CENTRAL ARIZONA GOVERNMENTS

STRATEGIC TRANSPORTATION SAFETY PLAN

TECHNICAL MEMORANDUM #2: NETWORK SCREENING RESULTS

July 10, 2015

ENGINEERING   ENFORCEMENT   EDUCATION   EMERGENCY RESPONSE

PREPARED FOR

CAG

PREPARED BY

CAMBRIDGE SYSTEMATICS

WITH

WILSON & COMPANY   GORDLEY GROUP

CAG STRATEGIC TRANSPORTATION SAFETY PLAN

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INTRODUCTION

The objective of Task 2 of the Central Arizona Governments (CAG) Regional Transportation Safety Plan project is to develop and apply a network screening approach for intersections, segments, and pedestrian and bicycle crash locations in the CAG region. Network screening is a process for reviewing a transportation network to identify and rank sites from most likely to least likely to realize a reduction in crash frequency or severity following implementation of a countermeasure. Those sites identified as most likely to realize a reduction in crash frequency or severity can be studied in more detail to identify crash patterns, contributing factors, and appropriate countermeasures.[1]

This memo describes the results of the network screening process for the CAG region. An earlier project memo (draft Technical Memorandum #2) documented data availability and the proposed approach and scope of the network screening process. Key sections of the earlier memo and additional details of the network screening methodology are included in Technical Appendix A of this memo. Preliminary analysis results also were presented to the project Multidisciplinary Safety Committee (MDSC) at its April meeting. Based on feedback from that meeting, the list of potential intersections to be studied was expanded to include all local road intersections.

NETWORK SCREENING RESULTS

Intersections

To identify intersections with the greatest potential for safety improvements, crashes from 2009 to 2013 were first associated with the nearest intersection through a spatial analysis process. Crashes which occurred within 250 feet on an intersection were identified as "intersection crashes." Intersections with more than five total crashes over the five-year analysis period (i.e., more than one per year) were selected for further study. Using these criteria, 55 intersections were chosen for evaluation. See Appendix B for the full list of intersections studied in the network screening analysis. For each of the 55 candidate intersections, the following performance measures were then calculated:[2]

- **Crash Frequency:** The average number of crashes occurring at a particular intersection in a one-year period.
- **Equivalent Property Damage Only:** The average number of equivalent property damage only (EPDO) crashes occurring at a particular intersection in a one-year period. The EPDO measure is calculated by

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[1] AASHTO Highway Safety Manual, 2010, p. 4-1.
[2] See AASHTO Highway Safety Manual for more information on these performance measures.

applying a weighting factor to each crash according to its severity, and then summing the weighted crash frequency. See Appendix C for more information.

- **Crash Rate:** The number of crashes that occur at a given intersection during a certain time period in relation to exposure (the number of vehicles entering the intersection).

Once the performance measures were calculated, the candidate intersections were ranked separately for each measure. The top 10 intersections for each performance measure are shown in Tables 1 to 3. The rankings for each performance measure were then summed to develop a composite score for each intersection, which was then sorted to develop the final ranking. Table 4 and Figure 1 show the top 10 intersections with potential for safety improvement based on this methodology. The full ranking for each performance measure and the combined scoring is shown in Appendix B.

Table 1.   Intersection Screening Results
Ranked by Crash Frequency

Rank	Intersection	Traffic Control	Total Crashes	Fatal Crashes	Serious Injury Crashes	Minor Injury Crashes	Possible Injury Crashes	Property Damage Only Crashes	Million Entering Vehicles	Total Crashes	EPDO Crashes	Crash Rate
			2009-2013 Total						**Annual Average**			
1	SR 87/Beeline Highway at Longhorn Road at U.S. 260	Signal	79	0	1	9	10	59	10.4	15.8	89	1.5
2	SR 87/Beeline Highway at Bonita Street	Signal	40	0	1	9	8	22	8.7	8.0	77	0.9
3	U.S. 60 at Escudilla Drive at Main Street	Signal	34	0	0	0	8	26	4.8	6.8	22	1.4
4	U.S. 60 at Radanovich Boulevard at Globe Food Mart access road	Signal	27	1	2	1	4	19	3.9	5.4	346	1.4
5	SR 260 at Manzanita Drive at Granite Dells Road	Signal	27	0	2	2	2	21	4.2	5.4	56	1.3
6	U.S. 60/Ash Street at Hill Street	Signal	23	0	1	2	5	15	4.4	4.6	42	1.1
7	Broad Street at Oak Street	Stop Sign	21	0	1	1	4	15	2.7	4.2	35	1.6
8	SR 188/Apache Trail at U.S. 60 at Russell Road	Signal	21	0	3	4	9	5	4.6	4.2	96	0.9
9	SR 87/Beeline Highway at Main Street	Signal	21	1	0	2	3	15	7.8	4.2	307	0.5
10	SR 260 at Forest Drive	Signal	19	0	0	5	5	9	8.1	3.8	32	0.5

Table 2.   Intersection Screening Results
Ranked by Equivalent Property Damage Only

Rank	Intersection	Traffic Control	2009-2013 Total						Annual Average			
			Total Crashes	Fatal Crashes	Serious Injury Crashes	Minor Injury Crashes	Possible Injury Crashes	Property Damage Only Crashes	Million Entering Vehicles	Total Crashes	EPDO Crashes	Crash Rate
1	SR 87/Beeline Highway/Duthie-Martin Highway at SR 188	Stop Sign	8	2	0	0	1	5	3.2	1.6	583	0.5
2	U.S. 60 at Radanovich Boulevard at Globe Food Mart access road	Signal	27	1	2	1	4	19	3.9	5.4	346	1.4
3	SR 347/John Wayne Parkway at Papago Road	Stop Sign	14	1	0	5	1	7	3.8	2.8	314	0.7
4	U.S. 60/Ash Street at Hackey Avenue at Willow Street	Stop Sign	9	1	1	0	1	6	7.4	1.8	313	0.2
5	SR 87/Beeline Highway at Main Street	Signal	21	1	0	2	3	15	7.8	4.2	307	0.5
6	SR 260 at SR 87 at Malibu Drive	Signal	18	1	0	2	3	12	8.7	3.6	307	0.4
7	SR 260 at Valley Road at Highline Drive	Stop Sign	18	1	0	1	2	14	2.8	3.6	301	1.3
8	SR 188/Apache Trail at U.S. Highway 60 at Russell Road	Signal	21	0	3	4	9	5	4.6	4.2	96	0.9
9	SR 87/Beeline Highway at Longhorn Road at U.S. 260	Signal	79	0	1	9	10	59	10.4	15.8	89	1.5
10	SR 87/Beeline Highway at Bonita Street	Signal	40	0	1	9	8	22	8.7	8.0	77	0.9

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Table 3.   **Intersection Screening Results**
Ranked by Crash Rate

