Pavement Management Program for the Town of Cave Creek
Final Report

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providing engineering solutions to improve pavement performance

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EXECUTIVE SUMMARY

Project Overview

The Town of Cave Creek hired Applied Pavement Technology, Inc. (APTech) to implement a pavement management system for the Town's paved roadway network. This involved documenting the overall condition of the pavement network, determining maintenance and rehabilitation needs, determining the impact on pavement life of performing the work, providing recommendations for distribution of pavement maintenance budget, and prioritizing maintenance and rehabilitation activities for the coming years.

A pavement management system is a set of tools or methods that assist decision-makers in finding the optimum strategies for providing, evaluating, and maintaining pavements in a serviceable condition over a period of time. Overall, pavement management is used by agencies to make cost-effective pavement planning decisions.

During this project, a pavement management database (using the MicroPAVER™ software) and maps were developed that will be updated and maintained by the Town as a part of its ongoing pavement management program.

Systems Inventory and Network Definition

Approximately 80 centerline-miles (over 8.5 million ft^2) of pavement are present in the Cave Creek pavement network. Of the total pavement area less than 1 percent is portland cement concrete (PCC) pavement; the rest consists of chip seal surface treatment (ST) or asphalt (AC) surfaced roadways.

Using the Town's geographic information system (GIS), a map of the roads maintained by the Town was developed. This provided location information used for referencing individual pavement sections. APTech also determined the pavement type, street type, and estimated last construction dates for each pavement section identified. In addition, APTech assigned ranking values to prioritize application of limiting funding to the most critical pavements.

Pavement Condition Assessment Procedure

The pavement condition was determined using the pavement condition index (PCI) method, which follows American Society for Testing and Material (ASTM) guidelines documented in the *ASTM-D6433 Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys* standard. The PCI procedure is a visual assessment procedure that allows for rapid data collection, provides a single numerical value representing the pavement condition, and is consistent, objective, and repeatable. A representative sample of each pavement section is inspected by recording type, severity, and quantity of various types of pavement distresses, such as cracking, potholes, and rutting. PCI inspections can be performed using basic equipment with limited impact to the traveling public.

The PCI scale ranges from 0 (representing a pavement in failed condition) to 100 (representing a pavement with no distress). In general, pavements with a PCI above 60 that are not exhibiting significant load-related distress will usually benefit from preventive maintenance actions, such as crack sealing and patching. Pavements with a PCI of 35 to 60 may require major rehabilitation,

such as extensive repairs and/or an overlay. When the PCI is less than 30, reconstruction is often the most viable alternative due to the substantial damage to the pavement structure.

Pavement Condition Inspection Results

Overall, Town-maintained pavements have an average PCI rating of 66. Figure ES-1 shows the breakdown of pavements by area and PCI range. The majority of the pavement (over 70 percent) has a PCI greater than 50, meaning relatively inexpensive maintenance treatments can be used to extend the pavement life on these pavement sections. Only 3 percent of the area is in such poor condition that reconstruction may be the most viable alternative.

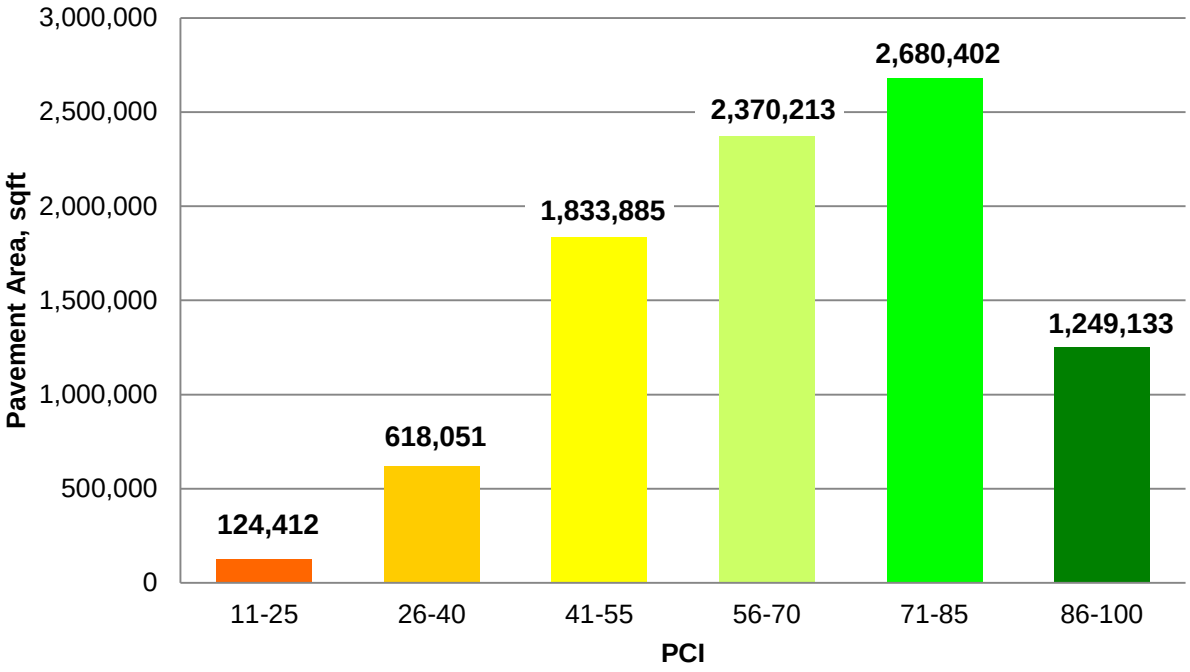


Figure ES-1. Pavement inventory by condition.

Using the current condition and age of the pavements, APTech developed pavement performance models, which are relationships between pavement age and condition, and are used to forecast future conditions. Pavement performance models are critical to a successful pavement management system. They can be used to predict when a major overlay will be needed, or determine the optimal timing of a preventive maintenance activity. This allows the Town to plan for future expenditures, and to determine the timing of preventive maintenance applications to obtain the maximum pavement life extension using the available (and often limited) funding levels.

Recommended Maintenance and Rehabilitation Program

APTech determined feasible maintenance and rehabilitation activities, developed treatment protocols to determine treatment application to maximize benefits, estimated treatment costs, and performed an analysis of various funding levels.

For purposes of this analysis, pavement repairs were categorized as follows:

- Major rehabilitation – activities, such as an overlay or reconstruction, applied to the entire pavement to correct or improve existing structural or functional requirements.
- Preventive maintenance – localized repair of distressed areas, including such items as crack sealing and patching.

While maintenance and rehabilitation (M&R) needs are identified based on the current and projected pavement condition and the type of facility, projects ultimately are selected based on the available funding in any given year. M&R programs were evaluated based on the following funding levels:

- Do nothing, which is used to show the effect of performing no work, and helps to demonstrate the effects of the other plans.
- Backlog (unfunded maintenance) elimination provides an indication of the type of pavement-related work required over the next 6 years to eliminate the backlog of rehabilitation work, regardless of the funding level.
- Constrained annual budgets of $500,000, $800,000, and $1,000,000 were evaluated for maintaining the pavement network.

The predicted pavement network conditions under these scenarios are summarized in figure ES-2.

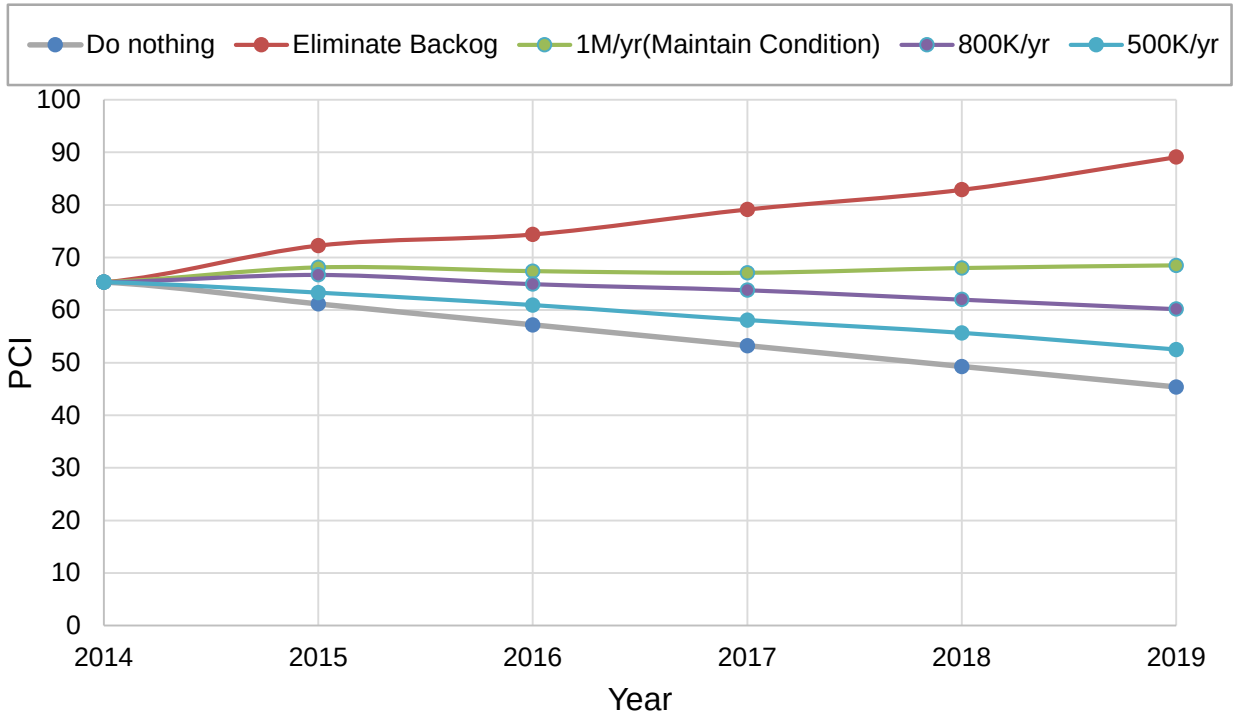


Figure ES-2. Estimated future area-weighted network conditions under analyzed scenarios.

For each of the scenarios considered, a 6-year analysis period (2014 through 2019) and a 3 percent annual inflation rate were used. The network PCI is expected to drop to 45 by the end of

2019 if no rehabilitation or maintenance projects are funded. The predicted 2019 network PCI is 89 for a funding level that would eliminate major rehabilitation backlogs, which requires $9.25 million over the next 6 years. Under constrained funding, the average PCI will be 52.5 for an annual budget of $500,000, 60.2 for an annual budget of $800,000, and 68.5 for an annual budget of $1,000,000. A target condition based scenario to maintain the current condition over the analysis period has yielded results very similar to the plan with an annual budget of $1,000.000.

A recommended M&R plan was then developed based on an annual funding level of $800,000 by closely evaluating and customizing the preliminary recommendations produced through the MicroPAVER™ analysis to better suit the Town's needs. The recommended M&R plan is different from the preliminary $800,000 plan discussed in Figure ES-2; the recommended M&R plan was designed to improve the condition of town's major roads using a combination of maintenance, preservation and rehabilitation treatments to better address the pavement conditions observed during the visual surveys. If the recommended M&R plan is implemented, the Town's pavement network PCI is forecasted to be 68 in 2019. A separate 2-year pavement maintenance and preservation plan was also developed to maintain the conditions of the Town roads that are in relatively good condition. A list of pavement sections that have stopgap and safety repair needs (primarily to address localized areas of high-severity distresses) has also been developed.

Conclusions

APTech has established a pavement management system for the Town of Cave Creek. This included creating a pavement database, assessing current pavement conditions, and developing a maintenance and rehabilitation plan. APTech will provide training on the use of the MicroPAVER™ software for the Town's staff and this will enable the Town to be prepared to self-maintain and use the pavement management system, allowing it to make data-driven decisions for maintaining the Town's pavement network.

Overall, the Town pavement network has an average PCI of 66. Approximately 60 percent of the pavement surface area is eligible for pavement preservation efforts, which are more cost-effective than performing major rehabilitation activities after the pavement has deteriorated to a worse condition. The performance models created by APTech will help the Town determine when a pavement will no longer benefit from these treatments, and more substantial work, such as an overlay, must be performed. If no work is performed, the PCI is expected to drop to 45 at the end of the 5-year analysis period. At the expected funding level of $800 thousand a year, the recommended maintenance and rehabilitation plan is predicted to provide an average PCI of 68 at the end of the same period.

The M&R plan providing the basis for the recommended $800K funding level focuses attention on the Town's primary roads, and neglects some of the needs of the residential routes. It also addresses project specific treatments rather than global conditions. What all of this means is that while this finding level may provide for stable conditions over the next 5 years, we believe that this will not be sustainable in the long-term, and additional funding will be required to maintain the roadway network at the current condition level. We have provided a recommended suitable mid-term solution.

INTRODUCTION TO PAVEMENT MANAGEMENT

Cities and towns have long been responsible for maintaining their pavement infrastructure. Careful management of the pavements has become increasingly important as competition for scarce resources and expectations for agency accountability have increased. Faced with this daunting task agencies often find themselves asking many different questions similar to the following:

- What pavements should we address first?
- On what pavements is our money best spent?
- What annual budget do we need to keep our pavement network at its current condition over the next few years?
- How are our pavements really performing over time?
- Are we better off spending our money on pavements in very poor condition, or letting those bad pavements deteriorate while we concentrate on keeping good roads in good condition?

To answer these questions, and many more, pavement management practitioners developed the first pavement management systems (PMS) in the 1970s. In simple terms, a PMS is a systematic process that: 1) assesses the current pavement condition, 2) predicts future pavement condition, 3) determines maintenance and rehabilitation needs, and 4) prioritizes these needs to make the best use of anticipated funding levels (i.e., maximizing benefit while minimizing costs). The remainder of this section introduces some of the history of pavement management, provides definitions for common pavement management-related terms, and discusses the different components of a modern day PMS in more detail.

Historical Perspective of Pavement Management

The concept of pavement management has evolved significantly since its inception in the 1970s. As standardized condition survey techniques came into place, more information regarding the cause of pavement deterioration became available. This information was then used to readily assess available repair alternatives and select the better repair strategy. This approach greatly improved the effectiveness of selected rehabilitation treatments since they were now being chosen to address the deficiencies present and prevent their recurrence.

As computerized pavement management systems became available, an even more sophisticated level of analysis became possible. With today's systems, the results of the pavement condition surveys are used to assess current pavement conditions, and to identify pavement deterioration trends. This capability provides an agency with the ability to forecast future pavement conditions. As a result, agencies are able to assess the long-term impacts of decisions made today on future network conditions and identify the optimal time for repair so that funding can be scheduled in advance of the forecasted need.

The importance of identifying not only the best repair alternative but also the optimal time of repair has been documented in U.S. Army Corps of Engineers, Construction Engineering Laboratory (USACERL) Technical Report M-90/05 and is summarized in figure 1 (Shahin and Walther 1990). This figure shows that over the first 75 percent of the pavement life,

approximately 40 percent of the pavement condition deterioration takes place. After this point, the pavement deteriorates much faster with the next 40 percent drop in pavement condition occurring over the next 12 percent of the pavement life. The financial impact of delaying repairs until the second drop in pavement condition can mean repair expenses four to five times higher than repairs triggered over the first 75 percent of the pavement life.

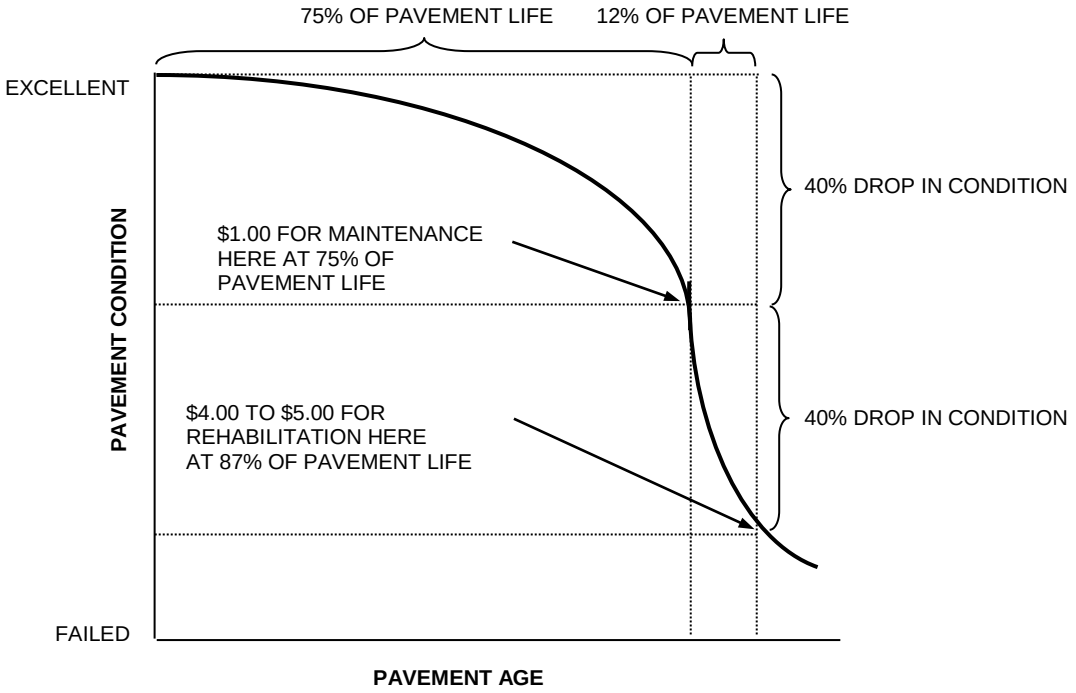


Figure 1. Typical pavement condition life cycle (Shahin and Walther 1990)[1].

Definition of Terms

This section provides definitions of some of the more general terms used in this report.

- **Backlog** – Amount of unfunded maintenance and rehabilitation (M&R).
- **Branch** – A part of the network that is a distinct entity and has a unique function. Each road and parking lot in the pavement network is considered a separate branch. Note that a branch does not have to have consistent characteristics throughout its area, such as surface type or age.
- **Condition analysis** – Determination of current pavement condition in terms of amount of deterioration present, cause of deterioration, and deterioration rate.
- **Deterioration rate** – Drop in pavement condition in terms of points per year.
- **Effect on pavement life** – The effect that a treatment has on the remaining life of a section. For example, complete reconstruction yields an essentially new pavement with all of its life (as defined by the performance model assigned to the section) remaining.
- **Family** – Group of pavement sections that deteriorate in a similar manner.

[1] Shahin, M.Y. and J.A. Walther. 1990. Pavement Maintenance Management for Roads and Streets Using the MicroPAVER System. Technical Report M-90/05. Army Corps of Engineers Construction Engineering Laboratory (USACERL), Champaign, IL.

- **Impact analysis** – A comparison of different M&R plans to determine the impact that different decisions will have on the pavement network.
- **M&R** – This is an abbreviation for "maintenance and rehabilitation," but generally refers to any pavement work activities, such as localized maintenance, rehabilitation, and reconstruction.
- **MicroPAVER™** – A pavement management system developed by the U.S. Army Corps of Engineers. It consists of a Microsoft® Access database for storing inventory and condition information and some analysis tools.
- **Needs analysis** – The determination of M&R requirements, associated costs, and scheduling subject to constraints (e.g., funding levels or desired network condition) for a specified period of time (often 1 to 5 years).
- **Network** – A broad grouping of pavements within a specified physical area, sometimes managed separately (such as districts within a city or subdivisions within a town).
- **Pavement condition index (PCI)** – A numerical indicator between 0 and 100 that reflects the surface condition of a pavement. PCI inspections are performed in accordance with ASTM D-6433, *Standard Test Method for Roads and Parking Lots Pavement Condition Index Surveys*[2], and correspond with MicroPAVER™ pavement management software.
- **Pavement maintenance** – Routine maintenance actions, both preventive and reactive, applied to preserve the pavement structure.
- **Pavement rehabilitation** – Work undertaken to restore the serviceability and extend the life of an existing pavement. This includes overlays and other work necessary to return an existing pavement to a condition of structural or functional adequacy.
- **Performance** – Change in pavement condition over time.
- **Performance model** – Mathematical description of the expected values that pavement attributes will take during a specified analysis period.
- **Preventive maintenance** – Maintenance activities performed with the primary objective of slowing the rate of pavement deterioration.
- **Prioritization** – Technique used to determine which M&R activities should be performed when there is insufficient funding to perform all required M&R.
- **Regression analysis** – Statistical tool that is used to relate two or more variables in a mathematical equation.
- **Sample unit** – A subdivision of a pavement section for PCI inspection purposes.
- **Section** – A part of a branch that has consistent characteristics throughout its area. The PMS analyzes pavement information at the section level; therefore, a section is considered the management unit. This means that pavement condition is analyzed at the section level and that pavement M&R recommendations are made at the section level.
- **Stopgap Maintenance** – Maintenance activities performed to keep the pavement operational in a safe condition.

[2] American Society for Testing and Materials (ASTM). 2007. *Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys.* ASTM D6433-07. American Society for Testing and Materials, West Conshohocken, PA.

- **Treatment trigger** – A set of conditions that must exist in order for a treatment to be considered. For example, in order for a thin asphalt concrete (AC) overlay to be considered a viable treatment for a pavement section, the following criteria need to be met: 1) the section PCI must be between 40 and 70, and 2) the section must have an asphalt surface.

General PMS Components

A PMS is comprised of six basic components, as shown in figure 2. To illustrate the general concepts of the PMS approach, each of these different components are discussed in more detail below.

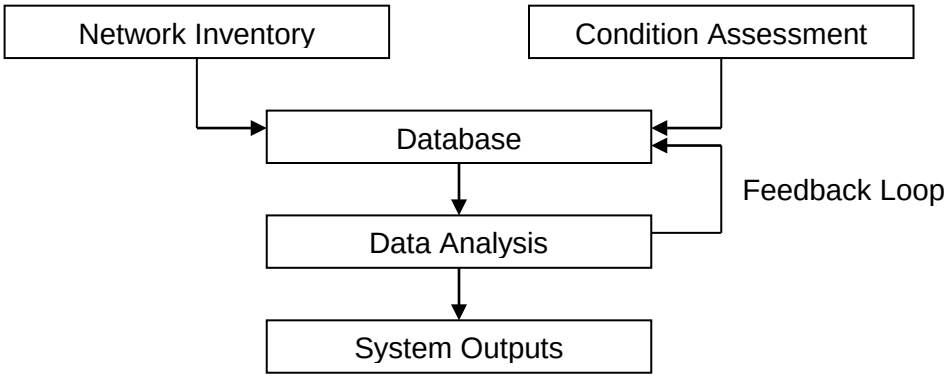


Figure 2. Basic components of a PMS.

Network Inventory

Network inventory is used to define the physical characteristics of the pavements being managed. Typically, the collected inventory information includes location information, pavement characteristics (such as length, width, and type), construction and maintenance histories, and traffic data. The network inventory is the foundation for the PMS.

