# SCOTTSDALE TRANSPORTATION COMMISSION
## Notice and Agenda

**Date: Thursday, October 21, 2021**
**Time: 5:15 P.M.**
**Location: Virtual**
**Live Stream: https://www.scottsdaleaz.gov/scottsdale-video-network/live-stream**

**Meeting will be held electronically and remotely**
Until further notice, Transportation Commission meetings are being held electronically to virtually attend and listen/view the meeting in progress. Transportation Commission meetings are televised on Cox Cable Channel 11/streamed online at ScottsdaleAZ.gov (search "live stream") or will be available on Scottsdale's YouTube channel to allow the public to listen/view the meeting in progress.

## Call To Order

### Roll Call

| | |
|---|---|
| Don Anderson, Vice-Chair | Mary Ann Miller, Commissioner |
| Pamela Iacovo, Chair | Kerry Wilcoxon, Commissioner |
| Karen Kowal, Commissioner | Andy Yates, Commissioner |
| B. Kent Lall, Commissioner | |

### Public Comment

Spoken comment is being accepted on both agendized and non-agendized items. To sign up to speak on these items, please **click here**. Request to speak forms must be submitted no later than 90 minutes before the start of the meeting.

Written comment is being accepted for both agendized and non-agendized items and should be submitted electronically at least 90 minutes before the meeting. These comments will be emailed to the Transportation Commission and posted online prior to the meeting. To submit a written public comment electronically, please **click here**.

1. **Approval of Meeting Minutes---------------------------------------------------------- Discussion and Action**
   Regular Meeting of the Transportation Commission – September 16, 2021

2. **Median Opening Analysis ---------------------------------------------------- Presentation and Discussion**
   Reviewing data for left-in left-out median openings compared to standard median openings – David Smith, Traffic Engineer Senior and guest Brendan Russo Ph.D., P.E., Associate Professor, Department of Civil Engineering, NAU

3. **Five Year Paving Prioritization Plan -----------------------------------------Presentation and Discussion**
   Paving prioritization based off PCI survey – Shayne Lopez, Transportation & Streets Paving Manager

4. **Cool Paving Update ------------------------------------------------------------Presentation and Discussion**
   Update on Cool Paving findings – Shayne Lopez, Transportation & Streets Paving Manager

5. **Commission Identification of Future Agenda Items------------------------------------------ Discussion**
   Commission members identify items or topics of interest to staff for future Commission presentations

**Adjournment**

♿ Persons with a disability may request a reasonable accommodation by contacting Kyle Lofgren at 480-312-7637. Requests should be made 24 hours in advance, or as early as possible, to allow time to arrange the accommodation. For TYY users, the Arizona Relay Service (1-800-367-8939) may also contact Kyle Lofgren at 480-312-7637.

**DRAFT SUMMARIZED MINUTES**

**CITY OF SCOTTSDALE**
**TRANSPORTATION COMMISSION**
**REGULAR MEETING**

**Thursday, September 16, 2021**

**Meeting Held Electronically and Remotely**

## 1. CALL TO ORDER

Chair Iacovo called the regular meeting of the Scottsdale Transportation Commission to order at 5:15 p.m. She noted that Commissioner Pochowski resigned from the Commission. She congratulated Commissioner Lall for his reappointment. Commissioner Wilcox will be in attendance at the October meeting.

## 2. ROLL CALL

**PRESENT**: Pamela Iacovo, Chair
Don Anderson, Vice Chair
Karen Kowal
B. Kent Lall
Mary Ann Miller
Andy Yates

**STAFF:** Mark Melnychenko, Transportation & Streets Director
Susan Conklu, Senior Transportation Planner
Dave Meinhart, Transportation Planning Manager

## 3. PUBLIC COMMENT

Written public comments were included in the packet materials and were submitted by: Kevin Olson, Lourdes Vera, Michael Lanin, Kenneth Steinke, Sharon Oberritter, Charles Pospisil, Michael Husar, Diana Krasnow, John Rodwick, Seth Rosenberg, Michael Weiner, Cathie Ernst, Laurens Kusters, Adrienne Knauer, Christine Lee Kinchen, D. Wine, Sara Muth, Linda Tucker, Lawrence Tucker, Susan Kauffman, Chuck Blackmon, Lori Lundberg, Kerry Olsson, Howard Myers, Jim Fiemann, Cynthia Westrom, Stephanie Brown, Dr. Alisa McMahon.

## 4. APPROVAL OF MINUTES

VICE CHAIR ANDERSON MOVED TO APPROVE THE SPECIAL MEETING MINUTES OF THE TRANSPORTATION COMMISSION ON AUGUST 4, 2021 AS PRESENTED. COMMISSIONER LALL SECONDED THE MOTION, WHICH CARRIED 6-0 WITH CHAIR IACOVO, VICE CHAIR ANDERSON, COMMISSIONERS KOWAL, LALL, MILLER AND YATES VOTING IN THE AFFIRMATIVE WITH NO DISSENTING VOTES.

A typographical error was identified.

VICE CHAIR ANDERSON MOVED TO APPROVE THE REGULAR MEETING MINUTES OF THE TRANSPORTATION COMMISSION ON AUGUST 19, 2021 AS AMENDED. COMMISSIONER LALL SECONDED THE MOTION, WHICH CARRIED 6-0 WITH CHAIR IACOVO, VICE CHAIR ANDERSON, COMMISSIONERS KOWAL, LALL, MILLER AND YATES VOTING IN THE AFFIRMATIVE WITH NO DISSENTING VOTES.

## 5. TRANSPORTATION ACTION PLAN

Dave Meinhart, Transportation Planning Manager, reviewed the online questionnaire process, which had a response period of August 25th through September 3rd and a total of 222 individual responses. Questions and response percentages were reviewed.

Chair asked if the results reflected which source of information was most effective in informing the public about their ability to comment on the TAP. Mr. Meinhart stated that to his knowledge, that level of information was not available. Responders were not asked from which media source they received the information, however, there were nearly 5,000 impressions on the Nextdoor app.

Chair inquired how the findings would be used. Mr. Meinhart stated that as these are all questions related to the direction of TAP, one goal was to receive confirmation that the trajectory is not outside of what the community feels is important. Secondly, it provides information as to areas where additional public outreach and education would be helpful.

Commissioner asked if the responses could be cross-referenced according to what area of the City the responder resides. Mr. Meinhart stated that the questionnaire asked for geographic locations for individuals, however, he would have to follow up regarding whether it is possible to cross-tabulate.

Commissioner inquired about the intent to use the same survey again in the future. Mr. Meinhart stated that they may use the tool, but not in conjunction with this plan development.

Chair noted that she was one of the questionnaire respondents and that she found it to be very well done.

Mr. Meinhart reviewed responses in terms of travel lane additions. Commissioner referenced Indian School Road and asked about the possibility of signal coordination to assist traffic flow, as opposed to adding lanes. Mr. Meinhart stated that Indian School is already very coordinated at this point. This can be affected as pedestrians press the crosswalk buttons.

Chair noted that the Indian School Road is included as a corridor to add travel lanes, however it is also listed as a corridor to delete travel lanes. She asked how staff identifies the specific area of the roadway being addressed. Mr. Meinhart acknowledged that this is one of the challenges on this type of questionnaire. Some responses are more detailed that others and some are not as specific in terms of identifying locations. Staff uses its professional judgment to discern intent, however the number of conflicting responses is modest.

Chair suggested that signal timing and signal improvements could be included as a subcategory under the traffic congestion flow and safety question. Mr. Meinhart stated that they are different issues, to some degree. Many of the questions on signal timing were from drivers on side streets awaiting a signal change.

Mr. Meinhart reviewed responses on alternate forms of transportation. Chair noted that as of 256 total responses, approximately 170 are related to a vehicle of some type.

Mr. Meinhart reviewed responses to the question regarding to which areas of the City resources should be dedicated over the next five to ten years. Also addressed were general demographic questions, which were collected while providing anonymity of respondents. It is notable that greater outreach is needed for the younger population, as there were only two responses under the age of 25. There were also comments received specifically on the draft TAP, as opposed to the questionnaire. Multiple comments were received regarding 128th Street in the vicinity or the Jomax Road alignment where the corridor crosses the McDowell Sonoran boundary, with an interest in not connecting the roadway. There were other comments received regarding the following topics: Crosswalk design concerns; Chaparral Road widening; extending light rail; development density; not in favor of roundabouts; future widening of Rio Verde Drive should include a wildlife crossing near 124th Street.

Commissioner asked for an update on the 128th Street extension. Mr. Meinhart stated that they must complete the public outreach process before making any recommendations. This will be discussed when the plan comes before the Commission for recommendation to City Council. In response to a Commissioner question, Mr. Meinhart stated his belief that no comments were submitted in favor of the extension as part of this questionnaire. However, such comments of support were received in the past, particularly in times of fires.

Commissioner recalled discussing 128th Street some ago, particularly in terms of right-of-way and inquired as to the status of a plan at this time. Mr. Meinhart reiterated that there will be a recommendation once the next steps in the public input process have been completed. Chair noted that the 128th Street topic was presented to the Commission in January of 2019. The Commission agreed with City staff that the City would retain right-of-way, that 128th Street would not go through the Preserve, but that there might be an emergency access road available pending the construction of 118th Street. The City Council ultimately decided that 128th Street would remain in the Transportation Master Plan. It is good news that this issue is now going through the public process and that the Commission will have another chance to discuss it and make a recommendation.

Chair inquired about plans to encourage more participation in the questionnaire process from younger residents. Mr. Meinhart stated that staff is currently discussing this issue, but does not yet have an official plan. Possibilities include outreach to high schools. Commissioner suggested a focus on the age group of 18 to 24. A possible resource is ASU's Student Chapter of the American Society of Civil Engineers. Mr. Meinhart clarified that there are no plans to reissue the questionnaire. The virtual open house is much more focused on providing information.

Mr. Meinhart discussed the draft TAP, including proposed changes. There is a plan to develop a glossary. Commissioner made corrections regarding Commission meeting times. There was agreement that two sections not be part of the TAP.

Mr. Meinhart asked for input on the Street Element section and the Transit Element. Commissioner noted that the TAP references the suspended downtown trolley, noting that it would be helpful to add verbiage to the effect that service is currently suspended due to COVID.

Commissioner addressed the bullet point, "Reinstate the third Downtown circulator," noting that refers to the trolley, but that the reader may not know this references the trolley specifically. Transportation & Street Director Mark Melnychenko stated that there is the potential for rebranding the existing system. There is confusion regarding the trolley system, which consists of local routes. This can be confused with the Downtown circulator, which people think is the trolley. The document will be reviewed and changes made to reduce the confusion.

Mr. Meinhart invited feedback on the Bikeway Element. Chair commended staff on the comprehensiveness of this section.

The Trail Element was addressed. Chair asked for confirmation that this section received comments and suggestions from the Paths and Trails Subcommittee. Mr. Meinhart confirmed this understanding. Both the Bike and Trail Elements were reviewed with the Subcommittee at its August meeting.

Mr. Meinhart discussed the Pedestrian Element. There being no questions, the Implementation Program was addressed. One public comment suggested wording of a future wildlife underpass on Rio Verde Drive. Commissioner made a clarification on the land size. The graphic indicates it totals 206.7 miles, however it should read 206.7 million square feet. Mr. Meinhart concurred that Commissioner was correct. Commissioner suggested utilizing the term lane miles for ease of understanding. Mr. Meinhart stated that staff would look into this possibility.

In response to a Commissioner question, Mr. Meinhart confirmed that the inclusion of a program in TAP is not a guarantee that all will be implemented immediately or without further modification. Commissioner suggested inclusion of this clarifying language in the document. He reviewed the next steps in the process.

Commissioner suggested that marketing materials be placed in roundabout locations in order to highlight the benefits of this traffic management tool, including saving lives. Mr. Meinhart stated that staff can discuss this possibility. Hurdles include the sign ordinance. There is the potential to place information at the library.

## 6. UPDATE ON THE BICYCLE AND RELATED DEVICES ORDINANCE

Susan Conklu, Senior Transportation Manager, provided a brief background of the devices, regulations and data report. City Council has provided input and direction on revisions to the regulations and staff are in this process. The current ordinance allows staff to make changes to the restricted areas and parking requirements.

Chair commended Ms. Conklu in terms of an excellent job in presenting the updates. She asked how the regulations are being enforced.

City staff continues to meet and coordinate with device companies. Ms. Conklu stated that the majority of violations that occur with companies are related to parking. Scottsdale EZ is the avenue for a member of the public, business owner or City staff to generate a ticket, describing the issue or complaint. Scottsdale Police Department receives a copy of each ticket and follow up as needed, up to and including citations.

Chair inquired as to the average number of tickets per month. Ms. Conklu stated that she did not have that figure readily available, however, there has been a significant decrease over the past year with fewer devices in use. Chair suggested a future agenda item to look at the pattern of usage of the scooters and volume of tickets.

In response to a Commissioner question, Ms. Conklu stated that there is currently one operator in the City at this time.

## 7. OTHER TRANSPORTATION PROJECTS AND PROGRAM STATUS

Mr. Melnychenko gave a brief review of the following projects:

- City Council unanimous approval of Old Town Bicycle Master Plan
- Five key routes integrated into the Neighborhood Bikeways portion of the Transportation Action Plan
- Dunn Transportation selected as trolley service contractor with operations beginning August 13, 2021
- New bus stop maintenance contractor, Service Link, started July 2021
- Bus shelter upgrades
- Mountain View Road improvements
- Thomas Road/82nd Street sidewalks
- Concrete repairs
- Pavement treatment

Commissioner recommended looking into the design of expansion joints for the sidewalk upheaval issues.

Chair asked what is involved with a bus stop maintenance program. Mr. Melnychenko stated the two main activities are power washing and trash collection. There is also coordination with adjacent property owners and City departments in terms of graffiti and homelessness issues.

Chair inquired about the lighting for the new bus stop structures. Mr. Melnychenko stated that certain locations are lit, and others are not. Specific identification of these locations can be placed as a future agenda item.

## 8. COMMISSION IDENTIFICATION OF FUTURE AGENDA ITEMS

Chair summarized the list, including Ms. Conklu's data report on scooter usage and violation totals and identification of lit and unlit bus stops.

Commissioner referred to a project by USA's Transportation Research Department regarding connected vehicle technology on the 101 through Scottsdale and stated that it would be interesting to receive an update in the future. Commissioner commended staff for their work on the TAP.

## 9. ADJOURNMENT

With no further business to discuss, being duly moved by Vice Chair Anderson and seconded by Commissioner Kowal, the meeting adjourned at 7:30 p.m.

AYES: Chair Iacovo, Vice Chair Anderson, Commissioners Lall and Miller
NAYS: None

SUBMITTED BY:

eScribers, LLC

***Note: These are summary action meeting minutes only. A complete copy of the audio/video recording is available at http://www.scottsdaleaz.gov/boards/transp.asp**

# SCOTTSDALE TRANSPORTATION COMMISSION REPORT

**To:** **Transportation Commission**
**From:** **David R. Smith, Senior Traffic Engineer**
**Subject:** **Left-in / Left-out channelized median research of effectiveness**
**Meeting Date:** **October 21, 2021**

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**Action:** Information and Discussion

**Purpose:**

Discuss the transportation research that was completed in cooperation between the City of Scottsdale (COS) and Northern Arizona University (NAU) to study the potential safety benefits of the left-in / left-out (LILO) channelized median as a traffic control device deployed throughout the COS.

**Background:**

For decades, the COS has utilized the LILO channelized median to facilitate left turning vehicles. The idea behind the LILO is to provide a staging area for left turning vehicles without the need for additional traffic control – such as a traffic signal. Left turns are essentially broken into a two (2) stage movement allowing smaller gaps in traffic to be utilized to completely execute the turn. Creating this two-stage movement makes it easier for drivers to navigate across wider streets with higher traffic volumes. The treatment was first utilized on Shea Boulevard. **Figure 1** is an aerial depiction of a LILO treatment on Shea Boulevard at Becker Lane, which is just over ½ mile east of the Loop 101 interchange. **Figure 2**, Indian Bend Road at 84th Street, is what is considered a control site – a location that does not utilize a raised median and relies on the open area for left turns to be negotiated by drivers.

The COS engaged NAU to develop a scope of work and ultimately executed a contract to perform research on the LILO median treatment to develop a statistical analysis of their safety effectiveness.

**Figure 1 – Shea Boulevard at Becker Lane**

**Figure 2 – Indian Bend Road at 84th Street**

**Scope of Work:**

The contract scope between the City of Scottsdale and NAU included the following objectives:

- Conduct a crash analysis of existing LILO sites in Scottsdale (along with identified control sites) to assess the overall safety performance of the LILO treatments.
- Analyze factors associated with the crash frequency and/or severity at LILO sites to assess what conditions may be most conducive to LILO treatments.

Also included in the scope of work were the necessary tasks and deliverables to achieve and document the objectives. The tasks and corresponding deliverables included the following:

- ***Literature Review.*** Comprehensive literature review of relevant research papers, articles, reports, and other public and private sector publications related to LILO treatments. The primary research tool utilized is called the TRID database which is maintained by the Transportation Research Board (TRB). A short report summarizing these findings would be the deliverable for this task.
- ***Data collection.*** This task was primarily completed by COS staff. The data collection included the city-wide inventory of LILO locations and corresponding control sites (sites that did not use a median treatment but permitted the same left-in/left-out turning movements either with pavement markings (two-way left turn lane, or TWLTL) or no markings at all; collision data for each LILO and control site, specific roadway geometric characteristics for each site (such as acceleration lengths, type of treatment, etc), signing, and markings. Part of the data collection also included 3rd party counting services – turning movement counts at the minor street/driveway approaches and turns "in" as well as daily traffic counts on the mainline. The deliverable was the COS information provided to NAU.
- ***Statistical Analyses and Development of Recommendations.*** Using the data sources detailed in the previous bullet, statistical models were developed by NAU to explore the factors which are statistically associated with the crash frequency and/or severity. The methods used, as outlined in nationally recognized publications such as the Highway Safety Manual (HSM), include negative binomial and binary logistic regression modelling to analyze crash frequency and severity, respectively. Analyses were conducted for specific collision types (sideswipe, angle, left-turn, etc) and collision severities to identify

conditions under which the LILO treatment are most effective. The deliverable was a memo to City staff detailing the results of the statistical modeling.

- ***Final technical report including recommendations and presentation.*** This represents both the task (to create report and presentation) and the deliverable.

**Report:**

The completed final report is provided along with this item in brief. A summary of the findings of the report are listed below:

- The crash modification factors (CMF's) development through the cross-sectional analysis method indicate that the LILO treatment was associated with a reduction in total collisions, angle/left-turn collisions, all injury collisions, and severe injury collisions. That stated, only the CMF for angle/left-turn collisions were statistically significant at a 95$^{th}$ percent confidence interval.
- The CMF's developed through the Empirical-Bayes before/after analysis indicated that the LILO treatment was associated with a reduction in total crashes and injury crashes, with only results for all injury crashes and moderate/severe injury crashes being significant at the 95$^{th}$ percent confidence level.
- An analysis of the impact of different design variables (signing, striping, acceleration length of the exiting turn bay, etc) did not result in any statistically significant findings.

**Next steps**

The next step will be for the NAU staff to finalize the report. Once finalized, it is anticipated that the report will be peer reviewed nationally for various publication opportunities. It is also anticipated that a nationally adopted crash modification factor (CMF) will be created for the LILO treatment type by the Federal Highway Administration (FHWA). This CMF can then be applied and used by practitioners nationally in the future. Future presentations on the topic are also anticipated at future Transportation Research Board (TRB) conferences, most likely January 2023. For additional information, Dr. Brendan Russo, Associate Professor of Civil Engineering at Northern Arizona University, can be contacted at Brendan.Russo@nau.edu or 928-523-8094. City of Scottsdale staff contact information below.

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**Staff Contact:** David R. Smith, 480-312-7613, drsmith@scottsdaleaz.gov

# Analysis of the Safety Impacts of Left-In Left-Out Intersection/Driveway Treatments

## Draft Report

**PI: Brendan Russo, Ph.D., P.E., Associate Professor**
**Northern Arizona University (NAU)**
**P.O. Box 15600**
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**Undergraduate Research Assistant: Mary Kayser**

**October 2021**

## ACKNOWLEDGEMENTS

The authors would like to thank the City of Scottsdale for funding this project and providing multiple data sets necessary for the analyses. Specifically, the authors would like to thank David Smith, P.E., P.T.O.E., Samuel Taylor, P.E., and Amy Zhang for their assistance in obtaining data and providing guidance. The authors would also like to acknowledge undergraduate NAU student Cole Robertson for assistance with initial data collection.


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# TABLE OF CONTENTS



# LIST OF TABLES



# LIST OF FIGURES

# 1.0 INTRODUCTION AND BACKGROUND

The City of Scottsdale, Arizona contains numerous examples of left-in left-out (LILO) treatments at intersections and driveways where the minor street/driveway is stop-controlled and the major street is free-flowing. These treatments are typically applied on arterial roadways with medians and consist of a channelizing island in the median which helps direct vehicles turning left both on to and out of minor streets or driveways. Additionally, the treatment contains an exclusive left turn lane for vehicles turning left on to minor streets/driveways and left turn refuge with varying acceleration lane lengths for vehicles turning left out of minor streets/driveways (these left-turning vehicles then merge with major street traffic). Examples of aerial views of LILO treatments in Scottsdale are shown in Figure 2.1 and Figure 2.2.

The City of Scottsdale began installing the LILO treatment several decades ago as a potential alternative to signalized intersections (i.e. locations with high minor street left turn volumes but not meeting traffic signal warrants) and it was thought that these treatments make left turns easier for drivers and are relatively safer. The treatment is applied at locations that otherwise would have a standard median opening or two-way left-turn lane (TWLTL). The LILO treatment was originally installed on the Shea Blvd. corridor in Scottsdale and was expanded to other locations (approximately ~60 as of 2021) as they seemed to operate well. Although anecdotal evidence seems to indicate the LILO treatments in Scottsdale perform well with respect to operations and safety, a comprehensive analysis of this treatment has not been conducted. This lack of a concrete data-driven analysis provided the motivation for this study, which provides the first (to the authors' knowledge) comprehensive safety analysis of the LILO treatment.

