PAVEMENT CONDITION SURVEY

Prepared For:

Town of Carrboro

April 2019

LaBella
Powered by partnership.

LaBella Associates, P.C.
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Town of Carrboro
Pavement Condition Survey

Final Report- April 2019

N.C. License # C-0430

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Town of Carrboro, North Carolina
2019 Pavement Condition Survey

I. INTRODUCTION

LaBella Associates, P.C. (LaBella) is a consulting engineering firm with offices in Greensboro, Winston-Salem, and Charlotte, North Carolina. LaBella specializes in serving public agency clients and offers a full range of municipal engineering services in transportation, infrastructure management, stormwater management, water and sewer, neighborhood improvements, solid waste and recycling, and construction administration disciplines.

LaBella was retained by the Town of Carrboro (Town) to perform a pavement condition assessment of the Town street system. LaBella identified approximately 46.61 miles of Town maintained asphalt roadway. A visual pavement condition survey of these streets was conducted by LaBella. These street segments were rated by driving each segment on a block to block basis and observing eight common pavement surface distresses and their corresponding severity levels.

The data from the observations on the rated streets was entered into an automated pavement management software program which generated a Pavement Condition Rating (PCR) for each street segment (see Table 7 on page 10 for methodology). In addition, the pavement management program generated recommended maintenance activities to address the deficiency on each street segment. Recommended secondary, third, and fourth maintenance activities and costs, when applicable, were also calculated by the software and entered into the final database. Costs for the recommended maintenance activities were calculated using current local unit maintenance costs provided by the Town of Carrboro (See Table 10, page 14).

Streets are listed based on Pavement Condition Ratings (PCRs) assigned as the "Rating" attribute within the database. Streets were categorized by the municipality as either low volume (Class A) or high volume (Class B) streets. Certain low volume or high volume streets may have higher or lower importance for the municipality based upon the number of dwelling units served, commercial traffic, or projected land development and traffic growth.

II. FINDINGS

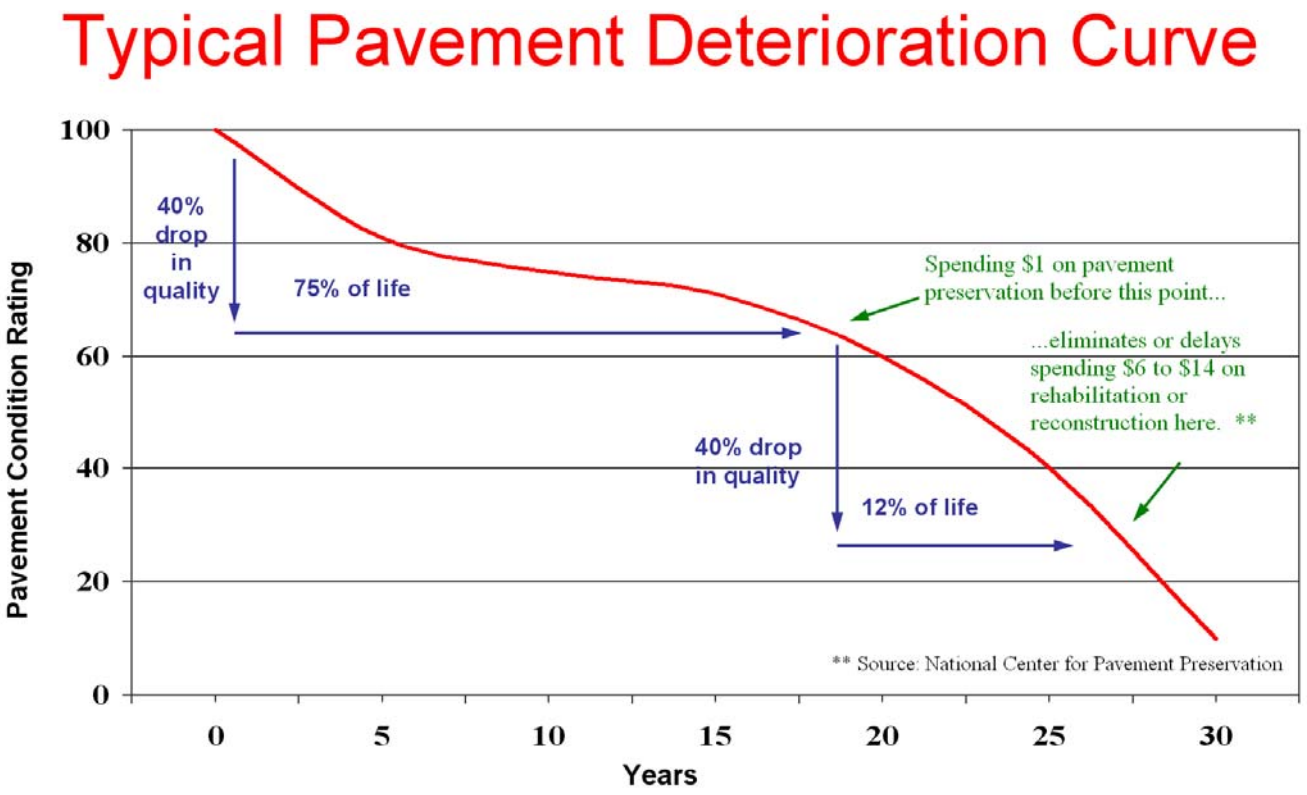
The Town of Carrboro's street system is in "Good" condition with an overall weighted average PCR value of 87.3. This is an increase from 86.1 since the 2014 Pavement Condition Survey. This overall condition rating is slightly above average when compared to other municipalities. To put this figure in perspective, the estimated weighted PCR value for NC municipalities is approximately 80. There are some streets that exhibit moderate and severe alligator cracking. Street segments exhibiting 50% or more of moderate to severe alligator cracking should be analyzed in further detail for consideration of total reconstruction.

The primary maintenance needs are crack sealing, patching and resurfacing to correct moderate to severe alligator cracking, and moderate to severe block cracking. Based upon the results of this survey, approximately 1.15 miles of streets or 2.47% of the rated street system is recommended for resurfacing within the next year. Resurfacing as well as other maintenance needs are determined based on the pavement distress, its severity level, and the traffic volume (low or high) of the street. Recommended maintenance activities for each pavement distress are detailed in Table 8 on page 13. Once these immediate needs are addressed, LaBella recommends that Carrboro resurface approximately 3.1 miles of street segments per year. This rate would provide

the generally accepted optimum 15 year paving cycle. See Typical Pavement Deterioration Curve below. Such a cycle will allow the Town to maximize the effectiveness of its maintenance funds by providing for timely resurfacing of streets before they deteriorate to a point where more expensive rehabilitation or reconstruction is needed. It is LaBella's recommendation that this year's street maintenance funds be allocated to include resurfacing and high priority routine maintenance, primarily full-depth patching and crack sealing.

Approximately 25.51% (11.89 of 46.61 miles) of the rated streets in the Town of Carrboro need some level of routine maintenance or resurfacing. This figure is below the average for North Carolina municipalities, which is approximately 47%. This survey indicated a total estimated maintenance need for crack sealing, full depth patching, short overlay, and plant mix resurfacing of approximately $657,292. This represents an average estimated expenditure of $14,102 per mile for the entire rated Town street system. It should be noted that **this cost estimate is for pavement repair only**. Additional costs of 25-40% can be incurred for drainage improvements, administration, milling (prior to resurfacing), utility adjustments, work zone traffic control, and other items.