The first decision that an agency should make with respect to network inventory is which pavement areas to include in the PMS. While it is probable that major pavement areas—such as driving lanes, parking lanes and lots, and intersections—will be included in the database, the actual selection of the pavement facilities to be included in the PMS is up to the agency.

Once a decision has been made about which pavements to include in the database, information about these pavements must be collected. It is important to keep three guidelines in mind when determining the extent of historical information to include in the inventory. First, the data should be accessible so that large quantities of time are not invested in a records search. Second, the collected information should serve a purpose. Third, the information must be chosen to ensure that the PMS is capable of meeting the analysis needs of the agency.

Although there is flexibility in the amount of information that must be collected and the manner that is it stored in a PMS database, there are some types of information that are mandatory. The following list outlines the types of information that must be collected in order for the system to operate correctly:

- *Pavement location* – Physical locations of the pavements need to be identified.

- *Pavement dimensions* – Length, width, and/or area of the pavement sections.
- *Surface type* – Describes the pavement surface/structure; for the Town of Cave Creek, the following surface types are identified:
  - AC: Asphalt concrete pavement.
  - PCC: Portland cement concrete pavement.
  - GR: Gravel road or parking lot.
  - ST: Surface Treatment (primarily chip seal surfaces)
- *Last construction date* – Date of original construction or last major rehabilitation, such as reconstruction or an overlay.

Examples of other information that are beneficial to record in a PMS database are included in the following list (note that this list is not comprehensive):

- *Pavement cross-section* – Information on the thicknesses and material types of each pavement layer.
- *Traffic* – Types and levels of traffic.
- *Maintenance history* – Date, type, and cost of maintenance activities performed on the pavements.
- *Testing data* – Coring, boring, deflection, roughness data, and so on.
- *Drainage facilities* – Type and location of drainage facilities.
- *Shoulders or curbs* – Type and location of shoulders or curbs.

In addition to there being mandatory types of information included in a PMS, there are also organizational requirements for building a database, as follows:

- Each network must have one or more branches.
- Each branch must have one or more sections.
- Each branch must have a defined use (i.e. roadway or parking lot).
- Each section must be contained within a single branch.
- Each section must have a last construction date, area, and surface type.

Since pavement maintenance and rehabilitation recommendations, pavement deterioration rates, and cost estimates are determined at the section level, a section's characteristics should be as consistent as possible in terms of pavement design and construction, traffic, and condition. There should also be a systematic method for assigning branch and section names and identifiers.

Condition Assessment

Pavement management decisions depend on some method of pavement evaluation. The method selected to evaluate pavement condition is extremely important because it is the basis of all recommendations. For that reason, it is critical to select an objective and repeatable procedure so that PMS recommendations are reliable.

Pavement managers must evaluate their needs when determining not only the type of condition data to collect, but also how often to collect the data. For example, an agency experiencing rapid deterioration rates may elect to survey its pavements more frequently than the average organization, or to survey high-priority pavements on a more frequent basis than low-priority areas. Each agency must carefully evaluate its own circumstances to ensure that the data collection aspects of their PMS match both its needs and financial means. The PCI method is the one of most commonly used methods to evaluate pavement conditions and this method has been used to assess the condition of the Town's roadways.

Database

Once the network inventory and pavement condition data have been collected, a database can be established to store and use the information. Although a manual filing system may be possible for a small network, the efficiency and cost-effectiveness of storing data on a computer makes an automated database the most practical alternative, especially when a comprehensive PMS is desired. MicroPAVER™, which is distributed by the American Public Works Association (APWA), was used as the Town's PMS software program.

Data Analysis

Data analysis can occur at the network or project level. At the network level, potential rehabilitation needs of the entire network are evaluated and prioritized for planning and scheduling budget needs over a multi-year period. The objective of network-level analysis is to evaluate rehabilitation needs for a future time period and prioritize project lists so that the agency makes the best use of the limited funds available for M&R. After the planning and programming decisions have been made during the network-level analysis, the information in the database can be used to supplement a project-level analysis. At the project-level, each individual project is investigated in detail to determine the appropriate rehabilitation treatment.

System Outputs

There are a number of different methods for presenting the results of the analyses, including tables, reports, graphs and maps. Because of the volume of information obtained from a PMS, graphical reports are generally more effective than comprehensive project reports for people who need to quickly evaluate large amounts of data.

Many agencies have found value in linking their PMS to maps to display information through color-coded maps. As with the graphical display, this capability has greatly enhanced the usefulness of the PMS to agencies that need to convey a lot of information in a short period of time. Map links are perhaps most useful in displaying the funded projects in each year of the analysis and for displaying pavement condition results.

Feedback Loop

An often-overlooked component of a PMS is the development of a feedback loop. The feedback loop establishes a process by which actual performance and cost data are input back into the models used in the pavement management analysis. For example, the PMS may use models that estimate the life of an asphalt overlay at 12 years. Actual performance data may show that the life of the agency's overlays is closer to 8 to 10 years. This type of information should be used to update the pavement management models so that the system recommendations remain reliable and become improved with time.

PROJECT BACKGROUND

The Town of Cave Creek is located in Maricopa County, 33 miles north of Phoenix. The Town's pavement network infrastructure is not currently managed through a formalized pavement management system. The town uses an engineering judgment-based approach to program projects on an as-needed basis. To assist the town in better managing this valuable asset, it's necessary to implement a pavement management system to effectively and efficiently identify pavement treatments, pavement treatment costs, and timing of treatment applications.

The Town of Cave Creek hired APTech to implement a pavement management system for its roadway network. Specific steps for implementation of a pavement management system for Cave Creek include:

- Conducting an inventory of all Town-managed roadways. The inventory includes identification (and mapping) of all Town-maintained roadways and an assessment of the existing pavement condition of all Town-maintained paved roadways (e.g., length of cracking, area of patching).
- Determining the pavement maintenance and rehabilitation treatment needs based on the existing pavement condition.
- Identifying the annual pavement maintenance and rehabilitation budget needs.
- Prioritizing pavement maintenance and rehabilitation (M&R) projects.

Scope of Work

The scope of work consisted of the following tasks:

- **Task 1 – Project Initiation and Kickoff Meeting** (conducted in January 2014): The primary objective of this task was to discuss project details, scope, and work schedule with the Town staff. APTech also used this opportunity to obtain key information related to the Town's pavement network and to become more familiar with the Town's roadway system and goals for the use of a pavement management system.
- **Task 2 – Roadway Network Definition**: Using the information provided by the Town, APTech developed a MicroPAVER™ database and a GIS map for the Town's pavement network and identified individual pavement sections for surveys.
- **Task 3 – Condition Assessment** (conducted in February 2014): Under this task APTech conducted visual pavement condition surveys to identify the type, severity and extent of the visible pavement distresses for the calculation of the PCI value for each pavement section identified in Task 2.
- **Task 4 – Database Development**: Under this task APTech customized the MicroPAVER™ database for the Town. A quality assurance check was also performed as a part of this task to check on referential information consistency.
- **Task 5 – Pavement Deterioration Estimates**: Under this task, APTech developed pavement deterioration models for the Town's pavement network. Since construction histories were not available for a vast majority of the roadways, APTech developed

expert models using experience from work performed in other cities in Arizona (e.g. Gila Bend and Goodyear).

- **Task 6 – Maintenance and Rehabilitation Program Development**: Under this task APTech investigated the impact of various budget scenarios and eventually developed a draft M&R plan for the Town.
- **Task 7 – Install Software and Provide Training** (tentatively planned for mid-May 2014): APTech will install the MicroPAVER™ software for the Town and provide training on its use to manage the Town's pavement network and develop M&R plans.
- **Task 8 – Final Report**: This draft report discusses the project process, results of the condition surveys and network condition, summaries of the maintenance and preservation scenarios developed, and budget requirements. Once the M&R plan provided in this draft report is finalized, APTech will prepare a final report.
- **Task 9 – Revisit, Review, and Evaluate Application at the Three-Year Milestone**: This task provides for follow-on support after the implementation of the system, and for a review of the performance prediction and program needs after three years. It is fully envisioned, and fairly normal for agencies with new implementations to have questions once the system is in their hands. APTech will provide a reasonable level of support after the system is in place.

The project deliverables include the pavement management database, a network definition map, a pavement condition map, and this report. APTech will also install the MicroPAVER™ software on Town computers and provided training in the management of the Town's pavement network and development of M&R plans.

PAVEMENT INVENTORY AND EVALUATION RESULTS

Systems Inventory and Network Definition

The Cave Creek pavement network was defined using information obtained from the Town geographic information system (GIS) and discussions with Town officials. Since detailed information on construction histories were not available, APTech estimated construction or rehabilitation dates based on the current condition of the pavement observed during the pavement inspections. The construction history entries can be easily updated in the MicroPAVER™ database as new or additional information becomes available.

Network definition is the process of dividing a collection of roadways into a logically organized system. A pavement management system requires that network definition activities be conducted to facilitate the storage and reporting of information and to provide a sound engineering basis for making M&R recommendations. The procedures outlined in American Society for Testing and Materials (ASTM) D6433, *Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys*, were followed during the network definition process.

Pavement divisions are established by creating an organizational hierarchy of the pavement network. The pavement network for the Town of Cave Creek consists of branches, sections, and sample units. A branch consists of the entire length of a road. A section is a subdivision of a branch containing pavement with the same design, construction history, traffic, and condition. Finally, sections are divided into sample units. Sample units are relatively small areas. Within selected sample units, distress types and severities are identified and quantified to estimate repair needs and to calculate PCIs.

Approximately 80 centerline-miles (over 8.5 million ft^2) of pavement, which consists of 251 pavement sections, were evaluated on the Cave Creek network as part of this implementation. The pavement sections were divided into three pavement types: asphalt, chip seal and portland cement concrete (PCC). Figure 3 shows the distribution of pavement area by pavement type. The GIS information from the Town included the gravel roads with in the town boundaries. Although they were not inspected and are not included in the various analysis conducted for this project, these gravel roads were inventoried in the MicroPAVER™ database.

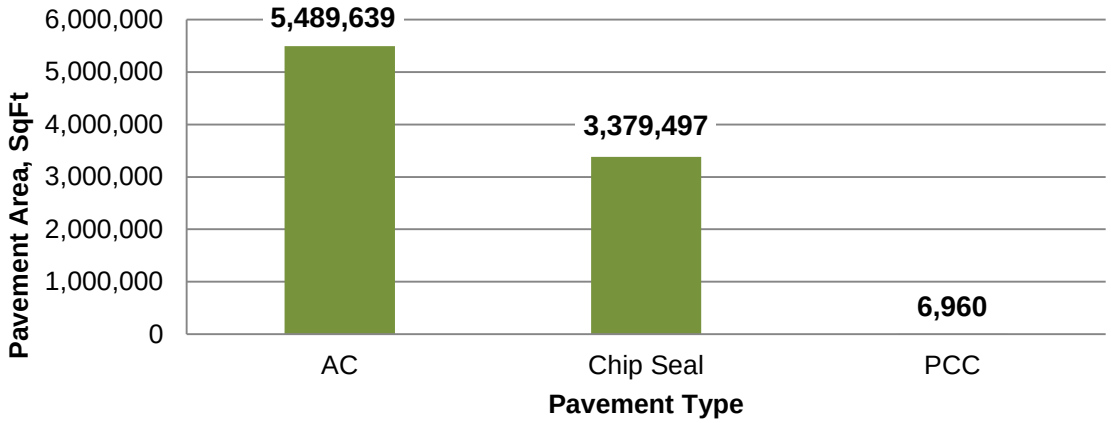


Figure 3. Pavement inventory by pavement type.

Pavement Condition Assessment Procedure

One of the most important components of a pavement management system is the methodology for the systematic assessment of pavement conditions, since pavement condition data are used to identify current M&R needs, predict future needs, and project the impact on overall network conditions of alternative M&R strategies. Because of its importance to the pavement management system, the approach used to evaluate pavement condition must not only provide the level of detail required for the data analysis needs, but must also be repeatable among inspectors.

The PCI procedure described in ASTM D6433, *Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys* was used to assess pavement condition during the pavement evaluations conducted in February 2014. The PCI provides a numerical indication of the overall pavement condition. The PCI procedure is one of the standard approaches used by the pavement management industry to visually assess pavement condition. It was developed to provide a consistent, objective, and repeatable tool to represent the overall pavement condition. This methodology involves walking the pavement length, identifying the type and severity of existing distress, and measuring the quantity (generally, length, area, or number of slabs affected) of distress. It is not cost-effective, or necessary, to inspect every sample unit in a section to make network-level planning decisions. The sampling rate presented in table 1 was used to determine a representative condition and to estimate distress quantities present in each roadway section.

Table 1. Sampling rate for roads.

Total Area (ft2)	Total Number of Samples	Number of Samples to Inspect
1 to 12,500	1-5	1
12,501 to 25,000	6-10	2
25,001 to 37,500	11-15	3
37,501 to 100,000	16-40	4
>100,000	41+	10%

Figure 4 illustrates PCI condition ranges. The PCI scale ranges from a value of 0 (representing a pavement in a completely failed condition) to a value of 100 (representing a pavement with no distress). In general terms, pavements with a PCI above 60 that are not exhibiting significant amounts of load-related distress (e.g., alligator cracking in the wheel-path) will benefit from preventive maintenance actions, such as crack sealing and patching. Surface treatments such as chip seals and slurry seals are a cost-effective way to extend pavement life when the pavement surface is still in good condition, generally when the PCI is between 70 and 85. Pavements with a PCI between 30 and 60 are more likely candidates for major rehabilitation activities (such as an HMA overlay). Often, when the PCI is less than 30, reconstruction is the most viable alternative due to presence of the substantial damage to the pavement structure.

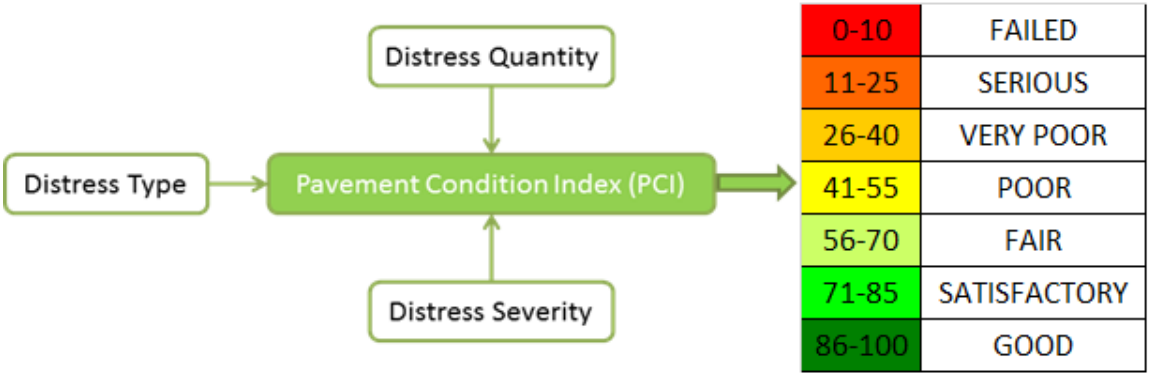


Figure 4. PCI condition ranges.

Although PCI ratings can be used as a general guideline for identifying the repair type, examining the individual distresses measured during the inspection is often more useful in assessing the cause(s) of deterioration. The PCI procedure divides distresses into three categories based on the expected cause of the distress. By knowing the cause(s) of the pavement deterioration, appropriate repair and rehabilitation alternatives can be identified.

The three categories of distress types are load-related distresses (such as alligator cracking, rutting, or corner breaks), climate-related distresses (such as block cracking or blowups), and other distresses (which include distresses that are not directly related to load or climate, such as lane/shoulder drop-off). Load-related distresses are defined as being caused by vehicular traffic and may provide an indication of structural deficiency. Climate-related distresses often signify the presence of aged and/or environment-susceptible materials. Asphalt pavement distresses are summarized in table 2.

Table 2. Asphalt pavement distresses by category (as categorized in MicroPAVER™).

Load-Related	Climate-Related	Other
• Fatigue (Alligator) Cracking • Edge Cracking • Potholes • Rutting	• Block Cracking • Joint Reflection Cracking • Longitudinal and Transverse (L&T) Cracking • Raveling • Weathering	• Bleeding • Bumps and Sags • Corrugation • Depression • Lane/Shoulder Drop-off • Patching • Polished Aggregate • Railroad Crossing • Shoving • Slippage Cracking • Swelling

Pavement Condition Inspection Results

Overall, the area-weighted PCI of the Town-maintained roadways 66. Figure 5 shows the area-weighted PCI by pavement type, which ranges from a PCI of 71 for chip seal pavements to a 47 for concrete pavements. Figure 6 shows the pavement area associated with each condition category. During the condition inspection, the APTech survey crew also documented distresses observed on the pavement surface through digital photographs, both to record typical conditions and to highlight areas of concern. Due to the very large number of pictures, a separate DVD that

includes all pictures taken and a file format that allows these pictures to be viewed on Google Earth will be provided. Pictures of typical distresses observed are included in Appendix A.

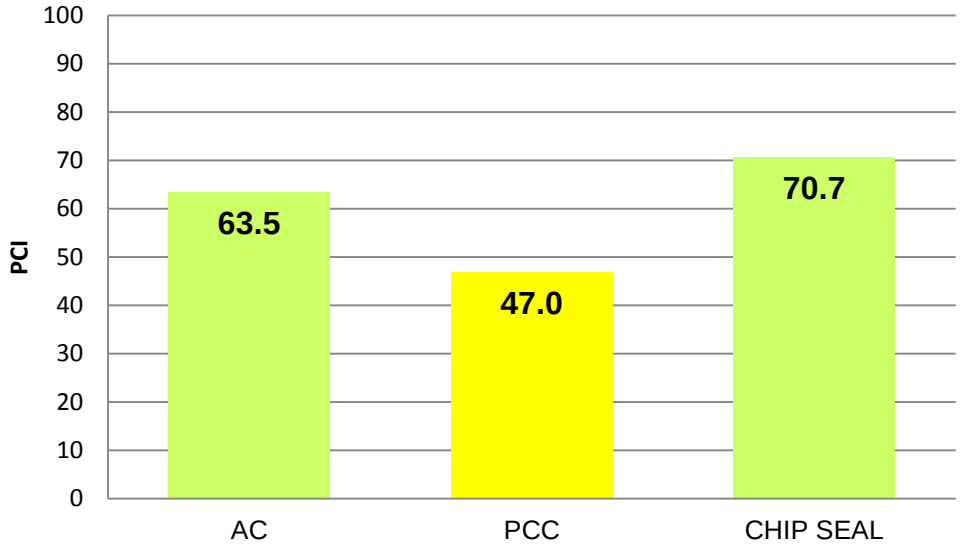


Figure 5. Pavement condition by pavement type.

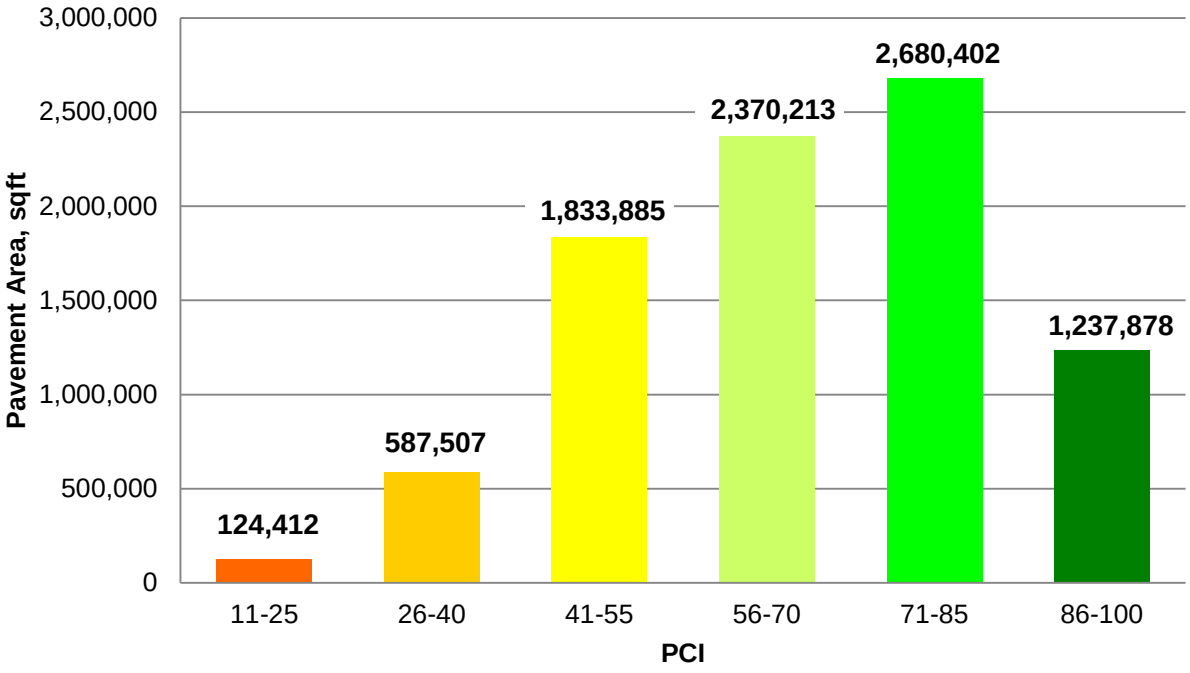


Figure 6. Pavement inventory by condition.

While the area-weighted PCI of the Cave Creek roadway network is 66, the conditions vary drastically. The results of the pavement condition inspection indicated that 29 percent of the pavement area (2,545,804 ft^2) have PCIs below 56; however, more than 44 percent of the area (3,918,280 ft^2) is in satisfactory or good condition with PCIs above 71.

The summary of 2014 PCI results for each pavement section is shown in figure 7 (downtown vicinity only) and listed in Appendix B. A map summarizing the entire 2014 PCI condition assessment is presented in Appendix C.

