IMPLEMENTING PAVEMENT MANAGEMENT SYSTEMS FOR LOCAL AGENCIES

IMPLEMENTATION GUIDE

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EXECUTIVE SUMMARY

Systematic management of pavements has become increasingly important as pavements continue to age and deteriorate and funding levels have decreased due to reduced funding or increased competition for funds. The use of a pavement management system (PMS) is intended to provide roadway managers with a systematic process for generating answers to many of their pavement management questions.

Pavement management can be simply defined as the process of maintaining the pavement infrastructure cost-effectively. The American Public Works Association (APWA) defines pavement management in the following way (1993):

Pavement management is a systematic method for routinely collecting, storing, and retrieving the kind of decision-making information needed to make maximum use of limited maintenance (and construction) dollars.

Pavement management is, in essence, a process that includes a series of steps that will help the user analyze work plan alternatives. Combined with practical judgment and local knowledge, the pavement management recommendations can be used to help make final roadway investment decisions.

COST AND BENEFITS

It is important to understand the benefits and associated costs of any investment in pavement management before starting the process. Therefore, the types of benefits that can be realized by an agency that implements a pavement management process include:

- Providing a centralized location for pavement inventory condition information, construction, maintenance, and rehabilitation records.
- Providing a method to analyze the consequences of various funding levels on pavement conditions.
- Improving scheduling of pavement works; assisting as a decision making tool in optimizing rehabilitation, maintenance, and trade-off options.
- Providing the information needed to analyze the cost-effectiveness of treatment repairs.
- Allowing an agency to answer "what-if" type questions regarding pavement repair programs and funding levels.
- Justifying budget needs to elected officials and other stakeholders.

The costs associated with pavement management can include software acquisition and installation, personnel training, data collection, database building, and system maintenance and updates.

WHY INVEST IN PAVEMENT MANAGEMENT?

Many agencies are constrained by limited budgets and personnel resources. Even with those constraints, the agencies that were interviewed about their pavement management practices for this study had a variety of reasons for investing in pavement management. They reported that the investment was worthwhile because pavement management provides the tools an agency needs to address management challenges and to provide a consistent and rational management method that helps in rational resource allocation, optimal use of funds, pavement rehabilitation cost reductions, pavement treatment selection, pavement life extensions, and increased credibility with stakeholders.

DESIGNING A PAVEMENT MANAGEMENT PROCESS

The development of a systematic and repeatable pavement management process is a key component in the effective planning and management of a pavement network. The steps outlined below serve as a Guide for customizing a pavement management process that fits the needs of each local agency.

Prior to starting the implementation process, it is recommended that agencies consider naming a champion and forming a steering committee to work as a group in establishing a process to meet the needs of the agency. For larger agencies, involving a number of staff from all levels and a variety of divisions within the organization helps shape the management process to meet the needs of all potential users in the organization.

Step 1: Define the Roadway Network and Collect Inventory Data

The first step in designing a pavement management process is to define the roadway network. A roadway network is comprised of an inventory of the physical characteristics of the roadways being managed by the agency. After segments are defined in a manner that best fits the needs of the given agency, the inventory information for each segment is collected by either estimating the data or collecting all needed information. The exact type of inventory information required by an agency depends on what data will be used by the agency to support its decisions.

Step 2: Collecting Condition Data

Pavement condition data are a major factor in any data-driven, decision-making pavement management process. Within the pavement management process, the condition data can be used to help identify current maintenance and rehabilitation needs, to predict future needs, and to assess the overall impact on the network. Therefore, the type of condition data required and the level of detail depends on the agency and the pavement management process used. Condition data will be collected using either manual or automated data collection methods. With either method, distress data will be estimated or measured.

Step 3: Predict Condition

With current pavement condition assessed, agencies are equipped with the information needed to predict the future condition of a segment. In pavement management, conditions are predicted in terms of performance models that estimate the average rate of pavement deterioration each year. Pavement conditions can be predicted for the pavement network using either average deterioration rates or performance prediction models.

Step 4: Select Treatments

The fourth step in designing the pavement management process is to select appropriate treatments for the roadway network. Treatments are selected using cyclical schedules or treatment trigger rules. The recommended treatments are then prioritized using ranking or benefit/cost analysis.

Step 5: Report Results

Project results can be reported using different methods to highlight important factors which will assist decision makers with their final decisions. Data reporting is an effective method of communicating not only the recommendations from the pavement management process but also transferring related information to decision makers. The data can be used to generate reports and charts to extract relevant information pertaining to any segments under consideration. The results can be presented either by using standard charts and reports or customized summaries.

Step 6: Select Pavement Management Tool

The selection of a pavement management tool is influenced by the requirements of the agency and users needs. The tool provides a platform to store the pavement management information and to perform different types of analysis depending on whether a spreadsheet, GIS tool, and/or a pavement management system (public or private) is selected. Depending on the needs of the agency, a local agency can also opt to use a combination of pavement management software and customized spreadsheets and/or GIS software to suit their requirements.

Step 7: Keep the Process Current

Pavement management is a dynamic process that requires regular updates. Pavement management is not a one-time activity, so agencies must make an effort to update the information incorporated in the pavement management process. Data management is a key component to maintaining the database and keeping the information current.

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PAVEMENT MANAGEMENT IMPLEMENTATION GUIDE

1. INTRODUCTION TO THE GUIDE

Systematic management of pavements has become increasingly important as pavements continue to age and deteriorate and funding levels have decreased due to reduced funding or increased competition for funds. The use of a pavement management system (PMS) is intended to provide roadway managers with a systematic process for generating answers to questions such as:

- What roads am I responsible for? When were they built and last rehabilitated?
- What is the existing condition of the road network?
- What is an acceptable condition goal (level of service) to provide?
- What amount of funding is needed to obtain the desired condition of the roads now and into the future?
- How will the road network condition change if funding levels are changed?
- What maintenance, preservation, and rehabilitation strategies have been most cost-effective on our road network?
- Are there alternate treatment strategies that would be more cost-effective and result in better conditions?
- What is the most economical way to maintain the road network over time?

This Guide was developed to provide an overview of pavement management practices for those individuals faced with the challenge of maintaining roadway networks. The purpose of the Guide is to serve as a tool to assist local agencies in using pavement management practices to the extent best suited for them.

In an effort to provide meaningful implementation recommendations to users of this Guide, several agencies from around the state of Illinois (City of Macomb, City of Naperville, City of Villa Park, Champaign County, Edgar County, McHenry County, and Stark County) were selected to serve as case study examples to highlight the variety of processes and procedures available for successful pavement management implementation. Their practices and recommendations are shared throughout the Guide.

The Guide has been organized into the eight sections listed below:

1. Introduction to the Guide.
2. What is Pavement Management?
3. What are the Benefits and Costs Associated with Pavement Management?
4. Why Invest in Pavement Management?
5. Designing a Pavement Management Process.
6. Summary
7. References
8. Bibliography
9. Glossary of Terms

Sections 1 through 4 provide background information regarding pavement management, while section 5 provides the step-by-step details to direct an agency in designing a pavement management process. Section 6 summarizes the Guide contents. Section 7 provides the references used to create the document and section 8 includes additional references for the agency that is interested in obtaining further information about pavement management topics. Section 9 provides a glossary of terms used in the Guide.

In addition to this Guide, a State-of-the-Art and State-of-the-Practice Synthesis was created that includes further details on local agency pavement management. It can serve as a valuable resource for additional information regarding the various topics discussed in this Guide. Copies of the Synthesis are available through the ICT website.

2. WHAT IS PAVEMENT MANAGEMENT?

Pavement management can simply be defined as the process of maintaining the pavement infrastructure cost-effectively. The American Public Works Association (APWA) defines pavement management as the following (1983):

Pavement management is a systematic method for routinely collecting, storing, and retrieving the kind of decision-making information needed to make maximum use of limited maintenance (and construction) dollars.

Pavement management is, in essence, a process that includes a series of steps that will help the user analyze work plan alternatives. Those recommendations will then be combined with practical judgment to make final investment decisions.

Pavement management can support decisions at various levels (strategic, network, and project) within the organization. The decisions made at each level include (Zimmerman and Wolters 2008):

- **Strategic** – At the strategic level, policy makers make decisions that influence long-term strategic efforts within the organization. These decisions may include setting performance targets, funding allocations, and preservation strategies.
- **Network** – At the network level, information such as the current and future network conditions are used to make tactical decisions about the effects of various short- and long-range budgets, the consequences of various investment strategies, and the work options for the pavement network over a typical 5-year timeframe.
- **Project** – At the project level, the decisions are focused over a short timeframe (e.g., 2 years) and can include the selection of maintenance activities, materials, and pavement design thicknesses.

In this Guide, the pavement management practices discussed focus on network-level management and apply to all pavements under the agency's jurisdiction. The primary goal of network-level management is to prioritize which pavement segments should be maintained, rehabilitated, or reconstructed.

3. WHAT ARE THE BENEFITS AND COSTS ASSOCIATED WITH PAVEMENT MANAGEMENT?

It is important to understand the benefits and associated costs of any investment in pavement management before starting the process. Therefore, the types of benefits that can be realized by an agency that implements a pavement management process include (WSDOT 1994):

- Providing a centralized location for pavement inventory *(location, pavement type, area, mileage, and functional classification);* condition information; construction, maintenance, and rehabilitation records.
- Providing a method to analyze the consequences of various funding levels on pavement conditions.
- Improving scheduling of pavement works to reduce excessive rehabilitation costs.
- Assisting as a decision making tool in optimizing rehabilitation, maintenance, and trade-off options.
- Providing the information needed to analyze the cost-effectiveness of different treatment repairs.
- Allowing an agency to answer “what-if” type questions regarding pavement repair programs and funding levels.
- Justifying budget needs to elected officials and other stakeholders.

The benefits an agency will realize from the use of pavement management will depend on the methods and tools utilized. These factors also impact the costs associated with pavement management, which generally include the following:

- Software acquisition and installation.
- Personnel training.
- Data collection.
- Database building.
- System maintenance and updates.

4. WHY INVEST IN PAVEMENT MANAGEMENT?

Many agencies are constrained by limited budgets and personnel resources. Even with those constraints, the agencies that were interviewed to highlight their pavement management practices had a variety of reasons for investing in pavement management, including:

- Provides a rational engineering decision for selecting projects. – *Stark County*
- Helps identify the right treatments for the right roadways at the right time. – *Edgar County*
- Reduces political pressure to make certain treatment selections. – *Champaign County*
- Serves as a tool to help an agency secure more funding for pavement needs. – *McHenry County*

> **"The cost (of pavement management) is worth it. You only have one chance to make the right decision, and pavement management helps you do that."**
>
> **-Stark County, IL**

Pavement management provides the tools an agency needs to address management challenges and to provide a consistent and rational management method that allows for the following practices:

- A rational and objective method to identify resource allocation.
- Optimal use of available funds.
- Reduction in pavement rehabilitation costs over time.
- Identification of accurate treatment for the pavement segments through roadway assessment.
- Estimates of pavement life extensions correlated to treatment timing of treatment applications.
- Increased credibility with stakeholders.

5. DESIGNING A PAVEMENT MANAGEMENT PROCESS

The development of a systematic and repeatable pavement management process is a key component in the effective planning and management of a pavement network. The steps outlined in this section serve as a Guide for customizing a pavement management process that fits the needs of each local agency.

Prior to starting the implementation process, it is recommended that agencies consider naming a champion and forming a steering committee to work as a group in establishing a process to meet the needs of the agency. The establishment of a champion is imperative to seeing the successful completion of the project as the individual spearheads all needed activities. The selected individual should understand the benefits of pavement management and be able to convey those to all within the agency, including top management.

> **"Involve a lot of people in the selection and implementation process….by forming a steering committee."**
>
> **-McHenry County, IL**

For larger agencies, involving a number of staff from all levels and a variety of divisions within the organization helps shape the management process to meet the needs of all potential users in the organization. The types of design decisions that should be directed by the steering committee include (WSDOT 1994):

- What data should be included in the pavement management process?
- Which division will be accountable for pavement management?
- How will each division provide information to the pavement management process?
- How will each division use the pavement management results?
- What should be the timeline for the implementation?

Incorporating a variety of staff members can help establish a sense of buy-in and ownership in the process for all participants early on in the project. McHenry County used a steering committee of more than ten individuals from various parts of the organization to direct their pavement management implementation. The process was done as part of their overall asset management program.

With a unified team formed and pavement management goals established, an agency is ready to tackle the challenge of designing their pavement management process. The steps of the process are defined in the following sections and follow the steps shown in figure 1. The decisions associated with each step are highlighted in the figure.

