Pavement Preservation: A Minnesota Journey, and NRRA Research Update

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Introduction

Pavement preservation is work that is planned and performed to improve or sustain the condition of roadways in a state of good repair while minimizing the life-cycle cost.

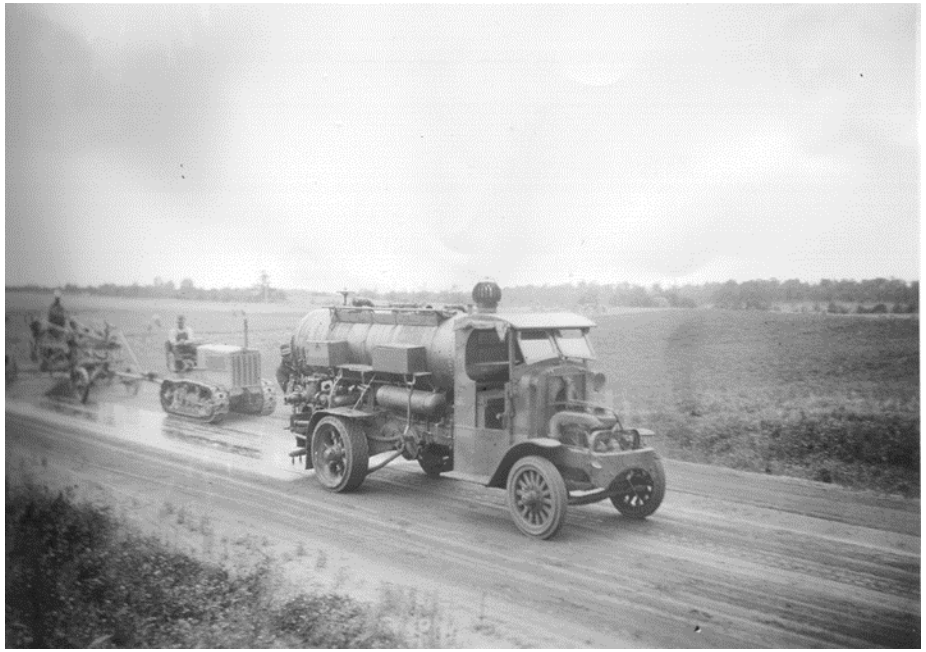
Pavement preservation programs include:

1. Improved pavement performance
2. Higher customer satisfaction
3. Increased cost effectiveness
4. Increased safety

- History of pavement preservation methods used in Minnesota historically between 1930 and the early 1990s.
- Showcase studies that OMRR and MnROAD have done that have increased pavement preservation.
- Update on NRRA Pavement Preservation Efforts

Early Beginnings – 1920s-1940s

Initial maintenance techniques - Light bituminous surface treatments



TH18 (169)
Elk River to Zimmerman Construction

Development of Techniques

- 1960s-1970s: Crack sealing and slurry seals.
- 1980s-1990s: Chip seals and overlays.

MnDOT/MnROAD Work in Microsurfacing

- 5 MnROAD maintenance projects helped demonstrate advancements in traditional and flexible micro surfacing. Began in 1999 with two demonstrations on the mainline and continued in 2003 & 2006 with more research at MnROAD.
- In 2003, different crack-repair techniques prior to micro surfacing treatment. 12 test sections (ML) received crack resealing, leveling of cupped transverse cracks, filling of rutted wheel paths, and control treatments. Two-lift crack repairs provided the longest effect on ride.
- In 2006 treated four LVR test sections with PG 48-34 micro surfacing to provide a mix rigid enough for rut filling but also flexible enough to inhibit low temperature cracking. Results led to a 2012 micro surfacing project with Kraton that used high polymer modified emulsion on an interstate test section. Use of softer -34°C base asphalt enhanced the performance of micro surfacing in colder northern-climate states.

MnDOT/MnROAD Work in Microsurfacing

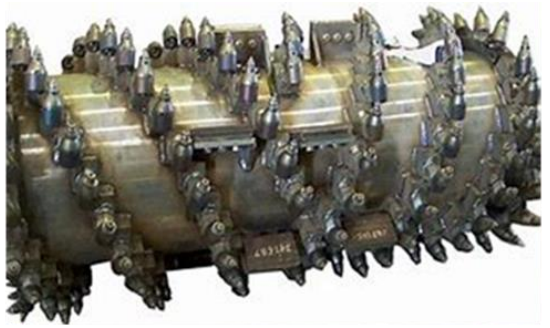
Results from 2003 Study on MnROAD Mainline

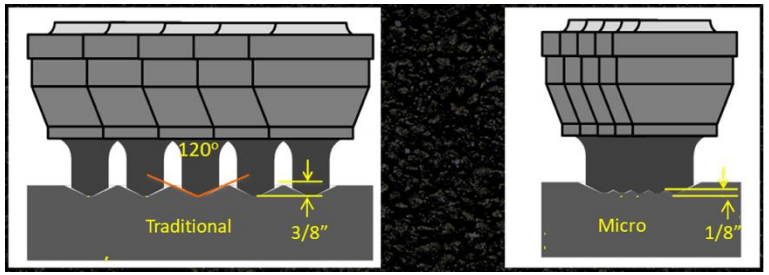
Cell #	Reseal cracks	Transverse Crack Repair[b]	MiniMac Slurry Seal / Micro-Surfacing	
		Both Lanes	Passing Lane (#) Layers	Driving Lane (#) Layers
1	Yes	Crack Reseal Only		
2	Yes		MiniMac (1)	MiniMac (2)
3	No	Control Cell – No Maintenance Work Performed		
4	Yes	Mastic	Micro (2)	Micro (2)
14	Yes	Mastic	MiniMac (2)	MiniMac (2)
15	Yes	MiniMac	Micro (1) over MiniMac (1)	Micro (1) over MiniMac (1)
16	Yes	Mastic		
17	No	Control Cell – No Maintenance Work Performed		
18	Yes	Mastic	Micro (1)	Micro (2)
19	Yes		Micro (1)	Micro (1)
20[a]	Yes		Micro (1)	Micro (1)
21	Yes		Micro (1)	Micro (2)
22	Yes		Micro (1)	Micro (1)
23[a]	Yes	Crack Reseal Only		

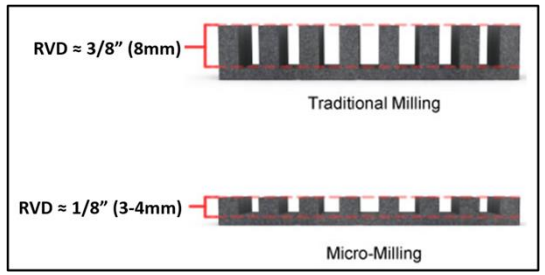
Cell #	Ride					Cracks leveled ?	Surface Course / (#) of Layers
	IRI Before		IRI After		% improve-ment		
	m/km	in/mi	m/km	in/mi			
1	2.07	129.4	1.99	124.4	4.0%	no	Crack Reseal Only
2	2.26	141.3	0.99	61.9	128.3%	no	MiniMac (2)
3	2.37	148.1	2.19	136.9	8.2%	Control Cell – no activity	
4	3.95	246.9	1.96	122.5	101.5%	mastic	Micro (2)
14	2.64	165.0	1.34	83.8	97.0%	mastic	MiniMac (2)
15	3.06	191.3	2.67	166.9	14.6%	slurry	Micro (1) over MiniMac (1)
16	3.44	215.0	2.65	165.6	29.8%	mastic	none
17	2.75	171.9	3.68	230.0	- 25.3%	Control Cell – no activity	
18	2.43	151.9	1.77	110.6	37.3%	mastic	Micro (2)
19	2.78	173.8	2.02	126.3	37.6%	no	Micro (1)
20	1.17	73.1	1.01	63.1	15.8%	no	Micro (1)
21	1.25	78.1	1.04	65.0	20.2%	no	Micro (2)
22	1.45	90.6	1.39	86.9	4.3%	no	Micro (1)
23	1.70	106.3	2.95	184.4	- 42.4%	no	Crack Reseal Only

