The 2016 Ohio Department of Transportation (ODOT) pavement database has 3,626 segment records for the Northeast Ohio Areawide Coordinating Agency (NOACA) region. The NOACA region has a total of 3,330 centerline miles of roadways including freeways and federal-aid highways which is equivalent to 8,561 lane-miles. The regional segment average Pavement Condition Ratings (PCR) is about 77.

In the City of Seven Hills there are 3.66 centerline miles of federal-aid roads, which are equivalent to 12.18 lane-miles within the city boundary that include State Route 176 (SR 176). The 2016 ODOT pavement database has four segment records for the City of Seven Hills roadway system. Each record comprises of several fields of various information and measures such as Street name, Length (miles), Lane-miles length, Number of Lanes, Function Class, Pavement Condition Ratings (PCR), etc.

According to the PCR measure, all the pavement lane-miles are currently in the “Good” to “Very Good” condition. Some kind of preventive maintenance is always recommended while the road is still in good condition.

This pavement study includes four parts:

- Part I: The 2016 pavement network condition,
- Part II: The 2018 backlog,
- Part III: The Maintenance and Rehabilitation (M&R) program,
- Part IV: The Comparative analysis.

Considering the five-year study period of 2018 – 2022, this pavement study focuses on the required preventive maintenance treatments and some rehabilitation techniques rather than reconstruction.

Part I of this study analyzes the 2016 pavement network condition and tabulates the important information of all the four road segments in the City of Seven Hills.

In Part II, the backlog is defined as the cost of pavement rehabilitation of all roads within one year (2018) and bringing the average network PCR to 80. Backlog is a “snapshot” or relative measure of outstanding rehabilitation work.

Part III introduces the optimal preventive maintenance and rehabilitation strategy for each segment and its recommended implementation year based on the NOACA maintenance decision tree.

Finally, Part IV compares the backlog and the “M&R” program with the NOACA transportation asset management strategies. All these strategies were compared regarding their costs, the average network PCR and percent of the lane-miles below the acceptable level.
The City of Seven Hills is located in Cuyahoga County. Seven Hills was originally part of Independence Twp., incorporated as a village in 1927 and as a city in 1961. The early history of Seven Hills is closely tied to the development of the two neighboring communities of Independence and Brooklyn. Independence was known early for its orchards, vineyards, and stone quarries, prominent in the area before the Civil War. Later, large areas of land were cleared and used for farming. In 1914 the eastern portion of Independence Twp. was incorporated as the Village of Independence. The remainder of the township later became the Village of Seven Hills.

As of the Northeast Ohio Areawide Coordinating Agency (NOACA) 2015 estimates, the city had a population of 11,581 and employment of 3,555. The City of Seven Hills highway includes State Route 176 (SR 176). Cleveland-Hopkins International Airport is the nearest airport.

Map 1 illustrates the City of Seven Hills location in the NOACA region.
Map 1: City of Seven Hills Location in the NOACA Region
For the purpose of this study:

**Pavement Reconstruction** is defined as the replacement or reestablishment of the original pavement structural capacity by the placement of the equivalent or increased pavement structure. Reconstruction may utilize either new or recycle materials for the reconstruction of the complete pavement structure.

**Pavement Rehabilitation** is defined as resurfacing, restoration, and rehabilitation (3R) work consisting of structural enhancements that extend the service life of an existing pavement and/or improve its structural capacity. Rehabilitation techniques include restoration treatments and/or structural overlays. This may include partial recycling of the existing pavement, placement of additional surface materials, and/or other work necessary to return an existing pavement to a condition of structural or functional adequacy.

**Preventive Maintenance** is considered as cost effective treatments to an existing roadway system and its appurtenances that preserves the system, delays future deterioration, and maintains or improves the functionality condition of the system without increasing structural capacity. Projects that address deficiencies in the pavement structure or increase the structural capacity of the facility are not considered preventive maintenance.

Maintaining the roadways in a state of good repair is essential and experience has shown that, over time it is less expensive to invest in preventive maintenance and/or rehabilitation in an ongoing basis rather than in reconstruction of pavement that has deteriorated to a poor condition.