Overall, the primary objectives of this study include the following:

- Conduct a crash analysis of LILO sites in Scottsdale, Arizona (along with identified control sites) to assess the overall safety performance of the LILO treatment trough development of crash modification factors.
- Analyze the potential impacts of different design features at LILO sites on crash frequencies.
- Analyze the potential impacts of the LILO treatment (along with design features) on crash severity.

## 1.1 POTENTIAL IMPACTS OF THE LILO TREATMENT

A comprehensive search of existing research literature yielded no results with respect analyses of the impacts of LILO treatments similar to those existing in Scottsdale (which strengthened the motivation for this study). That being said, LILO treatments have the potential to provide several benefits as compared with standard median openings or TWLTLs:

- Because an acceleration length is provided for vehicles turning left out of minor streets/driveways, drivers can focus on finding adequate gaps in traffic on the major street one direction at a time for the most part. This may reduce driver error and potentially prevent angle or left turn crash types which more often result in injuries or fatalities as compared with other crash types (e.g. rear ends, sideswipes, etc.).

- While LILO treatments have typically been applied at 3-leg intersections (i.e. “T-intersections”), some have been applied at 4-leg intersections as shown in Figure 2.1. In these cases, the application of the LILO treatment reduces the number of potential conflict points by preventing through movements on the minor street/driveway. It’s important to note, however, that adequate access to adjacent properties should be considered in these cases.
- LILO treatments also have the potential to improve operations (i.e. reduce delay) for left turning vehicles by allowing motorists to focus more on one direction of traffic when determining whether gaps in major street traffic are adequate to complete the turn (thereby potentially accepting smaller but still safe gaps). It should be noted that potential impacts on operations are beyond the scope of this study, as only safety impacts are investigated.

Past research has shown that converting full turning movement operation to right-in right-out (RIRO) operation at stop-controlled 3-leg intersections results in 45%, 68%, and 80% reductions in total, intersection-related, and fatal/injury crashes, respectively (Le et al., 2018). Additionally, another reference reported that typical crash rates may be reduced from 0.3 crashes per million entering vehicles to 0.1 crashes per million entering vehicles when a full-access 3-leg intersection is converted to RIRO operation (MNDOT, 2011). While the RIRO treatment operates much differently than the LILO treatment, the results show that reducing potential conflict points can result in decreased crashes. Overall, there is no existing research literature assessing the performance of the LILO treatment, which as noted previously, provides motivation for this study.

## 1.2 EVALUATING THE SAFETY IMPACTS OF ROADWAY DESIGN FEATURES

According to the American Association of State Highway and Transportation Officials (AASHTO) Highway Safety Manuel (HSM), there are three primary types of study designs that can be used to perform safety effectiveness evaluations for roadway design features (HSM, 2010):

- Experimental before-after studies
- Observational cross-sectional studies
- Observational before-after studies

All of these types of studies have advantages, disadvantages, and limitations with respect to the types of data that are required and available. Experimental before-after studies require analysis of treatments specifically installed so that their effectiveness can be evaluated; a group of similar sites is selected and randomly assigned to be either a treatment site or control site. Since this is not the case with the LILO treatments in Scottsdale, the experimental before-after study type is not considered for evaluation of the LILO treatment.

Cross-sectional studies utilize data from both treatment and control sites and utilize statistical modeling techniques that consider the crash experience of sites with and without a particular treatment of interest during a time period after the treatment has been installed (HSM, 2010). The difference in crash experience between the treatment and control sites is measured using a statistical model and used to determine the effectiveness of the treatment. This type of study is well-suited to assess the safety impacts of the LILO treatments in Scottsdale since most of the treatments were installed before 2014, allowing a cross-sectional analysis to be conducted using LILO treatment and control sites utilizing data from 2014-2019. Further details regarding the cross-sectional analyses and results with respect to the LILO treatments in Scottsdale are provided in Chapter 3.0 of this report.

Within the category of observational before-after studies, the empirical-Bayes (EB) before-after study design is generally regarded as the most robust method. In this design, both before and after data for treatment sites are utilized along with crash prediction models developed from control sites to obtain an estimate of ‘expected’ crashes using a weighting factor. These ‘expected’ crash estimates are then compared with observed crashes at the treatment sites to estimate the safety effectiveness of the treatment. It is possible to use the EB before-after method to evaluate the safety impacts of the LILO treatments in Scottsdale, however, the installation dates for the LILO treatments vary widely. This limits the analysis to include only sites installed after 2000 since only data after this year were available. Despite this limitation, EB before-after analyses were conducted using a subset of the LILO treatment sites and further discussion on this method and results are provided in Chapter 4.0 of this report.

In both the cross-sectional and EB before-after studies described above, the primary goal was to develop crash modification factors (CMFs) for installation of the LILO treatment. A CMF is defined as “a multiplicative factor used to compute the expected number of crashes after implementing a given countermeasure at a specific site” (Gross et al., 2010). As shown in Figure 1.1 which displays the concept of how CMFs can be interpreted, a CMF below 1.0 indicates that a treatment is expected reduce crashes, while a CMF greater than 1.0 indicates a treatment is expected to increase crashes. To calculate the expected percent change in crashes using a CMF, one would simply apply the following formula: Expected percent change = 100*(1-CMF). This expected percent change is also known as a crash reduction factor (CRF). It’s important to note that separate CMFs for total crashes, different crash types, and different crash severities can be developed for a single treatment.

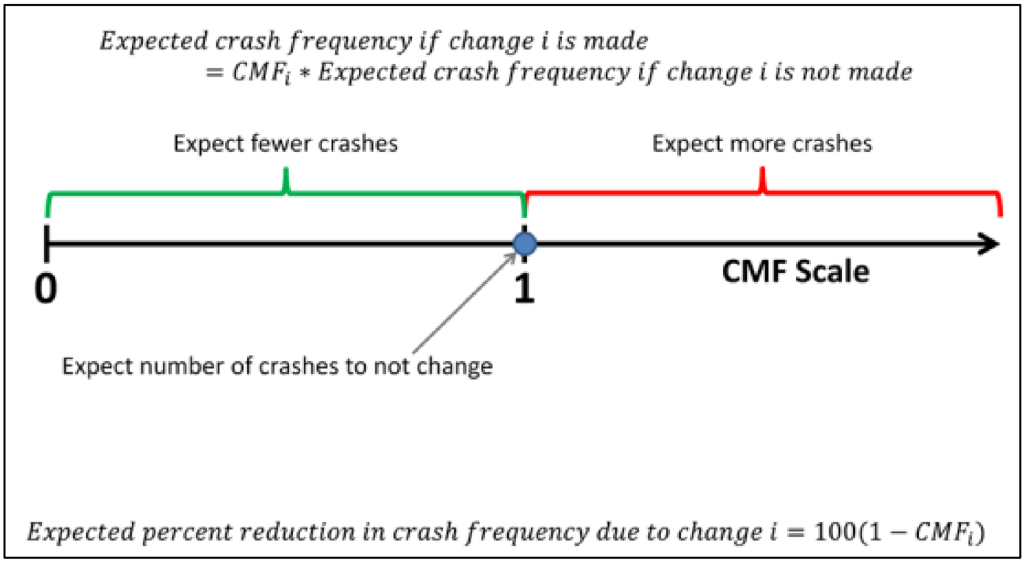


**Figure 1.1: Concept of Crash Modification Factors (Gayah and Donnell, 2014)**

One important consideration with respect to CMFs is whether they are determined to be statistically significant or not. Essentially, for a CMF to be statistically significant, it would need to be significantly different than 1.0 at a desired confidence level. Typically in traffic engineering, a 95% confidence level is desired to make strong conclusions about a certain statistical analysis. The standard error of a CMF can be used to determine whether it is statistically significant or not by calculating a 95% confidence interval using the following formula (Gross et al., 2010):

$$\text{Confidence Interval} = \text{CMF} \pm (\text{Cumulative Probability} * \text{Standard Error}) \quad (1)$$

Where the cumulative probability value is 1.960 for a 95% confidence interval. If 1.0 falls within this 95% confidence interval, then a CMF would not be considered statistically significant because one cannot conclude that it is significantly different than 1.0. It's important to note that although transportation agencies would desire to use statistically significant CMFs, even CMFs that are not statistically significant can show general expected crash trends for installation of a certain treatment, albeit with a lower level of confidence.

# 2.0 DATA DESCRIPTION

## 2.1 TREATMENT AND CONTROL SITE IDENTIFICATION

As mentioned previously, there are approximately ~60 locations with the LILO treatment in Scottsdale, Arizona. However, the available budget for this study allowed for an analysis of 25 LILO treatment locations, along with 25 control site locations (without the LILO treatment). The LILO treatment sites included in this study were identified in consultation with City of Scottsdale staff, and were chosen such that they represented a typical application and had relatively higher turning movements compared with lower volume LILO sites. The control sites selected for this study represent locations similar to the LILO treatment sites in terms of roadway, crash, and traffic characteristics but without the LILO treatment and were also selected in consultation with City of Scottsdale staff. Example aerial images of LILO treatment sites are shown in Figure 2.1 and Figure 2.2 and an example aerial image of a control site is shown in Figure 2.3. Table 2.1 shows a list of the LILO treatment and control sites selected for this study which includes the unique site number, cross streets, site type, and the year in which the LILO treatment was installed (for LILO sites only).

**Figure 2.1: Aerial view of Shea Blvd and 100$^{th}$ Street – LILO Site (#11) (Google, 2021)**

**Figure 2.2: Aerial view of Shea Blvd and 104$^{th}$ Street – LILO Site (#20) (Google, 2021)**

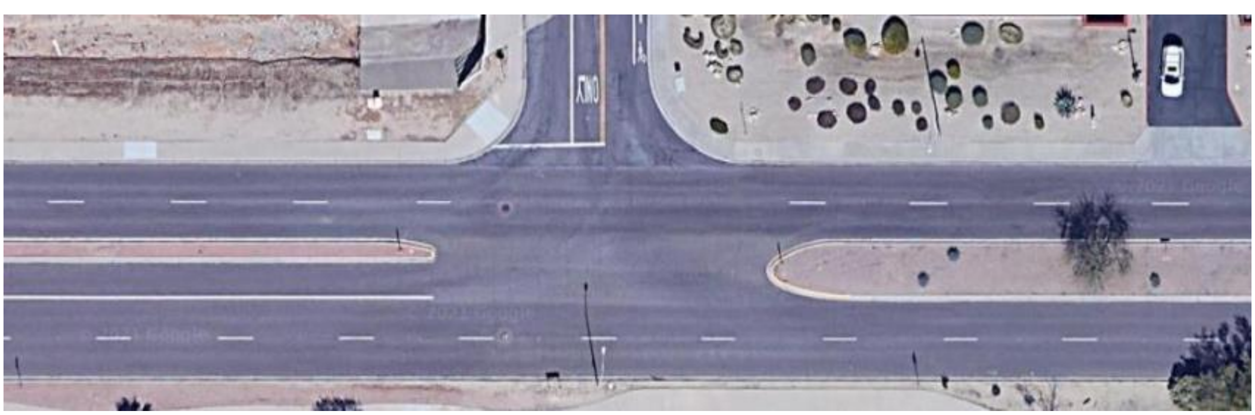

**Figure 2.3: Aerial view of Via Linda and 108$^{th}$ Street – Control Site (#28) (Google, 2021)**

Table 2.1: List of Treatment (LILO) and Control Study Sites

| Site # | North/South Street | East/West Street | Site Type | Year LILO Installed |
|---|---|---|---|---|
| 1 | Pima | Paraiso | LILO | 2012 |
| 2 | Pima | DC Marketplace | LILO | 2007 |
| 3 | 78th | Frank Lloyd Wright | LILO | 2013 |
| 4 | 82nd | Frank Lloyd Wright | LILO | 2016 |
| 5 | Redfield | Frank Lloyd Wright | LILO | 2013 |
| 6 | Celtic | Frank Lloyd Wright | LILO | 2016 |
| 7 | Camino del Santo | Frank Lloyd Wright | LILO | 2016 |
| 8 | Sweetwater | Frank Lloyd Wright | LILO | 2013 |
| 9 | 77th | Shea | LILO | 2017 |
| 10 | Becker Lane | Shea | LILO | 2007 |
| 11 | 100th | Shea | LILO | 1990 |
| 12 | 120th | Shea | LILO | 1990 |
| 13 | 142nd | Shea | LILO | 1999 |
| 14 | Hayden | 74th | LILO | 2002 |
| 15 | Scottsdale | Joshua Tree Lane | LILO | 1997 |
| 16 | Via Linda | 94th | LILO | 2018 |
| 17 | 104th | McDowell Mtn Ranch | LILO | 2009 |
| 18 | N Paradise View | Indian Bend | LILO | 2009 |
| 19 | Via De La Sendero | Indian Bend | LILO | 2010 |
| 20 | 104th | Shea | LILO | 1990 |
| 21 | Access to Mountain View Park | Mountain View | LILO | 2016 |
| 22 | 118th | Shea | LILO | 1990 |
| 23 | 8180 Vintage Apts | Shea | LILO | 2010 |
| 24 | Access to Chaparral Plaza | Chaparral | LILO | 2003 |
| 25 | 108th | Shea | LILO | 1990 |
| 26 | 100th | Bell | Control | N/A |
| 27 | Via Linda | Cholla | Control | N/A |
| 28 | 108th | Via Linda | Control | N/A |
| 29 | 78th | Shea | Control | N/A |
| 30 | 66th | Shea | Control | N/A |
| 31 | 68th | Cactus | Control | N/A |
| 32 | 70th | Cactus | Control | N/A |
| 33 | 74th | Cactus | Control | N/A |
| 34 | Sundown | Cactus | Control | N/A |
| 35 | 105th | McDowell Mountain Ranch | Control | N/A |
| 36 | 90th | Bell | Control | N/A |
| 37 | Scottsdale | Cochise | Control | N/A |
| 38 | Scottsdale | Royal Palm | Control | N/A |
| 39 | 84th | Indian Bend | Control | N/A |
| 40 | 75th | Osborn | Control | N/A |
| 41 | 70th | Goldwater | Control | N/A |
| 42 | Civic Center Plaza | Drinkwater | Control | N/A |
| 43 | 75th | Thomas | Control | N/A |
| 44 | 87th | McDowell | Control | N/A |
| 45 | 64th | Osborn | Control | N/A |
| 46 | Scottsdale | Silverstone | Control | N/A |
| 47 | 83rd | McDonald | Control | N/A |
| 48 | 85th | McDowell | Control | N/A |
| 49 | Chase Bank d/w | Dynamite | Control | N/A |
| 50 | Pinnacle Peak | Alma School | Control | N/A |

Once LILO treatment and control sites were identified, numerous roadway and traffic data were collected for each site. Geometric/roadway characteristic data were collected primarily via Google Earth aerial imagery and/or Street View (Google, 2021) for each site, and these data include:

- Number of lanes (including exclusive turn lanes) as well as total widths for both directions of the major road and the minor road/driveway.
- Type of median treatment on the roadway segment near the intersection (e.g. raised median, TWLTL, etc.) and width of median treatment.
- Speed limit on the major roadway.
- For the LILO treatment sites, additional data related specifically to the LILO treatment characteristics were collected including:
    - Presence of a raised vs. painted channelizing island.
    - Acceleration length provided for vehicles turning left from the minor street/driveway onto the major street.
    - Presence of signs related specifically to the LILO treatment. It should be noted that there is no 'typical' application of signs at these sites, and the combination of signs installed varied widely. Some sites did not have any LILO-specific signage and included only object markers (example shown in Figure 2.4), while some sites included combinations of a sign with a ''channelizing island' image, a yield sign, and a merge sign (example shown in Figure 2.5).

Traffic volume data were then obtained for each LILO treatment and control site. First, volume counts were collected in March, 2021 for each treatment and control site by approach for 48 hours and by turning movement for AM and PM peak periods in 15 minute increments. From these data, Average Daily Traffic (ADT) values were calculated for the major and minor street at each study intersection. Next, historical traffic volumes were provided by the City of Scottsdale dating back to the year 2000. ADT values for the major street segment for each intersection were identified, and since Scottsdale collected these data every other year historically, straight line interpolation was used to obtain an ADT value for the major street segment at each study intersection for every year from 2000-2019. Historical minor street ADTs counts did not exist, so these values were estimated based on the minor/major street ADT ratio observed in the 2021 counts and applied historically. Additionally, the 2021 counts were used to calculate the percentage of left turn volume on the minor road approach and major road approach, and these values were applied historically at each site for analysis in this study. It should be noted that the year 2020 is excluded from this study because the Covid-19 Pandemic drastically changed traffic volume and crash patterns and did not represent typical operating conditions. Table 2.2 shows a summary of roadway and traffic characteristics for each LILO treatment and control site including major road speed limit, mean major and minor street average ADT values, number of lanes, and LILO characteristics (at the treatment sites only). It should be noted that only ADT values for 2014-2019 (the means of which are presented in Table 2.2) are used in the cross-sectional analyses, though values dating back to 2000 are used at some sites in the empirical-Bayes before-after analyses depending on the year of LILO treatment installation.

## Table 2.2: Roadway and Traffic Characteristics for Treatment and Control Study Sites

| Site # | Site Type | Major Road Speed Limit (mph) | Mean ADT (2014-2019) | | | Total Number of Lanes** | | LILO Characteristics | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Major Road | Minor Road | Minor Road Left Turn % | Major Road | Minor Road Approach | LILO Signs Present? | Accel. Length (ft.) | Raised vs. Painted Channelizing Island |
| 1 | LILO | 45 | 28,243 | 297 | 66.1 | 8 | 1 | Yes | 190 | Raised |
| 2 | LILO | 45 | 44,028 | 1,666 | 34.8 | 8 | 2 | Yes | 315 | Raised |
| 3 | LILO | 45 | 36,420 | 1,352 | 23.7 | 8 | 2 | Yes | 265 | Raised |
| 4* | LILO | 45 | 40,973 | 642 | 22.5 | 8 | 1 | Yes | 265 | Raised |
| 5 | LILO | 45 | 23,605 | 1,005 | 65.4 | 7 | 2 | No | 185 | Raised |
| 6* | LILO | 45 | 28,528 | 259 | 80.0 | 6 | 1 | No | 115 | Raised |
| 7* | LILO | 45 | 28,354 | 242 | 59.5 | 5 | 1 | No | 100 | Painted |
| 8 | LILO | 45 | 28,184 | 720 | 45.5 | 6 | 2 | No | 335 | Raised |
| 9* | LILO | 45 | 41,089 | 377 | 32.7 | 7 | 1 | No | 90 | Painted |
| 10 | LILO | 45 | 44,488 | 1,039 | 50.8 | 8 | 2 | Yes | 250 | Raised |
| 11 | LILO | 45 | 41,083 | 841 | 60.4 | 7 | 1 | Yes | 285 | Raised |
| 12 | LILO | 50 | 41,891 | 818 | 77.5 | 8 | 2 | Yes | 285 | Raised |
| 13 | LILO | 50 | 30,153 | 230 | 78.4 | 8 | 2 | Yes | 315 | Raised |
| 14 | LILO | 45 | 16,200 | 604 | 37.4 | 6 | 2 | Yes | 300 | Raised |
| 15 | LILO | 45 | 46,584 | 177 | 37.5 | 7 | 1 | Yes | 230 | Raised |
| 16* | LILO | 40 | 23,790 | 431 | 63.2 | 5 | 1 | No | 150 | Raised |
| 17 | LILO | 40 | 11,881 | 867 | 91.9 | 6 | 2 | Yes | 130 | Raised |
| 18 | LILO | 40 | 18,270 | 590 | 75.0 | 6 | 2 | Yes | 100 | Raised |
| 19 | LILO | 40 | 20,716 | 1,638 | 60.1 | 5 | 1 | No | 200 | Raised |
| 20 | LILO | 50 | 41,041 | 910 | 15.7 | 7 | 1 | Yes | 285 | Raised |
| 21* | LILO | 40 | 12,946 | 633 | 44.9 | 5 | 1 | No | 160 | Raised |
| 22 | LILO | 50 | 41,925 | 612 | 72.9 | 7 | 2 | Yes | 290 | Raised |
| 23 | LILO | 45 | 45,277 | 557 | 55.0 | 8 | 1 | Yes | 185 | Raised |
| 24 | LILO | 30 | 16,810 | 1,252 | 29.8 | 5 | 1 | No | 125 | Raised |
| 25 | LILO | 50 | 37,588 | 64 | 100.0 | 7 | 1 | Yes | 300 | Raised |
| 26 | Control | 45 | 12,037 | 1,069 | 81.0 | 7 | 1 | N/A | N/A | N/A |
| 27 | Control | 40 | 11,902 | 422 | 83.3 | 5 | 2 | N/A | N/A | N/A |
| 28 | Control | 40 | 11,850 | 1,546 | 43.9 | 5 | 2 | N/A | N/A | N/A |
| 29 | Control | 40 | 39,687 | 692 | 11.4 | 8 | 2 | N/A | N/A | N/A |
| 30 | Control | 45 | 42,243 | 311 | 37.5 | 7 | 1 | N/A | N/A | N/A |
| 31 | Control | 45 | 29,863 | 252 | 59.5 | 4 | 1 | N/A | N/A | N/A |
| 32 | Control | 45 | 29,543 | 186 | 15.4 | 4 | 1 | N/A | N/A | N/A |
| 33 | Control | 45 | 35,260 | 364 | 14.0 | 4 | 1 | N/A | N/A | N/A |
| 34 | Control | 45 | 35,169 | 156 | 29.4 | 4 | 1 | N/A | N/A | N/A |
| 35 | Control | 40 | 2,910 | 219 | 11.1 | 5 | 1 | N/A | N/A | N/A |
| 36 | Control | 45 | 17,806 | 829 | 75.9 | 6 | 2 | N/A | N/A | N/A |
| 37 | Control | 40 | 37,179 | 845 | 38.0 | 7 | 2 | N/A | N/A | N/A |
| 38 | Control | 45 | 39,092 | 236 | 18.2 | 7 | 1 | N/A | N/A | N/A |
| 39 | Control | 40 | 20,636 | 203 | 64.5 | 5 | 1 | N/A | N/A | N/A |
| 40 | Control | 35 | 10,524 | 429 | 45.1 | 5 | 1 | N/A | N/A | N/A |
| 41 | Control | 35 | 11,828 | 1,524 | 72.2 | 6 | 2 | N/A | N/A | N/A |
| 42 | Control | 35 | 9,307 | 1,924 | 20.8 | 6 | 2 | N/A | N/A | N/A |
| 43 | Control | 40 | 28,352 | 196 | 41.1 | 4 | 1 | N/A | N/A | N/A |
| 44 | Control | 45 | 29,553 | 1,516 | 46.0 | 7 | 1 | N/A | N/A | N/A |
| 45 | Control | 40 | 11,200 | 1,566 | 48.5 | 5 | 2 | N/A | N/A | N/A |
| 46 | Control | 50 | 35,170 | 404 | 37.5 | 6 | 2 | N/A | N/A | N/A |
| 47 | Control | 40 | 21,191 | 372 | 52.2 | 4 | 1 | N/A | N/A | N/A |
| 48 | Control | 45 | 29,530 | 2,509 | 25.4 | 7 | 2 | N/A | N/A | N/A |
| 49 | Control | 50 | 14,635 | 273 | 57.6 | 8 | 1 | N/A | N/A | N/A |
| 50 | Control | 40 | 7,722 | 870 | 20.4 | 5 | 2 | N/A | N/A | N/A |

*ADT means based on years only after LILO installation

**Includes exclusive turn lanes

**Figure 2.4: Street view of Frank Lloyd Wright Blvd. and Redfield Rd. – LILO Site (#5) (Google, 2021)**

**Figure 2.5: Street view of Shea Blvd. and 100th Street – LILO Site (#11) (Google, 2021)**

## 2.2 CRASH DATA COLLECTION

City-wide crash data were obtained from the City of Scottsdale for the years 2000-2019 for use in this study. Using these data, all crashes occurring within 300 feet from the center of each intersection for LILO treatment and control sites (to account for crashes associated with the LILO refuge and acceleration areas) were identified for inclusion in this study. These crash data included numerous variables of interest, with crash type and severity being most relevant for this study. It was anticipated that angle, left-turn, and sideswipe-same crashes would be the types potentially most affected by installation of a LILO treatment, so crashes were summarized by these categories at each site (with angle and left-turn crashes combined because these are similar types) along with total crashes. It should be noted that the 'left-turn' crash category includes all crashes coded as such in the Scottsdale crash database and may involve a vehicle turning left onto or out of the minor road (it was not possible within the scope of this study to differentiate between the two using the crash database). Additionally, crashes were summarized by severity (i.e. injury severity of the most severely injured crash-involved person) in three different categories: all injury crashes (KABC), moderate/severe/fatal injury crashes (KAB) and severe/fatal injury crashes (KA). The definitions of the different severity levels are as follows: K = fatal injury, A = severe/serious injury, B = minor/non-severe injury C = possible injury, and O = no injury (property damage only). Table 2.3 shows average annual crashes by type and severity for each LILO treatment and control site. It should be noted that these annual average crash values are for the years 2014-2019 which are used in the cross-sectional analyses, though crash data dating back to 2000 are used at some sites in the empirical-Bayes before-after analyses depending on the year of LILO treatment installation.