While working through the pavement management process, agencies should consider all steps needed to complete the implementation process and the impact of choices at each step on subsequent decisions. Details of impacts are noted throughout the discussion so that the users of the Guide can see how choices might impact future implementation decisions.

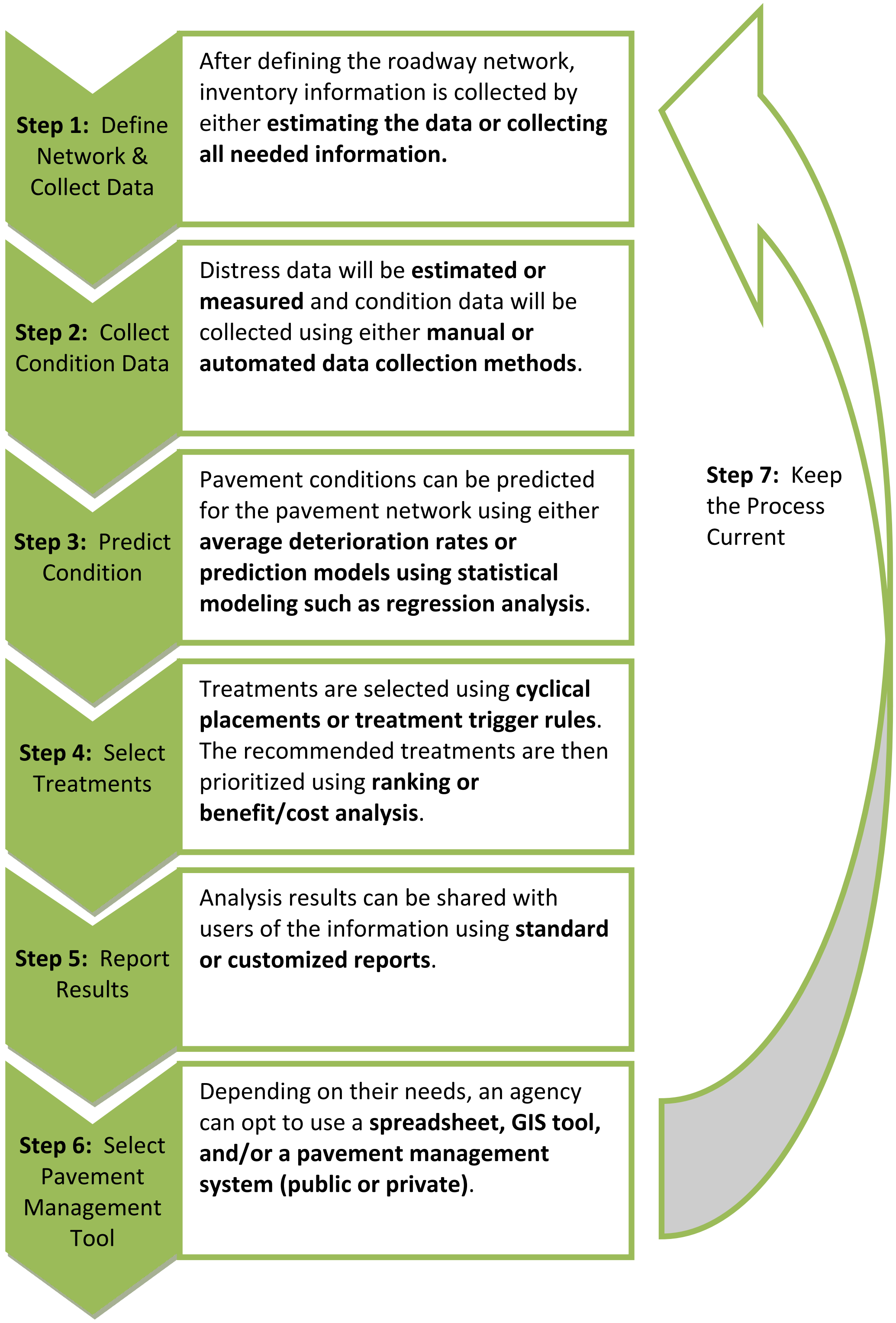


Figure 1. Pavement management process design steps.

5.1. Step 1: Define the Roadway Network and Collect Inventory Data

Step 1: Define Network & Collect Data

After defining the roadway network, inventory information is collected by either **estimating the data or collecting all needed information.**

The first step in designing a pavement management process is to define the roadway network. A roadway network is comprised of an inventory of the physical characteristics of the roadways being managed by the agency. The inventories are typically built by dividing the network roadways into manageable segments. These segments are divided based on similar characteristics, and they are of specific importance since they will serve as the basis for planning future maintenance and rehabilitation projects. Factors that may define the boundary between roadway segments include changes in the following attributes:

- Pavement surface type (e.g., hot-mix asphalt or portland cement concrete).
- Pavement structure (e.g., pavement materials or thickness).
- Construction history (e.g., different construction periods, different contractors, or different materials and techniques).
- Roadway geometry (e.g., number of traffic lanes).
- Traffic (e.g., volume or patterns).
- Pavement condition (e.g., significant variation in condition that is not simply an isolated area).
- Geographic boundaries (e.g., intersections, bridges, waterways, jurisdiction limits, railroad crossings).

Using these factors as a guideline, meaningful segments can be created and used by the agency to identify pavement repair needs. Some municipalities utilize block-by-block segments while counties tend to create longer roadway segments. For instance, McHenry County recommends that agencies consider making the length of each pavement segment equivalent to the length of a logical project. This technique allows work recommendations to be more meaningful since it promotes the use of one segment to define the length of maintenance or rehabilitation project, which eliminates the need to group multiple segments together to create recommended maintenance and rehabilitation projects.

> **"Make pavement segments of logical project length"**
> **-McHenry County, IL**

After segments are defined in a manner that best fits the needs of the given agency, the inventory information for each segment is collected. Typical inventory data collected for a pavement management system includes:

- Roadway Name – A written description of the roadway name and any corresponding numeric references.
- Pavement Location – Physical reference to the location, including "beginning location" and "ending location" designations.
- Pavement Dimensions – Values including length, width, and/or area.

- Pavement Type – The material that comprises, at a minimum, the pavement surface.
- Construction History – Details of the latest maintenance and rehabilitation treatments and construction date, and, if possible, original construction dates and additional maintenance and rehabilitation records.

The data outlined above serves as the minimum amount of data needed to complete the segment inventory. Additional data that may be beneficial to the agency to support the pavement management processes includes, but is not limited to:

- Functional Classifications – Type of service the roadway was intended to provide (e.g., arterial, collector, or local/residential).
- Layer Thicknesses – All the thicknesses of the layers above subgrade.
- Subgrade Information – Type and material classification.
- Drainage Characteristics – Occurrence of curb and gutter or ditches and related details.
- Ownership information – Details on jurisdiction.
- Shoulder Data – Shoulder type and width.
- Traffic Information – Details on average daily traffic (ADT) and truck traffic.

The desired inventory data is summarized for each pavement segment defined in the network. While some inventory data require updates with time, information such as names, location, and dimensions do not normally require modifications unless changes have been made to the network. Compiled inventory information can be stored a variety of ways:

- Paper records.
- Electronic spreadsheets.
- Databases (e.g., either stand-alone database or a database as part of pavement management software).
- Maps (e.g., GIS-based maps).

5.1.1. Selecting the Appropriate Methodology

The exact type of inventory information required by an agency depends on what data will be used by the agency to support its decisions. Further consideration of inventory data requirements is needed when an agency decides to implement pavement management software, as discussed in Step 6, Selecting Software.

The definition of the pavement network and the collection of inventory data can be labor-intensive tasks. Therefore, as the agency determines the extent of needed inventory data for their agency's pavement management process, it can move forward by either estimating data or collecting needed information for each pavement segment.

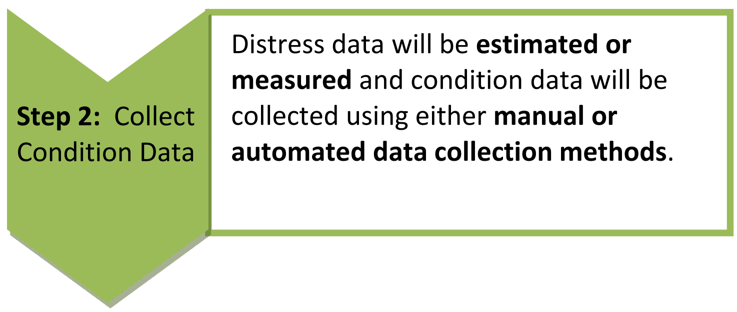
> The **City of Naperville** estimated the inventory quantities for the roadway network to begin setting up the pavement management system. The City gradually updated inventory information, such as pavement thicknesses, while conducting work on the streets during condition surveys and pre-construction scoping surveys.

Estimating data allows agencies without readily available summaries of information to complete an inventory and move forward with the pavement management process without needing to collect every detailed piece of information. Estimated quantities can be updated in the future to correct the inventory information. For example, roadway lengths and widths may be estimated to complete the initial inventory, but the information can be updated to reflect field conditions during a pavement condition survey.

Some agencies decide that it is worth the time and effort to complete the summary of all inventory data prior to moving forward with the other implementation steps. For those agencies that are planning to collect all information, data may be obtained from an agency's existing paper or electronic records that detail the attributes the agency is interested in tracking. Also, missing data can often be supplemented by expert knowledge of those that have been with the agency for a significant period of time (e.g., construction managers and maintenance supervisors can often help populate information regarding construction history). Data from the Illinois Road Information System (IRIS) may also be obtained through the IDOT by contacting the Office of Programming and Planning or the Bureau of Local Roads, Central Office. Additionally, available GIS files from IDOT can provide a variety of inventory information.

The decision to estimate inventory quantities rather than collect data prior to other implementation steps should be based on the agency's analysis and reporting needs as well as the resources available to collect and maintain the data with time.

5.2. Step 2: Collect Condition Data



Pavement condition data are a major factor in any data-driven, decision-making pavement management process. Within the pavement management process, the condition data can be used to help identify current maintenance and rehabilitation needs, to predict future needs, and to assess the overall impact on the network. Therefore, the type of condition data required and the level of detail depends on the agency and the pavement management process used. Collecting pavement condition data can be an elaborate process, so selecting an appropriate method is an important step for an agency.

Condition data that are not used to support decisions or are not needed for specific reporting purposes should not be considered essential to the pavement management process as it may be difficult to keep the data current. Special attention must be given to balancing the level of desired data and the resources available to collect and maintain the data into the future.

When selecting a condition data collection method, there are two main considerations:

- Data quantity – Data quantity refers to what and how much information is collected. Both have time and cost implications since the greater the volume of data collected or the more detailed the collected data, the higher the cost of data collection.
- Data quality - Although the associated cost of the data increases, more detailed data for analysis can result in better analysis decisions. For most agencies, the goals for network-level surveys are to develop appropriate budgetary needs and to evaluate the performance of previously implemented strategies.

A trade-off exists between collecting all of the condition data that might be needed to assist in making effective network decisions and collecting enough data to make good decisions, and this trade-off is in large part governed by agency needs and the associated resources (Zimmerman et al. 2011).

The main source of information to support pavement management is pavement distress data, such as cracking, potholes, and rutting. For those agencies with expanded resources for condition data collection, additional data related to surface characteristics, subsurface characteristics, and structural conditions might also be collected. As mentioned previously, all of this information may help an agency make strong network-level decisions. However, most local agencies do not have the resources to fund all of these data collection activities. Therefore, this section focuses on the collection of pavement distress information through surface condition surveys. For those agencies interested in collecting additional pavement condition data, resources can be found in the reference and bibliography sections.

Pavement distress data can be collected using either a manual or automated method. The type of survey performed can also vary. Some agencies perform pavement condition surveys that require the raters to measure distress. Others simplify the rating process by estimating distress quantities. The options discussed in this section have a tremendous impact on the resources required to collect the data, so agencies should consider these choices carefully. Additional details on the collection of condition data are provided in the Synthesis document that was produced in conjunction with this Guide.