This pavement study analyzes the current status of the Seven Hills pavement network condition and considers the five-year study period of 2018-2022. It mainly focuses on the required roadway pavement preventive maintenance treatments and some rehabilitation techniques rather than reconstruction. The 2016 Ohio Department of Transportation (ODOT) pavement database was used as the input data and RoadMatrix software was utilized as the NOACA Pavement Management platform.

Seven roadway pavement preventive maintenance and rehabilitation treatments were considered in the Seven Hills pavement network analysis for the study period and Table 1 illustrates the selected treatment and their associated planning level costs.
### Table 1: Selected Pavement Treatments and Their Planning Level Costs

<table>
<thead>
<tr>
<th>Maintenance Treatment Type</th>
<th>Cost per SQ FT (2016$)</th>
<th>Estimated Cost per 12-FT lane-Mile (2016$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crack Fill</td>
<td>0.08</td>
<td>5,100</td>
</tr>
<tr>
<td>Joint Repair</td>
<td>0.24</td>
<td>15,200</td>
</tr>
<tr>
<td>Crack Fill and Slurry</td>
<td>0.4</td>
<td>25,300</td>
</tr>
<tr>
<td>Preventive Maintenance Minor</td>
<td>0.5</td>
<td>31,700</td>
</tr>
<tr>
<td>Micro – Pave Type</td>
<td></td>
<td>Surface Treatment</td>
</tr>
<tr>
<td>Selective Patch, Mill and 1.5” O/L</td>
<td>1.5</td>
<td>95,000</td>
</tr>
<tr>
<td>2.0 inch Hot Mix Mill and Overlay</td>
<td>1.9</td>
<td>120,400</td>
</tr>
</tbody>
</table>

### Pavement Maintenance Treatment Definitions

**Crack Fill**: it is the placement of asphalt emulsion into non-working cracks to reduce water infiltration and to reinforce the adjacent pavement.

**Slurry Seal**: a mixture of fine aggregate, asphalt emulsion, water, and mineral filler, used when the primary problem is excessive oxidation and hardening of the existing surface. Slurry seals are used to retard surface raveling, and improve surface friction.

**Joint Repair**: used to remove deteriorated concrete pavement long joint/crack repairs. It minimizes infiltration of surface water and incompressible material into the joint system.
Preventive Maintenance (Minor): typically applied to pavements in good condition having significant remaining service life. Examples of minor preventive treatments include asphalt crack sealing, chip sealing, slurry or micro-surfacing, thin and ultra-thin hot-mix asphalt overlay, and concrete joint sealing.

Micro – Pave (Type II Surface Treatment): consist of the application of a mixture of water, asphalt emulsion, aggregate (very small crushed rock), and chemical additives. It is used to treat surfacing and rut filling on roads that get moderate to heavy levels of traffic.

2.0in Hot Mix Mill & Overlay: applied as a maintenance treatment. Thin overlays should only be placed on structurally sound pavements. That is because they offer little structural improvement, but they can renew the surface in terms of functional performance (i.e., ride quality).

Selective Patching, Mill & 1.5 O/L: it is primarily done to extend the life of a roadway. Patch mill and overlay projects are designed to remove damaged portions of the roadway and replace it with new smooth pavement.

This report includes the following four parts:

I. The 2016 status of the Seven Hills pavement network condition,

II. The 2018 “backlog” treatment list,

III. The optimal preventive maintenance and rehabilitation strategies, and

IV. The comparative analysis.
PART I: 2016 PAVEMENT CONDITION

In order to provide an accurate assessment of the current status and further pavement analyses, the pavement network is required to be divided into homogeneous discrete sections in terms of surface distress, traffic volumes, pavement structure, etc. The 2016 ODOT pavement database has four segment records for the City of Seven Hills roadway system. Each record comprises of several fields of various information and measures such as Street name, Length (miles), Lane-miles length, Number of Lanes, Function Class, Pavement Condition Ratings (PCR), etc.

Based on the utilized ODOT database, there are 3.66 centerline miles of federal-aid eligible roads which are equivalent to 12.18 lane-miles in the City of Seven Hills. The total area of roadway is 849,024 Sq. Ft.