Rank	Intersection	Traffic Control	2009-2013 Total						Annual Average			
			Total Crashes	Fatal Crashes	Serious Injury Crashes	Minor Injury Crashes	Possible Injury Crashes	Property Damage Only Crashes	Million Entering Vehicles	Total Crashes	EPDO Crashes	Crash Rate
1	Broad Street at Oak Street	Stop Sign	21	0	1	1	4	15	2.7	4.2	35	1.6
2	SR 87/Beeline Highway at Longhorn Road at U.S. 260	Signal	79	0	1	9	10	59	10.4	15.8	89	1.5
3	Hill Street at Sycamore Street	Stop Sign	16	0	0	1	0	15	2.2	3.2	7	1.4
4	U.S. 60 at Escudilla Drive at Main Street	Signal	34	0	0	0	8	26	4.8	6.8	22	1.4
5	U.S. 60 at Radanovich Boulevard at Globe Food Mart access road	Signal	27	1	2	1	4	19	3.9	5.4	346	1.4
6	SR 260 at Valley Road at Highline Drive	Stop Sign	18	1	0	1	2	14	2.8	3.6	301	1.3
7	SR 260 at Manzanita Drive at Granite Dells Road	Signal	27	0	2	2	2	21	4.2	5.4	56	1.3
8	SR 77 at Tiger Mine Road	Stop Sign	7	0	1	0	0	6	1.1	1.4	21	1.2
9	Broad Street at Yuma Street	Stop Sign	11	0	0	0	0	11	2.0	2.2	2	1.1
10	Broad Street at Cedar Street	Signal	12	0	1	1	1	9	2.3	2.4	28	1.1

Table 4.   Intersection Screening Results
Final Ranking

Final Rank	Intersection	Traffic Control	Frequency Rank	EPDO Rank	Crash Rate Rank	Composite Score
1	U.S. 60 at Radanovich Boulevard at Globe Food Mart access road	Signal	4	2	5	11
2	SR 87/Beeline Highway at Longhorn Road at U.S. 260	Signal	1	9	2	12
3	SR 260 at Manzanita Drive at Granite Dells Road	Signal	4	12	7	23
4	SR 260 at Valley Road at Highline Drive	Stop Sign	11	7	6	24
5	Broad Street at Oak Street	Stop Sign	7	16	1	24
6	SR 87/Beeline Highway at Bonita Street	Signal	2	10	14	26
7	SR 188/Apache Trail at U.S. 60 at Russell Road	Signal	7	8	15	30
8	U.S. 60/Ash Street at Hill Street	Signal	6	15	11	32
9	U.S. 60 at Escudilla Drive at Main Street	Signal	3	26	4	33
10	SR 347/John Wayne Parkway at Papago Road	Stop Sign	14	3	24	41

Figure 1.   Top 10 Intersections with Potential for Safety Improvement

Rank	Intersection Name
1	U.S. 60 at Radanovich Boulevard at Globe Food Mart access road
2	SR 87/Beeline Highway at Longhorn Road at U.S. 260
3	SR 260 at Manzanita Drive at Granite Dells Road
4	SR 260 at Valley Road at Highline Drive
5	Broad Street at Oak Street
6	SR 87/Beeline Highway at Bonita Street
7	SR 188/Apache Trail at U.S. 60 at Russell Road
8	U.S. 60/Ash Street at Hill Street
9	U.S. 60 at Escudilla Drive at Main Street
10	SR 347/John Wayne Parkway at Papago Road

Segments

To conduct roadway segment analysis, crashes outside of the 250-foot intersection buffer were associated with the nearest roadway segment from the comprehensive roadway file for the CAG region (see Appendix A for more discussion on the files used in the network screening analysis). Those within 100 feet of a roadway segment were included in the segment screening process. A 100 foot buffer was chosen to allow for minor misalignment of crashes and roadways. Ninety-two percent of segment crashes were matched within 10 feet of a segment.

Similar to the process for intersections, each segment was evaluated on the basis of several performance measures, including:

- Total crash rate (crashes per million vehicle miles traveled).
- Severe crash density (fatal and serious injury crashes per mile of roadway).
- Severe crash rate (fatal and serious injury crashes per million vehicle-miles traveled).
- Potential for reduction of severe crashes (the number of observed severe crashes minus the anticipated number of severe crashes based on the average severe crash rate for comparable segments). See Appendix D for a more detailed discussion of comparable segments and the process used to calculate this performance measure.

Once the performance measures were calculated, segments were ranked separately for each measure. Segments within each category were then assigned a score of 1 (low-risk) to 5 (high-risk).[3] Segments with no severe crashes from 2009 through 2013 were automatically placed into the low-risk category. Additionally, segments with only one or two severe crashes were placed into the low-medium risk category. This was necessary to prevent very short segments with only a few severe crashes from being shown as high-risk segments on the basis of crash density and rate. The remaining segments (those with more than two severe crashes from 2009 to 2013) accounted for roughly 15 percent of the roadway mileage in the CAG region. These segments were divided into medium, medium-high, and high-risk categories for each performance measure, such that each category accounted for roughly 5 percent of the total roadway mileage.

After the segments were categorized for each performance measure, a composite score was developed by summing the individual performance measure scores for each segment and ranking the segments based on this composite score. Segments were again divided into medium, medium-high, and high-risk categories based on the composite score, with each accounting for roughly five percent of the total roadway mileage.

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[3] This categorization scheme is based on the risk mapping process developed in the usRAP Pilot Project, Phase 2 report, with some modifications. Harwood et al. 2008. usRAP Pilot Program Phase II Report. https://www.aaafoundation.org/sites/default/files/usRAPPhaseIIReport.pdf.

Maps illustrating the results of the segment screening process for each performance measure and for the combination of measures are shown in Figures 2 to 5.