5.2.1. Distress Survey Approaches

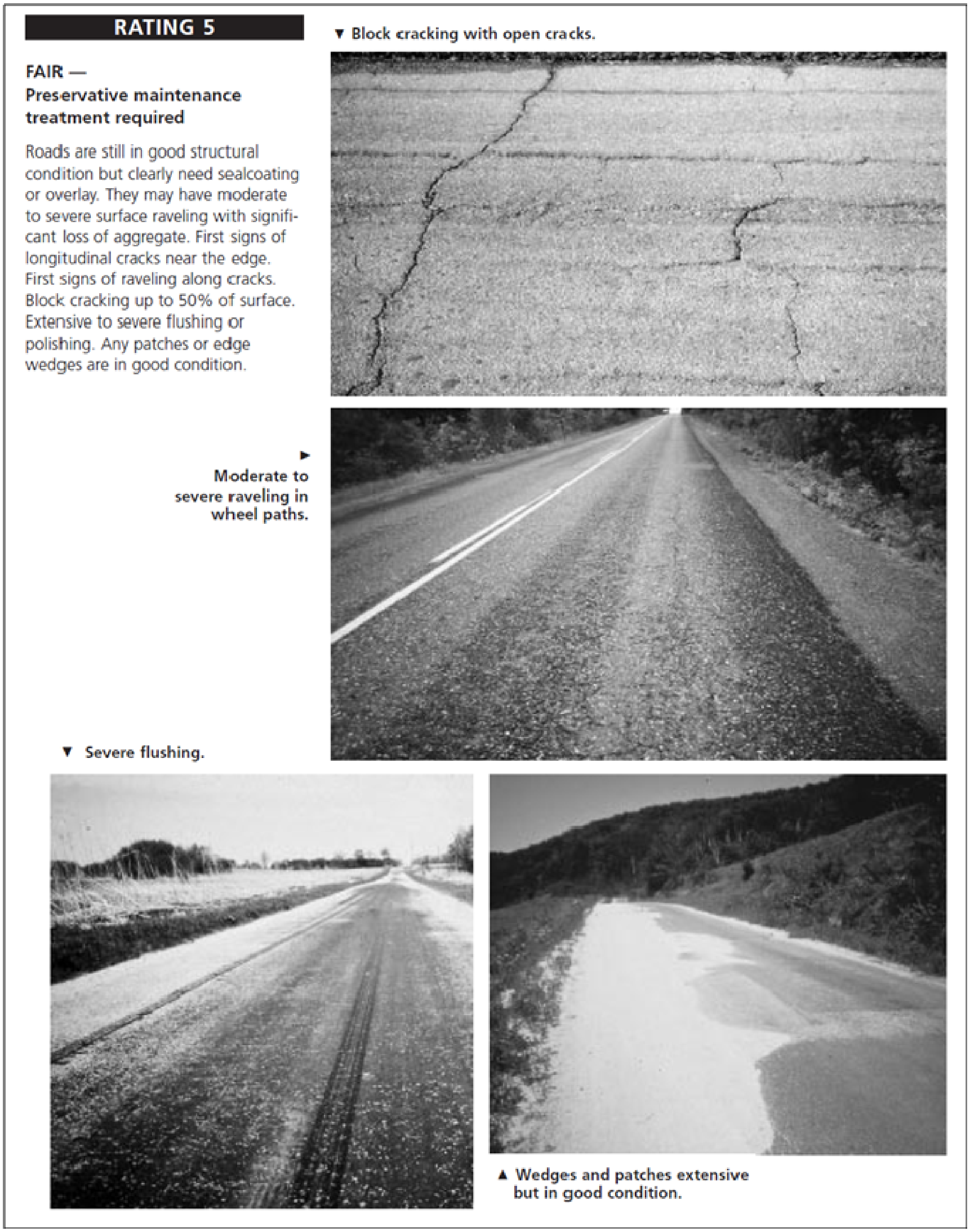
There are a variety of methods available for determining distress quantities; the methods typically involve surveys that focus on either an estimate of distress or a detailed measurement of distress. Although many variations among these methodologies exist, several examples are presented to illustrate the range of complexities in terms of the survey procedures and methodologies used in pavement management systems.

5.2.1.1. Surveys Based on Estimated Distresses

When distresses are estimated during surveys, the distress severity and quantity information is determined without direct measures. A survey based on estimated distress is the Pavement Surface Evaluation and Rating (PASER) rating procedure, which involves visually rating the surface condition of a pavement on a scale from 1 to 10, with 1 indicating a pavement in failed condition and 10 being a pavement in excellent condition (Walker et al. 2002).

The PASER rating procedure is based on a series of descriptions and related photographs for each of the individual rating categories (a sample is shown in figure 2) that are used by a rater to evaluate the overall condition of an individual pavement segment.

During the procedure, the general condition of the roadway is determined (e.g., new pavement, pavement in poor condition, etc.). Next, the pavement distresses are evaluated subjectively and the rater selects an appropriate surface rating on the 1 to 10 scale presented in the PASER manual. Individual pavements may not have all of the types of distress listed for a particular rating, but the general description should match what is observed in the field. The PASER rating scale can generally be translated into the maintenance categories shown in table 1.



RATING 5

FAIR —
Preservative maintenance treatment required

Roads are still in good structural condition but clearly need sealcoating or overlay. They may have moderate to severe surface raveling with significant loss of aggregate. First signs of longitudinal cracks near the edge. First signs of raveling along cracks. Block cracking up to 50% of surface. Extensive to severe flushing or polishing. Any patches or edge wedges are in good condition.

▼ **Block cracking with open cracks.**

► **Moderate to severe raveling in wheel paths.**

▼ **Severe flushing.**

▲ **Wedges and patches extensive but in good condition.**

Figure 2. Sample PASER rating for asphalt pavement with rating of 5 (Walker et al. 2002).

Table 1. PASER ratings related to maintenance
and repair strategies (Walker et al. 2002).

PASER Rating	General Description of Maintenance/Repair Needs
9 & 10	No maintenance required
8	Little or no maintenance
7	Routine maintenance, crack sealing and minor patching
5 & 6	Preservative treatments (seal coating)
3 & 4	Structural improvements and leveling (overlay or recycle)
1 & 2	Reconstruction

Complete guidelines for rating the pavement surface using the PASER system are available from the Transportation Information Center, University of Wisconsin – Madison (Walker et al. 2002).

Another survey procedure that uses estimated distresses to determine the condition of the pavement segment is the Condition Rating Survey (CRS) procedure used by IDOT (IDOT 2004). CRS values range from 1.0 to 9.0 in tenth-point increments. A CRS rating of a 1.0 denotes a pavement that has totally failed, and a CRS rating of 9.0 denotes a newly constructed pavement surface. A summary of the ratings is provided below (IDOT 2004):

- Poor ($1.0 \leq CRS \leq 4.5$). The pavement is critically deficient and in need of immediate improvement.
- Fair ($4.6 \leq CRS \leq 6.0$). The pavement is approaching a condition that will likely necessitate improvement over the short term.
- Satisfactory ($6.1 \leq CRS \leq 7.5$). The pavement is in acceptable condition (low end) to good condition (high end) and not in need of improvement.
- Excellent ($7.6 \leq CRS \leq 9.0$). The pavement is in excellent condition.

The CRS rating is calculated using deduct values that reduce the rating from a 9.0 when distresses are present. The deduct values are determined based on the five most prevalent distress types occurring in a pavement segment. The Condition Rating Survey Manual developed in April 2004 provides several images of distress ratings to aid a surveyor in properly determining distress types and the related CRS rating for a pavement segment. Figure 3 shows an example of an asphalt pavement with a CRS score of 5.9 compared to another pavement with a CRS score of 5.8.

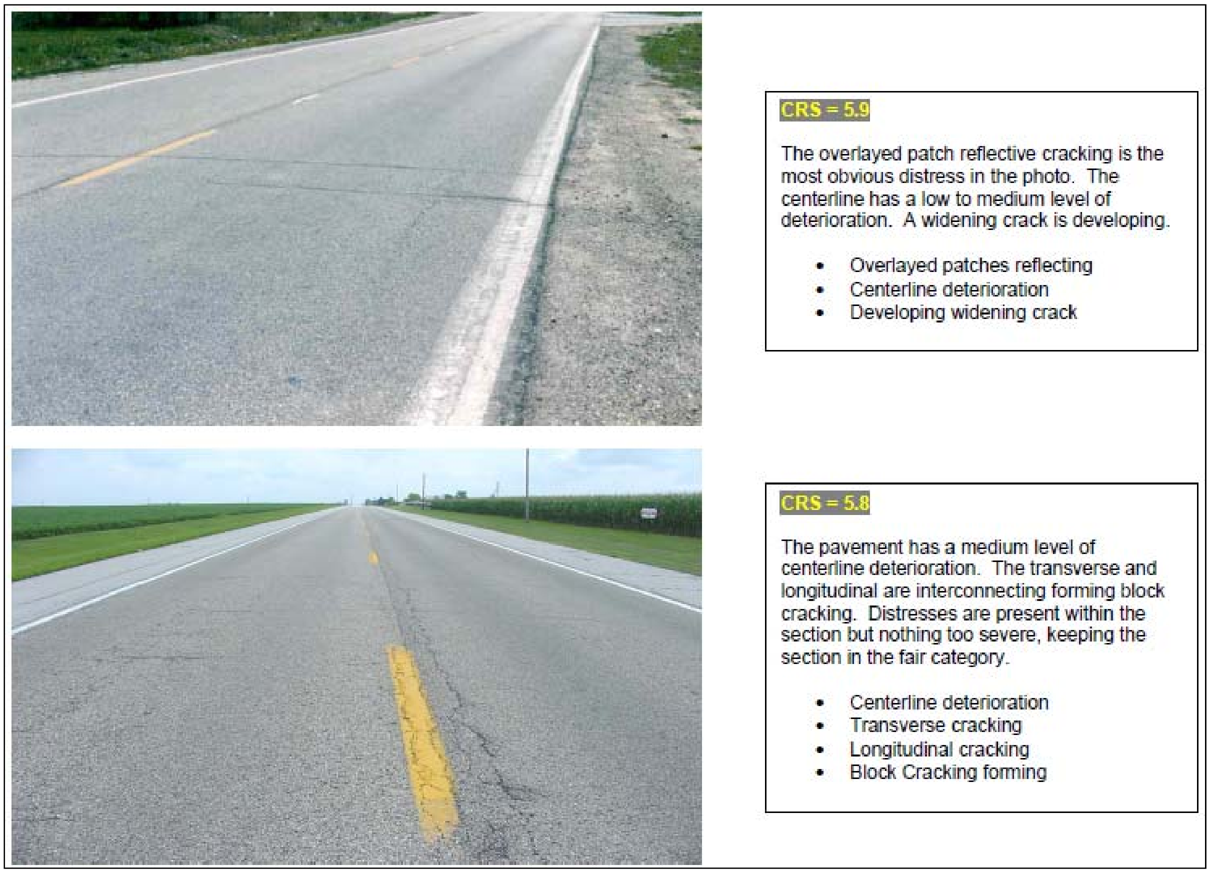


Figure 3. Pavements with a CRS scores of 5.9 and 5.8 (Illinois Department of Transportation 2004).

5.2.1.2. Surveys Based on Measured Distresses

The pavement condition index (PCI) survey is an example of a detailed survey method. It was developed by the U.S. Army Corps of Engineers, adopted by the American Public Works Association and ASTM International (formerly the American Society for Testing and Materials), and documented in ASTM D6433, *Standard Test Method for Roads and Parking Lots Pavement Condition Index Surveys* (ASTM 2009). The PCI methodology is a rating system that measures the pavement integrity and surface operational condition based on a 100-point rating scale, as shown in figure 4 (ASTM 2009). According to this methodology, the pavement network is first divided into branches (e.g., individual road), sections (e.g., segments with consistent work history), and sample units.

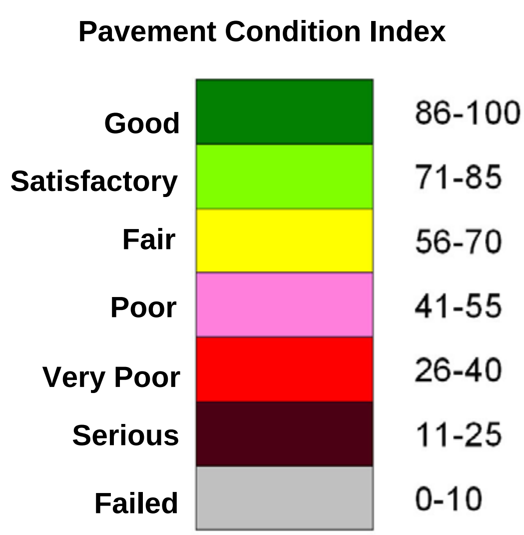


Figure 4. Pavement Condition Index ratings.

Pavement surveys are conducted on sample units. A sample unit is a small segment of pavement of required size, which is then inspected in detail. For example, sample units in asphalt-surfaced pavements are each approximately 2,500 square feet, plus or minus 1,000 square feet (ASTM 2009). A representative percentage of sample units are randomly selected and inspected. Since the inspected sample units are used to characterize the condition of the entire section, it is important that they are representative of that condition. Detailed pavement condition surveys are conducted by identifying the type, severity, and amount of each distress in representative sample units selected according to systematic sampling procedures.

