NCAT-MnROAD Pavement Preservation Group Study

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Observed Performance Dashboard - User Manual

Using dashboard features of Qlik Sense (Release 3.0)

Contents

1. Pavement Preservation Group Study overview

The Pavement Preservation Group (PG) Study was initiated in the summer of 2012 as part of NCAT's fifth Test Track research cycle. Phase I of the study was funded by seven state DOTs and FP2 (formerly the Foundation for Pavement Preservation) through Transportation Pooled Fund TPF-5(267), with the Alabama Department of Transportation (ALDOT) as the lead organization. The initial effort consisted of placing various preservation treatments on a low-traffic volume county road in Auburn, Alabama. Although pavement preservation treatments have been applied to test sections on the NCAT Pavement Test Track, the PG study sections were placed on an off-track roadway to eliminate any effects resulting from the accelerated traffic rate.

Based on the preliminary results of the 2012-2015 research cycle, the study was continued during NCAT's sixth Test Track research cycle, with support from 15 state DOTs and FP2. The scope of work was extended to add more test sections on a high-traffic volume roadway in Alabama. In addition, NCAT and MnROAD formed a partnership to provide practical and implementable results for both cold and warm U.S. climates. As a result, new test sections were constructed in 2016 on low- and high-traffic volume roadways near Pease, Minnesota, to replicate several of the treatments already in place in Alabama. To minimize construction variability, the same contractors and crews that participated during the construction of the first test sections in 2012 were used again in the new test sites in Alabama and Minnesota.

The study's success continued, gathering support for an additional research cycle. Phase II was initiated in 2018 under Transportation Pooled Fund TPF-5(375) led by the Minnesota Department of Transportation (MnDOT). Twenty-two state DOTs, the Federal Highway Administration (FHWA), and FP2 contributed to this new effort. Phase II focused on the continuation of data collection and analysis of existing sections. In addition, construction of new test sections with cold recycled technologies was performed in 2019 on a city street in Minnesota, as this set of treatments that had yet to be completed during the 2016 round of construction.

Figure 1 summarizes the characteristics of each test location.

Warm Climatic Region		Cold Climatic Region		
US-280 (High Traffic Volume)	LEE-159 (Low Traffic Volume)	US-169 (High Traffic Volume)	CSAH-8 (Low Traffic Volume)	70th Street (Recycled Sections)
• 34 treated sections • 7 control sections (untreated) • Section length ~ 528ft	• 23 treated sections • 2 control sections (untreated) • Section length ~ 100ft	• 21 treated sections • 8 control sections (untreated) • Section length ~ 528ft	• 22 treated sections • 8 control sections (untreated) • Section length ~ 528ft	• 9 treated sections • 7 control sections (untreated) • Section length ~ 500ft

Figure 1. Summary of pavement preservation test locations

2. Data Sources for Dashboard (Release 3.0)

This dashboard summarizes pavement performance data collected for each of the sections previously described. Specifically, three pavement surface indicators are compiled in this tool (cracking, pavement roughness, rutting). Pavement performance data is collected using an inertial profiler, laser systems, and high-resolution cameras that are mounted into a van. The inertial profiler allows for collecting measurements of longitudinal profiles from both wheelpaths. These profiles are translated into pavement roughness measurements represented by the international roughness index (IRI). Dual scanning lasers are utilized to gather transverse profile measurements from both wheelpaths that are translated into rutting depths. High-resolution cameras record multiple lane pictures that are processed to map and quantify cracking. Figure 2 shows the three performance indicators.

The frequency of data collection varies depending on the parameter being tested and the location. In warm climate locations with mild winters and no significant snow events, measurements were taken more frequently. Measurements were also taken before the sections were treated (to assess the pre-treatment condition), and just after construction. Performance thresholds are defined according to the Moving Ahead for Progress in the 21st Century Act (MAP-21) indicators, explained in the following section.
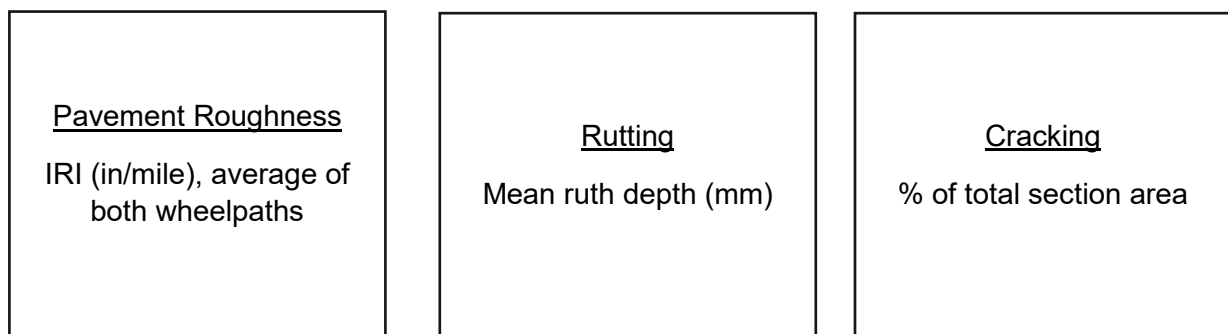
Pavement Roughness	Rutting	Cracking
IRI (in/mile), average of both wheelpaths	Mean ruth depth (mm)	% of total section area

Figure 2. Pavement condition data

3. Pavement Condition Thresholds and Overall Pavement Condition

The Federal Highway Administration, through its Moving Ahead for Progress in the 21st Century Act (MAP-21), has defined a series of thresholds or metrics that help determine whether a pavement section is in good, fair, or poor condition with respect to IRI, rutting, and percent cracking. Table 1 shows the defined thresholds for asphalt pavements used in the dashboard.

Table 1. MAP-21 Condition Thresholds for Asphalt Pavements (FHWA 2018)

Performance Indicator / Indicator Category	IRI (in/mile)	Rutting (mm)	Cracking (% of area)
Good	<95	<5	< 5
Fair	95-170	5-10	5-20
Poor	>170	>10	>20

With the defined thresholds and their specific combination, it is possible to determine the overall pavement section condition as shown in Table 2. Treated sections, as well as control sections, were subdivided into smaller subsections to have different pre-treatment conditions for a given treatment type. Subsections with the same pre-treatment condition and type were grouped together.

