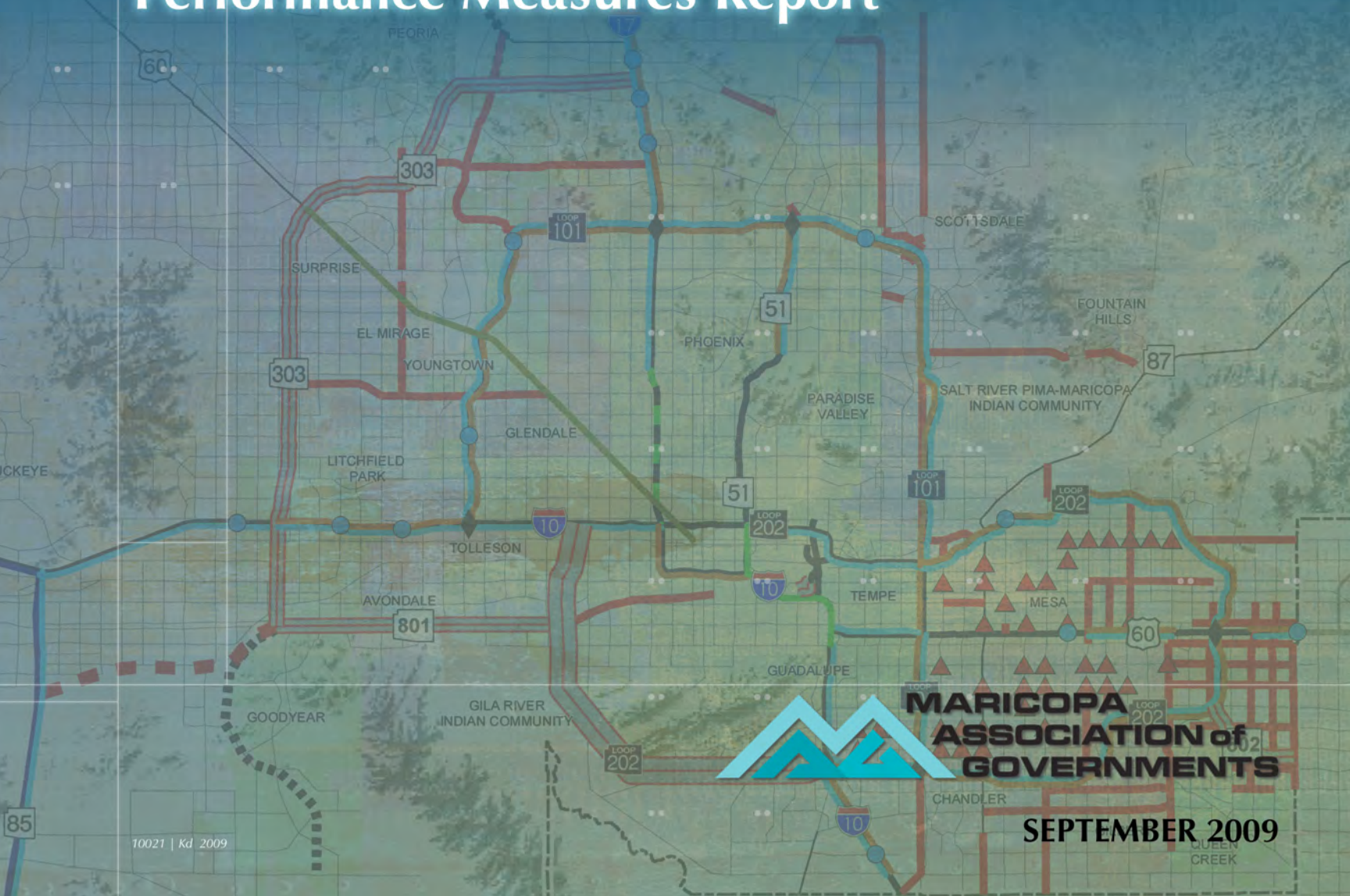
Performance Measurement Framework and Congestion Management Update Study

Phase II
Performance Measures Report



MARICOPA ASSOCIATION of GOVERNMENTS

SEPTEMBER 2009

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Performance Measurement Framework and Congestion Management Update Study

Phase II – Performance Measures Report

Prepared for:

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September 2009

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1.0 Introduction

1.1 DEVELOPING AND APPLYING A PERFORMANCE MEASUREMENT FRAMEWORK

The Maricopa Association of Governments (MAG) has developed a Performance Measurement Framework to illustrate the most important characteristics associated with the status of surface transportation in the MAG region. The purpose of this framework is to:

- Enhance planning and programming decision-making processes by enabling MAG to better monitor and evaluate progress toward the achievement of strategic goals
- Provide the tools necessary to better understand regional trends in transportation system performance
- Provide a factual basis to better inform policy-makers based on objectives-based, performance driven planning

A table displaying the complete set of the measures that currently make up the MAG Performance Measurement Framework is provided in Appendix A. A subset of these performance measures were selected for inclusion in this Example Report based on the availability of data during 2006 and 2007. The performance measures addressed in this report include the following:

- Limited Access Highway and High Occupancy Vehicle (HOV) Lane Performance
  - Access and Mobility Measures
    - Throughput – Vehicle (Annual Average Daily Traffic (AADT) and Annual Average Weekday Traffic (AAWDT))
    - Throughput – Freight (Estimated Truck Volume)
    - Lost Productivity (Percent of Productivity Lost)
    - Per Capita Vehicle-Miles of Travel (VMT)
  - Travel Time, Travel Time Variability, and Delay Measures
    - Speed (Average Corridor and Point-based Speeds)
    - Point-to-Point Travel Times (Average Commute Time)
    - Travel Time Variability (Average Travel Time, Travel Time and Buffer Indices, and 80th /95th percent travel times)
    - Extent of Congestion (Percent of Time Congested)
  - Safety Measures
    - Crash/Injury/Fatality Rates on Freeways (Crashes per Million VMT)
    - Crash/Injury/Fatality Totals for Large Truck-Involved Crashes on Freeways (Total Number of Truck-Involved Crashes)

- Arterial Performance
  - Access and Mobility Measures
    - Throughput – Vehicle (Weighted Corridor Throughput)
  - Travel Time, Travel Time Variability, and Delay Measures
    - Spatial Extent of Congestion (Percent of Time Congested)
  - Safety Measures
    - Intersection Crash Ranking (25 intersections with highest crash severity scores)
    - Crash/Injury/Fatality Totals for Large Truck-Involved Crashes on the Arterial System (Total Number of Truck-Involved Crashes)
- Transit Performance
  - Access and Mobility Measures
    - Transit Boardings (Total Number of Annual Transit Boardings)
    - Boardings per Revenue Mile (Total Number of Annual Transit Boardings / Total Number of Transit Agency Revenue Miles)
  - Travel Time, Travel Variability, and Delay Measures
    - Transit On-Time Performance (Percentage of "On-Time" Trips)
  - System Accessibility and Modal Options Measures
    - Percent of Park and Ride Capacity Used (Percentage of Parking Capacity Utilized)
    - Vehicle Revenue Miles of Transit Service per Agency (Total Revenue Miles of Transit Service)
    - Subsidy Per Boarding (Operating Cost Per Boarding Minus Fare Collected)
    - Transit Share of Travel (Estimate of the Percentage of Total Commuter Trips Made Using Transit)
- Bicycle/Pedestrian Performance
  - Safety Measures
    - Bicycle and Pedestrian Crash Totals for the MAG Region (Total Number of Crashes Involving Bicycles or Pedestrians)
  - System Accessibility and Modal Options Measures
    - Bicycle and Pedestrian Share of Travel (Estimate of the Percentage of Total Commuter Trips Made by People on Bicycles or Pedestrians)
- Quality of Life Performance
  - Single Occupancy Vehicle Commuter Trip Reduction Measures
    - Participation in MAG Region Trip Reduction Program (Total Number of Program Participants)

A large amount of data is collected annually in the MAG region related to the movement of people, goods, and services. Data from the Arizona Department of Transportation's (ADOT) Freeway Management System (FMS) is collected continuously seven days a week, twenty-four (24) hours per day, 365 days per year, from sensors and other systems that detect and record the movement of vehicles across a large portion of the MAG region. In addition, traffic data is collected on arterial roadways through both permanent and temporary counting stations deployed by a variety of MAG member agencies. Moreover, periodic studies are conducted to collect information on topics such as the average number of people in cars, the proportion of trucks on the roadways, and levels of congestion on the freeways. The challenge is to make sense of it all – to create a compelling story that informs citizens who use the facilities and community leaders who are asked to make decisions regarding both current and future infrastructure improvements, management, and operation of the transportation system.

This report is intended to provide a snapshot of how the transportation system is currently performing, as well as highlight interesting attributes and facts regarding its performance. Although this report will not present solutions to the region's transportation problems, the information contained herein will serve the public and assist elected officials and other leaders in making decisions regarding future transportation related investments. In particular, the Performance Measurement Framework will be incorporated into MAG's Congestion Management Process (CMP), which will serve as a component of the region's long-range planning process. The CMP will identify congested locations, attempt to determine the causes of congestion, and suggest strategies for mitigating that congestion. The CMP will also assess the potential impacts of various congestion mitigation strategies, both positive and negative, and propose packages of project-related improvements for use in moderating conditions at congestion hotspots and along heavily congested corridors.

1.2 LINKING PERFORMANCE MEASURES TO REGIONAL GOALS

The Regional Transportation Plan is based on four core regional goals:

1. System Preservation and Safety: Transportation infrastructure that is properly maintained and safe, preserving past investments for the future

2. Access and Mobility: Transportation systems and services that provide accessibility, mobility and modal choices for residents, businesses and the economic development of the region

3. Sustaining the Environment: Transportation improvements that help sustain our environment and quality of life

4. Accountability and Planning: Transportation decisions that result in effective and efficient use of public resources and strong public support

These goals, and the fifteen (15) regional objectives that support them, played a major role in the development of the Performance Measurement Framework. MAG also convened a Technical Advisory Group (TAG) composed of representatives from member jurisdictions and operating agencies to ensure that a wide range of interests and concerns were reflected in the Framework.

This report should be considered to be a "living" document that will evolve over time as performance measures are added to or removed from the regional framework and new techniques for presenting information are introduced that can more effectively highlight the transportation-related challenges facing the MAG region.

1.3 REPORT ORGANIZATION

This report contains the following key sections:

1.0 Introduction (current section) – This section outlines the content of the report, including background information concerning the MAG Regional Performance Measurement Framework and a description of how performance measures are linked to MAG's core regional goals and objectives.

2.0 Limited Access Highway & HOV Lane Performance – This section includes descriptions of the region's freeway network and FMS system, as well as maps, charts, and tables that illustrate access, mobility, travel time, travel time variability, delay, and safety-related performance on select freeway corridors.

3.0 Arterial Performance – This section includes a description of the region's network of arterial roadways, as well as maps, charts, and tables that illustrate access, mobility, travel time, delay, and safety-related performance on select arterial corridors.

4.0 Transit Performance – This section includes a description of the regional transit system, as well as maps, charts, and tables that illustrate access, mobility, travel time, reliability, delay, system accessibility, modal options, and quality of life-related performance on the regional transit network.

5.0 Bicycle/Pedestrian Performance – This section includes an overview of the regional bicycle/pedestrian network, as well as charts and tables that illustrate safety, system accessibility, and modal option-related performance on the regional bicycle/pedestrian network.

6.0 Quality of Life Performance – This section includes a description of transportation demand management activities being undertaken in the MAG region, as well as a table describing participation in the county's trip reduction program.

2.0 Limited Access Highway and HOV Lane Performance

2.1 SYSTEM DEFINITION

2.1.1 MAG Regional Freeway Network

The freeway system in Maricopa County encompasses fifty-three (53) miles of Interstate highway, and one-hundred and sixty-three (163) miles of other freeways and expressways. Interstate highways include I-10 (the Maricopa/Papago Freeway – extending from south of Phoenix and continuing west toward California) and I-17 (the Black Canyon Freeway – coming south from Flagstaff and terminating in Phoenix). Other important freeways and expressways include: U.S. 60 (the Superstition Freeway), Loop 202 (the Red Mountain/Santan Freeway), Loop 101 (the Price/Pima/Agua Fria Freeway), SR 51 (the Piestewa Freeway), and SR 143 (the Hohokam Expressway).

As with most urban freeway systems, the chief problem on freeways in the MAG region is related to roadway congestion. Congestion is typically characterized by slower-than-desired speeds, increased travel times, increased vehicle crashes, and increased operating costs. Lost productivity due to congestion costs approximately $100 billion each year in the U.S. Vehicle crashes—many caused by congestion—drain another $70 billion per year[1]. According to the Texas Transportation Institute's 2009 Annual Urban Mobility Report, congestion in the greater Phoenix metropolitan area cost (based on wasted time and fuel) $1.89 billion in 2007. The average cost of congestion per traveler during 2007 was $1,034.

2.1.2 ADOT Freeway Management System (FMS)

To better manage congestion in the region, ADOT has deployed an integrated package of intelligent transportation system (ITS) tools and strategies commonly referred to as a Freeway Management System (FMS). Initially becoming operational in 1996, the FMS currently includes a core system that combines mainline and HOV lane vehicle detection, ramp metering, variable message signs (VMS), closed circuit television (CCTV), and an overarching communications system, all connected to the ADOT Traffic Operations Center (TOC). Other ITS-oriented tools currently operated by ADOT and its regional partners include: the statewide 511 Traveler Information System, the Highway Condition Reporting System (HCRS), the Regional Community Network (to support enhanced interagency communication and sharing of video and data), and the Regional Archived Data System (RADS).

As of 2009, the FMS covers approximately 130 miles of the region's freeways, expressways, and Interstates, with another 37 miles currently in design for near-term construction. According to

[1] Source: ADOT ITS, http://www.az511.com/Documents/adot_its.pdf

the MAG 2007 Regional Transportation Plan (RTP) Update, FMS coverage is expected to grow to 225 miles by 2023.

The objectives of the FMS include[2]:

- Make optimum use of the freeway system by employing effective freeway management techniques
- Provide a safe and efficient environment for the freeway users
- Manage freeway incidents, special events, and abnormal conditions
- Implement the infrastructure needed for long-term ITS enhancements of freeway system
- Operate a system that builds and maintains credibility with the motoring public
- Provide automatic sharing of freeway information with adjacent jurisdictions as well as control of traffic-interchange signals
- Centralize the management of the freeway system

According to ADOT, similar systems elsewhere in the U.S. have reduced accidents by 25 percent, and can reduce peak emissions by 10 percent. Other benefits of the FMS include:

- Reduces congestion by identifying and determining the nature of incidents so that they can be quickly cleared
- Saves lives, time, and money
- Improves safety, reduces congestion, enhances mobility, minimizes environmental impact, and saves energy
- Minimizes or eliminates freeway breakdown conditions during peak periods,
- Maximizes the utilization of physical capacity and increases vehicle throughput.
- Rapid detection and clearing of accidents helps to reduce congestion and the secondary collisions that frequently occur and cause additional delay

2.1.3 Freeway Network Definition for Performance Reporting

The following freeways, expressways, and Interstates (hereafter referred to as limited access highways), were selected for inclusion in this report based on the coverage of the ADOT FMS during 2006 and 2007:

- I-10 from 83rd Avenue to Chandler Boulevard
- I-17 from Maricopa Traffic Interchange (TI) to Peoria Avenue
- SR 51 from I-10/Loop 202 to Bell Road
- Loop 202 from I-10/SR 51 to Loop 101
- U.S. 60 (Superstition Freeway) from I-10 to Gilbert Road/Val Vista Drive
- Loop 101 from Guadalupe Road to Loop 202
- SR 143 from I-10 to Loop 202–McDowell Road

[2] http://www.az511.com/Documents/adot_its.pdf

To support corridor-level performance reporting, these limited access highways were divided into analysis corridors with limits as indicated in Table 2.1. A map depicting the analysis corridors is displayed in Figure 2.1. For the purposes of reporting, these corridors will be labeled A through M as shown on the table. Corridor-level performance reporting will provide an indication of where deficiencies exist, as well as facilitate the analysis and prioritization of specific congestion mitigation strategies as part of the MAG Congestion Management Process (CMP). As the ADOT FMS is expanded to include other limited access highways, performance data from these newly instrumented corridors will be included as part of future versions of this report.

High Occupancy Vehicle (HOV) lane performance is reported separately for the analysis corridors that contain HOV lane coverage. These corridors are depicted using dashed lines on the map in Figure 2.2; specific limits are indicated in Table 2.1. The hours of HOV operation are from 6:00 – 9:00 AM and from 3:00 – 7:00 PM on weekdays on all corridors. The Loop 101 and SR 143 currently do not have HOV operations within the study area.

Table 2.1 Limited Access Highway and HOV Lane Analysis Corridors

Corridor ID	Corridor Limits	Length in Miles[3]	HOV lanes along this corridor as of 2007
A	I-10 Papago: 83rd Ave to I-17	7.9	Yes
B	I-10 Papago: I-17 to SR 51	4.3	Yes
C	I-10 Maricopa: SR 51 to U.S. 60	6.4	Yes
D	I-10 Maricopa: U.S. 60 to Chandler Boulevard	6.9	Yes
E	I-17: Maricopa Traffic Interchange to I-10	5.9	No
F	I-17: I-10 to Peoria Avenue	8.8	Partial[4]
G	SR 51: I-10/Loop 202 to Glendale Avenue	5.7	Yes
H	SR 51: Glendale Avenue to Bell Road	7.8	Partial[5]
I	Loop 202: I-10/SR 51 to Loop 101	10.0	Yes
J	U.S. 60: I-10 to Loop 101	4.0	Yes
K	U.S. 60: Loop 101 to Val Vista Drive	8.9	Yes
L	Loop 101: Guadalupe Road to Loop 202	5.3	No
M	SR 143: I-10 to Loop 202/McDowell Road	3.7	No

Source: Maricopa Association of Governments – 2007 Base Network

[3] Corridor lengths in this table are approximate. Performance measure reporting will be based on exact lengths, which vary by direction of travel due to slight differences in detector location for opposing general-purpose and HOV lanes.

[4] For corridor F, I-17: NB HOV lanes are from McDowell Road to Peoria Avenue (8.1 miles), while SB HOV lanes are from Peoria Avenue to Thomas Road (7.1 miles)

[5] For corridor H, SR 51: HOV lanes are from Glendale Avenue to E. Shea Blvd. (3.5 miles)

Figure 2.1

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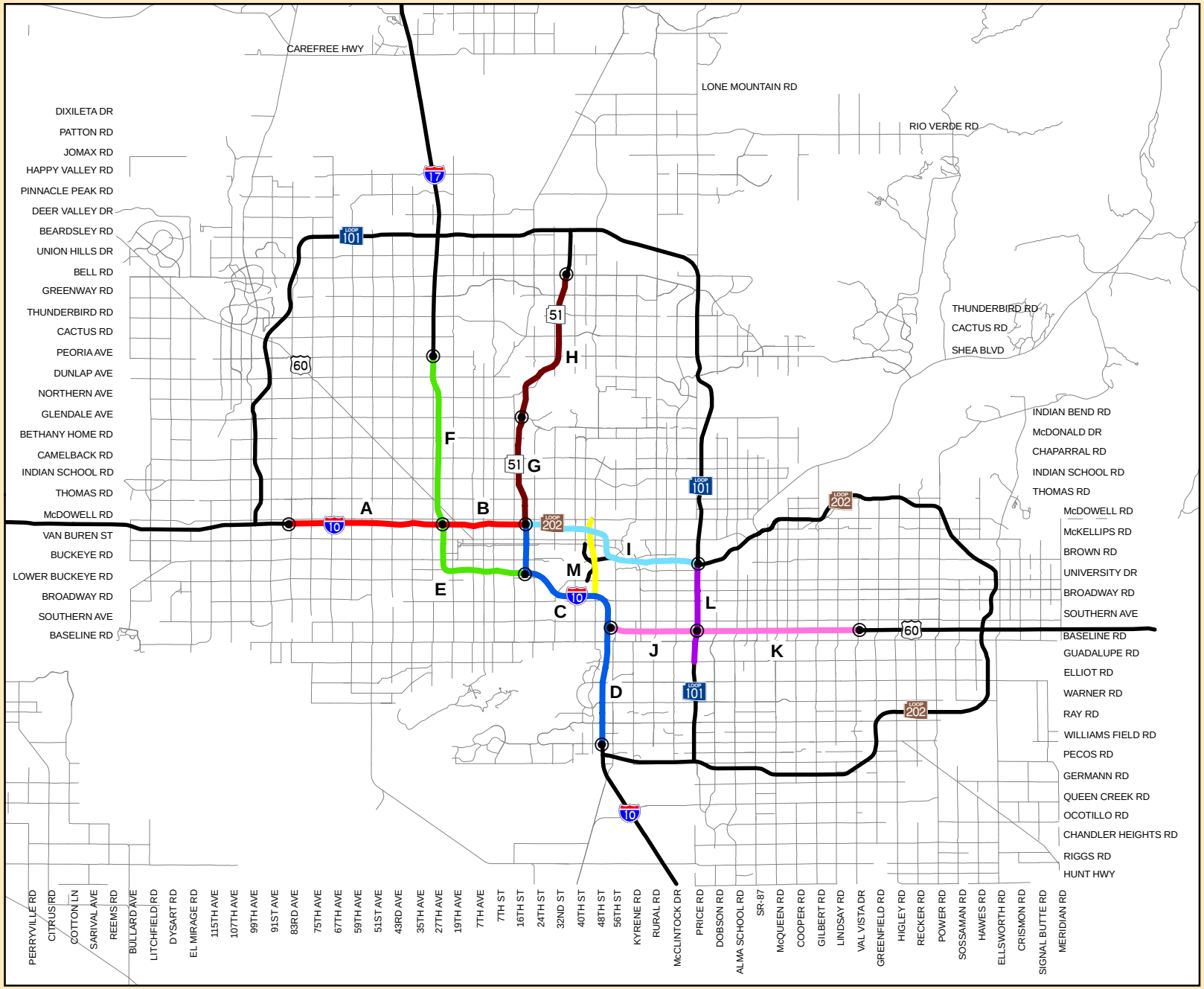
Performance Measures Study

Limited Access Highway Study Limits



Legend

Limited Access Highways (2007)

- I-10 Papago
- I-10 Maricopa
- I-17
- Loop 101
- SR 143
- Loop 202
- SR 51
- US 60
- Freeways (non-instrumented)
- Major Roads
- Breakpoint For Throughput Analysis
- A Analysis Corridor ID

While every effort has been made to ensure the accuracy of this information, the Maricopa Association of Governments makes no warranty, expressed or implied, as to its accuracy and expressly disclaims liability for the accuracy thereof.

0 5 10 15 20 Miles

N

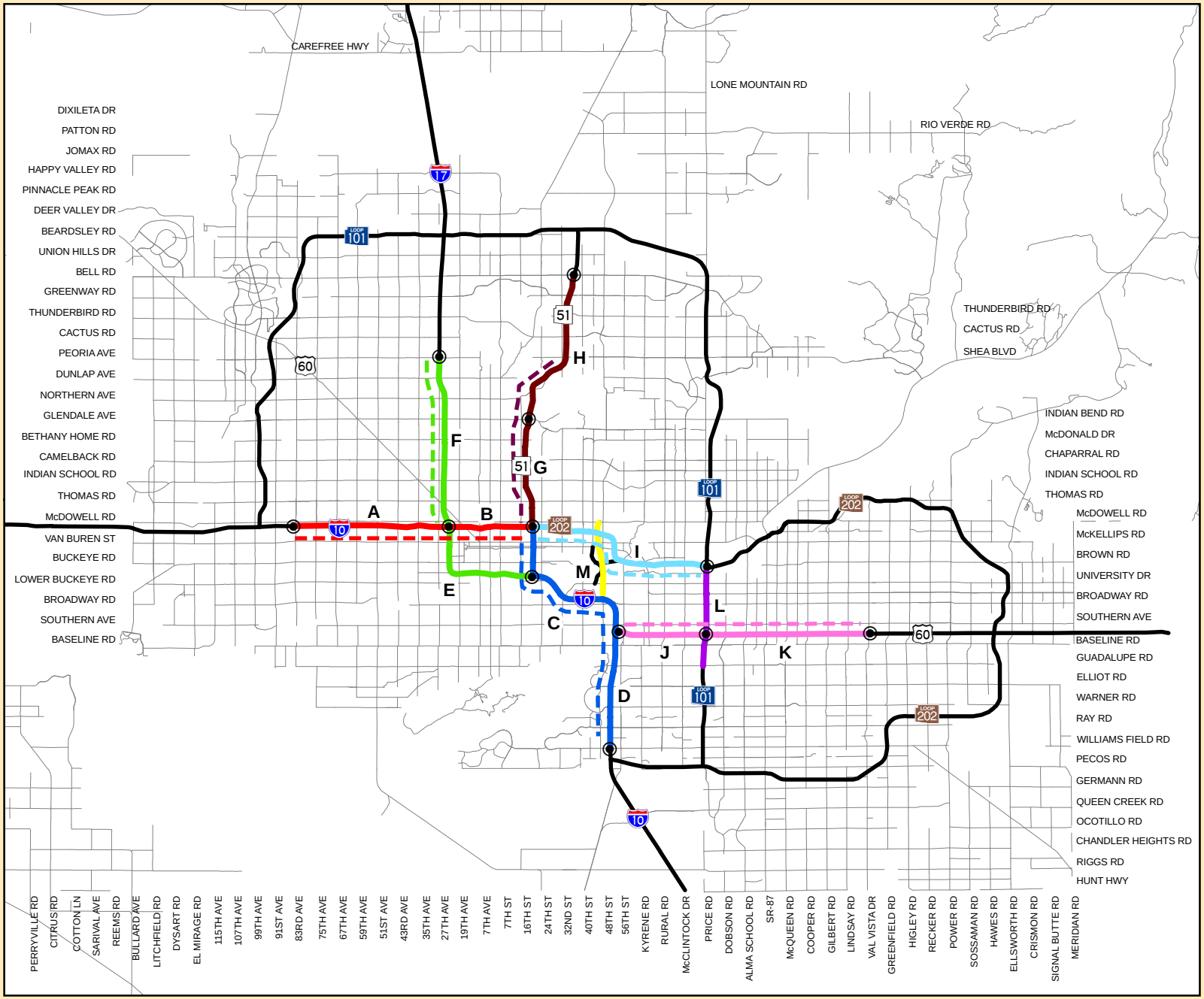
Source: Maricopa Association of Governments

Figure 2.2

MARICOPA ASSOCIATION of GOVERNMENTS

Performance Measures Study

Limited Access Highway HOV Lanes



Legend

Limited Access Highways (2007)

- I-10 Maricopa HOV Lane
- I-10 Papago
- I-17
- Loop 202
- SR 51
- US 60
- Loop 101
- SR 143
- Freeways (non-instrumented)
- Major Roads
- Breakpoint For Throughput Analysis
- A — Analysis Corridor ID

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Source: Maricopa Association of Governments

2.2 METHODOLOGY FOR BASE FREEWAY DATA SET

To facilitate the calculation of freeway performance measures, a base data set was derived for 2006 and 2007 using traffic data from the ADOT FMS. Most of the performance measures in Section 2 of this report were derived from this base data set. This section describes the data collection, quality control, and data analysis procedures used to derive the base data sets for the 2006 and 2007 analysis years.

2.2.1 Data Collection

A major component of the ADOT FMS is traffic detection. When the FMS was initially implemented, it was designed to cover the most congested parts of the freeway system (about 50% of the system), with 519 in-pavement loop detectors or passive acoustic detectors placed at roughly one-third mile intervals that covered 86.5 centerline-miles of freeway in the Phoenix region. However, a review of the FMS in 2006 identified the need for increased maintenance and/or replacement of aging detectors as essential for improving the reliability of the system. Limited resources have prevented maintenance of the entire sensor system, and as a result, the number of sensors has gradually declined to 199 spaced at roughly 1-mile intervals. Of these 199 detectors, 58 detectors (spaced at roughly 3-mile intervals) receive priority maintenance. When aging detectors are replaced, passive-acoustic detectors are used in lieu of in-pavement detectors to save on installation and maintenance costs.

At each of the 199 detector stations, speed, volume and lane occupancy data are collected every 20 seconds on a lane-by-lane basis for all general-purpose lanes at that location, as well as for HOV lanes. Although data is collected at 20-second intervals, ADOT aggregates the data into 5-minute summaries for permanent storage. Data is collected 24 hours per day, 365 days per year.

Lane-by-lane volume, speed, and lane occupancy percentage data in 5-minute intervals were obtained for ADOT FMS detector locations for each day of each analysis year. The daily data were in the form of ASCII text files, which were imported into Statistical Analysis Software (SAS) for data processing.

2.2.2 Data Validity and Quality Control

Using SAS, a series of 13 data validity and quality control checks were applied to identify questionable or suspect data. These checks are consistent with the data quality procedures used for FHWA's Mobility Monitoring Program. More detail on these checks is included in Appendix A. In conducting the data quality checks, it was evident that there were sensor outages or other events that caused data to be missing at various dates and times. These include the following locations:

- STN 1141, I-10 WB HOV at Fillmore Street (Milepost 147.937)
- STN 1092, I-10 WB HOV North of Buckeye (Milepost 148.897)
- STN 1041, I-10 WB HOV at 25th Street (Milepost 150.26)
- STN 1047, I-10 WB HOV West of 32nd Street/University Drive (Milepost 151.473)

The data for detector stations 1041 and 1141 was missing for the entire year for both 2006 and 2007. While evaluating the performance measure results for 2006, it was apparent there were additional problems on I-10 westbound in the HOV lane at detector stations 1092 and 1047. These locations had lane occupancy percentages of 100% (or near 100%) throughout most of the day. After reviewing various options for dealing with this issue, a decision was made that the development of performance measurement data for these locations would occur based on the removal of bad data, replacing it with data interpolated from available data stations. The other statistically valid alternative that was not selected would have been to insert "no data available" notations for the missing sections to indicate the geographic extent of the missing data.

2.2.3 Data Analysis

Using SAS, the lane-by-lane detector volumes and speeds were translated into station-, link- and corridor-level statistics using the following steps:

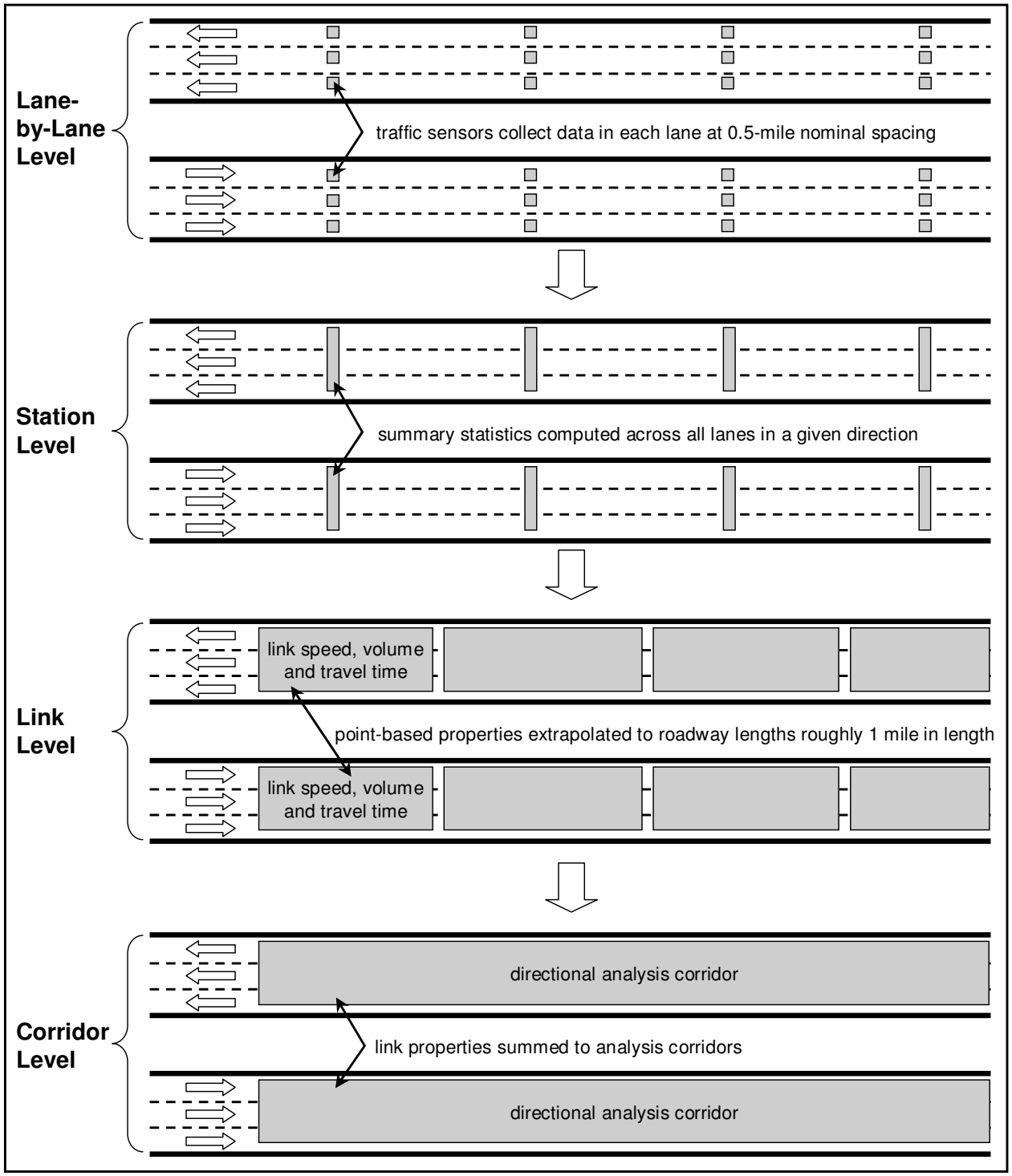
For each 5-minute time period of each day, the lane-by-lane data at each detector location were combined into a station across all lanes in a direction. Traffic volumes were summed across all lanes, while a weighted average speed was calculated based on respective traffic volumes in each lane. The weighted average speeds represent the time-mean speeds at a specific station.

The 5-minute station data were expanded to links by assuming that each detector had a zone of influence equal to half the distance to the detectors immediately upstream and downstream from it. The measured speeds and volumes were assumed to remain constant within each zone of influence, and travel times along each link were calculated by dividing the equivalent link length by the average travel speed.

The 5-minute link data were aggregated with adjacent links to form the analysis corridors listed in Table 2.1. The beginning and end points of the analysis corridors were based on logical breakpoints such as major highway interchanges or other locations where traffic conditions were expected to change because of traffic or roadway characteristics. They range from 3.7 to 10 miles in length. Corridor travel times for each 5-minute interval were calculated as the summary of link travel times. Whenever a link travel time was missing, the whole corridor travel time for that 5-minute interval was set to a null value. In order to minimize the harmonic fluctuations associated with speed data, an average corridor speed for each 5-minute interval was calculated as the corridor length divided by corridor travel time. These speeds represent space-mean speeds across the analysis corridor.

Figure 2.3 illustrates the process whereby lane-by-lane detector volumes and speeds were expanded into analysis corridors. This process resulted in three distinct datasets consisting of 5-minute volume, speed, and travel time statistics at the station-, link- and analysis corridor level for each day of the analysis year. This data served as the base data set for all subsequent access, mobility, travel time, travel time variability, and delay performance measures. Separate base data sets were prepared for each analysis year (2006 and 2007).

Figure 2.3 Evolution of Detector-Level Data into Analysis Corridors



Other analysis parameters used in preparing the base data sets for performance analysis included the following:

- With the exception of throughput measures, only weekday data (Monday through Friday) are included in the analysis.

- With the exception of throughput measures, holidays were excluded from the analysis, as they are considered atypical of normal travel patterns. These holidays include the following:
  - New Year's Day
  - Martin Luther King, Jr. Day
  - President's Day/Washington's Birthday
  - Memorial Day
  - Independence Day
  - Labor Day
  - Thanksgiving Day (and the day after)
  - Christmas (and the day before or after, depending on day of week)
  - New Year's Eve Day
- The periods for analysis were defined as follows:
  - AM peak period: 6:00 AM to 9:00 AM
  - Midday period: 9:00 AM to 3:00 PM
  - PM peak period: 3:00 PM to 7:00 PM

2.3 LIMITED ACCESS HIGHWAY AND HOV LANE PERFORMANCE MEASURES

2.3.1 Access and Mobility Measures

Background: Access and mobility measures provide fundamental information on how effective the freeway system is in moving people and goods into, through and within the region. Information is provided on how many vehicles traverse the general-purpose and HOV lanes.

2.3.1.1 Throughput – Vehicle

Definition: Vehicle throughput is defined as the number of vehicles traversing a freeway. Measures of vehicle throughput include the annual average daily traffic (AADT) volume and annual average weekday traffic (AAWDT) volume, both of which are reported in units of vehicles per day. According to the AASHTO Traffic Data Guidelines, AADT is defined as the estimated mean daily traffic volume including weekend traffic (i.e., it represents the total traffic volume divided by the number of days in the year (365)). AAWDT is the estimated mean traffic volume for weekdays (Monday-Friday) and does not include weekend travel volumes.

Objective: Increase vehicle volume throughput.

Source: Vehicle throughput was calculated using archived data from Arizona DOT's Freeway Management System. Volume data for freeways in areas not covered by the ADOT Freeway Management System may be obtained from other sources such as ADOT Multimodal Planning Division (MPD) Vehicle Counts and the 2006/2007 MAG Regional Traffic Volume Study. In addition, MAG publishes a Regional Volume Map that reports volume data for areas far beyond the extent of the ADOT Freeway Management System.

Time Scale: AM peak period (6:00 AM to 9:00 AM), Midday period (9:00 AM to 3:00 PM), PM peak period (3:00 PM to 7:00 PM), daily (24 hours), weekday (24 hours, excluding weekend days)

Methodology: Using SAS and the corridor-level base data set as a starting point, AADT is calculated by summing the 5-minute volumes over a 24-hour period for each day of the analysis year, and then calculating the average daily volume over all days for that year. As mentioned previously, the calculation of AADT includes all days of the analysis year, including weekends and holidays. AADT has been calculated separately for general-purpose (GP) lanes and HOV lanes for each direction of travel. The results for AADT were exported to ArcGIS and mapped on a systemwide map – see Figure 2.4 (GP lanes) and Figure 2.5 (HOV lanes). Station-level base data were aggregated in a similar manner and were used to pinpoint the detector station with the highest AADT volume along each analysis corridor on these maps. This was done because the highest volumes usually drive roadway performance (e.g., if a bottleneck exists, the volumes downstream of that bottleneck are typically reduced, and are therefore not a good measure of demand.) To add clarity, AADT results for both the general-purpose lanes and HOV lanes are also reported in chart format for 2006 and 2007, along with the percent change from 2006 (see Table 2.2).

Using a similar approach, AAWDT has been calculated in SAS by summing the 5-minute volumes over a 24-hour period for each weekday of the analysis year, and then calculating the average daily volume over all weekdays for that year. The calculation of AAWDT includes all holidays, but excluded weekend days. AAWDT has been calculated separately for general-purpose lanes and HOV lanes for each direction of travel. The results for AAWDT were exported to ArcGIS and mapped on a systemwide map – see Figure 2.6 (GP lanes) and Figure 2.7 (HOV lanes). Station-level base data were aggregated in a similar manner and were used to pinpoint the detector station with the highest AAWDT volume along each analysis corridor on these maps. AAWDT results for both the general-purpose lanes and HOV lanes are also reported in chart format for 2006 and 2007, along with the percent change from 2006 (see Table 2.3).

SAS has also been used to calculate average vehicle throughput per lane by hour for each analysis corridor A through M. Using the base data set as a starting point, the 5-minute volumes have been aggregated for each day of the analysis year. The average hourly volumes are then calculated over all days for that year. Average vehicle throughput by hour has been calculated separately for general-purpose lanes and HOV lanes for each direction of travel. The results for average vehicle throughput by hour have been exported to Microsoft Excel and graphed (see Figure 2.8 - one graph is included for each analysis corridor). The shading in these figures indicates the peak periods of travel.

In addition to the volume data contained in this section of the report, volume data for sections of the region's limited access highways not covered by the ADOT FMS can be found in Appendix B.

Explanation of Results and Analysis: As seen in Figure 2.4, average daily traffic volumes (AADT) on general-purpose lanes are highest on I-10 (Papago and Maricopa), U.S. 60 east of Loop 101, and on portions of Loop 101, with these corridors exhibiting volumes in excess of 75,000 vehicles per day. The highest average daily volumes (AADT) occur on I-10 Papago westbound from SR 51 to I-17, with an AADT of 99,928 vehicles per day (vpd) in 2007. Average weekday volumes (AAWDT) along this corridor are approximately 4 percent higher, with an AAWDT of 104,230 vpd in 2007. The lowest traffic volumes occur on northbound SR 143 (the Hohokam Expressway), with an AADT of 23,352 vpd and an AAWDT of 25,690 vpd in 2007. As seen in Tables 2.2 and 2.3, from 2006 to 2007, the largest volume increase occurred on Loop 101 northbound from Guadalupe Road to Loop 202. The largest decrease occurred on I-17 northbound from the Maricopa Traffic Interchange to I-10.

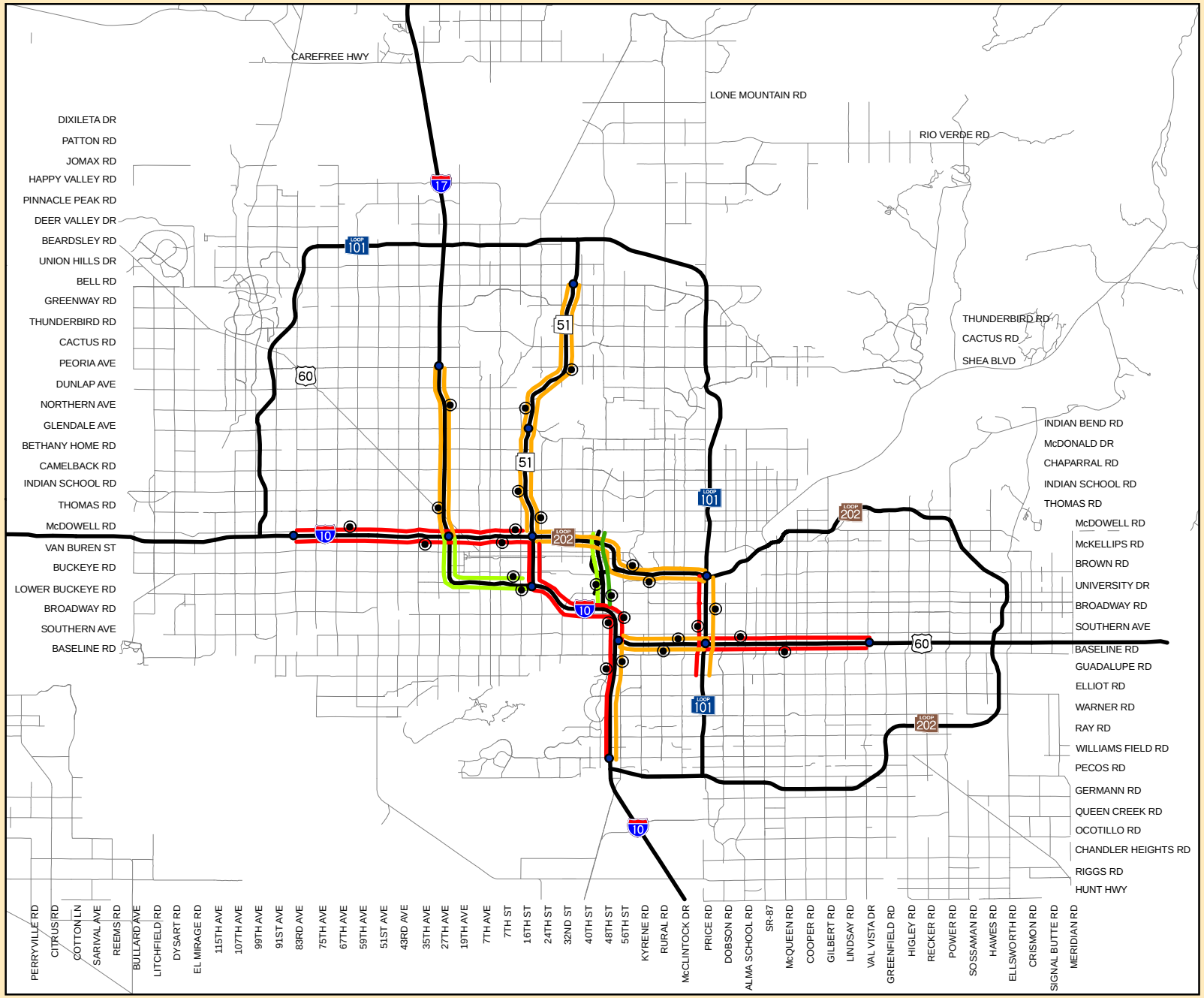
As seen in Figure 2.5, average daily volumes (AADT) on HOV lanes are highest on I-10 Papago eastbound from I-17 to SR 51, and on I-10 Maricopa eastbound from SR 51 to U.S. 60, with volumes in excess of 17,000 vpd. Average weekday volumes (AAWDT) along these corridors are approximately 8 percent higher, with AAWDT volumes of 19,339 vpd and 18,526 vpd, respectively. The lowest HOV lane volumes occur on SR 51 southbound from Glendale Avenue to I-10/Loop 202, with an AADT of 7,160 vpd and an AAWDT of 8,151 vpd in 2007. From 2006 to 2007, the largest volume increase occurred on SR 51 southbound HOV lanes from Bell Road to Glendale Avenue. The largest decrease occurred on U.S. 60 eastbound from I-10 to Loop 101.

Figure 2.4

MARICOPA ASSOCIATION of GOVERNMENTS

Performance Measures Study

Annual Average Daily Traffic Volumes General Purpose Lanes



Legend

Annual Average Vehicles Per Day (2007)

- < 25,000
- 25,000 - 49,999
- 50,000 - 74,999
- 75,000 - 100,000
- Freeways
- Major Roads
- Highest Volume
- Breakpoints

While every effort has been made to ensure the accuracy of this information, the Maricopa Association of Governments makes no warranty, expressed or implied, as to its accuracy and expressly disclaims liability for the accuracy thereof.

0 5 10 15 20 Miles

N

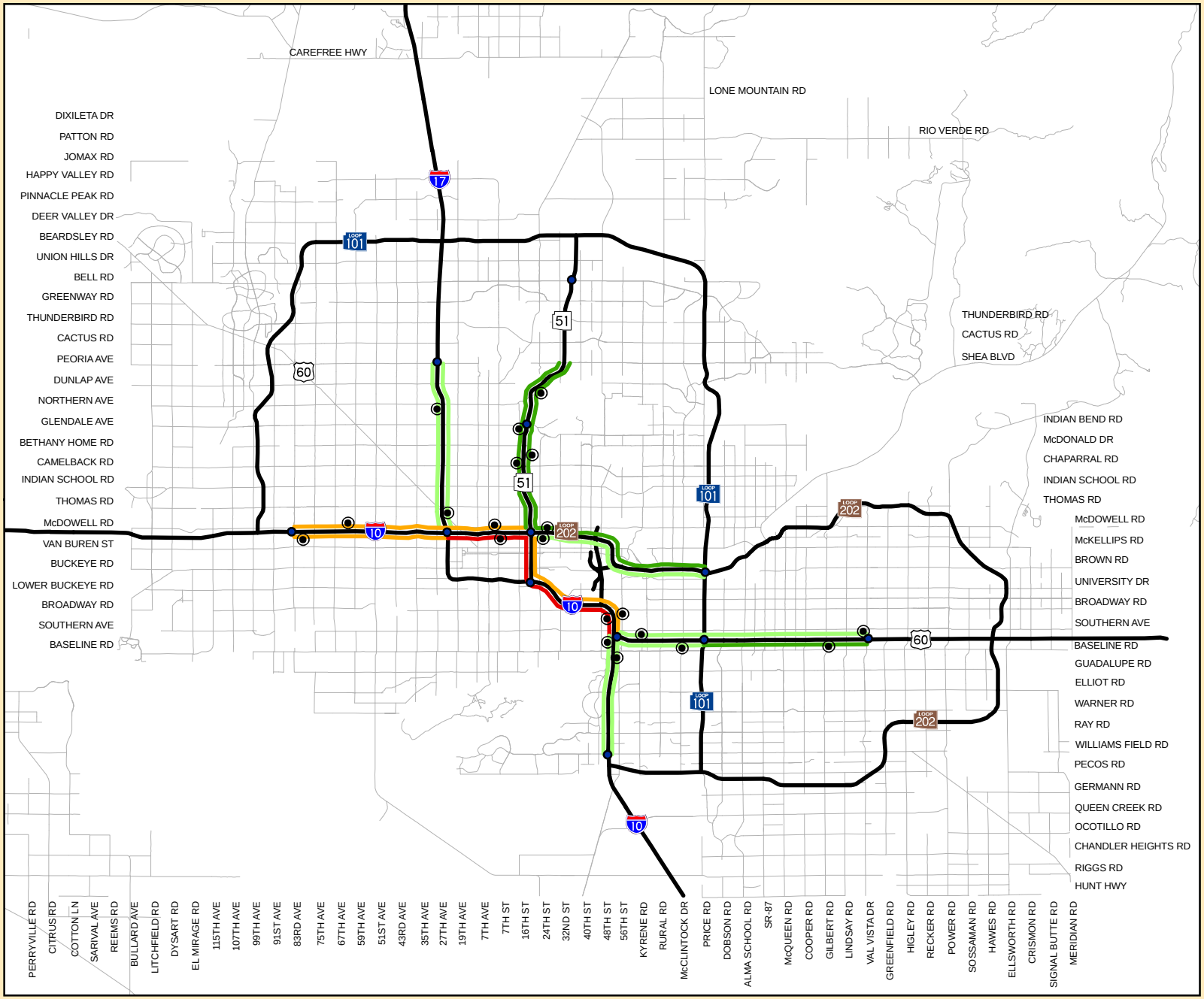
Source: Arizona DOT Freeway Management System

Figure 2.5

MARICOPA ASSOCIATION of GOVERNMENTS

Performance Measures Study

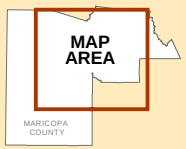
Annual Average Daily Traffic Volumes HOV Lanes



Legend

Annual Average Vehicles Per Day (2007)

- < 10,000
- 10,000 - 12,999
- 13,000 - 16,999
- 17,000 - 20,000
- Freeways
- Major Roads
- Highest Volume
- Breakpoints



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0 5 10 15 20 Miles

N

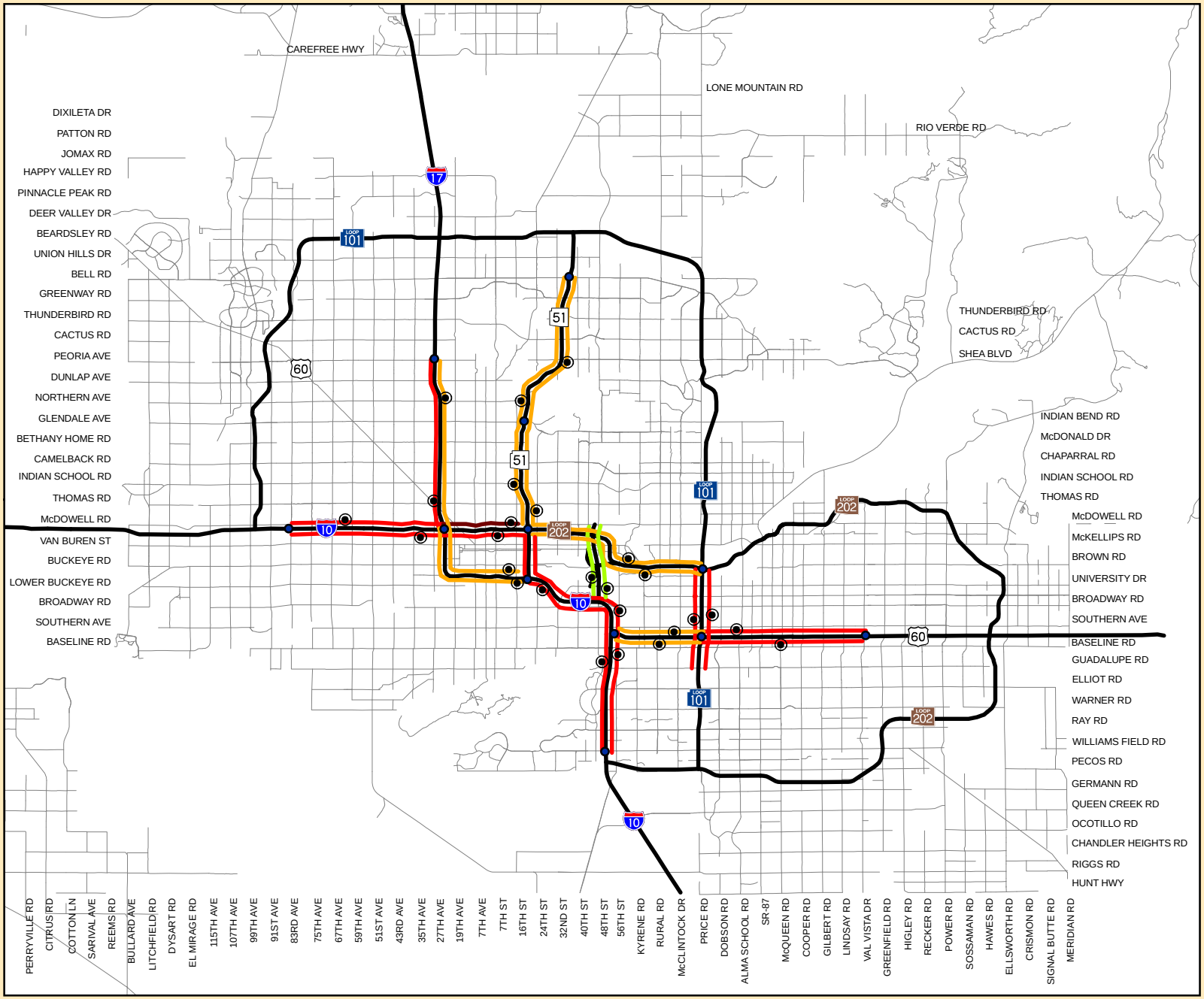
Source: Arizona DOT Freeway Management System

Figure 2.6

MARICOPA ASSOCIATION of GOVERNMENTS

Performance Measures Study

Annual Average Weekday Traffic Volumes General Purpose Lanes



Legend

Annual Average Vehicles Per Day (2007)

- < 25,000
- 25,000 - 49,999
- 50,000 - 74,999
- 75,000 - 100,000
- Freeways
- Major Roads
- Highest Volume
- Breakpoints

While every effort has been made to ensure the accuracy of this information, the Maricopa Association of Governments makes no warranty, expressed or implied, as to its accuracy and expressly disclaims liability for the accuracy thereof.

0 5 10 15 20 Miles

N

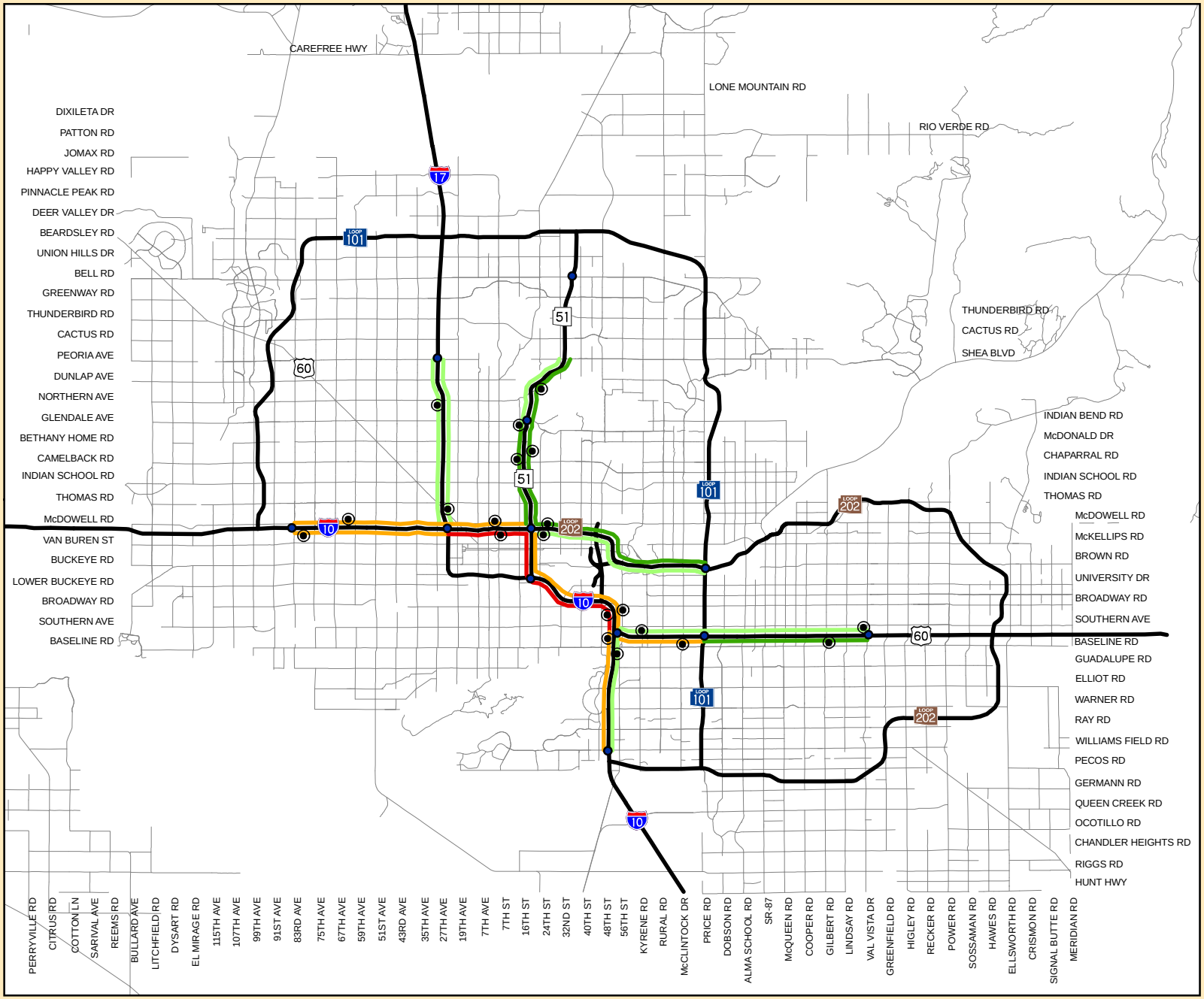
Source: Arizona DOT Freeway Management System

Figure 2.7

MARICOPA ASSOCIATION of GOVERNMENTS

Performance Measures Study

Annual Average Weekday Traffic Volumes HOV Lanes



Legend

Annual Average Vehicles Per Day (2007)

- < 10,000
- 10,000 - 12,999
- 13,000 - 16,999
- 17,000 - 20,000
- Freeways
- Major Roads
- Highest Volume
- Breakpoints

While every effort has been made to ensure the accuracy of this information, the Maricopa Association of Governments makes no warranty, expressed or implied, as to its accuracy and expressly disclaims liability for the accuracy thereof.

