180078

To: Public Works and Environmental Concerns Committee
Through: Carl Goldsmith, Director of Public Works
From: Ray Schwab, Civil Engineer II
Date: January 31, 2018
Subject: Pavement Management Procedures and Policy

Background

With the implementation of a comprehensive asset management software system (Cartegraph) in March of 2016, the Public Works Department replaced its 20 year old pavement management software and converted to the pavement management system (PMS) module within the Cartegraph Operations Management System (OMS) software package.

Aspiring to achieve a fundamental snapshot of the current condition of all roadways that the Lombard maintains, the Village entered into a professional services agreement with Cartegraph. Professional pavement engineers and a specialized pavement rater inventoried, inspected and evaluated the Village's roadway network. This established a reliable and accurate baseline condition for all pavements. The resulting information was imported into OMS. Lastly, a formal technical report that includes a network summary (functional class and pavement type), present condition (overall condition index), various funding scenarios and program recommendations was prepared. That Executive Summary Report is included as an attachment to this memorandum.

Refer to the Village webpage under the Construction Project Information page, specifically under the Roadway Pavement Survey & Inventory Project for additional project background information (http://www.villageoflombard.org/5434/25153/Roadway-Pavement-Survey-Inventory?activeLiveTab=widgets).

Goals and Implementation of PMS/OMS

In 1993 the American Public Works Association (APWA) defined pavement management in the following way: "*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.*"

Achieving a successful PMS process involves the following 7 steps[1];
Step 1: Defining the Pavement Network &Collecting Data
Step 2: Collecting Condition Data Distresses
Step 3: Predicting Future Conditions
Step 4: Selecting the Appropriate Pavement Treatments
Step 5: Report Results Analysis
Step 6: Selecting the Proper Pavement Management Tools
Step 7: Keep the Process Current

OMS and the raw data collected by Cartegraph achieves the first 5 steps of the process. For step 6, Village staff will need to make practical recommendations based on the collected data, current distress curves and decision matrices. This process will play a large part in the 5 to 10 year CIP planning process regarding the forecasting of roadway maintenance and improvements projects. PMS in conjunction with the other modules of the OMS system will assist in developing CIP project priorities based on location, pavement condition, functional classification, the condition of other assets within roadway segments and

the eligibility of the project for grants or outside funding. For step 7 staff and administration must continue to commit time and resources to ensure that decisions based on dependable and accurate data.

Recommendations

Staff recommends the following policies and procedures pertaining to PMS (OMS) be incorporated into the CIP process. Please cross-reference with those recommendations listed on page 15 of the Cartegraph report.

1. **BUDGET SCENARIOS**
   Given the Village's current budget constraints, staff recommends that the current programmed funding level of $3.75M to $4.00M be maintained until additional funding sources become available. This keeps the Overall Condition Index (OCI) at the same level as inventoried by Cartegraph in the fall of 2017. Staff will focus on maintenance tasks so as to ensure the full service life of a roadway (refer Figure 1 on Page 5 of the Cartegraph report, the Pavement Performance Curve) thus maximizing the effectiveness of CIP dollars.

2. **REGULAR PAVEMENT INSPECTION AND CONDITION UPDATES**
   Staff recommends that the Village continue to collect pavement condition data every10 years for the entire network (versus the 3 years recommended by Cartegraph) and every 5 years for Collector/Arterial roadways. Future pavement data collection should include structural condition evaluations using Ground Penetrating Radar (GPR) testing, Falling-Weight Deflectometer (FWD) testing, and pavement coring in areas where historical data is poor or non-existent.

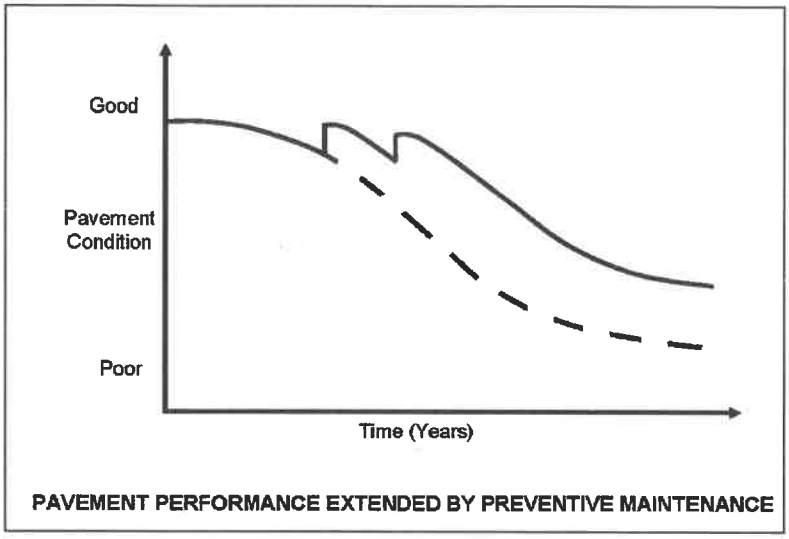
3. **SETTING ACCEPTABLE LEVELS OF PAVEMENT PERFORMANCE THRESHOLDS**
   This is a very dynamic topic that needs to be reviewed yearly during the early development of OMS/PMS/CIP process. The Village Board of Trustees, Public Works and Environmental Concerns Committee and Public Works staff must work together to balance acceptable levels of service versus the amount of available funding.

4. **MAINTENANCE AND REHABILITATION ALTERNATIVES**
   Village staff concurs with Cartegraph that strategies will need to be periodically reviewed to ensure pavement conditions are being addressed at the appropriate time and that budget dollars are used effectively. Staff will continue to monitor the use new products, techniques and technologies through professional societies (ASCE, APWA, NAPA & ACPA), publications, seminars, IDOT and fellow municipalities.