Without a continued financial commitment and dedicated funding for street maintenance and resurfacing efforts, pavement ratings will decrease. Ultimately, postponing recommended maintenance activities typically leads to pavement failures and subsequently costly major rehabilitation or reconstruction. As can be seen from the Typical Pavement Deterioration Curve below, spending $1 on pavement preservation prior to a pavement condition rating of roughly 60 will eliminate or delay spending $6 to $14 on rehabilitation or reconstruction at a later date.



III. SUMMARY OF PAVEMENT CONDITION SURVEY

A. Procedures

The procedures used for this survey include:

- An inventory of the physical characteristics of selected segments of the municipality's streets. These characteristics include block number, length, number of lanes, width, type of pavement, presence of sidewalk and curb and gutter per street segment side, and asphalt height above gutter.
- Evaluation of the surface pavement distresses on selected street segments. Alligator cracking, block/transverse cracking, reflective cracking, rutting, raveling, bleeding, ride quality, and patching are measured according to well-defined severity levels. Alligator cracking is measured in detail by the percentage in increments of ten percent (10%) of the segment having each severity level (Light, Moderate, or Severe) of this distress. The other distresses are measured as an overall condition and categorized as light, moderate, or severe in distress level.
- Categorizing of the type of traffic volume on each segment. The municipality assigns all streets as either low volume or high volume streets. Low volume streets are typically lightly traveled residential streets. High volume streets are more heavily traveled arterial or collector streets and typically receive a higher level of maintenance and repair than low volume streets.
- Entering and compilation of the collected field and post processing information into a usable database management system. This Microsoft™ Access application **USI Total Pavement Access (USI-TPA**) enables the user to sort and query the Town street system database by street name, high or low volume class, priority (high, medium, or low), rating (PCR), maintenance activity, and distress type to access estimated cost information of selected query data.

B. Pavement Condition

The predominant distress types that require maintenance are alligator cracking (the most critical pavement distress), block/transverse cracking, and patching. Approximately 14.5% of the rated street system was noted as having some level of alligator cracking and approximately 75% of the rated street system exhibited some level of block cracking. Most of the block cracking was light, which requires no recommended maintenance at this time. Patching was noted on approximately 10.6% of the rated streets; most of this is in the form of light patching.

C. Priorities

Although all recommended maintenance activities are needed right away, for most public agencies there are typically more maintenance needs than funds available. Therefore, the suggested types of maintenance should be prioritized. High Priority maintenance should include full-depth patching, short overlay, and resurfacing of alligator cracking and rutting. Medium Priority maintenance includes resurfacing of severe block/transverse cracking, severe reflective cracking, severe raveling, and severe bleeding. Low Priority maintenance typically consists of resurfacing of moderate block/transverse cracking, moderate reflective cracking,

moderate raveling, rough ride quality, and moderate to severe patching. See Table 1 for maintenance priorities.

Carrboro should continue to dedicate its maintenance funding towards preventive maintenance practices and structural repair. This emphasis would reduce the rate of deterioration on pavements that exhibit light distress levels and it would extend the economic life of these streets by delaying the need for more costly maintenance or rehabilitation methods. Studies and empirical evidence from many agencies have shown that timely use of preventive maintenance practices is the most economically sound use of limited funds. Preventive maintenance and structural repair should also further reduce the maintenance cost per mile in future years. **Maintaining an aggressive patching and resurfacing program should be a high priority for the Town of Carrboro in tandem with allocating adequate funds and resources to accomplish this task**. Ultimately, postponing recommended maintenance activities typically leads to pavement failures and subsequently costly major rehabilitation or reconstruction.

In summary, LaBella recommends a continuation or expansion of current street maintenance funding. Carrboro has current needs of approximately $657,292 which does not include preparatory activities and administrative costs. This includes recommended resurfacing of 1.15 miles of street segments at a cost of approximately $236,849. It is recommended that once the immediate resurfacing needs are met, the Town budget for annual resurfacing of about 3.1 miles of street segments per year in order to achieve a desired 15 year resurfacing cycle. This will require nearly $633,000 annually at today's unit prices including preparatory patching. It is LaBella's recommendation that this year's and future street maintenance funds be distributed to include resurfacing and high priority routine maintenance. The Town currently has a need for routine maintenance measures of approximately $420,443. It would be desirable to secure sufficient funding to achieve the maintenance schedule recommended above. The Town should consider reviewing the budget for these measures annually in order to assure adequate funding for the optimum economic life of its street system.

TABLE 1
PRIORITY BY TYPE OF MAINTENANCE

PRIORITIES	Total Miles	Total Cost	Cost Per Mile	Percentage of Cost
HIGH PRIORITY: Routine Maintenance, Resurfacing of Alligator Cracking and Rutting	11.27	$553,365	$49,101	84.2%
MEDIUM PRIORITY: Resurfacing of Severe Block/Transverse Cracking, Severe Reflective Cracking, Severe Raveling, and Severe Bleeding	0.48	$74,568	$155,350	11.3%
LOW PRIORITY: Resurfacing of Moderate Block or Reflective Cracking and Raveling, Resurfacing of Severe Ride Quality and Patching	0.14	$29,359	$209,857	4.5%
Total Repairs	**11.89**	**$657,292**	**$55,281**	**100.0%**

D. Pavement Condition Survey and Management System

Information provided to the Town by our Pavement Condition Survey and Management System includes:

- An updated basic inventory of bituminous paved streets with block number, length, number of lanes, width, type of pavement, location of sidewalk and curb and gutter existence per street segment side, and asphalt height above gutter.
- Pavement distresses, by type and magnitude, along with the PCRs for each street segment.
- Recommended maintenance activities (primary and secondary) and anticipated repair costs.
- Digital copies of all data, reports, and charts.
- LaBella's Total Pavement Access (USI-TPA) application that enables the user to sort the Town database by street name, rating (PCR), maintenance activity, collected attributes and distress type. This program also allows the user to generate query summaries and alphabetical and rating (PCR) listings which can be printed to hard copy.
- List of street sections that includes field inventory data, distress ratings, and estimated repair function and cost data in an alphabetical listing and a listing of the street sections sorted by PCR from lowest to highest.
- List of street sections that includes field inventory data, distress ratings and estimated repair function and cost data for the high, medium, and low priorities highlighted in Table 1 on the previous page.

This information is advantageous for municipalities because:

- The survey is an objective evaluation of eight types of surface pavement distresses. Commonly accepted cost-effective maintenance practices are then recommended for repairing those pavement distresses.
- The survey permits the municipality to use its limited funds more cost efficiently for maintenance and resurfacing by prioritizing these activities.
- Streets with critical pavement distress are easily identified for further engineering investigation, testing, or pavement reconstruction.
- The computerized approach permits the municipality to vary the types of maintenance activities to allow budget planning for different levels of maintenance service.

E. Use of Survey Results

LaBella's Pavement Condition Survey is an objective evaluation of the amount and severity of eight types of pavement distresses. The inventory and analysis methods used for this project have been used for NCDOT and agencies throughout North Carolina and have proven to be valuable aids to street maintenance programs.

Municipal pavements are in a continuous state of deterioration. This deterioration rate depends upon many factors. Inadequate pavement thickness, unanticipated truckloads, and poor

drainage accelerate deterioration. Therefore, it is reasonable and prudent to conduct these surveys periodically (every 2 to 3 years) to monitor the condition of the street system.

Such periodic surveys not only indicate the rate of deterioration of the street system, but also provide the Town with a means to gauge the effectiveness of existing resurfacing programs and street maintenance activities. Additionally, these periodic surveys make it possible to build a history of all maintenance activities to assist in planning for more cost-effective maintenance procedures.

The results of the survey should never be used arbitrarily. There is no substitute for in-the-field engineering judgment and experience by Town personnel in determining the specific types of maintenance activities needed. The street ratings and recommended maintenance practices should be used as a guide for planning and scheduling maintenance activities.