Table 2.3: Crash Data Summary for Treatment (LILO) and Control Study Sites

| Site # | Site Type | Year LILO Installed | Average Annual Crashes (2014-2019) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Total Crashes | Angle-LT Crashes | Sideswipe Crashes | Injury (KABC) | Injury (KAB) | Injury (KA) |
| 1 | LILO | 2012 | 1.0 | 0.0 | 0.2 | 0.2 | 0.2 | 0.2 |
| 2 | LILO | 2007 | 3.0 | 1.7 | 0.5 | 1.7 | 1.3 | 0.3 |
| 3 | LILO | 2013 | 2.7 | 1.0 | 0.8 | 0.2 | 0.0 | 0.0 |
| 4* | LILO | 2016 | 7.3 | 1.3 | 0.7 | 1.7 | 0.3 | 0.3 |
| 5 | LILO | 2013 | 2.8 | 2.0 | 0.2 | 1.2 | 0.8 | 0.2 |
| 6* | LILO | 2016 | 1.0 | 0.7 | 0.3 | 0.3 | 0.3 | 0.0 |
| 7* | LILO | 2016 | 1.3 | 0.0 | 0.3 | 0.3 | 0.3 | 0.0 |
| 8 | LILO | 2013 | 3.0 | 0.3 | 0.3 | 1.0 | 0.5 | 0.0 |
| 9* | LILO | 2017 | 2.5 | 1.0 | 0.0 | 1.5 | 0.5 | 0.0 |
| 10 | LILO | 2007 | 3.2 | 0.5 | 0.5 | 0.5 | 0.0 | 0.0 |
| 11 | LILO | 1990 | 2.3 | 0.3 | 0.5 | 0.8 | 0.3 | 0.0 |
| 12 | LILO | 1990 | 2.5 | 0.5 | 0.7 | 0.8 | 0.5 | 0.0 |
| 13 | LILO | 1999 | 4.0 | 0.2 | 0.3 | 1.8 | 0.8 | 0.0 |
| 14 | LILO | 2002 | 0.5 | 0.2 | 0.0 | 0.2 | 0.2 | 0.0 |
| 15 | LILO | 1997 | 0.5 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 |
| 16* | LILO | 2018 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 17 | LILO | 2009 | 1.7 | 1.5 | 0.0 | 1.0 | 0.7 | 0.0 |
| 18 | LILO | 2009 | 1.2 | 0.5 | 0.3 | 0.3 | 0.2 | 0.0 |
| 19 | LILO | 2010 | 2.8 | 1.3 | 0.3 | 0.7 | 0.5 | 0.0 |
| 20 | LILO | 1990 | 2.5 | 0.7 | 0.0 | 1.5 | 0.5 | 0.3 |
| 21* | LILO | 2016 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 22 | LILO | 1990 | 1.5 | 0.5 | 0.5 | 0.3 | 0.2 | 0.0 |
| 23 | LILO | 2010 | 1.5 | 0.2 | 0.0 | 0.5 | 0.0 | 0.0 |
| 24 | LILO | 2003 | 1.5 | 0.5 | 0.2 | 0.5 | 0.5 | 0.0 |
| 25 | LILO | 1990 | 0.7 | 0.0 | 0.2 | 0.3 | 0.3 | 0.2 |
| | | **LILO Site Mean** | **2.1** | **0.6** | **0.3** | **0.7** | **0.4** | **0.1** |
| 26 | Control | N/A | 1.5 | 1.2 | 0.0 | 0.5 | 0.3 | 0.0 |
| 27 | Control | N/A | 0.8 | 0.7 | 0.0 | 0.2 | 0.2 | 0.0 |
| 28 | Control | N/A | 1.2 | 0.2 | 0.0 | 0.7 | 0.5 | 0.0 |
| 29 | Control | N/A | 1.3 | 0.3 | 0.3 | 0.7 | 0.2 | 0.0 |
| 30 | Control | N/A | 2.0 | 0.8 | 0.3 | 1.0 | 0.5 | 0.0 |
| 31 | Control | N/A | 3.2 | 0.7 | 0.3 | 1.5 | 0.8 | 0.2 |
| 32 | Control | N/A | 2.0 | 0.0 | 0.3 | 0.8 | 0.7 | 0.0 |
| 33 | Control | N/A | 3.2 | 0.7 | 0.2 | 0.7 | 0.2 | 0.0 |
| 34 | Control | N/A | 0.8 | 0.2 | 0.3 | 0.2 | 0.2 | 0.0 |
| 35 | Control | N/A | 1.7 | 1.0 | 0.0 | 0.8 | 0.5 | 0.0 |
| 36 | Control | N/A | 1.2 | 0.8 | 0.0 | 0.2 | 0.0 | 0.0 |
| 37 | Control | N/A | 4.2 | 2.8 | 0.3 | 1.2 | 0.8 | 0.0 |
| 38 | Control | N/A | 1.7 | 0.2 | 0.0 | 1.2 | 0.7 | 0.2 |
| 39 | Control | N/A | 0.7 | 0.2 | 0.2 | 0.5 | 0.2 | 0.0 |
| 40 | Control | N/A | 1.3 | 0.2 | 0.0 | 0.3 | 0.2 | 0.0 |
| 41 | Control | N/A | 0.8 | 0.3 | 0.5 | 0.5 | 0.2 | 0.0 |
| 42 | Control | N/A | 0.7 | 0.3 | 0.2 | 0.2 | 0.2 | 0.0 |
| 43 | Control | N/A | 3.2 | 0.8 | 0.3 | 1.0 | 0.3 | 0.2 |
| 44 | Control | N/A | 4.3 | 3.0 | 0.0 | 1.5 | 1.2 | 0.5 |
| 45 | Control | N/A | 5.0 | 2.8 | 0.0 | 1.7 | 1.0 | 0.2 |
| 46 | Control | N/A | 1.0 | 0.2 | 0.0 | 0.2 | 0.0 | 0.0 |
| 47 | Control | N/A | 0.8 | 0.7 | 0.0 | 0.3 | 0.2 | 0.0 |
| 48 | Control | N/A | 3.0 | 1.7 | 0.2 | 1.3 | 0.8 | 0.0 |
| 49 | Control | N/A | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 50 | Control | N/A | 0.5 | 0.2 | 0.0 | 0.2 | 0.0 | 0.0 |
| | | **Control Site Mean** | **1.8** | **0.8** | **0.1** | **0.7** | **0.4** | **0.1** |

*Means based on years only after LILO installation

# 3.0 CROSS-SECTIONAL SAFETY ANALYSES

As noted in previously in Chapter 1.2, cross-sectional analyses can utilize statistical modelling to determine the safety effectiveness of a roadway treatment. In this study, that modelling framework involves development of annual crash prediction models, also known as safety performance functions (SPFs). Essentially, these models are developed to predict annual crash frequencies as a function of exposure variables (in this case major and minor road ADT), and site characteristics (in this case, an indicator variable for presence of the LILO treatment). The parameter estimates for the LILO treatment variable in the model output can then be used to determine the safety effectiveness of the treatment compared with the control sites. Given the non-negative integer nature of crash frequency data (i.e. discrete count data), negative binomial (NB) regression is used to develop these crash prediction models. The NB modelling framework is extremely common in this application (HSM, 2010), and takes the following form in this study:

Predicted Annual Crash Frequency = $e\hat{}(\beta_1 X_1 + \beta_2 X_2 + \beta_i X_i)$ (2)

Where $\beta_i$ are model estimated parameters and the $X_i$ are values of independent variables (e.g. major road ADT, minor road ADT, and LILO treatment indicator (LILO = 1, control site = 0)). It should be noted that the p-value associated with each $\beta_i$ parameter estimate can be used to determine statistical significance; if the p-value is less than 0.05, that parameter would be considered statically significant at the 95% confidence level. Annual crash frequency would be considered the dependent variable in this modelling framework. Given the relative overdispersion of crash data (i.e. variance is greater than the mean), the NB modelling framework also estimates an 'overdispersion parameter' which is not especially relevant for the cross-sectional analyses, but is utilized for the EB before-after analyses which will be discussed in Chapter 4.0 of this report. Further more detailed discussion of the NB modelling framework can be found elsewhere (Washington et al., 2011).

To assemble the modelling dataset for the cross-sectional analyses, the number of crashes, major street ADT, and minor street ADT were summarized for each site (both treatment and control) and each year from 2014-2019. It should be noted that for the LILO treatment sites, six locations had LILO installation dates after 2013, and only years after installation were included in this data set (with the year of installation also excluded). This resulted in a total of 279 site-years of observations for this modeling (129 site-years for treatment sites and 150 site-years for control sites). With this dataset, six different NB models were estimated for different crash types/severities including:

- Total crashes
- Angle/Left-Turn (LT) crashes
- Sideswipe-same direction crashes
- All injury (KABC) crashes
- KAB injury crashes
- KA injury crashes

It should also be noted that for modelling purposes, the natural log (Ln) of ADT values were used just to improve interpretability of results (if ADT is used directly, the parameter estimates are extremely small decimal values).

Table 3.1 shows the results of the six NB regression models estimated for the cross-sectional analyses including $\beta_i$ parameter estimates, p-values, and overdispersion parameter. Of most importance are the parameter estimates for the LILO treatment indicator in each model. A negative parameter estimate indicates that parameter would tend to reduce annual crash frequencies, while a positive parameter estimate indicates that parameter would tend to increase annual crash frequencies. The parameter estimates for the LILO treatment can be converted to CMFs by simply taking e^($\beta_{LILO\ Treatment}$). For example, the CMF for total crashes is calculated to be: $CMF_{total\ crashes}$ = e^(-1.106) = 0.899 which translates to an expected crash reduction of 100*(1-0.899) = 10.1%.

**Table 3.1: Negative Binomial Regression Models Developed for Cross-Sectional Analyses**

| Crash Type | Parameter Estimates | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Intercept | | Ln Major Road ADT | | Ln Minor Road ADT | | **LILO Treatment Indicator** | | | Over-dispersion Parameter |
| | β | P-value | β | P-value | β | P-value | **β** | **Std. Error** | **P-value** | |
| Total Crashes | -6.128 | <0.001 | 0.483 | <0.001 | 0.305 | <0.001 | **-0.106** | **0.118** | **0.368** | 0.305 |
| Angle/Left-Turn Crashes | -7.030 | <0.001 | 0.174 | 0.283 | 0.780 | <0.001 | **-0.404** | **0.185** | **0.029** | 0.492 |
| Sideswipe Crashes | -13.265 | <0.001 | 1.029 | 0.002 | 0.156 | 0.345 | **0.399** | **0.288** | **0.166** | <0.001 |
| All Injury Crashes | -5.903 | 0.001 | 0.405 | 0.011 | 0.237 | 0.019 | **-0.160** | **0.170** | **0.346** | 0.289 |
| KAB Injury Crashes | -5.817 | 0.011 | 0.287 | 0.145 | 0.318 | 0.014 | **-0.167** | **0.216** | **0.439** | 0.185 |
| KA Injury Crashes | -21.571 | 0.013 | 1.585 | 0.042 | 0.399 | 0.270 | **-0.288** | **0.618** | **0.641** | 3.116 |
| *Note: Underlined text indicates β parameter estimate is significant at 95% confidence level | | | | | | | | | | |

As shown in Table 3.1, the parameter estimates for the LILO treatment indicator are negative for total crashes, angle/left-turn crashes, all injury crashes, KAB injury crashes, and KA injury crashes, indicating the LILO treatment would tend to decrease crashes for all of these crash types/severities as compared to the control sites. However, only the estimate for angle/left-turn crashes is statistically significant at the 95% confidence level. The parameter estimate for sideswipe crashes is positive, indicating the LILO treatment may tend to increase this crash type compared to the control sites, though the estimate is not statistically significant. These results indicate that the LILO treatment is promising in terms of crash reduction compared with control sites, as the benefits of the expected reduction in total, angle-left turn (particularly since this is a statistically significant finding), and crashes in all severity categories is likely to outweigh potential increases in sideswipe crashes (which tend to be lower severity compared with other crash types). It is likely the potential increase in sideswipe crashes is associated with the merging action associated with the refuge and acceleration length provided with the LILO treatment.

Table 3.2 shows the CMFs, CRFs, standard error, and statistical significance for each crash type/severity obtained from the cross-sectional analyses. Most notably, the LILO treatment CMF for angle/left-turn crashes is 0.688 (33.2% reduction) and is statistically significant at the 95% confidence level. To help visualize the model-predicted crashes for LILO treatment vs. control sites, Figure 3.1 shows model-predicted annual total crashes and Figure 3.2 shows model-predicted annual angle/left-turn crashes across a range of major street ADTs with minor street ADT set to the overall average of 758 vehicles per day.

**Table 3.2: CMFs and CRFs Developed from Cross-Sectional Analyses**

| Crash Type | Crash Modfication Factor (CMF) | Crash Reduction Factor (CRF) % | Standard Error | Statistically Significant at 95% Confidence? |
|---|---|---|---|---|
| Total Crashes | 0.899 | 10.1% | 0.118 | No |
| Angle/Left-Turn Crashes | 0.668 | 33.2% | 0.185 | Yes |
| Sideswipe Crashes | 1.490 | -49.0% | 0.288 | No |
| All Injury Crashes | 0.852 | 14.8% | 0.170 | No |
| KAB Injury Crashes | 0.846 | 15.4% | 0.216 | No |
| KA Injury Crashes | 0.750 | 25.0% | 0.618 | No |

It should be noted that several variables related to left-turn volumes were tested as part of the cross-sectional analyses. The following variables were tested for inclusion in the NB regression models and all were found to be **not** statistically significantly associated with crash frequencies:

- Minor road left turn percentage
- Major road left turn percentage
- Cross-product of left-turn volume and conflicting major road through volume.

In addition to testing statistical significance for inclusion in the NB regression models, scatterplots summarizing average annual crash frequencies vs. minor road left-turn percentage were developed using data from years 2014-2019 for both LILO and control sites. Separate scatterplots were developed for both total crash frequency and angle/left-turn crash frequency and they are shown in Figure 3.3 and Figure 3.4, respectively. Although the LILO sites have a slightly higher average minor road left-turn percentage than the control sites (55.2% and 42.0%, respectively), it is clear from examining these scatterplots that minor road left-turn percentage does not appear to be strongly correlated with total or angle/left turn crash frequencies.

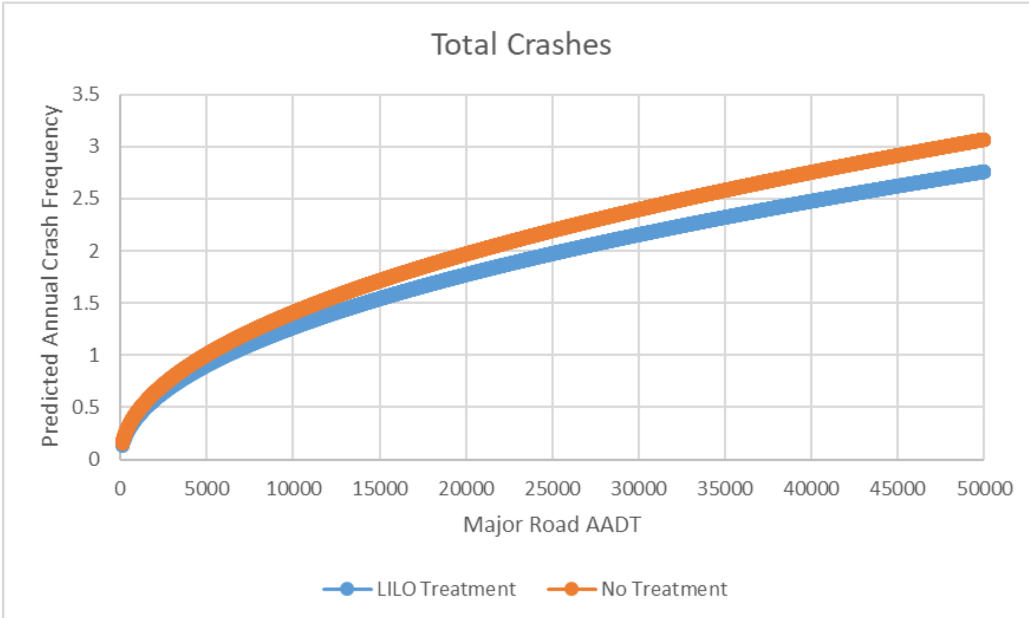


**Figure 3.1: Model-Predicted Annual Total Crash Frequency for LILO and Control Sites**

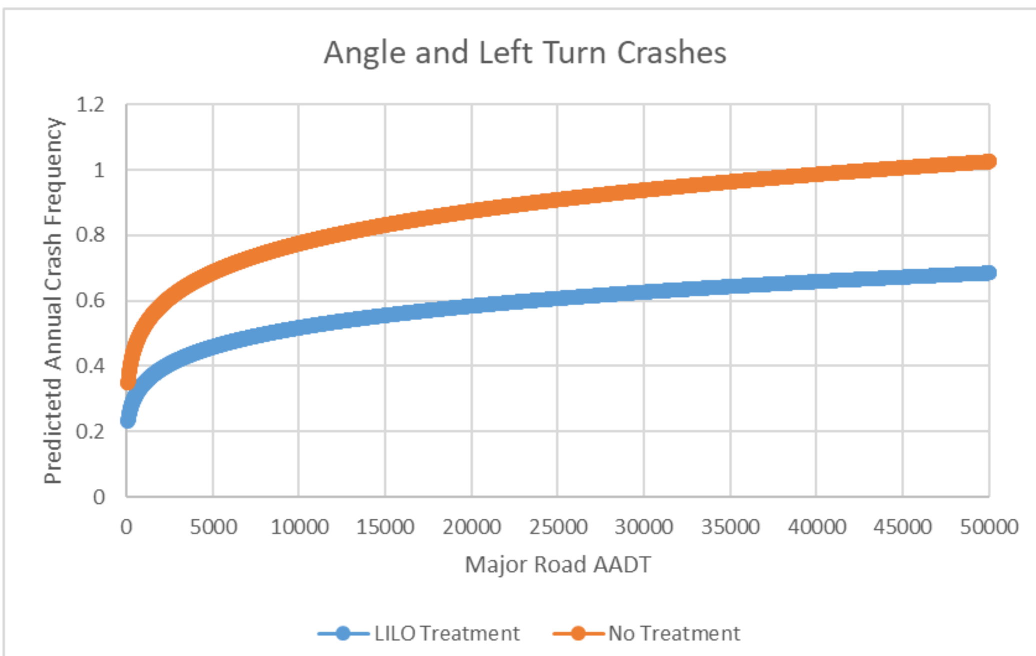


**Figure 3.2: Model-Predicted Annual Angle/Left-Turn Crash Frequency for LILO and Control Sites**

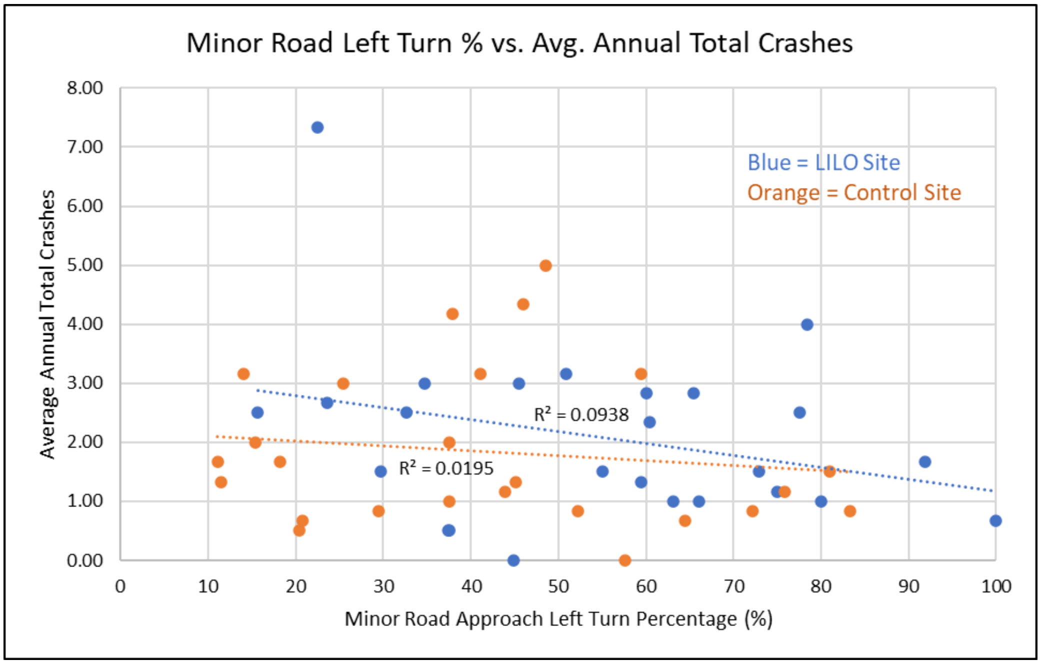


**Figure 3.3: Summary of Minor Road Left-turn Percentage vs. Average Annual Total Crash Frequency for LILO and Control Sites**

