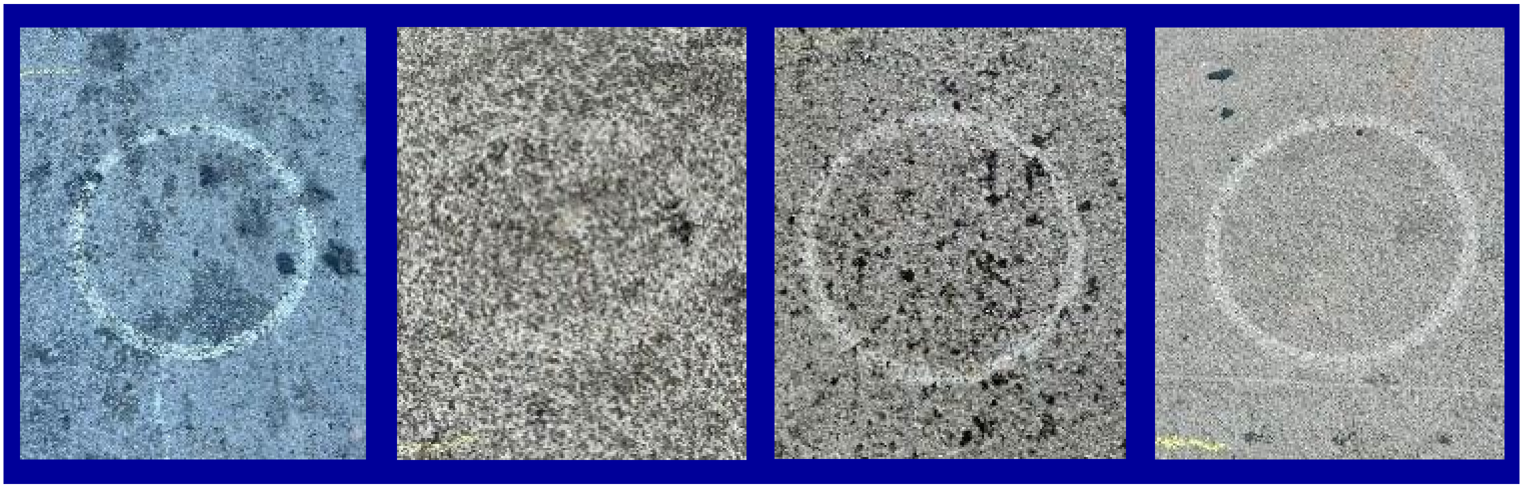

Phase II: EVALUATION OF COOL PAVEMENT SURFACE TREATMENTS USING FRICTION, TEXTURE AND ADHSESION PROPERTIES

PREPARED FOR:
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EXECUTIVE SUMMARY

This report provides a second round of assessment to cool pavement projects that were installed in 2023. The evaluation continues the performance assessment in terms of surface texture, friction, and adhesion strength to existing surface. In this report the surface testing was conducted at five sites in five council districts to monitor the performance change in the applied treatment with respect to control pavement and compare it with phase I testing data. Three cool pavement products were assessed; GAF, SealMaster and GuardTop. Calibrated equipment from the previous testing phase I were utilized in the assessment namely; CT Meter, DF Tester, and Pull-off tester. The study also conducted visual assessment on all sites to monitor any surface crack initiation and propagation, delamination from existing pavement and change in color due to traffic tire imprints. In summary, texture friction and adhesion strength measurements depend on several factors including, cool pavement product, traffic, environmental factors, and characteristics of exiting pavement mixture characteristics.

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1 OVERVIEW

The University of Texas at San Antonio and TRANSTEC Group provided surface friction, texture and adhesion testing as part of an evaluation of the cool pavement treatment for the City of San Antonio. A list of the cool pavement project sites is shown in Table 1. These projects among others were also tested in 2023 shortly after installation, and the corresponding testing date is shown in the table for each site. The first round of evaluation was completed and published in February 2024 (Masad et al. 2024). For this second round of testing evaluation, the projects on Mountain Star, SW 21st St., and Piper Dr. were tested on 25th October 2024, and the projects on Carol Crest and Lucinda were tested on 26th October 2024.

At each location, pavement surface texture and friction testing were performed on the treated section and control section. The adhesion between cool pavement treatment and existing pavement surface was performed only on the treated areas. The map presented in Figure 1 shows the approximate locations of the project sites at five council districts.

Table 1. Cool pavement treatment locations, installation, and initial testing information.

Council District	Project site	From	To	Product	Installer	Installation Date	Initial Testing Date(s)
2	Carol Crest St.	Argonne Dr.	Kay Ann Dr.	GAF Streetbond	Creative Paving	17 May 2023	21 June 2023
3	Lucinda St.	Ashley Dr.	Sams Dr.	GuardTop Iron (dark)	Gallo Paving	13 July 2023	21 Sept. 2023
4	Mountain Star St.	Stephens Ranch	Wolf Point	SealMaster	Gallo Paving	2 May 2023	22 June 2023 & 21 Sept. 2023
5	SW 21st St.	Saltillo Rd.	S. Laredo St.	SealMaster	Gallo Paving	1 May 2023	21 Sept. 2023
7	Piper Dr.	Loy	Freeman Dr.	GuardTop Iron (dark)	Gallo Paving	13 July 2023	20 Sept. 2023

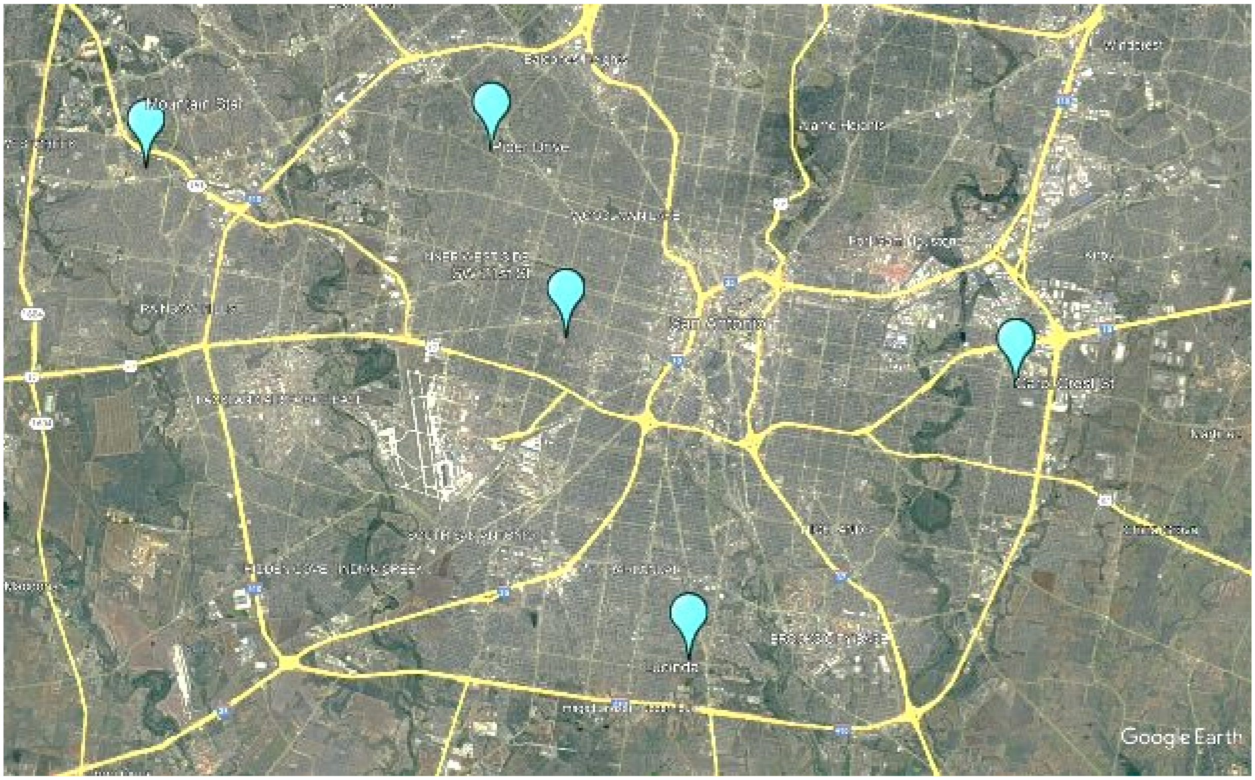


Figure 1. Approximate locations of cool pavement projects.

2 COOL PAVEMENT PRODUCTS AND SITES SELECTION

2.1 Cool Pavement Products

Three cool pavement products were evaluated in the second phase of evaluation. Description of each product is as follows:

SealMaster (SolarPave®) is a polymer emulsion coating manufactured with UV resistant, reflective light-colored mineral pigments to provide minimum solar reflectance of 0.33. It is blended with ant-slip aggregate to increase surface texture.

