Interstate 10/Interstate 17
Corridor Master Plan (FY 2014)

Needs Assessment Report

June 1, 2016

MARICOPA ASSOCIATION of GOVERNMENTS

ADOT

U.S. Department of Transportation
Federal Highway Administration

SPINE 10 17 Corridor Master Plan

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Corridor Master Plan (FY 2014)

Needs Assessment Report

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MAG Contract #585

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Overview

The 35-mile Spine Interstate corridor begins at the Interstate 10 (I-10)/State Route (SR) 202L Pecos Stack system traffic interchange (Pecos Stack) and extends north and west on I-10 (Maricopa Freeway) to the I-10/Interstate 17 (I-17) Split system traffic interchange (Split). It then continues west and north on I-17 (Black Canyon Freeway) to the I-17/SR-101L North Stack system traffic interchange (North Stack). The corridor width is approximately 1.5 miles on each side of the defined freeway corridor and is completely contained within the cities of Chandler, Tempe and Phoenix and the town of Guadalupe.

The Maricopa Association of Governments (MAG), in partnership with the Federal Highway Administration and Arizona Department of Transportation (ADOT), launched this study to develop a Corridor Master Plan for the I-10 and I-17 Interstate corridor. The Interstate corridor is referred to as the "Spine" because it serves as the backbone for transportation in the Phoenix metropolitan area. In fact, the corridor handles more than 40 percent of all daily Interstate traffic in the region.

The I-10/I-17 "Spine" Corridor Master Plan effort, otherwise known as the "Spine" study, will investigate various operational and improvement strategies for these two freeway corridors. The Spine study will be fully multimodal, in that the full range of regional transportation modes and concepts will be evaluated to identify the best system solution. This includes exploring multimodal alternatives on the parallel and crossing arterial routes that will complement the freeway corridors' ability to transport people, vehicles and goods.

The current MAG *Regional Transportation Plan* (RTP) allocates $648.5 million for improvements to the I-10 portion of the corridor and $821.6 million for I-17 improvements, totaling $1.47 billion. This amount includes funding for any identified near-term improvements in addition to long-range improvements. The Spine study will identify how to best use these funds to achieve the greatest benefit to the region. It will also define funding shortfalls associated with the preferred corridor improvement approach so that additional funding allocations can be considered to address the shortfalls.

Purpose of the Study

The Spine study's intended key outcome will be an improvement and implementation strategy documented as the I-10/I-17 Corridor Master Plan to appropriately manage travel demand and travel movements in the I-10 and I-17 corridors through 2040. The plan will identify a project, and/or group of projects, to incorporate into the RTP.

Phases of the project, and/or group of projects, will then be programmed for future detailed study, environmental clearance, design, right-of-way (ROW) acquisition, utility relocation and construction in the MAG Transportation Improvement Program and any local agency capital improvement programs as applicable. The Needs Assessment Report will be prepared to inform future National Environmental Policy Act (NEPA) efforts resulting from the I-10/I-17 Corridor Master Plan. For the purpose of writing this report, the best attempts have been made to obtain the latest and most current data as of December 2014.

Near-term Improvements

The RTP has identified a program of projects throughout the Phoenix metropolitan area for construction. The Interstate improvement projects, identified by MAG and ADOT, within the Spine study area (named the "Near-term Improvements") are planned for construction over the next 5 years and are included in the "No-Build" 2040 analysis. The Near-term Improvements include:

ADOT-planned projects:

- I-17 Active Traffic Management System enhancement
- I-17 auxiliary lanes between the Split and 19th Avenue
- additional I-10 outbound (eastbound) lane between SR-51 and U.S. Route 60 (US-60)
- I-10 ramp improvements between SR-143 and US-60 that will relieve congestion by "braiding" ramps to minimize lane changes and a pedestrian bridge over I-10 at Alameda Drive
- additional general purpose lanes in each direction on I-10 between Ray and Baseline Roads and a pedestrian bridge over I-10 at Guadalupe Road
- SR-202L (South Mountain Freeway)

Valley Metro near-term improvements to its light rail network:

- Northwest Phase I Light Rail Extension to Dunlap Avenue
- Northwest Phase II Light Rail Extension to Metrocenter
- Capitol I-10 West Light Rail Extension
- South Central Light Rail Transit Extension
- West Phoenix/Central Glendale Transit Corridor

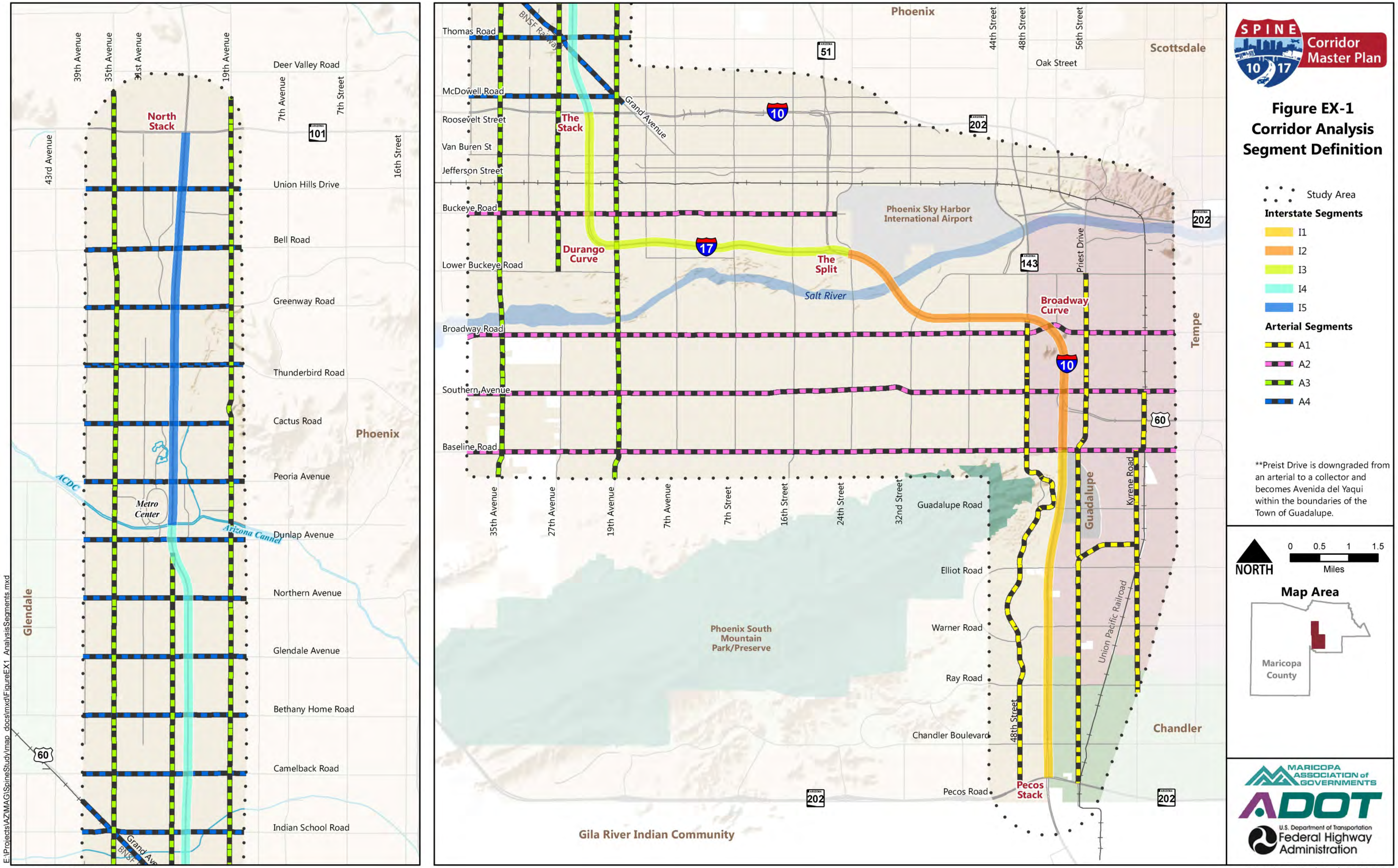
Segments

To help present all of the information associated with the Spine study coherently, the study's corridors of interest were split into segments and groups. The information provided for these groups is not intended to be comprehensive and merely highlights the exceptional items in each segment. The Spine Interstates of interest were split into five segments starting in the south with Segment I1. The arterial corridors of interest were organized into four groups of arterials starting in the south with Segment A1. The segments and groups are shown in Figure EX-1.

Interstate

- **Segment I1**: I-10, SR-202L to Baseline Road – This segment begins at the Pecos Stack and heads north along I-10 until Baseline Road.
- **Segment I2**: I-10, Baseline Road to the Split – This segment continues north along I-10 from Baseline Road following I-10 around the Broadway Curve to end at the Split.
- **Segment I3**: I-17, the Split to the I-10/I-17 Stack system traffic interchange (the Stack) – This segment goes west along I-17 from the Split and follows the Durango Curve to the north, ending at the Stack.
- **Segment I4**: I-17, the Stack to Arizona Canal Diversion Channel (ACDC) – This segment continues north along I-17 from the Stack to the ACDC, which is just south of Dunlap Avenue near Metrocenter.
- **Segment I5**: I-17, ACDC to the North Stack – This segment continues north along I-17 from the ACDC to the North Stack.

Figure EX-1 Corridor Analysis Segment Definition



Source: ADOT, ALRIS, FEMA

Map Last Updated: 5/26/2016

Arterial

Segment A1: 48th Street, 56th Street/Priest Drive and Kyrene Road – These arterials are in the southern portion of the Spine study area and run north-to-south parallel to I-10.

Segment A2: Baseline Road, Southern Avenue, Broadway Road and Buckeye Road – These arterials run east-to-west and are located between the I-17 inner loop section and Phoenix South Mountain Park/Preserve.

Segment A3: 35th Avenue, 27th Avenue and 19th Avenue – These arterials run north-to-south parallel to I-17 in the northern portion of the Spine study area.

Segment A4: East-to-west arterials crossing I-17 – This group of arterials includes the following arterials that cross I-17 (starting from the south):

- McDowell Road
- Grand Avenue
- Thomas Road
- Indian School Road
- Camelback Road
- Bethany Home Road
- Glendale Avenue
- Northern Avenue
- Dunlap Avenue
- Peoria Avenue
- Cactus Road
- Thunderbird Road
- Greenway Road
- Bell Road
- Union Hills Drive

Segment Profiles

The following gives a high-level gap analysis of each of the corridors of interest within the Spine study area.

Segment I1: I-10, SR-202L to Baseline Road

Environmental and Community Issues

- South Mountain Park/Preserve is a Section 4(f) and Section 6(f) resource and traditional cultural property.
- Town of Guadalupe's ethnic, linguistic and social traditions form a cohesive community.

Traffic, Demand, Operations and Access Issues

- Even with programmed widening, eastbound I-10 just south of Warner Road (Cutline 12 on Figure 3-5) would operate at level of service (LOS) E by 2040 during the PM peak.
- Despite programmed widening, the interchange of I-10/Baseline Road would operate at LOS E by 2040. This failing condition is largely driven by LOS E operations for eastbound I-10 and LOS F operations for eastbound Baseline Road.

Infrastructure Age/Condition Issues

- Portland cement concrete pavement (PCCP) on the majority of the segment will be over 40 years old by 2040.
- A major regional drainage basin and regional canals are along the segment.
- City of Tempe Transportation Plan shows a direct high-occupancy vehicle (DHOV) on I-10 in this segment by 2040.

Transit Infrastructure Issues

- The Pecos Road park-and-ride lot is a key transit facility supporting the I-10 East RAPID bus service. This is one of two dedicated RAPID bus park-and-ride facilities that currently does not have a direct access connection to a regional freeway. Once the South Mountain Freeway is built, the Pecos Road park-and-ride lot will have access to South Mountain by a westbound slip ramp at the 40th Street interchange.

Bike and Pedestrian Infrastructure Issues

- Currently, there is no bike and pedestrian access across I-10 except at major mile crossings. A pedestrian bridge crossing is planned in the Near-term Improvements at Guadalupe Road.

Safety Issues

- The I-10 segment and traffic interchanges between Ray and Baseline Roads have a high to moderate crash frequency rating. This segment has also been identified as a hotspot for nighttime, driving under the influence (DUI) and truck-related crashes.

Technology Infrastructure Issues

- The following dynamic message signs (DMS) are located on this segment of I-10: one westbound (inbound) at Ray Road and two eastbound (outbound) at Warner Road and Ray Road. ADOT is in the process of implementing additional DMS south of SR-202L to advise travelers heading west toward the Spine study area. ADOT does not have vehicle detection implemented east of Chandler Boulevard.
- Ramp meters are set to time-of-day operations and are not linked to main line speeds or ramp queues.

Commerce and Economic Factors

- Moderate employment density is located just south of Guadalupe.
- Moderate to heavy manufacturing and transportation sectors are south of Guadalupe.

Agency and Public Feedback

- Dangerous merging and weaving – causes congestion.
- Improve interchanges.
- Add DHOV entrances/exits.
- Entrance/exit ramp issues exist.
- Create bicycle/pedestrian crossings.
- Add bicycle lanes/bicycle facilities.
- Build commuter rail.
- Build more light rail.

Segment I2: I-10, Baseline Road to the Split

Environmental and Community Issues

- Nine Priority 1 leaking underground storage tanks (LUSTs) occur within the corridor, with three LUSTs less than a mile from I-10 between the Salt River and Interstate. LUSTs are prominent throughout this segment on both sides of I-10 and to the north of the Interstate surrounding the airport as of March 26, 2013.
- Two small Superfund sites occur north of I-10 at approximately the Lower Buckeye Road alignment or the Salt River, one at the 32nd Street alignment and the other west of the 44th Street alignment.
- Cemeteries flank I-10 at the Broadway Curve. One of the cemeteries, Tempe Double Butte, is National Register of Historic Places (NRHP)-eligible under Criteria A, B and C. This site is also afforded protection under Section 4(f). The other cemetery, Bell Butte Cemetery, is not NRHP-eligible.
- The Salt River flows east-to-west, crossing I-10 east of the Split. The Tempe Drain and associated wetlands parallel University Drive/32nd Street, connecting with the Salt River just north of the I-10 bridge.
- The Western and Highline Canals cross I-10 within this segment.
- Proposed improvements near Phoenix Sky Harbor International Airport would require Federal Aviation Administration review and approval and may need to conform to all current Federal Aviation Administration circulars, statutes, and associated regulations, including the Sky Harbor Airport Layout Plan (revised February 25, 2011), at the time of design and implementation.
- Potential environmental justice concerns exist with low-income populations in areas adjacent to this segment.

Traffic, Demand, Operations and Access Issues

- By 2040 during the PM peak, eastbound I-10 would experience failing conditions in this segment: LOS F at 44th Street (Cutline 9 in Figure 3-5) and just south of Broadway Road (Cutline 10 in Figure 3-5), and LOS E at Baseline Road (Cutline 11 in Figure 3-5).
- In the westbound direction, failing conditions are forecast at the following locations: LOS E at Baseline Road (Cutline 11 in Figure 3-5), LOS F at 44th Street (Cutline 9 in Figure 3-5), and LOS F just west of 32nd Street (Cutline 8 in Figure 3-5).
- Congested conditions would persist for 12 hours or longer each day on westbound I-10 for the entire segment. Eastbound I-10 is expected to operate under congested conditions for 11 hours of the day from Broadway Road to Baseline Road.
- Five of the six service traffic interchanges between Baseline Road and the Split are projected to fail by 2040: at Baseline Road, 48th Street, 40th Street, 32nd Street and 24th Street.

Infrastructure Age/Condition Issues

- Segment has the 24th Street half-diamond interchange.
- City of Tempe Transportation Plan shows a DHOV on I-10 between US-60 and Broadway Road by 2040.
- No DHOV ramps connect to I-17 at the Split.
- PCCP from the I-10 Salt River crossing to the Split will be over 50 years old.
- Segment contains three system traffic interchanges: US-60 transition, I-10/SR-143 and the Split.
- Segment contains the I-10 Salt River crossing.
- Near the Split, this segment has a conflict with the Runway Protection Zone of Phoenix Sky Harbor International Airport.

Transit Infrastructure Issues

- The highest commuter bus ridership within the study area occurs in this segment. A majority of East Valley commuter services operate in this segment.

Bike and Pedestrian Infrastructure Issues

- Currently, there is no bike and pedestrian access across I-10 except at major mile crossings. A pedestrian bridge crossing is planned in the near-term improvements at Alameda Drive.
- City of Tempe Transportation Plan shows a pedestrian bridge over I-10 along Western Canal by 2040.

Safety Issues

- This segment was observed to have high crash frequency, moderate to high fatal and incapacitating crashes and high truck-related crashes.

Technology Infrastructure Issues

- Ramp meters are not linked to main line speeds or ramp queues and are set to time-of-day operations.
- Limited opportunities exist to divert traffic from I-10 in the event of a crash, closure or to balance congestion (SR-143 provides a viable freeway alternate).

Commerce and Economic Factors

- High employment density is located near the SR-143/I-10 interchange.
- Very high employment density is found approaching the Split.
- This is currently the highest segment for manufacturing and transportation, with very dense areas of such development along the Broadway Curve.
- Second highest percentage of trucks is found in the segment near the Broadway Curve (13 percent).

Agency and Public Feedback

- Dangerous merging and weaving causes congestion.
- Improve interchanges.
- Add direct HOV entrances/exits.
- Entrance/exit ramp issues exist.
- Create bicycle/pedestrian crossings.
- Add bicycle lanes/bicycle facilities.

- Add pedestrian facilities.
- Build commuter rail.
- Build more light rail.

Segment I3: I-17, the Split to the Stack

Environmental and Community Issues

- Six Priority 1 LUSTs occur adjacent to I-17, three between 7th Street and 7th Avenue and three between Washington and Roosevelt Streets. A heavy concentration of LUSTs is located north of I-17 in this segment and otherwise focused along major roads.
- Two Superfund sites occur within this segment. One site, which is on the National Priority Superfund Site list, traverses the corridor between Lower Buckeye and Broadway Roads east of 19th Avenue. The other site traverses the corridor between Buckeye Road and Washington Street.
- Historic overlays are adjacent to I-17 between 7th Avenue and Washington Street.
- Potential environmental justice concerns are present, with minority and low-income populations.
- Two historic cemeteries abut I-17 within this segment. Greenwood Memory Lawn Mortuary and Cemetery is a privately owned cemetery located in the southwestern quadrant of the Stack, abutting the I-10 and I-17 frontage roads. This site is NRHP-eligible under Criteria A and C. Cementerio Lindo is located north of I-17 at 15th Avenue and is NRHP-eligible under Criterion A. Both cemeteries are protected under Section 4(f) as historic resources.
- One Section 4(f) recreational site—Green Valley Park, a City of Phoenix park—is located south of I-17 at 14th Street and Watkins Road.
- Near the Durango Curve, I-17 traverses a 100-year floodplain associated with the Salt River. An open earthen drainage ditch that has previously been determined to be a Water of the United States is located just north of I-17 near 12th Street.

Traffic, Demand, Operations and Access Issues

- Northbound I-17 is forecast to operate above capacity (LOS F) north of Washington Street (Cutline 6 in Figure 3-5) and at 19th Avenue (Cutline 7 in Figure 3-5) in this segment by 2040.
- Two of the seven service traffic interchanges in this segment will operate at LOS E by 2040: at Buckeye Road and Jefferson/Adams Street. Interstate operations drive these failing conditions.
- Numerous locations in this segment are anticipated to experience severe congestion and volume-to-capacity (v/c) ratios in excess of 1.25 (northbound in the PM peak, southbound in the AM peak).

Infrastructure Age/Condition Issues

- The Split to the Stack is the longest stretch of the Interstate corridor with only three general purpose lanes in each direction.
- The Split to the Stack has a higher density of lane drops and taper-type ramps than other sections of the Spine Interstate corridor, which will be corrected (under the Near-Term Improvement plan) by adding auxiliary lanes in both directions between the Split and 19th Avenue.
- 19th Avenue to the Stack has the most nonstandard service traffic interchange access points in the Spine Interstate corridor.
- The Split to Peoria Avenue has the tightest ROW constraints.
- PCCP between the Split and Peoria Avenue will be over 75 years old by 2040.
- The Split to Peoria Avenue has a speed limit of 55 miles per hour (mph).
- Segment has four of the oldest Interstate bridges in the corridor.
- 16th Street to Washington Street has the most old bridges, the only two bridges in poor condition and numerous bridges in fair condition.
- The Durango Curve is within the Salt River floodplain.
- Two 21-foot siphon drains cross I-17 in this segment.
- The Split is within the Phoenix Sky Harbor International Airport Runway 7R-25L Runway Protection Zone and has some light pole penetrations of the Title 14 Part 77 airspace surface and the One Engine Inoperative airspace surface.
- Two active railroad crossings and one abandoned railroad crossing of the Interstate are in this segment.

Transit Infrastructure Issues

- No commuter express bus services currently operate within this segment of I-17, partly because of the lack of HOV facilities and an HOV connection between I-17 and I-10.
- The South Central Light Rail Transit (LRT) is planned to cross under I-17 at Central Avenue; however, the I-17 bridge clearance is insufficient for LRT. Plans exist to increase the clearance of the I-17 bridge over Central Avenue.

Bike and Pedestrian Infrastructure Issues

- None.

Safety Issues

- System ramps at the Stack, the Split and the US-60/I-10 system interchange have a high number of nighttime crashes.
- Moderate to high truck-related crashes were observed in this segment.
- The I-17 frontage roads north of Buckeye Road have a high crash rate.

Technology Infrastructure Issues

- Ramp meters are set to time-of-day operations and are not linked to main line speeds or ramp queues.
- There are limited opportunities to divert freeway traffic south of I-17 in the event of a closure or significant congestion. Without wayfinding equipment or infrastructure on viable routes south of I-17 (Broadway Road), getting travelers, particularly truck drivers, back onto the freeway is challenging.

Commerce and Economic Factors

- High or very high employment density is found throughout this segment, but is more concentrated near the Split.
- Moderate manufacturing and transportation sectors are found along this segment, with a couple of high density sections just north of the Durango Curve and near the Split.
- Heaviest percentage of trucks in the segment are at the Durango Curve.

Agency and Public Feedback

- Dangerous merging and weaving causes congestion.
- Add vehicle lanes.
- Add direct HOV entrances/exits.
- Build more freeways/highways.
- Build mid-mile vehicular and pedestrian bridges.
- Improve interchanges.
- Entrance/exit ramp issues exist.
- Create bicycle/pedestrian crossings.
- Add bicycle lanes/bicycle facilities.
- Add pedestrian facilities.
- Build more light rail.
- Increase bus service.

Segment I4: I-17, the Stack to ACDC

Environmental and Community Issues

- Fourteen Priority 1 LUSTs occur in this segment, distributed at each of the major crossroads from I-10 to Bethany Home Road. Heavy concentrations of LUSTS occur along Grand and 27th Avenues, with other LUSTs occurring at major arterial intersections.
- A Superfund site is located west of I-17 at approximately 35th Avenue from the north side of McDowell Road north to Grand Avenue (see Segment A3).
- Potential environmental justice concerns exist with minority and low-income populations.

Traffic, Demand, Operations and Access Issues

- By 2040 during the PM peak, I-17 general purpose lanes are expected to operate at LOS E and worse in both directions at Camelback Road (Cutline 4 in Figure 3-5) and just north of McDowell Road (Cutline 5 in Figure 3-5) in this segment.
- Nine of 10 interchanges in this segment of the corridor would operate at LOS E or F: McDowell Road being the only interchange that would not fail by 2040.
- The entirety of I-17 in this segment (northbound in PM and southbound in AM) would operate over capacity by 2040 with multiple locations experiencing v/c ratios in excess of 1.00.
- Congested conditions in excess of 12 hours per day are expected for both directions of travel on this segment of I-17 by 2040.

Infrastructure Age/Condition Issues

- I-17 between McDowell Road to Dunlap Avenue has the tightest ROW constraints.
- PCCP between the Split and Peoria Avenue will be over 75 years old by 2040.
- The Split to Peoria Avenue has a speed limit of 55 mph.

Transit Infrastructure Issues

- The HOV lane in the southbound direction terminates at Indian School Road. Discontinuity of HOV lanes minimizes the potential travel time savings that non-single occupancy vehicle users can offer if such facilities are provided.
- The West Phoenix Central Glendale LTR extension project will cross I-17 at either Camelback Road or Glendale Avenue.

Bike and Pedestrian Infrastructure Issues

- Only one pedestrian bridge at Maryland Avenue and one pedestrian tunnel at the Arizona Canal cross I-17.

Safety Issues

- This segment of I-17 has a high crash frequency, high truck-related crashes and moderate to high DUI crashes. I-17 northbound has a moderate crash rate.
- The I-17 northbound and southbound frontage roads have moderate to high nighttime crashes.
- All the traffic interchanges have moderate to high crash frequency, truck-related crashes, nighttime and DUI crashes. Most of them have a moderate crash rate and severe (fatal and incapacitating injury) crashes.
- This Interstate segment, in terms of safety, has the most sections of high crash frequency and moderate crash rates. It also has truck and DUI-related crash issues.

Technology Infrastructure Issues

- This segment will be part of ADOT's Near-term Improvements, which is implementing active traffic management strategies on I-17. This is envisioned to include additional detection, variable speeds, dynamic ramp metering and strategies for wrong-way driving prevention.

Commerce and Economic Factors

- Moderate employment density exists, especially near the Stack.
- Light manufacturing and transportation sectors are found in this segment, with a high concentration near the Stack.

- Heavy manufacturing and transportation exists at the Grand Avenue crossing and along Grand Avenue to the northwest.

Agency and Public Feedback:

- Dangerous merging and weaving causes congestion.
- Entrance/exit ramp issues.
- Widen freeway lanes.
- Add emergency lanes.
- Add vehicle lanes.
- Add direct HOV entrances/exits.
- Create crossings.
- Build more freeways/highways.
- Improve interchanges.
- Create bicycle/pedestrian crossings.
- Add bicycle lanes/bicycle facilities.
- Add pedestrian facilities.
- Build more light rail.
- Increase bus service.
- Add transit options.

Segment I5: I-17, ACDC to the North Stack

Environmental and Community Issues

- No Priority 1 LUSTs occur in this segment. LUSTs occur at major intersections and in a cluster along 19th and Peoria Avenues. No Superfund sites occur.
- Low-income populations exist along I-17 between Thunderbird Road and Dunlap Avenue; there are pockets of minority populations along I-17 throughout the segment.
- Cave Creek Golf/Recreation Area is over 3.5 miles long and is a Section 4(f) resource.
- I-17 crosses the Arizona Canal and ACDC near Dunlap Avenue, and the Grand Canal between Indian School and Thomas Roads.

Traffic, Demand, Operations and Access Issues

- By 2040 during the PM peak, the I-17 general purpose lanes are expected to operate at LOS E and worse in both directions in this segment.
- Six of the seven service traffic interchanges in this segment of the corridor would operate at LOS E or F by 2040, with Utopia Road the only interchange not failing.
- All of northbound I-17 in the PM peak would operate at LOS E or F, with a few locations experiencing v/c ratios in excess of 1.10.
- Congested conditions in excess of 12 hours per day are expected for both directions of travel on this segment of I-17.

Infrastructure Age/Condition Issues

- The speed limit changes at Peoria Avenue. North of Peoria Avenue, the speed limit is 65 mph, and south of Peoria Avenue, the speed limit is 55 mph.
- Bridges at Peoria Avenue, Cactus Road, Thunderbird Road, Greenway Road and Bell Road were built in the mid-1960s.
- Peoria Avenue, Cactus Road, Thunderbird Road and Greenway Road have the oldest pump stations in the Spine study area.
- General concern of flooding on the cross road during large storm events at Peoria Avenue, Cactus Road, Thunderbird Road, Greenway Road and Bell Road.

Transit Infrastructure Issues

- Bell Road park-and-ride lot is 99 percent utilized, despite the opening of an additional park-and-ride at I-17 and Happy Valley. Parking capacity can constrain the growth of transit ridership in the study area.
- Metrocenter park-and-ride lot does not have direct access to I-17.
- The transit vehicle occupancy rate capacity is greater for services operating within the I-17 corridor over the I-10 corridor. The I-10 corridor operates at 36 percent seated capacity, while the I-17 corridor operates at 49 percent seated capacity. Refer to Tables 5-5 and 5-6 for specific ridership data.
- The Northwest Phase II Extension will cross over I-17 at Mountain View Road.

Bike and Pedestrian Infrastructure Issues

- There are no pedestrian bridges or tunnels or mid-mile crossing of I-17.

Safety Issues

- This segment of I-17 has moderate to high crash frequency and moderate DUI crashes.
- The I-17 northbound and southbound frontage roads in this segment have moderate to high nighttime crashes.
- All the traffic interchanges in this segment have moderate to high crash frequency, truck-related crashes, nighttime and DUI crashes. Most of them have moderate to high crash rate and moderate severe (fatal and incapacitating injury) crashes.

Technology Infrastructure Issues

- This segment will be part of ADOT's Near-term Improvements, which is implementing Active Traffic Management strategies on I-17. This is envisioned to include additional detection, variable speeds, dynamic ramp metering and strategies for wrong-way driving prevention.

Commerce and Economic Factors

- Light to moderate employment density is found in this segment, with the moderate density being near the Metrocenter area and the Deer Valley employment center.
- Mostly light manufacturing and transportation sectors are found along this segment, with a couple of moderate sections near Metrocenter and the North Stack.

Agency and Public Feedback

- Dangerous merging and weaving causes congestion.
- Add emergency lanes.
- Widen freeway lanes.
- Create connections.
- Create crossings.
- Create bicycle/pedestrian crossings.
- Add bicycle lanes/bicycle facilities.
- Build more light rail.
- Add transit options.

Segment A1: 48th Street, 56th Street/Priest Drive and Kyrene Road

Environmental and Community Issues

- 48th Street is surrounded by residential developments.
- Priest Drive (Avenida del Yaqui) bisects cohesive Guadalupe.
- South Mountain Park/Preserve is a Section 4(f) and Section 6(f) resource and traditional cultural property.

Traffic, Demand, Operations and Access Issues

- Currently, a half mile of 48th Street north of Guadalupe Road operates at LOS E. Operations on this road will deteriorate to LOS F by 2040 in both the AM and PM peak.
- The half-mile segment of Priest Drive south of Baseline Road currently operates with a v/c ratio of 1.01 to 1.25 in the AM peak and a v/c ratio in excess of 1.25 in the PM peak (see Figures 3-6 and 3-8). These failing conditions are expected to persist into 2040 despite programmed improvements to I-10.

Infrastructure Age/Condition Issues

48th Street – Elliot Road to Broadway Road

- Speed limit reduced to 35 mph and then 25 mph from 40 mph north of Piedmont Road and then increased to 45 mph north of Baseline Road.
- Typical section reduced to one lane in each direction between Guadalupe Road and Arizona Grand Parkway.
- Roundabout at Arizona Grand Parkway and high concentration of stop signs are located between Arizona Grand Parkway and Baseline Road.
- Major drainage infrastructure crossing and along the 48th Street corridor between Guadalupe and Broadway Roads.

Priest Drive – Elliot Road to Broadway Road

- Speed limit reduced to 25 mph from 35 mph (south) and 40 mph (north) between Elliot and Baseline Roads.
- Typical section reduced to one lane in each direction between Elliot and Baseline Roads through Guadalupe. This area is actually called Avenida del Yaqui and is a collector, not an arterial.
- High concentration of stop signs and crosswalks between Elliot and Baseline Roads through Guadalupe.
- Two schools in the town of Guadalupe.

Kyrene Road – Elliot Road to Broadway Road

- At-grade railroad crossing goes diagonally through the Elliot Road intersection.
- Two crossings of the Western Canal are in located along Kyrene Road in this section.
- Large-diameter drainage infrastructure is between Ray and Elliot Roads.

Transit Infrastructure Issues

- Commuter bus routes 520, 521 and 522 travel arterial streets and have no formal park-and-ride to stop at along the Interstate corridor, creating far less efficient routes.

Bike and Pedestrian Infrastructure Issues

- **48th Street:** Bike lanes on 48th Street drop north of Arizona Grand Parkway. High bicycle and pedestrian crash rates have been reported on the segment of 48th Street between Warner Road and Chandler Boulevard and at the intersection at Chandler Boulevard.
- **Priest Drive:** Bike lanes on Priest Drive drop south of Baseline Road. High bicycle and pedestrian crash rates have been reported on the segment of Priest Drive between Broadway Road and SR-202L and at the Baseline Road and University Drive intersections.
- **Kyrene Road:** High bicycle and pedestrian crash rates have been reported at the intersection of Kyrene and Guadalupe Road. Tempe’s Transportation Master Plan shows planned pedestrian bridge at the Kyrene Road and Baseline Road intersection by 2020 and several improved at-grade intersection crossings along Kyrene Road by 2040.

Safety Issues

- SR-143 has moderate to high crash frequency and moderate nighttime crashes and high DUI crashes.
- 48th Street between Baseline and Elliot Roads has high fatal crashes.
- High pedestrian and bike crash arterial segments were observed along 48th Street south of Baseline Road and Priest Drive north of Baseline Road.
- Priest Drive and University Drive, Southern Avenue and 48th Street, and Chandler Boulevard and 48th Street intersections have high pedestrian and bike crashes.

Technology Infrastructure Issues

- Three different agencies (Cities of Phoenix, Tempe and Chandler) manage their arterial signals and infrastructure, which are connected to their respective Traffic Management Centers (TMCs). Through regional systems, agencies are able to view other agencies' closed-circuit television (CCTV). There is a signalized intersection at Guadalupe Road and Priest Drive (Avenida del Yaqui). Signals at this intersection belong to the Town of Guadalupe, and there is an intergovernmental agreement between the Town and the Maricopa County Department of Transportation to maintain the signals. This intersection is not connected to a central traffic signal management system, and signal operations are not actively managed or changed in response to real-time traffic conditions.
- Gaps in telecommunications infrastructure on Priest Drive, 48th Street and east-to-west arterials in this segment.
- Challenging to coordinate detours/re-routes among agencies in the event of a closure on this segment of I-10. The western parallel arterial is 48th Street and is managed by the City of Phoenix. The eastern parallel arterials are Priest Drive and Kyrene Road, which are managed by the Cities of Chandler and Tempe. Priest Drive might not be a viable alternate from Elliot to Baseline Roads (through Guadalupe).
- Staffing levels at local TMCs in this segment do not provide full-time coverage at all centers for changes to signal operations during business hours. Typical hours for local TMCs are 6 a.m. to 6 p.m., Monday through Friday. Local agencies do not staff their respective TMCs after business hours or on weekends. There is limited real-time information available on arterials (congestion, speed) and limited real-time information disseminated to travelers (Tempe has a planned DMS on Elliot Road near Kyrene Road, and at Baseline Road east of Kyrene Road).

Commerce and Economic Factors

- Moderate to high employment density is found along Priest Drive, with the heaviest section just south of Guadalupe.
- Heavy manufacturing and transportation sectors are found along Priest Drive south of Guadalupe.

Agency and Public Feedback

- None.

Segment A2: Baseline Road, Southern Avenue, Broadway Road and Buckeye Road

Environmental and Community Issues

- Five Priority 1 LUSTs occur, one at Southern Avenue and 48th Street, one at Baseline Road east of 44th Street, and three south of Buckeye Road between 7th Street and 7th Avenue. LUST sites occur along all three major arterials with concentrations occurring at 19th Avenue between 7th Street and 7th Avenue, Broadway Road between 44th Street and the study limits to the east and along Baseline Road east of I-10.
- One Superfund site is located just north of Broadway Road. Buckeye Road traverses a second Superfund site that extends from the western study limits to approximately 27th Avenue and then south between 27th Avenue and the airport. The Salt River flows east-to-west in this segment, parallel to and north of Broadway Road.
- Potential environmental justice concerns exist with minority populations on all corridors in this segment.
- Potential environmental justice concerns exist with low-income populations along Broadway Road.
- Higher concentrations of prehistoric and historic canals and archaeological sites are present.

Traffic, Demand, Operations and Access Issues

- In the PM peak, Broadway Road between 24th and 32nd Streets and a half mile west of 40th Street, Southern Avenue a half mile east of 40th Street and Baseline Road a mile west of I-10 are expected to operate under failing conditions by 2040. One segment of Baseline Road directly west of I-10 is forecast to experience a v/c ratio in excess of 1.25.

Infrastructure Age/Condition Issues

Baseline Road – 48th Street to Priest Drive

- Large concentration of traffic signals exists (see Figure 4-6).
- Arizona Mills Mall is on the northern side of Baseline Road east of I-10.
- One school is located along Baseline Road in this section.

Southern Avenue – 19th Avenue to 32th Street

- Moderate concentration of traffic signals exists (see Figure 4-6).
- Varying speed limit exists.
- Seven schools are located along this segment.

Broadway Road – 48th Street to Hardy Drive

- Large concentration of traffic signals exists (see Figure 4-6).
- Speed limit is reduced.
- I-10 traffic interchange is located here.
- Reduced lane cross section exists.
- Two schools are located along Broadway Road in this section.

Buckeye Road – 27th Avenue to Central Avenue

- Moderate concentration of traffic signals exists (see Figure 4-6).
- I-17 traffic interchange is located here.
- Two schools are located along Buckeye Road in this section.

Transit Infrastructure Issues

- South central light rail planned route will cross Baseline Road, Southern Avenue, Broadway Road, and Buckeye Road at Central Avenue.

Bike and Pedestrian Infrastructure Issues

- **Baseline Road:** Bike lanes on Baseline Road drop between 7th Avenue and 16th Street and from 40th Street east through Tempe. High bicycle and pedestrian crash rates have been reported on the segments of Baseline Road between Central Avenue and 7th Street and east of 32nd Street through Tempe. High bicycle and pedestrian crash rates have also been reported at the I-10 and Priest Drive intersections.
- **Southern Avenue:** Bike lanes on Southern Avenue drop east of 48th Street. High bicycle and pedestrian crash rates have been reported on the segments of Southern Avenue between 19th and 7th Avenues, 16th and 24th Streets and east of Priest Drive. Tempe's Transportation Master Plan shows planned bike lanes along Southern Avenue by 2020.
- **Broadway Road:** No bike facilities are present on Broadway Road in the study area. High bicycle and pedestrian crash rates have been reported on the segments of Broadway Road between 32nd and 48th Streets and east of Priest Drive through Tempe. Tempe's Transportation Master Plan shows planned bike lanes and an improved at-grade intersection at Broadway Road and Kyrene Road by 2020.
- **Buckeye Road:** No bike facilities are present on Buckeye Road.

Safety Issues

- Broadway Road, Southern Avenue and Baseline Road east of 32nd Street have high crash frequency, high incapacitating injury and fatal crashes, truck-related crashes and DUI crashes.
- Broadway Road's intersections with 19th Avenue and Central Avenue and Baseline Road's intersections with 19th Avenue, 7th Avenue, Central Avenue and the I-17 traffic interchange have high crash rates.
- Broadway and Baseline Roads west of Central Avenue have a high pedestrian and bike crash.
- High pedestrian and bike crashes exist along Southern Avenue between 19th and 7th Avenues, 7th and 24th Streets and east of Priest Drive.
- Southern Avenue and 48th Street and Baseline Road and Kyrene Road intersections have high pedestrian and bike crashes.

Technology Infrastructure Issues

- Two agencies (Cities of Phoenix and Tempe) manage arterial signals and infrastructure; however, the agencies are currently not connected and are not able to view each other's signals/CCTV cameras.
- Gaps in telecommunications infrastructure on Baseline Road, Broadway Road and Southern Avenue limits connectivity to signals and CCTV.
- Challenging to coordinate detours/re-routes in the event of a closure on this segment of I-10. Through Tempe, there are viable parallel arterials (48th Street and Priest Drive), but through Phoenix there are challenges diverting traffic north of I-10 past Broadway Road.
- There is limited real-time information available on arterials (congestion, speeds), and limited real-time information disseminated to travelers (Tempe has a planned DMS on Broadway Road between Priest Drive and Kyrene Road). No DMS are planned on Phoenix arterials for traveler information.

Commerce and Economic Factors

- Moderate to heavy employment density is found along Broadway Road, specifically near the Split and Broadway Curve.
- Moderate to heavy employment density is found along Buckeye Road near the Durango Curve.
- Heavy manufacturing and transportation sectors are found along Broadway Road and Southern Avenue near the Broadway Curve.
- Moderate to heavy manufacturing and transportation sectors are found along Buckeye Road near the Durango Curve.

Agency and Public Feedback

- None.

Segment A3: 35th Avenue, 27th Avenue and 19th Avenue

Environmental and Community Issues

- Hazardous materials concerns are far more infrequent north of Camelback Road and south of Lower Buckeye Road, focused at the major intersections; however, a cluster occurs both north and south of Peoria Avenue at 19th Avenue.
- Priority 1 LUSTs occur, with five west of 27th Avenue between Thomas Road and Washington Street, three along Thomas Road west of I-17 and six along 27th Avenue north of Grand Avenue.
- No Priority 1 LUSTs occur north of Bethany Home Road. Heavy LUST concentrations occur throughout the corridor between Lower Buckeye and Camelback Roads.
- Segment A3 roads traverse Superfund sites, including 35th Avenue south of Indian School Road to south of Thomas Road. All three roads cross a Superfund site between Washington Street and Buckeye Road. One National Priority Superfund site is located east of 19th Avenue south of Lower Buckeye Road.
- A number of potential Section 4(f) recreation sites are in this segment. Key potential Section 4(f) sites include Deer Valley Park, Cave Creek Park, Cave Creek Golf Course, Encanto Park and Encanto Golf Course/Encanto 9-Hole Executive Golf Course. Cave Creek Park and Encanto Park are also Section 6(f) sites.
- The Salt River flows east-to-west in this segment; 19th and 35th Avenues cross the river between Buckeye and Broadway Roads. North of Union Hills Drive, 35th Avenue crosses Skunk Creek and a Maricopa County floodway.
- Historic districts in the segment include Oakland Historic District, Villa Verde Historic District and North Encanto Historic District.
- Potential environmental justice concerns exist with minority and low-income populations south of Dunlap Avenue.

Traffic, Demand, Operations and Access Issues

- By 2040, LOS E conditions are scattered throughout the extents of 19th Avenue, Grand Avenue and 35th Avenue in the study area. LOS F conditions are anticipated on 19th Avenue from Lower Buckeye Road to I-17 and significant portions of Grand Avenue.

Infrastructure Age/Condition Issues

19th Avenue – Buckeye Road to Dunlap Avenue

- High concentration of signals exists between Buckeye Road and Van Buren Street.
- High concentration of railroad crossings exists between Buckeye Road and Van Buren Street.
- High concentration of mid-block crosswalks and schools exists between Thomas and Camelback Roads.
- High concentration of schools exists between Indian School Road and Dunlap Avenue.
- High concentration of signals exists between Indian School and Bethany Home Roads.
- Reduced speed limit exists between Buckeye and Indian School Roads.
- Light rail corridor is located between Camelback Road and Dunlap Avenue.
- Old bridges/reinforced concrete box culvert between Indian School and Camelback Roads and Dunlap and Peoria Avenues.

27th Avenue – Buckeye Road to Peoria Avenue

- High concentration of signals exists between Buckeye and Indian School Roads.
- High concentration of schools exists from Van Buren Street to McDowell Road and from Northern Avenue to Peoria Avenue.
- Reduced speed limit exists between Van Buren Street and Encanto Boulevard.

35th Avenue – McDowell Road to Bethany Home Road

- High concentration of traffic signals exists between McDowell and Camelback Roads.
- High concentration of schools exists from Thomas to Camelback Roads.
- Railroad crossing is located at Grand Avenue.

Transit Infrastructure Issues

- On-time performance of transit (bus) operations can be affected by at-grade freight railroad crossings on 35th Avenue just south of Indian School Road, on 27th Avenue just south of Thomas Road and on 19th Avenue just south of Madison Street..
- The Capitol I-10 West LTR Project will cross a railroad at 19th Avenue and will enter the I-10 median west of the Stack system interchange.

Bike and Pedestrian Infrastructure Issues

- **19th Avenue:** Bike lanes are only present on the portion of the corridor between Baseline and Broadway Roads. High bicycle and pedestrian crash rates have been reported on the segments of the corridor between Indian School and Cactus Roads, and between Bell Road and Union Hills Drive. High bicycle and pedestrian crash rates have also been reported at every major arterial intersection between Indian School Road and Dunlap Avenue.
- **27th Avenue:** No bike facilities are present on 27th Avenue in the study area. High bicycle and pedestrian crash rates have been reported on the segment of 27th Avenue between Thomas Road and Glendale Avenue. High bicycle and pedestrian crash rates have also been reported at the Indian School Road intersection.
- **35th Avenue:** Bike lanes are only present on the portions of the corridor between Southern Avenue and Lower Buckeye Road and north of Bell Road. High bicycle and pedestrian crash rates have been reported on the segments of 35th Avenue between McDowell and Bethany Home Roads and between Glendale and Peoria Avenues. High bicycle and pedestrian crash rates have also been reported at the Glendale Avenue, Northern Avenue and Dunlap Avenue intersections.

Safety Issues

- These corridors between Van Buren Street and Cactus Road and the major arterial intersections have moderate crash frequency and crash rates.
- North of Thomas Road, most of the 1-mile segments along these roadways have moderate to high incapacitating injuries, truck-related and DUI crashes.
- 19th Avenue corridor intersections have high bus-related crashes.
- Moderate crash frequencies and crash rates in this segment. 35th Avenue arterial segments and arterial intersections between Thunderbird and Lower Buckeye Roads were observed to have moderate to high pedestrian and bike crashes.
- Most of the 19th Avenue arterial segments and arterial intersections between Bell and Indian School Roads were observed to have moderate to high pedestrian and bike crashes.
- 27th Avenue arterial segments and arterial intersections between Dunlap Avenue and Thomas Road were observed to have moderate to high pedestrian and bike crashes.
- Because of the high number of schools on 35th Avenue and 19th Avenue and because 19^{th} Avenue is a transit corridor, these corridors between Union Hills Drive and Buckeye Road need a reassessment of existing pedestrian and bike infrastructure for pedestrian and bike safety improvements.

Technology Infrastructure Issues

- There is existing City of Phoenix fiber telecommunications on 35th Avenue from Dunlap Avenue to Bell Road; there is no existing fiber north of Bell Road or south of Dunlap Avenue, although there is fiber on 27th Avenue from approximately Thomas Road to Northern Avenue. Valley Metro Light Rail has fiber on 19th Avenue from Camelback to Bethany Home Roads, and there will be fiber from Bethany Home Road to Dunlap as part of the light rail extension (under construction).
- Connectivity to some Phoenix traffic signals is available through wireless communications on these routes.
- No wayfinding technology or infrastructure exists to support Interstate traffic diversions resulting from a closure or extreme congestion on these parallel arterials.
- No real-time data collection infrastructure exists on these arterials for speeds, volumes or congestion levels.

- The City of Phoenix has one DMS on 19th Avenue (southbound between Thunderbird and Greenway Roads), but it is not typically activated.
- Traffic signal coordination is through pre-set timing plans based on time of day.
- Coverage of CCTV cameras is limited to most major intersections on 35th Avenue. 19th Avenue has CCTV cameras only at its intersections with Indian School Road, Union Hills Drive and near SR-101L.

Commerce and Economic Factors

- Heavy employment density exists along 19th Avenue between the Stack and the Durango Curve.
- Moderate manufacturing and transportation sectors are found along 35th Avenue, 27th Avenue and 19th Avenue around the Durango Curve.
- Job centers in this segment include Metrocenter, colleges and the Deer Valley employment center.

Agency and Public Feedback

- None.

Segment A4: East-to-west arterials crossing I-17

Environmental and Community Issues

- Twelve Priority 1 LUST sites occur along the east-to-west streets within this segment. A Superfund site is located west of I-17 both north and south of Thomas Road, almost reaching McDowell Road within the study area, and stops south of Indian School Road with the exception of a small area that is just southwest of Grand Avenue. The heaviest concentration of LUST sites within this segment occur on the streets between McDowell Road, Thomas Road, Indian School Road and Grand Avenue. Farther north the frequency decreases, with the exception of Peoria Avenue.
- Potential environmental justice concerns exists with minority and low-income populations south of Dunlap Avenue.
- A number of potential Section 4(f) sites are located in this segment. Key potential Section 4(f) sites include Deer Valley Park, Cave Creek Golf Course, Cave Creek Park, the Rose Mofford Sports Complex (inclusive of Rose Mofford Dog Park) and Encanto Golf Course/Encanto 9-Hole Executive Golf Course. The Rose Mofford Sports Complex is also a Section 6(f) site.
- Historic districts in the segment include Oakland Historic District, Villa Verde Historic District and North Encanto Historic District.

Traffic, Demand, Operations and Access Issues

- By 2040, 10 of the 18 westbound interchange approaches of arterials crossing I-17 are anticipated to operate at LOS E or worse in the PM peak. The 10 westbound interchanges are: Greenway Road, Peoria Avenue, Dunlap Avenue, Northern Avenue, Glendale Avenue, Bethany Home Road, Camelback Road, Indian School Road, Thomas Road, and McDowell Road.
- By 2040, two of the 17 eastbound interchange approaches will operate at LOS E.

Infrastructure Age/Condition Issues

McDowell Road

- High concentration of traffic signals and two railroad crossings exists.
- Four schools are located along McDowell Road, with two near 35th Avenue, one near 31st Avenue and one near 19th Avenue.
- Reduced speed at I-17 exists east of 27th Avenue (40 mph to 35 mph).

Thomas Road

- High concentration of traffic signals and one railroad crossing exists.
- Two schools are located along Thomas Road, both near 39th Avenue.
- Reduced speed at I-17 exists east of 27th Avenue (40 mph to 35 mph).

Grand Avenue

- Two six legged intersections book end Grand Avenue at 35th Avenue and 19th Avenue.
- Old bridge over Grand Canal.
- Reduced speed north of the Grand Avenue/Thomas Road/19th Avenue intersection.

Indian School Road

- High concentration of traffic signals exists.
- One railroad crossing is located at Grand Avenue/35th Avenue intersection.
- Three schools are located along Indian School Road, two near 19th Avenue and the other just west of 27th Avenue.
- Reduced speed at I-17 exists east of 27th Avenue (40 mph to 35 mph).

Camelback Road

- One light rail crossing exists at 19th Avenue.
- Three schools are located along Camelback Road east of I-17.

Bethany Home Road

- High concentration of traffic signals exists.
- One light rail crossing exists at 19th Avenue.
- Three schools are located along Bethany Home Road, all near 27th Avenue.

Glendale Avenue

- High concentration of traffic signals exists.
- One light rail crossing exists at 19th Avenue.
- Three schools are located along Glendale Avenue.

Northern Avenue

- One light rail crossing exists at 19th Avenue.
- Four schools are located along Glendale Avenue.

Dunlap Avenue

- High concentration of traffic signals exists.
- One light rail crossing exists at 19th Avenue.
- Six schools are located along Dunlap Avenue in this section.
- One mid-block pedestrian crossing exists.

Peoria Avenue

- High concentration of traffic signals exists.
- Three schools are located along Peoria Avenue, all just east of I-17.

Cactus Road

- High concentration of traffic signals exists.
- Two schools are located along Cactus Road, one near 35th Avenue and the other near 19th Avenue.

Thunderbird Road

- High concentration of traffic signals exists.
- One school is located near 19th Avenue.

Greenway Road

- High concentration of traffic signals exists.
- One school is located along Greenway Road.

Bell Road

- High concentration of signals exists.
- One school is located along Bell Road just west of I-17.

Union Hills Drive

- Three schools are located along Union Hills Drive.

Transit Infrastructure Issues

- At-grade freight railroad crossings on Thomas Road just west of 27th Avenue, on McDowell Road just west of 19th Avenue, on Van Buren Street just west of 19th Avenue and on 24th Street just south of Jackson Street can affect on-time performance of transit operations.
- Commuter buses that operate within the study area are affected by at-grade freight railroad crossings at Adams and Jefferson Streets just west of 19th Avenue.

Bike and Pedestrian Infrastructure Issues

- The bicycle and pedestrian network in the northern portion of the study area lacks sufficient east-to-west connectivity. No bike facilities are present on Van Buren Street, McDowell Road, Thomas Road, Camelback Road, Bethany Home Road, Glendale Avenue, Northern Avenue, Dunlap Avenue, Peoria Avenue, Cactus Road, Thunderbird Road, Greenway Road or Bell Road.
- High bicycle and pedestrian crash rates have been reported on portions of the entire segment in the study area of the following east-to-west arterial corridors: Van Buren Street, McDowell Road, Thomas Road, Indian School Road, Camelback Road, Bethany Home Road, Northern Avenue, Dunlap Avenue, Peoria Avenue, Cactus Road, Thunderbird Road and Bell Road.
- High bicycle and pedestrian crash rates have also been reported at 15 out of the 26 total (58 percent) major arterial intersections between Indian School Road and Peoria Avenue and 35th and 19th Avenues.

Safety Issues

- Most east-to-west arterials and their intersections with 35th Avenue, 27th Avenue, I-17 and 19th Avenue have moderate to high crash frequencies, crash rates, severe injuries, truck-involved and DUI crashes.
- High crash frequencies, crash rates, severe injuries, truck and DUI-related crashes in this. All the east-to-west arterials crossing I-17 and arterial intersections in this segment have moderate to high pedestrian and bike crashes. These segments should also have a reassessment of existing pedestrian and bike infrastructure for pedestrian and bike safety improvements since they link 35th Avenue and 19th Avenue.
- The Camelback Road, Northern Avenue and Peoria Avenue traffic interchanges have high pedestrian and bike-related crashes.

Technology Infrastructure Issues

- There are very limited installations of fiber telecommunications on east-to-west arterials crossing I-17 or within the Spine study area. Bell Road, Dunlap Avenue, Northern Avenue and Indian School Road have limited fiber.
- East-to-west traffic signals are pre-set on a time of day pattern (not responsive to actual traffic conditions).
- There is limited coordination or interface between transit and the traffic signals, with the exception of coordinating with Valley Metro Light Rail. As light rail extends north to Dunlap Avenue, there will be additional coordination of those signals on 19th Avenue.
- There is no CCTV camera coverage at intersections east of I-17 other than SR-101L, Union Hills Drive and Indian School Road. 35th Avenue has relative good coverage at major intersections.

Commerce and Economic Factors

- Moderate employment density is found along Grand Avenue north of the Stack.
- Heavy manufacturing and transportation sectors are found along Grand Avenue north of the Stack.

Agency and Public Feedback

- None.

Service Traffic Interchanges

In addition to the Interstate and arterial segments, individual interchanges along the corridor were evaluated to determine which interchanges warranted improvements and to establish their respective priorities relative to each other. Tables EX-1 to EX-3 present the results of this analysis. The data summarized in these tables originate from the detailed data found in this Needs Assessment Report. Service traffic interchanges were assigned a relative score of 1 (poor), 2 (fair) or 3 (good).

For the environmental category, the data summarized in figures in Chapter 2 of this report were the source of the scoring. This was a qualitative ranking of each site based on data shown on these maps.

For the crossroad/traffic interchange operations category, these data were captured from both Chapter 3 and Appendix E of this report. The v/c data were extracted from Appendix I. For a score of 3 (good), the v/c ratio had to be less than 0.73. For a score of 2 (fair), the v/c ratio had to be between 0.73 and 0.84. For a score of 1 (poor), the v/c ratio had to be 0.85 or greater. For LOS criteria, the LOS had to be between A and C to score a 3 (good), D to score a 2 (fair), and E or F to score a 1 (poor).

For the safety category, these data were captured from Chapter 7. Scores correlated to the figures in Chapter 7, with "very low" scoring a 3 (good), "low" and "moderate" scoring a 2 (fair), and "high" scoring a 1 (poor). The safety score was based on an average of both the traffic interchange intersections (the dots on the figures) and the arterial roadway approach segments.

For the infrastructure category, these data were captured from Chapters 4, 5 and 6. Bridge and pump station scores were based on a qualitative average of infrastructure condition and age from Chapter 4. Geometry was based on the desirability of the interchange's geometric configuration. Transit scores were derived from Chapter 5, and bicycle and pedestrian scores were derived from Chapter 6.

For the economic development category, the basis of these scores was derived from Chapter 9, using mostly the heat map figures in that chapter.

Finally, for the public feedback category, these data were generated using the Chapter 10 heat maps.

Table EX-1 Service Traffic Interchange Summary, I-10 and I-17 (Split to Stack)

Category Evaluation Metric		Interstate 10												Interstate 17 (Split to Stack)								
		Chandler Blvd. TI	Ray Road TI	Warner Road TI	Elliot Road TI	Guadalupe Road Grade Separation	Baseline Road TI	Southern Avenue Grade Separation	Broadway Road TI	48th Street TI	40th Street TI	32nd Street/ University Dr. TI	24th Street TI	16th Street TI	7th Street TI	Central Avenue Grade Separation	7th Avenue TI	19th Avenue TI	Buckeye Road TI	Grant Street TI	Jefferson Street/ Adams Street TI	Van Buren Street Grade Separation
	Rank	34	29	33	22	37	2	31	25	4	30	23	15	18	21	20	9	5	27	16	24	26
	Weighted Score	251	230	248	217	273	172	239	221	179	230	218	207	212	213	212	189	181	225	208	220	222
Environmental – 10% Category Weight																						
Potential hazardous materials avoidance		3	3	3	2	3	3	3	3	3	2	2	2	1	1	1	2	2	3	3	1	3
Section 4(f) and 6(f) avoidance		3	3	3	3	3	3	3	1	3	3	3	3	2	2	3	3	2	3	3	3	3
Water resource avoidance		3	2	3	3	3	2	3	3	3	3	1	3	3	3	1	3	2	2	2	2	3
Commercial/industrial land use avoidance		1	1	3	1	3	1	2	2	2	1	1	1	1	1	1	1	2	1	1	1	2
Residential land use avoidance		3	3	2	3	1	3	2	3	2	3	3	3	3	2	2	2	3	1	2	1	2
Environmental justice and Title VI avoidance		3	3	3	3	1	3	3	3	2	3	3	3	3	1	1	1	3	1	1	1	1
Category average score * 100		**267**	**250**	**283**	**250**	**233**	**250**	**267**	**250**	**250**	**250**	**217**	**250**	**217**	**167**	**150**	**200**	**233**	**183**	**200**	**150**	**233**
Crossroad/Traffic Interchange Operations – 20% Category Weight																						
AM: northbound intersection approach v/c		3	3	2	2	X	2	X	1	3	3	1	3	1	1	X	1	1	3	3	3	X
AM: southbound intersection approach v/c		3	3	3	3	X	3	X	X	3	3	3	2	3	3	X	3	3	X	1	2	X
AM: eastbound intersection approach v/c		2	1	2	3	X	1	X	3	1	2	1	X	2	2	X	2	1	1	X	3	X
AM: westbound intersection approach v/c		3	3	3	3	X	3	X	1	1	1	1	3	X	3	X	3	3	3	3	3	X
AM: northbound/eastbound off ramp v/c		3	1	3	2	X	1	X	2	1	1	1	X	2	3	X	1	3	3	3	3	X
AM: northbound/eastbound on ramp v/c		2	1	2	1	X	2	X	3	3	3	3	3	X	1	X	1	1	3	2	2	X
AM: southbound/westbound off ramp v/c		2	1	3	1	X	1	X	1	1	1	3	3	X	1	X	2	3	3	1	1	X
AM: southbound/westbound on ramp v/c		3	3	3	3	X	2	X	2	3	3	2	X	3	3	X	3	3	3	3	3	X
AM: eastbound/northbound arterial v/c		1	1	1	2	X	1	X	1	1	3	1	3	1	1	X	2	1	1	3	2	X
AM: westbound/southbound arterial v/c		3	3	3	3	X	1	X	3	1	3	2	3	3	3	X	3	3	3	3	3	X
PM: northbound intersection approach v/c		3	3	3	3	X	2	X	2	1	3	1	2	1	2	X	2	1	1	1	1	X
PM: southbound intersection approach v/c		3	1	1	1	X	1	X	X	2	3	1	2	2	3	X	2	3	X	1	3	X
PM: eastbound intersection approach v/c		3	1	3	3	X	1	X	2	1	1	1	X	2	2	X	3	2	3	X	3	X
PM: westbound intersection approach v/c		2	1	1	1	X	2	X	1	1	1	1	1	X	3	X	3	1	3	3	2	X
PM: northbound/eastbound off ramp v/c		3	3	3	2	X	1	X	3	3	3	1	X	2	3	X	3	3	2	3	2	X

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		Chandler Blvd. TI	Ray Road TI	Warner Road TI	Elliot Road TI	Guadalupe Road Grade Separation	Baseline Road TI	Southern Avenue Grade Separation	Broadway Road TI	48th Street TI	40th Street TI	32nd Street/ University Dr. TI	24th Street TI	16th Street TI	7th Street TI	Central Avenue Grade Separation	7th Avenue TI	19th Avenue TI	Buckeye Road TI	Grant Street TI	Jefferson Street/ Adams Street TI	Van Buren Street Grade Separation
	Rank	34	29	33	22	37	2	31	25	4	30	23	15	18	21	20	9	5	27	16	24	26
	Weighted Score	251	230	248	217	273	172	239	221	179	230	218	207	212	213	212	189	181	225	208	220	222
PM: northbound/eastbound on ramp v/c		1	1	2	1	X	2	X	1	3	1	3	3	X	1	X	1	1	3	1	1	X
PM: southbound/westbound off ramp v/c		1	1	2	1	X	1	X	3	1	1	3	3	X	1	X	1	1	3	1	1	X
PM: southbound/westbound on ramp v/c		3	1	3	1	X	1	X	1	1	1	1	X	2	1	X	1	3	3	2	3	X
PM: eastbound/northbound arterial v/c		3	2	3	3	X	1	X	3	1	3	1	3	2	3	X	3	3	3	3	3	X
PM: westbound/southbound arterial v/c		2	1	1	2	X	1	X	2	1	2	1	2	2	3	X	2	1	1	3	3	X
Daily 2040 arterial approach volume		2	2	3	2	X	1	X	2	1	2	2	3	3	3	X	3	3	3	3	3	X
TI northbound approach 2040 LOS		3	3	3	3	X	2	X	2	1	3	1	2	1	2	X	2	1	1	1	1	X
TI southbound approach 2040 LOS		3	1	1	1	X	1	X	X	2	3	1	2	2	3	X	2	3	X	1	3	X
TI eastbound approach 2040 LOS		3	1	3	3	X	1	X	3	1	1	1	X	1	1	X	2	3	3	X	3	X
TI westbound approach 2040 LOS		2	1	1	1	X	2	X	1	3	1	1	1	X	1	X	1	1	3	3	2	X
Crossroad arterial capacity constraints		3	3	3	3	3	1	3	2	3	3	3	2	3	2	3	3	2	3	3	2	3
Category average score * 100		**250**	**177**	**235**	**208**	**300**	**146**	**300**	**196**	**169**	**212**	**158**	**242**	**200**	**212**	**300**	**212**	**208**	**252**	**222**	**235**	**300**
Safety – 30% Category Weight																						
Crash frequency (2009–2013)		2	2	3	1	3	1	3	3	1	3	2	3	2	3	3	2	2	3	3	3	3
Crash rate (2009–2013)		2	1	3	1	3	1	3	3	3	3	2	3	3	2	3	2	2	2	X	3	3
Fatal crashes (2009–2013)		3	3	3	3	3	3	3	3	3	3	3	2	2	3	3	2	2	3	X	3	3
Incapacitating and fatal crashes (2009–2013)		3	3	3	3	3	2	3	3	3	3	3	2	2	2	2	2	2	3	X	3	3
Bicycle and pedestrian crashes (2009–2013)		3	3	2	2	3	1	3	3	3	3	3	2	2	3	3	2	3	3	X	3	3
Truck crashes (2009–2013)		1	3	3	1	3	1	3	2	2	3	1	2	2	2	2	1	1	1	X	3	3
Nighttime crashes (2009–2013)		3	3	2	2	3	3	3	2	1	2	2	2	3	3	2	2	1	3	X	2	1
DUI crashes (2009–2013)		3	2	3	2	3	1	2	3	2	3	3	3	2	2	2	2	1	3	X	3	3
Bus crashes (2009–2013)		3	3	2	3	3	3	2	3	3	3	3	3	3	2	3	3	3	3	X	3	3
Category average score * 100		**256**	**256**	**267**	**200**	**300**	**178**	**278**	**278**	**233**	**289**	**244**	**244**	**233**	**244**	**256**	**200**	**189**	**267**	**300**	**289**	**278**

Table EX-1 Service Traffic Interchange Summary, I-10 and I-17 (Split to Stack)

Category Evaluation Metric		Interstate 10												Interstate 17 (Split to Stack)								
		Chandler Blvd. TI	Ray Road TI	Warner Road TI	Elliot Road TI	Guadalupe Road Grade Separation	Baseline Road TI	Southern Avenue Grade Separation	Broadway Road TI	48th Street TI	40th Street TI	32nd Street/ University Dr. TI	24th Street TI	16th Street TI	7th Street TI	Central Avenue Grade Separation	7th Avenue TI	19th Avenue TI	Buckeye Road TI	Grant Street TI	Jefferson Street/ Adams Street TI	Van Buren Street Grade Separation
	Rank	**34**	**29**	**33**	**22**	**37**	**2**	**31**	**25**	**4**	**30**	**23**	**15**	**18**	**21**	**20**	**9**	**5**	**27**	**16**	**24**	**26**
	Weighted Score	**251**	**230**	**248**	**217**	**273**	**172**	**239**	**221**	**179**	**230**	**218**	**207**	**212**	**213**	**212**	**189**	**181**	**225**	**208**	**220**	**222**
Infrastructure – 25% Category Weight																						
Geometric assessment		3	3	3	3	3	2	2	2	1	3	3	2	3	1	1	1	1	1	1	1	1
Bridge assessment		3	2	2	2	3	2	2	2	2	2	3	2	2	2	1	2	1	2	1	2	2
Pump station assessment		X	X	X	X	X	X	X	3	X	X	X	X	2	X	2	X	X	3	X	X	2
Existing transit use/future accommodations		3	3	3	3	1	2	3	3	1	1	3	1	3	3	1	3	2	3	1	3	1
Bicycle and pedestrian accommodations		3	2	2	2	3	1	1	1	1	1	1	1	1	3	3	1	1	1	1	2	1
	Category average score * 100	**300**	**250**	**250**	**250**	**250**	**175**	**200**	**220**	**125**	**175**	**250**	**150**	**220**	**225**	**160**	**175**	**125**	**200**	**100**	**200**	**140**
Economic Development – 5% Category Weight																						
2040 employment density		2	2	2	2	3	2	2	1	1	2	1	1	1	1	1	1	2	2	2	1	1
2040 manufacturing and transportation job density		1	2	1	1	3	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Truck percentages		1	2	2	2	3	1	1	2	1	1	2	1	1	2	2	1	1	1	2	1	2
	Category average score * 100	**133**	**200**	**167**	**167**	**300**	**167**	**133**	**133**	**100**	**133**	**133**	**100**	**100**	**133**	**133**	**100**	**133**	**133**	**167**	**100**	**133**
Public Feedback – 10% Category Weight																						
Traffic congestion		2	2	2	2	3	1	1	1	1	3	1	1	3	3	2	3	2	2	2	1	1
Safety		2	2	3	2	2	1	1	1	1	2	3	1	2	1	1	1	2	2	2	1	1
Public transit		1	2	2	2	3	2	2	2	2	2	2	3	2	2	1	2	2	2	2	2	1
Bicycle/pedestrian		2	2	2	2	1	1	1	1	2	3	3	3	2	1	1	1	3	2	2	3	3
Access		1	2	2	2	2	1	1	1	1	3	2	1	1	2	2	2	2	2	2	1	1
	Category average score * 100	**160**	**200**	**220**	**200**	**220**	**120**	**120**	**120**	**140**	**260**	**220**	**180**	**200**	**180**	**140**	**180**	**220**	**200**	**200**	**160**	**140**

Notes: 3 = good, 2 = fair, 1 = poor, X = not applicable/not available

DUI = driving under the influence, LOS = level of service, TI = traffic interchange, v/c = volume-to-capacity ratio

Table EX-2 Service Traffic Interchange Summary, I-17 (Stack to ACDC), I-17 (ACDC to North Stack) and Other Crossings

Category Evaluation Metric		Interstate 17 (Stack to Arizona Canal Diversion Channel)									Interstate 17 (Arizona Canal Diversion Channel to North Stack)							Other Crossings						
		McDowell Road TI	Grand Avenue Grade Separation	Thomas Road TI	Indian School Road TI	Camelback Road TI	Bethany Home Road TI	Glendale Avenue TI	Northern Avenue TI	Dunlap Avenue TI	Peoria Avenue TI	Cactus Road TI	Thunderbird Road TI	Greenway Road TI	Bell Road TI	Union Hills Drive TI	Utopia Road TI	Salt River Bridge Crossing	11th Avenue Grade Separation	15th Avenue Grade Separation	SP Railroad Crossing	BNSF/Grand Railroad Crossing	Grand Canal Crossing	ACDC/Arizona Canal Crossing
	Rank	**28**	**32**	**7**	**17**	**8**	**19**	**11**	**13**	**3**	**1**	**10**	**6**	**14**	**12**	**35**	**36**	**—**	**—**	**—**	**—**	**—**	**—**	**—**
	Weighted Score	**225**	**247**	**187**	**209**	**188**	**212**	**203**	**205**	**179**	**158**	**199**	**185**	**205**	**204**	**254**	**264**	**—**	**—**	**—**	**—**	**—**	**—**	**—**
Environmental – 10% Category Weight																								
Potential hazardous materials avoidance		1	1	2	3	2	2	3	3	3	3	3	3	3	3	2	3	3	1	1	1	1	3	3
Section 4(f) and 6(f) avoidance		3	3	3	3	3	3	2	3	3	2	3	3	3	3	2	3	3	3	3	3	3	3	2
Water resource avoidance		3	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3	1	3	3	2	3	1	1
Commercial/industrial land use avoidance		1	1	1	1	1	1	2	2	1	1	2	1	2	1	1	1	3	2	2	1	1	2	1
Residential land use avoidance		3	3	2	3	3	2	1	2	3	3	1	2	2	3	2	3	3	2	2	3	3	3	3
Environmental justice and Title VI avoidance		3	3	2	3	3	2	1	1	3	3	2	2	2	3	2	3	3	1	1	3	3	3	3
Category average score * 100		**233**	**233**	**217**	**267**	**250**	**217**	**200**	**233**	**267**	**233**	**233**	**233**	**250**	**267**	**200**	**267**	**267**	**200**	**200**	**217**	**233**	**250**	**217**
Crossroad/Traffic Interchange Operations – 20% Category Weight																								
AM: northbound intersection approach v/c		3	X	3	2	2	2	2	2	2	3	3	3	3	3	3	X	X	X	X	X	X	X	X
AM: southbound intersection approach v/c		1	X	1	1	1	1	1	1	1	1	1	1	1	1	X	X	X	X	X	X	X	X	X
AM: eastbound intersection approach v/c		1	X	1	1	1	1	1	1	1	1	3	1	1	1	3	X	X	X	X	X	X	X	X
AM: westbound intersection approach v/c		3	X	3	3	2	3	1	2	3	3	3	3	1	3	3	X	X	X	X	X	X	X	X
AM: northbound/eastbound off ramp v/c		3	X	3	3	3	3	3	3	3	3	3	3	2	3	2	X	X	X	X	X	X	X	X
AM: northbound/eastbound on ramp v/c		1	X	3	3	3	3	3	3	3	3	3	3	3	3	3	X	X	X	X	X	X	X	X
AM: southbound/westbound off ramp v/c		3	X	1	2	3	3	3	3	3	1	1	2	3	3	3	X	X	X	X	X	X	X	X
AM: southbound/westbound on ramp v/c		3	X	3	3	3	3	3	3	3	2	1	1	1	2	2	X	X	X	X	X	X	X	X
AM: eastbound/northbound arterial v/c		1	X	1	1	1	1	1	1	1	1	3	3	1	2	3	X	X	X	X	X	X	X	X
AM: westbound/southbound arterial v/c		3	X	3	3	2	3	2	3	2	3	3	3	1	3	3	X	X	X	X	X	X	X	X
PM: northbound intersection approach v/c		3	X	1	1	1	1	1	1	1	1	1	1	1	1	1	X	X	X	X	X	X	X	X
PM: southbound intersection approach v/c		2	X	2	1	1	1	1	1	1	1	1	1	1	1	X	X	X	X	X	X	X	X	X
PM: eastbound intersection approach v/c		3	X	1	2	2	1	1	2	1	1	3	2	1	2	1	X	X	X	X	X	X	X	X
PM: westbound intersection approach v/c		1	X	1	1	1	1	1	1	1	1	3	2	1	2	1	X	X	X	X	X	X	X	X
PM: northbound/eastbound off ramp v/c		3	X	3	3	3	3	3	2	1	1	1	3	1	2	1	X	X	X	X	X	X	X	X

Table EX-2 Service Traffic Interchange Summary, I-17 (Stack to ACDC), I-17 (ACDC to North Stack) and Other Crossings

Category Evaluation Metric		Interstate 17 (Stack to Arizona Canal Diversion Channel)									Interstate 17 (Arizona Canal Diversion Channel to North Stack)							Other Crossings						
		McDowell Road TI	Grand Avenue Grade Separation	Thomas Road TI	Indian School Road TI	Camelback Road TI	Bethany Home Road TI	Glendale Avenue TI	Northern Avenue TI	Dunlap Avenue TI	Peoria Avenue TI	Cactus Road TI	Thunderbird Road TI	Greenway Road TI	Bell Road TI	Union Hills Drive TI	Utopia Road TI	Salt River Bridge Crossing	11th Avenue Grade Separation	15th Avenue Grade Separation	SP Railroad Crossing	BNSF/Grand Railroad Crossing	Grand Canal Crossing	ACDC/Arizona Canal Crossing
	Rank	**28**	**32**	**7**	**17**	**8**	**19**	**11**	**13**	**3**	**1**	**10**	**6**	**14**	**12**	**35**	**36**	**—**	**—**	**—**	**—**	**—**	**—**	**—**
	Weighted Score	**225**	**247**	**187**	**209**	**188**	**212**	**203**	**205**	**179**	**158**	**199**	**185**	**205**	**204**	**254**	**264**	**—**	**—**	**—**	**—**	**—**	**—**	**—**
PM: northbound/eastbound on ramp v/c		3	X	1	3	3	3	3	2	2	1	1	1	3	2	3	X	X	X	X	X	X	X	X
PM: southbound/westbound off ramp v/c		3	X	3	3	3	3	3	3	3	2	1	2	3	2	3	X	X	X	X	X	X	X	X
PM: southbound/westbound on ramp v/c		3	X	3	3	3	3	3	3	1	2	2	2	1	3	1	X	X	X	X	X	X	X	X
PM: eastbound/northbound arterial v/c		3	X	3	3	1	2	1	2	2	1	3	2	1	2	3	X	X	X	X	X	X	X	X
PM: westbound/southbound arterial v/c		2	X	1	1	1	1	1	1	1	1	1	1	1	1	2	X	X	X	X	X	X	X	X
Daily 2040 arterial approach volume		3	X	2	1	1	1	1	1	1	1	2	2	2	2	2	X	X	X	X	X	X	X	X
TI northbound approach 2040 LOS		3	X	1	1	1	1	1	1	1	1	1	1	1	1	1	X	X	X	X	X	X	X	X
TI southbound approach 2040 LOS		2	X	2	1	1	1	1	1	1	1	1	1	1	1	X	3	X	X	X	X	X	X	X
TI eastbound approach 2040 LOS		3	X	2	3	3	3	3	3	2	1	3	3	1	3	3	3	X	X	X	X	X	X	X
TI westbound approach 2040 LOS		1	X	1	1	1	1	1	1	1	1	3	2	1	2	3	3	X	X	X	X	X	X	X
Crossroad arterial capacity constraints		2	3	2	3	3	2	2	3	1	1	1	1	2	2	2	3	X	2	3	X	X	X	X
	Category average score * 100	**238**	**300**	**196**	**204**	**192**	**196**	**181**	**192**	**165**	**150**	**200**	**192**	**150**	**204**	**226**	**300**	**X**	**200**	**300**	**X**	**X**	**X**	**X**
Safety – 30% Category Weight																								
Crash frequency (2009–2013)		2	3	1	1	1	1	1	1	1	1	2	1	3	1	3	3	X	X	X	X	X	X	X
Crash rate (2009–2013)		1	3	2	2	1	2	2	2	2	1	2	1	3	1	3	X	X	X	X	X	X	X	X
Fatal crashes (2009–2013)		3	3	3	2	3	3	3	3	2	2	3	2	3	3	3	X	X	X	X	X	X	X	X
Incapacitating and fatal crashes (2009–2013)		2	3	2	1	2	3	2	1	1	1	2	2	2	1	2	X	X	X	X	X	X	X	X
Bicycle and pedestrian crashes (2009–2013)		3	3	1	1	1	1	1	1	1	1	1	1	2	2	3	X	X	X	X	X	X	X	X
Truck crashes (2009–2013)		2	3	1	1	2	2	2	2	1	1	2	1	3	1	3	X	X	X	X	X	X	X	X
Nighttime crashes (2009–2013)		2	2	1	1	1	2	1	1	1	1	2	2	1	3	3	X	X	X	X	X	X	X	X
DUI crashes (2009–2013)		2	2	1	1	1	1	2	1	1	1	1	1	2	1	2	X	X	X	X	X	X	X	X
Bus crashes (2009–2013)		3	2	3	3	3	2	3	3	2	2	3	3	3	3	3	X	X	X	X	X	X	X	X
	Category average score * 100	**222**	**267**	**167**	**144**	**167**	**189**	**189**	**167**	**133**	**122**	**200**	**156**	**244**	**178**	**278**	**300**	**X**	**X**	**X**	**X**	**X**	**X**	**X**

Table EX-2 Service Traffic Interchange Summary, I-17 (Stack to ACDC), I-17 (ACDC to North Stack) and Other Crossings

Category Evaluation Metric	Interstate 17 (Stack to Arizona Canal Diversion Channel)									Interstate 17 (Arizona Canal Diversion Channel to North Stack)							Other Crossings						
	McDowell Road TI	Grand Avenue Grade Separation	Thomas Road TI	Indian School Road TI	Camelback Road TI	Bethany Home Road TI	Glendale Avenue TI	Northern Avenue TI	Dunlap Avenue TI	Peoria Avenue TI	Cactus Road TI	Thunderbird Road TI	Greenway Road TI	Bell Road TI	Union Hills Drive TI	Utopia Road TI	Salt River Bridge Crossing	11th Avenue Grade Separation	15th Avenue Grade Separation	SP Railroad Crossing	BNSF/Grand Railroad Crossing	Grand Canal Crossing	ACDC/Arizona Canal Crossing
Rank	**28**	**32**	**7**	**17**	**8**	**19**	**11**	**13**	**3**	**1**	**10**	**6**	**14**	**12**	**35**	**36**	**—**	**—**	**—**	**—**	**—**	**—**	**—**
Weighted Score	**225**	**247**	**187**	**209**	**188**	**212**	**203**	**205**	**179**	**158**	**199**	**185**	**205**	**204**	**254**	**264**	**—**	**—**	**—**	**—**	**—**	**—**	**—**
Infrastructure – 25% Category Weight																							
Geometric assessment	3	3	3	3	3	3	3	3	3	2	2	2	2	3	3	3	3	3	3	1	1	3	3
Bridge assessment	3	3	3	3	3	3	3	3	2	2	2	2	2	2	3	3	2	2	2	3	3	2	2
Pump station assessment	X	X	2	3	X	X	X	3	X	1	1	1	1	3	X	X	X	X	X	X	X	X	X
Existing transit use/future accommodations	3	3	1	3	1	3	3	3	3	3	3	3	3	2	3	3	X	1	1	X	X	X	X
Bicycle and pedestrian accommodations	2	1	2	2	1	1	1	1	1	1	1	1	1	1	3	1	3	1	1	X	X	1	3
Category average score * 100	**275**	**250**	**220**	**280**	**200**	**250**	**250**	**260**	**225**	**180**	**180**	**180**	**180**	**220**	**300**	**250**	**267**	**175**	**175**	**200**	**200**	**200**	**267**
Economic Development – 5% Category Weight																							
2040 employment density	1	1	1	2	2	2	2	2	1	1	2	3	3	2	2	2	X	2	2	X	X	X	X
2040 manufacturing and transportation job density	1	1	1	2	2	3	2	2	1	1	2	2	2	1	1	1	X	1	1	X	X	X	X
Truck percentages	1	1	1	1	1	1	2	2	2	2	1	2	2	2	3	1	X	2	2	X	X	X	X
Category average score * 100	**100**	**100**	**100**	**167**	**167**	**200**	**200**	**200**	**133**	**133**	**167**	**233**	**233**	**167**	**200**	**133**	**X**	**167**	**167**	**X**	**X**	**X**	**X**
Public Feedback – 10% Category Weight																							
Traffic congestion	1	1	1	2	2	2	2	2	2	2	3	2	3	3	3	3	X	3	3	X	X	X	X
Safety	1	2	2	2	2	2	2	2	1	1	2	2	2	2	2	1	X	1	1	X	X	X	X
Public transit	2	2	2	3	1	3	1	1	1	1	1	1	1	1	1	1	X	2	2	X	X	X	X
Bicycle/pedestrian	2	2	2	1	2	2	2	2	2	2	2	2	2	2	3	3	X	2	2	X	X	X	X
Access	1	1	1	2	1	2	2	2	2	2	3	3	2	2	1	1	X	2	2	X	X	X	X
Category average score * 100	**140**	**160**	**160**	**200**	**160**	**220**	**180**	**180**	**160**	**160**	**220**	**200**	**200**	**200**	**200**	**180**	**X**	**200**	**200**	**X**	**X**	**X**	**X**

Notes: 3 = good, 2 = fair, 1 = poor, X = not applicable/not available

ACDC = Arizona Canal Diversion Channel, DUI = driving under the influence, LOS = level of service, TI = traffic interchange, v/c = volume-to-capacity ratio

Table EX-3 Service Traffic Interchange Ranking

Rank	Interchange	Total Weighted Score	Environmental Score	Operations Score	Safety Score	Infrastructure Score	Economic Score	Public Feedback Score
1	Peoria Ave TI	158	233	150	122	180	133	160
2	Baseline Road TI	172	250	146	178	175	167	120
3	Dunlap Ave TI	179	267	165	133	225	133	160
4	48th Street TI	179	250	169	233	125	100	140
5	19th Avenue TI	181	233	208	189	125	133	220
6	Thunderbird Road TI	185	233	192	156	180	233	200
7	Thomas Road TI	187	217	196	167	220	100	160
8	Camelback Road TI	188	250	192	167	200	167	160
9	7th Avenue TI	189	200	212	200	175	100	180
10	Cactus Road TI	199	233	200	200	180	167	220
11	Glendale Avenue TI	203	200	181	189	250	200	180
12	Bell Road TI	204	267	204	178	220	167	200
13	Northern Avenue TI	205	233	192	167	260	200	180
14	Greenway Road TI	205	250	150	244	180	233	200
15	24th Street TI	207	250	242	244	150	100	180
16	Grant Street TI	208	200	222	300	100	167	200
17	Indian School Road TI	209	267	204	144	280	167	200
18	16th Street TI	212	217	200	233	220	100	200
19	Bethany Home Road TI	212	217	196	189	250	200	220
20	Central Avenue Grade Separation	212	150	300	256	160	133	140
21	7th Street TI	213	167	212	244	225	133	180
22	Elliot Road TI	217	250	208	200	250	167	200
23	32nd Street/University Drive TI	218	217	158	244	250	133	220
24	Jefferson/Adams Street TI	220	150	235	289	200	100	160
25	Broadway Road TI	221	250	196	278	220	133	120
26	Van Buren Street Grade Separation	222	233	300	278	140	133	140
27	Buckeye Road TI	225	183	252	267	200	133	200
28	McDowell Road TI	225	233	238	222	275	100	140
29	Ray Road TI	230	250	177	256	250	200	200
30	40th Street TI	230	250	212	289	175	133	260
31	Southern Avenue Grade Separation	239	267	300	278	200	133	120
32	Grand Avenue Grade Separation	247	233	300	267	250	100	160
33	Warner Road TI	248	283	235	267	250	167	220
34	Chandler Blvd TI	251	267	250	256	300	133	160
35	Union Hills Drive TI	254	200	226	278	300	200	200
36	Utopia Road TI	264	267	300	300	250	133	180
37	Guadalupe Road Grade Separation	273	233	300	300	250	300	220

Notes: green = good, yellow = fair, red = poor
TI = traffic interchange

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1 Introduction and Background

1.1 Study Overview

The Maricopa Association of Governments (MAG), in partnership with the Federal Highway Administration (FHWA) and Arizona Department of Transportation (ADOT), launched this study to develop a Corridor Master Plan for the Interstate 10 (I-10) and Interstate 17 (I-17) corridor. This corridor is referred to as the "Spine" because it serves as the backbone for transportation in the Phoenix metropolitan area. In fact, the corridor handles more than 40 percent of all daily Interstate traffic in the region.

For the purpose of writing this report, the best attempts have been made to obtain the most current data as of December 2014.

1.1.1 Background

In recent years, ADOT and FHWA have been developing corridor planning studies in the form of design concept reports and environmental impact statements as part of the I-10 Corridor Improvement Study and I-17 Corridor Improvement Study. These studies looked at ways to add capacity (for example, general purpose lanes) to both I-10 and I-17 in the Phoenix area.

The two previous studies identified long-term improvements that would have required more funding than was available in the ***Regional Transportation Plan*** (RTP) for either corridor. ADOT and MAG agreed, and FHWA accepted, the decision to rescind the studies in 2012 after it was determined that separate studies may not result in the best overall plan and that many of the studies' recommendations were not prudent. However, the studies also identified a number of near-term improvements that could be carried forward and implemented by ADOT through a separate but parallel effort. It is also important to note that much of the planning, engineering and environmental information from those studies will be folded into the new I-10/I-17 Corridor Master Plan.

1.1.2 Location of Study Area

The I-10/I-17 Corridor Master Plan is a planning-level study for proposed transportation improvements in Maricopa County and within the cities of Chandler, Tempe and Phoenix and the town of Guadalupe. The 35-mile Spine corridor begins at the I-10/State Route (SR) 202L Pecos Stack system traffic interchange (Pecos Stack) in the southern part of Phoenix, extends north and west on I-10 (Maricopa Freeway) to the I-10/I-17 Split system traffic interchange (Split), then continues north on I-17 (Black Canyon Freeway) to the I-17/ SR-101L North Stack system traffic interchange (North Stack) (Figure 1-1). Although the I-10 Inner Loop from the Split to the Stack is within the study area, it is being excluded from the Spine study because the Deck Park Tunnel precludes any future widening and has a set of its own unique issues. MAG will be launching a separate study that will focus solely on the I-10 Inner Loop.

The initial corridor study area extends approximately 1.5 miles on each side of the defined Interstate corridor, but may expand during the study depending on the early findings. The assumed 3-mile corridor width includes the following parallel arterial streets: 48th Street and 56th Street/Priest Drive from Chandler Boulevard to Broadway Road, Kyrene Road from Chandler Boulevard to Southern Avenue, Baseline Road from 35th Avenue to the Union Pacific Railroad (UPRR) line, Southern Avenue from 35th Avenue to the UPRR line, Broadway Road from 35th Avenue to the UPRR line, Buckeye Road from 35th Avenue to 24th Street, 27th Avenue from Lower Buckeye Road to SR-101L and 19th Avenue and 35th Avenue from Baseline Road to SR-101L.

1.1.3 Purpose of the Study

The I-10/I-17 Corridor Master Plan effort will analyze various long-term strategies to improve mobility in the corridor. The study will evaluate the full range of transportation modes and concepts to identify the best multimodal, system solutions. These long-term improvements are envisioned as a combination of traditional methods, new technology and increased use of transit. The key outcome of the Spine study will be a detailed strategy to manage traffic in the I-10 and I-17 corridors through 2040. Study recommendations will be programmed in the MAG RTP and Transportation Improvement Program (TIP).

The current MAG RTP allocates $1.47 billion for the Spine study area. This amount includes funding for any identified near-term improvements (see Figure 1-2) in addition to long-range improvements. The Spine study will identify how to best allocate these funds to achieve the greatest benefit to the region. It will also define funding shortfalls associated with the preferred corridor improvement approach so that additional funding allocations can be identified.

The primary purpose of the I-10/I-17 Corridor Master Plan is to develop an improvement and implementation strategy to appropriately manage travel demand and movements in the I-10 and I-17 corridors. The strategy is envisioned to identify a project, or group of projects, to incorporate into the RTP and TIP. Phases of the project, or group of projects, will then be programmed for future environmental clearances, design, right-of-way (ROW) acquisition and construction. The Needs Assessment Report will be used to inform future National Environmental Policy Act (NEPA) actions resulting from the corridor master plan.

1.2 No-Build Alternative

The RTP has identified a program of projects throughout the Phoenix metropolitan area for construction. These projects are separate from the improvements that will be recommended through the Spine study. The Interstate improvement projects, identified by MAG and ADOT, within the Spine study area (named the "near-term improvements") are planned for construction over the next 5 years and are included in the "No-Build" alternative for 2040. The near-term improvements include:

ADOT-planned projects:

- I-17 Active Traffic Management System enhancement
- I-17 auxiliary lanes between the Split and 19th Avenue
- additional I-10 outbound (eastbound) lane between SR-51 and U.S. Route 60 (US-60)
- I-10 ramp improvements between SR-143 and US-60 that will relieve congestion by "braiding" ramps to minimize lane changes and a pedestrian bridge over I-10 at Alameda Drive
- additional general purpose lanes in each direction on I-10 between Ray and Baseline Roads and a pedestrian bridge over I-10 at Guadalupe Road
- SR-202L (South Mountain Freeway)

Valley Metro near-term improvements to its light rail network:

- Northwest Phase I Light Rail Extension to Dunlap Avenue
- Northwest Phase II Light Rail Extension to Metrocenter
- Capitol I-10 West Light Rail Extension
- South Central Light Rail Transit Extension
- West Phoenix/Central Glendale Transit Corridor

These improvements have been advanced toward construction to provide the greatest benefit to the community. The near-term projects within the Spine study area are shown in Figure 1-2.

1.3 Local Transportation Plans and Initiatives

The Spine study area is completely contained within the cities of Chandler, Tempe and Phoenix and the town of Guadalupe. In addition to the MAG RTP and the ADOT TIP, each of the local municipalities, Valley Metro and Sky Harbor International Airport have transportation plans and initiatives that outline their vision for transportation within their jurisdictions. All of the pertinent transportation plans and initiatives will be taken into account when developing final recommendations for the Spine study. The major local agency transportation plans and initiatives are listed below:

- City of Chandler
  - *Transportation Master Plan* (2009)
  - *General Plan* (2008)
- City of Tempe
  - *Transportation Master Plan* (2015)
  - *General Plan 2040* (2015)
- City of Phoenix
  - *Transportation Master Plan 2050* (2015)
  - *Bicycle Plan* (2014)
  - *General Plan* (2015)
  - *Sky Harbor Layout Plan* (2011)
- Town of Guadalupe
  - *General Plan* (1992)
- Valley Metro
  - MAG RTP

Throughout the study, all of the plans and initiatives of the local agencies will be taken into consideration.

1.3.1 Phoenix Transportation 2050

On August 25, 2015, Transportation 2050 (T2050), a 35-year citywide transportation plan, was approved by City of Phoenix voters. T2050 increases Phoenix's existing transportation sales tax by three-tenths of a cent to seven-tenths of a cent (or 70 cents on a $100 purchase) to fund a program of transportation improvements through 2051. The additional money generated by the sales tax increase will fund bus service improvements, light rail construction, new transit-related technology, bicycle and pedestrian infrastructure and street improvements, all of which are outlined in Phoenix's Transportation Master Plan 2050 by the Citizens Committee on the Future of Phoenix Transportation. The following are the key goals of T2050:

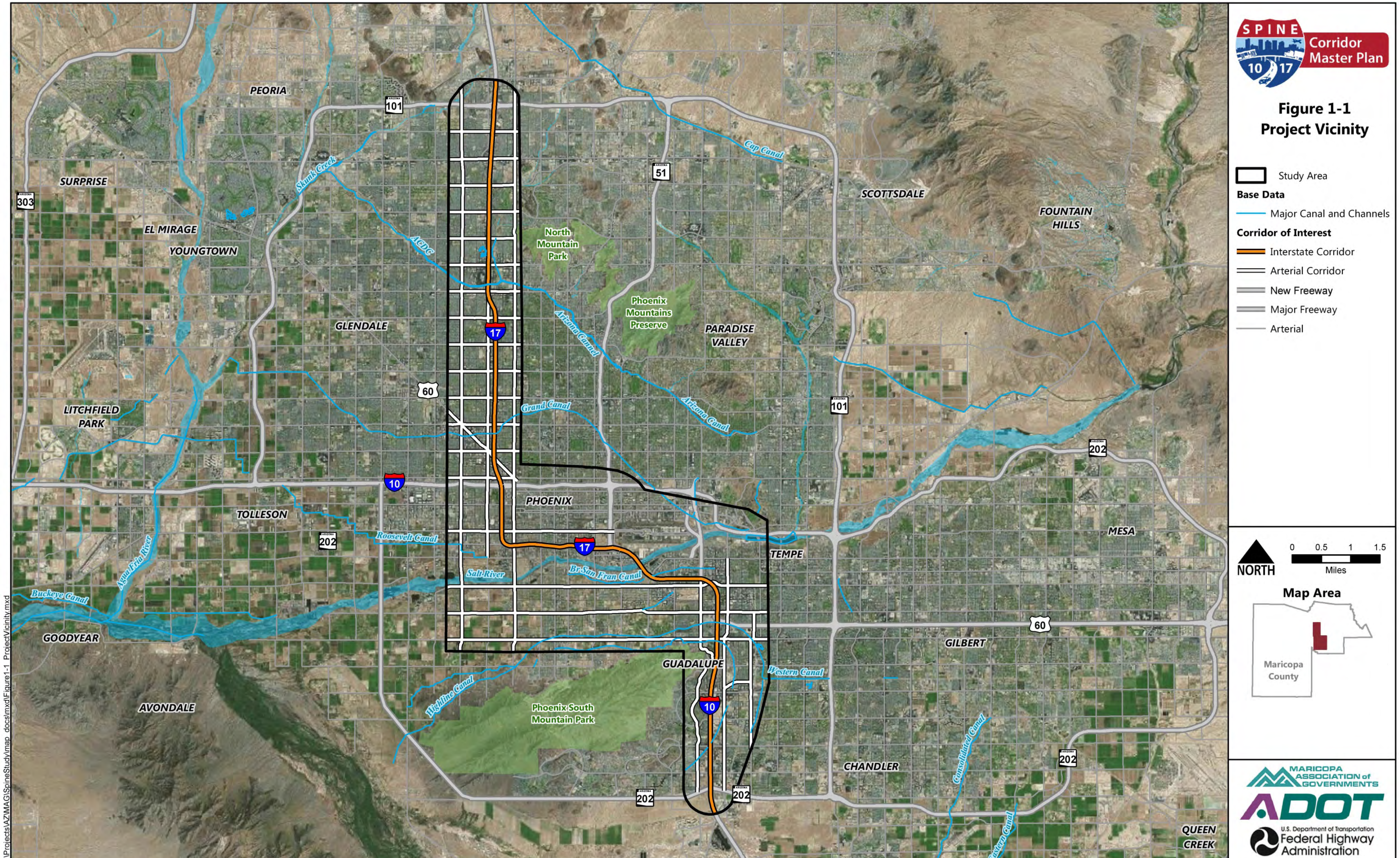
- improved frequency on local bus service.
- service through midnight on weekdays and 2 a.m. on weekends for local bus and Dial-A-Ride service
- new transit-related technology, such as Wi-Fi on buses and trains, reloadable transit passes, real-time data for Dial-A-Ride and security improvements for bus and light rail
- 75 miles of new RAPID routes
- 42 miles of new light rail
- addition of a new light rail station
- 680 miles of new asphalt pavement on major arterial streets
- 1,000 miles of new bicycle lanes
- 135 miles of new sidewalks
- 2,000 new street lights
- $240 million for major street improvement projects

It is understood that T2050 will contain projects that contribute to the goals and objectives of the Spine Study. Since the T2050 program has yet to be fully developed and adopted by the Phoenix City Council, it will not be incorporated into the Final Needs Assessment Report. However, as information becomes available, it will be considered as the Spine alternatives screening process advances over the next year. A more detailed look at these improvements can be found in Figures 1-3 to 1-5.

1.3.2 Key Economic Corridors

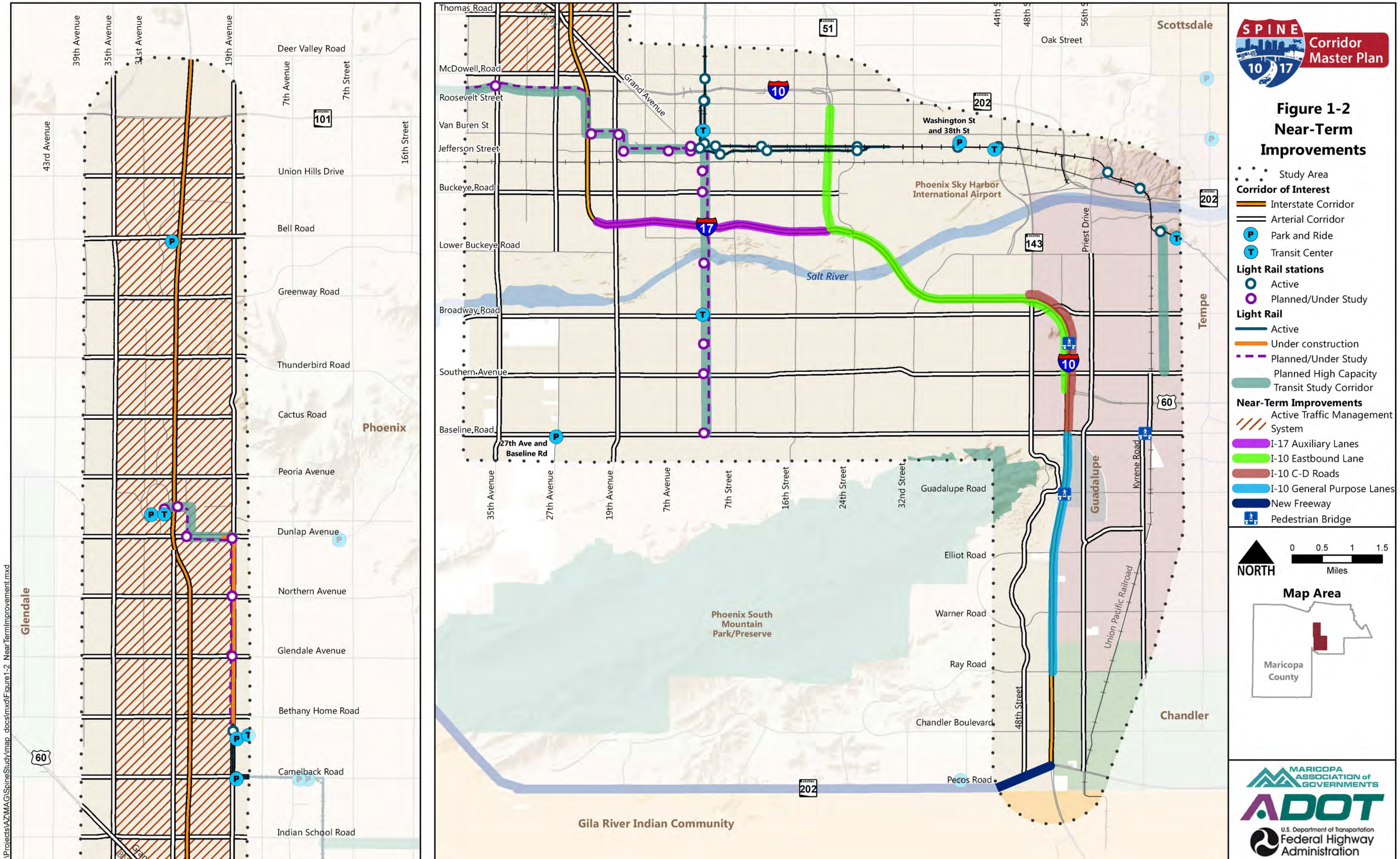
The Spine corridor is located at a junction of routes to three major markets: Texas to the east, California to the west and Mexico to the south. ADOT has identified key corridors that connect these three markets to Phoenix and has tentative plans to improve them. The Spine corridor has been identified as part of one of these key corridors. Studies are currently underway regarding how to improve these key corridors, and the study results will be taken into consideration moving forward.

Figure 1-1 Project Vicinity



Source: ADOT, ALRIS, FEMA

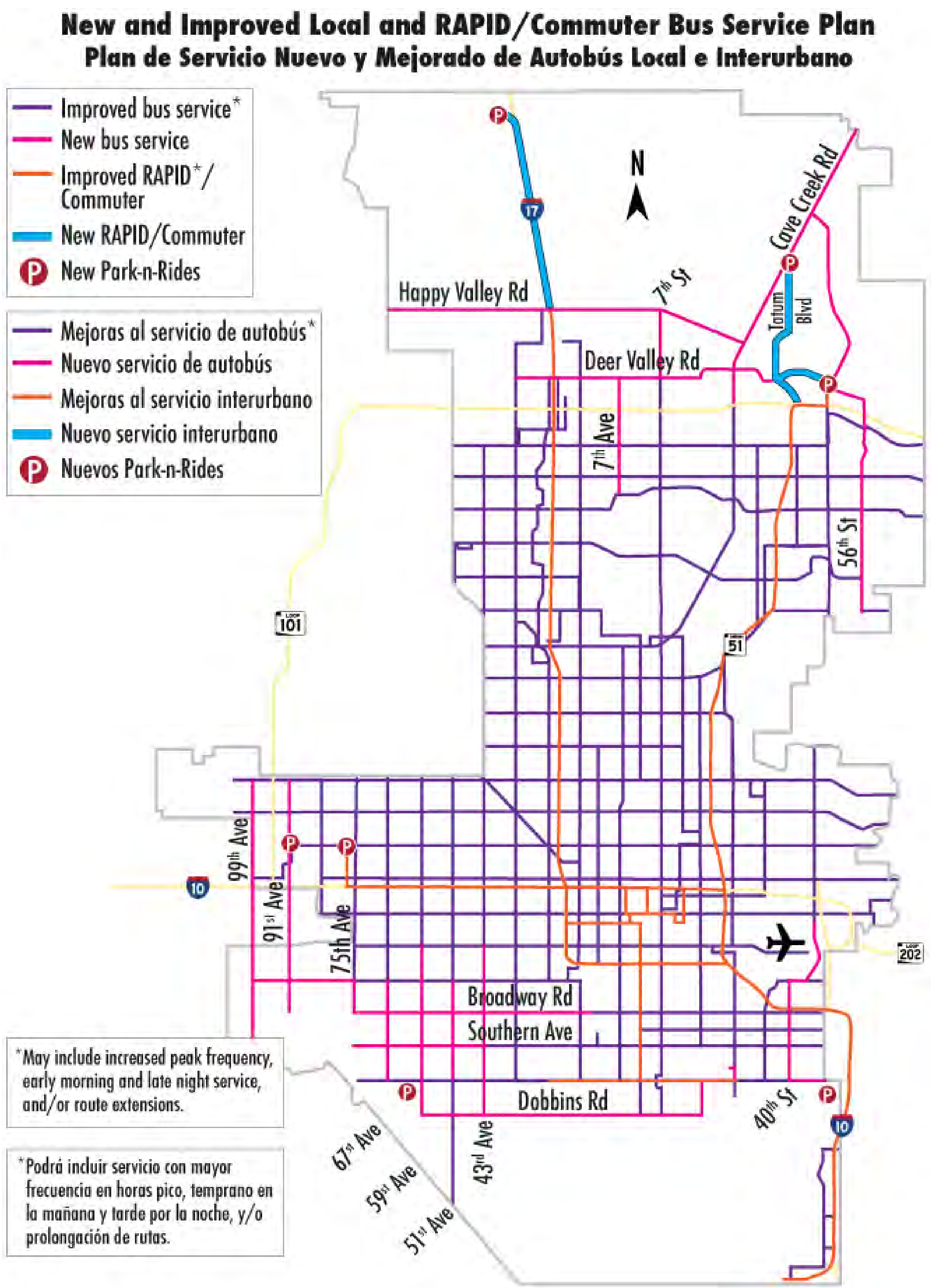
Figure 1-2 Near-Term Improvements



Source: ADOT, VM

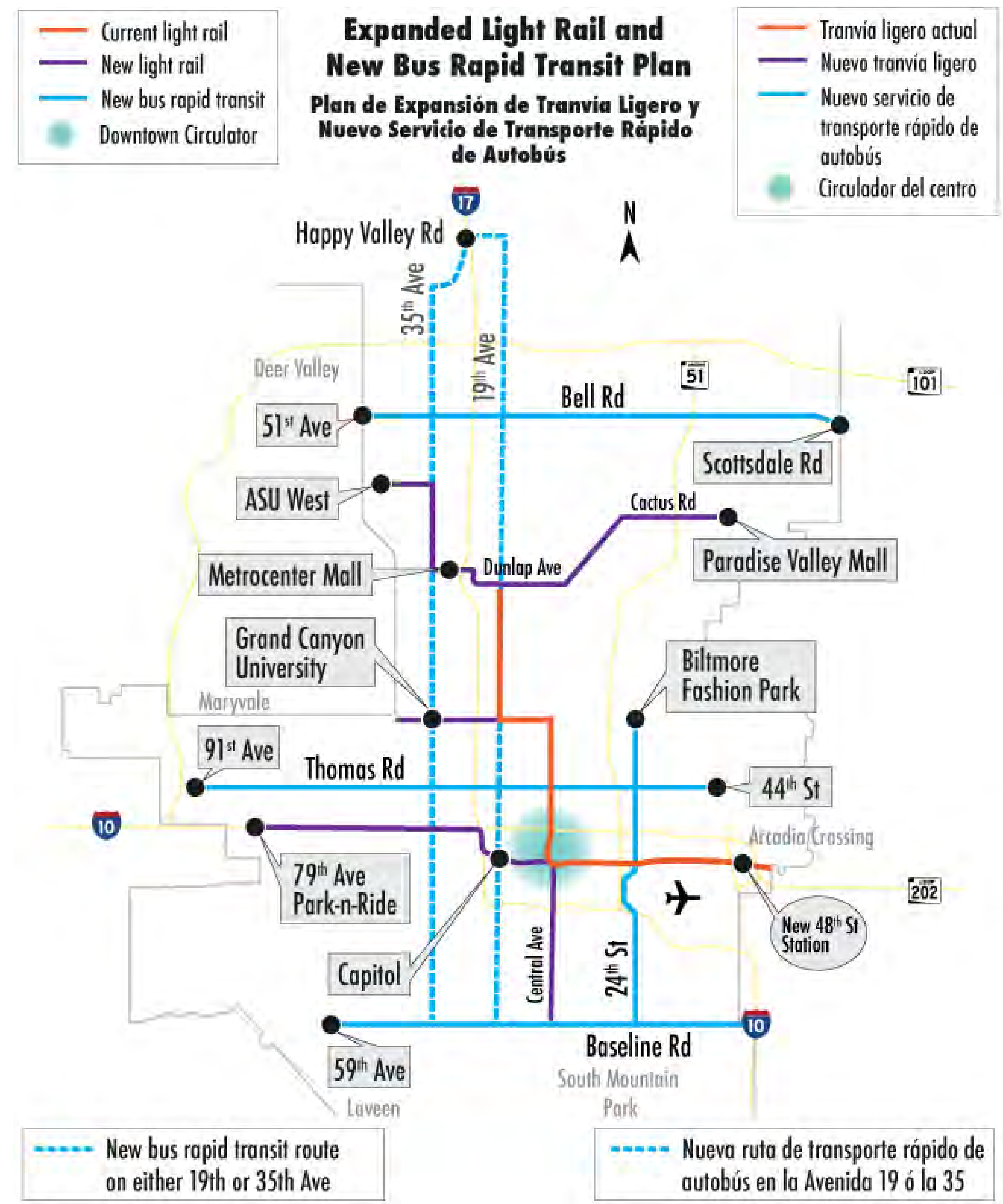
Map Last Updated: 5/24/2016

Figure 1-3 T2050 New Bus Map



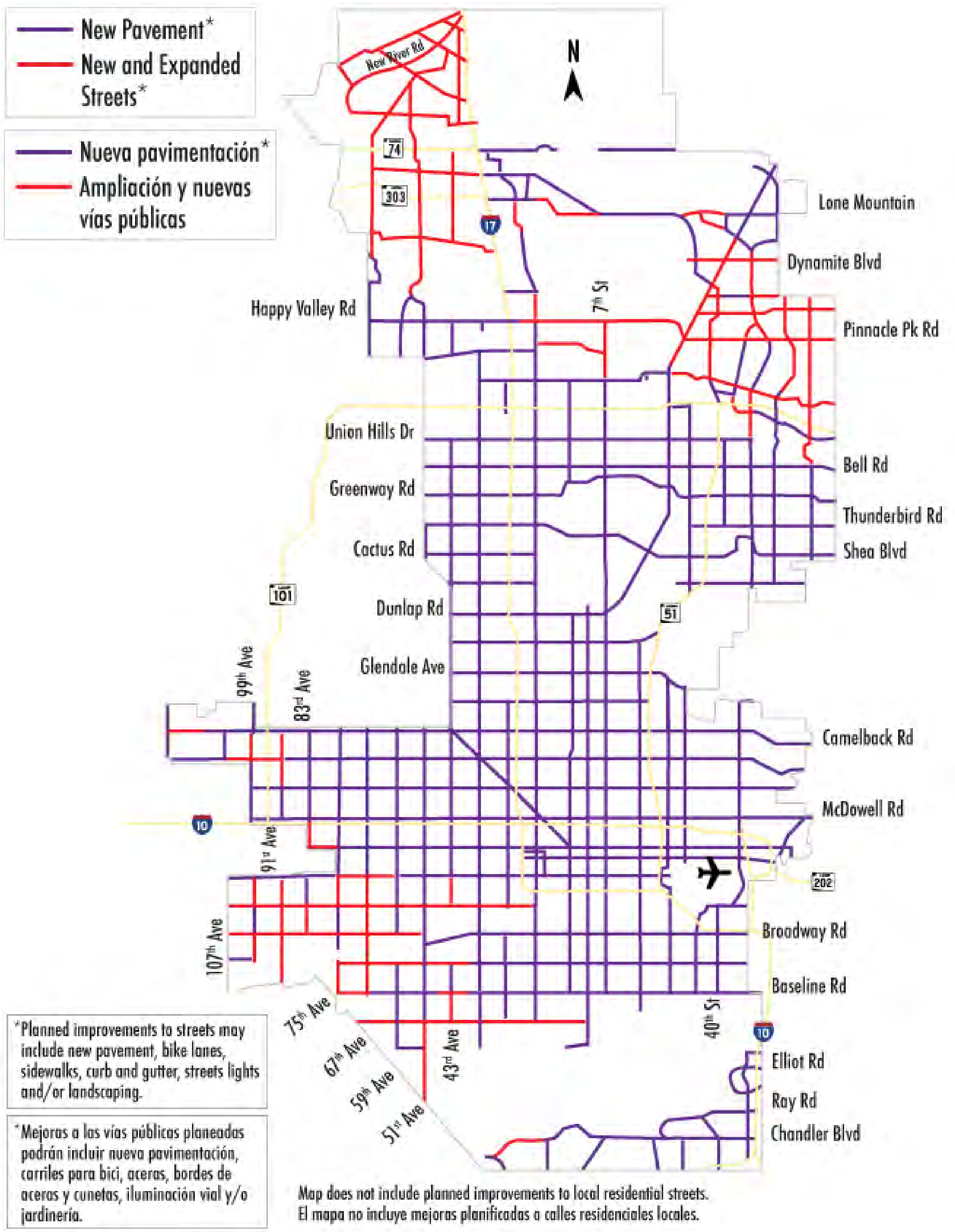
Source: http://movephx.org/get-the-facts/maps/

Figure 1-4 T2050 New Light Rail Transit Map



Source: http://movephx.org/get-the-facts/maps/

Figure 1-5 T2050 New Street Map



Source: http://movephx.org/get-the-facts/maps/

1.4 Moving Ahead for Progress in the 21st Century

Moving Ahead for Progress in the 21st Century (MAP-21), signed into law in 2012, creates a performance-based and multimodal program to address the many challenges facing the U.S. transportation system. An element of MAP-21 established Transportation Performance Management to implement performance measures by using system information.