Table 2. MAP-21 Overall Condition for Asphalt Pavements (FHWA 2018)

Overall Pavement Section Performance	Combination of performance indicators (From Table 1)
Good	All three indicators rated as "Good"
Poor	2 or more indicators rated as "Poor"
Fair	All other possible combinations of performance indicators

Federal Highway Administration. (2018). *Moving Ahead for Progress in the 21st Century*. Retrieved from: https://www.fhwa.dot.gov/map21/

4. Dashboard Features and User Guide

The main panel (Figure 3) displays the testing locations. Select the desired climate-traffic conditions by clicking on the corresponding button.
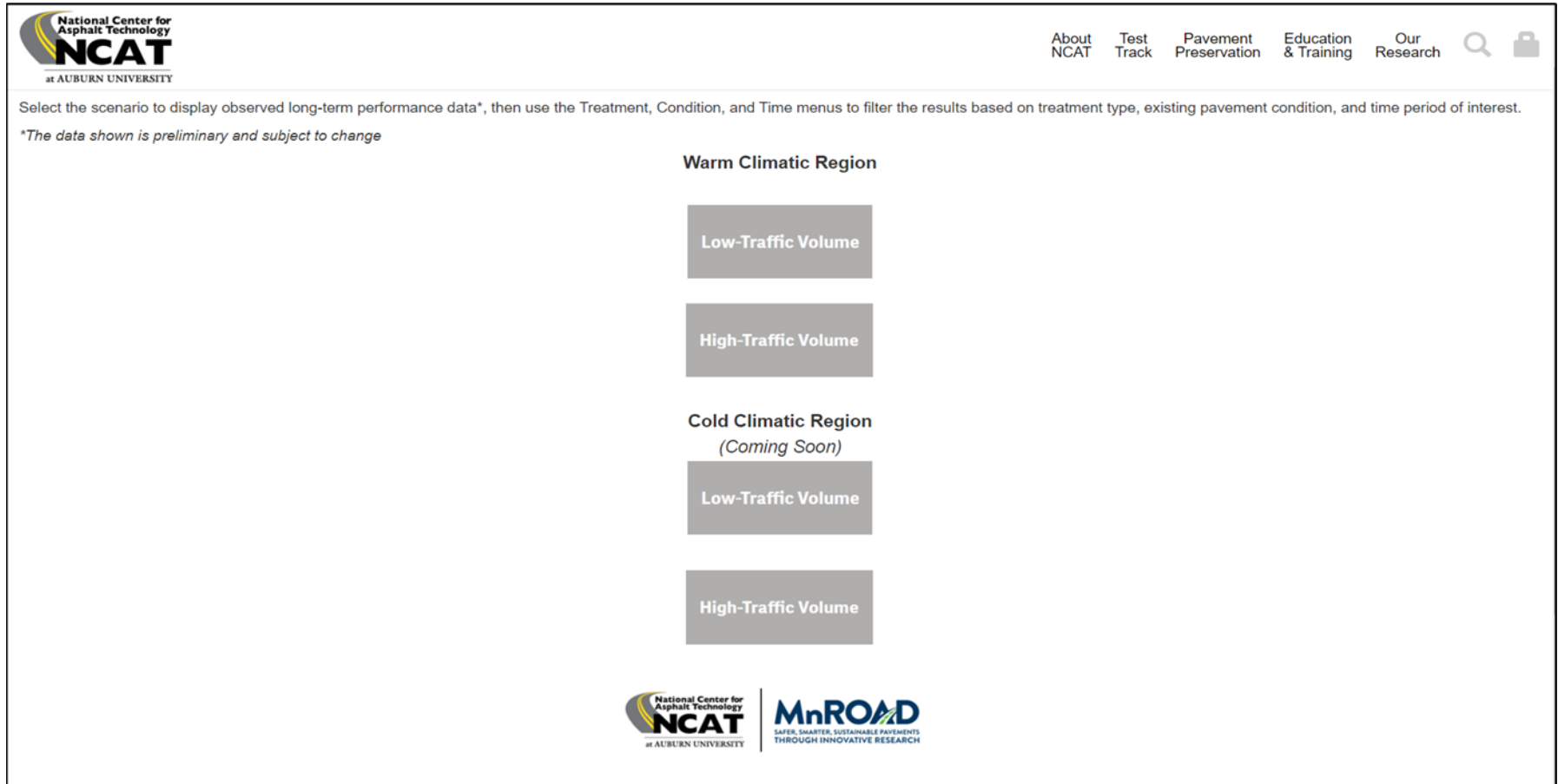