GAF Streetbond (DuraShield®) Solar Gray is a two-component waterborne epoxy-modified acrylic coating blended with silica aggregates. The coating is formulated using ultraviolet reflective technology to provide an initial solar reflectance of 0.33. According to the manufacturer, GAF Streetbond has no odor during and after installation, and it resists UV damage. It is fully recyclable with asphalt.

GuardTop (CoolSeal®) is a water-based asphalt emulsion seal coat. It has fine aggregate and asphalt content of at least 32% and 10% by weight, respectively. It has a Solar Reflectance of 0.33 and a final cured grey color.

2.2 Sites Selection

The selection of the cool pavement sites was based on an analytical approach utilizing a series of data sets between January and February of 2023. The data sets consist of; urban heat index, equity score, energy burden, urban tree canopy, pavement condition, and population. The COSA used heat and equity data to identify candidate census tracts with high scores of temperatures, poverty, and percentage of people of color. Within the candidate census tracts, COSA selected streets that were in adequate pavement condition and had minimal tree canopy.

3 MEASURING EQUIPMENT

DF Tester and CT Meter were used to collect the data reported herein. The DF Tester was calibrated on 9 October 2024. The CT Meter was calibrated on 19 September 2024. The Pull-off tester is a newly acquired device in 2023.

3.1 Circular Track Meter (CT Meter)

Pavement surface texture was measured with the Nippo Sangyo CT Meter (Figure 2). The CT Meter is a laser-based device that reports surface texture and reports it as mean profile depth (MPD) in accordance with ASTM E 1845, Standard Practice for Calculating Pavement Macrotexture Mean Profile Depth. The CT Meter measures pavement surface texture around a circular path with a radius of 142 mm. Transtec operates the CT Meter in accordance with ASTM E2157-15, Standard Test Method for Measuring Pavement Macrotexture Properties Using the Circular Track Meter.

Figure 2. Circular Track Meter (CT Meter).

3.2 Dynamic Friction Tester (DF Tester)

Pavement surface friction was measured with the Nippo Sangyo DF Tester (Figure 3). The DF Tester measures friction using three rubber sliders mounted to a disk that spins parallel to the test surface. The disk has a radius of 142 mm, corresponding to the path of the CT Meter texture measurements. A gravity-fed water system wets the pavement surface and when the disk reaches the desired upper limit rotational speed (typically 80 km/h), the DF Tester lowers the disk to the pavement surface. Friction is measured based on torque as the disk rotational velocity decreases to zero due to friction between the rubber sliders and the pavement surface. Transtec operates the DF Tester in general accordance with ASTM E1911, Standard Test Method for Measuring Paved Surface Frictional Properties Using the Dynamic Friction Tester.

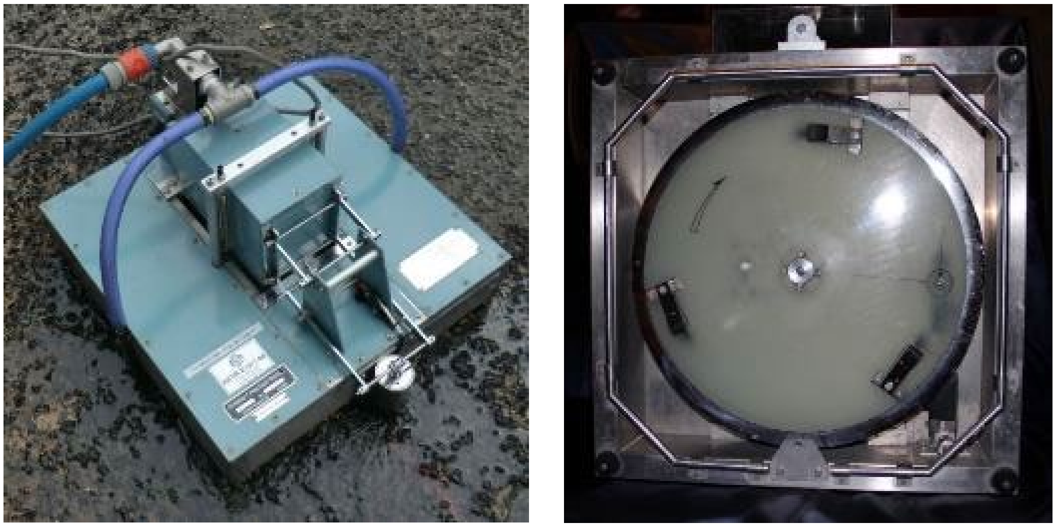


Figure 3. Dynamic Friction Tester (DF Tester).

3.3 Pull-off tester

The purpose of the adhesion test is to evaluate the bonding strength between the cool pavement treatment and existing pavement. The Pull-off adhesion testing provides a convenient, standardized, and rapid technique for evaluating the adhesion strength of a coating to an underlying substrate (Liddell et al. 2023). It is the most widely used method to assess bond strength (ASTM D 4541). In this assessment, the adhesion tester evaluates the pull-off strength of the treatment layer by determining the maximum tensile pull-off force of coating away from pavement using hydraulic pressure (Figure 4). Coating adhesion is an indicator of how well the treatment has bonded to the pavement surface. In a standard ASTM D4541 pull-off adhesion test a pull stub is attached to a coated substrate and then removed through vertical loading. The force required to separate the coating from its substrate provides a measure of its adhesion strength.

Figure 4. Pull-off tester and diagram of the adhesion test procedure.

Testing methodology

The pull-off tester is applied on wheelpath and off wheelpath in the treated section only (see Figure 5). The maximum pull-off force is determined when the cylindrical aluminum disk is separated from the surface. The maximum loading time is also determined from the load -time curve provided by the instrument. Using the peak load and the maximum time until the separation, the total adhesion energy index (kN. sec) is determined representing the area under the triangle. The summary of the pull-off forces and maximum time are compiled in Table 24.

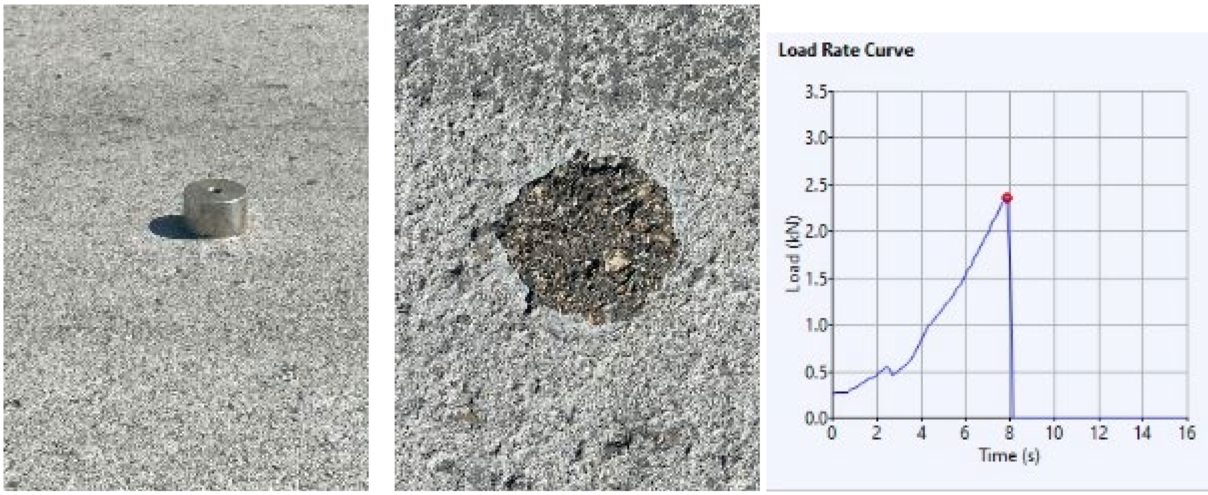


Figure 5. Demonstration of Pull-off tester at SW 21st St with peak load over time diagram.

4 MEASUREMENT PLAN

At each treatment site, friction and texture measurements were conducted on both the treated section and on a control section of the same or similar pavement surface. Five measurements were made in the wheelpath (refer to as on Wheelpath), and two measurements were made outside of the wheelpath (refer to as off wheelpath), to capture any potential variations in texture and friction due to traffic wear. Due to lane closure limitations at each site, measurements of longitudinal locations were at different intervals to cover as much of the treated section as was closed. On some of the streets, the entire treated section was available and on others it was a portion of the treated section.