Figure 2.   Risk Map 1: Crash Rate
Crashes per Vehicle-Mile Traveled
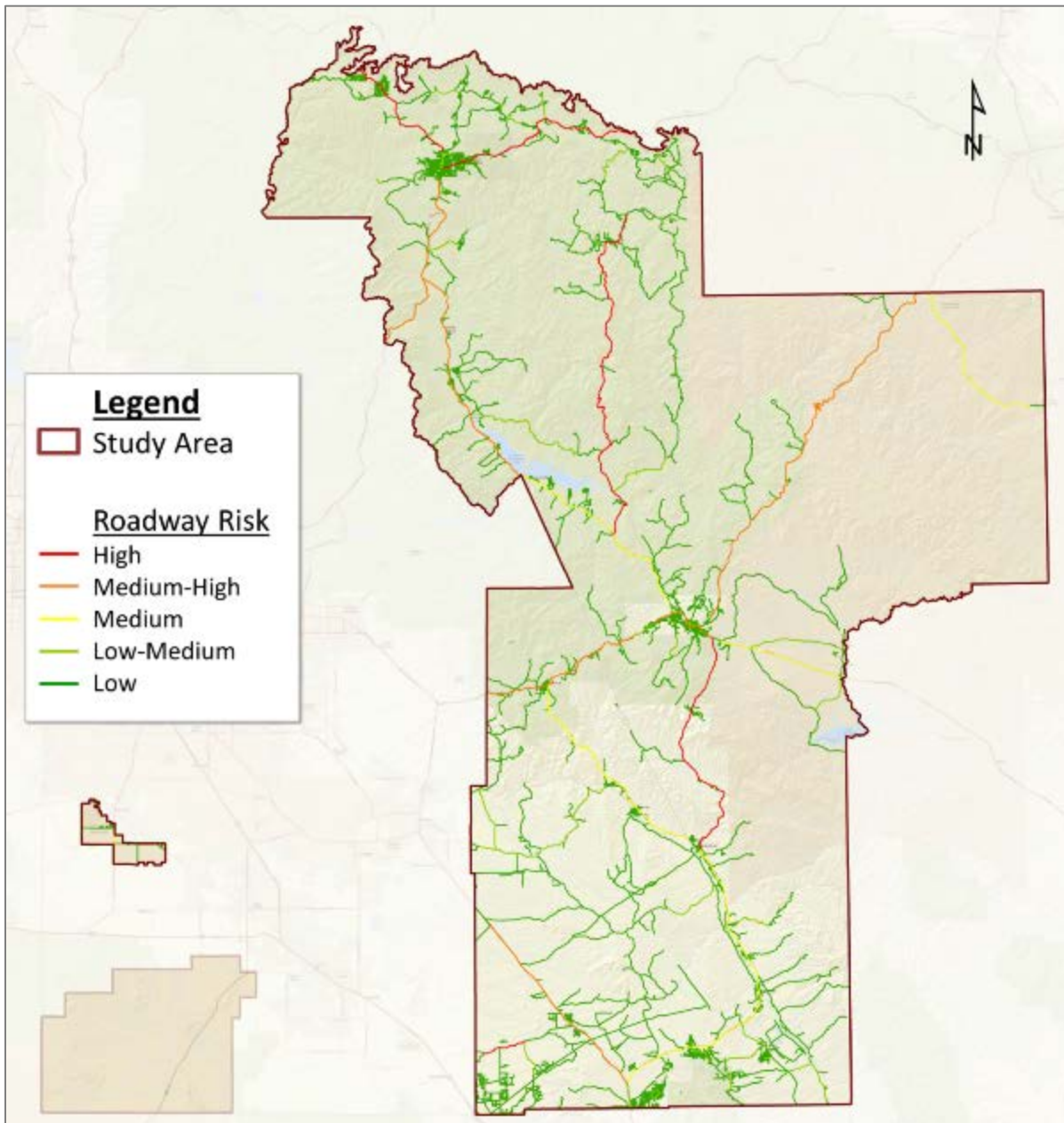
Source: CAG, Arizona DOT, Cambridge Systematics, Inc., Esri.

Figure 3. Risk Map 2: Severe Crash Density
Fatal and Serious Injury Crashes per Mile
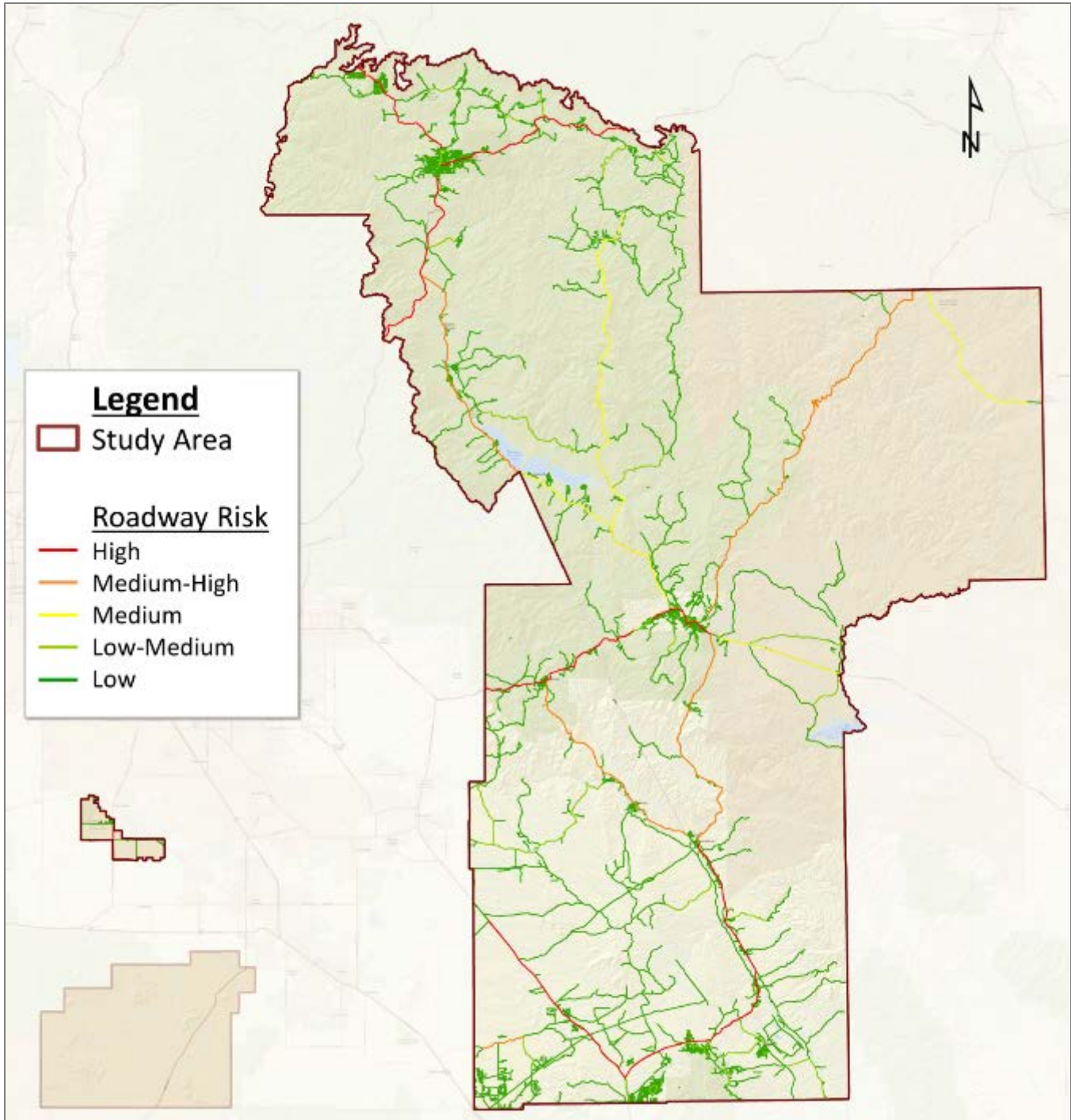
Source: CAG, Arizona DOT, Cambridge Systematics, Inc., Esri.