Figure 3. Dashboard Main Panel

After selecting the desired conditions, a new window will open. This window is divided into four main components (Figure 4), explained in the following subsections.
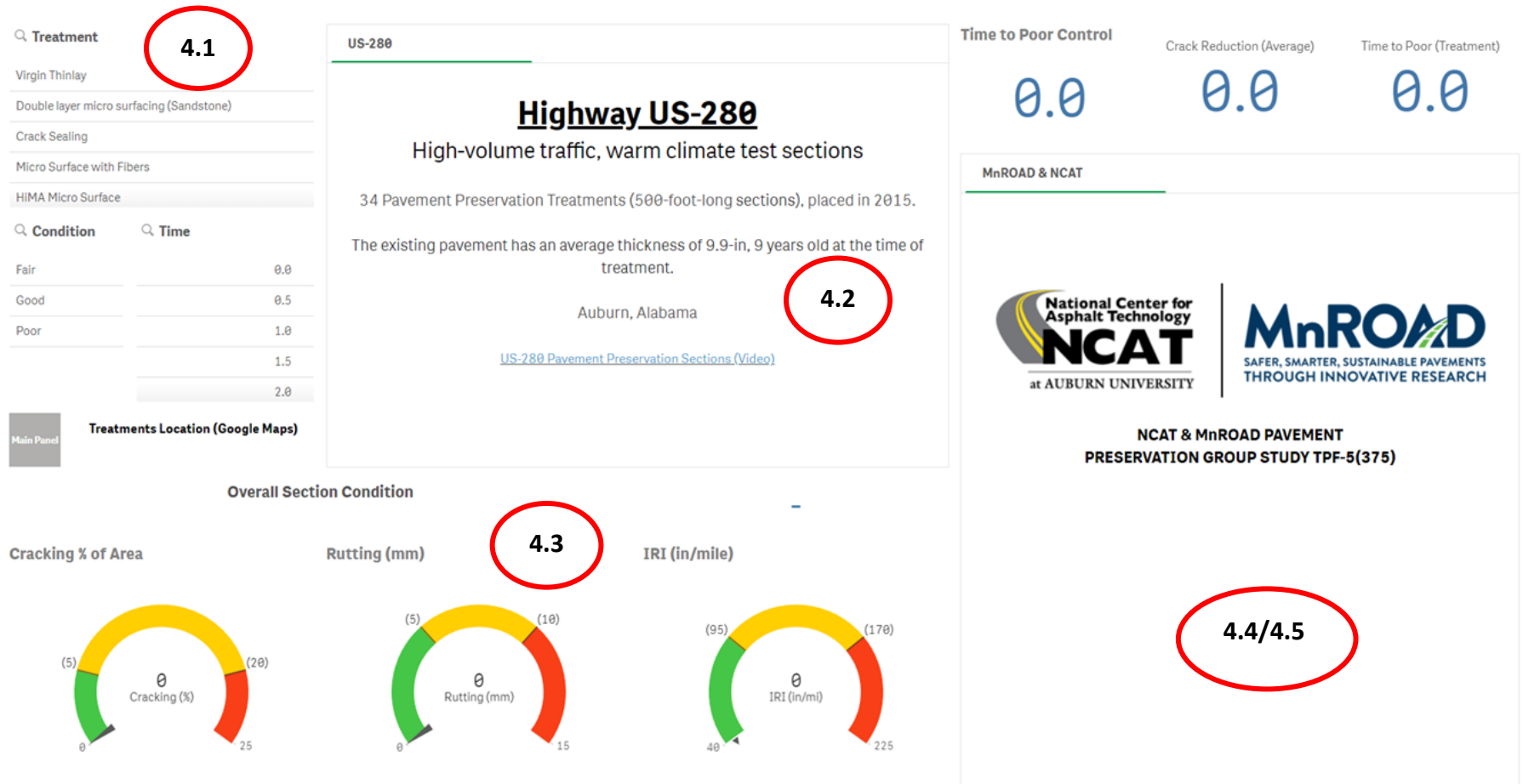

Figure 4. Dashboard Display (Warm climatic/High-Volume Traffic Region Example)

4.1 Selecting Site Conditions

The first component of the dashboard allows for the selection of specific site conditions (Figure 5).
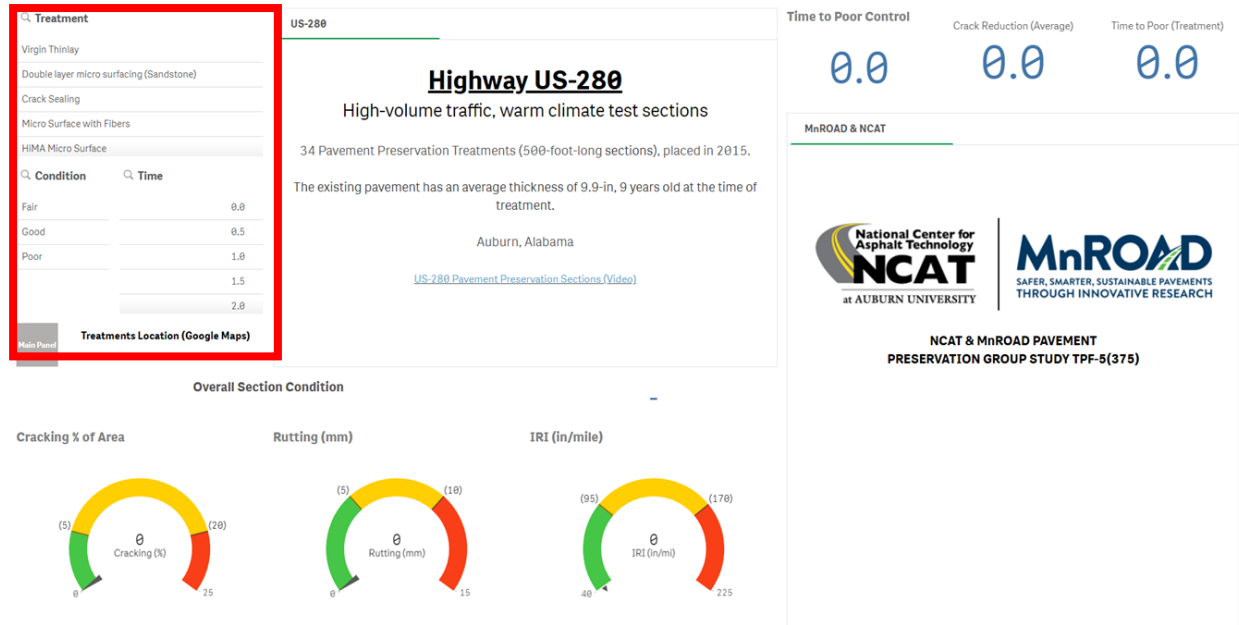
Figure 5. Conditions section panel

First, select the desired pavement preservation treatment to display from the drop-down "Treatment" menu (Figure 6).
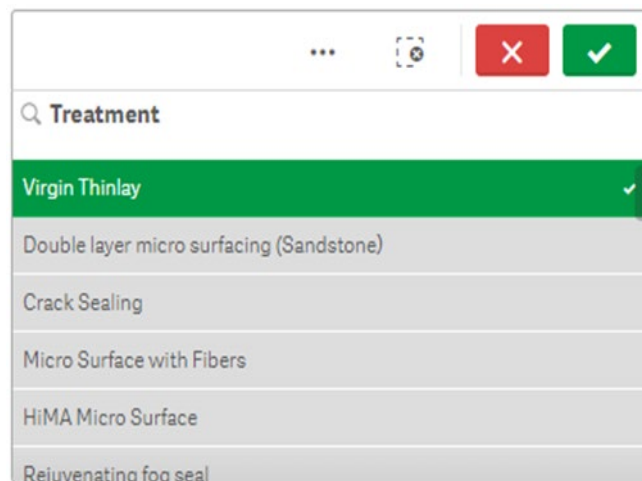
Figure 6. Treatment selection panel

If multiple treatments are selected, the average values of their respective indicators will be displayed in the IRI & rutting charts, gauge panel, and cracking/IRI panel (further explained in subsections 4.2, 4.3 and 4.4/4.5 respectively). Therefore, it is recommended to select one treatment at a time for displaying its respective indicators.