5. **MONITORING CRITICAL PAVEMENT CONDITION LEVELS**
   As Cartegraph states, maintaining pavements above critical condition levels is important as it is more costly to repair a pavement segment once it deteriorates below an acceptable condition level (those with an OCI of 50 or below). Currently, the Village's roadway network has 11%)of roadways that fall below that threshold. Staff recommends that a goal of 8% of the Village's pavement network be under an OCI level of 50 in 5 years and in 10 years that 2% of the Village's pavement network be under an OCI level of 50.

6. **PREVENTATIVE MAINTENANCE**
   As stated in the Cartegraph report, early intervention (i.e. preventative maintenance) will result in longer pavement life cycle. Using the right treatment on the right road at the right time for the right reason is critical for maximizing the effectiveness of available funding. Delaying or deferring preventative maintenance can result in an exponential cost increase for pavement restoration. Staff recommends that aggressive preventative maintenance of newly reconstructed

and resurfaced roadways be continued and regularly scheduled maintenance be applied as programmed. This will noticeably reduce the rate at which the OCI declines. Refer to the figure below[2].



PAVEMENT PERFORMANCE EXTENDED BY PREVENTIVE MAINTENANCE

7. **DATA INTEGRITY AND REVIEW**
   Staff concurs with Cartegraph that it is imperative to maintain good records (construction history updates), keep pavement inventories current and to invest time in reviewing prediction curves, treatment types, treatment costs and decision protocols on an annual basis.

Summary

Staff seeks the Public Works and Environmental Concerns Committee's input on levels of services, (i.e. overall OCI levels) suggested levels of funding and general overall PMS policy based on the Cartegraph report and proposed staff recommendations as stated in the attached report and this memorandum. Based upon the Committee's direction, a Pavement Management Policy will be developed that will articulate the Village's goals and objectives for an effective pavement management system.

REFERENCES

1 Illinois Center for Transpiration, *Implementing Pavement Management Systems For Local Agencies*, August 2011

2 Bureau of Design and Environmental Manual, Illinois Department of Transportation, Division of Highways, *Chapter 52 Pavement Preservation*, Published September 2010, Revised January 2018

OTHER SOURCES

Bureau of Design and Environmental Manual, Illinois Department of Transportation, Division of Highways, *Chapter* 53 Pavement Rehabilitation, Published September 2010, Revised January 2018

The Book on Better Roads, Author; Blair Barnhardt, APM, Published by The Barnhardt Group, Kennesaw Georgia.

Cartegraph

Village of Lombard, IL | Pavement Management Report

Executive Summary Report

Date: February 1, 2018
Prepared by: Cartegraph

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1.0 Executive Summary

Introduction

Roadway infrastructure strategic planning has become an essential component in the management of public facilities driven by aging roadways, population growth, and the current reality of constrained maintenance budgets. Emphasis is now being placed on not only knowing the true cost of providing services to the public but also understanding what will be required to maintain an acceptable level of services throughout the life of the asset. Most organizations are moving to sustainable asset management, which includes determining the best scenario where resources become most effective.

The Village of Lombard, IL retained Cartegraph to perform pavement condition assessments and support the Village's Operations Management System (OMS) initiatives. This project included pavement condition assessment, conducted in Fall 2017, on approximately 148 centerline miles of the Lombard's roadway network. It also includes an upload of all required pavement condition data into the Lombard's OMS Program as well as budget and condition based scenario analysis on 148 miles of roadway that is directly under the Village's maintenance jurisdiction.

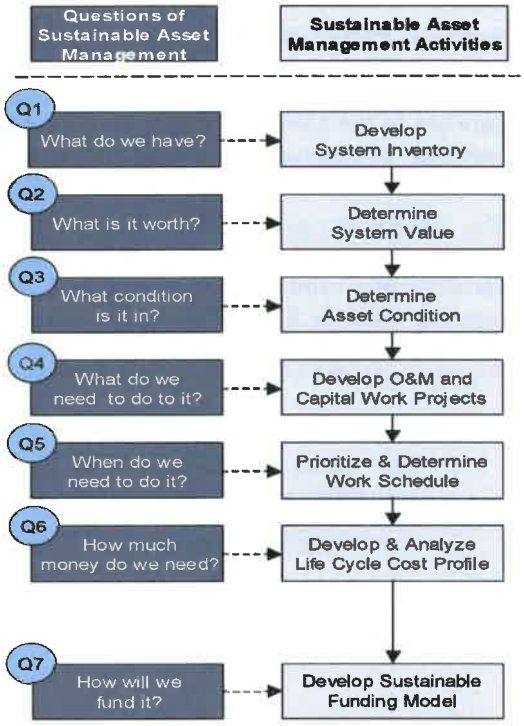
Lombard now can use the results of the pavement condition assessment to review:

- The overall performance of the Village's pavement network to provide recommended rehabilitation strategies to maintain/improve the condition of the Village's streets.
- A centralized, comprehensive and consistent pavement inventory data.
- Timely and objective pavement condition results and summaries.
- The present status of a complete, network-wide pavement needs assessment.

2.0 Basic Principles

Lombard's approach to this project is grounded in the principles of sustainable asset management and is based upon seven fundamental questions.

1. What do you have and where is it? (Inventory)
2. What is it worth? (Costs/Replacement Rates)
3. What are its condition and expected remaining service life? (Condition and Capability Analysis)
4. What is the level of service expectation and what needs to be done? (Capital, Operation and Maintenance Plans)
5. When do you need to do it? (Prediction, Capital, and Operating Plans)
6. How much will it cost and what is the acceptable level of risk(s)? (Short- and Long-term financial planning identified by Village staff)
7. How do you ensure long-term affordability? (Short- and Long-term Plan resulting from the study)



This report and associated recommendations will provide the basis for answering these questions.

