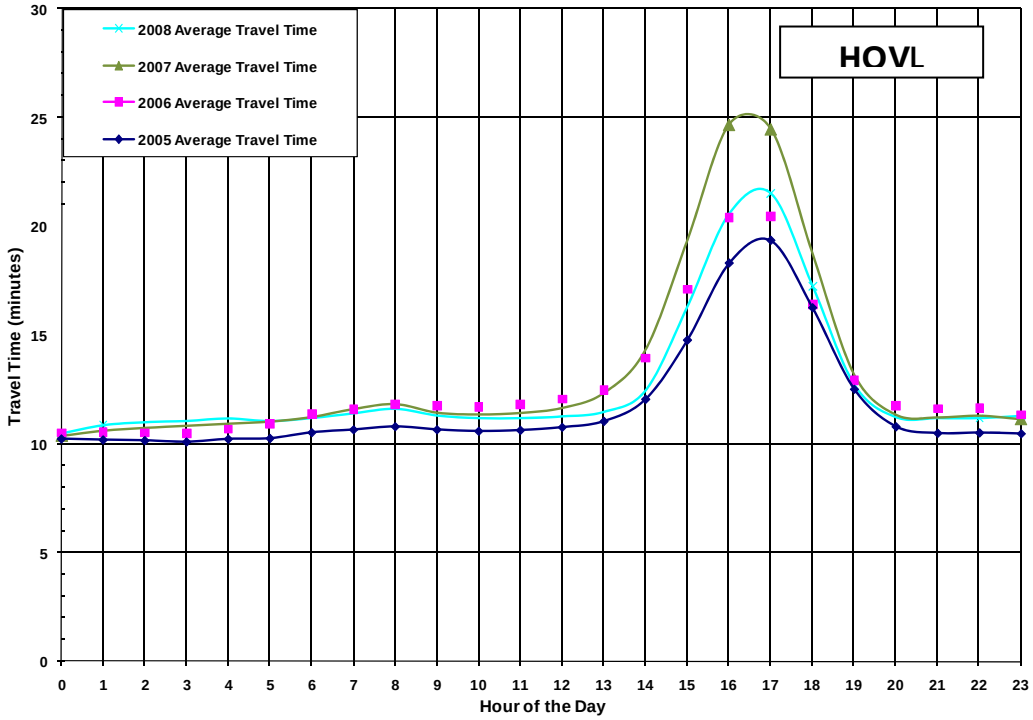
Exhibit 3-18: Southbound Mainline Travel Time by Time of Day (2005-2008)



Source: SMG analysis of PeMS data

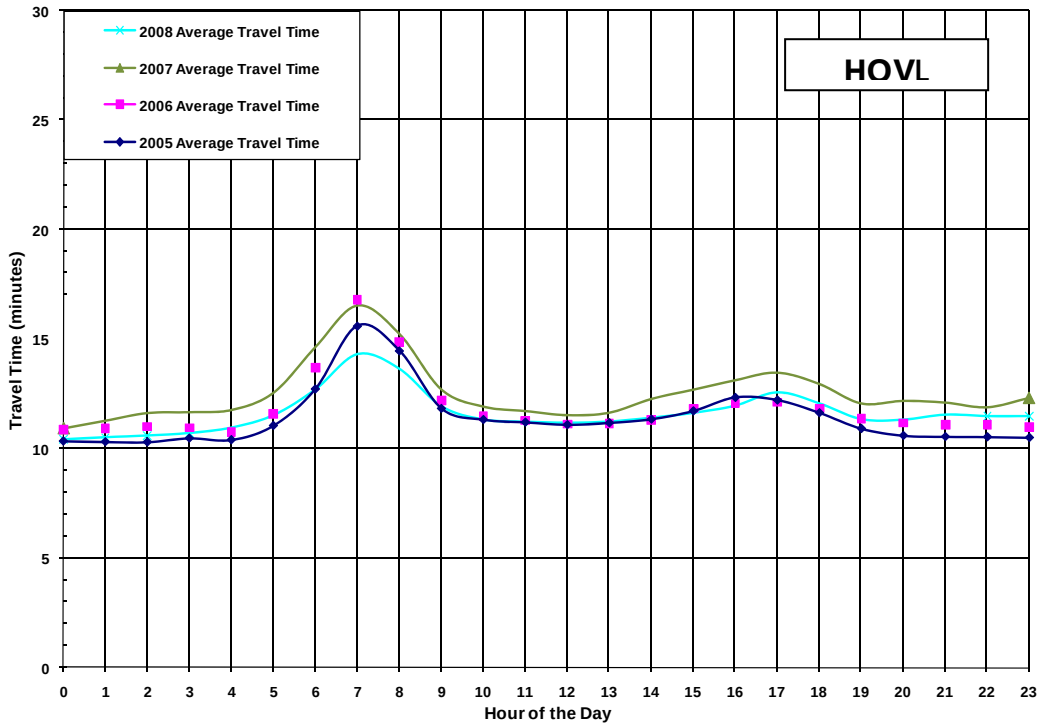
Exhibits 3-19 and 3-20 illustrate travel times on the HOV facility. These exhibits show a similar pattern of travel time compared to the mainline, with greater travel times in the northbound direction compared to the southbound. A notable difference between the mainline and the HOV facilities is that travel time on the HOV facility is less than the mainline in the southbound direction. In 2008, it took about 17 minutes to travel the southbound mainline compared to only 14 minutes on the southbound HOV facility at 7:00 AM.

Exhibit 3-19: Northbound HOVL Travel Time by Time of Day (2005-2008)



Source: SMG analysis of PeMS data

Exhibit 3-20: Southbound HOVL Travel Time by Time of Day (2005-2008)



Source: SMG analysis of PeMS data

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RELIABILITY

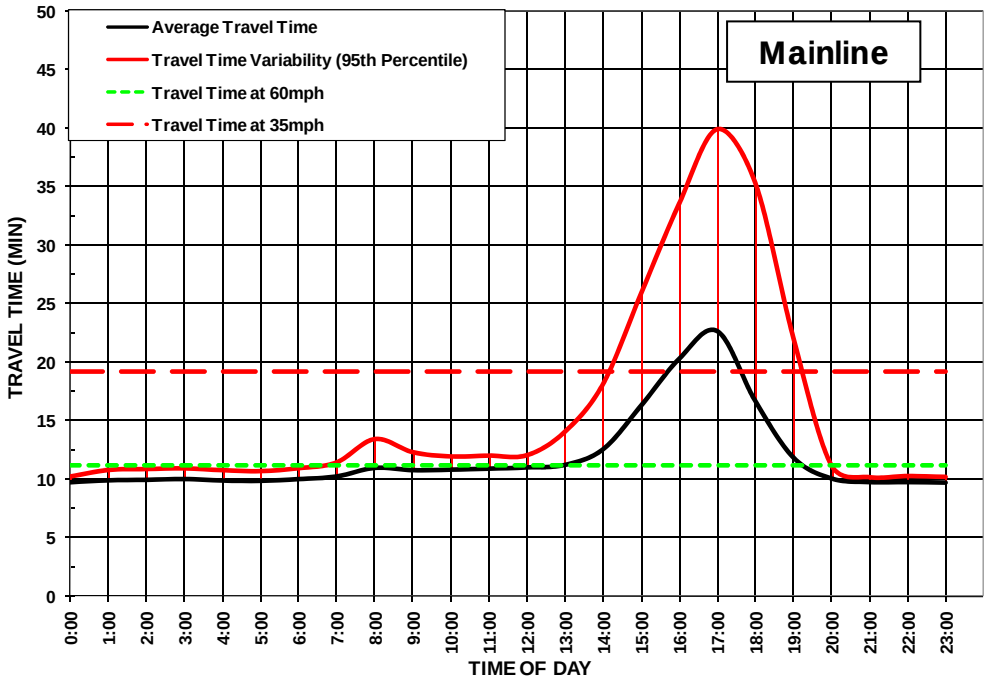
Reliability captures the relative predictability of the public's travel time. Unlike mobility, which measures the rate of travel, the reliability measure focuses on how travel time varies from day to day. To measure reliability, the study team estimated travel time variability using PeMS data. The 95th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

Exhibits 3-21 to 3-36 on the following pages illustrate the variability of travel time along the SR-57 Corridor on weekdays for the years 2005, 2006, 2007, and 2008. Exhibits 3-21 through 3-28 present travel time variability for the mainline in the northbound direction followed by the southbound. Similarly, Exhibits 3-29 through 3-36 show travel time variability for the HOV facility beginning with the northbound and followed by the southbound direction.

For the mainline facility, the 5:00 PM peak hour was the most unpredictable in addition to being the slowest hour in the northbound direction. In 2005 (shown in Exhibit 3-21), motorists driving the entire length of the corridor had to add 17 minutes to an average travel time of 23 minutes (for a total travel time of 40 minutes) to ensure that they arrived on time 95 percent of the time. This is 28 minutes longer than the 12-minute travel time at 60 mph. In 2006 (Exhibit 3-22), the time needed to arrive on time 95 percent of the time decreased to 34 minutes, but hovered at slightly above 35 minutes during the following two years (Exhibits 3-23 and 3-24). The variability in travel time during the northbound PM peak period is greater than the corresponding southbound AM peak period. This is consistent with the greater congestion and delay experienced in the northbound direction.

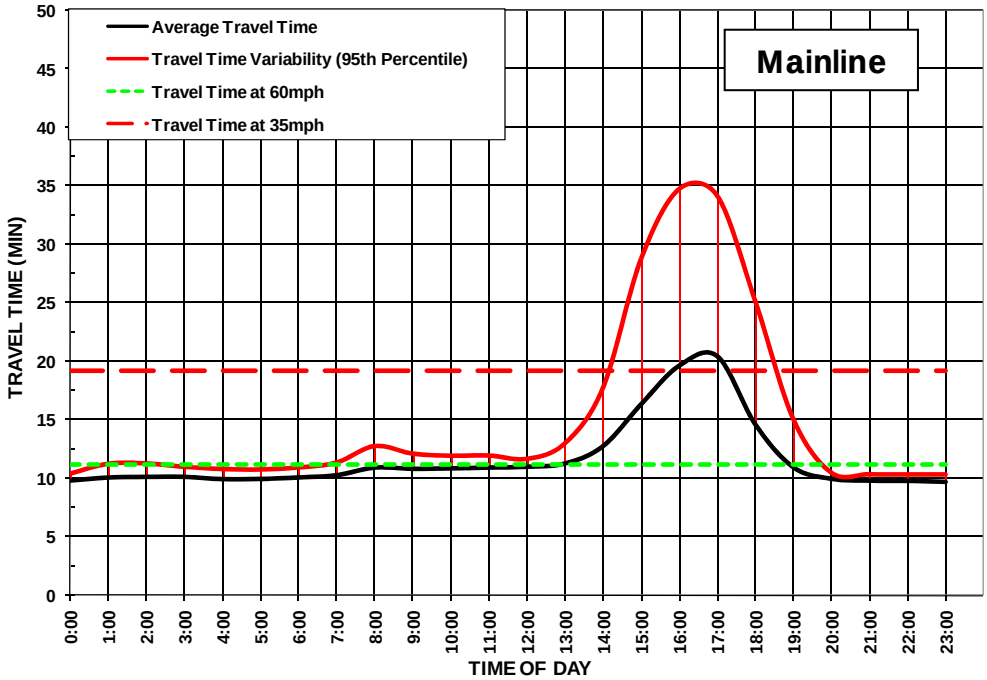
For the northbound HOV during the 5:00 PM peak hour (Exhibit 3-29), a driver needs to add 11 minutes to an average travel time of 23 minutes to ensure an on-time arrival 95 percent of the weekdays in 2005. This corresponds to a total travel time of 34 minutes. In 2006 (Exhibit 3-30), the time needed to arrive on time 95 percent of the time decreased to 32 minutes, but increased to almost 40 minutes in 2007 (Exhibit 3-31), and declined to 38 minutes in 2008 (Exhibit 3-32).

Exhibit 3-21: Northbound Mainline Travel Time Variability (2005)



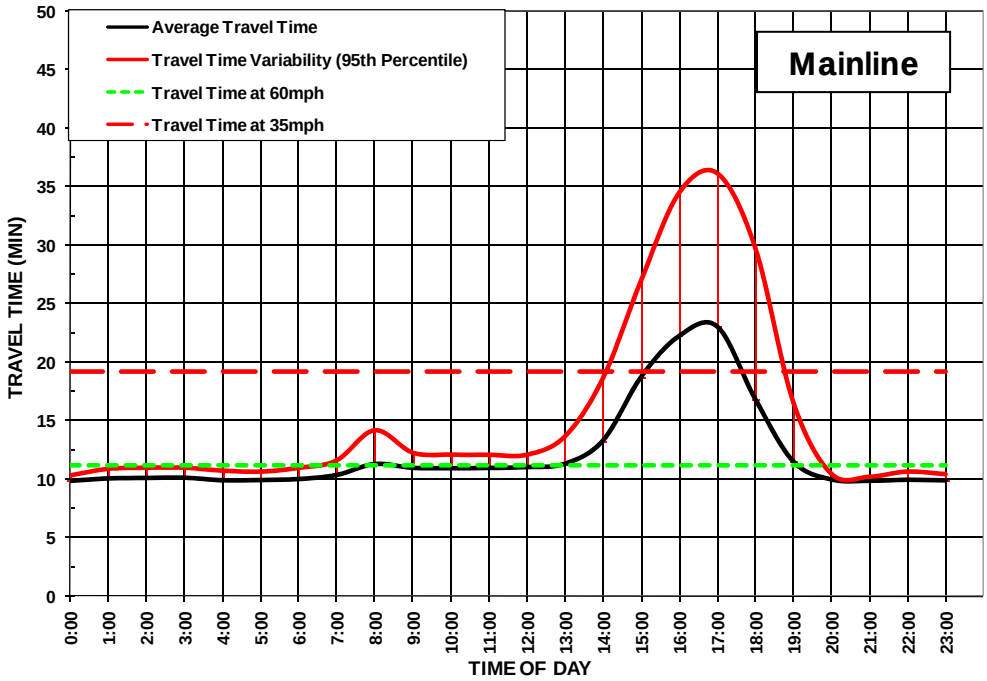
Source: SMG analysis of PeMS data

Exhibit 3-22: Northbound Mainline Travel Time Variability (2006)



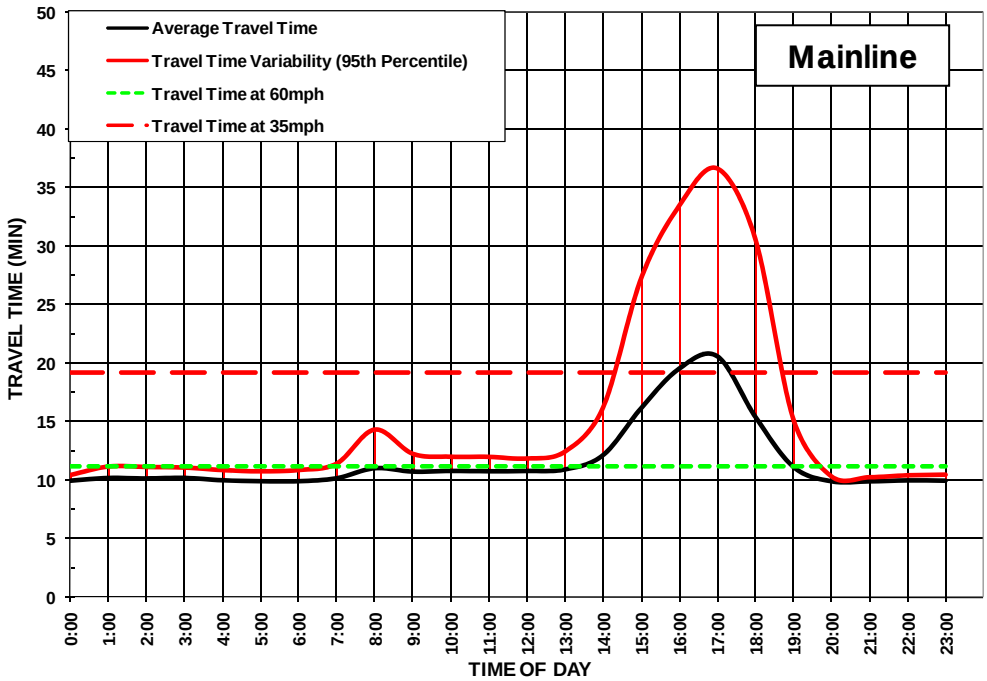
Source: SMG analysis of PeMS data

Exhibit 3-23: Northbound Mainline Travel Time Variability (2007)



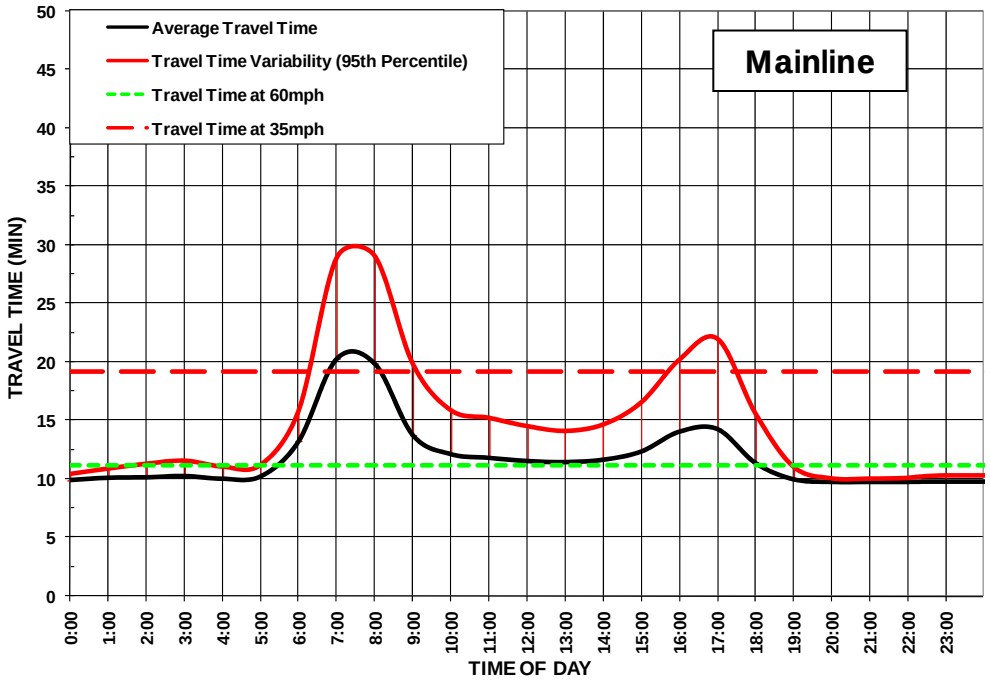
Source: SMG analysis of PeMS data

Exhibit 3-24: Northbound Mainline Travel Time Variability (2008)



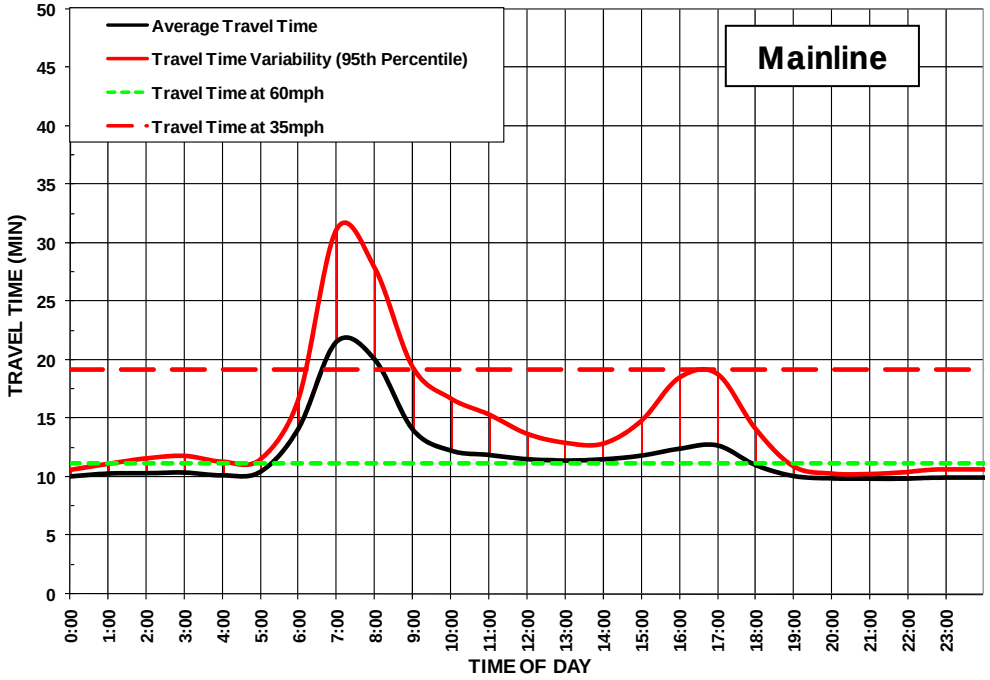
Source: SMG analysis of PeMS data

Exhibit 3-25: Southbound Mainline Travel Time Variability (2005)



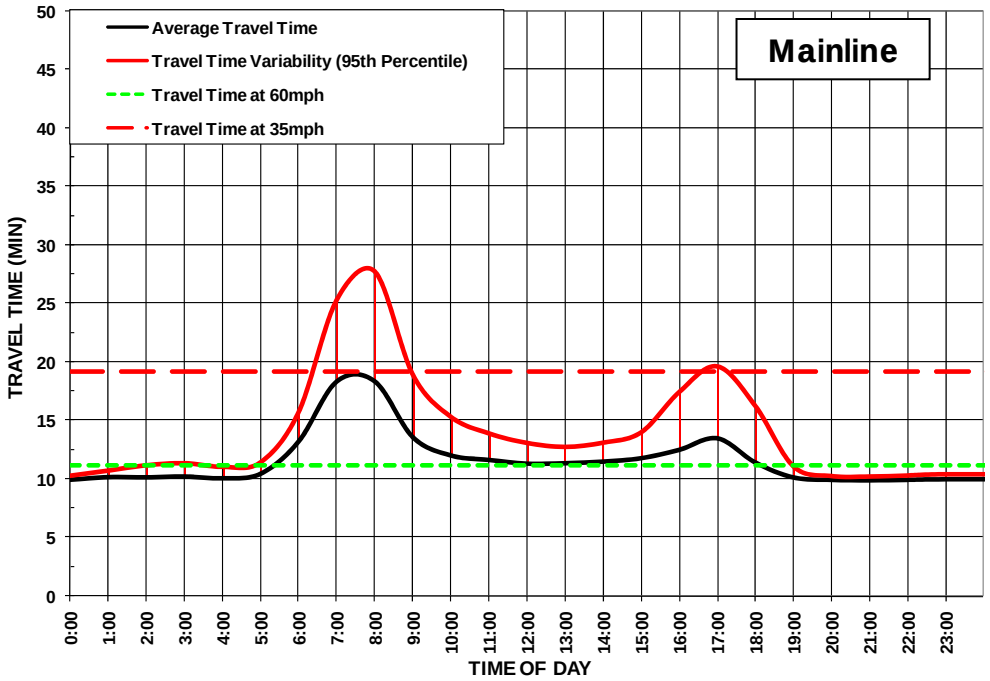
Source: SMG analysis of PeMS data

Exhibit 3-26: Southbound Mainline Travel Time Variability (2006)



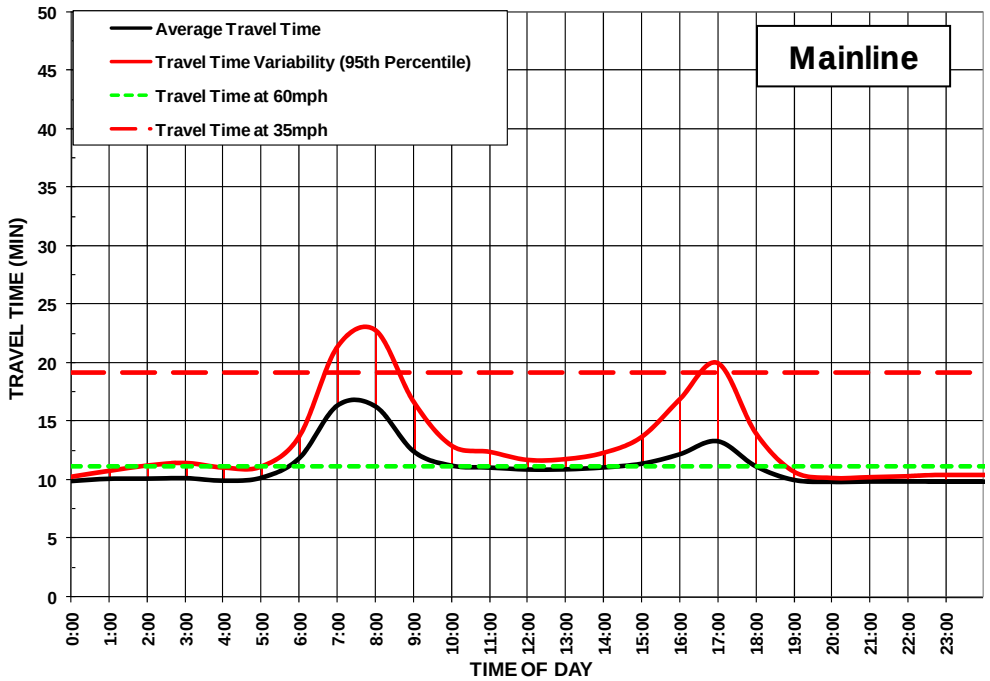
Source: SMG analysis of PeMS data

Exhibit 3-27: Southbound Mainline Travel Time Variability (2007)



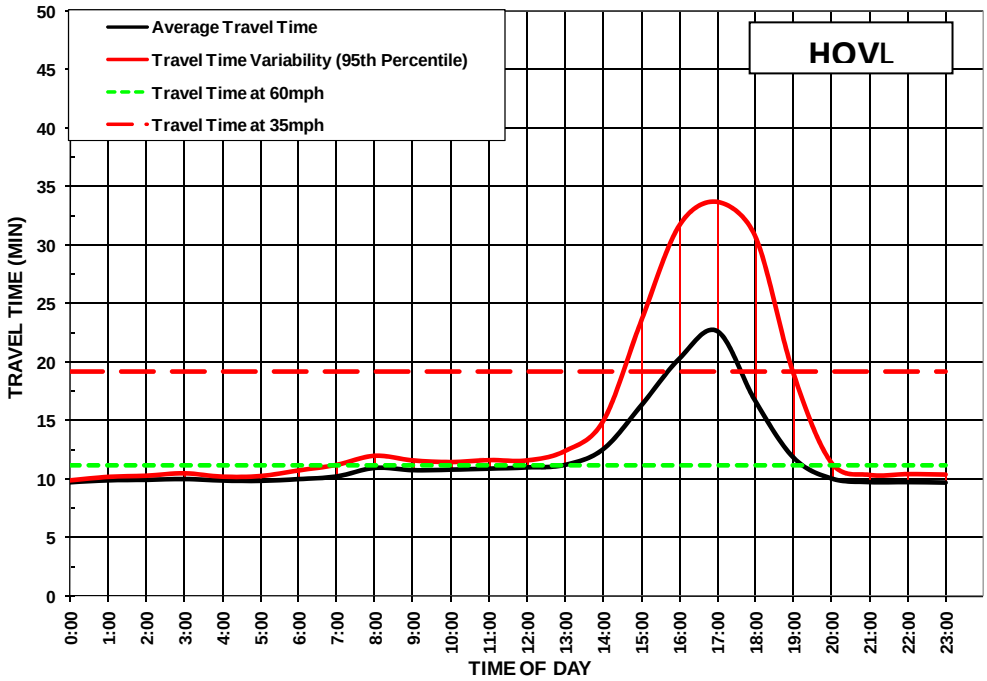
Source: SMG analysis of PeMS data

Exhibit 3-28: Southbound Mainline Travel Time Variability (2008)