A visual determination of the wheelpath was made at each test section (refer to Figure 6). Most streets showed a single wheelpath between parked vehicles on each side of the street. The SW 21st St. had three visible wheelpath, one to the east and two on the west side of the street due to parked vehicles. The eastmost wheelpath was measured on SW 21st St. On Lucinda, there were four visible wheelpath. The outside wheelpath on the east side was measured. Additional details about measurement placement are found in the results section.

At each site, CT Meter measurements were collected first since DF Tester measurements require wetting the pavement surface which would affect CT Meter measurements. Before moving the CT Meter, a manufacturer-supplied guide was used to mark the exact position for the DF Tester such that measurements would be completed in the same location (Figure 7). New DF Tester rubber sliders were installed for each set of control/treated site measurements.

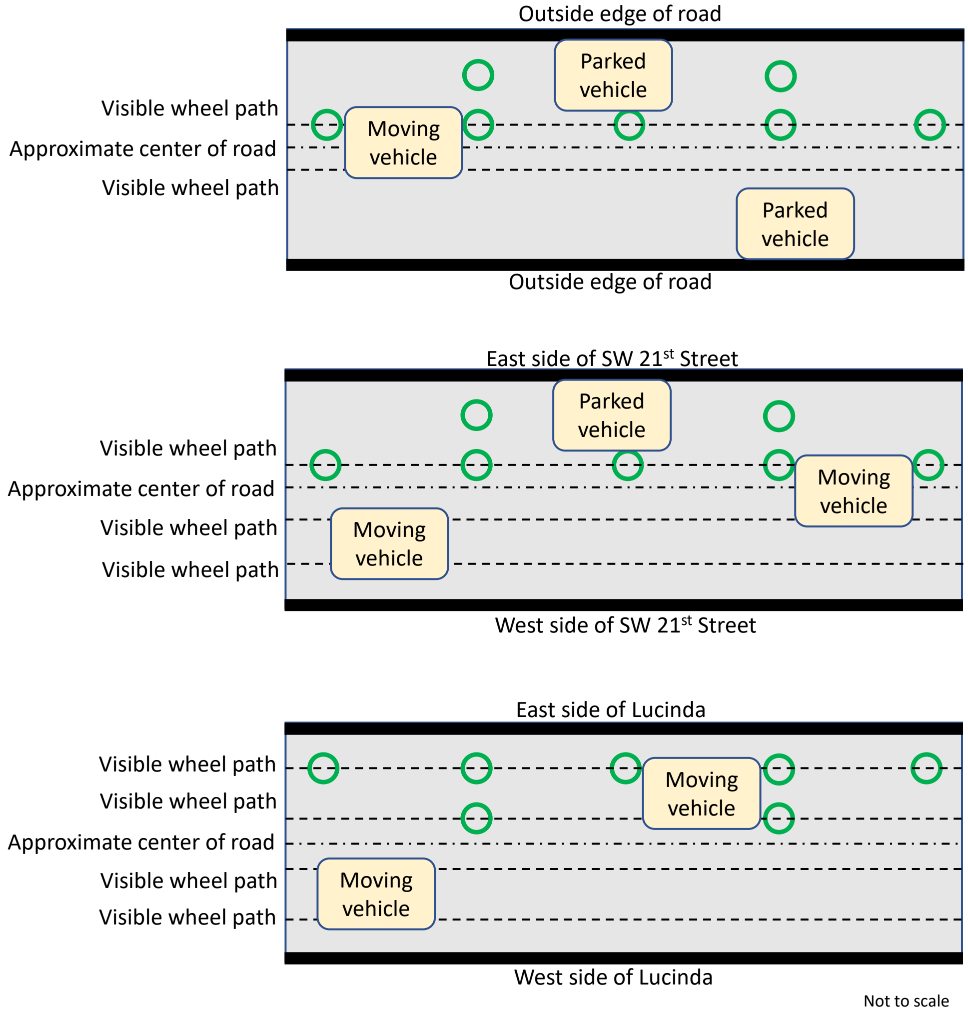


Figure 6. Typical measurement locations relative to traffic.

Figure 7. Example of marking from the CT Meter to align DF Tester in the same location.

5 MEASUREMENT RESULTS

A total of five treatment sites were included in the measurement series (Table 1). Details of the exact measurement locations and resulting data for each site are presented below. As noted above, CT Meter texture measurements are reported as MPD in mm. DF Tester friction coefficients (μ) are reported for 20, 40, and 60 kph test speeds.

5.1 Carol Crest Str.

For this location, the surface treatment began near the end of Argonne Dr., continued along Carol Crest St., and ended after turning the corner onto Kay Ann Dr. The control section was a 200-ft section on Kay Ann Dr. prior to a pavement surface change. A surface treatment application was made on the control section sometime between the initial testing (2023) and the current testing that is not part of this project. Data from the control section for 2024 cannot be compared to the data from 2023 because of the surface treatment. From the cool pavement treatment starting on Argonne Dr. the measurements were made at 70, 250, 400, 550, and 675 ft distances along Carol Crest St. The wheelpath was 10 ft from the west curb and the outside of wheelpath data was collected at 5 ft from the west curb.

The control section measurements were made at 6, 50, 100, 150, and 200 ft from the treatment end. The wheelpath and outside of the wheelpath distances were 10 and 5 ft, respectively, from the north curb. Figure 8 shows the treated section in yellow highlight and control section in green and Figure 9 shows the marked testing location.

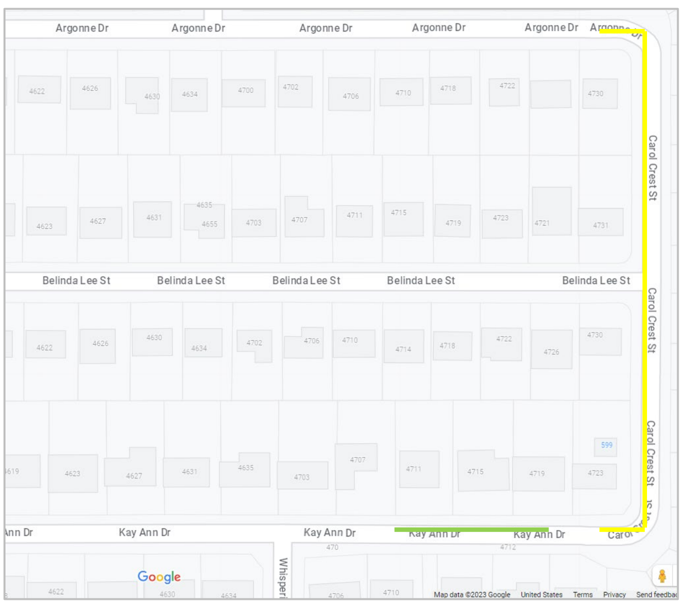


Figure 8. Measurement locations on Carol Crest St. and Kay Ann Dr.

Figure 9. Photos of Carol Crest St. treatment.

5.1.1 Texture Results

Texture values (MPD) for the treated and control sites are shown in Table 2 for the wheelpath test locations and in Table 3 for the test locations outside of the wheelpath.

Table 2. MPD on wheelpath test locations on Carol Crest St. and Kay Ann Dr.

Test Number	Control	Treated
	MPD (mm)	MPD (mm)
1	0.34	0.42
2	0.49	0.54
3	0.43	0.49
4	0.48	0.44
5	0.42	0.5
Average	0.43	0.48

Table 3. MPD off wheelpath on Carol Crest St. and Kay Ann Dr.

Test Number	Control	Treated
	MPD (mm)	MPD (mm)
1	0.44	0.99**
2	0.49	0.54
Average	0.47	0.54

** excluded for being over the limit

5.1.2 Friction Results

DF Tester friction values on wheelpath test locations for the treated and control sites are shown in Table 4, and values for the test locations off wheelpath are shown in Table 5.

Table 4. DF Tester friction coefficients (μ) on wheelpath on Carol Crest St. and Kay Ann Dr.

Test Number	Control			Treated		
	20 km/h	40 km/h	60 km/h	20 km/h	40 km/h	60 km/h
1	0.36	0.30	0.28	0.48	0.44	0.41
2	0.43	0.38	0.38	0.55	0.50	0.50
3	0.44	0.38	0.39	0.51	0.50	0.46
4	0.41	0.38	0.33	0.60	0.56	0.54
5	0.43	0.39	0.38	0.50	0.44	0.39
Average	0.41	0.37	0.35	0.53	0.49	0.46

Table 5. DF Tester friction coefficients (μ) off wheelpath on Carol Crest St. and Kay Ann Dr.