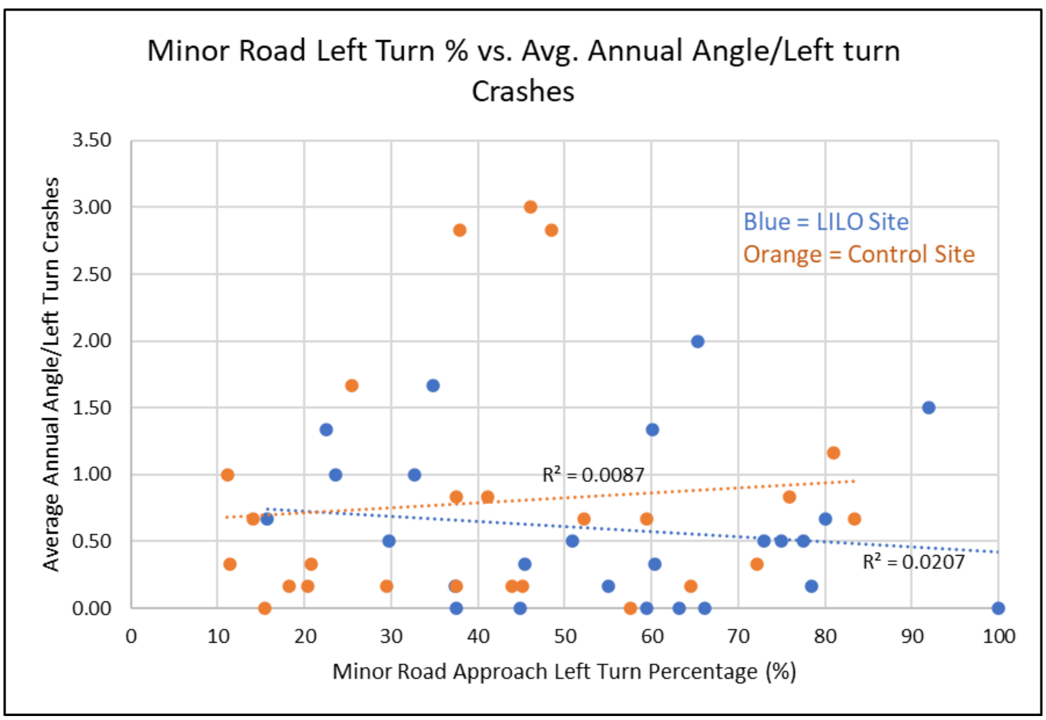


**Figure 3.4: Summary of Minor Road Left-turn Percentage vs. Average Annual Angle/Left-turn Crash Frequency for LILO and Control Sites**

# 4.0 EMPRICIAL BAYES BEFORE-AFTER ANALYSES

As mentioned previously in Chapter 1.2, an EB before-after analysis was also conducted on a subset of the LILO treatment sites. At sites # 11,12,13,15, 20, 22, and 25, the LILO treatment was installed before the year 2000, and at site # 2, the roadway did not exist before the LILO treatment was installed. Therefore, these sites were excluded from the EB before-after analysis as ‘before’ data was not available, and the remaining subset included 17 LILO treatment sites (which is still within the HSM recommendation of using a minimum of 10-20 sites for EB before-after analyses).

In contrast to the cross-sectional analyses, the EB before-after method uses up to 5 years of crash data both before and after LILO installation (with the installation year excluded) at the treatment sites along with predicted crashes based on models developed with the data from control sites. A weighted combination of the observed and model-predicted crashes is used to determine an ‘expected’ number of crashes at each treatment site and these estimates are compared with observed ‘after’ crashes to determine the safety effectiveness of the treatment. The EB method requires a 14-step process which is shown in Figure 4.1, and further details of each step can be found elsewhere (HSM, 2010).

It’s important to note there are a few limitations with respect to the EB before-after method in this study. First, as already noted, the analyses can only be conducted on a subset of the LILO treatment sites which reduces the sample size. Second, the installation dates for LILO sites in the remaining subset vary widely from 2002 to 2018. In these cases, only 1 or 2 years of before or after data can be included in the study. That being said, EB before-after analyses were conducted for the same crash types/severities as the cross-sectional analyses:

- Total crashes
- Angle/Left-Turn (LT) crashes
- Sideswipe-same direction crashes
- All injury (KABC) crashes
- KAB injury crashes
- KA injury crashes

Before conducting the EB before-after analyses, crash prediction models (SPFs) were estimated using data only from the control sites which estimate the predicted annual crash frequency as a function of major and minor street ADTs. These models were developed using the same NB regression framework previously described in Chapter 3.0, and the results of these models are presented in Table 4.1 and are utilized in the EB before-after analyses.

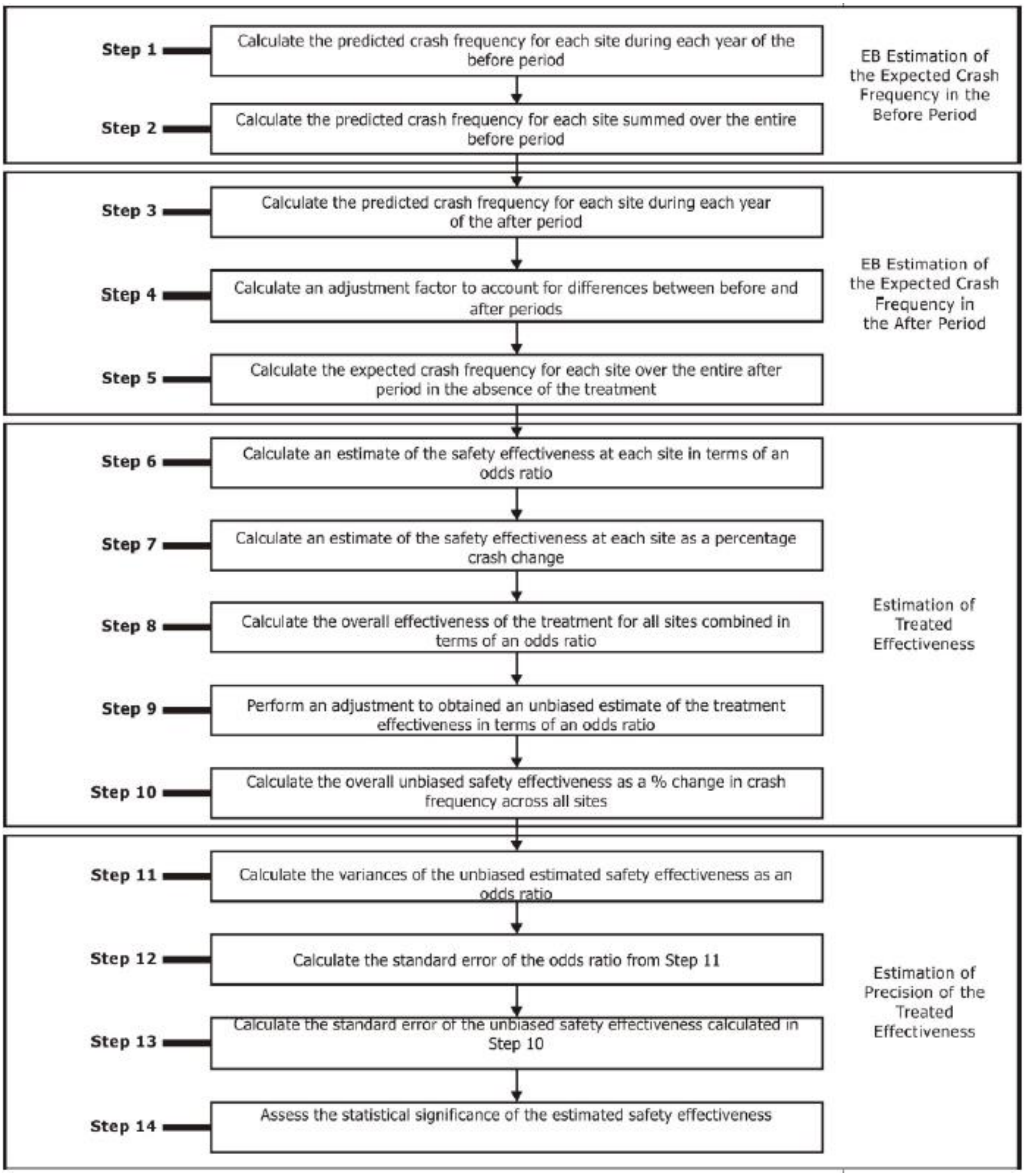


**Figure 4.1: Empirical Bayes Before-After Evaluation Process (HSM, 2010)**

**Table 4.1: Negative Binomial Regression Models Developed for Empirical Bayes Before-After Analyses (Control Sites Only)**

| Crash Type | Parameter Estimates | | | | | | |
|---|---|---|---|---|---|---|---|
| | Intercept | | Ln Major Road ADT | | Ln Minor Road ADT | | Over-dispersion Parameter |
| | β | P-value | β | P-value | β | P-value | |
| Total Crashes | <u>-5.444</u> | 0.001 | <u>0.444</u> | 0.001 | <u>0.258</u> | 0.007 | 0.372 |
| Angle/Left-Turn Crashes | <u>-6.982</u> | 0.003 | <u>0.257</u> | 0.200 | <u>0.647</u> | <0.001 | 0.733 |
| Sideswipe Crashes | <u>-10.845</u> | 0.049 | <u>0.928</u> | 0.047 | -0.069 | 0.807 | <0.001 |
| All Injury Crashes | <u>-6.308</u> | 0.004 | <u>0.454</u> | 0.013 | 0.225 | 0.068 | 0.071 |
| KAB Injury Crashes | <u>-8.087</u> | 0.006 | <u>0.491</u> | 0.047 | <u>0.353</u> | 0.032 | 0.162 |
| KA Injury Crashes | <u>-22.329</u> | 0.039 | 1.512 | 0.102 | 0.631 | 0.187 | 1.000 |
| *Note: Underlined text indicates β parameter estimate is significant at 95% confidence level | | | | | | | |

The results of the six EB before-after analyses are presented in Table 4.2, which includes the CMF, CRF, standard error and whether the CMF is statistically significant for the six different crash types/severities. The results for total crashes and sideswipe crashes are quite similar to those of the cross-sectional analysis – a modest decrease in total crashes and increase in sideswipe crashes, neither being statistically significant. The results for angle/sideswipe crashes differ from those in the cross-sectional analysis in that the EB before-after analysis shows a slight increase in these crash types, though it's not statistically significant. This is an unexpected result, but a more careful examination shows that this result is driven by sites # 3,4, and 5 (all on the Frank Lloyd Wright corridor) which experienced a total of 6, 4 and 11 angle/left-turn crashes, respectively, in the 5-year after period after LILO installation. This is not completely surprising given crashes tend to be rare and somewhat random events which are influenced by both deterministic factors and stochastic (random and unpredictable) factors (HSM, 2010). If these three sites (#3, 4, and 5) are removed from the analysis, the CMF for angle/left-turn crashes becomes 0.650 (35.0% reduction) and is statistically significant at the 90% confidence level – results much closer to those observed in the cross-sectional analysis. Because of this finding, it's recommended that the CMF obtained in the cross-sectional analysis be treated as the recommended finding (especially given the result was statistically significant at 95% confidence in the cross-sectional analysis).

**Table 4.2: CMFs and CRFs Developed from Empirical Bayes Before-After Analyses**

| Crash Type | Crash Modfication Factor (CMF) | Crash Reduction Factor (CRF) % | Standard Error | Statistically Significant at 95% Confidence? |
|---|---|---|---|---|
| Total Crashes | 0.935 | 6.5% | 0.105 | No |
| Angle/Left-Turn Crashes | 1.158 | -15.8% | 0.263 | No |
| Sideswipe Crashes | 1.427 | -42.7% | 0.357 | No |
| All Injury Crashes | 0.735 | 26.5% | 0.124 | Yes |
| KAB Injury Crashes | 0.586 | 41.4% | 0.149 | Yes |
| KA Injury Crashes | 0.599 | 40.1% | 0.384 | No |

Turning to the EB before-after results for the different injury categories, as shown in Table 4.2, crash frequencies for all three injury categories showed a reduction after the LILO treatment (similar to the findings in the cross sectional analyses but with different magnitudes). However, the CMFs for all injury crashes and KAB injury crashes (0.735 and 0.586, respectively) were found to be statistically significant at 95% confidence in the EB before-after analysis (they were not statistically significant in the cross-sectional analyses). This result shows that the LILO treatment does seem to be consistent in reducing more severe crashes, and the statistically significant CMFs obtained from the EB before-after analysis should be considered the more conclusive finding.

# 5.0 POTENTIAL SAFETY IMPACTS OF LILO DESIGN FEATURES

While the previous two chapters of this report presented analyses of the overall safety impacts of LILO treatments through development of CMFs, another objective of this study was to assess the potential impacts of different design features specifically at LILO sites on crash frequencies. As such, a NB regression model was estimated for total crashes using the same framework described previously in Chapter 3.0, but using only data from LILO treatment sites (2014-2019) and considering additional variables beyond major and minor street ADT. The results of this model are presented in Table 5.1 which include variables related to the LILO channelizing island design, signage, acceleration length, speed limit, and the cross product of peak hour minor road left turn traffic and major road traffic, among others. In examining the p-values in Table 5.1, it is apparent that none of the variables are significant at the 95% confidence level (or even a 90% confidence level for that matter). Based on these results, a strong conclusion cannot be made with respect to the performance of different LILO design features with the available data set. Further research and monitoring over time may be warranted to further explore potential impacts of specific LILO design features.

**Table 5.1: Negative Binomial Model to Assess LILO Design Features**

| Parameter | β | Standard Error | P-value |
|---|---|---|---|
| Intercept | -3.360 | 3.279 | 0.305 |
| Ln Major ADT | 0.123 | 0.335 | 0.714 |
| Ln Minor ADT | 0.235 | 0.183 | 0.197 |
| LILO - Raised channelizing island | -0.389 | 0.439 | 0.376 |
| LILO - No signs present | 0.235 | 0.225 | 0.296 |
| LILO - Accel. length less than 200 ft | -0.310 | 0.213 | 0.144 |
| Speed Limit 45-50mph | 0.226 | 0.315 | 0.472 |
| Raised Median | 0.046 | 0.475 | 0.922 |
| Ln Cross Product LT Minor-Major Volume | 0.112 | 0.126 | 0.374 |
| Overdispersion parameter | 0.209 | 0.090 | - - |

# 6.0 CRASH SEVERITY ANALYSIS

While the previous described analyses have focused on crash frequencies, it's also important to investigate how installation of the LILO treatment may impact injury severity outcomes given a crash has occurred. To assess the potential impacts of the LILO treatment on crash severity (i.e. most severely injured crash-involved person) at the crash-level, a series of binary logistic (logit) regression models were estimated to analyze factors associated with crash severity. In these analyses, the dependent variable is a binary indicator (1= injury of any severity (KABC) and 0=no injury). The binary logit model is appropriate given this binary nature of the dependent variable, and in this framework, the probability of a crash resulting in any level of injury is estimated as (Washington et al., 2011):

$$P_i = \frac{EXP[\beta_o+\beta_1 X_{1,i}+\beta_2 X_{2,i}+\cdots+\beta_K X_{K,i}]}{1+EXP[\beta_o+\beta_1 X_{1,i}+\beta_2 X_{2,i}+\cdots+\beta_K X_{K,i}]} \quad (3)$$

where: $P_i$ is the probability of crash $i$ resulting in any level of injury, $\beta_0$ is the model constant, and $\beta_1$,.. $\beta_K$ are estimable parameters corresponding with explanatory site and crash variables $X_K$. In interpreting model results, a negative $\beta$ estimate indicates that variable is associated with a decrease in injury probability, and the opposite is true for a positive $\beta$ estimate. Additionally, odds ratios are estimated with the models which can be used to determine the expected percent change in the probability of a crash resulting in an injury for that particular independent variable.

First, a model was estimated using all crashes occurring at LILO treatment and control sites for years 2014-2019 (note for the few LILO sites installed after 2013, only crashes occurring in the years after installation were included in this dataset). This dataset consisted of 268 crashes occurring at LILO sites and 276 crashes occurring at control sites (544 total). This model includes only an indicator for the LILO treatment as the independent variable which results in an estimate of the probability of a crash resulting in an injury at a LILO site vs. a control site, all else being equal. The results of this model are shown in Table 6.1, and the LILO treatment indicator variable has a negative parameter estimate (which implies a reduction in injury probability). The odds ratio for the LILO binary indicator is 0.864, which translates to a 13.6% reduction in probability of injury for crashes occurring at a LILO site compared to a control site, all else being equal. However, it's important to note that this result is not statistically significant given the p-value for the LILO indicator (0.413) is greater than 0.05.

**Table 6.1: Binary Logit Severity Model with Only LILO Treatment Indicator Variable**

| Parameter | β | Standard Error | P-value | Odds Ratio |
|---|---|---|---|---|
| Constant | -0.519 | 0.124 | <0.001 | 0.595 |
| LILO Treatment Indicator | -0.147 | 0.179 | 0.413 | 0.864 |

While the results in Table 6.1 show that in general it seems crashes occurring at LILO sites have a lower probability of injuries occurring (although it was not a statistically significant result), there are many other crash and roadway characteristics which may be associated with crash severity. Therefore, another model was estimated which includes additional variables related to time of day, crash type, roadway width, and speed limit. The results of this model are shown in Table 6.2. The results show that the LILO treatment indicator still indicates a reduction in probability of injury even when accounting for crash type and other variables, though it is still not statistically significant. Estimates for time-of-day variables (compared with off-peak times), roadway width, and speed limit variables are not statistically significant predictors of crash severity. However, several crash type variables were statistically significant (compared with sideswipe and other crash types). It was found that left-turn crashes exhibited the highest probability of injury, followed by single-vehicle and angle crashes. This is a notable result because the cross-sectional analysis presented in Chapter 3.0 showed a statistically significant reduction in angle/left-turn crash frequency associated with the LILO treatment, indicating the LILO treatment may be successful in preventing these relatively more severe crash types.

**Table 6.2: Binary Logit Severity Model with LILO Treatment Indictor plus Other Variables**

| Parameter | β | Standard Error | P-value | Odds Ratio |
|---|---|---|---|---|
| Constant | -1.378 | 0.630 | 0.029 | 0.252 |
| LILO Treatment Indicator | -0.270 | 0.239 | 0.260 | 0.764 |
| Night time 11pm-6am | 0.211 | 0.465 | 0.650 | 1.234 |
| AM Peak 6-10am | 0.272 | 0.254 | 0.283 | 1.313 |
| PM Peak 3-7pm | 0.105 | 0.217 | 0.630 | 1.110 |
| Single vehicle crash | 1.010 | 0.371 | 0.006 | 2.746 |
| Angle crash | 0.827 | 0.325 | 0.011 | 2.287 |
| Left Turn crash | 1.152 | 0.337 | 0.001 | 3.164 |
| Rear end crash | 0.700 | 0.296 | 0.018 | 2.013 |
| Main Street N/E bound total width | -0.014 | 0.014 | 0.299 | 0.986 |
| Main Street S/W bound total width | 0.007 | 0.013 | 0.579 | 1.007 |
| Center treatment width | 0.031 | 0.031 | 0.328 | 1.031 |
| Speed limit 40mph | -0.278 | 0.475 | 0.558 | 0.757 |
| Speed limit 45mph | -0.200 | 0.462 | 0.666 | 0.819 |
| Speed limit 50mph | 0.258 | 0.539 | 0.632 | 1.294 |
| Note: underlined text indicates statistically significant variables at 95% confidence | | | | |

Finally, a binary logit model was estimated with only LILO treatment site data in an attempt to determine whether certain LILO-specific features (e.g. signage, acceleration length, etc.) might be associated with crash severity. The results of this model are shown in Table 6.3. While several parameter estimates change slightly compared with the model results presented previously in Table 6.2, of primary interest are the LILO-specific variables. The presence of a raised channelizing island (as opposed to painted) and a LILO site having no signs present (compared with some combination of signs present) were not statistically significantly associated with crash severity. Sites with acceleration lengths of 200 ft. or less (compared to acceleration lengths of more than 200 ft.) were associated with an increased probability of injury, though this result is only marginally significant (at the 90% confidence level, but not 95%). However, an additional model was run with acceleration length of 200 ft. or less as the only predictor, and this variable became even less significant (p-value = 0.398), which indicates there may be some unobserved correlation with other variables, and strong conclusions should not be drawn regarding this acceleration length result.