A pre-treatment condition based on MAP-21 indicators, can be selected using the "Condition" drop-down menu (Figure 7). It allows users to display cracking curves and results (further explained in section 4.4) for a given cracking pre-treatment condition. In cold region sections, due to observed progressions in main indicators and data availability, IRI curves are presented instead of cracking curves (further explained in section 4.5). Thus, the pre-treatment condition was disabled for the cold climate region.
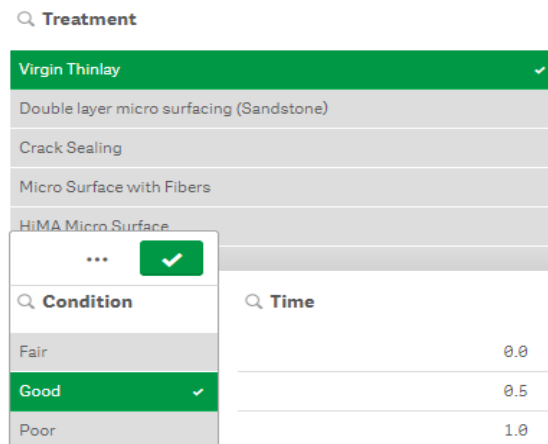
Figure 7. Pre-treatment condition selection panel

For cracking or IRI panels, results can be filtered for a specific point or range in time using the "Time" drop-down list (Figure 8). If no time inputs are selected, the interface will display the results for the entire service life of the section.
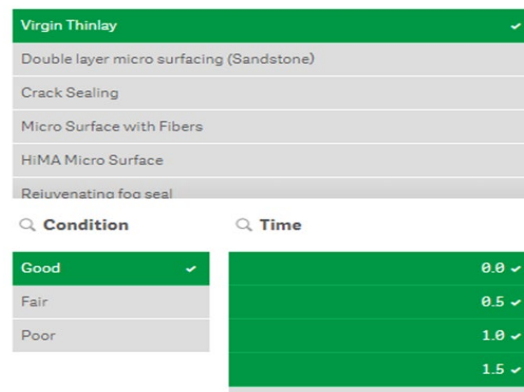

Figure 8. Time range selection in Time panel

4.2   Section Picture, Rutting and IRI or Cracking charts

After selecting the desired inputs, an image of the selected treatment will be displayed in the dashboard (Figure 9). The displayed image corresponds to an overview of the current overall condition of the section (image does not vary for specific time or pre-treatment condition selections).
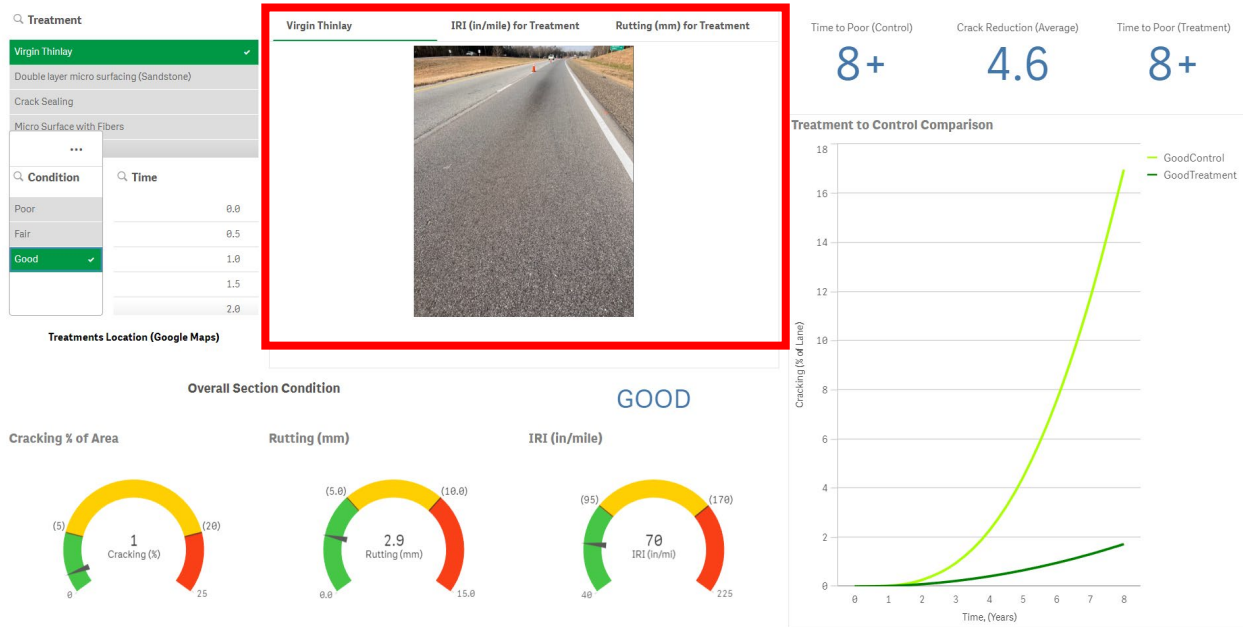

Figure 9. Treatment picture

In this area, two tabs will be enabled containing the average IRI (for warm climate region) or cracking (for cold climate region) and rutting measurements for the selected section (or sections if multiple were selected). Click on the desired tab (Figure 10) to see measurements at three different times:

- <u>Pre-Const</u> (Pre-construction or pre-treatment condition): measurement taken before the section was treated.
- <u>Post-Const</u> (Post-construction): first measurement after treatment.
- <u>Current:</u> most recent measurement taken.