Test Number	Control			Treated		
	20 km/h	40 km/h	60 km/h	20 km/h	40 km/h	60 km/h
1	0.49	0.44	0.42	0.62	0.59	0.60
2	0.45	0.39	0.38	0.66	0.62	0.62
Average	0.47	0.42	0.40	0.64	0.61	0.61

5.2 Lucinda

Measurements were made on the treated surface of Lucinda from Sams Dr. toward E. Ashley Rd. and on the control section of Lucinda from Sams Dr. toward Bernard Dr. Longitudinal spacing between measurements was nominally 50 ft on both the treated and control sections. The wheelpath location was 3.5 ft from the east curb. The off wheelpath measurements were taken at 6 ft from the east curb. The map in Figure 10 shows the measurement area of the treated section in yellow and the control section in green and Figure 11 shows the marked testing location.

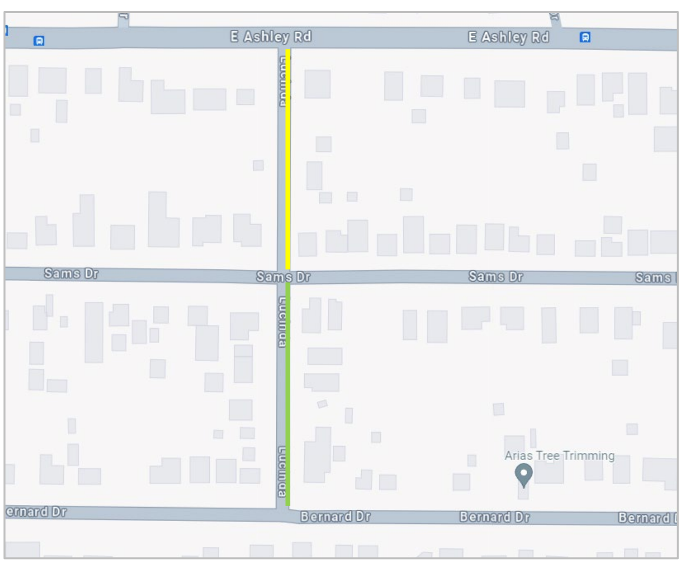


Figure 10. Approximate locations of measurements on Lucinda.

Figure 11. Photos of Lucinda treatment.

5.2.1 Texture Results

Texture values (MPD) for the treated and control sites are shown in Table 6 on wheelpath and in Table 7 off wheelpath test locations.

Table 6. MPD on wheelpath on Lucinda St.

Test Number	Control	Treated
	MPD (mm)	MPD (mm)
1	0.76	0.37
2	0.55	0.39
3	0.65	0.36
4	0.59	0.35
5	0.63	0.36
Average	0.64	0.37

Table 7. MPD off wheelpath on Lucinda St.

Test Number	Control	Treated
	MPD (mm)	MPD (mm)
1	0.54	0.33
2	0.53	0.32
Average	0.54	0.33

5.2.2 Friction Results

DF Tester friction values on wheelpath test locations for the treated and control sites are shown in Table 8, and values for the test locations off wheelpath are shown in Table 9.

Table 8. DF Tester friction coefficients (μ) on wheelpath on Lucinda St.

Test Number	Control			Treated		
	20 km/h	40 km/h	60 km/h	20 km/h	40 km/h	60 km/h
1	0.50	0.49	0.45	0.33	0.28	0.28
2	0.60	0.55	0.55	0.33	0.28	0.28
3	0.57	0.55	0.51	0.32	0.27	0.22
4	0.59	0.56	0.54	0.34	0.28	0.28
5	0.55	0.51	0.50	0.33	0.27	0.28
Average	0.56	0.53	0.51	0.33	0.28	0.27

Table 9. DF Tester friction coefficients (μ) off wheelpath on Lucinda St.

Test Number	Control			Treated		
	20 km/h	40 km/h	60 km/h	20 km/h	40 km/h	60 km/h
1	0.48	0.47	0.45	0.34	0.29	0.28
2	0.53	0.50	0.50	0.37	0.31	0.28
Average	0.51	0.49	0.48	0.36	0.30	0.28

5.3 Mountain Star

Measurements were made on the treated surface of Mountain Star north of the alley between Summer Vail and Stephens Ranch, and the control section was south of the same alley. Longitudinal spacing between measurements was nominally at 50 ft intervals on the treated and 40 ft intervals on the control section. The on wheelpath location was 12 ft from the west curb. The off wheelpath measurements were taken at 6 ft from the west curb. The map in Figure 12 shows the approximate measurement area of the treated section in yellow and the control section in green and Figure 13 shows the marked testing location.

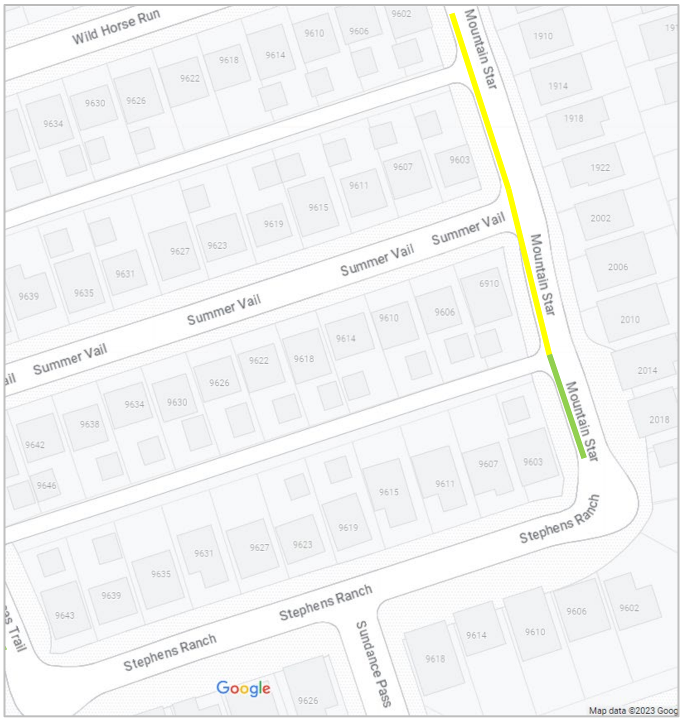


Figure 12. Measurement locations on Mountain Star.

Figure 133. Photos of Mountain Star treatment.

5.3.1 Texture Results

Texture values (MPD) for the treated and control sites are shown in Table 10 on wheelpath, and in Table 11 off wheelpath test locations.

Table 10. MPD on wheelpath on Mountain Star.

Test Number	Control	Treated
	MPD (mm)	MPD (mm)
1	0.87	0.74
2	0.88	0.62
3	0.89	0.59
4	0.83	0.67
5	0.93	0.85
Average	0.88	0.69

Table 11. MPD off wheelpath on Mountain Star.

Test Number	Control	Treated
	MPD (mm)	MPD (mm)
1	0.82	0.73
2	0.97	0.85
Average	0.90	0.79

5.3.2 Friction Results

DF Tester friction values on wheelpath test locations for the treated and control sites are shown in Table 12. Friction values for the test locations off wheelpath are shown in Table 13.

Table 12. DF Tester friction coefficients (μ) on wheelpath on Mountain Star.

Test Number	Control			Treated		
	20 km/h	40 km/h	60 km/h	20 km/h	40 km/h	60 km/h
1	0.28	0.30	0.29	0.25	0.26	0.25
2	0.27	0.28	0.28	0.29	0.28	0.28
3	0.30	0.31	0.32	0.29	0.28	0.28
4	0.31	0.33	0.33	0.27	0.27	0.28
5	0.28	0.29	0.29	0.22	0.23	0.27
Average	0.29	0.30	0.30	0.26	0.26	0.27

Table 13. DF Tester friction coefficients (μ) off wheelpath on Mountain Star.

Test Number	Control			Treated		
	20 km/h	40 km/h	60 km/h	20 km/h	40 km/h	60 km/h
1	0.49	0.49	0.48	0.29	0.28	0.28
2	0.51	0.51	0.51	0.29	0.28	0.28
Average	0.50	0.50	0.50	0.29	0.28	0.28

5.4 SW 21st Str.

Measurements were made on the treated surface of SW 21st St. between S. Laredo and Persyn St. and measurements were made on the control section of SW 21st St. between S. Loredo and Potosi St. Longitudinal spacing between measurements was approximately 50 ft on both the treated and control sections. The wheelpath location was 9 ft from the east curb, a slight change from last year's 8 ft from the east curb, to align better with the visible wheelpath. The off wheelpath measurements were taken at 4 ft from the east curb. The map in Figure 14 shows the measurement area of the treated section in yellow and the control section in green and Figure 15 shows the marked testing location.