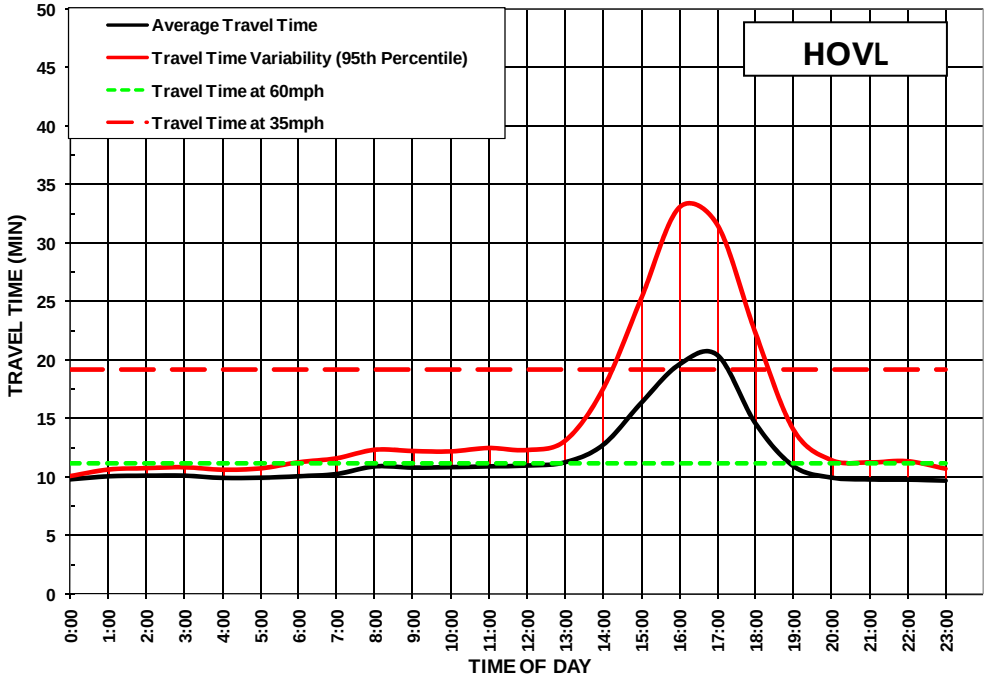
Source: SMG analysis of PeMS data

Exhibit 3-29: Northbound HOVL Travel Time Variability (2005)



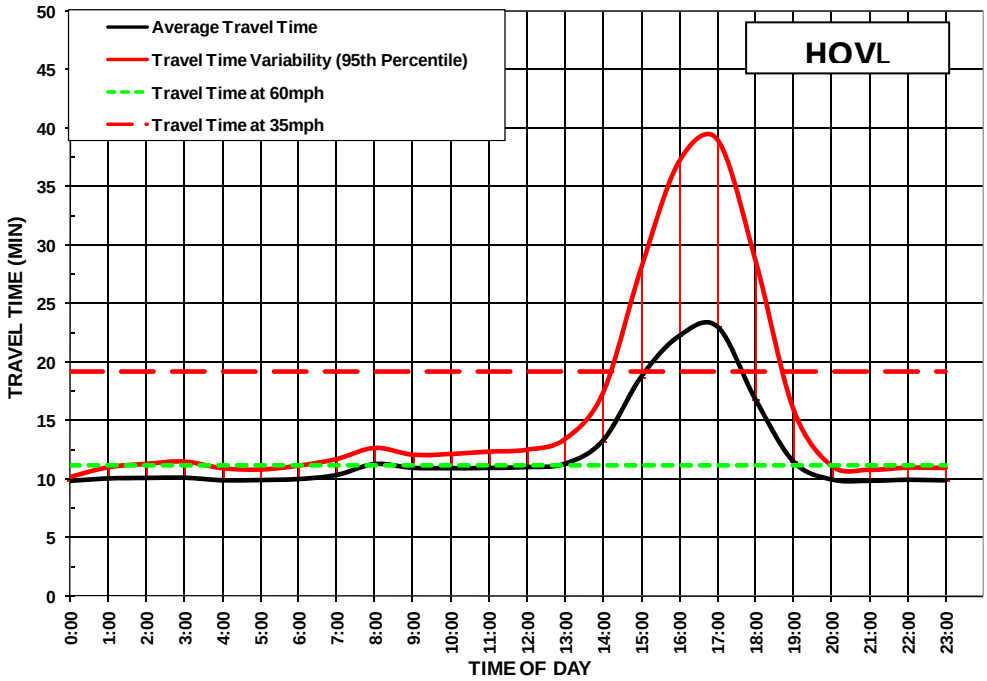
Source: SMG analysis of PeMS data

Exhibit 3-30: Northbound HOVL Travel Time Variability (2006)



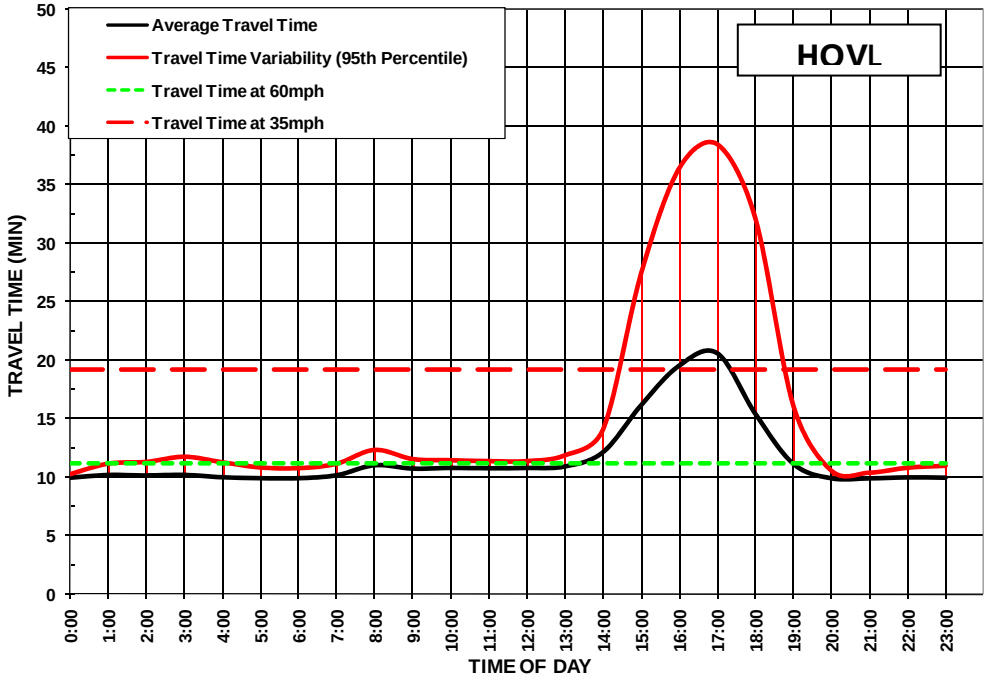
Source: SMG analysis of PeMS data

Exhibit 3-31: Northbound HOVL Travel Time Variability (2007)



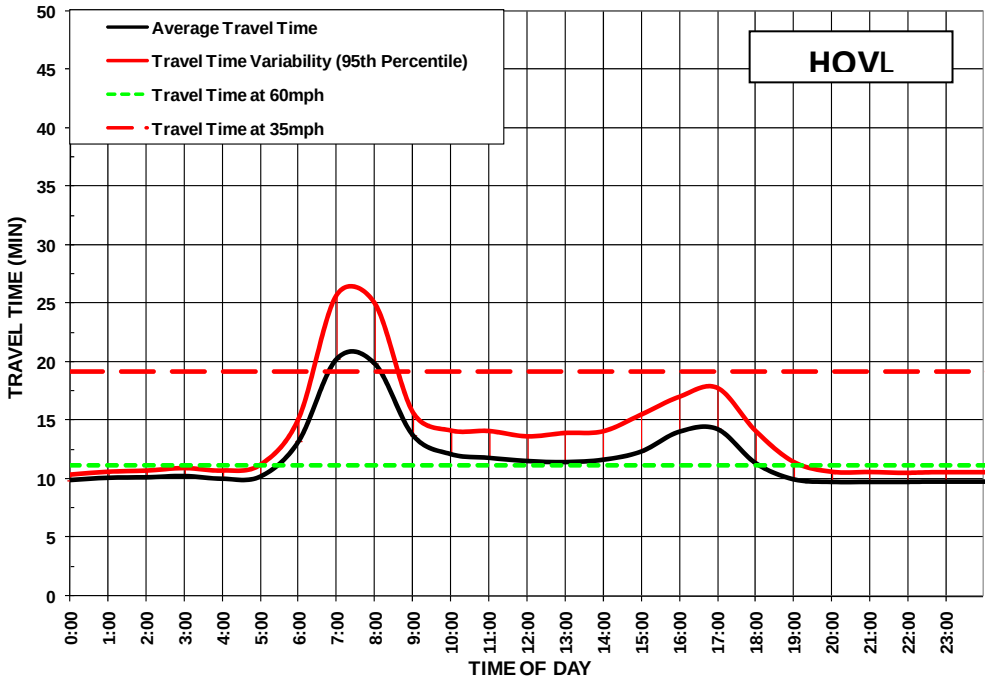
Source: SMG analysis of PeMS data

Exhibit 3-32: Northbound HOVL Travel Time Variability (2008)



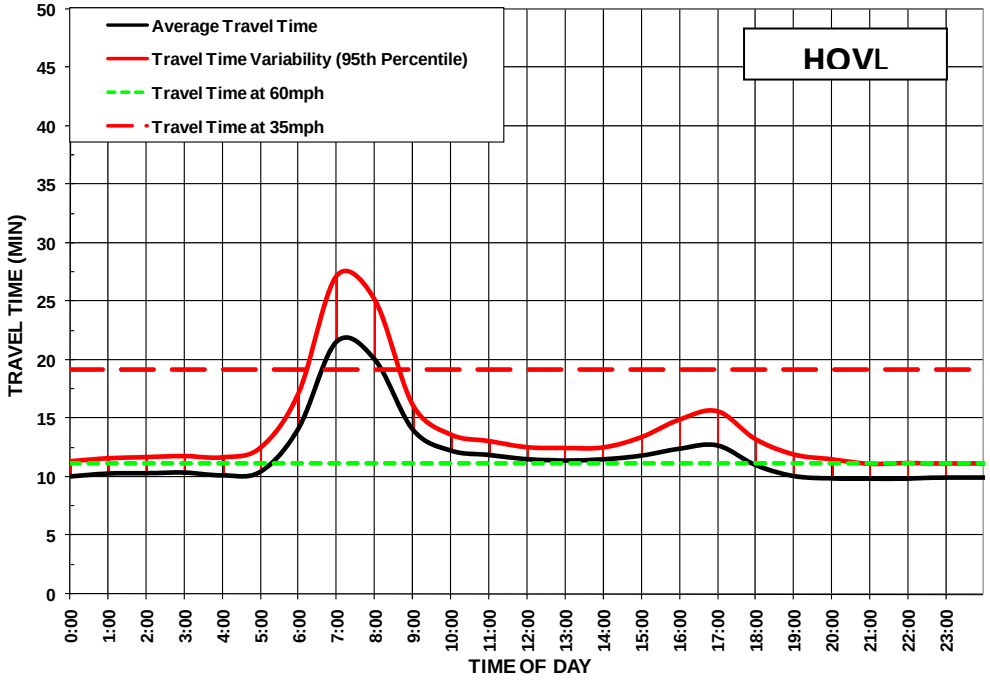
Source: SMG analysis of PeMS data

Exhibit 3-33: Southbound HOVL Travel Time Variability (2005)



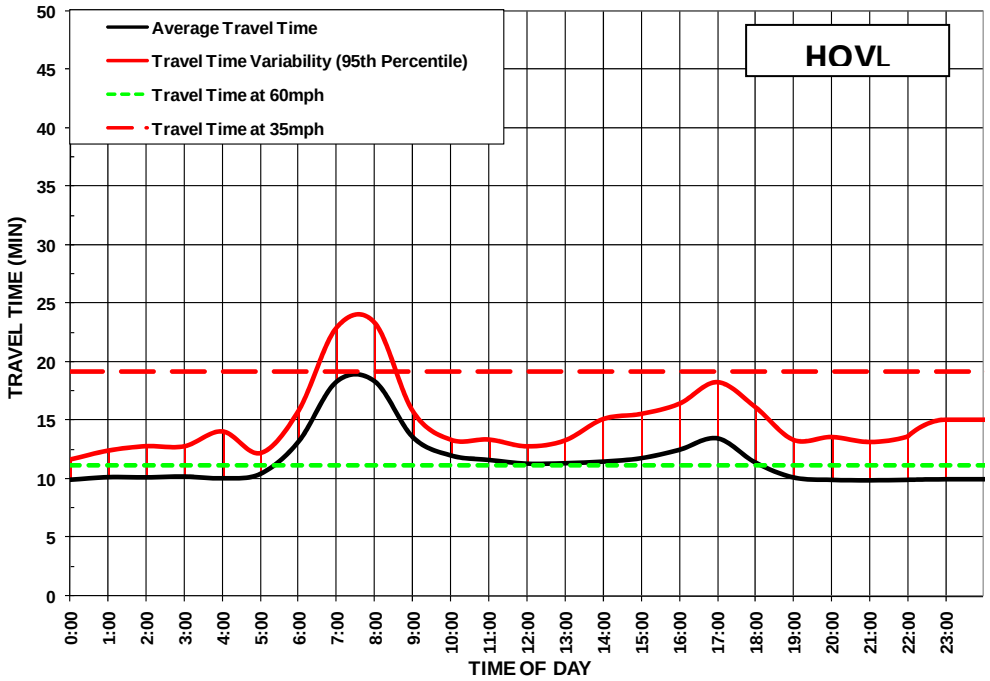
Source: SMG analysis of PeMS data

Exhibit 3-34: Southbound HOVL Travel Time Variability (2006)



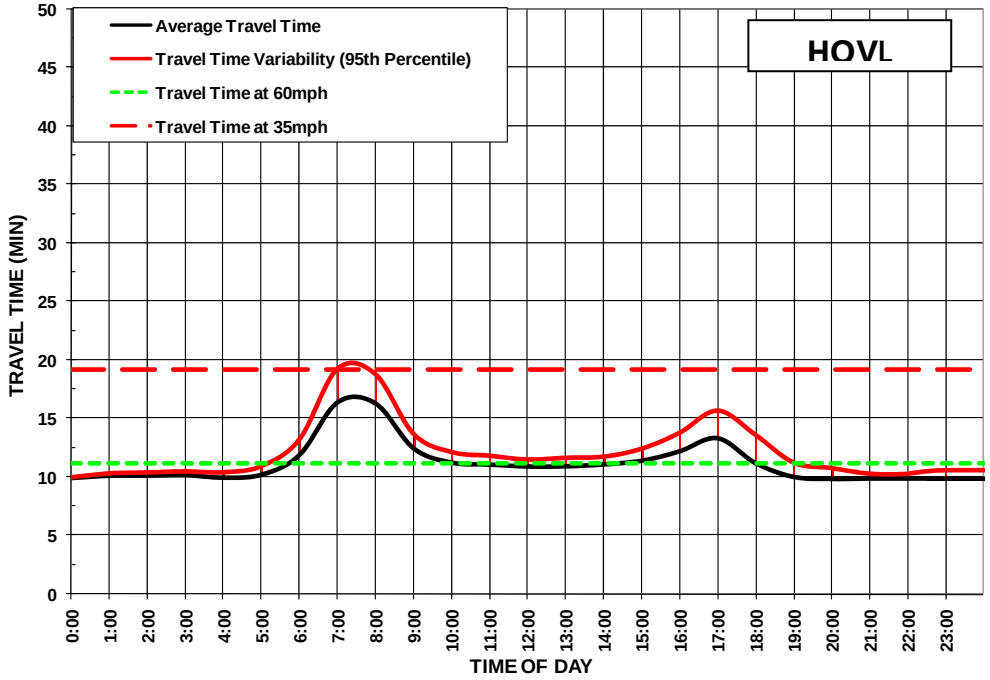
Source: SMG analysis of PeMS data

Exhibit 3-35: Southbound HOVL Travel Time Variability (2007)



Source: SMG analysis of PeMS data

Exhibit 3-36: Southbound HOVL Travel Time Variability (2008)



Source: SMG analysis of PeMS data

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SAFETY

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

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

For the three-year period of 2005-2007, the SR-57 Corridor experienced a total of 960 accidents which includes both fatalities and injuries, according to Caltrans Table B data in Exhibit 3-37. The rate of fatalities and injuries for this Corridor is similar to other State highway facilities with similar operating characteristics. However, the total accident rate for the SR-57 (1.32) is higher than the rate on similar facilities (1.04), which reveals that there were a higher number of non-injury accidents on SR-57.

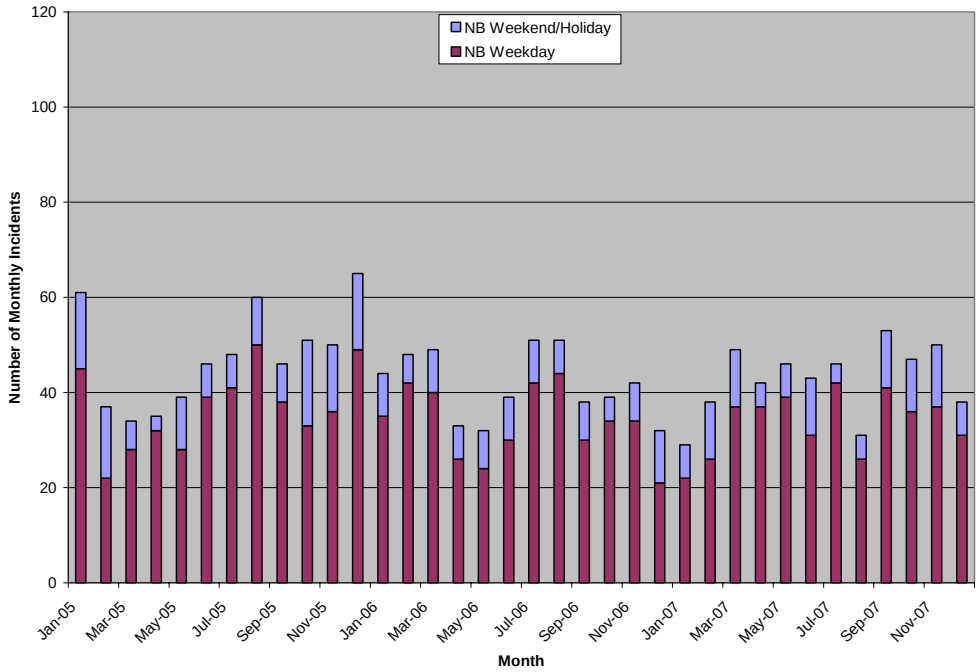
Exhibit 3-37: Total Number of Accidents by Type and Accident Rate (2005-2007)

Number of Accidents on SR-57			Accident Rates					
			Actual Rates on SR-57			Average Rates on Similar Facilities		
Fat	Inj	F+I	Fat	F+I	Total	Fat	F+I	Total
9	951	960	0.003	0.31	1.32	0.005	0.32	1.04

Source: Caltrans Table B

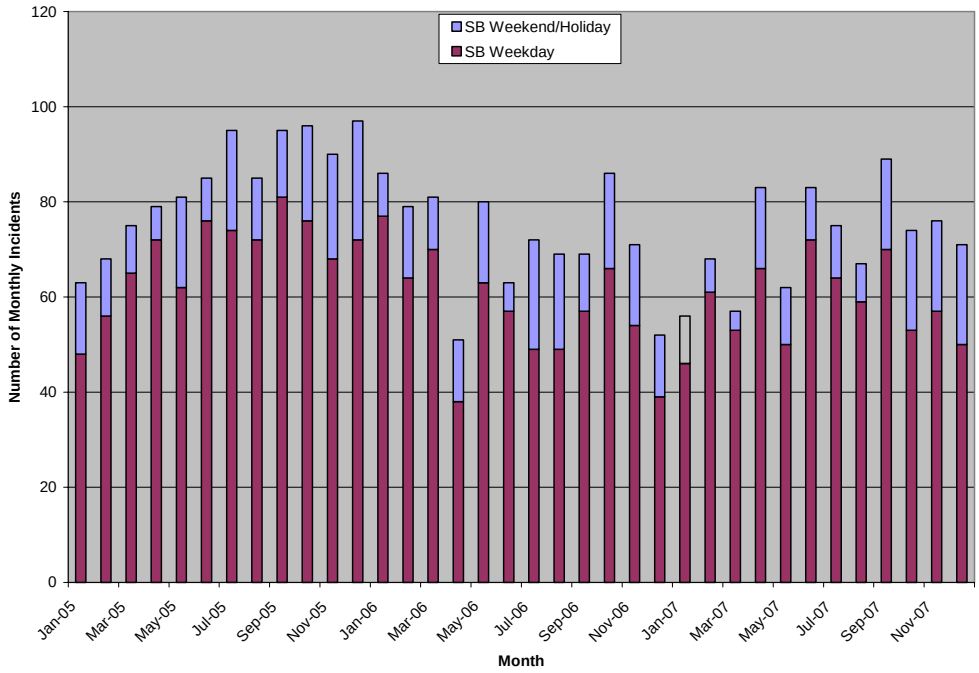
Another way to analyze safety data is to look at when accidents occur. Exhibits 3-38 and 3-39 summarize the total number of weekday and weekend/holiday accidents by month in the northbound and southbound directions respectively during the three year period of 2005-2007. The exhibits show that the month of December 2005 experienced the highest number of accidents in both directions of travel (about 65 in the northbound direction and 95 in the southbound). The exhibits also show that the southbound direction has the highest number of accidents during all three years. Note that the number of accidents are not separated by mainline or HOV facility.

Exhibit 3-38: Total Northbound SR-57 Accidents by Month (2005-2007)



Source: Caltrans TASAS via PeMS

Exhibit 3-39: Total Southbound SR-57 Accidents by Month (2005-2007)



Source: Caltrans TASAS via PeMS

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PRODUCTIVITY

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

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

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

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

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

Exhibit 3-40: Lost Productivity Illustrated

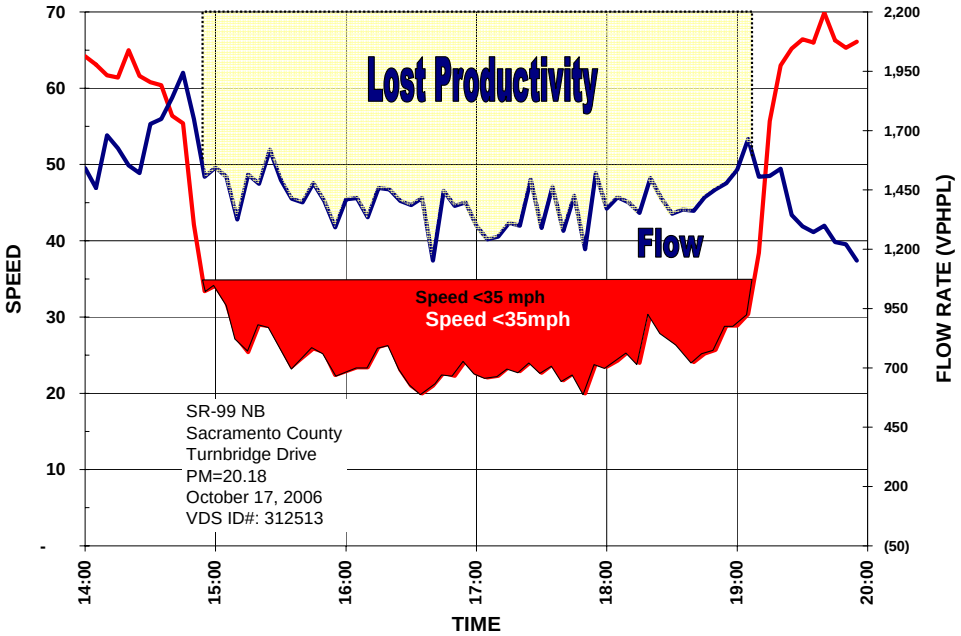
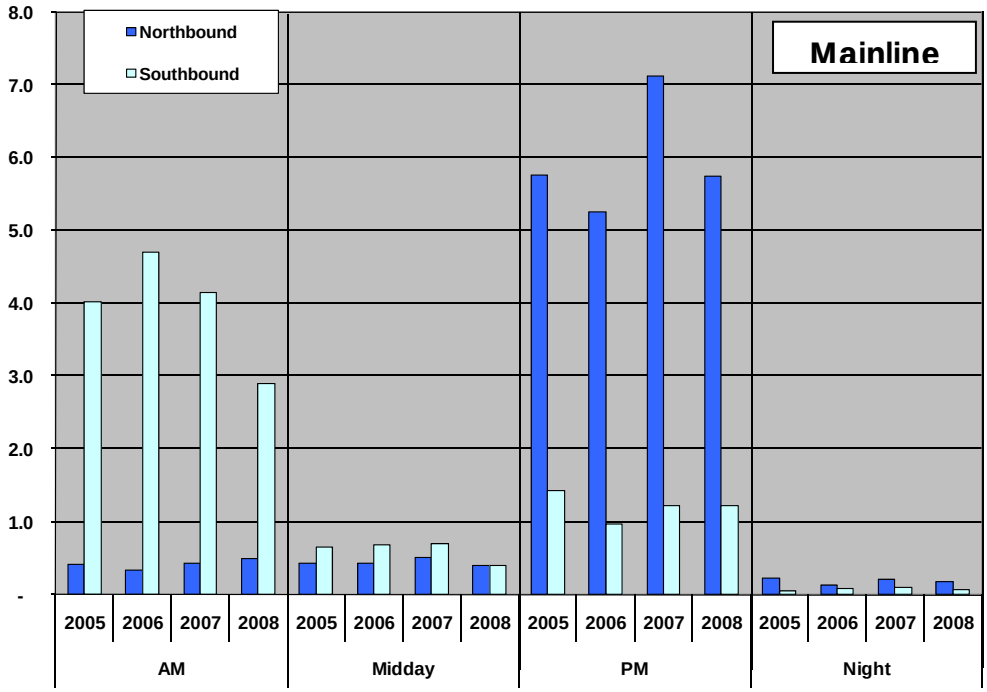


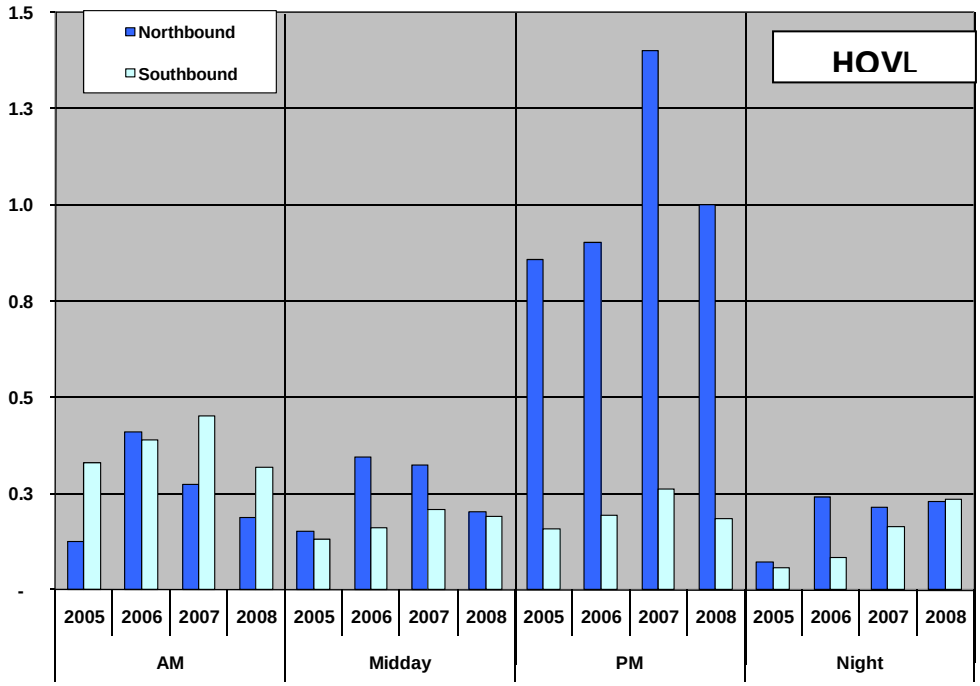
Exhibit 3-41 and 3-42 summarize the productivity losses on the SR-57 mainline and HOV facilities during the 2005-2008 period. The trends in the productivity losses are comparable to the delay trends. The largest productivity losses occurred in the PM peak hours in the northbound direction, which is the time period and direction that experienced the most congestion. These exhibits clearly show that the northbound direction in both the mainline and HOV facilities were less productive than the southbound direction, as evident by the taller blue-colored bars. Additionally, these exhibits illustrate productivity gains from 2007 to 2008 in both the mainline and HOV facilities, as shown by the decreases in lost lane-miles from 2007 to 2008 in almost every time period.