A total of thirty-nine distress types (twenty types for asphalt pavements and nineteen for concrete pavements) are defined with three levels of severity (i.e., high, medium, or low) (ASTM 2009). Each combination of distress type, severity, and extent has a deduct value associated with it, which is determined by using available graphs for different types of distresses. Distresses that are considered to be more damaging to the pavement (such as fatigue cracking) have higher deduct points associated with them than distresses that are less critical (such as transverse cracks). Once each distress's deduct value is determined, they are added together to get the total deduct value for that sample unit. This value is then adjusted depending on how many distresses were used. The deduct values are subtracted from a perfect score of 100 to determine the PCI for that sample unit. A weighted average of all the PCIs for the inspected sample units within a single section are then used to represent the condition of that section. Many pavement management systems calculate the PCI based on the distress inputs entered into the software.

Edgar County uses a customized PASER rating (1 to 5) obtained during windshield surveys. These ratings are used to define a desired level of service for each segment. This rating is used by the agency in combination with Average Daily Traffic (ADT) to group roadway characteristics on a scale of 1 to 5. The ratings are then converted to a customized prioritization number which is used to arrive at applicable pavement maintenance fixes.

Stark County uses a modified version of the Pavement Condition Rating (PCR used by the Ohio Department of Transportation (DOT) and i available through the DOT's website. The methodology and related forms gave Stark County the basis they needed to evaluate their pavements. Stark County customized the procedure to incorporate adverse crown as a distress for the survey of oil and chip roads. This distress is a critical driver in the maintenance and rehabilitation decisions by the County and, therefore, was added to the survey procedure to aid in project selection.

In addition to PASER surveys that are collected each year, **McHenry County** has a consultant perform CRS on a 2- to 3-year cycle using IDOT standards. These ratings are used by the County to develop work plans and condition prediction models for their roadway network. The County also recommends making sure "not to overstate how much the treatment improves the condition, as it can result in incorrect performance curves."

5.2.2. Distress Survey Collection Methods

After determining the survey approach for collecting the distress data, an agency must choose between the two primary methods of collecting pavement condition data: manual and automated.

5.2.2.1. Manual Distress Survey Collection Method

Manual surveys are generally considered to be visual assessments of field conditions conducted by one or more individuals who view the pavement through the windshield of a vehicle or as they walk the pavement. Data from a manual survey may be recorded on a sheet of paper, into a handheld tool, or in a computer.

5.2.2.2. Automated Distress Survey Collection Method

Automated surveys are conducted using vehicles equipped with specialized cameras and sensing devices that record images and data related to the pavement being evaluated (NCHRP 2004). An example data collection vehicle is shown in figure 5.

Figure 5. Data collection vehicle (SSI 2011).

The data collected with the automated equipment must be processed to convert it into a usable format using fully or semi-automated means. “Fully automated” data collection and processing uses computers to interpret, reduce, and analyze the images and sensor data collected in the field without human intervention. Alternatively, “semi-automated” data processing is also used to convert the data collected using automated collection means, but images will be viewed by people who interpret the images to identify distress information.

5.2.3. Selecting Appropriate Methodology

With a range of levels of sophistication and required resources (time and money) to complete condition data collection, a significant amount of consideration must be given to this choice of survey procedures.

When choosing between estimated and measured distress procedures, it is important to consider the advantages and disadvantages of each approach. For instance, survey procedures that are based on estimated distress quantities have the advantage of being able to be conducted fairly quickly and, therefore, very economical. However, procedures such as the PASER rating, which estimates a condition rating instead of using measured distress quantities, might not meet the analysis needs of the agency. Specifically, if the agency desires to have detailed distress data for activities such as estimating localized maintenance quantities (e.g., crack sealing or patching quantities), a survey procedure that provides that type of information must be used, such as the PCI. Some agencies may elect to develop their own unique pavement rating system by customizing other survey procedures to better meet their needs, as have Edgar and Stark Counties, or elect to use more than one survey method to describe the condition of their road network, as have McHenry County.

The choice between using manual or automated surveys can be determined by evaluating the advantages and disadvantages associated with each procedure listed in table 2. Agencies must also consider matching the formatting of the data collected with the pavement management tool selected in step 6 of the implementation process.

Table 2. Advantages and disadvantages of manual and automated surveys (AASHTO 2006).

Survey Methodology	Advantages	Disadvantages
Manual	• Detailed distress information can be collected • Simple to conduct • No capital expenditures required	• Resource intensive • High safety risk • Potential for high variability in the data without strong training programs and quality control checks
Automated	• Lends itself to capturing large quantities of data • Multiple types of data can be collected at the same time • Data can be collected at traffic speeds • Images are stored and available for other uses	• May require a large capital investment or contracting fees • Data must be viewable from the pavement lanes • Some distress characteristics are difficult to capture (e.g. weathering and raveling of the pavement surface)

Figure 6 provides a representation of the types of survey procedures available to the agencies and the related level of sophistication and resources required to collect the information.

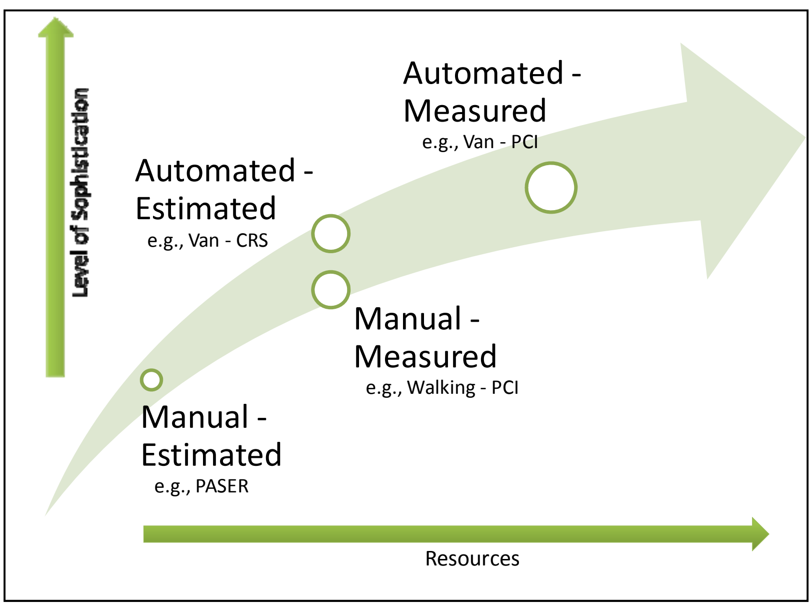


Figure 6. Selecting a survey method.

5.3. Step 3: Predict Condition

Step 3: Predict Condition

Pavement conditions can be predicted for the pavement network using either **average deterioration rates or prediction models using statistical modeling such as regression analysis**.

With current pavement condition assessed, agencies are equipped with the information needed to predict the future condition of a segment. In pavement management, conditions are predicted in terms of performance models that estimate the average rate of pavement deterioration each year. In addition to forecasting future conditions, performance models assist with the following activities (Broten 1997):

- Identifying the appropriate timing for pavement maintenance and rehabilitation for each segment.
- Identifying the most cost-effective treatment strategy for pavement segments in the network.
- Estimating pavement needs and associated budgets required to address agency-specified goals, objectives, and constraints.
- Demonstrating the consequences of different pavement investment strategies.

If an agency wants to develop a multi-year pavement maintenance and repair program, it needs to project pavement condition into the future. Prediction models are used to determine the future condition of a pavement segment. A performance curve is calculated by evaluating past historical data often in terms of pavement age and condition. The models can be produced for any measure of condition according to agency need.

The most basic form of a performance model is an average rate of deterioration for a single pavement section or a group of pavement sections with similar characteristics, known as pavement families. The creation of average deterioration rates is a simple process that works well when an agency is interested in using paper or spreadsheet methods of evaluating the performance of their pavement network. More sophisticated performance models are often used by agencies that invest in pavement management software, since the programs often provide the tools to create and use the prediction equations for either individual pavement segments or groups of pavements with similar characteristics.

5.3.1. Average Rates of Deterioration

Using the collected condition information, deterioration rates can be estimated for pavement sections using the following equation:

$$DeteriorationRate = \frac{(PastRating - CurrentRating)}{NumberOfYearsBetweenRatings}$$

An agency can also calculate the deterioration rate for groups of pavement segments using average conditions and pavement ages in the above equation to estimate an average deterioration rate for the pavement family. The calculated deterioration rates for the individual section or pavement families can then be used to estimate the condition of the pavement segments for a year or two into the future based on the assumption that deterioration will continue at the same rate. In addition, if distress types are recorded in the selected condition survey, the types of distresses present can provide further insight into the cause of pavement deterioration. Agencies using spreadsheet methods may be best served using average deterioration rates to predict condition.

5.3.2. Prediction Models using Statistical Analysis

The development of prediction models using statistical analysis is a more complex activity than creating average rates of deterioration. Often agencies accomplish the creation of these models within the pavement management software they utilize. For example, those agencies that use The MicroPAVER software developed by the U.S. Army Corps of Engineers develop performance prediction models using a general procedure called the Family Method. The method consists of the following steps (Shahin 1994):

1. Define the pavement family – A group of pavement sections with similar deterioration curves is defined as the family. The MicroPAVER software allows the user to define the family based on stored inventory data (e.g., pavement type, functional classification, traffic information, etc.). Once a family is created, the condition data, in terms of PCI, and pavement age information for all pavement segments in the family are compiled into a file that is used to create the performance model.
2. Filter the data – The MicroPAVER software flags data for sections that show condition increases as the pavement section ages. Also, the software flags data that is outside of defined boundaries that are used to indicate when pavement sections have conditions that do not meet expected conditions over the life of the pavement.
3. Conduct data outlier analysis – The software also allows for the statistical removal of unusual data that may be improperly impacting the performance modeling of a pavement family. Data is removed using statistical analysis to detect data that exceed user-defined confidence intervals.
4. Develop the family model – With data filtered and outliers removed, the MicroPAVER software allows for the creation of a prediction model. The model is constrained to have a decreasing slope since the condition cannot increase with age. The developed model, which defines the average behavior of the pavement sections, extends across the available condition data and future conditions are predicted by extrapolating the curve.
5. Predict the pavement section condition – Within MicroPAVER, the predicted condition of pavement segments are defined by the pavement section's position relative to the family prediction curve. A modified prediction curve for each pavement segment is created by "shifting" the family curve to the latest condition/age point for the segment and using the shifted performance model to predict future pavement section conditions. Example family and segment performance prediction curves are shown in figure 7.

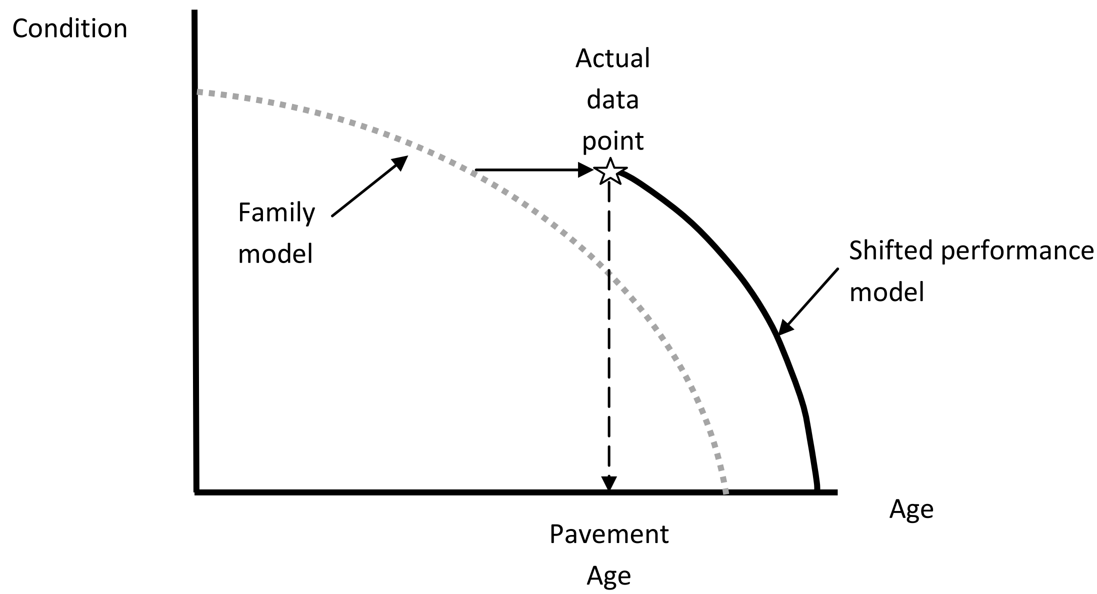


Figure 7. Pavement segment prediction in relation to a family model (based upon Shahin 1994).