MnDOT Work with Combination Treatments

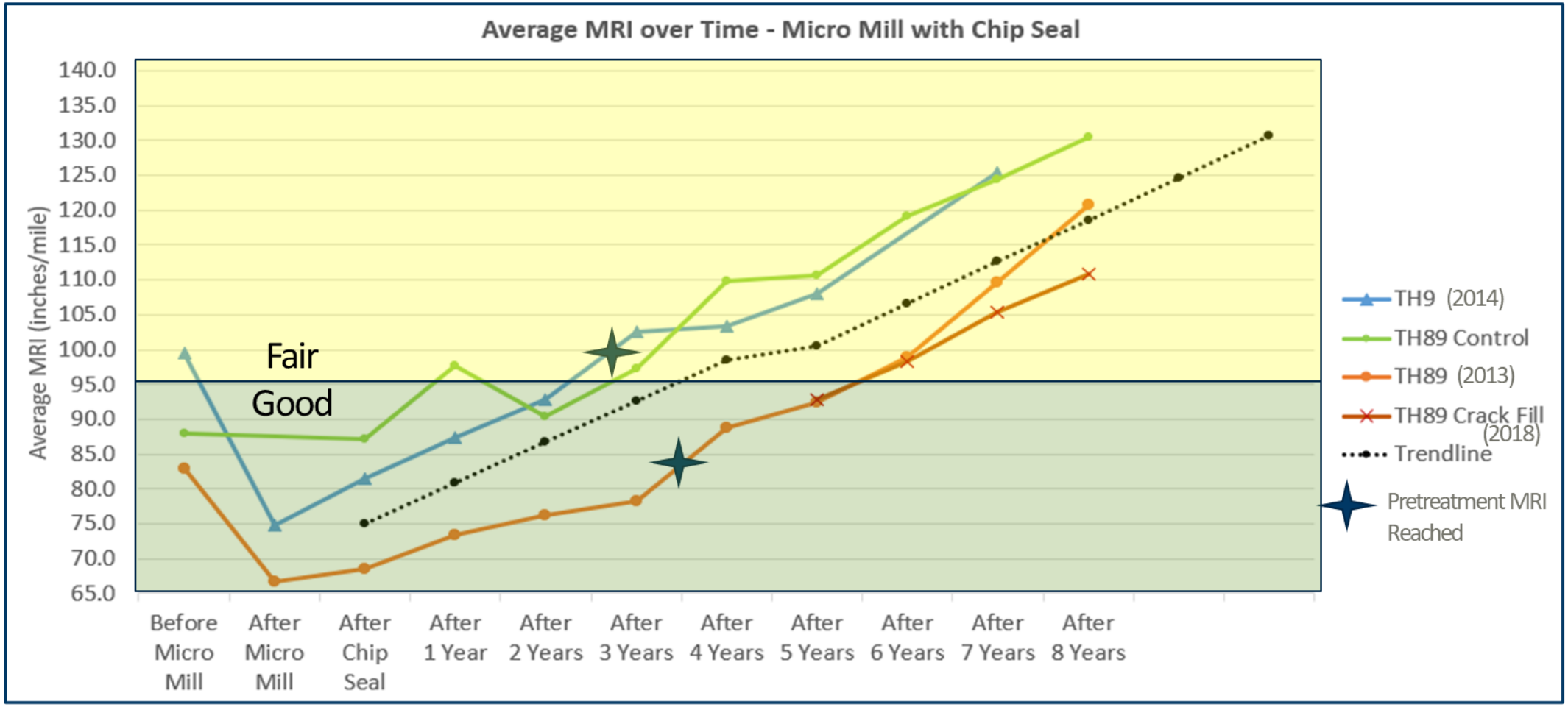
- **What is Pavement Micro Milling?**
  - Teeth spaced 0.200 inch (≈ 3/16”)
    - (About three times the teeth on a traditional milling drum)
- **Lower Ridge to Valley Depth – RVD**
  - RVD is the height difference between the lowest and highest points of the milled surface.
  - RVD characterizes a milled surface.
- **Important when placing thin surface treatments.**



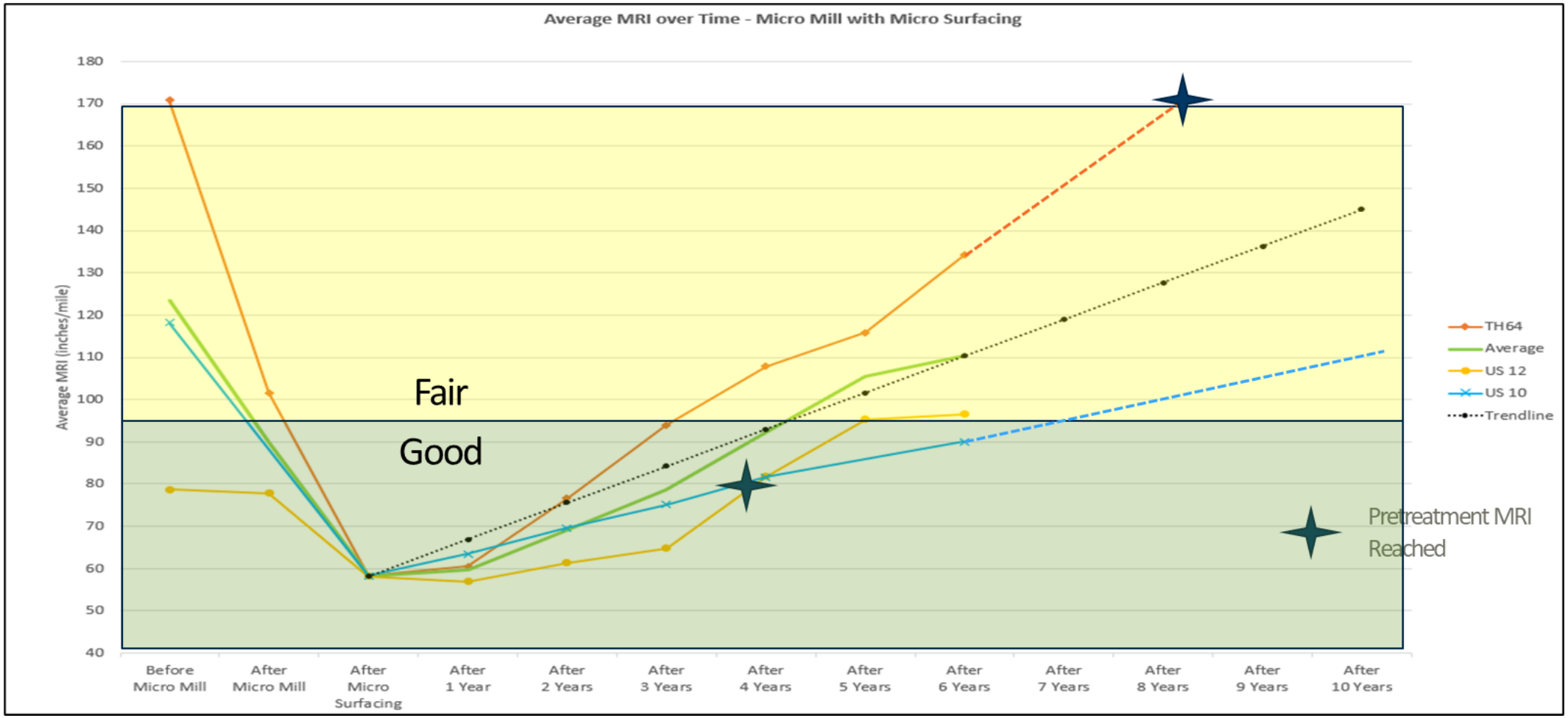




MnDOT Work with Combination Treatments



MnDOT Work with Combination Treatments



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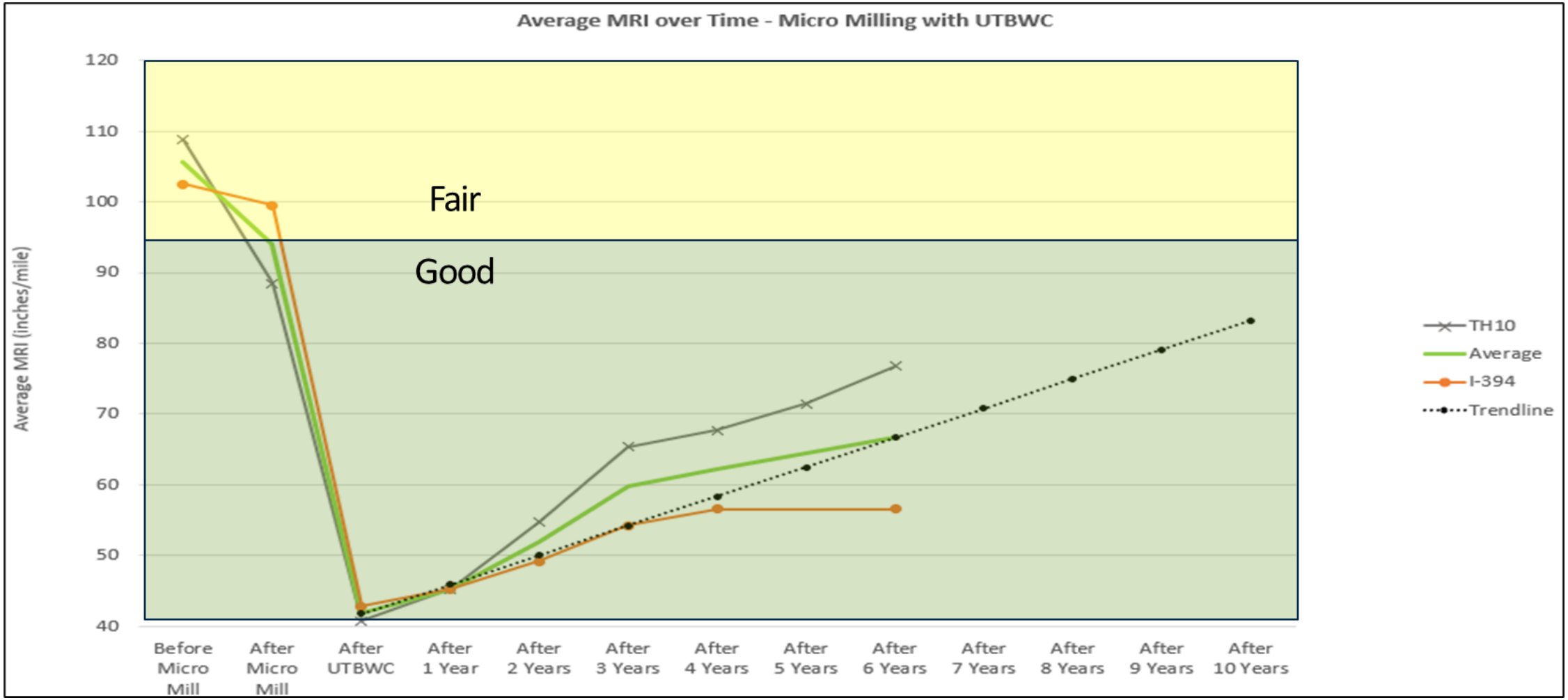
MnDOT Work with Combination Treatments