Figure 4. **Risk Map 3: Severe Crash Rate**
Fatal and Serious Injury Crashes per VMT
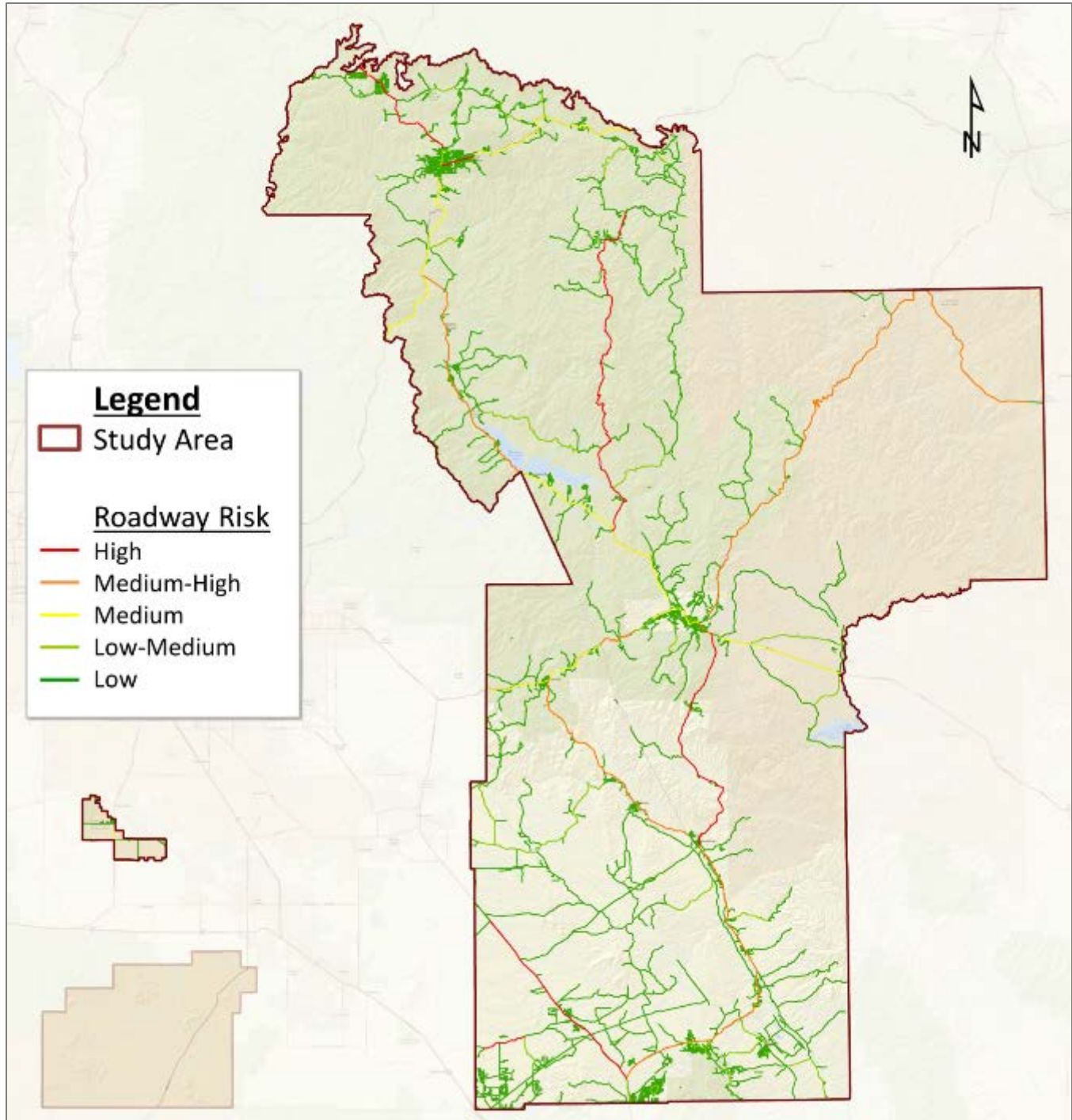
Source: CAG, Arizona DOT, Cambridge Systematics, Inc., Esri.
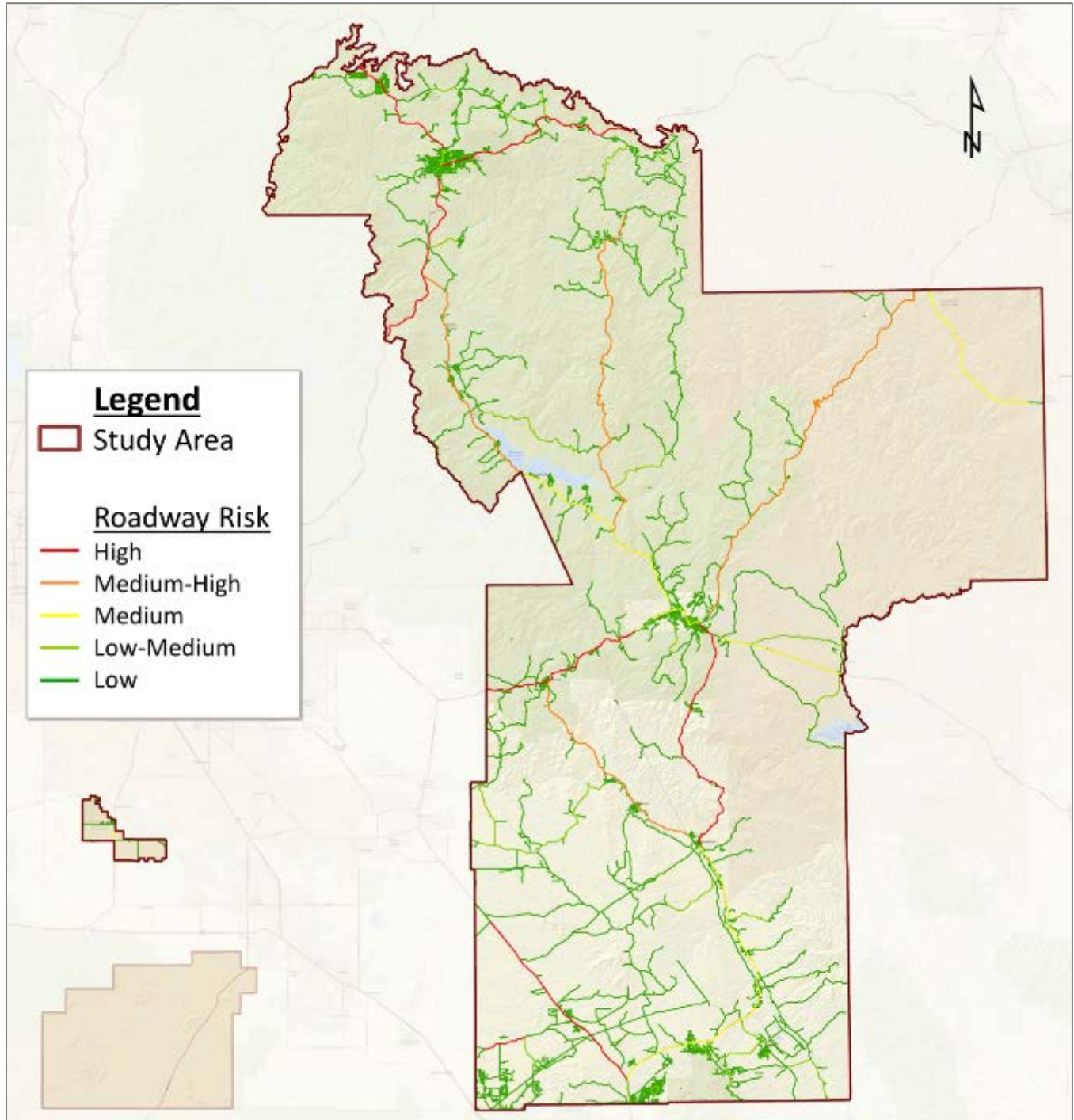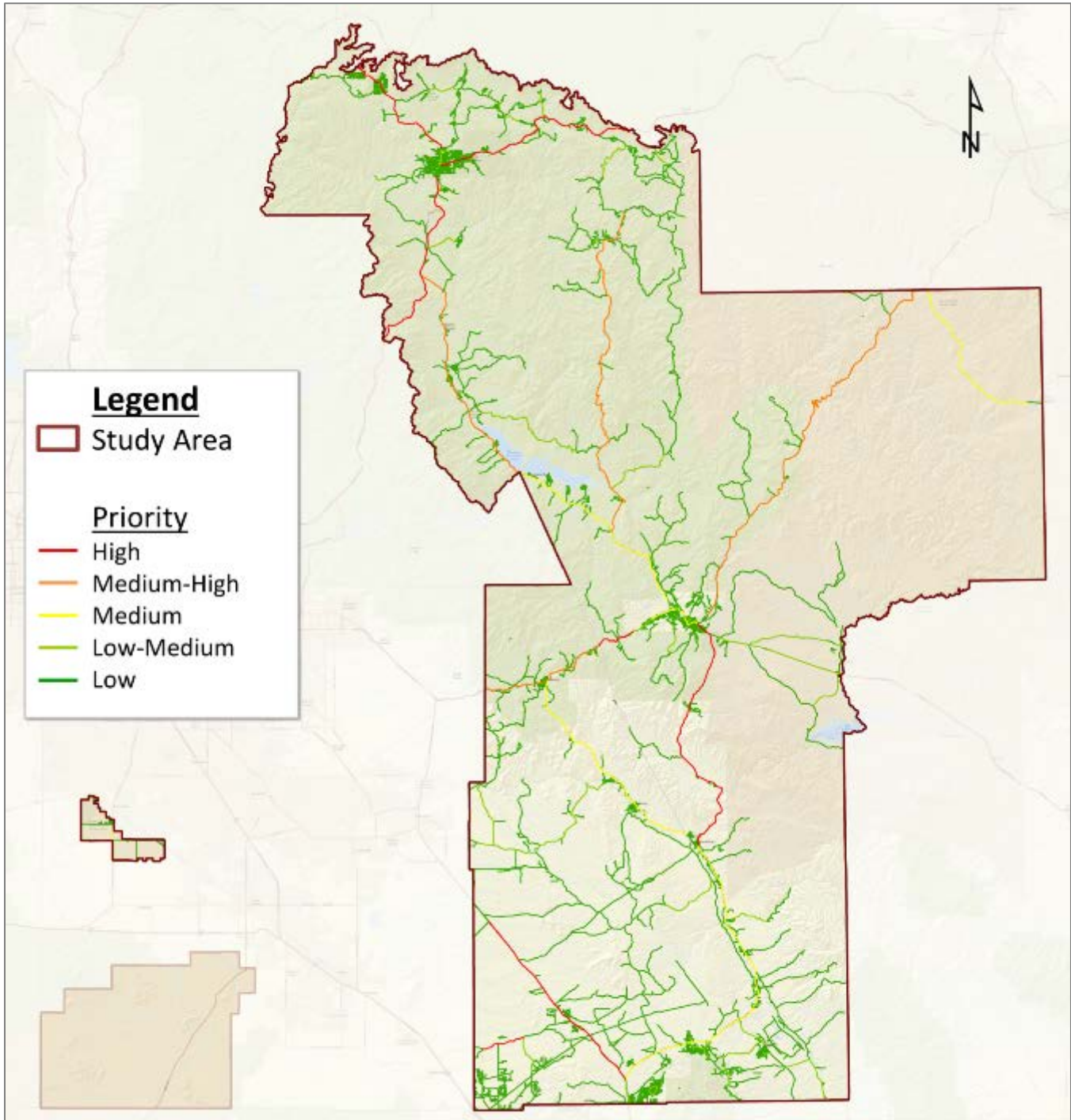
Figure 5.   Risk Map 4: Potential for Reduction of Severe Crashes

