2024 Pavement Evaluation Report
Tucker, GA
October, 2024

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1 Executive Summary

Roadway Asset Services, LLC (RAS) performed a pavement condition assessment for Tucker, GA to provide an accurate assessment of the pavement network. The pavement data collection started on March 10, 2024 and completed on May 22, 2024. This report provides the processes and procedures for pavement condition data collection and evaluation, and assessment of the results for the City's maintained roadway network.

The pavement condition assessment included an automated mobile data collection, a Pavement Condition Rating (PCR) calculated using RAS's pavement analysis tool - Technical Rating Intelligence Program (Road TRIP^{TM}), the International Roughness Index (IRI), a Riding Comfort Index (RCI), a weighted PCI (Pavement Condition Index) score, and the delivery of an ESRI file geodatabase. The assessment and conditions rating were performed in general accordance with national standards, where applicable.

The network PCR was determined following the American Society for Testing Materials (ASTM) D6433-11 "Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys." The IRI is a general measurement of the ride quality of a street section and was performed in accordance with AASHTO R 43-07 and ASTM E950. IRI indexes were obtained from measured longitudinal road profiles and were processed using a quarter-car model at 52.80-foot intervals (0.010/mi). The RCI values are normalized to a scale of 0 to 100.

The PCI is a measure of the overall serviceability provided by a pavement to the vehicle driver. For this project, the PCI was requested to be calculated using a combination of the PCR and the Riding Comfort Index (RCI) to match the scoring system used for the previous pavement assessment, performed by Stantec. The RCI value is calculated from field collected measurements (IRI) of the pavement ride quality. After finding the PCR scores, the PCI score can be calculated by using the following equation to get an overall score for each segment of road:

$$\textbf{PCI} = (0.66 \times \textbf{PCR}) + (0.33 \times \textbf{RCI})$$

1.1 Inspection Breakdown

The City's roadway network system surveyed as part of this pavement condition project included:

Table 1.1: Tucker, GA PCI Ranges by Percent

Pavement Condition Index (PCI) Range	Condition Description	Total Area (yd2)	Total Distance (Centerline Miles)	Percent of Network (Centerline Miles)
86 – 100	**Excellent**	**273,226**	**16.36**	**9.6%**
71-85	**Good**	**1,299,384**	**81.68**	**48.0%**
56-70	**Fair**	**688,240**	**43.09**	**25.4%**
41-55	**Poor**	**278,885**	**17.91**	**10.5%**
26-40	**Very Poor**	**144,368**	**10.09**	**5.9%**
11-25	**Serious**	**14,540**	**1.07**	**0.6%**
0-10	**Failed**	**0**	**0**	**0.0%**
Total of Rated Segments		**2,698,643**	**170.19**	**100%**

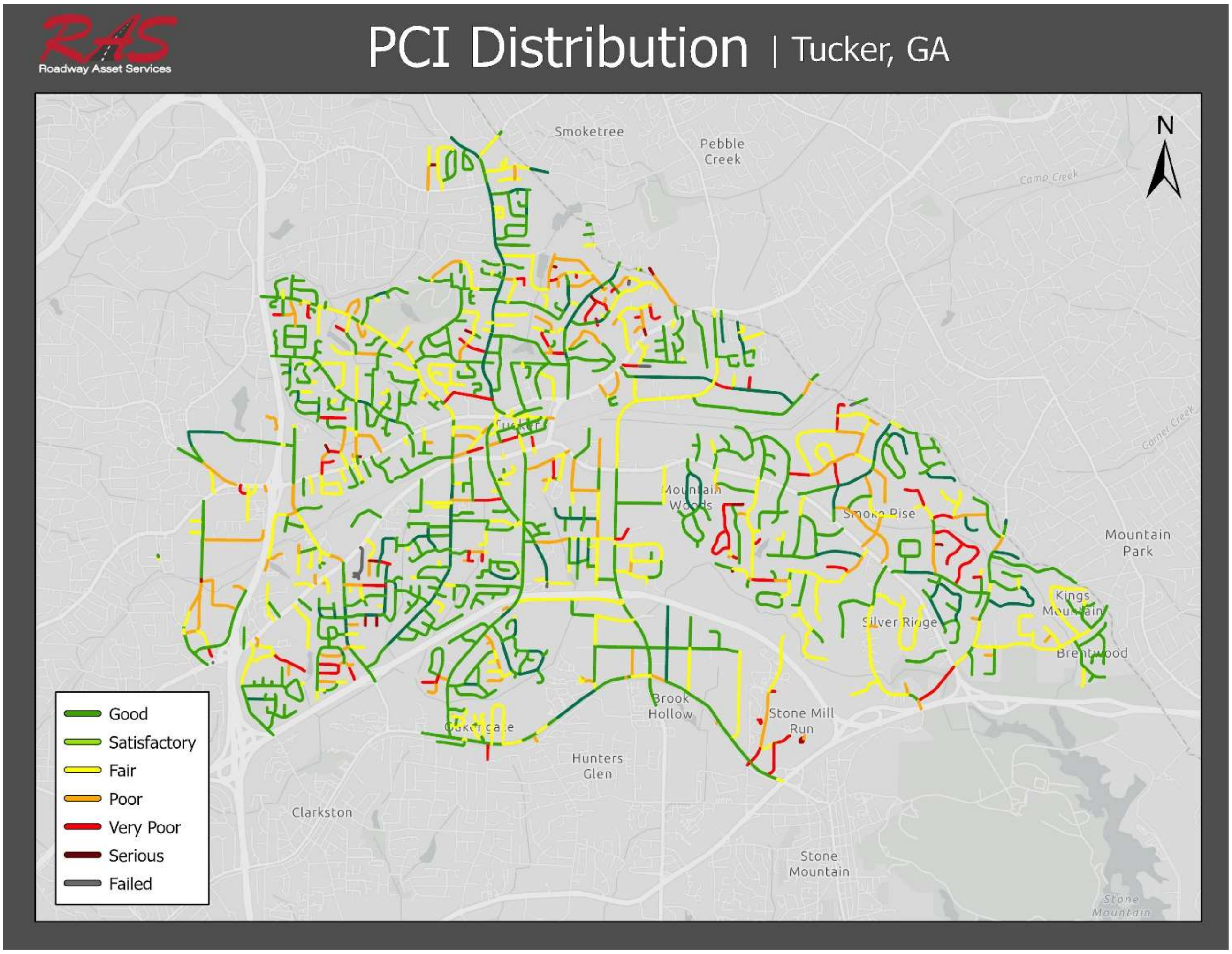


Figure 1.1 Tucker, GA PCI Distribution

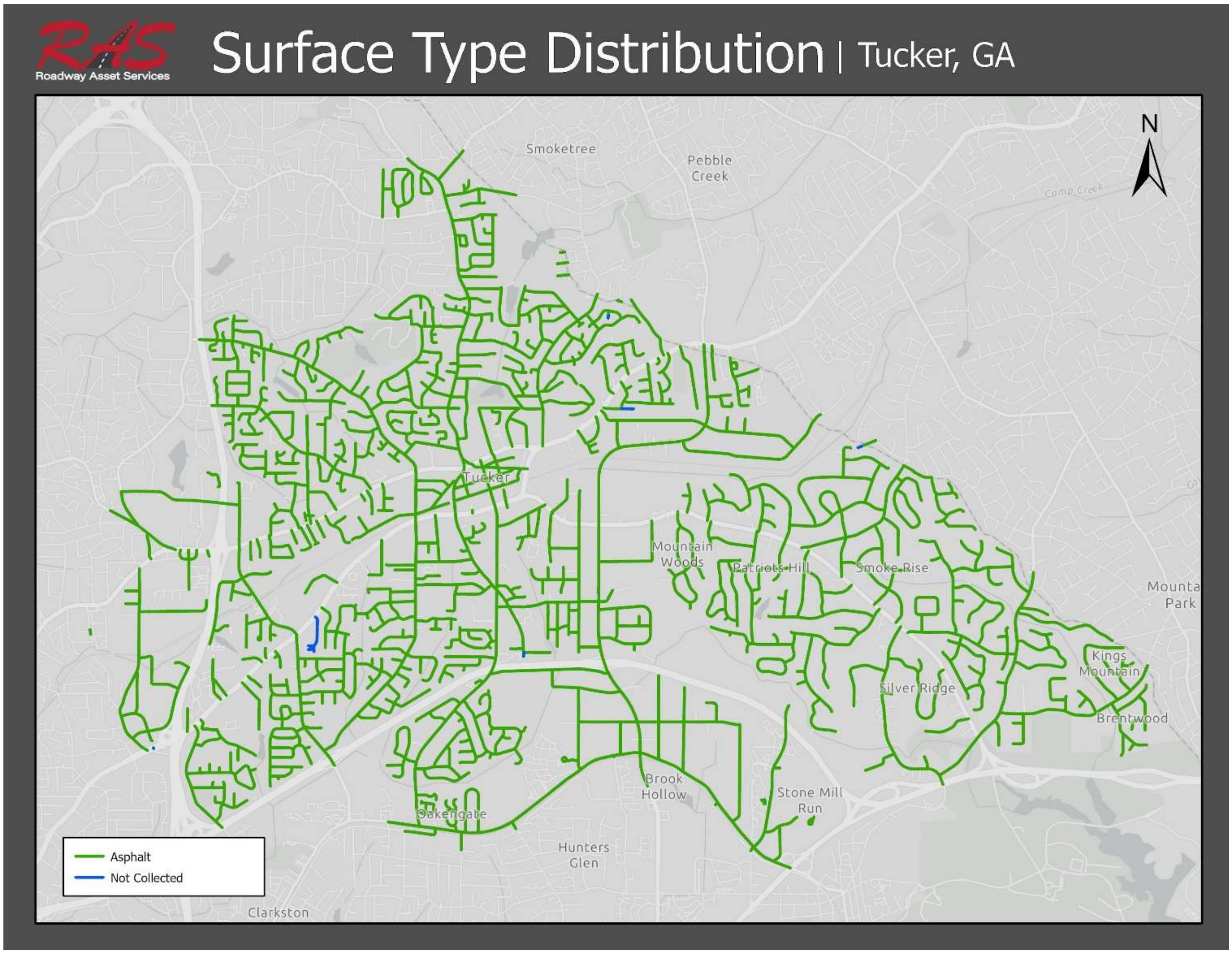


Figure 1.2: Tucker, GA Surface Type Distribution

1.2 Condition Results

RAS's pavement analysis tool, Technical Rating Intelligence Program (Road TRIP™), was used to evaluate and classify the distresses, and calculate the PCR. The PCR is a numerical rating of the pavement condition based on the type, severity, and density of distresses observed on the pavement surface. The PCI is a measure of the overall serviceability provided by a pavement to the vehicle driver. The IRI value is normalized to provide a value between 0 and 100. This report presents the normalized IRI value to represent the general ride quality of the pavement surface. In this report, the PCI represents the blended score of the PCR and RCI (.66 PCR X .33 RCI). The RCI value is calculated from the field measured IRI value to better match values collected during the previous assessment performed by Stantec. At the time of collection, the weighted arithmetic average PCI for all roads was **70.** Following Table 1.1, the network is in a "**Fair**" condition.

1.3 Budget Scenarios

RAS performed several five-year maintenance and preservation program scenarios for the city of Tucker, GA. The city's annual budget is $4,500,000 for their streets. RAS also ran a Do-Nothing, A Fix-All, a Steady State PCI and a series of 7 additional models the city requested for a period of 5 years to develop a PCI trend. These budgets were applied in BOSS for the development of a financially optimized 5-year plan.

Optimization is a broad-based term that has many different definitions. For most pavement management systems, optimization is the ability to prioritize a multi-year rehabilitation plan using several different factors that are important to the city of Tucker and based on sound engineering constraints. RAS infuses financial optimization by identifying two key components of a financial analysis:

- *Need Year – when a road/segment becomes critical, meaning it is getting closer to dropping into the next more expensive rehabilitation category.*
- *Cost of Deferral – identifying the cost of deferral between a road/segment's current rehabilitation category and it's next category.*

Understanding the "Cost of Segment Deferral" allows the analysis to maximize the City's limited funds in the best manner possible.

Using information provided by the City, RAS pavement management experience, and industry standards, RAS assigned the PCI impact to each maintenance activity and is presented in Tables 7.1 to 7.3.

A 5% inflation rate per year was applied to the maintenance and rehabilitation activity costs in the 5-year models.

Commonly Used Acronyms

- **AC** Asphalt Concrete
- **ASTM** American Society for Testing and Materials
- **BOSS** Budget Optimization Street Selector
- **BR** Brick
- **GR** Gravel
- **GPS** Global Positioning System
- **RCI** Riding Comfort Index
- **LCMS** Laser Crack Measurement System
- **PCC** Portland Cement Concrete
- **PCS** POS Computer System
- **PCI** Pavement Condition Index
- **PCR** Pavement Condition Rating
- **POS** Position and Orientation System
- **RAC** Roadway Asset Collection vehicle
- **RAS** Roadway Asset Services
- **Road TRIP™** Road Technical Rating Intelligence Program
- **ROW** Right-of-way
- **Traditional PCI** ASTM Pavement Condition Index
- **UNS** Unsurfaced

2 Introduction

An asphalt pavement surface begins to oxidize and deteriorate from the day it is constructed. While concrete pavements may have longer durability, they also began deteriorating after construction due to joint failure and subgrade weakening. Many factors affect the deterioration rate, such as, but not limited to, the traffic loads, climatic conditions, age, material durability, subgrade support, damage caused by poor drainage, and construction materials and techniques. These factors cause the deterioration rate to be different for every pavement section. To manage a large pavement network, "family performance" curves are developed from available data to represent the expected performance and to help determine optimal times to apply preventive and rehabilitation treatments. To develop more accurate curves, periodic evaluations and assessment of the pavement condition must be performed to gain a realistic representation of condition versus age of the pavement network.

Pavement deterioration is a non-linear process. Initial deterioration occurs at a slow rate. After approximately 40% to 50% of a pavement's service life, a pavement segment reaches an "inflection point' after which pavement condition rapidly deteriorates. Understanding the condition and age at which this rapid drop in occurs is unbelievably valuable in determining the optimal time for maintenance (Figure 2.3). Properly understanding pavement conditions allows for cost effective preventive maintenance versus reactive maintenance at a much higher cost.

Standard industry practice is to assess a pavement network every three to five years. More frequent assessments will likely not detect significant changes in condition since most pavement segments. More than five years between assessments will likely miss critical changes and will not provide adequate data to define a deterioration curve where preventive maintenance is best applied. RAS recommends assessments every three years for networks greater than 100 miles. Local and residential streets can be delayed to every five years, because they are expected to deteriorate at a slower rate compared to arterial/collector streets. Local street deterioration is based on climatic conditions more than traffic loads. However, if funding is not separated by arterial/collector streets versus local streets, the assessments should be done in the same year to provide equivalent information for the decision process.

Here, we describe the tools, processes and procedures used to collect and analyze pavement condition data as well as provide a summary of the results obtained from calculating each segment's PCI, PCR and RCI.