Answering the seven fundamental questions outlined above helps create a plan for successful asset management. It also should be noted asset management is not just a set of procedures and steps, but a philosophy of the Village's organizational culture. This also applies to the community and Village Committee and Board levels. The Pavement Management Report will provide Village staff with a series of important tools, which can be used to begin the education and communication process.

Pavement Preservation is "a program employing a network level, long-term strategy that enhances pavement performance by using an integrated, cost-effective set of practices that extend pavement life, improve safety and meet motorist expectations."

Source: FHWA Pavement Preservation Expert Task Group

Lombard's Pavement Management Program

The Village's pavement management system, which is a part of the Lombard OMS, is a program designed to assist with the management, maintenance, and construction of roadways. This software program provides a means to collect, store, and analyze information on pavement conditions and determine treatment needs to make optimal use of capital funds. OMS does not replace the knowledge of the Village staff but can be a valuable tool to assist with the overall transportation assets planning needs.

Through a systematic analysis of pavement life cycles, OMS can determine the most cost-effective means to keep pavements functioning at a desirable condition level. **Figure 1** below illustrates the need for a roadway "wellness" program. As seen in **Figure 1**, one dollar spent on pavement preservation activities early in a roadway's life could translate to a saving of up to ten dollars over the life of the roadway. This shows the benefits and needs of why Lombard should maintain a working pavement management program.

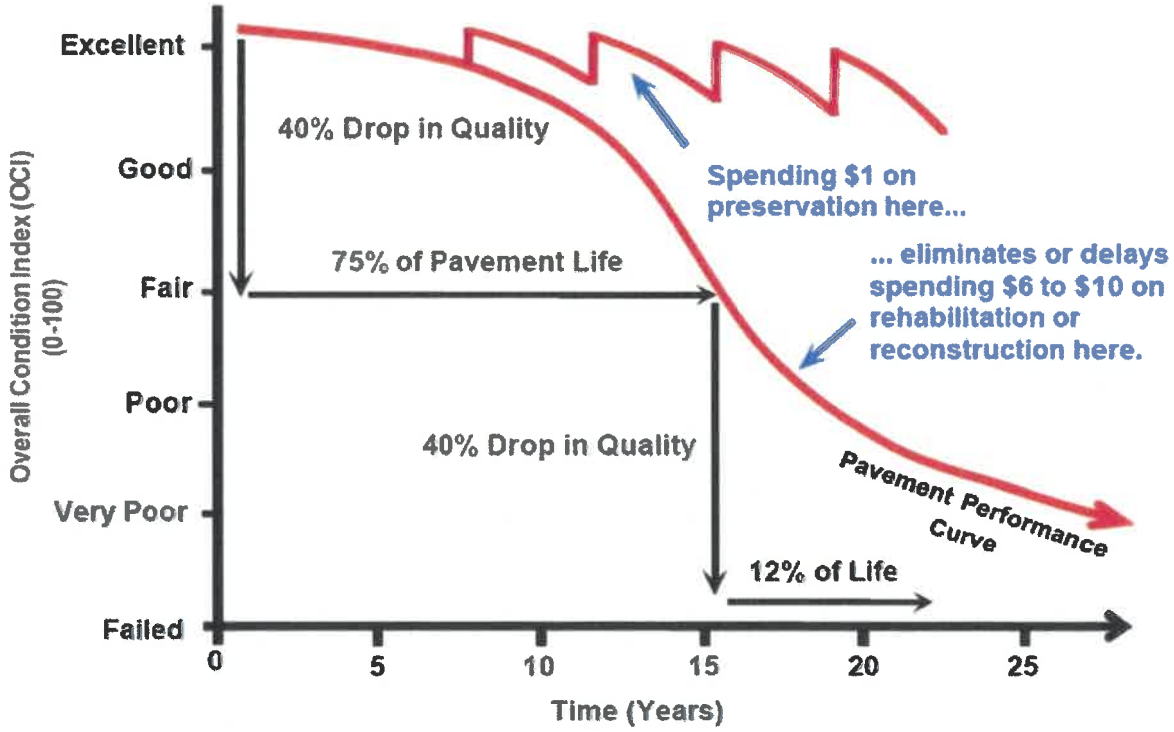


Figure 1. The relationship between pavement condition and maintenance cost over time (adopted from Principles of Pavement Preservation FHWA-SA-99-015)

3.0 Pavement Condition Assessment Approach and Results

What condition is it in?

The overall current pavement condition, also known as the *present status*, is extremely important because it provides useful data to the users and provides the information necessary for subsequent analysis. The objective of the present status analysis is to provide updated performance information on the roadway network and allow the Village to evaluate:

- The **deterioration** of roadways as determined by the performance indicators; and,
- The **overall change** in the network performance indicator distributions over time.

Pavement Condition Index (PCI)

PCI provides an important set of pavement condition criteria that can be used to determine the costs to maintain a roadway network. The Lombard's average PCI, based on the most recent inspection data, is **74.2**. The pavement condition evaluation is performed based on three components:

- **Type** is defined as 'What is the defect?' in terms of the classification of the type of distress observed on the pavement surface.
- **Severity** is defined as 'How bad is the defect?' in terms of the measurement or degree of wear associated with the condition of the pavement surface.
- **Extent** refers to quantity or 'How much?' of the pavement is affected by a particular surface distress.