Exhibit 3-41: Average Lost Lane Miles by Direction, Time Period, and Year (Mainline)



Source: SMG analysis of PeMS data

Exhibit 3-42: Average Lost Lane Miles by Direction, Time Period, and Year (HOVL)



Source: SMG analysis of PeMS data

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PAVEMENT CONDITION

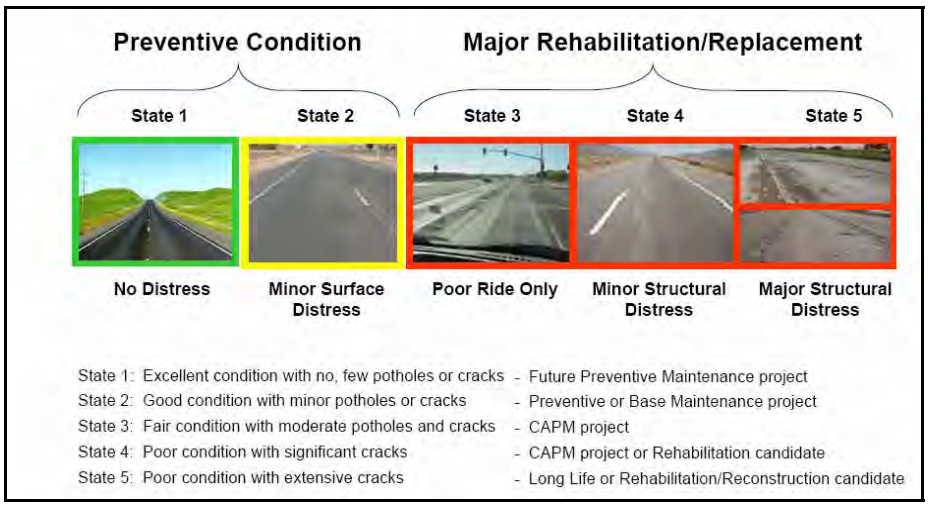
The condition of the roadway pavement (or ride quality) on the corridor can influence its traffic performance. Rough or poor pavement conditions can decrease the mobility, reliability, safety, and productivity of the corridor, whereas smooth pavement can have the opposite effect. Pavement preservation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

Pavement Performance Measures

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

Using distressed lane miles allows us to distinguish among pavement segments that require only preventive maintenance at relatively low costs and segments that require major rehabilitation or replacement at significantly higher costs. All segments that require major rehabilitation or replacement are considered to be distressed. Segments with poor ride quality are also considered to be distressed. Exhibit 3-43 provides an illustration of this distinction. The first two pavement conditions are considered roadway that provides adequate ride quality and is structurally adequate. The remaining three conditions are included in the calculation of distressed lane-miles.

Exhibit 3-43: Pavement Condition States



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

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

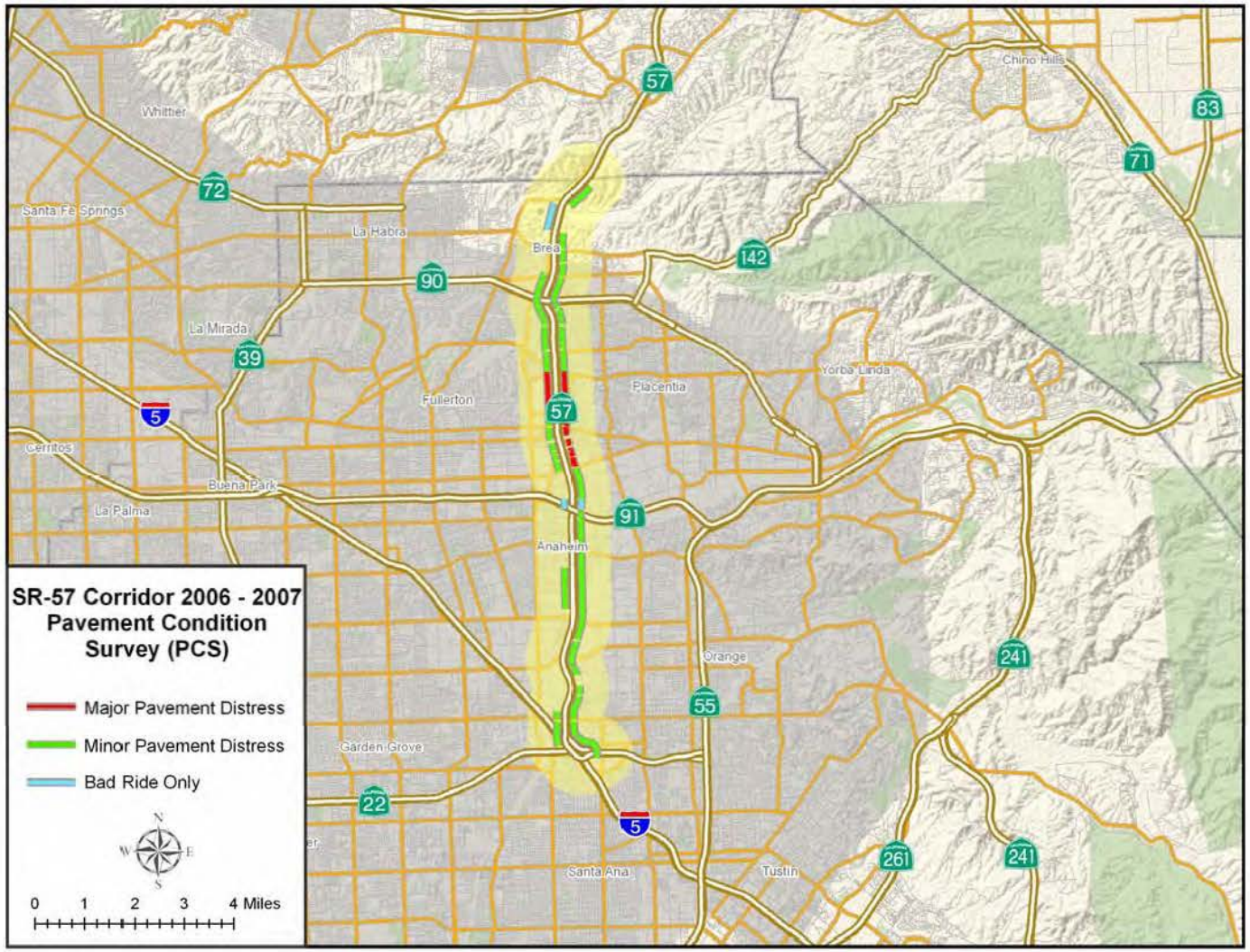
Existing Pavement Conditions

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

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

Exhibit 3-44 shows pavement distress along the SR-57 Corridor according to the 2007 PCS data. The three categories shown in this exhibit represent the three distressed conditions that require major rehabilitation or replacement and were presented earlier in Exhibit 3-43.

Exhibit 3-44: Distressed Lane-Miles on SR-57 Corridor (2006-2007)



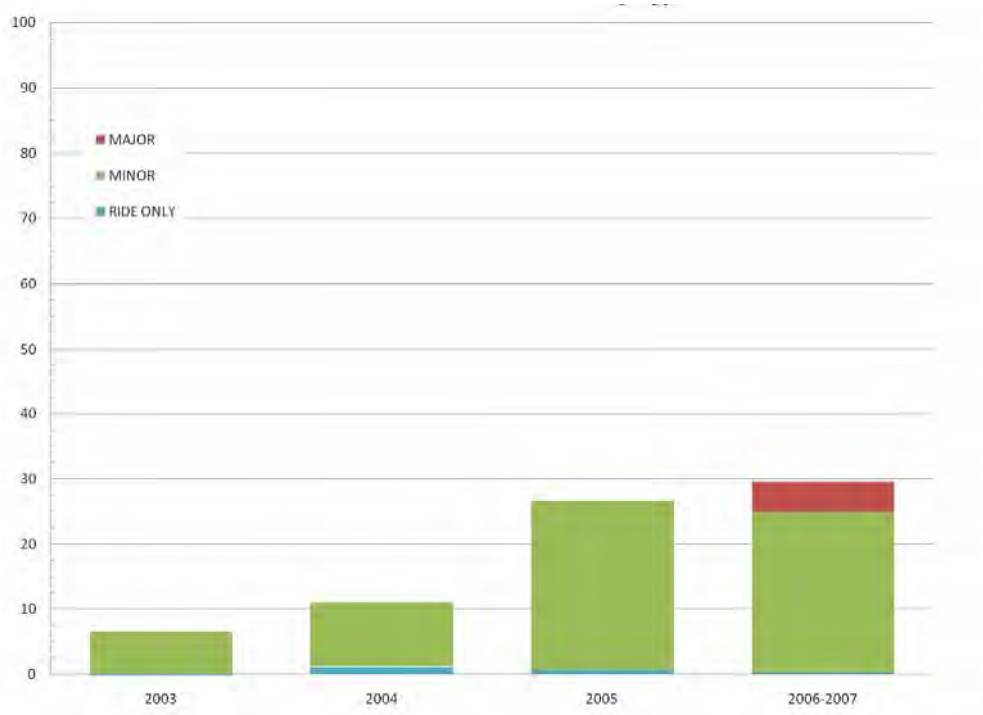
Source: SMG mapping of 2007 Pavement Condition Survey data

The SR-57 Corridor shows pavement distress equal to that of an average freeway in the northern, more urbanized part of Orange County. Much of the corridor has at least one lane exhibiting minor pavement distress. There is also a one to two mile section with major pavement distress in the middle of the corridor near Placentia and Fullerton. The rest of the corridor, mostly near Anaheim, exhibits no pavement distress or only ride quality issues.

Exhibit 3-45 compares results from prior pavement condition surveys along the SR-57 Corridor. The number of distressed lane-miles has increased since 2003. Most of the growth is due to an increase in minor pavement distress, although about four lane-miles of major pavement distress appeared in the 2007 PCS.

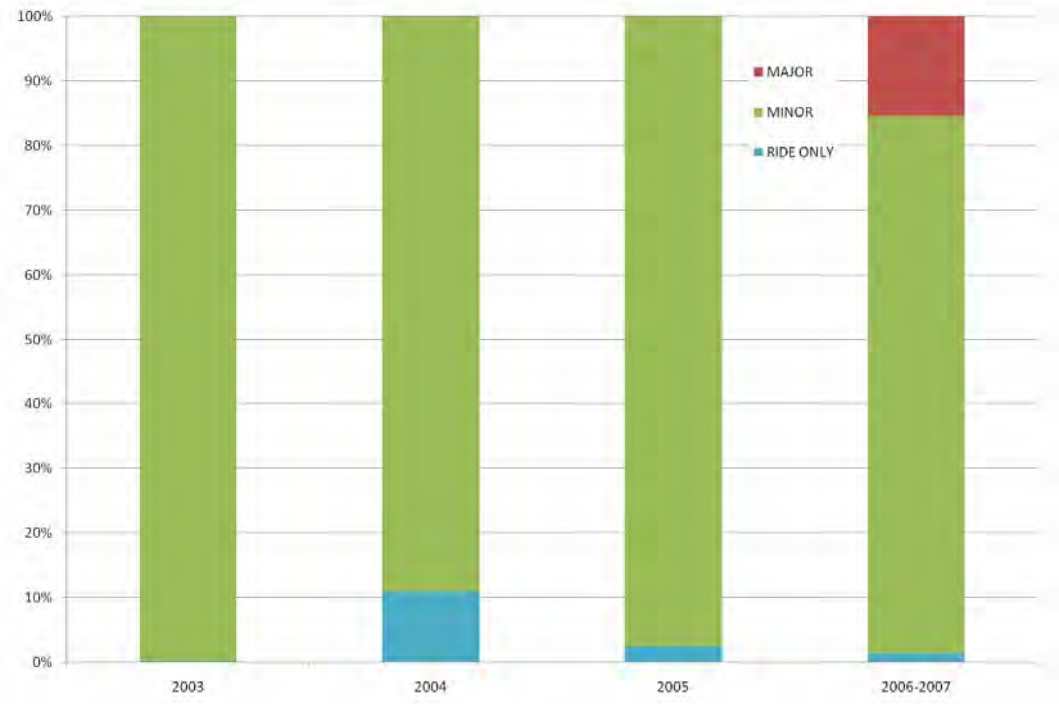
The change in the percent mix of distressed lane-miles is shown more clearly in Exhibit 3-46. As seen in the exhibit, minor distress represents over 80 percent of the pavement issues along the SR-57 Corridor. Some major distress appeared in the last PCS and it accounts for about 15 percent of the distressed lane-miles. Ride only issues have tended to be less than five percent of the distressed lane-miles and have been fully addressed in recent years.

Exhibit 3-45: SR-57 Distressed Lane-Miles Trends



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

Exhibit 3-46: SR-57 Distressed Lane-Miles by Type



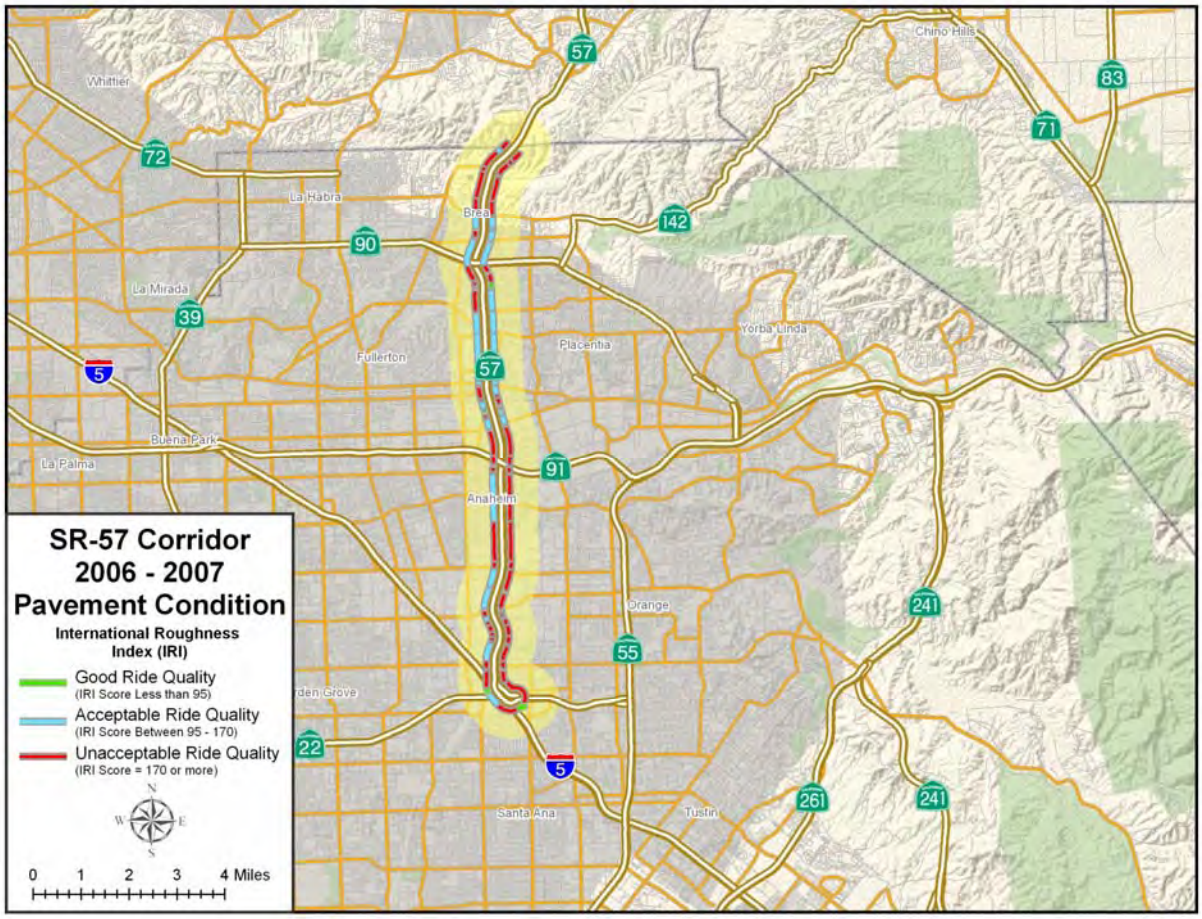
Source: SMG analysis of 2003 to 2007 Pavement Condition Survey data

Exhibit 3-47 shows IRI along the study corridor for the lane in each freeway segment with the poorest pavement condition. Pavement investment decisions are made on this basis. As the exhibit shows, the entire corridor has ride quality issues (IRI greater than 170). Not all of these sections appear in Exhibit 3-47 due to algorithms and thresholds in the PSR.

The study corridor comprises roughly 116 lane-miles, when the conditions of all lanes are considered. Of these lanes:

- 31 lane-miles, or 27 percent, are considered to have good ride quality (IRI ≤ 95)
- 61 lane-miles, or 52 percent, are considered to have acceptable ride quality (95 < IRI ≤ 170)
- 25 lane miles, or 21 percent, are considered to have unacceptable ride quality (IRI > 170)

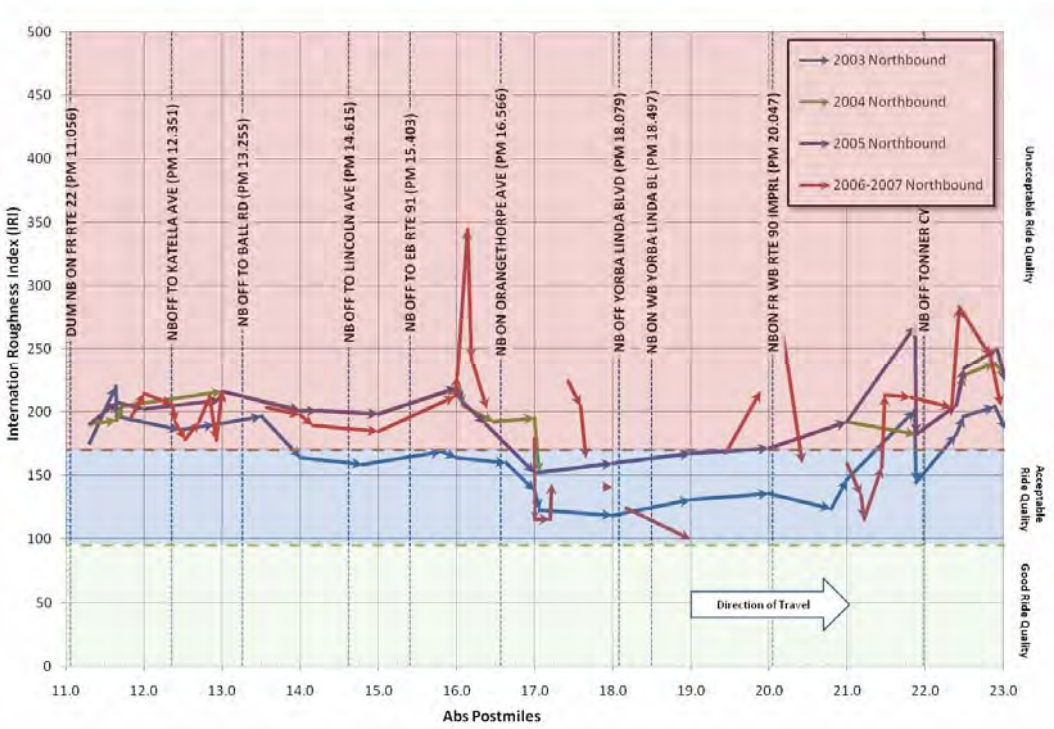
Exhibit 3-47: SR-57 Road Roughness (2006-2007)



Source: SMG mapping of 2007 Pavement Condition Survey data

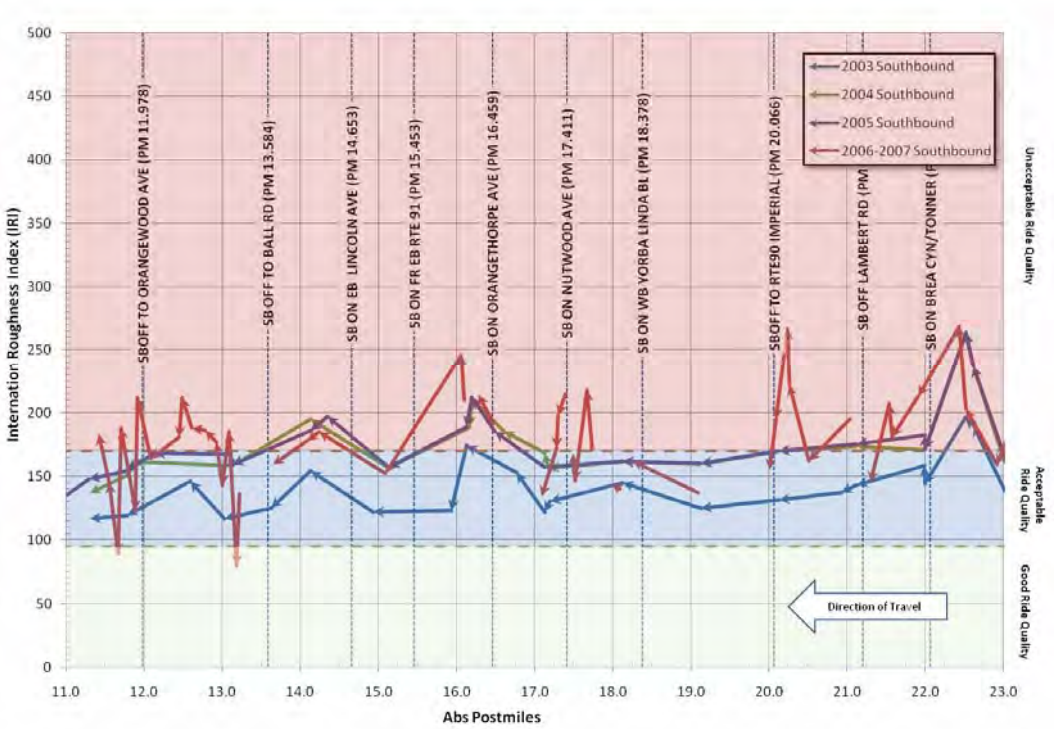
Exhibits 3-48 and 3-49 present ride conditions for the SR-57 Corridor using IRI from the last four pavement surveys. The information is presented by postmile and direction. The exhibits include color-coded bands to indicate the three ride quality categories defined by Caltrans: good ride quality (green), acceptable ride quality (blue), and unacceptable ride quality (red). The surveys show consistent patterns of good, acceptable, and unacceptable ride quality. Unlike many freeways in the state, SR-57 has had fairly steady ride quality over the last few surveys. The exhibits exclude a number of sections that were not measured or had calibration issues (i.e., IRI = 0) in the 2006-07 period.

Exhibit 3-48: Northbound SR-57 Road Roughness (2003-2007)



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

Exhibit 3-49: Southbound SR-57 Road Roughness (2003-2007)



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

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4. BOTTLENECK IDENTIFICATION AND ANALYSIS

Potential bottlenecks were identified in the Preliminary Performance Assessment document in August 2008. They were identified based on a variety of data sources, including HICOMP, probe vehicle runs, and PeMS. Significant field visits were also conducted in November and December 2008 to confirm these bottleneck locations. As a result of the field work and additional data analysis, the reoccurring bottlenecks were identified for both directions. The initial analysis from the Preliminary Performance Assessment is found in the Appendix.

Northbound Bottlenecks

Starting from the I-5/SR-22/SR-57 Interchange and moving northbound, the following bottlenecks were identified:

Northbound Mainline

- Orangethorpe on-ramp: this bottleneck extends all the way to south of the SR-91 Interchange.
- Imperial Highway on-ramp: this bottleneck extends past the Imperial Highway off-ramp.
- Lambert on-ramp: this bottleneck extends to Imperial Highway.

Southbound Bottlenecks

Starting from the Orange/Los Angeles County Line and moving southbound, the following bottlenecks were identified:

Southbound Mainline

- Imperial Highway on-ramp: this bottleneck can extend to the Lambert Road on-ramp.
- Chapman Avenue (City of Fullerton) on-ramp: this bottleneck can extend back to Yorba Linda Boulevard due to the dual merge with the Nutwood Avenue on-ramp.
- Ball Road on-ramp: this is a smaller bottleneck that can extend to Lincoln Avenue.

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 bottleneck areas, the performance statistics previously presented for the entire corridor can then be broken down by bottleneck area. This way, the relative contribution of each bottleneck area to

the degradation of the corridor performance can be gauged. The performance statistics that lend themselves to such segmentation include:

- Mobility
- Safety
- Productivity

The analysis of bottleneck areas is based on 2007 data (when available) and limited to the mainline facility due to the limited detection available on the HOV facility. 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 SR-57. The red lines in the exhibit represent the bottleneck locations and the arrows represent the bottleneck areas.