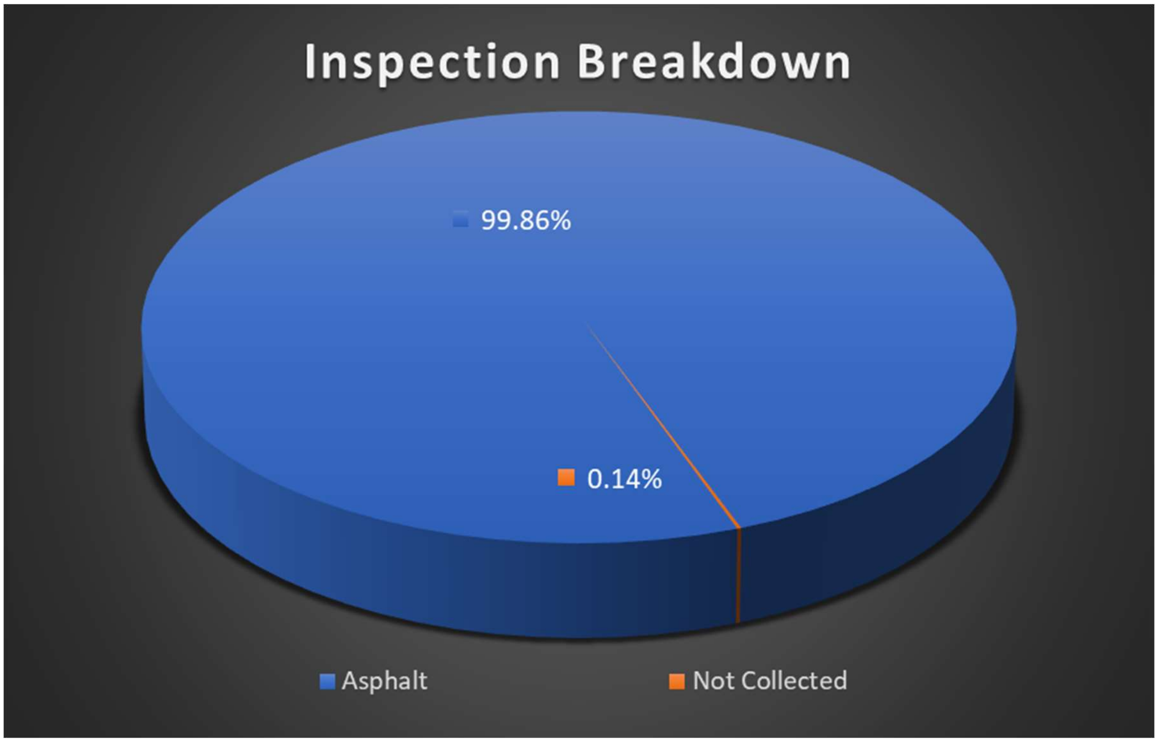


Figure 2.1: Tucker, GA Inspection Breakdown

Table 2.1: Tucker, GA Inspection Breakdown

Item	Description	Centerline Miles	Percent of Centerline Miles
1	Asphalt Segments with PCI	170.19	99.86%
2	Not Collected - Does Not Exist	0.05	0.03%
3	Not Collected – Gated	0.37	0.22%
4	Not Collected - Not Accessible	0.01	0.01%
5	Not Collected - Not Paved	0.08	0.06%
6	Not Collected - Short Segment	0.03	0.02%
	Total With PCI	170.19	99.86%
	Total Without PCI	0.24	0.14%
	Total	**170.43**	**100.00%**

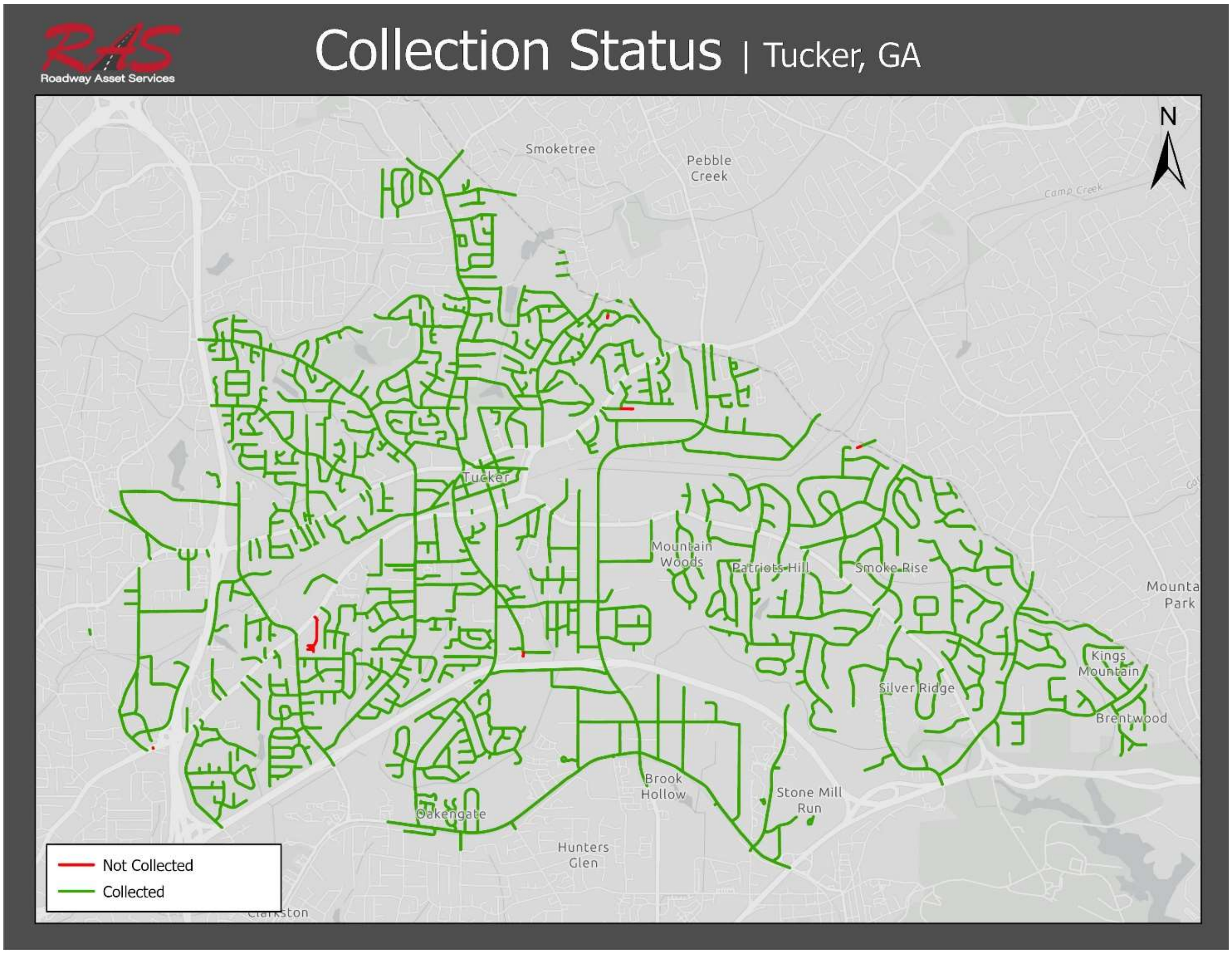


Figure 2.2: Tucker, GA Roadway Network (Collection Status)

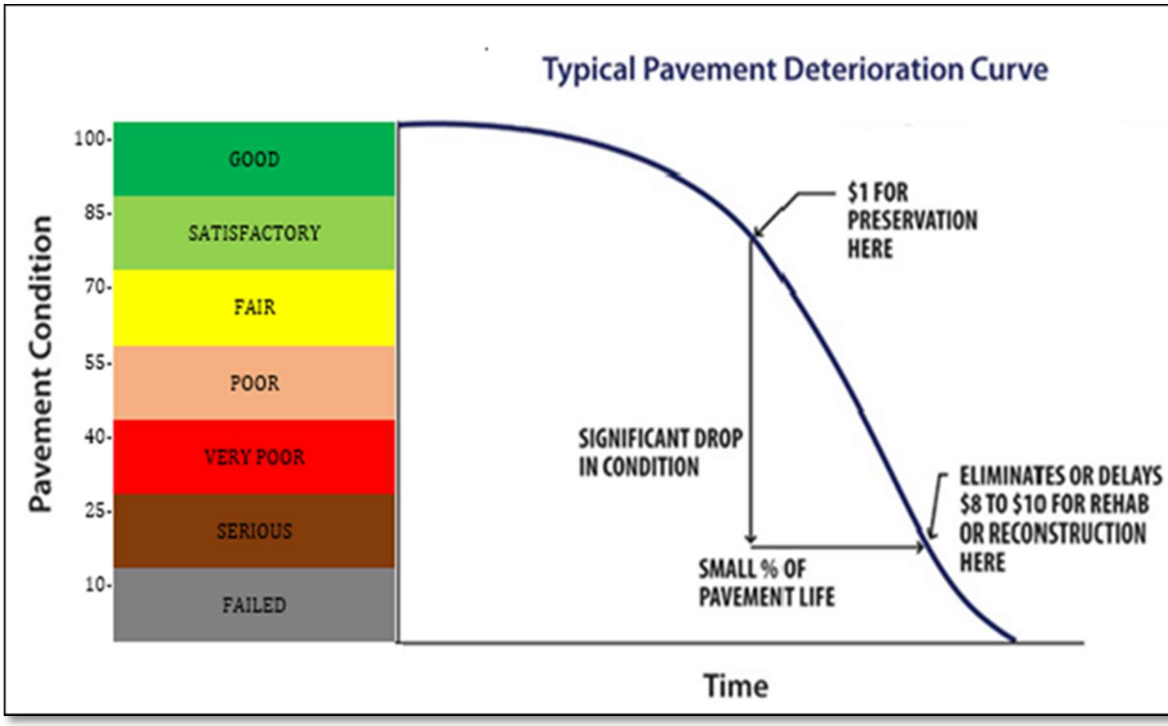


Figure 2.3: Deterioration Curve Example

3 Project Scope & Methodology

The overall project scope of work contains seven tasks outlined below:

1. Verify City's Street network,
2. Perform mobile image data collection,
3. Determine the Pavement Condition Rating (PCR),
4. Determine Riding Comfort Index (RCI),
5. Determine the Pavement Condition Index (PCI),
6. Budget Analysis in RAS's BOSS™ software,
7. Prepare pavement final report.

3.1 Pavement Condition Assessment

Roadway Asset Services, LLC (RAS) performed a pavement condition survey for Tucker, GA beginning March 10, 2024 and completed on May 22, 2024, covering approximately 170 centerline miles of roadway. RAS used a Roadway Asset Collection (RAC) vehicle to collect street level ROW images and Laser Crack Measurement System (LCMS-2) pavement images. The collected LCMS-2 pavement images were used to identify street segment pavement distresses and severities through analysis, while the 360-degree panoramic ROW images were used to confirm pavement distresses.

Roadway networks are usually divided into three pavement surface types: asphalt (AC), Portland cement concrete (PCC), and unsurfaced (UNS). Due to the nature and scope of the project, pavement imagery and data were only collected on asphalt and concrete roads.

To determine the general distress characteristics of each roadway segment, RAS utilized a RAC vehicle, which combine multiple engineered technologies to collect real-time pavement data, ROW data, and images at posted speed limits. This eliminates the need to place pavement inspection technicians in the field near vehicle traffic. A detailed listing and description of the RAC equipment is included in Section 10.0 of this report.

Mobile image collection of the City's roadway network was accomplished through coordination with the City's GIS map provided for the survey areas, as displayed in Figure 2.2. Efforts associated with mobile image collection included review of client GIS street centerline file, route planning based on GIS street centerline, and coordination of existing construction projects along the City's streets.

This project applied the ASTM D6433-11 'Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys' pavement condition analysis method on collected LCMS-2 images to determine the road segment and network PCR. The ASTM D6433-11 method covers the process of quantifying pavement conditions and identifies pavement distress types, distress extent measurements, and distress severity to determine the deduct values for each distress type. ASTM D6433-11 outlines the method of PCR value calculation, which includes determining the deduct values, correcting for number of distresses in each survey, and calculating the PCR value by subtracting the maximum deduct value from one hundred.

The ASTM D6433-11 procedure also outlines how the road network is divided into Sections and Sample Units; first identifying the branches of the pavement with different uses, then dividing each branch into sections based on pavement design, construction history, traffic, and condition. RAS used the sections defined by the city of Tucker in their provided GIS database files. These sections typically can then be divided into sample units that are approximately 2,500 square feet in size. However, for this evaluation, RAS used the option to evaluate 100% of the lanes driven by the RAC vehicle. Instead of averaging the number of sample units inspected within each section, RAS provided one PCR score determined by measuring all the distresses within the driven lane to determine the PCR for each section.

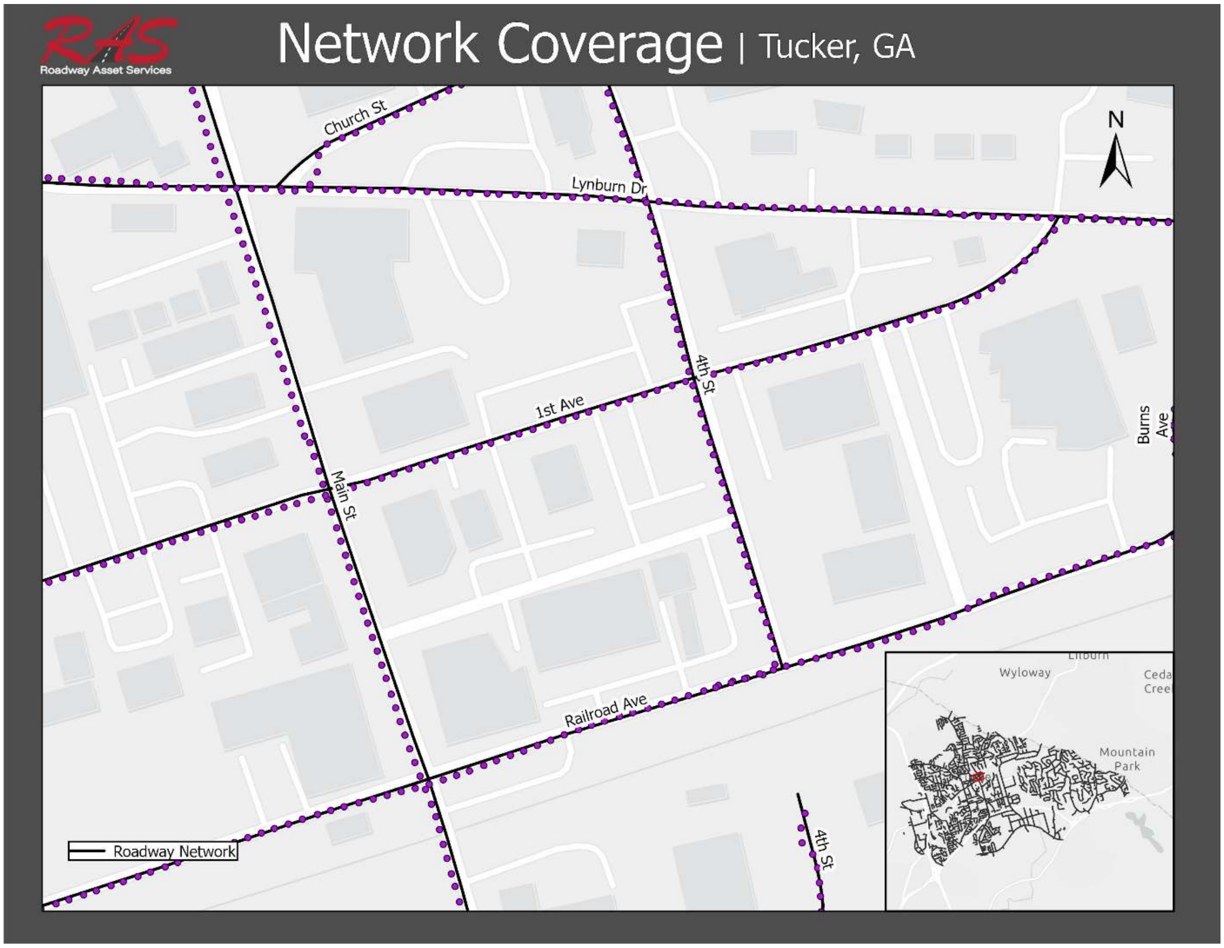


Figure 3.1: Tucker, GA Network Coverage Map

The RAS RAC vehicle collects pavement and ROW images concurrently, approximately every 20 feet along each street segment. All pavement rating is done automatically through RAS's Technical Rating Intelligence Program (Road TRIP™) to ensure we accurately capture all the distresses and false positives are minimalized using proper sensor settings and logic engineering definitions of each distress.