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MnDOT Work with Combination Treatments

2022 Cost Comparison of Micro Milling with Thin Surface Treatments									
Treatment	Treatment Cost		Micromilling Cost		Total Cost		Treatment Life	Annualized Treatment Cost	
	Lane Mile	Square Yard	Lane Mile	Square Yard	Lane Mile	Square Yard		Lane Mile	Square Yard
Chip Seal	$ 13,800	$ 1.96	$ 13,600	$ 1.93	$ 27,400	$ 3.89	3.5	$ 7,829	$ 1.11
Micro-surfacing	$ 26,350	$ 3.74	$ 13,600	$ 1.93	$ 39,950	$ 5.67	10	$ 3,995	$ 0.57
UTBWC	$ 46,500	$ 6.61	$ 13,600	$ 1.93	$ 60,100	$ 8.54	12	$ 5,008	$ 0.71

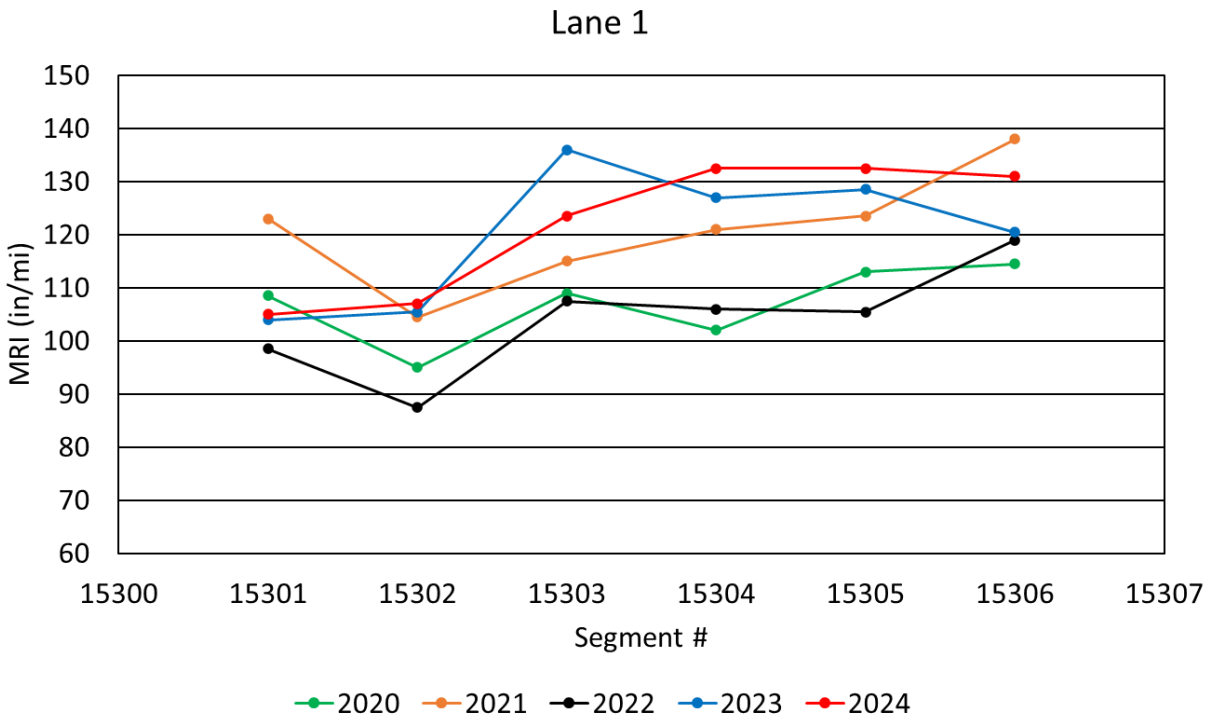
- **Improved Ride Quality**:
  - Immediate improvement of 20-30% in measured Mean Roughness Index (MRI) when micro milling is combined with chip sealing.
  - Significant improvement in ride quality observed with micro milling and micro-surfacing treatments on certain road projects.
  - For Ultra-Thin Bonded Wear Course (UTBWC) treatments, micro milling improved ride quality from "Fair" to "Very Good" range.
- **Extended Pavement Life**:
  - Micro milling with chip seal extends pavement service life by 3-4 years.
  - Micro-surfacing treatments, expected pavement service life extension is around 8-10 years.
  - UTBWC treatments with micro milling projected to last 12 or more years before reaching pretreatment ride quality.
  - ***UTBWC + micro milling – star performer. Has the highest initial cost, but it is the most cost effective.***

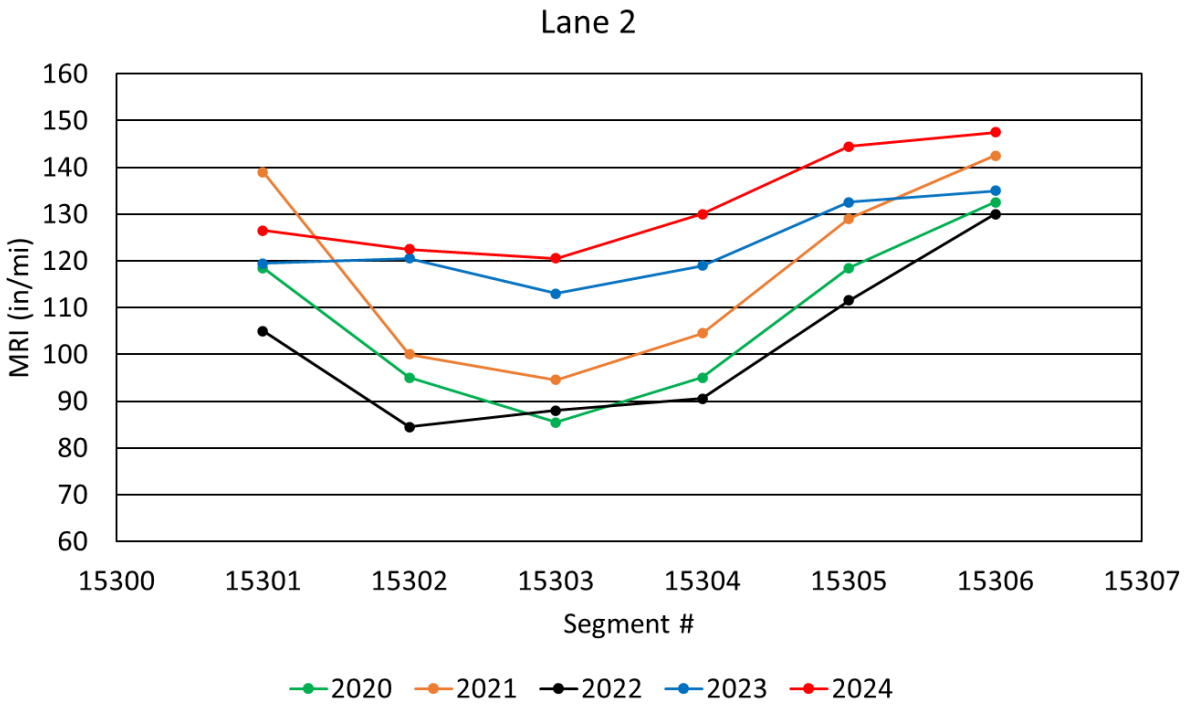
MnDOT Work: Micro Milling with Slurry Seal

CSAH28 Micro Milling with Slurry Seal:

- In spring of 2021 MnDOT developed a special $1.5M Maintenance Innovation Fund to implement innovative preventive maintenance activities or treatments.
- CSAH28 Pavement was slated for a 3” mill and overlay.
- It is a low traffic volume, two-lane rural roadway.
- Last surfaced in 2010? with micro-surfacing treatment.
- Heard ND had placed a slurry seal using micro milled RAP millings.
- A 5-mile-long segment of CSAH28 was selected for application of this treatment.
- RAP millings hauled to a nearby pit.
- Sampled obtained for mix design (2 weeks).
- Crushed and screened to size type II or III aggregate for slurry seal.