The extent and severity of each pavement surface distress type are combined using different weighting factors to generate a PCI for each pavement section. This rating can range from 0 to 100. A value of 100 indicates that the surface of the roadway section is free of distress and a value less than 30 is generally accepted to be in poor condition. A PCI value of 60 generally marks the point at which the distresses are becoming noticeably significant.

The calculation of the PCI is based on methods described in the ASTM D-6433-11 Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys.

Figure 2 illustrates a typical pavement condition rating scale: Typical values for a newly constructed roadway range from 90 to 100. The PCI level at which a pavement becomes in need of rehabilitation is typically in the 35 to 65 range. Based on the PCI rating scale displayed in **Figure 2**, the Village's average PCI of 74.2 corresponds to an average pavement condition of Very Good. Pavement networks that are in Very Good condition are perfect candidates for pavement preservation activities such as asphalt overlays, surface treatments, and localized repairs. If pavements in Very Good condition are left untreated, they will eventually require a more significant rehabilitation or reconstruction to improve their condition in the future.

Figure 2: Typical Pavement Condition Index (PCI) Rating Scale

Since the Village's OMS describes pavement condition in terms of Overall Condition Index (OCI), OMS has been programmed to equate PCI values for each segment as the segment OCI. In other words, pavement segment PCI and OCI describe the same value and are interchangeable.

Figure 3 below shows the roadway network performance indicator represented by the OCI range of the Village's roadway network.

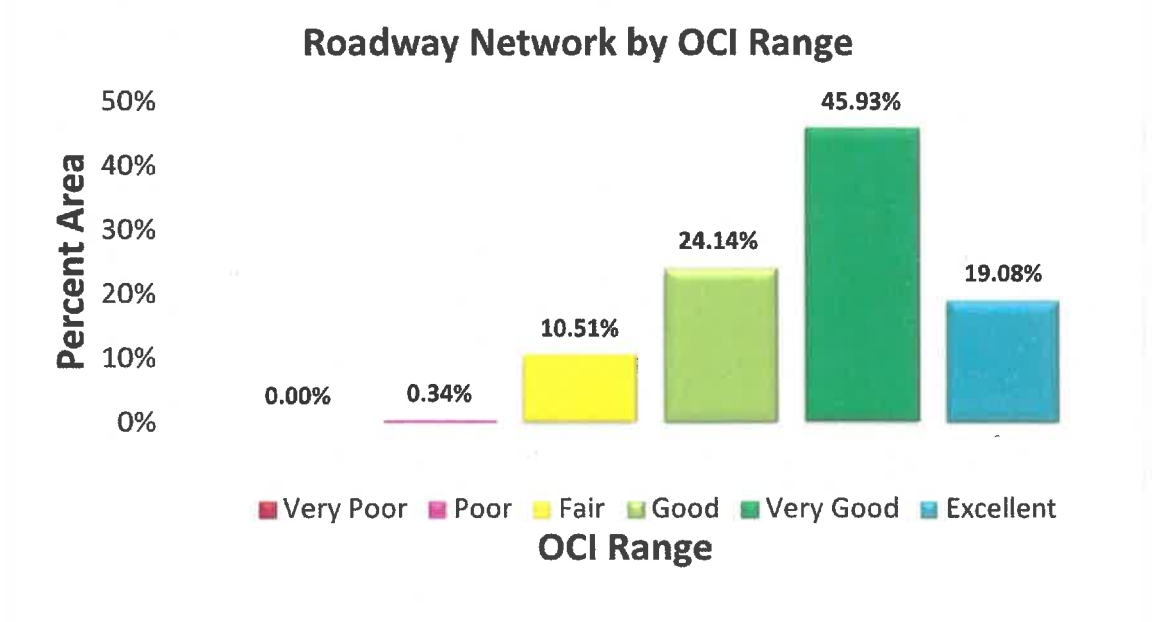


Figure 3: Network Condition by OCI Range

The Roadway Inventory Report, with the most recent inspected OCI values for the Village roadway network, is presented in **Appendix A**. This report is listed by street, and also includes pavement class, functional class, and OCI values for each pavement section of roadway.

To help better correlate PCI values with visual condition of streets, **Figures 5 through 12** below exhibit pictures of roadway pavements at different PCI values. Roadway pavements ranging in value from a PCI of 90 to a PCI of 21 are included. The pictures show that the amount and severity of distresses gradually and consistently increase as the PCI of the pavement decrease.

All pictures presented in these figures represent roadway pavements found within Lombard's pavement network.

