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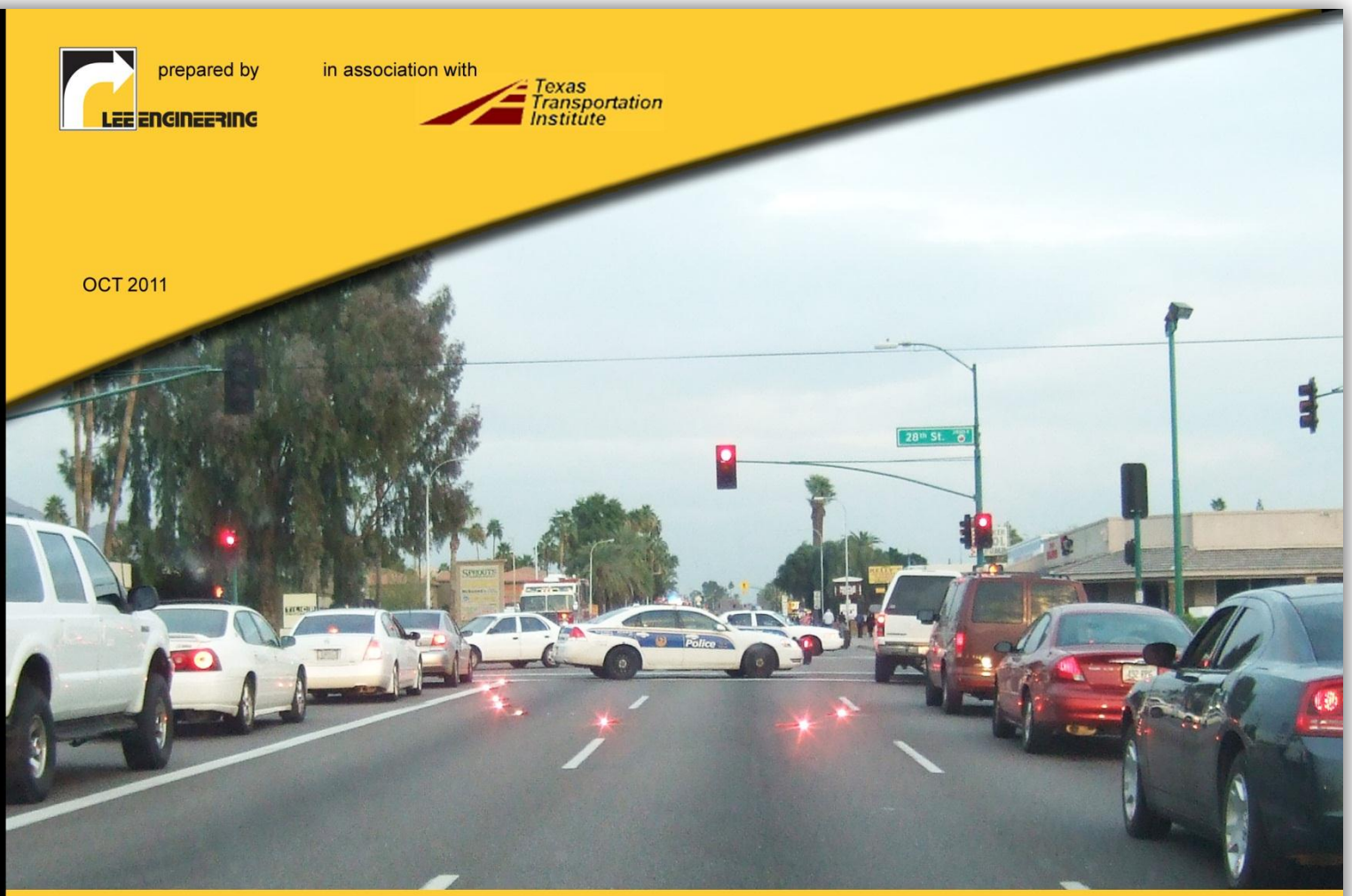
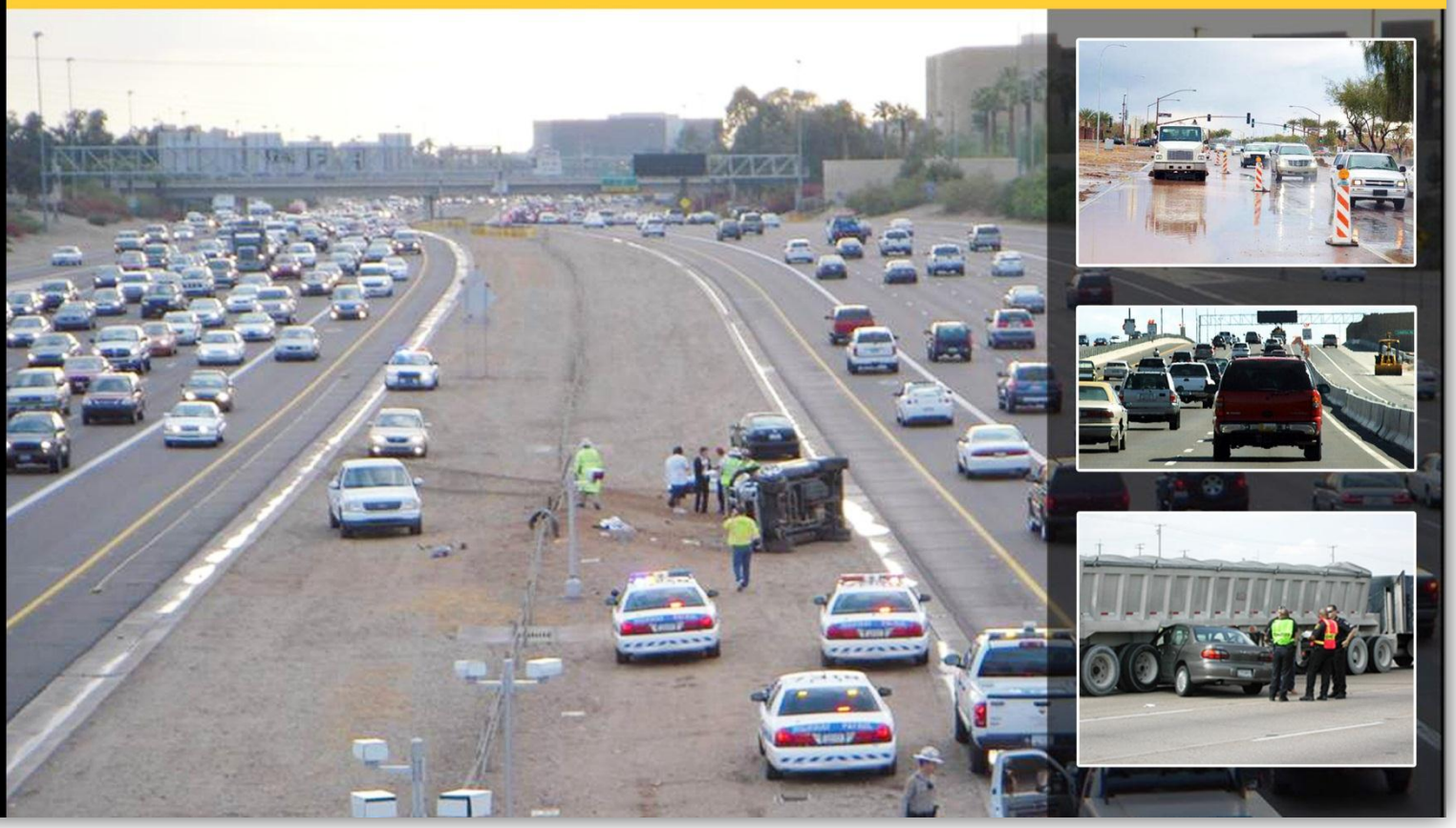


MAG NON-RECURRING CONGESTION STUDY
FINAL REPORT

MARICOPA ASSOCIATION of GOVERNMENTS



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FINAL REPORT

PREPARED FOR MARICOPA ASSOCIATION of GOVERNMENTS

PREPARED BY LEE ENGINEERING

Expires 6-30-2012

IN ASSOCIATION WITH Texas Transportation Institute

October 2011

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ACRONYMS

ACRONYM	MEANING
AADT	Annual Average Daily Traffic
ADOT	Arizona Department of Transportation
ADT	Average Daily Traffic
ASAP	Alabama Service and Assistance Patrol
ATIS	Advanced Travel Information System
ATIS	Advanced Traveler Information Systems
AVL	Automatic Vehicle Location
BCR	Benefit Cost Ratio
BPM	Best Practice Model
BTI	Buffer Time Index
C2C	Center-to-Center Communications
CAD	Computer-Aided Dispatch
Caltrans	California Department of Transportation
CBD	Central Business District
CCTV	Closed Circuit Television
CIP	Capital Improvement Program
CMAQ	Congestion Mitigation and Air Quality
CMP	Congestion Management Process
CMS	Congestion Management System
DLM	Dynamic Lane Merge
DMS	Dynamic Message Sign
DRD	Dynamic Route Diversion
EMS	Emergency Management System
ERR	Economic Rate of Return
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMS	Freeway Management System
FSP	Freeway Service Patrol
FSPE	Freeway Service Patrol Evaluation
FTA	Federal Transit Administration
GIS	Geographic Information Systems

ACRONYM	MEANING
GP	General Purpose
GPS	Global Positioning System
HAR	Highway Advisory Radio
HCM	Highway Capacity Manual
HCRS	Highway Condition Reporting System
HILS	Hardware-in-the-Loop Simulation
HOV	High Occupancy Vehicle
HRI	Highway-Rail Interface
IEEE	Institute of Electrical and Electronics Engineers
IEN	Information Exchange Network
IRVN	Interagency Remote Video Network
ITS	Intelligent Transportation System
ITSI	Intelligent Transportation System Infrastructure
LRT	Light Rail Transit
MAC	Media Access Control
MAG	Maricopa Association of Governments
MCDOT	Maricopa County Department of Transportation
MPO	Metropolitan Planning Organization
MSU	Montana State University
NEMA	National Electrical Manufacturers Association
NRC	Non-Recurring Congestion
NYSDOT	New York State Department of Transportation
OIC	Operations Information Center
PANs	Personal Area Networks
PDO	Property Damage Only
PeMS	Performance Measurement System
PHD	Person Hours of Delay
PIC	Public Information Center
RADS	Regional Archived Data System
RC	Recurring Congestion
RCI	Roadway Congestion Index
RCN	Regional Community Network
REACT	Regional Emergency Action Coordinating Team

ACRONYM	MEANING
RIITS	Regional Integration of ITS
RPTA	Regional Public Transportation Authority/Valley Metro
RTP	Regional Transportation Plan
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
SED	Socioeconomic Data
SIP	State Implementation Plan
SOV	Single Occupancy Vehicle
STP	Surface Transportation Program
SWZs	Smart Work Zones
TAZ	Traffic or Transportation Analysis Zone
TBI	Travel Behavior Inventory
TCM	Transportation Control Measure
TDM	Transportation Demand Management
TIP	Transportation Improvement Program
TIS	Traveler Information System
TMA	Transportation Management Area
TMA	Transportation Management Association
TMC	Traffic Management Center
TMS	Traffic Management System
TOC	Traffic Operations Center
TRI	Travel Rate Index
TSM	Transportation System Management
TSMS	Transportation System Management Strategies
TTI	Travel Time Index
UICS	Unified Incident Command Systems
USDOT	United States Department of Transportation
V/C	Volume-to-Capacity Ratio
VANET	Vehicular Ad-Hoc Network
VHD	Vehicle Hours of Delay
VHT	Vehicle Hours Traveled
VMT	Vehicle Miles Traveled
VSL	Variable Speed Limits
WSDOT	Washington State Department of Transportation

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Executive Summary

MARICOPA ASSOCIATION of GOVERNMENTS

MAG Non-Recurring Congestion Study

Traffic delays are caused by recurring and non-recurring events. Recurring congestion—when daily peak demand exceeds the roadway capacity—is regular, easily identifiable, and measurable. Non-recurring congestion (NRC) is generally random making its delay more difficult to identify, measure, and counteract. With NRC estimated to be as much as 70% of total congestion per national studies, there is a need to ascertain and mitigate its effects.

This study had two key objectives. The first was to identify and quantify NRC on both freeway and arterial systems in the MAG region relating to causes such as traffic incidents, construction, severe weather, special events, and signal control malfunctions. The second was to identify countermeasures to mitigate the impact of NRC.

For the freeways system assessment, travel times were obtained from 2009 sensor data along five freeway study sections. For the arterial system assessment, travel time data was obtained using *Bluetooth*™ matching technology along five arterial study sections. The difference in recurring and non-recurring travel times were determined to be NRC. Each NRC event was then classified by the causes.

Incidents and construction were the primary NRC causes on the study sections. NRC represented a significant portion of the regional congestion based on an extrapolation of the study data. Thus, the mitigation of NRC—focused on incident and construction countermeasures—is instrumental for improving traffic operations, reducing emissions, and deferring costly roadway capacity expansion.

ESSENTIAL FINDINGS

Table 1 shows the total weekday congestion as 54% recurring and 46% non-recurring on the freeway study sections while the weekend congestion was entirely due to non-recurring events. This meant there was no recurring congestion that exceeded a 15% threshold to account for variability in "normal" speeds on the weekends. This finding made sense because there was adequate roadway capacity during the weekend when there is very little commuter traffic on the freeway sections. Figure 1 shows the distribution of the NRC causes.

TABLE 1
Weekday & Weekend Recurring and Non-Recurring Freeway Congestion

FREEWAY STUDY SECTIONS	Recurring Congestion (veh-hrs)	Non-Recurring Congestion (veh-hrs)	Total (veh-hrs)	% NRC
Weekday Conditions (from 2009)				
I-10 WB: SR 51 to I-17	89,167	97,491	186,658	52%
I-17 SB: I-10 to I-10	2,874	13,822	16,696	83%
Loop 202 WB: 46th St to 22nd St	68,514	40,407	108,921	37%
I-10 WB: Ray to Southern Ave	140,080	39,324	179,404	22%
US 60 EB: I-10 to Loop 101	23,299	82,017	105,316	78%
Total for Weekday	**323,933**	**273,062**	**596,994**	**46%**
Weekend Conditions (from 2009)				
I-10 WB: SR 51 to I-17	-	2,097	2,097	100%
I-17 SB: I-10 to I-10	-	2,567	2,567	100%
Loop 202 WB: 46th St to 22nd St	-	2,741	2,741	100%
I-10 WB: Ray to Southern Ave	-	74	74	100%
US 60 EB: I-10 to Loop 101	-	18,167	18,167	100%
Total for Weekend	**-**	**25,645**	**25,645**	**100%**

The arterial study sections were comprised of primary segments and associated secondary segments. The primary segments consisted of the main study roadways: 35th Avenue, 51st Avenue, Indian School Road, 7th Street, and Rural Road. Table 2 summarizes the recurring congestion and NRC for each primary study section (with any associated secondary segments noted) for weekdays and weekends and Figure 2 shows the distribution of NRC causes.

Weekday and weekend non-recurring congestion was overwhelmingly due to vehicular incidents and construction for both freeways and arterial streets.

TABLE 2
Weekday & Weekend Recurring and Non-Recurring Congestion on Arterials

ARTERIAL STUDY SECTIONS	Recurring Congestion (veh-hrs)	Non-Recurring Congestion (veh-hrs)	Total (veh-hrs)	% NRC
Weekday Conditions (various durations in 2010)				
35th Ave Corridor (w/Bell Rd)	87,914	103,393	98,307	11%
51st Ave Corridor (w/T-Bird, Peoria & Northern)	84,024	3,250	87,274	4%
Indian School Rd Corridor	48,526	11,951	60,477	20%
7th St Corridor	53,701	6,087	59,788	10%
Rural Rd Corridor (w/Rio Salado, Mill & University)	72,882	1,404	74,286	2%
Total for Weekday	**347,047**	**33,085**	**380,132**	**9%**
Weekend Conditions (various durations in 2010)				
35th Ave Corridor (w/Bell Rd)	25,144	4,620	29,764	16%
51st Ave Corridor (w/T-Bird, Peoria & Northern)	27,618	2,133	29,751	7%
Indian School Rd Corridor	26,164	4,969	31,133	16%
7th St Corridor	15,901	5,906	21,807	27%
Rural Rd Corridor (w/Rio Salado, Mill & University)	30,167	4,397	34,564	13%
Total for Weekend	**124,994**	**22,025**	**147,019**	**15%**

FIGURE 1
Distribution of Weekday and Weekend NRC Causes on Freeway Study Sections

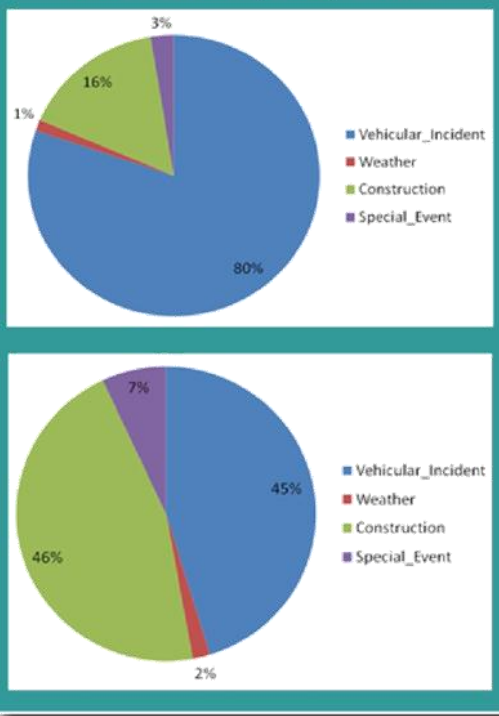
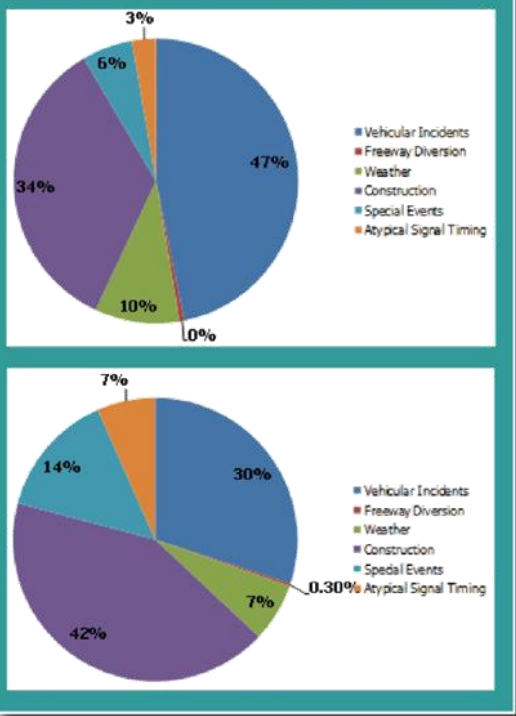


FIGURE 2
Distribution of the Weekday and Weekend NRC Causes on Arterial Study Sections



The next step in the assessment process was to expand the recurring and non-recurring congestion from the study sections to the rest of MAG region. The study found the extrapolated annual congestion from both freeways and arterials combined were as follows:

Total Congestion (recurring and non-recurring):

12% on freeways (10,584,875 veh-hrs)
88% on arterials (77,946,262 veh-hrs)

Non-Recurring Congestion Only:

38% on freeways (5,078,017 veh-hrs)
62% on arterials (8,340,250 veh-hrs)

The total congestion breakdowns provide very conservative estimates for congestion on arterials. The arterials comprise 73% of the region's lane miles and carry nearly two-thirds of all travel in the Phoenix region. The estimated recurring congestion on arterials include delays at intersections during normal undersaturated conditions. The estimated NRC on arterials are extrapolations based on observed NRC on study arterials that are some of the highest crash locations in the region.

For division between NRC and recurring congestion, the freeway study sections had 52% recurring congestion and 48% NRC. However, there was 89% recurring congestion and 11% NRC on the arterial study sections (arterials are expected to have high recurring congestion since stop delay at signalized intersections is included). For NRC only comparisons, the arterials accounted for 62% of the congestion and freeways comprised the remaining 38 percent. The results suggest that addressing congestion on arterials should be part of any regional congestion mitigation strategy, especially given the extensive arterial grid system in the Phoenix region.

RELEVANT COUNTERMEASURES

A cross-referencing of the study's literature review with local knowledge of the MAG region's traffic and operations characteristics, including NRC countermeasures already employed and input from the Study Advisory Group, generated multiple relevant possible countermeasures for freeway and/or arterial application. The following shortlist of countermeasures was developed and is presented in order of increasing cost/complexity within each roadway category.

Freeways

- Enhanced traffic incident management programs and strategies;
- Installation and monitoring of vehicle sensors, and dissemination of resulting traffic information;
- Improved information dissemination via existing permanent dynamic message signs (DMS);
- Enhanced ramp metering system;
- Use of dynamic lane merge control within construction zones; and
- Implementation of Active Traffic Management strategies (e.g., dynamic lane assignment and/or variable speed limits).

Arterials

- Enhanced traffic incident management programs and strategies;
- Installation and monitoring of vehicle sensors, and dissemination of resulting traffic information;
- Improved information dissemination via existing permanent DMS;
- Use of portable DMS to disseminate immediate information concerning NRC events; and
- Dynamic/adaptive traffic signal control that adjusts traffic control during NRC events.

PILOT PROJECT ON COUNTERMEASURES

The framework for a pilot project was developed to counteract NRC along the I-10 corridor in the West Valley. The pilot project is intended to work cooperatively with and build upon the work already done by the Traffic Incident Management (TIM) Coalition for this particular corridor. The framework for the pilot project will include the definition of the various TIM Focus Areas that include processes, activities, and protocols currently utilized by all agencies involved in any TIM activity along the I-10 corridor.

PROPOSED PARTICIPANTS	
DPS	
ADOT	Construction Maintenance Valley Project Management ALERT
MAG	
Maricopa County	Traffic Management Division REACH Medical Examiner's Office
City of Phoenix	Street Transportation Department Police & Fire Departments Public Transit Department Information Technology Services
City of Avondale	Traffic Engineering Division Police & Fire Departments Information Technology Department
City of Goodyear	Streets & Traffic Operations Police Traffic Unit Fire Department Information & Technology Services Dept.

Town of Buckeye	Public Works Department - Streets Police & Fire Departments Information Technology Department
Valley Metro RPTA	
FHWA	
Arizona Professional Towing & Recovery Association, Inc.	

Preliminary Scope Elements for the I-10 Corridor Pilot Project

The pilot project is envisioned as the initiation of a four-phased approach to refining traffic incident management along the study corridor. The focus of the pilot project will be to improve interagency communications, better accommodate driver decisions, influence driver decisions, and to improve traffic control during a non-recurring event. The following describes the proposed phases and what could be included in each:

Phase 1 - Enhance Agency Communication and Coordination Process:
This phase will define who, how and when a corridor agency will be notified when a major incident blocks two or more lanes on I-10 and what the proper course of action by the various agencies is. It will make use of existing DMS signs with agreement of what messages are displayed under what lane closure scenarios. A unified process will be established for communicating with and providing updates to the media.

Phase 2 - Implement Arterial Street Signal Timing Strategies for Freeway Incidents:
The primary arterial streets to be considered are McDowell Road, Van Buren Street and MC 85. One concept is that is that McDowell will accept additional traffic in the event of westbound I-10 lane closure and Van Buren and MC 85 will accept additional traffic in the event of eastbound I-10 lane closure. The thinking behind that is that right turns will be made when departing the I-10 off-ramp which will accommodate more vehicles than if left turns are made. However, either case also requires left turns when the rerouted vehicles reach McDowell, Van Buren or MC 85. Special timing plans could be deployed to provide extra time at the intersections receiving the rerouted traffic and progression in the direction of the I-10 movement being accommodated. Although this is an initial concept, simulation modeling of this scenario as well as additional scenarios (such as both right and left turns from I-10 ramps and two-way progression on McDowell and Van Buren/MC 85) could be part of the second phase of the pilot project.

Phase 3 - Provide Infrastructure Improvements:
The need for infrastructure improvements will be identified, such as additional DMS or additional fiber-optic communications in the corridor, linking all agencies via the RCN. Another potential infrastructure improvement is CCTV at the intersections along McDowell Road, Van Buren Street and MC 85. This potentially will include communication from TMCs (both cities and ADOT) to traffic signals along the corridors needed to complete the deployment of special timing plans to accommodate extra diverted I-10 traffic when incidents occur.

Phase 4 - Potential New Methods and Technology:
This phase, if done, would result from information gained in phases 1 and 2. This would be an innovative approach to congestion management such as active traffic management. Strategies of active traffic management include variable speed limits, temporary shoulder use, junction control, and dynamic signing and rerouting.

A final step for the Pilot Project is the Evaluation Plan. The Evaluation Plan identifies the performance measures that should be analyzed to determine the success of the pilot project. The plan also identifies the types of data needed to assess the performance of the countermeasures.

PILOT PROJECT I-10 CORRIDOR MAP

CHAPTER 1

INTRODUCTION

REPORT CONTENT

The Lee Engineering/Texas Transportation Institute (TTI) team has conducted this study on non-recurring congestion for the Maricopa Association of Governments.

The overall goal of the study was to identify appropriate countermeasures that would help recover lost roadway capacity due to non-recurring congestion (NRC). This could effectively delay the immediate need for costly new road capacity construction.

The first objective of the study was to gain a better understanding of the role played by various random incidents related to traffic, weather, and special events that result in non-recurring traffic congestion on the freeway and arterial systems in the region. Such an understanding is recognized as a prerequisite for a more focused approach in applying operational countermeasures. Thus the study quantified the types and magnitude of NRC for the MAG region.

The second objective of the study was to identify countermeasures, or mitigation strategies, that address NRC causes and develop a corridor pilot test to demonstrate the effectiveness of the various strategies.

This chapter summarizes the work completed during Task 1 – Literature Review. The literature review consisted of three components: 1) reviewing existing literature on sources of congestion, 2) reviewing existing literature on countermeasures to non-recurring congestion, and 3) developing a taxonomy of non-recurring congestion terms. The remaining five chapters concern the methodology for quantifying NRC, the data collection effort and NRC analysis results, relevant countermeasures, implementation plan, and potential pilot study of NRC countermeasures.

SOURCES OF CONGESTION

Overall Composition of Congestion

TTI's 2009 Mobility Report (Shrank, Lomax 2009) ranks the Phoenix urban area in the top 15 within the U.S. in terms of total congestion, delay per person, and the cost of congestion. These mobility measures consist of both recurring and non-recurring sources of congestion. Research from the US Department of Transportation summarizes the national sources of congestion as shown in Figure 1.1.

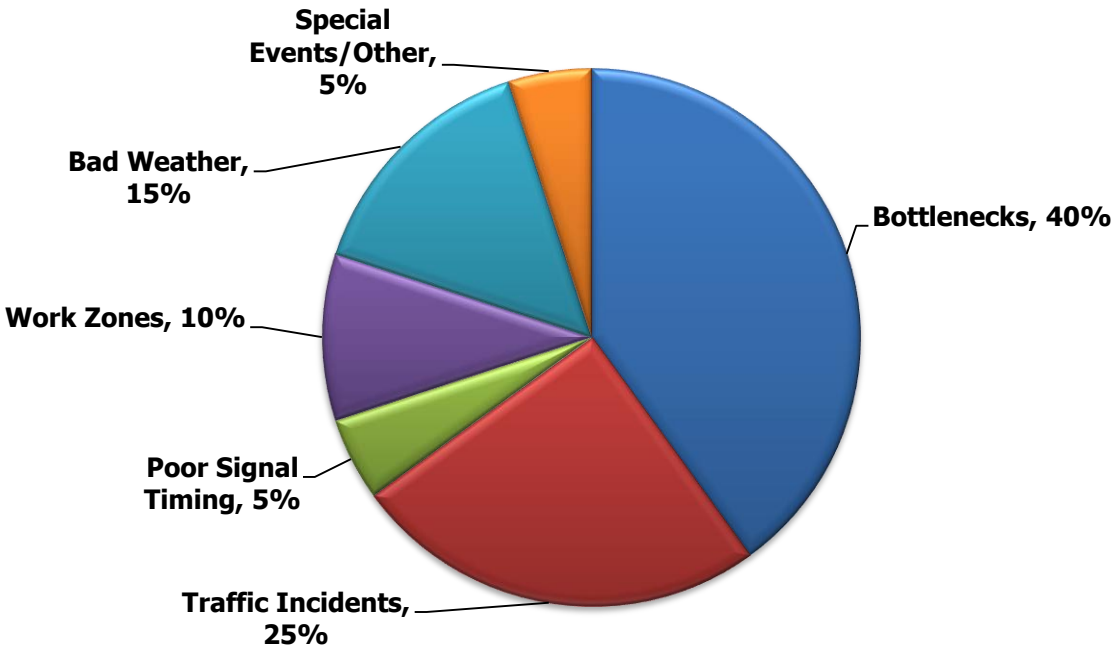
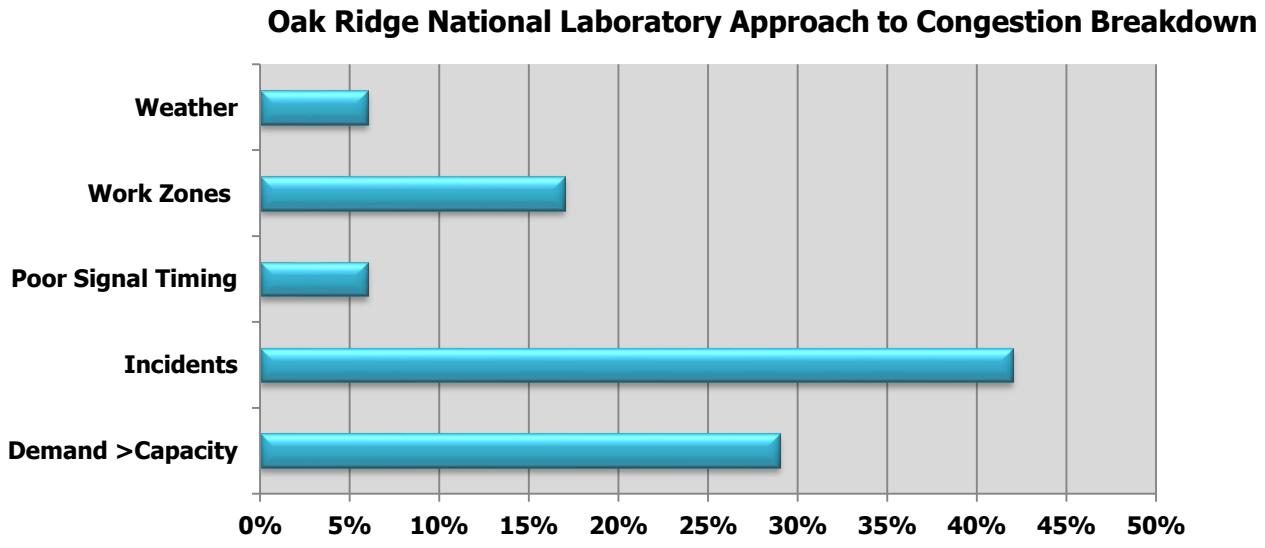
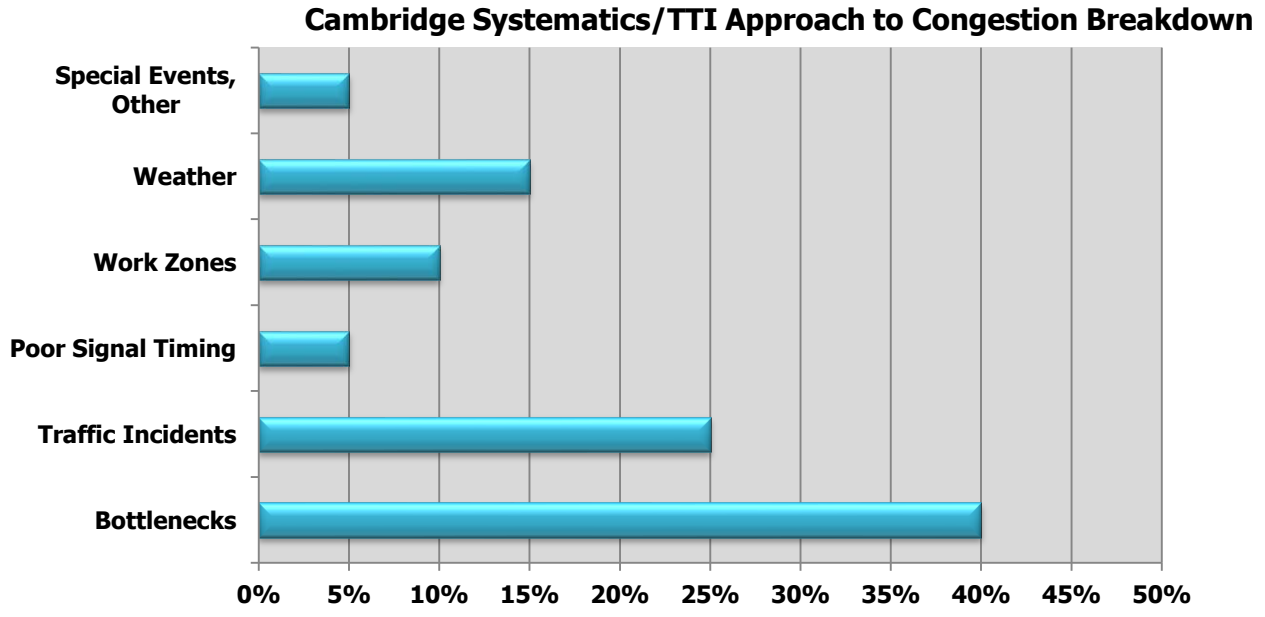


Figure 1.1 – Sources of Total Congestion

An observation regarding non-recurring congestion and its place in the bigger picture of overall roadway congestion is found in Alan Pisarski's book *Commuting in America III* (2007). Pisarski states on page 129, "Certainly one of the central findings of this work is that many of the congestion problems we face are a product of vehicle breakdowns, construction and repair activities on the roadway, weather and poor signal timing – all of which have ameliorative solutions that do not involve building new facilities. It is this finding that has given rise to efforts at better management of facilities, improved information and more rapid response to unexpected events." Pisarski also presents his interpretation of the relative sources of congestion based on the results from two major studies. The charts from that discussion are recreated here as Figure 1.2A and Figure 1.2B.





Figures 1.2A and 1.2B – Sources of Congestion from Varying Studies

Pisarski further observes "The fact that these approaches differ is not a criticism of either but rather an indication of early stages of investigation we are in today. These numbers must be considered as estimates, and are very preliminary in character in both their values and structure. Note that the ORNL approach gives a smaller share to demand-exceeding-capacity problems (labeled bottlenecks in the Cambridge Systematics, Inc./TTI work) and also to weather problems."

A report from Washington State describes the factors that cause congestion to form by discussing the results of a series of analyses that examine congestion on freeways in the greater Seattle region

(Washington State Department of Transportation (WSDOT)). This research effort uses measured roadway performance data for an entire year on roughly 120 miles of urban freeway, and includes all crashes and non-crash related incidents in which WSDOT personnel responded, and weather data for the region. The author states that the seven sources of congestion are traffic incidents, weather, and work zones, fluctuations in demand, special events, traffic control devices, and bottlenecks/inadequate base capacity. The study found that rain influenced almost as much of the observed congestion as vehicle crashes.

A study in California described a methodology that was developed to identify and measure recurrent and non-recurrent congestion on freeways using loop detectors or other surveillance systems (Skabardonis, Varaiya, & Petty, Measuring Recurrent and Nonrecurrent Traffic Congestion, Paper No. 03-4261, 2003). Two factors were considered when measuring non-recurrent delay in this research: crashes (any event that involved vehicle collisions) and non-accident incidents (breakdowns, debris, other traffic hazards, etc.). The methodology was applied to three actual freeway corridors in California: I-210, I-880, and I-10. The study concluded that non-recurrent delay was between 13% and 30% of the total delay along the three study corridors, and this portion of delay depends heavily on the extent of recurrent delay.

Sources of NRC

A study by Oak Ridge National Laboratory (ORNL) further categorized the causes of non-recurring congestion. Non-recurring congestion is also sometimes referred to as temporary loss of capacity (TLC). According to a study by the Oak Ridge National Laboratory, the primary causes and contribution of non-recurring delay include crashes, work zones, vehicle breakdowns, adverse weather and signal timing (Chin, Franzese, Greene, & Hwang, 2002). Figure 1.3 presents the relative frequency of these causes of non-recurring congestion according to ORNL.

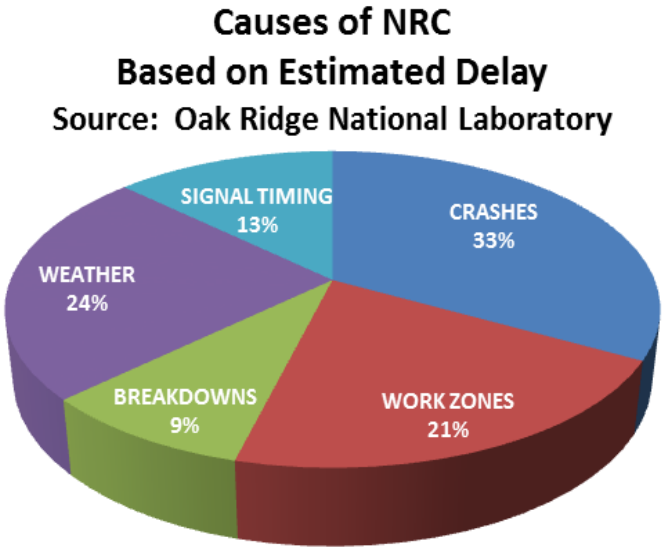


Figure 1.3 – Sources of NRC

A 2003 study (Hallenbeck, Ishimaru, & Nee, 2003) in Washington State focused on NRC on urban freeways resulting from lane-blockages found:

- The percentage of delay resulting from non-recurring congestion was highly variable;
- Lane blockage incidents were responsible for 2 to 20% of total daily delay;
- Non-recurring delay is responsible for 30-50% of all peak period, peak direction delay but is responsible for 30-70% of total daily delay;
- Lane blockage incidents generally account for 10-35% of total non-recurring delay;
- Only 1 – 10% of peak period delay was caused by lane blockage incidents due to high levels of recurring congestion and the relatively infrequency of lane blockages during the peak periods; and
- Expressing non-recurring delay as a percentage of total congestion does not adequately describe the magnitude of the problem because the number of vehicle hours of non-recurring delay can increase significantly.

NRC Source – Incidents

A lane blocking incident of a short duration during a peak or near-peak period can result in substantial delays well after the blockage is removed. In Phase 2 of this referenced study, the test was extended to include an examination of the effects of incidents involving the shoulders of the freeway; spillback from incident-caused congestion on one freeway that affects a second freeway that feeds traffic onto the initially congested facility; special events; and weather (Kopf, Nee, Ishimaru, & Hallenbeck, 2005).

The Washington State project showed that this process can be automated, making the data preparation effort now the primary determinant of the cost of additional work of this kind. Unfortunately, even with the addition of shoulder incidents, special events, and weather to lane blocking events, the automated process was unable to assign a significant proportion of the non-recurring delay occurring on Seattle freeways. The detailed analysis of freeway performance showed that much of the delay caused by specific incidents occurs in places or at times removed from the incident itself. The result is that much of the observed non-recurring delay cannot be assigned to specific causes by the current analytical process. The Phase 2 analysis also confirmed that the congestion effects of specific incidents and other traffic disruptions are highly dependent on the background traffic conditions at the time of the disruption.

A study by the University of California Irvine further looked at the contribution of incident characteristics on the congestion caused by the incidents. The report provided a review of a research project for measuring non-recurring congestion impacts of crashes (Recker, Golob, & Yazdan, 2007). The objective of this project was to develop and apply an analytic procedure that estimates the amount of traffic congestion (vehicle hours of delay) that is caused by different types of crashes that occur on urban freeways in California. Computations of non-recurring delay were successfully performed for 870 crashes that occurred on weekdays throughout the period of March through December 2001 on the six major Orange County non-toll freeways. The results of the study indicate that the following crash characteristics are crucial in identifying those crashes that are likely to cause the most delay: (a) how many vehicles are involved in any crash occurring during the weekday AM peak, and whether the crash is in the left lane or not, (b) how many vehicles are involved in a crash occurring in the midday period, and whether there is a truck involved in the crash, (c) which lane a PM peak period crash is located in, and whether or not it is a single-vehicle crash, (d) whether or not a truck is involved in any crash, and finally, (e) whether or not the crash occurs on Friday.

Another study in California analyzed the data on I-880. The study presented the findings from the analysis of incident data collected as part of the I-880 field experiment, originally conducted to evaluate the effectiveness of the freeway service patrols implemented at a particular freeway section (Skabardonis, Petty, Bertini, Varaiya, Noeimi, & Rydzewski, 1997). The I-880 field experiment produced one of the largest databases on incidents and freeway traffic-flow characteristics at the time, which included data on incidents and speed-flow-occupancy rates, and probe-vehicle runs (at seven minute headways) along the study corridor.

The researchers define incidents as crashes, vehicle breakdowns, spilled loads, or any other random event that reduces the capacity of the road and causes congestion if the traffic demand exceeds the reduced capacity at the incident location. The impact of incidents on traffic flow depends on the incident frequency, location, type, severity, and duration; the traffic demand and capacity at the facility; and the availability of incident management programs. The results of the field data analysis revealed that during the study, there was an average of 47 incidents per day during the peak period. Most of these incidents were vehicle breakdowns on the shoulder, but 10% were crashes, and 4% blocked travel lanes. Time of day, day of the week, presence of shoulders, traffic volumes, and weather conditions accounted for the variability in the incident occurrence. Incident response, clearance times, and durations were reduced from 29 minutes to 18 minutes, and the response time to assisted breakdowns was reduced by 57% after the implementation of freeway service patrols.

NRC Source – Weather

In a Washington State study, researchers evaluated the qualitative relationship between weather patterns and surface traffic conditions in Seattle using data from two data mines at the University of Washington (Dailey, 2006). Seven freeway loops in north Seattle that were paired with inductance loops and in a known convergence zone (known to expect more rainfall) were examined in this study. The research concluded that while rainfall does affect traffic conditions, other congestion causes may outweigh the effect of weather. A more recent and comprehensive study, the SHRP 2 Analytical Procedures for Determining the Impacts of Reliability Mitigation Strategies, reported that bad weather (rain) made up 17.7% of delay which was almost as much as vehicular crashes in Seattle.

Obviously, the impact of weather on NRC will be highly dependent on a region's climate. A check of the National Climatic Data Center (NCDC) of the National Oceanic and Atmospheric Administration (NOAA) website, http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms, for any weather events (e.g., dust storms, rain, thunderstorms, etc.) for 2009 and 2008, in Maricopa County, was performed. It showed there were 33 and 56 of these events, respectively. In fact, two-thirds to three-fourths of these events occurred between July and the middle of September.

NRC Source – Work Zones

Work zones narrow lanes or reduce the total number of lanes available. They also can reduce speed limits and frequently include right/left lane shifts. Essentially, these physical changes decrease available or effective roadway capacity. The SHRP 2 study showed only 1.2% of Seattle's delay was due to construction on major urban freeways. However, this percentage only included lane closures during active construction or maintenance activity along the roadway (i.e., delay construction closures are only allowed to occur on urban area freeways during the late night hours or weekends, when volumes are low). Thus, even when congestion is significant (measured in terms of either the queue length or the amount of time an individual spends in that queue) as a result of construction lane closures, total vehicle delay (vehicle-hours) is small relative to the amount of delay experienced in the peak periods when volumes are high. Additionally, the database did not include "long-term" construction activities, such as narrowed lanes during lengthy construction projects or the presence of construction barrels on shoulders

in and approaching the work zone, which are likely to also cause minor disruptions in "normal" traffic flows.

NRC Source – Special Events

Special events can cause congestion because they create significant fluctuations in demand. The starting and ending times of major events create surges in traffic demand that overwhelm roadway capacity near the event. However, the SHRP 2 study demonstrated the difficulty in quantifying the impacts of special events relative to NRC. Many variables exist such as, no uniform definition of special events in terms of minimum attendance, inconsistent durations (i.e., variable end times), sporting events vs. community events, etc. It concluded that, "…special event data need to be applied on a site-specific basis and, therefore, require not only descriptive information (time, location, and size) but also local knowledge of the likely routes of travel affected by the event."

NRC Source – Traffic Control

Signal malfunctions and out-of-sync signal timing result in less than optimal operations, causing congestion. As a worst case, the malfunction can result in flashing or all-way stop operation. This would cause every vehicle to stop at the intersection, creating long queues as capacity was reached. Out-of-sync operation of a signal running free with no cycle length could result in more stops and delay on the arterial. Out-of-sync operation with a clock that has drifted, resulting in a less than ideal offset, would also result in more stops and delay on the arterial street.

Impacts on Freight Industry

Congestion also has an impact on the trucking and freight industry. The trucking industry moves nearly 60 percent of the tons of freight in the U.S. Freight moved by trucks is dependent on the transportation roadway infrastructure and the level-of-service maintained on those roadways. Congestion on these roadways is a cost to the trucking industry, but non-recurring congestion has a greater impact due to its unpredictable nature.

A 2007 New Jersey study by Rensselaer Polytechnic Institute on congestion impacts to the trucking industry notes that "Recurring delay (delay due to congestion) is detrimental to the movement of freight on the highway. But… recurring delay can be accounted for in trucking companies' cost calculations and scheduling. Non-recurring delay… cannot be anticipated due to the unpredictable nature of its occurrence. As such, trucking companies cannot adjust cost calculations and schedules giving less reliability in the delivery time of goods (especially in congested urban areas during peak hours)."

COUNTERMEASURES FOR NRC

This section of the technical memorandum discusses literature findings on countermeasures for non-recurring congestion. The countermeasures listed here are grouped by the source of non-recurring congestion that can be reduced by a given countermeasure.

Countermeasures for NRC Caused by Incidents

Because incident congestion is a major factor in non-recurring congestion, there are several studies in the literature reviewed that focus on the countermeasures to reduce congestion caused by incidents.

Improved Incident Management Programs/Procedures

Cunard conducted a review of various incident management programs that have been implemented throughout the United States (Cunard, 2000). Cunard used the definition of an incident (mechanical failure, crash, abandoned vehicles, roadway debris, etc.) as a random event that is unpredictable in

relation to its time and location and that non-recurring congestion is typically caused by incidents. He defined incident management as a planned and coordinated, possibly a multi-agency/multi-jurisdictional, process to detect and remove highway traffic disruptions and restore capacity as safely and quickly as possible. The effectiveness of an incident management program depends on how well the following are administered: incident detection, incident verification, incident response, incident site management, traffic management/motorist information, and incident clearance time/recovery. The paper also describes the costs of incident management programs, and provides several examples of programs to suit any budget. Low-cost incident management programs include incident management trailers, route diversion plans (shown through detour signs, DMS, etc.), push bumpers (installed on law enforcement vehicles to remove disabled vehicles), designated crash investigation sites, "Move It" Programs (programs that stress the need for motorists to move vehicles from the roadway after a crash immediately), freeway service patrols, and technological improvement in crash data collection. Medium-cost management programs include major incident response teams, creating an incident reporting telephone number, and telephone call boxes strategically placed along the roadside. High-cost programs include traffic operations centers, incident detection/verification techniques (electronic surveillance, CCTV, AVI, fixed observers, aerial observance), and advanced motorist information techniques (DMS, highway radio, traffic reports on television, Internet, etc.).

A paper on incident management in Alabama reports on an approach used to evaluate the mobility-related benefits of freeway service patrols achieved by quicker incident response and clearance as applied to the Alabama Service and Assistance Patrol (ASAP) operating in the Birmingham area (Heath & Turochy, 2009). The evaluation tool uses ASAP data as well as simulation modeling, and also produces a detailed benefit-cost analysis of the ASAP program. The results of the study show that the ASAP program reduced both delay and incident duration, and indicate that the program is cost-effective with regard to incident management.

Another paper on incident management in Florida describes the effort to apply data mining techniques to query service patrol databases for incident analyses (Zhan, Gan, & Hadi, 2006). The Florida DOT applied geocoding techniques to data in the service patrol databases for Broward and Palm Beach Counties to determine the exact location for each "incident" listed to conduct specific incident analyses on service areas with the highest incident frequency. Incident analysis based on spatial information can be used to identify locations with high incident rates, which could lead to rescheduling service patrol vehicles, changing the services areas, or other methods to improve the service. The results of the study show that geocoding was used to assess the service quality at different service areas and to identify target areas for service improvement.

The Road Ranger program in Florida is a freeway service patrol (FSP) that was designed to assist disabled vehicles along congested freeway segments and also to relieve peak period non-recurring congestion through quick detection, verification, and removal of freeway incidents in the State of Florida (Zhou, Hagen, Singh, & Clark, 2006). It consists of approximately 88 vehicles in fleet and provides its free service along 918 centerline miles. The program is funded by the Florida Department of Transportation and its partners, and is bid out to private contractors. A study was conducted to examine and evaluate the benefits of the Road Ranger service patrol against their operating costs in five Districts and the Florida Turnpike Enterprise in Florida (Zhou, Hagen, Singh, & Clark, 2006). The Road Ranger program provides direct benefits to the general public in terms of reduced delay, fuel consumption, air pollution and improved safety and security. The benefit would be expected to be more significant during peak periods when demand reaches or exceeds capacity than in off-peak and mid-day periods where capacity may not be as significant an issue. The costs considered in this analysis include costs of administration, operation, maintenance, employee salaries, and overhead costs. Incident data were

obtained from the daily logs maintained by the Road Ranger service providers containing important information about the time, duration, location, and type of service provided. Other data collected for this study include average daily traffic volume, geometric characteristics of freeways, unit cost of Road Ranger service, etc. The Freeway Service Patrol Evaluation (FSPE) model developed by the University of California-Berkley was calibrated and used to estimate the benefit-cost ratio for the Road Ranger program. The estimated benefit/cost ratios based on delay and fuel savings indicate that the Road Ranger program produces significant benefits in all five Districts and the Turnpike. The range of benefit to cost ratios of Road Ranger programs in different districts is from 2.31:1 to 21.4:1.

Another study examined the communications aspect of incident management on arterial streets (Raub, 1999). According to the research, the successful and rapid clearance of an incident is dependent on the coordination of operations, expedited removal of elements interfering with traffic, and the consideration of traffic movement and how an incident will affect that movement. The author states that on-scene coordination may be the most important element related to reducing the time that an incident affects traffic. There should be inter-organization communication and an overall command in order to relay the correct information to all parties involved in the management of an incident, such as specific instructions for response, the need for traffic assistance or lane/road closure, etc. The author suggests providing education and training to the public on how to report incidents which will expedite the incident detection, clearance, and recovery time. The author also stresses the importance of communicating with en-route motorists to reduce delay and manage alternate routes should an incident occur.

Improved Traffic Management at Incidents

A study for the Michigan Department of Transportation investigated dynamic lane assignment (Michigan Department of Transportation and Michigan State University, 2003). Upon seeing signs informing motorists of a merge ahead, drivers will typically take one of two actions: they will merge early, moving from the discontinuous lane as soon as possible, typically creating a long, single-lane queue that moves at slow speeds, or they will merge late, waiting until the last opportunity to switch lanes, staying in the discontinuous lane and often forcing a merge at the point of closure. Dynamic lane merge (DLM) is an ITS technology that can be used in work zones to alleviate the congestion and crashes this mix of reactions can cause. The technology uses electronics and communications equipment to monitor traffic flow and, as queuing increases at approaches to lane closures, regulates the merge, requiring either early merge or late merge depending on traffic conditions. The results from the testing of early merge control found:

1. Average travel speed increased from 40 to 46 mph during the morning peak period.
2. Crashes were reduced from an average of 1.2 per month during the 4 months prior to activation to no crashes after activation.

A study in California looked at both traffic management and incident management impacts on incident congestion (Kwon, Mauch, & Varaiya, 2006). The paper presented a method to divide the total congestion into six components: congestion caused by incidents, special events, lane closures, adverse weather, the congestion that could be eliminated by ideal ramp metering, and the residual delay. The method was applied to a section of I-880 in the San Francisco Bay Area from January to June. The results of the study conclude that one-third of the congestion delay occurs at recurrent bottlenecks and could be potentially be eliminated by ideal ramp metering. Also, incidents and special events contribute to 18% of the delay, which can be reduced by more rapid detection and response, and information on DMSs.

A study for the Texas Department of Transportation examined ramp closures on freeways as part traffic management for incident management (Waller, Boyles, Fajardo, & Karoonsoontawong, 2007). The study examined incident severity as a measure to determine if a ramp closure should be considered. Microsimulation modeling was used to also look at ramp locations and ramp closure duration on effects of improving incident management.

Mei et al. conducted a research effort aimed at integrating wireless vehicular ad-hoc network (VANET) communication into a microscopic traffic simulation environment (Mei, Hu, Rouphail, & Lee, 2010). The simulation tools used for this study were DYNASMART-P, Aimsum, and Python, which emulated drivers' response to traffic messages distributed via VANETs. There were two networks involved in this study: the highway network and the VANET. Vehicles equipped with wireless communication capabilities move along the highway network and transmit data to other equipped vehicles, such as speed and location. There were two response types modeled in this study: Dynamic Route Diversion (DRD), which allows a driver to choose alternative paths to bypass an incident, and Variable Speed Limits (VSL), which minimizes abrupt decelerations due to reductions in roadway capacity. Eight scenarios were evaluated in this study, using different percentages of market penetration of equipped vehicles and incidents. The results of this study indicate that DRD or a combination of DRD and VSL is an effective way to alleviate congestion, but not VSL alone.

Improved Traveler Information

Richards and McDonald wrote a report evaluating the effectiveness of traffic information in an urban network by analyzing data from "real-life" case studies collected from seven locations in urban areas in the United Kingdom to assess driver response to DMS messages (Richards & McDonald, 2007). Traffic data was collected and analyzed for incidents occurring at each of the seven locations, and there were several key findings. For all case studies, there was evidence of drivers diverting because of an incident when an incident DMS message was displayed, but it was difficult to distinguish the effects of different information sources on the driver's behavior. The authors also concluded that there was not a conclusive correlation between incident severity and driver response, and the application of DMS in an urban area is likely to have only limited benefits.

Another research study evaluated the impact of DMS on toll road users in Orlando using a pre-deployment (one DMS) and a post-deployment (29 DMSs) survey analysis (Al-Deek, Vankata, & Flick, 2009). A detailed telephone survey was administered and modeling was performed to estimate the effects of DMS deployment on attitudes and behavior of toll road travelers. The study says that mitigating non-recurring congestion on toll roads is more critical because commuters who make trips on these facilities tend to assume that the out of pocket cost will ensure these facilities will provide them with the least travel time when compared to other alternatives. The modeling in this research compared the role of DMS in the pre- and post-deployment overall satisfaction and diversion behavior of the toll road commuters. The results of the study showed that DMS helped some commuters make diversion decisions in the event of congestion, but overall satisfaction did not change significantly.

A study by Hu et al. used simulation to examine traveler information. This paper describes the proposed advanced traveler information evaluation method and the accompanying DYNASMART-P case study that modeled the capacity reduction due to work zone activities in the Research Triangle region in North Carolina, and the relative effectiveness of various Advanced Traveler Information System (ATIS) scenarios (Hu, Williams, Rouphail, Khattak, & Zhou, 2009). The scenarios included a no work zone, no ATIS, existing ATIS, and two ATIS alternatives (20% and 30% ATIS). The results of the study concluded that as ATIS usage increased, the diversion rates increased, as drivers began to use alternate routes, the vehicles on the original route were reduced, and there were lower average travel and stop times. The

study also presents a benefit-cost analysis to determine the value of the ATIS benefits on the one-year work zone activity (resurfacing).

Rathi et al. describe a 'closed-loop' framework that integrated two tools, MITSIMLab and DynaMIT, to assess the impact of dynamic route guidance disseminated through Dynamic Message Signs in response to simulated severe crashes (Rathi, Antoniou, Wen, Ben-Akiva, & Cusak, 2008). The case study was based on a freeway from lower Westchester County in New York, where drivers commonly experience heavy traffic conditions during commute periods. Two scenarios were modeled separately using NYSDOT data, and were representative of the frequent closures and bottlenecks that occur on this network. The results of the study concluded that using DMS can significantly reduce the travel times due to incidents and non-recurring congestion in general.

A Washington State study looked at a threshold-based method to replicate different scenarios using loop detector data on freeways and arterials in Bellevue, Washington, which can quantitatively capture en-route travelers' real-time decision on diversion and the diversion's impact on the alternative route without the need for theoretical assumptions (Wu, Hallenbeck, & Wang, 2010). Two types of en-route travelers' diversion decisions were investigated: diversion on the freeway to the arterial when the en-route traveler observes congestion, and concurrent diversion to the alternative arterial while the main arterial is impacted by freeway diversion. Performance measures, including freeway downstream occupancy, diversion rate, ramp occupancy, and arterial occupancy and volume were used to investigate the cause and effect of the diversion based on different levels of congestion. The results of this study concluded that travelers tend to seek an alternative route when freeway traffic suffers from high congestion, but travelers are less responsive to non-recurring ("unusual") congestion.

Improved Data Mining and Analysis

The research presented in a paper by Lee et al. demonstrates how data mining can be used in deriving traffic diversion plans (Lee, Jeng, & Chandrasekar, 2002). According to the author, the ultimate goal of the traffic diversion plan under a non-recurring congestion situation is not only to divert the traffic to alleviate congestion, but also to control diverted traffic volumes effectively to prevent traffic breakdowns on alternative routes. The research mined and analyzed data generated from a simulation of an incident situation; and the results conclude that once an incident has occurred it takes more time to bring the traffic back to normal conditions. Therefore, timely action is necessary and alternative routes should be monitored closely while implementing the diversion plan.

The purpose of the research by Ozbay and Noyan was to develop a model that can automatically learn emerging patterns in data to aid in the prediction of incident clearance times (Ozbay & Noyan, 2005). By assigning values from a real data set to the decision variables, incident patterns were extracted and a "possible world" for the duration prediction problem is created. In this study, dependency networks are generated from predictors that affect the incident clearance times. The models presented in this paper could eventually be used by "decision makers," including traffic engineers, TMC operators, or transportation planners.

A California study examined a methodology to develop analytical tools to enable CalTrans to better measure and predict non-recurrent congestion throughout the state (Dowling, Skabardonis, Carroll, & Wang, 2004). The researchers define non-recurrent congestion as the amount of delay to the traveling public that is caused by any of all of the following: incidents (including collisions, breakdowns, and debris), work zones, special events, and inclement weather. In order to compute non-recurrent congestion, one must subtract the amount of recurrent delay from total delay. Two methodologies were developed: the freeway Performance Measurement System (PeMS), which uses data from surveillance

systems, and the recommended non-PeMS method, which is a more general and multipurpose method. There are several steps in the procedure for the application of the Non-PeMS Method, which are the selection of sample facilities/days, data collection and processing, estimating hourly demand for sample days, estimating capacity for sample facilities, computing recurrent delay, estimating incident-related delay (type, severity, and duration), estimating work-zone-related delay, computing weather delay, computing delay due to special events, and the extrapolation of results for quarterly, annual, and district totals.

Countermeasures for NRC Caused by Weather

To address non-recurring congestion caused by weather, road weather management systems can provide information on the impact of weather events on the roadway system. The US Department of Transportation has sponsored the development of Clarus weather information system to reduce the impact of adverse weather events on the surface transportation system. Better weather information can be turned into traveler information to allow travelers to make informed decisions about travel decisions, mode choice, and route choice.

Countermeasures for NRC Caused by Traffic Signal Timing

Incidents that cause non-recurring congestion on arterial streets are different than those on a freeway facility. A study conducted for the Texas Department of Transportation found that a single lane mid-block closure on an arterial street has a minor impact on roadway operations while a malfunctioning signal can have a dramatic impact (Short & Leudtke, 1994).

The study indicated that reducing the time to detect and respond to a signal malfunction could significantly reduce stops, delays, and fuel consumption. Reductions in detection and response times can be achieved with an effectively managed signal system. Other incidents such as railroad crossings, utility failures, and flooding that are not typically associated with freeways were also found to have significant impacts on arterial street operations. This is important to MAG because nearly two-thirds of all travel in the MAG region occurs on arterials.

Adaptive signal control and other non-traditional solutions are another countermeasure being implemented in an attempt to improve signal system efficiencies, reduce congestion, enhance signal control responsiveness to incidents, and reduce signal re-timing costs. A paper by Hunter, et al. presents the initial findings of a hardware-in-the-loop simulation (HILS) of ACTRA (time of day) and SCATS (adaptive) signal control on an eleven-intersection arterial section in Cobb County, Georgia (Hunter, Roe, & Wu, 2010). The initial findings indicate that during peak hours both control strategies provide similar performance, but at the hours bordering the peak hours, adaptive control (SCATS) provides control more tailored to the current conditions.

Countermeasures for NRC Caused by Work Zones

Smart work zones (SWZs) are being deployed around the United States as a way to inform drivers dynamically about traffic conditions within a work zone. These systems provide real-time information to travelers, informing them about traffic and impacts such as lane closures or speed reductions in and around work zones. SWZs use sensors to detect traffic flow conditions on the work zone approaches. These data are then used to alert drivers of congestion or speed differentials in an effort to improve operations or safety. Agencies that are considering deploying SWZs are often faced with the challenge of trying to justify the cost of an SWZ system to decision makers who may be more inclined to use the funds for more traditional maintenance purposes. Although a number of states have evaluated SWZ systems, there has not been much effort to identify trends across multiple tests or extend those findings to predict likely impacts of proposed deployments.

According to an FHWA document, "nearly 25 percent of non-recurring freeway delay, or about 482 million hours, is attributed to work zones (Federal Highway Administration, 2007)." The study further states the successful deployment of technology to provide traveler information at work zones led to the following benefits:

- Between 50 and 85 percent of drivers surveyed said that they changed their route at least sometimes in response to travel time, delay or alternate route messages provided by work zone ITS;
- Simulation indicated that queue lengths could be reduced from 56 to 60 percent; and
- Simulation also indicated system-wide total delay could be reduced from 41 to 75 percent.

A study in Michigan looked at speed management as a countermeasure to congestion in work zones. Static speed limits in work zones may not reflect current conditions, which can lead to low speed limit compliance and create high variance in vehicle speeds. A Michigan DOT 2003 study found that the speed limits displayed by VSL and operating speeds increased, driver compliance improves and more consistent speeds resulted.

Countermeasures for NRC Caused by Special Events

The research presented from a study by Lassacher, et al. applied a variety of traffic management strategies to manage congestion resulting from football games at Montana State University in Bozeman, Montana in 2007 (Lassacher, Veneziano, Albert, & Ye, 2009). A traffic management plan was developed for MSU home football games and incorporated several congestion mitigation strategies, such as real-time traveler information from DMS signs and public outreach programs, closures of roads that are not suited for heavy traffic volumes, traffic signal timing, and real-time traffic monitoring. The results of the study concluded that several types of strategies, such as signal retiming and manual traffic control, could be successfully applied in a rural community to manage congestion from planned special events. The study also found that inter-agency cooperation was essential to the success of this research.

A special event can cause non-recurring congestion and requires additional traffic management strategies. Another study investigated and evaluated manual traffic control at all-way, stop-controlled intersections during special events (Ye, Veneziano, & Lassacher, 2009). It first uses a simulation method to investigate saturation flow rate under manual operation. This method was then applied to field data collected at a special event in Bozeman, Montana to evaluate manual traffic control. The results of the study found that the signal length of manual operation was longer than what optimized signal timing should be, which demonstrated that the simulation method is useful in determining more effective traffic management strategies. The study also concluded that in order to develop a better manual control timing plan during special events, inter-agency cooperation is key, including the police department, the organization responsible for the special event, and the entities responsible for managing the roadway.

CHAPTER 2

METHODOLOGY FOR QUANTIFYING NRC

INTRODUCTION

The first objective of this study was to gain a better understanding of the role played by various random incidents related to traffic, weather, and special events that result in non-recurring traffic congestion on the freeway and arterial systems in the region. Such an understanding is recognized as a prerequisite for a more focused approach in applying operational countermeasures. Thus the study quantified the types and magnitude of NRC for the MAG region.

This chapter summarizes the work completed for Task 2 – Methodology for Quantifying Non-Recurring Congestion & Data Collection Plan. It outlines the approach that was used to quantify and analyze NRC, including the existing (historical) data and new data (field-collected) that was necessary to address the objectives stated above.

BACKGROUND

As discussed in Chapter 1, there have been a variety of attempts to quantify NRC and mitigate the congestion from non-recurring events. However, a study to do the same specifically pertaining to the MAG region has not been conducted previously. Moreover, the investigation of NRC at the arterial roadway level, which accommodates about two-thirds of all vehicle travel in the region, has been secondary in other studies. From information in Chapter 1, the national studies estimate that the sources of congestion are distributed approximately as follows:

- Bottlenecks (overcapacity) account for 29 to 40% of total congestion
- Incidents account for 25 to 42% of total congestion (42-60% of NRC)
- Work zones account for 10 to 17% of total congestion (17-24% of NRC)
- Poor signal timing accounts for 5 to 6% of total congestion (about 8% of NRC)
- Bad weather accounts for 6 to 15% of total congestion (8-25% of NRC)
- Special events/other account for about 5% of total congestion (about 8% of NRC)

Therefore, based on the prevalence of NRC and lack of previous studies pertinent to the MAG region and/or arterial roadways, this study assessed the total occurrence of NRC across the MAG region with respect to freeways and arterials for an entire calendar year.

Non-recurring congestion is defined as follows:

> *Congestion caused by atypical events such as highway crashes, sudden lane or road closures, weather conditions, or sudden traffic demand increases induced by a special event such as a football game. Non-recurring congestion can occur at any time, including midday, overnight, weekends, and also during peak periods when it adds to already present recurring congestion.*

Before investigating NRC, a discussion concerning the relationship between "congestion" and "delay" is needed. Characteristics of congestion include over-capacity traffic volumes, slow speeds, numerous stops, and long delays to motorists. Delay is the amount of time it takes to traverse a roadway segment minus the amount of time it would take to traverse that roadway segment at free-flow conditions (i.e., the posted speed limit). The delay incurred is usually the measure of effectiveness selected to represent the extent, or magnitude, of the congestion. Thus, the two terms may be thought of interchangeably, at least in context of freeway traffic operations where free-flow conditions result from the absence of congestion.

For urban arterial roadway environments, recurrent congestion and non-recurring congestion can be expressed similarly to freeways. The elements/events that cause non-recurring congestion on a freeway would still be the same potential causes of non-recurrent delay on an arterial, although the applicability and effects of each type of NRC is likely different. Traffic on an uncongested arterial roadway will likely incur some delay from signalized intersection traffic control.

The combination of NRC and recurrent congestion (or inherent delay) makes up the overall congestion/delay experienced by the motorist as shown in Figure 2.1's example comparison. This delay to the motorist can be measured at any point or time given the right data inputs. What cannot be discerned without further information is the proportional share due to NRC. In order to do this, a baseline representation of typical, non-NRC influenced conditions, must be developed. The same data then needs to be collected during a NRC event, and preferably multiple occurrences of the same type of NRC over a period of time to generate an average effect. When these data sets are compiled and compared, the resulting difference (increase) in delays experienced by motorists can then be attributed to the associated NRC event.

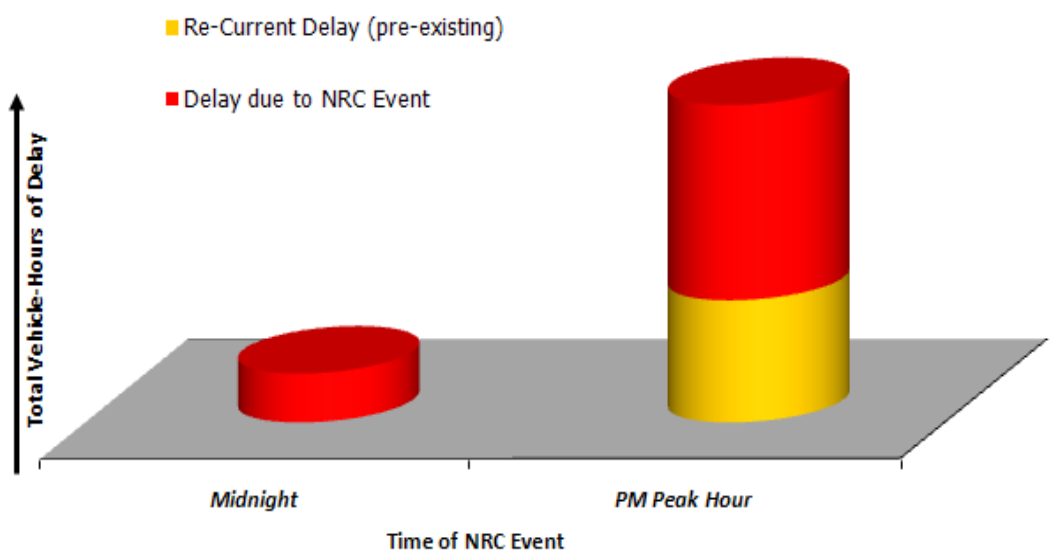


Figure 2.1 – Example Composition of Delay at Different Time Periods

METHODOLOGY FOR QUANTIFYING NRC

The general approach for quantifying NRC is to identify and measure congestion on "normal days" (i.e., days that do not have a non-recurring event) to compare with congestion on days with non-recurring events. The difference between congestion levels will be the congestion attributable to the non-recurring conditions. Travel time and speed data was the primary data used to quantify congestion.

The methodology for obtaining speed and travel time data is divided into two separate approaches for freeways and arterials due to the available data. For the freeways, the methodology relies on historical data (from 2009) that was available from the Arizona Department of Transportation (ADOT). Freeway data used in this study originates from lane-specific freeway sensors that are part of Arizona's Freeway Management System (FMS). The FMS gathers data from roadway sensors located between 1 mile and one-third of a mile on local freeways. Every twenty seconds, speeds, volumes, and occupancy (i.e., the duration of time that a vehicle is present at the sensor) are gathered by the FMS from each traffic controller, and archived for later retrieval.

The procedures for assessing NRC on a freeway are as follows:

1. Obtain freeway link travel time/speed data from the ADOT FMS database.
2. Segment the link data into morning peak period, evening peak period, and off-peak.
3. Divide the data into time periods affected by non-recurring events and time periods without any non-recurring events. Time periods without non-recurring events are nominally considered "normal" with the associated recurring congestion.
4. Calculate the congestion for "normal" time periods by corridor.
5. Calculate the congestion for time periods affected by non-recurring events by corridor.
6. Calculate the difference in congestion for "normal" time periods and non-recurring event time periods. This difference is the congestion due to non-recurring events.

The arterial speed and travel time data were obtained by a combination of newly collected travel time data and historical MAG data. The collection of new data could only be accomplished on a limited number of corridors due to the scope of the project. Thus, NRC congestion results from the new data collection were extrapolated to the other corridors with the help of historical MAG data and any other available data sources.

Non-recurring event information was available from the following databases (each of these data sources are discussed in more detail in subsequent sections of this chapter):

- Incidents – Private Data Sources in conjunction with the Arizona Location Identification Surveillance System (ALISS) and ADOT's Highway Condition Reporting System (HCRS)
- Work Zones – ADOT's HCRS, Phoenix's Temporary Restriction and Closure System (TRACS)
- Poor Traffic Control/Signal Operation – Agency signal maintenance records
- Inclement Weather – National Climatic Data Center, Weather Underground website
- Special Events – published schedules of major sporting and festival events

The newly collected arterial travel time data is from an arterial monitoring system that uses devices to anonymously detect and collect media access control (MAC) addresses from in-vehicle Bluetooth™ devices that happen to be within the traffic stream. The travel times were captured continuously, thereby capturing data sets pertaining to "normal" operations (i.e., typical recurrent delay) and pertaining to non-recurrent events. Similar to the freeway methodology, a baseline computation of the average delay incurred on the roadway was compared against the data collected during NRC events.

The resulting difference is the magnitude of delay attributable to the NRC event. The difference for the arterial methodology from the freeway methodology is the shorter data collection period. The freeway data covered an entire year of historical data. The arterial data collection occurred during a 20-week period from June 2010 through October 2010 in addition to data collected during the pilot test from May 2010 to June 2010. The non-recurring events were monitored in each arterial corridor during the data collection period.

The methodology for the arterial travel time data collection is highlighted in Appendices 2A and 2B. Appendix 2A provides a sample (pilot study) of data collected on 35th Avenue and on Bell Road in the City of Phoenix. Appendix 2B provides a complete description of the data collection unit installation.

NRC Data Sources

The factors impacting NRC must be collected and correlated with the travel time/speed data. The following NRC factors and data sources will be used in quantifying the causes of NRC. Each data source is described in more detail below.

Traffic (Volume, Speed and Travel Time)

With respect to freeways, ADOT's Freeway Management System (FMS) was utilized to obtain and extract traffic operations data (vehicle volume, speed, and lane occupancy) for the subject location/segment. The FMS gathers data from roadway sensors located about every one-third mile on local freeways. Every twenty seconds, speeds, volumes, and occupancy (i.e., the duration of time that a vehicle is present at the sensor) are gathered by the FMS from each traffic controller, and archived for later retrieval. Historical FMS data from 2009 was used, with any data gaps filled with data from earlier years, if needed.

Some of the arterial roadways in the MAG region have been outfitted with enhanced monitoring equipment as well. These SMART corridors, as implemented through the AZTech™ Model Deployment Initiative, were considered as possible sources for arterial traffic operations data similar to the FMS data. However, due to their limited extents and poor correlation with potential NRC events, the arterial traffic operations data was gathered directly in the field during the data collection task of the study. The arterial field data, in the form of travel times, was captured by performing anonymous wireless address matching (AWAM) of the MAC addresses of Bluetooth™ devices (see Appendix 2C for more details). Traffic volumes were also collected periodically by traditional means.

Construction/Work Zones

Freeway construction activity was gathered by querying private data, reviewing historical data from ADOT's Highway Condition Reporting System (HCRS), and from the City of Phoenix's specialized database. This data was used to determine if any lane closures or related construction activity contributes to NRC.

As discussed during one the project's Study Advisory Group (SAG) meetings, most cities have website postings of work zone/closure activities on arterials. City websites for construction activity/work zones were monitored for each identified corridor and any immediate parallel routes. To the extent possible, field data collection efforts were coordinated with scheduled work zone activities. Once data collection had initiated on a given corridor all work zone activities were logged and tracked.

Incidents/Crashes

Considering that the majority of NRC is related to traffic crashes or incidents, it was critical to compile a comprehensive crash database that considered not only crashes but also incidents such as minor

breakdowns or any non-police-reported events that may affect traffic. There were three possible crash/incident data sources to be used with the historical data. ADOT has two sources of incident data: the HCRS and the Accident Location Identification Surveillance System (ALISS). However, the HCRS source only reports incidents on the state highway system (freeways and arterials), and ALISS compiles and reports all roadway system crashes, albeit at a rate lagging behind present time since it is based on the receipt/input of law enforcement reports. Consequently, they will not include incidents like the examples cited earlier. The third source is private data which integrates most of this information in real-time including incidents off the state highway system. The three sources were evaluated but private data was the primary source with the other two sources used to supplement or clarify any data gaps in the private data.

For the arterial data collection being conducted on the project, the project team obtained incident information from the Regional Archive Data System (RADS) provided by AzTech. Phoenix Fire dispatch records within the RADS database offered detailed incident information for the study corridors.

Weather

Weather information was obtained from a web-based database called Weather Underground. Weather Underground has developed the world's largest network of personal weather stations (almost 10,000 stations in the US and over 3,000 across the rest of the world) that provides its users with the most localized weather conditions available. This data source has been used successfully in previous research for the United States Department of Transportation (US DOT).

The nearest available weather stations from Weather Underground was identified for each corridor. The historical data on these corridors was collected and monitored throughout the data collection process.

Special Events

All known major special event venues (e.g., stadiums, Phoenix International Raceway, Arizona State University, etc.) that could impact the study corridors are displayed in Figures 2.2 and 2.3 under the Initial Corridor Screening section. The project team obtained schedules from venue websites to monitor planned events during the field data collection phase. Any major planned community event (e.g., parades, festivals, state fairs, etc.) were also noted as these types of event may also affect traffic patterns; however, none occurred near the study corridors during the data collection period.

Traffic Control/Signal Operation Data

According to the National Traffic Signal Report Card 2007, timings are poorly maintained, monitored, and updated across the nation. This NRC study will be among the first of its kind to attempt to quantify the effects of signal malfunctions.

Signal malfunctions and out-of-sync signal timing result in less than optimal operations, causing congestion. As a worst case, the malfunction can result in flashing or all-way stop operation. This would result in stops for every vehicle on the street, creating long queues as capacity was reached. Out-of-sync operation of a signal running free with no coordinated cycle length could result in more stops and delay on the arterial. Out-of-sync operation with a clock that has drifted, resulting in a less than ideal offset, or from loss of communication would also result in more stops and delay on the arterial street. To collect this type of information, maintenance records from individual cities were reviewed to determine the frequency and duration of these events.

INITIAL CORRIDOR SCREENING

One of the project objectives was to make recommendations on candidate corridors for a pilot test of mitigation strategies for non-recurring congestion. During the data collection planning, the project team did some initial screening of corridors. In order to get the most out of the available data sources for the study, it was important that the corridors analyzed be carefully selected where there is known high traffic variability to capture the full impacts of NRC.

Through existing partnerships with private traffic data providers, the project team reviewed available private traffic data for the MAG region. The data showed inconsistent standard deviations for travel times/speeds, and thus did not reveal any clear trends that could be used to identify corridors. However, the team was able to utilize the MAG 2007 Travel Time Study in identifying the corridors with high variability (i.e., standard deviations) in their travel time for both freeway and arterials.

MAG provided a recent list of top 100 crash prone (crash risk) intersections and a map with the top 50 intersections. These intersections were identified based on MAG's Network Screening Methodology (NSM-I). This methodology is provided in Appendix 2D. These intersections' crash records were instrumental in identifying the arterial corridors with potentially unreliable travel.

Through coordination and consultation with various municipalities and local knowledge of the region, the project team identified some corridors with known/perceived variability due to high frequency of NRC. Based on the information gained from these sources, five proposed arterial corridors were identified and are shown in Figure 2.2. Alternative corridors are also shown which were considered, but not exercised, for additional data collection.

In addition, an initial assessment of available data on the travel reliability of freeway corridors in the MAG region was conducted by the project team. An initial list of corridors was identified from previous work done on urban mobility in the Phoenix area. The following five freeway corridors were determined to have the greatest unreliability in travel:

1. Loop 202 WB: 46th St to 22nd St
2. US 60 EB: I-10 to Loop 101
3. I-17 SB: Stack @ I-10 to I-17/I-10 Split
4. I-10 WB: Ray Road to Southern Ave
5. I-10 WB: Mini Stack @ L202/SR 51 to Stack @ I-17

These corridors are displayed in Figure 2.3.

Figure 2.2 – Candidate Arterial Corridors

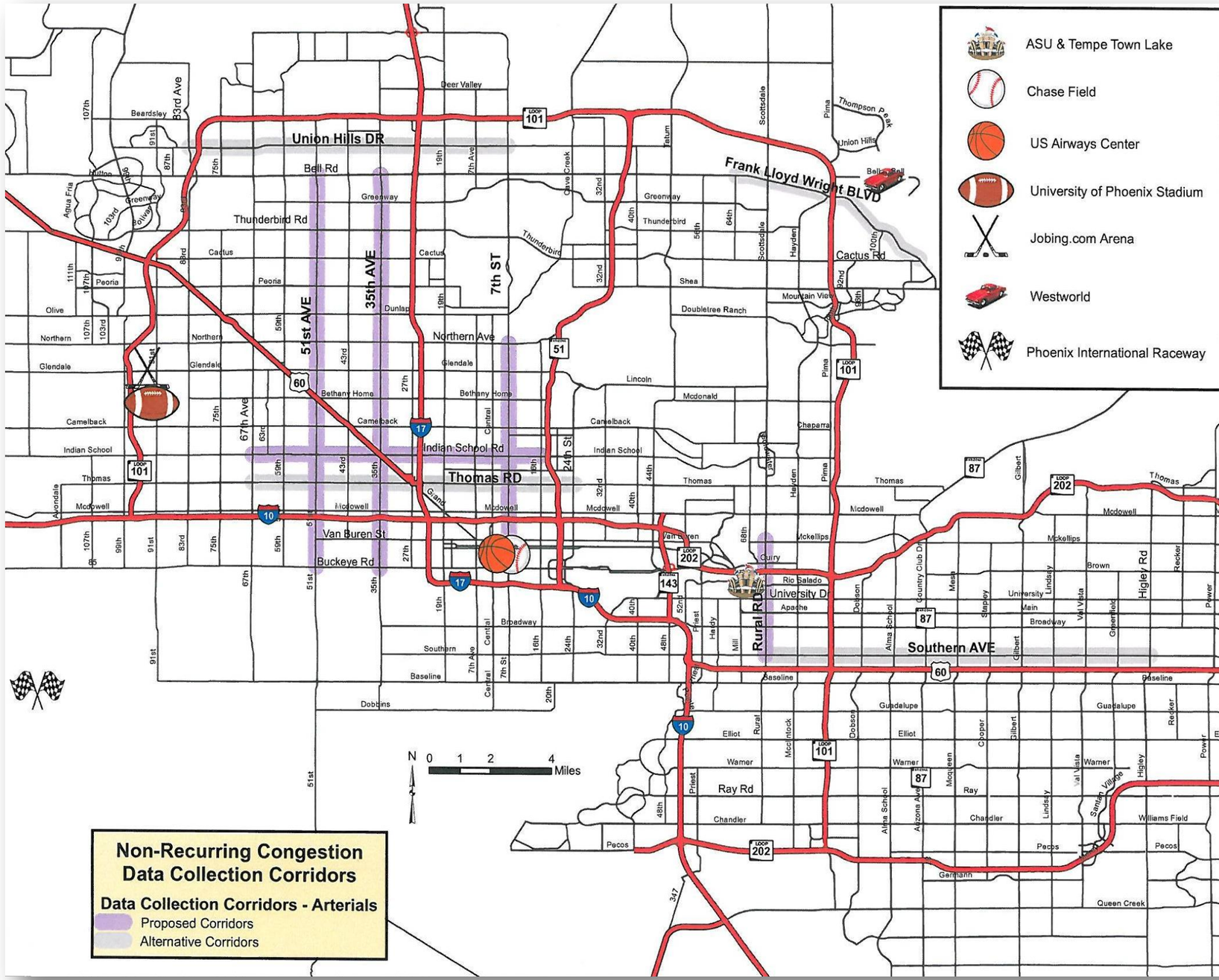
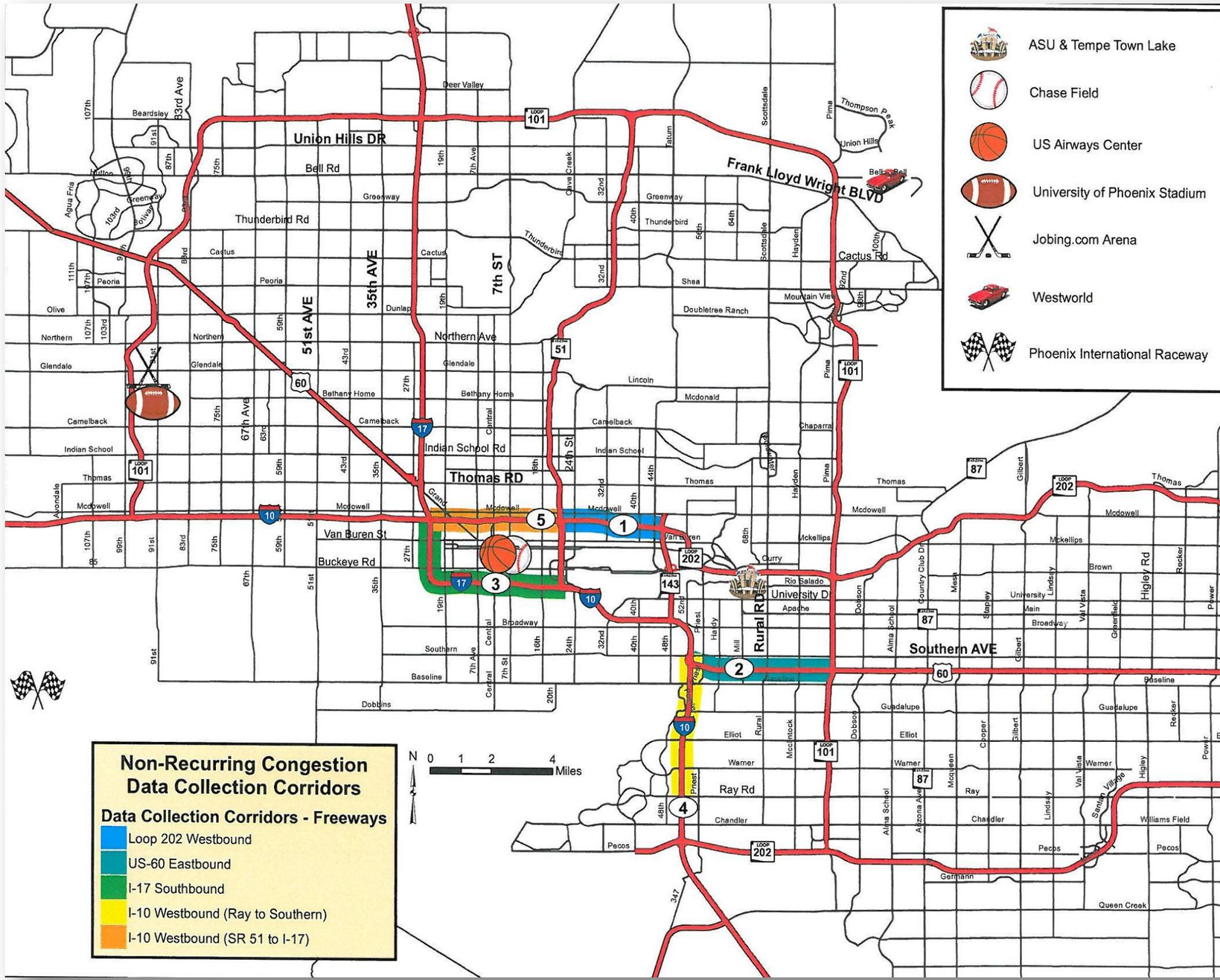


Figure 2.3 – Candidate Freeway Corridors



CHAPTER 3

DATA COLLECTION RESULTS AND ESTIMATION OF THE IMPACTS OF NRC

INTRODUCTION

This chapter summarizes the work completed for Task 3 of the study which entailed data collection and analysis. The data used was generated from in-field collections and review of historical databases. All of the information reviewed and analyzed culminated in the determination of NRC causes, the estimated delay due to NRC, and the concluded impact of NRC (and the benefits from reducing its effect).