The International Roughness Index (IRI) and longitudinal profiles were collected using an ICC inertial profiling system in accordance with ASTM E950, AASHTO Standard M328-14, AASHTO R43-13, and AASHTO Standard R56-14. For the network collection project, RAS collected RCI data and presented the results in the final database based on the following:

- Line lasers were used in each wheel path to increase repeatability of measurements and to reduce variability due to wheel path cracking and concrete tinning.
- The ICC profiler routinely achieves 98%+ cross-correlations on certification sites, making it one of the most accurate devices available for RCI and profile measurement.
- The operation and verification of the inertial profiling system shall be expertly conducted in accordance with AASHTO Standard R57-14.

ROW images were also collected as part of this project. The RAC vehicle is configured with a Point Gray Ladybug 5+ 32MP 360-degree camera to provide a full panoramic image of the ROW, displayed in Figure 3.2. The images were captured at roughly 20-foot intervals and were post-processed using collected inertial and GPS data. This allowed for more accurate asset extraction to be completed.

The measuring of pavement width is accomplished utilizing the calibrated Ladybug imagery in conjunction with the LCMS-2 imagery and inertial GPS data. Using 360-degree view of the ladybug, RAS can accurately and repeatably measure from edge of pavement to edge of pavement for each road segment. This provides a more accurate area calculation for better budgeting and forecasting. For cul-de-sac sections an average width measurement is taken for the straight portion and the bulb. RAS can also calculate the areas of each segment independently and get a true area of the cul-de-sac section. This is one of the things that get discussed at the working session prior to data collection. The length of a road segment is determined from the GIS database provided by the City. RAS understands that the GIS is not always 100 % accurate. In these cases, after collection is complete, RAS can use the GPS trajectory of the van to determine the true beginning and ending of the road to get a more accurate length and ultimately more accurate area measurement.

Figure 3.2: Right-of-Way Image Example

3.2 Pavement Condition Rating (PCR) Calculation

A pavement distress inventory consists of identifying specific pavement surface distress types that are associated with degradation of a pavement surface due to traffic loads, environmental factors, lack of maintenance and other anthropogenic or natural occurrences. The distress type is then assigned a severity rating (low/medium/high), and the extents of the distress type and severity are recorded. For this project, the pavement distress types, causes and measurements were inventoried utilizing the ASTM D6433-11 method. The inspections covered **<u>100% of the length of a section</u>** for the outside lane of travel.

Each street segment's PCR was calculated utilizing Road TRIP™. The calculation tool within Road TRIP™ is based on the ASTM D6433-11 method of calculating a street segment's PCR value using the observed pavement distresses and severities in the inventory database and ASTM D6433-11 deduct curves for each distress type. ASTM D6433-11 is based on a 0 to 100 rating scale where 0 represents a failed roadway condition and 100 represents an excellent roadway condition.

3.3 International Roughness Index (IRI) and Riding Comfort Index (RCI) Calculation and Analysis

As part of this contract, IRI values were collected along the survey segments utilizing a high-speed three laser profiler. The IRI is a general measurement of the ride quality of a street section and was performed in accordance with AASHTO R 43-07 and ASTM E950. IRI indexes were obtained from measured longitudinal road profiles and were processed using a quarter-car model at 52.80-foot intervals (0.010/mi). RAS utilized a three-laser surface profiling system for evaluating the smoothness of the pavement. The profiler uses infrared lasers and precision accelerometer to obtain accurate and precise profile measurements. The values reported provided to the City are in units of inches per mile. It should be noted that IRI indexes can "spike", resulting in erroneous data being reported along sections of roads where slow speeds (below 15mph) are involved. Another cause of data spikes are abrupt stops caused by stop signs, slow going traffic, or road characteristics (gutter pans, manholes, etc...).

Categorization of IRI indexes can vary from state to state and are typically determined by the agency (e.g., City, DOT, County, etc.). For this report, the results have been based on a common category system that has been in use by a variety of agencies (5.1). The values for IRI should range from 0 to 700 inches/mile. Any values above 700 inches/mile are flagged and changed to be equal to 700 in/mi as they are caused by several reasons mentioned above. The lower the IRI number, the smoother the ride and conversely, higher values indicate a rougher ride. Several states are reviewing their strategic repair and rehabilitation programs based on IRI values for previously identified road sections using IRI.

In this report, the reported IRI values are the normalized value (0-100) of the field measured IRI (0-700). These normalized IRI values are inverted so that the higher values represent smoother pavement surfaces and the lower values represent rougher surfaces. To calculate the weighted PCI, for comparison to the previous assessment results from Stantec, RAS used the field measured IRI in the following formula to calculate the RCI, which was then used to combine with PCR to obtain the reported PCI. The RCI value is similar to the normalized IRI, but only used in this report to calculate the PCI value.

$$\text{RCI} = 10 * (26.67 - 3.82 * Ln(IRI))$$

4 Description of Distress Analysis

Fully automated distress reduction methods are used to classify and rate the distress; therefore, acceptance checks are performed by viewing the pavement images. The data collection vehicle includes software programs that overlay the distress ratings directly on the pavement image to allow viewing of the image and ratings together. Checks of distress ratings are a manual process in which samples of data are visually inspected for accuracy of the ratings. Since distress rating checks are very time-consuming, we commonly begin sampling checks before data collection/rating is complete. Because of this overlap, there is opportunity to promptly re-collect or resurvey any sections with data that do not meet quality criteria. Everything captured in the survey vehicle is GPS-tagged and allows for real time QC to ensure nothing is missed during data collection.

RAS post-processes the pavement and Right-of-Way (ROW) imagery from the RAC vehicle for each day of image collection. A data collection session, which is referred to as a survey, begins when the RAC crew selects “Start” in the collection software on board the RAC vehicle and ends when they select “Stop.” In a single day, we will collect multiple survey sets. With a completed day of collection, RAS pavement engineers and GIS analysts use Pavemetrics® Road Inspect Software to generate all the source data used by Road TRIP™. Every survey set is linked to a uniquely identified road segment, which is used as an identifier during the analysis of the sample area, then identification of the distress extent / severity, and ultimately the distress density for each road segment is added to the database.

Figure 4.1 shows a few of the different tool’s RAS utilized within Road TRIP™ during the QC process. In the upper left corner, we can observe the segment ID, all the images linked to that segment, the rated distresses and exercise the option to manually add a patch area if the Road TRIP™ tool has not identified the patch. RAS utilizes Microsoft® Azure Computer Vision algorithm to identify patches. The algorithm has been specially tested and trained by RAS to produce accurate patch detection. The upper right corner displays the Ladybug images, which the user can toggle between forward, left, right, right-rear, or left-rear facing views. The lower left corner lists the distresses rated in the segment selected with the severity, quantity, density and how many points are deducted from the PCI based on the ASTM D6433-11 deduct curve values. The lower right corner displays the rutting measured by the Laser Profiler and visually displayed by the LCMS-2 3D data.

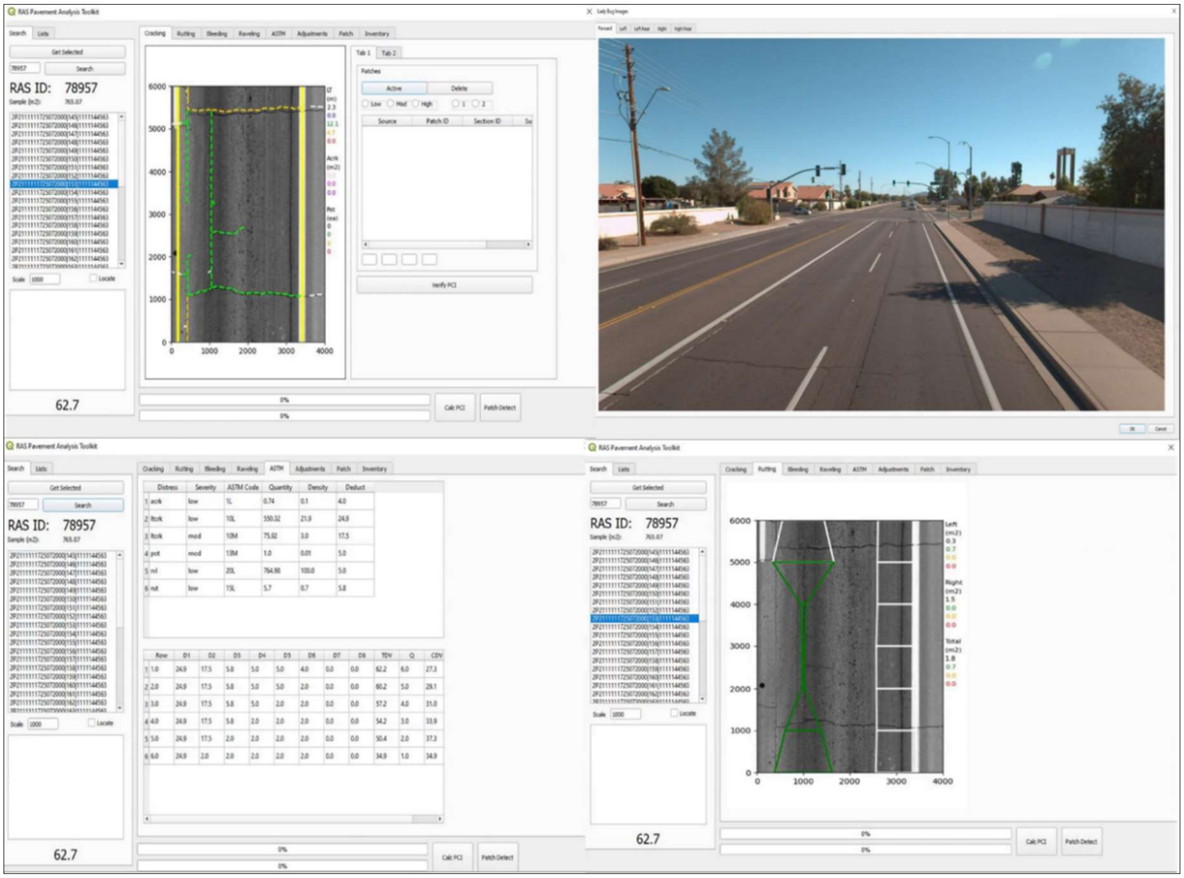
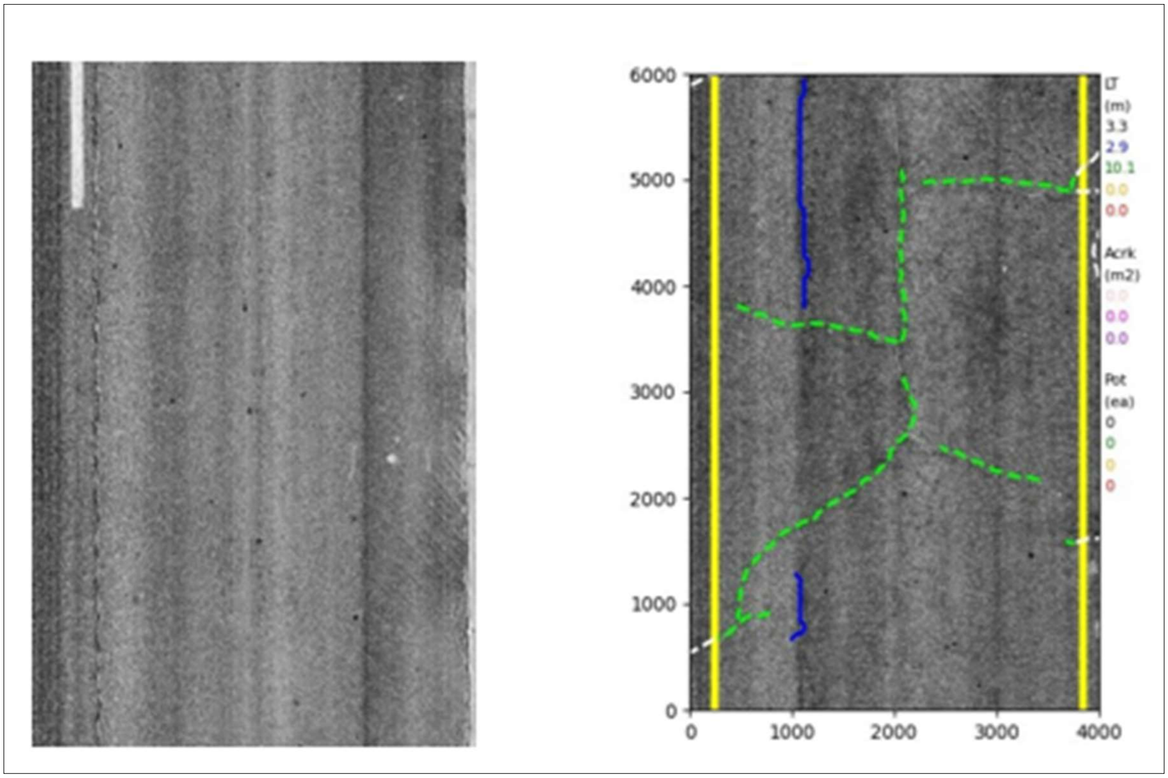


Figure 4.1: RAS Pavement Analysis Tool Example

This method of pavement distress inventory provides a quantifiable and repeatable process to the City. Each street segment, in conjunction with the pavement and ROW imagery, allows pavement engineers to review each road segment, allowing for an open quality control process that is defendable and repeatable.

Road TRIP™ uses the depth map created by the Laser Crack Measurement System (LCMS) to locate the valleys and fissures within the surface of the roadway. These valleys and fissures are then measured and rated. Figures 4.2 and 4.3 display an example of distress overlay images.


6000
5000
4000
3000
2000
1000
0
0
1000
2000
3000
4000
LT
(m)
3.3
2.9
10.1
0.0
0.0
Acrk
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Pot
(ea)
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Figure 4.2: LCMS Post PCI Processing Image

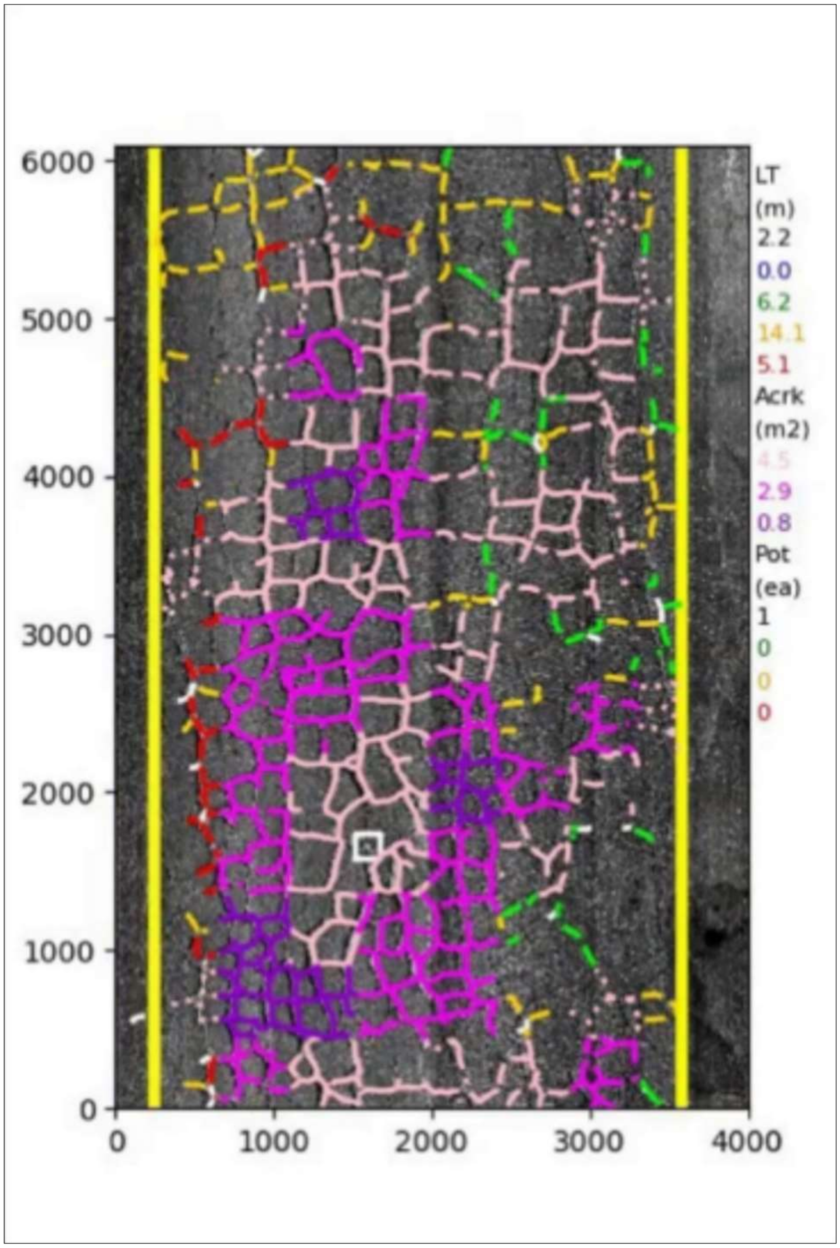

Figure 4.3: Example of Distress Overlay Images

The yellow line indicates the boundary of rated sample, green, yellow, and red lines indicate longitudinal and transverse cracking of low, moderate, and high extent, the pink, magenta, and violet lines indicate areas of low, moderate, and high severity cracking that has been filtered because it does not meet minimum length or width requirements. The overlay images provide a visual means by which to review the sensor.

