Pavement Management 101 White Paper

Executive Summary:

Communities throughout the U.S. are challenged to meet funding needs for maintaining, operating, and improving their roadway systems. The most cost effective way to manage these investments is through a comprehensive pavement asset management approach. Under such an approach, investment decisions are driven by strategic policies and criteria including: pavement condition, roadway classification, level of service and safety, and others. The investment philosophy of "keeping good roads good" results in lowest overall life-cycle costs; however, this often does not resonate with users who may think a "worst road first" approach is the best way to manage the system.

Similar to other communities throughout the country, Albany relies on street specific condition ratings and pavement management software programs to identify and prioritize the condition related needs of our street system. These software programs are important tools as they help to provide accurate (based on facts), transparent, and unbiased information to policy makers and pavement managers. All pavements deteriorate in a similar and predictable way and these programs help predict when pavements need treatment, which repair methods are most appropriate, and what pavement management approaches are most cost effective over the long term.

The needs of Albany's street system far exceed the community's ability to fund improvements. Albany is not alone; communities across the country face a similar challenge. The obvious solution is to secure additional resources to fund investment needs. This is not a simple task, yet needs to be considered in the context of future economic and social viability as well as community livability for current and future residents.

Purpose of this document:

It is important to note that effective pavement management is paramount to achieving sustainable, lowest lifecycle cost investment of our local transportation system infrastructure network. This whitepaper is intended to provide a fundamental overview of pavement management. It provides the foundation necessary for future discussions about the condition of Albany's streets and strategies for preserving the community's investments in pavement infrastructure.

What is pavement (asset) management?

The following definition is from the American Association of State Highway and Transportation Officials (AASHTO):

> *"Transportation asset management (TAM) is a strategic and systematic process of operating, maintaining, upgrading, and expanding physical assets effectively throughout their lifecycles. It focuses on business and engineering practices for resource allocation and utilization, with the objective of better decisions-making based upon quality information and well defined objectives."*

In other words, the objective of an effective pavement management program is to provide good roadways (at the community's defined level of service) at the lowest, sustainable lifecycle cost possible.

"Pavement Management Primer"[1] from the Federal Highway Administration (FHWA):

"Pavements represent the largest capital investment in any modern roadway system. Maintaining and operating pavements on a large roadway system typically involves complex decisions about how and when to resurface or apply other treatments to keep the roadway performing and operating costs at a reasonable level. Traditional methods, used since Roman times, left these decisions up to a road supervisor who would select treatments based on his extensive knowledge and experience. This system is still widely practiced and works well in low traffic areas or where repair/restoration funds are not limited. In most cases, however, this is not the situation. First, rarely are there enough funds to complete all identified road repairs, and second, high traffic levels severely restrict when roads can be closed for maintenance.

Pavement management brings more science into this process. A pavement management system consists of three major components:

1. *a system to regularly collect roadway condition data*
2. *a computer database to sort and store the collected data*
3. *an analysis program to evaluate repair or preservation strategies and suggest cost-effective projects to maintain roadway conditions*

In most agencies, these components are then combined with planning needs and political considerations to develop annual highway repair/preservation programs.

Data collection ranges from simple "windshield surveys" to the use of elaborate testing vehicles that measure smoothness, skid resistance, faulting, and cracking in the road surface. Some agencies own and operate their own vehicles; others contract out the data collection. To make fair comparisons between potential projects, the highways are divided into segments that are more or less equal in length. The data from each segment is stored as one record in the database. The length of a typical segment ranges from 0.1 mile to 1 mile.

The database and analysis are usually set up using commercially available software. The size of the database will vary depending on the number of highways and the length of segment used for analysis. Most pavement management software vendors provide customized input screens, analysis packages, and reports as needed by the agency.

The analysis part of a pavement management system attempts to predict how long a pavement segment will last with a certain kind of repair under the given traffic loads, climate, and other factors. This analysis is based primarily on the collective experience of roadway experts (road supervisors) and on the historical costs incurred for repairs or reconstruction. More sophisticated analysis packages also predict annual repair costs, overall system performance, and expected pavement conditions on related routes within planning corridors. Overall, the intent of the analysis is to identify the most cost-effective ways to maintain a roadway system in satisfactory condition. Many systems provide a kind of learning process to the analysis program based on the actual performance trends of the highway system. After a few cycles of data collection, these systems can predict the local conditions with remarkable accuracy.