Exhibit 4-1: Dividing the SR-57 Corridor into Bottleneck Areas (Northbound)

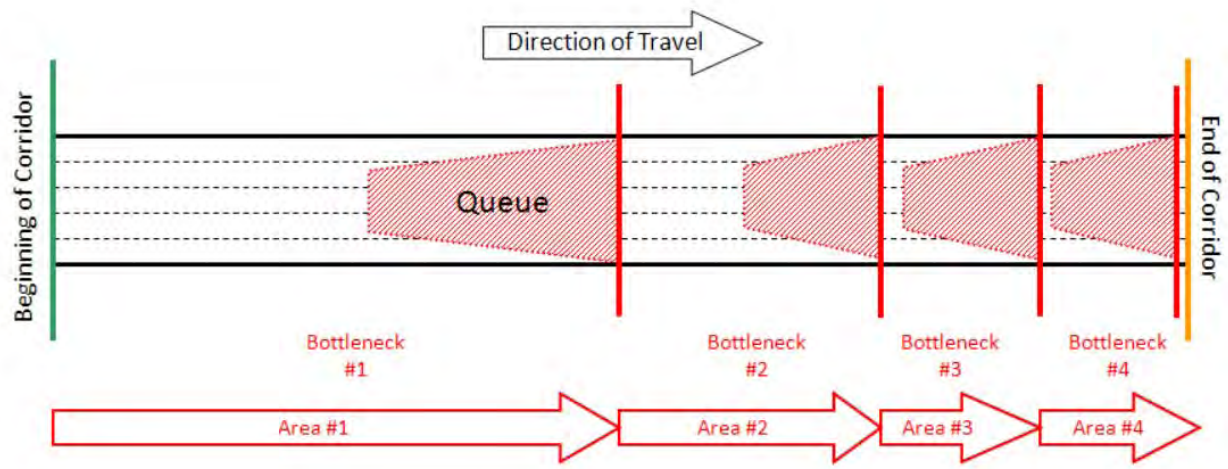
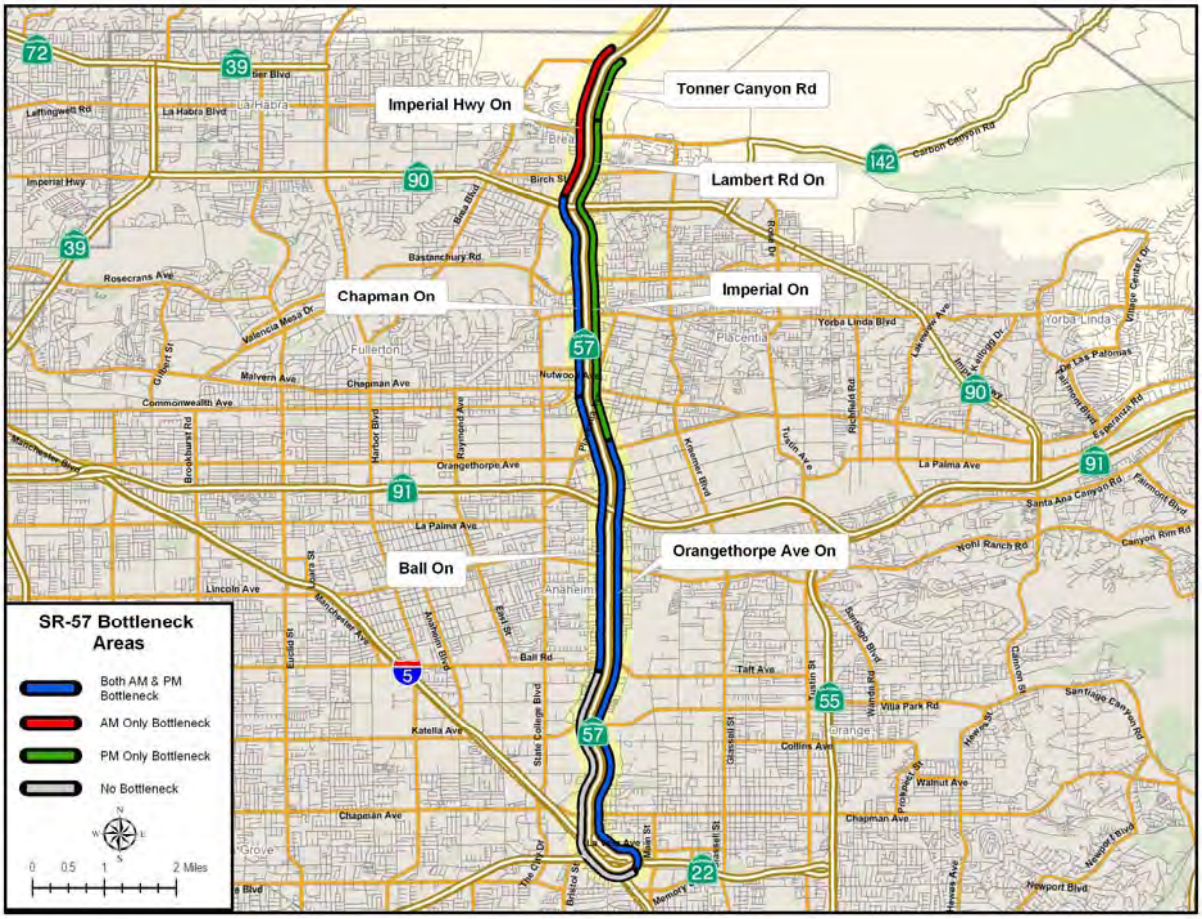


Exhibit 4-2 graphically illustrates the location of each of the bottleneck locations and areas for the SR-57 Corridor. Exhibits 4-3 and 4-4 further summarize each of the bottleneck locations and associated bottleneck areas.

Exhibit 4-2: Map of Bottleneck Locations and Bottleneck Areas



Dividing the corridor into bottleneck areas makes it easier to compare the various segments of the freeway with each other. This section will use the previously discussed performance measures of mobility, safety, 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.

Exhibit 4-3: Northbound SR-57 Identified Bottleneck Areas

Bottleneck Location	Bottleneck Area	Active Period		From		To		Distance (miles)
		AM	PM	Abs	CA	Abs	CA	
Orangethorpe Ave On	I-5/SR-22/SR-57 IC to Orangethorpe Ave On	✓	✓	0.12	10.70	5.83	16.50	5.7
Imperial Hwy On	Orangethorpe Ave On to Imperial Hwy On		✓	5.83	16.56	9.13	19.80	3.3
Lambert Rd On	Imperial Hwy On to Lambert Rd On		✓	9.13	19.80	10.43	21.10	1.3
Tonner Canyon Rd	Lambert Rd On to Tonner Canyon Rd		✓	10.43	21.10	11.35	22.06	0.9

Exhibit 4-4: Southbound SR-57 Identified Bottleneck Areas

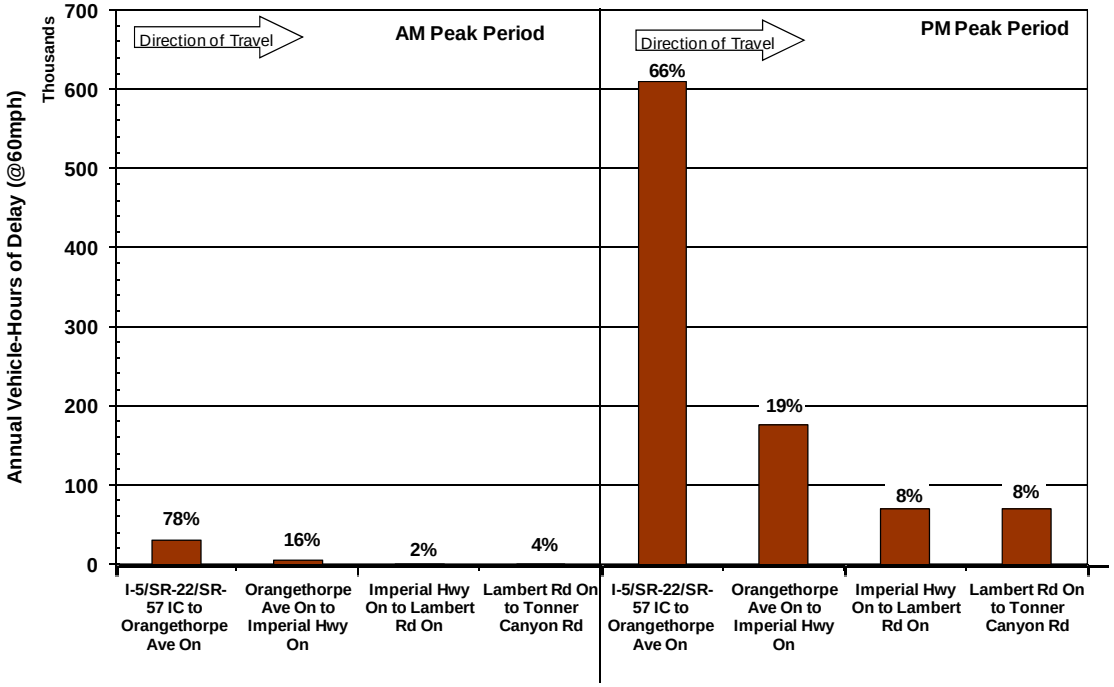
Bottleneck Location	Bottleneck Area	Active Period		From		To		Distance (miles)
		AM	PM	Abs	CA	Abs	CA	
Imperial Hwy On	South of Tonner Canyon Rd to Imperial Hwy On	✓		11.35	22.06	9.19	19.95	2.2
Chapman On	Imperial Hwy On to Chapman On	✓	✓	9.19	19.95	6.64	17.18	2.6
Ball On	Chapman On to Ball On	✓	✓	6.64	17.18	2.73	13.27	3.9
None	Ball on to I-5/SR-22/SR-57 IC	N/A		2.73	13.27	0.12	10.70	2.6

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.

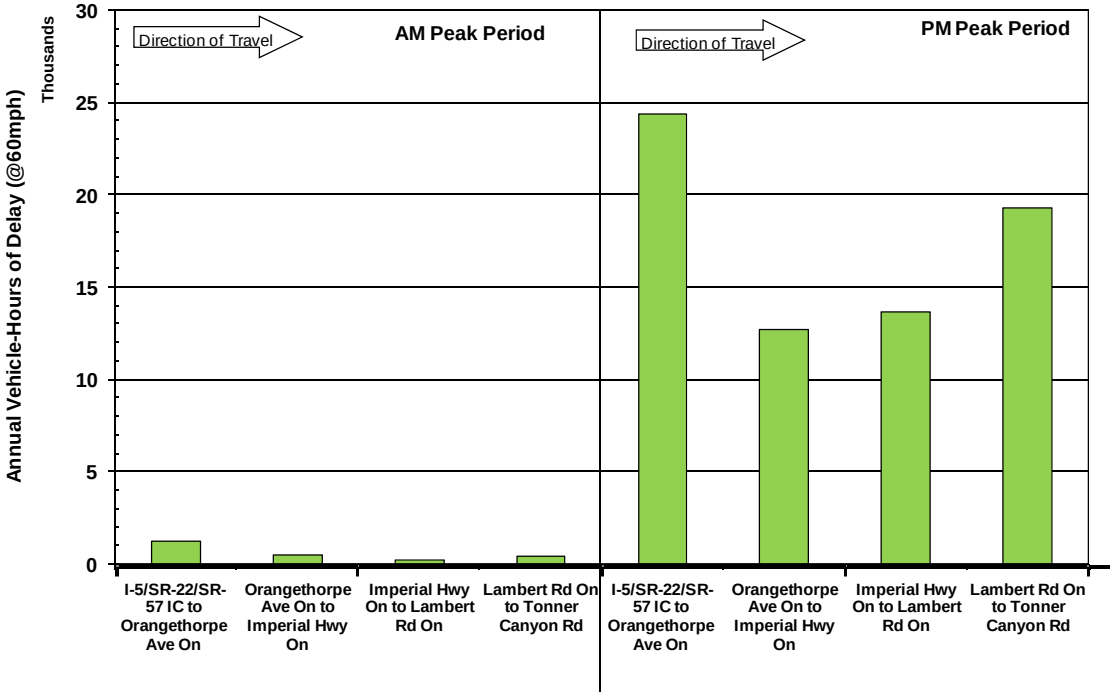
Exhibits 4-5 and 4-7 illustrate the vehicle-hours of delay experienced by each bottleneck area. In the northbound direction, the delay during the AM peak is noticeably less than the PM peak with all segments of the corridor having experienced less than 100,000 annual vehicle-hours of delay during the AM peak. However, during the PM peak, the single segment between the I-5/SR-22/SR-57 Interchange and Orangethorpe Avenue experienced over 600,000 vehicle-hours of delay (66 percent of the corridor's delay during the PM peak), making it the most congested segment on the corridor. Delay in the southbound direction illustrates a reversed pattern of travel from the northbound direction with greater delay during the AM peak than the PM peak. The segment from Imperial Highway to Chapman (City of Fullerton) experienced the most AM delay with over 160,000 hours (37 percent), while the segment from Chapman (City of Fullerton) to Ball experienced the most PM delay with under 74,000 (37 percent).

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



Source: SMG analysis of PeMS data

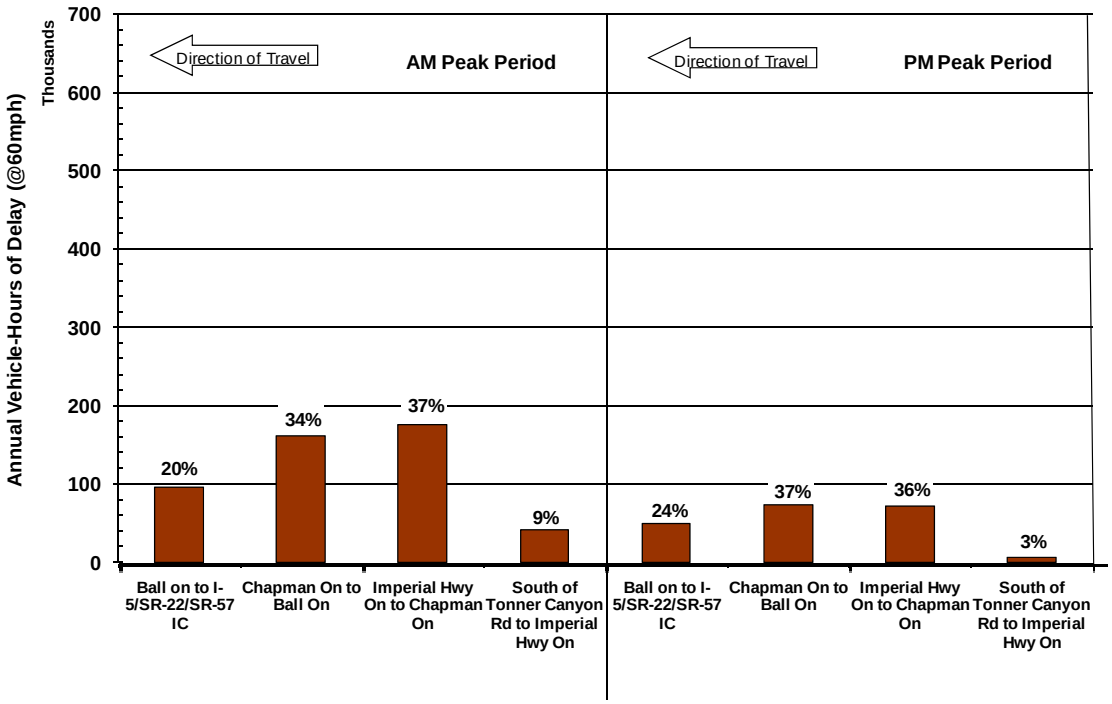
Exhibit 4-6: Northbound Delay per Lane Mile (2007)



Source: SMG analysis of PeMS data

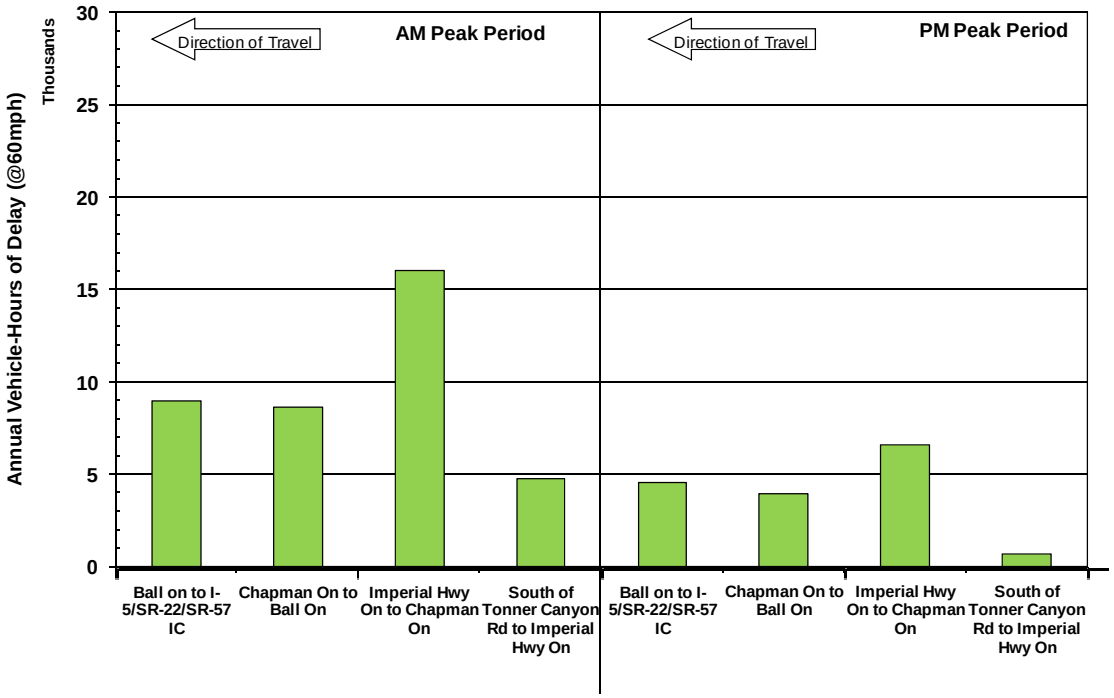
Exhibits 4-6 and 4-8 have been normalized to reflect delay per lane mile. The delay calculated for each bottleneck area was divided by the total lane-miles for each bottleneck area to obtain delay per lane mile. The results of these exhibits indicate a similar pattern to Exhibits 4-5 and 4-7. Exhibit 4-6 illustrates a greater contrast between delay in the AM and PM peaks in the northbound direction with the PM peak having experienced considerably more delay per lane mile in each bottleneck area than the AM peak. Exhibit 4-8 remained consistent with Exhibit 4-7, showing the same pattern of delay and the same segment with the greatest delay, from Imperial Highway to Chapman (City of Fullerton) during both AM and PM peak periods.

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



Source: SMG analysis of PeMS data

Exhibit 4-8: Southbound 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.

Concentrated highway collisions may be indicative of safety issues. TASAS produces a "Table C" that reports collision concentrations. It counts the total number of collisions for three, six, 12, 24, and 36-month periods. Locations with four or more collisions and significance in the three, six, or 12-month period are flagged as requiring investigation. The northbound direction did not yield any Table C locations. However, there were several Table C locations in the southbound direction. Exhibit 4-9 shows the number of Table C collisions by bottleneck area during three different 12-month periods. In the southbound direction, the bottleneck area from Ball to the I-5/SR-22/SR-57 Interchange experienced the most Table C collisions with 170 during the July 2004-June 2007 period. This bottleneck area also experienced high levels of delay during both peak periods with roughly a quarter of the corridor's delay during both AM and PM peaks.

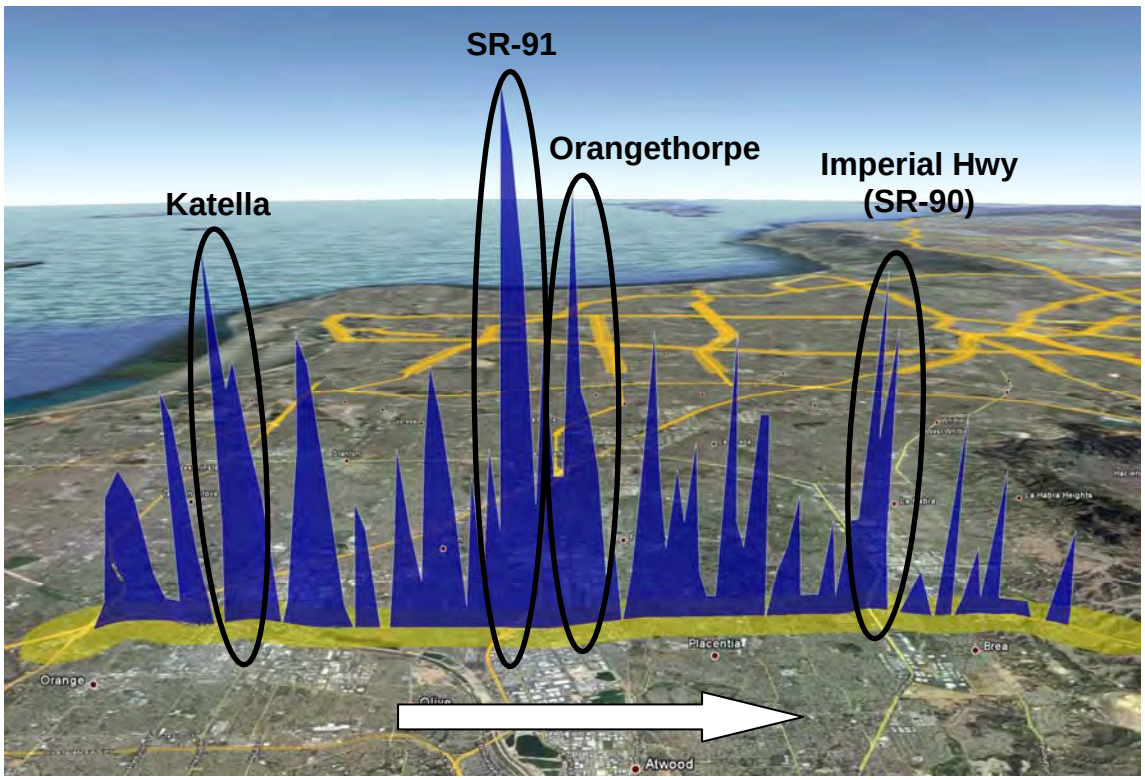
Exhibit 4-9: Southbound SR-57 Table C Locations and Collisions

From		To		Bottleneck Area	Number of Table C Accidents[1]			
Abs	CA	Abs	CA		July 04-June 05	July 05-June 06	July 06-June 07	36 Mo Total
11.35	22.06	9.19	19.95	South of Tonner Canyon Rd to Imperial Hwy On	50	36	43	129
9.19	19.95	6.64	17.18	Imperial Hwy On to Chapman On	43	60	60	163
6.64	17.18	2.73	13.27	Chapman On to Ball On	Not a Table C Location			
2.73	13.27	0.12	10.70	Ball on to I-5/SR-22/SR-57 IC	51	61	58	170
				Southbound Total	144	157	161	462

Exhibit 4-10 shows the location of all collisions (Table C and other) plotted along the SR-57 Corridor in the northbound direction. The spikes show the total number of collisions (fatality, injury, and property damage only) that occurred within a 0.1 mile segment during 2007. The year 2007 is the most current year provided by PeMs. The highest spike corresponds to roughly 20 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.

In the northbound direction, Exhibit 4-10 shows that a large number of collisions occurred around Katella Avenue, at the SR-91 Interchange, near Orangethorpe Avenue, and at Imperial Highway (SR-90). It is common for high collision location to correspond to a bottleneck location. For example, a high spike of collisions occurred at Orangethorpe Avenue, which is also a bottleneck location.

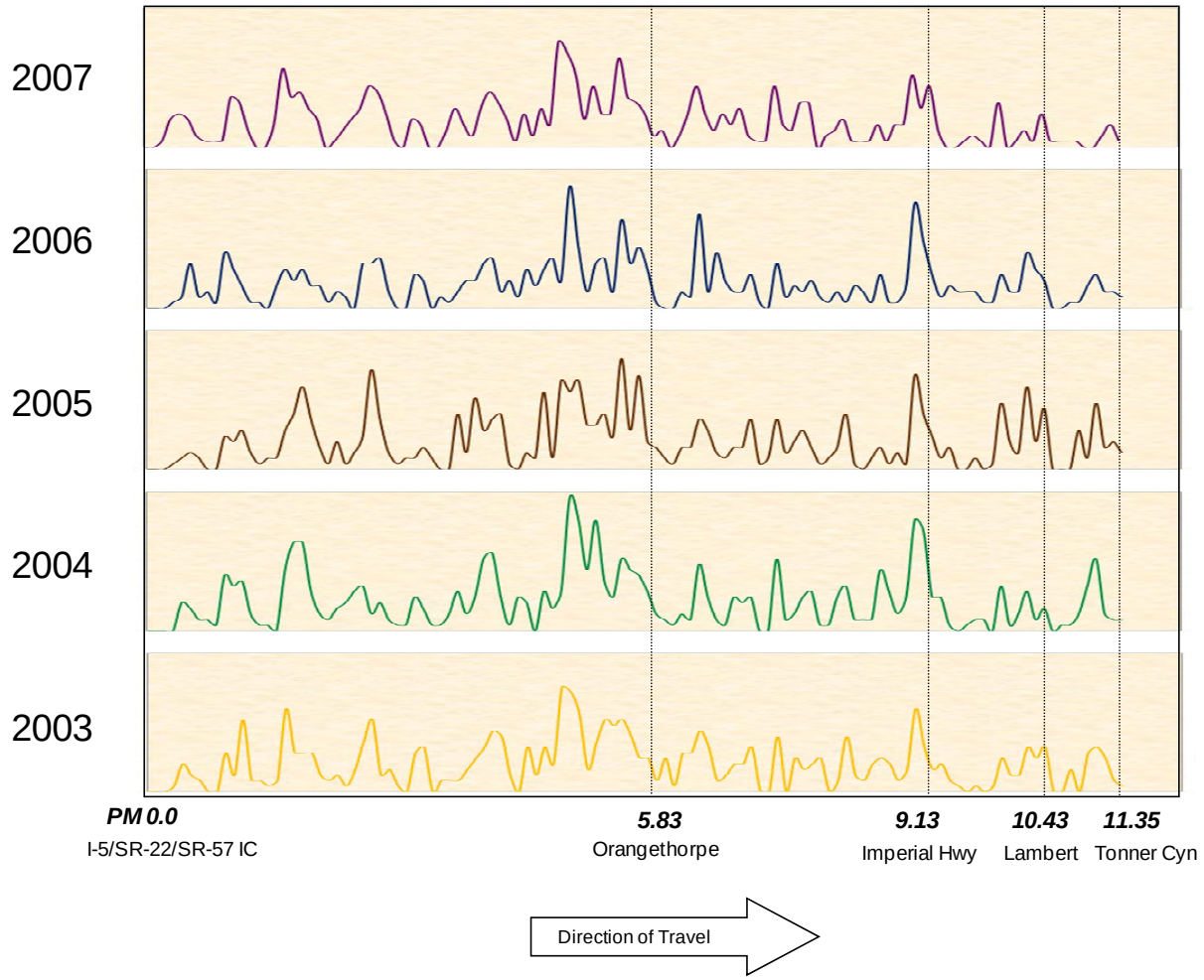
Exhibit 4-10: Northbound SR-57 Location of Collisions (2007)



Source: SMG mapping of TASAS data

Exhibit 4-11 provides a comparison of collision data between 2003 and 2007 by bottleneck area. Similar to Exhibit 4-10, the largest spike corresponds to roughly 22 collisions over 0.1 miles. Exhibit 4-11 demonstrates that the pattern of collisions has remained fairly consistent from one year to the next. Most notably, the group of collisions between Ball Road (PM 2.7) and Orangethorpe (PM 5.8) has continuously experienced the greatest concentration of accidents since 2003. The number of collisions occurring at the other two locations has appeared to decline slightly during this five-year period. This is probably a result of decreased traffic and congestion.