5 Results

The overall pavement network health of the city of Tucker can be assessed by reviewing Figure 5.2 in more detail. This graph illustrates the percentage of the network by area that falls into each descriptive condition category. A few areas for review are as follows:

- Shape of Distribution – Figure 5.1 illustrates a distribution that is shifted to the right and peaks between a PCI of 71 to 85. This is indicative of an agency that has an ongoing maintenance program and is actively re-investing in the roadway network using preventative measures.
- Average PCI – The City's network average PCI at the time of collection is 70 and this is above the averages that are typically seen across the Country between a 60 to 65.
- Good Roads – Currently 10% of the City's roadways fall into the Good condition category, which is a healthy amount.
- Backlog – these are the roads that fall below an PCI of 40 and land in the Very Poor, Serious, and Failed condition categories. About 7% of the roadway network falls into these categories, which is a reasonably number. However, current status can often be deceiving as backlog can grow at an alarming rate. The funding scenarios discussed further in this report will illustrate that the City's current budget is not adequate to arrest the growth in backlog over the next 5-year period.

5.1 Pavement Condition Rating (PCR Results)

Table 5.1: Tucker, GA Condition Scale

Pavement Condition Index (PCI)	Condition Description
86 – 100	GOOD
71 – 85	SATISFACTORY
56 – 70	FAIR
41 – 55	POOR
26 – 40	VERY POOR
11 – 25	SERIOUS
0 – 10	FAILED

Table 5.2: Tucker, GA All PCR Ranges by Percent

Pavement Condition Rating (PCR) Range	Condition Description	Total Area (yd2)	Total Distance (Centerline Miles)	Percent of Network (Centerline Miles)
86 – 100	**Excellent**	**1,063,133**	**69.53**	**40.8%**
71-85	**Good**	**691,412**	**41.02**	**24.1%**
56-70	**Fair**	**513,031**	**31.83**	**18.7%**
41-55	**Poor**	**221,510**	**13.39**	**7.9%**
26-40	**Very Poor**	**152,439**	**10.39**	**6.1%**
11-25	**Serious**	**55,077**	**3.88**	**2.3%**
0-10	**Failed**	**2,041**	**0.15**	**0.1%**
Total of Rated Segments		**2,698,643**	**170.19**	**100%**

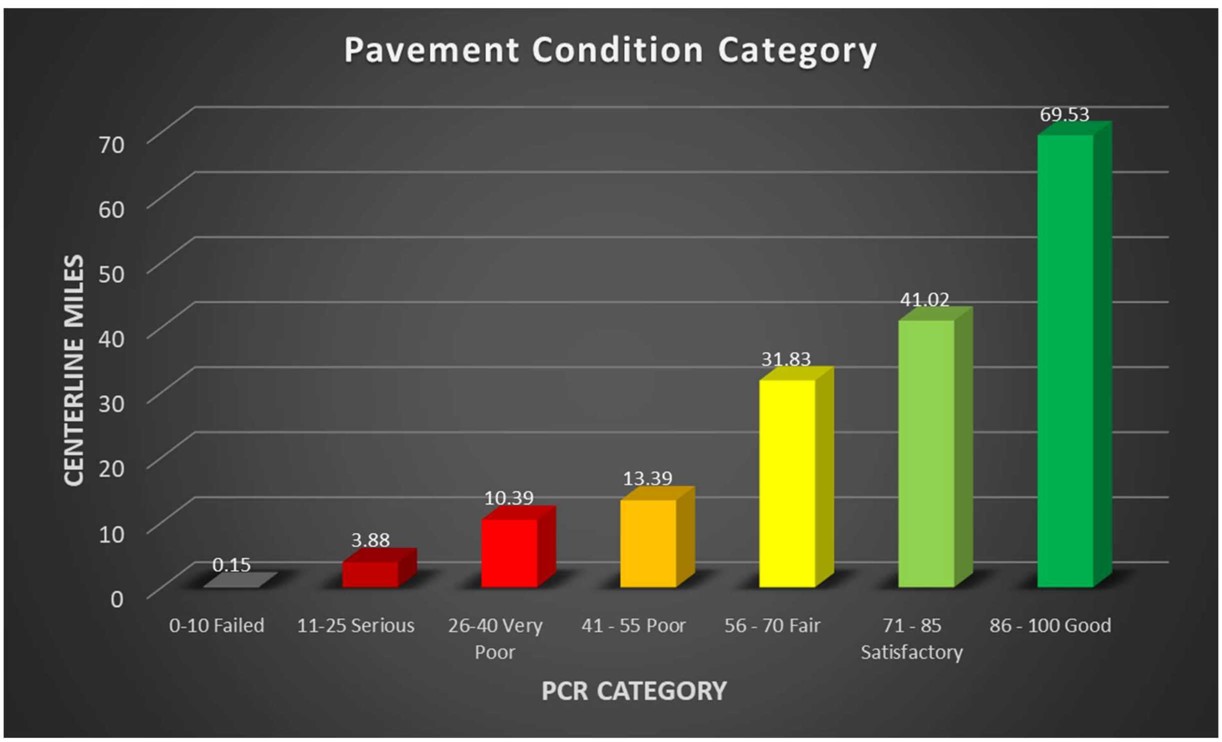

Figure 5.1: Tucker, GA PCR Ranges by Mileage

Figure 5.2 displays the Pavement Condition Rating distribution throughout the City's survey area roads. Figure 5.3 displays an example zoomed-in PCR map with the actual PCR values for each roadway section.

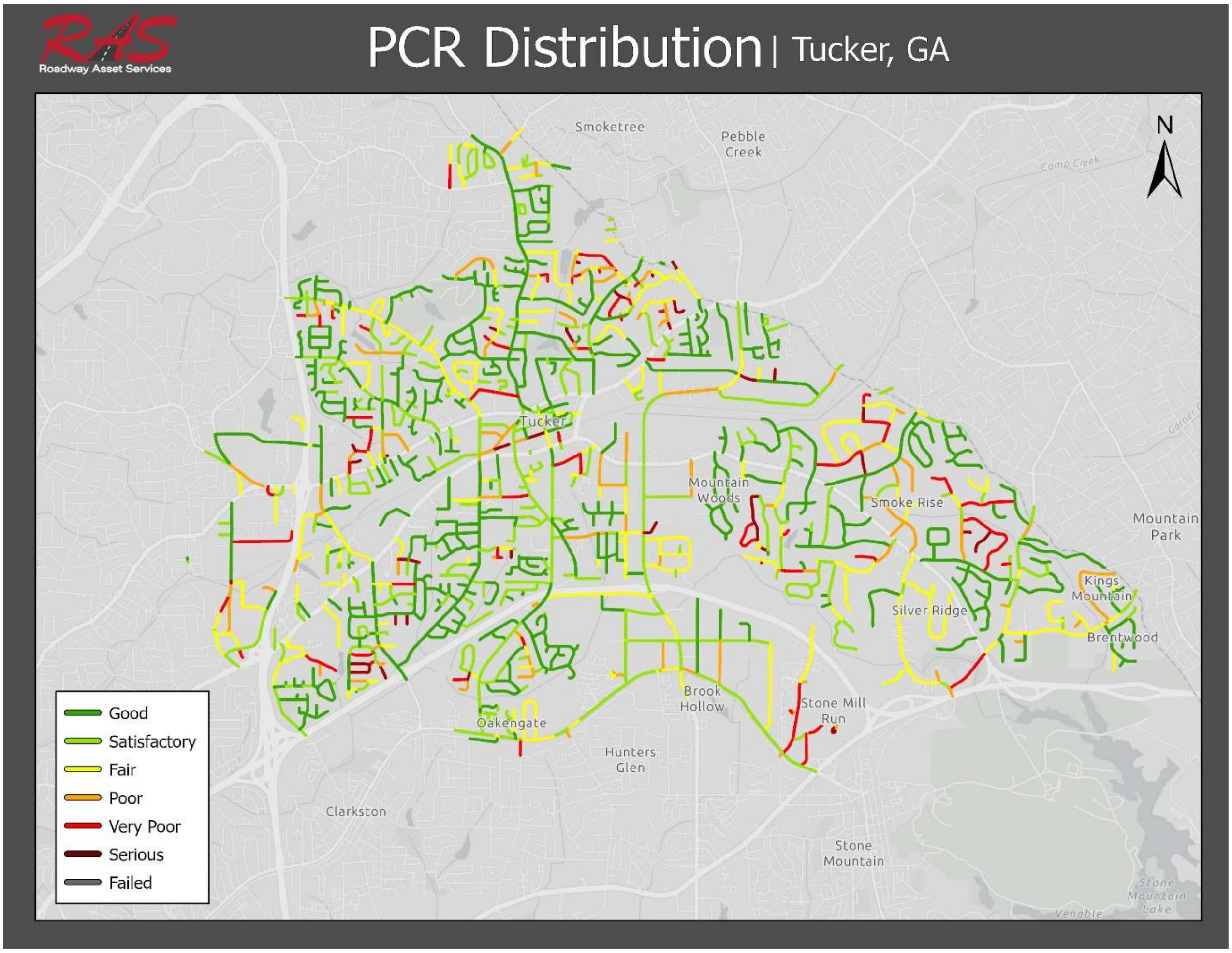

Figure 5.2: Tucker, GA PCR Distribution Map

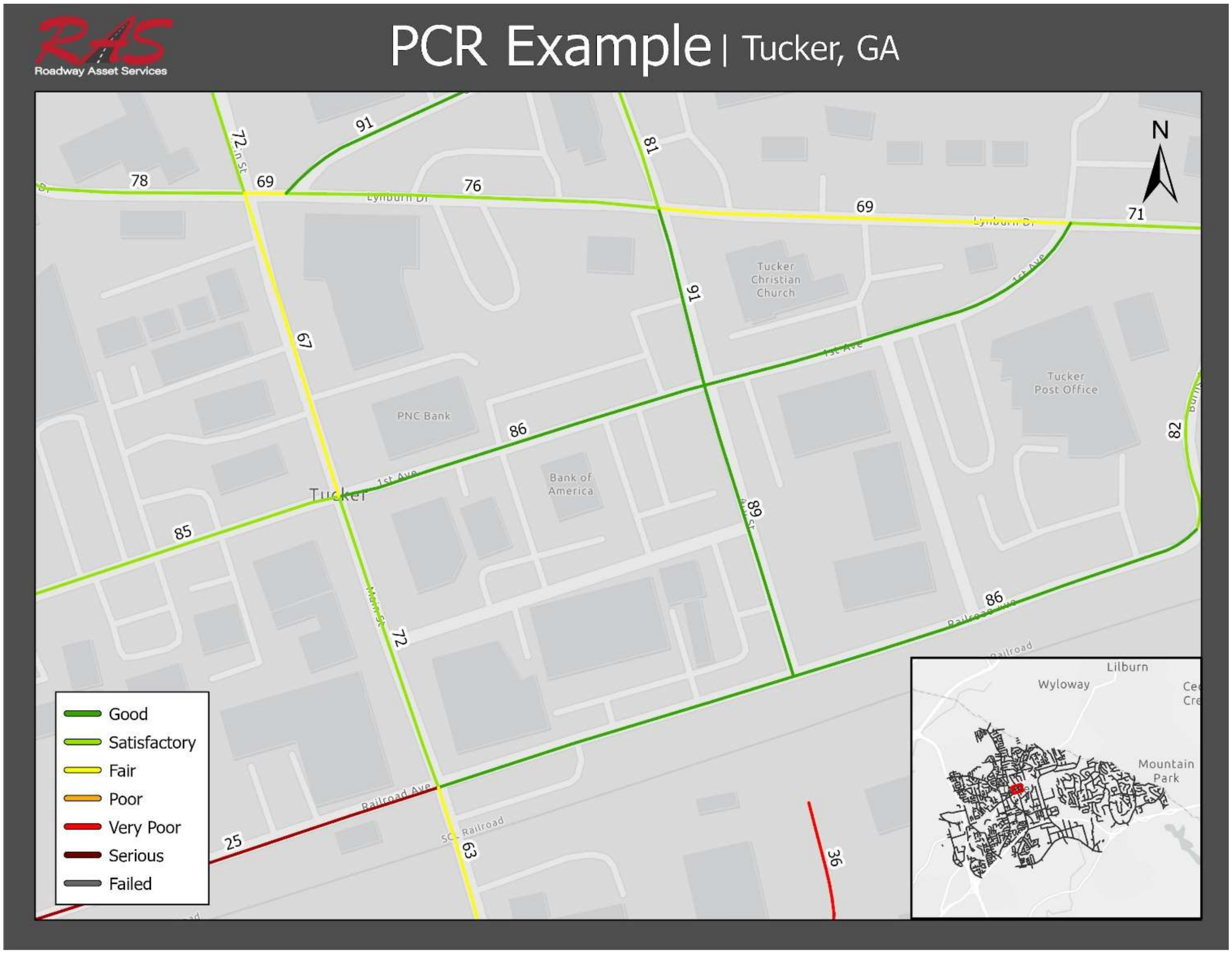

Figure 5.3: Tucker, GA PCR Example Map

5.2 International Roughness Index (IRI) Results

Table 5.3 shows the overall IRI condition of the network based on surface types. Figure 5.5 displays an example zoomed-in IRI map with the actual normalized IRI values for each roadway section.