[1] ***https://www.fhwa.dot.gov/infrastructure/asstmgmt/pmprimer.pdf***

The most common uses of the pavement management information are by planning departments in roadway agencies for scheduling repair and reconstruction projects. In addition, pavement management information is used by road supervisors departments for evaluating repair methods and by engineering groups for evaluating pavement designs."

How are Pavements Evaluated?

As noted in the FHWA Pavement Management Primer, there are many ways to assess pavement condition (and anticipated remaining life). The City of Albany uses visual inspection as the primary technique employed. This is an appropriate system-wide evaluation technique for goal setting, prioritization, and financial planning. Through this technique, each street is assigned a Pavement Condition Index (PCI). Below is the Standard PCI Rating Scale from the American Society of Testing and Materials (ASTM D 6433 – 07):

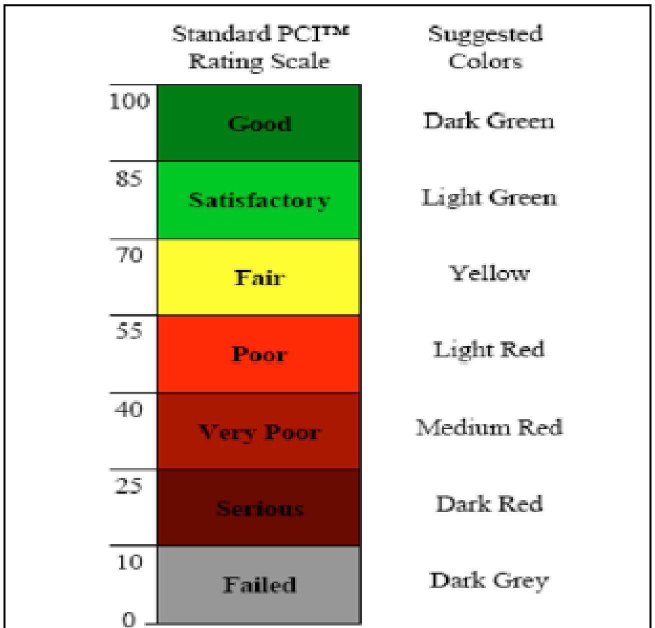


FIG. 1 Pavement Condition Index (PCI), Rating Scale, and Suggested Colors

The following photographs provide examples of pavement condition ratings (i.e. good, fair, failed, etc.) for roadways in Albany:

Good Condition - PCI = 85 to 100
[N. Albany Road near bridge – PCI = 96]

Fair Condition – PCI = 55 to 70
[34th Ave near Columbus – PCI = 64]

Very Poor Condition - PCI = 25 to 40
[Hill Street, 20th-24th Ave – PCI = 33]

Failed Condition Streets - PCI < 10
[Oak Street @ school – PCI = 5]

The City of Albany utilizes StreetSaver® pavement management software as the roadway condition assessment data repository and investment decision tool. StreetSaver® is the most widely used pavement management software program by Oregon cities and counties. The City of Albany completes a “field” pavement condition assessment every three to five years, and includes approximately 1,557 individual roadway segments within the City’s 196 road-mile network. This information is used to prioritize roadway pavement restoration projects within the City’s 5-year Capital Improvement Program (CIP). In addition, this software provides recommendations regarding which type of pavement restoration treatment (i.e. slurry seal, overlay, reconstruction, etc.) should be utilized for each roadway pavement being addressed. As roads are considered for improvement, staff will conduct additional testing when visual inspection alone is not adequate or additional information is necessary for pavement structural design.

<u>How Pavements Fail</u>:

Pavements typically deteriorate slowly during the first few years after installation and at a much accelerated rate thereafter. Although pavement designs and materials vary, the "deterioration curve" for all pavements is similar. The National Center for Pavement Preservation provides the following condition versus age pavement deterioration curve:

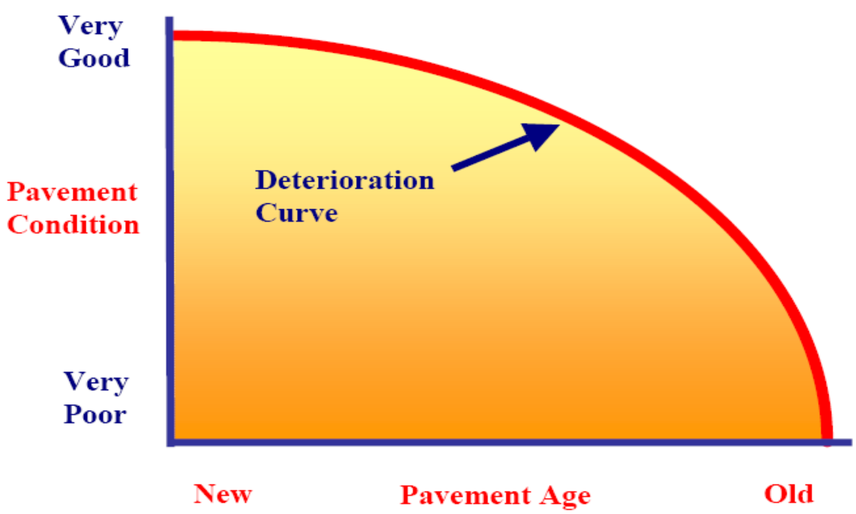
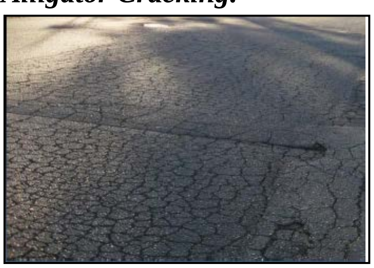


Figure 1-3: Pavement Deterioration Curve

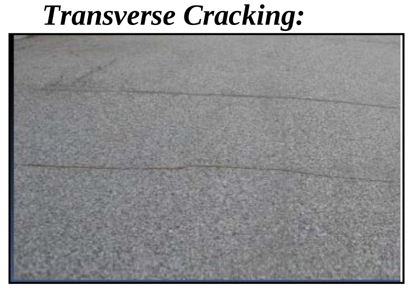
Pavement distresses or failure modes include (and are not limited to):

Alligator Cracking:



Longitudinal Cracking:

Transverse Cracking:



Raveling:

Rutting:

Surface Distortion:

<u>Overview of Typical Pavement Treatment/Restoration Options</u>:

There are several options to rehabilitating/renewing pavements including:

- Crack Sealing
- Fog Sealing
- Slurry Sealing
- Chip Sealing (a.k.a. seal coat, bituminous surface treatment or BST)
- Microsurfacing
- Thin Overlay
- Mill and Overlay
- Full-Depth Reclamation (FDR)
- Traditional Reconstruction

For existing roadways above a PCI of 70, the following treatments are typically utilized:

Crack Sealing – A maintenance procedure that involves placement of specialized materials into working cracks using unique configurations to reduce the intrusion of incompressibles (e.g. sand/grit, road salts, etc.) into the crack to prevent intrusion of water into the underlying pavement layers. Working cracks are defined as those that experience significant horizontal movements, generally greater than about 2 mm (0.1 in.).

Fog Seal – A light application of slow setting asphalt emulsion diluted with water, used to renew old asphalt surfaces and to seal small cracks and surface voids.

Slurry Seal – A mixture of slow setting emulsified asphalt, well-graded fine aggregate, mineral filler, and water. It is used to fill cracks and seal areas of old pavements, to restore a uniform surface texture, to seal the surface to prevent moisture and air intrusion into the pavement, and to provide skid resistance.

For existing roadways with a PCI between 50 and 70, the following treatments are typically utilized:

Microsurfacing – A mixture of polymer modified asphalt emulsion, mineral aggregate, mineral filler, water, and other additives, properly proportioned, mixed and spread on a paved surface.

Chip Seal – A rehabilitation treatment in which a pavement surface is sprayed with asphalt (generally emulsified) and then immediately covered with aggregate and rolled. Chip seals are used primarily to seal the surface of a pavement with non load-associated cracks and to improve surface friction, although they also are commonly used as a wearing course on low volume roads.

Thin Overlay – A pavement rehabilitation treatment, typically 1.5-inches or less in depth in which a well graded hot mix (or warm mix) asphalt (HMA or WMA) is thoroughly compacted into a uniform dense mass over an existing pavement.

For existing roadways with a PCI between 25 and 50, the following treatment is typically utilized:

Thick Overlay – A pavement rehabilitation treatment, typically 2-inches, in which a well graded hot mix (or warm mix) asphalt (HMA or WMA) is thoroughly compacted into a uniform dense mass over that existing pavement. Often this process includes removing pavement material (i.e. "milling") from the surface of the existing pavement prior to receiving the overlay.