Various agencies have created statistically developed performance models using other pavement management software and spreadsheet tools. Figure 8 illustrates an asphalt surface (AC) performance curve used by Champaign County. The curve is representative of the pavement's anticipated performance over time. The development of pavement prediction models based on condition data were used by Champaign County to gain approval for budget allocation for county roads.

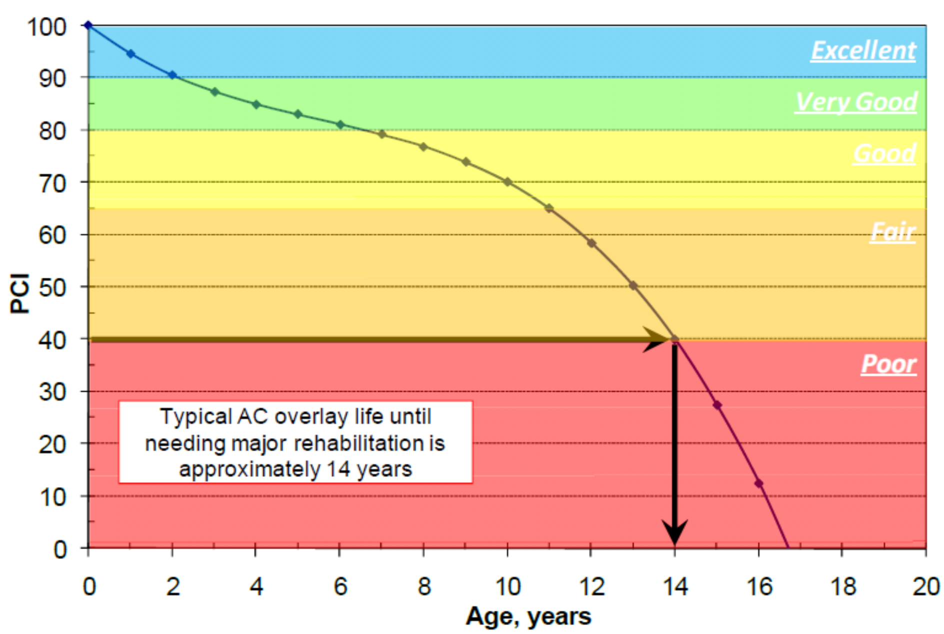


Figure 8. Champaign County performance prediction model for AC pavements (ARA 2009).

There are a variety of approaches that can be used to develop prediction models. For instance, McHenry County created a deterioration curve for the PCI based upon the average ages of its three surface types. The City of Naperville, on the other hand, developed a PCI performance curve that was then used to determine funding needs for the City.

> **"The PMS currently has deterioration curves, one for the three major surface types."**
> **- McHenry County, IL**

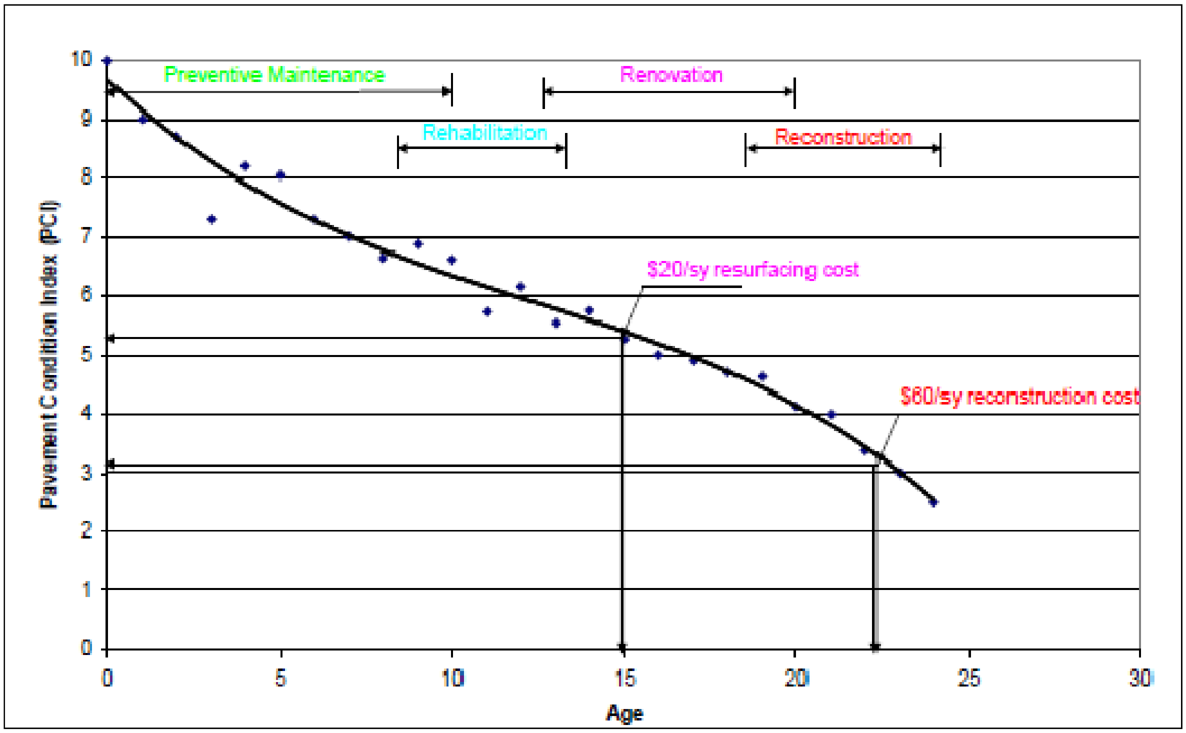


Figure 9. City of Naperville performance prediction model (City of Naperville 2008).

5.3.3. Selecting Appropriate Methodology

Most pavement management software can be used to generate database-specific performance prediction models using the actual pavement condition data. Therefore, agencies that choose to use pavement management software should be able to handle pavement performance prediction inside of the software. For agencies using a spreadsheet or databases outside of pavement management software, it is a more difficult to develop and use statistically developed prediction models. Therefore, it is recommended that average rates of deterioration be used to predict condition. In either scenario, the developed models can be used to illustrate performance trends and develop budget scenarios to analyze the impact of the funding availability and investments on the condition of the entire network.

5.4. Step 4: Select Treatments

Step 4: Select Treatments

Treatments are selected using **cyclical placements or treatment trigger rules**. The recommended treatments are then prioritized using **ranking or benefit/cost analysis**.

The fourth step in designing the pavement management process is to select appropriate treatments for the roadway network. The selection of treatments is based on the agency's defined maintenance and rehabilitation strategy, which is created by selecting trigger values to identify segments needing repair. Trigger values are thresholds that can be used to signify the need for various treatments to be applied to pavement segments. For example, pavement age, pavement surface condition, or traffic can be used as a factor to determine the eligibility of a pavement for repair. The selection of a treatment can be based on either a cyclical selection or the creation of treatment rules.

5.4.1. Cyclical Treatment Selection

One method of selecting a treatment for a pavement segment is through a cyclical method of applying a treatment to given pavement sections. Many agencies select maintenance strategies based on pavement age. These treatments are then repeated at specific time intervals. For example, an agency may chose to chip seal all pavements on a 7-year cycle. The agency can then divide the pavement network into seven regions and cycle through the regions every 7 years.

The placement of the treatment increases the pavement life and, if applied at the correct time, can prolong the life of the pavement. However, the timing of such a treatment is critical to its performance and overall cost-effectiveness. Therefore, it is difficult to achieve the most effective treatment timing using cyclical treatment selection as the cyclical placement is regimented and does not allow for flexibility in addressing the placement of the treatment at the right time for each pavement segment independently.

5.4.2. Treatment Rules

In addition to the creation of cyclical treatment triggers, another method of treatment selection is the use of treatment rules that are developed into a matrix or a decision tree. To develop treatment rules, an agency needs to define its treatment strategy. That is, select treatments that will be applied at specific condition levels for pavements with specific inventories. An example treatment matrix is shown in figure 10. This matrix is used by Champaign County to select an appropriate treatment and determine the overall needs of the pavement network based on collected surface and estimated structural condition information in the form of PCI and Rolling Weight Deflectometer (RWD) deflections, respectively.

Champaign County uses the treatment matrix in conjunction with its pavement management system to analyze PCI ratings and pavement structural information to arrive at an appropriate and effective treatment method for particular pavement segments based on the traffic levels of the roadway.

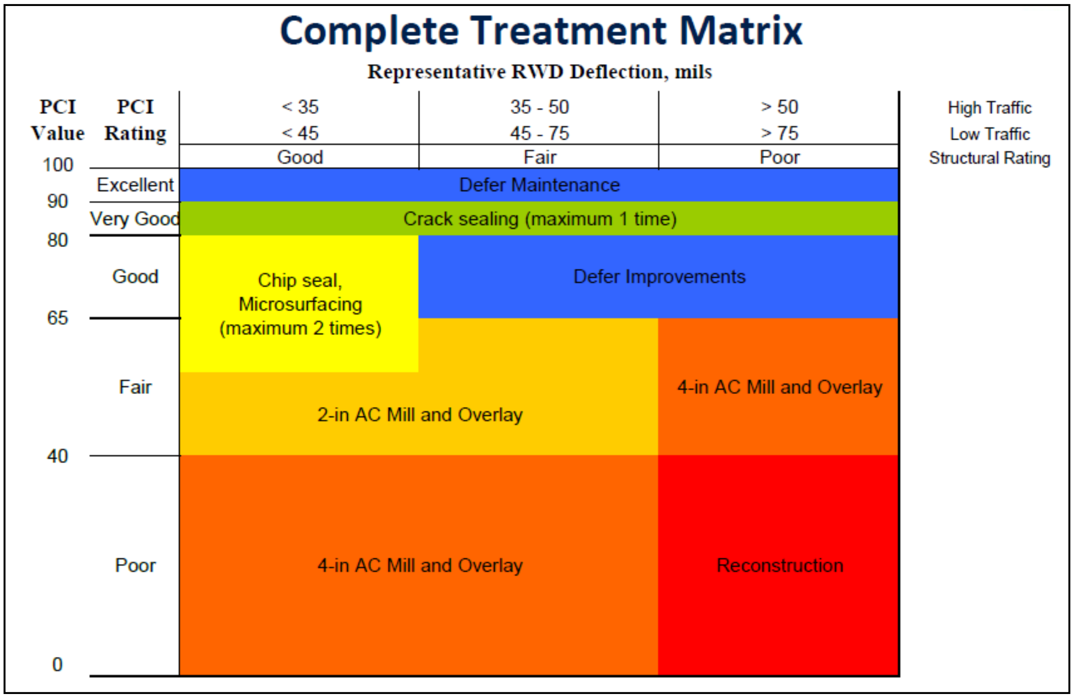


Figure 10. Champaign County treatment matrix (ARA 2009).

Other forms of treatment rules can be developed, including decision trees for selecting treatments for the roadway segments. A decision tree contains a strategy for each branch of the tree, generating specific treatment options for various categories defined by the agency. Some agencies, such as the City of Macomb, develop treatment rules based solely on the condition rating of the pavement segments. With treatment selection rules established, recommended projects must be selected to match agency funding levels.

The **City of Macomb** developed a customized rating system to assess their network condition. The rating system is a non-measurable and manual method in which the pavements are rated as either “good, fair, poor, or failed”. This rating on the segment is then used to determine possible maintenance and rehabilitation strategies for each rating level.

Good – minor maintenance (crack seal)
Fair – maintenance (crack seal and spot repairs)
Poor – major repair (mill and overlay)
Failed **–** reconstruction roadway.

5.4.3. Ranking

Project priorities can be selected using a ranking of projects based on some type of agency priority, such as pavement condition, functional classification, and/or traffic levels as described in this section or by using benefit/cost analysis as described in the next section. Ranking is the simplest method of selecting projects and normally results in a yearly evaluation of selected projects. One method of using the ranking approach is to fix the pavements in the worst condition first. However, this “worst-first” approach does not help maintain those pavements that are in good condition and can lead an agency into a costly cycle that does not provide any funding for the preservation of pavements. If an agency decides to use a ranking technique, it generally follows the steps listed below (Zimmerman 2011).