The PCR measure is a qualitative description of the structural state of the pavement. The PCR values span a spectrum of descriptive narrative ranging from “Very Good” to “Very Poor”. Each roadway segment is scored from 0 to 100 with 0 representing completely distressed pavement and 100 indicating perfect pavement condition. The lane-mile weighted average of the City of Seven Hills segment PCRs is about 87. Table 2 and Figure 1 summarize the 2016 Seven Hills pavement network conditions by percentages of roadway lane-miles length.

Table 2: 2016 Seven Hills Pavement Network Condition

<table>
<thead>
<tr>
<th>Pavement Condition</th>
<th>PCR Range</th>
<th>Lane-Miles</th>
<th>Percent of Lane-Miles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Poor</td>
<td>0 - 39</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Poor</td>
<td>40 - 54</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Fair to Poor</td>
<td>55 - 64</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Fair</td>
<td>65 - 74</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Good</td>
<td>75 - 89</td>
<td>11.46</td>
<td>94.1%</td>
</tr>
<tr>
<td>Very Good</td>
<td>90 - 100</td>
<td>0.72</td>
<td>5.9%</td>
</tr>
</tbody>
</table>
As indicated, all the pavement lane-miles are currently in the “Good” to “Very Good” condition and the lane-mile weighted average PCR also represents a “Good” condition. Some kind of preventive maintenance is always recommended while the road is still in good condition.

Map 2 illustrates the 2016 Seven Hills roadway pavement condition for each segment record and Table 3 tabulates the 2016 Seven Hills pavement condition listing.
Map 2: 2016 City of Seven Hills Pavement Condition

Pavement Condition Rating
- Very Poor, 0 - 39
- Poor, 40 - 54
- Fair to Poor, 55 - 64
- Fair, 65 - 74
- Good, 75 - 89
- Very Good, 90 - 100
- Municipal Boundary
Table 3: 2016 City of Seven Hills Pavement Condition Listing

<table>
<thead>
<tr>
<th>ROAD NAME</th>
<th>FROM</th>
<th>TO</th>
<th>FUNCTION CLASS</th>
<th>LANE-MILES</th>
<th>PCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>HILLSIDE RD</td>
<td>SR 176</td>
<td>SEVEN HILLS ECL</td>
<td>MAJOR COLLECTOR</td>
<td>2.46</td>
<td>86</td>
</tr>
<tr>
<td>PLEASANT VALLEY RD</td>
<td>SR 176</td>
<td>LUDWIN DR</td>
<td>PRINCIPAL ARTERIAL-OTHER</td>
<td>4.88</td>
<td>87</td>
</tr>
<tr>
<td>ROCKSIDE RD</td>
<td>MURAL DR</td>
<td>LOMBARDO CENTER</td>
<td>PRINCIPAL ARTERIAL-OTHER</td>
<td>0.72</td>
<td>94</td>
</tr>
<tr>
<td>ROCKSIDE RD</td>
<td>W 9TH ST</td>
<td>MURAL DR</td>
<td>PRINCIPAL ARTERIAL-OTHER</td>
<td>4.12</td>
<td>85</td>
</tr>
</tbody>
</table>
**PART II: 2018 CURRENT BACKLOG**

The backlog is defined as the cost of pavement rehabilitation of all roads within the current year (2018) and bringing the average network PCR to 80. Backlog is a “snapshot” or relative measure of outstanding rehabilitation work. The backlog not only represents how far behind the pavement network is in terms of its present physical condition, but also its cost value serves as a benchmark to measure the impact of various funding strategies. Additionally, the current backlog offers a basis for comparison to future and/or past year’s backlogs.

The backlog strategy does not utilize any pavement preventive maintenance treatments, but instead considers rehabilitation or reconstruction treatments. This strategy achieves the average network PCR 80, and also maintains all the pavement conditions above the minimum acceptable level. In this study, the minimum acceptable PCR for the arterial roadway function class is 55 and for the major and minor collector is 50.