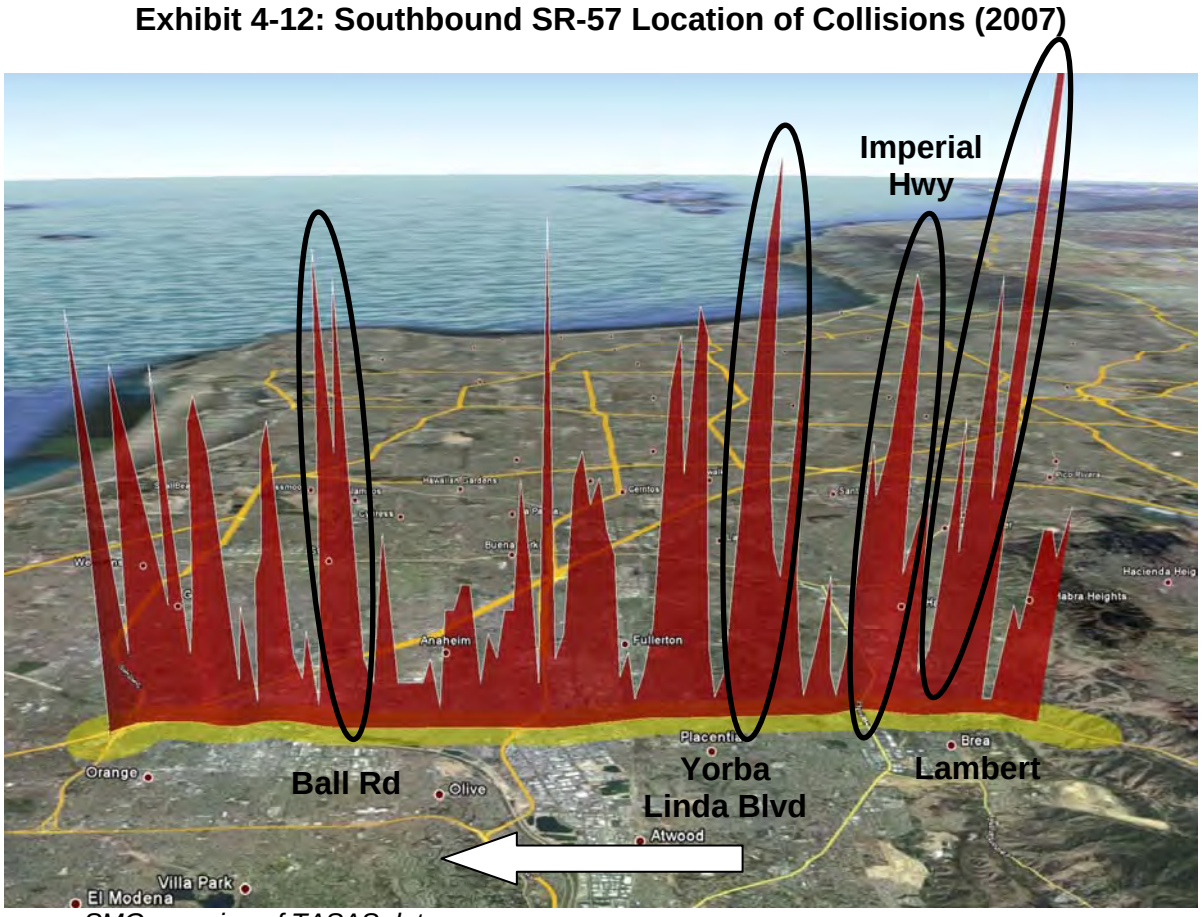
Exhibit 4-11: Northbound SR-57 Location of Collisions (2003-2007)



Source: SMG analysis of TASAS data

Exhibit 4-12 illustrates similar data for SR-57 in the southbound direction during 2007. The largest spike corresponds roughly to 34 collisions per 0.1 miles. The pattern in the southbound direction is similar to the northbound direction but with increased intensity, reflecting a greater number of accidents in the southbound direction compared to the northbound. Moving southbound, high collision locations can be found at Lambert Road, Imperial Highway (SR-90), Yorba Linda Boulevard, and Ball Road. Imperial Highway and Ball Road area also identified bottleneck locations in the southbound direction.

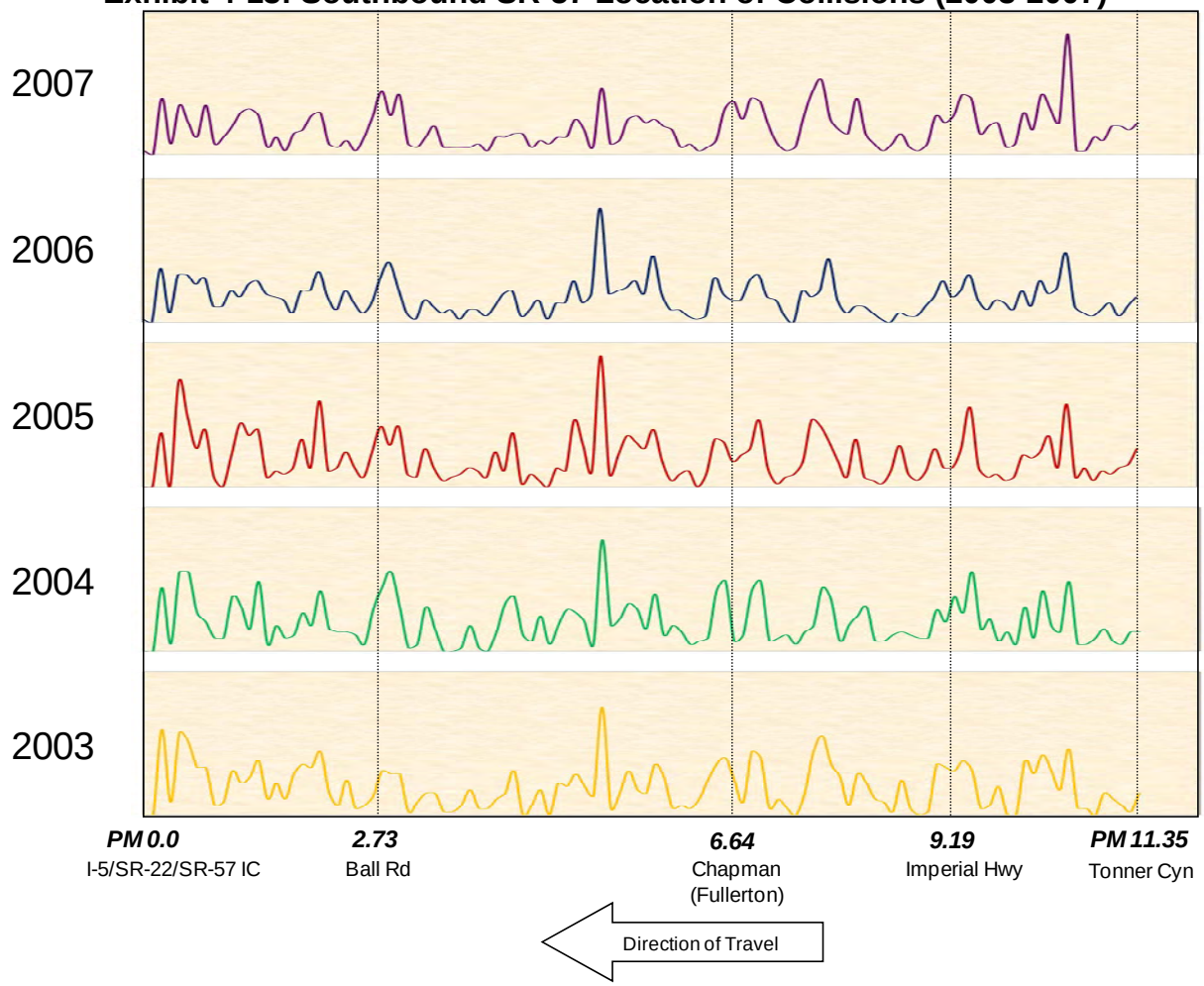
Exhibit 4-12: Southbound SR-57 Location of Collisions (2007)



Source: SMG mapping of TASAS data

Exhibit 4-13 provides a comparison of collision data for the southbound direction between 2003 and 2007. As the exhibit shows, the pattern of collisions has been fairly steady from one year to the next. Since 2003, the southbound direction experienced a slight decrease in the number of collisions between the I-5/SR-22/SR-57 Interchange and Ball Road. Additionally, the spike near SR-91 (PM 5.2) consistently experienced the highest number of collisions, but decreased significantly between 2006 and 2007.

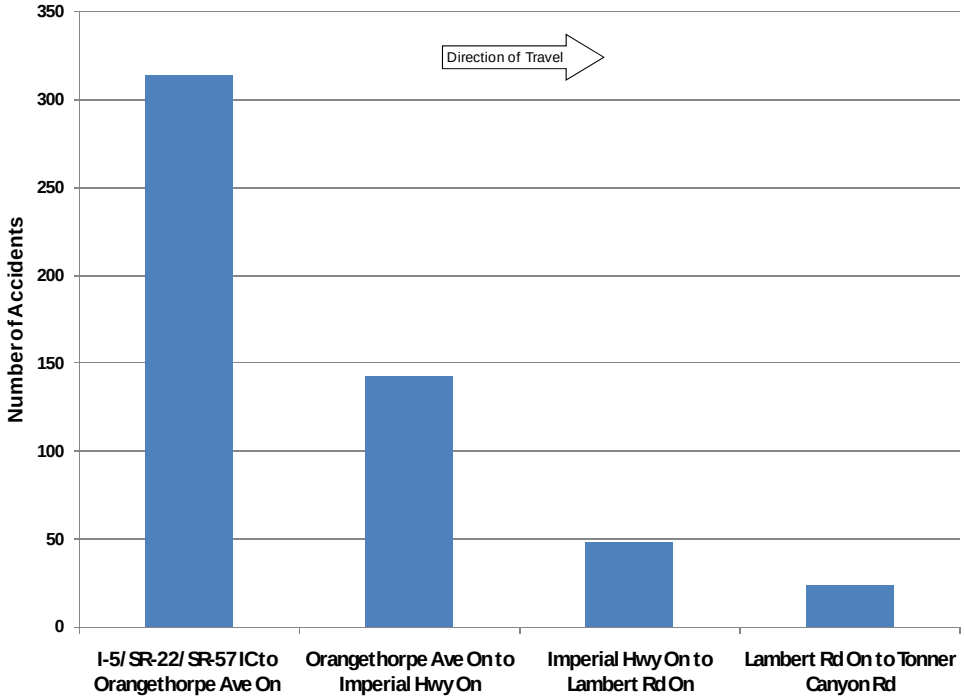
Exhibit 4-13: Southbound SR-57 Location of Collisions (2003-2007)



Source: SMG analysis of TASAS data

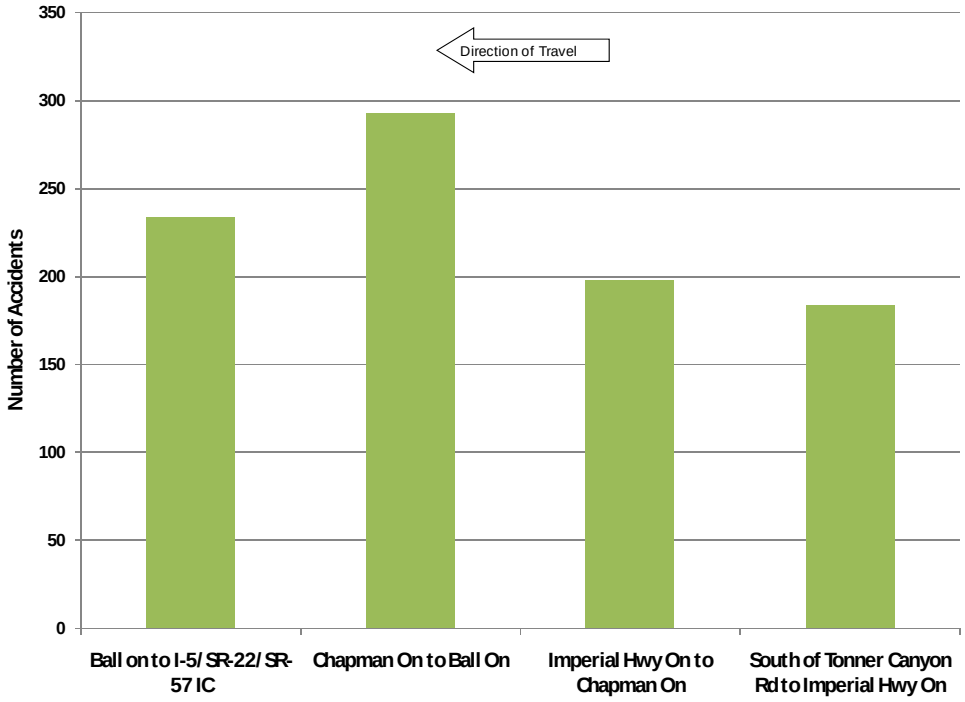
Exhibits 4-14 and 4-15 summarize the average annual accidents reported in TASAS by bottleneck area. The bars show the average annual accidents that occurred in 2005, 2006, and 2007, the latest three years available in TASAS through PeMS. The exhibits show that the bottleneck areas with the greatest number of accidents (I-5/SR-22/SR-57 to Orangethorpe in the northbound and Chapman (City of Fullerton) to Ball in the southbound direction) were also the segments that cover the longest distances. The segment from I-5/SR-22/SR-57 to Orangethorpe experienced an average 310 annual accidents (Exhibit 4-14), and the segment from Chapman to Ball experienced an average 290 annual accidents (Exhibit 4-15).

Exhibit 4-14: Northbound SR-57 Average Annual Accidents (2005-2007)



Source: SMG analysis of TASAS data

Exhibit 4-15: Southbound SR-57 Average Annual Accidents (2005-2007)



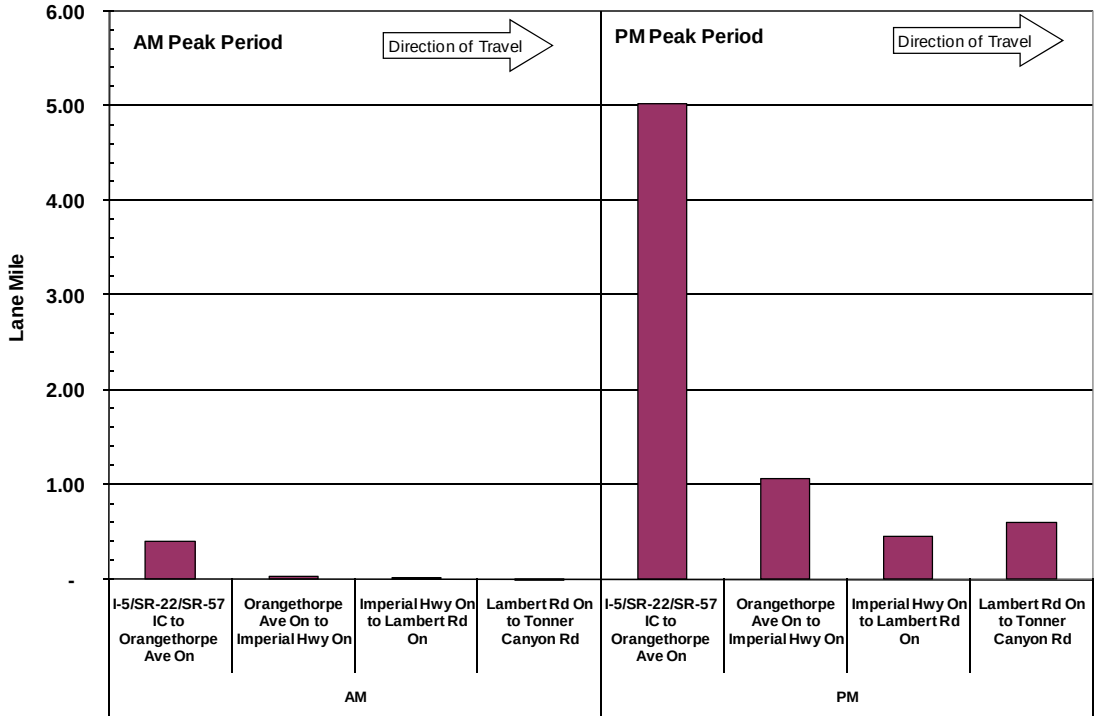
Source: SMG analysis of TASAS data

Productivity by Bottleneck Area

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

Exhibits 4-16 and 4-17 show the productivity losses for both directions of the corridor. In the northbound direction, the segment from the I-5/SR-22/SR-57 Interchange to Orangethorpe had the worst productivity of any segment on the study corridor. It experienced a productivity loss of over 5.0 lane miles during the PM peak. During the AM peak, the northbound direction experienced relatively high productivity with all segments of the corridor experiencing less than a half-mile of productivity loss.

Exhibit 4-16: Northbound SR-57 Lost Lane Miles (2007)

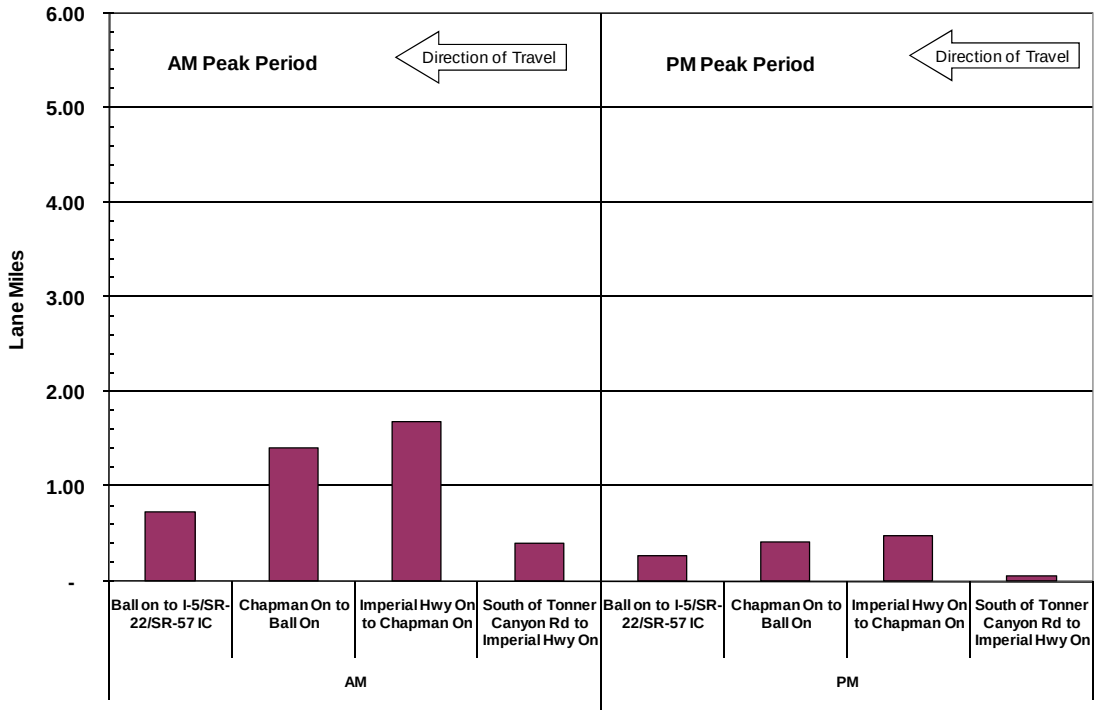


Source: SMG analysis of PeMS data

In the southbound direction, the segment from Imperial Highway to Chapman (City of Fullerton) experienced the greatest productivity loss during the AM peak (1.7 mile), and the PM peak (0.5 mile).

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

Exhibit 4-17: Southbound SR-57 Lost Lane Miles (2007)



Source: SMG analysis of PeMS data

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 SR-57 study corridor, field observations were conducted by the project consultant team in June, November, and December 2008 during the AM and PM peak hours. The most recent field reviews were conducted on December 3, 5, and 10, 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.

The following section discusses every bottleneck location identified on the corridor (including minor bottlenecks), whereas as the previous section (Section 4) only identified the major bottlenecks for bottleneck area analysis purposes.

Mainline Facility

Northbound Bottlenecks and Causes

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

Katella Avenue On

Exhibit 5-1 is an aerial photograph of the northbound SR-57 mainline at the Katella Avenue interchange. As indicated in the exhibit, back-to-back merging from each of the Katella Avenue on-ramps adds about 700 vehicles per hour (vph) to the mainline traffic demand. When the mainline traffic demand is high (e.g. 7,000 vph), a bottleneck condition and traffic congestion typically forms. An example of this is shown in the inset photograph below.

Exhibit 5-1: Northbound SR-57 at Katella Avenue On

Ball Road On

Exhibit 5-2 is an aerial photograph of the northbound SR-57 mainline at the Ball Road interchange. During the PM peak hours, the mainline traffic is at about 6,000 vph in four lanes, or 1,500 vph per lane (vphpl). As indicated in the exhibit, back-to-back merging from each of the Ball Road on-ramps adds about 1,100 vph to the mainline traffic demand. This results in a fairly heavy mainline traffic demand of nearly 1,800 vphpl, which often creates a bottleneck condition and traffic congestion.

Exhibit 5-2: Northbound SR-57 at Ball Road On

Lincoln Avenue On

Exhibit 5-3 is an aerial photograph of the northbound SR-57 mainline at the Lincoln Avenue interchange. During the PM peak hours, the mainline traffic can reach 6,000 vph with four lanes. An additional through-lane is available for the 450 vph of on-coming traffic from the first Lincoln Avenue on-ramp. The second Lincoln Avenue on-ramp must merge with the mainline and the first Lincoln Avenue on-ramp traffic, which combined, can carry up to 6,500 vph in five lanes. Just north of the second Lincoln Avenue on-ramp merge, the mainline traffic loses two through-lanes as one lane becomes an auxiliary lane exiting off to eastbound SR-91, and the other lane becomes an auxiliary lane exiting off to westbound SR-91. As a result, much of the connector off-ramp traffic must weave right, while the mainline traffic and on-ramp traffic must weave left to travel on the three lanes available to through-traffic. This active weaving causes the mainline traffic to breakdown, creating bottleneck conditions and resulting in traffic congestion.

Exhibit 5-3: Northbound SR-57 at Lincoln Avenue On

SR-91 On/Lane Drop/Orangethorpe Avenue Off (Lane Drop)

Exhibit 5-4 is an aerial photograph of the northbound SR-57 mainline at the SR-91 on-ramps and the Orangethorpe Avenue off-ramp interchange. A variety of merging and weaving activities occur at this interchange as a result of the SR-91 eastbound and westbound on-ramp traffic, the mainline lane drop, and the SR-57 traffic exiting Orangethorpe Avenue. As shown in the inset aerial photograph and field photograph below, mainline traffic at the westbound SR-91 on-ramp can reach 5,500 vph in three lanes, with an added lane for the on-ramp traffic carrying about 1,800 vph. Just north of this are two on-coming lanes from the eastbound SR-91, with traffic reaching 2,500 vph merging onto the SR-57 mainlines. Immediately north of the SR-91 connector, one mainline lane is dropped and becomes an auxiliary lane exiting off Orangethorpe Avenue, which requires on-coming SR-91 traffic to weave left, while mainline traffic destined for Orangethorpe Avenue must weave right. As a result of this heavy cross-weaving and the high traffic demand at this location, a bottleneck condition and congestion occurs, as is evident in the inset field photograph.

Exhibit 5-4: Northbound SR-57 at SR-91 On/Orangethorpe Avenue Off

Orangethorpe Avenue On

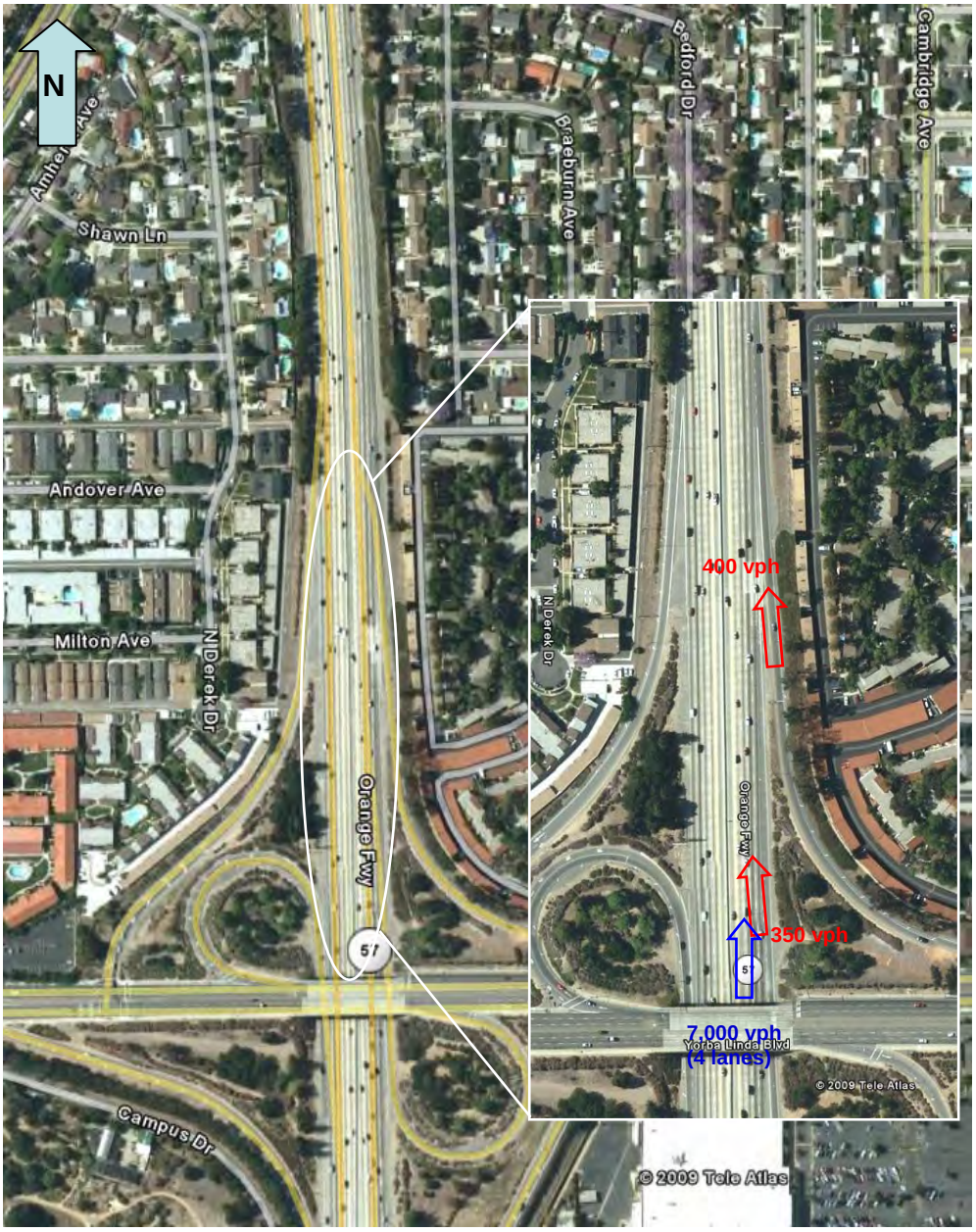
Exhibit 5-5 is an aerial photograph of the northbound SR-57 mainline at the Orangethorpe on-ramp. During the PM peak hours, mainline traffic can reach 8,000 vph with five lanes. About 700 vph of Orangethorpe Avenue on-ramp traffic must merge with the mainline traffic and weave left since the outside lane becomes an auxiliary lane. This merging and weaving activity results in a bottleneck condition. This bottleneck and congestion clears just north of the on-ramp and the mainline traffic merges.

Exhibit 5-5: Northbound SR-57 at Orangethorpe Avenue On

Yorba Linda Boulevard On

Exhibit 5-6 is an aerial photograph of the northbound SR-57 mainline at the Yorba Linda Boulevard interchange. During the PM peak hours, the mainline traffic can reach 7,000 vehicles per hour (vph) with four lanes. Back-to-back ramp merges from Yorba Linda Boulevard adds approximately 750 vph (350 vph from the first on-ramp, 400 vph from the second on-ramp) to the mainline traffic. The four lanes cannot accommodate this amount of traffic thus resulting in a bottleneck and congestion that occurs at this location.