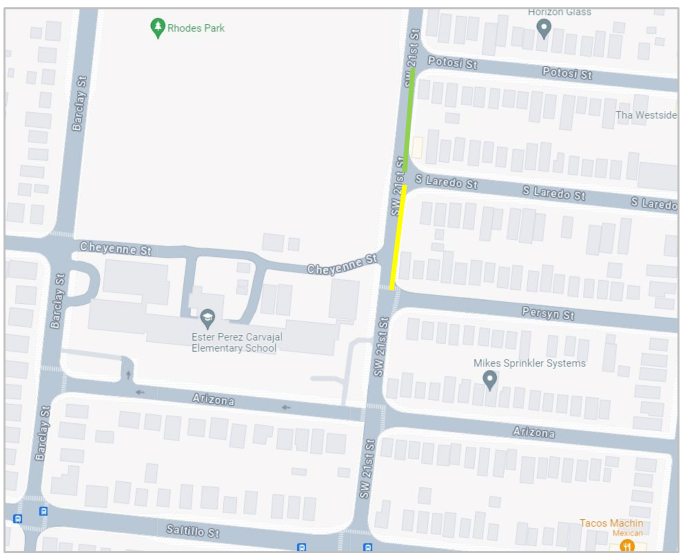


Figure 14. Approximate locations of measurements on SW 21st St.

Figure 15. Photos of SW 21st St. treatment.

5.4.1 Texture Results

Texture values (MPD) for the treated and control sites are shown in Table 14 on wheelpath and in Table 15 off wheelpath test locations.

Table 14. MPD on wheelpath on SW 21st St.

Test Number	Control MPD (mm)	Treated MPD (mm)
1	0.58	0.43
2	0.51	0.45
3	0.55	0.46
4	0.51	0.45
5	0.67	0.43
Average	0.56	0.44

Table 15. MPD off wheelpath on SW 21st St.

Test Number	Control MPD (mm)	Treated MPD (mm)
1	0.57	0.4
2	0.49	0.37
Average	0.53	0.39

5.4.2 Friction Results

DF Tester friction values on wheelpath test locations for the treated and control sites are shown in Table 16, and values for the test locations off wheelpath are shown in Table 17.

Table 16. DF Tester friction coefficients (μ) on wheelpath on SW 21st St.

Test Number	Control			Treated		
	20 km/h	40 km/h	60 km/h	20 km/h	40 km/h	60 km/h
1	0.40	0.39	0.39	0.28	0.26	0.26
2	0.41	0.39	0.38	0.29	0.27	0.27
3	0.42	0.39	0.39	0.32	0.28	0.28
4	0.49	0.46	0.45	0.30	0.28	0.28
5	0.41	0.39	0.39	0.30	0.28	0.28
Average	0.43	0.40	0.40	0.30	0.27	0.27

Table 17. DF Tester friction coefficients (μ) off wheelpath on SW 21st St.

Test Number	Control			Treated		
	20 km/h	40 km/h	60 km/h	20 km/h	40 km/h	60 km/h
1	0.61	0.57	0.57	0.37	0.33	0.32
2	0.69	0.66	0.65	0.35	0.32	0.31
Average	0.65	0.62	0.61	0.36	0.33	0.32

5.5 Piper Dr.

Measurements were made on the treated surface of Piper Dr. from Loy Dr. southwest and the measurements on the control section were on Loy Dr. approximately centered on Piper Dr. to avoid visual changes in pavement on Loy Dr. east and west of Piper Dr. Longitudinal spacing between measurements was approximately 50 ft on both the treated and control sections. The wheelpath location was 9 ft from the east curb on Piper and 11 ft from the north curb on Loy. The off wheelpath measurements were taken at 4.5 ft from the east curb on Piper Dr. and 5.5 ft on Loy Dr. The slight variation on wheelpath location on Piper Dr. was to better align with visible wheelpath. The map in Figure 16 shows the approximate measurement area of the treated section in yellow and the control section in green and Figure 17 shows the marked testing location.

Note: It is not known whether the control surface on Loy Dr. is the same as the treated pavement surface on Piper Dr.

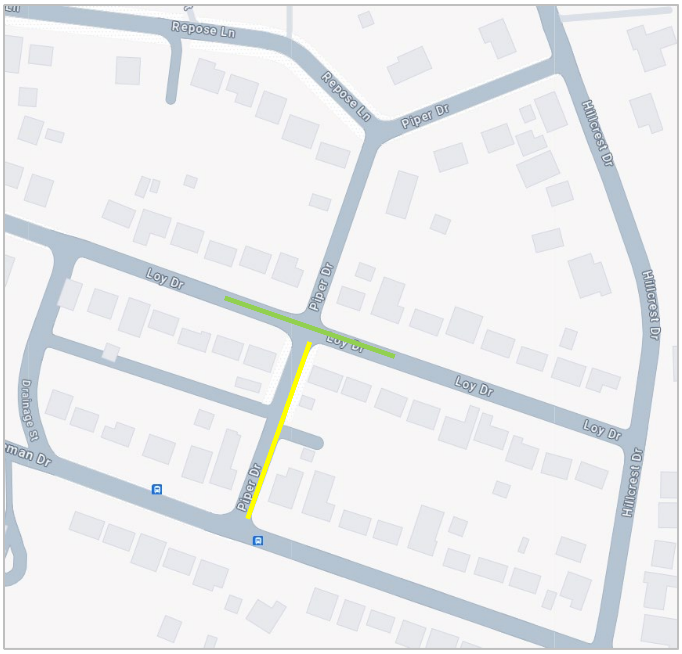


Figure 16. Measurement areas on Piper and Loy Dr.

Figure 17. Photos of Piper Dr. treatment.

5.5.1 Texture Results

Texture values (MPD) for the treated and control sites are shown in Table 18 on wheelpath and in Table 19 off wheelpath test locations.

Table 18. MPD on wheelpath on Piper and Loy Dr.

Test Number	Control	Treated
	MPD (mm)	MPD (mm)
1	0.51	0.33
2	0.57	0.33
3	0.47	0.3
4	0.66	0.3
5	0.55	0.35
Average	0.55	0.32

Table 19. MPD off wheelpath on Piper and Loy Dr.

Test Number	Control	Treated
	MPD (mm)	MPD (mm)
1	0.47	0.32
2	0.56	0.32
Average	0.52	0.32

5.5.2 Friction Results

DF Tester friction values on wheelpath test locations for the treated and control sites are shown in Table 20, and values for the test locations off wheelpath are shown in Table 21.

Table 20. DF Tester friction coefficients (μ) on wheelpath on Piper and Loy Dr.

Test Number	Control			Treated		
	20 km/h	40 km/h	60 km/h	20 km/h	40 km/h	60 km/h
1	0.50	0.48	0.46	0.38	0.31	0.29
2	0.52	0.51	0.50	0.34	0.29	0.28
3	0.51	0.50	0.47	0.36	0.30	0.28
4	0.55	0.53	0.53	0.41	0.33	0.30
5	0.40	0.39	0.39	0.37	0.32	0.30
Average	0.50	0.48	0.47	0.37	0.31	0.29

Table 21. DF Tester friction coefficients (μ) off wheelpath on Piper and Loy Dr.

Test Number	Control			Treated		
	20 km/h	40 km/h	60 km/h	20 km/h	40 km/h	60 km/h
1	0.61	0.59	0.57	0.35	0.28	0.28
2	0.61	0.57	0.54	0.43	0.33	0.33
Average	0.61	0.58	0.56	0.39	0.31	0.31

5.6 Overall Summary

Table 22 summarizes the average texture and friction results from each of the test sites. For simplicity, only the DF Tester friction value at 20 km/h for each site as this is the friction value commonly reported for surface evaluation.

Table 22. Overall summary of average texture and friction results for all sites in 2024.

Treatment Location	Texture (MPD, mm)				Friction (DFT20)			
	On Wheelpath		Off Wheelpath		On Wheelpath		Off Wheelpath	
	Control	Treatment	Control	Treatment	Control	Treatment	Control	Treatment
Carol Crest[1]	0.43	0.48	0.47	0.54	0.41	0.53	0.47	0.64
Lucinda	0.64	0.37	0.54	0.33	0.56	0.33	0.51	0.36
Mountain Star	0.88	0.69	0.9	0.79	0.29	0.26	0.5	0.29
SW 21st St.	0.56	0.44	0.53	0.39	0.43	0.3	0.65	0.36
Piper Dr.*	0.55	0.32	0.52	0.32	0.5	0.37	0.61	0.39
Minimum	0.43	0.32	0.47	0.32	0.29	0.26	0.47	0.29
Maximum	0.88	0.69	0.90	0.79	0.56	0.53	0.65	0.64

* A Control site was on a different street than a treated site.

From the summary of the texture and friction data, the minimum and maximum records of all sites are aligned with other studies conducted by Martino and Weissmann (2008) on 71 asphalt pavement state highways in Texas. In their study, the MPD ranges from 0.39 to 3.80 mm and the DFT20 ranges from 0.20 to 0.90. Table 22 suggests that the treated and untreated pavement conditions are within range with equivalent state highways providing adequate surface characteristics.