It is the intent of this report to emphasize the importance of maintaining the Town roadway assets. Based on current industry pricing, it is estimated that the Town maintained streets, which are comprised of approximately 623,200 square yards of asphalt pavement, have an estimated value of $19.3 million. To be a good steward of the Town street system, it is prudent that preventative maintenance practices continue and that a sustained financial investment be made to maintain these roadway assets. “There is no more fundamental transportation capital investment than system preservation – keeping existing infrastructure in good condition. If preservation investment is deferred, costs increase dramatically, leading to the saying ‘pay me now or pay me more – lots more – later.” - Washington Department of Transportation 2007 – 2026 Highway System Plan.

In an effort to further Carrboro’s preventative maintenance practices, the Town could look at adding the following maintenance activities:

Maintenance Activities	Distress	Pavement Age	Benefit
Fog Seal Coating Fog Seal Rejuvenator	Light Oxidation	1 to 5 years	Replenishes asphalt chemicals; extends pavement life
Slurry Seal Microsurfacing	Moderate Ravel	5 to 10 years	Seals pavement; extends pavement life
BST Cape Seal	Severe Block Cracking	10 to 15 years	Seals cracks; extends pavement life

The key to preventive maintenance is to use the right maintenance activity for the right pavement at the right time. When this is accomplished, maintenance funding is used to its fullest potential.

F. Acknowledgment

LaBella appreciates the Town of Carrboro’s cooperation during the pavement survey. Daniel Snipes, Aaron Vereoni and John Garland were very helpful and instrumental in working with LaBella in supplying field data collection support and information required for preparation of this report.

IV. Basic Street Inventory Data

Carrboro has a total of 48.44 miles of Town maintained roadway that were identified by LaBella. This report addresses the 46.61 miles of paved asphalt roadway (Pavement Type = "P") streets that were rated. Table 2 lists the breakdown of surface types for all Town maintained streets, while tables 3 through 5 below list the basic inventory data for rated Town maintained street segments.

Table 2
Pavement

Surface Type	Miles	Percent of System
Plant Mix Asphalt (P)	46.61	96.2
Concrete (C)	-	-
Unpaved (U)	1.83	13.8
Total	**48.44**	**100.0**

Table 3
Sidewalk

Location	Length (linear mi)
Left Side	15.1
Right Side	17.0
Total	**32.1**

Table 4
Curb and Gutter

Location	Length (linear mi)
Left Side	30.5
Right Side	30.5
Total	**61.0**

Table 5
Low and High Volume Street Breakdown

Volume	% Miles	Miles	Lane Miles	Avg Rating	Cost Per Mile	Total Cost	% Cost
Low	90.0	41.96	82.60	87.1	$13,189	$553,453	84.2
High	10.0	4.65	9.66	88.6	$22,341	$103,839	15.8
Total	**100**	**46.61**	**92.26**	**87.3**	**$14,101**	**$657,292**	**100**

V. FINDINGS AND SUPPORTING DATA

A. Results

The Pavement Condition Survey provides an objective evaluation by visual observation of eight types of pavement distress and the relative amount and severity of each type of distress. A pavement distress summary conducted for the Town of Carrboro is shown in Table 6 on page 9. The following are some observations from the survey:

- Approximately 25.51% of the rated streets in Carrboro are in need of some type of maintenance. The overall estimated cost for repairing these streets is $657,292 or $14,102 per mile system wide.

- The most predominant distress was found to be block cracking. Approximately 75% of the surveyed street system exhibits some level of block cracking. Approximately 2.68 miles (5.7%) exhibits moderate block cracking requiring crack sealing on low and high volume streets. Approximately 0.48 miles (1%) exhibits severe block cracking requiring 1.5" Plant Mix Asphalt (PM) Resurfacing and BST Seal on low and high volume streets.

- The most structurally damaging and costliest distress to repair is alligator cracking. Approximately 14.5% of the rated street system exhibits some level of alligator cracking. About 1.61 miles (3.5%) of roadway exhibit a severe level requiring full-depth patching. About 0.55 miles (1.2%) of roadway are at a moderate level requiring skin patching for low volume streets and full-depth patching for high volume streets. Alligator cracking is a high priority distress and is the most serious pavement distress because it results from a structural pavement failure. Unless corrected, it will progress to the point of requiring complete pavement reconstruction.

Table 6
PAVEMENT CONDITION SURVEY DISTRESS SUMMARY FOR RATED STREETS

Distress Items	Miles Low Volume	Miles High Volume	Total Miles	% Miles
1. Alligator Cracking				
None	35.87	3.99	39.86	85.5
Light	4.08	0.51	4.59	9.8
Moderate	0.50	0.05	0.55	1.2
Severe	1.51	0.09	1.61	3.5
2. Block Cracking				
None	10.35	1.31	11.66	25.0
Light	28.77	3.02	31.79	68.2
Moderate	2.37	0.31	2.68	5.7
Severe	0.48	0.00	0.48	1.0
3. Reflective Cracking				
None	41.81	4.65	46.46	99.7
Light	0.16	0.00	0.16	0.3
Moderate	0.00	0.00	0.00	0.0
Severe	0.00	0.00	0.00	0.0
4. Rutting				
None	40.96	4.65	45.61	97.8
Light	1.00	0.00	1.00	2.1
Moderate	0.00	0.00	0.00	0.0
Severe	0.00	0.00	0.00	0.0
5. Raveling				
None	41.15	4.53	45.68	98.0
Light	0.81	0.12	0.93	2.0
Moderate	0.00	0.00	0.00	0.0
Severe	0.00	0.00	0.00	0.0
6. Bleeding				
None	41.96	4.65	46.61	100.0
Light	0.00	0.00	0.00	0.0
Moderate	0.00	0.00	0.00	0.0
Severe	0.00	0.00	0.00	0.0
7. Ride Quality				
None	0.00	0.00	0.00	0.0
Light	41.57	4.51	46.08	98.8
Moderate	0.39	0.14	0.53	1.1
Severe	0.00	0.00	0.00	0.0
8. Patching				
None	37.56	4.11	41.67	89.4
Light	3.02	0.38	3.41	7.3
Moderate	0.99	0.01	1.00	2.1
Severe	0.40	0.14	0.54	1.2
Total	**41.96**	**4.65**	**46.61**	**100.00**

Note: Columns may not add up exactly due to rounding.

The type of distress that was observed on each street segment is shown in the final database, the Access database application (**USI-TPA),** and hard copy street listings provided in Appendix B.

The type and amount of distress that was observed on each street segment was used to obtain a Pavement Condition Rating (PCR). This rating has a scale between 0 and 100 and a basic description of each category is as follows:

Rating	General Condition
91-100	Very Good
81-90	Good
66-80	Fair
51-65	Poor
0-50	Very Poor

Each street segment begins with a rating of 100 and points are deducted from this rating based on the type and severity of distress. Deductions are the same for Class A (low volume) and B (high volume) streets. Deduct values for the severity levels of each distress are given below in Table 7.