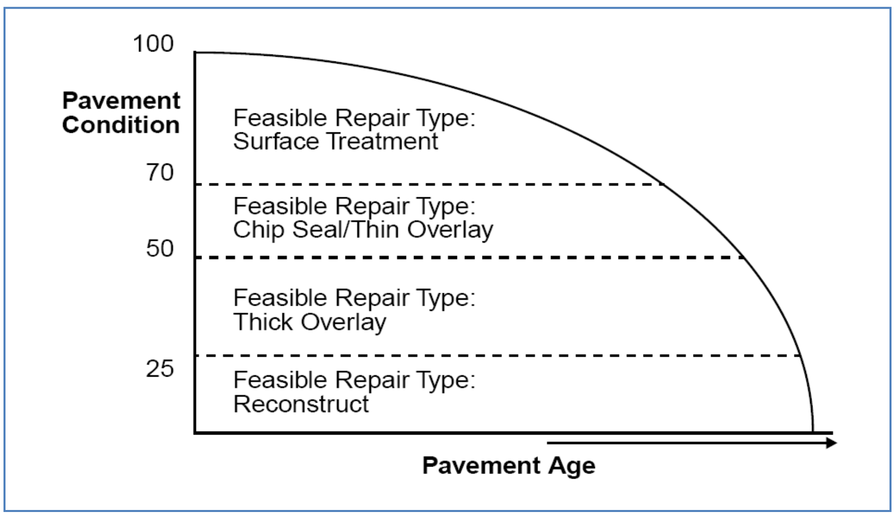
For existing roadways below a PCI of 25, the following treatments are typically utilized:

Full Depth Reclamation – A pavement reconstruction technique in which the full flexible pavement section and a predetermined portion of the underlying materials are uniformly pulverized and blended together to produce a homogeneous stabilized course (SBC).

Traditional Reconstruction – A pavement renewal technique in which the existing pavement as well as underlying materials are removed and replaced with new material courses (including gravel borrow, crushed rock and asphalt or Portland Cement Concrete pavement) in accordance with new pavement installation requirements.

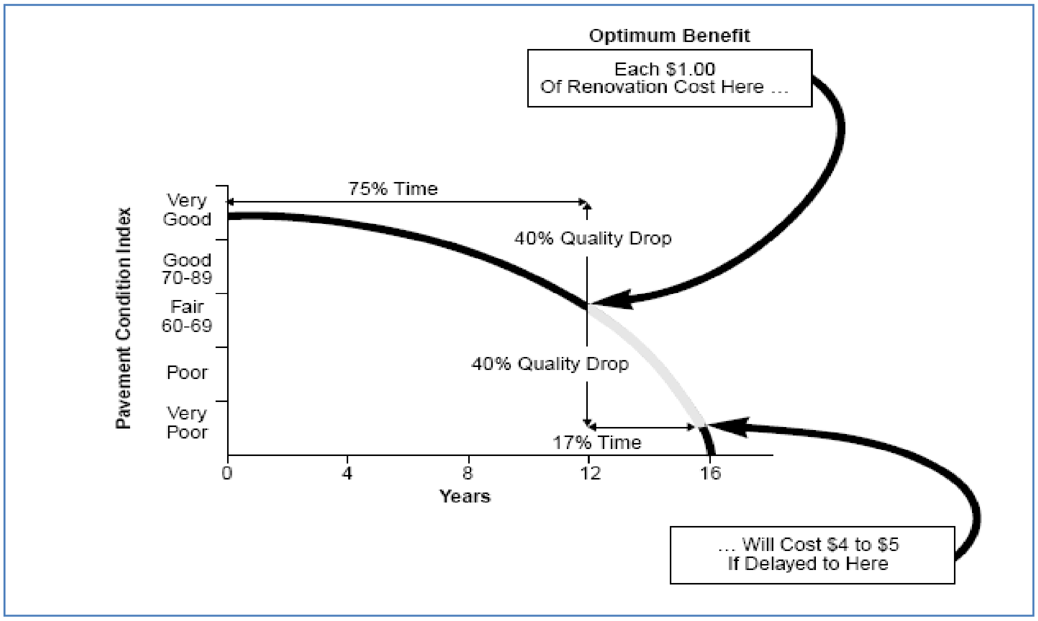
The selection of the most appropriate pavement preservation/renewal treatment option is primarily dependent upon the overall pavement condition, type of pavement failures, and pavement age relationship.