Micro Milling with Slurry Seal: Pathway Van Results





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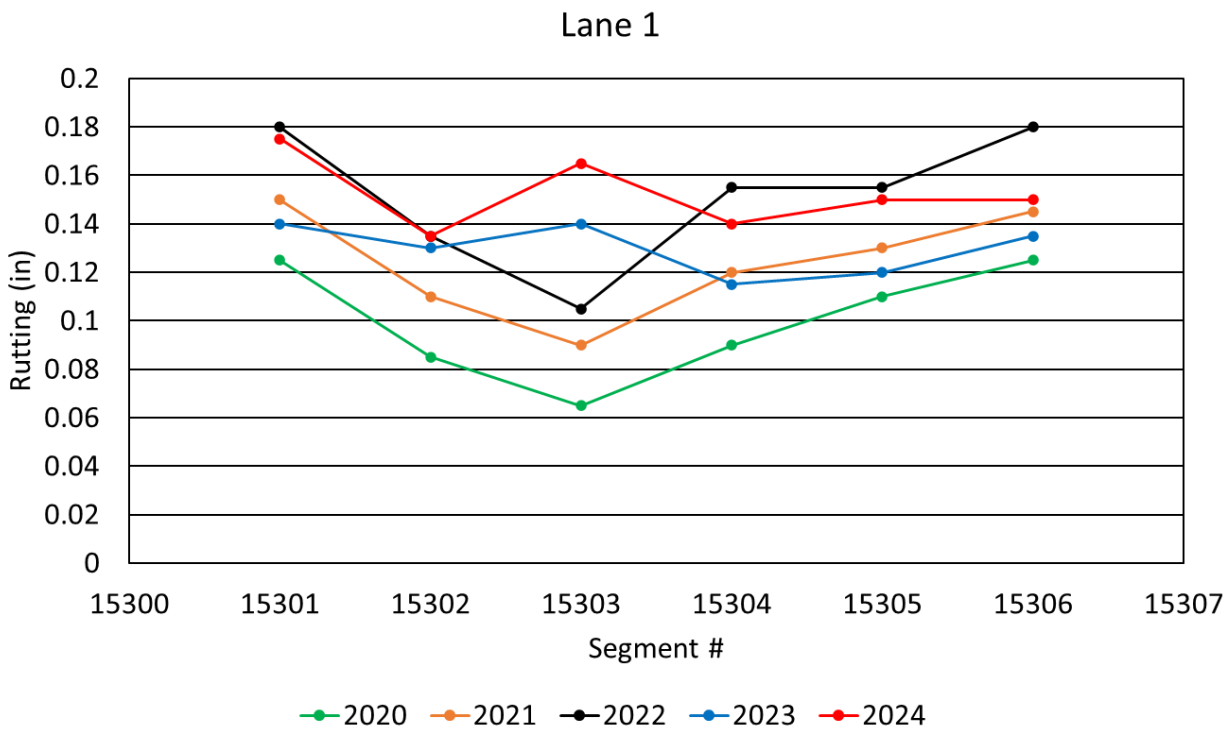
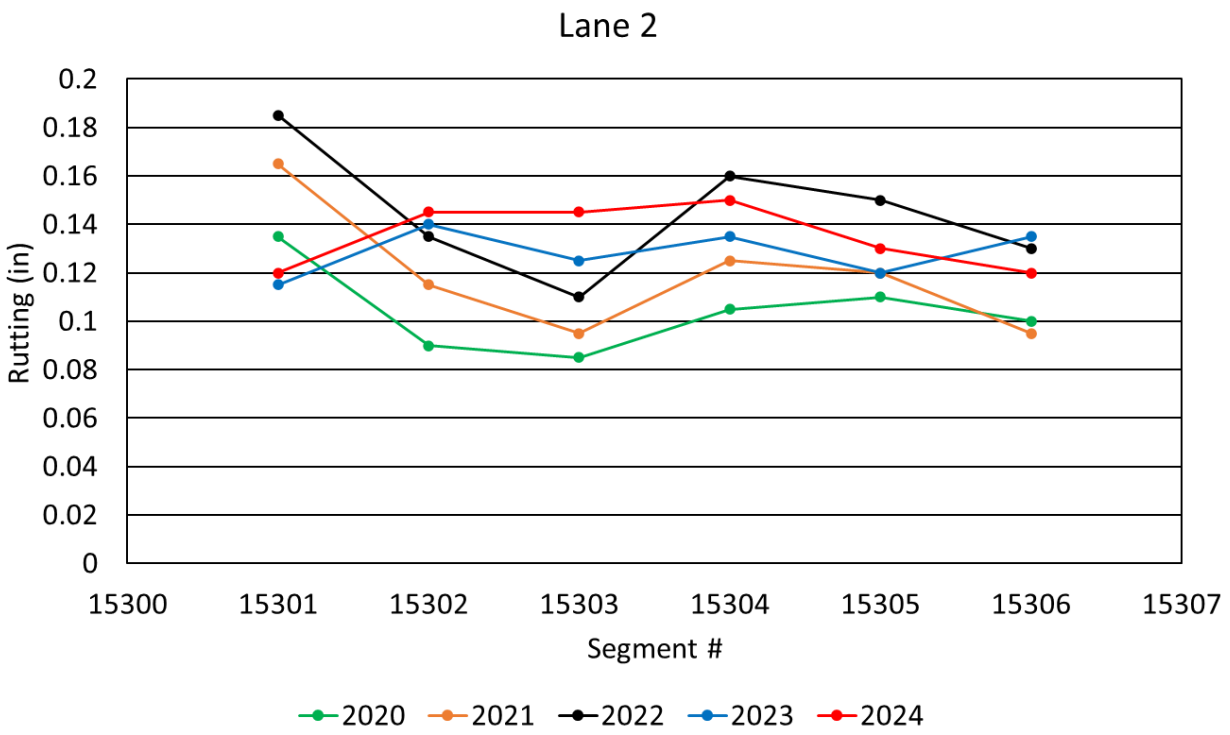
Micro Milling with Slurry Seal: Pathway Van Results