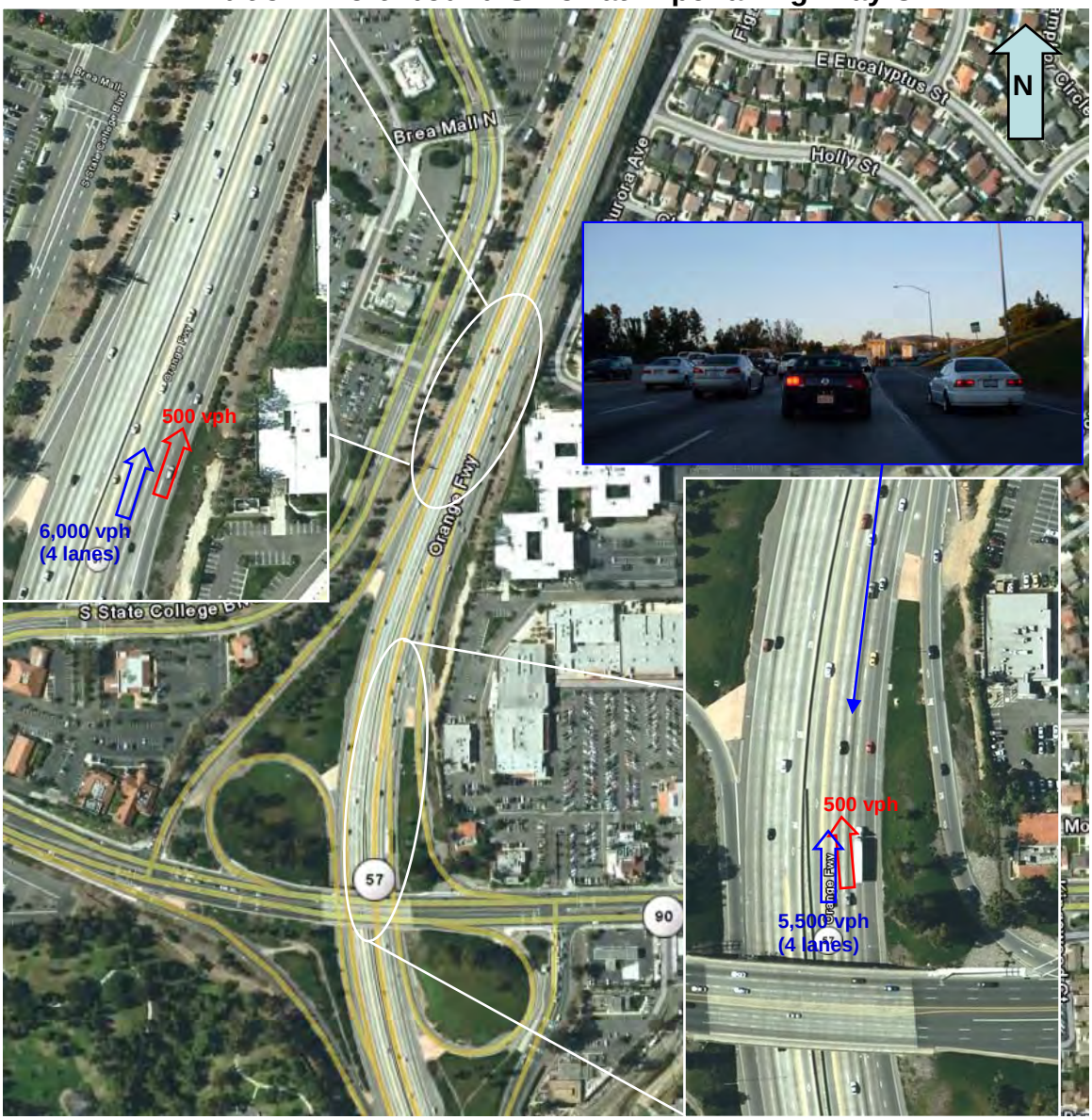
Exhibit 5-6: Northbound SR-57 at Yorba Linda Boulevard On



Imperial Highway On

Exhibit 5-7 is an aerial photograph of the northbound SR-57 mainline at the Imperial Highway interchange. During the PM peak hours, the mainline traffic can reach 6,000 vehicles per hour (vph) with four lanes. The two on-ramps merge back to back within a quarter-mile of each other adding up to 1,000 vph for the two on-ramps, resulting in a bottleneck and congestion in this location. This interchange location also has rolling terrain and reverse horizontal curves starting from south of the off-ramp to just north of the on-ramp, which compounds the congestion by causing vehicles to brake and slow down.

Exhibit 5-7: Northbound SR-57 at Imperial Highway On



Lambert Road On

Exhibit 5-8 is an aerial photograph of the northbound SR-57 mainline at the Lambert Road on-ramp. During the PM peak hours, the mainline traffic can reach 5,500 vehicles per hour (vph) with four lanes. This location only forms a bottleneck during the PM peak hour periods with the added demand of the on-ramp traffic of about 1,000 vph. Although this ramp is metered, platoons of vehicles form and must merge with the freeway mainline traffic, causing mainline traffic flow to break down. This, along with a short merge and steep grade creates bottleneck conditions and traffic congestion. Throughout the PM peak period, the steady stream of vehicles (platoons) merges on the freeway, as shown in the inset photographs.

Exhibit 5-8: Northbound SR-57 at Lambert Road On

Southbound Bottlenecks and Causes

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

Imperial Highway On

Exhibit 5-9 is an aerial photograph of the southbound SR-57 mainline at the Imperial Highway interchange. During the AM peak hours, the mainline traffic can reach 6,000 vph with four lanes. As indicated in the exhibit, the two on-ramps merge back-to-back within less than a quarter-mile of each other adding a total of 1,050 vph (350 vph from the first on-ramp, 700 from the second on-ramp). The combined freeway traffic flow is nearly 1,800 vphpl, which is near the capacity threshold level. This interchange location also has rolling terrain and reverse horizontal curves starting from north of the off-ramp to south of the on-ramp which also impacts the traffic flow creating more congestion.

Exhibit 5-9: Southbound SR-57 at Imperial Highway On

Nutwood Avenue-Chapman Avenue On

Exhibit 5-10 is an aerial photograph of the southbound SR-57 mainline at the Nutwood Avenue-Chapman Avenue (City of Fullerton) on-ramps. Mainline traffic can reach 7,000 vph which includes 450 vph from Nutwood Avenue on-ramp. An additional 750 vph from the Chapman Avenue on-ramp contributes to a total freeway flow of over 1,900 vphpl, which is near the capacity threshold level. The Nutwood Avenue and Chapman Avenue on-ramps are back-to-back ramps spaced approximately a quarter-mile of each other. Traffic merging from the Nutwood Avenue on-ramp does not have adequate time and distance to merge with mainline traffic before traffic merging from the Chapman Avenue on-ramp. The back-to-back short merges from the two ramps and the high demand results in creating bottleneck conditions and congestion at this location during both the AM and PM peak hours.

Exhibit 5-10: Southbound SR-57 at Nutwood Avenue-Chapman Avenue On

Ball Road On

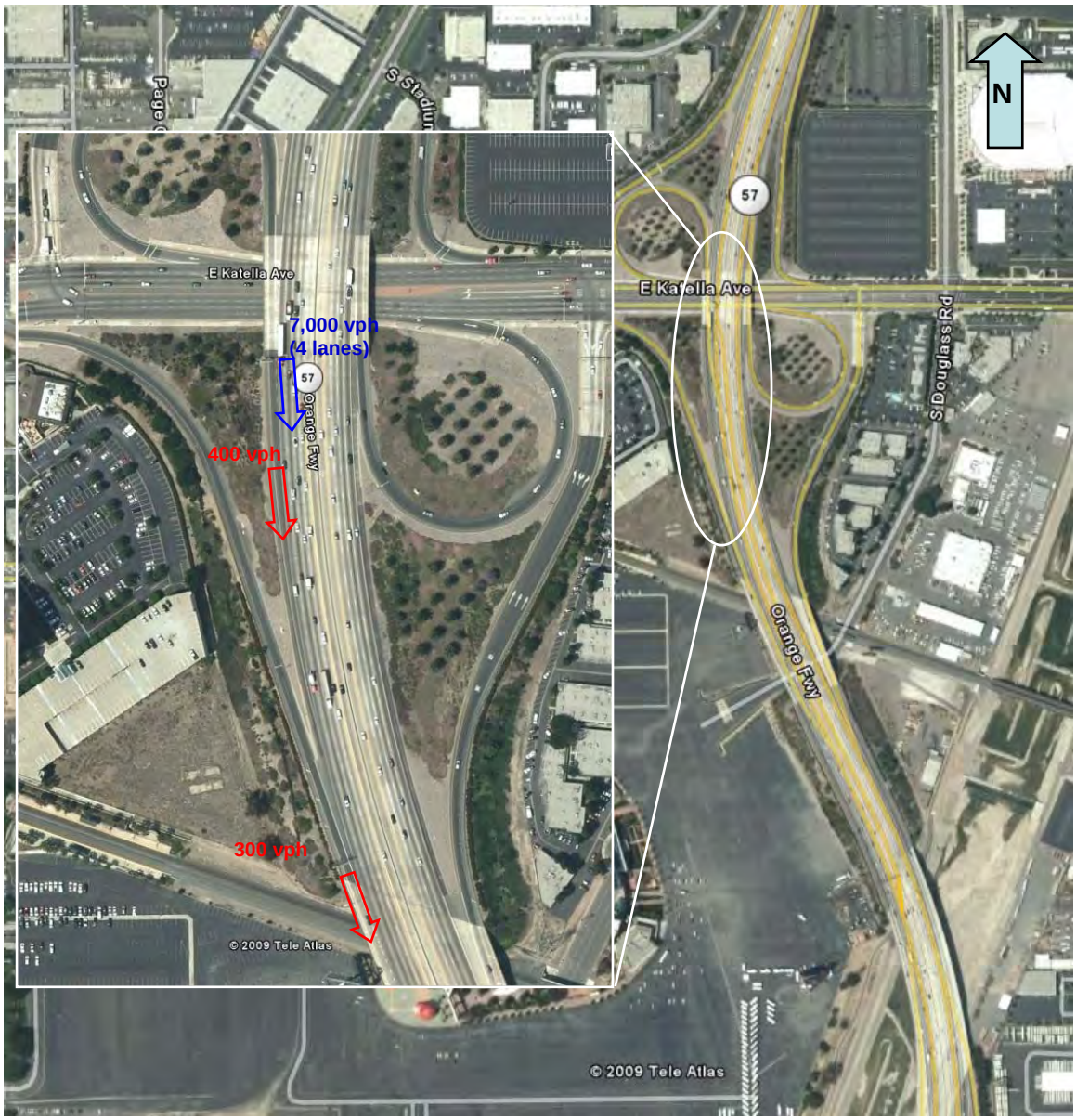
Exhibit 5-11 is an aerial photograph of the southbound SR-57 mainline at the Ball Road interchange. The combined freeway traffic reaches 7,500 vph with four lanes, which includes 300 vph from the first on-ramp and 500 vph from the second on-ramp. The two Ball Road on-ramps are spaced less than a quarter-mile of each other. The close spacing of merging traffic does not allow for the first Ball Road on-ramp traffic to merge completely with mainline traffic before having to merge again with the second Ball Road on-ramp traffic. The back-to-back merge coupled with the high demand of almost 1,900 vphpl results in creating bottleneck conditions and congestion. An example of this is illustrated in the two inset photographs.

Exhibit 5-11: Southbound SR-57 at Ball Road On

Katella Avenue On

Exhibit 5-12 is an aerial photograph of the southbound SR-57 mainline at the Katella Avenue interchange. The combined freeway traffic can reach 7,700 vph with four lanes, which includes 400 vph from the first on-ramp and 300 vph from the second on-ramp. The two Katella Avenue on-ramps are spaced less than a quarter-mile of each other. These back-to-back merges coupled with the high traffic demand results in creating bottleneck locations and congestion.

Exhibit 5-12: Southbound SR-57 at Katella Avenue On



I-5 Off at the SR-57 Terminus

Exhibit 5-13 is an aerial photograph of the southbound SR-57 terminus to the I-5/SR-22 off-ramps. The SR-57 ends with two lanes exiting to the southbound I-5 and three lanes exiting to the eastbound and westbound SR-22. The I-5 off-ramp carries up to 3,400 vph. As indicated in the inset photo, vehicles are queued on the left two lanes exiting to the I-5, while traffic exiting to the SR-22 eastbound and westbound (right three lanes) travel unimpeded. The bottleneck causing the congestion is from the I-5 mainline causing the connector ramp traffic to back up onto the SR-57 mainline.

Exhibit 5-13: Southbound SR-57 at I-5 Off

High-Occupancy Vehicle (HOV) Facility

Bottleneck and causality analyses were also conducted for the HOV facilities on the SR-57. The bottleneck locations on the HOV facility were initially determined based on PeMS data analysis and later verified by field reviews that confirmed the actual bottleneck locations and identified the causes. The HOV facility along the SR-57 operates on a full-time basis with a vehicle occupancy requirement of two plus (2+) in both directions, but is buffer-separated from the mainline facility with varying widths. The proceeding section describes the bottleneck locations and the causes for the bottlenecks that were verified on the SR-57 HOV facilities.

Northbound SR-57 HOV Facility Bottlenecks and Causes

PeMS data analysis and field reviews conducted April and May 2009 during the weekday peak period confirm two major bottlenecks in the northbound direction at the following locations:

- SR-91 HOV direct connector and Orangethorpe Avenue
- Lambert Road

The SR-91 HOV direct connector and Orangethorpe Avenue bottleneck is caused by the high demand of HOV traffic at this location while the Lambert Road HOV bottleneck is caused by the steep vertical curve of the road. Exhibit 5-14 presents the PeMS speed contour diagram of the northbound SR-57 HOV lane for a sample day in April 2009 and for an average of all weekdays in the month of March 2009.

Exhibit 5-14: Northbound SR-57 HOVL PeMS Speed Contours, 2009

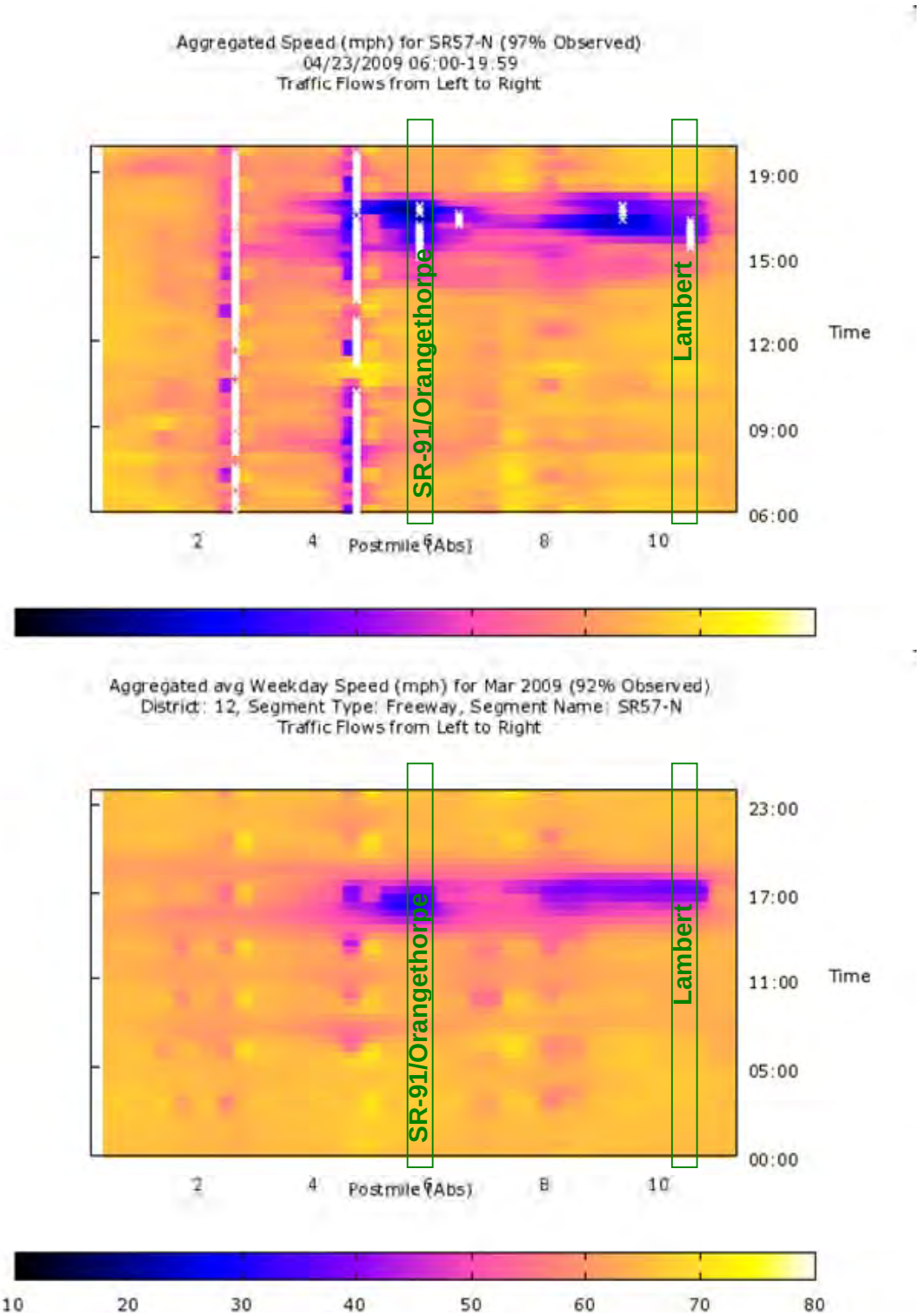


Exhibit 5-15 is an aerial photograph of the SR-91 HOV direct connector and Orangethorpe Avenue. The SR-57 mainline HOV facility cannot handle the additional surge in demand and merge from the SR-91 HOV direct connector and results in this bottleneck condition. Although there is no ingress/egress at this location, on a typical day, as much as 1,500 vph from the HOV lane must merge with 500 vph coming from the SR-91 HOV direct connector combined, exceeding the available capacity of the facility. This bottleneck has been observed during multiple field visits and is illustrated in the inset field photographs.

Exhibit 5-15: Northbound SR-57 between SR-91 HOV Direct Connector and Orangethorpe Avenue

Exhibit 5-16 is an aerial photograph of the HOV lane bottleneck area for the Lambert Road location. HOV traffic must climb a steep vertical curve at this location which causes a bottleneck to form upstream that queues back over two miles. Once traffic passes the peak of the vertical curve, the bottleneck clears, as illustrated in the exhibit.

Exhibit 5-16: Northbound SR-57 HOVL at Lambert Road

Southbound SR-57 HOV Facility Bottlenecks and Causes

PeMS data analysis and field reviews conducted in April and May 2009 during the weekday peak period confirm one major bottleneck in the southbound direction at the Nutwood Avenue and Chapman Avenue ingress/egress.

This bottleneck location is caused by weaving traffic entering and exiting at the HOV lane ingress/egress area during the peak hours. Exhibit 5-17 presents the PeMS speed contour diagram of the southbound SR-57 HOV lane for a sample day in April 2009 and for an average of all weekdays in the month of March 2009. As indicated in the exhibit, this bottleneck location is within the mainline congestion area. As a result, the vehicles on the HOV lane that intend to exit the corridor must stop to squeeze into the mainline congested traffic stream. Similarly, the vehicles on the mainline which intend to enter the HOV lane must do so from a very low speed, disrupting the HOV lane flow.

Exhibit 5-17: Southbound SR-57 HOVL PeMS Speed Contours (2009)

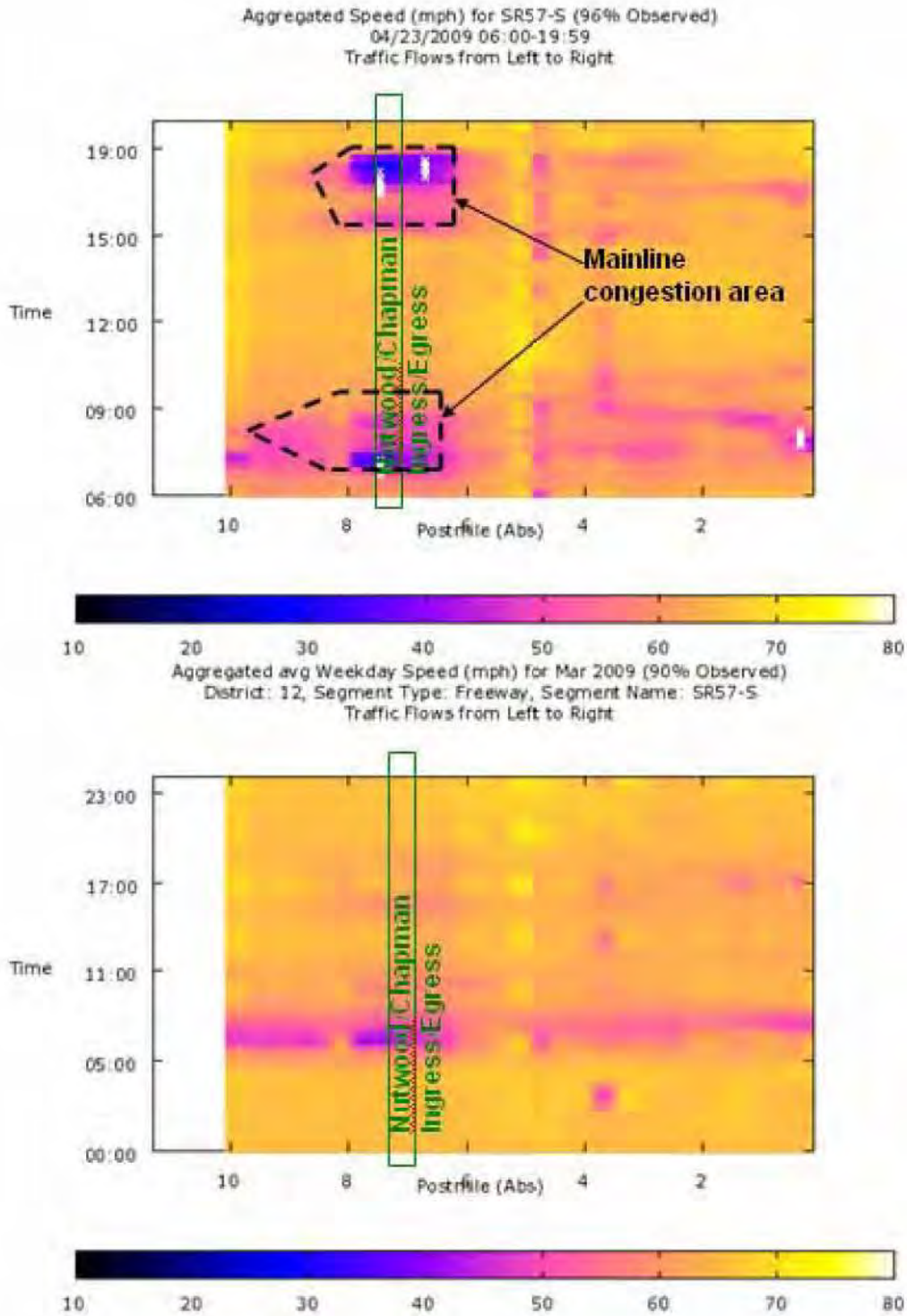


Exhibit 5-18 is the aerial photograph of the bottleneck location of the HOV lane ingress/egress area at Nutwood Avenue and Chapman Avenue. When the mainline freeway is congested, vehicles have a difficult time entering and exiting the HOV lane. As a result, bottleneck conditions occur and vehicles queue behind this area. The HOV volume at this location can reach 1,700 vph which is near the threshold capacity level of 1,800 vph

Exhibit 5-18: Southbound SR-57 HOVL Ingress/Egress at Nutwood Avenue and Chapman Avenue

6. ENVIRONMENTAL ELEMENTS

Before pursuing any major project, there are many environmental factors that are considered. Caltrans District 12 provided the following summary of environmental factors that may be impacted by the SR-57 widening project, which is currently in design.

Air Quality

The Clean Air Act is the comprehensive Federal law that regulates air emissions from area, stationary, and mobile sources. This law authorizes the U. S. Environmental Protection Agency to establish National Ambient Air Quality Standards (NAAQS) to protect public health and the environment.

Implementation of the project would involve federal approvals, which will necessitate demonstrating project conformance with the State Implementation Plan. The purpose of the Implementation Plan is to attain and maintain the National Ambient Air Quality Standards. Concerning Mobile Source Air Toxics (MSAT), when a NEPA document is required, a determination must be made as to whether the project will meaningfully increase emissions. If so, a qualitative analysis is required. If the project will create new or add substantial capacity to the route with traffic volumes where the Average Annual Daily Traffic (AADT) is projected to be in the range of 140,000 to 150,000 or greater, by the design year, a quantitative analysis is required.

SR-57 is located in the South Coast Air Basin (SCAB). Federal and State standards exist for lead, nitrogen dioxide, sulfur dioxide, and inhalable particulates labeled PM_{10} and $PM_{2.5}$. The SCAB is in a federal non-attainment status with regards to carbon monoxide, and for the ozone eight-hour standard.

Wetlands

The US Army Corps of Engineers (the Corps) and Environmental Protection Agency jointly define wetlands as “those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support…a prevalence of vegetation typically adapted for life in saturated soil conditions.” There is a potential for wetlands to exist at the following locations, although confirmation of wetlands requires formal delineation according to the protocol required by the Corps.

- Tonner Canyon Creek crosses SR-57 near the county line. Several blue-line (perennial) streams are found on both sides of the highway, which drain into Tonner Canyon Creek and have features essential to wetlands. The extent of these natural drains is unknown.

- Two blue-line streams located west of SR-57 and south of Tonner Canyon are found within one mile of SR-57. These streams may meet the definition of a wetland, although the extent of wetland is unknown.
- An oil field is located on the east of SR-57 and south of Tonner Canyon Creek. According to USGS maps, there are three unnamed streams running through the hillside into developed areas. Large sections of these streams may qualify as wetlands.
- Loftus Channel, east of SR-57, is tributary to Fullerton Creek, and may contain wetlands.
- Fullerton Creek crosses SR-57, and is fed by several unnamed streams. Portions of this creek and its tributaries may meet the definition of wetland.
- The large section of the Santa Ana River south of SR-57 is fully concrete-lined, and not expected to support vegetation. However, those sections of the river which are only partially modified have the potential to support wetlands, the extent of which is unknown.
- Santiago Creek, Collins Channel, and Bitterbrush Channel are partially improved blue-line streams and are tributaries to the Santa Ana River. These streams may meet the definition of wetland, dependent upon a full delineation study.
- Carbon Creek is entirely concrete-lined and is not expected to contain a wetland.

There are also small ponds in Craig and Centennial Regional Parks which are used by migratory birds.

Hazardous Materials

There are no hazardous material disposal sites within one mile of SR-57 or the proposed extension.

Visual

SR-57 is located in north Orange County, which is heavily urbanized. North of Lambert Road in Brea, the terrain is rural; however, no alteration is proposed to SR-57 beyond that interchange. Views from the freeway would be slightly diminished in quality by the added lane northbound. Views to the freeway would also be minimally affected at right-of-way edges and community entrances. Overall changes in character are considered low to moderate.

Construction Impacts

Noise produced by construction equipment on the proposed widening projects would occur with varying intensities and duration during the phases of construction. These phases would occur over an estimated two year period. Because of phased construction, no single location would experience a long-term period of construction noise.

Permits and Approvals

The proposed extension of SR-57 to SR-1 along the bed of the Santa Ana River would affect water of the U.S. Impacts to these waters would be identified, and appropriate mitigation proposed, in the Environmental Document. Offsite mitigation would be required for the extension.

Permits and approvals would be required for construction of the two widening projects in the 2006 STIP. Exhibit 5-1 outlines the required permits and approvals.