**Table 6.3: Binary Logit Severity Model with LILO Treatment Characteristics (LILO Treatment Sites Only)**

| Parameter | β | Standard Error | P-value | Odds Ratio |
|---|---|---|---|---|
| Constant | -3.458 | 1.621 | 0.033 | 0.031 |
| Night time 11pm-6am | -1.030 | 0.895 | 0.250 | 0.357 |
| AM Peak 6-10am | 0.309 | 0.384 | 0.421 | 1.362 |
| PM Peak 3-7pm | 0.154 | 0.326 | 0.638 | 1.166 |
| Single vehicle crash | <u>1.474</u> | <u>0.527</u> | <u>0.005</u> | <u>4.365</u> |
| Angle crash | 0.811 | 0.501 | 0.106 | 2.250 |
| Left Turn crash | 0.585 | 0.539 | 0.278 | 1.795 |
| Rear end crash | <u>1.064</u> | <u>0.432</u> | <u>0.014</u> | <u>2.899</u> |
| Main Street N/E bound total width | -0.004 | 0.028 | 0.872 | 0.996 |
| Main Street S/W bound total width | 0.006 | 0.035 | 0.862 | 1.006 |
| Center treatment width | <u>0.152</u> | <u>0.063</u> | <u>0.015</u> | <u>1.165</u> |
| Speed limit 40mph | -1.060 | 1.082 | 0.327 | 0.346 |
| Speed limit 45mph | -1.430 | 1.176 | 0.224 | 0.239 |
| Speed limit 50mph | -0.526 | 1.119 | 0.638 | 0.591 |
| LILO - Raised channelizing island | -0.209 | 1.044 | 0.841 | 0.811 |
| LILO - No signs present | 0.401 | 0.754 | 0.595 | 1.493 |
| LILO - Accel. length less than 200 ft | 0.736 | 0.406 | 0.070 | 2.087 |
| Note: underlined text indicates statistically significant variables at 95% confidence | | | | |

# 7.0 SUMMARY AND CONCLUSIONS

This study presented an analysis of the potential safety impacts of LILO treatments in Scottsdale, Arizona. Crash, traffic, and roadway data were collected for 25 LILO treatment sites and 25 control sites (similar sites but without the LILO treatment) to complete the analyses. CMFs and CRFs were developed for different crash types and severities using both cross-sectional and EB before-after study designs. Additionally, the potential impacts of specific LILO design features on crash frequencies were assessed, and factors associated with crash severity in terms of the overall LILO treatment and specific LILO design features were evaluated. To the authors' knowledge, this study presents the first analysis of the potential safety impacts of the LILO treatment. The primary conclusions of this study include the following:

- The CMFs developed through cross-sectional analyses indicated that the LILO treatment was associated with a reduction in total crashes, angle/left-turn crashes, all injury crashes, KAB injury crashes, and KA injury crashes, though only <u>the CMF for angle/left-turn crashes (CMF=0.668, 33.2% reduction) was statistically significant at the 95% confidence level</u>. Additionally, the CMF for sideswipe-same direction crashes indicated the LILO treatment was associated with an increase of this crash type, though the result was not statistically significant.

- The CMFs developed through EB before-after analyses using a subset of the LILO treatment sites (17 sites) indicated that the LILO treatment was associated with a reduction in total crashes, all injury crashes, KAB injury crashes, and KA injury crashes. Most notably, the CMFs for all injury crashes (CMF=0.735, 26.5% reduction) and KAB injury crashes (CMF=0.586, 41.4% reduction) were statistically significant at the 95% confidence level. The CMFs for angle/left-turn and sideswipe-same crashes indicated the LILO treatment was associated with an increase of these crash types, though neither result was statistically significant. An inspection of the angle/left turn crash analysis revealed this result was driven largely by three sites, and this result should not be considered a strong conclusion.

- An analysis of the potential impacts of specific LILO design features on crash frequency showed that no variables (e.g. channelizing island type, signage, acceleration length) were significantly associated with crash frequency. These results may have been limited by sample size, and further research and monitoring over time may be warranted to further explore these potential impacts.

- An analysis of factors associated with crash severity showed that the LILO treatment was associated with a reduced probability of injury in the event of a crash occurrence compared with control sites, though this result was not statistically significant. Finally, in an analysis using only LILO treatment site data, it was found that LILO-specific design features were not significantly associated with crash severity, though again, this could due to sample size limitations and further investigation may be warranted.

## 7.1 PRACTICAL IMPLICATIONS FOR THE CITY OF SCOTTSDALE

Overall, the findings of this study indicate that the LILO is a promising treatment, as it was found to significantly reduce (at the 95% confidence level) angle/left-turn crashes, all injury crashes, and KAB injury crashes through analyses using two different types of statistical analyses. This indicates that the City of Scottsdale is warranted in considering subsequent applications of the LILO treatment at locations which are generally similar to the sites assessed in this study in terms of volumes, speeds, geometry, etc.

In terms of the potential safety impacts of specific LILO design features, based on the data assembled in this study for the 25 LILO treatment sites, there were no significant associations found between crashes and the signage present, acceleration length, speed limit of the major road, or median type. Of these findings, perhaps most notably, the varying application of signage at the LILO treatment sites does not appear to impact safety. In fact, there was no difference in safety performance found between LILO sites with signs vs. no signs (object marker only), indicating that future installations may not require specialized signage. Finally, it should be noted that these results are based only on the 25 LILO sites analyzed as part of this study. Subsequent analyses of other existing or future LILO treatments may provide additional guidance as to the potential impacts of specific LILO design features.

# 8.0 REFERENCES

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# Safety Impacts of Left-In Left-Out (LILO) Median Openings

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# Introduction: LILO Median Openings

- Typically applied on arterial roadways with medians and consist of a channelizing island in the median which helps direct vehicles turning left both on to and out of minor streets or driveways.

Aerial view of Shea Blvd and 104th Street: LILO Site

Aerial view of Via Linda and 108th Street: Control Site



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# More Examples

Aerial view of Frank Lloyd Wright & Sweetwater: LILO Site (raised median)


Aerial view of Frank Lloyd Wright & Camino del Santo: LILO Site (painted median)




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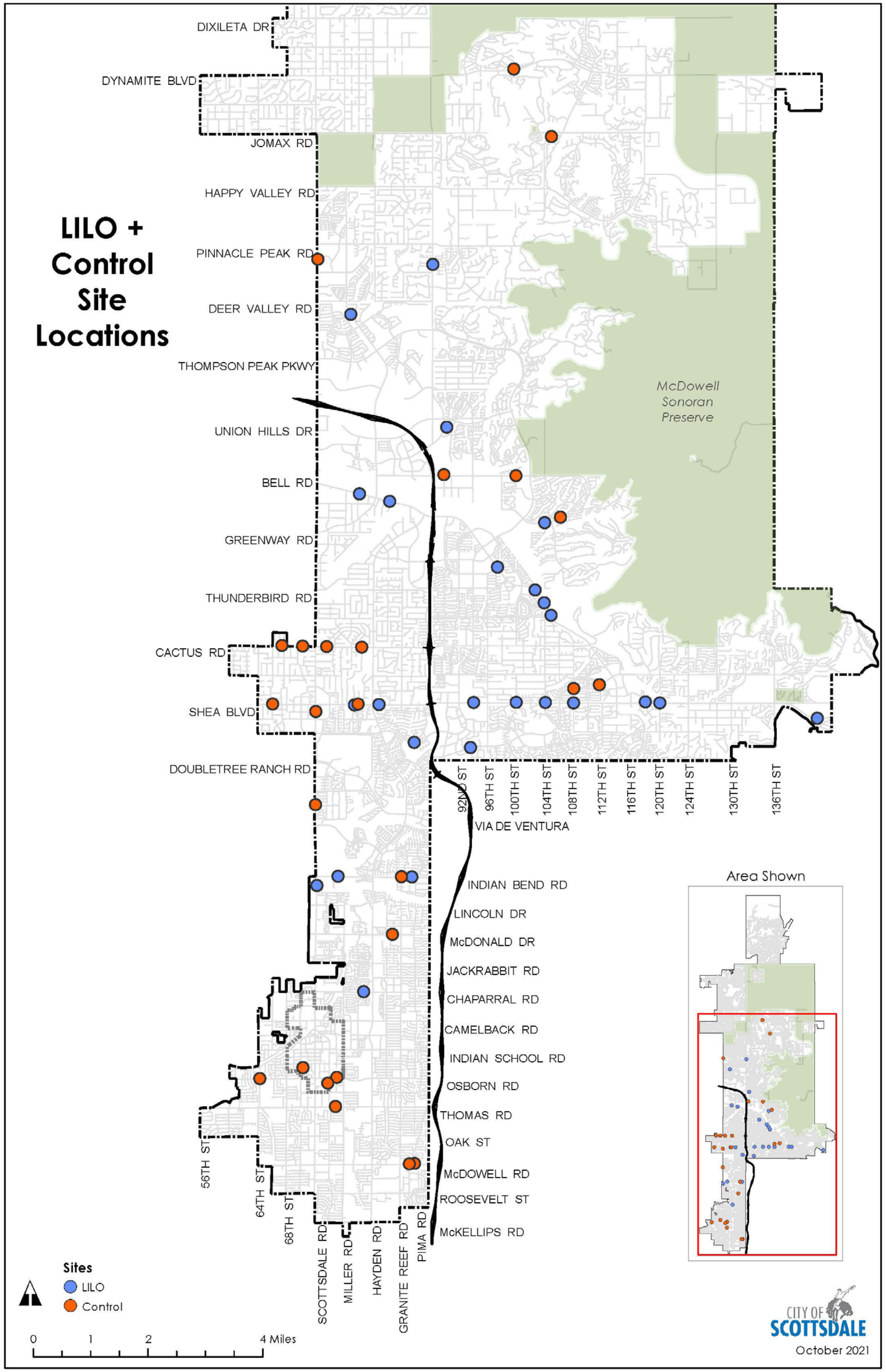
# LILO & Control Sites



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# Agenda

- History
- Tasks from Scope of Work
- Technical Report
- Results

Aerial view of Pima Rd & DC Marketplace: LILO Site (raised median)

# History: LILO Median Openings in Scottsdale

- First utilized along the Shea Boulevard corridor in early 1990’s
- Facilitate left turns (safety + improve access)
- Minimize need for traffic signal installation
- 2021: nearly 60 treatments city-wide
- Attempt to quantify effectiveness in terms of safety benefit
- September 2020 – inquiry to national peers
- November 2020 – Scope of Work created
- February 2021 – Executed contract with NAU

Aerial view of Pima Rd & Trailside View Dr: LILO Site (painted median)

# Tasks

From approved scope of work:

1) Literature Review - NAU
2) Data Collection – primarily City staff
   a) Site Inventory
   b) Collision Data
   c) Roadway Geometry + Traffic Data (turning movements & daily traffic (ADT))

Aerial view of Indian Bend & 84th St – Control Site




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# Study Objectives

From approved scope of work:

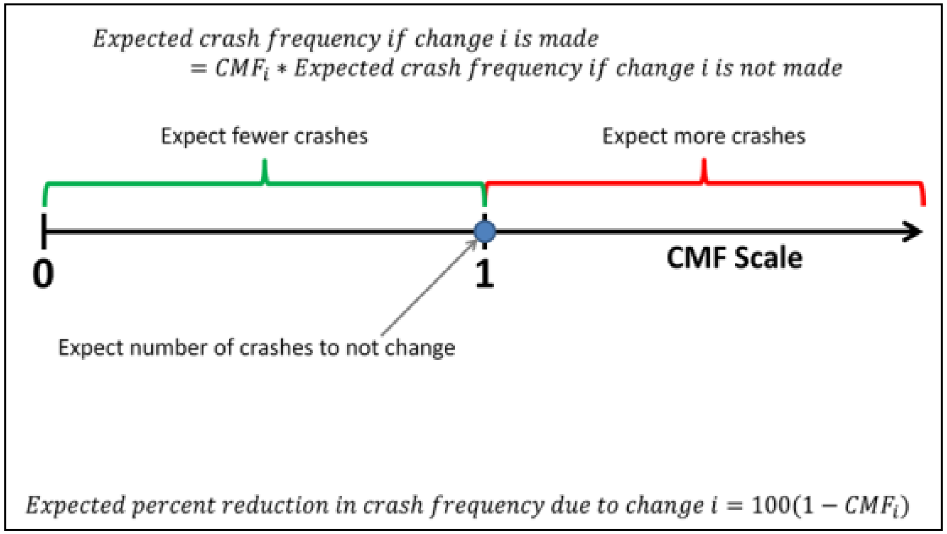
1) "Conduct a crash analysis of existing LILO sites in Scottsdale, Arizona (along with identified control sites) to assess the overall safety performance of the LILO treatment." (i.e. develop CMFs)
2) "Analyze factors associated with crash frequency and/or severity at LILO sites to assess what conditions may be most conducive to LILO treatments."

# Crash Modification Factors (CMFs)

- CMFs are used by agencies to estimate expected change in crashes after specific treatment is applied
- Provided on Federal Highway Administration's CMF Clearinghouse
- <u>No CMFs exist for LILO median treatment</u>
  - Relatively unique treatment – no documentation in research literature
  - Also reached out to the ITE community with little feedback received

Statistical significance: level of confidence that results are not due to chance.

- Typically, transportation engineers would desire a 95% confidence level to make strong conclusions




Source: Gayah and Donnell, 2014

# Data Collection: Crash Data

- Collected crash data within 300 ft from the center of each LILO and control site (2000-2019):
  - Total crashes
  - Angle/left turn crashes
  - Sideswipe crashes
  - All injury crashes
  - KAB injury crashes (K = fatal, A = serious, and B = possible injury crashes)
  - KA injury crashes (K = fatal A = serious)

# Data Collection: Geometry and Volume Data

- Collected volumes for two weekdays for each site in March 2021
  - Historical volumes provided by Scottsdale
- Used Google Earth/maps to collect geometric / roadway data:
  - Number of lanes, lane and median width
  - Raised vs. pained channelizing island (LILO)
  - Acceleration length (LILO)
  - LILO-specific signage



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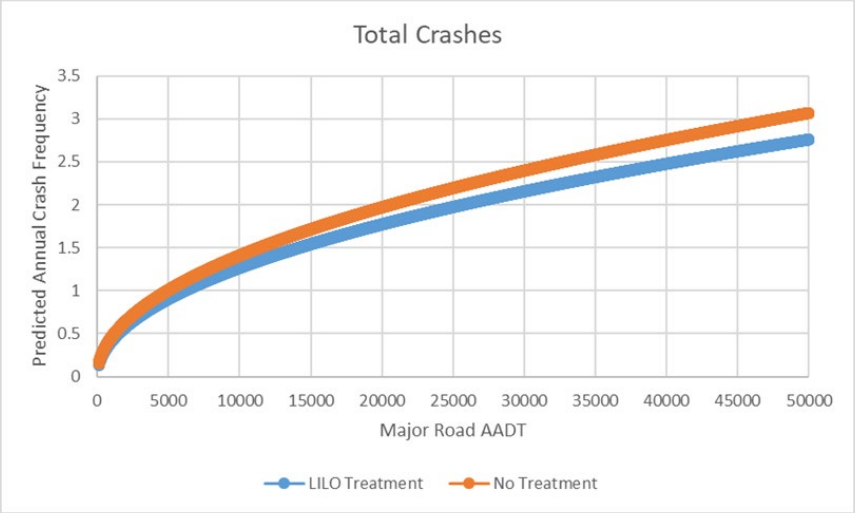
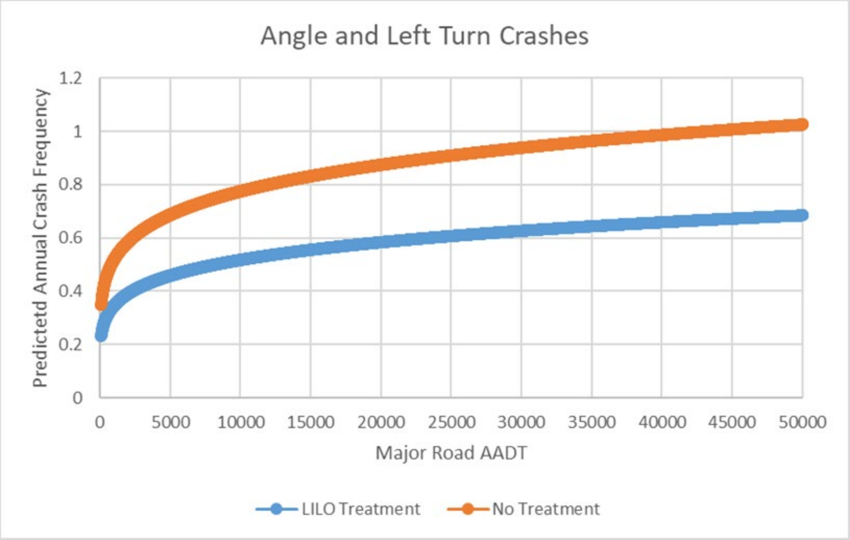
# Cross-Sectional Analysis

- Negative binomial regression models estimated using LILO and control site data from 2014-2019 for different crash types.
- Minor road and major road ADT accounted for, with LILO indicator variable included in models to estimate LILO effect.
- For total crashes results are as follows:
  - Total crashes, angle/left-turn crashed decrease
  - Sideswipe crashes increase
  - All injury crashes reduced with fatal and serious collisions further reduced



# Results: Cross-Sectional Analysis

- CMFs based on cross-sectional analyses:




| Crash Type | Crash Modfication Factor (CMF) | Crash Reduction Factor (CRF) % | Standard Error | Statistically Significant at 95% Confidence? |
|---|---|---|---|---|
| Total Crashes | 0.899 | 10.1% | 0.118 | No |
| Angle/Left-Turn Crashes | 0.668 | 33.2% | 0.185 | Yes |
| Sideswipe Crashes | 1.490 | -49.0% | 0.288 | No |
| All Injury Crashes | 0.852 | 14.8% | 0.170 | No |
| KAB Injury Crashes | 0.846 | 15.4% | 0.216 | No |
| KA Injury Crashes | 0.750 | 25.0% | 0.618 | No |



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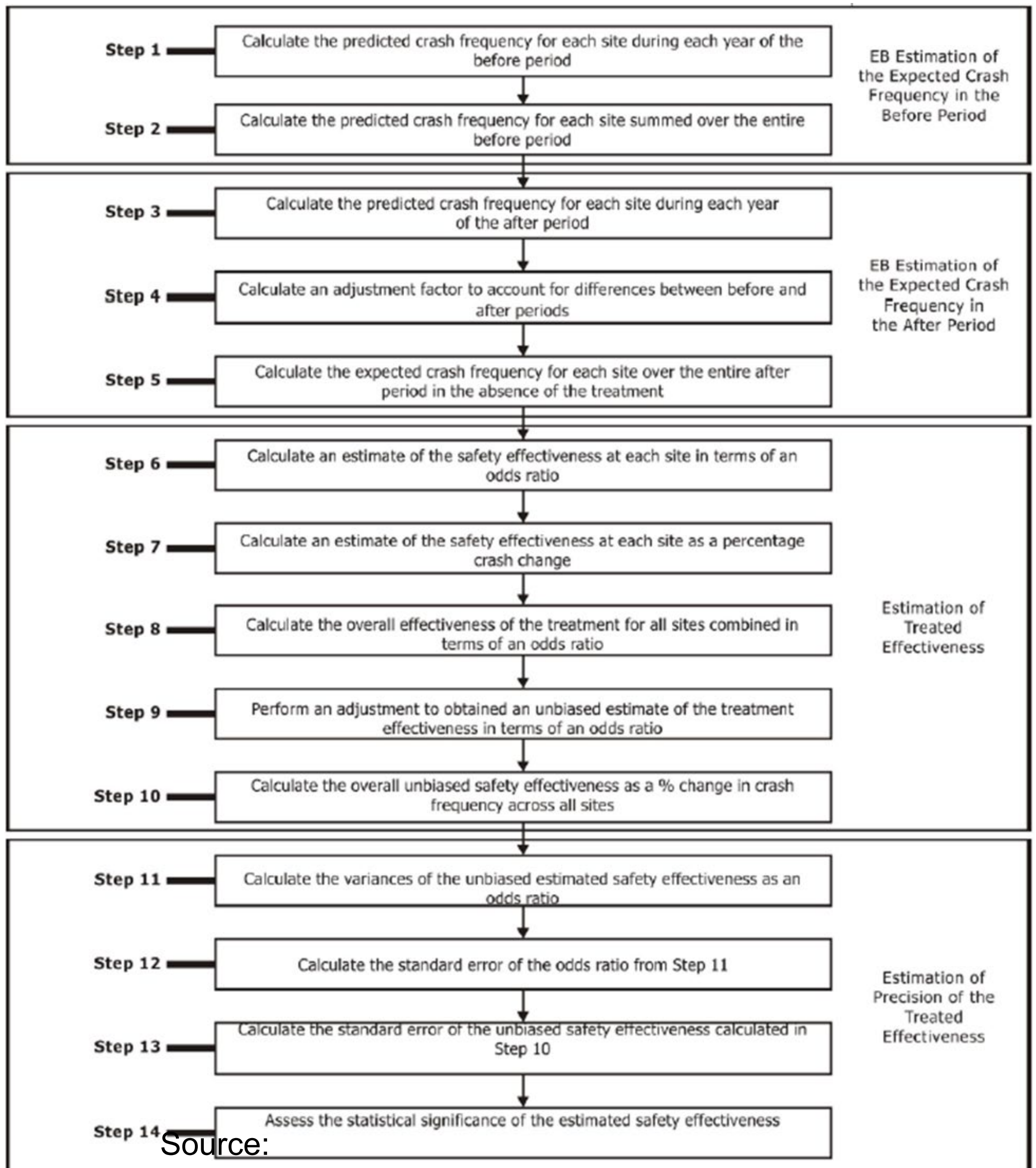
# Empirical Bayes Before-After Analysis

- 14 step process
- Conducted on subset of the LILO sites (17 sites) based on install date




Source: HSM, 2010

# Results: Empirical Bayes (EB) Before-After Analysis

- CMFs developed with EB before-after analyses:

| Crash Type | Crash Modfication Factor (CMF) | Crash Reduction Factor (CRF) % | Standard Error | Statistically Significant at 95% Confidence? |
|---|---|---|---|---|
| Total Crashes | 0.935 | 6.5% | 0.105 | No |
| Angle/Left-Turn Crashes | 1.158 | -15.8% | 0.263 | No |
| Sideswipe Crashes | 1.427 | -42.7% | 0.357 | No |
| All Injury Crashes | 0.735 | 26.5% | 0.124 | Yes |
| KAB Injury Crashes | 0.586 | 41.4% | 0.149 | Yes |
| KA Injury Crashes | 0.599 | 40.1% | 0.384 | No |



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# Results: Impacts of LILO Design Features

- Using the negative binomial regression model, the estimated impacts of the respective LILO site design features are below:

| Parameter | β | Standard Error | P-value |
|---|---|---|---|
| Intercept | -3.360 | 3.279 | 0.305 |
| Ln Major ADT | 0.123 | 0.335 | 0.714 |
| Ln Minor ADT | 0.235 | 0.183 | 0.197 |
| LILO - Raised channelizing island | -0.389 | 0.439 | 0.376 |
| LILO - No signs present | 0.235 | 0.225 | 0.296 |
| LILO - Accel. length less than 200 ft | -0.310 | 0.213 | 0.144 |
| Speed Limit 45-50mph | 0.226 | 0.315 | 0.472 |
| Raised Median | 0.046 | 0.475 | 0.922 |
| Ln Cross Product LT Minor-Major Volume | 0.112 | 0.126 | 0.374 |
| Overdispersion parameter | 0.209 | 0.090 | - - |



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# Conclusions and Implications for City of Scottsdale

- Based on data for this study, the LILO is a treatment that promotes safety for left-turning vehicles and should be continued to be applied at appropriate locations.
- Statistically significant reductions in angle/left turn and injury crashes.
- Future applications may be considered at sites generally similar to those in this study.