0 5 10 15 20 Miles

N

Source: Arizona DOT Freeway Management System

Table 2.2 Results for AADT by corridor and % change from 2006 – 2007

Corridor ID	Analysis Corridor	Dir	From	To	Annual Average Daily Traffic (AADT)					
					General-purpose Lanes			HOV Lanes		
					2006	2007	% Change	2006	2007	% Change
A	I-10 Papago	EB	81st Avenue	I-17	85,268	83,296	-2.3%	12,593	13,478	7.0%
		WB	I-17	82nd Avenue	88,262	90,287	2.3%	13,200	16,123	22.1%
B	I-10 Papago	EB	I-17	SR 51	87,893	89,302	1.6%	17,728	17,969	1.4%
		WB	SR 51	I-17	101,089	99,928	-1.1%	15,973	15,848	-0.8%
C	I-10 Maricopa	EB	SR 51	U.S. 60	84,374	85,638	1.5%	17,725	17,133	-3.3%
		WB	U.S. 60	SR 51	84,417	80,938	-4.1%	13,296	14,057	5.7%
D	I-10 Maricopa	EB	U.S. 60	Chandler Blvd	79,844	76,808	-3.8%	12,465	12,083	-3.1%
		WB	Chandler Blvd	U.S. 60	73,153	71,170	-2.7%	11,201	11,255	0.5%
E	I-17	NB	Maricopa TI	I-10	53,632	49,392	-7.9%	N/A	N/A	N/A
		SB	I-10	Maricopa TI	49,246	45,438	-7.7%	N/A	N/A	N/A
F	I-17	NB	I-10	Peoria Ave.	66,333	65,923	-0.6%	11,460	11,314	-1.3%
		SB	Peoria Ave.	I-10	77,104	72,398	-6.1%	11,947	12,174	1.9%
G	SR 51	NB	I-10/Loop 202	Glendale Avenue	58,945	59,088	0.2%	9,539	8,263	-13.4%
		SB	Glendale Avenue	I-10/Loop 202	54,914	56,179	2.3%	7,040	7,160	1.7%
H	SR 51	NB	Glendale Avenue	Bell Road	59,850	60,722	1.5%	7,521	8,321	10.6%
		SB	Bell Road	Glendale Avenue	57,928	59,944	3.5%	7,169	9,476	32.2%
I	Loop 202	EB	I-10/SR 51	Loop 101	65,995	67,603	2.4%	10,105	10,688	5.8%
		WB	Loop 101	I-10/SR 51	58,965	61,591	4.5%	8,541	9,143	7.0%
J	U.S. 60	EB	I-10	Loop 101	60,323	59,947	-0.6%	18,098	12,995	-28.2%
		WB	Loop 101	I-10	68,755	67,899	-1.2%	11,170	10,777	-3.5%
K	U.S. 60	EB	Loop 101	Val Vista Dr.	85,166	88,273	3.6%	10,262	8,421	-17.9%
		WB	Val Vista Dr.	Loop 101	79,380	81,165	2.2%	11,725	11,091	-5.4%
L	Loop 101	NB	Guadalupe Road	Loop 202	68,273	73,809	8.1%	N/A	N/A	N/A
		SB	Loop 202	Guadalupe Road	76,689	79,804	4.1%	N/A	N/A	N/A
M	SR 143	NB	I-10	Loop 202/ McDowell	23,691	23,352	-1.4%	N/A	N/A	N/A
		SB	Loop 202/ McDowell	I-10	24,612	25,006	1.6%	N/A	N/A	N/A

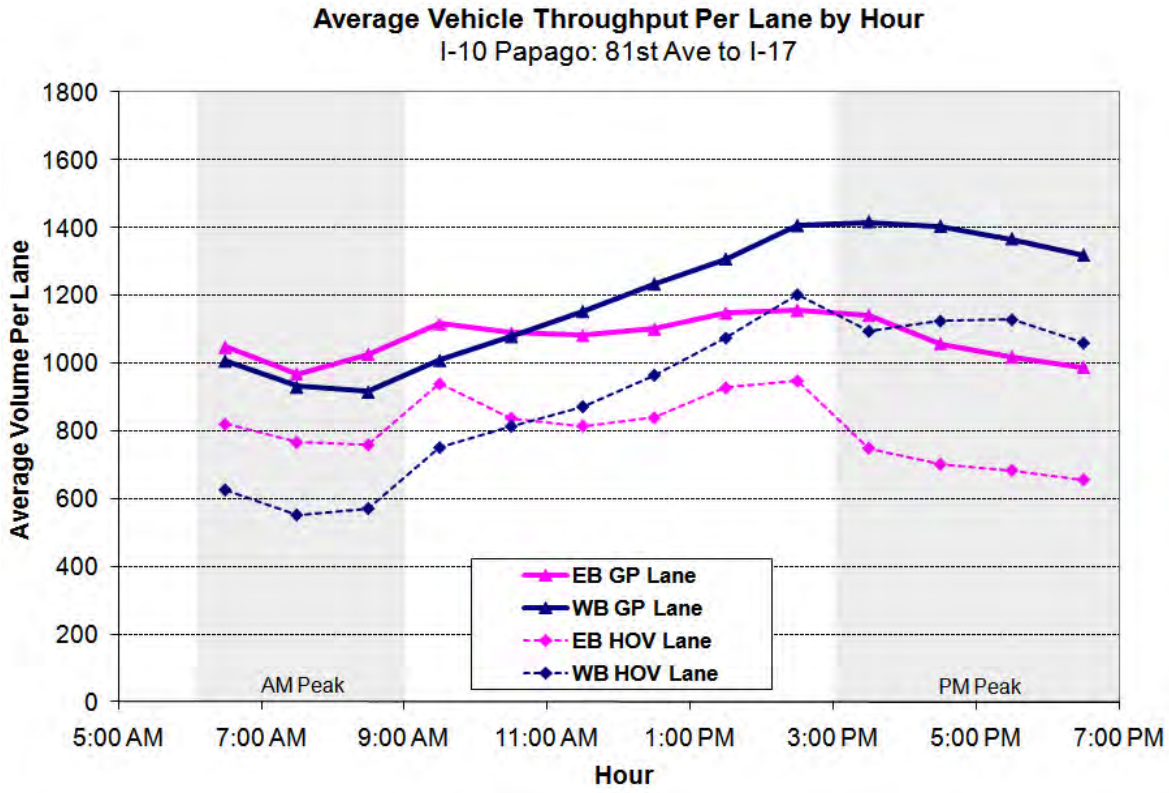
Source: ADOT FMS

Table 2.3 Results for AAWDT by corridor and % change from 2006 – 2007

Corridor ID	Analysis Corridor	Dir	From	To	Annual Average Weekday Daily Traffic (AAWDT)					
					General-purpose Lanes			HOV Lanes		
					2006	2007	% Change	2006	2007	% Change
A	I-10 Papago	EB	81st Avenue	I-17	88,664	87,014	-1.9%	13,154	14,132	7.4%
		WB	I-17	82nd Avenue	92,677	94,832	2.3%	13,734	16,788	22.2%
B	I-10 Papago	EB	I-17	SR 51	92,423	94,283	2.0%	19,011	19,339	1.7%
		WB	SR 51	I-17	105,382	104,230	-1.1%	16,518	16,440	-0.5%
C	I-10 Maricopa	EB	SR 51	U.S. 60	90,991	94,227	3. 6%	18,831	18,526	-1.6%
		WB	U.S. 60	SR 51	92,057	90,411	-1.8%	14,334	15,762	10.0%
D	I-10 Maricopa	EB	U.S. 60	Chandler Blvd	84,901	82,542	-2.8%	13,370	13,020	-2.6%
		WB	Chandler Blvd	U.S. 60	77,105	75,874	-1.6%	12,629	12,815	1.5%
E	I-17	NB	Maricopa TI	I-10	59,126	55,382	-6.3%	N/A	N/A	N/A
		SB	I-10	Maricopa TI	53,604	50,153	-6.4%	N/A	N/A	N/A
F	I-17	NB	I-10	Peoria Ave.	69,812	69,759	-0.1%	12,205	12,172	-0.3%
		SB	Peoria Ave.	I-10	80,885	76,079	-5.9%	12,678	12,935	2.0%
G	SR 51	NB	I-10/Loop 202	Glendale Avenue	64,884	64,854	-0.1%	10,702	9,394	-12.2%
		SB	Glendale Avenue	I-10/Loop 202	60,655	61,977	2.2%	7,917	8,151	3.0%
H	SR 51	NB	Glendale Avenue	Bell Road	66,849	67,524	1.0%	8,399	8,920	6.2%
		SB	Bell Road	Glendale Avenue	64,280	66,383	3.3%	8,084	10,544	30.4%
I	Loop 202	EB	I-10/SR 51	Loop 101	73,639	73,210	-0.6%	11,358	11,518	1.4%
		WB	Loop 101	I-10/SR 51	65,592	65,715	0.2%	6,982	9,740	0.6%
J	U.S. 60	EB	I-10	Loop 101	63,804	64,800	1.6%	19,170	14,412	-24.8%
		WB	Loop 101	I-10	73,437	73,698	0.4%	12,117	12,424	2.5%
K	U.S. 60	EB	Loop 101	Val Vista Dr.	91,518	95,476	4.3%	11,043	9,333	-15.5%
		WB	Val Vista Dr.	Loop 101	85,503	87,858	2.8%	12,770	12,575	-1.4%
L	Loop 101	NB	Guadalupe Road	Loop 202	74,495	79,162	6.3%	N/A	N/A	N/A
		SB	Loop 202	Guadalupe Road	83,555	85,099	1.9%	N/A	N/A	N/A
M	SR 143	NB	I-10	Loop 202/ McDowell	26,218	25,690	-2.0%	N/A	N/A	N/A
		SB	Loop 202/ McDowell	I-10	28,180	28,537	1.3%	N/A	N/A	N/A

Source: ADOT FMS

Figure 2.8a Average Vehicle Throughput Per Lane by Hour



Source: ADOT FMS

Figure 2.8b Average Vehicle Throughput Per Lane by Hour

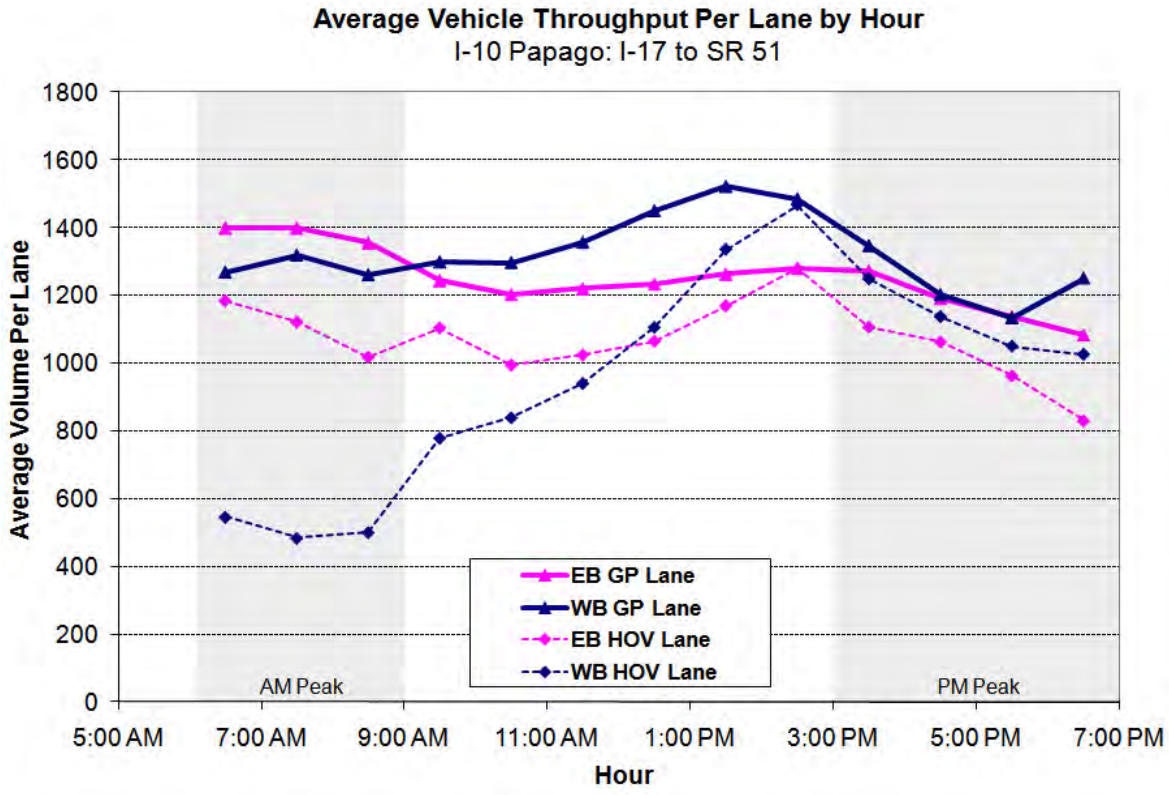


Figure 2.8c Average Vehicle Throughput Per Lane by Hour

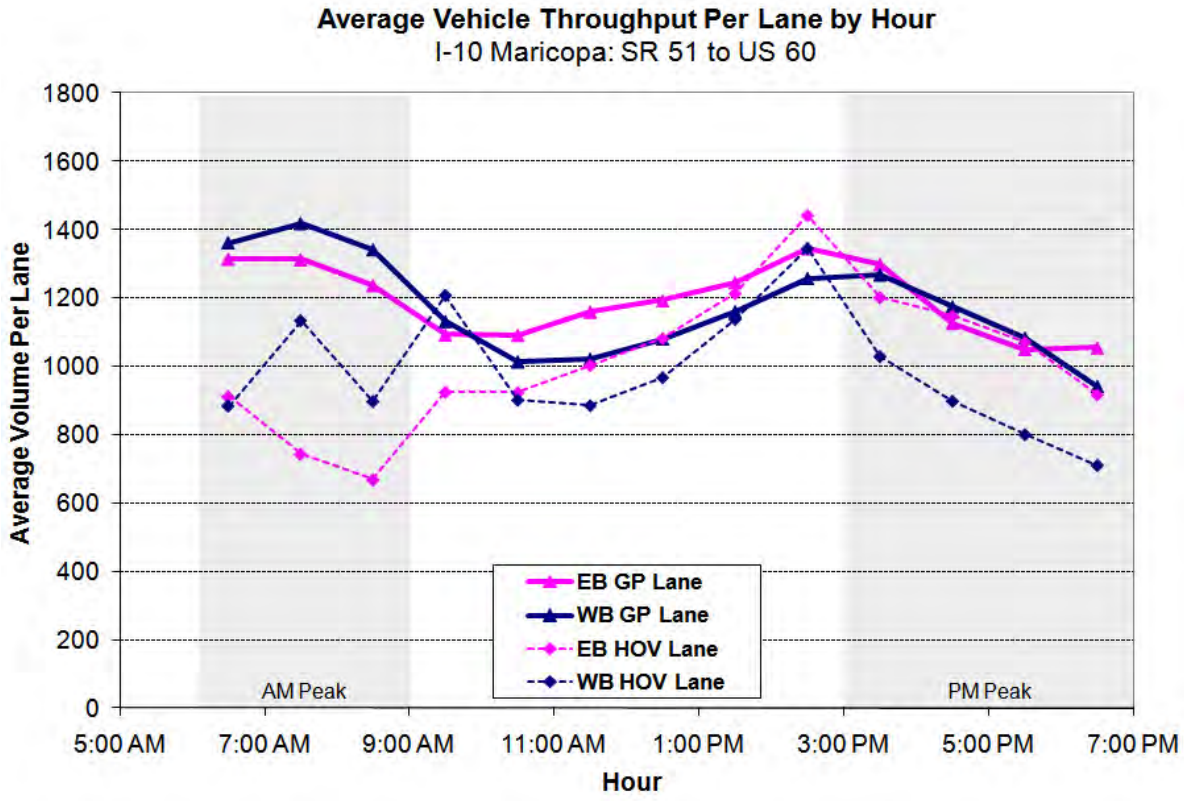


Figure 2.8d Average Vehicle Throughput Per Lane by Hour

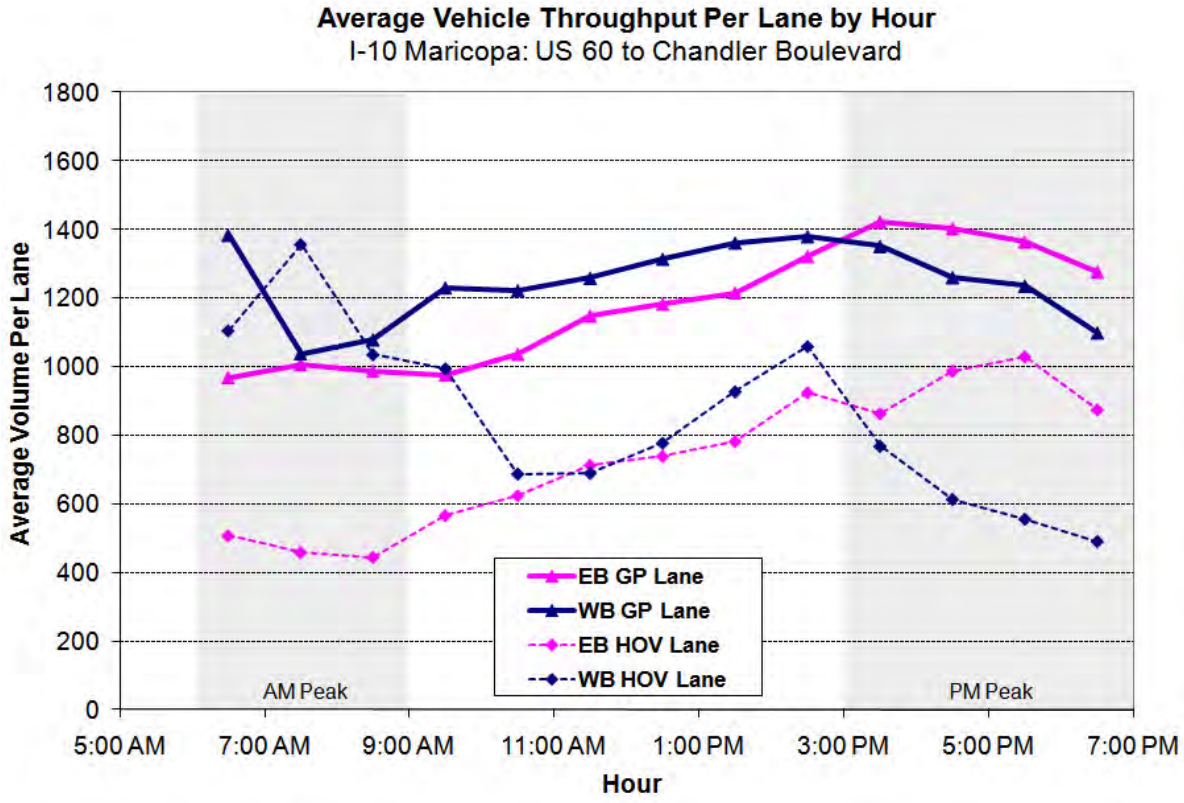


Figure 2.8e Average Vehicle Throughput Per Lane by Hour

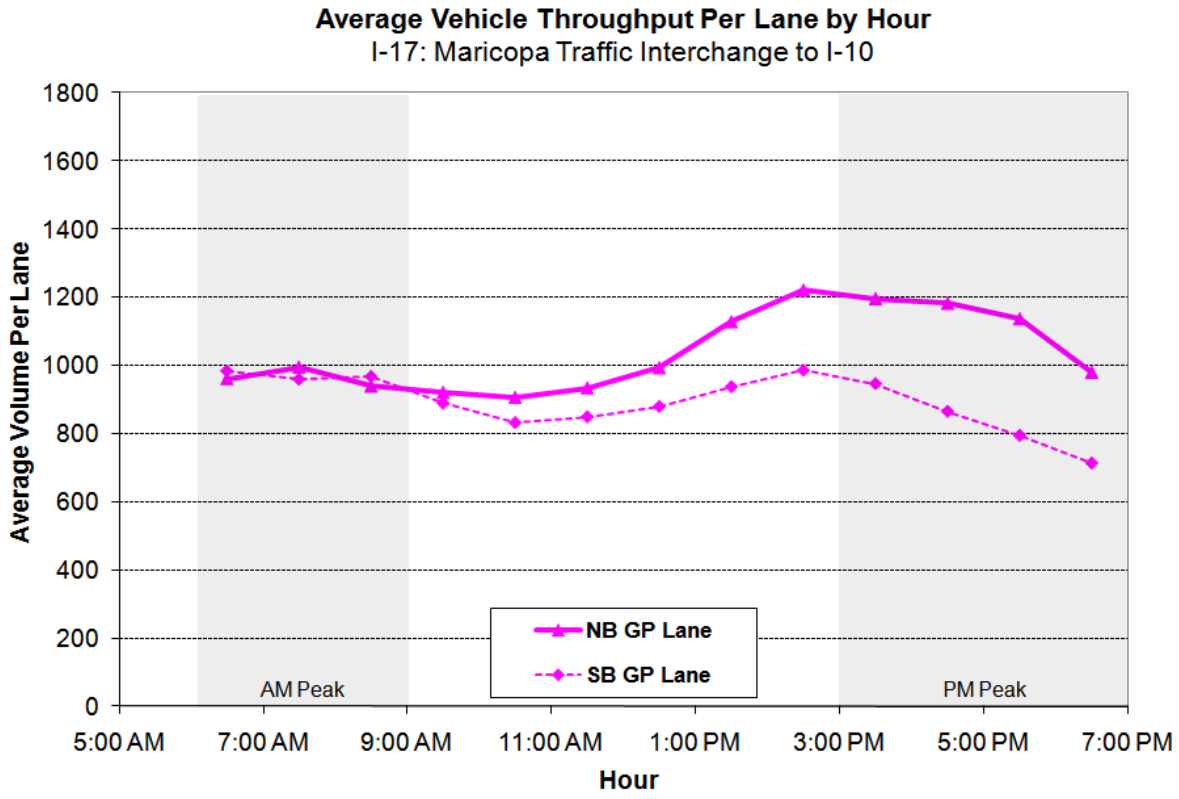


Figure 2.8f Average Vehicle Throughput Per Lane by Hour

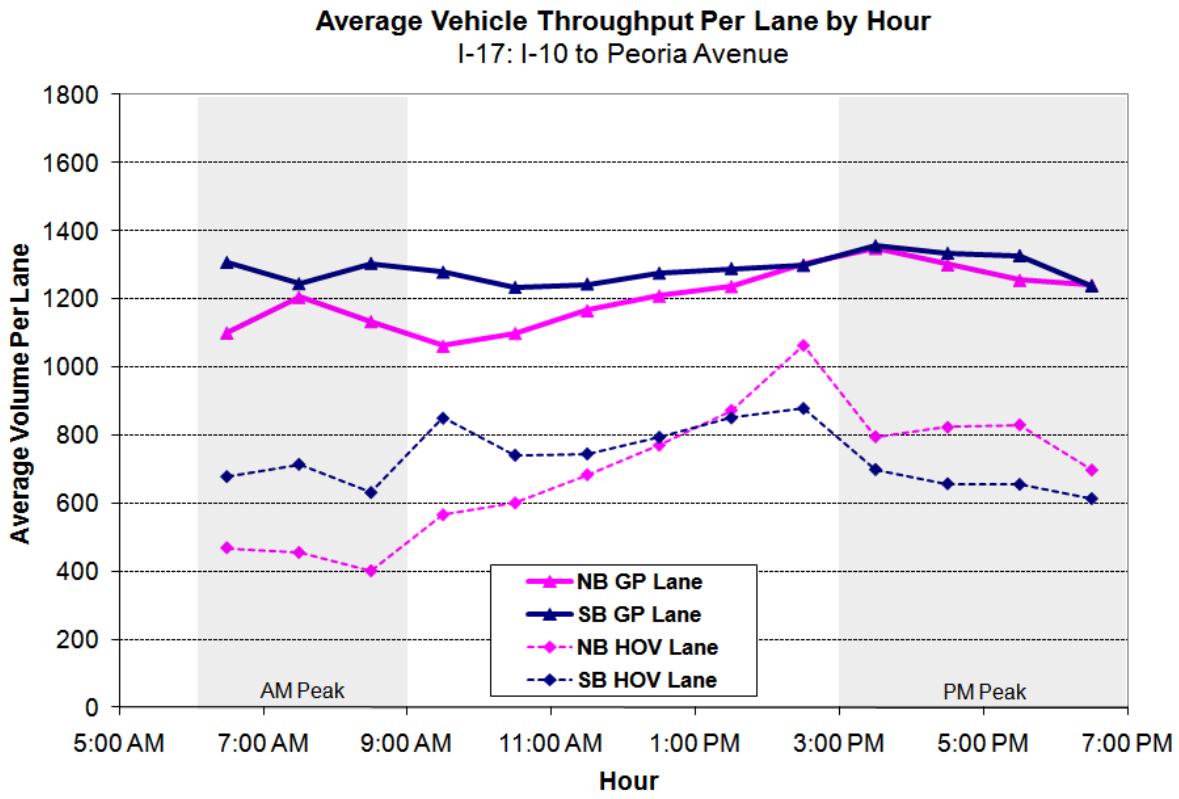


Figure 2.8g Average Vehicle Throughput Per Lane by Hour

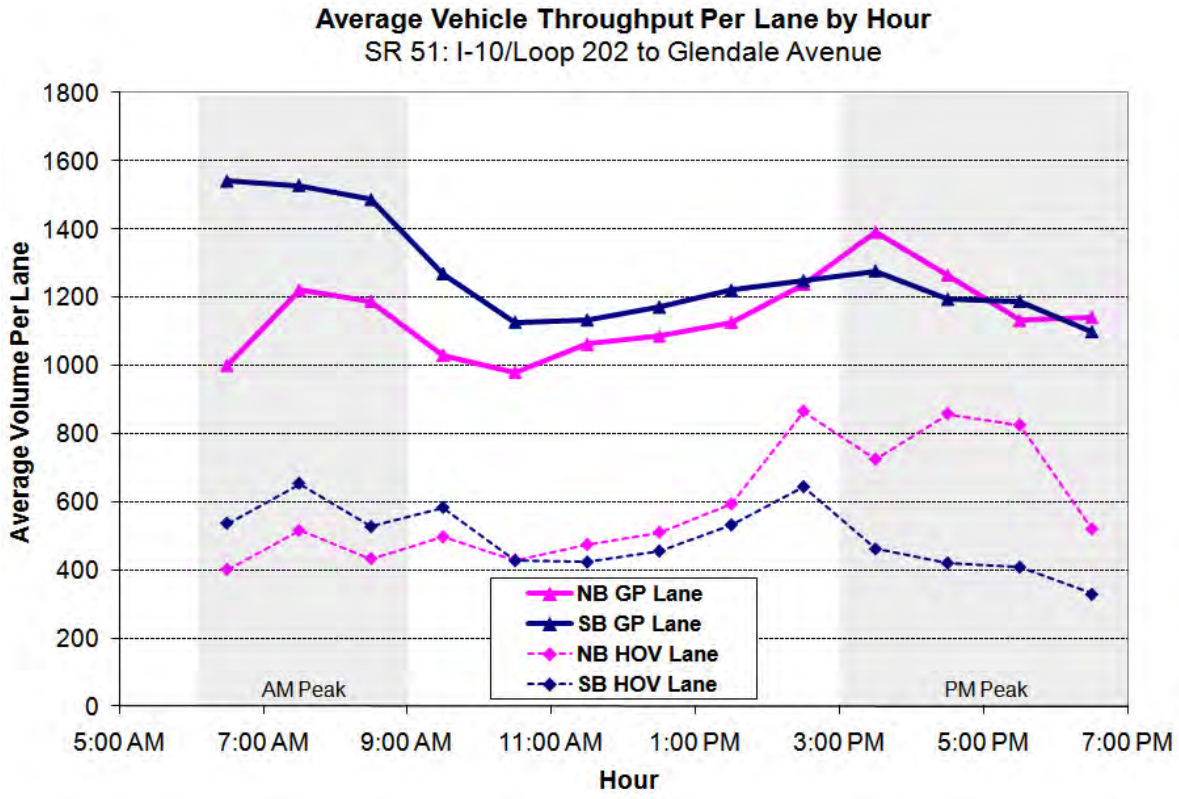


Figure 2.8h Average Vehicle Throughput Per Lane by Hour

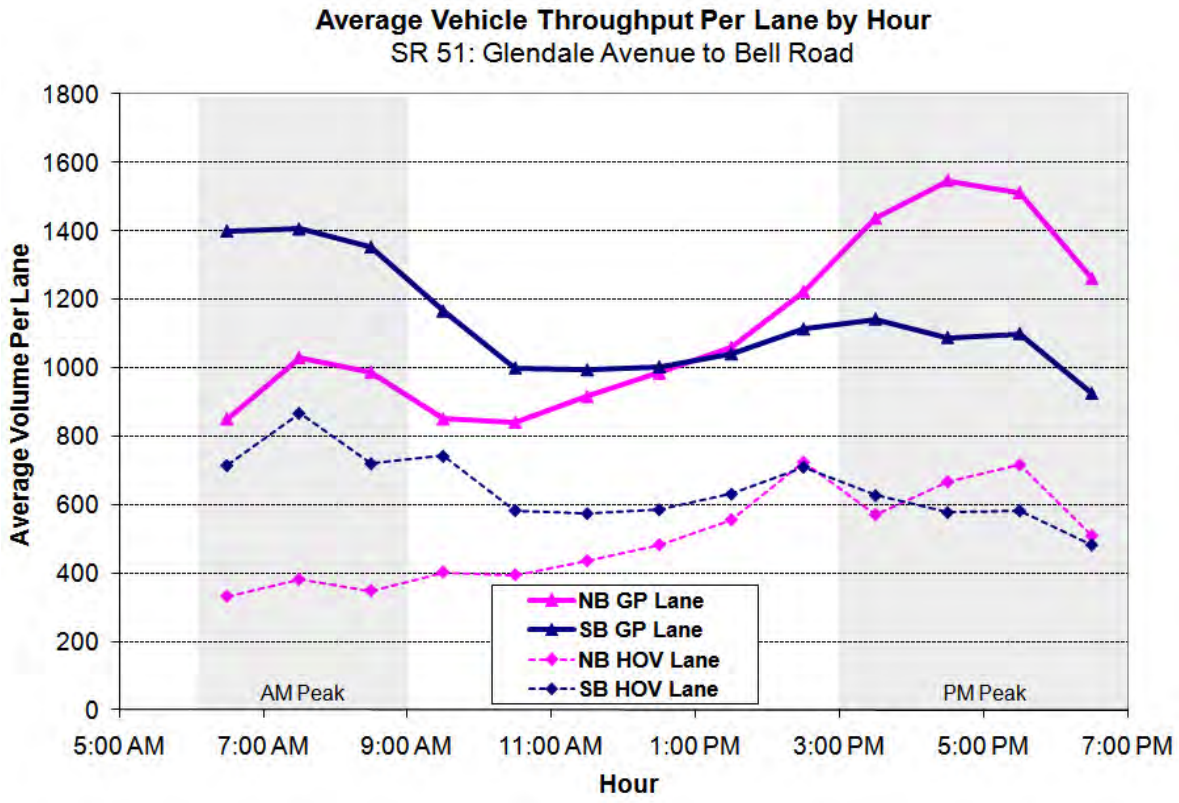


Figure 2.8i Average Vehicle Throughput Per Lane by Hour

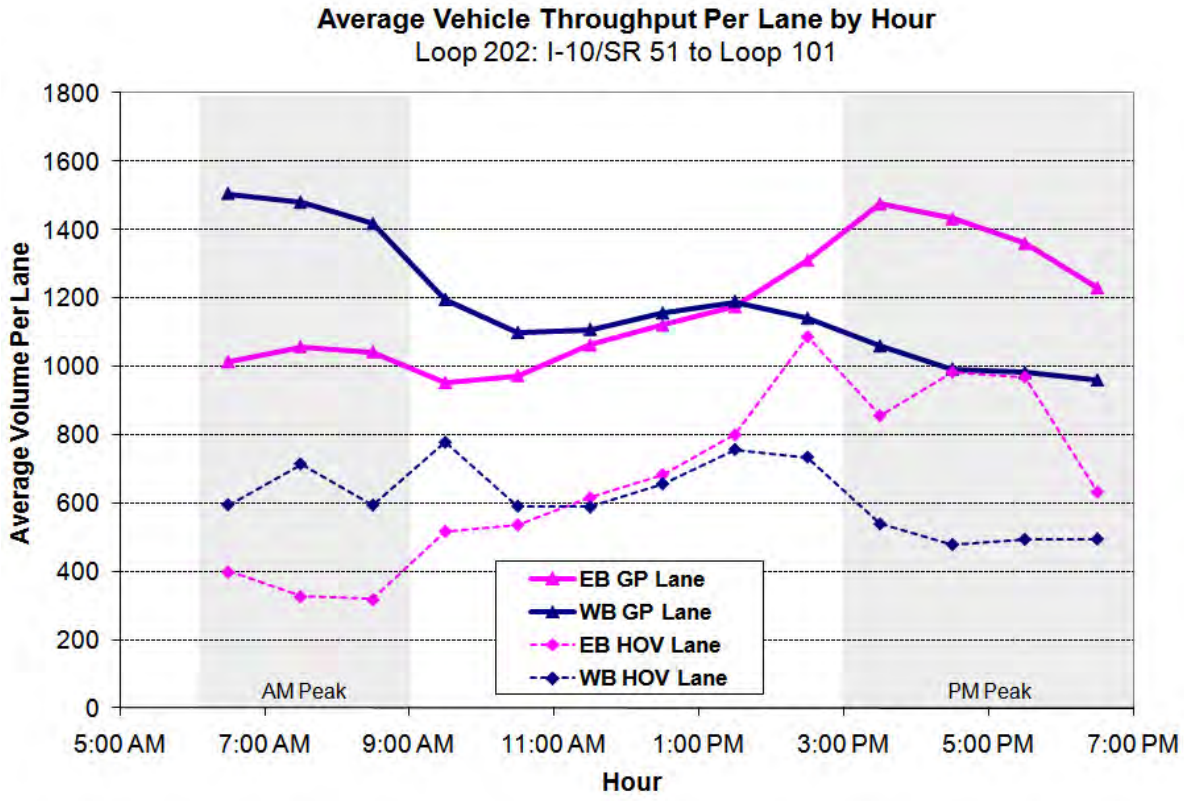


Figure 2.8j Average Vehicle Throughput Per Lane by Hour

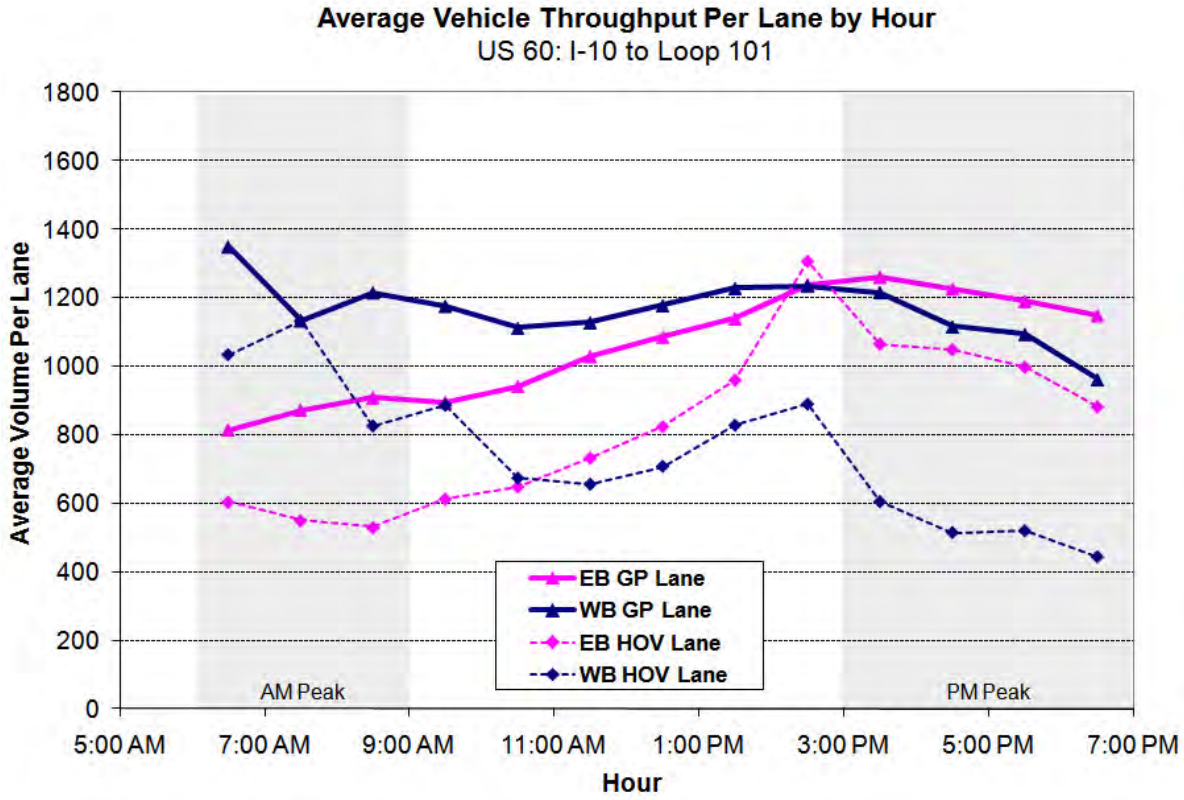


Figure 2.8k Average Vehicle Throughput Per Lane by Hour

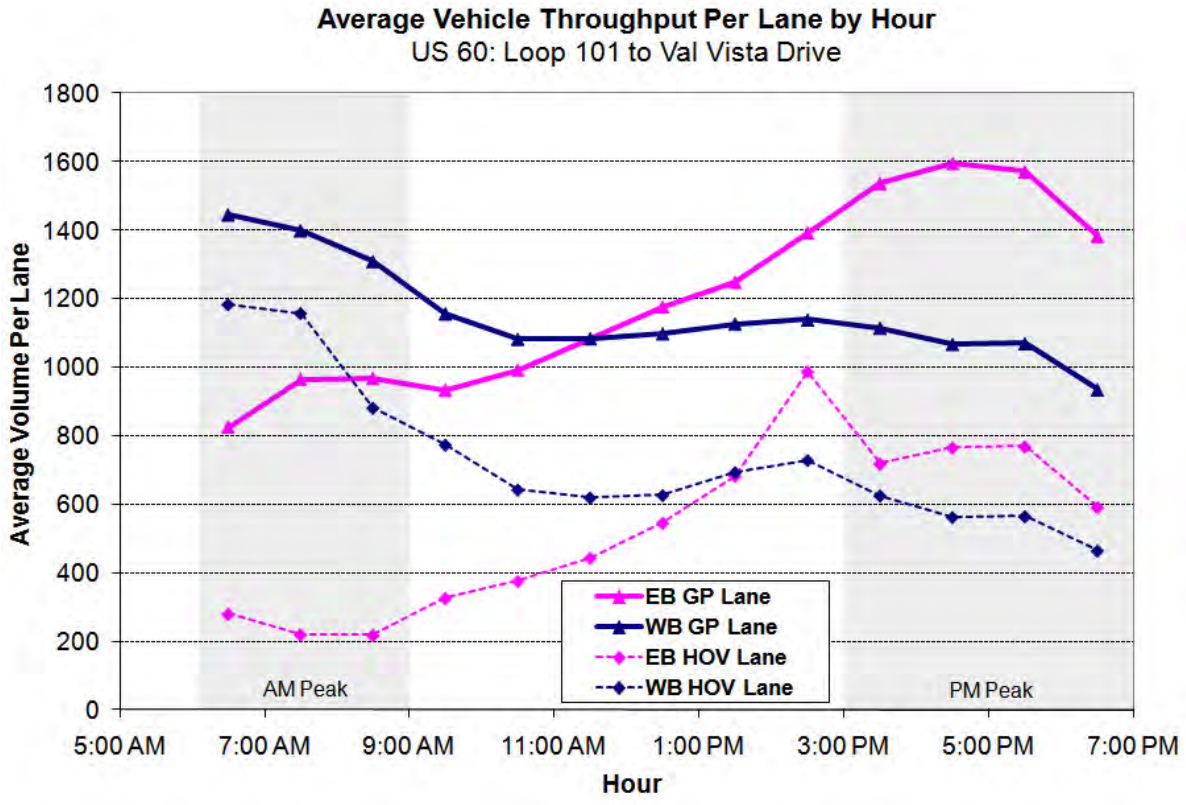


Figure 2.8l Average Vehicle Throughput Per Lane by Hour

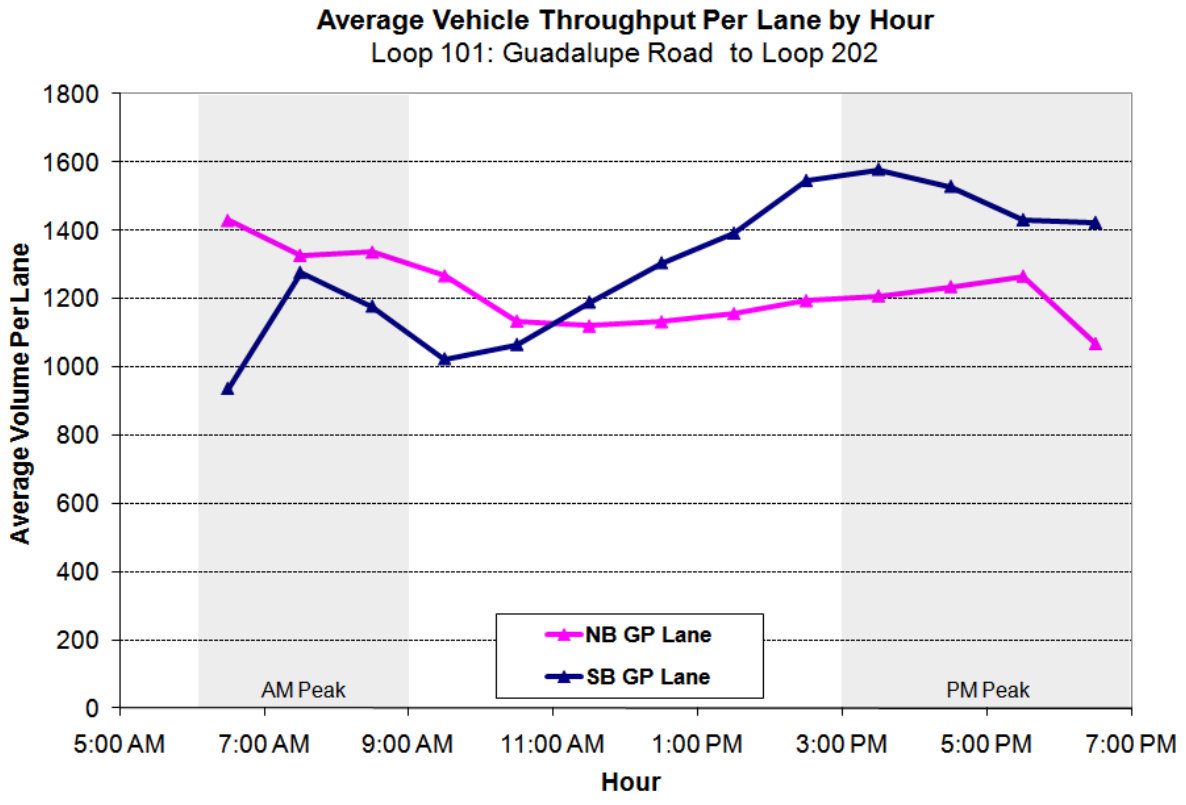
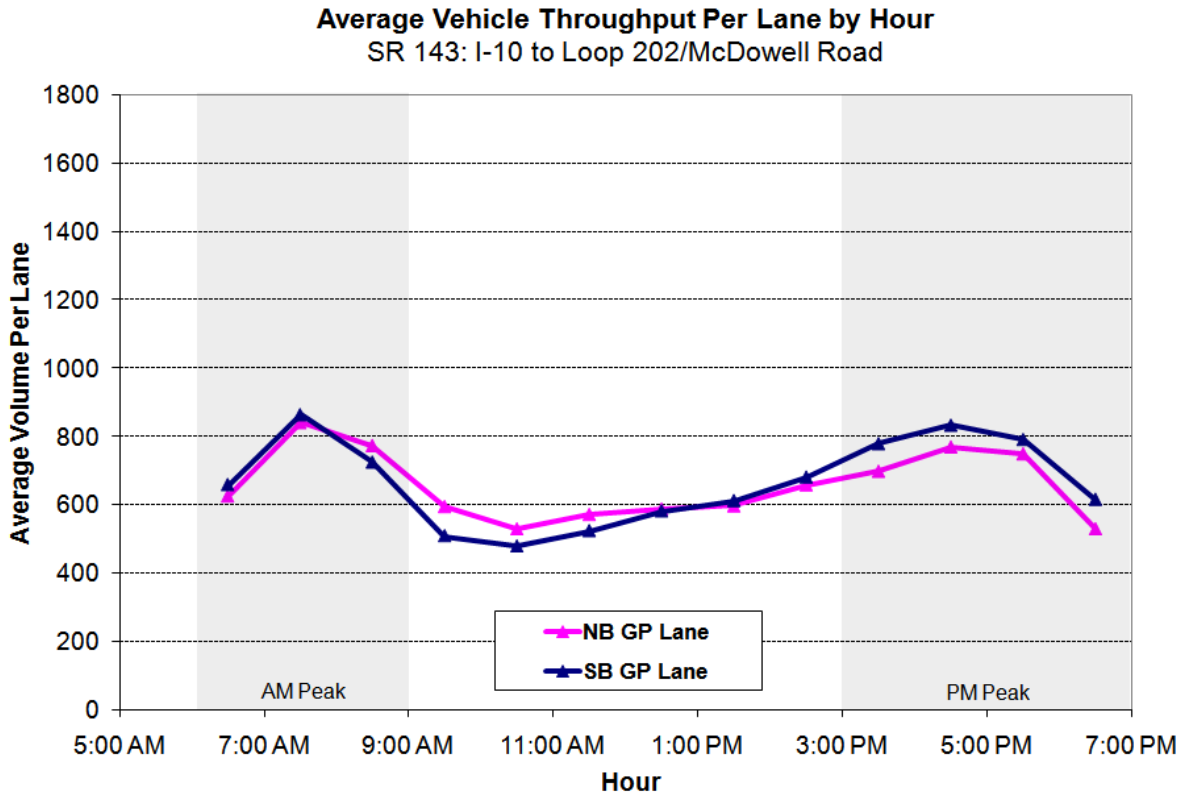


Figure 2.8m Average Vehicle Throughput Per Lane by Hour



2.3.1.2 Throughput – Freight

Definition: Freight throughput is defined as the number of trucks traversing a length of freeway. Freight throughput is measured by the annual average daily truck traffic volume, reported in units of trucks per day. Having quantitative information about the mix of travel – vehicles for personal travel as opposed to goods movement – helps in making decisions about traffic improvements and/or operational management strategies. Solutions aimed at portions of the transportation network that accommodate primarily passenger vehicles may be quite different for sections that have a high proportion of freight vehicles, considering both the purpose of travel, as well as vehicle characteristics.

Objective: Manage freight throughput into, through, and within the region.

Source: Freight volumes were derived from two-way traffic counts acquired from the 2007/2008 Multimodal Freight Analysis Study conducted by ADOT's MPD.

Time Scale: Daily (24 hours)

Methodology: Freight volumes have been derived from two-way traffic counts acquired from the ADOT Multimodal Planning Division (MPD). Freeway traffic volumes are collected by ADOT through two procedures:

- Automatic Traffic Recorder (ATRs): The ATRs collect data 24 hours a day, 365 days a year, for each lane. The equipment records traffic volumes, speed, and classification of vehicles. The MPD uses these data to develop seasonal factors, daily factors, axle factors and to estimate VMT. These factors are applied to all coverage counts.
- Coverage counts: Coverage counts are needed to ensure that adequate geographic coverage exists for all roads under the jurisdiction of the State highway authority. In simple terms, "coverage counts" are short duration data collection efforts that are undertaken to ensure that "at least some" data exist for all roads maintained by the agency. Coverage counts are performed using temporary counting devices set up on an intermittent basis.

As indicated by ADOT, a truck for the purpose of this performance measure is defined as any commercial vehicle (a motor vehicle designed, used, or maintained primarily for the transportation of property) with a gross vehicle weight rating or gross combination weight rating greater than 10,000 pounds

The ADOT MPD reports a T-factor for some count locations in the state, which is the percentage of trucks at each count station as derived from classification counts. However, there are no T-factors available for the count stations located within the limits of the analysis corridors. Therefore, truck percentages were derived from data reported in the Arizona Multimodal Freight Analysis Study.

To calculate freight throughput, traffic counts have been downloaded from the MPD Traffic Counts web page. Two-way annual average daily traffic (AADT) counts were selected for count stations located within the limits of each analysis corridor. AADT for each count station was multiplied by the T-factor from the Freight Study to obtain an estimate of truck traffic at each station. In examining the results, it has been observed that the T-factor for stations on I-10 (Maricopa Freeway) south of U.S. 60 (analysis corridor D) was 35%, which is considerably

higher than other locations along I-10 (analysis corridors A, B and C), which have truck percentages closer to 10.9%. In addition, truck percentages on U.S. 60 (Superstition Freeway) and SR 101 (Price Freeway) are recorded at 17%. In general, the ADOT Office of Multimodal Planning recommended that truck percentages should not exceed a range between 9% and 12%. Therefore, the T-factor for analysis corridors D, J, and K have been adjusted to 12% for consistency with the values suggested by ADOT. ADOT has also recommended that truck volumes in excess of 20,000 AADT be constrained, and were adjusted accordingly. Adjusted counts for each corridor have been summed and divided by the number of count stations to come up with the arithmetic mean. This number is used to represent the two-way average annual daily truck volume for each corridor. The results for freight throughput are reported in chart format for 2007, as shown in Table 2.4.[6]

Explanation of Results and Analysis: As seen in Table 2.4, truck volumes are highest on I-10 Papago between I-17 and SR 51, with a two-way average truck volume of 23,700 trucks per day. Truck volumes are lowest on SR 143 between I-10 and Loop 202/McDowell Road.

Table 2.4 Freight Throughput Results

Corridor ID	Analysis Corridor	From	To	Two-way Truck Volume (2007)
A	I-10 Papago	81st Avenue	I-17	20,200
B	I-10 Papago	I-17	SR 51	23,700
C	I-10 Maricopa	SR 51	U.S. 60	20,000
D	I-10 Maricopa	U.S. 60	Chandler Boulevard	19,200
E	I-17	Maricopa Traffic Interchange	I-10	12,200
F	I-17	I-10	Peoria Avenue	18,700
G	SR 51	I-10/Loop 202	Glendale Avenue	16,100
H	SR 51	Glendale Avenue	Bell Road	10,500
I	Loop 202	I-10/SR 51	Loop 101	15,300
J	U.S. 60	I-10	Loop 101	19,300
K	U.S. 60	Loop 101	Val Vista Drive	20,400
L	Loop 101	Guadalupe Road	Loop 202	20,000
M	SR 143	I-10	Loop 202/McDowell Road	9,000

Source: ADOT MPD 2007/2008 Multimodal Freight Analysis Study

[6] The volumes contained in the table are estimates and not observed truck volumes. To avoid depicting a false sense of precision, volumes have been rounded to the nearest hundred vehicles. As the data contained in the table is not based on observed truck volumes, no comparison has been made against an estimate for 2006.

2.3.1.3 Lost Productivity

<u>*Definition*</u>: Freeways are generally designed to operate at a throughput capacity of around 2,000 vehicles per lane per hour (vplph[7]). When heavy congestion occurs, the slow speed at which vehicles are moving reduces the actual roadway capacity experienced (i.e., even though the roadway is full of densely packed cars, considerably fewer than 2,000 vehicles per hour per lane can pass a point along that congested freeway segment.). In these cases, because of congestion, the roadway infrastructure cannot serve the number of vehicles it should be able to accommodate.

The term *lost productivity* (or lost capacity) is used to describe how much design capacity has been lost due to congestion. It is defined as the difference between base design capacity (assumed to be 2,000 vplph) and actual service volumes when heavy congestion is present. It is computed only when speeds are less than 45 mph. It is reported as a percentage in this report to allow comparison between locations with different numbers of lanes, and to provide non-traffic engineers with an easy to understand statistic that describes the magnitude of the congestion problem.

Lost productivity is of significant importance in those bottleneck locations where the greatest congestion occurs, as these locations limit the number of users that can use the roadway downstream of that location - even though vehicle speeds have returned to free flow conditions. Locations where losses in roadway productivity are high usually correlate well with places where congestion forms frequently. It is in these types of locations that roadway improvements can often have the greatest effectiveness.

Lost productivity is also a good indicator to use when examining the effectiveness of traffic operations improvements such as incident response programs. Operational improvements allow traffic to flow more freely, which increases vehicle throughput in congested areas, thus bringing actual throughput closer to the roadway's intended (and designed) capacity.

The lost productivity graphics found in this section are not directly correlated with the cost of congestion. Cost to recover the productivity lost to congestion is a function of the cost of the roadway improvements (capacity expansion, operational improvements, etc.) needed to mitigate the congestion that is causing the loss in productivity. Alternatively, the cost of the delays being experienced as a result of the loss of productivity are properly calculated using data on the size of the delays being experienced by different classes of vehicles (i.e., commercial vehicles and passenger vehicles) on the roadway.

<u>*Objective*</u>: Decrease lost productivity.

<u>*Source*</u>: Lost productivity is derived from speed and flow data obtained from ADOT Freeway Management System Archived Data for years 2006 and 2007.

<u>*Time Scale*</u>: AM peak period (6:00 AM to 9:00 AM), Midday period (9:00 AM to 3:00 PM), PM peak period (3:00 PM to 7:00 PM)

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[7] Actual roadway capacity varies from road segment to road segment based on lane width, shoulder width, terrain, and various other factors. See the Highway Capacity Manual for details.

Methodology: Like all other roadway performance statistics, lost productivity changes with time and location. Of most significant interest when monitoring roadway performance are those points where lost productivity is highest (i.e., where congestion is most significantly limiting the use of the available right-of-way.). The contour graphics created for Extent of Congestion (see Section 2.3.2.4) have been used to select the points of most significant congestion by selecting those locations where congestion occurs most frequently (i.e., the graphic is black) and where the duration of that congestion is longest (the width of the black area is greatest). These locations are depicted on a system-wide map as Points of Lost Productivity (see Figure 2.9). Data on vehicle volumes and speeds were then obtained for the specific detectors that correspond to these locations. For most corridors, locations were selected for both the AM and PM peak periods, as the productivity of the roadway differs in these time periods as do the locations of the bottlenecks.

For each location, the station-level base data set was used to compare the average travel speed within each 5-minute interval to a speed threshold of 45 mph. If the average travel speed was below the threshold, that time period was flagged, and lost productivity (2,000 vplph – actual traffic volume expressed in vplph) was computed. This was done for each 5-minute time interval of each day of the analysis year. Lost productivity for that station was computed for non-holiday weekdays in the analysis year where speeds within that 5-minute interval were less than 45 mph. The results for lost productivity for years 2006 and 2007 have been exported to Microsoft Excel and graphed to demonstrate how lost productivity varies by time of day at each lost productivity point. To make these graphics easier to understand, lost productivity is expressed as the Percent of Capacity Lost. In these graphs, the amount of productivity lost is displayed as a percentage of capacity. Zero percent indicates the roadway is operating at capacity, or is serving all demand for travel it is experiencing without significant delay. A value of -20% means that for that time period, the roadway is experiencing heavy queue formation, and is providing 20% less throughput than it was designed to provide (i.e., only 1,600 vplph, instead of 2,000 vplph). To make these graphs even easier to read, a second label has been added on the right side of each graph. This label indicates the Percent of Capacity Maintained. It is computed as 1.0 – the percent of capacity lost due to congestion. Consequently, a 20 percent loss of productivity is equivalent to maintaining 80% of the design capacity of a roadway. In Figure 2.10, one full-size graph has been provided, accompanied by a number of smaller stamp sized graphs representing the remaining locations indicated on the map in Figure 2.9.

Explanation of Results and Analysis: Figure 2.10 includes 23 graphs that illustrate the amount of design capacity (productivity) being lost due to congestion on freeways in the MAG Region. Each graph includes data from both 2006 and 2007. The result, as noted elsewhere in this report, was heavy congestion on many area freeways. On some of those freeways, that congestion grew notably worse from 2006 to 2007.

The first seven graphs illustrate the performance of different segments of the I-10 freeway. That performance is far from optimal. Figure 2.10a shows that in 2007, I-10 Eastbound near 59th Avenue on average operated below 45 mph between roughly 6:30 and 8:30 in the morning. For much of that time, fewer than 50 percent of the vehicles that freeway was designed to carry were able to use that section of roadway. During 2006, that section of roadway had been able to maintain its design flows. Figure 2.10b shows that the eastbound HOV lane is even less productive, serving less than 40 percent of the theoretical capacity due in large part to slow speeds.

Westbound (Figure 2.10c), the roadway does not work efficiently in the PM peak period. In this graph, it is also possible to see how growth in the region in 2007 was extending the duration of the peak period, and further eroding freeway performance. This is indicated by the longer time period during which productivity was lost in 2007 versus 2006. Regional growth also increased the loss of productivity during time periods where congestion was already occurring in 2006. On the other hand, in 2007 the HOV lane performance in at least one location improved slightly late in the peak period (see Figure 2.10d), as it recovered more quickly in 2007 than it did in 2006. That said, during the peak period as a whole, this section of roadway was able to serve fewer vehicles in 2007 than 2006. The roadway was able to recover more quickly in 2007, despite the higher level of congestion present earlier in the peak period.

This same mixture of effects is present in Figures 2.10e and 2.10f. In 2007, congestion caused productivity in the general-purpose lanes to drop earlier in the day, resulting in the freeway operating less efficiently (serving just over 40% of its design capacity.) On the other hand, while the HOV lanes experienced this same shift to earlier congestion in 2007, the roadway recovered slightly earlier, thus decreasing the total amount of lost productivity that would otherwise have occurred. For I-10 westbound at Guadalupe (Figure 2.10g), the only change from 2006 to 2007 is some additional erosion of productivity. In this case, the GP lanes are only able to serve 60% or their designed traffic volume.

These same basic patterns occur on I-17 northbound both west of 16th Street and at Lincoln Street (Figures 2.10h and 2.10i.) Interestingly, during 2007 minor improvements in productivity occurred southbound on I-17 (Figures 2.10j and 2.10k), although roadway productivity is still very low (less than 60 percent of the intended volumes are served.)

Figure 2.10l shows little change in productivity between 2006 and 2007 on SR 51 northbound, while Figures 2.10m and 2.10n both show improvements. Figure 2.10m shows improvements to the general-purpose lanes' performance (which is already fairly good – at 80% of design capacity with only about an hour per day of lost roadway efficiency), while Figure 2.10n shows even more improvements in the HOV lane.

Figure 2.10o illustrates relatively modest declines in the productivity of Loop 202 eastbound, while Figures 2.10p and 2.10q show similar declines westbound.

Figure 2.10s shows an interesting drop in performance between 2006 and 2007, with the loss of productivity beginning significantly earlier in the PM peak and ending later than in 2006.

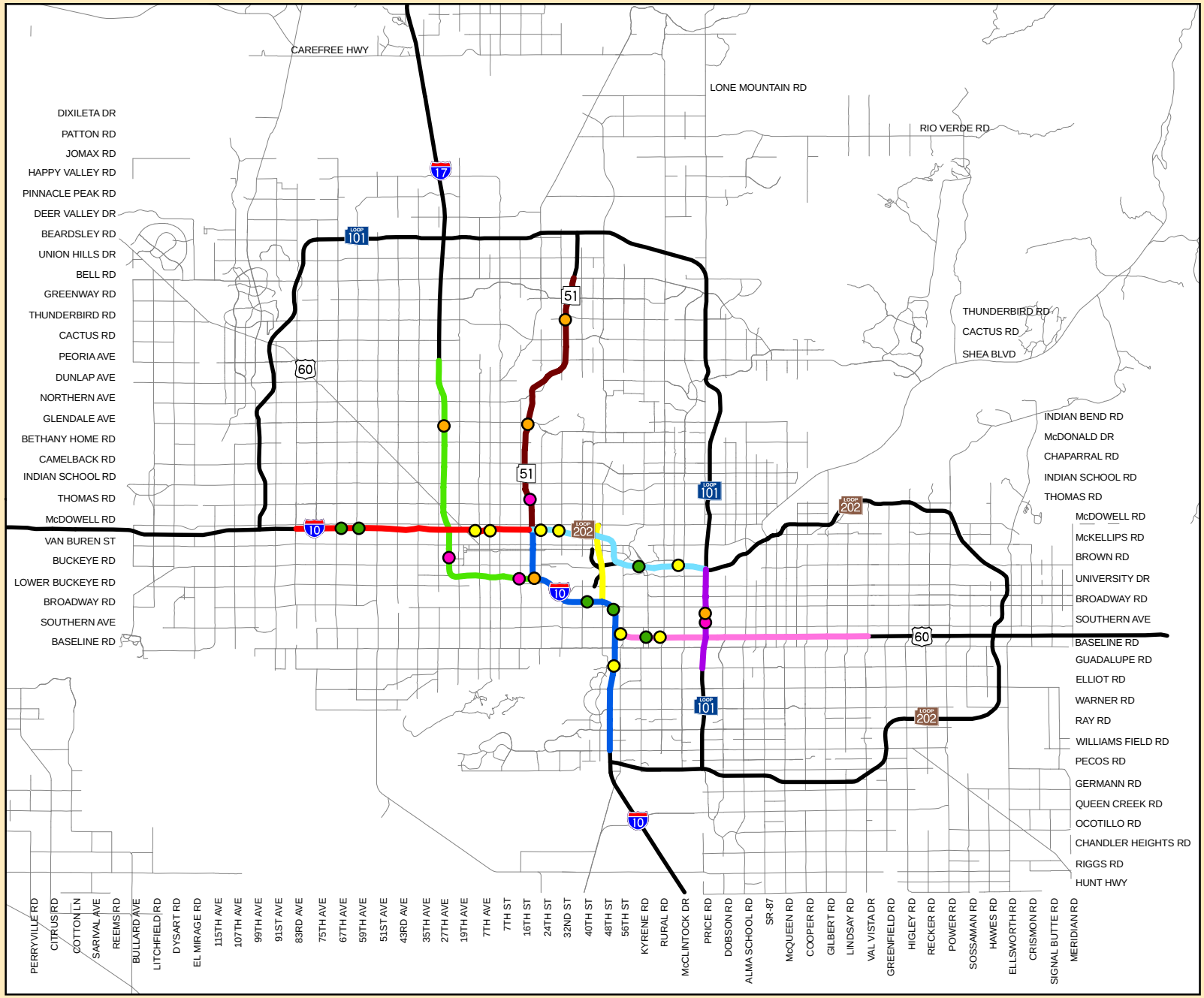
Finally, Figures 2.10v (northbound Loop 101) and 2.10w (southbound Loop 101) show mixed changes on that roadway, with minor decreases in productivity northbound (dropping to 65%) and modest improvements in productivity southbound (rebounding to just under 80% of design.)

Figure 2.9

MARICOPA ASSOCIATION of GOVERNMENTS

Performance Measures Study

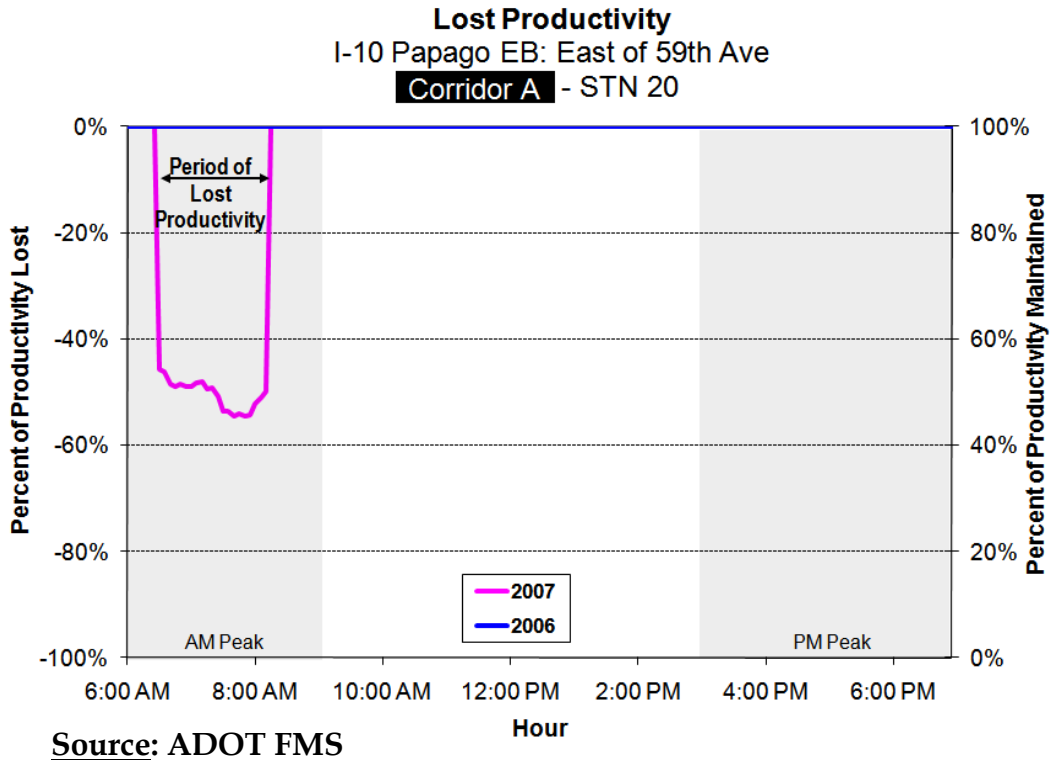
Limited Access Highway Lost Productivity



While every effort has been made to ensure the accuracy of this information, the Maricopa Association of Governments makes no warranty, expressed or implied, as to its accuracy and expressly disclaims liability for the accuracy thereof.

Source: ADOT Freeway Management System
Archived Data for years 2006 and 2007

Figure 2.10a Example of Lost Productivity (AM Peak Period)



Source: ADOT FMS

Figure 2.10b Example of Lost Productivity (PM Peak Period)

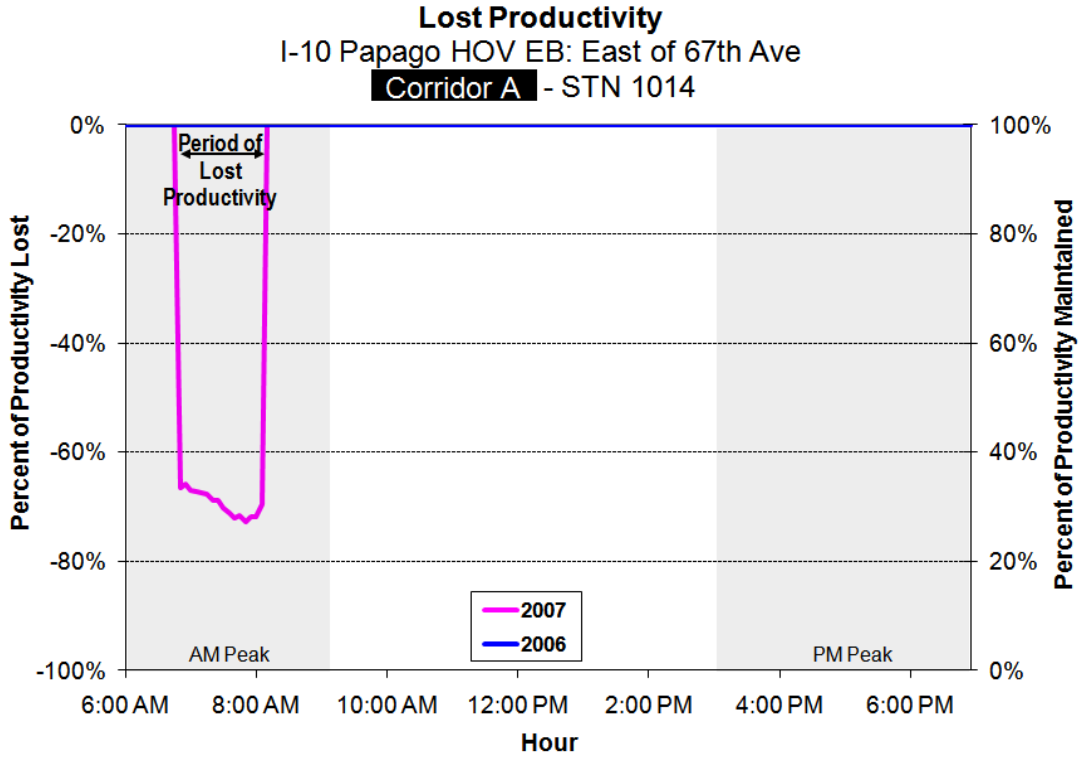


Figure 2.10c

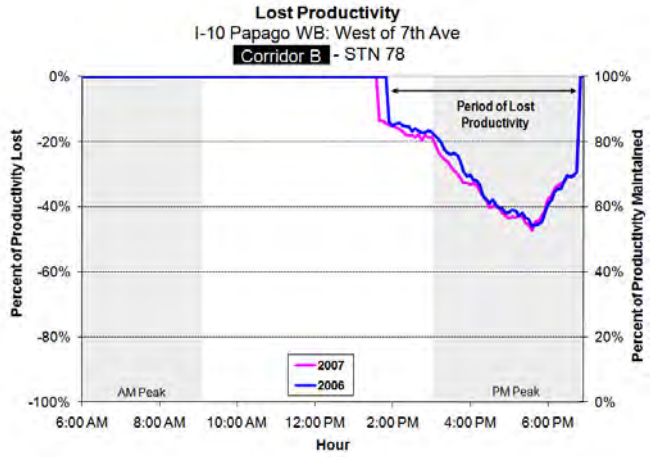


Figure 2.10d

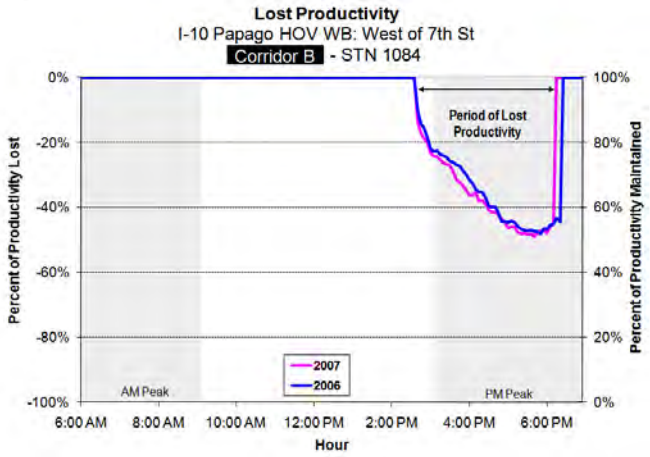


Figure 2.10e

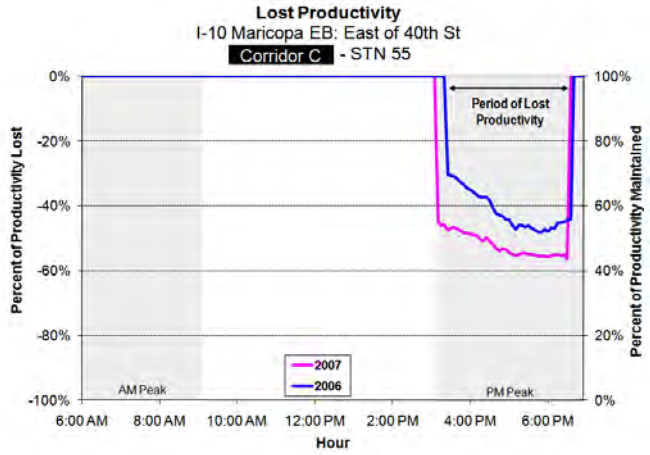


Figure 2.10f

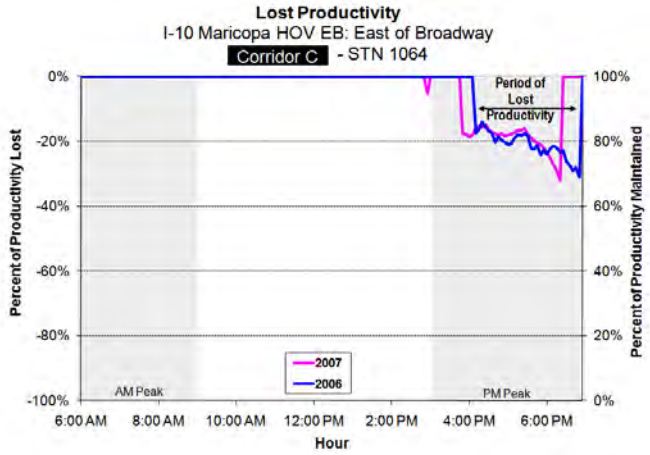
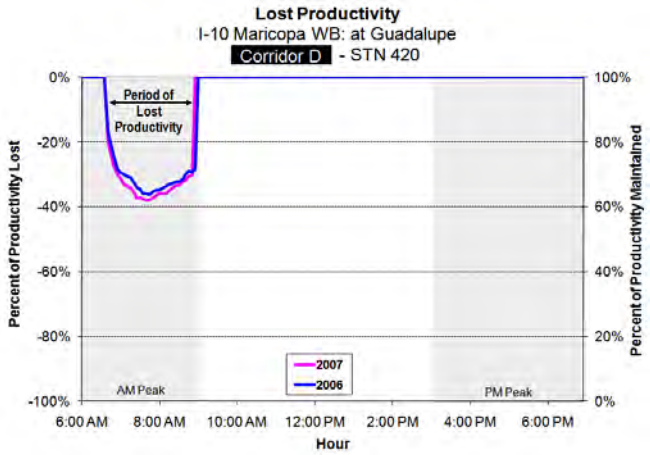


Figure 2.10g



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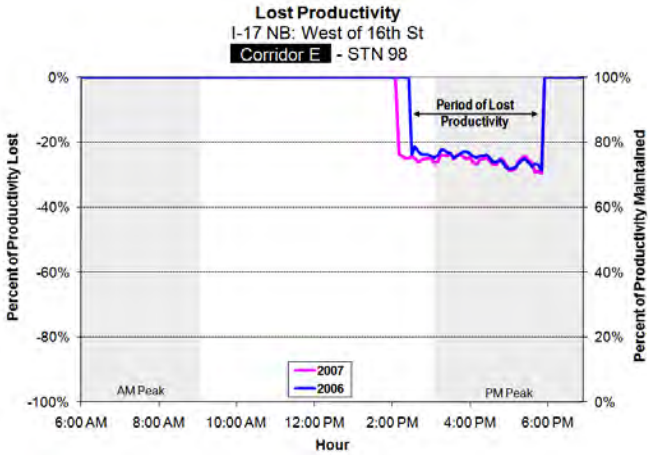

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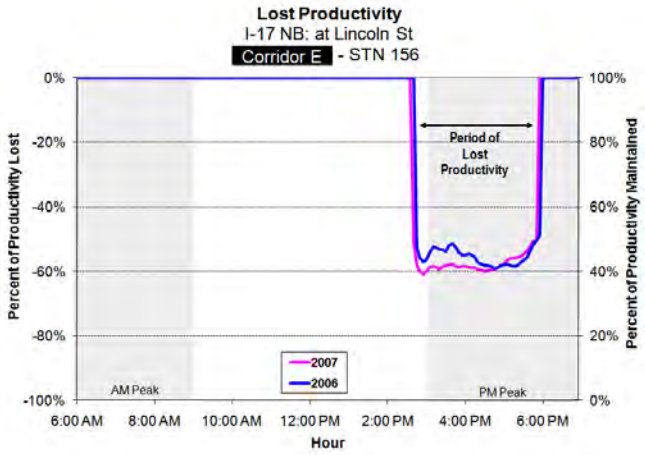

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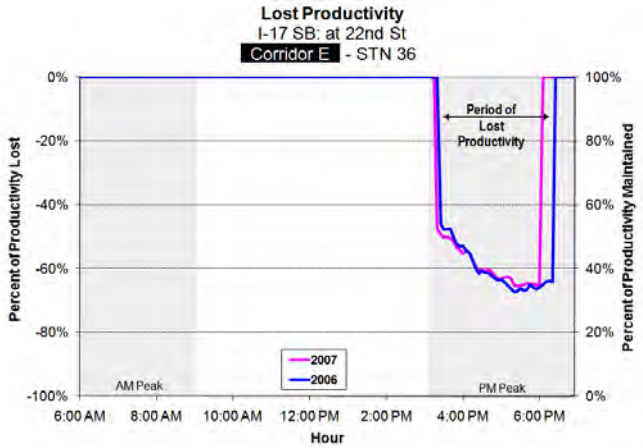