By establishing performance-based criteria, MAP-21 increases the accountability and transparency of federal surface transportation programs and improves decision making by basing it on performance-based planning and programming.

MAP-21 established the following seven performance-based criteria and goals:

- **Safety** – To achieve a significant reduction in traffic fatalities and serious injuries on all public roads.
- **Infrastructure condition** – To maintain the highway infrastructure asset system in a state of good repair.
- **Congestion reduction** – To achieve a significant reduction in congestion on the National Highway System.
- **System reliability** – To improve the efficiency of the surface transportation system.
- **Freight movement and economic vitality** – To improve the national freight network, strengthen the ability of rural communities to access national and international trade markets and support regional economic development.
- **Environmental sustainability** – To enhance the performance of the transportation system while protecting and enhancing the natural environment.
- **Reduced project delivery delays** – To reduce project costs, promote jobs and the economy and expedite the movement of people and goods by accelerating project completion through eliminating delays in the project development and delivery process, including reducing regulatory burdens and improving agencies' work practices.

These performance criteria and goals will be used to evaluate federally funded surface transportation projects to create a performance and outcome-based transportation program. This report is structured to assess the existing condition of each of these seven criteria, which will then help inform the type of alternatives needed to improve in the deficient categories.

2 Environmental Factors

2.1 Introduction

The I-10/I-17 Corridor Master Plan is intended to provide an assessment of alternative capacity proposals. The *Interstate 10 Corridor Improvement Study and Draft Environmental Impact Statement (DEIS)/Section 4(f) Evaluation* (I-10 Corridor Study), which encompasses the segment of I-10 within the Spine study area between SR-202L and the Split was initiated by ADOT and FHWA in 2001 (ADOT 2009a). The *Interstate 17/Black Canyon Freeway Corridor Study and DEIS/Section 4(f) Evaluation* (I-17 Corridor Study), which encompasses the segment of I-17 within the Spine study area (from the Split north to the North Stack), began in 2009 (ADOT 2009b). The 2003 MAG RTP through the 2010 MAG RTP update include the study recommendations. Both studies were suspended in 2012 because of fiscal and operational constraints.

The current MAG RTP (2035) identifies potential capacity improvements within the Spine study area on I-10 between SR-202L and 32nd Street and on I-17 between the Split and SR-101L. The MAG RTP and the 2013 Central Phoenix Transportation Framework Study are investigating innovative alternatives to improving LOS on both I-10 and I-17. The process of analyzing environmental impacts addresses a comprehensive suite of social, economic and natural resources. Three major factors of consideration were evaluated when developing the list of critical environmental elements for the Spine study, including:

- past primary public concerns regarding other major Interstate projects in the Phoenix metropolitan area, including concerns expressed during the previous studies on I-10 and I-17
- determination of environmental issues that would differentiate alternatives following ADOT's Planning and Environmental Linkages (PEL) process
- the potential for the proposed project alternatives to cause significant adverse environmental effect on the resource in the study area's urban setting

Based on the results of this evaluation, the environmental analysis deemed the resources listed in Table 2-1 as not critical for inclusion in this study. These resources were deemed not critical because they would not differentiate between possible alternatives or they were simply not present. However, these resources would be accounted for in future NEPA environmental determinations associated with projects stemming from the master plan process.

Table 2-1 Resources Considered as Not Critical for Study Inclusion

Resource	Rationale for determination
Biological resources	Biological resources within the expanded study area are diminished and consistent; biology is not a resource issue that will differentiate alternatives following ADOT's PEL process.
Cumulative impacts	Cumulative impacts assessments completed for the I-10 Corridor Study and the I-17 Corridor Study classified impacts as primarily neutral/positive/minor and not likely to differentiate among alternatives. Similarly, this is not a resource issue that will differentiate alternatives in the expanded study area.
Farmlands (prime or unique)	The expanded study area is located primarily in a highly disturbed urban area; therefore, potential impacts on prime or unique farmlands would not differentiate alternatives following ADOT's PEL process.
Material sources and waste materials	Specific design elements of future alternatives in the expanded study area are unknown at this point in ADOT's PEL process. Multiple ADOT-approved material sources are local to the expanded study area; therefore, this resource is not an issue that will differentiate alternatives following ADOT's PEL process.
National natural landmarks	No national natural landmarks are located in the expanded study area (National Park Service 2009).
Navigable waters	Although the lower Salt River through Phoenix, including the expanded study area, was found navigable in Arizona (State of Arizona Court of Appeals 2010), this issue would not differentiate alternatives following ADOT's PEL process.
Noise	Traffic noise is an issue that garners considerable public interest in the design and implementation of transportation facilities. Current ambient noise levels within the expanded study area are typical of an urban/suburban environment. Noise mitigation on existing Interstates and arterials in the form of walls, berms and barriers would minimize future impacts in noise-sensitive areas. Therefore, noise is not an issue that would differentiate alternatives following ADOT's PEL process.
Outstanding Arizona waters	No outstanding Arizona waters are located in the expanded study area (Arizona Department of Environmental Quality, A.A.C. R18-11-112[G]).
Secondary impacts	Secondary impacts assessments completed for the I-10 Corridor Study and the I-17 Corridor Study classified impacts as primarily neutral/positive/minor and not likely to spur secondary impacts. Similarly, this issue would not significantly differentiate alternatives within the expanded study area.
Sections 404 and 401, Clean Water Act	The Salt River is the primary water of the United States through Phoenix, with most of the expanded study area disturbed and lacking additional waters of the United States. Although potential impacts between alternatives that span the river could vary, this issue would not significantly differentiate alternatives within the expanded study area.
Soils and geologic resources	Outside of the Salt River, soils and geologic features are a diminished resource because of the highly disturbed urban character of the expanded study area; therefore, they are not an issue that will differentiate alternatives following ADOT's PEL process.
Sole source aquifer	The expanded study area is not located in a sole source aquifer (EPA 2013a).
Utilities	Utilities are located throughout the expanded study area; however, potential impacts are not an issue that will differentiate alternatives following ADOT's PEL process.
Visual resources	The expanded study area encompasses a highly disturbed urban area. Visual resources are not an issue that will differentiate alternatives following ADOT's PEL process.
Wild and Scenic Rivers	No wild and scenic rivers (36 CFR 297) are located in the expanded study area.
Wilderness areas	No wilderness areas (36 CFR 293) are located in the expanded study area.

Notes: A.A.C. = Arizona Administrative Code, ADOT = Arizona Department of Transportation, CFR = Code of Federal Regulations, EPA = U.S. Environmental Protection Agency, I-10 = Interstate 10, I-17 = Interstate 17, PEL = Planning and Environmental Linkages

The following resources were identified in the environmental analysis as critical environmental elements:

- air quality
- hazardous materials
- Section 4(f) and Section 6(f) resources
- land use and jurisdiction
- socioeconomics
- Title VI/environmental justice
- cultural resources

The Spine corridor expanded study area was examined and evaluated for each critical element. This document describes the existing conditions for each of the elements and identifies potential issues that will be used in the screening of alternatives as part of the I-10/I-17 Corridor Master Plan.

Environmental elements not deemed as critical for inclusion in this study may be evaluated as part of future NEPA projects following the development of the recommended alternative(s). Additionally, should the study identify transportation solutions outside of the expanded study area, further data collection and analysis may be needed.

2.2 Affected Environment and Environmental Concerns

The baseline report describes the natural and built environment within the expanded study area by resource topic. The discussion for each topic concludes with environmental concerns and recommendations for additional analysis and coordination for future projects recommended by the I-10/I-17 Corridor Master Plan.

2.2.1 Physical and Natural Environment

Air Quality

Identifying and developing transportation modes for safely, efficiently and effectively moving people, goods and services through the Phoenix metropolitan area would be expected to contribute to the region's long-term attainment of air quality goals by reducing vehicle miles traveled, which in turn would reduce vehicle emissions. The air quality analysis summarizes existing conditions and the potential effects of modal options within the Spine study area. Future quantitative analysis of mobile source criteria pollutants, air toxics and greenhouse gases for the Proposed Action alternatives is addressed later in the discussion.

Regulatory Setting

The Clean Air Act (CAA) was the first comprehensive legislation aimed at reducing levels of air pollution throughout the United States. The 1970 law required the U.S. Environmental Protection Agency (EPA) to establish National Ambient Air Quality Standards (NAAQS) intended to protect the public health, including sensitive population groups, with an adequate margin of safety (Table 2-2). Secondary NAAQS are set at levels designed to protect the public by accounting for the effects of air pollution on vegetation, soil, materials, and other aspects of the general welfare.

Periodic Review and Modification of NAAQS

EPA is required to periodically review the NAAQS and modify primary and secondary standards as necessary, in compliance with 42 CFR 85.

Table 2-2 National Ambient Air Quality Standards

Pollutant	Averaging time	Primary standard[a]	Secondary standard[a]	Form
Carbon monoxide (CO)	8-hour	9 ppm[b]	—	Not to be exceeded more than once per year
	1-hour	35 ppm	—	Not to be exceeded more than once per year
Lead (Pb)	Rolling 3-month average[c]	0.15 μg/m^3	0.15 μg/m^3	Not to be exceeded
Nitrogen dioxide (NO_2)	1-hour	100 ppb	—	98th percentile, averaged over 3 years
Ozone (O_3)	Annual arithmetic mean[d]	53 ppb	53 ppb	Annual mean
	8-hour[e]	0.075 ppm	0.075 ppm	Annual fourth-highest daily maximum 8-hour concentration average over 3 years
Particulate matter less than 2.5 microns ($PM_{2.5}$)	Annual	12 μg/m^3	15 μg/m^3	Annual mean, averaged over 3 years
	24-hour	35 μg/m^3	35 μg/m^3	98th percentile, averaged over 3 years
Particulate matter less than 10 microns (PM_{10})	24-hour	150 μg/m^3	150 μg/m^3	Not to be exceeded more than once per year on average over 3 years
Sulfur dioxide (SO_2)	1-hour[f]	75 ppb	—	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
	3-hour	—	0.5 ppm	Not to be exceeded more than once per year

Source: U.S. Environmental Protection Agency (2012)

Notes: ppm = parts per million; μg/m^3= micrograms per cubic meter; ppb = parts per billion

[a] Primary standards set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against visibility impairment and damage to animals, crops, vegetation, and buildings.

[b] Because of mathematical rounding, a measured value of 9.5 ppm or greater is necessary to exceed the standard.

[c] Final rule signed October 15, 2008. The 1978 lead standard (1.5 μg/m^3 as a quarterly average) remains in effect until 1 year after an area is designated for the 2008 standard, except that in areas designated nonattainment for the 1978 standard, the 1978 standard remains in effect until implementation plans to attain or maintain the 2008 standard are approved.

[d] The official level of the annual O_3 standard is 0.053 ppm, equal to 53 ppb, which is shown here for the purpose of clearer comparison to the 1-hour standard.

[e] Final rule signed March 12, 2008. The 1997 ozone standard (0.08 ppm, annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years) and related implementation rules remain in place. In 1997, EPA revoked the 1-hour ozone standard (0.12 ppm, not to be exceeded more than once per year) in all areas, although some areas have continued obligations under that standard ("anti-backsliding"). The 1-hour ozone standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is less than or equal to 1.

[f] Final rule signed June 2, 2010. The 1971 annual and 24-hour SO_2 standards were revoked in that same rulemaking. However, these standards remain in effect until 1 year after an area is designated for the 2010 standard, except in areas designated nonattainment for the 1971 standards, where the 1971 standards remain in effect until implementation plans to attain or maintain the 2010 standard are approved.

Criteria Pollutants

The NAAQS set maximum allowable concentrations for seven criteria pollutants: carbon monoxide (CO), ozone (O_3), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), particulate matter less than or equal to 2.5 microns in diameter and less than or equal to 10 microns in diameter ($PM_{2.5}$ and PM_{10}), and lead (Pb). The Arizona Department of Environmental Quality (ADEQ), as delegated by EPA, is responsible for monitoring and enforcing air quality regulations in Arizona. Similarly, the Maricopa County Air Quality Department (MCAQD) is responsible for monitoring and enforcing air quality regulations in Maricopa County. The Arizona State Implementation Plan (SIP), developed in accordance with the CAA Amendments (CAAA), contains the major state requirements with respect to transportation and air quality. Table 2-2 lists the primary and secondary standards established for each criteria pollutant. Criteria pollutants typically associated with vehicle traffic are CO, O_3, nitrogen oxides (NO_x), $PM_{2.5}$, and PM_{10}.

EPA is required to periodically review the NAAQS and modify each of the standards as necessary. EPA recently modified the NAAQS, 2008 and 2012, respectively, for 8-hour O_3 and annual $PM_{2.5}$, based on new studies that showed lower levels were needed to protect public health (http://www.epa.gov/air/criteria.html).

Mobile Source Air Toxics

Controlling air toxic emissions became a national priority with the passage of the CAAA of 1990, whereby Congress mandated that EPA regulate 188 air toxics, also known as hazardous air pollutants. EPA has assessed this expansive list in its latest rule on the Control of Hazardous Air Pollutants from Mobile Sources (72 *Federal Register* 37: 8430, February 26, 2007), and identified a group of 93 compounds emitted from mobile sources that are listed in its Integrated Risk Information System (IRIS) (http://cfcpub.epa.gov/ncea/iris/index.cfm). In addition, EPA identified seven compounds with significant contributions from mobile sources that are among the national and regional-scale cancer risk drivers from its 1999 National Air Toxics Assessment (http://www.epa.gov/ttn/atw/nata1999/). These pollutants, otherwise known as mobile source air toxics (MSATs), are:

- benzene
- formaldehyde
- naphthalene
- diesel particulate matter/diesel exhaust gases
- acrolein
- 1, 3-butadiene
- polycyclic organic matter

MSAT Sources and Health Effects

Of the seven MSATs, only benzene is considered by EPA as a known human carcinogen; the remaining six are considered either probable or possible carcinogens. Some toxic compounds are present in fuel and are emitted to the air when the fuel evaporates or passes through the engine unburned. Other toxics are emitted from the incomplete combustion of fuels or as secondary combustion products. Metal air toxics also result from engine wear or from impurities in oil, diesel fuel, or gasoline.

EPA is the lead authority for administering the CAA and its amendments, and has specific statutory obligations with respect to hazardous air pollutants and MSATs. EPA is in the continual process of assessing human health effects, exposures, and risks posed by air pollutants. The agency maintains the IRIS, which is "a compilation of electronic reports on specific substances found in the environment and their potential to cause human health effects" (http://www.epa.gov/iris/). Each report contains assessments of non-cancerous and cancerous effects for individual compounds and quantitative estimates of risk levels from lifetime oral and inhalation exposures with uncertainty spanning perhaps an order of magnitude.

Other organizations are also active in the research and analyses of human health effects of MSATs, including the Health Effects Institute (HEI). Two HEI studies are summarized in Appendix D of FHWA's *Interim Guidance Update on Mobile Source Air Toxic Analysis in NEPA Documents* (2012). Among the adverse health effects linked to MSAT compounds at high exposures are: cancer in humans in occupational settings, cancer in animals, and irritation to the respiratory tract, including the exacerbation of asthma. Less obvious are the adverse human health effects of MSAT compounds at current environmental concentrations (http://pubs.healtheffects.org/view.php?id=282) or in the future as vehicle emissions substantially decrease (http://pubs.healtheffects.org/view.php?id=306).

Climate Change

Climate change refers to long-term changes in temperature, precipitation, wind patterns, and other elements of the earth's climate system. An ever-increasing body of scientific research attributes these climatological changes to greenhouse gas (GHG) emissions, which trap the sun's energy in the earth's atmosphere by absorbing and reflecting some of it to the earth rather than allowing the energy to escape back to space. This is called the "greenhouse effect." Of particular concern is GHGs generated from the production and use of fossil fuels.

While climate change has been a concern for several decades, the establishment of the Intergovernmental Panel on Climate Change by the United Nations and World Meteorological Organization in 1988 has led to increased efforts devoted to GHG emissions reduction and climate change research and policy. These efforts are primarily concerned with the emissions of GHGs generated by human activity including carbon dioxide (CO_2), methane, nitrous oxide, tetrafluoromethane, hexafluoroethane, sulfur hexafluoride, HFC-23 (fluoroform), HFC-134a (s, s, s, 2-tetrafluoroethane), and HFC-152a (difluoroethane).

Federal Attainment Status and Implementation Plans

The CAAA mandated that EPA designate geographic areas of the country that have measured pollutant concentrations exceeding the levels prescribed by the air quality standards as “nonattainment.” The CAAA classifies nonattainment areas and specifies compliance deadlines for these areas. Areas of the country that have measured pollutant concentrations that are less than the NAAQS are designated attainment areas. Areas that have attained the standards after a period of nonattainment and that have plans in place to reduce emissions are classified as maintenance areas. The Spine study area is located in Maricopa County, an area that has been designated by EPA as a “marginal” nonattainment area for 8-hour O_3, a “serious” nonattainment area for PM_{10}, and a maintenance area for CO. Maricopa County is in attainment for all other criteria pollutants, including NO_2, $PM_{2.5}$, SO_2, and Pb.

State and Local Plans

Portions of Maricopa County are currently designated as maintenance for CO and nonattainment for 8-hour O_3 and PM_{10} for the NAAQS. A description of the attainment status and MAG air quality plans that address the federal air quality standards is provided below.

Carbon Monoxide: There have been no violations of the 1-hour CO standard since 1984 and the 8-hour standard since 1996. On March 9, 2005, EPA redesignated the Maricopa County nonattainment area as having met the federal air quality standards for CO, effective April 8, 2005. EPA also approved the *MAG Maintenance Plan*, which indicates that the standards would be maintained through 2015. The nonattainment area is now a maintenance area. In March 2013, the MAG 2013 *Carbon Monoxide Maintenance Plan* was submitted to EPA, which indicates that the standards would be maintained through 2025.

One-Hour Ozone: There were no violations of the 1-hour ozone standard at any monitor after 1996. On June 14, 2005, EPA redesignated the Maricopa County nonattainment area as having met the federal 1-hour O_3 standard and the area was reclassified as a Maintenance Area. EPA also approved the *MAG Maintenance Plan*, which indicates that the standard would be maintained through 2015. However, on June 15, 2005, EPA revoked the 1-hour standard.

Eight-Hour Ozone: In June 2004, EPA designated the 8-hour O_3 nonattainment boundary, located mainly in Maricopa County and Apache Junction in Pinal County. The area had a June 2009 attainment date. MAG submitted an *Eight-Hour Ozone Plan* (2007a) that demonstrated attainment of the standard by June 2008. In February 2009, the *MAG 2009 Eight-Hour Ozone Redesignation Request and Maintenance Plan* was submitted to EPA, which demonstrated that the standard would be maintained through 2025. There have been no violations of the 0.08 parts per million (ppm) 8-hour standard at air quality monitors since 2004. On June 13, 2012, EPA published a final notice to approve the MAG 2007 *Eight-Hour Ozone Plan*. On September 17, 2014, EPA published a final notice to approve the *MAG 2009 Eight-Hour Ozone Redesignation Request and Maintenance Plan*.

In 2008, EPA revised the 8-hour ozone standard to 0.075 ppm from 0.08 ppm. On May 21, 2012, EPA published a final rule to designate the Maricopa nonattainment area as a Marginal Area. The boundaries of the nonattainment area were expanded slightly to the west and south to include new power plants. On June 27, 2014, the *MAG 2014 Eight-Hour Ozone Plan – Submittal of Marginal Area Requirements for the Maricopa Nonattainment Area* was transmitted to EPA. Because of a subsequent court ruling, EPA published a final rule on March 6, 2015, revising the attainment date for Marginal Areas from December 31, 2015, to July 20, 2015.

PM10 (particulate matter that is 10 microns in diameter or less): Currently, the Maricopa County nonattainment area is classified as a Serious Area for PM_{10} particulate pollution. The new *MAG 2012 Five Percent Plan for PM-10* is designed to meet the requirements of the Clean Air Act and address the technical approvability issues with the prior *2007 Five Percent Plan* identified by EPA. The plan contains a wide variety of existing control measures and projects that have been implemented to reduce PM_{10} and includes a new measure designed to reduce PM_{10} during high risk conditions, including high winds. While the *2007 Five Percent Plan for PM-10* was withdrawn to include new information, a wide range of control measures in that plan, which continue to be implemented to reduce PM_{10}, were resubmitted. The plan demonstrated that the measures will reduce emissions by 5 percent per year and demonstrated attainment of the PM_{10} standard as expeditiously as practicable, which was 2012.

On July 20, 2012, EPA made a completeness finding on the plan, which stopped the sanctions clocks related to the withdrawal of the prior 2007 plan. On June 10, 2014, EPA published a final notice to fully approve the *MAG 2012 Five Percent Plan for PM-10*, effective July 10, 2014. In that notice, EPA determined that the PM_{10} nonattainment area has met the PM_{10} standard based on 2010 to 2012 monitoring data.

Transportation Conformity

The conformity requirement is based on CAA Section 176(c), which prohibits the U.S. Department of Transportation and other federal agencies from funding, authorizing, or approving plans, programs, or projects that do not conform to the SIP for attaining the NAAQS. “Transportation Conformity” applies to highway and transit projects and takes place on two levels: the regional (planning and programming level) and the project level. Any Proposed Action must conform at both levels to be approved.

Conformity requirements apply only in nonattainment and “maintenance” (former nonattainment) areas for the NAAQS, and only for the specific NAAQS that are or were violated. EPA regulations at 40 Code of Federal Regulations (CFR) 93 govern the conformity process. Conformity requirements do not apply in unclassifiable/attainment areas.

Regional conformity is concerned with how well the regional transportation system supports plans for attaining the NAAQS for the six criteria pollutants. Arizona has nonattainment or maintenance areas for all five of the transportation-related “criteria pollutants” as well as sulfur dioxide, which is not a transportation-related pollutant, and is not currently required by the CAA to be covered in transportation conformity analysis. Regional conformity is based on emission analysis of RTPs and TIPs that include all transportation projects planned for a region over a period of at least 20 years (for the RTP) and 4 years (for the TIP). Conformity on the RTP and TIP involves using travel demand and emission models to determine whether or not the implementation of those projects would conform to emission budgets or interim tests for analysis years showing that requirements of the CAA and the SIP are met. FHWA and the Federal Transit Administration (FTA) make the determinations that the RTP and TIP conform to the SIP for achieving the CAA goals. If the design concept, scope and “open-to-traffic” schedule of a proposed transportation project are consistent with how the project was modeled in the regional emissions analysis for the RTP and the TIP, then the proposed project meets regional conformity requirements. Future projects in the Spine study area identified in the TIP must demonstrate conformity with the SIP.

Affected Environment

As it relates to air quality within the Spine study area, the affected environment can be described in terms of historical monitored criteria pollutant levels and sensitive land uses.

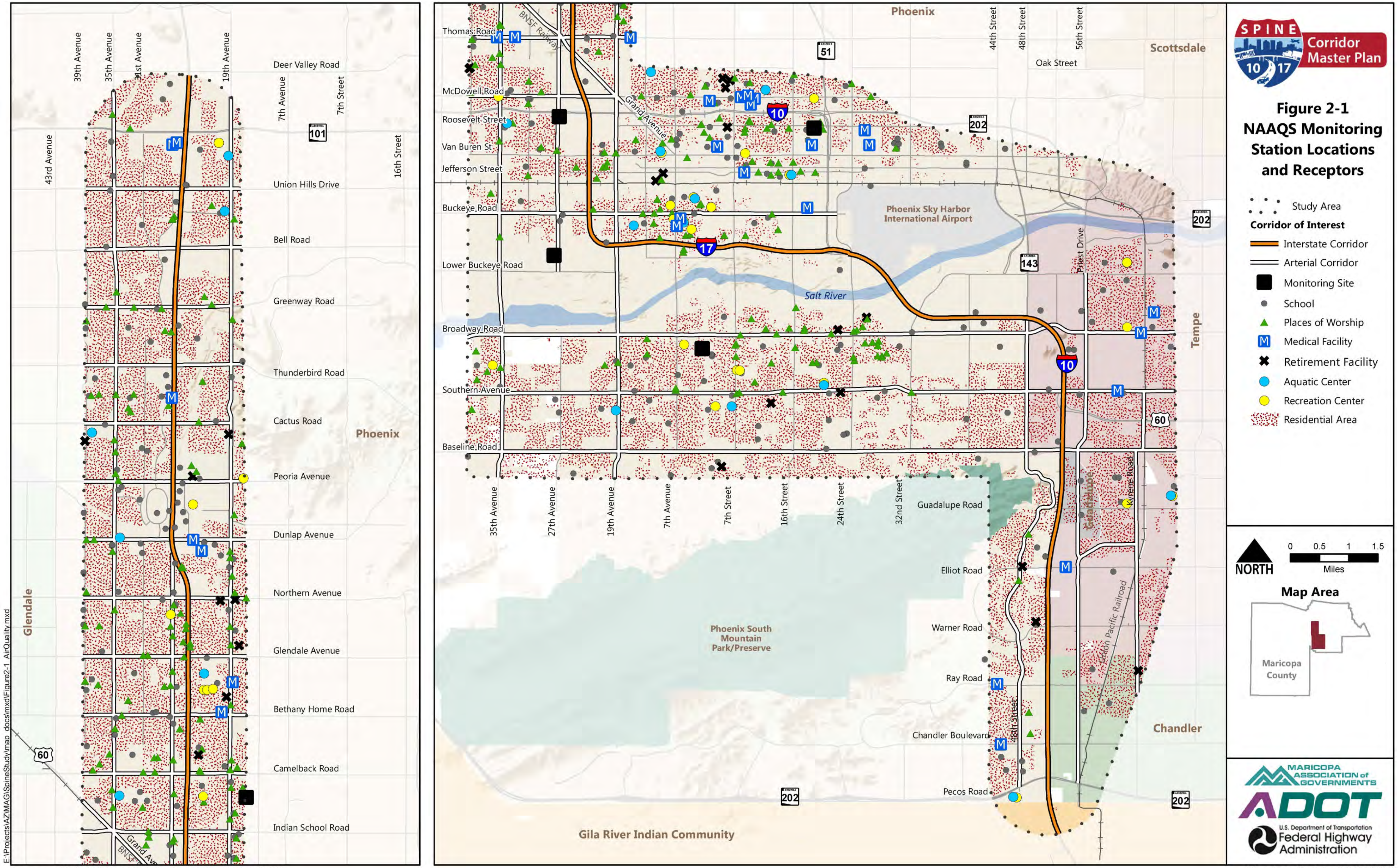
Existing Air Quality

MCAQD maintains an area wide network of monitoring stations that routinely measure pollutant concentrations in the ambient air. These stations provide data to assess compliance with the NAAQS and to evaluate the effectiveness of pollution control strategies. The relevant monitored pollutants are O_3, NO_2, CO, PM, and SO_2.

Table 2-3 presents the maximum concentrations for these pollutants including exceptional events measured at the ADEQ JLG Supersite monitoring station at 4530 North 17th Avenue (Air Quality System [AQS] ID: 04-013-9997), the MCAQD Central Phoenix monitoring station at 1645 East Roosevelt Street (AQS ID: 04-013-3002), the MCAQD South Phoenix monitoring station at 33 West Tamarisk Avenue (AQS ID: 04-013-4003), the MCAQD Greenwood monitoring station at 27th Avenue and I-10 (AQS ID: 04-013-3010), and the MCAQD Durango Complex monitoring station at 27th Avenue and Durango Street (AQS ID: 04 013-9812) as reported by these agencies to EPA for the 3 most recent years for which data are available (2012 to 2014). Figure 2-1 shows the locations of these five monitoring sites.

As shown in Table 2-3, the bold values represent a measured concentration that exceeds the NAAQS for the listed criteria pollutants; however, the only compliance exceedances of the NAAQS have occurred for the 8-hour O_3 standard, which is a regional pollutant and would not be assessed at the project level for alternatives within the expanded corridor study area. For $PM_{2.5}$, maximum 24-hour monitored concentrations have exceeded the NAAQS during the 2012 to 2014 monitoring period, but the 98th percentile concentrations that establish compliance have not.

Figure 2-1 NAAQS Monitoring Station Locations and Receptors



Source: ADEQ, ADOT, ALRIS, ESRI, FEMA, MAG, MCFCD

Map Last Updated: 5/11/2016

Table 2-3 Recent Monitored Ambient Air Quality Data

Pollutant	Averaging period	NAAQS	2012		2013		2014	
Ozone (O_3)			1st Max.	4th Max.	1st Max.	4th Max.	1st Max.	4th Max.
AQS ID: 040139997[a]	8-hour	0.075 ppm	**0.084**	**0.076**	**0.084**	**0.079**	**0.084**	**0.077**
AQS ID: 040133002[b]			**0.084**	**0.077**	**0.079**	0.075	**0.077**	0.071
AQS ID: 040134003[c]			**0.087**	**0.078**	**0.081**	0.075	**0.080**	0.073
Carbon monoxide (CO)			1st Max.	2nd Max.	1st Max.	2nd Max.	1st Max.	2nd Max.
AQS ID: 040139997[a]	1-hour	35 ppm	2.9	2.8	3.2	2.8	3.0	2.6
AQS ID: 040133002[b]			33	3.3	2.8	2.7	3.6	3.0
AQS ID: 040134003[c]			3.5	3.0	3.5	3.1	3.7	3.3
AQS ID: 040133010[d]			4.3	3.5	3.3	3.1	2.9	2.9
Carbon monoxide (CO)			1st Max.	2nd Max.	1st Max.	2nd Max.	1st Max.	2nd Max.
AQS ID: 040139997[a]	8-hour	9 ppm	1.8	1.6	2.0	1.9	2.2	2.1
AQS ID: 040133002[b]			2.7	2.0	2.1	2.1	2.5	2.4
AQS ID: 040134003[c]			2.3	1.6	2.3	2.2	2.9	1.9
AQS ID: 040133010[d]			3.2	2.1	2.5	2.4	2.6	2.1
Particulate matter less than 2.5 microns ($PM_{2.5}$)			1st Max.	98th Pct.	1st Max.	98th Pct.	1st Max.	98th Pct.
AQS ID: 040139997[a]	24-hour	35 µg/m^3	**55.9**	19	**44.9**	22	**63.4**	23
AQS ID: 040134003[c]			**70.8**	21	**97.3**	26	**101.7**	27
AQS ID: 040139812[e]			**74.4**	25	**66.9**	27	**56.4**	24
Particulate matter less than 2.5 microns ($PM_{2.5}$)			Annual Mean		Annual Mean		Annual Mean	
AQS ID: 040139997[a]	Annual	15 µg/m^3	7.9		7.3		7.0	
AQS ID: 040134003[c]			9.2		9.6		10.3	
AQS ID: 040139812[e]			11.6		10.5		10.1	
Particulate matter less than 10 microns (PM_{10})			1st Max.	2nd Max.	1st Max.	2nd Max.	1st Max.	2nd Max.
AQS ID: 040139997[a]	24-hour	150 µg/m^3	120	120	**262**	**193**	**193**	97
AQS ID: 040133002[b]			117	115	**328**	**182**	**182**	**146**
AQS ID: 040134003[c]			134	125	**294**	**186**	**170**	**169**
AQS ID: 040139812[e]	24-hour	150 µg/m^3	124	111	**303**	**209**	**172**	**162**
AQS ID: 040133010[d]			145	138	**273**	**207**	**208**	**157**

Table 2-3 Recent Monitored Ambient Air Quality Data

Source: U.S. Environmental Protection Agency (2015), Air Data Monitor Values Report. http://www.epa.gov/airdata/ad_rep_mon.html. Accessed April, 1, 2015.

Notes: AQS = Air Quality System, ID = identification, Max. = maximum, µg/m^3 = micrograms per cubic meter, NAAQS = National Ambient Air Quality Standards, Pct. = percentile, ppm = parts per million; **bold** indicates NAAQS exceedance

PM_{10} concentrations associated with U.S. Environmental Protection Agency-approved exceptional events have been excluded. PM_{10} exceedances listed in 2013 and 2014 are the result of exceptional events in 2013 or 2014; to date, the U.S. Environmental Protection Agency has not approved the 2013 and 2014 exceptional events.

[a] JLG Supersite, 4530 N. 17th Avenue [b] Central Phoenix, 1645 E. Roosevelt Street [c] South Phoenix, 33 W. Tamarisk Avenue
[d] Greenwood, 27th Avenue and Interstate 10 [e] Durango Complex, 27th Avenue and Durango Street

Similarly, for PM_{10} the 1st and 2nd maximum 24-hour monitored concentrations have exceeded the NAAQS during this period, but these values are the result of exceptional events and do not represent compliance exceedances.

Carbon Monoxide. According to the requirements of 40 CFR Section 93.116, an FHWA-sponsored project must not cause or contribute to any new violations of the NAAQS, not increase the frequency or severity of any existing violations, and not delay attainment of any NAAQS. Because CO emissions are associated with motor vehicles and transportation projects, and because the project is located in a CO maintenance area, CO is a pollutant of concern in the project-level analysis. In accordance with EPA guidance, an intersection screening assessment and dispersion modeling analysis for computing CO concentrations at congested intersections was completed for the I-10 Corridor Study (ADOT 2009a). The intersection screening methods were based on EPA criteria in the *Guidelines for Modeling Carbon Monoxide from Roadway Intersections* (EPA 1992).

Using EPA criteria such as LOS, delay, and total volumes, specific intersections were selected for a CO "hot spot" analysis. Intersections were also chosen based on their geographical location so that the final list of sites would be representative of the entire corridor.

Maximum 1- and 8-hour CO concentrations were predicted for existing conditions in 2007, which was the latest year for which Phoenix-specific vehicle registration data were available at the time of the study. There were no exceedances of the 1-hour CO standard of 35 ppm predicted at any of the selected intersections. The highest estimated 1-hour CO concentration was 6.5 ppm at the I-10 westbound ramps and 40th Street. There were also no exceedances of the 8-hour CO standard of 9 ppm predicted at any of the selected intersections. The study results support the attainment status of the expanded study area and larger Phoenix Maintenance Area for CO.

Particulates. Federal regulation 40 CFR Section 93.123 requires a quantitative impact assessment for projects located in a PM_{10} nonattainment area. At the time of the I-10 Corridor Study and the I-17 Corridor Study, EPA had not finalized the methodologies for conducting a quantitative PM_{10} modeling analysis.

A qualitative analysis was prepared for the I-10 Corridor Study according to the guidelines established in *Transportation Conformity Guidance for Qualitative Hot-spot Analyses in $PM_{2.5}$ and PM_{10} Nonattainment and Maintenance Areas* (EPA 2006). Using vehicle delay as a proxy for particulate emissions, reductions in particulate emissions for proposed alternatives were predicted.

Mobile Source Air Toxics. In its Final Rule, issued under the authority in Section 202 of the CAA, EPA examined the impacts of existing and newly promulgated mobile source control programs, including its reformulated gasoline program, its national low emission vehicle standards, its Tier 2 motor vehicle emissions standards and gasoline sulfur control requirements and its proposed heavy duty engine and vehicle standards and on-highway diesel fuel sulfur control requirements. Based on an FHWA analysis using EPA's Motor Vehicle Emissions Simulator (MOVES2010b) model, as shown in Figure 2-2, even if vehicle miles traveled (VMT) increases by 102 percent as assumed from 2010 to 2050, a combined reduction of 83 percent in the total annual emissions for the priority MSATs is projected for the same time period. These pollutants, otherwise known as MSATs, are handled as follows:

- no analysis for projects with no potential for meaningful MSAT effects
- qualitative analysis for projects with low potential MSAT effects
- quantitative analysis to differentiate alternatives for projects with higher potential MSAT effects

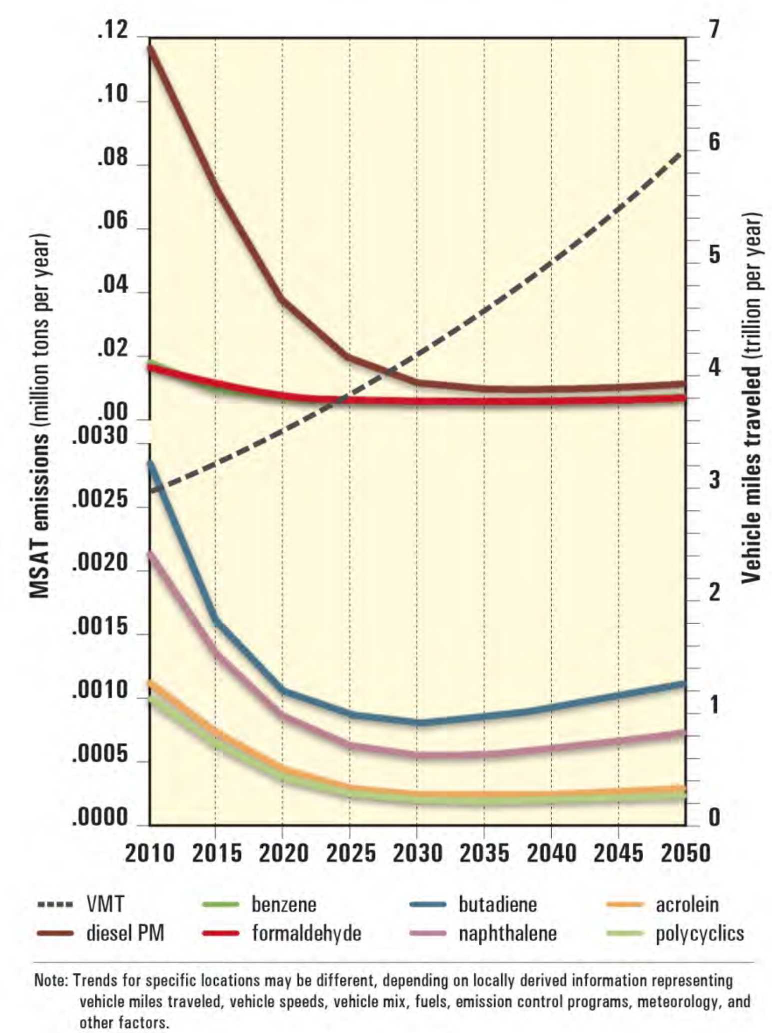
For projects warranting MSAT analysis, the seven priority MSATs should be analyzed. A category 3 quantitative MSAT assessment was completed for the I-10 Corridor Study, comparing the total estimated emissions for the 2007 existing conditions and future No-Build and Build alternatives using VMT as a proxy for MSAT emissions. Higher VMT for the future alternatives were estimated to result in higher total emissions of diesel particulates in those years compared with the existing conditions. The percentage change in VMT is approximately equivalent to the percentage change in total emissions of diesel particulates. However, overall MSAT emissions, including diesel particulates, would decrease because of stricter EPA vehicle emissions standards in future years, as indicated in Figure 2-2.

For transportation conformity and NEPA purposes, criteria pollutant concentrations are generally predicted at locations, referred to as receptors that are adjacent to the existing or future facility. For roadway projects, receptors are typically located on sidewalks and other pedestrian areas in the vicinity of intersections where vehicle queuing occurs and potential pollution concentrations are highest. Transit project receptors are on station platforms, bus stops/bays and park-and-ride lots.

Land Use and Sensitive Receptors

Additional receptor locations are appropriate for determining concentrations of certain pollutants. For particulates, Section 7.2.2 of Appendix W to 40 CFR Part 51 provides guidance on the selection of critical receptor sites, and recommends that receptor sites be placed in sufficient detail to estimate the highest concentrations and possible violations of an NAAQS. The selection of receptor sites for all PM NAAQS should be determined on a case-by-case basis, taking into account project-specific factors that may influence areas of expected high concentrations such as prevailing wind directions, monitor locations, topography and other factors.

Figure 2-2 Projected National MSAT Emission Trends, 2010–2050, for Vehicles Operating on Roadways, Using EPA's MOVES2010b Model



NAAQS primary standards set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children and the elderly, as noted in Table 2-2. In addition to residential areas, areas within the Spine study area where these populations (sensitive receptors) can be found include schools, recreation centers, parks, and places of worship. Table 2-4 lists the number of sensitive receptors by land use category within the expanded study limits. Receptors are also shown in Figure 2-1.

Table 2-4 Sensitive Receptors

Analysis area	Residential (acres)	Schools	Places of worship	Medical facilities	Retirement facilities	Parks	Recreation centers	Public pools
Expanded study area	33,365	259	250	30	26	145	31	20

Sources: Maricopa County Department of Transportation, Maricopa Association of Governments, Arizona Department of Environmental Quality, ESRI

Environmental Concerns and Recommendations for Future Analysis

Areas of Sensitivity

People are exposed to toxic air pollutants in many ways that can pose health risks, such as breathing contaminated air, eating contaminated food products, drinking water contaminated by toxic air pollutants and touching (making skin contact with) contaminated soil, dust or water. Children are especially sensitive to exposure to MSATs. Young children are especially vulnerable because they often ingest soil from their hands or from objects they place in their mouths. According to EPA's *Toxicity and Exposure Assessments for Children's Health*, benzene concentrations in indoor air are significant contributors to children's exposures.

EPA has created a monitoring program (Hot Spot Exposure Assessment Program) to assist in developing a model to "accurately identify and assess personal exposures to air toxics in microenvironments." This program includes the following studies: *Fresno Asthmatic Children's Environmental Study (FACES)*, the *Baltimore Traffic Study*, and the *Los Angeles School Bus Exposure Assessment*. These studies focus primarily on exposure of toxic air pollutants and diesel particulates in particular on children in their homes, schools and near roadways. Data supporting associations between environmental exposures to MSATs and adverse health effects for asthmatic children were obtained.

Data Gaps

Geographic information system (GIS) data developed for the I-10 Corridor Study and the I-17 Corridor Study were reviewed for completeness and relevance. Current information for the land use types shown in Table 2-4 was requested where available. Of particular interest are current school counts and locations within the Spine study area, given the importance of assessing potential health effects of MSATs on schoolchildren. These data were obtained from MAG and the Flood Control District of Maricopa County. One additional data set that can be useful in assessing potential roadside exposure on children walking to school would be the location of existing and proposed safe routes for school children.

Future Impact Analysis Requirements

MSAT Category 3 Assessment. The appropriate category (1, 2, or 3) of MSAT impact assessment for the Spine study area will depend on the transportation network affected by the alternatives proposed. Proposed alternatives affecting transportation facilities operating at an average daily traffic (ADT) in excess of 150,000 vehicles per day (vpd) would be considered projects with higher potential MSAT effects. The I-10 and I-17 segments within the Spine Interstate corridor currently operate at between 90,000 and 260,000 vpd: therefore, impact assessment would be required in accordance with FHWA's interim guidance for assessing MSAT emissions under NEPA (FHWA 2012).

PM_{10} Hot-Spot Analysis. EPA issued draft guidance in 2010 for performing quantitative hot-spot analyses for PM_{10} and $PM_{2.5}$ transportation emissions, which went into effect on December 20, 2012, after the conclusion of a grace period that began on this date in 2010 (75 *Federal Register* 79730). The FHWA and EPA guidance document *Transportation Conformity Guidance for Quantitative Hot-Spot Analyses in $PM_{2.5}$ and PM_{10} Nonattainment and Maintenance Areas* defines projects of localized air quality concern as certain highway and transit projects that involve significant levels of diesel traffic or any other project identified in the $PM_{2.5}$ or PM_{10} SIP as a localized air quality concern (EPA 2013b). The criteria to define a project of localized air quality concern, provided in 40 CFR 93.123(b)(1), are listed below.

- new or expanded highway projects that have a significant number of or significant increase in diesel vehicles, such as facilities with greater than 125,000 ADT, where 8 percent or more of such ADT is diesel truck traffic (10,000 ADT)
- projects affecting intersections that are at a LOS D, E or F, with a significant number of diesel vehicles, or that that will change to LOS D, E or F because of increased traffic volumes from a significant number of diesel vehicles related to the project
- new bus and rail terminals and transfer points that have a significant number of diesel vehicles congregating at a single location
- expanded bus and rail terminals and transfer points that significantly increase the number of diesel vehicles congregating at a single location
- projects in or affecting locations, areas or categories of sites that are identified in the PM_{10} or $PM_{2.5}$ implementation plan or implementation plan submission, as appropriate, as sites of possible violation

Future alternatives will be measured against the above criteria to determine the need for a "hot-spot" conformity demonstration and for NEPA purposes.

MOVES2014 Emissions Model. MOVES2014 is the latest version of MOVES and incorporates EPA rulemakings promulgated since the last MOVES release in June 2012, new emissions data and new features that users have requested. MOVES2014 also includes the NONROAD2008 model, allowing for modeling of both on-road and nonroad mobile sources within the MOVES platform. The new model also includes the benefits of the Tier 3 motor vehicle and emissions standards that will take effect in 2017.

On October 7, 2014, EPA published a *Federal Register* notice on the release of MOVES2014 for SIPs and transportation conformity. EPA currently intends to include in the notice a 2-year grace period for using MOVES2014 for transportation conformity purposes. MOVES2014 will be required for new regional emissions analyses for transportation conformity determinations ("regional conformity analyses") that begin after the end of the grace period. In addition, MOVES2014 will be required for new PM and CO hot-spot analyses for project-level conformity determinations that begin after the grace period ends.

Air quality remains a critical resource to the citizens of Arizona. The current status of air quality in the Valley is discussed at length in this report to recognize its importance. However, in terms of the study itself, it is highly unlikely that air quality will serve to differentiate the performance of the alternatives being considered in the screening process associated with the master plan and related PEL document. Therefore, a quantitative analysis using the MOVES model will be deferred as determined necessary in later NEPA analyses to support specific projects generated from the Spine master plan.

Hazardous Materials

The hazardous materials assessment presents the regulatory setting and database review conducted for the Spine study area evaluation. Data from the previous I-10 and I-17 corridor studies were evaluated. Transportation projects may result in effects to hazardous materials, given past land uses and both documented and undocumented releases. Known releases can occur from leaking underground storage tanks (LUSTs) that may contain hazardous substances such as gasoline, diesel fuel or other fuel products. Other releases may occur from hazardous substances associated with past land uses or the storage of hazardous waste. Resulting soil and groundwater contaminants commonly include petroleum products such as fuels and oils, solvents and metals.

Regulatory Setting

Numerous federal regulations have been developed to regulate the use, transportation, storage, removal and treatment of hazardous materials. In addition, Arizona has developed an underground storage tank (UST) program.

Comprehensive Environmental Response, Compensation and Liability Act. The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980 (42 United States Code [USC] Section 9601 et seq.) regulates former and newly discovered uncontrolled waste disposal and spill sites. In addition to establishing the National Priorities list of contaminated sites and the "Superfund" cleanup program, CERCLA:

- established prohibitions and requirements concerning closed and abandoned hazardous waste sites
- provided for liability of persons responsible for releases of hazardous waste at these sites
- established a trust fund to provide for cleanup when no responsible party could be identified

Superfund Amendments and Reauthorization Act. Superfund Amendments and Reauthorization Act of 1986 (Public Law 99-499) made the following changes to CERCLA:

- stressed the importance of permanent remedies and innovative treatment technologies in cleaning up hazardous waste sites
- required CERCLA actions to consider the standards and requirements found in other State and federal environmental laws and regulations
- provided new enforcement authorities and settlement tools
- increased State involvement in every phase of the Superfund program
- increased the focus on human health problems posed by hazardous waste sites
- encouraged greater citizen participation in making decisions on how sites should be cleaned up

Resource Conservation and Recovery Act. The Resource Conservation and Recovery Act (RCRA) of 1976 (42 USC Section 6901 et seq.) is the principal federal law in the United States governing the disposal of solid waste and hazardous waste. This law gives EPA the authority to regulate the identification, generation, transportation, storage, treatment and disposal of solid and hazardous materials and hazardous wastes. It also sets forth a framework for managing non-hazardous solid wastes. The 1986 amendments to RCRA enabled EPA to address environmental problems that could result from underground tanks storing petroleum and other hazardous substances.

Clean Air Act. The CAA protects the general public from exposure to airborne contaminants that are known to be hazardous to human health. Under this act, EPA established National Emissions Standards for Hazardous Air Pollutants, which are emissions standards for air pollutants, including asbestos.

Clean Water Act. Clean Water Act § 402(p) regulates discharges and spills of pollutants, including hazardous materials, to surface waters and groundwater.

Safe Drinking Water Act. The Safe Drinking Water Act [42 USC Section 300(f) et seq.] regulates discharges of pollutants to underground aquifers.

Toxic Substances Control Act. The Toxic Substances Control Act (15 USC § 2601 et seq.) regulates the manufacturing, inventory and disposition of industrial chemicals, including hazardous materials.

Hazardous Materials Transportation Act. The Hazardous Materials Transportation Act (49 USC Sections 1801–1819 and related regulations at 49 CFR Section 101, 106, 107 and 171–180) regulates the transport of hazardous materials by motor vehicles, marine vessels and aircraft.

Hazardous and Solid Waste Amendments. Federal Hazardous and Solid Waste Amendments (Public Law 98-616, 98 Stat. 3221) are amendments to RCRA that focused on waste minimization and phasing out land disposal of hazardous waste as well as corrective action for releases. Some of the other mandates of this law include increased enforcement authority for EPA, more stringent hazardous waste management standards and a comprehensive UST program.

State of Arizona Underground Storage Tank Program. Under the administration of ADEQ as designated by Title 49 of the Arizona Revised Statutes (UST Regulation at A.R.S. Section 49-1001 et seq.), Arizona developed a program to further regulate USTs. Arizona's UST Program is designed to prevent, detect and clean up releases of petroleum and other hazardous substances from USTs into the groundwater, surface soils and subsurface soils. The State program also provides financial assistance to UST owners and operators for upgrading and removing old or failing tanks and for cleaning up site contamination from leaking USTs or LUSTs.

Affected Environment

A review of agency databases maintained by EPA (2013a) and ADEQ (2013) were completed for the expanded study area. The information in the database is more than 1 year old. The purpose of the regulatory database review was to evaluate and identify the presence of hazardous materials or similar environmental concerns present in the expanded study area.

The environmental database search and study area reconnaissance revealed the following potential hazardous material sites, which are generally dispersed throughout the expanded study area:

- 2,523 sites with USTs
- 1,462 sites with LUSTs
- 54 sites with Priority 1 LUSTs
- 57 large-quantity generators (LQGs)
- 16 Superfund sites
- 2 National Priority Superfund sites
- 2 Treatment, Storage, Disposal Facilities (TSDFs)
- 4 Waste Transfer and Processing Facilities (WTPFs)
- 7 brownfields
- 26 Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) sites
- 2,285 RCRA sites
- 151 sites in the Toxic Release Inventory
- 10 sites listed under the Toxic Substances Control Act

Figure 2-3 shows the location of hazardous waste sites throughout the Spine study area expanded study area, and Figure 2-4 specifically shows the location of UST, LUST, and Priority 1 LUST sites. Appendix A provides additional detail on hazardous material sites within the expanded study area.

USTs. There are 2,523 identified USTs dispersed throughout the expanded study area. A higher density of USTs is located along Grand Avenue north of I-10 and along US-60 south of downtown Phoenix (Figure 2-4).

LUSTs. ADEQ has identified 1,462 LUSTs within the expanded study area. The LUSTs are present throughout the study area; however, there is a much higher concentration of locations along Grand Avenue north of I-10, along US-60 south of I-10, and along I-10 south of Sky Harbor International Airport (Figure 2-4).

Priority 1 LUSTs. There are 54 LUSTs within the expanded study area identified by ADEQ as Priority 1 sites. ADEQ identifies Priority 1 LUST sites as having contracts already in place to perform environmental assessments and cleanups. The Priority 1 LUST sites are located within the expanded study area along I-10 and I-17 between Southern Avenue and Bethany Home Road, primarily near major intersections (Figure 2-4).

LQGs. LQGs are industries that generate more than 2,200 lbs. of hazardous waste in any calendar month. ADEQ has identified 57 LQGs in the expanded study area. The LQGs are located throughout the study area Figure 2-3 shows the locations of LQGs within the Spine study area.

Superfund. Sixteen Superfund areas have been identified by ADEQ within the expanded study area. The largest of the sites crosses the study area along Van Buren Street; however, other locations are generally located near Grand Avenue north of I-10 and in areas south of downtown Phoenix and Sky Harbor International Airport. Among the Superfund sites, the 19th Avenue Landfill Site, located between Lower Buckeye Road and the Salt River, east of 19th Avenue, has been identified as a National Priority Superfund Site. Figure 2-3 shows the locations of Superfund areas within the Spine study area.

TSDFs. Two TSDFs have been identified within the expanded study area including Clean Harbors, located at 15th Avenue and Lincoln Street. A second TSDF is located south of Chandler Boulevard and east of 56th Street. Figure 2-3 shows the locations of the TSDFs within the Spine study area.

WTPFs. Four WTPF sites are located within the expanded study area including the City of Phoenix 27th Avenue WTPF, located at 27th Avenue and south of Lower Buckeye Road. Two WTPFs are located on Broadway Road between 27th and 35th Avenues and a third WTPF is located at the southwestern corner of 35th Avenue and Cactus Road. Figure 2-3 shows the locations of the WTPFs within the Spine study area.

Brownfields. Brownfields are properties that have or potentially have a hazardous substance, pollutant or contaminant that would need to be cleaned up before being redeveloped or reused. EPA and ADEQ have identified seven brownfields within the Spine study area. The first is Suntown Laundry, located north of Camelback Road, east of 19th Avenue. The second is the East Washington Fluff Facility, located near 5th Street and Buckeye Road. Two brownfields are located on Broadway Road near 15th Avenue and Central Avenue, two are located on Jackson Street near Central Avenue and 9th Street and one is located south of Grand Avenue and east of 39th Avenue. Figure 2-3 shows the locations of the Brownfield sites within the Spine study area.

CERCLIS Sites. The CERCLIS is part of a comprehensive database and management system in the inventory of CERCLA sites that catalogs and tracks sites addressed by the Superfund program. There are 26 EPA-identified CERCLIS sites located within the study area. The majority of the sites are located along US-60 south and west of downtown Phoenix, as well as along Grand Avenue north of I-10. Two sites are located in the northern part of the Spine study area along I-17 between Thunderbird Road and Peoria Avenue. Ten CERCLIS sites are located near the intersection of Grand Avenue and 19th Avenue and south of Buckeye Road, on 35th Avenue near Van Buren Street, near Sky Harbor International Airport, and on Southern Avenue east of Kyrene Road. Figure 2-3 shows the locations of CERCLIS sites within the Spine study area.

RCRA Sites. There are 2,285 identified RCRA sites dispersed throughout the expanded study area. A higher density of RCRA sites is located along Grand Avenue north of I-10, along US-60 south of downtown Phoenix and south of Sky Harbor International Airport. Additional clusters of sites are located east of the Broadway Curve, north and west of Sky Harbor International Airport, east of 56th Street at the southern end of the corridor and east and west of I-17 at the northern end of the corridor. Figure 2-3 shows the locations of RCRA sites within the Spine study area.

Toxic Release Inventory. The EPA Toxic Release Inventory includes 151 sites within the expanded study area. The sites are located throughout the study area, with the majority located along Grand Avenue north of I-10 and south of Sky Harbor International Airport. Thirty-nine sites are located along Grand Avenue, east of the Broadway Curve and south of the Salt River. Figure 2-3 shows the locations of Toxic Release Inventory sites within the Spine study area.

Toxic Substances Control Act. Ten sites within the expanded study area have been associated with the Toxic Substances Control Act by EPA. The sites are dispersed within the southern portion of the expanded study area, between Grand Avenue north of I-10 and the southern end of the study area. Figure 2-3 shows the locations of Toxic Substances Control Act sites within the Spine study area.

Environmental Concerns and Recommendations for Future Analysis

The hazardous materials databases used to prepare this section are at least 2 years old, which may present limitations on the accuracy of the data. For example, existing LUST sites may have been remediated in the interim, or existing USTs may have begun leaking and are either yet to be identified, or may have been identified but are not updated in the reference database. Future projects resulting from the I-10/I-17 Corridor Master Plan will require new data for evaluation.

The sites of primary concern within the study area would include sites that have known or high potential for hazardous materials releases to the soil or groundwater. These sites, if required for acquisition, could require high remediation costs and extensive coordination with regulatory agencies. Examples of these types of sites include current or former service stations with known LUSTs, permitted sites with recorded violations against their permits or reported releases such as accidental spills.

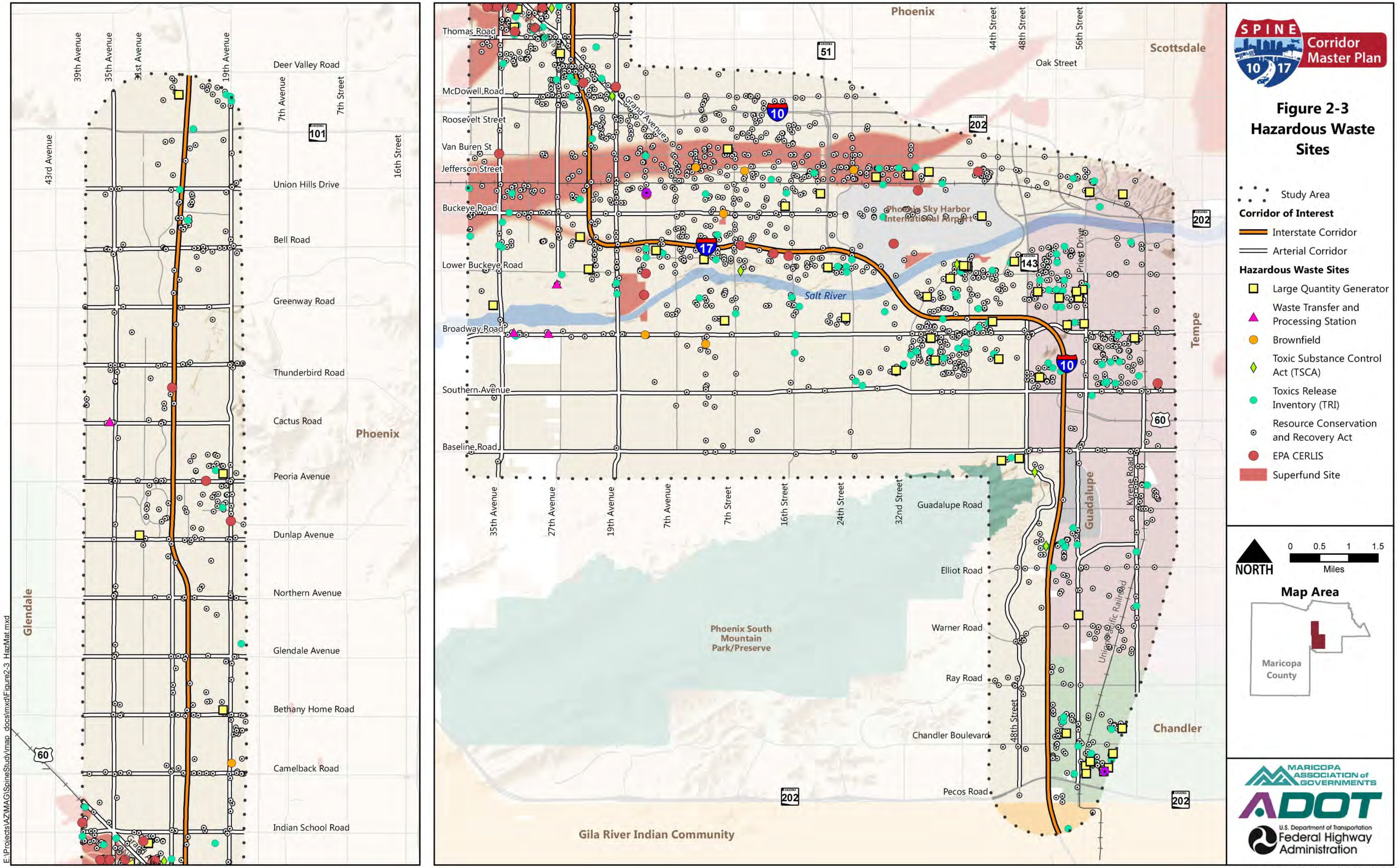
Sites within the study area that would be of primary concern include:

- 19th Avenue Landfill, which has been identified as a National Priority Superfund Site
- 54 National Priority LUST sites
- 1,462 LUST sites

Permitting

A Phase I Environmental Site Assessment may be warranted for any and all areas where land will be acquired. Because of the presence of underground Superfund plumes, which may change over time, any subsurface disturbances that approach the water table should be investigated.

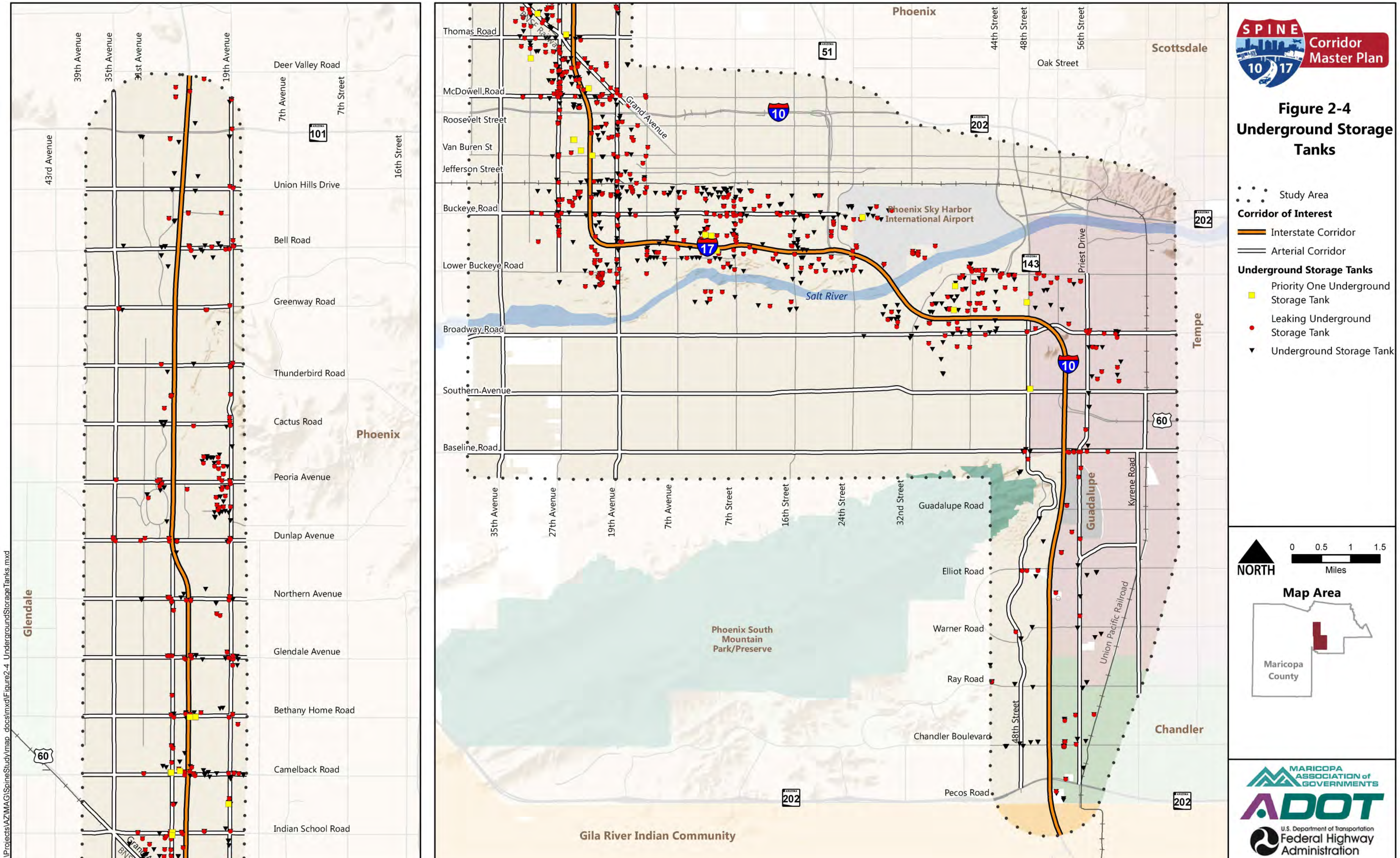
Figure 2-3 Hazardous Waste Sites



Source: ADOT, ALRIS, FEMA, EPA, ADEQ

Map Last Updated: 5/11/2016

Figure 2-4 Underground Storage Tanks



Source: ADOT, ALRIS, FEMA, ADEQ

Map Last Updated: 5/11/2016

Asbestos and lead-based paint sampling and testing may be required for any existing load-bearing concrete bridge structures, painted roadway surfaces or adjacent acquired structures that are to be modified, affected or demolished. The preparation of a lead-based paint abatement plan and asbestos removal and disposal plan would be required. Additionally, if structures are to be modified, affected or demolished, a National Emissions Standards for Hazardous Air Pollutants notification would need to be submitted.

Any construction related to excavating or drilling activities should be undertaken in a precautionary manner when working adjacent to active gasoline stations, over former gasoline stations, or over listed LUST sites. Many of the LUST sites may have been closed, resold or transformed into other businesses and may not have visible signs or surface indications of their existence. During construction, any observation of strong gasoline or other hydrocarbon fumes during excavation or other subsurface work should be reported and work should stop immediately while further guidance is sought.

Residual concentrations of pesticides and herbicides may be present in agricultural areas within the expanded study area. Soil sampling may be appropriate in these areas.

Given the length and expanse of the study area, the discovery of undocumented or unknown hazardous materials sites or other environmental concerns may occur during construction beyond the known or listed regulatory facilities or incidents of concern.

Section 4(f) and Section 6(f) Resources

This section presents the regulatory setting and existing resources potentially protected by Section 4(f) and, in some cases, by Section 6(f).

Regulatory Setting

Section 4(f)

Section 4(f) of the U.S. Department of Transportation Act of 1966 states that the Secretary of Transportation:

> May approve a transportation program or project … requiring the use of publicly owned land of a public park, recreation area, or wildlife and waterfowl refuge of national, state, or local significance, or land of an historic site of national, state, or local significance (as determined by the federal, state, or local officials having jurisdiction over the park, area, refuge, or site) only if … there is no prudent and feasible alternative to using that land and the program or project includes all possible planning to minimize harm to the park, recreation area, wildlife and waterfowl refuge, or historic site resulting from the use [49 USC 303(c)].

A "use" of a Section 4(f) resource, as defined in 23 CFR Part 771.135(p), occurs:

- When property or a resource is permanently incorporated into a transportation facility
- When there is a temporary occupancy of land that is adverse in terms of the statute's preservation purpose
- When there is a constructive use of a Section 4(f) resource

A constructive use of a Section 4(f) resource occurs when a transportation project does not incorporate land from a Section 4(f) resource, but the project's proximity impacts are so severe that the protected activities, features, or attributes that qualify a resource for protection under Section 4(f) are substantially impaired. For example, a constructive use can occur when:

- The projected noise level increase attributable to the project substantially interferes with the use and enjoyment of a noise-sensitive facility of a resource protected by Section 4(f).
- The proximity of the project substantially impairs aesthetic features or attributes of a resource protected by Section 4(f), where such features or attributes are considered important contributing elements to the value of the resource. Examples of such an effect would be the location of a proposed transportation facility in such proximity that it obstructs or eliminates the primary views of an architecturally significant historical building, or substantially detracts from the setting of a Section 4(f) resource that derives its value in substantial part due to its setting.
- The project results in a restriction of access that substantially diminishes the utility of a significant publicly owned park, recreation area or historic site.

Historic Properties. A historic site is considered a Section 4(f) resource if it is listed on or eligible for listing on the National Register of Historic Places (NRHP) and qualifies for protection. Typically, sites eligible under Criteria A, B or C as defined below are considered Section 4(f) resources; sites eligible under Criterion D would be subject to Section 4(f) if they warrant preservation in place. Such sites must be:

- Associated with events that have made a significant contribution to the broad patterns of our history (Criterion A)
- Associated with the lives of persons significant in our past (Criterion B)
- Embodies the distinctive characteristics of a type, period or method of construction; or represents the work of a master; or possesses high artistic values or represents a significant distinguishable entity whose components may lack individual distinction (Criterion C)
- Has yielded, or is likely to yield, information important to history or prehistory (Criterion D)

With respect to historic districts, Section 4(f) applies to properties within the district that contribute to its eligibility or are individually eligible for listing in the NRHP.

***de minimis* Finding.** With the passage of the Safe, Accountable, Flexible and Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) in 2005, Section 4(f) requirements were amended to allow that, under certain circumstances, direct uses of a Section 4(f) resource could have no adverse effect on the protected resource. In determining *de minimis*, impact avoidance, minimization and mitigation or enhancement measures included in the project to address the impacts and adverse effects to the Section 4(f) resource can be considered in the Section 4(f) evaluation. Use of a Section 4(f) resource may be determined to be *de minimis* if it does not adversely affect the activities, features and attributes that qualify the resource for protection under Section 4(f). This is evidenced by a "no adverse effect" determination during the Section 106 process for historic properties and through coordination with the officials with jurisdiction over parks, recreational areas or refuges. Use of a Section 4(f) resource is allowed when a *de minimis* impact finding is supported by the written concurrence of the officials with jurisdiction over the resource. The officials with jurisdiction are informed of FHWA's intent to make a *de minimis* determination based on their written concurrence in the Section 106 finding of no adverse effect.

With the passage of SAFETEA-LU, Congress amended Section 4(f) requirements to allow FHWA to approve a project that would result in a *de minimis* impact on a resource afforded protection under Section 4(f) without having to evaluate an avoidance alternative(s) typically required for a Section 4(f) evaluation.

The 2008 Section 4(f) Final Rule established procedures for determining when a direct use would result in a *de minimis* impact on a Section 4(f) resource. As it relates to an affected area, the regulation (23 CFR Part 774.17) defines a *de minimis* impact as follows: "For parks, recreation areas, and wildlife and waterfowl refuges, a *de minimis* impact is one that will not adversely affect the features, attributes, or activities qualifying the property for protection under Section 4(f)." With respect to historic properties, a "no adverse effect" determination, with agency concurrence, could be used to support a *de minimis* Section 4(f) finding. FHWA would make a *de minimis* determination only after the public has been provided an opportunity to comment and after the official with jurisdiction has submitted written concurrence.

The first requirement when dealing with properties afforded Section 4(f) protection is to develop specific measures to minimize harm, with avoidance of the resource being the preferred approach. It is recommended that each alternative carried forward be analyzed for direct use, constructive use and, if warranted, measures to minimize harm. If avoidance is determined not to be "prudent and feasible," then measures to minimize impacts would be developed and would require coordination with vested agencies, jurisdictions and possibly major user groups on the part of ADOT and FHWA.

Section 6(f)

Section 6(f), which refers to Section 6(f)(3) of the Land and Water Conservation Fund (LWCF) Act (Public Law 88-578), requires that any property or resource acquired or developed with LWCF assistance be maintained perpetually in public outdoor recreation use. The acquisition of a Section 6(f) resource requires that the property be replaced in-kind, and only with the approval of the National Park Service. Section 6(f) resources are also protected under Section 4(f).

Affected Environment

The Spine study area was reviewed for publicly owned parks, recreational areas, wildlife and waterfowl refuges and historic properties protected under Section 4(f). Data sources included:

- 2014 aerial photography
- GIS files showing the location of parks, recreation areas and historic properties in the expanded study area
- municipal parks and recreation websites
- National Park Service and Arizona State Parks LWCF grant recipient lists for Arizona
- limited field reconnaissance to resolve discrepancies in the data

Once proposed alternatives are selected, each alternative will be evaluated to ensure that Section 4(f) resources within 0.25 mile will be identified and included in the impact assessment. This 0.25-mile buffer will account for potential constructive use impacts (for example, noise and visual impacts) that may extend outside of the area where direct impacts could occur. If a future alternative is less than 0.25 mile from the expanded study area boundary as defined in this document, reevaluation will be required to ensure all potentially affected Section 4(f) resources are identified.

Figure 2-5 shows the location of potential Section 4(f) resources within the Spine study area, and Appendix B (Tables B-1 through B-4) provides a list of properties within 1 mile on either side of I-10 and I-17 that were preliminarily evaluated for Section 4(f) resource potential. Table B-5 lists properties in the expanded study area located outside the 1-mile buffer. The Section 4(f) resources shown in Figure 2-5 and identified in Appendix B are all the Section 4(f) resources currently known; future analysis within the Spine study area may identify additional Section 4(f) resources.

The resources listed in Tables B-1 to B-4 in Appendix B are generally listed in geographic order from south to north, and Section 6(f) resources are listed in bold, italic font. The properties in Table B-5 are listed in alphabetical order. Additionally, Tables B-1 to B-4 in Appendix B provide the location of each resource and its map identification number, the agency or owner having jurisdiction over the resource and whether the resource is recommended for protection under Section 4(f). The following list summarizes the total number of potential Section 4(f) and Section 6(f) resources in the Spine corridor expanded study area:

- 21 Section 6(f) resources
- 47 publicly owned recreation areas
- 145 publicly owned parks
- 210 historic properties, including buildings, historic districts, cemeteries and linear structures
- 259 schools, including those with recreation areas

Several historic cemeteries are located in the corridor that would also be subject to Section 4(f). These include the Tempe Double Butte Cemetery near the Broadway Curve (NRHP-eligible under Criteria A, B and C), the Greenwood Lawn Mortuary near the Stack (NRHP-eligible under Criteria A and C), and Cementerio Lindo near I-17 and 15th Avenue (NRHP-eligible under Criterion A).

No wildlife or waterfowl refuges were identified in the Spine study area.

Recreation areas include schools, athletic fields, trails, recreation centers, golf courses, stadiums and swimming pools. Trail segments must traverse publicly owned land to qualify for Section 4(f) protection. Land ownership of trail segments potentially affected by future alternatives would be confirmed during the NEPA process. In addition to the historic properties referenced above, hundreds of buildings in the Spine study area are older than (or approaching) 50 years old. If they are found eligible under Section 4(f) requirements or form eligible districts, they would also be considered Section 4(f) resources. Listed schools have athletic fields or other recreational facilities, but such facilities must be publicly available to qualify for Section 4(f) protection. Public availability of school recreational facilities potentially affected by future alignments would be determined during the NEPA process.

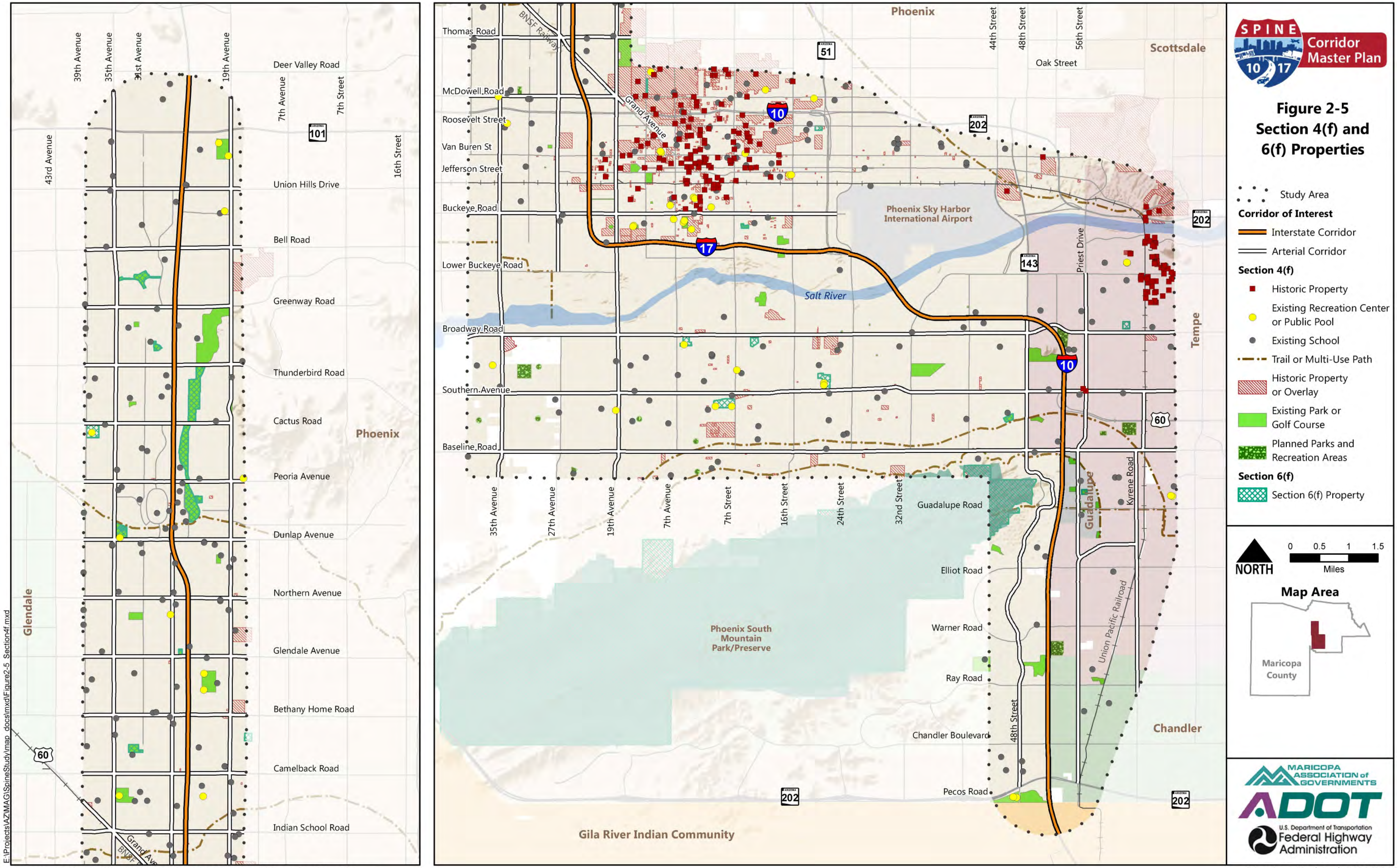
Tempe received approximately 10 LWCF multipark grants where the subject parks are not named in the title of the grant. During the NEPA process, additional research will be required to determine whether potentially affected parks were acquired or developed with any of the unnamed grants.

Environmental Concerns and Recommendations for Future Analysis

With respect to known potential Section 4(f) resources in the study area:

- The resources are more densely located along I-17 north of I-10, less dense along I-10 south of US-60, and least dense around the Salt River and Sky Harbor International Airport.
- The dispersal of potential Section 4(f) resources could constrain future alternatives, especially on either side of I-17. West of I-17, parks are regularly spaced, with a north-to-south axis of parks between 27th and 35th Avenues.

Figure 2-5 Section 4(f) and 6(f) Properties



Source: ADOT, ALRIS, FEMA, MAG, MCFCD, City of Phoenix, City of Tempe

Map Last Updated: 5/11/2016

- The Cave Creek Golf Course, Cave Creek Recreation Area and Rose Mofford Sports Complex could constrain alternatives for over 3.5 miles east of I-17.
- Historic properties and districts could constrain alternatives near the downtown Phoenix core.
- The portion of South Mountain Park/Preserve in the Spine study area is one of the City of Phoenix's highest-use recreation areas and a Section 6(f) resource.
- The Town of Guadalupe owns five parks within a 1.5-mile stretch between Baseline Road and the southern town boundary. All the parks are within 0.75 mile east of I-10 and would constrain alternatives in this area. It is possible that future alternatives would not be able to avoid all Section 4(f) resources in this area given the proximity of the Guadalupe parks to South Mountain Park/Preserve. Biehn Colony Park, in the center of Guadalupe, is also a Section 6(f) resource and should be avoided.
- While schools are located throughout the expanded study area, it is anticipated that most school recreation areas are not publicly available.

Should the project result in Section 4(f) involvement, a Section 4(f) evaluation report would be developed to document:

- coordination with local jurisdictions and, as warranted, project stakeholders
- attempts to avoid the resources
- direct or constructive use impacts
- measures to minimize harm
- any impacts from temporary occupancy of a Section 4(f) resource

In addition, all properties recommended in Appendix B as "potential" Section 4(f) resources would require further coordination with the local official having jurisdiction over each resource to determine whether the resource is of local significance and whether it would be affected by a future alternative. Determining the Section 4(f) eligibility of a school requires investigation into whether the publicly owned school's recreational facilities are available for public use.

Coordination with the district(s) having jurisdiction over the school is recommended to make this determination. If a school's recreational facility is available for public use outside of school hours without prior authorization, then the school is afforded Section 4(f) protection. Even fenced schools would be considered Section 4(f) resources if their gates remain open.

Historic properties that are also potentially Section 4(f) resources would require coordination with the official having jurisdiction, the State Historic Preservation Office, and/or local preservation agencies to determine whether the resource is locally important or whether the resource would be affected by a future alternative.

Water Resources

Regulatory Setting

The Clean Water Act (CWA) established regulations for discharge of water pollutants and water quality standards for surface water. Section 404 of the CWA regulates the placement of fill or dredged material into waters of the United States (waters). The U.S. Army Corps of Engineers (USACE) has regulatory jurisdiction of waters. Any agency initiating an action subject to Section 404 is required to obtain a certification from the state in which the pollutant discharge originates or from the interstate water pollution control agency with jurisdiction over the affected waters. In Arizona, Section 401 of the CWA is administered by ADEQ or EPA.

Under Section 303(d) of the CWA, states are required to develop lists of impaired and threatened waters that do not meet or are not expected to meet state water quality standards. It also requires that states develop limits, or total maximum daily loads, for the pollution sources of an impaired water body.

Executive Order 11988 requires federal agencies to avoid long- and short-term adverse impacts on floodplains to the extent possible and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative.

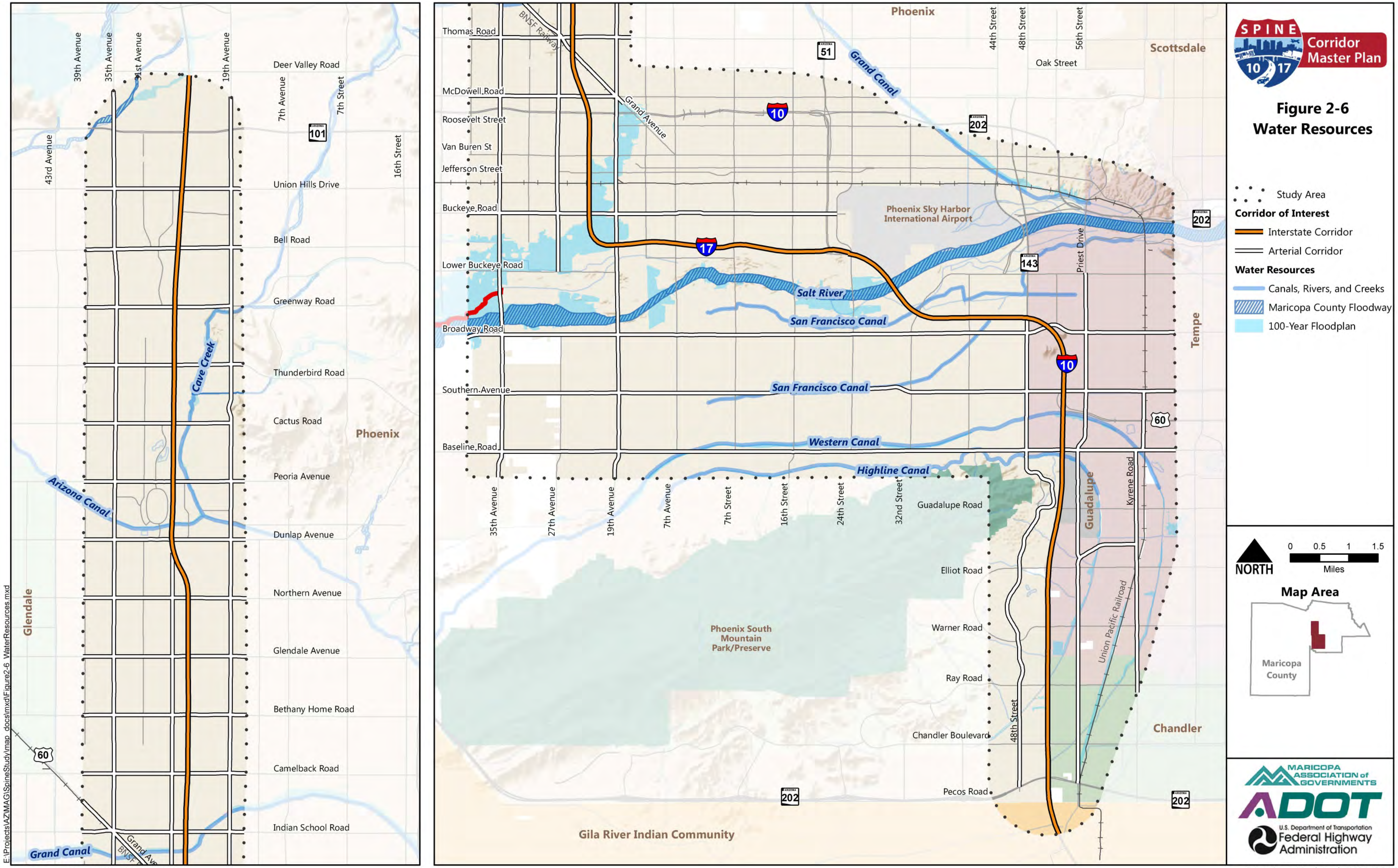
Affected Environment

As shown in Figure 2-6, the primary drainage within the study area is the Salt River, which crosses I-10 in Segment I2, flows parallel to I-17 along Segment I3, and crosses 19th and 35th Avenues in Segment A3. Because of the construction of dams upstream, the segment of the Salt River within the study area has essentially been dry since 1939. Flows within the Salt River are influenced by groundwater withdrawals, effluent discharges from wastewater treatment plans, stormwater runoff, the surrounding canal systems, and release of floodwaters from Tempe Town Lake (ADOT 2008a). Between the 23rd Avenue Wastewater Treatment Plant and the Gila River, or downstream of 35th Avenue, the Salt River is impaired by dichloro-diphenyl-trichloroethane metabolites and toxaphene and chlordane in fish tissue (ADEQ 2014).

According to jurisdictional delineations completed for previous projects along the Interstate segments within the Spine study area, the following waters have been identified:

- Salt River: The Salt River is under the jurisdiction of USACE as a waters because it is connected to the Gila River, which is a tributary of a navigable water, the Colorado River.
- Grand Canal: Intersecting I-17 at Indian School Road, the Grand Canal is a concrete-lined waterway operated by Salt River Project to deliver water to agricultural, municipal and residential customers.
- Arizona Canal: The Arizona Canal is a concrete-lined waterway serving a similar function as the Grand Canal; it intersects I-17 between Dunlap and Peoria Avenues.
- ACDC: This channel is 16.5 miles long, runs parallel to the Arizona Canal and provides 100-year flood protection.
- 12th Street open earthen drainage ditch: This tributary of the Salt River is an open earthen drainage ditch located near the intersection of 12th and Durango Streets, north of I-17.
- Cave Creek: This ephemeral wash runs parallel to I-17 between Greenway Road and Dunlap Avenue and flows into the ACDC. At its closest point, Cave Creek is 575 feet east of I-17.
- Tempe Drain at University Drive/32nd Street: The Tempe Drain is a perennially flowing human-made drainage channel fed by treated effluent from the City of Tempe Kyrene Water Reclamation Facility, cooling tower blow-down water from the Salt River Project Kyrene Generating Station and stormwater runoff from portions of the cities of Tempe and Phoenix. It flows into the Salt River at its crossing with I-10, creating standing water and a narrow low-flow channel within the riverbed. The Tempe Drain has been determined to be a waters. Human-induced wetlands surround the Tempe Drain from upstream of University Drive to its outfall at the Salt River (ADOT 2008a, 2012).

Figure 2-6 Water Resources



Source: ADOT, ALRIS, FEMA, ADEQ

The study area contains Federal Emergency Management Agency-mapped floodplains that would potentially be affected by future projects through the addition of fill, excavation and/or construction of bridges and other roadway structures. Impacts on floodplains from roadway and transportation construction would need to be mitigated to reduce or eliminate induced increases to 100-year flood water surface elevations, in keeping with applicable local, State and/or federal regulations.

2.2.2 Socioeconomic Environment

Land Use and Jurisdiction

Land use is a representation of the current physical use of the land, along with entitled developments (for example, planned residential communities that municipal and/or county planning boards have approved).

Regulatory Setting

The Spine study area, which has a total area of 133 square miles, covers portions of the cities of Phoenix (109 square miles), Tempe (18 square miles) and Chandler (3 square miles), as well as the town of Guadalupe (1 square mile). It also contains small areas (county islands) of unincorporated Maricopa County (2 square miles). Several community plans govern growth and development in the Spine study area and the surrounding region, including:

- Black Canyon/Maricopa Freeway Specific Plan
- City of Chandler General Plan: Build-out & Beyond
- City of Tempe General Plan 2040
- City of Phoenix General Plan 2015
- North Mountain Redevelopment Area Plan
- Guadalupe's most recent master plan, adopted in 1992 and not updated since
- Sky Harbor Airport Layout Plan (revised February 25, 2011)
- Federal Aviation Administration advisory circulars, statutes and associated regulations

Because portions of Phoenix Sky Harbor International Airport lie within or adjacent to the expanded study area, corridor improvements within the vicinity of the airport could be subject to an Obstruction Evaluation/Airport Airspace Analysis conducted by the Federal Aviation Administration.

Affected Environment

Situated within a metropolitan area of over four million people, land development within the corridor is generally urban in nature, ranging in some areas to suburban, with few vacant parcels. No land within the expanded study area is under the jurisdiction of the Arizona State Land Department or the Bureau of Land Management. General information on the Spine corridor expanded study area land use was obtained through online research and analysis of available GIS data in July 2014. Table 2-5 provides the total area of various land uses within the study area.

Land within the expanded study area is almost entirely developed. Figure 2-7 shows general existing land uses within the study area. In the northern half of the corridor, land uses are primarily residential, while industrial and office uses dominate the study area's southern half, from around Indian School Road to the south.

Interspersed within the mostly residential, industrial and commercial properties in the study area are schools, playground areas, libraries, institutional facilities, parks and public and private golf courses. Besides the I-10 and I-17 rights of way, major surface transportation facilities within the expanded study area include Grand Avenue and the parallel UPRR, SR-143 and SR-202L.

Table 2-5 Land Uses within the Spine Corridor Expanded Study Area

Land use category	Total acreage within the expanded study area
Residential	33,365
Commercial – Retail	7,129
Commercial – Office	2,803
Institutional	4,671
Industrial	10,948
Transportation	9,547
Open Space	7,047
Vacant	5,187
Other	4,210
Total	**84,907**

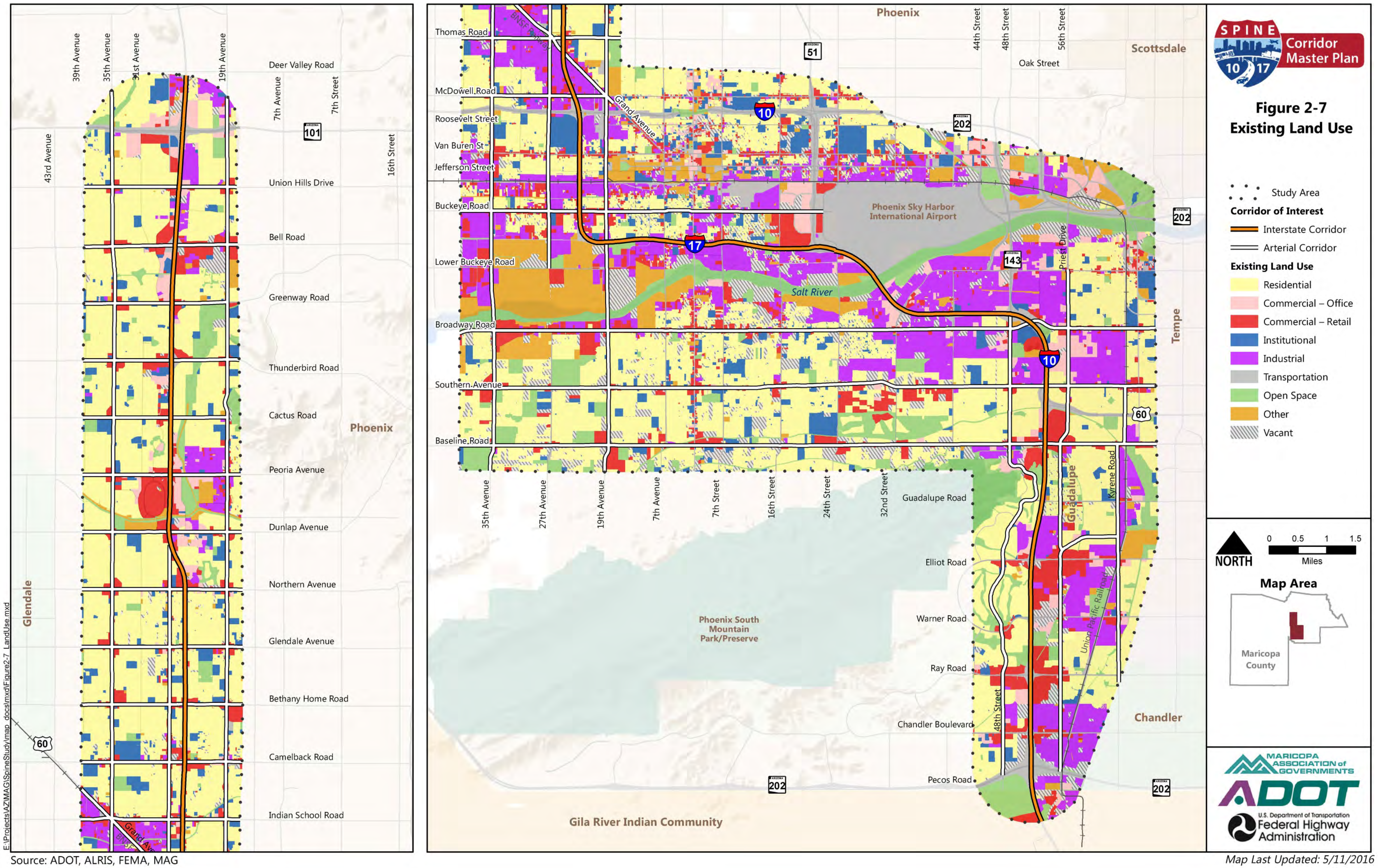
Environmental Concerns and Recommendations for Future Analysis

Land use in the study area does not present any unique physical attributes that warrant special consideration not typically accounted for on this type of project. Potential differences among possible alternatives that may occur in the study area as a result of land use designations could include the varying extent of displacements, property acquisition and access changes needed. Different alignment alternatives may require different amounts of land to be converted to transportation use within residential, commercial or industrial areas.

Additional analysis to determine whether alternatives would be consistent with adopted land use plans and zoning is recommended during subsequent studies. It is recommended that alternative alignment locations and designs be compatible with existing commercial and industrial land uses and, to the extent practicable, adjacent residential land uses as well.

Overall, consistency with existing and future land use plans and zoning should be included in the criteria used to screen and compare alternatives.

Figure 2-7 Existing Land Use



Source: ADOT, ALRIS, FEMA, MAG

Socioeconomics

Socioeconomics describe the ways that economic activity affects and is shaped by a social group. A society's economy can progress, stagnate, or regress at different levels, ranging from local to global, depending on the group analyzed.

Affected Environment

Population

The population for study area's socioeconomic analysis is distributed among the cities of Phoenix, Tempe and Chandler and the town of Guadalupe. Overall, the expanded study area and surrounding area has experienced substantial increases in population and development over the past 10 years.

Maricopa County's population growth has ranked among the highest in the nation since 2000. Table 2-6 presents population and growth data for the study area.

The population is dispersed throughout the expanded study area, predictably becoming less dense within industrial areas and transportation corridors. Densities exceeding 10,000 persons per square mile occur in areas with high-density housing, most commonly in the area surrounding downtown Phoenix.

Table 2-6 Spine Corridor Expanded Study Area Population and Growth Data

Jurisdiction	2000	2010	Growth	2013 estimate	Estimated 3-year increase
Phoenix	1,321,045	1,445,632	9.4%	1,513,367	4.7%
Tempe	158,625	161,719	2.0%	168,228	4.0%
Guadalupe	5,228	5,523	5.6%	6,072	9.9%
Chandler	176,581	236,123	33.7%	249,146	5.5%
Maricopa County	3,072,149	3,817,117	24.2%	4,009,412	5.0%

Source: U.S. Census Bureau (2014)

Employment

Primary employment in the study area includes government, health care, finance, education, and technology. Phoenix's largest employers are the State of Arizona, Banner Health, City of Phoenix, Wells Fargo, Bank of America and Maricopa County, with each entity employing more than 12,500 persons (Greater Phoenix Economic Council 2014). Of these, most of the State of Arizona's government agencies have offices within the study area, in the Capitol District. The Grand Industrial District, while not a single employer, occupies a large tract of land within the study area surrounding the I-17/I-10 stack and the point where I-17 crosses under US-60/Grand Avenue. The Tell Industrial District is located immediately south of the I-17 Maricopa Expressway between 7th and 15th Avenues. Phoenix's downtown offices lie within the expanded study area as well. Sky Harbor International Airport, the workplace of many City of Phoenix employees and a regional employment center, is also within the study area.

In addition to Arizona State University, the largest private-sector employers in Tempe are Wells Fargo, Safeway, Freescale Semiconductor, Honeywell, Chase, American Airlines (US Airways), Insight Direct, TEAM Security, Express Scripts, IKON Office Solutions, Edward Jones, State Farm, Sonora Quest Laboratories and ABM Janitorial Services (About.com Phoenix 2014). In Tempe, the expanded study area is home to many office buildings, industrial facilities, and auto dealerships within 1 mile of I-10. Tempe's few remaining large tracts of undeveloped land are located in this area, and several have recently been developed or are being developed into high-density apartment and condominium complexes. Single-family residences predominate farther east in Tempe within the study area.

Guadalupe is not a major employment center but rather is home to an estimated 1,490 housing units (U.S. Census Bureau 2012). It is bounded on the north, east and south by the City of Tempe and on the west by I-10. A hotel and restaurant strip is located at the northern end of the town along Baseline Road, and an industrial commercial area is located at the southern end, just south of the government complex.

The City of Chandler's largest employers include Intel, Bank of America, Chandler Unified School District, Wells Fargo, Verizon Wireless, Freescale Semiconductor, Chandler Regional Medical Center and PayPal, each with over 2,000 employees (City of Chandler 2014). As in Tempe, the area proximate to I-10 in Chandler is a mix of commercial uses, consisting of industrial facilities hotels and restaurants, retail stores, auto dealerships and repair shops and distribution centers.

Neighborhood Cohesion and Character

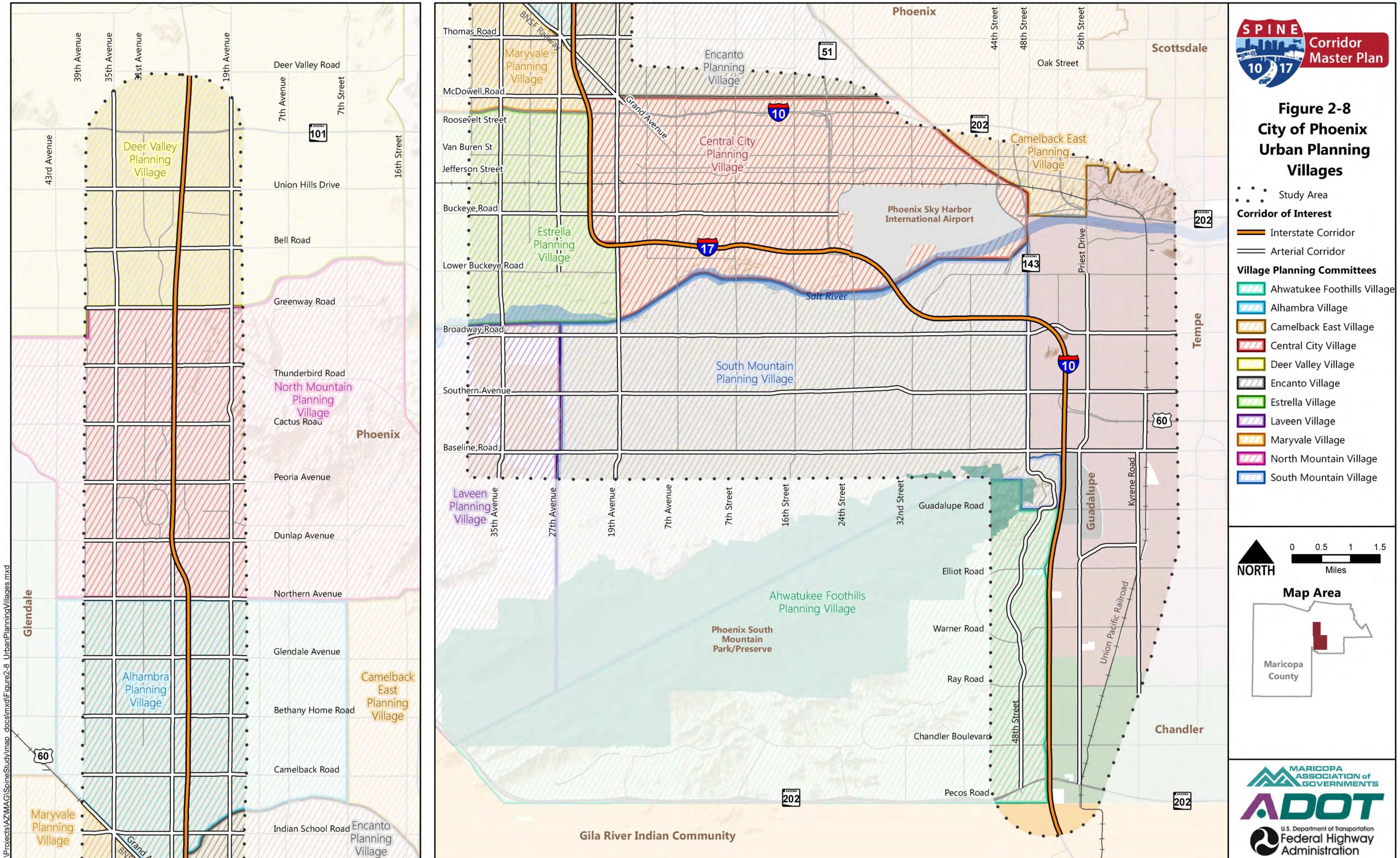
The City of Phoenix is divided into 15 urban villages. As shown in Figure 2-8, eight of them, Ahwatukee Foothills, Alhambra, Central City, Deer Valley, Encanto, Estrella, Maryvale and South Mountain, are located partially within the project corridor. Phoenix's city government has offices and community centers in each of these districts and holds monthly community planning meetings at each, reflecting the neighborhood associations as indicators of community cohesion. There are 25 such associations within the expanded study area just from the I-17/I-10 stack south.

The metropolitan Phoenix area is laid out in a grid pattern, with arterial streets running north-to-south and east-to-west spaced 1 mile apart. Neighborhoods within these square-mile sections often developed in quarter-section or half-section chunks as land was subdivided and sold off to developers. The resulting neighborhoods through much of the study area reflect this development pattern, with commercial properties, including neighborhood retail and services, generally located along the arterial streets.

The presence of historic districts within the expanded study area, while based on individual or collective architectural or historic resources, may indicate a measure of community cohesion. Historic districts within the study area are located adjacent to I-17 and include Phoenix's Woodland, Oakland, F. Q. Story, Villa Verde and North Encanto districts. No historic districts lie within the expanded study area in Tempe, Guadalupe or Chandler.

The Town of Guadalupe exhibits a strong sense of community cohesion, to the extent that no traffic interchange was constructed on I-10 at Guadalupe Road and Avenida del Yaqui interrupts Priest Drive with numerous stop signs and a 25 miles per hour (mph) speed limit, from just north of Elliot Road through to Baseline Road, as it passes through Guadalupe.

Figure 2-8 City of Phoenix Urban Planning Villages



Source: ADOT, ALRIS, FEMA, City of Phoenix

Map Last Updated: 5/26/2016

Environmental Concerns and Recommendations for Future Analysis

Construction of new transportation facilities or transportation enhancements in the study area could possibly result in property acquisitions, which might require the displacement or relocation of residents and businesses. Based on the size of some of the industrial properties within the expanded study area, the ability to relocate acquired businesses elsewhere within the community could be limited, resulting in possible losses of jobs, property tax income for local governments and sales tax revenue. Nearby housing for displaced residents may be available, depending on market demand.

Different alignment alternatives could have varying impacts on neighborhood continuity. It is recommended that considered alternatives not encroach much beyond the existing transportation network. Impacts to community cohesion and character; access to institutions such as schools, libraries and government offices and impacts on emergency response times and other public services would vary from one alternative to another and would require individual analysis.

As with all construction projects, access during and after construction is likely to be of primary concern to residents and business owners. An aggressive public and business community involvement program is recommended to minimize issues and assist businesses.

Overall, potential differences in impacts on socioeconomics, especially residential and commercial displacements, should be included in the criteria used to screen and compare alternatives.

Environmental Justice/Title VI

Environmental Justice

The 1994 Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations,* directs that programs, policies and activities identify and address, as appropriate, disproportionately high and adverse human health and environmental effects on minority and low-income populations.

Title VI of the Civil Rights Act of 1964

Title VI of the Civil Rights Act of 1964 (Title VI) and related statutes ensure that individuals are not excluded from participation in, denied the benefit of or subjected to discrimination under any program or activity receiving federal financial assistance on the basis of race, color, national origin, age, sex and disability.

Affected Environment

Figures 2-9 and 2-10 illustrate the minority percentage of the total population and percentage of households below the poverty level, respectively, in the expanded study area, by census block group.

The 2010 Census data indicate that minority populations are distributed throughout the study area, with higher concentrations of minority populations toward the center of the corridor, in central and southern Phoenix and in Guadalupe. The percentage of minority populations represents over 63.2 percent of the total population throughout the expanded study area, and this is higher than the corresponding percentages for Maricopa County (41.3 percent) and the cities Phoenix (53.5 percent), Tempe (37.7 percent) and Chandler (38.3 percent). The Town of Guadalupe's population is 97.6 percent minority (that is, either Hispanic, non-white, or both). Because census blocks containing protected populations have been identified in this environmental overview, further analysis to identify elderly populations and female heads of household will occur to support subsequent study phases.