Table 7
DEDUCT VALUES

PAVEMENT DISTRESS	SEVERITY			
	None (N)	Light (L)	Moderate (M)	Severe (S)
Alligator Cracking (AL, AM, AS) (Multiplied by percent)	0	25	60	99
Block/Trans Cracking (BK)	0	5	20	35
Reflective Cracking (RF)	0	5	10	20
Rutting (RT)	0	5	15	25
Raveling (RV)	0	5	25	35
Bleeding (BL)	0	5	15	25
Ride Quality (RQ)	0	0	10	25
Patching (PA)	0	5	10	15

As an example, presume a street segment has the following pavement distresses: 20% Light Alligator Cracking (AL), Moderate Rutting (RT), Light Patching (PA), and no other pavement distresses. The Pavement Condition Rating would be:

PCR = 100 - (AL) - (RT) - (PA)
PCR = 100 - (0.2 x 25) - (15) - (5) = 75

Please note that the Pavement Condition Rating (PCR) does not differentiate between low volume and high volume streets. The same criteria is used to rate each street. However, the Town staff may want to separate these streets for analysis purposes. In regards to recommended maintenance activities, low volume and high volume streets are evaluated independently as shown in Table 8 on page 13. Depending on the street volume along with the pavement distress, the recommended maintenance activity may vary as shown in Table 8. Additionally, Table 9 on page 13 indicates how low volume and high volume streets are handled differently in regards to resurfacing needs when there is a high percentage of alligator cracking present and moderate or severe rutting.

The bar graph shown on the next page in Figure 1 illustrates the percentage of rated streets in the Town of Carrboro that have PCRs in each condition category for the last five surveys (2005, 2008, 2011, 2014 and 2019). As the graph illustrates, well over half of the rated street system is presently in very good or good condition in 2019 survey. Approximately 85.1% of the rated streets in the Town of Carrboro have a PCR that is considered in very good or good condition (PCR = 81-100), while approximately 7.3% of the rated street system was found to be in poor or very poor condition (PCR = 0-65). LaBella recommends that the Town set a goal of maintaining the percentage of streets in very poor and poor condition to less than 10%. Although the matter of reducing the streets in poor and very poor condition is important, the Town should also concentrate on streets in "Fair" condition, which includes 7.5% of the street system, (PCR = 66-80) where the cost of maintenance is more cost-effective.

If proper repairs and maintenance are not performed, a comparison of a street segment's rating over time will indicate the rate of pavement deterioration. The effects of maintenance practices may also be reflected in a comparison of PCR values. For instance, a street segment's PCR will increase after resurfacing or a declining PCR may be stabilized with patching or crack sealing.

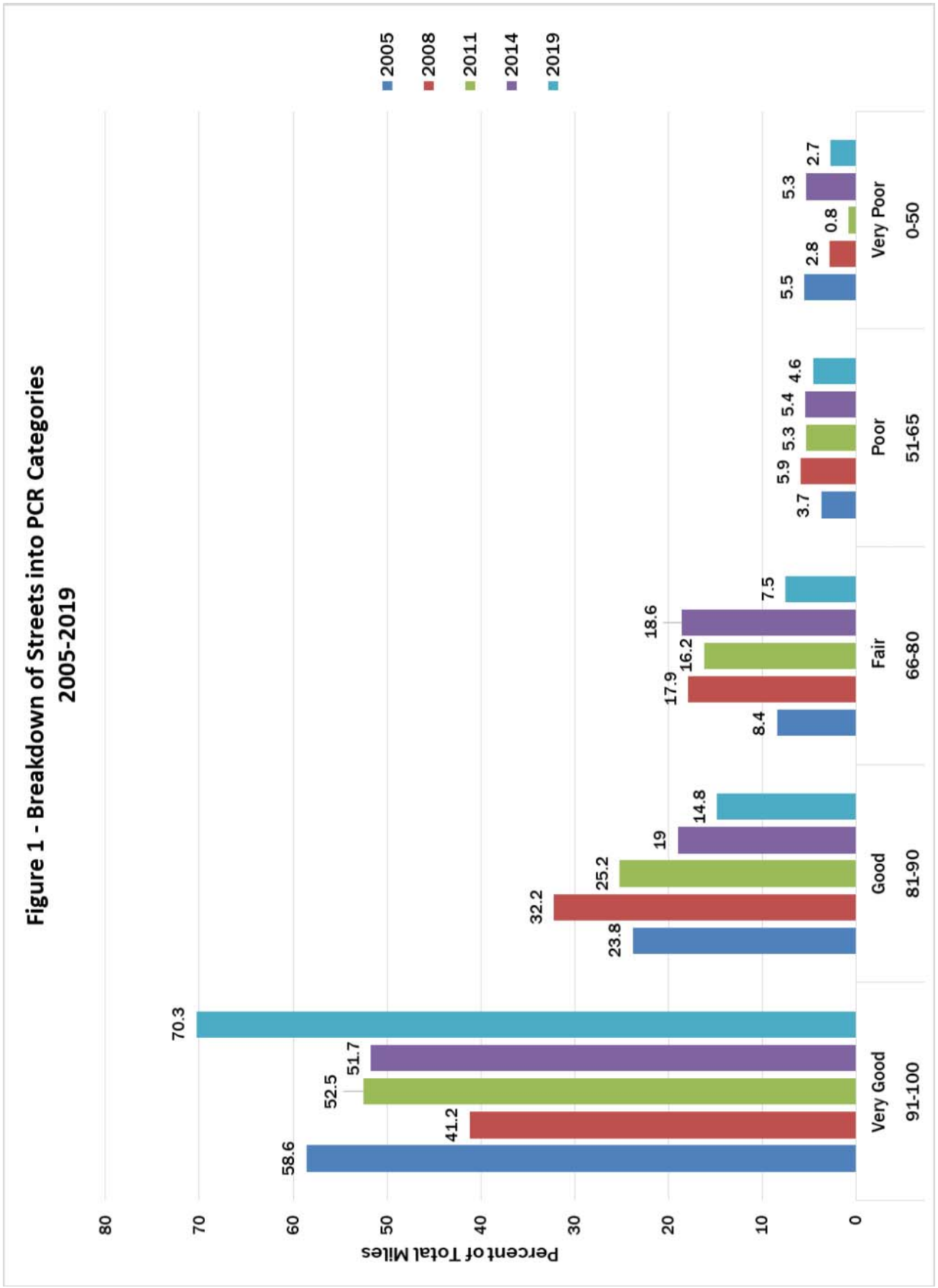


Figure 1 - Breakdown of Streets into PCR Categories
2005-2019
2005
2008
2011
2014
2019
Percent of Total Miles
0
10
20
30
40
50
60
70
80
Very Good
91-100
58.6
41.2
52.5
51.7
70.3
Good
81-90
23.8
32.2
25.2
19
14.8
Fair
66-80
8.4
17.9
16.2
18.6
7.5
Poor
51-65
3.7
5.9
5.3
5.4
4.6
Very Poor
0-50
5.5
2.8
0.8
5.3
2.7

VI. MAINTENANCE RECOMMENDATIONS

A. Maintenance Activities

The types of maintenance activities used in the Pavement Condition Survey analysis are listed below in Table 8. These activities are commonly accepted for cost-effective minimum levels of maintenance service. They include crack sealing, joint repair, full-depth patching, skin patching, short overlay, and complete resurfacing of a street segment with a 1.5" plant mix (PM), a 1.5" PM and BST Seal, and 2" PM asphalt.

Table 8
MAINTENANCE ACTIVITIES

PAVEMENT DISTRESS	LOW VOLUME STREETS			HIGH VOLUME STREETS		
	Light (L)	Moderate (M)	Severe (S)	Light (L)	Moderate (M)	Severe (S)
Alligator Cracking (AL, AM, AS)	None	4' Wide Skin Patch	4' Wide Full-Depth Patch	None	8' Wide Full-Depth Patch	8' Wide Full-Depth Patch
Block/Transverse Cracking (BK)	None	Crack Sealing	1.5" PM Resurfacing and BST Seal	None	Crack Sealing	1.5" PM Resurfacing and BST Seal
Reflective Cracking (RF)	None	Crack Sealing	Joint Repair	None	1.5" PM Resurfacing	Joint Repair
Rutting (RT)	None	None	1.5" PM Resurfacing	None	Short Overlay	1.5" PM Resurfacing
Raveling (RV)	None	1.5" PM Resurfacing	1.5" PM Resurfacing	None	1.5" PM Resurfacing	1.5" PM Resurfacing
Bleeding (BL)	None	None	1" PM Resurfacing	None	None	1.5" PM Resurfacing
Ride Quality (RQ)	None	None	1.5" PM Resurfacing	None	None	1.5" PM Resurfacing
Patching (PA)	None	None	Short Overlay	None	None	1.5" PM Resurfacing

If a high percentage of the pavement surface has alligator cracking, resurfacing is recommended as shown below in Table 9. All severe alligator cracking should be repaired with full-depth patching prior to resurfacing.

