State Route 377

Road Safety Assessment

from SR277 to SR77

October 2022

Prepared for:

Arizona Department of Transportation, Traffic Safety Section
1615 West Jackson Street, Mail Drop 065R
Phoenix, Arizona 85007-3217

Prepared by:

Michael Baker INTERNATIONAL
We Make a Difference
Phoenix, Arizona

4M SAFETY

In association with:

Arizona Road Safety Assessment Program
Arizona Department of Transportation, Traffic Safety Section

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Project Introduction

This project was initiated by the Arizona State Senate through Senate Bill 1820 as a response to residents expressing concerns about the safety of the SR 377 corridor. The Arizona Department of Transportation (ADOT) selected Michael Baker International to conduct a roadway safety assessment (RSA) using funds appropriated by the Senate bill.

RSAs are formal examinations of intersections or entire road corridors from a safety performance viewpoint. The concept of RSAs originated in the UK in the 1990s and has been adopted in many countries with much success. The ADOT RSA program was developed based on the Federal Highway Administration (FHWA) program guidelines.

All RSAs are performed by an independent multi-disciplinary team and are led by an experienced person trained in performing RSAs. The RSA team considers the safety of all road users, qualitatively estimates, and reports on potential road safety issues, and identifies opportunities for safety improvements. The RSA team reviews police crash reports and conducts field observations during different times of the day such as day/night and peak/non-peak hours.

This RSA was conducted on the entire length of SR 377 between SR 277 and SR 77. The RSA team reviewed crash data, traffic volumes, law enforcement experience, resident survey responses, observed existing conditions in the field along the study corridor, and recommended potential solutions to improve the overall safety performance of the state route.

A detailed map showing the RSA limits is shown in **Figure 1**.

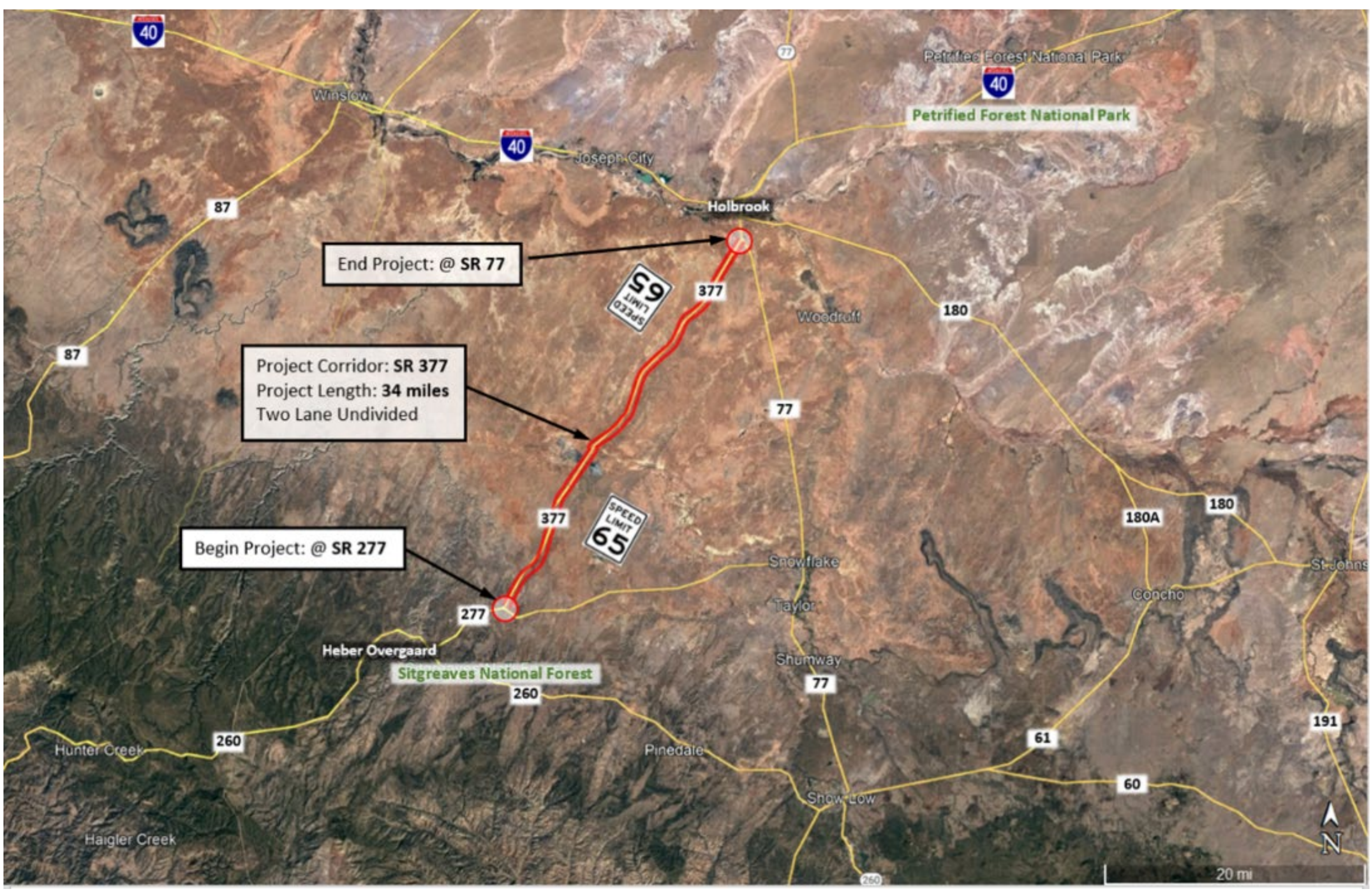


Figure 1 – Location Map

RSA Team

The independent, multi-disciplinary RSA team was led by Smitha Kundur, Traffic Section Manager from Michael Baker International. The RSA team and the key stakeholders included:

RSA Team

- Kerry Wilcoxon, P.E., PTOE, RSP_1 – ADOT, State Traffic Safety Engineer
- Amirul Rajib, P.E. – ADOT, RSA Program Manager
- Smitha Kundur, P.E., PTOE – Michael Baker International, RSA Team Leader
- Nathan Zigler, P.E. – Michael Baker International, Project Engineer
- Michael Kuzel, P.E. – 4M Safety, Human Factors Expert
- Daniel Oldham – ADOT, Engineering Specialist
- Zach Singer – ADOT, Engineering Support
- Glen Robinson – ADOT, Traffic Enforcement Support

Stakeholder Team

- Ed Wilson – ADOT, Northeast District Engineer
- Carl Ericksen – ADOT, Northeast Assistant District Engineer
- Captain Jeffrey Sharp, District 3 Captain, Department of Public Safety (DPS)
- Chief Deputy Brian Swanty, Navajo County Sheriff

RSA Process

A Road Safety Assessment is a formal examination of road user safety by an independent, multi-disciplinary team which includes experienced and qualified members. The RSA team followed the processes described by the FHWA RSA Guidelines. A brief description of the process is described in this section followed by detailed descriptions in the following sub-sections.

The initial stages of this project involved developing an understanding of the characteristics of the corridor using aerial imagery, GIS software, and other digital mapping tools, and reviewing resident perspective that ADOT gathered via a public survey. Traffic volume and crash data were collected and reviewed, and the team presented a summary of this information to the project stakeholders in a start-up meeting. The start-up meeting provides an opportunity for the RSA team to get background information on the project corridor from the stakeholders, and for the RSA team and stakeholders to coordinate objectives, schedule, and responsibilities.

Following the start-up meeting, the RSA team conducted field reviews spanning multiple days for various driving conditions. Existing roadway characteristics and driver behaviors were observed. RSA team members formed independent evaluations, and then collaboratively discussed these evaluations with the other team members to inventory safety issues and develop effective solutions. The team debriefed the project stakeholders with a presentation of field findings and preliminary recommendations of proposed safety countermeasures. Further review and evaluation of the field conditions and background information refined the recommendations made in this report, however most of these were initially presented in the debriefing meeting. To provide information that would assist in prioritization and funding opportunities, planning level cost estimates for recommendations are provided as well as a benefit-cost analysis was completed where appropriate crash modification factors are available for proposed countermeasures.

The following sub-sections provide more detailed discussions of the RSA process described above:

Roadway Characteristics

SR 377, approximately 33.8 miles long between SR 277 and SR 77, is a rural, undivided, two-lane highway. It is the primary route connecting the small communities of Holbrook and Joseph City to Heber-Overgaard and the subsequent Mogollon Rim communities further west along the SR 260. The roadway traverses generally flat/rolling terrain through sparse pinion and juniper forest at an average elevation of approximately 5,500 feet. The roadway alignment has numerous horizontal and vertical curves. Land ownership adjacent to the roadway includes the US National Forest, Bureau of Land Management, Arizona State Trust Land, and private ownership, essentially un-populated in the immediate vicinity. The roadway has passing/no-passing zones but no dedicated passing lanes and a posted speed limit of 65-mph along the entire project corridor. Numerous unimproved fire roads and access roads intersect SR 377 along the length of the corridor. Key features are bulleted below:

- 2 through Lanes (1 NB & 1 SB lane)
- Narrower travel lanes (varies between 11' and 12' wide)
- 200 feet right-of-way
- Minimal paved shoulders (less than 2' from edge line for majority of roadway)

Traffic Volume Data

The traffic count firm, All Traffic Data Services (ATD) collected 24-hour average daily traffic volumes (ADT) in 15-minute intervals over a 7-day period (June 1st – 7th, 2022). The data was collected at three different locations along the corridor as shown in **Figure 2**. Traffic volume, speed, and vehicle classifications are also included in **Figure 2**.

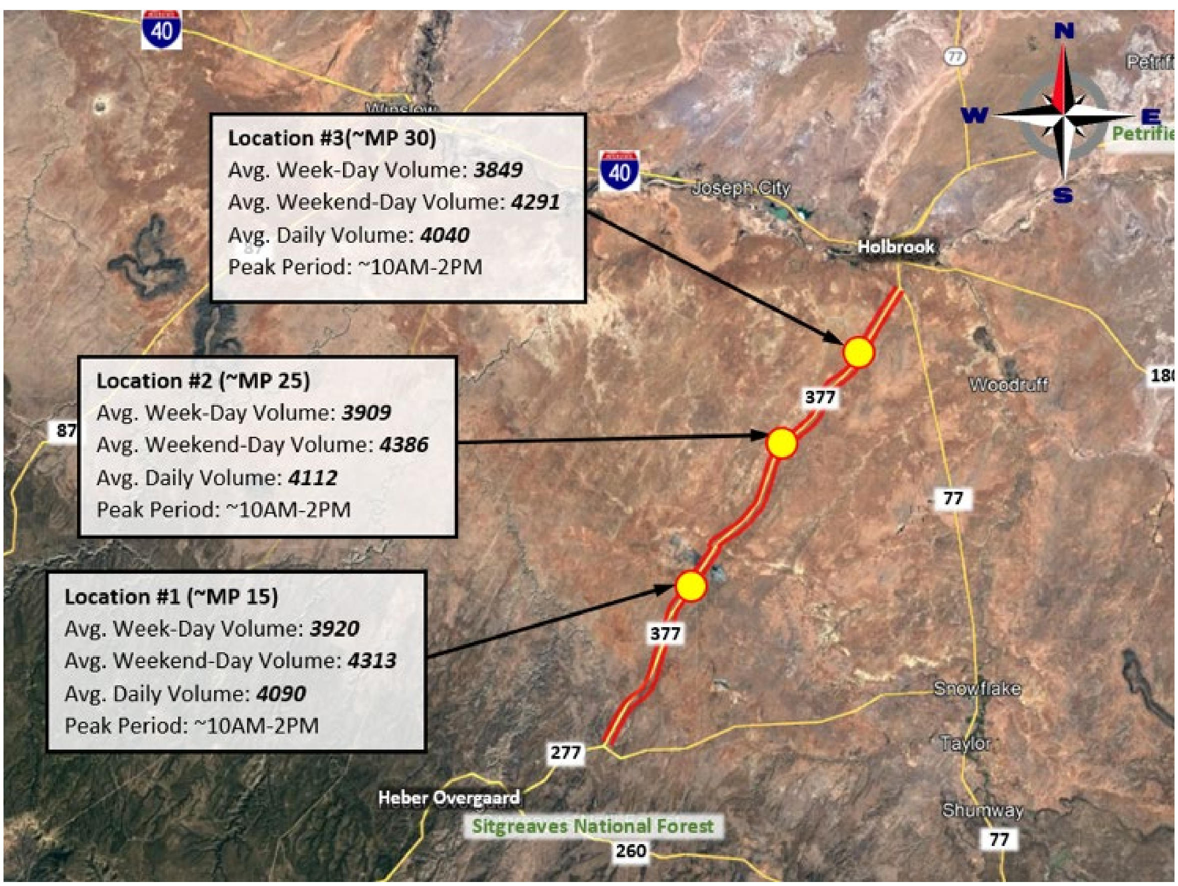


Figure 2 – Traffic Volumes

The historical ADT along the corridor was collected for previous years from the ADOT Traffic Data Management System (TDMS) website. **Table 1** shows the historical traffic volumes and the calculated growth rate for the corridor. SR 377 experienced an approximate 4% annual growth rate in traffic volume which was relatively steady until the last several years which first saw a decline (likely related to Covid-19 pandemic effects) and then a large rebound. According to input from law enforcement familiar with the area, the significant surge in volume seen since 2020 correlates to mobile phone mapping applications changing suggested routes for the Petrified National Forest to use SR-377. Other anecdotal evidence suggests that trucks were increasingly using SR-377 as a cut through route to the Interstate 40. The vehicle classification data shown in **Table 2** and **Appendix B** shows a significant average heavy vehicle and bus percentage of 14%.

Table 1 – Growth Rate

Year	ADT	Yearly Growth %	Average Growth %
SR 377			
2016	2,607		
		3.80%	
2017	2,706		
		4.84%	
2018	2,837		
		3.35%	5.51%
2019	2,932		
		-7.71%	
2020	2,706		
		23.29%	
2022	4,113		

Table 2 – Traffic Classifications

Traffic Classifications	
85%	Passenger Vehicles
13%	Heavy Vehicles
1%	Motorcycles
1%	Buses

Traffic volume patterns through a 24-hour day were similar for all days of the week and showed a distinct peak occurring from 10 AM to 2PM, as shown in **Figure 4** below.

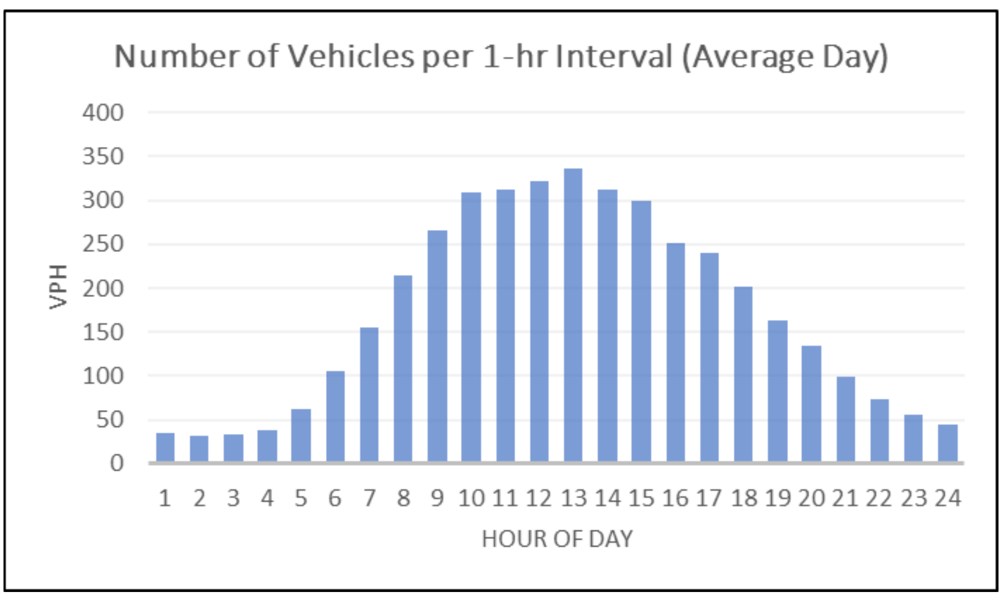


Figure 3 – Graphical Representation of Daily Volumes

Speed data was collected at the three locations. 85th percentile speed along the corridor is shown in **Figure 5** below for each day. The average 85th percentile speed for all days is 72 MPH, which is just 7 MPH over the posted speed limit of 65 MPH.