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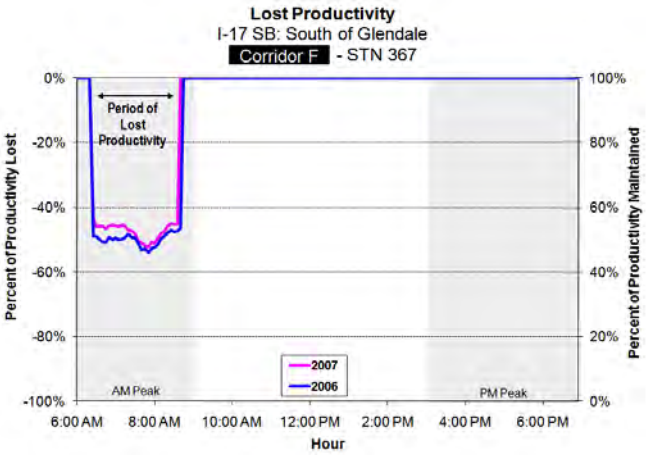

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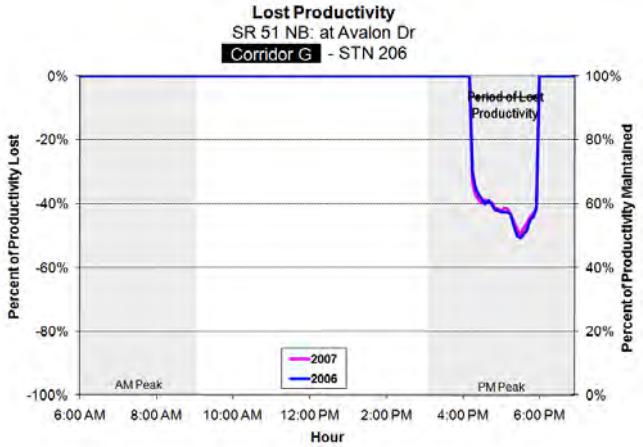

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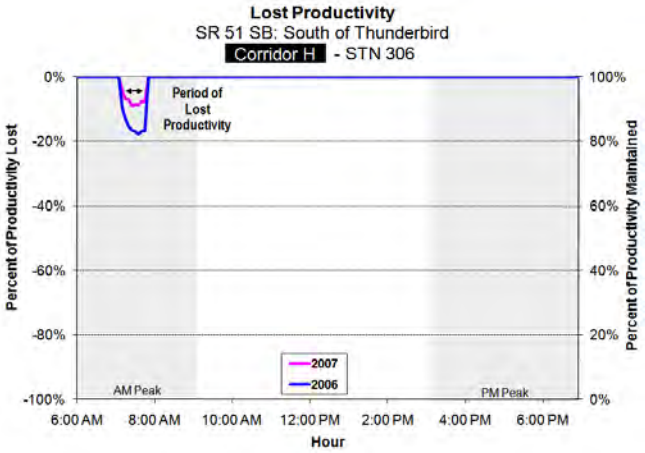

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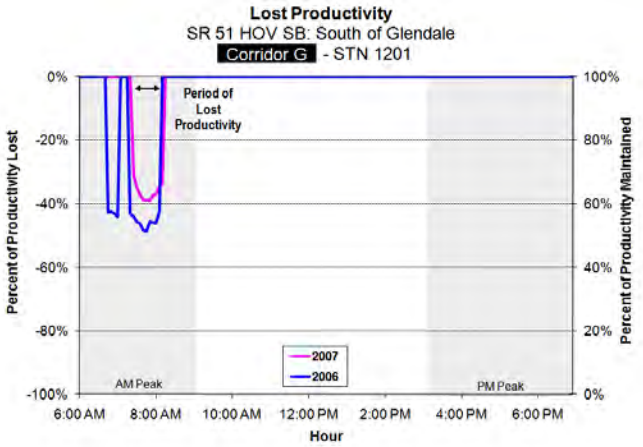
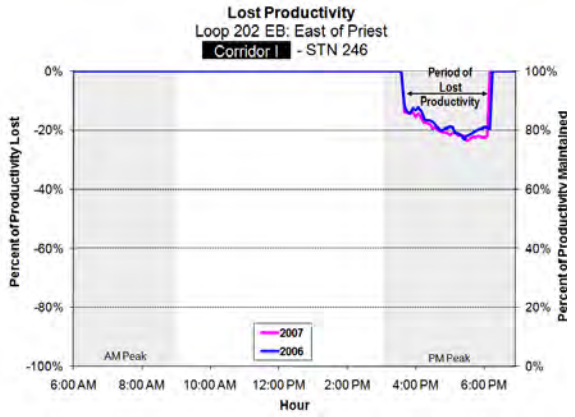


Figure 2.10o



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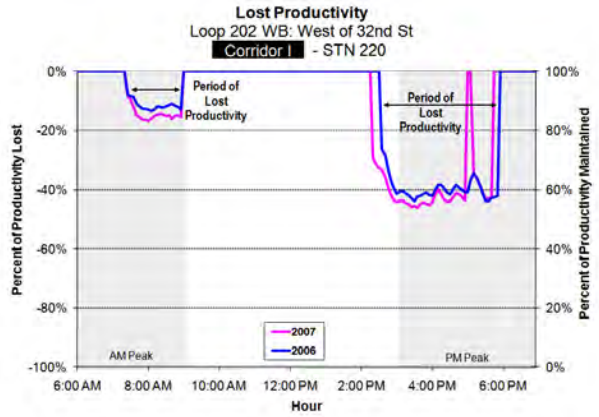

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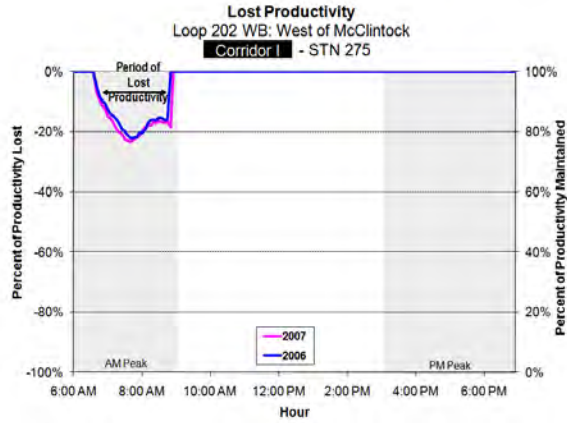


Figure 2.10r

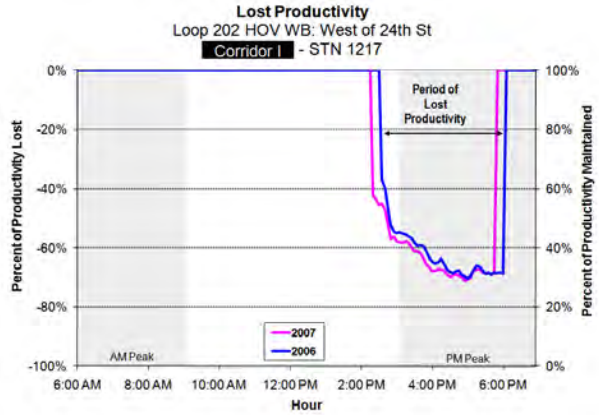


Figure 2.10s

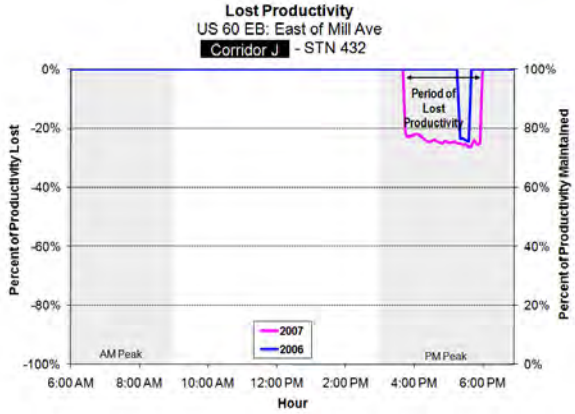
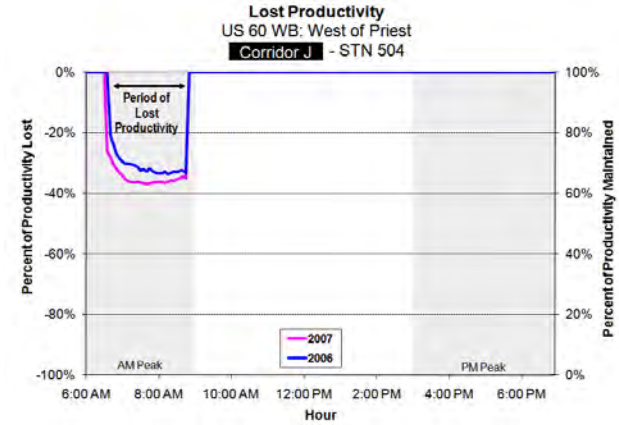


Figure 2.10t



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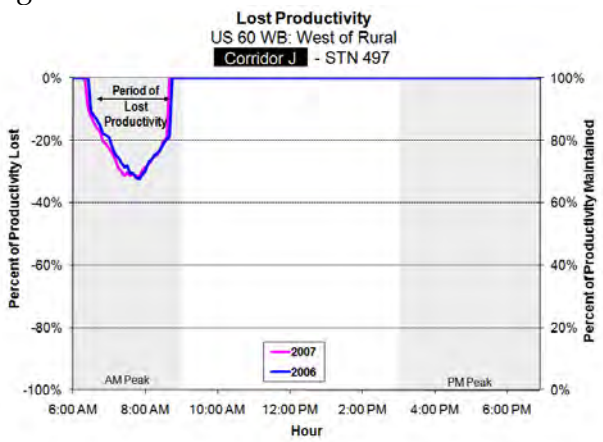

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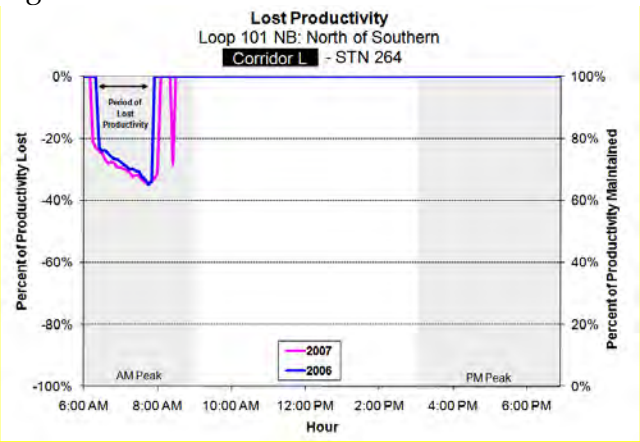

Figure 2.10w

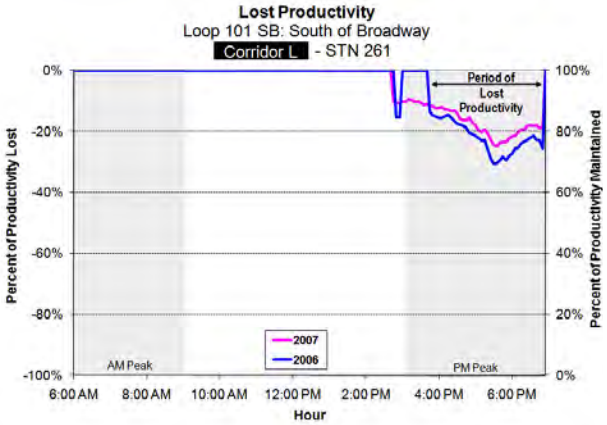

Table 2.5 Average Productivity Lost During Peak Period

Corridor ID	Analysis Corridor	Milepost	Detector Station	Nearest Cross Street	Dir	Peak Period	Average % of Productivity Lost During Peak Period (2007)
A	I-10 Papago	138.8	STN 20	59th Ave.	EB	AM	**50.4%**
A	I-10 Papago (HOV)	137.9	STN 1014	65th Ave.	EB	AM	**69.4%**
B	I-10 Papago	144.6	STN 78	9th Ave.	WB	PM	30.6%
B	I-10 Papago (HOV)	145.7	STN 1084	4th St.	WB	PM	37.1%
C	I-10 Maricopa	152.4	STN 55	42nd St.	EB	PM	**52.0%**
C	I-10 Maricopa (HOV)	153.5	STN 1064	53rd St.	EB	PM	19.3%
D	I-10 Maricopa	156.4	STN 420	Calle Biehn	WB	AM	33.3%
E	I-17	195.1	STN 98	15th St.	NB	PM	25.6%
E	I-17	199.3	STN 156	Lincoln St.	NB	PM	**57.5%**
E	I-17	194.5	STN 36	22nd St.	SB	PM	**59.3%**
F	I-17	205.7	STN 367	Lamar Rd.	SB	AM	47.4%
G	SR 51	1.79	STN 206	Avalon Dr.	NB	PM	42.2%
H	SR 51	11.3	STN 306	Voltaire Ave.	SB	AM	7.5%
G	SR 51 (HOV)	5.5	STN 1201	Lamar Rd.	SB	AM	36.2%
I	Loop 202	6.5	STN 246	Roosevelt St.	EB	PM	19.5%
I	Loop 202	1.6	STN 220	31st St.	WB	AM/PM	14.5%/39.3%
I	Loop 202	8.5	STN 275	78th St.	WB	AM	17.6%
I	Loop 202 (HOV)	0.6	STN 1217	22nd St.	WB	PM	**62.6%**
J	US 60	173.7	STN 432	Forest Ave.	EB	PM	24.3%
J	US 60	172.4	STN 504	Albert Ave.	WB	AM	34.8%
J	US 60	174.4	STN 497	La Rosa Dr.	WB	AM	24.2%
L	Loop 101	53.7	STN 264	Golf ave.	NB	AM	29.5%
L	Loop 101	53.2	STN 261	Aspen Dr.	SB	PM	16.2%

Source: ADOT FMS

2.3.1.4 Per Capita Freeway Vehicle-Miles of Travel

Definition: Per Capita Freeway Vehicle-Miles of Travel (VMT) is defined as the average number of freeway miles a person in the Phoenix-Mesa urbanized area travels by vehicle per day. This measure tracks overall personal vehicle use travel trends for the region. By factoring total travel by the population of the region, it is possible to track trends in how much individuals consume of the region's highway supply. By tracking Per Capita Freeway VMT, it is possible to determine whether changes in traffic volume are the result of growth in population (e.g., due to natural growth and in-migration), or if in fact residents are making more trips and/or traveling longer distances.

Objective: Increase personal mobility.

Source: Data were obtained from the ADOT Highway Performance Monitoring System (HPMS).

Time Scale: Per Capita Freeway VMT is reported on an annual basis by year.

Methodology: VMT and population data for 2006 and 2007 were obtained from the ADOT Highway Performance Monitoring System (HPMS) for the Phoenix-Mesa urbanized area. The boundaries of the Phoenix-Mesa urbanized area are established based on US Census Bureau data and include the Census urbanized area plus transportation centers, shopping centers, major places of employment, satellite communities, and other major trip generators near the edge of the urbanized area, including those expected to be in place in the near future. As part of HPMS reporting, ADOT submits reports on the condition and performance of its roadways to the Federal Highway Administration each year (some traffic counts are updated monthly). According to ADOT, HPMS data is based on two types of counts:

- Automatic Traffic Recorders (ATRs) The ATRs collect data 24 hours a day, 365 days annually, for each lane. The equipment records traffic volumes, speed and classification of vehicles. ADOT uses this data to develop seasonal factors, daily factors, axle factors and estimate VMT. These factors are applied to all coverage counts.
- Coverage Counts: Coverage counts are needed to ensure that adequate geographic coverage exists for all roads under the jurisdiction of the State highway authority. In simple terms, coverage counts are short duration data collection efforts that are undertaken to ensure that at least some data exist for all roads maintained by the agency.

ADOT uses ATR data and coverage counts to estimate daily VMT for interstates, freeways, and other expressways in the Phoenix-Mesa urbanized area. This daily VMT has been divided by the current estimate of population for the urbanized area to obtain per capita freeway VMT. Per capita freeway VMT results are displayed in chart format for years 2006 and 2007, with the percent change from 2006 also reported as shown in Table 2.6.

Explanation of Results and Analysis: As seen in Table 2.6, the average person in the Phoenix-Mesa urbanized area traveled 8.5 freeway miles by vehicle per day in 2007, which is a decrease of 3.2 percent compared to 2006. Total freeway travel also decreased slightly from 29,451,000 vehicle miles of travel in 2006 to 29,416,000 vehicle miles of travel in 2007.

Generally speaking, although uban interstate mileage remained the same between 2006 and 2007, freeway-based travel decreased slightly. Preliminary reports indicate that travel on urban interstates fell to an even greater extent between 2007 and 2008, which ADOT suspects was primarily the result of spiking gasoline prices and the looming recession.

Table 2.6 Results for Per Capita Freeway VMT in the Phoenix-Mesa Urbanized Area[8]

	2006	2007	% Change from 2006
VMT by Functional Class: Interstates	9,778,000	9,677,000	-1.0%
VMT by Functional Class: Other Expressways and Freeways	19,673,000	19,739,000	0.3%
Total Freeway VMT	29,451,000	29,416,000	-0.1%
Population of Phoenix-Mesa Urbanized Area	3,350,000	3,459,000	3.2%
Per Capita Freeway VMT	8.8	8.5	-3.5%

Source: ADOT HPMS

[8] Note: these results do not include the Avondale MSA

2.3.2 Travel Time, Travel Time Variability, and Delay Measures

Background: Among the measures that are most meaningful to travelers and system managers alike are those related to their experience of everyday travel. How much time should I allow to get to my destination? How likely is it that I will experience delay? What will happen if I change the time that I depart – will it make any difference if I make my trip during the peak hour, as opposed to the middle of the day? These are expressed through measures of speed, travel time, travel time variability, and delay.

2.3.2.1 Speed

Definition: Speed is a direct measure of vehicle performance on a roadway. It is a measure of congestion intensity, where intensity is defined as the amount that speed drops below an adopted standard for a given period of time. Congestion can be defined as either any speed below the posted speed limit, or a speed at some defined point below the posted speed limit. For example, on a freeway, congestion can be defined as occurring only when speeds drop below the point at which maximum vehicle throughput occurs (~45 mph).

Speed is a good point measure for reporting congestion. It is easily understood by the general public. It can also be used to report travel conditions over a roadway segment and, is therefore often used interchangeably with travel time or travel rate. Speed is defined as the average speed of vehicles measured at a specific location or traveling along a specific length of roadway. Average speed is a ready measure of the overall performance of the corridors. It can indicate whether traffic is better or worse at different times of the day. It can help to set priorities about which corridors are most in need of improvement. Tracked over time, it can indicate whether strategies are working to get traffic flowing again.

Objective: Maintain acceptable average corridor travel speeds

Source: Speed data were obtained from ADOT Freeway Management System Archived Data

Time Scale: AM peak period (6:00 AM to 9:00 AM), Midday period (9:00 AM to 3:00 PM), PM peak period (3:00 PM to 7:00 PM)

Methodology: Using SAS and the station-level base data from ADOT's fifty-eight (58) Traffic Monitoring System (TMS) traffic sensors as a starting point, the weighted average speed for each 5-minute interval at each TMS station was assigned to an analysis time period (e.g., AM peak period, Midday period, PM peak period). For each TMS station, an average speed for each analysis time period was calculated as the average speed across all 5-minute intervals included in that time period, across all non-holiday weekdays for that analysis year. The SAS analysis resulted in a data set that included average speed for each TMS station and analysis time period (GP and HOV lanes reported separately), which were exported to ArcGIS and mapped on a system-wide map as point-based speeds.

To facilitate an additional (side-by-side) comparison of point-based average speeds against average corridor level speeds, each speed map also indicates average speed for each of the

region's seven freeway corridors (with I-10 broken into two sections). These corridor level speeds were created using SAS and the link-level base data set as a starting point.[9] Subsequently, link data for each 5-minute time interval were aggregated with adjacent links across the entire length of the freeway corridor. A corridor travel time for each 5-minute interval was calculated as the summary of link travel times. Whenever a link travel time was missing, the whole corridor travel time for that 5-minute interval was set to a null value (i.e., that length of roadway was not included in the average speed calculation for that corridor.) An average corridor speed for each 5-minute interval was calculated as the freeway corridor length for which valid data were available divided by freeway corridor travel time for that roadway length. The average corridor speeds for each 5-minute interval were assigned to an analysis time period (e.g., AM peak period, Midday period, PM peak period). For each freeway corridor, an average speed for each analysis time period was calculated as the average speed across all 5-minute intervals included in that time period, across all non-holiday weekdays for that analysis year. The SAS analysis resulted in a data set that included average speeds for each freeway corridor (GP and HOV lanes reported separately) by direction of travel, for each analysis time period.

Figure 2.3 graphically depicts the process whereby lane-by-lane detector volumes and speeds were expanded into analysis corridors. This process resulted in three distinct datasets consisting of 5-minute volume, speed, and travel time statistics at the station-, link- and analysis corridor level for each day of the analysis year.

The results of these two sets of analysis, point-based and corridor level average speed have been mapped on a set six (6) system-wide maps providing results separately for GP and HOV lanes during the AM peak period, Midday period, and PM peak period – see Figures 2.11 through 2.16. Results of the corridor level speed analysis are also provided in graphical format (see Figure 2.17) (two graphs, one for each direction of travel, are provided for each of the eight corridors), and in chart format for 2007, with the change from 2006 also reported (see Table 2.7).

Explanation of Results and Analysis: While vehicle speeds vary over time and space within the freeway system, it is often useful to summarize that variation into a single number in order to track the changes occurring within a roadway. Consequently, Figures 2.11 through 2.17 have been developed to provide information concerning both average conditions, as well as measures of the variability of the speed data that make up those averages. This allows for a much more robust analysis of freeway performance.

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[9] For each 5-minute time period of each day, the lane-by-lane data at each detector location were combined into a station representing all lanes in one direction of travel. Based on this station-level data, a weighted average speed was calculated based on the respective traffic volumes in each lane. The 5-minute station data were expanded to link-level data by assuming that each detector had a zone of influence equal to half the distance to the detectors immediately upstream and downstream from it. The measured speeds and volumes were assumed to remain constant within each zone of influence, and travel times along each link were calculated by dividing the equivalent link length by the average travel speed.

The color-coded corridor speeds shown in Figures 2.11 through 2.16 illustrate the often directional nature of much of the congestion found on freeways in the MAG region. This is confirmed by the line graphs in Figure 2.17. By examining the average point speeds listed next to the color-coded lines in Figures 2.11 through 2.16, it is possible to identify specific problem locations within each corridor.

While the maps in Figures 2.11 through 2.16 illustrate the geographic variation in speeds around the region, the line graphs shown in Figure 2.17 illustrate how speeds change over time within each of the corridors. For example, upon examination of the first two graphs in Figure 2.17, it can be observed that speeds vary by time of day eastbound on I-10 from 83rd Ave to SR 51. Early in the AM peak period, a trip along that corridor averages slightly better than 40 mph. In the heart of the AM peak period, speeds drop well into the 30's, only to rise above 50 mph shortly before the end of the peak period. At the same time, speeds are changing geographically (as shown in Figure 2.11) as the traveler heads east on I-10. Slower traffic is found near 67th Ave than at 81st while other slow spots occur near the I-17 interchange.

These two types of graphics provide considerable insight into the performance of the freeway system. Key points that become apparent when looking over these graphics include the following.

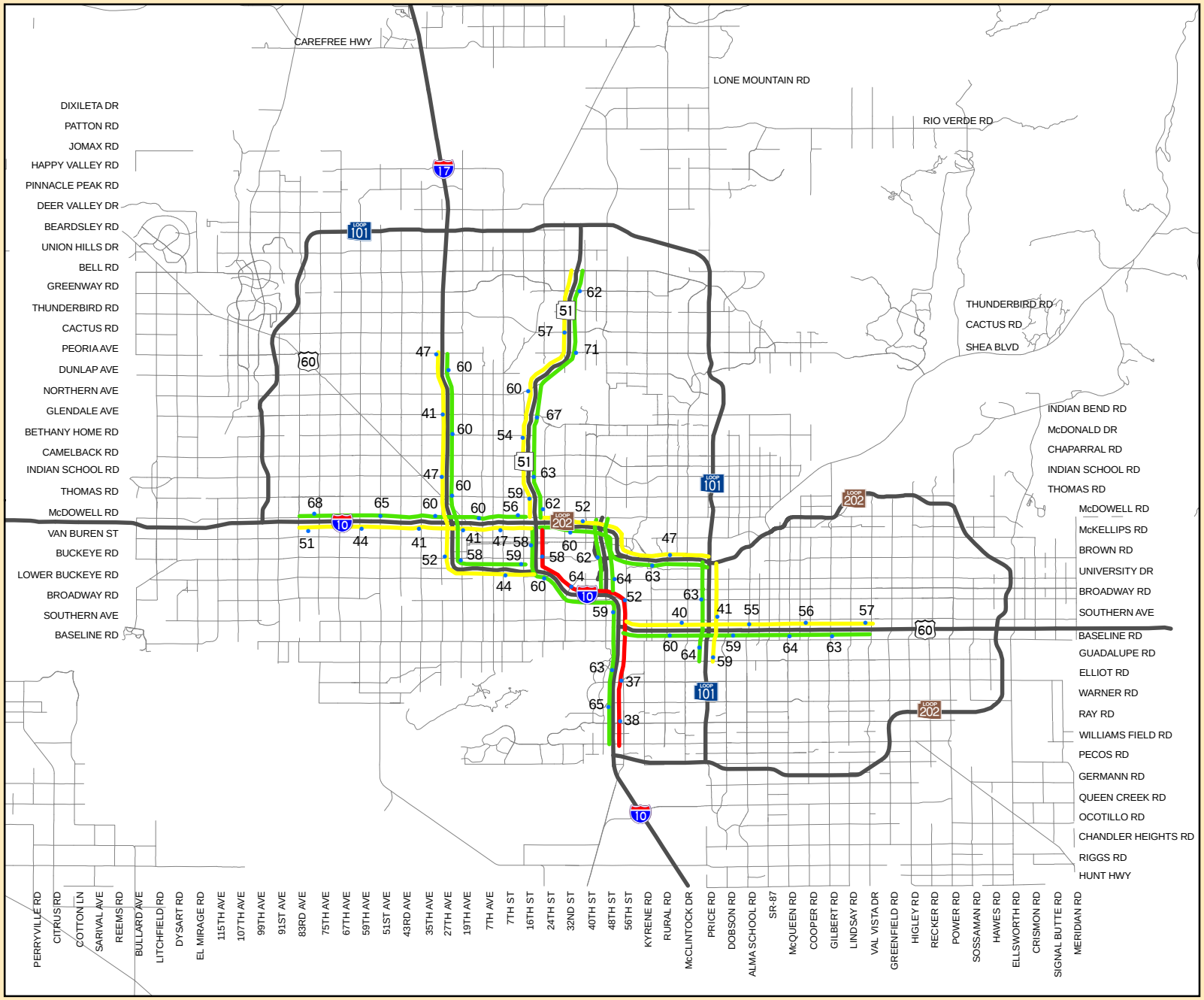
- Both the map-based graphics and the line graphics illustrate that the region's HOV system has considerable congestion. In Figure 2.17 it is apparent that most of the HOV lanes provide only a modest travel time benefit as compared to GP lanes, especially in the PM peak period. As shown, speeds on the HOV lanes tend to track the general purpose lane speeds fairly closely. While working better than their neighboring general purpose lanes, they are, in many cases, providing relatively modest travel time savings. These travel time savings are more evident in the AM peak period.
- Considerable variation is present in the speeds found in different parts of the two peak periods. Trips occurring at the beginning, middle, and end of the peak period will experience very different average speeds. For example, average speed on the Loop 202 WB between the Loop 101 and I-10/SR 51 (see Figure 2.17i) drops from 53 mph at 6:00 am to 39 mph at 7:30 am, and climbs back to 50 mph by 9:00am.
- Congestion in the MAG region forms much earlier than in many other US cities. For example, by 6 AM, average corridor speeds on I-17 southbound from Peoria Avenue to the Maricopa Traffic Interchange have already dropped below 45 mph. Congestion also tends to dissipate earlier than in many other cities. For example, by 6 PM, average corridor speeds on the Loop 202 westbound from the Loop 101 to I-10 have recovered significantly from their PM Peak Period low of 35 mph.

Figure 2.11

MARICOPA ASSOCIATION of GOVERNMENTS

Performance Measures Study

Average AM Peak Period Corridor Speeds General Purpose Lanes



Note:
Colored bars represent average speeds along each corridor.

Numbers indicate select average station speeds.

While every effort has been made to ensure the accuracy of this information, the Maricopa Association of Governments makes no warranty, expressed or implied, as to its accuracy and expressly disclaims liability for the accuracy thereof.

0 5 10 15 20 Miles

N

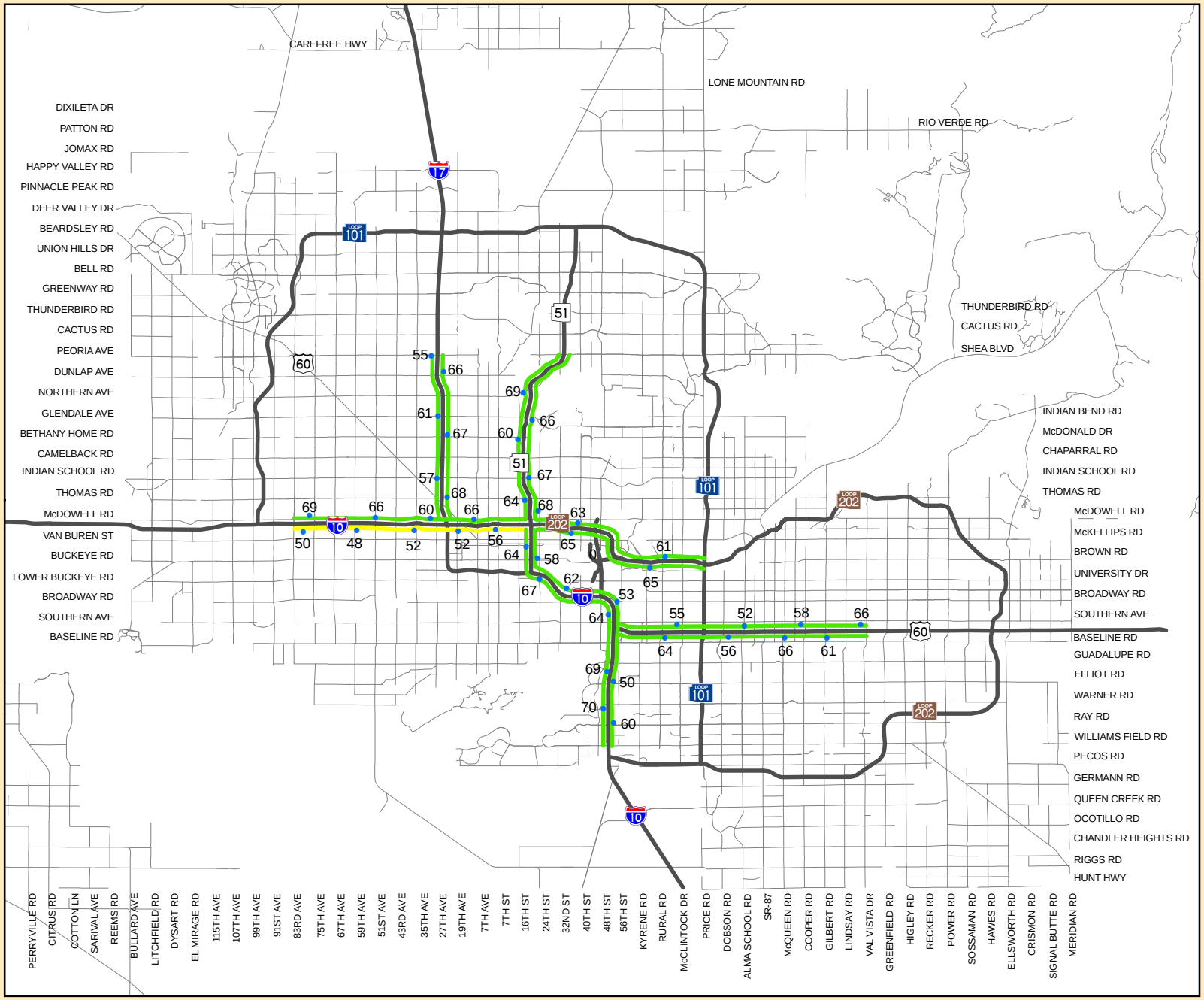
Source: ADOT Freeway Management System Archived Data

Figure 2.12

MARICOPA ASSOCIATION of GOVERNMENTS

Performance Measures Study

Average AM Peak Period Corridor Speeds HOV Lanes



Legend

Average Corridor Speeds (2007)

- 25.0 - 40.0 MPH
- 40.1 - 55.0 MPH
- > 55 MPH
- Freeways
- Major Roads
- 55 Sensor Station Speed

Note:
Colored bars represent average speeds along each corridor.

Numbers indicate select average station speeds.

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0 5 10 15 20 Miles

N

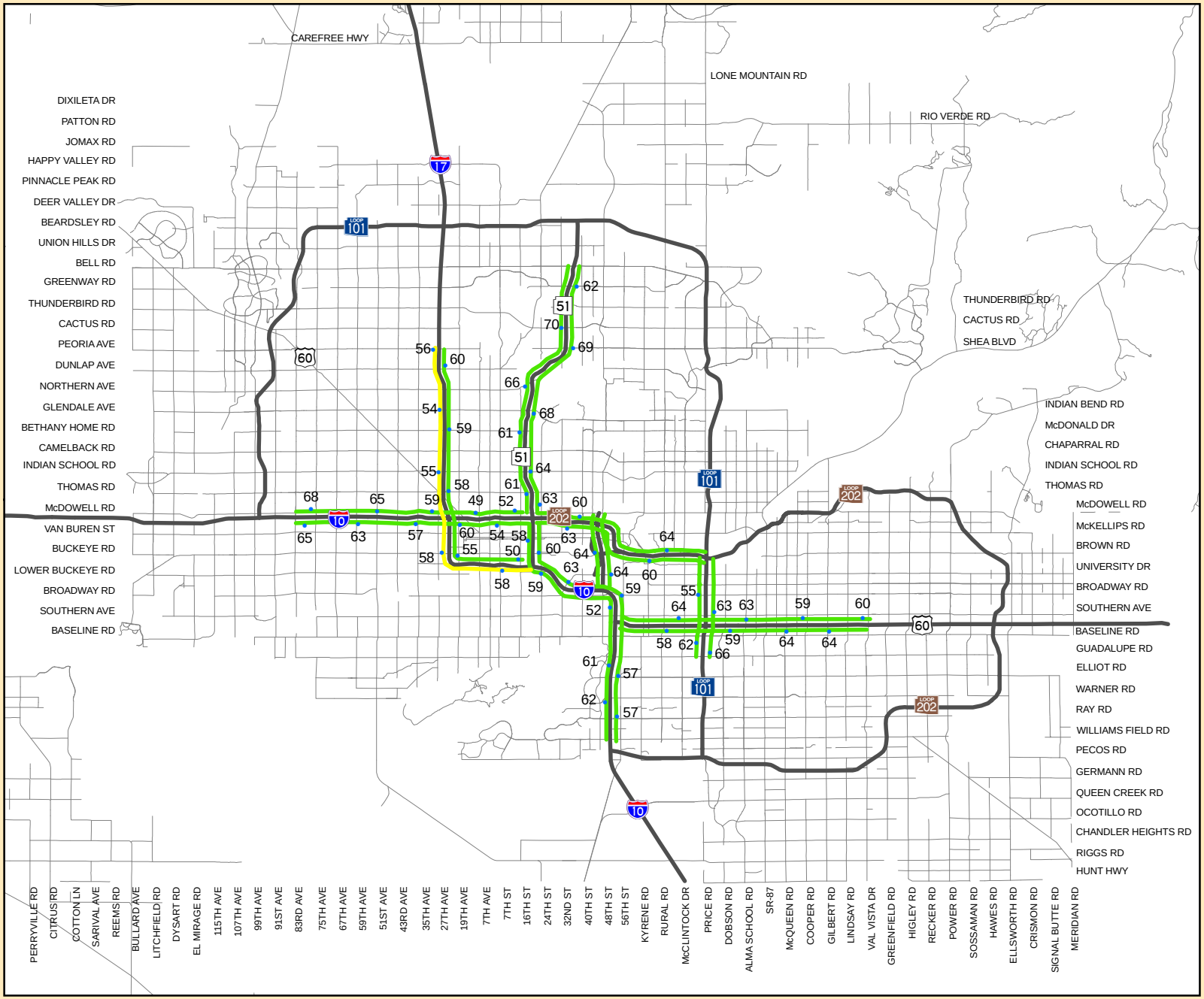
Source: ADOT Freeway Management System Archived Data

Figure 2.13

MARICOPA ASSOCIATION of GOVERNMENTS

Performance Measures Study

Average Midday Period Corridor Speeds General Purpose Lanes



Legend

Average Corridor Speeds (2007)

- 25.0 - 40.0 MPH
- 40.1 - 55.0 MPH
- > 55 MPH
- Freeways
- Major Roads
- 55 Sensor Station Speed

Note:
Colored bars represent average speeds along each corridor.

Numbers indicate select average station speeds.

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0 5 10 15 20 Miles

N

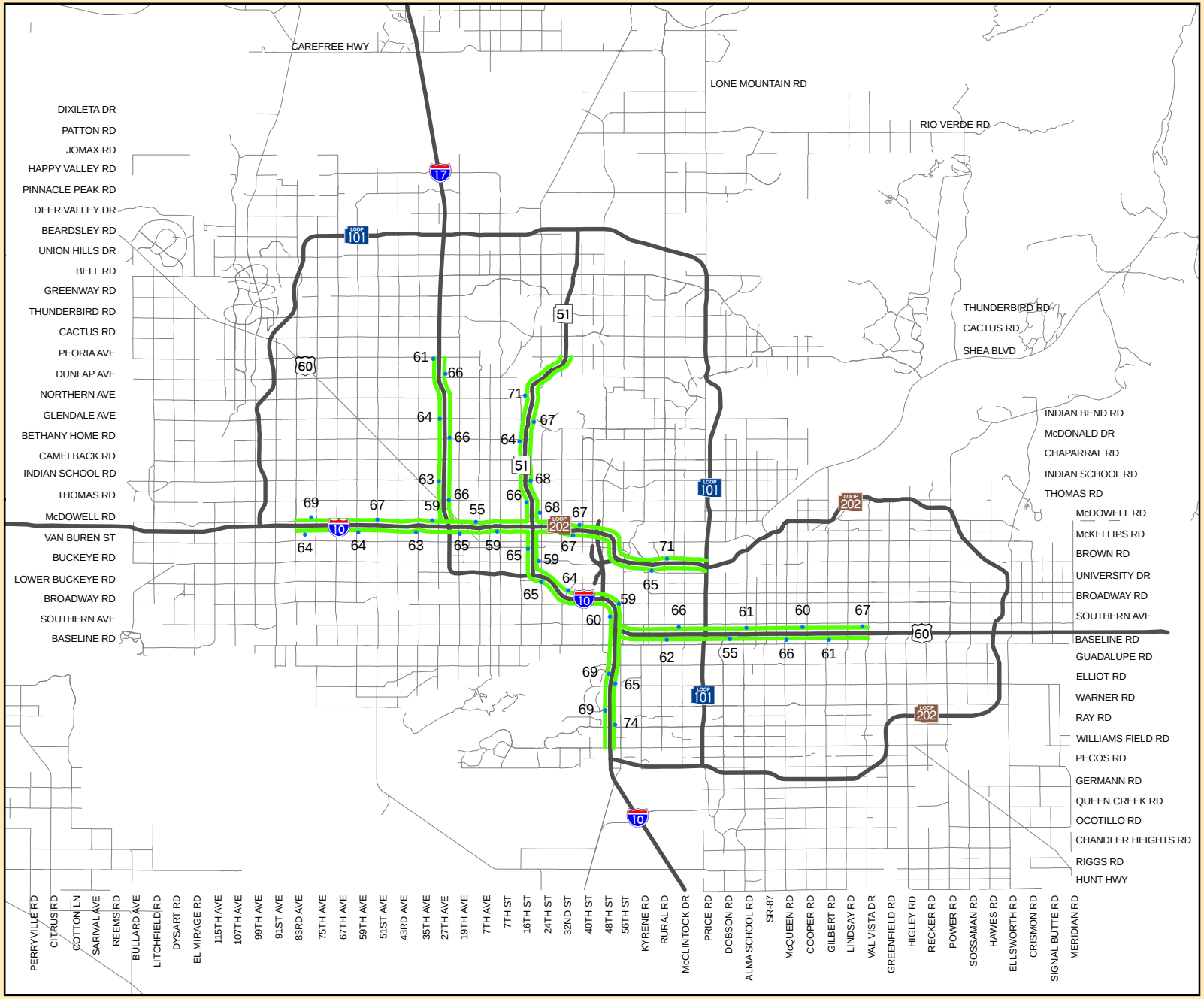
Source: ADOT Freeway Management System Archived Data

Figure 2.14

MARICOPA ASSOCIATION of GOVERNMENTS

Performance Measures Study

Average Midday Period Corridor Speeds HOV Lanes



Legend

Average Corridor Speeds (2007)

- 25.0 - 40.0 MPH
- 40.1 - 55.0 MPH
- > 55 MPH
- Freeways
- Major Roads
- 55 Sensor Station Speed

Note:
Colored bars represent average speeds along each corridor.

Numbers indicate select average station speeds.

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0 5 10 15 20 Miles

N

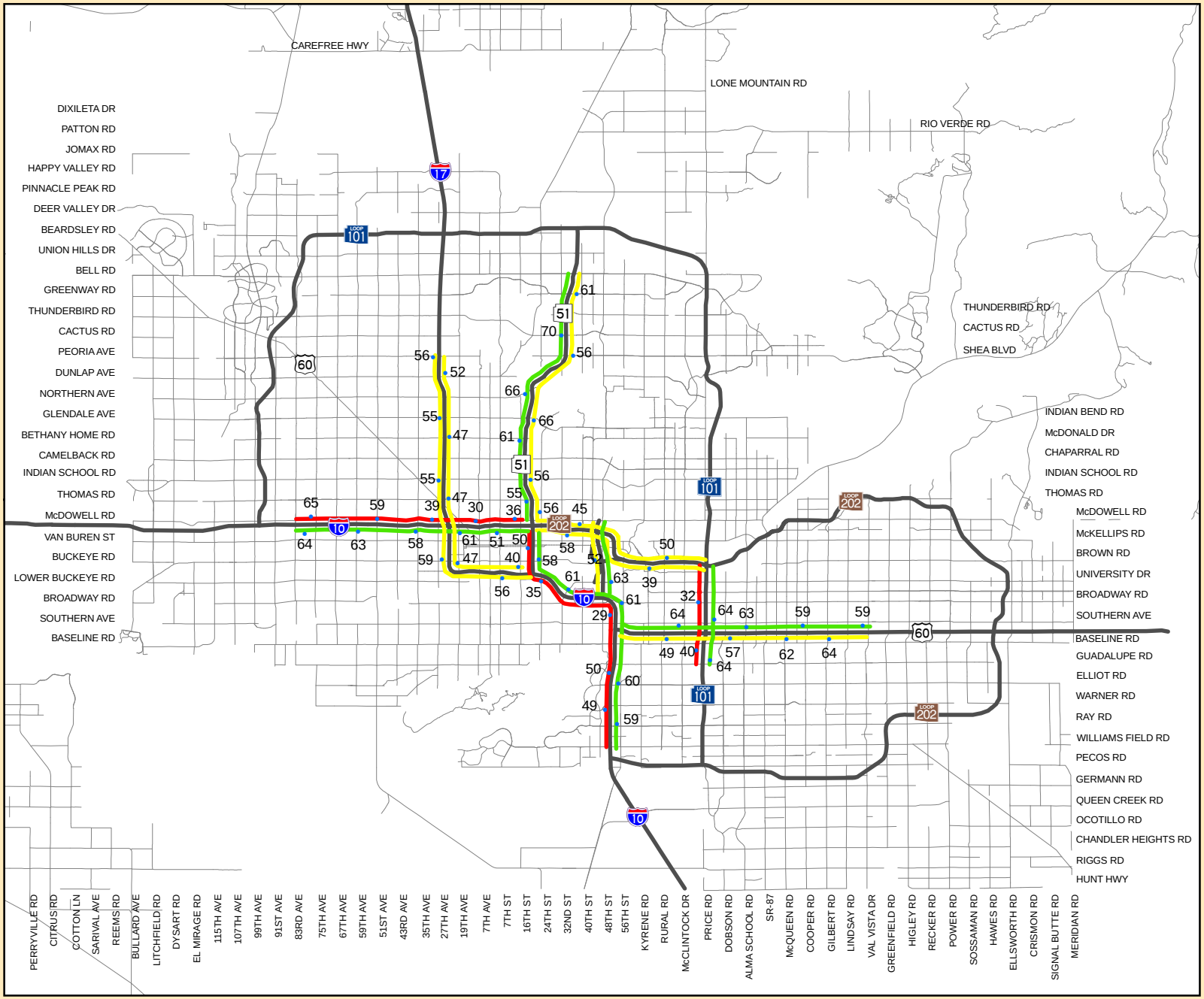
Source: ADOT Freeway Management System Archived Data

Figure 2.15

MARICOPA ASSOCIATION of GOVERNMENTS

Performance Measures Study

Average PM Peak Period Corridor Speeds General Purpose Lanes



Legend

Average Corridor Speeds (2007)

- 25.0 - 40.0 MPH
- 40.1 - 55.0 MPH
- > 55 MPH
- Freeways
- Major Roads
- 55 Sensor Station Speed

Note:
Colored bars represent average speeds along each corridor.

Numbers indicate select average station speeds.

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0 5 10 15 20 Miles

N

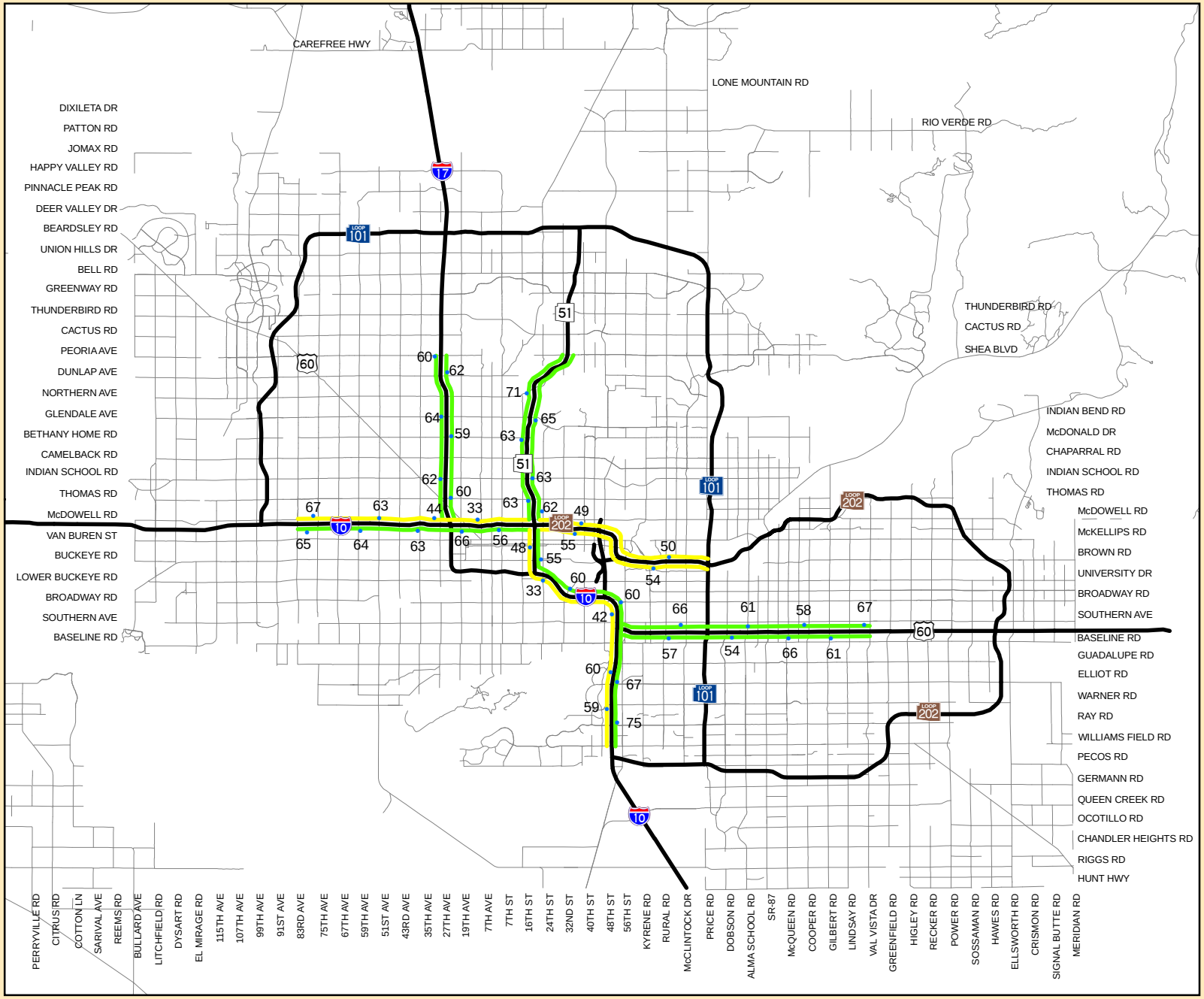
Source: ADOT Freeway Management System Archived Data

Figure 2.16

MARICOPA ASSOCIATION of GOVERNMENTS

Performance Measures Study

Average PM Peak Period Corridor Speeds HOV Lanes



Legend

Average Corridor Speeds (2007)

- 25.0 - 40.0 MPH
- 40.1 - 55.0 MPH
- > 55 MPH
- Freeways
- Major Roads
- 55 Sensor Station Speed

Note:
Colored bars represent average speeds along each corridor.

Numbers indicate select average station speeds.

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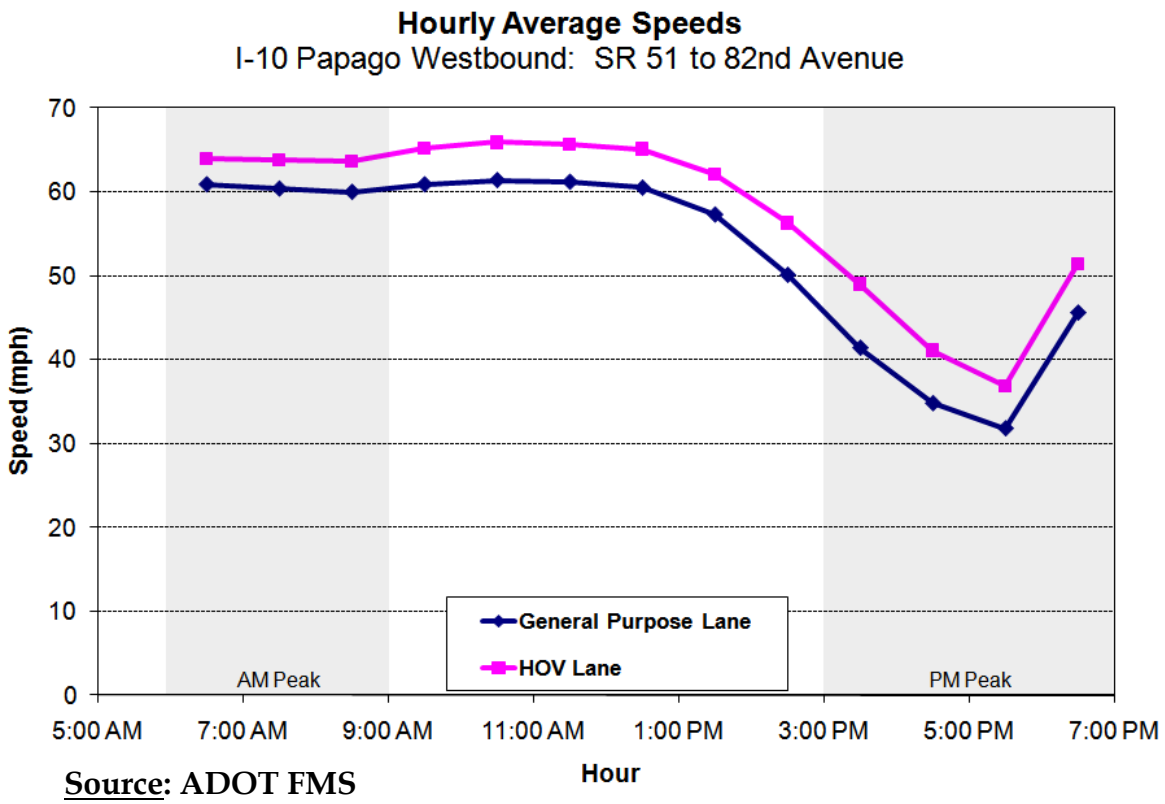
0 5 10 15 20 Miles