Exhibit 6-1: Required Approvals for Northbound Widening on SR-57

AGENCY	APPROVAL REQUIRED
U.S. Fish and Wildlife Service	Consultation pursuant to Section 7 of the Endangered Species Act.
U.S. Army Corps of Engineers	Nationwide Permit per Section 404 of the Clean Water Act.
Regional Water Quality Control Board	Statewide NPDES permit per Section 402 of the Clean Water Act. Water Quality Certification per Section 401 of the Clean Water Act.
CA Dept. of Fish and Game	1601 Streambed Alteration Agreement per Section 1601 of the CA Fish and Game Code

APPENDIX

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

A4. BOTTLENECK ANALYSIS

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

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

- Caltrans Highway Congestion Monitoring Program (HICOMP) 2006 report
- Probe vehicle data (from Caltrans District 12 electronic tachometer runs)
- Freeway Performance Measurement System (PeMS)
  - *Speed contour plots*
  - *Flow data*
- Aerial photos and field observations

HICOMP

The team initially identified potential problem areas by reviewing the latest (2006) Caltrans HICOMP report. As illustrated in Exhibit A4-1 and A4-2, congested queues form upstream from bottlenecks, which are located "at the front" (downstream end) of the congested segment. The potential bottleneck areas are identified with blue circles in the northbound direction and red circles in the southbound direction.

In the <u>northbound</u> direction, there are potentially two major bottleneck locations during the AM and PM peak period:

- Orangethorpe Avenue (AM)
- Tonner Canyon Road (PM)

In the <u>southbound</u> direction, there is potentially one major bottleneck that accounts for congestion in the AM and PM peak periods:

- Chapman Avenue (City of Orange) (AM and PM)

Further analysis is needed to determine their actual locations and possibly any other bottlenecks along the corridor not identified in the HICOMP. For example, the southbound direction may contain multiple queues that spill into each other. HICOMP provides a good starting point for comparing to other data sources as a more detailed analysis is conducted.

Exhibit A4-1: 2007 HICOMP AM Congestion Map with Potential Bottlenecks

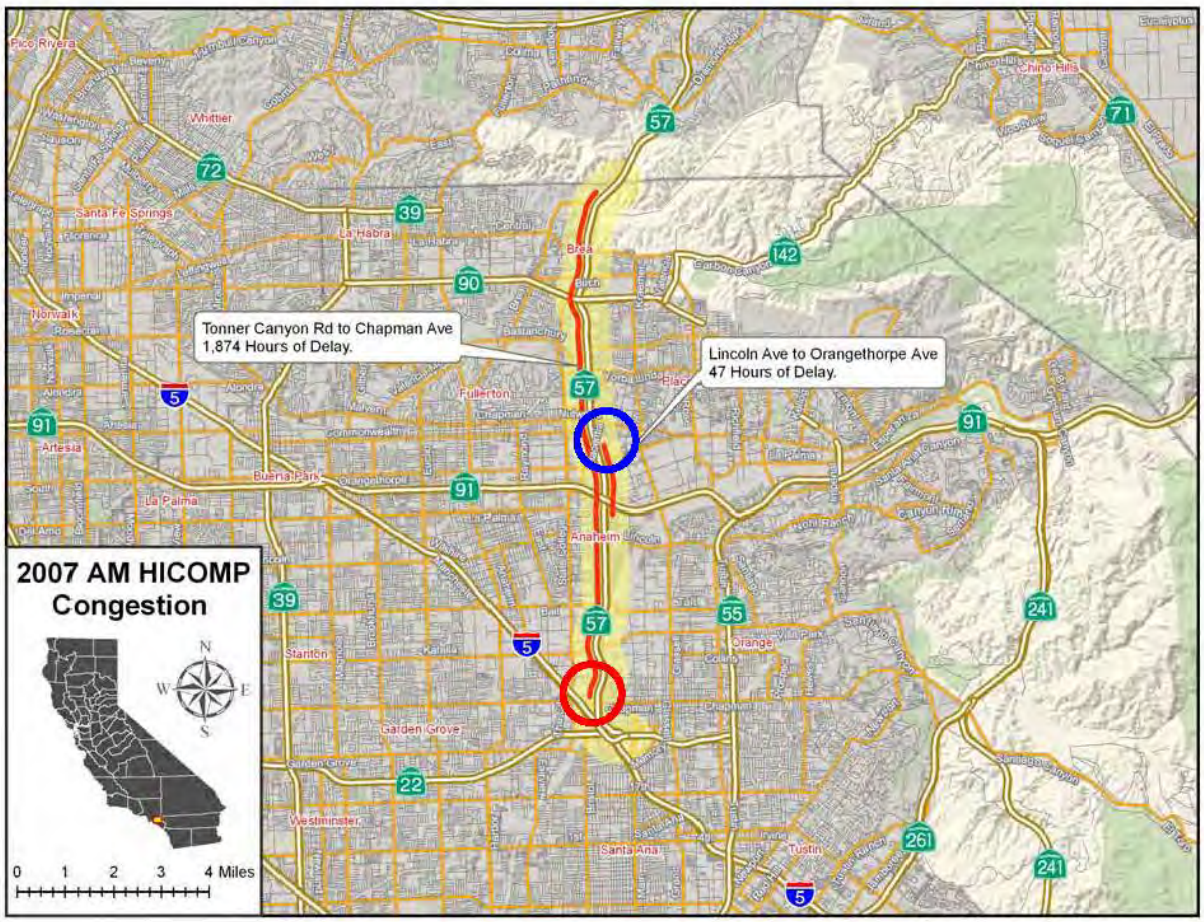
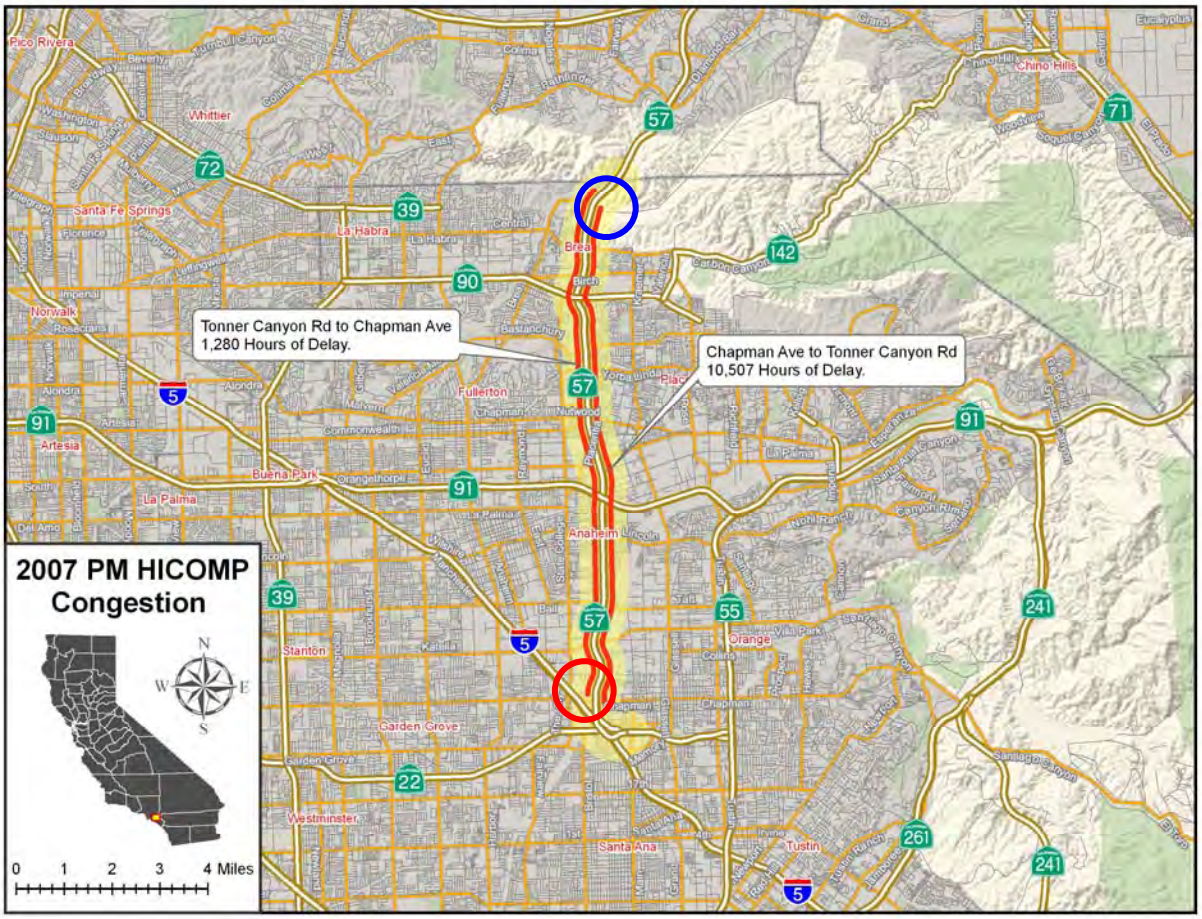


Exhibit A4-2: 2007 HICOMP PM Congestion Map with Potential Bottlenecks



Probe Vehicle Runs

The study team used probe vehicle data to also identify bottlenecks, verify the bottlenecks identified from the HICOMP data, and conduct additional analysis. Probe vehicle (or electronic tachometer) runs provide speed plots across the corridor for various departure times. Caltrans collects the data by driving a vehicle equipped with an electronic device (e.g., tachometer or global positioning system) along the corridor at various departure times (typically in 20 to 30 minute regular intervals), usually in a middle lane, during peak periods. Actual speeds are recorded as the vehicle traverses the corridor length. A bottleneck can be found at the end of a slow congested speed location where speeds pick up to 30 to 50 miles per hour.

Caltrans District 12 collected probe vehicle run data on May 10, 2007 for the SR-57 freeway from the Orange/Los Angeles County line to the I-5/SR-22/SR-57 Interchange. The freeway corridor runs were conducted from approximately 6 AM to 9:30 AM and from 3 PM to 7:30 PM.

Exhibit A4-3 illustrates the SR-57 northbound probe vehicle runs conducted on May 10, 2007 at 7:00 AM, 8:20 AM, 9:00 AM, 4:00 PM, 5:00 PM, and 6:20 PM. As indicated, there are slow speeds (congestion) and bottlenecks evident in both the AM and PM peak hours in the northbound direction.

As shown in the exhibit, the major northbound bottlenecks from the probe vehicle runs were identified at:

- Orangethorpe Avenue on-ramp (AM and PM)
- Imperial Highway on-ramp (PM)
- Lambert Road on-ramp (PM)

Exhibit A4-4 illustrates the SR-57 southbound probe vehicle runs conducted on May 10, 2007 at 7:00 AM, 7:40 AM, 9:00 AM, 3:00 PM, 4:40 PM, and 6:00 PM. As indicated, there are slow speeds (congestion) and bottlenecks evident in both the AM and PM peak hours in the southbound direction as well.

As indicated in the exhibit, the major southbound bottlenecks from the probe vehicle runs were identified at:

- Yorba Linda Boulevard on-ramp (PM)
- Chapman Avenue (City of Fullerton) on-ramp (AM and PM)
- Lincoln Avenue on-ramp (AM and PM)
- Ball Road on-ramp (AM)
- Orangewood Ave off-ramp (PM)
- Chapman Avenue (City of Orange) off-ramp (PM)

Exhibit A4-3: Northbound Sample Probe Vehicle Runs – 2007

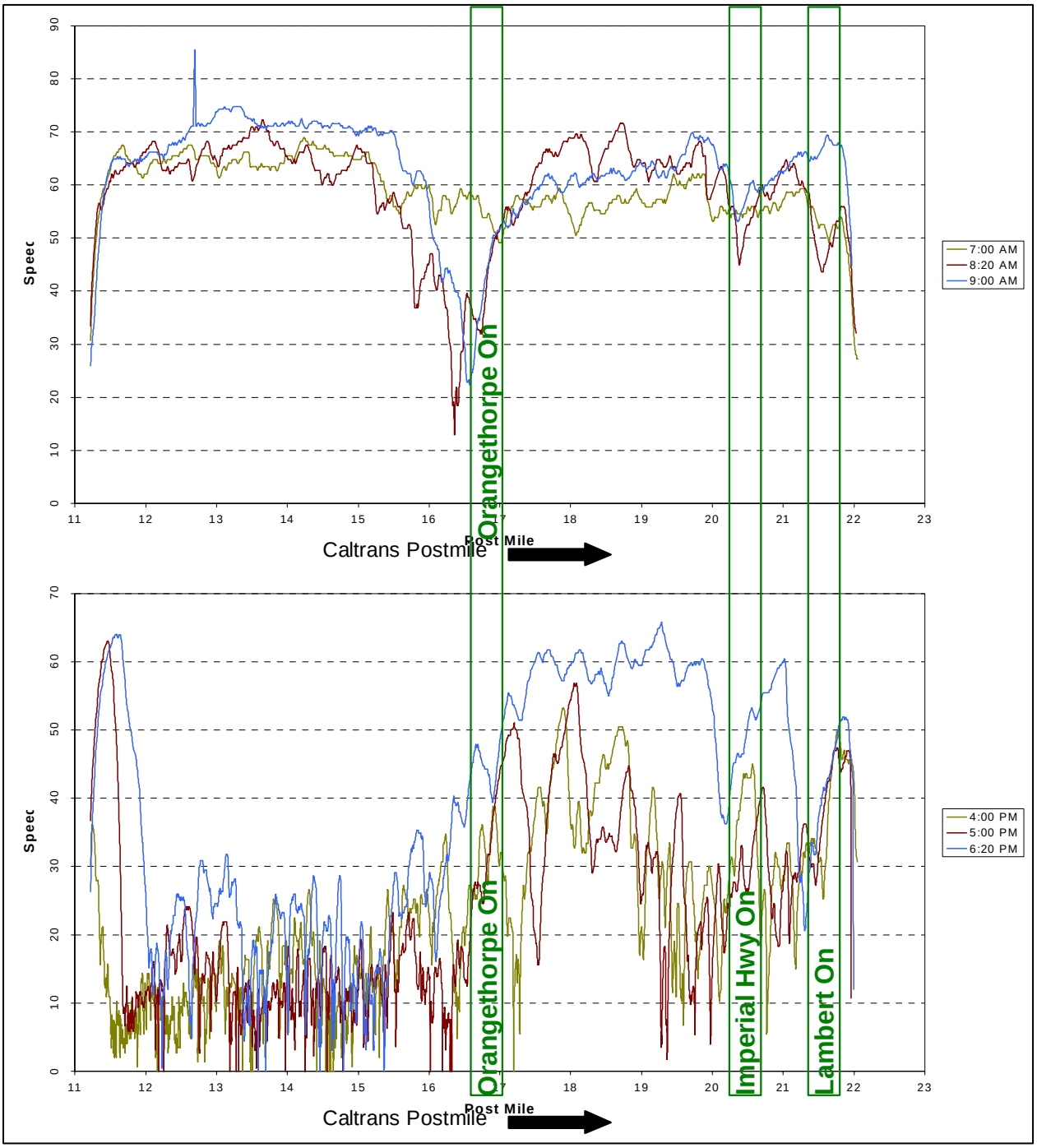
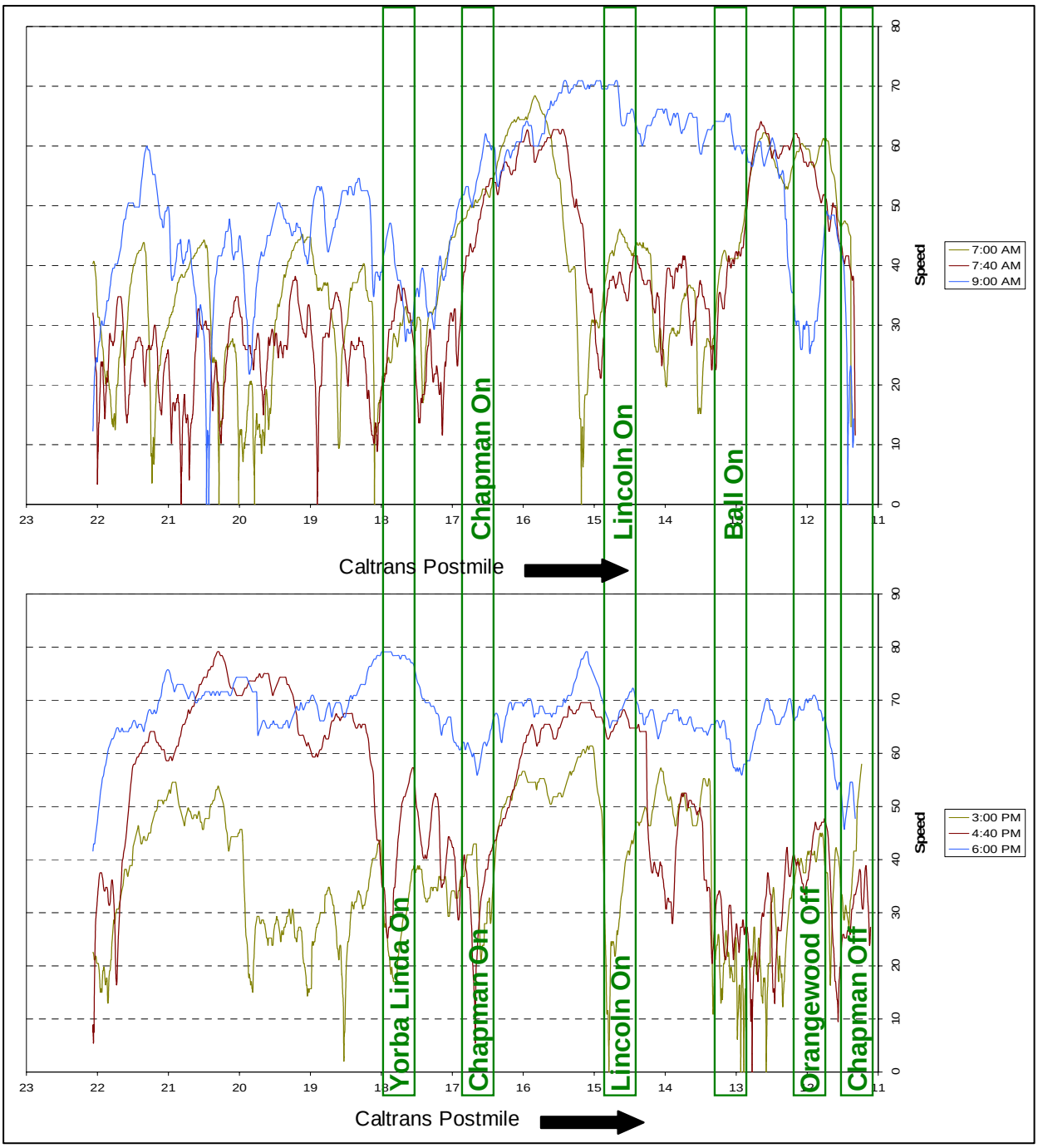


Exhibit A4-4: Southbound Sample Probe Vehicle Runs – 2007



Freeway Performance Measurement System (PeMS)

PeMS provides speed profile plots that are very similar to probe vehicle graphs. The PeMS speed profile plots can also be used to identify potential bottleneck locations. Unlike the probe vehicle runs, the speed plot displays a single time snapshot across the corridor and separate plots are developed for each 5-minute interval. For example, an 8 AM plot shows the speed at 8 AM for one end of the corridor and at 8 AM for the other. With probe vehicle runs, the time advances as the vehicle drives down the corridor, so the time at the end of the corridor is equal to the departure time plus the travel time. Despite this technical difference, both PeMS speed profile plots and probe vehicle graphs can be used to identify problem areas. PeMS also aggregates speed profile plots into speed contour plots that show how speeds change over time.

NORTHBOUND

Exhibit A4-5 shows illustrative speed contour plots for Tuesday, September 18, 2007 and Wednesday, September 19, 2007. The speed contour plots were selected to represent a typical weekday and highlight bottleneck locations and resulting congestion. The speed contour plots shown are typical for the SR-57 freeway in the northbound direction (traffic moving left to right on the plot). Along the vertical axis is the time period from 4 AM to 8 PM. Along the horizontal axis is the corridor segment from the SR-55/I-5/SR-57 Interchange to the Orange/Los Angeles County Line. The various colors represent the average speeds corresponding to the color speed chart shown below the diagram. As shown, the dark blue blotches represent congested areas where speeds are reduced. The ends of each dark blotches represent bottleneck areas, where speeds pickup after congestion, typically to 30 to 50 miles per hour. The horizontal length of each plot is the congested segment, queue lengths. The vertical length is the congested time period.

Exhibit A4-6 provides speed profile plots for Tuesday, September 18, 2007. The speed profile plots represent a typical weekday sample to illustrate the bottleneck locations and congestion formed from them at a particular time in the day, in this case at 8 AM in the morning and 5 PM in the evening. The speed profile plots were selected to represent a typical speed profile diagram for the SR-57 freeway in the northbound direction (traffic moving left to right on the plot).

The study team selected additional days to examine and confirm the trends identified in the September sample days. Exhibit A4-7 provides speed contours for weekday samples in April 2007. The same bottleneck locations are identified on each of the two different sample days, indicating a recurring pattern of the bottleneck locations.

In addition to multiple days, averages over longer time periods were also analyzed. Exhibit A4-8 illustrates the 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 A4-5: PeMS Northbound SR-57 Speed Contour Plots – September 2007