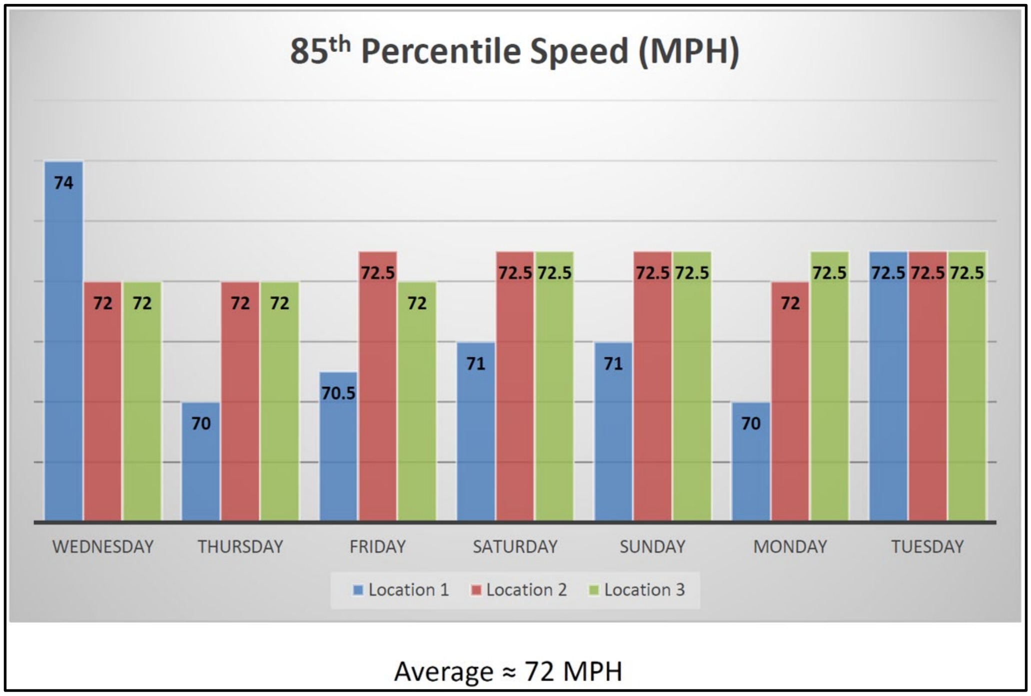


Figure 4 – Pedestrian and Bicyclist Volumes

Evaluation of Crash Data

The last full five years (2017 to 2021) and partial year (2022) crash data was provided by ADOT and summarized by the RSA Team and presented in the start-up meeting. The crash data figures are found in **Appendix B** and a summary of the crashes are shown below:

- There were 170 total crashes on SR 377 from January 1st, 2017, to May 31st, 2022
- The majority of the crash types on SR 377 are single vehicle (68%)
- Approximately 23% were passing related crash types (head-on & sideswipes)
- 5 fatal, 22 suspected major injury, 45 suspected minor injury, 98 possible or no injury
- 60% of crashes occurred in a light condition, 32% in dark conditions, and 8% during dawn or dusk
- There was one pedestrian related fatality
- There were no bicycle related crashes
- Crashes were consistent throughout the entire corridor without obvious hotspots

In addition to the crash data, ADOT also provided the RSA team with the detailed crash reports for all fatal and injury crashes. The team reviewed the crash reports after observing existing conditions in the field. A summary of the crash report details is shown below:

- Three of the five fatal crashes were head-on crashes related to passing
- Majority of the opposing direction side swipes are the result of passing
- Numerous single vehicle crashes were likely to have resulted from overcorrecting from edge of road departures and many of these resulted in re-entering the road and crossing into the opposing lane, risking a more severe incident
- Numerous non-fatal crashes were high risk incidents that could have been fatal had they occurred at a slightly different time

Public Survey

ADOT developed and initiated a public survey to gather the perspective of area residents and frequent road users. The survey was conducted from February to March 4th, 2022, via an online survey hosted on ADOT's website and paper survey questionnaires that were mailed to residents and provided to local businesses. Local and online news outlets provided coverage to increase public awareness and ADOT received a high number of responses, indicating a high level of public awareness was achieved. The survey questionnaire consisted of 4 questions and an opportunity for open ended comments. ADOT provided the RSA team the survey results to be evaluated as part of this project. Survey responses are summarized below. Detailed questionnaire survey results are included in **Appendix B:**

- The top three primary safety issues based on the survey responses are, in the order of priority:
  - Not enough passing lanes
  - Driver behavior
  - Road is too narrow
- The top three safety related improvements (of eight options) based on the survey responses are, in order:
  - Add more passing lanes
  - Widen the roadway
  - Extend the length of existing passing lanes
- Common concerns expressed in the open-ended comment portion of the survey are:
  - Lanes feel very narrow, especially for bigger vehicles
  - Witnessing head-on "close calls" related to dangerous passing behaviors
  - Dangerous driver behaviors
  - The roadway is becoming busier

Start-Up Meeting

The Start-up Meeting was held virtually on Wednesday, June 22, 2022. The RSA team members presented the preliminary information to the project stakeholders, discussed project background information and the RSA's expected objectives and schedule.

Background information such as roadway geometry, crash data and traffic data were presented and discussed at the start-up meeting. A collaborative discussion was facilitated to share information and give the RSA Team more insight into the corridor before the field observations. During the start-up meeting, Department of Public Safety (DPS) and ADOT Northeast District officials provided the following information:

- It was mentioned that the recent increase in volumes may be correlated to mapping applications changing the suggested route to the Petrified National Forest to use SR 377
- The District has been placing asphalt millings on the shoulders throughout the corridor to stabilize the shoulder from erosion and provide a more forgiving roadside edge for drivers
- There were recently constructed improvements (2019) along prominent horizontal curves that improved curve superelevation, shoulder width, signing and pavement marking
- Local driving experience suggests heavy aggressive driving between milepost 8 to milepost 15
- Trucks were previously restricted from using SR 377 back in the late 1990's or early 2000's

Field Reviews

Field reviews were conducted Thursday, June 23rd and Friday, June 24th, 2022. These days were chosen to observe both weekday and weekend driving conditions. The temperature during the day-time field observations for both days was in the high 80s and the weather was mostly sunny with occasional rain as afternoon thunderstorms quickly passed through the area. Site reviews consisted of driving the entire corridor, walking various portions to take spot measurements and observe roadside conditions. The RSA Team divided into three groups for the initial drives through the corridor to provide greater opportunities to observe road user's behavior and to foster a more diverse observational perspective of the roadway. Careful attention was given to observing driver behaviors such as passing tendencies and aggression, how users were interacting with the roadway environment and situations posed by the complexities, and variables that it creates. In addition to multiple drives through the corridor in both directions in separate vehicles, the RSA Team also drove the corridor multiple times in a single vehicle to collaboratively discuss observations. Drives through the corridor were deliberately timed so that the RSA team could observe all periods of the corridor traffic throughout the day (off peak/on peak and daylight/night conditions). The periods that the team drove SR 377 are listed below:

- ✓ Morning off peak (prior to lunch time peak period starting around 10 AM)
- ✓ Peak period (between 10AM to 2PM)
- ✓ Afternoon off peak (after 2PM)
- ✓ Dark (After 8 PM)

A summary of the types of data collected during the field reviews:

- Observational Data
    - ✓ Driver behaviors
    - ✓ Traffic patterns
    - ✓ Roadway environment
- Measurable Data
    - ✓ Lane widths
    - ✓ Pavement widths
    - ✓ Edge of pavement heights
    - ✓ Roadway embankment slopes
    - ✓ Sign dimensions
    - ✓ Ball bank

Preliminary Findings Meeting

The RSA team members who conducted the field review presented the preliminary findings from the field reviews Friday, July 1st, 2022, to the project team and project stakeholders. Attendees were:

- Amirul Rajib – ADOT
- Kerry Wilcoxon – ADOT
- Mona Aglan-Swick – ADOT
- George Williams -ADOT
- Daniel Oldham – ADOT
- Ed Wilson – ADOT
- Glen Robinson – ADOT
- Zach Singer – ADOT
- Anthony Castleman – ADOT
- Jason Stephens – ADOT
- Stephen Craver – ADOT
- Captain Jeffrey Sharp – AZDPS
- Chief Deputy Brian Swanty – NCSO
- Smitha Kundur – Michael Baker International
- Nathan Zigler – Michael Baker International
- Spenser Samour – Michael Baker International
- Michael Kuzel – 4M Safety

During this meeting, the preliminary findings by the RSA team and the potential opportunities for safety related improvements for SR 377 were discussed. These preliminary findings and improvements were refined and developed into the final recommendations described in the later sections of this report.

Observations and Recommendations

Good Practices

It is important to have a complete understanding of how a roadway corridor is operating when conducting an RSA and part of that is recognizing what features are contributing positively to its function. A summary of good practices that the RSA Team observed is listed below and examples are shown in **Figure 6**:

- Safety improvements along prominent horizontal curves include:
  - Chevrons
  - Delineators
  - Warning signs
  - Widened paved shoulders (~4')
  - Edge rumble strips
  - Pavement marking has good reflectivity at night
- Advance curve warning signs and advisory speed limits appropriate based on the field ball bank data
- Millings placed on shoulder (approximately 30 to 40 percent based on field observations)
- Appropriate posted speed limits based on the 85^{th} percentile speed
- Good sign reflectivity along entire corridor
- Transverse rumble strips at the ends of the corridor for advance warning of intersections
- "No Passing Zone" signs along corridor that matches striping
- Significant lengths of the corridor have tapered edge of pavement, minimizing edge drop off
- Millings placed on shoulders provide benefit vs untreated
- Adequate un-paved shoulder at Despain Ranch Road and SB Zineff Road for turning vehicles to decelerate
- Exclusive northbound right-turn lane at access road at M.P. 7

Figure 5 – Good Practices

Human Factors Evaluation and Crash Characteristics

Highway systems have three primary components: the roadway, traffic control, and users. Highway designers and traffic engineers must integrate the needs and constraints of all three components to provide a safe and operationally efficient system. While studies have reported that human factors represent a significant portion of the cause for crashes on the highway system, the performance, decision making, and behavior of road users is known to be influenced by features and conditions of the roadway and traffic control. Safe roads exist when highway designers and traffic engineers recognize that humans make mistakes, that humans are vulnerable, and that redundancy is critical. Highway designers and traffic engineers can meet the goal of providing a safe road by providing features and conditions that make roads self-explaining for all types and classes of users and more forgiving.

Review of the crash reports revealed two primary factors that contributed to most of the crashes along the corridor: 1) lane departures that led to runoff road single vehicle crashes; and 2) vehicles attempting overtaking maneuvers at inappropriate locations or with insufficient gaps, which may lead to head-on, sideswipe or runoff road single vehicle crashes that involve the overtaking vehicle or uninvolved vehicles.

The field reviews identified three driver behaviors that are likely to contribute to these crashes:

1. Drivers were generally observed to accept a shy distance, depicted in **Figure 6**, from the centerline to provide a larger lateral space for opposing direction drivers. This decision has the effect of moving the vehicle of these drivers towards the edge line. In areas where the pavement edge is close to the edge line, this increases the risk of a lane departure onto the unpaved shoulder. The occurrence of a road departure onto the soft shoulder further increases the risk of a steering overcorrection, leading to a single vehicle crash or return to the roadway and involvement of other vehicles in a crash.

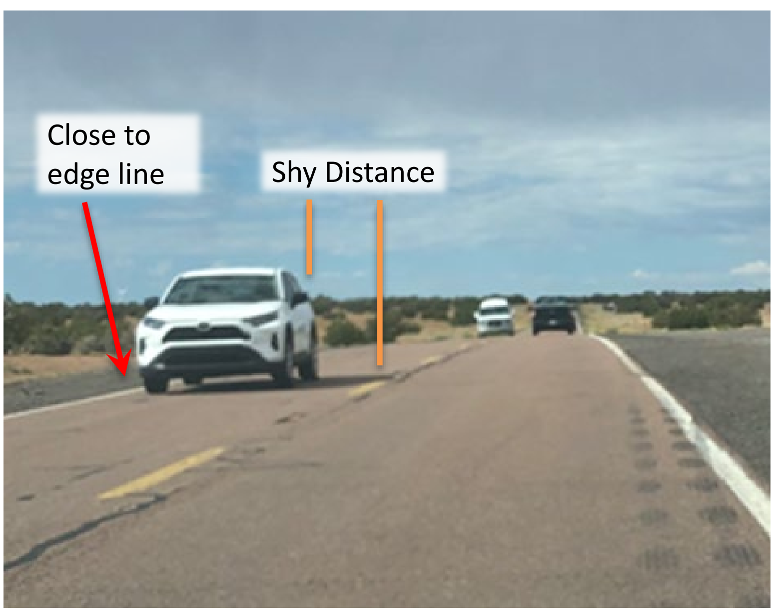


Figure 6 – Shy Distance

2. The drivers were observed to range in behavior, with some demonstrating more aggressive tendencies (i.e., passing in no passing zones, at higher speed and with short gaps) to others that had less to non-aggressive tendencies (i.e., driving the speed limit, not demonstrating a desire to pass, and moving away from passing vehicles). The mix of behaviors can be a contributing factor in crashes, especially when an aggressive driver approaches a slower moving platoon, as demonstrated in **Figure 7**. The overtaking attempts can lead to unnecessary, uncomfortable and potentially uncontrolled responses by the drivers being overtaken and approaching vehicles, including moving toward the road edge, and braking within or at the head of the platoon. The aggressive acts of drivers can also lead to aggressive acts by others.

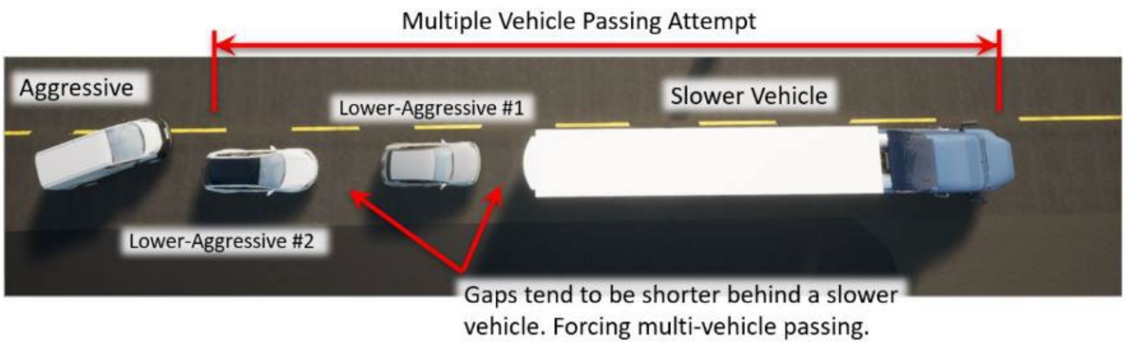


Figure 7 – Multiple Vehicle Passing Attempt

3. Drivers were willing to pass in no passing zones even without platooning and lead car traveling at the posted speed limit, as shown in **Figure 8**. While the decision may be a demonstration of impatience, the action will only occur because the overtaking driver feels comfortable making the overtaking maneuver. However, these actions also have the potential to lead to mistakes, both by the overtaking driver and in the responses of other road users. For example, while the pass may be successful, the overtaking driver may not appreciate the limited sight distance that warrants the no passing zone, which can lead to the need for an aggressing maneuver to return to the lane after the pass or an evasive steer away maneuver by the approaching driver, either of which can lead to a runoff road event and single vehicle crash.

Figure 8 – Passing in No-Passing Zone

Issues and Recommendations

The RSA Team carefully evaluated the background data included in the earlier sections of this report and extensively reviewed the existing roadway environment and driver behaviors observed in the field. Each member of the multi-disciplinary team drew upon their unique experiences and competencies to assess the corridor for issues and provide recommendations. The following are safety related improvements that the RSA Team recommends addressing safety issues observed on SR 377 and benefits and estimates for these recommended improvements.

1A Lane Delineation Issues

- Striping NOT along recent curve improvements is generally deteriorated, and in some places missing.
- Deteriorated striping is difficult to see at night and can contribute to losing track of lane with glare from opposing vehicles' headlights.

1B Lane Delineation Recommendations

- ➢ Refresh striping with retro-reflective pavement markings.
- Install centerline rumble strips.
- Install edge line rumble strips (requires wider shoulder).
- Human factors considerations: Striping provides feedforward guidance for steering inputs by drivers, especially during nighttime hours. A lack of striping or poor retro reflectivity will affect the visual guidance available to drivers, especially in conditions where they may be seeking assistance.
- ➢ Estimated Cost: $913,000 (See **Appendix C**).

Figure 9 – Pavement Marking Issues

1C Recommendations Construction Concept

- Striping on projects that are above 4,000' elevation is typically performed with dual part epoxy. The entire length of roadway should be re-striped to provide consistent appearance and lane delineation.
- Edge line and centerline rumble strips should be constructed as shown on ADOT Standard Drawing M-22 and detailed in the current ADOT Traffic Engineering Guidelines and Processes.