Warm Climatic Region
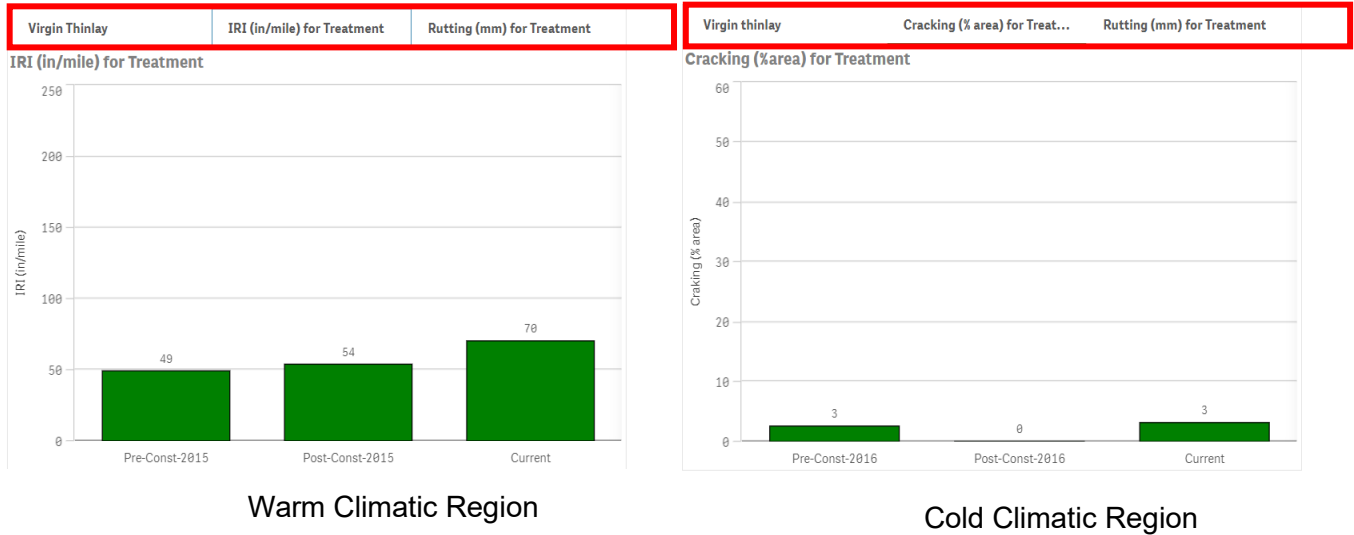
Cold Climatic Region

Figure 10. Treatment measurements three different times

The bars in the rutting and IRI or cracking charts are color-coded to reflect the condition category according to the MAP-21 criteria.

4.3 MAP-21 Indicators Gauge and Overall Condition

The gauges shown in Figure 11, display the average cracking, rutting and IRI for **the most recent measurements and for the selected treatment** (or average between sections if multiple treatments were selected)
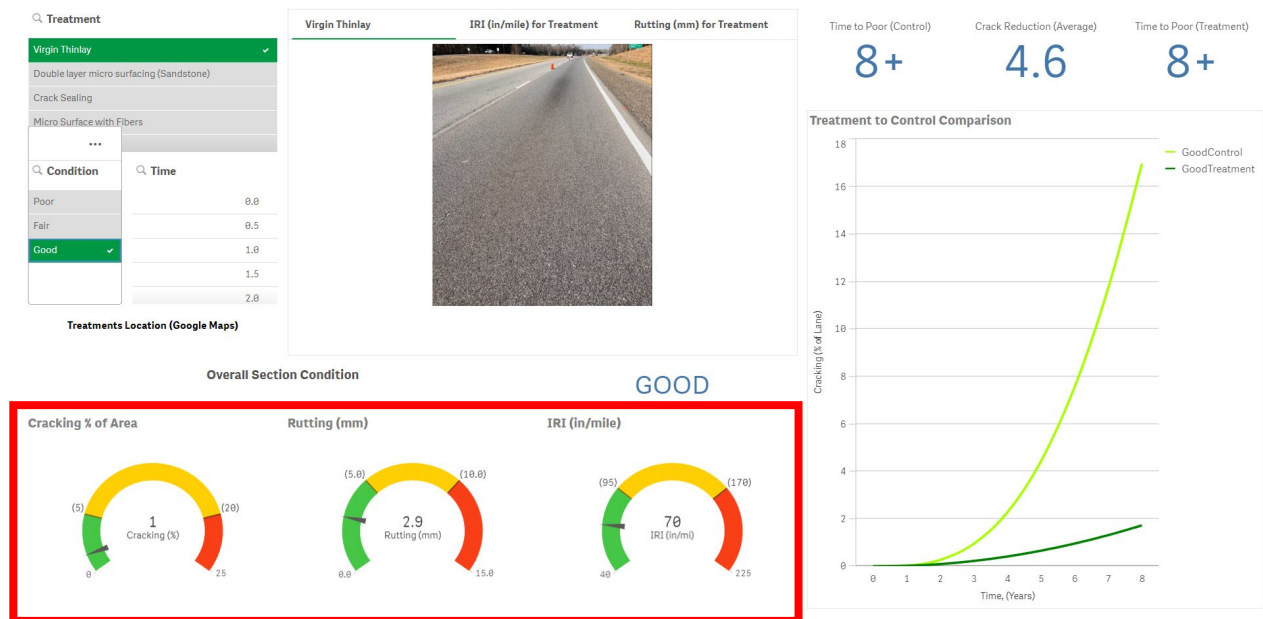
Figure 11. IRI, cracking and rutting gauges