# Conclusions and Implications for City of Scottsdale

- These LILO design features were not found to be statistically significant:
  - No difference in sites with LILO signs vs. no signs (object marker only)
  - No difference in sites with different acceleration lengths
  - Conclusions based only on 25 LILO sites analyzed

- Anticipated that results from this report will be disseminated to the transportation community through publishing and presentation at conferences such as the annual meeting of the Transportation Research Board

# Questions/Comments?

- Contact information
  - Email: Brendan.russo@nau.edu
  - Phone: 928-523-8094

# SCOTTSDALE TRANSPORTATION COMMISSION REPORT

**To:** Transportation Commission
**From:** Shayne Lopez, Paving Manager
**Subject:** Paving Prioritization
**Meeting Date:** October 21, 2021

## ITEM IN BRIEF

**Action:** Presentation and discussion

**Purpose:** Provide information on paving prioritization

**Background:**
The city's pavement network is one of the largest asset groups, consisting of more than 20 million square yards of paved surface area with an estimated value of $1 billion (per 2015 IMS Report). Successful management of the pavement network is critical to ensure a safe operating transportation infrastructure for the public. Pavement management is the process of evaluating, prioritizing, and maintaining pavements to provide maximum benefits from available funds. In short, pavement management aims to perform the right treatment at the right time using a data driven, defensible process.

Development of the 5-year Paving Plan takes careful consideration of the current budget, current treatment types, contractual pricing for treatments, and new pavement condition through Pavement Condition Index (PCI) data (Figure 1). The paving plan will provide treatment recommendations to effectively use the current budget. The accuracy of the recommendations of a pavement model depends on reoccurring data collection of the actual condition of the roadway; on average agencies perform surveys every 3-5 years. With a functional pavement model, the Pavement Management Section will be best equipped to focus on maximizing value with limited resources.

The city contracted with IMS to develop the 2020 Pavement Condition Survey. Their scope of work included PCI data collection, data analysis, and data integration into the city's pavement modeling software, Lucity.

**Update:**
IMS completed the 2020 pavement survey, uploaded data into the City's paving model, and performed an analysis which produced a 5-year treatment plan at the current budget level ($5.9M). The analysis also included 5-year budget recommendations (Figure 2) for various PCI levels:

- Do-Nothing –identifies the effect of spending no capital for 5 years. After 5 years, this scenario results in a network average PCI drop from a 66 to a 60 and an increase in backlog (Very Poor & Poor roadways) to 2%.

- Current Budget (Green Dashed Line in Figure 2) – represents the City's current budget of $5.9M annually dedicated to pavement preservation and rehabilitation. This level of funding will result in a network average PCI score of 68 and a backlog of 0%.

- Steady State PCI –funding level required to maintain the current network average PCI at a 66. The annual budget required to do so is on the order of $3.5M annually, however backlog (Very Poor & Poor roadways) will climb to 1%.

- PCI (70) –funding level required to achieve a 'very good' PCI rating (70-85). The annual budget required to do so is on the order of $8.5M annually

- PCI (80) –funding level required to achieve the high end of a 'very good' PCI rating. The annual budget required to do so is on the order of $29.5M annually. This scenario demonstrates the sharp cost increase to maintain higher levels of service within the community.

**Next Steps:**
Staff submitted a budget package for consideration for an annual increase of $2.6M for FY23-28. This increase corresponds with the annual budget recommendation to achieve a 'very good' PCI rating.

**Attachments:**

| PCI Range | Description | Relative Remaining Life | Definition |
|---|---|---|---|
| 85 – 100 | Excellent | 15 to 25 Years | Like new condition – little to no maintenance required when new; routine maintenance such as crack and joint sealing. |
| 70 – 85 | Very Good | 12 to 20 Years | Routine maintenance such as patching and crack sealing with surface treatments such as seal coats or slurries. |
| 60 – 70 | Good | 10 to 15 Years | Heavier surface treatments, chip seals and thin overlays. Localized panel replacements for concrete. |
| 40 – 60 | Marginal to Fair | 7 to 12 Years | Heavy surface-based inlays or overlays with localized repairs. Moderate to extensive panel replacements. |
| 25 – 40 | Poor | 5 to 10 Years | Sections will require very thick overlays, surface replacement, base reconstruction, and possible subgrade stabilization. |
| 0 – 25 | Very Poor | 0 to 5 Years | High percentage of full reconstruction. |

**Figure 1 – Pavement Condition Index (PCI) in Descriptive Terms**

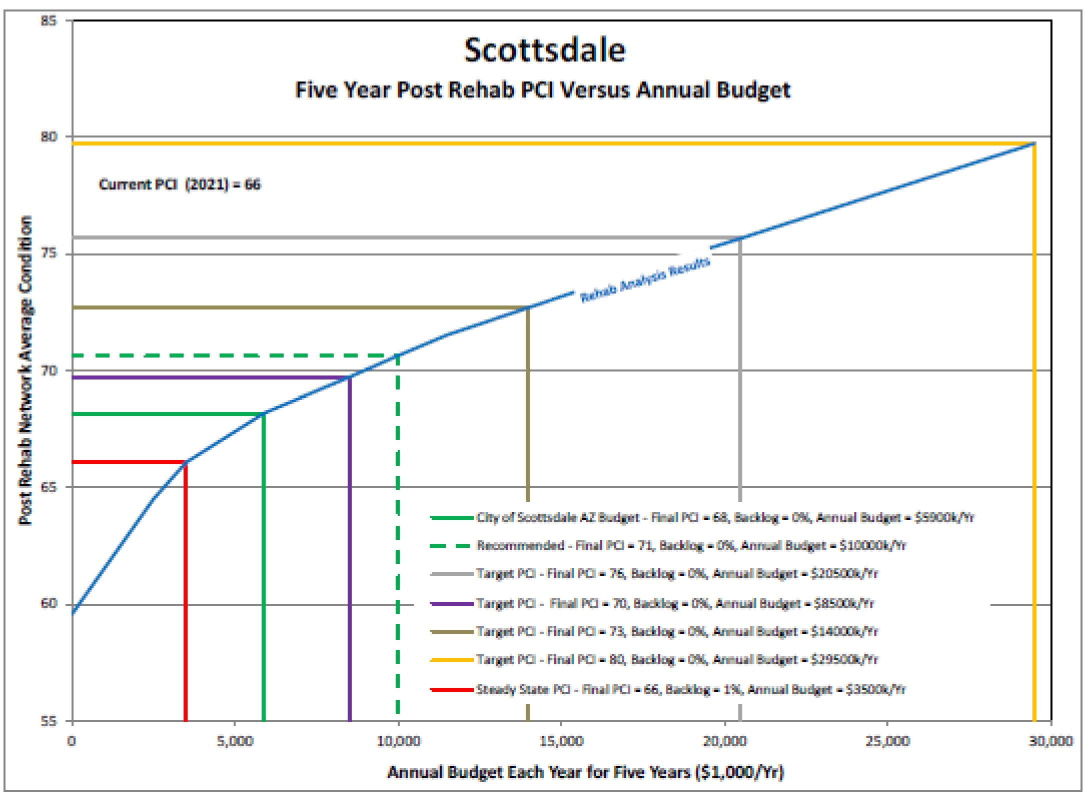


**Figure 2 – 5-Year Post Rehab PCI Analysis Results**

**Staff Contact:** Shayne Lopez, 480-312-5665, slopez@scottsdaleaz.gov

# Paving Prioritization

## Transportation Commission
## October 21, 2021

CITY OF SCOTTSDALE
TRANSPORTATION

# Overview

- Scottsdale at a Glance
- Pavement Management
- PCI
- Survey Results
- Five Year Plan
- Next Steps
- Q&A

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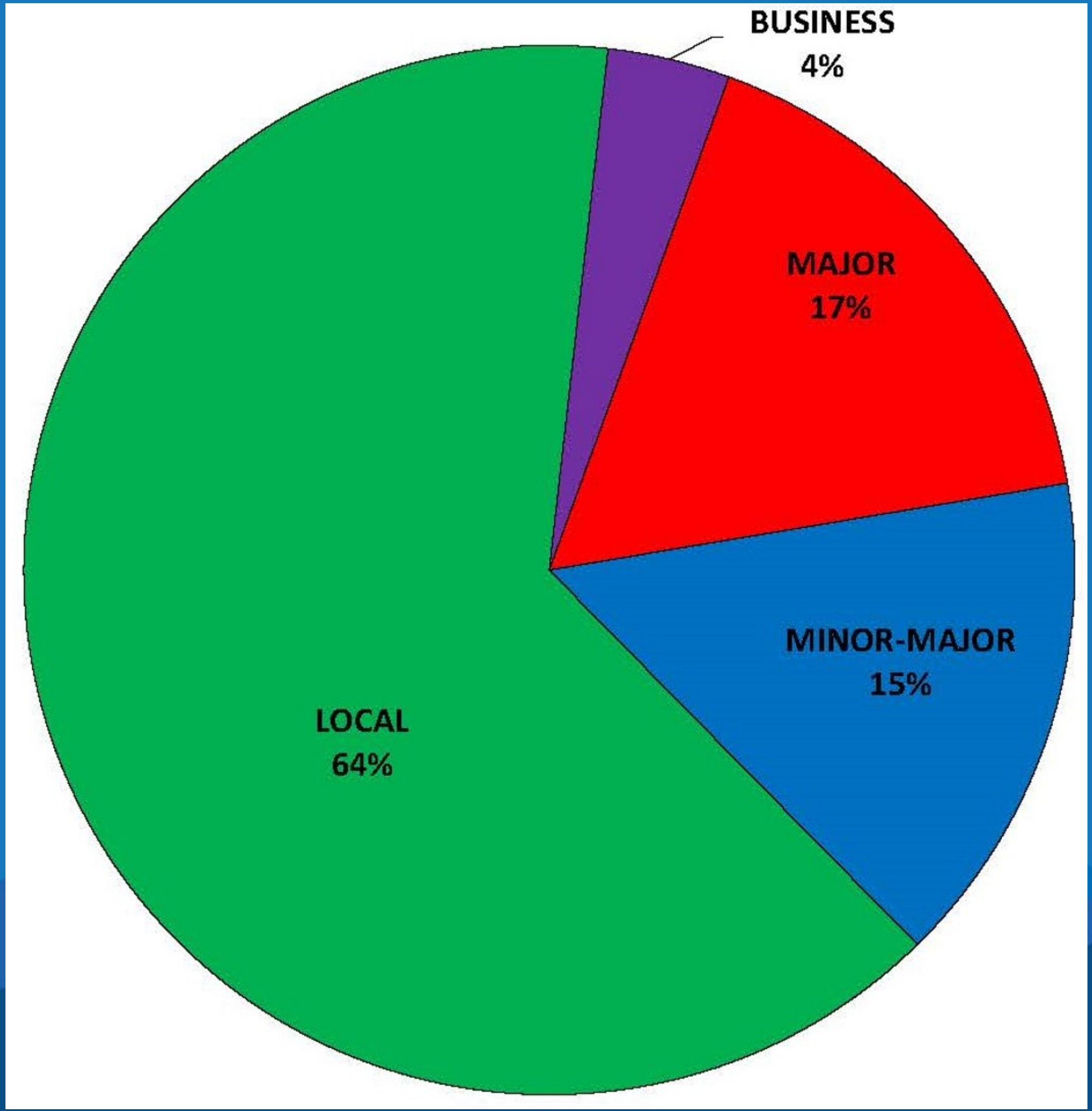
# Scottsdale at a Glance




- **Centerline Miles of Pavement: ~** 907
- **Square Yards of Pavement:** 20+ Million
- **Value Est.:** $1 Billion
- **All asphalt cement pavement, no Portland cement concrete roadways. Mostly curbed drainage conditions**

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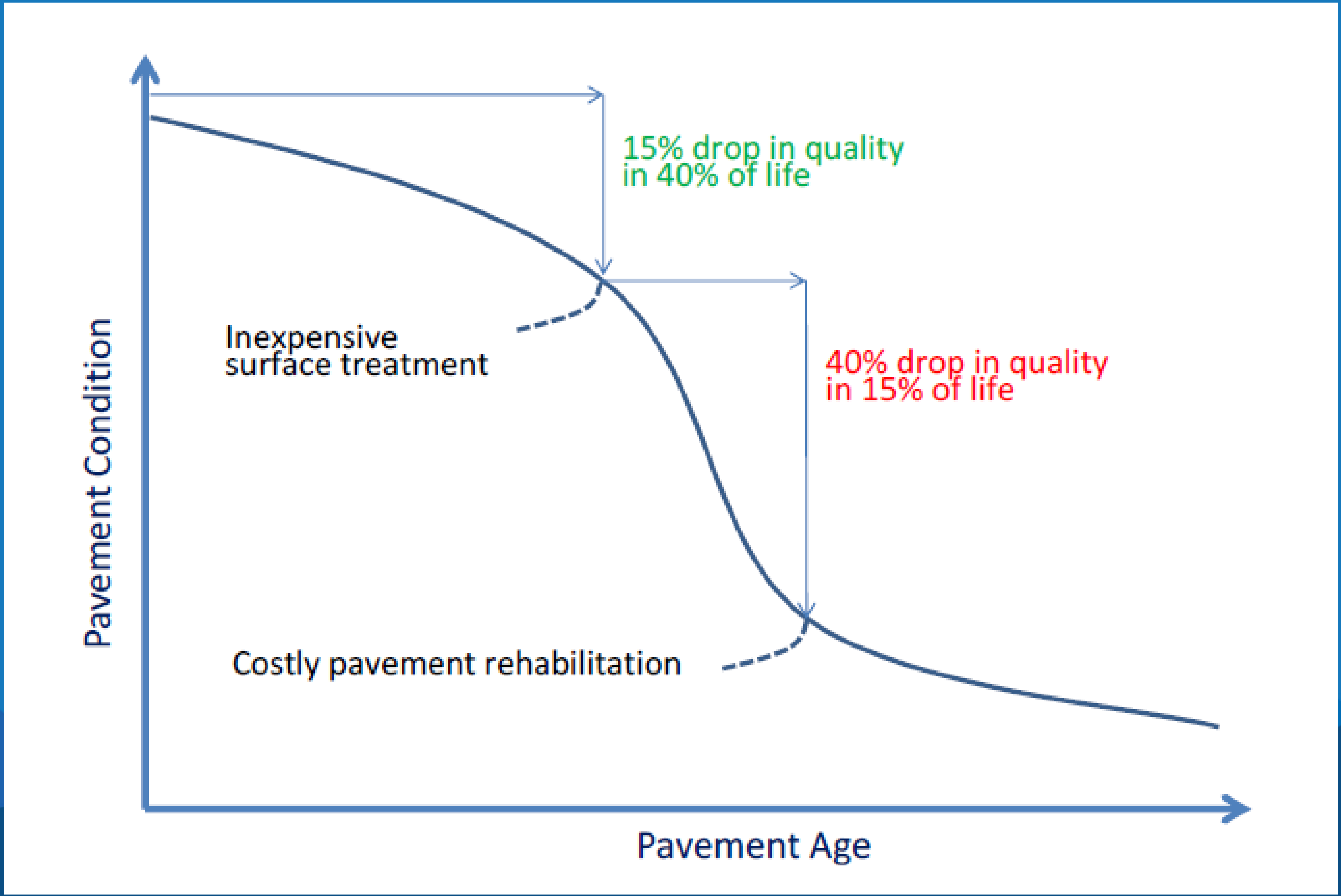
# Pavement Management




**Evaluate, prioritize, and maintain pavements to provide maximum benefits from available funds.**

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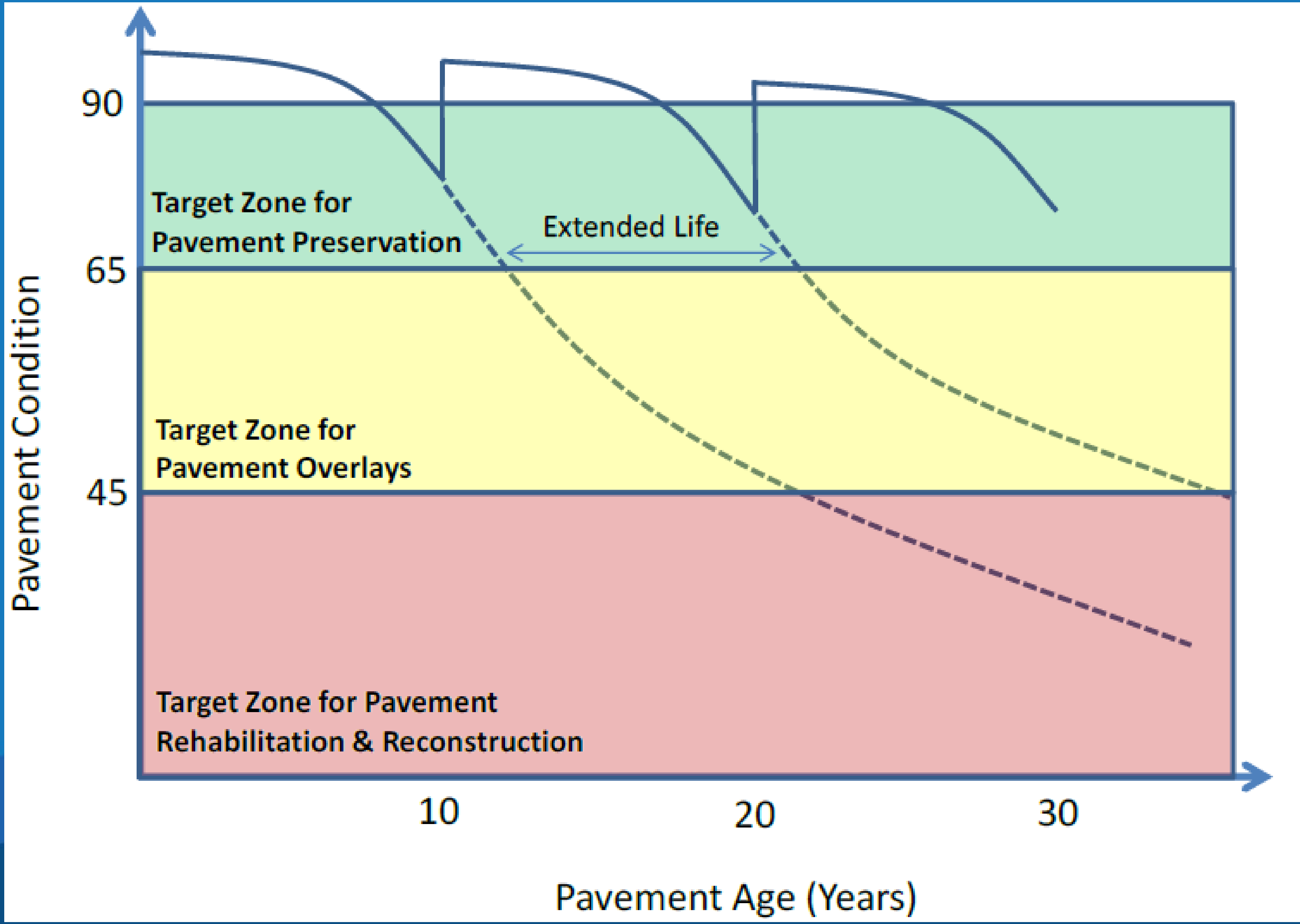
# Pavement Management




"The <u>RIGHT</u> treatment at the <u>RIGHT</u> time to maximize serviceable pavement

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TRANSPORTATION

# Pavement Condition Index (PCI)

- PCI is a numerical rating of the pavement condition based on the type and severity of distresses observed/measured on the pavement surface. Values range from 100 to 0.