- Assess needs for a given year by identifying all pavement sections that are not in excellent condition.
- Calculate treatment costs by multiplying the cost of the appropriate treatment for each level of repair times the project area.
- Sort the needs in priority order using the ranking methodology established by the agency. For a worst-first strategy, the road sections in worst condition would be the highest priority.
- Select projects in accordance with the prioritized listing until there is no funding left for that year.
- Consider any remaining unfunded needs in the next year and repeat the process.

5.4.4. Benefit/Cost Analysis

A benefit/cost analysis allows an agency to work at prioritizing, or even optimizing, the choice of treatments on a multi-year period. This approach is preferred over a ranking approach because multiple treatments are considered, consequences of delaying or accelerating a treatment are evaluated, and the cost-effectiveness of a treatment is taken into account in developing the program recommendations (Broten 1997).

> The **Village of Villa Park** utilizes the benefit/cost ratio from the analysis of treatment options from their IMS Pave Pro software to determine a list of candidate maintenance and rehabilitation projects. The benefit/cost values are used to prioritize the work on the pavement network.

The benefits of the treatment, which are normally represented as the increase in pavement condition, are divided by the construction cost to determine the benefit/cost ratios, as shown in figure 11. Therefore, the longer the pavement stays in good condition, the more benefit will be accrued by the user and the higher the benefit/cost ratio. Those projects which provide the greatest benefit for the funds expended are considered the best choices.

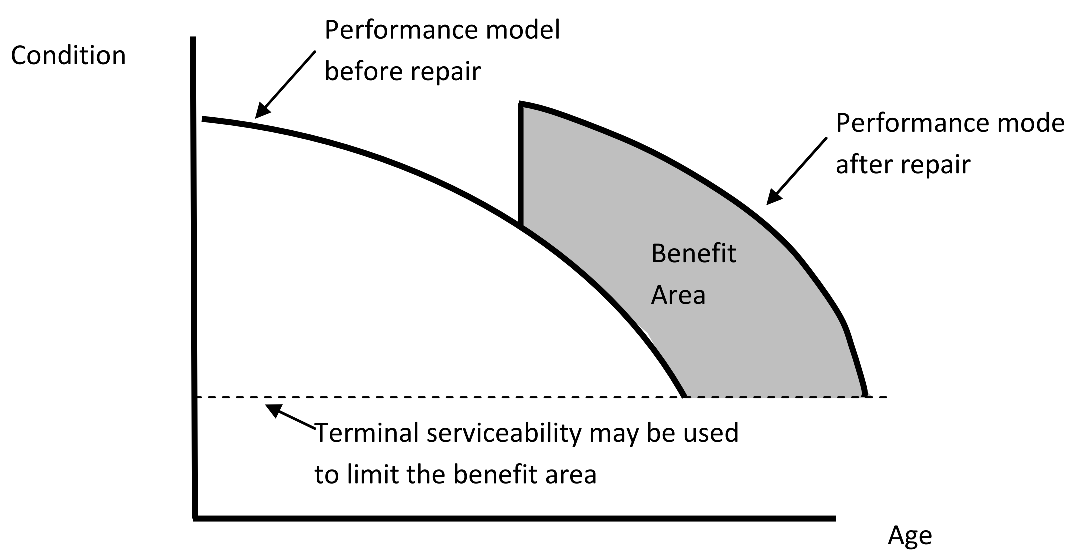


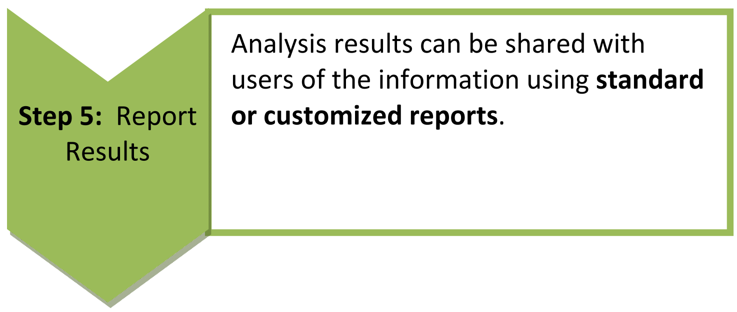
Figure 11. Benefit determination using performance curves (Broten 1997).

5.4.5. Selecting Appropriate Methodology

To help identify the most appropriate treatment for each project, agencies may choose to use either a cyclical schedule or treatment rules. Cyclical timing works well for agencies that utilize a spreadsheet to manage the pavement network, whereas the creation of treatment rules, while possible within a spreadsheet, can be cumbersome. Treatment rules are easily created within public and private pavement management software.

After treatments are determined they then must determine the prioritization of the projects since most agencies have more needs than available funding. Agencies can choose to prioritize projects based on ranking or through benefit/cost analysis. Benefit/cost analysis is best conducted inside a PMS, while ranking can be easily accomplished in a spreadsheet tool. The results of the treatment selection step provide final work plan recommendations for the agency.

5.5. Step 5: Report Results



The reporting of project results is the fifth step in the implementation process, in which the results of data analysis are presented. The findings can be reported using different methods to highlight important factors, which will assist decision makers in making various decisions. Data reporting is an effective method of communicating not only the recommendations of the pavement management process but also transferring related information to strategic decision makers. The data can be used to generate summaries of relevant information pertaining to any segments under consideration. In general, the results can be presented either by using standard reports or customized summaries.

5.5.1. Standard Reports

Typically, analyzed data can be represented in the form of standard reports and charts that are available from various pavement management software programs or from spreadsheets. The pavement management process tool provides a platform to utilize the results of an analysis and generate different types of reports, such as work history information, section information, and pavement condition information.

Standard graphics are often used to display percent of pavement mileage in various condition categories. Example pie and bar graphs for the City of Macomb and Champaign County are displayed in figures 12 and 13, respectively. These graphics provide a representation of the overall condition of the roadway network for each entity.

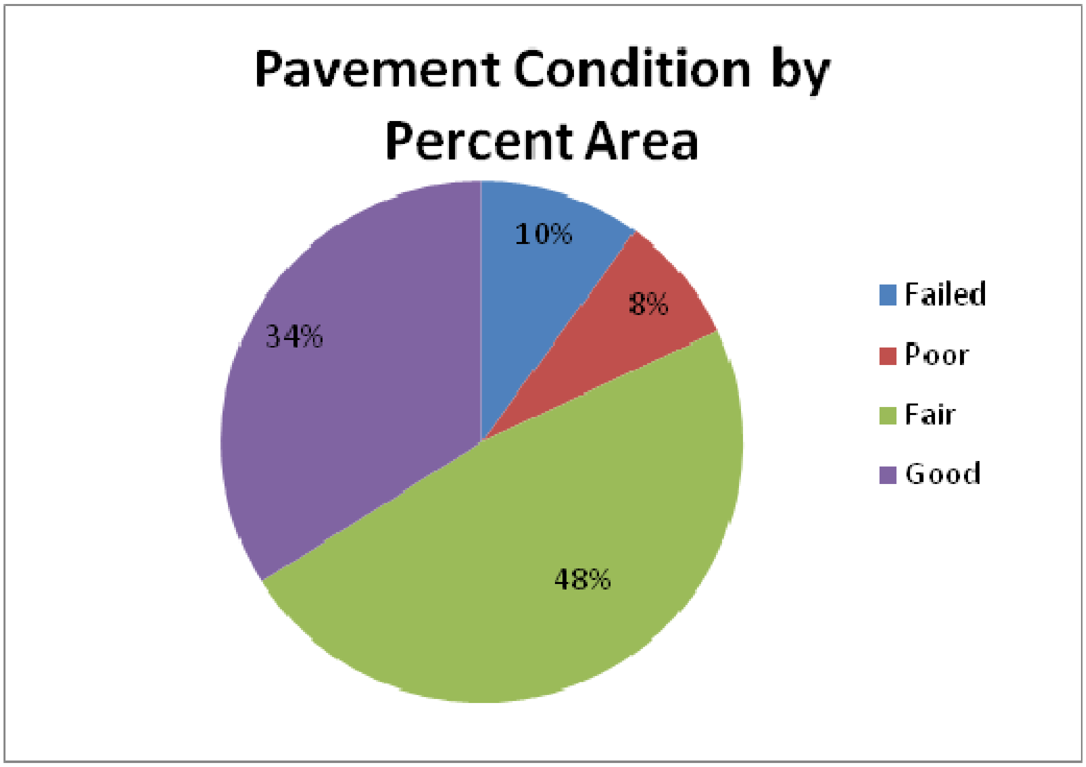


Figure 12. City of Macomb condition summary (City of Macomb 2011).

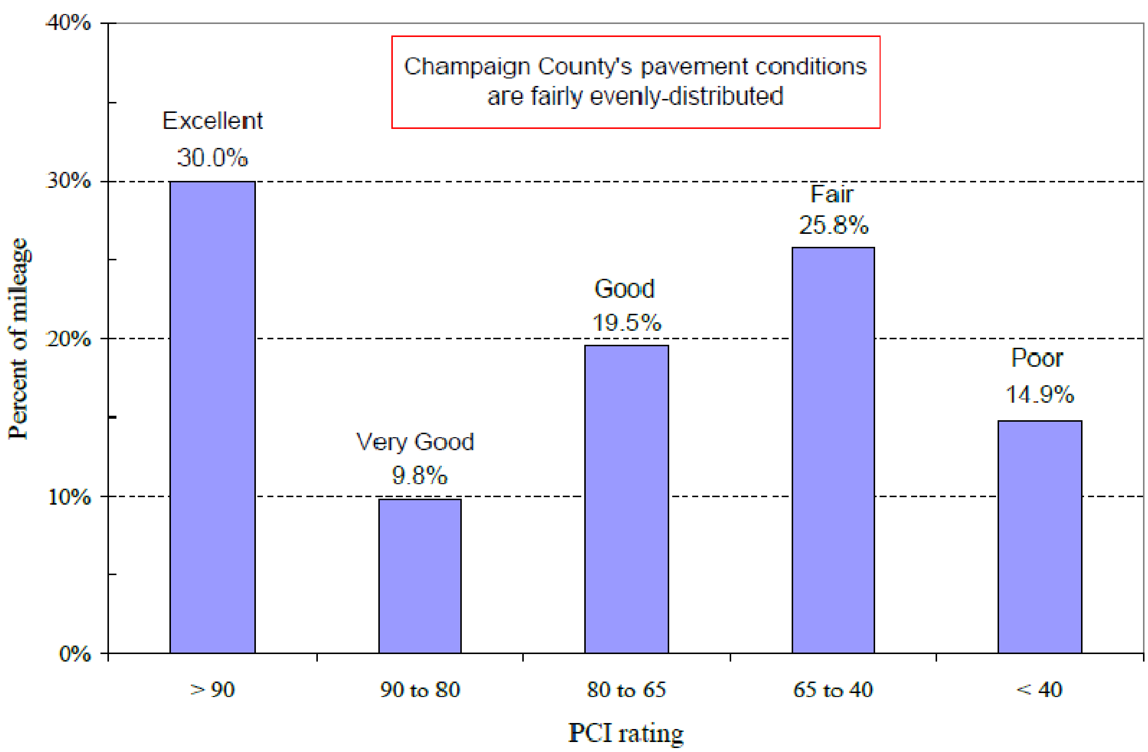


Figure 13. Champaign County condition summary (ARA 2009).

5.5.2. Customized Summaries

One advantage to implementing pavement management software is the ability to use the available data to generate user-defined reports that can be modified to suit the requirements of the agency. The customized summaries could also be accomplished with the use of spreadsheets or other customized reporting tools. Some pavement management software also facilitates the generation of reports linked to the GIS component of the database or separately-managed GIS software. An example of a summarized work plan that is linked to the GIS map is shown in figure 14.

In 2010, the Public Works Group at the **City of Macomb** proposed a half percent increase in sales tax to support roadway needs. To gain support for the increased funding, the Public Works group developed a presentation (including GIS maps) showing how the pavement network will perform with and without the proposed increase in funds.