Source: CAG, Arizona DOT, Cambridge Systematics, Inc., Esri.

Figure 6.   Risk Map 5: Recommended Segments for Safety Improvements

Source: CAG, Arizona DOT, Cambridge Systematics, Inc., Esri.

Pedestrian and Bicycle Crash Locations

Pedestrian and bicycle crash locations were screened on the basis of total crashes from 2004 to 2013. More years of data are used due to the lower number of pedestrian and bicycle-related crashes. Similar to the intersection screening process, crashes involving one or more nonmotorists were assigned to the nearest intersection, within a 250 foot buffer. The pedestrian and bicycle crash location summary is shown in Table 5. All intersections with one or more pedestrian or bike crashes during this period are shown.

Due to the relatively small number of pedestrian and bicycle crashes, a more detailed analysis of contributing factors is not recommended. However, the locations identified in Table 5 could be evaluated to determine whether improvements may be needed to reduce the likelihood of future crashes at those intersections. The Pedsafe and Bikesafe guide and countermeasure selection systems may be a useful resource to CAG for evaluating pedestrian and bike crashes and identifying appropriate countermeasures.[4]

Table 5. Pedestrian and Bicycle Crash Locations
2004-2013

Intersection	Total Crashes	Fatal Crashes	Serious Injury Crashes	Minor Injury Crashes	Possible Injury Crashes	PDO Crashes
SR 87/Beeline Highway at Bonita Street	9	0	1	3	4	1
SR 87/Beeline Highway at Longhorn Road at U.S. Highway 260	6	0	1	3	0	2
SR 260 at Forest Drive	4	0	0	3	1	0
S Broad Street at E Sycamore Street	4	0	2	2	0	0
SR 260 at Zurich Drive	3	0	0	0	3	0
W American Avenue at N Rockcliff Boulevard	3	0	0	1	1	1
U.S. 60 at East Street	3	0	1	1	1	0
SR 87/Beeline Highway at Phoenix Street	3	0	1	1	1	0
U.S. 60 at Radanovich Boulevard at Globe Food Mart access road	3	1	1	0	1	0
U.S. 60/Ash Street at Hackey Avenue at Willow Street	3	2	1	0	0	0
SR 260 at SR 87 at Malibu Drive	2	0	0	1	1	0
SR 87/Beeline Highway at Cedar Lane	2	0	0	1	1	0
SR 87/Beeline Highway at Main Street	2	0	0	1	0	1
SR 260 at S Goodnow Road	2	0	0	0	2	0
SR 87/Beeline Highway at Frontier Street	2	0	1	1	0	0

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[4] Federal Highway Administration. http://pedbikesafe.org/.