The graphic below (from the Local Agency Pavement Management Application Guide, published by The Northwest Technology Transfer Center) illustrates the application of example "treatment options" based on PCI.



It should be noted that the categorization of the treatment options (based on existing PCI ranges) provides general guidance for determining system-wide maintenance strategies, and subsequent financial needs, and is not the sole criterion used by staff to determine the appropriate treatment or repair method for a given street at the time of construction.

The diagram below represents the relationship of the value of the needed investment to restore the pavement to a very good condition from where the current condition of the pavement might be (i.e. costs vs. PCI):



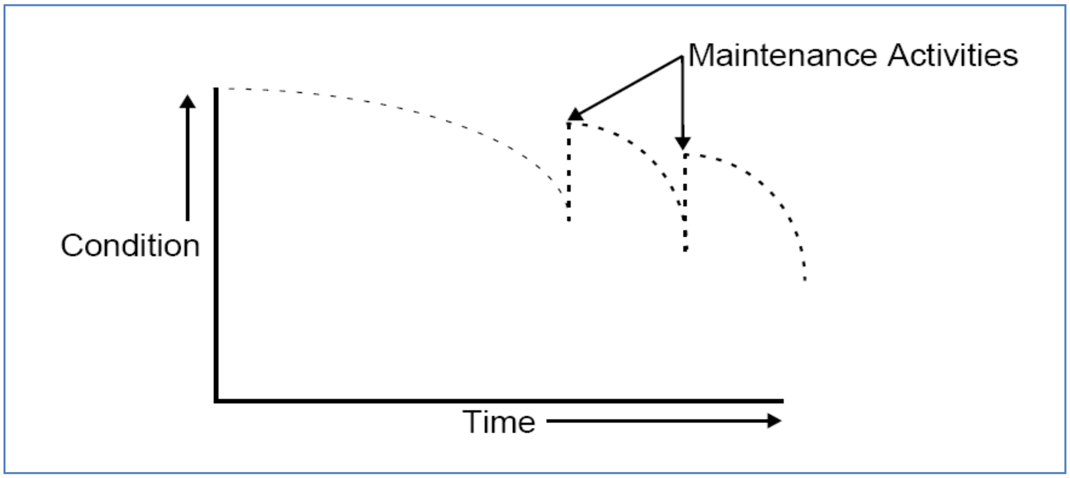
The table below provides a cost comparison between the types of pavement restoration treatments based on local and regional project examples:

Type of Treatment	Unit Cost*
Crack Sealing	$1.00 - $1.50 per lin. ft.
Fog Sealing	$1.00 - $2.00 per sq. yd.
Slurry Sealing	$1.50 - $4.00 per sq. yd.
Chip Sealing	$2.50 - $4.00 per sq. yd.
Microsurfacing	$3.00 - $4.50 per sq. yd.
Thin Overlay	$30 - $40 per sq. yd.
Mill and Overlay	$40 - $50 per sq. yd.
Full Depth Reclamation	$150 - $170 per sq. yd.
Reconstruction	$200 - $230 per sq. yd.

***These unit costs are approximate (will vary based on project scope/size) and intended to illustrate the comparative magnitude of treatment type versus cost**

Based on these factors, it is apparent that the most cost effective investment strategy is to renovate/renew pavements about every 8-10 years. This approach leads towards achieving the “lowest life-cycle” investment costs possible, for providing effective transportation services.

This "tactical pavement renovation investment strategy," whereby smaller, incremental improvements are deployed to increase pavement condition is illustrated in the following diagram:



What this discussion demonstrates is the most economically viable way (i.e. resulting in lowest lifecycle costs) to manage roadways is to "keep good roads good." At those junctures for strategic investment (identified as "Maintenance Activities" above), a corresponding increase in the PCI resulted. This is contrary to a "worst roads first" investment philosophy, which is often the perception of roadway users and unfortunately practiced by some roadway authorities.