N

Source: ADOT Freeway Management System Archived Data

Figure 2.17a



Source: ADOT FMS

Figure 2.17b

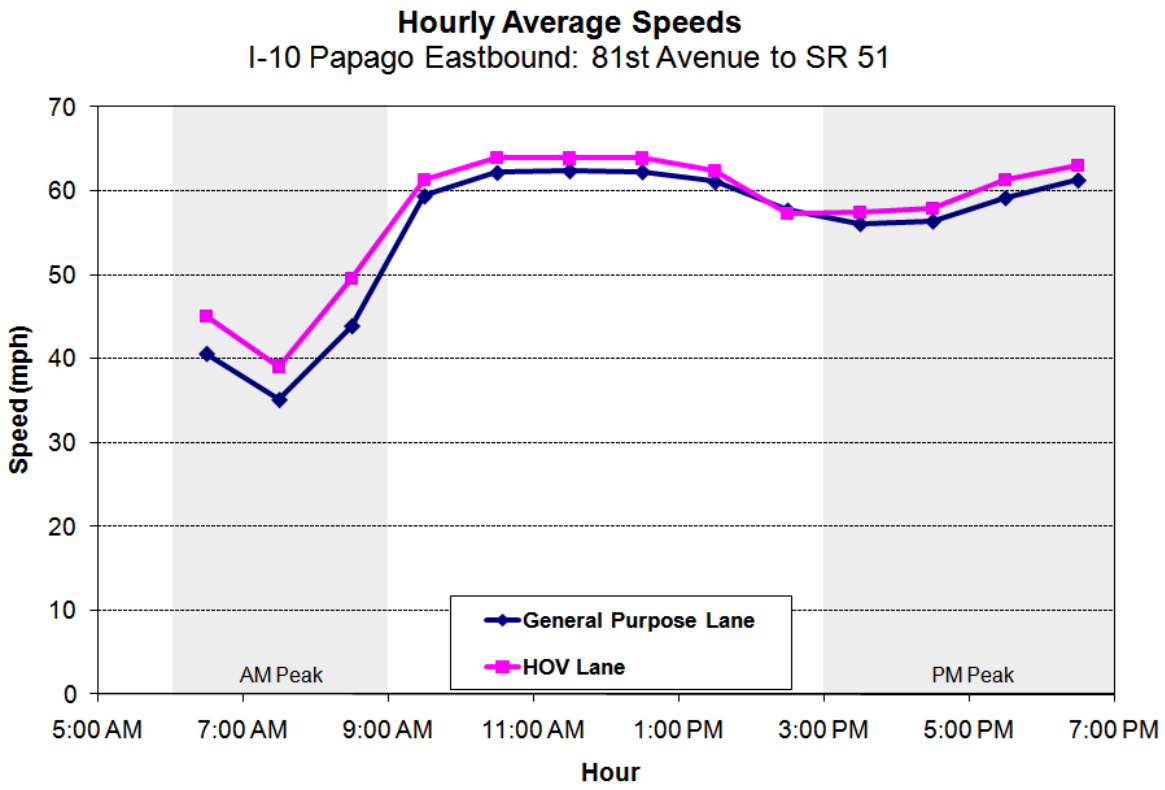


Figure 2.17c

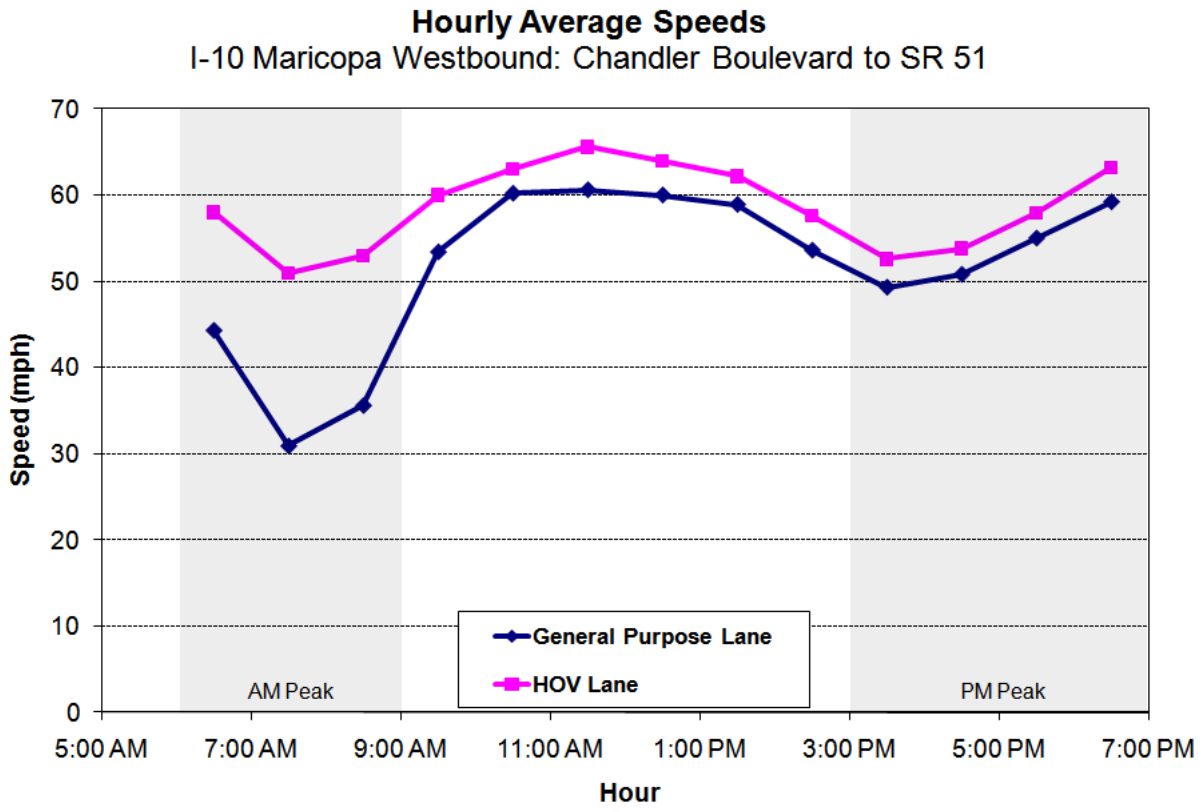


Figure 2.17d

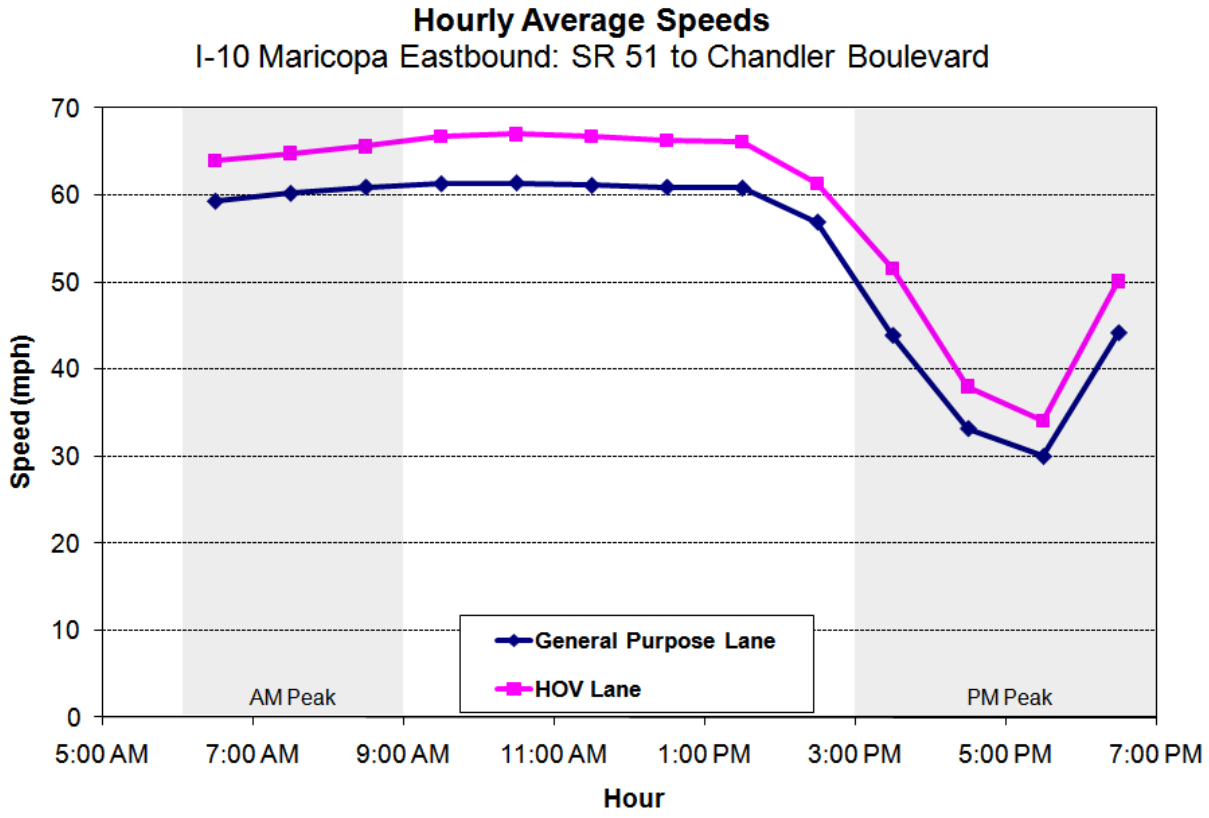


Figure 2.17e

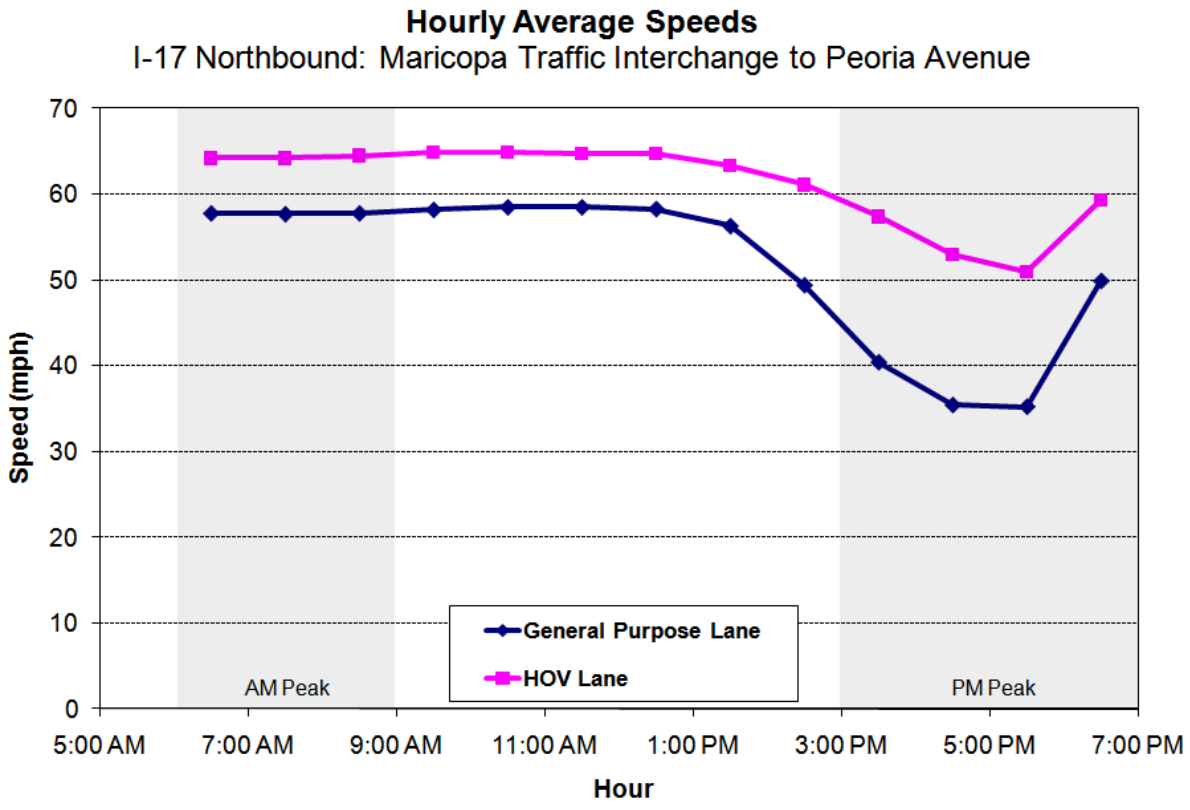


Figure 2.17f

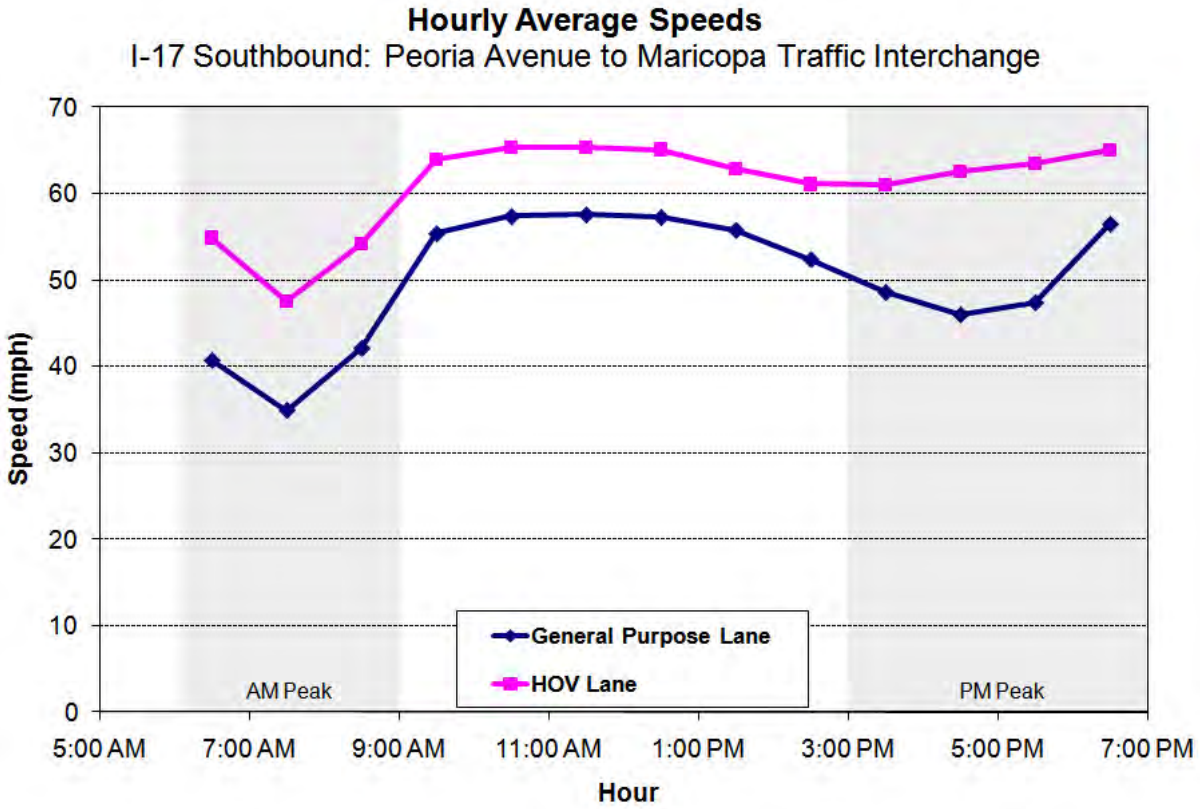


Figure 2.17g

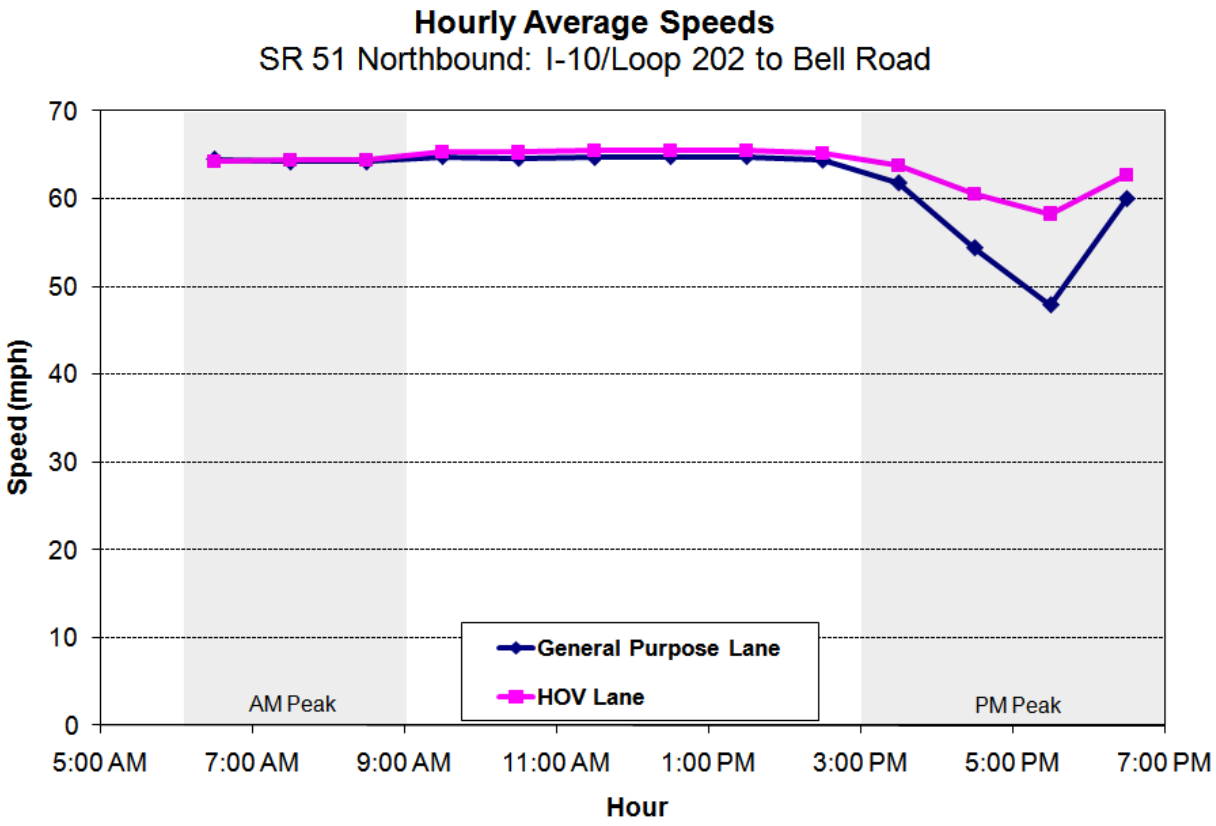


Figure 2.17h

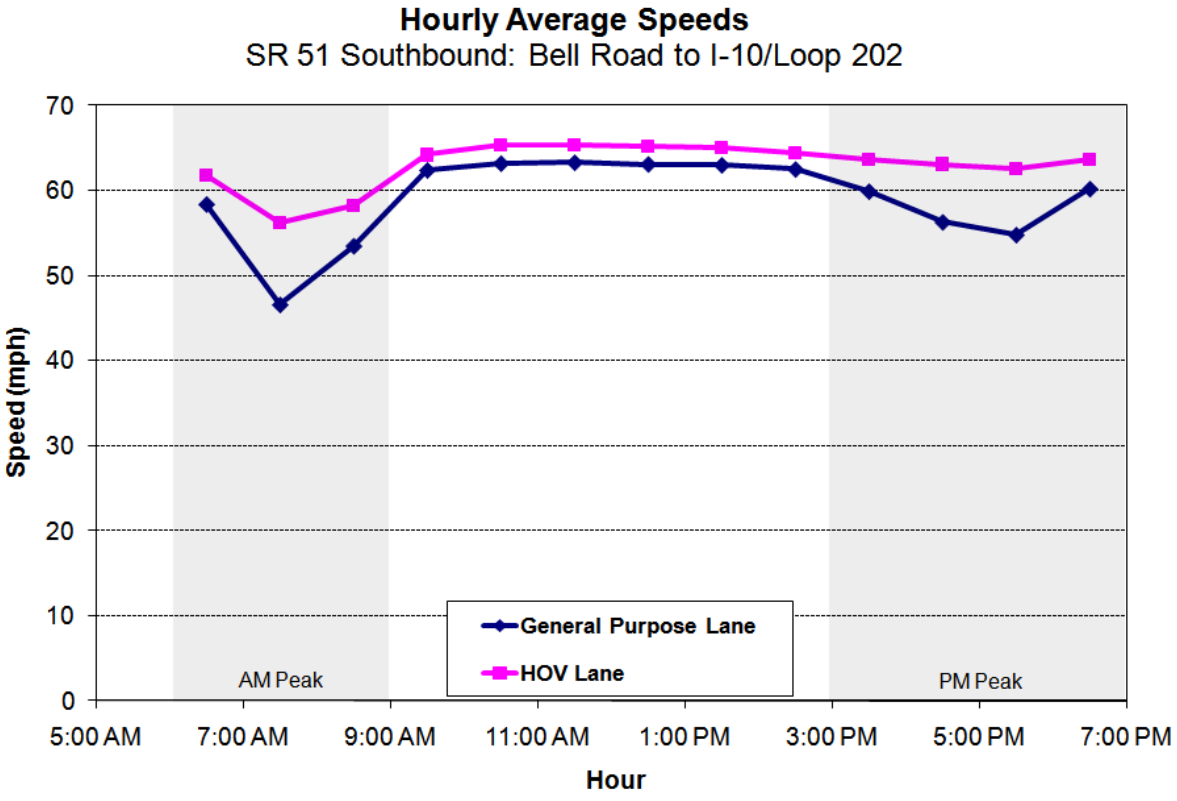


Figure 2.17i

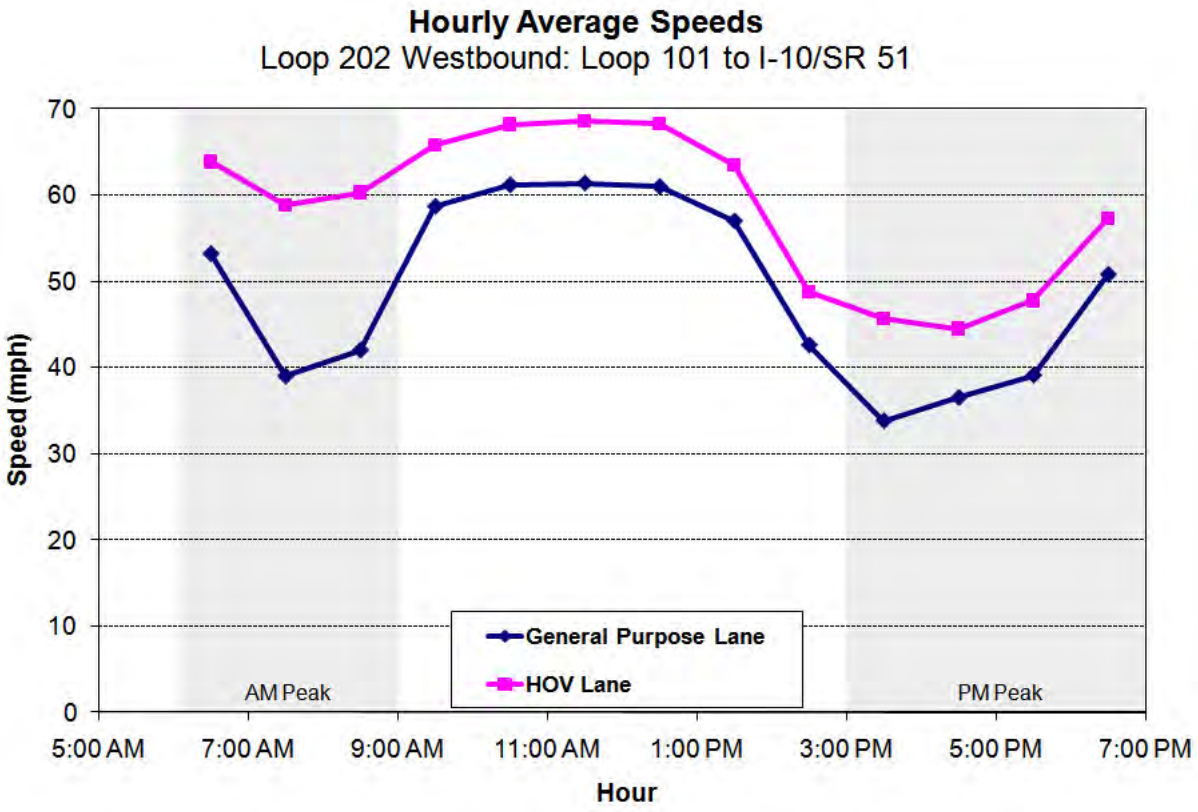


Figure 2.17j

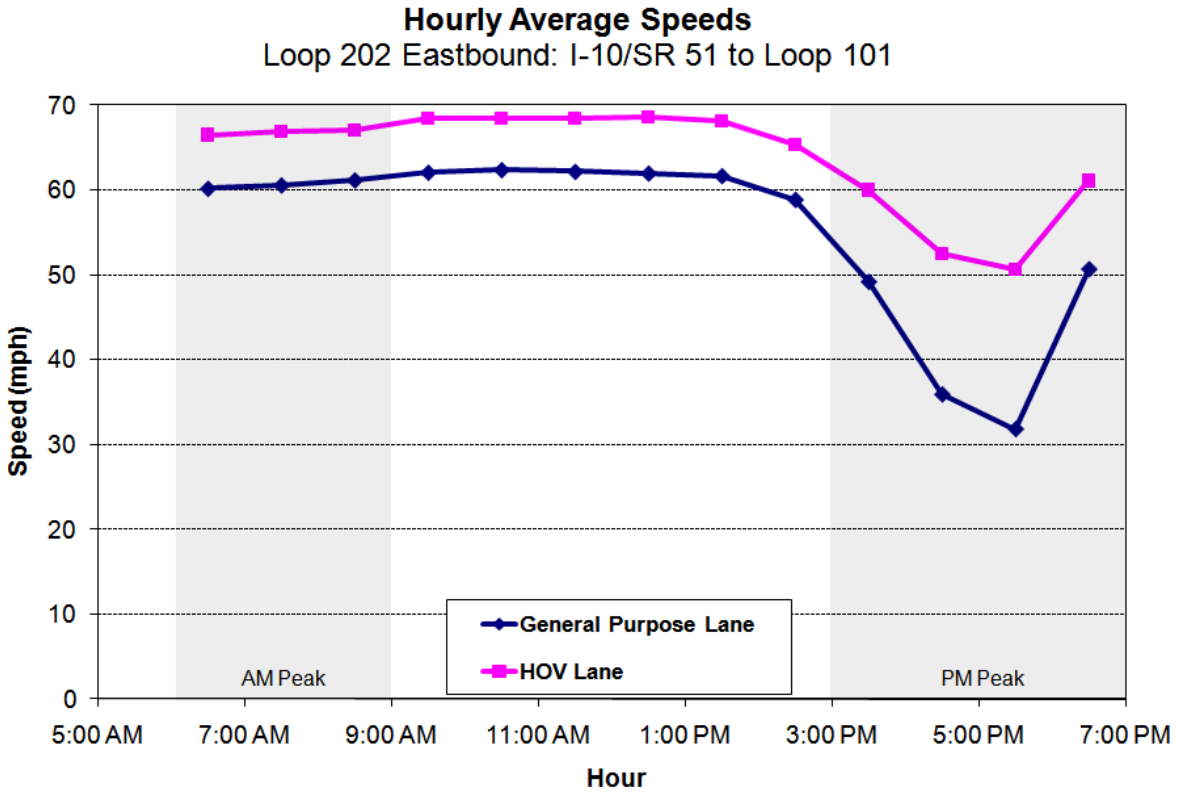


Figure 2.17k

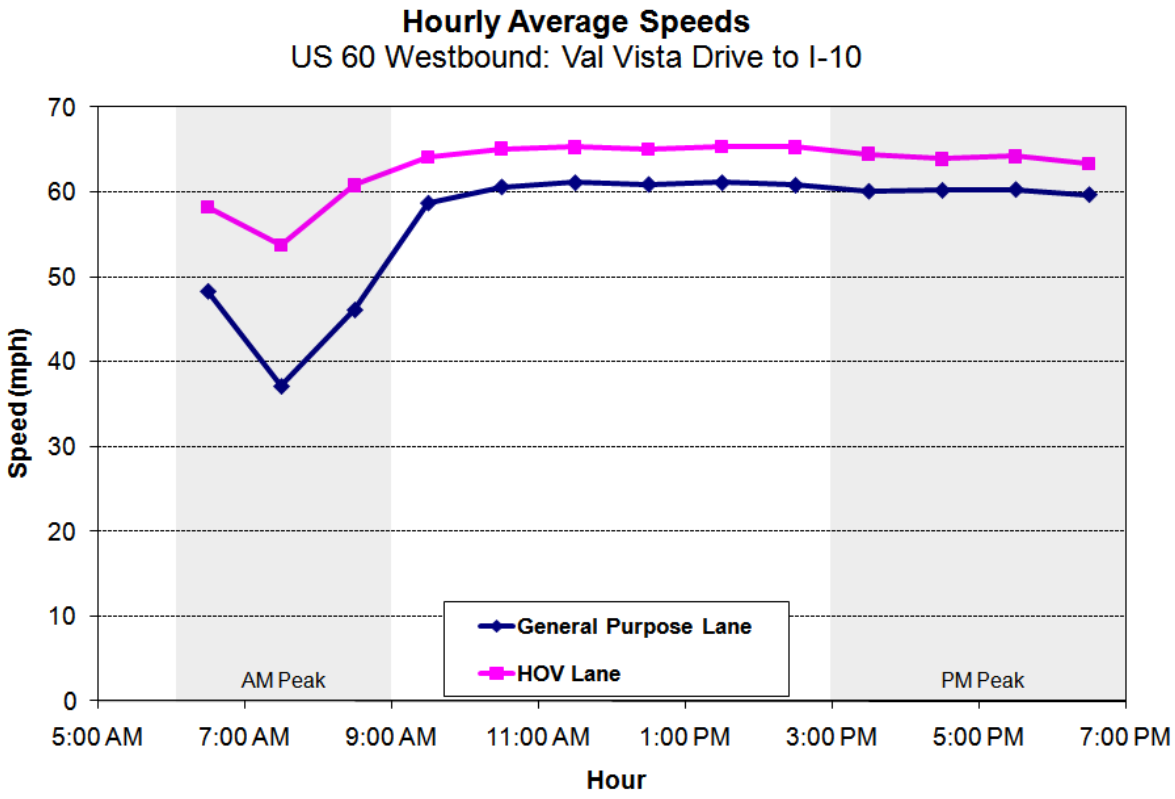


Figure 2.17l

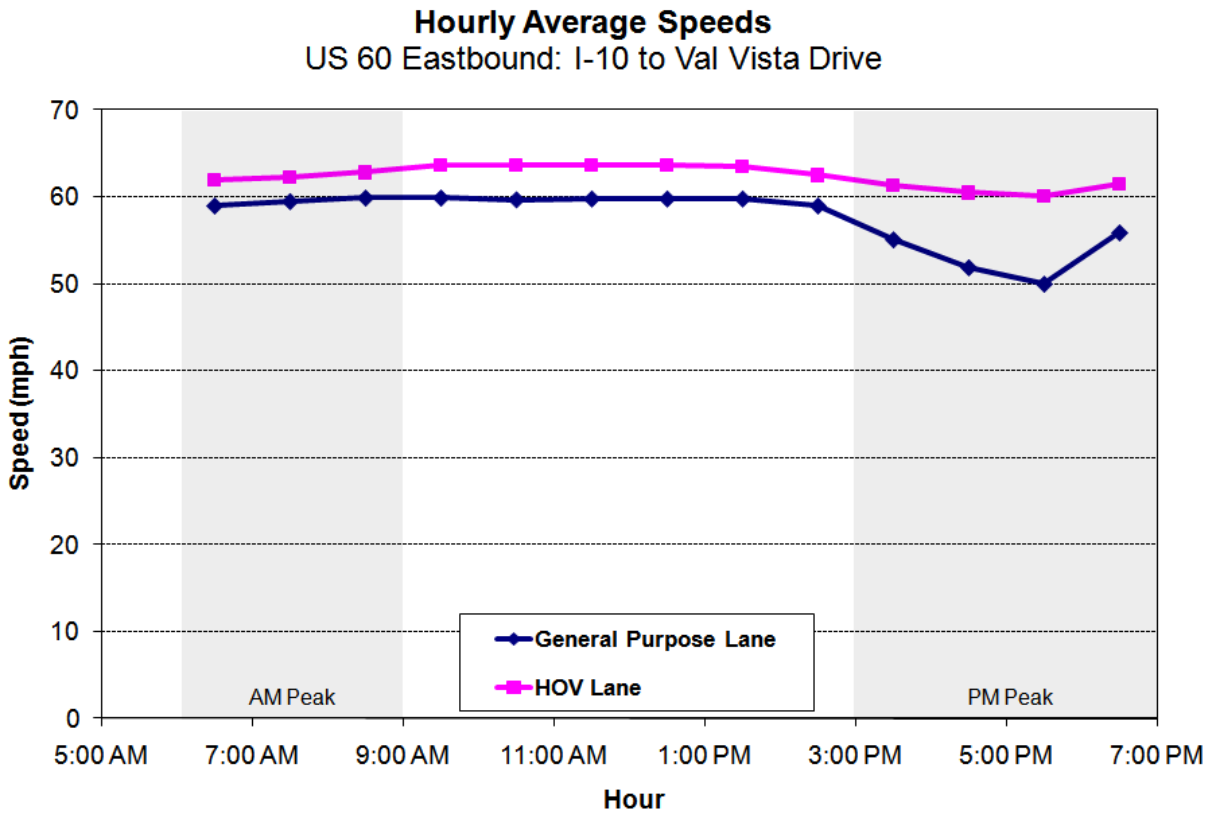


Figure 2.17m

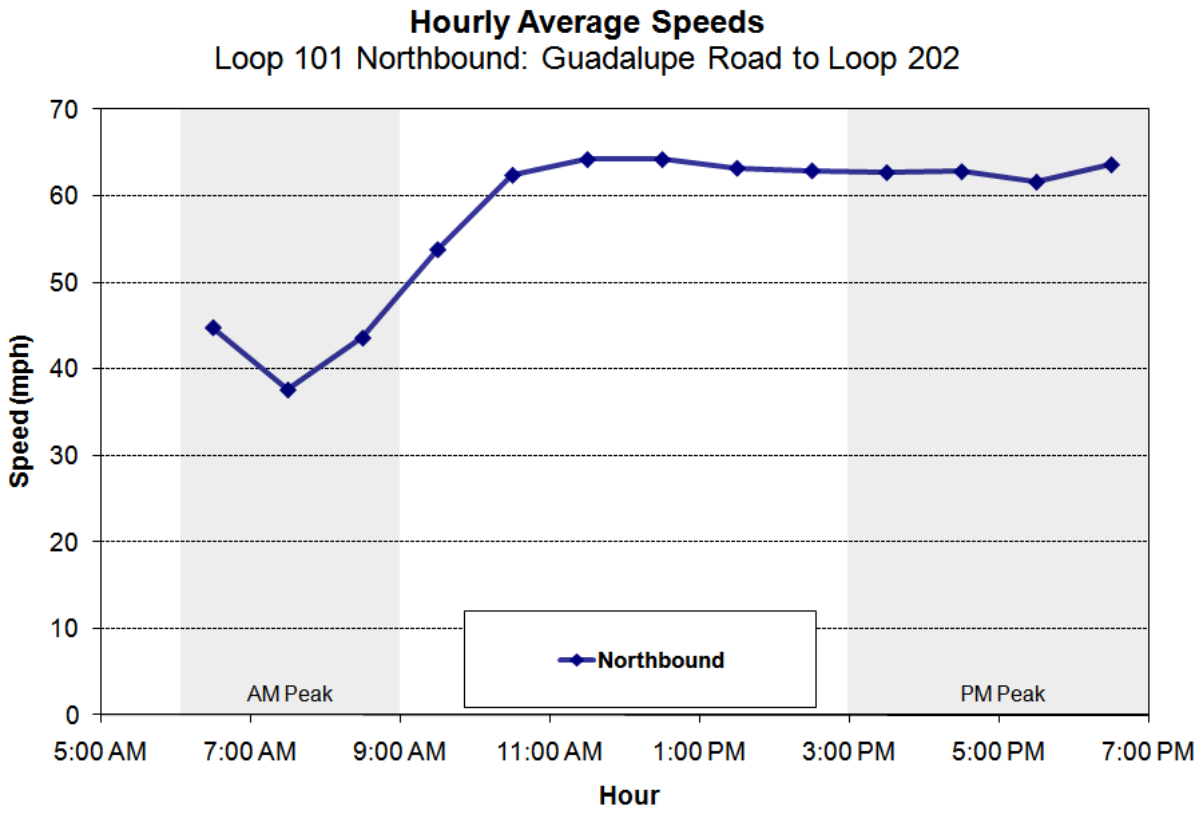


Figure 2.17n

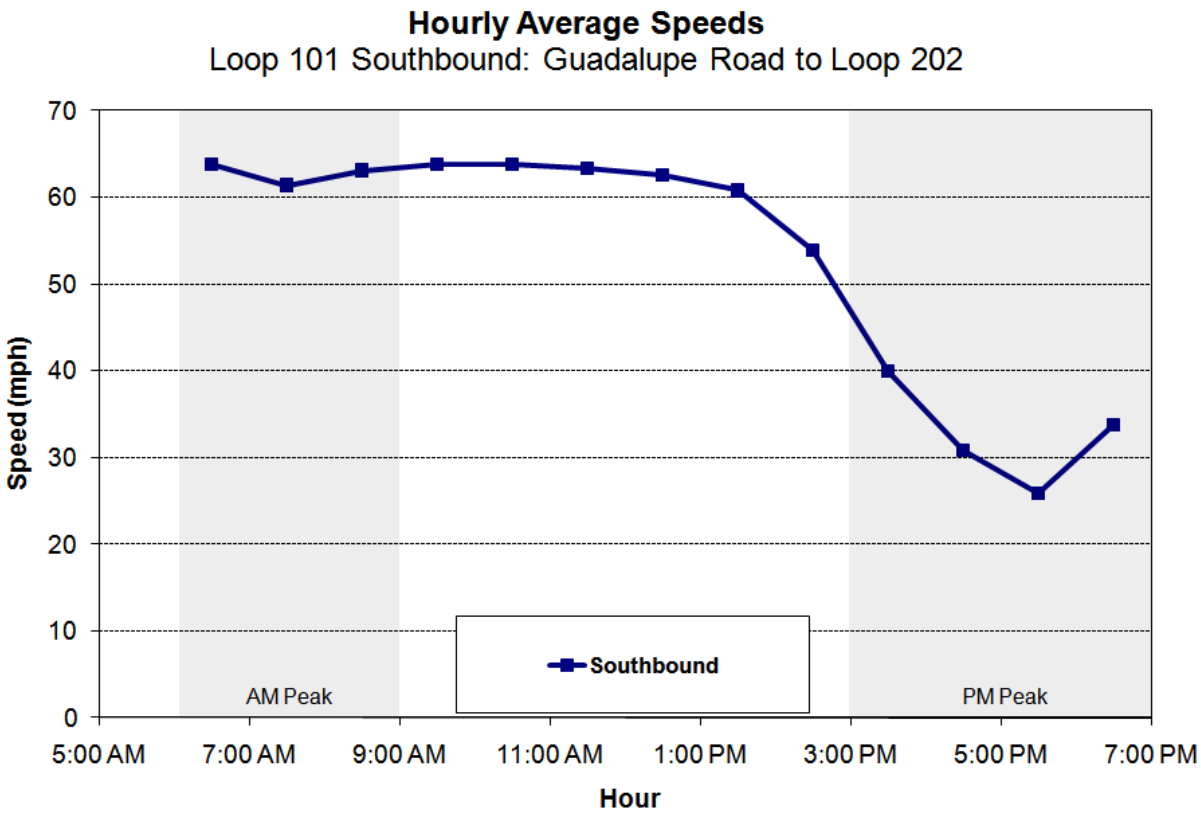


Figure 2.17o

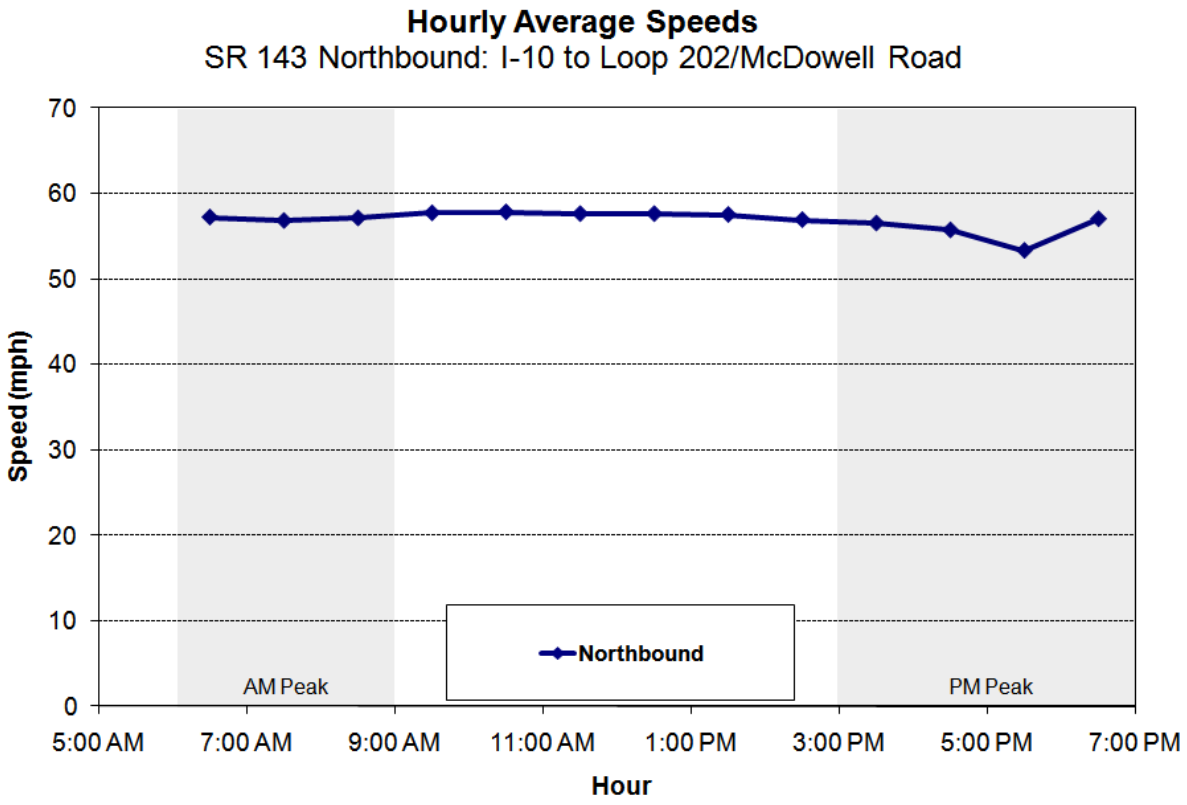


Figure 2.17p

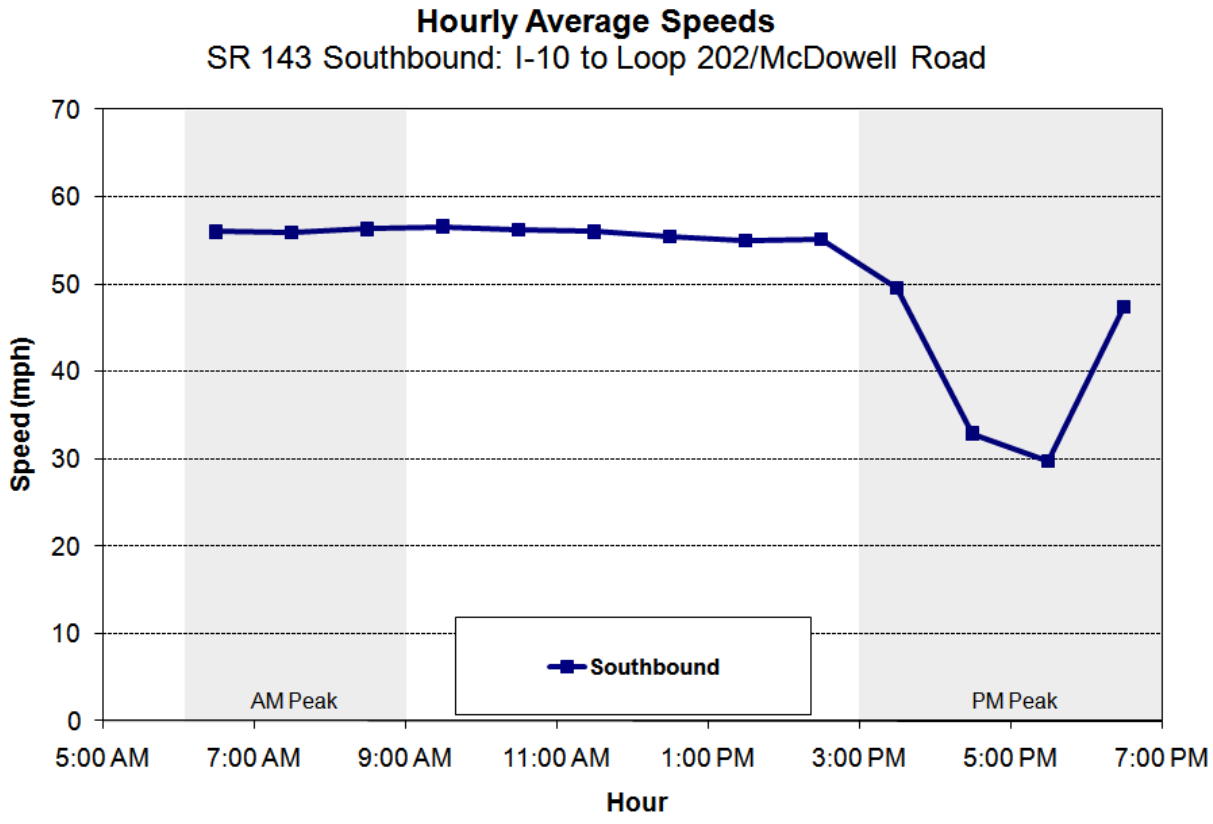


Table 2.7 Results for Average Speed for Freeway Corridors

Corridor ID	Freeway Corridor	Dir	AM Peak Period		PM Peak Period	
			2007	Change from 2006	2007	Change from 2006
A+B	I-10 Papago: 81st Avenue to SR 51	EB	39.6	0.0	58.8	1.1
	I-10 Papago EB HOV: 81st Avenue to SR 51	EB	44.1	-4.2	60.5	-1.5
	I-10 Papago: SR 51 to 82nd Avenue	WB	60.4	0.2	36.6	-1.5
	I-10 Papago HOV: SR 51 to 82nd Avenue	WB	63.8	-1.3	42.2	-0.7
C+D	I-10 Maricopa: SR 51 to Chandler Blvd	EB	60.1	1.6	34.8	1.9
	I-10 Maricopa HOV: SR 51 to Chandler Blvd	EB	64.7	2.0	39.2	2.2
	I-10 Maricopa: Chandler Blvd to SR 51	WB	36.3	-0.1	54.5	-0.1
	I-10 Maricopa HOV: Chandler Blvd to SR 51	WB	56.6	-0.4	64.7	1.1
E+F	I-17: Maricopa Traffic Interchange to Peoria Avenue	NB	57.8	-0.1	38.9	-1.9
	I-17 HOV: McDowell Road to Peoria Avenue	NB	64.3	-0.7	53.9	-0.7
	I-17: Peoria Ave to Maricopa Traffic Interchange	SB	39.1	0.0	49.3	2.2
	I-17 HOV: Peoria Avenue to Thomas Road	SB	51.9	-4.7	63.6	0.7
G+H	SR 51: I-10/Loop 202 to Bell Road	NB	64.3	-0.8	53.4	-0.3
	SR 51 HOV: McDowell Road to Shea Blvd	NB	64.4	-1.6	60.2	-1.4
	SR 51: Bell Road to I-10/Loop 202	SB	52.3	3.0	56.9	2.5
	SR 51 HOV: Shea Blvd to I-10/Loop 202	SB	58.5	-2.4	63.1	-1.1
I	Loop 202: I-10/SR 51 to Loop 101	EB	60.7	-0.3	37.6	-0.5
	Loop 202 HOV: I-10/SR 51 to Loop 101	EB	66.8	0.4	53.4	0.2
	Loop 202: Loop 101 to I-10/SR 51	WB	44.0	-0.1	41.2	-0.8
	Loop 202 HOV: Loop 101 to I-10/SR 51	WB	60.7	0.1	49.3	-1.1
J+K	US 60: I-10 to Val Vista Drive	EB	59.5	2.3	52.4	3.8
	US 60 HOV: I-10 to Val Vista Drive	EB	62.3	2.0	60.7	3.0
	US 60: Val Vista Drive to I-10	WB	43.4	0.0	60.1	2.0
	US 60 HOV: Val Vista Drive to I-10	WB	57.1	-3.1	63.8	-0.4
L	Loop 101: Guadalupe Road to Loop 202	NB	41.8	-0.1	62.6	-0.2
	Loop 101: Loop 202 to Guadalupe Road	SB	62.6	0.2	29.9	-1.7
M	SR 143: I-10 to Loop 202/McDowell Road	NB	57.0	-0.6	55.1	0.9
	SR 143: Loop 202/McDowell Road to I-10	SB	56.0	0.4	34.5	-3.4

Source: ADOT FMS

2.3.2.2 *Point-to-Point Travel Times*

Definition: Point-to-point travel time is the average time required to traverse a fixed distance of freeway in a single direction. Point-to-point travel times were calculated for specific freeway origin-destination (O-D) pairs that are representative of common commutes in the MAG region (see Figure 2.18):

From:	**To:**	**When:**
I-10 at 83rd Avenue	202 at 101	Midday period
US 60 at Val Vista Drive	SR 143 at Sky Harbor Blvd	AM peak period
101 at US 60	I-10 at 7th Street	PM peak period
101 at Guadalupe	I-17 and Dunlap	AM peak period
I-17 at 19th Avenue	I-10 at Elliot	PM peak period
I-10 at Warner Road	SR 143 at University	AM peak period
I-10 at 83rd Avenue	SR 51 at Bell Road	PM peak period

Objective: Maintain reasonable travel times on typical commute corridors in the region. The percent increase in average travel time should be less than the percent increase in traffic volume.

Source: Travel time data were derived from ADOT Freeway Management System Archived Data for years 2006 and 2007.

Time Scale: Reporting period differs for each O-D pair. Time periods are defined as: AM peak (6:00 AM to 9:00 AM), Midday period (9:00 AM to 3:00 PM), PM peak (3:00 PM to 7:00 PM)

Methodology: Using SAS and the link-level base data as a starting point, link data for each 5-minute time interval were aggregated with adjacent links across the entire length of the freeway O-D pair. A total travel time for each 5-minute interval was calculated as the sum of link travel times along a specific route between the origin and destination. Only the specific links that fell within the limits of the O-D pairs were included for analysis. The travel times for each 5-minute interval were assigned to an analysis time period (e.g., AM peak period, Midday period, PM peak period). For each O-D pair, an average travel time for the specified time period was calculated as the average travel time across all 5-minute intervals included in that time period, across all non-holiday weekdays for that analysis year. The SAS analysis resulted in a dataset that included average peak period or off-peak period travel time for each representative O-D pair. The results were exported to ArcGIS and mapped on a system-wide map showing the locations and limits of each O-D pair. Travel time results were color-coded for each O-D pair, with the legend depicting average travel time for that peak period commute. These results were also reported in chart format for 2006 and 2007, with the change from 2006 also reported (see Table 2.8).

Explanation of Results and Analysis: Table 2.8 provides travel times for common commutes in the MAG region. Figure 2.18 below, provides a map view of the origins and destinations for these commutes, meant to be illustrative of typical trips made in the region.

The travel time changes shown in Table 2.8 are illustrative of many of the measured changes in freeway performance between 2006 and 2007 provided elsewhere in this report. They show that freeway conditions in the MAG region are changing, but those changes are generally modest in size and scope and differ from facility to facility across the region. Travel on two of the representative trips in the region became faster in 2007 than 2006. The other five trips remained essentially the same, experiencing changes in travel time of less than one minute. Changes from 2006 to 2007 are modest in size, with the largest, O-D 5, representing a five percent change in travel time. The other changes are approximately 1 to 2 percent, and are small enough that they are unlikely to be noticeable to the public.

Table 2.8 Average Travel Time Results for Typical Commutes

Commute ID	From	To	Time Period	Dir	Average Travel Time (min)		
					2006	2007	Change from 2006
O-D 1	I-10 at 83rd Avenue - east of Loop 101	Loop 202 at Loop 101 - near Tempe Marketplace	Midday	EB	22	22	0
O-D 2	US 60 at Val Vista Drive - midway between Loop 101 and Loop 202	SR 143 at Sky Harbor Blvd - just east of Sky Harbor Airport	AM Peak	WB	22	22	0
O-D 3	Loop 101 at US 60 - south of Loop 202 (Red Mountain)	I-10 at 7th Street - north of downtown Phoenix	PM Peak	WB	19	19	0
O-D 4	Loop 101 at Guadalupe - south of US 60	I-17 at Dunlap - near MetroCenter Mall	AM Peak	NB	32	32	0
O-D 5	I-17 at 19th Avenue - east of the Durango Curve	I-10 at Elliot - midway between US 60 and Loop 202 (Santan)	PM Peak	WB	24	23	-1
O-D 6	I-10 at Warner Road - midway between US 60 and Loop 202 (Santan)	SR 143 at University - west end of Tempe, near Sky Harbor Airport	AM Peak	NB	12	12	0
O-D 7	I-10 at 83rd Avenue - east of Loop 101	SR 51 at Bell Road - south of Loop 101	PM Peak	EB/ NB	26	25	-1

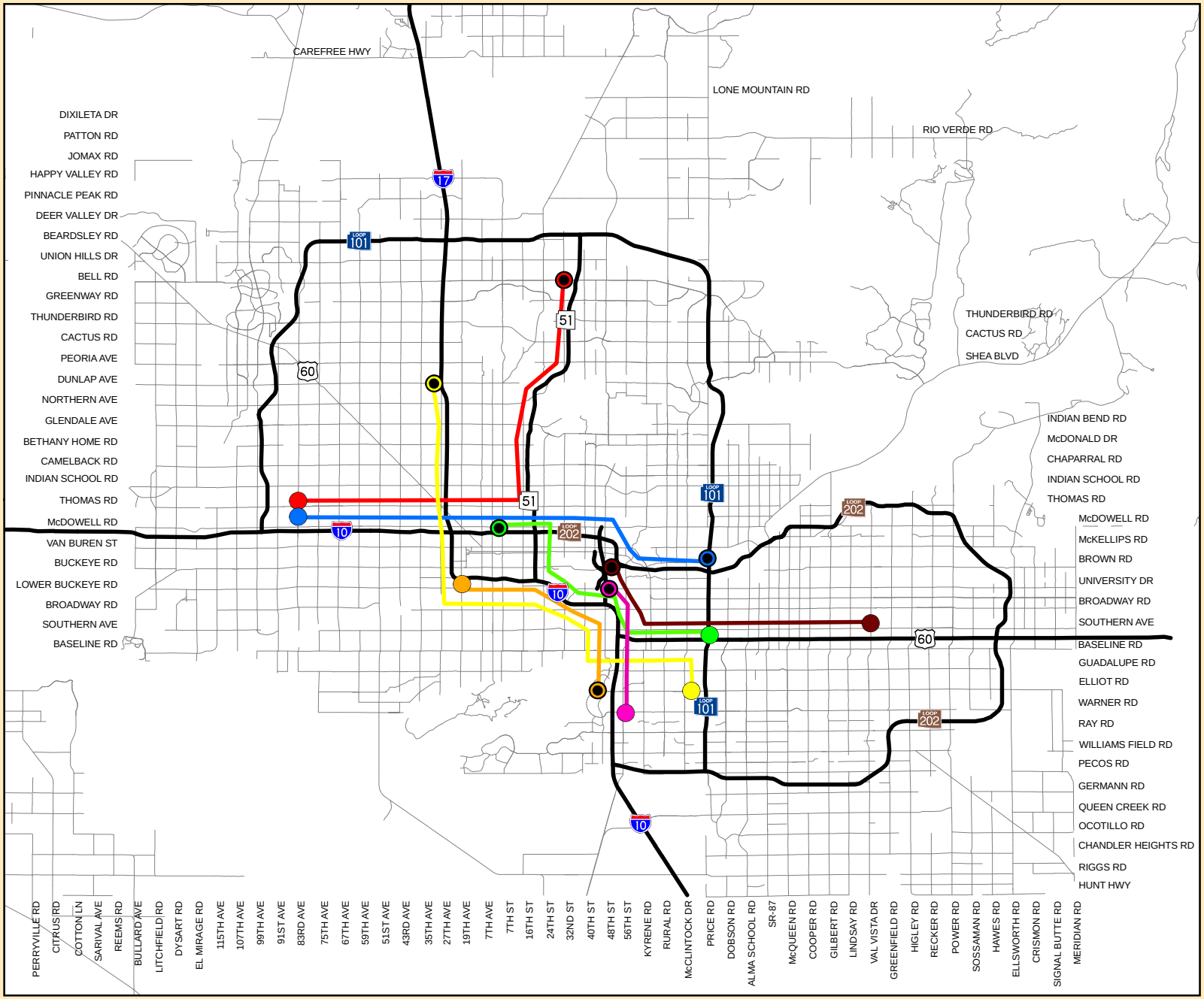
Source: ADOT FMS

Figure 2.18

MARICOPA ASSOCIATION of GOVERNMENTS

Performance Measures Study

Regional Commutes



While every effort has been made to ensure the accuracy of this information, the Maricopa Association of Governments makes no warranty, expressed or implied, as to its accuracy and expressly disclaims liability for the accuracy thereof.

0 5 10 15 20 Miles

N

Source: ADOT Freeway Management System
Archived Data for years 2006 and 2007

2.3.2.3 *Travel Time Variability*

Definition: Travel time variability is defined as the level of consistency in travel conditions over time and is measured by describing the distribution of travel times occurring during a particular data collection period (e.g., from a few months to many years[10]). By reporting on the variability of travel time for a specific origin-destination pair, roadway, or roadway segment, as well as its mean condition, the congestion reporting process gives a more robust depiction of travel conditions. Reporting on travel time variability also has the benefit of identifying the impacts that unusual occurrences (e.g., accidents, special event traffic) have on travel times, as well as the effects that transportation agencies' mitigation efforts (e.g., incident response programs) have on those unusual travel conditions.

Three measures are used to describe travel time variability:

1. Travel Time (expressed as an index, the TTI), which is the average time it takes to travel during peak hours compared to free flow conditions

2. Buffer Time (expressed as an index, the BI), which is a measure of variability that represents the extra time (or time cushion) that travelers should add to their average travel time to ensure on-time arrival

3. Planning Time (expressed as an index, the PTI), which is the total time a traveler should allow to ensure on-time arrival

All three measures are derived from the travel time distribution – once established, any measures that describe the size and shape of the travel time distribution can be very easily calculated. Essentially, the travel time distribution is the result of the interaction between all the sources of congestion (bottlenecks, incidents, work zones, weather, special events, etc.).

The TTI is the best index for describing routine peak period conditions (i.e., the amount of congestion that occurs in the peak hour simply because roadway capacity is insufficient to handle traffic demand.). The PTI is the best measure for describing the time required for a very important trip (e.g., a trip to the airport to catch a flight) when the traveler does not know the routine conditions, as it is based on free flow conditions. On the other hand, no typical commuter compares travel time to free flow conditions; they compare travel to their expected conditions, and that is what the BI does. The BI is the best measure for describing to a typical commuter how much time a really bad day will add to his/her commute. The BI and PTI both answer key policy questions, while the TTI is best for describing routine conditions.

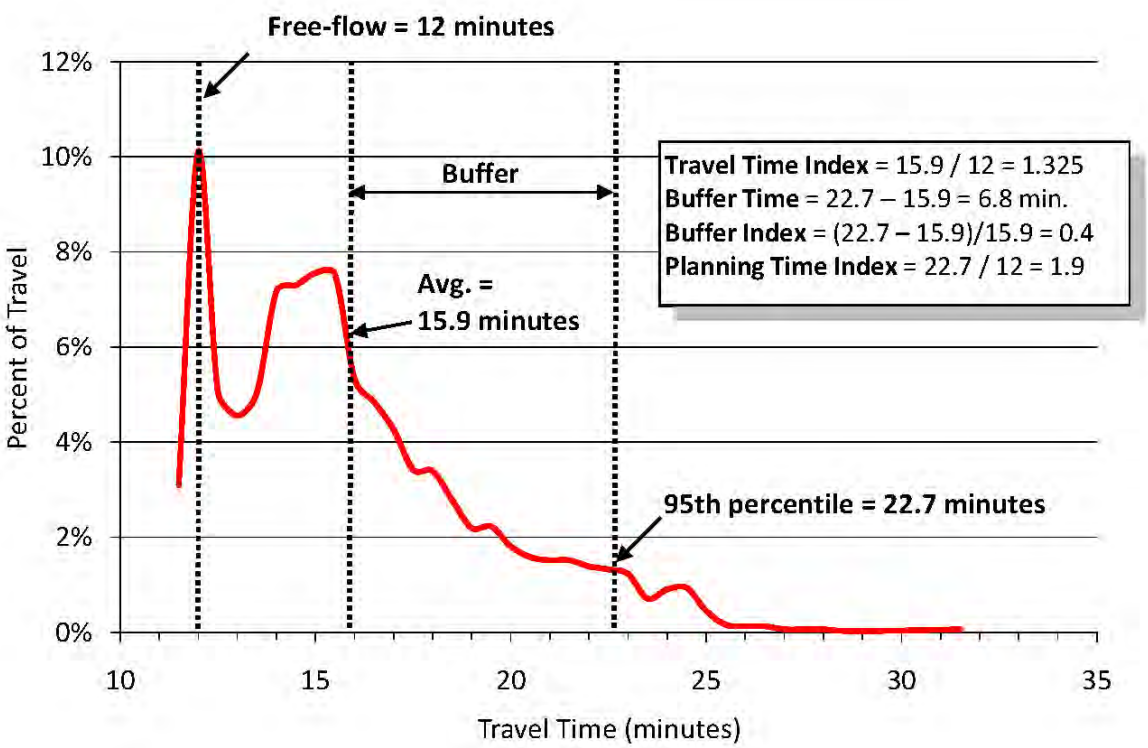
Because travel time variability is defined by the extent to which travel times vary over time, it is useful to develop frequency distributions to determine exactly how much variability exists. Calculating the average travel time and the size of the buffer, the extra time needed by travelers

[10] Note: although travel time variability can be assessed with as little as a few months worth of data, the reliability of any variability assessment will improve as the temporal extent of the data set being analyzed grows (e.g., basing analysis on several years' vs. several months' worth of data).

to ensure a high rate of on-time arrival, helps us to develop a variety of other measures (see Figure 2.19). The axes associated with this frequency distribution indicate:

- Vertical Axis = Percentage of Travel, or the percentage of all trips during a given period (e.g., the AM peak period) that experience a certain travel time
- Horizontal Axis = Travel Time in Minutes, or the amount of time required to make a certain trip during a given period (e.g., the AM peak period)

Figure 2.19 Understanding Travel Time Variability[11]



Based on an assessment of MAG's performance reporting needs, the BI and TTI were selected as the two primary measures for reporting travel time variability for inclusion in this report. The BI is calculated as the ratio between the difference of the 95th percentile travel time and the average travel time divided by the average travel time, as shown in the following equation:

$$\text{Buffer Index } (\%) = \frac{\text{95th Percentile Travel Time - Average Travel Time}}{\text{Average Travel Time}}$$

[11] Travel Time Index = ratio of average travel time to free flow travel time

Buffer Time Index = (95th percentile travel time – average travel time) / average travel time

Planning Time Index = 95th percentile travel time / free flow travel time

The BI is reported as an index value. In the example above, a value of 0.4 means that for a 16-minute average trip, a traveler should budget an additional 40% of trip time (i.e., a seven [7] minute buffer) to ensure 95% on-time arrival. The 95th percentile travel time is important because it describes the worst travel time experience for a given trip each month. It is an excellent measure of the amount of time required for trips for which the traveler would be highly penalized for being late, such as trips to the airport to catch a flight. It (or the indices based on it) has become the de facto standard measure for assessing variability of travel time.

The TTI is calculated as the ratio of average peak travel time to an off-peak (free-flow) standard, as shown in the following equation:

$$\text{Travel Time Index } (\%) = \frac{\text{Average Travel Time}}{\text{Free Flow Travel Time}}$$

For the purposes of MAG reporting, free-flow travel time is calculated based on a free-flow speed of 60 mph for freeways. The TTI is reported as an index value. In the example in Figure 2.19, a value of 1.325 means that average peak travel times are 32.5% longer than off-peak travel times.

Free flow travel time, average travel time, and 95th percentile travel times are the basis of these measures. The average travel time is the best descriptor of the time that a traveler can expect to spend while making a specific trip, while the 95th percentile travel time describes the worst travel time experience for a given trip. Both are excellent trend indicators that account for the wide range of factors that affect roadway performance. Unfortunately, the fact that all trips are incorporated into the average and 95th percentile travel times make them less sensitive to the operational programs that MAG and ADOT are implementing to deal with operational disruptions, such as incident response. Recent work conducted by the Transportation Research Board (TRB) has indicated that the 80th percentile travel time appears to be a good statistic for reporting on the effects that these kinds of programs have on travel conditions. Therefore, for the purposes of MAG travel time variability reporting, the average, 80th percentile, and 95th percentile travel times will also be reported.

Objective: Improve travel time variability in the region as measured through reductions in the Buffer Index and Travel Time Index along key freeway corridors.

Source: Travel time variability was derived from travel time data from ADOT Freeway Management System Archived Data for years 2006 and 2007.

Time Scale: AM peak period (6:00 AM to 9:00 AM) and PM peak period (3:00 PM to 7:00 PM).

Methodology: Travel time variability is most meaningful when reported in terms of typical commute corridors. Considering various types of trips between key origins and destinations, the corridors included in Table 2.9 were selected for reporting variability.

Using SAS and the link-level base data set as a starting point, the 5-minute link travel time data were aggregated into the relevant corridors to be reported. The average travel times for each 5-minute interval were assigned to an analysis time period (e.g., AM peak period, Midday period, PM peak period). For each analysis time period, the 5-minute travel time data were ranked in order of magnitude. A frequency count was obtained to determine the number and percent of trips that fell into each analysis time period (i.e., the travel time distribution). For example, how

many trips took 10 minutes, 11 minutes, etc. during the peak time being analyzed. The travel time distribution data were used to determine the average, 80th percentile, and 95th percentile travel times for each analysis corridor and analysis time period, which were subsequently used to calculate the BI and TTI.

Table 2.9 Travel Time Variability Reporting Corridors

Corridor ID	Corridor Limits	Length in Miles[12]
A	I-10 Papago: 81st Avenue to I-17	7.9
B	I-10 Papago: I-17 to SR 51	4.3
C	I-10 Maricopa: SR 51 to US 60	6.4
D	I-10 Maricopa: US 60 to Chandler Boulevard	6.9
E + F	I-17: Maricopa Traffic Interchange to Peoria Avenue	14.8
F	I-17: I-10 to Peoria Avenue	8.8
G+H	SR 51: I-10/Loop 202 to Bell Road	13.5
I	Loop 202: I-10/SR 51 to Loop 101	10.0
J+K	US 60: I-10 to Val Vista Drive	12.9
L	Loop 101: Guadalupe Road to Loop 202	5.3
M	SR 143: I-10 to Loop 202/McDowell Road	3.7

Source: Maricopa Association of Governments

Travel time distribution charts have been generated using Microsoft Excel to stratify the percentage of travel occurring during each period according to the travel time required for each individual trip. Travel time distributions charts have been generated for each direction of travel along the analysis corridors for both the AM and PM peak periods. Travel time distributions for both GP and HOV lanes are shown on each graph. Two full size distribution graphs – one displaying AM peak period travel conditions (2.20a) and one displaying PM peak period travel conditions (2.20b), have been provided and are accompanied by smaller stamp size graphs representing conditions along the remaining corridors (see Figure 2.20c). These graphs provide excellent representations of the variability in travel time along the various corridors. Simply looking at the shape of the curve provides a good understanding of the consistency and variability of travel along that corridor.

[12] Corridor lengths in this table are approximate lengths. Performance measure reporting will be based on exact lengths, which vary by direction of travel due to slight differences in detector location for opposing GP and HOV lanes.

Separate tables are also provided for Average (Table 2.10), 80th percentile, (Table 2.11) and 95th percentile (Table 2.12) travel times, TTI (Table 2.13), and BI (Table 2.14). Results are provided separately for GP and HOV lanes during the AM and PM peak periods. On all of these tables, data is provided for 2007, with the change from 2006 also reported.

Examining the shape of the travel time distribution is an excellent way to get a quick feel for how congested a given corridor is, how variable the travel times are for that corridor, and what that variability means in terms of how reliable trips on that corridor are for the people using those roadways. The two annotated figures 2.20a and 2.20b are good examples of this type of graphic.

The first of these figures (Figure 2.20a, I-10: Papago Eastbound in the AM peak period) shows the variability in travel times present on a moderately congested corridor. After accounting for a small percentage of trips being made in wide open conditions (~7 percent of trips with sub-7 minute travel times, meaning the roadway is moving faster than the speed limit), this graphic shows a fairly high initial peak, indicating that, in the morning peak period, a moderate percentage (~22%) of both general purpose (GP) trips and HOV trips (~28%) are made at the speed limit. However, the fairly long tail on the right side of the graph (those travel times greater than 15 minutes) indicates that a significant portion of trips also occur in congested conditions. On this roughly 8 mile long corridor, a travel time of more than 16 minutes means that a motorist averages less than 30 mph over the length of the corridor. Since not all of the corridor is in stop and go conditions (see the contour graphs in the section 2.3.2.4), these results suggest that many AM peak period trips on this corridor are experiencing very heavy congestion and very slow speeds over significant portions of that 7 mile corridor.

In contrast, Figure 2.20b (I-10: Papago Eastbound in the PM peak period) illustrates an uncongested time period on this same corridor. The shape of the curve for both general purpose and HOV lanes is almost a vertical line, with no obvious tail. Over 75% of HOV trips and almost 60% of general purpose trips are made at speeds slightly faster than the speed limit, while another 40 percent of GP trips and 20 percent of HOV trips are made under free flow conditions.

A simple visual inspection of any travel time distribution graph such as these will tell an observer: 1) whether a corridor is congested or not, and 2) how variable the conditions are within that corridor. The more vertical the travel time distribution, the more consistent the travel in the corridor. The flatter the distribution, the greater the variability in travel. Thus, in Figure 2.20a, not only does the reader learn that the corridor has considerable congestion, but also from the fairly flat but raised shape of the right side of the distribution curve that congestion is common and fairly severe. When examined numerically, the average (mean) trip takes a little over 12.5 minutes (compared to the 8 minute free flow trip), and on one day out of every month (95% of the time), a traveler is likely to spend twice that long (more than 25 minutes) making this trip. It is this lack of reliability in travel conditions which is particularly exasperating to travelers, and costly to shippers and freight haulers.

Explanation of Results and Analysis: Figure 2.20c presents the travel time distribution graphs for all of the study corridors. Tables 2.10 through 2.14 provide the key numeric values based on these distributions. Graphics are presented for the AM peak period, Midday period and PM peak period for each corridor. HOV and GP lane performance for each corridor are plotted on the same graphic, allowing comparison of the relative performance of the HOV and GP lanes.

Because detector locations for the HOV and GP lanes can be slightly different, in some cases HOV and GP free flow travel times are slightly different. This simply means that the length of the instrumented roadway is slightly different for HOV and GP lanes.

Not surprisingly, since all of the study corridors are in core portions of the greater metropolitan area, some congestion is observed on each of the graphics, although most corridors have very little significant midday congestion. In general, the HOV lanes show considerably less congestion than the general purpose lanes. That said, several of the HOV lanes in the region do experience significant congestion. Prime examples of this are the westbound I-10 HOV lane approaching US 60 in the morning and between SR 51 and I-17 in the evening. Similar conditions exist on the eastbound I-10 HOV lane approaching I-17 in the morning and SR 143/US 60 in the evening.

Other significant findings apparent in these graphics are as follows:

Loop 202 westbound in the PM peak period is frequently uncongested in both the HOV and GP lanes (40 to 50 percent of trips are made in free flow conditions.) However, the effects of the bottleneck at the end of the corridor where Loop 202 meets the I-10, as well as the effects of incidents and other disruptions are also apparent given the flat distribution of travel times (2 to 5 percent of all trips fall within each one minute travel time interval from 11 to 20 minutes for both HOV and GP lanes.) Like several other corridors in the MAG Region, this is an excellent illustration of a highly variable set of travel conditions, likely to create public frustration with the performance of the roadway system.

In several cases, the travel time patterns for both HOV and GP lanes are very similar. For example, see I-10 Papago EB: 83rd Ave to I-17 in the AM peak period. In such cases, the HOV lanes have a travel time pattern that essentially mirrors the GP travel time pattern. On these corridors little advantage is being gained by users of the HOV lane system. This lack of travel time advantage is likely to discourage the formation of carpools and use of bus transit, contrary to the public policy intent under which HOV lanes are operated.

On other corridors (e.g., Loop 202 westbound in the AM peak period, US 60 westbound in the AM peak period, SR 51 southbound from Bell Rd to I-10 in the AM peak period, and the reverse trip in the PM peak period) the HOV lane operates much faster and more reliably than the parallel GP lanes, meeting its public policy objectives. In all three of these cases, the GP lanes operate poorly, having relatively few free flow days (most are likely associated with days near holidays, when traffic volumes are very light) and with a significant number of days of moderate congestion.

Table 2.10 gives the average (mean) travel time for all non-holiday weekdays in 2007 along with the change in travel time for each of the reporting sections. Travel times are reported for both the AM and PM peak periods, and for both general purpose and HOV lanes (when HOV lanes are present.) Travel times are reported for a total of 22 sections (11 sections, each in two directions).

During the morning peak period, changes in travel time are very modest. All but three sections had changes in travel time of less than 15 seconds, a value so low as to be within the margin of error of the travel time computation. Only two sections had changes greater than or equal to 30 seconds, with both showing decreases in travel time; SR 51 southbound from Bell Rd to Loop 202 (1 minute decrease) and US 60 eastbound from I-10 to Val Vista (30 second decrease.)

During the evening peak period, more change was observed. Nine segments showed changes in travel time greater than 30 seconds from 2006 to 2007. The largest improvement was eastbound on US 60 from I-10 to Val Vista Drive, which showed a 1.1 minute improvement (just under ten percent.)

Table 2.11 provides the 80th percentile travel times and changes in 80th percentile travel times from 2006 to 2007. The 80th percentile travel times are representative of the travel times most commuters perceive of as their normal commute. They represent the worst trip a traveler can expect during any given week. As with average travel times, the changes from 2006 to 2007 were modest. Only two of the 22 study sections showed changes in travel time greater than 30 seconds. Both were southbound on I-17 and included the northern section of roadway from Peoria Avenue to I-10. In both cases, the 80th percentile trip time increased more than 1.5 minutes. For HOV lanes, three sections showed increases in travel time greater than 30 seconds and three had increases in travel time greater than one minute.

In the afternoon peak, changes in the 80th percentile were more significant. Nine of the 22 general purpose lane study sections showed changes in travel time greater than 30 seconds. Only three of those showed an increase in travel time. The largest changes were a 1.7 minute increase in travel time northbound on I-17 from the Maricopa Traffic Interchange to Peoria Avenue, and a 1.7 minute decrease in travel time on eastbound US 60 from I-10 to Val Vista Drive. The afternoon performance of the region's HOV lanes did not change as dramatically. Only four of the 18 reporting sections showed changes in 80th percentile trip times greater than 30 seconds.

Table 2.12 shows the 95th percentile travel times for the 22 study sections. The 95th percentile travel time illustrates the most extreme travel times experienced by travelers. They are most often caused by major traffic disruptions (e.g., major traffic accidents.) In the morning peak period six of the 22 study sections had changes in the 95th percentile travel time that were greater than 30 seconds. Half of those changes were decreases in travel time. Two of them were greater than 2 minutes, one an increase in travel time (a 2.2 minute increase southbound on I-17 from Peoria Avenue to I-10), and one a decrease in travel time (a 2.8 minute decrease southbound on SR 51 from Bell Road to I-10.) Seven of the morning peak 95th percentile HOV lane travel times changed by more than 30 seconds, five of them increasing. The largest change was an increase of 4.5 minutes on eastbound I-10 Papago, from 81st Avenue to I-17.

In the afternoon, ten of the 22 general purpose lane study sections had changes in their 95th percentile travel times of greater than 30 seconds. Eight of those sections had increased travel times. The largest change by far was northbound on I-17 from the Maricopa Traffic Interchange to Peoria Avenue, which experienced a 4.8 minute increase. For HOV lane performance in the PM peak period, six of the 18 study sections showed changes of greater than 30 seconds, with three of those changes being increases in travel time.

Lastly, Tables 2.13 and 2.14 provide the Travel Time and Buffer indices for the region's freeways. Both indices allow for more direct comparison between study sections, as they remove the bias caused by the differences in study section lengths.

The Travel Time Index for the AM peak period shows that in the morning, the westbound I-10 Maricopa study section from Chandler Blvd. to US 60 has by far the worst congestion. It has a

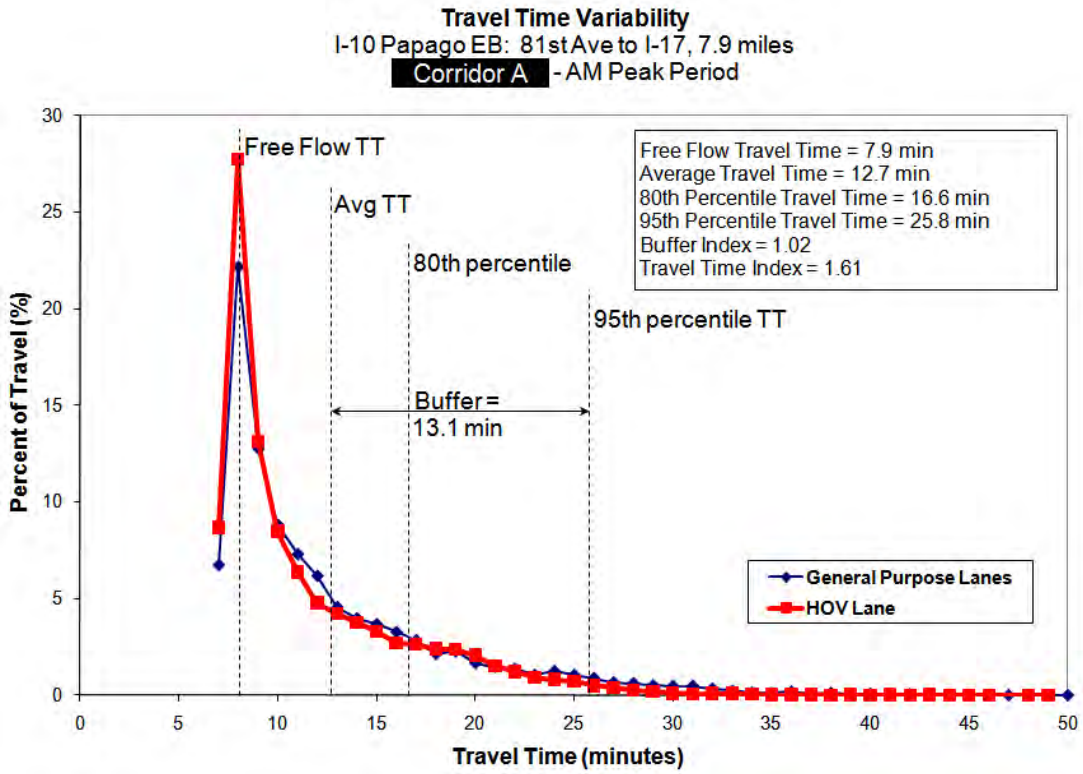
TTI of 2.26, while the next worst section has a TTI of 1.61. Changes from 2006 to 2007 are all insignificant.

In the evening, three study sections have TTI's greater than 2.0. They include I-10 Papago, westbound from SR 51 to I-17 (TTI = 2.29, the worst of the study sections), I-10 Maricopa, eastbound from SR 51 to US 60 (TTI = 2.2), and Loop 101, southbound from Loop 202 to Guadalupe (TTI = 2.01).

The Buffer Index illustrates routes with highly variable (and thus frustrating) travel times. In the mornings, the I-10 Papago section traveling eastbound from 81st Avenue to I-17 has a BI of over 1.0. That means that a traveler needs to double their expected peak period travel time in order to make sure they arrive on time at their destination 95 percent of the time. The HOV lane for this section also has the highest BI of all AM peak period study sections. Two other general purpose lane study sections, I-17 southbound from Peoria Avenue to I-10, and the I-10 westbound from the Chandler Blvd. to US 60 both have Buffer Indices of 0.79.

During the afternoon peak period, no BI exceeds 1.0, but eight study sections do have Buffer Indices greater than 0.5, indicating that travelers need to add significant amounts of time to their trip plans if they absolutely must arrive at their destination on time.