90 OCI

Asphalt Concrete

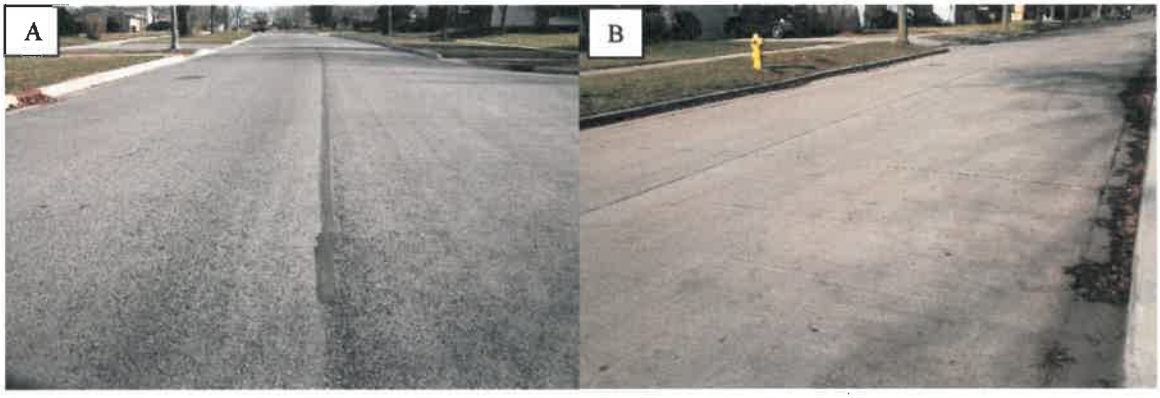


Figure 5: (a) Lilac Way between Lodge Ln and Bradley Ln with a 90 PCI

(b) Highland Ave between Madison St and Washington Blvd with a 90 PCI

80 OCI

Asphalt Concrete

Figure 6: (a) Magnolia Cir between Cherry Ln and Lilac Way with an 81 PCI

(b) Hammerschmidt Ave between Harrison Rd and Taylor Rd with an 82 PCI

70 OCI

Asphalt Concrete

Figure 7: (a) Harding Rd between Elizabeth St and Lincoln St with a 72 PCI
(b) Washington Blvd between Main St and Garfield Terr with a 71 PCI

60 OCI

Asphalt Concrete

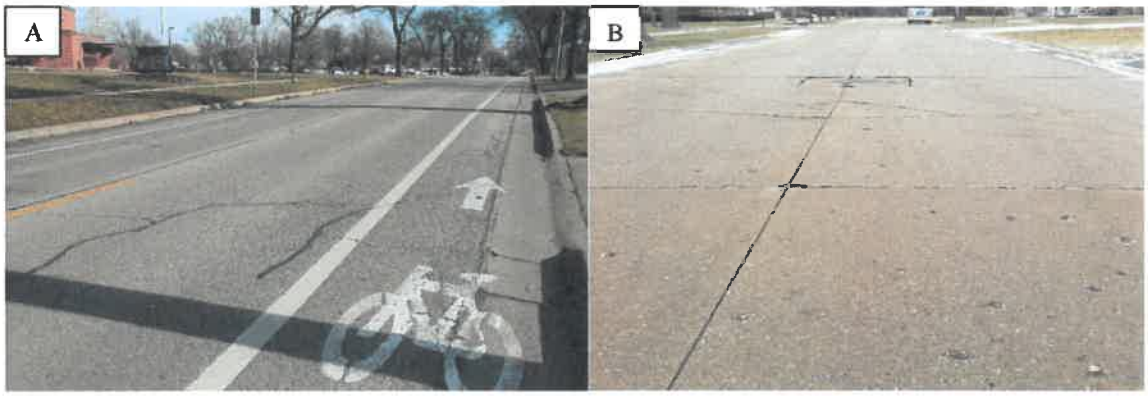


Figure 8: (a) Madison St between Green Valley Dr and Park Rd with a 60 PCI
(b) Taylor Rd between Lombard Ave and Grace St with a 62 PCI

50 OCI

Asphalt Concrete

Figure 9: (a) Edson Ave between Wilson Rd and Central Ave with a 52 PCI
(b) Wilson Rd between Hammerschmidt Ave and Stewart Ave with a 52 PCI

40 OCI

Asphalt Concrete

Figure 10: (a) Garfield Terr between Hickory St and Washington Blvd with a 40 PCI
(b) Fairfield Ave between Pleasant Ln and Berkshire Ave with a 41 PCI

30 OCI

Asphalt Concrete

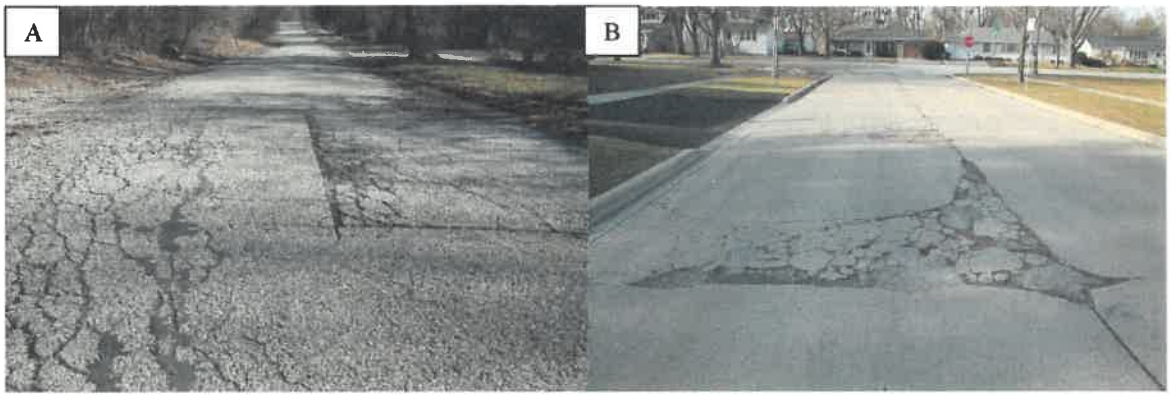


Figure 11: (a) Willow St between Vance St and Finley Rd with a 32 PCI
(b) Pleasant Ave between Charlotte St and Main St with a 30 PCI