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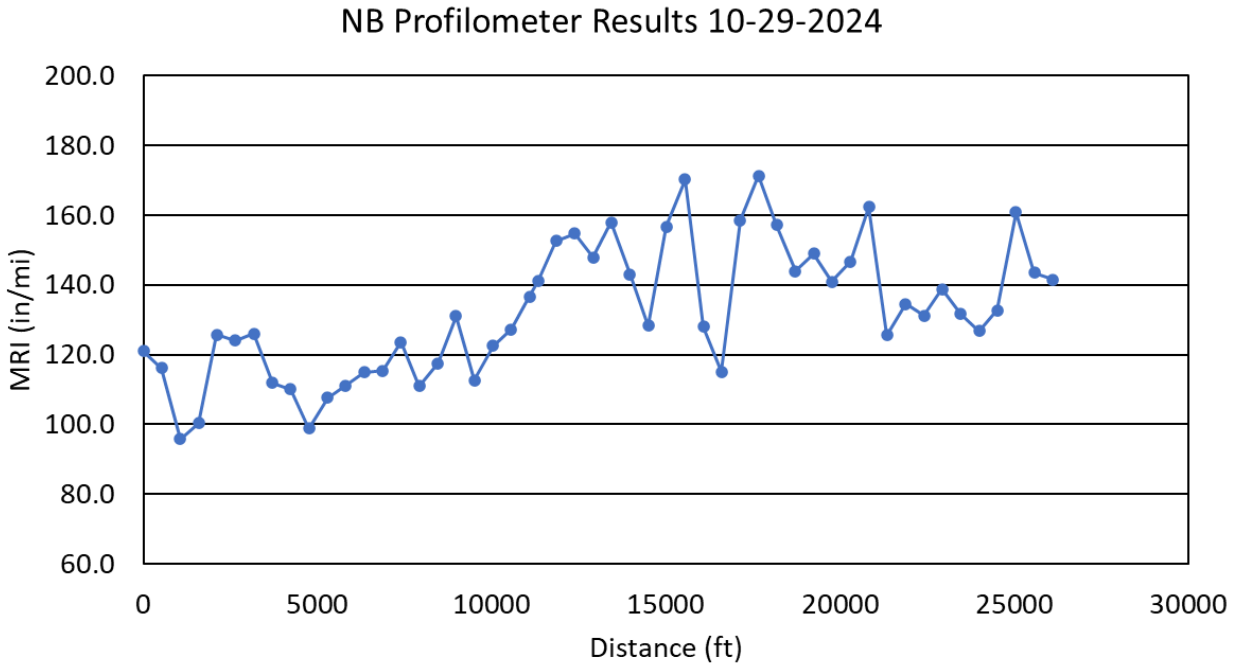
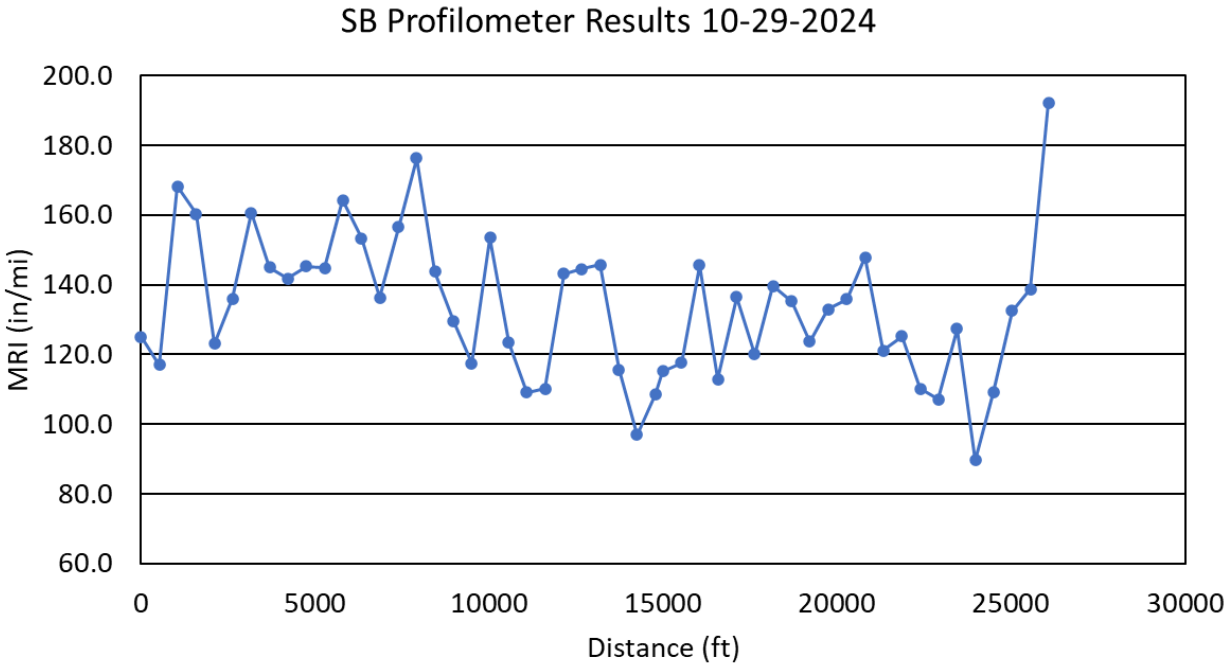
Micro Milling with Slurry Seal: Profilometer Results

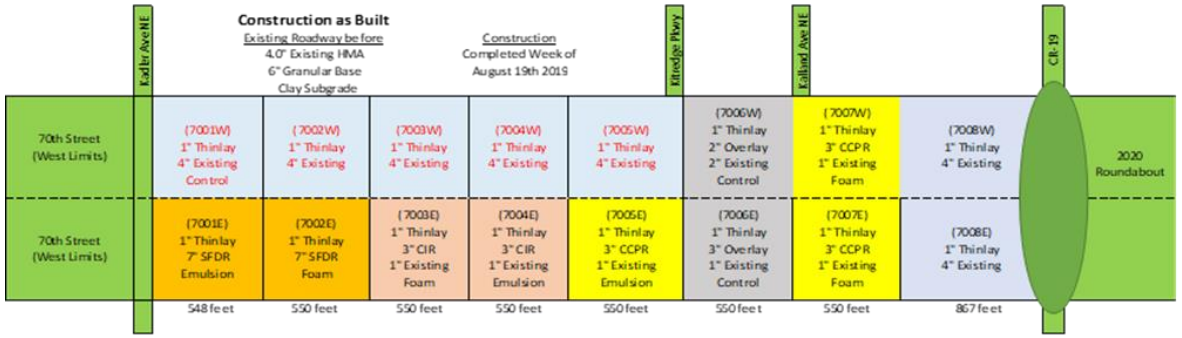


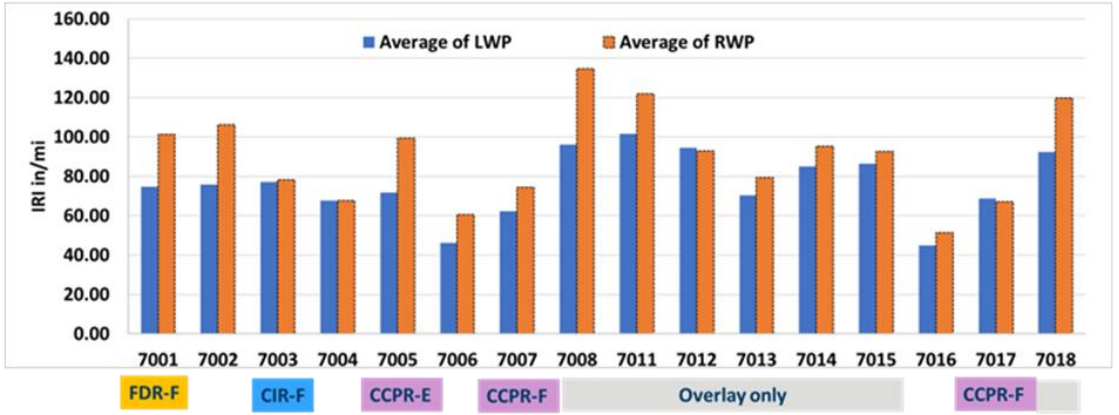


MnDOT/MnROAD Work

70th Street – PG 2 Efforts:

- 2019 Construction (Thinlays over)
  - Control (no other work)
  - SFDR (foam-emulsion)
  - CIR (foam-emulsion)
  - CCPR (foam-emulsion)
  - 2 Regular Mill/Fills
- 2 Year Observations
  - Ride (IRI)
    - 2019 IRI over 300 in/mi
    - 2021 IRI 60-100 in/mi
  - Reflective Cracking
    - Difference in controls and recycled sections cracking
  - Rutting – not an issue





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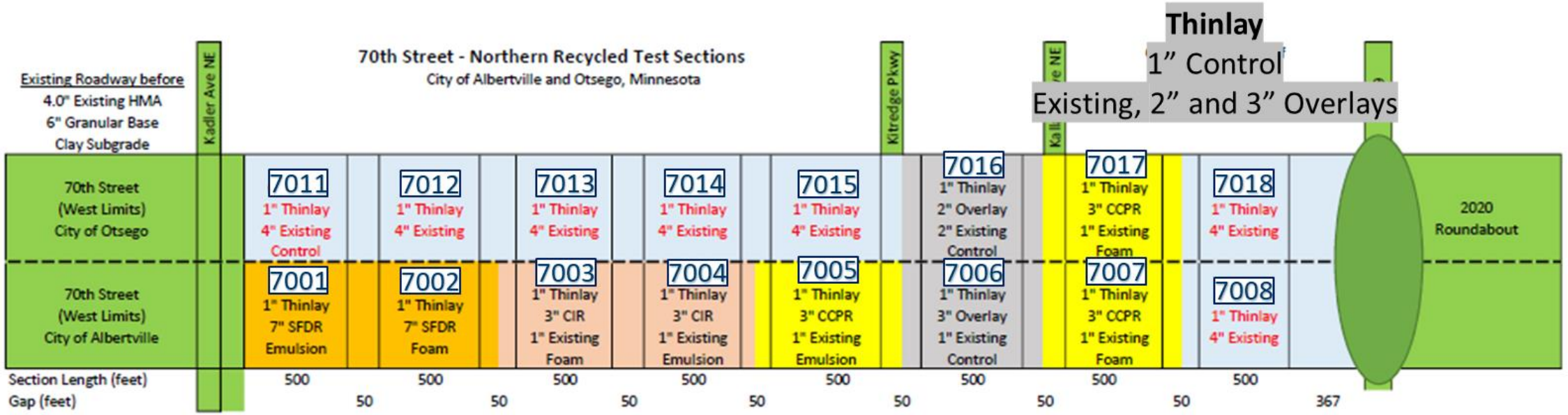
Pavement Preservation Northern Recycling

70th Street As Built (1/10 mile)