Figure 2.20a



Source: ADOT FMS

Figure 2.20b

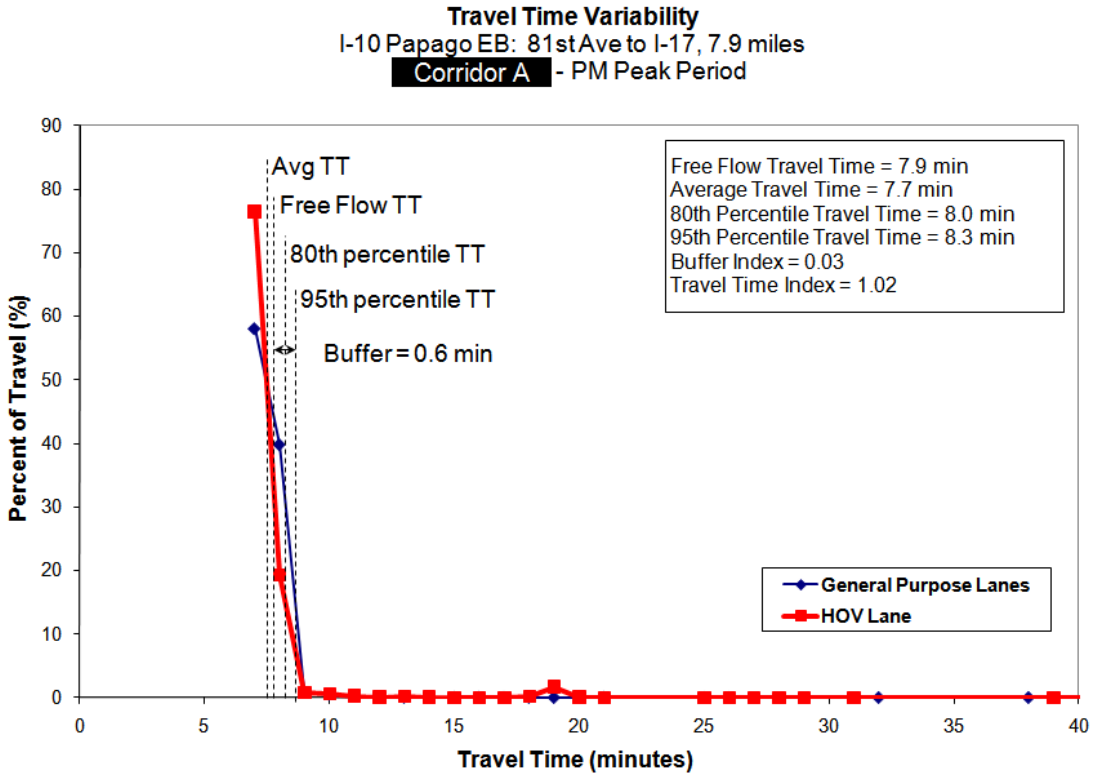
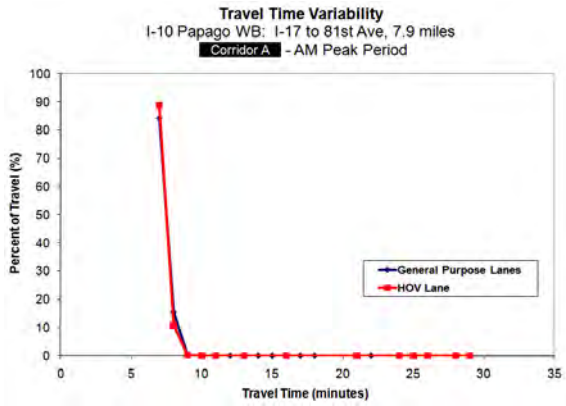
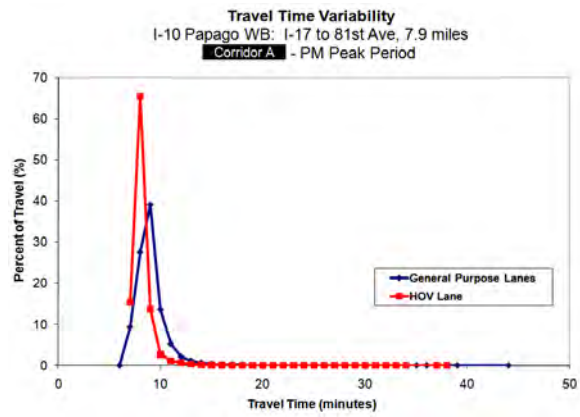
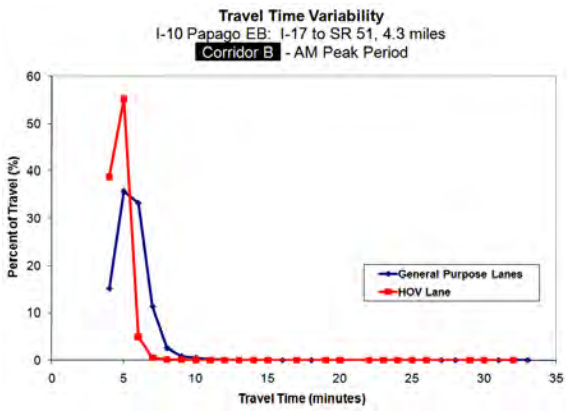
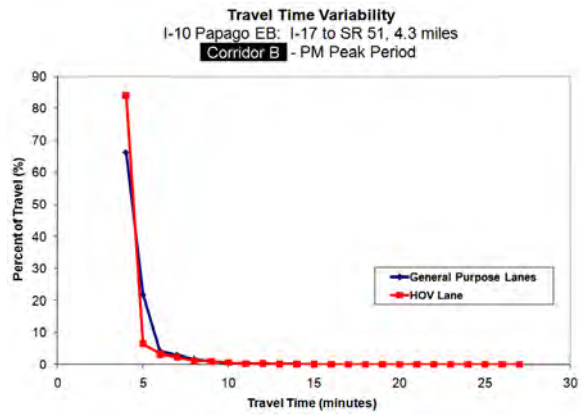


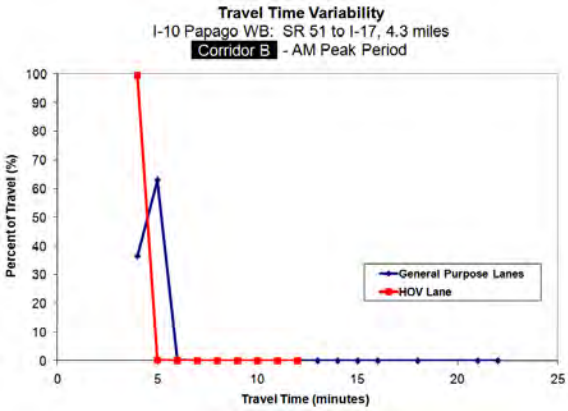
Figure 2.20 c

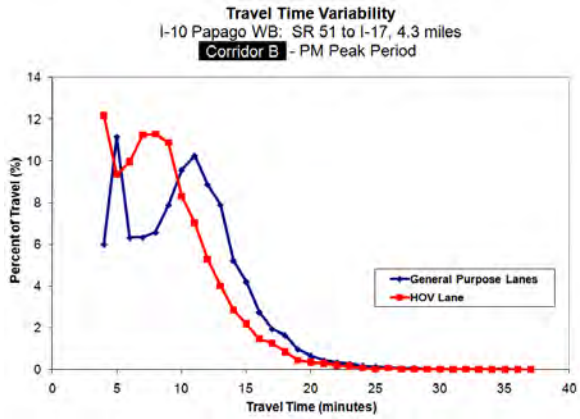

Travel Time Variability
I-10 Papago WB: I-17 to 81st Ave, 7.9 miles
Corridor A - AM Peak Period
Percent of Travel (%)
Travel Time (minutes)
General Purpose Lanes
HOV Lane

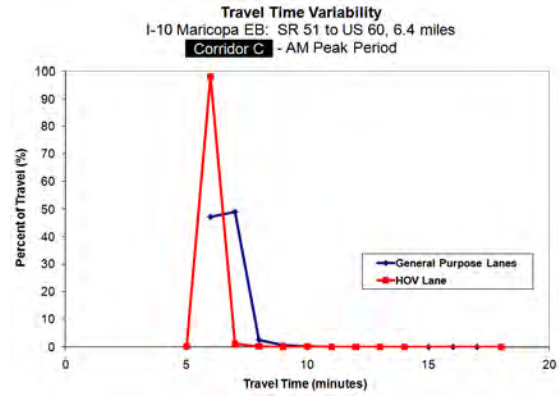

Travel Time Variability
I-10 Papago WB: I-17 to 81st Ave, 7.9 miles
Corridor A - PM Peak Period
Percent of Travel (%)
Travel Time (minutes)
General Purpose Lanes
HOV Lane

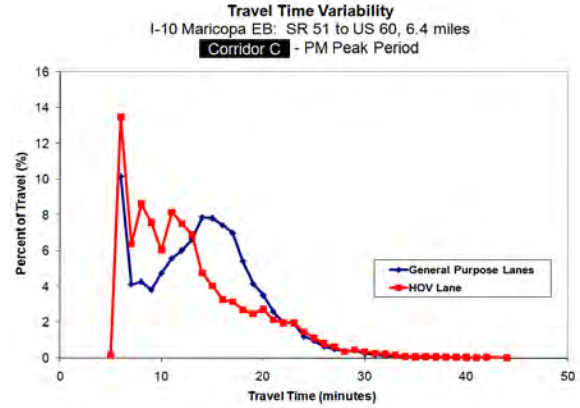

Travel Time Variability
I-10 Papago EB: I-17 to SR 51, 4.3 miles
Corridor B - AM Peak Period
Percent of Travel (%)
Travel Time (minutes)
General Purpose Lanes
HOV Lane


Travel Time Variability
I-10 Papago EB: I-17 to SR 51, 4.3 miles
Corridor B - PM Peak Period
Percent of Travel (%)
Travel Time (minutes)
General Purpose Lanes
HOV Lane

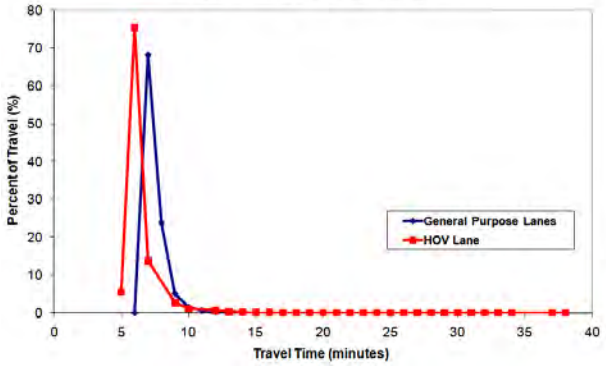

Travel Time Variability
I-10 Papago WB: SR 51 to I-17, 4.3 miles
Corridor B - AM Peak Period
Percent of Travel (%)
Travel Time (minutes)
General Purpose Lanes
HOV Lane


Travel Time Variability
I-10 Papago WB: SR 51 to I-17, 4.3 miles
Corridor B - PM Peak Period
Percent of Travel (%)
Travel Time (minutes)
General Purpose Lanes
HOV Lane

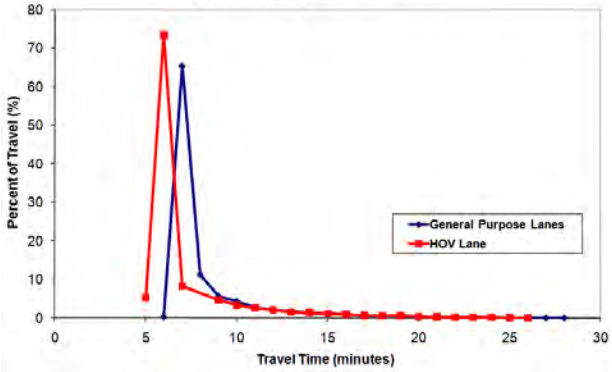

Travel Time Variability
I-10 Maricopa EB: SR 51 to US 60, 6.4 miles
Corridor C - AM Peak Period
Percent of Travel (%)
Travel Time (minutes)
General Purpose Lanes
HOV Lane


Travel Time Variability
I-10 Maricopa EB: SR 51 to US 60, 6.4 miles
Corridor C - PM Peak Period
Percent of Travel (%)
Travel Time (minutes)
General Purpose Lanes
HOV Lane

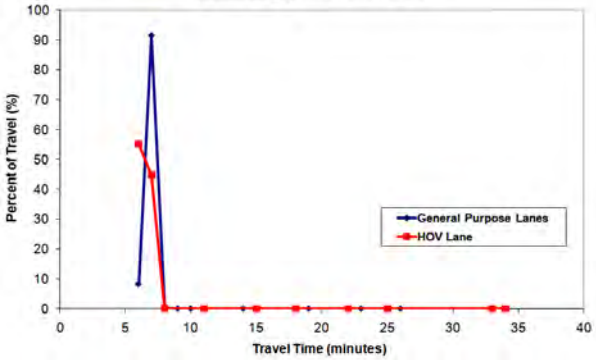
Travel Time Variability
I-10 Maricopa WB: US 60 to SR 51, 6.4 miles
Corridor C - AM Peak Period



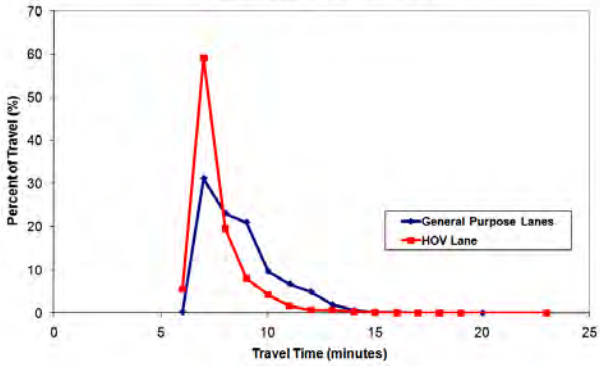
Travel Time Variability
I-10 Maricopa WB: US 60 to SR 51, 6.4 miles
Corridor C - PM Peak Period



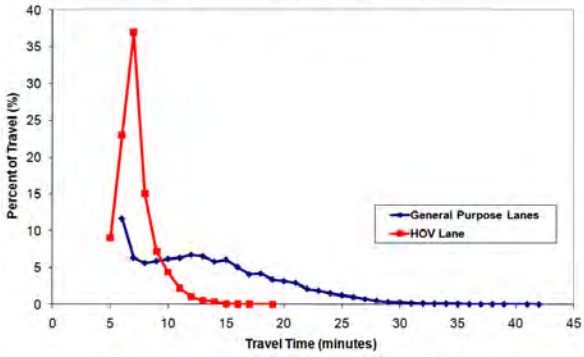
Travel Time Variability
I-10 Maricopa EB: US 60 to Chandler Boulevard, 6.9 miles
Corridor D - AM Peak Period



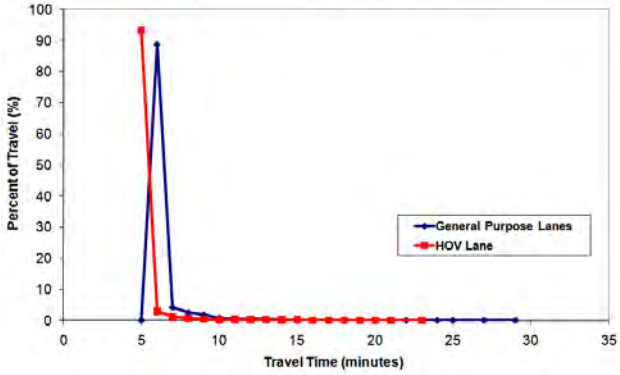
Travel Time Variability
I-10 Maricopa EB: US 60 to Chandler Boulevard, 6.9 miles
Corridor D - PM Peak Period



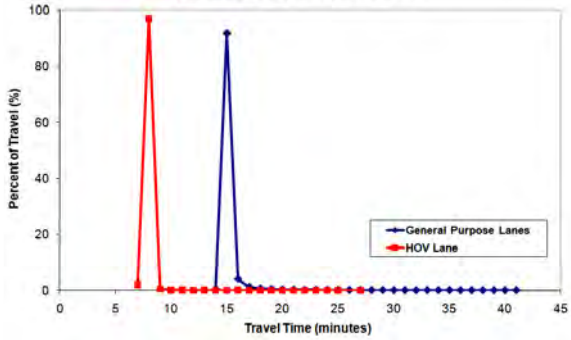
Travel Time Variability
I-10 Maricopa WB: Chandler Boulevard to US 60, 6.9 miles
Corridor D - PM Peak Period



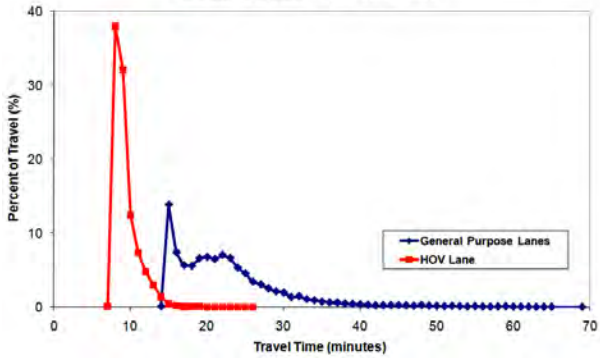
Travel Time Variability
I-10 Maricopa WB: Chandler Boulevard to US 60, 6.9 miles
Corridor D - PM Peak Period



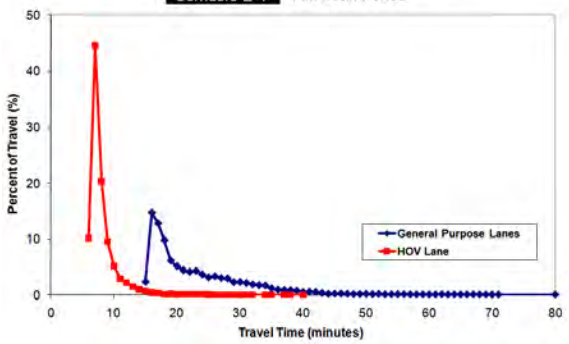
Travel Time Variability
I-17 NB: Maricopa Traffic Interchange to Peoria Ave, 14.7 miles
Corridors E+F - AM Peak Period



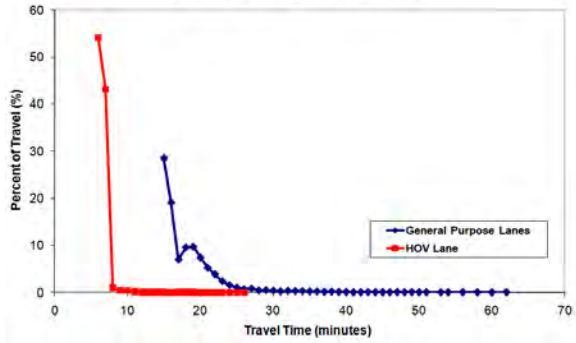
Travel Time Variability
I-17 NB: Maricopa Traffic Interchange to Peoria Ave, 14.7 miles
Corridors E+F - PM Peak Period



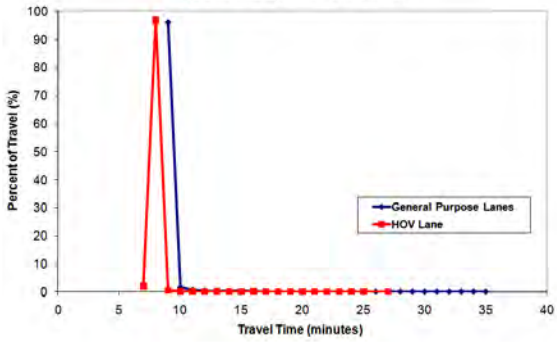
Travel Time Variability
I-17 SB: Peoria Ave to Maricopa Traffic Interchange, 14.7 miles
Corridors E+F - AM Peak Period



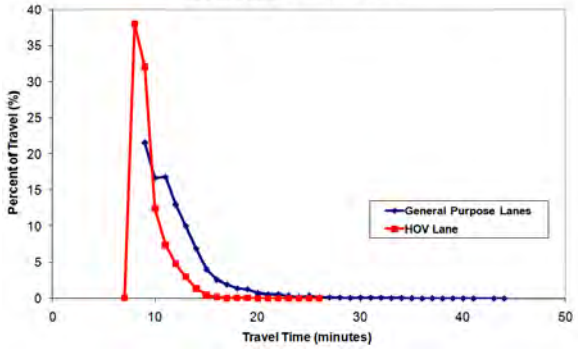
Travel Time Variability
I-17 SB: Peoria Ave to Maricopa Traffic Interchange, 14.7 miles
Corridors E+F - PM Peak Period



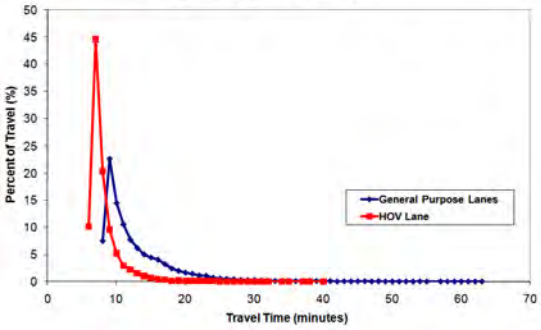
Travel Time Variability
I-17 NB: I-10 to Peoria Avenue, 8.8 miles
Corridor F - AM Peak Period



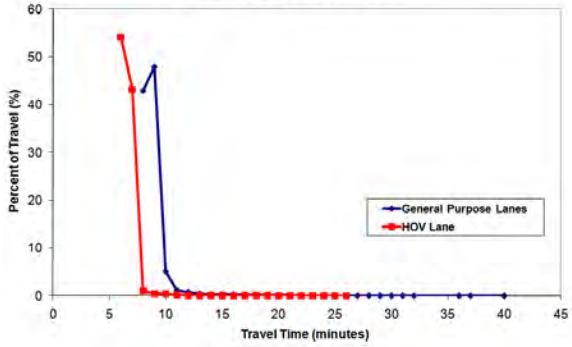
Travel Time Variability
I-17 NB: I-10 to Peoria Avenue, 8.8 miles
Corridor F - PM Peak Period



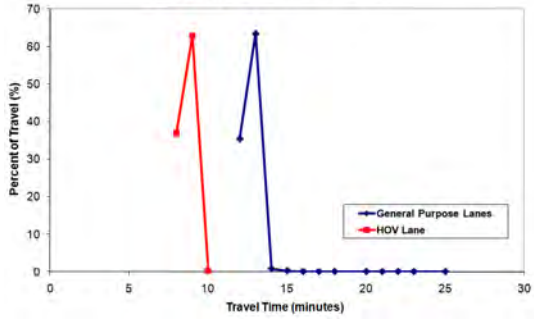
Travel Time Variability
I-17 SB: Peoria Avenue to I-10, 8.8 miles
Corridor F - AM Peak Period



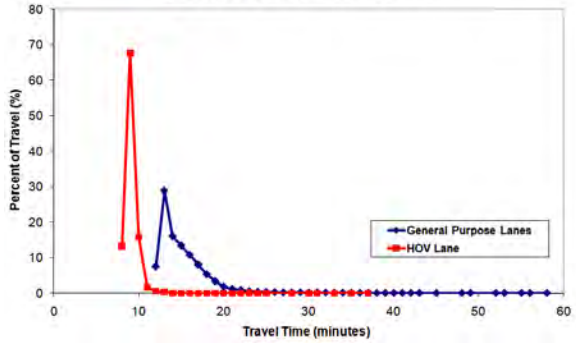
Travel Time Variability
I-17 SB: Peoria Avenue to I-10, 8.8 miles
Corridor F - PM Peak Period

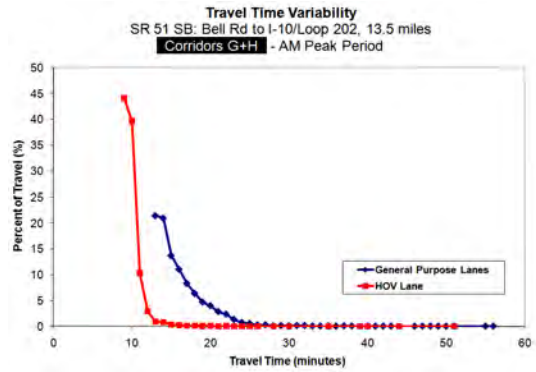


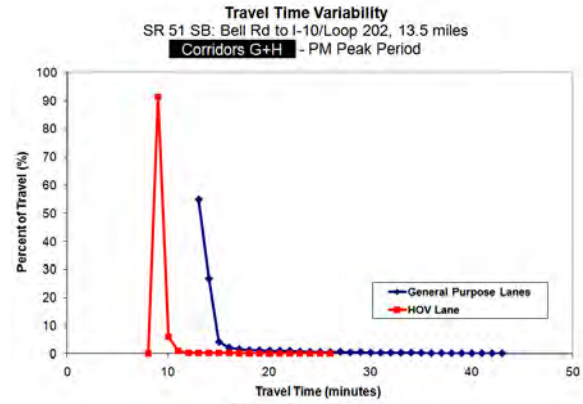
Travel Time Variability
SR 51 NB: I-10/Loop 202 to Bell Rd, 13.5 miles
Corridors G+H - AM Peak Period

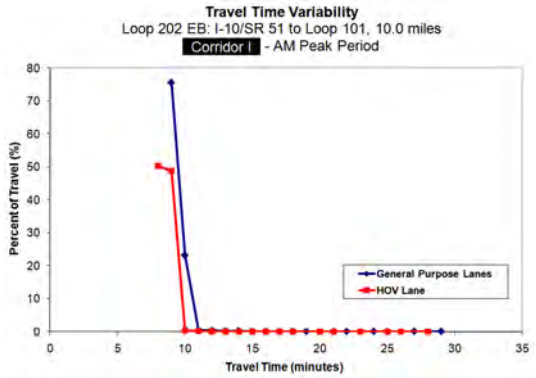


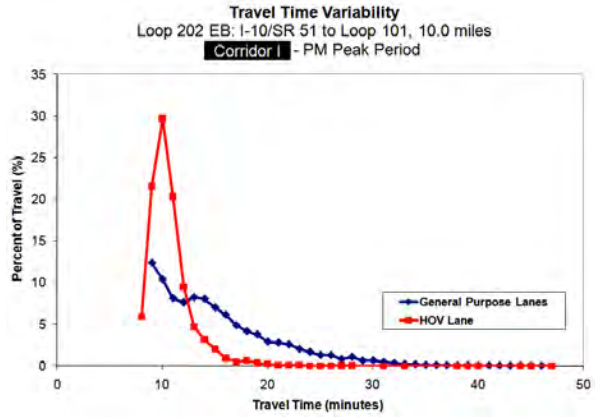
Travel Time Variability
SR 51 NB: I-10/Loop 202 to Bell Rd, 13.5 miles
Corridors G+H - PM Peak Period

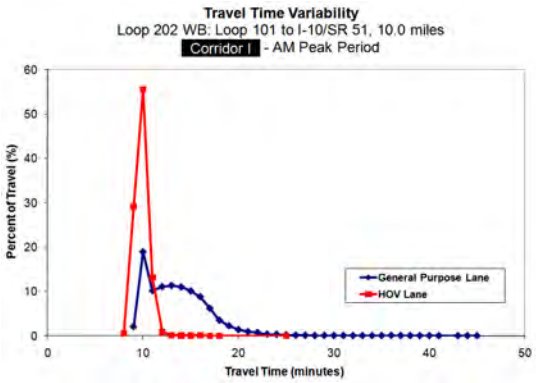


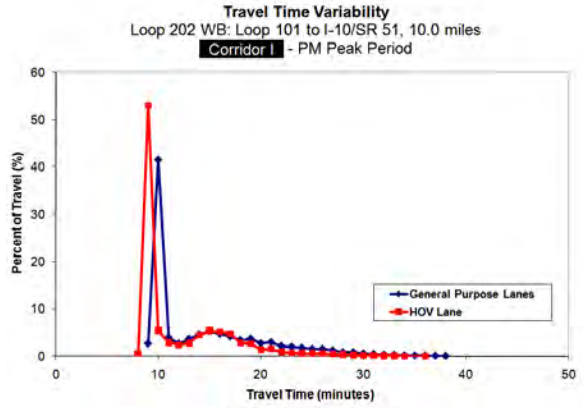

Travel Time Variability
SR 51 SB: Bell Rd to I-10/Loop 202, 13.5 miles
Corridors G+H - AM Peak Period
Percent of Travel (%)
Travel Time (minutes)
General Purpose Lanes
HOV Lane

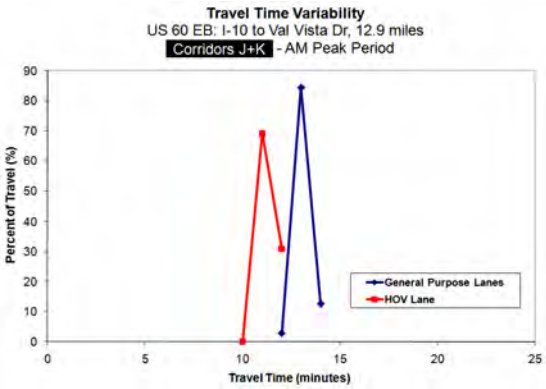

Travel Time Variability
SR 51 SB: Bell Rd to I-10/Loop 202, 13.5 miles
Corridors G+H - PM Peak Period
Percent of Travel (%)
Travel Time (minutes)
General Purpose Lanes
HOV Lane

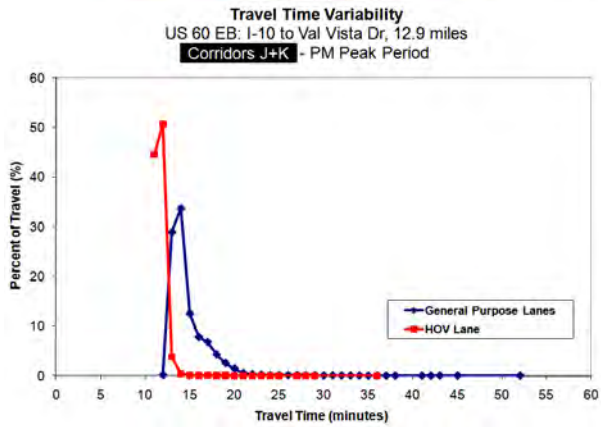

Travel Time Variability
Loop 202 EB: I-10/SR 51 to Loop 101, 10.0 miles
Corridor I - AM Peak Period
Percent of Travel (%)
Travel Time (minutes)
General Purpose Lanes
HOV Lane

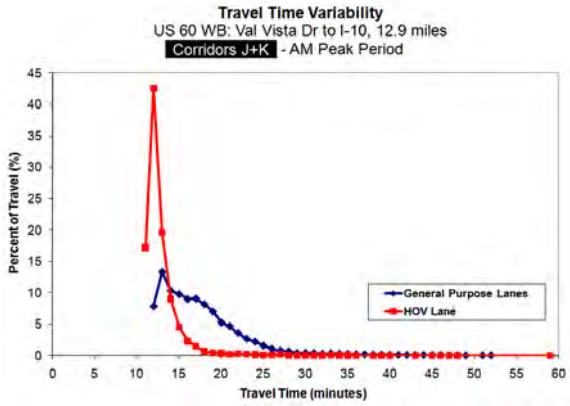

Travel Time Variability
Loop 202 EB: I-10/SR 51 to Loop 101, 10.0 miles
Corridor I - PM Peak Period
Percent of Travel (%)
Travel Time (minutes)
General Purpose Lanes
HOV Lane

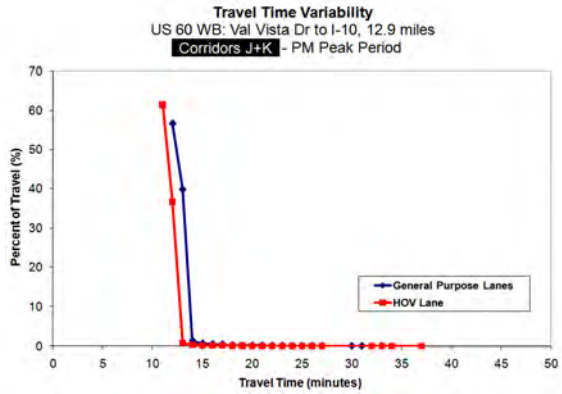

Travel Time Variability
Loop 202 WB: Loop 101 to I-10/SR 51, 10.0 miles
Corridor I - AM Peak Period
Percent of Travel (%)
Travel Time (minutes)
General Purpose Lane
HOV Lane

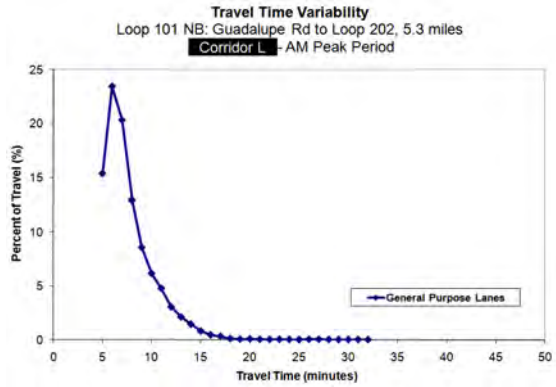

Travel Time Variability
Loop 202 WB: Loop 101 to I-10/SR 51, 10.0 miles
Corridor I - PM Peak Period
Percent of Travel (%)
Travel Time (minutes)
General Purpose Lanes
HOV Lane

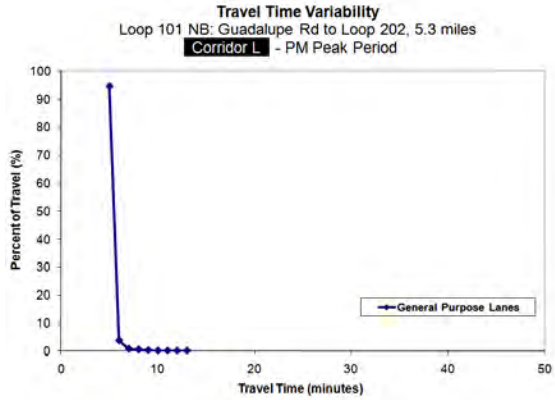

Travel Time Variability
US 60 EB: I-10 to Val Vista Dr, 12.9 miles
Corridors J+K - AM Peak Period
Percent of Travel (%)
Travel Time (minutes)
General Purpose Lanes
HOV Lane

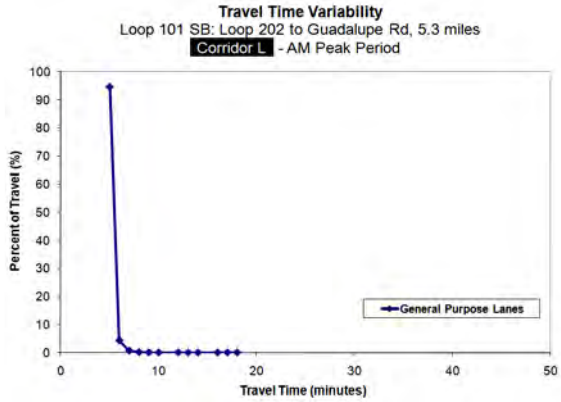

Travel Time Variability
US 60 EB: I-10 to Val Vista Dr, 12.9 miles
Corridors J+K - PM Peak Period
Percent of Travel (%)
Travel Time (minutes)
General Purpose Lanes
HOV Lane

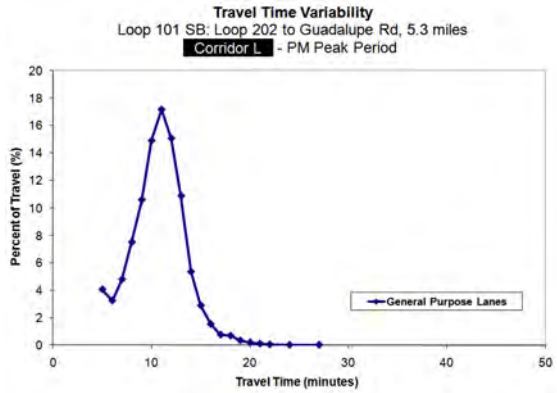

Travel Time Variability
US 60 WB: Val Vista Dr to I-10, 12.9 miles
Corridors J+K - AM Peak Period
Percent of Travel (%)
Travel Time (minutes)
General Purpose Lanes
HOV Lane

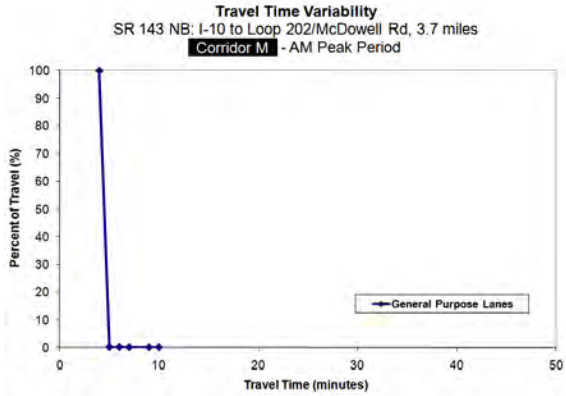

Travel Time Variability
US 60 WB: Val Vista Dr to I-10, 12.9 miles
Corridors J+K - PM Peak Period
Percent of Travel (%)
Travel Time (minutes)
General Purpose Lanes
HOV Lane

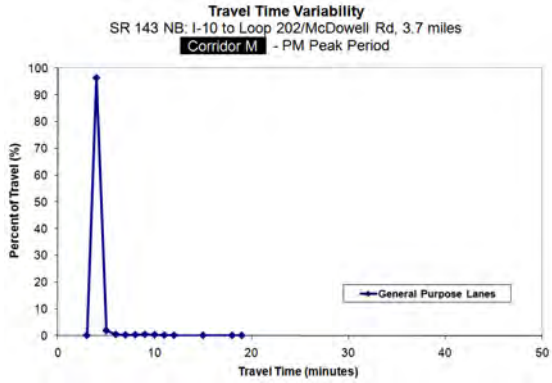

Travel Time Variability
Loop 101 NB: Guadalupe Rd to Loop 202, 5.3 miles
Corridor L - AM Peak Period
Percent of Travel (%)
Travel Time (minutes)
General Purpose Lanes

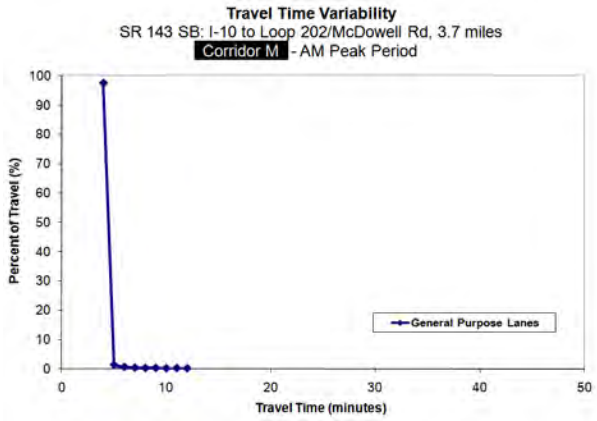

Travel Time Variability
Loop 101 NB: Guadalupe Rd to Loop 202, 5.3 miles
Corridor L - PM Peak Period
Percent of Travel (%)
Travel Time (minutes)
General Purpose Lanes


Travel Time Variability
Loop 101 SB: Loop 202 to Guadalupe Rd, 5.3 miles
Corridor L - AM Peak Period
Percent of Travel (%)
Travel Time (minutes)
General Purpose Lanes


Travel Time Variability
Loop 101 SB: Loop 202 to Guadalupe Rd, 5.3 miles
Corridor L - PM Peak Period
Percent of Travel (%)
Travel Time (minutes)
General Purpose Lanes


Travel Time Variability
SR 143 NB: I-10 to Loop 202/McDowell Rd, 3.7 miles
Corridor M - AM Peak Period
Percent of Travel (%)
Travel Time (minutes)
General Purpose Lanes


Travel Time Variability
SR 143 NB: I-10 to Loop 202/McDowell Rd, 3.7 miles
Corridor M - PM Peak Period
Percent of Travel (%)
Travel Time (minutes)
General Purpose Lanes


Travel Time Variability
SR 143 SB: I-10 to Loop 202/McDowell Rd, 3.7 miles
Corridor M - AM Peak Period
Percent of Travel (%)
Travel Time (minutes)
General Purpose Lanes

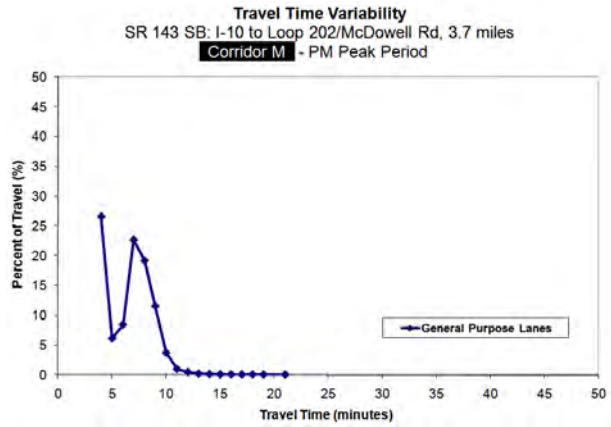

Travel Time Variability
SR 143 SB: I-10 to Loop 202/McDowell Rd, 3.7 miles
Corridor M - PM Peak Period
Percent of Travel (%)
Travel Time (minutes)
General Purpose Lanes

Table 2.10 Results for Average Travel Time

Corridor ID	Analysis Corridor	Dir	From	To	Average Travel Time (minutes)							
					AM Peak Period				PM Peak Period			
					General Purpose Lanes		HOV Lanes		General Purpose Lanes		HOV Lanes	
					2007	Change from 2006	2007	Change from 2006	2007	Change from 2006	2007	Change from 2006
A	I-10 Papago	EB	81st Avenue	I-17	12.7	0.1	11.7	1.4	7.7	-0.2	7.7	0.3
		WB	I-17	82nd Avenue	7.3	-0.1	7.3	0.3	9.1	0.8	8.2	0.6
B	I-10 Papago	EB	I-17	SR 51	5.6	-0.1	4.7	-0.1	4.8	0	4.5	0
		WB	SR 51	I-17	4.5	0	4	0	10.2	0	8.7	-0.3
C	I-10 Maricopa	EB	SR 51	US 60	6.6	-0.3	5.9	-0.2	14.2	-0.8	12.7	-0.6
		WB	US 60	SR 51	7.5	-0.1	7	0	8.3	0.1	7.4	-0.2
D	I-10 Maricopa	EB	US 60	Chandler Blvd	6.7	0	6.5	-0.2	8.7	-0.5	7.6	-0.6
		WB	Chandler Blvd	US 60	13.5	0.1	7.2	0.2	6.2	0	5.3	-0.2
E + F	I-17 NB	NB	Maricopa Traffic Int.	Peoria Avenue	15.1	0	7.8	0.1	22.5	1	9.3	0.2
		SB	Peoria Avenue	Maricopa Traffic Int.	23	0	8.1	0.7	18.2	-0.9	6.6	-0.1
F	I-17	NB	I-10	Peoria Avenue	9	0.1	7.8	0.1	12	0.3	9.3	0.2
		SB	Peoria Avenue	I-10	12.9	0.2	8.1	0.7	8.9	-0.8	6.6	-0.1
G + H	SR 51	NB	I-10 / Loop 202	Bell Road	12.6	0.2	8.6	0.2	15.2	0.1	9.2	0.3
		SB	Bell Road	I-10/Loop 202	16	-1	9.9	0.4	14.8	-0.6	9.2	0.2
I	Loop 202	EB	I-10/SR 51	Loop 101	9.4	0	8.5	-0.1	15.2	0.2	10.7	0
		WB	Loop 101	I-10/SR 51	13.6	0	9.9	0	14.5	0.3	12.2	0.3
J + K	US 60	EB	I-10	Val Vista	13	-0.5	11.3	-0.4	14.8	-1.1	11.7	-0.6
		WB	Val Vista	I-10	17.4	0	12.9	0.7	12.6	-0.4	11.5	0
L	Loop 101	NB	Guadalupe Road	Loop 202	7.7	0			5.1	0		
		SB	Loop 202	Guadalupe Road	5.1	0			10.7	0.6		
M	SR 143	NB	I-10	Loop 202/ McDowell Road	3.9	0			4	-0.1		
		SB	Loop 202/ McDowell Road	I-10	4.1	0			6.6	0.6		

Source: ADOT FMS

Table 2.11 Results for 80th Percentile Travel Time

Corridor ID	Analysis Corridor	Dir	From	To	80th Percentile Travel Time (minutes)							
					AM Peak Period				PM Peak Period			
					General Purpose Lanes		HOV Lanes		General Purpose Lanes		HOV Lanes	
					2007	Change from 2006	2007	Change from 2006	2007	Change from 2006	2007	Change from 2006
A	I-10 Papago	EB	81st Avenue	I-17	16.6	0.5	15.3	3	8	0	7.5	0.1
		WB	I-17	82nd Avenue	7.5	-0.1	7.4	0.3	9.7	1	8.5	0.7
B	I-10 Papago	EB	I-17	SR 51	6.3	-0.2	5	-0.1	4.9	-0.1	4.3	-0.1
		WB	SR 51	I-17	4.6	0	4.1	0	13.4	0.2	11.5	-0.3
C	I-10 Maricopa	EB	SR 51	US 60	6.8	-0.4	6	-0.2	18.4	-1.4	17.5	-1.2
		WB	US 60	SR 51	7.9	0	7.5	0	9	0	8.2	-0.1
D	I-10 Maricopa	EB	US 60	Chandler Blvd	6.9	0	6.6	-0.3	9.8	-0.6	8.1	-0.8
		WB	Chandler Blvd	US 60	18.4	0.1	8.1	0.5	6	0	5.2	-0.1
E + F	I-17 NB	NB	Maricopa Traffic Int.	Peoria Avenue	15.1	-0.1	7.8	0	26.7	1.7	10.3	0.5
		SB	Peoria Avenue	Maricopa Traffic Int.	28.6	1.5	8.9	1.1	20.3	-1.3	6.6	-0.2
F	I-17	NB	I-10	Peoria Avenue	9	0	7.8	0	13.7	0.4	10.3	0.5
		SB	Peoria Avenue	I-10	15.8	1.4	8.9	1.1	9	-1.2	6.6	-0.2
G + H	SR 51	NB	I-10/Loop 202	Bell Road	12.7	0.1	8.7	0.2	16.9	0	9.5	0.2
		SB	Bell Road	I-10/Loop 202	18.2	-1	10.3	0.5	14.3	-1.2	9.2	0
I	Loop 202	EB	I-10/SR 51	Loop 101	9.5	0	8.7	0	19.3	0.5	11.7	0
		WB	Loop 101	I-10/SR 51	16.1	0.1	10.4	0	19.3	0.7	16	0.4
J + K	US 60	EB	I-10	Val Vista	13.4	-0.3	11.6	-0.4	16.1	-1.7	11.9	-0.7
		WB	Val Vista	I-10	20.5	0.4	13.5	1	12.8	-0.2	11.6	0
L	Loop 101	NB	Guadalupe Road	Loop 202	9.4	-0.3			5.2	0		
		SB	Loop 202	Guadalupe Road	5.1	0			12.7	0.3		
M	SR 143	NB	I-10	Loop 202/ McDowell Road	4	0.1			4	0		
		SB	Loop 202/ McDowell Road	I-10	4.1	-0.1			8.3	0.5		

Source: ADOT FMS

Table 2.12 Results for 95th Percentile Travel Time

Corridor ID	Analysis Corridor	Dir	From	To	95th Percentile Travel Time (minutes)							
					AM Peak Period				PM Peak Period			
					General Purpose Lanes		HOV Lanes		General Purpose Lanes		HOV Lanes	
					2007	Change from 2006	2007	Change from 2006	2007	Change from 2006	2007	Change from 2006
A	I-10 Papago	EB	81st Avenue	I-17	25.8	1.8	22	4.5	8.3	0.2	8	0.4
		WB	I-17	82nd Avenue	7.6	-0.5	7.7	0.4	11.6	1.8	9.6	1.1
B	I-10 Papago	EB	I-17	SR 51	7.4	-0.4	5.6	-0.3	7.4	0.5	6.9	0.3
		WB	SR 51	I-17	4.7	0	4.2	0.1	17.5	0.7	15.8	0
C	I-10 Maricopa	EB	SR 51	US 60	7.3	-1.1	6.2	-0.7	23.5	-2.7	24.3	-3.3
		WB	US 60	SR 51	8.9	0.3	8.5	0.1	14.7	1.3	12.3	-1.4
D	I-10 Maricopa	EB	US 60	Chandler Blvd	7.1	0	6.8	-0.5	12	0	10.1	-1
		WB	Chandler Blvd	US 60	24.2	0	10.3	1.3	8.3	0.9	5.9	-1.4
E + F	I-17 NB	NB	Maricopa TI	Peoria Avenue	15.9	-0.1	8	0	36.3	4.8	12.6	0.2
		SB	Peoria Avenue	Maricopa TI	38.1	0.7	12.5	3.1	25.3	-1	7	0
F	I-17	NB	I-10	Peoria Avenue	9.3	0.1	8	0	18.5	1.7	12.6	0.2
		SB	Peoria Avenue	I-10	23.1	2.2	12.5	3.1	10.2	-2	7	0
G + H	SR 51	NB	I-10/Loop 202	Bell Road	12.9	0.1	8.9	0.2	20.4	0	10.2	0.4
		SB	Bell Road	I-10/Loop 202	21.9	-2.8	11.7	0.9	23.2	-0.5	9.8	0.2
I	Loop 202	EB	I-10/SR 51	Loop 101	9.8	0	8.9	0	26.3	2.4	14.6	1.1
		WB	Loop 101	I-10/SR 51	19.3	0.1	10.9	0	26.4	2	21.4	1.3
J + K	US 60	EB	I-10	Val Vista	13.7	-0.2	11.8	-0.6	18.8	-2.3	12.5	-1.1
		WB	Val Vista	I-10	26	0	16.4	1.8	13.2	-1	12	0.1
L	Loop 101	NB	Guadalupe Road	Loop 202	12.7	-0.8			5.5	0.1		
		SB	Loop 202	Guadalupe Road	5.5	-0.1			14.9	0		
M	SR 143	NB	I-10	Loop 202/ McDowell Road	4.1	0.1			4.3	-0.1		
		SB	Loop 202/ McDowell Road	I-10	4.3	0			9.6	0.3		

Source: ADOT FMS

Table 2.13 Results for Travel Time Index

Corridor ID	Analysis Corridor	Dir	From	To	Travel Time Index							
					AM Peak Period				PM Peak Period			
					General Purpose Lanes		HOV Lanes		General Purpose Lanes		HOV Lanes	
					2007	Change from 2006	2007	Change from 2006	2007	Change from 2006	2007	Change from 2006
A	I-10 Papago	EB	81st Avenue	I-17	1.61	0.02	1.48	0.17	1.02	0	1.04	0.02
		WB	I-17	82nd Avenue	1	-0.02	1.01	0	1.21	0.1	1.09	0.06
B	I-10 Papago	EB	I-17	SR 51	1.29	-0.03	1.1	-0.01	1.12	0	1.09	0.02
		WB	SR 51	I-17	1.03	0.01	1	0	2.29	-0.01	1.97	-0.06
C	I-10 Maricopa	EB	SR 51	US 60	1.03	-0.05	1	-0.02	2.2	-0.12	1.99	-0.09
		WB	US 60	SR 51	1.05	-0.01	1	0	1.18	0.02	1.06	-0.02
D	I-10 Maricopa	EB	US 60	Chandler Blvd	1.01	0	1	-0.01	1.26	-0.08	1.11	-0.09
		WB	Chandler Blvd	US 60	2.26	0.02	1.23	0.05	1.06	0	1.03	-0.02
E + F	I-17 NB	NB	Maricopa TI	Peoria Avenue	1.04	0	1.01	0.01	1.54	0.07	1.13	0.01
		SB	Peoria Avenue	Maricopa TI	1.54	0.01	1.18	0.1	1.22	-0.05	1.01	0
F	I-17	NB	I-10	Peoria Avenue	1.04	0.01	1.01	0.01	1.39	0.04	1.13	0.01
		SB	Peoria Avenue	I-10	1.57	0.02	1.18	0.1	1.09	-0.09	1.01	0
G + H	SR 51	NB	I-10/Loop 202	Bell Road	1	0	1	0	1.14	0	1.03	0.02
		SB	Bell Road	I-10/Loop 202	1.16	-0.06	1.05	0.02	1.09	-0.03	1.01	0.01
I	Loop 202	EB	I-10/SR 51	Loop 101	1.01	0.01	1	0	1.6	0.02	1.14	0
		WB	Loop 101	I-10/SR 51	1.37	0.01	1.02	0	1.47	0.03	1.28	0.03
J + K	US 60	EB	I-10	Val Vista	1.02	-0.03	1	-0.01	1.15	-0.09	1.01	-0.04
		WB	Val Vista	I-10	1.39	0.01	1.08	0.05	1.02	-0.01	1.01	0.01
L	Loop 101	NB	Guadalupe Road	Loop 202	1.44	0			1.01	0		
		SB	Loop 202	Guadalupe Road	1.01	0			2.01	0.11		
M	SR 143	NB	I-10	Loop 202/ McDowell Road	1.05	0			1.09	-0.02		
		SB	Loop 202/ McDowell Road	I-10	1.07	-0.01			1.74	0.16		

Source: ADOT FMS

Table 2.14 Results for Buffer Index

Corridor ID	Analysis Corridor	Dir	From	To	Buffer Index							
					AM Peak Period				PM Peak Period			
					General Purpose Lanes		HOV Lanes		General Purpose Lanes		HOV Lanes	
					2007	Change from 2006	2007	Change from 2006	2007	Change from 2006	2007	Change from 2006
A	I-10 Papago	EB	81st Avenue	I-17	1.02	0.11	0.87	0.19	0.03	0.02	0	0
		WB	I-17	82nd Avenue	0.01	-0.04	0.02	0.02	0.28	0.1	0.17	0.07
B	I-10 Papago	EB	I-17	SR 51	0.32	-0.05	0.18	-0.04	0.52	0.09	0.47	0.06
		WB	SR 51	I-17	0.03	0	0	0	0.72	0.08	0.8	0.06
C	I-10 Maricopa	EB	SR 51	US 60	0.09	-0.11	0	-0.04	0.66	-0.09	0.89	-0.17
		WB	US 60	SR 51	0.17	0.04	0.15	0	0.74	0.13	0.66	-0.17
D	I-10 Maricopa	EB	US 60	Chandler Blvd	0.02	0	0	-0.04	0.39	0.08	0.31	-0.04
		WB	Chandler Blvd	US 60	0.79	-0.02	0.41	0.14	0.32	0.15	0	-0.17
E + F	I-17 NB	NB	Maricopa TI	Peoria Avenue	0.05	-0.01	0	0	0.61	0.14	0.34	0
		SB	Peoria Avenue	Maricopa TI	0.65	0.02	0.52	0.28	0.39	0.01	0	0
F	I-17	NB	I-10	Peoria Avenue	0.03	0.01	0	0	0.54	0.1	0.34	0
		SB	Peoria Avenue	I-10	0.79	0.15	0.52	0.28	0.15	-0.11	0	0
G + H	SR 51	NB	I-10/Loop 202	Bell Road	0	0	0	0	0.32	0	0.08	0.03
		SB	Bell Road	I-10/Loop 202	0.35	-0.09	0.16	0.07	0.52	0.01	0.01	0.01
I	Loop 202	EB	I-10/SR 51	Loop 101	0.02	0	0	0	0.73	0.14	0.34	0.1
		WB	Loop 101	I-10/SR 51	0.41	0	0.07	0	0.8	0.1	0.68	0.07
J + K	US 60	EB	I-10	Val Vista	0.04	0.01	0	-0.04	0.27	-0.05	0.04	-0.06
		WB	Val Vista	I-10	0.49	0	0.24	0.09	0.03	-0.06	0	0
L	Loop 101	NB	Guadalupe Road	Loop 202	0.64	-0.11			0.02	0.02		
		SB	Loop 202	Guadalupe Road	0.03	-0.02			0.39	-0.09		
M	SR 143	NB	I-10	Loop 202/ McDowell Road	0.04	0.01			0.06	0		
		SB	Loop 202/ McDowell Road	I-10	0.04	0			0.45	-0.09		

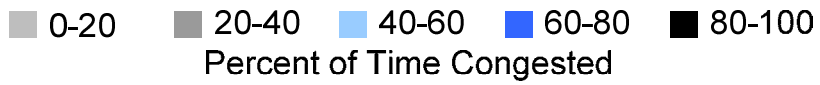
Source: ADOT FMS

2.3.2.4 *Extent of Congestion*

Definition: Extent of congestion is defined as the frequency with which congestion forms along a corridor. The geographic extent of congestion varies from day to day on each corridor, and the combined temporal and geographic extent of congestion can be illustrated using contour graphics, as seen in Figure 2.22. These graphics describe how often each roadway is congested, and where and when that congestion occurs. This allows an analysis of the location of bottlenecks and presents a clear visual image of their relative significance. For the purposes of MAG performance measurement reporting, congestion is defined as lane occupancy greater than or equal to 35% for any five (5) minute period. This is equivalent to level of service (LOS) F, or breakdown conditions. The contour graphic illustrates the frequency with which congestion forms by time of day along the corridor. The specific statistic presented is the *frequency with which congestion forms*.

The contour graphics show time (from midnight to midnight) on the horizontal axis, and the milepost location along each corridor on the vertical axis. The north- or eastbound direction of travel is shown on the right side of the page, and the south- or westbound direction of travel is shown on the left side of the page. The graphic is colored light gray where congestion forms less than one (1) day per week (less than 20%of the time), dark gray is less than twice per week but more than once per week (20 to 40% of the time), light blue areas experience congestion less than three (3) days per week (40 to 60% of the time), dark blue experiences congestion less than four (4) days per week (60 to 80% of the time), and black is more than four (4) days per week (80 to 100% of the time). The legend located on the contour graphics themselves displays these conditions as indicated in Figure 2.21.

Figure 2.21 Example of Contour Graphic Legend



Objective: Reduce the frequency with which congestion forms along freeway corridors in the MAG region.

Source: ADOT Freeway Management System Archived Data for 2007.

Time Scale: AM peak period (6:00 AM to 9:00 AM), Midday period (9:00 AM to 3:00 PM), PM peak period (3:00 PM to 7:00 PM)

Methodology: Using SAS and the station-level base data set as a starting point, lane occupancy data are taken from the reported ADOT FMS detector data. For this analysis congestion is defined as occurring when lane occupancy is greater than 35 percent. SAS is used to flag any five-minute time period when occupancy is greater than 35 percent. This was done for each 5-minute time period for all non-holiday weekdays in the analysis year. By aggregating across all days, this was then converted to the percent of days during which congestion was present for each 5-minute time period in the day. The results were exported to Microsoft Excel and interpolated to half-mile intervals and then graphed using the surface chart option. To make the graphics easier to read the surface plots (i.e., contour diagrams) for both directions of travel

are placed side by side in a layout program, with a strip map showing the approximate location of major intersecting roadways in between the two contour diagrams.

Contour plots for all major freeways in the MAG region with traffic detection infrastructure are provided in Figures 2.22 through 2.34.

Explanation of Results and Analysis: I-10 has by far the greatest extent of monitoring infrastructure in the region. It also has some of the most significant congestion. Both the general-purpose (GP) and HOV lanes experience significant congestion. In the general-purpose lanes (Figure 2.22) congestion forms daily in two significant regions both westbound and eastbound. Westbound, congestion forms consistently (50% of weekdays) as early as 6:15 AM both approaching US 60 and several miles prior to that point (just after Chandler Blvd.) Once it starts to form, congestion quickly fills in between these points, providing four solid miles of slow traffic that routinely lasts until 9:30 AM and occasionally later. In the PM peak period, congestion most commonly forms around 2 PM near the Loop 202. Congestion initially spills backwards (upstream) from that point, but as the peak period continues, congestion moves downstream as well, frequently extending for over six miles and more on very bad days.

Eastbound, congestion during the AM peak period is not as severe as westbound, but starts even earlier, with frequent (more than half the days) congestion occurring as early as 5:40 AM near milepost 137 (roughly half way between 83rd Avenue and the I-17 interchange.) It frequently extends over 4 miles and generally moderates prior to 9 AM. In the afternoon, eastbound congestion forms in several different sections simultaneously just prior to 3 PM, both approaching US 60 and SR 143. Conditions quickly deteriorate around these points, with congestion growing into a solid block over six miles long that does not dissipate until almost 7 PM.

Lesser blocks of congestion are also apparent in both directions of travel in the afternoon, with some locations experiencing routine midday congestion.

As noted in the previous section, the I-10 HOV lanes are not immune to the congestion on this corridor. As shown in Figure 2.23, congestion forms on the HOV lanes in locations similar to those noted for the general-purpose lanes. Interestingly, because ADOT allows single occupancy vehicles to use the HOV lanes prior to 3 PM, congestion often (roughly 40% of the time) forms in the HOV lanes at key congestion locations (between mileposts 145.5 and 147 – near SR 51 – westbound, and between mileposts 151 and 152.5 - near SR 143 - eastbound) prior to the start of HOV lane restrictions. In the core congestion areas, once congestion forms, the HOV lanes never recover. On the edges of the most congested sections, the reduction in volume caused by the imposition of the HOV lane restrictions allows the HOV lane to recover slightly.

Additional analysis is needed to determine if a change in HOV lane policy on I-10 (e.g., starting the HOV lane restrictions at 2 PM) might keep the HOV lanes free flowing throughout the afternoon.

Figures 2.24 and 2.25 illustrate the congestion on I-17's general purpose and HOV lanes, respectively. In the morning, I-17 experiences congestion hot spots over much of its length southbound from as early as 5:30 AM and routinely lasting until around 9:00 AM. The most significant congestion forms near Camelback Road (between mileposts 204 and 205) where

congestion occurs essentially every day. Southbound I-17 also experiences routine congestion in the afternoon peak period, but this routine congestion is limited to the approaches to the Maricopa Traffic Interchange (between mileposts 194 and 195.5).

In the afternoon, it is the northbound movement along I-17 that experiences most of the congestion. Most commonly, congestion forms initially just north of the Maricopa Traffic Interchange at milepost 194. This occurs as early as 2:20 in the afternoon (30 percent of the time.) It then grows throughout the PM peak period before dissipating between 6:00 and 6:30 PM. Congestion forms as often as 40 percent of the time during the heart of the PM peak period at any given location along the northbound corridor, but the I-10 interchanges are specifically prone to congestion.

The I-17 HOV lanes are not as routinely congested as the I-10 HOV lanes. However, there are congestion points approaching Glendale Avenue (milepost 206.5) southbound in the morning and near the Maricopa Traffic Interchange - forming on half of weekdays at milepost 201- in the afternoon.

Figures 2.26 and 2.27 illustrate the congestion occurring on the Loop 202 general purpose and HOV lanes, respectively. Westbound Loop 202 is unusual in that it experiences significant congestion in both the AM and PM peak periods. The AM congestion occurs in two places, the three miles between the Loop 101 interchange and Scottsdale Road and from the SR 143 interchange to I-10. In the PM, only the western congestion approaching the I-10 interchange routinely forms. However, in the morning congestion lasts for only about two hours (from 7 to 9 AM near the I-10, and from 6:30 to 8:30 approaching Scottsdale Road.) In the afternoon, congestion routinely exists from 2 PM until almost 7 PM. Unlike westbound Loop 202, eastbound Loop 202 only routinely congests in the PM peak period. It also congests as early as 2:45 PM near milepost 7.5 (near Scottsdale Road) and routinely lasts until as late as 6:30 PM. It grows geographically as the PM peak period continues, frequently expanding to as much as 5 miles, and periodically covering as much as 7 miles just prior to 6 PM.

Unlike some freeways, Loop 202's HOV lanes do not experience significant AM peak period congestion, but both directions of travel do experience some PM peak period congestion. Westbound, HOV lane congestion occurs on the approaches to I-10. Congestion frequently forms as early as 2 PM, an hour before the HOV lane restrictions come into effect. As for I-10 and I-17, once the HOV lane breaks down, it does not generally recover until the end of the peak period, which often occurs as late as 6:40 PM. In fact, congestion appears to be worst just prior to the 3 PM start of the HOV lane restriction, extending up to 2 miles from the I-10 interchange. Unlike the westbound HOV lane (and I-10 and I-17), the eastbound Loop 202 HOV lane does not routinely breakdown until 4:20 in the afternoon, well after the HOV restrictions are in place. Congestion can last until around 6 PM and stretches for parts of four miles (roughly from the SR 143 interchange to Scottsdale road), with congestion occurring on as many as half of all weekdays in the peak period.

Figures 2.28 and 2.29 illustrate congestion on US 60. This road has relatively little HOV congestion (small amounts in the afternoon peak period approaching the I-10 interchange), and modest general-purpose lane congestion westbound in the morning and eastbound in the afternoon. In both cases, congestion forms approaching the interchange with I-10 near milepost 172. In the morning, congestion routinely forms as early as 6:15 AM, frequently extends four

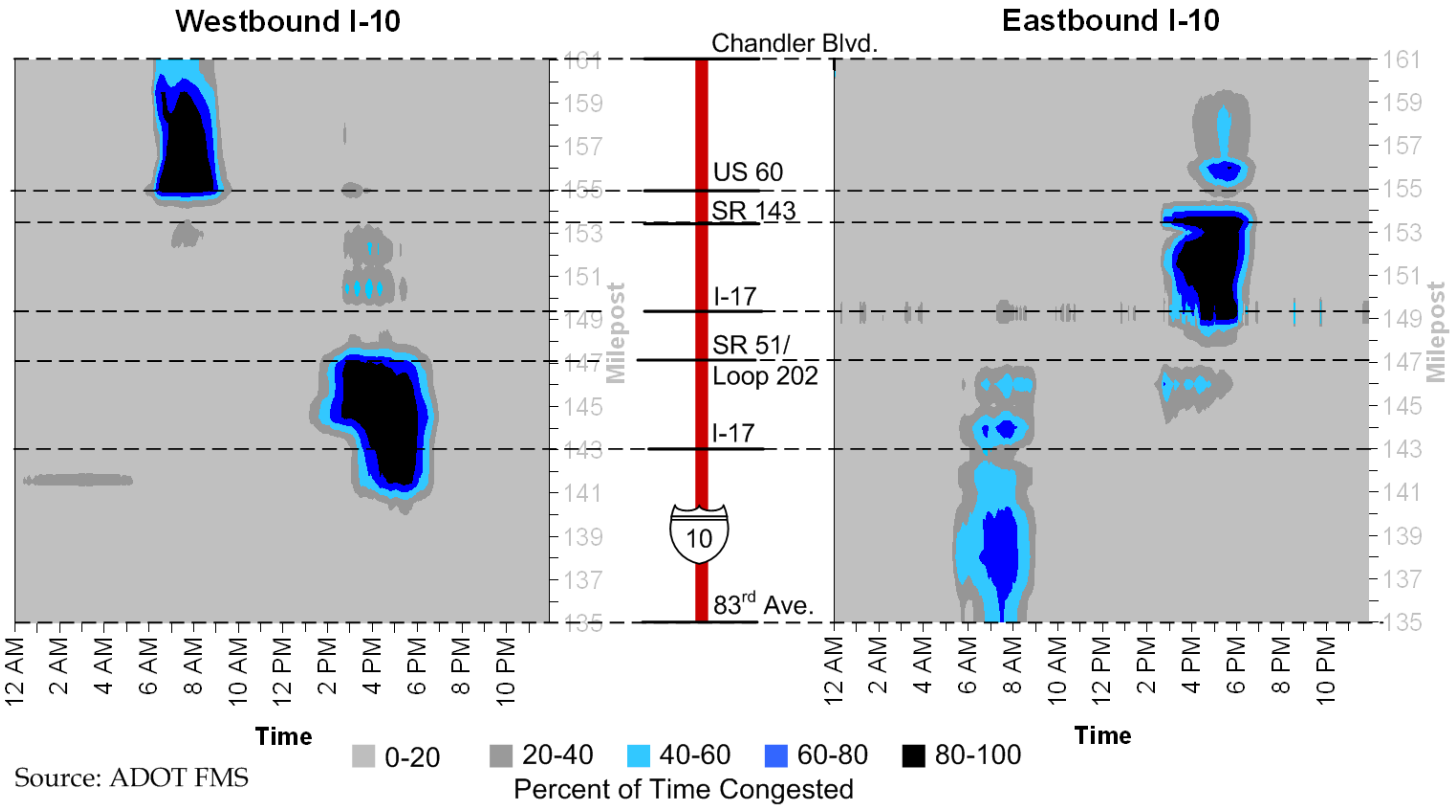
miles, and dissipates by 9 AM. In the afternoon, congestion forms less frequently, but as often as one in three days, congestion forms as early as 3:30 PM.

Figure 2.30 and 2.31 illustrate congestion on SR 51. This road has the lowest congestion levels of all the instrumented freeways in the MAG Region. Congestion forms routinely southbound in three different locations during the AM peak period, between Bell Road and Shea Blvd, approaching Glendale Avenue, and halfway between Glendale and the I-10 interchange. Congestion forms late, relative to other area freeways (near 7 AM), with the majority of congestion gone by 8:30 AM. During the PM peak period, the major congestion point is northbound between I-10 and Glendale Avenue. Congestion routinely forms by 4 PM, but dissipates by 6 PM. The SR 51 HOV lanes experience only spot congestion, with the only location of significance occurring during the morning peak period, southbound near Glendale Avenue.