Intersection	Total Crashes	Fatal Crashes	Serious Injury Crashes	Minor Injury Crashes	Possible Injury Crashes	PDO Crashes
E Ash Street/U.S. 60 at S 6th Street	2	0	1	1	0	0
SR 87 at Main Street	1	0	0	1	0	0
SR 87 at E Sherman Drive	1	0	0	1	0	0
SR 77 at SR 79	1	0	0	1	0	0
SR 87 at Strawberry Drive	1	0	0	1	0	0
SR 260 at Ranger Station Road	1	0	0	1	0	0
U.S. 60 at 2nd Street	1	0	0	1	0	0
SR 260 at Diamond Point	1	0	0	1	0	0
SR 188/Apache Trail at U.S. 60 at Russell Road	1	0	0	0	1	0
U.S. 60/Ash Street at Hill Street	1	0	0	0	1	0
U.S. 60/Ash Street at High Street	1	0	0	0	1	0
U.S. 60 at New Street	1	0	0	0	0	1
S McLane Road at W Longhorn Road	1	0	0	0	1	0
N McLane Road at W Saddle Lane	1	0	0	0	1	0
E Frontier Street at S Colcord Road	1	0	0	1	0	0
W Bonita Street at S Colcord Road	1	0	0	0	1	0
U.S. 60/N Broad Street at Santee Street	1	0	0	1	0	0
N Broad Street at E Mesquite Street	1	0	0	0	1	0
N Broad Street at E Cedar Street	1	0	0	1	0	0
E Maple Street at S Hill Street at S Sutherland Street	1	0	0	1	0	0
E Ash Street/U.S. 60 at E Prickly Pear Drive	1	0	0	1	0	0
SR 77 at Rockcliff Boulevard	1	0	1	0	0	0
SR 77 at Saddlebrooke Boulevard	1	0	1	0	0	0
U.S. 60 at Calle de Loma	1	0	1	0	0	0
U.S. 60/Ash Street at N Broad Street at Silver Street	1	1	0	0	0	0

RECOMMENDATIONS

The network screening analysis identifies several potential intersections and corridors to be studied for the application of safety countermeasures. In the next phase of the project, the consultant team will review specific locations or corridors to identify safety issues and develop recommendations for safety projects. To identify the breadth of safety concerns and countermeasures appropriate for application in the CAG region, we recommend a mix of locations be considered for further evaluation, including intersections, segments, and pedestrian and

bicycle crash locations. This approach would give CAG a thorough understanding of the range of safety issues that are prevalent in the region and how countermeasures can be applied in a variety of contexts. We recommend that the consultant team and CAG Project Manager discuss the network screening results to collaboratively determine the highest priorities for project development.

TECHNICAL APPENDIX

Appendix A.   Data Sources and Integration

Several spatial datasets were collected for use in the network screening process, including crash data (2004-2013); a roadway inventory for the CAG region (Certified Public Mileage or CPM file); traffic volume data for ADOT and local roads (Highway Performance Management System or HPMS file and CPM file); an intersection (Junction) file; a shoulder inventory; a travel lane inventory; and a speed limit file. All data were provided to CS by GISWorks Consulting, with approval from Central Arizona Governments Staff.

In order to conduct network screening, crash and roadway files must be integrated through a GIS process. For the intersection screening process, crashes were spatially joined to an intersection ('Junctions') file provided to Cambridge Systematics. Based on feedback from the project Steering Committee, another intersection file was developed to include all local road intersections. The spatial join process was then repeated using this local intersection file and the results of both processes were merged. In both cases, a 250 foot distance threshold was used, compared to a 100 foot threshold for segments.

The process of integrating crashes and segments is similar, but somewhat more complex. The CPM file was used as the base roadway file for the segment screening analysis, but additional roadway inventory and traffic volume data also was required. Because the CPM file and other roadway attribute files use a common linear referencing system, they could be conflated using ArcGIS linear referencing tools. This allowed each segment to account for all of the variables of interest.

Based on the initial data received and additional datasets created in the spatial join process, CS developed a set of variables to be used in the network screening analysis process. A Microsoft Access database was used in conjunction with Microsoft Excel for the network screening analysis. The variables considered in the network screening process are listed in Table A-1, along with their description and source.

Table A-1 Network Screening Variables

Variable	Description	Source
Crash severity	Injury severity reported at the crash level. Crash severity is categorized according to the most severe injury resulting from the crash.	Crash GIS file
Pedestrian or bicyclist involvement	Indicated by the 'TotalNonMotorists' field being greater than 0.	Crash GIS file
Roadway functional class	Functional class designation for each segment.	Certified Public Mileage GIS file
Urban/rural roadway or crash location	Urban/rural designations are based on the functional class designation.	Certified Public Mileage GIS file
Traffic control	The type of traffic control present at an intersection, including signals, stop signs, proposed signals, or roundabouts. Other 'junctions,' such as curb cuts, were removed for the analysis.	Junctions GIS file
Number of lanes	The number of through lanes, as indicated in the 'ThruLanes' field. Segments with a '0' value are assumed to have two lanes per guidance from GISWorks.	Certified Public Mileage GIS file and Travel Lane Inventory
Traffic volume	Annual vehicle miles traveled, reported in millions. Daily segment volume were converted to vehicle miles traveled by multiplying the segment ADT by the segment length.	HPMS GIS file, Certified Public Mileage GIS file
Presence or absence of a shoulder and its width	Whether a shoulder is present and, if so, how wide it is.	Shoulder Inventory GIS file
Speed limit	The speed limit for each roadway segment. Available for ADOT roads only.	Speed limit GIS file

Appendix B.   Complete Intersection Ranking

Table B-1 Intersections Evaluated in Network Screening Process
Ranked by Composite Score