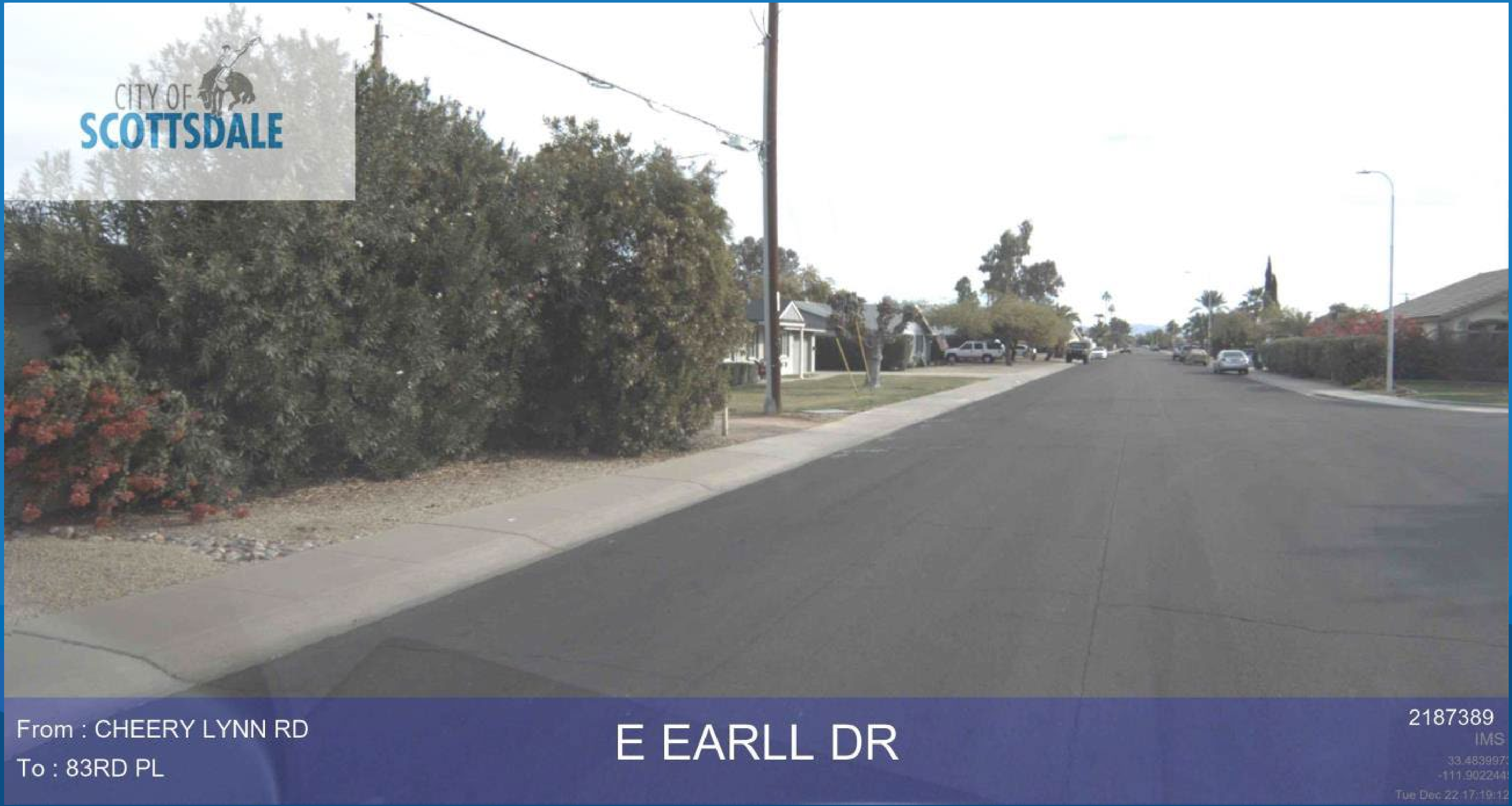
| PCI Range | Description | Relative Remaining Life | Definition |
|---|---|---|---|
| 85 – 100 | Excellent | 15 to 25 Years | Like new condition – little to no maintenance required when new; routine maintenance such as crack and joint sealing. |
| 70 – 85 | Very Good | 12 to 20 Years | Routine maintenance such as patching and crack sealing with surface treatments such as seal coats or slurries. |
| 60 – 70 | Good | 10 to 15 Years | Heavier surface treatments, chip seals and thin overlays. Localized panel replacements for concrete. |
| 40 – 60 | Marginal to Fair | 7 to 12 Years | Heavy surface-based inlays or overlays with localized repairs. Moderate to extensive panel replacements. |
| 25 – 40 | Poor | 5 to 10 Years | Sections will require very thick overlays, surface replacement, base reconstruction, and possible subgrade stabilization. |
| 0 – 25 | Very Poor | 0 to 5 Years | High percentage of full reconstruction. |

# Pavement Condition Index (PCI)

- PCI = 97

# Pavement Condition Index (PCI)

- PCI = 80



# Pavement Condition Index (PCI)

- PCI = 65

# Pavement Condition Index (PCI)

- PCI = 55

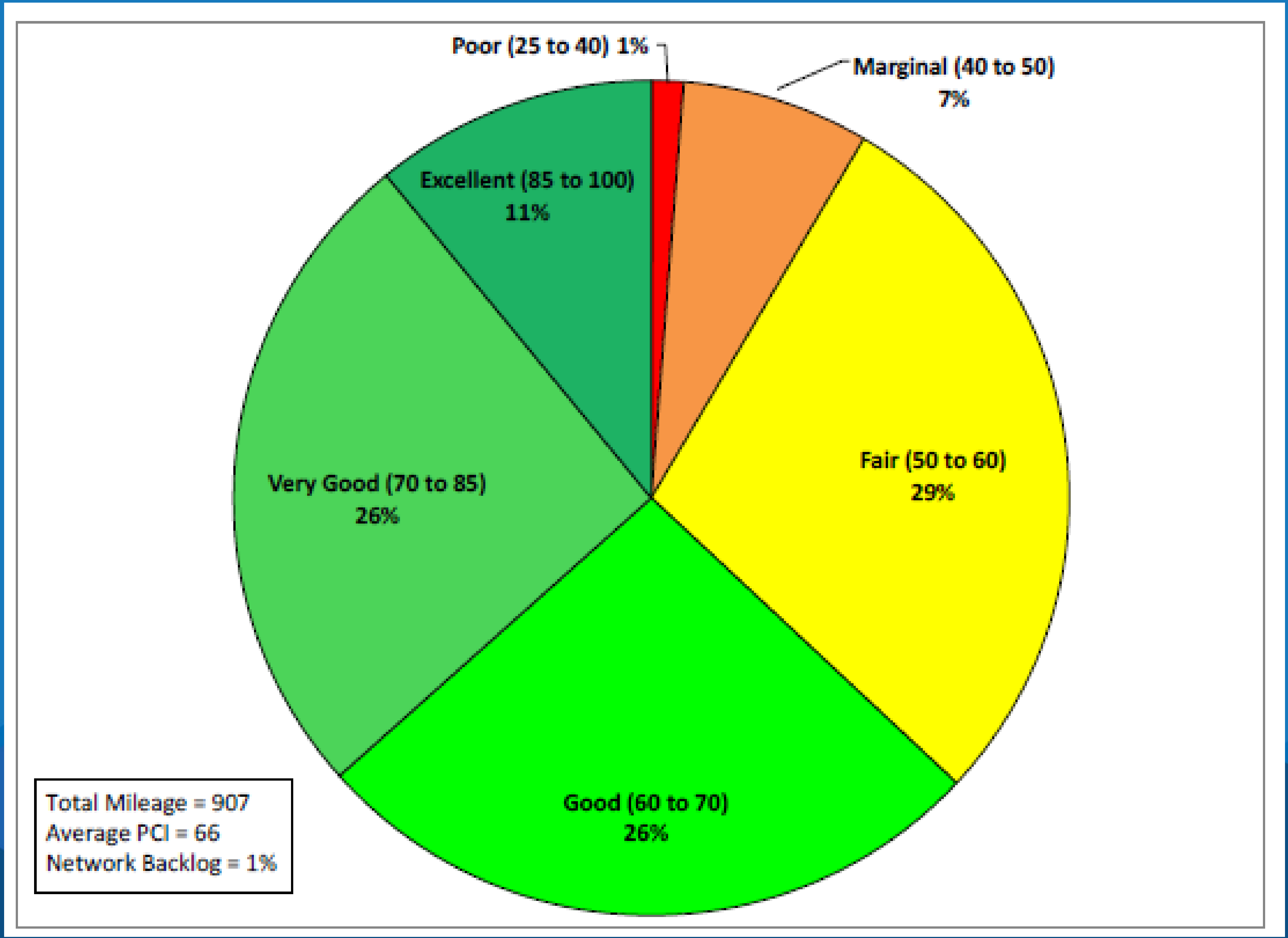
# Pavement Condition Index (PCI)

- PCI = 40

# Pavement Condition Index (PCI)

- PCI = 34

# Survey Results

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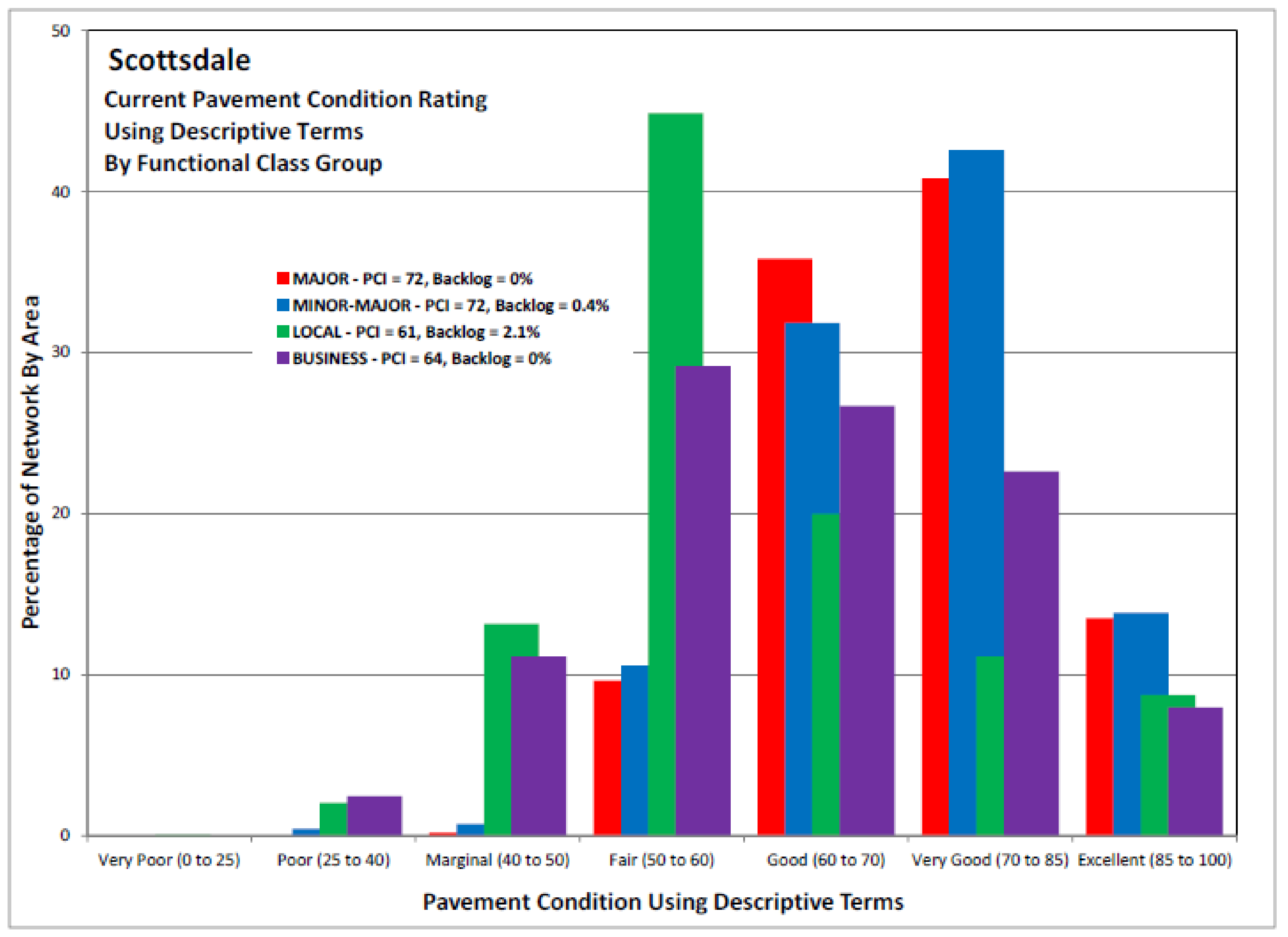
# Survey Results

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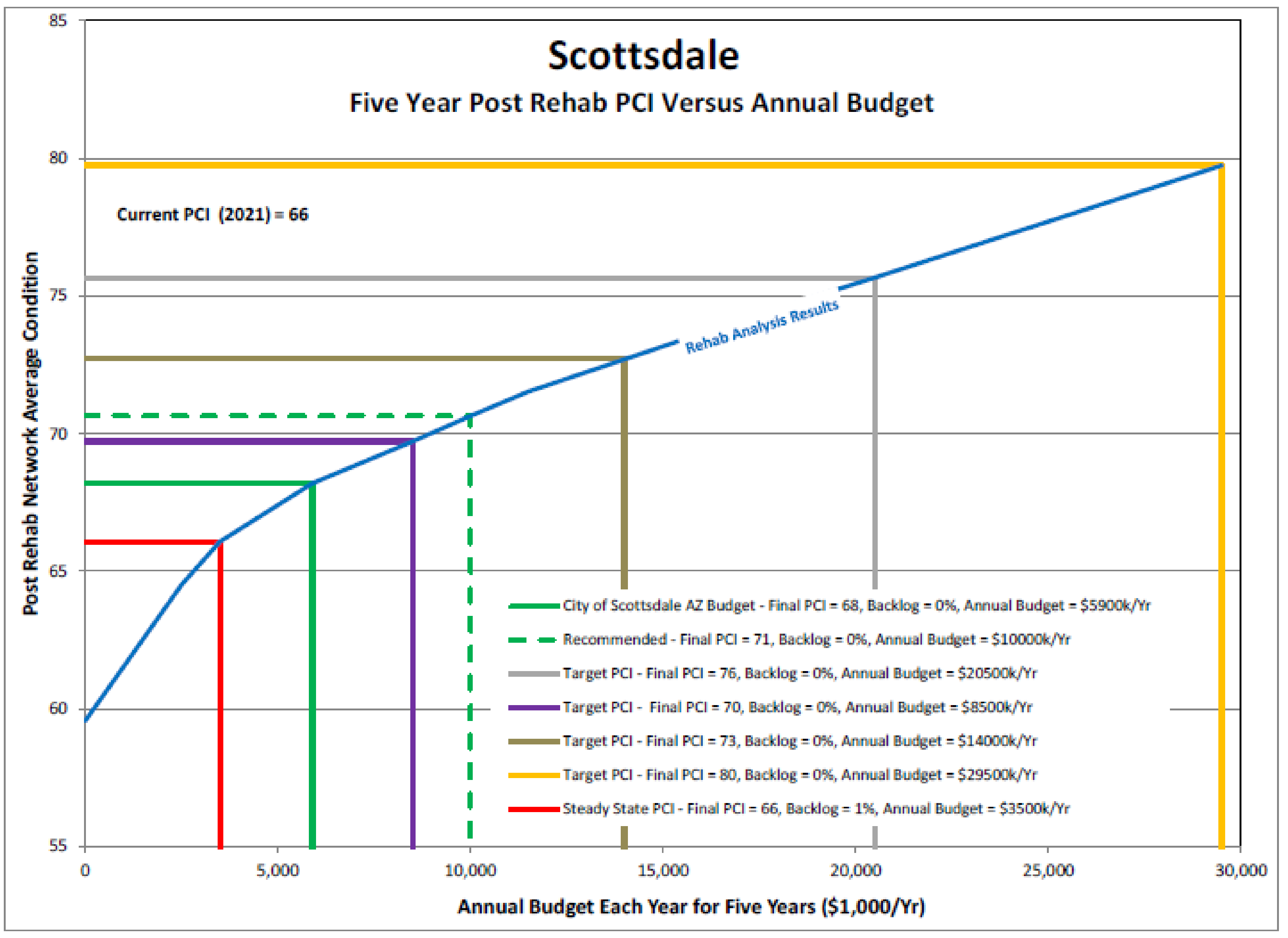
# Survey Results




- Current annual budget = $5.9M
- Proposed annual budget to reach 70 PCI by 2026 = $8.5M

CITY OF SCOTTSDALE TRANSPORTATION

## *Model Details with Selected Supersegments by Year Report*

Scottsdale AZ FY22-26 Client Budget- IMS

**Model Description:** 82 **FY22-26 Client Budget**

| Model Yr: | Superseg Code: | Superseg Desc: | Rehab: | Pavement: | Classification: | Area: | Begin PCI: | Total Cost: |
|---|---|---|---|---|---|---|---|---|
| 2021 | PID-3131 | PID-3131 - 84TH | Surface Trt / Micro II | Asphalt | LOCAL | 12319 | 72.20 | $29,566.08 |
| 2021 | PID-3127 | PID-3127 - EAGLE RIDGE | Surface Trt / Micro II | Asphalt | MAJOR | 20302 | 71.50 | $54,815.34 |
| 2021 | PID-3108 | PID-3108 - ALMA SCHOOL | Surface Trt / Micro II | Asphalt | MINOR-MAJOR | 23169 | 72.00 | $55,605.56 |
| 2021 | PID-3068 | PID-3068 - HUALAPAI | Surface Trt / Micro II | Asphalt | LOCAL | 72464 | 72.40 | $173,914.40 |
| 2021 | PID-3293 | PID-3293 - 83RD | Surface Trt / Micro II | Asphalt | LOCAL | 8452 | 71.30 | $20,284.38 |
| 2021 | PID-3294 | PID-3294 - 84TH | Surface Trt / Micro II | Asphalt | MINOR-MAJOR | 7322 | 72.50 | $17,573.21 |
| 2021 | PID-3295 | PID-3295 - MONTERRA | Surface Trt / Micro II | Asphalt | LOCAL | 21216 | 72.10 | $50,918.57 |
| 2021 | PID-3299 | PID-3299 - 111TH | Surface Trt / Micro II | Asphalt | LOCAL | 30884 | 71.60 | $74,121.10 |
| 2021 | PID-327 | PID-327 - VIA DONA | Surface Trt / Micro II | Asphalt | LOCAL | 263 | 73.10 | $631.59 |
| 2021 | PID-3267 | PID-3267 - 92ND | Surface Trt / Micro II | Asphalt | MINOR-MAJOR | 21196 | 72.70 | $50,870.74 |
| 2021 | PID-3189 | PID-3189 - 89TH | Surface Trt / Micro II | Asphalt | LOCAL | 4795 | 71.60 | $11,508.71 |
| 2021 | PID-3205 | PID-3205 - 125TH | Surface Trt / Micro II | Asphalt | LOCAL | 1238 | 77.80 | $2,972.34 |
| 2021 | PID-428 | PID-428 - 92ND | Surface Trt / Micro II | Asphalt | LOCAL | 10565 | 71.40 | $25,356.18 |
| 2021 | PID-3409 | PID-3409 - BELL | Surface Trt / Micro II | Asphalt | MAJOR | 61499 | 70.90 | $166,048.40 |
| 2021 | PID-3412 | PID-3412 - LEGACY | Surface Trt / Micro II | Asphalt | MAJOR | 52677 | 70.20 | $142,226.88 |
| 2021 | PID-3413 | PID-3413 - THOMPSON PEAK | Surface Trt / Micro II | Asphalt | MAJOR | 68296 | 71.90 | $184,398.92 |
| 2021 | PID-3414 | PID-3414 - SCOTTSDALE | Surface Trt / Micro II | Asphalt | MAJOR | 74098 | 71.30 | $200,065.88 |
| 2021 | PID-939 | PID-939 - PINNACLE PEAK | Surface Trt / Micro II | Asphalt | MAJOR | 20289 | 72.00 | $54,781.31 |
| 2021 | PID-796 | PID-796 - SAHUARO | Surface Trt / Micro II | Asphalt | BUSINESS | 27792 | 71.30 | $66,702.00 |
| 2021 | PID-736 | PID-736 - PIMA | Surface Trt / Micro II | Asphalt | MAJOR | 33036 | 72.80 | $89,196.92 |
| 2021 | PID-3395 | PID-3395 - SCOTTSDALE | Surface Trt / Micro II | Asphalt | MAJOR | 19519 | 71.20 | $52,700.38 |
| 2021 | PID-3313 | PID-3313 - BLACK MOUNTAIN | Surface Trt / Micro II | Asphalt | LOCAL | 13529 | 70.80 | $32,470.16 |
| 2021 | PID-3341 | PID-3341 - 132ND | Surface Trt / Micro II | Asphalt | LOCAL | 31787 | 72.50 | $76,288.70 |
| 2021 | PID-3363 | PID-3363 - DOVE VALLEY | Surface Trt / Micro II + Rf | Asphalt | MINOR-MAJOR | 3485 | 70.00 | $8,782.38 |
| 2021 | PID-392 | PID-392 - SCOTTSDALE | Surface Trt / Micro II + Rf | Asphalt | MAJOR | 23755 | 72.40 | $67,225.53 |
| 2021 | PID-3075 | PID-3075 - WILLIAMS | Surface Trt / Micro II + Rf | Asphalt | MINOR-MAJOR | 12699 | 72.50 | $32,002.72 |

# 5 – Year Plan

CITY OF SCOTTSDALE

# Next Steps

**Budget**

- Submit budget increase request for $2.6M to achieve ‘very good’ PCI rating of 70.

**Current/Future Pavement Condition Surveys**

- 2021 Parking lot (In-progress)
- 2025 citywide (proposed)

# Paving Prioritization

# Questions?

Transportation Commission
October 21, 2021

CITY OF SCOTTSDALE
TRANSPORTATION

# SCOTTSDALE TRANSPORTATION COMMISSION REPORT

**To:** Transportation Commission
**From:** Shayne Lopez, Paving Manager
**Subject:** Cool Pavement Update
**Meeting Date:** October 21, 2021

## ITEM IN BRIEF

**Action:** Presentation and discussion

**Purpose:** Presentation on the 1-year findings of the City of Phoenix Cool Pavement pilot program

**Background:**
Cool pavements (CP) include a range of technologies that communities are exploring as part of their heat island reduction efforts. Cool pavement reflects heat rather than retaining it. Cool Pavement reflects up to 40% of sunlight, compared to 10% reflected by dark pavement. This may help reduce rising nighttime temperatures and improve the livability of our cities in the summer months. Colorized seal coats and asphalts have been around for a while. Cool pavement uses existing material and technology in a new way. It can be sprayed or applied with a squeegee, just like the other surface treatments we apply to city roads. It is a water-based asphalt treatment that is applied on top of the existing asphalt pavement and is made with asphalt, water, an emulsifying agent (soap), mineral fillers, polymers and recycled materials. It contains no harmful chemicals and is compatible with traditional asphalt.