Environmental Concerns and Recommendations for Future Analysis

Environmental Justice

While it does not present any particular limitations from a construction standpoint, the high percentage of minority population in portions of the expanded study area raises the potential for transportation alternatives to affect protected populations. Environmental justice factors that could differentiate the viability of alternatives in the study area include displacements and relocations, traffic noise, and access changes to businesses that may be owned or chiefly patronized by minority populations.

It is also recommended that a community of comparison be defined to establish a baseline and further refine the environmental justice analysis. The analysis will be included in the alternatives development and screening process.

Title VI

Targeted outreach was undertaken during this study to provide protected populations meaningful opportunities to participate and contribute to the study process. Of the three public meetings held in the winter of 2015, the first public meeting was held at a local elementary school in a predominantly Hispanic neighborhood in South Phoenix. Hispanic community groups and community leaders were also included in the stakeholder distribution list and received information about the study, the public meetings and online survey.

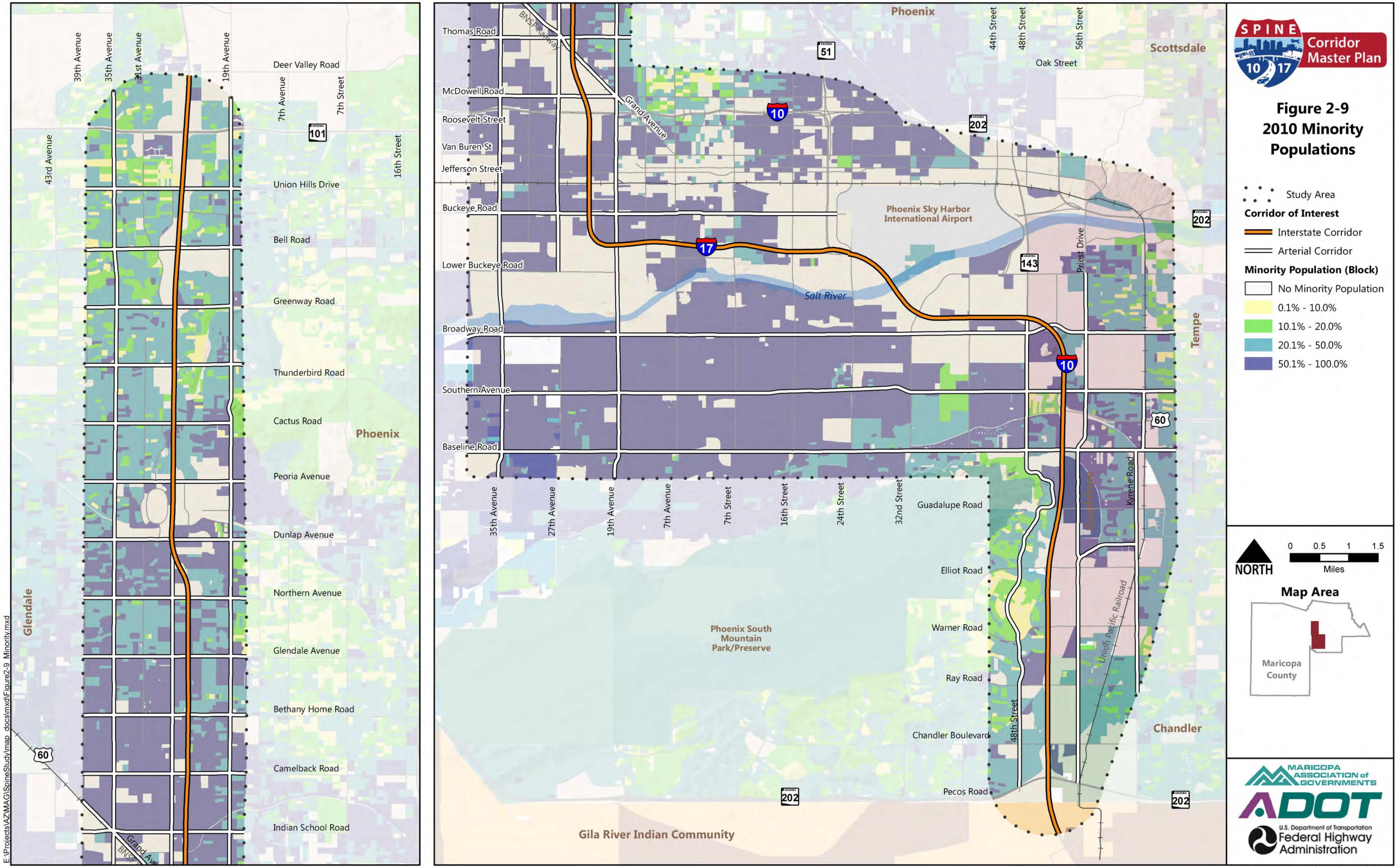
All handout materials at the three public meetings were available in both English and Spanish, and Spanish interpretation was available to meeting attendees. Information about the study, associated public meetings and online survey was advertised in local newspapers; two of which were Spanish-language newspapers and one an African American-audience newspaper. The online survey was available in both English and Spanish for those who had comments but were unable to attend the public meetings. To encourage participation in the process and obtain public feedback, MAG attended three community events. The first was a combination Health Fair and Produce on Wheels event that took place on February 21, 2015, at the Golden Gate Community Center. The second event, another Produce on Wheels event, also took place at the Golden Gate Community Center on March 7, 2015. That same day, MAG attended the third event, the Arizona Black Rodeo Rawhide. At these events MAG staff encouraged attendees to complete the survey either online through a tablet or through a hard-copy version of the survey (available in both English and Spanish).

Overall, environmental justice and Title VI impacts may not necessarily establish differences between possible alternatives in the expanded study area. However, potential differences in impacts on protected populations and communities should be addressed when screening and comparing alternatives.

2.2.3 Cultural Resources

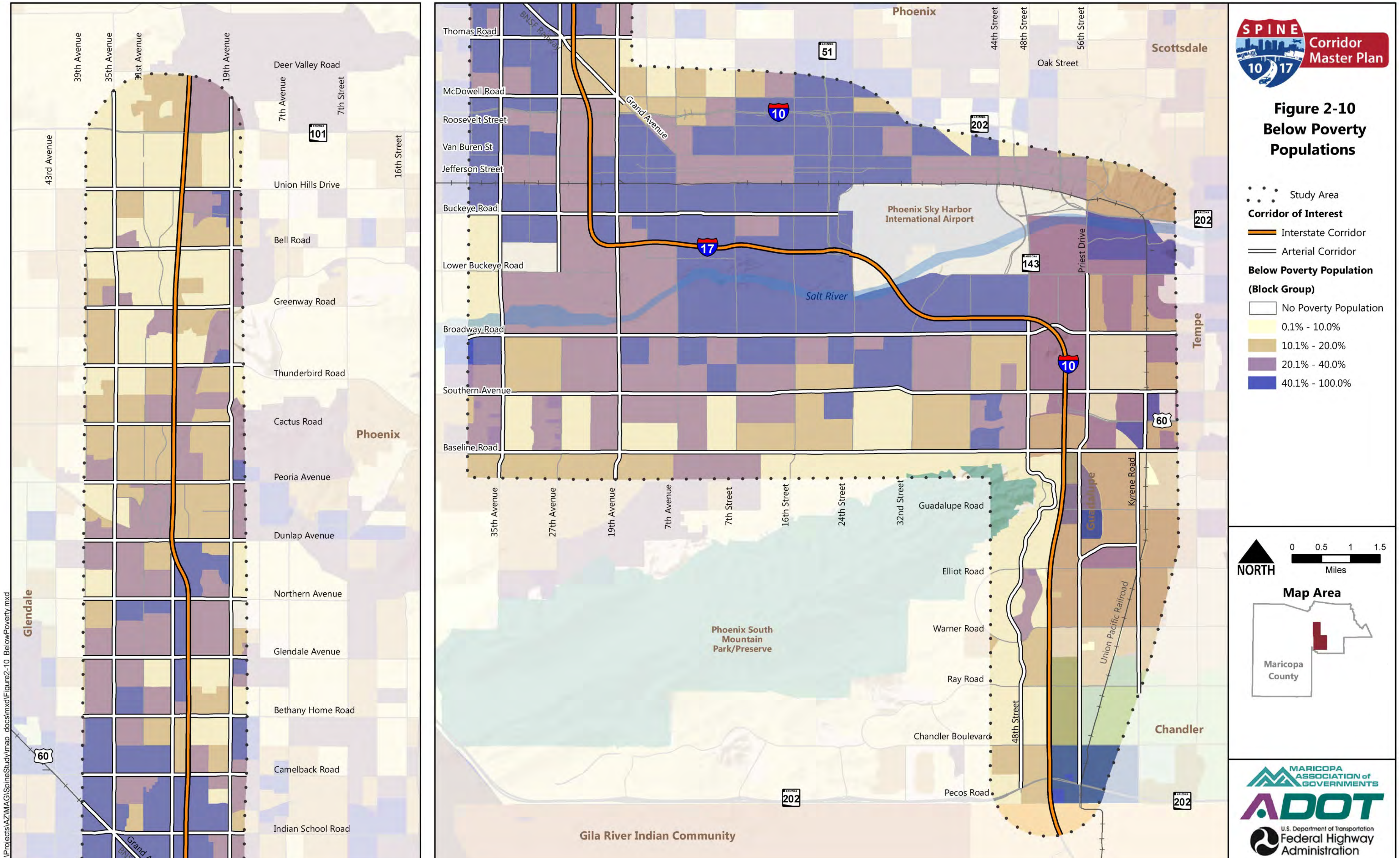
Cultural resources are properties that reflect the heritage of local communities, states and nations. Properties judged to be significant and to retain sufficient integrity to convey that significance are termed "historic properties" and are afforded certain protection in accordance with state and federal legislation. The National Historic Preservation Act (NHPA) of 1966, as amended [36 CFR 800.16(l)(1)] defines a historic property as any prehistoric or historic district, site, building, structure or object included in, or eligible for inclusion in, the NRHP. This includes artifacts, records and remains that are related to and located within such properties.

Figure 2-9 2010 Minority Populations



Source: ADOT, ALRIS, FEMA, Census

Figure 2-10 Below Poverty Populations



Source: ADOT, ALRIS, FEMA, Census

Historic property includes properties of traditional religious and cultural importance to Native American tribes or Native Hawaiian organizations and that meet the NRHP criteria. Traditional cultural properties, having heritage value for contemporary communities (often, but not necessarily, Native American groups), also can be determined eligible for, and listed in, the NRHP because of their association with historic cultural practices or beliefs that are important in maintaining the cultural identities of such communities.

Regulatory Setting

Section 106 of the NHPA requires federal agencies to consider the potential effects of their undertakings on historic properties. Effects can be direct and result in physical alteration to the property or indirect, as when the characteristics that qualify the property for NRHP listing are altered as a result of visual, auditory or atmospheric intrusions.

Properties may be of local, state or national importance. Typically, historic properties are at least 50 years old, but younger properties may be considered for listing if they are of exceptional importance. To be considered eligible for listing in the NRHP, a property must meet at least one of the criteria previously described in the section, *Section 4(f) and Section 6(f) Resources*.

Records searches were conducted on AZSITE, at the NRHP website, and at the ADOT Bridge Inventory website for this study. GIS data were also obtained from the National Park Service, Maricopa County Flood Control District, City of Phoenix Historic Preservation Office and the City of Tempe; these data provided information about historic properties and cemeteries within the study area. In addition, two ethnic heritage survey reports were reviewed for data (Dean and Reynolds 2004, 2006). The ethnic heritage reports are available on the City of Phoenix Historic Preservation Office website.

Affected Environment

As a result of the records search, 176 previously recorded archaeological sites, 326 historic properties, and 17 historic bridges were identified within the current study area. These sites are listed in tables provided in Appendix C. The known cultural resources consisted of:

- 2 historic roads
- 3 historic railroads
- 11 historic canals
- 20 historic bridges
- 326 historic structures/buildings/districts/features
- 1 historic cemetery
- 6 historic artifact scatters
- 1 historic shrine
- 5 prehistoric petroglyphs
- 9 prehistoric features
- 5 historic features
- 22 prehistoric artifact scatters
- 19 prehistoric villages or habitations
- 1 sherd (historic or prehistoric fragment of pottery) scatter (scattered cultural artifacts and debris) of unknown affiliation
- 1 artifact scatter of unknown age
- 1 feature of unknown age
- 7 prehistoric canals
- 24 multicomponent sites
- 58 sites of unknown age and affiliation

Several of the cultural resources sites listed in Table C-1 are major Hohokam village sites that may require Phase I and Phase II data recovery if a build alternative is selected and if they cannot be avoided by construction activities. These include but are not limited to Las Colinas, Pueblo Salado, Dutch Canal Ruin, Canal Patricio System, Las Canopas, Pueblo Del Monte, Los Hornos, La Ciudad, Pueblo Patricio, Casa Buena, Pueblo Viejo, Las Guanacos and Pueblo Grande.

The NRHP eligibility status of properties identified in Table C-1 were based solely on information found on the AZSITE cultural resources database; they are as follows:

- 4 sites listed
- 38 sites determined eligible
- 8 sites determined not eligible
- 34 sites recommended eligible
- 8 sites recommended not eligible
- 2 sites with mixed eligibility status
- 36 sites that have not been evaluated
- 62 sites with unknown eligibility status

The NRHP eligibility status of properties identified in Table C-2 were based mostly on information obtained from the National Park Service and the NRHP website. Data from the City of Phoenix Historic Preservation Office website and/or GIS data received from the City of Phoenix and the City of Tempe were gathered for a distance of 1 mile from the Interstate highways. They are as follows:

- 107 eligible sites (NRHP or City of Phoenix Register were not specified; nor was it known whether these are determined eligible or recommended eligible)
- 15 sites that are listed on both the NRHP and the City of Phoenix Register
- 163 sites that are listed on the NRHP
- 24 sites that are listed on the City of Phoenix Register
- 1 site that has an unknown eligibility status

The 20 historic bridges identified through ADOT records in Table C-3 have not been evaluated for NRHP inclusion. On March 10, 2005, the Advisory Council on Historic Preservation adopted the Section 106 Exemption Regarding Effects to the Interstate Highway System (2005). As a result of the exemption, 15 of the 20 historic bridges in Table C-3 (Structures 00731, 00729, 00727, 00725, 00723, 00721, 00719, 00717, 00607, 00555, 00600, 00554, 01950, 00410 and 00796), which are part of the I-10 and I-17 systems, are exempt from the Section 106 process. The remaining five bridges (Structures 00178, 07770, 09175, 09178 and 09203) have been previously evaluated for NRHP inclusion by FraserDesign (2008). Bridge structures 00178, 09175, 09178 and 09203 were recommended not eligible for inclusion in the NRHP (FraserDesign 2008). Bridge structure 07770, the 17th Avenue Underpass, is recommended eligible for inclusion in the NRHP under Criterion A as a handsomely detailed, well-preserved example of Depression-era bridge construction (FraserDesign 2008).

Also, a portion of I-10 within the study area is not exempt from the Section 106 process. The inclusion of the I-10 Deck Park Tunnel between mileposts 144.5 and 145.5 in FHWA's (2015) Final List of Nationally and Exceptionally Significant Features of the Federal Interstate Highway System indicates that this portion of I-10 was determined to possess national significance and to be of exceptional importance (that is, it meets the requirements of Criteria Consideration G for properties that have achieved significance in the last 50 years). In other words, FHWA designated the I-10 Deck Park Tunnel an exception to the Advisory Council on Historic Preservation's exemption, so any construction within those milepost limits (144.5 to 145.5) would need to be considered under the Section 106 process.

In addition to these resources, there are approximately 47,000 in-use historic structures within 1 mile of the highways that have not been officially evaluated for NRHP inclusion. These historic structures, however, are more than 50 years old and may possibly require documentation as the project progresses. It is probable that some of the structures could be grouped together to form historic districts.

At least six modern/historic cemeteries (that is, Greenwood Memory Cemetery, Double Butte Cemetery, Twin Buttes County Cemetery, Pioneer Memorial Park, Cementerio Lindo and Maricopa County Cemetery) are located within the study area. If a build alternative is defined/selected through any of the cemeteries, at a minimum, intensive documentation, research, ethnographic interviews, detailed mapping and evaluations for NRHP inclusion are probable.

Environmental Concerns and Recommendations for Future Analysis

With respect to cultural resources in the study area:

- The archaeological resources are more densely located south of Indian School Road and north of Elliot Road, generally along the Salt River, and are less dense north of Indian School Road and south of Elliot Road. Several major Hohokam village sites may require Phase I and Phase II data recovery if a build alternative is selected and they cannot be avoided by construction activities. These include but are not limited to Las Colinas, Pueblo Salado, Dutch Canal Ruin, Canal Patricio System, Las Canopas, Pueblo Del Monte, Los Hornos, La Ciudad, Pueblo Patricio, Casa Buena, Pueblo Viejo, Las Guanacos and Pueblo Grande.
- Based on available data, the existence of 47,000 unevaluated historic properties older than 50 years old dispersed within 1 mile of the highways could constrain future alternatives in three general areas: north of Peoria Avenue, between Dunlap and 24th Street (north of the Salt River), and between Broadway Road (south of the Salt River) and Chandler Boulevard.
- NRHP-listed or eligible historic properties and districts could constrain alternatives near the downtown Phoenix and Tempe cores.
- The South Mountains have been identified in previous studies as a traditional cultural property by tribal communities.
- Numerous prehistoric canals and historic canals crisscross through the study area. These may require Phase I and Phase II data recovery if a build alternative is selected and if they cannot be avoided by construction activities.
- At least six modern/historic cemeteries are located within the study area in the vicinity of the I-17/I-10 interchange, north of I-17 between 19th Avenue and Central, and in the vicinity of the Broadway Curve. If a build alternative is defined/selected through any of the cemeteries, at a minimum, intensive documentation, research, ethnographic interviews, detailed mapping and evaluations for NRHP inclusion are probable.

If a build alternative is defined and selected, FHWA will need to determine the overall project effect on historical properties (that is, "no historic properties affected," "no adverse effect" or "adverse effect"). Their effect determination will actuate the next steps for Section 106 compliance. Generally, cultural resources mandates require ongoing Section 106 consultation with land management agencies, municipalities, tribal communities and the public; ongoing discussions with agencies regarding survey/documentation/mitigation needs and permitting and development of agreement documents (for example, Memorandum of Agreement) for a project of this magnitude. Any agreement documents related to the Section 106 process will be used to guide future consideration and treatment of cultural resources. See Appendix D for a complete list of cultural resource sites identified in the PEL.

2.3 Summary of Identified Issues

In the following sections, environmental issues are summarized for the various study area segments. See Figure EX-1 for a graphical representation of the Spine study area's segmentation.

Segment I1: I-10, SR-202L to Baseline Road

Segment I1 contains several key sites of environmental concern, specifically South Mountain Park/Preserve and the town of Guadalupe. South Mountain Park/Preserve is a Section 4(f) and Section 6(f) resource and a traditional cultural property. The town of Guadalupe has ethnic, linguistic and social traditions that form a cohesive community. LUST sites occur adjacent to I-10. Numerous unevaluated historic properties older than 50 years are dispersed within 1 mile of I-10 and could constrain future alternatives in this segment.

Segment I2: I-10, Baseline Road to the Split

Potential Section 4(f), Section 6(f), environmental justice, water resources, cultural resources, LUST sites and agency coordination concerns are present in this segment. Low-income populations in areas adjacent to the segment may indicate environmental justice issues would need to be addressed. Two cemeteries flank I-10 at the Broadway Curve, one of which is protected under Section 4(f). Proposed improvements near Phoenix Sky Harbor International Airport would require Federal Aviation Administration review and approval and may need to conform to all current Federal Aviation Administration circulars, statutes and associated regulations including the Sky Harbor Airport Layout Plan (revised February 25, 2011) at the time of design and implementation. Numerous unevaluated historic properties older than 50 years are dispersed within 1 mile of I-10 and could constrain future alternatives in this segment. Nine Priority 1 USTs occur, numerous LUSTs, and two small Superfund sites are also present. Additionally, water resources identified in the segment include the Salt River and Tempe Drain.

Segment I3: the Split to the Stack

Superfund sites, historic overlays, two cemeteries, water resources, a Section 4(f) recreational site and potential environmental justice conditions exist in Segment I3. Privately owned Greenwood Memory Lawn Mortuary and

Cemetery and Cementerio Lindo are NHRP-eligible and protected under Section 4(f). The Salt River 100-year floodplain traverses I-17 in this segment. Numerous LUSTs and six Priority 1 LUSTs occur in the segment. Two Superfund sites occur within this segment, traversing the corridor between Lower Buckeye and Broadway Roads east of 19th Avenue (on the National Priority Superfund site list) and between Buckeye Road and Washington Street.

Segment I4: I-17, the Stack to ACDC

Potential environmental justice concerns exist within the segment given the presence of minority and low-income populations. Fourteen Priority 1 LUSTs, heavy concentrations of LUSTS, and a Superfund site are located within Segment I4.

Segment I5: I-17, ACDC to the North Stack

Cave Creek Golf Course and adjoined recreation facilities run roughly parallel to I-17 within this segment. These facilities are Section 4(f) resources. In addition, numerous unevaluated historic properties could constrain future alternatives. LUSTs occur at major intersections and along 19th and Peoria Avenues.

Segment A1: 48th Street, 56th Street/Priest Drive and Kyrene Road

As noted for Segment I1, the town of Guadalupe has a cohesive community based on ethnic, linguistic and social traditions. The town is bisected by Priest Drive/Avenida del Yaqui. South Mountain Park/Preserve is a Section 4(f) and Section 6(f) resource and a traditional cultural property.

Segment A2: Baseline Road, Southern Avenue, Broadway Road and Buckeye Road

Potential environmental justice concerns exist with minority populations in all corridors of this segment and with low-income populations along Broadway Road. Concentrations of LUSTs, five Priority 1 LUSTs and a Superfund site are present. Prehistoric and historic canals and archaeological sites are also present within the segment.

Segment A3: 35th Avenue, 27th Avenue and 19th Avenue

Segment A3 contains a number of potential Section 4(f) and Section 6(f) recreational facilities and schools. Several historic districts are also within the boundaries of the segment, including Oakland Historic District, Villa Verde Historic District and North Encanto Historic District. Potential environmental justice concerns exist with minority and low-income populations. Heavy concentrations of LUSTs occur throughout the segment, including 14 Priority 1 LUSTs. Multiple Superfund sites and one National Priority Superfund site are also located in Segment A3.

Segment A4: East-to-west arterials crossing I-17

Segment A4 contains a number of potential Section 4(f) and Section 6(f) recreational facilities and schools. Several historic districts are also within the boundaries of the segment, including Oakland Historic District, Villa Verde Historic District and North Encanto Historic District. In addition, potential environmental justice concerns exist with minority and low-income populations. Multiple LUSTs, 12 Priority 1 LUSTs and a Superfund site exist within Segment A4.

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3 Travel Demand and Traffic Operations Factors

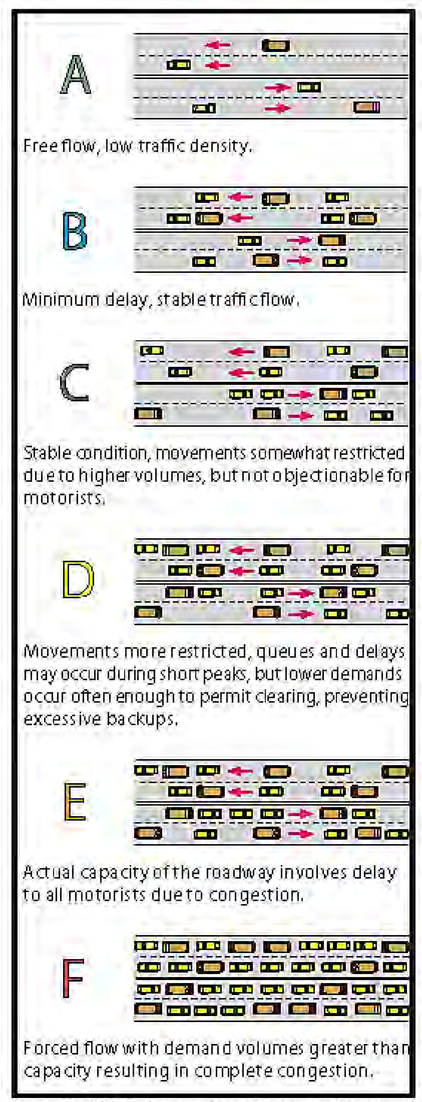
3.1 Existing Year 2014 and Future Year 2040 Operations

A series of analyses were performed to identify characteristics of existing and anticipated future travel within the study area. Analyses relied on available ADOT Freeway Management System (FMS) data and outputs from the MAG travel demand model for existing Year 2014 conditions and forecast Year 2040 conditions. These analyses were performed to gain insight into how the Spine Interstate corridor and adjacent facilities will operate in the future and how those operations compare with current study area conditions. In the following sections, the results of analyses examining corridor operations are presented. These analyses include: LOS, required number of lanes, travel times, duration of congestion, Interstate access and identification of key origin and destination pairs within the study area.

3.2 Level of Service Definition

Transportation engineers and planners commonly use a rating system to measure the operational status of roadway segments, interchanges and intersections that make up a local roadway network. This rating system is referred to as LOS, which yields a measurement of the performance of network components. As defined in the *Highway Capacity Manual 2010*, LOS is a qualitative measure describing operating conditions associated with a traffic stream. As shown in Figure 3-1, six levels of service are defined using letters, with LOS A representing the best operating condition and LOS F the worst. The various levels of service are generally defined as follows:

Figure 3-1 Level of Service



Source: North I-25 Environmental Impact Statement, Colorado Department of Transportation/Federal Transit Administration/Federal Highway Administration, August 17, 2008.

LOS A represents free flow.

LOS B is in the range of stable flow, but the presence of other users in the traffic stream begins to be noticeable.

LOS C is in the range of stable flow, but marks the beginning of the range in which the operation of individual users becomes significantly affected by others.

LOS D represents high-density but stable flow. Speed and freedom to maneuver are severely restricted, and the driver experiences a generally poor level of comfort and convenience.

LOS E represents operating conditions at or near the capacity level. All speeds are reduced to a low but relatively uniform value.

LOS F is used to define forced or breakdown flow. This condition exists wherever the amount of traffic approaching a point at a given period of time exceeds the amount that can traverse the point.

LOS is derived by comparing traffic volumes on a given roadway segment to roadway capacities. Roadway capacities are defined for different roadway types—in this case, general purpose Interstate lanes, high-occupancy vehicle (HOV) lanes, and arterial lanes—based on the volume of traffic each facility type would be expected to carry. The approximate capacity of the different facility types is summarized in Table 3-1.

Table 3-1 Roadway Capacity, by Facility Type

Facility type	Vehicles per hour per lane
High-occupancy vehicle lanes	1,700
General purpose Interstate lanes	1,750
Arterials	700
Frontage roads	1,000

MAG maintains a regional travel demand model that estimates traffic volumes based on varying levels of travel demand generated by the region's population and employment. These model-generated traffic volumes can be compared with the roadway capacities defined in Table 3-1 to create a volume-to-capacity (v/c) ratio. The v/c ratio indicates the anticipated congestion and associated LOS that may occur on the roadway network.
Table 3-2 summarizes the LOS thresholds used in the analysis of the study area roadways. For example, a general purpose Interstate lane with a capacity of 1,750 vehicles would be considered to operate at an accetpable LOS until traffic volumes reached 84 percent of the capacity, or approximately 1,470 vehicles per hour per lane.

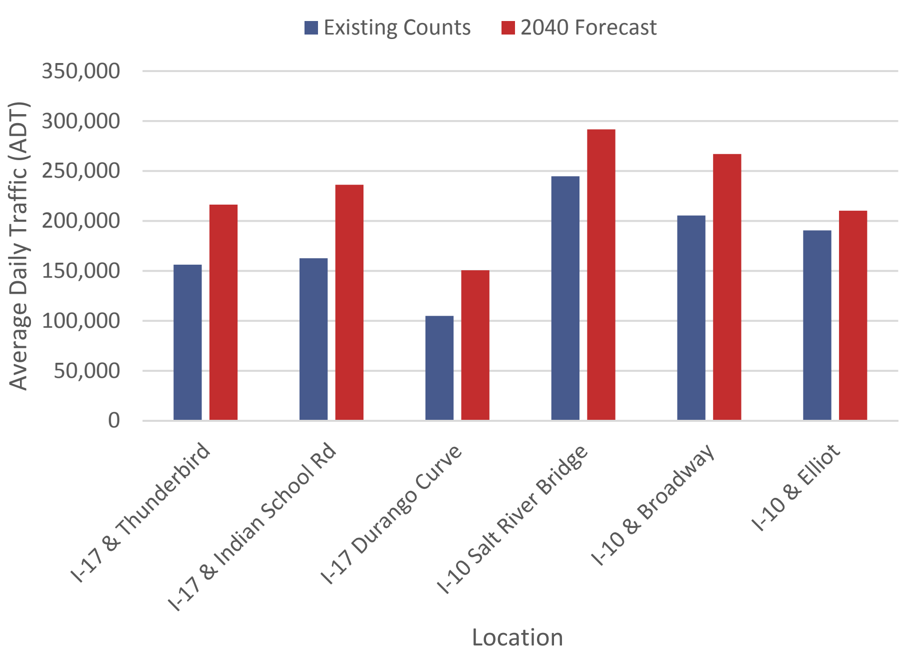
Table 3-2 Level of Service Thresholds

	Volume-to-capacity ratio thresholds	
Level of Service	Lower	Upper
A	0.00	0.50
B	0.51	0.60
C	0.61	0.72
D	0.73	0.84
E	0.85	1.00
F	1.01	+

3.3 Study Area Traffic Volumes and Level of Service

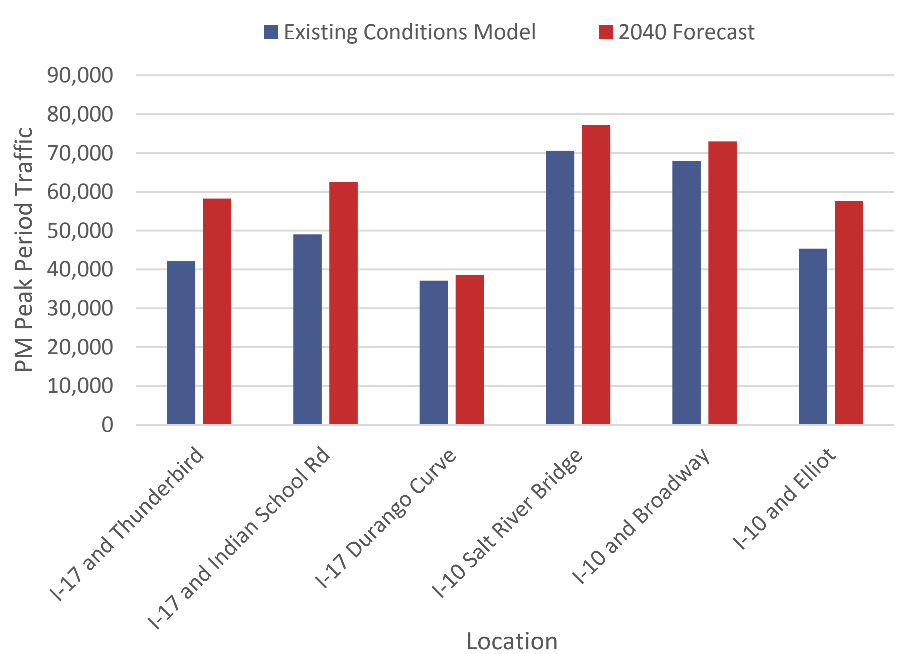
The Spine Interstate corridor currently carries a significant portion of the Valley's Interstate traffic during the day and is particularly congested during peak periods. In the future, these traffic volumes are anticipated to only increase, resulting in additional congestion in the study area. Figure 3-2 compares existing and forecast daily traffic along several segments of the corridor, with Figure 3-3 providing a similar comparison for the PM peak travel period. As indicated in these figures, approximately 50,000 to 70,000 additional daily trips will occur in the corridor by 2040. During the PM peak, the increase ranges from as low as 1,500 vehicles near the Durango Curve to as much as 15,000 vehicles at I-17 and Thunderbird Road.

Figure 3-2 Comparison of Existing Year 2014 and Year 2040 Daily Traffic Volumes



Notes: I-10 = Interstate 10, I-17 = Interstate 17

Figure 3-3 Comparison of Existing Year 2014 and Year 2040 PM Peak Period Traffic Volumes



Notes: I-10 = Interstate 10, I-17 = Interstate 17

These volumes were used to estimate the anticipated LOS throughout the Spine study area. To define LOS in the study area, a series of cutlines were defined throughout the corridor. These cutlines are essentially imaginary lines drawn across the corridor at various locations, across which a given volume of traffic is expected to travel. The capacities of the various roadway facilities at these cutlines are defined and then compared with the associated volumes on the various facilities that cross the cutline. Figures 3-4 and 3-5 display the results of the cutline analysis for the PM peak period for existing Year 2014 and Year 2040 conditions, respectively. Detailed volume, lane configuration, and capacity data at each cutline is provided in Appendix E.

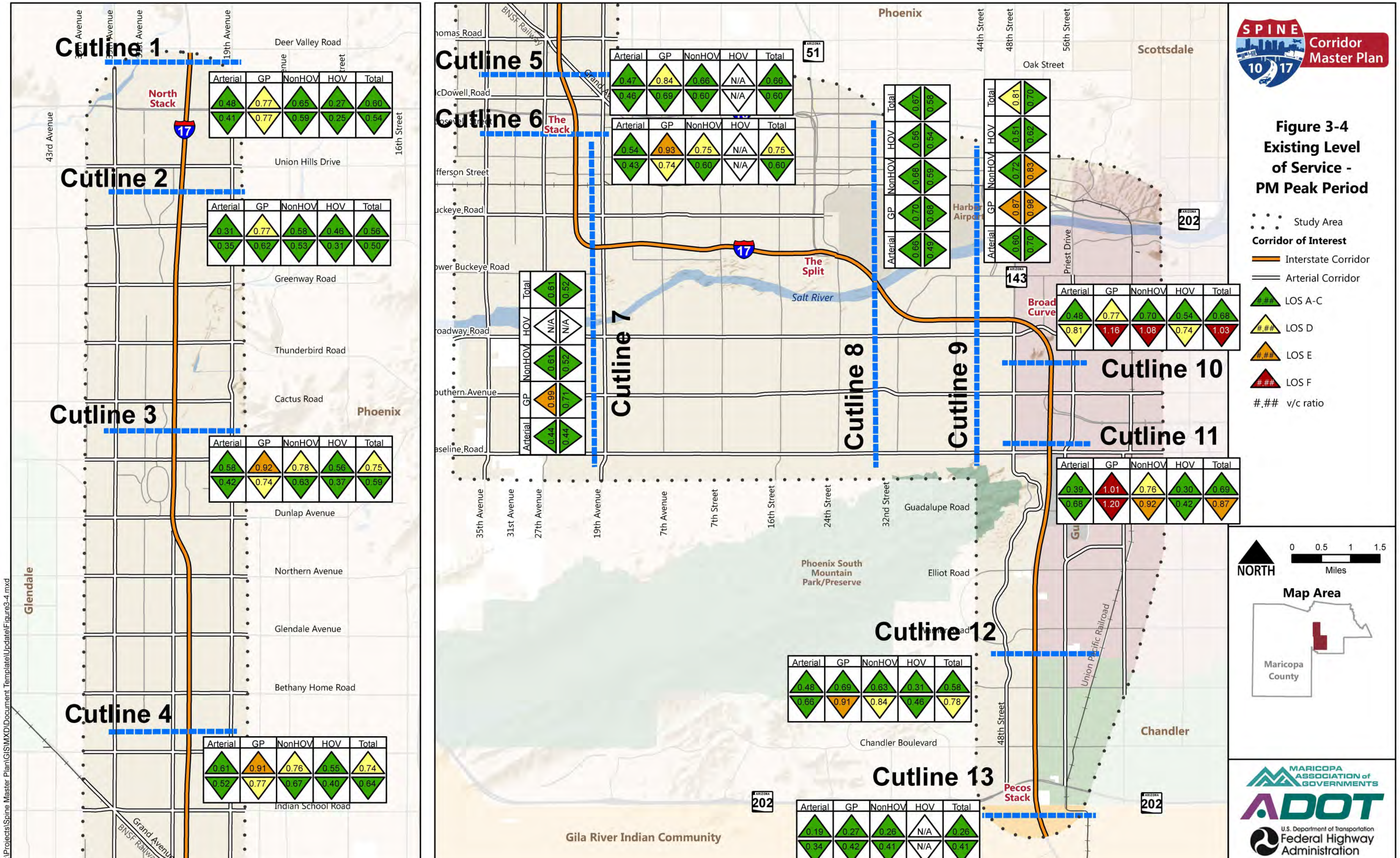
As indicated in Figure 3-4, the arterial and HOV facilities generally operate at acceptable LOS D or better today. The general purpose Interstate lanes, however, experience congestion at several locations throughout the study area, including:

- I-17 northbound in the vicinity of Peoria Avenue
- I-17 northbound in the vicinity of Camelback Road
- I-17 northbound in the vicinity of Van Buren Street
- I-17 northbound in the vicinity of the Durango Curve
- I-10 eastbound and westbound in the vicinity of 40th Street
- I-10 eastbound in the vicinity of the Broadway Curve
- I-10 eastbound and westbound in the vicinity of Baseline Road
- I-10 eastbound in the vicinity of Ray Road

Figure 3-5 illustrates that these conditions are generally expected to continue or deteriorate along I-17 by 2040. Between the Stack and the North Stack, both northbound and southbound I-17 general purpose lanes will be congested during the PM peak period by 2040. Between the Stack and the Split, I-17 northbound will be congested. On I-10, between the Split and Baseline Road, congestion is expected in both the eastbound and westbound directions, with the exception of westbound travel near the Broadway Curve and eastbound travel near 32nd Street. Conditions along this portion of the corridor will actually improve as a result of near-term corridor improvements. South of Baseline Road, congestion during the PM peak period will be limited to the eastbound direction only.

While cutlines provide a high-level overview of corridor operations, a more detailed, supplementary analysis of study area LOS was conducted to gain an understanding of specific areas within the corridor that could be targeted for future improvement. Figures 3-6 and 3-7 show the results of the analysis for the PM peak period under existing Year 2014 and Year 2040 conditions, respectively. This analysis was also performed for the AM peak period, with results for existing Year 2014 and Year 2040 conditions displayed in Figures 3-8 and 3-9, respectively. In these graphics, orange segments represent links operating at a v/c ratio of 0.85 to 1.00, or LOS E. Red and purple segments represent links operating over capacity (or at LOS F), with purple segments identifying the most congested segments with v/c ratios exceeding 1.25.

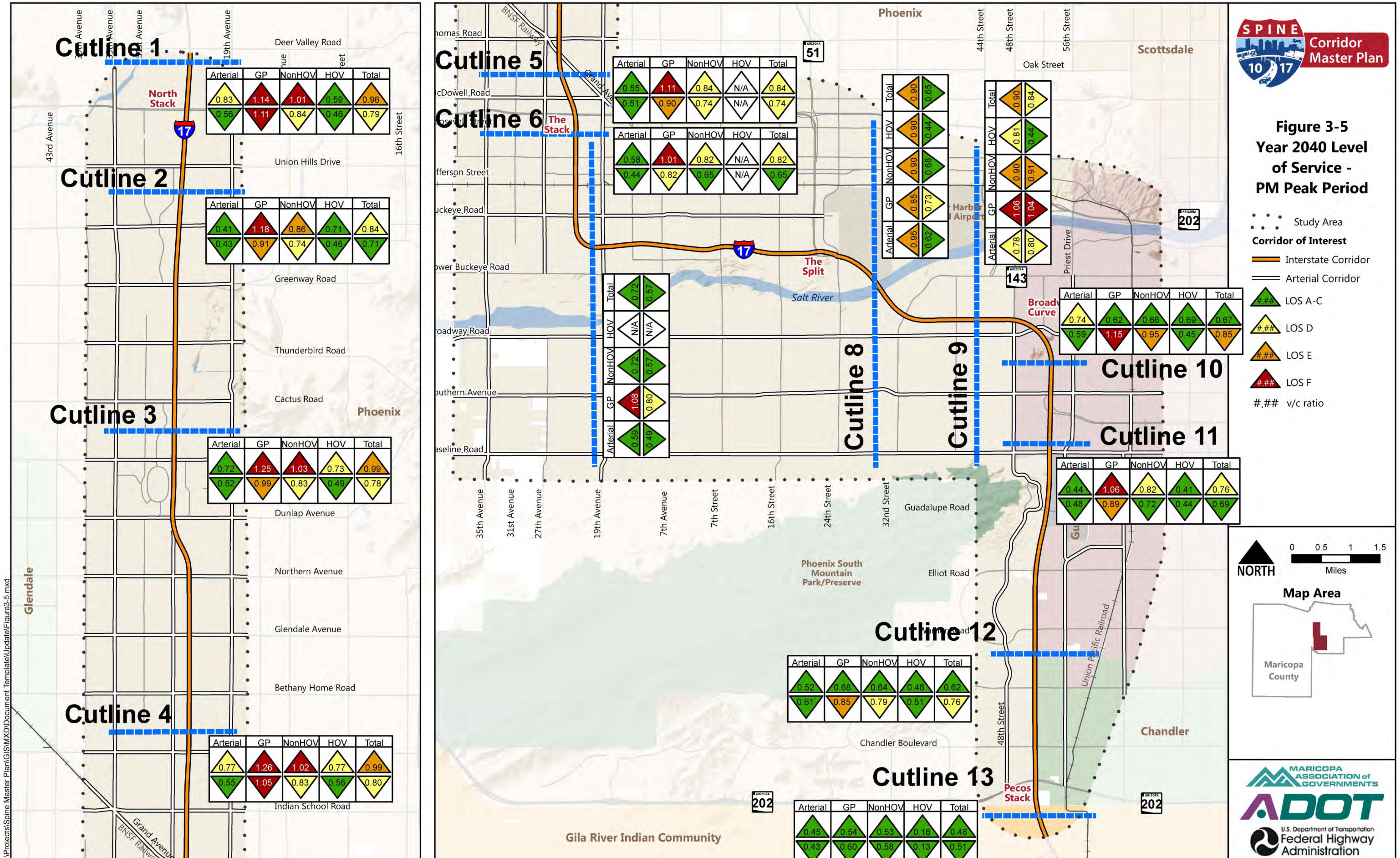
Figure 3-4 Existing Level of Service – PM Peak Period



Data Source: ADOT, ALRIS, FEMA, MAG Travel Demand Model

Map Last Updated: 5/12/2016

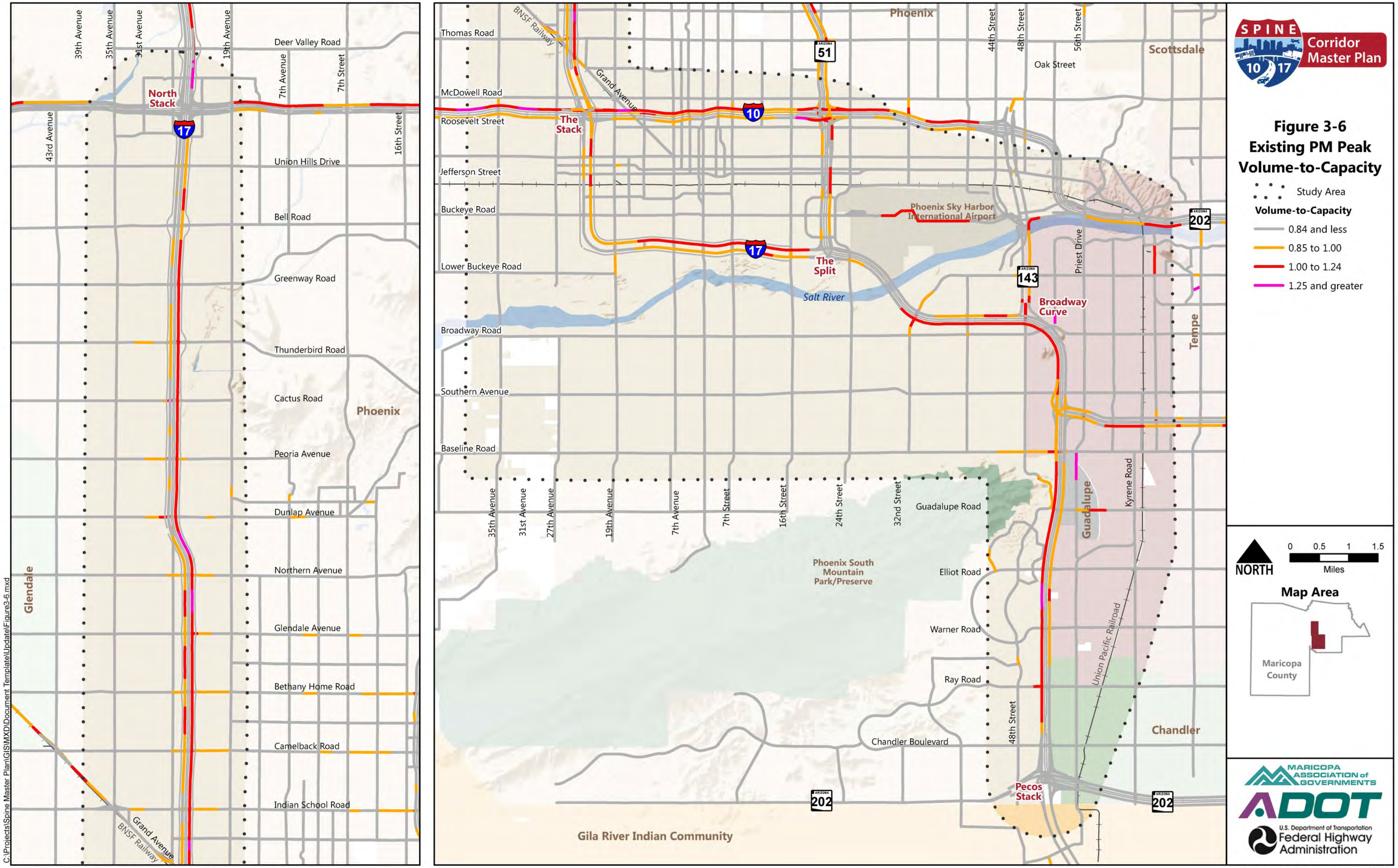
Figure 3-5 Year 2040 Level of Service – PM Peak Period



Data Source: ADOT, ALRIS, FEMA, MAG Travel Demand Model

Map Last Updated: 5/13/2016

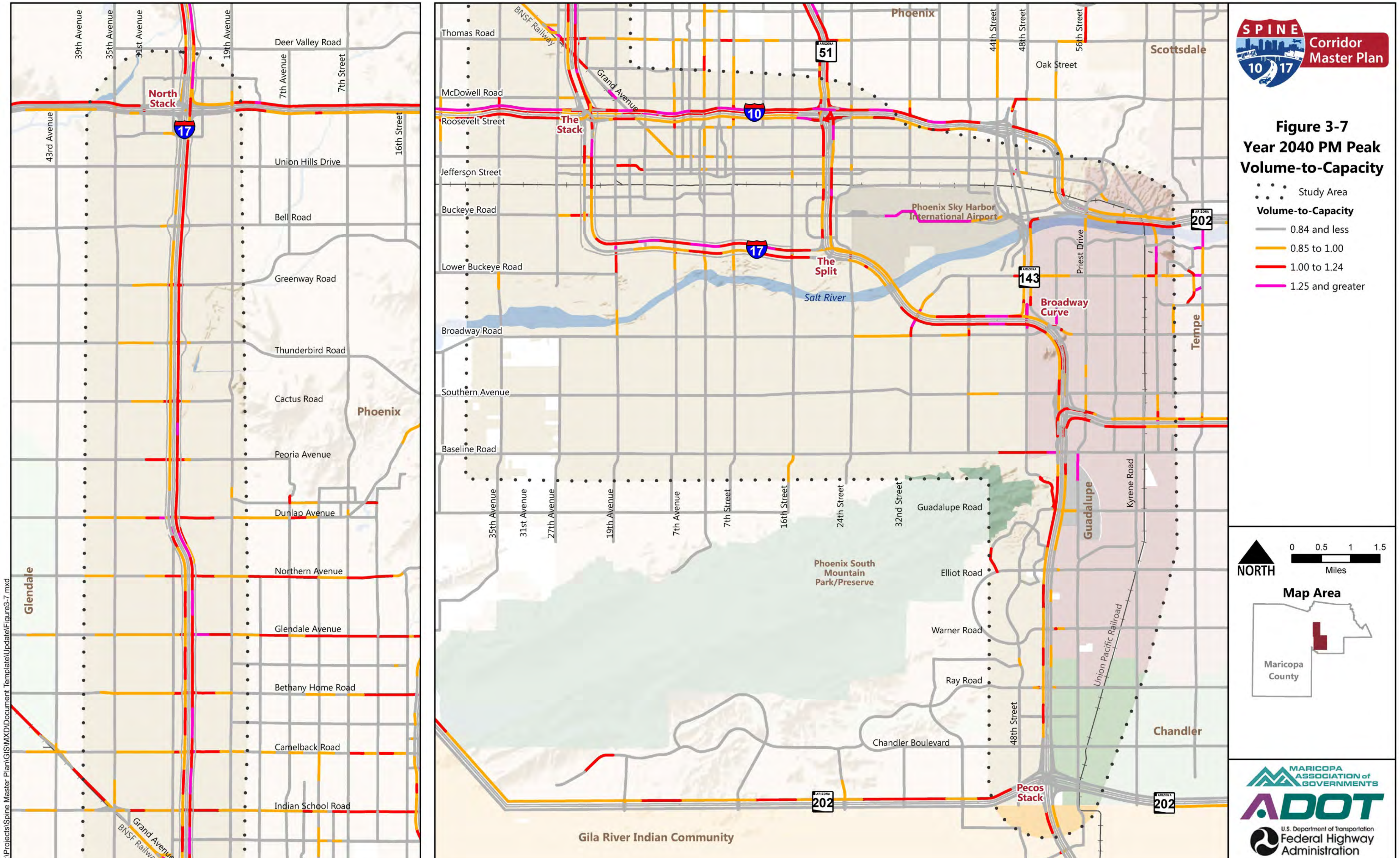
Figure 3-6 Existing PM Peak Volume-to-Capacity



Data Source: ADOT, ALRIS, FEMA, MAG Regional Travel Model

Map Last Updated: 5/13/2016

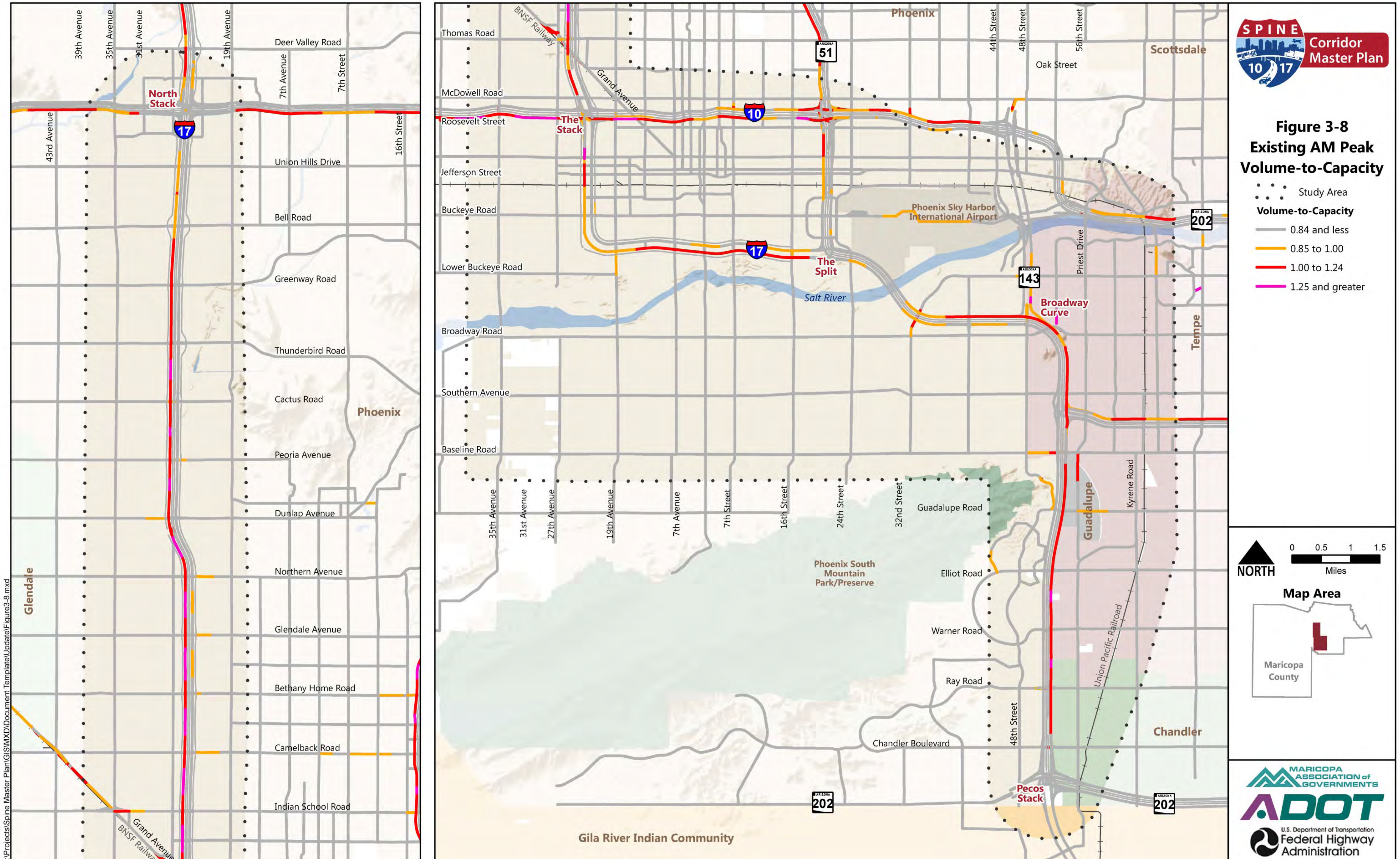
Figure 3-7 Year 2040 PM Peak Volume-to-Capacity



Data Source: ADOT, ALRIS, FEMA, MAG Regional Travel Model

Map Last Updated: 5/13/2016

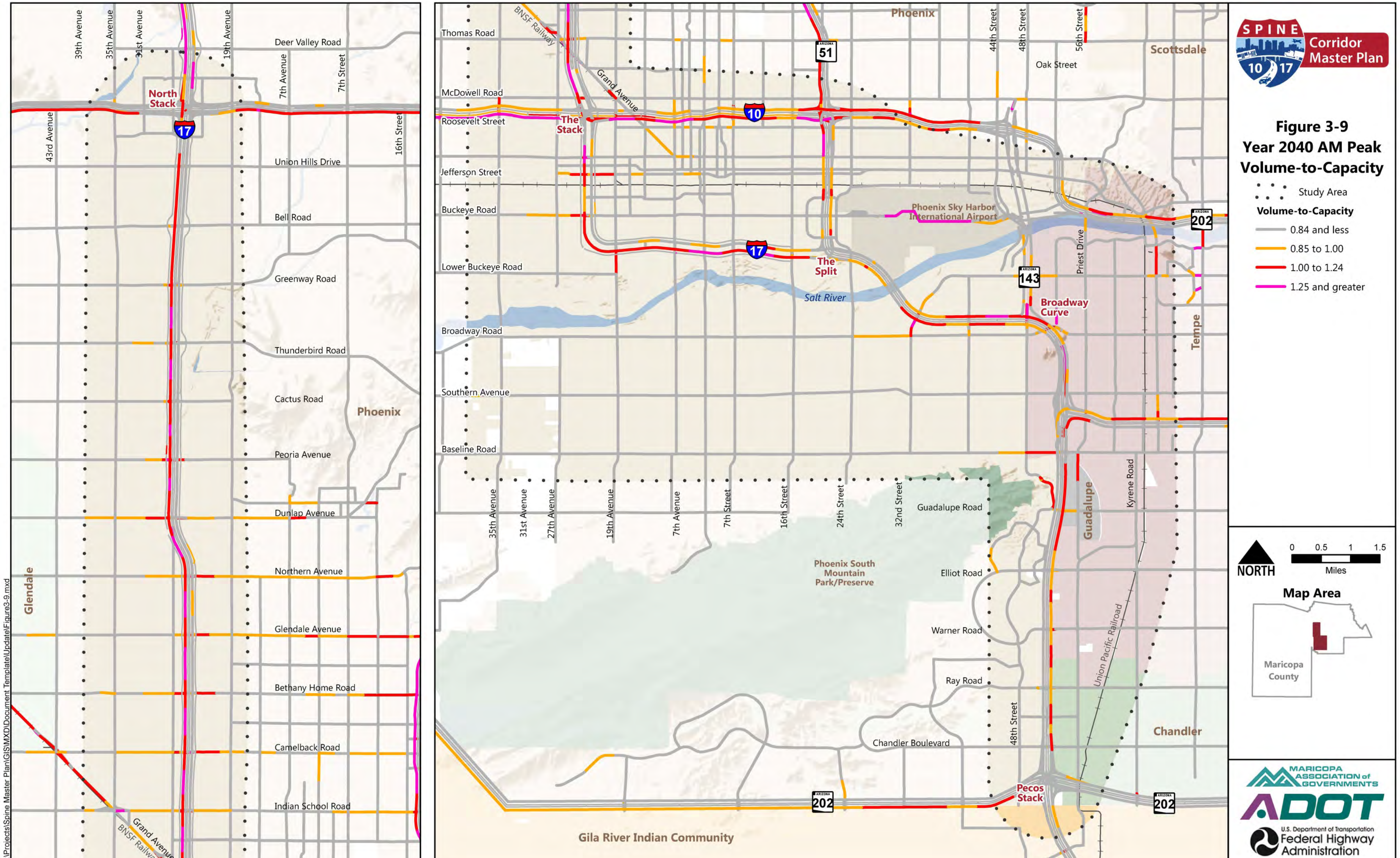
Figure 3-8 Existing AM Peak Volume-to-Capacity



Data Source: ADOT, ALRIS, FEMA, MAG Regional Travel Model

Map Last Updated: 5/13/2016

Figure 3-9 Year 2040 AM Peak Volume-to-Capacity



Data Source: ADOT, ALRIS, FEMA, MAG Regional Travel Model

Map Last Updated: 5/13/2016

3.4 Capacity Needs for Unconstrained Demand (Lanes)

Using estimates of future Year 2040 traffic volumes, it is possible to identify the number of general purpose travel lanes that would be needed to accommodate, without congestion, all of the traffic that desires to use the Interstates. Figure 3-10 illustrates the number of general purpose lanes that would be needed in each direction to accommodate the forecast Year 2040 traffic volumes during the PM peak period. In the PM peak alone, as many as 22 travel lanes would be needed along some sections of the corridor. In fact, considering that AM peak period traffic is relatively similar to that of the PM peak, but with the higher demands in the opposite direction, it is estimated that up to 24 to 26 travel lanes could be needed along portions of I-17, particularly north of the Split. Details regarding the derivation of number of lanes depicted in Figure 3-10 is provided in Table 3-3.

Table 3-3 Capacity Needs for Unconstrained Demand (Lanes)

Table 3-3 Capacity Needs for Unconstrained Demand (Lanes)

Cutline	Direction	Interstate volume	PM peak period lane capacity	Desired number of lanes
Cutline 1	Northbound	54,816	7,284	9
	Southbound	32,303	7,284	6
Cutline 2	Northbound	62,783	7,284	11
	Southbound	40,777	7,284	7
Cutline 3	Northbound	69,229	7,284	12
	Southbound	43,983	7,284	8
Cutline 4	Northbound	74,605	6,856	13
	Southbound	48,174	6,856	9
Cutline 5	Northbound	67,666	6,856	12
	Southbound	49,169	6,856	9
Cutline 6	Northbound	56,271	6,856	10
	Southbound	37,885	6,856	7
Cutline 7	Eastbound	28,802	6,856	6
	Westbound	45,314	6,856	8
Cutline 8	Eastbound	54,545	6,856	10
	Westbound	62,578	6,856	11
Cutline 9	Eastbound	58,372	6,856	11
	Westbound	58,321	6,856	11
Cutline 10	Northbound	43,026	6,856	8
	Southbound	58,360	6,856	11
Cutline 11	Northbound	33,070	7,284	6
	Southbound	32,662	7,284	6
Cutline 12	Northbound	32,910	7,284	6
	Southbound	35,412	7,284	6
Cutline 13	Northbound	24,134	7,284	4
	Southbound	23,905	7,284	4

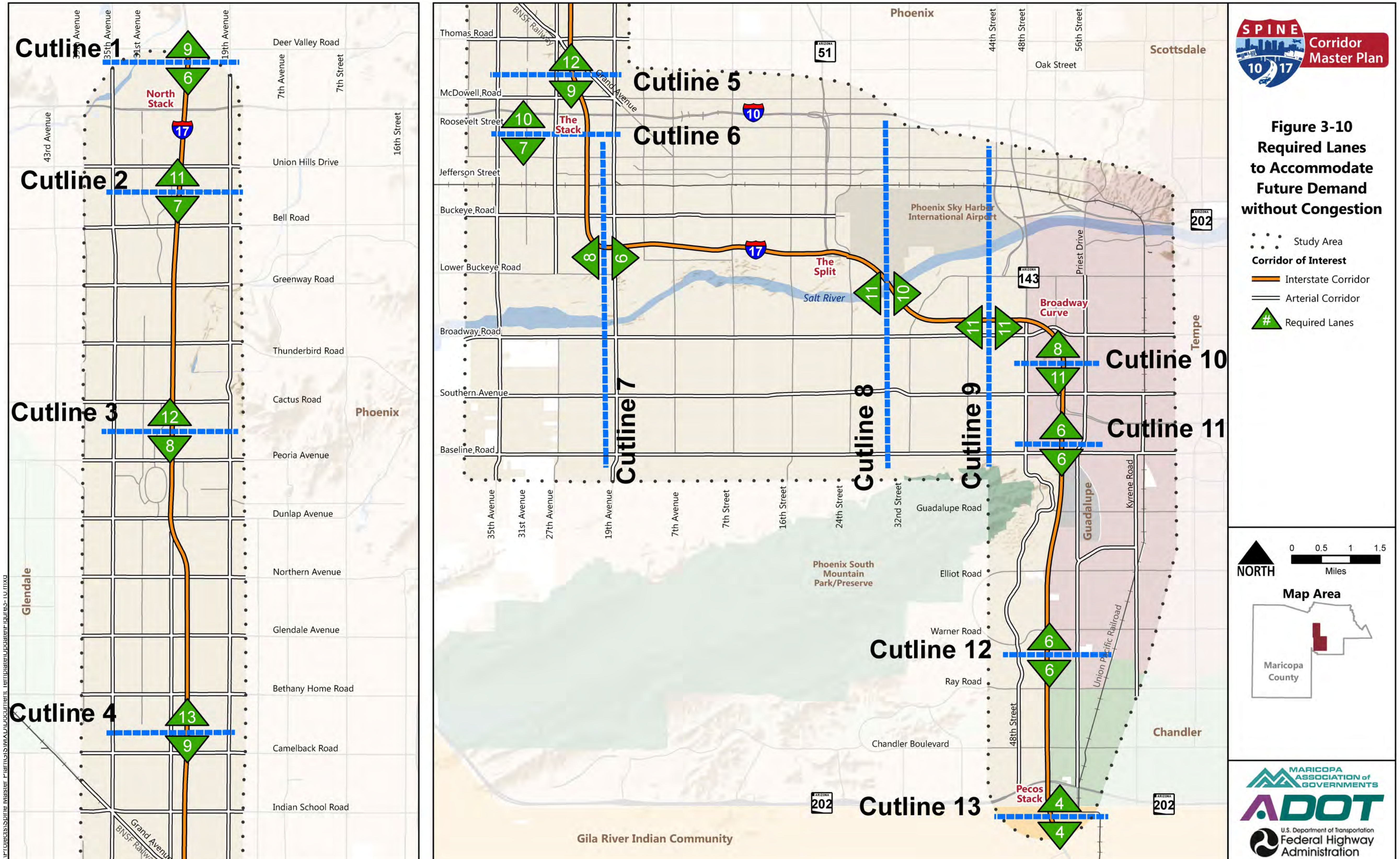
Note: PM peak period lane capacity is for a 4-hour period.

3.5 Travel Times

Another estimate of how well the Spine Interstate corridor is operating today, and is expected to operate into the future, is the amount of time it takes drivers to travel between various origins and destinations throughout the corridor. Figure 3-11 illustrates selected origins and destinations along the corridor, labeled A through G. Travel times between the various points are summarized in Table 3-4 for uncongested conditions (free flow), today's conditions and anticipated Year 2040 conditions during the AM and PM peak travel periods.

When comparing free-flow travel times with today's actual travel times, it is evident that a significant amount of time is already lost today when traveling during the peak periods. Travel times will increase in the future on the majority of the Interstate corridor segments. In areas where travel time stays the same or decreases, it is attributable to near-term improvements plans between now and 2020. For example, the trip along I-17 between SR-101L (A) and downtown Phoenix (D) is expected to increase by an additional 10 minutes during both the AM and PM peak travel periods. While this may not seem like a lot, it is the equivalent of spending an additional 3 ½ days in traffic each year.

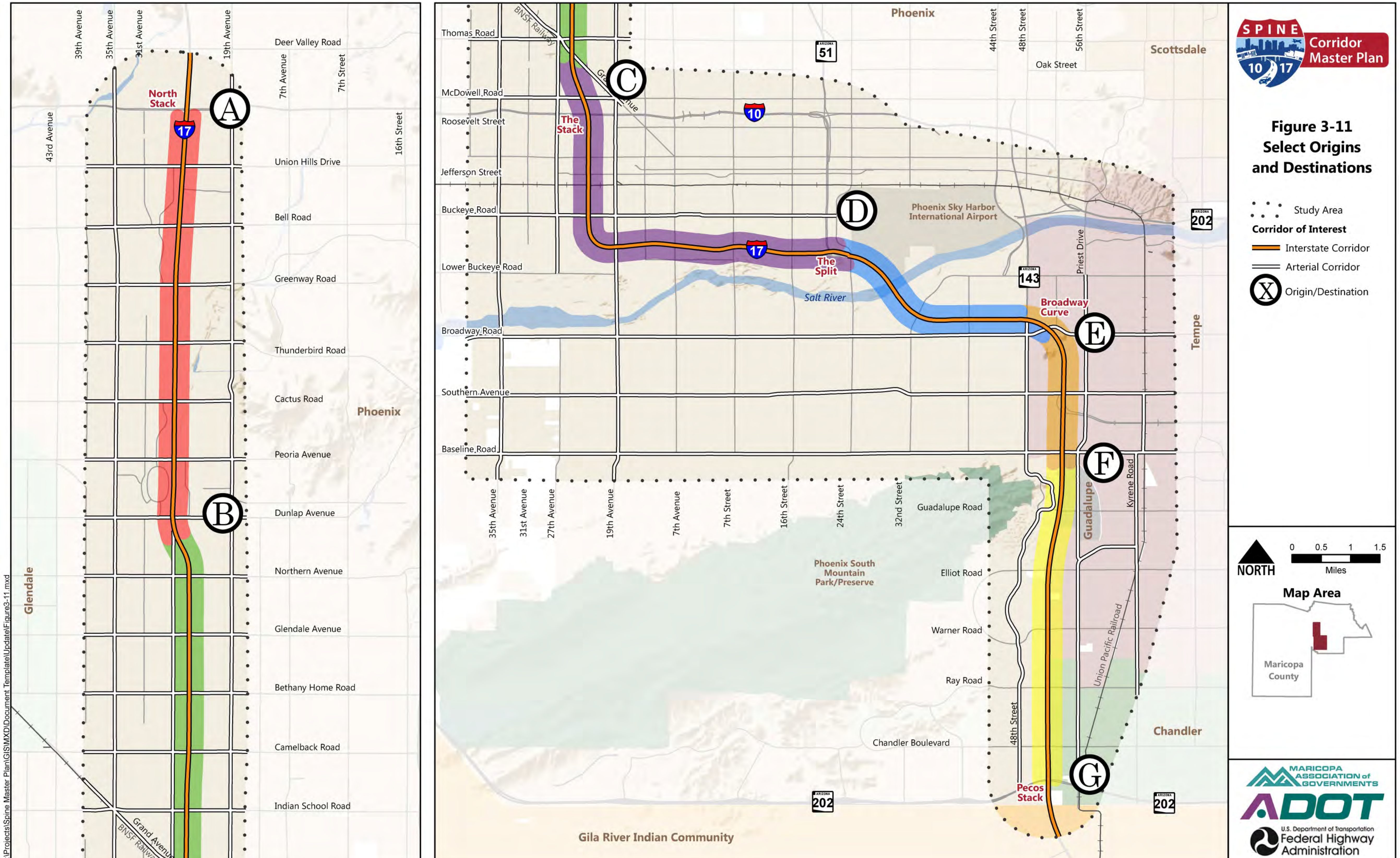
Figure 3-10 Required Lanes to Accommodate Future Demand without Congestion



Data Source: ADOT, ALRIS, FEMA, MAG Travel Demand Model

Map Last Updated: 5/13/2016

Figure 3-11 Select Origins and Destinations



Data Source: ADOT, ALRIS, FEMA

Map Last Updated: 5/13/2016

Table 3-4 Travel Times, in Minutes

	To A: I-17 and SR-101L			To B: I-17 and Dunlap Road			To C: I-17 and Thomas Road			To D: I-17 and I-10			To E: I-10 and SR-143			To F: I-10 and Baseline Road			To G: I-10 and SR-202L		
AM peak period																					
From A: I-17 and SR-101L	—	—	—	6	11	13	11	25	30	17	37	47	20	41	53	22	43	55	27	48	60
From B: I-17 and Dunlap Road	6	7	7	—	—	—	5	14	17	11	26	34	14	30	40	16	32	42	21	37	47
From C: I-17 and Thomas Road	11	14	14	5	7	7	—	—	—	6	12	17	9	16	23	11	18	25	16	23	30
From D: I-17 and I-10	17	21	22	11	14	15	6	7	8	—	—	—	3	4	6	5	6	8	10	11	13
From E: I-10 and SR-143	20	26	28	14	19	21	9	12	14	3	5	6	—	—	—	2	2	2	7	7	7
From F: I-10 and Baseline Road	22	30	31	16	23	24	11	16	17	5	9	9	2	4	3	—	—	—	5	5	5
From G: I-10 and SR-202L	27	41	40	21	34	33	16	27	26	10	20	18	7	15	12	5	11	9	—	—	—

Table 3-4 Travel Times, in Minutes

	To A: I-17 and SR-101L			To B: I-17 and Dunlap Road			To C: I-17 and Thomas Road			To D: I-17 and I-10			To E: I-10 and SR-143			To F: I-10 and Baseline Road			To G: I-10 and SR-202L		
PM peak period																					
From A: I-17 and SR-101L	—	—	—	6	8	9	11	17	18	17	26	29	20	32	36	22	36	39	27	47	47
From B: I-17 and Dunlap Road	6	11	13	—	—	—	5	9	9	11	18	20	14	24	27	16	28	30	21	39	38
From C: I-17 and Thomas Road	11	24	29	5	13	16	—	—	—	6	9	11	9	15	18	11	19	21	16	30	29
From D: I-17 and I-10	17	35	45	11	24	32	6	11	16	—	—	—	3	6	7	5	10	10	10	21	18
From E: I-10 and SR-143	20	40	51	14	29	38	9	16	22	3	5	6	—	—	—	2	4	3	7	15	11
From F: I-10 and Baseline Road	22	43	54	16	32	41	11	19	25	5	8	9	2	3	3	—	—	—	5	11	8
From G: I-10 and SR-202L	27	50	60	21	39	47	16	26	31	10	15	15	7	10	9	5	7	6	—	—	—

Notes: See Figure 3-11 for locations A through G. Green shading indicates uncongested (free-flow) conditions, yellow shading indicates today's conditions and red shading indicates 2040 conditions.

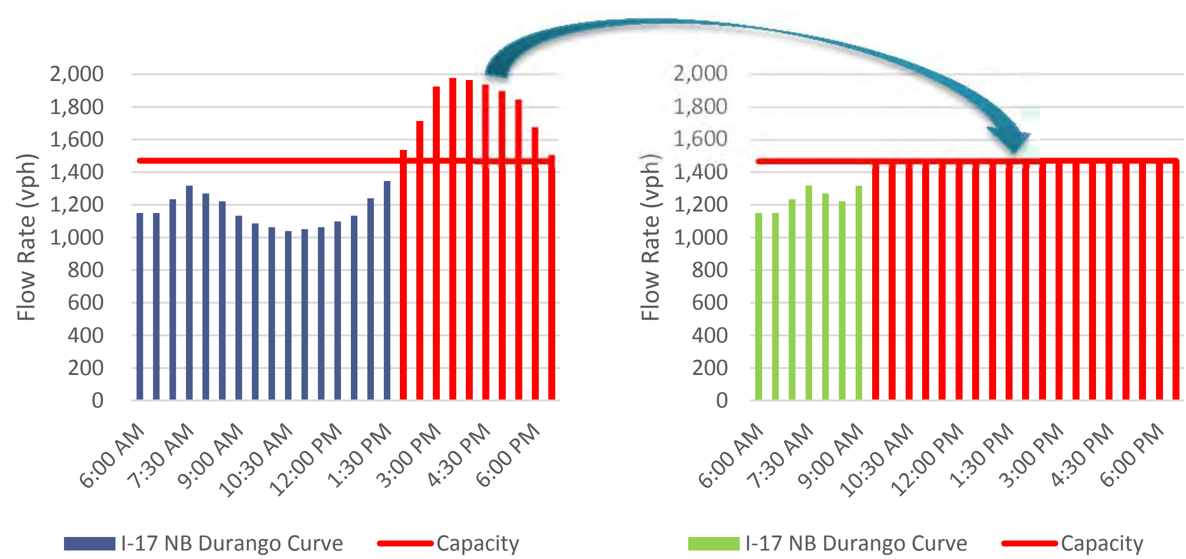
I-10 = Interstate 10, I-17 = Interstate 17, SR-143 = State Route 143, SR-202L = State Route 202L

3.6 Duration of Congestion

Travel in the Spine Interstate corridor is typically congested today during the AM and PM peak travel periods. This is anticipated to continue into the future. However, with the additional amount of traffic anticipated to want to travel in the corridor in the future, the number of hours during which congestion occurs is anticipated to increase in the future. Today's peak-hour volumes were reviewed to determine at what level of hourly travel demand the speed in the general purpose Interstate lanes drops to congested levels, with travel speeds of 50 mph or less.

It was determined that approximately 1,470 vehicles per hour per lane can be accommodated throughout the corridor before speeds will drop to congested levels. These data correlate with the LOS D threshold discussed in Section 3.2. Forecast Year 2040 traffic volumes throughout the day were compared with this threshold level to estimate of how many hours of congestion would be expected to occur in the future. Forecast Year 2040 volumes were distributed into 30-minute intervals using existing MAG performance dashboard data. In some intervals, the forecast Year 2040 volumes exceeded the congested flow rate. In these cases, the excess volume was distributed to the nearest interval with available uncongested capacity to account for the traffic phenomenon known as *peak spreading* (example shown in Figure 3-12). The number of hours that each segment of the corridor reached the congested flow rate was tallied. The results, summarized in Figure 3-13, indicate that congestion is expected to no longer be contained during the peak travel hours, but will continue for much longer portions of the day. In some instances, congestion is expected to last more than 12 hours.

Figure 3-12 Example of Peak Hour Spreading



Notes: I-17 = Interstate 17, NB = northbound, vph = vehicles per hour

3.7 Accessing the Interstate

In addition to the delays experienced by travelers once on the Interstates, drivers would experience additional delay going to, from and across the Interstate corridor. The level of congestion at the corridor interchanges can be estimated by comparing the interchange volumes to the capacity of the roadways entering the interchanges. Figures 3-14 and 3-15 display the anticipated LOS and associated level of congestion at each of the study area interchanges in the PM peak for today's conditions and anticipated Year 2040 conditions, respectively. As indicated in the figures, over 75 percent of the corridor interchanges are operating at LOS D or better today. In the future, less than 40 percent of the corridor interchanges will operate at LOS D or better.

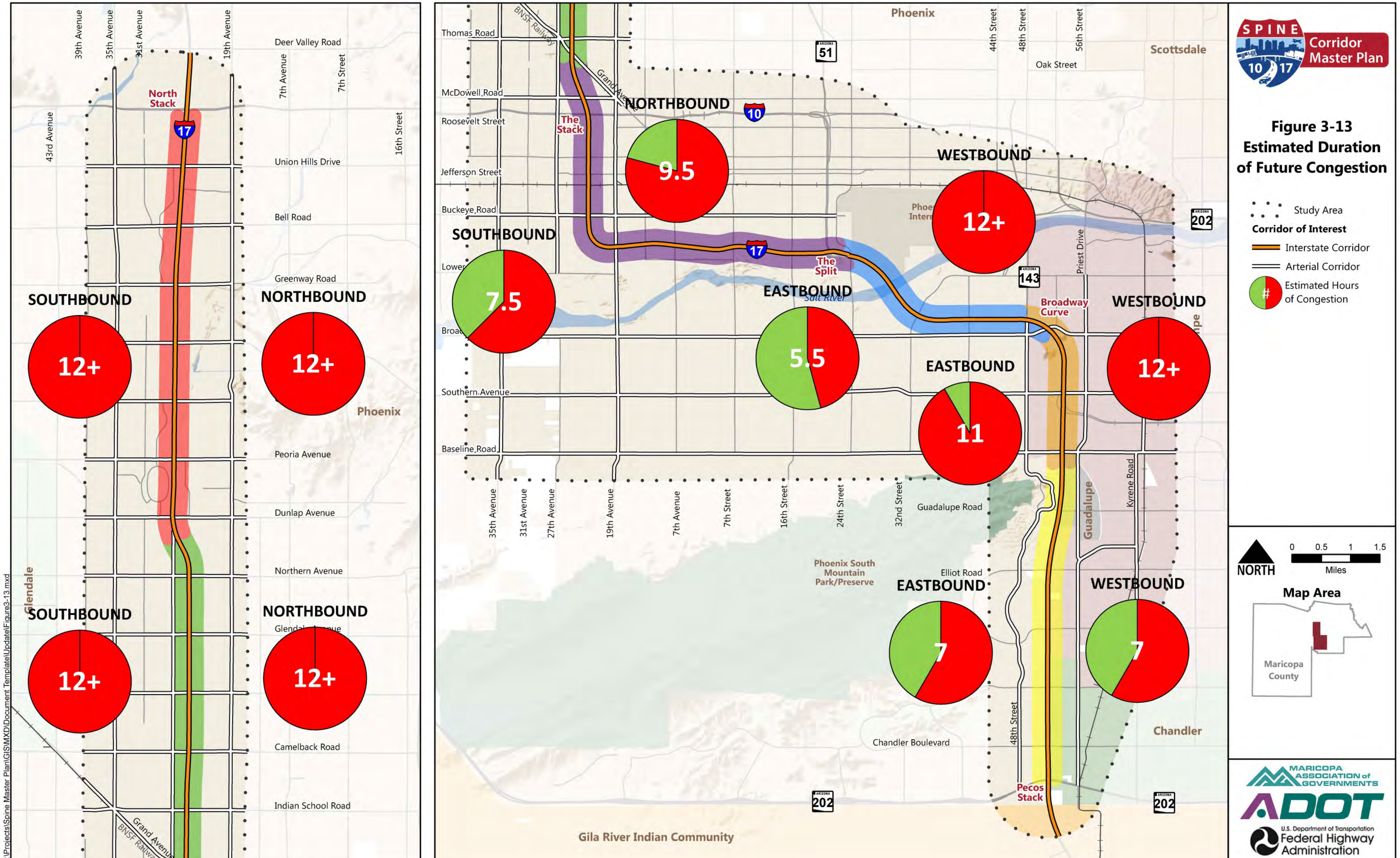
While overall interchange operations are reported to be acceptable in many locations, it is important to note that certain approaches may have traffic volumes that exceed the available capacity. Figures 3-16 and 3-17 illustrate the LOS on the corridor interchange approaches in the PM peak for today's conditions and anticipated Year 2040 conditions, respectively. Today, over half of the Interstate approaches are operating at LOS D or better, whereas almost 80 percent of the arterial approaches are operating at LOS D or better. In the future, less than one-third of the Interstate approaches will operate at LOS D or better, while over half of the arterial approaches will operate at LOS D or better. Table 3-5 summarizes interchange performance under existing Year 2014 and Year 2040 conditions.

Table 3-5 Summary of Corridor Interchange Performance

Facility	LOS A ≤0.50	LOS B 0.51–0.60	LOS C 0.61–0.72	LOS D 0.73–0.84	LOS E 0.85–1.00	LOS F ≥1.01	Acceptable LOS D or better	Failing LOS E or F	Total
Existing Year 2014 conditions									
Interchanges	1 (3%)	2 (6%)	5 (16%)	17 (53%)	7 (22%)	0 (0%)	25 (78%)	7 (22%)	32
Arterial approaches	5 (8%)	14 (22%)	17 (27%)	14 (22%)	8 (13%)	5 (8%)	50 (79%)	13 (21%)	63
Interstate approaches	4 (7%)	2 (3%)	13 (22%)	14 (24%)	21 (36%)	4 (7%)	33 (57%)	25 (43%)	58
All approaches	9 (7%)	16 (13%)	30 (25%)	28 (23%)	29 (24%)	9 (7%)	83 (69%)	38 (31%)	121
Forecast Year 2040 conditions									
Interchanges	0 (0%)	2 (6%)	2 (6%)	8 (25%)	11 (34%)	9 (28%)	12 (38%)	20 (63%)	32
Arterial approaches	2 (3%)	5 (8%)	11 (17%)	18 (29%)	11 (17%)	16 (25%)	36 (57%)	27 (43%)	63
Interstate approaches	1 (2%)	3 (5%)	6 (10%)	7 (12%)	24 (41%)	17 (29%)	17 (29%)	41 (71%)	58
All approaches	3 (2%)	8 (7%)	17 (14%)	25 (21%)	35 (29%)	33 (27%)	53 (44%)	68 (56%)	121

Note: LOS = level of service

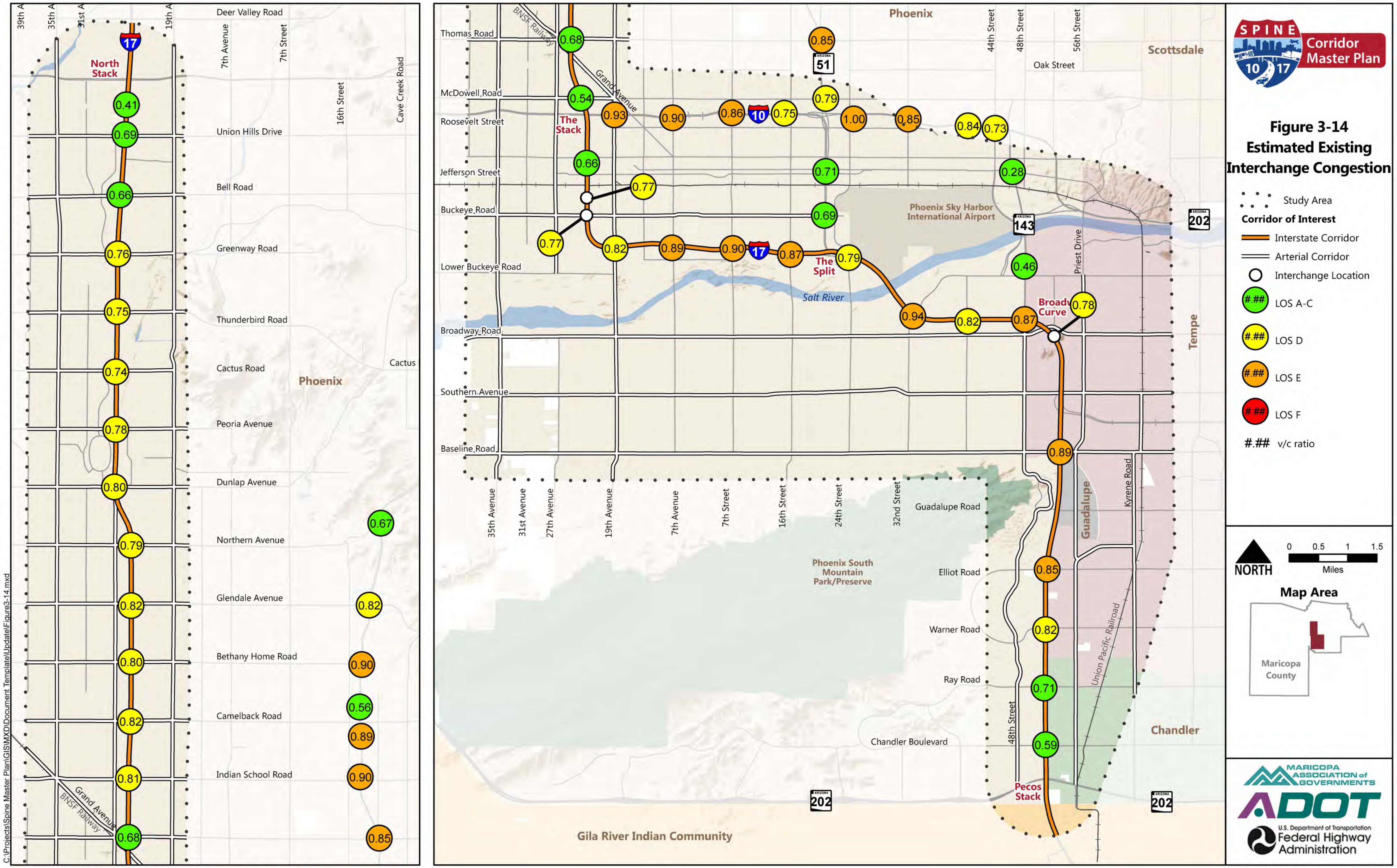
Figure 3-13 Estimated Duration of Future Congestion



Data Source: ADOT, ALRIS, FEMA, MAG Travel Demand Model

Map Last Updated: 5/12/2016

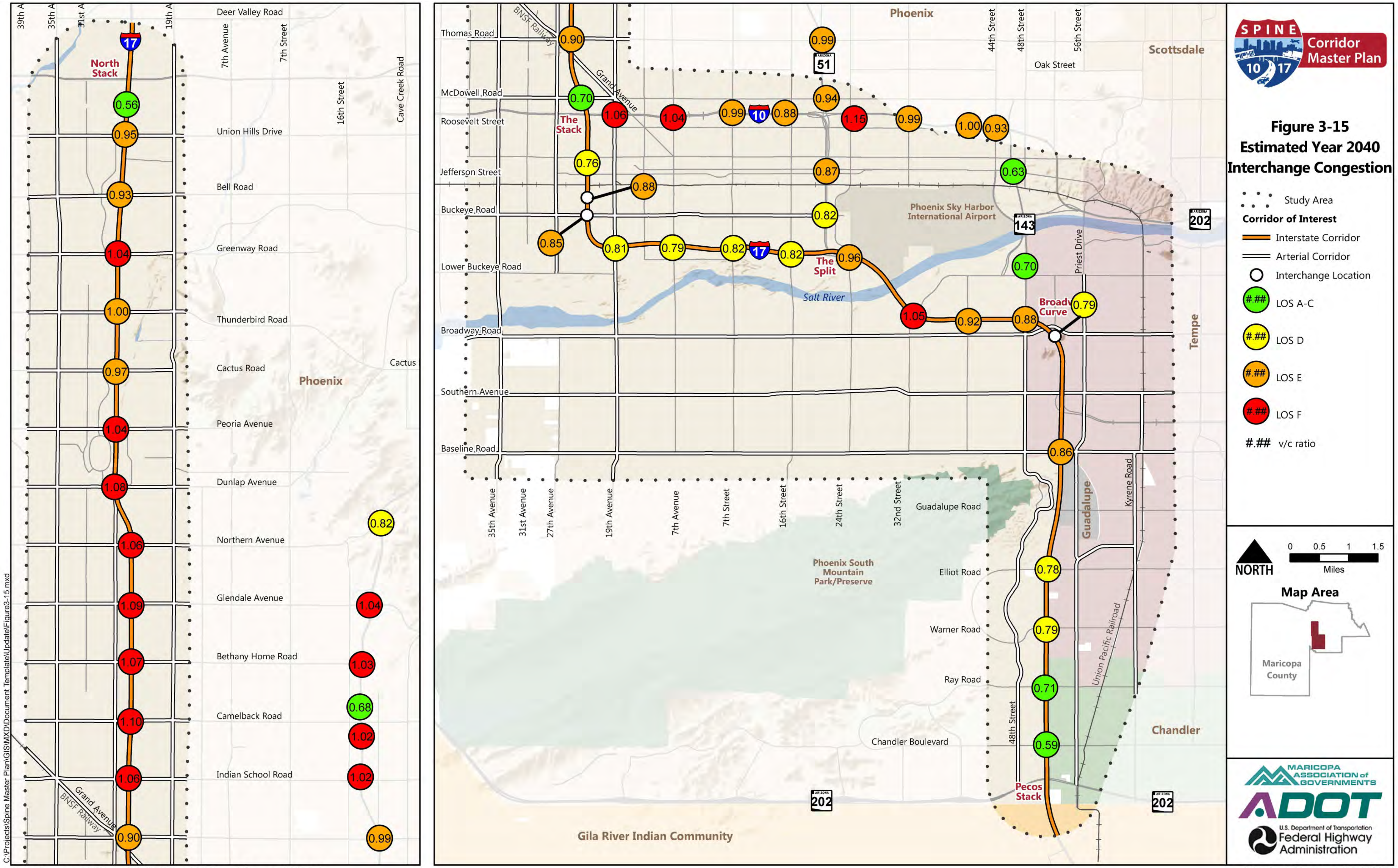
Figure 3-14 Estimated Existing Interchange Congestion



Data Source: ADOT, ALRIS, FEMA, MAG Travel Demand Model

Map Last Updated: 5/13/2016

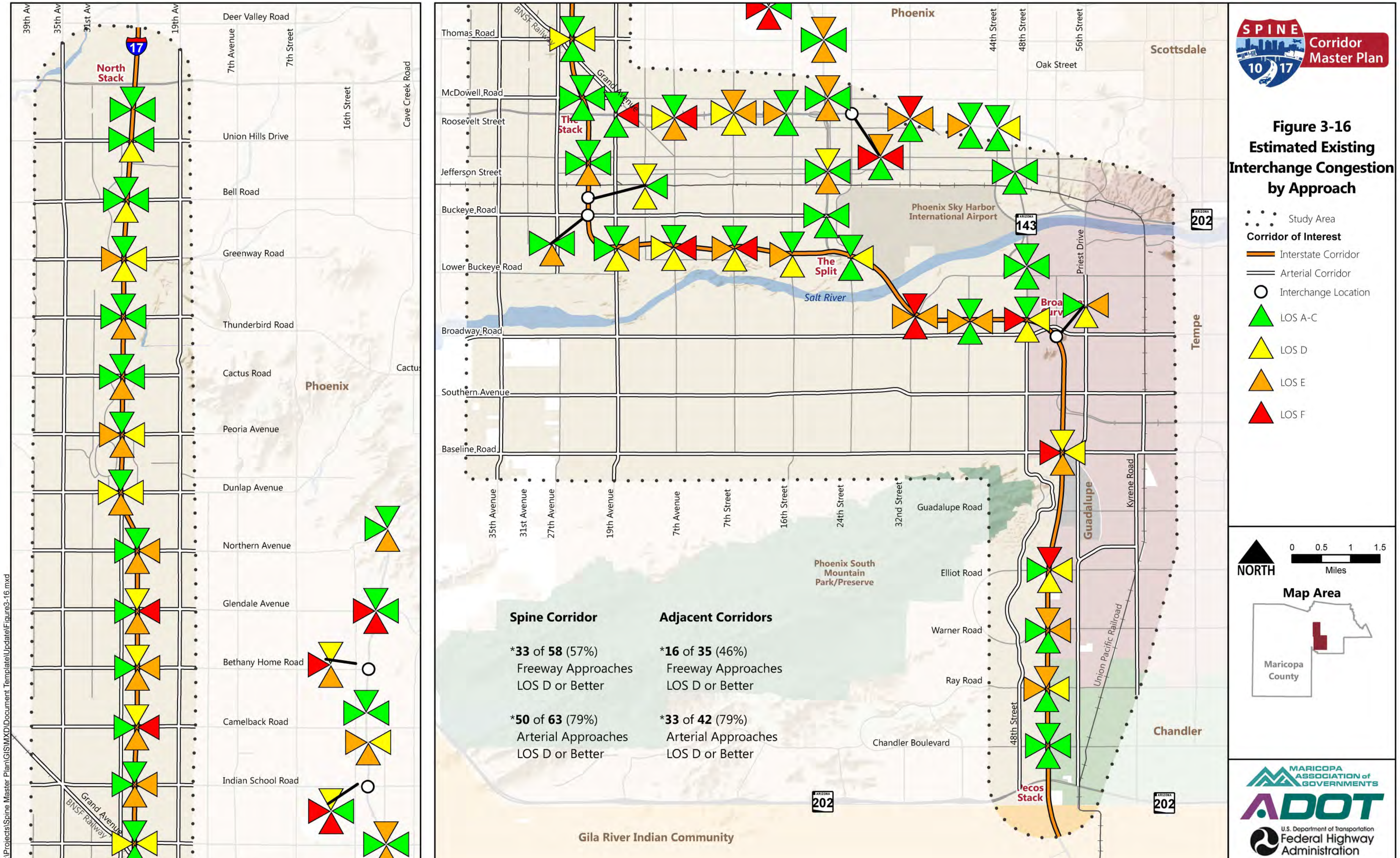
Figure 3-15 Estimated Year 2040 Interchange Congestion



Data Source: ADOT, ALRIS, FEMA, MAG Travel Demand Model

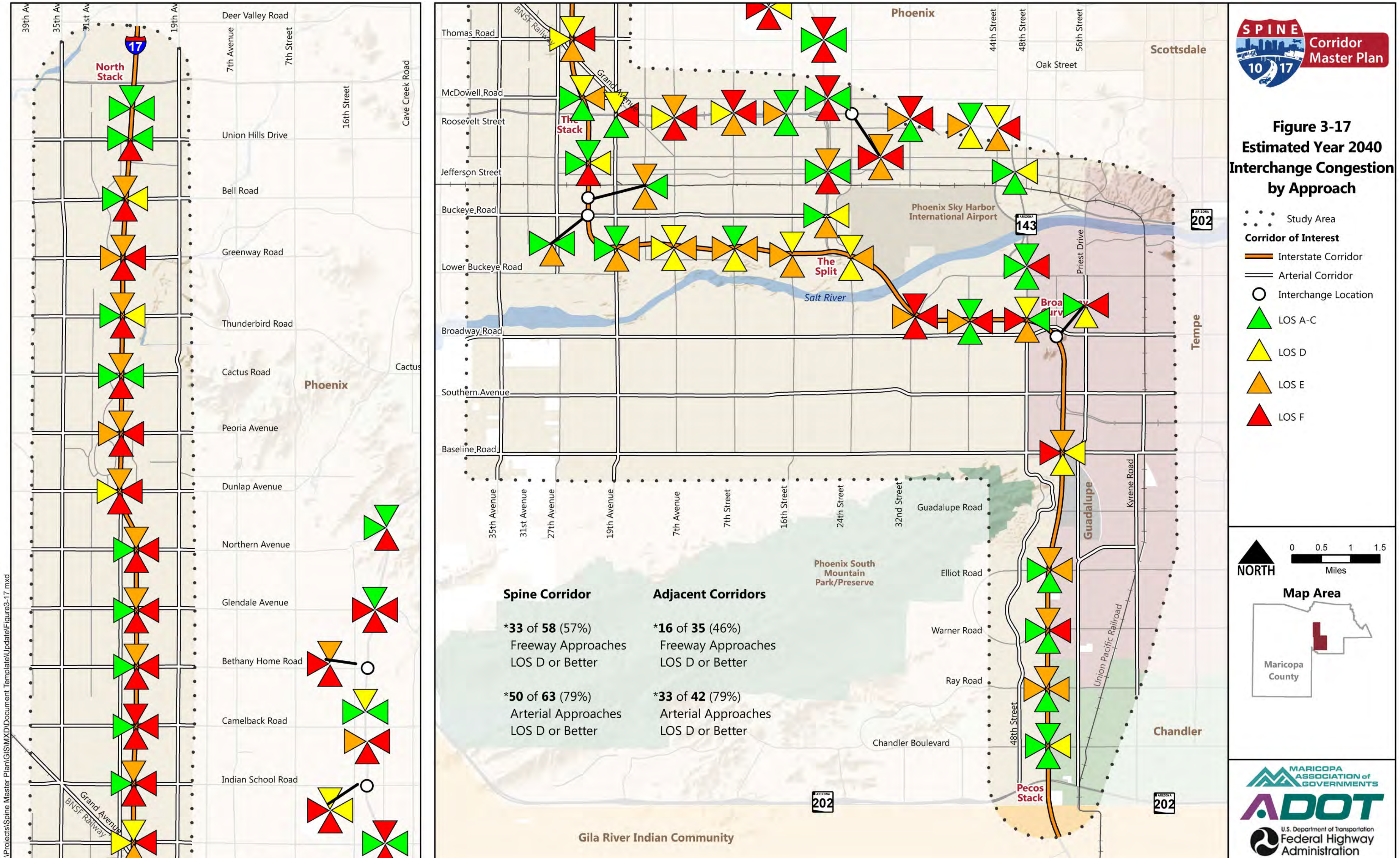
Map Last Updated: 5/13/2016

Figure 3-16 Estimated Existing Year 2014 Interchange Congestion by Approach



Data Source: ADOT, ALRIS, FEMA, MAG Travel Demand Model

Figure 3-17 Estimated Year 2040 Interchange Congestion by Approach

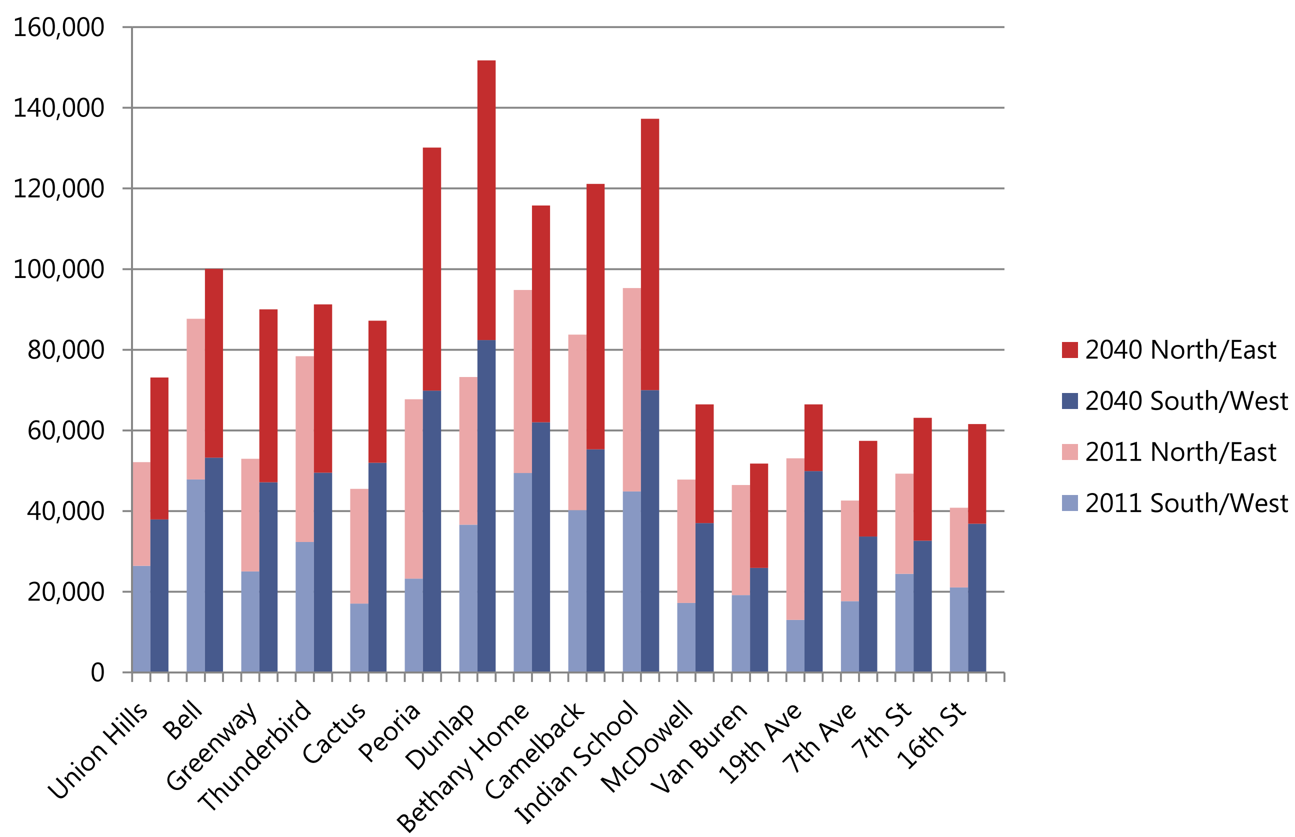


Data Source: ADOT, ALRIS, FEMA, MAG Travel Demand Model

Map Last Updated: 5/13/2016

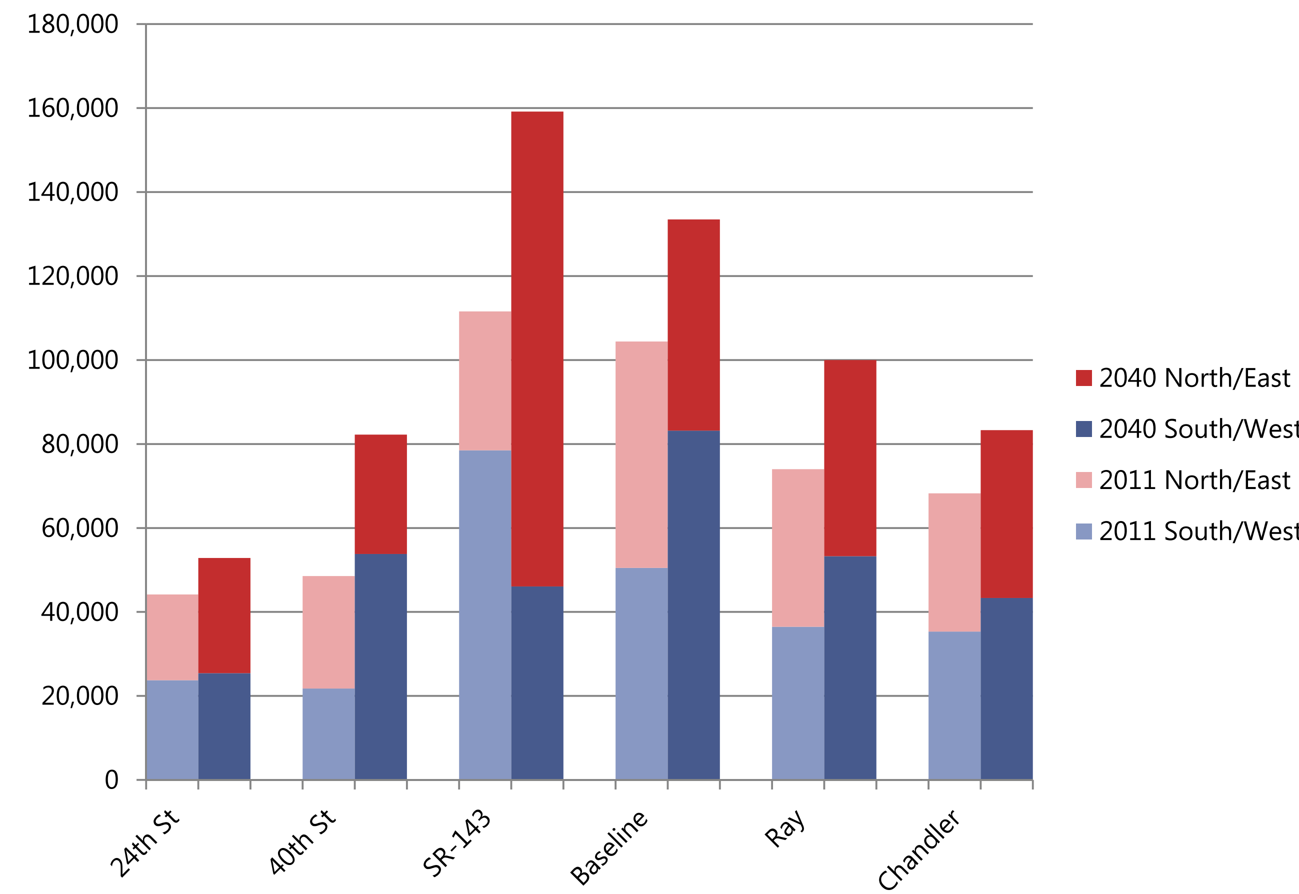
While the majority of the arterial approaches today are operating acceptably, there was some disparity in the directional approach volumes accessing the Interstates. Figures 3-18 and 3-19 provide a comparison of the daily arterial approach volumes along the corridor, by direction, for I-17 and I-10, respectively. Most notably, volumes approaching I-17 from the west are higher at Cactus Road, Peoria Avenue, McDowell Road and Van Buren Street. On I-10, volumes are much higher from the west at 19th Avenue and from the east at SR-143.

Figure 3-18 Daily Arterial Approach Volumes for I-17, by Direction



Notes: I-17 = Interstate 17

Figure 3-19 Daily Arterial Approach Volumes for I-17/I-10, by Direction



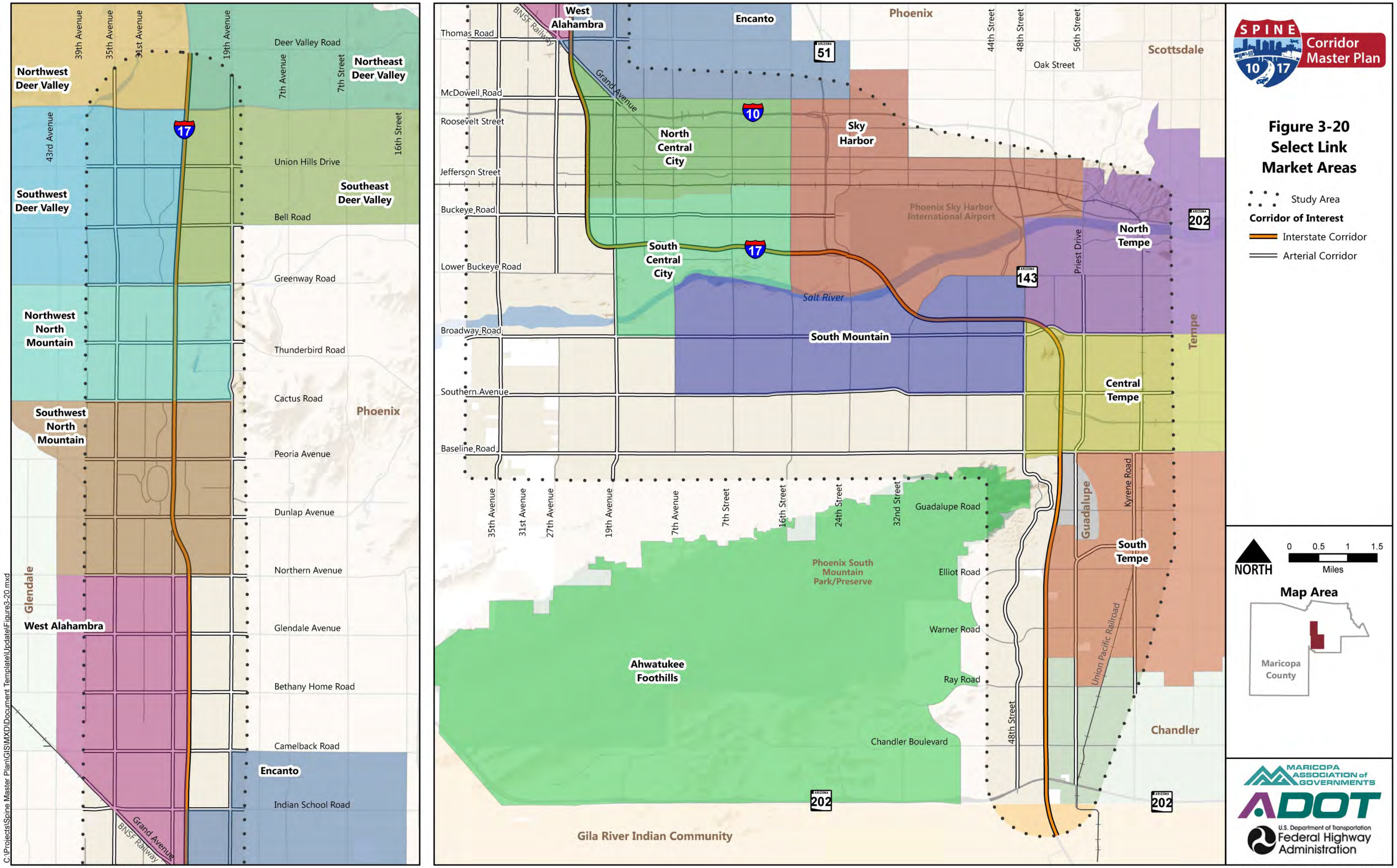
Notes: I-10 = Interstate 10, I-17 = Interstate 17

3.8 Identification of Key Study Area Origin-Destination Pairs

To better understand the travel characteristics of vehicles using the Spine Interstate corridor, specifically the primary markets served by the facility, a select link analysis was performed at various locations along the corridor for the forecast Year 2040 PM peak period. Select link analysis isolates a specific link in the transportation network and extracts more detailed information about users of the facility, such as the origin and destination of their trips. Using this information about trip origins and destinations, a list of the most critical origin-destination connections served by the corridor was compiled. Figure 3-20 displays the top market areas served by the Spine Interstate corridor, and Table 3-6 summarizes the most prominent origin-destination pairs along various segments in the corridor. Table 3-6 indicates that several key origin-destination pairs in the study area could be targeted for strategies to reduce travel in the corridor to alternative routes or modes; however, each represents only 1 to 4 percent of the total traffic in the corridor.