Rank	Intersection	Traffic Control	2009-2013 Total						Annual Average				Criteria Rank			Composite Score
			Total Crashes	Fatal Crashes	Serious Injury Crashes	Minor Injury Crashes	Possible Injury Crashes	Property Damage Only Crashes	Million Entering Vehicles	Total Crashes	EPDO Crashes	Crash Rate	Frequency Rank (Total Crashes)	Severity Rank (EPDO)	Crash Rate Rank	
1	U.S. 60 at Radanovich Boulevard at Globe Food Mart access road	Signal	27	1	2	1	4	19	3.9	5.4	346	1.4	4	2	5	11
2	SR 87/Beeline Highway at Longhorn Road at U.S. 260	Signal	79	0	1	9	10	59	10.4	15.8	89	1.5	1	9	2	12
3	SR 260 at Manzanita Drive at Granite Dells Road	Signal	27	0	2	2	2	21	4.2	5.4	56	1.3	4	12	7	23
4	SR 260 at Valley Road at Highline Drive	Stop Sign	18	1	0	1	2	14	2.8	3.6	301	1.3	11	7	6	24
4	Broad Street at Oak Street	Stop Sign	21	0	1	1	4	15	2.7	4.2	35	1.6	7	16	1	24
6	SR 87/Beeline Highway at Bonita Street	Signal	40	0	1	9	8	22	8.7	8.0	77	0.9	2	10	14	26
7	SR 188/Apache Trail at U.S. Highway 60 at Russell Road	Signal	21	0	3	4	9	5	4.6	4.2	96	0.9	7	8	15	30
8	U.S. 60/Ash Street at Hill Street	Signal	23	0	1	2	5	15	4.4	4.6	42	1.1	6	15	11	32
9	U.S. 60 at Escudilla Drive at Main Street	Signal	34	0	0	0	8	26	4.8	6.8	22	1.4	3	26	4	33
10	SR 347/John Wayne Parkway at Papago Road	Stop Sign	14	1	0	5	1	7	3.8	2.8	314	0.7	14	3	24	41
11	SR 87/Beeline Highway at Main Street	Signal	21	1	0	2	3	15	7.8	4.2	307	0.5	7	5	33	45
12	Broad Street at Cedar Street	Signal	12	0	1	1	1	9	2.3	2.4	28	1.1	19	23	10	52

Rank	Intersection	Traffic Control	2009-2013 Total						Annual Average				Criteria Rank			
			Total Crashes	Fatal Crashes	Serious Injury Crashes	Minor Injury Crashes	Possible Injury Crashes	Property Damage Only Crashes	Million Entering Vehicles	Total Crashes	EPDO Crashes	Crash Rate	Frequency Rank (Total Crashes)	Severity Rank (EPDO)	Crash Rate Rank	Composite Score
13	Hill Street at Sycamore Street	Stop Sign	16	0	0	1	0	15	2.2	3.2	7	1.4	13	38	3	54
14	SR 260 at SR 87 at Malibu Drive	Signal	18	1	0	2	3	12	8.7	3.6	307	0.4	11	6	38	55
15	U.S. 60 at E Ash Street	Signal	14	0	1	1	1	11	3.4	2.8	28	0.8	14	22	20	56
16	SR 260 at Cornerstone Way at Moonlight Drive	Stop Sign	13	0	0	6	3	4	3.0	2.6	31	0.9	18	20	19	57
17	SR 260 at Forest Drive	Signal	19	0	0	5	5	9	8.1	3.8	32	0.5	10	19	36	65
17	SR 77 at Saddlebrooke Boulevard	Signal	10	0	3	1	0	6	3.6	2.0	65	0.6	23	11	31	65
19	U.S. 60 at East Street	Stop Sign	9	0	2	1	1	5	3.1	1.8	47	0.6	26	13	29	68
20	SR 77 at SR 79	Stop Sign	14	0	0	0	4	10	3.6	2.8	10	0.8	14	34	23	71
21	SR 87/Beeline Highway/Duthie-Martin Highway at SR 188	Stop Sign	8	2	0	0	1	5	3.2	1.6	583	0.5	37	1	34	72
22	U.S. 60 at New Street	Signal	9	0	1	1	2	5	2.6	1.8	29	0.7	26	21	26	73
22	U.S. 60 at Miami Avenue	Signal	9	0	0	3	0	6	2.0	1.8	13	0.9	26	31	16	73
24	U.S. 60 at Ragus Road	Stop Sign	10	0	1	0	2	7	3.2	2.0	26	0.6	23	25	27	75
24	SR 260 at Orion Drive at Milky Way at Walters Lane	Stop Sign	9	0	0	1	2	6	1.9	1.8	9	0.9	26	36	13	75
24	SR 77 at Tiger Mine Road	Stop Sign	7	0	1	0	0	6	1.1	1.4	21	1.2	40	27	8	75
27	Airport Road at McLane Road	Stop Sign	9	0	0	3	1	5	2.2	1.8	15	0.8	26	30	22	78
28	U.S. 60 at 3rd Street	Signal	14	0	0	0	1	13	3.2	2.8	5	0.9	14	47	18	79

Rank	Intersection	Traffic Control	2009-2013 Total						Annual Average				Criteria Rank			
			Total Crashes	Fatal Crashes	Serious Injury Crashes	Minor Injury Crashes	Possible Injury Crashes	Property Damage Only Crashes	Million Entering Vehicles	Total Crashes	EPDO Crashes	Crash Rate	Frequency Rank (Total Crashes)	Severity Rank (EPDO)	Crash Rate Rank	Composite Score
28	U.S. 60/Ash Street at Hackey Avenue at Willow Street	Stop Sign	9	1	1	0	1	6	7.4	1.8	313	0.2	26	4	49	79
30	SR 260 at Tyler Parkway at Rim Club Parkway	Signal	12	0	0	0	2	10	3.0	2.4	6	0.8	19	41	21	81
31	U.S. 60/Ash Street at N Broad Street at Silver Street	Signal	12	0	1	2	2	7	8.8	2.4	34	0.3	19	18	45	82
32	Broad Street at Yuma Street	Stop Sign	11	0	0	0	0	11	2.0	2.2	2	1.1	22	53	9	84
33	U.S. 60 at Forest Avenue	Signal	9	0	0	0	1	8	1.9	1.8	4	1.0	26	48	12	86
34	U.S. 60/Ash Street at N Broad Street at Evans Avenue	Stop Sign	9	0	2	0	2	5	9.3	1.8	45	0.2	26	14	54	94
35	7th Street at U.S. 60	Stop Sign	9	0	0	2	1	6	6.5	1.8	11	0.3	26	32	44	102
36	SR 260 at Zurich Drive	Stop Sign	10	0	0	1	2	7	7.6	2.0	10	0.3	23	35	48	106
37	SR 260 at Pinon Road	Stop Sign	5	0	1	0	0	4	1.8	1.0	21	0.5	48	28	32	108
38	U.S. 60 at El Camino	Stop Sign	8	0	0	1	0	7	2.8	1.6	5	0.6	37	43	30	110
39	SR 87/Beeline Highway at Frontier Street	Stop Sign	9	0	0	1	3	5	8.5	1.8	11	0.2	26	32	53	111
39	Cedar Street at Hill Street	Stop Sign	6	0	0	0	1	5	1.3	1.2	3	0.9	44	50	17	111
41	SR 87/Beeline Highway at Phoenix Street	Stop Sign	6	0	1	3	1	1	5.2	1.2	34	0.2	44	17	51	112
42	SR 260 at SR 87 at Flowing Springs Road	Stop Sign	5	0	0	2	0	3	1.6	1.0	9	0.6	48	37	28	113
43	SR 260 at Zane Grey Highway at Kohl's Ranch Road	Stop Sign	8	0	0	1	0	7	3.2	1.6	5	0.5	37	43	35	115
44	SR 87/Beeline Highway at Cedar Lane	Stop Sign	7	0	0	3	2	2	5.3	1.4	17	0.3	40	29	47	116