Table 5.3: Tucker, GA All IRI Ranges by Percent

IRI Category	Condition Description	Total Area (Sq. Yd.)	Total Distance (Miles)	Percent of Network (Miles)
86 - 100	**Good**	**315,805**	**17.40**	**10.2%**
71 - 85	**Satisfactory**	**1,297,981**	**79.17**	**46.5%**
56 - 70	**Fair**	**827,792**	**55.63**	**32.7%**
41 - 55	**Poor**	**187,281**	**13.15**	**7.7%**
26- 40	**Very Poor**	**49,113**	**3.45**	**2.0%**
11-25	**Serious**	**14,963**	**1.04**	**0.6%**
0-10	**Failed**	**5,708**	**0.35**	**0.2%**
Total of Rated Segments		**2,698,643**	**170.19**	**100.0%**

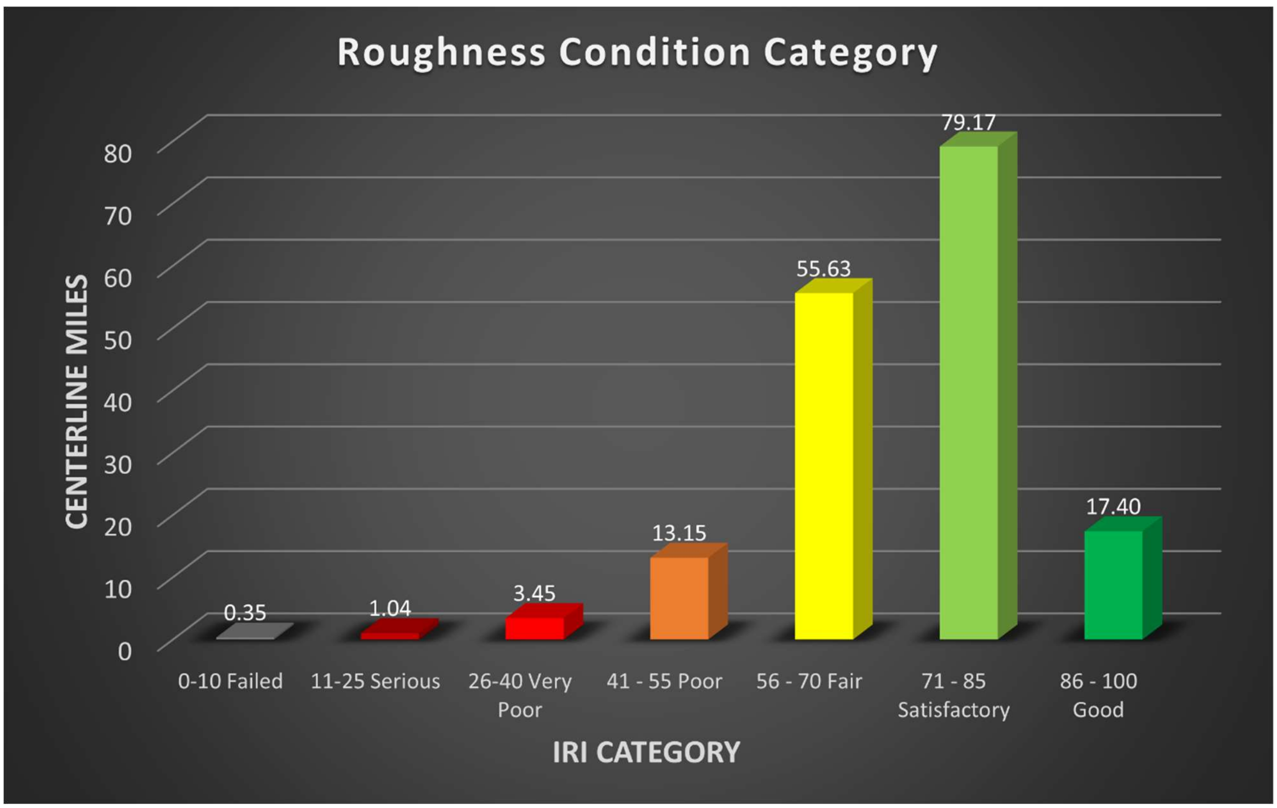

Figure 5.4 Tucker, GA IRI Ranges by Mileage

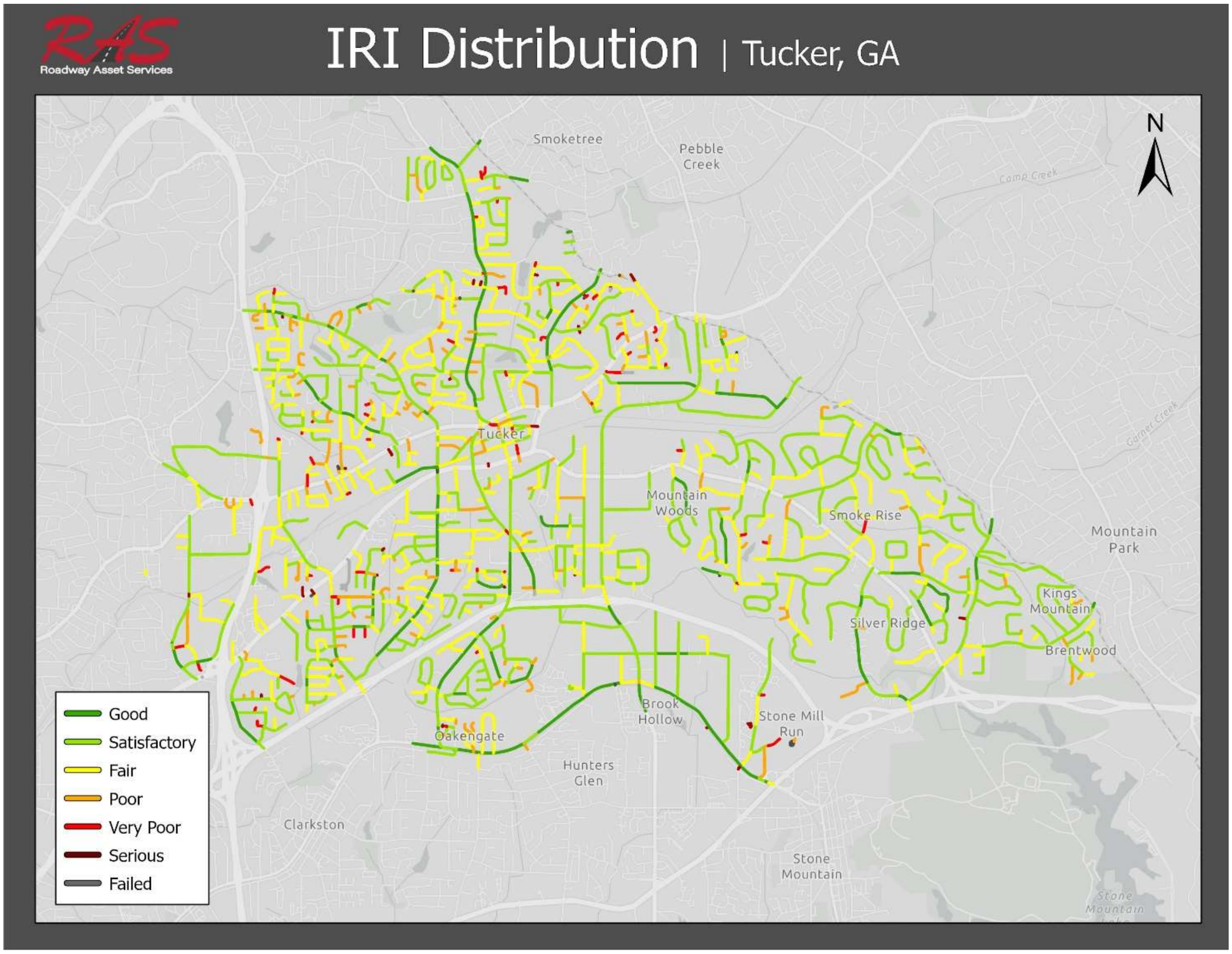

Figure 5.5: Tucker, GA IRI Distribution Map

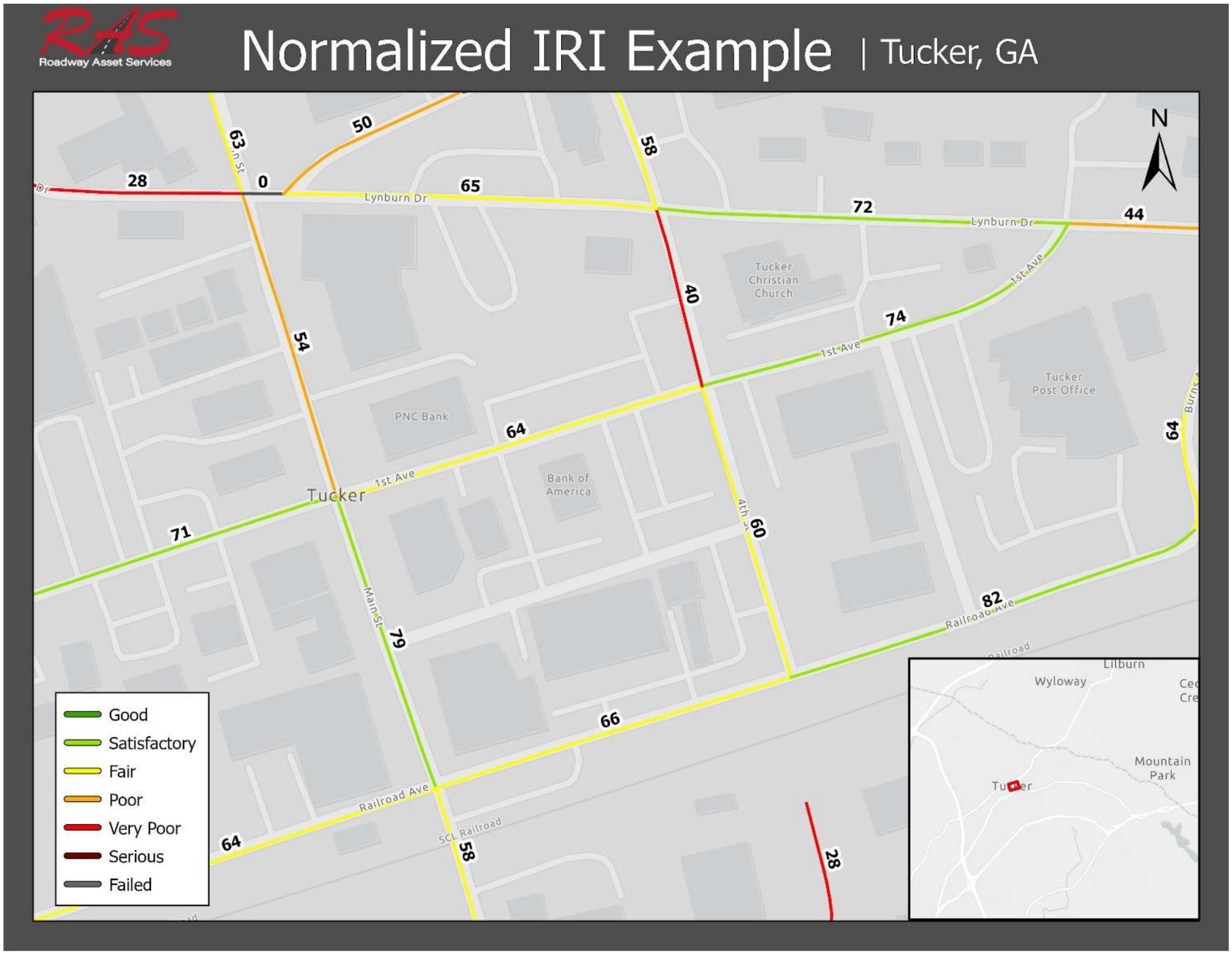

Figure 5.6: Tucker, GA Normalized IRII Example Map

5.3 Pavement Condition Index (PCI) Results

The Pavement Condition Index (PCI) is a measure of the overall serviceability provided by a pavement to the vehicle driver. After finding the PCR scores, calculated from the field measured IRI values, and inputting them into the formula in section 3.3, a PCI score was calculated by using the following equation to get an overall score for each segment of road:

$$\mathbf{PCI = (0.66 \times PCR) + (0.33 \times RCI)}$$

Based upon the provided relationship between PCR and the RCI, in order to determine PCI, the values previously presented as PCR may be impacted by several points depending on the severity of the RCI value. A smooth road may have a slightly increased PCI value after incorporating the RCI, while a rough road with a low RCI score may slightly decrease the PCI. Since the relationship is based upon an 66:33 ratio, the PCI value will not deviate from the original PCR by more than 33 points.

Table 5.4: Tucker, GA All PCI Ranges by Percent

Pavement Condition Index (PCI) Range	Condition Description	Total Area (yd2)	Total Distance (Centerline Miles)	Percent of Network (Centerline Miles)
86 – 100	**Excellent**	**273,226**	**16.36**	**9.6%**
71-85	**Good**	**1,299,384**	**81.68**	**48.0%**
56-70	**Fair**	**688,240**	**43.09**	**25.4%**
41-55	**Poor**	**278,885**	**17.91**	**10.5%**
26-40	**Very Poor**	**144,368**	**10.09**	**5.9%**
11-25	**Serious**	**14,540**	**1.07**	**0.6%**
0-10	**Failed**	**0**	**0**	**0.0%**
Total of Rated Segments		**2,698,643**	**170.19**	**100%**