2A Emergency Pull-off Issues

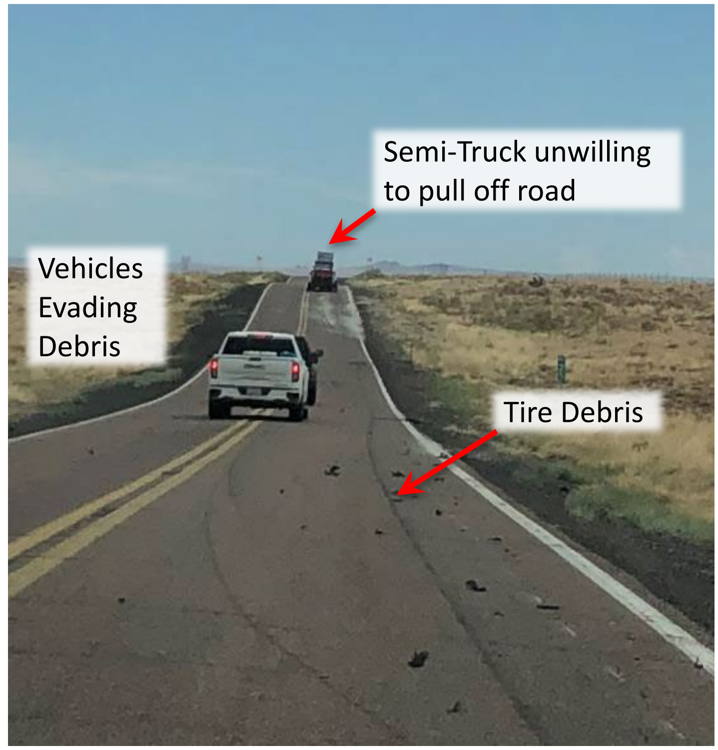


Figure 10 – Emergency Pull-Off Issues

- Significant lengths of corridor where shoulders are under-developed, pull-offs in an emergency would be uncomfortable or unsafe.
- Observed a Semi-Truck refusing to pull off the road for a flat tire for 10 miles. Tire eventually disintegrated, leaving large debris and causing vehicles to cross double yellow lines to avoid. Truck had hazards lights on indicating an intentional decision to not pull off the road.

2B Emergency Pull-off Recommendations

- Develop consistent and obvious graded pull-offs at 1-mile intervals for emergency use as an interim condition to shoulder widening.
- Human factors considerations: Graded pull-offs provide for system redundancy, accepting that driver will make mistakes, both during normal driving and during emergency situations.

➢ Estimated Cost: $566,100 (See **Appendix C**).

2C Recommendations Construction Concept

- A schematic conceptual design for graded shoulder widening to serve as emergency pull-off is shown below. The cross slope of the pull out should match the cross slope of the adjacent pavement. Asphalt millings could be placed on top and compacted to stabilize the shoulder to make it more apparent to drivers. One improved shoulder pull out should be constructed per mile per travel direction and should be constructed at locations to best maximize existing conditions available for pulling off the road.

Figure 11 – Conceptual Design for Emergency Pull-Offs

3A Access Roads Issues

- Multiple access roads intersecting SR 377 do not have shoulder widening or well graded unpaved shoulders to pull out of the travel way to decelerate.
- Access roads without solid yellow stripe to prohibit passing.

3B Access Roads Recommendations

- Develop graded shoulder areas for more frequently used access roads (10 locations) for vehicle deceleration.
- Place solid yellow stripes in front of all access roads to prohibit passing.
- Place Advance Intersection Warning signs to warn of possibility of turning or entering traffic.

➢ Estimated Cost: $123,300 (See **Appendix C**).

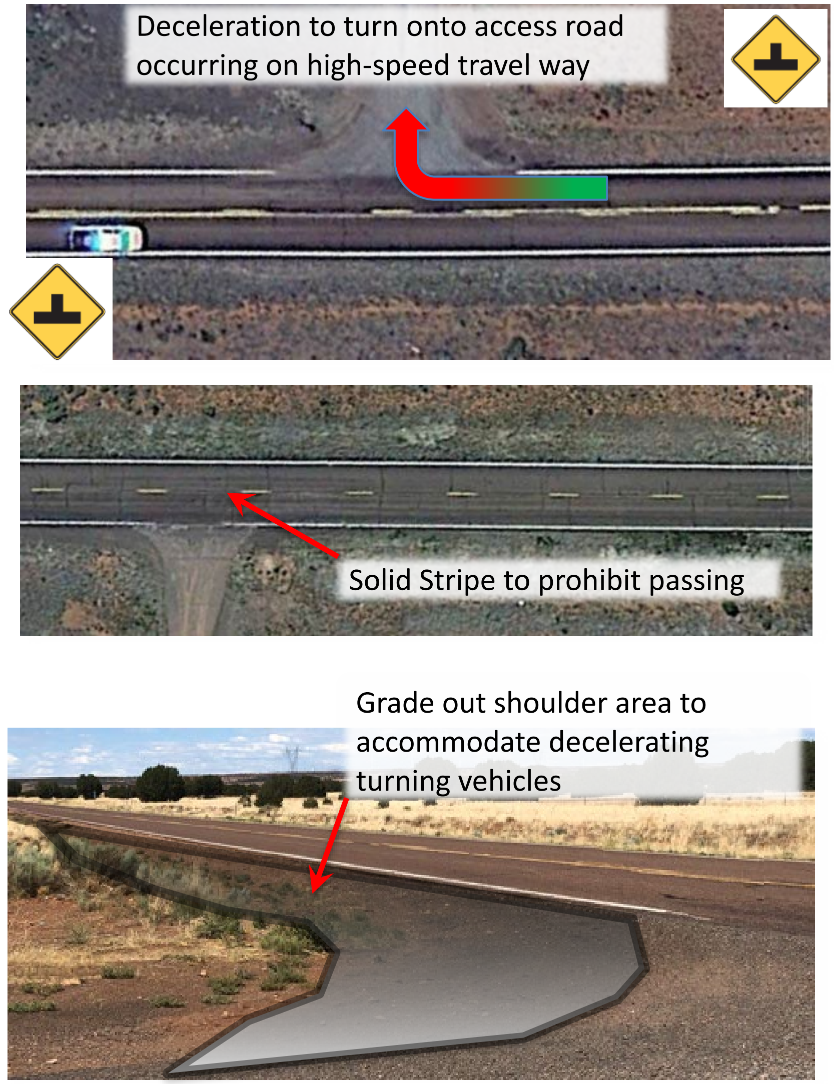


Figure 12 – Recommendations at Access Roads

3C Recommendations Construction Concept

- A schematic conceptual design for graded shoulder widening to accommodate vehicles decelerating outside of the paved travel lane is shown below along with a table showing the locations where this treatment is recommended:

Location (M.P.)
4.2 (SB)
8.4 (SB)
9.6 (NB)
9.9 (SB)
11.9 (NB)
15.3 (SB)
16.9 (NB)
24.6 (NB)
27.6 (SB)
31.3 (SB)

Figure 13 – Conceptual Design for Graded Shoulder at Access Roads

4A Roads Edge Issues

- Undesirable combination of the following:
  - Narrower (< 12 ft) lanes through the entire corridor.
  - Higher heavy vehicle percentage (14%).
  - Minimal edge of pavement beyond edge stripe.
  - Edge of pavement elevation drop offs over 3”, difficulty maintaining soil or millings at edge.
  - Driver shy distance pushes wheel path near edge.
  - Crash reports indicate vehicles leaving edge of road and overcorrecting.

4B Road Edge Recommendations

- Construct widened paved shoulders with safety edge.
- Widened shoulders will allow edge line rumble strips.
- “Shoulder Drop Off”, “Low Shoulder”, “No Shoulders” Warning signs as interim condition at appropriate locations.

➢ Estimated Cost: $47 Million (See **Appendix C**).

Figure 14 – Pavement Edge Issues

4C Recommendations Construction Concept

- Widen the roadway in both directions (9’ preferred) to provide width for 12 feet lanes and either 5 feet or 8 feet paved shoulder. Construct a safety edge to make the roadway more forgiving to lane departures.

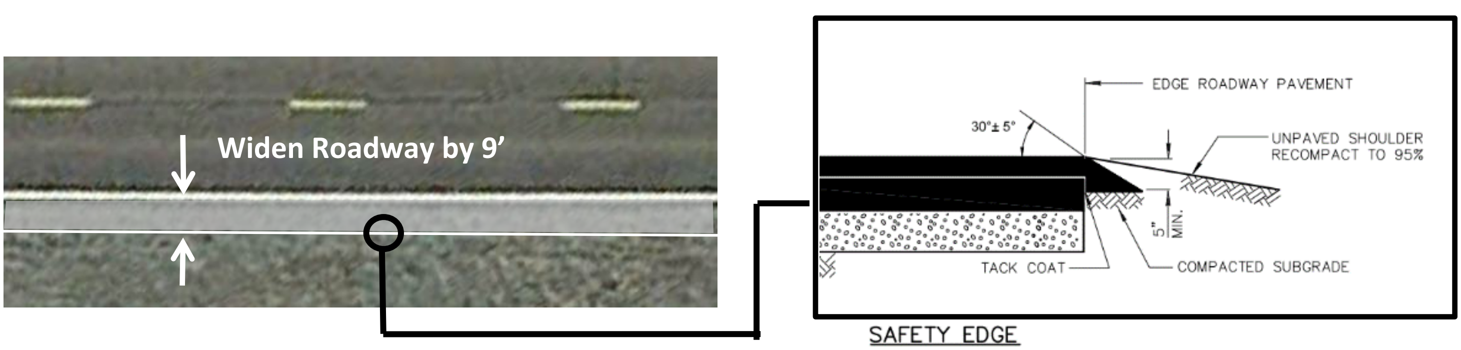


Figure 15 – Conceptual Design for Safety Edge

5A Passing Related Issues

- Human factors
  - Willingness to pass at no passing zones.
  - Impatience behind platoons of vehicles.
- Higher heavy vehicle percentage (14%)
  - Heavy vehicles are more likely to be passed.
  - Heavy vehicles are more difficult to pass.
- Recent traffic growth
  - Large recent growths in volume.
  - Higher volumes will increase passing interactions.
- Evaluation of Crash Data
  - Majority of fatality crashes are head-on.
  - Significant number of opposing side swipe crashes.
  - Many non-fatal crashes relating to passing could have been fatal.

Year	ADT	Yearly Growth %	Average Growth %
SR 377			
2016	2,607		5.51%
		3.80%	
2017	2,706		
		4.84%	
2018	2,837		
		3.35%	
2019	2,932		
		-7.71%	
2020	2,706		
		23.29%	
2022	4,113		

Figure 16 – Passing Related Issues

5B Passing Related Recommendations

- Construct passing lanes at strategic locations in both directions.
- Review existing passing zones at vertical and horizontal
- Human factors considerations: Adding passing lanes at strategic locations can aid to reduce driver aggressivity at inappropriate locations.

➢ Estimated Cost: $19 Million (See **Appendix C**).

5C Recommendations Construction Concept

- According to the ADOT Roadway Design Guidelines and the ADOT Policy on Design of Passing Lanes and Climbing Lanes, passing lanes should have a length between 1,300 ft and 2 miles and should be spaced at intervals between 3 and 5 miles. Passing lanes should be designed to ADOT Standard Detail M-4
- Using the criteria above, preliminary locations for recommended 1.50 mile long passing lanes were chosen to provide passing opportunities at existing no passing zones. Generally, these locations were selected on segments that would avoid conflict with existing access roads and would not fall on long segments of straight roadway where passing is easier.
- Passing lane recommendations include an 8’ wide adjacent shoulder, additional widening to include widening the existing narrow travel lanes to 12’ wide, matching the new 12’ wide passing lane width.
- The recommended passing lane locations assumes that NB and SB passing lanes are constructed adjacent to each other to minimize conflicts with access roads, however final locations should be evaluated further in a scoping report and preliminary design to consider existing roadway features and design configurations to accommodate constraints.