Additional analysis was conducted using the select link data to determine the portion of trips using the Spine Interstate corridor that had either an origin or destination within the study area, within the MAG region, or outside of the MAG region. Table 3-7 summarizes these results.

Figure 3-20 Select Link Market Areas



Data Source: ADOT, ALRIS, FEMA

Map Last Updated: 5/12/2016

Table 3-6 Critical Select Link Origin-Destination Pairs

Select link	Point A	Point B	A to B and B to A trips	All trips on link	AB/BA trips as % of all trips
I-17 between Bell and Union Hills Roads	Northwest Deer Valley	Northwest North Mountain	1,506	70,102	2
	Northwest Deer Valley	Southwest Deer Valley	2,193	70,102	3
	Northwest Deer Valley	Southwest North Mountain	2,065	70,102	3
	Southwest Deer Valley	Northeast Deer Valley	1,046	70,102	1
I-17 between Cactus Road and Peoria Avenue	Arrowhead Glendale	Southwest North Mountain	1,031	74,813	1
	Northwest Deer Valley	Southwest North Mountain	1,943	74,813	3
	Northwest North Mountain	Southwest North Mountain	2,552	74,813	3
	Southeast Deer Valley	Southwest North Mountain	1,719	74,813	2
	Southeast Deer Valley	West Alhambra	1,011	74,813	1
	Southwest Deer Valley	Southwest North Mountain	2,589	74,813	3
I-17 between Thomas and McDowell Roads	Southwest North Mountain	North Central City	1,318	71,719	2
	West Alhambra	North Central City	2,024	71,719	3
	West Alhambra	Sky Harbor	1,112	71,719	2
I-17 at the Durango Curve	West Alhambra	South Mountain	986	54,649	2
I-10 between 24th and 32nd Streets	Encanto	Central Tempe	1,205	90,400	1
	Encanto	South Mountain	1,163	90,400	1
	Encanto	South Tempe	1,039	90,400	1
	North Central City	Central Tempe	1,220	90,400	1
	North Central City	North Tempe	1,316	90,400	1
	North Central City	South Tempe	1,096	90,400	1
	South Central City	North Tempe	1,122	90,400	1
I-10 between 40th and 48th Streets	Encanto	South Tempe	1,039	84,104	1
	North Central City	North Tempe	1,229	84,104	1
	North Central City	South Tempe	1,096	84,104	1
	Sky Harbor	Central Tempe	1,010	84,104	1
	Sky Harbor	South Tempe	1,095	84,104	1
	South Central City	North Tempe	994	84,104	1

Table 3-6 Critical Select Link Origin-Destination Pairs

Select link	Point A	Point B	A to B and B to A trips	All trips on link	AB/BA trips as % of all trips
I-10 between Broadway Road and US-60	Encanto	South Tempe	1,117	88,728	1
	North Central City	South Tempe	1,096	88,728	1
	Sky Harbor	Ahwatukee Foothills	1,360	88,728	2
	Sky Harbor	Central Tempe	1,484	88,728	2
	Sky Harbor	South Tempe	1,778	88,728	2
I-10 between Baseline and Elliot Roads	Central Tempe	Ahwatukee Foothills	1,301	65,849	2
	Central Tempe	South Tempe	1,207	65,849	2
	North Tempe	Ahwatukee Foothills	2,489	65,849	4
	North Tempe	South Tempe	1,515	65,849	2
	Sky Harbor	Ahwatukee Foothills	1,360	65,849	2
	Sky Harbor	South Tempe	1,214	65,849	2
	South Mountain	Ahwatukee Foothills	1,009	65,849	2
	South Mountain	South Tempe	1,519	65,849	2
I-17 between Camelback and Bethany Home Roads	Southwest North Mountain	Encanto	1,360	71,789	2
	Southwest North Mountain	North Central City	1,318	71,789	2
	Southwest North Mountain	West Alhambra	1,527	71,789	2

Notes: I-10 = Interstate 10, I-17 = Interstate 17, US-60 = U.S. Route 60

Table 3-7 Trip Origin/Destination Analysis

Trip origin – destination	Percentage of all trips
Study area – study area	25
Study area – MAG region	57
MAG region – MAG region	11
At least one trip end outside of MAG region	7

Note: MAG = Maricopa Association of Governments

3.9 Transportation System Management and Transportation Demand Management

Transportation system management (TSM) refers to an integrated approach that continuously strives to optimize the performance of the multimodal transportation system. This is accomplished through multimodal, crossjurisdictional systems and services. These systems are designed to improve efficiency, safety and reliability of the transportation system. Implementation of TSM programs helps accommodate the safe and efficient movement of people and freight within the transportation system.

Transportation demand management (TDM) reduces congestion by encouraging more efficient use of existing transportation infrastructure through alternatives to driving alone. Reducing vehicle miles traveled also helps improve air quality by decreasing vehicular emissions contributing to the total amount of air pollutants. TDM programs encourage reductions in travel demand within the transportation system. TDM activities generally focus on both improved travel choice and incentives to reduce driving alone. These programs promote alternatives to driving alone, including carpooling, vanpooling, transit, walking and bicycling. TDM also encourages alternative work schedules that reduce trips, including teleworking and compressed work schedules. TDM activities generally focus on commute trips and student trips during peak travel periods.

3.10 Summary of Identified Issues

In the following sections, issues relating to travel demand, operations and corridor access are discussed for the various study area segments.

Segment I1: I-10, SR-202L to Baseline Road

Despite programmed widening on this segment of I-10, issues relating to operations and corridor access are still expected by 2040. Specifically, eastbound I-10 at Cutline 12 is projected to operate at LOS E in the Year 2040 PM peak. To accommodate all future demand without congestion in the Year 2040 PM peak, further widening to six general purpose lanes in each direction will be required on I-10. As far as corridor access is concerned, the I-10 traffic interchange at Baseline Road is also anticipated to operate at LOS E in the Year 2040 PM peak because of failing operations on eastbound I-10 (LOS E) and eastbound Baseline Road (LOS F).

Segment I2: I-10, Baseline Road to the Split

In the Year 2040 PM peak, I-10 experiences failing conditions at three of four segment cutlines in both the eastbound and westbound directions. At the most congested cutline, Cutline 9, a total of 22 lanes would be needed on I-10 to accommodate all PM peak travel demand without congestion. Without the addition of any lanes, congested conditions by 2040 are expected to spread outside of the morning and afternoon peaks and last for 11 hours in the eastbound direction and 12 hours or longer in the westbound direction. In addition to the operational issues for general purpose lanes in this segment of I-10, there are a number of corridor access issues. In fact, five of six interchanges between Baseline Road and the Split are projected to fail by 2040.

Segment I3: I-17, the Split to the Stack

In the Year 2040 PM peak, northbound I-17 is forecast to operate above capacity at both cutline locations in this segment. Numerous locations in this segment are also anticipated to experience severe congestion: v/c ratios in excess of 1.25 (northbound in the PM peak and southbound in the AM peak). Given the high demand forecast for this facility, I-17 would need to be expanded to 10 lanes in just the northbound direction at Cutline 6 to accommodate all Year 2040 PM peak demand without congestion. These congested conditions on I-17 are also expected to create corridor access issues. Because of congestion on the Interstate facilities, two of seven interchanges in this segment are anticipated to operate at LOS E: Buckeye Road and Jefferson/Adams Street.

Segment I4: I-17, the Stack to ACDC

In the Year 2040 PM peak, I-17 general purpose lanes are expected to operate at LOS E or worse in both directions at both cutline locations in this segment. In fact, the entirety of this segment of I-17 is expected to operate over capacity in the peak direction of travel (northbound in PM peak and southbound in AM peak), with multiple locations experiencing v/c ratios in excess of 1.25. It would take 13 lanes in the northbound direction alone to accommodate forecast volumes without congestion.

Additionally, this segment of the corridor will experience access issues, with nine of 10 interchanges operating at LOS E or F. Without mitigation, congested conditions are expected to exceed 12 hours per day in both directions of this segment of I-17.

Segment I5: I-17, ACDC to the North Stack

In this segment of I-17 in the Year 2040 PM peak, general purpose lanes are expected to operate at LOS E or worse in both directions at all three cutline locations. All of northbound I-17 is projected to operate at LOS E or F, with a few locations experiencing v/c ratios in excess of 1.25. To accommodate forecast demand, I-17 would need to be widened to 12 lanes in just the northbound direction at certain locations. Without mitigation, congested conditions in excess of 12 hours per day are expected for both directions of travel on this segment of I-17. In addition to the congestion on the general purpose lanes, vehicles on this segment are anticipated to experience congestion at the traffic interchanges, with six of seven operating at LOS E or F.

Segment A1: 48th Street, 56th Street/Priest Drive and Kyrene Road

A couple of currently congested areas on these arterial facilities are expected to remain congested or experience further congestion by 2040. Currently, the half mile of 48th Street north of Guadalupe Road operates at LOS E. Operations on this segment will deteriorate to LOS F by 2040 in both the AM and PM peak. The half-mile segment of Priest Drive south of Baseline Road currently operates with a v/c ratio of 1.01 to 1.25 in the AM peak and a v/c ratio in excess of 1.25 in the PM peak. These failing conditions are expected to persist into 2040 despite programmed improvements to the adjacent, parallel facility, I-10.

Segment A2: Baseline Road, Southern Avenue, Broadway Road and Buckeye Road

In the PM peak, Broadway Road between 24th and 32nd Streets and a half mile west of 40th Street, Southern Avenue a half mile east of 40th Street and Baseline Road a mile west of I-10 are expected to operate under failing conditions by 2040. Additionally, the segment of Baseline Road directly west of I-10 is forecast to experience a v/c ratio in excess of 1.25.

Segment A3: 35th Avenue, 27th Avenue and 19th Avenue

By 2040, LOS E conditions are scattered throughout the extents of 19th Avenue and 35th Avenue in the study area. LOS F conditions are anticipated on 19th Avenue from Lower Buckeye Road to I-17.

Segment A4: East-to-west arterials crossing I-17

By 2040, 10 of 18 westbound interchange approaches of arterials crossing I-17 are anticipated to operate at LOS E or worse in the PM peak. Two of 17 eastbound interchange approaches will operate at LOS E.

By 2040, LOS E conditions are scattered throughout the extents of Grand Avenue in the study area. LOS F conditions are anticipated on significant portions of Grand Avenue.

4 Roadway Infrastructure

4.1 Introduction

To assess the infrastructure needs of the Spine study area, the existing conditions of all the corridors of interest and infrastructure within the Spine study area are compiled in this chapter. The corridors of interest have been chosen by identifying key transportation corridors within the Spine study area. These corridors include both Interstate corridors and major arterial corridors (Figure 4-1).

4.1.1 Interstate 10 and Interstate 17

The two Interstate segments within the Spine study area are I-10 (extending from the Pecos Stack in the southern part of Phoenix to the Split) and I-17 (extending from the Split to the North Stack).

The I-10 segment is the primary route that connects southern Arizona with the Phoenix metropolitan area, a heavily used commuter route into and out of downtown Phoenix and a major east-to-west corridor for the southwestern United States.

The I-17 segment is a heavily used commuter route to downtown Phoenix, and is the southern segment of the only Interstate that connects northern Arizona with the Phoenix metropolitan area and southern Arizona.

4.1.2 Arterials

Twenty-five arterials have been identified as corridors of interest within the Spine study area. The primary group of arterials consists of ten arterials that are parallel to the Spine Interstate corridors:

- 48th Street
- Priest Drive
- Kyrene Road
- Baseline Road
- Southern Avenue
- Broadway Road
- Buckeye Road
- 35th Avenue
- 27th Avenue
- 19th Avenue

All of these arterials are approximately within 1 mile of the Spine Interstate corridors, with the exception of Baseline Road. Given their proximity to the Spine Interstate corridor, the parallel arterials function as relieving corridors and the primary alternative routes to the Interstates when demand exceeds the Interstates' capacity or when there is an incident on the Interstate corridors. For the purpose of the Spine study, a secondary group of 15 arterials has been identified as the crossing arterials; this group includes the following:

- McDowell Road
- US-60/Grand Avenue
- Thomas Road
- Indian School Road
- Camelback Road
- Bethany Home Road
- Glendale Avenue
- Northern Avenue
- Dunlap Avenue
- Peoria Avenue
- Cactus Road
- Thunderbird Road
- Greenway Road
- Bell Road
- Union Hills Drive

These arterials are all of the major arterials that cross I-17 between the Stack and the North Stack and include a service interchange connection with I-17 except for US-60/Grand Avenue. The crossing arterials perform the important function of connecting the Interstate corridor to the parallel arterial connectors and providing the only crossings of I-17 between two heavily populated regions of the Phoenix metropolitan area. Because these arterials are the only crossings of I-17 between the Stack and the North Stack, they become pinch points in the east-to-west transportation system, which causes the Interstate and arterial intersections to break down during peak hours. This breakdown of the arterial system affects the operations of I-17 when the traffic interchange ramps back up onto the main line. The other major arterials within the Spine study area not designated as corridors of interest have significantly less crossing volumes due to land use and the presence of Sky Harbor International Airport, the South Mountains and the Salt River.

4.2 Design Exceptions

4.2.1 Interstates

Although records of all of the design variances and exceptions for the I-10 and the I-17 corridors exist, these records are not all compiled at a central location. The only way these documents can be identified is by searching through the project archives, which was outside of the scope of this study. As the recommendations of the Spine study are advanced, an element of the design effort will be to identify and evaluate all of the design variances and design exceptions within the limits of the recommendations to determine whether the design variances and design exceptions will be rectified. Refer to the ADOT *Design Exception and Design Variance Process Guide* for more information on ADOT design exceptions and design variances.

4.2.2 Arterials

Requests were made with the Cities of Chandler, Tempe and Phoenix and the Town of Guadalupe for design variances and exceptions that exist on the identified arterial corridors of interest. At the time of preparation of this report, information on existing arterial design variances and design exceptions had not been received by the study team. Refer to Section 3.3 in the *Interstate 10/Interstate 17 Corridor Master Plan Controlling Design Criteria and Design Exception/Variance Procedures* document for more information on design exception procedures for the Cities of Chandler, Tempe and Phoenix.

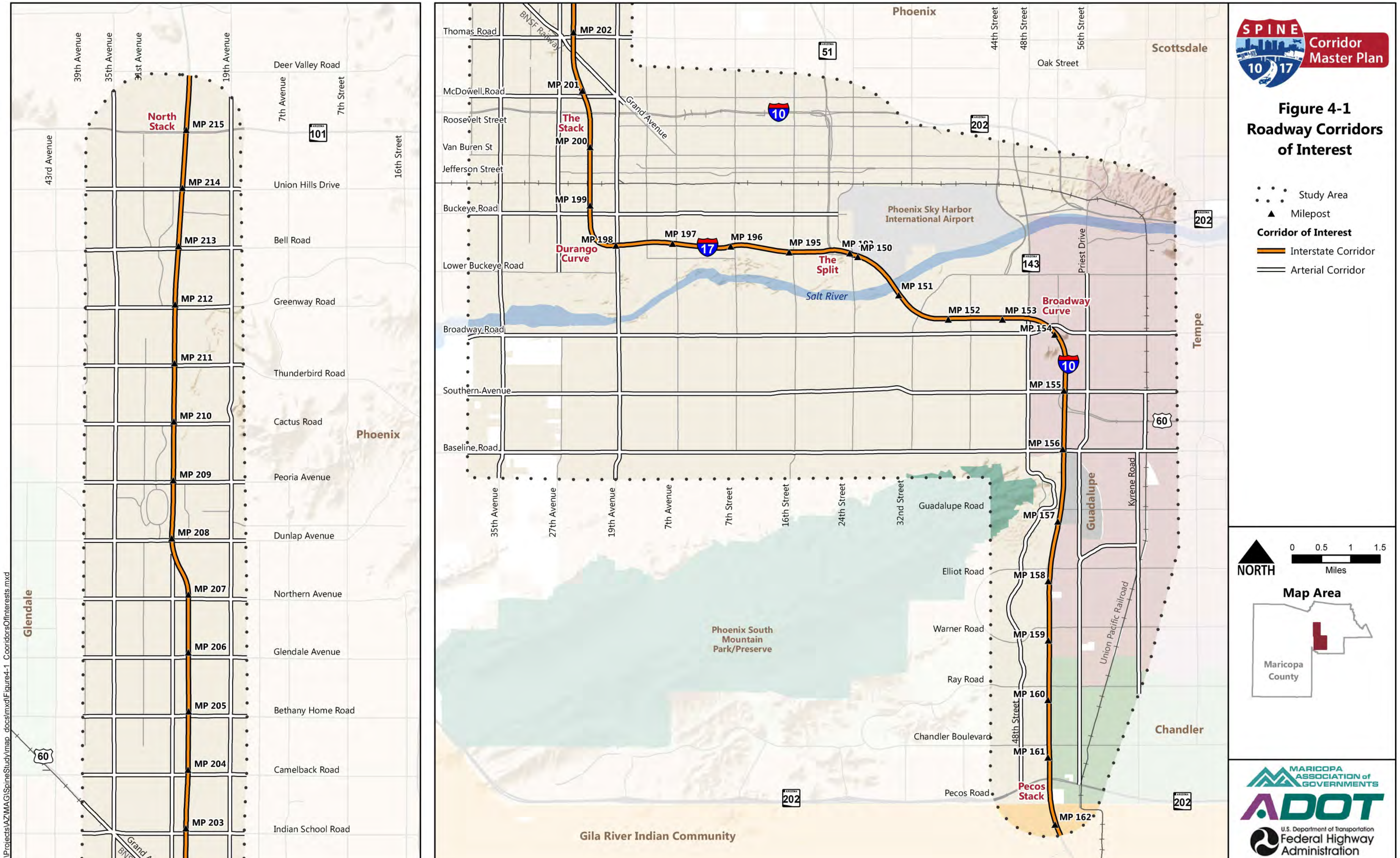
4.3 Right-of-Way

Transportation ROW is a type of permanent easement granted or reserved over the land for transportation purposes. Agencies that own transpiration facilities must own the land on which the transportation facility exists in the form of ROW to build and maintain the facility. The ROW can either be acquired through a purchase or a condemnation process in which fair market value is paid for the property. Sufficient ROW must exist within the transportation corridor to accommodate the transportation facility and its maintenance.

4.3.1 Interstates

Figure 4-2 shows an inventory of the I-10 and I-17 lanes and the ADOT ROW. This figure gives a high-level look at where ROW constraints may exist on the Interstate corridor and where there may be available ROW for additional Interstate widening. Much of the existing I-10/I-17 ROW is adjacent to developed private property.

Figure 4-1 Roadway Corridors of Interest



Source: ADOT, ALRIS, FEMA

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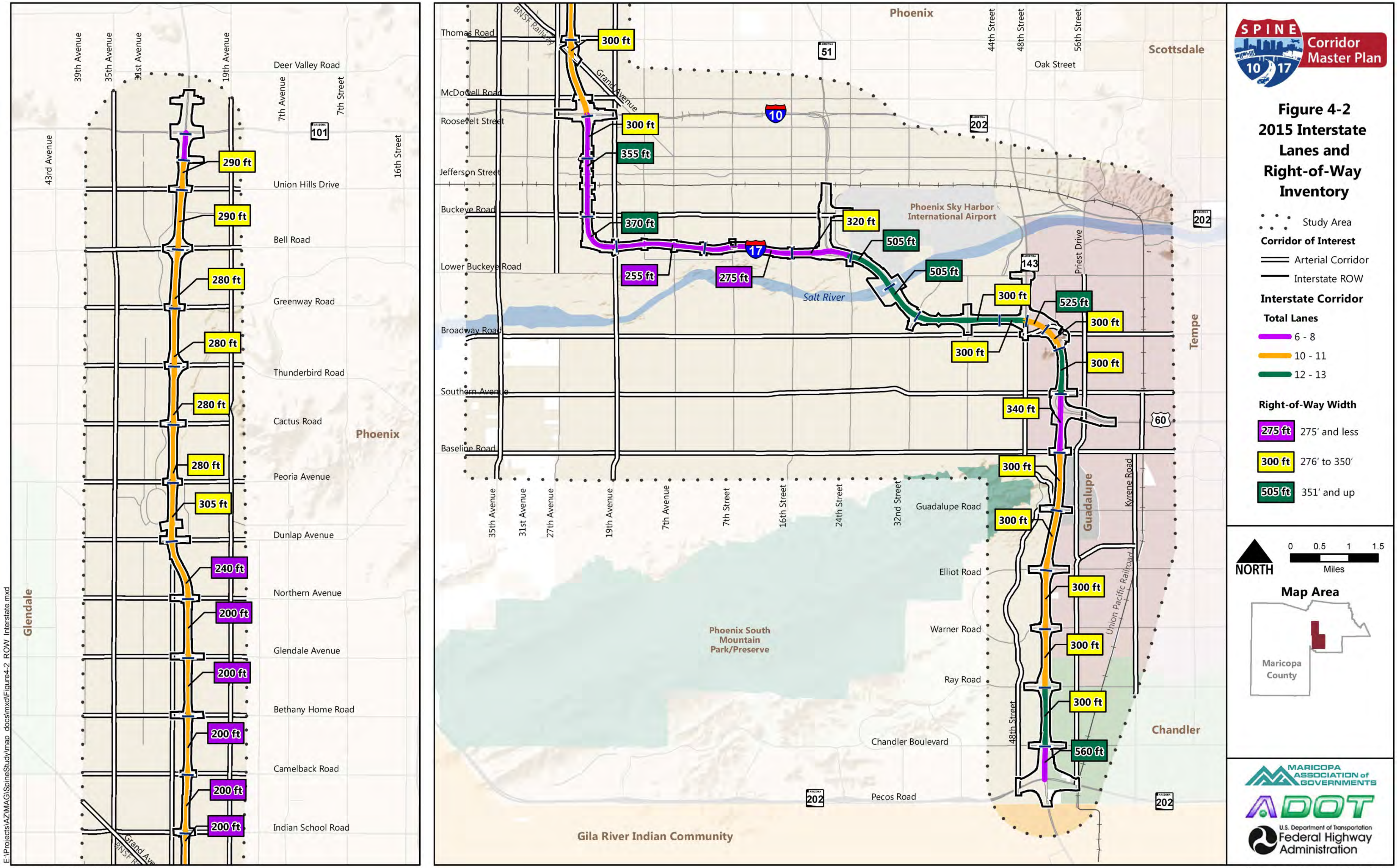
Figure 4-2 2015 Interstate Lanes and Right-of-Way Inventory



Source: ADOT, ALRIS, FEMA

Map Last Updated: 5/3/2016

It would be expensive to acquire additional ROW along most of the Interstate corridor because the adjacent property is developed; however, there are segments along the Interstate that are adjacent to less-developed property that may be easier to obtain if additional ROW is needed to facilitate any projects in those areas.

4.3.2 Arterials

Arterial ROW widths were not complied in a figure for this report. Given the number of miles of arterials covered in this corridor, the ROW shapes and widths were not available to summarize in a figure. Similar to the Interstate scenario, most of the existing arterial ROW is adjacent to private developed property. Additional ROW acquisition for roadway improvements typically would be expensive and most likely unpopular with affected stakeholders. Typical major arterial ROW widths for each of the cities and towns are listed in Table 4-1.

Table 4-1 City Arterial Right-of-Way Range

City	Arterial right-of-way range (feet)
Chandler	100–140
Guadalupe	110–130
Tempe	110–130
Phoenix	100–140

4.4 Existing Lane Configuration

The capacity and flow of vehicles in a corridor is significantly affected by the number of lanes and configuration of the lanes within that corridor. The more lanes you have on a corridor, the more vehicles you can move through the corridor.

4.4.1 Interstates

From the Pecos Stack to the I-10/US-60 interchange, I-10's current typical section consists of three general purpose lanes, one HOV lane and one auxiliary lane in each direction. The Broadway Curve project, currently being designed, is scheduled to be constructed by 2020. It will increase I-10's cross section from three to four general purpose lanes from the Pecos Stack to the I-10/US-60 interchange. As the Interstate corridor goes through the Broadway Curve from the I-10/US-60 interchange to the Split, the typical section has a varying lane configuration with the total number of lanes fluctuating between 10 and 13. The Broadway Curve project will add braided ramps through the Broadway Curve to remove the ramp weaving off the I-10 main line.

From the Split to the Stack, I-17's typical section consists of three general purpose lanes in each direction. Between the Split and 19th Avenue, a project scheduled to be constructed by 2020 will add auxiliary lanes in both directions of I-17 through that section. The final segment of the Spine Interstate corridor, from the Stack to the North Stack, has three general purpose lanes with a HOV lane and an auxiliary lane in each direction.

Figure 4-2 shows the total number of Interstate lanes within the Spine study area, and Figure 4-3 shows the Interstate lane configuration.

4.4.2 Arterials

The typical sections for arterials within the Spine study area range from two lanes with no median to six lanes with a two-way, left-turn center lane or a raised median. Figure 4-4 shows the lane configuration for the arterial corridors of interest. Most of the arterials have a six-lane cross section with a two-three split and a two-way, left-turn lane.

The majority of the arterial corridors of interest identified as part of the Spine study area are within the Phoenix city limits. A City of Phoenix policy dating to 1982 dictates that arterial lane configurations have a lane split that favors vehicles leaving the center of the city.

4.5 Corridor Physical Characteristics

In addition to the number of lanes and the lane configuration, physical characteristics of the corridors affect their capacity and flow.

4.5.1 Interstates

The entire length of I-10 within the Spine study area has a posted speed limit of 65 mph. From the Split to Peoria Avenue, I-17 has a posted speed of 55 mph; from Peoria Avenue to the North Stack, the posted speed limit increases to 65 mph.

Physical characteristics of the Interstate corridors can have both positive and negative effects on the corridor's vehicle capacity as well as the speed at which vehicles travel through the corridor. Figure 4-5 identifies select physical corridor characteristics for the Interstates that affect the capacity and speed of the corridor. These characteristics include speed limit, lane drops, lane adds, taper type ramps and schools. Schools are included in the Interstate physical characteristics because of the constraints schools can put on Interstate widening projects because of noise and air quality regulations.

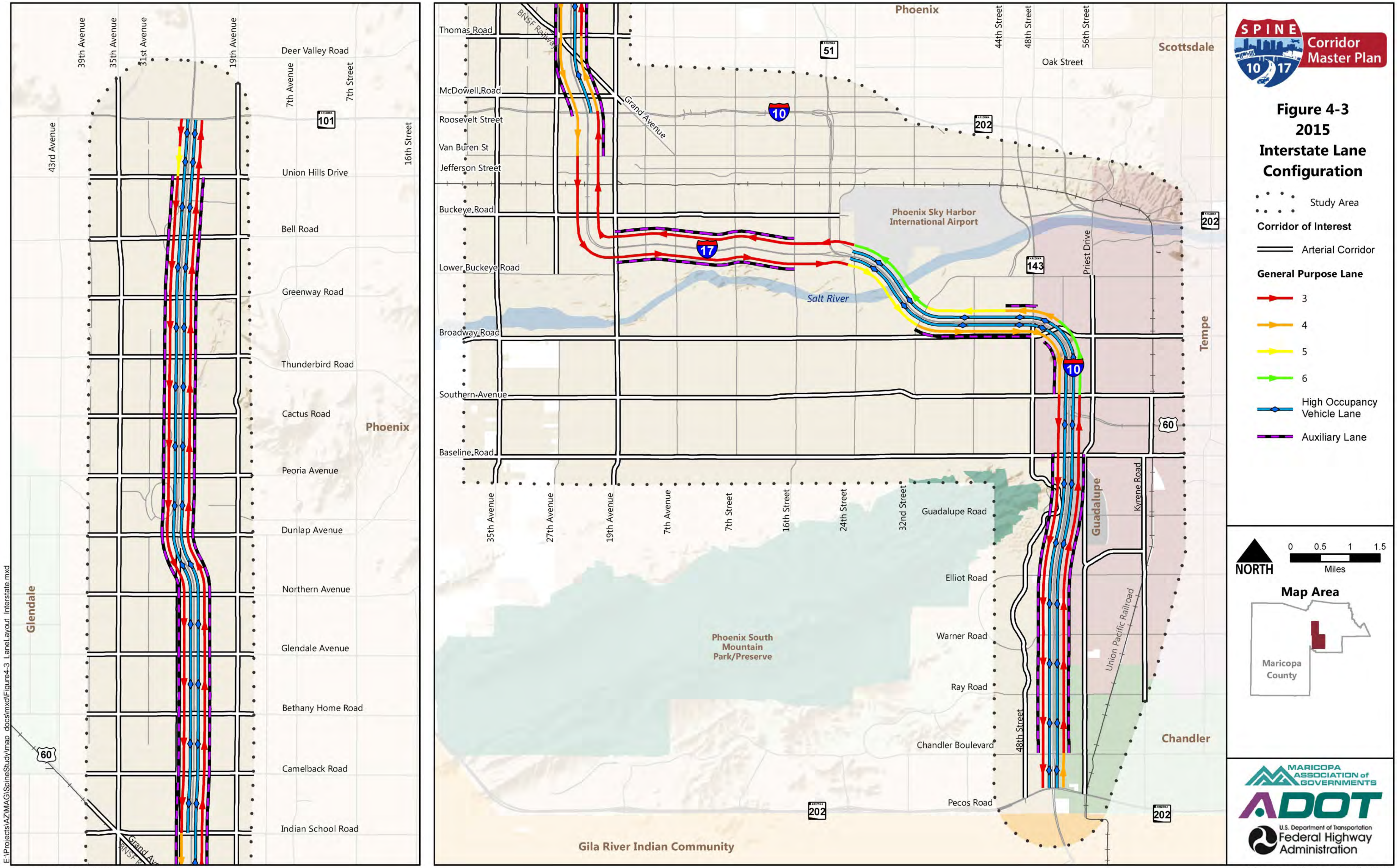
4.5.2 Arterials

Similar to the Interstate corridor, the physical characteristics of the arterial corridors significantly affects vehicular flow and speed. Arterials, by their nature and design, have many more elements that disrupt vehicular flow than do the Interstates. These elements range from physical impediments (such as traffic control, lane drops, crosswalks and in-lane bus stops) to pedestrian and vehicular traffic-generating locations (such as schools or transit stations). Identifying arterial physical characteristics that affect arterial flow within the corridor will assist future analysis of the arterial corridor of interest network to make it more efficient for the majority of its users. Figure 4-6 identifies select physical characteristics on the corridors of interest that affect vehicular flow.

4.6 Access (Linkages)

Linkages between the Interstate corridors and the arterial corridors of interest are an important aspect of the Spine study (see Figure 4-7). Because the Spine study views the Interstate corridor and arterial corridors as parallel systems that can support each other, it is important for vehicular traffic to be able to move easily from the Interstate to the arterial network and vice versa.

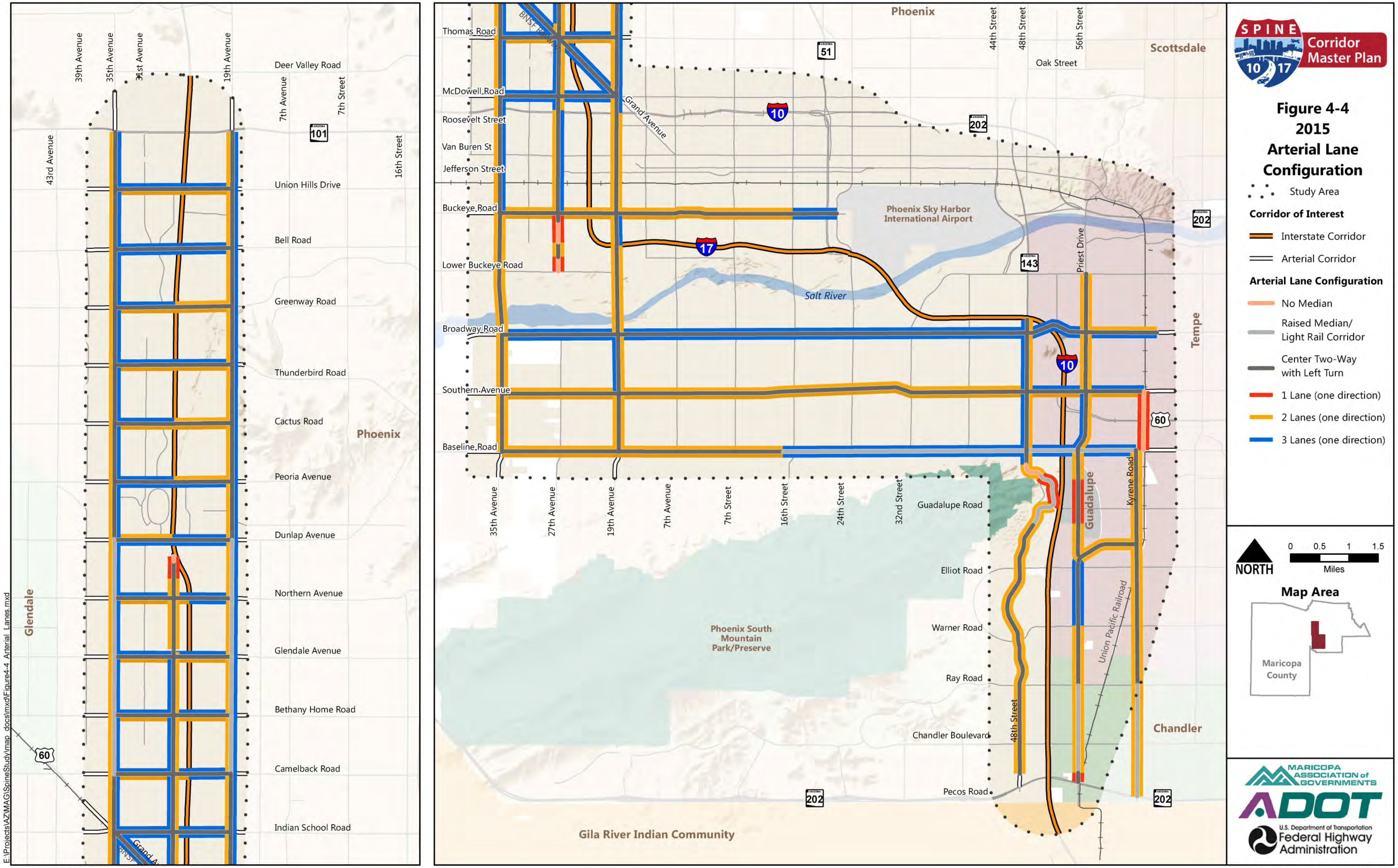
Figure 4-3 2015 Interstate Lane Configuration



Source: ADOT, ALRIS, FEMA

Map Last Updated: 5/3/2016

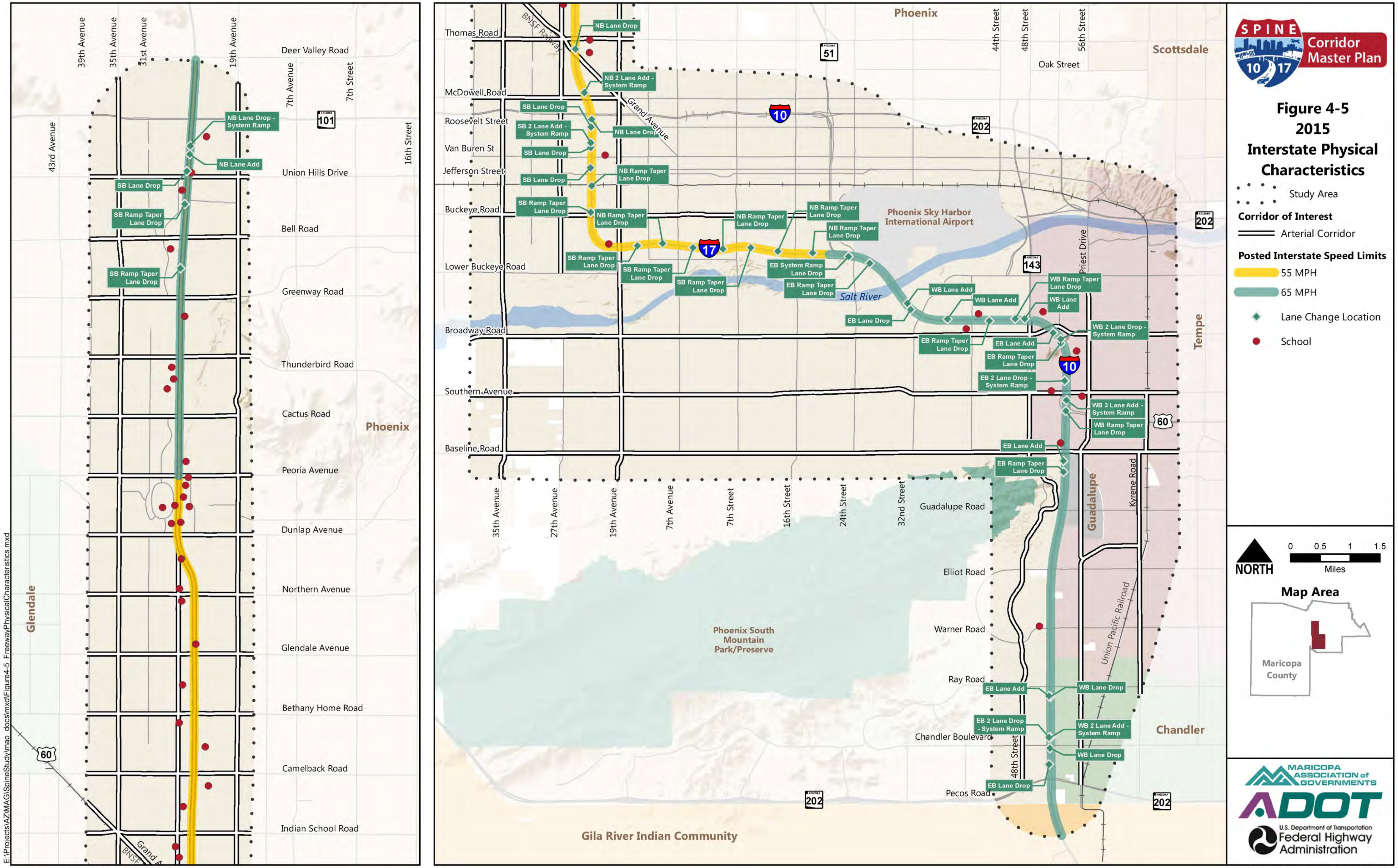
Figure 4-4 2015 Arterial Lane Configuration



Source: ADOT, ALRIS, FEMA, HDR

Map Last Updated: 5/3/2016

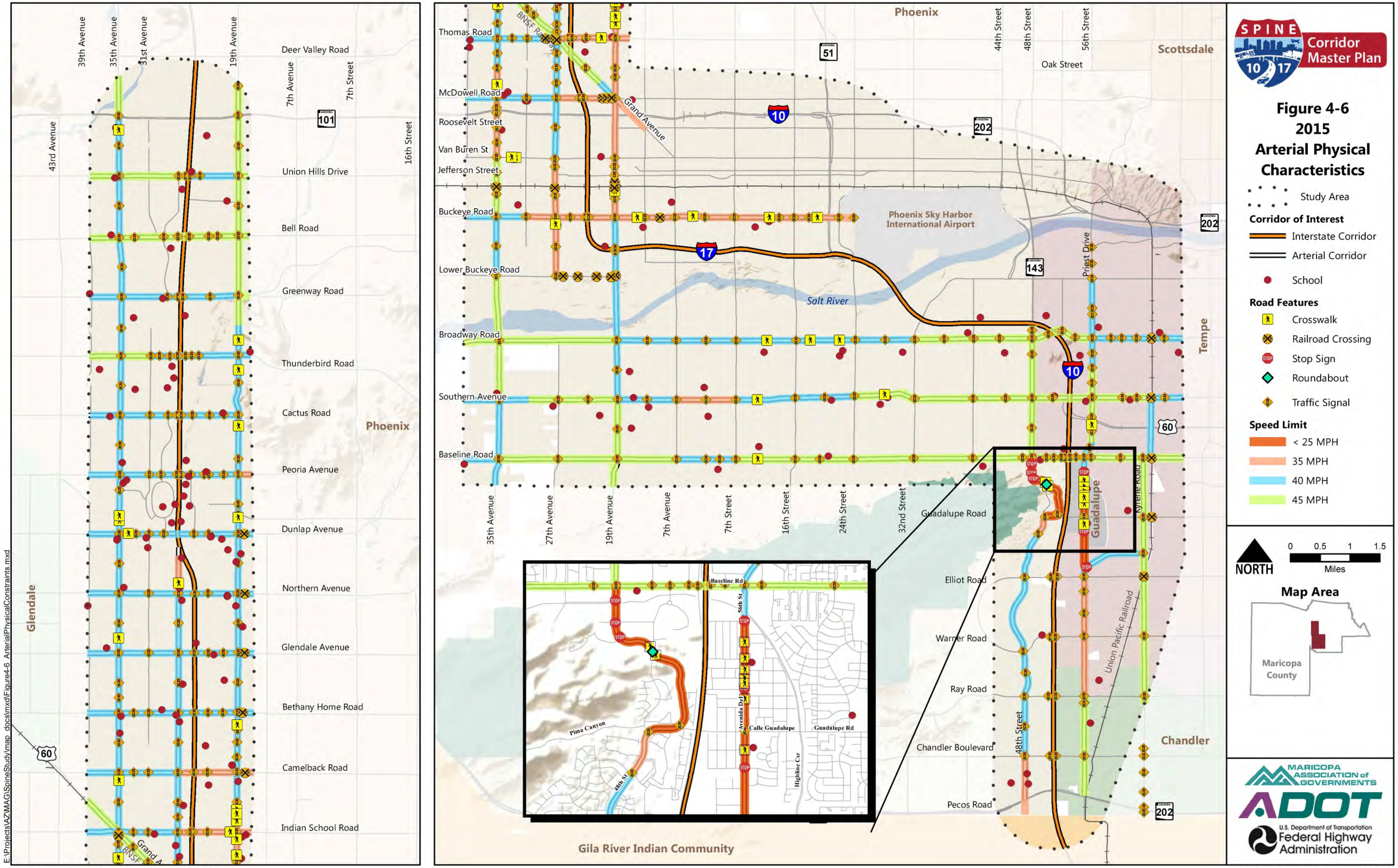
Figure 4-5 2015 Interstate Physical Characteristics



Source: ADOT, HDR

Map Last Updated: 5/3/2016

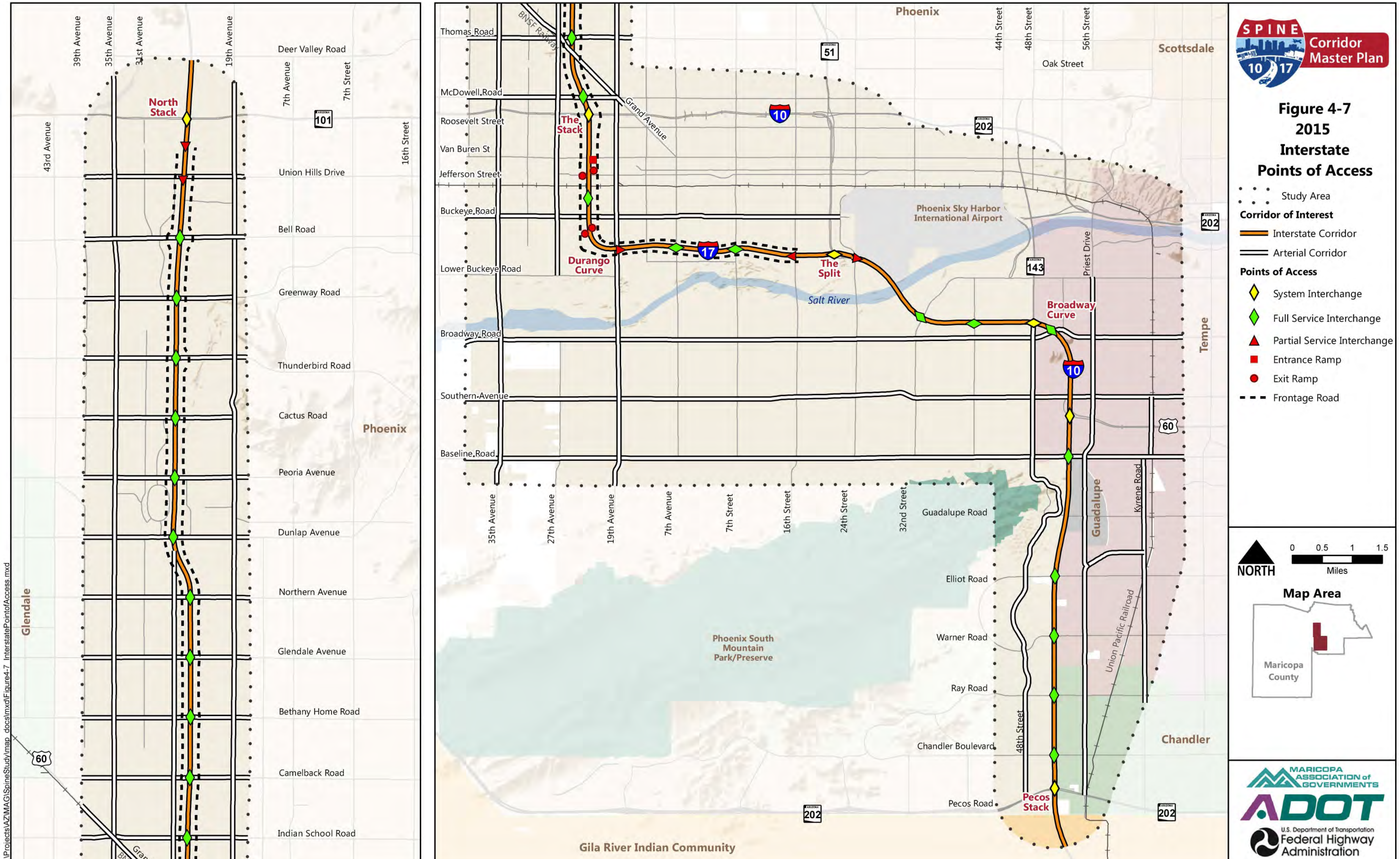
Figure 4-6 2015 Arterial Physical Characteristics



Source: ADOT, COP,Tempe, Chandler, HDR

Map Last Updated: 5/3/2016

Figure 4-7 2015 Interstate Points of Access



Source: ADOT, HDR

Map Last Updated: 5/6/2016

4.6.1 Interstates

Along the Interstate corridor there are 37 points of access. I-10 has 4 system interchanges (1 shared with I-17), 8 full service interchanges and 1 partial service interchange. I-17 has 3 system interchanges (1 shared with I-10), 16 full service interchanges, 4 partial service interchanges and 2 groups of isolated service ramps. In addition to the interchanges, I-17 has a frontage road system from 16th Street to Utopia Road north of Union Hills Drive.

4.6.2 Arterials

All of the crossing arterial corridors of interest and Buckeye Road connect I-17 to the 35th Avenue and 19th Avenue arterial corridors of interest. 27th Avenue is connected to I-17 by Buckeye Road and the crossing arterials from McDowell Road to Northern Avenue. Baseline Road, Southern Avenue and Broadway Road connect I-10 to its parallel arterials—48th Street, Priest Drive and Kyrene Road. These corridors provide the links needed to connect communities divided by the Interstate as well as provide the link between the arterial network and the Spine Interstate corridor. As shown in Figure 4-6, the I-17 crossing arterials have much higher densities of traffic signals than the parallel corridors of interest. With the higher density of signals in addition to the Interstate service interchanges, the crossing arterials frequently become congested and break down operationally at the points where they cross the Interstate corridor.

4.7 Pavement Age

Pavement makes up a large part of any roadway network's infrastructure. Within the Spine study area, I-10 and I-17 are paved with Portland cement concrete pavement (PCCP) and an asphalt rubber asphaltic concrete friction coarse (AR-ACFC) overlay. The arterials are all paved with asphaltic concrete (AC) pavement except within the ADOT control of access limits, where the arterials are paved with PCCP and maintained by ADOT. The design life for AC pavement and AR-ACFC is 10 years, while the design life for PCCP is 30 years. The actual life of the pavement depends on the amount of traffic, type of traffic, environmental conditions and maintenance during the pavement life. Because all of the AC pavement and AR-ACFC within the Spine study area will require rehabilitation prior to 2040 through regular pavement preservation programs, this report considers only PCCP.

4.7.1 Interstates

Figure 4-8 shows the current age of the concrete pavement base on I-10 and I-17. As stated above, the design life of PCCP is typically 30 years. As shown in Figure 4-8, a large segment of PCCP on I-17 between 16th Street and Peoria Avenue is over 50 years old. By 2040, all of the PCCP within the Spine interstate corridor will be past its 30-year design life. However, because climate conditions in the Phoenix metropolitan area do not degrade PCCP at rates found elsewhere in the country, PCCP can typically last much longer than its design life. It is important to note that large segments of PCCP will need to be replaced on the Spine Interstate corridor by 2040 and funds should be set aside for that replacement.

4.7.2 Arterials

As stated previously, arterials outside of ADOT ROW feature AC pavement and do not have PCCP in their pavement structural section. Given that AC pavement has a design life of 10 years, for the purpose of the Spine study it is assumed that all of the AC pavement will be replaced through regular pavement replacement programs during the time frame covered by this study.

4.8 Bridge Age and Condition

Numerous bridges are located on the Spine corridors of interest, which makes bridges a vital component of the Spine study area's roadway infrastructure and a significant budget item when considering lifecycle costs. There are a total of 148 bridges and reinforced concrete boxes (RCBs) on the Spine roadway corridors. Figure 4-9 shows the location and age of all of the bridges and RCBs on corridors of interest within the Spine study area. Insets for the Interstate system interchanges are provided in Figure 4-10.

The bridge condition is divided into three categories: good, fair, and poor. These categories are determined by FHWA condition ratings for the three primary structural elements of a bridge: deck (National Bridge Inventory [NBI] code 58), superstructure (NBI code 59) and substructure (NBI code 60), as defined by FHWA's *Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges*. The ratings were determined as follows:

Good. All of the bridge structural elements have an inspection condition rating of 7 and above, which means that all primary structural element conditions range from some minor problems to no problems at all.

Fair. All of the bridge structural elements have an inspection condition rating of 5, 6 or above, which means that the primary structural elements do not suffer from a condition range worse than minor section loss, cracking, spalling or scour to minor deterioration.

Poor. At least one bridge structural element has an inspection condition rating of 4 or below, which means that a primary structural element has advanced deterioration (fatigue cracks in steel, shear cracks in concrete or scour having removed substructure support) to advanced section loss (deterioration, spalling or scour). Bridges in poor condition are not inherently unsafe; if a bridge is determined to be unsafe it is closed.

Figure 4-11 shows the current condition of all bridges on the Spine corridors of interest. Out of the 148 bridges, there are currently 86 bridges in good condition, 60 bridges in fair condition and 2 bridges in poor condition. Insets for the Interstate system interchanges are provided in Figure 4-12. Refer to Appendix F for the NBI bridge database covering the 148 bridges within the Spine study area.

In addition to having condition ratings, bridges have two classifications based on bridge inspection data that describe the condition of the bridge as structurally deficient or functionally obsolete.

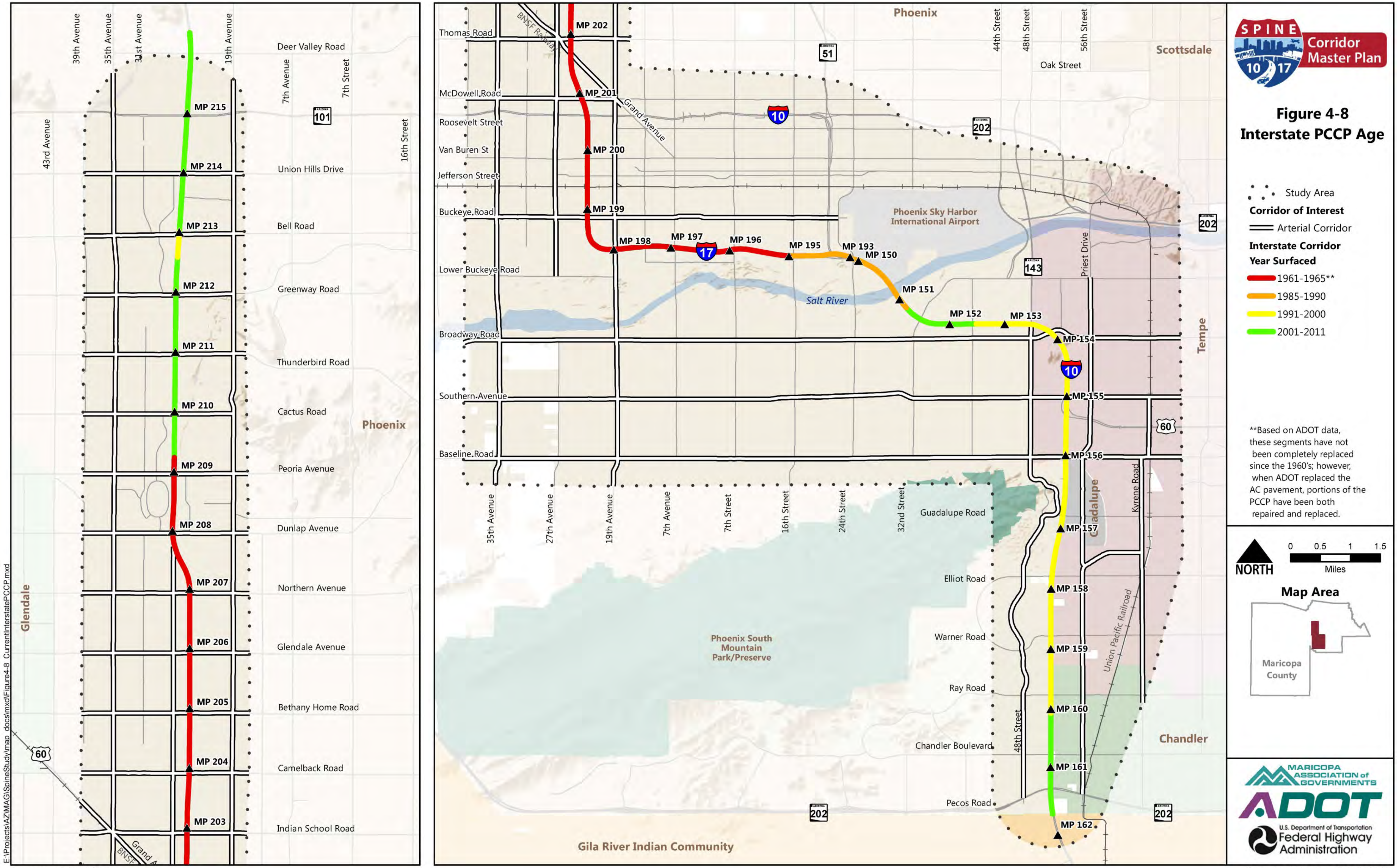
Structurally deficient is used to describe a bridge that has one or more structural defects that need attention. Any bridge that has a poor condition rating is also classified as structurally deficient. A structurally deficient classification does not signify that the bridge is unsafe, but rather that it has deterioration of one or more of its major components.

Functionally obsolete is used to describe a bridge that is no longer functionally adequate for the task for which it was originally designed. Scenarios that could warrant a functionally obsolete rating include, but are not limited to:

- not enough width for additional lanes
- not enough space for emergency shoulders
- less than the minimum vertical clearance

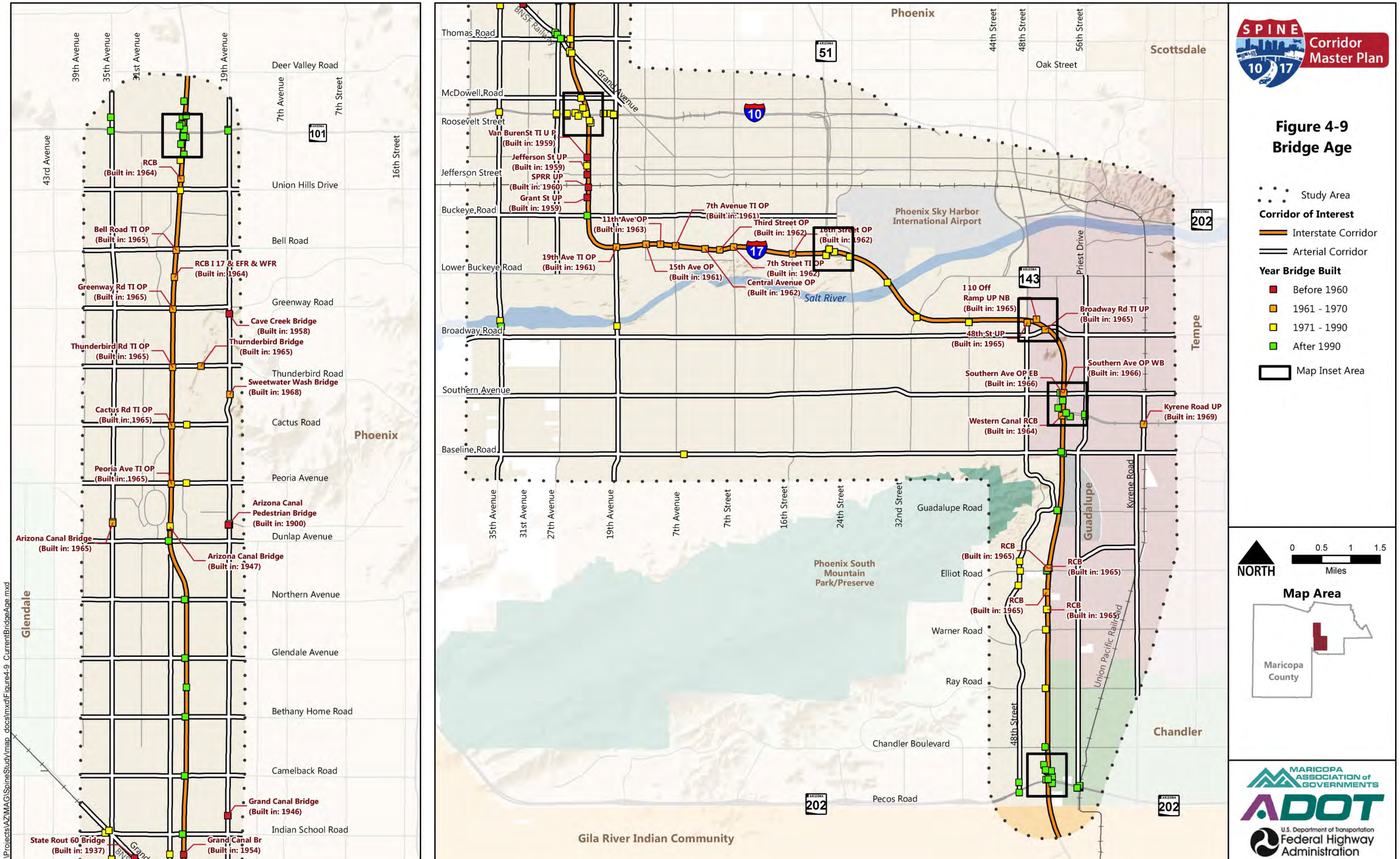
A classification of functionally obsolete communicates only about the ability of the bridge to perform its designed function and does not communicate anything about the bridge's structural condition and integrity.

Figure 4-8 2015 Interstate PCCP Age



Source: ADOT, HDR

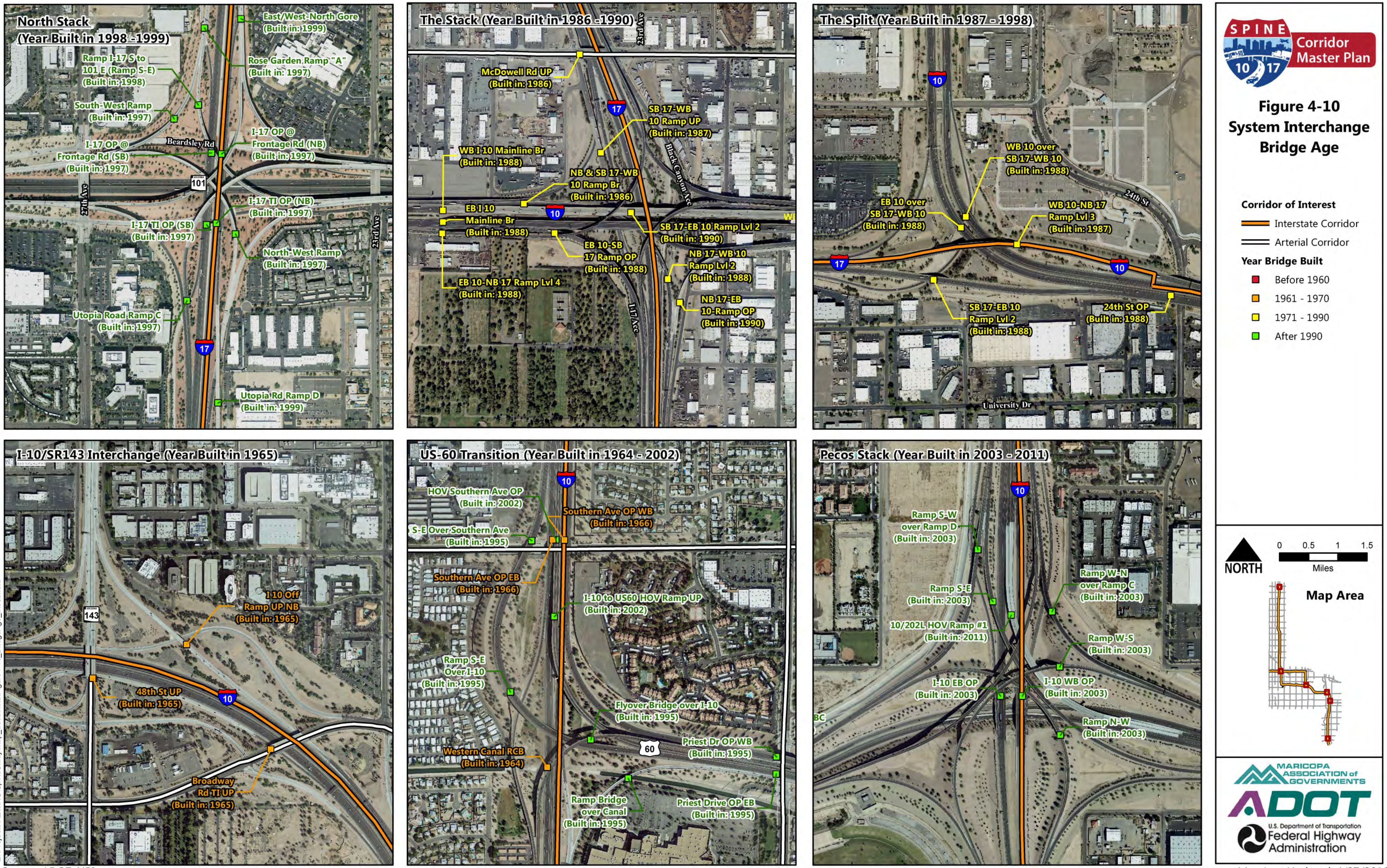
Figure 4-9 Bridge Age



Data Source: ADOT, NBI

Map Last Updated: 5/6/2016

Figure 4-10 2015 System Interchange Bridge Age



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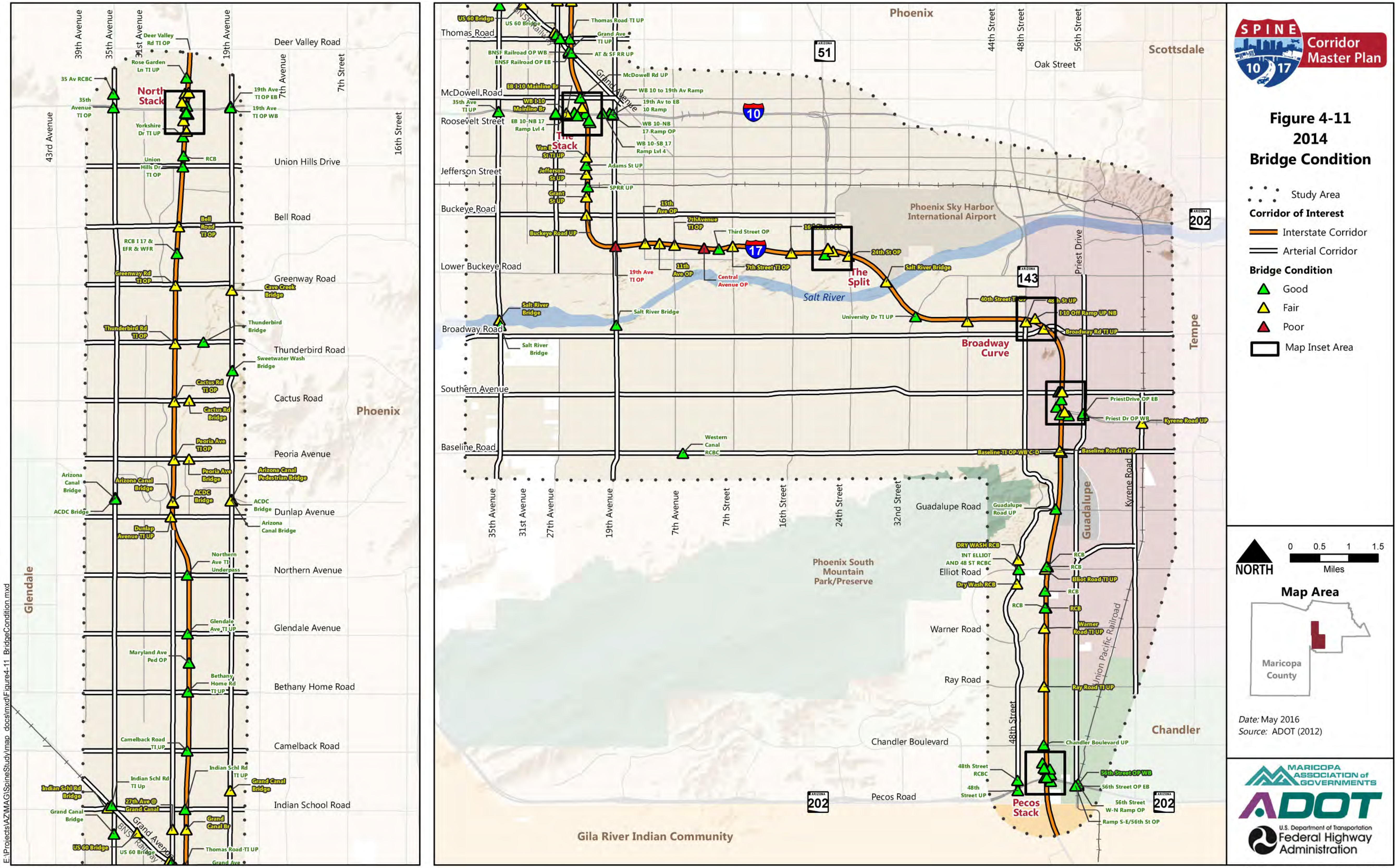
Source: ADOT, NBI

Map Last Updated: 4/27/2016

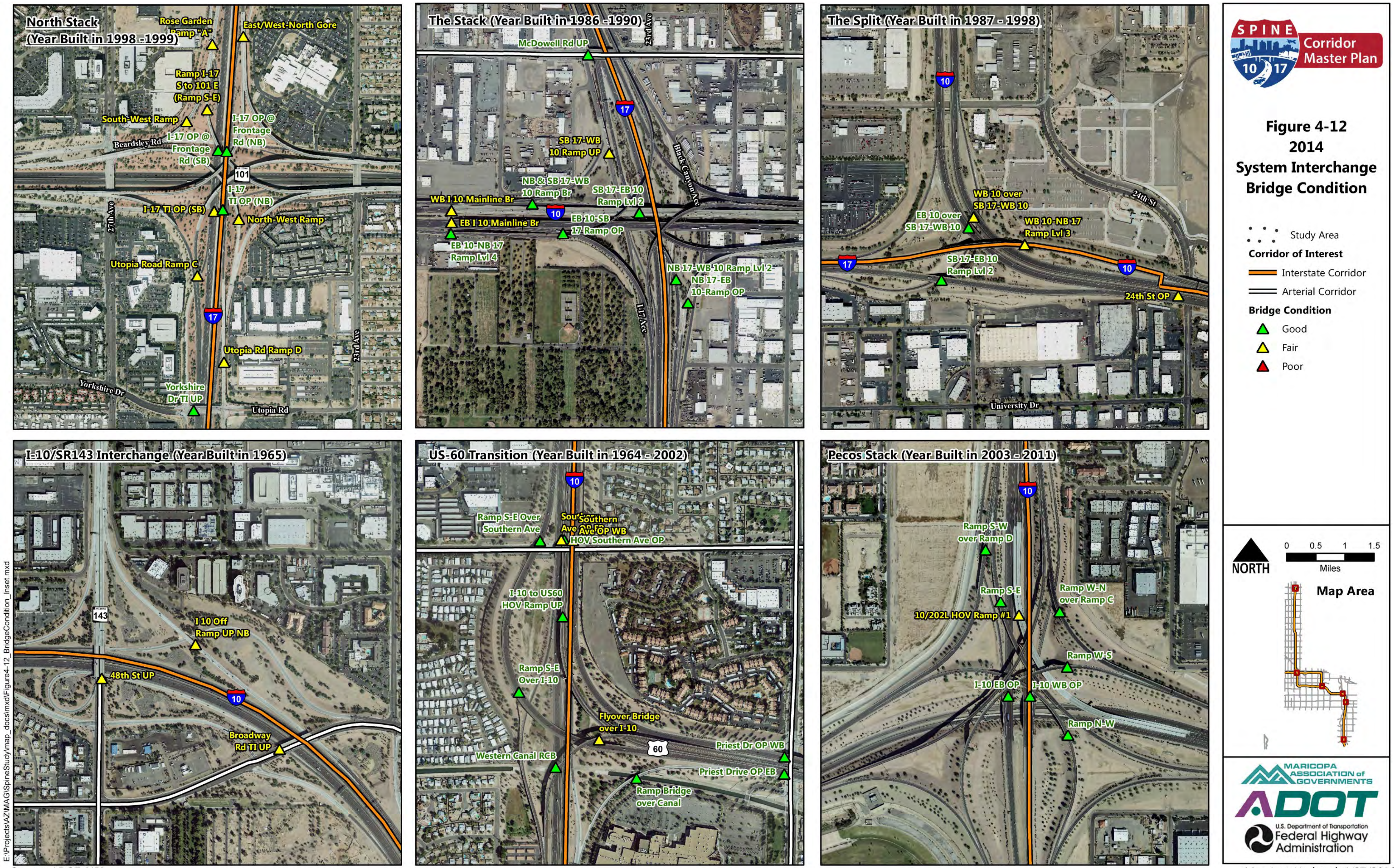
Figure 4-11 2014 Bridge Condition



Source: ADOT, NBI

Map Last Updated: 5/6/2016

Figure 4-12 2014 System Interchange Bridge Condition



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Source: ADOT, NBI

Map Last Updated: 4/27/2016

4.8.1 Interstates

Of the 148 bridges on the Spine corridors of interest, 101 are located on I-10 and I-17. Eight of those structures are RCBs and 93 bridges. As Table 4-2 shows, 99 of the bridges and RCBs on the Interstates are in good or fair condition and two of the bridges on the Interstates are in poor condition. Table 4-3 shows the number of bridges within the Spine Interstate corridors that fall into the structurally deficient and functionally obsolete categories.

Table 4-2 Interstate Bridge Condition

Bridge condition	Bridges	Reinforced concrete boxes	All structures
Good	45	7	52
Fair	46	1	47
Poor	2	0	2
Total	**93**	**8**	**101**

Table 4-3 Interstate Bridge Classification

Bridge status	All structures
Not deficient	62
Structurally deficient	2
Functionally obsolete	34
No data	3
Total	**101**

4.8.2 Arterials

In addition to the bridges on the Interstates, the arterials have a significant number of bridges. Figure 4-9 shows the location and age of arterial bridges on the Spine arterial corridors of interest. The same criteria used to determine the condition of the Interstate structures was applied to the bridges and RCBs on the arterials. Figure 4-11 shows the current condition of arterial bridges on the Spine arterial corridors of interest.

The Spine arterial corridors of interest have 47 structures. Of those, 41 are bridges and 6 are RCBs. As shown in Table 4-4, all of the bridges and RCBs on the Spine arterial corridors of interest are in good or fair condition. Table 4-5 shows the number of bridges within the Spine arterial corridors that fall into the structurally deficient and functionally obsolete categories.

Table 4-4 Arterial Bridge Condition

Bridge condition	Bridges	Reinforced concrete boxes	All structures
Good	11	2	12
Fair	30	4	34
Poor	0	0	0
Total	**38**	**6**	**44**

Table 4-5 Arterial Bridge Classification

Bridge status	All structures
Not deficient	23
Structurally deficient	0
Functionally obsolete	22
No data	2
Total	**44**

4.9 Drainage Facilities

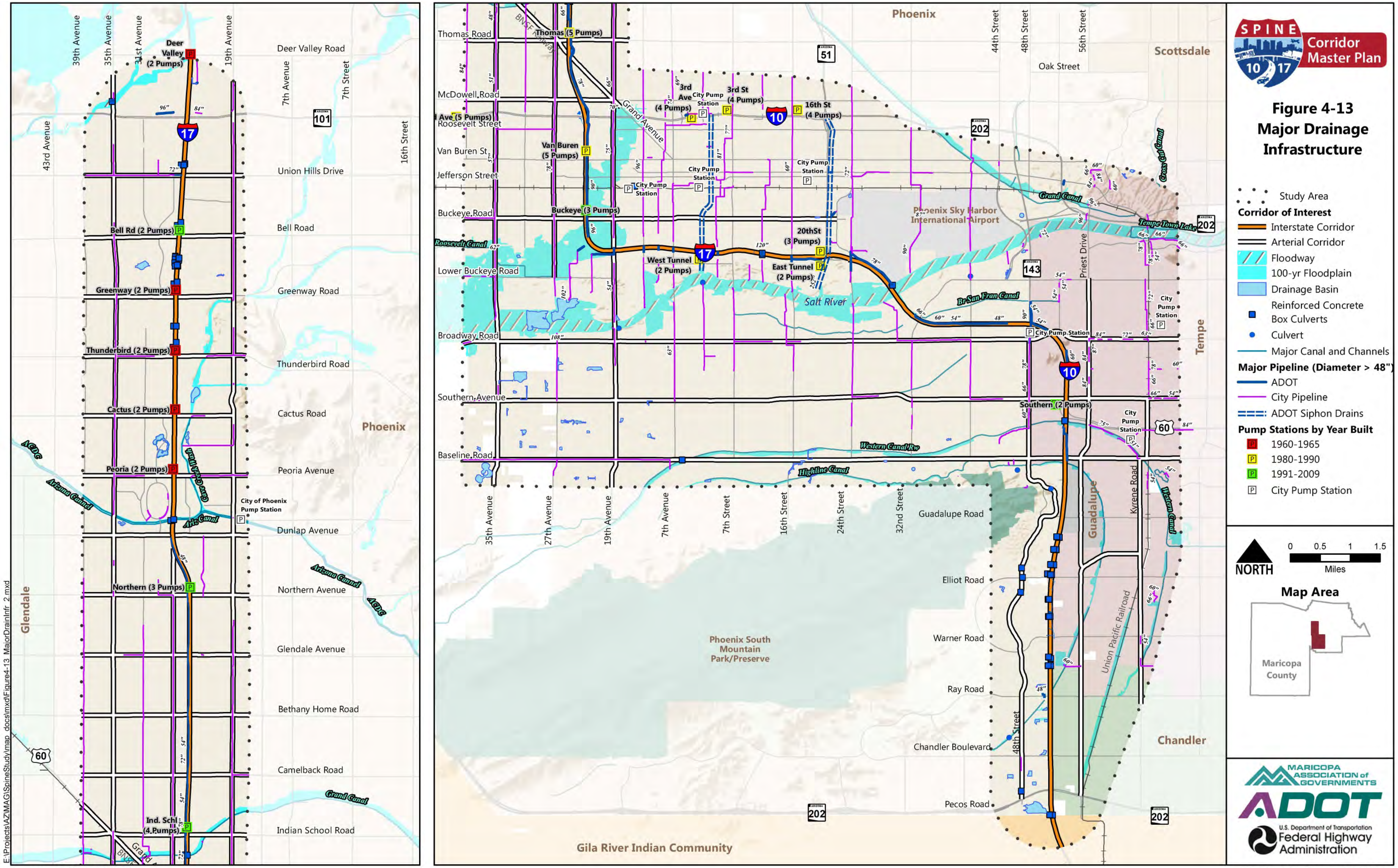
This section discusses the numerous drainage features within the Spine study area. The drainage features include pump stations, drainage trunk lines, large channels, flood control, irrigation and natural washes.

4.9.1 Pump Stations and Other Major Drainage Features

Figure 4-13 shows the location of pump stations and other major drainage facilities within the Spine study area. There are 26 pump stations within the Spine study area. ADOT owns and maintains 19 of the 26 pump stations (Table 4-6) and is currently completing a detailed needs assessment for all ADOT-maintained pump stations. The City of Phoenix owns and maintains 5 pump stations, and the City of Tempe owns and operates 2 pump stations (Table 4-6). ADOT, City of Phoenix and City of Tempe have major on-site drainage infrastructure within the Spine study area. The City of Chandler and Town of Guadalupe do not have major on-site drainage infrastructure within the Spine study area. See Appendix G for the ADOT pump station data.

ADOT drainage facilities located within the Spine study area include the on-site Interstate drainage and associated detention basins within the I-10 and I-17 corridors. Two 21-foot drainage tunnels go under downtown Phoenix and the western edge of Phoenix Sky Harbor International Airport, conveying stormwater from I-10, SR-51 and SR-202L to the Salt River. See Figure 4-13 for the location of these systems.

Figure 4-13 Major Drainage Infrastructure



Source: ADOT, COP, FEMA

Map Last Updated: 5/6/2016

Table 4-6 Pump Stations

Owner	# of pump stations
Arizona Department of Transportation	19
City of Chandler	0
City of Tempe	2
City of Phoenix	5
Town of Guadalupe	0
Total	**26**

Both the Salt River Project and the Flood Control District of Maricopa County (FCDMC) own flood control and irrigation facility systems within the Spine study area. Salt River Project's major facilities include:

- Highline Canal
- Western Canal
- San Francisco Branch Canal
- Grand Canal
- Arizona Canal

FCDMC's major facilities include the Guadalupe Flood Retarding Structure spillway and dams and retention basins off of the Guadalupe Highline Canal. The City of Phoenix, City of Tempe and Town of Guadalupe have major elements of their stormwater drainage facilities within the Spine study area. The City of Chandler has elements of its drainage facilities within the Spine study area but no major facilities. The ADOT, City of Phoenix, City of Tempe, Town of Guadalupe and FCDMC major drainage facilities are listed in Table 4-7.

Table 4-7 City, County and State Major Drainage Facilities

Owner	Drainage facility
City of Phoenix	Southeast Phoenix Regional Drainage Basin
	Salt River Low Flow Channel – 19th Avenue to Interstate 10
	35th Avenue and Dobbins Road Basin and Storm Drain
	South Phoenix Laveen Drain
	27th Avenue and South Mountain Basin
	Baseline Road Storm Drain
	23rd Avenue and Roeser Road Storm Drain
	26th Avenue and Verde Lane Basin
	24th Avenue and Camelback Road Basin
	Downtown Phoenix Drainage System, Phase I – Planned
City of Phoenix and City of Tempe	48th Street Storm Drain
Arizona Department of Transportation and City of Tempe	Arizona Department of Transportation Pit and Diversion Channel
Town of Guadalupe	Guadalupe Drainage Improvement Project
	Guadalupe Highline Canal Project
Flood Control District of Maricopa County	Durango Complex
	Arizona Canal Diversion Channel
Flood Control District of Maricopa County and City of Phoenix	Cave Creek Wash Channelization

Table 4-7 City, County and State Major Drainage Facilities

4.10 Railroad Network

The main portion of the railroad network within the Phoenix metropolitan area is located in the Spine study area. Both UPRR and Burlington Northern Santa Fe (BNSF) own rail lines going through the Spine study area, and both have railroad yards within the Spine study area. Figure 4-14 shows the location of the rail lines and railroad yards within the Spine study area.

4.11 Aviation Impacts

Phoenix Sky Harbor International Airport is the ninth-busiest airport in the country and plays a significant role in the nation's aviation network. Given that Phoenix Sky Harbor International Airport is a huge economic generator for the Phoenix metropolitan area, county and even state, any issue that could potentially affect the airport must be carefully evaluated.

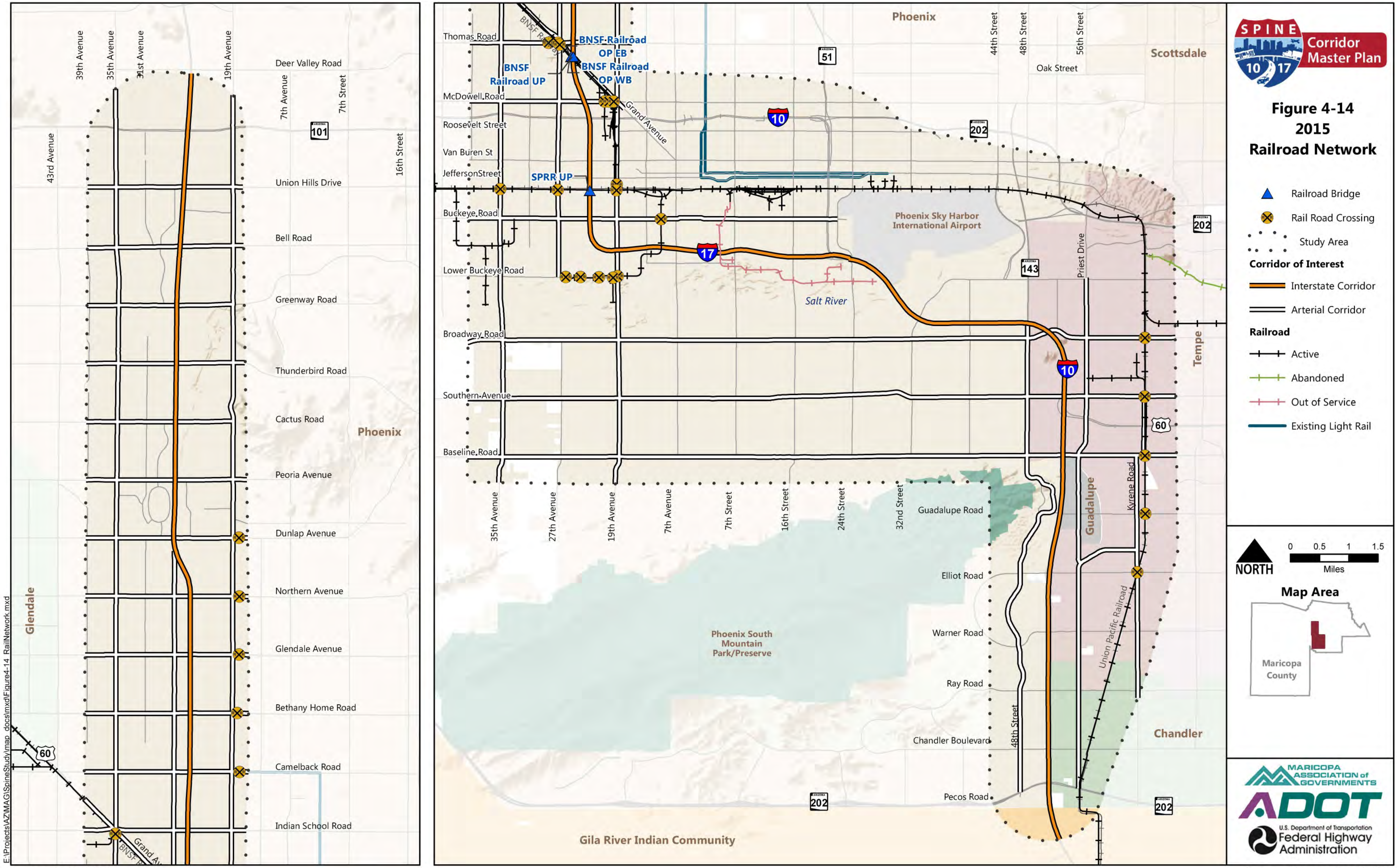
The southwestern portion of airport is located near the Split and is currently within specific navigable airspace limits for the southernmost runway (Runway 7R-25L). A detailed analysis of the airspace and any associated impacts has been performed and is included as a separate study in Appendix H. It should be noted that the existing conditions have been in existence since Runway 7R-25L was constructed and commissioned in October 2000, and that the Federal Aviation Administration is aware of the encroachments. Any changes to the Spine corridor within the limits of Runway 7R-25L will evaluate how to eliminate or mitigate the existing penetrations into the aircraft airspace safety surfaces.

4.12 Summary

The infrastructure needs of the Spine study area can be divided into three categories:

- Interstate infrastructure
- corridors of interest infrastructure
- I-17 crossing corridors of interest infrastructure

Figure 4-14 2015 Railroad Network



Source: ADOT, HDR

Map Last Updated: 5/16/2016

The categories are further discussed in the following sections.

4.12.1 Interstate Infrastructure

The I-17 segment between the Split and Peoria Avenue is the oldest section of the Spine Interstate corridor. Because it is the oldest segment, it has some of the oldest Interstate infrastructure and the tightest ROW footprint. Below is a sketch the segment's characteristics:

- The Split to the Stack is the longest stretch of the Interstate corridor with only three general purpose lanes in each direction.
- The Split to the Stack has a higher density of lane drops and taper type ramps than other sections of the Spine Interstate corridor.
- 19th Avenue to the Stack has the most nonstandard service interchange access points in the Spine Interstate corridor.
- The Split to Peoria Avenue has the tightest ROW constraints.
- PCCP between the Split and Peoria Avenue will be over 75 years old by 2040.
- The Split to Peoria Avenue has a speed limit of 55 mph.
- 16th Street to Washington Avenue has the most old bridges, contains the only two bridges in poor condition and has a large number of bridges in fair condition.
- The Durango Curve is within the Salt River floodplain.
- The Split and a segment of I-10 are within the Phoenix Sky Harbor International Airport Runway 7R-25L Runway Protection Zone and has some light pole penetrations of the Title 14 Part 77 airspace surface and the One Engine Inoperative airspace surface.

4.12.2 Corridors of Interest

Segments of five parallel corridors of interest have been identified as having the most significant physical infrastructure constraints.

Priest Drive – Elliot Road to Broadway Road

- In the town of Guadalupe between Elliot and Baseline Roads, Priest Drive is designed as a collector road and the speed limit is reduced to 25 mph from 35 mph (south) and 40 mph (north).
- Typical section reduced to one lane in each direction between Elliot and Baseline Roads through Guadalupe.
- High density of stop signs and crosswalks between Elliot and Baseline Roads through Guadalupe.
- High density of traffic signals between Baseline and Broadway Roads.

Baseline Road – 48th Street to Priest Drive

- There is a high density of signals.
- Arizona Mills Mall is on the northern side of Baseline Road east of I-10.
- One school is located on the segment.

Broadway Road – 48th Street to Hardy Drive

- There is a high density of signals.
- Speed limit is reduced.
- There is a reduced lane cross section.
- Two schools are located on segment.

19th Avenue – Buckeye Road to Dunlap Avenue

- There is a high density of signals and railroad crossings between Buckeye Road and Van Buren Street.
- There is a high density of mid-block crosswalks and schools between Thomas and Camelback Roads.
- There is a high density of schools between Indian School Road and Dunlap Avenue.
- There is a high density of signals between Indian School and Bethany Home Roads.
- The speed limit is reduced between Buckeye and Indian School Roads.
- Light rail corridor is between Camelback Road and Dunlap Avenue.
- Old bridges/RCB culvert between Indian School and Camelback Roads and between Dunlap Avenue and Peoria Avenue.

27th Avenue – Buckeye Road to Peoria Avenue

- There is a high density of signals between Buckeye and Indian School Roads.
- There is a high density of schools from Van Buren Street to McDowell Road and from Northern to Peoria Avenues.
- The speed limit is reduced between Van Buren Street and Encanto Boulevard.

35th Avenue – McDowell Road to Bethany Home Road

- There is a high density of signals between McDowell and Camelback Roads.
- There is a high density of schools from Thomas to Camelback Roads.
- There is a railroad crossing at the Thomas Road, Grand Avenue and 27th Avenue intersections.

4.12.3 I-17 Crossing Corridors of Interest

Since the I-17 crossing arterials provide the only access across I-17 and to I-17 in the northern part of the Spine study area, it is important to make those arterials work in the most efficient manner possible. In general, the I-17 crossing arterials have a higher density of signals and schools than the other corridors of interest. The service interchanges to I-17 also add a flow-interrupting component by introducing large amounts of traffic to the arterials and adding more traffic control to the I-17 crossing arterials. The more signals on a corridor, the more the flow of vehicular traffic is interrupted. These physical characteristics, in conjunction with the service interchanges, entail more physical constraints to vehicular flow than most of the other parallel corridors of interest.

McDowell Road

- high density of signals and railroad crossings
- four schools

- reduced speed at I-17 east of 27th Avenue (40 mph to 35 mph)

Thomas Road

- high density of signals and railroad crossings
- two schools
- reduced speed at I-17 east of 27th Avenue (40 mph to 35 mph)

Indian School Road

- high density of signals
- one railroad crossing
- three schools
- reduced speed at I-17 east of 27th Avenue (40 mph to 35 mph)

Bethany Home Road

- high density of signals
- three schools

Dunlap Avenue

- high density of signals
- one railroad crossing
- six schools
- one mid-block pedestrian crossing

Peoria Avenue

- high density of signals
- three schools

Cactus Road

- high density of signals
- two schools

Thunderbird Road

- high density of signals
- one school

Bell Road

- high density of signals
- one school

Table 4-8 summarizes the crossing arterials' characteristics.

Table 4-8 East-to-west I-17 Crossing Arterials Physical Characteristics Summary

Corridor	Signals	Schools	Railroad crossings	Crosswalks	# of arterial lanes		Speed limit (miles per hour)
					eastbound	westbound	
Buckeye Road	7	1	0	0	2	2	35, 40
McDowell Road	6	5	3	0	3	3	35, 40
Thomas Road	8	2	3	1	2	3	35, 40
Grand Avenue	8	1	2	0	3	3	45
Indian School Road	8	5	1	1	3	3	35, 40
Camelback Road	7	4	1	0	2/3	3	35, 40
Bethany Home Road	8	4	1	0	2	3	40
Glendale Avenue	7	3	1	0	2	3	40
Northern Avenue	5	5	1	0	2/3	3	40
Dunlap Avenue	8	**10**	1	1	3	2/3	40
Peoria Avenue	**10**	**8**	0	0	3	3/2	40
Cactus Road	**9**	2	0	0	2	3/2	40
Thunderbird Road	**9**	3	0	0	2	3	40, 45
Greenway Road	6	3	0	0	2	3/2	40
Bell Road	8	2	0	0	3	3	45
Union Hills Road	6	3	0	0	2	3	40, 45
Buckeye Road	7	1	0	0	2	2	35, 40
McDowell Road	6	5	3	0	3	3	35, 40
Thomas Road	8	2	3	1	2	3	35, 40

Notes: green = low, yellow = medium, red = high

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5 Transit Service

This chapter describes the existing and planned transit services and related capital investments within the Spine study area. For the purpose of writing this report, the best attempts have been made to obtain the latest and most current data as of December 2014. Transit services currently provided in the study area include commuter buses, vanpools, light rail transit (LRT), local fixed-route bus, demand response and the PHX Sky Train.

Commuter bus service is a transit service designed to serve peak-period commuter markets between suburban neighborhoods and the Phoenix central business district. Service operates during peak periods with a limited number of inbound passenger stops, connecting residential areas or suburbs/cities with regional employment centers. Demand response is a form of public transportation characterized by flexible routing or scheduling that provides door-to-door service. Demand response, also known as Dial-a-Ride, provides service to three groups: Americans with Disabilities Act (ADA) certified individuals, people who have a disability but are not ADA certified and seniors over the age of 65. The PHX Sky Train is a free service that directly connects travelers from the 44th Street and Washington Street light rail and transit station to terminals 3 and 4 of Sky Harbor Airport with ultimate plans to extend service to the airport car rental facility.

These transit services are supported by related transit capital investments such as operations and maintenance facilities, HOV lanes, park-and-ride facilities, transit centers, and other passenger amenities. The following agencies/organizations currently operate or plan transit investments, including support infrastructure, in the study area:

- Valley Metro
- MAG
- ADOT
- Cities of Chandler, Phoenix and Tempe

5.1 Inventory of Services

As previously noted, a wide range of transit services operate in the study area. Many of these services are part of Valley Metro's regional implementation of TDM strategies. Ten commuter express routes, including Valley Metro Express and City of Phoenix RAPID service, operate within the study area. While most of these routes originate outside of the study area, the majority of the miles traveled are on the I-17 and I-10 corridors. Nine local fixed-route bus routes operate adjacent to the I-17 and I-10 corridors, providing transit service for most of the people commuting within and in close proximity to the study area. Vanpool and demand response services are also operated within the study area but serve very specific mobility needs. Figures 5-1 and 5-2 give an overview of the transit system within the Phoenix metropolitan area in October 2014.

5.1.1 Interstate\HOV-based Services

Commuter Buses

Commuter buses provide limited stop service between outlying cities into the Phoenix central business district . These routes generally originate from park-and-ride lots located along the I-10, I-17, SR-202L, and US-60 corridors. Commuter bus routes operate Monday through Friday during peak periods only as specified in Table 5-1. The number of AM peak period trips into the central business district and PM peak period trips out of the central business district depends on the demand of each particular subarea within the overall study area. Routes 480 and 450 are especially notable because they account for 53 percent of both the AM and PM peak period trips in the study area. Figure 5-3 shows the commuter bus routes identified in the study area that together operate 75 inbound and 75 outbound trips per day.

Figure 5-1 Valley Metro System Map

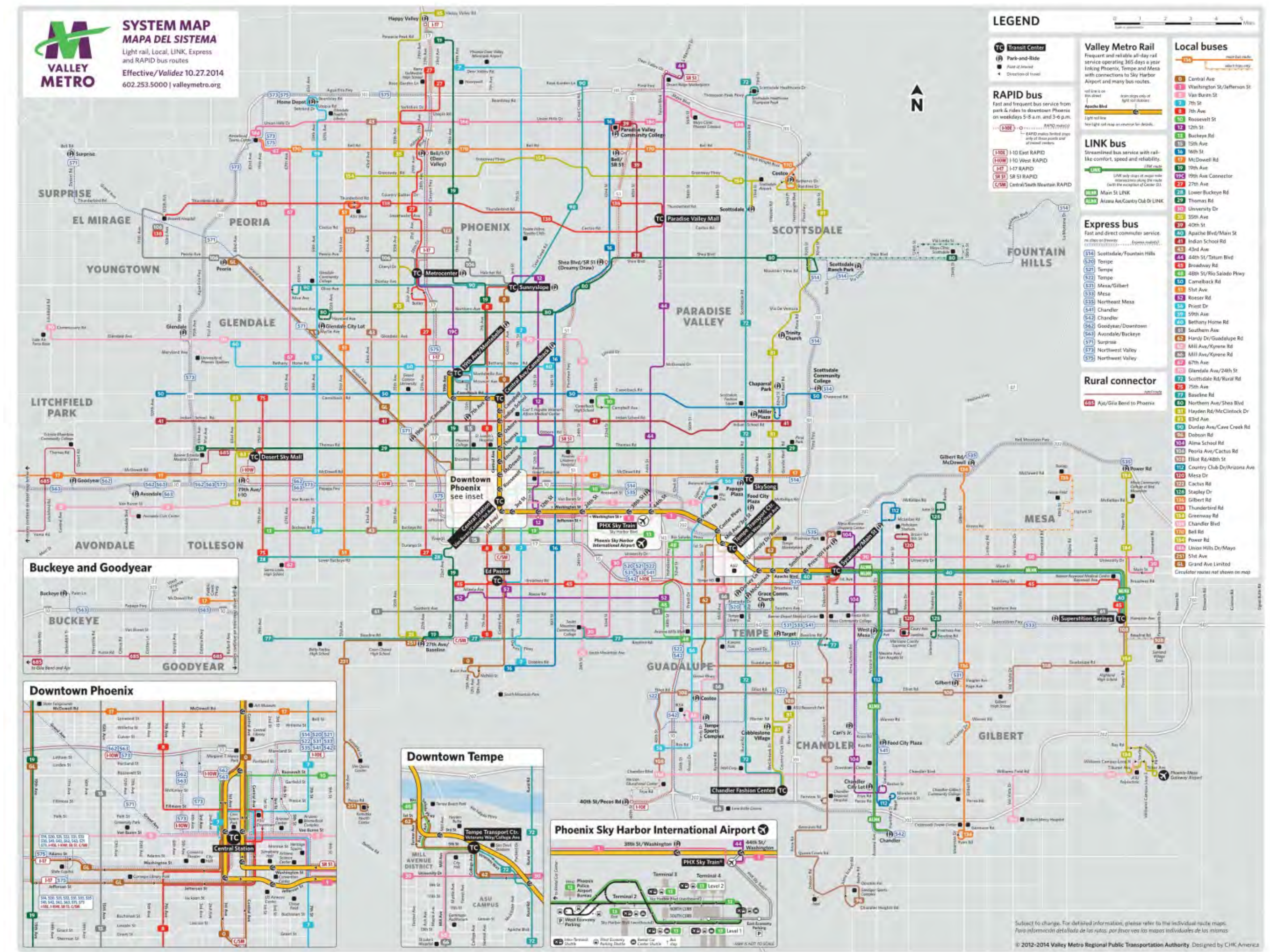


Table 5-1 Commuter Bus Service Schedule

Commuter bus route	Corridor	Service span		Trips per day	
		Days of operation	Hours of operation	Inbound	Outbound
520	I-10 via US-60	Monday–Friday	6:00 AM–6:56 AM 4:10 PM–5:10 PM	2	2
521	I-10 via US-60	Monday–Friday	6:00 AM–6:58 AM 4:10 PM–5:10 PM	4	4
522	I-10	Monday–Friday	6:00 AM–6:57 AM 4:10 PM–5:10 PM	4	4
531	I-10 via US-60	Monday–Friday	5:29 AM–7:24 AM 3:20 PM–5:15 PM	6	6
533	I-10 via US-60	Monday–Friday	5:05 AM–7:00 AM 3:40 PM–6:05 PM	6	6
541	I-10 via US-60	Monday–Friday	5:08 AM–7:14 AM 3:38 PM–5:10 PM	4	4
542	I-10 via SR-202L	Monday–Friday	5:55 AM–7:25 AM 3:35 PM–5:15 PM	6	6
562	I-10	Monday–Friday	6:00 AM–7:58 AM 4:05 PM–6:05 PM	4	4
563	I-10	Monday–Friday	5:35 AM–7:50 AM 4:10 PM–6:35 PM	4	4
571	I-10 via SR-101L	Monday–Friday	5:30 AM–7:53 AM 4:05 PM–6:52 PM	4	4
573	I-10 via SR-101L	Monday–Friday	5:09 AM–7:54 AM 4:05 PM–6:52 PM	4	4
575	I-17 via SR-101L	Monday–Friday	5:55 AM–6:50 AM 4:15 PM–5:15 PM	3	3
480 (I-17)	I-17	Monday–Friday*	5:06 AM–8:19 AM 3:05 PM–6:20 PM	25	26
450 (I-10E)	I-10	Monday–Friday*	5:10 AM–8:10 AM 3:21 PM–6:06 PM	15	14

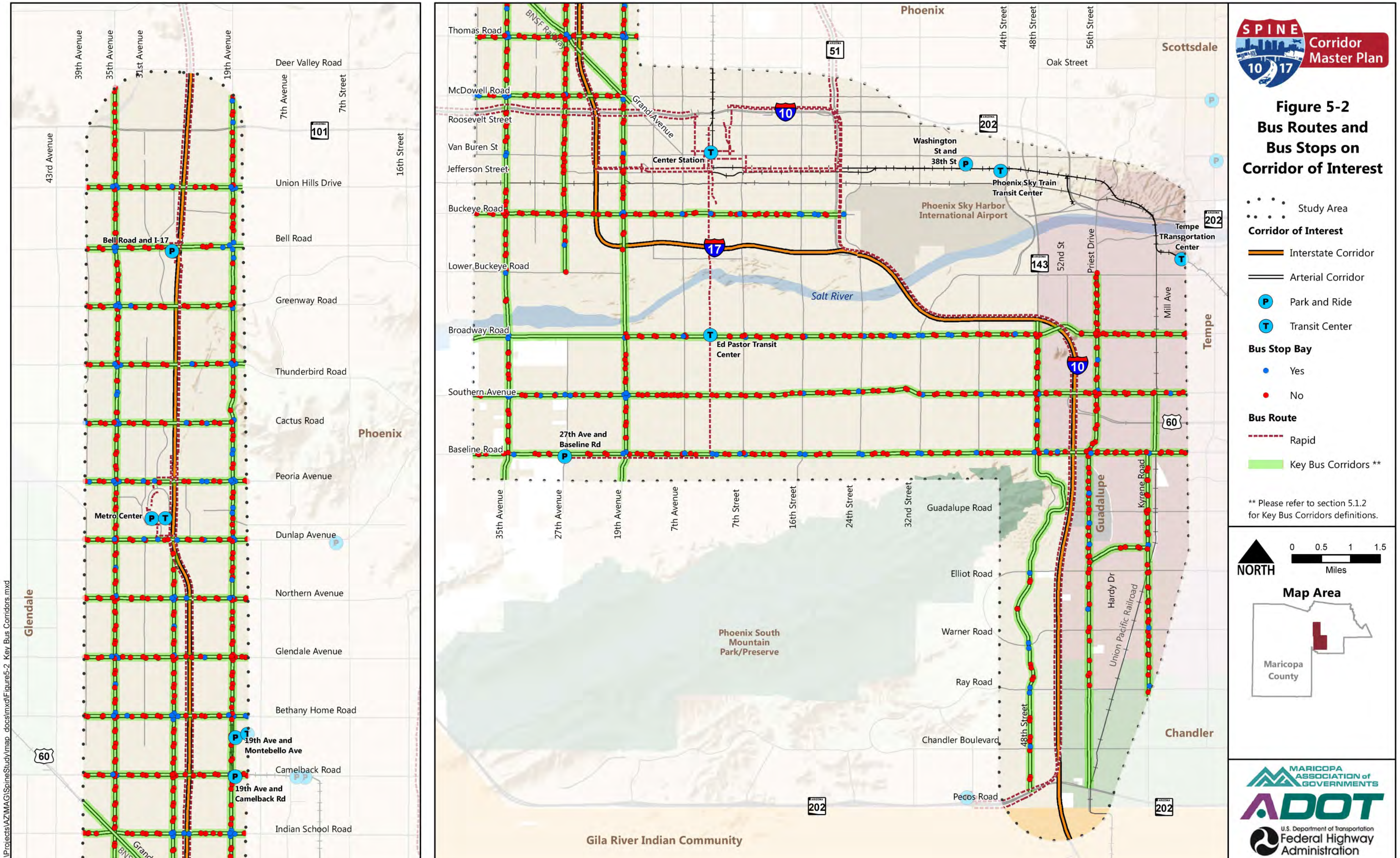
Table 5-1 Commuter Bus Service Schedule

Commuter bus route	Corridor	Service span		Trips per day	
		Days of operation	Hours of operation	Inbound	Outbound
I-10W	I-10	Monday–Friday[a]	5:23 AM–8:52 AM 3:22 PM–6:36 PM	12	13
			Total	**75**	**75**

Source: Valley Metro (2015), *Valley Metro Transit Book*. Effective October 27, 2014 through April 26, 2015.
Notes: I-10 = Interstate 10, I-17 = Interstate 17, US-60 = U.S. Route 60
[a] These routes operate on a Friday lite schedule.

Commuter bus routes serving Chandler, Gilbert, and Mesa operate more frequently than commuter bus routes from Tempe or northwest Phoenix. Chandler residents are provided with direct access to commuter bus routes 522 and 542 from several park-and-ride facilities in and near downtown Chandler and major activity centers. Commuter bus routes 520, 521, 531, 533 and 541 can be accessed from several park-and-ride facilities located near the US-60 corridor. Commuter bus route I-10 East originates and operates entirely within the study area. Commuter bus route I-17 originates just north of the study area at the Happy Valley park-and-ride but operates mainly within the study area.

Figure 5-2 Bus Routes and Bus Stops on Corridors of Interest



Source: ADOT, MAG, VM, COP

All of the commuter bus routes that originate outside of the study area terminate at Central Station or the State Capitol in downtown Phoenix. Commuter bus routes 520, 521, 531, 533 and 541 operate on I-10 via US-60 and originate at the following locations:

- 520: SR-101L/Apache Boulevard
- 521: SR-101L/Baseline Road
- 531: Gilbert Road/Elliot Road
- 533: Southern Avenue/Power Road
- 541: Arizona Avenue/Ray Road

Commuter bus route 522 originates in Tempe at the intersection of Elliot Road and River Parkway. This route operates on I-10 with limited-stop service to the central business district in downtown Phoenix, and continues to the State Capitol at 17th Avenue and Adams Street. Commuter bus route 542 originates at the Chandler park-and-ride located at the intersection of Germann Road and Hamilton Street. Commuter bus route 542 operates on the I-10 via SR-202L with nonstop service to Central Station located at the intersection of Van Buren Street and Central Avenue in Phoenix, before continuing to the State Capitol. Commuter bus route 575 originates in northwest Phoenix at the Arrowhead Towne Center located at 77th Avenue and Bell Road. Commuter bus route 575 travels on I-17 via SR-101L, providing limited-stop service to Central Station. Commuter bus route I-17 originates at the Happy Valley park-and-ride located at Happy Valley Road and I-17 just north of the study area and terminates at Central Station. Commuter bus route I-10 East originates at 40th Street and Pecos Road and terminates at Central Station. Table 5-1 identifies the operating characteristics of each commuter service.

Vanpool

Vanpools operate throughout the entire Valley Metro service area without designated routes. Valley Metro facilitates initial communication between a group of people with similar transit needs. Once a group of 6 to 15 people is established, a designated vanpool member is assigned with the responsibility of driving the van. The van is provided by Valley Metro, and the passengers share the cost of operations. Although there is no dedicated route, several vanpools operate from park-and-ride facilities. Riders may leave their vehicles at the park-and-ride facility in the morning and return to their vehicles at the agreed-upon return time. Based on the 2013 Valley Metro Park-and-Ride Survey, 13 vanpools were identified as operating out of three park-and-ride locations. Seven vanpools operate from the Bell Road/I-17 park-and-ride facility, while one vanpool operates from the Metrocenter Transit Center/park-and-ride. Finally, five vanpools operate from the 40th Street/Pecos Road park-and-ride. The 40th Street/Pecos Road park-and-ride is located just outside of the study area, but serves the I-10 East commuter bus route which directly serves the study area. Table 5-2 identifies the level of vanpool activity at publicly owned park-and-ride facilities within the study area.

Table 5-2 Vanpool Activity at Park-and-Ride Facilities

Park-and-ride facilities	Route connections	Number of vanpools
Bell Road/I-17	I-17 RAPID, 27, 170	7
Metrocenter Transit Center and park-and ride	I-17 RAPID, 27, 35, 90, 106	1
40th Street/Pecos Road (just outside the study area)	I-10 East, 108, ALEX	5

Source: Valley Metro (2013), *Valley Metro Park-and-Ride Survey* Note: I-17 = Interstate 17

5.1.2 Parallel and Intersecting Services

Light Rail Transit

Existing high-capacity transit service in the study area is provided by the Valley Metro light rail system and is shown in Figure 5-4. The 20-mile-long line serves 28 passenger stations and features several park-and-ride facilities accessible at select light rail stations. Within the study area, light rail serves the cities of Phoenix and Tempe with several transfer opportunities to local bus service. Light rail operates seven days a week with weekday service from 4:15 AM to 12:45 AM and varying weekend service hours. On weekdays light rail operates with 12-minute frequencies for most of the day and 20-minute frequencies during early morning and late evening time periods. This schedule offers 87 trips per direction on a typical weekday. Saturday service operates on 15-minute frequencies during the peak, and 20-minute frequencies during the off-peak. Sunday operates on 20-minute frequencies all day. Table 5-3 identifies the LRT operating characteristics.

Table 5-3 Light Rail Transit Service Schedule

Days of operation	Hours of operation (Weekday)	Frequency (minutes)	
		Peak/Midday	Early morning/evening
Monday–Thursday	4:40 AM–12:05 AM	12	20
Friday	4:40 AM–3:05 AM	12	20
Saturday	5:00 AM–3:05 AM	15	20
Sunday	5:00 AM–12:05 AM	NA	20

Source: Valley Metro (2015), *Valley Metro Transit Book*. Effective October 27, 2014 through April 26, 2015.