Stabilized Full Depth Reclamation
Emulsion + Foam with Control

Cold In-place Recycling
Foam + Emulsion with Control

Cold Central Plant Recycling
Emulsion + Foam with Control

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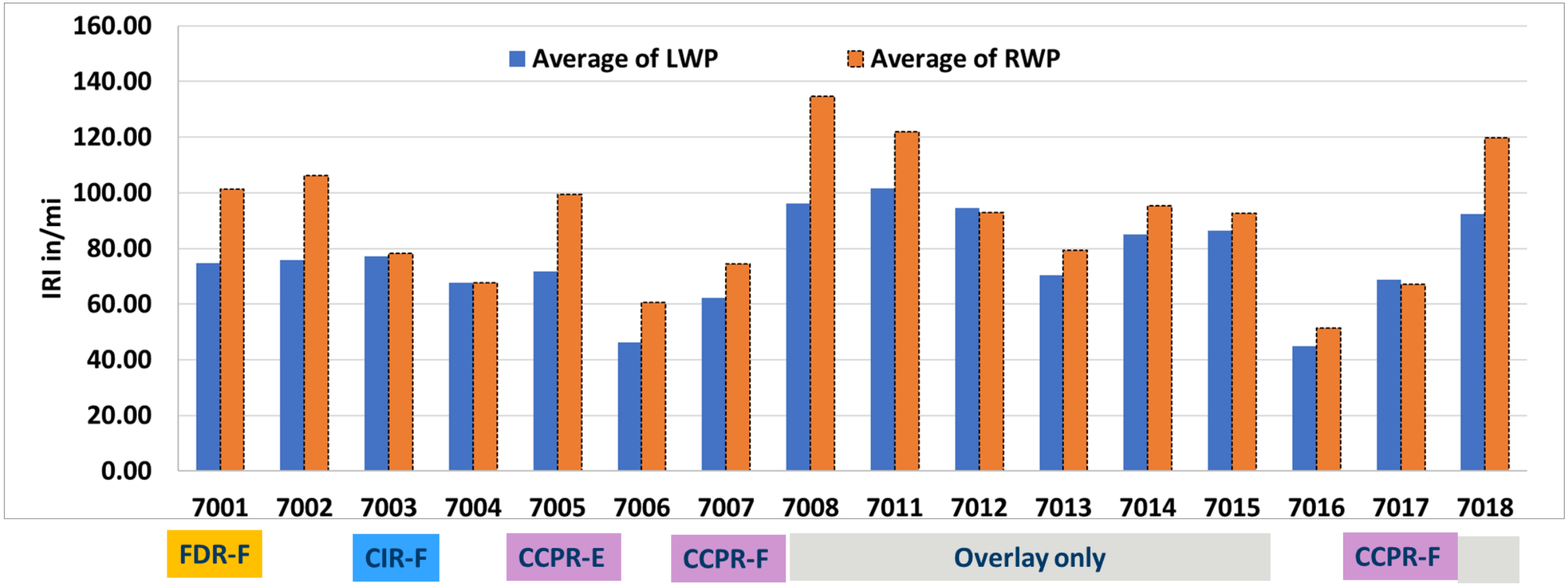
Ride in September 2023



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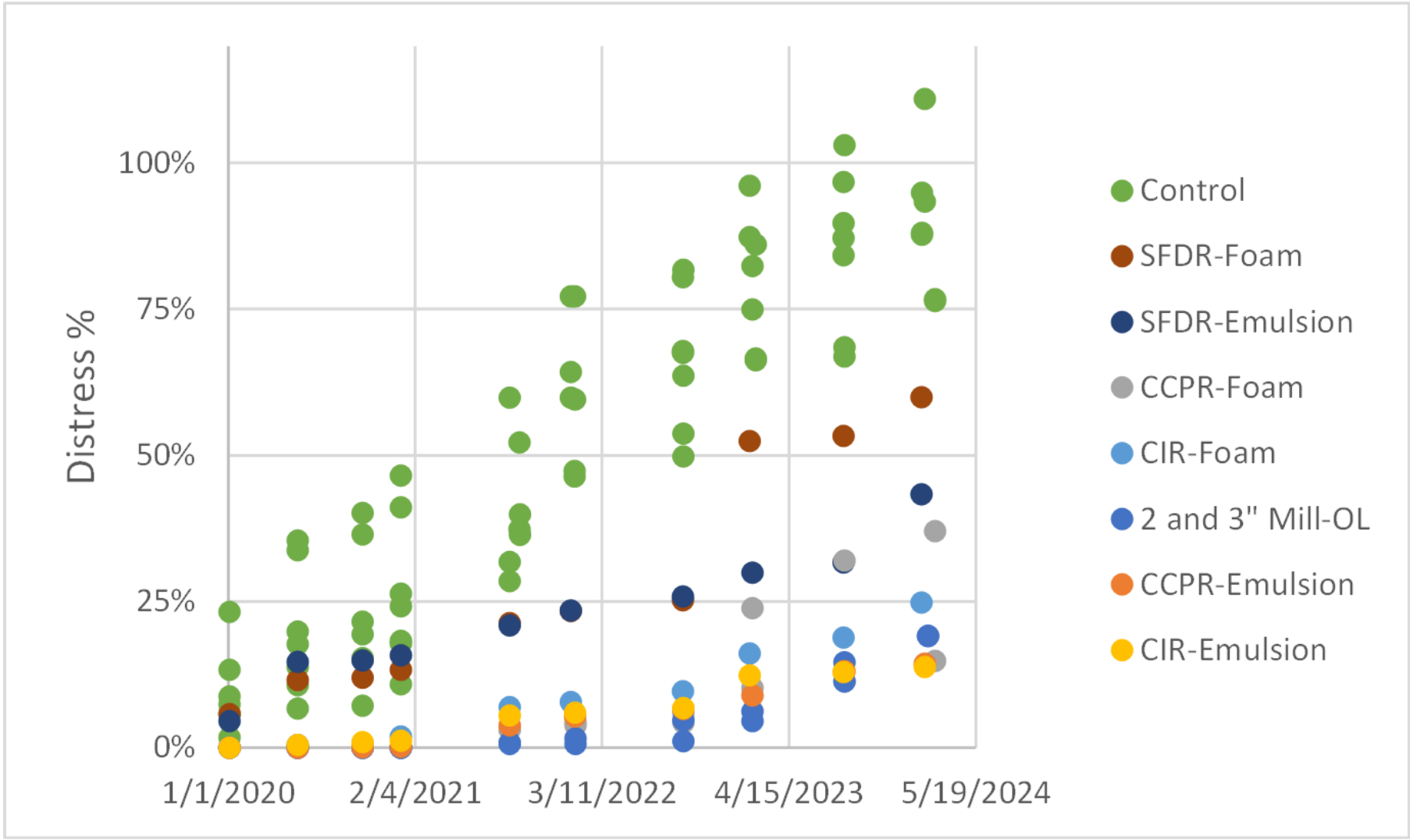
Total Returning Cracking in September 2023



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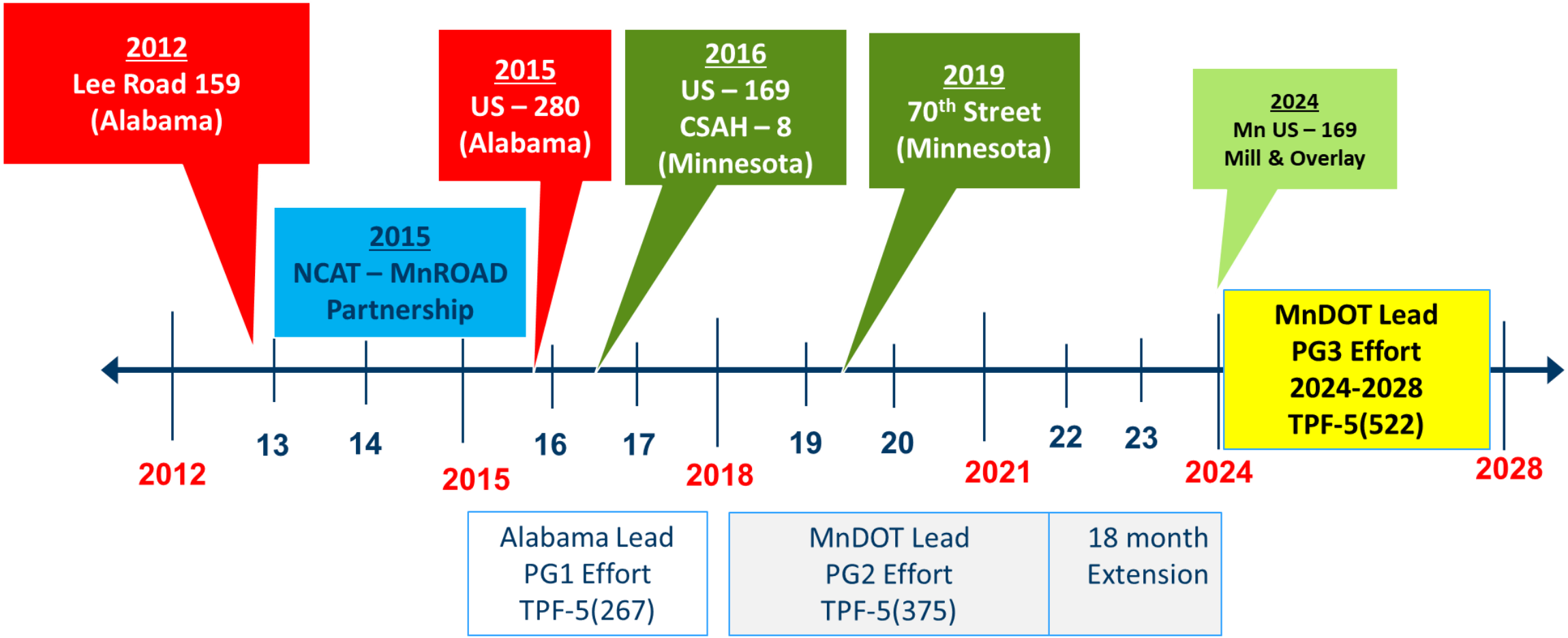
MnDOT Efforts Leading to PG3