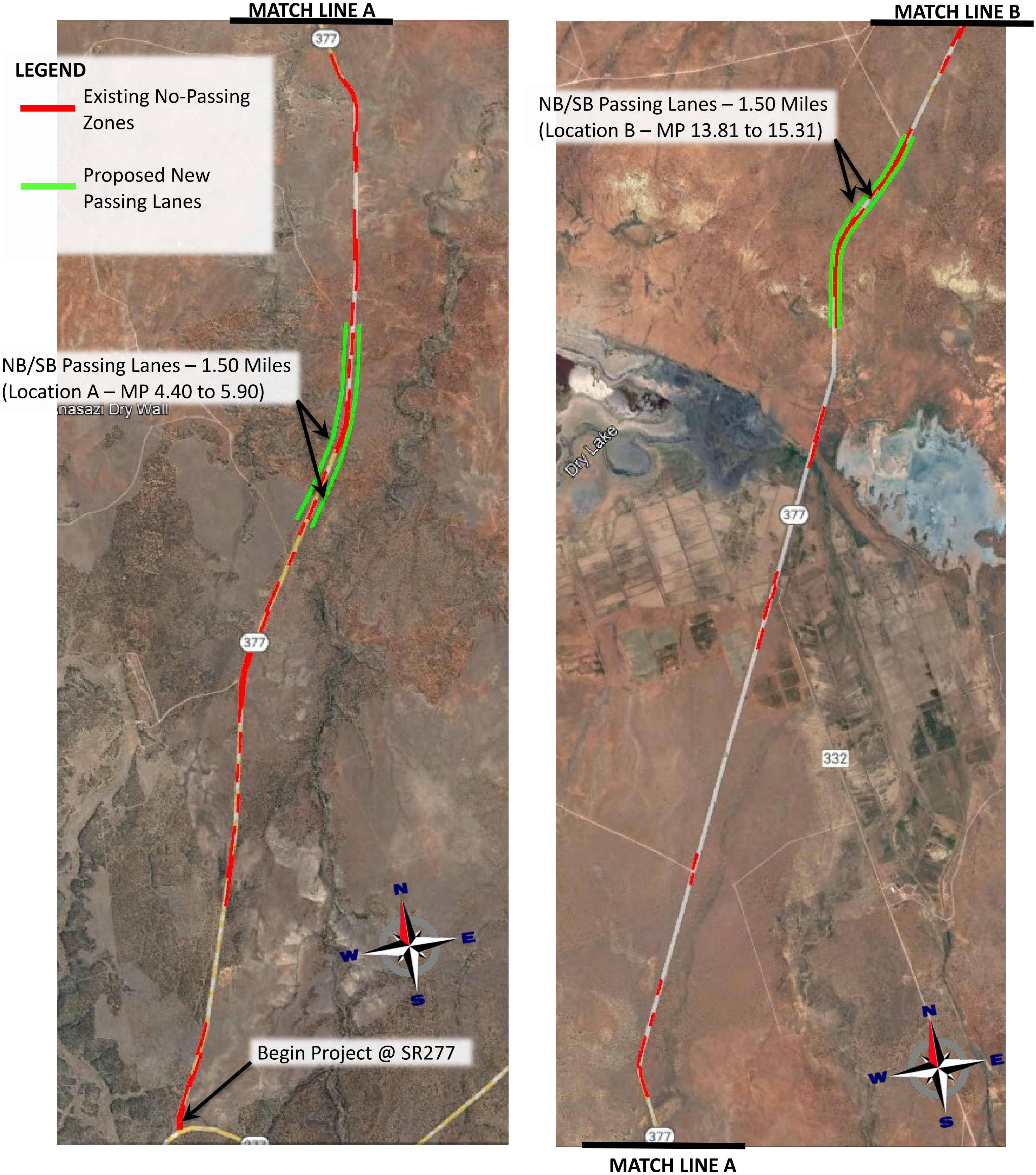


Figure 17 – Existing/Proposed Passing Zones

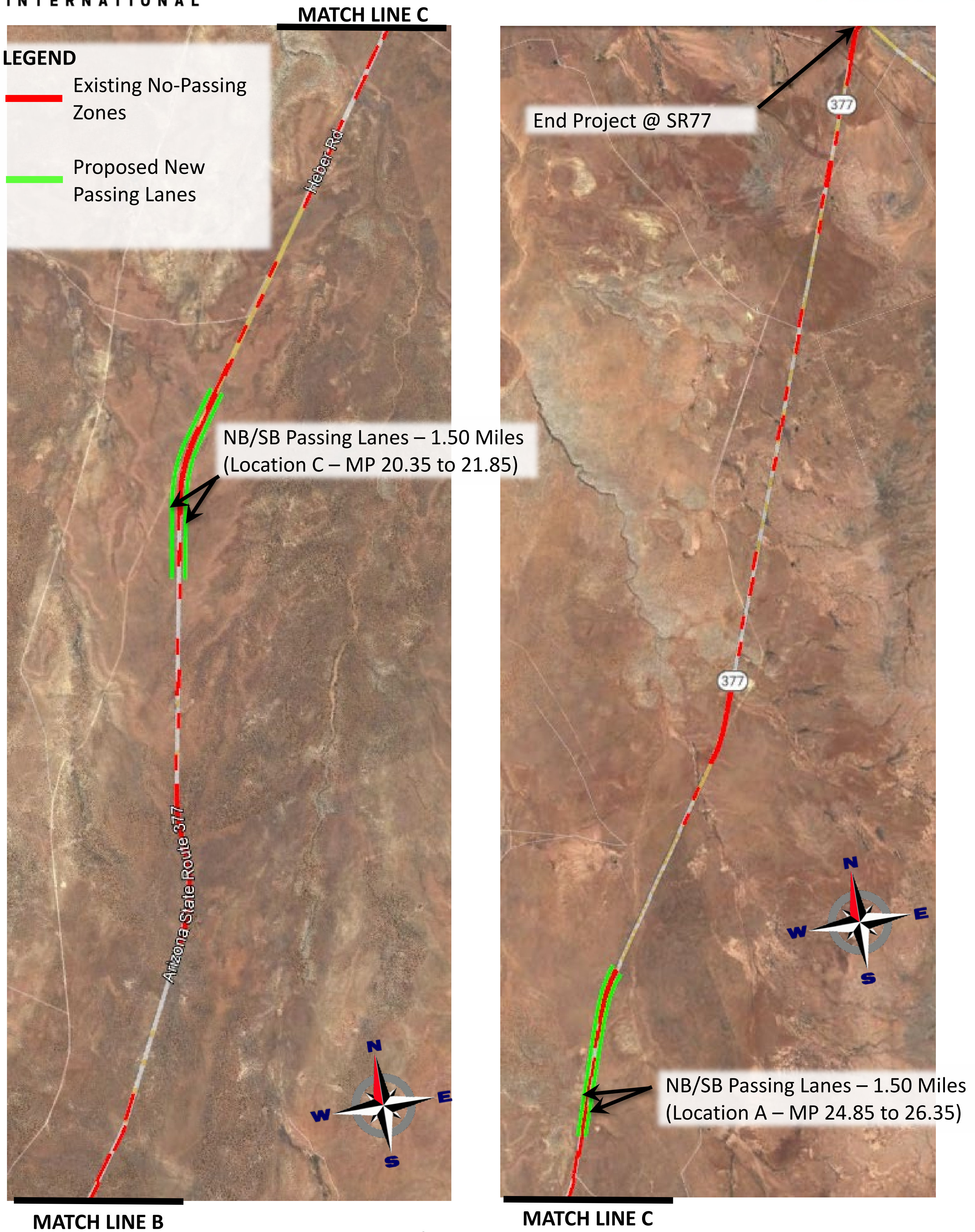


Figure 17 – Existing/Proposed Passing Zones (Continued)

Education

Based on the RSA Team's observations of the corridor and the evaluation of crash reports, specific efforts to increase education will not be likely to provide an improvement to roadway safety as the large majority of crashes occurring on the corridor are being caused by drivers who live outside of the region. Targeting these drivers with increased education would be impractical and any effort would be unlikely to result in any benefit.

Law Enforcement Perspective and Suggestions

The RSA team met with the key law enforcement stakeholders who manage enforcement activities on SR 377. Below is a summary of items that were discussed:

- SR 377 is a very difficult corridor for officers to provide enforcement activities because of the following factors:
  - The road width is not wide enough for officers to do a U-turn to pull over opposing direction traffic, officers must manage a 3-point turn which puts them and other drivers at greater risk.
  - There are inadequate locations that provide good opportunity for vehicles to pull over off the roadway if stopped by an officer. This results in unsafe situations for drivers and officers as drivers will either pull over at unsafe locations or will continue driving while the officer is attempting to pull them over.
- The lack of consistent shoulders, and steep shoulder grades in some areas, risks officer's vehicles being damaged or becoming stuck if the officers need to pull off the road.
- It was noted that this road had been a route that has restricted large trucks to travel on in the past, and this was a topic that was posed by the law enforcement stakeholders as something they viewed would positively impact SR 377 if the restriction was feasible to reinstate.
- It was noted that increasing the width of paved shoulders to 5' would still not provide enough width for officers to safely perform U-turns in the roadway or to safely pull over drivers to the side of the road.
- Law enforcement noted that they have seen a significant increase in traffic volume over the last several years
- Due to the existing conditions, **the risk to drivers currently outweighs the benefits of increasing enforcement**, however if shoulder and pavement widths are widened to provide a safe width to pull over drivers and to perform U-turns, increased enforcement activities would be feasible and would realistically reduce certain types of crashes and reduce unsafe driving behaviors.

Benefit-Cost Analysis

A benefit cost analysis (BCA) was performed for the countermeasures that are expected to mitigate crashes along the corridor that were recommended in the previous section. BCA was only calculated for the fatal and serious injury crashes per Federal Highway Safety Improvement Program (HSIP) guidelines. Systemic countermeasures are only evaluated for the BCA, spot improvements like graded shoulder at access points were not evaluated for BCA. Only 4- and 5-star crash reduction factors (CRF) available in the Clearinghouse website were used. CRF's for various countermeasures recommended for this project are included in **Appendix D**.

A description of the calculations of combined crash reduction factors (CCRF) and BCA process for each of the countermeasures is described below:

CCRF for Pavement marking improvements

Pavement marking improvements for the entire corridor are expected to include upgrading existing deteriorated markings to retro-reflective pavement markings and installation of centerline rumble strips.

Upgrade existing markings to retro-reflective pavement markings:

- Crash Reduction Factor (CRF1) = average of available crash reduction factors for all crash types (14.1) including fatal and serious injury crashes
- Crashes for countermeasure No. 1 = all crash types along the corridor (170). BCA is only calculated for fatal and serious injury crashes
- Total number of crashes = all crashes along the corridor (170)

Install centerline rumble strips:

- Crash Reduction Factor (CRF2) = average of available crash reduction factors for head on and sideswipe crashes (38.4) including fatal and serious injury crashes
- Crashes for countermeasure No. 2 = head-on and sideswipe crashes along the corridor (38). BCA is only calculated for fatal and serious injury crashes
- Total number of crashes = all crashes along the corridor (170)

CCRF = (CRF1 x no. of crashes for countermeasure No. 1/total cashes) + (CRF2 x no. of crashes for countermeasure No. 2/total crashes) = 22.68

CCRF for Shoulder improvements

Shoulder improvements are expected to include 1 foot for travel lane widening in each direction, 8 feet shoulder widening in each direction, edge line rumble strips and safety edge. CRF's are not available for lane widening, therefore, CRF' for shoulder widening, edge line rumble strips and safety edge are used to calculate the CCRF.

Shoulder widening with edge line rumble strips:

- Crash Reduction Factor (CRF1) = average of available crash reduction factors for all crash types and run-off road crashes (42.6) including fatal and serious injury crashes
- Crashes for countermeasure No. 1 = all crash types along the corridor (170). BCA is only calculated for fatal and serious injury crashes
- Total number of crashes = all crashes along the corridor (170)

Install safety edge:

- Crash Reduction Factor (CRF2) = average of available crash reduction factors for all crash types and run-off road crashes (16.3) including fatal and serious injury crashes
- Crashes for countermeasure No. 2 = all crash types along the corridor (170). BCA is only calculated for fatal and serious injury crashes
- Total number of crashes = all crashes along the corridor (170)

Combined crash reduction factor (CCRF) = (CRF1 x no. of crashes for countermeasure No. 1/total cashes) + (CRF2 x no. of crashes for countermeasure No. 2/total crashes) = 58.84

CCRF for Passing Lane improvements

Passing lane improvements are expected to include 1 foot for travel lane widening in each direction, periodic 12 feet passing lanes at 4 locations (total of 12 miles for northbound and southbound combined), shoulder widening, edge line rumble strips and safety edge at the passing lane locations.

Shoulder widening with edge line rumble strips:

- Crash Reduction Factor (CRF1) = average of available crash reduction factors for all crash types and run-off road crashes (42.6) including fatal and serious injury crashes
- Crashes for countermeasure No. 1 = all crash types with the 12 miles of passing lanes (61). BCA is only calculated for fatal and serious injury crashes
- Total number of crashes = all crashes along the corridor (170)

Install safety edge:

- Crash Reduction Factor (CRF2) = average of available crash reduction factors for all crash types and run-off road crashes (16.3) including fatal and serious injury crashes
- Crashes for countermeasure No. 2 = all crash types with the 12 miles of passing lanes (61). BCA is only calculated for fatal and serious injury crashes
- Total number of crashes = all crashes along the corridor (170)

Install periodic passing lanes:

- Crash Reduction Factor (CRF3) = average of available crash reduction factors for all crash types (38.5) including fatal and serious injury crashes
- Crashes for countermeasure No. 3 = all crash types along the corridor (170). BCA is only calculated for fatal and serious injury crashes
- Total number of crashes = all crashes along the corridor (170)

Combined crash reduction factor (CCRF) = (CRF1 x no. of crashes for countermeasure No. 1/total cashes) + (CRF2 x no. of crashes for countermeasure No. 2/total crashes) + (CRF3 x no. of crashes for countermeasure No. 3/total cashes) = 59.61

Benefit-Cost Ratio (BCR)

BCR is calculated individually for each of the three countermeasures described above using the BCR Tabulation for Arizona Department of Transportation (ADOT) HSIP application process. **Table 3** shows the BCR for each of the countermeasures. BCR calculations are included in **Appendix E**.

Table 3 – Benefit Cost Ratio

Counter Measure	Annual Benefit	Annual Cost	BCR
Pavement Marking Improvements	$2,707,440	$146,204	18.5
Shoulder Improvements	$7,024,064	$5,010,763	1.4
Passing Lane Improvements	$7,115,983	$2,052,462	3.4

As shown in **Table 3**, the annual benefits for shoulder improvements and passing lane improvements are much higher than the benefits for the pavement marking improvements. However, due to the high costs associated with shoulder improvements and passing lane improvements, the BCR is significantly lower for these two countermeasures compared to the pavement marking and rumble strip construction. It is important to note that it is common for lower cost countermeasures to have a higher BCR, which may draw attention away from the higher total benefit of the higher cost countermeasures. It is also important to highlight two limitations of the BCA for the shoulder improvement countermeasures that would understate the benefits. The first is that the BCA for this countermeasure cannot capture benefits that will occur due to increased law enforcement activities. The second is that the BCA does not consider the many no-injury or minor-injury crashes that would be prevented by shoulder widening that are inherently at high risk of having a higher severity outcome.

Safety Related Maintenance Issues

See **Appendix F** for Maintenance Checklist that details safety related maintenance issues observed in the field.

Tabular Summary of Improvements/Countermeasures

Table 4 summarizes the RSA team's observations and potential opportunities to improve safety. These suggested improvements/countermeasures are presented as options for consideration; the road owner may also identify other effective alternative improvements and countermeasures. While every attempt has been made to identify potential safety issues and provide countermeasure options, the safety performance of the roadway remains the responsibility of the roadway owner and roadway users. The safety related maintenance issues are not included in this table. A more detailed summary of potential safety countermeasures is provided in **Appendix D**.

The RSA team is available to provide additional clarifications to ADOT as they review and respond to this report and pursue countermeasures.

Table 4 – TABULAR SUMMARY OF IMPROVEMENTS/COUNTERMEASURES

Final Report Recommendations - RSA Team										
							Concept Implementation Estimates			
Suggested Countermeasure		Priority (H,M,L)	Affected Crash Type	Existing Fatal and Serious Injury Crashes	CMF	Exptd Crash Red Factor	DWG? (Y/N)	Concept Level Benefit①	Concept Level Cost①	Concept B/C
1	12 feet passing lane, 1 foot travel lane widening, 8 feet shoulders, edgeline rumble strips and safety edge at 4 locations (1.5 mile each)	H	All	27	0.4	59.61	Y	$7,115,983	$2,052,462	3.47
2	Install emergency pull-offs	H	All	27	*	*	Y	*	$566,100**	*
3	1 foot travel lane widening, construct 8 feet shoulder widening with edgeline rumble strips and safety edge for the entire corridor	M	All	27	0.41	58.84	Y	$7,024,064	$5,010,763	1.40
4	Upgrade existing marking to retro-reflective pavement markings, install centerline rumble strips	L	All	27	0.77	22.68	N	$2,707,440	$146,204	18.52
5	Install shoulder improvements for access roads	L	Rear ends	27	*	*	Y	*	$123,300**	*
6	Maintain/enhance shoulder millings	L	All	27	*	*	N	*	***	*
7	Signing (replace missing signs, delineators, object markers and add additional warning signs)	L	All	27	*	*	N	*	***	*

① Annuall benefits and costs. Please see appendix of the report for total costs
* CMF/CFR are not available
** One time construction cost only
*** Cost assumed as part of the NE District maintenance budget

Next Steps

The RSA Team requests that the road owner prepare a written response that addresses the potential safety issues and proposed countermeasures. This response can be sent to the RSA Program Manager and should identify how each of the safety issues will be addressed or give the basis for why they won't be addressed. The RSA Program Manager can provide an example response letter to assist in the response. Send the response letter to:

Amirul Rajib
RSA Program Manager
1615 W. Jackson St. MD065R
Phoenix, AZ 85007
Arajib@azdot.gov

APPENDIX A

RSA AGENDA

Michael Baker INTERNATIONAL

Michael Baker Jr., Inc.
Phoenix, Arizona

Michael Baker INTERNATIONAL

Project Memorandum

To:	Kerry Wilcoxon, PE, PTOE, RSP_1, ADOT Amirul Rajib, ADOT Daniel Oldham, ADOT Zachary Singer, ADOT Michael Kuzel, P.E., 4M Safety
From:	Smitha Kundur, PE. Michael Baker International Nathan Zigler, PE. Michael Baker International
Subject:	Road Safety Assessment for State Route 377, from Holbrook to Heber Intent of RSA and RSA Team Expectations
Date:	June 17th, 2022

INTRODUCTION

The purpose of this memorandum is to inform you of the Road Safety Assessment (RSA) project along State Route 377 from Holbrook to Heber. RSA Team members are expected to review the RSA information package, participate in RSA Days 1, 2, and 3, and review the draft RSA report.

The field reviews and debriefing for the study intersection are scheduled to take place on the following days:

- Project Kick-off Meeting – Thursday, May 26th
- Data Collection – Wednesday, June 1 – Tuesday, June 7
- Briefing Meeting (Virtual) – Wednesday, June 22nd
- Conduct Field Review – Thursday, June 23rd
- Conduct Field Review – Friday, June 25th
- Conduct Field Review – Saturday, June 25th
- Debriefing Meeting (Virtual) – Thursday, July 1st
- Draft Report – Friday, July 22nd
- Final Report – Friday, August 19th

The following sections will explain the reason for this RSA and the purpose of the RSA Team in addition to providing you with the project schedule and contact information for the individuals involved with this project.

Purpose

Road Safety Assessments are formal examinations of specific roadway intersections, segments or corridors from a safety performance viewpoint to identify safety improving recommendations. The Arizona Department of Transportation (ADOT) RSA program was developed based on the Road Safety Audit Guidelines published by the Federal Highway Administration (FHWA) and this RSA will follow the approach detailed by these guidelines.

All RSAs are performed by an independent multi-disciplinary team and are led by a person trained in performing RSAs. The RSA team considers the safety of all road users, qualitatively estimates and reports on potential road safety issues and identifies opportunities for safety improvement (prioritized by risk). The RSA team reviews law enforcement crash reports and conducts field observations during different times of the day such as day/night and peak/non-peak hours.

RSAs focus on identifying practical and obtainable road safety solutions at roadways with high crash risk in the region. As with all RSAs, the aim will be to answer the following questions:

- What elements of the road may present a safety concern: to what extent, to which road users, and under what circumstances?
- What opportunities exist to eliminate or mitigate identified safety concerns?