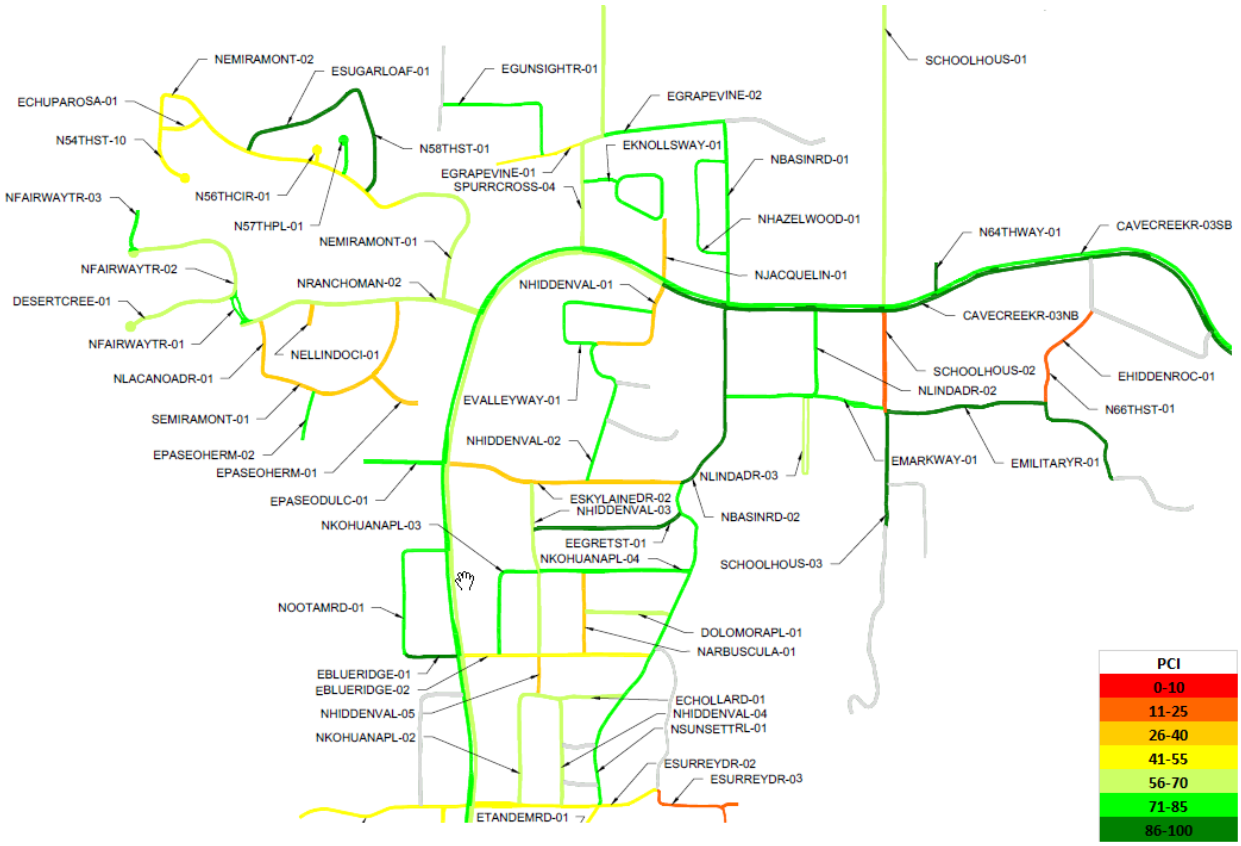


Figure 7. Sample pavement condition map (downtown vicinity).

MICROPAVER CUSTOMIZATION

Background

MicroPAVER™ is a pavement management software tool developed by the US Army Corps of Engineers and distributed by the APWA. It stores pavement inventory information, calculates pavement conditions using visual assessment data, develops models to predict future pavement performance, stores past performance data, and develops basic M&R plans. The software was customized to reflect the specific conditions and needs for maintaining the pavements for the Town of Cave Creek. Customizing MicroPAVER™ is essential to ensure the analysis results are meaningful and applicable to the specific agency needs. APTech defined the MicroPAVER™ inputs using past pavement management experience and assistance from the Town.

MicroPAVER™ permits the user to define many database fields to meet specific requirements. This customization occurs at three levels: the network level (e.g., all Town-maintained roads), the branch level (e.g., entire street length), and the section level (e.g., portions of each street with the same surface and condition). The Cave Creek pavement system is represented by a single network, where each road is a unique branch. Sections are used to further break each branch into smaller areas with common attributes (such as pavement type and general condition). Sample units are also identified within each section, as required by the inspection process.

The customization of the Town of Cave Creek pavement management system can be broken down into the following areas:

- Database-related customization.
- Performance modeling.
- M&R alternatives.

Each of these areas is addressed under separate headings in this chapter.

Database-Related Customization

Network-Level Customization

At the network level, the network identifier and name can be customized, and user-definable fields can be developed. The Cave Creek database has been customized at the network level as shown in figure 8 and as follows:

- There is one network in the database consisting of all city roads. The network identifier is Cave Creek, and the network name is Cave Creek Roads.
- User-defined fields of information were not utilized at the network level. Three fields (NSort1, NSort2, and NSort3) remain available for use, and an unlimited number of additional user-defined fields can also be created in the future. These fields can be used to store other inventory information about the network, which is not generally necessary if only one network is present. For example, if the Town were split into networks of different districts, a user-defined field could be created to store the name of the person in charge of that district.

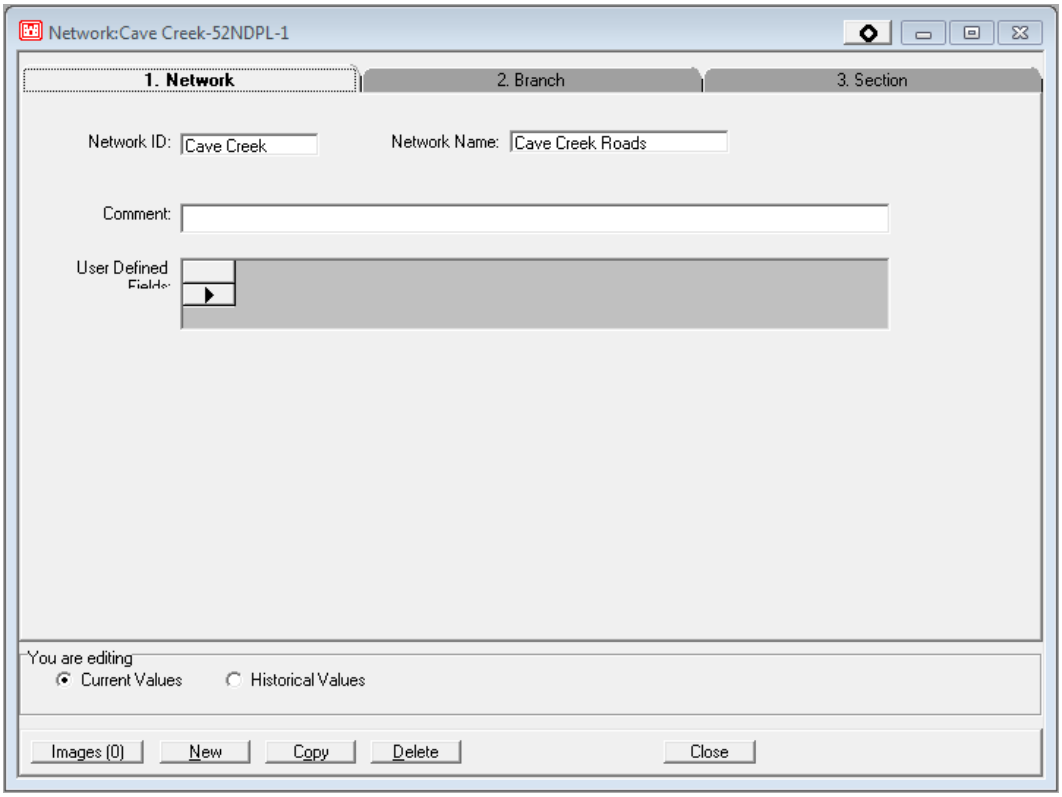


Figure 8. Network level customized database fields.

Branch-Level Customization

Within a network are branches. A branch is a single entity that serves a distinct function. In MicroPAVER™, the user is able to customize the facility identifier, the facility name, and the branch use; user-definable fields can also be developed. The Cave Creek MicroPAVER™ system has been customized at the branch level as shown in figure 9 and as follows:

- The branch ID is limited to a total of ten characters. Due to this limitation, the branch ID is most times a shortened form of the branch name.
- The branch name is a clear description of the branch, typically comprised of the road name.
- The use of the pavement is defined as Roadway. This feature could be used to differentiate Town-maintained alleys or parking lots, if added to the database in the future.
- User-defined fields of information were not utilized at the branch level. Three fields (BSort1, BSort2, and BSort3) remain available for future use, and an unlimited number of additional user-defined fields can also be created. For example, if the road has an alternate name, a user-defined field could be created to store it. Similarly, if the road has an assigned route number, it could be stored in a user-defined field

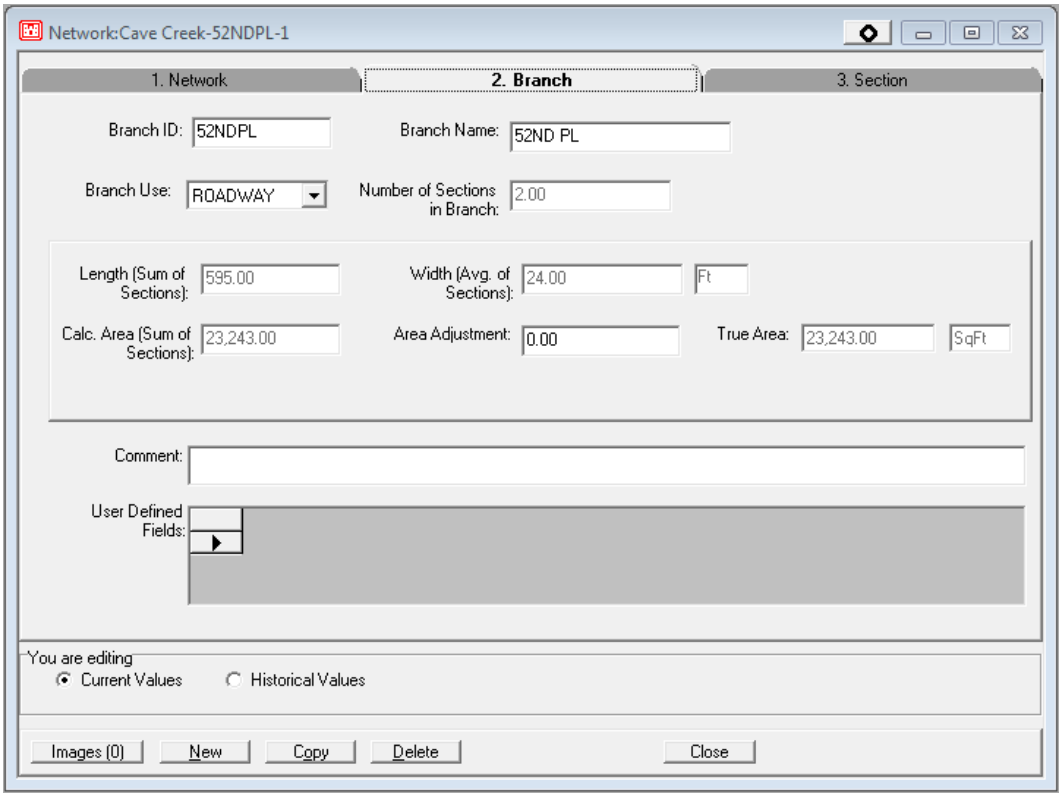


Figure 9. Branch level customized database fields.

Section-Level Customization

A section is a subdivision of a branch used to define pavements with common attributes, such as cross section, construction date, traffic level, and general condition. In MicroPAVER™, the user is able to customize the section identifier, from/to descriptors, use, pavement type, rank, category, street type, and zone. In addition, there are three user-definable fields (SSort1, SSort2, and SSort3) available for use. The Cave Creek system has been customized at the section level as shown in figure 10 and as follows:

- The section identifiers within a branch are numbered starting with 1 (i.e., 1, 2, 3 and so on).
- The from/to fields provide a reference of location, using intersections as references when possible.
- Length, width, and true area indicate the dimensions and size of the section. The true area is used to determine extrapolated distress quantities, costs, and quantities for rehabilitation needs and is used when reporting area-weighted PCI results. The sections were developed based on similar surface appearance and pavement condition.
- Ranks of primary, secondary, and tertiary have been assigned to guide M&R recommendations. Primary roads are the five main roads used in the town (Cave Creek Road, Care Free Highway, Schoolhouse Road, Spur Cross Road, and Fleming Springs Road). The remaining paved roads where designated a secondary rank while all the gravel roads have a designation of tertiary.

- MicroPAVER™ requires a pavement type, which is referred to as "surface type" by the software, to be provided. The pavement types used in the Cave Creek database are AC (asphalt concrete), ST (surface treated-chip seal) and PCC (portland cement concrete).
- Last construction date identifies the most recent year of surface construction. Ideally, this would be the date of last rehabilitation (such as an overlay or reconstruction). However, due to limited work history, APTech has used a combination of estimations from field inspection and back-calculated dates form the performance models to provide the last construction dates.
- User-defined fields of information were not utilized at the section level. Three fields (SSort1, SSort2, and SSort3) remain available for use, and an unlimited number of additional user-defined fields can also be created in the future. There are also default fields available for category, zone, lane, shoulder, street type, and grade. One possible use of the section user-defined fields would be to track the type and condition of paint markings present on the roadway. User-defined fields could also be used to store safety information such as types of accidents on a section of roadway. These fields could also be used to store traffic count information.

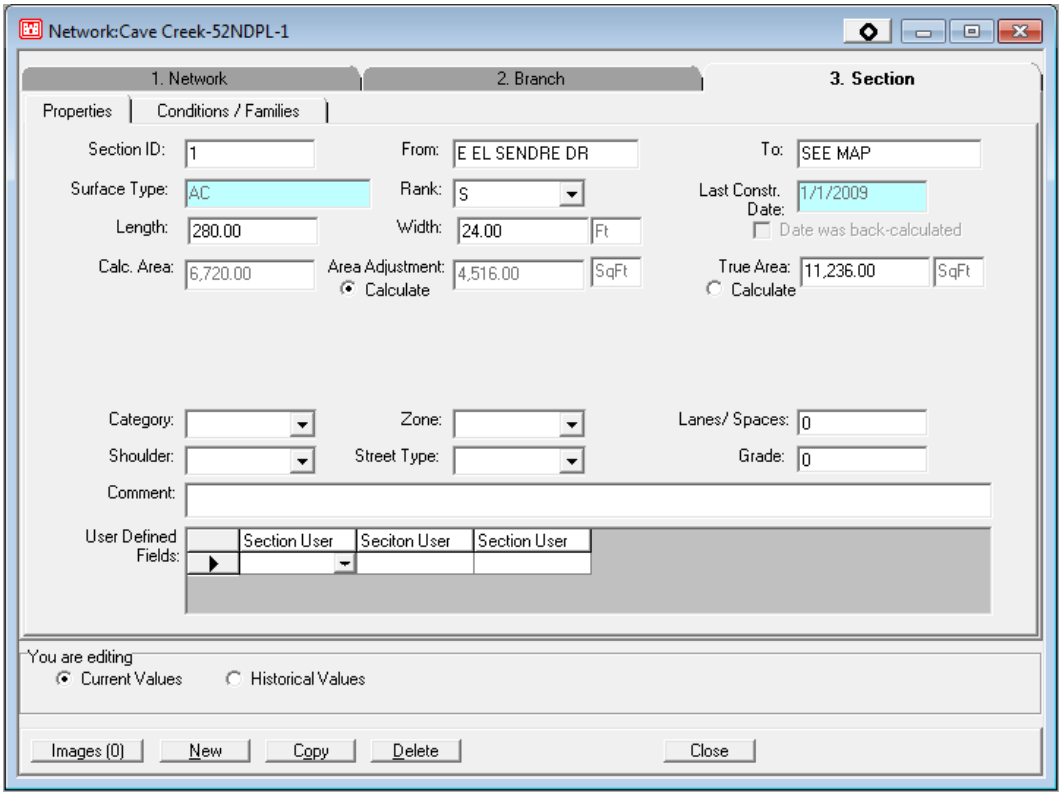


Figure 10. Section level customized database fields.

Performance Modeling

Performance models play an essential role in developing pavement M&R programs. The performance models are used within a pavement management system to predict pavement performance over time, helping to determine the appropriate time to apply maintenance or rehabilitation to maximize the benefits from the expenditure. In addition, by projecting the rate

at which the pavement condition will change over time, a meaningful life cycle cost analysis can be performed to compare the costs of different rehabilitation alternatives.

A PCI assessment provides the condition of the pavement at the time of the inspection. However, for developing future M&R plans, it is also valuable to be able to predict the future PCI of the pavement sections. This can be done in MicroPAVER™ through the development and application of performance models. By using the actual pavement condition data from all inspections and the known age at the time of inspection, it is possible to develop database-specific performance models for groups of pavements. First, the pavement network is divided into groups of pavements called "families," which are comprised of sections that are expected to perform in a similar manner over time. For example, AC surfaced roadway pavements that receive heavy traffic might be grouped into one family, whereas AC surfaced pavements that are primarily used for residential traffic might comprise another family.

Figure 11 graphically illustrates the application of performance model prediction. In this example, a pavement family model was developed using past pavement condition data (shown as black points) and statistically fitted through the data to develop the performance model (shown as the blue curve). For a given pavement section, if the pavement is performing better (or worse) than the rest of the pavement family (for example, see PCI value at 10 years), the model is "shifted" horizontally within MicroPAVER™ to represent the improved pavement condition (shown as the orange modified family model). In this example, the model shift results in an extension of predicted future pavement condition from the original pavement family model.

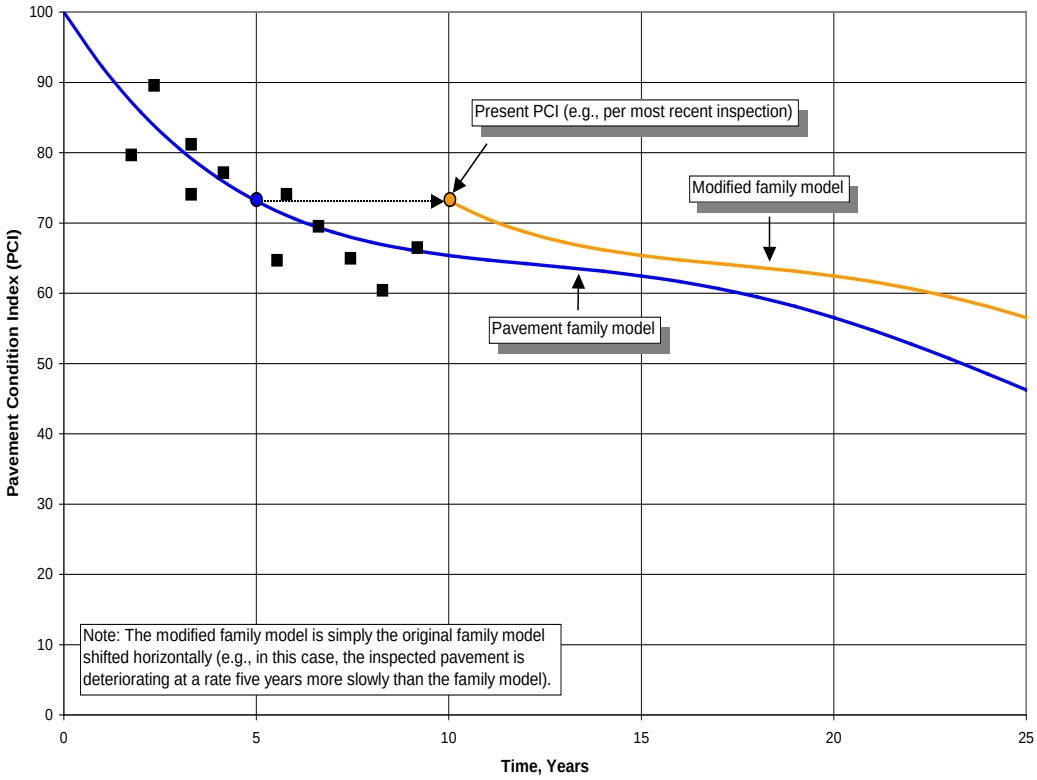


Figure 11. Example of pavement performance model application.

Performance characteristics such as pavement use, pavement type, surface type, and traffic level can be investigated to determine their impact on pavement performance. Due to the limited work

history for pavements included in the Cave Creek network, pavements were divided into three families: asphalt pavements, chip seal pavements, and PCC pavements. The performance curve developed for asphalt, chip seal, and PCC pavements are shown in figures 12, 13, and 14, respectively.

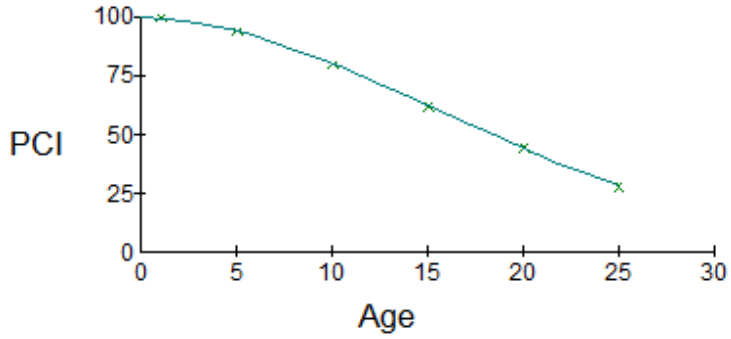


Figure 12. Asphalt pavement performance model.

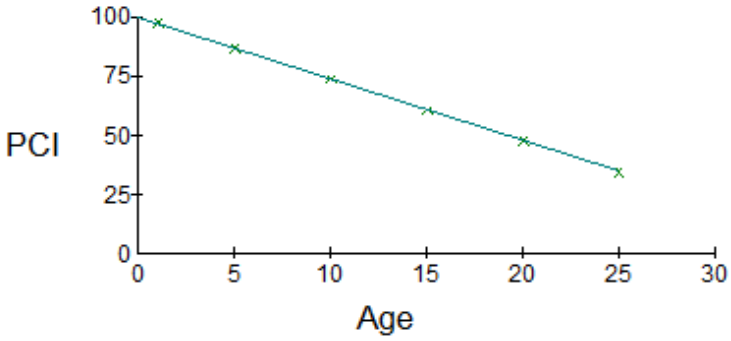


Figure 13. PCC pavement performance model.

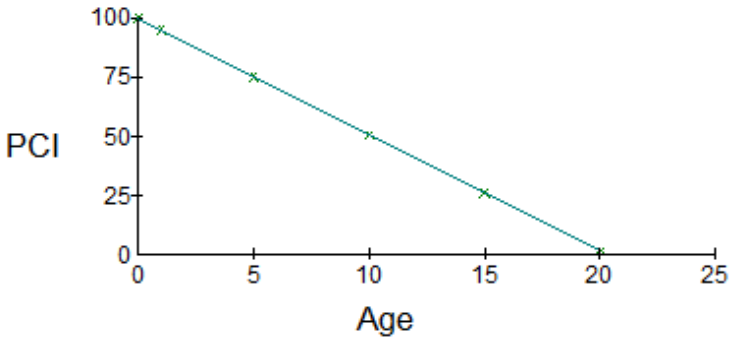


Figure 14. Chip seal pavement performance model.

Since construction history information was not available, performance models could not be developed based on statistical analysis of the pavement condition. Rather, expert models were developed based on APTech's experience in working with other cities of similar size in Arizona (e.g., Gila Bend and Goodyear). Each performance model starts with a PCI of 100 at year 0 (i.e., at the time of construction or major rehabilitation) and decreases over time. These models are utilized when creating the rehabilitation plan.