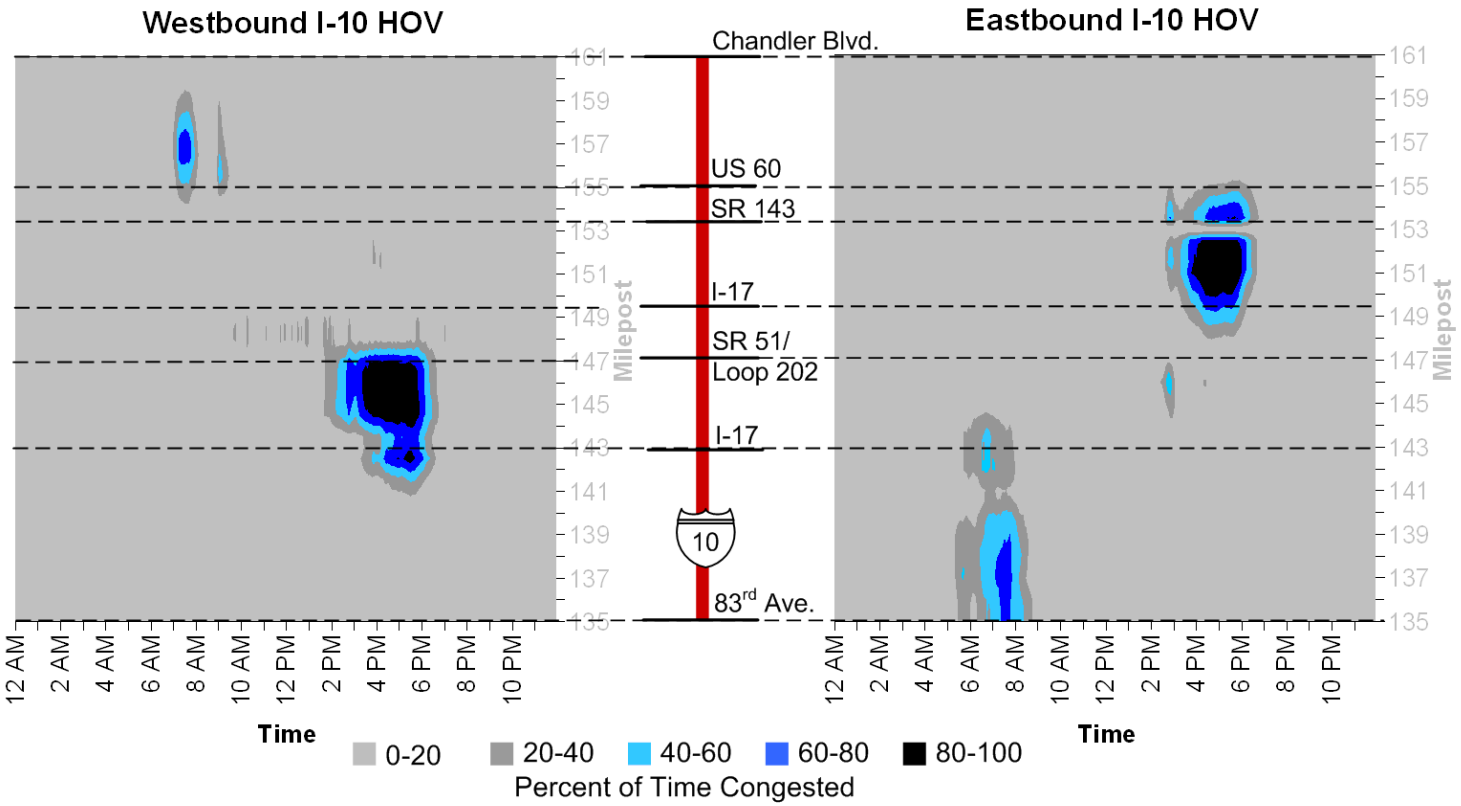
Figure 2.32 shows congestion on Loop 101 from Loop 202 to Guadalupe Road. Southbound, congestion is routinely present along the entire length of this section of freeway. It routinely forms as early as 3 PM and lasts until 7 PM. Northbound, congestion routinely forms as early as 6 AM, with much of the length of the corridor congested by 6:30 AM. The most frequently congested location is near milepost 52, along the northern extent of the facility (nearing the Loop 202 interchange). It is usually the last part of the facility to return to free flow conditions. This often does not occur until 10 AM.

The last of the congestion contour graphics is Figure 2.33. It illustrates the congestion on SR 143. ADOT data show only limited northbound congestion on this road. However, southbound, congestion forms routinely on SR 143 approaching the I-10 interchange around 3:30 in the afternoon. This congestion grows to include over 2 miles of slow traffic, and routinely lasts until after 6:15 PM.

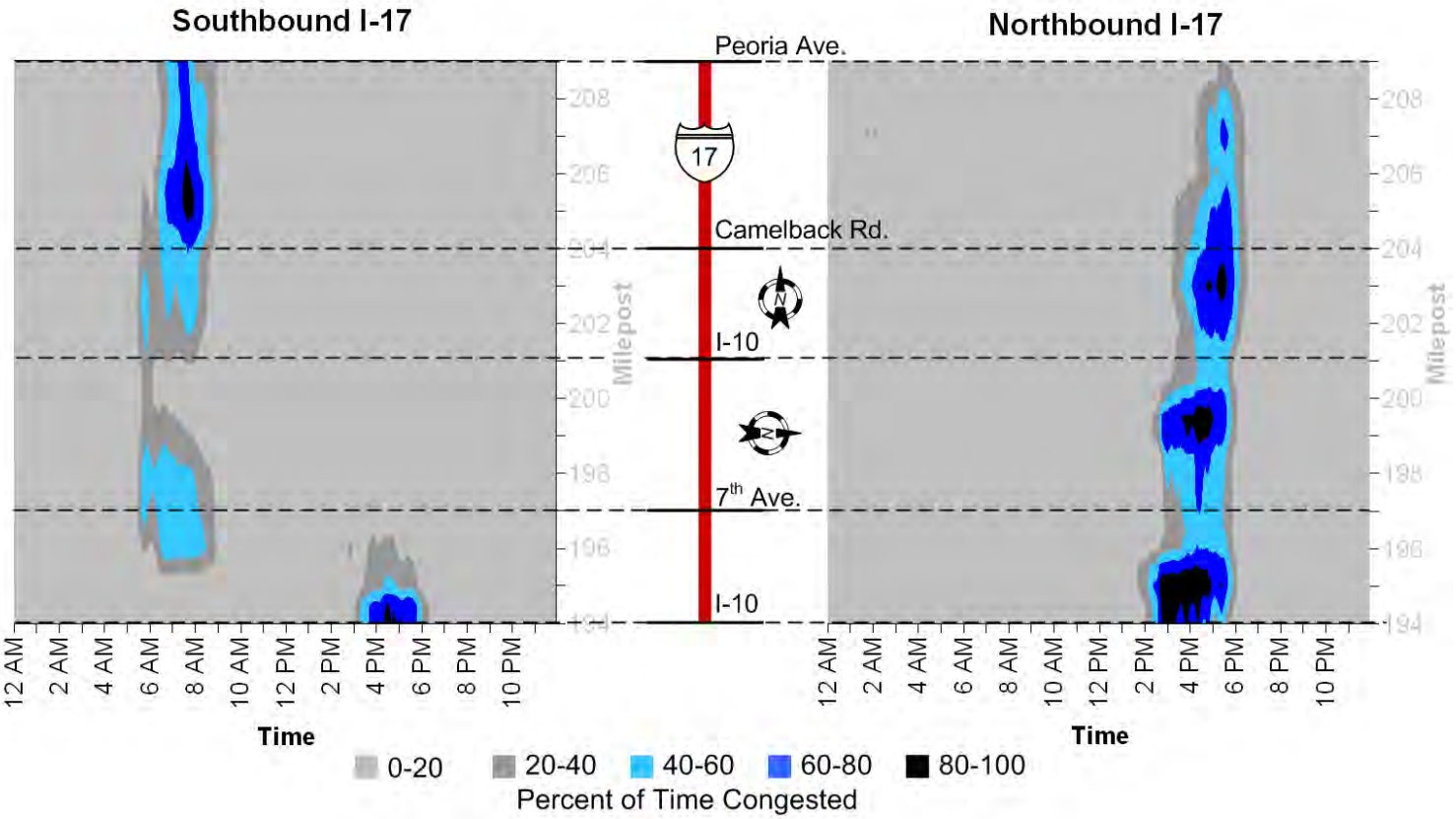
Figures 2.22 and 2.23 Percent of Time Congested on I-10 (2007)

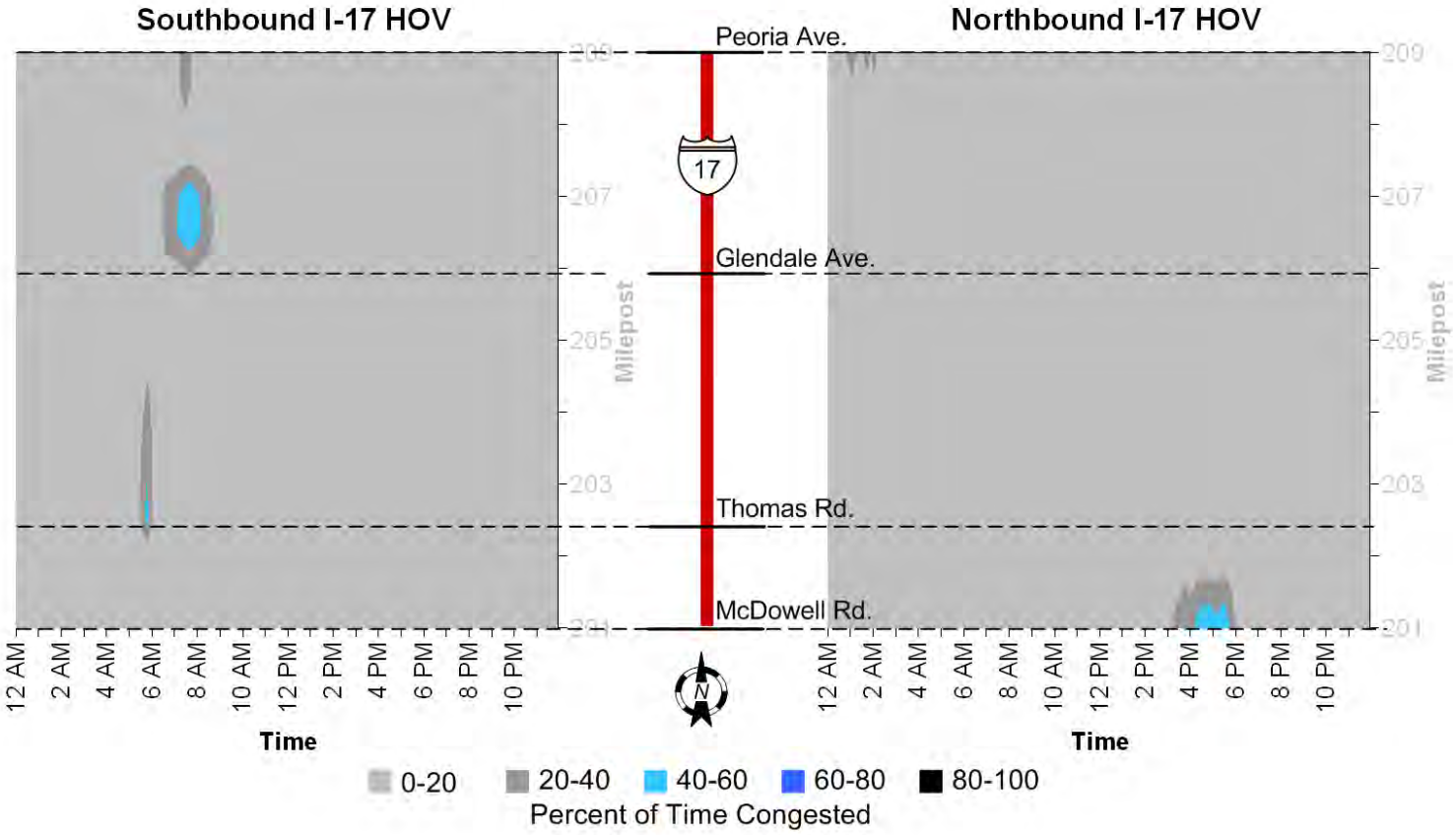


Source: ADOT FMS

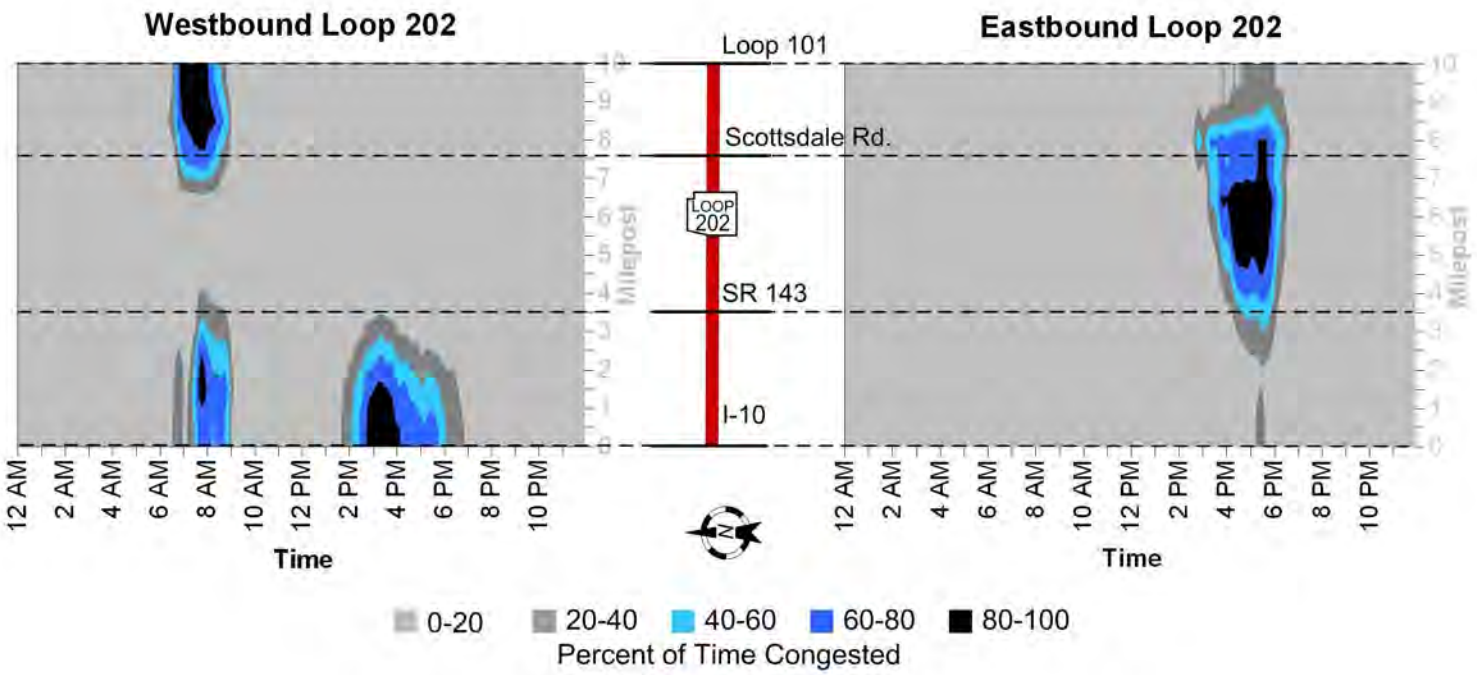


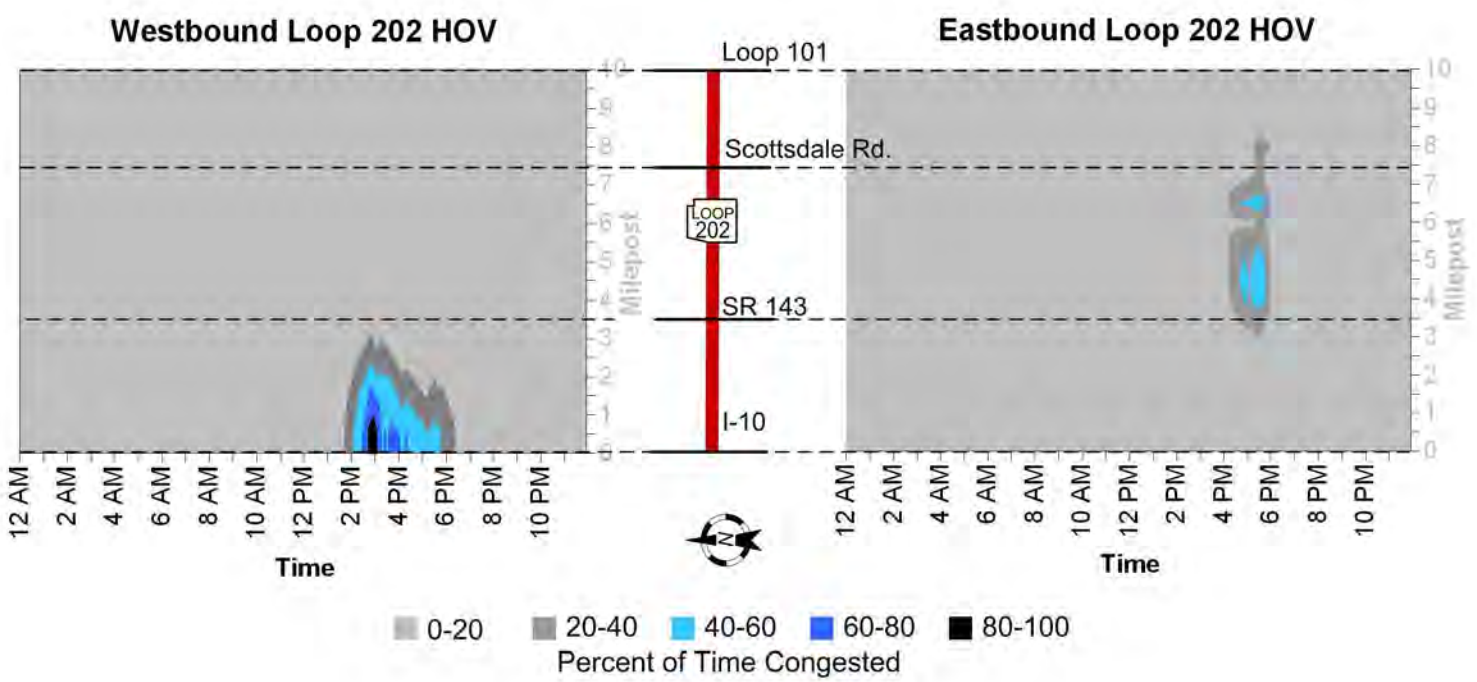
Figures 2.24 and 2.25 Percent of Time Congested on I-17 (2007)



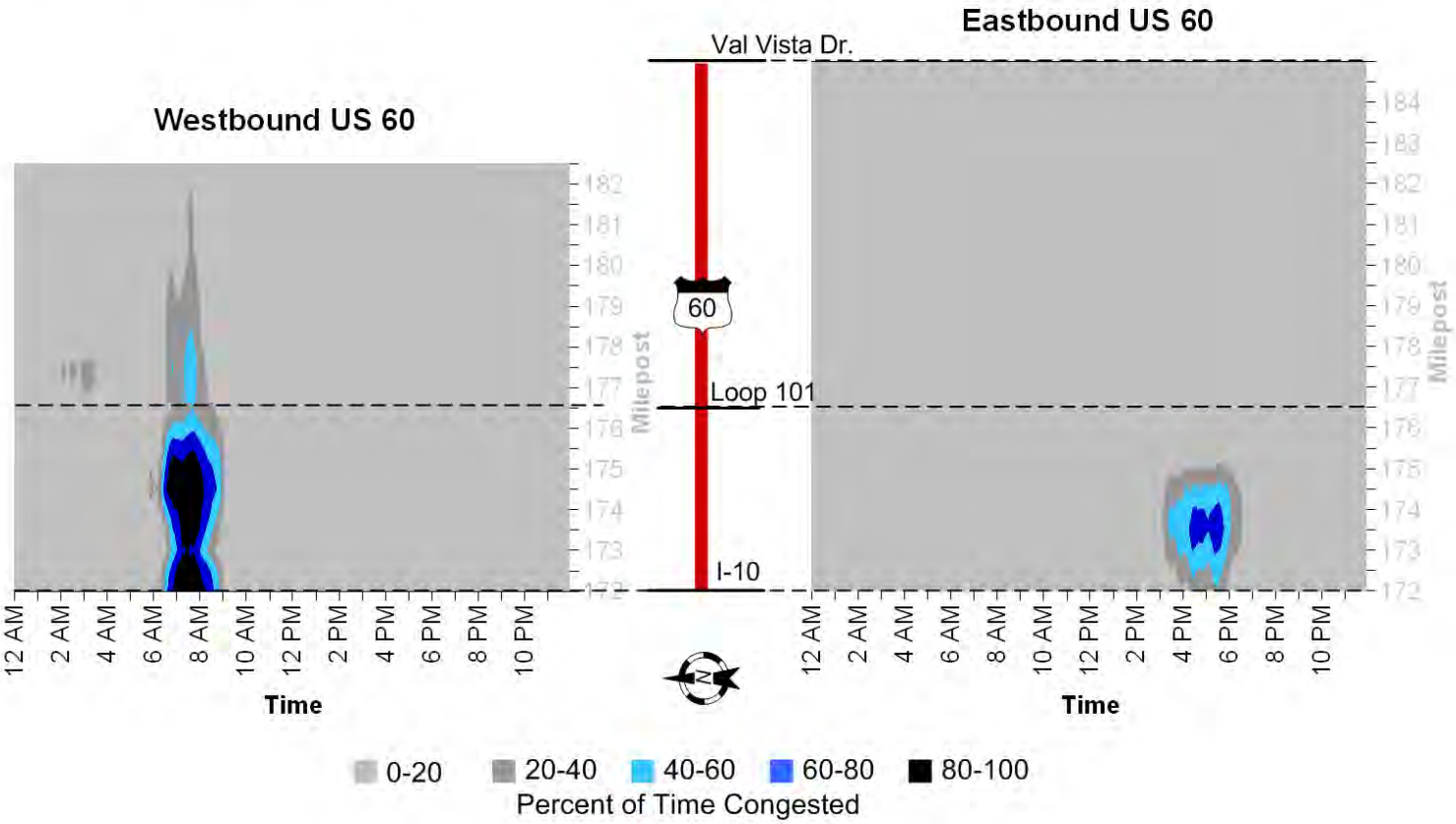


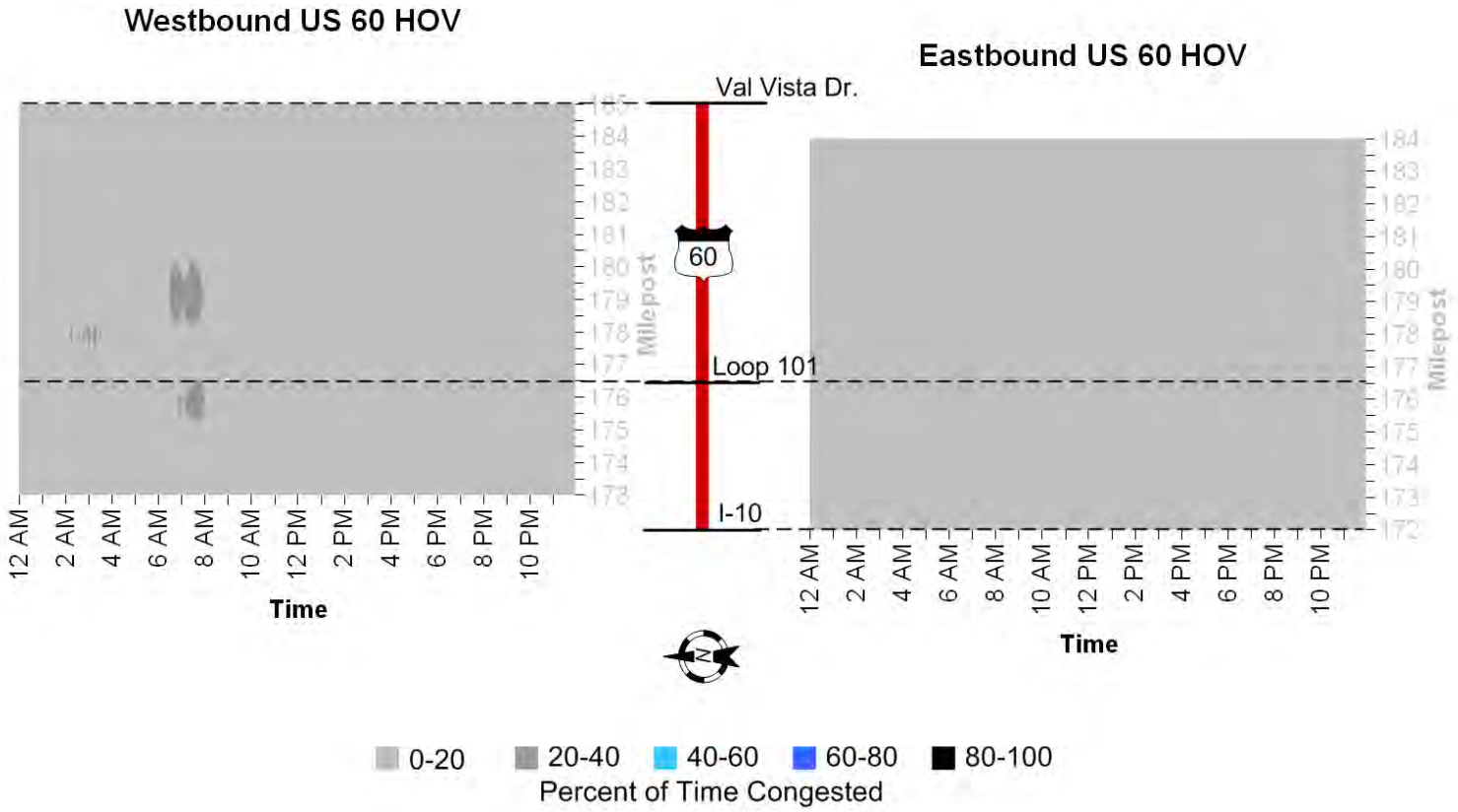
Figures 2.26 and 2.27 Percent of Time Congested on Loop 202 (2007)



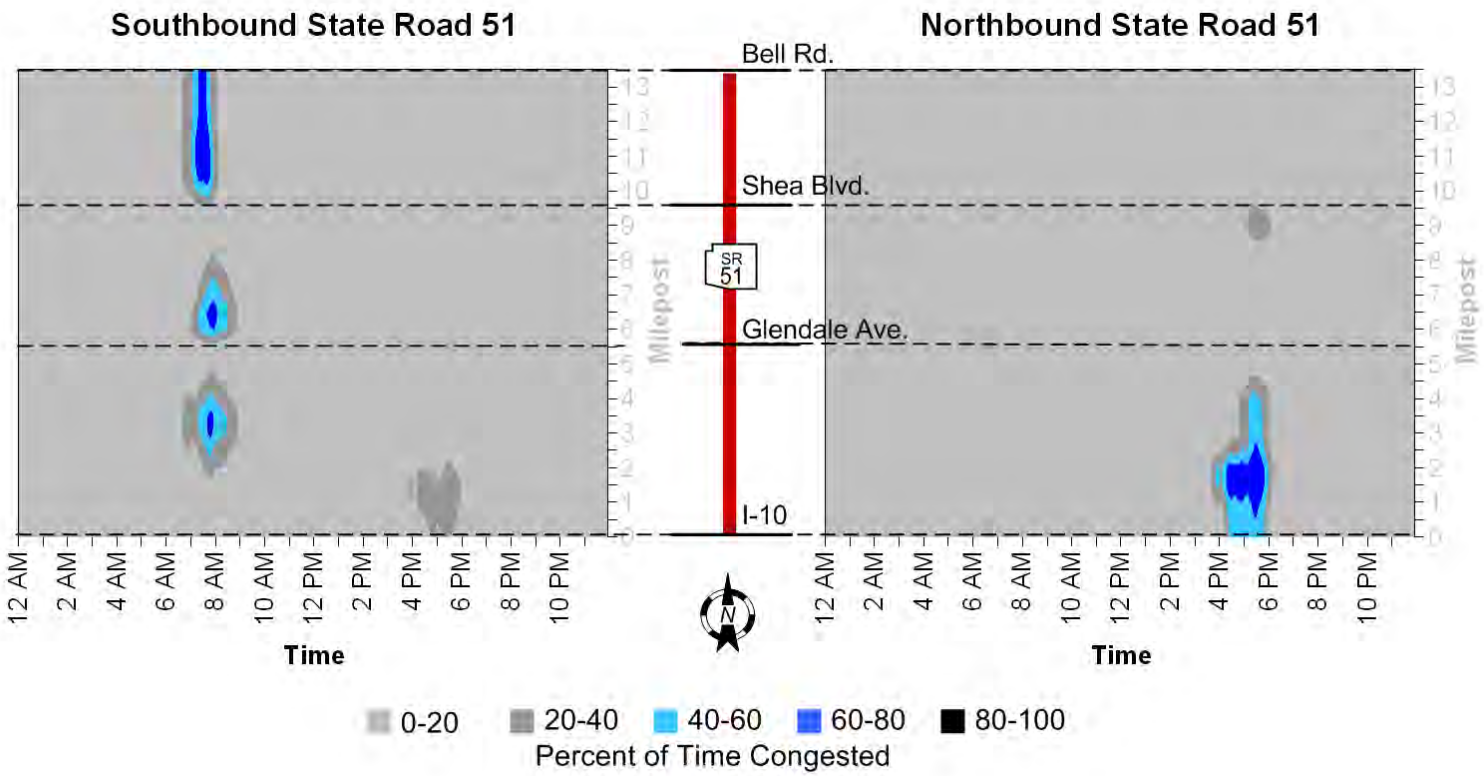


Figures 2.28 and 2.29 Percent of Time Congested on US 60 (2007)





Figures 2.30 and 2.31 Percent of Time Congested on State Road 51 (2007)



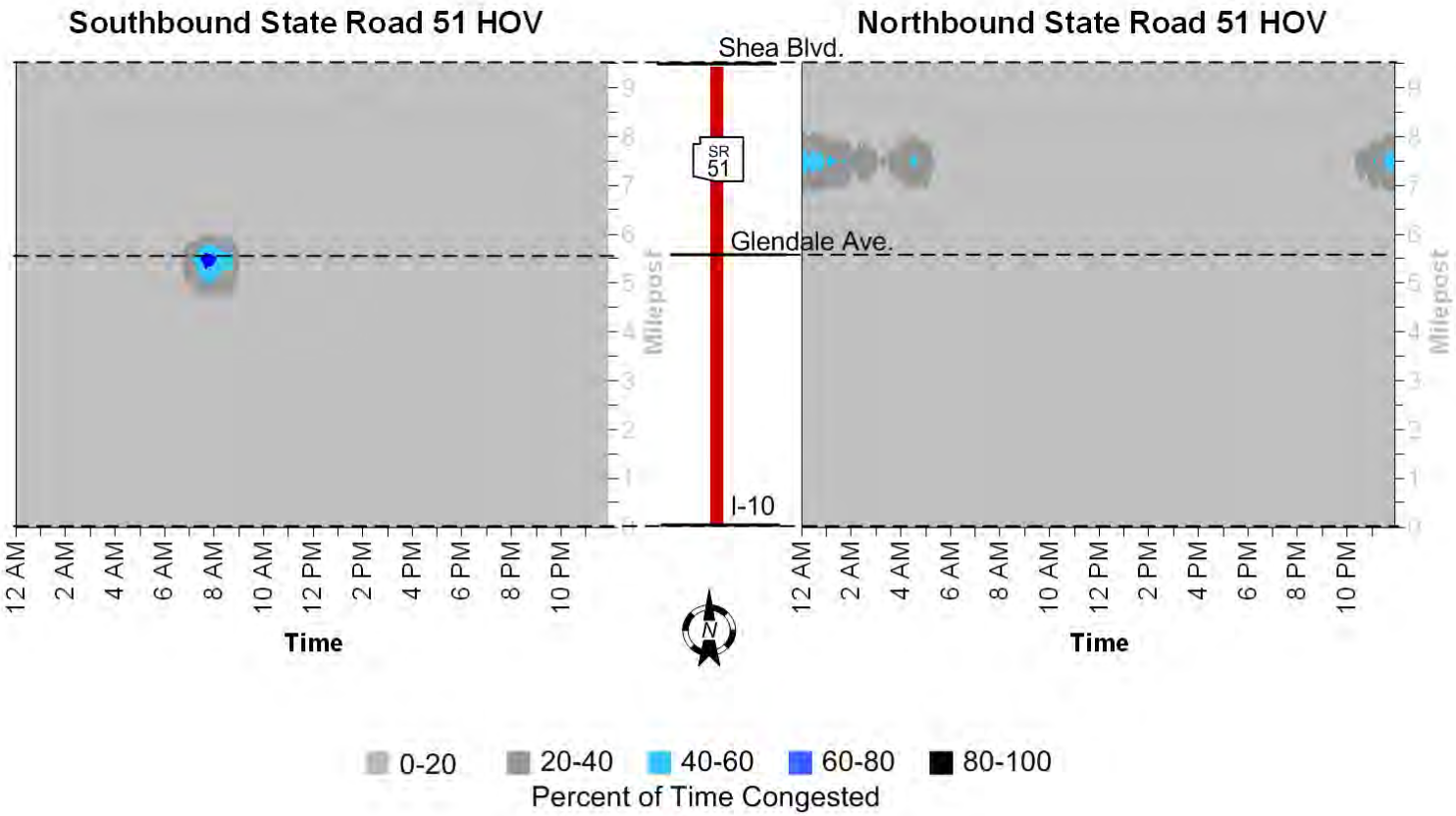


Figure 2.32 Percent of Time Congested on Loop 101 (2007)

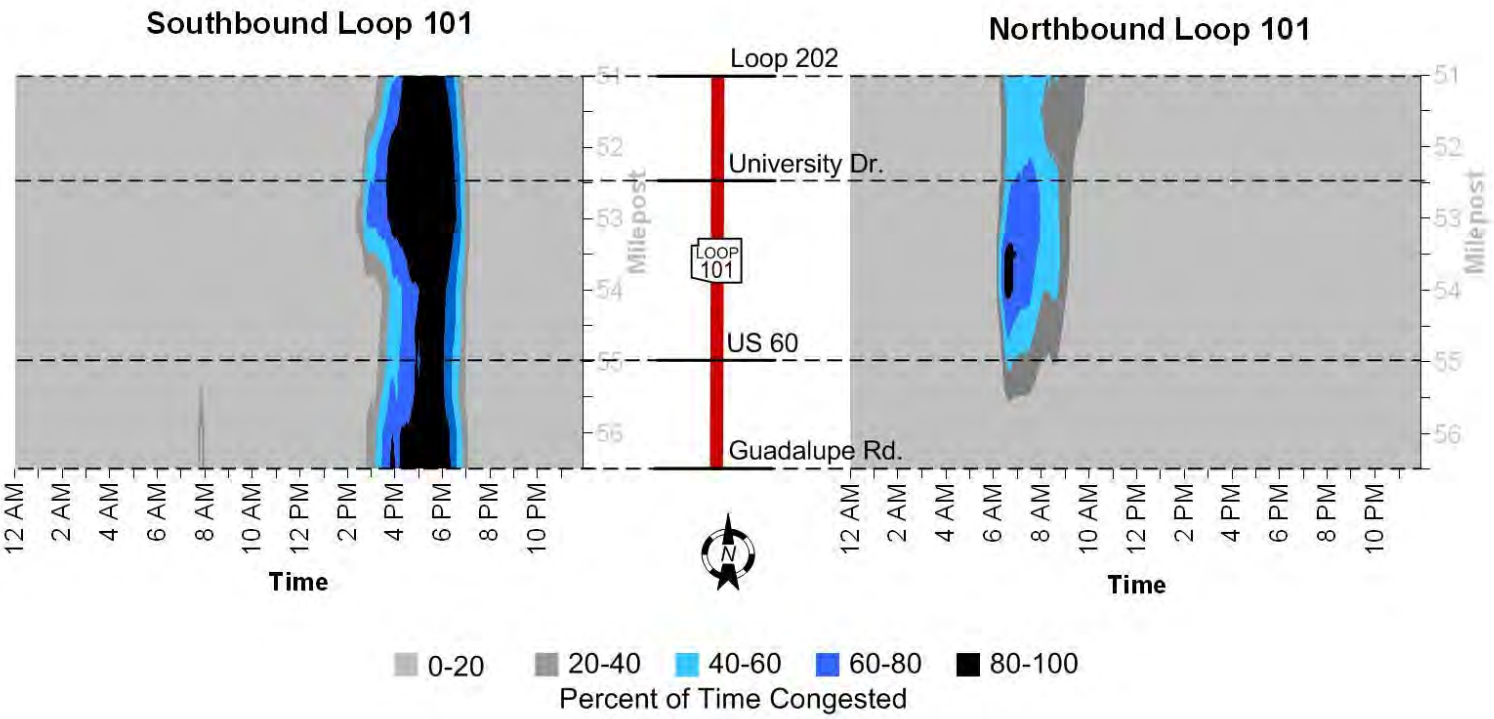
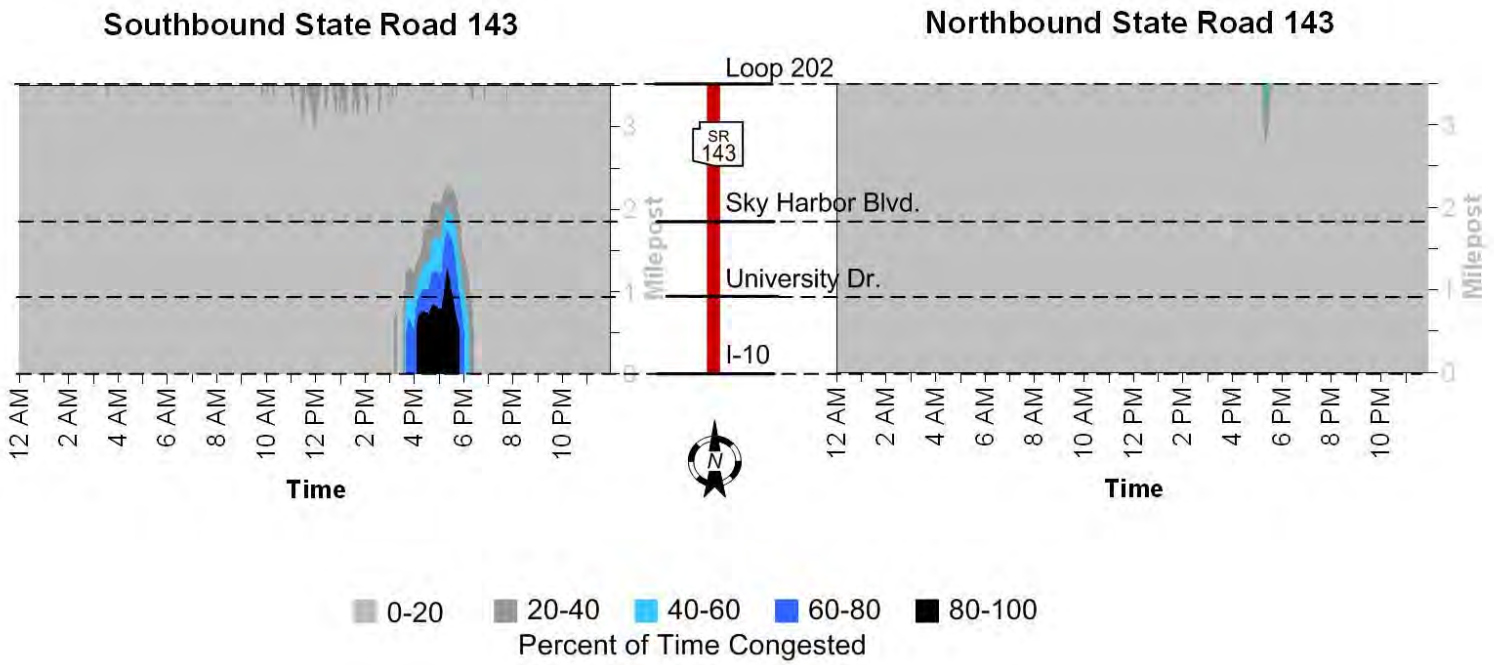


Figure 2.33 Percent of Time Congested on State Road 143 (2007)



2.3.3 Safety Measures

Background – Statistics indicate that nearly 66% of all crashes, and 40% of all fatal crashes in Arizona, occur in the MAG region[13]. Data collected as part of safety-related performance measures can be used to better inform decisision-makers regarding the region's roadway safety needs, as well as provide a valuable resource to support updates to safety-related planning documents (e.g., MAG's Strategic Transportation Safety Plan).

2.3.3.1 Crash/Injury/Fatality Rates on Freeways in the MAG Region

Definition: Crash, injury, and fatality rates are defined as the number of crashes, number injured, and fatalities per million vehicle miles of travel (VMT) along specific freeways during a one-year period[14].

Objective: To determine the extent to which increases in crash, injury, and fatalities can be associated with percent changes in traffic volume. Trends indicated by these rates can serve as good indicators of the changes in roadway safety in the region.

Source: ADOT Accident Location Information Surveillance System (ALISS).

Time Scale: Results are provided for a 3-year period from 2005 to 2007.

Methodology: All of the analyses that generated annual crash frequencies, crash rates, and other information depicted graphically in this section were performed by MAG staff. Crash data pertinent to the MAG region were obtained by MAG from the ADOT Accident Location Information Surveillance System (ALISS). The ALISS database is maintained by ADOT and contains data on all crashes reported to ADOT by the cities, counties and other law enforcement entities within the state; a Police Accident Report (PAR) form is completed by a local enforcement official at the crash scene. A copy of this form is sent to ADOT where the data are keyed into ALISS. All crashes are commonly categorized as Property Damage Only (PDO), Injury, or Fatal Crashes. Crashes that do not result in any personal injury, and sustain vehicle damages estimated to be less than $1,000 are not reported to ALISS. Bicycle and pedestrian injury crashes are reported and entered in the ALISS database only if they involve a motorized vehicle. Consequently, crashes that involve only bicycles and pedestrians are not currently captured in the ALISS database. It is also believed that many PDO crashes in the region are unreported as drivers involved in such crashes exchange insurance information and promptly leave the crash scene. Most crashes recorded in ALISS are geocoded or located by map coordinates by ADOT staff. However, some crash report forms do not contain sufficient details for establishing an accurate map location. As a result, based on current estimates, nearly 20 percent of all crashes cannot be accurately geocoded.

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[13] MAG Regional Transportation Plan 2007 Update, page 21-1.

[14] The ADOT Highway Performance Monitoring System (HPMS) indicates that there were a total of 29,416,000 VMT on MAG region freeways (Interstates, Expressways, and Freeways) during 2007.

Graphs depicting crash, injury, and fatality rates have been developed by MAG for the I-10, I-17, SR 51, US 60, Loop 101, and Loop 202 corridors encompassing 2005, 2006, and 2007 – see Figures 2.34, 2.35, and 2.36.

Explanation of Results and Analysis: For freeways, the total crash rates and injury crash rates per million VMT appear to be consistent on a year-to-year basis. Total crash and injury crash rates are greatest on I-17 and US 60, followed by I-10 and SR 51. Results indicate that the Loop 101 and Loop 202 consistently have the lowest crash and injury rates as compared to all other freeways analyzed. Although I-10 experiences higher traffic volumes than any other roadway in the MAG region, crash and injury crash rates are lower for the I-10 corridor than for either I-17 or US 60.

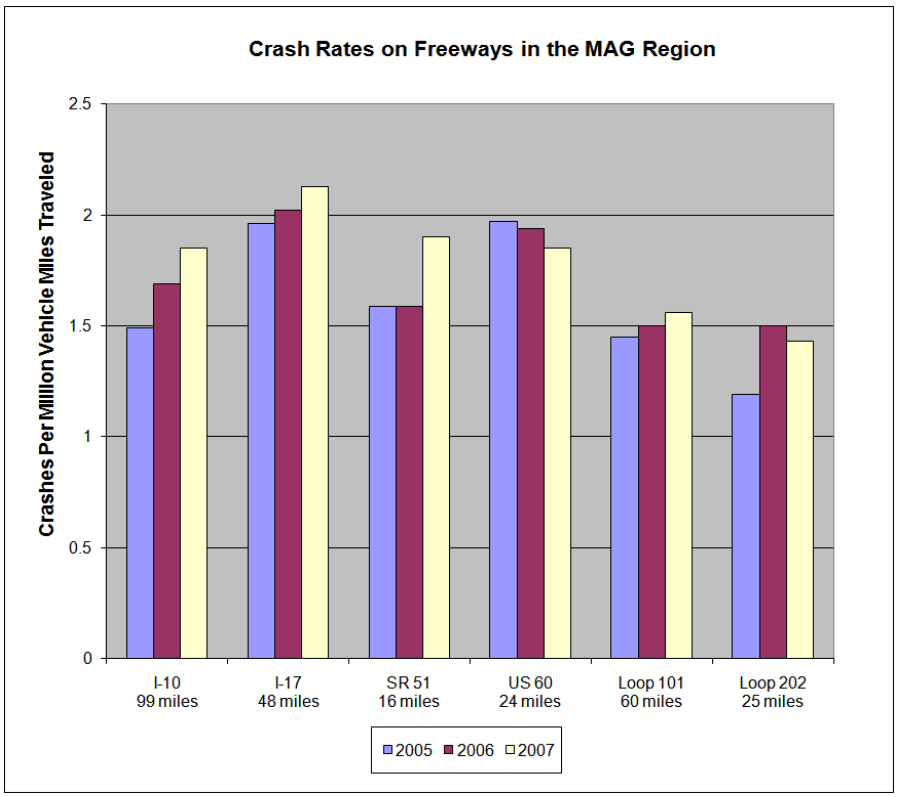
Although national statistics are not currently available concerning total crash rates and injury crash rates, the U.S. Department of Transportation's Bureau of Transportation Statistics does compile detailed national statistics concerning average fatality rates. These data indicate the following[15]:

- Urban Interstates & Freeways - .0054 fatalities per million VMT
- Rural Interstates & Freeways - .0104 fatalities per million VMT

A review of fatality rates for I-10 and I-17 shows that despite having significant portions that would be considered urban in nature, both of these roadways have exhibited fatality rates that are greater than the national average for rural interstates and freeways. During 2005 – 2007, the only urban roadways whose fatality rates were consistently at or below the national average for urban interstates and freeways were SR 51, US 60, and Loop 101.

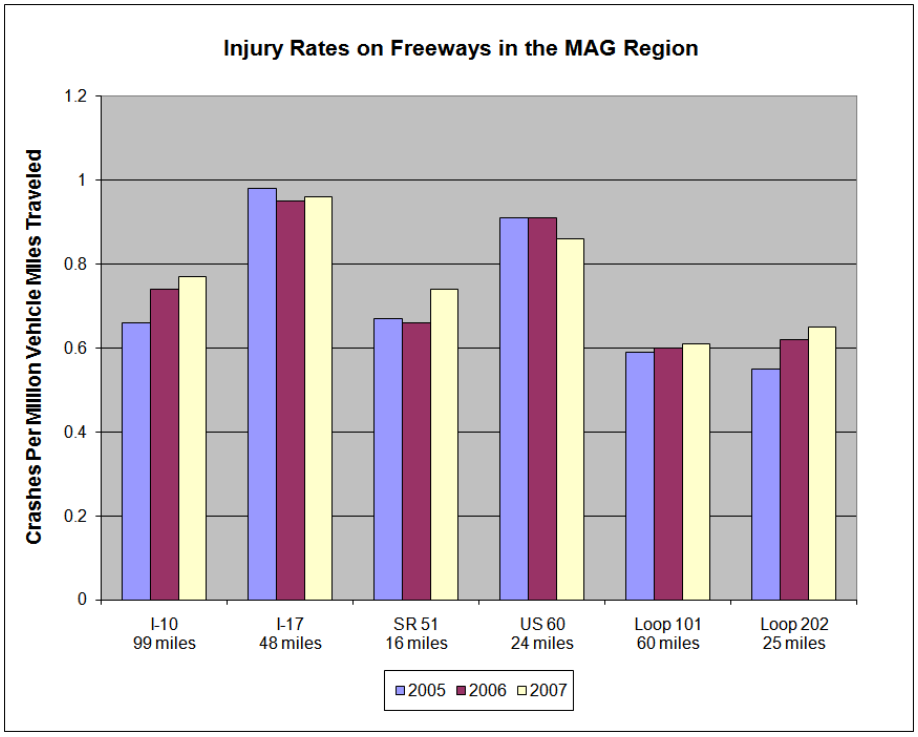
[15] Data provided by Bureau of Transportation Statistics Information Service

Figure 2.34 Crash Rates on Freeways in the MAG Region



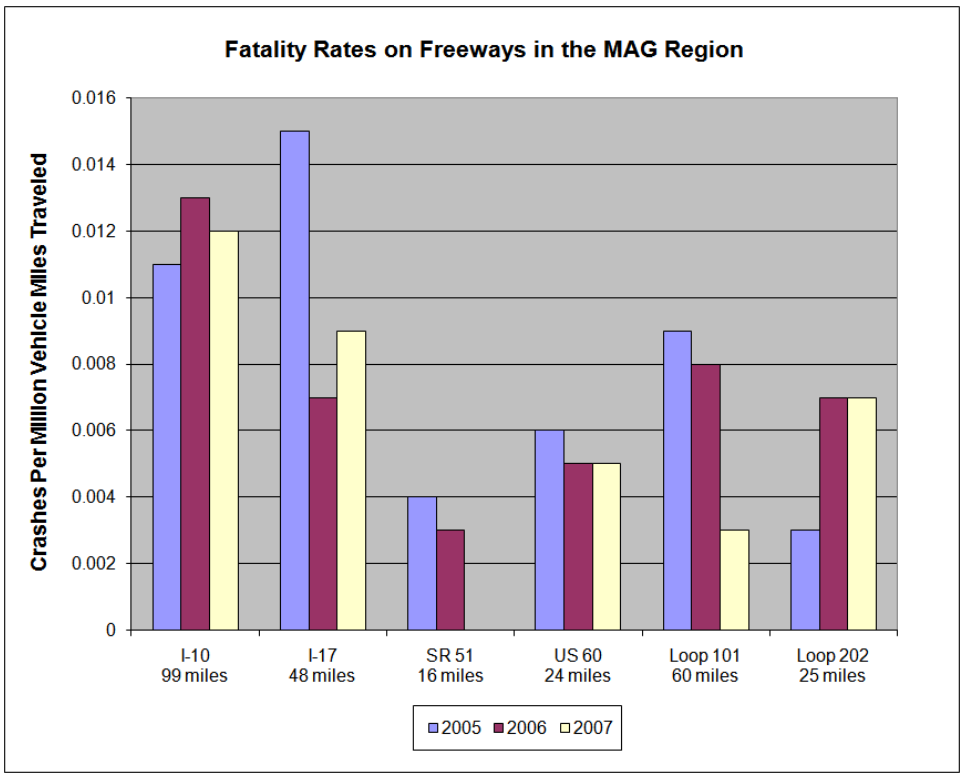
Source: ADOT ALISS

Figure 2.35 Injury Rates on Freeways in the MAG Region



Source: ADOT ALISS

Figure 2.36 Fatality Rates on Freeways in the MAG Region



Source: ADOT ALISS

2.3.3.2 *Crash/Injury/Fatality Totals for Large Truck Involved Crashes on Freeways in the MAG Region*

Definition: Crash, injury, and fatality totals for large truck involved crashes are defined as the total number of crashes, injury crashes, and fatal crashes occurring along specific freeways during a one-year period.

As indicated in the ALISS data entry instruction manual, a truck for the purpose of this performance measure is defined as any of the following:

- A commercial vehicle (a motor vehicle designed, used, or maintained primarily for the transportation of property) with a gross vehicle weight rating of gross combination weight rating greater than 10,000 pounds
- A bus providing seating for nine (9) or more persons, including the driver, and used primarily for the transportation of persons
- A vehicle of any type with a hazardous materials placard

Objective: To reduce the number of truck involved crashes, injury crashes, and fatal crashes across the region or on a given freeway.

Source: ADOT Accident Location Information Surveillance System (ALISS).

Time Scale: Results are provided for a 3-year period from 2005 to 2007.

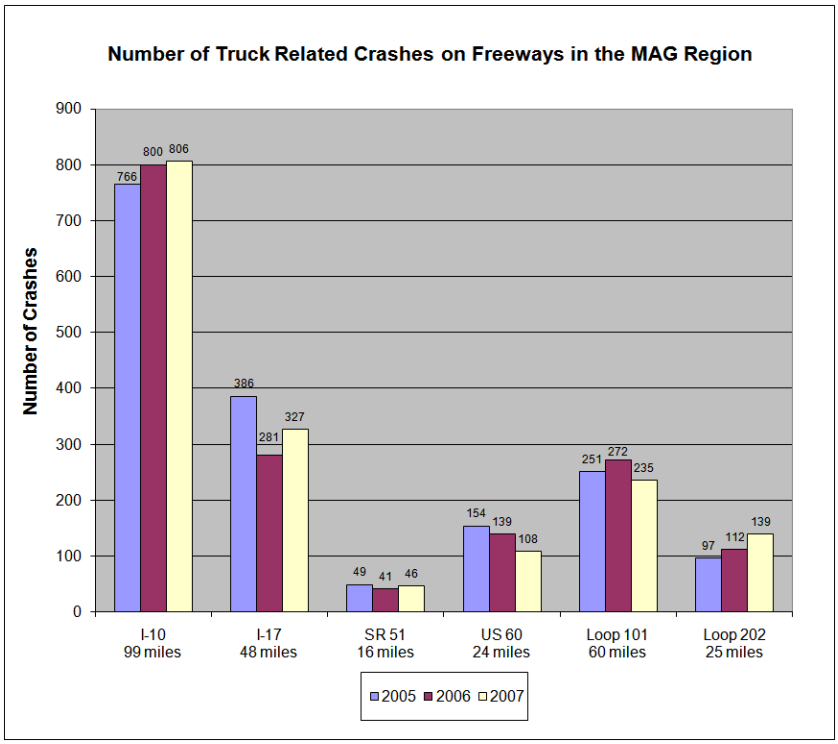
Methodology: All of the analyses that generated annual crash frequency information depicted graphically in this section were performed by MAG staff. Truck-related crash, injury, and fatality data were obtained from the ADOT ALISS. For a more detailed description of ALISS, see the Methodology description found in Section 2.3.3.1.

Ideally, this measure would determine how the number of truck involved crashes, injury crashes, and fatal crashes changes over time, especially as related to changes in truck traffic volume (given the availability of this data). However, the required level of information on truck traffic volumes is currently not available for the MAG region. Until truck volume data becomes available for computing crash rates, the magnitude and severity of the truck crash experience on the freeway system can be assessed by tracking the total number of crashes involving large trucks by crash severity.

Graphs depicting crash, injury, and fatality totals for I-10, I-17, SR 51, US 60, Loop 101, and Loop 202 encompassing 2005, 2006, and 2007 are shown in Figures 2.37, 2.38, and 2.39.

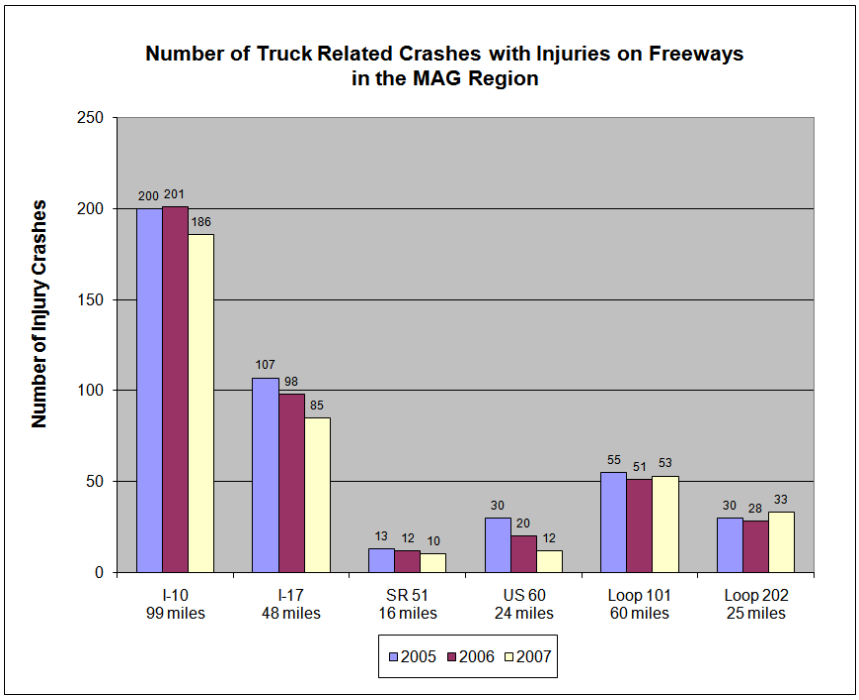
Explanation of Results and Analysis: A comparison of the average number of truck related crashes on each roadway against the number of miles of freeway associated with each roadway, indicates that I-10 and I-17 experience the highest number of truck-related crashes per mile of roadway (ratios of approximately 8 and 6.9, respectively) followed by US 60 (5.54), Loop 202 (4.64), Loop 101 (4.2), and SR 51 (2.8). Moreover, the number of fatal truck involved crashes on I-10 and I-17 is much larger than for all other freeways (with the exception of Loop 101, which is the second longest freeway in the region).

Figure 2.37 Number of Truck Related Crashes on Freeways in the MAG Region



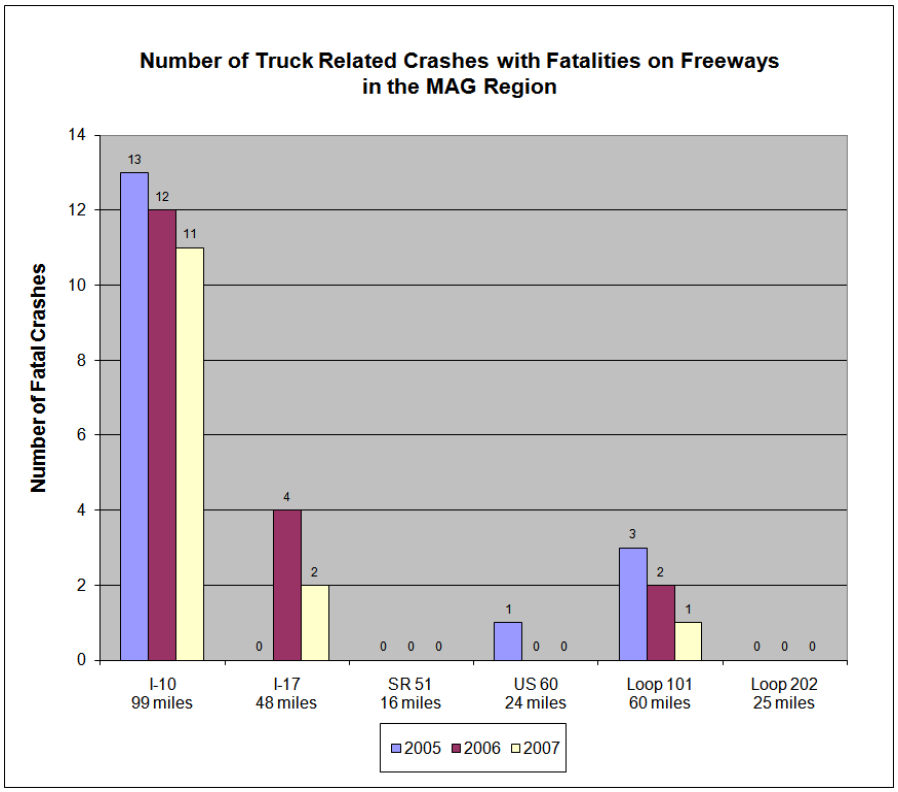
Source: ADOT ALISS

Figure 2.38 Number of Truck Related Crashes with Injuries on Freeways in the MAG Region



Source: ADOT ALISS

Figure 2.39 Number of Truck Related Crashes with Fatalities on Freeways in the MAG Region



Source: ADOT ALISS

3.0 Arterial Performance

3.1 SYSTEM DEFINITION

The major arterials selected for inclusion in this report were chosen due to the fact that they carry large volumes of traffic across the Valley and represent major traffic movements throughout the region. These arterials in some instances parallel the freeway corridors defined in Section 2 of this report, and in other instances carry traffic to and from areas not well-served by freeways.

Roadways included in the analysis of arterial performance include:

- Bell Road from Litchfield to Scottsdale Rd (24.7 mi.)
- Frank Lloyd Wright Blvd from Scottsdale Rd to Shea Blvd (6.8 mi.)
- Glendale Avenue from 91st Ave to Scottsdale Rd (19.2 mi.)
- Indian School Rd from Cotton to Loop 101 North (31.2 mi.)
- Southern Ave from 19th Ave to Tomahawk Rd (33 mi.)
- Baseline Rd from 51st Ave to Ellsworth Rd (31 mi.)
- Chandler Blvd from 3rd Ave to Gilbert Rd (16.8 mi)
- 59th Ave from Van Buren to Deer Valley Rd (16 mi.)
- 7th St from Baseline to Deer Valley Rd (21.1 mi.)
- Scottsdale Rd from Baseline Rd to Cave Creek (31.1 mi.)
- Country Club Dr from Riggs Rd to McDowell Rd (17.2 mi.)
- Grand Avenue from 7th Avenue to Loop 101 (14.3 mi.)
- 19th Avenue from Baseline to Deer Valley Rd (21.1 mi.)
- 14 McDowell Road from Litchfield to Loop 101 N (27.1 mi.)
- 15 Shea Boulevard from SR 51 to Frank Lloyd Wright Blvd (10 mi.)
- Dysart from Bell Road to I-10 (12.5 mi.)
- Power Road from Loop 202 (Red Mountain Freeway) to Elliot Rd (8.4 mi.)

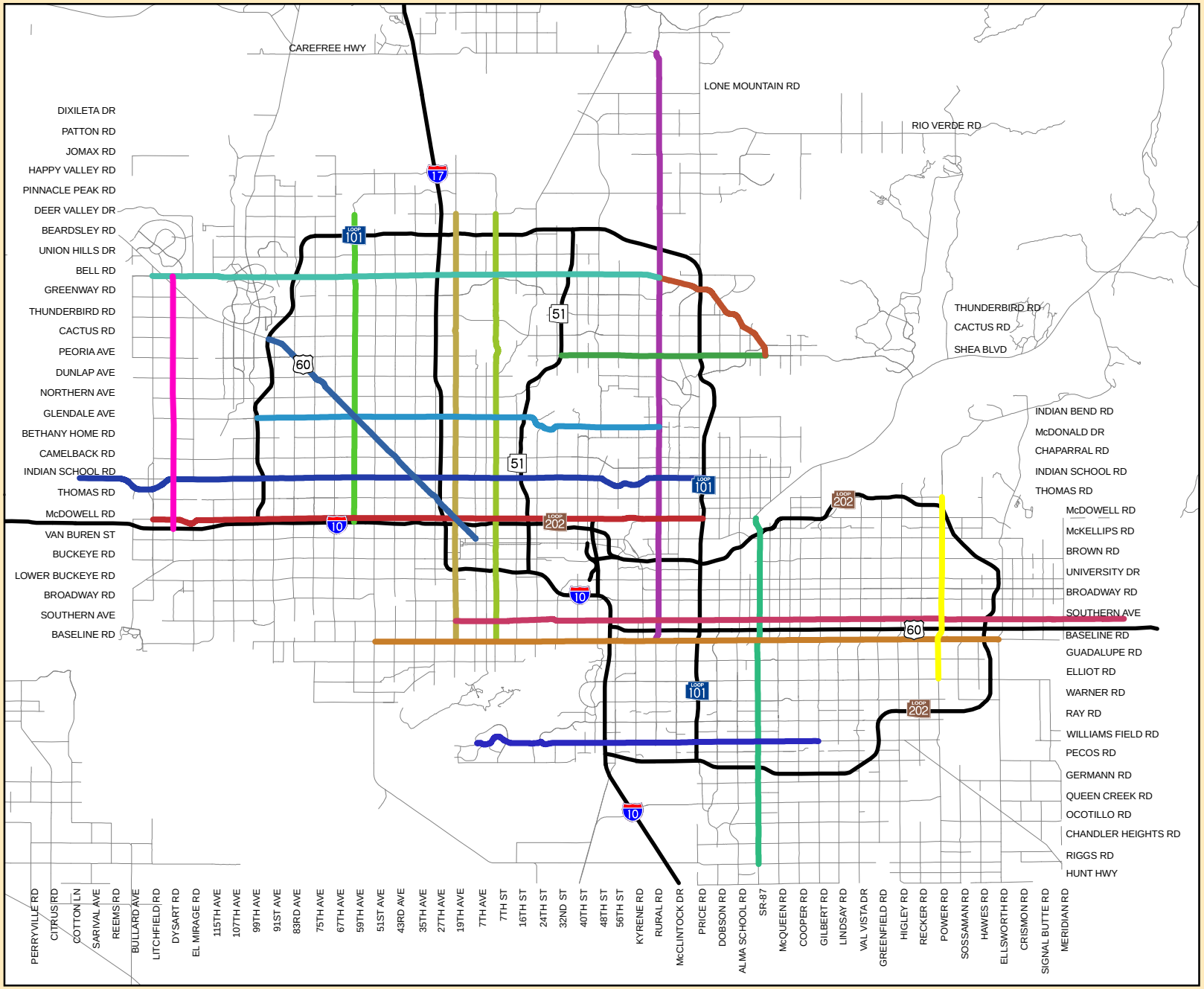
A map depicting the arterials analyzed as part of this report is displayed in Figure 3.1.

Figure 3.1

MARICOPA ASSOCIATION of GOVERNMENTS

Performance Measures Study

Arterial Study Limits



Legend

Arterials (2007)

- 19TH AVE
- 59TH AVE
- BASELINE RD
- BELL Rd/ SUN VALLEY PKWY
- CHANDLER BLVD
- COUNTRY CLUB DR
- DYSART RD
- FRANK LIOYD WRIGHT BLVD
- GLENDALE AVE / LINCOLN DR
- GRAND AVE
- HAPPY VALLEY RD/7th ST
- INDIAN SCHOOL RD
- McDOWELL RD
- POWER RD
- SCOTTSDALE RD
- SHEA BLVD
- SOUTHERN AVE
- Freeways
- Major Roads

While every effort has been made to ensure the accuracy of this information, the Maricopa Association of Governments makes no warranty, expressed or implied, as to its accuracy and expressly disclaims liability for the accuracy thereof.

0 5 10 15 20 Miles

N

Source: Maricopa Association of Governments

3.2 METHODOLOGY FOR BASE DATA SET

To calculate arterial performance measures, a base data set was derived for 2006 and 2007 using traffic data from the Maricopa Association of Governments 2007 Regional Travel Time and Speed Study, as well as the 2006/2007 MAG Regional Traffic Volume Study. Most of the analyses contained in this section of the report have been derived from these base data sets.

3.2.1 DATA COLLECTION AND ANALYSIS

3.2.1.1 TRAFFIC VOLUMES

During 2006 and 2007 MAG collected traffic count data for 775 locations from around the region as part of the 2006/2007 MAG Regional Traffic Volume Study. Count locations were selected to match those used in 2002, excluding those locations where it was anticipated that local jurisdictions would be collecting their own count data (MAG subsequently requested this count data from the relevant local jurisdictions). When count data from the study was combined with that provided by local jurisdictions, it resulted in a total of over 2,000 count locations being available for analysis.

Count data was collected using traffic counters and road tubes to derive the volume, number of axles, and direction of traffic at each count site. In order to ensure adequate quality control of all data collected as part of this study, all data was checked to determine whether any inconsistencies or unusually large variations occurred between time intervals. Data was also reviewed on a roadway link basis to ensure that there was uniformity along each roadway according to direction of travel. Any data identified as being inconsistent with overall travel patterns was deleted (provided that at least 24 consecutive hours of quality data still remain after the deletion). If 24 consecutive hours of accurate data was not available, an additional 48 hours of data was collected to replace the faulty data.