To provide a comparison of the cool pavement sites performance in the next sections, it is important to incorporate the texture and friction measurements from 2023 as part of Phase I of this study shown in Table 23.

Table 23. Overall summary of average texture and friction results for all sites in 2023.

Treatment Location	Texture (MPD, mm)				Friction (DFT 20)			
	On Wheelpath		Off Wheelpath		On Wheelpath		Off Wheelpath	
	Control	Treatment	Control	Treatment	Control	Treatment	Control	Treatment
Carol Crest[1]	0.54	0.58	0.52	0.71	0.35	0.58	0.46	0.65
Lucinda	0.55	0.41	0.5	0.39	0.51	0.27	0.51	0.29
Mountain Star	0.84	0.76	0.85	0.76	0.3	0.29	0.56	0.31
SW 21st St.	0.53	0.46	0.44	0.45	0.53	0.3	0.66	0.33
Piper Dr.[1]	0.52	0.35	0.73	0.35	0.44	0.27	0.5	0.3

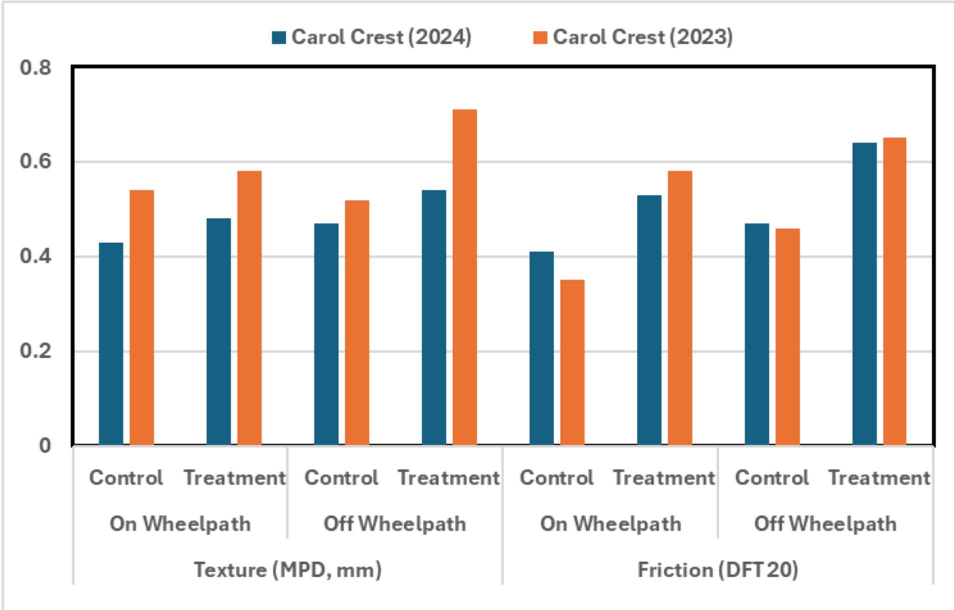
Although the testing data were collected in 2024 at the sites using same equipment and operator, the exact locations in which the equipment was placed varied based on available spaces from parked vehicles, traffic control, and surface conditions being dry and free from debris. However, the number of testing data is considered representative of the site conditions.

6 DISCUSSIONS OF RESULTS

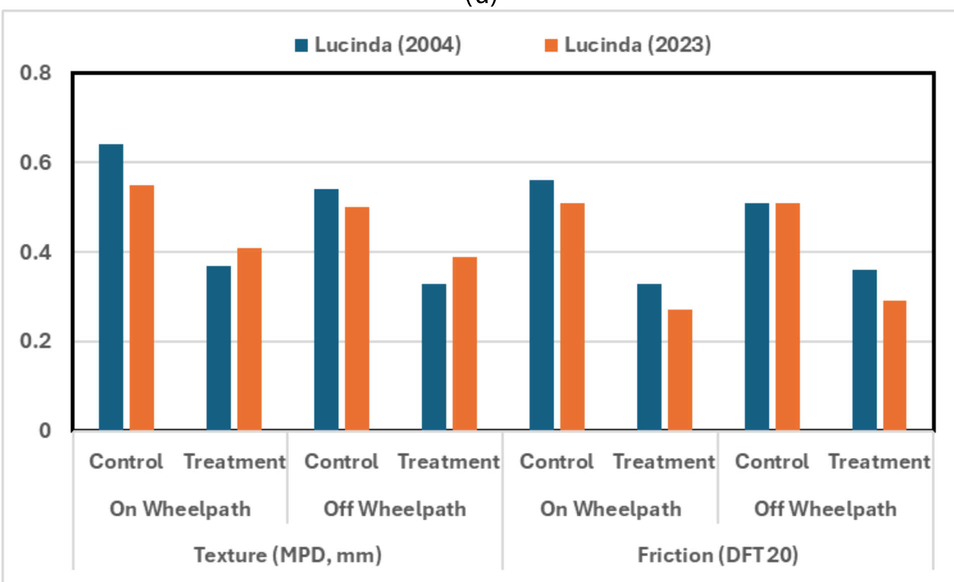
6.1 Friction and Texture measurements

Figures 18 (a-e) present the texture and friction measurements of Tables 22 and 23 for the five sites. In general, there is no specific pattern that supports whether either texture or friction increases or decreases due to traffic and environmental effect. As suggested by literature, dependent on asphalt pavement materials characteristics (e.g., aggregate type, binder source and grade, air voids, etc.) they tend to affect the evolution of texture and friction over time (Xiao et al. 2023). Generally, the applied treatment to certain extent can help with restoring texture and friction on deteriorated surface to meet specification guidelines but not necessarily maintain them over a period of time.

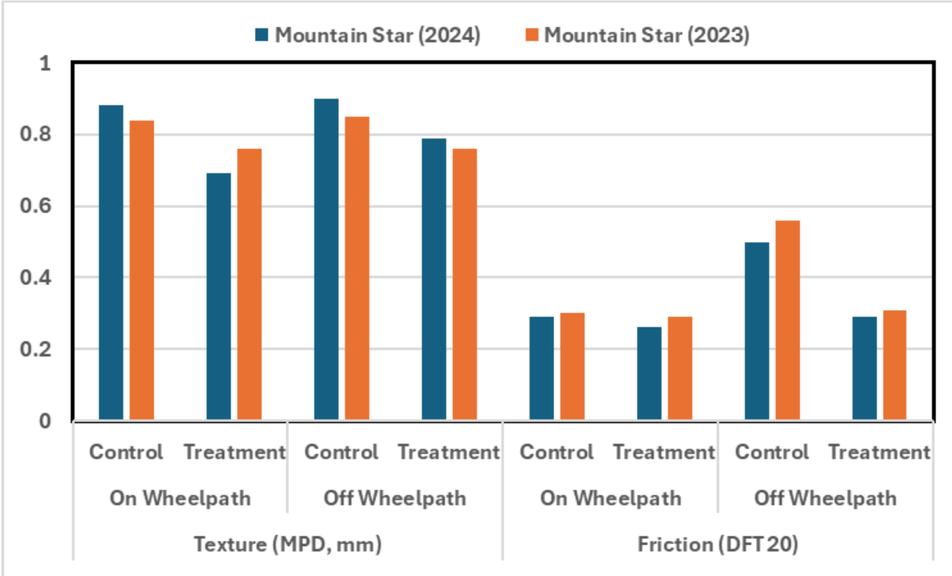
As can be shown, the applied treatments at four sites with SealMaster and GuardTop tend to reduce the surface texture by 30% in 2024 and by 20% in 2023 as compared to control pavement. However, on the contrary, treated sections tend to decrease the friction by 32% in 2024 and 39% in 2023 as compared to control pavement. The GAF treated site, on the contrary, showed increase in texture by 13% in 2024 and 22% in 2023 and friction by 33% in 2024 and 54% in 2023. As expected, increasing texture is generally associated with increasing friction and vice versa. The consistency for this trend in all sites after >500 days of performance suggests that the treatment continues to maintain and preserve the surface characteristics under traffic and environmental effect changes. There are two factors that affect treatment performance; environmental effect and traffic. The following is a discussion on the effect of traffic and environmental effect on the texture and friction of cool pavement treatment considering their performance since installation.