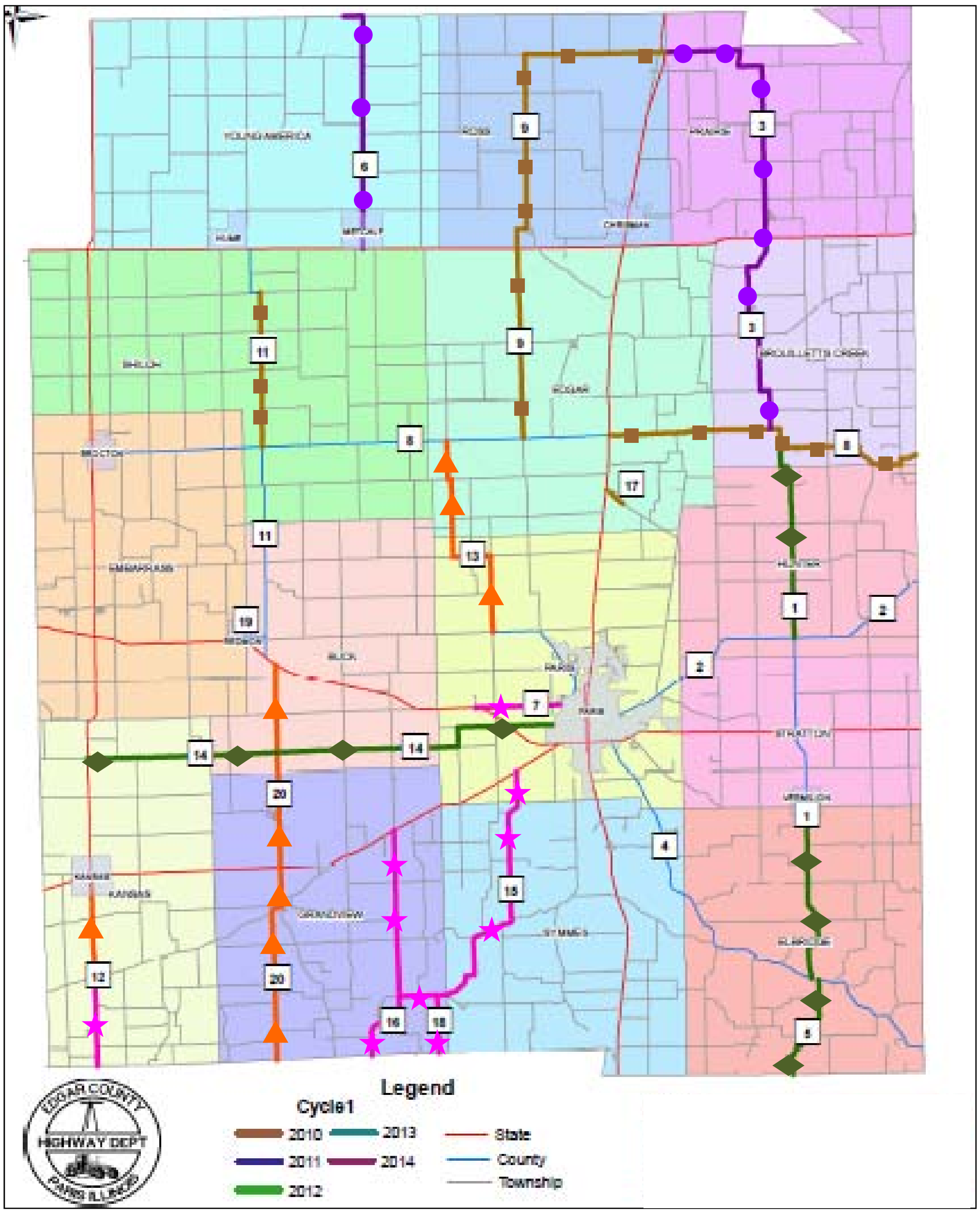


Figure 14. Edgar County 5-year work plan (Edgar County 2011).

The results of the pavement management analysis can also be used to generate summaries for presentations to decision makers. An example that displays a comparison of budget scenarios that relay the impact of the budget on the condition of the City of Naperville's roadway network is shown in figure 15. The effect of budget changes on the network condition, often referred to as "what if" scenarios, are often very effective at showing decision makers the need for continued and/or increase levels of funding for the road networks.

The **City of Naperville** developed prediction models to conduct a budget analysis in 2010. These models were used to determine that $12 million was needed to maintain the system at the current condition level. The results of the budget analysis were used to present the gap between the current allocations and requirements for citywide maintenance and operations. As part of the study, the budget analysis served as a key component in helping decision makers justify a new plan for city wide fees to cover the monetary deficit.

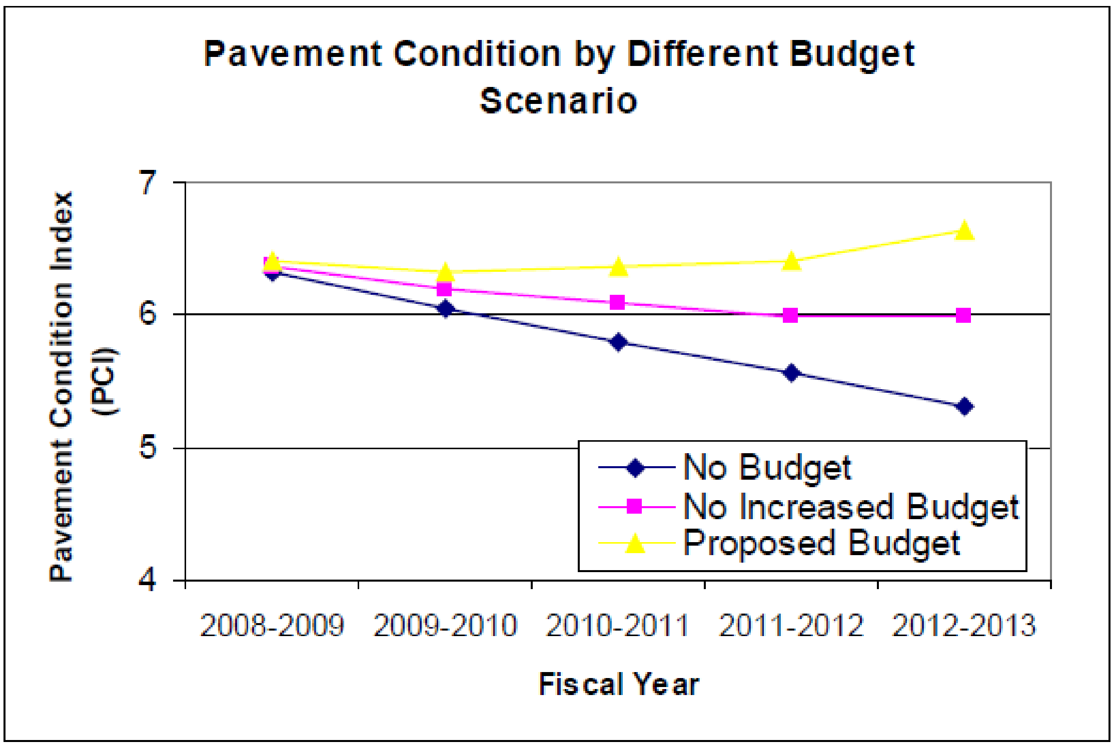


Figure 15. City of Naperville proposed budget needs (City of Naperville 2008).

5.4.5. Selecting Appropriate Methodology

Most agencies use a combination of standard and customized summaries to display their pavement management information. The visual aids generated depend on the needs of an agency and the type of information to be represented. As shown throughout this section, a variety of forms exist for creating visual aids to report pavement management data. General guidance on the types of visual aids that work best for sharing data with various users of pavement management information and examples of each is summarized in table 3.

Table 3. Visual aids for reporting information to the users of pavement management data (Broten 1997).

Visual Aid	When to Use	Examples
Tables	• Incorporate into a report or document for detailed-oriented user (engineers, planners, etc.) • Display extensive amount of detailed information • Support detailed analysis and provide technical information	• Inventory listing (e.g., segment location and name, surface type, age, traffic) • Condition listing (e.g., segment name, condition indices) • Maintenance listing (e.g., segment name, year of maintenance activity, maintenance type and cost) • Budget listing (e.g., money proposed for repairs for each segment or for various functional classifications)
Charts	• Present information to nontechnical audiences, such as elected officials and the public • Emphasize points to be made (easy method to convey simple summaries)	• Pie chart (shows size of each part as a percentage of the whole) – figure 12 • Column chart (show how items change with time or compare to one another) – figure 13 • Line chart (shows how items change over time and can compare "what if" budget scenarios) – figure 15
Maps	• Display single type of information on a geographical basis • Present information to nontechnical audiences, such as elected officials and the public	• Segment surface type • Color-coded current condition • Color-coded projects by year • Future condition for a funding scenario • Deferred projects

5.6. Step 6: Select Pavement Management Tool

Step 6: Select Pavement Management Tool

Depending on their needs, an agency can opt to use a **spreadsheet, GIS tool, and/or a pavement management system (public or private).**

The selection of a pavement management tool is influenced by the requirements of the agency and users' needs. The tool provides a platform to store the pavement management information and to perform different types of analysis depending on whether a spreadsheet, GIS tool, and/or a pavement management system (public or private) is selected.

Depending on the needs of the agency, a local agency can also opt to use a combination of pavement management software and customized spreadsheets and/or GIS software to suit their requirements. The majority of case study agencies that participated in this project use a combination of spreadsheets, pavement management software, and GIS tools to manage their road networks. In some cases the agencies use a combination of all three tools to complete their pavement management process. For example, they may use their pavement management system to produce customized summaries of pavement information and also determine benefit/cost ratios for various treatment scenarios for pavement segments in their network. Then they might use the spreadsheet tools to finalize work plan recommendations and create further tables of pavement information. Finally, the summarized information may be linked to a GIS map and shared graphically.

The case studies indicated that the participating agencies use several different pavement management systems and some agencies use a combination of Excel spreadsheets and pavement management software. The **City of Macomb** uses Excel spreadsheets as a PMS to assess the condition of their network in combination with their GIS system for data reporting. **Stark County** worked with the Illinois GIS Transportation Coalition and used the street centerline from NAVTEQ to establish the network limits and the GIS map to serve as the basis for pavement data storage.

If an agency decides that pavement management software is the ideal tool for them, there are a number of pavement management software programs to consider. Some of the available public domain and proprietary pavement management software programs commonly used in Illinois and highlighted in this Guide include:

<u>Public Domain Software</u>

- MicroPAVER by the U.S. Army Corps of Engineers.
- RoadSoft GIS by Center for Technology and Training at Michigan Technological University.
- StreetSaver by the Metropolitan Transportation Commission in the San Francisco Bay Area, California.
- Utah Local Assistance Program – Transportation Asset Management System (Utah LTAP-TAMS).

Proprietary Software

- PAVEMENTview by Cartegraph.
- PavePro Manager by Infrastructure Management Services (IMS).
- PubWorks by Tracker Software Corporation.
- RoadCare by Applied Research Associates, Inc.

Table 4 compares various features of these pavement management software programs evaluated for this implementation Guide. The general capabilities of the pavement management tools most commonly used are outlined in figure 16.

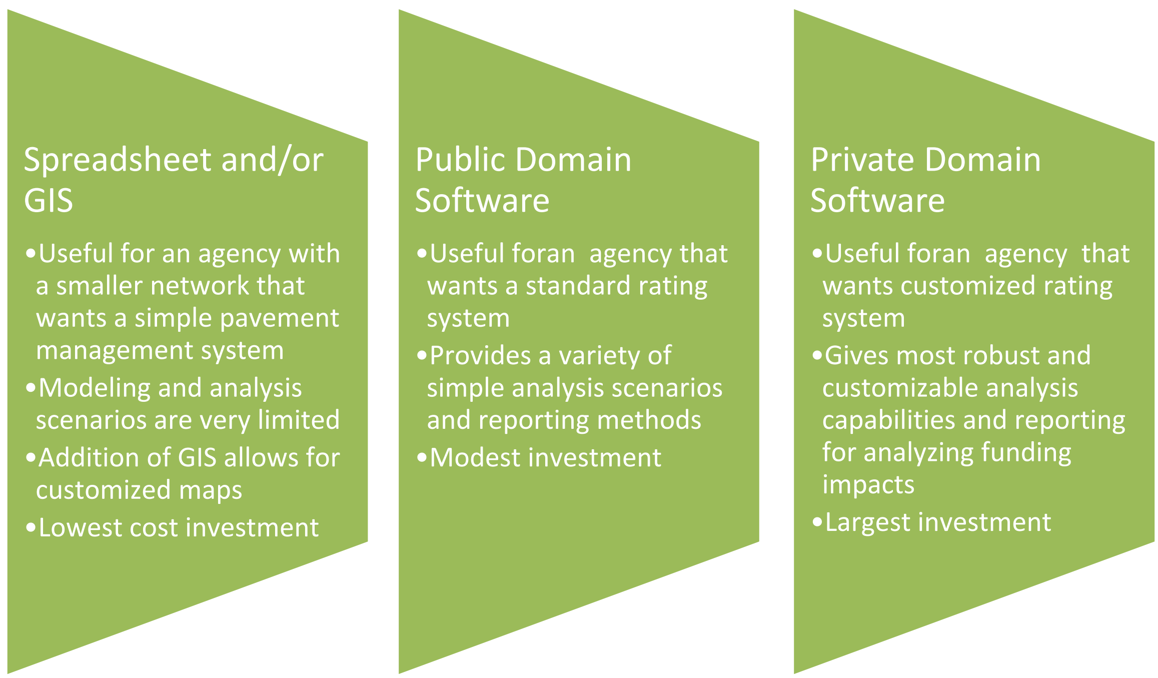


Figure 16. Comparison of pavement management tools.