Local Fixed-route Bus

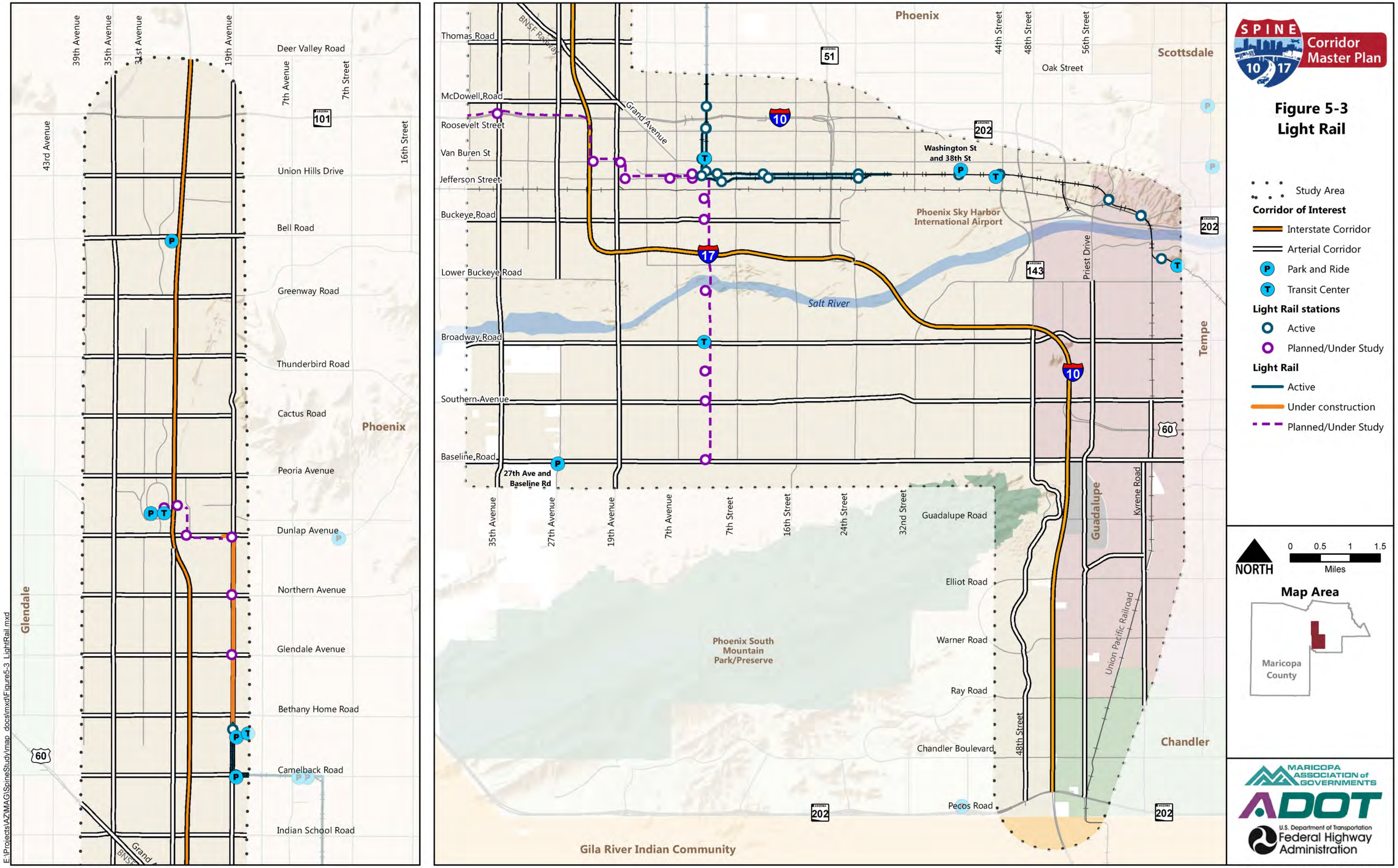
Valley Metro has defined two separate categories of local fixed-route bus service: local fixed-route and key local fixed-route. These classifications are based on fundamental differences in the expected level of service and performance of each route.

Local fixed-route bus routes serve as the backbone of the region’s transit system by providing a network of interconnected services that allow passengers to travel throughout the region. These routes serve destinations along and within close proximity to arterial roadways. To meet the potentially higher demand for service along the corridors, these routes provide (compared with rural areas or low-density neighborhoods) more frequent service. The minimum service span standard of 16 hours each weekday provides a basic level of service from approximately 5:00 AM to 10:00 PM, with reduced service hours on weekends.

Key local fixed-route bus services are defined in part by their operating characteristics, but also by three distinct qualifiers: low-income population served, zero-auto ownership households served, and past transit performance, which includes an annual ridership of at least one million.

Valley Metro also provides commuter bus services to the South Mountain area. Central South Mountain East and Central South Mountain West use two park-and-rides in the study area and connect South Mountain with downtown Phoenix. Both routes can be found on Figure 5-3.

Figure 5-3 Light Rail



Sourcnce: ADOT, VM

Map Last Updated: 5/16/2016

These routes represent the premier local services that have achieved or are expected to achieve a higher level of demand than most other local bus routes. Based on this higher expectation, the minimum standard of service for headways is set at more frequent intervals during peak periods. This allows passengers to have greater flexibility in trip choices and minimizes the potential for overcrowded conditions.

Currently, 23 local fixed-route bus routes operate within the study area which includes 9 key local fixed-routes. These routes have been examined for service span, frequency, and performance, the results of which are discussed in the following sections. In general, most local routes operate seven days a week, with a minimum operating frequency of 30 minutes. Several key local fixed-route services operate at 15-minute frequencies or better during peak periods.

There are 9 local fixed-route bus routes that operate on corridors of interest. Two local routes, 19 (19th Avenue) and 35 (35th Avenue), operate on arterial streets parallel to I-17 ranging from SR-101L to the I-10 stack interchange, which is located south of McDowell Road. These routes have transfer opportunities at Buckeye Road, Southern Avenue, and Baseline Road. Four local routes, 13 (Buckeye Road), 45 (Broadway Road), 61 (Southern Avenue), and 77 (Baseline Road), operate adjacent to I-10 between Buckeye Road and Baseline Road. Three local routes, 48 (48th Street), 56 (Priest Drive), and 66 (Mill Avenue\Kyrene Road), run parallel to I-10 and provide excellent transfer opportunities to the eastbound and westbound local routes adjacent to I-10.

The other 14 local fixed-route bus routes operate on corridors running east and west orthogonally to I-17 and provide transfer opportunities to not only other transit services identified in this study but other bus routes that cross I-10 and I-17 in the north-to-south direction. The specific route numbers for the 14 local fixed-route bus routes are: 17, 29, 41, 50, 60, 70, 80, 90, 106, 122, 138, 154, 170 and 186. All 23 routes can be found in Table 5-4, which identifies operating characteristics of each local fixed-route and key local fixed-route service. This information was found in Valley Metro's Transit Standards and Performance Measures Phase I Report.

Table 5-4 Local Fixed-route Bus Service Characteristics

Local route	Type	Corridor	Service span		Frequency (minutes)	
			Days of operation	Hours of operation (weekdays)	Peak	Off-peak
13	Local	Buckeye Road	Monday–Sunday	5:27 AM–9:53 PM	30	30
19	Key local	19th Avenue	Monday–Sunday	4:41 AM–11:27 PM	25	25
35	Key local	35th Avenue	Monday–Sunday	5:02 AM–11:03 PM	15	30
45	Key local	Broadway Road	Monday–Sunday	5:14 AM–12:05 AM	15	30
48	Local	48th Street	Monday–Sunday	5:23 AM–12:49 AM	30	30
56	Local	Priest Drive	Monday–Sunday	4:44 AM–12:24 AM	30	30
61	Key local	Southern Avenue	Monday–Sunday	4:58 AM–12:28 AM	15	30
66	Local	Kyrene Road	Monday–Sunday	4:51 AM–12:28 AM	30	30
77	Local	Baseline Road	Monday–Sunday	5:02 AM–12:15 AM	30	30
17	Key local	McDowell Road	Monday–Sunday	5:07 AM–11:04 PM	10	20
29	Key local	Thomas Road	Monday–Sunday	5:06 AM–11:25 PM	8	8
41	Key local	Indian School Road	Monday–Sunday	5:18 AM–11:18 PM	10	10
50	Key local	Camelback Road	Monday–Sunday	4:55 AM–10:38 PM	10	15
60	Local	Bethany Home Road	Monday–Sunday	5:00 AM–9:25 PM	30	30
70	Key local	Glendale Avenue	Monday–Sunday	4:38 AM–11:00 PM	15	30
80	Local	Northern Avenue	Monday–Sunday	4:43 AM–10:19 PM	30	30
90	Local	Dunlap Avenue	Monday–Sunday	5:12 AM–10:07 PM	30	30
106	Local	Peoria Avenue	Monday–Sunday	4:23 AM–10:00 PM	30	30
122	Local	Cactus Road	Monday–Sunday	5:40 AM–8:55 PM	60	60
138	Local	Thunderbird Road	Monday–Sunday	4:51 AM–10:06 PM	30	30
154	Local	Greenway Road	Monday–Sunday	5:12 AM–10:32 PM	30	30
170	Local	Bell Road	Monday–Sunday	4:57 AM–10:43 PM	30	30
186	Local	Union Hills Drive	Monday–Sunday	5:06 AM–10:28 PM	30	30

Table 5-4 Local Fixed-route Bus Service Characteristics

Source: Valley Metro (2015), *Valley Metro Transit Book*. Effective October 27, 2014 through April 26, 2015.

5.2 Transit Operations Performance

5.2.1 Commuter Bus

Commuter bus routes I-17 and I-10 East capture far more riders than the other commuter express routes combined. Combined weekday average ridership for commuter bus routes I-17 and I-10 East is 2,218. Weekday average ridership for all the other commuter express bus routes is 1,679. Average weekday ridership for all commuter bus routes is 3,897.. Commuter bus route 533 originating at Superstition Springs Transit Center and park-and-ride in Mesa and commuter bus route 542 originating at the Chandler park-and-ride have the highest daily boardings, with a combined average of 811 daily riders. Average weekday carrying capacity for all commuter bus routes in the study area is 9,580. The commuter bus routes in the study area currently operate with a 41 percent occupancy rate, meaning that on average 41 percent of the 9,580 spaces in the system are occupied. However, the commuter bus routes operating within the I-17 corridor have an average occupancy rate of 49 percent compared with a 36 percent occupancy rate of the routes operating within the I-10 corridor.

Typical commuter buses operating in the Valley Metro region can accommodate approximately 40 seated passengers and 20 standing passengers. However, some vehicles in the fleet, such as articulated buses, can comfortably accommodate additional seated and standing passengers. With the average overall occupancy rate of 41 percent, most of the commuter bus routes provide adequate seating for passengers. However, individual trips during peak usage times will experience occupancy levels exceeding 100 percent of seated capacity.

The commuter bus routes identified in this study have an average on-time performance of 95 percent, while the average on-time performance for all other bus routes in the Valley Metro system is 93.7 percent. Reliability of transit services is extremely important to both the success of specific routes and the entire transit system. Transit services that have a poor record of on-time performance can have a significant influence on a rider's choice to use public transit. Based on fiscal year 2014 data from Valley Metro, on-time performance for routes operating in the I-17 corridor was better (98 percent on-time) than routes operating in the I-10 corridor (92 percent). Table 5-5 identifies commuter bus route performance. Table 5-6 identifies commuter bus route carrying capacity.

Table 5-5 Commuter Bus Route Performance

Commuter bus route	Corridor	Average daily ridership	Average daily boardings per trip	Average daily boardings per revenue hour	Typical inbound scheduled travel time (minutes)	Typical outbound scheduled travel time (minutes)	On-time performance (%)
I-10 corridor							
520	I-10 via US-60	45	11	11	54	59	89
521	I-10 via US-60	107	13	12	52	59	94
522	I-10	108	14	13	53	60	89
531	I-10 via US-60	269	22	19	60	65	90
533	I-10 via US-60	417	35	34	57	60	96
541	I-10 via US-60	173	22	20	63	68	91
542	I-10 via SR-202L	394	33	34	50	65	93
450 (I-10E)	I-10	691	24	25	44	49	95
I-10 corridor average		**276**	**22**	**21**	**54**	**61**	**92**
I-17 corridor							
575	I-17 via SR-101L	166	28	24	60	65	99
480 (I-17)	I-17	1,527	30	28	51	55	97
I-17 corridor average		**847**	**29**	**26**	**56**	**60**	**98**
Total average		**561**	**25**	**23**	**54**	**61**	**95**

Source: Valley Metro (2015), *Valley Metro Regional Transit Performance Report*
Notes: I-10 = Interstate 10, I-17 = Interstate 17, US-60 = U.S. Route 60

Table 5-6 Commuter Bus Route Carrying Capacity

Commuter bus route	Corridor	Existing transit carrying capacity					
		Trips per day	Seating/ trip	Standing/ trip	Trip carrying capacity	Daily carrying capacity	% capacity used
I-10 corridor							
520	I-10 via US-60	4	39	20	59	236	19
521	I-10 via US-60	8	39	20	59	472	23
522	I-10	8	37	19	56	448	24
531	I-10 via US-60	12	37	19	56	672	40
533	I-10 via US-60	12	54	28	82	984	42
541	I-10 via US-60	8	40	21	61	488	35
542	I-10 via SR-202L	12	55	28	83	996	40
450 (I-10E)	I-10	29	41	21	62	1,798	38
I-10 corridor subtotal		**93**	**342**	**176**	**518**	**6,094**	**36**
I-17 corridor							
575	I-17 via SR-101L	6	36	18	54	324	51
480 (I-17)	I-17	51	41	21	62	3162	48
I-17 corridor subtotal		**57**	**77**	**39**	**116**	**3,486**	**49**
Total		**150**	**419**	**215**	**634**	**9,580**	**41**

Source: Valley Metro (2015), Valley Metro Seating Capacity
Notes: I-10 = Interstate 10, I-17 = Interstate 17, US-60 = U.S. Route 60

Most commuter bus passengers are considered choice riders based on their propensity to have access to a vehicle, but they chose to use transit for a variety of reasons. Valley Metro strives to improve reliability, safety and comfort while continuing to provide excellent service and thus capture more ridership from this unique market.

Light Rail Transit

Within the study area, there are 13 LRT passenger stations with transfer opportunities to commuter and local fixed-route bus service. As shown in Table 5-7, fiscal year 2014 average daily ridership was nearly 44,000, with a system high of 6.02 boardings per mile. LRT transports an average of 89 people per revenue hour, boarding nearly 96 passengers for a one-direction trip from Main Street/Sycamore to 19th Avenue/Montebello. Table 5-7 identifies LRT performance characteristics.

Table 5-7 Light Rail Transit Operations Performance

Mode	Average daily ridership	Average daily boardings per revenue mile	Average daily boardings per revenue hour	Scheduled travel time (eastbound: 7:00 AM) (minutes)	Scheduled travel time (westbound: 5:00 PM) (minutes)	On-time performance
Light rail	43,826	6.02	89.33	65	65	93%

Source: Valley Metro (2015), *Valley Metro Regional Transit Performance Report*

5.2.3 Local Fixed-route Bus

Local fixed-route bus routes identified in this study perform relatively well compared with other routes in the system. The total average daily ridership for local routes serving the study area is 91,342, accounting for 53 percent of the total average daily boardings of 173,588 for all local routes. Local routes within the study area have a significant impact on system-wide ridership considering that local buses account for 76 percent of annual total Valley Metro fixed-route and light rail ridership.

The average daily boardings per revenue mile in fiscal year 2014 for local routes in the study area were 2.2. The average daily boardings per revenue mile for all local bus routes in the system have a negligible difference of 2.3. Local bus routes identified in the study area have an average on-time performance of 93.1 percent, while all local bus routes within the system operate with a similar average on-time performance of 93.6 percent. Table 5-8 identifies local fixed-route bus service performance characteristics for fiscal year 2014.

Table 5-8 Local Fixed-route Bus Service Operations Performance on Corridors of Interest

Local route	Corridor	Average daily ridership	Average daily boardings per revenue mile	Average daily boardings per revenue hour	On-time performance (%)
0	Central Avenue	3,943	2.55	32.9	93
3	Van Buren Street	4,730	2.64	38.9	91
7	7th Street	3,861	1.91	31.0	92
8	7th Avenue	2,046	1.97	17.1	95
13	Buckeye Road	1,092	1.41	16.8	94
16	16th Street	3,282	2.12	27.9	96
19	19th Avenue	6,465	2.18	27.0	94
27	27th Avenue	3,986	2.86	32.7	92
35	35th Avenue	6,677	2.86	34.7	91
45	Broadway Road	4918	2.11	26.1	92
48	48th Street	1,231	1.99	27.9	92
56	Priest Drive	2,139	2.04	26.2	92
61	Southern Avenue	6,194	2.28	29.0	93
66	Kyrene Road	1,046	1.53	21.4	90
77	Baseline Road	3,487	2.28	32.2	92
17	McDowell Road	7,424	2.90	30.5	93
29	Thomas Road	9,940	4.08	46.7	91
41	Indian School Road	8,984	3.24	35	91
50	Camelback Road	6,592	3.06	38.5	90
60	Bethany Home Road	2,899	3.23	37.1	88
70	Glendale Avenue	6,946	2.62	32.4	90
80	Northern Avenue	2,162	1.68	23.4	95
90	Dunlap Avenue	2,733	2.34	28	96
106	Peoria Avenue	3,077	1.81	22.2	95
108	Elliot Road	1,045	0.76	8.1	92
122	Cactus Road	303	2.11	34.7	98
138	Thunderbird Road	1,260	1.28	18.8	94
154	Greenway Road	1,171	1.07	16.6	96
170	Bell Road	2,999	2.06	26.4	96
186	Union Hills Drive	1,603	1.28	18.9	98

Source: Valley Metro (2015), *Valley Metro Regional Transit Performance Report*

5.3 Transit Mode Share

Mode share examines the percentage of transit passengers to the number of individuals that travel past a specified point in a specified corridor. The segments below were chosen by evaluating where the majority of commuter bus routes travel, to capture an accurate ratio of transit versus non-transit commuters.

In the Phoenix metropolitan region, the volume of PM peak period commuters exceeds the AM peak period commuters. This study defines the AM peak period from 6 to 9 o'clock and the PM peak period from 2 to 6 o'clock. Although the PM peak period is 1 hour longer than the AM peak period, the volumes in the evening are far greater. Commuter bus boardings could not be differentiated by inbound and outbound trips. The average daily boardings were divided by two to calculate the mode share for each corridor in a single direction. The percentage of transit mode share among commuters only is higher than reported in Table 5-10 because of non-commuter traffic that contributes to the total traffic volume. Truck traffic, including local delivery, commercial business, long-haul freight, etc., contributes to the traffic volume. Table 5-9 indicates that transit mode share ranges from as low as 0.7 percent (PM peak period along I-10: Exit 155 Baseline Road to Elliot Road) to as high as 4.9 percent (AM peak period along I-10: Broadway Curve: Exit 153 SR-143).

Table 5-9 Average Weekday Transit Mode Share

Corridor	Commuter bus daily ridership	Commuter bus one-way ridership	AM peak (6–9) total travelers	PM peak (2–6) total travelers	AM peak transit mode share (%)	PM peak transit mode share (%)
I-10: Broadway Curve: Exit 153 SR-143	2,204	1,102	22,448	45,413	4.9	2.4
I-10: Exit 155 Baseline Road to Elliot Road	502	251	17,269	33,627	1.5	0.7
I-17: Exit 202 Indian School Rd. to Camelback Rd.	1,693	847	25,764	37,377	3.3	2.3
I-17: Exit 199A Grant Street to Adams Street	1,693	847	22,143	24,896	3.8	3.4

Sources: Maricopa Association of Governments (2013), Annual Average Daily Traffic Counts;
Valley Metro (2015), *Valley Metro Regional Transit Performance Report*
Notes: I-10 = Interstate 10, I-17 = Interstate 17

5.4 Planned Transit Service Improvements

This section identifies planned major transit service improvements such as new routes and services. Planned minor adjustments such as changes to service span and frequency adjustments are excluded.

The Valley Metro Short Range Transit Program has identified additional commuter bus services. A few local fixed-route bus routes within the study area will be modified in terms of funding only. Service hours or frequency will not be affected by these changes in funding sources. LRT service within the study area is anticipated to grow 26.6 miles by 2034. Five LRT extensions have been identified and are outlined in Table 5-10.

5.4.1 Interstate\HOV-based Services

Commuter Bus Services

Two projects identified in the Valley Metro Short Range Transit Program for commuter bus service are:

- New South Mountain Loop 202 RAPID (fiscal year 2019)
- Gilbert Express (fiscal year 2020)

Vanpool

Growth of regional vanpool services and the specific expansion of services within the study area are contingent on demand. Valley Metro actively seeks opportunities to expand this program, which provides small groups of commuters that have a similar origin and destination with a transit alternative to traditional fixed-route transit services.

5.4.2 Parallel and Intersecting Services

Light Rail Transit

Valley Metro is responsible for planning, developing, and operating the region's high-capacity transit system. Since operations of the 20-mile light rail starter line commenced in December 2008, Valley Metro has begun planning, designing, and constructing 26.6 additional miles of high-capacity/LRT, which is estimated to be completed by 2034. Table 5-10 summarizes the five future high-capacity transit corridors that are located within or connected to the study area.

Northwest Phase I Light Rail Extension to Dunlap Avenue

Valley Metro's Northwest Extension Phase I is a 3.2-mile expansion of light rail service on North 19th Avenue. The project, which is currently under construction, will extend light rail service north on 19th Avenue from Montebello Avenue to Dunlap Avenue. The extension is programmed to be open for revenue service in 2016. The Northwest Extension includes three stations, one park-and-ride, and connections to bus service at Bethany Home Road and Glendale, Northern, and Dunlap Avenues. This extension is scheduled to open in 2016 and will support nearly 20,000 residents and another 20,000 employees. It will serve as an essential means of travel in an area where 14 percent of households depend on transit. The extension is projected to add approximately 5,000 new riders and attract additional development to north-central Phoenix.

Northwest Phase II Light Rail Extension to Metrocenter

Phase II of the project will extend west on Dunlap Avenue, then north on 25th Avenue to Mountain View Road. The approved route will terminate on Mountain View Road just west of I-17. While Valley Metro is currently planning on extending the LRT to directly serve the Metrocenter, the I-17 crossing to Metrocenter Mall is not currently included in the RTP. Phase II is scheduled to open in 2026.

Capitol I-10 West Light Rail Extension

The Capitol/I-10 West extension, formerly known as Phoenix West, will extend light rail approximately 11 miles from downtown Phoenix, through the State Capitol area, to approximately 79th Avenue and I-10. This is Valley Metro's first Interstate corridor project, providing the growing West Valley with a higher-capacity and more efficient transit operation by 2023. The enhancement of transit service in the West Valley will provide residents with greater access to jobs, schools, and their community. It will also connect to major employment centers such as the State Capitol and help ease congestion on I-10.

Capitol I-10 originates at the light rail starter line in downtown Phoenix at Central Avenue/1st Avenue and Washington Street/Jefferson Street. The alignment will travel west to 18th Avenue or 19th Avenue, then north to Van Buren Street. It would run along the southern side of Van Buren Street west to I-17. Then the alignment will travel north along the frontage road that is just west of I-17 until it reaches I-10. In I-10, light rail would operate within the Interstate median to about 47th Avenue, then transition via a bridge over the westbound Interstate traffic lanes to the northern side of I-10, where it would remain on the northern side of the Interstate, terminating at the existing 79th Avenue park-and-ride.

South Central Light Rail Transit Extension

The proposed South Central Avenue Light Rail Extension would extend the light rail approximately 5 miles south from the existing light rail line in downtown Phoenix to Baseline Road in south-central Phoenix. The estimated date of completion is 2034. Seven passenger station locations have been identified. The extension will provide enhanced transit services to a community with high transit ridership and will support neighborhood revitalization and connectivity between downtown Phoenix and south-central Phoenix.

West Phoenix/ Central Glendale Transit Corridor

The West Phoenix/Central Glendale Alternatives Analysis is a 2-year transit corridor study to identify mobility enhancements in west Phoenix and Glendale by 2026. The study extends from 19th Avenue to SR-101L, Northern Avenue to Camelback Road. The corridor would continue toward the city of Glendale from the Northwest Extension currently under construction along 19th Avenue in Phoenix.

Table 5-10 Light Rail Transit Planned Capital Improvements

City	Name	Length (miles)	Estimated completion date	Description
Phoenix	Northwest Phase I	3.2	2016	Provides access to light rail for a largely transit-dependent population of 20,000 residents and 20,000 employees originating at Bethany Home Road/19th Avenue and terminating at Dunlap Avenue/19th Avenue aligned adjacent to I-17.
Phoenix	Capitol I-10 West[a]	11.0	2023	Provides a high-capacity transit corridor between the growing West Valley and the central business district. The corridor originates at Central Station and terminates at I-10/59th Avenue.
Phoenix	South Central[a]	5.0	2034	Provides access to light rail for a largely transit-dependent population originating at Central Station and terminating at Baseline Avenue/Central Avenue.
Phoenix	Northwest Phase II[a]	1.7	2026	Provides enhanced mobility options for a largely transit-dependent population of 10,000 family housing units and 20,000 employees originating at 19th Avenue/Dunlap Avenue and terminating at Metrocenter Mall.
Phoenix/ Glendale	West Phoenix/ Central Glendale[a]	5.6	2026	Provides a high-capacity corridor between downtown Glendale and the existing light rail system. The study area is targeted around major activity centers such as Grand Canyon University and downtown Glendale.

Source: Maricopa Association of Governments (2014), *2035 Regional Transportation Plan*

Notes: I-10 = Interstate 10, I-17 = Interstate 17

[a] project under study

Local Fixed-route Service

No major adjustments to the existing local fixed-route network are identified in the MAG RTP for the study area.

5.5 Existing Capital Investments

This section provides an inventory of facilities, amenities, and features that improve the performance and appeal of transit to riders. Transit priority features reduce the travel time of transit, creating the opportunity for riders to reach their destination faster. Safe, convenient, and easily accessible passenger facilities equipped with desired amenities increase the propensity for commuters to use transit, while the optimization of performance improves the riders' experience by providing maximum mobility and quality of service.

5.5.1 Transit Priority Features

Traffic Signal Priority

Valley Metro is exploring opportunities to improve service, reliability, and on-time performance. Implementation of transit signal priority (TSP), queue jump signals, bypass lanes and/or curb extensions assist busses in maintaining a punctual schedule. TSP is less interruptive to general traffic operations than traffic signal preemption used by emergency response vehicle. With TSP, a request for signal priority will extend a green light momentarily and ensure that a bus moves through the intersection should traffic conditions permit. Currently, LRT is the only service within the study area that utilizes TSP; however, Valley Metro currently operates two bus routes that utilize TSP exclusively outside of the study area.

The expansion of TSP within the study area may improve transit operations reliability; however, traffic signal controllers may need to be upgraded to support transit priority. Likewise, the Valley Metro regional vehicle management system (VMS), which includes GPS-enabled vehicle location, data and voice communications, and other functions, can support the required in-vehicle hardware and software necessary to enable TSP if the system is upgraded. The City of Phoenix and Valley Metro VMS are planning to upgrade or replace the existing VMS in FY 2017.

HOV Facilities

HOV facilities are intended to encourage carpooling, vanpooling and bus ridership. Valley Metro operates a commuter fleet on the available 57 miles of HOV lanes for inbound and outbound trips within the Spine study area. Currently, I-10 and I-17, north of the Stack, have HOV lanes from 6 a.m. to 9 a.m. and from 3 p.m. to 7 p.m. All HOV lanes require a minimum of two persons in each vehicle; however, single occupant motorcycles and all licensed alternative fuel vehicles regardless of the number of occupants are also permitted.

Commuter bus services operate within existing HOV facilities provided in the study area. HOV facilities provide for more reliable commute times and have the potential to reduce passenger travel times based on HOV facility demand and user compliance. Table 5-11 differentiates the mileage of HOV facilities on the I-10 and I-17 corridors.

Table 5-11 High-occupancy Vehicle Facilities

Corridor	Direction	Segment	HOV lane length (miles)
I-17	North	Stack Interchange to Happy Valley Road	17.5
	South	Happy Valley Road to Indian School Road	15.0
I-10	East	Chandler Boulevard to Broadway Curve	12.0
	West	Broadway Curve to Chandler Boulevard	12.0

Source: Google.com (2015), *Google Maps*
Notes: HOV = high-occupancy vehicle, I-10 = Interstate 10, I-17 = Interstate 17

Ramp Meter Bypass

In 2013, ADOT provided a ramp meter bypass at Dunlap Avenue on the southbound frontage road. Vehicles with more than one occupant traveling southbound while attempting to access I-17 at Dunlap Avenue were able to bypass the ramp meter without waiting for a signal. ADOT has since removed the HOV ramp meter bypass and has installed a double metered signalized ramp. All vehicles must stop and await a green signal before proceeding on to I-17.

Direct Ramp Connection

The Bell Road/I-17 park-and-ride facility provides direct HOV access to the I-17 southbound general purpose lanes via a dedicated ramp. Park-and-ride users can access the I-17 southbound frontage road directly from the park-and-ride facility parking lot. The ramp splits into two lanes; a dedicated HOV and an access lane that runs on the frontage road adjacent to the I-17. The HOV lane merges on to the general purpose lanes on I-17. Single-occupant vehicles (SOVs) that want to access I-17 must follow the access lane until they are south of Greenway Avenue. Once SOVs pass the Interstate interchange, they can access I-17 from the ramp on Greenway Avenue.

Passenger Facilities

Park-and-rides

Eight existing publicly owned park-and-ride facilities have been identified within and near the study area, providing 3,245 parking spaces. All of the existing park-and-ride facilities are located in the city of Phoenix. All of the park-and-ride facilities provide access to local bus operations. Depending on location, park-and-rides within the study area provide access to commuter bus and light rail. Table 5-12 identifies the existing park-and-ride facilities in the study area. By 2015, a new park-and-ride located at Baseline Road/24th Street will be opened for passenger use. No other park-and-ride facilities have been identified for future construction within the study area.

Table 5-12 Park-and-ride Vehicle Capacity

Park-and-ride facilities	Route connections	Vehicle capacity
Happy Valley Road park-and-ride	35, I-17 RAPID	512
Bell Road/I-17	27, 170, I-17 RAPID	350
Metrocenter Transit Center	19C, 27, 35, 90, 106, I-17 RAPID	215
19th Avenue/Montebello Avenue park-and-ride	15, 19, 19C, 60, Light Rail	794
19th Avenue/Camelback Road park-and-ride	19, 50, 60, Light Rail	410
27th Avenue/Baseline Road park-and-ride	19,35,77, 251	212
38th Street/Washington Street park-and-ride	1, Light Rail	190
40th Street/Pecos Road park-and-ride	108, ALEX, I-10 East RAPID	562
	Total	**3,245**

Source: Valley Metro (2013), *Valley Metro Park-and-Ride Survey*
Note: I-17 = Interstate 17

Transit Centers

There are six existing transit centers in the study area, all of which serve local bus operations; however, some facilities also serve commuter bus and light rail. Table 5-13 identifies the existing transit center facilities in the study area. The 19th Avenue/Montebello Transit Center and the Metrocenter Transit Center are the only facilities in the study area that also have a park-and-ride function.

Bus Stops

There are currently 2,241 bus stops identified within the study area as shown in Figure 5-1. Bus stop amenities depend on the location and ridership at a particular stop. Stops that experience high ridership have the propensity to offer more amenities to support the stop's use. Nearly 15 percent of the bus stops in the study area have bays, 75 percent have a bench, 60 percent have shelters, and 11 percent are fitted with bike racks.

Table 5-13 Transit Center Route Connections

Transit centers	Route connections	Public parking	Modes served
19th Avenue/Montebello Avenue Transit Center	15, 19, 19C, 60, Light Rail	Yes	Bus, light rail
Central Station Transit Center	0, 1, 3, 7, 8, 10, 12, GAL, 514, 560, 562, 571, 573, 575, I-10 West RAPID, I-17 RAPID, DASH, Light Rail	No	Circulator, bus, RAPID, Express, light rail
Ed Pastor Transit Center	0, 7, 8, 45, 52, Central/South Mountain RAPID	No	Bus, RAPID
Metrocenter Transit Center	19C, 27, 35, 90, 106, I-17 RAPID	Yes	Circulator, bus, RAPID
Phoenix Sky Train Station	1, 3, 44, Light Rail	No	Bus, light rail
Tempe Transportation Center	48, 62, 65, 66, 72, Orbit, Light Rail	No	Circulator, bus, light rail

Source: Valley Metro (2013), *Valley Metro Park-and-Ride Survey*
Note: I-17 = Interstate 17

5.5.2 Transit Capital Performance

Transit Use of HOV Facilities

Traffic counts for northbound and southbound general purpose lanes and HOV facilities on the I-10 corridor were captured at the I-10/SR-143 interchange. Traffic counts for the northbound and southbound lanes for the I-17 corridor were captured at I-17/Indian School Road. As a percentage of general purpose lane traffic volumes, the northbound HOV facility on I-17 during PM peak periods has the highest percentage of HOV use at 12 percent, while the eastbound AM peak period HOV facility has lowest ratio at 8 percent. Table 5-14 provides a comparison of mainline volumes and HOV volumes by designated Interstate corridor segment.

Table 5-14 High-occupancy Vehicle Transit Mode Share Percentage

Direction	Segment	HOV lane length (miles)	Average weekday main line traffic volume		Average weekday HOV traffic volume		Total average weekday traffic volume		Average % HOV use	
			AM	PM	AM	PM	AM	PM	AM	PM
Interstate 17										
North	Stack Interchange to Happy Valley Road	17.5	12,702	26,851	1,261	3,810	13,963	30,661	9	12
South	Happy Valley Road to Indian School Road	15	20,214	21,745	2,268	2,821	22,482	24,566	10	11
Interstate 10										
East	Chandler Boulevard to the Split	12	18,118	42,314	1,470	5,146	19,588	47,460	8	11
West	The Split to Chandler Boulevard	12	34,005	33,494	3,336	3,761	37,341	37,255	9	10

Source: Maricopa Association of Governments (2013), Annual Average Daily Traffic Counts
Note: HOV = high-occupancy vehicle

Park-and-Ride Use

There are currently eight park-and-ride facilities in the study area that support and encourage public transit. Park-and-rides offer several amenities depending on the capacity and use of each facility. These amenities help facilitate both vanpooling and carpooling. The total number of parking spaces provided among all of the identified park-and-rides is 3,245, while the average number of spaces per facility is 405. Overall, the percentage of parking use for the identified facilities is 45 percent. Most of the facilities provide parking capacity that exceeds the demand, with the exception of the Bell Road/I-17 park-and-ride, with an average parking use of 99 percent. While the Bell Road/I-17 park-and-ride is at its capacity, all of the other facilities have at least 30 percent parking vacancy. The parking use at the 27th Avenue/Baseline Road park-and-ride is 16 percent, providing copious space to support future transit service expansion. The combined average parking use at the 19th Avenue/Montebello park-and-ride and the 19th Avenue/Camelback Road park-and-ride, both LRT park-and-rides, is 15.5 percent, which also provides enough space to support future transit service expansion. Percent use of park-and-ride facilities is based on AM peak survey samples collected on a typical weekday. Two major factors—proximity to downtown and amount of service from commuter bus routes—were found to affect the percentage use of park-and-ride facilities. Proximity to downtown was especially important for light rail park-and-rides. Table 5-15 identifies the percent use of park-and-ride facilities within the study area.

Table 5-15 Park-and-ride Use

Park-and-ride facilities	Vehicle capacity	% use
Happy Valley Road park-and-ride	512	56
Bell Road/I-17	350	99
Metrocenter Transit Center	215	63
19th Avenue/Montebello park-and-ride	794	14
19th Avenue/Camelback Road park-and-ride	410	17
27th Avenue/Baseline Road park-and-ride	212	16
38th Street/Washington Street park-and-ride	190	69
40th Street/Pecos Road park-and-ride	562	60
All park-and-ride facilities outside study area	6,718	52
Total	**9,963**	**50**

Note: I-17 = Interstate 17
Source: Valley Metro (2013), *Valley Metro Park-and-Ride Survey*

5.6 Transit Summary

The assessment of current transit conditions yields some general findings that identify potential needs within the study area. School zones affect travel speeds and may impact on-time performance of transit. When the travel speeds of the HOV and SOV lanes are similar, or the HOV lane is slower than the SOV lanes, the incentive to use transit is weakened. It may be more difficult to attract choice riders to transit. None of the park-and-rides have a slip ramp providing direct access to the HOV lane. Buses are forced to merge several lanes of traffic to access the HOV lane which creates a travel time barrier for transit. Site specific issues related to transit are summarized by corridor segment below.

Segment I1: I-10, SR-202L to Baseline Road

- Pecos Road park-and-ride is a key transit facility supporting the I-10 East RAPID service. This is one of two dedicated RAPID bus park-and-ride facilities that do not have direct access connection to a regional Interstate. This not only affects the commuter bus route but the three vanpools that operate out of this park-and-ride.

Segment I2: I-10, Baseline Road to the Split

- The highest commuter bus ridership within the study area occurs within this segment. A majority of East Valley commuter bus services operate within this segment.

Segment I3: I-17, the Split to the Stack

- No commuter express bus services currently operate within this segment of the I-17 due in part to the lack of HOV facilities and an HOV connection between I-17 and I-10.

Segment I4: I-17, the Stack to ACDC

- The HOV lane in the southbound direction terminates at Indian School Road. Discontinuity of HOV lanes minimizes the potential travel time savings that non-SOV users can offer if such facilities are provided.

Segment I5: I-17, ACDC to the North Stack

- Bell Road park-and-ride is at 99 percent utilization. Parking capacity can constrain the growth of transit ridership in the study area as well as the seven vanpools that currently operate out of this park-and-ride.
- Metrocenter park-and-ride does not have direct access to the I-17, affecting the vanpool that operates out of this park-and-ride.
- The transit vehicle occupancy rate capacity is greater for services operating within the I-17 corridor than the I-10 corridor. The I-10 corridor operates at 36 percent seated capacity, while the I-17 corridor operates at 49 percent seated capacity.

Segment A1: 48th Street, Priest Drive, Kyrene Road

- Increased development intensity and the introduction of the Tempe Streetcar in downtown Tempe could affect the performance of local service operating on 48th Street and Kyrene Road.

Segment A2: Baseline Road, Southern Avenue, Broadway Road and Buckeye Road

- The South Central Light Rail Extension will implement traffic signal priority where traffic conditions permit, which could affect the operations of local service on these east-to-west corridors.
- The routing of local transit services on these segments may require reconfiguration to optimize transfers to the planned South Central Light Rail Extension.

Segment A3: 35th Avenue, 27th Avenue and 19th Avenue

- At-grade freight railroad crossing on 35th Avenue just south of Indian School Road, on 27th Avenue just south of Thomas Road and on 19th Avenue just south of Madison Street can affect on-time performance of transit operations.

Segment A4: East-to-west arterials crossing I-17

- At-grade freight railroad crossings on Thomas Road just west of 27th Avenue, on McDowell Road just west of 19th Avenue, on Van Buren Street just west of 19th Avenue and on 24th Street just south of Jackson Street can affect on-time performance of transit operations.
- Commuter buses that operate within the study area are affected by at-grade freight railroad crossings at Adams and Jefferson Streets just west of 19th Avenue.

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6 Bicycle and Pedestrian Infrastructure

According to American Community Survey 5-year estimates (2009 to 2013), the percentage of commuters walking and bicycling to work in Maricopa County are 1.6 percent and 0.8 percent, respectively. Furthermore, the Valley Metro On-Board Survey Report indicates that 4.6 percent of people using the transit system accessed it by bicycling, while 87.2 percent accessed it by walking. An analysis of the census block groups that fall within the Spine study area revealed that commuters in these locations walk and bicycle to work at greater rates than the county average. In the study area, 2.7 percent of commuters walk to work, while 1.4 percent bicycle to work. The bicycle and pedestrian facilities within the study area are depicted in Figure 6-1. This chapter provides an overview of existing bicycle and pedestrian facilities in the study area and evaluates bicycle and pedestrian performance based on available data.

6.1 Bicycle Facilities

The Spine study area has 290 miles of bicycle facilities, which are generally divided into the following categories: bicycle lanes, bicycle routes, and multiuse paths. Although accounting for just 3 percent of the land area in Maricopa County, the study area encompasses approximately 10 percent of the County's bicycle facilities. A brief description of each bicycle facility type is provided in the sections below.

6.1.1 Bicycle Lanes

As defined by the National Association of City Transportation Officials, a bicycle lane is a portion of a roadway that has been designated by striping, signs, and pavement markings for the preferential or exclusive use of bicycles. These facilities enable bicyclists to travel at their own speed and limit vehicular interference. Bicycle lanes promote safe interaction between motorists and bicyclists by facilitating predictable behavior and movements. There are 170 miles of bicycle lanes in the study area, accounting for approximately 59 percent of the study area's bicycle network.

6.1.2 Bicycle Routes

A bicycle route is defined as a segment of a system of bikeways that is typically limited to residential streets. Bicycle routes are designated by signs only and thus feature no bicycle-specific infrastructure. There are currently 39 miles of bicycle routes in the study area, accounting for approximately 14 percent of the study area's bicycle network.

6.1.1 Multiuse Paths

A multiuse path is a facility completely separate from the roadway and motorized traffic that is designated for nonmotorized, mixed use. Multiuse paths can be paved or unpaved. There are currently 80 miles of multiuse paths in the study area, accounting for approximately 27 percent of the study area's bicycle network.

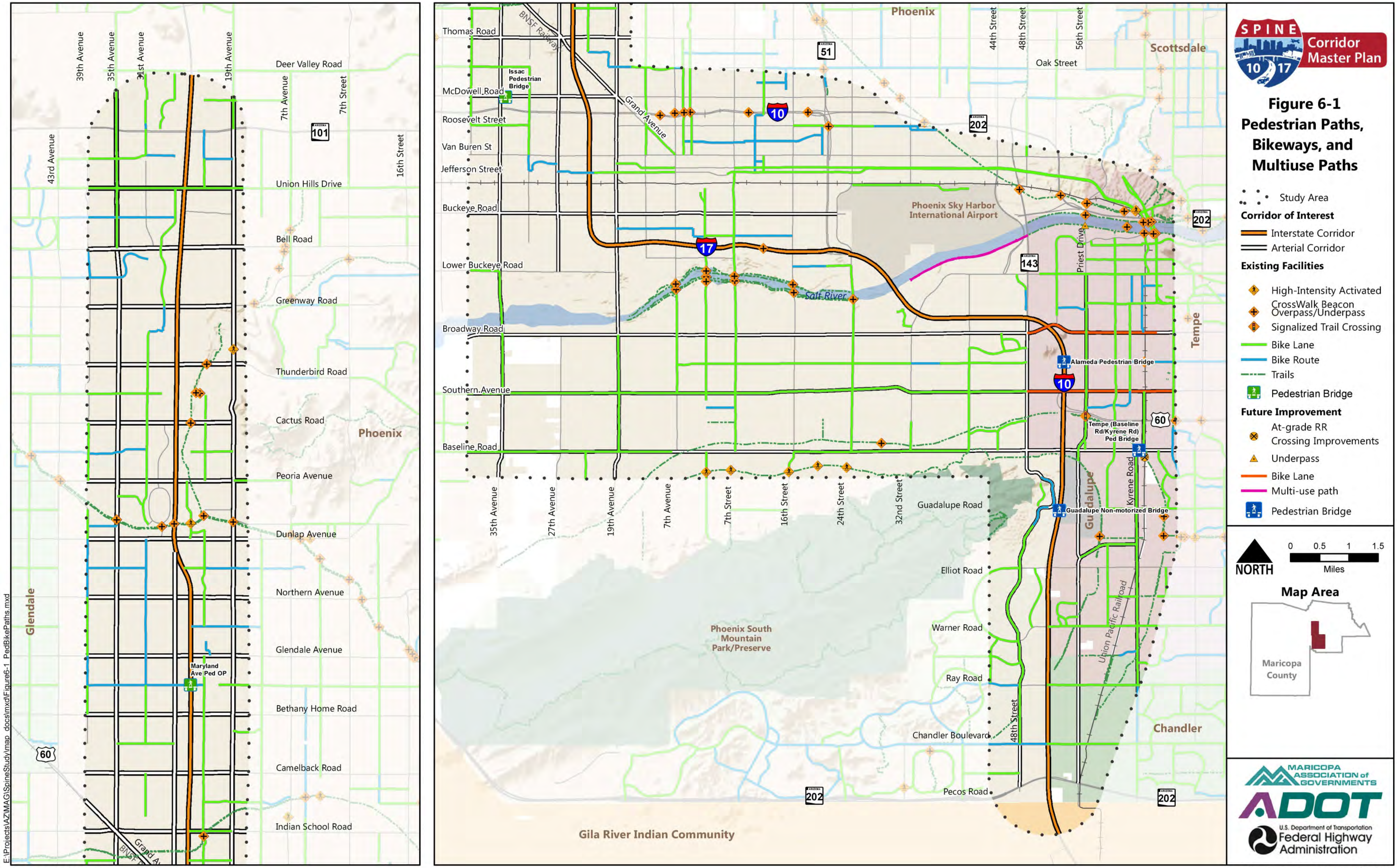
6.2 Pedestrian Facilities

Pedestrian facilities come in various forms but generally include sidewalks, multiuse paths, crosswalks, mid-block crossings, and under/overpasses. These facilities are developed to maximize pedestrian safety and to facilitate predictable behavior and movements between pedestrians and motorists. Although specific design criteria and requirements are set by the various jurisdictions within the study area, the MAG *Pedestrian Policies and Design Guidelines* (2005) provide regional guidance for developing safe and comfortable pedestrian facilities. These guidelines establish design minimums for safe pedestrian facilities, which include but are not limited to:

- Walkways should be at least 6 feet wide and be visually and functionally separate from the path of vehicles.
- Walkway surfaces should be smooth and slip-resistant, without cracks, indents, or steep grades.
- Ramps should be provided at all intersection corners and changes in elevation.
- Walkways should be physically separated from vehicular traffic by at least one vertical or horizontal element.
- All pedestrian crossings of vehicular traffic should have a defined crosswalk.
- Pedestrian facilities should provide direct connections to transit stops where applicable.

Although specific data regarding the extent of pedestrian facilities in the study area is unavailable, most of the pedestrian network was developed in accordance with these design minimums, with new developments often adhering to even higher standards.

Figure 6-1 Pedestrian Paths, Bikeways, and Multiuse Paths



Source: ADOT, MAG

Map Last Updated: 5/10/2016

6.3 Bicycle and Pedestrian Performance

To evaluate bicycle and pedestrian performance, an analysis of available count and crash data was conducted. The findings from this analysis are provided in the sections below.

6.3.1 Bicycle Counts

From 2013 to 2014, MAG conducted a study to develop a regional bicycle counting strategy to gather reliable data on bicycling trends and patterns over time. The study consisted of both automated and manual counts at over 120 sites throughout the region, several of which fell within the Spine study area. Data collected from these sites provide a good indication of the volume of bicycle activity occurring in the study area each day. Average daily weekday bicycle volumes at select locations in the study area are summarized in Table 6-1 below.

Table 6-1 Bicycle Counts in the Spine Study Area

Location	Jurisdiction	Facility type	Average daily weekday volume
11th Street and Jefferson Street	Phoenix	No facility[a]	40
23rd Avenue and Peoria Road	Phoenix	Bike lane	50
23rd Avenue and Maryland Avenue	Phoenix	Bike lane	174
12th Street and McDowell Road	Phoenix	Bike lane	117
39th Avenue and Grand Canal Bike Path	Phoenix	Multiuse path	40
19th Avenue and Northern Road	Phoenix	No facility[a]	219
19th Avenue and Glendale Avenue	Phoenix	No facility[a]	271
35th Avenue and Camelback Road	Phoenix	No facility[a]	268
35th Avenue and Van Buren Street	Phoenix	No facility[a]	396
Central Avenue and Mohave Street	Phoenix	Bike lane	90
19th Avenue and Indian School Road	Phoenix	No facility[a]	274
19th Avenue and Thomas Road	Phoenix	No facility[a]	192
48th Street and Guadalupe Road	Phoenix	Bike lane	126
24th Street and Washington Street	Phoenix	Bike lane	137
Hardy Drive and Western Canal Bike Path	Tempe	Multiuse path	87
Mill Avenue and 10th Street	Tempe	Bike lane	2,244
Rural Road and Southern Avenue	Tempe	No facility[a]	560
Rio Salado Downstream Dam Bridge	Tempe	Multiuse path	480

Source: Maricopa Association of Governments (2014), *MAG Bicycles Count: Final Report and Implementation Plan*
[a] indicates a roadway with no bicycle-specific infrastructure or treatments (bike lane, signs, etc.)

6.3.2 Bicycle and Pedestrian Vehicle Crashes

A review of bicycle and pedestrian crash data revealed that 3,043 bicycle and pedestrian crashes occurred in the study area between 2009 and 2013. These crashes represented 25 percent of the total bicycle and pedestrian crashes in Maricopa County over the same period, despite the study area accounting for just 3 percent of the County's total land area. Furthermore, 33 percent of the County's fatal crashes during this period occurred in the study area. With the exception of 2012, bicycle and pedestrian vehicle crashes have increased each year in the study area. In the 5-year period from 2009 to 2013, there was a 22 percent increase in total bicycle and pedestrian vehicle crashes in the study area. The total bicycle and pedestrian vehicles crashes that occurred in the study area from 2009 to 2013 are summarized, by injury severity, in Table 6-2.

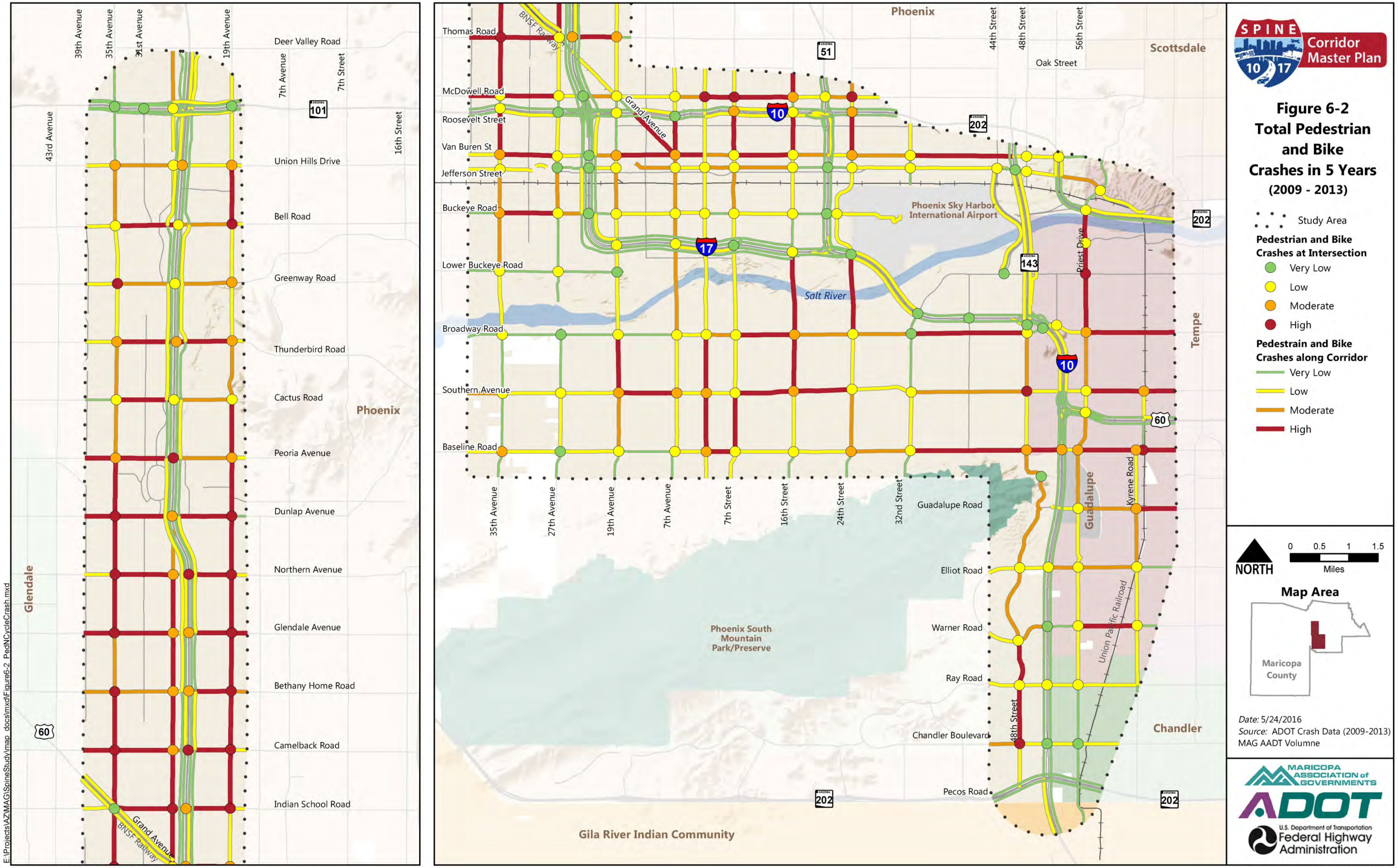
Comparing local crash statistics with national averages provides a good indication of pedestrian performance in the study area and the greater metropolitan region. According to *Dangerous by Design*, a report published by the National Complete Streets Coalition in 2014, the Phoenix-Mesa-Scottsdale metropolitan statistical area ranks as the ninth most dangerous large metro area in the nation for pedestrians. This ranking is based on a Pedestrian Danger Index (PDI) that uses data on the share of commuters who walk to work and the most recent 5 years of pedestrian fatality data to predict the likelihood of a person on foot being hit by a vehicle and killed. From 2008 to 2013, the Phoenix metropolitan area PDI was 118.64, more than double the national PDI of 52.2. Similarly, the annual pedestrian deaths per 100,000 people were higher in the Phoenix metropolitan region than the national average: 1.86 versus 1.56. In the period from 2003 to 2012, pedestrian fatalities accounted for 17 percent of all traffic deaths in the Phoenix metropolitan region, well above the national figure of 12 percent.

Table 6-2 Bicycle and Pedestrian Vehicle Crashes, by Injury Severity (2009 to 2013)

Injury severity	2009	2010	% Change 2009–2010	2011	% Change 2010–2011	2012	% Change 2011–2012	2013	% Change 2012–2013
No injury	49	49	0	68	39	67	–1	61	–9
Possible injury	167	163	–2	161	–1	160	–1	211	32
Non-incapacitating injury	227	236	4	249	6	238	-4	260	9
Incapacitating injury	92	110	20	117	6	97	–17	117	21
Fatal	25	35	40	25	–29	26	4	33	27
Total	**560**	**593**	**6**	**620**	**5**	**588**	**–5**	**682**	**16**

Source: Arizona Department of Transportation Crash Data (2009 to 2013)

Figure 6-2 Total Pedestrian and Bike Crashes in 5 Years (2009–2013)



Source: ADOT Crash Data (2009-2013)

Map Last Updated: 5/24/2016

6.4 Bicycle and Pedestrian Key Findings

In an effort to identify key bicycle and pedestrian infrastructure and safety issues within the Spine study area, a gap analysis was conducted. This analysis identified gaps in the bicycle and pedestrian network and locations where accident rates are comparatively high. The results of this evaluation are organized by arterial corridor groups and summarized in the sections below.

Segment A1: 48th Street, 56th Street/Priest Drive and Kyrene Road

The following bicycle and pedestrian issues have been identified for the 48th Street, 56th Street/Priest Drive, and Kyrene Road corridors in the study area:

- **48th Street:** Bike lanes on 48th Street drop north of Arizona Grand Parkway. High bicycle and pedestrian crash rates have been reported on the segment of 48th Street between Warner Road and Chandler Boulevard and at the intersection at Chandler Boulevard.
- **Priest Drive:** Bike lanes on Priest Drive drop south of Baseline Road. High bicycle and pedestrian crash rates have been reported on the segment of Priest Drive between Broadway Road and SR-202L and at the Baseline Road and University Drive intersections.
    - **Kyrene Road:** High bicycle and pedestrian crash rates have been reported at the intersection of Kyrene Road and Guadalupe Road.

Segment A2: Baseline Road, Southern Avenue, Broadway Road and Buckeye Road

The following bicycle and pedestrian issues have been identified for the Broadway Road, Southern Avenue, and Baseline Road corridors in the study area:

- **Broadway Road:** No bike facilities are present on Broadway Road in the study area. High bicycle and pedestrian crash rates have been reported on the segments of Broadway Road between 32nd Street and 48th Street and east of Priest Drive through Tempe.
- **Southern Avenue:** Bike lanes on Southern Avenue drop east of 48th Street. High bicycle and pedestrian crash rates have been reported on the segments of Southern Avenue between 19th Avenue and 7th Avenue, 16th Street and 24th Street, and east of Priest Drive.
    - **Baseline Road:** Bike lanes on Baseline Road drop between 7th Avenue and 16th Street and from 40th Street east through Tempe. High bicycle and pedestrian crash rates have been reported on the segments of Baseline Road between Central Avenue and 7th Street and east of 32nd Street through Tempe. High bicycle and pedestrian crash rates have also been reported at the I-10 and Priest Drive intersections.

Segment A3: 35th Avenue, 27th Avenue and 19th Avenue

The following bicycle and pedestrian issues have been identified for the 35th Avenue, 27th Avenue, and 19th Avenue corridors in the Spine study area:

- **35th Avenue:** Bike lanes are only present on the portions of the corridor between Southern Avenue and Lower Buckeye Road and north of Bell Road. High bicycle and pedestrian crash rates have been reported on the segments of 35th Avenue between McDowell Road and Bethany Home Road and between Glendale Avenue and Peoria Avenue. High bicycle and pedestrian crash rates have also been reported at the Glendale Avenue, Northern Avenue, and Dunlap Avenue intersections.
- **27th Avenue:** No bike facilities are present on 27th Avenue in the study area. High bicycle and pedestrian crash rates have been reported on the segment of 27th Avenue between Thomas Road and Glendale Avenue. High bicycle and pedestrian crash rates have also been reported at the Indian School Road intersection.
    - **19th Avenue:** Bike lanes are only present on the portion of the corridor between Baseline Road and Broadway Road. High bicycle and pedestrian crash rates have been reported on the segments of the corridor between Indian School Road and Cactus Road, and between Bell Road and Union Hills Drive. High bicycle and pedestrian crash rates have also been reported at every major arterial intersection between Indian School Road and Dunlap Avenue.

Segment A4: East-to-west arterials crossing I-17

The following bicycle and pedestrian issues have been identified for the major arterial corridors that cross the I-17 in the northern portion of the Spine study area:

- The bicycle and pedestrian network in the northern portion of the study area lacks sufficient east-west connectivity. No bike facilities are present on Buckeye Road, Van Buren Street, McDowell Road, Thomas Road, Camelback Road, Bethany Home Road, Glendale Avenue, Northern Avenue, Dunlap Avenue, Peoria Avenue, Cactus Road, Thunderbird Road, Greenway Road, or Bell Road.
- High bicycle and pedestrian crash rates have been reported on portions of or the entire segment in the study area of the following east-west arterial corridors: Van Buren Street, McDowell Road, Thomas Road, Indian School Road, Camelback Road, Bethany Home Road, Northern Avenue, Dunlap Avenue, Peoria Avenue, Cactus Road, Thunderbird Road, and Bell Road.
    - High bicycle and pedestrian crash rates have also been reported at 15 out of the 26 total (58 percent) major arterial intersections between Indian School Road and Peoria Avenue and 35th Avenue and 19th Avenue.

Conclusions

The gap analysis identified several areas where the bicycle and pedestrian network in the study area is inconsistent and provides poor connectivity. Additionally, a majority of the intersections and corridor segments that have experienced high crash rates lack dedicated bicycle facilities. Future improvements to the bicycle and pedestrian network should prioritize these locations in an effort to create a fully connected network that facilitates the safe movement of bicyclists and pedestrians.

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7 Safety

Researching the frequency and rate of crashes throughout the corridor helps identify current and future problem areas. Crashes generally increase in areas where there are more vehicles. Crash rates identify areas with an unusually high number of crashes compared with the number of vehicles traveling on the road. This information helps to identify the location of potential improvements.

A high-level crash analysis was conducted for the Spine study area to understand and identify the location of high-crash hotspots within the study area and along the Spine corridors of interest. These hotspots will then be used in the process to identify mitigation strategies and will assist in the evaluation process during the alternative analysis phase of the Spine study.

7.1 Safety Planning in the Corridor

The Arizona 2014 Strategic Highway Safety Plan provides a comprehensive framework for reducing fatalities and serious injuries on public roadways. This plan identifies actions and strategies to be taken over next 5 years to reduce the number of fatalities and serious injuries in Arizona by 3 to 7 percent.

7.2 Data and Approach

As part of the safety evaluation of the Spine study area, a crash analysis was conducted to identify crash patterns, trends and types using the crash data provided by ADOT's Traffic Safety Division. Crash data for the analysis included the 5-year crash analysis period from January 1, 2009, through December 31, 2013. As part of this analysis, crash frequency, crash rate, severity, pedestrian and bicycle crashes, crashes related to buses, LRT crashes, truck crashes, nighttime crashes and driving under the influence (DUI) crashes were reviewed.

Data indicated that there were 354 fatalities and 91,034 reported crashes within the study area during the 5-year analysis period. Compared with the number of total crashes in the entire MAG region, the study area accounts for approximately 26 percent of all crashes in the region. In addition, 22 percent of the MAG region's crash fatalities occurred within the Spine study area. Historical crash data analysis indicates that one person dies every 5 days within the study area because of a traffic crash.

To evaluate safety performance of the entire Spine study area, a statistical analysis was performed on the crash data for the entire study area, and the data were divided into the four following ratings:

- very low = below the 15th percentile
- low = 15th–50th percentile
- moderate = 51st–85th percentile
- high = over 85th percentile

These ratings and their associated ranges were used to describe the study area's Interstate and arterial segments and associated intersections.

The categories of severe crashes (fatal and incapacitating), pedestrian and bicycle crashes, DUI-involved crashes and truck and bus crashes have a low number of crashes within the 5-year analysis period. Given the low number of crashes in those categories, the "very low" rating is used to indicate only locations that have no crashes in the 5-year analysis period.

Because of barrier separation and other Interstate characteristics, crashes on I-10 and I-17 are analyzed based on direction of travel. Crashes on arterial segments, with the exception of the crash rate category, are analyzed with both directions combined because arterials are smaller facilities and not barrier-separated. All Interstate service interchanges were treated as a single intersection for the purposes of this analysis and included all crashes on the arterial and both on and off service ramps within a 400-foot radius of the intersection of the Interstate and arterial. In areas where a spread diamond existed, a 600-foot radius was used. For arterial intersections, a 250-foot radius from the center point of the intersection was used to determine which crashes were intersection crashes and which crashes were segment crashes.

Valley Metro Light Rail-related crash data for a 3-year period (2012 to 2014) was used for an analysis of LRT-involved crashes. Since the total LRT-involved crashes were less than 1 percent of the study area crashes and LRT-involved crashes are different from the other types of crashes, only the three ratings of low, moderate and high were used. One crash was considered low, two crashes were considered moderate and three or more crashes were considered high.

7.3 Crash Frequency

Crash frequency represents the number of crashes that occurred during the crash analysis time period regardless of the leve of injury. Since crashes are relatively rare events, it is important that a safety analysis include an adequate period of study. Crash averaging allows for the normalizing of crash data over a longer period than 1 year to account for annual anomalies that can skew the analysis. The analysis summarized the average of 5 years of total crashes by Interstate segments, arterial segments and intersections. The sum of all crashes was divided by the number of years of analysis (5 years) to calculate the average number of crashes per year. Average crash frequency for each location is compared with the average crash frequency ranges shown in Table 7-1 and is categorized as very low, low, moderate or high.

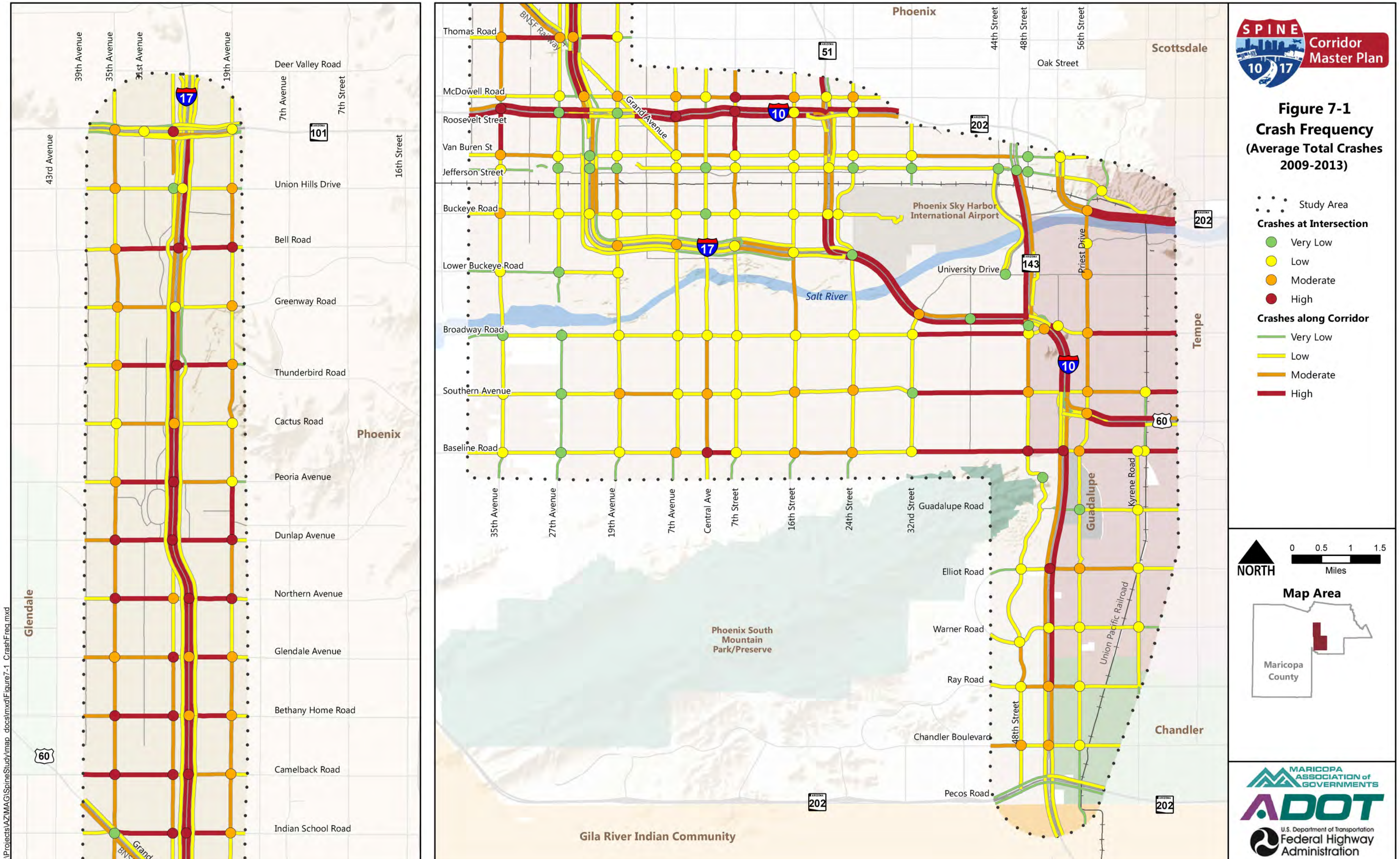
Table 7-1 Crash Frequency Ranges

Rating	Intersection	Along arterial and Interstate corridor
Very low	<9 average crashes	<3 average crashes
Low	9–24 average crashes	3–20 average crashes
Moderate	24–36 average crashes	20–35 average crashes
High	>36 average crashes	>35 average crashes

Source: HDR, March 2015

Figure 7-1 shows the crash frequency analysis along the corridors of interest and at intersections. There are six system interchanges within the study area. Their locations and crash frequency are shown in Figure 7-2.

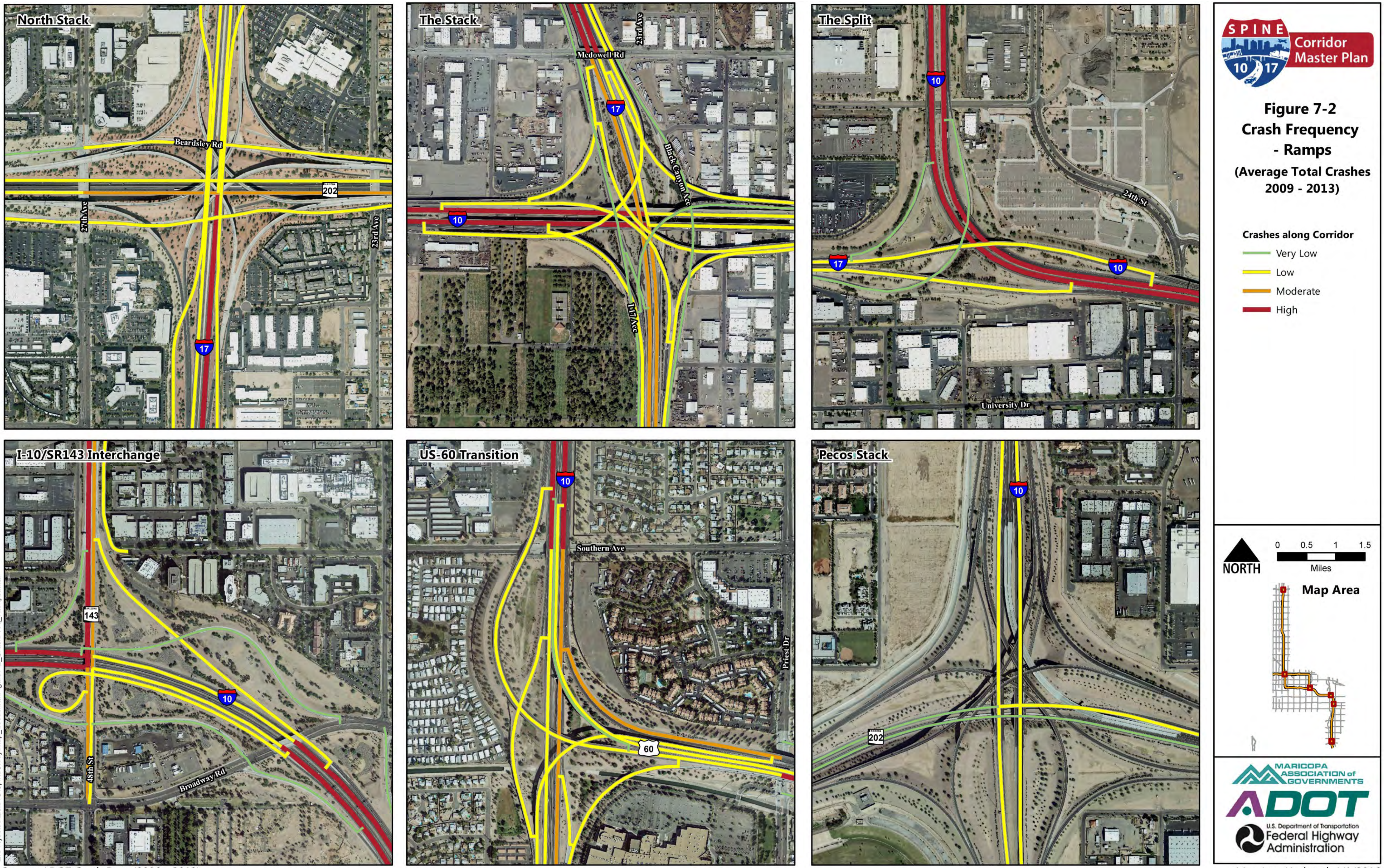
Figure 7-1 Crash Frequency (Average Total Crashes 2009–2013)



Source: ADOT Crash Data (2009-2013)

Map Last Updated: 5/11/2016

Figure 7-2 Crash Frequency – Ramps (Average Total Crashes 2009–2013)



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Source: ADOT Crash Data (2009 - 2013)

Map Last Updated: 4/1/2016

Identifying high crash frequency locations is critical for conducting a safety evaluation and recommending mitigation measures to improve overall safety. Table 7-2 summarizes locations along and adjacent to the Spine corridors of interest that have a high crash frequency, which refers to more than 35 average crashes along the corridor and more than 36 average intersection crashes.

Table 7-2 High Crash Frequency Locations along Corridors of Interest

Category	Route	Location
Interstates	Interstate 17 northbound	• McDowell Road to Cactus Road • Bell Road to State Route 101L
	Interstate 17 southbound	• Greenway Road to McDowell Road
	Interstate 10 eastbound	• State Route 51 to Southern Avenue
	Interstate 10 westbound	• Ray Road to Baseline Road • Southern Avenue to State Route 51
Arterials	Bell Road	Between 19th Avenue and 35th Avenue
	Thunderbird Road	
	Peoria Avenue	
	Dunlap Road	
	Northern Avenue	
	Glendale Avenue	
	Bethany Home Road	
	Camelback Road	
	Indian School Road	
	Thomas Road	
	Broadway Road	• Between 32nd Street and 48th Street • East of Priest Drive
	Southern Avenue	
	Baseline Road	
Intersections	Interstate 17 traffic interchanges	• Bell Road • Thunderbird Road • Peoria Avenue • Dunlap Road • Northern Avenue • Camelback Road • Indian School Road
	Interstate 10 traffic interchanges	• Baseline Road • Elliot Road
	35th Avenue	• Dunlap Avenue • Northern Avenue • Bethany Home Road • Camelback Road
	19th Avenue	• Bell Road • Dunlap Avenue • Northern Avenue
	27th Avenue	• Glendale Avenue • Bethany Home Road • Camelback Rad • Indian School Road
	Baseline Road	• Central Avenue • 48th Street

Source: HDR, March 2015

7.4 Crash Rate

Crash rates were calculated for both corridor segments and intersections. Arterial and Interstate segment crash rates were calculated for each direction by dividing the number of crashes in each direction by the directional traffic volume per mile of segment length. Segment crash rates have the unit designation of per million vehicles per mile (MVM). Crash rates were determined for each direction for the Interstate and arterial segments. Intersection crash rates are calculated by dividing the number of crashes by number of vehicles entering the intersection. Interstate interchanges with arterials calculate total entering volumes into an intersection by combining the entering Interstate ramp volumes and the entering arterial volumes. Intersection crash rates have the unit designation of per million entering vehicles (MEV). The crash rate of each segment and intersection is categorized by comparing them with the ranges shown in Table 7-3. Figure 7-3 shows the segment and intersection and crash rates. System ramp crash rates are shown in Figure 7-4.

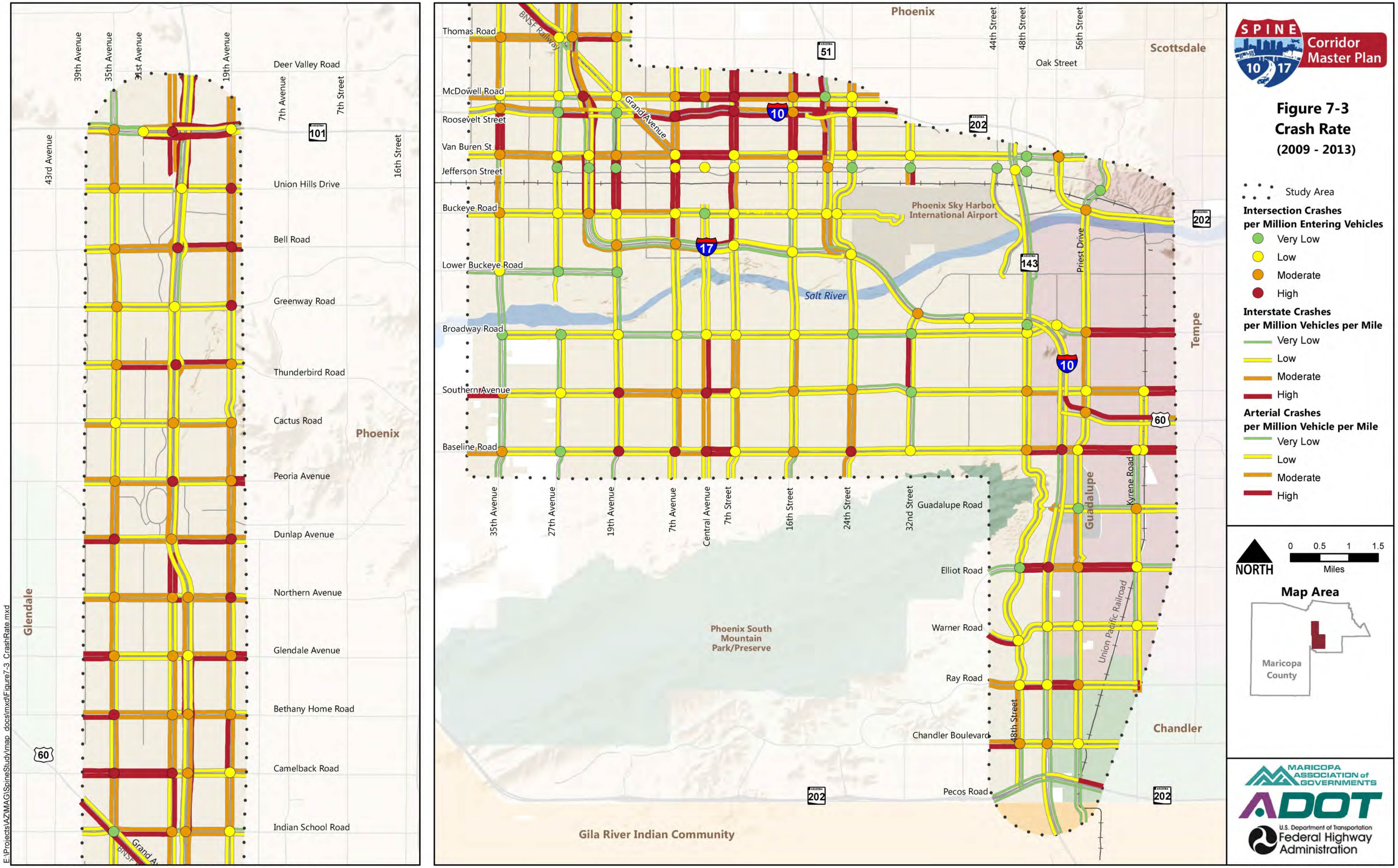
Table 7-3 Crash Rate Ranges

Rating	Intersection	Along arterial	Along Interstate
Very low	<0.7 crash/MEV	<0.8 crash/MVM	<0.74 crash/MVM
Low	0.7–1.3 crashes/MEV	0.8–2.5 crashes/MVM	0.74–1.8 crashes/MVM
Moderate	1.3–1.9 crashes/MEV	2.5–3.9 crashes/MVM	1.8–2.75 crashes/MVM
High	>1.9 crashes/MEV	>3.9 crashes/MVM	>2.75 crashes/MVM

Source: HDR, March 2015
Notes: MEV = million entering vehicles, MVM = million vehicles per mile

Determining the crash rate for the Spine study area is important because it normalizes crash frequency based on the exposure that a specific segment or intersection has to vehical utilization. Since segments and intersections with larger vehicular volumes have a greater probability of a crash happening than segments and intersections with lower vehicular volumes, normalizing the crash frequencies with vehicular volumes through crash rates allows direct comparisons between segments and intersections that have different vehicular volumes.

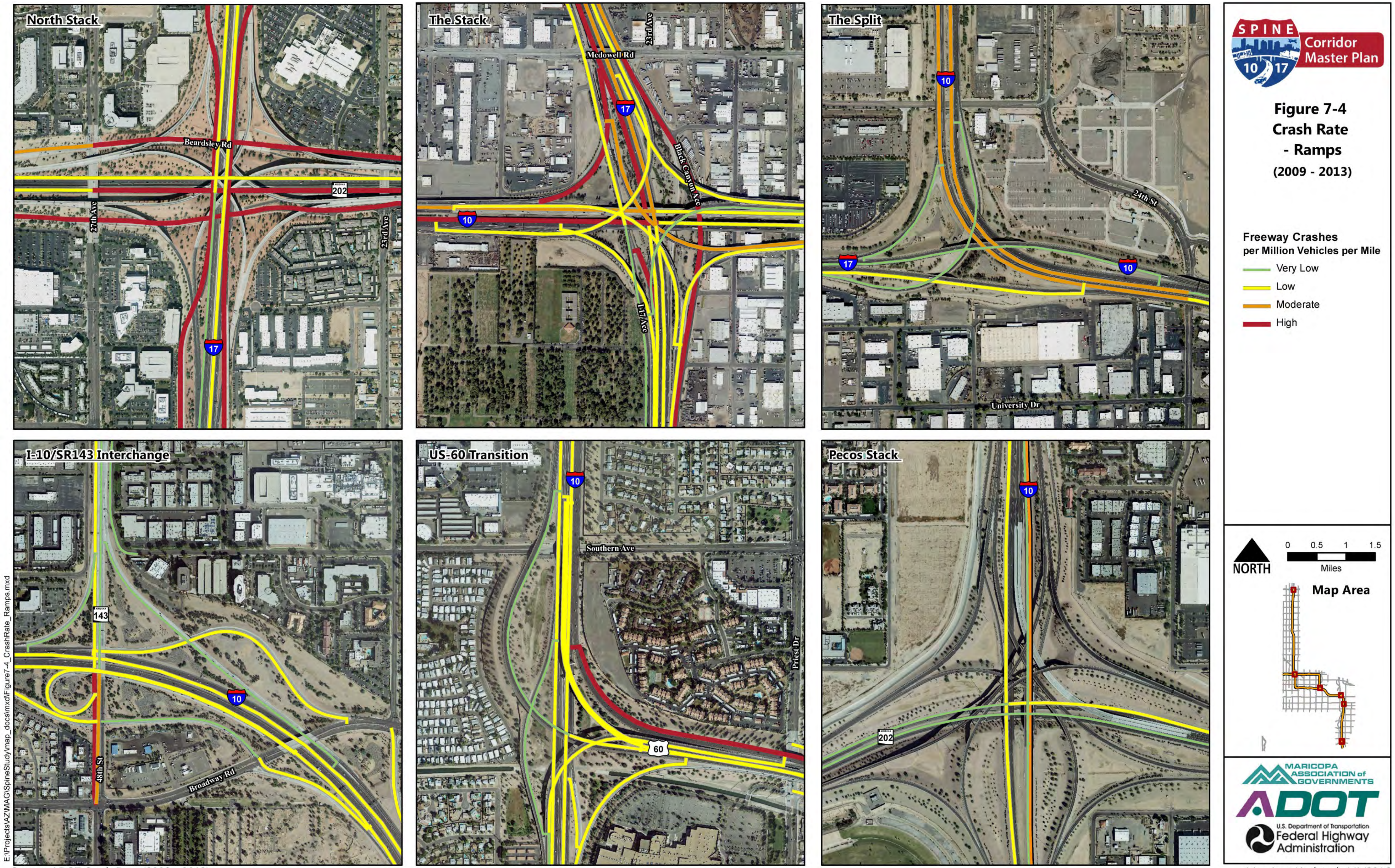
Figure 7-3 Crash Rate (2009–2013)



Source: ADOT Crash Data (2009-2013), MAG AADT Volume

Map Last Updated: 4/1/2016

Figure 7-4 Crash Rate – Ramps (2009–2013)



Source: ADOT Crash Data (2009 - 2013)

Map Last Updated: 4/1/2016

A segment or an intersection that has a high crash frequency does not always translate into a segment or an intersection that has a high crash rate, which assists in identifying areas with unusually high number of crashes. This allows for a high-level identification and prioritization of these locations when considering safety improvements.

Table 7-4 summarizes locations within the Spine study area that have a high crash rate. A high crash rate represents areas that have greater than 2.75 crashes / MVM along an Interstate segment, 3.9 crashes / MVM along an arterial segment and greater than 1.9 crashes / MEV at intersections.

Table 7-4 High Crash Rate Locations along Corridors of Interest

Category	Route	Location
Interstates	Interstate 17 northbound frontage road	• Buckeye Road to McDowell Road • Indian School Road to Glendale Avenue • Union Hills Drive to Deer Valley Road
	Interstate 17 southbound frontage road	• Deer Valley Road to Union Hills Drive • Glendale Avenue to Bethany Home Road • Van Buren Street to Buckeye Road
	Interstate 17 southbound	• Thomas Road to Roosevelt Street
Arterials	Bell Road westbound	• Interstate 17 to 19th Avenue
	Thunderbird Road eastbound	• 35th Avenue to Interstate 17
	Thunderbird Road westbound	• 35th Avenue to Interstate 17
	Dunlap Road eastbound	• 45th Avenue to 35th Avenue • Interstate 17 to 19th Avenue
	Northern Avenue eastbound	• 27th Avenue to Interstate 17
	Glendale Avenue eastbound	• 45th Avenue to 35th Avenue • Interstate 17 to 15th Avenue
	Glendale Avenue westbound	• 45th Avenue to 35th Avenue • 19th Avenue to 15th Avenue
	Bethany Home Road eastbound	• 45th Avenue to 35th Avenue
	Camelback Road	• 45th Avenue to 27th Avenue
	Indian School Road eastbound	• 35th Avenue to 27th Avenue
	Grand Avenue southbound	• 39th Avenue to Thomas Road
	Thomas Road eastbound	• Interstate 17 to 19th Avenue
	Broadway Road	• Priest Drive to Mill Avenue
	Southern Avenue	• 45th Avenue to 35th Avenue • Hardy Drive to Mill Avenue
	Southern Avenue westbound	• Central Avenue to 7th Street
	Baseline Road	• Central Avenue to 7th Street • Priest Drive to Mill Avenue

Table 7-4 High Crash Rate Locations along Corridors of Interest

Category	Route	Location
	Baseline Road eastbound	• 48th Street to Interstate 10
	19th Avenue	• Washington Street to Buckeye Road
	19th Avenue southbound	• Bethany Home Road to Camelback Road
	27th Avenue	• Dunlap Avenue to Northern Avenue
	27th Avenue northbound	• Indian School Road to Camelback Road
	35th Avenue	• Roosevelt Street to Van Buren Street
Intersections	Interstate 17 traffic interchanges	• Bell Road • Thunderbird Road • Peoria Avenue • McDowell Road
	Interstate 10 traffic interchanges	• Baseline Road • Elliot Road
	35th Avenue	• Dunlap Avenue • Bethany Home Road • Camelback Road
	19th Avenue	• Union Hill Road • Bell Road • Greenway Road • Dunlap Avenue • Northern Avenue • Southern Avenue • Baseline Road
	27th Avenue	• Camelback Road
	Baseline Road	• 7th Avenue • Central Avenue • 24th Street
	Southern Avenue	• Central Avenue

Source: HDR, March 2015

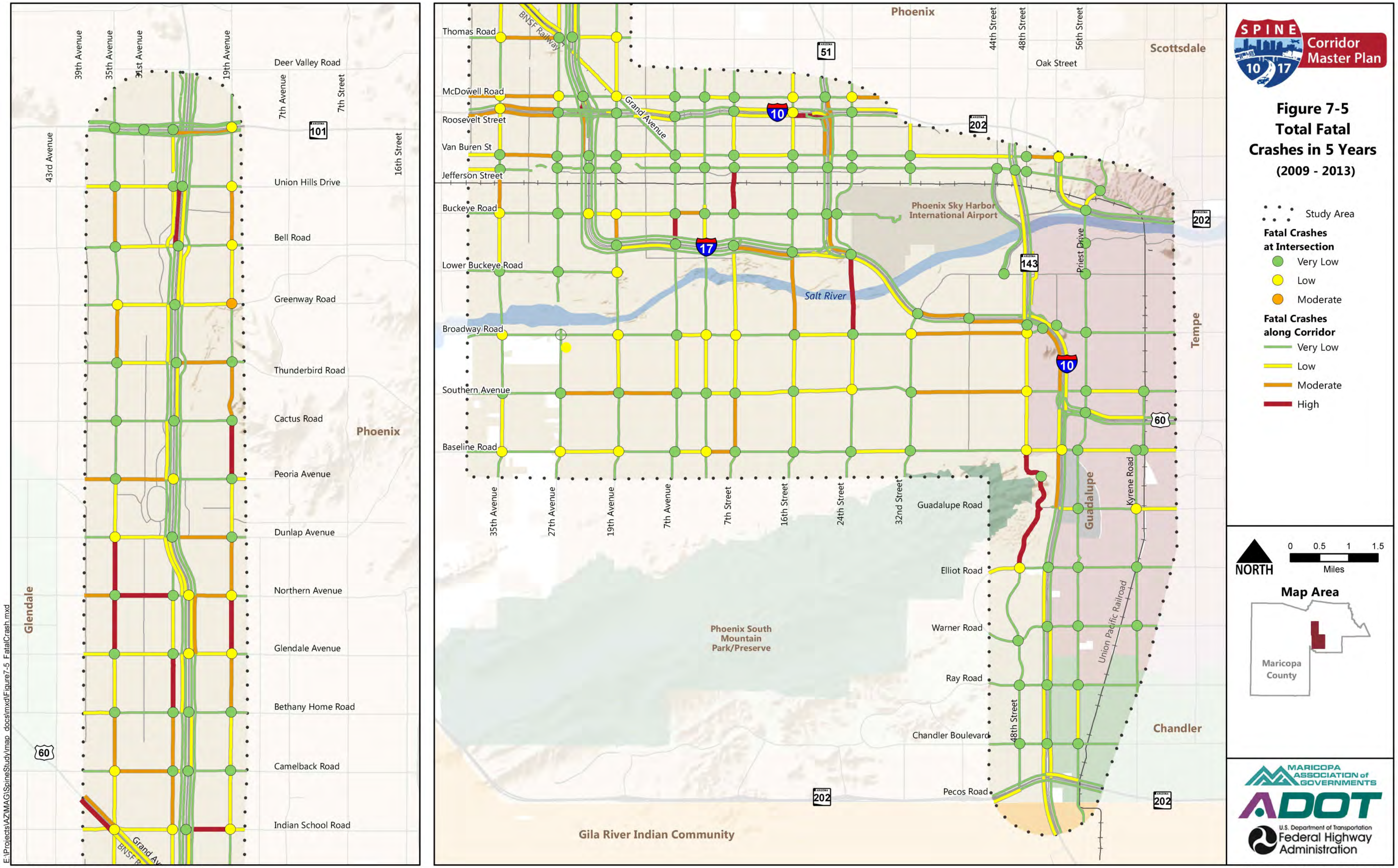
7.5 Crash Severity

All of the crashes listed in the ADOT Traffic Safety Division crash data had one of six severity ratings: no injury, possible injury, non-incapacitating injury, incapacitating injury, fatal and unknown. Each crash was rated based on based on the worst injury resulting from the crash. For the purposes of the Spine study, only the severity ratings of fatal and incapacitating were evaluated.

7.5.1 Fatal Crashes

Figure 7-5 shows the total number of fatal crashes along the Spine study area segments and at the intersections over a 5-year period. Fatal crash insets for the system ramps are shown in Figure 7-6.

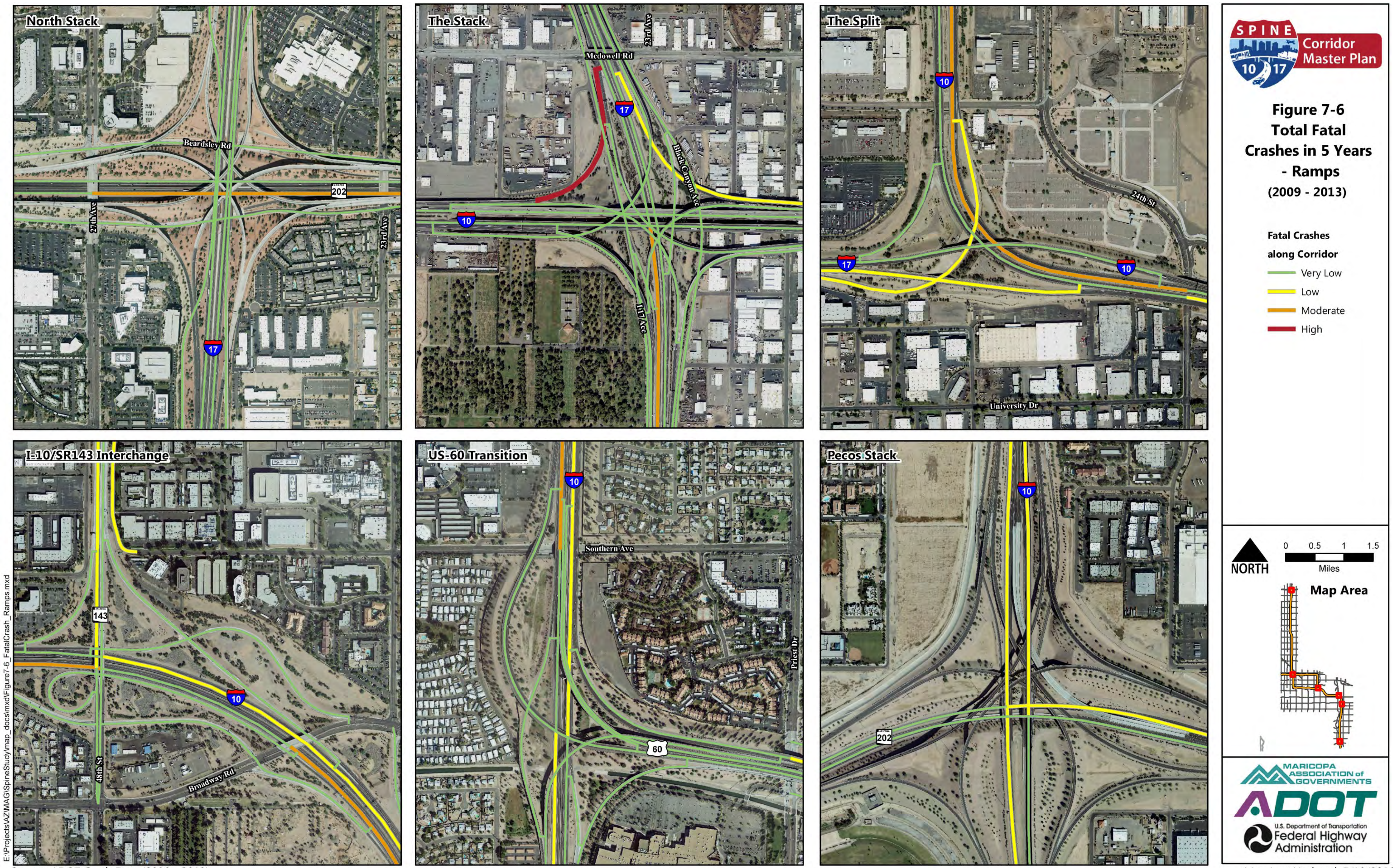
Figure 7-5 Total Fatal Crashes in 5 Years (2009–2013)



Source: ADOT Crash Data (2009-2013)

Map Last Updated: 5/11/2016

Figure 7-6 Total Fatal Crash Rate in 5 Years – Ramps (2009–2013)



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Source: ADOT Crash Data (2009 - 2013)

Map Last Updated: 5/10/2016

Table 7-5 outlines the ranges used for determining the fatal crash designations used along the segments and at the intersections. Given the low number of fatal crashes that occurred at intersections in the Spine study area, intersections are only rated as very low, low, or moderate.

Table 7-5 Fatal Crash Ranges

Rating	Intersection	Along arterial and Interstate corridor
Very low	<1 crash/5 years	<1 crash/5 years
Low	1–2 crashes/5 years	1–2 crashes/5 years
Moderate	>2 crashes/5 years	2–3 crashes/5 years
High	Not applicable	>3 crashes/5 years

Source: HDR, March 2015

Table 7-6 summarizes the locations that have a high frequency of fatal crashes in the Spine study area.

Table 7-6 High Fatal Crash Locations in the Spine Study Area

Category	Route	Location
Interstates	Interstate 17 southbound	• Glendale Avenue to Bethany Home Road
	Interstate 10/Interstate 17 Interchange (The Stack)	• Ramp Southbound to Westbound
Arterials	Northern Avenue	• 35th Avenue to 27th Avenue
	Indian School Road	• Interstate 17 to 19th Avenue
	Grand Avenue	• 45th Avenue to 35th Avenue
	19th Avenue	• Cactus Road to Peoria Avenue • Northern Avenue to Glendale Avenue
	27th Avenue	• Glendale Avenue to Bethany Home Road
	35th Avenue	• Dunlap Avenue to Glendale Avenue
	48th Street	• Baseline Road to Elliot Road

Source: HDR, March 2015

7.5.2 Total Incapacitating and Fatal Crashes

Since fatal crashes can be affected by factors outside of roadway safety issues like not wearing a seatbelt and age/condition of the vehicle, a better indicator of a roadway safety issue causing severe injury is to combine the number of fatal and incapacitating crashes. While this results in a much high number of events when compared with just fatal crashes, the crash events are not as skewed by the statistical abnormality of a fatal crash.

The impact of fatal and incapacitating crashes is significant and affects the community through loss of lives, reduced market productivity, impacts to workforce and the healthcare system and travel delays during the incident. Identifying and evaluating high fatal and incapacitating injury crash locations is necessary for developing a plan of recommended mitigation and countermeasures to reduce the number and severity of these types of crashes.

Total incapacitating and fatal crashes within the Spine study area are presented in Figure 7-7. System interchange ramps are shown in Figure 7-8. Table 7-7 shows the ranges used to generate the total fatal and incapacitating injury crash maps.

Table 7-7 Fatal and Incapacitating Injury Crash Ranges

Rating	Intersection	Along arterial and Interstate corridor
Very low	<1 crash/5 years	<1 crash/5 years
Low	1–3 crashes/5 years	1–3 crashes/5 years
Moderate	3–7 crashes/5 years	3–7 crashes/5 years
High	>7 crashes/5 years	>7 crashes/5 years

Source: HDR, March 2015

Because the occurrence of fatal and incapacitating crashes has a low frequency compared with the total number of all crashes, one crash in the 5-year analysis period defines the very low category and more than seven crashes in the 5-year analysis period defines the high category. The ranges for the Interstate and arterial segments and the study area intersections are the same.

7.6 Pedestrian and Bicycle Involved Crashes

Chapter 6 also discusses pedestrian and bicycle safety. Unlike the vehicular data available for the Spine study, current and historical volume counts for pedestrians and bicycles do not exist for the Spine study area. Because of the lack of volume data for pedestrians and bicycles, the pedestrian and bicycle involved crash figures created for this report are only for crash frequency and not crash rate. While the crash frequency map will help identify locations that need to be evaluated for pedestrian and bicycle safety improvements, it does not help with the prioritization of those locations because the crash frequencies are not normalized with the pedestrian and bicycle volumes using the facilities at those locations.

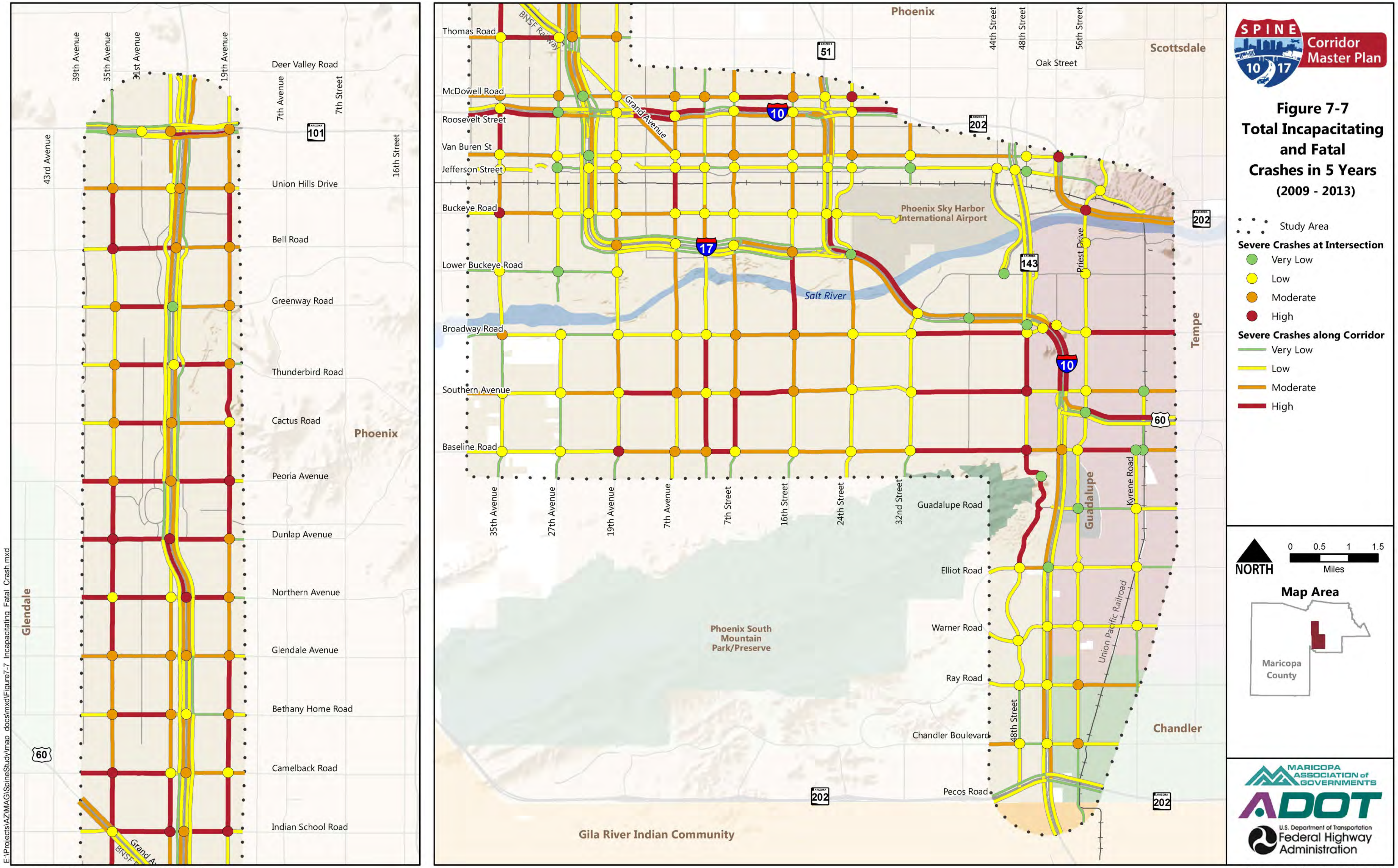
Over the 5-year analysis period, one pedestrian was killed every month by a vehicle in the Spine study area, and 31 pedestrians are either killed or injured for every 100,000 residents because of traffic crashes within the Spine study area. Total pedestrian and bicycle involved crashes at the intersections and along the Interstate and arterial segments are summarized in Figure 7-9. The ranges used to determine the frequency ratings in Figure 7-9 are shown in Table 7-8.

Table 7-8 Pedestrian and Bicycle Involved Crash Ranges

Rating	Intersection	Along Arterial and Interstate Corridor
Very low	<1 crash/5 years	<1 crash/5 years
Low	1–3 crashes/5 years	1–2 crashes/5 years
Moderate	3–6 crashes/5 years	2–5 crashes/5 years
High	>6 crashes/5 years	>5 crashes/5 years

Source: HDR, March 2015

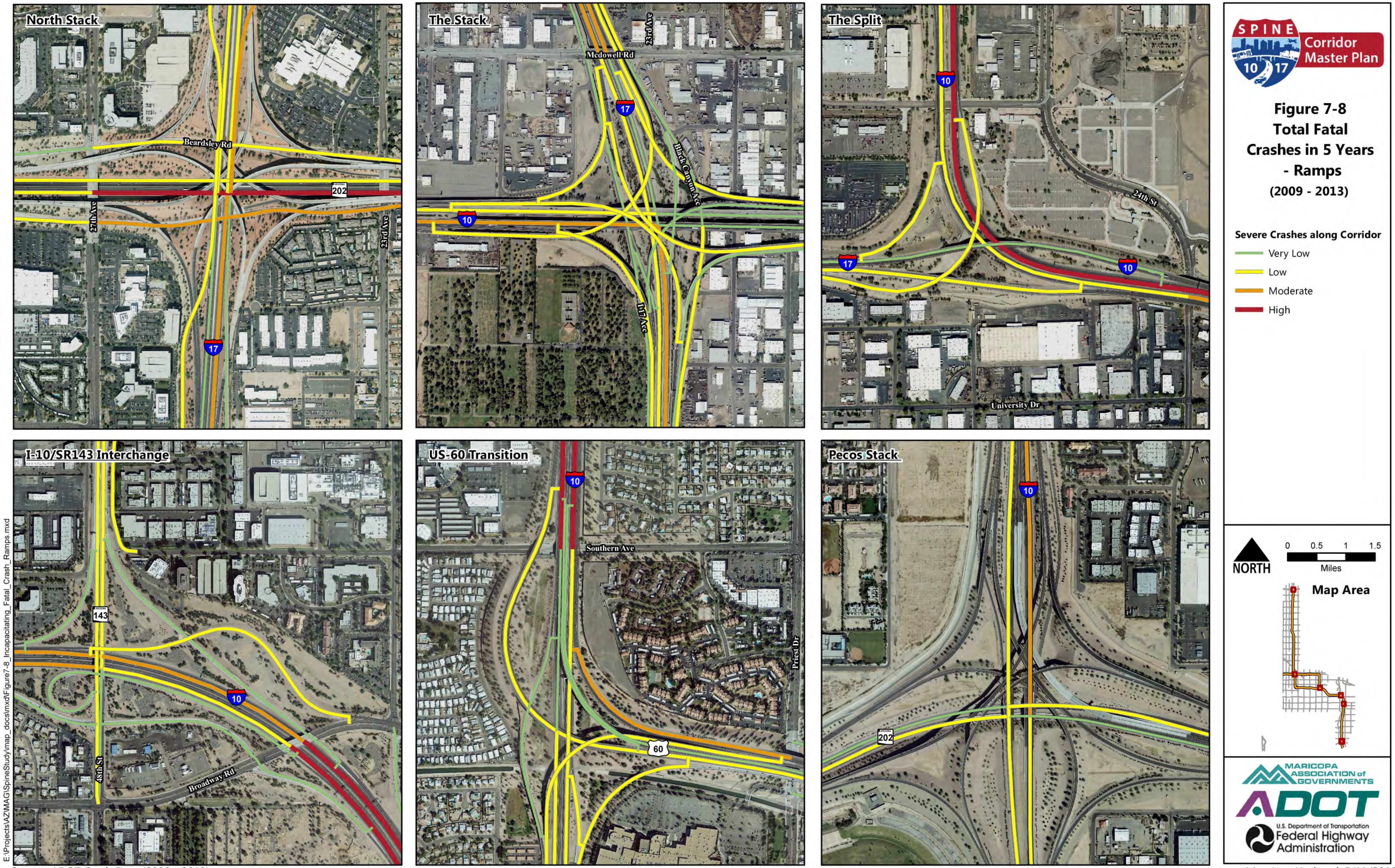
Figure 7-7 Total Incapacitating and Fatal Crashes in 5 Years (2009–2013)



Source: ADOT Crash Data (2009-2013)

Map Last Updated: 5/11/2016

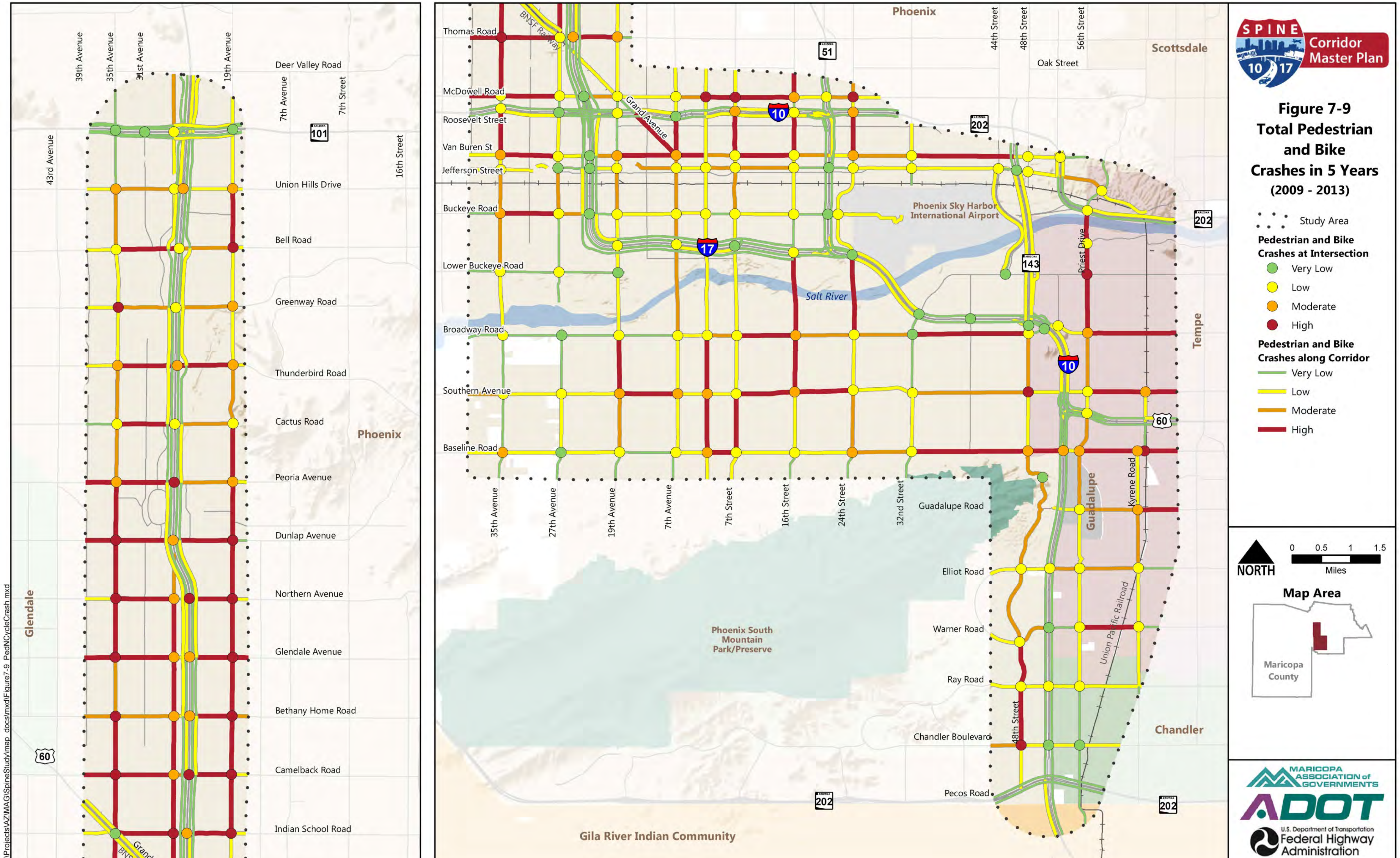
Figure 7-8 Total Fatal Crashes in 5 Years – Ramps (2009–2013)



Source: ADOT Crash Data (2009 - 2013)

Map Last Updated: 5/11/2016

Figure 7-9 Total Pedestrian and Bike Crashes in 5 Years (2009–2013)



Source: ADOT Crash Data (2009-2013)

Map Last Updated: 5/11/2016

If there was less than one total pedestrian/bike crashes during the 5-year analysis period, it was categorized as very low. More than six crashes for intersections and five crashes for Interstate and arterial segments was categorized as high. Table 7-9 summarizes the high pedestrian and bicycle crash locations within the Spine study area.