Carol Crest (2024)
Carol Crest (2023)
0.8
0.6
0.4
0.2
0
Control
Treatment
Control
Treatment
Control
Treatment
Control
Treatment
On Wheelpath
Off Wheelpath
On Wheelpath
Off Wheelpath
Texture (MPD, mm)
Friction (DFT20)

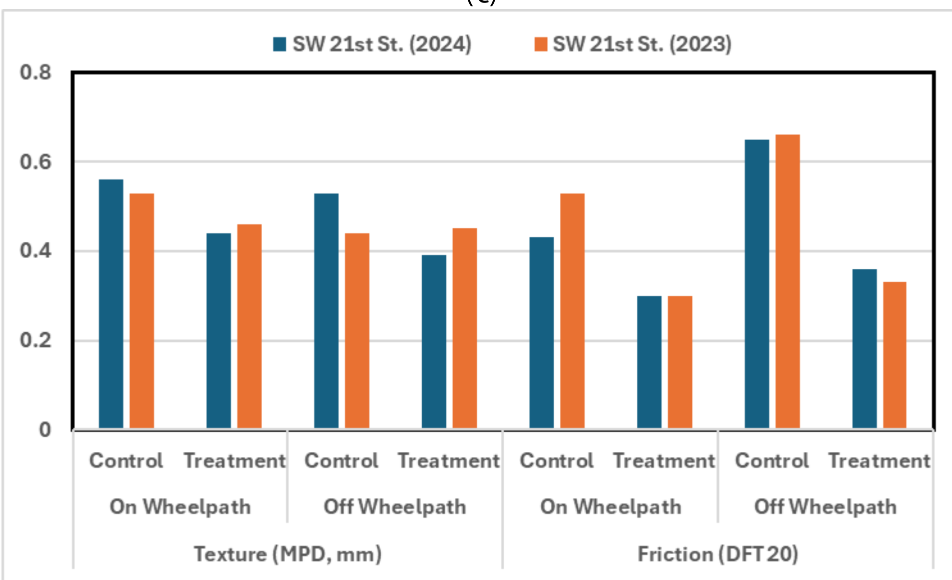
(a)


Lucinda (2004)
Lucinda (2023)
0.8
0.6
0.4
0.2
0
Control
Treatment
Control
Treatment
Control
Treatment
Control
Treatment
On Wheelpath
Off Wheelpath
On Wheelpath
Off Wheelpath
Texture (MPD, mm)
Friction (DFT20)

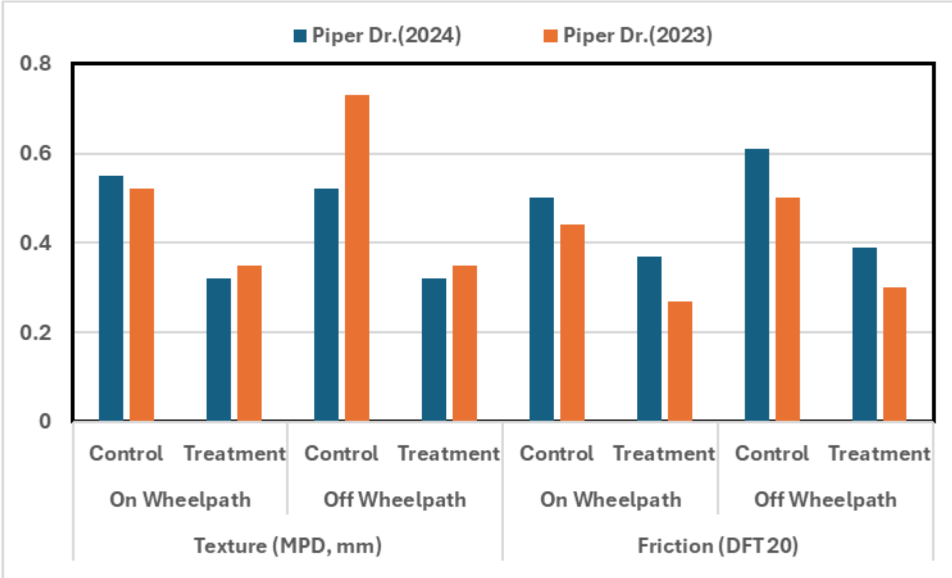
(b)


Mountain Star (2024)
Mountain Star (2023)
1
0.8
0.6
0.4
0.2
0
Control
Treatment
Control
Treatment
Control
Treatment
Control
Treatment
On Wheelpath
Off Wheelpath
On Wheelpath
Off Wheelpath
Texture (MPD, mm)
Friction (DFT20)

(c)


SW 21st St. (2024)
SW 21st St. (2023)
0.8
0.6
0.4
0.2
0
Control
Treatment
Control
Treatment
Control
Treatment
Control
Treatment
On Wheelpath
Off Wheelpath
On Wheelpath
Off Wheelpath
Texture (MPD, mm)
Friction (DFT20)

(d)



(e)

Figure 18. Summary of texture and friction measurements for all projects in 2023 and 2024.

6.2 Effect of traffic and environmental factors

The off wheelpath areas are not exposed to the same traffic volume as on wheelpath areas as evident in the tire imprints. With the testing conducted either in the parking lane or between the wheelpath, it is fair to assume that the off wheelpath areas are mostly affected by environmental factors (heat, rainfall, solar radiation, moisture, etc.) only. Therefore, tracking the texture, and friction measurements changes in the off wheelpath areas is indicator of the treatment performance to environmental effect over time. In addition, comparing the off wheelpath measurements on treated sections against their counterparts on control sections, is indicator of treatment effect to pavement surface. Arguably, considering the on wheelpath measurements changes is indicator of the treatment performance under traffic and environmental effect combined.

The following formula is considered when analyzing the effect of traffic and environmental factors for control and treated surfaces.

Relative difference (%) = (Treatment property – Control property) / (Control property) x 100

Where "property" is referred to texture or friction measurements.

The average relative differences between surface texture in control and treated sections are 28% and 26% for on wheelpath and off wheelpath in 2024, respectively. This implies that traffic has negligible effect on the cool pavement treatment as they retain their integrity to reduce the MPD on applied surfaces.

The average relative differences between friction measurements in control and treated sections are 27% and 38% for on wheelpath and off wheelpath in 2024, respectively. This implies that traffic has considerable effect to smooth pavement surface due to the induced tire load to polish aggregates. In 2023, the average relative differences were 40% and 44% for on wheelpath and off wheelpath, respectively. This implies the short duration (nearly 60 days) of traffic exposure to impact surface friction changes.

With respect to individual treatment effect on pavement in 2024, GAF showed an increase in texture by an average 13% while SealMaster and GuardTop showed a reduction by 29% and 32%, respectively. For the friction measurements, GAF showed an increase of 33% while SealMaster and GuardTop showed a reduction of 31% and 34%, respectively.

The average relative differences between surface texture from 2023 to 2024 for all products are reduced by 10% and 13% for the on wheelpath and off wheelpath, respectively. On the other hand, for the friction measurements, the average relative differences increased by 16% and 14% for the on wheelpath and off wheelpath, respectively. This implies no significant difference between the texture and friction evolution with time on wheelpath and off wheelpath areas.

With respect to performance evolution with time (from 2023 to 2024), GAF has shown the most reduction of texture by an average of 21% followed by SealMaster at 8% and GuardTop at 9%. For the friction, GuardTop showed the most increase over time by an average of 25%, followed by GAF with 7% and GAF with a reduction of 5%.

6.3 Adhesion Strength

The energy index, which combines the force and time to pull the cool pavement coating off from existing surface, is an indication of adhesion strength when comparing products performance, defined as follows:

$$\text{Energy Index (kN.sec)} = 0.50 \times \text{Peak load (kN)} \times \text{Loading time (sec)}$$

As can be seen in Table 24, the adhesion on wheelpath is more than off wheelpath for all products in this evaluation phase (>500 days). This observation was also aligned with measurements in 2023 (< 200 days) with the exception of GAF. However, GAF and GuardTop have shown an increase in adhesion differential between on and off wheelpath while on the contrary SealMaster have shown a decrease of adhesion with time. This may be attributed to several factors but more importantly is the traffic loading effect that helps penetrate the coating materials into the substrate over time leading to increased adhesion strength (Table 25).

Another consideration is the aging of the coating materials over time that also contributed to increasing adhesion. This is supported by the evolution of adhesion over time as shown in Figure 19. The bonding strength systematically increases by various degrees among the cool pavement products after nearly a year from the last testing phase in 2023. The only exception was the GAF at the off wheelpath area.

Table 24: Pull-off adhesion testing data on treated surfaces.

	On Wheelpath		Off Wheelpath		On Wheelpath	Off wheelpath
Treatment Location	Peak load (kN)	Max Loading Time (sec)	Peak load (kN)	Max Loading Time (sec)	Energy Index (kN.sec)	
Carol Crest St.	2.53	7.60	2.76	6.50	9.61	8.96
Lucinda St.	2.97	7.60	2.49	6.10	11.28	7.58
Mountain Star St.	1.91	5.10	1.78	4.70	4.87	4.18
SW 21st St.	1.56	7.50	1.56	5.80	5.87	4.52
Piper Dr.	2.87	6.50	2.52	5.50	9.32	6.92

It is noted to mention that adhesion testing was limited to a single point at each of the sites in Table 24 due to the limited time provided by traffic control to conduct multiple testing points. Therefore, further testing is highly suggested to account for testing variabilities within the site.