3.2.1.2 TRAVEL SPEED

Data from the 2007 MAG Regional Travel Time and Speed Study serves as this report's primary source of travel time and speed data for arterials. The 2007 Regional Travel Time and Speed Study was designed to update, validate, and calibrate MAG's travel demand model, and to facilitate a comparison of 2007 data with data from previous years for the purpose of identifying trends in congestion and travel time with the goal of identifying problem locations for possible improvement.

As part of this study, MAG conducted in excess of 70,000 miles of floating car runs over 2,038 centerline miles. All roadways were mapped to establish centerlines and record relevant roadway features. Features recorded as part of the mapping process included: speed limits, school zones limits, and intersection control. Other characteristics noted as part of the mapping process included: area type, facility type, intersection geometry (historic and aerial), and city limits.

Travel speed data was collected from February 2007 through January 2008 on Tuesdays, Wednesdays, and Thursdays, during the morning and afternoon peak periods, and during the midday off-peak period as follows:

- Morning peak period: 6:30 to 8:30 AM
- Midday period: 9:00 to 11:00 AM
- Afternoon peak period: 4:00 to 6:00 PM

As part of this study, data was collected along arterials, freeways, and HOV lanes. On average, there were a total of 19 runs in each direction (eight (8) in each direction in the AM/PM peak period and three (3) in the midday) on each roadway included in the study.

A large portion of the quality control conducted as part of this project was carried out automatically by specialized computer algorithms. For example, the algorithms verified whether travel time runs were conducted during the correct time period and whether the minimum number of required data points was collected. On encountering problem areas (e.g., coming across an incident), drivers would record the run number, the type of problem encountered, and the time it occurred down to the second. Examples of incidents or events that drivers would record are: construction, accidents, school zones, trains, overflowing left-turn queues, school bus stops, emergency vehicles, and signal preemption. If the observation was determined to be non-recurring, the data for the segment was flagged so that it was not included in the calculation of average travel time. Consequently, the travel times and segment speeds reported by this survey represent "normal" conditions, but due to the exclusion of data for trips impeded by non-recurring congestion, underestimate actual average travel times and speeds.

3.3 ARTERIAL PERFORMANCE

3.3.1 ACCESS AND MOBILITY MEASURES

Background: Access and mobility measures provide fundamental information on how effective the arterial system is in moving people and goods into, through and within the region.

3.3.1.1 THROUGHPUT – VEHICLE

Definition: Vehicle throughput is defined as the number of vehicles traversing an arterial per period.

Objective: Improve mobility and increase vehicle volume throughput.

Source: Throughput data were obtained from the 2006/2007 MAG Regional Traffic Volume Study.

Time Scale: AM peak period (6:00 AM to 9:00 AM), Midday period (9:00 AM to 3:00 PM), and PM peak period (3:00 PM to 6:00 PM), daily (24 hour on weekdays)

Methodology: Traffic volumes from the 2006/2007 MAG Regional Traffic Volume Study have been compiled for each of the arterials listed in Section 3.1. For each time period, AM peak period, Midday period, and PM peak period, average hourly traffic volumes in each direction of travel along the arterial roadway network are displayed on a system-wide map - see Figures 3.2, 3.3, and 3.4.

In addition, a weighted average traffic volume has been calculated for the entirety of each arterial corridor included in this report. Weighted average traffic volumes are derived by multiplying traffic volume by segment length for one direction of each arterial sub-segment. The sum of the length of the arterial sub-segments for each arterial corridor was then calculated. Finally, the sum of the length times volume for all arterial sub-segments along each corridor was divided by the length of the entire corridor. The results of these calculations are provided in Table 3.1, which includes weighted average hourly traffic volumes for the AM peak period, Midday period, and PM peak period, as well as daily vehicle throughput for each arterial corridor.

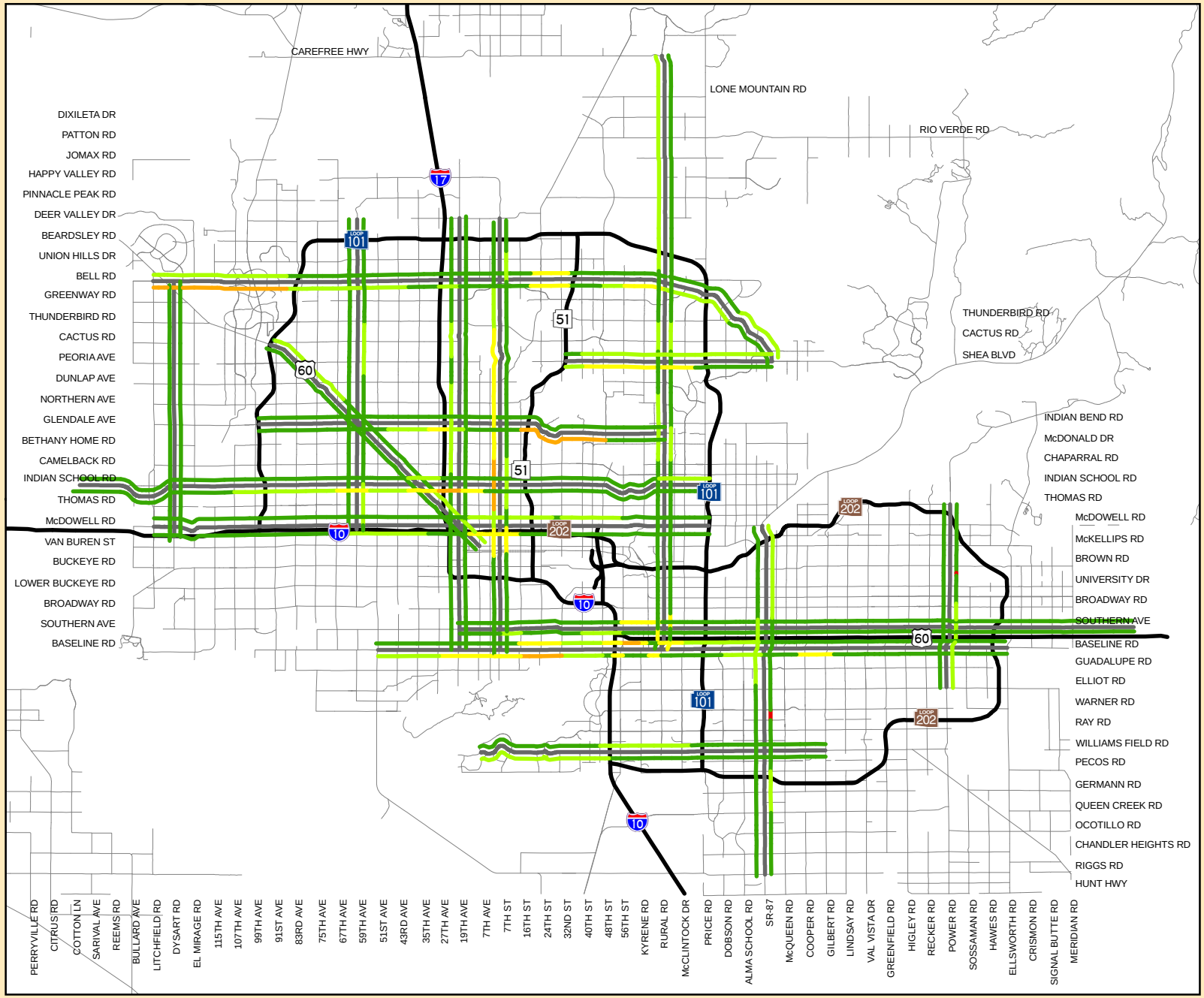
Explanation of Results and Analysis: As seen in Table 3.1, average hourly vehicle throughput on arterials is consistently higher during the PM peak period than during either the AM peak period or Midday period. Shea Boulevard carries the highest traffic volumes of all the arterial study corridors, with daily traffic volumes averaging more than 22,000 vehicles per day along each direction of travel. Bell Road/Sun Valley Parkway is the second highest, with daily volumes averaging more than 20,000 vehicles per day along each direction. The lowest traffic volumes observed in the arterials selected for inclusion in this study occur on Dysart Road, with daily volumes of approximately 7,900 vehicles per day along each direction of the corridor.

Figure 3.2

MARICOPA ASSOCIATION of GOVERNMENTS

Performance Measures Study

Average Hourly Arterial Volumes AM Peak Period



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0 5 10 15 20 Miles

N

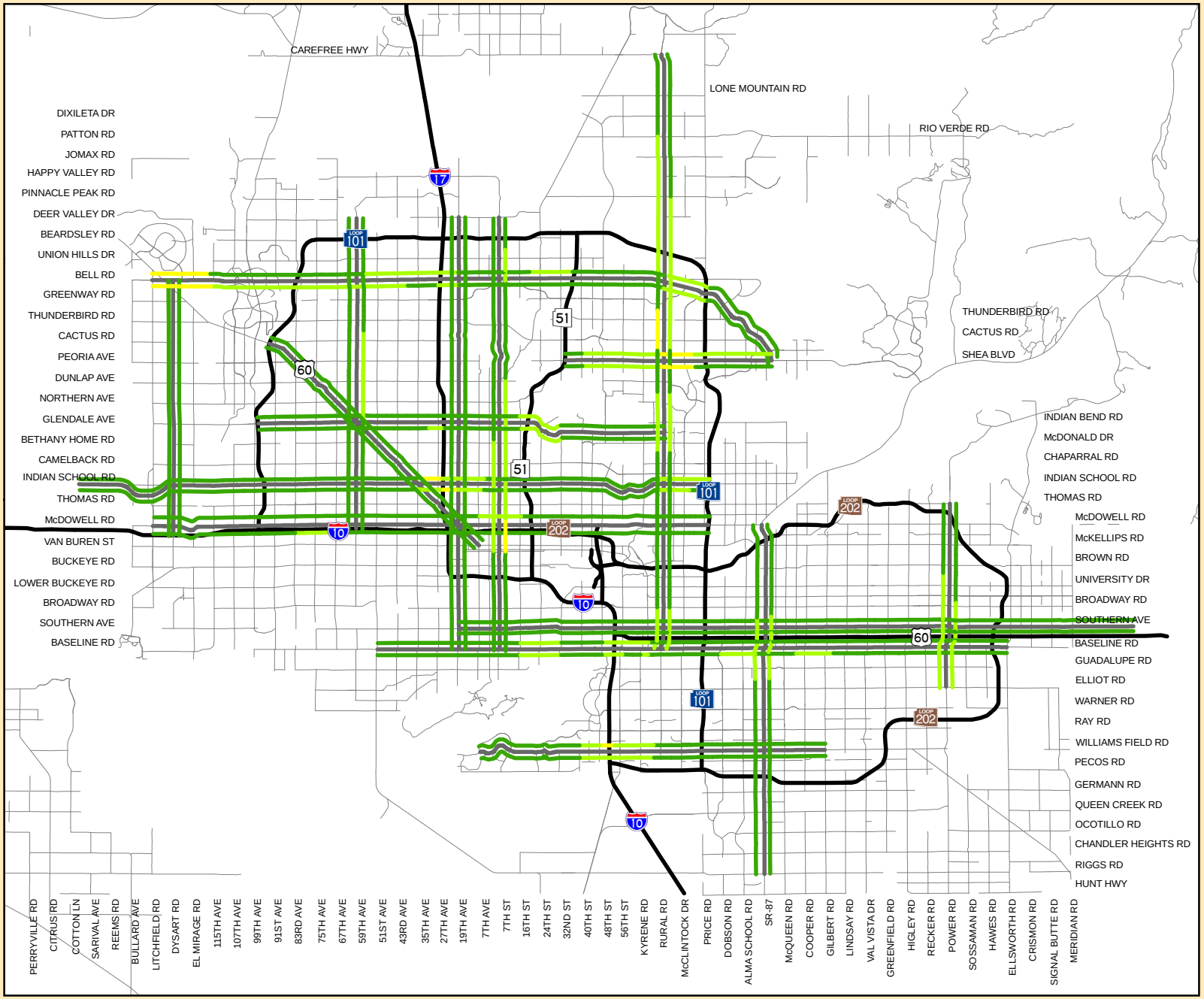
Source: 2006/2007 MAG Regional Traffic Volume Study.

Figure 3.3

MARICOPA ASSOCIATION of GOVERNMENTS

Performance Measures Study

Average Hourly Arterial Volumes Midday Period



Legend

Average Hourly Midday Period Volume (2007)

- < 1,100
- 1,101 - 1,600
- 1,601 - 2,100
- 2,101 - 2,800
- > 2,800
- Arterials
- Freeways
- Major Roads

While every effort has been made to ensure the accuracy of this information, the Maricopa Association of Governments makes no warranty, expressed or implied, as to its accuracy and expressly disclaims liability for the accuracy thereof.

0 5 10 15 20 Miles

N

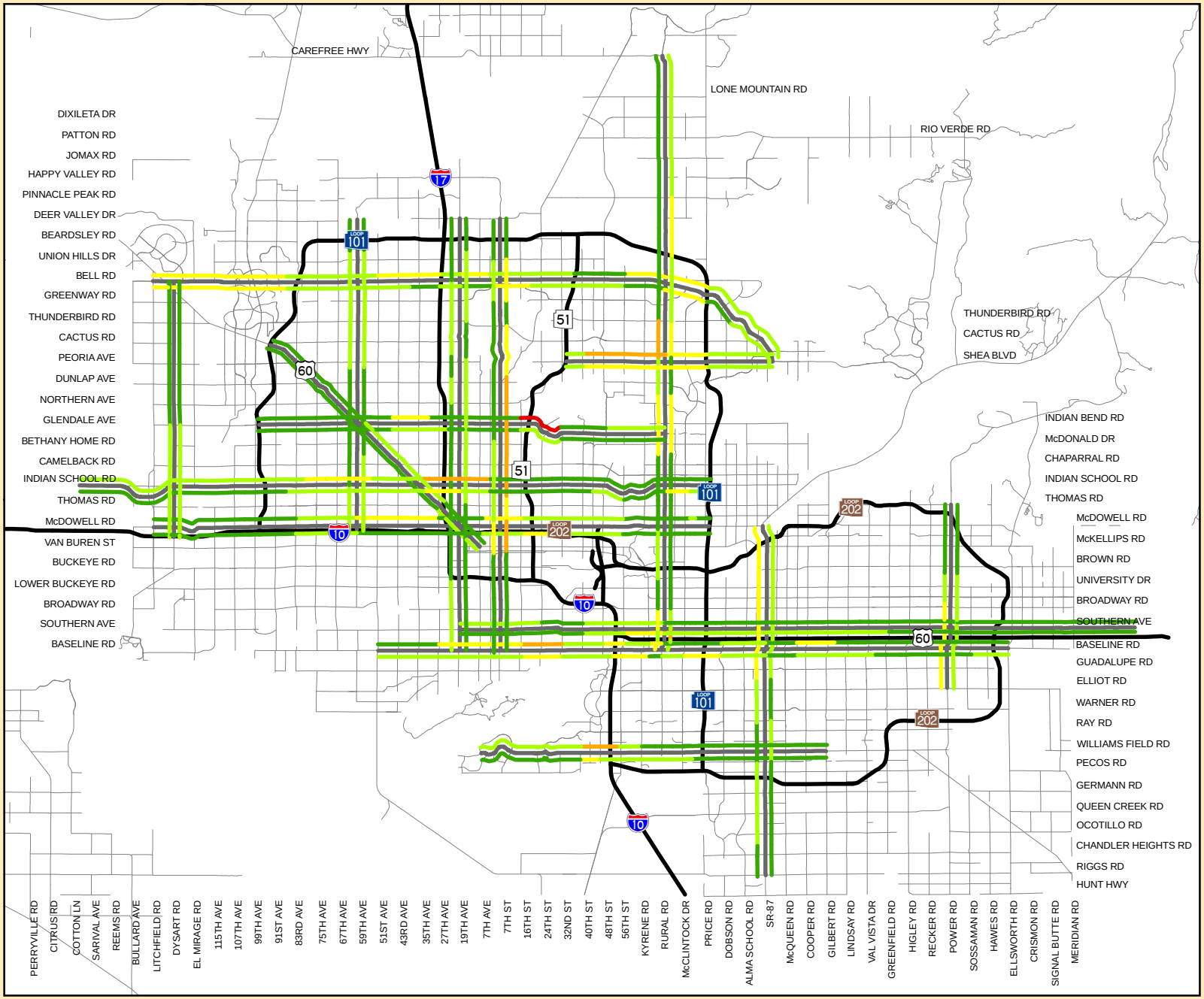
Source: 2006/2007 MAG Regional Traffic Volume Study.

Figure 3.4

MARICOPA ASSOCIATION of GOVERNMENTS

Performance Measures Study

Average Hourly Arterial Volumes PM Peak Period



Legend

Average Hourly PM Peak Period Volume (2007)

- < 1,100
- 1,101 - 1,600
- 1,601 - 2,100
- 2,101 - 2,800
- > 2,800
- Arterials
- Freeways
- Major Roads

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0 5 10 15 20 Miles

N

Source: 2006/2007 MAG Regional Traffic Volume Study.

Table 3.1 Arterial Vehicle Throughput*

Route Name	AM Peak Period Hourly Average	Midday Period Hourly Average	PM Peak Period Hourly Average	Daily Average
19th Ave - NB	660	672	1,050	12,165
19th Ave - SB	847	708	989	12,914
59th Ave - NB	950	936	1,255	15,071
59th Ave - SB	691	884	1,030	17,082
Baseline RD - EB	1,077	916	1,337	16,988
Baseline RD - WB	1,093	899	1,246	16,651
Bell Rd / Sun Valley Pkwy - EB	1,449	1,119	1,404	20,610
Bell Rd / Sun Valley Pkwy - WB	904	1,104	1,505	20,073
Chandler Blvd - EB	789	799	1,008	13,319
Chandler Blvd - WB	698	792	1,054	14,898
Country Club Dr - NB	1,318	832	1,196	13,683
Country Club Dr - SB	769	831	1,466	15,102
Dysart - NB	410	537	733	7,840
Dysart - SB	685	544	747	7,974
Frank Lloyd Wright Blvd - EB	1,072	1,058	1,354	17,881
Frank Lloyd Wright Blvd - WB	885	1,045	1,370	17,065
Glendale Ave / Lincoln Dr - EB	1,249	820	942	13,062
Glendale Ave / Lincoln Dr - WB	703	810	1,214	13,249
Grand Ave - NW	1,043	735	1,085	14,554
Grand Ave - SE	573	871	1,053	16,307
Happy Valley Rd/7th St - NB	936	1,059	1,657	17,580
Happy Valley Rd/7th St - SB	1,386	945	1,090	15,685
Indian School Rd - EB	1,102	901	1,083	16,299
Indian School Rd - WB	765	877	1,328	17,570
McDowell Rd - EB	873	813	1,002	13,240
McDowell Rd - WB	776	844	1,138	13,691
Power Rd - NB	1,179	1,055	1,161	17,026
Power Rd - SB	852	1,127	1,339	17,752
Scottsdale Rd - NB	869	1,078	1,378	17,463
Scottsdale Rd - SB	1,089	1,124	1,185	17,228
Shea Blvd - EB	1,470	1,289	1,613	22,296
Shea Blvd - WB	1,263	1,357	1,757	22,344
Southern Ave - EB	545	519	827	9,390
Southern Ave - WB	615	538	785	10,207

Source: 2006/2007 MAG Regional Traffic Volume Study

*Numbers are weighted averages along the entire arterial corridor.

3.3.2 TRAVEL TIME, TRAVEL TIME VARIABILITY, AND DELAY MEASURES

Background: Among the measures that are most meaningful to travelers and system managers alike are those related to their experience of everyday travel. How much time should I allow to get to my destination? How likely is it that I will experience delay? For the arterial network, these are expressed through measures of delay.

3.3.2.1 SPATIAL EXTENT OF CONGESTION

Definition: Spatial extent of congestion is defined as the percent of a given time period (e.g., the AM peak period) during which a roadway experiences average speeds below a certain pre-defined threshold speed. In order to derive the spatial extent of congestion for an entire arterial corridor, traffic speeds for the sub-sections of roadway that together make up that corridor are examined, with the individual sub-sections counted as congested if the mean speed for a given sub-section is 75% or less than the posted speed.

Objective: Determine whether strategies aimed at reducing traffic congestion on the arterial system are having the desired effect, and where additional efforts are required.

Source: 2007 MAG Travel Time and Speed Study

Time Scale: AM peak period (6:30 AM to 8:30 AM), Midday period (9:00 AM to 11:00 AM), PM peak period (4:00 PM to 6:00 PM) – as collected during the Travel Time and Speed Study

Methodology: Speeds from the Travel Time and Speed Study have been compiled for all sub-sections of each arterial roadway. As part of the Travel Time and Speed Study, data was collected along arterials, freeways, and HOV lanes. On average, there were a total of 19 runs in each direction (eight (8) in each direction during the AM and PM peak periods and three (3) during the Midday period) on each roadway included in the study. For each sub-section of the arterial roadway being analyzed, speeds for each direction of travel during the AM peak period, Midday period, and PM peak period were compared against posted speeds. System-wide maps have been prepared based on this analysis for the AM peak period, Midday period, and PM peak period. These maps provide a visual indication of the sub-sections of each arterial roadway for which the average speed was less than 75% of the posted speed during a given time period – see Figures 3.5, 3.6, and 3.7.

A table has also been prepared indicating the extent of congestion on the arterial network for each arterial corridor, for the AM peak period, Midday period, and PM peak period – see Table 3.2. To calculate the extent of congestion for an entire arterial corridor, travel speeds for all of the sub-segments along each corridor were compared to posted speeds. The portions of the corridor that averaged less than 75% of the posted speed were summed and divided by the length of the entire corridor.

Explanation of Results and Analysis: During the AM peak period, the southbound direction of Dysart Road experiences the greatest extent of congestion delay, with more than 60 percent of the corridor experiencing average travel speeds less than 75 percent of the posted speed. Power Road is highly congested during the AM peak period and Midday period, with 47 percent of the

arterial (both directions of travel) experiencing congestion delays in the morning, and more than 50 percent of the arterial experiencing delays during the Midday period. During the PM peak period, the westbound direction of Glendale Avenue/Lincoln Drive experiences the greatest extent of congestion delay, with more than 75 percent of the corridor experiencing average travel speeds less than 75 percent of the posted speed. The following additional arterials experience delays in excess of 50 percent during the PM peak period:

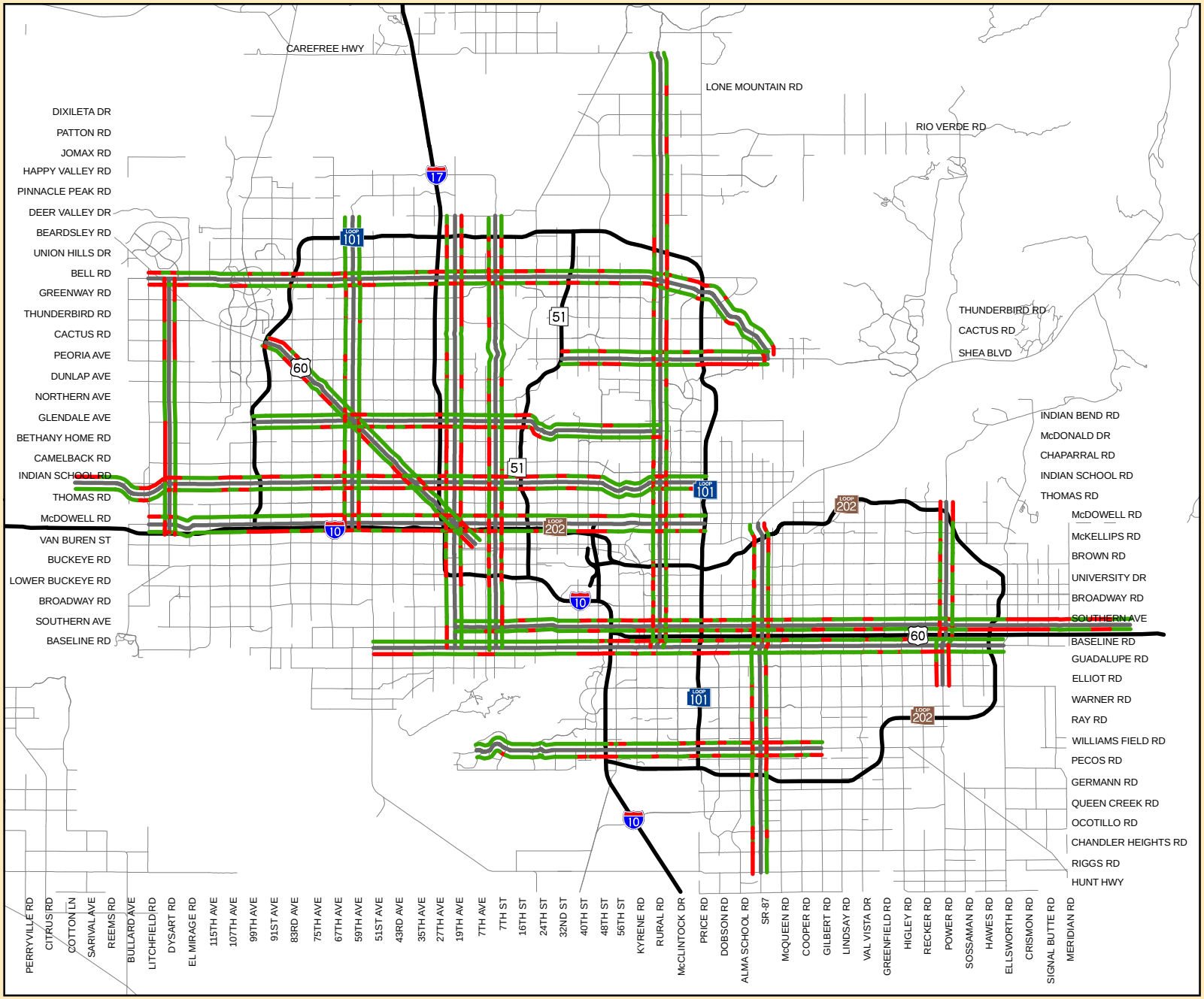
- Indian School Road (westbound)
- McDowell Road (westbound)
- Country Club Drive (southbound)

Figure 3.5

MARICOPA ASSOCIATION of GOVERNMENTS

Performance Measures Study

Arterial Spatial Extent of Congestion AM Peak Period



Legend

AM Peak Period Spatial Extent of Congestion (2007)

- Avg Speed Less than 75% of Posted Speed
- Avg Speed greater than 75% of Posted Speed
- Arterials
- Freeways
- Major Roads

Source: GPS-based data from the 2007 MAG Travel Time and Speed Study

While every effort has been made to ensure the accuracy of this information, the Maricopa Association of Governments makes no warranty, expressed or implied, as to its accuracy and expressly disclaims liability for the accuracy thereof.

0 5 10 15 20 Miles

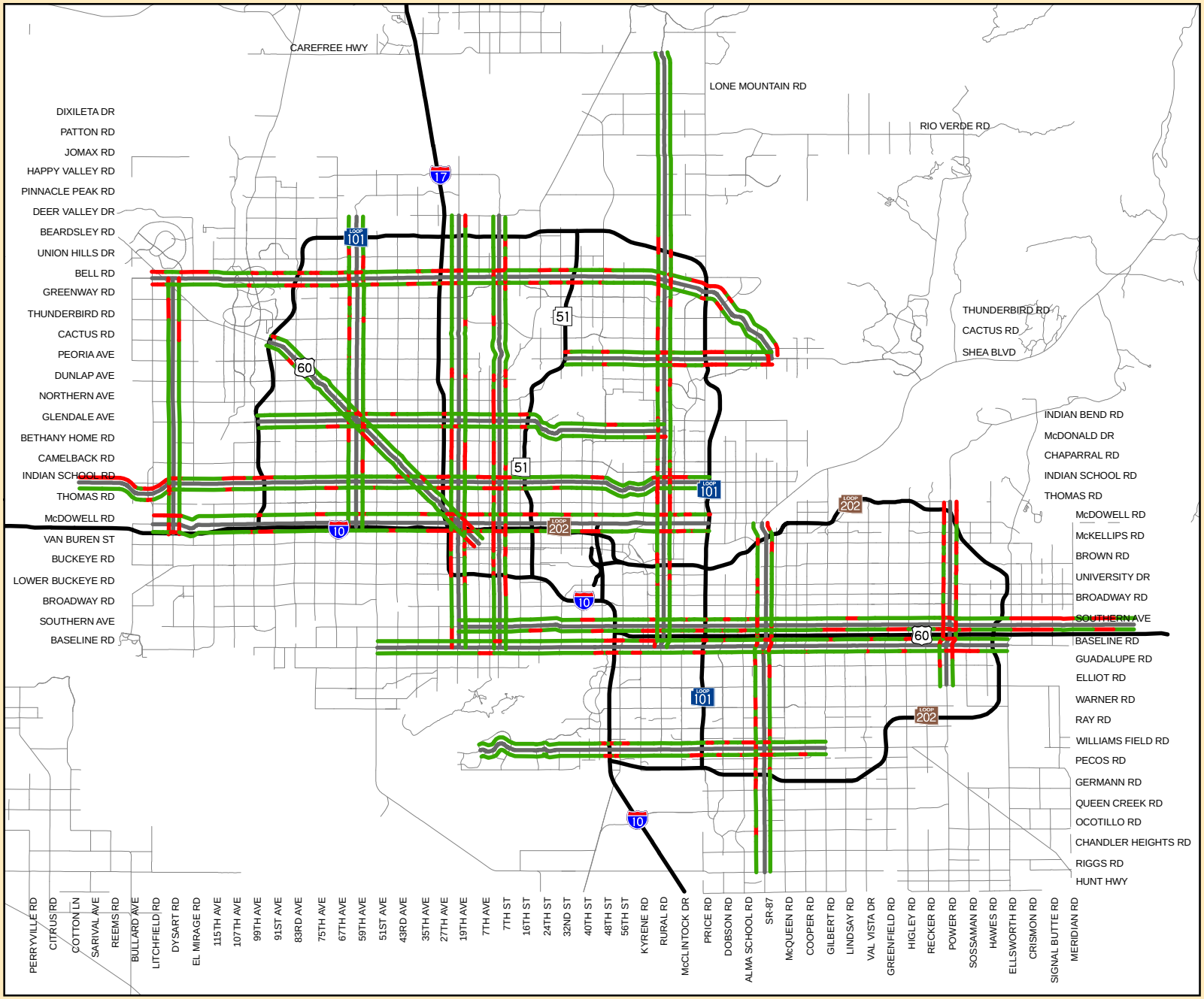
N

Figure 3.6

MARICOPA ASSOCIATION of GOVERNMENTS

Performance Measures Study

Arterial Spatial Extent of Congestion Midday Period



Legend

Midday Period Spatial Extent of Congestion (2007)

- Avg Speed Less than 75% of Posted Speed
- Avg Speed greater than 75% of Posted Speed
- Arterials
- Freeways
- Major Roads

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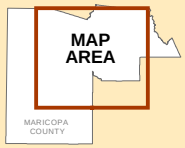
0 5 10 15 20 Miles

N



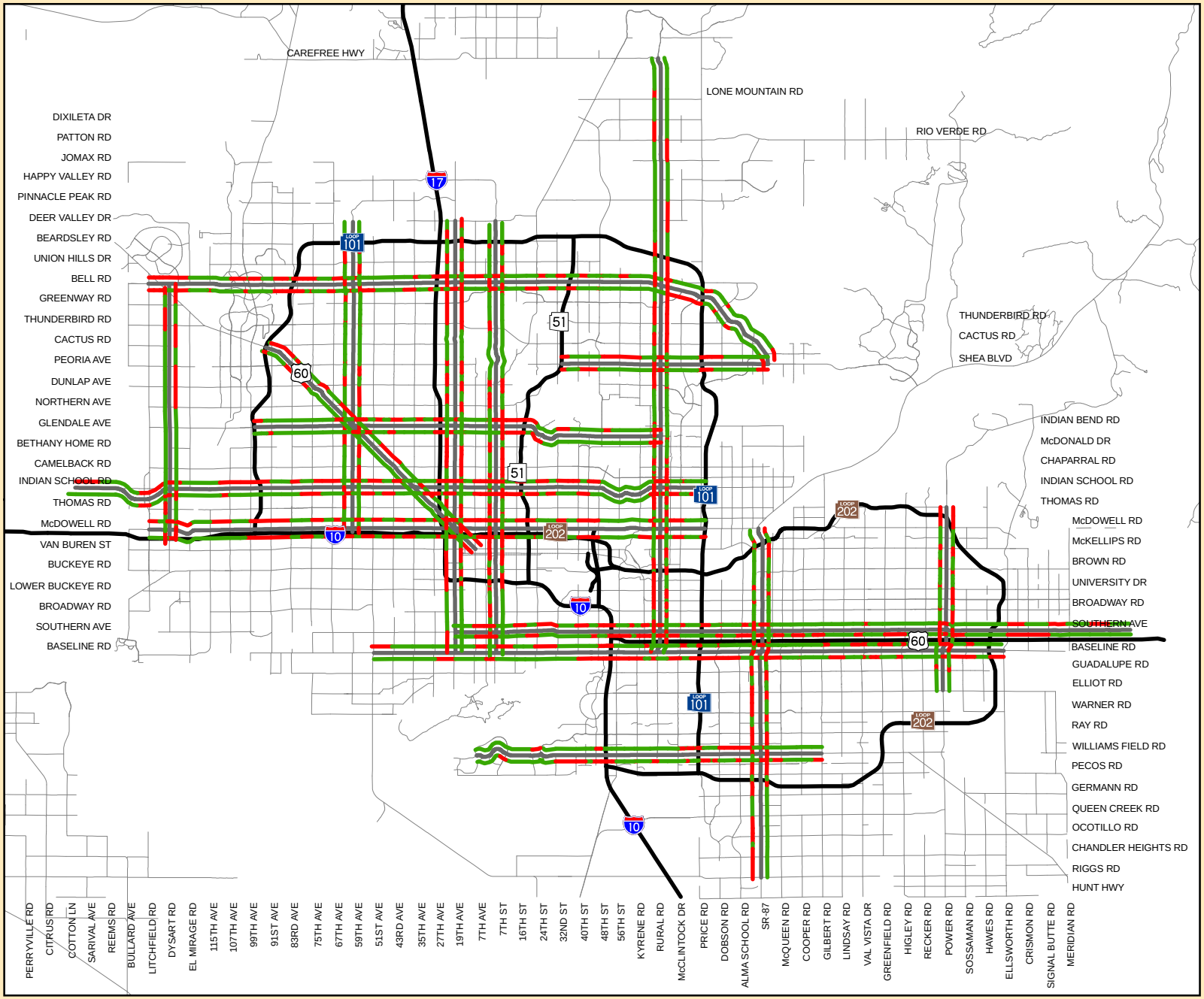
Source: GPS-based data from the 2007 MAG Travel Time and Speed Study

Figure 3.7

MARICOPA ASSOCIATION of GOVERNMENTS

Performance Measures Study

Arterial Spatial Extent of Congestion PM Peak Period



Legend

PM Peak Period Spatial Extent of Congestion (2007)

- Avg Speed Less than 75% of Posted Speed
- Avg Speed greater than 75% of Posted Speed
- Arterials
- Freeways
- Major Roads

Source: GPS-based data from the 2007 MAG Travel Time and Speed Study

0 5 10 15 20 Miles

N

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Table 3.2 Arterial Spatial Extent of Congestion

Route Name	AM Peak Period	Midday Period	PM Peak Period
19th Ave - NB	41.2%	19.6%	43.8%
19th Ave - SB	27.7%	21.6%	45.5%
59th Ave - NB	15.8%	12.0%	30.6%
59th Ave - SB	28.6%	25.0%	36.6%
Baseline RD - EB	29.9%	14.4%	37.6%
Baseline RD - WB	14.2%	14.9%	28.6%
Bell Rd / Sun Valley Pkwy - EB	31.5%	26.0%	33.2%
Bell Rd / Sun Valley Pkwy - WB	21.6%	35.6%	46.5%
Chandler Blvd - EB	32.1%	13.8%	37.2%
Chandler Blvd - WB	17.0%	16.5%	16.4%
Country Club Dr - NB	34.0%	21.6%	49.2%
Country Club Dr - SB	41.0%	35.1%	**60.2%**
Dysart - NB	21.9%	12.0%	39.0%
Dysart - SB	**61.1%**	20.3%	18.6%
Frank Lloyd Wright Blvd - EB	13.9%	14.3%	45.4%
Frank Lloyd Wright Blvd - WB	36.0%	39.8%	18.4%
Glendale Ave / Lincoln Dr - EB	40.9%	14.6%	21.8%
Glendale Ave / Lincoln Dr - WB	14.6%	10.6%	**75.9%**
Grand Ave - NW	14.7%	11.2%	46.8%
Grand Ave - SE	38.5%	11.2%	24.4%
Happy Valley Rd/7th St - NB	23.0%	21.6%	43.6%
Happy Valley Rd/7th St - SB	31.8%	38.3%	36.7%
Indian School Rd - EB	39.2%	15.6%	35.4%
Indian School Rd - WB	37.8%	32.4%	**51.4%**
McDowell Rd - EB	37.7%	25.1%	46.1%
McDowell Rd - WB	35.0%	29.4%	**57.3%**
Power Rd - NB	**47.2%**	**49.5%**	42.0%
Power Rd - SB	**46.8%**	**54.0%**	32.3%
Scottsdale Rd - NB	34.2%	14.0%	42.8%
Scottsdale Rd - SB	15.1%	19.4%	34.8%
Shea Blvd - EB	45.5%	24.4%	27.7%
Shea Blvd - WB	15.6%	24.6%	39.1%
Southern Ave - EB	30.0%	27.7%	39.7%
Southern Ave - WB	31.3%	16.1%	31.4%

Source: 2007 MAG Travel Time and Speed Study

3.3.3 SAFETY MEASURES

Background – The arterial street system is a vital component of the region's transportation network. Data from performance measures focused on arterial roadways can be used to support decision-making processes associated with both the region's safety planning processes, as well as the Arterial Life Cycle Program, thereby assisting MAG and its partners in making decision regarding the future allocation of funds in a manner that best meets local needs.

3.3.3.1 INTERSECTION CRASH RANKING

Definition – An "Intersection Crash," for the purpose of this performance measure, is defined as any crash occurring within 150 feet of an arterial intersection. This is the same definition used by ADOT in coding crashes as described in the ALISS data entry instruction manual.

Objective: Identify (over several years of analysis) those locations where planning and operations-related safety improvements are likely to have a significant impact, and determine the impact of those improvements. Over time, if improvements are made to an intersection, the impact of those improvements will be reflected in the crash severity score in the ensuing years.

To address the problem posed by intersections with high crash severity scores, a safety evaluation would first need to be performed. Potential safety improvements would then be evaluated based on their relative benefit/cost ratios. Given that crashes may result from a variety of intersection features, there is no specific dollar amount that would ensure an improvement that "makes a difference." The range of improvements could vary significantly including:

- Traffic Signal Timing Adjustments (approximately $3,500 per intersection)
- Addition of turning lanes ($70,000 - $150,000)
- Signalization of an unsignalized intersection ($200,000 to $400,000)

Source: ADOT Accident Location Information Surveillance System (ALISS).

Time Scale: Results are provided based on ALISS data from 2007.

Methodology – Intersection crash data were obtained from the ADOT ALISS. For a more detailed description of ALISS, see the Methodology description found in Section 2.3.3.1. Based on the MAG Transportation Safety Committee's recommendation, a weighting scheme was used to compute the crash "severity" score at all intersections in the MAG region. The weighting scheme used to calculate each intersection's crash severity score was based on the following criteria:

- For each fatal crash (K) , add 1,450 points
- For each incapacitating crash (A), add 100 points
- For each non-incapacitating crash (B), add 20 points
- For each crash possibly resulting in an injury (C), add 11 points
- For each property damage only (PDO) crash (O), add 1 point
- For each crash with unknown characteristics, add 1 point

The resulting list of the twenty-five (25) top-ranked intersections experiencing the highest crash severity scores is included in Table 3.3. The intersections identified on this table are also depicted on a system-wide map – see Figure 3.8. This map color codes the intersections listed in Table 2.1 according to the following method:

- Rank 1-5 – Red circle
- Rank 6-10 – Yellow circle
- Rank 11-15 – Green circle
- Rank 16-20 – Blue circle
- Rank 21-25 – Black circle

Explanation of Results and Analysis: As is indicated in Figure 3.8, the majority of intersections with high crash severity scores are clustered (as would be expected due to high traffic volumes) in and around the primary north-south arterial roadway corridors between and around SR 51 and I-17, as well as along Scottsdale and Hayden Roads. The map also indicates that a significant number of high crash severity intersections are located in outlying areas such as Mesa, Chandler, Peoria, and Avondale. As these areas have undergone significant growth over the last several years, it is quite possible that roadway infrastructure has become, in some cases, insufficient to keep up with current transportation demand, resulting in the high crash severity scores indicated at some of these jurisdictions' arterial intersections.

Table 3.3 – Arterial Intersections with the Highest Crash Severity Scores in the MAG Region (2007)

Regional Rank	Jurisdictions[16]	Intersection		O	C	B	A	K	Unknown	Severity
1	Mesa	BROADWAY ROAD	VAL VISTA DRIVE	40	9	10	1	3	0	4,785
2	Chandler	ARIZONA AVENUE	RAY ROAD	58	23	15	4	2	0	3,900
3	Phoenix	67TH AVENUE	INDIAN SCHOOL ROAD	99	25	21	2	2	0	3,882
4	Scottsdale	CAMELBACK ROAD	HAYDEN ROAD	42	9	15	5	2	0	3,837
5	Phoenix	19TH AVENUE	UNION HILLS DRIVE	38	17	21	2	2	0	3,737
6	Phoenix	35TH AVENUE	CACTUS ROAD	40	25	13	2	2	0	3,663
7	Phoenix	35TH AVENUE	BELL ROAD	44	29	15	1	2	0	3,649
8	Scottsdale	HAYDEN ROAD	SHEA BLVD	44	19	17	1	2	0	3,584
9	Peoria	83RD AVENUE	UNION HILLS DRIVE	57	17	3	2	2	1	3,397
10	Scottsdale	CHAPARRAL ROAD	HAYDEN ROAD	37	9	8	2	2	1	3,393
11	Phoenix	23RD AVENUE	BETHANY HOME ROAD	26	10	3	3	2	0	3,391
12	Phoenix	43RD AVENUE	UNION HILLS DRIVE	16	10	8	2	2	0	3,381
13	Phoenix	CENTRAL AVENUE	OSBORN ROAD	22	8	2	3	2	0	3,346
14	Maricopa County/Avondale	AVONDALE BLVD	MC 85	28	5	4	2	2	0	3,261
15	Scottsdale	FRANK LLOYD WRIGHT BLVD	SCOTTSDALE ROAD	45	13	4	0	2	0	3,162
16	Maricopa County/Goodyear	ESTRELLA PKWY	MC 85	11	6	4	1	2	1	3,155
17	Phoenix	33RD AVENUE	VAN BUREN STREET	19	5	3	1	2	1	3,133
18	Phoenix	16TH STREET	OAK STREET	13	7	2	1	2	1	3,128
19	Phoenix	CAVE CREEK ROAD	SHARON DRIVE	3	2	4	1	2	0	3,104
20	Phoenix	7TH STREET	NORTHERN AVENUE	58	23	22	9	1	1	3,091
21	Glendale	55TH AVENUE	BETHANY HOME ROAD	14	9	4	0	2	0	3,089
22	Phoenix	27TH AVENUE	INDIAN SCHOOL ROAD	75	36	24	7	1	0	3,083
23	Mesa	BROWN ROAD	RECKER ROAD	23	8	3	0	2	2	3,069
24	Phoenix	CAVE CREEK ROAD	SWEETWATER AVENUE	13	5	5	0	2	0	3,066
25	Maricopa County/Phoenix	51ST AVENUE	ESTRELLA DRIVE	6	0	2	1	2	0	3,046

Source: ADOT ALISS

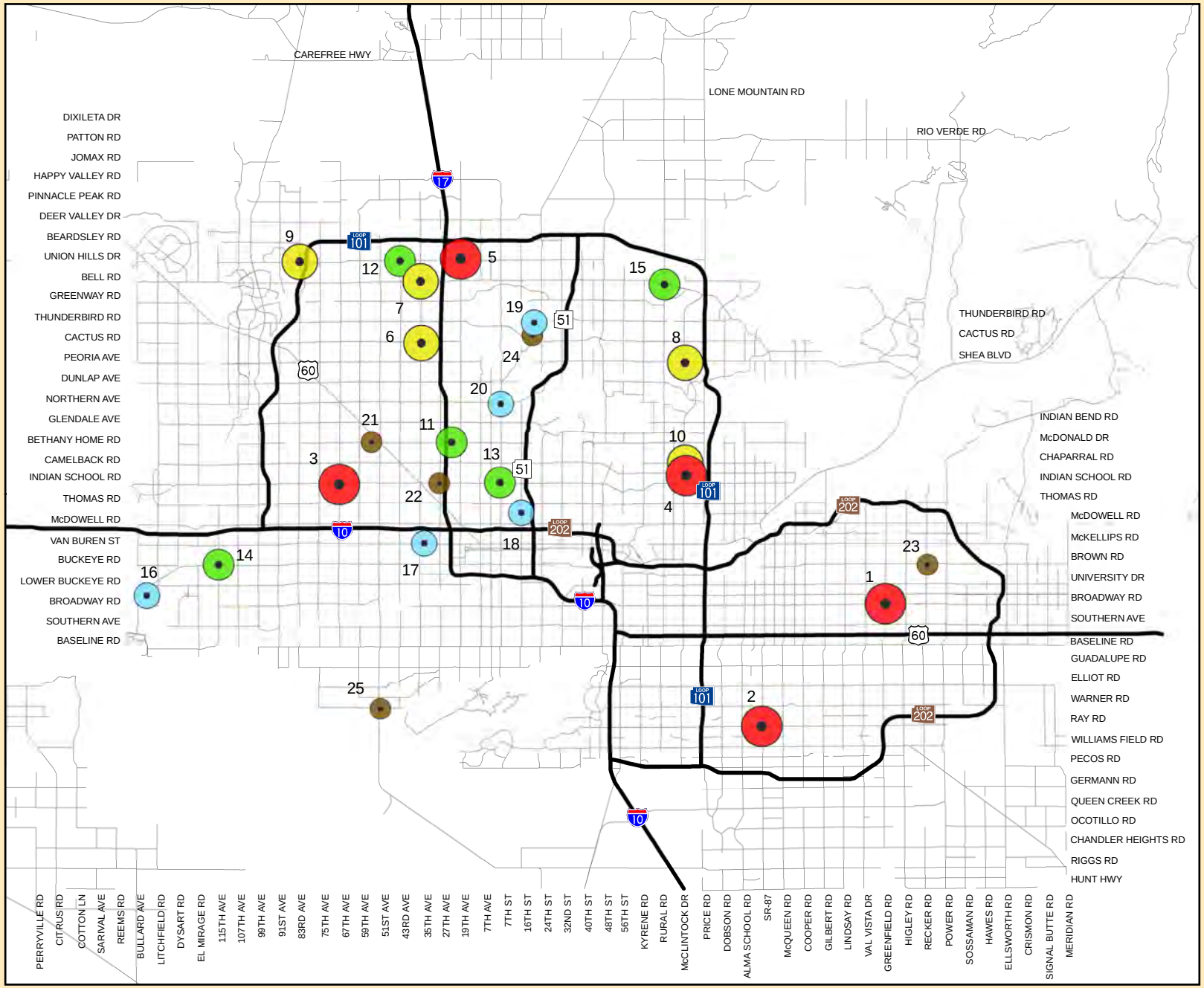
[16] The cities listed in the "Jurisdiction(s)" column are responsible for maintaining the intersections listed in the columns to their immediate right. In cases where Maricopa County is listed next to a local jurisdiation (i.e., rows 14, 16, and 25), the intersection resides within the local jurisdiction, but is maintained by the county.

Figure 3.8

MARICOPA ASSOCIATION of GOVERNMENTS

Performance Measures Study

Arterial Intersection Crash Ranking



Legend

Intersections with the Highest Crash Severity Scores (2007)

- 1 - 5
- 6 - 10
- 11 - 15
- 16 - 20
- 21 - 25
- Freeways
- Major Roads

While every effort has been made to ensure the accuracy of this information, the Maricopa Association of Governments makes no warranty, expressed or implied, as to its accuracy and expressly disclaims liability for the accuracy thereof.

0 5 10 15 20 Miles

N

Source: ADOT Accident Location Information Surveillance System

3.3.3.2 *CRASH/INJURY/FATALITY TOTALS FOR LARGE TRUCK INVOLVED CRASHES ON ARTERIALS IN THE MAG REGION*

Definition - Crash, injury, and fatality totals for large truck involved crashes on the MAG region arterial system are defined as the total number of crashes, injury crashes, and fatal crashes occurring across all MAG region arterial roadways during a one-year period.

Objective: To reduce the number of all truck involved crashes, injury crashes, and fatal crashes occurring on MAG region arterials.

Source: ADOT Accident Location Information Surveillance System (ALISS).

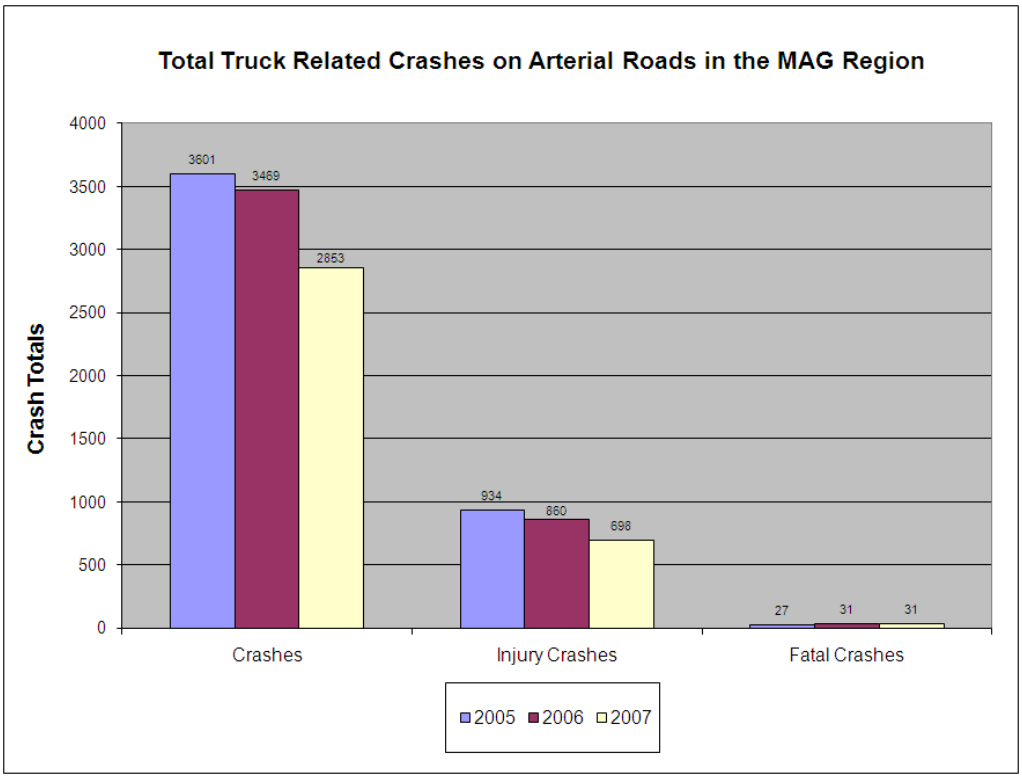
Time Scale: Results are provided for a 3-year period from 2005 to 2007.

Methodology: Crash, injury, and fatality data were obtained from the ADOT ALISS. For a more detailed description of ALISS, see the Methodology description found in Section 2.3.3.1. Figure 3.9 displays totals for all arterials roadways across the MAG region (for 2005, 2006, and 2007).

Ideally, this measure would determine how the number of truck involved crashes, injury crashes, and fatal crashes changes over time, especially as related to changes in truck traffic volume (given the availability of this data). However, the required level of information on truck traffic volumes is currently not available for the MAG region. Until truck volume data becomes available for computing crash rates, the magnitude and severity of the truck crash experience on the arterial system can be assessed by tracking the total number of crashes involving large trucks by crash severity.

Explanation of Results and Analysis: As is indicated in Figure 3.9, between 2005 and 2007 there were slight declines in the number of all truck involved crashes and truck-injury crashes on arterial roads in the MAG region. This decrease in crashes and injury crashes could be due to many factors. At this time it is not possible to make an exact determination regarding the primary factor(s) that have resulted in the reduction in truck related crashes. Attention should be paid to data as it is collected and assessed for 2008 and 2009 to determine whether any potential causal factors become more evident.

Figure 3.9 – Total Truck Related Crashes on Arterial Roads in the MAG Region



Source: ADOT ALISS

4.0 Transit Performance

4.1 System Definition

4.1.1 MAG Region Transit System

The transit system in the MAG region consists of a combination of local bus service, express bus service, arterial bus rapid transit service, circulator/shuttle services, dial-a-ride services, and as of the end of 2008, light rail service. As per the MAG Regional Transportation Plan, service levels on particular routes are determined by balancing demand for transit along those routes against the availability of funding. The Regional Public Transportation Authority (RPTA), commonly known as Valley Metro, is a membership organization aimed at helping to streamline transit service across the region. RPTA board member agencies include: Avondale, Buckeye, Chandler, El Mirage, Gilbert, Glendale, Goodyear, Maricopa County, Mesa, Peoria, Phoenix, Queen Creek, Scottsdale, Surprise, and Tempe. In September 2007, the RPTA board adopted the following mission, vision, and goals as part of its strategic plan.

Mission: RPTA will develop and deliver an integrated regional transit system with excellence, in collaboration with member agencies and through public and private partnerships. In doing so, it will improve the quality of life and the environment and support economic development.

Vision: Enable people in Maricopa County to travel with ease using safe, accessible, efficient, dependable, and integrated public transportation services.

Goals:

- Deliver cost-effective transit services
- Deliver on Proposition 400 projects and assist with city transit projects
- Integrate transit services across the region
- Increase transit visibility (marketing, customer satisfaction, and public-private partnerships)
- Hire/retain and develop top talent at every level
- Contribute to an enhanced quality of life in the region (air quality, congestion, and other services)

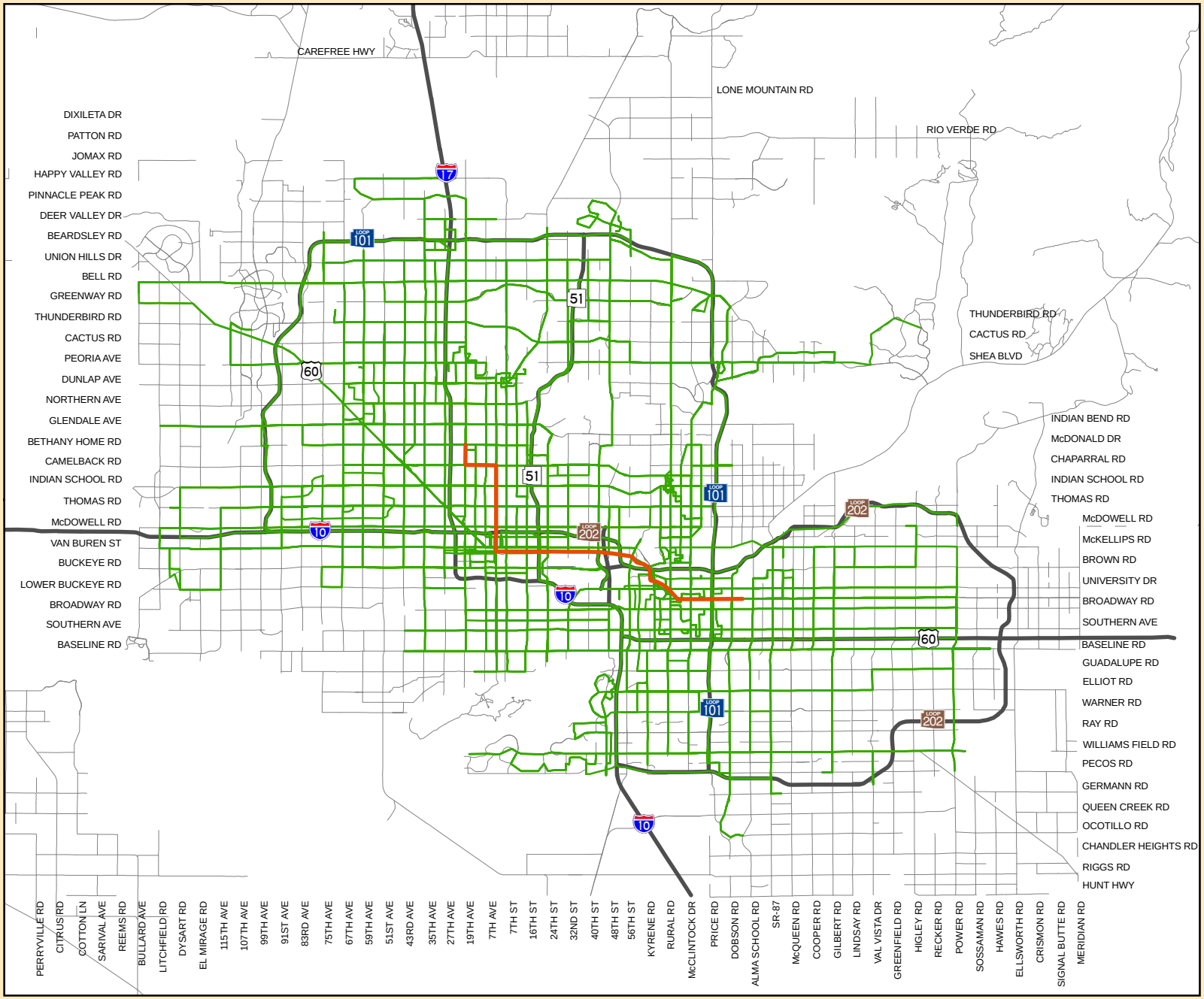
A map depicting the MAG region transit system is displayed in Figure 4.1.

Figure 4.1

MARICOPA ASSOCIATION of GOVERNMENTS

Performance Measures Study

Regional Transit Network Study Limits



Legend

Transit Network

- Light Rail Transit Coverage*
- Bus Transit Coverage
- Freeways
- Major Roads

* Light rail data not available for 2006, 2007, and 2008.

While every effort has been made to ensure the accuracy of this information, the Maricopa Association of Governments makes no warranty, expressed or implied, as to its accuracy and expressly disclaims liability for the accuracy thereof.

0 5 10 15 20 Miles

N

Source: Maricopa Association of Governments

4.2 Methodology for Collecting Base Transit Data Set

Data utilized to support the generation of transit performance measures was collected by RPTA for use as part of its 2008 Transit Performance Report and 2008 Comprehensive Annual Financial Report. In 2006, RPTA conducted a Service Efficiency and Effectiveness Study (SEES), one purpose of which was to develop transit-related performance measures to support the auditing requirements of Proposition 400. These performance measures were incorporated into the content of the 2008 Transit Performance Report. These reports are prepared and updated annually by RPTA for the purpose of providing input for use in the development of MAG's RTP updates and RPTA's Short Range Transit Plan, as well as to provide RPTA with an independently audited internal control tool designed to ensure that its assets are protected from loss, theft, or misuse.

The three largest operators of transit services in the MAG region are:

- City of Phoenix
- RPTA
- City of Tempe

The performance measures contained in this section of the report reflect data collected by RPTA concerning the operation of these agencies' services. As the data sets being analyzed are for 2006 and 2007, only bus-related modes of travel (express, local, and paratransit/dial-a-ride) are included; light rail transit service was not in operation at that time and is consequently not included as part of this report.

4.3 Transit Performance

4.3.1 Access and Mobility Measures

Background – Access and mobility measures provide fundamental information on how effectively the transit system is moving people across the region.

4.3.1.1 Transit Boardings

Definition: A boarding is an unlinked passenger trip. Every time a person boards a transit vehicle, even if making a transfer, it is counted as one boarding.

Objective: To better understand whether transit route or system usage is increasing, decreasing, or remaining relatively flat.

Source: Boarding data provided by staff from City of Phoenix Transit, RPTA, and City of Tempe, as well as from the 2008 Valley Metro Transit Performance Report.

Time Scale: Results are provided for 2006 and 2007.

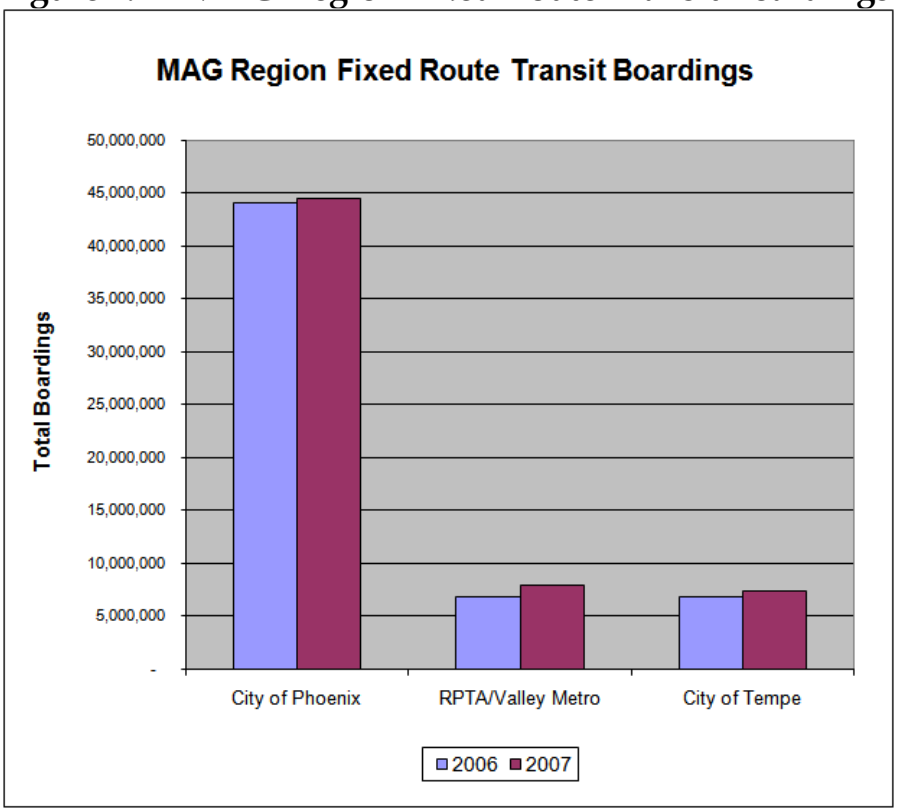
Methodology: Data for this measure was collected by the agencies involved based on information generated by their transit vehicles' on-board vehicle management systems and as recorded by drivers. Data concerning transit boardings is provided in Figures 4.2, 4.3, and 4.4.[17]

Explanation of Results and Analysis: Between 2006 and 2007 all of the region's fixed route transit services experienced increases in boardings. Of the agencies included in this study, the greatest increase occurred for RPTA, whose boardings increased by over 1.1 million, representing an increase of over 16%. During the same period, the smallest increase occurred for City of Phoenix Transit, which gained only 369,000 additional boardings, representing an increase of less than 1%. At least some of this growth in boardings is likely associated with the addition of revenue miles of service by some of these transit agencies during the same period.

During the same period, total boardings increased for East Valley Dial-A-Ride (DAR) transit service by just under 7.5%, while City of Phoenix Dial-A-Ride transit service had nearly 20,000 fewer boardings, a drop of almost 5%.

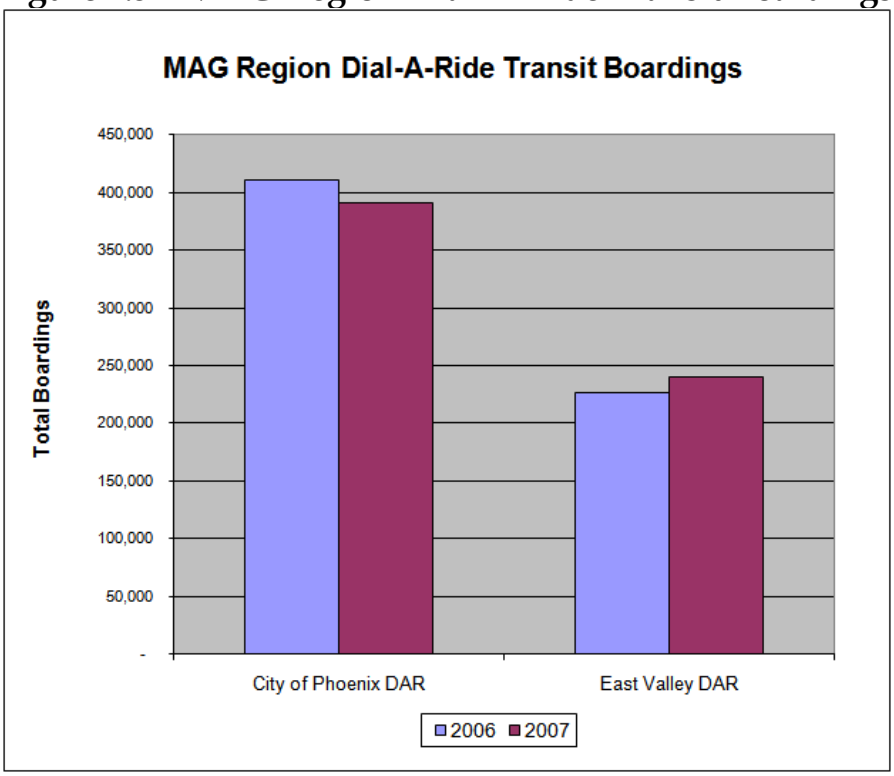
[17] The City of Tempe operates no Dial-A-Ride Service. As a result, no data for Tempe is included in Figure 4.3.

Figure 4.2 – MAG Region Fixed Route Transit Boardings



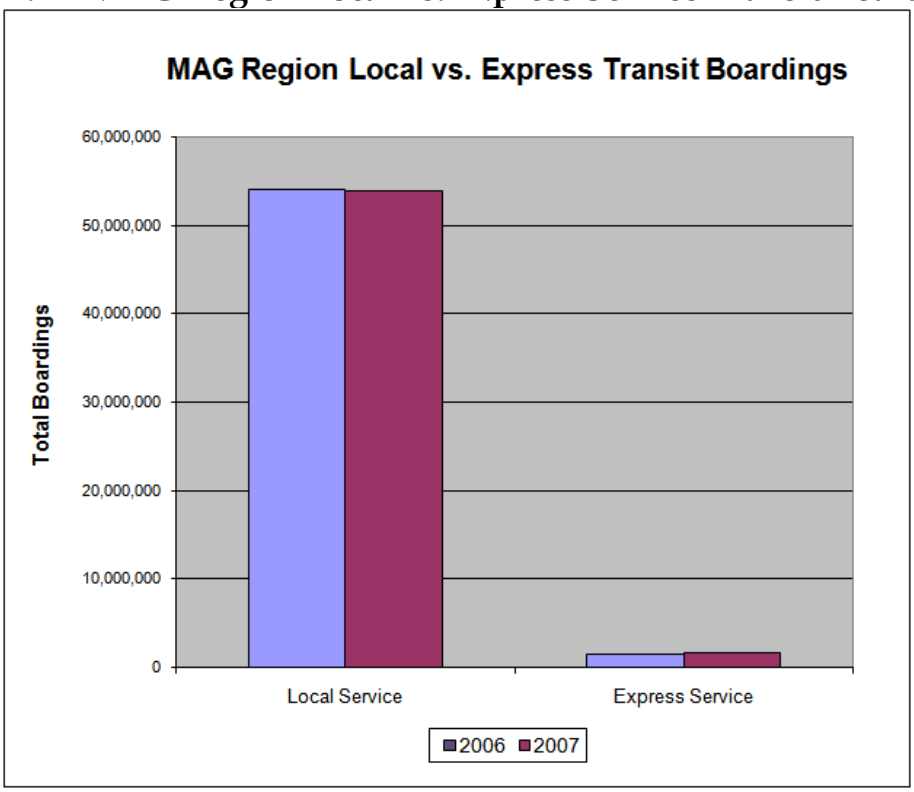
Source: City of Phoenix Transit, RPTA, and City of Tempe

Figure 4.3 – MAG Region Dial-A-Ride Transit Boardings



Source: City of Phoenix Transit and RPTA

Figure 4.4 – MAG Region Local vs. Express Service Transit Boardings



Source: 2008 Valley Metro Transit Performance Report

4.3.1.2 *Boardings per Revenue Mile*

Definition: Is defined as the total number of annual fixed route transit boardings for an agency divided by the total number of fixed route revenue miles generated by that agency.