The models are described by the following equations:

$AC\ PCI = 100 - (0.00001*Age) - (0.28815*Age^2) + (0.00968*Age^3) - (0.00011*Age^4)$

$Chip\ Seal\ PCI = 100 - (4.9*Age)$

$PCC\ PCI = 100 - (2.6*Age)$

When the construction dates are updated in the MicroPAVER™ database, improved performance models can be developed that reflect the deterioration observed on Cave Creek pavements.

Maintenance and Rehabilitation Alternatives

Maintenance Policies

Preventive maintenance is the application of treatments to pavement surfaces that are generally in good condition. The goal of preventive maintenance is to preserve the pavement system by slowing the rate of deterioration through proactive treatments. Since preventive maintenance treatments are usually very low in cost, their use is a cost-effective strategy for preserving network conditions. Preventive maintenance policies are established to define the type of maintenance action needed to correct each distress type observed during the pavement evaluation.

The critical PCI is the pavement condition level below which preventive maintenance actions are no longer cost-effective, and it represents the time when rehabilitation work should be triggered. Preventive maintenance actions are recommended above the critical PCI level. Table 3 shows the critical PCIs chosen for Cave Creek roads.

Table 3. Critical PCIs for Cave Creek roads.

Critical PCI	Road Type
65	Primary roads
55	Secondary AC roads
55	Secondary chip seal roads

Stopgap maintenance is recommended when rehabilitation activities are warranted but funding is insufficient to perform the needed level of work. The goal of these policies is to keep the pavement operational through the repair of distress type and severity level combinations that could create hazardous situations through the potential for tire damage, hydroplaning, or other safety concerns.

Tables 4 and 5 present localized preventive and stopgap maintenance policies that were used in MicroPAVER™ for AC and chip seal pavements, respectively. The localized preventive and stopgap maintenance policies primarily consist of crack sealing, partial and full-depth patching to address isolated areas of distresses to slow down the rate of deterioration of the pavement section. Only distress types observed in the Cave Creek roadway network are considered in the maintenance policies listed in tables 5 and 6. The maintenance activities recommended for the Town of Cave Creek will be discussed in later sections of this report.

Table 4. Localized preventive and stopgap maintenance policies for AC pavements.

Distress Type	Severity Level	Preventive Maintenance Action	Stopgap Maintenance Action
Alligator (Fatigue) Cracking	Low	Monitor	Monitor
	Medium	Monitor	Monitor
	High	Full Depth Asphalt Patching	Full Depth Asphalt Patching
Bleeding	Low	Monitor	Monitor
	Medium	Monitor	Monitor
	High	Partial Depth Asphalt Patching	Partial Depth Asphalt Patching
Block Cracking	Low	Monitor	Monitor
	Medium	Monitor	Monitor
	High	Partial Depth Asphalt Patching	Crack Sealing
Bumps and Sags	Low	Monitor	Monitor
	Medium	Full Depth Asphalt Patching	Monitor
	High	Full Depth Asphalt Patching	Full Depth Asphalt Patching
Depression	Low	Monitor	Monitor
	Medium	Partial Depth Asphalt Patching	Monitor
	High	Full Depth Asphalt Patching	Full Depth Asphalt Patching
Edge Cracking	Low	Monitor	Monitor
	Medium	Crack Sealing	Monitor
	High	Partial Depth Asphalt Patching	Patching - AC Shallow
Lane/Shoulder Drop off	Low	Monitor	Monitor
	Medium	Asphalt Patching (Leveling)	Monitor
	High	Asphalt Patching (Leveling)	Asphalt Patching (Leveling)
Longitudinal and Transverse (L&T) Cracking	Low	Monitor	Monitor
	Medium	Crack Sealing	Crack Sealing
	High	Partial Depth Asphalt Patching	Partial Depth Asphalt Patching
Patching and Utility Cut	Low	Monitor	Monitor
	Medium	Monitor	Monitor
	High	Full Depth Asphalt Patching	Full Depth Asphalt Patching
Potholes	Low	Full Depth Asphalt Patching	Full Depth Asphalt Patching
	Medium	Full Depth Asphalt Patching	Full Depth Asphalt Patching
	High	Full Depth Asphalt Patching	Full Depth Asphalt Patching
Raveling	Medium	Skin Patching	Monitor
	High	Partial Depth Asphalt Patching	Monitor
Rutting	Low	Monitor	Monitor
	Medium	Full Depth Asphalt Patching	Monitor
	High	Full Depth Asphalt Patching	Full Depth Asphalt Patching
Swelling	Low	Monitor	Monitor
	Medium	Full Depth Asphalt Patching	Monitor
	High	Full Depth Asphalt Patching	Full Depth Asphalt Patching
Weathering	Low	Monitor	Monitor
	Medium	Monitor	Monitor
	High	Monitor	Monitor

Table 5. Localized preventive and stopgap policies for chip seal pavements.

Distress Type	Severity Level	Preventive Maintenance Action	Stopgap Maintenance Action
Alligator (Fatigue) Cracking	Low	Monitor	Monitor
	Medium	Monitor	Monitor
	High	Full Depth Chip Seal Patch	Full Depth Chip Seal Patch
Bleeding	Low	Monitor	Monitor
	Medium	Monitor	Monitor
	High	Chip Seal Skin Patch	Chip Seal Skin Patch
Block Cracking	Low	Monitor	Monitor
	Medium	Crack Sealing	Monitor
	High	Crack Sealing	Crack Sealing
Bumps and Sags	Low	Monitor	Monitor
	Medium	Full Depth Chip Seal Patch	Monitor
	High	Full Depth Chip Seal Patch	Full Depth Chip Seal Patch
Depression	Low	Monitor	Monitor
	Medium	Chip Seal Skin Patch	Monitor
	High	Full Depth Chip Seal Patch	Full Depth Chip Seal Patch
Edge Cracking	Low	Monitor	Monitor
	Medium	Crack Sealing	Monitor
	High	Full Depth Chip Seal Patch	Crack Sealing
Lane/Shoulder Drop off	Low	Monitor	Monitor
	Medium	Full Depth Chip Seal Patch	Monitor
	High	Full Depth Chip Seal Patch	Full Depth Chip Seal Patch
Longitudinal and Transverse (L&T) Cracking	Low	Monitor	Monitor
	Medium	Crack Sealing	Monitor
	High	Full Depth Chip Seal Patch	Crack Sealing
Patching and Utility Cut	Low	Monitor	Monitor
	Medium	Full Depth Chip Seal Patch	Monitor
	High	Full Depth Chip Seal Patch	Full Depth Chip Seal Patch
Potholes	Low	Full Depth Chip Seal Patch	Full Depth Chip Seal Patch
	Medium	Full Depth Chip Seal Patch	Full Depth Chip Seal Patch
	High	Full Depth Chip Seal Patch	Full Depth Chip Seal Patch
Raveling	Medium	Monitor	Monitor
	High	Chip Seal Skin Patch	Monitor
Rutting	Low	Monitor	Monitor
	Medium	Full Depth Chip Seal Patch	Monitor
	High	Full Depth Chip Seal Patch	Full Depth Chip Seal Patch
Swelling	Low	Monitor	Monitor
	Medium	Full Depth Chip Seal Patch	Monitor
	High	Full Depth Chip Seal Patch	Full Depth Chip Seal Patch

Unit Costs

APTech used the cost data for maintenance activities in table 6 and rehabilitation activities in table 7 for estimating the cost of maintenance needs. The cost data is based on information from Town personnel and APTech experience.

Table 6. Unit costs for localized maintenance activities.

Activity	Work Unit	Unit Cost
Crack Seal-Asphalt	LF	$0.50
Fog seal	SF	$0.04
Partial Depth Asphalt Patch	SF	$2.75
Full depth Asphalt Patch	SF	$3.75
Asphalt Leveling Patch	SF	$2.75
Chip Seal Patch	SF	$0.68
Chip Seal Skin Patch	SF	$0.33

Table 7. Unit costs for preventive maintenance and rehabilitation activities.

Activity	Work Unit	Unit Cost
Complete Reconstruction[1]	SF	$2.33
Fog seal	SF	$0.04
Microsurfacing (single pass)	SF	$0.36
1.5" Milling	SF	$0.35
1.5" Asphalt Overlay	SF	$1.00
Chip Seal (Single Pass)	SF	$0.33
Slurry Seal	SF	$0.33
Rubberized Chip Seal (single pass) [2]	SF	$0.37

[1] Complete reconstruction is assumed to be 3 inches of AC layer over 8 inches of aggregate base course

[2] Cost of a rubberized chip seal assumed to similar to the cost a single chip seal plus a fog seal.

Using the unit cost and maintenance policies shown above, a cost by PCI table was developed for preventive, stopgap, and rehabilitation activities. These costs were used during the preliminary budget scenario analysis and comparison. The preliminary budget scenario analysis allows for a simple comparison of different budgets and condition targets. While costs by PCI ranges were developed for preventive and stopgap maintenance activities, these costs were not used during the development of the recommended maintenance and rehabilitation plans (discussed later).

In general, the costs for rehabilitating pavements with a PCI below 40 represent the cost of reconstruction. For PCIs between 40 and 70, the costs generally represent the cost of patching or the cost of an AC overlay with varying amounts of pre-overlay repairs. Finally, costs for pavements with a PCI above 70 are for preventive maintenance and repairs. The reconstruction costs are based on a cross section consisting of 3 inches of AC and 8 inches of aggregate base. An inflation rate of 3 percent was applied to the costs for work recommended beyond 2014. Table 8 shows the cost by PCI ranges of preventive and stopgap maintenance for AC and chip seal roads. Table 9 shows the cost by PCI ranges for rehabilitation activities for AC and chip seal roads.

Table 8. Cost by PCI range for preventive and stopgap maintenance.

PCI	AC		Chip Seal	
	Preventive	**Stopgap**	**Preventive**	**Stopgap**
0	$3.06	$0.49	$0.53	$0.03
10	$0.71	$0.13	$0.13	$0.01
20	$0.47	$0.09	$0.09	$0.01
30	$0.33	$0.07	$0.06	$0.01
40	$0.24	$0.05	$0.05	$0.01
50	$0.16	$0.04	$0.03	$0.01
60	$0.10	$0.03	$0.02	$0.00
70	$0.05	$0.03	$0.01	$0.00
80	$0.00	$0.02	$0.01	$0.00
90	$0.00	$0.01	$0.00	$0.00
100	$0.00	$0.01	$0.00	$0.00

Table 9. Cost by PCI range for rehabilitation activities.

PCI	AC	Chip Seal
0	$2.35	$0.33
10	$2.35	$0.33
20	$2.35	$0.33
30	$2.35	$0.33
40	$1.76	$0.33
50	$1.63	$0.33
60	$1.14	$0.33
70	$1.00	$0.33
80	$0.55	$0.33
90	$0.15	$0.15
100	$0.15	$0.15

Prioritization Guidelines

Prioritization is a technique used to determine which M&R activities should be performed when there is insufficient funding to perform all necessary work. A prioritization scheme should be developed such that more important pavements receive their recommended work on schedule and less important pavements have their recommended work postponed as necessary.

Priorities should consider all factors relevant in determining the relative importance of various pavements. Typically, agency policy is a key factor in determining priorities. For example, some agencies may determine that certain roadways are more important than others because of traffic patterns or other priorities.

The priorities used for Cave Creek roads are as follows:

1. Primary roads – the five major Town roads (Cave Creek Road, Carefree Highway, Fleming Springs Road, School House Road, and Spur Cross Road).
2. Secondary roads – all remaining roads.

When a constrained budget analysis is performed, MicroPAVER™ prioritizes projects in the following order:

- First Priority: Stopgap maintenance.
- Second Priority: Preventive maintenance.
- Third Priority: Major M&R above critical PCI with structural defects.
- Fourth Priority: Major M&R below critical PCI.

Preliminary Analysis

The preliminary analysis considered three constrained budget scenarios and two target condition scenarios over a five year period. The constrained budget scenarios are $1M, $800K, and $500K per year while the target conditions were backlog elimination and maintain current area-weighted average network condition. These scenarios were compared with a no funding/do nothing scenario to realize the effect each scenario has over a no funding scenario. The starting date (year 1) for the analysis was selected to be June 1, 2014 and the ending date (year 6) was selected to be June 1, 2019. Figure 15 illustrates the change in PCI over the analysis period due to the different scenarios. Figure 16 illustrates the total funding over the analysis period for the scenarios.

While we are not certain about the current and recent past level of spending, based on comments received during initial discussions with the Town it is believed that past spending has been at or below the $500K level. The models predict what the Town is currently experiencing; a gradual decline in condition as the Town struggles to maintain its primary routes at the expense of the residential routes. The currently proposed budget of $800k will barely maintain current PCI levels. In our opinion the Town may consider seeking additional funding to improve network conditions if possible. Growth of the Town and prolonged gradual decline of conditions has created what appears to be an unsustainable condition at current funding levels.

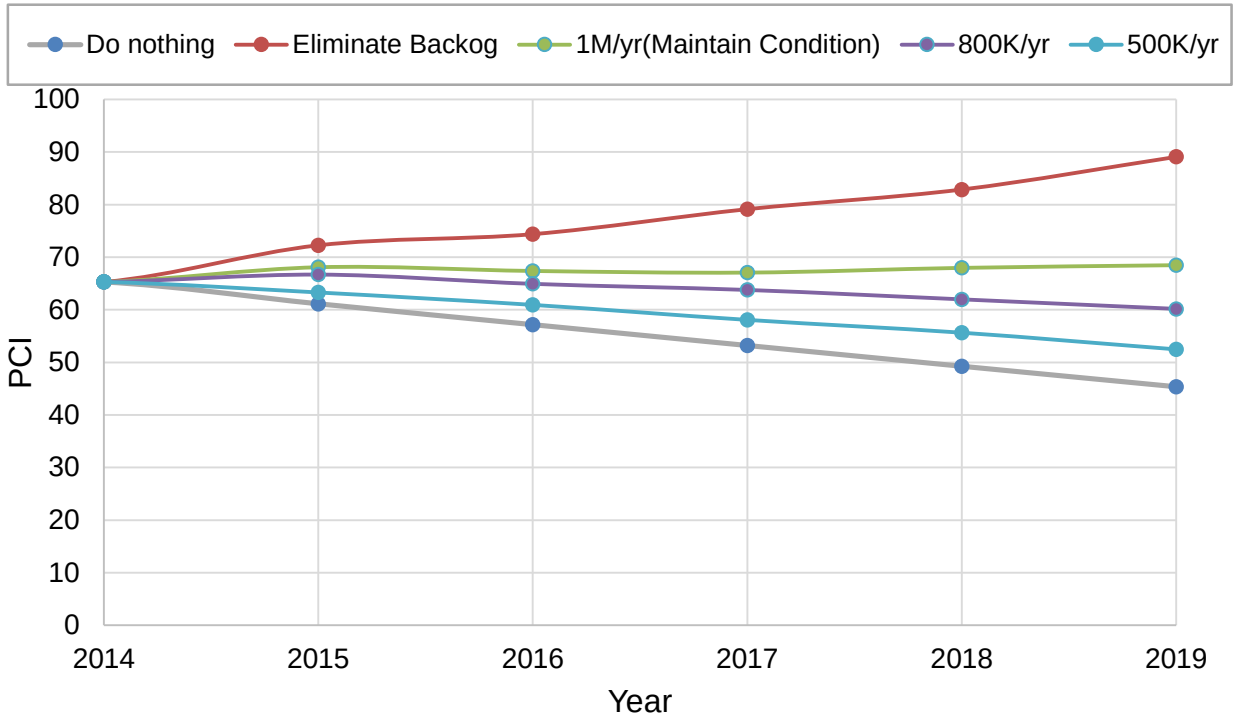


Figure 15. Change in condition for the considered scenarios.

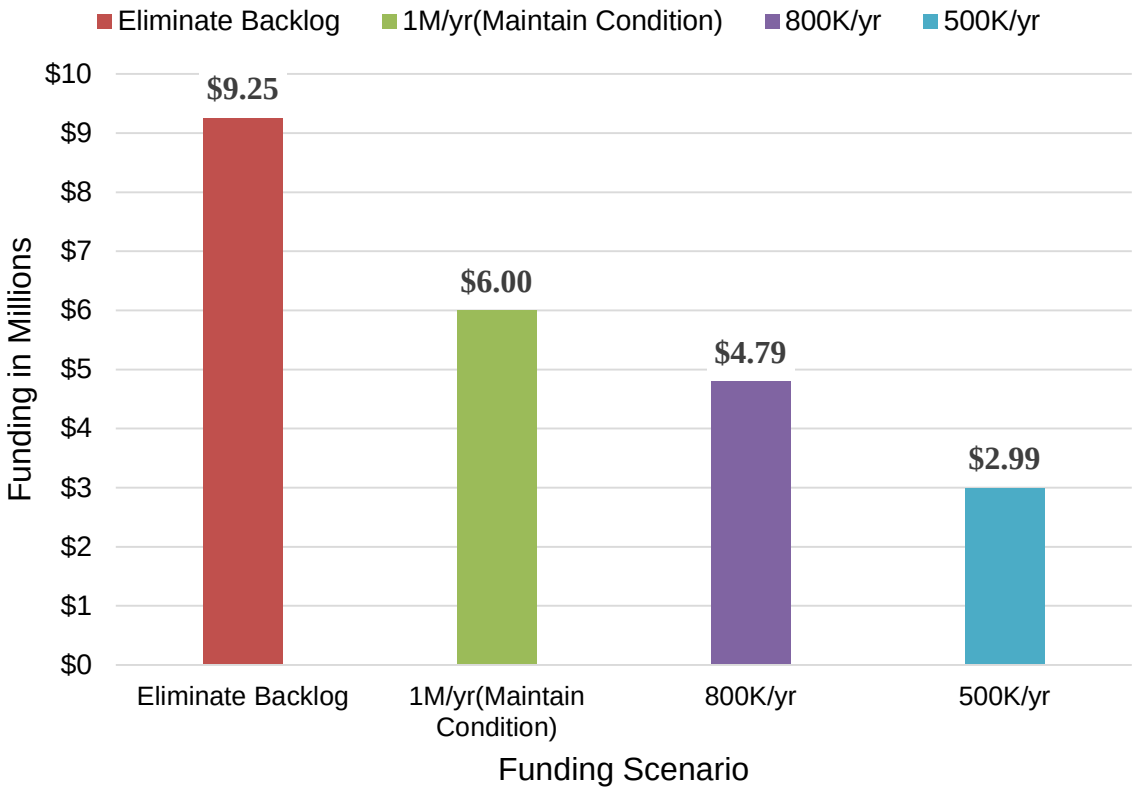


Figure 16. Total funding required for the considered scenarios.

The results of the preliminary analysis are summarized below:

- If no preventive maintenance or rehabilitation is done, the network PCI will drop by 21 points to 45 on year 6.
- For a funding level of $500K per year, the network PCI will drop by 13.5 points to 52.5. This scenario drops will place the network condition in poor condition.
- For a funding level of $800K per year, the network PCI will drop by 5.8 points to 60.2, keeping the average network condition in Fair condition but dropping to the lower range of that category.
- For a funding level of $1M per year, the network PCI will increase by 2.5 point to 68.5, keeping the condition in Fair condition and relatively close to the current conditions. This funding level yields very similar results as the target condition scenario which aims to maintain the current condition of the network.
- By allocating a total of $9.25M over a 6-year period ($1.63M per year), the network PCI will increase by 23.1 points to 89.1, which moves the average network condition into Good condition. This scenario aims to eliminate the backlog of major M&R work over the analysis period.

MAINTENANCE AND REHABILITATION PROGRAM

APTech has developed a 5-year maintenance plan based on a funding level of $800,000 per year. This recommended plan is different than the one discussed in the "preliminary analysis" section because this plan has been tailored to maintain Cave Creek's current network condition over the analysis period while improving the condition of some of the most used roadway sections of the Town. This makes cost- effective use of the $800,000 per year budget while enabling local considerations to be taken into account. In addition to this plan, APTech has also developed a 2-year plan for pavement preservation activities. The details of this plan and the effect of no rehabilitation on the Cave Creek pavement network are discussed in this section.

Effect of No Rehabilitation

If no funding is available for preventive and rehabilitation activities, the area-weighted average network PCI will drop to 45 after at the end of the analysis period. Appendix D shows the projected PCIs of each pavement section if no major rehabilitation work is performed in the next five years. The forecasted PCIs are determined using the prediction models developed for the Cave Creek pavement network (discussed in the previous chapter).

Recommended M&R Program

The recommended M&R program was developed by taking into consideration Cave Creek's primary objective of preserving its roadway network and addressing concerns on its major roads (primarily, Cave Creek Road and Carefree Highway). The recommended plan includes recommendation for rehabilitation of the five primary roads in the Town (Cave Creek Road, Carefree Highway, Fleming Springs Road, School House Road, and Spur Cross Road) within the first 3 years. The Town should consider adding a factor to account for additional costs related to design, striping, traffic control and other contingencies.

Table 10 summarizes the 5-year M&R plan that was developed based on an annual funding level of $800,000 by closely evaluating and customizing the preliminary recommendations produced through the MicroPAVER™ analysis to better suit the Town's needs. The analysis indicates that approximately $3.9 million is needed over the next 5 years, starting in 2015. If the recommended work plan is successfully implemented, the area-weighted network average PCI will be 68, virtually staying the same as the condition during the 2014 inspections, but with significant condition improvements to the major roads in the Town. A map of the M&R plan is provided in Appendix E.

The costs presented in table 10 are based on unit prices discussed previously in this report. The cost pertaining to "Repair" in table 10 were calculated assuming that a percent of the section area would need to be repaired to address localized distress before a preservation or rehabilitation activity to avoid premature deterioration of the improvement. The cost of repairs was assumed to be $2.75 per square foot.

- For pavement sections with PCIs below 40, 25 percent of the section area was assumed to need repairs.
- For pavement sections with PCIs between 40 and 50, 15 percent of the section area was assumed to need repairs;
- PCIs between 50 and 60, 10 percent of the section area was assumed to need repairs;

- For pavement sections with PCIs between 60 and 70, 5 percent of the section area was assumed to need repairs.

A separate list of pavement sections that are good candidates for pavement maintenance and preservation was also compiled and shown in table 11. It should be noted that the sections identified in table 11 show needs for the years 2014 and 2015 only. This is primarily because of uncertainty in the rate of deterioration of the distresses beyond the first 2 years.

Candidates sections listed in table 11 have PCIs over 65 and exhibit minimal load related distresses (less than 40 percent). Fog seal was recommended for all the chip seal pavements in table 11 because loose chips were observed during the field inspections of these pavement sections. Applying a fog seal will provide an extra layer of bituminous material to hold chips in place and mitigate raveling. The repair activities for these sections are mostly crack sealing and patching of localized distresses. The repair costs for 2014 were obtained from the distresses observed during the inspection and the repair costs for 2015 were obtained by adding 5 percent to the cost of repair if the repair would have been done in 2014. All costs are displayed in 2014 dollars (no inflation adjustment was applied). The pavement preservation activities are estimated to cost approximately $120,000over 2 years.