STUDY AREA AERIAL

PROJECT PARTICIPANTS

Name	Agency	Email	Phone
Project Participants			
George Williams	ADOT	gwilliams2@azdot.gov	602-262-4613
Mona Aglan-Swick	ADOT	maglan-swick@azdot.gov	602-712-7343
Anthony Casselman	ADOT	acasselman@azdot.gov	602-495-7065
Jerry McCoy	ADOT	jmccoy@azdot.gov	602-262-7173
John Litteer	ADOT	jlitteer@azdot.gov	
Jason Stephens	ADOT	jstephens@azdot.gov	
Glen Robinson	ADOT	grobison@azdot.gov	
Ed Wilson	ADOT	jwilson@azdot.gov	
Spenser Samour	Michael Baker International	spenser.samour@mbakerintl.com	602-798-7532
RSA Team Members – ADOT Project Manager			
Kerry Wilcoxon	ADOT	kwilcoxon@azdot.gov	602-712-2060
RSA Team Member – Team Leader			
Smitha Kundur, P.E.	Michael Baker International	Smitha.kundur@mbakerintl.com	602-294-2253
RSA Team Members – RSA Team Member			
Amirul Rajib	ADOT	arajib@azdot.gov	602-712-2332
Daniel Oldham	ADOT	doldham@azdot.gov	
Zachary Singer	ADOT	zsinger@azdot.gov	
Nathan Zigler, P.E.	Michael Baker International	NZigler@mbakerintl.com	602-798-7555
RSA Team Member - Human Factors Expert			
Michael Kuzel, P.E., CHFP	MAG	MKuzel@4MSafety.com	480-625-0872

SCHEDULE

Friday, June 17th – Final RSA information package to RSA team via email

Wednesday, June 22nd – RSA Day 1, Briefing Meeting

- Location: Virtual
- Attendees: RSA participants and team members

Thursday, June 23rd – RSA Day 2 Reviews

- Starting at 10 AM
- Location: on-site
- Attendees: RSA team members
- Team meeting/debriefing at various times of the day

Friday, June 24th and Saturday, June 25th – RSA Day 3 and Day 4 Reviews

- Location: on-site
- Attendees: RSA team members
- Team meeting/debriefing at various times of the day
- Ending at 3 PM on Saturday

Friday, July 1st – RSA Day 5

- 8:30 AM – 10:00 AM – Share findings with the RSA Team Members (Field review participants only)
    - **Location**: Virtual
    - **Attendees**: RSA Field Review Team
- 2 PM – 3 PM – Presentation of preliminary findings to the Project Owners and Participants (Debriefing Meeting)
    - **Location**: Virtual
    - **Attendees**: Project Participants and RSA field Review Team
- 3 PM – 4 PM – Prepare notes from the Debriefing Meeting
    - **Location**: Virtual
    - **Attendees**: RSA Field Review Team

Friday, July 22nd – Draft RSA report to the RSA team via email

Friday, August 19th – Draft RSA report to the RSA team via email after comments are incorporated

ADDITIONAL INFORMATION

All meetings will be held via teleconference. Call-in information will be sent in the meeting invitation.

Members of the RSA team will drive their own personal vehicle to the project. Each attendee will be responsible for providing their own safety equipment for their personal use.

APPENDIX B

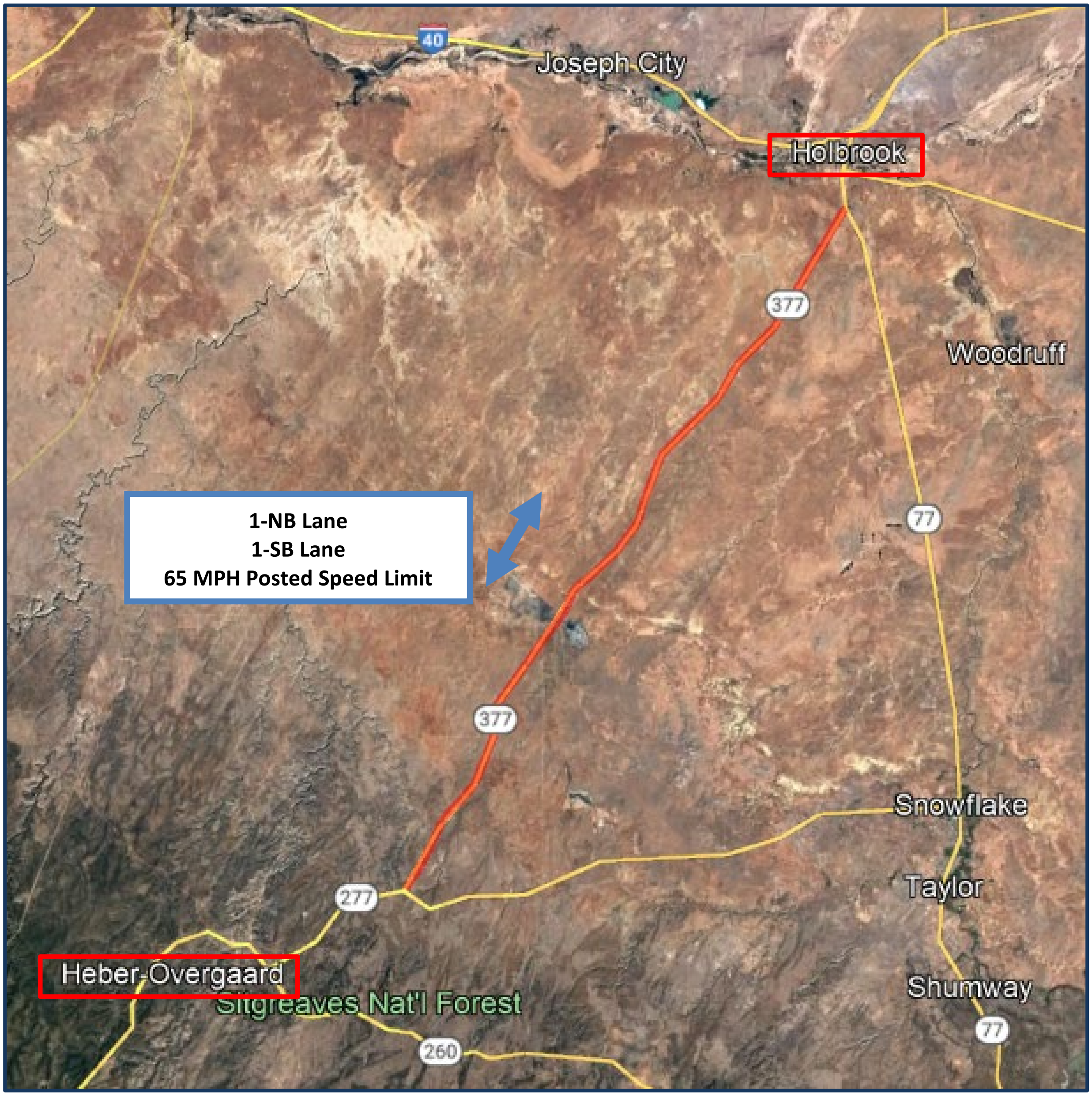
BACKGROUND INFORMATION

Michael Baker INTERNATIONAL

Michael Baker Jr., Inc.
Phoenix, Arizona

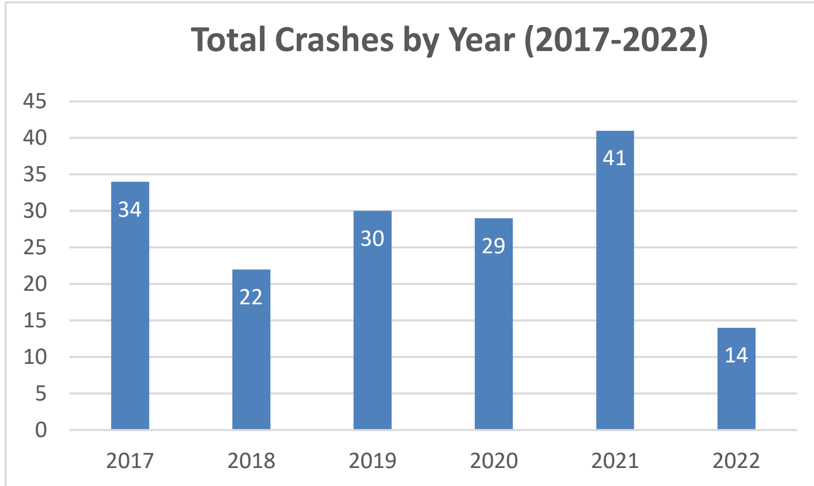
SR 377 from Holbrook to Heber

Geometry & Speed Limit

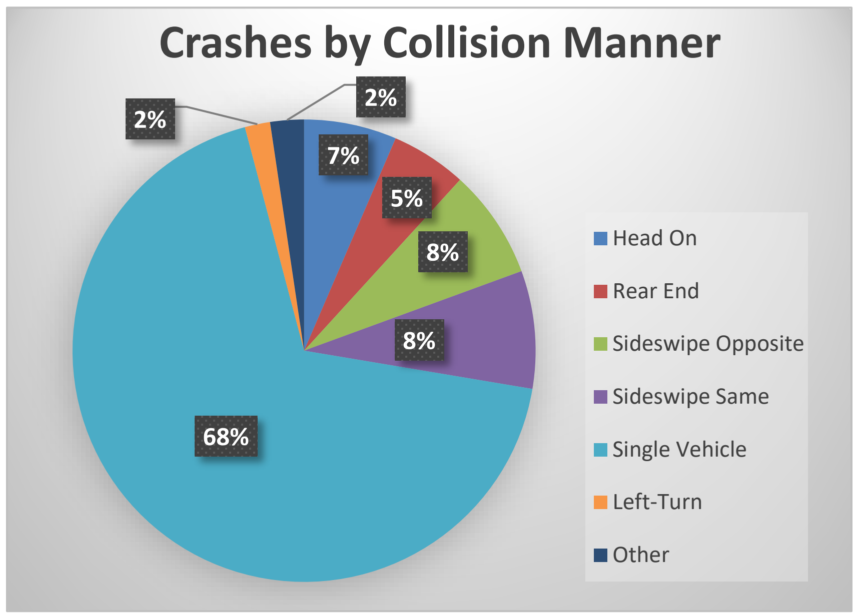


Crash Data Provided by the ADOT

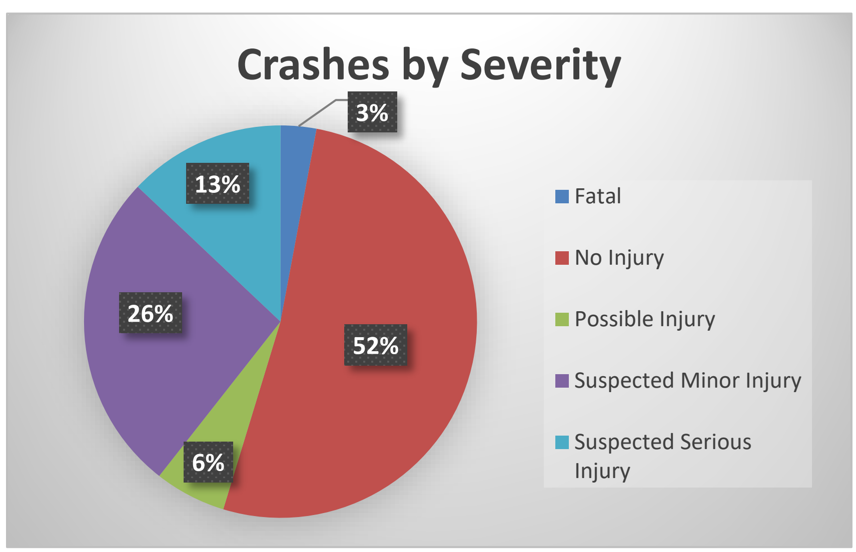
- 170 total crashes from 2017 to 2022 (5/31/2022)
  - **Year**
    - 34 in 2017
    - 22 in 2018
    - 30 in 2019
    - 29 in 2020
    - 41 in 2021
    - 14 in 2022 (till 5/31/2022)



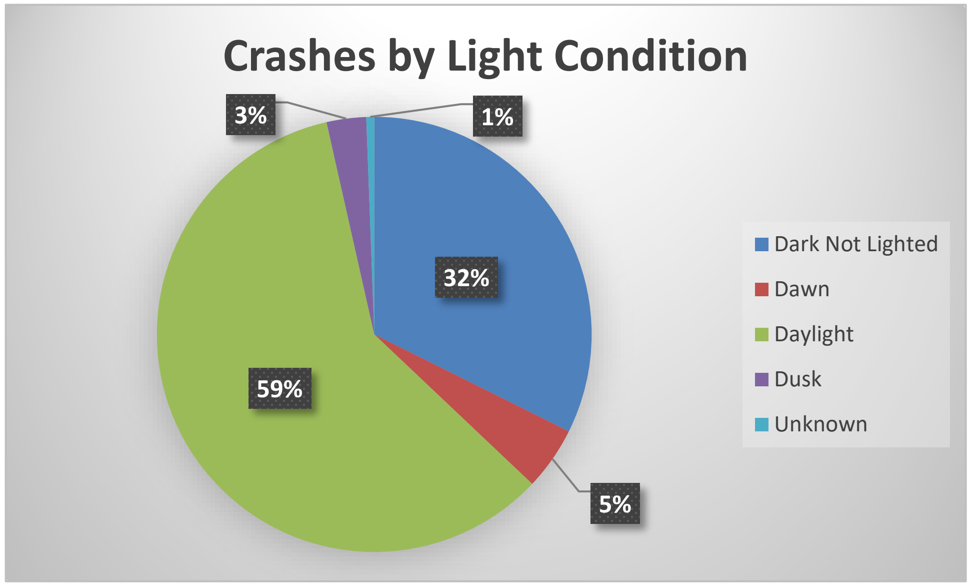
  - **Collision Type**
    - 11 Head On
    - 9 Read End
    - 13 Sideswipe Opposite Direction
    - 14 Sideswipe Same Direction
    - 116 Single Vehicle
    - 3 Left-Turn
    - 4 Other



  - **Severity of Injury**
    - 5 Fatal
    - 22 Suspected Serious Injury
    - 45 Suspected Minor Injury
    - 10 Possible Injury
    - 88 No Injury



- **Lighting Condition**
    - 8 Dawn
    - 101 Day Light
    - 5 Dusk
    - 55 Dark
    - 1 Unknown



Michael Baker INTERNATIONAL

Traffic Data

- Daily Traffic Volumes
  - Data was collected for a 24-hour period from Wednesday, June 1, 2022 to Tuesday, June 7, 2022 at 3 locations along SR 377: approximately at mile post (MP) 15 (Location 1), MP 25 (Location 2) and MP 30 (Location 3)

Location 1 Traffic Volume

Start Time	01-Jun-22 NB	SB	02-Jun-22 NB	SB	03-Jun-22 NB	SB	04-Jun-22 NB	SB	05-Jun-22 NB	SB	06-Jun-22 NB	SB	07-Jun-22 NB	SB	Week Average NB	SB
12:00 AM	22	17	13	17	26	24	27	13	23	13	17	30	38	35	24	21
01:00	15	15	24	21	24	13	17	12	11	19	11	30	13	20	16	19

Start Time	01-Jun-22 NB	SB	02-Jun-22 NB	SB	03-Jun-22 NB	SB	04-Jun-22 NB	SB	05-Jun-22 NB	SB	06-Jun-22 NB	SB	07-Jun-22 NB	SB	Week Average NB	SB
12:00 AM	22	18	13	17	36	20	31	10	23	15	19	28	39	35	26	20
01:00	15	16	24	22	26	16	17	13	16	15	14	36	13	20	18	20
02:00	13	12	15	17	26	14	20	13	10	5	17	25	4	28	15	16
03:00	17	21	10	8	26	18	24	21	11	14	16	30	20	16	18	18
04:00	18	32	14	31	23	18	15	19	23	14	19	30	18	19	19	23
05:00	26	29	28	32	28	38	25	24	20	28	30	41	42	48	28	34
06:00	59	50	53	48	61	66	49	39	40	56	60	50	82	64	58	53
07:00	100	63	71	65	81	85	106	95	64	52	87	69	106	78	88	72
08:00	160	93	164	93	146	98	139	115	111	89	114	83	100	71	133	92
09:00	162	99	136	132	157	144	202	123	165	124	137	120	129	138	155	126
10:00	203	111	164	116	124	153	185	123	181	178	149	136	134	146	163	138
11:00	183	118	147	140	198	133	191	128	179	184	138	152	148	155	169	144
12:00 PM	182	132	162	138	190	168	154	138	212	233	164	148	169	129	176	155
01:00	157	170	157	142	164	179	149	153	184	220	215	132	121	186	164	169
02:00	156	134	139	152	144	123	159	155	163	270	156	162	121	152	148	164
03:00	144	141	129	140	137	146	130	110	166	228	162	131	116	178	141	153
04:00	131	98	107	115	158	127	108	94	149	225	155	119	78	117	127	128
05:00	120	98	117	116	133	120	111	105	116	192	112	99	97	114	115	121
06:00	75	89	94	80	150	108	73	85	139	131	82	87	55	110	95	99
07:00	87	73	52	63	133	73	54	69	102	96	72	60	74	72	82	72
08:00	60	51	68	53	127	58	65	32	73	71	68	50	78	59	77	53
09:00	42	46	47	35	73	46	32	38	64	63	56	41	74	43	55	45
10:00	25	31	36	32	42	30	43	32	43	47	30	23	47	34	38	33
11:00	26	19	27	23	38	34	16	25	30	30	30	31	39	25	29	27
Total	2183	1744	1974	1810	2421	2015	2098	1759	2284	2580	2102	1883	1904	2037	2137	1975
Day	3927		3784		4436		3857		4864		3985		3941		4112	
AM Peak	10:00	11:00	08:00	11:00	11:00	10:00	09:00	11:00	10:00	11:00	10:00	11:00	11:00	11:00	11:00	11:00
Vol.	203	118	164	140	198	153	202	128	181	184	149	152	148	155	169	144
PM Peak	12:00	13:00	12:00	14:00	12:00	13:00	14:00	14:00	12:00	14:00	13:00	14:00	12:00	13:00	12:00	13:00
Vol.	182	170	162	152	190	179	159	155	212	270	215	162	169	186	176	169