5.6.1. Selecting Appropriate Methodology

Additional guidance on the selection of a pavement management tool is provided in figure 17. The selection of a software tool is based on the decisions made by the agency in steps 1 through 5 of the outlined pavement management process to meet the needs of the agency and its customers. In general, if an agency made process decisions that fall primarily on the left side of figure 17, then they are an agency that may be best suited with a spreadsheet tool. Those agencies that are interested in robust, customizable survey procedures and models, along with a variety of analysis scenarios, are best suited to implement proprietary pavement management software. Those agencies that fall between these two examples may be best suited with public domain software as it bridges the gap between the other tools. Of course, these choices must be balanced against the cost of the tools. When implementing the selected tool, agencies should look internally for expertise and, when needed, work with universities, vendors, or consultants for assistance in the implementation of the selected pavement management tool.

Table 4. Comparison of pavement management software features[1]

CRITERION DESCRIPTION	PAVEMENT MANAGEMENT SOFTWARE PROGRAMS							
	PUBLIC				PRIVATE			
	MicroPAVER	RoadSoft GIS	Utah LTAP TAMS	StreetSaver	RoadCare	PAVEMENTview Plus	PubWorks	PavePro Manager
Vendor	US Army Corps of Engineers	Michigan Technological University - Center for Technology & Training	Utah Local Technical Assistance Program	Metropolitan Transportation Commission	Applied Research Associates	Cartegraph	Tracker Software Corporation	Infrastructure Management Services
Website	www.apwa.net	www.roadsoft.org	www.utahltap.org	www.mtcpms.org	www.ara.com	www.cartegraph.com	www.pubworks.com	www.ims-rst.com
Laptop Data Collection	Yes	Yes	Yes	Additional program needed	*	Yes	Yes	*
Ability to Analyze Other Assets	No	Yes, signs, pavement markings, traffic counts, & traffic crashes	Yes	Yes, sidewalks, lights, sign, curb and gutter, & user-defined	*	Yes, sewer, signal, sign, storm, bridge, & lights	Yes, bridges, signs, culverts, guardrails, parks, & buildings	*
Default Pavement Condition Rating Measure	PCI	PASER	RSL	PCI	PCI, IRI	OCI	PASER	*
Analyzes Different Maintenance Strategies	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Analyzes Different Budget Scenarios	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
GASB 34 Reporting	No	Yes	No	Yes	*	Yes	Yes	*
GIS Integration	Yes	Yes	Additional software needed	Additional software needed	Additional software needed	Additional module-GIS director or own software	Additional module MapViewer needed	Additional software needed
Customization Capabilities	Yes	Only certain aspects	Yes	Yes	*	*	Additional modules available	Additional modules available
Cost (2011)	APWA members $995; non-members $1095	Contact vendor for more information	Utah-free/Out of state $500	$1500+, contact vendor for more information	Varies, contact vendor	Varies, contact vendor	Varies, contact vendor	Varies, contact vendor
User's Manual	Yes	Yes	Yes	Yes	*	Yes	Yes	*
Technical Assistance	Training courses or four-part web-based training	Telephone or web-based training	Free telephone or paid on-site arrangements	4-day training class twice per year and customized on-site training	*	On-site or web-based training; technical support by phone	Formal training at 1-day per module, free updates, software helpdesk	*

[1] PCI – Pavement Condition Index; PASER – Pavement Surface Evaluation and Rating System; RSL – Remaining Service Life; IRI – International Roughness Index; OCI – Overall Condition Index

(*) Denotes: Unable to obtain information at this time. Contact vendor for more information.

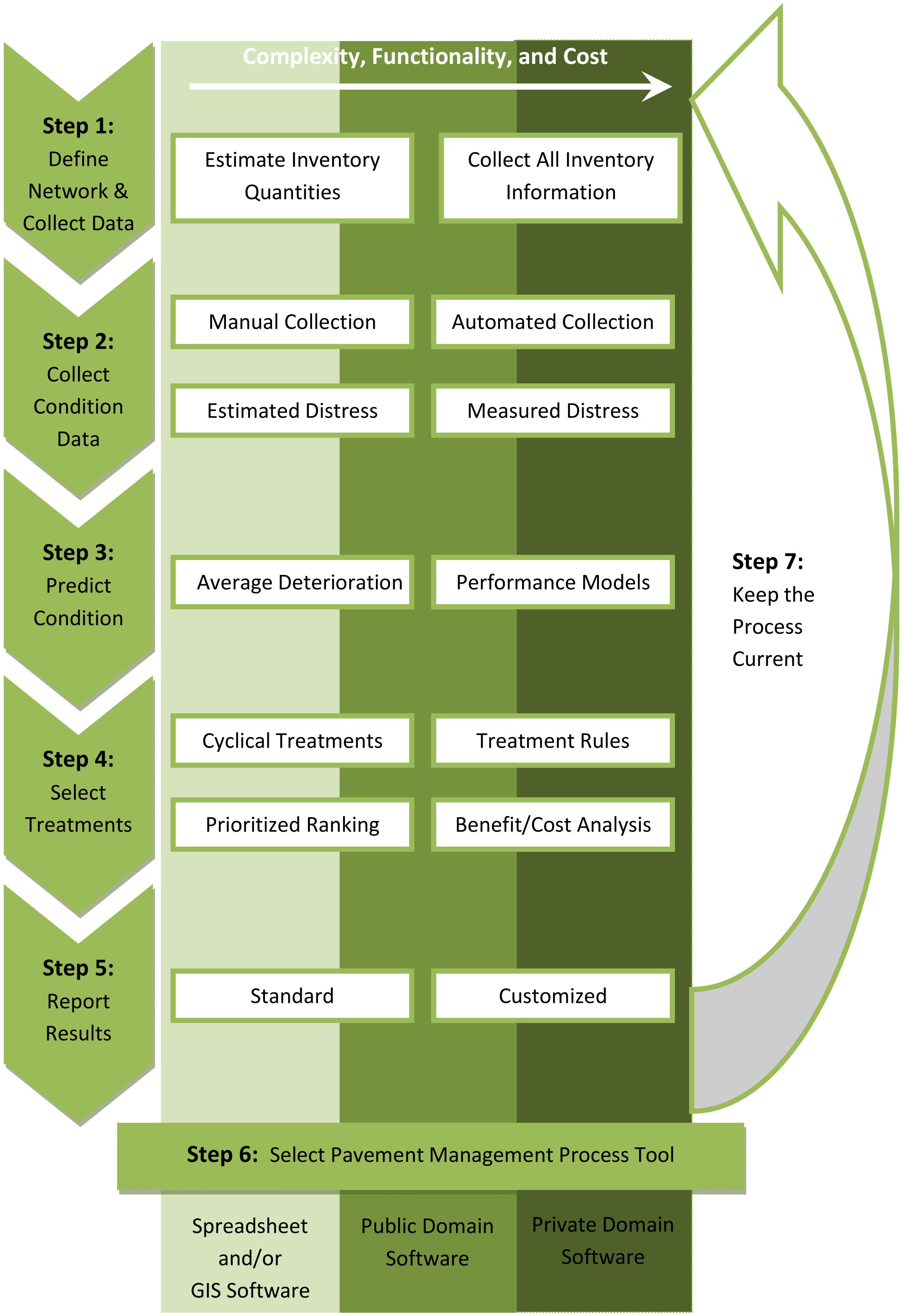


Figure 17. Pavement management options.

5.7. Step 7: Keep the Process Current

Pavement management is a dynamic process that requires regular updates. Pavement management is not a one-time activity, so agencies must make an effort to update the information incorporated in the pavement management process. Data management is a key component to maintaining the database and keeping the information current.

The required updates needed to keep the overall pavement management process current are outlined for the first five pavement management process steps:

1. Define Network and Collect Data – Inventory information related to pavement segments are relatively constant components of a database. These elements need to be updated only in the case of major changes to the pavement network. Work history details, however, should be updated on an annual basis to keep proper track of maintenance and rehabilitation activities on the pavement sections.
2. Collect Condition Data – General pavement management practices recommend that condition information is collected on a minimum 3-year cycle on pavement segments (Zimmerman 1996). Therefore, this data should be collected and updated in the pavement management spreadsheet or software on the same cycle.
3. Predict Condition – Average deterioration rates can be updated with each data collection cycle. If prediction models are utilized, consider updating them every 3 years when initially developed and then on a 5-year cycle after they are established.
4. Select Treatments – As agencies use the results of recommended treatments based on treatment selection processes, the rules and priorities should be updated to ensure that the process continues to improve in the future.
5. Report Results – Report results will be used by an agency with each new pavement management plan, which ideally should be conducted each year or on a maximum 3-year cycle to correspond with the 3-year data collection cycle.

6. SUMMARY

The details for implementing a pavement management program in a local agency are outlined in this document. Recommendations are provided for how to develop a process that best meets the given needs of an agency. As described throughout the document, the implementation process is very customizable and should be molded to best meet the needs of the agency. Overall, the implementation of a pavement management process will help those responsible for the management of roadway networks to make more effective management decisions. As the agencies highlighted in this Guide can attest, the use of pavement management has been invaluable to them, especially in the current tight funding environment, as they use the tools they have created to justify their pavement needs.

The case study agencies that were highlighted in the Guide include Champaign County, Edgar County, McHenry County, Stark County, City of Macomb, City of Naperville, and the Village of Villa Park. Full details of their implementation efforts, along with their successes and challenges, are included in the Synthesis that was created as part of this research project, but a few key quotes from the interview process include:

- The City of Naperville feels that “due to the state of the economy, the pavement management system has become more important.”
- Since Champaign County implemented their PMS, they are “now able to reduce political pressure,” when making pavement management decisions.
- The need for Edgar County’s PMS was recognized as the County wanted to have a systematic process in place for completing the “right work at the right time for the right reasons.”
- McHenry County encourages other agencies, “Don’t try to implement a PMS all at once: slowly integrate the program into your routine.”
- Stark County decided to implement a PMS because they “wanted to have more *engineering* behind decisions.”

Using the details of the case study agencies along with this Guide and information provided in the Synthesis from this project, an agency has multiple resources at hand to begin the pavement management implementation process.

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9. GLOSSARY OF TERMS

- **Backlog** – Amount of unfunded maintenance and rehabilitation.
- **Benefit-Cost Analysis** – Relates the economic benefits of a solution to the costs incurred in providing that solution.
- **Branch** – A part of the network that is a distinct entity and has a unique function. Each street in the City 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 pavement current condition in terms of overall condition, cause of deterioration, and deterioration rate.
- **Deterioration rate** – Change in condition index 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.
- **Impact analysis** – Comparing different maintenance and rehabilitation (M&R) plans to determine the impact that different decisions will have on the pavement network.
- **Needs analysis** – Determining maintenance and rehabilitation (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 separately managed (such as districts within a city of subdivisions within a town.)
- **Pavement Condition** – A quantitative representation of distress in pavement at a given point in time.
- **Pavement Maintenance** – All routine actions, both responsive and preventive, which are taken by the agency or other parties to preserve the pavement structure, including joints, drainage, surface, and shoulders as necessary for its safe and efficient utilization.
- **Pavement Management System** – A systematic method for routinely collecting, storing, and retrieving the kind of decision-making information needed to make maximum use of limited maintenance (and construction) dollars.
- **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.

- **Prioritization** – Technique used to determine which maintenance and rehabilitation (M&R) activities should be performed when insufficient funding exists to perform all required M&R.

- **Rehabilitation** – Work undertaken to restore serviceability and extend the service life of an existing facility.

- **Resulting performance model** – The performance model that a section is assigned after a treatment has been applied. For example, complete Portland cement concrete (PCC) reconstruction resulted in the section performance model being set as PCC.

- **Segment or 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 maintenance and rehabilitation recommendations are made at the section level.

- **Surface type** – The material used for the wearing course.

- **Treatments** – Materials and methods used to correct a deficiency in a pavement surface.

- **Treatment trigger** – A set of conditions that must exist in order for a treatment to be considered.