In addition to the work items listed in tables 10 and 11, it is also recommended that the Town perform stopgap maintenance to address safety issues that were identified due to the presence of high-severity distresses (with the exception of weathering and raveling). These are maintenance needs identified during the 2014 inspections. Table 12 shows the list of pavements recommended for stopgap and safety repairs. To avoid duplicating repair efforts and unnecessarily increasing costs, maintenance is likely not needed for sections that will be rehabilitated over the next 2 years; therefore, sections recommended for rehabilitation in table 10 for the years of 2014 and 2015 are not included in table 12. The stopgap and safety repair activities are estimated to cost approximately $50,000.

Table 10. Recommended maintenance and rehabilitation plan.

Recommended Year	Branch ID	Section ID	Surface	Condition before treatment	Work Type	Area (SF)	Cost in 2014 dollars
2015	CAVECREEKR	1NB	AC	46.38	Mill + Repair + 1.5" AC Overlay	110,517	$179,590
	CAVECREEKR	1SB		63.34		98,603	$146,672
	CAREFREEHW	*1EB-3rd ln*		49.32		*16,912*	*$27,482*
	CAREFREEHW	1WB	AC	64.36		144,461	$214,886
	CAREFREEHW	1WB-pass		54.27		28,130	$45,711
	ECOACHWHIP	1	AC	37.69	Repair + Chip Seal + Fog Seal	23,172	$18,132
	ECOACHWHIP	*2*		34.84		*7,575*	*$8,011*
	EROCKROSED	*1*		29.26		*20,836*	*$22,034*
	EQUAILBRUS	1		55.27		24,485	$15,793
	N46THST	1		48.34		25,190	$16,248
	DESERTCREE	*1*	*AC*	61.35	*Repair + Microsurfacing*	*24,612*	*$12,244*
	NFAIRWAYTR	*2*		64.4		*31,836*	*$15,838*
	EELSENDERO	*4*		61.32		*41,008*	*$20,401*
	53RDPL	*1*		62.32	*Repair + Fog Seal*	*11,953*	*$5,588*
2014 Total Cost $748,630							

Note: The sections highlighted in yellow have been added to the work plan since the previous version.

Table 10. Recommended maintenance and rehabilitation plan (continued).

Recommended Year	Branch ID	Section ID	Surface	Condition before treatment	Work Type	Area (SF)	Cost in 2014 dollars
2016	EPASEOHERM	1	Chip Seal	23.91	Repair + Chip Seal + Fog Seal	12,155	$12,854
	SEMIRAMONT	1		26.91		37,840	$40,016
	NLACANOADR	1		25.91		11,354	$12,007
	NELLINDOCI	1		28.91		5,228	$5,529
	67THPL	1		31.84		10,223	$10,811
	EMESQUITER	1		55.84		18,545	$9,412
	ECHOLLARD	1		48.89		19,764	$12,748
	NKOHUANAPL	2		53.89		21,184	$13,664
	NHIDDENVAL	*1*		25.91		*21,589*	*$22,830*
	NHIDDENVAL	*3*		44.89		*33,304*	*$26,060*
	NHIDDENVAL	*4*		51.89		*20,425*	*$13,174*
	NHIDDENVAL	*5*		20.89		*6,059*	*$6,407*
	NGALLOWAYD	1	AC	44.74		73,342	$57,390
	N56THST	6	AC	27.29	Mill + Repair + 1.5" AC Overlay	29,153	$59,399
	N56THST	7		51.57		11,434	$18,580
	CAVECREEKR	4NB		54.6		256,935	$417,519
	CAVECREEKR	*2WB*		58.65		*19,967*	*$29,701*
	ELONEMOUNT	*3*	*Chip Seal*	62.85	*Repair + Fog Seal*	*17,923*	*$3,181*
2015 Total Cost $771,282							

Table 10. Recommended maintenance and rehabilitation plan (continued).

Recommended Year	**Branch ID**	**Section ID**	**Surface**	**Condition before treatment**	**Work Type**	**Area (SF)**	**Cost in 2014 dollars**
2017	FLEMINGSPR	1	AC	30.57	Repair + 1.5" AC Overlay	91,280	$154,035
	FLEMINGSPR	2		42.2		122,483	$173,007
	FLEMINGSPR	3		44.09		29,565	$41,761
	SCHOOLHOUS	1		47.92		180,075	$229,596
	SCHOOLHOUS	6	Chip Seal	52.88		94,928	$121,033
	CONESTOGAT	*2*	*AC*	41.3		*30,272*	*$42,759*
	MAGUARRD	*1*	*Chip Seal*	54.97	*Repair + Chip Seal + Fog Seal*	*12,597*	*$6,393*
2016 Total Cost $768,584							
2018	ETANGLEWO	1	Chip Seal	32.03	Repair + Chip Seal + Fog Seal	22,898	$24,215
	EZENITHLN	1		11.03		24,930	$26,363
	ESUMMERSET	1		30.03		18,512	$19,576
	ESAWMILLCI	1		23.03		12,966	$13,712
	ERAINTREEC	1		32.03		14,482	$15,315
	NRIFLEMANR	1		1.03		37,816	$39,990
	NWILDERNES	1		15.03		35,301	$37,331
	ECLOUDRD	*6*		44.09		*7,531*	*$5,893*
	ESURREYDR	*2*		26.1		*39,345*	*$41,607*
	ESURREYDR	*3*		1.1		*12,877*	*$13,617*
	VICTORYDR	*1*		8.1		*6,767*	*$7,156*
	SPURRCROSS	2	AC	40.63	Repair + 1.5" AC Overlay	345,961	$488,670
	SPURRCROSS	4		45.36		24,822	$35,061
	ECLOUDRD	*3*		50.25		*19,818*	*$25,268*
2017 Total Cost $793,774							

Table 10. Recommended maintenance and rehabilitation plan (continued).

Recommended Year	Branch ID	Section ID	Surface	Condition before treatment	Work Type	Area (SF)	Cost in 2014 dollars
2019	ECIELORUN	1	Chip Seal	45.13	Repair + Chip Seal + Fog Seal	92,863	$59,897
	NPSODEORO	1		40.13		9,463	$7,405
	EROCKAWAYH	2		45.16		37,932	$24,466
	EROCKAWAYH	*4*		45.23		*36,320*	*$23,426*
	EYUCCARD	1		47.19		53,675	$34,620
	EMARKWAY	1		47.19		32,678	$21,077
	NLINDADR	3		33.19		15,222	$16,097
	NECHOCANYO	*2*		50.16		*78,936*	*$50,914*
	EWILLOWSPR	1	AC	22.91		99,355	$105,068
	NECHOCANYO	1		39.98		33,566	$26,265
	EHIGHLANDR	2		33.82		157,730	$166,799
	ELONEMOUNT	2		38.16		7,333	$5,738
	N72NDST	2		7.05		5,535	$5,853
	N72NDST	3		51.65		10,493	$6,768
	EBUTTECANY	2		42.78		28,436	$21,114
	NWILLOWCRO	1		39.09		15,196	$11,891
	NDESERTWIN	1		15.26		10,077	$10,656
	NDESERTWIN	2		28.97		30,237	$31,976
	NDESERTWIN	3		36.41		21,731	$22,981
	NCANYONSPR	1		32.16		45,694	$48,321
	EHIDDENSPR	1		23.83		7,571	$8,006
	EHIDDENSPR	2		28.17		27,859	$29,461
	EIRONWOODB	1		47.62		7,655	$4,937
	EIRONWOODB	2		37.29		28,865	$22,587
	EIRONWOODB	3		42.77		8,763	$6,857
2018 Total Cost $773,180							

Table 11. Candidate pavement sections for maintenance and preservation activities.

Year	Branch ID	Section ID	Surface Type	Area	2014 PCI	Work Type	Cost in 2014 dollars
2015	EPASEODULC	1	ST	19,021	77	Fog Seal	$761
	ESATNAMWAY	1	ST	15,072	80	Fog Seal	$603
	EVILLACASS	1	ST	15,067	80	Fog Seal	$603
	N49THST	1	ST	39,719	85	Fog Seal	$1,589
	N51STST	4	ST	59,223	84	Fog Seal	$2,369
	NKOHUANAPL	3	AC	22,809	76	Fog Seal	$912
	ECALVINST	1	AC	44,492	76	Repair	$627
	ECLOUDRD	5	AC	16,124	70	Repair + Slurry Seal	$8,279
	EELSENDERO	6	AC	31,983	76	Repair	$1,615
	EKNOLLSWAY	1	AC	29,905	82	Repair	$267
	ELONGRIFLE	1	AC	13,572	83	Repair	$38
	ESIERRAWAY	1	AC	25,255	75	Repair	$268
	N39THPL	1	AC	20,428	69	Repair + Microsurfacing	$7,855
	N48THST	1	AC	30,293	80	Repair	$509
	N54THST	9	AC	14,471	76	Repair	$540
	N57THPL	1	AC	10,318	79	Repair	$103
	NFAIRWAYTR	3	AC	8,707	78	Repair	$190
	NLINDADR	1	AC	19,675	81	Repair	$157
	NPRICKLEYP	1	AC	25,951	70	Repair + Slurry Seal	$9,192
	NPRICKLEYP	2	AC	13,071	73	Repair + Slurry Seal	$4,594
	NRANCHOMAN	1	AC	23,200	73	Repair + Slurry Seal	$8,949
	NROLLINGCR	1	AC	32,292	73	Repair + Slurry Seal	$11,228
	SENITAWAY	1	AC	9,397	85	Repair	$73
	52NDPL	1	AC	11,236	71	Repair + Fog Seal	$1,416
	52NDPL	2	AC	12,007	69	Repair + Fog Seal	$788
	53RDPL	2	AC	14,262	64	Repair + Fog Seal	$1,001
	EELSENDERO	2	ST	14,786	77	Repair + Fog Seal	$644
	N46THWAY	1	AC	7,538	84	Repair + Fog Seal	$341
	NLANGUIDLN	1	AC	19,078	70	Repair + Fog Seal	$838
2014 Total							**$66,349**

Year	Branch ID	Section ID	Surface Type	Area	2014 PCI	Work Type	Cost
2016	EAZURAPL	1	ST	31,570	81	Fog Seal	$1,263
	EAZUREHILL	1	ST	9,509	74	Fog Seal	$380
	EBELLAVIST	1	ST	34,539	75	Fog Seal	$1,382
	EGRAPEVINE	2	ST	23,881	77	Fog Seal	$955
	EGRAPEVINE	5	ST	60,958	70	Fog Seal	$2,438
	EGRAPEVINE	6	ST	30,728	70	Fog Seal	$1,229
	ELONEMOUNT	1	ST	30,436	81	Fog Seal	$1,217
	EMESQUITER	3	ST	32,923	77	Fog Seal	$1,317
	EPASEOHERM	2	AC	8,059	75	Fog Seal	$322
	ERIDGECRES	3	ST	25,837	71	Fog Seal	$1,033
	ERIDGECRES	4	ST	23,567	74	Fog Seal	$943
	EROCKAWAYH	5	AC	42,950	80	Fog Seal	$1,718
	ESABERD	1	ST	10,397	74	Fog Seal	$416
	N56THST	2	ST	12,238	81	Fog Seal	$490
	N58THST	3	ST	14,962	79	Fog Seal	$598
	N60THST	1	ST	14,775	81	Fog Seal	$591
	N78THST	1	ST	5,991	75	Fog Seal	$240
	NBASINRD	1	ST	34,964	84	Fog Seal	$1,399
	NECHOCANYO	3	ST	11,639	74	Fog Seal	$466
	NHAZELWOOD	1	ST	17,423	78	Fog Seal	$697
	NPIEDRAGRA	1	ST	21,013	81	Fog Seal	$841
	NRIDGEWAYD	1	ST	9,062	74	Fog Seal	$362
	NRIDGEWAYD	2	ST	78,746	73	Fog Seal	$3,150
	SECOPL	1	ST	29,545	81	Fog Seal	$1,182
	57THPL	1	AC	4,918	79	Repair + Fog Seal	$1,501
	CAREFREEHW	1EB	AC	166,507	78	Repair + Fog Seal	$6,770
	EARROYORD	2	ST	14,347	74	Repair + Fog Seal	$615
	EARROYORD	4	ST	25,856	71	Repair + Fog Seal	$1,129
	EARROYORD	5	ST	50,969	78	Repair + Fog Seal	$2,732
	ECONTINENT	2	ST	51,666	75	Repair + Fog Seal	$5,913
	EHIGHLANDR	1	ST	25,912	73	Repair + Fog Seal	$1,511
	NECHOCANYO	2	ST	78,936	70	Repair + Fog Seal	$3,157
	NEWCAHAVAR	1	ST	46,252	73	Repair + Fog Seal	$1,974
	NOLDSTAGER	1	ST	76,503	66	Repair + Fog Seal	$3,762
2015 Total							**$53,693**

Table 12. Pavement sections recommended for stopgap and safety repairs.

Branch ID	Section ID	Distress Description	Severity	Distress Quantity	Unit	Work Description	Work Quantity	Work Unit	2014 Cost
CONESTOGAT	2	Rutting	H	303	SqFt	Full Depth Asphalt Patching	303	SqFt	$1,135
EAGAVEDR	1	Depression	H	48	SqFt	Full Depth Asphalt Patching	80	SqFt	$300
EBLUERIDGE	2	Edge Cracking	H	58	Ft	Partial Depth Asphalt Patching	95	SqFt	$260
ECARRIAGED	1	Rutting	H	1,361	SqFt	Full Depth Chip Seal Patching	1,361	SqFt	$926
ECLOUDRD	1	Edge Cracking	H	19	Ft	Crack Sealing	19	Ft	$9
ECLOUDRD	1	Rutting	H	1,393	SqFt	Full Depth Chip Seal Patching	1,393	SqFt	$947
EDESERTHIL	1	Alligator Cracking	H	25	SqFt	Full Depth Asphalt Patching	49	SqFt	$184
EGRAPEVINE	1	Pothole	H	2	Count	Full Depth Chip Seal Patching	19	SqFt	$13
ESKYLINEDR	2	Edge Cracking	H	434	Ft	Crack Sealing	434	Ft	$217
ESURREYDR	1	Edge Cracking	H	26	Ft	Partial Depth Asphalt Patching	43	SqFt	$117
ESURREYDR	2	Lane Shoulder Drop off	H	367	Ft	Full Depth Chip Seal Patching	1,205	SqFt	$819
ESURREYDR	3	Edge Cracking	H	461	Ft	Crack Sealing	461	Ft	$231
EWILLOWSPR	1	Alligator Cracking	H	1,043	SqFt	Full Depth Asphalt Patching	1,177	SqFt	$4,415
FLEMINGSPR	1	Patching	H	2,025	SqFt	Full Depth Asphalt Patching	2,210	SqFt	$8,289
N26THST	1	Patching	H	1,093	SqFt	Full Depth Chip Seal Patching	1,230	SqFt	$836
N52NDST	3	Alligator Cracking	H	26	SqFt	Full Depth Asphalt Patching	51	SqFt	$189
N52NDST	3	Edge Cracking	H	994	Ft	Partial Depth Asphalt Patching	1,631	SqFt	$4,486
N62NDST	2	Rutting	H	2,209	SqFt	Full Depth Asphalt Patching	2,209	SqFt	$8,283
N72NDST	2	Lane Shoulder Drop off	H	9	Ft	Asphalt Patching (Leveling)	29	SqFt	$80
NHIDDENVAL	1	Edge Cracking	H	32	Ft	Crack Sealing	32	Ft	$16
NHIDDENVAL	1	Patching	H	63	SqFt	Full Depth Chip Seal Patching	99	SqFt	$67
NRIFLEMANR	1	Alligator Cracking	H	612	SqFt	Full Depth Chip Seal Patching	716	SqFt	$487
NRIFLEMANR	1	Edge Cracking	H	32	Ft	Crack Sealing - AC	32	Ft	$16
NSUNSETTRL	2	Edge Cracking	H	771	Ft	Partial Depth Asphalt Patching	1,265	SqFt	$3,478
NSUNSETTRL	2	Lane Shoulder Drop off	H	15	Ft	Asphalt Patching (Leveling)	49	SqFt	$134
SCHOOLHOUS	1	Lane Shoulder Drop off	H	412	Ft	Asphalt Patching (Leveling)	1,350	SqFt	$3,714
SCHOOLHOUS	2	Edge Cracking	H	662	Ft	Partial Depth Asphalt Patching	1,086	SqFt	$2,987
SCHOOLHOUS	2	Lane Shoulder Drop off	H	549	Ft	Asphalt Patching (Leveling)	1,802	SqFt	$4,957
SPURRCROSS	2	Lane Shoulder Drop off	H	56	Ft	Asphalt Patching (Leveling)	183	SqFt	$502
VICTORYDR	1	Edge Cracking	H	85	Ft	Partial Depth Asphalt Patching	139	SqFt	$382
Total Stopgap/Safety Repair Cost									**$48,476**

RECOMMENDED STRATEGIES FOR MANAGEMENT OF CAVE CREEK ROADS

This chapter summarizes the pavement management strategy for Cave Creek's roadway network. It includes recommended treatments and general treatment selection guidelines based on the type and severity of the distresses observed.

Based upon the discussions with the Town, it is understood that the Town is interested in maintaining the integrity of the existing pavements by having a routine crack sealing program to prevent moisture ingress into the pavement coupled with a mix preventive maintenance and rehabilitation activities to maintain its major roads in good condition.

Based on established engineering practices and the Town's preferences, a combination of treatments that includes crack sealing and patching, chip seals, slurry seals or microsurfacing, and thin HMA overlays are the recommended maintenance and rehabilitation options for the Cave Creek roadways.

Project and Treatment Selection Guidelines

The process of selecting the most appropriate treatments for maintenance and rehabilitation activities includes the following general steps:

- **Gather pavement information:** One of the first steps in the treatment selection process is to assemble a record of previously performed work. This includes information on the following: pavement type, pavement age and design life, traffic, and pavement cross section and materials. This type of information is often housed in a pavement management system or other database-based system.

- **Assess pavement condition:** In addition to gathering historical pavement information, the current condition of the pavement must be assessed in order to determine feasible preservation treatments. Ideally, the condition is determined based on a standard condition rating procedure (such as the Pavement Condition Index procedure previously cited) and includes a record of the types, severities, and the amounts of all distresses present on the pavement.

- **Evaluate pavement data:** In order to determine the most suitable treatment for a pavement section, the following questions should be considered:

  – Is there excessive distress (large quantities and/or severe levels of distress) on the pavement section or are the occurring distresses a warning sign of an underlying structural problem (like fatigue cracking and rutting)?
  – Are there other known pavement problems (e.g., material problems or signs of construction problems) on the pavement section?
  – Is there a history of pavement problems in this location?

  For pavement sections for which the answer to the majority of these questions is "yes," then the pavement is a candidate for major rehabilitation or future reconstruction. If the answer to the majority of these questions is "no" then the pavement section is likely to be a good

candidate for pavement preservation techniques such as crack sealing, slurry seals, and microsurfacing.

- **Identify feasible treatments:** The appropriate treatment strategy for a particular pavement is largely driven by the type, quantity, and severity of distress. Guidelines for determining recommended and feasible treatments are provided in table 13. Table 13 provides guidance for treatment selection based upon distress type and severity level. These characteristics are primarily based on a relationship between a single treatment and a single distress. When multiple distresses exist, the appropriate treatment to address each distress type should be examined and the recommended treatments must be used in combination with engineering judgment to make final treatment decisions.

- **Select most appropriate treatment:** Of the feasible treatments, the most appropriate treatment is one that best addresses the needs of the pavement while also meeting the constraints of the project. Ideally, the selection of the right treatment at the right time is governed by optimization (maximizing benefits for given constraints). However, treatment selection can be accomplished through a manual assessment of the benefits versus the anticipated project cost. In addition to the benefits and costs of the feasible treatments, the selection of the most appropriate preservation treatment also includes considering the variety of project constraints that affect treatment selection. Among the types of project constraints that should be considered when selecting the most appropriate preservation treatment are:

  – Availability of qualified contractors.
  – Availability of quality materials.
  – Time (of year) of construction.
  – Initial costs.
  – User preferences, including treatment aesthetics.
  – Facility downtime for construction.
  – Expected treatment life.

  The effect of these constraints will vary from project to project and should be taken into consideration as the final projects are selected for inclusion in a pavement maintenance and repair program.

Table 13. Recommended pavement maintenance techniques.

Distress Type	Severity Level	Maintenance Action for Asphalt Surfaced Pavements	Maintenance Action for Chip Seal Pavements
Alligator (Fatigue) Cracking	Low	Monitor	Monitor
	Medium	Monitor	Monitor
	High	Full-Depth Asphalt Patching	Full-Depth Asphalt Patching
Bleeding	Low	Monitor	Monitor
	Medium	Surface Treatment	Surface Treatment
	High	Mill and Thin Overlay	Surface Treatment
Block Cracking	Low	Monitor	Monitor
	Medium	Crack Sealing	Crack Sealing
	High	Mill and Thin Overlay	Crack Sealing
Bumps and Sags	Low	Monitor	Monitor
	Medium	Mill and Surface treatment	Re-level, Surface Treatment
	High	Mill and Overlay	Re-level, Surface Treatment
Depression	Low	Monitor	Monitor
	Medium	Partial Depth Asphalt Patching	Skin Patch
	High	Full Depth Asphalt Patching	Skin Patch
Edge Cracking	Low	Monitor	Monitor
	Medium	Crack Sealing	Crack Sealing
	High	Partial Depth Asphalt Patching	Crack Sealing
Lane/Shoulder Drop off	Low	Monitor	Monitor
	Medium	Asphalt Patching (Leveling)	Asphalt Patching (Leveling)
	High	Asphalt Patching (Leveling)	Asphalt Patching (Leveling)
Longitudinal and Transverse (L&T) Cracking	Low	Monitor	Monitor
	Medium	Crack Sealing	Crack Sealing
	High	Partial Depth Asphalt Patching	Patching-Asphalt Partial-Depth
Patching and Utility Cut	Low	Monitor	Monitor
	Medium	Monitor	Monitor
	High	Full Depth Asphalt Patching	Full Depth Asphalt Patching
Potholes	Low	Full Depth Asphalt Patching	Full Depth Asphalt Patching
	Medium	Full Depth Asphalt Patching	Full Depth Asphalt Patching
	High	Full Depth Asphalt Patching	Full Depth Asphalt Patching
Raveling	Medium	Fog Seal	Fog Seal
	High	Surface Treatment	Surface Treatment
Rutting	Low	Monitor	Monitor
	Medium	Microsurfacing or Partial Depth Mill/Fill	Wheel-path Microsurfacing
	High	Mill and Overlay	Wheel-path Microsurfacing
Swelling	Low	Monitor	Monitor
	Medium	Full-Depth Asphalt Patching	Mill/Skin Patch
	High	Full-Depth Asphalt Patching	Mill/Skin Patch
Weathering	Low	Monitor	N/A
	Medium	Fog Seal	N/A
	High	Slurry Seal	N/A

Note: Surface Treatment involves the placement of a chip seal, slurry seal, cape seal or microsurfacing, depending on project specific requirements.