20 OCI

Asphalt Asphalt

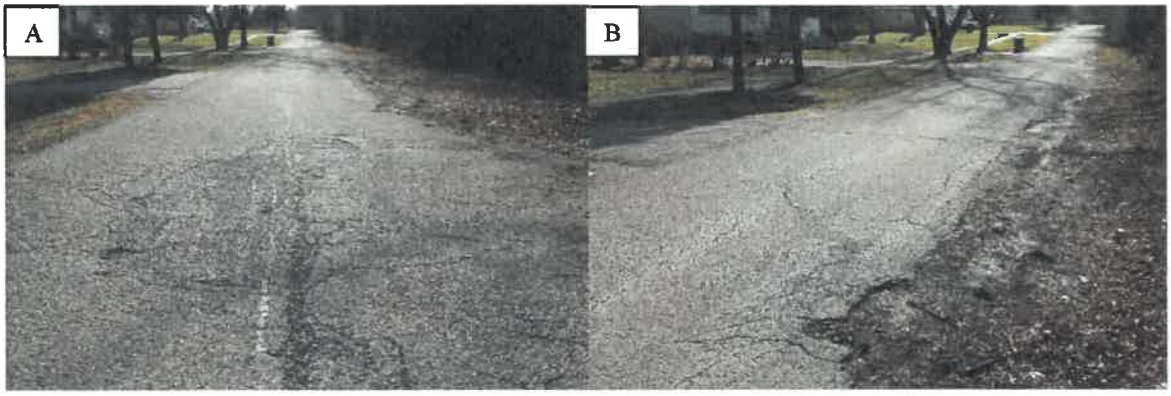


Figure 12: (a) Vance St between Willow St and Hickory St with a 21 PCI
(b) Vance St between Willow St and Hickory St with a 21 PCI

Ride Index (RI)

To adequately represent drivers' opinions of roadway conditions, a roadway profiling device is used to measure roughness or ride quality. The roughness profiling device meets the Class 1 ASTM E 950-98 designation for measuring the longitudinal profile of traveled surfaces. Class 1 profilers produce the highest standard of accuracy measurement provided in the industry.

The roadway profile data is used to assess how rough or smooth each roadway segment is. This ride quality assessment is termed the Ride Index (RI). Similar to the PCI, the resulting RI values can range from 0 to 100 in value. A value of 75 to 100 indicates an extremely smooth ride and a value of 0 to 25 indicates a rough ride. The Ride Index can only be determined for pavements where the test vehicle can maintain a speed of 15 mph or higher; therefore, some pavement segments within the Village's pavement may not have an associated Ride Index. For those segments that RI data could be successfully measured, the Ride Index is available for each road segment within the Village's OMS.

Figure 4 illustrates a typical roughness index scale. Based on the RI rating scale displayed in **Figure 4**, Lombard's average RI of 92.4 corresponds to an average ride quality of Excellent.

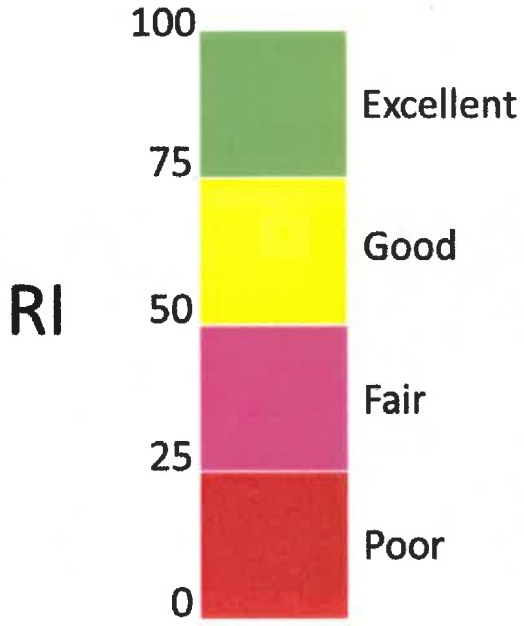


Figure 4: Typical Roughness Index Scale

What do We Have?

The roadway network that serves Lombard consists of a series of pavement segments which have functional classifications ranging from Arterial to Local. The data used to compile the pavement inventory was extracted from the Village's OMS database. The roadway network, according to functional classification, has been displayed in **Table 1** below. **Table 2** shows the roadway network according to pavement classification.

Table 1: Pavement Network Statistics by Functional Classification

Functional Classification	Weighted-Average Inspected OCI	Pavement Area, sqft	Sections	Pct Area
Arterial	76.8	3,593,757	264	18.4%
Collector	79.8	1,545,550	134	7.9%
Local	73.1	14,423,027	1,057	73.7%
Summary	**74.3**	**19,562,334**	**1,455**	**100%**

Table 2: Pavement Percent Area by Pavement Classification

Pavement Classification	Weighted-Average Inspected OCI	Pavement Area, sqft	Sections	Pct Area
Asphalt	71.9	14,998,079	1,119	76.7%
Concrete	81.9	4,564,255	336	23.3%
Summary	**74.2**	**19,562,334**	**1,455**	**100%**

What is it worth?

The estimated replacement value of the roadway pavement, based on 2017-dollar value, is approximately **$287 Million**. **Table 3** below provides a breakdown of the replacement value of the roadway network by pavement classifications. The unit costs used in **Table 3** are approximations and actual costs may vary; however, **Table 3** points towards the fact that the Village's pavement network is worth over 286 million dollars and that Lombard is taking the right step towards sustainable asset management by using OMS to manage the pavement network.

Table 3: Pavement Network Replacement Value

Pavement Classification	Pavement Area, sqft	Replacement Cost, $/sqft	Replacement Value
Asphalt	14,998,079	$ 13.00*	$ 194,975,027
Concrete	4,564,255	$ 20.00*	$ 91,285,100
Total	**19,562,334**		**$ 286,260,127**

**The replacement cost reflects pavement maintenance/reconstruction cost and do not overall roadway reconstruction cost.*

4.0 Rehabilitation Plan and Budget Development

What do we need to do to it?

The Village's OMS uses a decision tree approach to determine the technically feasible rehabilitation alternatives for each pavement section. The basic philosophy of the decision tree approach is to maximize the flexibility of the program. The decisions are user-defined to ensure that the process accurately models the decision process employed by the Village. **Appendix H** presents the treatment strategies and associated unit costs for all OCI triggers that are used to perform the budget and condition analysis. This treatment strategy was developed in conjunction with information gathered from Village staff and Cartegraph pavement management specialists.