Location 2 Traffic Volume

Start Time	01-Jun-22 NB	SB	02-Jun-22 NB	SB	03-Jun-22 NB	SB	04-Jun-22 NB	SB	05-Jun-22 NB	SB	06-Jun-22 NB	SB	07-Jun-22 NB	SB	Week Average NB	SB
12:00 AM	22	18	13	17	36	20	31	10	23	15	19	28	39	35	26	20
01:00	15	16	24	22	26	16	17	13	16	15	14	36	13	20	18	20
02:00	13	12	15	17	26	14	20	13	10	5	17	25	4	28	15	16
03:00	17	21	10	8	26	18	24	21	11	14	16	30	20	16	18	18
04:00	18	32	14	31	23	18	15	19	23	14	19	30	18	19	19	23
05:00	26	29	28	32	28	38	25	24	20	28	30	41	42	48	28	34
06:00	59	50	53	48	61	66	49	39	40	56	60	50	82	64	58	53
07:00	100	63	71	65	81	85	106	95	64	52	87	69	106	78	88	72
08:00	160	93	164	93	146	98	139	115	111	89	114	83	100	71	133	92
09:00	162	99	136	132	157	144	202	123	165	124	137	120	129	138	155	126
10:00	203	111	164	116	124	153	185	123	181	178	149	136	134	146	163	138
11:00	183	118	147	140	198	133	191	128	179	184	138	152	148	155	169	144
12:00 PM	182	132	162	138	190	168	154	138	212	233	164	148	169	129	176	155
01:00	157	170	157	142	164	179	149	153	184	220	215	132	121	186	164	169
02:00	156	134	139	152	144	123	159	155	163	270	156	162	121	152	148	164
03:00	144	141	129	140	137	146	130	110	166	228	162	131	116	178	141	153
04:00	131	98	107	115	158	127	108	94	149	225	155	119	78	117	127	128
05:00	120	98	117	116	133	120	111	105	116	192	112	99	97	114	115	121
06:00	75	89	94	80	150	108	73	85	139	131	82	87	55	110	95	99
07:00	87	73	52	63	133	73	54	69	102	96	72	60	74	72	82	72
08:00	60	51	68	53	127	58	65	32	73	71	68	50	78	59	77	53
09:00	42	46	47	35	73	46	32	38	64	63	56	41	74	43	55	45
10:00	25	31	36	32	42	30	43	32	43	47	30	23	47	34	38	33
11:00	26	19	27	23	38	34	16	25	30	30	30	31	39	25	29	27
Total	2183	1744	1974	1810	2421	2015	2098	1759	2284	2580	2102	1883	1904	2037	2137	1975
Day	3927		3784		4436		3857		4864		3985		3941		4112	
AM Peak	10:00	11:00	08:00	11:00	11:00	10:00	09:00	11:00	10:00	11:00	10:00	11:00	11:00	11:00	11:00	11:00
Vol.	203	118	164	140	198	153	202	128	181	184	149	152	148	155	169	144
PM Peak	12:00	13:00	12:00	14:00	12:00	13:00	14:00	14:00	12:00	14:00	13:00	14:00	12:00	13:00	12:00	13:00
Vol.	182	170	162	152	190	179	159	155	212	270	215	162	169	186	176	169

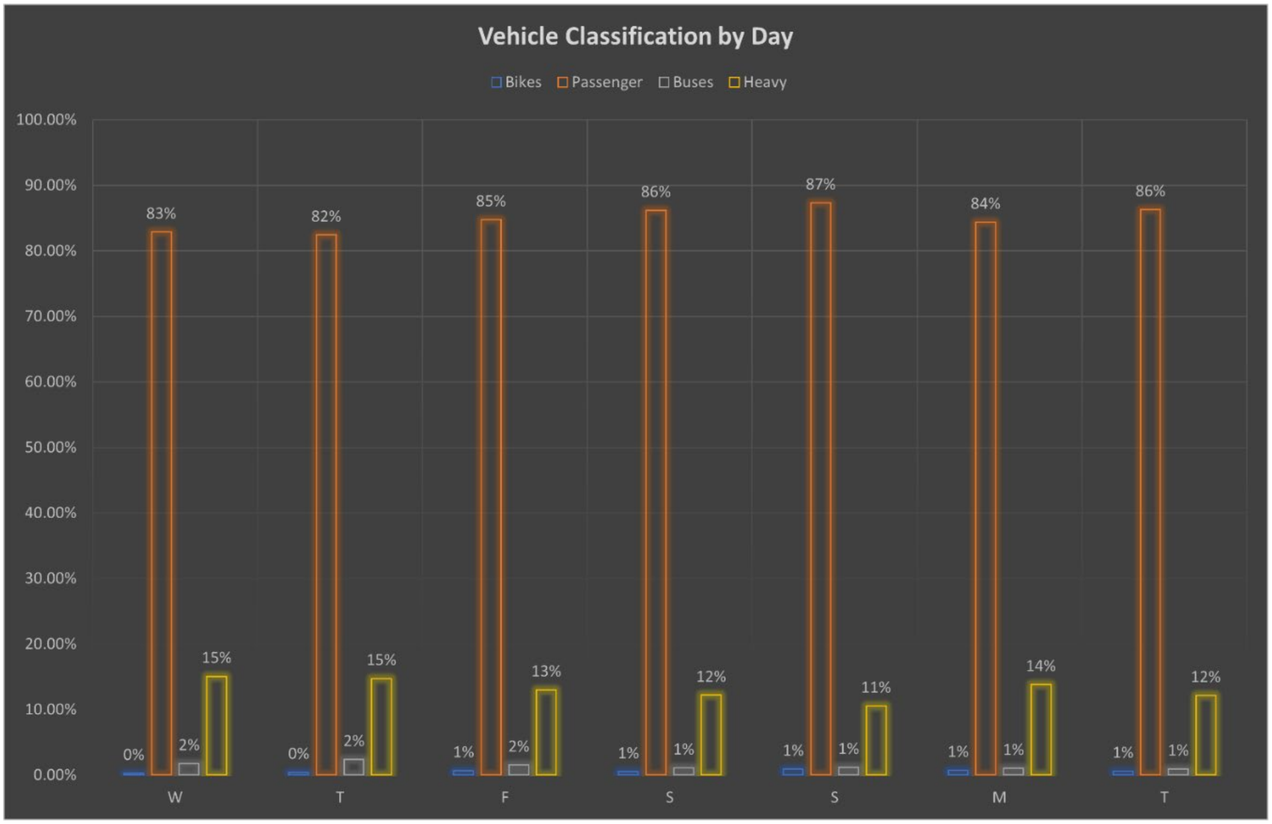
Location 3 Traffic Volume

Start	01-Jun-22		02-Jun-22		03-Jun-22		04-Jun-22		05-Jun-22		06-Jun-22		07-Jun-22		Week Average	
Time	NB	SB	NB	SB	NB	SB	NB	SB	NB	SB	NB	SB	NB	SB	NB	SB
12:00 AM	21	13	19	18	33	20	30	10	18	15	18	28	36	35	25	20
01:00	23	16	20	23	24	16	18	13	14	15	14	36	12	20	18	20
02:00	9	12	14	15	17	14	19	13	10	5	10	25	4	28	12	16
03:00	16	21	8	10	19	18	22	21	9	14	14	30	20	16	15	19
04:00	15	29	16	31	22	18	12	19	22	14	11	30	16	19	16	23
05:00	27	30	28	31	23	38	25	24	13	28	21	41	40	48	25	34
06:00	52	52	41	56	54	66	29	39	35	56	45	50	78	64	48	55
07:00	77	60	69	67	78	86	101	95	55	52	60	69	100	78	77	72
08:00	153	92	153	93	133	99	140	117	98	89	66	83	94	71	120	92
09:00	156	105	135	125	139	141	230	124	125	124	81	120	126	137	142	125
10:00	191	108	152	129	151	154	219	126	159	175	116	136	124	144	159	139
11:00	202	121	157	154	185	135	190	126	170	183	103	150	142	153	164	146
12:00 PM	179	144	151	130	186	169	160	140	179	227	91	144	159	129	158	155
01:00	155	161	158	137	184	179	139	153	185	212	153	132	113	179	155	165
02:00	160	133	138	152	143	128	162	155	150	256	186	160	114	152	150	162
03:00	139	130	120	128	119	144	122	111	143	219	201	127	110	174	136	148
04:00	144	100	121	117	165	126	110	94	125	218	125	117	76	117	124	127
05:00	122	102	119	113	123	122	115	106	98	188	131	99	90	114	114	121
06:00	91	84	101	116	156	108	76	86	117	131	103	87	52	110	99	103
07:00	91	65	72	94	135	73	61	69	76	96	131	60	68	72	91	76
08:00	63	54	69	52	129	58	51	32	84	71	90	50	72	59	80	54
09:00	38	44	52	41	98	46	46	38	54	63	66	41	70	43	61	45
10:00	40	29	40	29	58	30	39	32	47	47	59	23	44	34	47	32
11:00	26	19	30	21	34	34	18	25	27	30	32	31	38	25	29	26
Total	2190	1724	1983	1882	2408	2022	2134	1768	2013	2528	1927	1869	1798	2021	2065	1975
Day	3914		3865		4430		3902		4541		3796		3819		4040	
AM Peak	11:00	11:00	11:00	11:00	11:00	10:00	09:00	10:00	11:00	11:00	10:00	11:00	11:00	11:00	11:00	11:00
Vol.	202	121	157	154	185	154	230	126	170	183	116	150	142	153	164	146
PM Peak	12:00	13:00	13:00	14:00	12:00	13:00	14:00	14:00	13:00	14:00	15:00	14:00	12:00	13:00	12:00	13:00
Vol.	179	161	158	152	186	179	162	155	185	256	201	160	159	179	158	165

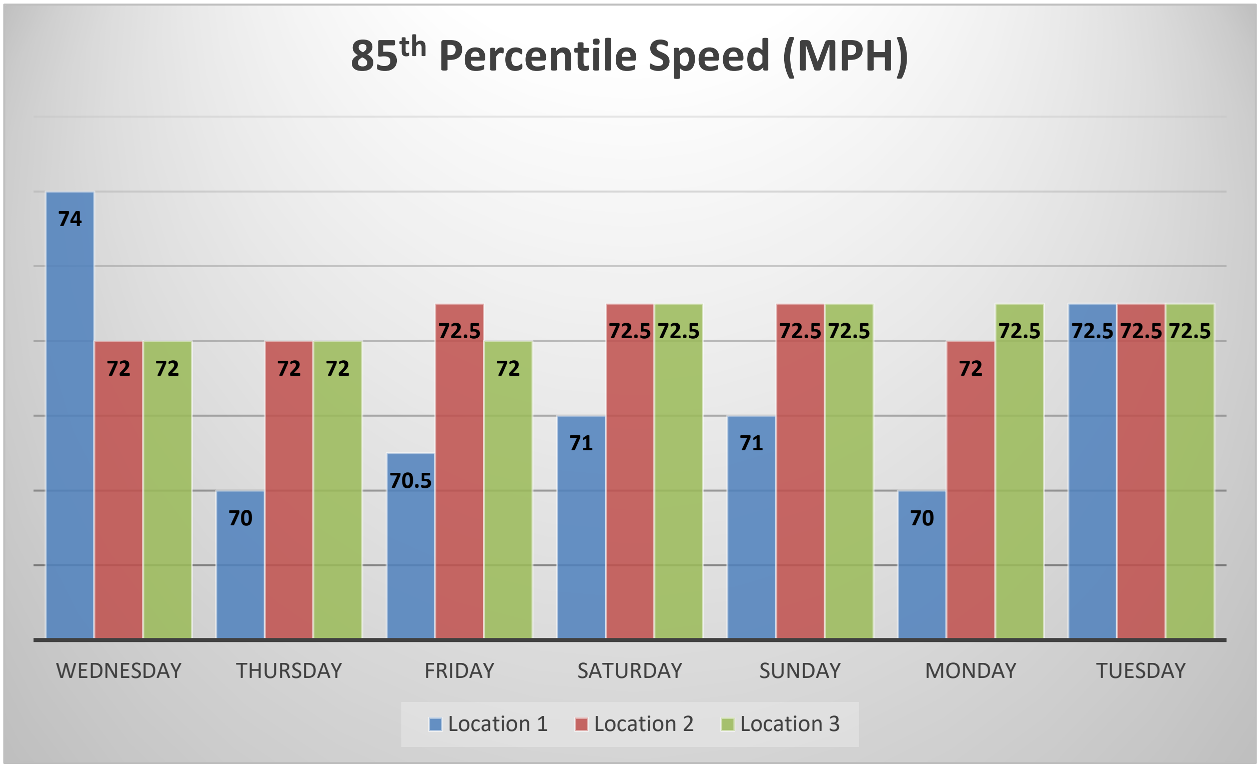
- Growth Rate (AOT TDMS)

Year	ADT	Yearly Growth %	Average Growth %
SR 377			5.51%
2016	2,607		
		3.80%	
2017	2,706		
		4.84%	
2018	2,837		
		3.35%	
2019	2,932		
		-7.71%	
2020	2,706		
		23.29%	
2022	4,113		

- Vehicle Classifications
    - Data was collected for a 24-hour period from Wednesday, June 1, 2022 to Tuesday, June 7, 2022 at 3 locations along SR 377: approximately at mile post (MP) 15 (Location 1), MP 25 (Location 2) and MP 30 (Location 3)

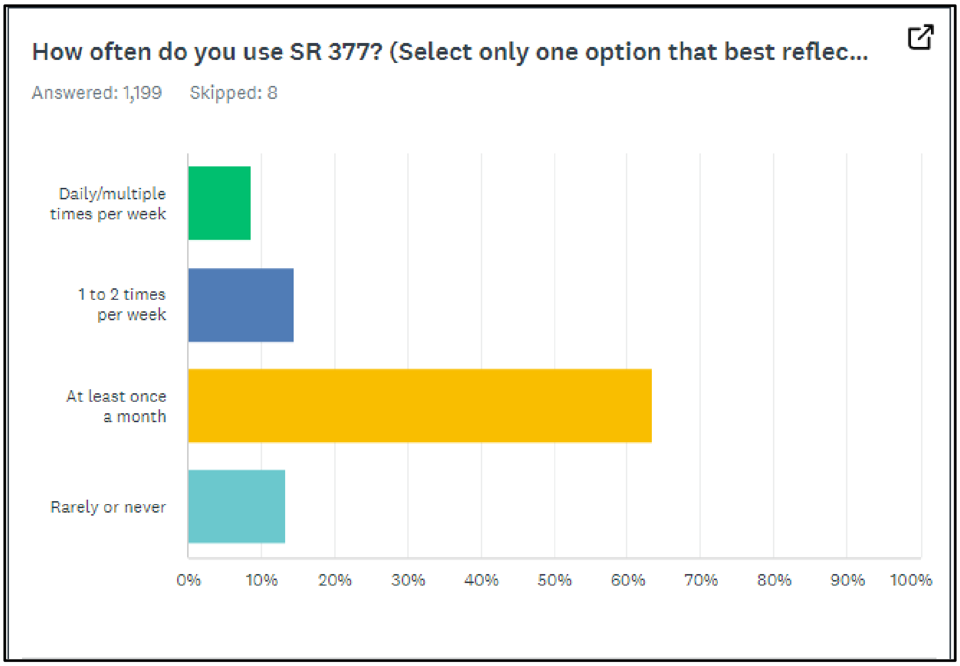


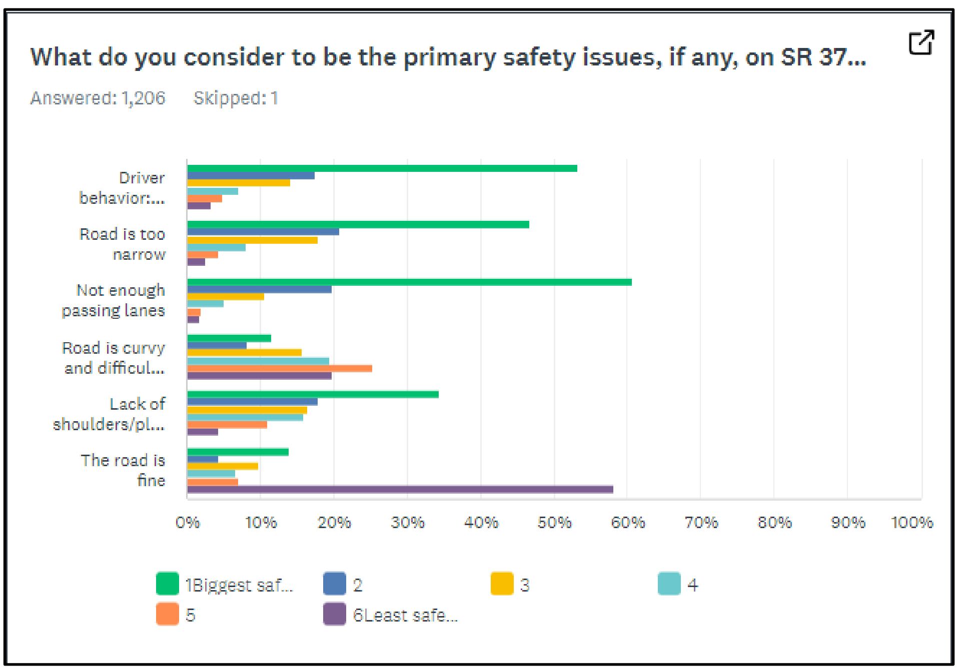
- 85th Percentile Speeds
    - Data was collected for a 24-hour period from Wednesday, June 1, 2022 to Tuesday, June 7, 2022 at 3 locations along SR 377: approximately at mile post (MP) 15 (Location 1), MP 25 (Location 2) and MP 30 (Location 3)