DATA COLLECTION PLAN

The approach to obtaining and quantifying NRC delay was documented in Chapter 2. The effort was divided between arterial roadways and freeways, with the subject corridors presented to and approved by the Study Advisory Group in advance. The assessment of each roadway system relied on two general components: 1) traffic characteristics (e.g., volume, speed) and 2) NRC events which could manifest as incidents (crashes), work zones, weather, special event traffic, and/or traffic signal malfunction. The arterial corridor traffic characteristic data was accumulated primarily through the Anonymous Wireless Address Matching (AWAM) collection methodology. NRC events were compiled from a variety of sources, which will be discussed in the next section. The freeway corridor traffic characteristics were gathered from an extensive review of the 2009 database from ADOT's Freeway Management System (FMS). NRC events relating to the studied freeway corridors were documented primarily from information compiled from NAVTEQ.

ARTERIAL DATA COLLECTION & ANALYSIS

The selection of the arterial corridors analyzed in this study was based on several factors: potential for crashes; proximity to special event locations (e.g., sporting venues); cross-section geometry; feedback from the Study Advisory Group; and jurisdiction. The length of the corridors was dictated by the available number of AWAM devices (14) and the maximum spacing of devices (2 miles) that still yielded acceptable sample data. With five months allotted in the study schedule for data collection, the study corridor data was collected in three deployments ranging in duration from a few weeks to a couple of months. An initial test deployment, which ultimately contributed to the overall data set, was installed in May 2010 and remained in place for 3.5 months. This initial testing/use of the AWAM devices provided valuable data to convey to the Study Advisory Group and to refine the collection methodology for subsequent deployments. The characteristics of the segments created within the corridors by the AWAM device placement are documented in Table 3.1 below while the geographic extents of the deployments and the location of the AWAM devices are shown in Figure 3.1 on the next page.

Table 3.1 – Arterial Study Corridor Characteristics

	PRIMARY CORRIDORS				
Arterial Corridors (Directional Segment I.D. Numbers)	**35th Ave** (3-16)	**51st Ave** (17-26 & 35-40)	**Indian School Rd** (33-34 & 41-48)	**7th Street** (49-60)	**Rural Road** (61-70)
Terminus (N or W)	Bell Rd	Bell Rd	67th Ave	Northern Ave	McKellips Dr
Terminus (S or E)	Buckeye Rd	Buckeye Rd	7th St	Washington/ Lincoln	Southern Ave
Direction	N-S	N-S	E-W	N-S	N-S
Jurisdiction(s)	Phoenix	Glendale & Phoenix	Phoenix	Phoenix	Tempe
Centerline Miles	14	11	8	7.25	4
Average Cross-Section (N to S, W to E)[1]	2-1-3(NB)	2-1-3(NB)	2-1-3(WB) 3-M-3 3-1-4 3-1-2(WB)	2-R-3(NB) 3-1-3	3-1-3
Approx. Average Daily Traffic[2]	30,500['10]	26,000['10]	37,500['10]	27,500['10]	38,100['10]
No. of Top 100 Crash Locs[3]	13	7	5	3	3
No. of Top Crash Locs per mile	0.93	0.64	0.63	0.41	0.75
Serve as Fwy Diversion Rte?	YES (I-17)	NO	NO	NO	NO
Special Event Proximity	NO	NO	NO	YES (Chase Field)	YES (ASU)

	SECONDARY CORRIDORS						
Arterial Corridors (Directional Segment I.D. Numbers)	**Bell Road** (1 & 2)	**Thunderbird Rd** (27-28)	**Peoria Ave** (29-30)	**Northern Ave** (31-32)	**University Ave** (71-72)	**Mill Ave** (73-74)	**Rio Salado Pkwy** (75-76)
Terminus (N or W)	51st Ave	51st Ave	51st Ave	51st Ave	Mill Ave	Rio Salado Pkwy	Mill Ave
Terminus (S or E)	35th Ave	35th Ave	35th Ave	35th Ave	Rural Rd	University Ave	Rural Rd
Direction	E-W	E-W	E-W	E-W	E-W	N-S	E-W
Jurisdiction(s)	Phoenix	Phoenix	Phoenix/ Glendale	Phoenix/ Glendale	Tempe	Tempe	Tempe
Centerline Miles	2	2	2	2	0.75	0.50	0.85
Average Cross-Section (N to S, W to E)[1]	3-M-3	3-M-3	2-1-3(WB)	2-1-3(WB)	2-1-2	1-M-1	2-M-2
Approx. Average Daily Traffic[2]	37,800['10]	37,230['10]	32,750['10]	28,100['10]	26,640['08]	18,200['06]	11,900['07]
No. of Top 100 Crash Locs[3]	1	3	0	1	1	0	0
No. of Top Crash Locs per mile	0.50	1.50	0.00	0.50	1.33	0.00	0.00
Serve as Fwy Diversion Rte?	YES (L101)	NO	NO	NO	NO	NO	NO
Special Event Proximity	NO	NO	NO	NO	YES (ASU)	YES (ASU)	YES (ASU)

Notes:
1 - X-X-X represents # lanes in one direction, median use (M = raised median, "1" = two-way left turn lane, "R" = reversible lane), # lanes in other direction
2 - as collected for the study or from city/MAG data sources
3 - per a MAG study of crash rates

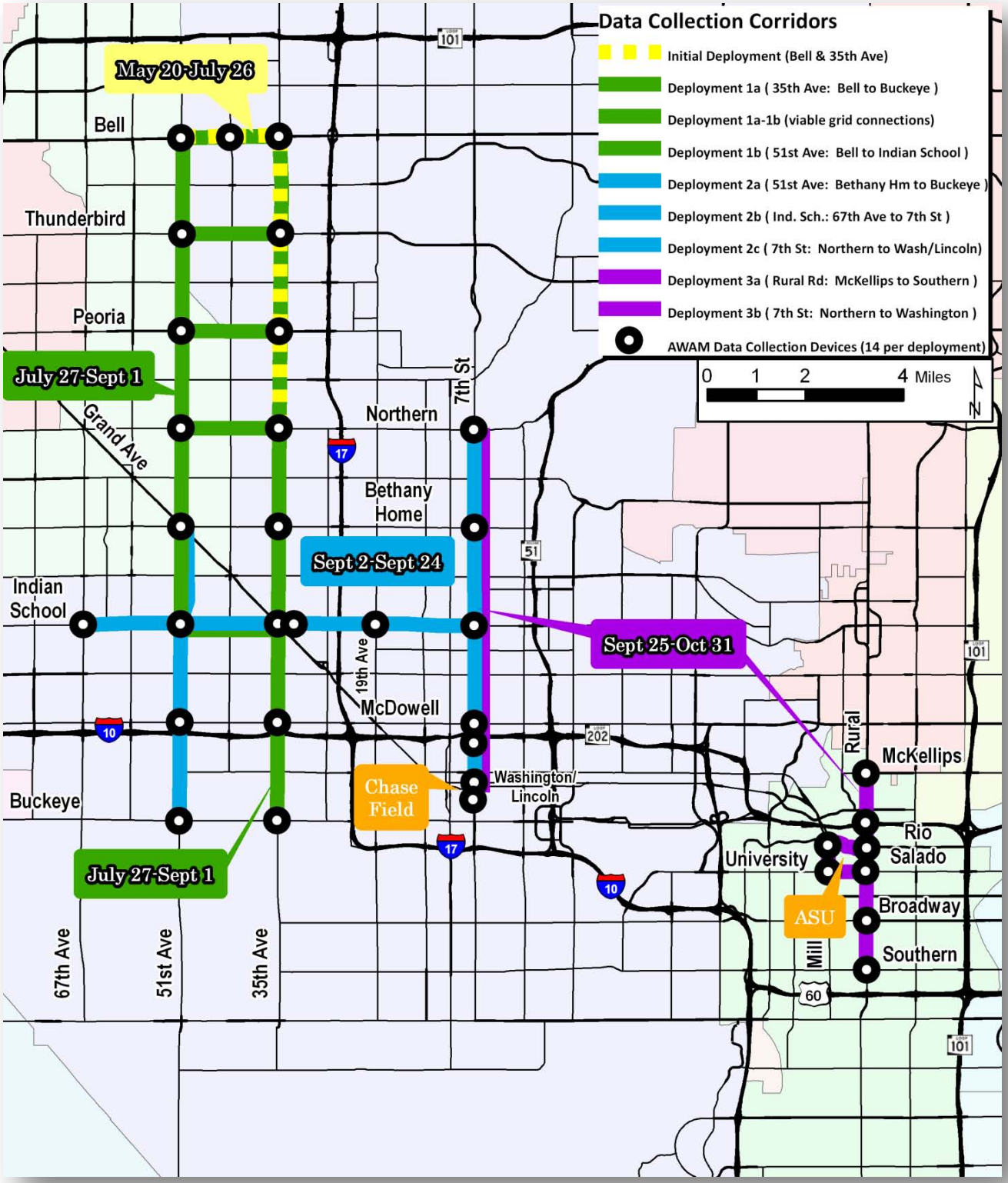


Figure 3.1 – Arterial Study Corridors & Data Collection Plan

Although a constant monitoring of traffic volumes on the subject corridors was not mandatory for this study, representative volume counts are needed to facilitate computations of the overall impact of non-recurring congestion in the form of vehicle-hours of delay. Therefore, representative 24-hour (minimum) counts were collected for the various corridors during the course of the data collection period. The volumes were collected using automatic traffic recorders which permit delineation of the traffic volumes in 10-minute intervals to aid in estimating the amount of traffic affected by transient NRC events. Other volume data available from MAG was used to supplement as necessary. Appendix 3A displays the volume data in tabular and graphical form.

Speed and Travel Time Data

Travel time data was obtained through the use of the AWAM devices, following the methodology presented in Chapter 2. The anonymous matching of the in-vehicle devices yielded travel time determinations for the segments defined by the deployment of the AWAM devices. Since the distances between the devices were also known, average travel speeds for the detected vehicles could also be determined. For the purpose of this study, the calculated travel times were used in the analysis since this measure correlates directly with delay incurred.

The AWAM device deployment covered 71 centerline miles and 377 centerline week-miles. There were 460,444 ten-minute intervals total for the 76 study roadway segments. For the recurring (baseline) weekday calculation, 264,449 intervals out of 309,445 (86%) were used. For the recurring (baseline) weekend, 128,448 intervals out of 150,999 (85%) were used.

Events that cause non-recurring congestion were recorded during the AWAM device deployment. Overall, there were 73,456 ten-minute intervals of NRC events out of 460,444 ten-minute intervals total (16%).

Table 3.2 shows a breakdown of the data collected by ten-minute interval. Table 3.3 summarizes the match rate obtained through AWAM. Table 3.4 shows a breakdown of the NRC events that occurred simultaneous to data collection by 10-minute interval.

Table 3.2 – Details of the Collected Arterial Data

	10-MINUTE INTERVALS COLLECTED	10-MINUTE INTERVALS WITH 1 OR MORE VEHICLE MATCH	INDIVIDUAL VEHICLE MATCHES	10-MINUTE INTERVALS IN BASELINE CALCULATION	VEHICLE MATCHES IN BASELINE CALCULATION
WEEKDAY	309,445	214,666	777,400	264,449	655,090
WEEKEND	150,999	107,033	328,952	128,448	281,818
TOTAL	460,444	321,699	1,106,352	392,897	936,908

AWAM match rates, relative to through traffic, were calculated using the 24-hour volume counts collected/obtained. This study deployed AWAM devices approximately 2 miles apart, collecting approximately 23 daytime (6 AM – 7PM) hourly valid matches or about 4 matches every 10 minutes. This match rate does allow for adequately matching travel time to non-recurring event data. The match rates for this study are slightly lower than those observed during prior studies in College Station, Texas and Houston, Texas where AWAM devices were deployed using 0.5 mile to 1.3 mile spacing.

Table 3.3 – AWAM Match Rate Summary

# Links	AADT Range	Length	Hourly Valid Matched Samples		Hourly Valid Match Rates	
			Average	Daytime Avg.	Average	Daytime Avg.
16	6,900 – 21,000	0.4 – 0.8	19	26	3.5%	3.0%
10	16,200 – 23,200	1.0 -1.8	21	28	3.0%	2.6%
50	6,200 – 30,800	2.0 – 2.2	15	21	2.8%	2.4%
76	**6,200 – 30,800**	**0.4 – 2.2**	**17**	**23**	**2.9%**	**2.6%**

Notes:
1. Daytime averages were weekdays from 6 AM – 7 PM.
2. Hourly valid match rates were hourly average valid matches divided by hourly directional traffic volumes.

Table 3.4 – Number of 10-Min Intervals for the Following Events

	10-MIN INTERVALS FOR:						
	ALL NRC EVENTS	VEHICULAR INCIDENTS	FREEWAY DIVERSION	WEATHER	CONSTRUC -TION	SPECIAL EVENTS	ATYPICAL TRAFFIC SIGNAL
WEEKDAY	50,221	2,150	112	1,025	41,988	758	4,188
	100%	4%	0%	2%	84%	2%	8%
WEEKEND	23,235	704	60	654	16,576	3,364	1,877
	100%	3%	0%	3%	71%	15%	8%

Causes of NRC

Per the literature review from this study, NRC on the arterial roadways was considered to be generated by six types of events:

- Incidents/Crashes
- Diversions from adjacent freeway closures
- Weather
- Construction/Work Zones
- Special Events
- Atypical traffic signal control such as preemption or flash (i.e., power failure)

Incidents/Crashes

There were two sources used to generate the data set for vehicular, motorcycle, and pedestrian crashes (incidents) on the study corridors. The first, and primary source, was the Regional Archived Data Server (RADS) which is administered by the Maricopa County Department of Transportation. The RADS database compiles logs of fire and emergency vehicle dispatches for the Phoenix metropolitan area. The other source for incident data was NAVTEQ. They compile their information from four types of sources: digital traffic sensors, GPS/probe devices within the traffic stream, private and government partners, and staff monitoring traffic conditions at operations centers. Since the NAVTEQ data provided accurate end times and the RADS data had more comprehensive arterial incident coverage, the two data sources complemented each other for the purposes of this study. The list of the vehicular incidents from RADS by corridor is included in Appendix 3B.

The initial dispatch time is assumed to be the start of the incident for the data obtained from RADS. If there are multiple dispatch logs for an incident, the last log is assumed to be the end of the incident. NAVTEQ data provided incident start and end times. When the last log in the RADS data was compared with the NAVTEQ end times, the duration of an incident lasted longer that the last dispatch indicated. Due to residual delay from a vehicular incident and the uncertainty of duration, a buffer of 10 minutes was applied before and 3 hours after the assumed/known start and end times, respectively. This is also consistent with the freeway analysis. Delay due to the incident that fell within these parameters was considered non-recurring. Application of this buffer allowed for calculation of delay without having a precise end time for the RADS data.

A comparative analysis of vehicular incidents collected by RADS and NAVTEQ on 35th Avenue during the arterial deployment months of June 2010 through August 2010 was conducted for this study. Table 3.5 displays the results of the comparison. The comparison of the two incident sources revealed that RADS captured more vehicular incidents than NAVTEQ on arterial roadways. Since NAVTEQ checks their incidents with RADS, there were no NAVTEQ incidents outside of the RADS data set.

Table 3.5 – 35th Avenue RADS vs. NAVTEQ Incident Comparison

Incident Type	Incidents Reported by NAVTEQ	Incidents Reported by RADS	NAVTEQ to RADS Match Rate
Injury Accident	40	64	63%
Motorcycle	1	5	20%
Pedestrian	1	5	20%
Bicycle	1	8	13%
Total	**43**	**82**	**52%**

Freeway Diversion

Freeway incidents on freeway segments parallel to the study corridors were obtained from the HCRS database, which provided start and end times plus detailed notes of each incident. Visual inspection of numerous freeway incidents indicated that 35th Avenue was the only arterial corridor in this study impacted by vehicle diversion when Interstate 17 had multiple or complete lane closures in either the northbound or southbound direction. Only freeway incidents that met these criteria and were adjacent to a corridor were included as a non-recurring event for that corridor.

Construction/Work Zones

With most of the study corridors located in the City of Phoenix, most of the construction/work zone information was obtained through querying of their Temporary Restriction and Closure System (TRACS) database. The database contains information, such as utility maintenance and roadway improvements, for planned/requested encroachments into the roadway right-of-way which could include roadway lane restrictions/closures. Systems similar to TRACS for tracking construction and work zone permits were not available for the other jurisdictions, so construction/work zone information was conveyed from phone interviews of the appropriate personnel. In these cases, the construction events either were deemed to be unrelated to the study corridor or were going to be occurring throughout the data collection period for the particular corridor/segment.

The available data does indicate which lane(s), if any, were blocked for construction; however, it is not known if and when the movement of construction equipment may be preventing vehicular travel on the open lanes adjacent to construction. For some construction activities, traffic signals may have been manually operated by police. Most construction permits required full traffic movements to be maintained at the intersections.

Weather

Weather patterns in the Phoenix metropolitan area are susceptible to isolated storms and events. Therefore, reliance on one weather station, such as Sky Harbor Airport, would not be a reasonable means of estimating non-recurring congestion effects from weather for the study corridors. Instead, the study relied on a network of individually run weather stations (see Figure 3.2) whose data is compiled by the website *wunderground.com* (i.e., "weather underground"). The stations record a variety of weather conditions such as temperature, humidity, wind speed/direction, and rainfall recorded (and the rate at which it fell). The rainfall rate data was used in conjunction with a threshold value established for the study (i.e., rainfall rates greater than 0.1 inches per hour) to determine when weather events may contribute to non-recurring congestion.

Stations were assigned to the corridors based on a number of factors. First, the stations were narrowed down based on the availability of that weather station during the duration of deployment. Weather stations were then further refined based on whether they collected rainfall data as not all weather stations are fully equipped. Finally, the weather station in closest proximity was selected to be used for the particular corridor.

Special Events

Based on the selected study corridors, there are three types of special events that may contribute to NRC. The 7th Street corridor is a primary means of ingress and egress for Chase Field (Arizona Diamondbacks) so the associated concentration of traffic generates non-recurring congestion. The Rural Road study corridor is adjacent to the Sun Devil Stadium in Tempe (ASU football), so similar NRC will be generated by traffic arriving and departing during Saturday home games. The Rural Road corridor and its adjunct loop on University Drive/Mill Avenue/Rio Salado Parkway will also capture any NRC associated with special events at the Tempe Beach Park which has a main entrance located at the northwest corner of Mill Avenue and Rio Salado Parkway. Days and times of the events were obtained from various sources associated with the specific venues. Dozens of other venues/events were investigated, but not included in the analysis as their number of expected attendees was too small (e.g., Tempe Improv), the major access from the freeway was not the study corridor (e.g., Tempe Center for the Arts), or the venue was more than a half mile away from the corridor (e.g., Dodge/Comerica Theater) to register an impact to delay per the study methodology.

Traffic Signal Control Changes or Servicing

Non-recurring congestion can be generated from atypical traffic signal operations at intersections. Signal control-related events that could cause NRC include emergency vehicle pre-emption, suspension of coordinated timing, when a signal goes into flash mode, manual operation of the signal, and signal control maintenance where lanes could be blocked to permit equipment replacement. Due to the collection effort, the traffic signal controller log data was generally obtained only for the intersections where AWAM devices were present even though signal controller events and NRC could be generated at the other traffic signals along the corridor. The logs were retrieved from the signal controllers or from city representatives with access to the information.

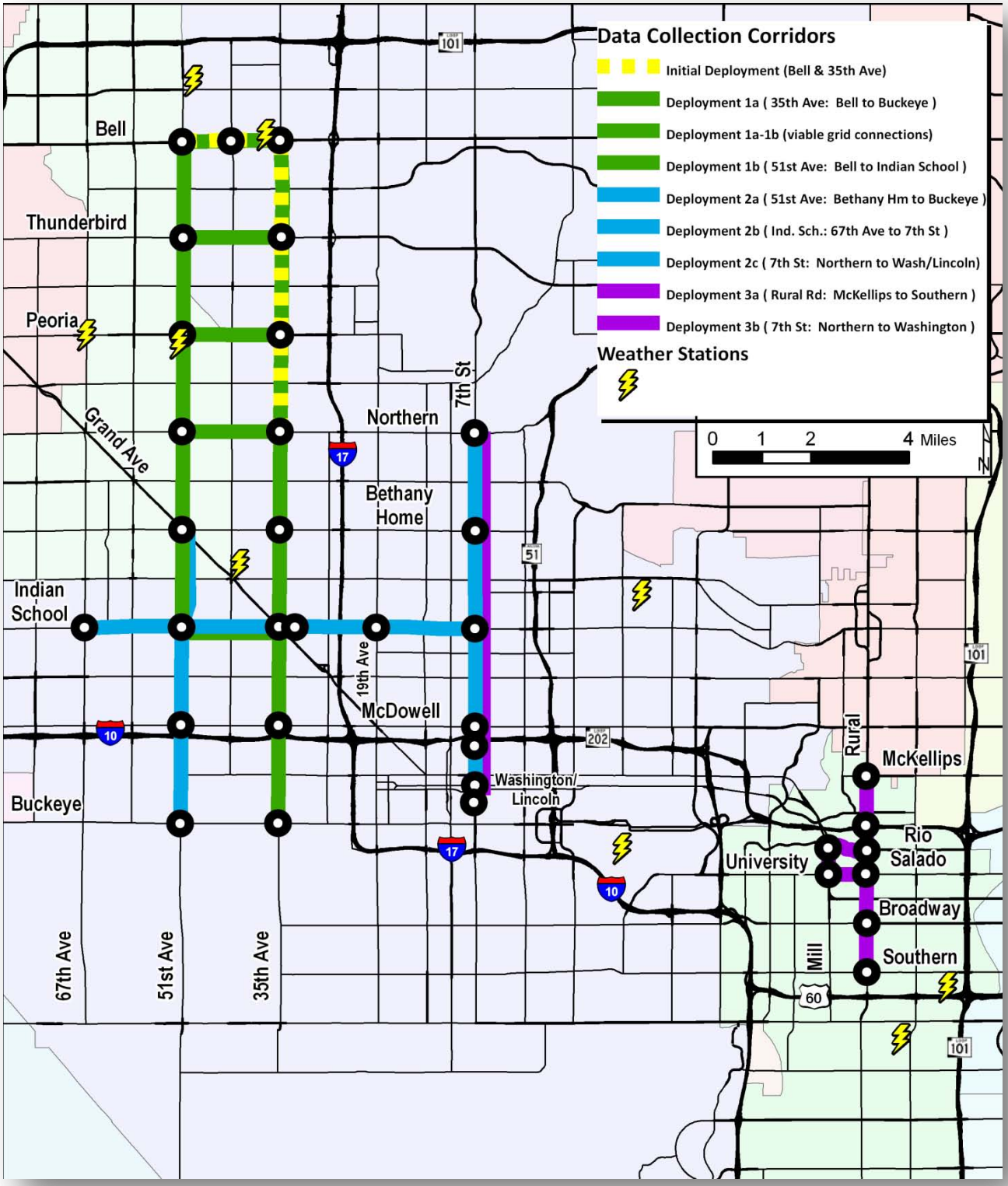


Figure 3.2 – Weather Stations Relating to Arterial Study Corridors

Delay Due to NRC

"Normal" recurring travel time for weekdays and weekends was calculated separately for each of the 76 roadway segments. For the weekday calculation, data for weekend days, holidays, and state furlough days were removed. Then time intervals were removed that had any vehicular incidents, freeway diversion, weather, special events, or atypical traffic control conditions. The remaining "normal" intervals were averaged per ten minute period of the day. These baseline conditions were then assigned, by time interval, to the complete weekday data set for a roadway segment. The weekend calculation of baseline conditions mirrored that of weekdays, except the weekend data set was comprised wholly of weekend days, holidays, and state furlough days combined.

A summary of the arterial roadway analysis for the 76 study roadway segments can be found in Appendix 3C. Table 3.6 through Table 3.8 provide a brief arterial analysis summary for each study roadway segment for weekdays, weekday peak hours, and weekends, respectively. Figures 3.3 and 3.4 provide a visual display of the percent of non-recurring congestion per study segment for weekday and weekends, respectively.

Table 3.6 – Arterial Analysis Weekday Summary

WEEKDAY RESULTS						
AWAM Equipped Segments	Recurring Delay (vehicle hours)	Non-Recurring Delay (vehicle hours)	Total Delay	% Recurring	% Non-Recurring	NRC Range
35th Ave Corridor (with Bell)	87,914	10,393	98,306	89%	11%	1% - 100%
51st Ave Corridor (with Thunderbird, Peoria, & Northern)	84,024	3,250	87,274	96%	4%	0% - 18%
Indian School Rd Corridor	48,526	11,951	60,477	80%	20%	1% - 76%
7th St Corridor	53,701	6,087	59,789	90%	10%	1% - 64%
Rural Rd Corridor (with Rio Salado, Mill, and University)	72,882	1,404	74,286	98%	2%	1% - 8%
Grand Total	**347,047**	**33,084**	**380,131**	**91%**	**9%**	**0% - 100%**

Table 3.7 – Arterial Analysis Weekday Peak Hours Summary

WEEKDAY PEAK HOURS (6 - 9 AM and 3 - 7 PM) RESULTS						
AWAM Equipped Segments	Recurring Delay (vehicle hours)	Non-Recurring Delay (vehicle hours)	Total Delay	% Recurring	% Non-Recurring	NRC Range
35th Ave Corridor (with Bell)	36,631	3,413	40,043	91%	9%	1% - 100%
51st Ave Corridor (with Thunderbird, Peoria, & Northern)	37,952	1,082	39,035	97%	3%	0% - 21%
Indian School Rd Corridor	25,163	5,973	31,136	81%	19%	0% - 84%
7th St Corridor	29,253	2,056	31,309	93%	7%	1% - 64%
Rural Rd Corridor (with Rio Salado, Mill, and University)	31,943	838	32,780	97%	3%	0% - 9%
Grand Total	**160,941**	**13,362**	**174,303**	**92%**	**8%**	**0% - 100%**

Table 3.8 – Arterial Analysis Weekend Summary

WEEKEND RESULTS						
AWAM Equipped Segments	Recurring Delay (vehicle hours)	Non-Recurring Delay (vehicle hours)	Total Delay	% Recurring	% Non-Recurring	NRC Range
35th Ave Corridor (with Bell)	25,144	4,620	29,764	84%	16%	1% - 71%
51st Ave Corridor (with Thunderbird, Peoria, & Northern)	27,618	2,133	29,751	93%	7%	1% - 33%
Indian School Rd Corridor	26,164	4,969	31,133	84%	16%	0% - 63%
7th St Corridor	15,901	5,906	21,807	73%	27%	0% - 94%
Rural Rd Corridor (with Rio Salado, Mill, and University)	30,167	4,397	34,564	87%	13%	0% - 56%
Grand Total	**124,993**	**22,025**	**147,018**	**85%**	**15%**	**0% - 94%**

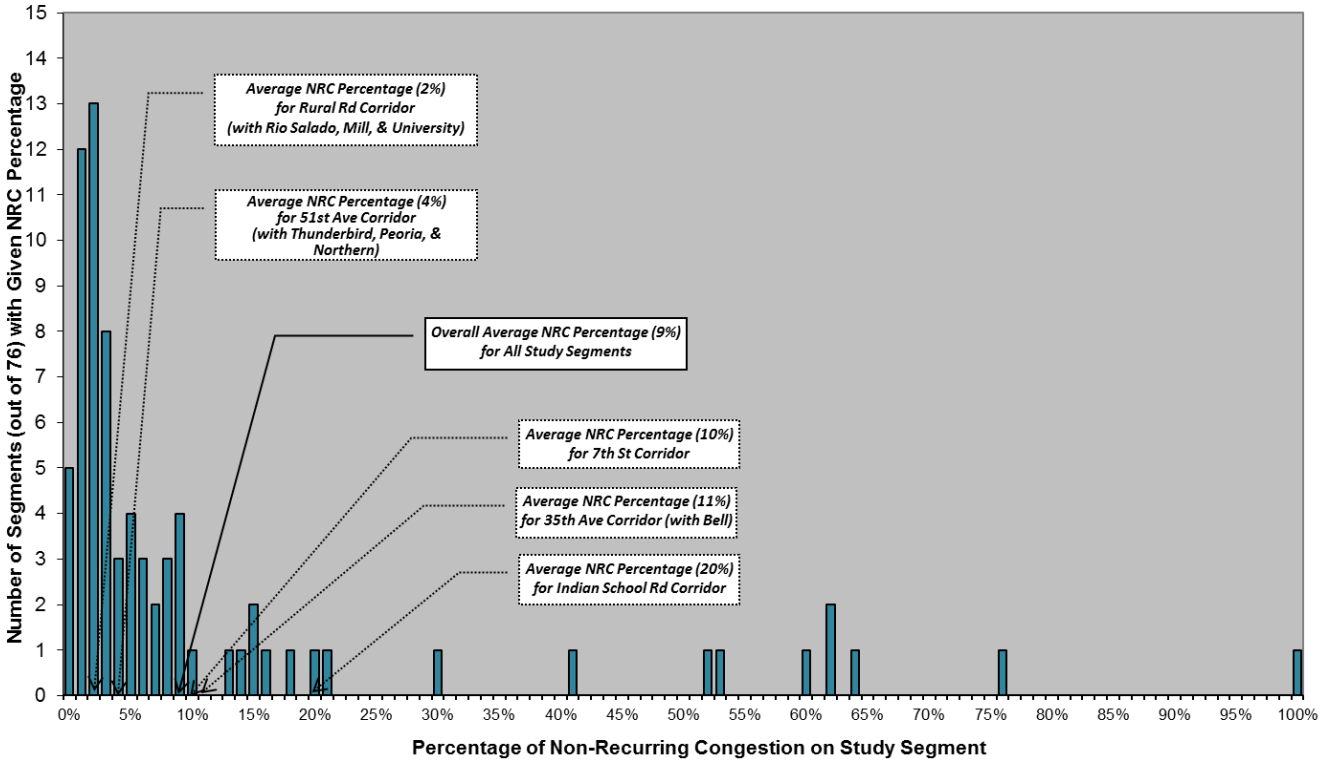


Figure 3.3 – Study Segment NRC Percentages – Weekdays

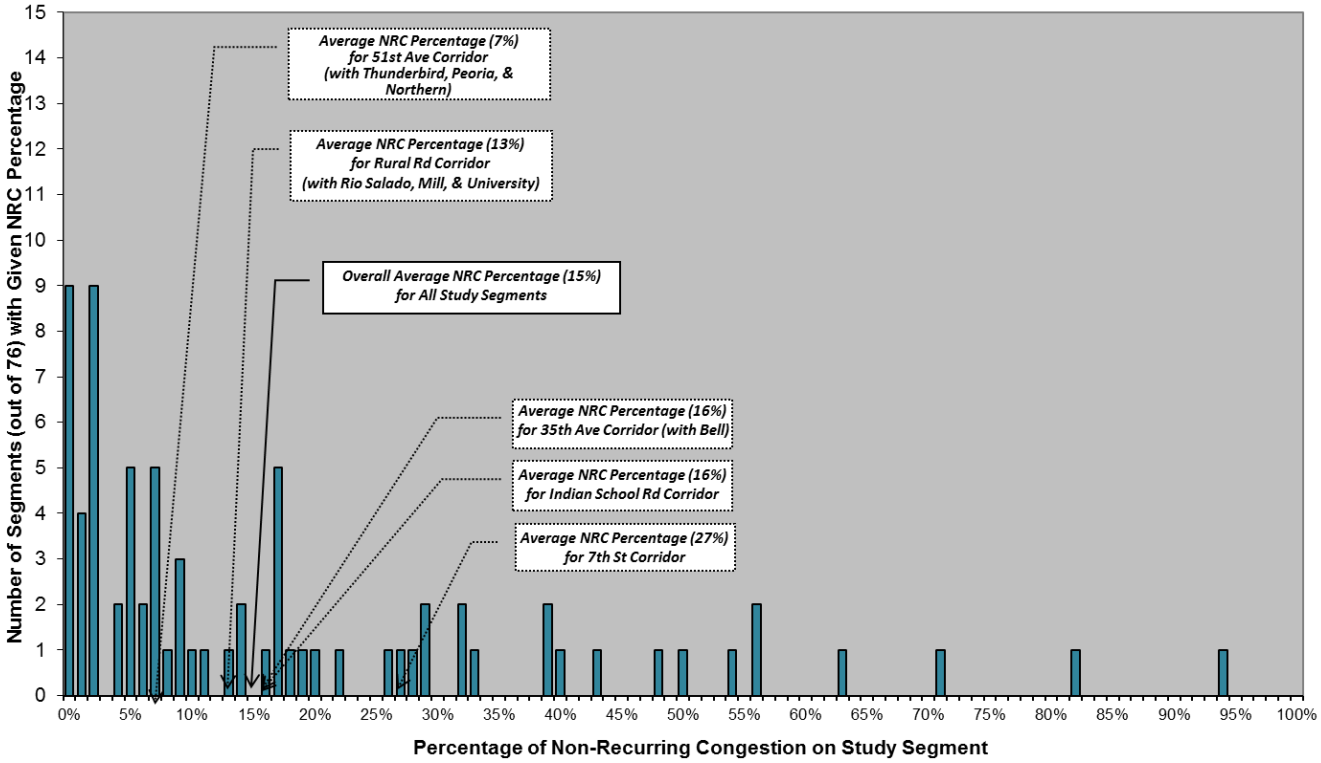


Figure 3.4 – Study Segment NRC Percentages – Weekends

During the study period, the 35th Avenue corridor experienced numerous incidents and construction activities. Most construction activities were inactive during peak hours, but occurred during the day. Thirty-fifth Avenue, south of I-10, experiences a greater concentration of truck traffic due to industrial land uses in the area. Bell Road has an interchange with I-17, one mile east of 35th Avenue. Thirty-fifth Avenue has an interchange with I-10, one quarter mile south of McDowell Road. Grand Avenue intersects 35th Avenue at-grade at Indian School Road although eastbound/westbound through traffic on Indian School Road can avoid the intersection by using its existing overpass.

The 51st Avenue corridor traverses the Cities of Phoenix and Glendale and serves as a typical suburban arterial. The roadway has an interchange with I-10, about one quarter mile south of McDowell Road. Grand Avenue intersects 51st Avenue at-grade at Bethany Home Road although northbound/southbound through traffic on 51st Avenue can avoid the intersection by using its existing overpass. Due to this roadway configuration and the signal cabinet location, only a small number of AWAM matches were obtained for Bethany Home Road; therefore, Bethany Home Road was not included as a secondary study corridor.

The Indian School Road corridor was under construction from approximately 6 AM to 6 PM during the entire data collection period according to TRACS.

The 7th Street corridor was used by Chase Field traffic on game days, which occurred on both weekdays and weekends. This corridor is unique in that it has a reversible lane on a greater portion of the corridor (beginning/ending just north of McDowell Road). The reversible lane serves southbound traffic during the AM peak period (6-9 AM) and northbound traffic during the PM peak period (4-6 PM). During these times, left-turns at major intersections are not permitted. Seventh Street has an interchange with I-10, one quarter mile south of McDowell Road.

The Rural Road corridor experienced very few incidents and deployed special event traffic control plans. The City of Tempe has an established traffic control plan for an extensive area surrounding the stadium. Restrictions include time-based controls (per the stage of the football game) that may limit intersection turn options and/or complete closures of certain directions of roadways (whether collector or arterial classification). Special events at Sun Devil Stadium and Tempe Beach Park only occurred on weekends. Rural Road, University Drive, Mill Avenue, and Rio Salado Parkway, in the vicinity of Arizona State University, are also heavily used by bicyclists and pedestrians. Due to low average vehicular speeds on Mill Avenue, it is possible that some of the AWAM matches were obtained from Bluetooth™ devices carried by a bicyclist. Rural Road has an interchange with SR 202, one half mile north of Rio Salado Parkway, and with US 60, one half mile south of Southern Avenue.

Since NRC is the difference between the recurring travel time (baseline conditions) and the actual travel time during an NRC event, the natural variation in travel time due to driver behavior and signal timing had to be filtered. Therefore, NRC was only calculated when the difference in travel times was at least 30%. This threshold was based on visual inspection of numerous examples and differed from the threshold used in the freeway analysis since arterial travel times were considered inherently more variable. The difference in travel time was multiplied by the volume for the time interval to convert the NRC to vehicle-hours of delay.

Recurring congestion was calculated when the difference between the free flow travel time and the recurring travel time was at least 30% for each interval without an NRC event. The free flow travel time was taken as the minimum recurring travel time as determined from the field data. This difference in travel time was multiplied by the volume for the time interval to obtain vehicle-hours of delay.

With six different sources of non-recurring congestion – vehicular incidents, freeway diversion, weather, construction, special events, and atypical traffic control conditions – the non-recurring delay could have been collected among 63 different possible combinations. For example, 1 = vehicular incidents, 2 = freeway diversion, 1+2 = vehicular incident + freeway diversion and so on. The data captured during the study did not register any combinations of NRC events greater than three occurring in any of the ten-minute periods.

The intervals with non-recurring congestion were assigned to one of six primary causes: vehicular incidents, weather, construction, special events, signal control, and freeway diversion. In cases where multiple causes occurred simultaneously, the associated NRC was divided and assigned according to the percentages presented in the Cambridge Systematics/TTI study (see Figure 3.5 below). Freeway Diversion was proportioned using the percentage shown for Traffic Incidents. These proportioned values were then summed to get the total NRC attributable to the primary causes.

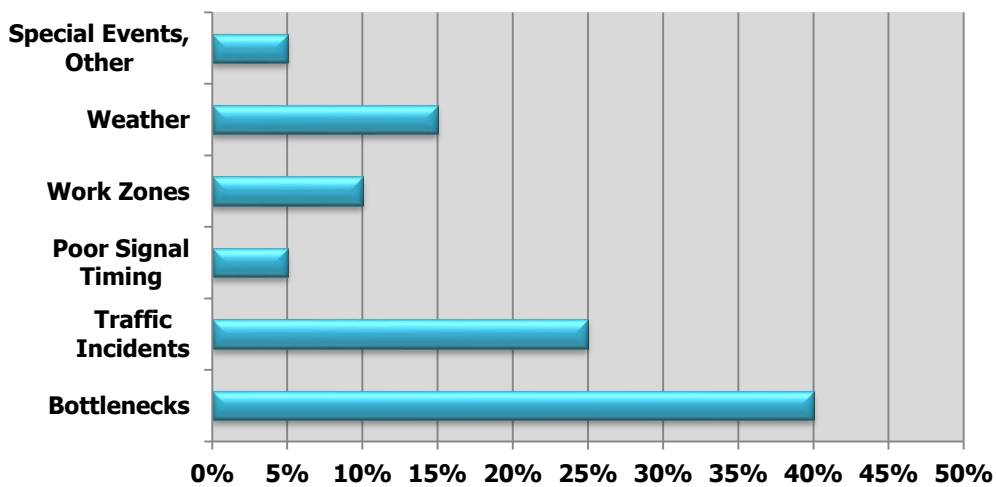


Figure 3.5 – Sources of Congestion

A sensitivity analysis was conducted on the weekday data for the 35th Avenue and 7th Street corridors which recalculated NRC and recurring congestion using a 20% threshold. When the results were compared to the original analysis which used 30%, the difference was smaller than 1%. This sensitivity analysis confirms that a 30% threshold for the arterial corridor analysis was appropriate. The sensitivity analysis results can be found in Appendix 3D.

An alternative method of calculating NRC was investigated as part of this study. In the original methodology, NRC was only calculated if the travel time was 30% more than the recurring travel time. The alternative method of calculating NRC includes this additional criterion: for intervals where recurring delay was lower than the free flow threshold and when non-recurring travel time was above the free flow threshold, NRC was calculated as the difference between non-recurring travel time and free flow travel time. The threshold is 30% for arterials. Analysis results can be found in Appendix 3E. This second method of calculating NRC was applied to weekday data from the 35th Avenue corridor. NRC using this method was 13.10% compared to the original NRC of 10.57% for this corridor (per previous Table 3.6). Since the difference in the NRC percentage is small, the original methodology is suitable for this study.

Impact of NRC

Figure 3.6 shows the total weekday congestion as 91% recurring and 9% non-recurring. Figures 3.7 and 3.8 break down the weekday NRC causes by combinations of factors and by the six primary causes, respectively.

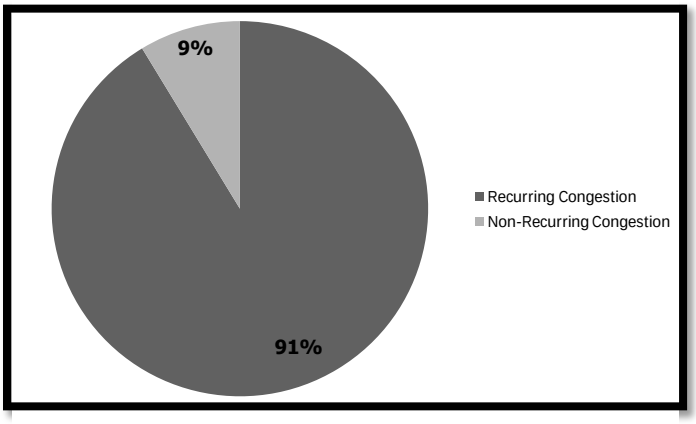


Figure 3.6 – Weekday Arterial Roadway Causes of Congestion

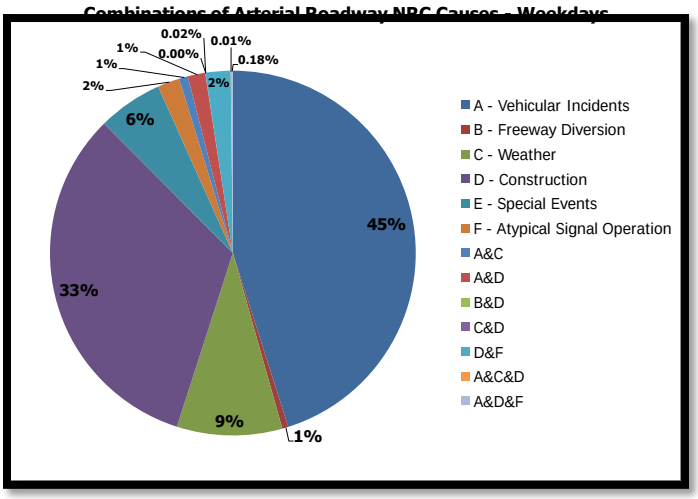


Figure 3.7 – Combinations of Weekday Arterial NRC Causes

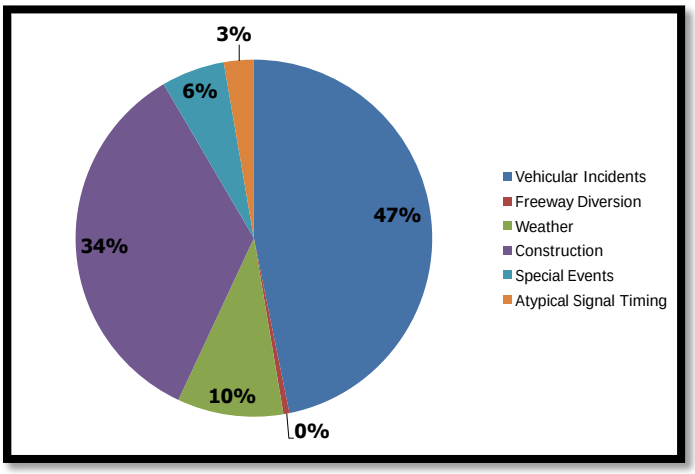


Figure 3.8 – Weekday Arterial Roadway NRC Causes

Figure 3.9 shows the total weekday peak hours' congestion as 92% recurring and 8% non-recurring. Figure 3.10 and Figure 3.11 break down the weekday peak hours' NRC causes by combinations of factors and the different primary causes, respectively.

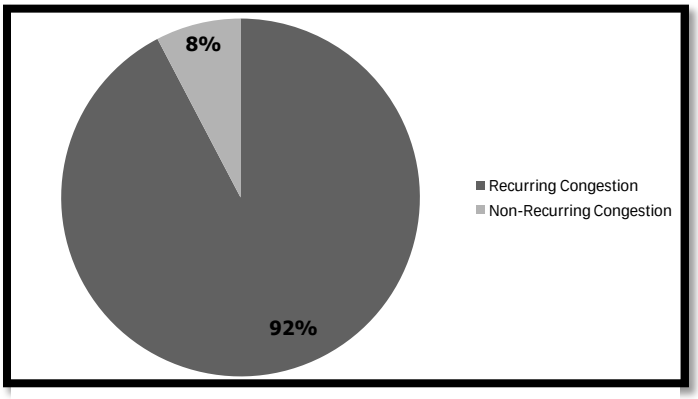


Figure 3.9 – Weekday Peak Hours Arterial Roadway Causes of Congestion

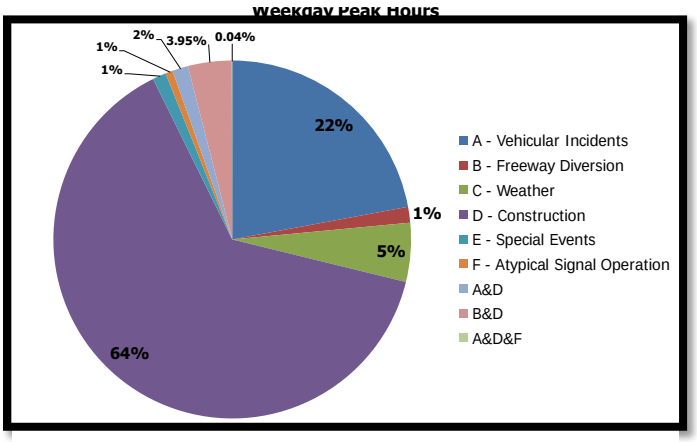


Figure 3.10 – Combinations of Weekday Peak Hours Arterial NRC Causes

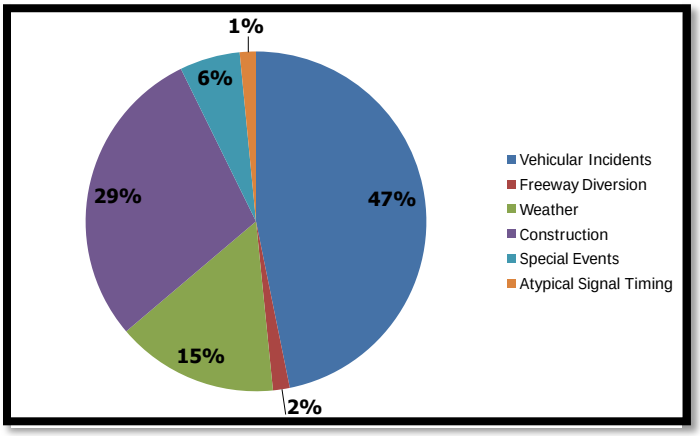


Figure 3.11 – Weekday Peak Hours Arterial Roadway NRC Causes

Figure 3.12 shows the total weekend congestion as 85% recurring and 15% non-recurring. Figure 3.13 and Figure 3.14 break down the weekend NRC causes by combinations of factors and the different primary causes, respectively.

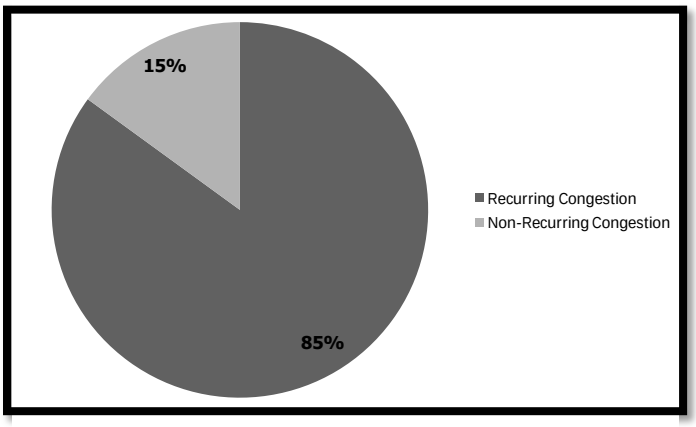


Figure 3.12 – Weekend Arterial Roadway Causes of Congestion

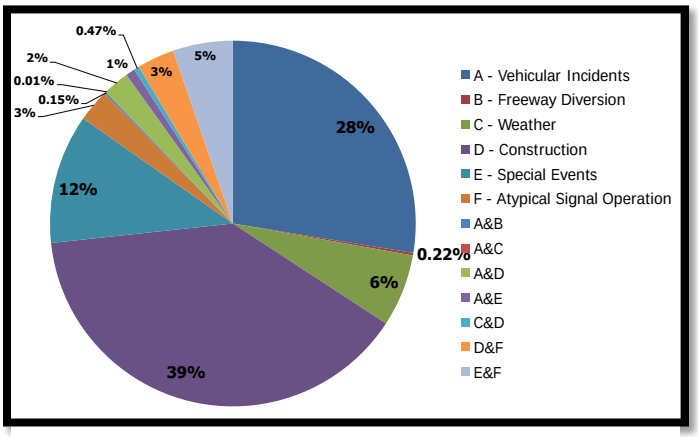


Figure 3.13 – Combinations of Weekend Arterial NRC Causes

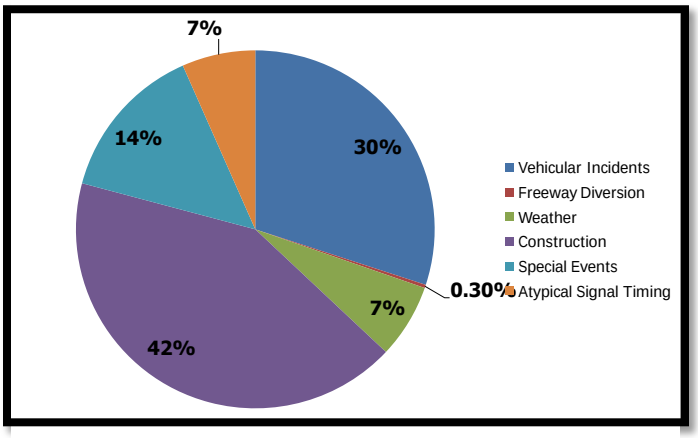


Figure 3.14 – Weekend Arterial Roadway NRC Causes

Extrapolation of Congestion

There are an estimated 1.96 million vehicle-miles occurring daily on the study corridors. Regional estimates of arterial vehicle-miles from 2007 indicate 35 million vehicle-miles occur per day. By comparing these totals, the studied corridors could represent about 5.6% of the arterial traffic occurring in the metropolitan area. The observed/computed delay caused by NRC accumulated from the study corridors during the collection periods was about 1,280 vehicle-hours per day. For the same period of time, the delay estimate for the metropolitan area (other 94.4%) would be about 22,850 vehicle-hours per day. This regional estimate is likely overestimated in that the study corridors were chosen for their propensity for NRC such that the other arterials comprising the regional total would likely experience less NRC.

Study Segments NRC Vehicle-Hours of Delay per Weekday[1]	1,170
Study Segments NRC Vehicle-Hours of Delay per Weekend Day/Holiday[1]	1,558
Study Segments Weighted Daily Average NRC Vehicle-Hours of Delay[2]	1,280
Estimated Percentage of All Regional Arterials Represented by Study Segments[3]	5.6%
Estimated NRC Vehicle-Hours of Delay per Day for the All Regional Arterials[4]	22,850

Notes

1 - Based on collected data/calculations
2 - Simple weighting based number of days for a typical week
3 - Estimated based on 1.96 M veh-mi occurring on study segments, and 35 M veh-mi (2007 data) for regional arterials
4 - Study Segments Daily Average NRC Delay divided by Estimated Proportion of Regional Arterials

The composition of the arterial traffic region-wide can be estimated as follows (see tabular information below): about 97% personal vehicles, about 2% trucks, and less than 1% transit (buses). Based on ridership estimates, vehicle occupancy rates, and road user costs (which include value of time, operating costs, etc.), the per-vehicle cost per hour of delay is estimated to be: almost $96/hour for buses; $106/hour for trucks; and about $28/hour for personal vehicles. At these rates, and given the estimated mode splits, delay caused by NRC costs vehicles (and their occupants) equates to about $29.90 per hour. So, the regional cost relating to NRC on arterials is about $683,000 dollars per day.

	Overall Traffic Composition		
	Transit (Bus)	Freight (Trucks)	Autos
Weekday 7AM-7PM Volume (vehicles)[1]	23,000		
Representative Hourly Volume (vehicles)	1,900		
Avg. Bus Headway per Direction (minutes)[2]	22		
Truck Percentage[3]		2%	
Number of Buses per Hour	6		
Number of Trucks per Hour		38	
Number of Autos per Hour			1,856
Avg. Vehicle Occupancy (at any one time)[4]	5.97	1.00	1.19
Road User Cost ($/hour)[5]	$ 16.00	$ 106.00	$ 24.56
Road User Costs per Average Vehicle ($/hour)[6]	$ 95.52	$ 106.00	$ 27.60
Costs Incurred on Corridor for the Hour[7]	$ 573.12	$ 4,028.00	$ 51,228.65
Percentage of Corridor Road User Costs	1%	7%	92%

Notes

1 Based on average of NRC studied corridors

2 From a GIS review of July 2010 transit routes for peak time operation

3 Typical value used for urban arterials, supported by data from 2006 MAG Vehicle Occupancy Study

4 Transit value estimated calculated from Valley Metro ridership information systemwide; Auto value from 2006 MAG Vehicle Occupancy Study

5 Road user costs for Transit User based on 2009 TTI study that presented estimated value of time for a passenger in an automobile (i.e., no operating/owner costs included) as $16/hr. The Freight User Cost ($106/hr) was based on the 2009 TTI study which showed its user costs as comprised of value of time, fuel, depreciation, interest, general maintenance, tires, repairs, and other similar costs. Estimate of Auto User Costs comprised of basic value of time cost ($16/hr) plus Lee Engineering estimated operating costs of $8.56/hr given a driver's average annual mileage of 12,500 miles and IRS $0.50 reimbursement per mile.

6 Road user costs multiplied by average vehicle occupancies. For Autos, first occupant assumed to bear ownership costs while additional occupant(s) assumed to incur user costs the same as a Transit user.

7 Costs based on persons (or vehicles in the case of Trucks), with the cost to the Auto passengers (i.e., non-owner) applied at the Transit Road User Cost rate

Freight and Transit

Some of the study corridors were divided by crossing railroad (35th Avenue & Rural Road) or light rail lines (7th Street & Rural Road). Since the traffic delays generated by these regular impedances would be considered part of the normal traffic operating conditions, they were not considered sources for non-recurring congestion.

Of the 71 centerline miles studied, approximately 2.5 miles do not have Valley Metro bus services. These corridors are 51st Avenue from Greenway to Thunderbird, 51st Avenue from Van Buren Street to Buckeye Road, and Rio Salado Parkway from Mill Avenue to Rural Road. Rio Salado Parkway from Mill avenue to Packard Drive does have FLASH, which is a Tempe-sponsored local bus service serving the ASU campus.

FREEWAY DATA COLLECTION & ANALYSIS

To identify the top five freeway corridors below, the project team reviewed 2007-09 sensor data from ADOT's Freeway Management System (FMS) that was used in the Urban Mobility Report. These study corridors are shown in Figure 3.15. They had the lowest reliability as measured by the Planning Index, which is statistically defined as the 95th percentile Travel Time Index (ratio of the average peak period

travel time to an off-peak travel time). The Planning Index represents the extra time most travelers include when planning peak period trips. For example, a value of 1.60 means that travelers plan for an additional 60% travel time above the off-peak travel times to ensure an on-time arrival 95% of the time.

1. Loop 202 WB: 46th St to 22nd St
2. US 60 EB: I-10 to Loop 101
3. I-17 SB: Stack at I-10 to I-17/I-10 Split-Merge
4. I-10 WB: Ray Road to Southern Ave
5. I-10 WB: Mini Stack at L202/SR 51 to Stack at I-17

Freeway Traffic Data Reduction

The freeway traffic data and incident data needed to be reduced and combined into an aggregate database for evaluation of non-recurring congestion. The 2009 freeway traffic data from ADOT's Freeway Management System was reduced to five-minute average speeds, travel times, and volumes. This data manipulation was done using Statistical Analysis System (SAS) routines developed by TTI as part of FHWA's national Urban Congestion Report Program.

NRC (Incident) Data Reduction

Incident data were in the general terms for crashes or vehicle breakdowns, work zones, weather events, and special events. For the incident data, private data from NAVTEQ was used to identify incidents on the study corridors. The exception to this was weather related data. The entire 2009 database was reduced by the following steps:

1. Using latitude and longitude coordinates, NAVTEQ incidents were plotted on a map to filter out potential incidents that could impact traffic along the study sections. With the exception of weather events, incidents that fell in sections within 1-mile of the study sections were also included to account for potential impacts resulting from downstream queues or upstream incidents.
2. Incidents were classified as one of four primary non-recurring causes: vehicular incidents (crashes, disabled vehicles, debris, etc.), weather, construction, and special events. Each incident was input into the appropriate 5-minute interval according to its start and end time.
3. A code was assigned to each incident type according to an established convention of field definitions. Generally, this code described the "severity" of the incident such as the number of lanes blocked during a crash. Note that if more than one vehicular incident and/or construction event occurred at the same time, the one that resulted in the most blocked lanes was input for that 5-minute interval.
4. Special events were limited to events that took place in major venues such as Chase Field or US Airways Center. These venues were within approximately 1.5 miles of the study sections and were selected based on local knowledge. This resulted in three of the five sections being potentially affected. Although there were other venues within 1.5 miles, they were geared towards concerts and had smaller capacities such as the Celebrity Theater and Dodge/Comerica Theater in downtown Phoenix. Parades, demonstrations, foot and bike races, etc. in downtown Phoenix were not counted because the reported start and end times ranged from limited hours to all weekend and it was assumed that traffic to these events would not significantly affect operations on the surrounding freeways. The ASU games at the Tempe Diablo Stadium were not counted because it was just beyond the 1.5 mile range for the US 60 EB section and it was noted that it is not the primary freeway used by the game traffic.

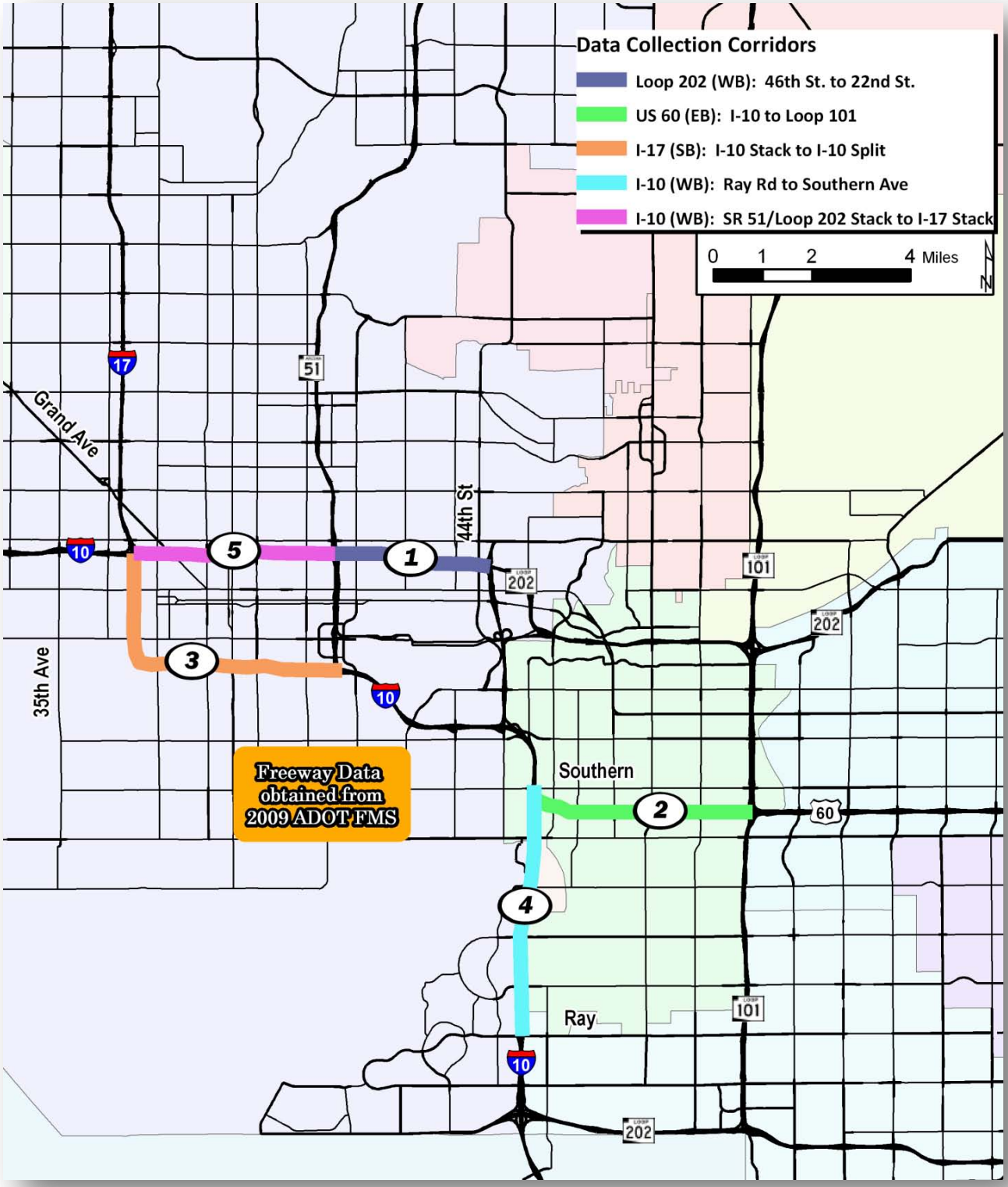


Figure 3.15 – Freeway Study Corridors

An analysis of vehicular incidents collected by RADS and NAVTEQ on I-10 WB from I-17 to SR 51 for the months of January 2009 and February 2009 was conducted for this study. Table 3.9 show the results of this comparison. The comparison of the two incident sources revealed that NAVTEQ captured more vehicular incidents than RADS on freeways. This is an opposite trend than what was seen on arterials.

Table 3.9 – 35th Avenue RADS vs. NAVTEQ Incident Comparison

Data Source	Incident Type	Number during Jan '09	Number during Feb '09	Sum of Jan & Feb '09
NAVTEQ	Crash	35	31	66
	Disable Vehicle	7	5	12
	Miscellaneous	1	0	1
	Total	**43**	**36**	**79**
RADS	Pedestrian-involved	1	2	3
	Hazardous materials	1	0	1
	Incident	0	1	1
	Injury Crash	13	8	21
	Vehicle on Fire	3	2	5
	Medical Emergency	4	4	8
	Total	**22**	**17**	**39**
Percentage of RADS Matching *NAVTEQ*		**51%**	**47%**	**49%**

Weather

Because weather events are so isolated in the MAG region and the fact that Weather Underground has the closest data points to the study sections (NOAA data was limited to only airports within MAG area), it was decided to utilize Weather Underground's data for both the freeway and arterial study sections. Weather stations (one or more) within the *wunderground.com* network of stations were assigned to certain freeway corridors based on proximity and other factors relative to the corridor (see Figure 3.16). The stations record a variety of weather conditions such as temperature, humidity, wind speed/direction, and rainfall recorded (and the rate at which it fell). The rainfall rate data was used in conjunction with same threshold value established for the arterial corridors to determine when weather events may be attributable to non-recurring congestion.

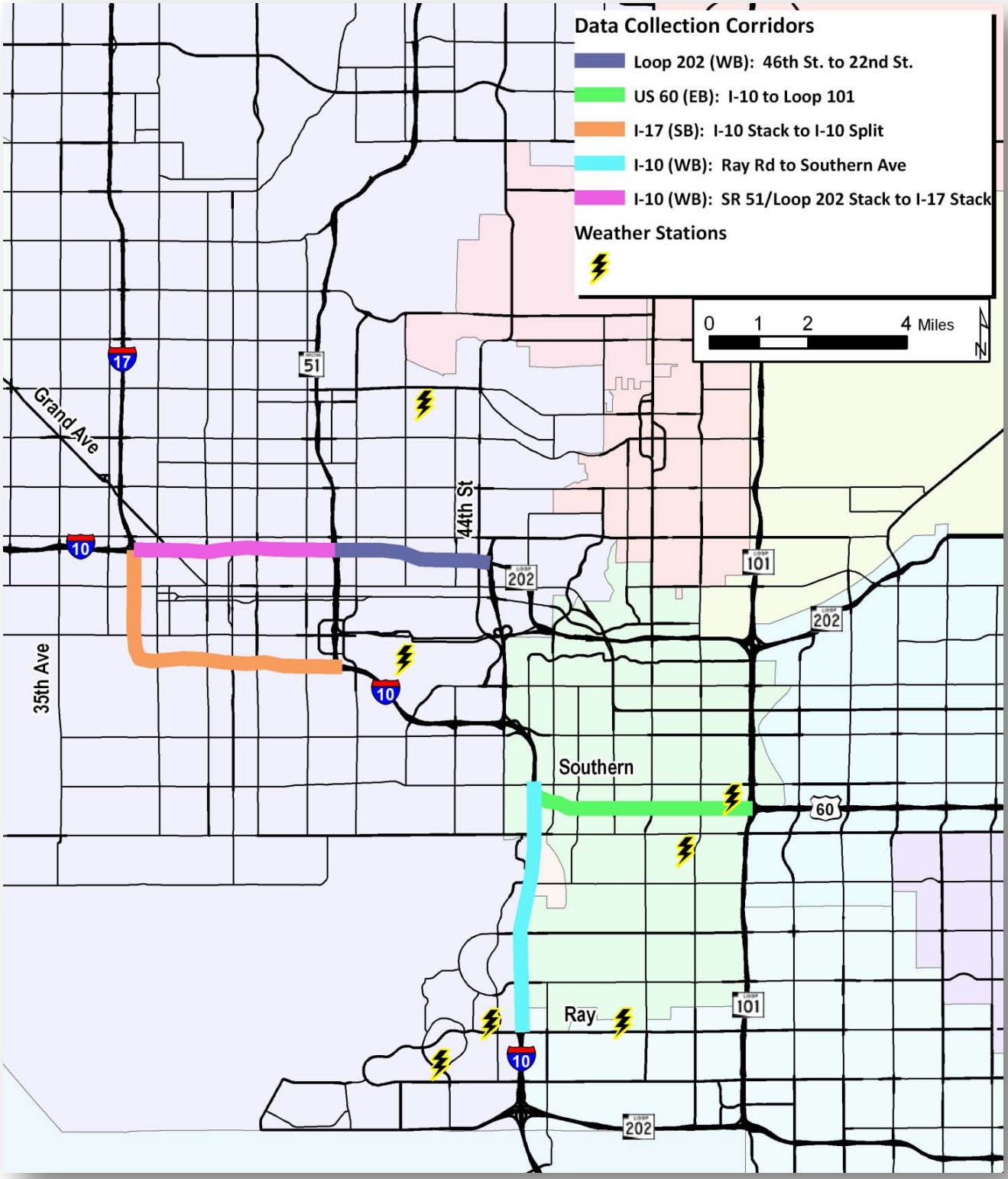


Figure 3.16 – Weather Stations Relating to Freeway Study Corridors

Delay and Impact of NRC

The following steps were taken to calculate the recurring and nonrecurring congestion from the traffic data and incident data.

1. Calculate the "Normal" Recurring Speeds, Travel Time, and Volumes

Weekday example:

i. Removed weekend days and holidays. This step was different than other studies but the Project team wanted to account for weekday vs. weekend traffic and its impacts on congestion. It was noted there seemed to be more special events and construction on weekends vs. weekdays thus it was believed that the congestion impacts would in fact be different;
ii. Removed intervals with any crashes, construction, weather, or special events; and
iii. Calculate average speed, travel time, and volume from remaining "normal" intervals

There were 525,600 five-minute intervals total for the five study sections. For weekday calculation, 275,695 intervals out of 375,840 (73%) were used. For weekend, 110,553 intervals out of 149,760 (74%) were used.

2. Non-Recurring Congestion (NRC) Calculation

NRC, or NRC delay, is the difference between the recurring travel time (calculated in step 1) and the actual travel time during a NRC event. To account for the variability in "normal" travel time and speed, NRC was only calculated when this difference was greater than least 15 percent. This was based on visual inspection of numerous examples. Table 3.10 below shows range of the difference in travel time and speed at the different thresholds examined.

Table 3.10 – Travel Time Difference (Congestion Thresholds)

	Weekday		Weekend	
Travel Time Difference (%)	Travel Time Difference (sec)	Speed Difference (mph)	Travel Time Difference (sec)	Speed Difference (mph)
5	9-35	1-3	9-24	2-3
10	20-68	3-6	20-45	5-6
15	31-100	4-8	31-68	7-8
20	43-131	5-10	42-86	9-10

One issue with merging the traffic data and incident data was that there were instances in which the full effects of the NRC due to crashes may not have been captured. If the start and end times of that crash are used from the incident data, the full congestion may not be included in that time interval. For example, Figure 3.17 on the following page shows there is delay well after the recorded end time of the crash. After further examination, the NRC was adjusted to include any delay that was 10 minutes before the start time or 3 hours after the end time, provided that it met the 15 percent threshold and there was no other NRC event present. The 10 minutes before the start time accounted for delay between the actual start time and the time it is reported. The 3 hours after the end time accounted for residual delay even after the incident has been cleared and the affected lanes have been reopened to traffic. Although the duration varies, this residual delay has been observed and documented in other studies.

Finally, the difference in travel time was multiplied by the recurring volume for each time interval to convert the NRC to vehicle-hours of delay.

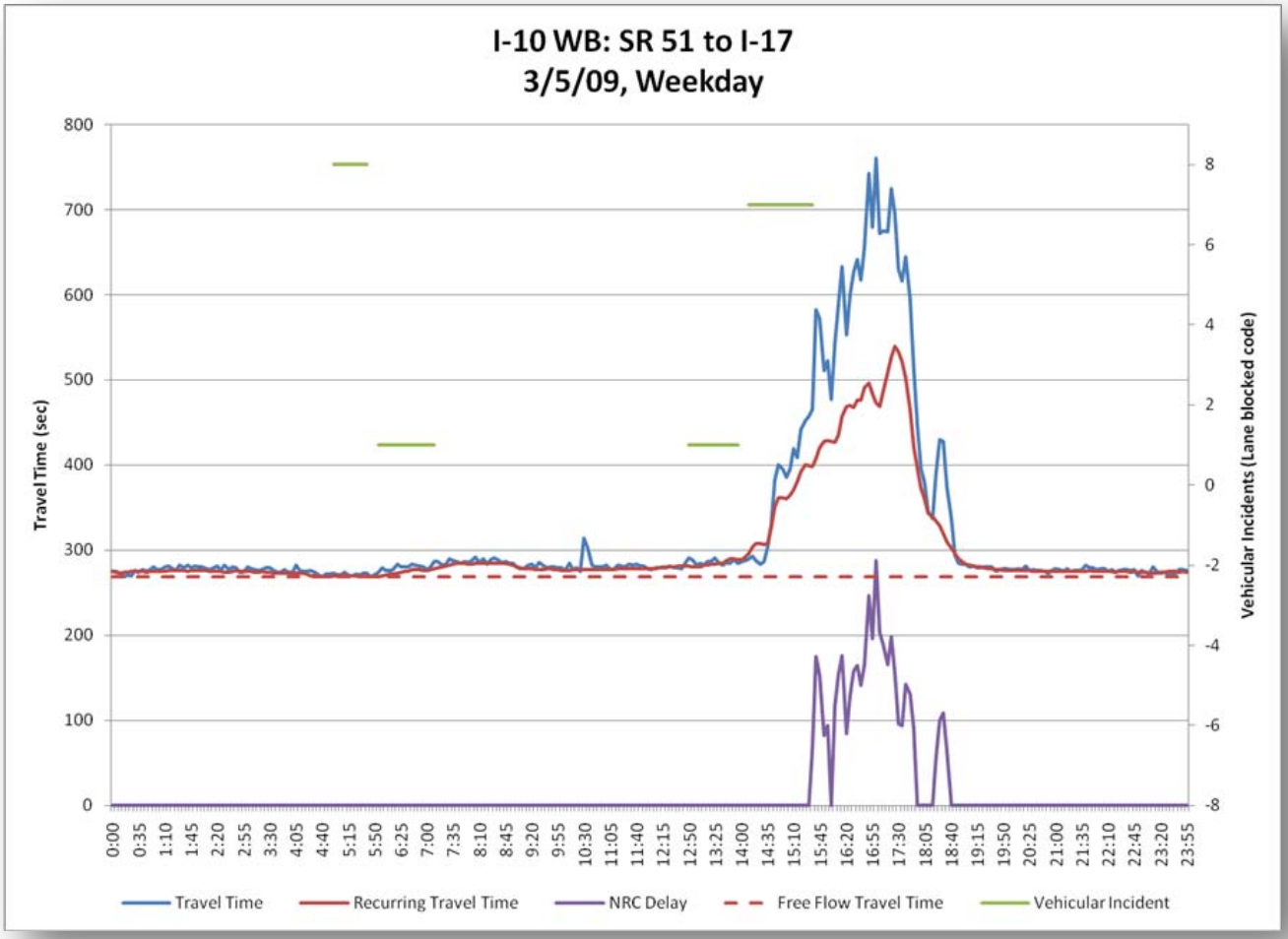


Figure 3.17 – Residual Non-Recurring Congestion Example

3. Recurring Congestion Calculation

Recurring congestion is the difference between the free flow travel time (minimum travel time of recurring travel time) and the recurring travel time (calculated in step 1) multiplied by the recurring volume for each interval without a NRC event. Recurring congestion was only calculated when this difference was greater than 15 percent.

4. Non-Recurring Congestion (NRC)

The NRC delay was divided among 15 different possible combinations. For example, 1=vehicular incidents, 2=weather…1+2=vehicular incident + weather and so on. Each NRC combination was proportioned to the same congestion breakdown in the Cambridge Systematics/TTI study as shown in Figure 3.5. These proportions were summed to get the total percentages for the four primary causes: vehicular incidents, weather, construction, and special events.

Results

Table 3.11 shows the total weekday congestion as 54% recurring and 46% non-recurring. These results are very similar to past studies which show NRC between 50-70 percent of total congestion. Figures 3.18 and 3.19 show the breakdown of NRC causes by the different combinations of factors and by the four primary causes (special events is abbreviated "SE" in the combination listing). In cases where two causes were happening simultaneously, the cause was proportioned to each cause.

Table 3.11 – 2009 Weekday Recurring and Non-Recurring Congestion (vehicle-hours)

Study Sections	Weekday Recurring	Weekday Non-Recurring	Total	% NRC
I-10 WB: SR 51 to I-17	89,167	97,491	186,658	52%
I-17 SB: I-10 to I-10	2,874	13,822	16,696	83%
Loop 202 WB: 46th St to 22nd St	68,514	40,407	108,921	37%
I-10 WB: Ray to Southern Ave	140,080	39,324	179,404	22%
US 60 EB: I-10 to Loop 101	23,299	82,017	105,316	78%
Total for Weekday	**323,933**	**273,062**	**596,994**	**46%**

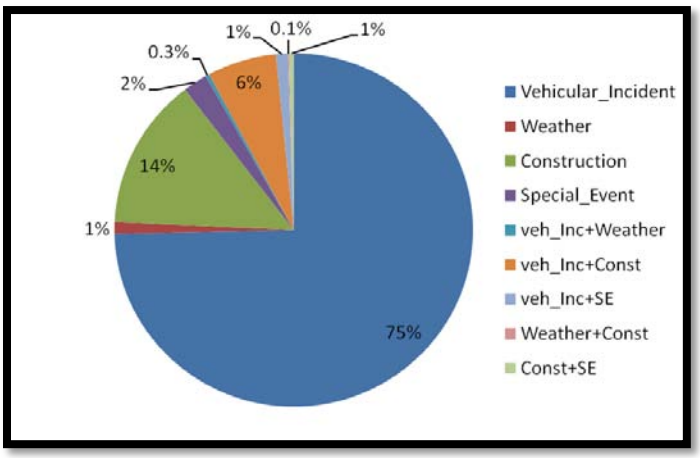


Figure 3.18 – 2009 Weekday Combinations of NRC Causes on Study Sections

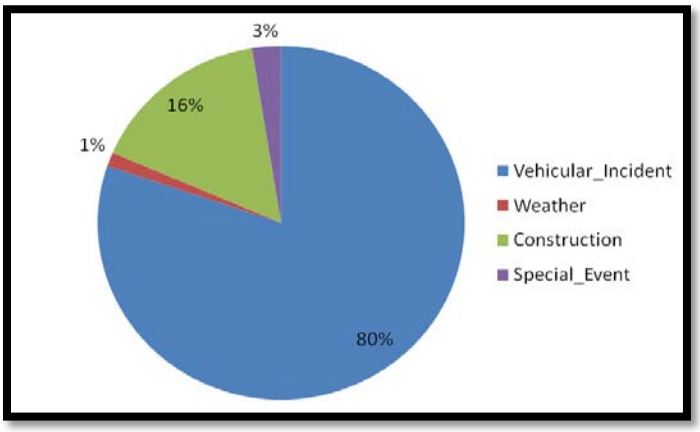


Figure 3.19 – 2009 Weekday NRC Causes on Study Sections

Similar to the arterial analysis, a second method of calculating NRC was investigated as part of this study. In the original methodology, NRC was only calculated if the travel time was 15% more than the recurring travel time. The second method of calculating NRC includes this additional criterion: for intervals where recurring delay was lower than the free flow threshold and when non-recurring travel time was above the free flow threshold, NRC was calculated as the difference between non-recurring travel time and free flow travel time. The threshold is 15% for freeways.

This method of calculating NRC was applied to weekday freeway data. NRC estimates per this second method were 47% compared to the original NRC of 46% for all freeway sections. Since there is essentially no difference in the NRC percentage, the original methodology is suitable for this study.

The same analysis was performed for the weekend data. Table 3.12 shows the total weekend congestion as all non-recurring. In other words, there was no recurring congestion that exceeded the 15 percent threshold on weekends. This finding makes sense because there is very little commuting weekend traffic that may cause recurring congestion. Similar to weekdays, Figures 3.20 and 3.21 breakdown the NRC by the combinations of factors and the primary causes (special events is abbreviated "SE" in the combination listing).

Table 3.12 – 2009 Weekends Recurring and Non-Recurring Congestion (vehicle-hours)

Study Sections	Weekend Recurring	Weekend Non-Recurring	Total	% NRC
I-10 WB: SR 51 to I-17	-	2,097	2,097	100%
I-17 SB: I-10 to I-10	-	2,567	2,567	100%
Loop 202 WB: 46th St to 22nd St	-	2,741	2,741	100%
I-10 WB: Ray to Southern Ave	-	74	74	100%
US 60 EB: I-10 to Loop 101	-	18,167	18,167	100%
Total for Weekend	**-**	**25,645**	**25,645**	**100%**

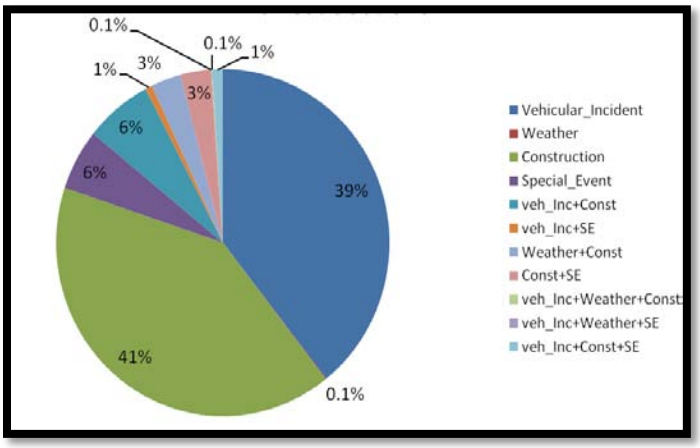


Figure 3.20 – 2009 Weekend Combinations of NRC Causes on Study Sections

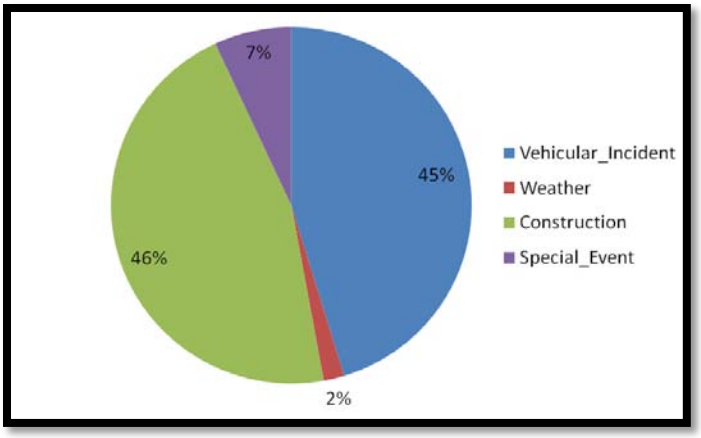


Figure 3.21 – 2009 Weekend NRC Causes on Study Sections

As might be expected, the previous figures present a different picture of the NRC breakdown compared to weekdays. Figure 3.20 shows construction related congestion being the highest on weekends at 41% closely followed by vehicular incidents at 39%. Similar to Figure 3.18, it also shows that the combination of them is 6% of the NRC. Overall, Figure 3.21 shows that weekend nonrecurring congestion was evenly split between vehicular incidents (45%) and construction (46%). Special events also increased from 3 to 7 percent. These results likely reflect ADOT's encouragement of nights and weekend construction and the nights and weekend special events schedule.