Table 9
MAINTENANCE FOR A HIGH PERCENTAGE OF ALLIGATOR CRACKING

VOLUME	CONDITION	RESURFACING
Low	AM & AS ≥ 50%	1.5" PM Resurfacing
	AM & AS ≥ 50% and M or S Rutting	2" PM Resurfacing
High	AM & AS ≥ 30%	1.5" PM Resurfacing
	AM & AS ≥ 30% and M or S Rutting	2" PM Resurfacing

B. Unit Costs for Maintenance Activities

The unit costs for maintenance activities are shown below in Table 10. These unit costs were provided by the Town of Carrboro.

Table 10
UNIT COSTS FOR MAINTENANCE ACTIVITIES

ACTIVITY	COST (PER SQUARE YARD)
Crack Sealing	$0.95
Skin Patching	$17.00
Joint Repair	$0.85
Full-Depth Patch (4" Depth)	$52.00
Short Overlay	$6.20
1" Plant Mix Resurfacing	$5.50
1.5" Plant Mix Resurfacing	$8.25
2" Plant Mix Resurfacing	$11.00
BST Seal (*also known as chip seal*)	$2.50

C. Maintenance Needs

A comparative table with a summary of maintenance needs for 2019 is shown on the next page in Table 11. These activities are based on objective descriptions of conditions existing at the time of the survey. Although the computer analysis determines the primary and secondary maintenance activities for these conditions, there may be isolated distresses that are not evident in the results. The secondary maintenance activities and costs, when applicable, are included in the primary totals.

Alligator cracking is a high priority distress and it accounts for approximately 54.29% of the recommended repair cost in the form of full-depth patching.

Figure 2, on page 16, illustrates the average system PCRs over the past five surveys (2005, 2008, 2009, 2014 and 2019). The overall PCR is good, the trend is upward from the last survey.

Figure 3, on page 17, illustrates how the total mileage is distributed among the various recommended maintenance activities. Approximately 16.01% of the system's rated streets are recommended for full depth patching and about 2.47% of the system's rated streets are recommended for resurfacing, primarily due to alligator cracking and block cracking.

Figure 4, on page 18, illustrates how the total cost is distributed among the various recommended maintenance activities. Approximately 36.03% of the system's cost is for maintenance in the form of resurfacing, as a primary maintenance activity that includes all necessary patching.

Figure 5, on page 19, illustrates how the total recommended repair cost is distributed between routine maintenance and resurfacing activities. Routine maintenance activities account for approximately 63.97% ($420,443) of the estimated maintenance while resurfacing activities account for 36.03% ($236,849) of the estimated maintenance needs.

Table 11

SUMMARY TABLE OF SUGGESTED PRIMARY MAINTENANCE ACTIVITIES FOR RATED STREETS

Primary Activity	Miles Lo Vol	Cost Lo Vol	Miles Hi Vol	Cost Hi Vol	Total Miles	% Miles	Total Cost	Cost/Mile	% Cost
Crack Sealing	0.97	$11,554	0.10	$1,593	1.07	2.30%	$13,147	$12,287	2.00%
Skin Patching	1.90	$17,161	0.00	$0.00	1.90	4.08%	$17,161	$9,032	2.61%
Full-Depth Patching	6.91	$323,088	0.55	$35,698.00	7.46	16.01%	$358,786	$48,095	54.59%
Short Overlay	0.31	$31,349	0.00	$0	0.31	0.67%	$31,349	$101,126	4.77%
Routine Maintenance Total (RM Total)	***10.09***	***$383,152***	***0.65***	***$37,291***	***10.74***	***23.04%***	***$420,443***	***$39,147***	63.97%
1 1/2" Plant Mix Asphalt Resurfacing	0.40	$95,733	0.27	$66,548	0.67	1.44%	$162,281	$242,210	24.69%
1 1/2" Plant Mix Asphalt Resurfacing and Seal	0.48	$74,568	0.00	$0	0.48	1.03%	$74,568	$155,350	11.34%
Resurface Total	***0.88***	***$170,301***	***0.27***	***$66,548***	***1.15***	***2.47%***	***$236,849***	***$204,180***	***36.03%***
Total Repair	**10.97**	**$553,453**	**0.92**	**$103,839**	**11.89**	**25.51%**	**$657,292**	**$55,281**	**100%**
None	30.99	$0	3.73	$0	34.72	74.49%	$0	$0	0%
Total System	**41.96**	**$553,453**	**4.65**	**$103,839**	**46.61**	**100%**	**$657,292**	**$14,102**	**100%**

** RM is routine maintenance* *Note: Columns may not add up exactly due to rounding.*

The results of the Pavement Condition Survey in the provided database and street listings have a code symbol in the 'Activity' column defining the controlling or primary maintenance activity for each street section. It should also be noted that a secondary maintenance activity has been incorporated into the database, when applicable, in the "Activity 2" field with associated cost data. A third and fourth activity and associated cost, when applicable, are also incorporated within the database as structured above. The code symbols are as follows:

CS = Crack Sealing
FDP = Full-Depth Patching
SO = Short Overlay
SKP = Skin Patching
PM 1.5 = 1/2" Plant Mix
PM1.5+S = 1 1/2" Plant Mix and BST Seal
PM2 = 2" Plant Mix

These maintenance activities can be categorized as either routine maintenance or resurfacing. Routine maintenance limits the detrimental effects of traffic loads and weather conditions. For the Town of Carrboro routine maintenance includes crack sealing, skin patching, full-depth patching, and short overlay. Resurfacing adds a new layer to the pavement's structure and improves its load carrying capacity.