The Oregon Department of Transportation published a recent report (Rough Roads Ahead: The Cost of Poor Highway Conditions to Oregon's Economy) which highlights the following:

> ***"Bringing deteriorated roads and bridges back to good condition costs significantly more than keeping them in good condition."***

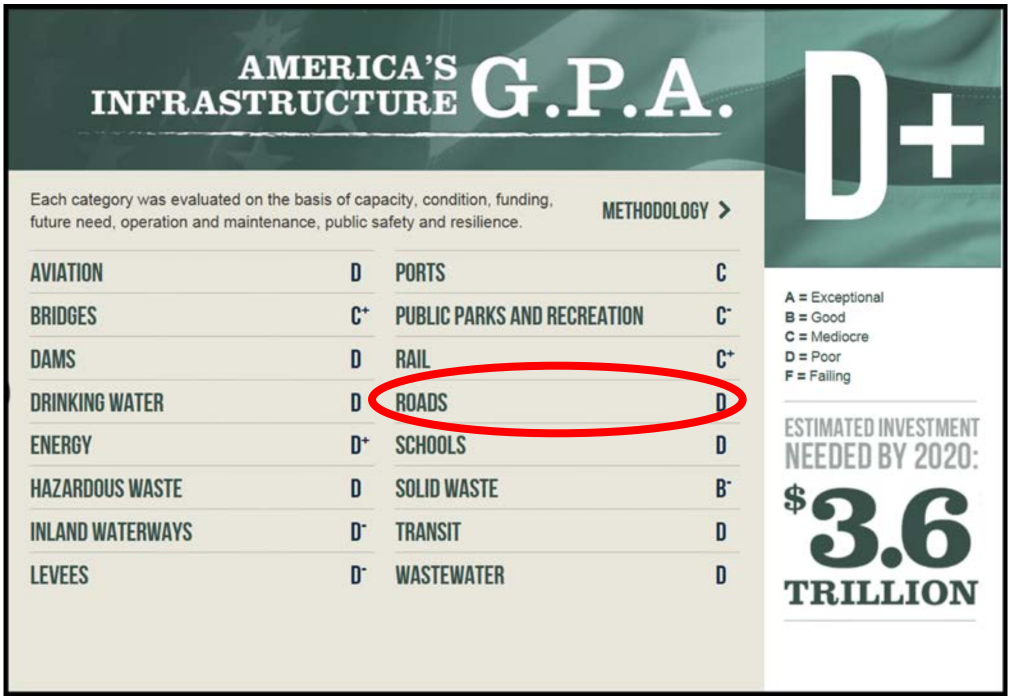
In addition, this report makes good arguments regarding how poor roadway conditions negatively impact other economic, social, and environmental factors (i.e. commerce, livability, air quality, safety, etc.) within our communities.

The "keep good roads good" investment strategy has already been adopted by the City of Albany. **Strategic Plan** (***"Theme: I. Great Neighborhoods"***) **Goal 2**[2], specifically "***Objective GN-4***[3]," documents the City's intention to maintain the City's roadway network. This objective prioritizes "collector and arterial" streets above local streets. In general, collector and arterial streets have been maintained at or near "satisfactory" condition; however, local streets have been maintained below this level of condition for many years to this point.

The Current Economic and Social Reality:

Unfortunately, funding challenges for roadways are not unique to the City of Albany. To illustrate this assertion, below is the "2013 Report Card for America's Infrastructure" from the American Society of Civil Engineers (ASCE):

[2] Goal 2: Provide an efficient transportation system with safe streets and alternative modes of transportation.
[3] Utilize available street funding to maintain collector and arterial streets (95 total lane miles) in satisfactory or better condition and address local street needs as funding allows. Additionally, seek other sources of funding for the street system.



Highlighted is the Grade of D for Roads. Currently, the Federal Highway Administration estimates that $170 billion in capital investment would be needed on an annual basis to significantly improve conditions and performance in the U.S.

Conclusion:

Communities across the country are faced with deteriorating infrastructure and inadequate funds to maintain and/or restore that infrastructure to desired levels. By utilizing a pavement asset management approach for street systems, communities can conduct system wide evaluations to prioritize improvements and establish strategies for infrastructure investments that achieve the lowest lifecycle cost possible. These strategies typically rely on the "keep good roads good" approach; a concept Albany has relied on for many years with arterial and collector streets.

Lastly, an effective pavement management program provides a comprehensive and transparent synopsis of the "state of the streets," and clearly articulates City Council policies and goals to efficiently manage, operate, and maintain the community's vital surface transportation system. As noted, clearly articulated, attainable, and sustainable investment and funding strategies are crucial for managing stakeholder expectations (i.e. tax and rate payers), and establishing trust in policy makers and transportation system managers to deliver effective and efficient roadway system services.