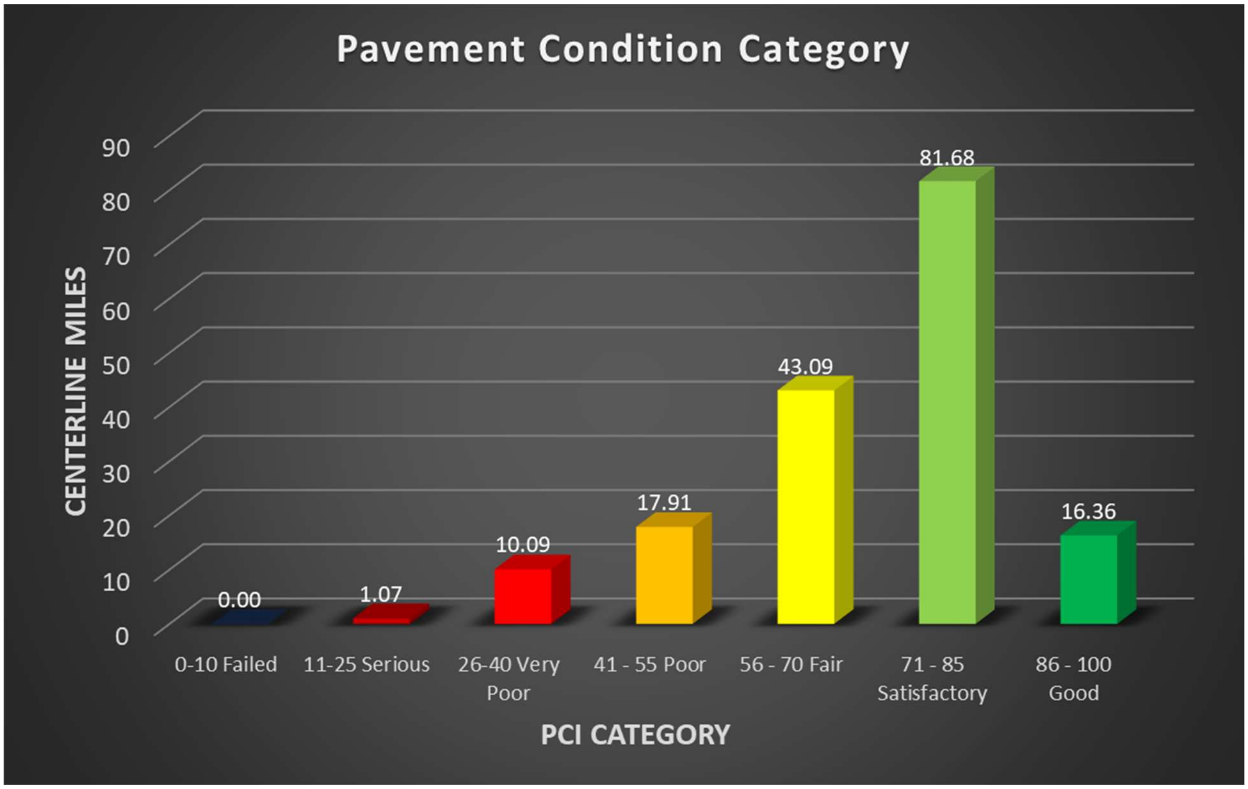

Figure 5.7: Tucker, GA PCI Ranges by Miles

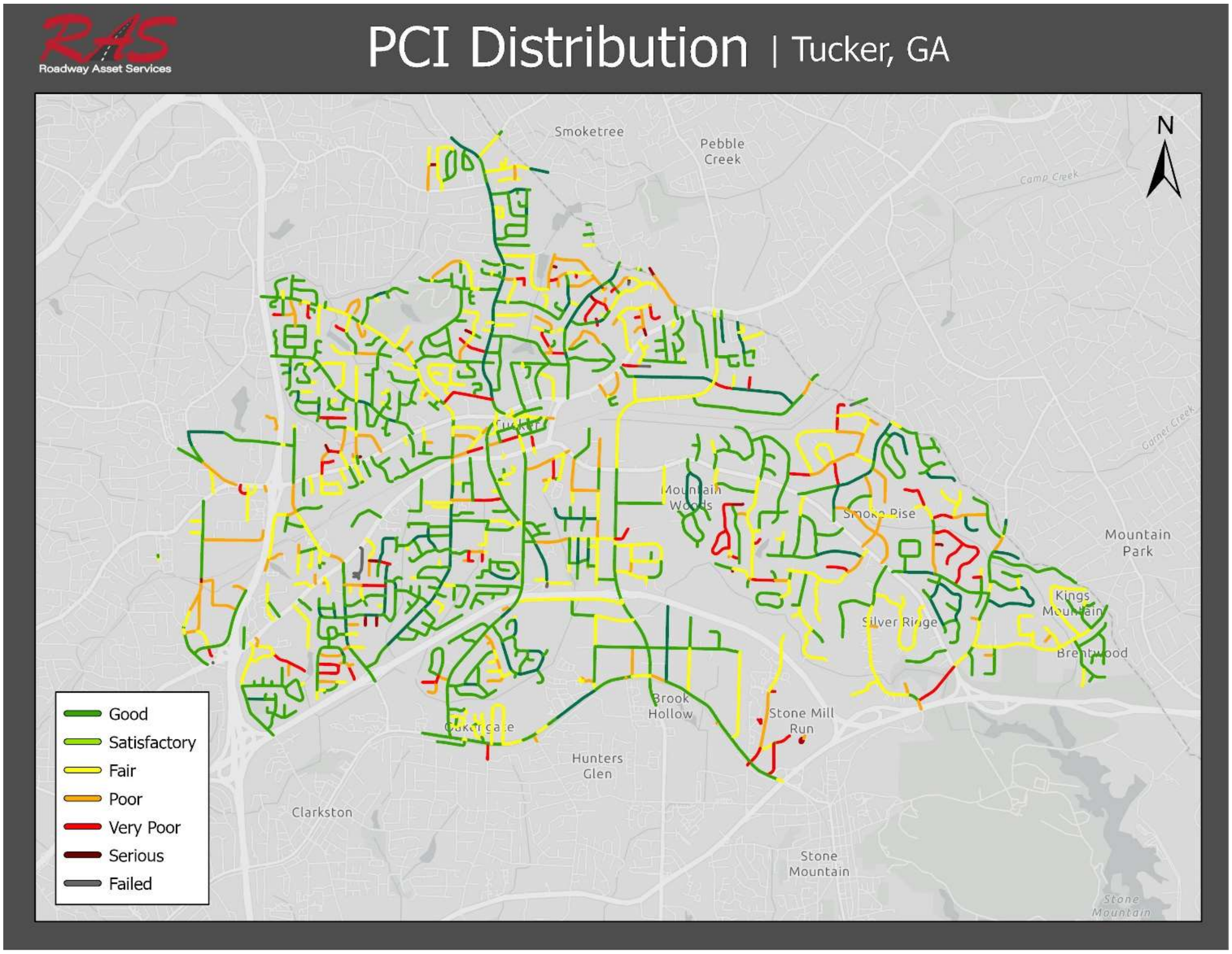

Figure 5.8: Tucker, GA PCI Distribution Map

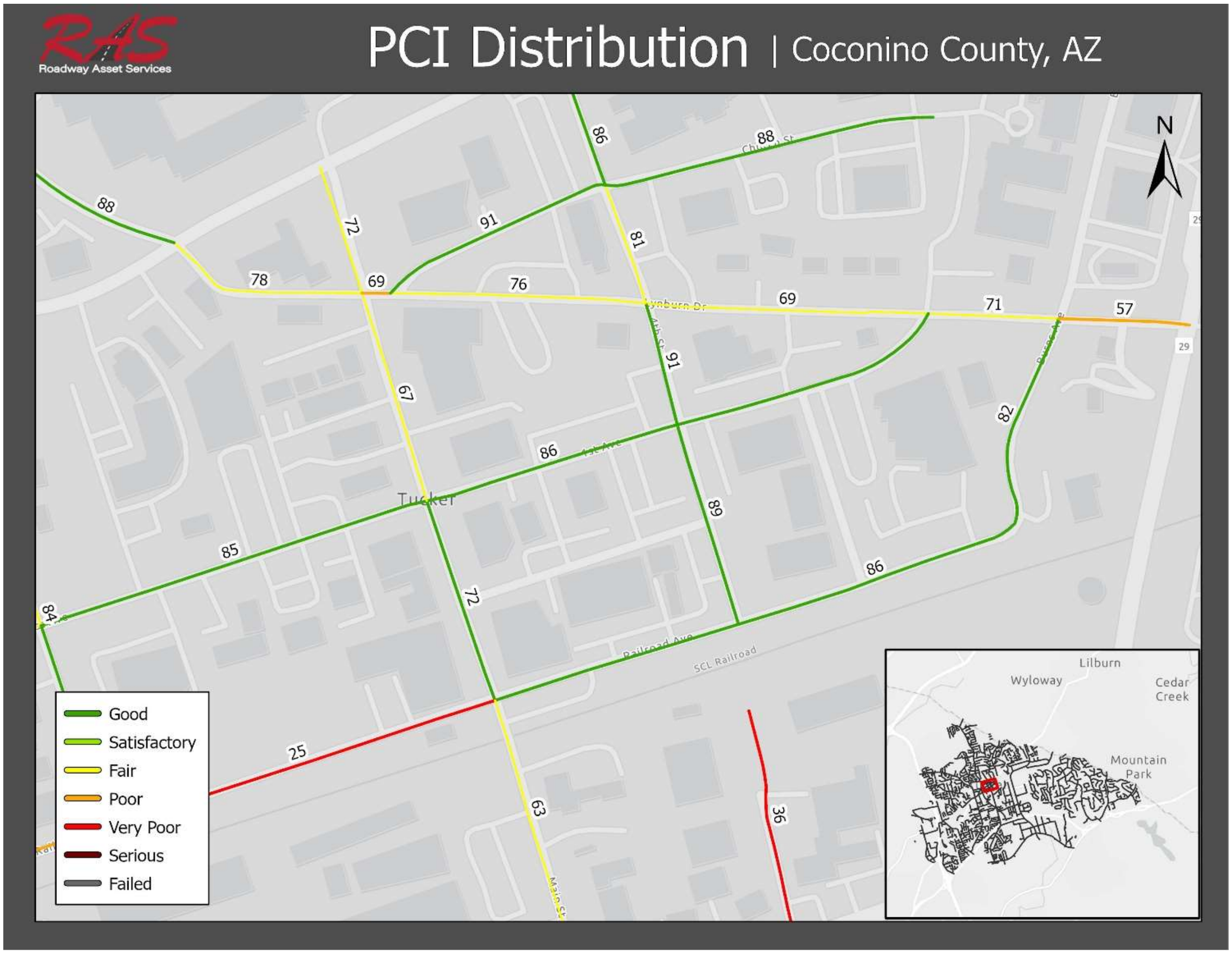

Figure 5.9: Tucker, GA PCI Example Map

5.4 Distress Breakdown by Severity

Figures 5.10, and Tables 5.5, 5.6 display the types of distresses found in the City's asphalt and concrete roads The figures and tables captioned "…Breakdown by Percentage of Segments" show the percentage of segments that contain a given distress and severity. Each distress is mutually exclusive, and the percentage doesn't represent coverage in a segment, yet only the existence of the distress in a segment. For example, 60% low alligator cracking means that 60% of the total asphalt segments in the network have some low alligator cracking. Similarly, 30% high alligator cracking means that 30% of the total asphalt segments have some high alligator cracking.

Tables and figures captioned "…Breakdown by Average Density" show the average density of a given distress and severity. For example, 1.85% low alligator cracking in Table 5.6 means that the average density of all segments with some low alligator cracking is only 1.85%. Table 5.5 shows that 60% of asphalt streets contain low severity alligator cracking, but Table 5.6 shows that the average density of low alligator cracking is 1.85% thus, this distress, on average, does not cover a large area of the network as a whole. It is also important to note that not all distresses carry equal weight when calculating PCR. For example, one pothole can have more of an impact on the PCR score than 100% low weathering, so the following tables and figures should only be used to gain an understanding of the distresses present in the network.

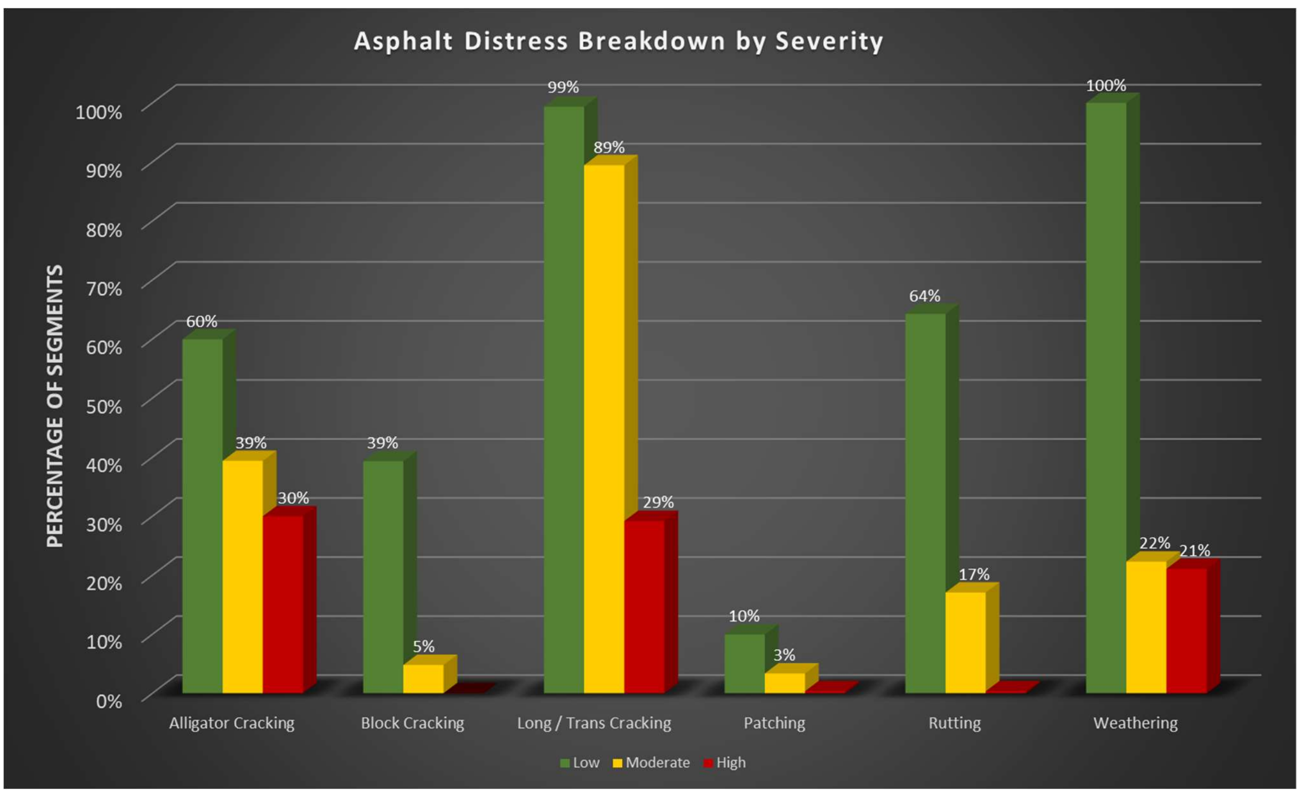

Figure 5.10: Tucker, GA Asphalt Distress Breakdown

Table 5.5: Tucker, GA Asphalt Distress Breakdown by % of Segments

Asphalt Distress Breakdown by % of Segments			
Distress/ Severity	**Low**	**Moderate**	**High**
Alligator Cracking	59.97%	39.38%	29.99%
Block Cracking	39.31%	4.81%	0.00%
Long / Trans Cracking	99.35%	89.45%	29.20%
Patching	9.97%	3.37%	0.36%
Potholes	0.07%	0.00%	0.00%
Rutting	64.28%	17.07%	0.36%
Weathering	100.00%	22.31%	21.09%

Table 5.6: Tucker, GA Asphalt Distress Breakdown by Average Density

Asphalt Distress Breakdown by Average Density			
Distress / Severity	**Low**	**Moderate**	**High**
Alligator Cracking	1.85%	0.82%	0.73%
Block Cracking	31.70%	6.02%	0.00%
Long / Trans Cracking	5.42%	0.63%	0.16%
Patching	2.22%	0.44%	0.56%
Potholes	0.10%	0.00%	0.00%
Rutting	1.09%	0.56%	0.44%
Weathering	99.97%	0.17%	0.40%

6 Pavement Maintenance/Preservation Funding

RAS performed various five-year pavement maintenance and preservation program scenarios for the City's consideration using Budget Optimization Street Selector (BOSS^{TM}) software.

The analysis runs a series of 12 profile models for increasing budgets to define how the City's budget will impact network PCI and network backlog. The scenarios include very small budgets, well below current funding and very large scenarios, well above current funding levels. The results from all scenarios are then used to establish a funding level trend. This approach will answer specific funding questions asked at the time of analysis but will also provide a 5-year maintenance and rehabilitation plan. The City's current budget is the only budget that used a forced selectin of the planned work. All other profile models were completely optimized with the restriction that no funding was used to treat roads with PCI's above a 65 for any model.

Before beginning the analysis, completed work is entered for roads that have had maintenance since the collection date up until the start date of the analysis. Additionally, the city was able to request roads be excluded from the analysis that they do not want included in the models. These two adjustments included with the aging of the collected data may impact the overall PCI to a point where it no longer matches the network PCI given in the section 1.3 of this report.

7 Scenarios and Budget Estimates

7.1 Deterioration curves

Deterioration curves were established for each roadway classification (major, intermediate, and local) and follow similar degradation standards as outlined by ASTM D6433 and the US Army Corps of Engineers. In future pavement condition assessments, it is suggested that the consultant conduct a thorough comparison of the current inspection data against the previous condition assessment. Such an analysis will allow for further refinement of the pavement deterioration curves to ensure they reflect reasonable rates of degradation in Tucker, GA. Such an analysis should be conducted after every pavement condition update. The pavement deterioration curves were assembled to establish a 100 - 0 deterioration curve for reach functional classification as demonstrated in Figure 7.1 below.