Resident Survey

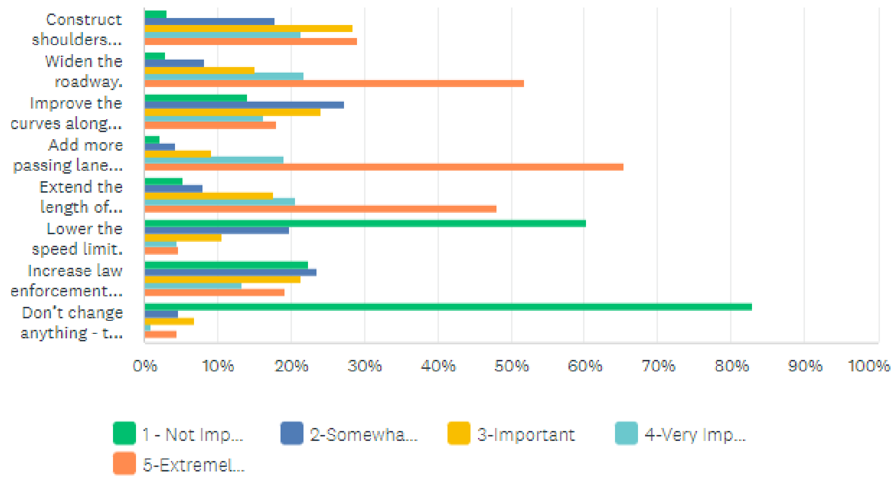
- Area residents and those who own summer homes or visit the area frequently were encouraged to provide their input by completing a survey conducted by ADOT in one of two ways: online or mail-in





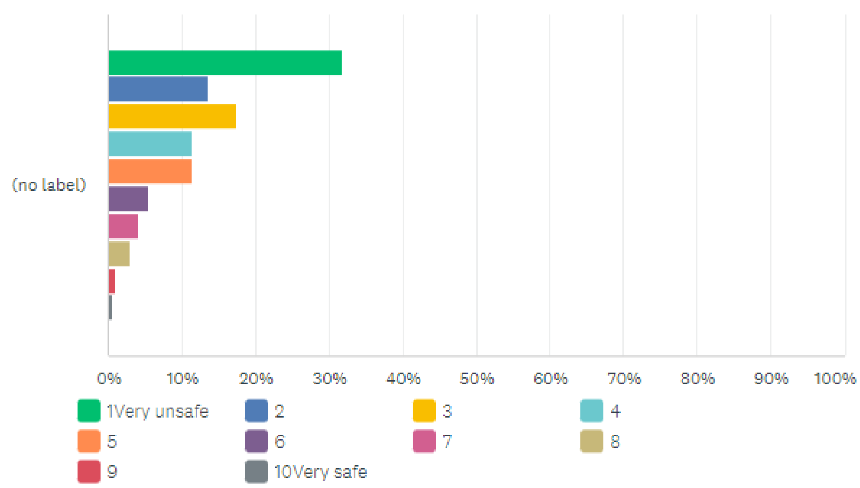
Please rate the following solutions that would most effectively addres...

Answered: 1,204 Skipped: 3



On a scale of 1 to 10, with 1 being very unsafe and 10 being very safe, h...

Answered: 1,201 Skipped: 6



Please share any specific safety or roadway concerns or comments rel...

Answered: 773   Skipped: 434

Definitely widen the road w/more passing lanes and more law enforcement presence would help.

377 is bad - 100% needs attention asap.

Road is too narrow for bigger vehicles and for pulling trailers, like a travel trailer, stock trailer and animal trailers.

Very narrow road with few passing lanes and some passing lanes that are too short.

There are no widened areas with passing lanes. No shoulder, no enforcement. I try to avoid using 377 due to unsafe conditions. Everytime I drive this road, I'm confronted with unsafe drivers.

Passing lanes needed badly.

Watched three near head-on collisions from speeding drivers in "no passing lanes" on my last trip on 377.

Busier than ever.

The highway should be four lanes from Holbrook to Heber. Extremely dangerous road, especially at night.

APPENDIX C
PLANNING LEVEL COST ESTIMATES

Michael Baker
INTERNATIONAL

Michael Baker Jr., Inc.
Phoenix, Arizona

Cost Estimate - Add 5' Shoulder W/ Safety Edge and Widen Existing Lane to 12'				
Description	**Unit**	**Unit Cost**	**Quantity**	**Cost**
Asphalt Concrete Pavement (Superpave 3/4 in Mix, High Traffic)	Tons	$120.00	80867	$9,704,040.00
Borrow	CY	$50.00	66098	$3,304,900.00
Aggregate Base Course	CY	$50.00	92537	$4,626,850.00
Removal of Pavement	SY	$10.00	39659	$396,590.00
Roadway Excavation	CY	$20.00	39659	$793,180.00
Edge Line Rumble Strip	LF	$0.30	356928	$107,078.40
			Construction Total	**$18,933,000.00**
Mobilization	10%			$1,893,300.00
Traffic Control	10%			$1,893,300.00
Survey	2%			$378,660.00
Unkown Item Contigency	22%			$4,165,260.00
			Misc. Total	**$8,331,000.00**
			Construction + Misc Total	**$27,264,000.00**
Construction Management	15%			$4,089,600.00
Construction Contigency	5%			$1,363,200.00
			Cost for 30.8* Mile Project Recommendations Length	**$32,716,800.00**
			Annual Maintenance Cost**	**$182,520.00**

***Cost Estimate accounts for recently constructed project which has improved existing conditions along 3 miles of curves to have 5' of pav**
****Assume $450 of annual maintenance cost per mile per 1' width of new AC added**

Cost Estimate - Add 8' Shoulder W/ Safety Edge and Widen Existing Lane to 12'				
Description	**Unit**	**Unit Cost**	**Quantity per Mile (Both Shoulders)**	**Cost**
Asphalt Concrete Pavement (Superpave 3/4 in Mix, High Traffic)	Tons	$120.00	114329	$13,719,480.00
Borrow	CY	$50.00	118976	$5,948,800.00
Aggregate Base Course	CY	$50.00	118976	$5,948,800.00
Removal of Pavement	SY	$10.00	39659	$396,590.00
Roadway Excavation	CY	$20.00	39659	$793,180.00
Edge Line Rumble Strip	LF	$0.30	356928	$107,078.40
			Construction Total	**$26,914,000.00**
Mobilization	10%			$2,691,400.00
Traffic Control	10%			$2,691,400.00
Survey	2%			$538,280.00
Unkown Item Contigency	22%			$5,921,080.00
			Misc. Total	**$11,843,000.00**
			Construction + Misc Total	**$38,757,000.00**
Construction Management	15%			$5,813,550.00
Construction Contigency	5%			$1,937,850.00
			Cost for 33.8* Mile Project Recommendations Length	**$46,508,400.00**
			Annual Maintenance Cost**	**$273,780.00**

***Cost Estimate accounts for recently constructed project which has improved existing conditions along 3 miles of curves to have 5' of pav**
****Assume $450 of annual maintenance cost per mile per 1' width of new AC added**

Cost Estimate - Add Passing Lane and Widen Existing Lane to 12' and Add 8' Shoulder				
Description	**Unit**	**Unit Cost**	**Quantity**	**Cost**
Asphalt Concrete Pavement (Superpave 3/4 in Mix, High Traffic)	Tons	$120.00	46530	$5,583,600.00
Borrow	CY	$50.00	58667	$2,933,350.00
Aggregate Base Course	CY	$50.00	46933	$2,346,650.00
Removal of Pavement	SY	$10.00	7040	$70,400.00
Roadway Excavation	CY	$20.00	7040	$140,800.00
Edge Line Rumble Strip	LF	$0.30	63360	$19,008.00
			Construction Total	**$11,094,000.00**
Mobilization	12%			$1,331,280.00
Traffic Control	7%			$776,580.00
Survey	2%			$221,880.00
Unkown Item Contigency	22%			$2,440,680.00
			Misc. Total	**$4,771,000.00**
			Construction + Misc Total	**$15,865,000.00**
Construction Management	15%			$2,379,750.00
Construction Contigency	5%			$793,250.00
			Cost for 12 Miles of Recommended Passing Lanes Length	**$19,038,000.00**
			Annual Maintenance Cost*	**$113,400.00**

***Assume $450 of annual maintenance cost per mile per 1' width of new AC added**

Cost Estimate - Add Emergency Pull Offs				
Description	**Unit**	**Unit Cost**	**Quantity per Mile**	**Per Mile Cost**
Asphalt Milling (6" Depth)(Compacted)	CY	$50.00	150	$7,500.00
Subgrade Preparation	SY	$10.00	440	$4,400.00
			Construction Total	**$11,900.00**
Mobilization	LS			$1,500.00
Traffic Control	LS			$1,000.00
Survey	LS			$250.00
Unkown Item Contigency	LS			$2,000.00
			Misc. Total	**$4,750.00**
			Construction + Misc Total	**$16,650.00**
Cost for Emergency Pull Offs Recommendations (1 per Mile per Direction)				**$566,100.00**

Cost Estimate - Add Un-Paved Graded Shoulder at Access Road Approaches				
Description	**Unit**	**Unit Cost**	**Quantity per Mile**	**Per Mile Cost**
Asphalt Milling (6" Depth)(Compacted)	CY	$50.00	69	$3,450.00
Subgrade Preparation	SY	$10.00	413	$4,133.00
			Construction Total	**$7,580.00**
Mobilization	LS			$1,500.00
Traffic Control	LS			$1,000.00
Survey	LS			$250.00
Unkown Item Contigency	LS			$2,000.00
			Misc. Total	**$4,750.00**
			Construction + Misc Total	**$12,330.00**
Cost for Grading at Access Roads Recommendations (10 Locations)				**$123,300.00**

Cost Estimate - New Striping and Centerline Rumble Strip				
Description	**Unit**	**Unit Cost**	**Quantity per Mile (Full Roadway)**	**Per Mile Cost**
Dual Component Epoxy Pavement Markings	LF	$0.60	31680	$19,008.00
Centerline Line Rumble Strip	LF	$0.30	5280	$1,584.00
			Construction Total	**$21,000.00**
Mobilization	LS			$1,500.00
Traffic Control	LS			$2,000.00
Unkown Item Contigency	LS			$2,000.00
			Misc. Total	**$6,000.00**
			Construction + Misc Total	**$27,000.00**
Cost for 33.8 Mile Project Recommendations Length				**$913,000.00**
Annual Maintenance Cost*				**$10,140.00**

***Assume $300 of annual maintenance cost per mile per**

APPENDIX D
CRASH REDUCTION FACTORS

Michael Baker
INTERNATIONAL

Michael Baker Jr., Inc.
Phoenix, Arizona

Countermeasure	Rating	CMF	CRF (%)	Crash Type	Crash Severity	Roadway Type	Area Type	Reference
Upgrade existing markings to wet-reflective pavement markings	5	0.871	12.9	All	Serious Injury, Minor Injury, Possible Injury	Principal Arterial, Other	Not Specified	Lyon, C., B. Persaud, and K. Eccles. "Safety Evaluation of Wet-Reflective Pavement Markers". Report No. FHWA-HRT-15-065. Federal Highway Administration. Washington, D.C. (October 2015)
	5	0.863	13.7	Wet Road	All	Principal Arterial, Other	Not Specified	
	5	0.887	11.3	All	All	Principal Arterial, Other	Not Specified	
	5	0.893	10.7	All	Fatal, Serious Injury, Minor Injury, Possible Injury	Principal Arterial, Other	Not Specified	
	5	0.89	11	Dry Weather	All	Principal Arterial, Other	Not Specified	
	5	0.874	12.6	Nighttime	All	Principal Arterial, Other	Not Specified	
	5	0.881	11.9	All	Fatal, Serious Injury, Minor Injury, Possible Injury	Principal Arterial, Other	Not Specified	
	5	0.861	13.9	Wet Road	All	Principal Arterial, Other	Not Specified	
	4	0.907	9.3	Nighttime, Wet Road	All	Principal Arterial, Other	Not Specified	
	4	0.87	13	Run Off Road	All	Principal Arterial, Other	Not Specified	
	4	0.87	13	Wet Road	All	Principal Arterial, Other	Not Specified	
	4	0.825	17.5	All	All	Not Specified	Not Specified	
	4	0.595	40.5	All	Fatal, Serious Injury, Minor Injury, Possible Injury	Not Specified	Not Specified	
	4	0.538	46.2	Run Off Road	All	Not Specified	Not Specified	
	4	0.751	24.9	Wet Road	All	Not Specified	Not Specified	
	4	0.838	16.2	Dry Weather	All	Not Specified	Not Specified	
	4	0.696	30.4	Nighttime	All	Not Specified	Not Specified	
	4	0.944	5.6	All	All	Not Specified	Not Specified	
	4	0.685	31.5	Wet Road	All	Not Specified	Not Specified	
	4	0.984	1.6	Dry Weather	All	Not Specified	Not Specified	
	4	0.979	2.1	Nighttime	All	Not Specified	Not Specified	
	4	0.977	2.3	All	All	Principal Arterial, Other	Not Specified	
	4	0.964	3.6	Run Off Road	All	Principal Arterial, Other	Not Specified	
	4	0.966	3.4	Nighttime	All	Principal Arterial, Other	Not Specified	
	4	0.979	2.1	Nighttime, Wet Road	All	Principal Arterial, Other	Not Specified	
	4	0.72	28	Wet Road	All	Not Specified	Not Specified	Park, E. S., P. J. Carlson, and A. Pike. "Safety Effects of Wet-Weather Pavement Markings". Accident Analysis and Prevention, Vol. 133, (2019)
	4	0.926	7.4	Dry Weather	All	Not Specified	Not Specified	
	4	0.466	53.4	Wet Road	Fatal, Serious Injury, Minor Injury, Possible Injury	Not Specified	Not Specified	
	4	0.836	16.4	Dry Weather	Fatal, Serious Injury, Minor Injury, Possible Injury	Not Specified	Not Specified	
	4	0.746	25.4	Run Off Road, Wet Road	All	Not Specified	Not Specified	
	4	0.88	12	Dry Weather, Run Off Road	All	Not Specified	Not Specified	
Install centerline and edgeline rumblestrips	5	0.8	20	All	All	Not Specified	Rural	Lyon, Craig; Bhagwant Persaud; and Kimberly Eccles. "Safety Evaluation of Centerline Plus Shoulder Rumble Strips." Federal Highway Administration, Report FHWA-HRT-15-048 (June 2015)
	5	0.771	22.9	All	K,A,B,C	Not Specified	Rural	
	5	0.742	25.8	Run off road	All	Not Specified	Rural	
	5	0.632	36.8	Head on	All	Not Specified	Rural	
	5	0.767	23.3	Sideswipe	All	Not Specified	Rural	
	5	0.842	15.8	All	All	Not Specified	Rural	
	5	0.812	18.8	All	K,A,B,C	Not Specified	Rural	
	5	0.613	38.7	Run off road	All	Not Specified	Rural	
	4	0.48	52	Head on	All	Not Specified	Rural	
	4	0.891	10.9	Sideswipe	All	Not Specified	Rural	
	5	0.653	34.7	All	All	Not Specified	Rural	
	5	0.558	44.2	All	K,A,B,C	Not Specified	Rural	
	5	0.758	24.2	Run off road	All	Not Specified	Rural	
	4	0.506	49.4	Head on	All	Not Specified	Rural	
	4	0.628	37.2	Sideswipe	All	Not Specified	Rural	
	4	0.975	2.5	All	All	Not Specified	Rural	
	4	0.92	8	Run off road	All	Not Specified	Rural	
	4	0.907	9.3	Sideswipe	All	Not Specified	Rural	
	4	0.851	14.9	Run off road	All	Not Specified	Rural	
	5	0.702	29.8	Run off road	All	Not Specified	Rural	
	5	0.679	32.1	Head on, sideswipe	All	Not Specified	Rural	
	4	0.817	18.3	Head on, sideswipe	All	Not Specified	Rural	
Install centerline rumblestrips	5	0.89	11	All	All	Not Specified	Rural	Torbic, D. J., Hutton, J. M., Bokenkroger, C. D., Bauer, K. M., Harwood, D. W., Gilmore, D. K., Dunn, D. K., Ronchetto, J. J., Donnell, E. T., Sommer III, H. J., Garvey, P., Persaud, B., and Lyon, C. NCHRP Report 641: Guidance for the Design and Application of Shoulder and Centerline Rumble Strips, Transportation Research Board, Washington D.C., (2009)
	4	0.98	2	All	All	Not Specified	Rural	
	5	0.96	4	All	All	Not Specified	Rural	
	5	0.78	22	All	K,A,B,C	Not Specified	Rural	
	4	0.94	6	All	K,A,B,C	Not Specified	Rural	
	5	0.91	9	All	K,A,B,C	Not Specified	Rural	
	5	0.51	49	Head on, sideswipe	All	Not Specified	Rural	
	4	0.74	26	Head on, sideswipe	All	Not Specified	Rural	
	4	0.65	35	Head on, sideswipe	All	Not Specified	Rural	
	5	0.63	37	Head on, sideswipe	All	Not Specified	Rural	
	5	0.55	45	Head on, sideswipe	K,A,B,C	Not Specified	Rural	
	4	0.56	44	Head on, sideswipe	K,A,B,C	Not Specified	Rural	
	4	0.65	35	Head on, sideswipe	K,A,B,C	Not Specified	Rural	
	5	0.55	45	Head on, sideswipe	K,A,B,C	Not Specified	Rural	
	5	0.91	9	All	All	Not Specified	Rural	
	5	0.88	12	All	K,A,B,C	Not Specified	Rural	
	5	0.7	30	Head on, sideswipe	All	Not Specified	Rural	