Extrapolation of Congestion

The final step was to expand the recurring and non-recurring congestion from these five study sections to the rest of MAG's freeway system. Table 3.13a shows that the total vehicle miles traveled (VMT) for the five study sections is 6 percent of the systemwide VMT. Dividing the systemwide VMT by the study section's total VMT yielded an expansion factor of 17. This factor was mulitplied by the sum of the weekday and weekend congestion to derive at the grand total of 10.6 Million vehicle-hours (MVH) of congestion.

Table 3.13a – Annual Total Freeway Congestion (vehicle-hours)

Study Sections	Vehicle Miles Traveled (VMT)	Weekday + Weekend Recurring	Weekday + Weekend Non-Recurring	Total
I-10 WB: SR 51 to I-17	469,314	89,167	99,588	188,755
I-17 SB: I-10 Stack to I-10 Split	347,033	2,874	16,389	19,263
Loop 202 WB: 46th St to 22nd St	232,888	68,514	43,148	111,662
I-10 WB: Ray to Southern Ave	459,935	140,080	39,398	179,478
US 60 EB: I-10 to Loop 101	265,434	23,299	100,184	123,483
Total	**1,774,604**	**323,933**	**298,707**	**622,640**
Systemwide	**29,450,000**	**5,506,858**	**5,078,017**	**10,584,875**

Note: Systemwide VMT based on 2007 HPMS data.

Alternatively, the total freeway congestion was also estimated for only the 52 sections that are instrumented with traffic sensors (see Table 3.13b). These sections make up approximately 43 percent of the lane miles but about 50 percent of the VMT within the urban area. This method resulted in an

expansion factor of 8. Thus, the grand total was 4.9 MVH for the 52 instrumented sections. Regardless of which expansion factor used, recurring and nonrecurring congestion was 52 percent and 48 percent, respectively, of the total congestion.

Table 3.13b – Annual Total Freeway (Instrumented Sections Only) Congestion (vehicle-hours)

Study Sections	Vehicle Miles Traveled (VMT)	Weekday + Weekend Recurring	Weekday + Weekend Non-Recurring	Total
I-10 WB: SR 51 to I-17	469,314	89,167	99,588	188,755
I-17 SB: I-10 Stack to I-10 Split	347,033	2,874	16,389	19,263
Loop 202 WB: 46th St to 22nd St	232,888	68,514	43,148	111,662
I-10 WB: Ray to Southern Ave	459,935	140,080	39,398	179,478
US 60 EB: I-10 to Loop 101	265,434	23,299	100,184	123,483
Total	**1,774,604**	**323,933**	**298,707**	**622,640**
Systemwide (52 sections)	**14,801,648**	**2,591,463**	**2,389,655**	**4,981,118**

Finally, to get a sense of the proportion of NRC that occurred on freeways versus arterials, the extrapolated annual congestion from both freeways and arterials were combined:

- Total Congestion (recurring and non-recurring): 12% on freeways (10,584,875 veh-hrs)
  88% on arterials (77,946,262 veh-hrs)
- Non-Recurring Congestion Only: 38% on freeways (5,078,017 veh-hrs)
  62% on arterials (8,340,250 veh-hrs)

The total congestion breakdowns seem reasonable given that arterials comprise 73% of the area's lane miles and carry nearly two-thirds of all travel in the Phoenix region. For division between NRC and recurring congestion, the freeway study sections had 52 percent recurring congestion and 48 percent NRC. However, there was 89 percent recurring congestion and 11 percent NRC on the arterial study sections (arterials are expected to have high recurring congestion since stop delay at signalized intersections is included). For NRC only comparisons, the arterials accounted for 62 percent of the congestion and freeways comprised the remaining 38 percent. The NRC-only results suggest that addressing recurring and non-recurring congestion on arterials should be part of any regional congestion mitigation strategy, especially given the extensive arterial grid system in the MAG region.

Freight and Transit

Additional data was gathered to estimate the impact of NRC on freight and transit operations. Truck AADT was estimated for freeways from truck factors provided by ADOT. Because trucks operate within the general purpose traffic, trucks will experience similar impacts of congestion and passenger cars. However, the economic impacts would be very different for trucks given that the value of time is significantly higher for commercial trucks as opposed to passenger cars. Thus, the impact on freight operations was estimated in terms of value of time.

Table 3.14 below shows the economic impact of non-recurring congestion on freeway truck traffic. Annually, there is $749 Million cost of non-recurring congestion to freight operations. This cost was calculated by summing the volume for each 10-minute interval where NRC was measured then multiplied by the average truck factor (weighted by section AADT), the value of time of commercial vehicles ($106/hr), and the expansion factor (17).

Table 3.14 – Economic Impacts of NRC on Freeway Truck Traffic

	Annual Vehicle-Hours with NRC	Annual Truck-Hours with NRC	Annual $ Impact
Weeday	3,807,293	384,537	$ 692,934,941
Weekend	308,214	31,130	$ 56,095,564
Total	4,115,507	415,666	$ 749,030,505

Valley Metro is the major transit provider within the MAG region. Current "Express" and "RAPID" bus route maps from Valley Metro's website were reviewed to get the total centerline miles and just the freeway's portion for each route. Additionally, the daily weekday average ridership for each route was collected from the FY08-09 Annual Ridership Report. The average ridership on each route was calculated by multiplying the percent freeway miles by the annual ridership as shown in Table 3.15.

Table 3.15 – Estimated Transit Ridership on Freeways

ID	ROUTE NAME	FWY MI.	TOTAL MI.	% FWY	FY08-09 Ridership	FWY Ridership	No. of Buses
510	Scottsdale Express	11.46	27.0	42%	23,598	10,003	1000
511	Tempe/Scottsdale Airpark	52.28	65.3	80%	10,514	8,412	2000
512	Scottsdale Express	12.8	42.6	30%	20,862	6,272	1000
520	Tempe Express	23	33.8	68%	34,274	23,328	2000
521	Tempe Express	23.0	36.3	63%	58,482	37,112	3250
531	Mesa/Gilbert Express	36.3	47.2	77%	87,105	66,940	3750
532	Mesa Express	30.9	40.9	76%	43,936	33,174	2000
533	Mesa Express	51.4	61.3	84%	103,170	86,509	2500
535	Red Mountain-Downtown Express	53.2	57.5	93%	28,815	26,663	1500
540	Chandler Express	25.1	40.3	62%	52,890	33,007	2000
541	Chandler Express	32.3	47.1	69%	91,703	62,901	2500
542	Chandler Express	49.7	54.4	91%	21,159	19,317	2000
560	Avondale Express	17.4	37.1	47%	17,783	8,350	1000
562	Goodyear-Downtown Express	30.7	37.1	83%	29,834	24,724	1500
573	Northwest Valley-Downtown Express	51.4	56.9	90%	54,641	49,418	3000
575	Northwest Valley-Downtown Express	44.4	50.5	88%	34,712	30,519	1500
581	North Mountain Express	16.6	34.3	48%	27,888	13,488	1500
582	North Mountain Express	14.0	28.4	49%	25,877	12,776	2000
590	Deer Valley Express	22.7	33.9	67%	31,884	21,365	2000
	EXPRESS Total	**598.7**	**831.8**	**72%**	**799,127**	**574,278**	
R1	SR-51 RAPID	28.4	48.6	58%	198,452	115,973	6500
R2	I-10 East RAPID	35.2	40.0	88%	233,318	205,502	7750
R3	I-10 West RAPID	17.52	24.6	71%	182,322	129,733	6750
R4	I-17 RAPID	26.68	38.3	70%	321,830	224,406	10750
	RAPID Total	**107.8**	**151.4**	**71%**	**935,922**	**675,615**	
	Grand Total	**706.5**	**983.3**	**72%**	**1,735,049**	**1,249,893**	**69,750**

Dividing the total freeway ridership by the total number of busses yields an average of 17.9 passengers per bus. Assuming these busses are part of the total weekday non-recurring congestion vehicle-hours, then there are 1.2 Million transit person-hours NRC delay as shown in Table 3.16. Using a value of time of $16/hr, there is $19.9 Million annual cost of non-recurring congestion on transit operations.

Table 3.16 – Economic Impacts of NRC on Transit (Freeways)

	Weekday NRC Vehicle-Hours	Transit Person-Hours	Annual $ Impact
Study Sections	273,062		
Systemwide	4,642,046	1,246,389	$19,942,229

CHAPTER 4

RELEVANT COUNTERMEASURES, REQUIRED RESOURCES, AND COST EFFECTIVENESS

INTRODUCTION

This chapter summarizes the work completed to identify countermeasures that are relevant and feasible for the MAG Region. It builds on the countermeasures found in the literature review (Chapter 1) and the results of the data collection and analysis phase (Chapter 3). Planning level cost estimates were considered for these countermeasures based on available national and local databases. The applicability of the listed countermeasures to the MAG region was considered along with the likely resources required to implement and maintain them. Finally, subsets of the countermeasures pertaining to freeway and arterial applications were determined to guide further consideration and possible pilot project development.

CAUSES OF NRC IN THE REGION

Arterial Corridors

As documented in Chapter 3, vehicle incidents were the dominant source of non-recurring congestion. Vehicular incidents and construction made up 81 percent of weekday ("W" in the following tables) non-recurring congestion on the arterial study corridors. This percentage was comprised of vehicular incidents at 47 percent and construction at 34 percent. Roadway construction activities included scheduled or unscheduled (i.e., emergency) roadway improvements and/or maintenance. These include activities such as general construction and utility repair. The next closest non-recurring congestion cause was weather at 10 percent, which was a higher contributor of non-recurring congestion than on the freeway study corridors.

These same two primary causes of non-recurring congestion were found for weekends ("WE" in the following tables) on arterials; however, their order of contribution reversed. Construction made up 42 percent of weekend non-recurring congestion on the arterial study corridors followed by vehicular incidents at 30 percent.

Given these results, the project team recommended focusing on potential arterial countermeasures that mitigate non-recurring congestion caused by vehicular incidents and road construction activities.

Freeway Corridors

The primary sources of non-recurring congestion on freeways were vehicular incidents and construction events. These two primary causes of non-recurring congestion made up 96 percent of weekday NRC on the freeway study corridors. Vehicular incidents made up 80 percent of weekday non-recurring congestion. These incidents included vehicular crashes as well as minor breakdowns or debris/roadway hazards. Construction events made up 16 percent of weekday non-recurring congestion. These events included scheduled or unscheduled (i.e., emergency) roadway improvements and/or maintenance. They include activities such as general construction, bridge repair, ramp work, guardrail work, landscaping, line painting, road work, roving work crew, and utility work.

The same two primary causes of non-recurring congestion, vehicular incidents and construction, made up 91 percent of weekend non-recurring congestion on the freeway study corridors. However, their proportions were significantly different than during weekday operations. Construction events made up 46 percent. This measurement could reflect Arizona Department of Transportation's (ADOT) encouragement of nights and weekend construction, particularly for major on-going construction projects. Vehicular incidents made up 45 percent of weekend non-recurring congestion.

Given these results, the project team recommended focusing on potential freeway countermeasures that mitigate non-recurring congestion caused by vehicular incidents and road construction activities.

ESTIMATED NRC ON STUDY CORRIDORS

Arterial Corridors

A ranking was developed for the arterial study corridors to determine which ones had the most non-recurring congestion and the potential to be candidates for the pilot project which is discussed in Chapter 6. Table 4.1 shows each of the arterial study corridor rankings based on the average of: (1) the rank based on total vehicle-hours of non-recurring congestion and (2) the rank based on the percentage of non-recurring congestion when compared to total congestion (W = weekday and WE = weekend).

Although the Indian School Road Corridor ranked highest, it should be noted that high levels of construction activities for the duration of data collection period on the corridor had an impact on the construction source of non-recurring congestion compared to a typical or normal month. Alternatively, 35th Avenue has historically experienced incidents that support its ranking within the study corridors.

Table 4.1 – Arterial Study Corridor Ranking

AWAM Equipped Segments	W + WE NRC (veh-hrs)	Veh-hr Rank	% NRC	% NRC Rank	Avg Rank	Rank
Indian School Rd Corridor	16,920	1	18%	1	1.00	**1**
35th Ave Corridor (with Bell)	15,013	2	12%	3	2.50	**2**
7th St Corridor	11,993	3	15%	2	2.50	**3**
Rural Rd Corridor (with Rio Salado, Mill, and University)	5,801	4	5%	4	4.00	**4**
51st Ave Corridor (with Thunderbird, Peoria, & Northern)	5,383	5	5%	5	5.00	**5**

Freeway Corridors

The same ranking system for arterials was applied to the freeway study corridors to see which ones had the most non-recurring congestion and the potential to be candidates for the pilot project. Table 4.2 shows each freeway study corridor's ranking based on the average of: (1) the rank based on total vehicle-hours of non-recurring congestion and (2) the rank based on the percentage of non-recurring congestion when compared to total congestion (W = weekday and WE = weekend).

Although the US 60 corridor ranked highest, it should be noted that the I-10 corridor (SR 51 to I-17) is part of the I-10 Integrated Corridor Management System demonstration project which could be used to help leverage funding of potential countermeasures.

Table 4.2 – Freeway Study Corridor Ranking

Freeway Study Sections	W + WE NRC (veh-hrs)	Veh-hr Rank	% NRC	% NRC Rank	Avg Rank	Rank
US 60 EB: 1-10 to Loop 101	100,184	1	81%	2	1.50	**1**
I-10 WB: SR51 to I-17	99,588	2	53%	3	2.50	**2**
I-17 SB: I-10 to I-10	16,389	5	85%	1	3.00	**3**
Loop 202 WB: 46th Street to 22nd Street	43,148	3	39%	4	3.50	**4**
I-10 WB: Ray Road to Southern Avenue	39,398	4	22%	5	4.50	**5**

Conclusions About Countermeaure Focus

As reported in the previous chapter, NRC accounted for 11% of the total congestion (non-recurring + recurring) estimated for the arterial study corridors during the data period. For the freeway study corridors, the percentage of total congestion attributable to non-recurring congestion was 48%. However, when considering the estimated extrapolation to the region, the proportion of region-wide NRC occurring on the arterials is projected to be 62% versus 38% on the freeways because of the extensive arterial travel in the region—73% of the region's lane-miles and nearly two-thirds of the region's vehicle-miles traveled. Therefore, in terms of regional delay caused by NRC, the contributions from arterial travel cannot be disregarded. Based on this conclusion, the following discussion includes descriptions of countermeasures approriate for freeway <u>or</u> arterial applications (and in some cases, countermeasures applicable to both facility types).

EFFECTIVENESS OF NRC COUNTERMEASURES BY SOURCE OF CONGESTION

Freeways

The following sub-sections present reviews of the current experience and the effectiveness of countermeasures on freeways that focus on vehicle incident and construction-related non-recurring congestion.

Incident NRC Countermeasures for Freeways

Many urban areas are developing regional transportation management systems that incorporate surveillance, communication, command, and traveler information. This is similar to the intelligent transportation systems ADOT and the local agencies are implementing in the MAG region. Two examples of the benefits of these regional systems are:

- The Houston TranStar system, in Harris County, Texas, which integrates the freeway management system, a freeway incident management program, ramp meter signals, closed circuit television verification, changeable message signs, HOV lane system, a regional computerized traffic signal system, emergency management operations, and motorist assistance program, showed a saving of 30 minutes for major freeway incidents. Total annual estimated delay savings is 572,095 vehicle-hours. Estimated economic value of these savings is $8,440,000 annually. TranStar has been shown to have an approximate benefit-to-cost ratio of 10:1.

- The NaviGAtor program, in Atlanta, GA resulted in an average 46-minute reduction in incident duration time and reduced incident delay by 7.25 million vehicle-hours. The NaviGAtor incident management component reduced the average incident duration time from 67

minutes to 21 minutes or by 69 percent. There were an estimated 13,544,000 vehicle-hours of delay before the program was implemented and only 6,290,000 vehicle-hours of delay after NaviGAtor. This amounts to a 54 percent reduction in delay. The NaviGAtor system includes a traffic management center (TMC), freeway management components, advanced traveler information systems, and an incident management program. TMC operators use vehicle detectors, closed circuit television (CCTV) cameras, dynamic message signs (DMS), and ramp meters to collect traffic data and manage incidents. When TMC operators identify an incident, they dispatch a Highway Emergency Response Operator (HERO) to provide motorist assistance or traffic control.

Other studies have focused on the effectiveness of individual countermeasures. One such countermeasure is to improve the detection and response time relating to incidents. Determination and verification of a location and the nature of incident that has occurred can reduce the impact of an incident. Improved detection and verification can be done through a variety of methods including improved closed-circuit TV (CCTV) camera coverage, deployment of service patrols, use of motorist call-in, police and fire dispatches; aerial, TOC/TMC observations, and use of private traffic data.

Examples of the benefits from CCTV camera surveillance have been found as follows:

- In Monroe County, New York, the camera deployment and ITS integration project reduced incident validation times by 50-80 percent saving 5-12 minutes per incident.
- In Toronto, the COMPASS traffic monitoring (CCTV and loop detectors) and traveler information on Highway 401 decreased the average incident duration from 86 to 30 minutes per incident.
- In Brooklyn, an incident management system on the Gowanus and Prospect Expressways used CCTV, highway advisory radio, dynamic message signs, and a construction information hotline to improve average incident clearance time by about one hour, a 66 percent improvement.

The MAG region has existing implementation of CCTV camera surveillance. They are located high above the roadway to provide visibility of traffic incidents. Most CCTV's can pan, tilt, and zoom from any workstation at the ADOT Traffic Operations Center (TOC). TOC control room staff constantly monitors the CCTV cameras. When staff becomes aware of an incident, they use these cameras to verify the incident and determine the appropriate response (e.g., post messages on Dynamic Message Signs). Five valley television stations have access to ADOT's live CCTV camera feeds to show freeway conditions.

The freeway study corridors are equipped with CCTV cameras and no improvements to the current implementation are suggested.

Examples of the benefits from implementation of freeway service patrols or courtesy patrols are as follows:

- Typically a freeway patrol program is designed to reduce traffic congestion and improve highway safety by responding to and assisting in traffic incidents.

- The benefit-to-cost ratio of Florida's Road Ranger freeway service program is 3.2:1 (ranging from 2.31:1 to 21.4:1 in different districts).
- The Motorist Assistance Program in Houston has a benefit-to-cost ratio as high as 23.3:1 with a positive impact on incident and delay reduction.
- The Alabama Service and Assistance Patrol (ASAP) program has an estimated benefit-to-cost ratio ranging from 1.7:1 to 23.4:1 with an average of 9.2:1. The mobility benefit ranged from $985,900 to $13,878,400 for 2005. Based on simulation, the ASAP creates almost uniformly increasing delay reductions with increasing incident duration reductions.

The MAG region has existing implementation of freeway service patrols. More than a half-dozen vehicles assist motorists in the MAG region 18 hours a day, 7 days a week. This service is operated by the Department of Public Safety (DPS).

The freeway study corridors comprise about 10%, at most, of the total centerline freeway miles in the MAG r. Deployment of additional freeway service patrols on the freeway study corridors during peak hours is a potential countermeasure for non-recurring congestion.

Site management and response teams are used to manage equipment and personnel and quickly mitigate an incident and minimize impact on traffic flow.

- ADOT's Arizona Local Emergency Response Team (ALERT) has averaged 15 major incident calls per month, or 185 a year, between 2001 and 2007. The average response time has ranged from 22 to just 18 minutes in 2006-07. The six-year average response time is 19 minutes, and the average incident duration has been 3 hours, 18 minutes.

The MAG region's ALERT program uses specially equipped vehicles that respond to incidents throughout the region, providing on-site command and control, portable DMS capability, and more. Deployment of additional ALERT vehicles on the freeway study corridors during peak hours is a possible countermeasure for non-recurring congestion.

Another countermeasure is to install push bumpers on law enforcement vehicles to remove disabled vehicles. The installation of these devices has shown to have a very high positive public perception.

- This countermeasure is already implemented in the MAG region as nearly all police and DPS vehicles have push bumpers. No improvements to the current implementation are suggested.

Quick clearance programs for freeways have also be used to move vehicles from the roadway after a crash immediately and restore traffic flow and reduce secondary crashes.

- In Houston, Texas, their SafeClear program was responsible for decreasing the number of freeway crashes 10.4 percent and decreasing by nearly 2,000 crashes after first year of implementation. This equated to a $35 million savings.
- Arizona Revised Statutes (§28-674) currently requires vehicles involved in crashes on limited access freeways to be removed, if possible and can be done safely, to a safe refuge area.

The MAG region has existing implementation of ITS resources that are used in conjunction with one another to clear incidents on freeways quickly. The ADOT TOC control room includes 32 video monitors and large screens used to display traffic speed and weather information. There are four workstations in the control room; operators at two of the stations monitor traffic in the MAG region and the other operators monitor traffic throughout the remainder of the state. The ADOT TOC control room staff constantly monitors the Department of Public Safety (DPS) Computer Aided Dispatch (CAD) system, speed maps, and CCTV cameras. When staff becomes aware of an incident, they use these cameras to verify the incident and determine the appropriate response (e.g., dispatch DPS, post messages on Dynamic Message Signs, and enter information into the Highway Condition Reporting System [HCRS]).

A potential improvement would be to increase the number of MAG region operators for at least the weekday peak periods. Another potential improvement would be to increase the accuracy of the speed and travel time maps in real-time. Currently, freeway speeds are obtained at fixed points on the freeway—i.e., time-mean speed information. The use of sensors relying on AWAM technology that could be deployed to take advantage of existing infrastructure could provide real-time space-mean vehicle speeds which are a more accurate representation for travel time purposes and may be useful in assessing instantaneous level of service conditions.

Examples of the benefits of implementing fixed or portable dynamic message signs to inform motorists about vehicle incidents are as follows:

- Modeling of 9 ITS projects in San Antonio, Texas indicated that integrating DMS, incident management, and arterial control systems could reduce delay by 5.9 percent. It also showed that freeway and arterial crashes could reduce by 2.8 and 2 percent, respectively.

- Another simulation study of the effectiveness of dynamic message signs indicated that integrating traveler information with traffic and incident management systems in Seattle, Washington could reduce delay by 1 to 7 percent, reduce stops by about 5 percent, lower travel time variability by 2.5 percent.

- Simulation of using dynamic message signs to warn drivers of incidents as part of a freeway management system in Fargo, North Dakota showed network travel times could be reduced by 8 percent and speeds increased by 8 percent.

The MAG region has existing deployments of dynamic message signs (DMS). They are large signs over freeway lanes used to display messages to the public once an incident has been verified by ADOT TOC staff. The freeway study corridors and most MAG region freeway sections are equipped with DMS. The existing DMS locations should be evaluated to determine whether additional locations would benefit the traveling public due to high incident/congestion conditions. Due to the common occurrence of commuters using multiple freeways, it may benefit drivers if DMS were activated on freeway corridors in advance of multiple interchanges that may lead to the incident corridor. Messages displayed in the DMS should also be evaluated to determine whether information could be improved such as route diversion suggestions and more accurate travel time. More accurate travel time could be obtained from the deployment of permanent traffic monitoring devices that rely on the AWAM technology, as was previously discussed above.

Another freeway countermeasure is ramp metering. Ramp metering has been used for over 40 years in some urban areas as a method to manage the demand entering freeway sections.

- A 2008 evaluation of ramp metering in the Minnesota Twin City region found a 22 percent freeway travel time savings and a 14 percent increase in throughput. They study found a 15:1 benefit cost ration when using just the cost of the ramp metering system.
- Study on I-880 in San Francisco showed a potential 33.2 percent delay reduction with ramp metering.

The freeway study corridors and most MAG region freeway sections are equipped with ramp metering in use during directional peak hours on weekdays. They activate based on time of day and day of the week and the metering pattern is determined from mainline traffic flows at the location. It is suggested that ramp meters be operated with more advanced control through the ADOT TOC. This advanced control is currently being considered for use in the MAG region.

Construction Activity Countermeasures for Freeways

The following second set of countermeasures is focused on reducing the non-recurring congestion caused by construction activity. There have been some large, comprehensive construction management efforts taken for reconstruction of major freeway sections and interchanges. These include a number of countermeasures to address non-recurring congestion caused by construction activity.

- In Albuquerque, New Mexico, work zone surveillance and response at the "Big I" Interchange reduced average clearance time by 44 percent. Work zone surveillance was achieved through closed circuit television cameras (CCTV), broadband wireless communications, and directional antennas. Motorists approaching the interchange of I-25 and I-40 were made aware of traffic conditions (lanes affected) via information displayed on dynamic message signs (DMS), and through strategic deployment of portable changeable message signs (CMS). In addition, pre-trip traffic information was updated every three minutes on the "BIG I" Internet web-site.

The use of route diversion to direct traffic to alternate route(s) around work zones has shown to be an effective countermeasure.

- FHWA document reports between 50 and 85 percent of drivers surveyed said that they changed their route at least sometimes in response to travel time, delay or alternate route messages provided by work zone ITS. Reductions in queue lengths from 56 to 60 percent are possible with simulations indicating reduction in system-wide total delay may range from 41 to 75 percent.

Highway Advisory Radio (HAR) is a countermeasure that uses a local radio station dedicated to providing traveler information.

- In Brooklyn, an incident management system on the Gowanus and Prospect Expressways used CCTV, highway advisory radio, dynamic message signs, and a construction information

hotline to improve average incident clearance time by about one hour, a 66 percent improvement.

Another countermeasure is to restrict construction activity during peak conditions. Non-peak (major) construction policy implementation can include region-wide or statewide policy prohibiting major construction activities during peak periods along urban freeways.

- ADOT does restrict construction activities during peak periods along urban freeways. Results of this are evident in the data collection analysis where weekends have the highest percentage of non-recurring congestion.

The MAG region utilizes its Freeway Management System to the greatest extent possible for freeway construction; however, it is often not installed when a freeway is first built, but instead is designed and constructed as part of the first freeway widening activities. FMS may need to be designed as a freeway is being built with future construction activities in mind.

Route diversion could be improved through use of more DMS in the region showing messages prior to multiple interchanges or popular arterial diversion routes that would allow motorists to change their route prior to encountering the freeway segment under construction. In addition, DMS messages could be displayed prior to roadwork notifying drivers of the duration of construction activities and best alternative routes.

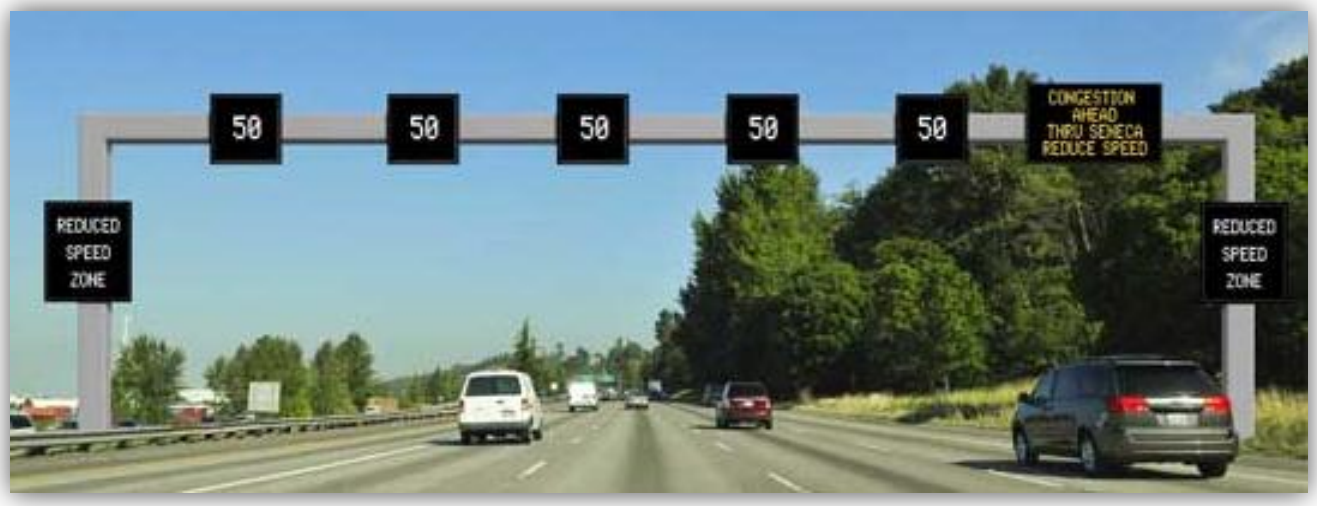
Highway Advisory Radio (HAR) is not implemented in the MAG region and not suggested as a countermeasure for NRC. Supplying local radio stations with traveler information may be a similar alternative to HAR that would better suit the MAG region.

Some states have tried to utilize a dynamic lane merge to improve the traffic flow in advance of, and at, lane closures. ITS technology can be used to monitor traffic flow and, as queuing increases at approaches to lane closures, regulates the merge, requiring either early merge or late merge depending on traffic conditions.

- Michigan Department of Transportation test of early merge found: 1) average travel speed increased from 40 to 46 mph during the morning peak period, and 2) crashes were reduced from an average of 1.2 per month during the 4 months prior to activation to no crashes after activation.

The use of variable speed limits (VSL), as part of Active Traffic Management, to manage speed (aka speed harmonization) on freeway corridors is gaining interest in the United States based on successful experiences in Europe. ITS technologies have been implemented that monitor traffic flow to change speeds to minimize speed differentials and maintain speed limit compliance. Successful European experience has typically implemented variable speed limits in conjunction with another treatment such as hard shoulder running during the peak periods.

- A Michigan DOT 2003 study found that both the speed limits displayed by VSL and operating speeds increased, driver compliance improve, and more consistent speeds resulted.



Source: www.wsdot.wa.gov

The MAG region, along with most of the country, does not implement Active Traffic Management. Its associated traffic management strategies that are not currently implemented in the MAG region are speed harmonization, queue warning, temporary shoulder use, junction control, construction site management, and truck restrictions. Active Traffic Management on one or more freeway study corridors could be considered as a possible countermeasure for NRC.

Another countermeasure that can be used for freeways or arterial streets under construction is smart work zones. Through the use of detectors and dynamic message signs, smart work zones can inform drivers of queues, delays, and need for diversion when conditions warrant due to lane closures. These systems can reduce mainline traffic volumes and improve perceived and actual safety.

- A 2008 USDOT report on the benefits of intelligent transportation systems in work zones, found an average 52 percent reduction in mainline traffic volume for I-294 in the District of Columbia and 10 percent reduction in mainline traffic volumes for a project on I-35 near Hillsboro, Texas.

There are also several emerging countermeasures being testing in pilot projects around the country. The actual benefits and costs of the projects are still pending. Examples of these are as follows:

- Dynamic ramp closures – San Francisco, California
- Shoulder running – Seattle, Washington; Minneapolis, Minnesota
- Traffic prediction – New Jersey Turnpike, New Jersey.

The potential use of the AWAM devices may provide the data feed needed to consider the development of a traffic prediction model for advance determination of likely non-recurring congestion conditions. Along these same lines, a more extensive deployment of vehicle detection stations/sensors would promote additional information which can aid officials in reviewing traffic conditions and/or disseminating the information to the public.

Another approach to mitigating non-recurring congestion is to attempt to minimize the number of incidents occurring due to faulty vehicle operations. State-mandated vehicle safety inspections would

help to control the number of unsafe vehicles operating on the roadways. At least 18 other states have periodic programs (annual or biannual) in place; however, some studies have suggested the cost-effectiveness of vehicle safety inspections is insignificant.

Table 4.3 below lists all of the non-recurring countermeasures mentioned above that are focused on mitigating non-recurring congestion caused by incidents and road construction activities on freeways.

Table 4.3 – Summary of NRC Countermeasures for Freeway Application

NRC Countermeasures	NRC Countermeasure Focus		Incident Element Focus					Applicability to MAG Region		Possible Next Steps
	Construction	Incidents	Public Awareness	Reducing # Incidents	Faster Detection	Faster Response	Faster Clearance	Currently in Use	Future Considerations ➔	
511 Traveler Info Dissemination	✓	✓	✓					✓	✓	Enhance
CCTV Camera Surveillance	✓	✓			✓			✓	✓	Enahnce
Highway Advisory Radio (HAR)	✓	✓	✓					X	✓	Test Variant
Info Dissemination via Permanent DMS	✓	✓	✓					✓	✓	Improve
Monitor Conditions per Real-Time Traffic Prediction	✓	✓			✓	✓		X	✓	Test
Restricted Work Zone Hours	✓							✓	✓	Enhance
Use of Dynamic Lane Merge Control	✓							X	✓	Consider
Use of Full or Dynamic Ramp Closures	✓	✓					✓	X	✓	Consider
Use of Smart Work Zones	✓							X	✓	Consider
Use of Variable Speed Limits	✓	✓		✓				X	✓	Test
Availability of Site Management/ Response Teams		✓				✓		✓	✓	Enhance
Broadcast Dynamic Route Diversion		✓	✓					X	✓	Consider
Enforce Quick Clearance Program/Law		✓	✓				✓	✓	✓	Improve
Install More/More Advanced Vehicle Detectors		✓			✓			✓	✓	Enhance
Permit Shoulder Running		✓				✓	✓	X	✓	Consider
Required Vehicle Safety Inspections		✓		✓				X	X	none
Use of Dynamic Lane Assignment		✓		✓			✓	X	✓	Test
Use of Advanced Ramp Metering System		✓		✓				✓	✓	Pending
Use of Service Patrols		✓		✓	✓	✓		✓	✓	Enahnce
Vehicles Equipped w/ Push Bumpers		✓					✓	✓	X	none

Arterials

There are very few examples of current experience and the effectiveness of non-recurring congestion countermeasures on arterials that are being used to address vehicle incident and roadway construction activities.

Countermeasures that can be applied to arterials to address either incident- or construction-related non-recurring congestion are:

Intelligent Transportation Systems (ITS)

The City of Scottsdale is an example of city-wide ITS deployment. They combine an advanced traffic management system with CCTV, DMS, and a media/public communication system. From the Scottsdale TMC, signal timing can be adjusted "on the fly" and manual control of the intersection can be taken to

clear long queues of vehicles. Scottsdale Traffic Management sends incident notifications to local media who broadcast on local public radio and offer direct notification to the public's cell phones. Scottsdale's use of ITS allows them to efficiently handle large crowds at special events like the Phoenix Open. It used to require 50 "on-street" police officers to manually operate the intersections affected by the event. Now it just takes one police officer posted in the Scottsdale Traffic Management Center.

Service Patrols

Nearly all of the service patrol type strategies around the nation are being applied mainly on limited access highways. The REACT program operated by Maricopa County, focused mainly on roads in unincorporated areas and a few cities in the West Valley, is perhaps the only program or one of very few such programs focused on arterials.

- A 2002 evaluation of Maricopa County's Regional Emergency Action Coordination Team (REACT) program showed a benefit to cost ratio ranging from 6.4:1 to 8:1 at that time.

CCTV

Increasingly, signalized intersections are being equipped with CCTV and their traffic signals are able to be dynamically managed from a traffic management center. Since arterial corridors parallel to freeway corridors are often used as route diversion, communication to local TMCs regarding freeway incidents may decrease non-recurring congestion. The results of Chapter 3 indicate that only multiple lane or full freeway closures affect parallel roadways one interchange upstream from an incident.

DMS

Some cities in the MAG region utilize permanent DMS, such as the Scottsdale, Phoenix, Peoria, Glendale, Surprise, Gilbert, and Chandler (all varying in extensiveness). The locations for the DMS are chosen primarily due to special event centers or proximity to freeway corridors. Permanent DMS could be installed on critical commuter corridors to provide travel time information and freeway conditions to motorists.

These, and other cities, also deploy portable DMS. These are commonly used upstream from construction zones. City transportation departments could work with local police to have a portable DMS system ready for deployment in their vehicles. This would provide a benefit for vehicular incidents in particular.

Push Bumpers

Push bumpers are already in use on nearly all DPS and police vehicles in the MAG Region.

Restrict Construction Activity During Peak Periods

Most cities in the MAG region restrict construction activity during the AM and PM peak hour and require full access and lane capacity at major intersections. The arterial volume data collection from this study

indicates that traffic volumes remain elevated throughout the day. Limiting construction activities to night and weekends may decrease non-recurring congestion.

Construction Activity Route Diversion

Most cities in the MAG region restrict construction activity during the AM and PM peak hour and require full access and lane capacity at major intersections. The arterial volume data collection from this study indicates that traffic volumes remain elevated throughout the day. Limiting construction activities to night and weekends may decrease non-recurring congestion.

Dynamic Signal Timing

The City of Scottsdale maintains 18 signal timing plans for each signal. Eight are emergency plans that can be quickly enabled for traffic collisions, stalled vehicles, or heavy event traffic. The City of Mesa will be implementing an Adaptive Traffic Control System (ATCS) around a major activity center. If their deployment proves to reduce delay, it may be the impetus to consider ATCS at other locations where highly variable traffic patterns occur. High variability can be caused by holiday shopping, special events, construction activities, and vehicular incidents.

Table 4.4 below summarizes the NRC countermeasures that are applicable to arterial deployment. The information also suggests possible countermeasure considerations for the MAG region based on its pre-existence (and opportunity for improvement) or potential for benefit based on use in other states.

Table 4.4 – Summary of NRC Countermeasures for Arterial Application

NRC Countermeasures	NRC Countermeasure Focus		Incident Element Focus					Applicability to MAG Region		Possible Next Steps
	Construction	Incidents	Public Awareness	Reducing # Incidents	Faster Detection	Faster Response	Faster Clearance	Currently in Use	Future Considerations ➔	
511 Traveler Info Dissemination	✓	✓	✓					✓	✓	Enhance
CCTV Camera Surveillance	✓	✓			✓			✓	✓	Enahnce
Dynamic Signal Timing to Adjust to NRC Events	✓	✓		✓				X	✓	Pending
Info Dissemination via Permanent DMS	✓	✓	✓					✓	✓	Improve
Info Dissemination via Portable DMS	✓	✓	✓					✓	✓	Test
Restricted Work Zone Hours	✓							✓	✓	Enhance
Availability of Site Management/ Response Teams		✓				✓		✓	✓	Enhance
Broadcast Dynamic Route Diversion		✓	✓					X	✓	Consider
Required Vehicle Safety Inspections		✓		✓				X	X	none
Use of Service Patrols		✓		✓				✓	✓	Enahnce
Vehicles Equipped w/ Push Bumpers		✓					✓	✓	X	none

RESOURCES NEEDED

Resources refer to the capital cost to implement and the ongoing operation and maintenance costs. The operation and maintenance costs typically include the human resources (or additional staffing) needed to operate and maintain a project or system. There is capital cost information from around the country on projects that attempt to mitigate non-recurring congestion caused by incidents and construction activity. There is less information, however, on the operation and maintenance costs as well as detailed information on the transferability of projects to other regions around the country. This section highlights the information available on the resources required to deploy.

The following highlights some of the costs available for representative projects from around the country:

Freeways

- The MAG region has had a Freeway Service Patrol Program since 2001.

- The Road Ranger Program in Florida that implemented freeway service program had a total cost of $1.1 million which averages about $55,500 per corridor.

- The annual cost of Houston TranStar includes annualized capital costs, annual operational costs of the Houston TranStar systems, and the annual cost of operation and maintenance of the field installations. The annualized cost estimate of $27.7 million.

- Motorist Assistance Patrol, Harris County, TX had an estimated benefit-cost of 23.3:1 with an annual cost of $362,000.

- SafeClear Program, Houston, TX had an estimated benefit-cost of 8.14:1 when considering its annual (capped) cost of $4,300,000 and first-year benefits of $35,000,000.

- The benefits of the NaviGAtor incident management program were determined during a before-and-after study that analyzed twelve months of data in the Atlanta metropolitan area. The HERO Motorist Assistance Patrol combined with the NaviGAtor incident management strategies had a benefit-cost ratio of 4.4:1 with a cost of $42M.

- The cost of the Alabama Service and Assistance Patrol (ASAP) during the 2004-2005 was $594,300.

- In the late 1990s, Monroe County Department of Transportation (MCDOT) undertook the ITS Camera Deployment and Systems Integration Project. The cost was $279,000 (2006).

- The Minnesota Twin City ramp metering study estimated an annual capital cost of $746,000 and an annual operating and maintenance cost of $896,000.

- Michigan DOT leased a Dynamic Lane Merge (DLM) system for I-94 reconstruction project initially for $120,000 (included design, install, calibrate, test, operate, and maintenance). The cost has dropped to $30,000 per deployment per direction (included installation, operation, inspection, maintenance, and removal).

- Minnesota DOT deployed Dynamic Late Merge system for $900 per day per direction.

- Michigan DOT leased 7 variable speed limit (VSL) trailers for 6 months at $400,900.The VSL system, which was deployed along I-96 in Lansing, consisted of seven trailers with remote traffic microwave sensors, solar power, controllers with radio frequency communication, and light-emitting diode (LED) speed displays. Work zone speed limits were based on traffic congestion, weather, presence of workers, and other factors.

- North Carolina DOT leased smart work zone system along I-95 near Fayetteville for $235,000. The system consisted of six speed sensors, eight changeable message signs (CMS) (two were used on alternate routes), six pan-tilt-zoom cameras (three in each direction), a command center, one laptop, and a dedicated project website. Delay information (i.e., delay in minutes, current date and time) was calculated and automatically displayed in real-time on the CMS. When a pre-determined

threshold was reached, the message was changed to provide travelers with alternate route information. The lease consisted of three items: mobilization, monthly rental, and remobilization. The bid was guaranteed for four months usage but not to exceed 10 months.

- Illinois DOT implemented a work zone Traffic Monitoring System (TMS) on I-64 construction project for $435,000. It consisted of 12 variable message signs (VMS) located within and in advance of the work zone so travelers can determine whether or not to take alternate routes, and 10 side-fire radar sensors. These sensors were mounted on portable trailers and measured speed, volume, and occupancy lane-by-lane. Real-time information about traffic conditions was posted to the VMSs and automatically posted to the project web site. Data was transmitted via cellular-IP back to the server located at the vendor's site. IDOT traffic center had capability to change the messages on the VMSs. Text and e-mail alerts were transmitted when pre-determined thresholds were reached. The TMS was deployed for 30 months.

- The Arkansas State Highway and Transportation Department (AHTD) leased an automated work zone information system (AWIS) in West Memphis for $495,000 which was less than 4% of the total reconstruction project cost. The AWIS included 12 queue detectors and five remotely controlled DMS which were linked to a central base station server via wireless communications, three HAR units, five pagers, and an email alert system. The traffic detectors were installed one mile on each side of the work zone. The DMSs were deployed over approximately 9 miles on each side of the work zone. The HARs range was approximately 23 miles. The server processed data from the queue detectors and disseminated messages to the DMS and HAR based on predefined messages for specific traffic conditions. AHTD staff and others were informed of traffic conditions via email and pager alert systems. The lease included personnel to monitor the system. Usually one person was required for periodic system maintenance and to be on-call after hours. The terms of the lease called for a daily fee paid to the contractor and a lump sum for the HARs. The fee was assessed each day the system was operational, thereby the state did not pay for any system down time.

- A real-time work zone traffic information system deployed for the I-496 project in Lansing, Michigan had an estimated benefit-cost of 1.97:1 with a cost of $5M ($2.5M for real-time information components and $2.5M for the system).

Given the incidental cost information presented above coupled with the characteristic information presented previously in Table 4.3, the following subset of Freeway NRC Countermeasures are presented (in order of generally increasing estimated implementation costs/complexity) for further consideration for this study's pilot project framework development:

- Installation, monitoring, and dissemination of vehicle sensors and its resulting data;
- Improved information dissemination via existing permanent DMS;
- Enhanced ramp metering system;
- Use of dynamic lane merge control within construction zones; and
- Implementation of Active Traffic Management strategies (e.g., dynamic lane assignment and/or variable speed limits)

Arterials

Due to limited deployment of systems specifically focused on monitoring for, or reducing, NRC on arterial roadways, data concerning resource needs is lacking. The one example, which is particular to the MAG region, is cited below.

- A 2002 evaluation of the Regional Emergency Action Coordination Team (REACT) program, as implemented in the MAG region at the time, estimated benefit-cost ratios from 6.4:1 (current operation) to 8.4:1 (maximum operation) with the following assumptions.

Callouts/year	Cost ($)	Benefit ($1,000)	B-C Ratio
100	103,200	664	6.43:1
150	126,550	996	7.87:1
175	142,350	1,162	8.16:1
200	158,100	1,328	8.40:1

In order to determine a subset of the arterial NRC countermeasures to consider further as part of this study, a qualitative assessment of their resource needs and ease of implementation was conducted. The countermeasures that were determined to have a combination of the least resources required and an implementation that could be carried out the easiest were (in order of generally increasing estimated implementation costs/complexity):

- Real-time traffic monitoring and control
- Improved information dissemination via existing permanent DMS;
- Use of portable DMS to disseminate immediate information concerning NRC event; and
- Dynamic signal timing to adjust traffic control to NRC events

CHAPTER 5

DEVELOPMENT OF AN IMPLEMENTATION PLAN

INTRODUCTION

This chapter offers a shortlist of countermeasures that could be implemented regionally over a period of five years by interested MAG member agencies. Estimated resources required by potential participating agencies are identified for each countermeasure including Estimated Initial Capital Costs, Estimated Annual Operating Costs, and agency staff requirements in Full Time Equivalents (Estimated FTEs).

SHORTLIST OF COUNTERMEASURES

Freeway NRC Countermeasures

The following groups of Freeway NRC Countermeasures were presented in Chapter 4 (in order of generally increasing estimated implementation costs/complexity) for further consideration for this study's pilot project framework development:

1. Improved real-time travel information dissemination;
2. Installation and monitoring of vehicle sensors and its resulting data;
3. Enhanced ramp metering system;
4. Use of dynamic lane merge control within construction zones and at other lane drop locations; and
5. Implementation of Active Traffic Management strategies (e.g., dynamic lane assignment and/or variable speed limits) at appropriate locations.

The countermeasures/concepts shown above were discussed further to spur the following modified (or different) NRC countermeasure ideas that are specific to the MAG region. Accompanying the introduction of the various NRC countermeasures below, the following descriptive elements are presented for each: local and/or national experience, potential facility application in the MAG Region, how the countermeasure affects or counteracts NRC, any additional elements to promote a successful (or comprehensive) deployment, and cost estimates (capital, operating, staff). The countermeasures are presented in no particular order in order to aid further discussion of their merits as a potential pilot project in the MAG region.

NRC Countermeasure Category No. 1: Improved real-time travel information dissemination

The ability to provide timely and accurate real-time traffic information and advisories to travelers that might be impacted by NRC and is an important traffic management tool. The AZ511.gov website is devoted to Arizona's portion of the national 511 travel information system. Current information on traffic conditions is available there, and a subset of the information is also accessible by dialing 5-1-1 from any landline or mobile phone from anywhere in Arizona. The system provides information for all ADOT roadways, some special event travel and parking information, travel times on seven freeway corridors in the Phoenix area, transfers incoming phone inquiries on transit to RPTA. Freeway condition information for the Phoenix metropolitan area is also accessible via cellular phones at the mobile 511 website – www.az511.com/pda.

In addition to the AZ511.gov website, there are a number of other websites such as Google Maps, NAVTEQ (www.traffic.com) and Mapquest that also provide accurate real-time traffic information. Some of the private sector websites provide additional services. For example, NAVTEQ provides SMS text alerts if a user's travel or commute route is seriously impacted by incidents, beyond a certain Jam Factor threshold that is defined in the user's profile.

Suggested countermeasures:
C1 – Improve the availability of real-time travel information by improving data availability to private sector travel information application developers

C2 – Provide real-time information on parallel arterials and transit routes

Other suggested initiatives/projects:
- An evaluation of the entire AZ511 website from an end user viewpoint – this may provide some insights on how to refine the website and focus on a few areas

C1 – Countermeasure Elements:
- Custom data feeds (RSS, XML) for any private developers who want to access FMS traffic data
- Enhanced functionality from existing FMS traffic cameras such as more frequent snapshot updates, video, or simulated motion through consecutive snapshots (if identified in the user survey as a desired application)

C2 – Countermeasure Elements:
- Travel time information on parallel arterials and transit
- Route planning utility that allows users to access information on their personalized route only (this is already available at NAVTEQ and might not be a function that the public sector needs to develop or support)

How these countermeasures reduce NRC:
C1 – This countermeasure would increase availability of real-time information, allowing road users to make more informed choices which could reduce the impact of NRC

C2 – Enhancement of the system to provide information pertaining to arterial roadways, especially those regularly utilized in conjunction to (or as an alternative to) the freeway system, will provide additional information for travelers to consider when determining their travel route, mode, or time. This could result in shifting of traffic demand to routes and modes that have unused capacity -- this requires a real-time information on arterials and transit which is currently unavailable

Implementation Costs:
C1 – Additional equipment needed for enhanced data sharing – computer servers and telecommunications

Cost of infrastructure and equipment	$500,000
Annual Operating Cost	$50,000 (10% of capital cost)
Staff required -- estimated FTEs	0.5
Responsible agency	ADOT

C2 – Provide real-time information on parallel arterials and transit routes

Cost to instrument one arterial mile	$25,000
Cost to acquire real-time transit information	$0
Annual operating cost	$5,000
Staff required -- estimated FTEs	1
Responsible agency – arterials	Local agency
Responsible agency – transit	RPTA/City of Phoenix

NRC Countermeasure Category No. 2: Expand Coverage for Real Time Traffic Monitoring

The foundation for this NRC countermeasure concept is that real-time knowledge of space-mean speed on a freeway can provide better information for interpretation by, and/or dissemination to, the road users. In order to achieve the real-time and space-mean characteristics of freeway traffic flow, Anonymous Wireless Address Matching (AWAM) devices could be used by establishing data collection stations (2- to 3-mile intervals) within existing infrastructure elements (e.g., DMS control cabinet). Another viable option would be to purchase real-time traffic flow data from the private sector. The space-mean speed data captured in real-time could be used to distribute actual travel time immediately, to calculate traffic density for the freeway, and/or for travel time reliability determination. This information, filtered as appropriate, could be broadcast to DMS, local media, phone applications, possibly aid in establishing a predictive model of traffic conditions, and could become a management tool for ADOT.

The private sector data is starting to show value in real-time applications on high demand facilities that have significant traffic volumes can produce reasonable representation of real-time conditions. MAG has determined that the private sector traffic speed data for the region is sufficiently accurate for travel demand model calibration purposes and is currently in the process to purchase archived data for 2010 from two vendors. Previous concerns about the accuracy of probe based data have gone away due to large sample sizes of probe vehicles available in most large metropolitan regions areas such as the MAG region.

Suggested Countermeasures:
C1 – Expand coverage of the FMS functions on the freeway system
C2 – Real-time speed monitoring on major arterials

C1 – Countermeasure Elements:
- Broadcasts more specific travel time information (i.e., specific segment) on DMS
- Display travel time information on a greater number of DMS
- Extend the time periods that travel time information is displayed on DMS
- Monitor travel time reliability to determine propensity for NRC events

C2 – Countermeasure Elements:
- Develop color coded speed map to disseminate to AZ511 and private sector travel information application developers
- Use travel time to develop prediction model based on historical trends by day and time coupled with trending at current time; provide that predicted MOE (density) on DMS
- Monitor travel time reliability to determine propensity for NRC events

How these countermeasures reduce NRC:
C1 – This countermeasure disseminates precise real-time travel time information to freeway users during their journey allowing them to make educated decisions about their travel route in order to avoid NRC.

C2 – Enhancing collection of travel time and speed information on arterial roadways, especially those regularly utilized in conjunction to (or as an alternative to) the freeway system, will provide additional information for travelers to consider when determining their travel route, mode, or time.

Implementation Costs:
C1 – Additional staff hours needed to determine specific travel time, post travel time information, and monitor DMS

Cost of infrastructure and equipment	$0
Annual Operating Cost	$15,000
Staff Required -- estimated FTEs	0.25
Responsible agency	ADOT

C2 – Collect real-time travel time and speed information on parallel arterials

Cost to instrument one arterial mile	$5,000
Annual operating cost	$5,000
Staff required – estimated FTEs	0.25
Responsible agency	Local agency

NRC Countermeasure Category No. 3: Improve Regional Integration

Travelers in the MAG region use roadways of multiple jurisdictions for many of the trips they make. Open communication and sharing of resources between jurisdictions can improve traffic management following a NRC event. In addition, there is a national cultural shift and setting of priorities due to mobility demand unable to be met by building new roads. Municipalities and government agencies in the MAG region could be more strategic in how existing resources are used and how they invest in future infrastructure to preserve existing roadway capacity through better operations. Arizona has been identified by FHWA as an Opportunity State to target efforts in advancing operations. There are several improvements recommended in the Arizona Operations Action Plan that relate to non-recurring congestion. A few are highlighted below:

- Travel time
- Develop regional performance measures
- Develop policies to allow alternate route information
- Develop relationships/IGAs to allow joint operations
- Advance signal coordination between jurisdictions
- Shared utilization of cameras, signals, DMS, etc.
- Establish incident management coalition (already in effect)
- Improved communications during traffic incidents (subscribe to private sector data feed at TMC level)

It must be noted that there are no new or additional federal or state funds available for states identified as Opportunity States. Any planned improvements to regional integration would have to be carried out with existing resources.

Suggested countermeasures:
C1 – Share resources between municipalities and government agencies to facilitate traffic management
C2 – Encourage jurisdictions to input information into RADS

C1 – Countermeasure Elements:
- Share utilization of cameras, signals, and DMS between agencies
- Share freeway travel times to post on arterials
- Coordinate with already established Incident Management Coalition

C2 – Countermeasure Elements:
- Encourage jurisdictions to input work zone and incident information into RADS to facilitate regional information sharing

How these countermeasures reduce NRC:
C1 – This countermeasure would allow better management of diverting traffic in the vicinity of a NRC event.

C2 – This countermeasure would collect NRC event information such as incidents which would allow future analysis of NRC in the region as well as facilitate multi-jurisdictional preparation for road closures or reduced capacity due to work zones.

Implementation Costs:
C1 – Time devoted to communication and information sharing

Cost of infrastructure and equipment	$0
Annual Operating Cost	$0
Staff required -- estimated FTEs	0.5 ADOT, 0.25 per member agency
Responsible agency	ADOT, MAG Member Agencies

C2 – Training and time required to upload data

Cost of Training	$5,000
Annual Operating Cost	$0
Staff required -- estimated FTEs	0.1 per member agency
Responsible agency	MAG Member Agencies

NRC Countermeasure Category No. 4: Implement Active Traffic Management

"[Active Traffic Management] is the ability to dynamically manage recurrent and non-recurrent congestion based on prevailing traffic conditions. Focusing on trip reliability, it maximizes the effectiveness and efficiency of the facility. It increases throughput and safety through the use of integrated systems with new technology, including the automation of dynamic deployment to optimize performance quickly and without the delay that occurs when operators must deploy operational strategies manually. This congestion management approach consists of a combination of operational strategies that, when implemented in concert, fully optimize the existing infrastructure and provide measurable benefits to the transportation network and the motoring public. These strategies include but are not limited to speed harmonization (variable speed limits), temporary shoulder use, junction control, and dynamic signing and rerouting. Managed lanes, as applied in the United States, are an obvious addition to this collection."

- FHWA's *Active Traffic Management: The Next Step in Congestion Management*

The key challenges for implementing Active Traffic Management (ATM) are:

- Funds for the installation of sophisticated FMS infrastructure
- Better tools required for Active Traffic Management at the TOC
- Highly skilled technical staff for advanced traffic management

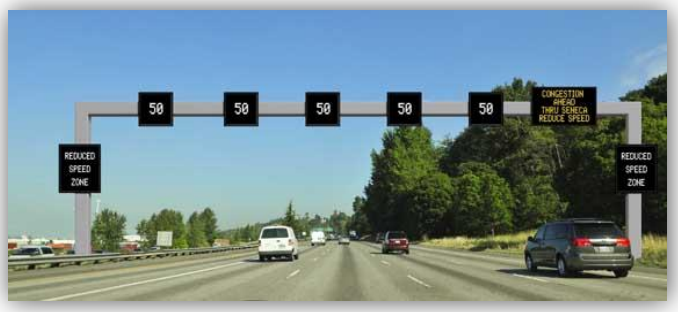
Of these, the staffing issue may be the biggest challenge due to inability to pay the requisite salaries for the required technical staff positions and inadequate position descriptions in the public sector. This issue, however, may be overcome by other models for delivery of such skilled services considered as a valuable public service.

Regional funds have already been programmed in the MAG RTP for expanding the FMS infrastructure. Through careful planning, it may be possible to reprogram available FMS funds to both acquire any required tools for ATM and to incorporate ATM infrastructure within a revised FMS expansion plan.

Existing Facility Application Examples:

- Minneapolis-St. Paul, Minnesota
  Minnesota DOT, as part of their priced dynamic shoulder lane project, is now operating variable speed controls and queue warnings in a three-mile segment of I-35W as part of their Urban Partnership grant, and an extension of the system is planned. They are studying the implementation of a similar approach for portions of I-94 between Minneapolis and St. Paul. A 2010 study estimated benefit/cost ratios (for 2030 and including safety benefits) between 15:1 and 50:1 (see Tables 1 and 2 at http://www.metrocouncil.org/planning/transportation/MHSIS/AppEATMmodel.pdf).

- Seattle, Washington
  Washington State DOT constructed a variable speed limit/queue warning system on approximately eight miles of I-5 as it approaches Downtown Seattle in the northbound direction. The signs post variable speed limits that help warn drivers of backups ahead in an attempt to smooth out traffic as it approaches a lane blocking incident. The overhead signs can also quickly close entire lanes and provide warning information to drivers before they reach slower traffic. This advance notification has initially shown to help reduce the number of congestion-related collisions, such as rear-end collisions. The I-5 ATM project is funded as part of WSDOT's Alaskan Way Viaduct and Seawall Replacement Project at $23.8M. WSDOT is also proceeding with the design and construction of a similar system on I-90 and SR 520 across Lake Washington as part of their Urban Partnership grant from USDOT.



<u>Suggested Countermeasure:</u>
C1 – Implement active traffic management on freeway corridors prone to NRC (e.g., approaches to I-10 Deck Park Tunnel)

C1 – Countermeasure Elements:
- Dynamic Ramp Metering (in progress by ADOT)
- Dynamic Lane Merge
- Peak Hour Shoulder Running
- Variable Speed Limits
- ¼ to ½ mile gantry structures
- Monitoring of freeway performance and Travel Time Reliability in corridors

How this countermeasure reduces NRC:
C1 – This countermeasure would actively manage traffic around blocked lanes from incidents, harmonize speed to reduce secondary incidents, and meter traffic entering the freeway based on congestion levels.

Implementation Costs:
C1 – Installation of infrastructure, equipment, and hiring of technical staff

Cost of infrastructure and equipment varies:
- Data loops/stations: $25,000
- TMC software for various traffic controls: $2.25M (e.g., speed harmonization = $1.5M)
- Gantry with foundation: $225,000
- Variable Speed Limit sign (shoulder): $15,000

Annual Operating Cost varies:
- $500 per structure (Gantry use example)
- $5,000 per DMS
- $1,000 per data station
- $3,000 per instance of VSL Sign
- Up to $40,000 per mile for fully instrumented section

Staff required -- estimated FTEs: 2 to 4
Responsible agency: ADOT

NRC Countermeasure Category No. 5: Improved Freeway Incident Response

Quick response and clearance reduce the amount of traffic exposed to non-recurring events and congestion. Although the MAG region is already proactive in identifying and responding to incidents via the FMS and operators at the Traffic Operations Center, ALERT Team and the Freeway Service Patrol, additional measures could be considered to enhance response times and effectiveness.

Suggested countermeasures:
C1 – Increase courtesy patrol to respond to disabled vehicles and incidents
C2 – Reduce the time incidents affect traffic; thereby, reducing NRC

Other suggested initiatives/projects:
- Expand coverage to include frontage roads and ramp/arterial intersections

C1 – Countermeasure Elements:
- Enhance DPS's Safe Commute program to provide more officers/vehicles, or extend hours of operation, or expand the freeway coverage

C2 – Countermeasure Elements:

- "SafeClear" Program (see inset below)

Houston SafeClear Program

In January 2005, the City of Houston began its SafeClear traffic incident management program. The program's primary objective is to improve public safety, i.e. a reduction of accidents, injuries and deaths on Houston freeways. A 2007 study comparing two years before/after data concluded that the program was successful by having the desired effect of reducing collisions, congestion, and crash clearance times. With the program in place there were 1300 fewer freeway crashes per year which translated into $35 million in savings per year. The program essentially divides Houston's freeways into segments with assigned private tow operators responsible for their own segments. By doing this it addresses problems associated with the 'free-for-all' that occurs as tow operators race towards disabled vehicles, thus minimizing response times and collisions (primary and secondary).

Houston's SafeClear program was modeled after a similar program in New York City. In the months leading up to formal action by the City Council creating the program, anecdotal information was collected such as Houston freeway incidents as reported by TranStar, incident management results of preventing accidents prepared by the Texas Transportation Institute at Texas A & M University. As part of a nationwide training effort, the American Traffic Safety Association reported that "Thirty percent of highway crashes are secondary crashes…and 18% of all highway deaths occur in those crashes".

Clearly, a secondary benefit of the program is improved travel times. When accidents are reduced, travel times improve. Disabled vehicles create both physical hazards and visual distractions, increasing the risks of collisions and increasing travel times.

As a result of concerns related to "ability to pay and owners' choice", City Council approved amendments to the freeway tow operator contracts in early 2005 to provide a free tow ($50 paid by the City) to a safe location no more than one mile from a freeway exit. There is no 'cash' incentive to clear a crash quicker; however, there is a performance requirement for tow operators to respond to calls within six minutes.

How these countermeasures reduce NRC:

C1 – This countermeasure reduces the overall time disabled vehicles or incident vehicles block travel lanes which can relieve the buildup of NRC.

C2 – This countermeasure reduces the overall time an incident remains on the freeway which can alleviate NRC quicker and prevent secondary incidents.

Implementation Costs:
C1/C2 – Additional service patrol vehicles and operating personnel

Cost of equipment:	$150,000 for 3 more service patrol vehicles
Annual Operating Cost:	$75,000
Staff required -- estimated FTEs:	3
Responsible agency:	ADOT and DPS

NRC Countermeasure Category No. 6: Dynamic Lane Control

Dynamic lane control/merge improves traffic flow in advance of, and at, lane closures. ITS technology can be used to monitor traffic flow and, as queuing increases at approaches to lane closures, regulates the merge, requiring either early merge or late merge depending on traffic conditions. This countermeasure could be applied in conjunction with an Active Traffic Management strategy or applied as needed for long-term construction projects (or known lane-drop locations).

Source: Michigan State University

Suggested countermeasures:
C1 – Monitor traffic flow for individual lanes and provide signs to drivers regulating lane merge in advance of, and at, lane closures

Other suggested initiatives/projects:
- Apply dynamic lane control in conjunction with an active traffic management strategy

C1 – Countermeasure Elements:
- Install sensors to monitor traffic flow
- In work zones, connect or equip portable DMS with traffic condition sensors
- Install infrastructure and signing to guide drivers at merge

How this countermeasure reduces NRC:
C1 – This countermeasure would facilitate real time data collection in each lane which would be used to provide information to drivers to regulate lane merge. This would result in better/smoother control of traffic during a NRC event or as a means to mitigate a possible secondary event (e.g., crash).

Implementation Costs:
C1 – Additional sensors, infrastructure, and signing

Cost of infrastructure and equipment	up to $1,000/day per direction (leased for construction)
Staff required – estimated FTEs	none (contractor)
Responsible agency	ADOT

Arterial NRC Countermeasures

The following subset of Arterial NRC Countermeasures were presented in Chapter 4 (in order of generally increasing estimated implementation costs/complexity) for further consideration for this study's pilot project framework development:

- Real-time traffic monitoring and control
- Improved travel information dissemination
- Use of portable DMS to disseminate immediate information concerning NRC event; and
- Adaptive signal timing to adjust traffic control to NRC events

The countermeasures/concepts shown above were discussed further to spur the following modified (or different) NRC countermeasure ideas that are specific to the MAG region.

NRC Countermeasure Category No. 7: Real-time Traffic Information

Real-time point-to-point travel time information would be very valuable to agency staff in actively managing traffic from the TMC. This information plus other timely traffic advisories to travelers on major arterials would help minimize NRC by redistributing traffic along less congested paths. Obtaining real-time travel times on the arterial road network in the MAG region would require extensive instrumentation for this data collection effort. An option for public agencies is to instrument selected corridors with data gathering devices such as the Anonymous Wireless Address Matching (AWAM) device. Another option would be to purchase real-time traffic speed information that is already being gathered and synthesized by a number of private sector traffic information providers. A number of national studies have verified the accuracy and reliability of the data provided by these data vendors such as INRIX, NAVTEQ and TrafficCast. The real-time point-to-point travel time estimates generated could be displayed on arterial DMS, provided to local media, broadcast via PDA website. This information could also be used to develop models and decision support systems to aid in Active Traffic Management.

<u>Existing Facility Application Examples:</u>

- Houston's *TranStar*
  - Performed a pilot deployment of AWAM on arterial streets on the west side of the City
- Minneapolis/University of Minnesota
  - Modified data feedback from signal sensors

<u>Suggested countermeasures:</u>

C1 – Expand coverage and distribution of real time speed and travel time data collection on arterials

C1 – Countermeasure Elements

- Instrument corridors with AWAM or purchase real-time traffic speed information from private sector
- Display travel time information on DMS
- Distribute gathered data to AZ511 or other agency websites for public access

<u>How this countermeasure reduces NRC:</u>

C1 – This countermeasure disseminates real-time travel time information to arterial users during their journey allowing them to make educated decisions on their travel route in order to avoid NRC.

Implementation Costs:
C1 – Collect real-time travel time and speed information on arterials and disseminate information

Cost of equipment	$150,000 (25 AWAM devices @ 2 mile spacing in grid = 64 square miles)
Annual Operating Cost	$63,000 ($210 per month per device)
Staff required -- estimated FTEs	0.25 per agency involved
Responsible agency	Local agencies

NRC Countermeasure Category No. 8: Adaptive Traffic Signal Control

Adaptive traffic signal control (ATSC) systems can quickly adapt the current timing plan to accommodate the diverted traffic from a non-recurring event. Also, incidents occurring at a system intersection could be better accommodated by the ATSC as it senses the reduced demand or even the concentrated use of an approach/lane. There are a number of different types of ATSC systems, but the basic premise is that existing signal control can be made more efficient through the use of additional sensor data, the interpretation of it (by the ATSC), and the real-time modification of the basic signal control parameters (cycle lengths, offsets, phase splits, phase sequencing). Although this countermeasure is not new, its more extensive use and capabilities are on the rise. For example, ATSC could help at signalized interchanges and along signalized arterial corridors when there is a surge in demand due to a freeway incident and travelers' diversions to parallel arterial routes.

Suggested Countermeasure:
C1 – Implement ATSC on arterials, especially where there are unpredictable fluctuations in traffic volume (e.g., Bell Road corridor, Glendale sports arena area, Rural Road/ASU, extend current Mesa project)

C1 – Countermeasure Elements:
- Install adequate detection required for ATSC system selected and integrate the ATSC system
- Obtain data from ATSC system, AWAM devices, or purchase private sector data to monitor travel time as a measure of effectiveness

How this countermeasure reduces NRC:
C1 – ATSC system signals would modify the basic signal control parameters in real-time in response to NRC events to reduce and prevent congestion.

Implementation Costs:
C1 – ATSC system and additional detection required

Cost of infrastructure and equipment	$800,000 ($40,000 per intersection – assume test of 20 intersections)
Annual Operating Cost	$100,000 ($5,000 per intersection)
Staff required -- estimated FTEs	none – assumed advantage is that staff monitoring and timing costs are reduced
Responsible agency	Local agencies

NRC Countermeasure Category No. 9: Improved Incident Response

Pinpointed and quicker response to incidents on arterial roadways could be realized by integrating real-time data/information feeds and additional vehicles at strategic stationing. Public agencies are increasingly exploring the use of private sector traffic data for various types of applications. The private sector data has shown useful for planning and historical applications, but may be lacking at this time

with respect to the arterial roadway network. As an alternative, AWAM devices could be deployed to establish a grid for monitoring real-time traffic conditions during the peak demand periods (when NRC would have the most impact). Expanded coverage area would necessitate additional response vehicles/staffing.

Existing Facility Application Example:

- Maricopa County REACT Program

Suggested countermeasure:

C1 – Enhance area of incident response on arterials. Establish a test section 8 miles by 8 miles (64 square miles) in contiguous jurisdictions. If private sector data unavailable, assume 2-mile spacing of AWAM devices to provide coverage. Assume one staffed truck per 16 square-mile area (an area 4 miles on a side) results in 4 staffed trucks strategically placed.

C1 – Countermeasure Elements:

- Monitor test area to detect major incidents by acquiring private real-time data or rely on AWAM coverage
- Monitor traffic conditions on potential alternative routes
- Strategically place staffed trucks for dispatch to assess/restore traffic conditions

How this countermeasure reduces NRC:

C1 – Quick incident response time and clearing vehicles and debris from travel lanes will reduce and prevent congestion. Monitoring potential alternative routes will allow traffic to be directed away from an NRC event that cannot be cleared quickly.

Implementation Costs:

C1 – Additional service/response vehicles and associated personnel plus real-time monitoring capabilities

Cost of infrastructure and equipment	$200,000 for three new vehicles + $100,000 to $200,000 for private sector data or AWAM coverage
Annual Operating Cost	$100,000 to $125,000
Staff Required -- estimated FTEs	6 to 8 (some current resource re-assignment considered)
Responsible agency	Local agencies

CHAPTER 6

DEVELOPMENT OF THE FRAMEWORK FOR A PILOT PROJECT

INTRODUCTION

This chapter presents the framework for a pilot project to counteract NRC along the I-10 corridor in the West Valley. The corridor defined for this pilot project is I-10 from I-17 to SR 85 as shown in Figure 6-1. The pilot project is intended to build upon and work cooperatively with the work already done by the Traffic Incident Management (TIM) Coalition. The framework for the pilot project will include the definition of the various TIM Focus Areas that include processes, activities and protocols, currently utilized by all agencies involved in any TIM activity in the I-10 corridor.

Figure 6.1 – Pilot Project I-10 Corridor Map

PROPOSED PARTICIPANTS IN THE I-10 CORRIDOR TIM PILOT PROJECT

- DPS
- ADOT
  - Construction
  - Maintenance
  - Valley Project Management
  - ALERT
- MAG
- Maricopa County
  - Traffic Management Division
  - REACT
  - Medical Examiner's Office
- City of Phoenix
  - Street Transportation Dept.
  - Police & Fire Departments
  - Public Transit Department
  - Information Technology Services
- City of Avondale
  - Traffic Engineering Division
  - Police & Fire Departments
  - Information Technology Dept.
- City of Goodyear
  - Streets and Traffic Operations
  - Police Traffic Unit
  - Fire Department
  - Information & Technology Services Dept.
- Town of Buckeye
  - Public Works Department – Streets
  - Police & Fire Departments
  - Information Technology Dept.
- Valley Metro RPTA
- FHWA
- Arizona Professional Towing & Recovery Association, Inc.

SCOPE FOR THE I-10 CORRIDOR TIM PILOT PROJECT

The pilot project is envisioned as a phased approach to incident management (a study-determined primary cause of NRC in the MAG region) along the study corridor. Figure 6-2 shows the recommended process for the project.

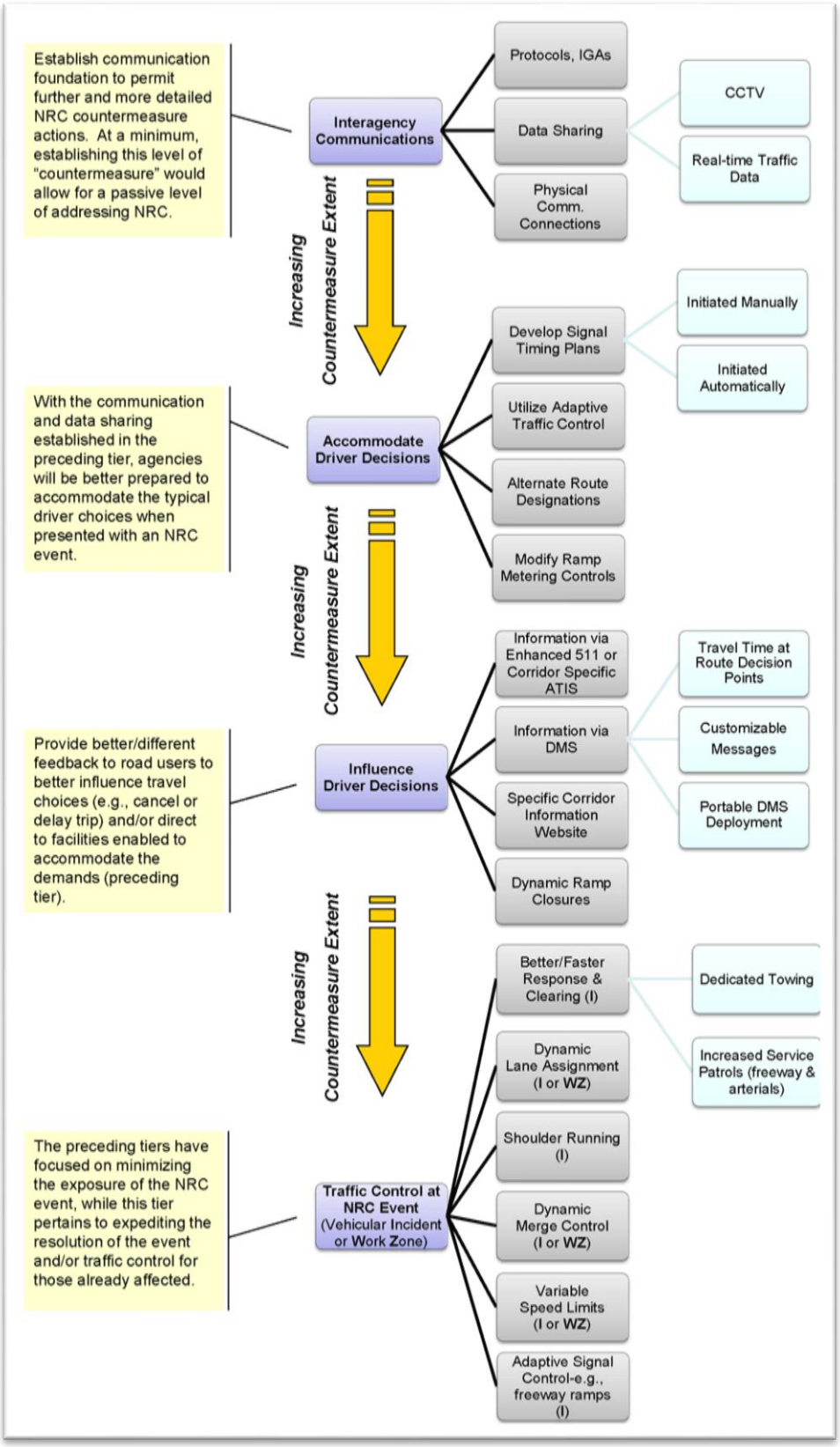


Figure 6.2 – Flow Chart of Proposed Pilot Project

The following identifies the proposed phases and what could be included in each:

1. **Interagency Communications: Enhance agency communication and coordination process** – This is a short term, immediately implementable phase building on the processes already being discussed by the TIM coalition. The logical focal point will be the ADOT Traffic Operations Center (TOC), however it must be determined if the additional coordination required with other agencies for this pilot project can be accommodated with existing staff resources. The TIM coalition has the framework for coordination with other agencies including the DPS, City of Phoenix, City of Avondale and Maricopa County. This phase will define who, how and when a corridor agency will be notified when a major incident blocks two or more lanes on I-10 and what the proper course of action by the various agencies is. It will make use of existing DMS signs with agreement of what messages are displayed under what lane closure scenarios. A unified process will be established for communicating with and providing updates to broadcast print and internet media.

2. **Accommodate Driver Decisions: Provide arterial street signal timing for incidents** – This will be a near term (within 2 years) phase in which traffic signal timing plans will be developed for the arterial streets near and parallel to I-10. This signal timing effort could be funded using the existing MAG Traffic Signal Optimization Program (TSOP). These signal plans would have longer cycle lengths favoring the directions of diverted I-10 traffic. Adaptive Traffic Signal Control (ATSC) could also be implemented. ATSC, particularly at I-10 traffic interchanges, can adapt to volatile traffic volumes expected with freeway lane closures. Additionally, ATSC may be a solution for signals with communication limitations.

   The primary arterial streets initially will likely be McDowell and Van Buren. One idea is that McDowell will accept additional traffic in the event of westbound I-10 lane closure and Van Buren will accept additional traffic in the event of eastbound I-10 lane closure. The thinking behind that is that right turns will be made when departing the I-10 ramp which will accommodate more vehicles than if left turns are made. However, in either case, that also requires left turns when the rerouted vehicles reach McDowell or Van Buren.

   The special timing plans will provide extra time at the intersections receiving the rerouted traffic and progression in the direction of the I-10 movement being accommodated. Although this concept is the initial thinking, simulation modeling of this scenario as well as additional scenarios (such as both right and left turns from I-10 ramps and two-way progression on McDowell and Van Buren) will be made. The first such signal timing efforts will be in locations where communication between a city TOC and the signals along McDowell and/or Van Buren either exists now or will in the near future. Currently, the City of Phoenix has about 75 percent of their signals along McDowell and Van Buren between 35th Avenue and 83rd Avenue communicating with their TMC via leased telephone lines. In early 2013 a federally-funded project will be completed that will provide fiber or wireless communication to all signals in west Phoenix along McDowell Road, Thomas Road, and Indian School Road.

   Maricopa County has communications on MC 85 between 75th Avenue and Cotton Lane. The City of Avondale does not have communication to many of their signals at this time although they do have an ATMS and have some conduit and fiber. Avondale has also attempted wireless communication but is generally not satisfied with the results. Buckeye does not have an ATMS but is proceeding with conduit and fiber installation as development occurs. Currently, the ramp signals on I-10 in this area are operated by ADOT; however there is no

communication between them and the ADOT TOC. They are planned to be controlled in the future from the TOC.

A local agency in the corridor has expressed a common concern regarding their ability to take on additional signal timing tasks that may be associated with this pilot project. This concern needs to be addressed in finalizing the scope of the pilot project.

3. **Influence Driver Decisions: Provide infrastructure improvements** – This phase will be a medium term program (3-5 years) that will require budgeting for the improvements. Needs for infrastructure improvements will be identified, such as additional fiber-optic communications in the corridor, linking all agencies via the Regional Community Network (RCN) or additional DMS. Another potential infrastructure improvement is CCTV at the intersections along McDowell Road and Van Buren Street. These improvements could be programmed in August 2011 for the FY 2015 TIP as a potential regional project involving ADOT, DPS, MCDOT, Phoenix, Buckeye, Goodyear and Avondale. This potentially will include communication from TOCs (both cities and ADOT) to other signals along the corridor needed to complete deployment of timing plans to accommodate extra diverted I-10 traffic when incidents occur.

   A project in the MAG TIP for FY 2015 will fund the extension of the FMS along I-10 from 83rd Avenue to Dysart Road by 2016. The recent I-10 widening project from Dysart Road to Sarival Avenue included installation of three 3-inch conduits with pull boxes on the north and south sides of I-10 which will be utilized, at least in part, for FMS. Although there are current and future plans for additional I-10 widening between Sarival Avenue and Verrado Way, the new lanes will be located within the present median (as was the case for the completed segment from Loop 101 to Dysart Road) thereby minimizing the likelihood of FMS infrastructure being included in the work. Widening of I-10 from Verrado Way to SR 85 is expected within a later phase of the Regional Transportation Plan. The basic infrastructure (conduit, pull boxes) for FMS is only a foundational need for the purpose of the pilot project. Other FMS/ITS elements that would need to be implemented or considered include the actual fiber communication lines, dynamic message signs (DMS), CCTV cameras, vehicle sensor stations, ramp metering, road weather information system (RWIS) sites, and dust warning systems.

4. **Traffic Control at NRC Event: Potential new methods and technology** – This phase, if done, would result from information gained in phases 1 and 2. It is included here as a potential longer term project that would likely be funded with federal funds, e.g. a TIGER grant. This would be an innovative approach to congestion management such as active traffic management. Strategies of active traffic management include variable speed limits, temporary shoulder use, junction control, and dynamic signing and rerouting.

PROPOSED EVALUATION PLAN FOR I-10 CORRIDOR TIM PILOT PROJECT

A final step for the Pilot Project is to develop an evaluation plan. The evaluation plan identifies the performance measures that should be analyzed to determine the success of the pilot project. The plan will also identify the types of data needed to assess the performance of the countermeasures. Note that one of the challenges will be comparing "before" and "after" measures for similar types of incidents. For example, sufficient data will need to be collected for a major vehicular incident "before" the pilot project is implemented so it can be compared to "after" traffic conditions with the same type of incident. Table 1 provides a list of potential performance measures to be used for the Pilot Project. This list needs to be vetted by the TIM coalition to select the final performance measures.

Table 6.1 – Potential Performance Measures for I-10 Corridor TIM Pilot Project

Types of Performance Measures	Performance Measure	Comments on PM
Advanced Traveler Information During Major Traffic Incidents	Change in 511 mobile utilization	ADOT tracks now and can provide 511 information
	Change in 511 utilization during major traffic incidents	
	Use of DMS for Detour Information (Freeway) Use of DMS for Detour Information (Arterials)	Based on percentage of available DMS actively used during incidents (Freeways & Arterials)
	Change in Web-page utilization	
	Coordination with Radio/TV media	Based on frequency of reports/updates
Traffic Management During Major Traffic Incidents	Peak corridor travel time increase (freeway)	General Purpose
	Average total duration of closure	
	Average percentage of peak-period hours subject to any lane closure	Peak-periods: 6am-9am & 3pm-7pm
	Transit schedule	Change in number and magnitude of schedule delays
	Arterial street travel time increase	Need non-incident baseline travel time data
	The average number of planned traffic signal detour plans utilized per incident occurrence	
	Volume and throughput of HOV lanes	
Safety Outcomes Due to Major Traffic Incidents	Average number of secondary crashes that can be attributed to each incident	Need to define secondary; Share with Safe Commute
	Average severity of a secondary crash (using KABCO scale)	Share with Safe Commute
	Average EMS response time (detection to on-scene)	Share with Safe Commute
Information Sharing and Reporting	Average time to notify all key TIM members	Share with Safe Commute

APPENDIX 1A

TAXONOMY

TAXONOMY

Access Management: A control of movement onto highways. Strategies include restricting the intersections and interchanges of other streets and highways, restricting or limiting the number of driveways or controlling these entrance points in some manner, as with traffic signs or signals.

AM Peak: The morning time period when traffic volumes are highest; also referred to as "morning rush hour"; it can often be more than 60 minutes in length; typically falls between 7:00 and 9:00AM in the Phoenix region.

Annual Average Daily Traffic (AADT): The total volume of traffic passing a point or segment of a highway in both directions for one year divided by the number of days in the year.

Arterial: A signalized street that primarily serves through-traffic and that secondarily provides access to abutting properties, with signal spacing of 1.0 mile or less.

Auto Occupancy: The number of persons per automobile, including the driver.

Average Daily Traffic (ADT): The average number of vehicles per day traveling in either direction on a roadway based on traffic volumes collected over a number of days greater than one but less than a year.

Average Travel Speed: The length of a highway segment divided by the time it takes to traverse that segment, including all delays is the calculation for a weighted average of speed.