SUMMARY

The Town of Cave Creek hired APTech to implement a pavement management system to document the overall condition of the pavement network and develop a maintenance and rehabilitation plan. This implementation included conducting a needs assessment, determining the impact of pavement life due to treatment application, providing recommendations for distribution of the annual pavement maintenance budget, and helping prioritize pavement M&R needs for future years.

In February 2014, APTech inspected approximately 80 centerline-miles of roadway pavement maintained by the Town. The 2014 area-weighted PCI of the inspected pavements at the Town of Cave Creek is 66, based on 251 pavement sections inspected. The following summarizes the findings from analyzing the PCI data and M&R planning scenarios:

- If no funding is provided for pavement maintenance and rehabilitation, the pavement system is expected to deteriorate from a 2014 area-weighted PCI of 66 to a PCI of 45 by 2019.
- Based on the results of the MicroPAVER™ constrained funding analysis, a recommended rehabilitation plan was developed. If the recommended rehabilitation and maintenance plan, at approximately $800,000 per year, is followed, the PCI is projected to be 68 in 2019. The recommended M&R plan is expected to address the concerns associated with the major roads in town (Cave Creek Road, Carefree Highway, Fleming Springs Road, School House Road, and Spur Cross Road).
- Addressing needs identified on the pavement maintenance and preservation plan is expected to reduce the rate of deterioration on the selected pavement sections identified and delay the need for major rehabilitation activities.

APPENDIX A – TYPICAL DISTRESS OBSERVED

TYPICAL DISTRESSES OBSERVED ON ASPHALT PAVEMENTS

CAREFREEHW-1WB-Passing Lane Alligator Cracking

CAVECREEKR-1SB Alligator Cracking

CAVECREEKR-2EB Start Overview

CAVECREEKR-4NB Patching

CONESTOGAT-2 L&T Cracking

DESERTCREE-1 Start Overview

STAGECOACH-1 Alligator Cracking

TYPICAL DISTRESSES OBSERVED ON CHIP SEAL PAVEMENTS

EBELLAVIST-1 Raveling

EBLUERIDGE-1 Depression

EBLUERIDGE-2 Block Cracking

ESAGUARORD-1 Bumps and Sags

EGUNSIGHTR-1 Rutting & Swelling

EROCKAWAYH-4 Lane Shoulder Drop-Off

APPENDIX B – PCI INSPECTION RESULTS

Branch ID	Section ID	Pavement Type	PCI	Distress Description
52NDPL	1	AC	72	Weathering, L&T Cracking, Lane/Shoulder Drop-off
	2	AC	70	L&T Cracking, Weathering
53RDPL	1	AC	67	Weathering, L&T Cracking
	2	AC	65	Weathering, L&T Cracking
57THPL	1	AC	83	Weathering, L&T Cracking, Lane/Shoulder Drop-off
67THPL	1	Chip Seal	43	Raveling
75THPL	1	AC	95	Weathering, L&T Cracking
CAREFREEHW	1EB	AC	82	L&T Cracking, Alligator Cracking, Weathering
	1EB-3rd ln	AC	54	Alligator Cracking, L&T Cracking, Raveling, Weathering, Patching
	1WB	AC	69	Patching, Weathering, Alligator Cracking, Patching, L&T Cracking
CAREFREEHW	1WB-pass	AC	59	Alligator Cracking, L&T Cracking
CAVECREEKR	1NB	AC	51	Alligator Cracking, L&T Cracking, Weathering, Patching
	1SB	AC	68	L&T Cracking, Alligator Cracking, Weathering
	2EB	AC	71	L&T Cracking, Weathering
	2WB	AC	67	Weathering, L&T Cracking, Alligator Cracking
	3NB	AC	89	L&T Cracking, Alligator Cracking
	3SB	AC	80	L&T Cracking, Alligator Cracking, Lane/Shoulder Drop-off
	4NB	AC	63	L&T Cracking, Alligator Cracking, Weathering, Raveling, Patching, Rutting
	4SB	AC	83	Weathering, L&T Cracking, Patching
CONESTOGAT	1	AC	91	L&T Cracking, Weathering
	2	AC	53	Alligator Cracking, Patching, L&T Cracking, Weathering, Rutting
CONTMOUNT	1	AC	91	Weathering, L&T Cracking
DESERTCREE	1	AC	66	Alligator Cracking, L&T Cracking, Edge Cracking, Weathering
DOLOMORAPL	1	Chip Seal	64	Raveling
EAGAVEDR	1	AC	24	Weathering, Alligator Cracking, L&T Cracking, Depression
EARROYORD	2	Chip Seal	80	Raveling
EARROYORD	3	AC	92	Weathering, L&T Cracking
	4	Chip Seal	77	Raveling
	5	Chip Seal	84	Raveling, L&T Cracking, Depression
EAZURAPL	1	Chip Seal	87	Raveling
EAZUREHILL	1	Chip Seal	80	Raveling
	3	Chip Seal	70	Edge Cracking, Raveling, Alligator Cracking
	4	AC	49	Rutting, Patching, Weathering, L&T Cracking, Alligator Cracking
EBELLAVIST	1	Chip Seal	81	Raveling

Branch ID	Section ID	Pavement Type	PCI	Distress Description
EBLOODYBAS	1	AC	94	Weathering, L&T Cracking
EBLUERIDGE	1	Chip Seal	96	Depression
EBLUERIDGE	2	AC	52	Alligator Cracking, L&T Cracking, Patching, Raveling, Edge Cracking, Rutting
EBUTTECANY	1	AC	47	Weathering, L&T Cracking, Alligator Cracking
	2	AC	62	Weathering, L&T Cracking, Depression, Alligator Cracking, Edge Cracking
ECALVINST	1	AC	77	L&T Cracking, Weathering, Depression, Alligator Cracking
ECANYONRID	1	AC	41	Weathering, Depression, Edge Cracking, Alligator Cracking, L&T Cracking, Raveling
	2	AC	86	L&T Cracking
ECARRIAGED	1	Chip Seal	40	Rutting, Raveling, Patching, L&T Cracking, Alligator Cracking
	2	AC	70	Lane/Shoulder Drop-off, Edge Cracking, L&T Cracking, Weathering
ECHOLLARD	1	Chip Seal	60	Raveling
ECHUCKWALL	1	AC	40	Weathering, L&T Cracking, Alligator Cracking
ECIELORUN	1	Chip Seal	71	L&T Cracking, Alligator Cracking, L&T Cracking, Raveling
ECLOUDRD	1	Chip Seal	47	Bleeding, Rutting, Alligator Cracking, L&T Cracking, Edge Cracking
	2	Chip Seal	85	Raveling, Rutting, Swelling,
	3	AC	66	L&T Cracking, Lane/Shoulder Drop-off
	4	AC	94	L&T Cracking, Weathering
	5	AC	71	Alligator Cracking, Weathering, L&T Cracking, Edge Cracking, Rutting, Lane/Shoulder Drop-off
	6	Chip Seal	65	Patching, Rutting, Raveling, Swelling
ECOACHWHIP	1	AC	42	Alligator Cracking, L&T Cracking, Weathering
	2	AC	39	L&T Cracking, Patching, Edge Cracking, Lane/Shoulder Drop-off
ECONTINENT	1	AC	61	L&T Cracking, Raveling, Weathering
	2	Chip Seal	81	Raveling, Depression, Lane/Shoulder Drop-off, Edge Cracking
EDESERTHIL	1	AC	32	Raveling, Alligator Cracking
EDESERTSAG	1	Chip Seal	43	L&T Cracking, Edge Cracking, Alligator Cracking
EEGRETST	1	Chip Seal	98	Swelling
EELSENDERO	1	Chip Seal	95	Depression, Patching, Swelling, Rutting
	2	Chip Seal	78	Raveling, Swelling, Rutting
	4	AC	66	L&T Cracking, Weathering, Depression, Alligator Cracking
EELSENDERO	5	AC	59	Weathering, L&T Cracking
	6	AC	77	Lane/Shoulder Drop-off, L&T Cracking

Branch ID	Section ID	Pavement Type	PCI	Distress Description
EGRAPEVINE	1	Chip Seal	54	Pothole, Raveling, Patching, Swelling, Depression
	2	Chip Seal	83	Raveling, Swelling, Edge Cracking
EGRAPEVINE	5	Chip Seal	76	Raveling, Patching
	6	Chip Seal	76	Raveling, Edge Cracking, Rutting
EGUNSIGHTR	1	Chip Seal	81	Lane/Shoulder Drop-off, Rutting, Raveling, Edge Cracking
EHIDDENSPR	1	AC	40	L&T Cracking, Alligator Cracking, Weathering
	2	AC	45	Weathering, Alligator Cracking, L&T Cracking, Depression, Edge Cracking
EHIDDENVAL	1	AC	88	L&T Cracking
EHIGHLANDR	1	Chip Seal	79	Raveling, Swelling, Lane/Shoulder Drop-off, Depression, Rutting
	2	AC	52	Weathering, L&T Cracking, Alligator Cracking, Block Cracking
EHORIZONDR	1	AC	67	L&T Cracking, Weathering, Patching
	2	AC	57	Weathering, L&T Cracking
EIRONWOODB	1	AC	67	L&T Cracking, Weathering, Alligator Cracking
	2	AC	56	Weathering, L&T Cracking, Alligator Cracking, Edge Cracking
	3	AC	62	Edge Cracking, L&T Cracking, Alligator Cracking, Weathering
EKNOLLSWAY	1	AC	83	Weathering, Alligator Cracking, L&T Cracking, Patching, Raveling
ELONEMOUNT	1	Chip Seal	87	Raveling
	2	AC t	57	Alligator Cracking, Weathering, Edge Cracking, L&T Cracking, Lane/Shoulder Drop-off
	3	Chip Seal	74	Raveling
	5	AC	69	Block Cracking, Patching
ELONGRIFLE	1	AC	84	L&T Cracking, Weathering
EMADDOCKRD	1	Chip Seal	49	Raveling, Lane/Shoulder Drop-off, Rutting
EMAGUAYDR	1	AC	90	Weathering, L&T Cracking
EMAMIEMAUD	1	AC	94	Weathering, L&T Cracking
EMARKWAY	1	Chip Seal	73	Patching, Rutting, Raveling, Depression
EMESQUITER	1	Chip Seal	67	Raveling, Lane/Shoulder Drop-off, Raveling
	3	Chip Seal	83	Raveling, Edge Cracking
EMILITARYR	1	Chip Seal	97	Rutting, Raveling
EMOUNTAINR	1	Chip Seal	50	L&T Cracking, Alligator Cracking, Patching
ENEWRIVERR	6	AC	44	L&T Cracking, Patching, Weathering, Alligator Cracking
EOCOTILLOR	1	Chip Seal	70	Raveling, Depression, Lane/Shoulder Drop-off, Rutting
EPALOVERDE	1	AC	63	L&T Cracking, Patching, Alligator Cracking

Branch ID	Section ID	Pavement Type	PCI	Distress Description
EPASEODULC	1	Chip Seal	78	Raveling, Rutting
EPASEOHERM	1	Chip Seal	35	Alligator Cracking, Patching, Weathering, L&T Cracking, Raveling, Block Cracking
EPASEOHERM	2	AC	79	L&T Cracking, Weathering, Swelling
EQUAILBRUS	1	AC	60	Weathering, Lane/Shoulder Drop-off, L&T Cracking, Alligator Cracking
	2	AC	94	L&T Cracking
ERACKENSAC	1	AC	96	Weathering
ERAINTREEC	1	Chip Seal	53	Block Cracking, Lane/Shoulder Drop-off, Alligator Cracking, Rutting, Raveling, Edge Cracking
EREDDOGDR	1	AC	49	L&T Cracking, Edge Cracking, Weathering, Alligator Cracking, Depression
ERIDGECRES	3	Chip Seal	77	Raveling
	4	Chip Seal	80	Raveling
EROCKAWAYH	2	Chip Seal	71	Raveling, L&T Cracking, Swelling, Lane/Shoulder Drop-off, Alligator Cracking
	3	Chip Seal	86	Raveling, Rutting
	4	Chip Seal	71	Lane/Shoulder Drop-off, Raveling, Depression
	5	AC	84	Weathering, Patching, L&T Cracking, Rutting, Swelling
EROCKROSED	1	AC	33	L&T Cracking, Alligator Cracking, Weathering, Lane/Shoulder Drop-off
ESABERD	1	Chip Seal	80	Raveling
ESAGUARORD	1	Chip Seal	68	Raveling, Swelling, Rutting, Bumps & Sags, Depression
ESATNAMWAY	1	Chip Seal	81	Swelling, Raveling
ESATNAMWAY	2	AC	64	Weathering, L&T Cracking
ESAWMILLCI	1	Chip Seal	44	Block Cracking, Alligator Cracking, Depression, Raveling
ESIERRAWAY	1	AC	76	Weathering, L&T Cracking
ESKYLINEDR	2	Chip Seal	29	Alligator Cracking, Raveling, Block Cracking, Patching
ESTEVENSRD	1	AC	43	L&T Cracking, Weathering, Alligator Cracking, Patching
ESUGARLOAF	1	AC	92	L&T Cracking
ESUMMERSET	1	Chip Seal	51	Alligator Cracking, Raveling, Block Cracking, Patching, L&T Cracking
ESURREYDR	1	AC	55	Alligator Cracking, L&T Cracking, Weathering, Edge Cracking
ESURREYDR	2	Chip Seal	47	Lane/Shoulder Drop-off, Alligator Cracking, L&T Cracking, Raveling, Rutting, Block Cracking
	3	Chip Seal	22	Lane/Shoulder Drop-off, Alligator Cracking, L&T Cracking, Raveling, Edge Cracking, Rutting
ETANDEMRD	1	Chip Seal	34	Raveling
ETANGLEWO	1	Chip Seal	53	Alligator Cracking, Raveling, Patching, Block Cracking, Rutting

Branch ID	Section ID	Pavement Type	PCI	Distress Description
ETANYARD	3	Chip Seal	72	Raveling, Patching, Alligator Cracking
ETAPEKIMRD	1	Chip Seal	99	Rutting
ETAPEKIMRD	2	AC	64	Lane/Shoulder Drop-off, L&T Cracking, Alligator Cracking
EVALLEYWAY	1	Chip Seal	72	L&T Cracking, Raveling, Edge Cracking
EVILLACASS	1	Chip Seal	81	Raveling, Swelling
	2	AC	63	L&T Cracking, Weathering, Edge Cracking, Alligator Cracking
	3	AC	47	Patching, Weathering, Alligator Cracking
	4	AC	84	L&T Cracking
EWILLOWSPR	1	AC	39	Block Cracking, Patching, Alligator Cracking, L&T Cracking
EYOLANTHAS	1	Chip Seal	100	Swelling
EYUCCARD	1	Chip Seal	73	Swelling, Depression, Rutting, Raveling
EZENITHLN	1	Chip Seal	32	Alligator Cracking, L&T Cracking, Swelling, Raveling, Alligator Cracking
FLEMINGSPR	1	AC	41	Rutting, Alligator Cracking, Patching, L&T Cracking, Block Cracking
	2	AC	54	L&T Cracking, Alligator Cracking, Swelling, Weathering, Rutting
	3	AC	56	Weathering, L&T Cracking, Alligator Cracking
MAGUARRD	1	Chip Seal	71	Raveling, Bumps & Sags
N26THST	1	Chip Seal	49	Alligator Cracking, L&T Cracking, Swelling, Patching, Raveling, Rutting, Block Cracking
N28THST	1	AC	33	Rutting, L&T Cracking, Alligator Cracking, Rutting, Block Cracking, Bleeding
N36THPL	1	AC	64	L&T Cracking, Alligator Cracking, Weathering, Depression
N36THST	1	AC	57	Weathering, Rutting, Alligator Cracking, L&T Cracking, Edge Cracking
N38THST	2	AC	73	Raveling, Edge Cracking, L&T Cracking, Lane/Shoulder Drop-off, Depression, Weathering, Alligator Cracking
N39THPL	1	AC	70	L&T Cracking, Alligator Cracking, Weathering
N44THST	1	AC	97	L&T Cracking, Raveling
	2	AC	86	L&T Cracking
N45THST	1	AC	91	L&T Cracking
N46THST	1	AC	53	Lane/Shoulder Drop-off, Alligator Cracking, L&T Cracking, Weathering
N46THWAY	1	AC	85	L&T Cracking, Weathering
N48THST	1	AC	81	L&T Cracking
	2	AC	64	Weathering, Patching, L&T Cracking
N49THST	1	Chip Seal	86	Raveling, Swelling, Depression, Patching
N50THST	1	Chip Seal	93	Swelling, Depression, Patching, Raveling,

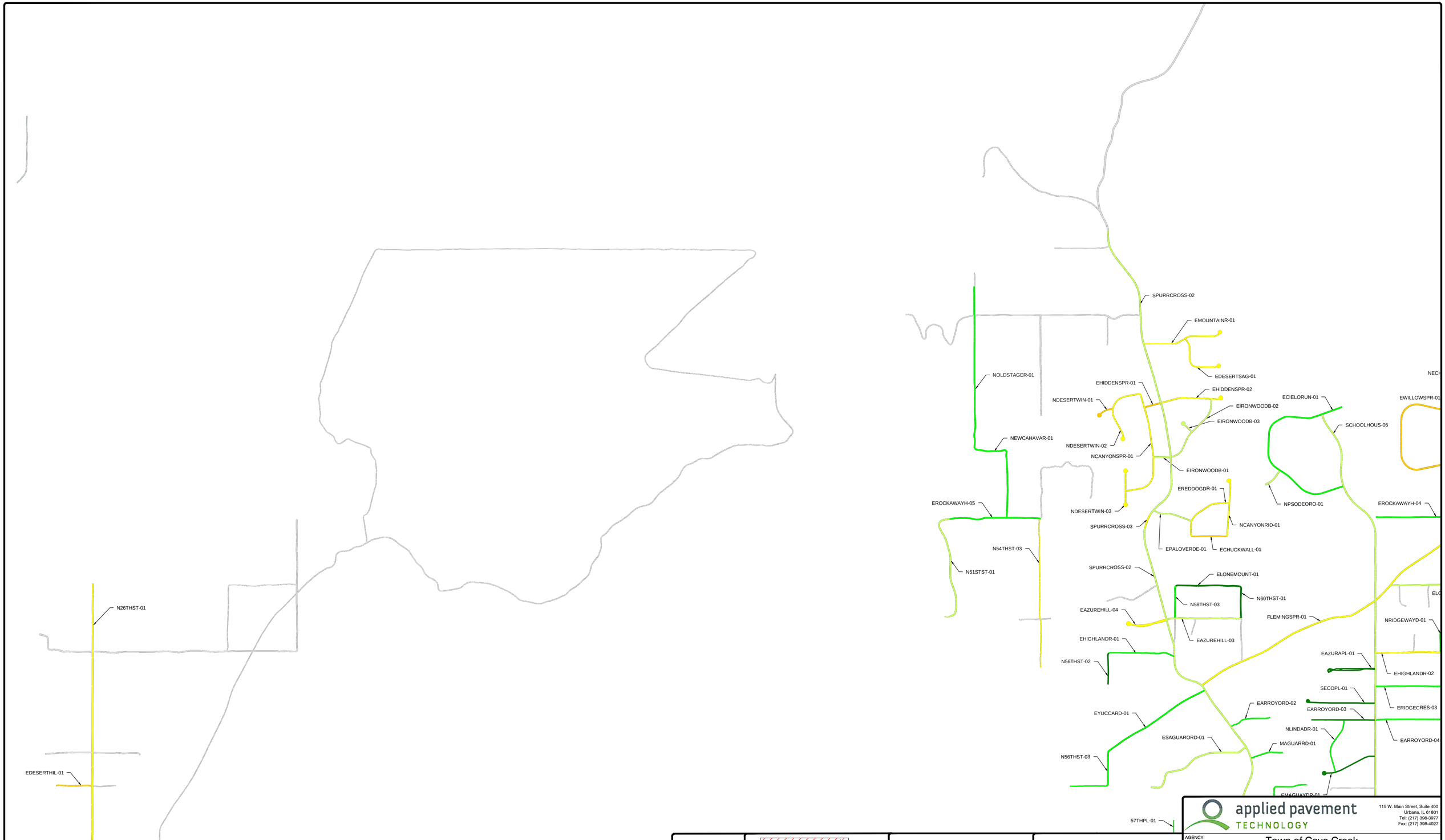
Branch ID	Section ID	Pavement Type	PCI	Distress Description
				Lane/Shoulder Drop-off
	2	AC	43	Alligator Cracking, Rutting, L&T Cracking, Patching
	4	AC	48	Lane/Shoulder Drop-off, Weathering, L&T Cracking
N51STST	1	AC	59	Lane/Shoulder Drop-off, Alligator Cracking, Weathering, L&T Cracking
	4	Chip Seal	85	Raveling, Lane/Shoulder Drop-off, Rutting
N52NDST	1	AC	63	Weathering, Lane/Shoulder Drop-off, Edge Cracking, L&T Cracking
	2	Chip Seal	92	Swelling, Rutting, Lane/Shoulder Drop-off, Depression, Rutting, Swelling
	3	AC	28	Edge Cracking, Alligator Cracking, Lane/Shoulder Drop-off, Weathering, L&T Cracking
N53RDST	1	Chip Seal	94	Rutting, Swelling
N54THST	3	AC	46	L&T Cracking, Patching, Weathering, Edge Cracking, Alligator Cracking
	9	AC	77	L&T Cracking, Depression
N56THST	2	Chip Seal	87	Raveling
	3	Chip Seal	76	Raveling, L&T Cracking, Rutting, Depression, Swelling, Alligator Cracking
	5	AC	91	L&T Cracking, Lane/Shoulder Drop-off, L&T Cracking, Alligator Cracking
	6	AC	34	Patching, Edge Cracking, Raveling, Block Cracking, Alligator Cracking, L&T Cracking, Weathering
	7	AC	60	Block Cracking
N58THST	1	AC	91	L&T Cracking
	2	AC	92	Weathering, L&T Cracking
	3	Chip Seal	85	Raveling, Edge Cracking, Depression, Raveling
N60THST	1	Chip Seal	87	Raveling
N61STST	1	AC	94	L&T Cracking, Weathering
N62NDST	1	AC	64	L&T Cracking, Patching, Weathering
	2	AC	12	Rutting, Weathering, Block Cracking, Alligator Cracking
N64THWAY	1	AC	87	L&T Cracking, Weathering
N69THST	2	AC	47	Alligator Cracking, Weathering, L&T Cracking
N71STST	1	AC	81	Weathering, Edge Cracking, L&T Cracking
N72NDST	2	AC	23	Lane/Shoulder Drop-off, L&T Cracking, Alligator Cracking, Weathering
	3	AC	71	Edge Cracking, Lane/Shoulder Drop-off, Alligator Cracking, Weathering
	5	AC	91	L&T Cracking, Weathering
KIVAHILLS	1	Chip Seal	81	Raveling, Edge Cracking