MnDOT/NCAT Preservation Group Studies:

- **NCAT - Lee Road 159**
- **TPF-5(267) PG1 -** *Accelerated Performance Testing for the NCAT Pavement Test Track (2015-2018).*
  - **Alabama – Lee Road 159 & US 280**
  - **Minnesota – Mille Lacs County CSAH 8 & US 169**
- **TPF-5(375) PG2 -** *National Partnership to Determine the Life Extending Benefits of Pavement Preservation Techniques (2018-2023).*
  - **70th Street NE – Rehabilitation & Thinlay Treatments**
- **TPF-5(522) PG3 –** *National Partnership to Improve the Quality of Pavement Preservation Treatment Construction and Data Collection Practices (2024-2028).*

MnDOT Efforts Leading to PG3



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PG3 - Pavement Preservation Future

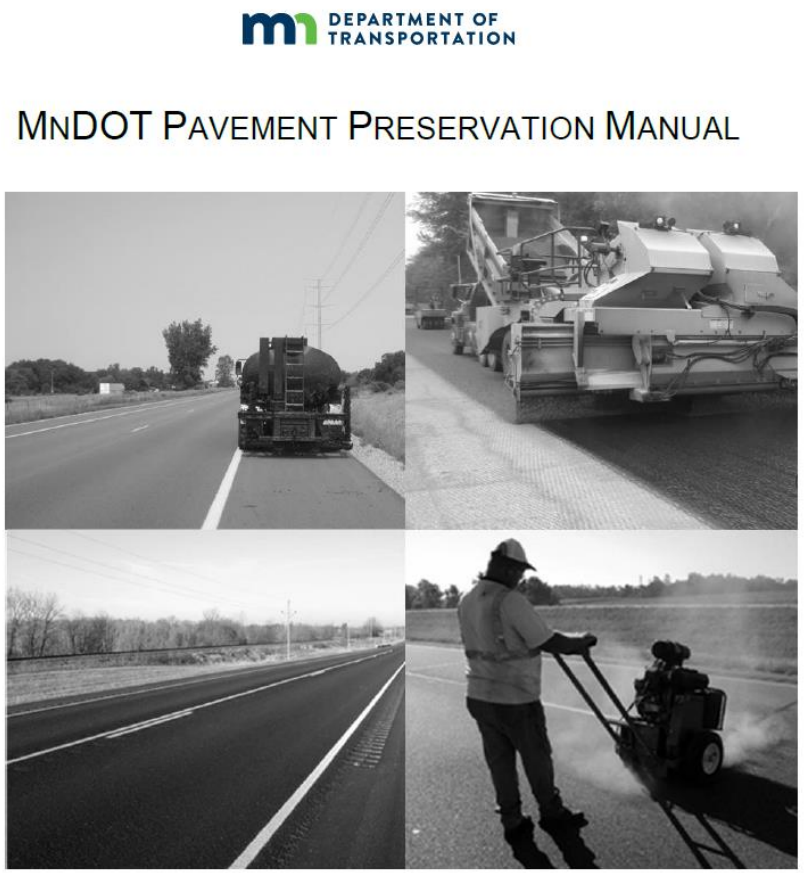
Improving the Quality of Pavement Preservation Treatment Construction and Data Collection Practices

Phase III (Jan 2024-Dec 2028)

- TPF-5 (522) – PG3
- Focus on State Implementation of Pavement Preservation Treatments
  - Specification review
  - Preconstruction technical support & training (virtual)
  - Construction support (on-site)
  - Performance monitoring
- Contracts with both NCPP and NCAT to support the effort
- Technical Advisory Panel Led (Agencies)
  - Guidance from NCPP, NCAT, FP2, FHWA
  - Sponsor meetings
    - Two in-person/year
    - Two virtual/year
- Pooled Fund Started January 2024 extending to December 2028

Future Efforts – Interactive Web Version of MnDOT Pavement Preservation Manual

- OMRR Preventative Maintenance Group members started working with MnDOT Training Services in Spring 2024 on transforming the Pavement Preservation Manual into an interactive web guide.
- Using the Concrete Office's developed CPR Guide as a model to build the Pavement Preservation interactive web guide. (https://dot.state.mn.us/materials/concretedocs/concretepavementrepairguide/ConcreteGuide/story.html)
- Will lead to future development of interactive case study chapters that deal with real world examples.



Future Efforts – Interactive Web Version of MnDOT Pavement Preservation Manual

5.501 Longitudinal Joint Treatment Options

After longitudinal joint deterioration has begun on a road, the available treatment options will depend on the severity of the deterioration. This section will highlight possible options based on severity level.

- Hot Pour Crack Sealant
- Mastic
- Micro Surfacing
- Bituminous Hand Patching
- Blow Patching
- Milling and Patching

5.501 Longitudinal Joint Treatment Options

Hot Pour Crack Sealant

If a longitudinal joint is experiencing low severity cracking, the best option is to use a hot pour crack sealant as detailed in Chapter 4. Hot pour sealant may be used to treat medium severity longitudinal joint cracking, provided there are not potholes or excessive raveling of the joint.

For longitudinal cracks, MnDOT does not specify routing and sealing, only clean and seal (Crack Filling) is specified for longitudinal cracks. As with any crack treatment method, ensuring the crack is clean and dry prior to applying sealant is paramount.

5.501 Longitudinal Joint Treatment Options

Mastic

This entails applying mastic to a deteriorated joint. This treatment is often used with medium to high severity longitudinal joint deterioration. Milling out extremely spalled areas prior to treatment will yield the best results. This treatment yields relatively low production and requires at least one lane closure. Re-striping the lane markings will likely be required, as will re-cutting of rumble strips, if applicable.

Step 1: Badly deteriorated longitudinal joint prior to mastic treatment.

Step 2: Mastic heater used to pour material into the joint.

Step 3: Box Screed used to evenly spread mastic along the longitudinal joint.

Step 4: Finished Appearance.

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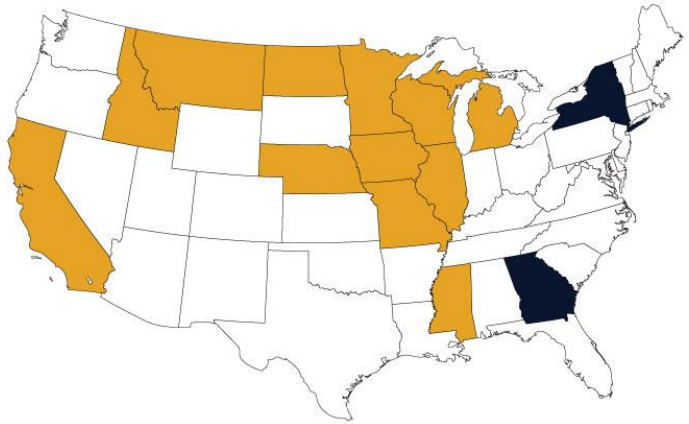
Future Efforts – Interactive Web Version of MnDOT Pavement Preservation Manual

- Currently in draft stages.
- Will end up as an interactive web based semi-decision tree for pavement preservation treatment selection, guidance on equipment use, estimated costs, and performance benefits.
- Project is always looking to document real world projects for use as case studies, be it through video during construction, and collection of information.

NRRA – National Road Research Alliance Research Update



14 States
FHWA
Mn LRRB

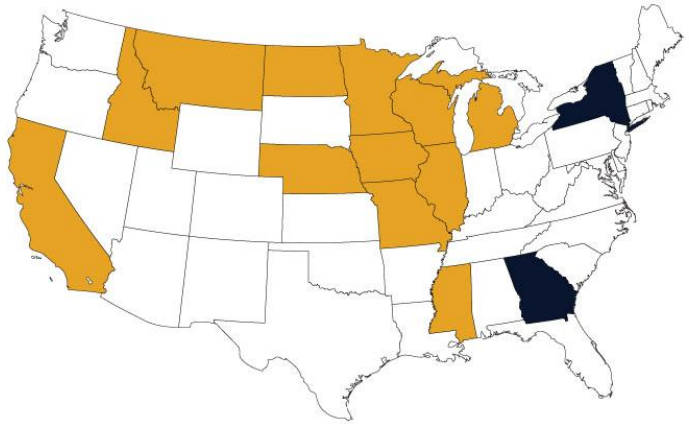
The National Road Research Alliance (NRRA) is a Pooled Fund with the goal to improve the future sustainability of our roads through research and a commitment to cooperative implementation. The alliance sponsors research at the MnROAD test track, one of the most sophisticated cold-weather pavement facilities in existence, as well as other locations.