AZTech™: The model deployment and regional management of an Intelligent Transportation System developed for the Phoenix Metropolitan area… a seamlessly integrated, multi-modal regional freeway and arterial street network focused on decreased travel time and enhanced motorist safety, mobility and roadway efficiency.

Before and After Study: A study undertaken to determine the effects of an implemented project, program, or policy change; performance measures are assessed before and after implementation to measure impacts; costs can also be taken into account and compared to benefits in order to gauge cost-effectiveness of the solution.

Benefit Cost Ratio (BCR): The ratio of a project's present value benefits to its present value costs. The BCR is useful for comparing projects of different scale or financial size since it assesses economic efficiency.

Bluetooth™: A proprietary open wireless protocol for exchanging data over short distances (using short length radio waves) from fixed and mobile devices, creating personal area networks (PANs). It provides a secure way to connect and exchange information between devices such as faxes, mobile phones, telephones, laptops, personal computers, printers, Global Positioning Systems (GPS) receivers, digital cameras, and video game consoles.

Bottleneck: A physical or geometric feature of a street or freeway that reduces the facility's capacity (or ability to accommodate traffic flow) as compared to other locations on the same facility.

Buffer Time Index (BTI): A measure of reliability, or more appropriately, *un*reliability. As it increases, travel times become more unreliable. It is added to average travel time to ensure on-time arrival with 95% certainty.

Capacity: The maximum number of vehicles that can reasonably be expected to pass over a lane or a roadway during a given time period under prevailing roadway and traffic conditions. The capacity is based on a variety of factors including lane and shoulder widths, vehicle types, roadway grades, etc. Typically, the maximum expressway capacity for automobiles is 2,000 vehicles per lane per hour. The effective capacity of a roadway can change because of weather, work zones, or traffic incidents.

Capital Costs: Nonrecurring or infrequently recurring costs of long-term assets, such as land, guideways, stations, buildings, and vehicles. These costs often include related expenses, for example, depreciation and property taxes. See also *operating costs*.

Capital Improvement Program (CIP): A plan created by the City to schedule major improvements and sources of funds to pay for those improvements. See also Transportation Improvement Program.

Carpool: An arrangement in which two or more people share the use, cost, or both, of traveling in privately owned automobiles between fixed points on a regular basis. See also vanpool.

Central Business District (CBD): The commercial heart of a city. The CBD or downtown is the central district of a city, usually typified by a concentration of retail and commercial buildings. Although applicable to any city, both terms usually refer to larger cities.

Channelization: Roadway facilities that accommodate turning movements. Typical examples are left and right turn pockets at an intersection.

Closed-Circuit Television (CCTV): Cameras used to view roadway conditions.

Collector: A type of roadway that provides traffic connections to/from local roads and arterials. Collectors have lower speed and carry lower levels of traffic than arterials.

Compressed Work Week: An alternative work schedule, in accordance with employer policy, that regularly allows a full-time employee to eliminate at least one work day every two weeks by working longer hours during the remaining days, resulting in fewer commute trips by the employee. See also, *Flex Time*.

Congested Travel: The congested peak period vehicle-miles of travel (VMT) divided by total VMT in the peak period (%). This is a relative measure of the amount of peak period travel affected by congestion.

Congestion: A condition which does not permit movement on a transportation facility at optimal legal speeds and is characterized by unstable traffic flows on freeways. Traffic demands vary significantly depending on the season of the year, the day of the week, and the time of day.

Congestion (Non-Recurring): Any delay experienced above or beyond recurrent delay. For freeways, it is the condition of overcrowding on a roadway caused by actions such as special events and/or traffic crashes, manifested by high densities, low speeds, stop-and-go driving, and increased delay. The capacity of a roadway, often mistaken as constant, can change because of weather, work zones, or traffic incidents.

Congestion (Recurrent): The delay that is experienced on a typical day, for a specific time period, when there is no non-recurring events such as traffic crashes, special events, etc. For freeways, it is the condition of overcrowding caused by demand exceeding capacity, manifested by high densities, low speeds, stop-and-go driving, and increased delay.

Congestion Gauge: Volume to capacity ratio on congested roadways.

Congestion Management Process (CMP): A federally mandated program (formerly Congestion Management System) within metropolitan planning areas to evaluate and develop transportation strategies and plans for addressing existing and future traffic congestion.

Congestion Mitigation and Air Quality Improvement Program (CMAQ): A categorical funding program created under the Intermodal Surface Transportation Efficiency Act. It directs funding to projects that contribute to meeting national air quality standards.

Corridor: A broad geographical band that follows a general directional flow or connects major sources of trips. It may contain a number of streets and highways and transit lines and routes.

Corridor Studies: Study with a focus on a segment of a particular travel corridor or travel shed. Land use, access issues, capacity, level of service, geometrics, and safety concerns are studied; alternatives are analyzed and recommendations are made. Corridor studies are usually prepared with the participation and cooperation of the affected communities and governmental agencies. Recommendations for improvements are often incorporated into the local comprehensive plans of the participating cities and continue to be used by implementing agencies as improvements in the corridor are made.

Crash Rate: The frequency with which traffic crashes have occurred along a defined roadway segment or intersection over a defined period of time.

Criterion/Criteria: Measures or factors used in the development or in the decision-making process for a transportation improvement.

Cut-Through Traffic: Traffic that uses the local street system in an unintended manner to circumvent congested intersections or corridors.

Delay per Vehicle per Mile: Delay per vehicle divided by the length of the roadway segment; this performance measure is used to facilitate the comparison of unequal roadway segments.

Delay: The amount of time it takes to traverse a given roadway segment minus the amount of time it would take to traverse that roadway segment at the posted speed limit if there were no interference. Also, the additional travel time experienced by a driver or passenger beyond what would reasonably be desired for a given trip. Delay, in association with non-recurring congestion on arterials and freeways, is the time over and above the amount of time it would take to traverse that roadway segment in ideal conditions (at the posted speed limit if there were no interference) and recurring congested conditions.

Demand: The number of vehicles desiring to use a given segment of roadway during a specified unit of time.

Density: The number of vehicles occupying a given length of a lane or roadway usually expressed in vehicles per mile.

Detector Loops: A component imbedded in the pavement and used to detect and classify the type of vehicles passing over them. The loops are linked to the lane controller and can be used individually to count traffic or to trigger the violation enforcement cameras or in tandem to measure vehicle speeds.

Downstream: A location past another location in the direction traffic flow is moving.

Driver Information Systems: Communication systems designed to provide motorists with the most recent information regarding freeway operating conditions.

Duration of Congestion: A measurement of the span of time during which a roadway segment would be considered congested. This is generally not directly measured and reported, but is imbedded in such overall congestion metrics as vehicle-hours of delay and person-hours of delay.

Dynamic Message Signs (DMS): Electronic signage that employs ITS technology and centralized control systems to change messages in real-time, providing motorists with timely and useful information.

Economic Rate of Return (ERR): The economic rate of return, sometimes referred to as the internal rate of return, gives the effective discount rate for which the project's benefits would just equal its costs, in present value terms. In other words, it is the discount rate that yields a BCR of 1.0.

Elasticity of Demand: A measure of the sensitivity of demand for a commodity to a change in its price. It equals the percentage change in consumption of the commodity that results from a one-percent change in its price. The greater the elasticity, the more price-sensitive the demand for the commodity. Price elasticity is an important indicator of the effects of pricing strategies.

Extent of Congestion: The maximum geographic extent of congestion on transportation system at any one time.

Federal Highway Administration (FHWA): An agency of the US Department of Transportation responsible for funding highways, trails, and ferries.

Federal Transit Administration (FTA): An agency of the US Department of Transportation responsible for funding transit systems. (They were formerly the Urban Mass Transit Administration.)

Financial Constraint: For transportation plans, it means that the total estimated costs of projects included in a plan cannot exceed estimated revenues and the estimated cost of constructing, operating, and maintaining the total (existing plus planned) transportation system over the period of the plan. For TIPs, it means funds must be identified for the period of the TIP and associated with specific projects.

Fixed Cost: A cost that remains relatively constant irrespective of the level of operational activity; expenditures that do not vary with output. Examples include land and rent.

Flex-Time: An employer policy allowing individual employees some flexibility in choosing the time, but not the number, of their working hours. See also, *Compressed Work Week*.

Forecast: A future projection of traffic volumes based on expected future land use patterns and population estimates.

Free Flow: A state of the traffic flow on freeways at which motorists can maintain their desired speed with little or no delay since congestion is not present.

Freeway Management Strategies (FMS): Operational improvements designed to maximize traffic flow for all vehicles using the freeway.

Functional Classification: Classification of roadways according to their primary function – mobility for through trips or access to adjacent lands. A four-class system is used to designate roads (principal arterials, minor arterials, collectors, local streets).

General-Purpose Lanes: Freeway lanes that are open for use by all vehicles (e.g., trucks, HOVs, single occupant vehicles).

Generated Traffic: Additional vehicle trips on a particular roadway or area that occur when roadway capacity is increased or travel conditions are improved, due to latent demand (additional trips that travelers would make if traffic conditions were improved). A portion of generated traffic often consists of *induced travel*, that is, an increase in total vehicle mileage (which excludes travel shifted from other times and routes).

Geographic Information System (GIS): A computer-based system that links the geographic location of map features to text information or databases.

Geometric Condition: The special characteristics of a facility, including approach grade, the number and width of lanes, lane use, and parking lanes.

Geometric Delay: The component of delay that results when geometric features cause vehicles to reduce their speed in negotiating a facility.

Grade Crossing: A crossing or intersection of roadways, railroad tracks, pedestrian walks, or combinations of these at the same level or grade.

Grade Separated: A crossing of roadways, railroad tracks, pedestrian walks, or combinations of these that do not intersect. Overpasses, underpasses, and bridge structures are common examples.

Growth Factor: A percentage increase applied to current traffic demands to estimate future demands.

High Occupancy Vehicle (HOV): Vehicles carrying at least two or more persons per vehicle. HOVs can include cars, vans, buses, trucks, or other vehicles that meet the desired occupancy requirement.

High-Occupancy Vehicle (HOV) Lanes: Highway lanes reserved for vehicle carrying more than one person. (The specific number of people in the vehicle or class of vehicles who can use this facility is established locally.) These lanes are officially denoted with a diamond marking and are sometimes called "diamond lanes." In the Phoenix metro area, HOV lanes can also be utilized by motorcycles and alternative fuel vehicles (AFV) displaying the proper license plate identification.

Highway Advisory Radio (HAR): Systems designed to broadcast information on traffic conditions in a particular area to motorists traveling in that area and who have immediate need for the information. Motorists are informed through freeway signs that they can access the broadcast via designated frequencies on their car radios.

Ideal Travel Time: The amount of time it would take to traverse a given roadway segment at the posted speed limit if there were no interference.

Incident: Temporary impediment on a roadway that impedes the normal flow of traffic such as vehicle crash, disabled vehicle, or debris.

Incident Delay: The component of delay that results from an incident, compared with the non-incident condition.

Incident Management: Managing forms of non-recurring congestion, such as spills, collisions, immobile vehicles, or any other impediment on arterials and freeways.

Index: A numerical scale used to compare variables with one another or with some reference number.

Infrastructure: The basic facilities, services, and installations needed for the functioning of a community or society, such as transportation and communications systems, water and power lines, and public institutions including schools, post offices, and prisons.

Integrated Traffic Management System: The development and application of network-wide data collection and sharing of traffic information system. The system can integrate data and control systems from freeways, arterials and city streets to provide real-time proactive traffic information and control. Implementation of the system would facilitate congestion management over the entire network across multi-jurisdictional boundaries. The system could provide incident detection, transit and emergency vehicle priority, and advance traveler information.

Intelligent Transportation System (ITS): The development or application of technology (electronics, communications, or information processing) to improve the efficiency and safety of surface transportation systems.

Intensity of Congestion: A measurement of the severity of congestion during its peak hour. Intensity is typically measured by such factors as peak hour level of service, peak hour volume-to-capacity (V/C) ratio, and peak hour speed.

Lane Controller: A microprocessor ETC component that coordinates the activities of all equipment in a single lane and generates the transactions assigned to individual customers using that lane.

Lane-Miles of Congestion: A measure that reflects mobility of a facility or a section of a facility. It indicates the road space that functions at less than free-flow speeds during the peak. It compares actual roadway volume with maximum acceptable volume for that roadway.

Latent Demand: The total number of potential users desiring to use a facility (street or freeway) at a given point.

Level of Service: As related to highways, the different operating conditions that occur on a lane or roadway when accommodating various traffic volumes. It is a qualitative measure of the effect of traffic flow factors, such as speed and travel time, interruption, freedom to maneuver, driver comfort and convenience, and indirectly, safety, and operating costs. It is expressed as levels-of-service A through F. Level A is a condition of free traffic flow where there is little or no restriction in speed or maneuverability caused by presence of other vehicles. Level F is forced-flow operation at low speed with many stoppages, with the highway acting as a storage area.

Life-Cycle Maintenance: A concept of keeping a facility useable at least through its design life by conducting scheduled maintenance.

Light Rail Transit (LRT): An electrically propelled vehicle operated singly or in trains on predominantly reserved, but not necessarily grade-separated, rights-of-way.

Major Construction: Roadway improvements that increase the operational characteristics of a highway facility, including decreasing congestion, increasing operating speed and reducing collisions.

Managed Lane: A lane or lanes designed and operated to achieve stated goals by managing access via user group, pricing, or other criteria. A managed lane facility typically provides improved travel conditions to eligible users.

Media Access Control (MAC): An electronic identifier, or tag, in a Bluetooth™ device for example. The MAC address serves as an electronic nickname for each electronic device in data communication. The MAC address is practically unique for each Bluetooth™ device.

Metering: The concept of regulating the amount of traffic that can enter into a downstream lane or freeway facility. See also, *Ramp Meter*.

Metropolitan Planning Organization (MPO): Federally mandated regional organizations responsible for comprehensive transportation planning and programming for in urbanized areas. Work products include the Transportation Plan, the Transportation Improvement Program, and the Unified Planning Work Program.

Mitigation: The specific improvements made to a roadway or intersection to bring a deficient facility back to or below the minimum standard.

Mixed Flow Lanes: See *General-Purpose Lanes*.

Mobility: The ability of a person or people to travel from one place to another.

Mode: A particular form of travel (e.g., walking, traveling by automobile, traveling by bus or traveling by train).

Model: A mathematical description of a real-life situation that uses data on past and present conditions to make a projection about the future. It is used for analysis of the system or its evaluation under various conditions.

Multimodal: Concerning or involving more than one transportation mode.

Multimodal Link: The connection between two or more passenger transportation methods (such as bicycle, walking, automobile, and transit).

Network: 1. In planning, a computerized system of links and nodes that describes a transportation system. 2. In highway engineering, the configuration of roadway that constitutes the total system. 3. In transit operations, a system of transit lines or routes, usually designed for coordinated operation.

Node: A defined point along a roadway corridor that marks the beginning and/or end of a segment.

Non-Motorized: Generally referring to bicycle, pedestrian and other modes of transportation not involving a motor vehicle.

Non-Recurring Congestion (NRC): Congestion caused by atypical events such as highway crashes, sudden lane or road closures, weather conditions, or sudden traffic demand increases induced by a special event such as a football game. Non-recurring congestion can occur at any time, including midday, overnight, weekends, and also during peak periods, and is above and beyond recurring congestion. Non-recurring congestion is also sometimes referred to as temporary loss of capacity (TLC). See also, Congestion (Non-Recurring) and Delay.

Off-Peak Period: Times of day outside the peak periods.

Operating Costs: The sum of all recurring costs (e.g., labor, fuel) that can be associated with the operation and maintenance of the system during the period under consideration.

Operational Improvement: A capital improvement consisting of installation of traffic surveillance and control equipment, computerized signal systems, motorist information systems, integrated traffic control systems, incident management programs, and transportation demand and system management facilities, strategies and program.

Owning Agency: The agency or jurisdiction that owns a specific device or data and is responsible for its installation, use, and maintenance.

Park-and-Ride: An access mode to transit and other HOV modes in which patrons drive private automobiles or ride bicycles to a transit station, stop, or carpool/vanpool waiting area and park the vehicle in the area provided for that purpose (park-and-ride lots, park-and-pool lots, commuter parking lots, bicycle rack or locker).

Parking Utilization: A measurement of the degree of use of the available parking. A high utilization percentage means that few spaces are available.

Peak Hour: The single hour of the day which the maximum amount of travel occurs. Usually defined by identifying the highest of four consecutive 15 minute traffic counts along primary roadways.

Peak Hour Volume: The volume of traffic passing a point or segment of a highway during the busiest hour of a typical day or peak period.

Peak Period: The period of the day during which the maximum amount of travel occurs. It may be specified as the morning (AM) or afternoon/evening (PM) peak. Usually from 6:00-9:00AM or 4:00-7:00 PM.

Percent Congested Travel: The congested peak period vehicle-miles of travel (VMT) divided by total VMT in the peak period. This is a relative measure of the amount of peak period travel affected by congestion.

Performance Measures: Objective measurements and observations to determine the degree of success a project, program, or initiative has had in achieving its stated goals and objectives.

Person Hours of Delay (PHD): Calculated by multiplying vehicle hours of delay (VHD) by the average vehicle occupancy rate. This reflects the fact that vehicle occupancy differs from place to place, and that the number of people affected by one vehicle hour of delay may vary.

Person-Trip: Trip made by a person from one location to another whether as a driver, passenger or pedestrian.

Planning Time Index: A ratio of travel time that provides 95% certainty of on-time arrival. A planning time index of 1.6 means for 95% certainty on-time arrival, for a trip that takes 15 minutes in light traffic, you need to plan for 15 x 1.6 = 24 minutes.

Platoon: Vehicles traveling at more or less the same speed, advancing as a collective entity.

PM Peak: The afternoon/evening time period when traffic volumes are highest; also referred to as "evening rush hour;" it can often be more than 60 minutes in length; typically falls between 4:00 and 7:00PM in the Phoenix region.

Preferential Access: An advantage offered to a group of users allowing rideshare vehicles and buses to access roadways faster than other vehicles by bypassing metered ramps.

Principal Arterial: A major surface street with relatively long trips between major points and with through-trips entering, leaving, and passing through an urban area.

Programmed Improvements: Projects found in the Transportation Improvement Program. See *Transportation Improvement Program*.

Property Damage Only (PDO) Crash: A reportable crash that did not result in any fatalities or notable injuries.

Public Transportation: Transportation service by bus, rail, paratransit, van, airplane or ship, offered by an operator on a regular basis to the general public.

Qualitative Analysis: A general concept which categorizes a process used in certain types of environmental or route location studies where multiple factors are compared in a systematic and comprehensive manner on the basis of sound judgment. Factors analyzed by using a qualitative analysis are such that they cannot be measured in monetary terms, have no apparent common denominators, and are not readily quantifiable.

Quantitative Analysis: The process used in certain economic, cost-benefit, engineering, or traffic studies where multiple factors, elements, and/or outcomes are evaluated and compared by the use of measurable data. Certain mathematical models, formulas, numerical indices, rankings, and value matrices may be used to assist with such a process.

Queue: A line of vehicles, bicycles, or persons waiting to be served by the system in which the flow rate from the front of the queue determines the average speed within the queue. Slowly moving vehicles or people joining the rear of the queue are usually considered part of the queue. The internal queue dynamics can involve starts and stops. A faster-moving line of vehicles is often referred to as a moving queue or a platoon.

Ramp Meter: A form of entrance ramp control used to reduce freeway congestion by managing vehicle flow from arterial-to-freeway connectors. The connector contains a traffic signal that regulates the flow of vehicles entering onto the mainline freeway. Some metered ramps have preferential access.

REACT Incident Management Program : Is comprised of rapid responders to incidents within Maricopa County. Its purpose is to assist Maricopa County Sheriff's Office as well as other agencies responding to incidents throughout the county by providing traffic incident management. This includes both anticipated and unexpected events. The primary directive is to provide emergency traffic management at incident sites to establish safety for emergency responders by applying necessary devices for traffic control at or adjacent to the incident site.

Real-Time Control: The processing of information or data in a sufficiently rapid manner so that the results of the processing are available in time to influence the process being monitored or controlled.

Recurring Congestion (RC): Congestion caused by the predictable daily increase in traffic demand that exceeds available capacity. This type of congestion typically occurs during the weekday AM and PM peak periods, and is generally caused by large numbers of commuters traveling between their workplaces and homes, particularly during the AM peak period. Recurring congestion can also occur on weekends, particularly in area with significant retail or recreational activity. Recurring congestion can also be seasonal in nature, particularly in relation to holidays and recreation destinations. See also, *Congestion (Recurring)*.

Regional Archived Data Server (RADS): A central point of data collection, distribution, and archiving managed by the Maricopa Department of Transportation.

Rehabilitation: Roadway improvements intended to correct conditions identified as deficient without major changes to the cross section. These projects should consist of removal and replacement of base and pavement, shouldering and widening and drainage correction as needed.

Revenue Neutral: Revenue-neutral pricing strategies involve rebating some or all of the revenue generated by pricing to toll payers, where generating revenue is not an objective of value pricing.

Reverse-Commute Transit: Transit from residence to an employment location in a direction opposite to the heaviest flow of traffic. In this region, primarily from the central city to a suburb.

Reversible Flow: Lanes than can be operated in reverse direction to reduce congestion during certain peak periods.

Ridesharing: The function of sharing a ride with other passengers in other vehicles. The term is usually applied to carpools and vanpools.

Road Pricing: An umbrella phrase that covers all charges imposed on those who use roadways. The term includes such traditional revenue sources as fuel taxes and license fees as well as charges that vary with time of day, the specific road used, and vehicle size and weight.

Roadway Section: A roadway section is a cross-section of a roadway which displays, travel lanes, turning lanes, bike lanes, sidewalks, and medians with their respective dimensions. Each classification of roadway has a corresponding roadway section.

Roadway Standards: The standards set by the City or governing agency for the construction of roadway and related improvements.

Routine Maintenance: Roadway maintenance consisting of sweeping, periodic applications of bituminous overlays, seal treatments, milling, crack routing and filling and base repair. These treatments are intended to help ensure the roadway can be used to the end of its design life. These projects are ineligible for federal funding.

SAFETEA-LU (Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users): Federal legislation authorizing highway, safety, transit and other surface transportation programs from 2005 through 2009; maintained many initiatives from ISTEA and TEA-21 with increased emphasis on certain areas such as highway safety. Congress has and can continue to extend the SAFETEA-LU bill to keep federal funds flowing to states.

Segment: The portion of a highway corridor between two defined points.

Severity Index: A weighted measure of the relative economic cost to society of the injuries and fatalities related to traffic crashes along a defined roadway segment.

Signal Preemption: A technology that triggers the green go-ahead on meters or traffic signals to allow emergency vehicles to more quickly move through freeway ramp entrances or intersections.

Single-Occupant Vehicle (SOV): A motor vehicle occupied by the driver only.

Special Event Traffic: A typical occurrence on or off the roadway system that introduces significant traffic demand (or concentrations thereof), reduced roadway capacity, and/or altered traffic flows/patterns for limited periods directly relating to the event. The starting and ending times of these events create surges in traffic demand that overwhelm roadway capacity near the event venue, causing congestion.

Spot Speed: The speed of a vehicle at a particular moment in time; different from link or time mean speed because it is a snapshot of a particular moment rather than speed over a certain distance.

Sprawl: Dispersed, auto-dependent development outside of compact urban and village centers, along highways, and in rural countryside.

Stable Flow: Levels of service A through E are representative of stable flow. It is characterized by the low density-high speed sides of the flow, speed, density curves.

Stakeholders: Individuals and organizations involved in or affected by the transportation planning process. Include federal/state/local officials, MPOs, transit operators, freight companies, shippers, and the general public.

State Implementation Plan (SIP): A federally required planning document prepared and maintained by the Maricopa Association of Governments. It identifies state actions and programs to implement designated responsibilities under the Clean Air Act.

Steering Committee: A selected group of citizens that are appointed to participate in the development and review of a planning document.

Street Design Guidelines: Standards for the design of a roadway including the width, shoulder area, and subsurface material. See also, *Roadway Standards*.

Surface Transportation Program (STP): Program which made funds available for a broad range of highway, mass transit, safety and environmental purposes. STP funds could be used for highway construction and 4R; bridge projects; transit capital projects; carpool, parking, bicycle and pedestrian facilities; highway and transit safety improvements; traffic monitoring, management and control facilities; transportation control measures; and wetland mitigation efforts.

Surveillance: The monitoring of traffic performance and control system operation.

Telecommuting: The elimination or reduction in commuter trips by routinely working part or full-time at home or at a satellite work station closer to home.

Throughput: The amount of vehicles/persons that can pass a point on a roadway or pass through an intersection over a specified period of time. Throughput can be equated to capacity if considering vehicles alone.

Time-Mean Speed: The arithmetic mean of the speed of vehicles passing a point during a given time interval.

Timing Plans: The plans created by transportation agencies to coordinate their traffic signals over a section or area of roadway in order to improve the efficiency of traffic flow.

Total Delay: Delay per vehicle multiplied by the peak hour volume in that roadway segment; expressed in vehicle-hours; this performance measure facilitates the comparison of corridors by considering the number of vehicles impacted by the congestion (e.g., Corridor A and Corridor B both have 5 minutes of delay per vehicle; however, Corridor A impacts 100 vehicles and Corridor B impacts 1,000 vehicles, suggesting Corridor B is a more significant problem).

Traffic Calming: Techniques such as speed bumps and tables, narrowed lanes, and traffic roundabouts used to slow traffic in or divert through traffic out of primarily residential neighborhoods.

Traffic Model: A traffic model is a tool for representing and analyzing the major ways people get around. Usually this tool is a software package which incorporates a road network, land use data, and a mathematical formula to distribute and route trips. The model is calibrated to existing traffic counts. Then it can be used to forecast traffic and test the effect of changes in the road network.

Traffic or Transportation Analysis Zone (TAZ): A subdivision of the project (or study) area for which demographic data are collected in order to estimate traffic volume. The arrival and departure pattern of the estimated traffic is also organized by TAZs.

Transit Signal Priority: A technology that triggers the green go-ahead on meters or traffic signals to allow transit vehicles to more quickly move through freeway ramp entrances or intersections.

Transportation Control Measure (TCM): A measure intended to reduce pollutant emissions from motor vehicles. Examples of TCMs include programs to encourage ridesharing or public transit usage, and city or county trip-reduction ordinances.

Transportation Demand: The quantity (of transportation) desired by users.

Transportation Demand Management (TDM): Actions that improve transportation system efficiency by altering transportation system demand using such strategies and facilities as: pricing, ridesharing; park-and-ride facilities, transit friendly development/zoning; and employer-based programs—such as staggered work hours and telecommuting. TDM programs improve the efficiency of existing facilities by changing demand patterns rather than embarking on capital improvements. Also known as Travel Demand Management.

Transportation Improvement Program (TIP): Defined in federal regulation as..."A staged multi-year program of transportation projects for a metropolitan planning area, excluding planning and research activities." Also a spending plan for federal funding expected to flow to the region from all sources for transportation projects of all types.

Transportation Management Association (TMA): Voluntary groups set up to manage and reduce the number of trips taken in an area. TMAs are often begun by employers in heavily congested corridors. TMAs are considered a benefit to employees to help relieve the stress of daily commuting.

Transportation System Management (TSM): Integrated protocols and computerized ITS systems used to manage roadway and transit facilities. TSM techniques improve system capacity without physical expansion or behavioral changes. Typical TSM measures involve continuous management and operation of traffic systems, and utilize integrated traffic control systems, incident management programs, and traffic control centers.

Transportation System Management Strategies (TSMS): Low-cost, easily implemented programs and methods to improve the efficiency and effective capacity of the existing transportation system. Typical TSM techniques can include installation of new traffic signals, creating new signal phases or phase retimings, minor lane widenings and restriping, curbside parking regulation changes, etc.

Travel Behavior Inventory (TBI) : A set of surveys identifying travel patterns and characteristics of people and vehicles within the metropolitan area.

Travel Demand Forecasting (Modeling): Used to generate the average trip lengths for a region. The average trip length measure can then be used in estimating vehicle miles of travel, which in turn is used in estimating gasoline usage or mobile source emissions of air pollutants.

Travel Time Index (TTI): A measure of the total amount of congestion. It is the ratio of the peak-period travel time to the travel time under ideal conditions. A Travel Time Index value of 1.3 indicates that peak-period travel takes 30 percent longer than under ideal conditions. Another way to think of this measure is as a "multiplier." That is, the value of the Travel Time Index is the amount you would multiply the "ideal" travel time by to get the actual travel time you experienced. Thus, "Travel Time Multiplier" would be an alternate name for this term.

Travel Time Reliability: The traveling public experiences large swings in congestion level, and their expectation or fear of unreliable traffic conditions affects both their view of roadway performance, and how and when they choose to travel. *Reliability* is commonly used in reference to the level of consistency in transportation service; and *Variability* might be thought of as the amount of inconsistency in *operating* conditions. Travel time reliability can be defined in terms of how travel times vary over time.

Travel Time: The amount of time, measured in the field, that it takes to traverse a given roadway segment.

Trip: A single or one-directional vehicle movement.

Two-Way-Left-Turn-Lane: A protected lane in the center of a road that allows people or vehicles to cross half-way before completing their crossing or turning movement. Also known as a refuge lane.

Typical Day: A weekday that exhibits travel patterns which occur on a regular basis; standard practice is to collect data on Tuesdays, Wednesdays, and Thursdays of weeks without holidays or other occurrences that may influence travel patterns.

Unified Incident Command Systems (UICS): When an emergency occurs and more than one agency is involved, there needs to be a way for the multiple groups to be under a single command structure. The Unified Incident Command System allows several agencies to develop unified objectives and strategies for the incident. This is accomplished without any loss of authority, responsibility or accountability. When an incident occurs, one "Incident Commander" from each agency reports to the command post. The command post will then implement the correct plan of action.

United States Department of Transportation (USDOT): The department of the federal government that includes the Federal Highway Administration (FHWA), Federal Aviation Administration (FAA), and the Federal Transit Administration (FTA). USDOT is headed by the Secretary of Transportation, a cabinet-level post.

Unstable Flow: This is representative of a breakdown in traffic conditions that occurs at the maximum flow boundary of level of service E. Unstable flow is characterized by the high density-low speed sides of the flow, speed, density curves.

Upstream: The opposite direction to which traffic flow is moving.

Urbanized Area: An area with a population of 50,000 or more designated by the U.S. Census Bureau, within boundaries that are identified by state and local officials, subject to approval by the Secretary of Transportation.

User Cost: The total dollar cost of a trip to a user for a particular mode of transportation. Includes out-of-pocket costs such as transit fares, gas, oil, insurance, and parking for autos plus a valuation of implicit cost, such as waiting and travel times.

User Management: User management defines how and which types of users can utilize a facility, such as HOV occupancy requirements, access points, barrier separation, and user fees. Restrictions may vary by time of day or day of the week.

Value Pricing: A concept that uses monetary incentives to manage congestion during peak travel periods on tolled highways and crossing facilities.

Vanpool: An organized ridesharing arrangement in which 7 to 15 people travel together on a regular basis in a van. The van may be publicly owned, company owned, individually owned, leased, or owned by a third party. Expenses are shared and there is usually a regular volunteer driver. See also *Carpool*.

Variability: The amount of inconsistency in operating conditions.

Variable Speed Control: A system designed to optimize traffic flow on the freeway mainline by regulating the speed of vehicles on the facility.

Vehicle Delay per 100,000 VMT: The total vehicle delay (in vehicle-hours) divided by the amount of VMT. This is a relative measure of the total delay and will not be as affected by changes in the level of sensor instrumentation for a particular city.

Vehicle Hours of Delay (VHD): A common measure of congestion on roadways; it is the sum total of delay experienced by all vehicles on the link, sub-network or network. Delay can be thought of as the difference between actual travel time and estimated travel time at free-flow travel speed, and is therefore a measure that is readily understood by the traveling public.

Vehicle Hours Traveled (VHT): The total vehicle hours expended traveling on the roadway network in a specified area during a specified time period.

Vehicle Miles Traveled (VMT): The measurement of the total miles traveled by all vehicles in a specified area during a specified time.

Vehicle Separators/Profilers: An AVI system component located on a gantry or at the side of a lane. They perform functions similar to light curtains. The class of vehicles is determined based on the profile of the passing vehicle.

Vehicle Trip: A one-way journey made by an auto, truck or bus to convey people or goods.

Vehicle-Hour: Equivalent to one vehicle delayed for one hour.

Video Surveillance: The use of pan-tilt-zoom, steerable moving picture cameras to survey a toll plaza, ETC collection area, or a segment of roadway to monitor for incidents.

Volume-Demand-to-Capacity Ratio (V/C): A measure that reflects mobility and quality of travel of a facility or a section of a facility. It compares roadway demand (vehicle volumes) with roadway supply (carrying capacity). For example, a V/C of 1.00 indicates the roadway facility is operating at its capacity. It is a common performance measure for MPOs and is widely used in CMP and transportation studies.

Work zones: An area where roads are being fixed or improved. They have narrow lanes or reduce the total number of lanes available. They also can reduce speed limits and frequently include right/left lane shifts. All of these physical changes temporarily decrease available or effective roadway capacity.

APPENDIX 1B

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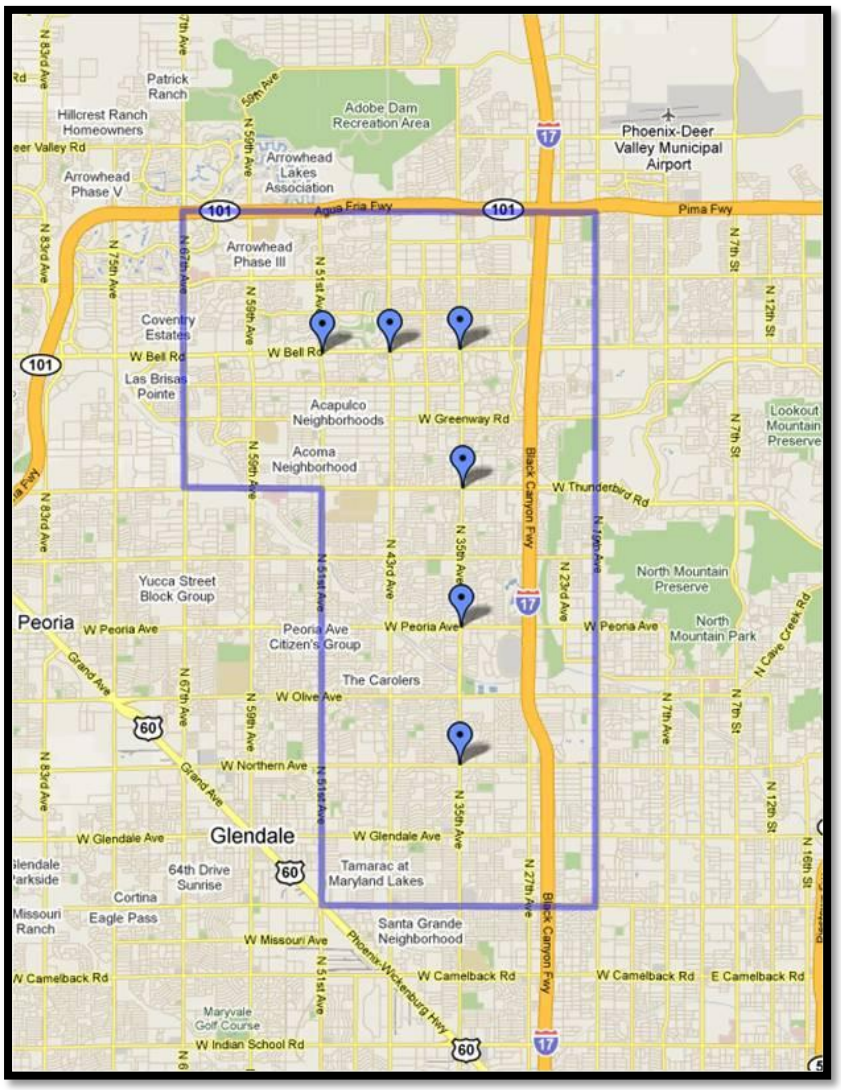
APPENDIX 2A

PILOT TEST OF DATA COLLECTION

Darryl Puckett of Texas Transportation Institute met with representatives of the City of Phoenix and Lee Engineering on Thursday, May 20, 2010 at 9am local time at the intersection of 35th Avenue and Northern Avenue. After a brief explanation of the installation procedure, the reader equipment was installed inside the signal cabinet and the antenna protector affixed with silicone adhesive. Connector cables were deployed through the hinge side of the cabinet door without penetrations in the cabinet itself. Cellular service was somewhat minimal at this location so the cellular modem was deployed externally in the protector as well. This condition was repeated at 51st Avenue and Bell Road where a similar installation was performed.

Subsequent installations were accomplished at all of the planned locations shown on the concept drawing below and names as follows:

1. 35th Avenue and Northern Avenue
2. 35th Avenue and Peoria Avenue
3. 35th Avenue and Thunderbird Road
4. 35th Avenue and Bell Road
5. Bell Road and 43rd Avenue
6. Bell Road and 51st Avenue



All of the installations (except for 51st Avenue and Bell Road) were completed by 2pm local time on Thursday.

While data was successfully transmitted back to the server in Houston on Thursday, it was determined that due to the relatively low traffic volumes, matches could be improved with the substitution of higher gain antennas on the Bluetooth adapters. Arrangements were made with the City of Phoenix staff to meet on Friday morning to assist with the antenna substitutions and complete the installation at 51st at Bell. The substitution consisted of removal of the exterior protector, exchange of the antenna and reattachment of the protector. This was all accomplished between 7:30 and 11am local time, and the signal technician returned to the shop. While the field work only consumed about 1 hour total on Friday, the technician was held on site in order to confirm operation, just in case a visit to one of the cabinet sites might be required. That was not the case and subsequent visits were not required.

Final interface configurations were accomplished and the data site is now available for access. It can be gained at HUhttp://ttihouston.tamu.edu/bluetooth/bluetooth_monitor_matches.aspx?i=phoenixUH.

A sample of the results from Monday, May 24th is shown below.

Photos of the actual installations are shown in the following figures:

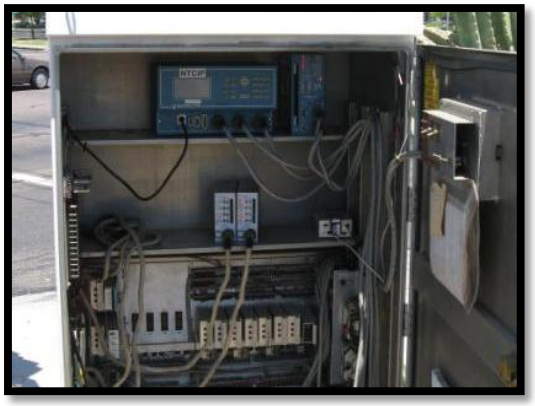
35th Avenue & Northern Avenue

35th Avenue & Peoria Avenue

35th Avenue & Thunderbird Road

35th Avenue & Bell Road

Bell Road & 43rd Avenue

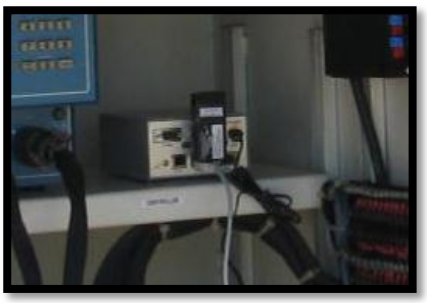


Bell Road & 51st Avenue

APPENDIX 2B

TRAVEL TIME MONITORING SYSTEM

Travel Time Monitoring System



The travel time monitoring system is placed inside traffic signal cabinets with a power connection available. Although a rare occurrence, the travel time monitoring system can be disrupted if the GFCI outlet trips the circuit and cuts off electricity. An external antenna is required for most installations. The external antenna will be accommodated within an 'antenna protector' as shown on the next page. The image to the right shows the travel time monitoring system installed in a City of Phoenix traffic signal cabinet.

The permanent equipment installation (i.e. long-term installations) requires an external antenna. These installations have a cabinet penetration that is waterproofed with silicone sealer and a standard PVC conduit connector. In the cases where the antenna is removed later, the penetration opening is closed with an oil-tight gasketed conduit hole seal, such as a WAS100 by Hubbell Wiegmann. There are side penetration options also, but they still require that the antenna extend up and past the roof of the cabinet.

The temporary installations require no cabinet penetration as the antenna cable is routed around the cabinet door frame or other penetration (like a vent opening or other). The base is attached with silicone sealer and can be removed without damage to the cabinet as shown to the left.

Our field software is designed to 'push' the collected data to the Host IP address in the form of UDP datagrams. The device comes equipped with an Ethernet port and contains a full TCP/IP stack. To minimize issues with firewalls or other integrations in the short term for temporary deployments, cellular communications with a modem are provided and used. In practice, the deployment will work with virtually any form of standard TCP/IP protocols and take advantage of cellular, fiber, WiFi, WiMax, or whatever may be available.

While data rates can vary greatly based on the volume of Bluetooth devices being read, we estimate approximately five (5) megabytes per day on a heavily traveled roadway, somewhat less on roadways with low to moderate traffic volumes.

The host processing in Houston, Texas gathers all the incoming data from the field collection units and processes it for subsequent distribution to specific applications that may reside outside of the hosting environment, typically with an XML feed, designed for that purpose.

Overhead power lines or other causes of cellular service interference can prevent the travel time monitoring system from delivering the collected data. An alternative collection point may have to be selected if this occurs.

APPENDIX 2C

ANONYMOUS WIRELESS ADDRESS MATCHING (AWAM)

Anonymous Wireless Address Matching (AWAM)

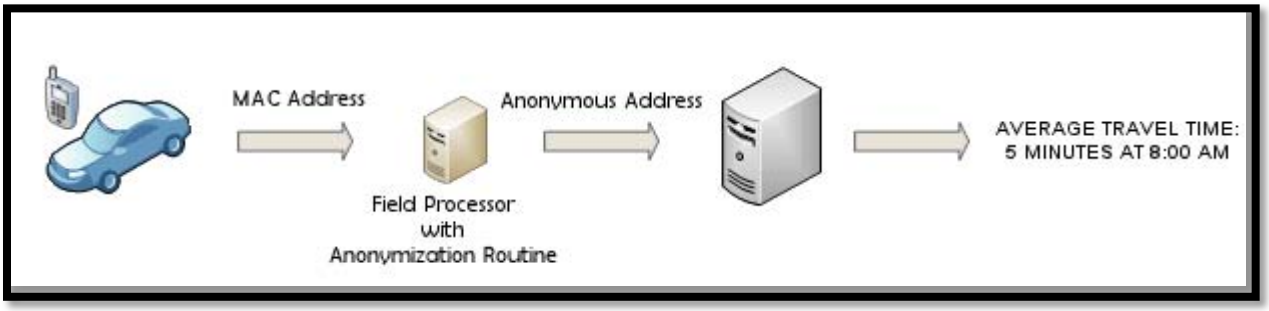
AWAM, developed by the Texas Transportation Institute, utilizes the Media Access Control (MAC) address of enabled *Bluetooth™* devices to determine average travel times and speeds on roadways instrumented with the proper equipment. The methods used by AWAM simply search for device addresses and do not poll any other information from the *Bluetooth* device. Each *Bluetooth* device read contains the timestamp, device reader location, and MAC address of the device. A sample record generated by AWAM might look like the following:

01/01/2010 10:00:00 AM, Highway10_FirstStreet,00:1E:7D:E7:6E:6D

In theory, the MAC address is a unique identifier assigned to every Ethernet network interface, including Bluetooth adapters. MAC addresses read by AWAM are not directly associated with a specific user and do not contain any personal data or information that could be used to identify or "track" an individual's whereabouts. Several issues with AWAM make it even more difficult to trace a MAC address to an individual device.

1. Occasionally, manufacturers do not ensure that MAC addresses are unique, so multiple network interfaces can have the same MAC address. This is not a common occurrence but it does happen.
2. MAC addresses can be assigned by software in many network interfaces meaning that the original MAC address can be changed by the user.

In addition, all addresses collected by AWAM are anonymized through encryption immediately upon receipt. This ensures that actual device addresses are not sent or stored anywhere—rather a random set of characters. For example, a device with the address *00:24:9F:E1:FE:98* might be changed to *MDA6MjM6RDc6REQ6MzI6QkM* at the instant it's read by the field controller.



Users with additional privacy concerns are able to turn off the *Bluetooth* discovery function of their device which prevents it from being read by AWAM.

APPENDIX 2D

MAG NETWORK SCREENING METHODOLOGY FOR INTERSECTIONS

Network Screening Methodology for Intersections

Introduction

Improving intersection safety is identified in the MAG Strategic Transportation Safety Plan as a regional priority. Recent crash statistics for the region show that 60 percent of traffic related injuries and 40 percent of fatalities are caused by crashes at intersections. In order to target specific locations for road safety improvements it is necessary to screen the region's road network and identify and rank high risk locations. A methodology that helps perform a network screening based on crash risk has been adopted by MAG for this purpose. A network screening approach that is based purely on crash frequency tend to be biased in favor of intersections with high volumes as they will have higher numbers of crashes. Similarly, a network screening that applies weights for different crash severities tend to bias the outcome in favor of location with a high crash high severity. At the 2009 TRB[1] annual meeting a paper on a network screening methodology, based on research work done by the Wisconsin DOT, was presented. This method, with a slight modification, has been adopted for use in the MAG region, and is referred to as the Network Screening Methodology (NSM-I) for Intersections. As recommended in the TRB paper the analysis period was kept to the three most recent years for which crash data are available.

Intersection Safety Network Screening Methodology

The first step in the application of NSM-I is the identification of the complete list of intersections, number of crashes by crash severity (KABCO scale), number of vehicles involved in each crash, collision manner, number of pedestrian involved and the number of bicyclists involved. Only the crashes that are identified in ALISS as "intersection related" will be analyzed in the NSM-I. Since ALISS data cannot be edited by any entity other that Arizona DOT, none of ALISS data will be corrected for errors prior to analysis. In other words, all crash data are assumed to be 100 percent accurate.

The NSM-I generates a composite intersection ranking based on four crash attributes: (a) Crash Frequency (CF), (b) Crash Severity (CS), (c) Crash Type (CT) and (d) Crash Rate (CR). The fourth factor CR was not included in the Wisconsin DOT methodology. The MAG Transportation Safety Committee determined it was necessary to include crash rates in the network screening analysis.

[1]Qin X., Laracuante L., Noyce D.A., Chitturi M. *Systemwide Intersection Safety Prioritization Development and Assessment*. In TRB 2009 Annual Meeting, Washington, D.C.

Crash Frequency (CF)

The total number of crashes that occurred during the period of analysis, or crash frequency, at each intersection is first summarized. The Crash Frequency Score or **CF Score** for any intersection is the ratio of, the crash frequency at the intersection to the highest intersection crash frequency for the region, for the same period of analysis.

CF Score for Intersection i
= (Total number of crashes at Intersection i/ Highest number of crashes recorded for any intersection in the analysis area)

Crash Severity (CS)

Every crash is assigned a crash severity (KABCO scale) based on the highest resulting injury from the crash. The equivalent sum of all crash severities, or CS value, for an intersection can be generated by the application of the KABCO weight scale shown in Table 1. An intersection's CS value is calculated as the sum of the products of the total number of crashes of a particular severity multiplied by the weight associated with that crash severity. The **Crash Severity Score** for an intersection is the ratio between CS value for the intersection to the maximum CS value for the network being analyzed.

CRASH SEVERITY	WEIGHT
Fatal Crash(K)	1,450
Incapacitating (A)	100
Non-Incapacitating (B)	20
Possible Injury (C)	11
PDO (O)	1
Unknown	1

Table 1. Crash Severity Weights

[1]Qin X., Laracuante L., Noyce D.A., Chitturi M. *Systemwide Intersection Safety Prioritization Development and Assessment*. In TRB 2009 Annual Meeting, Washington, D.C.

Crash Type (CT)

The ALISS database provides information on the Crash Type or Collision Manner for each recorded crash – such as rear-end, right angle, head-on etc. Campbell and Knapp[2] have described a procedure for calculating the average crash cost per vehicle/pedestrian/bicyclist for different types of collision manner. This method is utilized in the Wisconsin DOT methodology. Table 2 lists the estimated crash cost by crash severity provided by FHWA, same as that used by ADOT.

Table 2: Crash Cost by Injury Severity

Crash Severity	$ Value
Fatal Crash(K)	$5,800,000
Incapacitating (A)	$400,000
Non-Incapacitating (B)	$80,000
Possible Injury (C)	$42,000
PDO (O)	$4,000
Unknown	$4,000

These crash costs were used to calculate the average cost per vehicle, pedestrian or bicyclist that is involved in any crash of any particular Crash Type or Collision Manner. This calculation requires a detailed examination of crashes, with the number of vehicles, pedestrians and bicyclists involved in each. All intersection related crashes in the database were queried for the number of crashes by injury severity, number of units involved in the crashes and by collision manner. Table 3 shows the results, as the cost per each vehicle/pedestrian/bicyclist involved in any crash of a particular collision manner.

[2]Campbell J.R., Knapp K., *Alternative Crash Severity Ranking Measures and the Implication on Crash Severity Ranking Procedures.* Proceedings of the Mid-Continent Transportation Research Symposium, Ames, Iowa, 2005

Table 3. Crash Costs by Crash Type per Vehicle / Pedestrian /Bicyclist.

Injury Severity	REAR END		ANGLE RIGHT ANGLE		SINGLE		SIDE SWIPE SAME DIRECTION		ANGLE OPPOSITE DIRECTION	
	Crashes	Units	Crashes	Units	Crashes	Units	Crashes	Units	Crashes	Units
O	23,133	48,912	17809	36534	4289	4289	7635	15535	12064	24845
C	6,488	14,405	5941	12632	532	532	702	1465	5035	10708
B	2,088	4,839	4249	9210	750	750	284	640	3971	8557
A	350	854	1183	2684	208	208	70	164	1189	2597
K	29	73	165	381	28	28	8	19	101	219
Unknown	0	0	0	0	0	0	0	0	0	0
	$840,268,000	**69,083**	**$2,090,878,000**	**61,441**	**$345,100,000**	**5,807**	**$157,144,000**	**17,823**	**$1,638,806,000**	**46,926**
Cost Per Vehicle	**$12,163**		**$34,031**		**$59,428**		**$8,817**		**$34,923**	

Injury Severity	REAR TO SIDE		SIDE SWIPE OPPOSITE DIRECTION		HEAD ON		OTHER & UNKNOWN		# of Peds	# of Bicyclists
	Crashes	Units	Crashes	Units	Crashes	Units	Crashes	Units		
O	1731	3466	403	836	195	410	558	1206	108	312
C	75	152	50	108	79	180	100	222	411	700
B	18	36	44	106	90	200	116	271	660	1010
A			14	34	36	80	35	89	318	223
K			1	3	8	19	7	21	62	12
Unknown	0	0	0	0	0	0	0	0	24	63
	$11,514,000	**3,654**	**$18,632,000**	**1,087**	**$72,098,000**	**889**	**$70,312,000**	**1,809**	**$557,390,000**	**270,500,000**
Cost Per Vehicle	**$3,151**		**$17,141**		**$81,100**		**$38,868**		**$352,110**	**$116,595**

Table 3: Crash Cost per Vehicle / Pedestrian /Bicyclist.

Table 4 Summary of Per Unit Crash Costs

Crash Type/Collision Manner	Cost per Vehicle / Pedestrian / Bicyclist
Rear End	$ 12,163
Angle Right Angle	$ 34,031
Single	$ 59,428
Side Swipe Same Direction	$ 8,817
Angle Opposite Direction	$ 34,923
Rear To Side	$ 3,151
Side Swipe Opposite Direction	$ 17,141
Head On	$ 81,100
Other & Unknown	$ 38,868
Pedestrian Crashes	$352,110
Bicyclist Crashes	$116,595

The Crash Type (CT) Cost for an intersection is calculated by multiplying the number of units involved in a crash by the cost per vehicle/pedestrian/bicyclist for each type of collision manner, and summing the results.

$$\text{CT Cost} = \sum_{i=1}^{n} (N_i * CM_i)$$

N_i - Number of units (vehicles, pedestrians or bicyclists) involved in a crash of a specific Collision Manner
CM_i– Cost per Vehicle/Pedestrian/Bicyclist by Collision Manner (see Table 4)
n – Number of crashes at the intersection

The Crash Type Cost for an intersection is ratio between Crash Type Cost at a particular intersection to maximum of Crash Type Cost at all intersections in the region.

Crash Rate (CR)

The Wisconsin DOT methodology was modified by MAG by the addition of the Crash Rate, the fourth factor, as suggested by the MAG Transportation Safety Committee in October 2009. This factor is defined as follows:

CR value for intersection i
= Average annual crash rate at intersection i for the analysis period / Maximum value of all average intersection crash rates for the region
= CR / Max (CR)

The first application of this methodology was for identifying the 100 high crash risk intersections in the MAG region, using crash data for 2006, 2007 and 2008. There were over 17,000 specific intersection crash location for this analysis period. The computation of CR values for this many intersections in the was deemed infeasible at this time due to lack of traffic volume data at these locations for each of the 3 analysis years. Therefore, the highest ranked 100 intersections were determined first based on interim intersection safety scores that were based ONLY on CF, CS and CT, with the weights 1/5, 3/5 and 1/5 respectively.

$$\mathbf{ISS} = \left(\frac{1}{5} * \frac{\mathbf{CF}}{\mathbf{Max(CF)}}\right) + \left(\frac{3}{5} * \frac{\mathbf{CS}}{\mathbf{Max(CS)}}\right) + \left(\frac{1}{5} * \frac{\mathbf{CT}}{\mathbf{Max(CT)}}\right)$$

Next, the CR values were determined for these 100 intersections and applied in the final step to determine the Intersection Safety Score as described next.

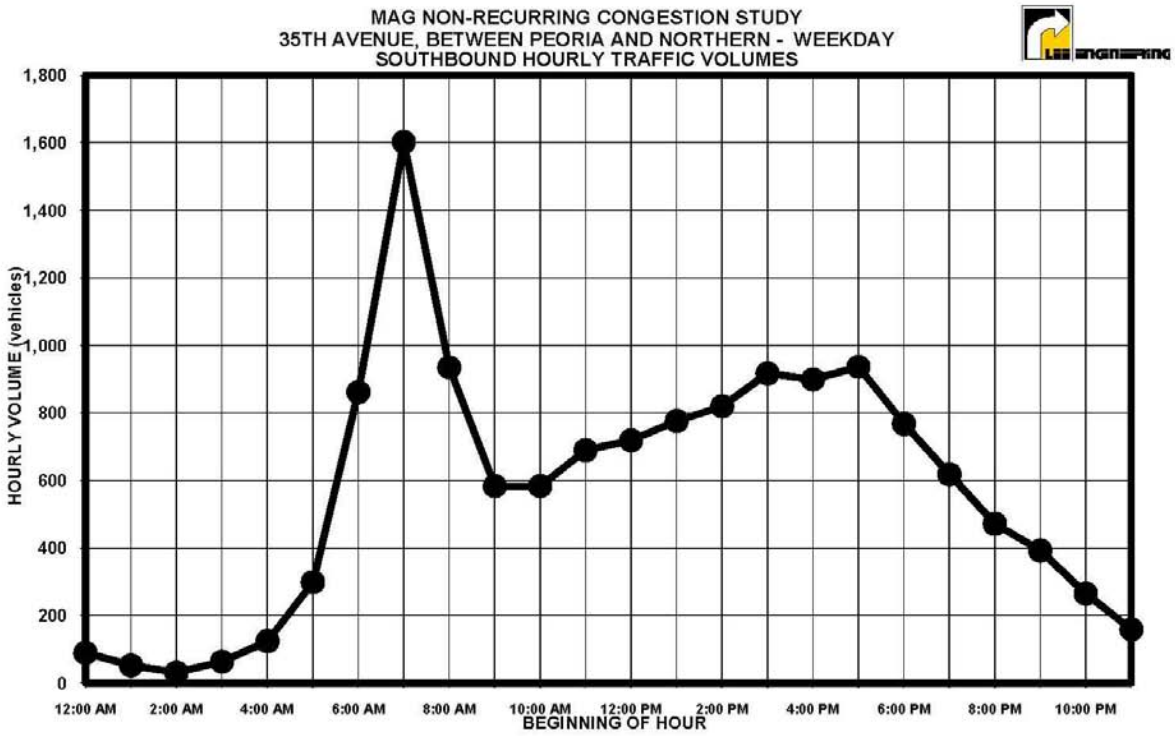
Intersection Safety Score (ISS)

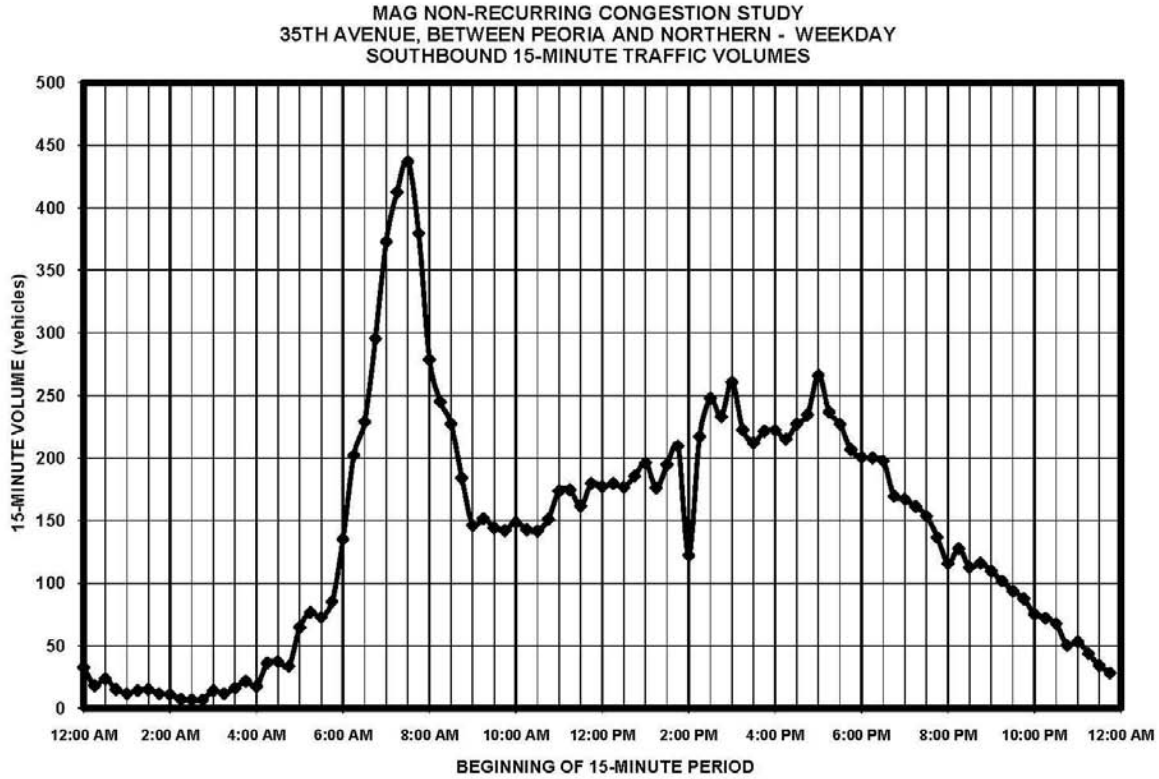
The final Intersection Safety Score (ISS) for an intersection is determined by combining all four scores, as shown in the formula below. Severity Index score CS is weighted higher in the final scoring process as the motive of the Network Screening process is to eliminate crashes with higher severity at intersections.

$$\mathbf{ISS} = \left(\frac{1}{5} * \frac{\mathbf{CF}}{\mathbf{Max(CF)}}\right) + \left(\frac{2}{5} * \frac{\mathbf{CS}}{\mathbf{Max(CS)}}\right) + \left(\frac{1}{5} * \frac{\mathbf{CT}}{\mathbf{Max(CT)}}\right) + \left(\frac{1}{5} * \frac{\mathbf{CR}}{\mathbf{Max(CR)}}\right)$$

APPENDIX 3A

24-HOUR ARTERIAL VOLUME DATA


MAG NON-RECURRING CONGESTION STUDY
35TH AVENUE, BETWEEN PEORIA AND NORTHERN - WEEKDAY
SOUTHBOUND HOURLY TRAFFIC VOLUMES
HOURLY VOLUME (vehicles)
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
BEGINNING OF HOUR


MAG NON-RECURRING CONGESTION STUDY
35TH AVENUE, BETWEEN PEORIA AND NORTHERN - WEEKDAY
SOUTHBOUND 15-MINUTE TRAFFIC VOLUMES
15-MINUTE VOLUME (vehicles)
500
450
400
350
300
250
200
150
100
50
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
12:00 AM
BEGINNING OF 15-MINUTE PERIOD

MAG NON-RECURRING CONGESTION STUDY
35TH AVENUE, BETWEEN PEORIA AND NORTHERN - WEEKDAY
SOUTHBOUND

BEGIN PERIOD	MORNING 15 MINUTES	MORNING 60 MINUTES	EVENING 15 MINUTES	EVENING 60 MINUTES	BEGIN PERIOD
12:00 AM	32.5	**89**	177	**719**	**12:00 PM**
12:15 AM	18	68	179.5	738	12:15 PM
12:30 AM	23.5	64	176.5	734	12:30 PM
12:45 AM	15	56	185.5	752	12:45 PM
1:00 AM	11.5	**52**	196	**776**	**1:00 PM**
1:15 AM	14	52	176	702	1:15 PM
1:30 AM	15	45	194.5	743	1:30 PM
1:45 AM	11.5	36	209.5	796	1:45 PM
2:00 AM	11	**31**	122	**820**	**2:00 PM**
2:15 AM	7	34	217	958	2:15 PM
2:30 AM	6.5	39	247.5	964	2:30 PM
2:45 AM	6.5	48	233	928	2:45 PM
3:00 AM	14	**63**	260.5	**917**	**3:00 PM**
3:15 AM	11.5	67	222.5	878	3:15 PM
3:30 AM	16	91	212	871	3:30 PM
3:45 AM	21.5	112	221.5	886	3:45 PM
4:00 AM	17.5	**124**	222	**899**	**4:00 PM**
4:15 AM	36	171	215	943	4:15 PM
4:30 AM	37	212	227	964	4:30 PM
4:45 AM	33.5	247	234.5	964	4:45 PM
5:00 AM	64.5	**299**	266	**936**	**5:00 PM**
5:15 AM	76.5	369	236.5	871	5:15 PM
5:30 AM	72.5	495	227	834	5:30 PM
5:45 AM	85	651	206.5	805	5:45 PM
6:00 AM	135	**862**	200.5	**768**	**6:00 PM**
6:15 AM	202	1,100	200	734	6:15 PM
6:30 AM	229	1,310	197.5	695	6:30 PM
6:45 AM	295.5	1,518	169.5	651	6:45 PM
7:00 AM	373	**1,602**	167	**618**	**7:00 PM**
7:15 AM	412.5	1,508	161	567	7:15 PM
7:30 AM	437	1,340	153.5	533	7:30 PM
7:45 AM	379.5	1,130	136.5	492	7:45 PM
8:00 AM	278.5	**935**	115.5	**472**	**8:00 PM**
8:15 AM	245	802	127.5	466	8:15 PM
8:30 AM	227	709	112.5	440	8:30 PM
8:45 AM	184	626	116	421	8:45 PM
9:00 AM	146	**584**	109.5	**392**	**9:00 PM**
9:15 AM	151.5	586	101.5	358	9:15 PM
9:30 AM	144	577	93.5	328	9:30 PM
9:45 AM	142	575	87.5	302	9:45 PM
10:00 AM	148.5	**584**	75	**265**	**10:00 PM**
10:15 AM	142.5	609	72	243	10:15 PM
10:30 AM	141.5	641	67.5	214	10:30 PM
10:45 AM	151	661	50	181	10:45 PM
11:00 AM	173.5	**689**	53	**159**	**11:00 PM**
11:15 AM	174.5	693	43.5	-	11:15 PM
11:30 AM	161.5	698	34	-	11:30 PM
11:45 AM	179.5	713	28	-	11:45 PM
AM PEAK VOLUME	**437**	**1,602**	**266**	**964**	PM PEAK VOLUME
PHF and TIME	**0.92**	**7:00 AM**	**0.91**	**2 peaks**	PHF and TIME
DAILY VOLUME	**13648.5**				

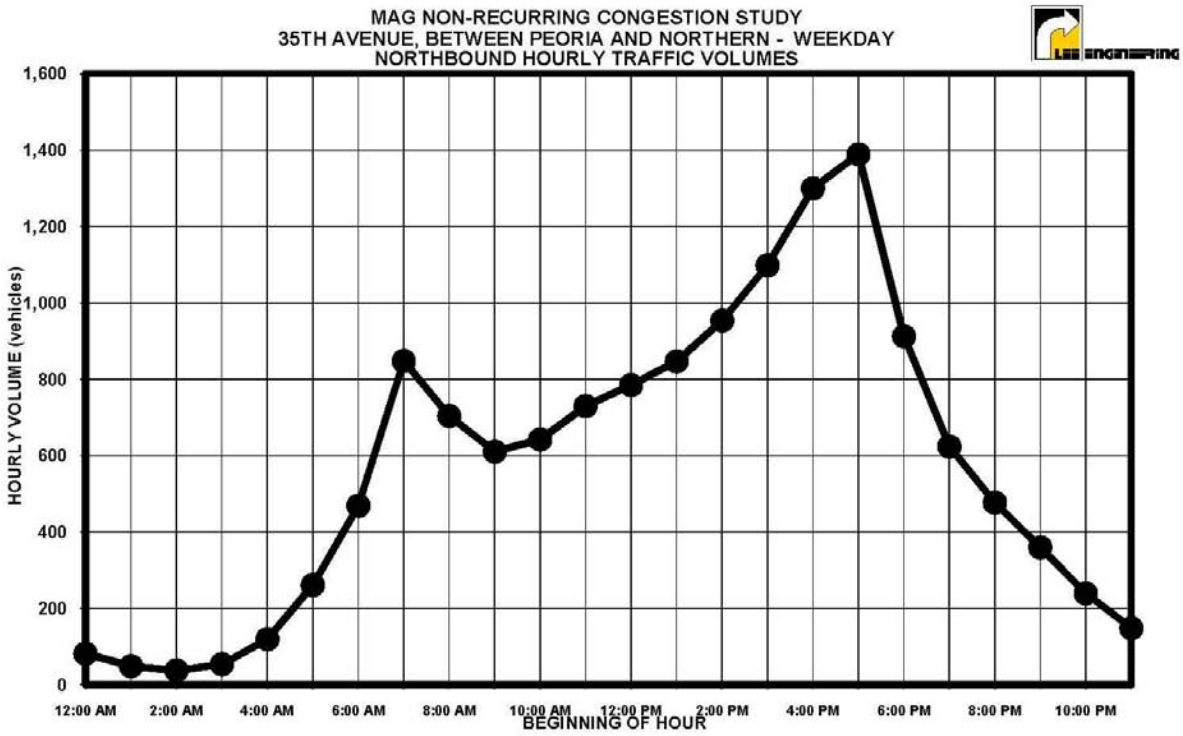
Analysis By: RCS Date: 11/12/2010

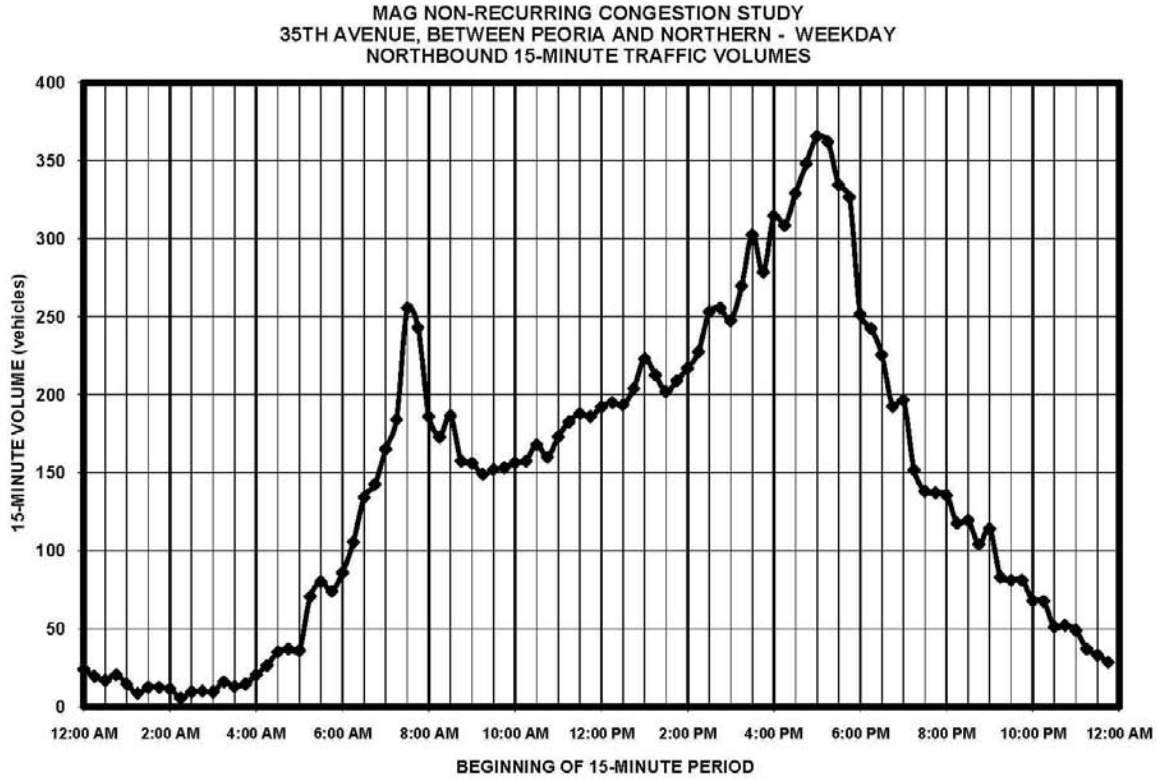
Checked By: LYK Date: 11/19/2010

MAG NON-RECURRING CONGESTION STUDY
35TH AVENUE, BETWEEN PEORIA AND NORTHERN - WEEKDAY
SOUTHBOUND
RANKED HOURLY VOLUMES AS A PERCENTAGE OF DAILY AND PEAK HOURLY VOLUMES

ACTUAL VOLUME	RANKED VOLUME	RANK	PORTION OF DAY	RATIO OF PEAK
89	1,602	1	11.74%	100.00%
52	936	2	6.86%	58.43%
31	935	3	6.85%	58.33%
63	917	**4**	**6.72%**	**57.21%**
124	899	5	6.58%	56.09%
299	862	6	6.31%	53.78%
862	820	7	6.00%	51.15%
1,602	776	**8**	**5.69%**	**48.44%**
935	768	9	5.62%	47.91%
584	719	10	5.26%	44.85%
584	689	11	5.05%	43.01%
689	618	12	4.53%	38.58%
719	584	13	4.28%	36.42%
776	584	14	4.28%	36.42%
820	472	15	3.45%	29.43%
917	392	16	2.87%	24.47%
899	299	17	2.19%	18.63%
936	265	18	1.94%	16.51%
768	159	19	1.16%	9.89%
618	124	20	0.91%	7.74%
472	89	21	0.65%	5.56%
392	63	22	0.46%	3.93%
265	52	23	0.38%	3.25%
159	31	24	0.23%	0.23%
13,649	**13,649**		**100.00%**	

Analysis By: RCS Date: 11/12/2010
Checked By: LYK Date: 11/19/2010


MAG NON-RECURRING CONGESTION STUDY
35TH AVENUE, BETWEEN PEORIA AND NORTHERN - WEEKDAY
NORTHBOUND HOURLY TRAFFIC VOLUMES
HOURLY VOLUME (vehicles)
1,600
1,400
1,200
1,000
800
600
400
200
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
BEGINNING OF HOUR


MAG NON-RECURRING CONGESTION STUDY
35TH AVENUE, BETWEEN PEORIA AND NORTHERN - WEEKDAY
NORTHBOUND 15-MINUTE TRAFFIC VOLUMES
15-MINUTE VOLUME (vehicles)
400
350
300
250
200
150
100
50
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
12:00 AM
BEGINNING OF 15-MINUTE PERIOD

MAG NON-RECURRING CONGESTION STUDY
35TH AVENUE, BETWEEN PEORIA AND NORTHERN - WEEKDAY
NORTHBOUND

BEGIN PERIOD	MORNING 15 MINUTES	MORNING 60 MINUTES	EVENING 15 MINUTES	EVENING 60 MINUTES	BEGIN PERIOD
12:00 AM	24	**81**	192	**785**	**12:00 PM**
12:15 AM	19.5	72	195	816	12:15 PM
12:30 AM	17	61	193.5	833	12:30 PM
12:45 AM	20.5	56	204	842	12:45 PM
1:00 AM	14.5	**48**	223	**847**	**1:00 PM**
1:15 AM	8.5	45	212.5	841	1:15 PM
1:30 AM	12.5	42	202	856	1:30 PM
1:45 AM	12.5	39	209	907	1:45 PM
2:00 AM	11.5	**37**	217	**953**	**2:00 PM**
2:15 AM	5.5	35	227.5	984	2:15 PM
2:30 AM	9.5	45	253	1,026	2:30 PM
2:45 AM	10	49	255.5	1,075	2:45 PM
3:00 AM	9.5	**53**	247.5	**1,098**	**3:00 PM**
3:15 AM	16	64	269.5	1,165	3:15 PM
3:30 AM	13	75	302.5	1,204	3:30 PM
3:45 AM	14.5	97	278.5	1,231	3:45 PM
4:00 AM	20.5	**119**	314.5	**1,300**	**4:00 PM**
4:15 AM	26.5	135	308.5	1,351	4:15 PM
4:30 AM	35	179	329	1,405	4:30 PM
4:45 AM	37	224	348	1,410	4:45 PM
5:00 AM	36	**261**	365.5	**1,389**	**5:00 PM**
5:15 AM	70.5	311	362	1,275	5:15 PM
5:30 AM	80	346	334.5	1,155	5:30 PM
5:45 AM	74	400	326.5	1,046	5:45 PM
6:00 AM	86	**468**	251.5	**912**	**6:00 PM**
6:15 AM	105.5	547	242.5	857	6:15 PM
6:30 AM	134	626	225.5	766	6:30 PM
6:45 AM	142.5	747	192.5	679	6:45 PM
7:00 AM	165	**848**	196.5	**623**	**7:00 PM**
7:15 AM	184	869	151.5	562	7:15 PM
7:30 AM	255.5	858	138	528	7:30 PM
7:45 AM	243	789	137	510	7:45 PM
8:00 AM	186	**703**	135.5	**477**	**8:00 PM**
8:15 AM	173	673	117.5	455	8:15 PM
8:30 AM	186.5	649	119.5	421	8:30 PM
8:45 AM	157.5	615	104	382	8:45 PM
9:00 AM	156	**610**	114	**359**	**9:00 PM**
9:15 AM	149	611	83	313	9:15 PM
9:30 AM	152	619	81	298	9:30 PM
9:45 AM	153	635	81	268	9:45 PM
10:00 AM	156.5	**642**	68	**239**	**10:00 PM**
10:15 AM	157.5	659	67.5	220	10:15 PM
10:30 AM	168	684	51	189	10:30 PM
10:45 AM	160	704	52	171	10:45 PM
11:00 AM	173	**730**	49	**148**	**11:00 PM**
11:15 AM	182.5	749	37	-	11:15 PM
11:30 AM	188	761	33	-	11:30 PM
11:45 AM	186	767	28.5	-	11:45 PM
AM PEAK VOLUME	**256**	**869**	**366**	**1,410**	PM PEAK VOLUME
PHF and TIME	**0.85**	**7:15 AM**	**0.96**	**4:45 PM**	PHF and TIME
DAILY VOLUME	**13725**				

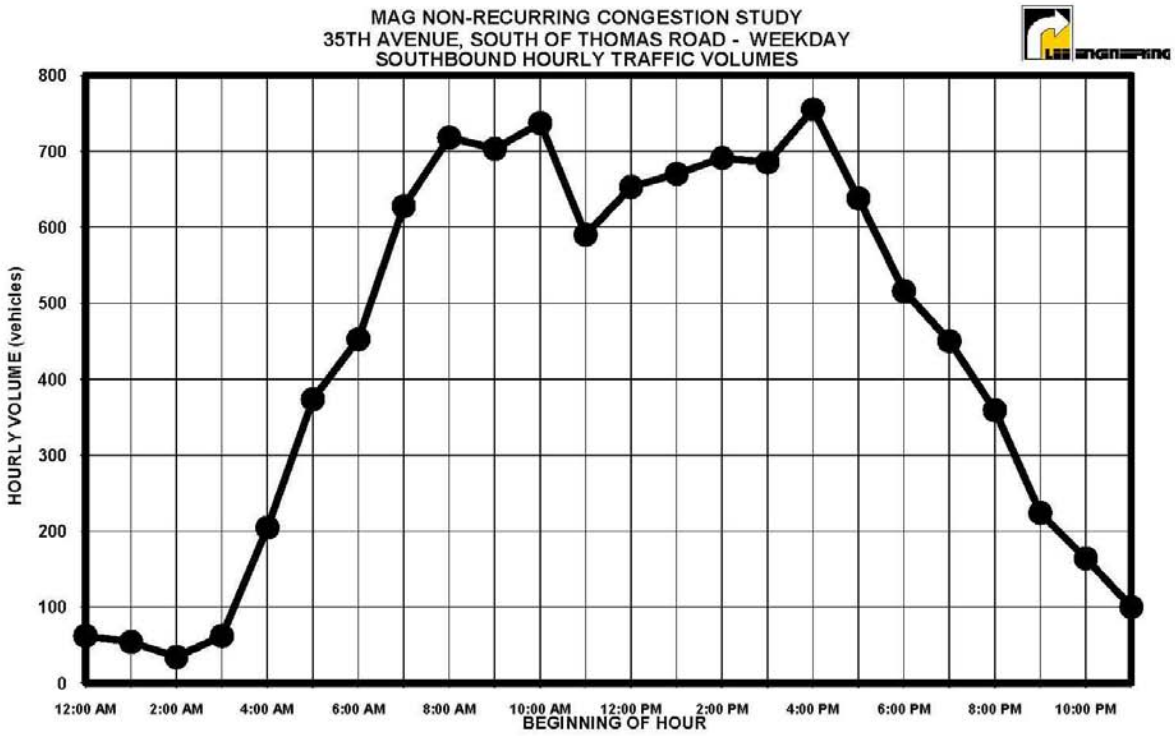
Analysis By: RCS Date: 11/12/2010

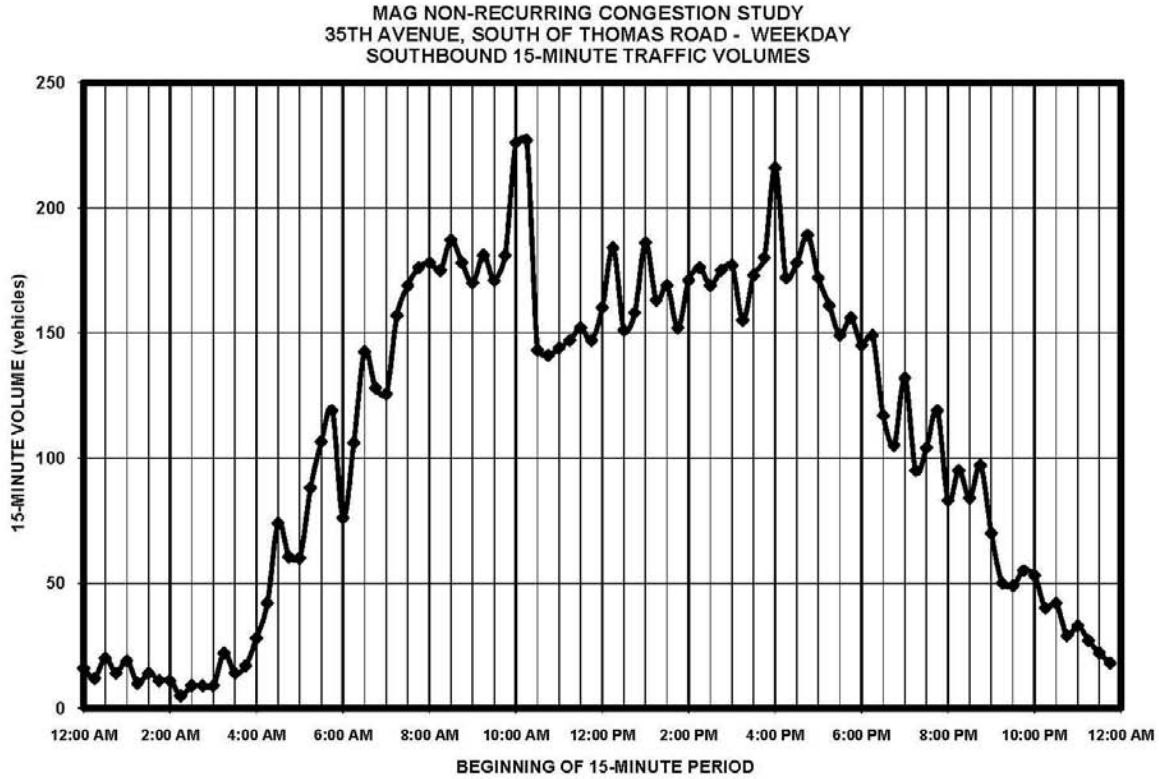
Checked By: LYK Date: 11/19/2010

MAG NON-RECURRING CONGESTION STUDY
35TH AVENUE, BETWEEN PEORIA AND NORTHERN - WEEKDAY
NORTHBOUND
RANKED HOURLY VOLUMES AS A PERCENTAGE OF DAILY AND PEAK HOURLY VOLUMES

ACTUAL VOLUME	RANKED VOLUME	RANK	PORTION OF DAY	RATIO OF PEAK
81	1,389	1	10.12%	100.00%
48	1,300	2	9.47%	93.63%
37	1,098	3	8.00%	79.08%
53	953	**4**	**6.94%**	**68.64%**
119	912	5	6.64%	65.68%
261	848	6	6.17%	61.04%
468	847	7	6.17%	60.97%
848	785	**8**	**5.72%**	**56.50%**
703	730	9	5.32%	52.54%
610	703	10	5.12%	50.63%
642	642	11	4.68%	46.24%
730	623	12	4.54%	44.87%
785	610	13	4.44%	43.93%
847	477	14	3.47%	34.32%
953	468	15	3.41%	33.71%
1,098	359	16	2.62%	25.86%
1,300	261	17	1.90%	18.76%
1,389	239	18	1.74%	17.18%
912	148	19	1.07%	10.62%
623	119	20	0.87%	8.57%
477	81	21	0.59%	5.83%
359	53	22	0.39%	3.82%
239	48	23	0.35%	3.46%
148	37	24	0.27%	0.27%
13,725	**13,725**		**100.00%**	

Analysis By: RCS Date: 11/12/2010
Checked By: LYK Date: 11/19/2010


MAG NON-RECURRING CONGESTION STUDY
35TH AVENUE, SOUTH OF THOMAS ROAD - WEEKDAY
SOUTHBOUND HOURLY TRAFFIC VOLUMES
HOURLY VOLUME (vehicles)
0
100
200
300
400
500
600
700
800
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
BEGINNING OF HOUR


MAG NON-RECURRING CONGESTION STUDY
35TH AVENUE, SOUTH OF THOMAS ROAD - WEEKDAY
SOUTHBOUND 15-MINUTE TRAFFIC VOLUMES
15-MINUTE VOLUME (vehicles)
0
50
100
150
200
250
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
12:00 AM
BEGINNING OF 15-MINUTE PERIOD