Results of the analysis indicate that there is no recommendation for pavement reconstruction treatments under the current 2018 backlog strategy. As illustrated, the average network PCR for the current year (2018) is 84.8, and all pavement conditions are above the minimum acceptable PCR.
In order to estimate the preventive maintenance and rehabilitation requirements of a pavement network over a period of time, the first step is to determine the “Need Year” or when a pavement segment requires rehabilitation. The “Need Year” of a pavement is defined as the year in which the pavement condition falls below a critical level. Pavement condition of a road segment deteriorates under traffic, climate, etc. and consequently its PCR value is reduced. Without any treatments and depending on the deteriorating factors, pavements perform differently and Figure 2 depicts the typical acceptable level and “Need Year” relation for several road segments. As shown, the definition of the acceptable level is a critical factor in determining the “Need Year” for any road segment.

In this study, the critical level is set by the minimum acceptable PCR. As mentioned earlier, in the NOACA region, the minimum acceptable PCR for the arterial roadway function class is 55 and for the major and minor collector is 50.

**Figure 2: The PCR Acceptable Level and “Need Year” Relation**
The second step is to determine any feasible preventive maintenance and/or rehabilitation strategies based on a decision tree approach. The “M&R” program determines the optimal preventive maintenance and rehabilitation strategy for each segment and its recommended implementation year based on the considered decision tree. The Appendix includes all the “M&R” treatments for the identified segments with the implementation year in the period of 2018 to 2022 and the “M&R” program cost includes all the deferred maintenance cost.
PART IV: COMPARATIVE ANALYSIS

The current NOACA transportation asset management policy includes two strategies:

- Maintain 15% Deficiency: this strategy attempts to maintain the total lane-miles with PCR below the acceptable level no more than 15%.

- Maintain an Average Network PCR of 80: applies a set of maintenance treatments in order to keep the roadway network average PCR more than, or equal to 80 over the study period.

This section compares the discussed backlog and the “M&R” program treatments with the NOACA transportation asset management strategies.

In addition to the above strategies, this comparative analysis considers another scenario as the minimum benchmark. The “Maintain Lowest Standard PCR” treatment strategy is based on the minimum PCR thresholds of 55 for arterials and 50 for collectors and a set of annual budget constraints. The annual budget constraints are calculated in three steps: First, the segments with the “M&R” recommended implementation in each specific analysis year are selected. Second, a subset of the selected segments which their “Need Years” are in the analysis period are identified. It should be noted that the selected segments with the “Need Year” beyond the analysis period are excluded from the budget constraint calculation. Third, the “M&R” treatment costs for the identified segments in the second step, are added together to provide an annual budget constraint for this scenario.

As discussed, all the above scenarios apply a decision tree approach to determine technically feasible maintenance and rehabilitation strategies for each segment requiring rehabilitation during the five-year period.

Table 4 summarizes the comparison results of all the above scenarios over the five-year period for the City of Seven Hills. In this table, the “5-Year Total Required Dollars” column shows the accumulation of the annual costs over five years calculated based on inflation-adjusted dollars for each strategy. Also, the Network average PCR is the lane-mile weighted average.
Table 4: Performance Comparison of the Constraint Scenarios

<table>
<thead>
<tr>
<th>Maintenance Strategy</th>
<th>Strategy Group</th>
<th>5-Year Total Required Dollars</th>
<th>Network Average PCR</th>
<th>Network PCR at the End of the 5-Year Period</th>
<th>Percent of Pavement below the Minimum PCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018 Current Backlog</td>
<td>2018 Backlog</td>
<td>0</td>
<td>84.8</td>
<td>-</td>
<td>0%</td>
</tr>
<tr>
<td>Maintain 15% Deficiency</td>
<td>NOACA Transportation Asset Management Targets</td>
<td>0</td>
<td>81</td>
<td>77</td>
<td>0%</td>
</tr>
<tr>
<td>Maintain an Average Network PCR of 80</td>
<td>Scenarios</td>
<td>236,508</td>
<td>81.5</td>
<td>79.6</td>
<td>0%</td>
</tr>
<tr>
<td>M&amp;R Program</td>
<td>Scenarios</td>
<td>336,906</td>
<td>86.4</td>
<td>85.3</td>
<td>0%</td>
</tr>
<tr>
<td>Maintain Lowest Standard PCR</td>
<td>Scenarios</td>
<td>0</td>
<td>81</td>
<td>77</td>
<td>0%</td>
</tr>
</tbody>
</table>

Note: The backlog required budget is for the year of 2018 only.