Table 7-9 High Pedestrian and Bicycle Crash Locations along Corridors of Interest

Category	Route	Location
Arterials	Bell Road	• 35th Avenue to Interstate 17
	Thunderbird Road	• 35th Avenue to 19th Avenue
	Cactus Road	• 35th Avenue to Interstate 17
	Peoria Avenue	• 45th Avenue to Interstate 17
	Dunlap Avenue	• 45th Avenue to 19th Avenue
	Northern Avenue	• 35th Avenue to 19th Avenue
	Glendale Avenue	• 45th Avenue to 15th Avenue
	Bethany Home Road	• Interstate 17 to 19th Avenue
	Camelback Road	• 45th Avenue to 19th Avenue
	Indian School Road	• 35th Avenue to 19th Avenue
	Thomas Road	• 45th Avenue to 19th Avenue
	McDowell Road	• 45th Avenue to 27th Avenue
	Buckeye Road	• 35th Avenue to 27th Avenue
	Broadway Road	• 7th Street to 16th Street • 32nd Street to Interstate 10 • Priest Drive to Mill Avenue
	Southern Avenue	• 19th Avenue to 7th Avenue • 7th Street to 24th Street • Priest Drive to Mill Avenue
	Baseline Road	• Central Avenue to 7th Street • 32nd Street to Interstate 10 • Priest Drive to Mill Avenue
	19th Avenue	• Union Hills Drive to Bell Road • Cactus Road to Indian School Road • Broadway Road to Southern Avenue
	27th Avenue	• Northern Avenue to Thomas Road
	35th Avenue	• Peoria Avenue to Glendale Avenue • Bethany Home Road to Van Buren Street
	48th Street	• Warner Road to Chandler Boulevard
	Priest Drive	• State Route 202L to Broadway Road

Table 7-9 High Pedestrian and Bicycle Crash Locations along Corridors of Interest

Category	Route	Location
Intersections	Interstate 17 traffic interchanges	• Peoria Avenue • Northern Avenue • Camelback Road
	35th Avenue	• Greenway Road • Dunlap Avenue • Northern Avenue • Glendale Avenue • Bethany Home Road • Camelback Road • Thomas Road
	19th Avenue	• Bell Road • Dunlap Avenue • Northern Avenue • Glendale Avenue • Bethany Home Road • Camelback Road • Indian School Road
	27th Avenue	• Indian School Road
	Southern Avenue	• 48th Street
	Baseline Road	• Kyrene Road

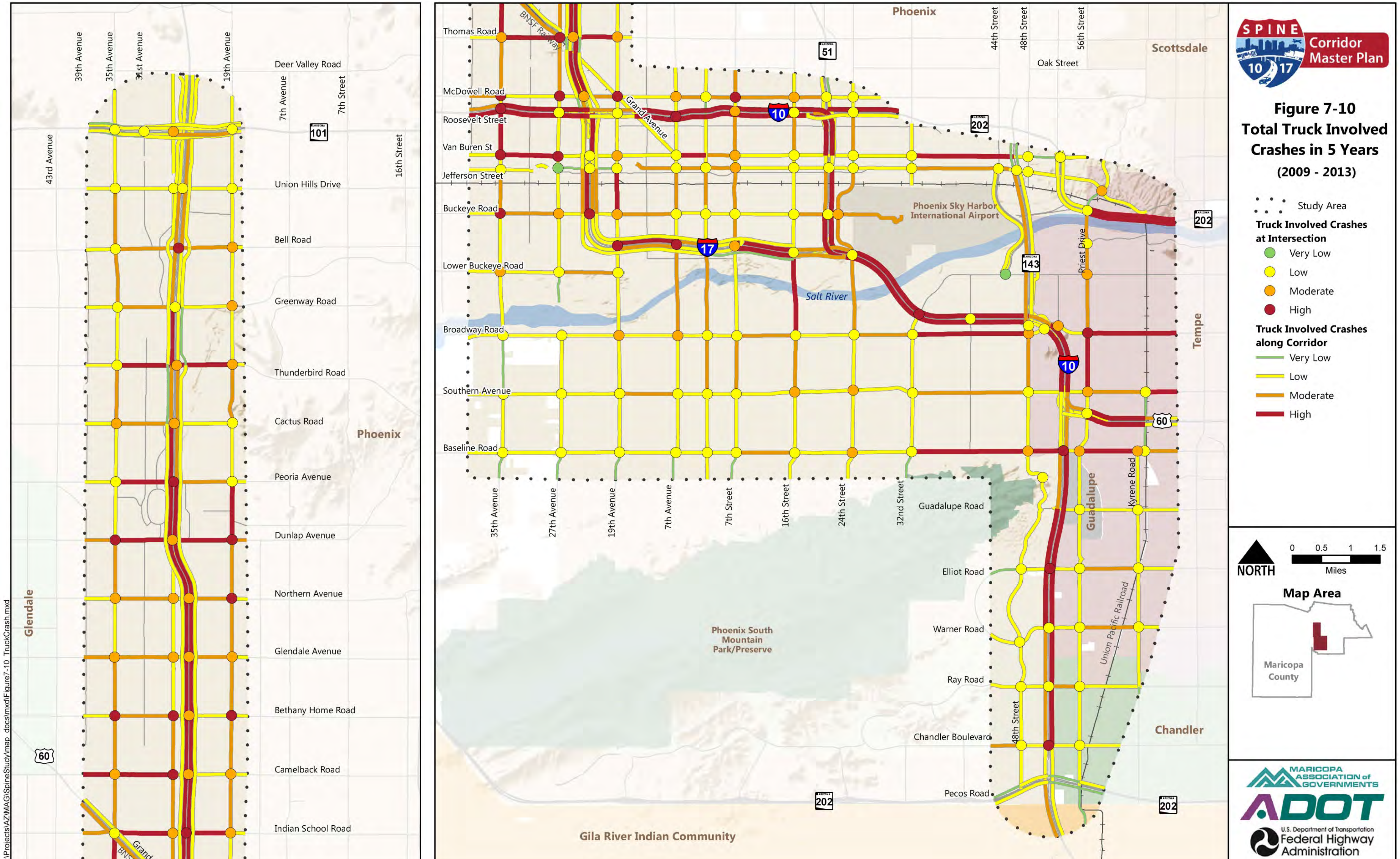
Source: HDR, March 2015

7.7 Other Crash Types

Crashes involving trucks, DUI and nighttime conditions were analyzed. The ranges for these ratings are shown in Table 7-10. Given the nature of crashes involving trucks and DUI being a small percentage of the total number of crashes, if there was less than one crash during the 5-year analysis period in a segment or at an intersection, it was categorized as very low. Instead of analyzing the total number of nighttime crashes in the Spine study area, the nighttime crashes were analyzed as a percentage of the total number of crashes.

In the crash database, the definition of a truck is a vehicle one ton or larger and includes all commercial trucks, transit and school buses and hauling trucks. Figure 7-10 shows the frequency of truck-related crashes on the Interstate and arterial segments and at intersections in the Spine study area. Frequency of truck-related accidents on system interchange ramps is shown in Figure 7-11.

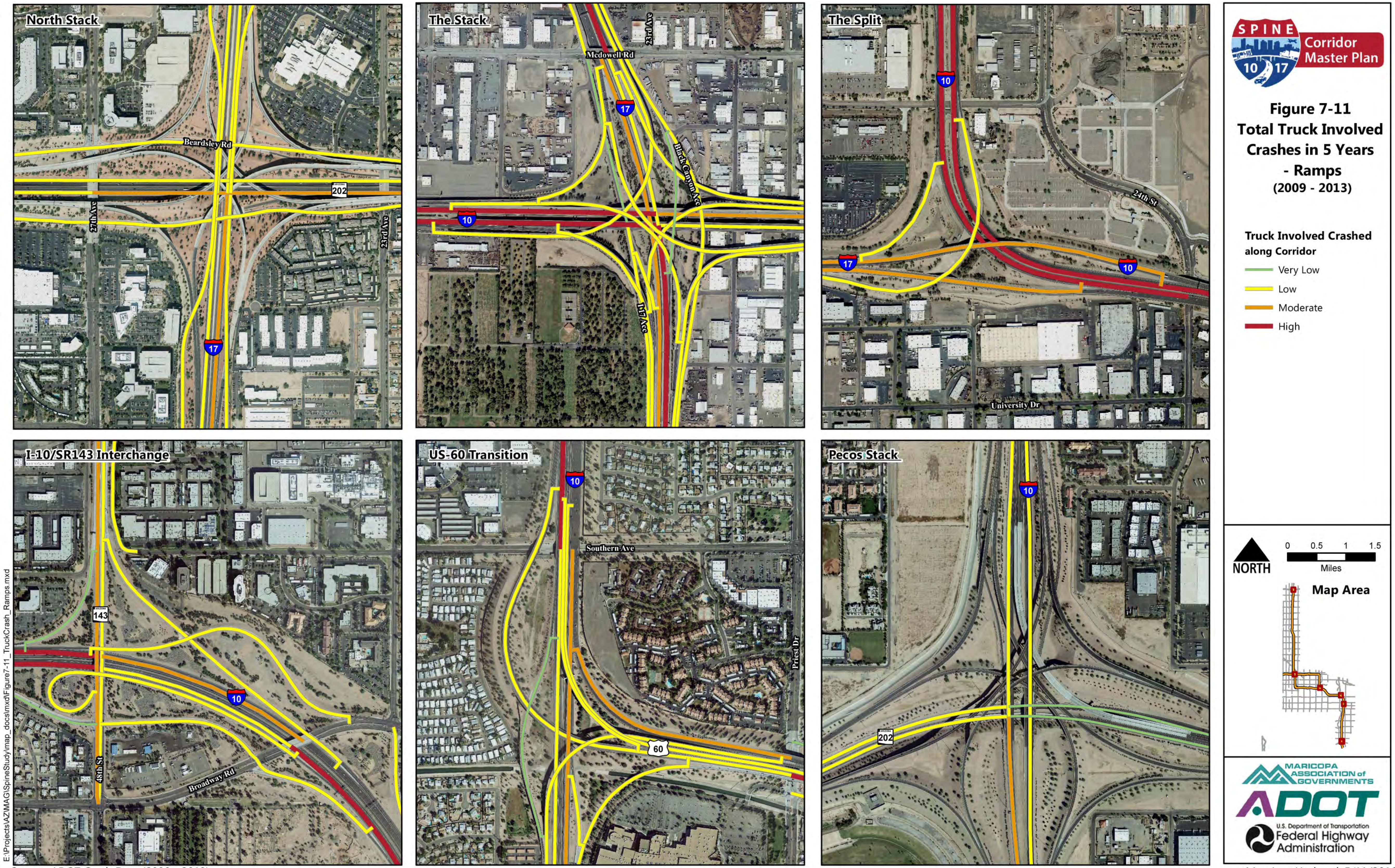
Figure 7-10 Total Truck Involved Crashes in 5 Years (2009–2013)



Data Source: ADOT Crash Data (2009-2013)

Map Last Updated:5/11/2016

Figure 7-11 Total Truck Involved Crashes in 5 Years – Ramps (2009–2013)



Source: ADOT Crash Data (2009 - 2013)

Map Last Updated: 5/11/2016

Table 7-10 Truck Involved Nighttime and DUI Involved Crash Ranges

Rating	Truck-related	% nighttime	DUI involved
Crashes at intersections			
Very low	<1 crash/5 years	<15% crash/5 years	<1 crash/5 years
Low	1–15 crashes/5 years	15%–22% crashes/5 years	1–4 crashes/5 years
Moderate	15–25 crashes/5 years	22%–29% crashes/5 years	4–8 crashes/5 years
High	>25 crashes/5 years	>29% crashes/5 years	>8 crashes/5 years
Crashes along corridor			
Very low	<1 crash/5 years	<12% crashes/5 years	<3 crashes/5 years
Low	1–12 crashes/5 years	12%–22% crashes/5 years	3–6 crashes/5 years
Moderate	12–23 crashes/5 years	22%–32% crashes/5 years	6–11 crashes/5 years
High	>23 crashes/5 years	>32% crashes/5 years	>11 crashes/5 years

Source: HDR, March 2015
Note: DUI = driving under the influence

Table 7-11 summarizes the locations where there is a high frequency of truck involved crashes along the Spine corridors of interest.

Table 7-11. Truck Involved Crash Locations along Corridors of Interest

Category	Route	Location
Interstate	Interstate 17 southbound	• Greenway Road to Thunderbird Road • Cactus Road to McDowell Road • Washington Street to Buckeye Road • 7th Street to 16th Street • 24th Street and Southern Avenue • Guadalupe Road to Warner Road
	Interstate 17 southbound	• Peoria Avenue to Van Buren Street • 19th Avenue to 7th Avenue • 7th Street to 16th Street • 24th Street and Southern Avenue • Baseline Road to Chandler Boulevard
Arterials	Thunderbird Road	• 35th Avenue to 19th Avenue
	Peoria Avenue	• 35th Avenue to Interstate 17
	Dunlap Avenue	• 35th Avenue to 19th Avenue
	Camelback Road	• 39th Avenue to Interstate 17
	Indian School Road	• 35th Avenue to 19th Avenue
	Thomas Road	• 35th Avenue to Interstate 17
	Broadway Road	• 32nd Street to Mill Avenue
	Southern Avenue	• Kyrene Road to Mill Avenue
	Baseline Road	• 32nd Street to Kyrene Road
	35th Avenue	• Indian School Road to Thomas Road • Interstate 10 to Van Buren Street
	19th Avenue	• Peoria Avenue to Dunlap Avenue • Washington Street to Buckeye Road
	Priest Drive	• Broadway Road to Southern Avenue
Intersections	Interstate 17 traffic interchanges	• Bell Road • Peoria Avenue • Indian School Road • Buckeye Road • 19th Avenue • 7th Avenue • 32nd Street • Baseline Road • Elliot Road • Chandler Boulevard
	35th Avenue	• Dunlap Avenue • Bethany Home Road • McDowell Road • Interstate 10 Traffic Interchange • Van Buren Street • Buckeye Road
	27th Avenue	• Bethany Home Road • Camelback Road • Thomas Road • McDowell Road • Van Buren Street
	19th Avenue	• Dunlap Avenue • Northern Avenue • Bethany Home Road • McDowell Road
	Broadway Road	• Priest Drive
	Priest Drive	• Guadalupe Road

Source: HDR, March 2015

Nighttime crashes refer to all the crashes that occurred during dark conditions—without or with the presence of ambient lighting. Evaluating locations where there is a high percentage of nighttime crashes helps identify locations that may require lighting, alignment delineation or other countermeasures to help mitigate the shorter sight distances resulting from darkness.

Figure 7-12 shows the nighttime crash percentages along the Interstate and arterial segments and at all the associated intersections. The Interstate system interchange ramps have moderate to high nighttime crashes, as shown in Figure 7-13.

Table 7-12 summarizes the locations where nighttime crashes account for a high percentage of the total crashes along the corridors of interest.

Table 7-12 High Nighttime Crash Percentage Locations along Corridors of Interest

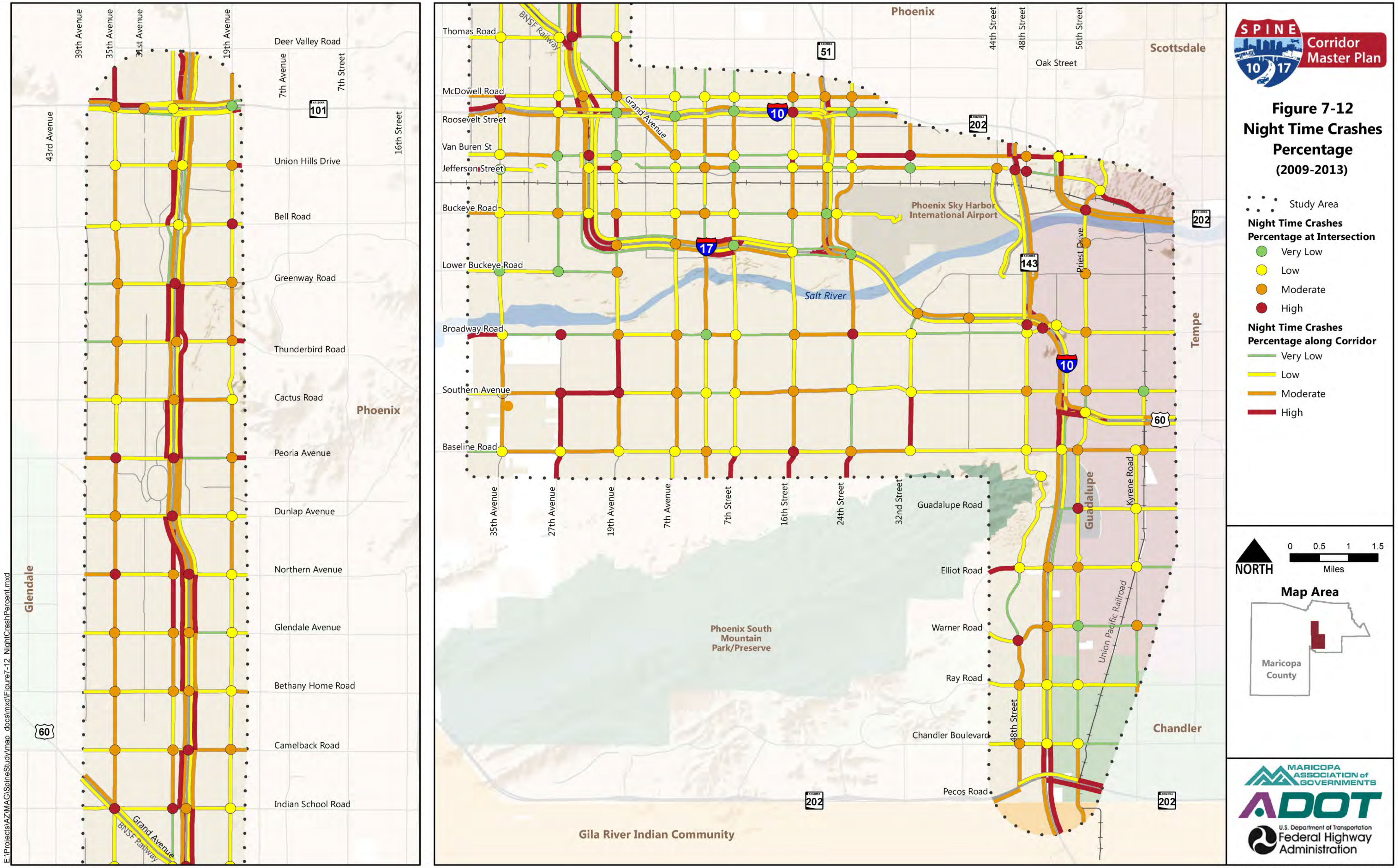
Category	Route	Segment/Crossroad
Interstates	Interstate 17 southbound frontage road	• Deer Valley Road to State Route 101L • Union Hills Drive to Bell Road • Greenway Road to Thunderbird Road • Cactus Road to Peoria Avenue • Dunlap Avenue to Bethany Home Road • Camelback Road to Indian School Road • McDowell Road to Interstate 10 • Central Avenue to 7th Street
	Interstate 17 northbound frontage road	• Greenway Road to Peoria Avenue • Northern Avenue to Glendale Avenue • Bethany Home Road to Camelback Road • Indian School Road to Thomas Road • McDowell Road to Interstate 10 • Central Avenue to 7th Street
	Interstate 17 northbound	• Greenway Road to Thunderbird Road • Durango Curve • Chandler Boulevard to south of State Route 202L
	Interstate 17 southbound	• State Route 101L to Union Hills Drive • Durango Curve • Southern Avenue to Baseline Road • Chandler Boulevard to Pecos Road
	Interstate 10/Interstate 17 Interchange (The Stack)	• Ramp southbound to westbound • Ramp westbound to northbound • Ramp eastbound to southbound • Ramp westbound to southbound • Portions of northbound and southbound frontage roads
	Interstate 10/Interstate 17 Interchange (The Split)	• Ramp southbound to westbound • Ramp eastbound to northbound
	Interstate 10/U.S. Route 60 Interchange	• Ramp westbound to southbound • U.S. Route 60 high-occupancy vehicle ramp • Baseline Road exit ramp • Portions of U.S. Route 60 northbound and Interstate 10 southbound
	Interstate 10/State Route 143 Interchange	• Ramp westbound to northbound

Table 7-12 High Nighttime Crash Percentage Locations along Corridors of Interest

Category	Route	Segment/Crossroad
Intersections	Interstate 17 traffic interchanges	• Greenway Road • Peoria Avenue • Dunlap Avenue • Northern Avenue • Camelback Road • Thomas Road • Van Buren Street
	35th Avenue	• Peoria Avenue • Northern Avenue • Indian School Road • McDowell Road
	27th Avenue	• Indian School Road • Broadway Road • Southern Avenue
	19th Avenue	• Bell Road • Southern Avenue
	Broadway Road	• 24th Street • 48th Street
	Baseline Road	• 16th Street
	48th Street	• Washington Street • Warner Road
	Priest Drive	• Guadalupe Road

Source: HDR, March 2015

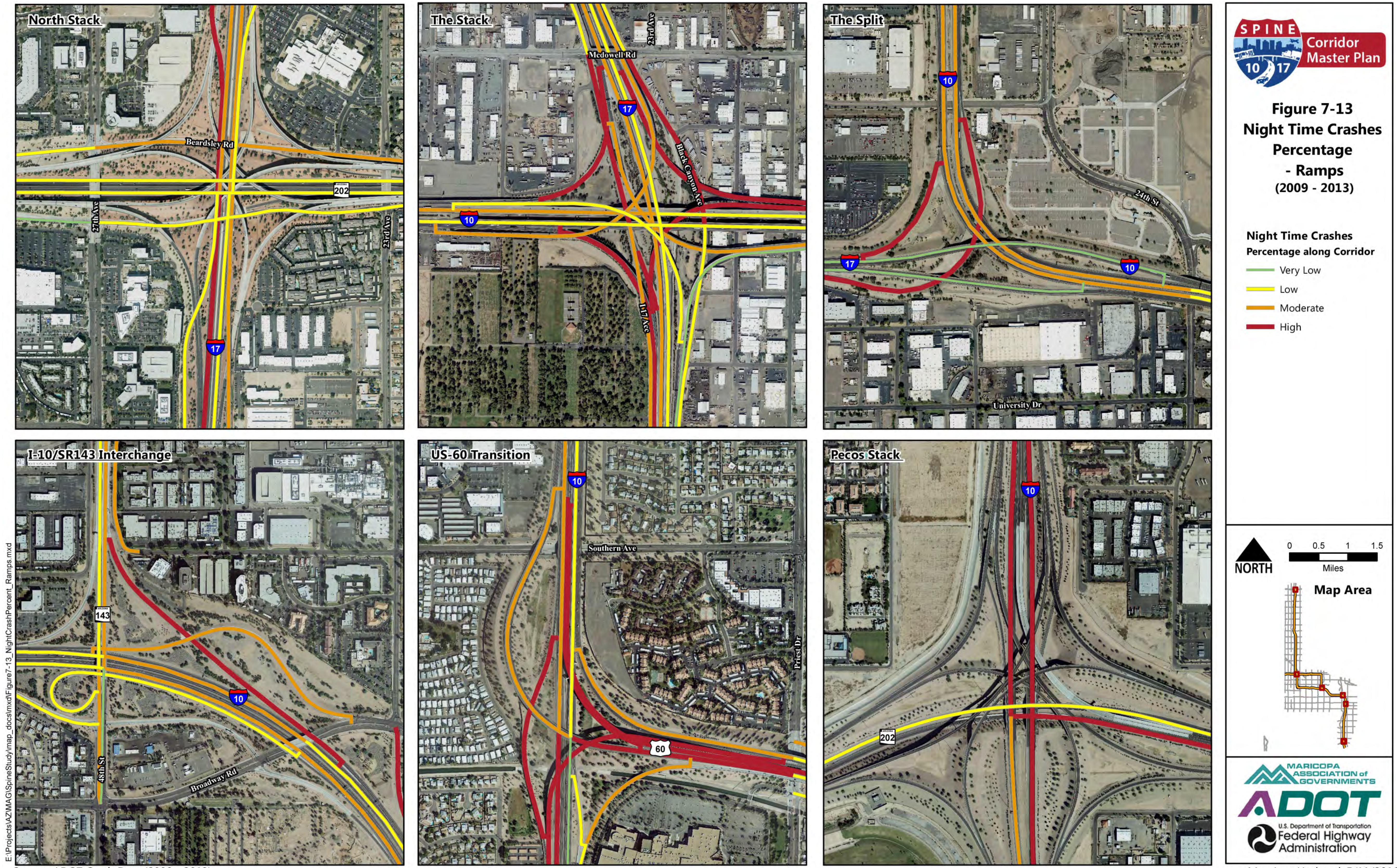
Figure 7-12 Nighttime Crashes Percentage (2009–2013)



Source: ADOT Crash Data (2009-2013)

Map Last Updated: 5/11/2016

Figure 7-13 Nighttime Crashes Percentage – Ramps (2009–2013)



Source: ADOT Crash Data (2009 - 2013)

Map Last Updated: 5/11/2016

DUI crashes include drivers under any influence type such as alcohol and/or drugs. Evaluating locations where there is a high number of DUI crashes can help identify locations that may require additional law enforcement presence in the Spine study area. Figure 7-14 shows the number of DUI crashes along the arterial and Interstate segments and at intersections within the Spine study area. DUI crashes along Interstate system interchange ramps are presented in Figure 7-15. Table 7-13 summarizes the high DUI crash locations along the Spine corridors of interest.

Table 7-13 High DUI Crash Locations along Corridors of Interest

Category	Route	Location
Interstates	Interstate 17 northbound	• Northern Avenue to Camelback Road • Indian School Road to McDowell Road • 16th Street to 7th Street
	Interstate 17 southbound	• Bell Road to Greenway Road • Northern Avenue to Camelback Road • Indian School Road to Thomas Road • Buckeye Road to 19th Avenue
	Interstate 10 eastbound	• 24th Street to 32nd Street • Broadway Road to Southern Avenue • Elliot Road to Warner Road
	Interstate 10 westbound	• Ray Road to Warner Road
	Interstate 10/Interstate 17 Interchange (The Stack)	• Ramp southbound to westbound
Intersections	Interstate 17 and Interstate 10 traffic interchanges	• Bell Road • Cactus Road • Peoria Avenue • Dunlap Avenue • Northern Avenue • Bethany Home Road • Camelback Road • Indian School Road • Thomas Road • 19th Avenue • Baseline Road

Source: HDR, March 2015
Note: DUI = driving under the influence

7.8 Crashes Involving Transit Buses

Crashes just involving transit buses were also analyzed as an individual group within the Spine study area. Figure 7-16 shows the rates for the study area segments and intersections related to crashes involving transit buses. Since Valley Metro operates transit buses along specific routes, crashes involving buses are limited to the bus routes only. The number of crashes at each location is compared with the ranges shown in Table 7-14 and is rated as very low, low, moderate and high. Crashes involving school buses were excluded from this analysis.

Table 7-14 Bus Involved Crash Ranges

Rating	Intersection	Along arterial and Interstate corridor
Very low	<1 crash/5 years	<1 crash/5 years
Low	1–2 crashes/5 years	1–2 crashes/5 years
Moderate	3–4 crashes/5 years	3–5 crashes/5 years
High	>4 crashes/5 years	>5 crashes/5 years

Source: HDR, March 2015

Figure 7-16 helps identify bus-related crash locations for future evaluation of mitigation measures that can be used to reduce the number of such crashes. Table 7-15 summarizes the high bus-related crash locations within the Spine study area.

Table 7-15 High Bus Involved Crash Locations along Corridors of Interest

Category	Route	Location
Interstates	Interstate 17 northbound	• Dunlap Avenue to Peoria Avenue
	Interstate 17 northbound frontage road	• McDowell Road to Thomas Road
Arterials	Dunlap Avenue	• Interstate 17 to 19th Avenue
	Bethany Home Road	• Interstate 17 to 19th Avenue
	McDowell Road	• West of 35th Avenue
	Buckeye Road	• 19th Avenue to 7th Avenue • 16th to State Route 51
	Southern Avenue	• Central Avenue to 7th Street • 16th Street to 32th Street • Interstate 10 to Priest Drive
	Baseline Road	• 16th Street to 24th Street
	35th Avenue	• Thunderbird Road to Cactus Road • Peoria Avenue to Dunlap Avenue • Lower Buckeye Rd. to Broadway Road
	27th Avenue	• McDowell Road to Interstate 10
Intersections	35th Avenue	• Dunlap Avenue
	27th Avenue	• Van Buren Street
	19th Avenue	• Thunderbird Road • Dunlap Avenue • Northern Avenue • Glendale Avenue • Bethany Home Road • Thomas Road • McDowell Road
	Broadway Road	• 48th Street

Table 7-15 High Bus Involved Crash Locations along Corridors of Interest

Category	Route	Location
	Priest Drive	• Washington Street • University Drive • Broadway Road • Elliot Road

Source: HDR, March 2015

7.9 Crashes Involving Light Rail

Crashes involving light rail vehicles were analyzed within the study area using the Valley Metro crash data for a 3-year period (2012 to 2014). Table 7-16 summarizes the light rail-related crashes by year within and outside of the Spine study area. A total of 80 light rail-related crashes occurred in the 3-year period, and 37 of those crashes occurred within the Spine study area.

Table 7-16 Light Rail Involved Crashes, by Year

Location	2012	2013	2014	Total
Inside Spine study area	15	12	10	37
Outside Spine study area	12	20	11	43
Total by year	**27**	**32**	**21**	**80**

Sources: Valley Metro, 2012–2014 LRT Crash Data; HDR, March 2015

Figure 7-17 shows the light rail-related crashes along the active light rail route. The ratings were determined such that low equaled one crash, moderate equaled two crashes and high equaled three or more crashes. A large percentage of the light rail-related crashes in the study area were along the Washington Street corridor.

7.10 Crash Characteristics by Region

MAG provided the Spine study team with its regional crash trends from 1999 to 2012. The MAG regional crash trend data were used to make a comparison between the crash data in just the Spine study area and the MAG region. Table 7-17 summarizes a comparison of the total crashes and the percentage of fatal, nighttime, truck-related, pedestrian and bicycle, truck and DUI crashes.

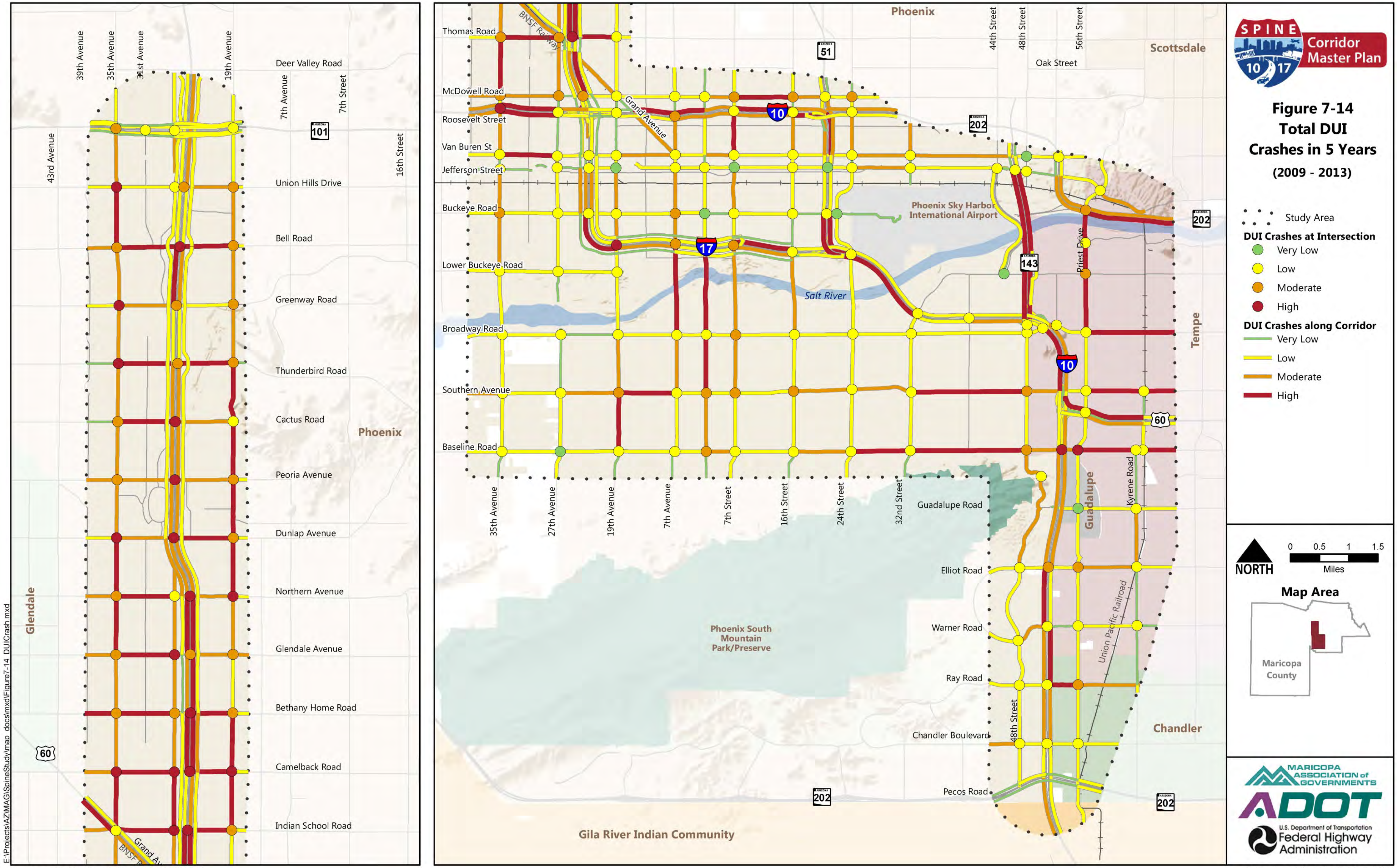
Table 7-17 Crash Characteristics, by Region[a]

Category	Maricopa Association of Governments region	Spine study area
Total crashes	348,647	91,034
% fatal	<1%	<1%
% pedestrian/bike	3%	2%
% truck	11%	13%
% nighttime	27%	22%
% DUI	5%	5%
% bus	1%	1%
Light rail crashes[b]	<1%	<1%

Sources: Arizona Department of Transportation Crash Data; HDR, March 2015
[a] Crashes from January 1, 2009, through December 31, 2013, were analyzed.
[b] Valley Metro 2012–2014 LRT Crash Data

MAG uses network screening methodology (NSM) to rank intersections and to identify locations for improvements. The NSM for intersections includes several safety assessment techniques that are then weighted and combined into an Intersection Safety Score. The NSM uses a composite ranking considering crash frequency, crash severity and crash type, which are weighted 25, 50 and 25 percent, respectively. Twenty-six of the Spine study area intersections in the City of Phoenix are ranked in top 100 of the MAG Region 3 Factor Ranking. The Spine study area intersections that fall in the top 100 are summarized in Table 7-18.

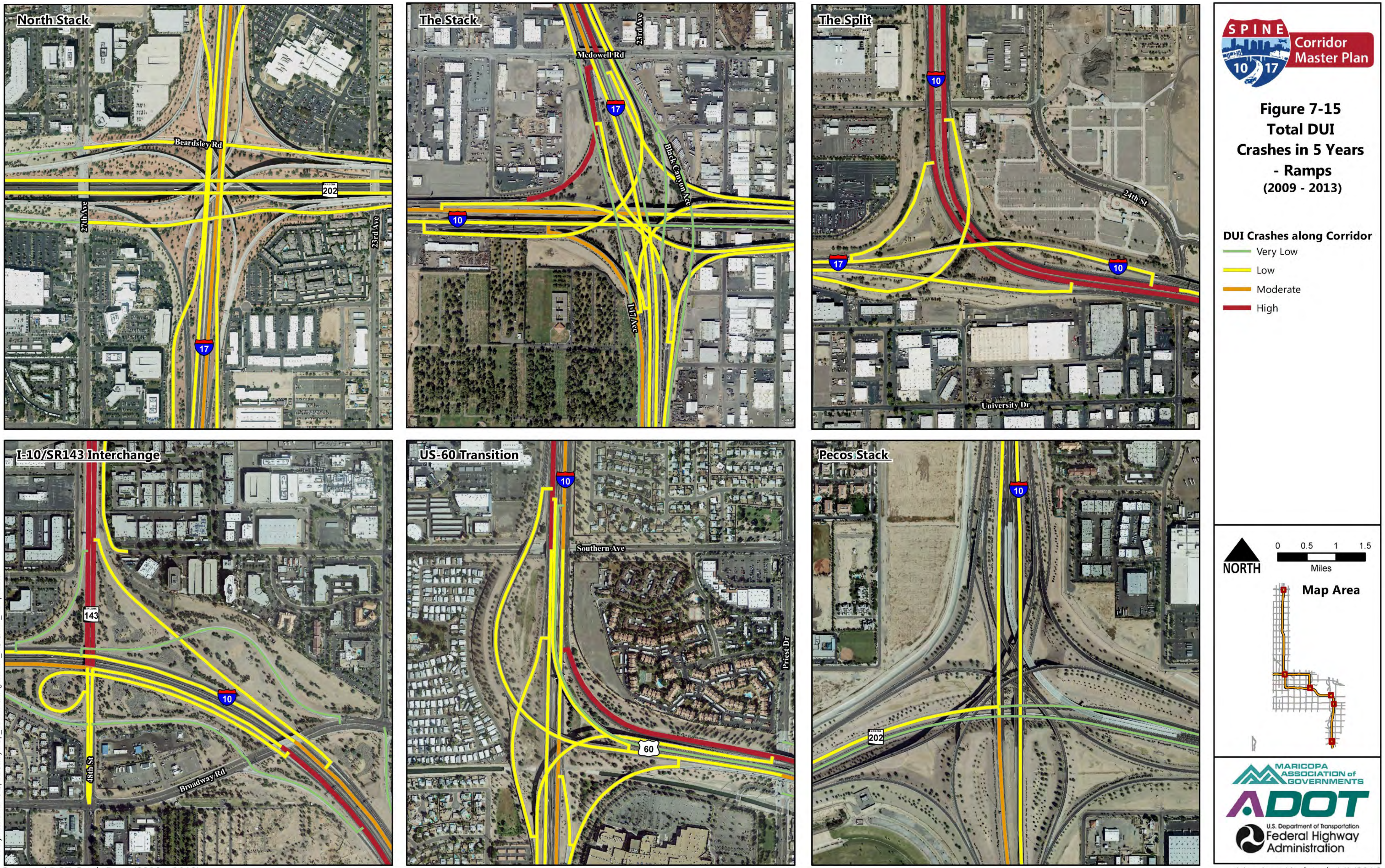
Figure 7-14 Total DUI Crashes in 5 Years (2009–2013)



Source: ADOT Crash Data (2009-2013)

Map Last Updated: 5/11/2016

Figure 7-15 Total DUI Crashes in 5 Years – Ramps (2009–2013)

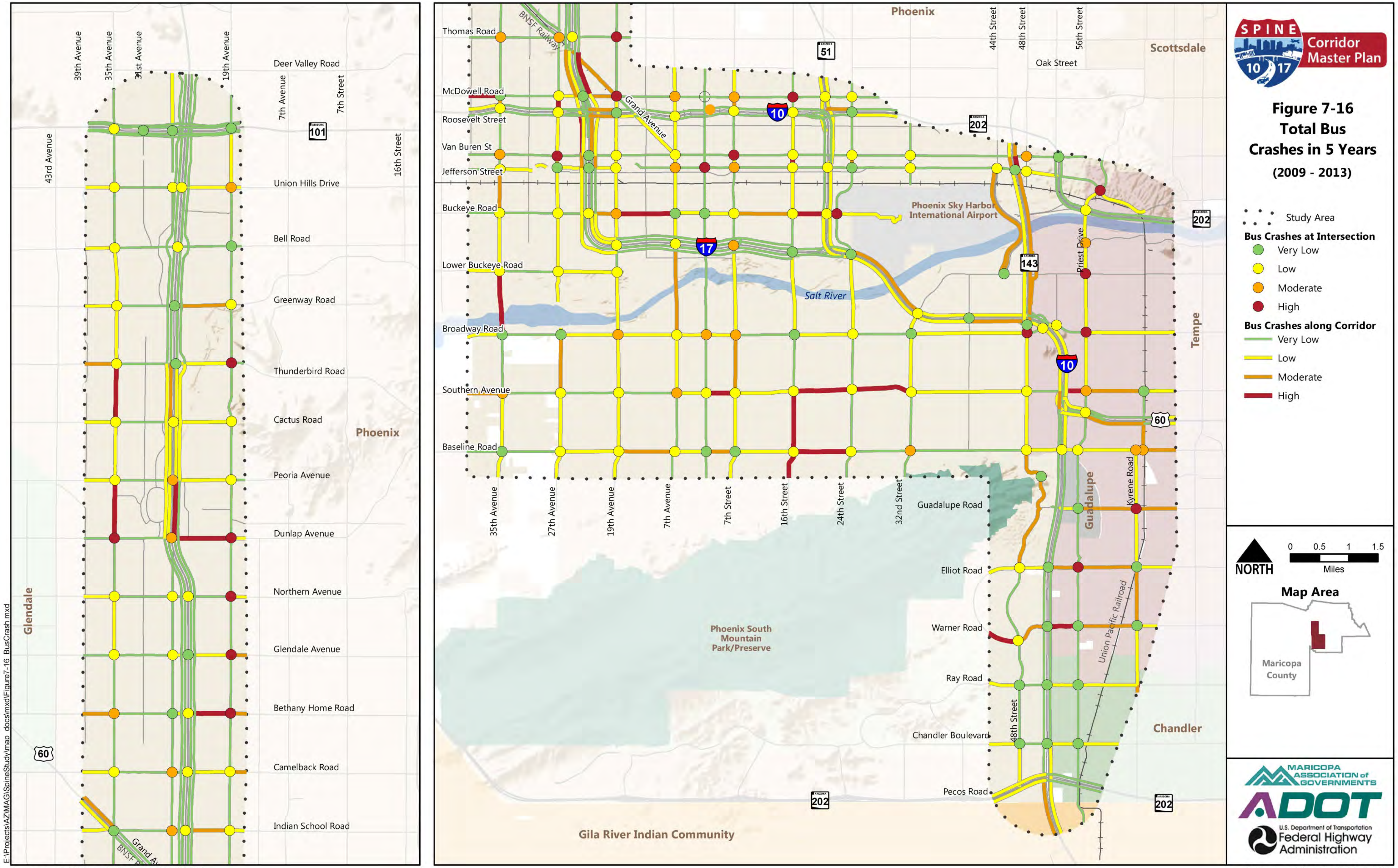


E:\Projects\AZ\MAG\SpineStudy\map_docs\mxd\Figure7-15_DUICrash_Ramps.mxd

Source: ADOT Crash Data (2009 - 2013)

Map Last Updated: 4/1/2016

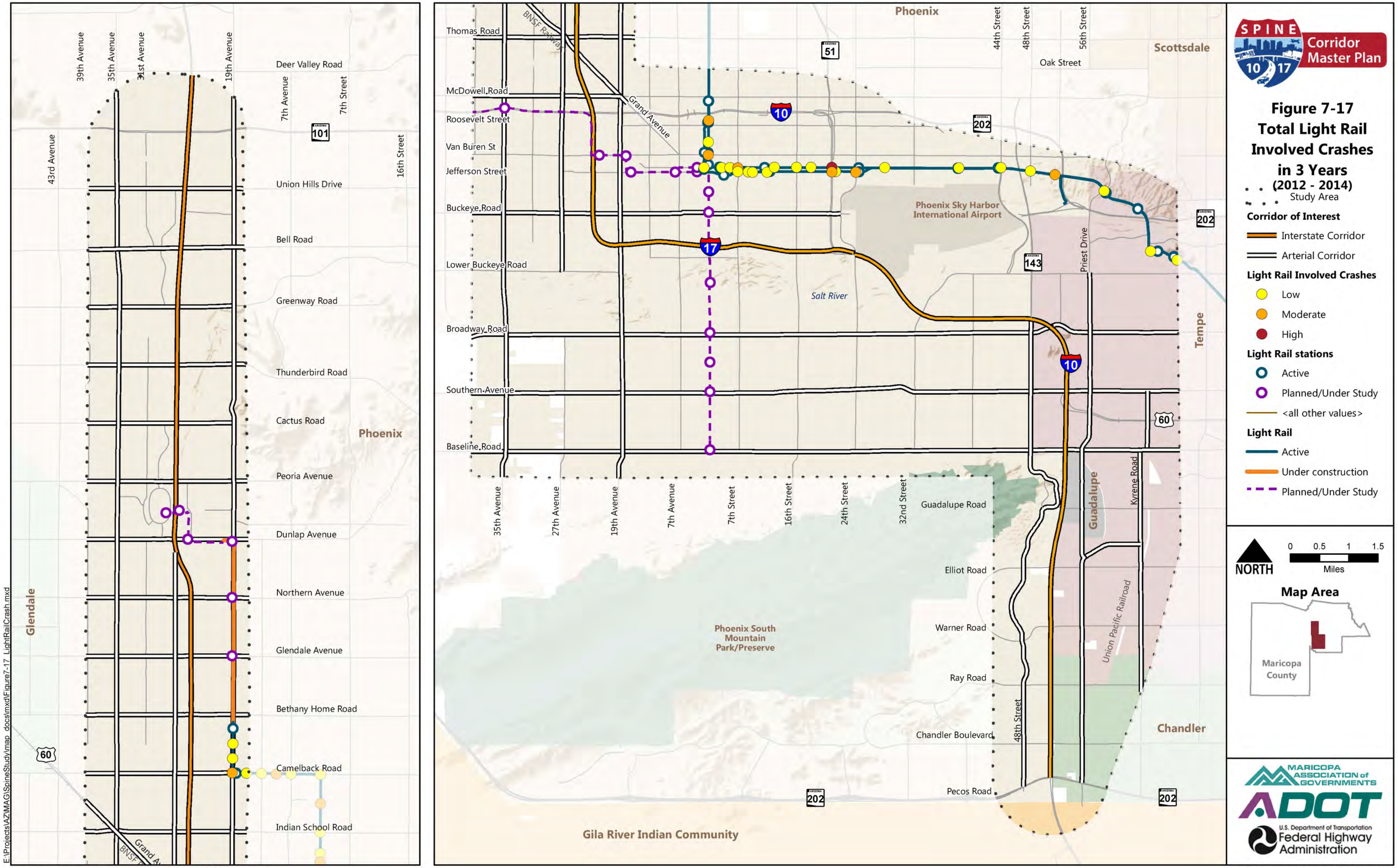
Figure 7-16 Total Bus Crashes in 5 Years (2009–2013)



Source: ADOT Crash Data (2009-2013)

Map Last Updated: 5/11/2016

Figure 7-17 Total Light Rail Involved Crashes in 3 Years (2012–2014)



Data Source: Valley Metro Crash Data (2012 - 2014)

Map Last Updated: 5/16/2016

Table 7-18 City of Phoenix Spine Study Intersections with the MAG Region Intersection Ranking

Intersection	Agency	Ranking
19th Avenue and Northern Avenue	Phoenix	13
27th Avenue and Indian School Road	Phoenix	21
19th Avenue and Indian School Road	Phoenix	22
19th Avenue and Bell Road	Phoenix	23
35th Avenue and Dunlap Avenue	Phoenix	24
Interstate 17 and Peoria Avenue	Phoenix	33
19th Avenue and Baseline Road	Phoenix	38
19th Avenue and Union Hills Drive	Phoenix	43
Interstate 17 and Thunderbird Road	Phoenix	45
48th Street and Baseline Road	Phoenix	56
19th Avenue and Greenway Road	Phoenix	60
35th Avenue and Buckeye Road	Phoenix	61
16th Street and McDowell Road	Phoenix	63
27th Avenue and Camelback Road	Phoenix	65
35th Avenue and Camelback Road	Phoenix	70
35th Avenue and McDowell Road	Phoenix	71
19th Avenue and Dunlap Avenue	Phoenix	76
35th Avenue and Glendale Avenue	Phoenix	79
48th Street and Southern Avenue	Phoenix	80
35th Avenue and Thunderbird Road	Phoenix	85
19th Avenue and Thomas Road	Phoenix	86
35th Avenue and Bell Road	Phoenix	90
19th Avenue and Bethany Home Road	Phoenix	93
27th Avenue and Glendale Avenue	Phoenix	95
19th Avenue and Glendale Avenue	Phoenix	97
35th Avenue and Peoria Avenue	Phoenix	98

Source: MAG Intersection Ranking, March 2015
Note: MAG = Maricopa Association of Governments

7.11 Summary

Twenty-six percent of the region's crashes happen within the study area, as well as 22 percent of the region's fatalities. Twenty-two percent of these crashes happen at night. There were just over 91,000 crashes in the study area between 2009 and 2013, with over 350 fatalities. Historically, on average, one person dies every 5 days within the study area because of a traffic crash.

The results of the high-level crash analysis for the Spine corridors of interest are consolidated in the Interstate corridors of interest crash summaries (Table 7-19) and the arterial corridors of interest crash summaries (Table 7-20). These table summaries are broken out into the Interstate and arterial segments outlined in the executive summary for the segment profiles and give a quick guide for where hotspots exist on the Spine corridors of interest, with green as very low, yellow as low, orange as moderate and red as high.

I-17 from the Stack to the North Stack (Interstate segments I4 and I5) has been identified as a safety hotspot for the Interstate corridor having high to moderate ratings in most of the crash categories identified in the Spine study.

Arterial segment A4, east-to-west arterials crossing I-17, has been identified as having most of the arterial safety hotspots with high to moderate ratings in most of the crash categories identified. Some of the arterials and arterial intersections in this segment also have high bus-related crashes as well.

Arterial segment A3, 35th Avenue, 27th Avenue and 19th Avenue, has also been identified as having a large number of safety hotspots with moderate to high crash frequencies, crash rates, incapacitating injury and fatal crashes, pedestrian and bicycle-related crashes, truck-related crashes, nighttime crashes, and DUI crashes. 35th Avenue and 27th Avenue south of Thomas Road have moderate to high bus-related crashes.

See Appendix I for more information regarding intersection crash rates.

Table 7-19 Interstate Crash Data

Extent	Crash frequency		Crash rate		Incapacitating and fatal crashes		Bike and pedestrian crashes		Truck crashes		Nighttime crashes		DUI crashes		Bus crashes	
	Segments	Inter-changes[a]	Segments	Inter-changes[a]	Segments	Inter-changes[a]	Segments	Inter-changes[a]	Segments	Inter-changes[a]	Segments	Inter-changes[a]	Segments	Inter-changes[a]	Segments	Inter-changes[a]
Segment I1 – Pecos Stack to Baseline Road																
NB: Pecos Stack to Ray Rd.																
NB: Ray Rd. to Baseline Rd.					LS[b]								LS			
SB: Pecos Stack to Ray Rd.																
SB: Ray Rd. to Guadalupe Rd.					LS								LS			
SB: Guadalupe Rd. to Baseline Rd.		N/A[c]		N/A		N/A		N/A		N/A		N/A		N/A		N/A
Segment I2 – Baseline Road to the Split																
NB: Baseline Rd. to Southern Ave.																
NB: Southern Ave. to SR-143																
NB: SR-143 to 32nd St.																
NB: 32nd St. to the Split																
SB: Baseline Rd. to Southern Ave.															LS	
SB: Southern Ave. to SR-143																
SB: SR-143 to 32nd St.																
SB: 32nd St. to the Split																
Segment I3 – the Split to the Stack																
NB: The Split to 7th St.																
NB: 7th St. to Buckeye Rd.															LS	
NB: Buckeye Rd. to the Stack									LS						LS	
SB: The Split to 7th St.																
SB: 7th St. to Buckeye Rd.													LS			
SB: Buckeye Rd. to the Stack																
Segment I4 – the Stack to ACDC																
NB: The Stack to Thomas Rd.																
NB: Thomas Rd. to Bethany Home Rd.							LS	LS								
NB: Bethany Home Rd. to ACDC						LS										
SB: The Stack to Thomas Rd.																
SB: Thomas Rd. to Bethany Home Rd.							LS	LS								
SB: Bethany Home Rd. to ACDC					LS	LS	LS				LS		LS			

Table 7-19 Interstate Crash Data

Extent	Crash frequency		Crash rate		Incapacitating and fatal crashes		Bike and pedestrian crashes		Truck crashes		Nighttime crashes		DUI crashes		Bus crashes	
	Segments	Inter-changes[a]	Segments	Inter-changes[a]	Segments	Inter-changes[a]	Segments	Inter-changes[a]	Segments	Inter-changes[a]	Segments	Inter-changes[a]	Segments	Inter-changes[a]	Segments	Inter-changes[a]
Segment I5 – ACDC to the North Stack																
NB: ACDC to Cactus Rd.															LS	
NB: Cactus Rd. to Bell Rd.					LS						LS				LS	
NB: Bell Rd. to the North Stack																
SB: ACDC to Greenway Rd.															LS	
SB: Greenway Rd. to the North Stack							LS						LS			

Notes: Shading in table represents the following: green as very low, yellow as low, orange as moderate and red as high.

ACDC = Arizona Canal Diversion Channel, DUI = driving under the influence, I-10 = Interstate 10, I-17 = Interstate 17, NB = northbound, North Stack = I-17/State Route 101L North Stack interchange, Pecos Stack = I-10/State Route 202L Pecos Stack interchange, SB = southbound, Split = I-10/I-17 Split interchange, SR = State Route, Stack = I-10/I-17 Stack interchange

[a] Interchanges at the dividing point of segments are included at the beginning of the next segment, not at the end of the previous segment.

[b] Majority of the segment is at a lower severity (LS) than indicated in the table. The worst-case segment was used to populate the table.

[c] not applicable – no interchange at this location

Table 7-20 Arterial Street Crashes

Extent	Crash frequency		Crash rate		Incapacitating and fatal crashes		Bike and pedestrian crashes		Truck crashes		Nighttime crashes		DUI crashes		Bus crashes	
	Segments	Inter-sections[a]	Segments	Inter-sections[a]	Segments	Inter-sections[a]	Segments	Inter-sections[a]	Segments	Inter-sections[a]	Segments	Inter-sections[a]	Segments	Inter-sections[a]	Segments	Inter-sections[a]
A1 – 48th Street, Priest Avenue/56th Street, Kyrene Road																
48th St.: South of Baseline Rd.	LS[b]	LS	LS	LS	LS		LS	LS				LS	LS		LS	
48th St.: North of Baseline Rd.		LS						LS				LS				LS
Priest Ave./56th St.: South of Baseline Rd.		LS	LS	LS		LS	LS				LS	LS				LS
Priest Ave./56th St.: North of Baseline Rd.			LS				LS	LS	LS			LS	LS	LS		
Kyrene Rd.: South of Baseline Rd.				LS			LS					LS	LS		LS	LS
Kyrene Rd.: North of Baseline Rd.																
A2 – Baseline Road, Southern Avenue, Broadway Road																
Baseline Rd.: West of 19th Ave.								LS								
Baseline Rd.: 19th Ave. to 7th St.	LS	LS	LS		LS	LS	LS	LS					LS		LS	
Baseline Rd.: 7th St. to 32nd St.	LS			LS			LS	LS	LS		LS	LS	LS		LS	
Baseline Rd.: East of 32nd St.		LS		LS		LS		LS		LS	LS	LS		LS		
Southern Ave.: West of 19th Ave.																
Southern Ave.: 19th Ave. to 7th St.			LS						LS				LS		LS	LS
Southern Ave.: 7th St. to 32nd St.					LS			LS								
Southern Ave.: East of 32nd St.				LS		LS	LS	LS							LS	LS
Broadway Rd.: West of 32nd St.						LS	LS	LS	LS	LS	LS	LS		LS		LS
Broadway Rd.: East of 32nd St.			LS	LS				LS		LS	LS	LS	LS			LS
A3 – 35th Avenue, 27th Avenue, 19th Avenue																
35th Ave.: South of Buckeye Rd.			LS			LS	LS	LS		LS		LS	LS		LS	LS
35th Ave.: Buckeye Rd. to Peoria Ave.	LS			LS		LS		LS	LS			LS	LS	LS	LS	LS
35th Ave.: North of Peoria Ave.	LS		LS		LS	LS		LS		LS		LS	LS		LS	
27th Ave.: South of Thomas Rd.						LS	LS		LS		LS	LS	LS		LS	LS
27th Ave.: North of Thomas Rd.			LS	LS	LS	LS		LS		LS	LS	LS	LS			
19th Ave.: South of Buckeye Rd.				LS		LS	LS	LS		LS	LS	LS	LS	LS		LS
19th Ave.: Buckeye Rd. to Indian School Rd.	LS	LS	LS	LS	LS		LS	LS	LS	LS	LS		LS			
19th Ave.: North of Indian School Rd.	LS	LS	LS	LS		LS			LS	LS	LS	LS		LS		LS

Table 7-20 Arterial Street Crashes

Extent	Crash frequency		Crash rate		Incapacitating and fatal crashes		Bike and pedestrian crashes		Truck crashes		Nighttime crashes		DUI crashes		Bus crashes	
	Segments	Inter-sections[a]	Segments	Inter-sections[a]	Segments	Inter-sections[a]	Segments	Inter-sections[a]	Segments	Inter-sections[a]	Segments	Inter-sections[a]	Segments	Inter-sections[a]	Segments	Inter-sections[a]
A4 – East-to-west arterials crossing I-17																
Buckeye Rd.: West of 7th Ave.		LS	LS			LS	LS	LS						LS	LS	LS
Buckeye Rd.: East of 7th Ave.									LS		LS			LS	LS	LS
McDowell Rd.: West of 7th Ave.			LS	LS			LS		LS			LS			LS	LS
McDowell Rd.: East of 7th Ave.		LS		LS	LS	LS	LS			LS			LS			LS
Thomas Rd.: West of I-17																
Thomas Rd.: East of I-17																
Grand Ave.: West of I-17					LS				LS		LS		LS		LS	
Grand Ave.: East of I-17			LS				LS				LS					
Indian School Rd.: West of I-17																
Indian School Rd.: East of I-17																
Camelback Rd.: West of I-17																
Camelback Rd.: East of I-17																
Bethany Home Rd.: West of I-17																
Bethany Home Rd.: East of I-17																
Glendale Ave.: West of I-17																
Glendale Ave.: East of I-17																
Northern Ave.: West of I-17																
Northern Ave.: East of I-17																
Dunlap Ave.: West of I-17																
Dunlap Ave.: East of I-17																
Peoria Ave.: West of I-17																
Peoria Ave.: East of I-17																
Cactus Rd.: West of I-17																
Cactus Rd.: East of I-17																
Thunderbird Rd.: West of I-17																
Thunderbird Rd.: East of I-17																
Greenway Rd.: West of I-17																
Greenway Rd.: East of I-17																

Table 7-20 Arterial Street Crashes

Extent	Crash frequency		Crash rate		Incapacitating and fatal crashes		Bike and pedestrian crashes		Truck crashes		Nighttime crashes		DUI crashes		Bus crashes	
	Segments	Inter-sections[a]	Segments	Inter-sections[a]	Segments	Inter-sections[a]	Segments	Inter-sections[a]	Segments	Inter-sections[a]	Segments	Inter-sections[a]	Segments	Inter-sections[a]	Segments	Inter-sections[a]
A4 – East-to-west arterials crossing I-17 (continued)																
Bell Rd.: West of I-17	Red	Orange	Orange	Orange	Red	Red	Red	Yellow	Orange	Yellow	Yellow	Yellow	Red	Orange	Green	Yellow
Bell Rd.: East of I-17	Red	Red	Red	Red	Orange	Orange	Orange	Red	Orange	Red	Yellow	Red	Red	Red	Green	Yellow
Union Hills Rd.: West of I-17	Yellow	Orange	Yellow	Orange	Orange	Orange	Orange	Orange	Yellow	Yellow	Yellow	Orange	Yellow	Red	Green	Yellow
Union Hills Rd.: East of I-17	Yellow	Orange	Yellow	Red	Orange	Orange	Yellow	Orange	Yellow	Yellow	Yellow	Orange	Orange	Orange	Yellow	Orange

Notes: Shading in table represents the following: green as very low, yellow as low, orange as moderate and red as high.
DUI = driving under the influence, I-17 = Interstate 17
[a] Intersections at the dividing point of segments are included at the beginning of the next segment, not at the end of the previous segment.
[b] Majority of the segment is at a lower severity (LS) than indicated in the table. The worst-case segment was used to populate the table.

8 Technology/ITS and System Management Facilities

8.1 Introduction

This section describes the current Intelligent Transportation Systems (ITS) and operations environment for the Spine corridors of interest network, including freeways and arterials. A key part of operations is those staff resources, systems and strategies that enable real-time monitoring and traffic management for freeway and arterial corridors in the study area. A key part of operations are those systems and strategies that partner agencies use to monitor and manage incidents, provide information to the traveling public and share information among agencies to enable real-time situational awareness and operations decision making. This chapter is organized into the following focus areas:

- Interstate operations and assets
- arterial operations and assets
- coordinated traffic incident management
- Spine study area system management and operations needs and gaps
- emerging technologies and operations approaches

8.2 Freeway Operations and Assets

8.2.1 ADOT Freeway Operations and Management

Freeway Management System

ADOT was an early adopter of ITS, which uses central operating systems and field technologies to proactively monitor and manage traffic on freeways. ADOT's FMS on I-10 and I-17 near the downtown Phoenix area was among the initial phases of FMS deployment in the region in 1995; the FMS now spans the urban area, with the most recent segment on I-17 (Peoria Avenue to the North Stack) providing full connectivity. ADOT's FMS is centrally controlled from ADOT's Traffic Operations Center (TOC), which is staffed 24 hours per day, 7 days per week, 365 days per year (24/7/365). This TOC also has statewide responsibility for traffic and incident management on state corridors. The FMS includes closed-circuit television (CCTV) cameras, vehicle sensors, dynamic message signs (DMS) and ramp meters for monitoring and mitigating traffic congestion on Phoenix-area freeways. The communication to the FMS field devices is provided through ADOT's extensive fiber-optic communication network that runs parallel to the major freeways.

Table 8-1 summarizes current FMS capabilities, field infrastructure and software/operating systems.

Table 8-1 ADOT Freeway Management System Summary

Management capabilities	Infrastructure	Software/Systems
• 24 hours per day, 7 days per week, 365 days per year TOC • ADOT Communications/Public Information staff located at TOC • ALERT incident response request/dispatch • Arizona Department of Public Safety officer at TOC	• Fiber communications on Interstate 17 and Interstate 10; fiber sharing with local agencies • Loop detector stations • Closed-circuit television cameras at 1-mile intervals in each direction • Ramp meters • Dynamic message signs	• TranSuite Advanced Traffic Management Software for Freeway Management System • TranSuite Signal Control Software • Highway Condition Reporting System road closure, incident and restriction database • ADOT 511 phone and az511.gov web system • Arizona Department of Public Safety Computer-aided Dispatch feed at TOC • Freeway travel times • AZTech Regional Archived Data Server

Notes: ADOT = Arizona Department of Transportation, TOC = Traffic Operations Center

The MAG RTP has added and enhanced the coverage of the region's FMS throughout the Phoenix metropolitan area freeways to better support traveler information and reduce congestion attributable to traffic incidents. FMS expansion has occurred throughout every extent of the Spine Interstate corridor, with the most recent addition in north Phoenix completing the I-17 FMS (up to the North Stack). Programmed plans for funding FMS expansion focus on corridors outside of the Spine study area.

ADOT is updating the FMS infrastructure and management control systems, including:

- Extending IP communications from the node buildings to the roadside field cabinets with fiber to Ethernet switches. This will enable future ITS technologies to be deployed in the field with reliable backbone communication.
- Installing IP CCTV devices instead of an analog CCTV combined with a separate IP video encoder. This device requires less maintenance, produces a reliable video stream and is state-of-the-art technology that will not be replaced anytime soon.
- CCTV and DMS control was previously controlled by two separate software clients through Camera Cameleon. ADOT is now integrating control into one software client that will be used to control both CCTV and DMS. Older DMS boards are now being replaced with newer technology that is more efficient and cost-effective.

8.2.1.2 Traffic Operations Center

ADOT's TOC monitors and manages the Phoenix FMS and provides central management of the statewide transportation network. The ADOT TOC operates 24/7/365, and responds to both recurring and nonrecurring congestion on state road facilities.

Figure 8-1 ADOT Traffic Operations Center

A TOC control room renovation was completed in 2012. This included a new and expanded video wall and updated operator workstations, as shown in Figure 8-1. Space within the TOC operations room was reconfigured to provide workspace for a public information officer and for Arizona Department of Public Safety (DPS) officers. Key activities at the TOC include:

- Monitor CCTV, loop detectors and DPS computer-aided dispatch for any incidents or abnormal traffic activity on state routes/highways.
- Implement advisory or alert messages on DMS boards (Phoenix and statewide).[1]
- Coordinate in real time with responders in the field during incident management and incident clearance.
- Coordinate with partner agencies (city and county arterial management, emergency services and other state and regional/local agencies as needed) during traffic incidents or emergencies.
- Disseminate alerts about crashes, closures or other impacts on the road network. This includes updating 511 when there is a major event, distributing alerts to agency/media email distribution lists and updating social media (Twitter, Facebook) with alert information as needed.
- Update databases with current closure/restriction information. These databases feed the 511 systems, and data/alerts are provided to private-sector subscribers.
- Implement traffic management strategies in response to real-time network conditions, such as incidents, hazards, work zones and special events.

Highway Condition Reporting System

The Highway Condition Reporting System (HCRS) is a central database that includes planned construction or restrictions, incidents, maintenance activity and other events affecting the roadway. Incidents and active construction activities can be updated by operators as conditions change. HCRS supplies information to the statewide 511 telephone service, az511.gov website and third-party information service providers (such as media). The Regional Archived Data System (RADS), which is the Maricopa County Department of Transportation (MCDOT)-owned central database, is located and maintained at the ADOT TOC.

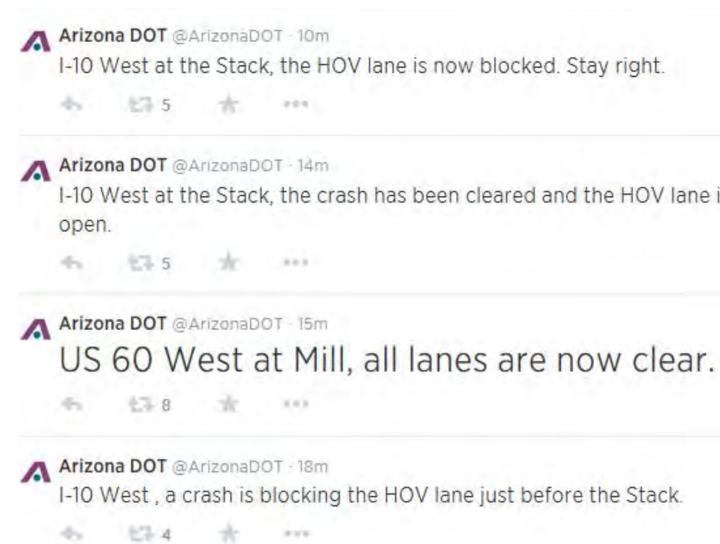
HCRS now inputs data from statewide operators, AMBER Alerts, Maricopa County ATIS, Phoenix Fire, ADOT DMS as well as local construction permitting systems.

Motorist/Traveler Information

A core mission of ADOT's freeway management and operations program is using tools, information and technology to provide timely and accurate road and travel conditions information to the public. Several regional tools and data-sharing agreements help to provide up-to-date incident and event information, which is then distributed by numerous dissemination strategies. ADOT's traveler information is distinguished by the following:

- ADOT added three additional public information officer/communications positions in the TOC, which provides extended traveler information coverage to support notifications. With a significant focus on social media for real-time alerts and notifications, it was important for ADOT Communications staff to be in close proximity to TOC operators to be able to push out alerts as traffic conditions change. ADOT makes extensive use of Twitter (@ArizonaDOT) to distribute information to partner agencies, media and the public. Communications staff from the TOC issue an average of 38 press releases per month, including planned closure notifications as well as major incident notifications. Figure 8-2 shows an example of ADOT's current Twitter strategy for incident notifications.

Figure 8-2 ADOT Social Media Notification



[1] The Southern TOC in Tucson, Arizona, is responsible for monitoring and managing FMS infrastructure in the greater Tucson metropolitan area. The Phoenix TOC serves as a back-up facility for Tucson.

- Arizona was an early adopter of 511 as the abbreviated dialing code for traffic and road conditions. Implemented in 2003, the 511 phone system provides corridor-based road and travel conditions information, alerts for high priority or widespread emergency road closures or conditions and links to neighboring states' 511s, transit and parks information. The 511 phone service averages approximately 20,000 calls per month, with winter months seeing increased use based on weather. The az511.gov website includes an interactive map that can zoom in on urban areas to provide camera views, red/yellow/green speed maps in urban areas, planned construction activity, active work zones and active incidents affecting the state transportation network. The 511 website also has a mobile version, although it is not heavily publicized. It averages 1,200 accesses per month.
- ADOT is updating its az511.gov website. In 2011, ADOT went through an extensive update and configuration change to the 511 phone service, which now provides 1,000 phone lines to support the system (this eliminated busy signals or hang ups during extremely busy periods, such as major winter storms in northern Arizona).
- Urban-area freeway travel times are available in Phoenix and Tucson for several corridors, and more corridors and DMS locations are being added to ADOT's program. Data from ADOT's freeway detectors is processed and converted to travel time estimates, which are automatically posted on freeway DMS during AM inbound peak travel directions and PM outbound peak travel directions. In 2009, ADOT initiated a pilot program to provide travel times on a select number of DMS in Phoenix. A formal evaluation showed that the travel time program was successful and well-received by the traveling public. With additional funding from MAG, ADOT is expanding the number of corridors and DMS in the travel time program to include most of metropolitan Phoenix. ADOT also recently initiated freeway travel time estimates in Tucson using the Tucson FMS detectors. Providing travel times for metropolitan statistical areas of more than 1 million is a requirement of Rule 1201. (Section 1201 of SAFETEA-LU established a Real-Time System Management Information Program, which requires states and regions to make available and share traffic and travel conditions information through real-time information programs.)

8.2.2 Current Initiatives and Priorities Related to Operations in the Spine Interstate Corridor

Near-term Improvements for I-17

In March 2015, ADOT initiated a Project Assessment to develop an Active Traffic Management (ATM) pilot on the I-17 corridor (from the Split to the North Stack). ATM includes technologies, equipment and operational strategies to proactively manage freeway corridors to maximize available lane capacity. Strategies include dynamic speed limits (to smooth traffic speeds during peak periods), dynamic ramp metering operations (to adjust metering rates based on main line Interstate speeds and volumes), potential arterial coordination enhancements for parallel arterials and strategies to address wrong-way driving. ADOT is initiating this project to address some of the unique constraints on I-17, including:

- limited ability to add capacity through traditional widening
- one arterial management jurisdiction (for coordinating on parallel arterials)
- frequent directional congestion during peak weekday periods (AM southbound, PM northbound)
- challenges with incident response and clearance during heavy congestion

These ATM strategies are relatively new, but are emerging in some areas of the country. ADOT is researching best practices and lessons learned from ATM deployments in Seattle, Minneapolis and on Interstate 66 in Virginia (which is currently under construction). ADOT is also researching international sites including the Managed Motorways program in Melbourne, Australia, and the United Kingdom ATM program.

Preliminary Integrated Corridor Management Planning for I-10

ADOT has been a key partner with agencies in the Phoenix metropolitan region looking at active system management and operations strategies. Integrated Corridor Management (ICM) seeks to improve network mobility by leveraging available capacity across multiple modes (freeway, arterial and transit) to balance recurring congestion as well as improve operations during incidents or closures on the freeway. Recognizing that adding capacity through traditional expansion projects is not always feasible, early ICM programs are demonstrating ways to improve overall network flow, utilization and reliability through improved real-time decision making by agencies based on real-time network conditions, improved information for travelers about travel options and improved/expanded operations strategies. I-10 has been a key focus for the region for initial ICM planning, and some level of expanded ICM implementation is envisioned to be a priority near-term strategy emerging from the Spine study.

Early project concepts for the I-10 corridor have focused primarily on incident-based congestion; that is, when a major freeway incident closes or significantly restricts traffic mobility on I-10, how can state and local partners safely and effectively manage diverting traffic onto the adjacent arterial network?

At present, there are some limitations on arterials adjacent to the Spine Interstate corridor, including:

- Limited real-time monitoring capability is available to be able to "see" what is happening on the arterial from an operations center.
- Limited staff resources are available to implement any changes to arterial signal operations in real time. Additionally, some of the signals are not currently connected to a central operations center.
- Few, if any, timing patterns have been created to handle high directional volumes of traffic, including appropriate offsets.
- Arterial traffic operations/management centers are typically open during business hours. ADOT is the only 24/7/365 traffic operations facility, but does not have the connectivity nor the authority to be able to operate municipal traffic control systems.

There are varying levels of field coordination between DPS and local police for maneuvering traffic onto arterials. There are established processes and protocols on-scene for freeway closures, but notifications and coordination do not always extend to local agencies that might be affected as a result of a detour.

Some positive steps have emerged, including:

- A MAG I-10 Traffic Signal Optimization Program (TSOP) project initiated discussions between ADOT, City of Phoenix and MCDOT about how to handle freeway incidents/after-hours incidents that occur on I-10 West (approximately 35th Avenue to SR-101L). A draft agreement is in progress that would allow MCDOT staff to manage Phoenix signals in that corridor according to predefined strategies and timing plans. A Phase II TSOP will assist in creating the timing plans to work in conjunction with the predefined strategies.
- ADOT has recently implemented a freeway-to-freeway alternate routing process for when major incidents affect a Phoenix-area freeway. This process implements freeway alternate route guidance on area DMS for

travelers approaching the closed freeway. For example, if there is a closure or major incident on I-10 near the tunnel, traffic approaching from I-10 to the east would see messages alerting them to use SR-51 or SR-143; traffic coming from the west would see messages advising them to use freeways in advance of the incident. This process provides only advisory messages for alternate freeways.

- MAG identified ICM as a regional priority as part of its 2012 ITS Strategic Plan. This has helped to elevate the conversation in the region, as well as the priority of more collaborative freeway/arterial operations.
- MCDOT, in partnership with the City of Scottsdale and ADOT, has developed a Loop 101 Incident Management Plan that coordinates freeway/arterial operations with public safety response to freeway closures along SR-101L through the city. This plan has been effective in numerous full closures since its completion in terms of ADOT diverting freeway traffic onto specific arterial routes that flush traffic through the arterial diversion and back on to the freeway.

Wrong-way Driving

Wrong-way driving has been a systemic issue in Arizona, causing incident and fatalities that could have been avoided. DPS receives an average of 25 calls per month reporting a wrong-way driver.

In response to the wrong-way driving problem, ADOT has installed new signs at various highway exit ramps throughout the state, including larger "do not enter" signs and an additional "wrong way" sign below located closer to the ground than traditional pole-mounted displays. Arrows painted on the lane with light reflectors are also being used at exit ramps alerting drivers to the direction of travel for that lane. ADOT has installed the new wrong-way measures at six exit ramps throughout the Phoenix valley (three on I-10 in Chandler and one north of the Spine study area on I-17). If the measures prove successful at eliminating the wrong-way incident numbers, ADOT will install the new measures at all 475 highway interchanges across the state.

8.3 Arterial Operations and Assets

8.3.1 Introduction and Overview

The Phoenix metropolitan area has been one of the fastest-growing regions in the nation over the past two decades. There are 13 Traffic Management Centers (TMCs) in the region, all operating their own infrastructure and arterial networks. The arterial traffic management infrastructure in the region includes approximately 3,000 signals operated by 13 different agencies, 75 percent of which are connected to a centralized signal system. One hundred and eight DMS and 715 CCTV cameras support real-time traffic management.

Arterial management agencies are also making investments in arterial monitoring and management infrastructure. The grid network of local streets provides some re-routing capabilities for most segments of the Spine arterial corridors. The local agencies of Phoenix, Tempe and Chandler are continuing to expand their arterial traffic monitoring and management capabilities to improve responsiveness to conditions on key arterials in real time.

A variety of management, infrastructure and software/systems are used by arterial network agencies with jurisdiction on the Spine arterial corridors. A summary of these capabilities is provided in Table 8-2.

Table 8-2 Arterial Traffic Management System Summary

Agency	Management capabilities	Infrastructure	Software/Systems
City of Phoenix	• TMC with coverage weekday business hours • Maintenance personnel on call after hours • Police and fire incident responders • Phoenix Transit Operations Control Center	• Citywide hybrid fiber/wireless communications, traffic signals, future arterial CCTV, and future blank-out signs and DMS • Limited number of DMS, primarily near the downtown area • AVL on all fire vehicles and preemption at some signals • AVL on transit vehicles	• Phoenix Fire CAD feed—currently provided to ADOT TOC and MCDOT TMC, and available through RADS connection • TranSuite central control system • Police CAD feed—currently not available to others • Phoenix Lane Restrictions System—currently tracks permitting and planned lane or road closures
City of Tempe	• TMC with coverage weekday business hours • City PIO • Police	• Citywide hybrid fiber/wireless communications, traffic signals, arterial CCTV • AVL on all fire vehicles and preemption at signals	• TranSuite central control system • Police CAD feed—currently not available to others • Tempe Lane Restrictions System—currently tracks permitting and planned lane or road closures
City of Chandler	• TMC with AM and PM peak period coverage weekday business hours • City PIO • Police	• Citywide fiber communications, traffic signals, Bluetooth detectors, arterial CCTV, arterial DMS, and minimal wireless devices at remote locations • AVL on all fire vehicles and preemption at signals	• TranSuite central control system • Police CAD feed—currently not available to others • Chandler Restrictions System—currently tracks permitting and planned lane or road closures • Arterial travel time program
MCDOT	• TMC with coverage weekday business hours • After hours pre-set control of Phoenix TMC system • County PIO	• Citywide hybrid fiber/wireless communications, traffic signals, arterial CCTV, and arterial DMS • Preemption at signals	• KITS central control system • DPS and Phoenix Fire CAD feed • MCDOT ATIS to enter lane restrictions into AZ511

Notes: ADOT = Arizona Department of Transportation, ATIS = Advanced Traveler Information System, AVL = Automated Vehicle Location, CAD = computer-aided dispatch, CCTV = closed-circuit television, DMS = dynamic message signs, DPS = Arizona Department of Public Safety, MCDOT = Maricopa County Department of Transportation, PIO = public information officer, RADS = Regional Archived Data System, TOC = Traffic Operations Center, TMC = Traffic Management Center

8.3.2 City of Phoenix

The TMC is located at Phoenix City Hall at 200 West Washington Street on the 6th floor. Five staff members work within the TMC Monday through Friday from 6:30 AM until 6:00 PM.

The City has ITS infrastructure deployed throughout the community, such as fiber-optic backbone, CCTV cameras, DMS and traffic signals. The communications system includes fiber, wireless and copper backbone and is used to transfer data feeds and information from ITS devices in the field back to the TMC for staff to manage and operate.

The City of Phoenix completed its first ITS Strategic Plan in April 2014 that outlines the infrastructure, systems and processes the City intends to invest in for the future.

The TMC oversees approximately 1,200 traffic signals, 24 miles of light rail intersection coordination, more than 100 CCTV cameras, 5 arterial DMS, more than 72 miles of fiber-optic backbone, more than 900 wireless radios and several miles of twisted-pair copper cable. The TMC uses a variety of management systems to manage all the ITS infrastructure and systems. The ITS Strategic Plan outlines future functionality for the Phoenix TMC to expand its operations and management capabilities to support the regional network.

The daily duties of the TMC staff includes working with Phoenix Right of Way for temporary traffic control, responding to outside agency request for signal timing letters and responding to complaints on signal operations around Phoenix. The TMC's main communication and coordination occurs with the Traffic Signal Maintenance group. They are responsible for maintaining traffic signals throughout the city and regularly coordinating with the Phoenix TMC regarding status and work orders. The Traffic Signal Maintenance group will handle any traffic signal maintenance issues outside of TMC business hours. There has been a designated Phoenix Street Transportation Department liaison to the Metro Light Rail Operations Control Center since inception of light rail for coordinating signalized intersections along the LRT corridor.

The Downtown Traffic Management System operates and manages the lane control signs and CCTV cameras in the downtown area during special events and includes specifically developed signal timing plans based on event ingress and egress. Currently the City has blank-out signs installed at specific locations to provide temporary lane control notifications. DMS are used primarily in the downtown area for special events ingress and egress information. The TMC and Phoenix Police Downtown Event Management Center have full control of the system to display directional information for the public. The DMS are located on high-capacity corridors traveled when people are exiting the downtown area. There are plans to expand the DMS along high-capacity corridors to display travel times.

The TranSuite Traffic Control System is used to manage the all traffic signals' current status, timing plan and connection to the communications backbone and also provides a mapping display on the TMC's video wall.

Phoenix is the primary stakeholder involved in the I-10 ICM signal detour plan that developed a concept of operations for potential full freeway closures, signal detour timing strategies and intergovernmental agreements (IGA) between ADOT, MCDOT and the City of Phoenix. An IGA is currently being developed to provide control of the City of Phoenix signal system after hours to the MCDOT TMC based on pre-set signal timing plan selections along I-10 west. This agreement is being developed for MCDOT to expand coverage of signal timing operations in the City of Phoenix during after hours operation. This could potentially be expanded to facilitate shared operations/control for the Spine arterial corridors.

Programmed plans through 2017 include:

- Creating predefined strategies and timing plans based on the developed concept of operations.
- Adding cameras and DMS throughout the City as well as focusing investments on the Downtown Traffic Management System for special event management purposes.
- Extending fiber backbone to cover more signal and ITS infrastructure throughout the City.

8.3.3 City of Tempe

Tempe's transportation system includes the arterial street system, bus network, bike trails and the METRO Light Rail line. In addition, Tempe is surrounded by ADOT's freeway system. The City of Tempe is an event-hosting "hotspot" in the region, with more than 150 special events throughout the city annually. There are a number of events that typically require road closures and support from police officers and fire department personnel and others to be able to manage the events. Events can require anywhere between 5 and 30 Tempe police officers to manage traffic around the event.

Both the City of Tempe and Valley Metro provide fixed-route transit service within Tempe. Tempe's three transit transfer centers provide a high concentration of bus routes for passenger connections. Long-range plans for transit improvements in Tempe include increased peak-period service on all routes, extended hours on all routes, implementation of new routes, bus pullouts where possible, additional transfer facilities where needed and continued planning and implementation of commuter rail and bus rapid transit.

The Tempe TMC manages the field and central ITS in the City, and will manage future infrastructure as it is deployed and integrated on key corridors. The City of Tempe TMC currently:

- manages existing traffic signals through the use of TranSuite Traffic Control System software
- manages existing CCTV cameras through the use of Luxriot and Replicam Video Management System software
- monitors the Phoenix Fire computer-aided dispatch data feed for incidents
- views ADOT cameras on the freeways throughout Tempe
- monitors METRO Light Rail stations via video security surveillance devices

Tempe currently operates 222 traffic signals on arterial and collector routes. An IGA is in place with ADOT for Tempe to own, operate and maintain the traffic signals at the freeway traffic interchanges. There are currently 39 CCTV cameras in place at arterial crossings throughout Tempe and 29 CCTV cameras in place along the METRO Light Rail line. Additional CCTV infrastructure is programmed for implementation in the next 4 years as part of projects programmed in the MAG TIP.

Tempe completed an ITS Strategic and Deployment Plan in 2012 that outlines the infrastructure, systems and processes the City intends to invest in for the future.

Over the past 2 years, Tempe has completed its first fiber infrastructure project, as well as two projects to install wireless radios at many of its major intersections, thereby reducing its reliance on leased lines, greatly improving bandwidth and experiencing significant savings in monthly fees. Using this upgraded infrastructure, Tempe staff can now view live video from 68 CCTV cameras that are Internet Protocol-based, providing valuable information to better manage the City's traffic network.

Through the MAG TSOP program, Tempe is completing signal synchronization along Southern Avenue from SR-101L to I-10 as well as detour signal timing plans along Southern Avenue and Baseline Road based on a full freeway closure along US-60 in Tempe.

Programmed plans through 2017 include fiber communications along Elliot Road and Rural Road and adding cameras and DMS at key locations throughout the City.

8.3.4 City of Chandler

The City of Chandler has a TMC located near the center of the City that operates traffic signal and ITS infrastructure Monday through Friday from 6:00 AM until 6:00 PM. A fiber communication network is in place on nearly all arterials throughout the City that connects a network of 216 traffic signals, three DMS, more than 800 video devices (consisting of pan/tilt/zoom CCTV and video image detectors) to the TMC. The City has recently completed the migration to the TranSuite Traffic Control System, which manages all traffic signals and ITS infrastructure. The City currently uses Siemens controllers using D4 (Fourth Dimension) controller software.

In 2013, the Chandler TMC retimed 104 signalized intersections (four timing plans per intersection) and conducted temporary timing changes at 46 signalized intersections in response to construction or special events. The number of intersections with LOS A to C has been increasing since 2007.

In 2011, the City of Chandler initiated an innovative project for measuring arterial travel time using Bluetooth readers and integrating the data with freeway travel times for dissemination through arterial DMS. The City has DMS on three major arterials that display real-time travel times from 6:00 AM to 7:00 PM Monday through Saturday. These signs are also used to provide traveler information in response to major incidents or road closures on a daily basis.

Programmed plans through 2017 include additional CCTV and fiber communications to expand the network of infrastructure throughout the City.

8.3.5 Maricopa County Department of Transportation

MCDOT owns and operates the RADS, which collects all ADOT FMS data, many local agency data sets and Phoenix Fire-filtered computer-aided dispatch data. RADS processes that data for a variety of purposes such as freeway travel times to be posted on freeway DMS. RADS has become a critical part of the region's data-sharing strategy. The system was linked with HCRS to provide real-time traffic data to support speed maps on the AZ511 website as well as supplemental road condition information collected from public safety agencies and local agencies not already provided through the HCRS system. MCDOT is responsible for management and oversight of RADS, and local jurisdictions provide data as appropriate to the RADS server. The RADS server is housed in the ADOT TOC, and ADOT provides IT support for maintenance activities to the server. MCDOT funds the system maintenance and ADOT supports the operations.

Future enhancements to RADS processes include:

- TMC center-to-center interfaces with other Cities
- transit information integration into RADS system
- support of "connected vehicle" development activities
- retrieval of DMS display data for archiving

Recently, MCDOT completed the development of a new system using RADS called ARIS (AZTech Regional Information System). ARIS uses a map-based interface that provides a road closure list by recent activity posted on HCRS and, when clicking on the map, shows red/yellow/green real-time speed where available on freeways and arterials, detector graphs showing before and after speeds around closure location, reporting and local CCTV camera images available near the closure location. ARIS is accessible by transportation agencies in the Phoenix metropolitan area and identifies "zones" of interest for each agency specified to receive alerts from the system when a closure occurs in its zone.

In 2011, MCDOT pursued the development of a system to share video over the Internet, providing real-time streaming video to more than just transportation agencies to help with public safety/emergency management departments' operations, particularly during incidents and special events. MCDOT has completed the CCTV over Internet project, called Video Distribution System, which provides real-time streaming camera images from partnering transportation agencies connected to the Camera Cameleon server at ADOT to the public safety/emergency management agencies that need to access those images.

Currently ADOT, MCDOT and the City of Scottsdale have deployed their cameras on the Video Distribution System. Not all public safety/emergency management agencies (police/fire) in the region have access to the transportation agencies' CCTV camera images—even within their own jurisdictions for which Video Distribution System addressed this gap to be able to view CCTV images. Many regional corridors cross multiple jurisdictions, and public safety/emergency management agencies having access to the CCTV camera coverage of those corridors allows for continuous monitoring of the corridor during incident management situations.

An IGA is being developed to provide control of the City of Phoenix signal system after hours to the MCDOT TMC based on pre-set signal timing plan selections along I-10. This agreement is being developed for MCDOT to expand coverage of signal timing operations in the City of Phoenix during after hours operation.

8.4 Summary of Assets

Figure 8-3 shows existing and planned (programmed) ITS infrastructure for the Interstate and key parallel arterials in the Spine study area. This includes fiber telecommunications, traffic signals, CCTV cameras and DMS.

8.5 Coordinated Traffic Incident Management

8.5.1 Arizona Department of Public Safety

General Overview

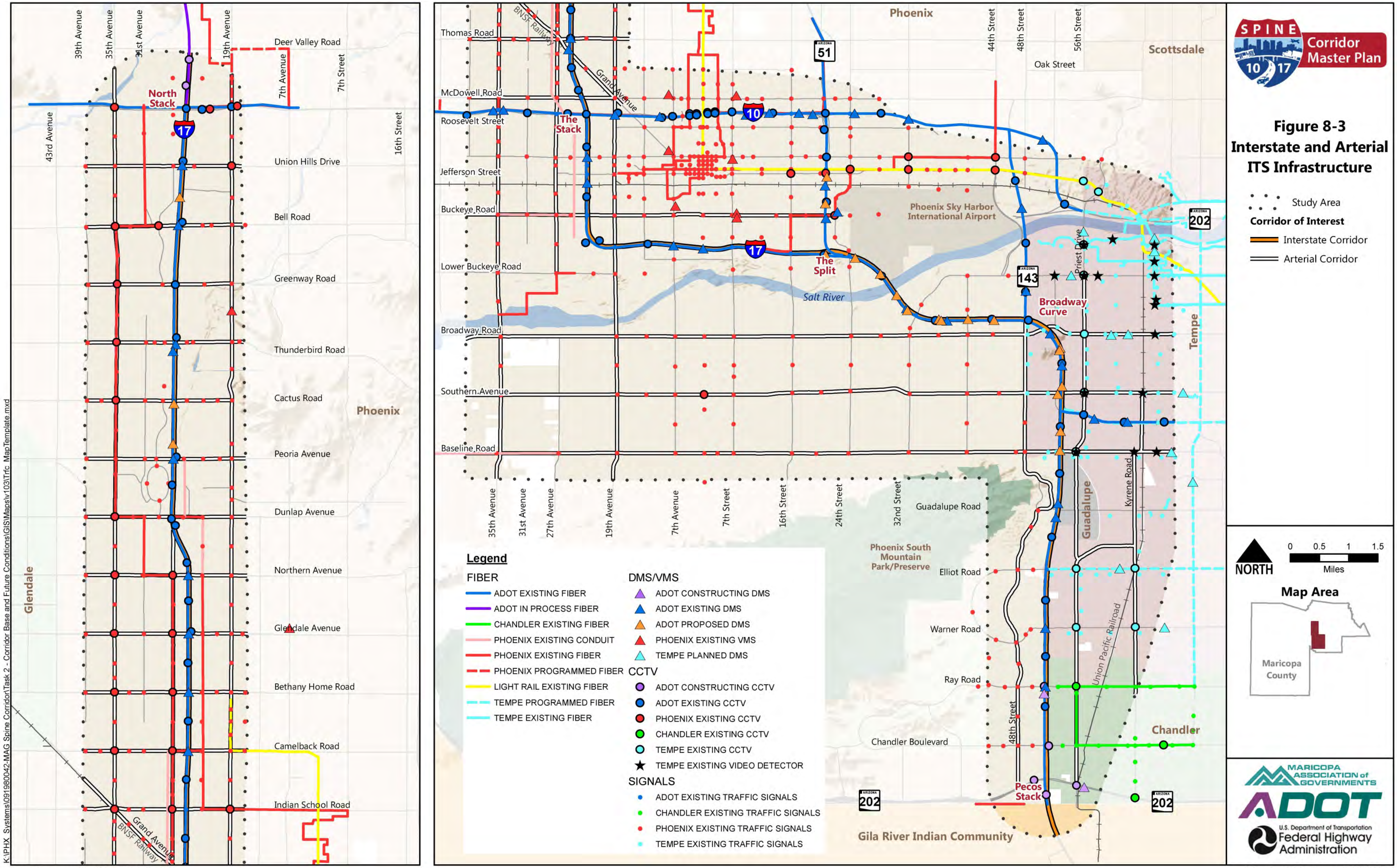
DPS operates a 24/7/365 dispatch center that dispatches statewide. A computer-aided dispatch system collects and disseminates incident logging information to DPS vehicles during dispatching to an incident scene. DPS computer-aided dispatch is provided to the ADOT TOC and MCDOT TMC through a dedicated workstation. All DPS vehicles have in-vehicle Mobile Data Terminals and Automated Vehicle Location to provide open communication with the dispatch center for efficient dispatching.

DPS has dedicated public information office staffers that are dispatched to incident command centers to help relay important incident closure and extent information to the media for the traveling public's benefit.

Freeway Service Patrol

DPS operates the Freeway Service Patrol, which patrols the Phoenix metropolitan area highways to locate and assist stranded motorists and eliminate road hazards and distractions that are safety concerns. Diagnosing minor vehicle problems, providing tools to help with repairs, assisting with flat tires or fuel or calling for a tow truck are part of the patrol's daily duties. Fully staffed, the Freeway Service Patrol is available 18 hours per day, 7 days per week. DPS and MAG co-fund this program for the Phoenix metropolitan area at $1 million per year in the MAG TIP. AAA Arizona also provides some sponsorship and support for the program.

Figure 8-3 Interstate and Arterial ITS Infrastructure



Data Source: ADOT, ALRIS, FEMA

Map Last Updated: 5/13/2016

Traffic Incident Management Coalition

In line with the National Traffic Incident Management Program and the National Unified Goal, DPS led the formation of the Phoenix Metro Traffic Incident Management (TIM) Coalition under the AZTech umbrella. ADOT is a major partner in the TIM Coalition, and other partners include MCDOT, MAG and local jurisdictions. The TIM Coalition consists of stakeholders from law enforcement, fire, emergency medical services, transportation and others and focuses on a planned and coordinated multidisciplinary process to detect, respond to and clear traffic incidents so that traffic flow may be restored as safely and quickly as possible. Reducing the amount of time a roadway is actually blocked and the amount of time a distraction remains on the side of the roadway will not only reduce the inconvenience to the motoring public by reducing congestion but, as studies have shown, it will also reduce the likelihood of secondary crashes—many of which involve first responders including law enforcement officers.

8.5.2 Arizona Department of Transportation

Arizona Local Emergency Response Team

ADOT's Arizona Local Emergency Response Team (ALERT) is a rapid first responder to incidents in the Phoenix metropolitan area. When an incident occurs on a state roadway within the metropolitan area and DPS estimates that the roadway or any lanes will be closed for 1 hour or longer, ALERT assistance is requested. The main purpose of ALERT is to establish safe traffic control in accordance with the *Manual on Uniform Traffic Control Devices*.

ALERT began in 1982 and has eight members that cover 464 centerline freeway miles. Response is provided 24/7/365 including the use of portable message boards and traffic control equipment. Dispatched ALERT responders coordinate with the ADOT TOC regularly while supporting traffic control at an incident.

The team has typically experienced 160 to 180 calls per year and approximately a 20-minute response time to the closure location. It clocks upwards of 2,500 labor hours providing assistance at closures.

Traffic Operations Center

The ADOT TOC plays a key role during incident management on freeways. TOC operators have real-time access to the DPS computer-aided dispatch, which provides filtered information for traffic management purposes such as incident location information, extents and length of lane closures and responding vehicles. This allows the operators to assess impacts on road conditions, traffic queuing, alternate routing options and surrounding freeway network to make adjustments to the FMS to alert or manage travelers in the area and/or coordinate with City TMCs as needed to facilitate full closures. A DPS sworn officer is now in the ADOT TOC during peak weekday commute hours (AM and PM); this supports improved coordination between the TOC and officers in the field during incident response.

Alternate Routing during Incidents

ADOT can provide two panels of information on its freeway message signs during incidents: (1) travel time and (2) incident information with a suggested alternate freeway route. In other areas of the Valley, ADOT is providing specific alternate arterial routes in close coordination with the City TMC (namely Scottsdale, as part of the Loop 101 Incident Management and Response Plan and partnership).

ADOT has completed a statewide alternate routing plan for freeway-to-freeway detour routing and is focused on incorporating arterial rerouting strategies into its plan. This is an effort to use ADOT's freeway message signs and other systems more effectively for the traveling public. ADOT began using this alternate plan in 2013. Operators provides two panels of information on freeway message signs during incidents in the peak hours of the day—one to show the incident information and suggest using an alternate if necessary and another to show the peak period current travel time for that segment the traveler is traveling on. ADOT suggesting that travelers use an alternate route during an incident has been useful to travelers to be able to make better decisions on their route. Operators are also providing information to travelers based on where they are rather than knowledge of the street system: example "Left 2 Lanes Blocked 6 Miles Ahead" rather than "Left 2 Lanes Blocked at 90th Street." The alternate routing program is planned to be expanded in 2014 to include suggesting specific arterial routes after coordination with the local agencies to confirm that the arterial route is prepared to handle freeway traffic that will be suggested to detour to that specific arterial.

8.5.3 Maricopa County Department of Transportation

MCDOT's Regional Emergency Action Coordinating Team is the region's arterial incident response team. Besides responding to incidents on MCDOT roads, the team also responds to arterial incidents in six other jurisdictions through established IGAs. Although the team does not specifically respond to incidents within the Spine study area currently, there is a potential for this service to be implemented within the study area.

8.5.4 Local Police/Fire

Each City within the Spine study area has its own police and fire department. Phoenix Fire dispatches local fire and emergency medical dispatching services for approximately 23 jurisdictions in the Phoenix metropolitan area. The Phoenix Fire Department's Regional Dispatch Center is considered a "secondary answering point" or "secondary PSAP" in the 911 system. This means that when an individual dials 911 to report an emergency the call will be answered by the local law enforcement agency first. This agency is known as the "primary answering point." The local law enforcement agency determines whether the emergency requires fire and/or medical services and, if so, transfers the call. When the 911 phone rings in the dispatch center, Phoenix Fire operators will answer and confirm the location of the emergency and the phone number and will determine what the emergency is before sending the incident off via the computer-aided dispatch system. Phoenix Fire operators will dispatch the call and be in constant communication with the responding units from the time that they acknowledge the receipt of the incident all the way through to its hopefully positive conclusion.

8.6 System Management Gaps and Needs

Agencies in the MAG region, including those within the Spine study area, have been actively implementing systems and technologies to support better real-time traffic management on the Interstates and arterials. Agencies recognize that some key gaps must be addressed to fully realize the operational benefits of the system and technology investments. As funding allows (through federal, state, regional TIP and local sources), agencies are incrementally improving and upgrading key systems and technology infrastructure. Operational initiatives, such as ICM and coordinated traffic incident management, are bringing agencies together to identify where gaps in coordination processes and communications hinder more effective traffic operations and management.

Recognizing that ATM is being planned and designed for the I-17 corridor as near-term improvements, this section describes specific gaps and needs for the Interstate and arterial networks in the Spine study area separate from ATM deployment. This section outlines gaps and needs from a technology and ITS perspective, including system management and operations. Funding has a direct link to many of the gaps identified, and influences staff levels, maintenance and ability to invest in communications infrastructure.

8.6.1 Gaps

Infrastructure

- Communications infrastructure is not complete for the arterial network; this means that not all traffic signals can be updated and changed from the TMCs.
- Portions of the Spine study area have limited detour/re-routing options in the event of a closure or significant congestion on the Interstates. I-17 has good parallel arterial options with 35th and 19th Avenues; light rail operations on 19th Avenue from Dunlap to Camelback Roads could require some specific coordination to implement. There are few parallel options immediately south of I-17 from the Durango Curve to approximately 32nd Street, with the only viable south option being Broadway Road. North of the Split, Phoenix Sky Harbor International Airport limits potential alternate routes. In Tempe, Priest Drive provides for a potential alternate route east of I-10. West of I-10 is 48th Street, which poses some challenge for alternate routing.
- CCTV camera coverage exists at 1-mile intervals on 35th Avenue (Bell to Indian School Roads), and Tempe has CCTV cameras installed on Priest Drive (at Elliot and Warner Roads). Chandler has a CCTV on Priest at Ray Road. There are a few additional arterial CCTV locations, but not within the immediate Spine study area. It would also be beneficial to have CCTV located for and dedicated to interchange traffic signal operations.
- No real-time speed/volume data is available for routes parallel to I-17 or I-10, which limits the ability to provide travel times or arterial congestion information.

Staffing

- Staffing at arterial TMCs is limited to weekday business hours. ADOT's TOC is open 24/7/365, but there is limited coordination directly with City traffic engineering and management after hours.
- Maintenance for ITS devices is typically completed on an as-needed basis, with limited preventive maintenance being performed with current resources. As deployment increases, there is a need to keep pace with maintenance.

Systems

- Real-time traveler information for arterials is limited and focuses primarily on incidents captured in RADS or disseminated via social media alerts or media traffic reports.
- Freeway ramp meters on I-17 and I-10 are currently set to a time-of-day operation. The I-17 near-term improvement will implement dynamic ramp metering on that corridor, which enables the ramp meters to be responsive to real-time traffic conditions rather than use preset time-of-day settings.
- Planned event information (such as scheduled road work or restrictions) is not always current and might not reflect actual work days or conditions. ADOT's HCRS is updated by operators and others at ADOT frequently, but for arterials, there is no direct coordination or direct data feed that captures planned construction or restrictions. Project implementation or permitting groups/divisions often handle the permit and scheduling requests. Often, these functions are outside of the traffic management/TOC, and internal system operating policies limit access to this information across different divisions.
- Agencies currently operate in a stand-alone environment, from a system integration perspective. Some progress is being made to be able to allow view-only access (to CCTV cameras, as an example), but there is currently no regional integration strategy. This applies to traffic management as well as transit operations. Phoenix, Tempe and Chandler are all currently using the TranSuite central signal system software.
- With the exception of Chandler, there is no "pre-warning" on arterials for incidents or travel conditions on the Interstates.

Coordinated Operations

- Alternate routing strategies for freeway closures (unplanned, incident-generated) are not developed for I-17 or I-10. If a freeway incident requires a closure, DPS will implement a closure and divert traffic onto arterials. Formal processes are not in place that require notifying City TMCs or local law enforcement that traffic is being detoured onto city streets.
- Traffic signal coordination across jurisdictions continues to be a challenge. MAG is helping to advance this through TSOP projects, and MAG encourages agency partnerships to submit TSOP applications for multijurisdictional corridor segments.
- There is limited to no coordination between the interchange signals, ramp meters and arterial traffic signals.
- There is limited real-time interaction between traffic management and transit operations, although this is not limited to the Spine study area. I-17 and I-10 are key routes for express bus services, and there are numerous local routes that use 35th Avenue, 19th Avenue, Priest Drive and the east-to-west corridors in the Spine study area. Unplanned disruptions to freeways, arterials or both affect transit service and schedules.

8.6.2 ITS and System Management and Operations Needs

There is a need for a more focused investment in ICM and mobility strategies and improved operations to support active corridor management for the Spine corridors of interest, as well as other Phoenix-area Interstates, freeways, and arterial networks. For the region to be successful in active freeway and arterial corridor management, individual improvements in agency jurisdictional oversight as well as improvements to existing operations of regional activities need to be completed.

Sustainable funding for implementation and operations is essential to each of the identified needs. The majority of infrastructure and technology investments are funded through a combination of federal, RTP and agency sources. Future funding must consider sustainability of the technology and system investments, lifecycle costing strategies (for planning and for asset management), public partnerships to leverage available resources and private partnerships to offset agency funding requirements for system management and operations.

Infrastructure

- Support alternate routing way finding and surveillance to safely route traffic from freeways to arterials and back to the freeways. Identify specific routing needs and restrictions for freight traffic that needs to re-route from the freeway.
- Address local agency communication connections to provide for stable, fiber communications on key arterials in the Spine study area.

- Identify potential active management strategies for specific portions of the Spine study area, based on travel demands and unique characteristics of the adjacent modal networks, factoring in planned near-term improvements.
- Identify ICM needs for specific portions of the Spine study area, including Interstate, arterial, and transit. ICM strategies can improve non-recurring/incident-based congestion responses, as well as address longer-term congestion and demand management needs.
- Connecting freeway signals with arterial network signals to affect throughput and travel time.

Staffing

- Increase agency personnel to support and prioritize corridor operations within the Spine study area. This includes state and local traffic management, as well as incident response and support resources (ALERT, Freeway Service Patrol, law enforcement).
- Increase maintenance personnel and/or resources to support additional infrastructure on the corridor, and proactively maintain ITS and technology investments to ensure operational reliability.
- Implement regular multiagency training to support maintenance response, incident response and media relations as they relate to coordinated traffic operations and management. With new tools being implemented, including more dynamic applications such as ATM and smart ramp metering, staff and partners should be educated on how they help the transportation network function more efficiently.
- Consider expanding the TIM Coalition to include regular participation by local law enforcement.

Systems

- Integrate real-time data into multiple agency systems to support cohesive operations and decision response for the corridor. This will also support a performance management strategy by making real-time information available to support strategy implementation by freeway, arterial and transit operations agencies.
- Expand data collection strategies so that real-time freeway and arterial information can be made available to the TOC/TMC staff as well as integrated into publicly available traveler information.
- Leverage and expand existing regional systems (RADS, HCRS) to support additional capabilities and enhanced data sharing.
- Begin planning for future requirements of connected and autonomous vehicles and how they will shape the system needs of agencies in the Spine study area. This will likely have broader impacts to other freeway and arterial networks in the region.
- Provide for more comprehensive traveler information that includes real-time data from arterials and freeways. Explore alternative data sources (for example, BlueTooth, probe, crowdsourced) to fill in data gaps.

Coordinated Operations

- Implement strategies for consistent messaging using multiple media (DMS, social media, 511, etc.) to travelers across jurisdictional boundaries and across the modal network (freeways, arterials and transit).
- Explore shared operations strategies between agencies to allow for system management and coverage beyond business hours. Steps are underway to develop such a strategy between MCDOT and Phoenix to support after-hours system coverage if there is an incident that will extend beyond current business hours.
- Establish predefined operational strategies for multiagency operations during full freeway closures, including traffic signal operations and timing, coordination with law enforcement in the field, preferred routes for detours, transit operations and other parameters.
- Provide advanced notification of lane restrictions or alternate routing options to travelers outside of specific study area limits with information about what is happening near the Spine study area.
- Put agreements and standard procedures in place for local agencies to operate freeway interchange signals during business hours and ADOT TOC to operate after hours.

8.7 Emerging Technologies and Operations Approaches

Technology continues to play a key role in current and future transportation systems management and operations. Agencies in the region (including those with facilities in the Spine study area) have been actively deploying and integrating traffic control and management systems, central operating systems, and traveler information systems to improve overall system management. This section outlines some emerging technologies and operations strategies that could address some of the existing and future operations challenges within the Spine study area. Some of these strategies, including ATM and ICM, are already being planned for key corridors in the region, including portions of the Spine study area.