MAG NON-RECURRING CONGESTION STUDY
35TH AVENUE, SOUTH OF THOMAS ROAD - WEEKDAY
SOUTHBOUND

BEGIN PERIOD	MORNING 15 MINUTES	MORNING 60 MINUTES	EVENING 15 MINUTES	EVENING 60 MINUTES	BEGIN PERIOD
12:00 AM	16	**62**	160	**653**	**12:00 PM**
12:15 AM	12	65	184	679	12:15 PM
12:30 AM	20	63	151	658	12:30 PM
12:45 AM	14	57	158	676	12:45 PM
1:00 AM	19	**54**	186	**670**	**1:00 PM**
1:15 AM	10	46	163	655	1:15 PM
1:30 AM	14	41	169	668	1:30 PM
1:45 AM	11	36	152	668	1:45 PM
2:00 AM	11	**34**	171	**691**	**2:00 PM**
2:15 AM	5	32	176	697	2:15 PM
2:30 AM	9	49	169	676	2:30 PM
2:45 AM	9	54	175	680	2:45 PM
3:00 AM	9	**62**	177	**685**	**3:00 PM**
3:15 AM	22	81	155	724	3:15 PM
3:30 AM	14	101	173	741	3:30 PM
3:45 AM	17	161	180	746	3:45 PM
4:00 AM	28	**205**	216	**755**	**4:00 PM**
4:15 AM	42	237	172	711	4:15 PM
4:30 AM	74	283	178	700	4:30 PM
4:45 AM	60.5	315	189	671	4:45 PM
5:00 AM	60	**374**	172	**638**	**5:00 PM**
5:15 AM	88	390	161	611	5:15 PM
5:30 AM	106.5	408	149	599	5:30 PM
5:45 AM	119	444	156	567	5:45 PM
6:00 AM	76	**453**	145	**516**	**6:00 PM**
6:15 AM	106	502	149	503	6:15 PM
6:30 AM	142.5	553	117	449	6:30 PM
6:45 AM	128	580	105	436	6:45 PM
7:00 AM	125.5	**628**	132	**450**	**7:00 PM**
7:15 AM	157	680	95	401	7:15 PM
7:30 AM	169	698	104	401	7:30 PM
7:45 AM	176	716	119	381	7:45 PM
8:00 AM	178	**718**	83	**359**	**8:00 PM**
8:15 AM	175	710	95	346	8:15 PM
8:30 AM	187	716	84	301	8:30 PM
8:45 AM	178	700	97	266	8:45 PM
9:00 AM	170	**703**	70	**224**	**9:00 PM**
9:15 AM	181	759	50	207	9:15 PM
9:30 AM	171	805	49	197	9:30 PM
9:45 AM	181	777	55	190	9:45 PM
10:00 AM	226	**737**	53	**164**	**10:00 PM**
10:15 AM	227	655	40	144	10:15 PM
10:30 AM	143	575	42	131	10:30 PM
10:45 AM	141	584	29	111	10:45 PM
11:00 AM	144	**590**	33	**100**	**11:00 PM**
11:15 AM	147	606	27	-	11:15 PM
11:30 AM	152	643	22	-	11:30 PM
11:45 AM	147	642	18	-	11:45 PM
AM PEAK VOLUME	**227**	**805**	**216**	**755**	PM PEAK VOLUME
PHF and TIME	**0.89**	**9:30 AM**	**0.87**	**4:00 PM**	PHF and TIME
DAILY VOLUME	**10523**				

Analysis By: LYK Date: 11/10/2010

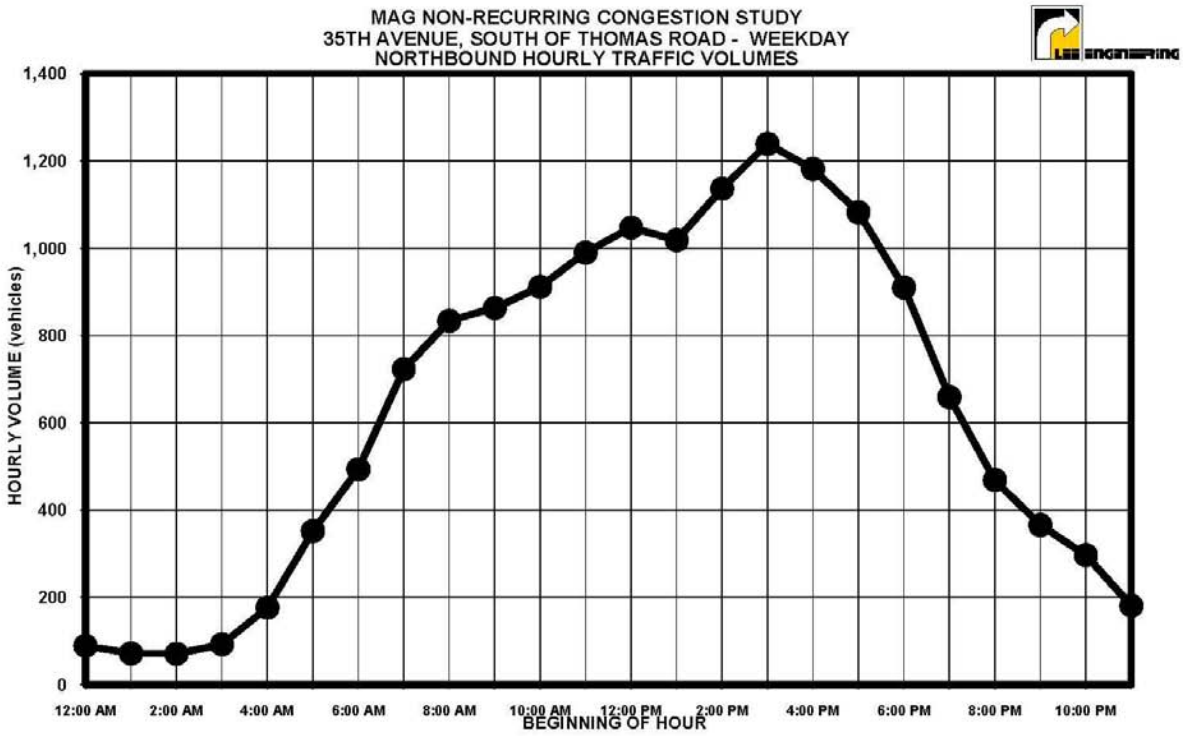
Checked By: LYK Date: 11/10/2010

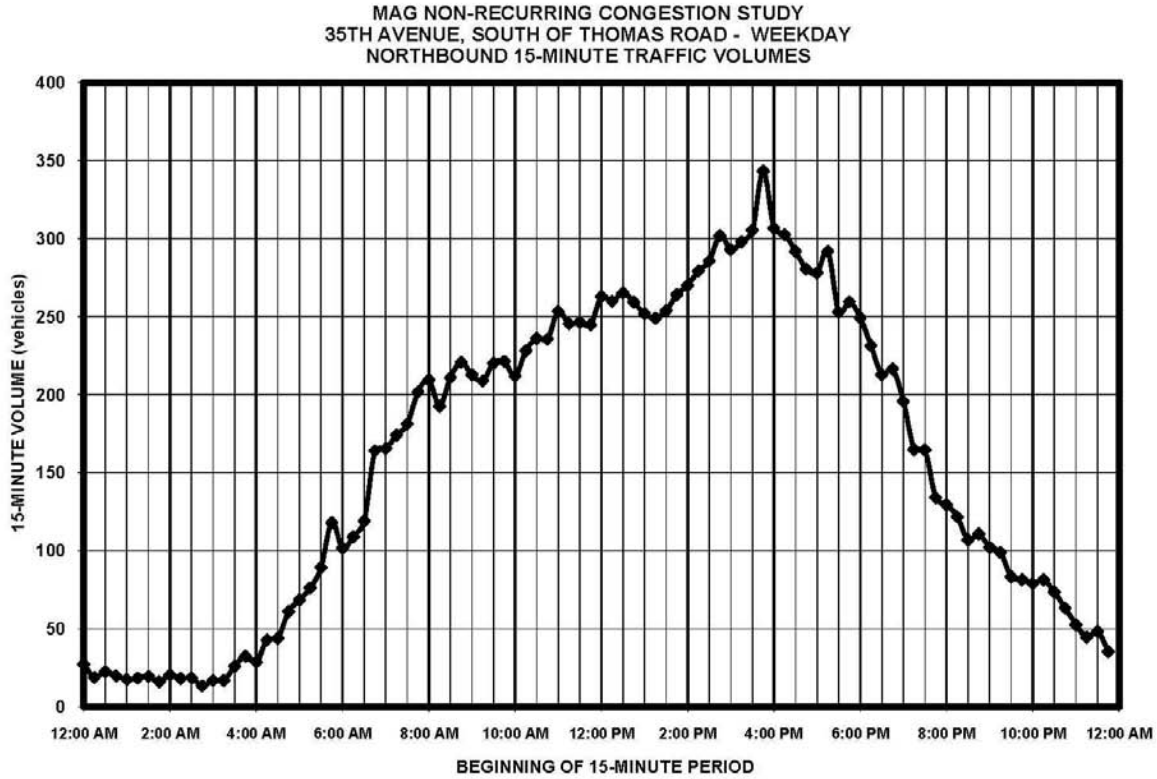
LEE ENGINEERING

MAG NON-RECURRING CONGESTION STUDY
35TH AVENUE, SOUTH OF THOMAS ROAD - WEEKDAY
SOUTHBOUND
RANKED HOURLY VOLUMES AS A PERCENTAGE OF DAILY AND PEAK HOURLY VOLUMES

ACTUAL VOLUME	RANKED VOLUME	RANK	PORTION OF DAY	RATIO OF PEAK
62	755	1	7.17%	100.00%
54	737	2	7.00%	97.62%
34	718	3	6.82%	95.10%
62	703	**4**	**6.68%**	**93.11%**
205	691	5	6.57%	91.52%
374	685	6	6.51%	90.73%
453	670	7	6.37%	88.74%
628	653	**8**	**6.21%**	**86.49%**
718	638	9	6.06%	84.50%
703	628	10	5.96%	83.11%
737	590	11	5.61%	78.15%
590	516	12	4.90%	68.34%
653	453	13	4.30%	59.93%
670	450	14	4.28%	59.60%
691	374	15	3.55%	49.47%
685	359	16	3.41%	47.55%
755	224	17	2.13%	29.67%
638	205	18	1.94%	27.09%
516	164	19	1.56%	21.72%
450	100	20	0.95%	13.25%
359	62	21	0.59%	8.21%
224	62	22	0.59%	8.21%
164	54	23	0.51%	7.15%
100	34	24	0.32%	0.32%
10,523	**10,523**		**100.00%**	

Analysis By: LYK Date: 11/10/2010
Checked By: LYK Date: 11/10/2010


MAG NON-RECURRING CONGESTION STUDY
35TH AVENUE, SOUTH OF THOMAS ROAD - WEEKDAY
NORTHBOUND HOURLY TRAFFIC VOLUMES
HOURLY VOLUME (vehicles)
1,400
1,200
1,000
800
600
400
200
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
BEGINNING OF HOUR


MAG NON-RECURRING CONGESTION STUDY
35TH AVENUE, SOUTH OF THOMAS ROAD - WEEKDAY
NORTHBOUND 15-MINUTE TRAFFIC VOLUMES
15-MINUTE VOLUME (vehicles)
400
350
300
250
200
150
100
50
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
12:00 AM
BEGINNING OF 15-MINUTE PERIOD

MAG NON-RECURRING CONGESTION STUDY
35TH AVENUE, SOUTH OF THOMAS ROAD - WEEKDAY
NORTHBOUND

BEGIN PERIOD	MORNING 15 MINUTES	MORNING 60 MINUTES	EVENING 15 MINUTES	EVENING 60 MINUTES	BEGIN PERIOD
12:00 AM	27.2	**88**	262.8	**1,047**	**12:00 PM**
12:15 AM	18.8	79	259.8	1,036	12:15 PM
12:30 AM	22.6	78	265.2	1,025	12:30 PM
12:45 AM	19.8	75	259.2	1,014	12:45 PM
1:00 AM	17.4	**71**	251.8	**1,019**	**1:00 PM**
1:15 AM	18.4	74	249	1,037	1:15 PM
1:30 AM	19.4	74	253.8	1,067	1:30 PM
1:45 AM	16	73	264	1,099	1:45 PM
2:00 AM	20.4	**70**	270	**1,137**	**2:00 PM**
2:15 AM	18.2	67	279.2	1,160	2:15 PM
2:30 AM	18.4	65	285.6	1,178	2:30 PM
2:45 AM	13.4	73	301.8	1,198	2:45 PM
3:00 AM	16.8	**92**	293	**1,239**	**3:00 PM**
3:15 AM	16.8	104	297.8	1,253	3:15 PM
3:30 AM	26	130	305.2	1,258	3:30 PM
3:45 AM	32.4	148	343.2	1,244	3:45 PM
4:00 AM	28.6	**176**	306.8	**1,182**	**4:00 PM**
4:15 AM	42.8	216	302.6	1,153	4:15 PM
4:30 AM	44	250	291.8	1,142	4:30 PM
4:45 AM	61	295	280.4	1,103	4:45 PM
5:00 AM	68.4	**352**	278	**1,082**	**5:00 PM**
5:15 AM	76.2	385	291.8	1,053	5:15 PM
5:30 AM	89.2	418	252.8	993	5:30 PM
5:45 AM	118	447	259.6	953	5:45 PM
6:00 AM	101.6	**493**	249.2	**910**	**6:00 PM**
6:15 AM	108.8	557	231.4	856	6:15 PM
6:30 AM	119	622	212.8	790	6:30 PM
6:45 AM	164	685	216.4	741	6:45 PM
7:00 AM	165.4	**722**	195.6	**659**	**7:00 PM**
7:15 AM	174	766	164.8	593	7:15 PM
7:30 AM	181.2	785	164.4	549	7:30 PM
7:45 AM	201.8	815	134	492	7:45 PM
8:00 AM	209.4	**834**	129.4	**468**	**8:00 PM**
8:15 AM	192.6	837	121.6	441	8:15 PM
8:30 AM	210.8	853	106.8	418	8:30 PM
8:45 AM	220.8	862	110.6	395	8:45 PM
9:00 AM	212.6	**863**	102	**365**	**9:00 PM**
9:15 AM	208.8	862	98.8	342	9:15 PM
9:30 AM	220.2	881	83.2	325	9:30 PM
9:45 AM	221.2	897	81.4	315	9:45 PM
10:00 AM	211.8	**912**	78.8	**297**	**10:00 PM**
10:15 AM	228.2	953	81.2	270	10:15 PM
10:30 AM	236	970	73.4	234	10:30 PM
10:45 AM	235.6	981	63.2	208	10:45 PM
11:00 AM	253.4	**990**	52.6	**181**	**11:00 PM**
11:15 AM	245.4	999	44.4	-	11:15 PM
11:30 AM	246.4	1,014	48.2	-	11:30 PM
11:45 AM	244.8	1,033	35.4	-	11:45 PM
AM PEAK VOLUME	**265**	**1,033**	**343**	**1,258**	PM PEAK VOLUME
PHF and TIME	**0.97**	**11:45 AM**	**0.92**	**3:30 PM**	PHF and TIME
DAILY VOLUME	**15248.8**				

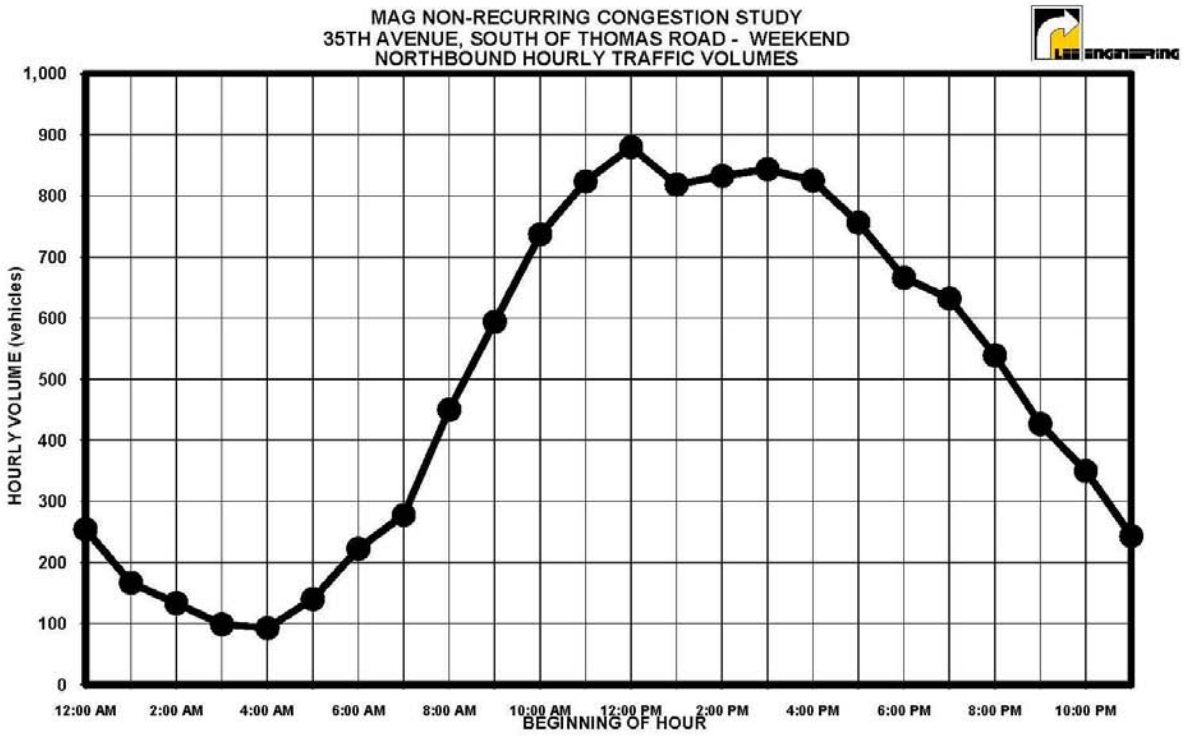
Analysis By: LYK Date: 11/10/2010

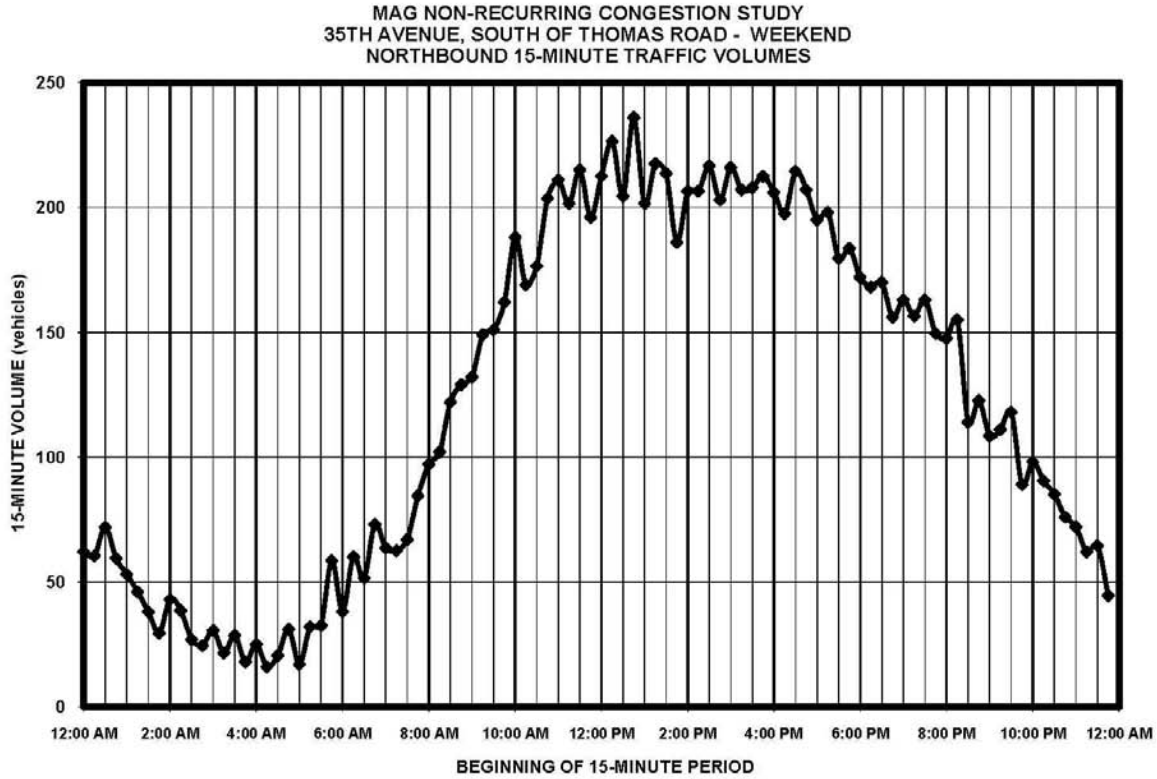
Checked By: LYK Date: 11/10/2010

MAG NON-RECURRING CONGESTION STUDY
35TH AVENUE, SOUTH OF THOMAS ROAD - WEEKDAY
NORTHBOUND
RANKED HOURLY VOLUMES AS A PERCENTAGE OF DAILY AND PEAK HOURLY VOLUMES

ACTUAL VOLUME	RANKED VOLUME	RANK	PORTION OF DAY	RATIO OF PEAK
88	1,239	1	8.13%	100.00%
71	1,182	2	7.75%	95.35%
70	1,137	3	7.45%	91.72%
92	1,082	**4**	**7.10%**	**87.33%**
176	1,047	5	6.87%	84.49%
352	1,019	6	6.68%	82.20%
493	990	7	6.49%	79.89%
722	912	**8**	**5.98%**	**73.56%**
834	910	9	5.97%	73.42%
863	863	10	5.66%	69.63%
912	834	11	5.47%	67.27%
990	722	12	4.74%	58.30%
1,047	659	13	4.32%	53.16%
1,019	493	14	3.24%	39.82%
1,137	468	15	3.07%	37.80%
1,239	365	16	2.40%	29.49%
1,182	352	17	2.31%	28.39%
1,082	297	18	1.95%	23.93%
910	181	19	1.18%	14.57%
659	176	20	1.16%	14.23%
468	92	21	0.60%	7.42%
365	88	22	0.58%	7.13%
297	71	23	0.47%	5.75%
181	70	24	0.46%	0.46%
15,249	**15,249**		**100.00%**	

Analysis By: LYK Date: 11/10/2010
Checked By: LYK Date: 11/10/2010


MAG NON-RECURRING CONGESTION STUDY
35TH AVENUE, SOUTH OF THOMAS ROAD - WEEKEND
NORTHBOUND HOURLY TRAFFIC VOLUMES
HOURLY VOLUME (vehicles)
1,000
900
800
700
600
500
400
300
200
100
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
BEGINNING OF HOUR


MAG NON-RECURRING CONGESTION STUDY
35TH AVENUE, SOUTH OF THOMAS ROAD - WEEKEND
NORTHBOUND 15-MINUTE TRAFFIC VOLUMES
15-MINUTE VOLUME (vehicles)
250
200
150
100
50
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
12:00 AM
BEGINNING OF 15-MINUTE PERIOD

MAG NON-RECURRING CONGESTION STUDY
35TH AVENUE, SOUTH OF THOMAS ROAD - WEEKEND
NORTHBOUND

BEGIN PERIOD	MORNING 15 MINUTES	MORNING 60 MINUTES	EVENING 15 MINUTES	EVENING 60 MINUTES	BEGIN PERIOD
12:00 AM	62	**254**	212.5	**880**	**12:00 PM**
12:15 AM	60.5	245	226.5	869	12:15 PM
12:30 AM	72	231	204.5	860	12:30 PM
12:45 AM	59.5	197	236	869	12:45 PM
1:00 AM	53	**167**	201.5	**819**	**1:00 PM**
1:15 AM	46	157	217.5	824	1:15 PM
1:30 AM	38	149	213.5	813	1:30 PM
1:45 AM	29.5	138	186	816	1:45 PM
2:00 AM	43	**133**	206.5	**833**	**2:00 PM**
2:15 AM	38.5	121	206.5	842	2:15 PM
2:30 AM	27	104	216.5	843	2:30 PM
2:45 AM	24.5	105	203	834	2:45 PM
3:00 AM	30.5	**99**	216	**844**	**3:00 PM**
3:15 AM	21.5	93	207	834	3:15 PM
3:30 AM	28.5	88	208	824	3:30 PM
3:45 AM	18	80	212.5	831	3:45 PM
4:00 AM	25	**93**	206	**825**	**4:00 PM**
4:15 AM	16	85	197.5	814	4:15 PM
4:30 AM	20.5	101	214.5	815	4:30 PM
4:45 AM	31	113	207	780	4:45 PM
5:00 AM	17	**140**	195	**756**	**5:00 PM**
5:15 AM	32	161	198	733	5:15 PM
5:30 AM	32.5	189	179.5	703	5:30 PM
5:45 AM	58.5	208	183.5	694	5:45 PM
6:00 AM	38	**223**	172	**666**	**6:00 PM**
6:15 AM	60	248	168	657	6:15 PM
6:30 AM	51.5	251	170	646	6:30 PM
6:45 AM	73	266	156	639	6:45 PM
7:00 AM	63.5	**278**	163	**632**	**7:00 PM**
7:15 AM	62.5	311	156.5	617	7:15 PM
7:30 AM	67	351	163	615	7:30 PM
7:45 AM	84.5	406	149.5	566	7:45 PM
8:00 AM	97	**450**	147.5	**539**	**8:00 PM**
8:15 AM	102	485	155	500	8:15 PM
8:30 AM	122	532	114	456	8:30 PM
8:45 AM	129	561	122.5	460	8:45 PM
9:00 AM	132	**594**	108.5	**427**	**9:00 PM**
9:15 AM	149	650	111	416	9:15 PM
9:30 AM	151	670	118	396	9:30 PM
9:45 AM	162	696	89	363	9:45 PM
10:00 AM	188	**737**	98	**350**	**10:00 PM**
10:15 AM	169	760	90.5	324	10:15 PM
10:30 AM	176.5	793	85	295	10:30 PM
10:45 AM	203.5	831	76	275	10:45 PM
11:00 AM	211	**824**	72	**243**	**11:00 PM**
11:15 AM	201.5	825	62	-	11:15 PM
11:30 AM	215	850	64.5	-	11:30 PM
11:45 AM	196	840	44.5	-	11:45 PM
AM PEAK VOLUME	**227**	**850**	**236**	**880**	PM PEAK VOLUME
PHF and TIME	**0.94**	**11:30 AM**	**0.93**	**12:00 PM**	PHF and TIME
DAILY VOLUME	**11800**				

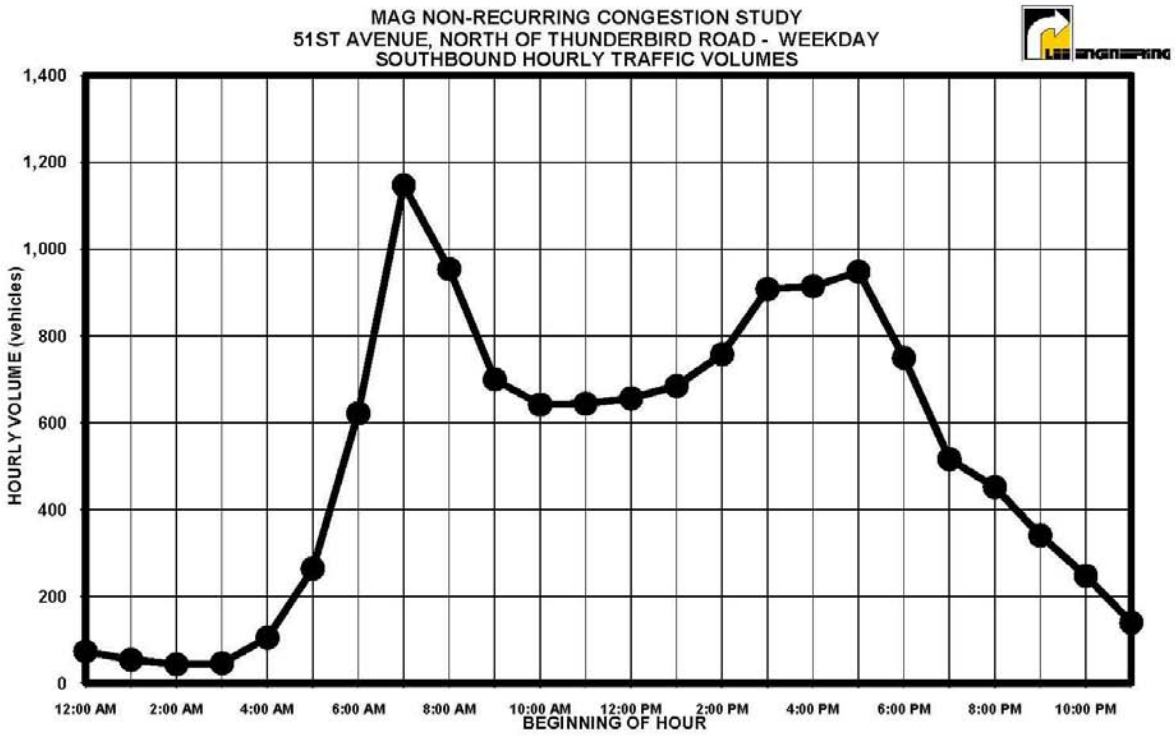
Analysis By: LYK Date: 11/10/2010

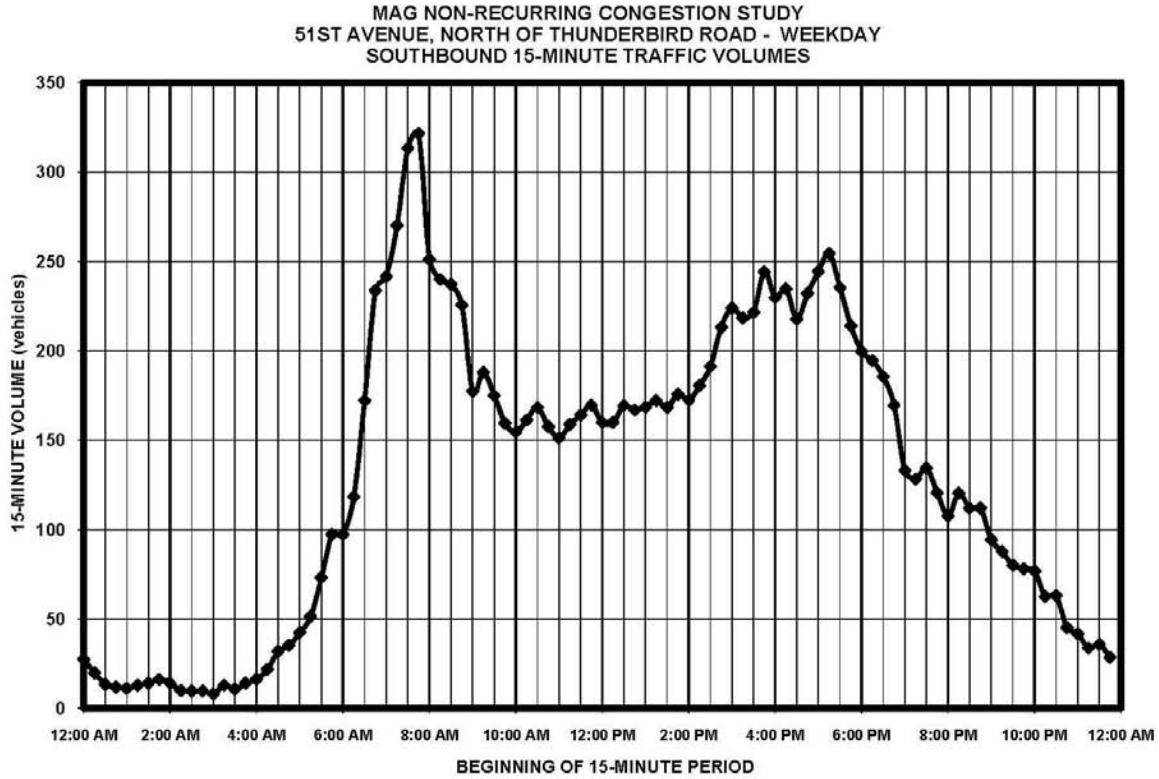
Checked By: LYK Date: 11/10/2010

MAG NON-RECURRING CONGESTION STUDY
35TH AVENUE, SOUTH OF THOMAS ROAD - WEEKEND
NORTHBOUND
RANKED HOURLY VOLUMES AS A PERCENTAGE OF DAILY AND PEAK HOURLY VOLUMES

ACTUAL VOLUME	RANKED VOLUME	RANK	PORTION OF DAY	RATIO OF PEAK
254	880	1	7.45%	100.00%
167	844	2	7.15%	95.91%
133	833	3	7.06%	94.66%
99	825	**4**	**6.99%**	**93.80%**
93	824	5	6.98%	93.63%
140	819	6	6.94%	93.06%
223	756	7	6.41%	85.96%
278	737	**8**	**6.25%**	**83.80%**
450	666	9	5.64%	75.72%
594	632	10	5.36%	71.86%
737	594	11	5.03%	67.54%
824	539	12	4.57%	61.28%
880	450	13	3.81%	51.17%
819	427	14	3.61%	48.49%
833	350	15	2.96%	39.74%
844	278	16	2.35%	31.55%
825	254	17	2.15%	28.88%
756	243	18	2.06%	27.63%
666	223	19	1.89%	25.30%
632	167	20	1.41%	18.93%
539	140	21	1.19%	15.92%
427	133	22	1.13%	15.12%
350	99	23	0.83%	11.20%
243	93	24	0.78%	0.78%
11,800	**11,800**		**100.00%**	

Analysis By: LYK Date: 11/10/2010
Checked By: LYK Date: 11/10/2010


MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, NORTH OF THUNDERBIRD ROAD - WEEKDAY
SOUTHBOUND HOURLY TRAFFIC VOLUMES
HOURLY VOLUME (vehicles)
1,400
1,200
1,000
800
600
400
200
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
BEGINNING OF HOUR


MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, NORTH OF THUNDERBIRD ROAD - WEEKDAY
SOUTHBOUND 15-MINUTE TRAFFIC VOLUMES
15-MINUTE VOLUME (vehicles)
350
300
250
200
150
100
50
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
12:00 AM
BEGINNING OF 15-MINUTE PERIOD

MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, NORTH OF THUNDERBIRD ROAD - WEEKDAY
SOUTHBOUND

BEGIN PERIOD	MORNING 15 MINUTES	MORNING 60 MINUTES	EVENING 15 MINUTES	EVENING 60 MINUTES	BEGIN PERIOD
12:00 AM	27.4	**72**	159.8	**656**	**12:00 PM**
12:15 AM	19.8	56	159.8	664	12:15 PM
12:30 AM	13.4	49	169.2	676	12:30 PM
12:45 AM	11.8	50	166.8	675	12:45 PM
1:00 AM	11	**54**	168.4	**684**	**1:00 PM**
1:15 AM	12.8	57	172	688	1:15 PM
1:30 AM	14	54	168.2	697	1:30 PM
1:45 AM	16	49	175.6	720	1:45 PM
2:00 AM	14	**43**	172.4	**757**	**2:00 PM**
2:15 AM	9.8	37	180.4	808	2:15 PM
2:30 AM	9.4	40	191.2	846	2:30 PM
2:45 AM	9.6	41	213	876	2:45 PM
3:00 AM	7.8	**45**	223.8	**907**	**3:00 PM**
3:15 AM	12.8	53	218.2	913	3:15 PM
3:30 AM	10.6	62	221.4	930	3:30 PM
3:45 AM	14	83	244	926	3:45 PM
4:00 AM	16	**104**	229.6	**914**	**4:00 PM**
4:15 AM	21.6	131	234.6	928	4:15 PM
4:30 AM	31.8	160	217.6	948	4:30 PM
4:45 AM	35	201	232	966	4:45 PM
5:00 AM	42.2	**264**	244.2	**948**	**5:00 PM**
5:15 AM	51.2	319	254.2	903	5:15 PM
5:30 AM	73	386	235.2	843	5:30 PM
5:45 AM	97.2	485	214	793	5:45 PM
6:00 AM	97.2	**621**	199.6	**749**	**6:00 PM**
6:15 AM	118.2	766	194.4	682	6:15 PM
6:30 AM	172.2	917	185.4	616	6:30 PM
6:45 AM	233.6	1,058	169.4	564	6:45 PM
7:00 AM	241.6	**1,146**	132.8	**515**	**7:00 PM**
7:15 AM	270	1,156	128	490	7:15 PM
7:30 AM	313.2	1,125	134.2	482	7:30 PM
7:45 AM	321.4	1,049	120.4	460	7:45 PM
8:00 AM	251	**953**	107.4	**451**	**8:00 PM**
8:15 AM	239.8	880	120.2	438	8:15 PM
8:30 AM	237	828	111.8	405	8:30 PM
8:45 AM	225.6	765	111.8	374	8:45 PM
9:00 AM	177.2	**699**	94.2	**340**	**9:00 PM**
9:15 AM	187.8	676	87.6	322	9:15 PM
9:30 AM	174.8	650	80	297	9:30 PM
9:45 AM	159.4	643	78	280	9:45 PM
10:00 AM	154.4	**641**	76.6	**247**	**10:00 PM**
10:15 AM	161.2	638	62.4	212	10:15 PM
10:30 AM	168.2	635	63	183	10:30 PM
10:45 AM	157.4	631	45	156	10:45 PM
11:00 AM	151.2	**643**	41.6	**139**	**11:00 PM**
11:15 AM	158.6	652	33.6	-	11:15 PM
11:30 AM	164	653	35.6	-	11:30 PM
11:45 AM	169.4	658	28.4	-	11:45 PM
AM PEAK VOLUME	**321**	**1,156**	**254**	**966**	PM PEAK VOLUME
PHF and TIME	**0.90**	**7:15 AM**	**0.95**	**4:45 PM**	PHF and TIME
DAILY VOLUME	**12593.6**				

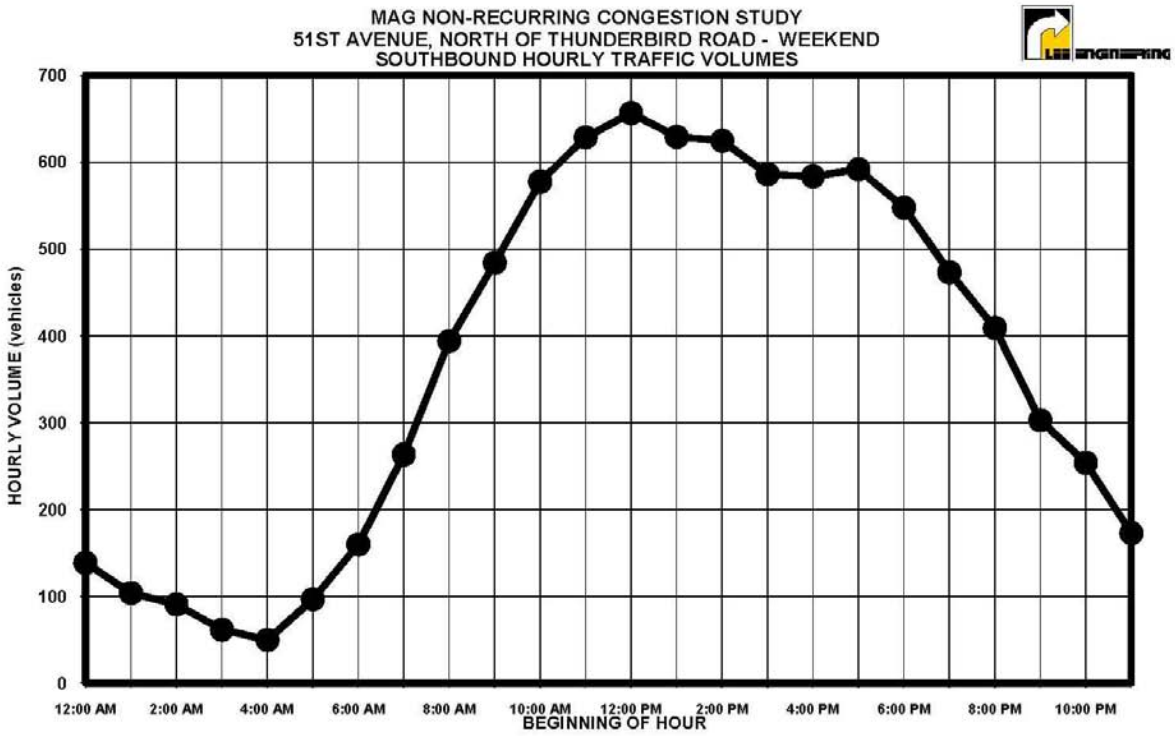
Analysis By: LYK Date: 11/10/2010

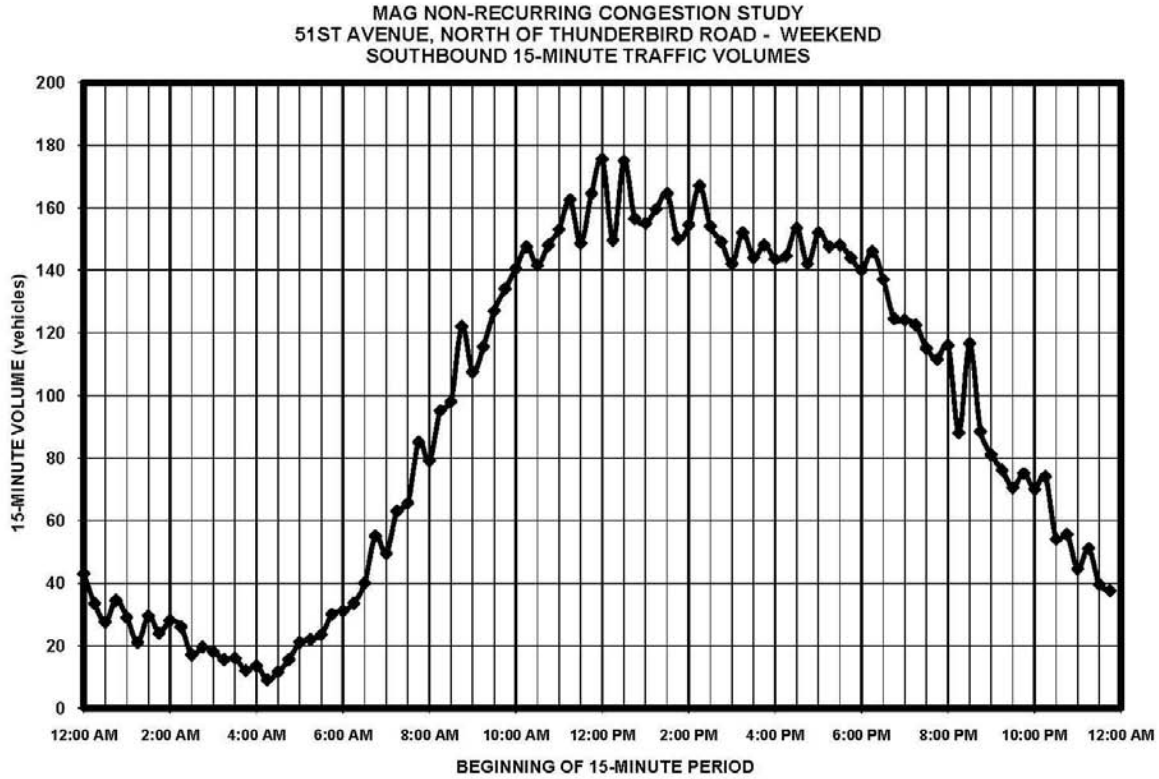
Checked By: LYK Date: 11/10/2010

MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, NORTH OF THUNDERBIRD ROAD - WEEKDAY
SOUTHBOUND
RANKED HOURLY VOLUMES AS A PERCENTAGE OF DAILY AND PEAK HOURLY VOLUMES

ACTUAL VOLUME	RANKED VOLUME	RANK	PORTION OF DAY	RATIO OF PEAK
72	1,146	1	9.10%	100.00%
54	953	2	7.57%	83.18%
43	948	3	7.52%	82.67%
45	914	**4**	**7.26%**	**79.72%**
104	907	5	7.21%	79.17%
264	757	6	6.01%	66.04%
621	749	7	5.95%	65.33%
1,146	699	**8**	**5.55%**	**61.00%**
953	684	9	5.43%	59.69%
699	656	10	5.21%	57.20%
641	643	11	5.11%	56.12%
643	641	12	5.09%	55.94%
656	621	13	4.93%	54.20%
684	515	14	4.09%	44.97%
757	451	15	3.58%	39.36%
907	340	16	2.70%	29.65%
914	264	17	2.09%	23.00%
948	247	18	1.96%	21.55%
749	139	19	1.11%	12.14%
515	104	20	0.83%	9.11%
451	72	21	0.57%	6.32%
340	54	22	0.43%	4.69%
247	45	23	0.36%	3.94%
139	43	24	0.34%	0.34%
12,594	**12,594**		**100.00%**	

Analysis By: LYK Date: 11/10/2010
Checked By: LYK Date: 11/10/2010


MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, NORTH OF THUNDERBIRD ROAD - WEEKEND
SOUTHBOUND HOURLY TRAFFIC VOLUMES
HOURLY VOLUME (vehicles)
0
100
200
300
400
500
600
700
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
BEGINNING OF HOUR


MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, NORTH OF THUNDERBIRD ROAD - WEEKEND
SOUTHBOUND 15-MINUTE TRAFFIC VOLUMES
15-MINUTE VOLUME (vehicles)
0
20
40
60
80
100
120
140
160
180
200
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
12:00 AM
BEGINNING OF 15-MINUTE PERIOD

MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, NORTH OF THUNDERBIRD ROAD - WEEKEND
SOUTHBOUND

BEGIN PERIOD	MORNING 15 MINUTES	MORNING 60 MINUTES	EVENING 15 MINUTES	EVENING 60 MINUTES	BEGIN PERIOD
12:00 AM	43	**139**	175.5	**657**	**12:00 PM**
12:15 AM	33.5	125	149.5	636	12:15 PM
12:30 AM	27.5	112	175	646	12:30 PM
12:45 AM	34.5	114	156.5	636	12:45 PM
1:00 AM	29	**104**	155	**629**	**1:00 PM**
1:15 AM	21	103	159.5	629	1:15 PM
1:30 AM	29.5	108	164.5	636	1:30 PM
1:45 AM	24	95	150	626	1:45 PM
2:00 AM	28	**91**	154.5	**625**	**2:00 PM**
2:15 AM	26	81	167	612	2:15 PM
2:30 AM	17	70	154	597	2:30 PM
2:45 AM	19.5	69	149	587	2:45 PM
3:00 AM	18	**62**	142	**586**	**3:00 PM**
3:15 AM	15.5	57	152	588	3:15 PM
3:30 AM	16	51	144	580	3:30 PM
3:45 AM	12	46	148	590	3:45 PM
4:00 AM	13.5	**50**	143.5	**584**	**4:00 PM**
4:15 AM	9	57	144.5	592	4:15 PM
4:30 AM	11.5	70	153.5	595	4:30 PM
4:45 AM	15.5	82	142	590	4:45 PM
5:00 AM	21	**97**	152	**592**	**5:00 PM**
5:15 AM	22	107	147.5	580	5:15 PM
5:30 AM	23.5	118	148	578	5:30 PM
5:45 AM	30	135	144	567	5:45 PM
6:00 AM	31	**160**	140	**548**	**6:00 PM**
6:15 AM	33.5	178	146	532	6:15 PM
6:30 AM	40	208	137	508	6:30 PM
6:45 AM	55	233	124.5	486	6:45 PM
7:00 AM	49.5	**263**	124	**473**	**7:00 PM**
7:15 AM	63	293	122.5	465	7:15 PM
7:30 AM	65.5	325	115	431	7:30 PM
7:45 AM	85	357	111.5	432	7:45 PM
8:00 AM	79	**394**	116	**409**	**8:00 PM**
8:15 AM	95	423	88	374	8:15 PM
8:30 AM	98	443	116.5	362	8:30 PM
8:45 AM	122	472	88.5	316	8:45 PM
9:00 AM	107.5	**484**	81	**303**	**9:00 PM**
9:15 AM	115.5	517	76	292	9:15 PM
9:30 AM	127	549	70.5	290	9:30 PM
9:45 AM	134	564	75	273	9:45 PM
10:00 AM	140.5	**578**	70	**254**	**10:00 PM**
10:15 AM	147.5	590	74	228	10:15 PM
10:30 AM	141.5	605	54	205	10:30 PM
10:45 AM	148	612	55.5	191	10:45 PM
11:00 AM	153	**629**	44.5	**173**	**11:00 PM**
11:15 AM	162.5	651	51	-	11:15 PM
11:30 AM	148.5	638	39.5	-	11:30 PM
11:45 AM	164.5	665	37.5	-	11:45 PM
AM PEAK VOLUME	**176**	**665**	**176**	**657**	PM PEAK VOLUME
PHF and TIME	**0.95**	**11:45 AM**	**0.94**	**12:00 PM**	PHF and TIME
DAILY VOLUME	**8875.5**				

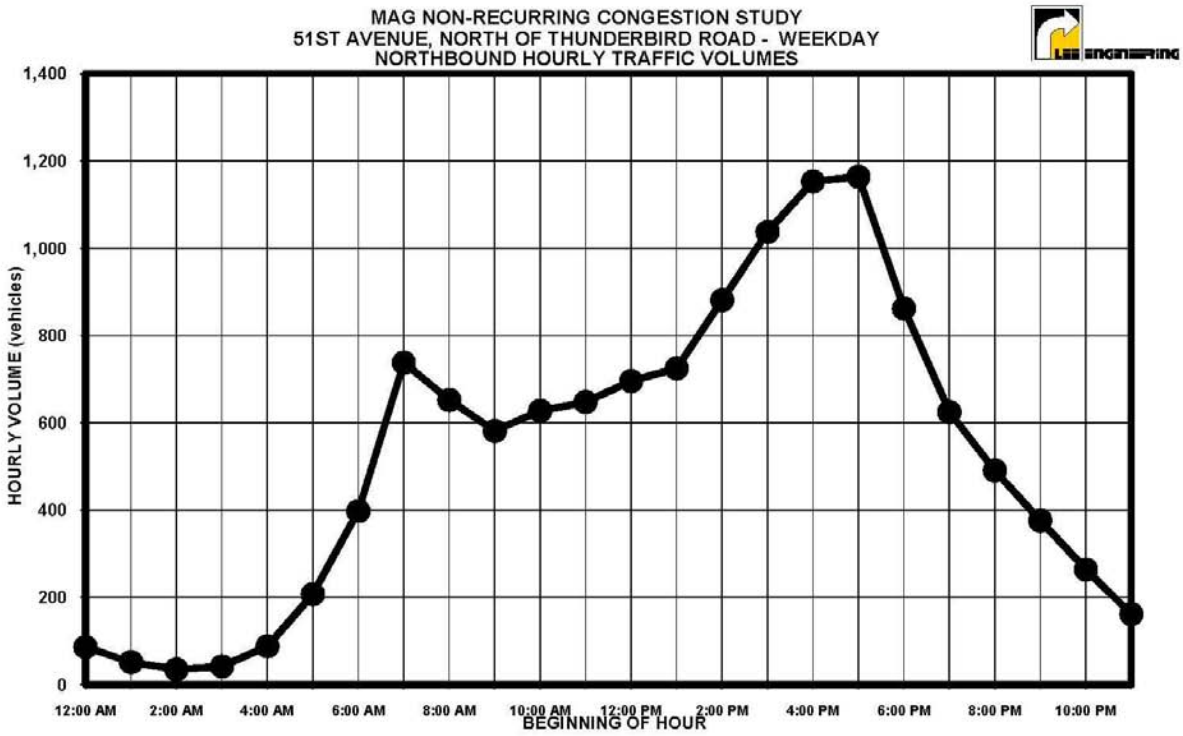
Analysis By: LYK Date: 11/10/2010

Checked By: LYK Date: 11/10/2010

MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, NORTH OF THUNDERBIRD ROAD - WEEKEND
SOUTHBOUND
RANKED HOURLY VOLUMES AS A PERCENTAGE OF DAILY AND PEAK HOURLY VOLUMES

ACTUAL VOLUME	RANKED VOLUME	RANK	PORTION OF DAY	RATIO OF PEAK
139	657	1	7.40%	100.00%
104	629	2	7.09%	95.81%
91	629	3	7.08%	95.73%
62	625	**4**	**7.04%**	**95.13%**
50	592	5	6.66%	90.10%
97	586	6	6.60%	89.26%
160	584	7	6.57%	88.88%
263	578	**8**	**6.51%**	**87.97%**
394	548	9	6.17%	83.40%
484	484	10	5.45%	73.72%
578	473	11	5.33%	72.05%
629	409	12	4.61%	62.30%
657	394	13	4.44%	60.02%
629	303	14	3.41%	46.08%
625	263	15	2.96%	40.06%
586	254	16	2.86%	38.61%
584	173	17	1.94%	26.28%
592	160	18	1.80%	24.30%
548	139	19	1.56%	21.10%
473	104	20	1.17%	15.77%
409	97	21	1.09%	14.70%
303	91	22	1.02%	13.79%
254	62	23	0.69%	9.37%
173	50	24	0.56%	0.56%
8,876	**8,876**		**100.00%**	

Analysis By: LYK Date: 11/10/2010
Checked By: LYK Date: 11/10/2010


MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, NORTH OF THUNDERBIRD ROAD - WEEKDAY
NORTHBOUND HOURLY TRAFFIC VOLUMES
HOURLY VOLUME (vehicles)
1,400
1,200
1,000
800
600
400
200
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
BEGINNING OF HOUR

MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, NORTH OF THUNDERBIRD ROAD - WEEKDAY
NORTHBOUND 15-MINUTE TRAFFIC VOLUMES
15-MINUTE VOLUME (vehicles)
350
300
250
200
150
100
50
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
12:00 AM
BEGINNING OF 15-MINUTE PERIOD

MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, NORTH OF THUNDERBIRD ROAD - WEEKDAY
NORTHBOUND

BEGIN PERIOD	MORNING 15 MINUTES	MORNING 60 MINUTES	EVENING 15 MINUTES	EVENING 60 MINUTES	BEGIN PERIOD
12:00 AM	24.2	**86**	179.4	**695**	**12:00 PM**
12:15 AM	25.2	78	165.4	696	12:15 PM
12:30 AM	16.2	65	174.6	712	12:30 PM
12:45 AM	20.4	62	176	717	12:45 PM
1:00 AM	16.2	**51**	179.8	**725**	**1:00 PM**
1:15 AM	12.2	44	181.2	737	1:15 PM
1:30 AM	13.6	42	180.2	749	1:30 PM
1:45 AM	9.2	36	183.4	806	1:45 PM
2:00 AM	9	**34**	192.2	**881**	**2:00 PM**
2:15 AM	10.4	35	193.4	947	2:15 PM
2:30 AM	7.8	32	237	1,012	2:30 PM
2:45 AM	7.2	38	258.4	1,038	2:45 PM
3:00 AM	9.6	**41**	258.2	**1,037**	**3:00 PM**
3:15 AM	7.2	47	258.8	1,054	3:15 PM
3:30 AM	13.6	58	262.6	1,086	3:30 PM
3:45 AM	11	70	257.6	1,118	3:45 PM
4:00 AM	15.4	**88**	274.6	**1,153**	**4:00 PM**
4:15 AM	18	101	291	1,191	4:15 PM
4:30 AM	25.4	126	295.2	1,204	4:30 PM
4:45 AM	29	167	292	1,190	4:45 PM
5:00 AM	28.2	**207**	313.2	**1,164**	**5:00 PM**
5:15 AM	43	240	303.2	1,087	5:15 PM
5:30 AM	66.6	278	281.8	1,018	5:30 PM
5:45 AM	69.4	328	265.6	950	5:45 PM
6:00 AM	60.8	**397**	236.2	**862**	**6:00 PM**
6:15 AM	81.4	486	234	801	6:15 PM
6:30 AM	116	570	214.6	733	6:30 PM
6:45 AM	139	675	177	669	6:45 PM
7:00 AM	150	**737**	175	**624**	**7:00 PM**
7:15 AM	165.2	765	166	580	7:15 PM
7:30 AM	221.2	775	151	533	7:30 PM
7:45 AM	201	702	132.2	505	7:45 PM
8:00 AM	177.6	**652**	131.2	**491**	**8:00 PM**
8:15 AM	175	605	118.2	461	8:15 PM
8:30 AM	148.2	563	123.2	439	8:30 PM
8:45 AM	151.4	576	118	408	8:45 PM
9:00 AM	130	**581**	101.4	**376**	**9:00 PM**
9:15 AM	133	601	96.2	347	9:15 PM
9:30 AM	161.2	617	92.6	323	9:30 PM
9:45 AM	157	631	85.4	293	9:45 PM
10:00 AM	150	**627**	73	**264**	**10:00 PM**
10:15 AM	148.8	633	72.4	239	10:15 PM
10:30 AM	175.2	636	62.6	210	10:30 PM
10:45 AM	153.2	622	55.6	184	10:45 PM
11:00 AM	155.6	**647**	48.4	**161**	**11:00 PM**
11:15 AM	152.4	671	43.2	-	11:15 PM
11:30 AM	161	684	37.2	-	11:30 PM
11:45 AM	178.4	698	32.6	-	11:45 PM
AM PEAK VOLUME	**221**	**775**	**313**	**1,204**	PM PEAK VOLUME
PHF and TIME	**0.88**	**7:30 AM**	**0.96**	**4:30 PM**	PHF and TIME
DAILY VOLUME	**12582.6**				

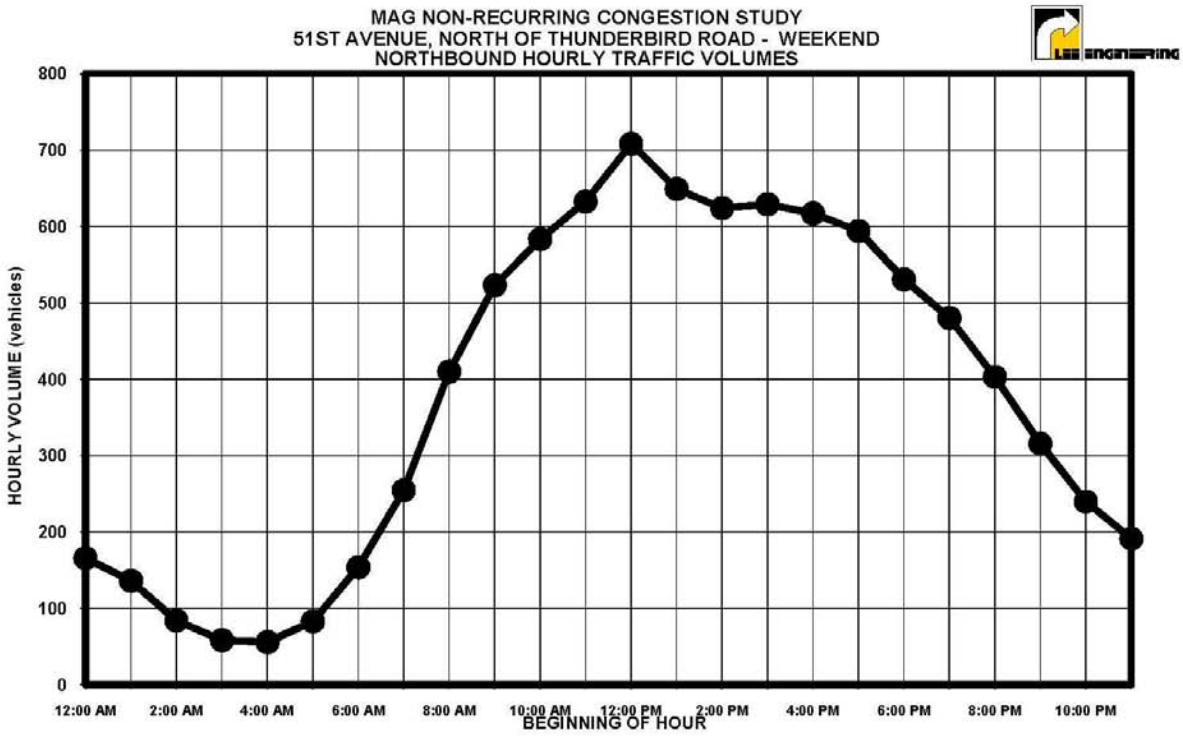
Analysis By: LYK Date: 11/10/2010

Checked By: LYK Date: 11/10/2010

MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, NORTH OF THUNDERBIRD ROAD - WEEKDAY
NORTHBOUND
RANKED HOURLY VOLUMES AS A PERCENTAGE OF DAILY AND PEAK HOURLY VOLUMES

ACTUAL VOLUME	RANKED VOLUME	RANK	PORTION OF DAY	RATIO OF PEAK
86	1,164	1	9.25%	100.00%
51	1,153	2	9.16%	99.05%
34	1,037	3	8.24%	89.12%
41	881	**4**	**7.00%**	**75.70%**
88	862	5	6.85%	74.05%
207	737	6	5.86%	63.36%
397	725	7	5.76%	62.26%
737	695	**8**	**5.53%**	**59.75%**
652	652	9	5.18%	56.04%
581	647	10	5.15%	55.63%
627	627	11	4.98%	53.89%
647	624	12	4.96%	53.63%
695	581	13	4.62%	49.94%
725	491	14	3.90%	42.16%
881	397	15	3.16%	34.13%
1,037	376	16	2.99%	32.27%
1,153	264	17	2.09%	22.65%
1,164	207	18	1.65%	17.80%
862	161	19	1.28%	13.87%
624	88	20	0.70%	7.54%
491	86	21	0.68%	7.39%
376	51	22	0.41%	4.40%
264	41	23	0.33%	3.56%
161	34	24	0.27%	0.27%
12,583	**12,583**		**100.00%**	

Analysis By: LYK Date: 11/10/2010
Checked By: LYK Date: 11/10/2010


MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, NORTH OF THUNDERBIRD ROAD - WEEKEND
NORTHBOUND HOURLY TRAFFIC VOLUMES
HOURLY VOLUME (vehicles)
0
100
200
300
400
500
600
700
800
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
BEGINNING OF HOUR

MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, NORTH OF THUNDERBIRD ROAD - WEEKEND
NORTHBOUND 15-MINUTE TRAFFIC VOLUMES
15-MINUTE VOLUME (vehicles)
0
20
40
60
80
100
120
140
160
180
200
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
12:00 AM
BEGINNING OF 15-MINUTE PERIOD

MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, NORTH OF THUNDERBIRD ROAD - WEEKEND
NORTHBOUND

BEGIN PERIOD	MORNING 15 MINUTES	MORNING 60 MINUTES	EVENING 15 MINUTES	EVENING 60 MINUTES	BEGIN PERIOD
12:00 AM	45.5	**166**	172.5	**708**	**12:00 PM**
12:15 AM	42.5	164	172.5	702	12:15 PM
12:30 AM	40	158	186	709	12:30 PM
12:45 AM	37.5	142	177	673	12:45 PM
1:00 AM	44	**136**	166.5	**649**	**1:00 PM**
1:15 AM	36.5	118	179.5	641	1:15 PM
1:30 AM	23.5	104	149.5	612	1:30 PM
1:45 AM	32	102	153.5	634	1:45 PM
2:00 AM	25.5	**84**	158.5	**624**	**2:00 PM**
2:15 AM	22.5	75	150.5	615	2:15 PM
2:30 AM	22	68	171.5	611	2:30 PM
2:45 AM	13.5	60	143.5	611	2:45 PM
3:00 AM	17	**58**	149	**629**	**3:00 PM**
3:15 AM	15	56	147	630	3:15 PM
3:30 AM	14	58	171.5	630	3:30 PM
3:45 AM	12	59	161.5	618	3:45 PM
4:00 AM	15	**56**	150	**617**	**4:00 PM**
4:15 AM	16.5	54	146.5	621	4:15 PM
4:30 AM	15.5	59	159.5	628	4:30 PM
4:45 AM	8.5	72	161	620	4:45 PM
5:00 AM	13	**83**	154	**594**	**5:00 PM**
5:15 AM	21.5	101	153.5	578	5:15 PM
5:30 AM	28.5	118	151	575	5:30 PM
5:45 AM	19.5	126	135.5	550	5:45 PM
6:00 AM	31.5	**154**	138	**531**	**6:00 PM**
6:15 AM	38	169	150.5	512	6:15 PM
6:30 AM	36.5	180	125.5	487	6:30 PM
6:45 AM	47.5	215	116.5	487	6:45 PM
7:00 AM	47	**255**	119	**480**	**7:00 PM**
7:15 AM	48.5	297	126	472	7:15 PM
7:30 AM	72	351	125	455	7:30 PM
7:45 AM	87	387	110	422	7:45 PM
8:00 AM	89	**410**	110.5	**403**	**8:00 PM**
8:15 AM	102.5	435	109.5	376	8:15 PM
8:30 AM	108	451	92	348	8:30 PM
8:45 AM	110.5	478	91	342	8:45 PM
9:00 AM	114	**523**	83	**316**	**9:00 PM**
9:15 AM	118.5	556	82	298	9:15 PM
9:30 AM	134.5	583	85.5	277	9:30 PM
9:45 AM	156	596	65	253	9:45 PM
10:00 AM	146.5	**584**	65.5	**240**	**10:00 PM**
10:15 AM	145.5	592	60.5	227	10:15 PM
10:30 AM	147.5	606	61.5	213	10:30 PM
10:45 AM	144	617	52	204	10:45 PM
11:00 AM	155	**633**	53	**191**	**11:00 PM**
11:15 AM	159.5	650	46	-	11:15 PM
11:30 AM	158	663	53	-	11:30 PM
11:45 AM	160	691	39	-	11:45 PM
AM PEAK VOLUME	**186**	**691**	**186**	**709**	PM PEAK VOLUME
PHF and TIME	**0.93**	**11:45 AM**	**0.95**	**12:30 PM**	PHF and TIME
DAILY VOLUME	**9118.5**				

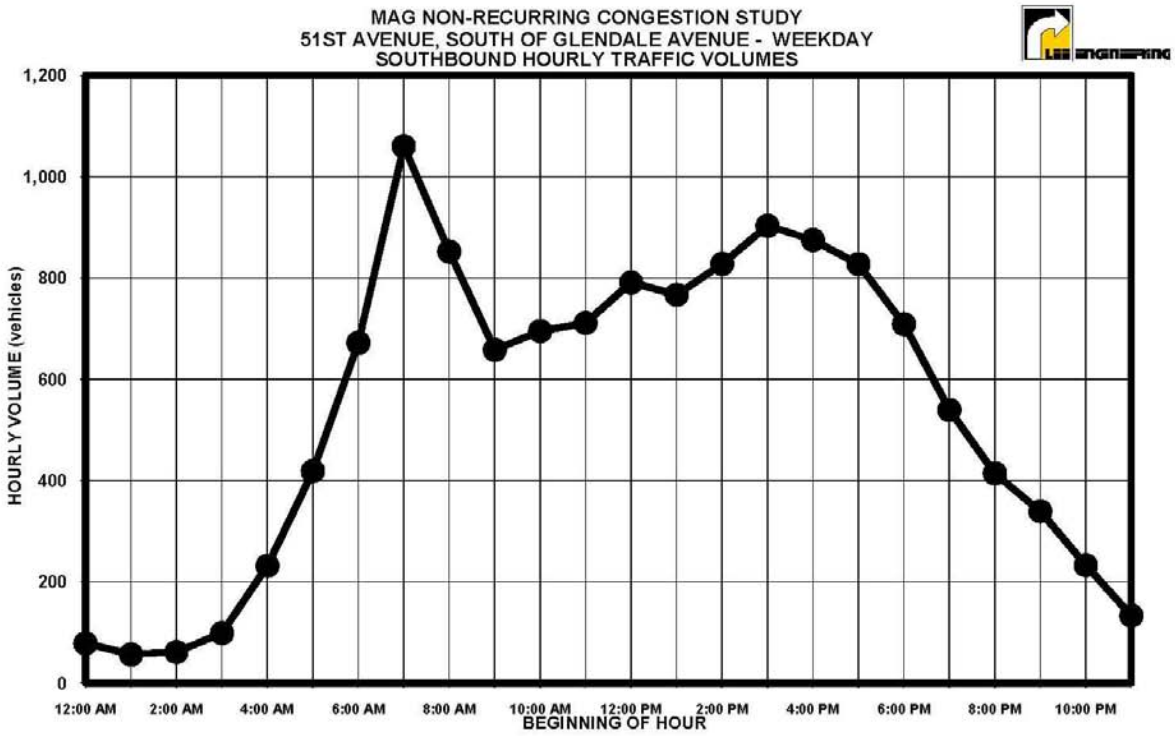
Analysis By: LYK Date: 11/10/2010

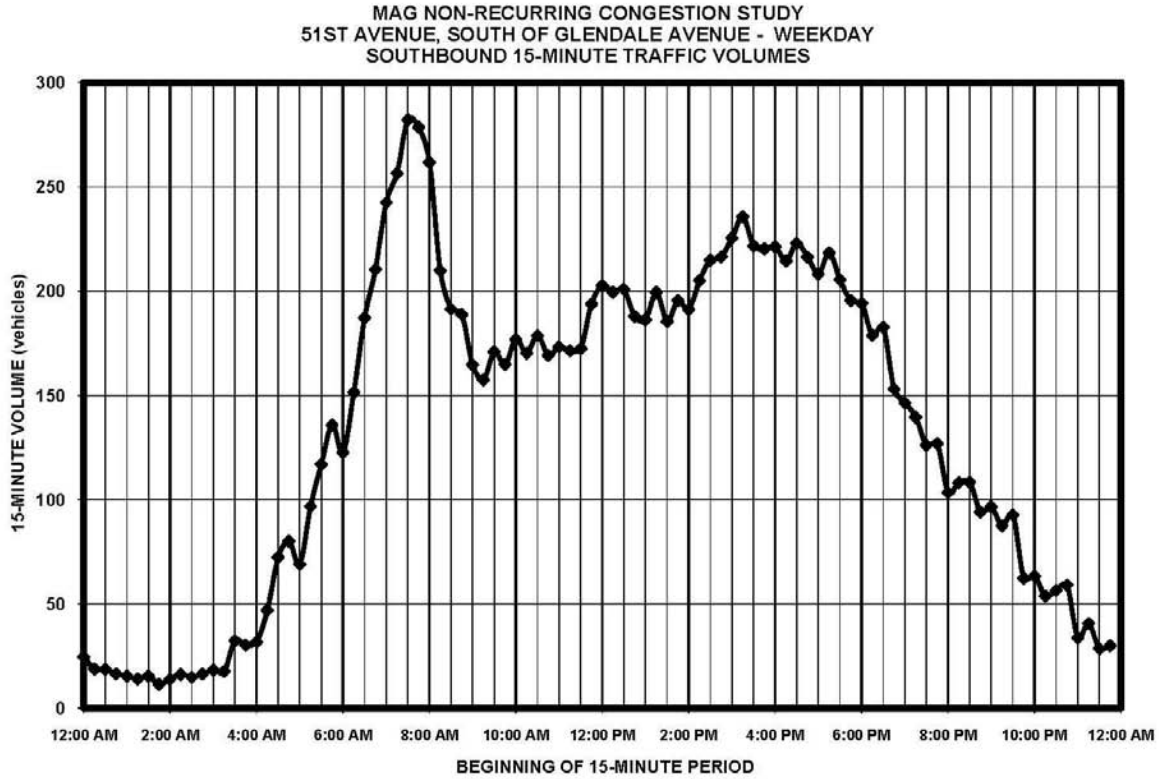
Checked By: LYK Date: 11/10/2010

MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, NORTH OF THUNDERBIRD ROAD - WEEKEND
NORTHBOUND
RANKED HOURLY VOLUMES AS A PERCENTAGE OF DAILY AND PEAK HOURLY VOLUMES

ACTUAL VOLUME	RANKED VOLUME	RANK	PORTION OF DAY	RATIO OF PEAK
166	708	1	7.76%	100.00%
136	649	2	7.12%	91.67%
84	633	3	6.94%	89.34%
58	629	**4**	**6.90%**	**88.84%**
56	624	5	6.84%	88.14%
83	617	6	6.77%	87.15%
154	594	7	6.51%	83.90%
255	584	**8**	**6.40%**	**82.42%**
410	531	9	5.82%	74.93%
523	523	10	5.74%	73.87%
584	480	11	5.26%	67.80%
633	410	12	4.50%	57.91%
708	403	13	4.42%	56.92%
649	316	14	3.46%	44.56%
624	255	15	2.79%	35.95%
629	240	16	2.63%	33.83%
617	191	17	2.09%	26.98%
594	166	18	1.81%	23.38%
531	154	19	1.68%	21.68%
480	136	20	1.49%	19.21%
403	84	21	0.92%	11.79%
316	83	22	0.90%	11.65%
240	58	23	0.64%	8.19%
191	56	24	0.61%	0.61%
9,119	**9,119**		**100.00%**	

Analysis By: LYK Date: 11/10/2010
Checked By: LYK Date: 11/10/2010


MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, SOUTH OF GLENDALE AVENUE - WEEKDAY
SOUTHBOUND HOURLY TRAFFIC VOLUMES
HOURLY VOLUME (vehicles)
1,200
1,000
800
600
400
200
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
BEGINNING OF HOUR


MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, SOUTH OF GLENDALE AVENUE - WEEKDAY
SOUTHBOUND 15-MINUTE TRAFFIC VOLUMES
15-MINUTE VOLUME (vehicles)
300
250
200
150
100
50
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
12:00 AM
BEGINNING OF 15-MINUTE PERIOD

MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, SOUTH OF GLENDALE AVENUE - WEEKDAY
SOUTHBOUND

BEGIN PERIOD	MORNING 15 MINUTES	MORNING 60 MINUTES	EVENING 15 MINUTES	EVENING 60 MINUTES	BEGIN PERIOD
12:00 AM	24.6	**78**	202.6	**791**	**12:00 PM**
12:15 AM	18.8	69	199.4	774	12:15 PM
12:30 AM	18.6	64	200.8	774	12:30 PM
12:45 AM	16.4	61	187.8	759	12:45 PM
1:00 AM	15.4	**56**	186.2	**766**	**1:00 PM**
1:15 AM	14	55	199.4	771	1:15 PM
1:30 AM	15.4	57	185.4	777	1:30 PM
1:45 AM	11.4	56	195.4	806	1:45 PM
2:00 AM	13.8	**61**	191.2	**827**	**2:00 PM**
2:15 AM	16.2	66	205	862	2:15 PM
2:30 AM	14.8	67	214.8	892	2:30 PM
2:45 AM	16.4	85	216.4	899	2:45 PM
3:00 AM	18.2	**98**	225.4	**903**	**3:00 PM**
3:15 AM	17.6	112	235.6	899	3:15 PM
3:30 AM	32.4	141	221.6	877	3:30 PM
3:45 AM	30.2	181	220.2	879	3:45 PM
4:00 AM	31.8	**231**	221.2	**875**	**4:00 PM**
4:15 AM	47	269	214.4	862	4:15 PM
4:30 AM	72.4	318	222.8	865	4:30 PM
4:45 AM	80.2	363	216.2	848	4:45 PM
5:00 AM	69	**419**	208.2	**827**	**5:00 PM**
5:15 AM	96.8	472	218.2	813	5:15 PM
5:30 AM	117	527	205.4	774	5:30 PM
5:45 AM	135.8	597	195.4	751	5:45 PM
6:00 AM	122.6	**672**	194	**708**	**6:00 PM**
6:15 AM	151.4	791	178.8	661	6:15 PM
6:30 AM	187.2	897	182.6	622	6:30 PM
6:45 AM	210.4	992	153	565	6:45 PM
7:00 AM	242.4	**1,060**	146.4	**539**	**7:00 PM**
7:15 AM	256.6	1,079	139.6	496	7:15 PM
7:30 AM	282.2	1,032	126	464	7:30 PM
7:45 AM	278.6	942	126.8	447	7:45 PM
8:00 AM	261.8	**852**	103.4	**414**	**8:00 PM**
8:15 AM	209.8	755	108.2	407	8:15 PM
8:30 AM	191.4	702	108.4	386	8:30 PM
8:45 AM	188.8	682	94	371	8:45 PM
9:00 AM	164.6	**658**	96.6	**339**	**9:00 PM**
9:15 AM	157.4	670	87.4	306	9:15 PM
9:30 AM	170.8	683	92.6	272	9:30 PM
9:45 AM	164.8	690	62.4	236	9:45 PM
10:00 AM	176.8	**695**	63.4	**233**	**10:00 PM**
10:15 AM	170.2	691	53.8	203	10:15 PM
10:30 AM	178.6	692	56.4	190	10:30 PM
10:45 AM	169.2	686	59	162	10:45 PM
11:00 AM	173.2	**711**	33.8	**133**	**11:00 PM**
11:15 AM	171.4	740	40.6	-	11:15 PM
11:30 AM	172.4	768	28.6	-	11:30 PM
11:45 AM	193.8	797	30	-	11:45 PM
AM PEAK VOLUME	**282**	**1,079**	**236**	**903**	PM PEAK VOLUME
PHF and TIME	**0.96**	**7:15 AM**	**0.96**	**3:00 PM**	PHF and TIME
DAILY VOLUME	**12945.4**				

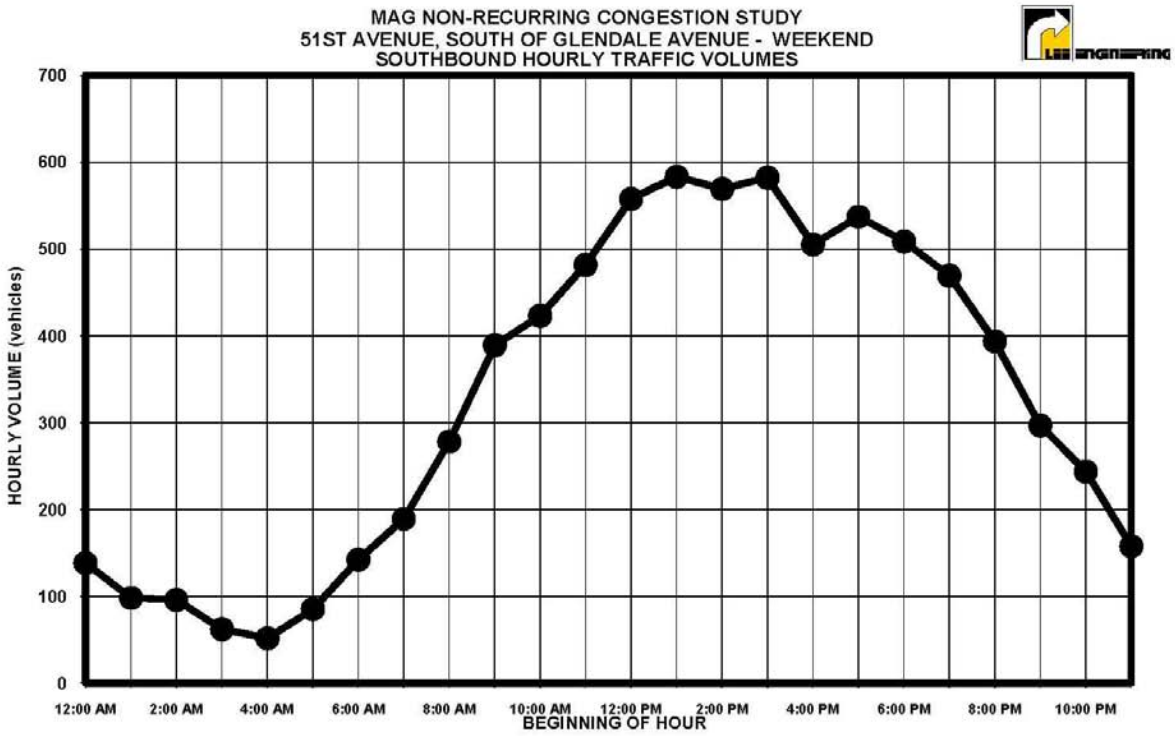
Analysis By: LYK Date: 11/10/2010

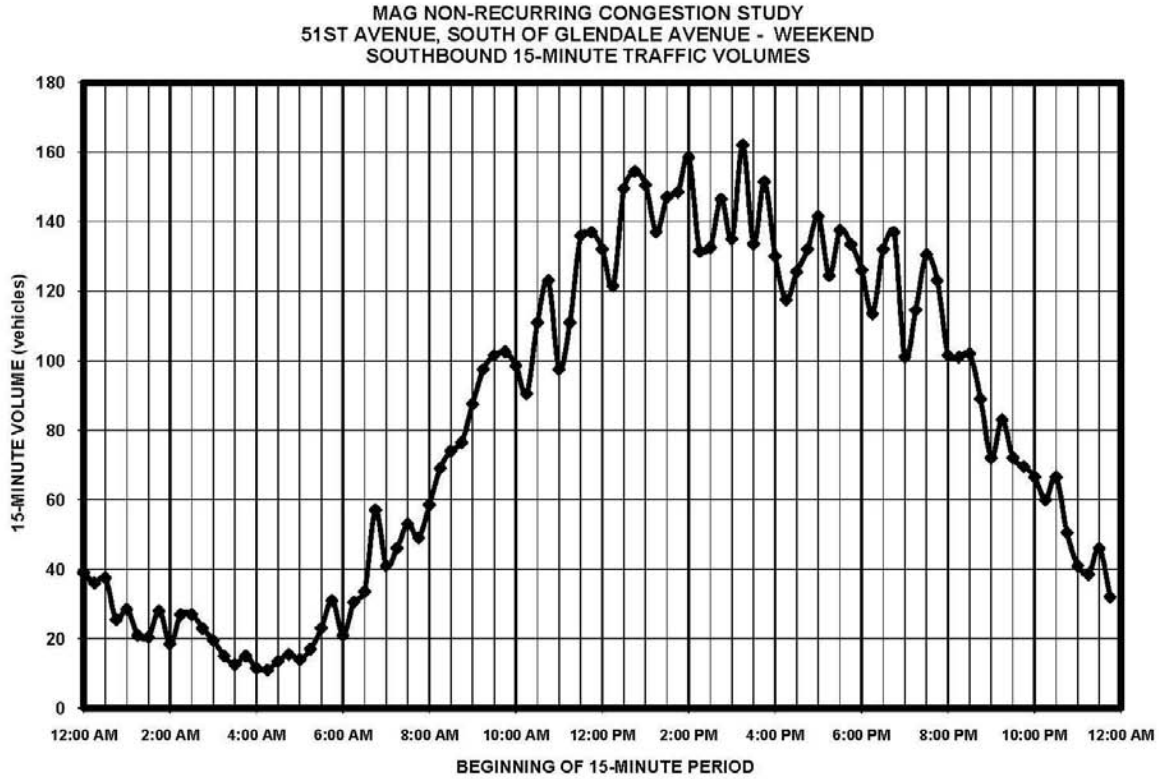
Checked By: LYK Date: 11/10/2010

MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, SOUTH OF GLENDALE AVENUE - WEEKDAY
SOUTHBOUND
RANKED HOURLY VOLUMES AS A PERCENTAGE OF DAILY AND PEAK HOURLY VOLUMES

ACTUAL VOLUME	RANKED VOLUME	RANK	PORTION OF DAY	RATIO OF PEAK
78	1,060	1	8.19%	100.00%
56	903	2	6.97%	85.19%
61	875	3	6.76%	82.53%
98	852	**4**	**6.58%**	**80.37%**
231	827	5	6.39%	78.07%
419	827	6	6.39%	78.05%
672	791	7	6.11%	74.60%
1,060	766	**8**	**5.92%**	**72.32%**
852	711	9	5.49%	67.07%
658	708	10	5.47%	66.84%
695	695	11	5.37%	65.56%
711	672	12	5.19%	63.37%
791	658	13	5.08%	62.05%
766	539	14	4.16%	50.84%
827	419	15	3.23%	39.50%
903	414	16	3.20%	39.06%
875	339	17	2.62%	31.99%
827	233	18	1.80%	21.95%
708	231	19	1.79%	21.83%
539	133	20	1.03%	12.55%
414	98	21	0.76%	9.28%
339	78	22	0.61%	7.40%
233	61	23	0.47%	5.77%
133	56	24	0.43%	0.43%
12,945	**12,945**		**100.00%**	