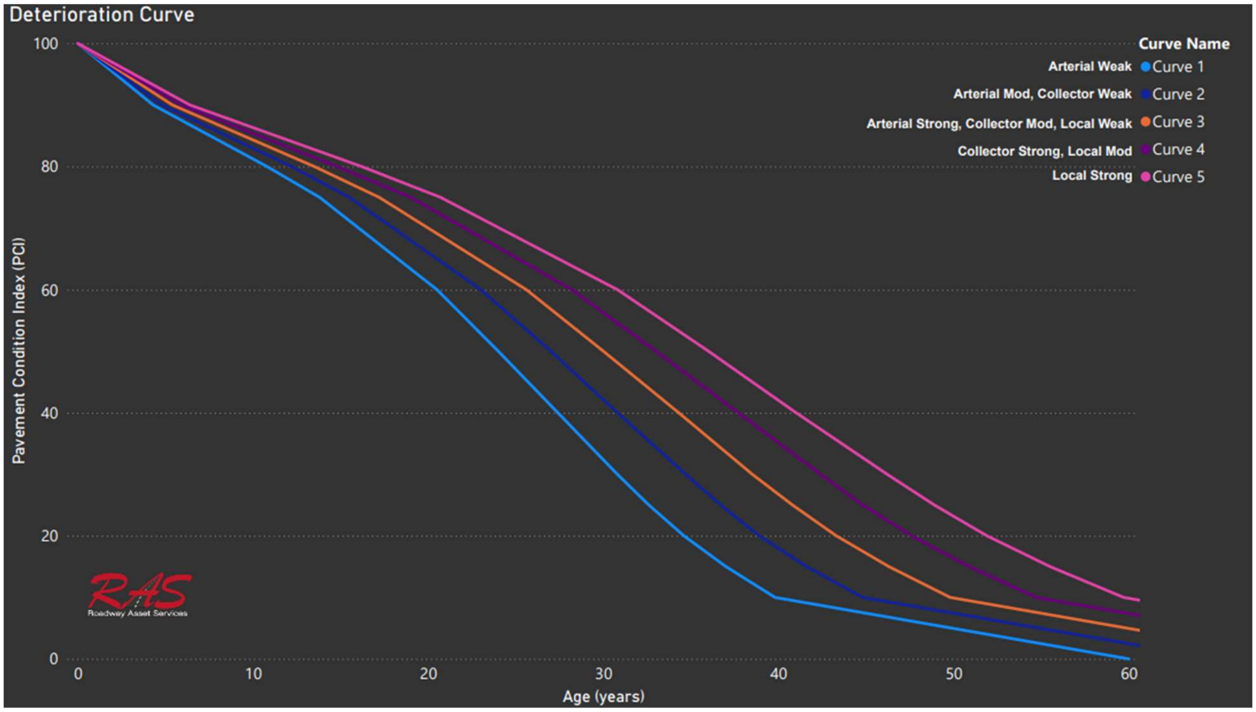

Figure 7.1: City of Tucker, GA Deterioration Curves with no Maintenance

These curves represent the deterioration of roads without maintenance.

Reviewing deterioration rates for unmaintained roads as part of each condition data collection cycle and adjusting deterioration curves is a recommended best practice.

7.2 Treatment Activities and Cost

Tables 7.1 to 7.3 summarize the maintenance strategy for roads within an PCI range, the cost of the maintenance per square yard, and the assumed PCI impact for each type of maintenance. The costs displayed in Tables 7.1 to 7.3 show the unit rate for roads with different strengths (defined by calculating the density of load associated distresses for each segment), where the rates are increased to consider structural patch work needed in the moderate and weak roads.

While asphalt reconstruction activities were utilized in the optimized models of BOSS, the City's current budget of $4.5M annually included a forced selection of planned work.

Table 7.1: City of Tucker, GA- Maintenance Suggestion by PCI Range (Arterial)

Treatment	Pavement Strength	Min PCI	Critical PCI	Max PCI	Cost per SY	Priority	Reset Value
Do Nothing	Strong	85	88	100	$ 0.00	4	0
Do Nothing	Moderate	85	88	100	$ 0.00	4	0
Do Nothing	Weak	85	88	100	$ 0.00	4	0
Surface Preservation	Strong	65	68	85	$ 0.00	3	15
Surface Preservation	Moderate	65	68	85	$ 0.00	3	15
Surface Preservation	Weak	65	68	85	$ 0.00	3	15
Surface Rehab + Patching	Strong	50	53	65	$ 34.85	2	95
Surface Rehab + Patching x1	Moderate	50	53	65	$ 35.85	2	95
Surface Rehab + Patching x2	Weak	50	53	65	$ 36.85	2	95
Structural Rehab	Strong	0	25	50	$ 43.35	1	95
Structural Rehab	Moderate	0	25	50	$ 44.35	1	95
Structural Rehab	Weak	0	25	50	$ 45.35	1	95

Table 7.2: City of Tucker, GA- Maintenance Suggestion by PCI Range (Collector)

Treatment	Pavement Strength	Min PCI	Critical PCI	Max PCI	Cost per SY	Priority	Reset Value
Do Nothing	Strong	85	88	100	$ 0.00	4	0
Do Nothing	Moderate	85	88	100	$ 0.00	4	0
Do Nothing	Weak	85	88	100	$ 0.00	4	0
Surface Preservation	Strong	65	68	85	$ 0.00	3	15
Surface Preservation	Moderate	65	68	85	$ 0.00	3	15
Surface Preservation	Weak	65	68	85	$ 0.00	3	15
Surface Rehab + Patching	Strong	50	53	65	$ 34.85	2	95
Surface Rehab + Patching x1	Moderate	50	53	65	$ 35.85	2	95
Surface Rehab + Patching x2	Weak	50	53	65	$ 36.85	2	95
Structural Rehab	Strong	0	25	50	$ 43.35	1	95
Structural Rehab	Moderate	0	25	50	$ 44.35	1	95
Structural Rehab	Weak	0	25	50	$ 45.35	1	95

Table 7.3: City of Tucker, GA- Maintenance Suggestion by PCI Range (Local)

Treatment	Pavement Strength	Min PCI	Critical PCI	Max PCI	Cost per SY	Priority	Reset Value
Do Nothing	Strong	85	88	100	$ 0.00	4	0
Do Nothing	Moderate	85	88	100	$ 0.00	4	0
Do Nothing	Weak	85	88	100	$ 0.00	4	0
Surface Preservation	Strong	65	68	85	$ 0.00	3	15
Surface Preservation	Moderate	65	68	85	$ 0.00	3	15
Surface Preservation	Weak	65	68	85	$ 0.00	3	15
Surface Rehab + Patching	Strong	30	33	65	$ 29.45	2	95
Surface Rehab + Patching x1	Moderate	30	33	65	$ 30.45	2	95
Surface Rehab + Patching x2	Weak	30	33	65	$ 31.45	2	95
Structural Rehab	Strong	0	25	30	$ 40.75	1	95
Structural Rehab	Moderate	0	25	30	$ 41.75	1	95
Structural Rehab	Weak	0	25	30	$ 42.75	1	95

Each maintenance strategy has a critical and non-critical PCI range. Streets that are not maintained when they are in the critical range will deteriorate into the next category of maintenance and will become more expensive the following year. The analysis prioritizes segments in the critical PCI range over segments that are in the non-critical PCI range. Given an unlimited budget, the analysis will select all segments in the critical PCI range followed by all segments in the non-critical PCI range.

Each maintenance strategy has a Cost of Deferral Priority which prioritizes selections within the critical PCI range (within 2-4 points of dropping into the next rehabilitation activity) and within the non-critical PCI range. The priority is sequenced by prioritizing the segments that cost more to defer than segments that cost less to defer, starting with the critical segments first. For example, the cost of deferring a strong Surface Rehab + Patching treatment at $29.45/sqyd to a Structural Rehab at $ 40.75/sqyd is $11.30/sqyd. The financially optimized model will prioritize the critical selections first and if there is funding left over, non-critical selections will then be selected and prioritized using the very same cost of deferral sequencing.

7.3 Scenarios

A variety of scenarios have been run to provide an understanding of the relationship between funding levels and the corresponding impact to network PCI and backlog. For this analysis, all roads having a PCI < 40 was considered backlog.

7.3.1 Do-Nothing

The Do-Nothing budget models the impact of applying zero maintenance. While it is not a scenario that occurs in practice, the Do-Nothing budget provides an understanding of the rate at which the level of service of the street network will deteriorate without maintenance and ensures the modeling engine is properly applying deterioration over time. In Figure 7.2 the gray line represents the PCI trend if there is zero maintenance applied for the next 5 years. The network PCI would drop to a 65.

7.3.2 Steady State Network PCI (SS PCI)

The Network PCI is generally accepted as the street networks measure of level of service to the community. The purpose of the Steady State Network PCI analysis is to identify the budget needed to maintain the network PCI as it was surveyed in 2024 and provide a steady level of service to the community.

Approximately $3,650,000 per year is needed to maintain a Network PCI of 71. However, this number can be deceiving as it does not take into consideration the backlog which can have a greater impact on the serviceability of the network as a whole. Backlog can grow at an alarming rate and it is important to note that $4,500,000 per year is required to maintain the current level of backlog.

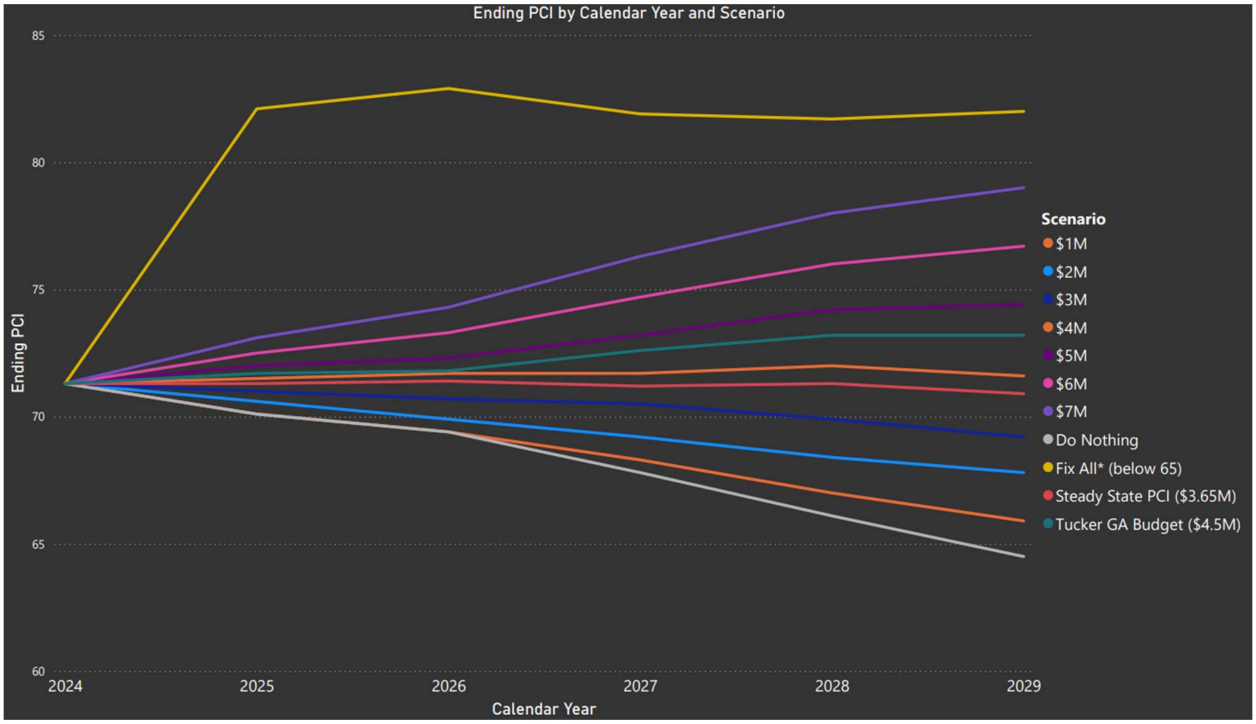

Figure 7.2: City of Tucker, GA- PCI Trend by Budget Scenario

7.3.3 Sample Maintenance Budgets versus PCI Improvement

Eight sample maintenance budgets were run to define the relationship between budget levels and network PCI. The 5-year budget scenario is set to start in the Calendar Year 2024 and end in 2020. The Tucker GA Budget includes a forced selection of planned work projects already determined by the City.

The network PCI in 2024 was 71. With the City's current budget of $4.5M annually, the network's condition will increase to a PCI of 73. Figure 7.3 can be used to answer and predict the network PCI at any funding level between $0 per year and $9,000,000 per year. Figure 7.3 was used to predict the PCI at the following budgets in Table 7.4.

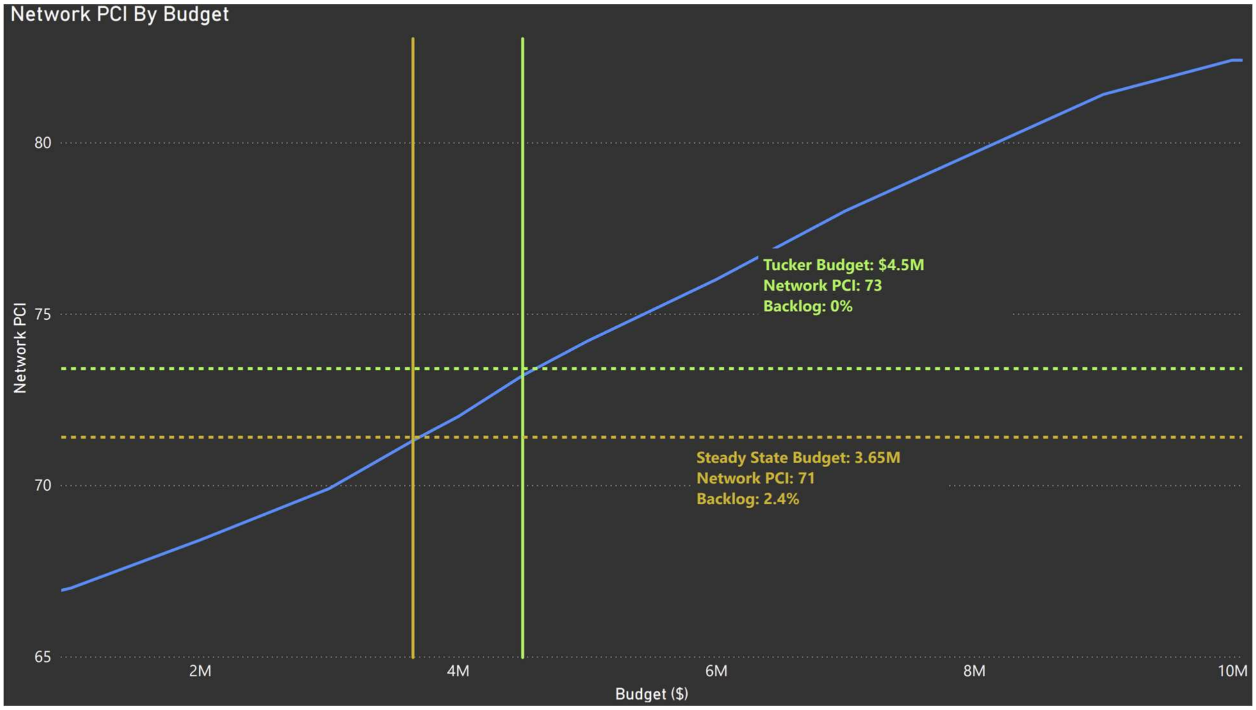

Figure 7.3: City of Tucker, GA- Predicted 5-Year Pavement Condition Index Outlook

Table 7.4: City of Tucker, GA- Predicted 5-Year Overall Condition Index Outlook

Budget	Network PCI
$1,000,000	66
$2,000,000	68
$3,000,000	69
$4,000,000	72
$5,000,000	74
$6,000,000	77
$7,000,000	79
$8,000,000	81
$9,000,000	83

8 Summary

In conclusion, Tucker's condition at the time of collection was in fair condition with a network average PCI of 70. After aging the data for the analysis and inputting completed work, the City's network is in Satisfactory condition with a network average PCI of approximately 71. This is a healthy number compared to the national average of 60 to 65. The City required a budget of $3.65 to maintain the current network PCI, but if the City's budget is less than $4.50M a year, the backlog will grow at an alarming rate. Additionally, the cost of materials and labor will inevitably increase causing a need for greater funding year over year. The biggest challenge for City staff will be the implementation of a preservation program that will proactively maintain roadways above a PCI of 65 before they fall into more expensive treatment categories, such as mill and overlay and full reconstruction. Due to the high cost of reconstruction of roads that fall into this category, it may be difficult to fund all critical roadways.