The Appendix lists all the treatments with their implementation years in the period of 2018 to 2022 for the above maintenance strategies.

Figure 3 illustrates the annual network average PCR for the discussed maintenance and rehabilitation strategies. It should be noted that the backlog scenario has only one value of 84.8 for 2018.
Figure 3: Average PCR Comparison by the Constraint Scenarios and by Year
As expected, the treatments of the “M&R” program maintain the pavement network condition with the highest network average PCR. This strategy a budget of over 300 thousands dollars during the analysis period.

The estimated cost of the “Maintain an Average Network PCR of 80” scenario is about 70 percent of the “M&R” budget and its network average PCR is six points less than that of the “M&R” program at the end of the five-year period.

There are four pavement segments in the city which are in the “Good” or “Very Good” conditions. Therefore, the “Maintain Lowest Standard PCR” and the “Maintain 15% deficiency” scenarios do not recommend any treatments for the analysis period.

The 2018 average network PCR is over 84 and therefore the 2018 backlog policy do not recommend any treatments. In order to maintain the current “Good” pavement condition, it is recommended to invest on the annual maintenance policy with much smaller budget rather than spending on the reconstruction treatments with high costs.
APPENDIX

2018 Current Backlog

As indicated in Table 4, the “2018 Current Backlog” cost is zero. Results of the analysis indicate that there is no recommendation for pavement reconstruction treatments under the 2018 current backlog strategy. As illustrated, the average network PCR for the current year (2018) is 84.8, and all pavement conditions are above the minimum acceptable PCR.
Maintain 15% Deficiency

As indicated in Table 4, the “Maintain 15% Deficiency” cost is zero and therefore, this strategy does not recommend any pavement maintenance treatments.
Maintain an Average Network PCR of 80

Pavement Treatment List

<table>
<thead>
<tr>
<th>ROAD NAME</th>
<th>FROM</th>
<th>TO</th>
<th>RECOMMENDED TREATMENT</th>
<th>LANE-MILES</th>
<th>IMPLEMENTATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROCKSIDE RD</td>
<td>W 9TH ST</td>
<td>MURAL DR</td>
<td>MICRO - PAVE (TYPE II SURF. TR.)</td>
<td>4.12</td>
<td>236,508, 2022</td>
</tr>
</tbody>
</table>

THE 2022 REQUIRED BUDGET FOR THE “MAINTAIN AN AVERAGE NETWORK PCR OF 80” STRATEGY $236,508

Note: The “Maintain an Average Network PCR of 80” strategy does not have any pavement maintenance treatments with the recommended implementation years of 2018, 2019, 2020 and 2021.
### M&R Program

**Pavement Treatment List**

<table>
<thead>
<tr>
<th>ROAD NAME</th>
<th>FROM</th>
<th>TO</th>
<th>RECOMMENDED TREATMENT</th>
<th>LANE-MILES</th>
<th>IMPLEMENTATION</th>
<th>COST (2019$)</th>
<th>YEAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROCKSIDE RD</td>
<td>W 9TH ST</td>
<td>MURAL DR</td>
<td>PREVENTATIVE MAINTENANCE MINOR</td>
<td>4.12</td>
<td>152,182</td>
<td>2019</td>
<td></td>
</tr>
<tr>
<td>PLEASANT VALLEY RD</td>
<td>SR 176 (BROADVIEW RD)</td>
<td>LUDWIN DR</td>
<td>PREVENTATIVE MAINTENANCE MINOR</td>
<td>4.88</td>
<td>184,724</td>
<td>2020</td>
<td></td>
</tr>
</tbody>
</table>

**THE 2019 REQUIRED BUDGET FOR THE “M&R” PROGRAM**

- $152,182

**THE 2020 REQUIRED BUDGET FOR THE “M&R” PROGRAM**

- $184,724

Note: The “M&R” program does not have any pavement maintenance treatments with the recommended implementation years of 2018, 2021 and 2022.
**Maintain Lowest Standard PCR**

As indicated in Table 4, the “Maintain Lowest Standard PCR” cost is zero and therefore, this strategy does not recommend any pavement maintenance treatments.