Analysis By: LYK Date: 11/10/2010
Checked By: LYK Date: 11/10/2010


MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, SOUTH OF GLENDALE AVENUE - WEEKEND
SOUTHBOUND HOURLY TRAFFIC VOLUMES
HOURLY VOLUME (vehicles)
0
100
200
300
400
500
600
700
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
BEGINNING OF HOUR


MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, SOUTH OF GLENDALE AVENUE - WEEKEND
SOUTHBOUND 15-MINUTE TRAFFIC VOLUMES
15-MINUTE VOLUME (vehicles)
0
20
40
60
80
100
120
140
160
180
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
12:00 AM
BEGINNING OF 15-MINUTE PERIOD

MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, SOUTH OF GLENDALE AVENUE - WEEKEND
SOUTHBOUND

BEGIN PERIOD	MORNING 15 MINUTES	MORNING 60 MINUTES	EVENING 15 MINUTES	EVENING 60 MINUTES	BEGIN PERIOD
12:00 AM	39	**138**	132	**558**	**12:00 PM**
12:15 AM	36	128	121.5	576	12:15 PM
12:30 AM	37.5	113	149.5	592	12:30 PM
12:45 AM	25.5	96	154.5	589	12:45 PM
1:00 AM	28.5	**98**	150.5	**583**	**1:00 PM**
1:15 AM	21	88	137	591	1:15 PM
1:30 AM	20.5	94	147	586	1:30 PM
1:45 AM	28	101	148.5	571	1:45 PM
2:00 AM	18.5	**96**	158.5	**569**	**2:00 PM**
2:15 AM	27	97	131.5	546	2:15 PM
2:30 AM	27	85	132.5	576	2:30 PM
2:45 AM	23	70	146.5	577	2:45 PM
3:00 AM	19.5	**62**	135	**582**	**3:00 PM**
3:15 AM	15	54	162	577	3:15 PM
3:30 AM	12.5	50	133.5	533	3:30 PM
3:45 AM	15	51	151.5	525	3:45 PM
4:00 AM	11.5	**52**	130	**505**	**4:00 PM**
4:15 AM	11	54	117.5	517	4:15 PM
4:30 AM	13.5	60	125.5	524	4:30 PM
4:45 AM	15.5	70	132	536	4:45 PM
5:00 AM	14	**85**	141.5	**537**	**5:00 PM**
5:15 AM	17	92	124.5	522	5:15 PM
5:30 AM	23	106	137.5	511	5:30 PM
5:45 AM	31	116	133.5	505	5:45 PM
6:00 AM	21	**142**	126	**509**	**6:00 PM**
6:15 AM	30.5	162	113.5	484	6:15 PM
6:30 AM	33.5	178	132	485	6:30 PM
6:45 AM	57	197	137	483	6:45 PM
7:00 AM	41	**189**	101	**469**	**7:00 PM**
7:15 AM	46	207	114.5	470	7:15 PM
7:30 AM	53	230	130.5	456	7:30 PM
7:45 AM	49	251	123	428	7:45 PM
8:00 AM	58.5	**278**	101.5	**394**	**8:00 PM**
8:15 AM	69	307	101	364	8:15 PM
8:30 AM	74	336	102	346	8:30 PM
8:45 AM	76.5	363	89	316	8:45 PM
9:00 AM	87.5	**389**	72	**297**	**9:00 PM**
9:15 AM	97.5	400	83	291	9:15 PM
9:30 AM	101.5	393	72	268	9:30 PM
9:45 AM	102.5	403	69.5	263	9:45 PM
10:00 AM	98.5	**423**	66.5	**244**	**10:00 PM**
10:15 AM	90.5	422	60	218	10:15 PM
10:30 AM	111	443	66.5	197	10:30 PM
10:45 AM	123	468	50.5	176	10:45 PM
11:00 AM	97.5	**482**	41	**158**	**11:00 PM**
11:15 AM	111	516	38.5	-	11:15 PM
11:30 AM	136	527	46	-	11:30 PM
11:45 AM	137	540	32	-	11:45 PM
AM PEAK VOLUME	**150**	**540**	**155**	**592**	PM PEAK VOLUME
PHF and TIME	**0.90**	**11:45 AM**	**0.96**	**12:30 PM**	PHF and TIME
DAILY VOLUME	**7834.5**				

Analysis By: LYK Date: 11/10/2010

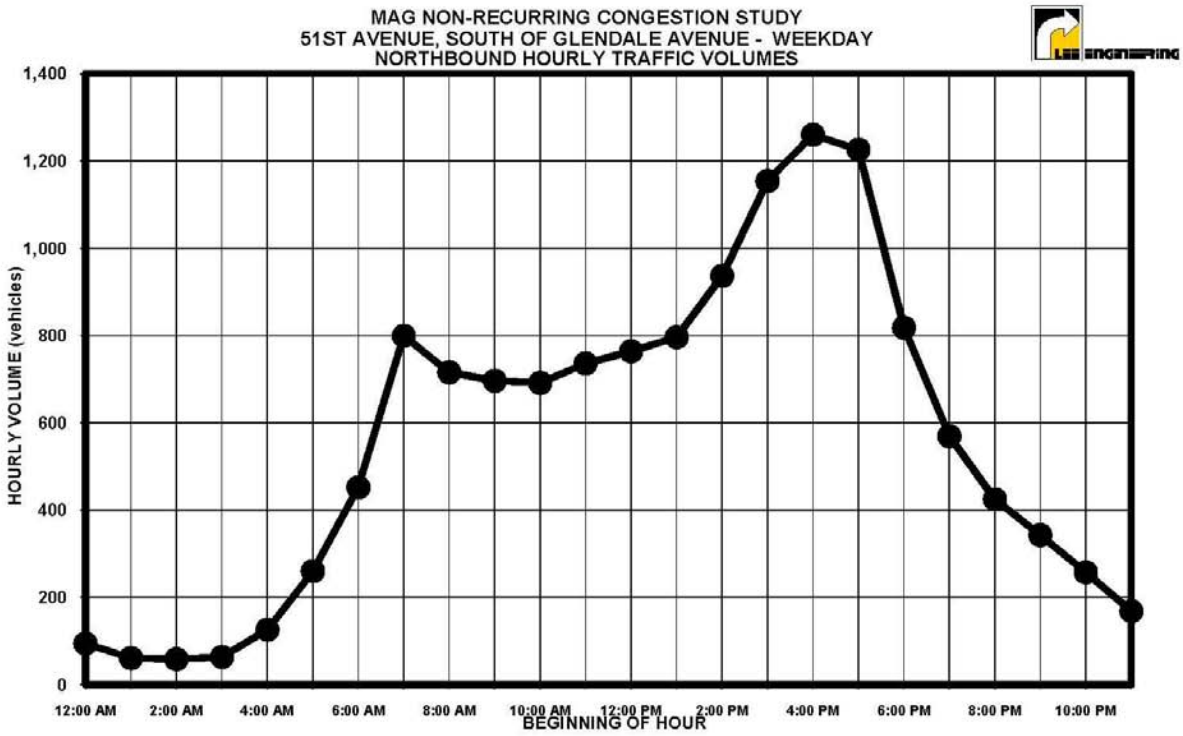
Checked By: LYK Date: 11/10/2010

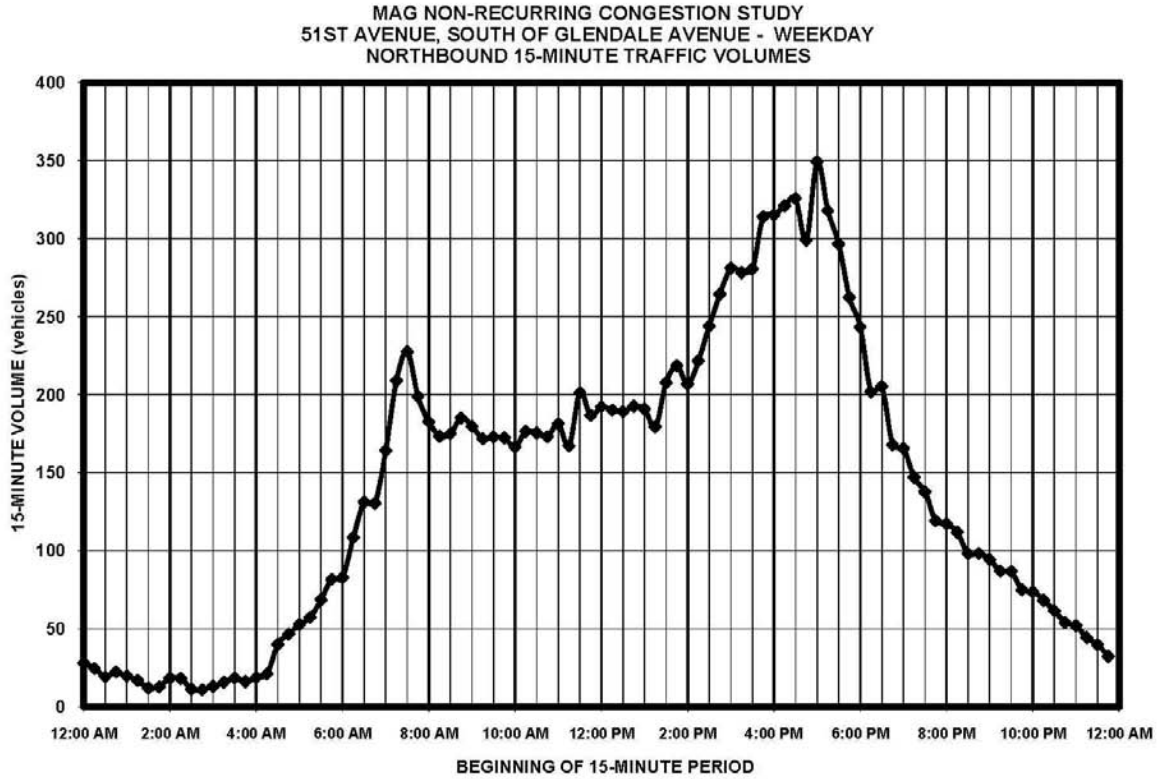
LEE ENGINEERING

MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, SOUTH OF GLENDALE AVENUE - WEEKEND
SOUTHBOUND
RANKED HOURLY VOLUMES AS A PERCENTAGE OF DAILY AND PEAK HOURLY VOLUMES

ACTUAL VOLUME	RANKED VOLUME	RANK	PORTION OF DAY	RATIO OF PEAK
138	583	1	7.44%	100.00%
98	582	2	7.43%	99.83%
96	569	3	7.26%	97.60%
62	558	**4**	**7.12%**	**95.63%**
52	537	5	6.85%	92.11%
85	509	6	6.49%	87.22%
142	505	7	6.45%	86.62%
189	482	**8**	**6.15%**	**82.59%**
278	469	9	5.99%	80.45%
389	423	10	5.40%	72.56%
423	394	11	5.02%	67.50%
482	389	12	4.97%	66.72%
558	297	13	3.78%	50.86%
583	278	14	3.55%	47.68%
569	244	15	3.11%	41.77%
582	189	16	2.41%	32.42%
505	158	17	2.01%	27.02%
537	142	18	1.81%	24.36%
509	138	19	1.76%	23.67%
469	98	20	1.25%	16.81%
394	96	21	1.22%	16.38%
297	85	22	1.08%	14.58%
244	62	23	0.79%	10.63%
158	52	24	0.66%	0.66%
7,835	**7,835**		**100.00%**	

Analysis By: LYK Date: 11/10/2010
Checked By: LYK Date: 11/10/2010


MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, SOUTH OF GLENDALE AVENUE - WEEKDAY
NORTHBOUND HOURLY TRAFFIC VOLUMES
HOURLY VOLUME (vehicles)
1,400
1,200
1,000
800
600
400
200
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
BEGINNING OF HOUR


MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, SOUTH OF GLENDALE AVENUE - WEEKDAY
NORTHBOUND 15-MINUTE TRAFFIC VOLUMES
15-MINUTE VOLUME (vehicles)
400
350
300
250
200
150
100
50
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
12:00 AM
BEGINNING OF 15-MINUTE PERIOD

MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, SOUTH OF GLENDALE AVENUE - WEEKDAY
NORTHBOUND

BEGIN PERIOD	MORNING 15 MINUTES	MORNING 60 MINUTES	EVENING 15 MINUTES	EVENING 60 MINUTES	BEGIN PERIOD
12:00 AM	28	**94**	192.2	**764**	**12:00 PM**
12:15 AM	24.4	85	190	762	12:15 PM
12:30 AM	19	78	189	752	12:30 PM
12:45 AM	22.2	70	192.6	770	12:45 PM
1:00 AM	19.6	**61**	190.8	**796**	**1:00 PM**
1:15 AM	16.8	59	179.2	812	1:15 PM
1:30 AM	11.8	61	207.6	854	1:30 PM
1:45 AM	12.6	60	218.4	891	1:45 PM
2:00 AM	18.2	**58**	206.6	**937**	**2:00 PM**
2:15 AM	18	53	221.6	1,011	2:15 PM
2:30 AM	11.2	51	244	1,068	2:30 PM
2:45 AM	10.8	58	264.4	1,104	2:45 PM
3:00 AM	13	**63**	281	**1,154**	**3:00 PM**
3:15 AM	15.6	69	278.2	1,188	3:15 PM
3:30 AM	18.4	74	280.6	1,231	3:30 PM
3:45 AM	16	95	314	1,276	3:45 PM
4:00 AM	18.6	**126**	315	**1,260**	**4:00 PM**
4:15 AM	21	160	321	1,295	4:15 PM
4:30 AM	39.8	196	325.6	1,291	4:30 PM
4:45 AM	46.4	225	298.8	1,262	4:45 PM
5:00 AM	52.6	**260**	349.2	**1,226**	**5:00 PM**
5:15 AM	57.2	290	317.8	1,120	5:15 PM
5:30 AM	68.4	341	296.4	1,003	5:30 PM
5:45 AM	81.6	403	262.2	912	5:45 PM
6:00 AM	82.6	**452**	243.2	**818**	**6:00 PM**
6:15 AM	108.2	533	201.6	740	6:15 PM
6:30 AM	131	634	205.2	685	6:30 PM
6:45 AM	130.2	731	167.8	618	6:45 PM
7:00 AM	164	**799**	165.4	**569**	**7:00 PM**
7:15 AM	209	818	147	521	7:15 PM
7:30 AM	227.6	782	137.6	485	7:30 PM
7:45 AM	198.6	729	119	446	7:45 PM
8:00 AM	182.4	**716**	117	**425**	**8:00 PM**
8:15 AM	173.4	713	111.6	402	8:15 PM
8:30 AM	174.8	711	98	377	8:30 PM
8:45 AM	185	709	98.2	366	8:45 PM
9:00 AM	179.6	**696**	94.2	**342**	**9:00 PM**
9:15 AM	171.6	683	86.8	322	9:15 PM
9:30 AM	172.8	688	86.6	303	9:30 PM
9:45 AM	172.2	690	74.8	278	9:45 PM
10:00 AM	166.4	**691**	73.6	**257**	**10:00 PM**
10:15 AM	176.4	706	68.2	235	10:15 PM
10:30 AM	175.2	696	61.4	211	10:30 PM
10:45 AM	173	722	53.8	189	10:45 PM
11:00 AM	181.2	**736**	51.8	**168**	**11:00 PM**
11:15 AM	167	747	44.2	-	11:15 PM
11:30 AM	201.2	770	39.6	-	11:30 PM
11:45 AM	186.6	758	32.2	-	11:45 PM
AM PEAK VOLUME	**228**	**818**	**349**	**1,295**	PM PEAK VOLUME
PHF and TIME	**0.90**	**7:15 AM**	**0.93**	**4:15 PM**	PHF and TIME
DAILY VOLUME	**13466.2**				

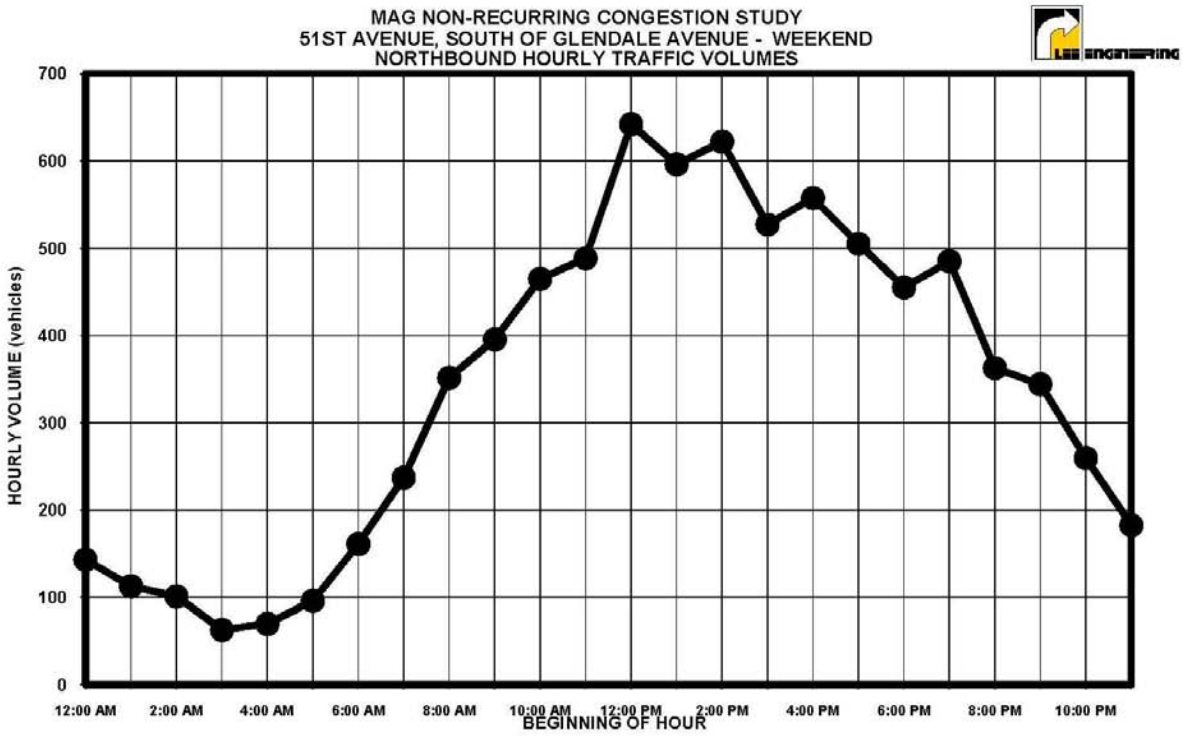
Analysis By: LYK Date: 11/10/2010

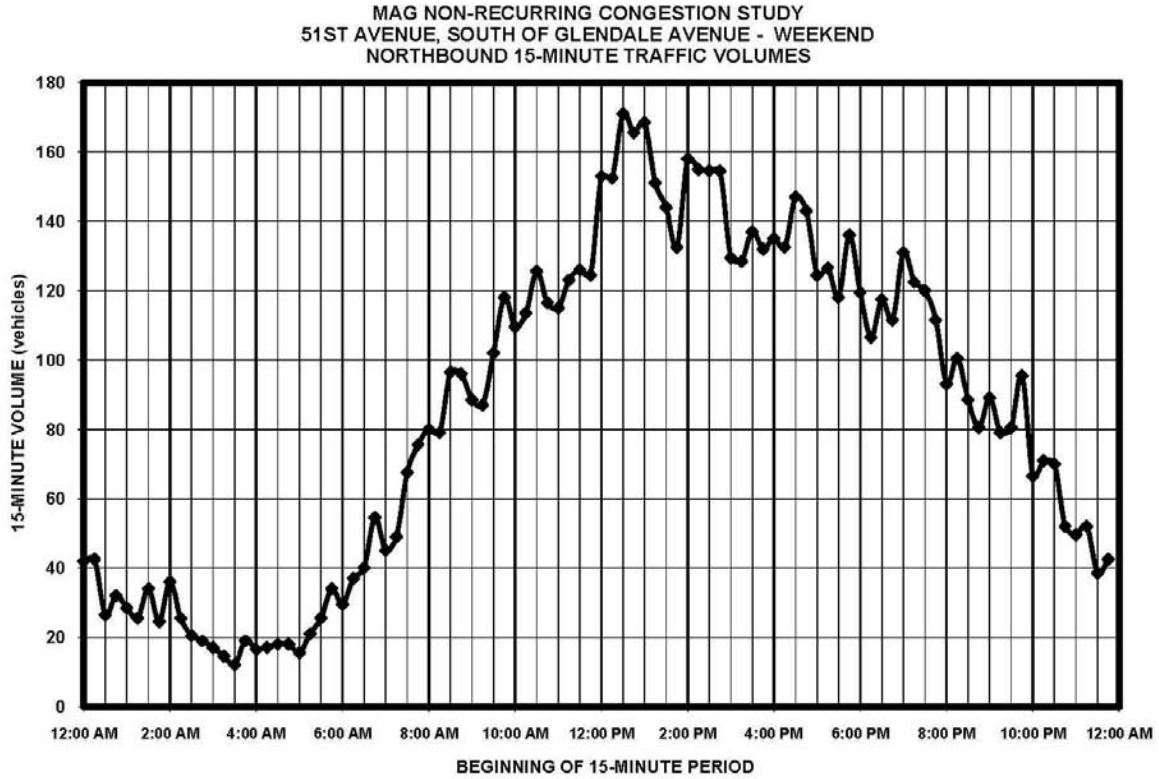
Checked By: LYK Date: 11/10/2010

MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, SOUTH OF GLENDALE AVENUE - WEEKDAY
NORTHBOUND
RANKED HOURLY VOLUMES AS A PERCENTAGE OF DAILY AND PEAK HOURLY VOLUMES

ACTUAL VOLUME	RANKED VOLUME	RANK	PORTION OF DAY	RATIO OF PEAK
94	1,260	1	9.36%	100.00%
61	1,226	2	9.10%	97.24%
58	1,154	3	8.57%	91.54%
63	937	**4**	**6.96%**	**74.31%**
126	818	5	6.07%	64.88%
260	799	6	5.93%	63.41%
452	796	7	5.91%	63.15%
799	764	**8**	**5.67%**	**60.60%**
716	736	9	5.47%	58.39%
696	716	10	5.31%	56.78%
691	696	11	5.17%	55.24%
736	691	12	5.13%	54.82%
764	569	13	4.23%	45.14%
796	452	14	3.36%	35.86%
937	425	15	3.15%	33.70%
1,154	342	16	2.54%	27.17%
1,260	260	17	1.93%	20.61%
1,226	257	18	1.91%	20.39%
818	168	19	1.25%	13.31%
569	126	20	0.93%	9.98%
425	94	21	0.70%	7.43%
342	63	22	0.47%	5.00%
257	61	23	0.45%	4.82%
168	58	24	0.43%	0.43%
13,466	**13,466**		**100.00%**	

Analysis By: LYK Date: 11/10/2010
Checked By: LYK Date: 11/10/2010


MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, SOUTH OF GLENDALE AVENUE - WEEKEND
NORTHBOUND HOURLY TRAFFIC VOLUMES
HOURLY VOLUME (vehicles)
0
100
200
300
400
500
600
700
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
BEGINNING OF HOUR


MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, SOUTH OF GLENDALE AVENUE - WEEKEND
NORTHBOUND 15-MINUTE TRAFFIC VOLUMES
15-MINUTE VOLUME (vehicles)
0
20
40
60
80
100
120
140
160
180
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
12:00 AM
BEGINNING OF 15-MINUTE PERIOD

MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, SOUTH OF GLENDALE AVENUE - WEEKEND
NORTHBOUND

BEGIN PERIOD	MORNING 15 MINUTES	MORNING 60 MINUTES	EVENING 15 MINUTES	EVENING 60 MINUTES	BEGIN PERIOD
12:00 AM	42	**143**	153	**642**	**12:00 PM**
12:15 AM	42.5	130	152.5	658	12:15 PM
12:30 AM	26.5	113	171	656	12:30 PM
12:45 AM	32	120	165.5	629	12:45 PM
1:00 AM	28.5	**113**	168.5	**596**	**1:00 PM**
1:15 AM	25.5	120	151	586	1:15 PM
1:30 AM	34	120	144	590	1:30 PM
1:45 AM	24.5	107	132.5	600	1:45 PM
2:00 AM	36	**101**	158	**622**	**2:00 PM**
2:15 AM	25.5	82	155	594	2:15 PM
2:30 AM	20.5	71	154.5	567	2:30 PM
2:45 AM	19	63	154.5	550	2:45 PM
3:00 AM	17	**63**	129.5	**527**	**3:00 PM**
3:15 AM	14.5	62	128.5	533	3:15 PM
3:30 AM	12	65	137	537	3:30 PM
3:45 AM	19	71	132	547	3:45 PM
4:00 AM	16.5	**70**	135	**558**	**4:00 PM**
4:15 AM	17	69	132.5	547	4:15 PM
4:30 AM	18	73	147	541	4:30 PM
4:45 AM	18	80	143	512	4:45 PM
5:00 AM	15.5	**96**	124.5	**505**	**5:00 PM**
5:15 AM	21	110	126.5	500	5:15 PM
5:30 AM	25.5	126	118	480	5:30 PM
5:45 AM	34	141	136	480	5:45 PM
6:00 AM	29.5	**161**	119.5	**455**	**6:00 PM**
6:15 AM	37	177	106.5	467	6:15 PM
6:30 AM	40	189	117.5	483	6:30 PM
6:45 AM	54.5	216	111.5	485	6:45 PM
7:00 AM	45	**237**	131	**485**	**7:00 PM**
7:15 AM	49	272	122.5	447	7:15 PM
7:30 AM	67.5	302	120	425	7:30 PM
7:45 AM	75.5	331	111.5	394	7:45 PM
8:00 AM	80	**352**	93	**363**	**8:00 PM**
8:15 AM	79	360	100.5	359	8:15 PM
8:30 AM	96.5	368	88.5	337	8:30 PM
8:45 AM	96	374	80.5	329	8:45 PM
9:00 AM	88.5	**396**	89	**344**	**9:00 PM**
9:15 AM	87	417	79	322	9:15 PM
9:30 AM	102	443	80.5	314	9:30 PM
9:45 AM	118	467	95.5	303	9:45 PM
10:00 AM	109.5	**465**	66.5	**260**	**10:00 PM**
10:15 AM	113.5	471	71	243	10:15 PM
10:30 AM	125.5	480	70	224	10:30 PM
10:45 AM	116.5	481	52	192	10:45 PM
11:00 AM	115	**489**	49.5	**183**	**11:00 PM**
11:15 AM	123	527	52	-	11:15 PM
11:30 AM	126	556	38.5	-	11:30 PM
11:45 AM	124.5	601	42.5	-	11:45 PM
AM PEAK VOLUME	**171**	**601**	**171**	**658**	PM PEAK VOLUME
PHF and TIME	**0.88**	**11:45 AM**	**0.96**	**12:15 PM**	PHF and TIME
DAILY VOLUME	**8221**				

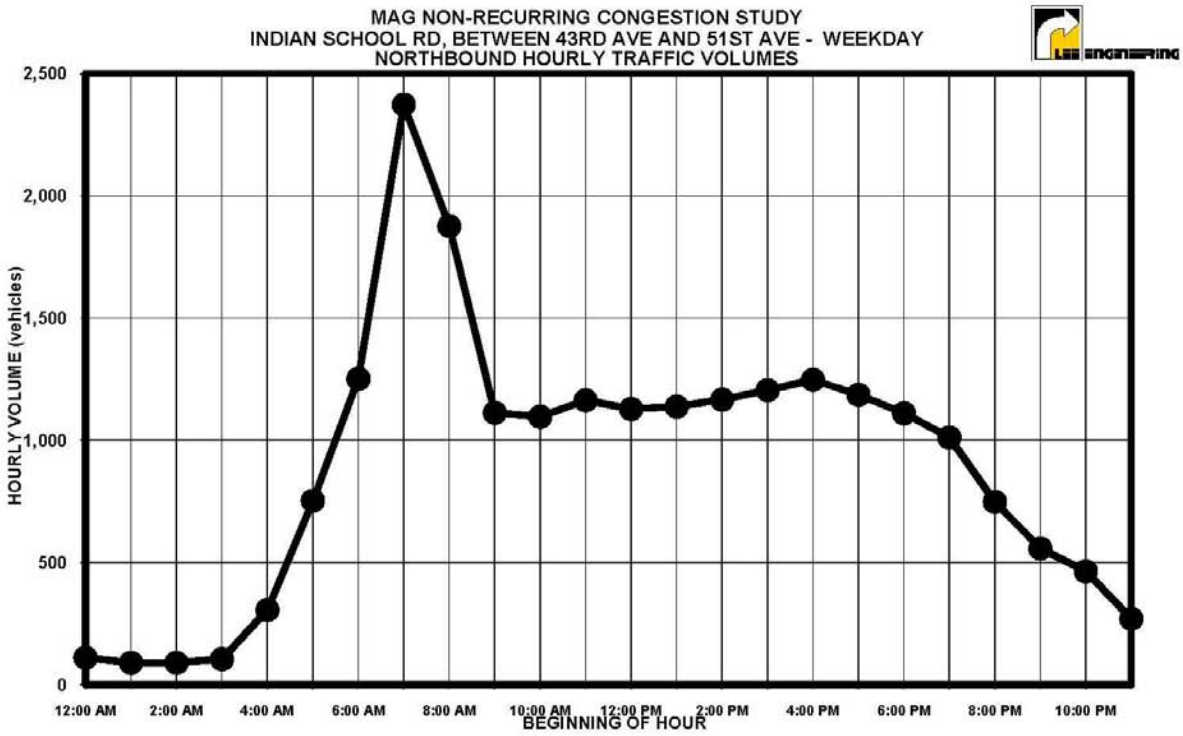
Analysis By: LYK Date: 11/10/2010

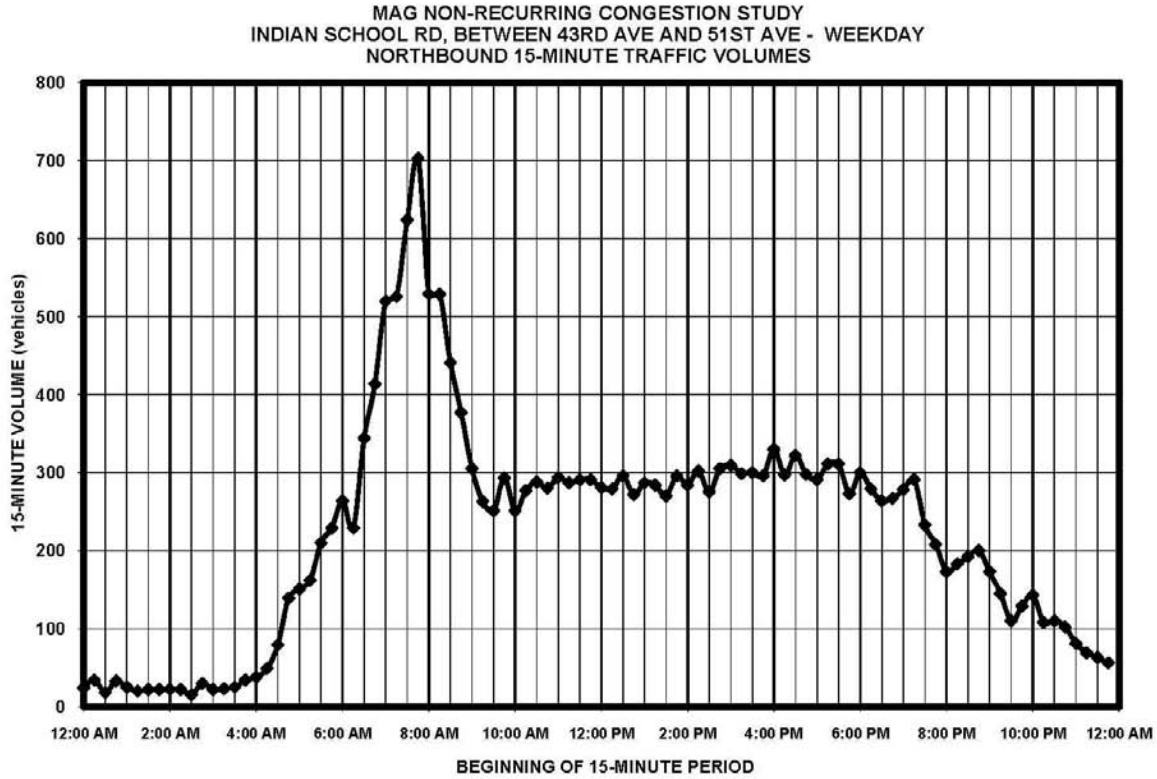
Checked By: LYK Date: 11/10/2010

MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, SOUTH OF GLENDALE AVENUE - WEEKEND
NORTHBOUND
RANKED HOURLY VOLUMES AS A PERCENTAGE OF DAILY AND PEAK HOURLY VOLUMES

ACTUAL VOLUME	RANKED VOLUME	RANK	PORTION OF DAY	RATIO OF PEAK
143	642	1	7.81%	100.00%
113	622	2	7.57%	96.88%
101	596	3	7.25%	92.83%
63	558	**4**	**6.78%**	**86.84%**
70	527	5	6.41%	82.09%
96	505	6	6.14%	78.66%
161	489	7	5.94%	76.09%
237	485	**8**	**5.90%**	**75.55%**
352	465	9	5.66%	72.43%
396	455	10	5.53%	70.87%
465	396	11	4.81%	61.60%
489	363	12	4.41%	56.46%
642	352	13	4.28%	54.75%
596	344	14	4.18%	53.58%
622	260	15	3.16%	40.42%
527	237	16	2.88%	36.92%
558	183	17	2.22%	28.43%
505	161	18	1.96%	25.08%
455	143	19	1.74%	22.27%
485	113	20	1.37%	17.52%
363	101	21	1.23%	15.73%
344	96	22	1.17%	14.95%
260	70	23	0.85%	10.83%
183	63	24	0.76%	0.76%
8,221	**8,221**		**100.00%**	

Analysis By: LYK Date: 11/10/2010
Checked By: LYK Date: 11/10/2010


MAG NON-RECURRING CONGESTION STUDY
INDIAN SCHOOL RD, BETWEEN 43RD AVE AND 51ST AVE - WEEKDAY
NORTHBOUND HOURLY TRAFFIC VOLUMES
HOURLY VOLUME (vehicles)
2,500
2,000
1,500
1,000
500
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
BEGINNING OF HOUR


MAG NON-RECURRING CONGESTION STUDY
INDIAN SCHOOL RD, BETWEEN 43RD AVE AND 51ST AVE - WEEKDAY
NORTHBOUND 15-MINUTE TRAFFIC VOLUMES
15-MINUTE VOLUME (vehicles)
800
700
600
500
400
300
200
100
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
12:00 AM
BEGINNING OF 15-MINUTE PERIOD

MAG NON-RECURRING CONGESTION STUDY
INDIAN SCHOOL RD, BETWEEN 43RD AVE AND 51ST AVE - WEEKDAY
EASTBOUND

BEGIN PERIOD	MORNING 15 MINUTES	MORNING 60 MINUTES	EVENING 15 MINUTES	EVENING 60 MINUTES	BEGIN PERIOD
12:00 AM	24	**109**	281	**1,128**	**12:00 PM**
12:15 AM	34	110	279	1,134	12:15 PM
12:30 AM	18	96	296	1,139	12:30 PM
12:45 AM	33	100	272	1,113	12:45 PM
1:00 AM	25	**89**	287	**1,137**	**1:00 PM**
1:15 AM	20	86	284	1,134	1:15 PM
1:30 AM	22	88	270	1,152	1:30 PM
1:45 AM	22	81	296	1,157	1:45 PM
2:00 AM	22	**89**	284	**1,166**	**2:00 PM**
2:15 AM	22	89	302	1,191	2:15 PM
2:30 AM	15	90	275	1,188	2:30 PM
2:45 AM	30	100	305	1,213	2:45 PM
3:00 AM	22	**104**	309	**1,204**	**3:00 PM**
3:15 AM	23	120	299	1,225	3:15 PM
3:30 AM	25	146	300	1,223	3:30 PM
3:45 AM	34	200	296	1,245	3:45 PM
4:00 AM	38	**305**	330	**1,247**	**4:00 PM**
4:15 AM	49	418	297	1,208	4:15 PM
4:30 AM	79	531	322	1,222	4:30 PM
4:45 AM	139	662	298	1,211	4:45 PM
5:00 AM	151	**752**	291	**1,186**	**5:00 PM**
5:15 AM	162	865	311	1,195	5:15 PM
5:30 AM	210	932	311	1,163	5:30 PM
5:45 AM	229	1,066	273	1,116	5:45 PM
6:00 AM	264	**1,251**	300	**1,110**	**6:00 PM**
6:15 AM	229	1,507	279	1,088	6:15 PM
6:30 AM	344	1,804	264	1,100	6:30 PM
6:45 AM	414	2,084	267	1,069	6:45 PM
7:00 AM	520	**2,373**	278	**1,010**	**7:00 PM**
7:15 AM	526	2,382	291	905	7:15 PM
7:30 AM	624	2,385	233	797	7:30 PM
7:45 AM	703	2,202	208	756	7:45 PM
8:00 AM	529	**1,876**	173	**748**	**8:00 PM**
8:15 AM	529	1,652	183	748	8:15 PM
8:30 AM	441	1,386	192	710	8:30 PM
8:45 AM	377	1,196	200	628	8:45 PM
9:00 AM	305	**1,112**	173	**557**	**9:00 PM**
9:15 AM	263	1,058	145	527	9:15 PM
9:30 AM	251	1,072	110	490	9:30 PM
9:45 AM	293	1,109	129	490	9:45 PM
10:00 AM	251	**1,096**	143	**463**	**10:00 PM**
10:15 AM	277	1,139	108	401	10:15 PM
10:30 AM	288	1,149	110	362	10:30 PM
10:45 AM	280	1,152	102	315	10:45 PM
11:00 AM	294	**1,163**	81	**269**	**11:00 PM**
11:15 AM	287	1,150	69	-	11:15 PM
11:30 AM	291	1,142	63	-	11:30 PM
11:45 AM	291	1,147	56	-	11:45 PM
AM PEAK VOLUME	**703**	**2,385**	**330**	**1,247**	PM PEAK VOLUME
PHF and TIME	**0.85**	**7:30 AM**	**0.94**	**4:00 PM**	PHF and TIME
DAILY VOLUME	**21544**				

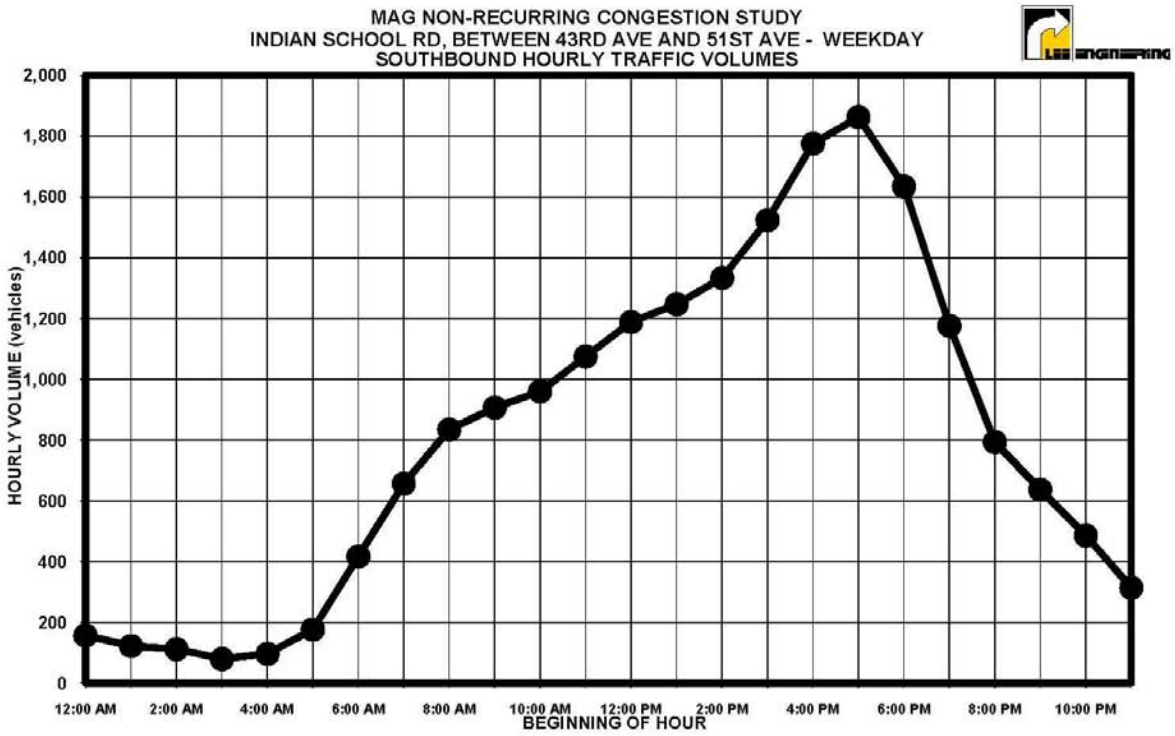
Analysis By: RCS Date: 11/12/2010

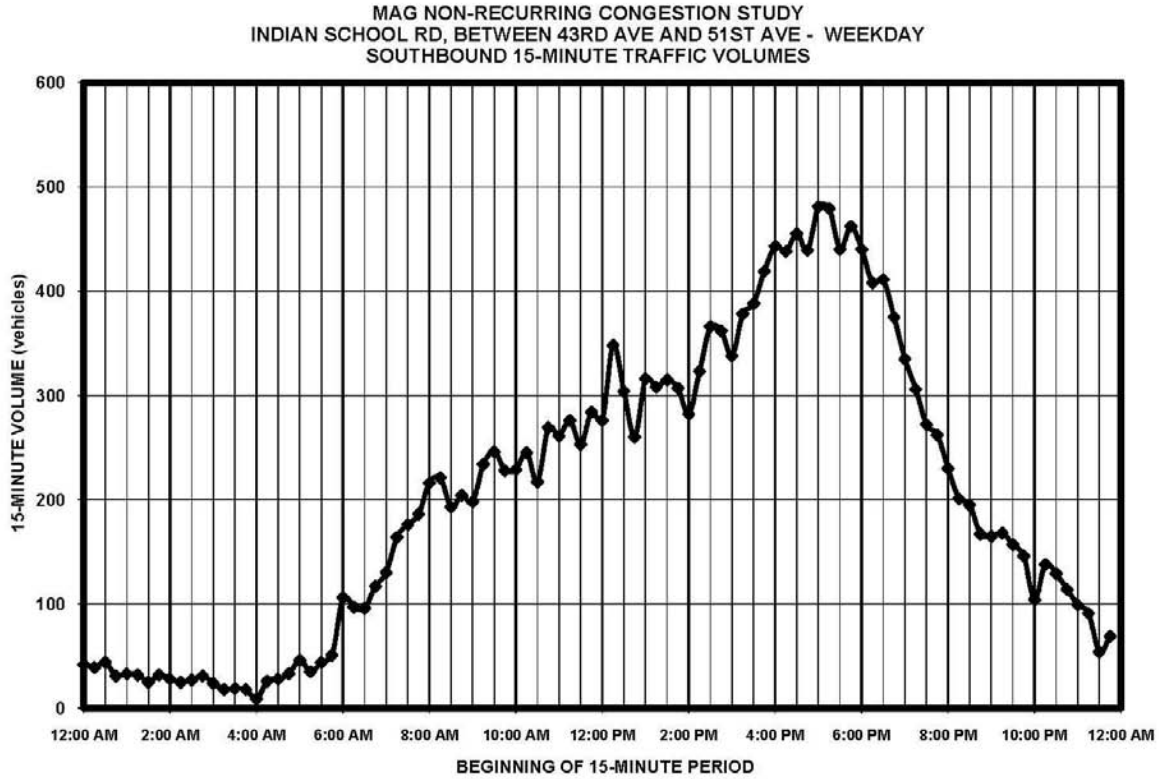
Checked By: LYK Date: 11/19/2010

MAG NON-RECURRING CONGESTION STUDY
INDIAN SCHOOL RD, BETWEEN 43RD AVE AND 51ST AVE - WEEKDAY
NORTHBOUND
RANKED HOURLY VOLUMES AS A PERCENTAGE OF DAILY AND PEAK HOURLY VOLUMES

ACTUAL VOLUME	RANKED VOLUME	RANK	PORTION OF DAY	RATIO OF PEAK
109	2,373	1	11.01%	100.00%
89	1,876	2	8.71%	79.06%
89	1,251	3	5.81%	52.72%
104	1,247	**4**	**5.79%**	**52.55%**
305	1,204	5	5.59%	50.74%
752	1,186	6	5.51%	49.98%
1,251	1,166	7	5.41%	49.14%
2,373	1,163	**8**	**5.40%**	**49.01%**
1,876	1,137	9	5.28%	47.91%
1,112	1,128	10	5.24%	47.53%
1,096	1,112	11	5.16%	46.86%
1,163	1,110	12	5.15%	46.78%
1,128	1,096	13	5.09%	46.19%
1,137	1,010	14	4.69%	42.56%
1,166	752	15	3.49%	31.69%
1,204	748	16	3.47%	31.52%
1,247	557	17	2.59%	23.47%
1,186	463	18	2.15%	19.51%
1,110	305	19	1.42%	12.85%
1,010	269	20	1.25%	11.34%
748	109	21	0.51%	4.59%
557	104	22	0.48%	4.38%
463	89	23	0.41%	3.75%
269	89	24	0.41%	0.41%
21,544	**21,544**		**100.00%**	

Analysis By: RCS Date: 11/12/2010
Checked By: LYK Date: 11/19/2010


MAG NON-RECURRING CONGESTION STUDY
INDIAN SCHOOL RD, BETWEEN 43RD AVE AND 51ST AVE - WEEKDAY
SOUTHBOUND HOURLY TRAFFIC VOLUMES
HOURLY VOLUME (vehicles)
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
BEGINNING OF HOUR


MAG NON-RECURRING CONGESTION STUDY
INDIAN SCHOOL RD, BETWEEN 43RD AVE AND 51ST AVE - WEEKDAY
SOUTHBOUND 15-MINUTE TRAFFIC VOLUMES
15-MINUTE VOLUME (vehicles)
600
500
400
300
200
100
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
12:00 AM
BEGINNING OF 15-MINUTE PERIOD

MAG NON-RECURRING CONGESTION STUDY
INDIAN SCHOOL RD, BETWEEN 43RD AVE AND 51ST AVE - WEEKDAY
WESTBOUND

BEGIN PERIOD	MORNING 15 MINUTES	MORNING 60 MINUTES	EVENING 15 MINUTES	EVENING 60 MINUTES	BEGIN PERIOD
12:00 AM	42	**156**	276	**1,188**	**12:00 PM**
12:15 AM	39	147	348	1,228	12:15 PM
12:30 AM	44	140	304	1,188	12:30 PM
12:45 AM	31	121	260	1,199	12:45 PM
1:00 AM	33	**122**	316	**1,246**	**1:00 PM**
1:15 AM	32	117	308	1,212	1:15 PM
1:30 AM	25	110	315	1,227	1:30 PM
1:45 AM	32	112	307	1,278	1:45 PM
2:00 AM	28	**111**	282	**1,333**	**2:00 PM**
2:15 AM	25	107	323	1,389	2:15 PM
2:30 AM	27	100	366	1,444	2:30 PM
2:45 AM	31	92	362	1,466	2:45 PM
3:00 AM	24	**79**	338	**1,523**	**3:00 PM**
3:15 AM	18	64	378	1,628	3:15 PM
3:30 AM	19	72	388	1,688	3:30 PM
3:45 AM	18	81	419	1,755	3:45 PM
4:00 AM	9	**96**	443	**1,775**	**4:00 PM**
4:15 AM	26	133	438	1,813	4:15 PM
4:30 AM	28	142	455	1,854	4:30 PM
4:45 AM	33	158	439	1,839	4:45 PM
5:00 AM	46	**176**	481	**1,862**	**5:00 PM**
5:15 AM	35	236	479	1,821	5:15 PM
5:30 AM	44	298	440	1,750	5:30 PM
5:45 AM	51	350	462	1,721	5:45 PM
6:00 AM	106	**416**	440	**1,634**	**6:00 PM**
6:15 AM	97	440	408	1,529	6:15 PM
6:30 AM	96	507	411	1,427	6:30 PM
6:45 AM	117	587	375	1,288	6:45 PM
7:00 AM	130	**656**	335	**1,175**	**7:00 PM**
7:15 AM	164	742	306	1,070	7:15 PM
7:30 AM	176	799	272	965	7:30 PM
7:45 AM	186	816	262	888	7:45 PM
8:00 AM	216	**834**	230	**793**	**8:00 PM**
8:15 AM	221	816	201	728	8:15 PM
8:30 AM	193	829	195	695	8:30 PM
8:45 AM	204	882	167	657	8:45 PM
9:00 AM	198	**906**	165	**636**	**9:00 PM**
9:15 AM	234	937	168	575	9:15 PM
9:30 AM	246	948	157	545	9:30 PM
9:45 AM	228	919	146	517	9:45 PM
10:00 AM	229	**960**	104	**485**	**10:00 PM**
10:15 AM	245	992	138	480	10:15 PM
10:30 AM	217	1,023	129	433	10:30 PM
10:45 AM	269	1,059	114	358	10:45 PM
11:00 AM	261	**1,074**	99	**313**	**11:00 PM**
11:15 AM	276	1,089	91	-	11:15 PM
11:30 AM	253	1,161	54	-	11:30 PM
11:45 AM	284	1,212	69	-	11:45 PM
AM PEAK VOLUME	**348**	**1,212**	**481**	**1,862**	PM PEAK VOLUME
PHF and TIME	**0.87**	**11:45 AM**	**0.97**	**5:00 PM**	PHF and TIME
DAILY VOLUME	**19549**				

Analysis By: RCS Date: 11/12/2010

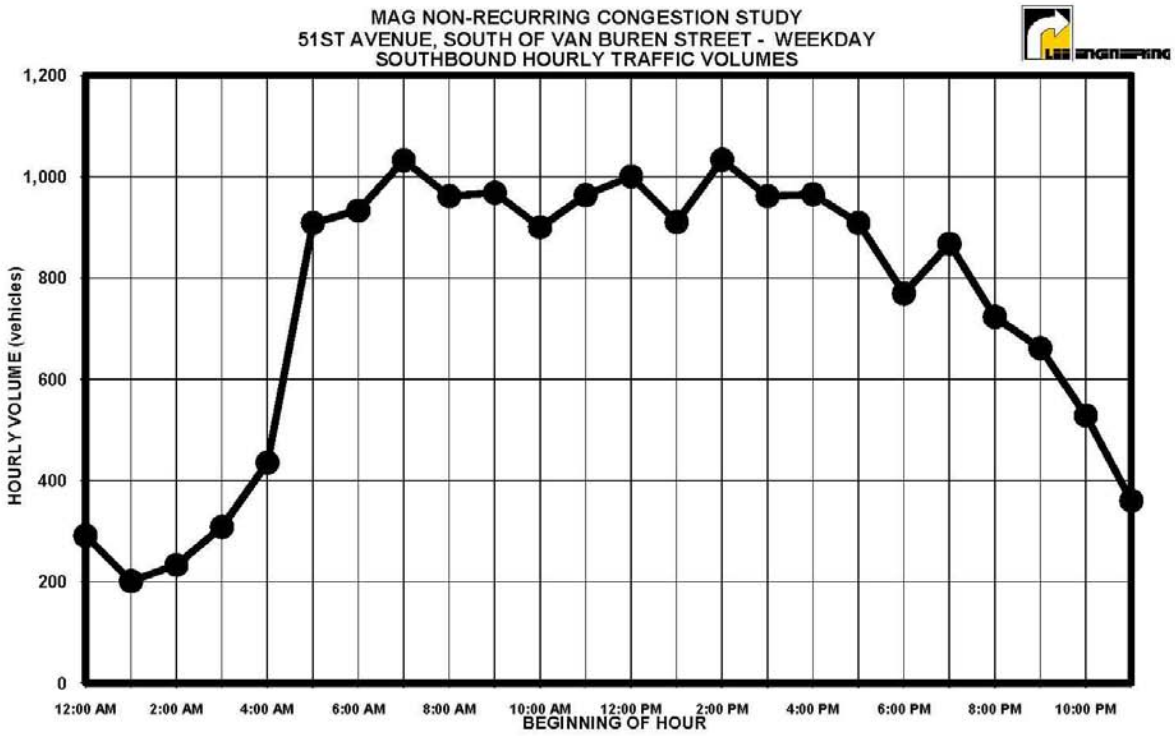
Checked By: LYK Date: 11/19/2010

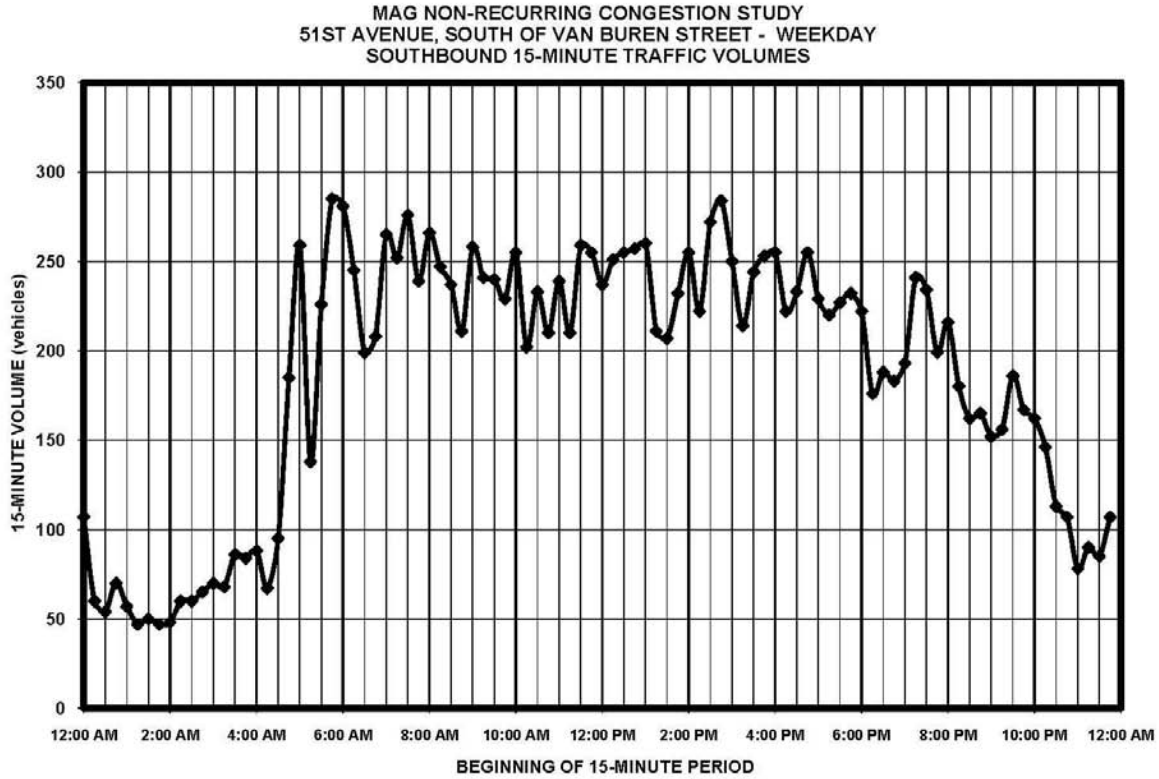
LEE ENGINEERING

MAG NON-RECURRING CONGESTION STUDY
INDIAN SCHOOL RD, BETWEEN 43RD AVE AND 51ST AVE - WEEKDAY
SOUTHBOUND
RANKED HOURLY VOLUMES AS A PERCENTAGE OF DAILY AND PEAK HOURLY VOLUMES

ACTUAL VOLUME	RANKED VOLUME	RANK	PORTION OF DAY	RATIO OF PEAK
156	1,862	1	9.52%	100.00%
122	1,775	2	9.08%	95.33%
111	1,634	3	8.36%	87.76%
79	1,523	**4**	**7.79%**	**81.79%**
96	1,333	5	6.82%	71.59%
176	1,246	6	6.37%	66.92%
416	1,188	7	6.08%	63.80%
656	1,175	**8**	**6.01%**	**63.10%**
834	1,074	9	5.49%	57.68%
906	960	10	4.91%	51.56%
960	906	11	4.63%	48.66%
1,074	834	12	4.27%	44.79%
1,188	793	13	4.06%	42.59%
1,246	656	14	3.36%	35.23%
1,333	636	15	3.25%	34.16%
1,523	485	16	2.48%	26.05%
1,775	416	17	2.13%	22.34%
1,862	313	18	1.60%	16.81%
1,634	176	19	0.90%	9.45%
1,175	156	20	0.80%	8.38%
793	122	21	0.62%	6.55%
636	111	22	0.57%	5.96%
485	96	23	0.49%	5.16%
313	79	24	0.40%	0.40%
19,549	**19,549**		**100.00%**	

Analysis By: RCS Date: 11/12/2010
Checked By: LYK Date: 11/19/2010


MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, SOUTH OF VAN BUREN STREET - WEEKDAY
SOUTHBOUND HOURLY TRAFFIC VOLUMES
HOURLY VOLUME (vehicles)
1,200
1,000
800
600
400
200
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
BEGINNING OF HOUR


MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, SOUTH OF VAN BUREN STREET - WEEKDAY
SOUTHBOUND 15-MINUTE TRAFFIC VOLUMES
15-MINUTE VOLUME (vehicles)
350
300
250
200
150
100
50
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
12:00 AM
BEGINNING OF 15-MINUTE PERIOD

MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, SOUTH OF VAN BUREN STREET - WEEKDAY
SOUTHBOUND

BEGIN PERIOD	MORNING 15 MINUTES	MORNING 60 MINUTES	EVENING 15 MINUTES	EVENING 60 MINUTES	BEGIN PERIOD
12:00 AM	107	**291**	237	**1,000**	**12:00 PM**
12:15 AM	60	241	251	1,023	12:15 PM
12:30 AM	54	228	255	983	12:30 PM
12:45 AM	70	224	257	935	12:45 PM
1:00 AM	57	**201**	260	**910**	**1:00 PM**
1:15 AM	47	192	211	905	1:15 PM
1:30 AM	50	205	207	916	1:30 PM
1:45 AM	47	215	232	981	1:45 PM
2:00 AM	48	**233**	255	**1,033**	**2:00 PM**
2:15 AM	60	255	222	1,028	2:15 PM
2:30 AM	60	263	272	1,020	2:30 PM
2:45 AM	65	289	284	992	2:45 PM
3:00 AM	70	**308**	250	**961**	**3:00 PM**
3:15 AM	68	326	214	966	3:15 PM
3:30 AM	86	325	244	974	3:30 PM
3:45 AM	84	334	253	963	3:45 PM
4:00 AM	88	**435**	255	**965**	**4:00 PM**
4:15 AM	67	606	222	939	4:15 PM
4:30 AM	95	677	233	937	4:30 PM
4:45 AM	185	808	255	931	4:45 PM
5:00 AM	259	**908**	229	**908**	**5:00 PM**
5:15 AM	138	930	220	901	5:15 PM
5:30 AM	226	1,037	227	857	5:30 PM
5:45 AM	285	1,010	232	818	5:45 PM
6:00 AM	281	**933**	222	**769**	**6:00 PM**
6:15 AM	245	917	176	740	6:15 PM
6:30 AM	199	924	188	805	6:30 PM
6:45 AM	208	1,001	183	851	6:45 PM
7:00 AM	265	**1,032**	193	**867**	**7:00 PM**
7:15 AM	252	1,033	241	890	7:15 PM
7:30 AM	276	1,028	234	829	7:30 PM
7:45 AM	239	989	199	757	7:45 PM
8:00 AM	266	**961**	216	**723**	**8:00 PM**
8:15 AM	247	953	180	659	8:15 PM
8:30 AM	237	947	162	635	8:30 PM
8:45 AM	211	950	165	659	8:45 PM
9:00 AM	258	**968**	152	**661**	**9:00 PM**
9:15 AM	241	965	156	671	9:15 PM
9:30 AM	240	926	186	661	9:30 PM
9:45 AM	229	919	167	588	9:45 PM
10:00 AM	255	**900**	162	**528**	**10:00 PM**
10:15 AM	202	884	146	444	10:15 PM
10:30 AM	233	892	113	388	10:30 PM
10:45 AM	210	918	107	360	10:45 PM
11:00 AM	239	**963**	78	**360**	**11:00 PM**
11:15 AM	210	961	90	-	11:15 PM
11:30 AM	259	1,002	85	-	11:30 PM
11:45 AM	255	998	107	-	11:45 PM
AM PEAK VOLUME	**285**	**1,037**	**284**	**1,033**	PM PEAK VOLUME
PHF and TIME	**0.91**	**5:30 AM**	**0.91**	**2:00 PM**	PHF and TIME
DAILY VOLUME	**17818**				

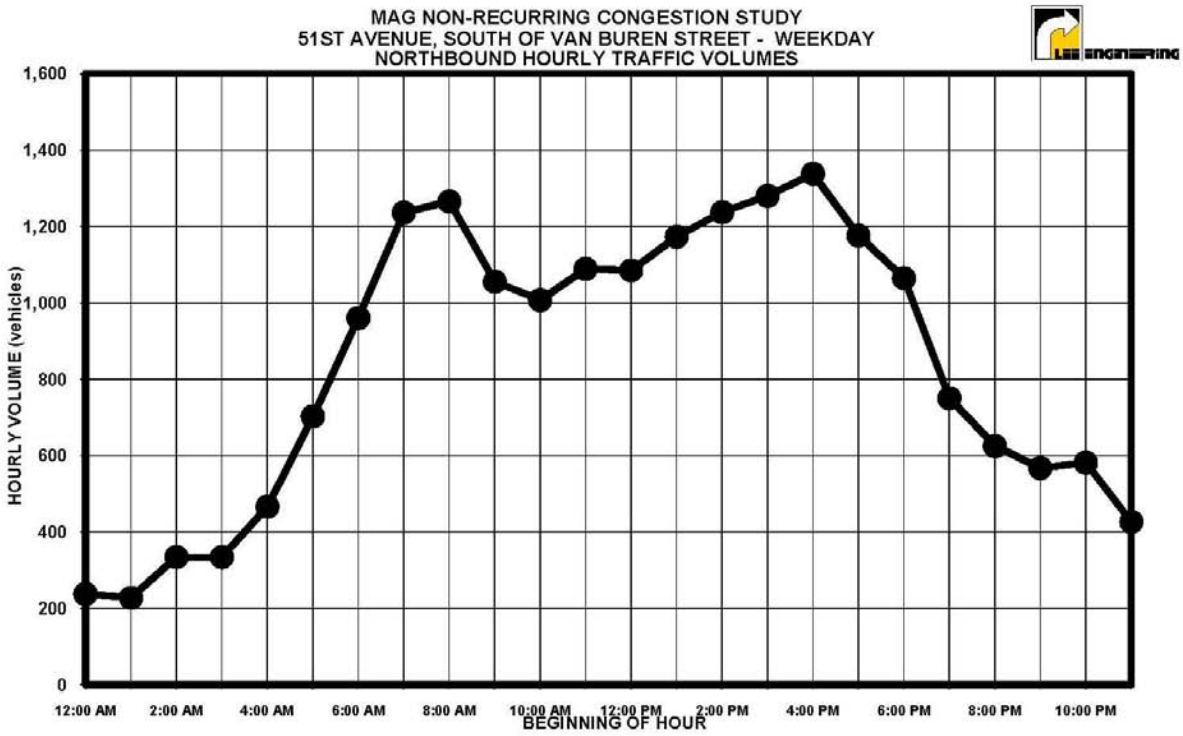
Analysis By: LYK Date: 11/10/2010

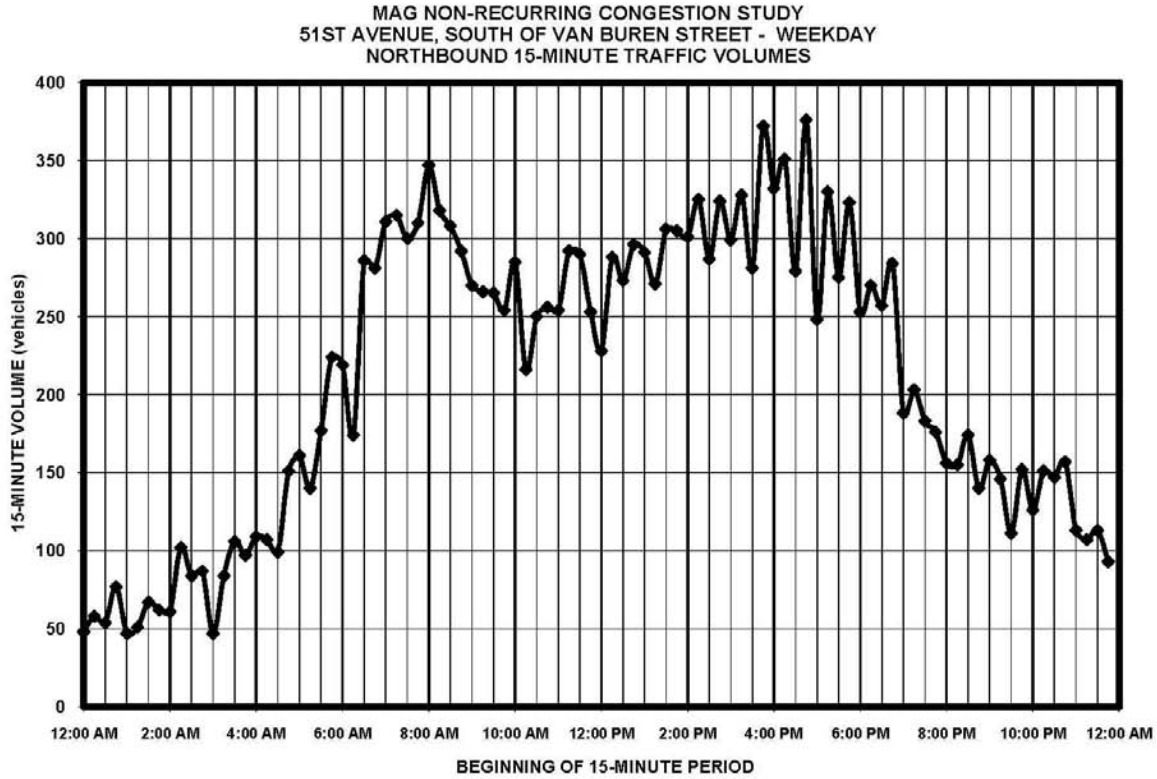
Checked By: LYK Date: 11/10/2010

MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, SOUTH OF VAN BUREN STREET - WEEKDAY
SOUTHBOUND
RANKED HOURLY VOLUMES AS A PERCENTAGE OF DAILY AND PEAK HOURLY VOLUMES

ACTUAL VOLUME	RANKED VOLUME	RANK	PORTION OF DAY	RATIO OF PEAK
291	1,033	1	5.80%	100.00%
201	1,032	2	5.79%	99.90%
233	1,000	3	5.61%	96.81%
308	968	**4**	**5.43%**	**93.71%**
435	965	5	5.42%	93.42%
908	963	6	5.40%	93.22%
933	961	7	5.39%	93.03%
1,032	961	**8**	**5.39%**	**93.03%**
961	933	9	5.24%	90.32%
968	910	10	5.11%	88.09%
900	908	11	5.10%	87.90%
963	908	12	5.10%	87.90%
1,000	900	13	5.05%	87.12%
910	867	14	4.87%	83.93%
1,033	769	15	4.32%	74.44%
961	723	16	4.06%	69.99%
965	661	17	3.71%	63.99%
908	528	18	2.96%	51.11%
769	435	19	2.44%	42.11%
867	360	20	2.02%	34.85%
723	308	21	1.73%	29.82%
661	291	22	1.63%	28.17%
528	233	23	1.31%	22.56%
360	201	24	1.13%	1.13%
17,818	**17,818**		**100.00%**	

Analysis By: LYK Date: 11/10/2010
Checked By: LYK Date: 11/10/2010


MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, SOUTH OF VAN BUREN STREET - WEEKDAY
NORTHBOUND HOURLY TRAFFIC VOLUMES
HOURLY VOLUME (vehicles)
1,600
1,400
1,200
1,000
800
600
400
200
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
BEGINNING OF HOUR


MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, SOUTH OF VAN BUREN STREET - WEEKDAY
NORTHBOUND 15-MINUTE TRAFFIC VOLUMES
15-MINUTE VOLUME (vehicles)
400
350
300
250
200
150
100
50
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
12:00 AM
BEGINNING OF 15-MINUTE PERIOD

MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, SOUTH OF VAN BUREN STREET - WEEKDAY
NORTHBOUND

BEGIN PERIOD	MORNING 15 MINUTES	MORNING 60 MINUTES	EVENING 15 MINUTES	EVENING 60 MINUTES	BEGIN PERIOD
12:00 AM	48	**237**	228	**1,085**	**12:00 PM**
12:15 AM	58	236	288	1,148	12:15 PM
12:30 AM	54	229	273	1,131	12:30 PM
12:45 AM	77	242	296	1,164	12:45 PM
1:00 AM	47	**227**	291	**1,173**	**1:00 PM**
1:15 AM	51	241	271	1,183	1:15 PM
1:30 AM	67	292	306	1,237	1:30 PM
1:45 AM	62	309	305	1,218	1:45 PM
2:00 AM	61	**334**	301	**1,237**	**2:00 PM**
2:15 AM	102	320	325	1,235	2:15 PM
2:30 AM	84	302	287	1,238	2:30 PM
2:45 AM	87	324	324	1,232	2:45 PM
3:00 AM	47	**334**	299	**1,280**	**3:00 PM**
3:15 AM	84	396	328	1,313	3:15 PM
3:30 AM	106	419	281	1,336	3:30 PM
3:45 AM	97	412	372	1,334	3:45 PM
4:00 AM	109	**466**	332	**1,338**	**4:00 PM**
4:15 AM	107	518	351	1,254	4:15 PM
4:30 AM	99	551	279	1,233	4:30 PM
4:45 AM	151	629	376	1,229	4:45 PM
5:00 AM	161	**702**	248	**1,176**	**5:00 PM**
5:15 AM	140	760	330	1,181	5:15 PM
5:30 AM	177	794	275	1,121	5:30 PM
5:45 AM	224	903	323	1,103	5:45 PM
6:00 AM	219	**960**	253	**1,064**	**6:00 PM**
6:15 AM	174	1,052	270	999	6:15 PM
6:30 AM	286	1,193	257	932	6:30 PM
6:45 AM	281	1,207	284	858	6:45 PM
7:00 AM	311	**1,236**	188	**750**	**7:00 PM**
7:15 AM	315	1,272	203	718	7:15 PM
7:30 AM	300	1,275	183	670	7:30 PM
7:45 AM	310	1,283	176	661	7:45 PM
8:00 AM	347	**1,265**	156	**625**	**8:00 PM**
8:15 AM	318	1,188	155	627	8:15 PM
8:30 AM	308	1,136	174	618	8:30 PM
8:45 AM	292	1,093	140	555	8:45 PM
9:00 AM	270	**1,055**	158	**567**	**9:00 PM**
9:15 AM	266	1,070	146	535	9:15 PM
9:30 AM	265	1,020	111	540	9:30 PM
9:45 AM	254	1,005	152	576	9:45 PM
10:00 AM	285	**1,007**	126	**581**	**10:00 PM**
10:15 AM	216	976	151	568	10:15 PM
10:30 AM	250	1,052	147	524	10:30 PM
10:45 AM	256	1,092	157	490	10:45 PM
11:00 AM	254	**1,089**	113	**426**	**11:00 PM**
11:15 AM	292	1,063	107	-	11:15 PM
11:30 AM	290	1,059	113	-	11:30 PM
11:45 AM	253	1,042	93	-	11:45 PM
AM PEAK VOLUME	**347**	**1,283**	**376**	**1,338**	PM PEAK VOLUME
PHF and TIME	**0.92**	**7:45 AM**	**0.89**	**4:00 PM**	PHF and TIME
DAILY VOLUME	**20214**				

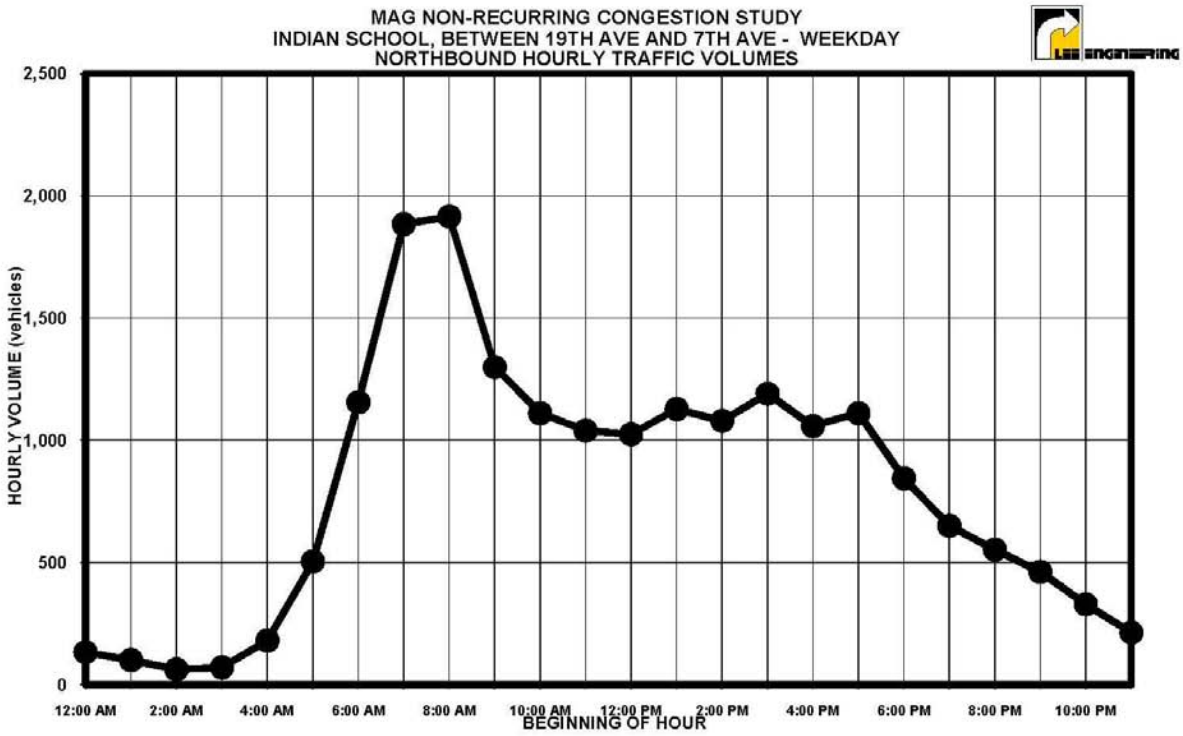
Analysis By: LYK Date: 11/10/2010

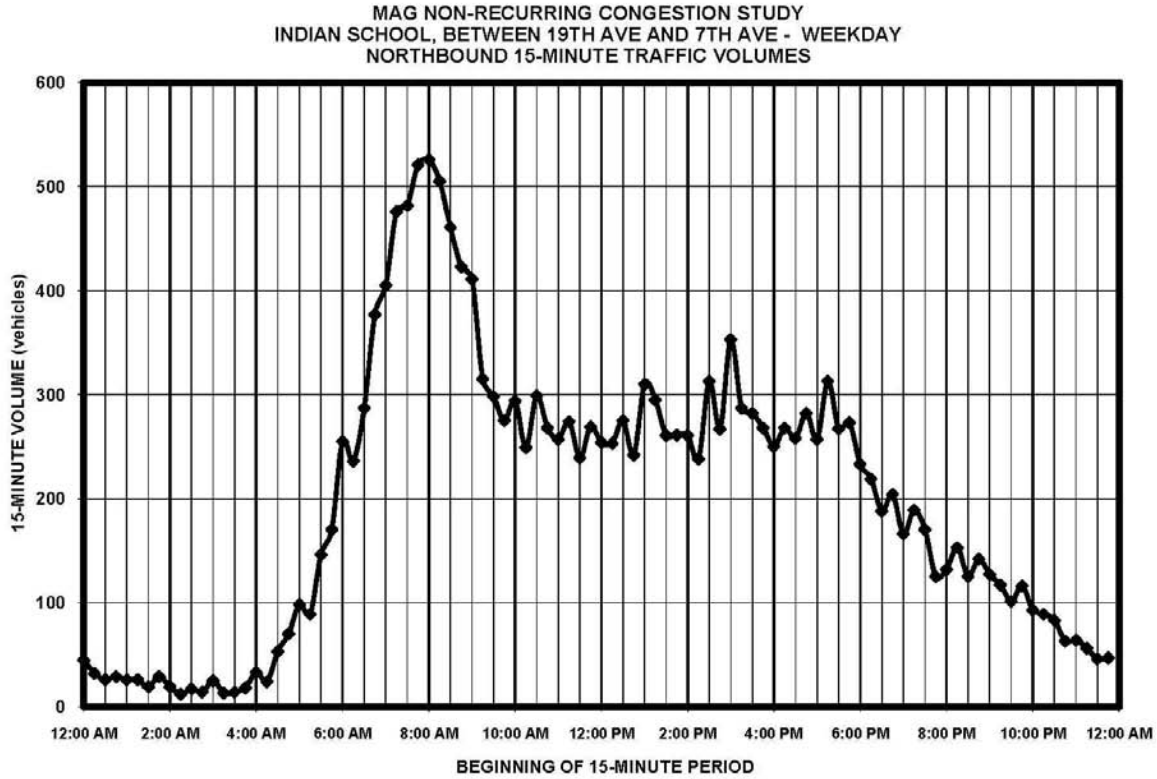
Checked By: LYK Date: 11/10/2010

MAG NON-RECURRING CONGESTION STUDY
51ST AVENUE, SOUTH OF VAN BUREN STREET - WEEKDAY
NORTHBOUND
RANKED HOURLY VOLUMES AS A PERCENTAGE OF DAILY AND PEAK HOURLY VOLUMES

ACTUAL VOLUME	RANKED VOLUME	RANK	PORTION OF DAY	RATIO OF PEAK
237	1,338	1	6.62%	100.00%
227	1,280	2	6.33%	95.67%
334	1,265	3	6.26%	94.54%
334	1,237	**4**	**6.12%**	**92.45%**
466	1,236	5	6.11%	92.38%
702	1,176	6	5.82%	87.89%
960	1,173	7	5.80%	87.67%
1,236	1,089	**8**	**5.39%**	**81.39%**
1,265	1,085	9	5.37%	81.09%
1,055	1,064	10	5.26%	79.52%
1,007	1,055	11	5.22%	78.85%
1,089	1,007	12	4.98%	75.26%
1,085	960	13	4.75%	71.75%
1,173	750	14	3.71%	56.05%
1,237	702	15	3.47%	52.47%
1,280	625	16	3.09%	46.71%
1,338	581	17	2.87%	43.42%
1,176	567	18	2.80%	42.38%
1,064	466	19	2.31%	34.83%
750	426	20	2.11%	31.84%
625	334	21	1.65%	24.96%
567	334	22	1.65%	24.96%
581	237	23	1.17%	17.71%
426	227	24	1.12%	1.12%
20,214	**20,214**		**100.00%**	

Analysis By: LYK Date: 11/10/2010
Checked By: LYK Date: 11/10/2010


MAG NON-RECURRING CONGESTION STUDY
INDIAN SCHOOL, BETWEEN 19TH AVE AND 7TH AVE - WEEKDAY
NORTHBOUND HOURLY TRAFFIC VOLUMES
HOURLY VOLUME (vehicles)
2,500
2,000
1,500
1,000
500
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
BEGINNING OF HOUR


MAG NON-RECURRING CONGESTION STUDY
INDIAN SCHOOL, BETWEEN 19TH AVE AND 7TH AVE - WEEKDAY
NORTHBOUND 15-MINUTE TRAFFIC VOLUMES
15-MINUTE VOLUME (vehicles)
600
500
400
300
200
100
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
12:00 AM
BEGINNING OF 15-MINUTE PERIOD

MAG NON-RECURRING CONGESTION STUDY
INDIAN SCHOOL, BETWEEN 19TH AVE AND 7TH AVE - WEEKDAY
NORTHBOUND

BEGIN PERIOD	MORNING 15 MINUTES	MORNING 60 MINUTES	EVENING 15 MINUTES	EVENING 60 MINUTES	BEGIN PERIOD
12:00 AM	45	**132**	254	**1,024**	**12:00 PM**
12:15 AM	32	113	253	1,080	12:15 PM
12:30 AM	26	107	275	1,122	12:30 PM
12:45 AM	29	100	242	1,108	12:45 PM
1:00 AM	26	**100**	310	**1,127**	**1:00 PM**
1:15 AM	26	93	295	1,078	1:15 PM
1:30 AM	19	79	261	1,021	1:30 PM
1:45 AM	29	77	261	1,073	1:45 PM
2:00 AM	19	**62**	261	**1,079**	**2:00 PM**
2:15 AM	12	68	238	1,171	2:15 PM
2:30 AM	17	69	313	1,220	2:30 PM
2:45 AM	14	66	267	1,189	2:45 PM
3:00 AM	25	**70**	353	**1,190**	**3:00 PM**
3:15 AM	13	78	287	1,087	3:15 PM
3:30 AM	14	89	282	1,068	3:30 PM
3:45 AM	18	128	268	1,044	3:45 PM
4:00 AM	33	**180**	250	**1,058**	**4:00 PM**
4:15 AM	24	245	268	1,065	4:15 PM
4:30 AM	53	310	258	1,110	4:30 PM
4:45 AM	70	403	282	1,119	4:45 PM
5:00 AM	98	**503**	257	**1,110**	**5:00 PM**
5:15 AM	89	660	313	1,086	5:15 PM
5:30 AM	146	807	267	992	5:30 PM
5:45 AM	170	948	273	913	5:45 PM
6:00 AM	255	**1,155**	233	**844**	**6:00 PM**
6:15 AM	236	1,305	219	777	6:15 PM
6:30 AM	287	1,545	188	747	6:30 PM
6:45 AM	377	1,740	204	729	6:45 PM
7:00 AM	405	**1,884**	166	**650**	**7:00 PM**
7:15 AM	476	2,005	189	616	7:15 PM
7:30 AM	482	2,034	170	580	7:30 PM
7:45 AM	521	2,013	125	535	7:45 PM
8:00 AM	526	**1,915**	132	**552**	**8:00 PM**
8:15 AM	505	1,800	153	547	8:15 PM
8:30 AM	461	1,610	125	511	8:30 PM
8:45 AM	423	1,447	142	487	8:45 PM
9:00 AM	411	**1,299**	127	**461**	**9:00 PM**
9:15 AM	315	1,182	117	427	9:15 PM
9:30 AM	298	1,116	101	399	9:30 PM
9:45 AM	275	1,117	116	381	9:45 PM
10:00 AM	294	**1,110**	93	**328**	**10:00 PM**
10:15 AM	249	1,073	89	299	10:15 PM
10:30 AM	299	1,098	83	266	10:30 PM
10:45 AM	268	1,038	63	229	10:45 PM
11:00 AM	257	**1,039**	64	**213**	**11:00 PM**
11:15 AM	274	1,036	56	-	11:15 PM
11:30 AM	239	1,015	46	-	11:30 PM
11:45 AM	269	1,051	47	-	11:45 PM
AM PEAK VOLUME	**526**	**2,034**	**353**	**1,220**	PM PEAK VOLUME
PHF and TIME	**0.97**	**7:30 AM**	**0.86**	**2:30 PM**	PHF and TIME
DAILY VOLUME	**19085**				