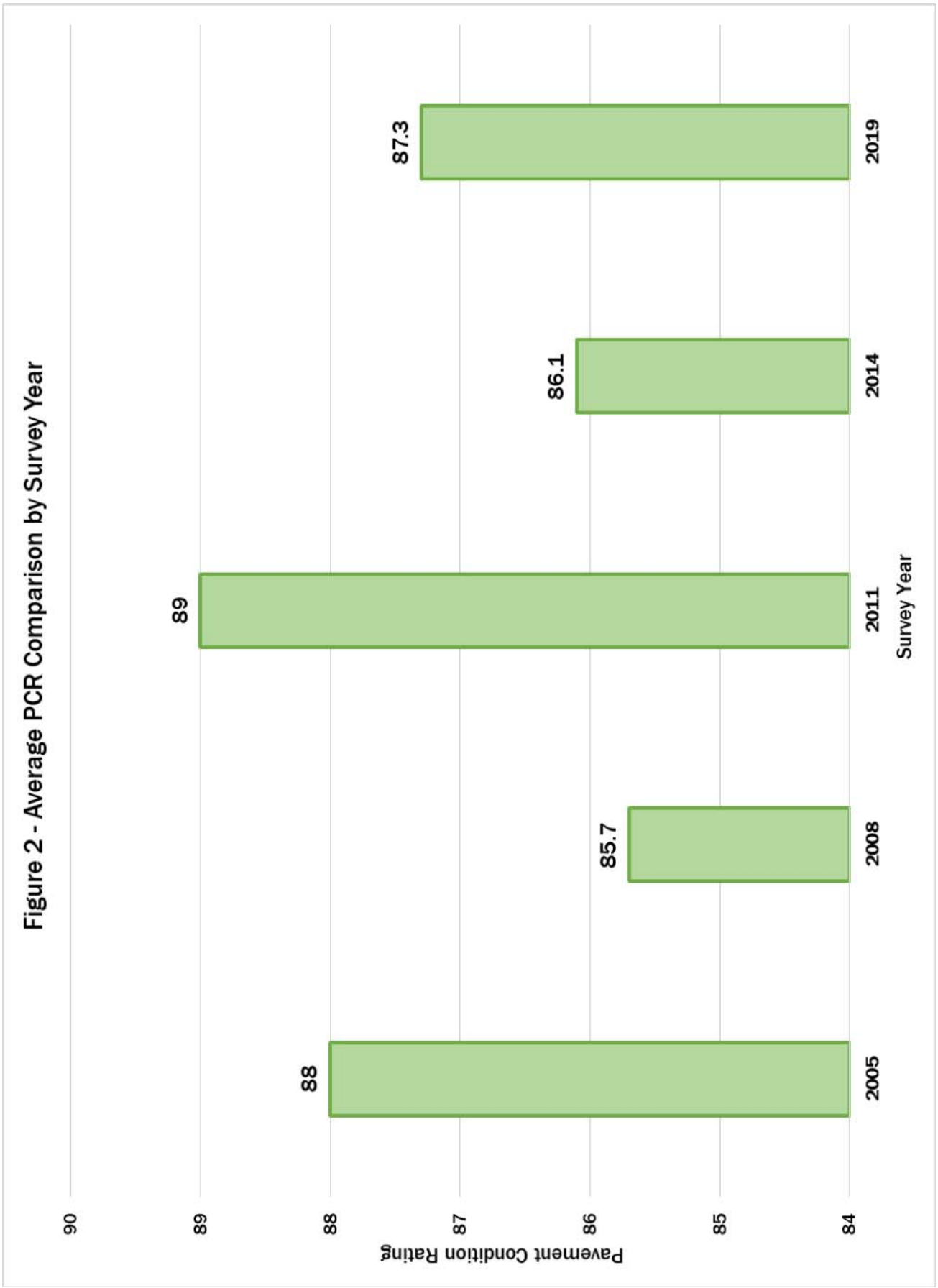


Figure 2 - Average PCR Comparison by Survey Year
Pavement Condition Rating
90
89
88
87
86
85
84
88
89
85.7
86.1
87.3
2005
2011
2008
2014
2019
Survey Year

FIGURE 3 - DISTRIBUTION OF MAINTENANCE NEEDS BY PRIMARY REPAIR TYPE (% OF MILES)

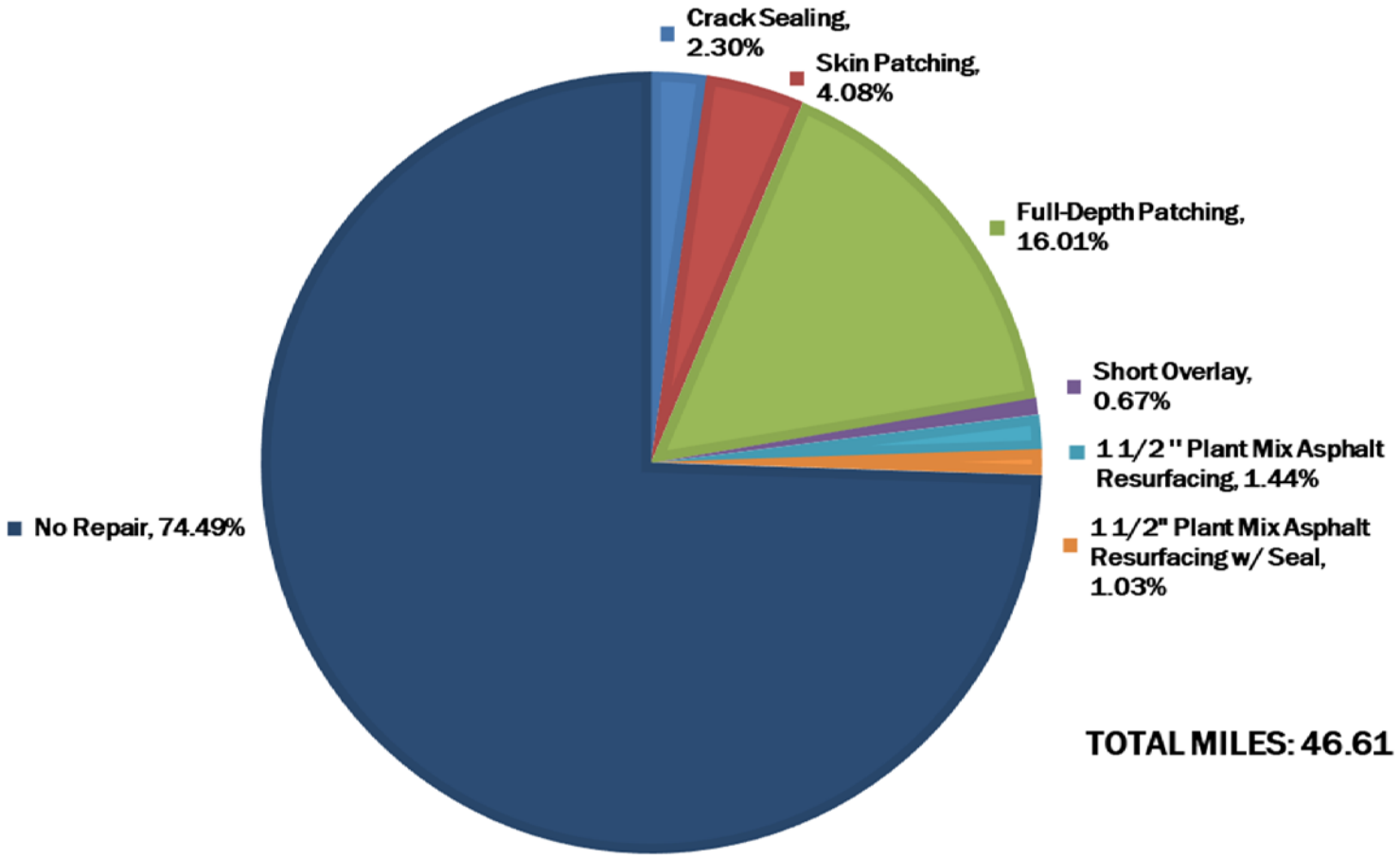
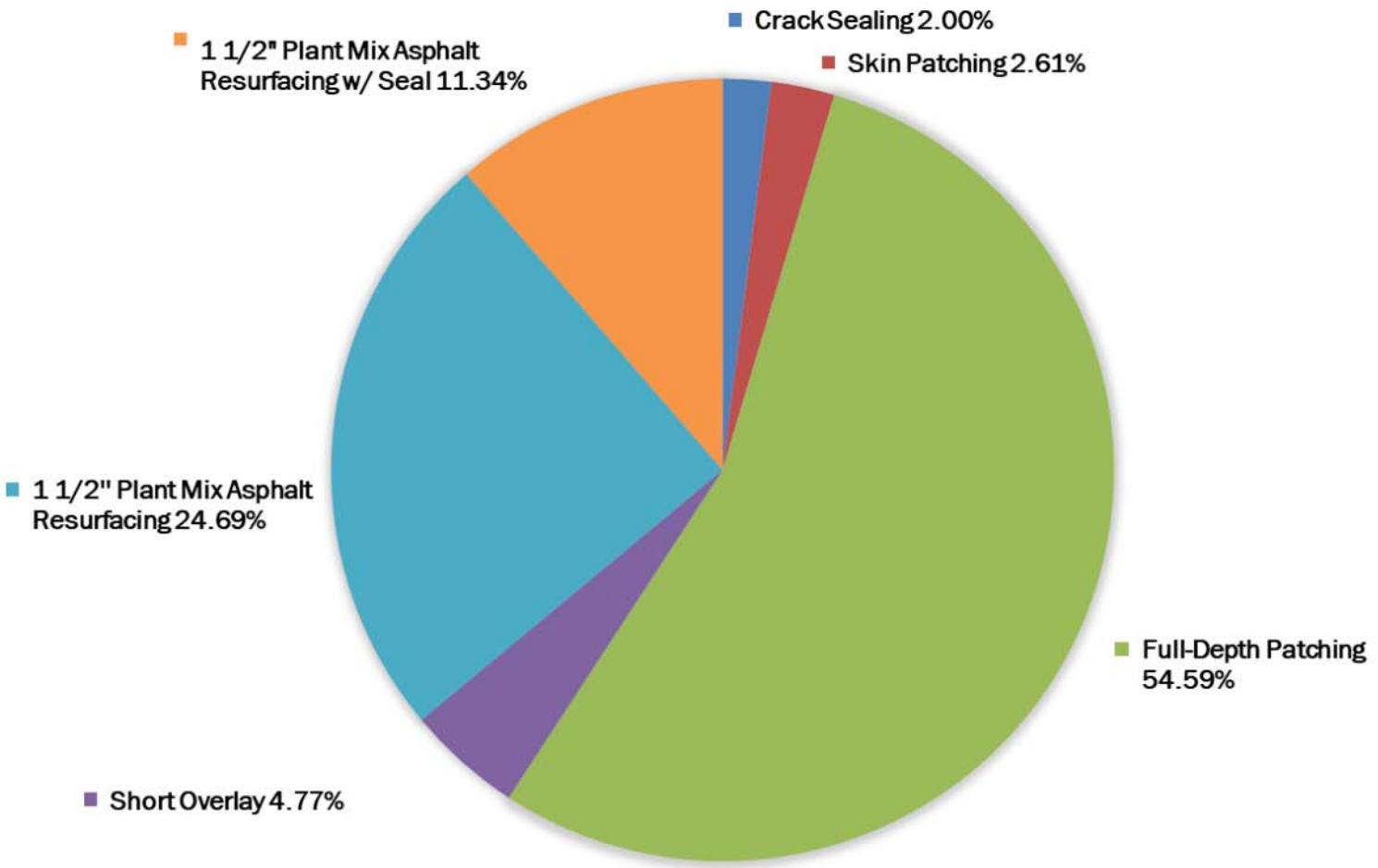