They also indicate the specific category for each of the indicators based on a color-coded scale and the thresholds shown in Table 1. An overall section condition is determined following the MAP-21 procedure explained in Table 2 (Figure 12).
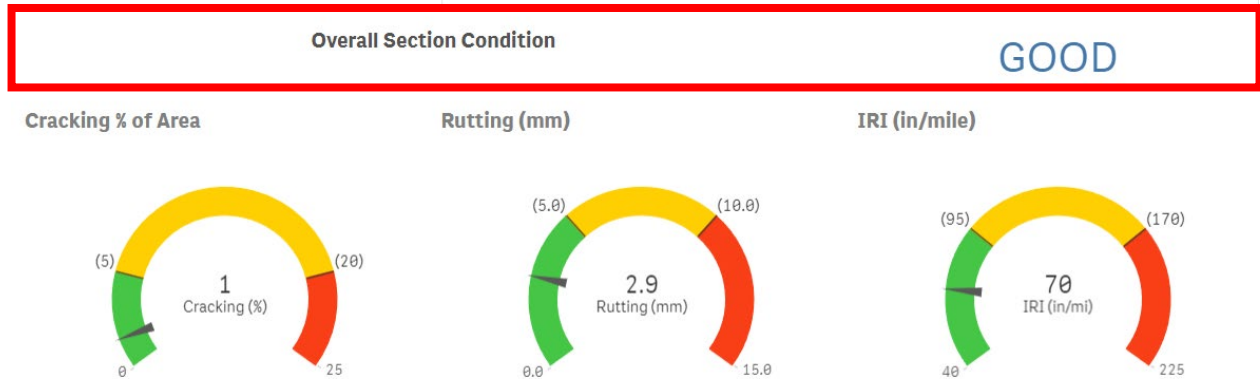

Figure 12. Overall section condition

4.4 Cracking Panel (Warm Climatic Region only)

The cracking panel (Figure 13) displays the chart with the cracking models (**predicted values from fitted models**) for both treated and control sections, and for the selected pre-treatment condition. A two-parameter sigmoidal model (Equation1) was used to represent cracking progression since this kind of model can maintain the independent variable into a defined range (% cracking range between 0% and 100%). Multiple curves could be also displayed if multiple "Treatments" or "Conditions" are selected.

$$Cracking(\%) = (1 - e^{-a \times (Time)^b}) \times 100 \qquad (1)$$

Where:

a: controls the rate of decay the curve rises towards its maximum.

b controls the shape of the curve, influencing the sensitivity to changes in "Time (years)".

Since on a single test section different cracking pre-treatments conditions could be observed; test sections were subdivided into homogenous subsections based on Table 1 thresholds, and as shown in Figure 14. Cracking was quantified as a percentage of the total subsection area. Subsections from a specific treatment and with the same pre-treatment condition were grouped; and models were generated.
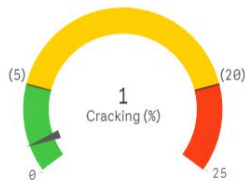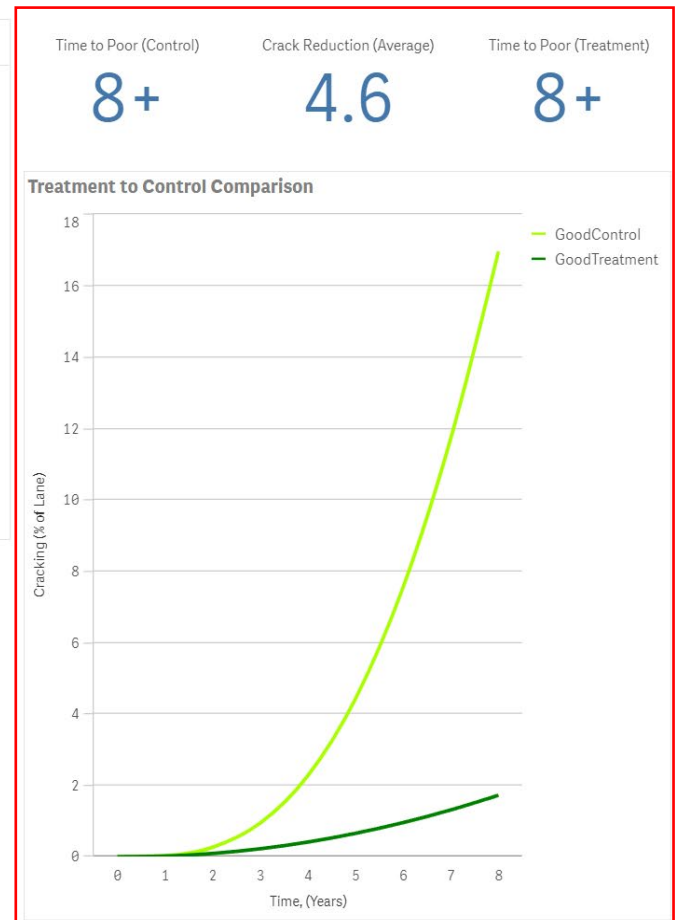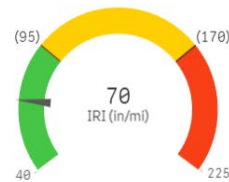
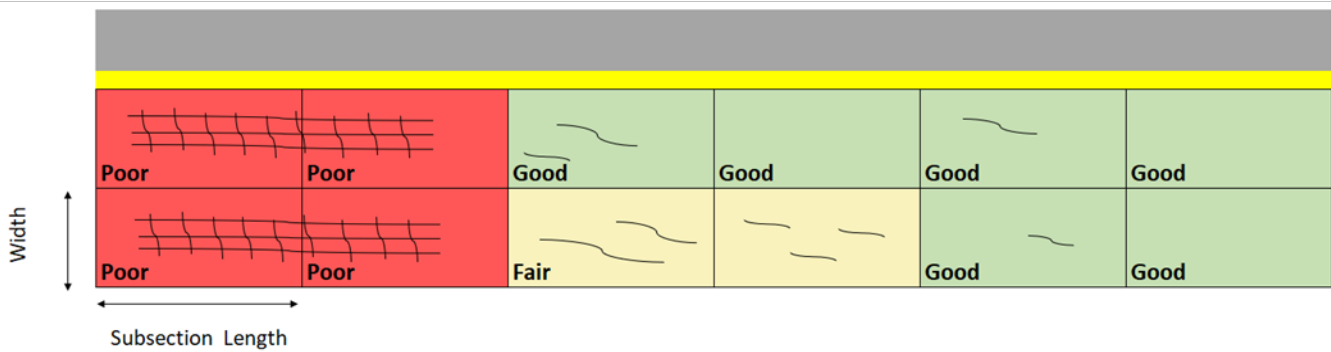**Figure 13.** Cracking panel (Virgin Thinlay example for warm climatic and high traffic volume region)
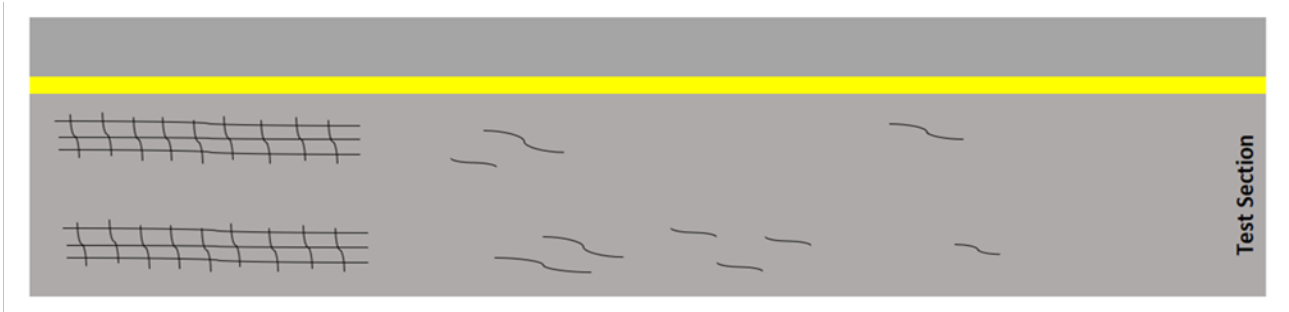
Figure 14. Schematic of subsectioning process for cracking quantification