Table 25. Effect of traffic on adhesion strength.

Product	% Adhesion increase (Energy index)	Performance period (days)	% Adhesion increase (Energy index)	Performance period (days)
GAF	-27	193	7	553
SealMaster	52	125	16	506
GuardTop	22	181	35	536

-ve is indication of higher adhesion off wheelpath than on wheelpath

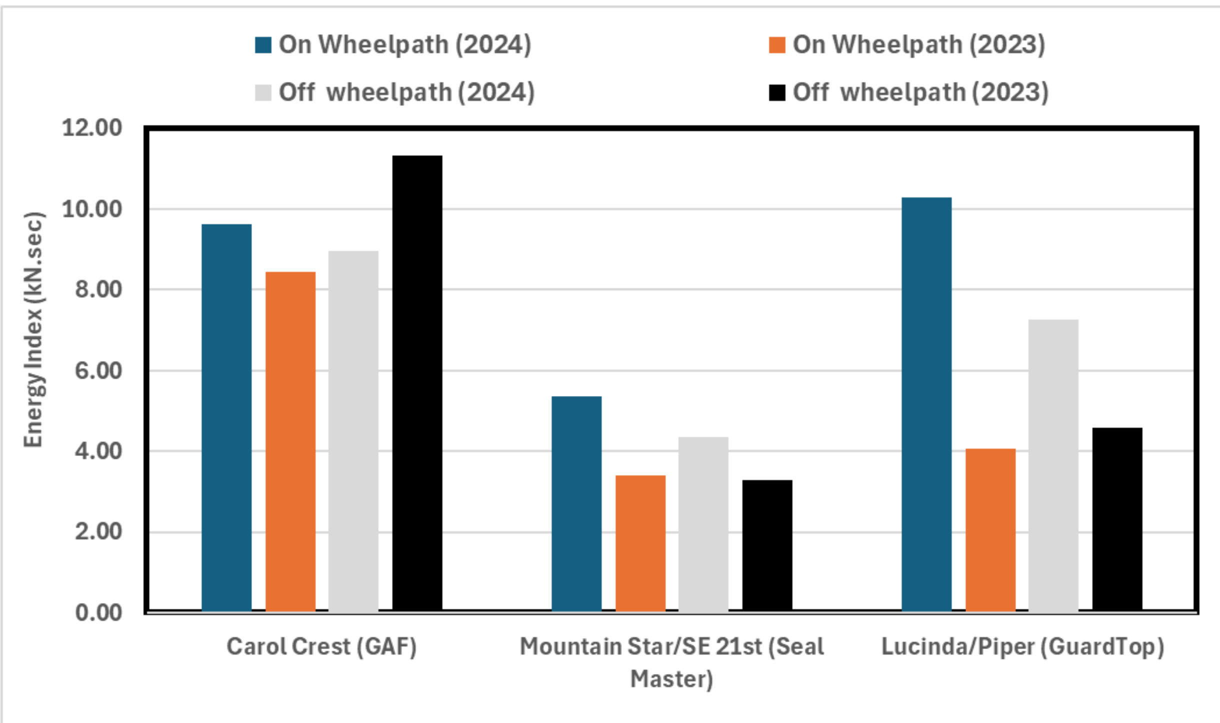


Figure 19. Evolution of adhesion strength over time.

7 SITES ASSESSMENT

Visual assessment was conducted to evaluate treatment and surface characteristics conditions to evaluate their performance after one year of treatment application. The following is the summary of the sites assessment.

7.1 Mountain Star

The SealMaster treatment showed no apparent sign of surface cracking. There was also no sign of delamination or degradation of the treatment particularly on wheelpath. At both ends of the treatment section along the interface with control section, one can notice the color separation line which suggests a fully intact treatment. However, the coloration of the treatment appears to become darken, particularly in the wheelpath areas as compared to the parking lanes along both directions. Surface discoloration occurred due to tire tracking and oil spills at various locations. Tire tracking is mostly visible on wheelpath and at the tuning paths with the intersection of crossing streets. Oil spills appear mostly at the parking lanes. The intensity of the tracking or oil spills is not severe to affect treatment integrity and adhesion with existing pavement surface. Overall, the SealMaster treatment from the preservation perspective seems to function fairly well (Figure 20).

Figure 20. Site photos from Mountain Star.

7.2 SW 21st St.

The SealMaster treatment showed excessive delamination in several areas particularly in the wheelpath of the lane adjacent to the school entrance. This may be attributed to high volume drop off and pick up traffic. A significant difference in the treatment surface appearance from both directions may suggest the inability of the treatment to sustain high volume stop-and-go traffic. Another observation is the complete delamination of the treatment at the turning lanes near the intersections with S. Laredo and Persyn St.

There was no apparent sign of excessive surface cracking with the exception of outer wheelpath (near sidewalk) in the opposite direction of the school. However, it was very minimal at time of inspection. It is noticeable from previous visits after rainfall that runoff accumulates along the edges with the side curb. The runoff, however, appears to have no effect on treatment delamination as they occurred primarily on wheelpath.

The discoloration of the treatment is affected by oil spills in few spots at the parking lane. However, they are very limited and have no effect in the treatment adhesion with existing surface. It is also noticeable that the significant difference in light coloration of the applied treatment in the parking lane and traffic lane is attributed to the tire rubber imprint. Overall, the treatment appears to be in poor condition due to high volume school traffic (Figure 21).

Figure 21. Site photos from SW 21st St.

7.3 Carol Crest St.

The GAF surface treatment appeared to be free from cracking and delamination from existing pavement. The treatment surface color is not clearly distinguished from a freshly applied asphalt pavement toward site ends and intersection with Belinda Lee St.

In terms of discoloration, there are no visible oil spills or tire tracking which may be attributed to the near dark color of the treatment. From the pavement preservation perspective, the treatment seems to function fairly well (Figure 22).

Figure 22. Site photos from Carol Crest St.

7.4 Lucinda

The GuardTop treatment for the most part of the site appears to be intact with few exceptions on wheelpath in the northbound direction to Ashley rd. This is the only site with no curb and sidewalk which attribute to the longitudinal cracking along the pavement edges in both directions. There is also noticeable longitudinal cracking on wheelpath in both directions with few that were previously sealed prior to the treatment. The width of non sealed cracks warrants the need for crack sealing treatment. In terms of the treatment discoloration, there is no sign of oil spills or tire tracking. Overall, the treatment appeared to be in acceptable condition considering the low traffic and lack of curbs that protect against pavement edges failure (Figure 23).

Figure 23. Site photos from Lucinda St.

7.5 Piper Dr.

The GuardTop treatment showed no delamination. With the exception of single longitudinal crack, the surface seems to be fully intact and well covering of existing pavement. Tire tracking is the most visible discoloration noticed in most areas of the treatment attributed to contrast of tire rubber and light treatment color. There is no significant difference in the treatment color at the interface with conventional pavement surface at Freeman Dr. Overall, the treatment appeared to be in fairly well conditions due to its adhesion and coverage to existing surface (Figure 24).

Figure 24. Site photos from Piper Dr.

8 CONCLUSIONS

In phase 2 of this pilot program, five cool pavement treated sites and control (untreated) sites were evaluated using surface texture, friction, and adhesion strength to existing pavement. Three cool pavement products were used in the sites namely, GAF, SealMaster, and GuardTop. The following is the summary of all findings;

- SealMaster and GuardTop treated sites showed reduction in texture and friction while, in contrast, GAF treated site showed increase in texture and friction compared to their control counterparts in 2024.
- When comparing between on wheelpath and off wheelpath characteristics, there was negligible difference in texture in both treated and control sites, but considerable reduction in friction for the case of on wheelpath due to the induced tire loading.
- Over time, traffic tends to polish and smooth pavement surface and reduce friction. Traffic also helps increase adhesion strength of cool pavement products to existing surface.
- In terms of adhesion strength when comparing on and off wheelpath, GuardTop had the highest increase in adhesion on wheelpath while GAF had a lesser degree of increase. SealMaster on the contrary showed reduction of strength with time.
- Site assessment implied that except SW 21st St., all sites have showed fairly well appearance, and performance in terms of surface crack intensity, delamination from exiting surface and discoloration.
- As concluded by the heat mitigation measure study conducted in parallel to this pavement assessment study, it was concluded that SealMaster and GuardTop had the highest and least in terms of reducing surface temperatures. On the other hand, GAF heat mitigation performance tends to stay in the middle among other treatment options.

9 ACKNOWLEDGEMENTS

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