When do we need to do it?

The estimation of when a pavement segment will need maintenance or rehabilitation is primarily based on pavement condition and pavement deterioration rate. Pavement performance models are used to apply the appropriate deterioration rate to each pavement segment over time and forecast the future condition of pavement segments. Pavement segments become candidates for maintenance or rehabilitation when their conditions reach or dip below their acceptable condition level.

How much money do we need?

The amount of funding required is determined by identifying the optimal rehabilitation strategy for each pavement section. This process is based on three parameters:

- Need year (year treatment is triggered)
- Appropriate treatment type
- Priority programming

Selecting the optimal strategy involves an assessment of the effectiveness of each strategy and an estimate of the capital cost to implement the maintenance and rehabilitation plan. This makes it possible to generate a maintenance and rehabilitation program based on an economic analysis for a given programming period.

Multiple funding scenarios can be analyzed on the Village's pavement network to answer "what-if" questions. Four budget scenarios have been generated for the period starting from January 1, 2019, and running for 5 years until December 31, 2023. The following is a list of the scenarios analyzed:

- ✓ Scenario 1 – Current budget *(Appendix D)*
- ✓ Scenario 2 – Increased budget of $5M Per Year *(Appendix E)*
- ✓ Scenario 3 – Maintain Current Condition OCI of 74 *(Appendix F)*
- ✓ Scenario 4 – Reach and Maintain OCI of 80 *(Appendix G)*

See **Appendix C** for a table and graph of all four budget and condition scenarios.

Scenario 1 – Current Budget

The Current budget scenario predicts what could happen to the Village's roadway network if an average annual funding of $3.8M is allocated for maintenance and rehabilitation. $3.75M per year is the estimated current annual funding available for the maintenance and rehabilitation of the Village's roadway pavement; actual annual funding varies from $2.5M to $5.3M over the analysis period. Under this scenario, Lombard would see the network OCI maintain its current (2017) value by the end of the analysis period. The OCI at the beginning of the analysis is 74.2 and it has an OCI of 74.3 by the end of the 5-year period. According to this scenario, 47% of the 5-year budget should be dedicated for

regular and preventative maintenance activities, while 53% of the budget should be earmarked for major repair, rehabilitation, and reconstruction projects.

Scenario 2 – Increased Budget

The Increased budget scenario predicts what could happen to the Village's roadway network if $5M per year is allocated for maintenance and rehabilitation. The increased budget is approximately 33% higher than the current budget. Under this scenario, the Village would see the network OCI increase by 6 points by the end of the analysis period. The OCI at the beginning of the analysis is 74.2 and it improves to an OCI of 80.2 by the end of the 5-year period. According to this scenario, 60% of the 5-year budget should be dedicated for regular and preventative maintenance activities, while 40% of the budget should be earmarked for major repair, rehabilitation, and reconstruction projects.

Scenario 3 – Maintain Current Condition

This scenario illustrates the costs of maintaining the pavement network condition at its current condition at OCI of 74 (at the time of the most recent inspection) during the analysis period. This scenario will cost the Village approximately **$3.5 million** per year to maintain the OCI over the 5-year period. According to this scenario, there should be an even split of the total 5-year budget between regular and/or preventive maintenance projects and major repair, rehabilitation, and reconstruction projects.

Scenario 4 – Reach and Maintain OCI of 80

This scenario illustrates the costs of increasing and maintaining the pavement network condition at an OCI of 80 during the analysis period. This scenario increases the Village's OCI by 6 points and will cost Lombard approximately **$5.8 million** per year over the 5-year period. According to this scenario, 28% of the 5-year budget should be dedicated for regular and preventative maintenance activities, while 72% of the budget should be earmarked for major repair, rehabilitation, and reconstruction projects. A larger portion of the budget is dedicated for major rehabilitation and reconstruction projects so that the goal of reaching an OCI of 80 by adding 6 points could be reached by rehabilitating/reconstructing roadway pavements with relatively low OCI values.

Discussion of Results

The four scenarios show a good contrast based on how each one yields a different average OCI result at the end of the analysis period. The results also give important insight to the Village to easily examine the effect of a specified budget stream on the overall performance of the network. Other sensitivity analyses, such as the effect of variations in rehabilitation unit costs, required pavement serviceability (Critical OCI) levels, rehabilitation, and treatment policies can also be evaluated to improve the decision-making matrix in the Village's work planning process.

The result of Scenario 1 shows that an annual budget of $3.75M will result in maintaining the current average OCI over the next 5 years whereas Scenario 2 shows that an annual budget of $5M will result in an improved OCI over the next 5 years. The results of Scenarios 3 and 4 show the funding required to reach and maintain higher OCI levels (74 and 80, respectively). While the resulting OCI from Scenarios 2 and 4 are preferable, the funding requirements for these scenarios are significantly higher than the funding used in Scenarios 1 and 3. **Appendices D – G** include detailed project selection and activity planning for each of the scenarios analyzed.

How do we ensure long-term affordability?

The accumulated investment of public funds expended to construct and maintain a pavement network amounts to a substantial figure. The Village roadway network contains over 148 centerline miles which represent over 19 million square feet of pavement. The replacement cost, as shown in **Table 3**, is estimated to be over **$286 million**. Total replacement is not a feasible plan for long-term affordability. To implement a more feasible approach, data concerning the condition of the network, its rate of deterioration, and the impact of maintenance and rehabilitation efforts on pavement serviceability levels are required. Lombard is on the right path to attain long-term affordability and the Village should continue to be proactive in the ongoing monitoring of its comprehensive pavement management system.