Figure 4 - Distribution of Maintenance Costs by Primary Type
Percentage of Total Cost
Total Cost: $657,292



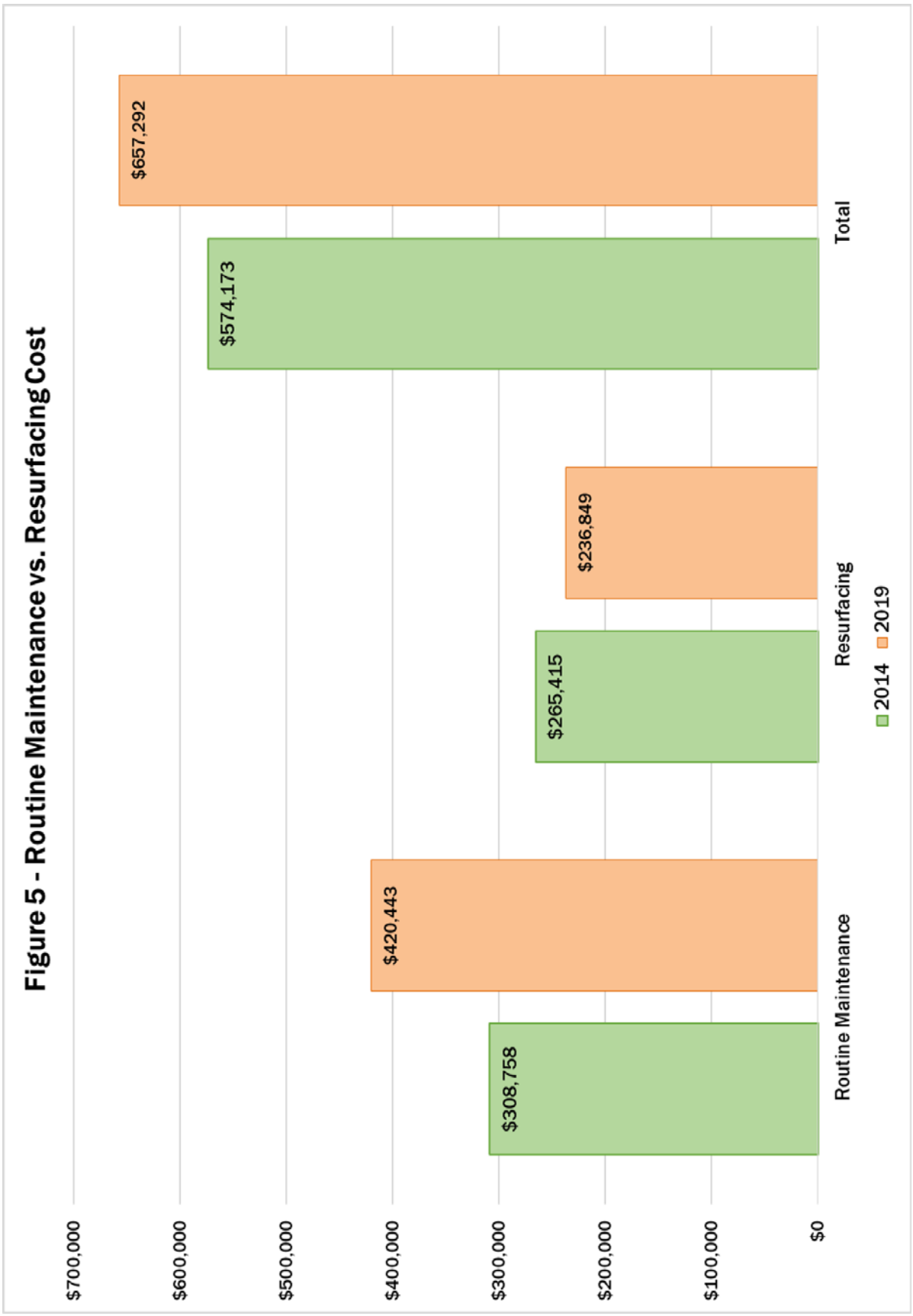


Figure 5 - Routine Maintenance vs. Resurfacing Cost
$700,000
$600,000
$500,000
$400,000
$300,000
$200,000
$100,000
$0
$657,292
$574,173
$236,849
$265,415
$420,443
$308,758
Total
Resurfacing
Routine Maintenance
2014
2019

D. Routine Maintenance

These important maintenance activities are included where surface pavement distresses are not present in sufficient magnitude to warrant complete plant mix resurfacing. Routine maintenance includes crack sealing, skin patching, full-depth patching, and short overlay.

The Pavement Condition Survey indicates that there are approximately 10.74 miles of streets requiring routine maintenance. The estimated cost of this work is $420,443 or $36,147 per mile, accounting for roughly 63.97% of the estimated total street maintenance cost need.