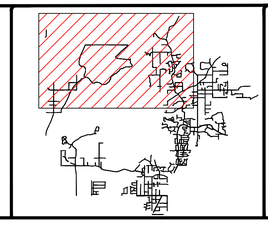
Branch ID	Section ID	Pavement Type	PCI	Distress Description
NARBUSCULA	1	AC	33	Alligator Cracking, Weathering, Block Cracking
NBASINRD	1	Chip Seal	84	Raveling, Edge Cracking, Lane/Shoulder Drop-off, Depression, L&T Cracking
NBASINRD	2	Chip Seal	90	L&T Cracking, Depression, Raveling
NCANYONRID	1	AC	49	L&T Cracking, Alligator Cracking, Weathering
NCANYONSPR	1	AC	50	Edge Cracking, L&T Cracking, Weathering, Alligator Cracking, Patching
NCREEKVIEW	1	AC	49	L&T Cracking, Alligator Cracking, Patching, Weathering, Depression, Rutting
NDESERTWIN	1	AC	31	Alligator Cracking, L&T Cracking, Weathering, Patching
	2	AC	46	L&T Cracking, Weathering, Alligator Cracking, Edge Cracking, Lane/Shoulder Drop-off
	3	AC	55	Weathering, L&T Cracking, Patching, Edge Cracking, Alligator Cracking
NECHOCANYO	1	AC	59	Bleeding, Block Cracking, L&T Cracking, Edge Cracking, Swelling, Patching
	2	Chip Seal	76	Raveling, Bumps & Sags, Rutting, Depression
	3	Chip Seal	80	Raveling, Depression
NELLINDOCI	1	Chip Seal	40	L&T Cracking, Raveling, Alligator Cracking, Patching
NEWCAHAVAR	1	Chip Seal	79	Raveling, Rutting, Swelling, Depression
NFAIRWAYTR	1	AC	79	L&T Cracking, Alligator Cracking, Weathering
	2	AC	69	L&T Cracking
	3	AC	79	L&T Cracking
NGALLOWAYD	1	AC	53	L&T Cracking, Weathering, Alligator Cracking, Edge Cracking
NHAZELWOOD	1	Chip Seal	84	Raveling, Depression, Swelling
NHIDDENVAL	1	Chip Seal	37	Patching, L&T Cracking, Raveling, Patching, Rutting, Alligator Cracking, Edge Cracking
	2	Chip Seal	74	Edge Cracking, Raveling, Lane/Shoulder Drop-off, Depression, Patching, POTHOLE
NHIDDENVAL	3	Chip Seal	56	Rutting, Depression, Patching, Alligator Cracking, L&T Cracking, Raveling
	4	Chip Seal	63	Raveling, Swelling
	5	Chip Seal	32	Swelling, Raveling
NJACQUELIN	1	Chip Seal	38	Raveling
NKOHUANAPL	1	AC	92	Weathering, L&T Cracking
	2	Chip Seal	65	Raveling
	3	AC	77	Raveling

Branch ID	Section ID	Pavement Type	PCI	Distress Description
	4	Chip Seal	77	Rutting, Raveling, Depression
NLACANOADR	1	Chip Seal	37	Patching, Swelling, L&T Cracking, Alligator Cracking
NLANGUIDLN	1	AC	71	L&T Cracking, Weathering
NLINDADR	1	AC	85	Weathering, L&T Weathering
	2	AC	80	Weathering, Lane/Shoulder Drop-off, L&T Cracking, Edge Cracking, Patching
	3	Chip Seal	59	Patching, L&T Cracking, Raveling
NOLDSTAGER	1	Chip Seal	72	Raveling, Rutting
NOOTAMRD	1	Chip Seal	80	Lane/Shoulder Drop-off, Rutting
NPIEDRAGRA	1	Chip Seal	88	Raveling
NPRICKLEYP	1	AC	71	L&T Cracking, Weathering, Alligator Cracking
	2	AC	74	L&T Cracking, Weathering, Edge Cracking
NPSODEORO	1	Chip Seal	66	L&T Cracking, Alligator Cracking, Raveling
NRANCHOMAN	1	AC	74	Lane/Shoulder Drop-off, L&T Cracking
	2	AC	60	L&T Cracking, Patching
NRIDGEWAYD	1	Chip Seal	80	Raveling
	2	Chip Seal	79	Raveling, Rutting
NRIFLEMANR	1	Chip Seal	22	Block Cracking, Weathering, Edge Cracking, Alligator Cracking
NROLLINGCR	1	AC	74	L&T Cracking, Raveling, Weathering
NSILVERSTA	2	AC	95	Weathering
NSUMMITDR	1	AC	49	Alligator Cracking, Raveling, Weathering, L&T Cracking
	2	AC	45	Alligator Cracking, Weathering
NSUNSETTRL	1	Chip Seal	76	Raveling, Rutting, Swelling, Lane/Shoulder Drop-off, Edge Cracking
	2	AC	53	Raveling, Edge Cracking, Lane/Shoulder Drop-off
NWILDERNES	1	Chip Seal	36	Patching, Alligator Cracking, L&T Cracking, Raveling, Edge Cracking, Block Cracking
NWILLOWCRO	1	AC	58	L&T Cracking, Weathering, Alligator Cracking
SCHOOLHOUS	1	AC	60	L&T Cracking, Alligator Cracking, Patching, Lane/Shoulder Drop-off, Raveling
	2	AC	22	Alligator Cracking, L&T Cracking, Lane/Shoulder Drop-off, Edge Cracking
	3	Chip Seal	89	Lane/Shoulder Drop-off
	6	Chip Seal	65	L&T Cracking, Alligator Cracking, Rutting, Raveling
SECOPL	1	Chip Seal	87	Raveling
SEMIRAMONT	1	Chip Seal	38	Edge Cracking, L&T Cracking, Alligator Cracking, Patching, Raveling, Swelling
SENITAWAY	1	AC	86	L&T Cracking, Weathering

Branch ID	Section ID	Pavement Type	PCI	Distress Description
SPURRCROSS	2	AC	56	L&T Cracking, Alligator Cracking, Patching, Weathering, Lane/Shoulder Drop-off, Rutting
	3	Concrete	47	Linear Cracking, Divided Slab, Joint Seal Damage
SPURRCROSS	4	AC	61	L&T Cracking, Patching, Weathering, Alligator Cracking
STAGECOACH	1	AC	32	L&T Cracking, Alligator Cracking, Raveling, Patching
VICTORYDR	1	AC	21	Edge Cracking, Block Cracking, Weathering, Alligator Cracking

APPENDIX C – PCI MAP





PAVEMENT CONDITION INDEX

PCI	
100	GOOD
85	SATISFACTORY
70	FAIR
55	POOR
40	VERY POOR
25	SERIOUS
10	FAILED
	GRAVEL

LEGEND

SECTION IDENTIFIER

N26THST-01

SECTION BREAK LINE

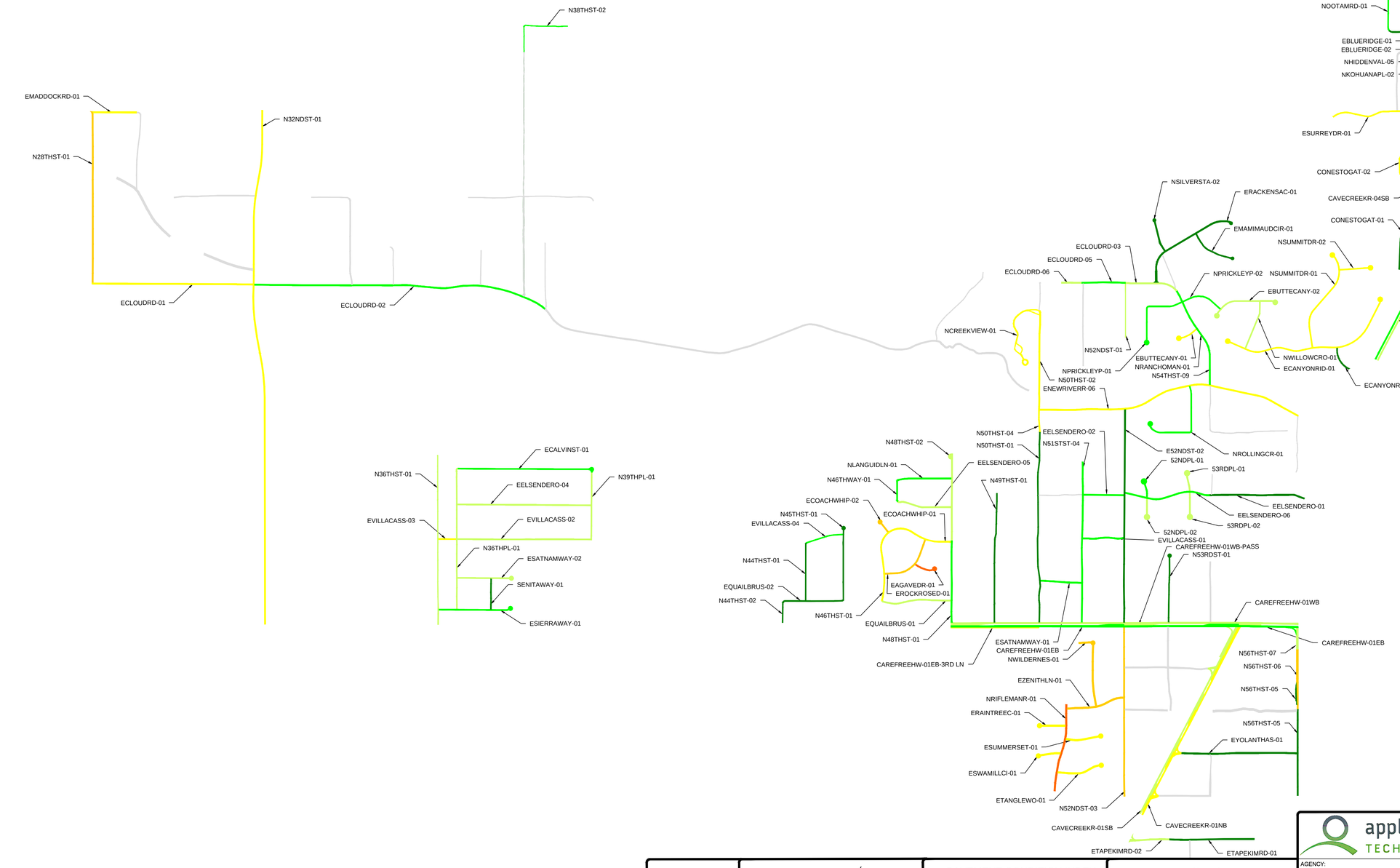
applied pavement TECHNOLOGY
115 W. Main Street, Suite 400
Urbana, IL 61801
Tel: (217) 398-3977
Fax: (217) 398-4027

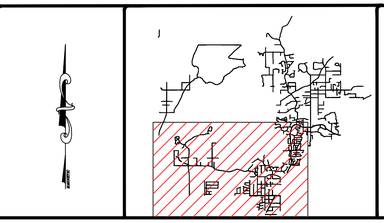
AGENCY: Town of Cave Creek

LOCATION: Cave Creek, Cave Creek, Arizona

PAGE TITLE: Pavement Condition Index Map

PROJECT DATE:	CREATION DATE:	PROJECT MANAGER:	JOB NUMBER:
OCT. 2013	MAR. 2014	MG	13-101-RM01
DRAWING SCALE:	LAST MODIFIED DATE:	REVISED BY:	DRAWN BY:
1"=800'	MAY 2014	TMM	TMM
FILENAME:		LAYOUT NAME/NUMBER:	FIGURE NUMBER:
Cave Creek.dwg		PCI	1





PAVEMENT CONDITION INDEX

PCI	
100	GOOD
85	SATISFACTORY
70	FAIR
55	POOR
40	VERY POOR
25	SERIOUS
10	FAILED
	GRAVEL

LEGEND

SECTION IDENTIFIER

N26THST-01

SECTION BREAK LINE

applied pavement TECHNOLOGY

115 W. Main Street, Suite 400
Urbana, IL 61801
Tel: (217) 398-3977
Fax: (217) 398-4027

AGENCY: Town of Cave Creek

LOCATION: Cave Creek, Cave Creek, Arizona

PAGE TITLE: Pavement Condition Index Map

PROJECT DATE:	CREATION DATE:	PROJECT MANAGER:	JOB NUMBER:
OCT. 2013	MAR. 2014	MG	13-101-RM01
DRAWING SCALE:	LAST MODIFIED DATE:	REVISED BY:	DRAWN BY:
1"=800'	MAY 2014	TMM	TMM
FILENAME:		LAYOUT NAME/NUMBER:	FIGURE NUMBER:
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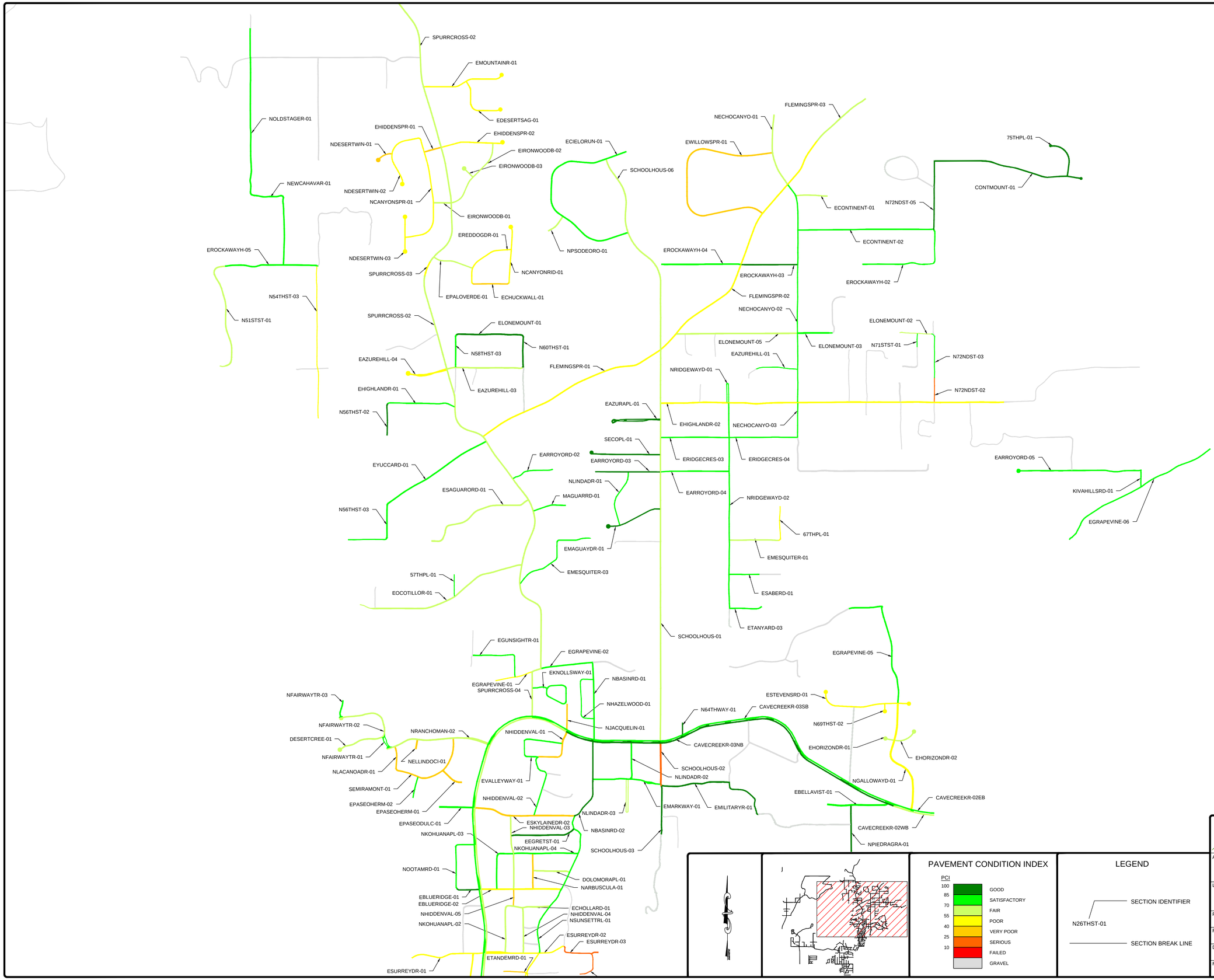

PAVEMENT CONDITION INDEX

PCI	
100	GOOD
85	SATISFACTORY
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	GRAVEL

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1"=800'	MAY 2014	TMM	TMM
FILENAME:		LAYOUT NAME/NUMBER:	FIGURE NUMBER:
Cave Creek.dwg		PCI	2

APPENDIX D– CURRENT AND FORECASTED PCI

Branch ID	Section ID	Pavement Type	2014 PCI	Forecasted PCIs (assuming no major M&R)			
				2015	2016	2017	2018
52NDPL	1	AC	72	67	64	60	56
52NDPL	2	AC	70	65	62	58	54
53RDPL	1	AC	67	62	59	55	51
53RDPL	2	AC	65	60	57	53	49
57THPL	1	AC	83	79	76	72	69
67THPL	1	Chip Seal	43	37	32	27	22
75THPL	1	AC	95	93	91	88	85
CAREFREEHW	1EB	AC	82	78	75	71	67
CAREFREEHW	1EB-3rd ln	AC	54	49	46	42	39
CAREFREEHW	1WB	AC	69	64	61	57	53
CAREFREEHW	1WB-pass	AC	59	54	51	47	43
CAVECREEKR	1NB	AC	51	46	43	39	36
CAVECREEKR	1SB	AC	68	63	60	56	52
CAVECREEKR	2EB	AC	71	66	63	59	55
CAVECREEKR	2WB	AC	67	62	59	55	51
CAVECREEKR	3NB	AC	89	86	83	79	76
CAVECREEKR	3SB	AC	80	76	72	69	65
CAVECREEKR	4NB	AC	63	58	55	51	47
CAVECREEKR	4SB	AC	83	79	76	72	69
CONESTOGAT	1	AC	91	88	85	82	79
CONESTOGAT	2	AC	53	48	45	41	38
CONTMOUNT	1	AC	91	89	86	83	80
DESERTCREE	1	AC	66	61	58	54	50
DOLOMORAPL	1	Chip Seal	64	58	53	48	43
EAGAVEDR	1	AC	24	20	17	14	11
EARROYORD	2	Chip Seal	80	74	69	64	59
EARROYORD	3	AC	92	89	86	83	80
EARROYORD	4	Chip Seal	77	71	66	61	56
EARROYORD	5	Chip Seal	84	78	73	68	63
EAZURAPL	1	Chip Seal	87	81	76	71	66
EAZUREHILL	1	Chip Seal	80	74	69	64	59
EAZUREHILL	3	Chip Seal	70	64	59	54	49
EAZUREHILL	4	AC	49	44	41	38	34
EBELLAVIST	1	Chip Seal	81	75	70	65	60
EBLOODYBAS	1	AC	94	91	89	85	83
EBLUERIDGE	1	Chip Seal	96	90	85	80	75
EBLUERIDGE	2	AC	52	47	44	40	37
EBUTTECANY	1	AC	47	43	39	36	33

Branch ID	Section ID	Pavement Type	2014 PCI	Forecasted PCIs (assuming no major M&R)			
				2015	2016	2017	2018
EBUTTECANY	2	AC	62	57	54	50	46
ECALVINST	1	AC	77	73	69	65	62
ECANYONRID	1	AC	41	37	34	31	28
ECANYONRID	2	AC	86	82	79	76	72
ECARRIAGED	1	Chip Seal	40	34	29	24	19
ECARRIAGED	2	AC	70	65	62	58	54
ECHOLLARD	1	Chip Seal	60	54	49	44	39
ECHUCKWALL	1	AC	40	36	33	30	27
ECIELORUN	1	Chip Seal	71	65	60	55	50
ECLOUDRD	1	Chip Seal	47	40	36	31	26
ECLOUDRD	2	Chip Seal	85	79	74	69	64
ECLOUDRD	3	AC	66	61	58	54	50
ECLOUDRD	4	AC	94	91	89	86	83
ECLOUDRD	5	AC	71	66	63	59	55
ECLOUDRD	6	Chip Seal	65	59	54	49	44
ECOACHWHIP	1	AC	42	38	34	31	29
ECOACHWHIP	2	AC	39	35	32	29	26
ECONTINENT	1	AC	61	56	53	49	45
ECONTINENT	2	Chip Seal	81	75	70	65	60
EDESERTHIL	1	AC	32	28	25	22	19
EDESERTSAG	1	Chip Seal	43	37	32	27	22
EEGRETST	1	Chip Seal	98	92	87	82	77
EELSENDERO	1	Chip Seal	95	89	84	79	74
EELSENDERO	2	Chip Seal	78	72	67	62	57
EELSENDERO	4	AC	66	61	58	54	50
EELSENDERO	5	AC	59	54	51	47	43
EELSENDERO	6	AC	77	73	69	65	62
EGRAPEVINE	1	Chip Seal	54	48	43	38	33
EGRAPEVINE	2	Chip Seal	83	77	72	67	62
EGRAPEVINE	5	Chip Seal	76	70	65	60	55
EGRAPEVINE	6	Chip Seal	76	70	65	60	55
EGUNSIGHTR	1	Chip Seal	81	75	70	65	60
EHIDDENSPR	1	AC	40	36	33	30	27
EHIDDENSPR	2	AC	45	41	37	34	31
EHIDDENVAL	1	AC	88	84	81	78	75
EHIGHLANDR	1	Chip Seal	79	73	68	63	58
EHIGHLANDR	2	AC	52	47	44	40	37
EHORIZONDR	1	AC	67	62	59	55	51
EHORIZONDR	2	AC	57	52	49	45	42
EIRONWOODB	1	AC	67	62	59	55	51