Countermeasure	Rating	CMF	CRF (%)	Crash Type	Crash Severity	Roadway Type	Area Type	Reference
Installing periodic passing lanes on rural two-lane highways	5	0.65	35	Non-intersection	K,A,B,C	Highway	Rural	Park, B., Fitzpatrick, K., and Brewer, M., "Safety Effectiveness of Super 2 Highways in Texas." Transportation Research Record: Journal of the Transportation Research Board, No. 2280, Transportation Research Board of the National Academies, Washington, D.C., 2012, pp. 38-50. DOI: 10.3141/2280-05
	5	0.58	42	All	K,A,B,C	Highway	Rural	
Widen Shoulder	4	0.771	22.9	All	All	Not Specified	Rural	Park, J., M. Abdel-Aty, and C. Lee. "Exploration and comparison of crash modification factors for multiple treatments on rural multilane roadways". Accident Analysis and Prevention, Vol. 70, (2014) pp. 167-177
	4	0.688	31.2	All	K,A,B,C	Not Specified	Rural	
	4	0.607	39.3	Run off road, single vehicle	All	Not Specified	Rural	
	4	0.566	43.4	Run off road, single vehicle	K,A,B,C	Not Specified	Rural	
Install shoulder rumble strips and widen shoulder	4	0.608	39.2	All	All	Not Specified	Rural	Park, J., M. Abdel-Aty, and C. Lee. "Exploration and comparison of crash modification factors for multiple treatments on rural multilane roadways". Accident Analysis and Prevention, Vol. 70, (2014) pp. 167-177
	4	0.541	45.9	Run off road, single vehicle	All	Not Specified	Rural	
Install safety edge	4	0.923	7.732	All	All	Principal Arterial Other	Rural	Graham, J.L., Richard, K.R. , O'Laughlin, M.K., Harwood, D.W., "Safety Evaluation of the Safety Edge Treatment" Report No. FHWA-HRT-11-024, Federal Highway Administration, Washington, DC. (2011)
	4	0.886	11.361	All	All	Principal Arterial Other	Rural	
	4	0.932	6.817	All	All	Principal Arterial Other	Rural	
	4	0.845	15.524	All	All	Principal Arterial Other	Rural	
	4	0.925	9.485	All	All	Principal Arterial Other	Rural	
	4	0.935	6.516	All	All	Principal Arterial Other	Rural	
	4	0.943	5.674	All	All	Principal Arterial Other	Rural	
	4	0.89	10.959	All	K,A,B,C	Principal Arterial Other	Rural	
	4	0.55	44.993	All	K,A,B,C	Principal Arterial Other	Rural	
	4	0.565	43.548	All	K,A,B,C	Principal Arterial Other	Rural	
	4	0.591	40.939	All	K,A,B,C	Principal Arterial Other	Rural	
	4	0.835	16.528	All	K,A,B,C	Principal Arterial Other	Rural	
	4	0.983	1.667	All	K,A,B,C	Principal Arterial Other	Rural	
	5	0.863	13.721	Run off road	All	Principal Arterial Other	Rural	
	4	0.909	9.08	Run off road	All	Principal Arterial Other	Rural	
	4	0.921	7.872	Run off road	All	Principal Arterial Other	Rural	
	4	0.918	8.183	Run off road	All	Principal Arterial Other	Rural	
	5	0.585	14.177	Run off road	All	Principal Arterial Other	Rural	
	4	0.952	4.786	Run off road	All	Principal Arterial Other	Rural	
	4	0.937	6.315	Run off road	All	Principal Arterial Other	Rural	
	4	0.808	19.175	Run off road	K,A,B,C	Principal Arterial Other	Rural	
	4	0.537	46.332	Run off road	K,A,B,C	Principal Arterial Other	Rural	
	4	0.836	16.402	Run off road	K,A,B,C	Principal Arterial Other	Rural	
	5	0.769	23.123	Run off road	K,A,B,C	Principal Arterial Other	Rural	
	4	0.897	10.293	Other	All	Principal Arterial Other	Rural	
	4	0.909	9.13	Other	All	Principal Arterial Other	Rural	
	4	0.934	6.603	Other	All	Principal Arterial Other	Rural	
	4	0.912	8.759	Other	All	Principal Arterial Other	Rural	
	4	0.874	12.586	Other	All	Principal Arterial Other	Rural	
	4	0.955	4.455	Other	All	Principal Arterial Other	Rural	
	4	0.944	5.587	Other	All	Principal Arterial Other	Rural	
	4	0.849	15.135	Other	K,A,B,C	Principal Arterial Other	Rural	
	4	0.575	42.488	Other	K,A,B,C	Principal Arterial Other	Rural	
	4	0.615	38.503	Other	K,A,B,C	Principal Arterial Other	Rural	
	5	0.63	36.972	Other	K,A,B,C	Principal Arterial Other	Rural	
	5	0.784	21.596	Other	K,A,B,C	Principal Arterial Other	Rural	
	4	0.953	4.676	Other	K,A,B,C	Principal Arterial Other	Rural	

APPENDIX E

BENEFIT-COST RATIO CALCULATIONS

Michael Baker INTERNATIONAL

Michael Baker Jr., Inc.
Phoenix, Arizona

Benefit-Cost Analysis for Pavement Marking Improvements

Agency:	ADOT	**Title of Project:**	SR 377 RSA

Benefit / Cost Ratio Tabulation

Annual Benefit Tabulation

Severity	Annual Average	Estimated **CRF*** Reduction	Total Reduction	Unit Cost	Annual Benefit
Fatal	**1.00**	**23%**	0.23	$9,515,371	$2,158,086
Suspected Serious Injury	**4.40**	**23%**	1.00	$550,499	$549,354
				Total Annual Benefits	$2,707,440

Costs

Total Project Cost	$913,000
Project Life (years)	10
Interest Rate (%)	8%
Capital Recovery Factor	0.1490
Annual Construction Cost	$136,064
Annual Maintenance Cost	$10,140
Total Annual Costs	$146,204

Benefit / Cost

Annual Benefit	Annual cost	Benefit / Cost Ratio
$2,707,440	$146,204	18.5

***REQUIRED: Use 4 and 5 star CMFs from ADOT Lists Only at Tabs 11 - 12 preferred. The CMF's CRF is used in the above calculation**

Benefit-Cost Analysis for 8 feet Shoulder Improvements

Agency:	ADOT	**Title of Project:**	SR 377 RSA

Benefit / Cost Ratio Tabulation

Annual Benefit Tabulation

Severity	Annual Average	Estimated **CRF*** Reduction	Total Reduction	Unit Cost	Annual Benefit
Fatal	**1.00**	**59%**	0.59	$9,515,371	$5,598,844
Suspected Serious Injury	**4.40**	**59%**	2.59	$550,499	$1,425,220
				Total Annual Benefits	$7,024,064

Costs

Total Project Cost	$46,508,400
Project Life (years)	20
Interest Rate (%)	8%
Capital Recovery Factor	0.1019
Annual Construction Cost	$4,736,983
Annual Maintenance Cost	$273,780.00
Total Annual Costs	$5,010,763

Benefit / Cost

Annual Benefit	Annual cost	Benefit / Cost Ratio
$7,024,064	$5,010,763	1.4

***REQUIRED: Use 4 and 5 star CMFs from ADOT Lists Only at Tabs 11 - 12 preferred. The CMF's CRF is used in the above calculation**

Benefit-Cost Analysis for Passing Lane Improvements

Agency:	ADOT	**Title of Project:**	SR 377 RSA

Benefit / Cost Ratio Tabulation

Annual Benefit Tabulation

Severity	Annual Average	Estimated **CRF*** Reduction	Total Reduction	Unit Cost	Annual Benefit
Fatal	**1.00**	**60%**	0.60	$9,515,371	$5,672,113
Suspected Serious Injury	**4.40**	**60%**	2.62	$550,499	$1,443,871
				Total Annual Benefits	$7,115,983

Costs

Total Project Cost	$19,038,000
Project Life (years)	20
Interest Rate (%)	8%
Capital Recovery Factor	0.1019
Annual Construction Cost	$1,939,062
Annual Maintenance Cost	$113,400.00
Total Annual Costs	$2,052,462

Benefit / Cost

Annual Benefit	Annual cost	Benefit / Cost Ratio
$7,115,983	$2,052,462	3.4

***REQUIRED: Use 4 and 5 star CMFs from ADOT Lists Only at Tabs 11 - 12 preferred. The CMF's CRF is used in the above calculation**

APPENDIX F
SAFETY RELATED MAINTENANCE ISSUES

Michael Baker International

Michael Baker Jr., Inc.
Phoenix, Arizona

RSA Team Checklist
Road Safety Issues Related to Maintenance

Safety Issue (Maintenance) Observed	Location Description (Leg, direction, corner)	Recommendation
Traffic Signal System		
Advance detection not coordinated with intersection	NA	
APS equipment not functioning	NA	
Damaged pedestrian PB	NA	
Excessive green time	NA	
Exposed signal pole hardware	NA	
Fading or distorted IISNS panels	NA	
IISNS lighting malfunction	NA	
Inadequate placement of PB relative to crosswalk	NA	
Insufficient crossing time for pedestrians	NA	
Malfunctioning traffic control equipment	NA	
Malfunctioning EVP	NA	
Mast arm casts a shadow in crosswalk	NA	
Missing or damaged signal equipment hardware	NA	
Missing pull box cover	NA	
PB located with no pedestrian facilities provided	NA	
Pedestrian signal head malfunction	NA	
Pedestrian signals not aligned with crosswalk	NA	
Poor nighttime signal visibility	NA	
Signal equipment damaged or covered	NA	
Signal equipment malfunctioning	NA	
Signal head missing LEDs	NA	
Signal heads angled improperly	NA	
Inadequate signal head clearance height	NA	
Signal indications do not match conditions	NA	
Poor signal timing	NA	
Video detection malfunction	NA	
Conflicting indications of closely spaced intersections	NA	
Signage		
Damaged signage	NA	
Inadequate pedestrian pushbutton signage	NA	
Inadequate signage size for condition	NA	
Install additional signs	NA	
Missing reflective tape on STOP signs	Zeniff, Hutch, Duck Lake, and Despain Ranch Rds	Add reflective tape to stop sign posts
Missing signage	NA	
Object Marker missing	MP 6.1 (West SIde), 15.2 (East Side)	Place object markers at all culvert openings occuring at access roads
Object markers causing visual obstruction	NA	
Poor sign retroreflectivity	NA	
Sign missing from sign post	NA	
Sign clutter	NA	
Sign placement does not match condition	NA	
Sign blocking signal heads	NA	
Signage covered by a tree or other obstruction	NA	
Signage inadequate or inappropriate for condition	NA	
Signage mounted too high/low	NA	
Signage post hit, damaged, leaning	NA	
Speed Feedback signs display error	NA	
Signage installed in the middle of a TWLT lane	NA	
Landscape		
Landscape needs to be removed	NA	
Landscape needs trimming	NA	
Debris		
Canal full of debris	NA	
Debris causing trip hazard or obstruction	NA	
Debris blocking drainage inlet	NA	

RSA Team Checklist
Road Safety Issues Related to Maintenance

Safety Issue (Maintenance) Observed	Location Description (Leg, direction, corner)	Recommendation
Roadway Pavement Conditions		
Cracks in concrete or pavement	NA	
Pavement heaving/shrinkage	NA	
Poor road surface condition	NA	
Roadside hazard	Throughout corridor	Many segments along entire corridor have >3 inch drop off from edge of AC that should (at minimum) be reduced by raising shoulder grade to meet edge of pavement
Separation of asphalt from concrete	NA	
Unstabilized shoulders	Throughout corridor	Many segments along entire corridor have un-paved shoulder that is deteriorated that should be re-graded and stabilized with millings or other treatment.
Pavement treatments create conflict with crosswalk	NA	
Striping & Marking		
Add striping	M.P. 0.6, 9.1, 6.9, 13.2, 20.20, 21.5,	Very Badly deteriorated or missing striping, See comments on fading striping below
Crosswalk marking does not align with ramp	NA	
Crosswalk marking faded	NA	
Faded or non-existing stop bar	NA	
Faded stencil markings	NA	
Faded striping	Throughout corridor	Most striping not on the recently improved horizontal curves are faded and need to be refreshed.
Inadequate delineation	NA	
Inadequate marking of raised facilities	NA	
Inadequate number and/or spacing of RPMs	NA	
Misplaced stop bar	NA	
No raised pavement markers	NA	
Old striping still visible, in conflict with new striping	NA	
School Crossing not compliant with ADOT standard	NA	
Sidewalk Conditions		
ADA surface treatment missing/inconsistent	NA	
Broken Sidewalk	NA	
Curb pulling away from sidewalk	NA	
Commercial advertisement blocking sidewalk	NA	
Parking on sidewalks	NA	
Missing or broken pavers in sidewalk or median	NA	
Missing sidewalk	NA	
Objects causing trip hazard	NA	
Rough sidewalk profile	NA	
Tree grates damaged, lifting	NA	
Uneven transitions	NA	
Lighting		
Bus Stop shelter missing lighting or vandalized	NA	
Faulty luminaire sensors	NA	
Lighting maintenance (note pole number)	NA	
Poor pathway lighting	NA	
Poor roadway lighting levels	NA	
Utilities		
Abandoned utility structures not removed	NA	
Utility line clearances causing obstructed views	NA	
Utility box set above ground level	NA	
Utility box settlement - trip hazard	NA	
Other		
Maintenance staff improper use of traffic control	NA	
Erosion	NA	
Exposed bridge railing edges	NA	
Graffiti	NA	
Loose or exposed electrical wiring	NA	
Open trenching not protected	NA	
Opened hand-holes	NA	
School pick-up and/or drop off encroaching on traffic	NA	
Transit operators not utilizing established bus stops	NA	
Unevenly repaired trench	NA	
Unprotected ditch and/or headwall	NA	