8.7.1 Active Traffic Management

ATM is the ability to dynamically manage recurrent and non-recurrent congestion based on prevailing and predicted traffic conditions. ATM strategies focus on influencing travel behavior with respect to lane and facility choices under various traffic conditions. They focus on proactive congestion management rather than reactive response to traffic conditions. Examples of ATM strategies include adaptive ramp metering, adaptive signal control, dynamic/variable speed limits (speed harmonization), dynamic lane use control, dynamic shoulder lanes, transit signal priority and queue warning, to name a few. These strategies can be deployed singularly to address a specific issue (for example, deploying adaptive ramp metering to control traffic flow onto an Interstate) or in combination to provide comprehensive congestion management and improved travel information and roadway safety.

The Washington State Department of Transportation (WSDOT) uses ATM as a key strategy to reduce collisions associated with congestion and blocked lanes. It uses a series of overhead lane signs to provide travelers with advance notice of traffic conditions. Variable speed limit signs adjust speed limits on the roadway based on real-time traffic, roadway and/or weather conditions. Dynamic lane use control, which opens or closes travel lanes in advance of closures or blockages, provides travelers with advance warning and allows traffic to merge into adjoining lanes prior to the blockage or closure. Figure 8-4 shows an example of some ATM technologies deployed in Washington. The system of traveler information and dynamic traffic management has proven helpful in managing storms or other emergency situations because the signs can be used to lower speed limits and help clear traffic from the site of an incident. It also improves work zone safety by facilitating the process of merging traffic and provides travelers with information about alternate routes. WSDOT has seen significant crash reductions on freeways with ATM deployed.

Figure 8-4 WSDOT ATM Deployed on Interstate 5

In the United Kingdom, an ATM system was deployed that involved the use of hard shoulders, ramp metering, variable signs, cameras and traveler information. Hard shoulders describes a situation where the shoulders of a road are opened for use as an auxiliary lane to help merging traffic and to create additional capacity. Overhead signs (DMS) provide clear information on the use of these lanes, which are opened only during peak hour traffic or when an additional travel lane is needed because of a closure or special event. The United Kingdom has found that the system has led to a large reduction in delays along its roadways (up to a 30 percent reduction), and it have received positive feedback from travelers about the use of the lanes and the information provided about them.

8.7.2 Integrated Corridor Management

The goal of ICM is to manage a corridor as a multimodal system and make operational decisions for the benefit of the corridor as a whole. Typically, different agencies are responsible for freeways, surface streets and transit systems, making it difficult to comprehensively and proactively manage congestion and improve mobility across a multimodal corridor. The foundation for ICM is that that agencies will realize significant improvements in the efficiency of transportation through increased collaboration between agencies, integration of existing infrastructure along major corridors and balancing network demand to capitalize on available capacity on other networks (as part of a broader demand management strategy).

The three leaders in ICM in the United States are Dallas, Minneapolis and San Diego. Some of the strategies used by these agencies for ICM include HOV lane management, arterial street monitoring systems, responsive traffic signal systems, parking management, real-time transit vehicle information and Decision Support Systems.

The Decisions Support Systems component of an ICM system is the foundation for coordination amongst existing transportation systems. It collects, analyzes and shares data from each of the transportation system components and generates and implements plans and strategies in real time, depending on how it is configured and how agencies have agreed to its implementation. Overall, ICM can improve corridor performance by enhancing situation awareness, delivering improved response and control and better informing travelers about traffic conditions. San Diego and Dallas were part of the federal ICM demonstration program.

ICM strategies have been in the planning and implementation stages in the MAG region for nearly a decade. Locally, ICM planning focuses on improving freeway/arterial coordination during incidents or closures of a freeway that necessitate traffic diverting onto adjacent arterials. For these ICM strategies, no new infrastructure was implemented; rather, it focused on improving lines of communication, establishing notification procedures among agencies and developing new operations strategies to better support freeway diversion and re-routing. These ICM strategies have been implemented on SR-101L as part of a partnership between ADOT, the City of Scottsdale, MCDOT, DPS and the Salt River Pima Maricopa Indian Community.

MAG was recently awarded a federal grant to support ICM planning for the I-10 corridor, including I-10 west, the downtown area (including the tunnel) and the southern portion of I-10 in the Spine study area.

8.7.3 Connected Vehicles

Connected vehicles are considered an emerging technology, although several connected vehicle applications are being actively tested as part of a national initiative through the U.S. Department of Transportation (USDOT). Connected vehicles represent an important partnership between public and private entities and are dependent on close coordination between transportation agencies, auto manufacturers, technology/application developers and a host of other partners to work through the technical, policy and safety impacts of these transformative capabilities.

The goal of connected vehicles is to help to improve real-time traffic, transit and parking data by using vehicle-to-infrastructure capabilities and anonymous information from travelers' wireless devices (which could be on a mobile or in-vehicle device). Figure 8-5 shows examples of these different communications interactions. Vehicle-to-vehicle capabilities allow for cars, trucks and buses to communicate with each other, and these capabilities are a big focus of the safety applications. Connected vehicle technology can be pertinent to cars, buses, trucks, trains, traffic signals, cell phones and other devices. For example, vehicles can communicate with traffic signals through either on-board devices or cell phone technology to eliminate unnecessary stops and reduce travel times. A mainstream example of this is emergency vehicle priority, where emergency vehicles are equipped with a device that sends signals to a traffic signal to change the signal to green in the direction that the vehicle is approaching. With connected vehicles, emergency priority could be better managed and assigned in the event that multiple emergency response vehicles are approaching a signal from different directions. Another example of a connected vehicle application is providing enhanced traveler information to provide more accurate travel time information for different modes as well as different route or detour options and the environmental impacts of their choices.

USDOT is putting a significant emphasis on testing connected vehicle applications in real-world environments. Several test beds around the county have been actively testing different connected vehicle applications; a Safety Pilot in Michigan was among the first to deploy these capabilities as part of an integrated test bed with active signals on city and state roadway facilities. A competitive process was recently initiated by USDOT to solicit pilot sites to deploy these technologies and get a better understanding of how they work in a real-world transportation network, operational impacts and what is needed for sustaining operations and management.

Maricopa County is at the forefront of connected vehicle technology, especially with respect to arterial-based connected vehicles. Maricopa County has implemented a program called Systematically Managed Arterial (SMART) Roadways to facilitate the collection of data to accurately assess transportation system performance and actively manage the system in real time. Some of the technology used in the SMART Roadway initiative includes traffic and freeway ramp signal priority including emergency and transit vehicle priority, enhanced real-time traveler information such as mobile incident warning and automated traveler alerts and advanced traffic signal technology such as equipping intersections with dedicated short-range radios, Wi-Fi and Bluetooth readers. The focus of the program is to connect vehicles to infrastructure deployed on the roadway, using existing technology to manage traffic in a more responsive and real-time manner.

Figure 8-5 Connected Vehicle Communications

8.7.4 Autonomous Vehicles

The concept of fully autonomous, or "driverless," vehicles is emerging but has not been implemented yet. Autonomous vehicle technology is machinery and software installed in a motor vehicle that provides the vehicle with the capability to drive without a human operator. Autonomous vehicles will have the capabilities to assess their environment, communicate with other vehicles and interact with databases through cloud and wireless technology. The anticipated benefits of autonomous vehicles include reduction or elimination of driver error, reduced crashes and reduced fatalities, increased mobility for the young and elderly who would otherwise be unable to drive, increased efficiency of traffic flow and fuel use and a reduction in parking need.

While completely autonomous vehicles have not yet been developed, vehicles with features of autonomy, such as electronic stability control or self-parking capabilities, have emerged. To realize the full potential of autonomous vehicles, corresponding traffic control systems will need to be developed and implemented to correspond with the in-vehicle technology.

The National Highway Traffic Safety Administration has developed the following four classes or levels of automation for vehicles:

- Level 0: The driver completely controls the vehicle at all times.
- Level 1: Individual vehicle controls are automated, such as electronic stability control or automatic braking; the vehicle is still driver-dependent.
- Level 2: At least two controls can be automated in unison, such as adaptive cruise control in combination with lane keeping.
- Level 3: The driver can fully cede control of all safety-critical functions in certain conditions. The car senses when conditions require the driver to retake control and provides a "sufficiently comfortable transition time" for the driver to do so.
- Level 4: The vehicle performs all safety-critical functions for the entire trip, with the driver not expected to control the vehicle at any time. Because this vehicle would control all functions from start to stop, including all parking functions, it could include unoccupied cars.

Since 2011, only four states (Nevada, California, Michigan and Florida) and the District of Columbia have enabled legislation to allow autonomous vehicles on public roads. Several policy and economic considerations surround autonomous vehicles, including enforcement/liability issues, economic impact of driverless cars for commercial purposes (goods movement, taxi/shuttle, etc.) and the ability of public transportation facilities and systems to support autonomous vehicles.

8.7.5 Adaptive Traffic Signals

Adaptive traffic signal control technologies allow the timing at signalized intersections to be changed in real time to best accommodate the current traffic patterns. Sensors at the intersections collect and process data to determine when and how long lights should be green to allow for the best traffic flow and ideally result in reduced congestion. The recommended signal timing that is implemented by the technology is evaluated every few minutes and is developed based on current sensor data as well as historical traffic data from that intersection. One of the biggest benefits of adaptive signal timing is during special events that cause irregular traffic patterns or during incidents where there may be reduced capacity on the road. However, adaptive traffic signals are beneficial even under normal traffic conditions because regular cycle lengths tend to be higher than needed for current traffic volumes, as they are set to accommodate the peak of the peak hours. Benefits include improved travel time reliability, reduced congestion and fuel consumption, prolonged effectiveness and efficiency of traffic signal timing plans, reduction in complaints about outdated signal timing and reduction in need for maintenance of signal coordination plans. Further, studies conducted by FHWA indicate that crashes could be reduced by up to 15 percent through the implementation of improved signal timing resulting from the reduction of congestion within an intersection that is often the cause of many crashes (www.fhwa.dot.gov/everydaycounts/technology/adsc/description.cfm).

There are many examples of the use of adaptive signal control throughout the world, and FHWA has put forth the Every Day Counts Adaptive Signal Control Technology Initiative to help mainstream the use of adaptive signal control technology throughout the country. Agencies in the region are beginning to test adaptive signal capabilities, and Bell Road will be among the first regionally significant corridor to implement adaptive traffic signal control, including the portion of Bell Road within the Spine study area.

8.7.6 Real-time Data

The lack of real-time data on many of the Spine study area arterial corridors is a significant gap for improving system operations and management and for coordinating freeway/arterial operations. Traditionally, agencies used loop (or similar) detection to obtain real-time speeds and volumes. ADOT has deployed loop detectors at approximately ⅓ mile spacing on the freeway as part of its FMS.

Arterials pose a challenge for implementing a similar strategy for collecting real-time speed and volume data because of intersections, driveways, different mixes of vehicles going at different speeds and the cost implications of instrumenting with traditional detection on arterials at a level and density to yield valuable information.

A host of new and emerging technologies is available to support better real-time data collection, particularly for arterials. Many agencies are making use of Bluetooth technologies to support corridor travel times. Crowdsourcing options, such as those available through private-sector providers, can also support corridor travel times. These private-sector companies use a combination of anonymous crowdsourced data as well as historical data to identify speeds. Several acknowledge their models are still being refined and that arterials pose some different challenges than freeway corridors. Connected vehicles, when deployed, can also serve as a valuable source of real-time information on the transportation network.

8.8 Summary of Identified Issues

In the following sections, issues relating to technology infrastructure and operations are discussed for the various study area segments.

Segment I1: I-10, SR-202L to Baseline Road

Only two DMS are within this segment of I-10, and no DMS are located south of SR-202L to advise travelers heading west toward the Spine study area. Ramp meters are set to time-of-day operations and are not linked to main line speeds or ramp queues.

Segment I2: I-10, Baseline Road to the Split

Limited opportunities exist to divert traffic from I-10 in the event of a crash, closure or to balance congestion (SR-143 provides a viable freeway alternate). Ramp meters are set to time-of-day operations and are not linked to main line speeds or ramp queues.

Segment I3: I-17, the Split to the Stack

There are limited opportunities to divert freeway traffic south of I-17 in the event of a closure or significant congestion. With no wayfinding equipment or infrastructure on viable routes south of I-17 (Broadway Road), getting travelers, particularly truck drivers, back onto the freeway is challenging. Ramp meters are set to time-of-day operations and are not linked to main line speeds or ramp queues.

Segment I4: I-17, the Stack to ACDC

This segment will be part of ADOT's Near-term Improvements, which is implementing ATM strategies on I-17. This is envisioned to include additional detection, variable speeds, adaptive ramp metering and strategies for wrong-way driving prevention.

Segment I5: I-17, ACDC to the North Stack

This segment will be part of ADOT's Near-term Improvements, which is implementing ATM strategies on I-17. This is envisioned to include additional detection, variable speeds, adaptive ramp metering and strategies for wrong-way driving prevention.

Segment A1: 48th Street, 56th Street/Priest Drive and Kyrene Road

Three different agencies (Cities of Phoenix, Tempe and Chandler) manage arterial signals and infrastructure, and none are currently connected to be able to view adjacent signals or CCTV cameras. There are gaps in telecommunications infrastructure on arterials in this segment. There is also limited real-time information available on arterials (congestion, speed) and limited real-time information disseminated to travelers. It is challenging to coordinate detours/re-routes in the event of a closure on this segment of I-10 because of a lack of wayfinding infrastructure but also limited viable alternate routes. Staffing levels at local TMCs in this segment have limited coverage for traffic signal changes during business hours and there is no staff for coverage at local TMCs after business hours.

Segment A2: Baseline Road, Southern Avenue, Broadway Road and Buckeye Road

Two agencies (Cities of Phoenix and Tempe) manage arterial signals and infrastructure; however, the agencies are currently not connected and are not able to view each other's signals or CCTV cameras. It is challenging to coordinate detours/re-routes in the event of a closure on this segment of I-10. Through Tempe, there are viable parallel arterials (48th Street and Priest Drive), but through Phoenix there are challenges diverting traffic north of I-10 past Broadway Road. There is also limited real-time information available on arterials (congestion, speeds), and limited real-time information disseminated to travelers.

Segment A3: 35th Avenue, 27th Avenue and 19th Avenue

There is no wayfinding technology or infrastructure to support Interstate traffic diversions resulting from a closure or extreme congestion on these parallel arterials. There is no real-time data collection infrastructure on these arterials for speeds, volumes or congestion levels. Existing arterial DMS are not used for traveler information. Traffic signal coordination is through pre-set time-of-day plans. Coverage of CCTV cameras is limited to most major intersections on 35th and 19th Avenues.

Segment A4: East-to-west arterials crossing I-17

There are very limited installations of fiber telecommunications on east-to-west arterials crossing I-17 or within the Spine study area. East-to-west traffic signals are pre-set on a time-of-day pattern (not responsive to actual traffic conditions). There is limited coordination or interface between transit and the traffic signals, with the exception of coordinating with METRO Light Rail. There is no CCTV camera coverage at intersections east of I-17 other than SR-101L, Union Hills Drive and Indian School Road.

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9 Commerce and Economic Development Factors

Businesses and industry generate a significant amount of traffic. In addition to traditional commuter trips, industry in the corridor generates trips involving large commercial trucks, delivery trucks, construction vehicles and taxis. Businesses need to move people and products in a safe and efficient manner, and the I-10 and I-17 transportation corridor plays an important role in supporting the region's economy. The study area represents approximately 3 percent of the land area in Maricopa County. However, it also represents approximately 30 percent of Maricopa County's total employment. The discussion below illustrates how the demands historically placed on I-10 and I-17 as major commuter and industrial routes are anticipated to continue in the foreseeable future. A decreasing reliability of I-10 and I-17 as dependable travel solutions has—and would continue to—adversely affect the state's economic productivity.

The study area represents roughly 2 percent of Maricopa County, but 30 percent of the jobs are located within the study area, and 31,500 trucks travel along segments of I-10 each day.

9.1 Employment

Both Interstates are essential to the region's economic vitality, with much of the Valley's industry and business located along the corridor. Figure 9-1 illustrates the density of employment in Maricopa County. Key employment centers in the study area include Phoenix Sky Harbor International Airport (one of the largest economic engines in the state), Arizona State University's Tempe and Phoenix campuses and the downtown Phoenix business core. Figure 9-2 illustrates that the current density of employment is expected to continue, if not increase, in the study area. It is important to provide good access to these jobs, but equally important to develop corridor solutions that minimize impacts on businesses adjacent to the corridor. Figure 9-3 segments the areas surrounding the corridor into focused areas of dense employment, called job centers, and displays the existing and future (2040) employment for each. The downtown Phoenix/Central Avenue job center is currently, and is anticipated to remain, the largest employment center along the corridor, experiencing growth from roughly 85,000 existing jobs to nearly 130,000 jobs by 2040. In fact, all job centers are expected to experience increased employment through 2040, some more so than others. In particular, downtown Tempe and west Chandler are projected to undergo relatively explosive employment increases 65 and 150 percent, respectively.

9.2 Freight

Nearly one-third of the total freight tonnage transported across the United States travels on I-10, primarily by truck. As the operational performance of I-10 and I-17 diminishes in the corridor, the ability to move goods and services in and out of the corridor would also be affected. Figures 9-4 and 9-5 illustrate the concentration of businesses in the study area that are significant generators of truck traffic for both existing and forecast 2040 conditions, respectively.

Truck traffic in the corridor is high today, with as many as one in six vehicles being a truck in some locations. Tables 9-1 and 9-2 summarize the percentage of total PM peak truck traffic at select locations in the corridor under today's conditions and forecast 2040 conditions, respectively. Figure 9-6 illustrates the current amount of medium and heavy trucks as a percentage of total daily traffic on study area roadways. Trucks are larger and accelerate more slowly than regular vehicles, which affects traffic flow. It will be important to consider the large number of trucks in the corridor as alternative improvement strategies are developed.

Table 9-1 Existing (2014) PM Peak Period Truck Percentages

Location	Total vehicles	Trucks	Truck percentage
I-10 and 91st Avenue	59,051	6,029	10
Broadway Curve	62,832	8,050	13
West of SR-143 and I-10	75,200	9,822	13
I-10 and Ray Road	41,299	4,882	12
Durango Curve	37,143	5,995	16
I-17 and Bell Road	42,960	2,488	6

Notes: I-10 = Interstate 10, I-17 = Interstate 17, SR-143 = State Route 143

Table 9-2 Forecast (2040) PM Peak Period Truck Percentages

Location	Total vehicles	Trucks	Truck percentage
I-10 and 91st Avenue	77,958	7,594	10
Broadway Curve	68,641	8,839	13
West of SR-143 and I-10	83,231	10,855	13
I-10 and Ray Road	51,901	5,937	11
Durango Curve	38,589	6,375	17
I-17 and Bell Road	61,791	4,049	7

Notes: I-10 = Interstate 10, I-17 = Interstate 17, SR-143 = State Route 143

Figure 9-1 Existing Employment Density

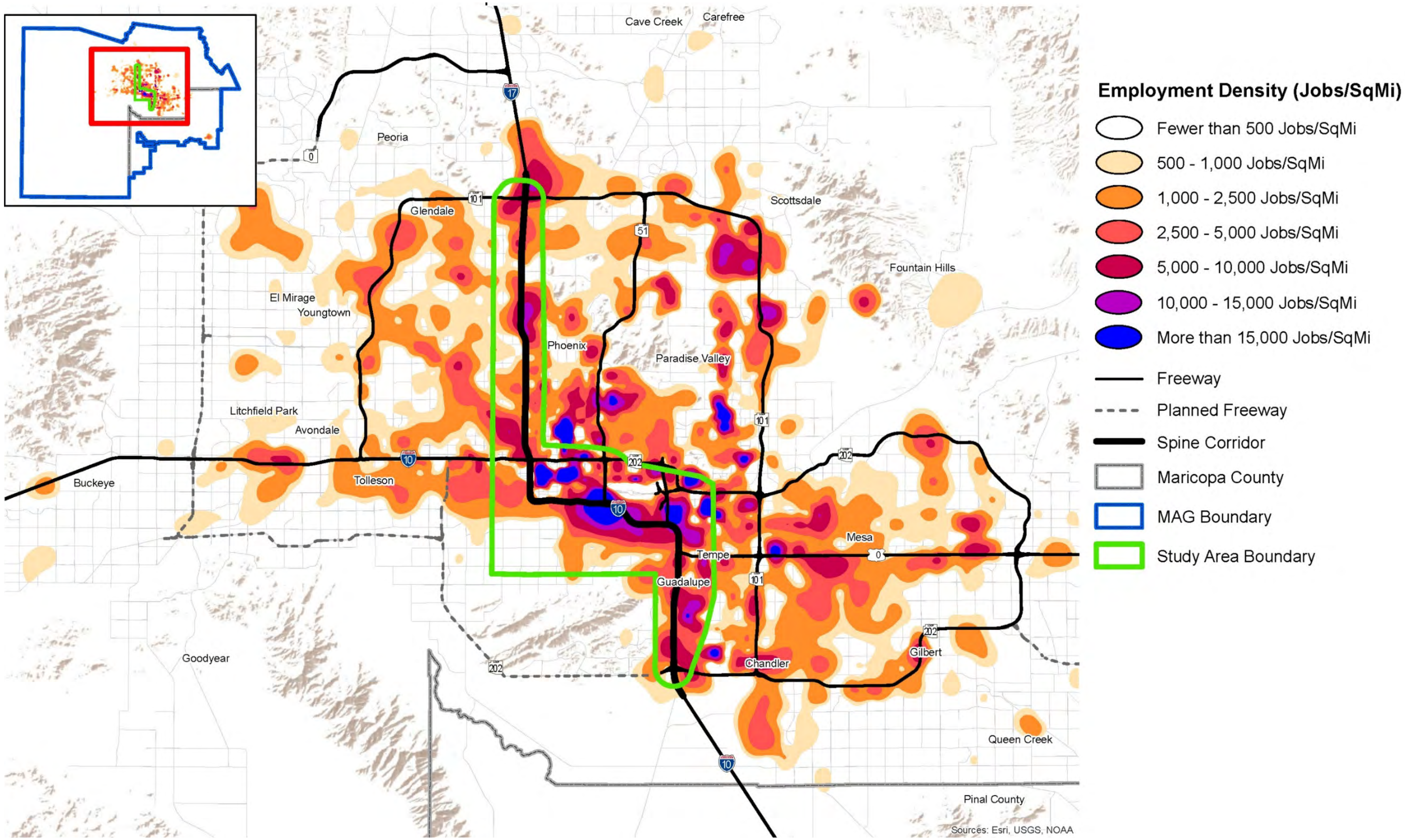


Figure 9-2 Forecast Year 2040 Employment Density

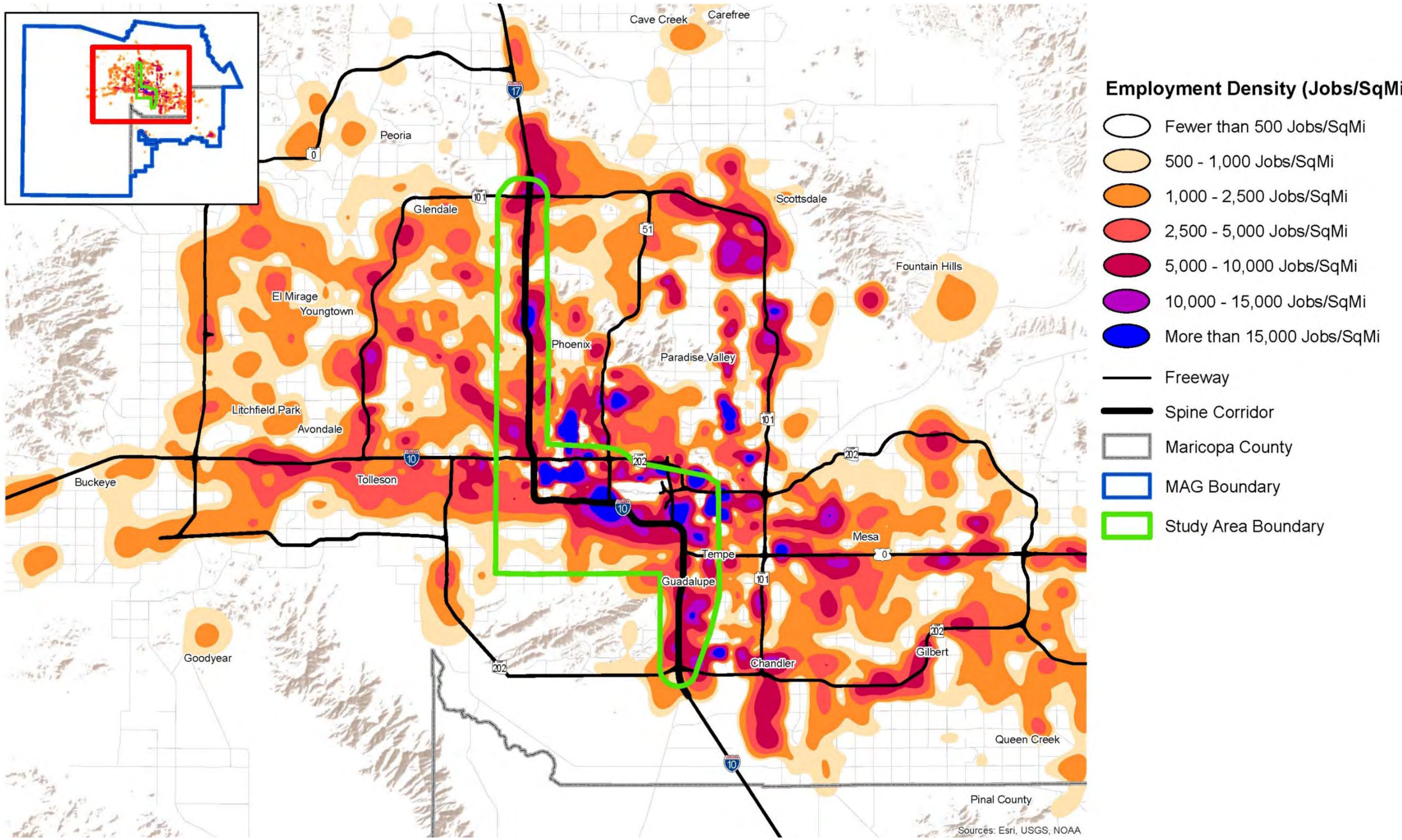
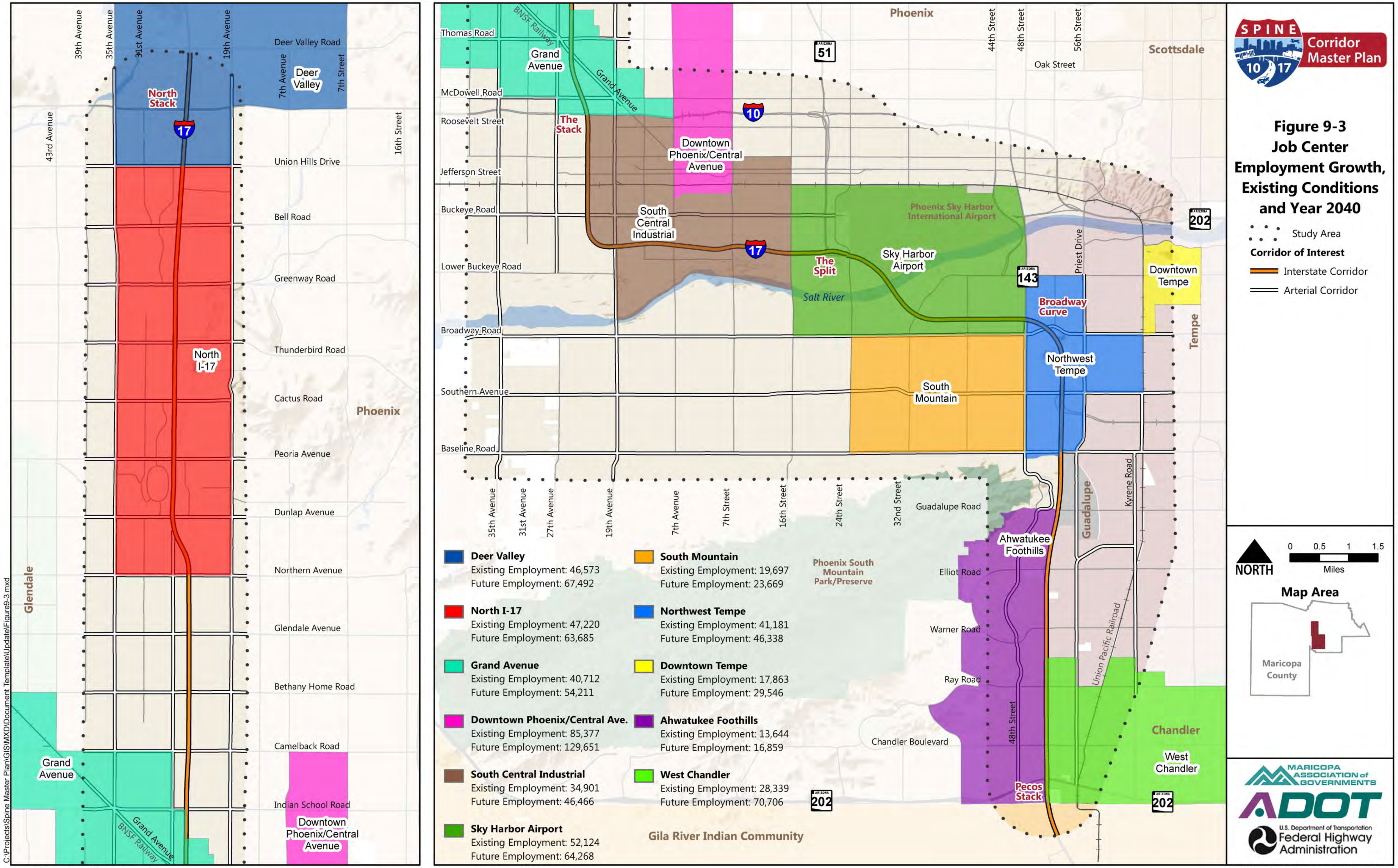


Figure 9-3 Job Center Employment Growth, Existing Conditions and Year 2040



Data Source: ADOT, ALRIS, FEMA

Map Last Updated: 5/13/2016

Figure 9-4 Existing Manufacturing and Transportation Sector Employment Density

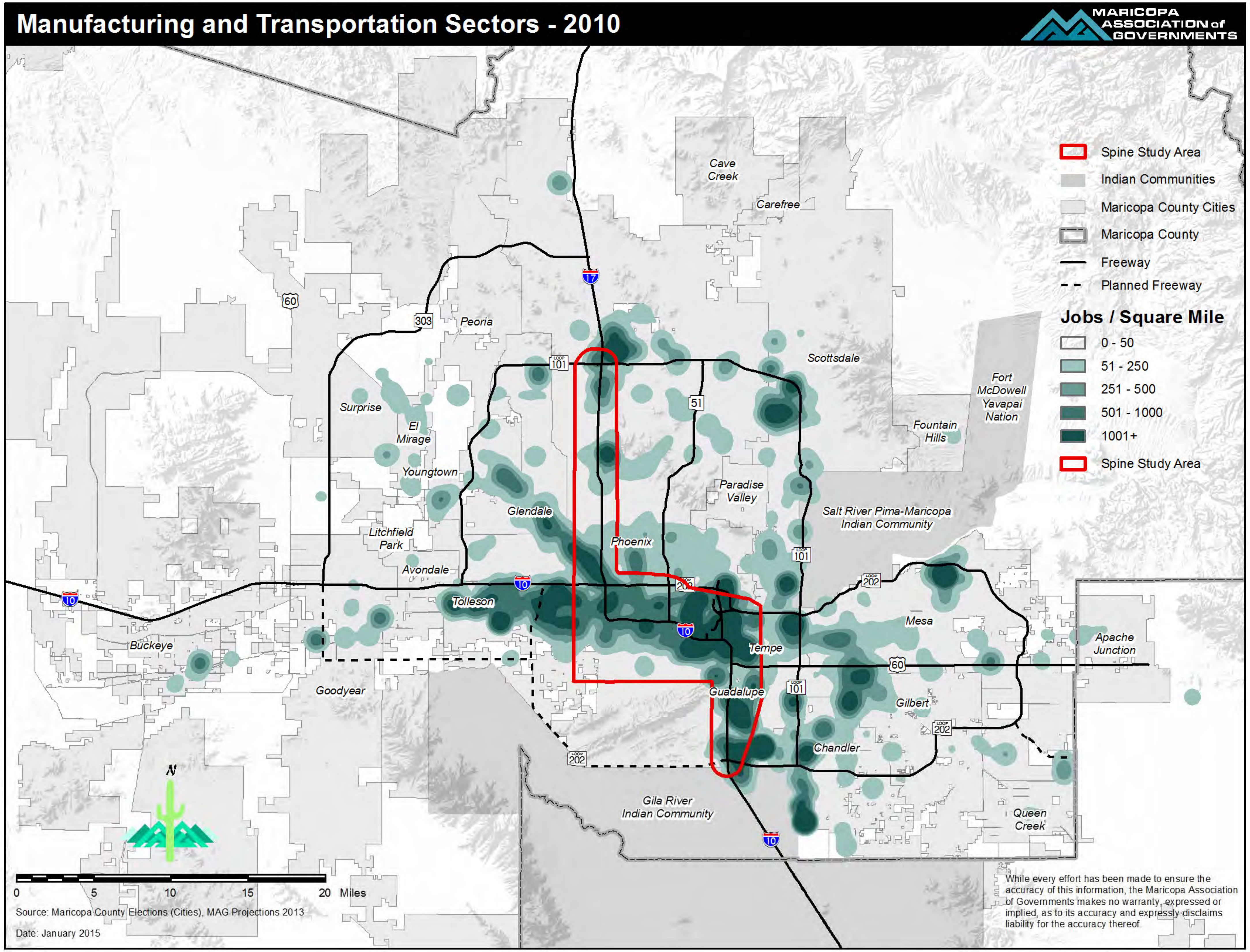


Figure 9-5 Forecast Year 2040 Manufacturing and Transportation Sector Employment Density

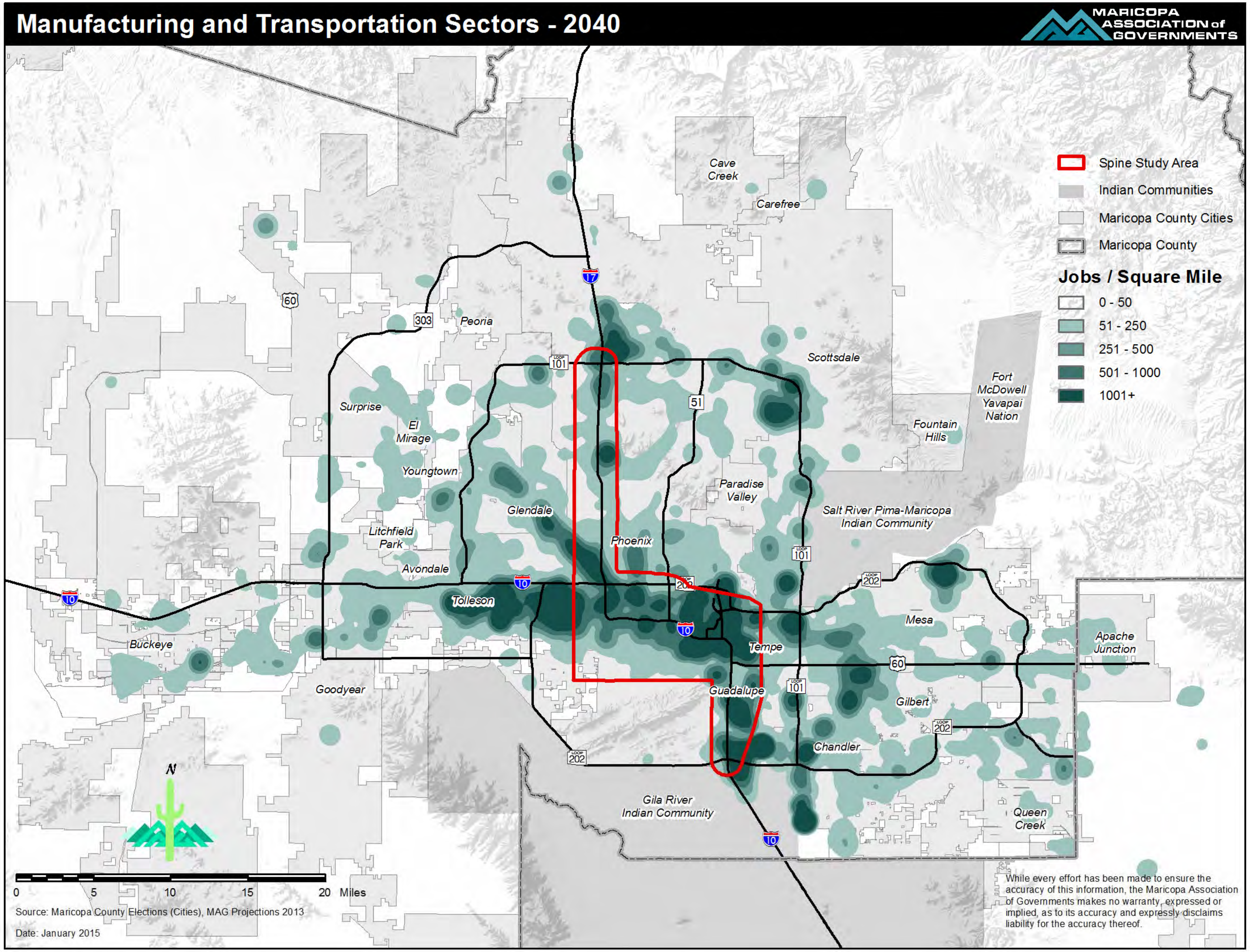
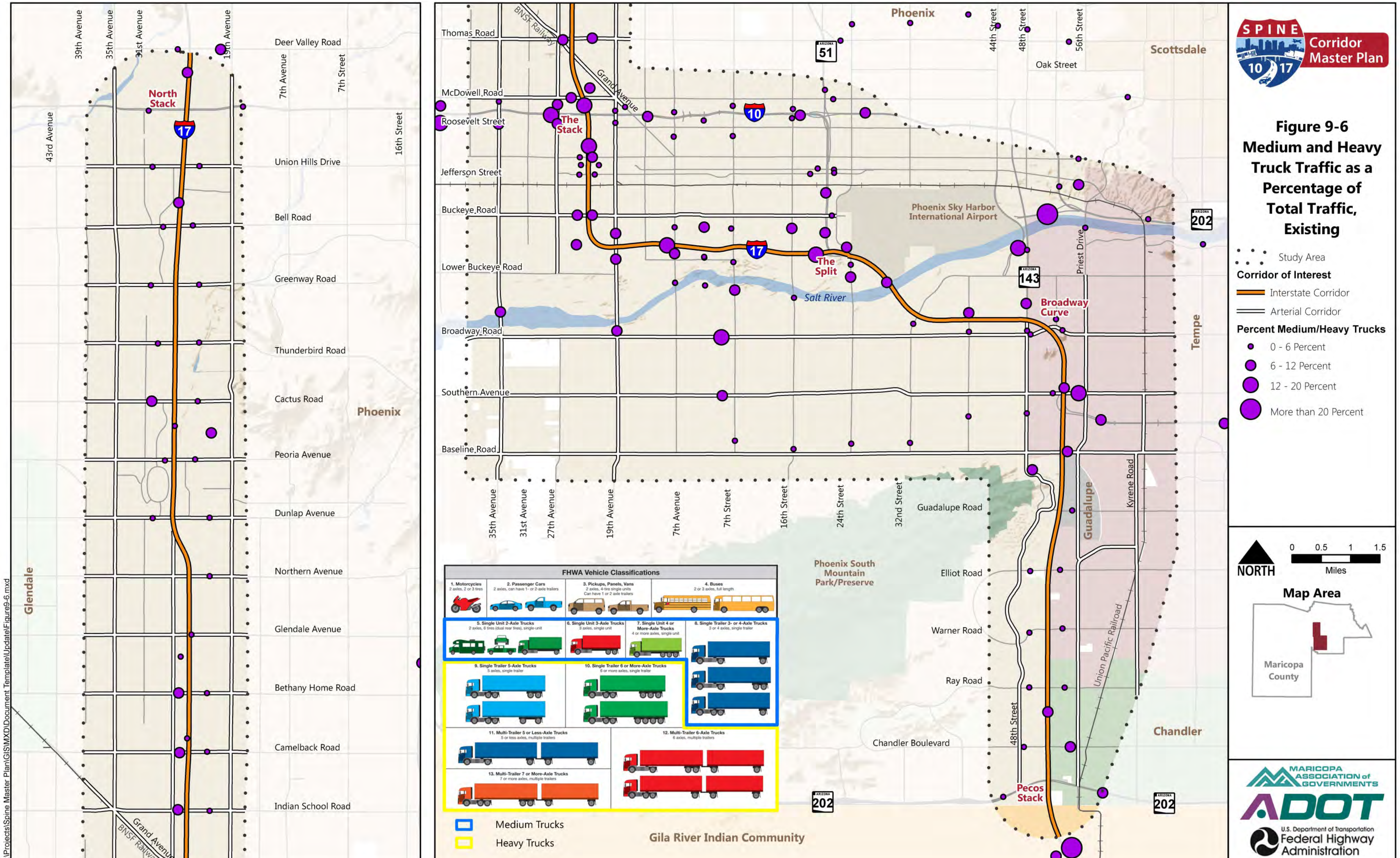


Figure 9-6 Medium and Heavy Truck Traffic as a Percentage of Total Traffic, Existing



Data Source: ADOT, ALRIS, FEMA

Map Last Updated: 5/13/2016

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10 Agency and Public Feedback

10.1 Introduction

The public involvement program for the Spine Study began with the inception of the study when the Public Involvement Plan (PIP) was drafted. Since it was completed, the PIP has served as a guiding document by identifying a comprehensive plan for engagement and outreach throughout the study.

This chapter will outline the execution of the PIP including the materials, techniques and results to date. For more detailed descriptions of the elements of the program, see the Draft Agency and Public Involvement Summary Report in Appendix J.

10.2 Agency and Public Involvement Program Components

10.2.1 Study Website, E-Blasts, E-Newsletters and Social Media

The study team used MAG's study website to create a project webpage to share information with the public. The website, located at spine.azmag.gov, initially introduced and provided general study information, such as study history and purpose. Closer to the public meeting dates, information related to the public meetings was added including links to collateral materials, comment submission information, public meeting locations and times and a link to related media stories. Outreach activities increased in mid-February 2015, when invitations to the public meetings were sent to the study's stakeholder database of over 11,000 recipients. Project partners also forwarded the invitation to a database of more than 32,700 subscribers. The MAG newsletter "MAGazine" featured the study on the cover of its February–April 2015 issue (Vol. 20, No. 1), which was printed for in-person distribution and posted to the study website. To augment the website and emails, 27 social media messages were posted containing information regarding the meetings and the availability of the MetroQuest online survey (Table 10-1).

Table 10-1 Social Media Posts, February 2015

Date	Website	Number of shares/retweets	Message
February 13, 14, 16	Twitter and Facebook	12	The I-10/I-17 Spine study is out for public input. Share your idea/thoughts by taking this survey, http://bit.ly/SpineMQ.
February 17	Twitter and Facebook	0	Do you live/travel along the I-10 or I-17? We want to hear from you! Take this survey, http://bit.ly/SpineMQ & help improve your commute.
February 18	Facebook	0	The Valley's Spine (I-10/I-17 corridor) is being studied to improve traffic flow. Public input is NEEDED, http://bit.ly/SpineMQ.
February 18	Facebook	2	Mark Your Calendar! I-10 and I-17 Spine Corridor Master Plan Public Meetings – (inserted display ad graphic)
February 18	Facebook	0	The I-10/I-17 Spine study is out for public input. Share your idea/thoughts by taking this survey, http://bit.ly/SpineMQ.
February 19	Facebook	0	Mark Your Calendar for Feb. 25th, 26th or Mar. 4th, I-10/I-17 Spine Corridor Master Plan Public Meetings - http://ow.ly/i/8H9ft! (inserted display ad graphic)
February 19	Facebook	2	Over 40% of ALL daily freeway traffic uses the Spine (I-10/I-17) Corridors! Take this survey, http://bit.ly/SpineMQ & help your commute.
February 23	Facebook	5	The Spine Study is out for public input, please take this survey & share your thoughts/ideas for the future, http://bit.ly/SpineMQ.
February 24	Facebook	1	40% of daily traffic drives along the I-10/I-17 "Spine" Corridor! We need your input, attend a public meeting.
February 24	Facebook	0	Spine Study public meetings are scheduled for 2/25, 2/26 & 3/4. Can't attend? Then take part in an online survey, http://bit.ly/SpineMQ.
February 24	Facebook	0	Spine Study (I-10/I-17 corridor) is looking at freeway, street, transit & more. Help shape the future of transp., http://bit.ly/SpineMQ.
February 25	Twitter	0	Do you live/travel along the I-10 or I-17? We want to hear from you! Take this survey, http://bit.ly/SpineMQ & help improve your commute.
February 25	Facebook	0	Come to the Spine study public meeting 6pm today at Academia del Pueblo Elementary School (201 E. Durango St., Phx)!
February 25	Facebook	0	Why is the Spine Study important to you? Check out this @arizonapbs Horizon episode to learn more, http://bit.ly/1DaMwlp (start at 12min.). (inserted PBS Channel 8 Horizon video clip link)
February 25	Facebook	0	Spine public meeting at 6pm at Academia del Pueblo Elementary School (201 E. Durango St., Phx), or participate online http://bit.ly/SpineMQ
February 13, 14, 16	Twitter and Facebook	12	The I-10/I-17 Spine study is out for public input. Share your idea/thoughts by taking this survey, http://bit.ly/SpineMQ .
	Total	**34**	

Notes: I-10 = Interstate 10, I-17 = Interstate 17

10.2.2 Media Relations and Newspaper Display Notices

A press release announcing the public meetings and MetroQuest was distributed on February 12 and 25 to the MAG media contact list as well as the study's stakeholder email database. As a result of the media notification, the local PBS affiliate, KAET Channel 8, recorded and aired a segment featuring the study. Additionally, prior to the first meeting on February 25, Spine Study Project Manager Bob Hazlett was interviewed by KTAR-FM regarding public input opportunities. During the first public meeting on February 25, the local CBS affiliate KPHO Channel 5 interviewed study team members. In addition to earned media, the study team notified stakeholders of the public meetings and opportunities to comment by placing five quarter-page display advertisements in five key publications with local distribution (Table 10-2).

Table 10-2 Public Meeting Newspaper Display Notices, February 2015

Publication	Publication Date
Ahwatukee Foothills News	Wednesday, February 11, 2015
Arizona Informant	Wednesday, February 11, 2015
Arizona Republic	Wednesday, February 11, 2015
East Valley Tribune	Thursday, February 12, 2015
Prensa Hispana	Thursday, February 12, 2015

10.2.3 MetroQuest Online Survey

Each method of notification emphasized the availability of the MetroQuest Online Survey that had been created to facilitate public comment during the public outreach phase between February 9 and March 18, 2015. The survey, featuring five interactive screens, provided an opportunity to learn about and engage with the study for stakeholders who were unable to attend meetings, as well as functioning as a complementary tool for those who were able to attend meetings. The five screens that made up the online survey were:

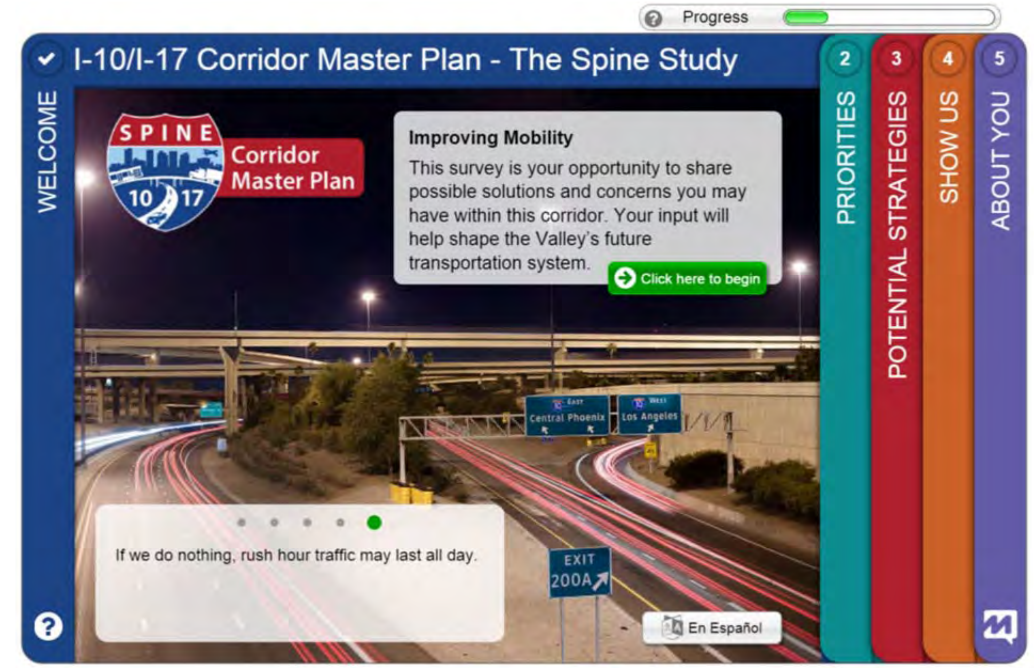
- Welcome – An introduction to the study purpose and goal of the survey (Figure 10-1).
- Priorities – A ranking screen on which respondents selected their top four priorities. As each category was clicked, a brief description with a photo was displayed, along with “Comment” and “Suggest Another Priority” buttons to encourage additional input.
- Potential Strategies – A rating screen that instructed respondents to rate five potential improvement strategies and provide additional comments on each. This screen also featured a real-time display that showed how respondents’ priorities performed under each strategy.
- Show Us – A map screen with interactive “pins” used to locate and describe issues within the corridor at the location at which they are experienced. General comments were also collected on this screen.
- Stay Involved – A form screen with optional fill-in-the-blanks and drop-down boxes for respondents’ demographic information and a space for an email address to be included in future project-related mailings.

Online survey stations were available at each of the public meetings. MAG also attended community events with hard copies of the survey as well as tablet computers allowing access to the electronic verson. Additionally, the MetroQuest Online Survey was available in English and Spanish.

10.2.4 Agency Scoping Letters

Concurrent to preparations for the public meetings, agency scoping invitation letters were sent to 178 agency representatives in advance of the planned Agency Information Meeting held on February 23, 2015. The letters contained the purpose and need for the study, study area boundaries, an invitation to the meeting, and a request for comments. Copies of the scoping letter and enclosures and a list of recipients are provided as appendixes to the Draft Agency and Public Involvement Summary Report (Appendix J).

Figure 10-1 MetroQuest Online Survey Welcome Screen



10.3 Meetings

10.3.1 Agency Information Meeting

During the Agency Information Meeting, stakeholders from local, regional and State agencies identified specific concerns, suggestions and recommendations, with a focus on future development, general plans and/or capital improvement projects that could be affected. Meeting attendees examined a series of 28 banners, viewed a presentation, participated in a question-and-answer session and completed comment forms. Forty stakeholders from 18 agencies attended. A copy of the Agency Information Meeting Summary, including a Summary of Comments Table, is included as an appendix to the Draft Agency and Public Involvement Summary Report (Appendix J).

10.3.2 Public Information Meetings

Three public information meetings were held throughout the study area during February and March 2015 (Table 10-3). Each meeting was held in an open house format. The meetings were held in three distinct communities in the Spine study area to promote easy access for the public and to increase the potential for diverse participation. The three public information meetings were set up in similar layouts, including the following five interactive areas:

- meeting sign-in
- display banners
- aerial map
- MetroQuest online survey (Figure 10-2)
- comment tables

Figure 10-2 Online Survey Station at March 4, 2015, Public Meeting

Source: Jacobs, 2015

In addition to the five areas outlined above, two project partners (ADOT Near-term Improvements and City of Phoenix Transit Department) attended the meetings to share information about their projects.

Table 10-3 Public Information Meetings

Date	Location	Attendance
Wednesday, February 25, 2015	Academia Del Pueblo Elementary School Gymnasium, 201 E. Durango St., Phoenix	9
Thursday, February 26, 2015	Deer Valley Community Center Multipurpose Room, 2001 W. Wahalla Ln., Phoenix	23
Wednesday , March 4, 2015	Four Points by Sheraton Grand Ballroom, 10831 S. 51st. St., Phoenix	36
	Total	**68**

10.4 Comments

Numerous comments were gathered through the public outreach methods previously described. The following sections summarize agency and general public comments received.

10.4.1 Agency Comments

Agency representatives in attendance at the Agency Information Meeting were offered an opportunity to complete a five-question survey regarding their agencies' interests and concerns about the study. Three completed surveys, three letters and four emails containing comments were collected. For more details, see the meeting summary included as an appendix to the Draft Agency and Public Involvement Summary Report (Appendix J). Table 10-4 captures comments submitted in writing.

Table 10-4 Agency Survey Comment Summary

Agency	Relation to study	Owned facilities in study area	Future plans	Specific issue/concern	Suggested alternatives
Arizona Department of Administration	Responsible for Capitol master planning	Yes. It has 50+ State-owned facilities within the study area.	In process of updating Capitol Complex Master Plan	I-10 West Light Rail Extension might have large impact.	Additional alternative modes: regional transportation options, commuter rail, light rail extensions, street cars, etc.
City of Phoenix Street Transportation Department	Much of the study area is within the City; partner agency that is affected positively and negatively	Yes. It owns adjacent signalized arterials.	All future plans related to arterial operations are being coordinated through MAG and ADOT.	Many of the signalized arterials have older signalized technology with limited capabilities that are inherent to active traffic management strategies.	None
City of Phoenix (department unknown)	Potential projects that can be accelerated for implementation; how City can help identify those projects	Yes. It owns streets (arterials, collectors, locals), transit operations, traffic signals and drainage facilities.	Phoenix Comprehensive Transportation Downtown Study, Pecos Basin Drainage Facilities, Future Northwest LRT Extension to Metrocenter	Adjacent neighborhoods and flood control	Integrated corridor management/ ITS; consolidated drainage facilities

Notes: ADOT = Arizona Department of Transportation, I-10 = Interstate 10, LRT = light rail transit, MAG = Maricopa Association of Governments

Additionally, agencies were invited to submit comments by standard mail. These comments are summarized in Table 10-5.

Table 10-5 Agency Standard Mail Comment Summary

Date	Agency	Summary of comments
February 9, 2015	Gila River Indian Community	Request to keep agency updated and submit cultural resources documents for review. The proposed project area is within ancestral lands.
March 2, 2015	U.S. Department of the Interior	National Historic Lands—Pueblo Grande Ruin and Irrigation Sites National Historic Landmark—are within the study area. Please minimize any potential impacts to the sites per Section 106 of the NHPA. Land and Water Conservation Fund and Urban Park and Recreation Recovery—Nuestro Park, Acacia Park, South Mountain Park/Preserve, Encanto Park and Verde Park—are assisted properties to which specific regulations apply. Contact information was provided for appropriate staff within the agency for each of the three departments represented in the letter.
March 13, 2015	City of Phoenix Aviation Department	The Aviation Department has several planned projects in the study area. The airport roadways and nearby State Route 143/Interstate 10 traffic interchange are congested. Airport officials are concerned that as traffic increases, cut-through traffic will further congest the airport. Several regulations, statues and circulars cited may be relevant to the study. Sky Train Stage 2 map was provided.

Email was the third method by which agency representatives shared comments and documentation relevant to the study. Table 10-6 summarizes the email comments received.

Table 10-6 Agency Email Comment Summary

Date	Agency	Summary of comments
February 6, 2015	Natural Resources Conservation Service (NRCS)	Request for more information. NRCS may have comments under the Farmland Protection Policy Act. Attached form CPA-106 can be used to inform NRCS about corridor alternatives. Agency cannot comment until alternatives are known. Included NRCS Web Soil Survey brochure.
February 24, 2015	Federal Aviation Administration	Ensure Advisory Circulars are referenced and used when near airport environment. Links to circulars, publications and a proposal portal provided. Airport Layout Plan attached to email. Respondent suggested coordination with City of Phoenix on updates to the Airport Layout Plan.
February 27, 2015	City of Tempe	Request for study area map so Tempe Community Development staff can comment.
March 18, 2015	City of Phoenix Historic Preservation Department	Noted that most information/survey activity of historic properties has been concentrated along I-10 through central Phoenix. Recently, ADOT commissioned a study of potentially eligible historic properties along I-17 from the I-10/I-17 Split, around the Durango Curve, north to State Route 101L. Moving forward, staff directed that a thorough historical resource survey be completed within the area of potential effects.

Notes: ADOT = Arizona Department of Transportation, I-10 = Interstate 10, I-17 = Interstate 17

10.4.2 Public Comments

Approximately 1,742 comments were obtained from members of the public from six comment sources: online survey, standard mail, email, telephone hotline messages and social media messages. Table 10–7 summarizes how many comments each method yielded.

Table 10-7 Comments, by Response Method

Source	Surveys/Comments
MetroQuest Online Survey	1,695
Printed forms	31
Email	10
Telephone hotline	3
Social media	3
Total	**1,742**

Key information obtained from the public included:

- Demographic information: home ZIP Code, frequency of Spine corridor of interest travel, mode of Spine corridor of interest travel, build/no-build preference and interest in the corridor (resident, business owner, etc.)
- Community priority preferences: add travel choices, emphasize jobs, increase connections, improve commerce, improve commute, minimize cost, promote neighborhoods and protect the environment
- Potential strategy preferences: freeway lanes, street lanes, special lanes, travel modes and access
- Map comments and written comments

The following list summarizes key demographic findings:

- Overall, 99 percent of users opted to take the English version of the survey.
- Ninety-seven percent of comments were obtained through the online survey.
- Ninety-three percent of commenters preferred building to meet future needs as opposed to planning no future improvements in the corridor.
- Eighty-three percent of respondents use their personal vehicle to travel in the corridor.

The following list summarizes key study preferences:

- Respondents ranked Improve Commute as the number-one priority, followed by Add Travel Choices (number two) and Protect the Environment (number three). Respondents were given the opportunity to suggest alternative priorities. The most commonly suggested priorities were, in order: safety, traffic congestion and transit.

- Commenters rated Travel Modes as the number-one preferred potential improvement strategy followed by Access (number two) and Freeways Lanes (number three). Three of the five provided strategies drew the majority of participant comments: Special Lanes, Freeway Lanes and Travel Modes.

Because most comments were received through the online survey, the following sections focus on how people responded to the survey.

Online Survey Participants' Demographic Information

Respondents were asked a series of questions to help the study team learn when, why and how they used the corridor. In addition, they were asked to provide a home ZIP Code. Figure 10-3 shows the ZIP Code areas in which residents reside. It is noteworthy that most of the participants do not live within the study area. Figure 10-4 shows the participants' interest in the corridor.

Figure 10-3 Online Survey Participants, by ZIP Code Area

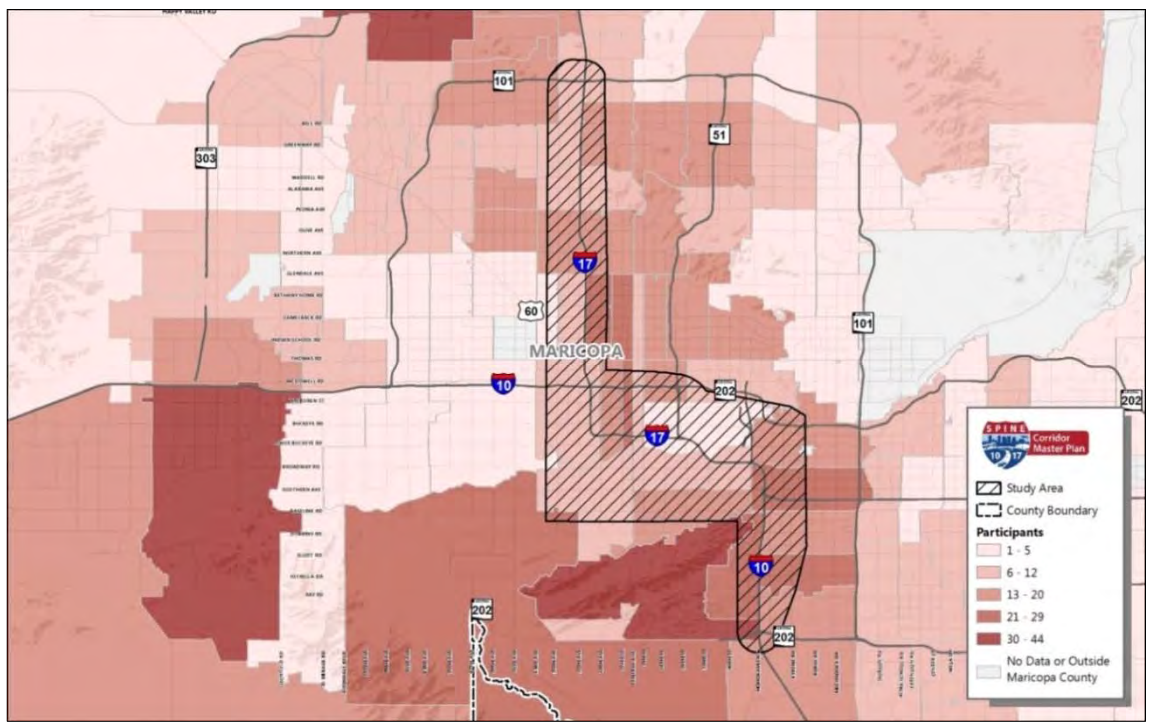
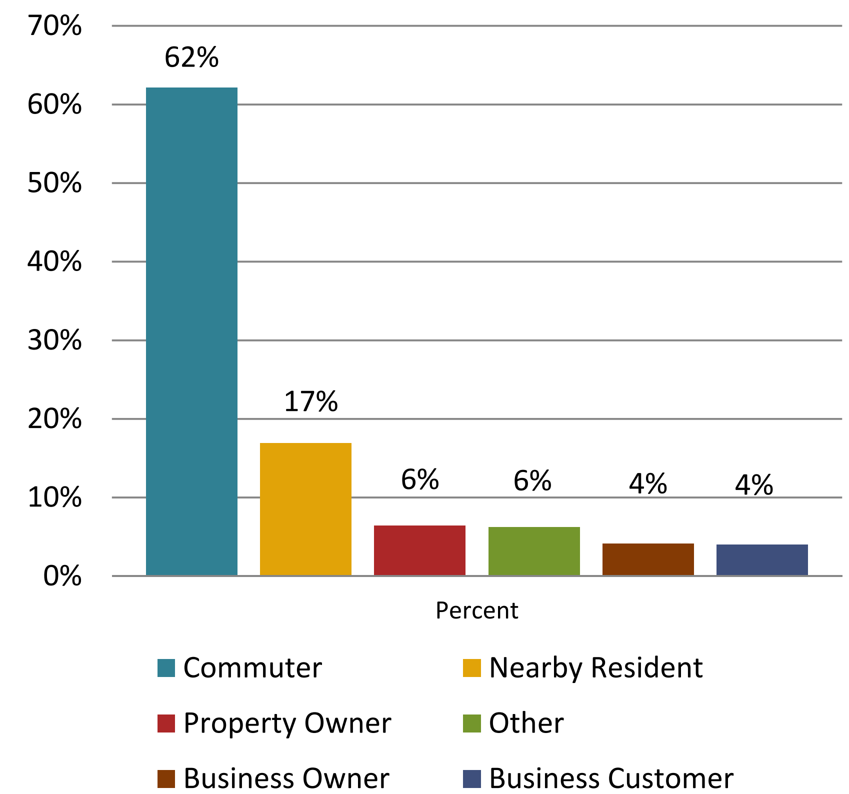


Figure 10-4 Online Survey Participants' Interest in Corridor



How often participants used the corridor is represented in Figure 10-5, and the use by ZIP Code is presented in Figure 10-6.

Figure 10-5 Online Survey Response to "How often do you use the Spine corridor?"

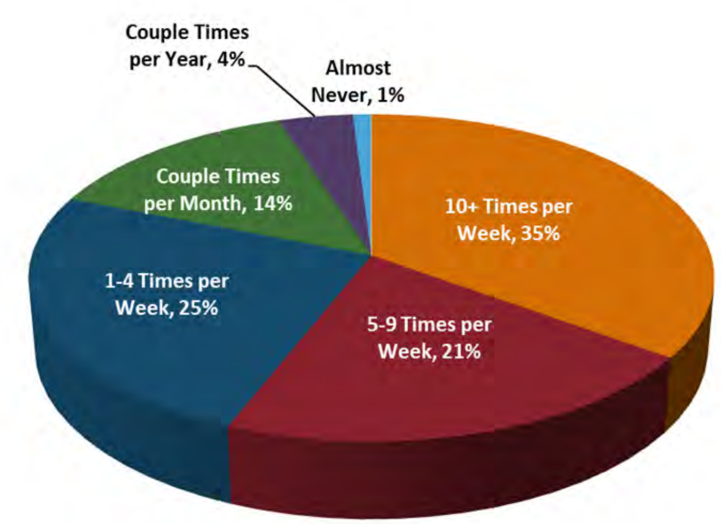
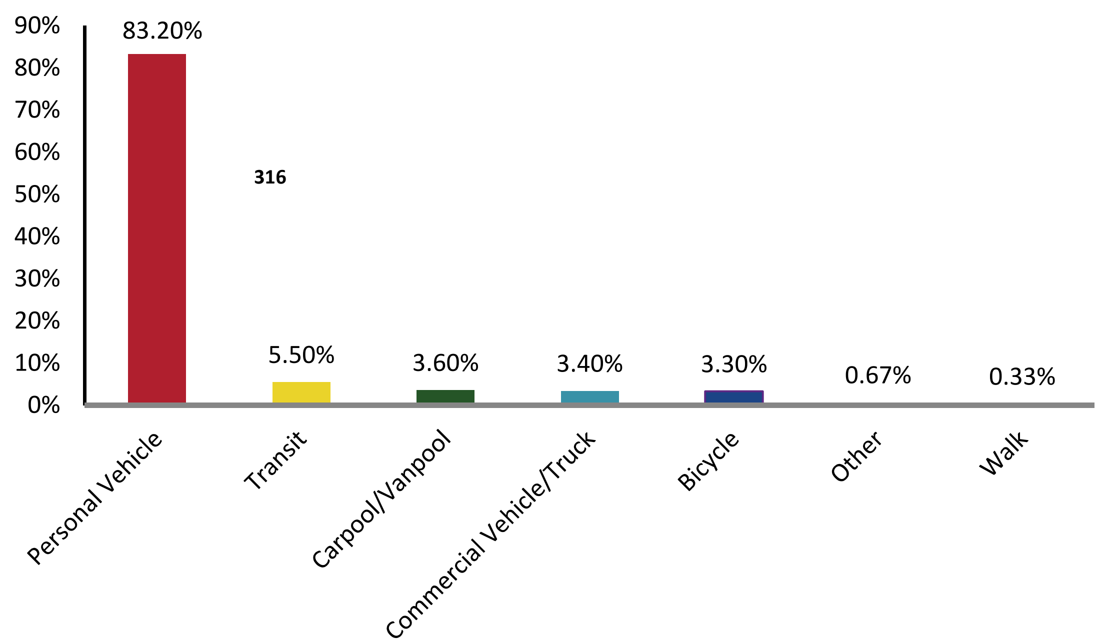
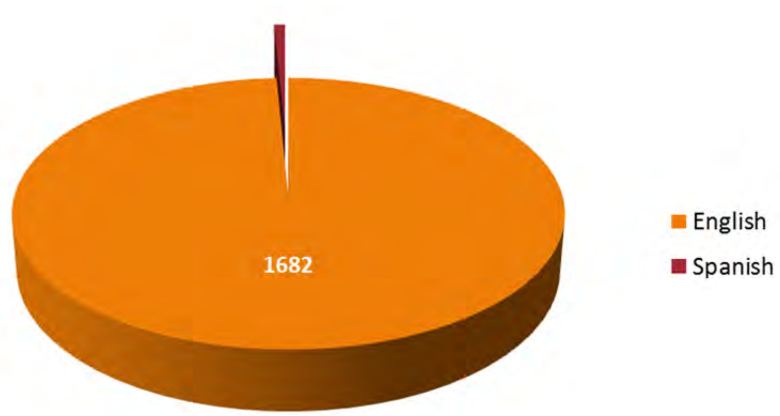


Figure 10-6 Online Survey Participants' Mode of Corridor Use



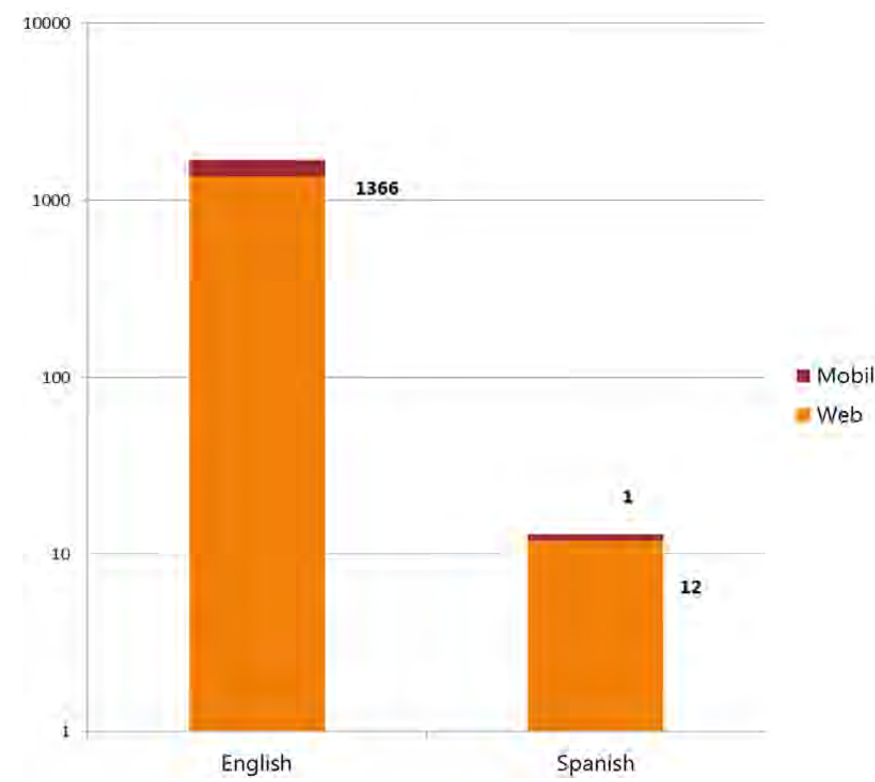
The number of English surveys submitted outnumbered the Spanish surveys by a large majority, as seen in Figure 10-7. This statistic does not necessarily represent how many users speak either language; it shows in which language they preferred to take the survey.

Figure 10-7 Online Survey English versus Spanish Responses



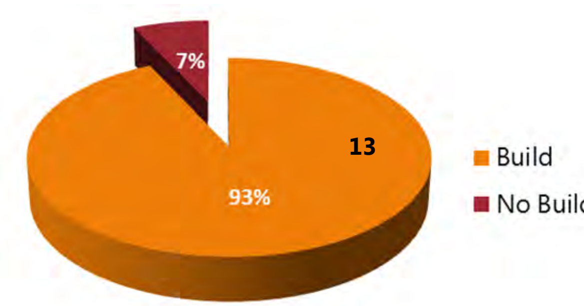
Respondents surveys were also tallied according to which electronic means they used to access the survey: via a mobile device or computer (Figure 10-8).

Figure 10-8 Online Survey Response Platform, by Device and Language



Respondents indicated they support building to meet future needs as opposed to the no-build alternative, as shown in Figure 10-9.

Figure 10-9 Online Survey Responses for Build versus No-Build



Strategy and Priority Comments

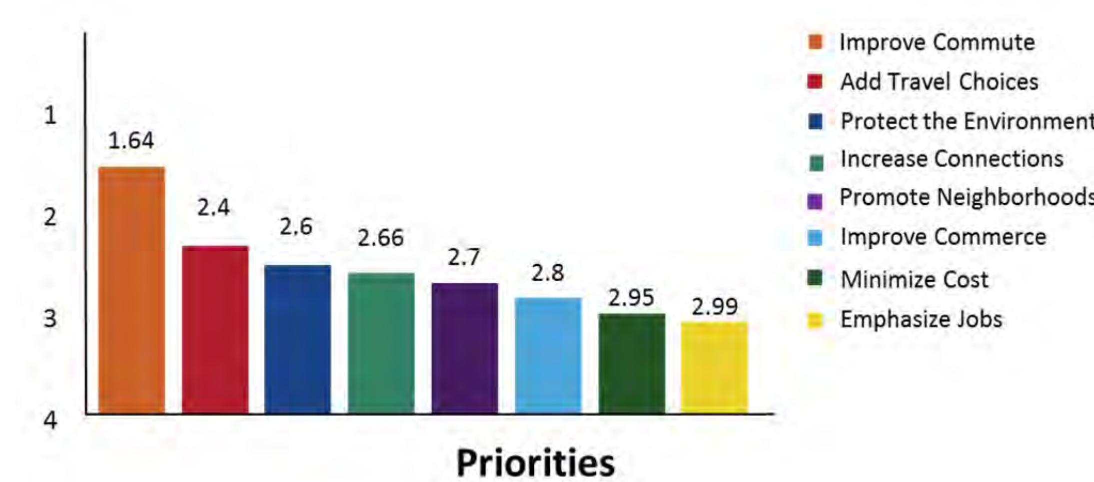
The first task of the MetroQuest survey asked participants to rank eight priorities against one another to determine the community's number-one priority. Descriptions for each priority are shown in Table 10-8.

Table 10-8 Online Survey Priorities and Text Descriptions

Priority	Text description
Improve Commute	I care about improving my commute, including making it faster, having consistent and reliable travel times, increasing access to real-time traffic conditions, improving safety, and/or making my commute cheaper.
Add Travel Choices	I care about enhancing transit, vanpools, bicycle, and pedestrian facilities, and encourage their use through more accessible and convenient locations and frequencies. This could include improved connectivity between types of transportation and/or access to real-time transit wait times.
Protect the Environment	I care about avoiding or minimizing impacts to the environment, and enhancing it whenever possible.
Increase Connections	I care about improving or adding connections onto and across the freeway to make my trips to work, home, and play easier and more convenient. This could include advanced communications between intersection traffic signals and on-ramp meters to minimize interchange congestion.
Promote Neighborhoods	I care about minimizing impacts to neighborhoods and schools, and improved quality of life. This includes promoting walkable communities, safe routes to schools, parks, open space, and noise reduction.
Improve Commerce	I care about how the transportation system affects business, including improving travel time reliability, accessing real-time travel information, minimizing traffic congestion, providing easier access and accommodating trucks.
Minimize Cost	I care about reducing spending of public funds for the construction, maintenance, and operation of the transportation system. This could include optimizing the existing transportation system through the use of technology so new construction costs may be minimized.
Emphasize Jobs	I care about creating and preserving jobs in the corridor, as well as improving access to those jobs, to encourage a vibrant and prosperous regional economy.

As each priority was clicked, a photograph depicting the priority and its text description was shown along with two buttons for further comment. One comment button was for a general comment. The other was marked "Suggest Another Priority." Both comment buttons were optional. Figure 10-10 shows how many times each priority was ranked as one of a user's top four priorities.

Figure 10-10 Online Survey Community Priorities Ranking



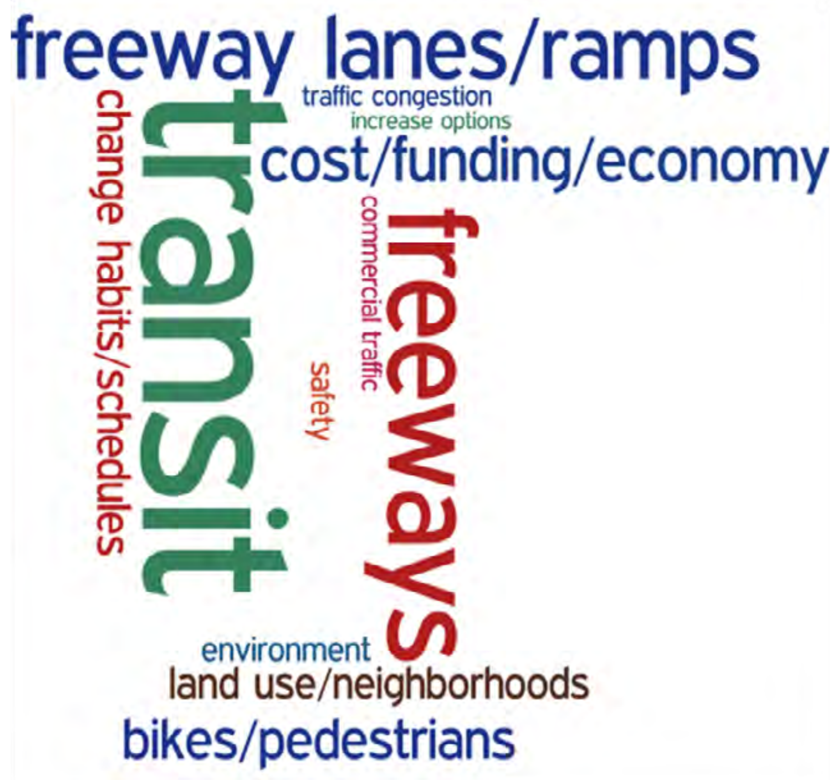
The 250 comments received through the Strategy Screen were coded primarily across 21 categories and secondarily across 125 subcategories that more specifically capture each comment's content. Figure 10-11 is a word cloud demonstrating a great interest in transit, freeways and freeway lanes and ramps. Also available on the Priority Screen was a "Suggest Another Priority" button. Forty alternative priorities were suggested, but over half of the suggestions were in three categories: Safety, Traffic Congestion and Transit. A complete list of suggested priorities is included as part of Appendix J.

Typical "Transit" comments included requests for increased transit services and adding new modes of transit service, but it is important to note that the general codes are neutral—so comments against transit are included as well. A set of secondary codes were used to further "drill down" on each comment. The list of comment codes is included as part of Appendix J.

Typical "Freeway" code comments included suggestions to build more freeways and create bypass routes, as opposed to the "Freeway Lanes and Ramps" code comments that often suggested adding lanes and creating special lanes.

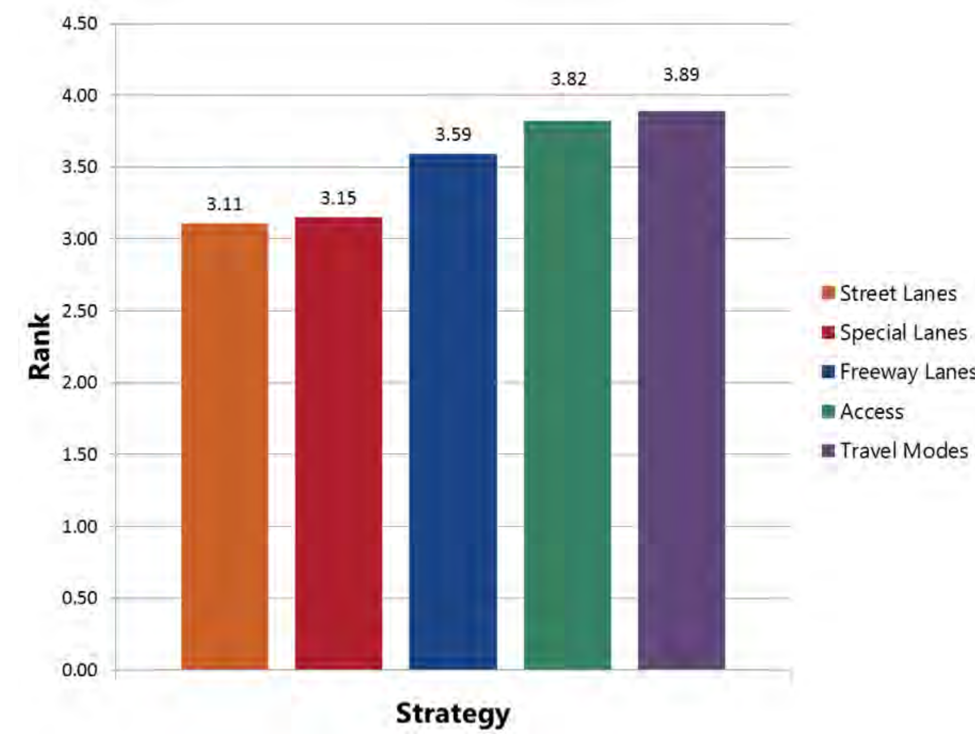
Specific comments from the Priority and Strategy screens are included as part of Appendix J.

Figure 10-11 Online Survey Priority Comments Word Cloud



The second task within the online survey prompted respondents to rank a set of five potential strategies according to their preference. As on the Priority Screen, an optional comment button was available on the Strategy Screen. Figure 10-12 shows Travel Modes received the highest ranking among the strategies, while Street Lanes received the lowest. Strategy Comment Codes are shown as part of Appendix J.

Figure 10-12 Online Survey Potential Improvement Strategy Ranking



Comments gathered from the Strategy Screen showed a high interest in freeway lanes, transit and freeways (Figure 10-13).

- Typical "transit" comments included suggestions regarding building new transit options and enhancing existing transit systems.
- Typical "freeway lanes" comments included those about special lanes (including toll and HOV), which generally supported HOV lanes but not toll lanes.
- Typical "freeways" comments focused on induced demand and improving interchanges.

Specific comments and a coding key are included as part of Appendix J.

Figure 10-13 Online Survey Strategy Comments Word Cloud

After the priority and strategy ranking exercises, respondents completed a mapping exercise on the Show Us screen using pins marked with six different topics:

1. Traffic Congestion
2. Safety
3. Public Transit
4. Cycling/Pedestrian
5. Access
6. Other

Respondents placed pins on specific points on a map of the corridor. As they placed each pin, a box containing an optional comment space appeared. Comments from each pin type were coded among the same topics used for the strategy and priority coding with added topic codes to accommodate the more detailed responses this portion of the survey yielded. For a complete list of topics used for coding map comments, see Appendix J.

Heat maps depicting the number of pins of each type have been included below in Figures 10-14 to 10-18.

Figure 10-14 Online Survey Traffic Congestion Pin Heat Map

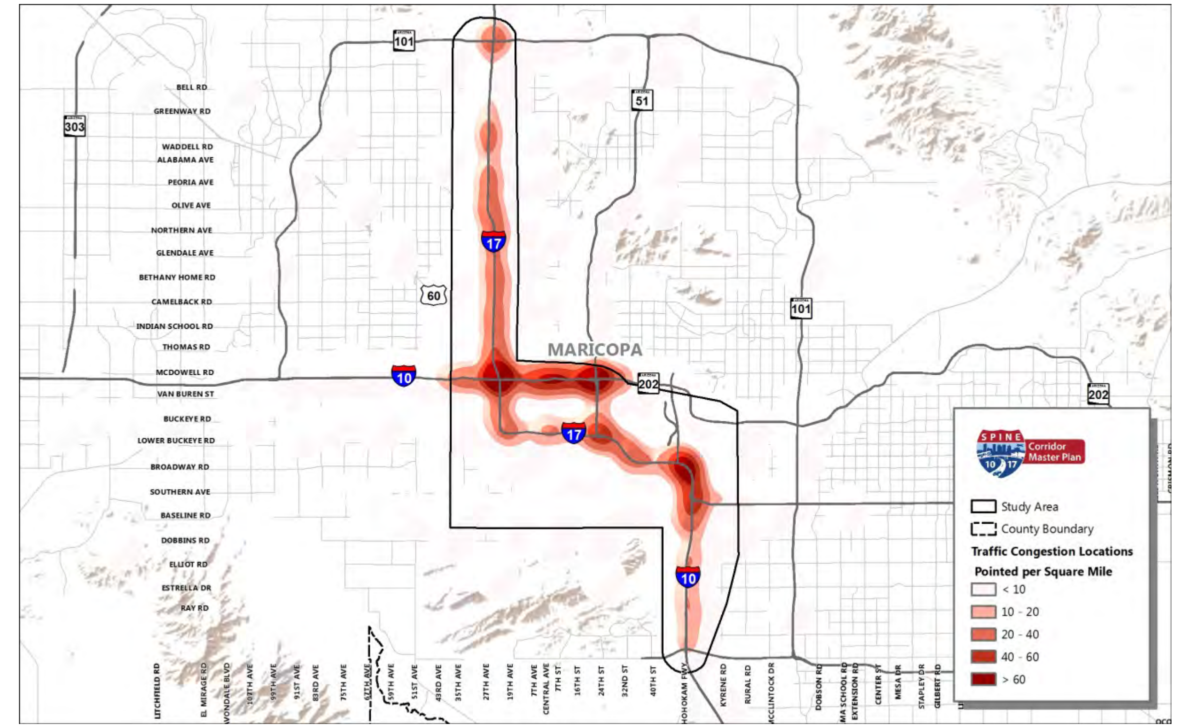


Figure 10-15 Online Survey Safety Pin Heat Map

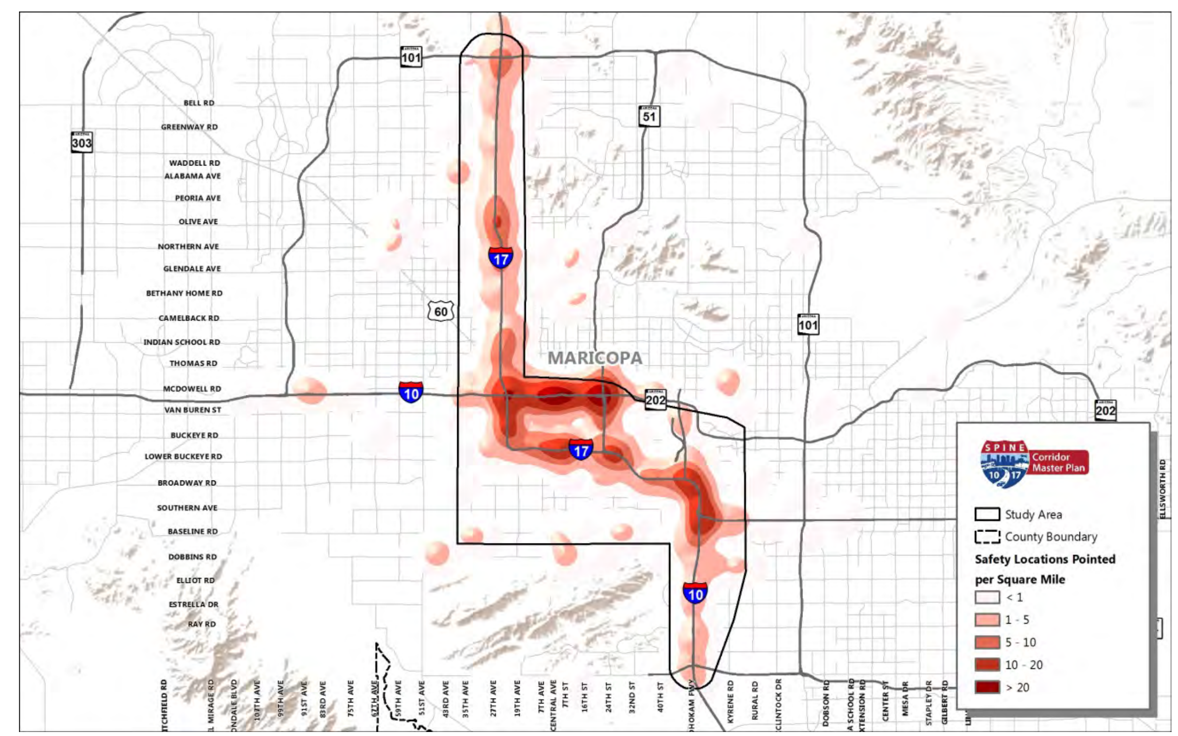


Figure 10-16 Online Survey Public Transit Pin Heat Map

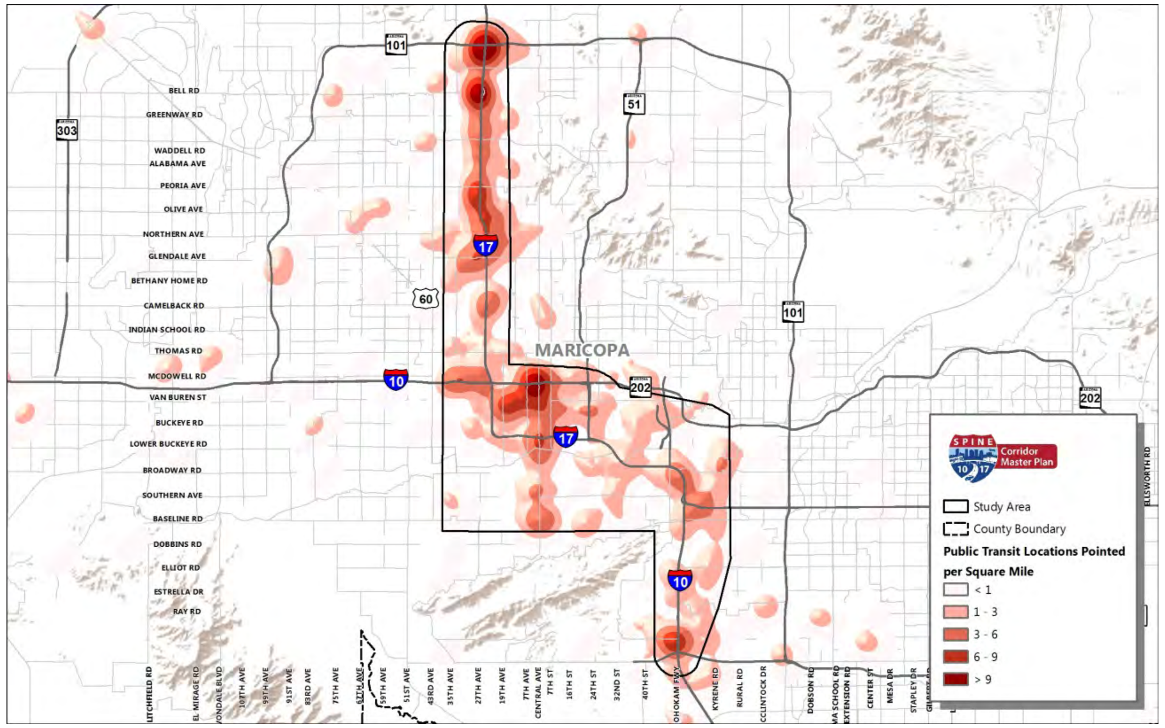


Figure 10-17 Online Survey Cycling/Pedestrian Pin Heat Map

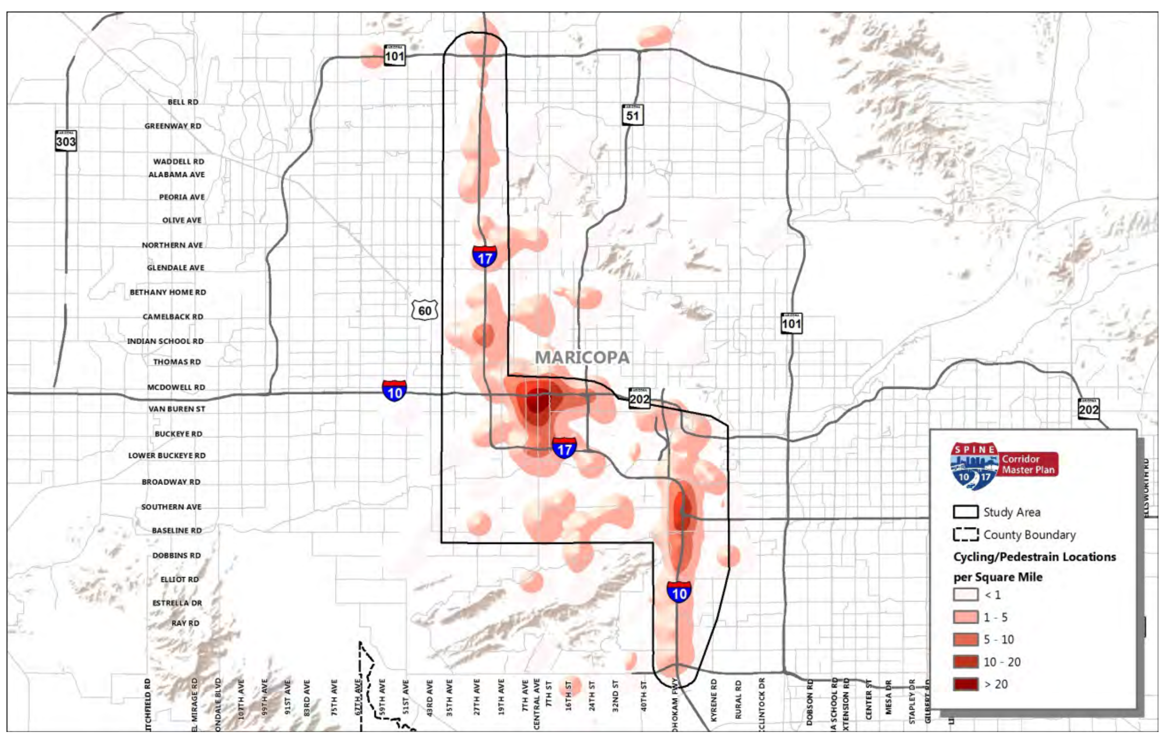
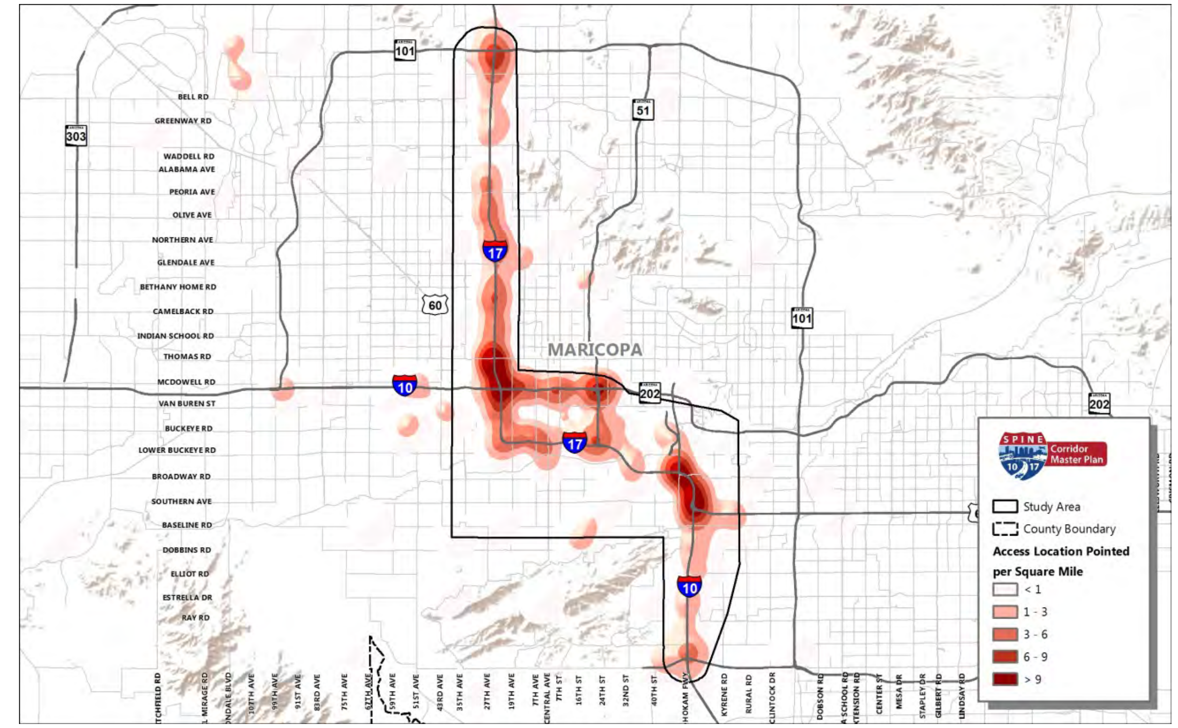
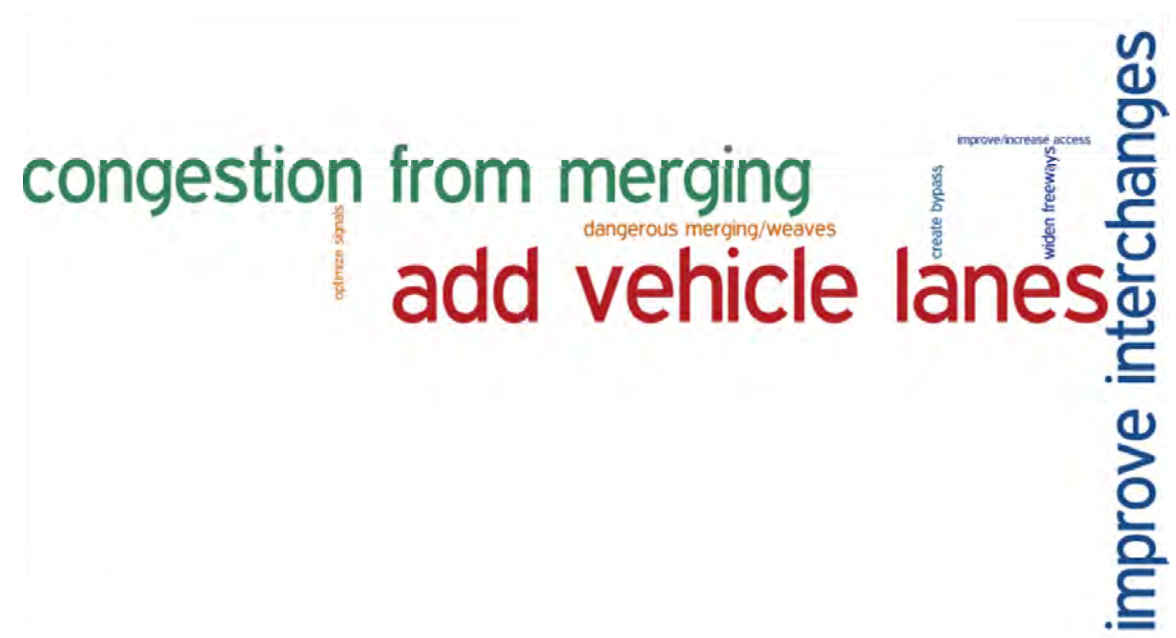


Figure 10-18 Online Survey Access Pin Heat Map



As shown in the word cloud in Figure 10-19, traffic congestion comments centered on adding vehicle lanes, congestion from merging and improving interchanges. The difference between the scale of the top three comment topics and the five other frequently mentioned topics is notable as well.

Figure 10-19 Online Survey Traffic Congestion Pin Comments Word Cloud



Respondents' sentiments regarding public transit also showed high concurrence, as the majority of transit drop pins comments fell into the "build more light rail" topic than any other (Figure 10-20). The next two highest topics were "increase bus service" and "add transit options."

Figure 10-20 Online Survey Public Transit Pin Comments Word Cloud

Cycling/Pedestrian pin comments commonly related to three topics (Figure 10-21):

1. Create bicycle/pedestrian crossings
2. Add bicycle lanes/bicycle facilities
3. Add pedestrian facilities

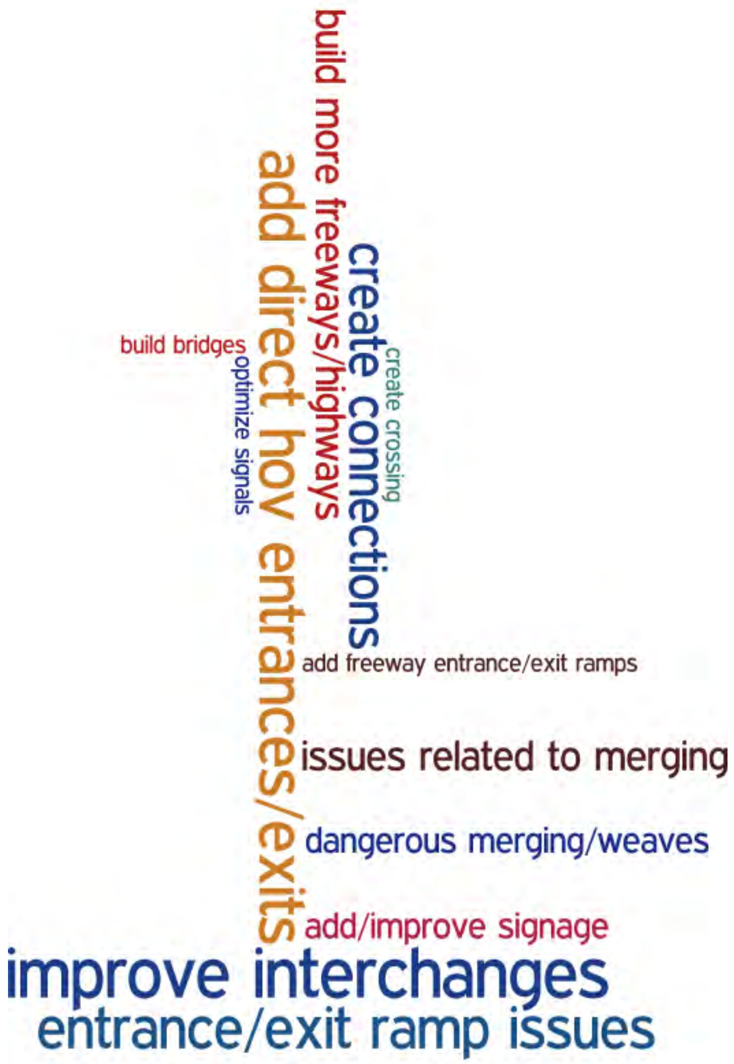
Respondents often stated they would like to ride a bike or walk to a destination but opted not to because they felt the infrastructure they needed to do so was not available.

Figure 10-21 Online Survey Cycling/Pedestrian Pin Comments Word Cloud

Responses from access pins were spread fairly evenly among a number of topics, as reflected by Figure 10-22. The top three topics in this group were:

1. Improve interchanges
2. Add direct HOV entrances/exits
3. Entrance/exit ramp issues

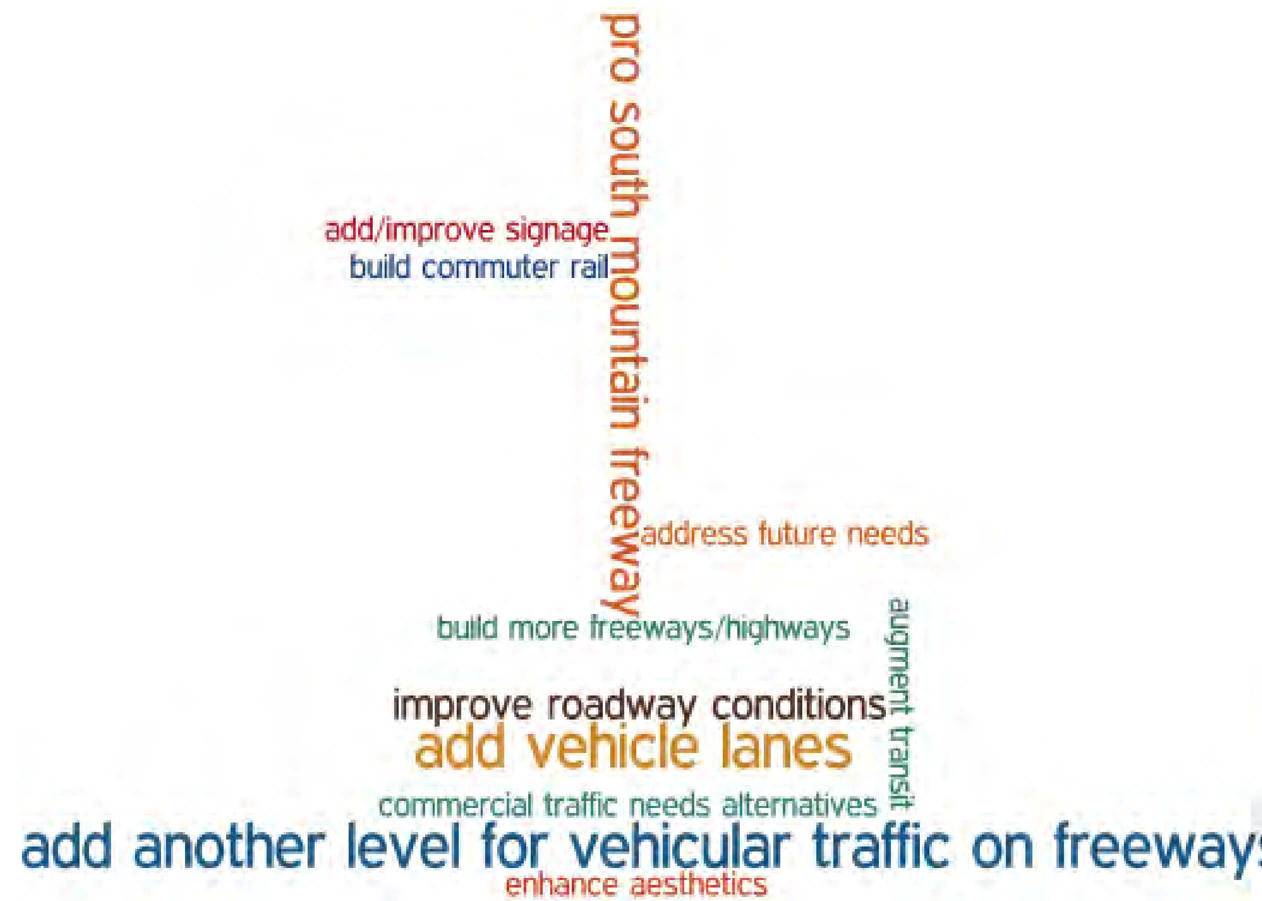
Figure 10-22 Online Survey Access Pin Comments Word Cloud



"Other" pin comments also had a relatively even distribution among frequent topics (Figure 10-23). The three most common topics were:

1. Add another level for vehicular traffic on freeways (or create a double-deck freeway)
2. Add vehicle lanes
3. Pro South Mountain Freeway

Figure 10-23 Online Survey "Other" Pin Comments Word Cloud



Comments input in conjunction with the "safety" pin type could not be organized to form word clouds. The resulting word cloud would been illegible because the difference between the highest value and the next highest value was so great that the difference between the font sizes was too great. In fact, more than 40 percent of all safety comments were attributed to the "dangerous merging/weaves" and "entrance/exit ramp issues" categories. The remaining 60 percent of comments were spread among numerous other topics with very little concurrence.

The following heat maps show the same pin concentrations as Figures 10-14 to 10-18 with the addition of boundaries around the highest concentrations. Pin comments were analyzed to determine the most frequent comment topics in each area for each pin type. Figures 10-24 to 10-28 show the outcome of that analysis.