Rank	Intersection	Traffic Control	2009-2013 Total						Annual Average				Criteria Rank			
			Total Crashes	Fatal Crashes	Serious Injury Crashes	Minor Injury Crashes	Possible Injury Crashes	Property Damage Only Crashes	Million Entering Vehicles	Total Crashes	EPDO Crashes	Crash Rate	Frequency Rank (Total Crashes)	Severity Rank (EPDO)	Crash Rate Rank	Composite Score
45	SR 260 at Oak Mobile Home Park access road	Proposed Signal	9	0	0	1	0	8	7.6	1.8	6	0.2	26	42	50	118
46	Oak Street at Pine Street	Stop Sign	6	0	0	0	1	5	1.7	1.2	3	0.7	44	50	25	119
47	SR 87 at Green Valley Pky/Tonto Apache Tribe Reservation	Signal	5	0	1	1	1	2	4.5	1.0	27	0.2	48	24	52	124
47	American Avenue at Calle Futura	Stop Sign	5	0	0	1	1	3	2.3	1.0	7	0.4	48	39	37	124
49	SR 260 at Goodnow Road	Stop Sign	7	0	0	1	0	6	3.6	1.4	5	0.4	40	45	40	125
50	U.S. 60 at Old Oak Street	Stop Sign	5	0	0	1	1	3	2.9	1.0	7	0.3	48	39	42	129
51	SR 260 at Houston Mesa Road	Stop Sign	7	0	0	0	1	6	4.8	1.4	3	0.3	40	49	43	132
52	Broad Street at Sycamore Street	Stop Sign	5	0	0	1	0	4	2.43	1	5	0.4	48	46	39	133
53	U.S. 60/Ash Street at High Street	Stop Sign	6	0	0	0	1	5	3.24	1.2	3	0.4	44	50	41	135
54	Ruiz Canyon Road at Jesse Hayes Road	Stop Sign	5	0	0	0	0	5	3.75	1	1	0.3	48	54	46	148
55	South Street at U.S. 60	Stop Sign	5	0	0	0	0	5	6.13	1	1	0.2	48	54	55	157

Appendix C.   Equivalent Property Damage Only (EPDO) Performance Measure

The EPDO network screening performance measure used in the intersection screening process uses crash cost to develop weights for each crash. Individual crashes are assigned an EPDO weight based on the most severe injury that resulted from the crash. For example, a crash involving a fatal injury is valued at $5,800,000, with an EPDO weight of 1,450. Similarly, a crash involving no injuries is valued at $4,000 and has an EDPO weight of 1. Once each crash is given an EDPO weight, the total EPDO score for a given site can be calculated by summing the individual EDPO crash weights. This weighting process allows locations with different crash severity distributions to be compared on a common basis.

The comprehensive crash costs recommended by FHWA and included in the Arizona Highway Safety Improvement Program Manual were used to develop EPDO weights. They account for wage and productivity losses, medical expenses, administrative expenses, motor vehicle damage, employer costs, and estimated costs resulting from lost quality of life. These crash costs are shown in Table C-1.

Table C-1   Comprehensive Crash Cost and EDPO Weights by Crash Severity

Crash Severity	Comprehensive Crash Cost	EPDO Weight
Property Damage Only	$4,000	1
Possible Injury	$42,000	10.5
Non-Incapacitating Injury	$80,000	20
Incapacitating Injury	$400,000	100
Fatal	$5,800,000	1,450

Source: Arizona Department of Transportation, Highway Safety Improvement Program Manual.

Appendix D.   Segment Analysis Methodology

To develop a better understanding of how each segment compares to other segments with similar characteristics, they were first classified into segment categories. Segments should be classified in such a way as to ensure operational and design characteristics are relatively consistent within the category. Given sufficient data, factors that could be considered for classification include traffic volume, speed, number of lanes, and functional class.

Given the size and characteristics of the CAG region, segments were divided into categories based on functional classification and traffic volume. Furthermore, in some cases there was only one category per functional classification. This was due to one or more limiting factors, including: 1) lack of comprehensive traffic volume data (Rural and Urban Local streets); 2) small number of segments (e.g., Rural Minor Arterial, Rural Principal Other, Urban Minor Collector, or Urban Principal Other); 3) narrow traffic volume range (Rural Minor Collector); and 4) small number of crashes (Urban Collector). This resulted in the formation of 13 segment categories, as shown in Table D-1.

For each segment category, the average severe crash rate was calculated (fatal and serious injury crashes per million vehicle miles traveled, last column of Table D-1). Then, the anticipated number of severe crashes was estimated for each segment by multiplying the group average by the segment volume. The formula is as follows:

[Anticipated Number of Fatal and Serious Injury Crashes along Segment] =
[Category Severe Crash Rate (Fatal and Serious Injury Crashes per Million VMT] x
[Segment Volume (Million VMT)]

Once the anticipated number of severe crashes was calculated for each segment, this was subtracted from the observed number of severe crashes to identify segments with a higher number of observed crashes than anticipated. These segments may be thought of as having potential for reduction of severe crashes. As shown in Risk Map 4, segments in the medium to high categories represent opportunities for reducing severe crashes.

Table D-1 Segment Characteristics

Segment Group	Minimum ADT	Maximum ADT	Average ADT	Number of Segments	Average Segment Length (Miles)	Total Segment Length (Miles)	Annual MVMT	Annual Severe Crashes	Severe Crash Rate
Rural Local	2	11,004	1,487	3,628	0.6	2,004.8	1,088.1	5.6	0.005
Rural Major Collector (1)	22	1,893	1,073	76	3.2	241.1	94.4	3.0	0.032
Rural Major Collector (2)	2,015	7,269	1,948	33	3.6	120.0	85.3	7.0	0.082
Rural Minor Arterial	1,325	11,626	3,094	16	13.2	210.8	238.1	24.6	0.103
Rural Minor Collector	47	1,365	334	119	1.4	163.9	20.0	3.2	0.160
Rural Principal Other	5,719	11,371	8,486	6	16.2	97.1	300.8	17.4	0.058
Urban Collector	123	6,954	1,621	188	0.3	50.5	29.9	1.4	0.047
Urban Local	35	4,573	738	2,767	0.1	371.4	100.1	2.6	0.026
Urban Minor Arterial (1)	52	1,926	1,169	60	0.2	13.6	5.8	0.6	0.104
Urban Minor Arterial (2)	2,061	4,997	3,592	73	0.2	16.3	21.4	0.2	0.009
Urban Minor Arterial (3)	5,276	21,891	6,919	15	0.5	6.8	17.2	0.6	0.035
Urban Minor Collector	123	552	231	10	0.4	4.3	0.4	0.0	0.000
Urban Principal Other	2,816	27,452	13,843	9	1.8	16.1	81.2	4.8	0.059
CAG Region Total	2	11,004	1,487	7,000	0.5	3,316.6	2,082.4	71.0	0.034

Notes: ADT – Average daily traffic; MVMT – Million vehicle miles traveled; Severe crash rate – Fatal and serious Injury crashes per million vehicle miles traveled.