For the Warm Climatic Region and High Traffic Volume location, some of the explained pre-treatment conditions did not exist in treated sections (i.e., a treated section could lack subsections categorized into one or more of the three pre-treatment conditions). Consequently, some charts might not be displayed, and a message will be shown ("The chart is not displayed because this pretreatment category was not present in the test section"). Some important concepts displayed in Figure 15 are explained as follows:
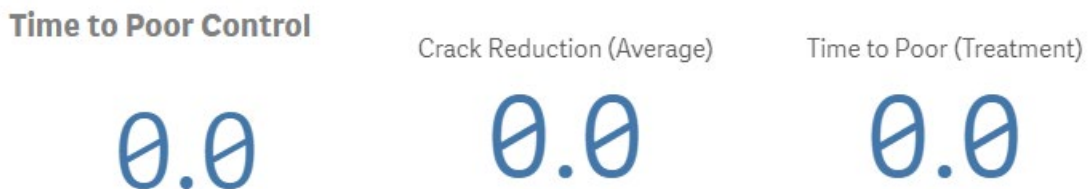

Figure 15. Cracking panel indicators

Time to Poor Control: Is the time, in years, expected for the control section (for a selected pre-treatment condition) to reach the "Poor" cracking condition category. Therefore, if the "Poor Condition" is selected, a value of 0.0 will be displayed since it the section is already in the poor category.

Crack Reduction (Average): Is the average cracking percentage reduction (average difference between the treated and control sections for the whole analysis period). If a specific "Time" is selected, the crack reduction for that specific point will be displayed.

Time to Poor (Treatment): Is the time, in years, expected for the treated section (for a selected pre-treatment condition) to reach the "Poor" cracking condition category. If this time exceeds the analysis period shown in the chart, a "+" sign will be shown indicating that the treatment as not reached the "Poor" condition during the study.

4.5 IRI Panel (Cold Climatic Region only)

The IRI panel (Figure 17) displays the chart with the IRI models (**predicted values from fitted models**) for both treated and control sections. An exponential model (Equation 2) was used to represent IRI progression since this kind of model has shown an effective ability to capture the IRI progression over time. Multiple curves could be displayed if multiple treatments are selected.

$$IRI_t(in/mile) = IRI_0 e^{\beta \times (Time)}$$ (2)

Where:

    IRI_t: estimated IRI at determined "Time (years)".
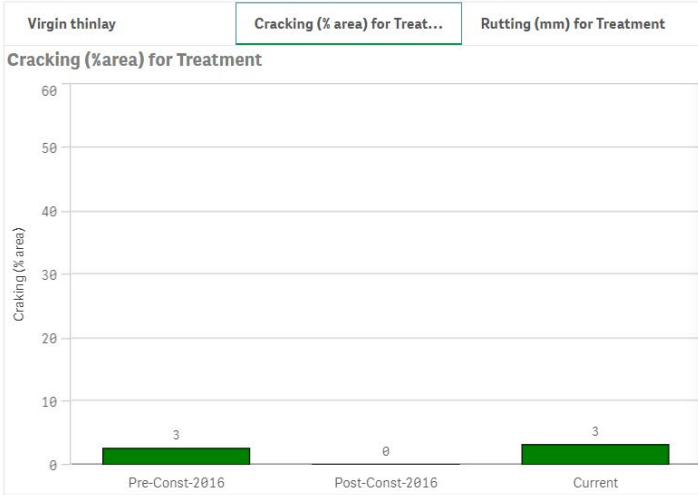 IRI_0 IRI at "Time = 0".
    β: regression parameter representing the deterioration rate of the IRI curve.