The Arizona State University (ASU) School of Sustainability and city of Phoenix (COP) partnered for a pilot to study reflective pavement in the summer 2020. This included eight (8) neighborhood pilot test sites across Phoenix and one (1) park area. The City of Phoenix Street Transportation Department identified 36 miles of local streets for cool pavement treatment, inclusive of all Council districts. Since various parts of the city experience different rain, monsoon conditions, and degrees of wear on the pavement, it should be an effective way to find out how well the treatment is working and how durable it is. The streets selected for this pilot project have asphalt that is in good condition and where a preservative surface treatment would be warranted.

**Update:**
The ASU/COP team reported the following results:

- Lower Surface Temperature
  - Roads with CP were measured 12°F and 10.5°F lower on average than untreated asphalt at noon and afternoon, respectively.
- Higher Surface Reflectivity
  - Surface solar reflectivity of the CP was around 33–38% when installed and declined over time. The solar reflectivity 10 months after installation ranged from 19–30% across the eight neighborhoods. For comparison, an untreated asphalt concrete surface had a consistent reflectivity of 12%.
- Lower Subsurface Temperature
  - Temperatures beneath the CP were lower (4.8°F on average) than beneath the untreated asphalt concrete surfaces.
- Lower Air Temperature
  - At 6’ height, air temperature was lower above CP treated streets by an average of 0.5°F and 0.3°F compared to untreated asphalt measured in the evening and daytime, respectively.
- Higher Mean Radiant Temperature
  - Represents a human’s total radiant heat exposure walking on the surfaces. Increased an average of 5.5°F at noon and afternoon hours due to higher surface reflectivity.

**Next Steps**
In addition to the results previously listed, there are also concerns with CP durability, maintenance, and aesthetic quality over time due to tire tracks and overall wear. ASU and COP will be undertaking additional work to study the benefits and disadvantages of CP that will be important to future decision-making on the feasibility of a pilot location in Scottsdale.

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**Staff Contact:** Shayne Lopez, 480-312-5665, slopez@scottsdaleaz.gov

# Cool Paving Update

## Transportation Commission
## October 21, 2021

CITY OF SCOTTSDALE
TRANSPORTATION

# Overview

- Background
- Project
- Data Gathering
- Findings
- Recommendations
- Discussion/Questions

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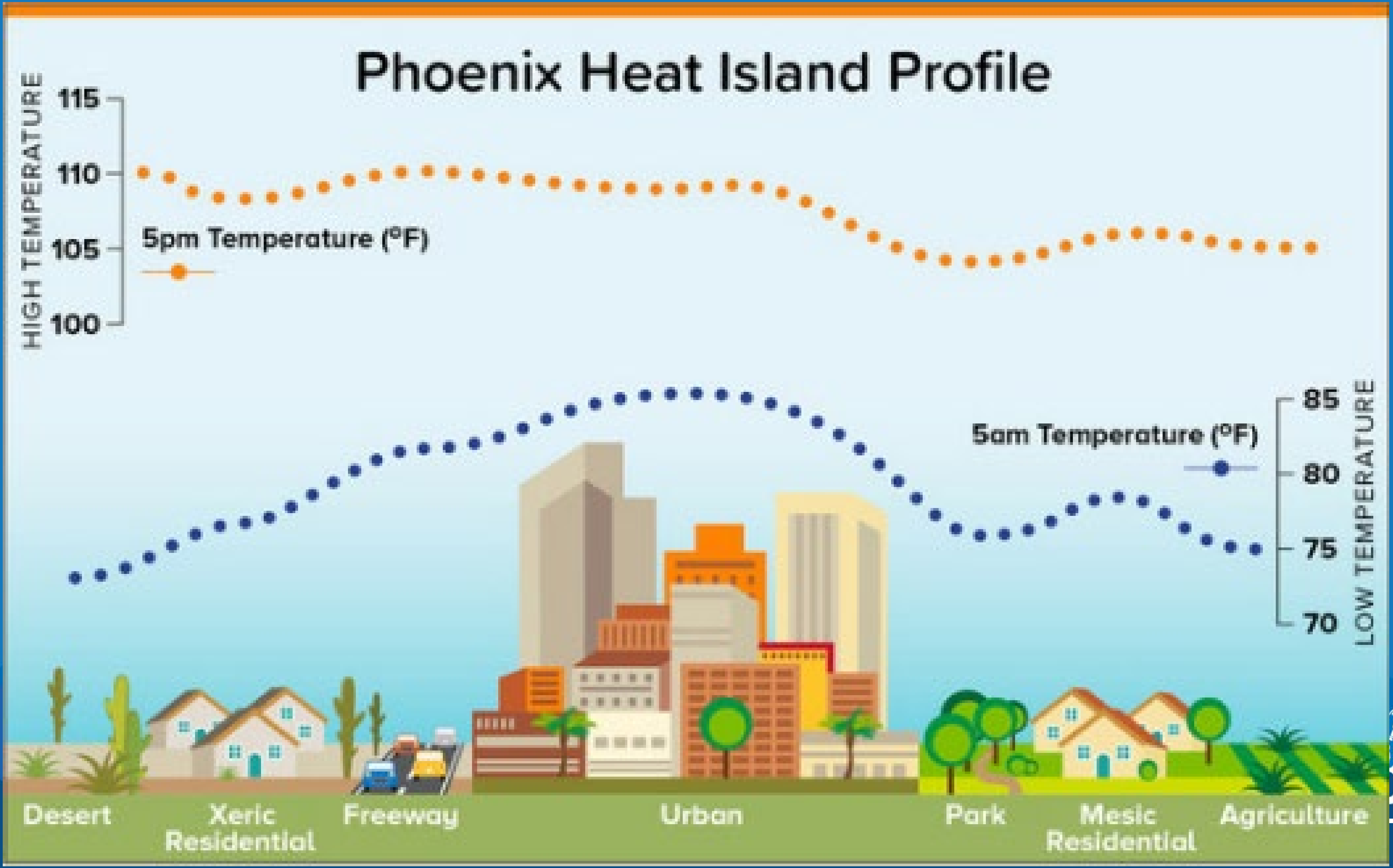
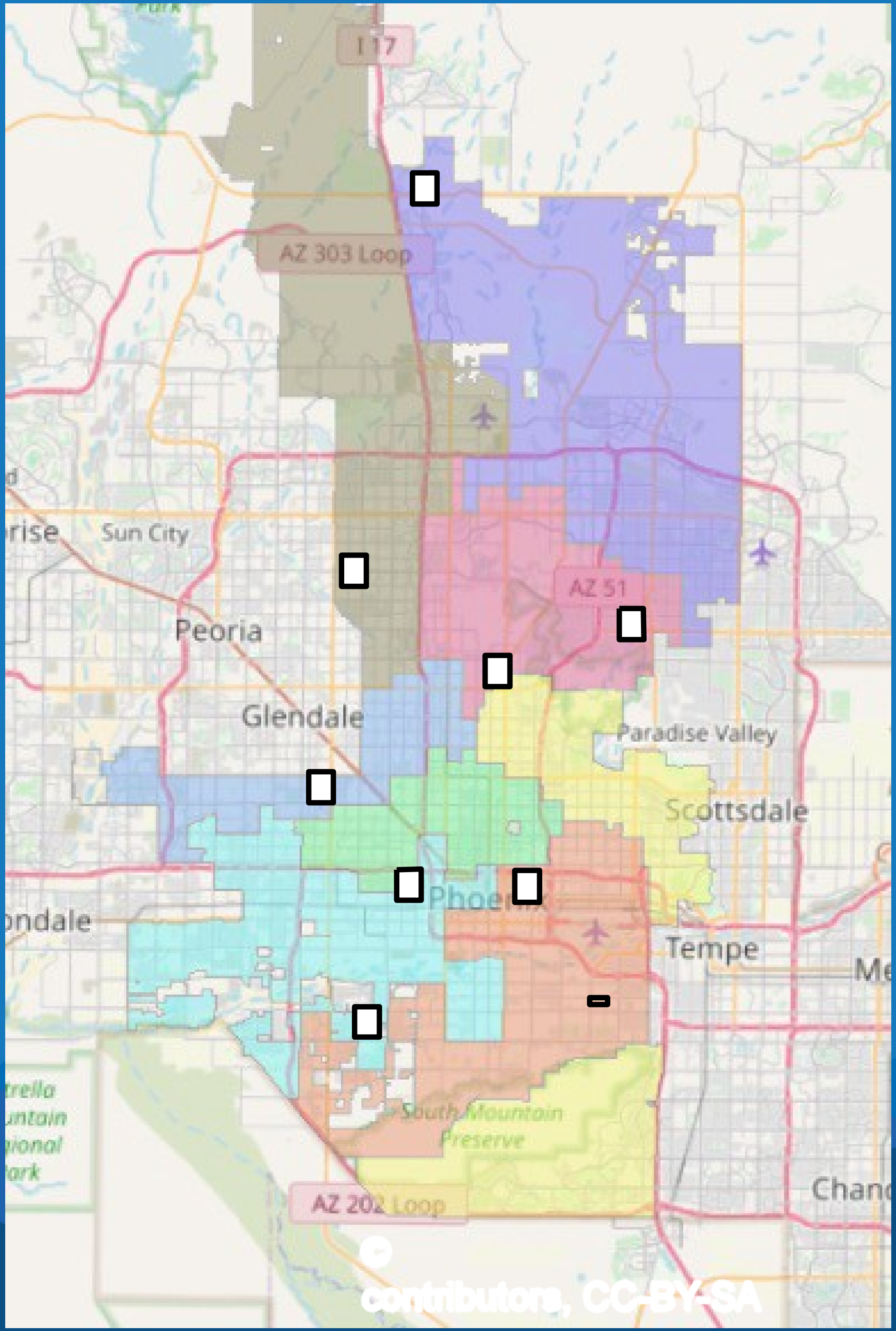
# Background



Phoenix Heat Island Profile
HIGH TEMPERATURE
115
110
105
100
5pm Temperature (°F)
5am Temperature (°F)
85
80
75
70
LOW TEMPERATURE
Desert
Xeric Residential
Freeway
Urban
Park
Mesic Residential
Agriculture




# Project

- 8 neighborhood pilot test sites across Phoenix (and 1 park street/parking lot)
- 36 miles (58km) of residential roads

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# Data Gathering

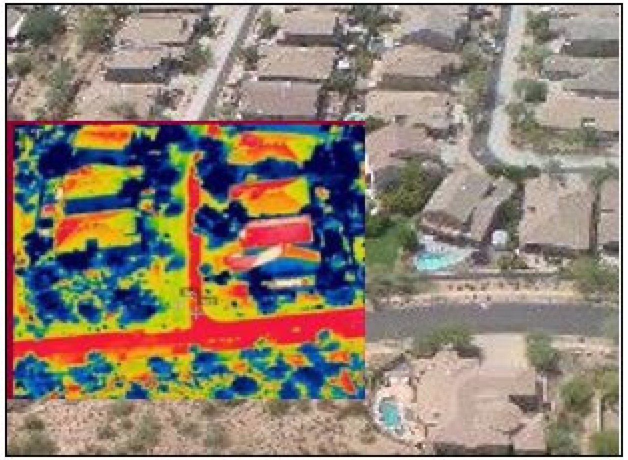
***Air temperature & Surface temperature:***
Thermocouples/ vehicle traverse

***Subsurface temperature:***
iButtons

***Reflectivity:***
Spectrometer

***Mean Radiant Temperature:***
MaRTy

***Surface Temperature***:
Helicopter overflight/thermal photography



# Findings

**Lower Surface Temperature**

- Roads with CP were measured 12°F and 10.5°F lower on average than untreated asphalt at noon and afternoon, respectively.

**Higher Surface Reflectivity**

- Surface solar reflectivity of the CP was around 33–38% when installed and declined over time. The solar reflectivity 10 months after installation ranged from 19–30% across the eight neighborhoods. For comparison, an untreated asphalt concrete surface had a consistent reflectivity of 12%.

**Lower Subsurface Temperature**

- Temperatures beneath the CP were lower (4.8°F on average) than beneath the untreated asphalt concrete surfaces.

**Lower Air Temperature**

- At 6’ height, air temperature was lower above CP treated streets by an average of 0.5°F and 0.3°F compared to untreated asphalt measured in the evening and daytime, respectively.

**Higher Mean Radiant Temperature**

- Represents a human’s total radiant heat exposure walking on the surfaces. Increased an average of 5.5°F at noon and afternoon hours due to higher surface reflectivity.

CITY OF SCOTTSDALE

# Recommendations

- Reduction in surface and sub-surface temperatures
  - Positives for improving the lifespan and performance of the pavement. Recommend that CP is applied to newer pavement to maximize benefit
- Minor reduction of air temperature
  - Study authors recommend that precise assessments of air temperature changes are conducted to determine the energy, water, and health impacts of any temperature differences.
- Further work is also required to provide Phoenix-based guidelines to mitigate surface dirt, tire markings, and degradation due to a lack of precipitation and the hot climate. This information would be important for Scottsdale in considering the feasibility of undertaking a CP pilot project

# Discussion/Questions

- Sources
  
  - U.S. Environmental Protection Agency. 2008. Reducing urban heat islands: Compendium of strategies. Draft. https://www.epa.gov/heat-islands/heat-island-compendium.
  - The City of Phoenix. 2021. Cool Pavement Pilot Program Joint Study between the City of Phoenix and Arizona State University Phoenix Cool Pavement Exec Summary_091420213.pdf
  - Middel. Arriane. Vanos, Jennifer (June 17th. 2021). Cool Pavement Evaluation (COPE) Phoenix [PowerPoint slides]. Urban Climate Research Center, Arizona State University. https://scottsdale.granicus.com/player/clip/10729
  

# TENTATIVE FUTURE AGENDA ITEMS

Rev.9-24-2021
*All Items Subject to Change*

## TRANSPORTATION COMMISSION

**MEETING DATE: November 18, 2021** **REPORTS/PRESENTATIONS DUE November 11**

- **Approval of Meeting Minutes ........................................................................................ Action**
  *Approval of Regular meeting minutes October 21, 2021*
- **Transportation Action Plan Review .............................Presentation, Discussion and Possible Action**
  *Discussion of the Transportation Action Plan – David Meinhart, Transportation Planning Manager*
- **Clever Devices Application on Buses.......................................................Presentation and Discussion**
  *Discussion of the status of the Clever Devices application that will provide computer aided dispatch vehicle locator system – Ratna Korepella, Transit Manager*
- **Review of Fiscal Year 2023-2027 CIP Projects ....................................................................Discussion**
  *Discuss Fiscal Year 2023 through 2027 CIP Projects – Dave Meinhart, Transportation Planning Manager*
- **Commission Identification of Future Agenda Items.............................................................Discussion**
  *Commissioners may identify items or topics of interest for future Commission meetings*

**MEETING DATE: December 16, 2021** **REPORTS/PRESENTATIONS DUE December 9**

- **Approval of Meeting Minutes ........................................................................................ Action**
  *Approval of Regular meeting minutes November 18, 2021*
- **Transportation Action Plan ........................................................ Presentation, Discussion and Action**
  *Discussion of the Transportation Action Plan and Commissions recommendations – David Meinhart, Transportation Planning Manager*
- **Other Transportation Projects and Programs Status .......................................................Information**
  *Status of projects and programs – Mark Melnychenko, Transportation & Streets Director*
- **Commission Identification of Future Agenda Items.............................................................Discussion**
  *Commissioners may identify items or topics of interest for future Commission meetings*

**MEETING DATE: January 20, 2022** **REPORTS/PRESENTATIONS DUE January 13**

- **Approval of Meeting Minutes ........................................................................................ Action**
  *Approval of Regular meeting minutes December 16, 2021*
- **Vacant Land ...........................................................................................Presentation and Discussion**
  *Impact on areas and traffic with new buildings created – Phil Kercher, Traffic Engineer & Ops Manager*
- **New Project Development ..............................................................Presentation and Discussion**
  *Project development and how it ties in with Transportation – Phil Kercher, Traffic Engineer & Ops Manager*
- **Bus Ridership and the Transit System.....................................................Presentation and Discussion**
  *Update on bus ridership and the Transit System – Ratna Korepella, Transit Manager*
- **Commission Identification of Future Agenda Items.............................................................Discussion**
  *Commissioners may identify items or topics of interest for future Commission meetings*

**MEETING DATE: February 17, 2022** **REPORTS/PRESENTATIONS DUE February 10**

- **Approval of Meeting Minutes ........................................................................................ Action**
  *Approval of Regular meeting minutes January 20, 2022*
- **Miller Road Bridge and Flood Control Project ...........Presentation, Discussion and Possible Action**

*Update on the Miller Road Bridge and Flood Control Project – David Meinhart, Transportation Planning Manager*

- **Commission Identification of Future Agenda Items..........................................................Discussion**
  *Commissioners may identify items or topics of interest for future Commission meetings*

**FUTURE ITEMS:**

- **Loop 101 Mobility Project..........................................................................Presentation and Discussion**
  *Kristin Darr, consultant*
- **Impact on Parking..................................................................................Presentation and Discussion**
  *Latest parking study, Walter Brodzinski, Right-Way Supervisor*
- **Urban Air Mobility ..................................................................................Presentation and Discussion**
  *Discuss Urban Air Mobility as Mode of Transportation*
- **Smart City...............................................................................................Presentation and Discussion**
  *Discussion on the City's participation in Smart City applications.*
- **Study and Results from Truck Platooning ..............................................Presentation and Discussion**
  *Update on Study and Results from Truck Platooning*
- **Electric Car Movement..............................................................................Presentation and Discussion**
  *Presentation on electric car movement – Hong Huo, Traffic Engineer Principal*
- **Shea and 124th Street Underpass ..............................................................Presentation and Discussion**
  *Update on underpass – Susan Conklu, Senior Transportation Planner*
- **Downtown Trolley......................................................................................Presentation and Discussion**
  *Update on trolly usage – Ratna Korepella, Transit Manager*
- **General Plan Update...................................................................................Presentation and Discussion**
  *Update on general plan – Erin Perreault*
- **Transit System Evaluation Recommendations................................................................. Action**
  *Presentation of the Transit Plan Evaluation Recommendations – Ratna Korepella, Transit Manager*
- **Update on MAG Prop 400E .........................................................................Presentation and Discussion**
  *Update on MAG Prop 400E – MAG staff*
- **Utilities Causing Project Delays……………………………………………………………………Discussion**
  *Discuss the delays utility projects are holding up project schedules and budgets- Mark Melnychenko, Transportation & Streets Director*
- **Scooter Pattern Usage…………………………………………………………Presentation and Discussion**
  *Discuss the number of EZ tickets received for scooter devices – Susan Conklu, Senior Transportation Planner*
- **Bus Stop Lighting……………………………………………………………………………….…Discussion**
  *Discuss future plans to light bus stop shelters – Ratna Korepella, Transit Manager*
- **Connected Vehicle Technology on Loop 101 ……...…………………………………………….…Discussion**
  *Discuss USA's Transportation Research Department regarding connected vehicle technology – Mark Melnychenko, Transportation & Streets Director*
- **Roundabout Education……...…………………………………………….….…Presentation and Discussion**
  *Discuss benefits of Roundabouts and how success is evaluated – Phil Kercher, Traffic Engineer & Ops Manager*

## PATHS & TRAILS SUBCOMMITTEE

**MEETING DATE: December 7, 2021** **REPORTS DUE November 30, 2021**

- **Approval of Meeting Minutes ............................................................................................................. Action**
  *Approval of Regular meeting minutes of October 5, 2021*

- **Vision Zero....................................................................................................Presentation and Discussion**
  *Information on Vision Zero (Tempe) – Susan Conklu, Senior Transportation Planner*
- **Equestrian Connectivity ......................................................................Presentation and Discussion**
  *Panel – Susan Conklu, Senior Transportation Planner*
- **Other Transportation Projects and Programs Status................................................................Information**
  *Status of projects and programs – Susan Conklu, Senior Transportation Planner*
- **Subcommittee Identification of Future Agenda Items..................................................................Discussion**
  *Subcommittee members may identify items or topics of interest for future Subcommittee meetings*

**FUTURE ITEMS:**

- **Wayfinding....................................................................................................Presentation and Discussion**
  *Update on Wayfinding – Susan Conklu, Senior Transportation Planner*
- **Bicycle Education Program ...............................................................Presentation and Discussion**
  *Update on Laws and Education – Susan Conklu, Senior Transportation Planner*
- **Bike Month Recap.........................................................................................Presentation and Discussion**
  *Information on Bike Month – Susan Conklu, Senior Transportation Planner*
- **Access to Indian Bend Wash ..............................................................Presentation and Discussion**
  *Better access and how the Parks Dept. can assist. – Susan Conklu, Senior Transportation Planner*
- **Path and Trail Gap Analysis ............................................................Presentation and Discussion**
  *Information on gaps in the citywide path and trails network – Greg Davies, Senior Transportation Planner*

## Lofgren, Kyle

**From:** Conklu, Susan
**Sent:** Tuesday, October 5, 2021 11:04 AM
**To:** Meinhart, David
**Cc:** Lofgren, Kyle
**Subject:** FW: Public Comment - Matt Metz

Hi Dave,

This is a new comment received from the general comment link on the draft TAP webpage.

We can share it in the next Transportation Commission packet for the public record.

Thanks,
Susan

*Susan Conklu, Senior Transportation Planner*
City of Scottsdale
Transportation Planning
480-312-2308
sconklu@scottsdaleaz.gov

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**From:** notifications@cognitoforms.com <notifications@cognitoforms.com>
**Sent:** Wednesday, September 29, 2021 2:25 PM
**To:** Conklu, Susan <SConklu@Scottsdaleaz.gov>
**Subject:** Public Comment - Matt Metz



# City of Scottsdale

Public Comment

## Entry Details

| | |
|---|---|
| FULL NAME | Matt Metz |
| ADDRESS | 9978 E Bayview Dr |
| PHONE | (480) 948-1066 |

| | |
|---|---|
| **EMAIL** | scottsdale@mattmetz.com |
| **COMMENTS** | Please do NOT widen Mountainview Rd. between 92nd St. and 96th St. This road is not nearly in need of five lanes (rather than current three), and widening would require removal of scores of beautiful mature trees, and will tempt drivers avoiding Shea to pass farther to the east (Mountainview east of 96th St.) which is a residential neighborhood. Thank you. |