Analysis By: RCS Date: 11/11/2010

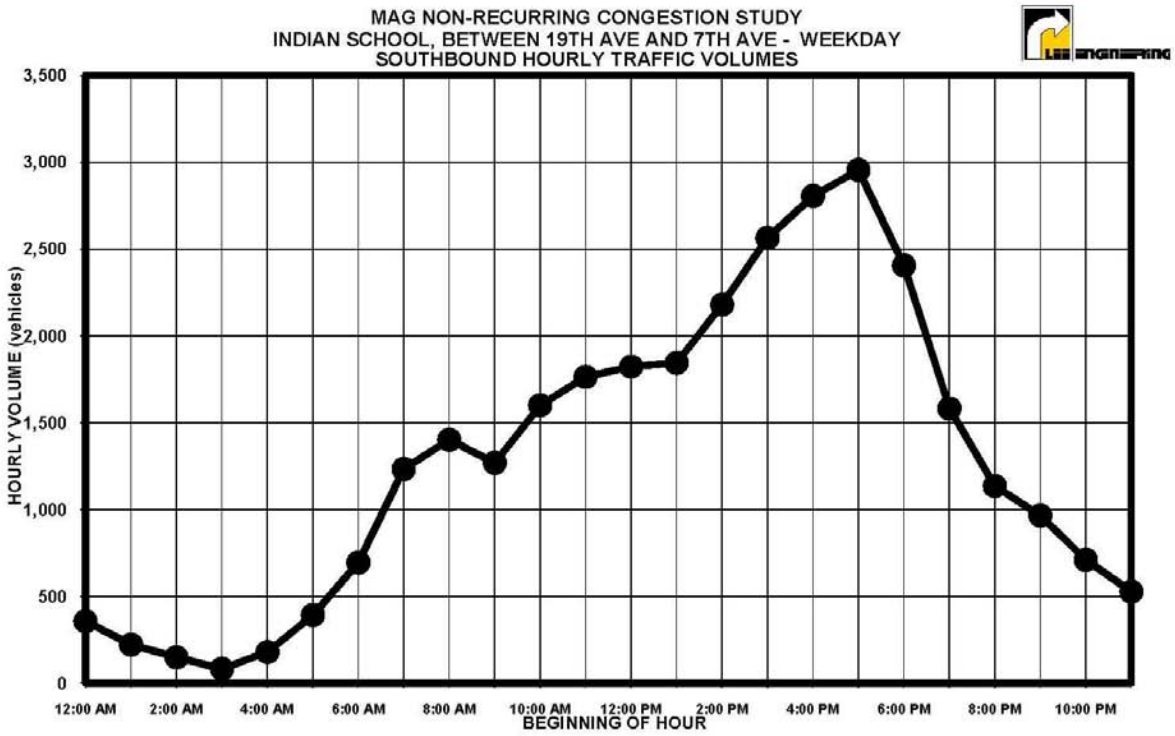
Checked By: LYK Date: 11/19/2010

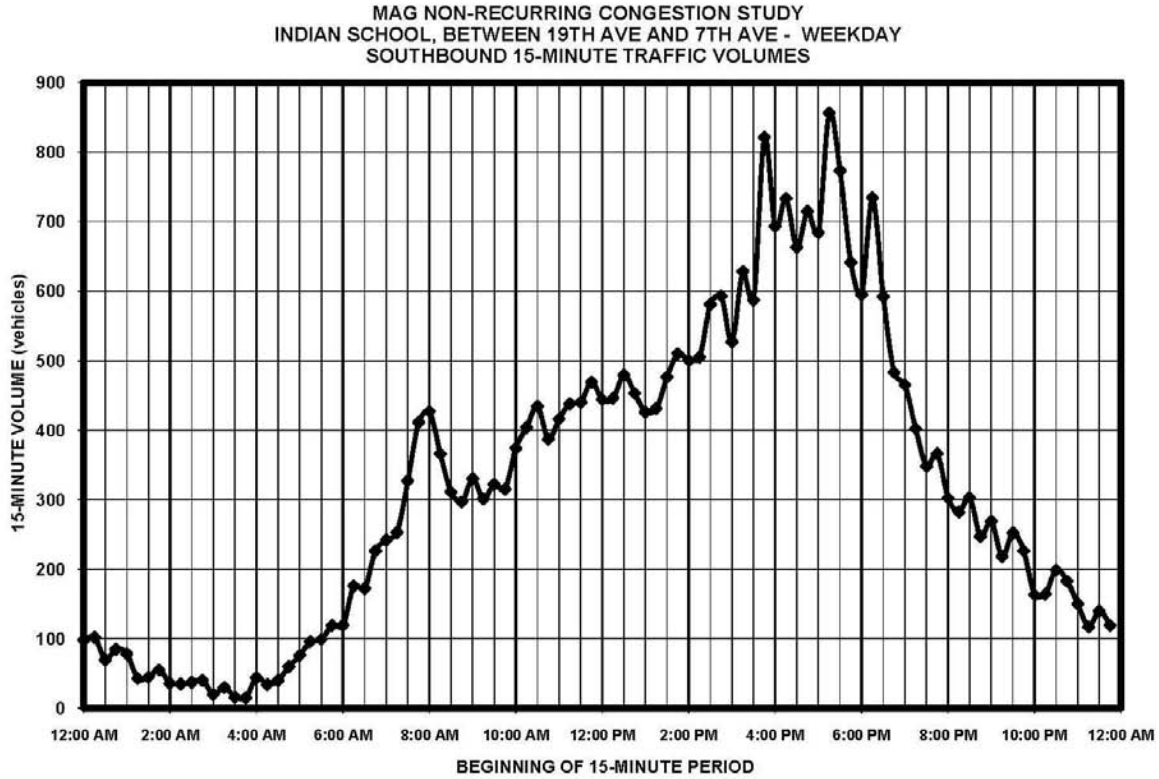
LEE ENGINEERING

MAG NON-RECURRING CONGESTION STUDY
INDIAN SCHOOL, BETWEEN 19TH AVE AND 7TH AVE - WEEKDAY
NORTHBOUND
RANKED HOURLY VOLUMES AS A PERCENTAGE OF DAILY AND PEAK HOURLY VOLUMES

ACTUAL VOLUME	RANKED VOLUME	RANK	PORTION OF DAY	RATIO OF PEAK
132	1,915	1	10.03%	100.00%
100	1,884	2	9.87%	98.38%
62	1,299	3	6.81%	67.83%
70	1,190	**4**	**6.24%**	**62.14%**
180	1,155	5	6.05%	60.31%
503	1,127	6	5.91%	58.85%
1,155	1,110	7	5.82%	57.96%
1,884	1,110	**8**	**5.82%**	**57.96%**
1,915	1,079	9	5.65%	56.34%
1,299	1,058	10	5.54%	55.25%
1,110	1,039	11	5.44%	54.26%
1,039	1,024	12	5.37%	53.47%
1,024	844	13	4.42%	44.07%
1,127	650	14	3.41%	33.94%
1,079	552	15	2.89%	28.83%
1,190	503	16	2.64%	26.27%
1,058	461	17	2.42%	24.07%
1,110	328	18	1.72%	17.13%
844	213	19	1.12%	11.12%
650	180	20	0.94%	9.40%
552	132	21	0.69%	6.89%
461	100	22	0.52%	5.22%
328	70	23	0.37%	3.66%
213	62	24	0.32%	0.32%
19,085	**19,085**		**100.00%**	

Analysis By: RCS Date: 11/11/2010
Checked By: LYK Date: 11/19/2010


MAG NON-RECURRING CONGESTION STUDY
INDIAN SCHOOL, BETWEEN 19TH AVE AND 7TH AVE - WEEKDAY
SOUTHBOUND HOURLY TRAFFIC VOLUMES
HOURLY VOLUME (vehicles)
3,500
3,000
2,500
2,000
1,500
1,000
500
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
BEGINNING OF HOUR


MAG NON-RECURRING CONGESTION STUDY
INDIAN SCHOOL, BETWEEN 19TH AVE AND 7TH AVE - WEEKDAY
SOUTHBOUND 15-MINUTE TRAFFIC VOLUMES
15-MINUTE VOLUME (vehicles)
900
800
700
600
500
400
300
200
100
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
12:00 AM
BEGINNING OF 15-MINUTE PERIOD

MAG NON-RECURRING CONGESTION STUDY
INDIAN SCHOOL, BETWEEN 19TH AVE AND 7TH AVE - WEEKDAY
SOUTHBOUND

BEGIN PERIOD	MORNING 15 MINUTES	MORNING 60 MINUTES	EVENING 15 MINUTES	EVENING 60 MINUTES	BEGIN PERIOD
12:00 AM	98	**355**	444	**1,822**	**12:00 PM**
12:15 AM	102	335	446	1,804	12:15 PM
12:30 AM	70	276	479	1,789	12:30 PM
12:45 AM	85	251	453	1,786	12:45 PM
1:00 AM	78	**221**	426	**1,843**	**1:00 PM**
1:15 AM	43	179	431	1,917	1:15 PM
1:30 AM	45	171	476	1,991	1:30 PM
1:45 AM	55	163	510	2,096	1:45 PM
2:00 AM	36	**148**	500	**2,179**	**2:00 PM**
2:15 AM	35	132	505	2,206	2:15 PM
2:30 AM	37	127	581	2,329	2:30 PM
2:45 AM	40	106	593	2,335	2:45 PM
3:00 AM	20	**81**	527	**2,563**	**3:00 PM**
3:15 AM	30	105	628	2,729	3:15 PM
3:30 AM	16	109	587	2,834	3:30 PM
3:45 AM	15	133	821	2,910	3:45 PM
4:00 AM	44	**178**	693	**2,804**	**4:00 PM**
4:15 AM	34	210	733	2,795	4:15 PM
4:30 AM	40	272	663	2,918	4:30 PM
4:45 AM	60	331	715	3,028	4:45 PM
5:00 AM	76	**390**	684	**2,954**	**5:00 PM**
5:15 AM	96	433	856	2,865	5:15 PM
5:30 AM	99	513	773	2,743	5:30 PM
5:45 AM	119	586	641	2,562	5:45 PM
6:00 AM	119	**693**	595	**2,404**	**6:00 PM**
6:15 AM	176	816	734	2,274	6:15 PM
6:30 AM	172	893	592	1,942	6:30 PM
6:45 AM	226	1,048	483	1,698	6:45 PM
7:00 AM	242	**1,233**	465	**1,581**	**7:00 PM**
7:15 AM	253	1,418	402	1,418	7:15 PM
7:30 AM	327	1,531	348	1,298	7:30 PM
7:45 AM	411	1,515	366	1,253	7:45 PM
8:00 AM	427	**1,401**	302	**1,134**	**8:00 PM**
8:15 AM	366	1,304	282	1,101	8:15 PM
8:30 AM	311	1,239	303	1,037	8:30 PM
8:45 AM	297	1,250	247	986	8:45 PM
9:00 AM	330	**1,268**	269	**965**	**9:00 PM**
9:15 AM	301	1,312	218	859	9:15 PM
9:30 AM	322	1,415	252	805	9:30 PM
9:45 AM	315	1,527	226	752	9:45 PM
10:00 AM	374	**1,599**	163	**709**	**10:00 PM**
10:15 AM	404	1,641	164	696	10:15 PM
10:30 AM	434	1,675	199	649	10:30 PM
10:45 AM	387	1,681	183	590	10:45 PM
11:00 AM	416	**1,763**	150	**526**	**11:00 PM**
11:15 AM	438	1,791	117	-	11:15 PM
11:30 AM	440	1,799	140	-	11:30 PM
11:45 AM	469	1,838	119	-	11:45 PM
AM PEAK VOLUME	**479**	**1,838**	**856**	**3,028**	PM PEAK VOLUME
PHF and TIME	**0.96**	**11:45 AM**	**0.88**	**4:45 PM**	PHF and TIME
DAILY VOLUME	**30814**				

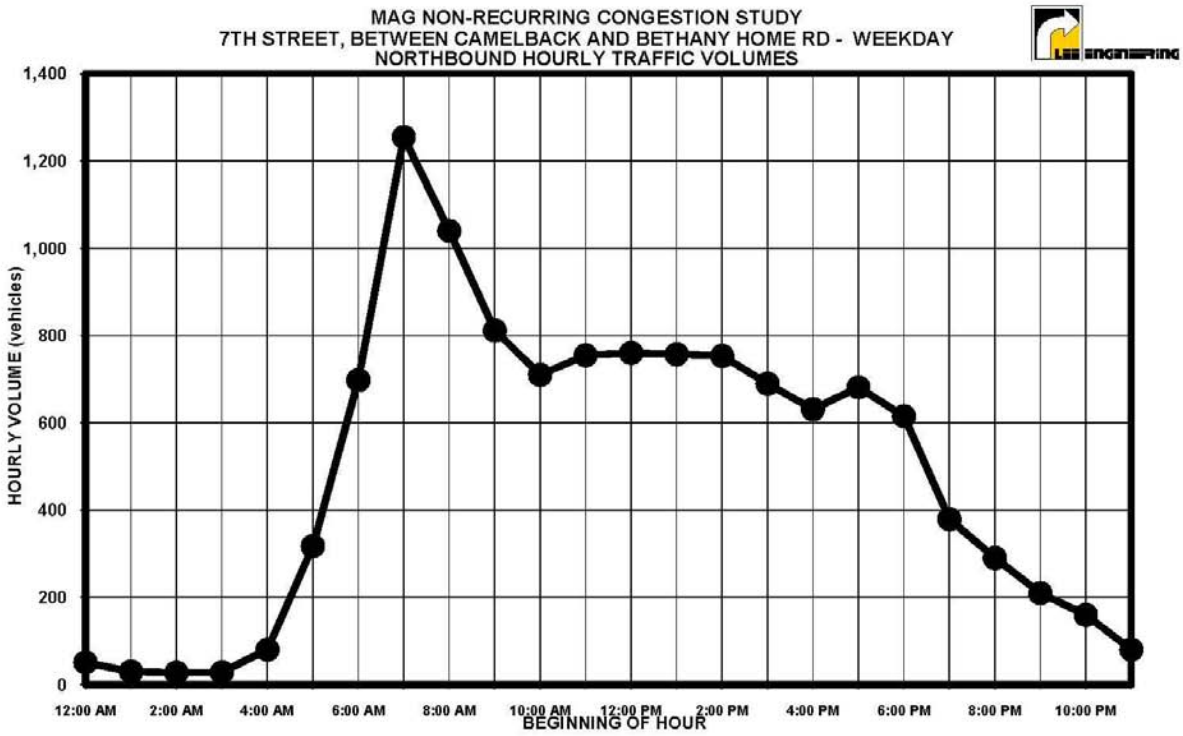
Analysis By: RCS Date: 11/11/2010

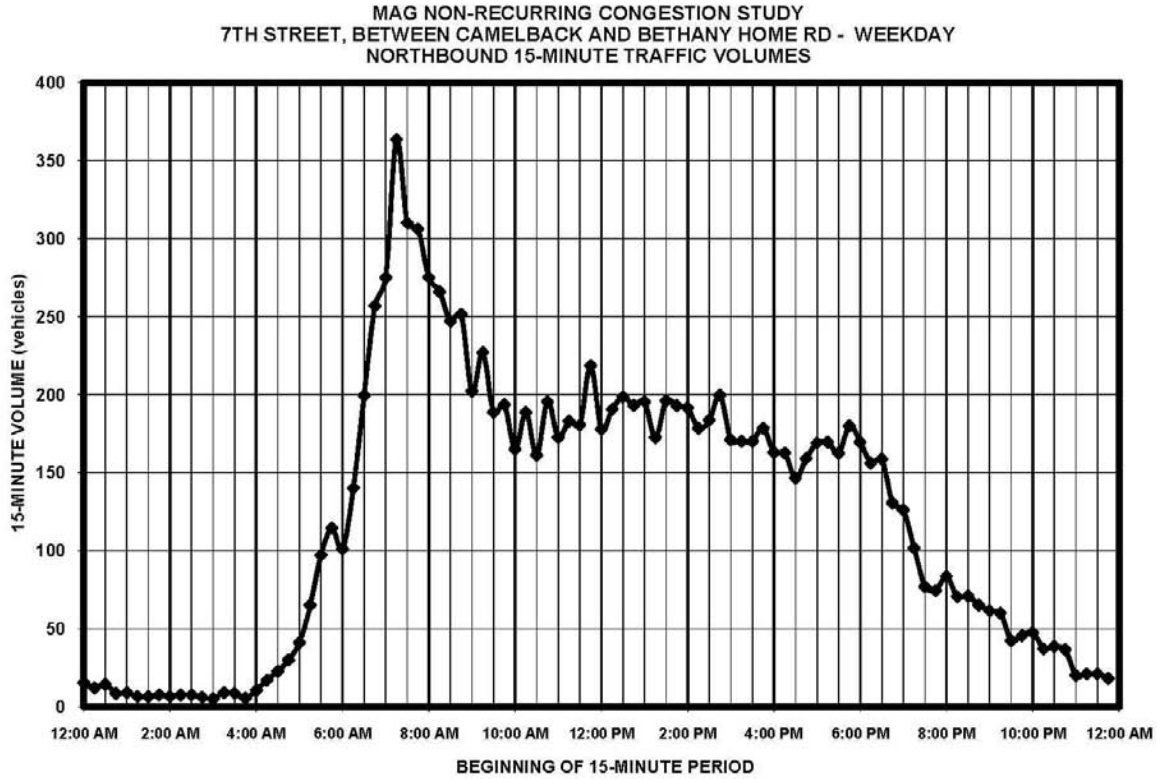
Checked By: LYK Date: 11/19/2010

MAG NON-RECURRING CONGESTION STUDY
INDIAN SCHOOL, BETWEEN 19TH AVE AND 7TH AVE - WEEKDAY
SOUTHBOUND
RANKED HOURLY VOLUMES AS A PERCENTAGE OF DAILY AND PEAK HOURLY VOLUMES

ACTUAL VOLUME	RANKED VOLUME	RANK	PORTION OF DAY	RATIO OF PEAK
355	2,954	1	9.59%	100.00%
221	2,804	2	9.10%	94.92%
148	2,563	3	8.32%	86.76%
81	2,404	**4**	**7.80%**	**81.38%**
178	2,179	5	7.07%	73.76%
390	1,843	6	5.98%	62.39%
693	1,822	7	5.91%	61.68%
1,233	1,763	**8**	**5.72%**	**59.68%**
1,401	1,599	9	5.19%	54.13%
1,268	1,581	10	5.13%	53.52%
1,599	1,401	11	4.55%	47.43%
1,763	1,268	12	4.12%	42.92%
1,822	1,233	13	4.00%	41.74%
1,843	1,134	14	3.68%	38.39%
2,179	965	15	3.13%	32.67%
2,563	709	16	2.30%	24.00%
2,804	693	17	2.25%	23.46%
2,954	526	18	1.71%	17.81%
2,404	390	19	1.27%	13.20%
1,581	355	20	1.15%	12.02%
1,134	221	21	0.72%	7.48%
965	178	22	0.58%	6.03%
709	148	23	0.48%	5.01%
526	81	24	0.26%	0.26%
30,814	**30,814**		**100.00%**	

Analysis By: RCS Date: 11/11/2010
Checked By: LYK Date: 11/19/2010


MAG NON-RECURRING CONGESTION STUDY
7TH STREET, BETWEEN CAMELBACK AND BETHANY HOME RD - WEEKDAY
NORTHBOUND HOURLY TRAFFIC VOLUMES
HOURLY VOLUME (vehicles)
1,400
1,200
1,000
800
600
400
200
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
BEGINNING OF HOUR


MAG NON-RECURRING CONGESTION STUDY
7TH STREET, BETWEEN CAMELBACK AND BETHANY HOME RD - WEEKDAY
NORTHBOUND 15-MINUTE TRAFFIC VOLUMES
15-MINUTE VOLUME (vehicles)
400
350
300
250
200
150
100
50
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
12:00 AM
BEGINNING OF 15-MINUTE PERIOD

MAG NON-RECURRING CONGESTION STUDY
7TH STREET, BETWEEN CAMELBACK AND BETHANY HOME RD - WEEKDAY
NORTHBOUND

BEGIN PERIOD	MORNING 15 MINUTES	MORNING 60 MINUTES	EVENING 15 MINUTES	EVENING 60 MINUTES	BEGIN PERIOD
12:00 AM	15.5	**51**	178	**760**	**12:00 PM**
12:15 AM	12	44	190.5	778	12:15 PM
12:30 AM	14.5	39	198.5	760	12:30 PM
12:45 AM	8.5	31	193	757	12:45 PM
1:00 AM	9	**30**	195.5	**757**	**1:00 PM**
1:15 AM	6.5	27	172.5	753	1:15 PM
1:30 AM	6.5	28	196	759	1:30 PM
1:45 AM	7.5	29	193	747	1:45 PM
2:00 AM	6.5	**28**	191.5	**753**	**2:00 PM**
2:15 AM	7.5	26	178.5	733	2:15 PM
2:30 AM	7.5	28	183.5	724	2:30 PM
2:45 AM	6	29	199.5	711	2:45 PM
3:00 AM	5	**28**	171	**690**	**3:00 PM**
3:15 AM	9	34	170	682	3:15 PM
3:30 AM	8.5	42	170	674	3:30 PM
3:45 AM	5.5	56	178.5	651	3:45 PM
4:00 AM	10.5	**80**	163	**631**	**4:00 PM**
4:15 AM	17	111	162.5	637	4:15 PM
4:30 AM	22.5	159	146.5	644	4:30 PM
4:45 AM	30	233	159	660	4:45 PM
5:00 AM	41	**318**	169	**681**	**5:00 PM**
5:15 AM	65	378	169.5	682	5:15 PM
5:30 AM	97	453	162.5	668	5:30 PM
5:45 AM	114.5	555	180	664	5:45 PM
6:00 AM	101	**698**	169.5	**615**	**6:00 PM**
6:15 AM	140	872	156	571	6:15 PM
6:30 AM	199.5	1,095	158.5	517	6:30 PM
6:45 AM	257	1,206	130.5	435	6:45 PM
7:00 AM	275	**1,255**	126	**379**	**7:00 PM**
7:15 AM	363.5	1,255	101.5	337	7:15 PM
7:30 AM	310	1,157	77	306	7:30 PM
7:45 AM	306	1,094	74.5	300	7:45 PM
8:00 AM	275	**1,040**	83.5	**290**	**8:00 PM**
8:15 AM	266	967	70.5	268	8:15 PM
8:30 AM	247	928	71	258	8:30 PM
8:45 AM	251.5	869	65	229	8:45 PM
9:00 AM	202	**811**	61.5	**210**	**9:00 PM**
9:15 AM	227	774	60	196	9:15 PM
9:30 AM	188.5	736	42.5	173	9:30 PM
9:45 AM	193.5	708	45.5	169	9:45 PM
10:00 AM	165	**710**	47.5	**160**	**10:00 PM**
10:15 AM	188.5	718	37	132	10:15 PM
10:30 AM	161	712	38.5	116	10:30 PM
10:45 AM	195.5	732	36.5	99	10:45 PM
11:00 AM	172.5	**755**	20	**80**	**11:00 PM**
11:15 AM	183	760	21	-	11:15 PM
11:30 AM	180.5	768	21	-	11:30 PM
11:45 AM	218.5	786	18	-	11:45 PM
AM PEAK VOLUME	**364**	**1,255**	**199**	**778**	PM PEAK VOLUME
PHF and TIME	**0.86**	**2 peaks**	**0.98**	**12:15 PM**	PHF and TIME
DAILY VOLUME	**11804**				

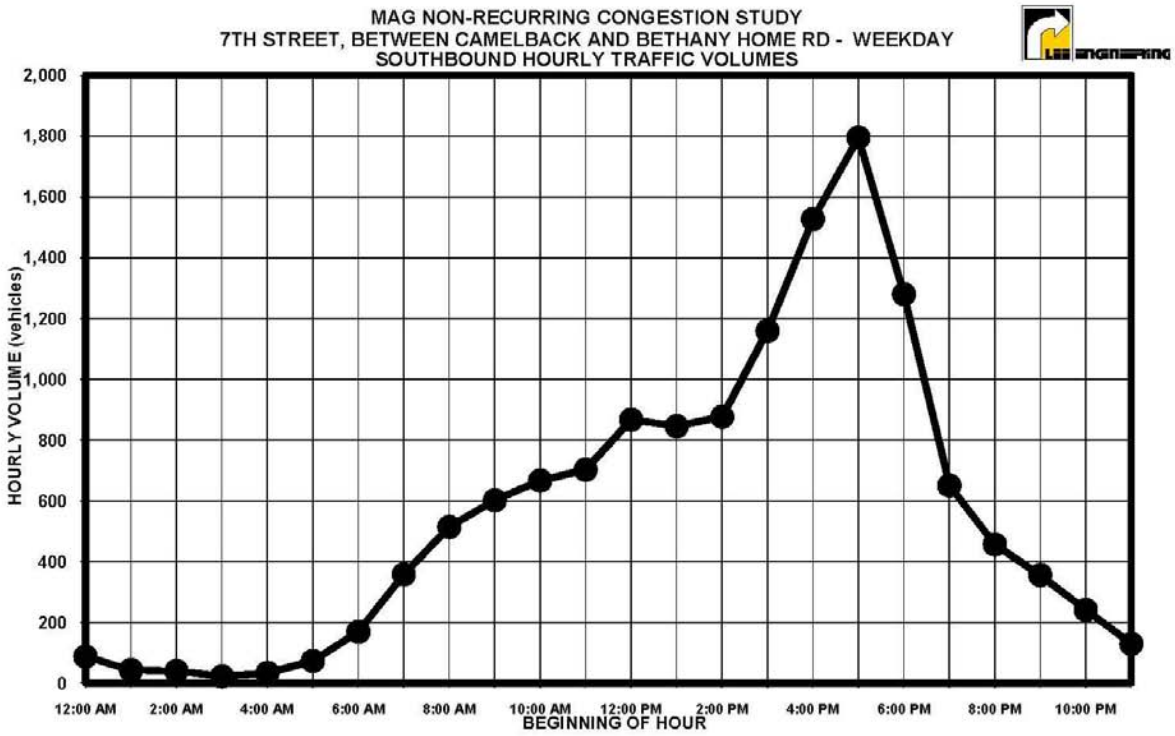
Analysis By: RCS Date: 11/11/2010

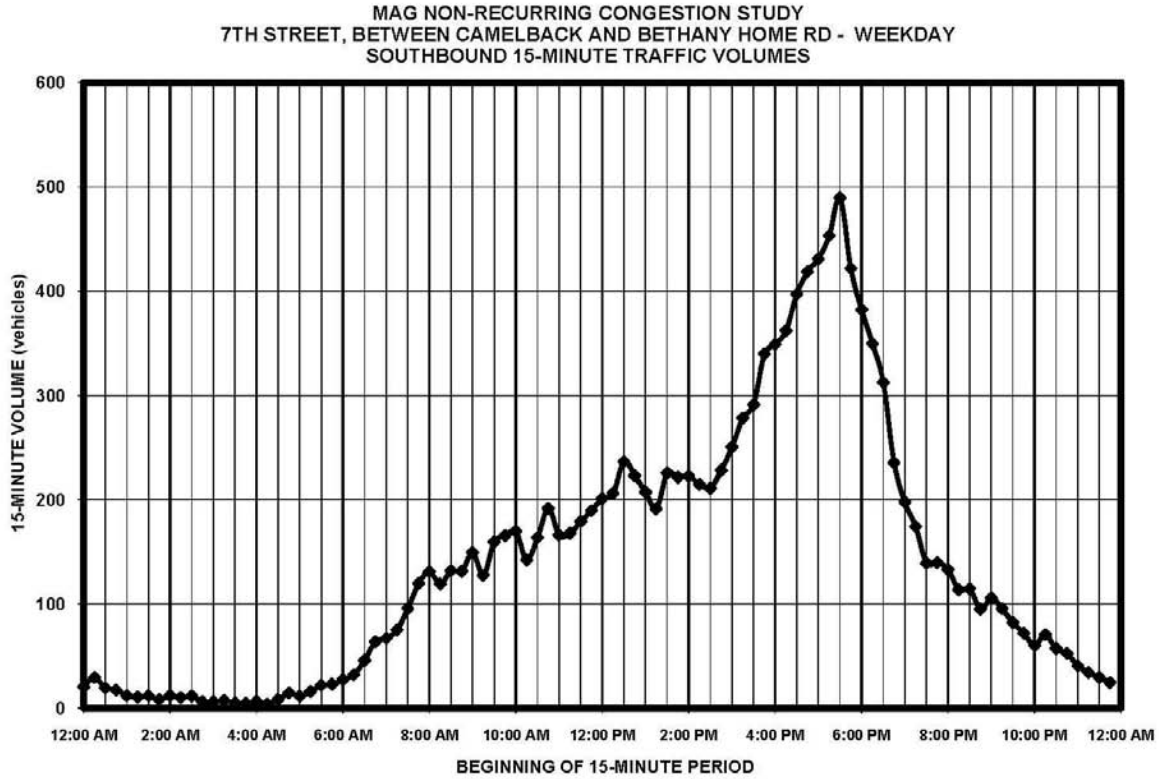
Checked By: LYK Date: 11/19/2010

MAG NON-RECURRING CONGESTION STUDY
7TH STREET, BETWEEN CAMELBACK AND BETHANY HOME RD - WEEKDAY
NORTHBOUND
RANKED HOURLY VOLUMES AS A PERCENTAGE OF DAILY AND PEAK HOURLY VOLUMES

ACTUAL VOLUME	RANKED VOLUME	RANK	PORTION OF DAY	RATIO OF PEAK
51	1,255	1	10.63%	100.00%
30	1,040	2	8.81%	82.86%
28	811	3	6.87%	64.65%
28	760	**4**	**6.44%**	**60.58%**
80	757	5	6.41%	60.34%
318	755	6	6.39%	60.14%
698	753	7	6.38%	60.02%
1,255	710	**8**	**6.01%**	**56.60%**
1,040	698	9	5.91%	55.60%
811	690	10	5.84%	54.96%
710	681	11	5.77%	54.28%
755	631	12	5.35%	50.30%
760	615	13	5.21%	48.98%
757	379	14	3.21%	30.21%
753	318	15	2.69%	25.31%
690	290	16	2.46%	23.12%
631	210	17	1.77%	16.70%
681	160	18	1.35%	12.71%
615	80	19	0.68%	6.38%
379	80	20	0.68%	6.38%
290	51	21	0.43%	4.03%
210	30	22	0.25%	2.35%
160	28	23	0.24%	2.23%
80	28	24	0.23%	0.23%
11,804	**11,804**		**100.00%**	

Analysis By: RCS Date: 11/11/2010
Checked By: LYK Date: 11/19/2010


MAG NON-RECURRING CONGESTION STUDY
7TH STREET, BETWEEN CAMELBACK AND BETHANY HOME RD - WEEKDAY
SOUTHBOUND HOURLY TRAFFIC VOLUMES
HOURLY VOLUME (vehicles)
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
BEGINNING OF HOUR


MAG NON-RECURRING CONGESTION STUDY
7TH STREET, BETWEEN CAMELBACK AND BETHANY HOME RD - WEEKDAY
SOUTHBOUND 15-MINUTE TRAFFIC VOLUMES
15-MINUTE VOLUME (vehicles)
600
500
400
300
200
100
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
12:00 AM
BEGINNING OF 15-MINUTE PERIOD

MAG NON-RECURRING CONGESTION STUDY
7TH STREET, BETWEEN CAMELBACK AND BETHANY HOME RD - WEEKDAY
SOUTHBOUND

BEGIN PERIOD	MORNING 15 MINUTES	MORNING 60 MINUTES	EVENING 15 MINUTES	EVENING 60 MINUTES	BEGIN PERIOD
12:00 AM	20.5	**87**	201	**867**	**12:00 PM**
12:15 AM	29.5	79	206	873	12:15 PM
12:30 AM	19.5	60	236.5	858	12:30 PM
12:45 AM	17.5	52	223	847	12:45 PM
1:00 AM	12	**43**	207	**845**	**1:00 PM**
1:15 AM	10.5	43	191	861	1:15 PM
1:30 AM	12	42	225.5	884	1:30 PM
1:45 AM	8	42	221.5	870	1:45 PM
2:00 AM	12	**40**	222.5	**876**	**2:00 PM**
2:15 AM	10	34	214.5	904	2:15 PM
2:30 AM	11.5	31	211	968	2:30 PM
2:45 AM	6	24	228	1,048	2:45 PM
3:00 AM	6	**23**	250.5	**1,159**	**3:00 PM**
3:15 AM	7	23	278	1,258	3:15 PM
3:30 AM	5	20	291	1,342	3:30 PM
3:45 AM	4.5	23	339.5	1,448	3:45 PM
4:00 AM	6.5	**33**	349	**1,527**	**4:00 PM**
4:15 AM	4	38	362	1,609	4:15 PM
4:30 AM	8	50	397	1,700	4:30 PM
4:45 AM	14.5	64	418.5	1,792	4:45 PM
5:00 AM	11.5	**73**	431	**1,795**	**5:00 PM**
5:15 AM	16	88	453	1,746	5:15 PM
5:30 AM	22	104	489.5	1,643	5:30 PM
5:45 AM	23	128	421.5	1,466	5:45 PM
6:00 AM	27	**169**	382	**1,280**	**6:00 PM**
6:15 AM	32	209	349.5	1,095	6:15 PM
6:30 AM	46	252	312.5	920	6:30 PM
6:45 AM	63.5	301	235.5	746	6:45 PM
7:00 AM	67	**357**	197.5	**650**	**7:00 PM**
7:15 AM	75	421	174	586	7:15 PM
7:30 AM	95.5	465	139	525	7:30 PM
7:45 AM	119.5	502	139.5	501	7:45 PM
8:00 AM	131	**514**	133	**456**	**8:00 PM**
8:15 AM	119	532	113.5	429	8:15 PM
8:30 AM	132	540	114.5	411	8:30 PM
8:45 AM	131.5	568	95	378	8:45 PM
9:00 AM	149	**602**	105.5	**355**	**9:00 PM**
9:15 AM	127.5	622	95.5	310	9:15 PM
9:30 AM	159.5	637	82	285	9:30 PM
9:45 AM	165.5	641	72	260	9:45 PM
10:00 AM	169.5	**667**	60	**240**	**10:00 PM**
10:15 AM	142	663	70.5	221	10:15 PM
10:30 AM	163.5	689	57	184	10:30 PM
10:45 AM	191.5	704	52.5	157	10:45 PM
11:00 AM	166	**702**	40.5	**129**	**11:00 PM**
11:15 AM	167.5	737	34	-	11:15 PM
11:30 AM	179	776	29.5	-	11:30 PM
11:45 AM	189.5	833	24.5	-	11:45 PM
AM PEAK VOLUME	**237**	**833**	**490**	**1,795**	PM PEAK VOLUME
PHF and TIME	**0.88**	**11:45 AM**	**0.92**	**5:00 PM**	PHF and TIME
DAILY VOLUME	**13483**				

Analysis By: RCS Date: 11/11/2010

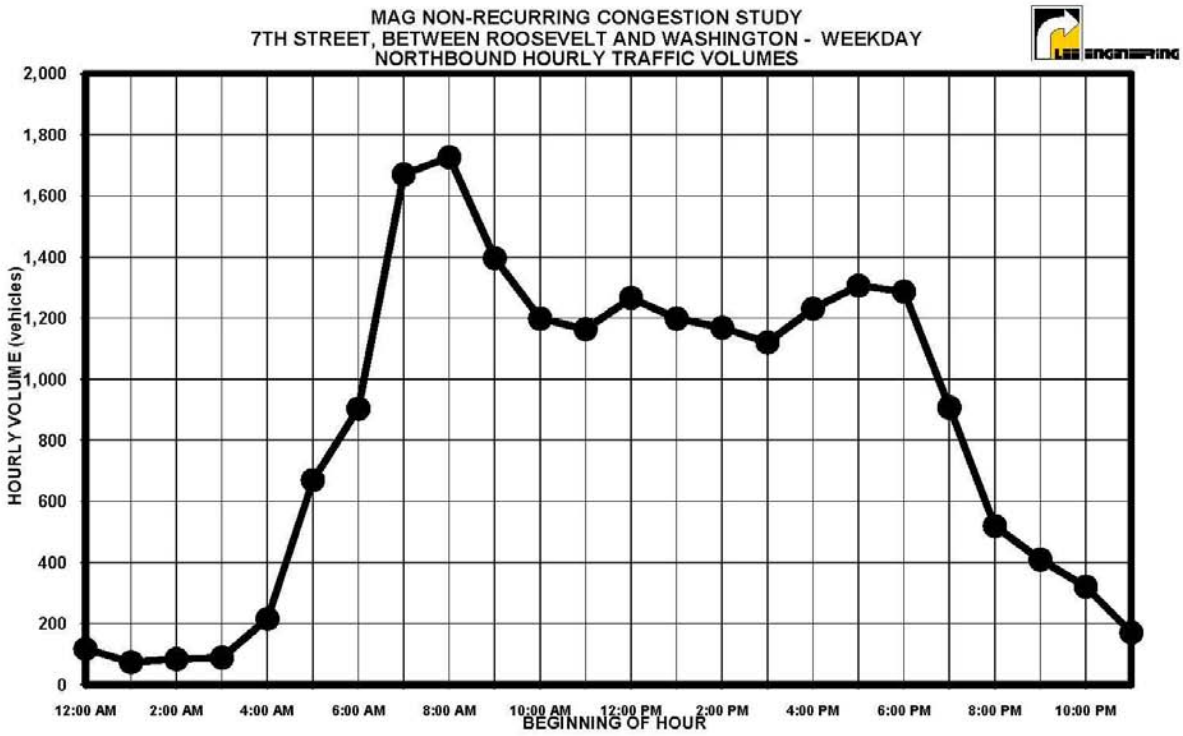
Checked By: LYK Date: 11/19/2010

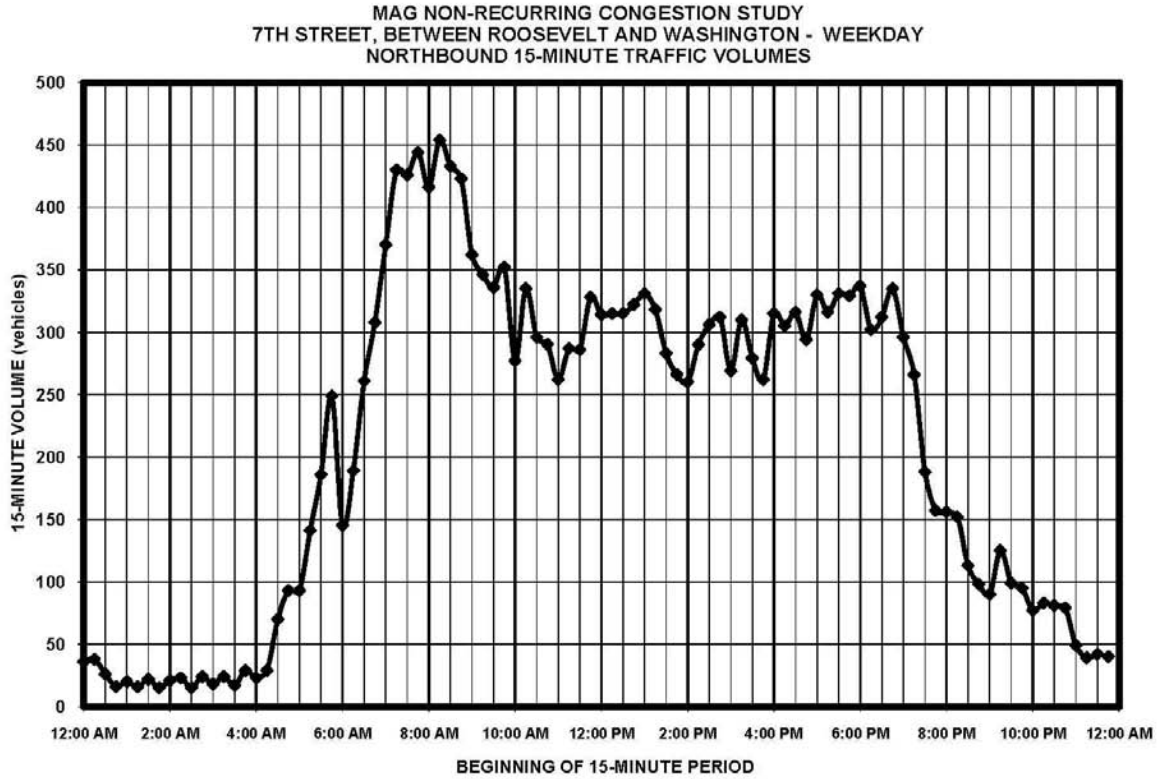
LEE ENGINEERING

MAG NON-RECURRING CONGESTION STUDY
7TH STREET, BETWEEN CAMELBACK AND BETHANY HOME RD - WEEKDAY
SOUTHBOUND
RANKED HOURLY VOLUMES AS A PERCENTAGE OF DAILY AND PEAK HOURLY VOLUMES

ACTUAL VOLUME	RANKED VOLUME	RANK	PORTION OF DAY	RATIO OF PEAK
87	1,795	1	13.31%	100.00%
43	1,527	2	11.32%	85.04%
40	1,280	3	9.49%	71.28%
23	1,159	**4**	**8.60%**	**64.57%**
33	876	5	6.50%	48.80%
73	867	6	6.43%	48.27%
169	845	7	6.27%	47.08%
357	702	**8**	**5.21%**	**39.11%**
514	667	9	4.94%	37.13%
602	650	10	4.82%	36.21%
667	602	11	4.46%	33.51%
702	514	12	3.81%	28.61%
867	456	13	3.38%	25.40%
845	357	14	2.65%	19.89%
876	355	15	2.63%	19.78%
1,159	240	16	1.78%	13.37%
1,527	169	17	1.25%	9.39%
1,795	129	18	0.95%	7.16%
1,280	87	19	0.65%	4.85%
650	73	20	0.54%	4.04%
456	43	21	0.32%	2.37%
355	40	22	0.29%	2.20%
240	33	23	0.24%	1.84%
129	23	24	0.17%	0.17%
13,483	**13,483**		**100.00%**	

Analysis By: RCS Date: 11/11/2010
Checked By: LYK Date: 11/19/2010


MAG NON-RECURRING CONGESTION STUDY
7TH STREET, BETWEEN ROOSEVELT AND WASHINGTON - WEEKDAY
NORTHBOUND HOURLY TRAFFIC VOLUMES
HOURLY VOLUME (vehicles)
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
BEGINNING OF HOUR


MAG NON-RECURRING CONGESTION STUDY
7TH STREET, BETWEEN ROOSEVELT AND WASHINGTON - WEEKDAY
NORTHBOUND 15-MINUTE TRAFFIC VOLUMES
15-MINUTE VOLUME (vehicles)
500
450
400
350
300
250
200
150
100
50
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
12:00 AM
BEGINNING OF 15-MINUTE PERIOD

MAG NON-RECURRING CONGESTION STUDY
7TH STREET, BETWEEN ROOSEVELT AND WASHINGTON - WEEKDAY
NORTHBOUND

BEGIN PERIOD	MORNING 15 MINUTES	MORNING 60 MINUTES	EVENING 15 MINUTES	EVENING 60 MINUTES	BEGIN PERIOD
12:00 AM	36	**116**	314	**1,266**	**12:00 PM**
12:15 AM	38	100	315	1,283	12:15 PM
12:30 AM	26	78	315	1,286	12:30 PM
12:45 AM	16	74	322	1,254	12:45 PM
1:00 AM	20	**73**	331	**1,198**	**1:00 PM**
1:15 AM	16	74	318	1,127	1:15 PM
1:30 AM	22	81	283	1,099	1:30 PM
1:45 AM	15	74	266	1,122	1:45 PM
2:00 AM	21	**83**	260	**1,168**	**2:00 PM**
2:15 AM	23	80	290	1,177	2:15 PM
2:30 AM	15	81	306	1,197	2:30 PM
2:45 AM	24	83	312	1,170	2:45 PM
3:00 AM	18	**88**	269	**1,120**	**3:00 PM**
3:15 AM	24	93	310	1,166	3:15 PM
3:30 AM	17	98	279	1,161	3:30 PM
3:45 AM	29	151	262	1,198	3:45 PM
4:00 AM	23	**215**	315	**1,230**	**4:00 PM**
4:15 AM	29	285	305	1,245	4:15 PM
4:30 AM	70	397	316	1,256	4:30 PM
4:45 AM	93	513	294	1,271	4:45 PM
5:00 AM	93	**669**	330	**1,306**	**5:00 PM**
5:15 AM	141	721	316	1,313	5:15 PM
5:30 AM	186	769	331	1,299	5:30 PM
5:45 AM	249	844	329	1,280	5:45 PM
6:00 AM	145	**903**	337	**1,286**	**6:00 PM**
6:15 AM	189	1,128	302	1,245	6:15 PM
6:30 AM	261	1,369	312	1,209	6:30 PM
6:45 AM	308	1,534	335	1,085	6:45 PM
7:00 AM	370	**1,670**	296	**907**	**7:00 PM**
7:15 AM	430	1,716	266	767	7:15 PM
7:30 AM	426	1,740	188	653	7:30 PM
7:45 AM	444	1,747	157	578	7:45 PM
8:00 AM	416	**1,726**	156	**519**	**8:00 PM**
8:15 AM	454	1,672	152	453	8:15 PM
8:30 AM	433	1,564	113	426	8:30 PM
8:45 AM	423	1,467	98	412	8:45 PM
9:00 AM	362	**1,396**	90	**409**	**9:00 PM**
9:15 AM	346	1,311	125	396	9:15 PM
9:30 AM	336	1,300	99	354	9:30 PM
9:45 AM	352	1,260	95	336	9:45 PM
10:00 AM	277	**1,198**	77	**320**	**10:00 PM**
10:15 AM	335	1,183	83	292	10:15 PM
10:30 AM	296	1,135	81	248	10:30 PM
10:45 AM	290	1,125	79	209	10:45 PM
11:00 AM	262	**1,163**	49	**170**	**11:00 PM**
11:15 AM	287	1,215	39	-	11:15 PM
11:30 AM	286	1,243	42	-	11:30 PM
11:45 AM	328	1,272	40	-	11:45 PM
AM PEAK VOLUME	**454**	**1,747**	**337**	**1,313**	PM PEAK VOLUME
PHF and TIME	**0.96**	**7:45 AM**	**0.97**	**5:15 PM**	PHF and TIME
DAILY VOLUME	**20199**				

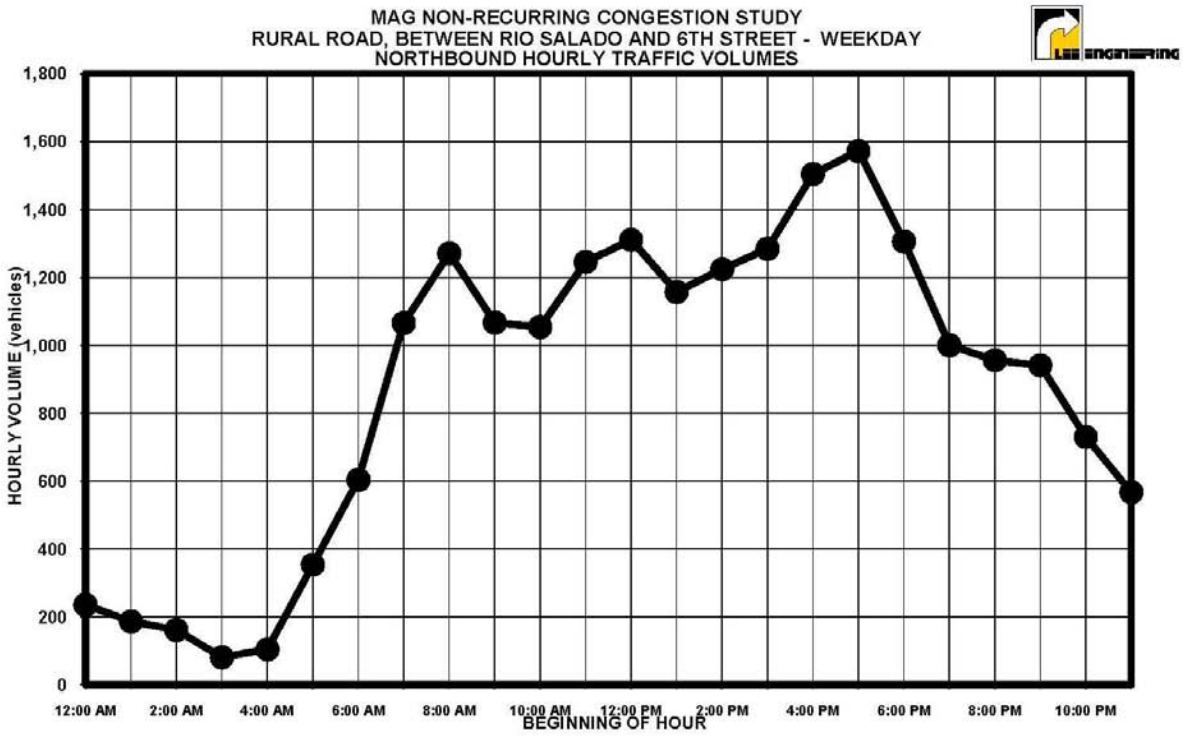
Analysis By: RCS Date: 11/11/2010

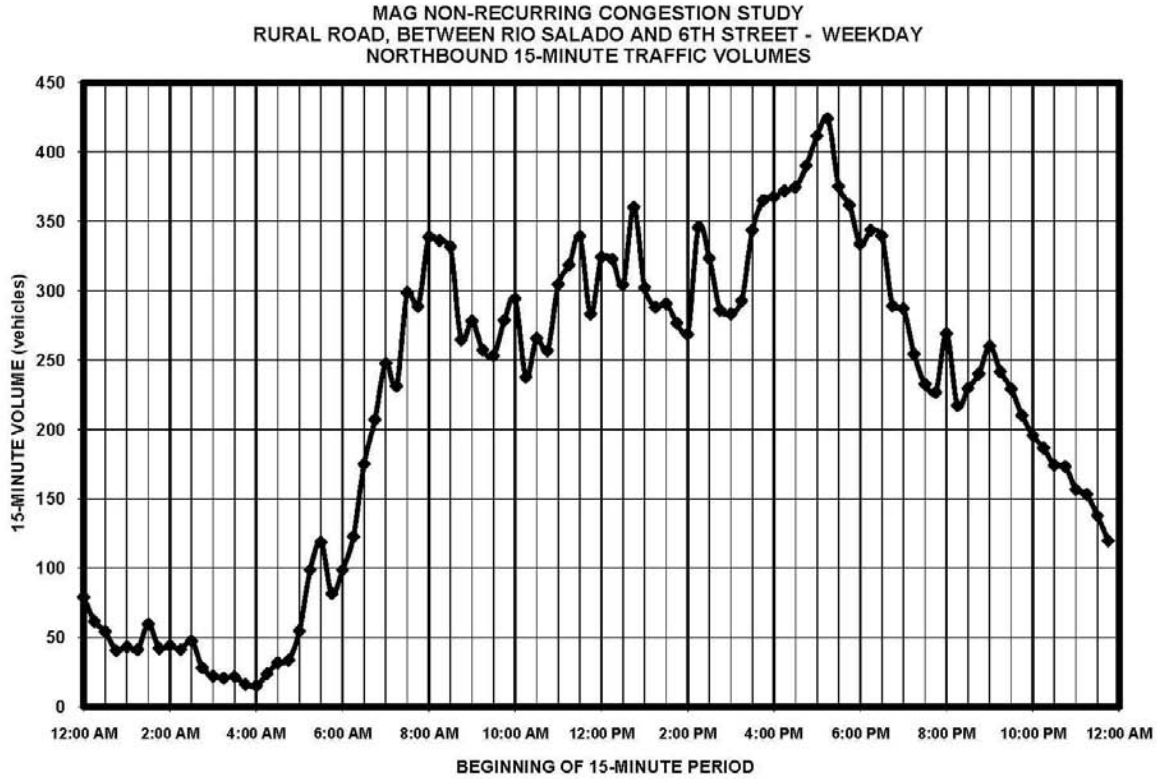
Checked By: RCS Date: 11/11/2010

MAG NON-RECURRING CONGESTION STUDY
7TH STREET, BETWEEN ROOSEVELT AND WASHINGTON - WEEKDAY
NORTHBOUND
RANKED HOURLY VOLUMES AS A PERCENTAGE OF DAILY AND PEAK HOURLY VOLUMES

ACTUAL VOLUME	RANKED VOLUME	RANK	PORTION OF DAY	RATIO OF PEAK
116	1,726	1	8.54%	100.00%
73	1,670	2	8.27%	96.76%
83	1,396	3	6.91%	80.88%
88	1,306	**4**	**6.47%**	**75.67%**
215	1,286	5	6.37%	74.51%
669	1,266	6	6.27%	73.35%
903	1,230	7	6.09%	71.26%
1,670	1,198	**8**	**5.93%**	**69.41%**
1,726	1,198	9	5.93%	69.41%
1,396	1,168	10	5.78%	67.67%
1,198	1,163	11	5.76%	67.38%
1,163	1,120	12	5.54%	64.89%
1,266	907	13	4.49%	52.55%
1,198	903	14	4.47%	52.32%
1,168	669	15	3.31%	38.76%
1,120	519	16	2.57%	30.07%
1,230	409	17	2.02%	23.70%
1,306	320	18	1.58%	18.54%
1,286	215	19	1.06%	12.46%
907	170	20	0.84%	9.85%
519	116	21	0.57%	6.72%
409	88	22	0.44%	5.10%
320	83	23	0.41%	4.81%
170	73	24	0.36%	0.36%
20,199	**20,199**		**100.00%**	

Analysis By: RCS Date: 11/11/2010
Checked By: RCS Date: 11/11/2010


MAG NON-RECURRING CONGESTION STUDY
RURAL ROAD, BETWEEN RIO SALADO AND 6TH STREET - WEEKDAY
NORTHBOUND HOURLY TRAFFIC VOLUMES
HOURLY VOLUME (vehicles)
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
BEGINNING OF HOUR


MAG NON-RECURRING CONGESTION STUDY
RURAL ROAD, BETWEEN RIO SALADO AND 6TH STREET - WEEKDAY
NORTHBOUND 15-MINUTE TRAFFIC VOLUMES
15-MINUTE VOLUME (vehicles)
450
400
350
300
250
200
150
100
50
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
12:00 AM
BEGINNING OF 15-MINUTE PERIOD

MAG NON-RECURRING CONGESTION STUDY
RURAL ROAD, BETWEEN RIO SALADO AND 6TH STREET - WEEKDAY
NORTHBOUND

BEGIN PERIOD	MORNING 15 MINUTES	MORNING 60 MINUTES	EVENING 15 MINUTES	EVENING 60 MINUTES	BEGIN PERIOD
12:00 AM	79	**235**	324	**1,311**	**12:00 PM**
12:15 AM	61.5	199	322.5	1,289	12:15 PM
12:30 AM	54	179	304	1,254	12:30 PM
12:45 AM	40.5	184	360	1,241	12:45 PM
1:00 AM	43	**186**	302	**1,157**	**1:00 PM**
1:15 AM	41	187	288	1,124	1:15 PM
1:30 AM	59.5	187	290.5	1,181	1:30 PM
1:45 AM	42	175	276.5	1,214	1:45 PM
2:00 AM	44	**161**	268.5	**1,224**	**2:00 PM**
2:15 AM	41	139	345.5	1,238	2:15 PM
2:30 AM	47.5	118	323.5	1,185	2:30 PM
2:45 AM	28	92	286	1,205	2:45 PM
3:00 AM	22	**80**	283	**1,284**	**3:00 PM**
3:15 AM	20.5	73	292.5	1,369	3:15 PM
3:30 AM	21.5	76	343.5	1,448	3:30 PM
3:45 AM	16	86	365	1,479	3:45 PM
4:00 AM	15	**104**	367.5	**1,504**	**4:00 PM**
4:15 AM	23.5	143	372	1,548	4:15 PM
4:30 AM	31.5	218	374.5	1,600	4:30 PM
4:45 AM	33.5	305	390	1,601	4:45 PM
5:00 AM	54.5	**353**	411.5	**1,572**	**5:00 PM**
5:15 AM	98.5	397	424	1,494	5:15 PM
5:30 AM	118.5	421	375	1,414	5:30 PM
5:45 AM	81.5	478	361.5	1,378	5:45 PM
6:00 AM	98.5	**603**	333.5	**1,306**	**6:00 PM**
6:15 AM	122.5	752	343.5	1,259	6:15 PM
6:30 AM	175	861	339.5	1,170	6:30 PM
6:45 AM	207	984	289	1,063	6:45 PM
7:00 AM	247.5	**1,066**	287	**1,000**	**7:00 PM**
7:15 AM	231	1,157	254	982	7:15 PM
7:30 AM	298.5	1,262	232.5	945	7:30 PM
7:45 AM	288.5	1,295	226.5	942	7:45 PM
8:00 AM	338.5	**1,271**	269	**956**	**8:00 PM**
8:15 AM	336	1,210	217	947	8:15 PM
8:30 AM	331.5	1,131	229.5	971	8:30 PM
8:45 AM	264.5	1,053	240	971	8:45 PM
9:00 AM	278	**1,067**	260	**941**	**9:00 PM**
9:15 AM	257	1,083	241.5	876	9:15 PM
9:30 AM	253	1,063	229	821	9:30 PM
9:45 AM	278.5	1,076	210	766	9:45 PM
10:00 AM	294	**1,054**	195.5	**729**	**10:00 PM**
10:15 AM	237.5	1,064	186.5	690	10:15 PM
10:30 AM	265.5	1,145	174	657	10:30 PM
10:45 AM	256.5	1,219	173	620	10:45 PM
11:00 AM	304.5	**1,245**	156.5	**567**	**11:00 PM**
11:15 AM	318.5	1,265	153	-	11:15 PM
11:30 AM	339	1,269	137.5	-	11:30 PM
11:45 AM	283	1,234	119.5	-	11:45 PM
AM PEAK VOLUME	**339**	**1,295**	**424**	**1,601**	PM PEAK VOLUME
PHF and TIME	**0.96**	**7:45 AM**	**0.94**	**4:45 PM**	PHF and TIME
DAILY VOLUME	**20969.5**				

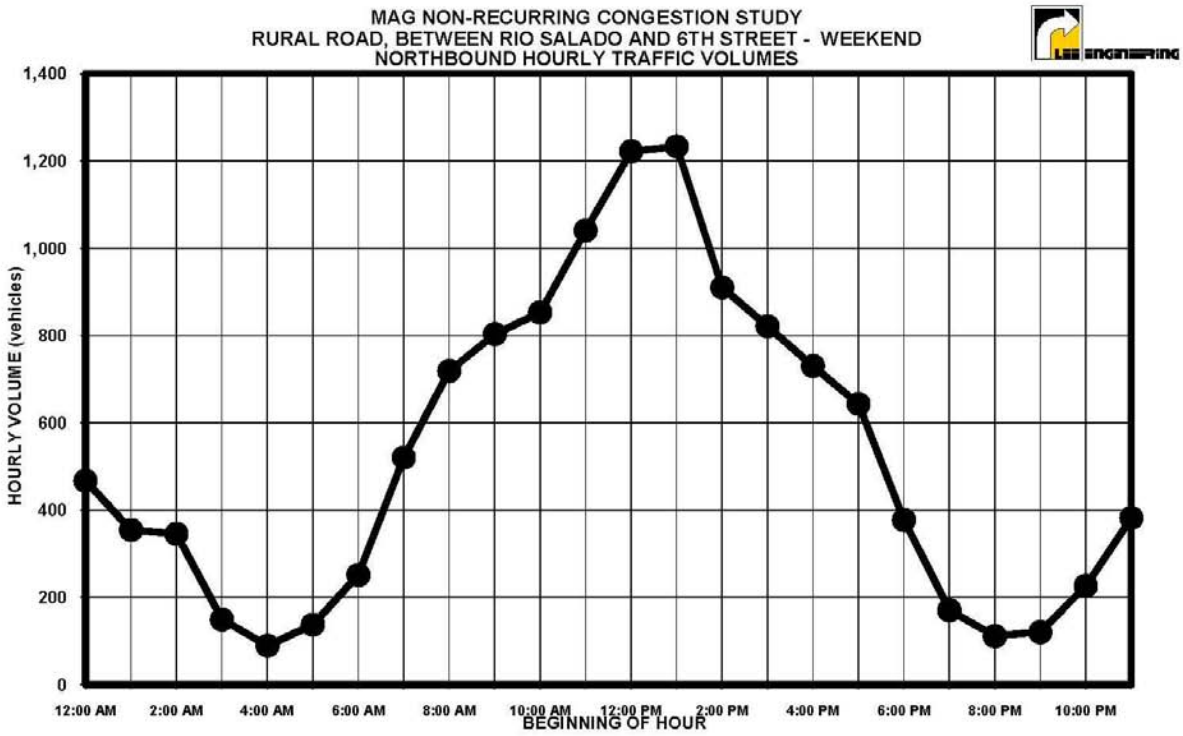
Analysis By: RCS Date: 11/11/2010

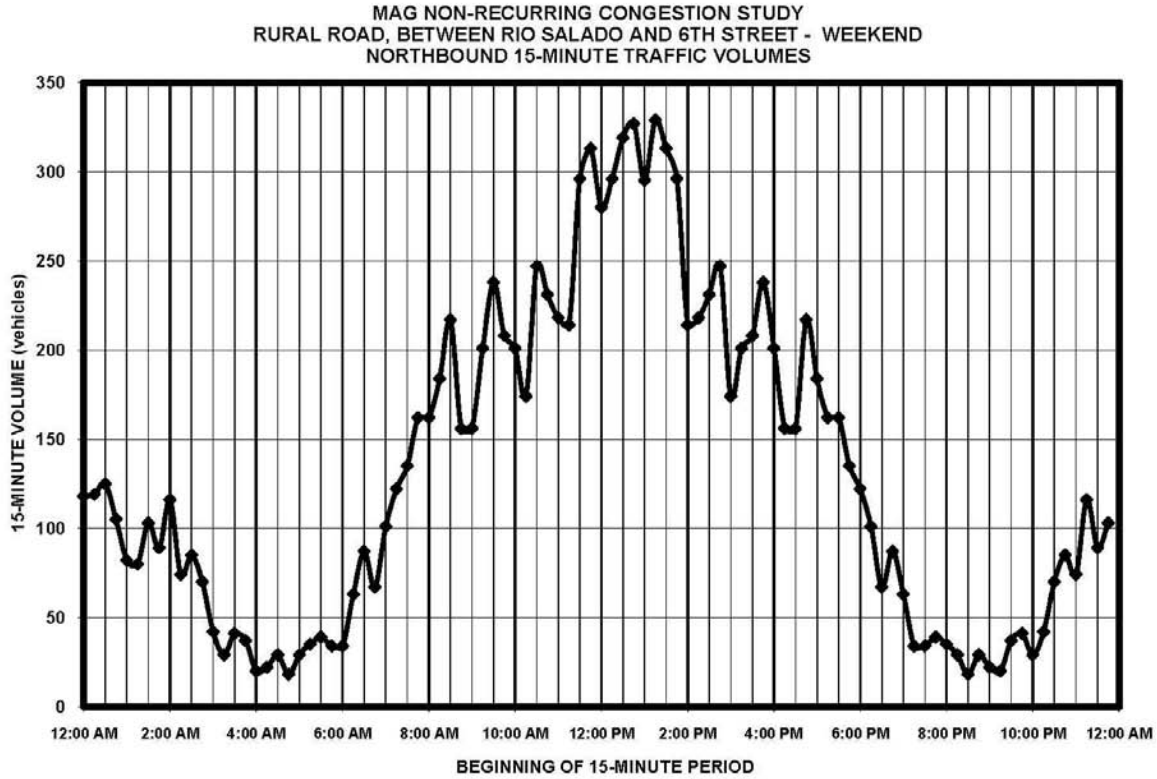
Checked By: LYK Date: 11/19/2010

MAG NON-RECURRING CONGESTION STUDY
RURAL ROAD, BETWEEN RIO SALADO AND 6TH STREET - WEEKDAY
NORTHBOUND
RANKED HOURLY VOLUMES AS A PERCENTAGE OF DAILY AND PEAK HOURLY VOLUMES

ACTUAL VOLUME	RANKED VOLUME	RANK	PORTION OF DAY	RATIO OF PEAK
235	1,572	1	7.50%	100.00%
186	1,504	2	7.17%	95.67%
161	1,311	3	6.25%	83.37%
80	1,306	**4**	**6.23%**	**83.05%**
104	1,284	5	6.12%	81.68%
353	1,271	6	6.06%	80.82%
603	1,245	7	5.94%	79.20%
1,066	1,224	**8**	**5.83%**	**77.83%**
1,271	1,157	9	5.52%	73.60%
1,067	1,067	10	5.09%	67.84%
1,054	1,066	11	5.08%	67.78%
1,245	1,054	12	5.02%	67.02%
1,311	1,000	13	4.77%	63.61%
1,157	956	14	4.56%	60.78%
1,224	941	15	4.49%	59.83%
1,284	729	16	3.48%	46.37%
1,504	603	17	2.88%	38.36%
1,572	567	18	2.70%	36.04%
1,306	353	19	1.68%	22.46%
1,000	235	20	1.12%	14.95%
956	186	21	0.88%	11.80%
941	161	22	0.77%	10.21%
729	104	23	0.49%	6.58%
567	80	24	0.38%	0.38%
20,970	**20,970**		**100.00%**	

Analysis By: RCS Date: 11/11/2010
Checked By: LYK Date: 11/19/2010


MAG NON-RECURRING CONGESTION STUDY
RURAL ROAD, BETWEEN RIO SALADO AND 6TH STREET - WEEKEND
NORTHBOUND HOURLY TRAFFIC VOLUMES
HOURLY VOLUME (vehicles)
1,400
1,200
1,000
800
600
400
200
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
BEGINNING OF HOUR


MAG NON-RECURRING CONGESTION STUDY
RURAL ROAD, BETWEEN RIO SALADO AND 6TH STREET - WEEKEND
NORTHBOUND 15-MINUTE TRAFFIC VOLUMES
15-MINUTE VOLUME (vehicles)
350
300
250
200
150
100
50
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
12:00 AM
BEGINNING OF 15-MINUTE PERIOD

MAG NON-RECURRING CONGESTION STUDY
RURAL ROAD, BETWEEN RIO SALADO AND 6TH STREET - WEEKEND
SOUTHBOUND

BEGIN PERIOD	MORNING 15 MINUTES	MORNING 60 MINUTES	EVENING 15 MINUTES	EVENING 60 MINUTES	BEGIN PERIOD
12:00 AM	118	**467**	280	**1,222**	**12:00 PM**
12:15 AM	119	431	296	1,237	12:15 PM
12:30 AM	125	392	319	1,270	12:30 PM
12:45 AM	105	370	327	1,264	12:45 PM
1:00 AM	82	**354**	295	**1,233**	**1:00 PM**
1:15 AM	80	388	329	1,152	1:15 PM
1:30 AM	103	382	313	1,041	1:30 PM
1:45 AM	89	364	296	959	1:45 PM
2:00 AM	116	**345**	214	**910**	**2:00 PM**
2:15 AM	74	271	218	870	2:15 PM
2:30 AM	85	226	231	853	2:30 PM
2:45 AM	70	182	247	830	2:45 PM
3:00 AM	42	**149**	174	**821**	**3:00 PM**
3:15 AM	29	127	201	848	3:15 PM
3:30 AM	41	120	208	803	3:30 PM
3:45 AM	37	108	238	751	3:45 PM
4:00 AM	20	**89**	201	**730**	**4:00 PM**
4:15 AM	22	98	156	713	4:15 PM
4:30 AM	29	111	156	719	4:30 PM
4:45 AM	18	121	217	725	4:45 PM
5:00 AM	29	**137**	184	**643**	**5:00 PM**
5:15 AM	35	142	162	581	5:15 PM
5:30 AM	39	170	162	520	5:30 PM
5:45 AM	34	218	135	425	5:45 PM
6:00 AM	34	**251**	122	**377**	**6:00 PM**
6:15 AM	63	318	101	318	6:15 PM
6:30 AM	87	377	67	251	6:30 PM
6:45 AM	67	425	87	218	6:45 PM
7:00 AM	101	**520**	63	**170**	**7:00 PM**
7:15 AM	122	581	34	142	7:15 PM
7:30 AM	135	643	34	137	7:30 PM
7:45 AM	162	725	39	121	7:45 PM
8:00 AM	162	**719**	35	**111**	**8:00 PM**
8:15 AM	184	713	29	98	8:15 PM
8:30 AM	217	730	18	89	8:30 PM
8:45 AM	156	751	29	108	8:45 PM
9:00 AM	156	**803**	22	**120**	**9:00 PM**
9:15 AM	201	848	20	127	9:15 PM
9:30 AM	238	821	37	149	9:30 PM
9:45 AM	208	830	41	182	9:45 PM
10:00 AM	201	**853**	29	**226**	**10:00 PM**
10:15 AM	174	870	42	271	10:15 PM
10:30 AM	247	910	70	345	10:30 PM
10:45 AM	231	959	85	364	10:45 PM
11:00 AM	218	**1,041**	74	**382**	**11:00 PM**
11:15 AM	214	1,103	116	-	11:15 PM
11:30 AM	296	1,185	89	-	11:30 PM
11:45 AM	313	1,208	103	-	11:45 PM
AM PEAK VOLUME	**319**	**1,208**	**329**	**1,270**	PM PEAK VOLUME
PHF and TIME	**0.95**	**11:45 AM**	**0.97**	**12:30 PM**	PHF and TIME
DAILY VOLUME	**12673**				

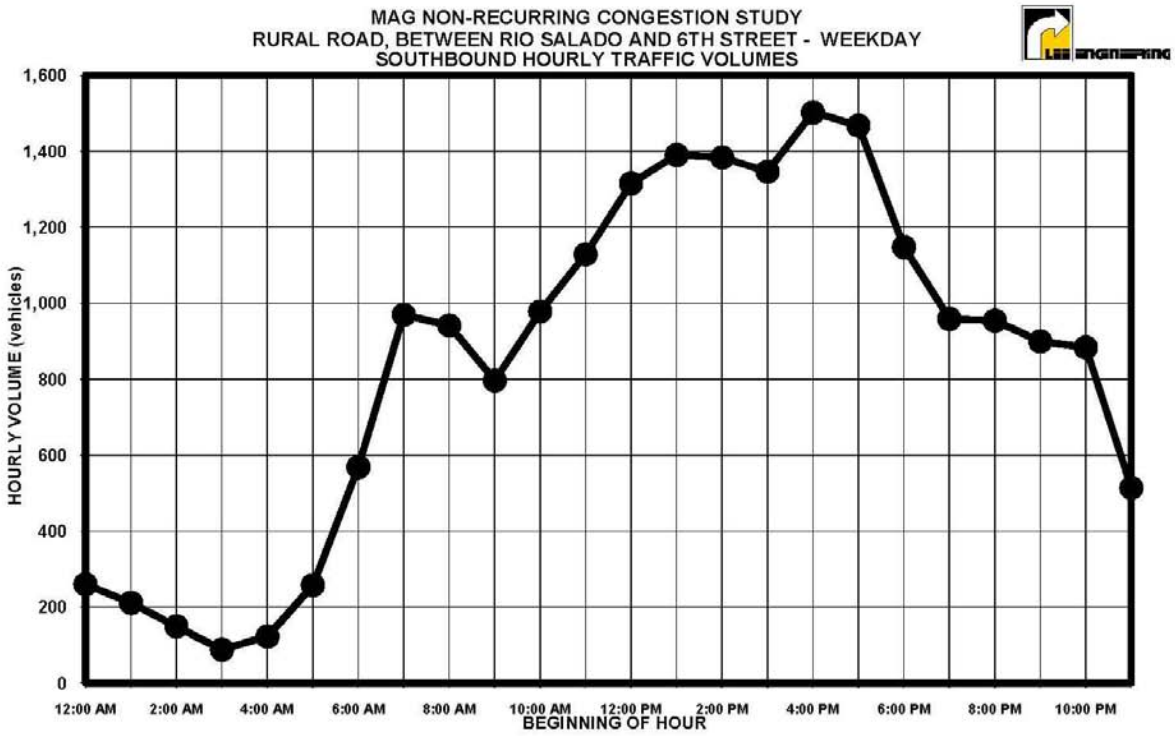
Analysis By: RCS Date: 11/11/2010

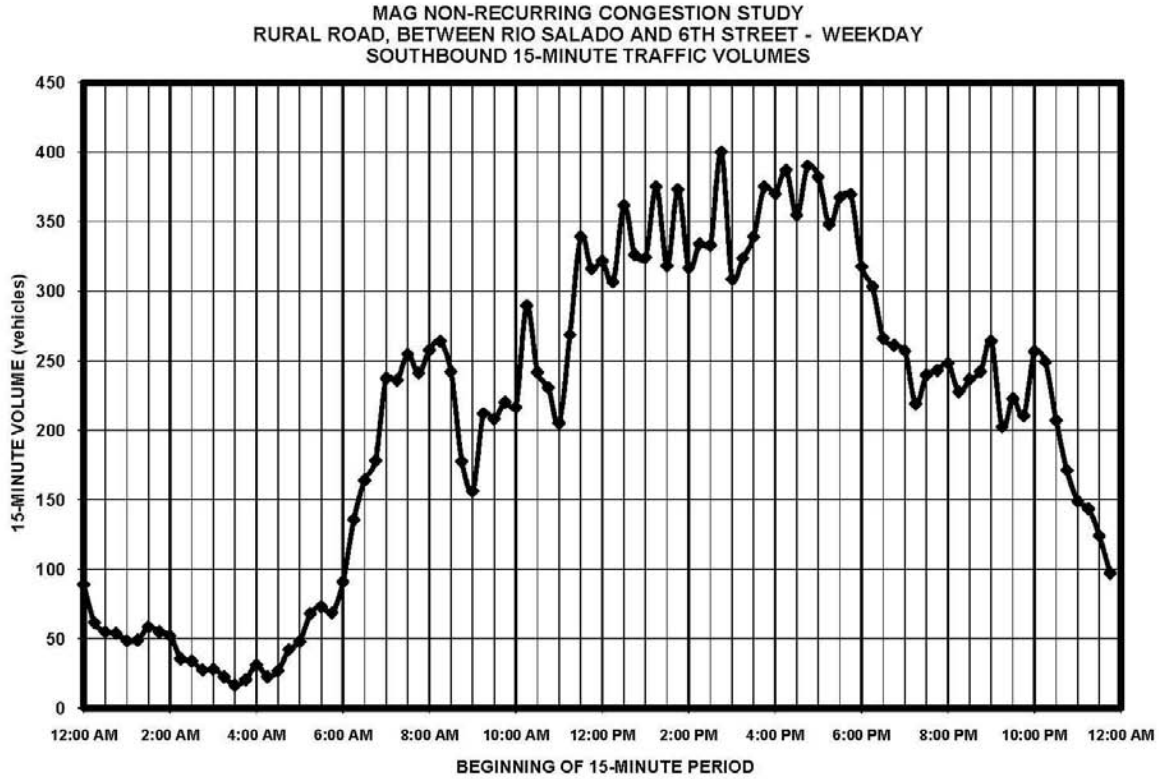
Checked By: RCS Date: 11/11/2010

MAG NON-RECURRING CONGESTION STUDY
RURAL ROAD, BETWEEN RIO SALADO AND 6TH STREET - WEEKEND
NORTHBOUND
RANKED HOURLY VOLUMES AS A PERCENTAGE OF DAILY AND PEAK HOURLY VOLUMES

ACTUAL VOLUME	RANKED VOLUME	RANK	PORTION OF DAY	RATIO OF PEAK
467	1,233	1	9.73%	100.00%
354	1,222	2	9.64%	99.11%
345	1,041	3	8.21%	84.43%
149	910	**4**	**7.18%**	**73.80%**
89	853	5	6.73%	69.18%
137	821	6	6.48%	66.59%
251	803	7	6.34%	65.13%
520	730	**8**	**5.76%**	**59.21%**
719	719	9	5.67%	58.31%
803	643	10	5.07%	52.15%
853	520	11	4.10%	42.17%
1,041	467	12	3.68%	37.88%
1,222	382	13	3.01%	30.98%
1,233	377	14	2.97%	30.58%
910	354	15	2.79%	28.71%
821	345	16	2.72%	27.98%
730	251	17	1.98%	20.36%
643	226	18	1.78%	18.33%
377	170	19	1.34%	13.79%
170	149	20	1.18%	12.08%
111	137	21	1.08%	11.11%
120	120	22	0.95%	9.73%
226	111	23	0.88%	9.00%
382	89	24	0.70%	0.70%
12,673	**12,673**		**100.00%**	

Analysis By: RCS Date: 11/11/2010
Checked By: RCS Date: 11/11/2010


MAG NON-RECURRING CONGESTION STUDY
RURAL ROAD, BETWEEN RIO SALADO AND 6TH STREET - WEEKDAY
SOUTHBOUND HOURLY TRAFFIC VOLUMES
HOURLY VOLUME (vehicles)
1,600
1,400
1,200
1,000
800
600
400
200
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
BEGINNING OF HOUR


MAG NON-RECURRING CONGESTION STUDY
RURAL ROAD, BETWEEN RIO SALADO AND 6TH STREET - WEEKDAY
SOUTHBOUND 15-MINUTE TRAFFIC VOLUMES
15-MINUTE VOLUME (vehicles)
450
400
350
300
250
200
150
100
50
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
12:00 AM
BEGINNING OF 15-MINUTE PERIOD

MAG NON-RECURRING CONGESTION STUDY
RURAL ROAD, BETWEEN RIO SALADO AND 6TH STREET - WEEKDAY
SOUTHBOUND

BEGIN PERIOD	MORNING 15 MINUTES	MORNING 60 MINUTES	EVENING 15 MINUTES	EVENING 60 MINUTES	BEGIN PERIOD
12:00 AM	89	**260**	321.5	**1,316**	**12:00 PM**
12:15 AM	61.5	219	306.5	1,318	12:15 PM
12:30 AM	55	207	361.5	1,387	12:30 PM
12:45 AM	54	210	326	1,343	12:45 PM
1:00 AM	48.5	**211**	324	**1,390**	**1:00 PM**
1:15 AM	49	215	375	1,383	1:15 PM
1:30 AM	58.5	201	318	1,342	1:30 PM
1:45 AM	55	177	373	1,357	1:45 PM
2:00 AM	52	**149**	316.5	**1,384**	**2:00 PM**
2:15 AM	35.5	125	334	1,376	2:15 PM
2:30 AM	34	112	333	1,365	2:30 PM
2:45 AM	27.5	95	400	1,371	2:45 PM
3:00 AM	28	**88**	308.5	**1,346**	**3:00 PM**
3:15 AM	22.5	91	323.5	1,408	3:15 PM
3:30 AM	16.5	91	339	1,471	3:30 PM
3:45 AM	20.5	101	375	1,487	3:45 PM
4:00 AM	31	**123**	370	**1,502**	**4:00 PM**
4:15 AM	22.5	140	387	1,514	4:15 PM
4:30 AM	27	185	354.5	1,475	4:30 PM
4:45 AM	42	231	390	1,488	4:45 PM
5:00 AM	48	**258**	382	**1,467**	**5:00 PM**
5:15 AM	68	301	348	1,403	5:15 PM
5:30 AM	73	368	367.5	1,358	5:30 PM
5:45 AM	68.5	459	369.5	1,256	5:45 PM
6:00 AM	91	**569**	317.5	**1,148**	**6:00 PM**
6:15 AM	135.5	715	303	1,087	6:15 PM
6:30 AM	164	816	266	1,003	6:30 PM
6:45 AM	178	906	261	977	6:45 PM
7:00 AM	237.5	**969**	257	**959**	**7:00 PM**
7:15 AM	236	989	219	950	7:15 PM
7:30 AM	254.5	1,017	239.5	958	7:30 PM
7:45 AM	241	1,005	243	955	7:45 PM
8:00 AM	257.5	**941**	248	**954**	**8:00 PM**
8:15 AM	264	840	227.5	970	8:15 PM
8:30 AM	242	788	236.5	945	8:30 PM
8:45 AM	177.5	754	242	931	8:45 PM
9:00 AM	156	**796**	264	**900**	**9:00 PM**
9:15 AM	212	857	202.5	892	9:15 PM
9:30 AM	208	934	222.5	939	9:30 PM
9:45 AM	220	968	210.5	923	9:45 PM
10:00 AM	216.5	**978**	256.5	**884**	**10:00 PM**
10:15 AM	289.5	967	249	776	10:15 PM
10:30 AM	241.5	946	207	671	10:30 PM
10:45 AM	230.5	1,043	171	588	10:45 PM
11:00 AM	205	**1,129**	149	**514**	**11:00 PM**
11:15 AM	268.5	1,245	143.5	-	11:15 PM
11:30 AM	339	1,283	124	-	11:30 PM
11:45 AM	316	1,306	97	-	11:45 PM
AM PEAK VOLUME	**362**	**1,306**	**390**	**1,514**	PM PEAK VOLUME
PHF and TIME	**0.90**	**11:45 AM**	**0.97**	**4:15 PM**	PHF and TIME
DAILY VOLUME	**20228**				

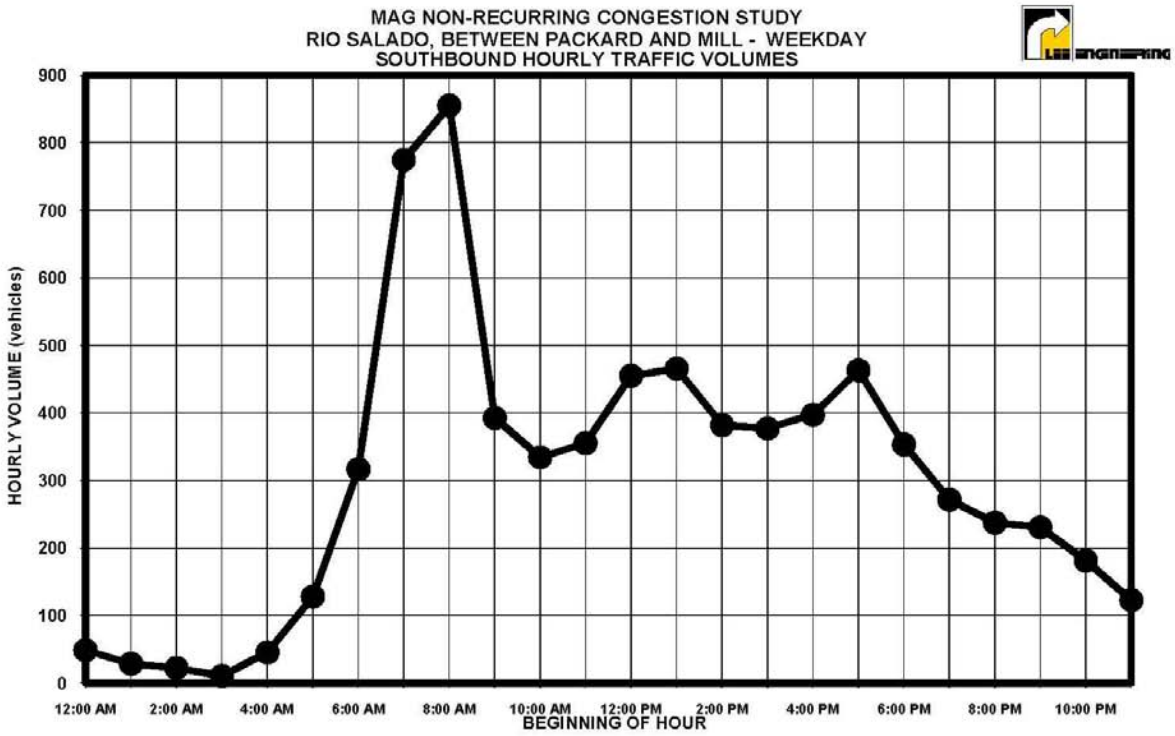
Analysis By: RCS Date: 11/11/2010

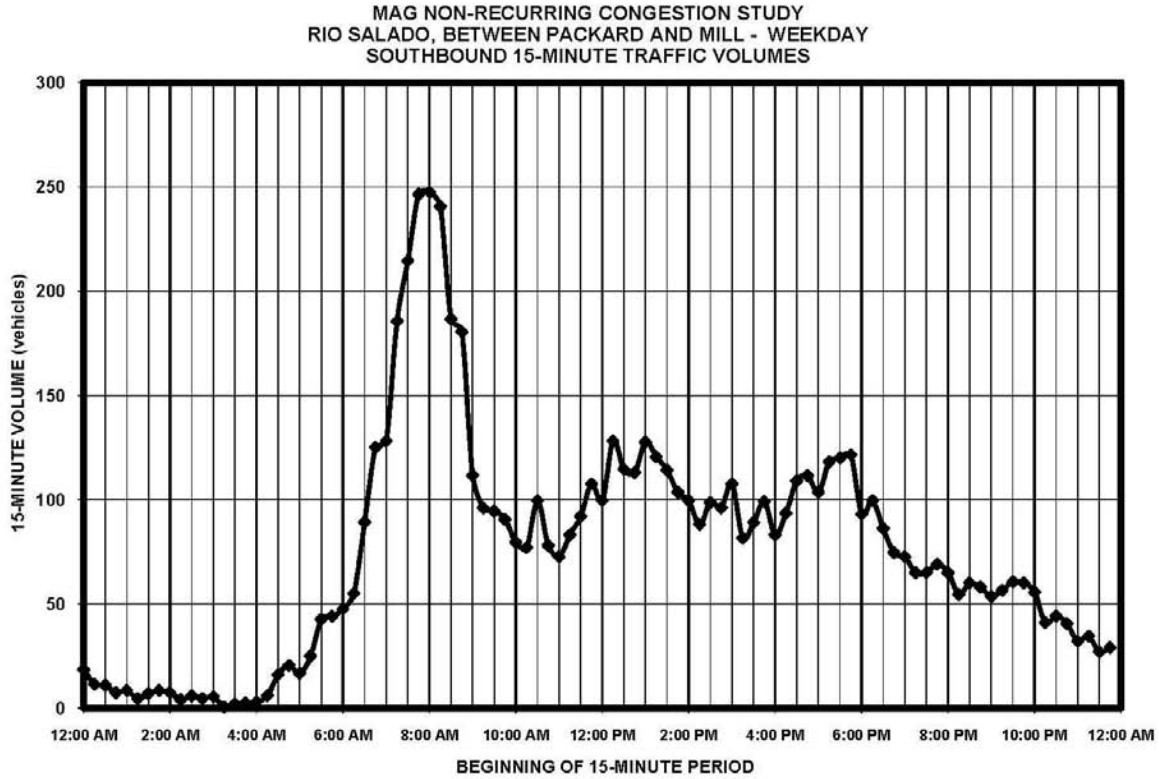
Checked By: LYK Date: 11/19/2010

MAG NON-RECURRING CONGESTION STUDY
RURAL ROAD, BETWEEN RIO SALADO AND 6TH STREET - WEEKDAY
SOUTHBOUND
RANKED HOURLY VOLUMES AS A PERCENTAGE OF DAILY AND PEAK HOURLY VOLUMES