Some important concepts displayed in Figure 16 are explained as follows:

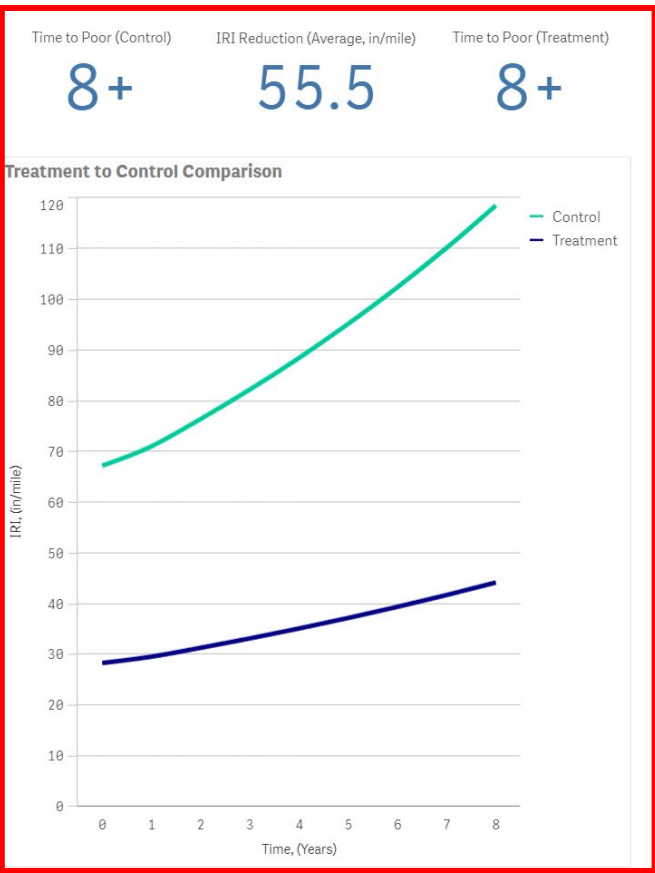| Time to Poor (Control)	IRI Reduction (Average, in/mile)	Time to Poor (Treatment)
8+	55.5	8+

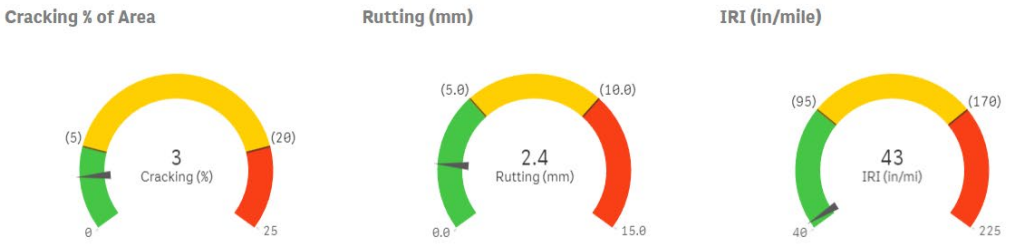**Figure 16.** IRI panel indicators

Figure 17. IRI panel (Virgin Thinlay Example for cold climate and high traffic volume region)

Time to Poor Control: Is the time, in years, expected for the control section (for a selected pre-treatment condition) to reach the "Poor" IRI condition category. If the section is already in a poor condition, a value of 0.0 will be displayed since it the section is already in the poor category.

IRI Reduction (Average): Is the average IRI reduction (average difference between the treated and control sections for the whole analysis period). If a specific "Time" is selected, the reduction in IRI for that specific point will be displayed.

Time to Poor (Treatment): Is the time, in years, expected for the treated section to reach the "Poor" IRI condition category. If this time exceeds the analysis period shown in the chart, a "+" sign will be shown indicating that the treatment as not reached the "Poor" condition during the study.

5 Complementary feature (Interactive Map)

As part of the dashboard and as a complementary tool, an interactive map was included to geographically locate the different treatments and display key construction properties. Click on "Treatments Location (Google Maps)" to open a new tab with the specific map (Figure 18). Select a treatment from the "Preservation Treatments" list or click on the test section on the map to display information on material types and application rates used during construction.
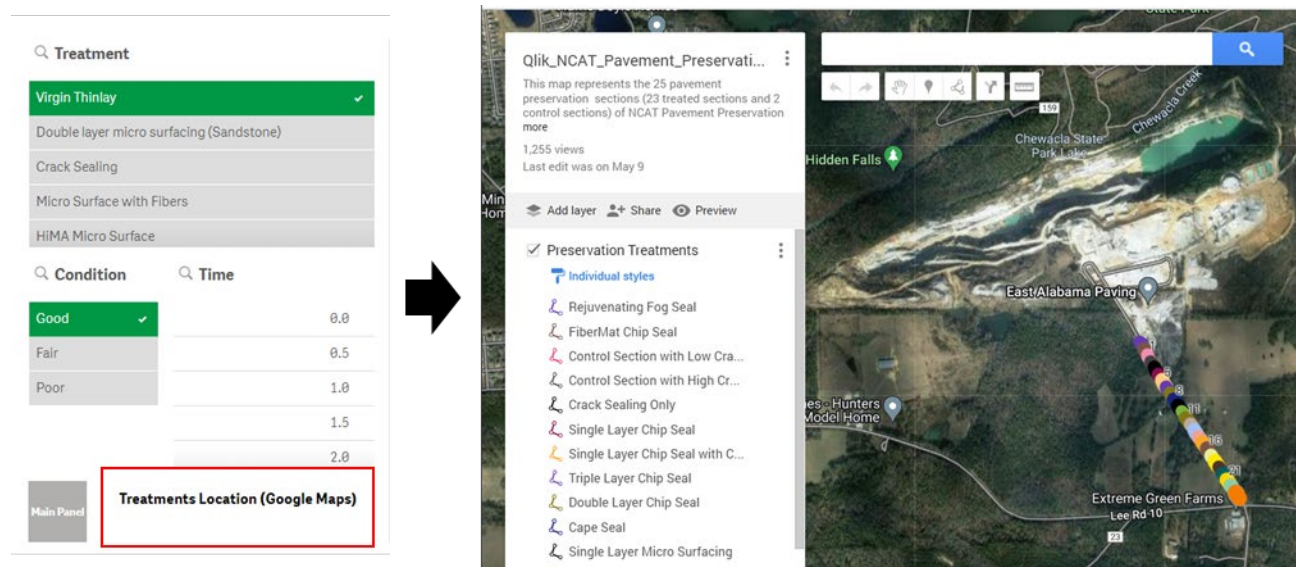

Figure 18. Interactive Map (Warm Climate/Low Volume Environment Example)

6 Contact Information

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