The following sections define the routine maintenance for the Town of Carrboro.

- ### Crack Sealing

  Crack sealing is needed for moderate block/transverse cracking on low and high volume streets and moderate reflective cracking on low volume streets. Block cracking is not a structural failure and does not usually progress rapidly. Cracks are generally caused by shrinkage of the asphalt and daily temperature cycling. Traffic loads can increase the severity of block cracking if water is allowed to penetrate into the cracks. Therefore, it is very important to seal these cracks to prevent water penetration into the base materials. The definition of moderate block/transverse cracking includes cracks that have been sealed previously but are beginning to open back up. **Although crack sealing is generally an effective preventive maintenance measure, it should not be used in place of patching to seal moderate to severe alligator cracking.** LaBella recommends crack sealing as a primary maintenance activity for approximately 1.07 miles of street segments. Crack sealing is also recommended as a secondary maintenance activity for 0.09 miles of street segments.

  Even though it will result in a higher initial cost, the use of a rubberized asphalt crack sealant is recommended. Because cracks must be resealed periodically, a continuing crack sealing program is required. Crack sealing can be a very cost-effective expenditure of funds.

- ### Skin Patch

  Skin patching is a maintenance practice used by the Town for repair of isolated locations of moderate alligator cracking. It seals the surface and slows the rate of deterioration. Alligator cracking is a structural failure of the pavement and can deteriorate rapidly if appropriate maintenance is not performed.

  Similar to full-depth patching, skin patching (where required) is included in the primary resurfacing activities. There are approximately 2,814 square yards of recommended skin patching. Approximately 842 square yards (20 street segments) are recommended as a primary maintenance activity at an estimated cost of $17,161 with the remaining 1,972 square yards to be performed as a secondary activity to resurfacing.

- **Joint Repair**

  Joint Repair is recommended for severe reflective cracking. Reflective cracking occurs when cracking at the joints of an old concrete pavement reflects to the surface of an asphalt overlay. Often repairs must be made to the Portland cement concrete pavement below the surface. Resealing or repairing of the concrete joints, either by crack pouring or major reconstruction of the old joint might be required. Slab stabilization may also be required if pumping is present. There are no street segments that exhibit severe reflective cracking.

- **Full-Depth Patch**

  Full-depth patching is required to repair severe alligator cracking. It involves the removal of the surface course, base course, and sub-grade, if necessary. New material should be placed in compacted lifts. Often, a full-depth asphalt repair can be used.

  There are an estimated 7,968 square yards of full-depth patching needed in Carrboro. Approximately 6,157 square yards (64 street segments) are recommended as a primary maintenance activity at an estimated cost of $358,786 (including secondary activities) with the remaining 1,811 square yards recommended as a secondary activity. Where resurfacing is recommended, the cost of full-depth patching is included in the total resurfacing cost. Those repairs must be done prior to any resurfacing activity.

  It is recommended that the Town of Carrboro maintain an aggressive patching program. This type of maintenance is very cost-effective in extending the useful life of pavements. Delaying this type of maintenance will cause pavements to fail at a much faster rate. Many streets requiring patching may need resurfacing in the near future. However, timely and thorough patching can postpone the need for resurfacing.

- **Short Overlays**

  Short overlays, or resurfacing portions of a street, are recommended on low volume streets with severe patching. There are two street segments (0.31 miles) requiring a short overlay as a primary activity.

E. Resurfacing

Plant mix resurfacing is a major maintenance activity. Plant mix resurfacing, combined with full-depth patching is used to repair structural damage. It is recommended for a variety of pavement distresses, as severity and magnitude increase, and some distress types require more immediate attention than others. Because the funds available for street resurfacing are typically limited, resurfacing activities need to be addressed by the type of pavement distress that causes the need. This section will address resurfacing activities by the type of distress that requires it.

The Pavement Condition Survey indicates that there are approximately 1.15 miles of streets requiring resurfacing. The estimated cost of this work is $236,849 or $204,180 per mile, accounting for roughly 36.03% of the estimated total street maintenance cost needs.

- **Alligator Cracking**

  Alligator cracking is the most serious pavement distress. It is a structural pavement failure that may be caused by traffic overload, inadequate design thickness, base or sub-grade failure, poor drainage, or a combination of these factors. It should be given top priority for proper repair. It is a progressive failure, and unless corrected it may progress to the point that the street may require complete pavement reconstruction.

  The Pavement Management program is set to determine the need for resurfacing when 30% of a segment on Class B (high volume) streets and 50% of a segment on Class A (low volume) streets has moderate and/or severe alligator cracking. The cost of full-depth patching is also included, where required, in the cost estimate of resurfacing. When light or no rutting exists with alligator cracking, no extra maintenance activity is recommended for low and high volume streets.

  When moderate or severe rutting exists with alligator cracking, a full-depth patching is recommended. These streets are in very poor structural condition and may require reconstruction. Possibly, some engineering testing is needed to determine if there are subsurface problems.

- **Block/Transverse Cracking**

  Block/Transverse cracking is not load associated but is caused by the shrinkage of asphalt and temperature fluctuations. The severity can increase if water penetrates into the cracks. Therefore, it is important to seal the block/transverse cracks to prevent water penetration into the pavement's base materials. Unless remedied, alligator cracking may develop.

  Crack sealing would be needed to repair moderate block/transverse cracking on low volume (Class A) and high volume (Class B) streets. Crack sealing is very effective and cost-effective alternative on low volume (Class A) streets. Generally, resurfacing streets due to moderate cracking would be a low priority, unless municipal officials have seen a continued increase in the cracking and/or there is difficulty keeping it crack sealed because of heavy traffic volumes. Severe block/transverse cracking requires a 1.5" plant mix resurfacing and BST seal. It is not practical to crack seal severe block cracking as a sole maintenance activity.

- **Reflective Cracking**

  Reflective cracking is generally not load associated but occurs on asphalt concrete which has been overlaid on old jointed concrete pavement. Reflective cracking is characterized by bulged joints above the riding surface and caused by movement of the concrete slab beneath the roadway surface. Where there is severe reflective cracking, joint repair is recommended. There are no roads in the Carrboro street system that exhibit severe reflective cracking at this time.

- **Rutting**

  Rutting is a surface depression that typically occurs in the wheel path(s) or at the edge of the pavement. It occurs when the pavement layers or sub-grade consolidate due to traffic loads. Rutting represents a structural failure and often occurs in conjunction with alligator cracking. To repair severe rutting, a 1.5" plant mix resurfacing is recommended for low volume streets and high volume streets.

- **Raveling**

  Raveling typically occurs on, but not limited to, bituminous surface treated (BST) streets, sometimes referred to as "tar-and-gravel". Raveling is identified by the loss of aggregate particles from the pavement surface. The inability of the liquid asphalt to hold the aggregate in place causes raveling. Resurfacing is needed to seal the pavement and provide a new wearing surface. A 1.5" plant mix resurfacing is recommended for both the moderate and severe conditions for both street classes (low and high volume).

- **Ride Quality**

  Ride quality is a relative indication of roughness and how the street rides to the public. Any number of factors including rutting, cracking, utility cuts, localized dips, or poor patching can cause rough ride quality. Improving rough ride quality requires a 1.5" plant mix resurfacing for severe conditions on low and high volume streets.

- **Patching**

  Patching is only an indication of the amount of surface area that has received some type of maintenance repair. The quality or condition of the patch is not considered in the evaluation. Severe patching indicates that a large amount of patching exists on the pavement. Resurfacing is recommended when patching covers more than 30% of a pavement's surface area. Where there is severe patching on low volume streets, a short overlay is recommended; for high volume streets with severe patching, a 1.5" plant mix resurfacing is recommended.