9 Appendix I: Distress Definitions (Colorado State University)

- AC Bleeding & Pumping (ft^2) represents excessive use of bituminous binder in the asphalt mix.
- AC Fatigue (Alligator) Cracking (ft^2) is associated with fatigue due to traffic loading and visually looks as interconnected cracks forming small pieces ranging in size from about 1” to 6” typically in the wheel path.
- AC Block Cracking (ft^2) usually intersect at nearly right angles and range from one foot to 10’ or more across. The closer spacing indicates more advanced aging caused by shrinking and hardening of the asphalt over time.
- AC Edge Cracking (ft) is parallel to and usually within 1.5 feet of the outer edge of the pavement. This distress is accelerated by traffic loading and can be caused by frost-weakened base or subgrade near the edge of the pavement.
- AC/PCC Lane/Shoulder Drop-off (ft) is a difference in elevation between the pavement edge and the shoulder. This distress is caused by shoulder erosion, shoulder settlement, or by building up the roadway without adjusting the shoulder level.
- AC Linear Cracking (trans/long) (ft) typically occurs in overlays where the crack is reflected through the overlaying asphalt surface.
- AC Patching (ft^2) is an area of pavement that has been replaced with new material to repair existing pavement.
- AC Potholes (count) are small, usually less than 30 inches in diameter, bowl-shaped depressions in the pavement surface. Generally, have sharp edges and vertical sides near the top of the hole.
- AC Raveling & Weathering (ft^2) is loss of pavement material from the asphalt surface. Typically raveling is caused by stripping of the bituminous film from the aggregate or hardening of asphalt due to aging. Poor compaction, especially in cold weather construction, or insufficient asphalt content can also cause raveling.
- AC Slippage Cracking (ft^2) are crescent of half-moon shaped cracks, usually transverse to the direction of travel. They are produced when braking or turning wheels cause the pavement to slide or deform.
- AC Rutting (ft^2) is a surface depression in the wheel paths.
- PCC Corner Break (slab count) is a crack that intersects the joints. Load repetition combined with loss of support and curling stresses usually cause corner breaks.
- PCC Divided Slab (slab count) is when a slab is divided into four or more pieces due to overloading, or inadequate support.

- PCC Durability "D" Cracking (slab count) is caused by freeze-thaw expansion of the large aggregate, which gradually breaks down the concrete. Usually appears as a pattern of cracks running parallel and close to a joint or linear crack.
- PCC Joint Sealant Damage (slab count) is any condition that enables soil or rocks to accumulate in the joints or allows significant water infiltration.
- PCC Linear Cracking (trans/long) (slab count) divide the slab in two or three pieces and are usually caused by a combination of repeated traffic loading, thermal gradient curling and repeated moisture loading.
- PCC Patching, Large/Utility Cut (slab count) is an area where the original pavement has been removed and replaced by new pavement.
- PCC Patching, Small (slab count) is an area where the original pavement has been removed and replaced by filler material.
- PCC Polished Aggregate (slab count) is caused by repeated traffic applications. There are no rough or angular aggregate particles to provide good skid resistance.
- PCC Popouts (slab count) is a small piece of pavement that breaks loose from the surface due to freeze-thaw action, combined with expansive aggregates. Usually range in diameter from 1 to 4 inches and in depth from ½ to 2 inches.
- PCC Punchout (slab count) is a localized area of the slab that is broken into pieces. This distress is caused by heavy repeated loads, inadequate slab thickness, loss of foundation support or localized concrete construction deficiency.
- PCC Scaling/Map Cracking/Crazing (slab count) is a network of shallow, fine or hairline cracks that extend only through the upper surface of the concrete. Usually caused by concrete over-finishing and may lead to scaling, which is the breakdown of the slab surface to a depth of ¼ to ½ in.
- PCC Shrinkage Cracks (slab count) are hairline cracks usually less than 6 feet long and do not extend across entire slab. They are formed during the setting and curing of the concrete and do not extend through the depth of the slab.
- PCC Spalling, Corner (slab count) is the breakdown of the slab within 1.5 feet of the corner. Usually caused by traffic loading or infiltration of incompressible materials, weak concrete and/or water accumulation and freeze-thaw action.
- PCC Spalling, Joint (slab count) is the breakdown of the slab edges within 1.5 feet of the joint. Usually caused by traffic loading or infiltration of incompressible materials, weak concrete and/or water accumulation and freeze-thaw action.

10 Appendix II: Automated Data Collection Equipment

10.1 Roadway Asset Collection (RAC) Vehicle

To determine the general distress characteristics of each roadway segment, RAS utilized one of our RAC vehicles, presented in Figure 7.1, to collect street level (ROW) imagery and downward (LCMS-2) pavement imagery.

The RAC vehicle components include:

Navigation System

- **Inertial Measurement Unit (IMU)**: Generates a true representation of vehicle motion in all three axes; producing continuous, accurate position and orientation information.
- **PCS**: Applanix POS/LV Computer System with DGPS (Provides accurate GPS coordinates for each subsystem) enables raw GPS data from as few as one satellite to be processed directly into the system, to compute accurate positional information in areas of intermittent, or no GPS reception.
- **GPS Receivers**: Embedded GPS receivers provide heading aiding to supplement the inertial data.
- **GPS Antennas**: Two GPS antennas generate raw observables data.
- **Sub-meter accuracy:** The system is rated to get 0.3 m accuracy in the X, Y position and 0.5 m in the Z position.

Distance Measuring Indicator (DMI)

- Computes wheel rotation information to aid vehicle positioning and collect high-resolution imagery at posted speeds.

Cameras

- Point Gray Ladybug 5+ 32MP 360 camera (Utilized for accurate ROW asset capture and extraction). This system is far superior to multiple mounted independent HD cameras others use.

Pavement Imaging System

- Second-generation Pavemetrics Laser Crack Measurement System (LCMS-2) provides 1mm resolution pavement imagery for automatic and continuous measuring of pavement cracking, texture, rutting geometrics, and other pavement distresses
- LCMS-2 camera is a laser array providing images used to evaluate data that conforms with ASTM D6433 protocols and provides a detailed array of data using two 1-millimeter resolution line scan cameras. A 1mm resolution is equivalent to over 4,000 laser points across the driven lane.
- Allows fully illuminated pavement image collection even in heavy shadow/canopy areas

Pavement Ride Quality

- An inertial profiler with line lasers (Used to capture Ride Comfort Index (RCI) measurements).

Figure 10.1: RAS RAC Vehicle

10.2 Quality Control/Assurance

All subsystems for the RAS vans are integrated using International Cybernetics Corporation's (ICC) collection core with tight synchronization between all data streams on the truck in real-time, referenced to both time and distance. All sensor locations are calibrated to the vehicle, together with the GPS and IMU, using 3D translations and rotations. This allows for the rapid calculation of the precise location of all sensor data. The RAC vehicle has received independent inertial profiler certification for accuracy and repeatability from the National Center for Asphalt Technology at Auburn University.

RAS RAC image collection includes a daily check of the on-board systems. This vehicle component check includes a calibration site survey of a nine-point grid in state plane coordinates (Figure 7.2). Each morning and afternoon, before and after a day's image collection, the RAC vehicle drives over the surveyed location. The RAC technician then extracts each point's location to verify the location of the point extracted was within approximately three feet of the surveyed points. RAS' QA/QC manual includes further details regarding RAC quality control procedures.

Number	Northing	Easting	Description	Latitude	Longitude	Elevation
10	1520841.17	605904.28	Nail & Disk	28.3102.56074	−81.0923.45205	67.49
11	1520832.20	605899.95	Nail & Disk	28.3102.47197	−81.0923.50046	67.58
12	1520819.80	605894.40	Nail & Disk	28.3102.34912	−81.0923.56246	67.47
13	1520835.95	605915.00	Nail & Disk	28.3102.50927	−81.0923.33175	67.56
14	1520826.92	605910.71	Nail & Disk	28.3102.41975	−81.0923.37968	67.65
15	1520789.93	605905.10	Nail & Disk	28.3102.30571	−81.0923.44241	67.50
16	1520831.65	605923.90	Nail & Disk	28.3102.46679	−81.0923.23189	67.51
17	1520822.57	605919.59	Nail & Disk	28.3102.37684	−81.0923.28011	67.52
18	1520811.42	605914.49	Nail & Disk	28.3102.26632	−81.0923.33712	67.42

Figure 10.2: 9-Point Calibration Site Example

Calibration of the laser profiling system includes laser sensor checks and block tests to ensure the accuracy of the height sensors, accelerometer calibration "bounce tests" to verify proper functioning of the height sensors and accelerometers and distance calibration to ensure accuracy of the DMI. Calibration of the DMI and some accelerometers occurs during field testing, and each is checked and recalibrated on a regular basis.

During image collection, the RAC technician reviews the images collected on-screen as they are collected and any issue with image clarity requires the collection run to end and the image quality issue to be resolved. This provides real-time verification that the equipment is operating correctly. Once resolved, the collection run begins from the beginning for the road segment collected. The RAC technician also monitors GPS reception during collection. If GPS reception is lost measured using positional dilution of precision (PDOP), the RAC technician stops the collection and resolves the GPS reception issue. Collection begins again once the GPS reception issue is resolved. The RAC technician will check each camera's exposure rate, image quality and GPS and IMU operation to ensure the RAC system is recording the image, GPS, DMI and IMU data and that the GPS location is within the stated project tolerance.

Each day's image and road data collection are recorded on a RAC server. Each night, the day's collection data is backed up to an external hard drive. The external hard drives are then mailed back to RAS' project office where the data is placed on a production server for post-processing of images and data, quality control review and pavement distress inventory.

The QC program for pavement condition data collection typically includes random sample audits, inter-rater reproducibility and data checks for accuracy and repeatability of the results. For this survey project random samples of the pavement condition data were selected and checked by the lead rater or QC personnel. If the pavement condition ratings did not meet quality standards, corrective action was taken, and the entire section was reviewed.

Cameras

- High-definition cameras with precision lenses allow for accurate asset extraction and videolog recording, but with lower frame rate: 15 images per second, with lower 1936x1456 color resolution.

Pavement Imaging System

- Two line-scan cameras and lasers configured to image 4m transverse road sections with 1 mm resolution (4000 pixel) at speeds that can reach 100 km/h, upgraded to the 3D imagery of the LCMS-2 camera system.

The QC program for pavement condition data collection typically includes random sample audits, inter-rater reproducibility and data checks for accuracy and repeatability of the results. For this survey project random samples of the pavement condition data were selected and checked by the lead rater or QC personnel. The QC selection process includes but is not limited to random sampling at ten-point PCI range increments with a minimum of 10% per range, a complete verification for any road with a ‘Very Poor’, “Serious”, or “Failed” PCI (0-40 PCI), a review of all high-density distresses, and a spatial review of neighboring PCI’s. If the pavement condition ratings did not meet quality standards, corrective action was taken, and the entire section was reviewed.

10.3 LCMS-2

Downward-facing LCMS-2 pavement imagery is collected for use in quantifying distress type, severity, and extents present on segments of road. The resolution of the imagery allows for distresses to be easily identified and measured during the analysis portion of the contract. Pavemetrics’ Laser Crack Measurement System (LCMS) is a high-speed and high-resolution transverse profiling system. Capable of acquiring full 4-meter width 3D profiles of a highway lane

at normal traffic speed, the system uses two laser profilers that acquire the shape of the pavement. Both the resolutions and acquisition rate of the LCMS are high enough to perform automatic cracking detection, macro-texture evaluation, rutting measurements, and much more. Custom optics and high-power pulsed laser line projectors allow the system to operate in full daylight or in nighttime conditions. Road profile data are collected onboard the inspection vehicle.

10.4 Profile

A road profile is a set of (X,Z) data points captured along the transversal axis of the road. A profile is captured each time the LCMS controller receives a trigger signal from the vehicle's odometer1. Typically, the LCMS system can capture one road profile every few millimeters (5 mm at

100km/h). Each profile consists of up to 4160 data points. This value will be referred to later in this document as being the number of points per profile.

The longitudinal profile of the road is generated by measuring its shape along an imaginary line in the direction of travel or longitudinal axis of the road. The longitudinal profile can then be used to compute various roughness indexes such as the RCI (Ride Comfort Index). The following guidelines should be followed to ensure proper readings from the Roughness subsystem:

- Maintain the recommended tire pressure.
- Ensure the wheels are balanced.
- Drive at speeds between 15.5 mph and 60 mph.
- Avoid quick accelerations and decelerations and sudden changes in direction.

A road section is a set of consecutive profiles that are merged and saved in a common file. A road section can be seen as a set of 3D coordinates (X, Y ,Z), where X is the coordinate along the transversal axis of the road, Y along the longitudinal axis, and Z is the depth axis, as displayed I Figure 7.3. The road section length is configurable and is set by the user before starting the acquisition. A typical road section length is between 5 to 10 meters.

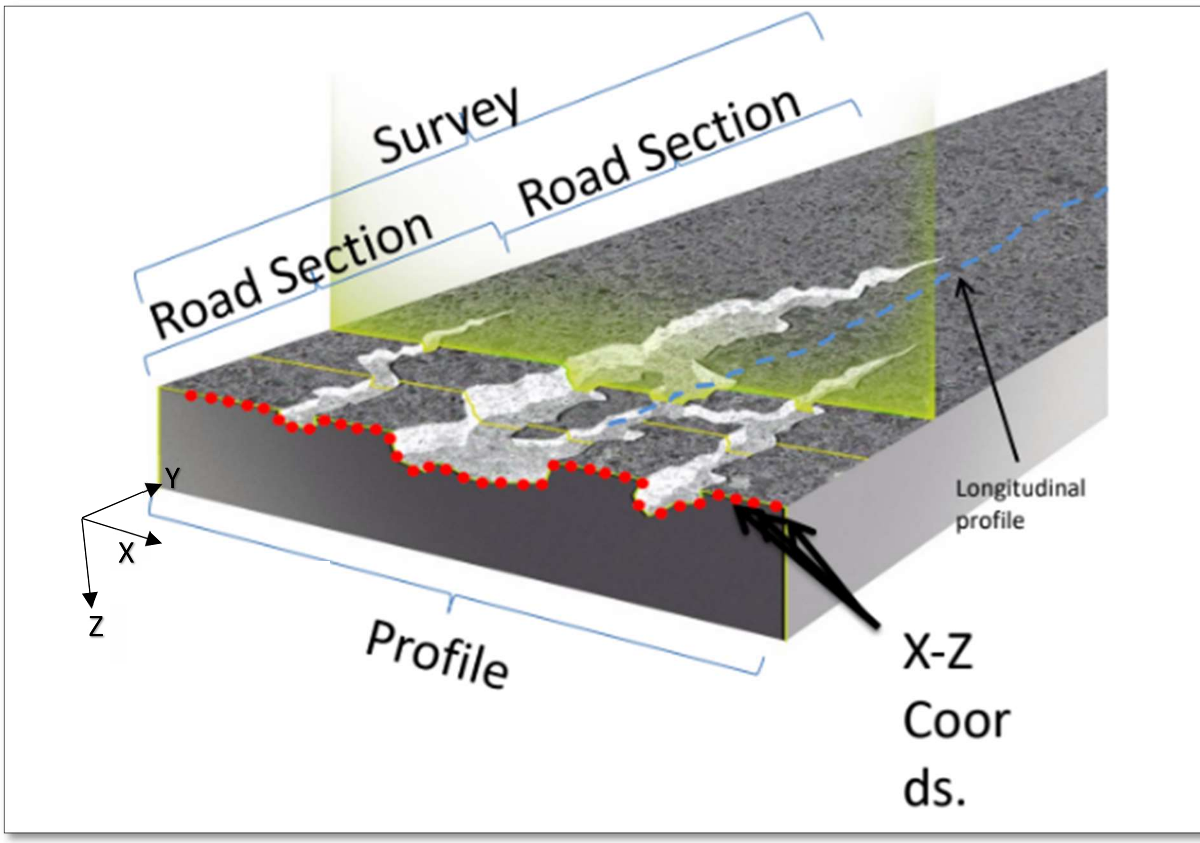

Figure 10.3: LCMS Data Definition