Recommendations

Budget Scenarios: The budget scenarios presented in **Appendix C** illustrate the effect different funding levels have on the Village's pavement management programming needs. Based on the 5-year budget and condition-driven results, the Village's suggested annual budget of $3.75M is sufficient to maintain the current condition whereas the increased annual budget of $5M is sufficient to improve the roadway network condition and meet a 5-year goal of reaching an average OCI of 80. It is imperative that the approach of working on roads in good and fair condition as well as those with low OCI values is followed. By balancing the need to maintain roadway segments that are in good condition and the desire to rehabilitate those that are in poor condition, the Village may be able to efficiently use its resources and reverse the continued deterioration of the roadway network. If not efficiently maintained, the network will deteriorate making it more difficult and costly to achieve the desired service levels.

Regular Pavement Inspection and Condition Updates: It is recommended that the Village continue to collect pavement condition data approximately every three years for the entire network. This is particularly important given the Village's desire to continue to monitor the status of the roadway network condition and react promptly with the appropriate treatment strategies. Not doing so will limit the reliability of the program's prediction modeling of future pavement performance and recommended rehabilitation forecast. Additionally, it is recommended that the Village considers further investigations of the structural condition of street sections that may require rehabilitation. Structural condition evaluations may be performed using Ground Penetrating Radar (GPR) testing, Falling-weight Deflectometer (FWD) testing, and pavement coring. These tests will enable the Village to evaluate the structural and subgrade characteristics of the tested street segments and allow for better rehabilitation and/or reconstruction designs. Cartegraph can continue to assist the Village with these structural evaluations and integrate the results with the Village's OMS to enable the Village to make better maintenance decisions.

Setting Acceptable Levels of Pavement Performance Thresholds: The benefit of early intervention (setting higher OCI triggers) allows for less expensive maintenance strategies to be implemented early on that can extend the life of the pavement. The downside to setting treatment triggers at a higher level is that it can create a maintenance backlog that may quickly become unmanageable. On the other hand, setting the OCI triggers at a lower threshold results in the Village's overall network pavement performance deteriorating with little intervention. Striving to maintain a pavement management program to sustain a manageable service level is the ultimate goal. This is an on-going process within the pavement program and it may take several years and iterations to find the right balance.

Maintenance and Rehabilitation Alternatives: The Village's OMS uses a decision tree approach to determine the technically feasible rehabilitation alternatives for each pavement section. **Appendix H** presents the Village's treatment strategies and associated unit costs for all OCI triggers that were used to perform the budget and condition analyses. The current treatments and selection criteria appear to be reasonable; however, it is good to constantly monitor and adjust ranges as needed. It is recommended that these strategies be reviewed each year to ensure pavement conditions are being addressed at the appropriate time and that budget dollars are used efficiently.

Monitoring Critical Pavement Condition Levels: It is important to maintain pavements above critical condition levels for two reasons–safety and cost-effectiveness. It is more costly to repair a pavement segment once it deteriorates below an acceptable condition level. The analysis of the OCI data reveals that only **11 percent** of the Village's pavement network has deteriorated to a point (OCI below 50) where costly rehabilitation or even reconstruction may be needed. On the other hand, most of the network (**89 percent**) is at the condition level where routine and preventive maintenance actions may be effective in preserving and prolonging the pavement infrastructure. Performing the right treatment at the right time is very important in the programming process. Delaying or deferring preventative maintenance can potentially result in an exponential increase in the cost of restoring the pavement in the future.

Preventative Maintenance: Continuing to apply preventative maintenance to roads in fair to good condition is recommended in order to extend the life of the Village's pavement network. Over time, this approach can produce substantial savings of taxpayers' dollars and improve the overall condition of the Village's pavement for everyday users. The Village may want to look at splitting dollars between

maintenance work and rehabilitation work to see if spending more money on rehabilitation will keep the network at a higher OCI. **Appendix H** presents the treatment strategies for all OCI triggers that were used to perform the budget and condition analysis.

Data Integrity and Review: As the pavement management program depends on, not only the annually-collected data but also the data in Lombard's OMS, it is imperative that the Village maintains good record-keeping. It is equally important that the Village invest time in reviewing prediction curves, treatment types, treatment costs, decision protocols, construction history updates, and overall data completeness on an annual basis.

Summary

It is recommended that the Village develop a policy that identifies the target OCI and review all maintenance and rehabilitation criteria so that Lombard can reach pavement management goals in a cost effective manner. By beginning the process of educating the community about the need for sustainable management of the pavement infrastructure, the financial impact to residents or users can be significantly reduced, especially if a reserve fund is utilized to mitigate the impact of future peaks in investment needs. This report includes the essential tools which can be used to begin the education and communication process, thus providing a systematic method to assist decision-makers in:

1. Selecting cost-effective strategies and actions to increase the safety and service life of their pavement network.
2. Protecting the investment made to the pavement network.

By developing and implementing a comprehensive pavement management program, the village may best serve the community's needs. Ultimately, the goal is to provide the residents and businesses of the Village of Lombard with a safe and efficient transportation network and protect the value and condition of one of the Village's most valuable assets. Cartegraph looks forward to continuing assisting The Village of Lombard on future projects and answering any questions that can contribute to the achievement of this goal.

List of Appendices

Appendix A — Roadway Inventory Report
Appendix B — Performance Indicators Graphs and Tables
Appendix C — Budget and Condition Scenarios
Appendix D — Scenario 1: Current Budget
Appendix E — Scenario 2: Increased Budget
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Appendix H — Rehabilitation Activities and Unit Rates