ACTUAL VOLUME	RANKED VOLUME	RANK	PORTION OF DAY	RATIO OF PEAK
260	1,502	1	7.42%	100.00%
211	1,467	2	7.25%	97.70%
149	1,390	3	6.87%	92.57%
88	1,384	**4**	**6.84%**	**92.14%**
123	1,346	5	6.65%	89.64%
258	1,316	6	6.50%	87.61%
569	1,148	7	5.67%	76.42%
969	1,129	**8**	**5.58%**	**75.16%**
941	978	9	4.83%	65.13%
796	969	10	4.79%	64.54%
978	959	11	4.74%	63.84%
1,129	954	12	4.72%	63.54%
1,316	941	13	4.65%	62.67%
1,390	900	14	4.45%	59.91%
1,384	884	15	4.37%	58.84%
1,346	796	16	3.94%	53.01%
1,502	569	17	2.81%	37.86%
1,467	514	18	2.54%	34.20%
1,148	260	19	1.28%	17.28%
959	258	20	1.27%	17.15%
954	211	21	1.04%	14.05%
900	149	22	0.74%	9.92%
884	123	23	0.61%	8.16%
514	88	24	0.43%	0.43%
20,228	**20,228**		**100.00%**	

Analysis By: RCS Date: 11/11/2010
Checked By: LYK Date: 11/19/2010


MAG NON-RECURRING CONGESTION STUDY
RIO SALADO, BETWEEN PACKARD AND MILL - WEEKDAY
SOUTHBOUND HOURLY TRAFFIC VOLUMES
HOURLY VOLUME (vehicles)
900
800
700
600
500
400
300
200
100
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
BEGINNING OF HOUR


MAG NON-RECURRING CONGESTION STUDY
RIO SALADO, BETWEEN PACKARD AND MILL - WEEKDAY
SOUTHBOUND 15-MINUTE TRAFFIC VOLUMES
15-MINUTE VOLUME (vehicles)
300
250
200
150
100
50
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
12:00 AM
BEGINNING OF 15-MINUTE PERIOD

MAG NON-RECURRING CONGESTION STUDY
RIO SALADO, BETWEEN PACKARD AND MILL - WEEKDAY
WESTBOUND

BEGIN PERIOD	MORNING 15 MINUTES	MORNING 60 MINUTES	EVENING 15 MINUTES	EVENING 60 MINUTES	BEGIN PERIOD
12:00 AM	18.5	**49**	99.5	**455**	**12:00 PM**
12:15 AM	11.5	39	128	483	12:15 PM
12:30 AM	11	32	114.5	476	12:30 PM
12:45 AM	7.5	28	113	475	12:45 PM
1:00 AM	8.5	**29**	127.5	**466**	**1:00 PM**
1:15 AM	4.5	28	120.5	438	1:15 PM
1:30 AM	7	27	114	405	1:30 PM
1:45 AM	8.5	26	103.5	390	1:45 PM
2:00 AM	7.5	**22**	99.5	**382**	**2:00 PM**
2:15 AM	4	20	88	390	2:15 PM
2:30 AM	6	17	98.5	384	2:30 PM
2:45 AM	4.5	13	96	374	2:45 PM
3:00 AM	5.5	**11**	107.5	**377**	**3:00 PM**
3:15 AM	0.5	8	81.5	353	3:15 PM
3:30 AM	2	14	89	365	3:30 PM
3:45 AM	2.5	28	99	385	3:45 PM
4:00 AM	3	**46**	83	**397**	**4:00 PM**
4:15 AM	6	59	93.5	418	4:15 PM
4:30 AM	16	78	109	442	4:30 PM
4:45 AM	20.5	105	111.5	453	4:45 PM
5:00 AM	16.5	**128**	103.5	**463**	**5:00 PM**
5:15 AM	25	159	118	453	5:15 PM
5:30 AM	42.5	189	120	434	5:30 PM
5:45 AM	44	236	121.5	400	5:45 PM
6:00 AM	47.5	**317**	93	**353**	**6:00 PM**
6:15 AM	55	397	99.5	333	6:15 PM
6:30 AM	89	528	86	298	6:30 PM
6:45 AM	125	653	74.5	277	6:45 PM
7:00 AM	128	**775**	72.5	**272**	**7:00 PM**
7:15 AM	185.5	894	65	264	7:15 PM
7:30 AM	214.5	949	65	254	7:30 PM
7:45 AM	246.5	921	69	249	7:45 PM
8:00 AM	247.5	**855**	65	**238**	**8:00 PM**
8:15 AM	240.5	719	54.5	226	8:15 PM
8:30 AM	186.5	575	60	228	8:30 PM
8:45 AM	180.5	483	58	229	8:45 PM
9:00 AM	111.5	**393**	53.5	**231**	**9:00 PM**
9:15 AM	96	361	56.5	233	9:15 PM
9:30 AM	94.5	342	60.5	217	9:30 PM
9:45 AM	90.5	347	60	201	9:45 PM
10:00 AM	79.5	**334**	55.5	**181**	**10:00 PM**
10:15 AM	77	327	41	158	10:15 PM
10:30 AM	99.5	333	44	151	10:30 PM
10:45 AM	78	326	40.5	134	10:45 PM
11:00 AM	72.5	**355**	32	**123**	**11:00 PM**
11:15 AM	83	382	34.5	-	11:15 PM
11:30 AM	92	427	27	-	11:30 PM
11:45 AM	107.5	450	29	-	11:45 PM
AM PEAK VOLUME	**248**	**949**	**128**	**483**	PM PEAK VOLUME
PHF and TIME	**0.96**	**7:30 AM**	**0.94**	**12:15 PM**	PHF and TIME
DAILY VOLUME	**7246**				

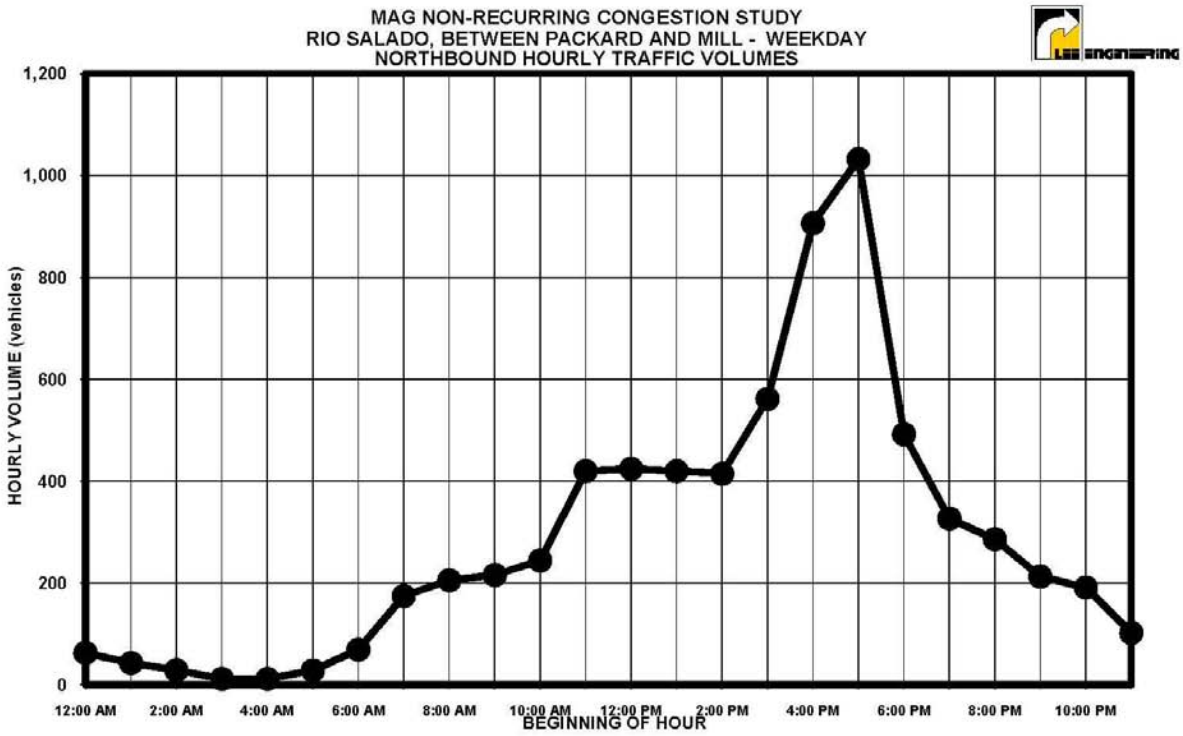
Analysis By: RCS Date: 11/11/2010

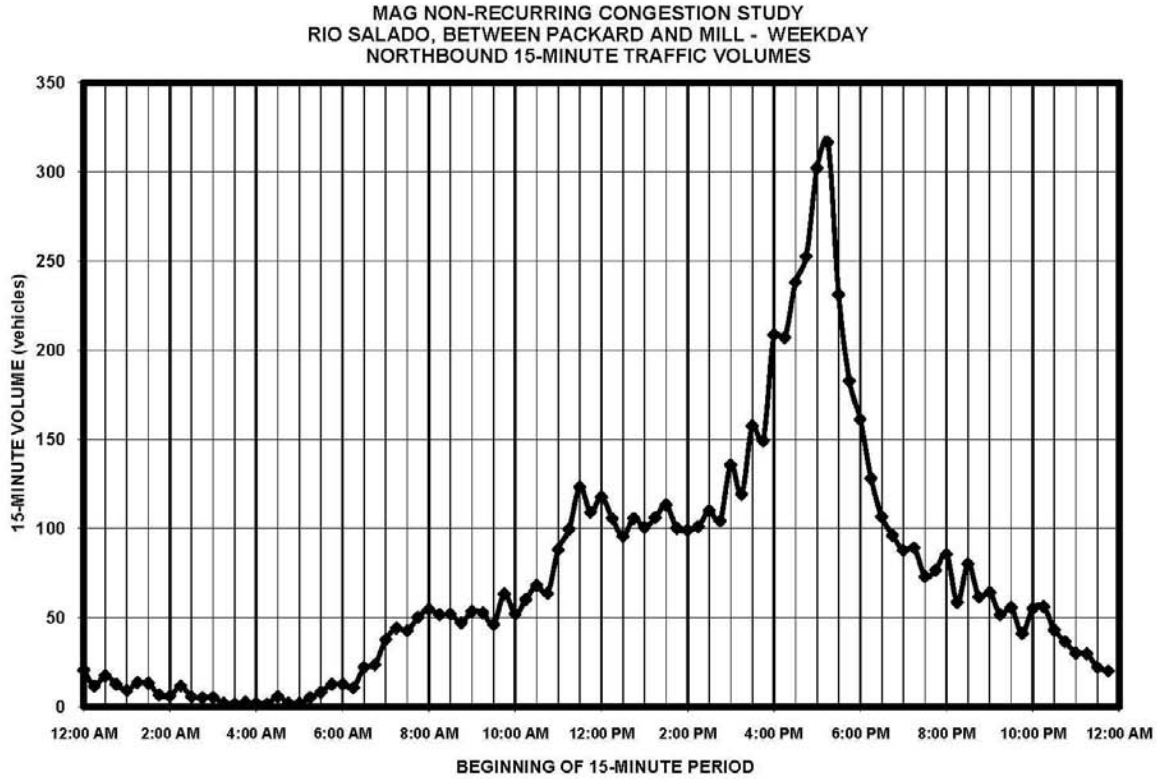
Checked By: RCS Date: 11/11/2010

MAG NON-RECURRING CONGESTION STUDY
RIO SALADO, BETWEEN PACKARD AND MILL - WEEKDAY
SOUTHBOUND
RANKED HOURLY VOLUMES AS A PERCENTAGE OF DAILY AND PEAK HOURLY VOLUMES

ACTUAL VOLUME	RANKED VOLUME	RANK	PORTION OF DAY	RATIO OF PEAK
49	855	1	11.80%	100.00%
29	775	2	10.69%	90.58%
22	466	3	6.42%	54.44%
11	463	**4**	**6.39%**	**54.15%**
46	455	5	6.28%	53.22%
128	397	6	5.48%	46.43%
317	393	7	5.42%	45.91%
775	382	**8**	**5.27%**	**44.68%**
855	377	9	5.20%	44.09%
393	355	10	4.90%	41.52%
334	353	11	4.87%	41.29%
355	334	12	4.61%	39.06%
455	317	13	4.37%	37.02%
466	272	14	3.75%	31.75%
382	238	15	3.28%	27.78%
377	231	16	3.18%	26.96%
397	181	17	2.50%	21.17%
463	128	18	1.77%	14.97%
353	123	19	1.69%	14.33%
272	49	20	0.67%	5.67%
238	46	21	0.63%	5.32%
231	29	22	0.39%	3.33%
181	22	23	0.30%	2.57%
123	11	24	0.14%	0.14%
7,246	**7,246**		**100.00%**	

Analysis By: RCS Date: 11/11/2010
Checked By: RCS Date: 11/11/2010


MAG NON-RECURRING CONGESTION STUDY
RIO SALADO, BETWEEN PACKARD AND MILL - WEEKDAY
NORTHBOUND HOURLY TRAFFIC VOLUMES
HOURLY VOLUME (vehicles)
1,200
1,000
800
600
400
200
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
BEGINNING OF HOUR


MAG NON-RECURRING CONGESTION STUDY
RIO SALADO, BETWEEN PACKARD AND MILL - WEEKDAY
NORTHBOUND 15-MINUTE TRAFFIC VOLUMES
15-MINUTE VOLUME (vehicles)
350
300
250
200
150
100
50
0
12:00 AM
2:00 AM
4:00 AM
6:00 AM
8:00 AM
10:00 AM
12:00 PM
2:00 PM
4:00 PM
6:00 PM
8:00 PM
10:00 PM
12:00 AM
BEGINNING OF 15-MINUTE PERIOD

MAG NON-RECURRING CONGESTION STUDY
RIO SALADO, BETWEEN PACKARD AND MILL - WEEKDAY
EASTBOUND

BEGIN PERIOD	MORNING 15 MINUTES	MORNING 60 MINUTES	EVENING 15 MINUTES	EVENING 60 MINUTES	BEGIN PERIOD
12:00 AM	20.5	**62**	117.5	**424**	**12:00 PM**
12:15 AM	11.5	51	105.5	407	12:15 PM
12:30 AM	17.5	53	95.5	408	12:30 PM
12:45 AM	12.5	48	105.5	425	12:45 PM
1:00 AM	9	**42**	100.5	**420**	**1:00 PM**
1:15 AM	13.5	39	106	418	1:15 PM
1:30 AM	13	37	113	413	1:30 PM
1:45 AM	6.5	30	100	410	1:45 PM
2:00 AM	6	**28**	99	**414**	**2:00 PM**
2:15 AM	11.5	27	101	451	2:15 PM
2:30 AM	5.5	18	110	469	2:30 PM
2:45 AM	5	14	104	516	2:45 PM
3:00 AM	5	**11**	135.5	**561**	**3:00 PM**
3:15 AM	2	8	119	634	3:15 PM
3:30 AM	1.5	8	157.5	722	3:30 PM
3:45 AM	2.5	12	149	803	3:45 PM
4:00 AM	2	**11**	208.5	**906**	**4:00 PM**
4:15 AM	1.5	11	207	1,000	4:15 PM
4:30 AM	5.5	15	238	1,109	4:30 PM
4:45 AM	2	17	252.5	1,102	4:45 PM
5:00 AM	2	**28**	302	**1,032**	**5:00 PM**
5:15 AM	5	38	316.5	891	5:15 PM
5:30 AM	8	44	231	703	5:30 PM
5:45 AM	12.5	58	182.5	578	5:45 PM
6:00 AM	12.5	**69**	161	**492**	**6:00 PM**
6:15 AM	10.5	94	128	418	6:15 PM
6:30 AM	22	127	106.5	379	6:30 PM
6:45 AM	23.5	148	96	346	6:45 PM
7:00 AM	37.5	**174**	87.5	**326**	**7:00 PM**
7:15 AM	44	191	89	324	7:15 PM
7:30 AM	42.5	199	73	294	7:30 PM
7:45 AM	50	208	76.5	301	7:45 PM
8:00 AM	54.5	**205**	85.5	**286**	**8:00 PM**
8:15 AM	51.5	204	58.5	264	8:15 PM
8:30 AM	52	205	80	257	8:30 PM
8:45 AM	47	199	61.5	233	8:45 PM
9:00 AM	53.5	**215**	64	**212**	**9:00 PM**
9:15 AM	52.5	214	51.5	203	9:15 PM
9:30 AM	46	221	55.5	208	9:30 PM
9:45 AM	63	243	41	195	9:45 PM
10:00 AM	52	**244**	55	**191**	**10:00 PM**
10:15 AM	60	280	56	166	10:15 PM
10:30 AM	68	319	43	139	10:30 PM
10:45 AM	63.5	374	36.5	118	10:45 PM
11:00 AM	88	**420**	30	**102**	**11:00 PM**
11:15 AM	99.5	449	29.5	-	11:15 PM
11:30 AM	123	455	22	-	11:30 PM
11:45 AM	109	428	20	-	11:45 PM
AM PEAK VOLUME	**123**	**455**	**317**	**1,109**	PM PEAK VOLUME
PHF and TIME	**0.92**	**11:30 AM**	**0.88**	**4:30 PM**	PHF and TIME
DAILY VOLUME	**6870.5**				

Analysis By: RCS Date: 11/11/2010

Checked By: RCS Date: 11/11/2010

MAG NON-RECURRING CONGESTION STUDY
RIO SALADO, BETWEEN PACKARD AND MILL - WEEKDAY
NORTHBOUND
RANKED HOURLY VOLUMES AS A PERCENTAGE OF DAILY AND PEAK HOURLY VOLUMES

ACTUAL VOLUME	RANKED VOLUME	RANK	PORTION OF DAY	RATIO OF PEAK
62	1,032	1	15.02%	100.00%
42	906	2	13.19%	87.79%
28	561	3	8.17%	54.36%
11	492	**4**	**7.15%**	**47.63%**
11	424	5	6.17%	41.09%
28	420	6	6.11%	40.65%
69	420	7	6.11%	40.65%
174	414	**8**	**6.03%**	**40.12%**
205	326	9	4.74%	31.59%
215	286	10	4.16%	27.66%
244	244	11	3.54%	23.59%
420	215	12	3.13%	20.83%
424	212	13	3.09%	20.54%
420	205	14	2.98%	19.86%
414	191	15	2.77%	18.46%
561	174	16	2.53%	16.86%
906	102	17	1.48%	9.84%
1,032	69	18	1.00%	6.64%
492	62	19	0.90%	6.01%
326	42	20	0.61%	4.07%
286	28	21	0.41%	2.71%
212	28	22	0.40%	2.66%
191	11	23	0.16%	1.07%
102	11	24	0.16%	0.16%
6,871	**6,871**		**100.00%**	

Analysis By: RCS Date: 11/11/2010
Checked By: RCS Date: 11/11/2010

APPENDIX 3B

RADS ARTERIAL VEHICULAR INCIDENTS DATA

35th Avenue Corridor (with Bell) RADS Vehicular Incident Data

Incident Number	Date	Dispatch Time	Last Logged Dispatch	Notes
Bell Road - 51st Avenue to 35th Avenue				
10149076	06/03/10	12:31 PM	12:48 PM	
10149981	06/04/10	11:14 AM	11:43 AM	
10150396	06/04/10	6:38 PM		
10151249	06/05/10	4:07 PM		
10155463	06/09/10	8:36 PM	8:42 PM	
10164546	06/19/10	9:45 AM	10:11 AM	
10166364	06/21/10	11:02 AM	12:01 PM	
10169512	06/24/10	3:39 PM	4:11 PM	
10175531	06/30/10	4:24 PM	4:58 PM	
10176123	7/1/10	8:29 AM	8:53 AM	Pedestrian
10178795	7/3/10	5:54 PM	6:00 PM	
10178795	7/3/10	5:54 PM	6:28 PM	
10179469	7/4/10	12:45 PM	1:24 PM	
10179508	7/4/10	1:34 PM		
10195365	7/20/10	10:18 PM	10:44 PM	
10195502	7/21/10	2:38 AM	2:42 AM	Building Fire
10204658	7/30/10	5:56 PM		
10210102	08/05/10	10:54 AM		
35th Avenue - Bell Road to Thunderbird Road				
10138487	05/23/10	10:02 AM		
10172756	06/27/10	9:29 PM		
10175531	06/30/10	4:24 PM	4:58 PM	
10175663	06/30/10	6:52 PM		
10179469	7/4/10	12:45 PM	1:24 PM	
10179508	7/4/10	1:34 PM		
10184520	7/9/10	5:31 PM		Motorcycle
10184569	7/9/10	6:28 PM	6:30 PM	
10197124	7/22/10	6:53 PM	7:09 PM	Building Fire
10199967	7/25/10	10:37 PM	10:50 PM	
10202618	7/28/10	6:25 PM		
10204658	7/30/10	5:56 PM		
10218089	08/13/10	12:27 PM	12:45 PM	Motorcycle
10222041	08/17/10	2:51 PM	3:08 PM	Motorcycle
10225978	08/21/10	10:01 AM		
35th Avenue - Thunderbird Road to Peoria Avenue				
10154013	06/08/10	12:38 PM	12:59 PM	
10157855	06/12/10	9:25 AM	9:35 AM	
10171482	06/26/10	2:09 PM	2:10 PM	
10172756	06/27/10	9:29 PM		
10175663	06/30/10	6:52 PM		
10184514	7/9/10	5:25 PM	5:38 PM	
10191725	7/17/10	8:18 AM	8:21 AM	
10194023	7/19/10	4:39 PM	4:40 PM	
10194943	7/20/10	2:30 PM	2:47 PM	
10199526	7/25/10	12:24 PM	1:18 PM	Medical Emergency
10203743	7/29/10	7:41 PM	8:13 PM	
10210203	08/05/10	12:37 PM	12:50 PM	Motorcycle
10220831	08/16/10	11:04 AM	11:21 AM	Motorcycle

35th Avenue Corridor (with Bell) RADS Vehicular Incident Data

Incident Number	Date	Dispatch Time	Last Logged Dispatch	Notes
10222041	08/17/10	2:51 PM	3:08 PM	Motorcycle
10223170	08/18/10	4:04 PM	4:35 PM	
10225189	08/20/10	2:53 PM		
10225578	08/20/10	10:07 PM	10:23 PM	Motorcycle
10225978	08/21/10	10:01 AM		
35th Avenue - Peoria Avenue to Northern Avenue				
10149048	06/03/10	12:06 PM	12:21 PM	
10150280	06/04/10	4:34 PM		
10157119	06/11/10	2:32 PM	2:48 PM	
10160017	06/14/10	4:45 PM		
10171482	6/26/10	2:09 PM	2:10 PM	
10178559	7/3/10	12:59 PM	1:32 PM	
10184514	7/9/10	5:25 PM	5:38 PM	
10184574	7/9/10	6:35 PM	6:53 PM	
10185100	7/10/10	10:34 AM		
10193632	7/19/10	9:43 AM	9:59 AM	Bicycle
10194488	7/20/10	5:03 AM	5:20 AM	
10194943	7/20/10	2:30 PM	2:47 PM	
10196001	7/21/10	4:13 PM		
10199526	7/25/10	12:24 PM	1:18 PM	Medical Emergency
10199812	7/25/10	6:43 PM	6:56 PM	Pedestrian
10203743	07/29/10	7:41 PM	8:13 PM	
10210203	08/05/10	12:37 PM	12:50 PM	Motorcycle
10213452	08/08/10	4:30 PM		
10213473	08/08/10	5:02 PM	5:10 PM	Bicycle
10214121	08/09/10	11:23 AM	11:59 AM	
10223014	08/18/10	12:50 PM	12:57 PM	Building Fire
10223170	08/18/10	4:04 PM	4:35 PM	
10231150	08/26/10	12:47 PM	1:08 PM	
10231954	08/27/10	9:17 AM		Medical Emergency
10234177	08/29/10	12:32 PM	12:59 PM	
10236419	08/31/10	8:50 PM	9:19 PM	
35th Avenue - Northern Avenue to Bethany Home Road				
10205623	7/31/10	5:02 PM		
10204618	7/30/10	5:21 PM		
10225030	08/20/10	12:24 PM	1:04 PM	
10226102	08/21/10	12:17 PM		
10231150	08/26/10	12:47 PM	1:08 PM	
10231954	08/27/10	9:17 AM		Medical Emergency
35th Avenue - Bethany Home Road to Indian School Road				
10202137	7/28/10	9:26 AM	9:58 AM	
10203080	7/29/10	8:11 AM	8:21 AM	Bicycle
10203059	7/29/10	7:37 AM	8:12 AM	
10209970	08/05/10	8:22 AM	8:42 AM	Pedestrian
10221979	08/17/10	1:47 PM		
10223948	08/19/10	11:13 AM		
10226102	08/21/10	12:17 PM		
10226736	08/22/10	12:32 AM	1:01 AM	
10227472	08/22/10	6:13 PM		

35th Avenue Corridor (with Bell) RADS Vehicular Incident Data

Incident Number	Date	Dispatch Time	Last Logged Dispatch	Notes
10230387	08/25/10	4:52 PM		Pedestrian
10233334	08/28/10	4:19 PM		
10233761	08/29/10	12:24 AM	12:45 AM	Pedestrian
10234806	08/30/10	6:36 AM	6:52 AM	Pedestrian
35th Avenue - Indian School Road to McDowell Road				
10221979	08/17/10	1:47 PM		
10228036	08/23/10	10:17 AM	10:38 AM	
10230387	08/25/10	4:52 PM		Pedestrian
10233649	08/28/10	9:19 PM	9:26 PM	Pedestrian
10235406	08/30/10	7:26 PM	7:48 PM	Bicycle
35th Avenue - McDowell Road to Buckeye Road				
10200375	07/26/10	12:06 PM		
10202636	7/28/10	6:43 PM		
10209277	08/04/10	2:12 PM		
10211547	08/06/10	6:07 PM	6:17 PM	Bicycle
10214196	08/09/10	12:59 PM	1:24 PM	
10225088	08/20/10	1:21 PM	1:34 PM	
10231402	08/26/10	5:24 PM		
10233157	08/28/10	12:41 PM		
10235406	08/30/10	7:26 PM	7:48 PM	Bicycle

Note: Green highlighting indicates that the Incident was located on an AWAM node and therefore is listed under multiple segments

51st Avenue Corridor (with Thunderbird, Peoria, and Northern) RADS Vehicular Incident Data

Incident Number	Date	Dispatch Time	Last Logged Dispatch	Notes
51st Avenue - Indian School Road to Bethany Home Road				
10200788	7/26/10	8:30 PM		
10200121	7/26/10	5:22 AM	5:51 AM	
10217018	08/12/10	11:04 AM	11:13 AM	
10217476	08/12/10	7:11 PM	7:20 PM	
51st Avenue - Bethany Home Road to Northern Avenue				
10201594	7/27/10	5:27 PM	5:31 PM	
10203061	7/29/10	7:40 AM	7:53 AM	
10204751	7/30/10	8:00 PM	8:32 PM	Motorcycle
10208459	08/03/10	5:26 PM		Bicycle
10210566	08/05/10	7:00 PM	7:11 PM	
10217838	08/13/10	7:58 AM	8:39 AM	
10222774	08/18/10	8:08 AM	8:30 AM	
10228173	08/23/10	12:32 PM	12:59 PM	
10233016	08/28/10	9:46 AM	10:16 AM	
10233300	08/28/10	3:38 PM		
51st Avenue - Northern Avenue to Peoria Avenue				
10200825	7/26/10	9:32 PM	9:52 PM	
10201594	7/27/10	5:27 PM	5:31 PM	
10203061	7/29/10	7:40 AM	7:53 AM	
10204751	7/30/10	8:00 PM	8:32 PM	Motorcycle
10204912	7/30/10	11:53 PM		Medical Emergency
10224129	08/19/10	2:18 PM	2:33 PM	
10225204	08/20/10	3:08 PM		
10233300	08/28/10	3:38 PM		
51st Avenue - Peoria Avenue to Thunderbird Road				
10204912	7/30/10	11:53 PM	12:54 AM	Medical Emergency
10208204	08/03/10	12:48 PM	1:02 PM	
10208220	08/03/10	1:10 PM		
10209254	08/04/10	1:49 PM	2:14 PM	
10218773	08/14/10	3:50 AM	4:21 AM	
10222811	08/18/10	9:01 AM	9:42 AM	
10224058	08/19/10	1:15 PM		
51st Avenue - Thunderbird Road to Bell Road				
10208204	08/03/10	12:48 PM	1:02 PM	
10208220	08/03/10	1:10 PM		
10208458	08/03/10	5:25 PM		
10220179	08/15/10	4:46 PM	5:39 PM	
10224058	08/19/10	1:15 PM		
Thunderbird Road - 51st Avenue to 35th Avenue				
10208488	08/03/10	5:53 PM		
10211340	08/06/10	2:39 PM		
10217259	08/12/10	3:19 PM		
10222041	08/17/10	2:51 PM	3:08 PM	Motorcycle
10224058	08/19/10	1:15 PM		
10225978	08/21/10	10:01 AM		
Peoria Avenue - 51st Avenue to 35th Avenue				
10203743	7/29/10	7:41 PM	8:13 PM	
10203246	7/29/10	11:41 AM		

51st Avenue Corridor (with Thunderbird, Peoria, and Northern) RADS Vehicular Incident Data

Incident Number	Date	Dispatch Time	Last Logged Dispatch	Notes
10204912	7/30/10	11:53 PM	12:54 AM	Medical Emergency
10207353	08/02/10	3:03 PM		
10210190	08/05/10	12:19 PM	12:25 PM	
10210203	08/05/10	12:37 PM	12:50 PM	Motorcycle
10217396	08/12/10	5:39 PM	6:00 PM	Motorcycle
10220434	08/15/10	10:32 PM	10:52 PM	
10220490	08/16/10	12:17 AM	12:38 AM	
10223170	08/18/10	4:04 PM	4:35 PM	
10224462	08/19/10	8:24 PM	8:56 PM	
10234705	08/30/10	2:00 AM	2:34 AM	
Northern Avenue - 51st Avenue to 35th Avenue				
10201797	7/27/10	9:38 PM		
10201594	7/27/10	5:27 PM	5:31 PM	
10203061	7/29/10	7:40 AM	7:53 AM	
10204751	7/30/10	8:00 PM	8:32 PM	Motorcycle
10207958	08/03/10	7:50 AM	7:51 AM	
10213470	08/08/10	4:51 PM		
10220501	08/16/10	12:49 AM	1:13 AM	
10229444	08/24/10	5:03 PM		
10231150	08/26/10	12:47 PM	1:08 PM	
10231954	08/27/10	9:17 AM		Medical Emergency
10233300	08/28/10	3:38 PM		

Note: Green highlighting indicates that the Incident was located on an AWAM node and therefore is listed under multiple segments

Indian School Road Corridor RADS Vehicular Incident Data

Incident Number	Date	Dispatch Time	Last Logged Dispatch	Notes
Indian School Road - 67th Avenue to 51st Avenue				
10241830	09/06/10	11:19 AM	11:31 AM	Pedestrian
10242213	09/06/10	6:53 PM		
10244580	09/09/10	8:40 AM		
10248000	09/12/10	7:19 PM	7:49 PM	
10252651	09/17/10	12:40 PM		Pedestrian
10256884	09/21/10	3:10 PM	3:39 PM	
10257139	09/21/10	7:52 PM		
10258000	09/22/10	5:11 PM		Building Fire
10259200	09/23/10	8:05 PM	8:34 PM	
10263234	09/27/10	8:00 PM		Pedestrian
Indian School Road - 51st Avenue to 35th Avenue				
10200121	7/26/10	5:22 AM	5:51 AM	
10230262	08/25/10	2:00 PM	2:24 PM	
10230387	08/25/10	4:52 PM		Pedestrian
10232552	08/27/10	8:20 PM	8:41 PM	
10233220	08/28/10	1:54 PM		
Indian School Road - 51st Avenue to 33rd Avenue				
10240534	09/04/10	9:13 PM		
10240565	09/04/10	9:45 PM	10:25 PM	
10245931	09/10/10	3:26 PM	3:50 PM	Motorcycle
10261656	09/26/10	9:24 AM	9:46 AM	
10263683	09/28/10	10:25 AM	10:50 AM	Motorcycle
Indian School Road - 33rd Avenue to 19th Avenue				
10243126	09/07/10	6:02 PM	6:18 PM	
10245807	09/10/10	12:48 PM		
10249069	09/13/10	7:43 PM		
10249091	09/13/10	8:00 PM	8:13 PM	Pedestrian
10251644	09/16/10	1:21 PM		
10251823	09/16/10	4:08 PM	4:26 PM	
10259633	09/24/10	9:35 AM		
10247767	09/12/10	2:23 PM		
Indian School Road - 19th Avenue to 7th Street				
10247767	09/12/10	2:23 PM		
10249001	09/13/10	6:32 PM	6:53 PM	
10249438	09/14/10	8:27 AM		
10255662	09/20/10	11:43 AM		Pedestrian
10258507	09/23/10	7:32 AM	8:04 AM	
10259832	09/24/10	12:54 PM	1:14 PM	Pedestrian

Note: Green highlighting indicates that the Incident was located on an AWAM node and therefore is listed under multiple segments

7th Street Corridor RADS Vehicular Incident Data

Incident Number	Date	Dispatch Time	Last Logged Dispatch	Notes
7th Street - Northern Avenue to Bethany Home Road				
10237498	09/01/10	9:43 PM	10:29 PM	
10252413	09/17/10	7:43 AM	7:46 AM	
10254416	09/19/10	3:18 AM	3:48 AM	
10260874	09/25/10	1:44 PM		Pedestrian
10265983	09/30/10	4:15 PM		
10265540	09/30/10	9:19 AM	9:44 AM	
10265983	09/30/10	4:25 PM		
7th Street - Bethany Home Road to Indian School Road				
10237509	09/01/10	9:57 PM	10:12 PM	Gas Leak
10239492	09/03/10	8:26 PM	8:58 PM	
10243561	09/08/10	7:32 AM	7:57 AM	
10245387	09/10/10	1:41 AM	2:10 AM	
10258647	09/23/10	10:08 AM		
10265540	09/30/10	9:19 AM	9:44 AM	
10248996	09/13/10	6:30 PM		
7th Street - Indian School Road to McDowell Road				
10246014	09/10/10	5:14 PM		
10246852	09/11/10	3:28 PM	3:33 PM	
10248996	09/13/10	6:30 PM		
10259592	09/24/10	8:45 AM	9:16 AM	
10265031	09/29/10	6:11 PM		
10265357	09/30/10	3:07 AM	3:15 AM	Building Fire
7th Street - McDowell Road to Roosevelt Street				
10243505	09/08/10	5:56 AM		
10244566	09/09/10	8:20 AM		
7th Street - Roosevelt Street to Washington Street				
10245815	09/10/10	1:01 PM	1:13 PM	
10265012	09/29/10	6:01 PM	6:27 PM	

Note: Green highlighting indicates that the Incident was located on an AWAM node and therefore is listed under multiple segments

Rural Road Corridor (with Rio Salado, Mill, and University) RADS Vehicular Incident Data

Incident Number	Date	Dispatch Time	Last Logged Dispatch	Notes
Rural Rd - Rio Salado to University				
10244171	9/8/10	7:06 PM	7:07 PM	Injury Accident
10246413	9/11/10	3:04 AM	4:16 AM	Medical Emergency
10251645	9/16/10	1:23 PM	1:42 PM	Motorcycle Accident
Rural Rd - University to Broadway				
10239808	9/4/10	4:18 AM	4:35 AM	
10242256	9/6/10	7:37 PM	8:12 AM	
10242335	9/6/10	9:12 PM	9:29 AM	
10244171	9/8/10	7:06 PM	7:07 PM	Injury Accident
10246413	9/11/10	3:04 AM	4:16 AM	Medical Emergency
10246794	9/11/10	2:16 PM	2:43 AM	
10248659	9/13/10	12:46 PM	12:57 PM	
10249048	9/13/10	7:20 PM	7:26 AM	
10251645	9/16/10	1:23 PM	1:42 PM	Motorcycle Accident
10252219	9/17/10	12:29 AM	12:35 PM	
10252256	9/17/10	2:06 AM	2:28 AM	
10263098	9/27/10	5:26 PM	5:49 AM	
University - Mill to Rural				
10243046	9/7/10	4:39 PM	5:00 PM	Motorcycle Accident
10244171	9/8/10	7:06 PM	7:07 PM	Injury Accident
10246413	9/11/10	3:04 AM	4:16 AM	Medical Emergency
10251645	9/16/10	1:23 PM	1:42 PM	Motorcycle Accident
Mill Ave - Rio Salado to University				
10239844	9/4/10	6:04 AM	6:18 AM	
Rio Salado - Mill to University				
10239844	9/4/10	6:04 AM	6:18 AM	

Note: Green highlighting indicates that the Incident was located on an AWAM node and therefore is listed under multiple segments

APPENDIX 3C

ARTERIAL NRC ANALYSIS SUMMARY

#	WEEKDAY RESULTS AWAM Equipped Segments	Recurring Delay (vehicle hours)	Non-Recurring Delay (vehicle hours)	Total Delay	% Recurring	% Non-Recurring	Vehicular Incidents (A)	Freeway Diversion (B)	Weather (C)	Construction (D)	Special Events (E)	Atypical Signal Timing (F)	Daily Volume	10-minute Intervals Collected	10-minute Intervals with 1 or more Vehicle Match	Individual Vehicle Matches	Intervals in Baseline Calculation	Matches in Baseline Calculation	A_Intervals	B_Intervals	C_Intervals	D_Intervals	E_Intervals	F_Intervals
1	Bell_51stAve to Bell_35thAve	581	87	669	87%	13%	42%	0%	17%	41%	0%	0%	19651	9879	7988	33275	8866	29306	64	13	360	575	0	1
2	Bell_35thAve to Bell_51stAve	0	233	233	0%	100%	28%	0%	13%	59%	0%	0%	18157	9879	7390	27751	7476	21590	62	0	13	2329	0	0
3	Bell_35thAve to Thunderbird_35thAve	2,163	920	3,083	70%	30%	5%	0%	1%	94%	0%	0%	14570	10004	7235	19959	5574	12163	38	0	13	4397	0	0
4	Thunderbird_35thAve to Bell_35thAve	740	1,228	1,968	38%	62%	8%	0%	3%	88%	0%	0%	16700	10005	7042	19660	6748	12868	38	0	17	3217	0	0
5	Thunderbird_35thAve to Peoria_35thAve	10,610	703	11,313	94%	6%	15%	1%	0%	84%	0%	0%	13655	10007	6808	19374	7310	15196	68	11	18	2601	0	63
6	Peoria_35thAve to Thunderbird_35thAve	220	356	576	38%	62%	55%	0%	2%	35%	0%	8%	13733	10012	6788	19071	9518	17952	69	0	14	348	0	63
7	Peoria_35thAve to Northern_35thAve	9,299	494	9,794	95%	5%	48%	0%	1%	44%	0%	7%	13655	10015	6867	18629	9381	17066	121	6	17	435	0	68
8	Northern_35thAve to Peoria_35thAve	3,915	1,060	4,976	79%	21%	34%	15%	0%	49%	0%	1%	13733	10006	7023	20538	8449	16763	121	35	13	1348	0	68
9	Northern_35thAve to BethanyHome_35thAve	5,844	78	5,922	99%	1%	33%	0%	67%	0%	0%	0%	13968	3535	2679	9042	3503	8862	15	8	7	2	0	2
10	BethanyHome_35thAve to Northern_35thAve	5,593	99	5,692	98%	2%	85%	0%	15%	0%	0%	0%	13253	3535	2614	7116	3475	6985	47	6	7	0	0	0
11	BethanyHome_35thAve to IndianSchool_35thAve	7,867	363	8,230	96%	4%	78%	2%	20%	0%	0%	0%	11370	3535	2509	7087	3476	6963	47	5	7	0	0	0
12	IndianSchool_35thAve to BethanyHome_35thAve	4,256	103	4,359	98%	2%	100%	0%	0%	0%	0%	0%	10523	3540	2677	7376	3329	7069	15	9	7	183	0	0
13	IndianSchool_35thAve to McDowell_35thAve	7,215	153	7,369	98%	2%	51%	23%	4%	22%	0%	0%	15249	3541	2688	8799	1683	4209	15	13	7	1834	0	0
14	McDowell_35thAve to IndianSchool_35thAve	7,211	1,830	9,041	80%	20%	9%	0%	1%	91%	0%	0%	16094	3540	2182	4595	3211	4138	24	6	7	288	0	7
15	McDowell_35thAve to Buckeye_35thAve	13,023	962	13,985	93%	7%	26%	0%	2%	72%	0%	0%	17308	3543	2449	6492	1465	3057	24	0	7	2062	0	7
16	Buckeye_35thAve to McDowell_35thAve	9,375	1,723	11,098	84%	16%	6%	0%	5%	89%	0%	0%	12594	3530	2539	7433	3506	7363	16	0	7	0	0	1
17	Bell_51stAve to Thunderbird_51stAve	2,130	20	2,150	99%	1%	100%	0%	0%	0%	0%	0%	12583	3531	2570	7933	3325	7283	16	0	7	183	0	1
18	Thunderbird_51stAve to Bell_51stAve	2,416	237	2,653	91%	9%	40%	0%	0%	60%	0%	0%	12596	3525	2570	7226	3480	7070	29	0	7	8	0	1
19	Thunderbird_51stAve to Peoria_51stAve	1,794	12	1,805	99%	1%	100%	0%	0%	0%	0%	0%	12582	3524	2583	7980	3487	7850	29	0	7	0	0	1
20	Peoria_51stAve to Thunderbird_51stAve	1,254	120	1,374	91%	9%	100%	0%	0%	0%	0%	0%	12946	3523	1822	4849	3499	4782	17	0	7	0	0	0
21	Peoria_51stAve to Northern_51stAve	5,275	18	5,293	100%	0%	100%	0%	0%	0%	0%	0%	13457	3522	1879	5552	3498	5466	17	0	7	0	0	0
22	Northern_51stAve to Peoria_51stAve	5,220	105	5,324	98%	2%	100%	0%	0%	0%	0%	0%	12945	3521	1723	3895	3457	3791	57	0	7	0	0	0
23	Northern_51stAve to BethanyHome_51stAve	4,122	64	4,185	98%	2%	92%	0%	8%	0%	0%	0%	13466	3520	1794	4820	3464	4690	49	0	7	0	0	0
24	BethanyHome_51stAve to Northern_51stAve	4,400	35	4,435	99%	1%	58%	0%	42%	0%	0%	0%	16202	3521	2639	6672	3310	6113	4	0	7	201	0	1
25	BethanyHome_51stAve to IndianSchool_51stAve	8,627	235	8,862	97%	3%	13%	0%	32%	55%	0%	0%	17269	3521	2658	7282	3509	7243	4	0	7	0	0	1
26	IndianSchool_51stAve to BethanyHome_51stAve	7,147	42	7,188	99%	1%	6%	0%	94%	0%	0%	0%	17299	3528	2721	11632	3515	11572	6	0	7	0	0	0
27	Thunderbird_51stAve to Thunderbird_35thAve	2,629	79	2,708	97%	3%	100%	0%	0%	0%	0%	0%	18502	3527	2753	11773	3514	11671	6	0	7	0	0	0
28	Thunderbird_35thAve to Thunderbird_51stAve	2,850	90	2,939	97%	3%	71%	0%	29%	0%	0%	0%	16804	3525	2969	11508	3450	11252	31	0	7	0	0	37
29	Peoria_51stAve to Peoria_35thAve	3,440	258	3,698	93%	7%	85%	0%	0%	0%	0%	15%	16804	3525	2969	11508	3450	11252	31	0	7	0	0	37
30	Peoria_35thAve to Peoria_51stAve	2,002	165	2,167	92%	8%	57%	0%	3%	0%	0%	39%	14598	3521	2803	10689	3446	10322	31	0	7	0	0	37
31	Northern_51stAve to Northern_35thAve	3,517	102	3,619	97%	3%	97%	0%	3%	0%	0%	0%	12286	3522	1947	5694	3492	5636	23	0	7	2	0	0
32	Northern_35thAve to Northern_51stAve	5,016	95	5,112	98%	2%	83%	0%	17%	0%	0%	0%	12968	3523	1978	6241	3493	6137	23	0	7	2	0	0
33	IndianSchool_51stAve to IndianSchool_35thAve	10,303	215	10,518	98%	2%	22%	0%	0%	78%	0%	0%	21544	3538	2746	8550	3334	7934	7	0	7	190	0	1
34	IndianSchool_35thAve to IndianSchool_51stAve	11,314	89	11,402	99%	1%	87%	0%	13%	0%	0%	0%	19549	3538	2118	4511	3523	4475	7	0	7	0	0	1
35	Montebello_51stAve to IndianSchool_51stAve	2,663	433	3,095	86%	14%	11%	0%	0%	89%	0%	0%	16207	1937	1339	3517	1463	2303	11	0	5	460	0	0
36	IndianSchool_51stAve to Montebello_51stAve	2,806	239	3,045	92%	8%	7%	0%	0%	93%	0%	0%	17269	1937	1362	4048	1463	2554	14	0	5	460	0	0
37	IndianSchool_51stAve to McDowell_51stAve	3,832	422	4,254	90%	10%	18%	0%	0%	82%	0%	0%	16207	1937	1543	6675	1475	4727	18	0	5	444	0	0
38	McDowell_51stAve to IndianSchool_51stAve	1,772	394	2,166	82%	18%	6%	0%	0%	94%	0%	0%	17269	1937	1559	7312	1475	4941	18	0	5	444	0	0
39	McDowell_51stAve to Buckeye_51stAve	6,111	62	6,173	99%	1%	74%	0%	1%	26%	0%	0%	17818	1937	1384	3437	1799	3266	16	0	5	122	0	0
40	Buckeye_51stAve to McDowell_51stAve	5,002	26	5,028	99%	1%	100%	0%	0%	0%	0%	0%	20214	1937	1437	4211	1916	4157	16	0	5	0	0	0
41	IndianSchool_67thAve to IndianSchool_51stAve	5,044	516	5,560	91%	9%	35%	0%	0%	57%	0%	8%	21544	1937	1532	7911	1568	5855	25	0	5	329	0	66
42	IndianSchool_51stAve to IndianSchool_67thAve	6,393	345	6,738	95%	5%	87%	0%	0%	13%	0%	0%	19549	1937	1447	6787	1782	6352	25	0	5	122	0	3
43	IndianSchool_51stAve to IndianSchool_33rdAve	3,976	268	4,244	94%	6%	22%	0%	1%	66%	0%	12%	21544	1937	1097	5260	1649	4378	7	0	5	276	0	184
44	IndianSchool_33rdAve to IndianSchool_51stAve	2,720	463	3,183	85%	15%	8%	0%	0%	76%	0%	16%	19549	1937	1036	4642	1008	2946	7	0	5	924	0	651
45	IndianSchool_33rdAve to IndianSchool_19thAve	1,421	1,582	3,004	47%	53%	10%	0%	0%	81%	0%	10%	21596	1461	994	3822	813	887	9	0	5	639	0	255
46	IndianSchool_19thAve to IndianSchool_33rdAve	1,017	3,144	4,160	24%	76%	5%	0%	0%	94%	0%	0%	21596	1461	1007	4086	813	991	9	0	5	639	0	0
47	IndianSchool_19thAve to IndianSchool_7thSt	2,245	2,479	4,723	48%	52%	10%	0%	0%	90%	0%	0%	19085	1716	1344	4267	1007	1645	9	0	5	697	0	0

#	WEEKDAY RESULTS AWAM Equipped Segments	Recurring Delay (vehicle hours)	Non-Recurring Delay (vehicle hours)	Total Delay	% Recurring	% Non-Recurring	Vehicular Incidents (A)	Freeway Diversion (B)	Weather (C)	Construction (D)	Special Events (E)	Atypical Signal Timing (F)	Daily Volume	10-minute Intervals Collected	10-minute Intervals with 1 or more Vehicle Match	Individual Vehicle Matches	Intervals in Baseline Calculation	Matches in Baseline Calculation	A_Intervals	B_Intervals	C_Intervals	D_Intervals	E_Intervals	F_Intervals
48	IndianSchool_7thSt to IndianSchool_19thAve	4,092	2,852	6,944	59%	41%	7%	0%	0%	93%	0%	0%	30814	1714	1332	4759	842	1856	9	0	5	865	0	0
49	Northern_7thSt to BethanyHome_7thSt	1,000	1,482	2,482	40%	60%	9%	0%	0%	86%	0%	5%	11804	5419	4825	15709	2083	1867	66	0	13	2762	0	1186
50	BethanyHome_7thSt to Northern_7thSt	501	908	1,409	36%	64%	3%	0%	0%	81%	0%	17%	13483	5419	1387	15645	2082	2863	60	0	13	2763	0	1186
51	BethanyHome_7thSt to IndianSchool_7thSt	3,797	197	3,994	95%	5%	39%	0%	0%	61%	0%	0%	11804	5419	1312	12188	3607	7084	68	0	13	1758	0	63
52	IndianSchool_7thSt to BethanyHome_7thSt	3,576	232	3,808	94%	6%	1%	0%	0%	99%	0%	0%	13483	5419	1338	13074	3434	6910	69	0	13	1931	0	63
53	IndianSchool_7thSt to McDowell_7thSt	9,741	1,702	11,442	85%	15%	26%	0%	1%	71%	0%	2%	13263	5419	3641	9872	4248	7811	86	0	13	1064	0	60
54	McDowell_7thSt to IndianSchool_7thSt	10,835	579	11,414	95%	5%	38%	0%	9%	31%	0%	21%	15338	5419	3714	13015	4358	11169	87	0	13	907	0	59
55	McDowell_7thSt to Roosevelt_7thSt	4,038	171	4,209	96%	4%	28%	0%	0%	61%	10%	0%	13263	5419	3358	10983	4595	8432	36	0	16	684	95	1
56	Roosevelt_7thSt to McDowell_7thSt	5,470	130	5,600	98%	2%	42%	0%	0%	47%	10%	0%	16779	5419	3311	11892	4744	9905	36	0	16	528	95	1
57	Roosevelt_7thSt to Washington_7thSt	5,560	521	6,081	91%	9%	6%	0%	1%	86%	8%	0%	20199	5309	3649	17833	2867	10189	22	0	16	2330	81	0
58	Washington_7thSt to Roosevelt_7thSt	6,404	146	6,550	98%	2%	41%	0%	1%	57%	2%	0%	20199	5309	3553	15208	4559	13114	22	0	16	635	81	0
59	Washington_7thSt to Lincoln_7thSt	1,367	12	1,379	99%	1%	0%	0%	1%	0%	99%	0%	20199	1456	954	2669	1416	2596	0	0	5	0	35	0
60	Lincoln_7thSt to Washington_7thSt	1,412	8	1,420	99%	1%	0%	0%	6%	0%	94%	0%	20199	1456	1066	3867	1416	3750	0	0	5	0	35	0
61	McKellips_Rural to L202_Rural	5,444	7	5,451	100%	0%	19%	0%	81%	0%	0%	0%	16000	3455	2839	14673	3442	14616	4	0	9	0	0	0
62	L202_Rural to McKellips_Rural	2,195	9	2,204	100%	0%	46%	0%	54%	0%	0%	0%	13505	3455	2743	13674	3442	13615	4	0	9	0	0	0
63	L202_Rural to RioSalado_Rural	2,026	0	2,026	100%	0%	0%	0%	0%	0%	0%	0%	18137	3455	3040	19911	3438	19813	6	0	9	0	0	2
64	RioSalado_Rural to L202_Rural	2,341	5	2,346	100%	0%	61%	0%	0%	0%	0%	39%	18698	3455	3014	18386	5231	26650	6	0	9	0	0	2
65	RioSalado_Rural to University_Rural	2,404	56	2,459	98%	2%	82%	0%	15%	0%	0%	3%	12673	3455	3010	16830	3417	16627	27	0	9	0	0	2
66	University_Rural to RioSalado_Rural	533	16	549	97%	3%	72%	0%	28%	0%	0%	0%	17232	3455	3002	16577	3417	16356	27	0	9	0	0	2
67	University_Rural to Broadway_Rural	7,470	139	7,609	98%	2%	51%	0%	49%	0%	0%	0%	20386	3455	2737	10185	3418	10005	22	0	15	0	0	0
68	Broadway_Rural to University_Rural	6,744	156	6,900	98%	2%	100%	0%	0%	0%	0%	0%	19336	3455	2765	9376	3815	9700	22	0	15	0	0	0
69	Broadway_Rural to Southern_Rural	488	42	531	92%	8%	88%	0%	12%	0%	0%	0%	9503	3455	2935	15999	3455	15999	10	0	9	0	0	0
70	Southern_Rural to Broadway_Rural	643	18	662	97%	3%	80%	0%	20%	0%	0%	0%	8929	3455	2982	15243	3436	15139	10	0	9	0	0	0
71	University_Mill to University_Rural	8,734	371	9,105	96%	4%	84%	0%	16%	0%	0%	0%	12359	3455	2711	9280	3412	9110	33	0	9	0	0	1
72	University_Rural to University_Mill	6,699	63	6,762	99%	1%	89%	0%	11%	0%	0%	0%	11935	3455	2817	8970	3412	8823	33	0	9	0	0	1
73	RioSalado_Mill to University_Mill	15,375	223	15,598	99%	1%	14%	0%	2%	0%	83%	0%	18304	3455	2074	4312	3354	4085	7	0	9	0	84	1
74	University_Mill to RioSalado_Mill	8,804	203	9,007	98%	2%	12%	0%	1%	0%	87%	0%	17922	3455	2147	4365	3354	4122	7	0	9	0	84	1
75	RioSalado_Mill to RioSalado_Rural	1,972	58	2,030	97%	3%	77%	0%	7%	0%	17%	0%	7246	3455	2191	5785	3354	5497	8	0	9	0	84	0
76	RioSalado_Rural to RioSalado_Mill	1,010	36	1,046	97%	3%	67%	0%	13%	0%	20%	0%	6871	3455	2418	6633	3354	6296	8	0	9	0	84	0
	Grand Total	**347,047**	**33,084**	**380,131**	**44%**	**6%**	**23%**	**0.3%**	**5%**	**17%**	**3%**	**1.3%**		**309445**	**214666**	**777400**	**264449**	**655090**	**2150**	**112**	**1025**	**41988**	**758**	**4188**

#	WEEKEND RESULTS AWAM Equipped Segments	Recurring Delay (vehicle hours)	Non-Recurring Delay (vehicle hours)	Total Delay	% Recurring	% Non-Recurring	Vehicular Incidents (A)	Freeway Diversion (B)	Weather (C)	Construction (D)	Special Events (E)	Atypical Signal Timing (F)	Daily Volume	10-minute Intervals Collected	10-minute Intervals with 1 or more Vehicle Match	Individual Vehicle Matches	Intervals in Baseline Calculation	Matches in Baseline Calculation	A_Intervals	B_Intervals	C_Intervals	D_Intervals	E_Intervals	F_Intervals
1	Bell_51stAve to Bell_35thAve	9	21	30	29%	71%	45%	0%	16%	39%	0%	0%	19651	4895	3712	12982	4579	11855	21	0	30	264	0	1
2	Bell_35thAve to Bell_51stAve	206	43	249	83%	17%	28%	0%	0%	72%	0%	0%	18161	4895	3586	11094	3723	8430	22	0	21	1147	0	1
3	Bell_35thAve to Thunderbird_35thAve	1,432	588	2,021	71%	29%	10%	0%	1%	89%	0%	0%	14566	4895	3382	8244	2888	5024	36	0	21	1965	0	0
4	Thunderbird_35thAve to Bell_35thAve	741	465	1,206	61%	39%	17%	5%	0%	78%	0%	0%	16700	4895	3316	8349	3409	5325	38	19	30	1421	0	0
5	Thunderbird_35thAve to Peoria_35thAve	415	414	829	50%	50%	13%	0%	2%	85%	0%	0%	13644	4895	3312	7941	3671	6016	42	0	38	1156	0	18
6	Peoria_35thAve to Thunderbird_35thAve	593	224	817	73%	27%	63%	0%	11%	24%	0%	3%	13731	4895	3394	8316	4696	7875	39	0	32	110	0	18
7	Peoria_35thAve to Northern_35thAve	2,537	247	2,785	91%	9%	99%	0%	0%	0%	0%	1%	13644	4895	3387	8244	4824	8124	34	0	13	0	0	24
8	Northern_35thAve to Peoria_35thAve	1,016	400	1,415	72%	28%	51%	0%	2%	44%	0%	3%	13731	4895	3517	9153	4351	7861	34	0	13	480	0	24
9	Northern_35thAve to BethanyHome_35thAve	1,999	29	2,029	99%	1%	100%	0%	0%	0%	0%	0%	14446	1583	1228	3748	1555	3681	14	0	13	0	0	1
10	BethanyHome_35thAve to Northern_35thAve	1,325	144	1,469	90%	10%	39%	16%	45%	0%	0%	0%	13967	1583	1236	3985	1535	3790	14	23	13	0	0	1
11	BethanyHome_35thAve to IndianSchool_35thAve	1,921	143	2,064	93%	7%	51%	0%	0%	48%	0%	0%	13258	1583	1192	3285	1461	2951	24	0	13	86	0	0
12	IndianSchool_35thAve to BethanyHome_35thAve	2,018	116	2,135	95%	5%	67%	0%	0%	32%	0%	0%	11381	1583	1132	3007	1463	2695	24	6	13	86	0	0
13	IndianSchool_35thAve to McDowell_35thAve	2,105	42	2,147	98%	2%	35%	0%	9%	56%	0%	0%	10522	1583	1258	3795	1442	3566	8	6	13	122	0	0
14	McDowell_35thAve to IndianSchool_35thAve	1,273	596	1,869	68%	32%	3%	0%	3%	94%	0%	0%	11800	1583	1274	4269	636	1628	8	0	13	934	0	0
15	McDowell_35thAve to Buckeye_35thAve	4,980	103	5,083	98%	2%	99%	0%	1%	0%	0%	0%	16085	1583	1035	2233	1563	2200	7	0	13	0	0	0
16	Buckeye_35thAve to McDowell_35thAve	2,574	1,044	3,617	71%	29%	8%	0%	1%	91%	0%	0%	17313	1583	1154	3113	729	1463	7	6	13	842	0	0
17	Bell_51stAve to Thunderbird_51stAve	893	5	897	99%	1%	90%	0%	10%	0%	0%	0%	8876	1583	1054	2551	1527	2467	21	0	30	0	0	5
18	Thunderbird_51stAve to Bell_51stAve	469	120	589	80%	20%	36%	0%	0%	64%	0%	0%	9119	1583	1094	2729	1405	2383	21	0	30	122	0	5
19	Thunderbird_51stAve to Peoria_51stAve	1,060	76	1,136	93%	7%	25%	0%	75%	0%	0%	0%	12597	1583	1021	2388	1524	2304	22	0	32	0	0	5
20	Peoria_51stAve to Thunderbird_51stAve	836	69	905	92%	8%	100%	0%	0%	0%	0%	0%	12586	1583	1072	2603	1524	2523	22	0	32	0	0	5
21	Peoria_51stAve to Northern_51stAve	1,119	20	1,139	98%	2%	75%	0%	25%	0%	0%	0%	12946	1583	853	1839	1556	1772	12	0	15	0	0	0
22	Northern_51stAve to Peoria_51stAve	1,726	90	1,816	95%	5%	53%	0%	47%	0%	0%	0%	13468	1583	911	2086	1556	2020	12	0	15	0	0	0
23	Northern_51stAve to BethanyHome_51stAve	837	20	857	98%	2%	100%	0%	0%	0%	0%	0%	7835	1583	777	1495	1565	1481	5	0	13	0	0	0
24	BethanyHome_51stAve to Northern_51stAve	555	55	609	91%	9%	79%	0%	21%	0%	0%	0%	8221	1583	843	1775	1565	1753	5	0	13	0	0	0
25	BethanyHome_51stAve to IndianSchool_51stAve	2,214	126	2,340	95%	5%	0%	0%	20%	80%	0%	0%	16207	1583	1110	2517	1516	2370	0	0	13	61	0	0
26	IndianSchool_51stAve to BethanyHome_51stAve	694	247	941	74%	26%	0%	0%	0%	100%	0%	0%	17269	1583	1194	2911	1516	2744	0	0	13	61	0	0
27	Thunderbird_51stAve to Thunderbird_35thAve	2,164	1	2,165	100%	0%	0%	0%	100%	0%	0%	0%	17299	1583	1259	4272	1545	4154	1	0	32	0	0	5
28	Thunderbird_35thAve to Thunderbird_51stAve	809	43	851	95%	5%	69%	0%	31%	0%	0%	0%	18502	1583	1287	4360	1545	4263	1	0	32	0	0	5
29	Peoria_51stAve to Peoria_35thAve	1,894	1	1,895	100%	0%	100%	0%	0%	0%	0%	0%	16804	1583	1231	4216	1559	4140	9	0	15	0	0	0
30	Peoria_35thAve to Peoria_51stAve	869	4	873	100%	0%	100%	0%	0%	0%	0%	0%	14598	1583	1210	3839	1559	3769	9	0	15	0	0	0
31	Northern_51stAve to Northern_35thAve	1,094	14	1,108	99%	1%	78%	0%	22%	0%	0%	0%	12286	1583	989	2422	1568	2407	2	0	13	0	0	0
32	Northern_35thAve to Northern_51stAve	2,199	49	2,248	98%	2%	75%	0%	25%	0%	0%	0%	12968	1583	1006	2740	1568	2713	2	0	13	0	0	0
33	IndianSchool_51stAve to IndianSchool_35thAve	4,698	246	4,944	95%	5%	8%	0%	7%	86%	0%	0%	21544	1583	1204	3196	381	608	1	0	13	74	0	0
34	IndianSchool_35thAve to IndianSchool_51stAve	5,632	11	5,643	100%	0%	98%	0%	2%	0%	0%	0%	19549	1583	973	1897	1569	1877	1	0	13	0	0	0
35	Montebello_51stAve to IndianSchool_51stAve	445	214	659	67%	33%	0%	0%	0%	100%	0%	0%	16207	806	559	1330	623	890	0	0	0	183	0	0
36	IndianSchool_51stAve to Montebello_51stAve	725	164	889	82%	18%	0%	0%	0%	100%	0%	0%	17269	1051	816	2164	822	1506	0	0	0	229	0	0
37	IndianSchool_51stAve to McDowell_51stAve	2,129	334	2,463	86%	14%	0%	0%	0%	100%	0%	0%	16207	1051	935	3562	912	2917	1	0	0	138	0	0
38	McDowell_51stAve to IndianSchool_51stAve	1,125	225	1,350	83%	17%	0%	0%	0%	100%	0%	0%	17269	1051	939	3863	912	3117	1	0	0	138	0	0
39	McDowell_51stAve to Buckeye_51stAve	1,125	225	1,350	83%	17%	0%	0%	0%	100%	0%	0%	17269	1051	939	3863	912	3117	1	0	0	138	0	0
40	Buckeye_51stAve to McDowell_51stAve	2,638	30	2,668	99%	1%	8%	0%	0%	92%	0%	0%	20214	1051	828	2098	1006	2011	2	0	0	43	0	0
41	IndianSchool_67thAve to IndianSchool_51stAve	3,830	456	4,286	89%	11%	81%	0%	0%	15%	0%	4%	21544	1051	929	4118	874	3536	9	0	0	168	0	7
42	IndianSchool_51stAve to IndianSchool_67thAve	3,474	709	4,182	83%	17%	91%	0%	0%	9%	0%	0%	19549	1051	907	3798	917	3471	9	0	0	122	0	7
43	IndianSchool_51stAve to IndianSchool_33rdAve	2,701	0	2,701	100%	0%	0%	0%	0%	0%	0%	0%	21544	1051	630	2506	934	2506	6	0	0	111	0	111
44	IndianSchool_33rdAve to IndianSchool_51stAve	1,780	41	1,820	98%	2%	0%	0%	0%	67%	0%	33%	19549	1051	632	2519	597	2223	6	0	0	454	0	372
45	IndianSchool_33rdAve to IndianSchool_19thAve	475	616	1,091	44%	56%	0%	0%	0%	81%	0%	19%	21596	1051	525	1384	491	387	1	0	0	560	0	257
46	IndianSchool_19thAve to IndianSchool_33rdAve	651	1,087	1,738	37%	63%	3%	0%	0%	97%	0%	0%	21596	1051	547	1548	491	534	1	0	0	560	0	0
47	IndianSchool_19thAve to IndianSchool_7thSt	1,356	631	1,987	68%	32%	3%	0%	0%	97%	0%	0%	19085	1051	803	2100	575	897	1	0	0	476	0	0

#	WEEKEND RESULTS AWAM Equipped Segments	Recurring Delay (vehicle hours)	Non-Recurring Delay (vehicle hours)	Total Delay	% Recurring	% Non-Recurring	Vehicular Incidents (A)	Freeway Diversion (B)	Weather (C)	Construction (D)	Special Events (E)	Atypical Signal Timing (F)	Daily Volume	10-minute Intervals Collected	10-minute Intervals with 1 or more Vehicle Match	Individual Vehicle Matches	Intervals in Baseline Calculation	Matches in Baseline Calculation	A_Intervals	B_Intervals	C_Intervals	D_Intervals	E_Intervals	F_Intervals
48	IndianSchool_7thSt to IndianSchool_19thAve	1,568	1,174	2,741	57%	43%	1%	0%	0%	99%	0%	0%	30814	1051	791	2102	520	933	1	0	0	531	0	0
49	Northern_7thSt to BethanyHome_7thSt	244	1,100	1,344	18%	82%	5%	0%	0%	81%	0%	14%	11804	2923	1889	4549	1059	859	17	0	0	1509	0	719
50	BethanyHome_7thSt to Northern_7thSt	128	2,152	2,280	6%	94%	4%	0%	0%	75%	0%	21%	13483	2923	1893	4488	1059	1079	16	0	0	1509	0	719
51	BethanyHome_7thSt to IndianSchool_7thSt	962	900	1,862	52%	48%	2%	0%	0%	98%	0%	0%	11804	2923	1707	3505	2154	2398	13	0	0	769	0	0
52	IndianSchool_7thSt to BethanyHome_7thSt	1,127	753	1,880	60%	40%	1%	0%	0%	99%	0%	0%	13483	2923	1752	3722	2062	2333	13	0	0	861	0	0
53	IndianSchool_7thSt to McDowell_7thSt	3,073	448	3,521	87%	13%	17%	0%	0%	83%	0%	0%	13263	2923	1770	3642	2366	2729	12	0	0	545	0	0
54	McDowell_7thSt to IndianSchool_7thSt	1,672	170	1,842	91%	9%	21%	0%	0%	79%	0%	0%	15338	2923	1910	4413	2381	3739	12	0	0	532	0	0
55	McDowell_7thSt to Roosevelt_7thSt	722	48	770	94%	6%	16%	0%	0%	65%	19%	0%	13263	2923	1468	3458	2621	2790	5	0	0	282	28	0
56	Roosevelt_7thSt to McDowell_7thSt	1,379	61	1,440	96%	4%	0%	0%	0%	74%	26%	0%	16779	2923	1568	4091	2669	3564	5	0	0	222	28	0
57	Roosevelt_7thSt to Washington_7thSt	2,623	208	2,831	93%	7%	0%	0%	0%	100%	0%	0%	20199	2591	1482	5149	1658	3070	3	0	0	930	0	1
58	Washington_7thSt to Roosevelt_7thSt	3,120	65	3,185	98%	2%	0%	0%	0%	100%	0%	0%	20199	2591	1446	4678	2266	4226	3	0	0	322	0	1
59	Washington_7thSt to Lincoln_7thSt	429	0	429	100%	0%	0%	0%	0%	0%	0%	0%	20199	719	308	517	718	517	0	0	0	0	0	1
60	Lincoln_7thSt to Washington_7thSt	422	0	422	100%	0%	0%	0%	0%	0%	0%	0%	20199	719	388	920	718	920	0	0	0	0	0	1
61	McKellips_Rural to L202_Rural	2,480	43	2,522	98%	2%	0%	0%	0%	0%	72%	28%	16000	1872	1710	8233	1793	7788	0	0	0	0	74	23
62	L202_Rural to McKellips_Rural	393	28	422	93%	7%	0%	0%	0%	0%	51%	49%	13505	1872	1636	7049	1793	6623	0	0	0	0	74	23
63	L202_Rural to RioSalado_Rural	1,501	102	1,602	94%	6%	0%	0%	0%	0%	82%	18%	18137	1872	1707	9759	1793	9088	0	0	0	0	74	23
64	RioSalado_Rural to L202_Rural	1,256	54	1,310	96%	4%	0%	0%	0%	0%	73%	27%	18698	1872	1717	9062	1793	8395	0	0	0	0	74	23
65	RioSalado_Rural to University_Rural	607	98	705	86%	14%	0%	0%	0%	0%	70%	30%	12673	1872	1682	9058	1788	8521	0	0	0	0	74	39
66	University_Rural to RioSalado_Rural	94	108	202	46%	54%	0%	0%	0%	0%	67%	33%	17232	1872	1706	8709	1788	8125	0	0	0	0	74	39
67	University_Rural to Broadway_Rural	4,953	87	5,040	98%	2%	38%	0%	0%	0%	36%	25%	20386	1872	1549	5005	1790	4650	6	0	0	0	74	22
68	Broadway_Rural to University_Rural	3,433	272	3,705	93%	7%	11%	0%	0%	0%	67%	22%	19336	1872	1501	4540	1790	4193	6	0	0	0	74	22
69	Broadway_Rural to Southern_Rural	187	0	187	100%	0%	0%	0%	0%	0%	0%	0%	9503	1872	1631	7544	1872	7544	0	0	0	0	0	0
70	Southern_Rural to Broadway_Rural	1,255	0	1,255	100%	0%	0%	0%	0%	0%	0%	0%	8929	1872	1648	7190	1872	7190	0	0	0	0	0	0
71	University_Mill to University_Rural	2,889	551	3,439	84%	16%	6%	0%	0%	0%	52%	42%	12359	1872	1493	4777	1762	4499	4	0	0	0	74	69
72	University_Rural to University_Mill	2,991	619	3,610	83%	17%	4%	0%	0%	0%	42%	54%	11935	1872	1505	4523	1762	4197	4	0	0	0	74	69
73	RioSalado_Mill to University_Mill	3,706	852	4,558	81%	19%	1%	0%	0%	0%	85%	14%	18304	1872	1189	2541	1194	1517	11	0	0	0	642	72
74	University_Mill to RioSalado_Mill	3,767	1,043	4,810	78%	22%	0%	0%	0%	0%	72%	28%	17922	1872	1220	2594	1194	1516	11	0	0	0	642	72
75	RioSalado_Mill to RioSalado_Rural	471	303	774	61%	39%	1%	0%	0%	0%	99%	1%	7246	1872	1254	3055	1225	1938	5	0	0	0	642	4
76	RioSalado_Rural to RioSalado_Mill	184	237	421	44%	56%	1%	0%	0%	0%	99%	0%	6871	1872	1318	3380	1225	2088	5	0	0	0	642	4
	Grand Total	**124,993**	**22,025**	**147,018**	**43%**	**9%**	**14%**	**0.1%**	**3%**	**20%**	**7%**	**3%**		**154743**	**109030**	**328700**	**127824**	**272373**	**708**	**60**	**654**	**20263**	**3364**	**2818**

APPENDIX 3D

ARTERIAL SENSITIVITY ANALYSIS RESULTS

WEEKDAY THRESHOLD SENSITIVITY RESULTS						
#	AWAM Equipped Segments	Recurring Delay (vehicle hours)	Non-Recurring Delay (vehicle hours)	Total Delay	% Recurring	% Non-Recurring
1	Bell_51stAve to Bell_35thAve	581	87	669	87%	13%
2	Bell_35thAve to Bell_51stAve	0	233	233	0%	100%
3	Bell_35thAve to Thunderbird_35thAve	2,163	920	3,083	70%	30%
4	Thunderbird_35thAve to Bell_35thAve	740	1,228	1,968	38%	62%
5	Thunderbird_35thAve to Peoria_35thAve	10,610	703	11,313	94%	6%
6	Peoria_35thAve to Thunderbird_35thAve	220	356	576	38%	62%
7	Peoria_35thAve to Northern_35thAve	9,299	494	9,794	95%	5%
8	Northern_35thAve to Peoria_35thAve	3,915	1,060	4,976	79%	21%
9	Northern_35thAve to BethanyHome_35thAve	5,844	78	5,922	99%	1%
10	BethanyHome_35thAve to Northern_35thAve	5,593	99	5,692	98%	2%
11	BethanyHome_35thAve to IndianSchool_35thAve	7,867	363	8,230	96%	4%
12	IndianSchool_35thAve to BethanyHome_35thAve	4,256	103	4,359	98%	2%
13	IndianSchool_35thAve to McDowell_35thAve	7,215	153	7,369	98%	2%
14	McDowell_35thAve to IndianSchool_35thAve	7,211	1,830	9,041	80%	20%
15	McDowell_35thAve to Buckeye_35thAve	13,023	962	13,985	93%	7%
16	Buckeye_35thAve to McDowell_35thAve	9,375	1,723	11,098	84%	16%
	35th Ave Corridor (with Bell) - 30% Analysis	**87,914**	**10,393**	**98,306**	**89.43%**	**10.57%**
1	Bell_51stAve to Bell_35thAve	3,029	150	3,179	95%	5%
2	Bell_35thAve to Bell_51stAve	255	356	611	42%	58%
3	Bell_35thAve to Thunderbird_35thAve	4,754	1,119	5,873	81%	19%
4	Thunderbird_35thAve to Bell_35thAve	2,415	1,370	3,784	64%	36%
5	Thunderbird_35thAve to Peoria_35thAve	10,924	782	11,707	93%	7%
6	Peoria_35thAve to Thunderbird_35thAve	1,719	405	2,124	81%	19%
7	Peoria_35thAve to Northern_35thAve	0	105	105	0%	100%
8	Northern_35thAve to Peoria_35thAve	6,403	1,171	7,574	85%	15%
9	Northern_35thAve to BethanyHome_35thAve	6,283	84	6,366	99%	1%
10	BethanyHome_35thAve to Northern_35thAve	6,049	105	6,155	98%	2%
11	BethanyHome_35thAve to IndianSchool_35thAve	8,164	383	8,547	96%	4%
12	IndianSchool_35thAve to BethanyHome_35thAve	4,941	118	5,059	98%	2%
13	IndianSchool_35thAve to McDowell_35thAve	7,418	161	7,579	98%	2%
14	McDowell_35thAve to IndianSchool_35thAve	7,217	1,962	9,179	79%	21%
15	McDowell_35thAve to Buckeye_35thAve	13,043	1,034	14,077	93%	7%
16	Buckeye_35thAve to McDowell_35thAve	9,377	1,838	11,215	84%	16%
	35th Ave Corridor (with Bell) - Revised 20% Analysis	**91,993**	**11,142**	**103,135**	**89.20%**	**10.80%**
49	Northern_7thSt to BethanyHome_7thSt	1000	1482	2482	40.30%	59.70%
50	BethanyHome_7thSt to Northern_7thSt	501	908	1409	35.56%	64.44%
51	BethanyHome_7thSt to IndianSchool_7thSt	3797	197	3994	95.08%	4.92%
52	IndianSchool_7thSt to BethanyHome_7thSt	3576	232	3808	93.91%	6.09%
53	IndianSchool_7thSt to McDowell_7thSt	9741	1702	11442	85.13%	14.87%
54	McDowell_7thSt to IndianSchool_7thSt	10835	579	11414	94.92%	5.08%
55	McDowell_7thSt to Roosevelt_7thSt	4038	171	4209	95.94%	4.06%
56	Roosevelt_7thSt to McDowell_7thSt	5470	130	5600	97.68%	2.32%
57	Roosevelt_7thSt to Washington_7thSt	5560	521	6081	91.43%	8.57%
58	Washington_7thSt to Roosevelt_7thSt	6404	146	6550	97.78%	2.22%
59	Washington_7thSt to Lincoln_7thSt	1367	12	1379	99.11%	0.89%
60	Lincoln_7thSt to Washington_7thSt	1412	8	1420	99.45%	0.55%
	7th Street Corridor - 30% Analysis	**53,701**	**6,087**	**59,789**	**89.82%**	**10.18%**
49	Northern_7thSt to BethanyHome_7thSt	1001	1679	2681	37.36%	62.64%
50	BethanyHome_7thSt to Northern_7thSt	847	1048	1895	44.70%	55.30%
51	BethanyHome_7thSt to IndianSchool_7thSt	4153	209	4362	95.22%	4.78%
52	IndianSchool_7thSt to BethanyHome_7thSt	4384	261	4645	94.38%	5.62%
53	IndianSchool_7thSt to McDowell_7thSt	9973	1841	11814	84.42%	15.58%
54	McDowell_7thSt to IndianSchool_7thSt	11153	637	11789	94.60%	5.40%
55	McDowell_7thSt to Roosevelt_7thSt	4038	217	4256	94.89%	5.11%
56	Roosevelt_7thSt to McDowell_7thSt	5470	201	5671	96.45%	3.55%
57	Roosevelt_7thSt to Washington_7thSt	5563	667	6229	89.30%	10.70%
58	Washington_7thSt to Roosevelt_7thSt	6453	181	6635	97.27%	2.73%
59	Washington_7thSt to Lincoln_7thSt	1367	14	1382	98.97%	1.03%
60	Lincoln_7thSt to Washington_7thSt	1413	8	1421	99.42%	0.58%
	7th Street Corridor - Revised 20% Analysis	**55,815**	**6,964**	**62,779**	**88.91%**	**11.09%**

APPENDIX 3E

ALTERNATIVE NRC METHODOLOGY ANALYSIS RESULTS

WEEKDAY 2ND NRC METHODOLOGY RESULTS						
#	AWAM Equipped Segments	Recurring Delay (vehicle hours)	Non-Recurring Delay (vehicle hours)	Total Delay	% Recurring	% Non-Recurring
1	Bell_51stAve to Bell_35thAve	581	87	669	87%	13%
2	Bell_35thAve to Bell_51stAve	0	233	233	0%	100%
3	Bell_35thAve to Thunderbird_35thAve	2,163	920	3,083	70%	30%
4	Thunderbird_35thAve to Bell_35thAve	740	1,228	1,968	38%	62%
5	Thunderbird_35thAve to Peoria_35thAve	10,610	703	11,313	94%	6%
6	Peoria_35thAve to Thunderbird_35thAve	220	356	576	38%	62%
7	Peoria_35thAve to Northern_35thAve	9,299	494	9,794	95%	5%
8	Northern_35thAve to Peoria_35thAve	3,915	1,060	4,976	79%	21%
9	Northern_35thAve to BethanyHome_35thAve	5,844	78	5,922	99%	1%
10	BethanyHome_35thAve to Northern_35thAve	5,593	99	5,692	98%	2%
11	BethanyHome_35thAve to IndianSchool_35thAve	7,867	363	8,230	96%	4%
12	IndianSchool_35thAve to BethanyHome_35thAve	4,256	103	4,359	98%	2%
13	IndianSchool_35thAve to McDowell_35thAve	7,215	153	7,369	98%	2%
14	McDowell_35thAve to IndianSchool_35thAve	7,211	1,830	9,041	80%	20%
15	McDowell_35thAve to Buckeye_35thAve	13,023	962	13,985	93%	7%
16	Buckeye_35thAve to McDowell_35thAve	9,375	1,723	11,098	84%	16%
	35th Ave Corridor (with Bell) - 30% Analysis	**87,914**	**10,393**	**98,306**	**89.43%**	**10.57%**
1	Bell_51stAve to Bell_35thAve	581	401	982	59%	41%
2	Bell_35thAve to Bell_51stAve	0	724	724	0%	100%
3	Bell_35thAve to Thunderbird_35thAve	2,163	1,812	3,975	54%	46%
4	Thunderbird_35thAve to Bell_35thAve	740	1,709	2,449	30%	70%
5	Thunderbird_35thAve to Peoria_35thAve	10,610	727	11,337	94%	6%
6	Peoria_35thAve to Thunderbird_35thAve	220	495	715	31%	69%
7	Peoria_35thAve to Northern_35thAve	9,299	595	9,894	94%	6%
8	Northern_35thAve to Peoria_35thAve	3,915	1,424	5,339	73%	27%
9	Northern_35thAve to BethanyHome_35thAve	5,844	78	5,922	99%	1%
10	BethanyHome_35thAve to Northern_35thAve	5,593	105	5,698	98%	2%
11	BethanyHome_35thAve to IndianSchool_35thAve	7,867	373	8,240	95%	5%
12	IndianSchool_35thAve to BethanyHome_35thAve	4,256	120	4,376	97%	3%
13	IndianSchool_35thAve to McDowell_35thAve	7,215	158	7,373	98%	2%
14	McDowell_35thAve to IndianSchool_35thAve	7,211	1,835	9,046	80%	20%
15	McDowell_35thAve to Buckeye_35thAve	13,023	964	13,987	93%	7%
16	Buckeye_35thAve to McDowell_35thAve	9,375	1,730	11,105	84%	16%
	35th Ave Corridor (with Bell) - 2nd NRC Analysis	**87,913**	**13,250**	**101,163**	**86.90%**	**13.10%**