Figure 10-24 Online Survey Traffic Congestion Pin Heat Map with Comment Areas

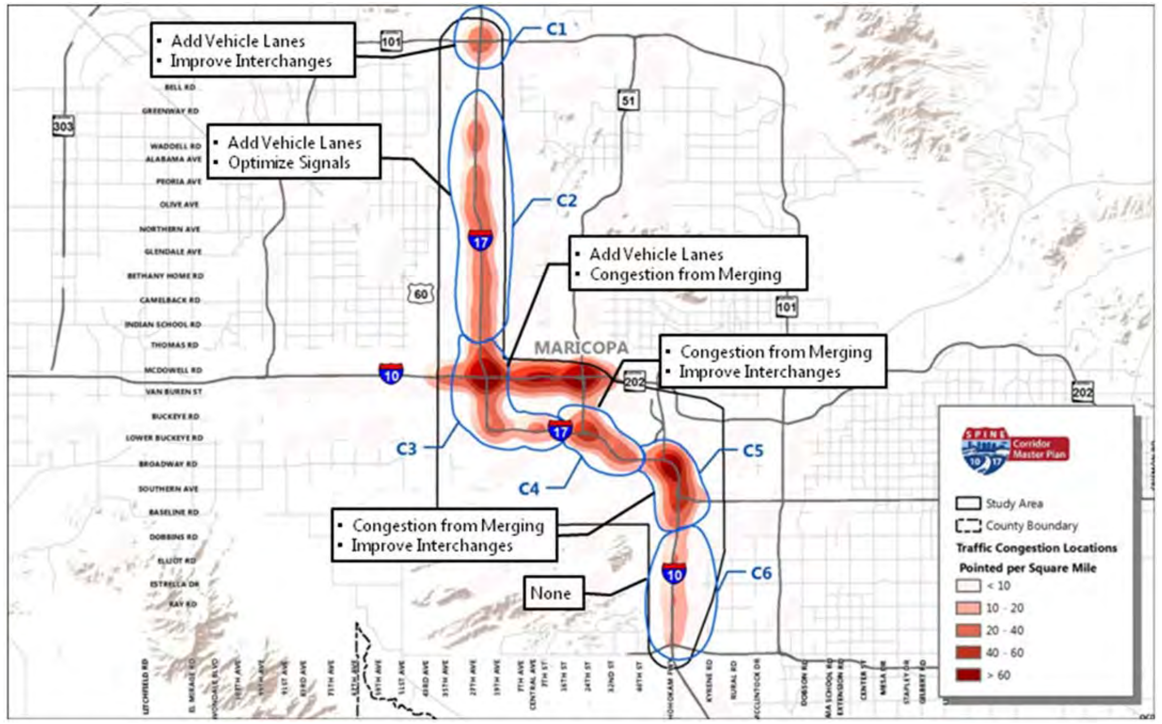


Figure 10-25 Online Survey Safety Pin Heat Map with Comment Areas

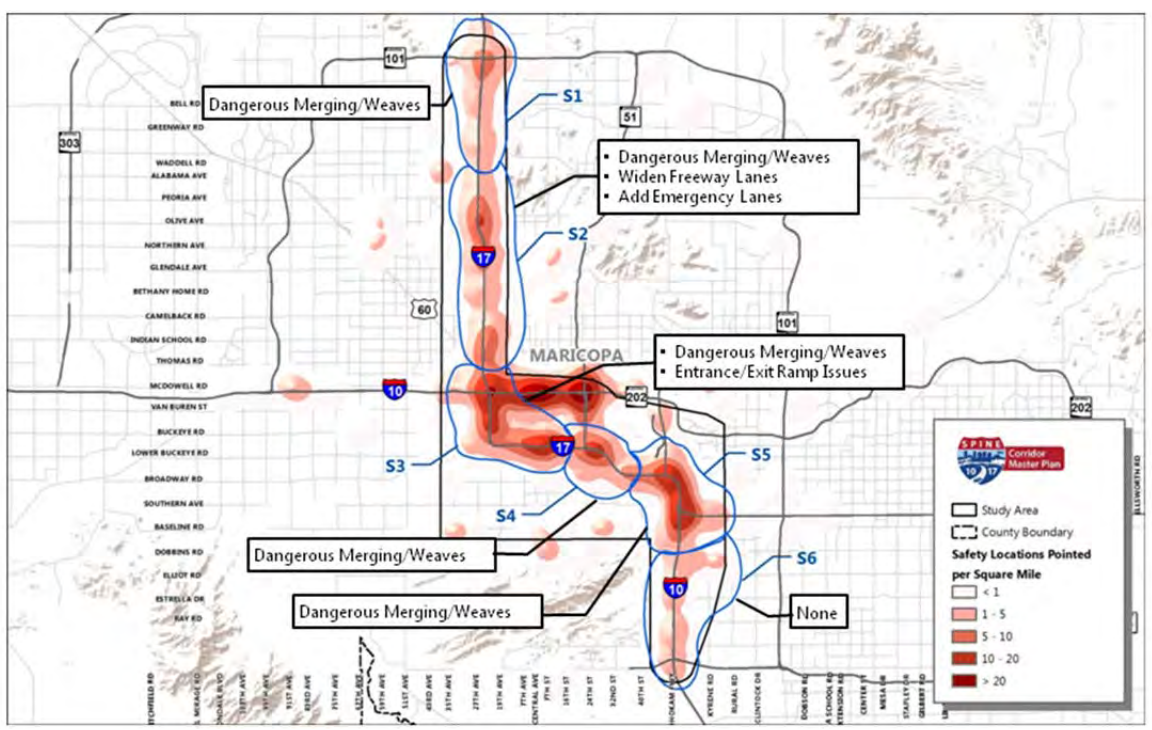


Figure 10-26 Online Survey Public Transit Pin Heat Map with Comment Areas

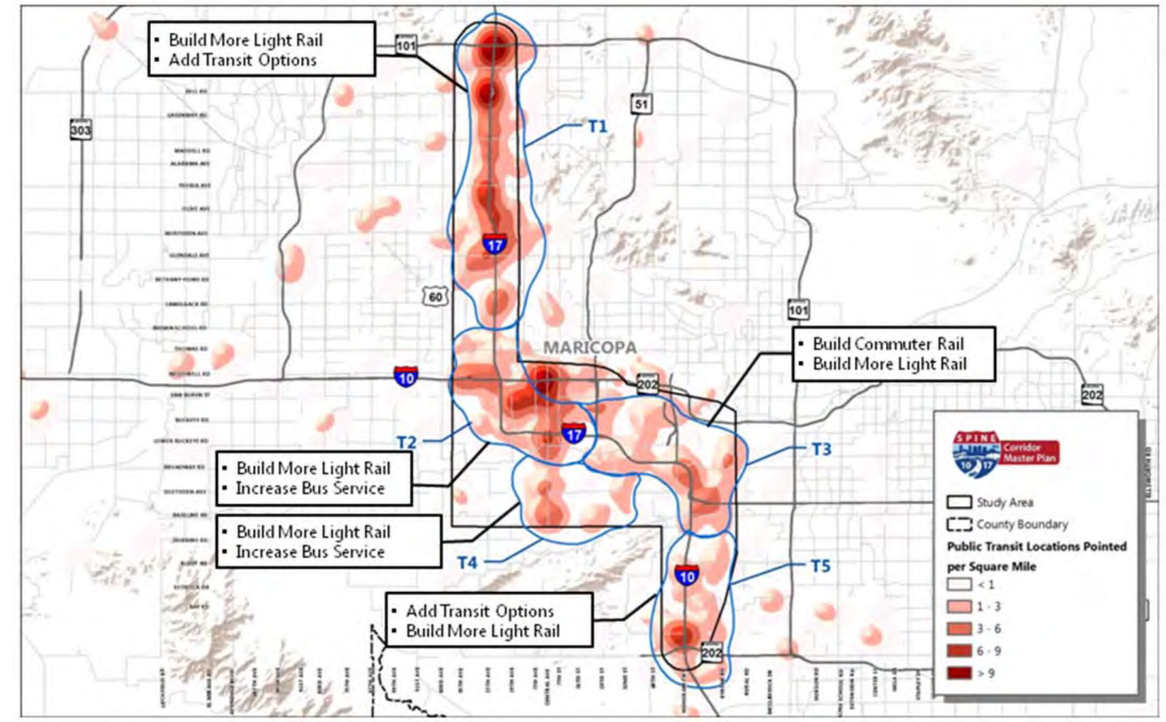


Figure 10-27 Online Survey Cycling/Pedestrian Pin Heat Map with Comment Areas

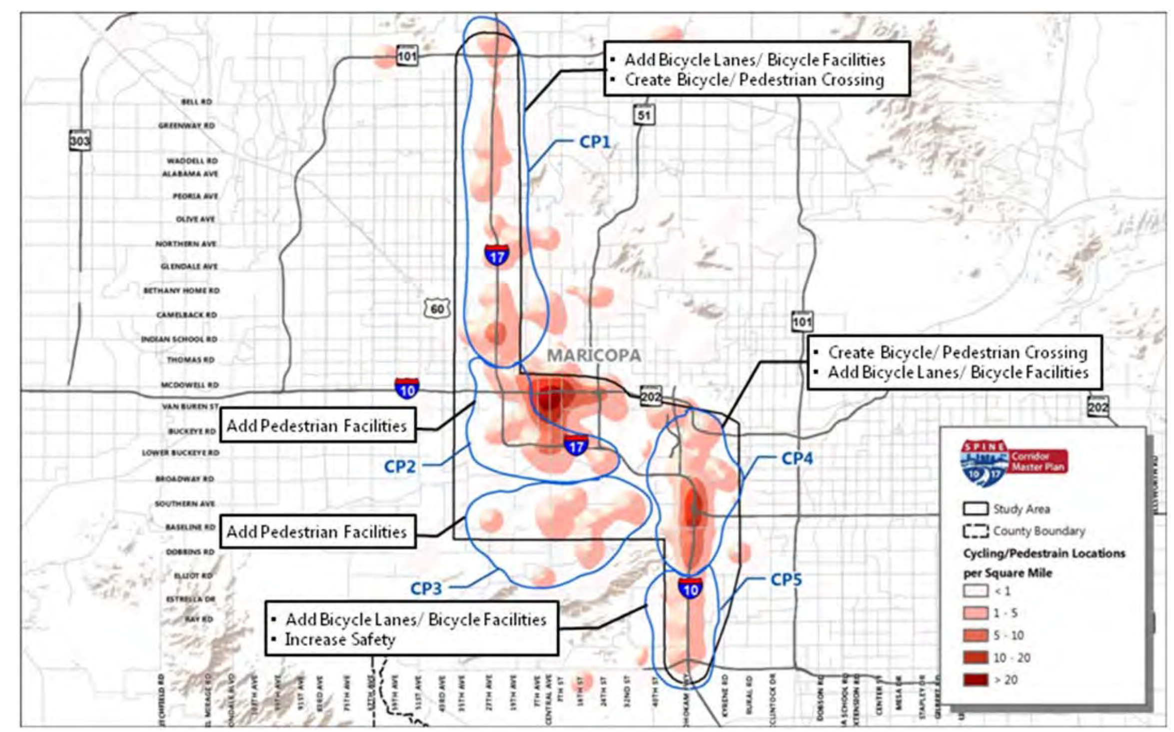
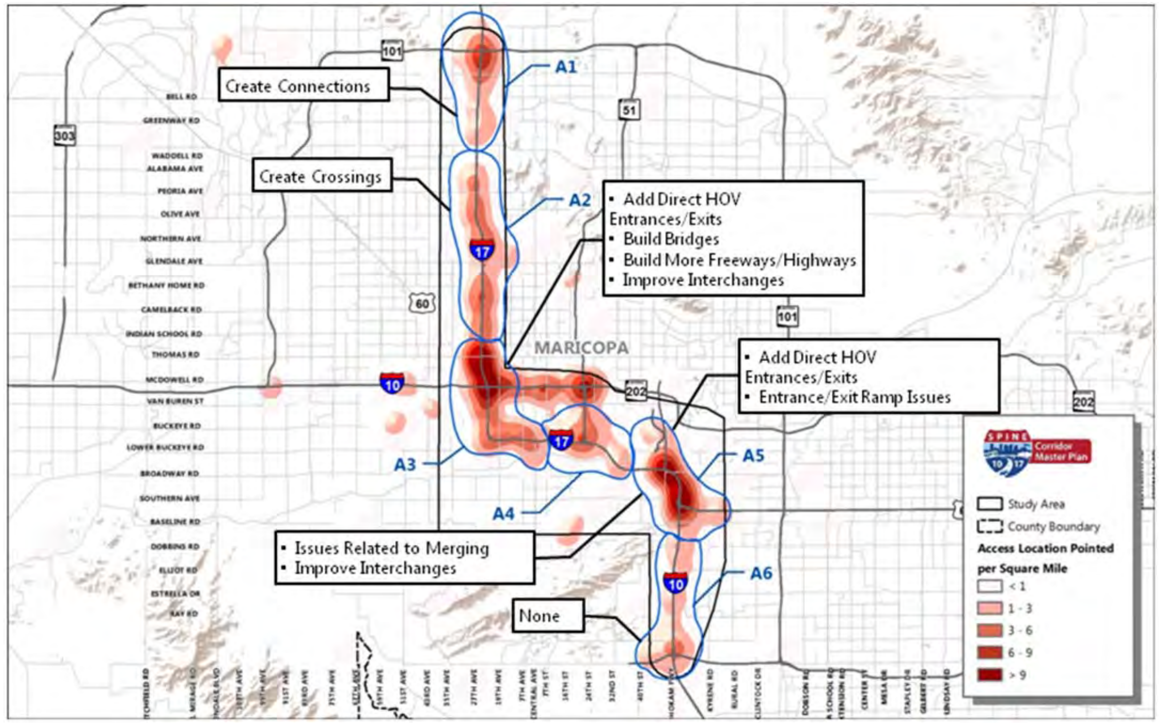


Figure 10-28 Online Survey Access Pin Heat Map with Comment Areas



11 Need and Purpose for the Proposed Action

11.1 Introduction

I-10 and I-17 are major transportation facilities through Arizona, Maricopa County, and within the metropolitan Phoenix area. Much of the two Interstates were completed in the metropolitan Phoenix area in the 1970s and 1980s (I-10 was not fully completed until 1990). Since then, no major upgrades to either Interstate have occurred while, as described below, the Phoenix region has grown at a rapid rate.

Both Interstates are critical to the effective and reliable movement of people, goods, and services throughout the region. (Approximately 43 percent of all travel in the region in 2014 occurred on weekdays on I-10 and I-17 within the corridor.) Being that the corridor is so heavily traveled, it acts as the backbone or "spine" of the regional transportation system, and therefore, inefficient performance of these two Interstates would greatly and adversely affect the operation of the region's entire transportation network.

The purpose of the I-10/I-17 Corridor Master Plan, as overseen by MAG, which is the regional planning and policy agency for the metropolitan Phoenix area (also known as the MAG region), is to first identify and characterize the operational problems facing the two Interstates in 2014 and as projected out to 2040. The plan also identifies alternative transportation solutions, or to propose actions, to address the problems.

This report establishes the need and purpose to support the proposed action to improve the operational performance of I-10, I-17 and the parallel and crossing arterials in the established corridor. This analysis follows FHWA guidance to define the "transportation problem(s)" warranting remedial action. The following assists in explaining some items considered in establishing the need and purpose for a proposed action. These items are not intended to be all-inclusive; they are intended as guides.

- Capacity and Demand – Is the capacity of the existing facilities inadequate for the present and projected traffic?
- System Linkage – Do the facilities serve as a "connecting link" to an overall, or as an integral part of, an integrated transportation system?
- Social Demands or Economic Development – If the condition of the facilities in question continues to degrade and they are unable to fulfill their intended purpose, , would social and economic characteristics of the surrounding region be adversely affected?
- Roadway Deficiencies – Are improvements necessary to correct existing roadway deficiencies because of substandard design or due to aging infrastructure? How would the proposed action improve it?

The report analyzes these questions to validate, identify, and characterize the operational problems facing both Interstates in a manner that follows FHWA guidance in implementing the National Environmental Policy Act of 1969 [42 United States Code Section 4332(2)(c)].

11.2 Need for the Proposed Action

In summary, the proposed action is needed to address travel demands from projected growth and distribution of population, housing, and employment on the transportation facilities in the Spine corridor and to correct existing and projected transportation system deficiencies. These needs are discussed in the following sections.

11.2.1 Chronology of Need

Historic Growth in Socioeconomic Factors

Regional context of growth patterns is important to understand the need for the proposed action in the Spine corridor. The metropolitan Phoenix area has experienced continuous growth since its inception in the mid-1900s. Those factors substantially contributing to the area being a popular destination for people and industry are well documented and include a mild climate, affordable cost of living, availability of a long-term water supply, and economic opportunities. The rapid and historical growth in terms of population, employment, and housing drove the development of transportation infrastructure in the region, starting with a continuously expanding system of local arterial streets laid out in a grid pattern in the valley to where, in 2014, a regional and Interstate freeway system compliments the local grid network. Two time periods reflect the relationship of the rapid growth with the transportation infrastructure development in the region.

- From approximately 1900 to 1950, the population in the region grew by more than 1,800 percent. By 1950, 105,000 people lived in Phoenix, with thousands more settling adjacent to its city limits. The arterial street network grew in support: in 1950, 311 miles of the arterial street grid had been developed.
- By 1960, the population in Maricopa County reached about 700,000, grew to just under 1 million in 1970, and just over 1.5 million in 1980. All of this growth occurred without the presence of a single freeway. From the early 1950s to the mid-1990s, population grew by over 500 percent (the population in the United States as a whole grew by approximately 70 percent during this time period).

While the Federal-Aid Highway Act of 1956 called for the creation of the nation's 42,500-mile national Interstate Highway System, it would not be until 1990 that the region would receive full benefit, with the completion of I-10 through central Phoenix. In the meantime, the system of local arterial streets continually expanded, but growth in the latter half of the 1900s created new challenges that were regional in context. In response, MAG was formed. One of these regional challenges related directly to transportation. The arterial street network that had served transportation needs well was no longer able to meet all the needs and demands of the driving public and businesses.

In 1960, a study was published by the U.S. Department of Commerce Bureau of Public Roads for the Arizona State Highway Commission. The study, *A Major Street and Highway Plan, Phoenix Urban Area, Maricopa County*, examined the relative merits of various major street and highway layouts for the urban area and its surroundings (Department of Commerce 1960). Ongoing study efforts culminated in 1985 with the plan for the 232-mile freeway system that eventually became the Regional Freeway and Highway System (RFS). The resulting system was an integrated urban Interstate system (that is, I-10 and I-17), outer-belt/loop-highway routes, and major arterial street system.

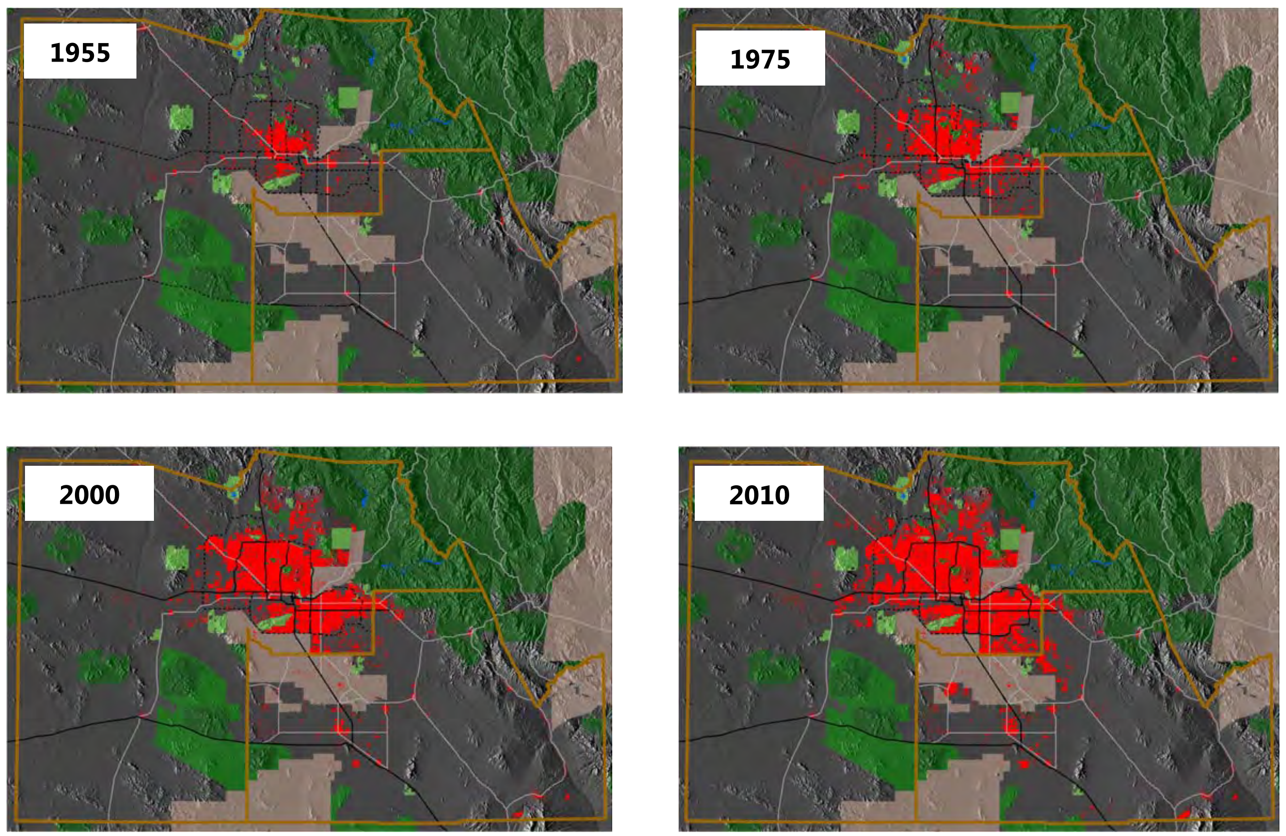
I-10 and I-17 served as the "spokes" into the urban core with the outer-belt/loop-highway routes later being planned around the two Interstates. While major investments to the RFS have been continuous since 1985, no major upgrades to I-10 and I-17 have occurred within the corridor since their initial completions. Consequently, outdated design features of I-10 and I-17 and the aging of the infrastructure have reduced the corridor's responsiveness to growing travel demand caused by the region's growth in population, employment, and housing.

Land development patterns have contributed to the reduced responsiveness. Figure 11-1 shows how the region's population and housing have grown outward from the urban core served by I-10 and I-17. Yet, as shown on Figure 11-2, the highest densities of employment locations remain along I-10 and I-17 in the Spine corridor. In 2014, 30 percent of all jobs in Maricopa County were along the corridor, which represents only 2 percent of the County's land.

Need as Established in Past Studies

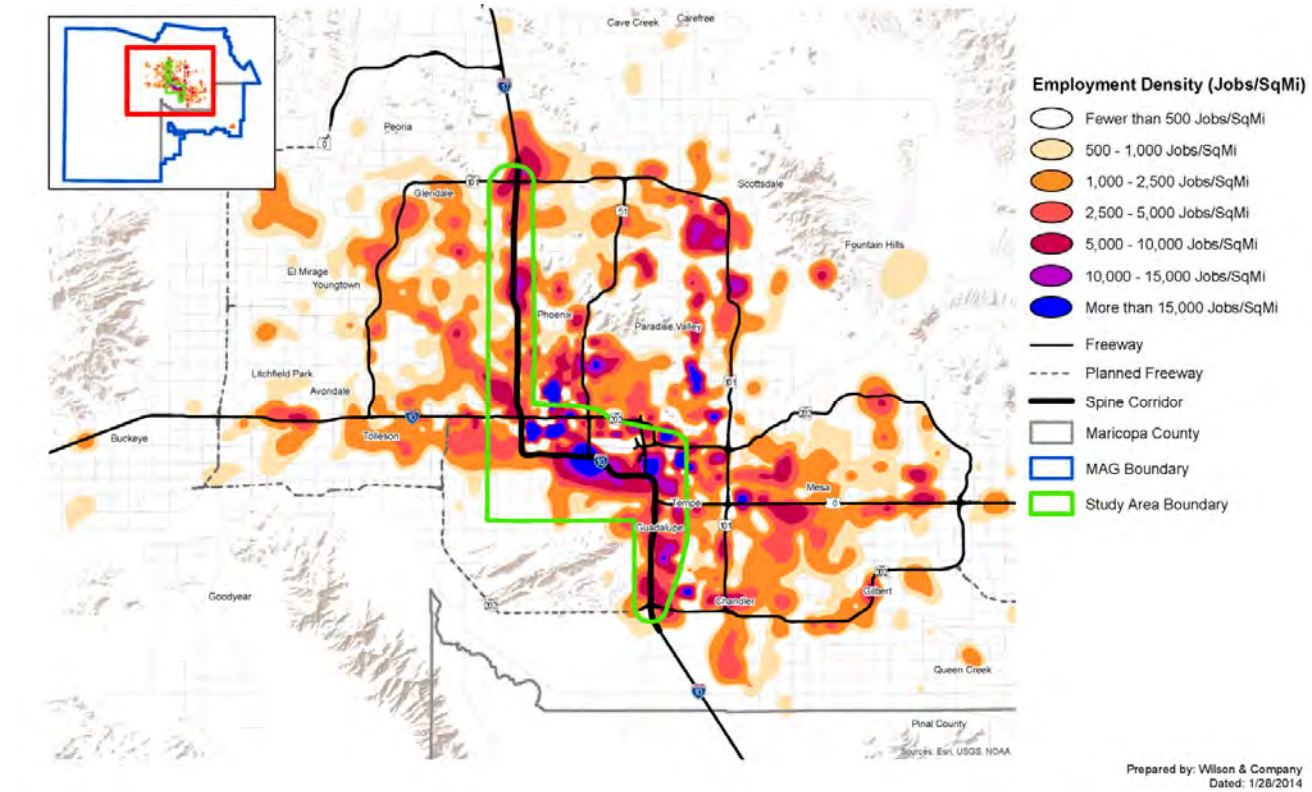
In 2003, MAG evaluated the effectiveness of transportation systems throughout the area in the 2003 RTP (MAG 2003). The plan proposed integrated modal improvements to the region's transportation highways, arterial streets, transit operations, and transportation management programs and technologies. Specific to highways, the plan called for new highway construction and improvements to existing highways, including both I-10 and I-17. Later updates to the RTP continued to identify major improvements to I-10 and I-17.

Figure 11-1 Historic Population Distribution in Maricopa County, 1955–2010



Source: Maricopa Association of Governments, 2008; used with permission.

Figure 11-2 Employment Density per Square Mile, 2014



Note: SqMi = square mile

Subsequent studies, having proposed specific improvements to the two Interstates, demonstrated how historic growth trends have led to failing operational characteristics in the corridor. Initiated by ADOT and FHWA in 2001, one notable study was the *Interstate 10 Corridor Improvement Study and Administrative Draft Environmental Impact Statement (DEIS)/Section 4(f) Evaluation* (ADOT 2009a), which examined the segment of I-10 from its interchange at SR-202L to the Split. Another notable study was the *Interstate 17/Black Canyon Freeway Corridor Study and Administrative DEIS/Section 4(f) Evaluation*(ADOT 2009b), which examined the segment of I-17 from the Split north to North Stack. While both studies were cancelled because of fiscal and operational constraints, the studies presented important conclusions in terms of how the region's rate and distribution of growth culminated in the poor operational characteristics along I-10 and I-17. Important observations supporting the need for action from the two studies relate to existing congestion, aging infrastructure, reduced safety and reliability, and increasing costs to the state's economic vitality.

The following summarizes the conclusions reached:

- The amount of traffic on the 35-mile corridor carries from 90,000 to 262,000 vpd. Approximately 43 percent of all travel in the metropolitan Phoenix area occurred daily on I-10 and I-17 in 2014.
- During morning commutes, some Interstate sections experience severe congestion lasting over 3 hours; the most severe congestion occurring on I-10 and I-17 associated with inbound traffic to downtown Phoenix. The amount and duration of congestion on both I-10 and I-17 are even worse during the evening commute when compared against the morning commute.

- The reliability and dependability of I-10 and I-17 have decreased because of the failing operations. Drivers have chosen to use alternative routes, which has caused other elements of the transportation network to become "stressed."
- Motorized vehicles have changed, and technology has advanced rapidly since I-10 and I-17 were placed into operation, outpacing the ability of the aging infrastructure to accommodate technological advancements such as increased vehicle speeds, vehicle-to-infrastructure communications, or provide innovative traffic management tools such as variable speed lanes and integrated seamless transit traffic management.
- Collisions on I-17 cause travel delay because existing shoulder widths do not provide adequate space for safely removing disabled vehicles from the travel lanes. Motorists are unable to move around accident sites, and emergency vehicles have difficulty accessing accidents. Accident rates on I-17 are higher than the statewide and MAG Freeway System averages, and each accident leads to a reduction in economic productivity in the region.
- The decreased reliability of I-10 and I-17 as dependable travel solutions has adversely affected the state's economic productivity. The corridor provides critical access to the Phoenix Sky Harbor International Airport (one of the largest economic engines in the state), Arizona State University Tempe and Phoenix campuses, and the downtown Phoenix business core. Many of the Valley's industry and business are located along the corridor.
- As I-10 and I-17 have become less dependable and reliable travel routes, adverse economic effects have included rising household transportation costs and higher public service costs.

Projected Growth in Socioeconomic Indicators

Table 11-1 illustrates that rapid growth as experienced in the past would continue in the foreseeable future.

Table 11-1 Projected Growth in Socioeconomic Indicators, 2014–2040

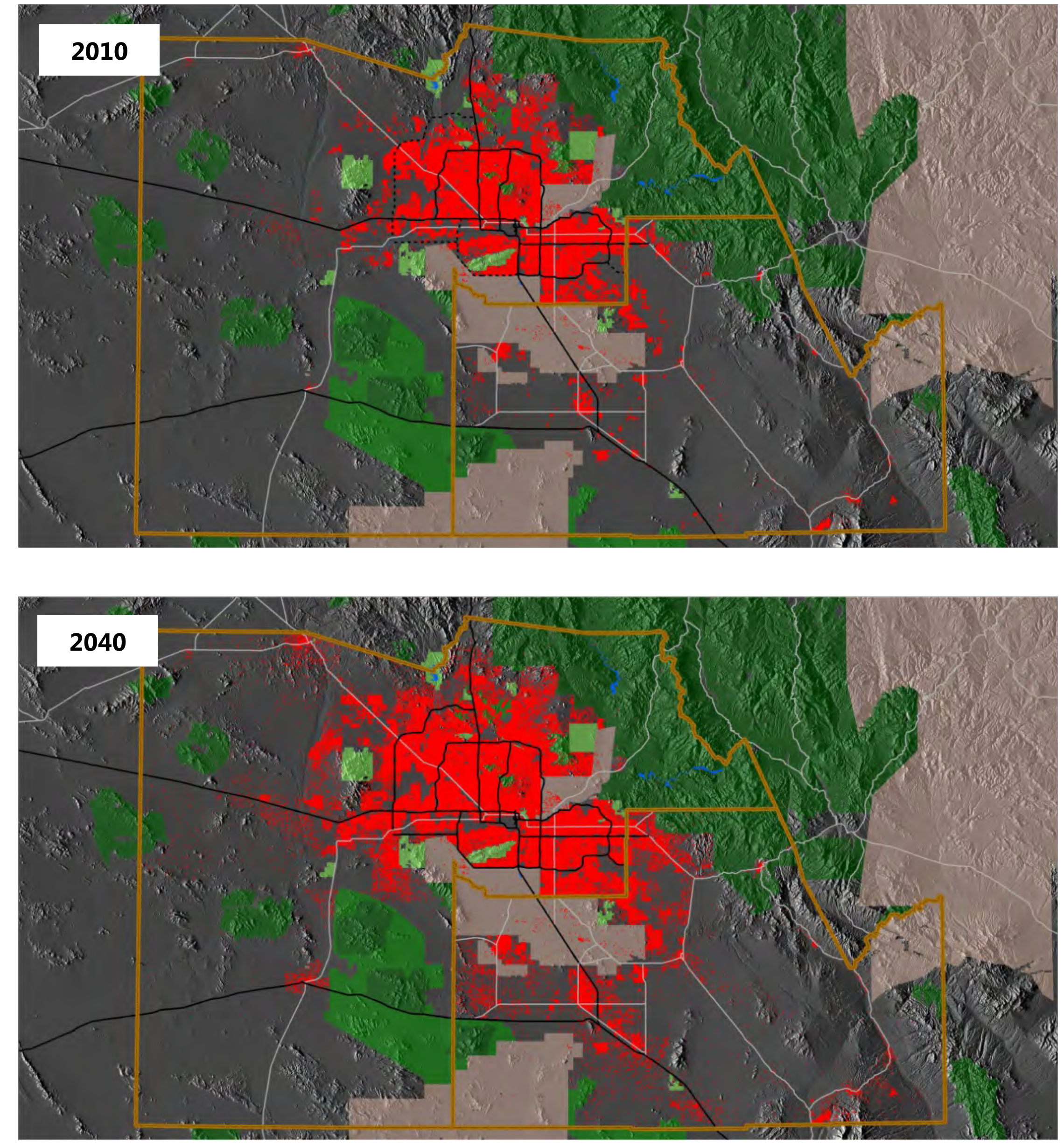
Socioeconomic indicator	2014	2040	Percentage change
Employment (excluding work-at-home and construction)	1,594,752	2,665,466	67
Population	4,277,650	6,625,516	55
Resident population	3,933,266	6,075,935	54
Dwelling units	1,708,755	2,421,543	42
Occupied dwelling units (resident households)	1,470,829	2,265,740	54

Source: Maricopa Association of Governments (2014)

When comparing the projected distribution of future population disbursement (shown on Figure 11-3) against the projected employment centers (shown on Figure 11-4), the demands historically placed on I-10 and I-17 as major commuter routes would continue in the foreseeable future. (It is estimated that 30 percent of all existing and future jobs in Maricopa County are, and would be, located within the corridor.) Placing further demand on the two Interstates to function as dependable transportation corridors is the existing and future need to continue to provide reliable routes for commercial traffic generated by the high density of businesses within the corridor as illustrated on Figure 11-5.

The projections in Table 11-1 illustrate a continued rapid growth rate that is suggestive of past growth in the region, and in a way is counter to the sustained and substantial downturn in growth rates for new housing and employment across the United States because of the worldwide recession that began in late 2007.

Figure 11-3 Projected Population Distribution, 2010–2030



Source: Maricopa Association of Governments (2008); used with permission.

Figure 11-4 Employment Density per Square Mile, 2040

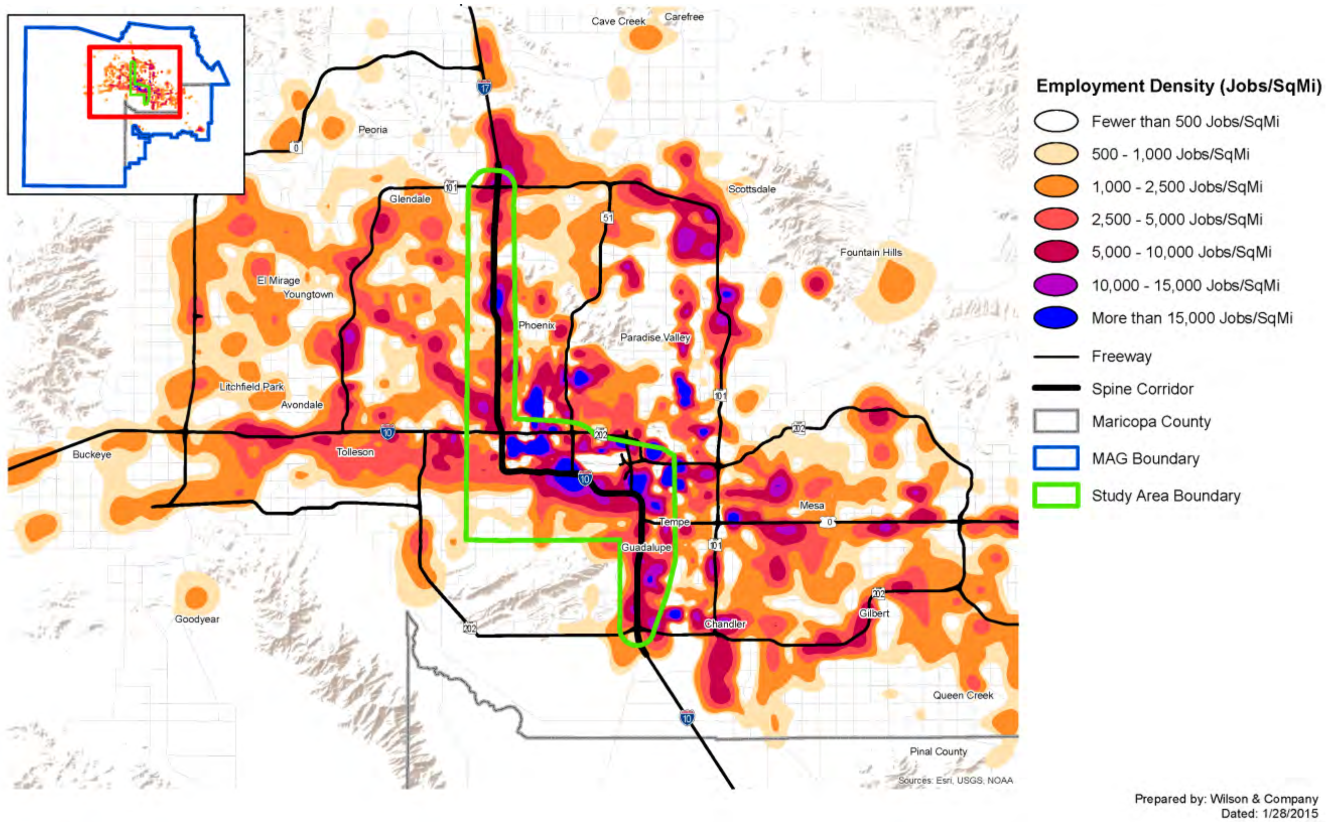
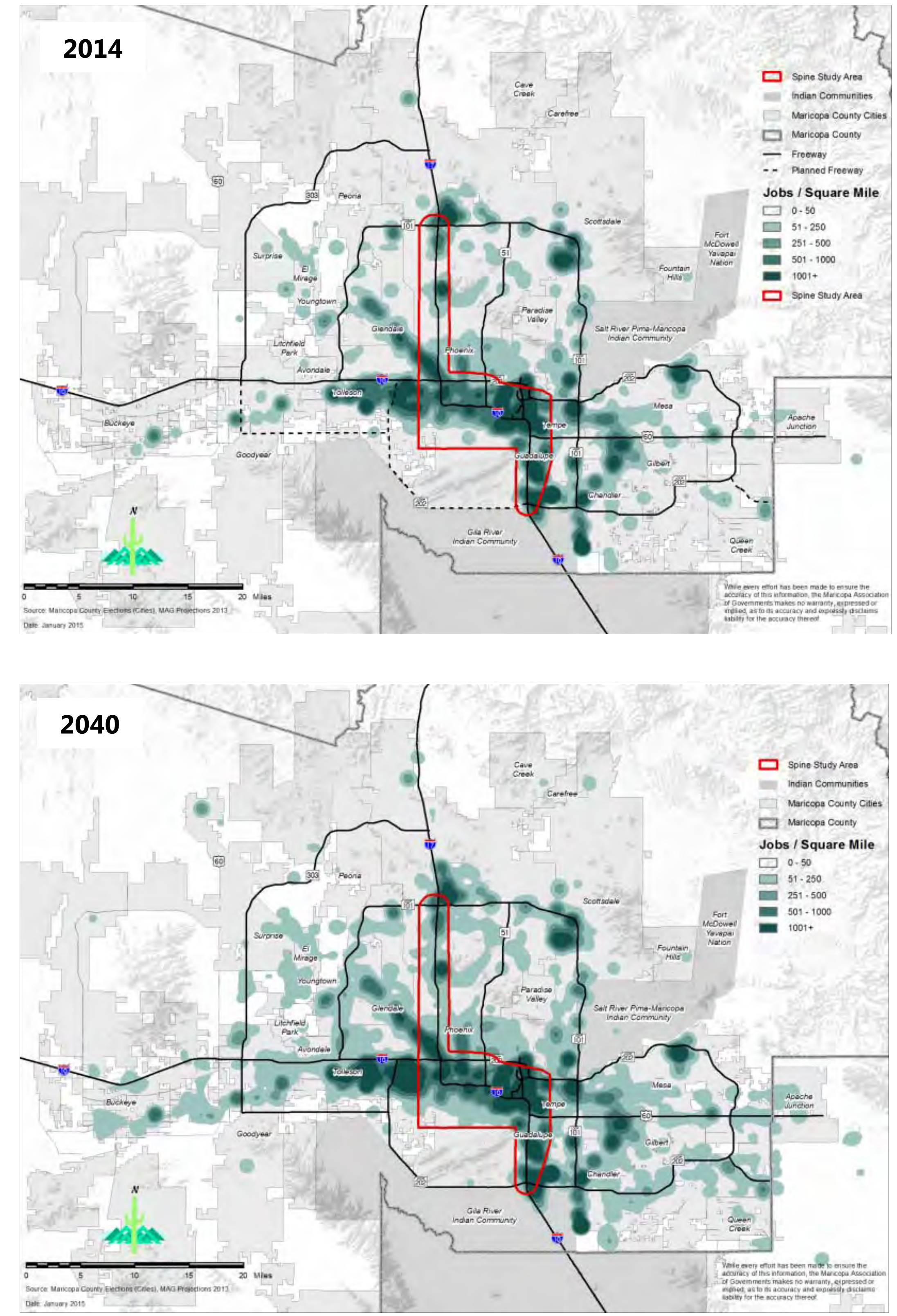


Figure 11-5 Commercial Traffic Generators



Source: Maricopa Association of Governments (2008); used with permission

Arizona particularly suffered the effects of this recession because, beginning in the early 2000s, Arizona in general and Maricopa County specifically enjoyed some of the fastest population, housing, and employment growth rates in the country. Local economies suffering the most in the recession were those, like Phoenix, that enjoyed a boom period linked to robust housing markets that became overbuilt and then stagnant. Past recessions, such as the savings and loans scandals of the late 1980s, substantially impaired the region's growth. Many savings and loan institutions closed, commercial real estate became drastically overbuilt, and businesses left Arizona daily. Yet, in a matter of years, dramatic economic growth resumed.

Because the need for the proposed action is predicated in part on projected growth, one might conclude the recession should be accounted for when predicting the need based on growth. An economic downturn associated with a given recession is, however, generally considered a short-term phenomenon with respect to the longer term planning horizon established for the proposed action. Socioeconomic indicators have steadily and consistently increased in the region since the early 1900s. The critical factors underlying these indicators remain unchanged.

11.2.2 Need Based on Existing and Projected Transportation Conditions

Every day, people travel to and from various destinations throughout the region. The purposes of the travel vary from work-related and personal travel to the movement of goods and delivery of services. People in the region use various means for travel. Cars, buses, light rail vehicles, bicycles, and walking are all forms (or modes) of travel occurring every day in the MAG region. Taken in its entirety, the amount of travel occurring in the region is referred to as transportation "demand." To allow individuals to meet the purposes of their travel with any travel mode(s) chosen, the region must have appropriate transportation infrastructure and systems in place. The extent of transportation infrastructure and the number of systems to accommodate travel demand are referred to as the transportation "capacity."

Taken in its entirety, the MAG region transportation network (including freeways, arterial streets, etc.) has the ability to accommodate a certain volume of travel during a given timeframe, while still managing to operate at an acceptable level of efficiency. Once that volume is exceeded (or when demand exceeds capacity), the network begins to operate inefficiently. This is referred to as "capacity deficiency."

If the transportation network is, or is projected to be, deficient in its capacity and is, therefore, unable to efficiently serve existing and future transportation needs in the MAG region, analysts would determine what aspects of the network are, or are projected to be, deficient (for example, arterial street network, RFS, or a combination of the two), and where in the system the deficiencies would occur. To make the assessment, analysts would need to know:

- Existing and projected demand for the network;
- The types, modes, lengths, and durations of travel that occur in the region today and in the future (for example, local, regional, Interstate, or a combination of the three); and
- Where the travel occurs now and would occur in the future

If deficiencies are found in the network, analysts can suggest the types of improvements to the region's transportation network necessary to address the deficiencies, in addition to testing the suggested improvements to assess their effectiveness. The tools used by analysts to assess the need for improvements are summarized in Table 11-2.

The following presents operational characteristics of the existing and future road network in the Spine corridor. An assessment of traffic volumes, traffic conditions, travel distributions, capacity deficiency, and travel times provides analysts a basis for evaluating the need for the proposed action.

The traffic assessment for the proposed action employed the MAG travel demand model as certified by FHWA and reviewed by EPA for air quality conformity. The model projects demand for multiple modes of travel, including automobile, bus, and light rail train. Key model inputs used to forecast travel demand included:

- Socioeconomic data based on the adopted general plans of MAG members, along with population and economic forecasts and the existing and planned transportation infrastructure as identified by MAG members
- The anticipated average number of vehicle trips within the MAG region (including those to and from the region's households) on a daily basis (MAG regularly monitors this number.)
- The distribution of transportation modes used by travelers in the MAG region (MAG also monitors this regularly.)
- The capacity of the transportation infrastructure to accommodate regional travel
- The future transportation infrastructure established using RTP-planned projects and improvements and from known arterial street network improvements assumed to be made by the County, cities, and private developers

Table 11-2 Traffic Analysis Tools

Issue identification	Analysis tool	Tool purpose
Is there currently a network capacity deficiency and would there be a network capacity deficiency in the future?	Existing and Future Traffic Volume Projections (Travel Demand Analysis)	Establish overall demand for use of the future network, including mode, trip type, and durations. Determine network capacity deficiencies including freeway, arterial street, modal deficiencies.
	Level of Service Analysis	Determine network performance in terms of the quality of service/efficiency.
	Existing and Projected Travel Time and Congestion Analysis	Determine projected level of delay and congestion.
	Trip Distribution (Select Link Analysis)	Identify trip origins and destinations to establish trip types occurring within a given area in the MAG region.

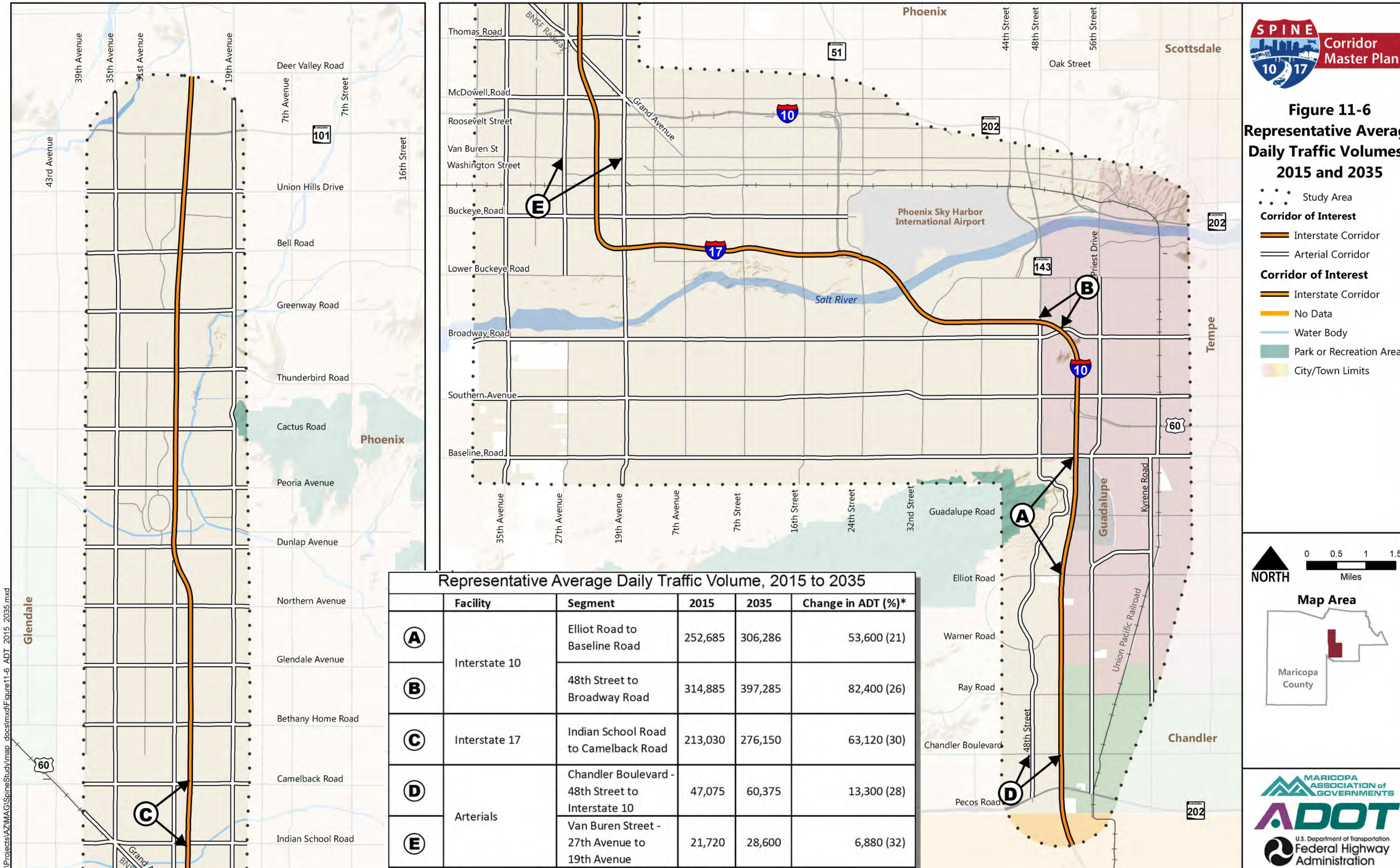
Representative Traffic Volumes in the Spine Corridor

The current and future transportation network in the corridor would include existing I-10 (Papago and Maricopa Freeways), I-17, and arterial streets. Figure 11-6 illustrates both representative volumes in the corridor and demonstrates how freeways are intentionally designed to handle much higher ADT volumes than arterial streets. The MAG travel demand model assumes different types of roads can accommodate different amounts of traffic. For example, a typical six-lane arterial street (for example, certain segments of Van Buren Street) could carry 51,000 vpd, while a typical six-lane freeway (for example, certain segments of I-17) could carry 165,000 vpd.

The 2035 network includes all of the improvements from the RTP, except for the proposed action in the corridor. Changes between the 2015 and 2035 arterial street network would be planned improvements to be made by the cities of Phoenix, Tempe, and Chandler; Maricopa County; and/or by private developers (with jurisdictional approval) to address local traffic needs associated with future development. The amount of change in traffic volumes between 2015 and 2035 on the arterial street network would vary throughout the corridor. Some locations may have large increases in projected traffic volumes, others small, and some might even experience reduced traffic. Projected traffic volumes also would vary because motorists may seek alternative routes in response to changes in land use, such as new construction or abandonment of employment, commercial, or retail centers.

When taken in its entirety, traffic on the arterial streets in the corridor would increase at a rate comparable to that of the arterial street network in the entire MAG region. The largest change in traffic would be on arterial streets located in undeveloped areas that would be developed in the future and/or would be widened by adding additional lanes.

Figure 11-6 Representative Average Daily Traffic Volumes, 2015 and 2035



	Facility	Segment	2015	2035	Change in ADT (%)*
A	Interstate 10	Elliot Road to Baseline Road	252,685	306,286	53,600 (21)
B		48th Street to Broadway Road	314,885	397,285	82,400 (26)
C	Interstate 17	Indian School Road to Camelback Road	213,030	276,150	63,120 (30)
D	Arterials	Chandler Boulevard - 48th Street to Interstate 10	47,075	60,375	13,300 (28)
E		Van Buren Street - 27th Avenue to 19th Avenue	21,720	28,600	6,880 (32)

Representative Average Daily Traffic Volume, 2015 to 2035

Note: ADT (%) = Average Daily Traffic (percent change between 2015 and 2035)

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Source: ADOT, ALRIS, FEMA

Map Last Updated: 5/16/2016

From observation, traffic volumes are typically higher on arterial street when the street is in proximity to a major freeway, has more capacity (more travel lanes), and, therefore, can accommodate more vehicles and/or is located within urbanized areas or near areas where land is subjected to more intensive uses.

A cut-line analysis of general purpose lane was undertaken to identify the number of lanes that would be needed in each direction to accommodate, without congestion, all of the traffic that would desire to use both Interstates during the PM peak period, often referred to as the "evening commute." As depicted on Figure 11-7, as many as 22 travel lanes would be required along some sections of the corridor during the PM peak period. Since the AM peak period, or "morning commute" traffic, is relatively similar to that of the PM peak period, but with higher demands in the "opposite direction," it is estimated that up to 24 to 26 travel lanes could be required along portions of I-17, particularly north of the Split. These conclusions are based on an unlikely assumption associated with creating "free-flow" traffic on the two Interstates; however, the lane analysis supports that volumes have and would continue to outpace the system's capacity to adequately handle the demand generated. Therefore, the system is experiencing capacity deficiencies that contribute to inefficient, poor, and unreliable operational characteristics.

Cutline Analysis

One way to illustrate travel demand is through use of a cut-line analysis. A cutline is an imaginary line used to represent the total traffic on freeways and arterial streets that cross (or would cross) this given line. This analysis is used to determine both the existing and future distribution of traffic on the freeway and arterial street networks. Thirteen cutlines were identified throughout the Spine study area.

Existing and Projected Levels-of-Service of Arterials and Interstates in the Spine Corridor

Transportation analysts have developed a uniform way to describe the overall quality provided by a given transportation facility, service, or network. In 1965, an LOS "report card" method was introduced, where highway quality of service was "graded" using six letters, "A" through "F." "A" represented the best LOS, and "F" represented the worst LOS. With the LOS approach, traffic engineers were better able to explain operating and design concepts of highways to the general public and elected officials. The LOS approach is now commonly used throughout the United States. Figure 11-8 depicts traffic conditions representing each graded designation.

LOS is most often modeled during the morning and evening commuting periods. These are the times when most motorists are on the roads, and when traffic volumes are highest. As a result, the operational efficiency of the network can be assessed under "worst-case" conditions.

For the traffic analysis, widely accepted LOS qualitative measures were applied to characterize operational conditions of traffic flow. These measures describe traffic conditions using factors such as speed and travel time, freedom to maneuver, traffic interruptions, and comfort and convenience. For freeways, LOS E describes operation at capacity. Operational characteristics at this level are volatile because there are virtually no usable gaps in the traffic. Vehicles are closely spaced, leaving little room to maneuver at speeds that still exceed 45 mph.

Any disruption, such as vehicles entering from an on-ramp or a vehicle changing lanes, can establish a "disruption wave" that affects traffic flow. At capacity, the traffic has no ability to compensate for even the most minor disruption, and any incident can be expected to produce a serious breakdown with extensive traffic back-up. Maneuverability within the traffic stream is extremely limited, and the levels of physical and psychological comfort afforded the driver are poor. Because of this, most transportation planners strive to design freeways to achieve LOS D or better.

In its essence, LOS is derived by comparing traffic volumes on a given roadway segment to roadway capacities. Capacities are defined for general-purpose freeway lanes, HOV lanes, and arterial lanes, based on the volume of traffic each facility type would be expected to carry. Table 11-3 summarizes the capacity of the different facility types.

Table 11-3 Roadway Capacities, by Facility Type, for the PM Peak Period

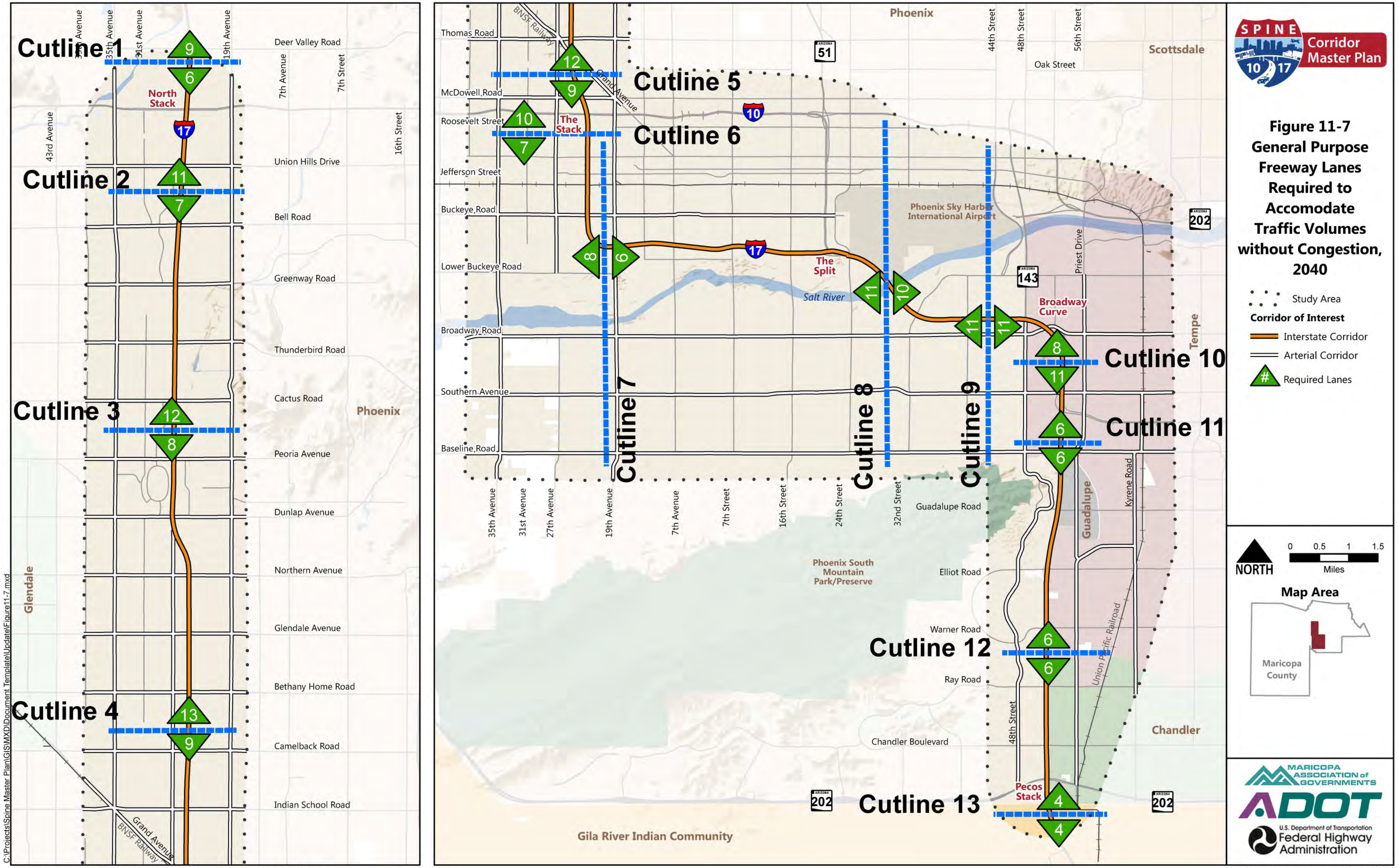
Lane type	Vehicles per hour per lane
HOV Lanes	1,700
General-purpose Freeway Lanes	1,750
Arterials	700
Frontage Roads	1,000

Model generated traffic volumes can be compared to the roadway capacities defined in Table 11-3 to create a v/c ratio. The ratio provides an indication of the anticipated congestion and associated LOS that may occur on a roadway network. Table 11-4 provides a summary of the LOS thresholds used in the analysis of corridor roadways.

Table 11-4 Levels of Service Thresholds

LOS	Volume-to-capacity ratio ranges	
	Lower	Upper
A	0.00	0.50
B	0.51	0.60
C	0.61	0.72
D	0.73	0.84
E	0.85	1.00
F	1.01	+

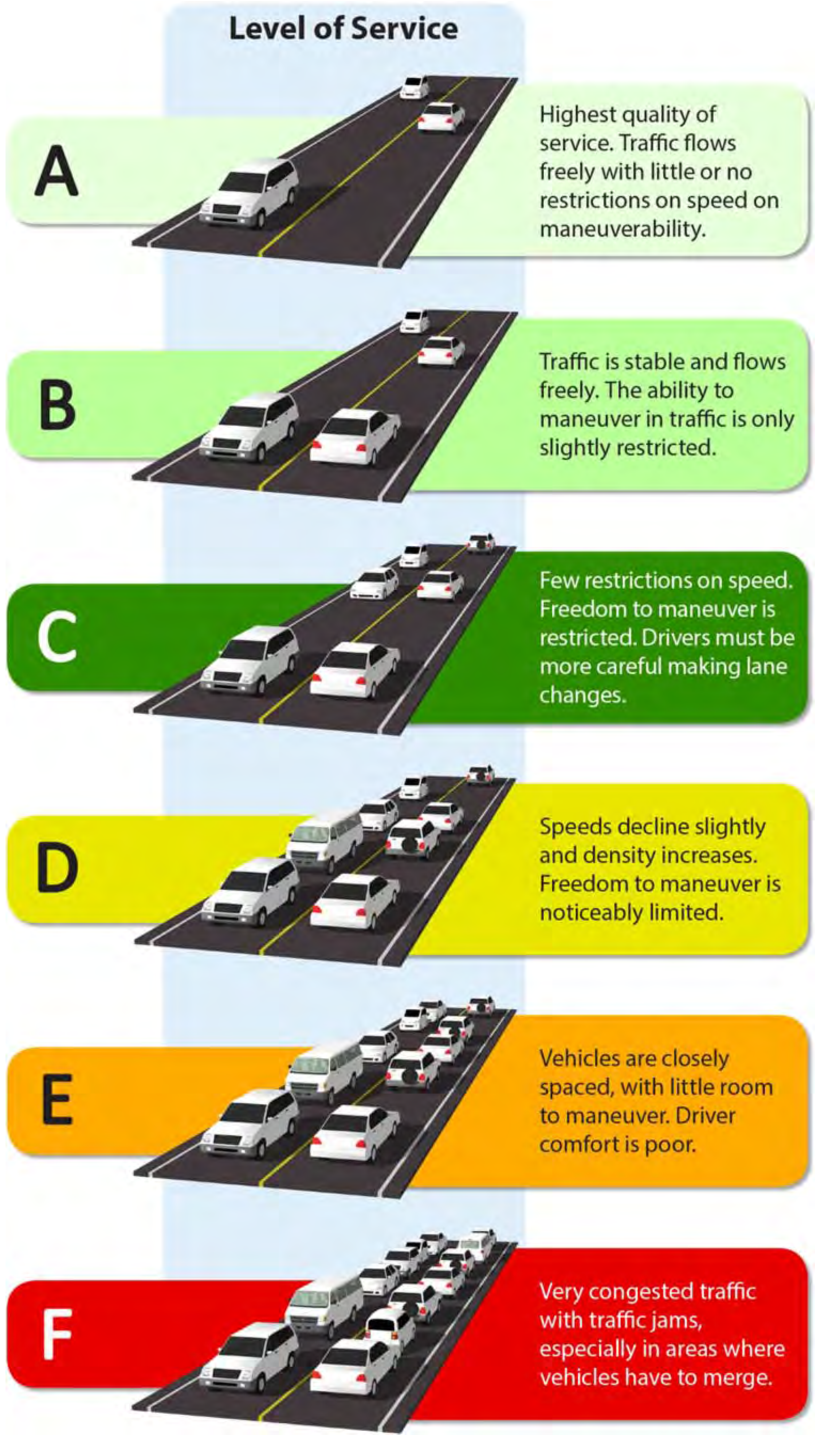
Figure 11-7 General Purpose Freeway Lanes Required to Accommodate Traffic Volumes without Congestion, 2040



Data Source: ADOT, ALRIS, FEMA, MAG Travel Demand Model

Map Last Updated: 5/13/2016

Figure 11-8 Representative Levels of Service



For the purposes of defining LOS in the corridor, a series of cutlines were defined throughout the corridor. Cutlines are essentially imaginary lines drawn across a corridor at various locations, across which a given volume of traffic is expected to travel. The capacities of the various roadway facilities at these cutlines are defined and then compared to the associated travel volumes that cross the cutlines.

Figure 11-9 and Figure 11-10 illustrate the LOS and v/c results of the cutline analysis for existing and 2040 conditions, respectively. The results reveal the following:

- Under existing conditions,
  - The arterial and HOV facilities are generally operating at acceptable LOS D or better today, with some isolated exceptions.
  - The I-10 and I-17 general-purpose freeway lanes are experiencing operational degradation in terms of LOS and v/c ratios at several locations throughout the corridor.
  - The greatest operational degradation is experienced at and adjacent to the Broadway Curve for both I-10 eastbound and westbound traffic.
- By 2040, conditions are generally expected to continue or deteriorate along I-17. North of the Stack, both northbound and southbound general-purpose lanes would operate poorly during the PM peak period. Between the Stack and the Split, I-17 northbound would also operate poorly.
- By 2040, poor operational characteristics are expected in both the eastbound and westbound direction for I-10 between the Split and Baseline Road. Conditions along a portion of the corridor (westbound travel near the Broadway curve and eastbound travel near 32nd Street) would actually improve because of planned "near-term" corridor improvements.

Volume-to-Capacity Ratio (v/c)

A ratio of model-generated traffic volumes compared to roadway capacity (defined in Table 2-3). The v/c ratio is intended to provide an indication of the anticipated congestion and associated LOS that may occur on the roadway network.

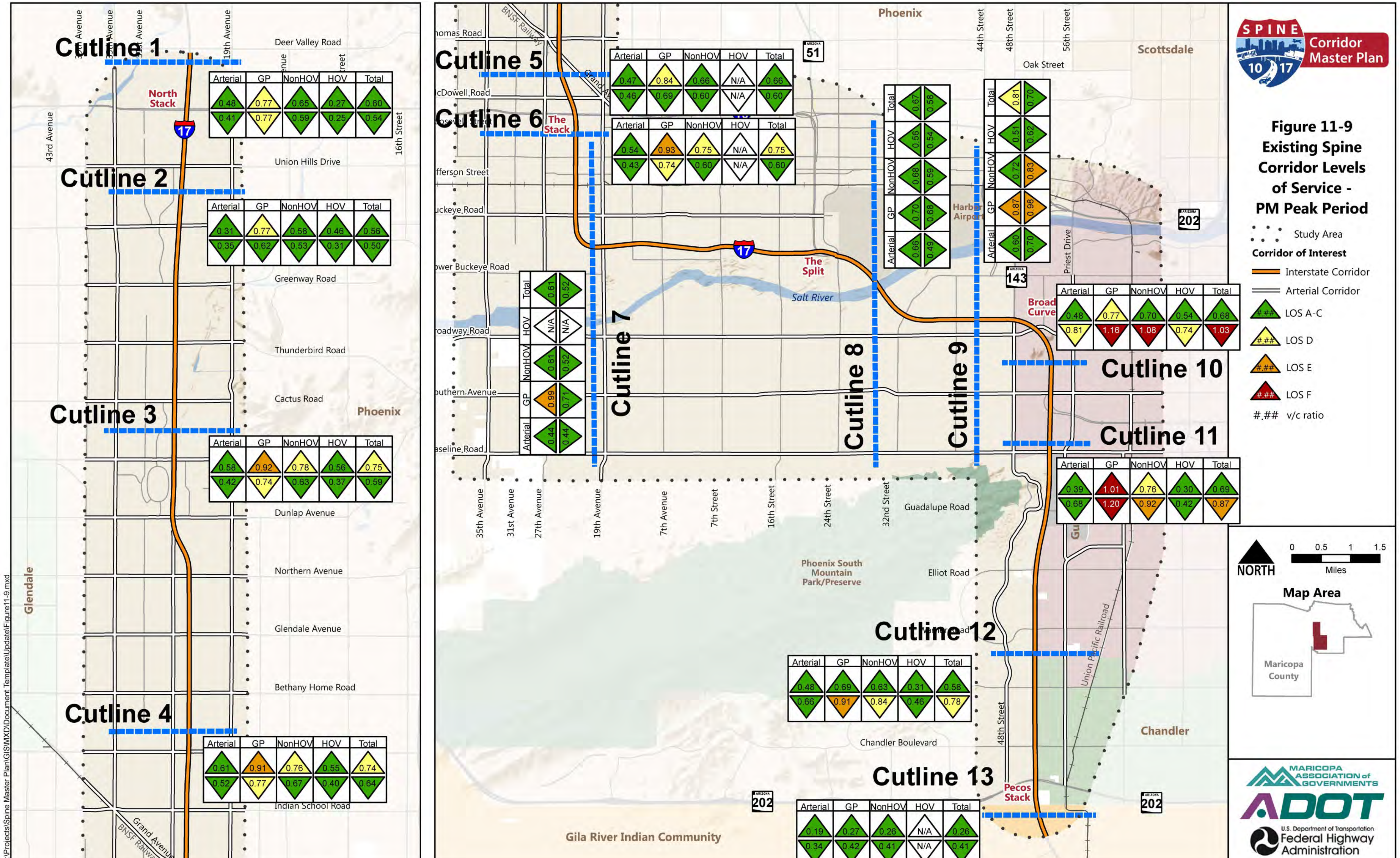
A lower v/c ratio correlates to a higher LOS, while a higher v/c ratio correlates to a higher LOS and more congestion.

The LOS and v/c ratio analyses for the arterials and mainlines reveal travelers are experiencing delays and poor operational performance along certain portions of the transportation network in the corridor and that demand for the facilities is outpacing the capacity of the facilities to accommodate the demand. This would lead to both a continued degradation in service performance and additional delays and congestion throughout the corridor.

Existing and Projected Levels of Service for Service Traffic Interchanges in Spine Corridor

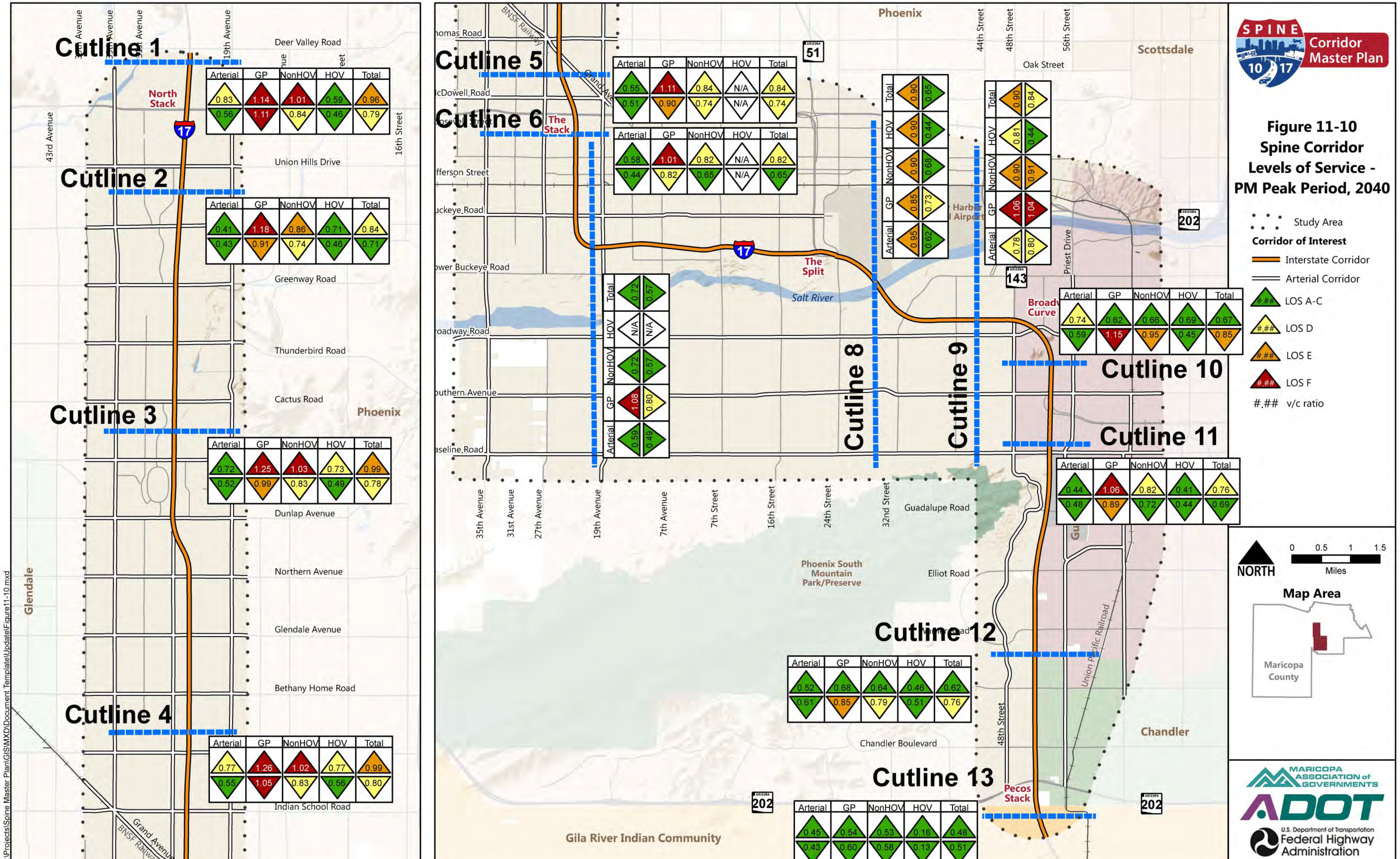
A similar analysis was conducted to assess the existing and future operational characteristics of the service traffic interchanges in the corridor in terms of LOS and v/c ratios. Figure 11-11 and Figure 11-12 display the LOS and v/c results of the cutline analysis for existing and 2040 conditions, respectively. The analyses revealed that while over 75 percent of the traffic interchanges are operating at LOS D or better under existing conditions, fewer than 40 percent of the corridor interchanges would operate at LOS D or better by 2040.

Figure 11-9 Existing Spine Corridor Levels of Service – PM Peak Period



Data Source: ADOT, ALRIS, FEMA, MAG Travel Demand Model

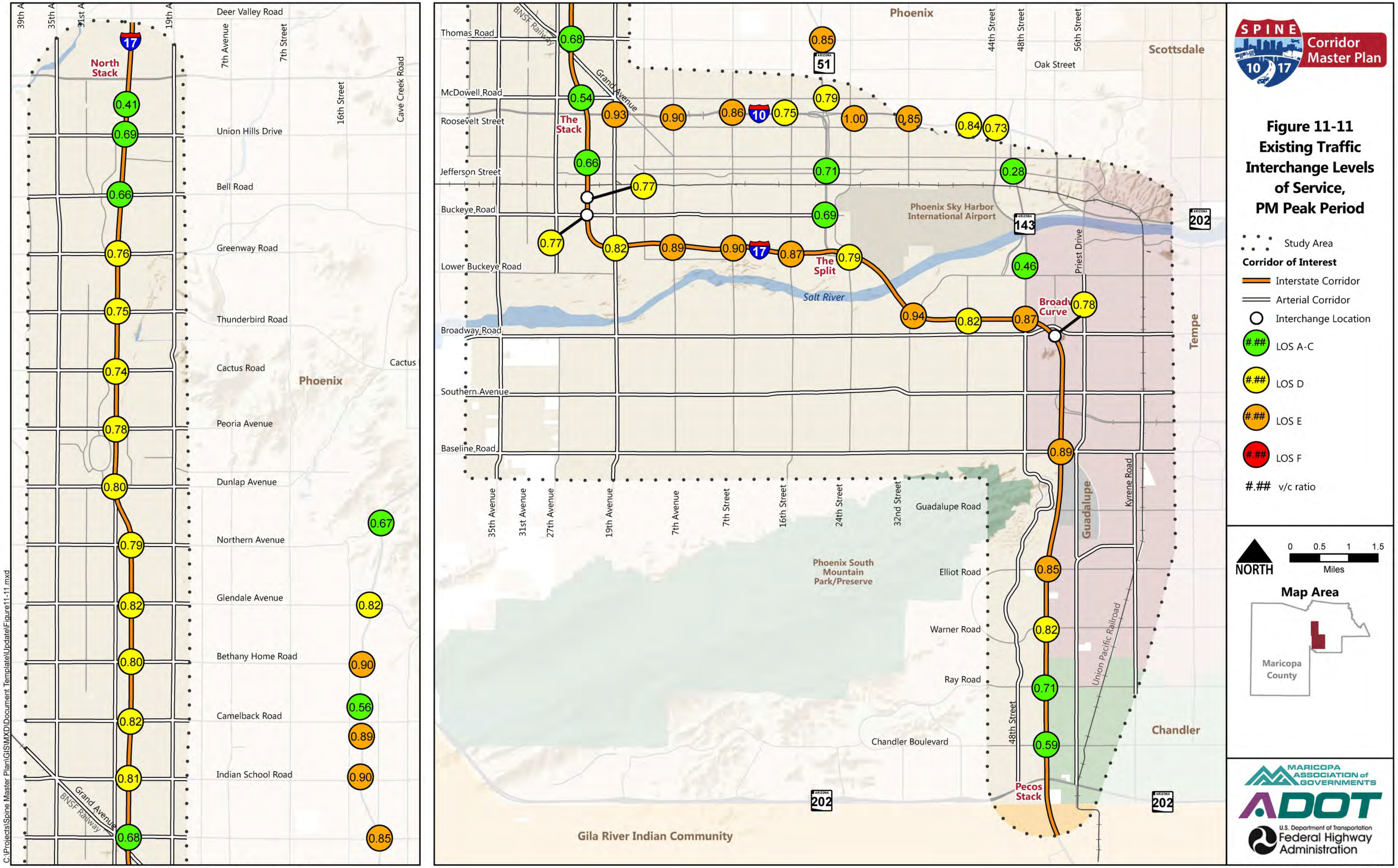
Figure 11-10 Spine Corridor Levels of Service – PM Peak Period, 2040



Data Source: ADOT, ALRIS, FEMA, MAG Travel Demand Model

Map Last Updated: 5/13/2016

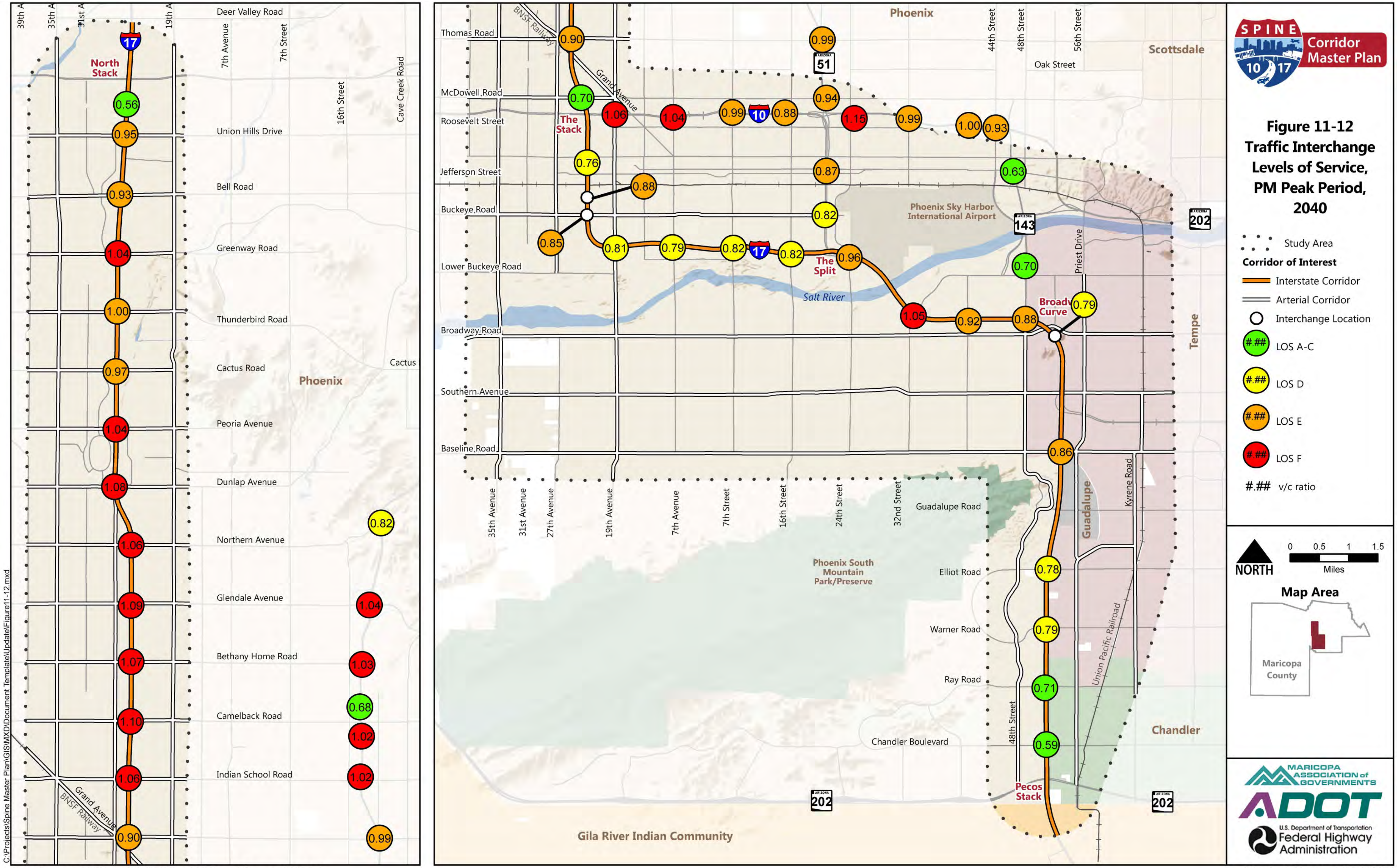
Figure 11-11 Existing Traffic Interchange Levels of Service, PM Peak Period



Data Source: ADOT, ALRIS, FEMA, MAG Travel Demand Model

Map Last Updated: 5/13/2016

Figure 11-12 Traffic Interchange Levels of Service, PM Peak Period, 2040



Data Source: ADOT, ALRIS, FEMA, MAG Travel Demand Model

Map Last Updated: 5/13/2016

While *overall* interchange operations are reported to be acceptable in many locations, traffic volumes along certain roadways approaching the interchange exceed, or would exceed in the future, the available capacity of those approaches. Figure 11-13 and Figure 11-14 illustrate the LOS on the corridor interchange approaches for existing and 2040 conditions, respectively. The analyses revealed over half of the freeway approaches are operating at LOS D or better under existing conditions, whereas almost 80 percent of the arterial approaches are operating at LOS D or better under existing conditions. By 2040, less than one third of the freeway approaches would operate at LOS D or better, while over half of the arterial approaches would operate at LOS D or better.

Travel Time in the Spine Corridor

In the Spine corridor, the continued degradation of the operational characteristics on and adjacent to I-10 and I-17 has resulted in decreased travel speeds throughout much of any given day on the region's roadway network. The amount of time a driver spends driving each day to and from the same origin and destination continues to increase. Travel time is important to most drivers, and an increase in travel time translates to increased deterioration of the poor traveling conditions during peak travel periods. It is important, therefore, to examine representative travel times in different locations and project what travel times would be by 2040.

Travel times to and from specific locations are presented on Figure 11-15 and Figure 11-16. Travel times between the various points are summarized in two tables embedded in the figure for uncongested conditions (free flow), existing condition, and conditions by 2040 for AM and PM peak periods.

A comparison of free-flow travel times to actual travel times under existing conditions reveals a substantial amount of time is already lost when traveling during the peak periods under existing conditions. Travel times would substantially increase in the future. For example, the trip along I-17 between SR-101L (A) and downtown (D) is expected to increase by an additional 10 minutes during both the AM and PM peak periods. This would be equivalent of spending an additional 3 ½ days in traffic each year. When considered in the context of hundreds of thousands of trips per day, over the course of more than 20 years, total time lost because of increased congestion—plus related personal and financial costs—would be substantial.

Congestion in the Spine Corridor

Congestion refers to undesirable traffic conditions. Generally, congestion exists when the LOS is E or F, when traffic on a freeway is moving at an average speed of 45 mph or less, and/or the traffic flow is often stop-and-go. Under existing conditions, travel in the corridor is typically congested during the AM and PM peak periods, and this condition would continue into the foreseeable future. With the added traffic projected to use the corridor, the number of hours during which congestion would occur would increase in the future. Existing peak hour volumes were reviewed to determine at what level of hourly traffic demand the speeds in the general-purpose freeway lanes would drop to congested levels, with travel speeds of 50 mph or fewer. It was determined that approximately 1,470 vehicles per hour per lane can be accommodated throughout the corridor before speeds would drop to congested levels. Forecasted 2040 traffic volumes throughout the day were compared to this threshold level to determine an estimate of how many hours congestion would be expected to occur in the future. The results, summarized on Figure 11-17, indicate congestion would no longer be contained during the peak travel hours, but would continue for much longer portions of the day. In some instances, congestion would last more than 12 contiguous hours over a 24-hour duration.

11.2.3 Need Based on System Linkage

Approximately 43 percent of all travel in the MAG region occurs daily on I-10 and I-17 within the corridor. Being that the corridor is so highly used, the operational degradation of these two Interstates greatly affects the operation of the region's entire transportation network. The 35-mile corridor, including the two Interstates, carries 90,000 to 262,000 vpd and is projected to approach 400,000 vpd by 2040. As reliability and dependability of I-10 and I-17 decrease from failing operations, drivers may likely choose to use alternative routes. As travelers divert their trips to other highway corridors and the local arterial street system, these transportation facilities, in turn, would experience higher levels of congestion and reduced performance.

Several transportation activities converge within the corridor, including light rail train, freeway bus rapid transit, express buses, local bus routes, park-and-ride lots, and HOV lanes. These forms of travel are dependent upon optimal performance of I-10 and I-17 in the corridor. Furthermore, RTP-planned improvements associated with these activities would only be able to perform at a level directly tied to the future operational performance of I-10 and I-17 in the corridor.

11.2.4 Need Based on Social Demands or Economic Development

Decreasing reliability of I-10 and I-17 as dependable travel solutions has, and would continue to, adversely affect the state's economic productivity. Both Interstates are essential to the economic vitality of the region, with much of the Valley's industry and business located along the corridor. For instance, the corridor provides critical accessibility to the Phoenix Sky Harbor International Airport (one of the largest economic engines in the state); Arizona State University's Tempe and Phoenix campuses; and the downtown Phoenix business core. In addition, nearly one-third of the total freight tonnage transported across the United States travels on I-10 primarily by truck. As the operational performance of I-10 and I-17 diminish in the corridor, the ability to move goods and services in and out of the corridor would also be affected.

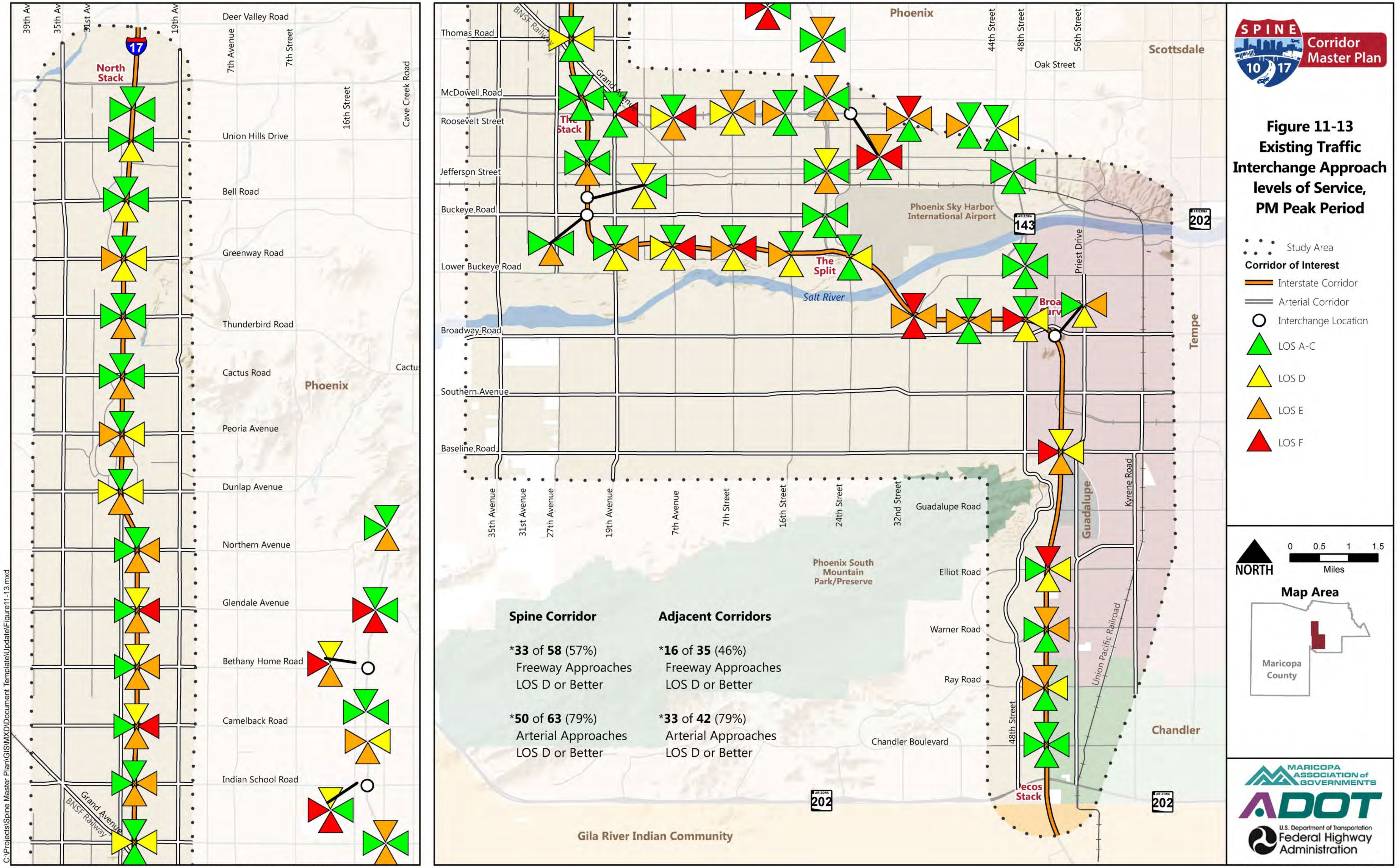
The quality of longstanding neighborhoods and communities along and near I-10 and I-17 could become adversely affected by the performance degradation of I-10 and I-17 since these roadways are a vital part of the communities along the Spine corridor. The Interstates allow people to interact, use transit, and access churches and other important gathering places. In essence, I-10 and I-17 are integral to community and neighborhood well-being. When I-10 and I-17 operate poorly, access to important places to gather and work and access to quality transit services are adversely affected, which, in turn, adversely affects the quality of neighborhoods and communities.

11.2.5 Need Based on Deficiency

Some infrastructure for the two Interstates is in need of substantial repair or replacement. Examples are:

- A preliminary assessment revealed 35 percent of the bridges in the corridor are functionally obsolete; the percentage is higher than both state and national averages
- Pavement on segments of the two Interstates in the corridor are over 30 years old; the typical design life of asphaltic pavement is 20 to 30 years based upon materials used

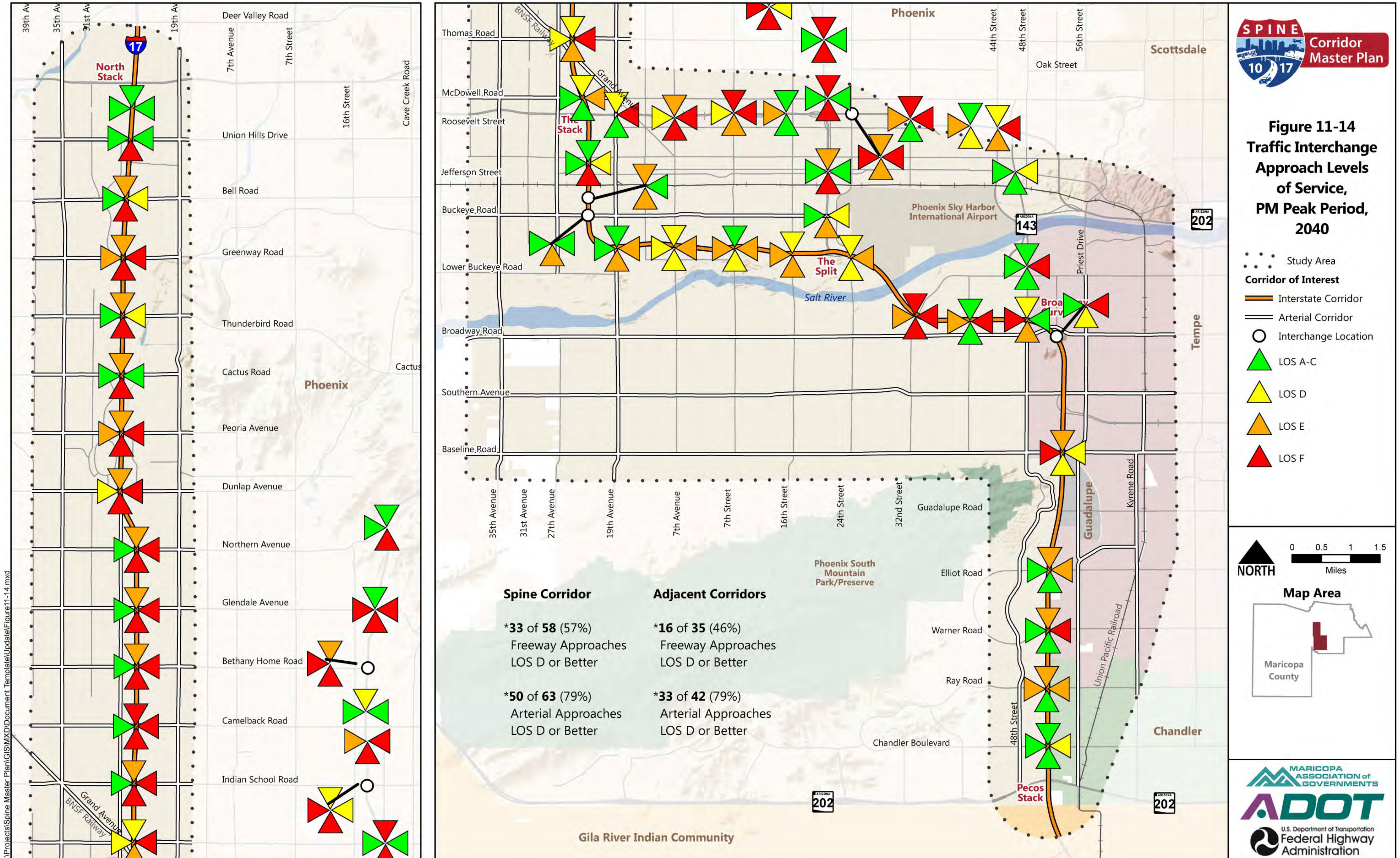
Figure 11-13 Existing Traffic Interchange Approach Levels of Service, PM Peak Period



Data Source: ADOT, ALRIS, FEMA, MAG Travel Demand Model

Map Last Updated: 5/13/2016

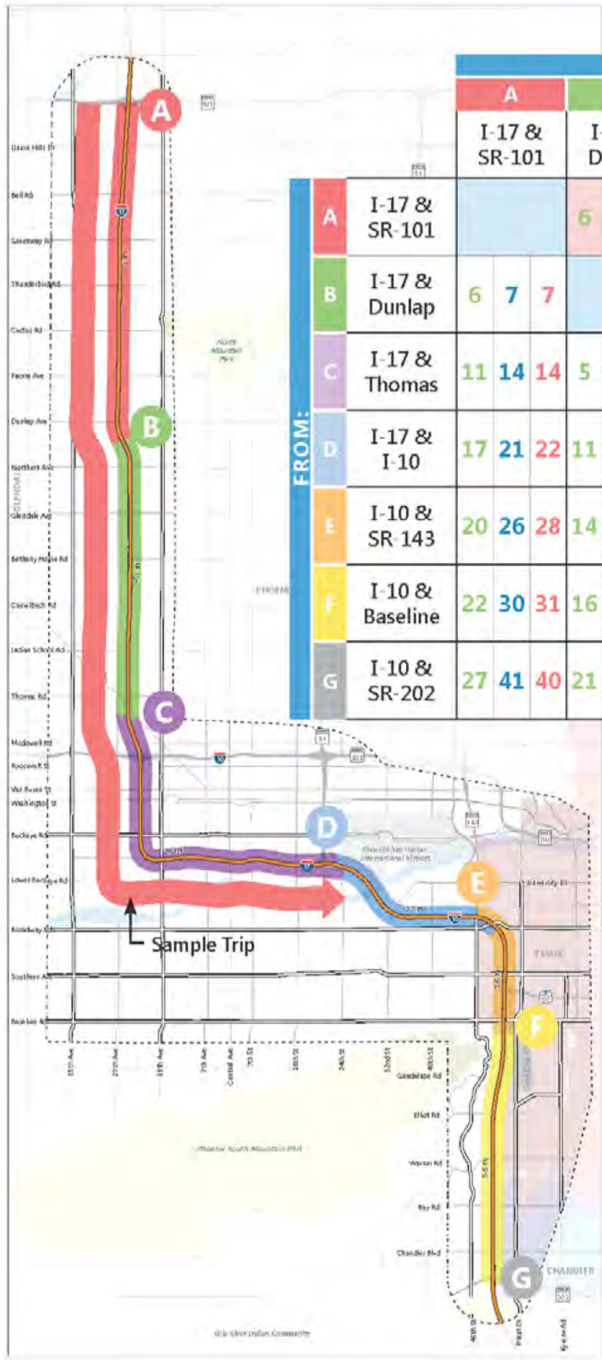
Figure 11-14 Traffic Interchange Approach Levels of Service, PM Peak Period, 2040



Data Source: ADOT, ALRIS, FEMA, MAG Travel Demand Model

Map Last Updated: 5/13/2016

Figure 11-15 Travel Times, Selected Origins, and Destinations, AM Peak Period



MORNING TRAVEL TIME MATRIX:

Cells show: uncongested / 2040 / today (see legend)

FROM: \ TO:	A I-17 & SR-101	B I-17 & Dunlap	C I-17 & Thomas	D I-17 & I-10	E I-10 & SR-143	F I-10 & Baseline	G I-10 & SR-202
A I-17 & SR-101		6 / 11 / 13	11 / 25 / 30	17 / 37 / 47	20 / 41 / 53	22 / 43 / 55	27 / 48 / 60
B I-17 & Dunlap	6 / 7 / 7		5 / 14 / 17	11 / 26 / 34	14 / 30 / 40	16 / 32 / 42	21 / 37 / 47
C I-17 & Thomas	11 / 14 / 14	5 / 7 / 7		6 / 12 / 17	9 / 16 / 23	11 / 18 / 25	16 / 23 / 30
D I-17 & I-10	17 / 21 / 22	11 / 14 / 15	6 / 7 / 8		3 / 4 / 6	5 / 6 / 8	10 / 11 / 13
E I-10 & SR-143	20 / 26 / 28	14 / 19 / 21	9 / 12 / 14	3 / 5 / 6		2 / 2 / 2	7 / 7 / 7
F I-10 & Baseline	22 / 30 / 31	16 / 23 / 24	11 / 16 / 17	5 / 9 / 9	2 / 4 / 3		5 / 5 / 5
G I-10 & SR-202	27 / 41 / 40	21 / 34 / 33	16 / 27 / 26	10 / 20 / 18	7 / 15 / 12	5 / 11 / 9	

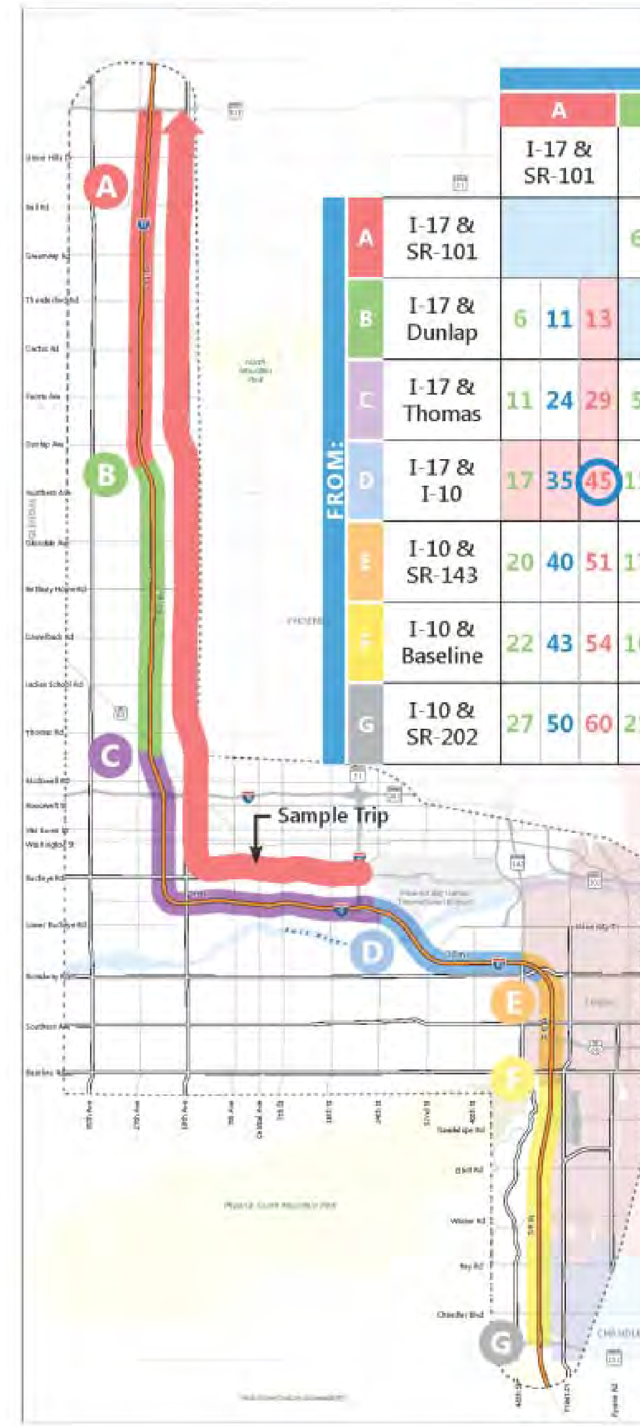
MORNING TRAVEL TIME IN MINUTES:

- # - Uncongested Conditions
- # - 2040
- ◯ - Sample Trip Travel Time
- # - Today

HOW TO READ THE MATRIX – 2040 SAMPLE TRIP TRAVEL TIME:

From A to D = Total 47 minutes

Figure 11-16 Travel Times, Selected Origins, and Destinations, PM Peak Period



EVENING TRAVEL TIME MATRIX:

FROM: \ TO:	A I-17 & SR-101	B I-17 & Dunlap	C I-17 & Thomas	D I-17 & I-10	E I-10 & SR-143	F I-10 & Baseline	G I-10 & SR-202
A I-17 & SR-101		6 / 8 / 9	11 / 17 / 18	17 / 26 / 23	20 / 32 / 36	22 / 36 / 33	27 / 47 / 47
B I-17 & Dunlap	6 / 11 / 13		5 / 9 / 9	11 / 18 / 20	14 / 24 / 27	16 / 28 / 30	21 / 29 / 38
C I-17 & Thomas	11 / 24 / 29	5 / 13 / 16		6 / 9 / 11	9 / 15 / 18	11 / 19 / 21	16 / 30 / 29
D I-17 & I-10	17 / 35 / 45	11 / 24 / 32	6 / 11 / 16		3 / 6 / 7	5 / 10 / 10	10 / 21 / 18
E I-10 & SR-143	20 / 40 / 51	17 / 29 / 38	9 / 16 / 22	3 / 5 / 6		2 / 4 / 3	7 / 15 / 11
F I-10 & Baseline	22 / 43 / 54	16 / 32 / 41	11 / 19 / 25	5 / 8 / 9	2 / 3 / 3		5 / 11 / 8
G I-10 & SR-202	27 / 50 / 60	21 / 39 / 47	16 / 26 / 31	10 / 15 / 15	7 / 10 / 9	5 / 7 / 6	

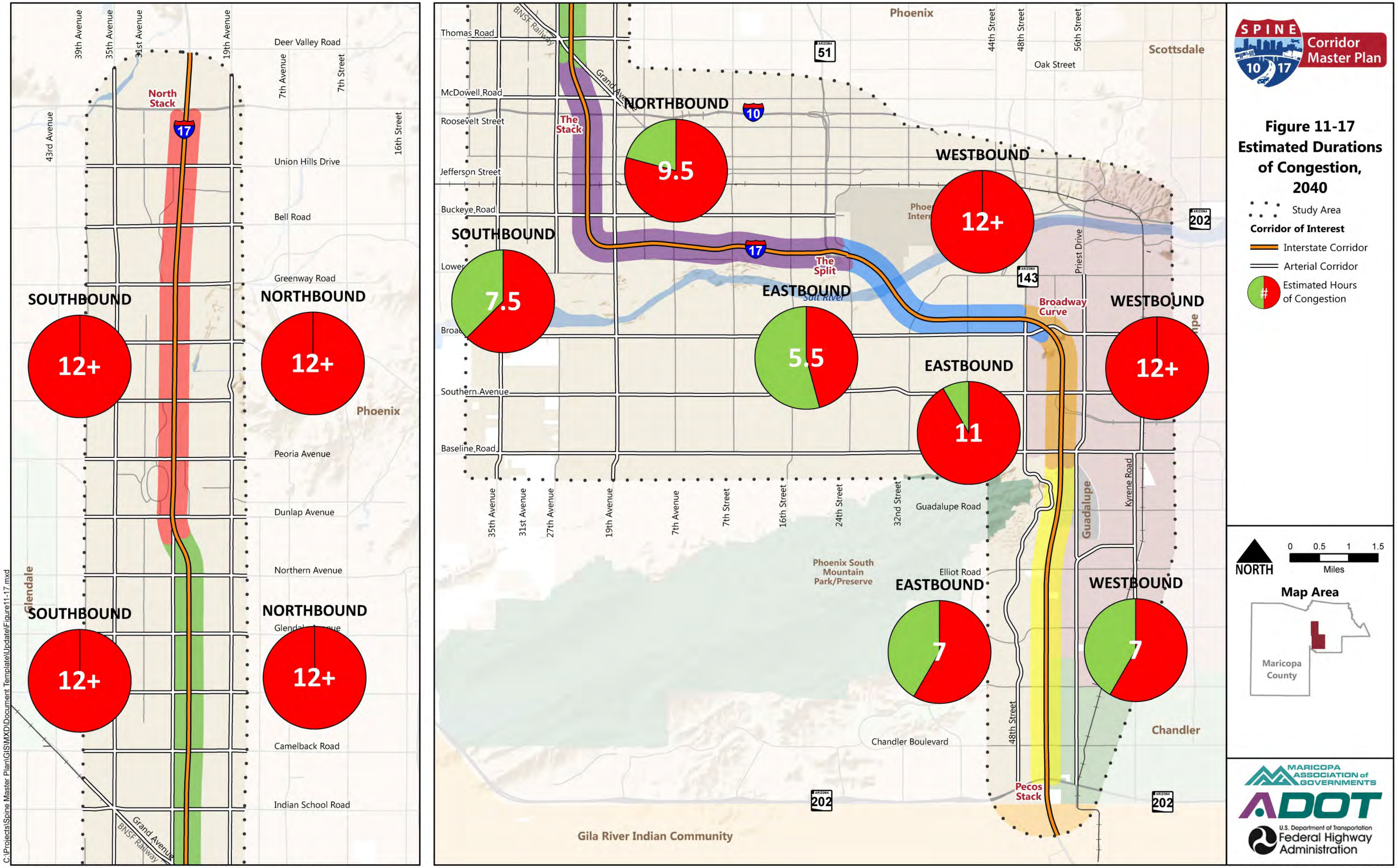
EVENING TRAVEL TIME IN MINUTES:

- # - Uncongested Conditions
- # - 2040
- ◯ - Sample Trip Travel Time
- # - Today

HOW TO READ THE MATRIX – 2040 SAMPLE TRIP TRAVEL TIME:

From D to A = Total 45 minutes

Figure 11-17 Estimated Duration of Congestion, 2040



Data Source: ADOT, ALRIS, FEMA, MAG Travel Demand Model

Map Last Updated: 5/13/2016

11.3 Purpose for the Proposed Action

The overarching purpose of the action being studied in the I-10/I-17 Corridor Master Plan is to identify and budget for preferred alternative solutions to the transportation challenges facing I-10 and I-17 to function within a regional transportation system as outlined above. The preferred solutions would include actions to:

- Provide capacity for future travel demand generated by projected population and employment growth
- Improve regional traffic flow and mobility through the corridor by reducing travel times and duration of congestion
- Reduce congestion on the local arterial street network and retain local access
- Efficiently accommodate regional and Interstate movement of people and goods
- Improve mobility in the corridor to be safer and more reliable
- Support economic vitality by providing efficient and convenient access to businesses and activity centers within the corridor
- Support system linkages and multi-modal connections within the corridor
- Meet regional goals and objectives, as well as satisfy voter expectations and mandates

The two Interstates are integral to the RFS, the region's integrated system of beltway and arterial freeways. This system serves as a principal component of the previously-described 2003 RTP, which provides a broad, integrated vision for the regional transportation system, addressing freeways, streets, transit, airports, bicycle and pedestrian facilities, freight, demand management, system management, and safety. The plan, which is regularly updated, includes only projects for which funding is available or is reasonably expected. It is a performance-based, integrated plan that recognizes different transportation needs in different areas of the MAG region.

Most of the transportation problems validated herein were identified in the RTP, its supporting documents, and past planning studies. Consequently, one of the purposes of the action would be to meet regional goals and objectives as established in the RTP, as well as satisfy voter expectations and mandates. The voter mandates are exemplified by the passages of Propositions 300 and 400. Voter approval of the one-half cent sales tax in 1985 (Proposition 300) and its continued endorsement in 2004 (Proposition 400) establish a history of continued public support for investment in regional transportation projects. Results from the *Maricopa County Official Canvas* (Maricopa County 2004) indicate voters in 90 percent of the County's 1,058 voting precincts voted in favor of Proposition 400 and the projects it would fund, which included major improvements to I-10 and I-17.

11.4 Conclusions

Information presented in this report shows that without major improvement to the transportation network in the corridor, the region's transportation network would suffer. Recognized as a potential transportation problem in the early 2000s (and as validated in this report), the already challenged movement of goods, services, and people would worsen in the foreseeable future. Travel demands from the projected growth in population, housing, and employment would continue to outpace the corridor's capacity to handle the demand, forcing commercial and non-commercial motorists to drive for much of each day in congested conditions. Other forms of travel (such as bus rapid transit and HOV use) dependent upon optimal performance of I-10 and I-17 in the corridor would also experience substantially reduced travel conditions. In all cases, stop-and-go traffic in the corridor would increase, and more costly delays in getting to and from destinations would result. Correspondingly, productivity would decline.

Major points in defining the transportation problem in the corridor are as follows.

- A comparison of projected distribution of future population disbursement against the projected employment centers reveals the demands historically placed on I-10 and I-17 as major commuter routes would continue in the foreseeable future. The existing and future need to continue to provide reliable routes for commercial traffic generated by the high density of businesses within the corridor would further exacerbate the suboptimal travel conditions.
- Already high traffic volumes are projected to continue to increase throughout the corridor. The demand on the system is exemplified by the conclusion that, for some segments of I-10 and I-17, 24-26 freeway lanes would be necessary to accommodate free-flow traffic.
- An analysis of LOS of both the arterial and freeway network and of the traffic interchanges in the corridor revealed poor operational characteristics for some of the facilities in the corridor would worsen in the foreseeable future.
- Already unacceptable travel times during peak travel periods would substantially worsen over time. Time lost for a single commuter because of congestion would equate to 3 ½ days each year.
- The duration of congestion would increase over time with some segments of the corridor experiencing 12 or more total hours of congestion each day.
- Parts of each Interstate warrant replacement or upgrade because of either design life expiration or the need to address more modern demands placed on the infrastructure.

In short, the Interstates, arterial streets, and traffic interchanges in the Spine corridor would not operate reliably nor efficiently with the socioeconomic indicators forecasted for the foreseeable future. Without major improvements, the corridor and its surroundings would suffer even greater costly congestion, travel delays, and limited options for moving goods, services, and people through the corridor.

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