Objective: To undertand how efficiently transit services are being provided. The higher the ratio, the more efficiently transit service is being provided.

Source: 2008 Valley Metro Transit Performance Report

Time Scale: Results are provided for 2006 and 2007.

Methodology: Data used to calculate this measure was collected by the agencies involved based on information generated by their transit vehicles' on-board vehicle management systems and as recorded by drivers. Results are provided in Table 4.1 and Figure 4.5.

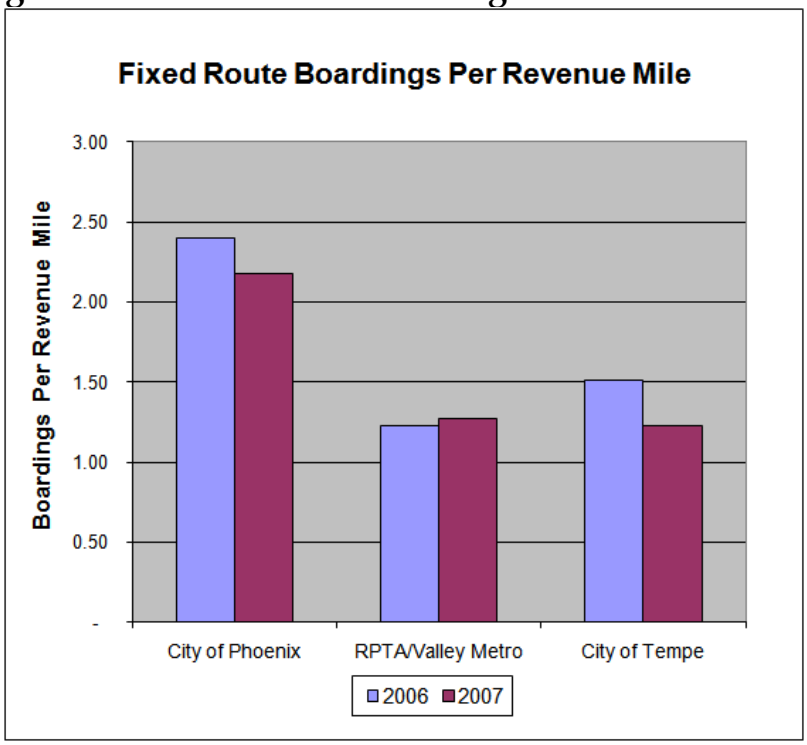
Explanation of Results and Analysis: During 2006 to 2007, there was a significant decrease in boardings per revenue mile for City of Phoenix (-9.17%) and City of Tempe (-18.87%), and only a relatively modest increase for RPTA (3.69%). These decreases may reflect the addition of early morning, late night, or weekend service on some routes. The most important impact of a drop in boardings per revenue mile is the likelihood of it leading to a rise in subsidy per boarding.

Table 4.1 – Fixed Route Boardings Per Revenue Mile

	2006	2007
City of Phoenix	2.40	2.18
RPTA/Valley Metro	1.23	1.27
City of Tempe	1.51	1.23

Source: 2008 Valley Metro Transit Performance Report

Figure 4.5 – Fixed Route Boardings Per Revenue Mile



Source: 2008 Valley Metro Transit Performance Report

4.3.2 Travel Time, Reliability, and Delay Measures

Background - Among the measures that are most meaningful to travelers and system managers alike are those related to the typical travel experience. Understanding the amount of time typically required for a transit-based trip, as well as the reliability of that trip is an important aspect of the quality of travel provided to the end user.

4.3.2.1 Transit On-Time Performance

Definition: A fixed route vehicle is considered "on-time" if it arrives at its scheduled destination no more than five (5) minutes early or late. A Dial-A-Ride vehicle is considered "on-time" if it arrives at its scheduled destination within 30 minutes of the pick-up time given to the passenger at the time of their reservation.

Objective: To track the extent to which fixed route and dial-a-ride transit vehicles adhere to their pre-determined schedules.

Source: 2008 Valley Metro Transit Performance Report

Time Scale: Results are provided for 2006 and 2007.

Methodology: Data for this measure was collected by the agencies involved based on information generated by their transit vehicles' on-board vehicle management systems and as recorded by drivers. Data concerning on-time performance is provided in Tables 4.2 and 4.3, and Figures 4.6, 4.7, and 4.8.[18]

Explanation of Results and Analysis: On-time performance for all transit services in the MAG region increased from 2006 to 2007, with the exception of City of Phoenix's fixed route service, which fell by 1%. Nevertheless, during 2007 all services, both fixed route and Dial-A-Ride, exceeded the 90% on-time performance goal laid out by RPTA and the City of Phoenix for their transit services.

Table 4.2 – Fixed Route Service On-Time Performance

	2006	2007
City of Phoenix	92%	91%
RPTA/Valley Metro	95%	96%
City of Tempe	88%	90%

Source: 2008 Valley Metro Transit Performance Report

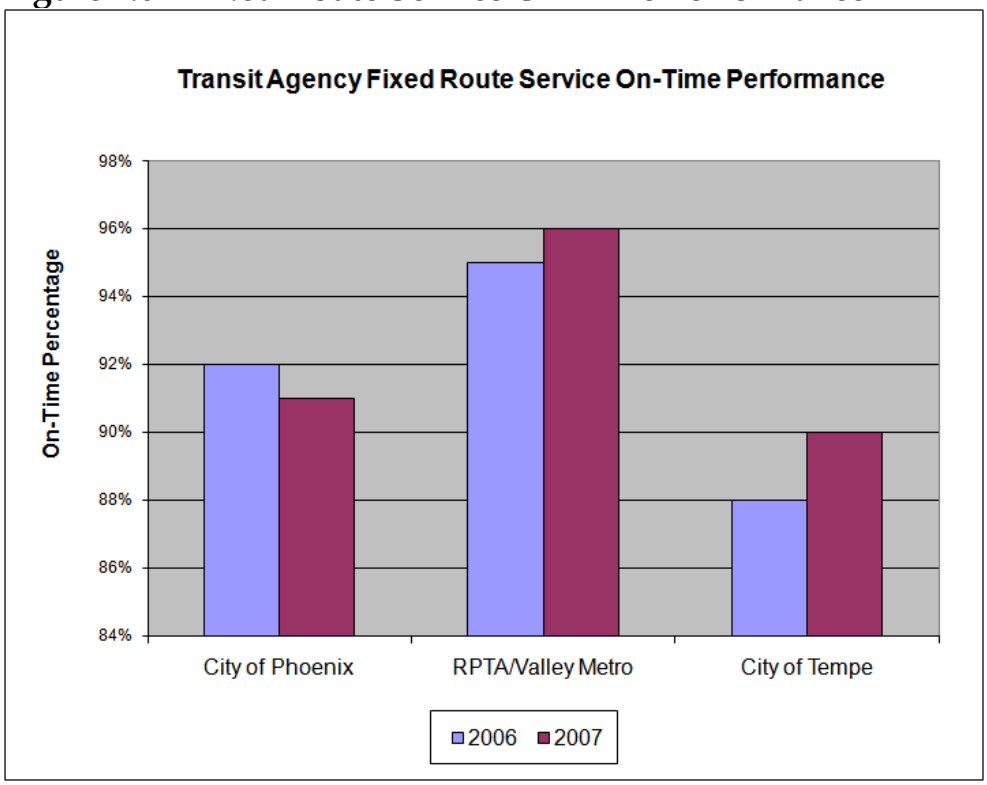
Table 4.3 – Dial-A-Ride Service On-Time Performance

	2006	2007
City of Phoenix	91.5%	93.2%
RPTA/Valley Metro	90%	92.7%

Source: 2008 Valley Metro Transit Performance Report

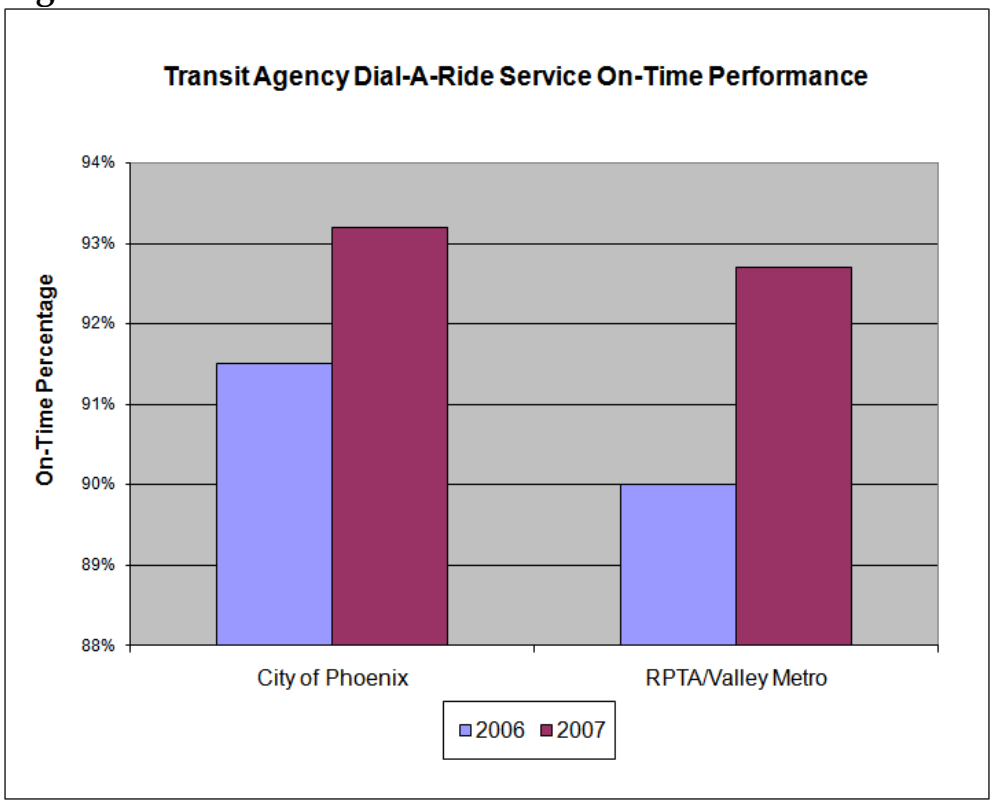
[18] The City of Tempe operates no Dial-A-Ride Service. As a result, no data for Tempe is included in Figure 4.7.

Figure 4.6 – Fixed Route Service On-Time Performance



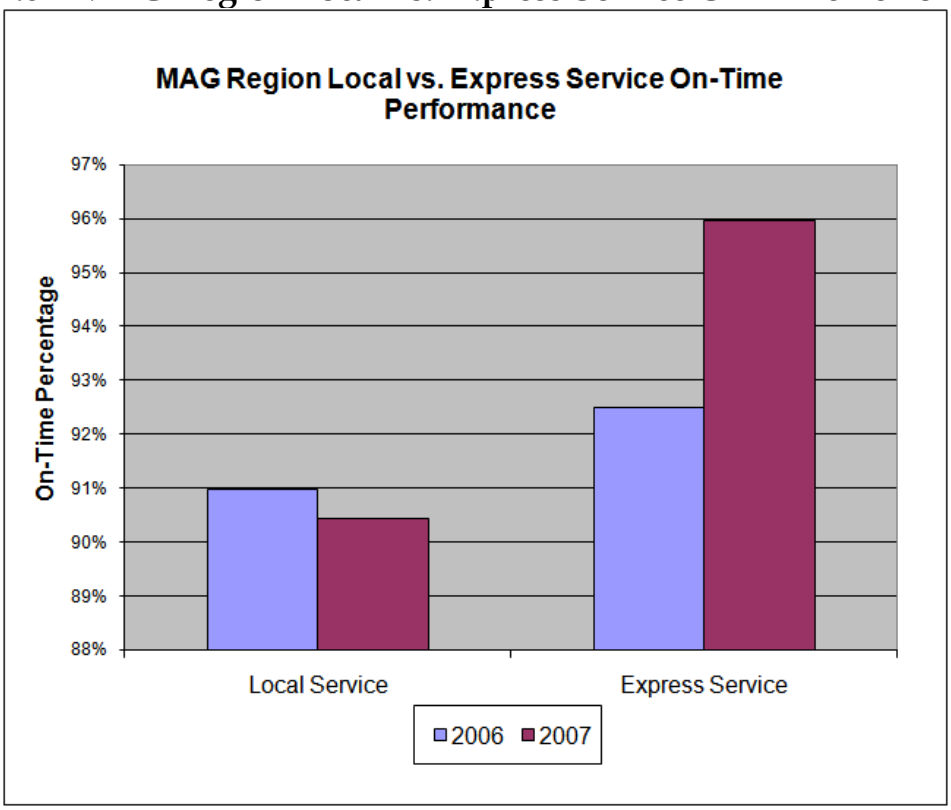
Source: 2008 Valley Metro Transit Performance Report

Figure 4.7 – Dial-A-Ride Service On-Time Performance



Source: 2008 Valley Metro Transit Performance Report

Figure 4.8 – MAG Region Local vs. Express Service On-Time Performance



Source: 2008 Valley Metro Transit Performance Report

4.3.3 System Accessibility and Modal Options Measures

Background – Tracking performance measures associated with system accessibility and the availability of different modal options (e.g., share of travel) will provide MAG and its partners with key data concerning the extent to which transit-based travel and other alternative modes of transportation are being accommodated.

4.3.3.1 Percent of Park and Ride Capacity Used

Definition: Percent of Park and Ride Capacity Used is defined as the percentage of parking capacity (number of available spaces) utilized at each operational Park and Ride facility.

Objective: To track the percentage of available park and ride capacity being used by the traveling public at various locations around the greater Phoenix metropolitan area. This information will assist decision-makers in assessing the success of regional efforts to facilitate increases in the percentage of transit-based travel, thus reducing congestion and assisting in the improvement of air quality.

Source: City of Phoenix Public Transit Department

Time Scale: Results are provided for 2006 and 2007.

Methodology: Percent of Park and Ride Capacity Used was provided by the City of Phoenix for each of its Park and Ride facilities for which data was collected during 2006 and 2007[19]. This metric represents the number of parking spaces utilized divided by the total number of parking spaces available at each facility. A map depicting Percent of Park and Ride Capacity Used is provided in Figure 4.9. Other park and ride locations are depicted on this map. These indicate locations where commuter vehicles are able to park, usually associated with large commercial developments. However, capacity and use data is not available for these locations.

Explanation of Results and Analysis: Results indicate increasing usage at all park and ride facilities between 2006 and 2007, with the greatest increases occuring at the Dreamy Draw (9.5%) and 79th Avenue (6.1%) facilities. As of 2007, the facilities experiencing the highest rates of use were located along I-10 near the Loop 202 interchange (96.3%) in the south Valley, and on I-17 just south of the Loop 101 (96.1%). The facilities experiencing the lowest rates of use were both along SR 51, off of Bell Road and 32nd Street.

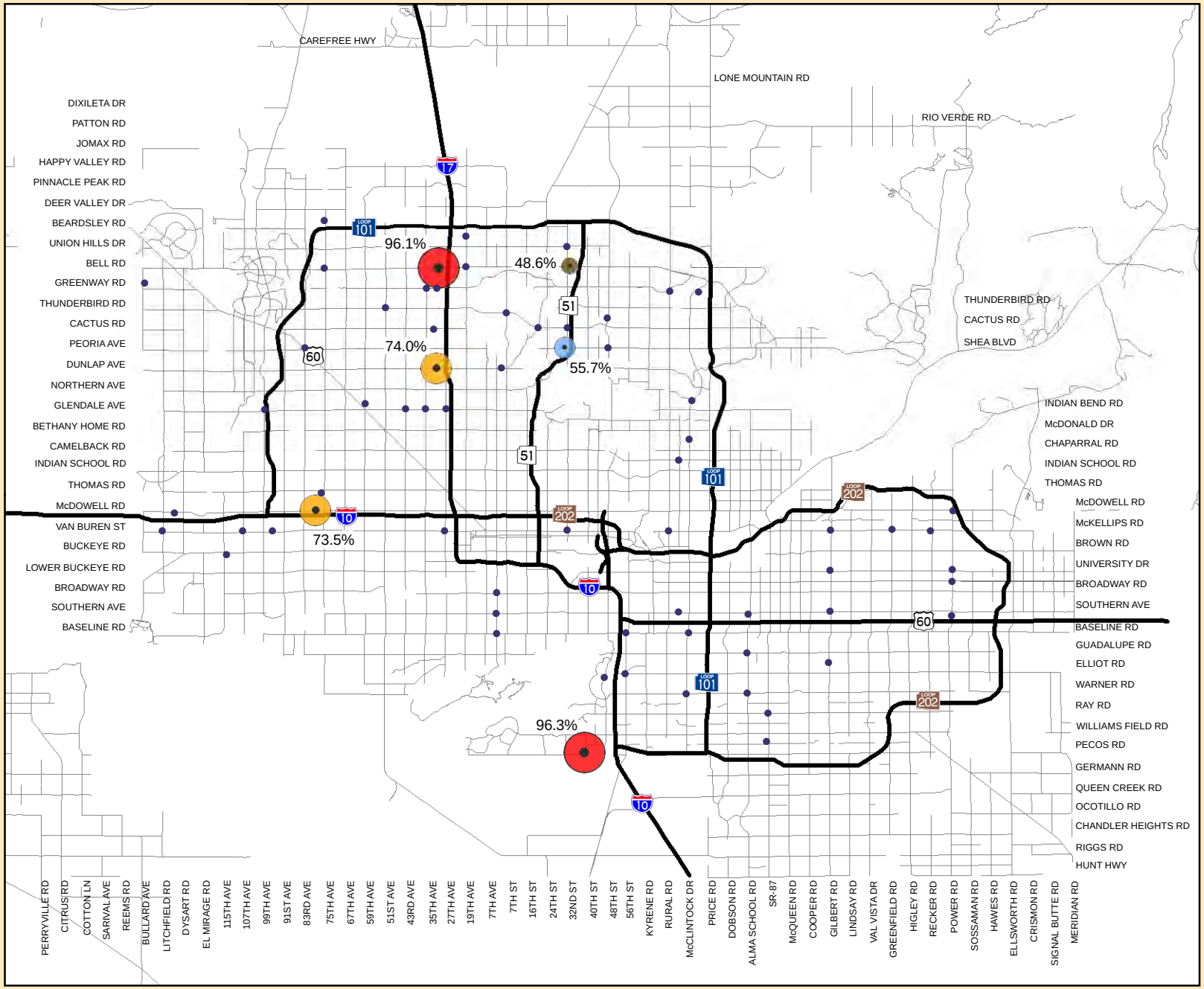
[19] The City of Phoenix Park and Ride Facilities included in this section were the only facilities for which utilization data was available during 2006 and 2007.

Figure 4.9

MARICOPA ASSOCIATION of GOVERNMENTS

Performance Measures Study

Percent of Park and Ride Capacity Used



Legend

Percentage of Parking Capacity Used (2007)

- 90.1 - 100.0%
- 80.1 - 90.0%
- 70.1 - 80.0%
- 60.1 - 70.0%
- 50.0 - 60.0%
- < 50%
- Other Park & Ride Locations For Which Usage Data Not Available
- Freeways
- Major Roads

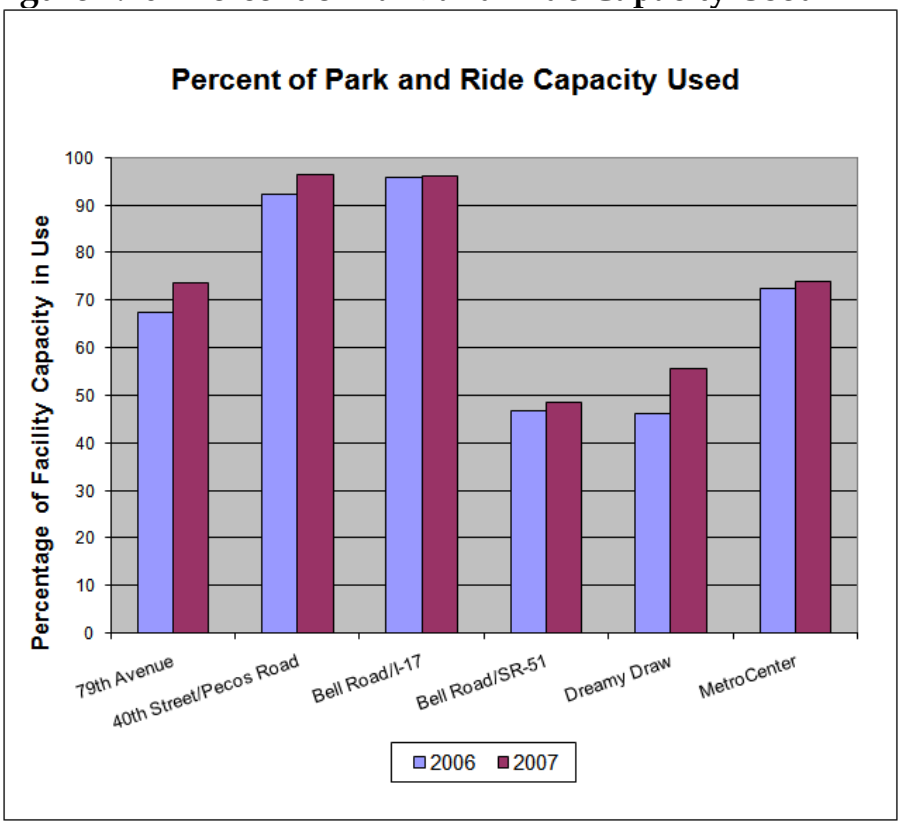
While every effort has been made to ensure the accuracy of this information, the Maricopa Association of Governments makes no warranty, expressed or implied, as to its accuracy and expressly disclaims liability for the accuracy thereof.

0 5 10 15 20 Miles

N

Source: City of Phoenix Public Transit

Figure 4.10 - Percent of Park and Ride Capacity Used



Source: City of Phoenix Public Transit Department

4.3.3.2 *Vehicle Revenue Miles of Transit Service Per Agency*

Definition: A revenue mile of service is defined as a mile traveled by a single transit vehicle in revenue collection mode that is available to pick up passengers.

Objective: To track the number of fixed route vehicle revenue miles of service made available to the traveling public by each of the three agencies included in this evaluation.

Source: 2008 Valley Metro Comprehensive Annual Financial Report

Time Scale: Results are provided based on data from 2006 and 2007.

Methodology: Data for this measure was collected from the 2008 Valley Metro Comprehensive Annual Financial Report. This data was provided to Valley Metro by each agency based on information generated by their fixed route transit vehicles' vehicle management systems. Data concerning fixed route revenue miles of service is provided in Table 4.4 and Figure 4.11.

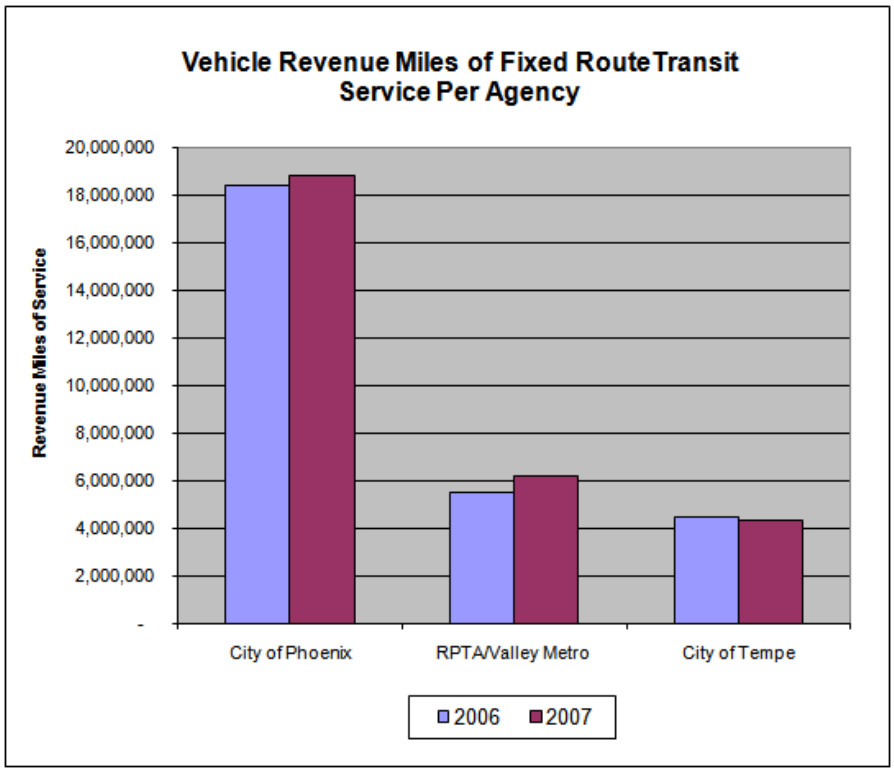
Explanation of Results and Analysis: During 2006 – 2007, RPTA experienced the greatest increase in fixed route vehicle revenue miles of service, both in gross mileage (697,500), as well as percentage increase (12.6%). Simultaneously, fixed route vehicle revenue miles of service grew for City of Phoenix Transit by just 2.2% and dropped by 2.8% for City of Tempe.

Table 4.4 - Vehicle Revenue Miles of Fixed Route Transit Service Per Agency

	2006	2007
City of Phoenix	18,412,020	18,826,324
RPTA/Valley Metro	5,521,319	6,218,876
City of Tempe	4,497,200	4,372,291

Source: 2008 Valley Metro Comprehensive Annual Financial Report

Figure 4.11 - Vehicle Revenue Miles of Fixed Route Transit Service Per Agency



Source: 2008 Valley Metro Comprehensive Annual Financial Report

4.3.3.3 Subsidy per Boarding

Definition: As per the 2008 RPTA Transit Performance Report, Subsidy per Boarding (or net operating cost per boarding) is defined as the operating cost per boarding minus the fare revenue collected per boarding.

Objective: To determine the amount of public funding required to make up the difference between the cost of providing transit service and the revenue generated by this service on a per boarding basis.

Source: 2008 Valley Metro Transit Performance Report

Time Scale: Results are provided based on data from 2006 and 2007.

Methodology: RPTA computed this measure based on data collected from the operation of City of Phoenix, RPTA, and City of Tempe fixed route transit services during 2006 and 2007 for inclusion as part of its 2008 Transit Performance Report. A graph displaying fixed route subsidy per boarding for each of these agencies is provided in Figure 4.12. In addition, the total fixed route subsidy for each agency is provided in tabular format as indicated in Table 4.5. The content of this table was generated by multiplying the subsidy per boarding by the total number of annual boardings for each agency for 2006 and 2007.

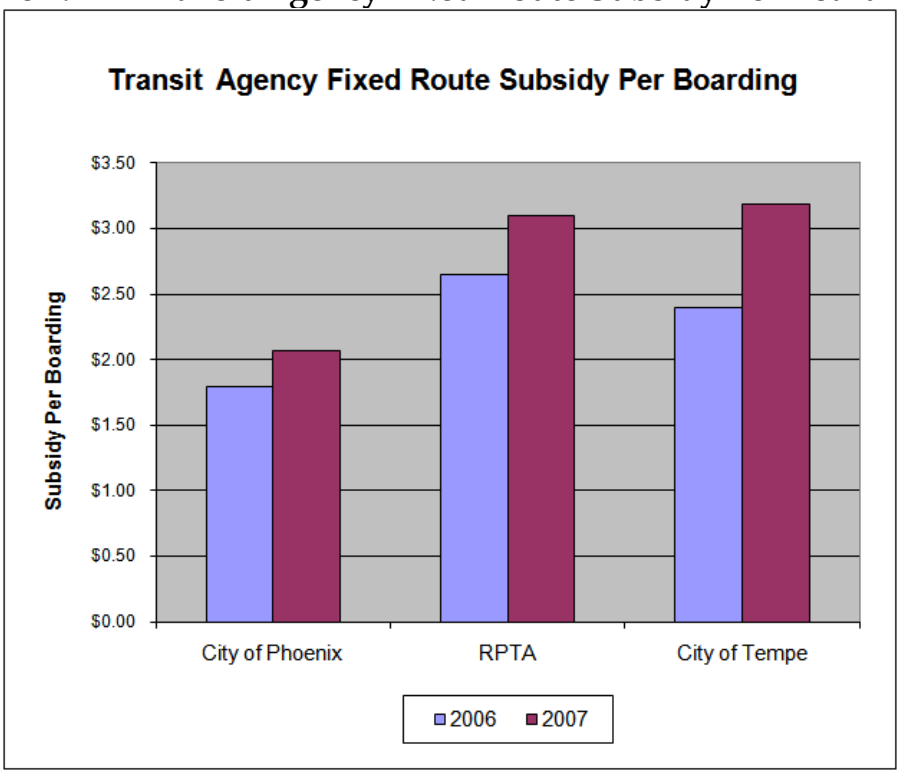
Explanation of Results and Analysis: As is indicated by Figure 4.12, subsidy per boarding increased between 2006 and 2007 for all three (3) of the agencies included in this analysis. As a result of the combination of an increase in total boardings of 8% and an increase in subsidy per boarding of just over 32.9% for the City of Tempe, its overall subsidy for fixed route service increased by the greatest amount, 43.5%, as compared to RPTA (36.6%) and the City of Phoenix (16.6%). As with the City of Tempe, RPTA's significant increase in overall fixed route service subsidy was the result of an increase in subsidy per boarding (16.9%) combined with an increase in total boardings of 16.8%. In contrast, the City of Phoenix's smaller increase in total fixed route service subsidy can at least partially be attributed to an increase in total boardings of only 0.84%. One contributing factor that may have played a role in the increase in subsidy per boarding for these agencies was the concurrent drop in boardings per revenue mile for City of Phoenix (-9.17%) and City of Tempe (-18.87%), and the relatively modest increase for RPTA (3.69%) during 2006-2007. This increase also reflects the addition of early morning, late night, and/or weekend service on some routes.

Table 4.5 – Total Fixed Route Subsidy By Agency

	2006	2007	Change
City of Phoenix	$78,941,363	$92,054,132	16.6%
RPTA	$17,945,972	$24,517,339	36.6%
City of Tempe	$16,340,513	$23,455,269	43.5%

Source: 2008 Valley Metro Transit Performance Report

Figure 4.12 – Transit Agency Fixed Route Subsidy Per Boarding



Source: 2008 Valley Metro Transit Performance Report

4.3.3.4 Transit Share of Commuter Travel

Definition: Transit share of travel provides a comparative *estimate* of the percentage of commuter trips taken in the MAG region via transit versus other modes of travel. Transit modes of travel included in the analysis found in this section consist of local bus service, express bus service, circulator/shuttle services, and dial-a-ride services. Future evaluations will include data for light rail service.

Objective: To assess the success of regional efforts to facilitate increases in the percentage of transit-based travel, thus reducing congestion and assisting in the improvement of air quality.

Source: Maricopa County Air Quality Department's Annual Trip Reduction Report.

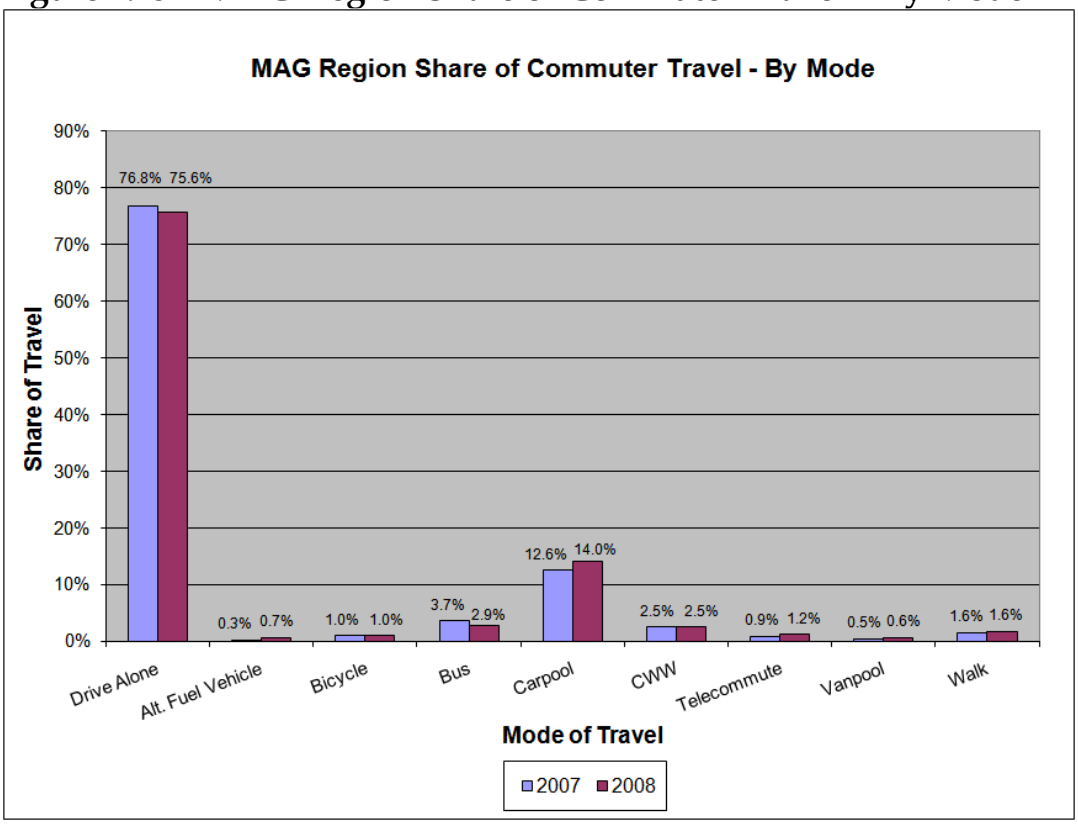
Time Scale: Results are provided based on survey data from 2007 and 2008.

Methodology: Data to support this measure was collected from the Maricopa County Air Quality Department's Annual Trip Reduction Program. Data from this program represents regional work-based trips only. The Trip Reduction Report tracks and analyzes the travel patterns of employees and students in Maricopa County in order to assess the effectiveness of the county's efforts to reduce single occupant vehicle trips and miles; at the present time, any organization with 50 more employees or students at a single site must participate. As of the end of 2008, there were 2,863 sites included in the Trip Reduction Program, representing 1,149 companies and other entities. To collect the data necessary to generate the Trip Reduction Report, Maricopa County administered a questionnaire to over 666,000 employees and students[20] associated with the entities involved in the county's trip reduction program, with an overall response rate of 78.3%. A graph depicting transit share of travel data collected as part of the Trip Reduction Report is provided in Figure 4.13. Transit share of travel data is also provided in tabular format as shown in Table 4.6.

Explanation of Results and Analysis: As is indicated in Figure 4.13, for all work trips there was a small decrease (1.2%) in single occupancy vehicle (SOV) use between 2007 and 2008. Even so, SOV-based travel remains by far the most common means of travel in the MAG region (75.6% in 2008). Although the results of the survey indicate a drop in transit use as a percentage of total regional travel from 3.7% to 2.9% (a decrease of 0.8%), this does not necessarily indicate that fewer residents of the MAG region utilized transit-based modes of travel during 2008. In fact, as per data produced by Valley Metro as part of its 2008 Transit Performance Report, the total number of transit boardings increased by 3.32% between 2007 and 2008.

[20] Trip Reduction Report questionnaires were sent to 576,969 employees and 89,657 students. Response rates were 78.6% and 76.3%, respectively.

Figure 4.13 – MAG Region Share of Commuter Travel – By Mode[21]



Source: Maricopa County Air Quality Department's Annual Trip Reduction Report.

Table 4.6 – Characteristics of Different Modes of Commuter Travel in the MAG Region[22]

	Average Trip Length (Miles)		Average Trip Time (Minutes)		Percent of Travel[23]	
	2007	2008	2007	2008	2007	2008
Drive Alone	13.32	12.24	21.04	21.59	76.8%	75.6%
Alt. Fuel Vehicle	15.79	16.9	24.77	26.48	0.3%	0.7%
Bicycle	5.32	6.12	16.84	16.85	1.0%	1.0%
Bus	11.07	14.03	33.24	34.07	3.7%	2.9%
Carpool	11.54	11.06	19.31	19.8	12.6%	14.0%
CWW	-16.3	-17.28		-29.56	2.5%	2.5%
Telecommute	-19.01	-19.65	-32.91	-32.93	0.9%	1.2%
Vanpool	28.6	21.82	27.71	30.25	0.5%	0.6%
Walk	1.78	2.04	13.82	13.96	1.6%	1.6%

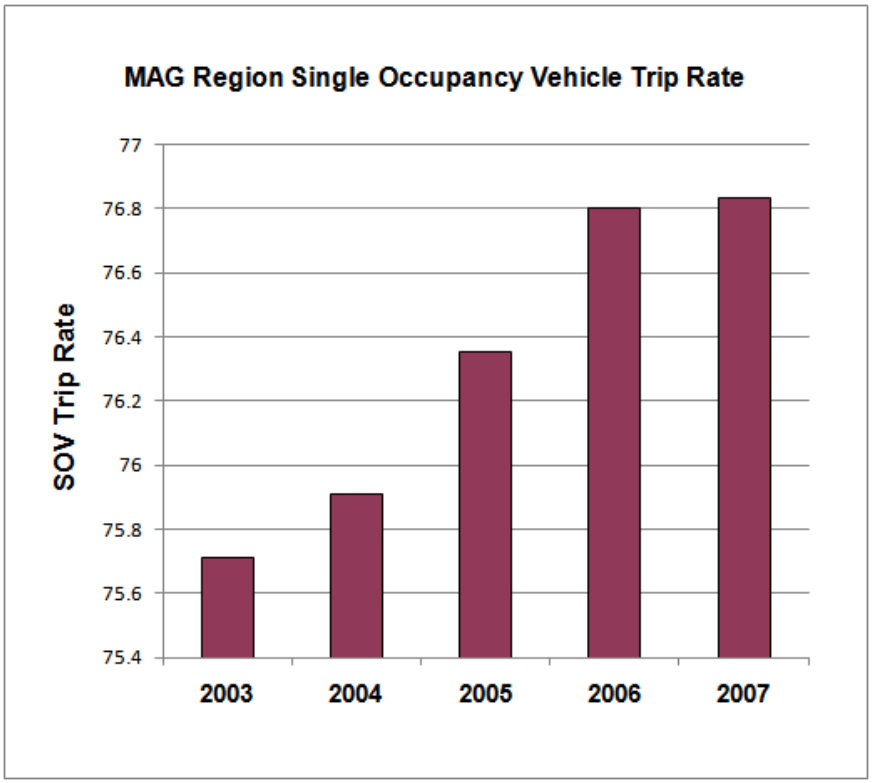
Source: Maricopa County Air Quality Department's Annual Trip Reduction Report.

[21] CCW – Compressed Work Week

[22] The data used to generate this table is based on the Maricopa County Air Quality Department's Annual Trip Reduction Survey. The most recent survey was administered to over 660,000 people.

[23] Due to rounding errors associated with the calculation of the percent of travel, the sum of the individual categories does not equal 100%.

Figure 4.14 – MAG Region Single Occupancy Commuter Vehicle Trip Rate



Source: Maricopa County Air Quality Department's Annual Trip Reduction Report.

5.0 Bicycle & Pedestrian Performance

5.1 System Definition

5.1.1 MAG Regional Bicycle and Pedestrian Network

The promotion of bicycle and pedestrian-based travel in the MAG region is actively supported by MAG through the efforts of various committees, including the Regional Bicycle Task Force and Pedestrian Working Group. These committees have pursued numerous planning-related efforts to improve opportunities for bicycle and pedestrian travel in the region, including developing the following documents:

- MAG Regional Bicycle Plan and Plan Update
- MAG Pedestrian Plan
- Regional Off-Street System (ROSS) Plan
- MAG Regional Bikeway Master Plan
- MAG Pedestrian Policies and Design Guidelines

The purpose of these documents is to facilitate the development of a safe, convenient, and efficient transportation network that residents of the MAG region can use to bike or walk safely to their destinations. In addition, every single bus or light rail rider is a pedestrian or a bicyclist at the two ends of their transit trip. By supporting non-motorized modes of travel, MAG and its partners hope to create areas where people elect to bike, walk, or use transit instead of using private vehicles, thereby assisting in the management of congestion and improvement of air quality. A map depicting the MAG region bicycle and pedestrian network is displayed in Figure 5.1.

Table 5.1 provides an overview of the growth of the region's bicycle and pedestrian network between 2001 and 2008.

Table 5.1 – Growth of the MAG Region Bicycle & Pedestrian Network (Miles)[24]

	2001	2003	2005	2008
Multi-Use Trail (Unpaved)	183.26	185.99	222.32	238.7
Multi-Use Trail (Paved)	128.47	143.11	162.38	218.8
Paved Shoulders	163.86	172.16	91.98	313.9
Bike Lanes	660.14	815.32	919.65	1,270.0
Bike Routes	374.01	393.44	477.91	480.8
Total Miles	***1,509.74***	***1,710.03***	***1,874.24***	***2,522.2***

Source: Maricopa Association of Governments

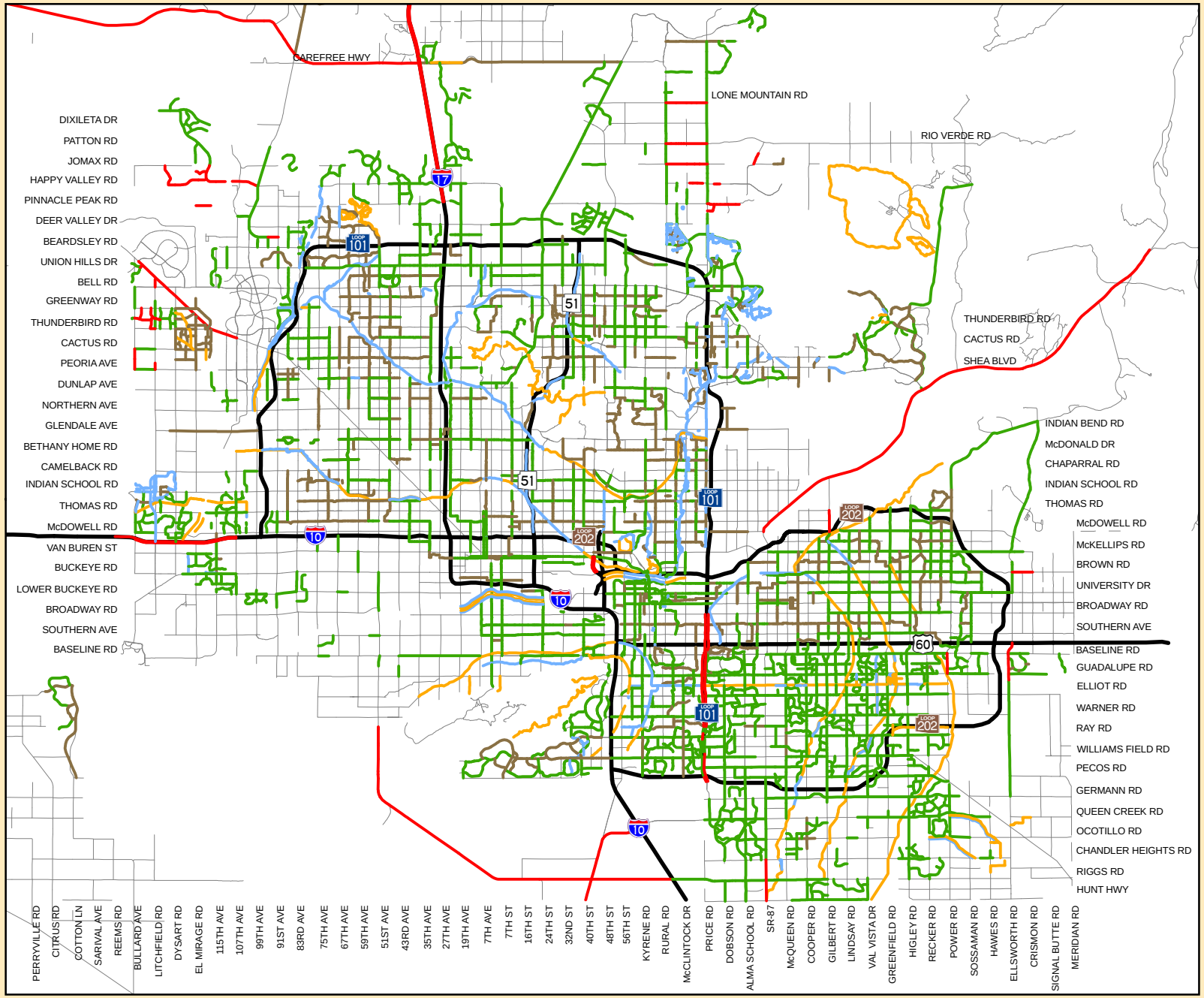
[24] It should be noted that the "pedestrian" network is composed of multi-use trails and does not reflect sidewalks.

Figure 5.1

MARICOPA ASSOCIATION of GOVERNMENTS

Performance Measures Study

Regional Bikeway and Pedestrian Network Study Limits



Legend

Bikeway & Pedestrian Network (2008)

- Multi-Use Unpaved (239 miles)
- Multi-Use Paved (219 miles)
- Bike Lane (1,270 miles)
- Bike Route (481 miles)
- Paved Shoulder (314 miles)
- Freeways (413 miles*)
- Major Roads (3,400 miles*)

* Centerline miles.

While every effort has been made to ensure the accuracy of this information, the Maricopa Association of Governments makes no warranty, expressed or implied, as to its accuracy and expressly disclaims liability for the accuracy thereof.

0 5 10 15 20 Miles

N

Source: Maricopa Association of Governments; MAG Model Network 2008.

5.2 Bicycle and Pedestrian Performance Measures

5.2.1 Safety Measures

Background – The design, deployment, and maintenance of safe bicycle and pedestrian facilities is an important part of any multi-modal transportation system. The development of safety-related performance measures for bicycle and pedestrian routes will assist decision-makers in better understanding conditions along these facilities and provide a basis for pursuing necessary improvements.

5.2.1.1 Bicycle & Pedestrian Crash Totals for the MAG Region

Definition: Crash, injury, and fatality totals for bicycle and pedestrian involved crashes are defined as the total number of crashes, injury crashes, and fatal crashes occurring across the MAG region during a one-year period.

Objective: Reduce the number of bicycle and pedestrian involved crashes, injury crashes, and fatal crashes. The availability of this data will also enable decision-makers to identify the extent to which safety improvements may be required on a regional level.

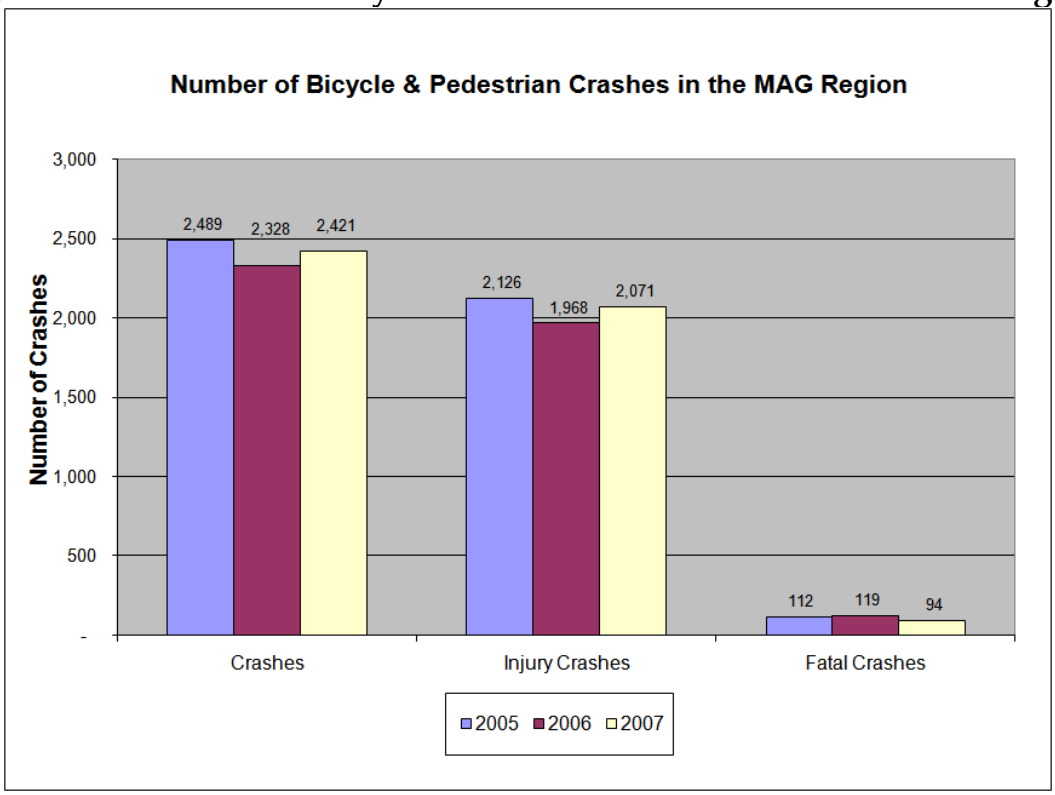
Source: MAG analysis of crash data from the ADOT Accident Location Information Surveillance System (ALISS).

Time Scale: Results are provided for a 3-year period from 2005 to 2007.

Methodology: Bicycle and pedestrian-related crash data were obtained from the ADOT ALISS database. For a more detailed description of ALISS, see the Methodology description found in Section 2.3.3.1. Bicycle and pedestrian-involved crash, injury crash, and fatal crash totals for the MAG region (for 2005, 2006, and 2007) were generated by MAG staff for inclusion in this report. A chart containing this data is provided in Figure 5.2.

Explanation of Results and Analysis: The annual number of bicycle and pedestrian crashes and injury crashes appear to be fairly stable from year to year, increasing or decreasing annually by no more 7-10%. Only the change in the number of fatal crashes falls outside of this range (decreasing by 26.6% between 2006 and 2007). However, some of this can be attributed to the fact that the number of fatal crashes is several orders of magnitude smaller than either crashes or injury crashes, resulting in there being an increased likelihood of more dramatic year-to-year changes (when calculated as percentage change) than for the larger data sets.

Figure 5.2 – Number of Bicycle & Pedestrian Crashes in the MAG Region



Source: ADOT Accident Location Information Surveillance System (ALISS)

5.2.2 System Accessibility and Modal Options Measures

Background – As is indicated in section 5.1, a number of planning-related efforts have taken place over the past few years, with the purpose of improving opportunities for bicycle and pedestrian travel in the region. Tracking performance measures associated with system accessibility and the availability of different modal options (e.g., share of travel) will provide MAG and its partners with key data concerning the extent to which those efforts have succeeded, as well as increase overall awareness of how travel via these alternative modes is being accommodated.

5.2.2.1 Bicycle & Pedestrian Share of Travel

Definition: Bicycle and pedestrian share of travel provides a comparative *estimate* of the percentage of trips taken in the MAG region via bicycle or walking versus other modes of travel.

Objective: Increase the percentage of non-motorized alternative modes of travel, thus reducing congestion and assisting in the improvement of air quality.

Source: Maricopa County Air Quality Department's Annual Trip Reduction Report

Time Scale: Results are provided based on survey data from 2007 and 2008.

Methodology: Data to support this measure was collected from the Maricopa County Air Quality Department's Annual Trip Reduction Report. The Trip Reduction Report tracks and analyzes the travel patterns of employees and students in Maricopa County in order to assess the effectiveness of the county's efforts to reduce single occupant vehicle trips and miles; at the present time, any organization with 50 more employees or students at a single site must participate in the production of this report. As of the end of 2008, there were 2,863 sites included in the Trip Reduction Report, representing 1,149 companies and other entities. To collect the data necessary to generate the Trip Reduction Report, Maricopa County administered a questionnaire to over 666,000 employees and students[25] associated with the entities involved in the county's trip reduction program, with an overall response rate of 78.3%. A graph depicting share of travel data collected as part of the Trip Reduction Report is provided in Figure 5.3. Share of travel data is also provided in tabular format as shown in Table 5.3. Figure 5.4 provides a breakdown of average trip lengths, broken down by mode of travel used.

Explanation of Results and Analysis: As is indicated in Figure 5.3, there was a small decrease (1.2%) in single occupancy vehicle (SOV) use between 2007 and 2008. Even so, SOV-based travel remains by far the most common means of travel in the MAG region (75.6% in 2008). With regard to bicycle and pedestrian modes of travel, survey results indicate no measurable change during this time period. Survey results further indicate that the longest commuting trips

[25] Trip Reduction Report questionnaires were sent to 576,969 employees and 89,657 students. Response rates were 78.6% and 76.3% respectively.

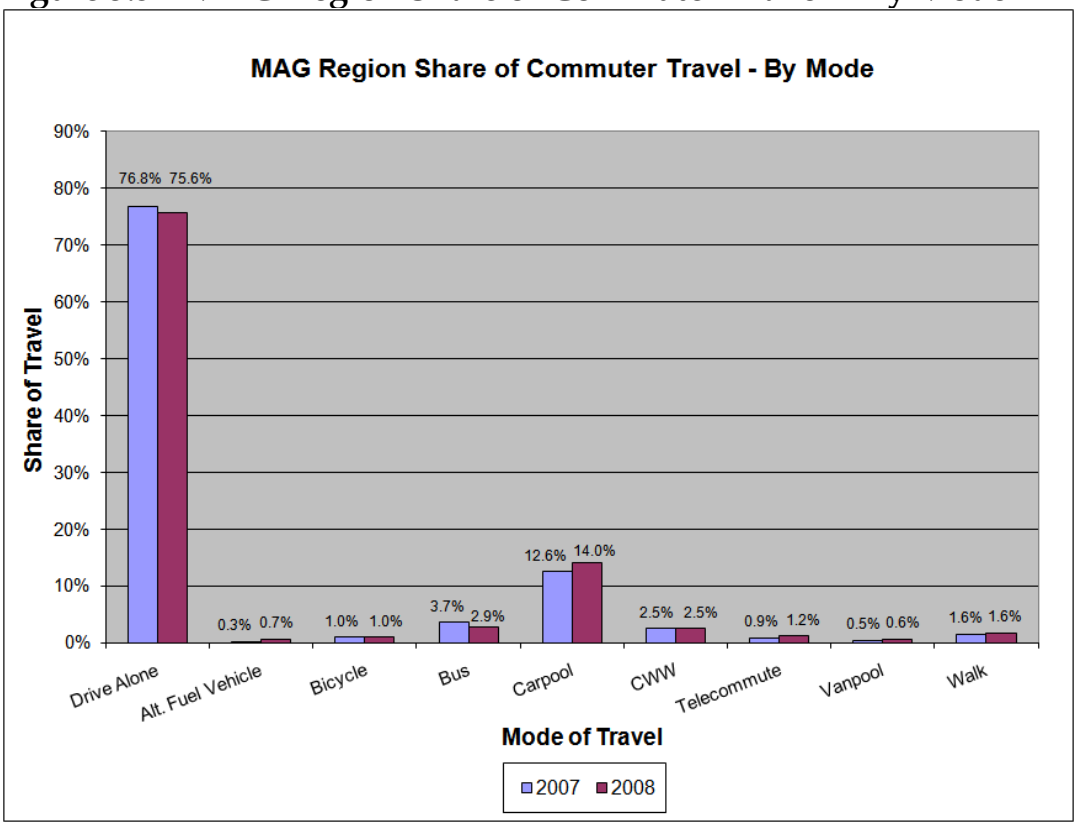
are vanpools (21.82 miles) and trips never taken (CWWs – 17.28 miles, and Telecommuting – 19.65 miles). This may be a sign that commuters who live farther from work are more likely to use these types of alternative modes of travel. At the same time, results indicate that bicycle and pedestrian trips have the shortest commuting trip lengths (6.12 miles and 2.04 miles, respectively).

Table 5.2 - Participation in MAG Region Trip Reduction Program

	2007	2008
Students	92,409	89,657
Employees	576,777	576,969
All	669,186	666,626

Source: Maricopa County Air Quality Department
Annual Trip Reduction Report

Figure 5.3 – MAG Region Share of Commuter Travel – By Mode



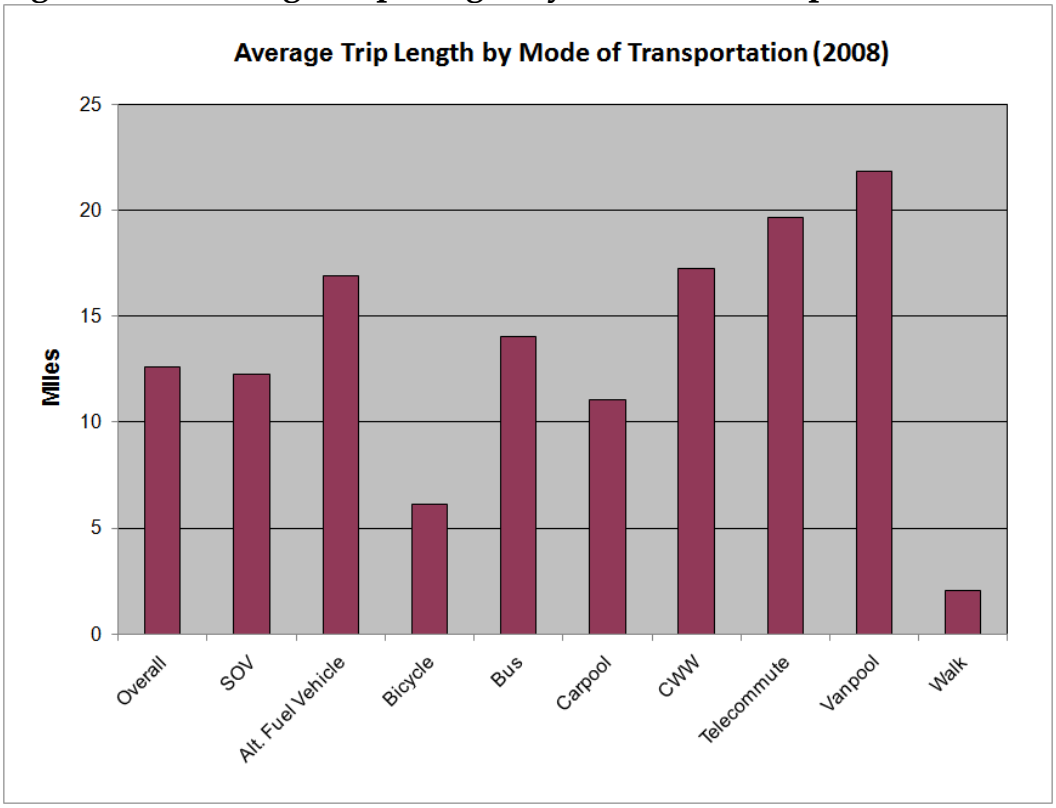
Source: Maricopa County Air Quality Department Annual Trip Reduction Report

Table 5.3 – Characteristics of Different Modes of Commuter Travel in the MAG Region[26]

	Average Trip Length (Miles)		Average Trip Time (Minutes)		Percent of Travel[27]	
	2007	2008	2007	2008	2007	2008
Drive Alone	13.32	12.24	21.04	21.59	76.8%	75.6%
Alt. Fuel Vehicle	15.79	16.9	24.77	26.48	0.3%	0.7%
Bicycle	5.32	6.12	16.84	16.85	1.0%	1.0%
Bus	11.07	14.03	33.24	34.07	3.7%	2.9%
Carpool	11.54	11.06	19.31	19.8	12.6%	14.0%
CWW	-16.3	-17.28		-29.56	2.5%	2.5%
Telecommute	-19.01	-19.65	-32.91	-32.93	0.9%	1.2%
Vanpool	28.6	21.82	27.71	30.25	0.5%	0.6%
Walk	1.78	2.04	13.82	13.96	1.6%	1.6%

Source: Maricopa County Air Quality Department Annual Trip Reduction Report

Figure 5.4 – Average Trip Length by Mode of Transportation



Source: Maricopa County Air Quality Department Annual Trip Reduction Report

[26] The data used to generate this table is based on the Maricopa County Air Quality Department's Annual Trip Reduction Survey. The most recent survey was administered to over 660,000 people.

[27] Due to rounding errors associated with the calculation of the percent of travel, the sum of the individual categories does not equal 100%.

6.0 Quality of Life Performance

6.1 System Definition

6.1.1 Quality of Life Related Issues

Quality of life-related issues are of growing concern to communities around the nation. The focus being placed on greater environmental quality, sustainable development, and healthy communities are evidence of an emphasis on an improved quality of life. Tracking quality of life-related performance measures is an important first step in providing community leaders with the information needed to implement substantive quality of life enhancement initiatives.

6.2 Transportation Demand Management Performance Measures

6.2.1 Single Occupancy Vehicle Commuter Trip Reduction Performance Measures

Background – Transportation Demand Management (TDM) refers to a collection of programs aimed at coordinating the efforts of employers, local, regional, and state agencies, and the general public, to promote the use of alternative modes of transportation over single occupancy vehicle use. Maricopa County administers a Trip Reduction Program (TRP) encompassing all employers and schools with 50 or more employees or students. Simultaneously, the State of Arizona's Travel Reduction Programs Office encourages state employees to make use of alternative modes of transportation through a variety of education and incentives-based activities. Finally, Valley Metro/RTPA offers a free ridematching service for use by residents interested in carpooling, vanpooling, and bicycling to work, as well as operates a Clean Air Campaign as part of its Regional Rideshare Program.

6.2.1.1 Participation in MAG Region Trip Reduction Program

Definition: Number of individuals (employees, students, and combined total) participating in the Maricopa County Trip Reduction Program (as indicated in the Maricopa County Air Quality Department's Annual Trip Reduction Report). The Trip Reduction Program plays an important role in the region's overall Transportation Demand Management (TDM) efforts, which includes parallel activities to encourage transit use, telecommuting, cycling and walking, and ridesharing and vanpooling, all aimed at increasing the efficiency of the regional transportation system and improving air quality.

Objective: Track and analyze journey to work travel patterns of employees and students in Maricopa County in order to assess the effectiveness of the county's efforts to reduce single occupant vehicle trips and miles.

Source: Maricopa County Air Quality Department's Annual Trip Reduction Report

Time Scale: Results are provided based on survey data from 2007 and 2008.

Methodology: The Maricopa County Air Quality Department's Trip Reduction Report tracks and analyzes the travel patterns of employees and students in Maricopa County in order to assess the effectiveness of the county's efforts to reduce single occupant vehicle trips and miles; at the present time, any organization with 50 more employees or students at a single site must participate in the production of this report. As of late 2007, there were 2,863 sites included in the Trip Reduction Report, representing 1,149 companies and other entities. To collect the data necessary to generate the Trip Reduction Report, Maricopa County administered a questionnaire to over 666,000 employees and students[28] associated with the entities involved in the county's trip reduction program, with an overall response rate of 78.3%. A table indicating total participation in the Trip Reduction Program by employees and students associated with the entities involved (for 2007 and 2008) is provided in Table 6.1.

Explanation of Results and Analysis: Results of the Trip Reduction Report Survey indicate continuing high levels of participation in the program which, according to the Trip Reduction Report, resulted in a savings of 12,934 tons of pollution due to the use of alternative modes of travel by program participants.

Table 6.1 - Participation in MAG Region Trip Reduction Program

	2007	2008
Students	92,409	89,657
Employees	576,777	576,969
All	669,186	666,626

Source: Maricopa County Air Quality Department
Annual Trip Reduction Report

[28] Trip Reduction Report questionnaires were sent to 576,969 employees and 89,657 students. Response rates were 78.6% and 76.3%, respectively.

Appendix A – MAG Performance Measurement Framework

Focus Area/Mode	Limited Access Highways (GP)	HOV Lanes	Arterials	Transit	Freight	Bicycle/Pedestrian (Non-Motorized)
Travel Time, Delay, & Reliability	Mean and 80th-95th Percentile & Point-to-Point Travel Times	Mean and 80th-95th Percentile & Point-to-Point Travel Times	Mean and 80th-95th Percentile & Point-to-Point Travel Times	Point-to-Point Travel Times	Point-to-Point Travel Times	
	Congestion – Spatial & Temporal	Congestion – Spatial & Temporal	Congestion – Spatial & Temporal	Congestion – Spatial & Temporal		
	Travel Time Variability	Travel Time Variability	Travel Time Variability	On-time Performance		
Incident Management	Incident Clearance Time		Incident Clearance Time			
Mobility – Throughput (People/Freight)	Volume (Person and/or Vehicle)	Volume (Person and/or Vehicle)	Volume (Person and/or Vehicle)	Ridership – by mode	Freight Volume	*Bicycle/Pedestrian LOS***
	On-Ramp Queue Size		Intersection LOS – based on V/C	Peak Hour Load Factor (Average Load Factor on Express bus/freeway BRT)	*Commodity flows from, to, within, and through the region, by mode*	*Per capita miles traveled*
	Lost Productivity		Signal Cycle Failures / Intersection Queue Size			
	Per Capita VMT		Per Capita VMT	Boardings per Revenue Mile		
Safety & Security	Crash/Injury/Fatality Rate		Intersection Crash Ranking	Crash Rate	Crash/Injury/Fatality rates for large truck involved crashes on the freeway system	Crash Totals for the Region
			Crash/ Injury/Fatality Rate	Transit Crime Rate (Safety Incidents per 100k vehicle miles)	Crash/Injury/Fatality rates for large truck involved crashes on the arterial system	*Number of Schools participating in Safe Routes to Schools program*
System Accessibility & Modal Options				Percent of Park and Ride Capacity Used	*Percent of freight terminals / intermodal facilities (air, rail, and truck cargo) located within 5 miles of a freeway*	*Sidewalk and/or Bicycle Network Completeness*
				Vehicle Revenue Miles of Service		*Availability of Safe Street Crossing Facilities for Access to Transit Stops*
				Percent of population residing within ¼ mile of local bus and ½ mile of LRT/Express Bus		*Bicycle Storage Facilities*
				Transit share of travel (by mode)		Bicycle/Pedestrian share of travel
System Preservation	*Bridge/Pavement Condition Rating*	*Bridge/Pavement Condition Rating*	*Bridge/Pavement Condition Rating*			
Environmental Preservation	*Air Quality Index*	*Air Quality Index*	*Air Quality Index*	*Air Quality Index*	*Air Quality Index*	*Vehicle Emissions Reduced by Pedestrians and Bicycle Users*
Quality of Life	*Customer Satisfaction*	*Customer Satisfaction*	*Customer Satisfaction*	*Customer Satisfaction*	*Customer Satisfaction*	*Customer Satisfaction*
	Participation in MAG Region Trip Reduction Program		Participation in MAG Region Trip Reduction Program	Participation in MAG Region Trip Reduction Program		Participation in MAG Region Trip Reduction Program
Cost Effectiveness	*Trips served/Time Savings per dollar invested*	*Trips served/Time Savings per dollar invested*	*Trips served/Time Savings per dollar invested*	*Trips served/Time Savings per dollar invested*	*Trips served/Time Savings per dollar invested*	

Yellow = data is available
Orange = some data is available, but additional refinement and/or data collection is needed prior to use
Red = limited or no data available, or significant additional refinement/analysis is needed prior to use

It is recommended that those performance measures which are *italicized & underlined* be reported only infrequently for the purpose of assessing behavioral and systemic changes occurring over.

** Note: Level of Service (LOS) measures are best used in assessing the need for planning-related improvements and are therefore best suited for use as part of an agency's Congestion Management Program.