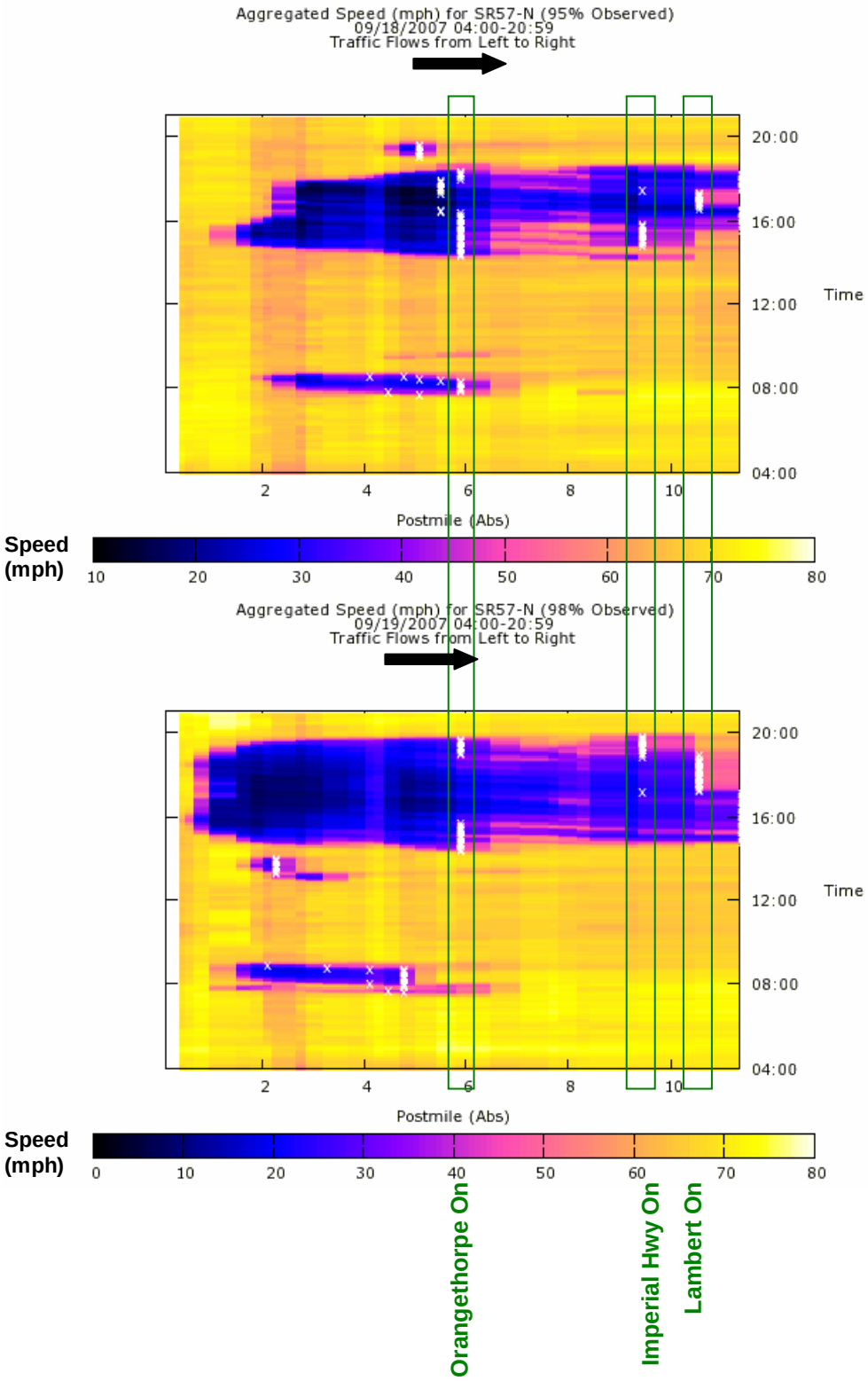


Exhibit A4-6: PeMS Northbound SR-57 Speed Profile Plots – September 18, 2007

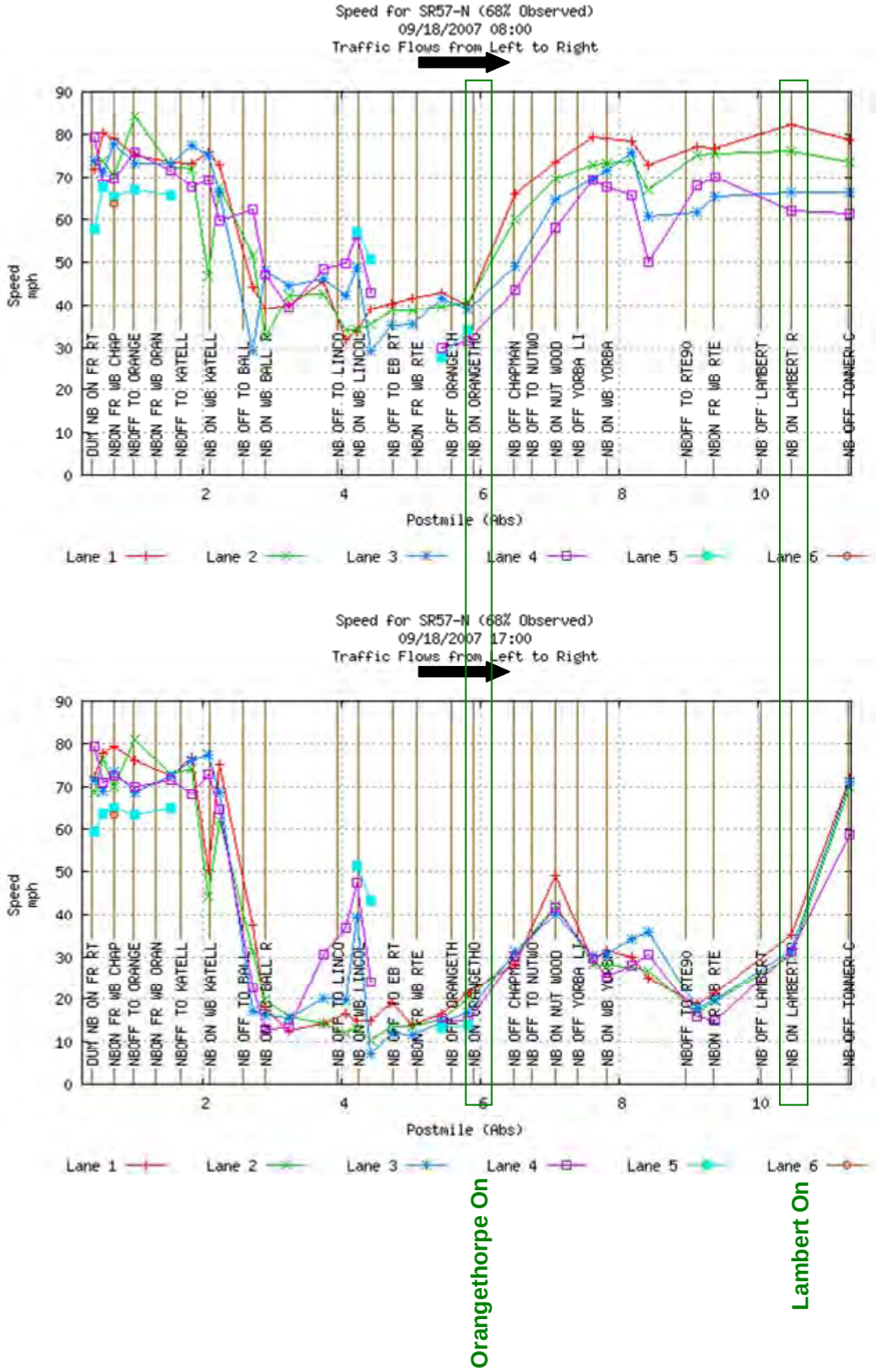


Exhibit A4-7: PeMS Northbound SR-57 Speed Contour Plots – April 2007

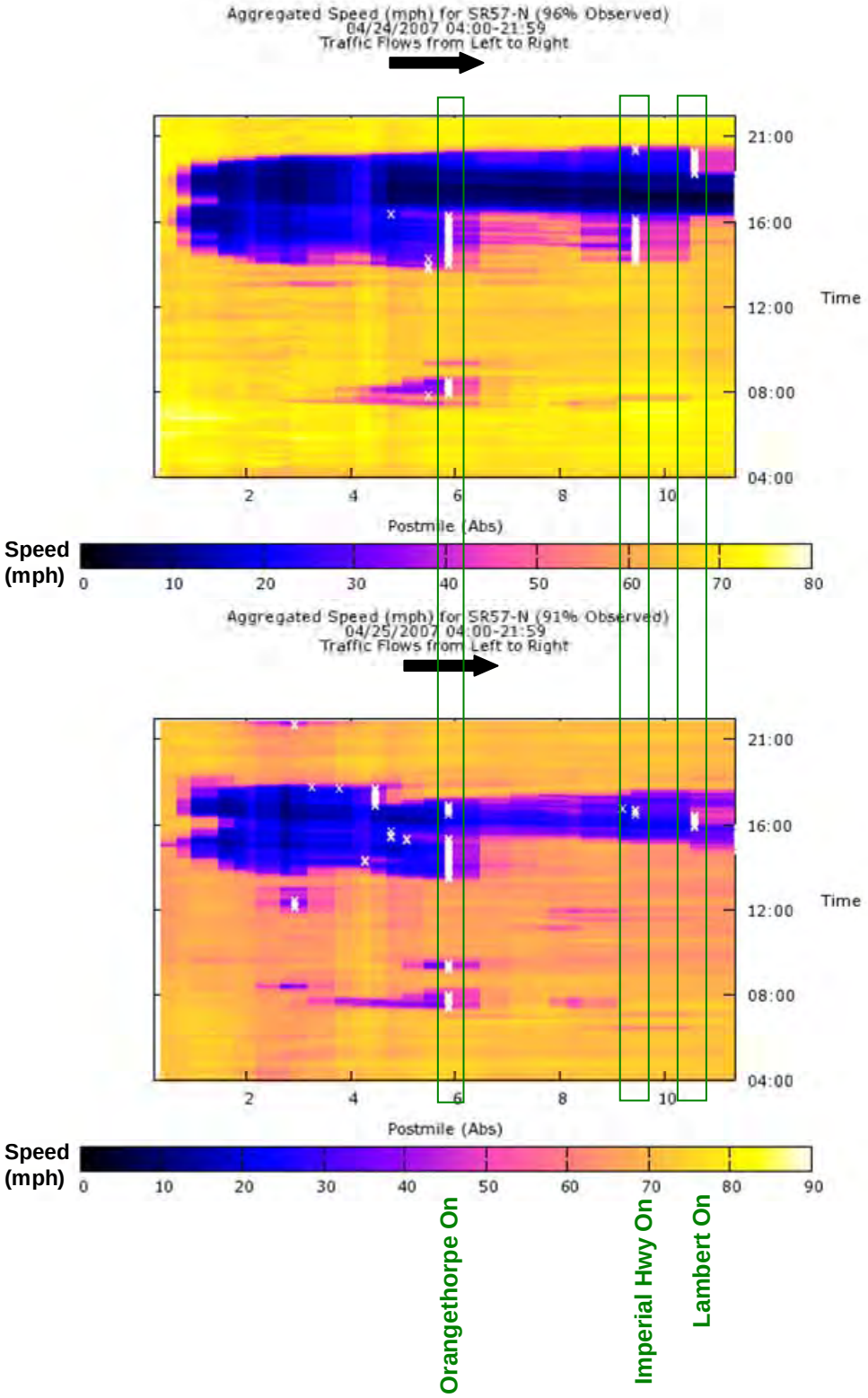
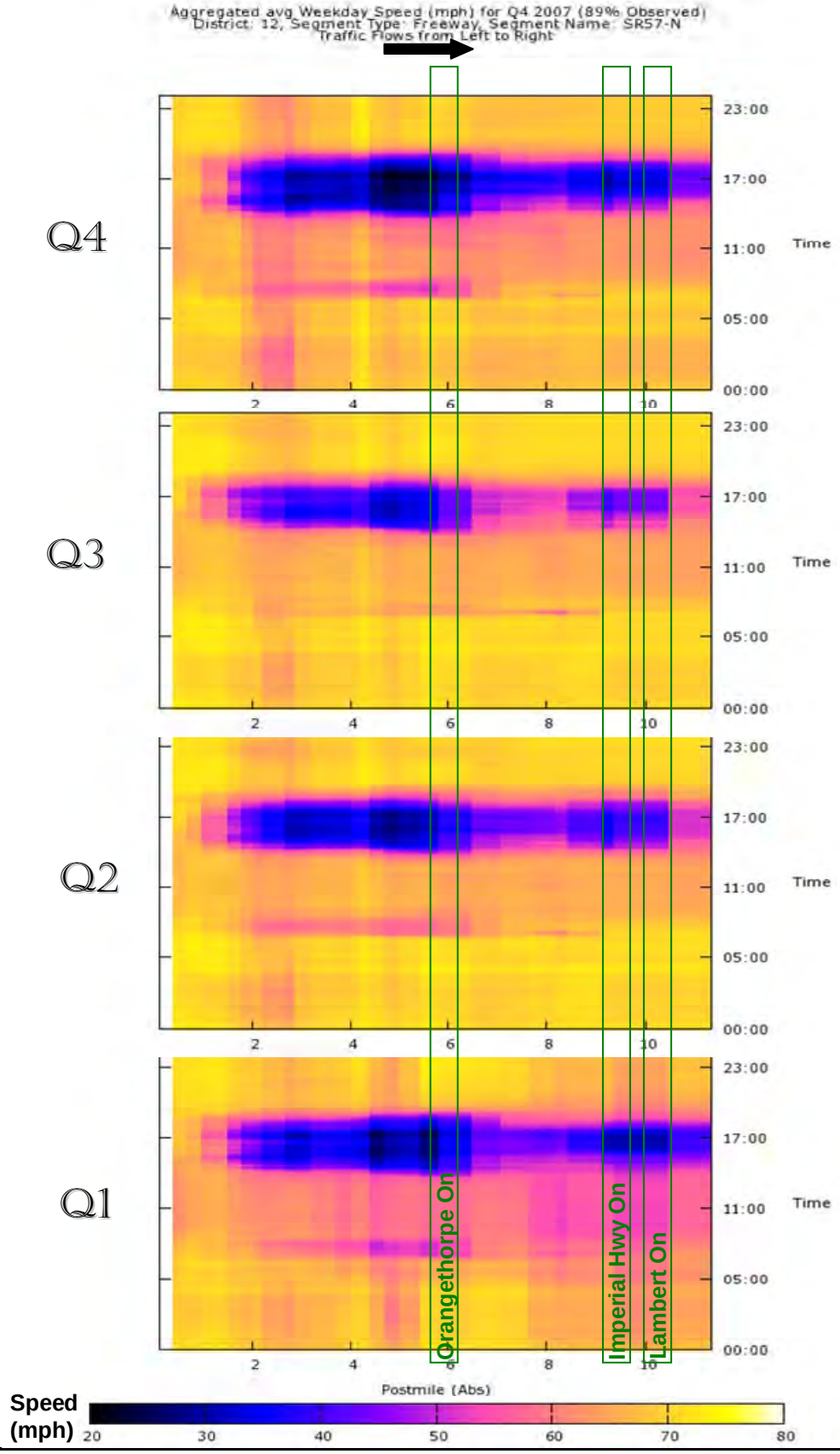


Exhibit A4-8: PeMS Northbound SR-57 Long (Speed) Contours – 2007 Avg. by Qtr.



As indicated in Exhibits A4-5 to A4-8, the major northbound bottlenecks identified from the PeMS data plots were identified at:

- Orangethorpe Avenue on-ramp (AM and PM)
- Imperial Highway on-ramp (PM)
- Lambert Road on-ramp (PM)

SOUTHBOUND

Similarly, the study team analyzed speed contour and speed profile plots for sample days in September and April 2007 for the southbound direction. Exhibits A4-9 to Exhibit A4-12 illustrate the speed contour and profile plots for the SR-57 freeway corridor in the southbound direction (traffic moving left to right on the plot). Along the vertical axis is the time period from 4 AM to 8 PM. Along the horizontal axis is the corridor segment from the Orange/Los Angeles County Line to the SR-55/I-5/SR-57 Interchange. Similar to the northbound PeMS speed contour analysis results, the PeMS eastbound speed contour analysis results indicated reoccurring bottleneck locations across multiple weekdays and quarterly averages.

As indicated from Exhibits A4-9 to A4-12, the major southbound bottlenecks identified from the PeMS data plots were identified at:

- Yorba Linda Boulevard on-ramp (AM and PM)
- Chapman Avenue (City of Fullerton) on-ramp (AM and PM)
- Lincoln Avenue on-ramp (AM and PM)
- Ball Road on-ramp (AM)
- Chapman Avenue (City of Orange) off-ramp (AM and PM)

Exhibit A4-9: PeMS Southbound SR-57 Speed Contour Plots – September 2007

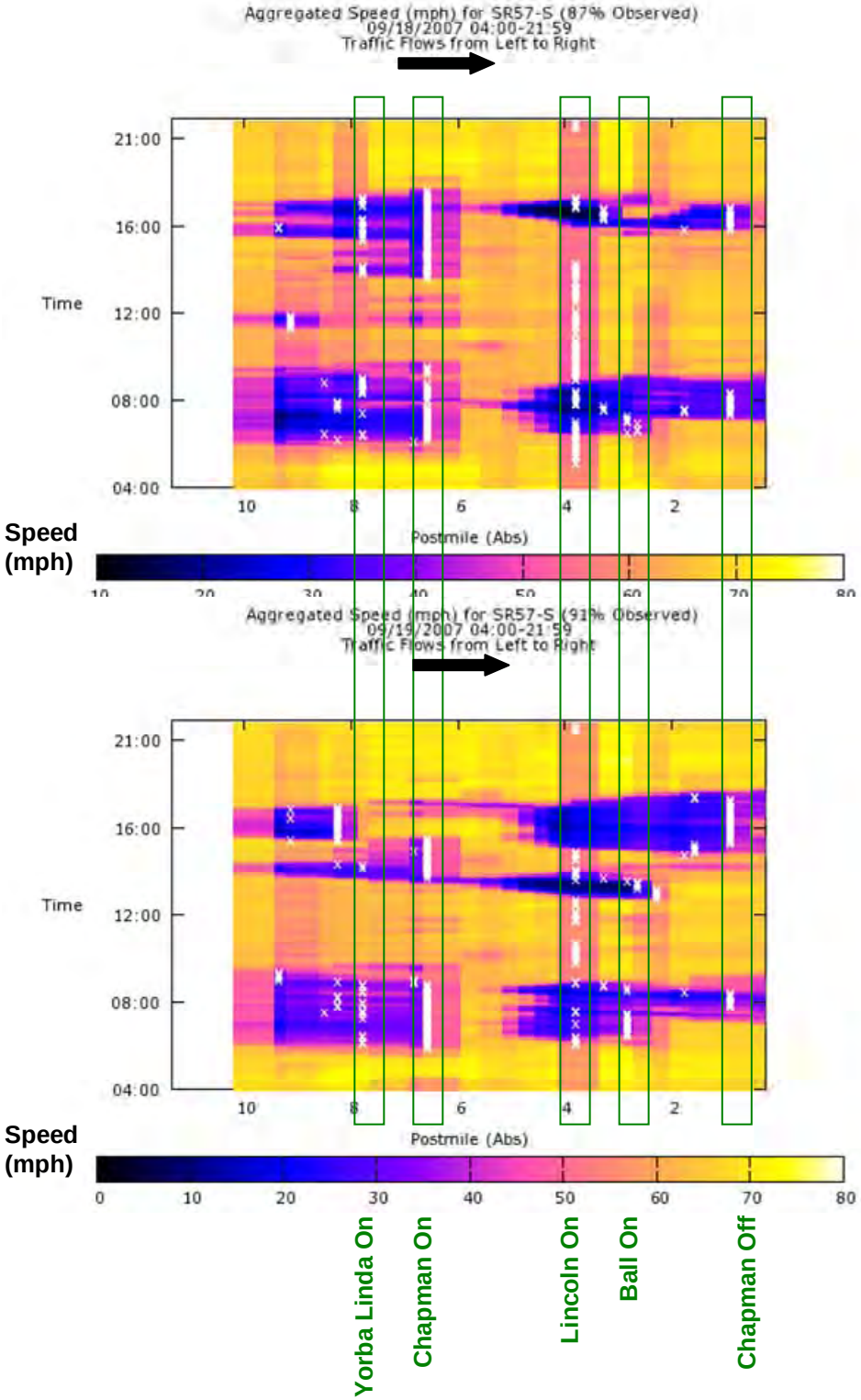


Exhibit A4-10: PeMS Southbound SR-57 Speed Profile Plots – September 18, 2007

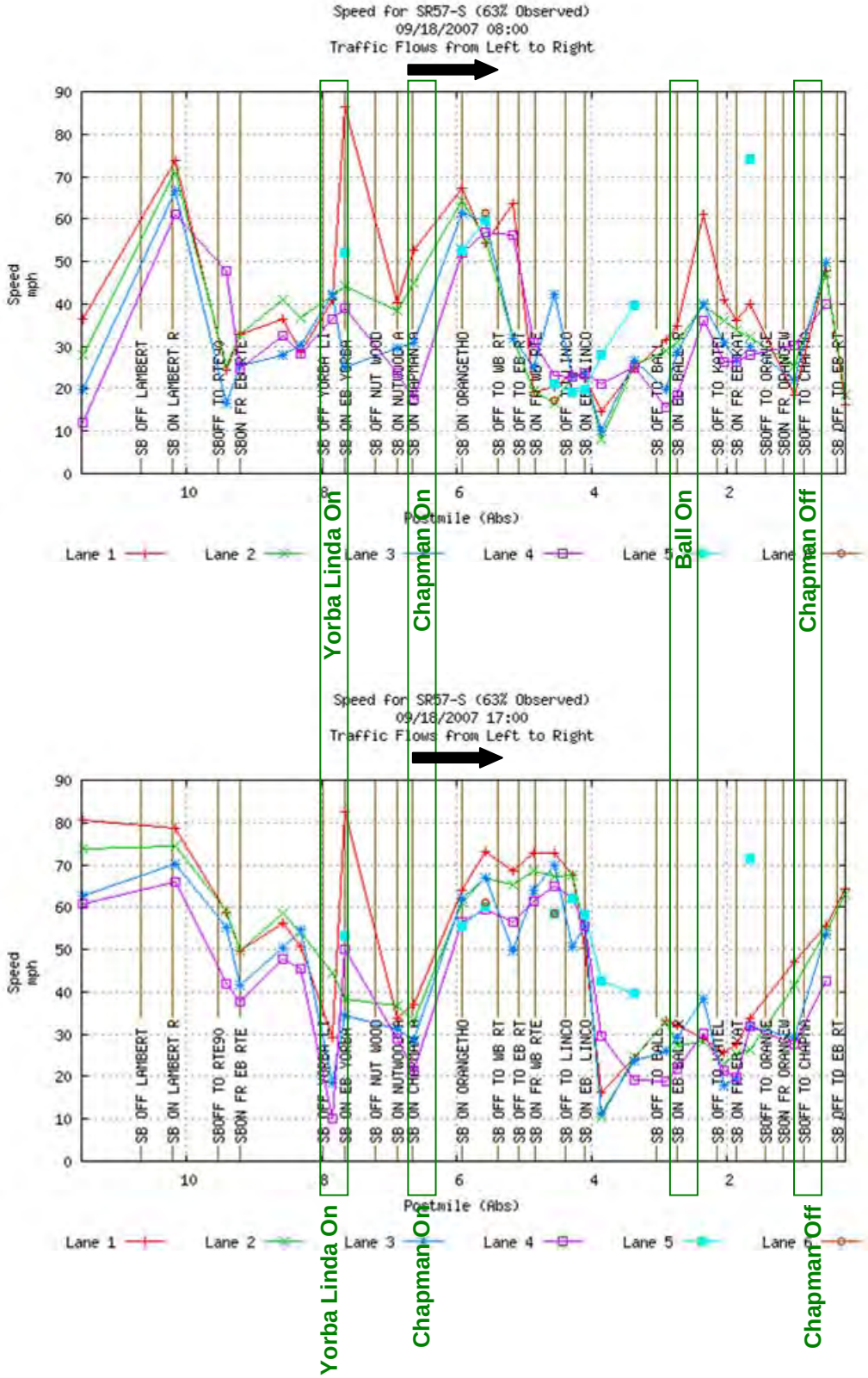


Exhibit A4-11: PeMS Southbound SR-57 Speed Contour Plots – April 2007

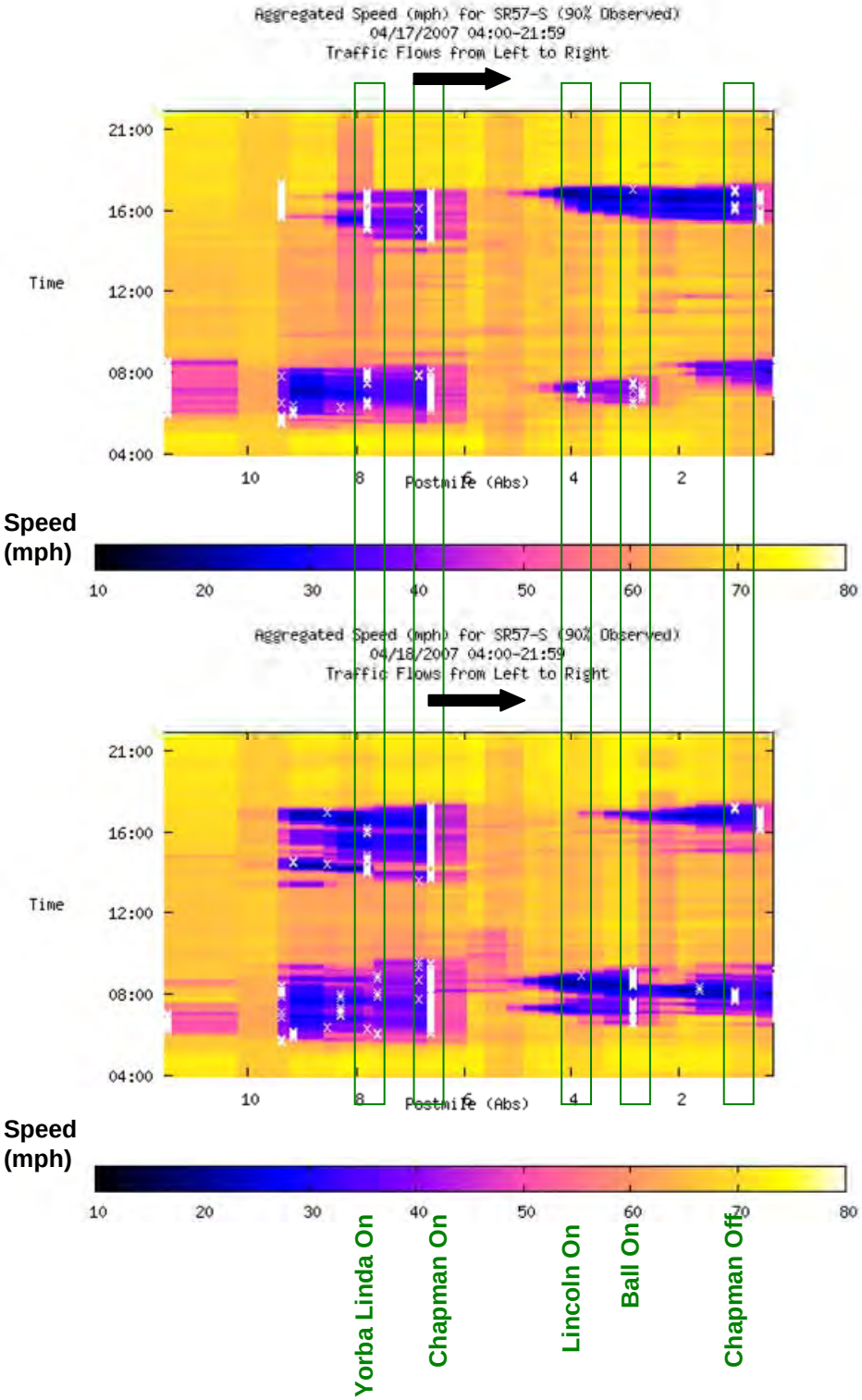
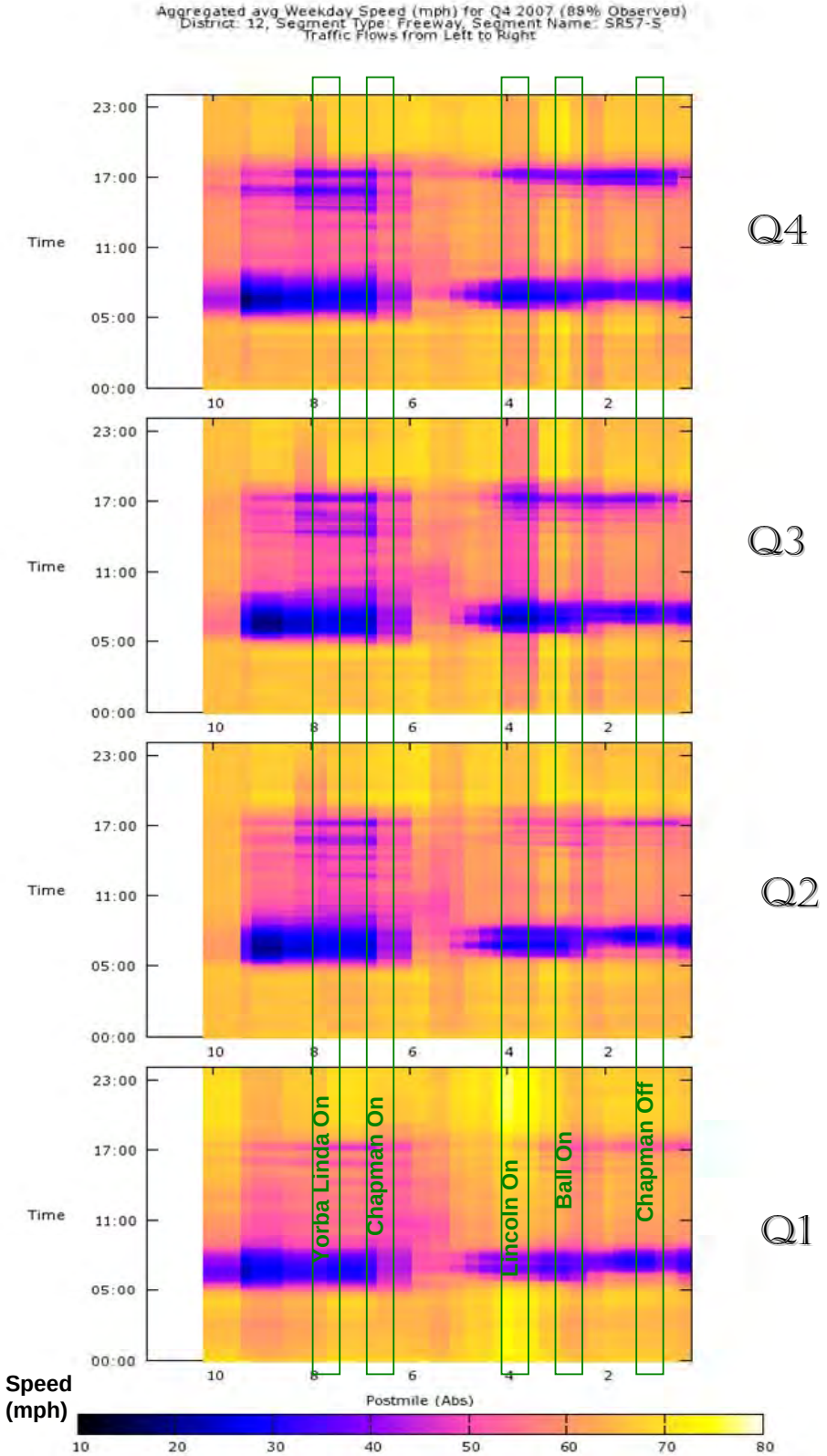


Exhibit A4-12: PeMS Southbound SR-57 Long (Speed) Contours – 2007 Avg. by Qtr.



Bottleneck Summary

Exhibit A4-13 provides a summary of the potential bottleneck locations based on the various sources: 2007 HICOMP report, Caltrans District 12 probe vehicle runs, and PeMS speed plots and speed contour plots. These locations have not been field verified. Additional data and/or extensive field reviews will be necessary to confirm their actual locations and identify the causes of these bottlenecks.

Exhibit A4-13: SR-57 Bottleneck Summary

	Bottleneck Area		HICOMP [a]		Caltrans [b]		PeMS [c]	
	Post Mile Range		Report		Probe Vehicle Runs		Speed Contours	
BOTTLENECK LOCATION	Caltrans	Absolute	AM	PM	AM	PM	AM	PM
NORTHBOUND								
Orangethorpe Ave on-ramp	16.60	5.89	√	-	√	√	√	√
Imperial Hwy on-ramp	19.81	9.20	-	-	-	√	-	√
Lambert Rd on-ramp	21.15	10.49	-	-	-	√	-	√
Tonner Canyon Rd	22.06	11.30	-	√	-	-	-	-
SOUTHBOUND								
Yorba Linda Bl on-ramp	18.18	7.64	-	-	-	√	√	√
Chapman Ave on-ramp	17.18	6.64	-	-	√	√	√	√
Lincoln Ave on-ramp	14.80	4.20	-	-	√	√	√	√
Ball Rd on-ramp	13.20	2.70	-	-	√	-	√	-
Orangewood Ave off-ramp	11.99	1.44	-	-	-	√	-	-
Chapman Ave off-ramp	11.40	0.86	√	√	-	√	√	√

NOTES:

[a] Based on 2007 HICOMP Report.

[b] Based on Caltrans District 12 sample problem vehicle runs, as part of Highway Congestion Monitoring Program (HICOMP) conducted May 10, 2007.

[c] Based on Performance Measurement System (PeMS) sample daily speed contours taken from April 2007 and September 2007, and quarterly weekday averages from 2007 data.

\- No indication of bottleneck from this source.