Branch ID	Section ID	Pavement Type	2014 PCI	Forecasted PCIs (assuming no major M&R)			
				2015	2016	2017	2018
EIRONWOODB	2	AC	56	51	48	44	41
EIRONWOODB	3	AC	62	57	54	50	46
EKNOLLSWAY	1	AC	83	79	76	72	69
ELONEMOUNT	1	Chip Seal	87	81	76	71	66
ELONEMOUNT	2	AC	57	52	49	45	42
ELONEMOUNT	3	Chip Seal	74	68	63	58	53
ELONEMOUNT	5	AC	69	64	61	57	53
ELONGRIFLE	1	AC	84	80	77	73	70
EMADDOCKRD	1	Chip Seal	49	43	38	33	28
EMAGUAYDR	1	AC	90	87	84	81	77
EMAMIEMAUD	1	AC	94	92	89	87	83
EMARKWAY	1	Chip Seal	73	67	62	57	52
EMESQUITER	1	Chip Seal	67	61	56	51	46
EMESQUITER	3	Chip Seal	83	77	72	67	62
EMILITARYR	1	Chip Seal	97	91	86	81	76
EMOUNTAINR	1	Chip Seal	50	44	39	34	29
ENEWRIVERR	6	AC	44	40	36	33	30
EOCOTILLOR	1	Chip Seal	70	64	59	54	49
EPALOVERDE	1	AC	63	58	55	51	47
EPASEODULC	1	Chip Seal	78	72	67	62	57
EPASEOHERM	1	Chip Seal	35	29	24	19	14
EPASEOHERM	2	AC	79	75	71	68	64
EQUAILBRUS	1	AC	60	55	52	48	44
EQUAILBRUS	2	AC	94	91	89	86	83
ERACKENSAC	1	AC	96	94	92	90	87
ERAINTREEC	1	Chip Seal	53	47	42	37	32
EREDDOGDR	1	AC	49	44	41	38	34
ERIDGECRES	3	Chip Seal	77	71	66	61	56
ERIDGECRES	4	Chip Seal	80	74	69	64	59
EROCKAWAYH	2	Chip Seal	71	65	60	55	50
EROCKAWAYH	3	Chip Seal	86	80	75	70	65
EROCKAWAYH	4	Chip Seal	71	65	60	55	50
EROCKAWAYH	5	AC	84	80	77	73	70
EROCKROSED	1	AC	33	29	26	23	20
ESABERD	1	Chip Seal	80	74	69	64	59
ESAGUARORD	1	Chip Seal	68	62	57	52	47
ESATNAMWAY	1	Chip Seal	81	75	70	65	60
ESATNAMWAY	2	AC	64	59	56	52	48
ESAWMILLCI	1	Chip Seal	44	38	33	28	23
ESIERRAWAY	1	AC	76	72	68	64	61

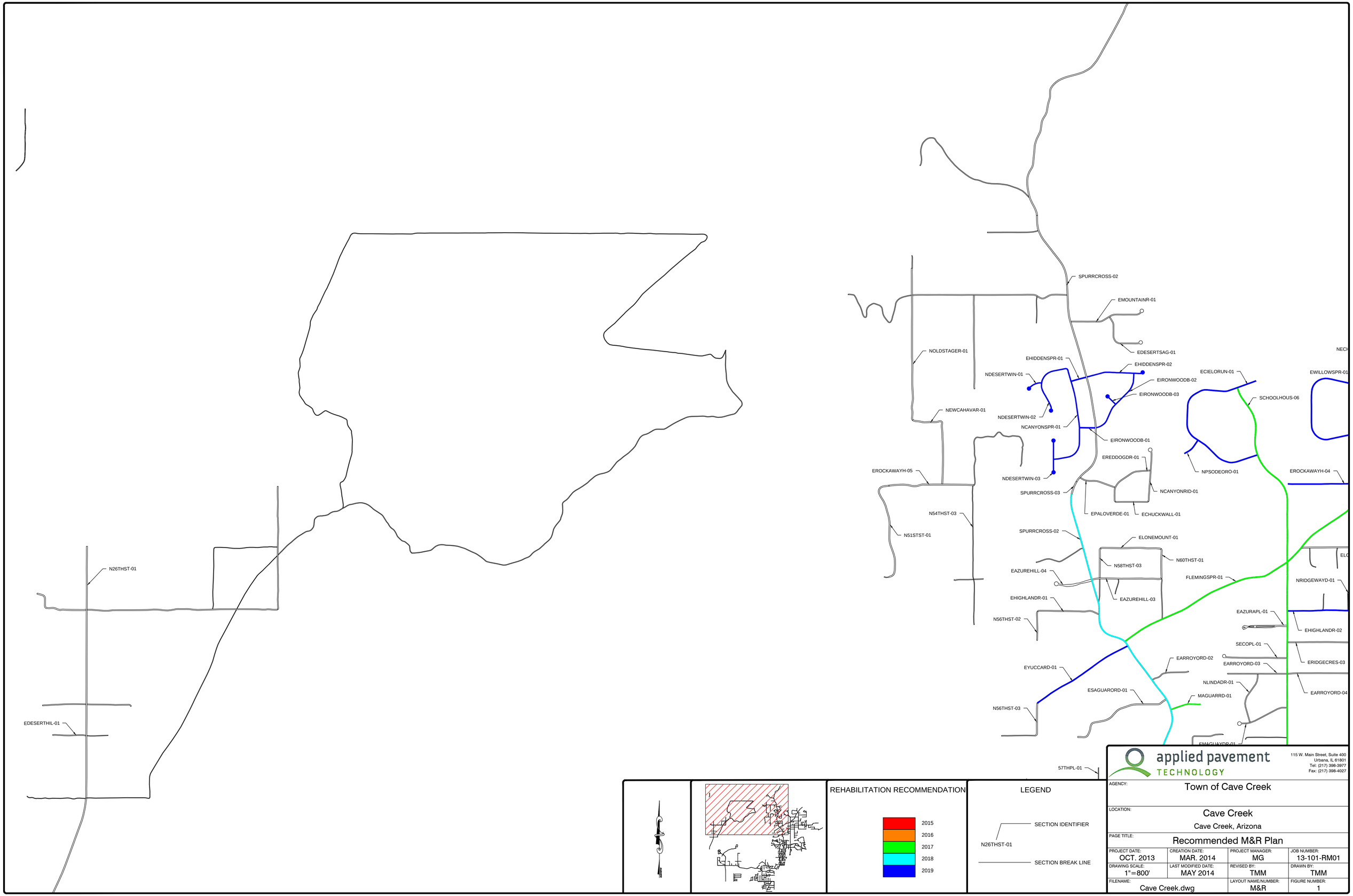
Branch ID	Section ID	Pavement Type	2014 PCI	Forecasted PCIs (assuming no major M&R)			
				2015	2016	2017	2018
ESKYLINEDR	2	Chip Seal	29	23	18	13	8
ESTEVENSRD	1	AC	43	39	35	32	29
ESUGARLOAF	1	AC	92	89	86	83	80
ESUMMERSET	1	Chip Seal	51	45	40	35	30
ESURREYDR	1	AC	55	50	47	43	40
ESURREYDR	2	Chip Seal	47	41	36	31	26
ESURREYDR	3	Chip Seal	22	16	11	6	1
ETANDEMRD	1	Chip Seal	34	28	23	18	13
ETANGLEWO	1	Chip Seal	53	47	42	37	32
ETANYARD	3	Chip Seal	72	66	61	56	51
ETAPEKIMRD	1	Chip Seal	99	93	88	83	78
ETAPEKIMRD	2	AC	64	59	56	52	48
EVALLEYWAY	1	Chip Seal	72	66	61	56	51
EVILLACASS	1	Chip Seal	81	75	70	65	60
EVILLACASS	2	AC	63	58	55	51	47
EVILLACASS	3	AC	47	43	39	36	33
EVILLACASS	4	AC	84	80	77	73	70
EWILLOWSPR	1	AC	39	35	32	29	26
EYOLANTHAS	1	Chip Seal	100	94	89	84	79
EYUCCARD	1	Chip Seal	73	67	62	57	52
EZENITHLN	1	Chip Seal	32	26	21	16	11
FLEMINGSPR	1	AC	41	37	34	31	28
FLEMINGSPR	2	AC	54	49	46	42	39
FLEMINGSPR	3	AC	56	51	48	44	41
MAGUARRD	1	Chip Seal	71	65	60	55	50
N26THST	1	Chip Seal	49	43	38	33	28
N28THST	1	AC	33	29	26	23	20
N36THPL	1	AC	64	59	56	52	48
N36THST	1	AC	57	52	49	45	42
N38THST	2	AC	73	68	65	61	57
N39THPL	1	AC	70	65	62	58	54
N44THST	1	AC	97	95	93	90	88
N44THST	2	AC	86	82	79	76	72
N45THST	1	AC	91	88	85	82	79
N46THST	1	AC	53	48	45	41	38
N46THWAY	1	AC	85	81	78	74	71
N48THST	1	AC	81	77	73	70	66
N48THST	2	AC	64	59	56	52	48
N49THST	1	Chip Seal	86	80	75	70	65
N50THST	1	Chip Seal	93	87	82	77	72

Branch ID	Section ID	Pavement Type	2014 PCI	Forecasted PCIs (assuming no major M&R)			
				2015	2016	2017	2018
N50THST	2	AC	43	39	35	32	29
N50THST	4	AC	48	43	40	37	34
N51STST	1	AC	59	54	51	47	43
N51STST	4	Chip Seal	85	79	74	69	64
N52NDST	1	AC	63	58	55	51	47
N52NDST	2	Chip Seal	92	86	81	76	71
N52NDST	3	AC	28	24	21	18	15
N53RDST	1	Chip Seal	94	88	83	78	73
N54THST	3	AC	46	42	38	35	32
N54THST	9	AC	77	73	69	65	62
N56THST	2	Chip Seal	87	81	76	71	66
N56THST	3	Chip Seal	76	70	65	60	55
N56THST	5	AC	91	88	85	82	79
N56THST	6	AC	34	30	27	24	21
N56THST	7	AC	60	55	52	48	44
N58THST	1	AC	91	88	85	82	79
N58THST	2	AC	92	89	86	83	80
N58THST	3	Chip Seal	85	79	74	69	64
N60THST	1	Chip Seal	87	81	76	71	66
N61STST	1	AC	94	91	89	86	83
N62NDST	1	AC	64	59	56	52	48
N62NDST	2	AC	12	8	5	2	0
N64THWAY	1	AC	87	83	80	77	73
N69THST	2	AC	47	42	39	36	33
N71STST	1	AC	81	77	73	70	66
N72NDST	2	AC	23	19	16	13	10
N72NDST	3	AC	71	66	63	59	55
N72NDST	5	AC	91	88	85	82	79
KIVAHILLS	1	Chip Seal	81	75	70	65	60
NARBUSCULA	1	AC	33	29	26	23	20
NBASINRD	1	Chip Seal	84	78	73	68	63
NBASINRD	2	Chip Seal	90	84	79	74	69
NCANYONRID	1	AC	49	44	41	38	34
NCANYONSPR	1	AC	50	45	42	39	35
NCREEKVIEW	1	AC	49	44	41	38	34
NDESERTWIN	1	AC	31	27	24	21	18
NDESERTWIN	2	AC	46	42	38	35	32
NDESERTWIN	3	AC	55	50	47	43	40
NECHOCANYO	1	AC	59	54	51	47	43
NECHOCANYO	2	Chip Seal	76	70	65	60	55

Branch ID	Section ID	Pavement Type	2014 PCI	Forecasted PCIs (assuming no major M&R)			
				2015	2016	2017	2018
NECHOCANYO	3	Chip Seal	80	74	69	64	59
NELLINDOCI	1	Chip Seal	40	34	29	24	19
NEWCAHAVAR	1	Chip Seal	79	73	68	63	58
NFAIRWAYTR	1	AC	79	75	71	68	64
NFAIRWAYTR	2	AC	69	64	61	57	53
NFAIRWAYTR	3	AC	79	75	71	68	64
NGALLOWAYD	1	AC	53	48	45	41	38
NHAZELWOOD	1	Chip Seal	84	78	73	68	63
NHIDDENVAL	1	Chip Seal	37	31	26	21	16
NHIDDENVAL	2	Chip Seal	74	68	63	58	53
NHIDDENVAL	3	Chip Seal	56	50	45	40	35
NHIDDENVAL	4	Chip Seal	63	57	52	47	42
NHIDDENVAL	5	Chip Seal	32	26	21	16	11
NJACQUELIN	1	Chip Seal	38	32	27	22	17
NKOHUANAPL	1	AC	92	89	86	83	80
NKOHUANAPL	2	Chip Seal	65	59	54	49	44
NKOHUANAPL	3	AC	77	73	69	65	62
NKOHUANAPL	4	Chip Seal	77	71	66	61	56
NLACANOADR	1	Chip Seal	37	31	26	21	16
NLANGUIDLN	1	AC	71	66	63	59	55
NLINDADR	1	AC	85	81	78	75	71
NLINDADR	2	AC	80	76	72	69	65
NLINDADR	3	Chip Seal	59	53	48	43	38
NOLDSTAGER	1	Chip Seal	72	66	61	56	51
NOOTAMRD	1	Chip Seal	80	74	69	64	59
NPIEDRAGRA	1	Chip Seal	88	82	77	72	67
NPRICKLEYP	1	AC	72	66	63	59	55
NPRICKLEYP	2	AC	74	70	66	62	59
NPSODEORO	1	Chip Seal	66	60	55	50	45
NRANCHOMAN	1	AC	74	70	66	62	59
NRANCHOMAN	2	AC	60	55	52	48	44
NRIDGEWAYD	1	Chip Seal	80	74	69	64	59
NRIDGEWAYD	2	Chip Seal	79	73	68	63	58
NRIFLEMANR	1	Chip Seal	22	16	11	6	1
NROLLINGCR	1	AC	74	70	66	62	59
NSILVERSTA	2	AC	95	92	90	87	84
NSUMMITDR	1	AC	49	44	41	38	34
NSUMMITDR	2	AC	45	41	37	34	31
NSUNSETTRL	1	Chip Seal	76	70	65	60	55
NSUNSETTRL	2	AC	53	48	45	41	38

Branch ID	Section ID	Pavement Type	2014 PCI	Forecasted PCIs (assuming no major M&R)			
				2015	2016	2017	2018
NWILDERNES	1	Chip Seal	36	30	25	20	15
NWILLOWCRO	1	AC	58	53	50	46	43
SCHOOLHOUS	1	AC	60	55	52	48	44
SCHOOLHOUS	2	AC	22	18	15	12	9
SCHOOLHOUS	3	Chip Seal	89	83	78	73	68
SCHOOLHOUS	6	Chip Seal	65	60	57	53	49
SECOPL	1	Chip Seal	87	81	76	71	66
SEMIRAMONT	1	Chip Seal	38	32	27	22	17
SENITAWAY	1	AC	86	82	79	76	72
SPURRCROSS	2	AC	56	51	48	44	41
SPURRCROSS	3	PCC	47	44	41	38	36
SPURRCROSS	4	AC	61	56	53	49	45
STAGECOACH	1	AC	32	28	25	22	19
VICTORYDR	1	AC	21	17	14	11	8

APPENDIX E – RECOMMENDED M&R PLAN MAP



REHABILITATION RECOMMENDATION

- 2015
- 2016
- 2017
- 2018
- 2019

LEGEND

- SECTION IDENTIFIER (N26THST-01)
- SECTION BREAK LINE

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PAGE TITLE: Recommended M&R Plan

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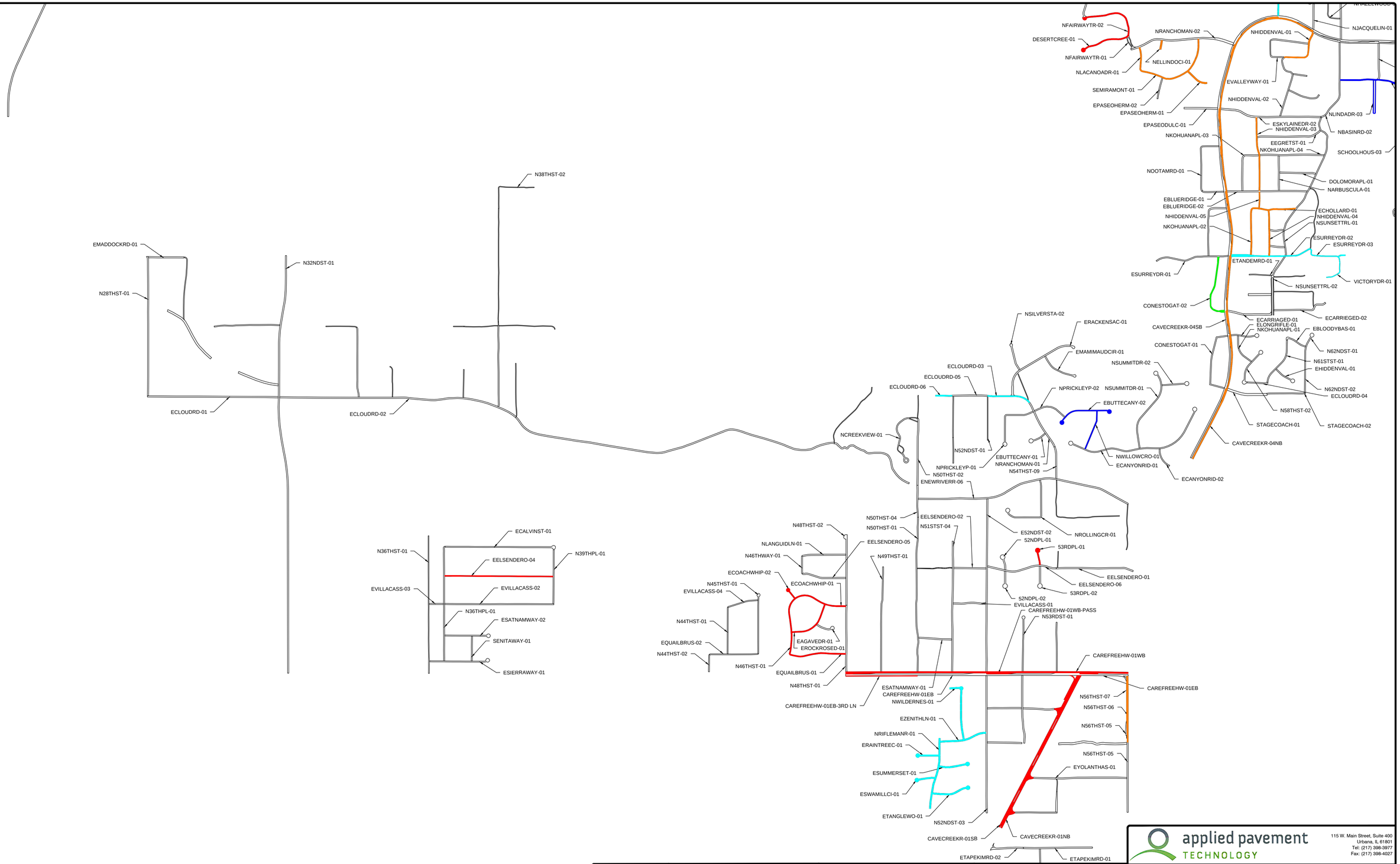

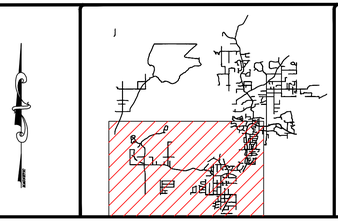

REHABILITATION RECOMMENDATION

2015
2016
2017
2018
2019

LEGEND

SECTION IDENTIFIER

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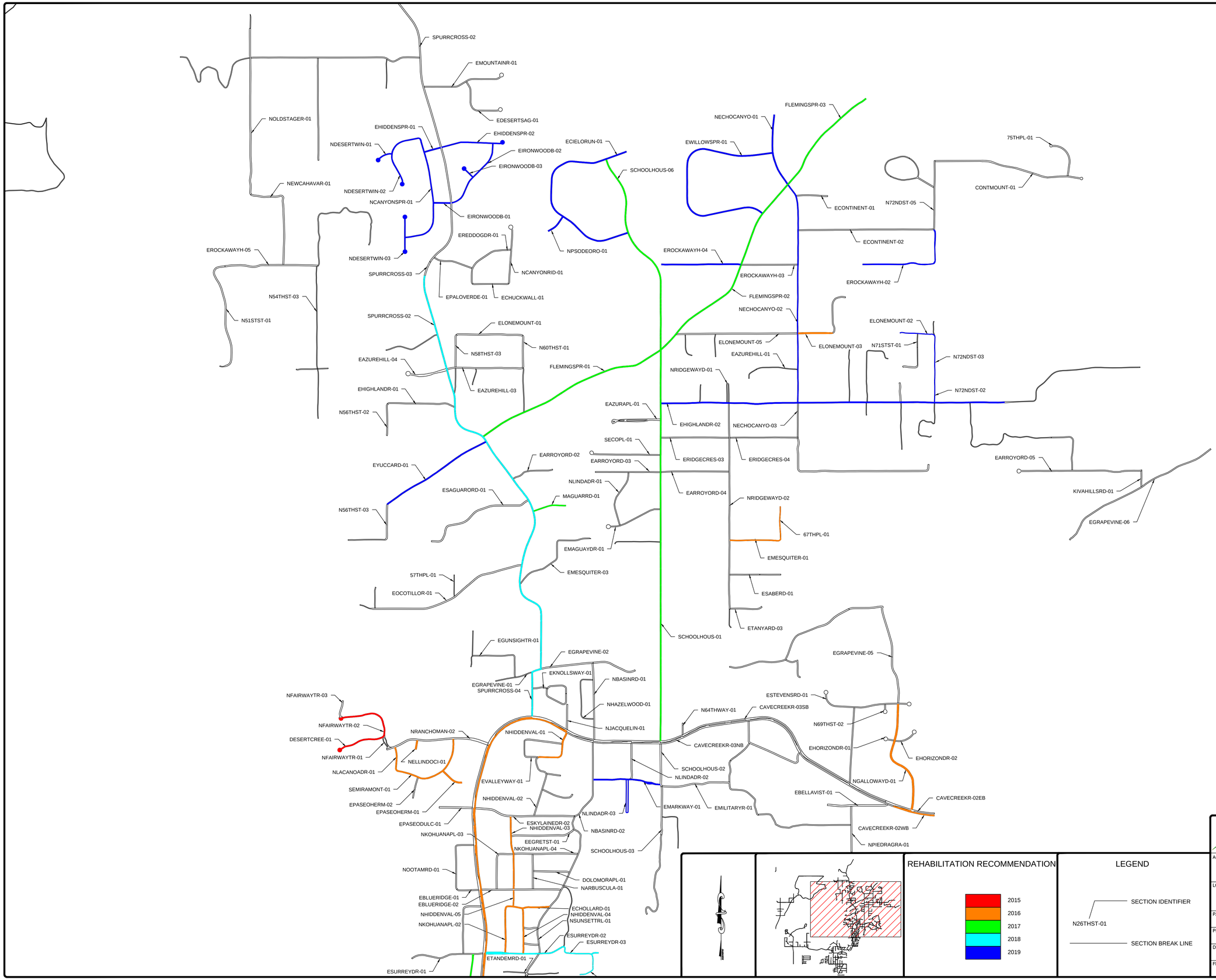

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REHABILITATION RECOMMENDATION

2015
2016
2017
2018
2019

LEGEND

SECTION IDENTIFIER

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LOCATION: Cave Creek, Cave Creek, Arizona			
PAGE TITLE: Recommended M&R Plan			
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