Phase I – January 2020 to January 2021 (TPF-5(341))

Phase II – February 2021 to Present (TPF-5(466))

Joel Ulring, PE
MnDOT Pavement Preservation Engineer

NRRA – National Road Research Alliance Research Update



Five Teams:

- Flexible (Bituminous Pavements)
- Geotechnical
- Intelligent Construction Technologies
- Preventive Maintenance
- Rigid (PCC Pavements)

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Joel Ulring, PE
MnDOT Pavement Preservation Engineer

NRRA – National Road Research Alliance Research Update

Active Projects – Flexible and PM Teams

- *Pavement Preservation for Lightly Surface Roadways*
- *Bio-Materials Maintenance Treatments*
- *Spray on Rejuvenator Synthesis*
- *Service Life Enhancement of Substrates Overlaid with Thin Overlays*
- *Reclamation and Recycling Techniques to Achieve Perpetual Pavement Characteristics*

NRRA – National Road Research Alliance Research Update

New Projects – 2023 Call for Research

- *Hot Rubber Seal Coating to Survive Wet and Freeze Environments*
- *Materials-Based Methods to Improve Rumble Strip Durability*
- *Use of Recycled Materials in Pavement Preservation*
- *Validation of Loose Mix Aging Procedures for Cracking Resistant Evaluation in Balanced Mix Design – Phase IIA*
- *Standardization of SIP Calculation for Hamburg Wheel Tracking Test*

NRRA – National Road Research Alliance Research Update

New Projects – 2023 Call for Research

- *Field Validation of Using Warm Mix Asphalt at Reduced Production Temperatures for Balanced Mix Design*
- *Continued Monitoring of Original I-94 Westbound Asphalt Overlay Sections and Use of Cracking and Performance Data MRCC Project*
- *Mix Rejuvenator Test Sections – Phase III*
- *Cold Asphalt Recycling Technologies using Rejuvenating Asphalt Emulsion*

NRRA – National Road Research Alliance Research Update

Hot Rubber Seal Coating to Survive Wet and Freeze Environments

PI: Zhanping You, Distinguished Professor, Michigan Technological University
TL: Joseph Podolsky, MnDOT

- Demonstrate the use of Hot Rubber Seal Coating of bituminous pavements to:
  - Reduce premature stripping
  - Extend the life of bituminous pavements
- Includes both lab and filed testing (Michigan)

NRRA – National Road Research Alliance Research Update

Materials-Based Methods to Improve Rumble Strip Durability

PI(s): Dan Swiertz, PE – Asphalt Materials, Inc., Katie DeCarlo, PhD – Heritage Research Group, Signe Reichelt, PE – Behnke Materials Engineering

TL: Tyler Hunt, Michigan DOT

- Review agency CLRS specifications, construction methods and studies
- Obtain field cores of newly constructed pavements to document “as-constructed” durability effects of CLRS relative to no rumble strip sections
- Evaluate the effects of VRAM on rumble strip durability
- Evaluate the effects of RPE on rumble strip durability
- Document effects of VRAM and RPE on rumble strip functionality
- Produce “Best Practices” guidelines for use of supplementary materials to improve CLRS durability

NRRA – National Road Research Alliance Research Update

Use of Recycled Materials in Pavement Preservation

PI(s): Adriana Vargas – NCAT, Fabricio Leiva – Clemson University
TL: Emil Bautista MnDOT

- Evaluate the feasibility of using recycled materials in chip seals and slurry surfacing treatments
- Estimate the economic and environmental benefits of using recycled materials in the preservation treatments studied
- Develop a plan for future implementation

NRRA – National Road Research Alliance Research Update

Validation of Loose Mix Aging Procedures for Cracking Resistance Evaluation in Balanced Mix Design (Phase IIA)

PI(s): Fan Yin – NCAT, Raquel Moraes – NCAT, Chen Chen – NCAT, Jo E. Sias & Eshan Dave – UNH, Fujie Zhou – Texas A&M

TL: Joseph Podolsky – MnDOT

- Address to major gaps associated with implementing loose mix aging in BMD
- Enhance the current practice for evaluating cracking resistance of asphalt mixtures in BMD
- Successful implementation will improve performance and life of asphalt pavements

NRRA – National Road Research Alliance Research Update

Standardization of SIP Calculation for Hamburg Wheel Tracking Test

PI(s): Fan Yin & Chen Chen – NCAT,
TL: Dan Kopacz – WI DOT

- SIP – Stripping Inflection Point
- Equipment manufacturers and asphalt practioners have developed different methods of calculating SIP over the years
- Objective is to develop analysis software to standardize and automate the calculation of SIP
- Software will be compatible with different HWTT testing equipment

NRRA – National Road Research Alliance Research Update

Field Validation of Using Warm Mix Asphalt (WMA) at Reduced Production Temperatures for Balanced Mix Design (BMD)

PI(s): Fan Yin & Nathan Moore – NCAT
TL: Emil Bautista - MnDOT

- "Road Forward" initiative to achieve net zero carbon emissions by 2050
- Lab research (NAPA-NCAT case study) shows promise of lower-temperature WMA improves cracking resistance of asphalt mixes
- Field validate feasibility of WMA for BMD in two projects

NRRA – National Road Research Alliance Research Update

Continued Monitoring of Original I-94 Westbound Asphalt Overlay Sections and Use of Cracking and Performance Data MRCC Project

PI(s): Eshan Dave, Ph.D. - UNH
TL: Ashley Buss – Iowa DOT

- I-94 Westbound asphalt overlay test cells built under NRRA Phase I focused on PCC pavement rehab.
- Focused on assessing different volumetric approaches of designing asphalt mixtures and track their field density evolution over time
- Referred to as the NRRA Reflective Cracking Phase I

NRRA – National Road Research Alliance Research Update

Mix Rejuvenator Test Sections – Phase III

PI(s): Jo Sias – UNH
TL: Michael Vrtis - MnDOT

- In 2019 field test sections were constructed as part of a mill and overlay project using wear course asphalt mixes with 40% RAP that incorporated seven different recycling agent (RA) products
- To date, after three years, no significant changes in laboratory measured properties of field cores nor any substantial distresses been observed in the test sections
- Additional monitoring of the test sections and testing of field cores is needed to fully evaluate the effectiveness of the RA products over time compared to the control mixes

NRRA – National Road Research Alliance Research Update

Cold Asphalt Recycling Technologies using Rejuvenating Asphalt Emulsion

PI(s): Hassan Tabatabaee, Ph.D. – Cargill Bioindustrial, Dan Swiertz, P.E. – Bitumix Solutions
TL: Terry Beaudry – MnDOT

- Evaluate the benefit of using rejuvenating asphalt emulsions in the CIR and CCPR process in leu of existing stabilization options (e.g., foamed asphalt, engineered emulsion) using concepts of balanced mixture design
- Provide preliminary usage and design guidelines for rejuvenating asphalt emulsions used in CIR and CCPR processes
- Develop a “roadmap” for rapid implementation of a test section utilizing rejuvenating asphalt emulsion stabilization
- Outcome will be a better understanding of rejuvenating asphalt emulsions and mix properties that influence performance

NRRA – National Road Research Alliance Research Update

Road Research

National Road Research Alliance

Link: www.dot.state.mn.us/mnroad/nrra/index

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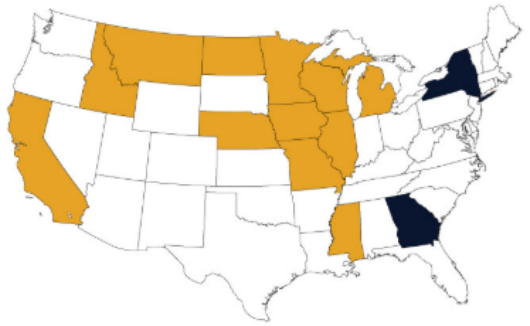
National Road Research Alliance

The National Road Research Alliance (NRRA) is a Pooled Fund with the goal to improve the future sustainability of our roads through research and a commitment to cooperative implementation. The alliance sponsors research at the MnROAD test track, one of the most sophisticated cold-weather pavement facilities in existence, as well as other locations.

The first phase of the NRRA is concluded in January 2021, but we moved forward with a Phase II to seamlessly begin in February 2021. In Phase II, our focus is narrowing to the two priorities of sustainability and application of intelligent construction technologies for all pavement projects.



Minnesota Asphalt Pavement Association

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THANK YOU!