



MnROAD
Safer, Smarter, Sustainable Pavements Through Innovative Research



National Center for
Asphalt Technology
NCAT
at AUBURN UNIVERSITY

NCAT/MnROAD Cracking Group Update

September 10, 2019

Michael Vrtis, Ph.D.

Cracking Group Experiments

NCAT Test Track

Top-down cracking



MnROAD

Low-temperature cracking

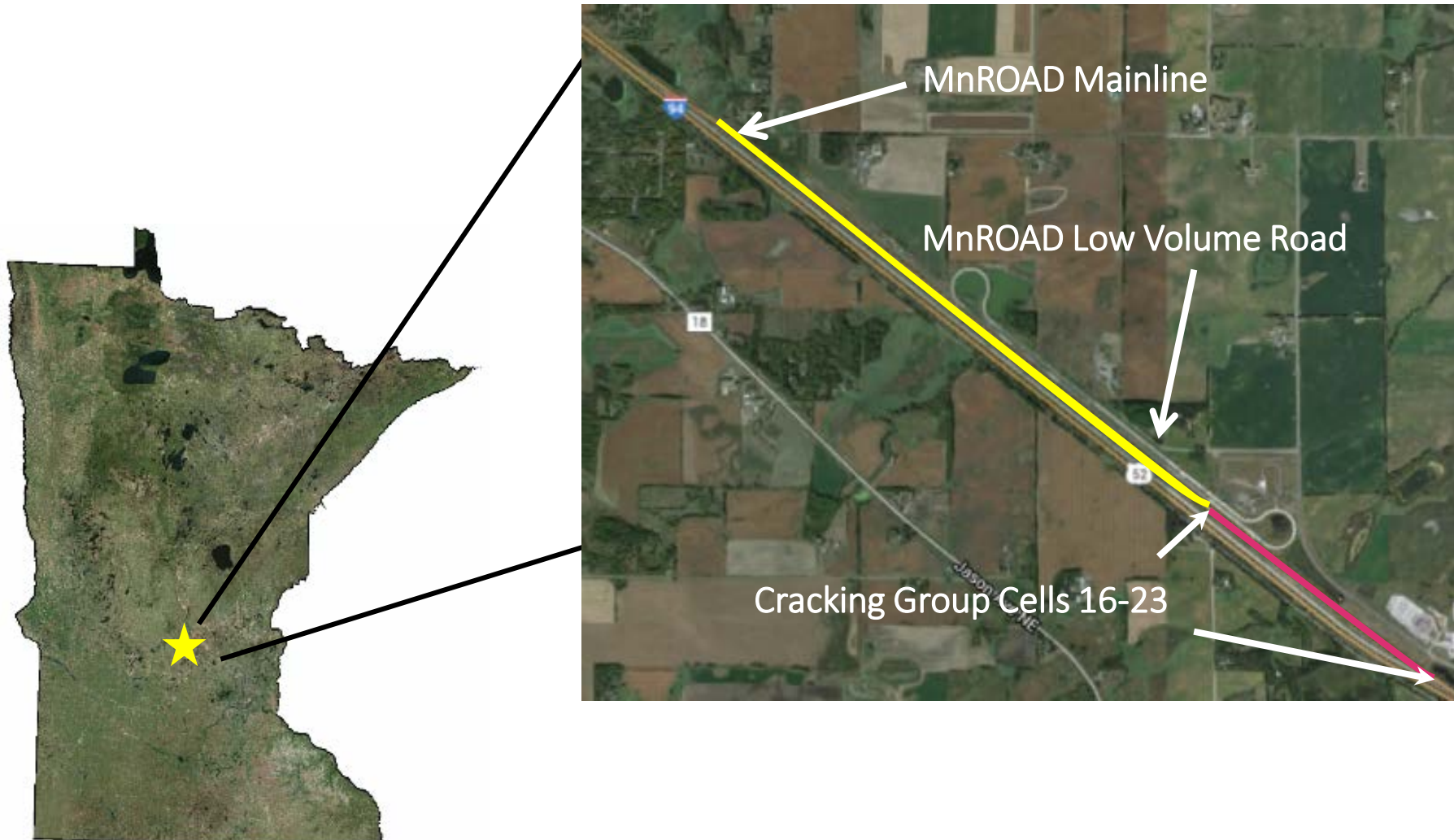


Outline

- Project Background
- Current Status
 - Ride
 - Cracking
 - FWD
 - Strain
- Future



MnROAD Site



MnROAD Cracking Group Cells



Cracking Group Experiment

- Primary objective
 - Correlate lab cracking tests to field performance
- Constraints
 - Short timeframe
 - Range of expected cracking
- Suite of lab cracking tests being performed by MnDOT and NCAT
- Identify the test(s) that best correlate with each type of field cracking



HMA Mixtures

- Mixtures selected to achieve range of low-temperature cracking (LTC) potential
 - Based on input from pooled-fund sponsor states
- Contractor selected, procured materials, submitted to NCAT
- NCAT performed mix designs
- Contractor produced/placed mixture

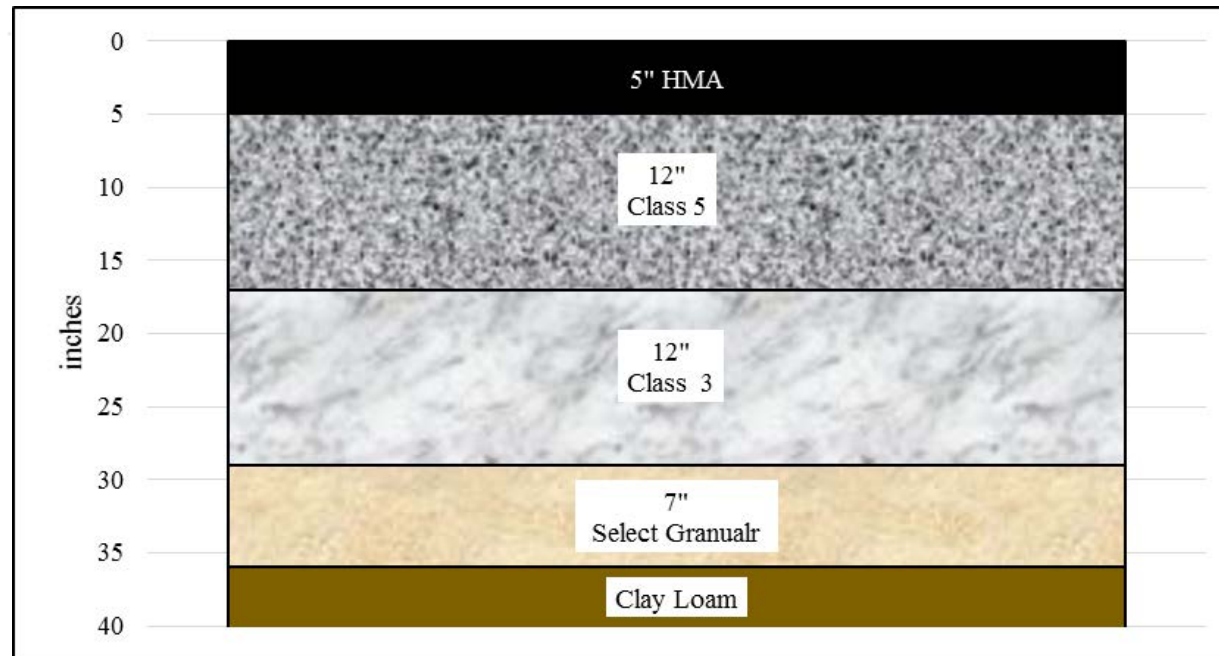
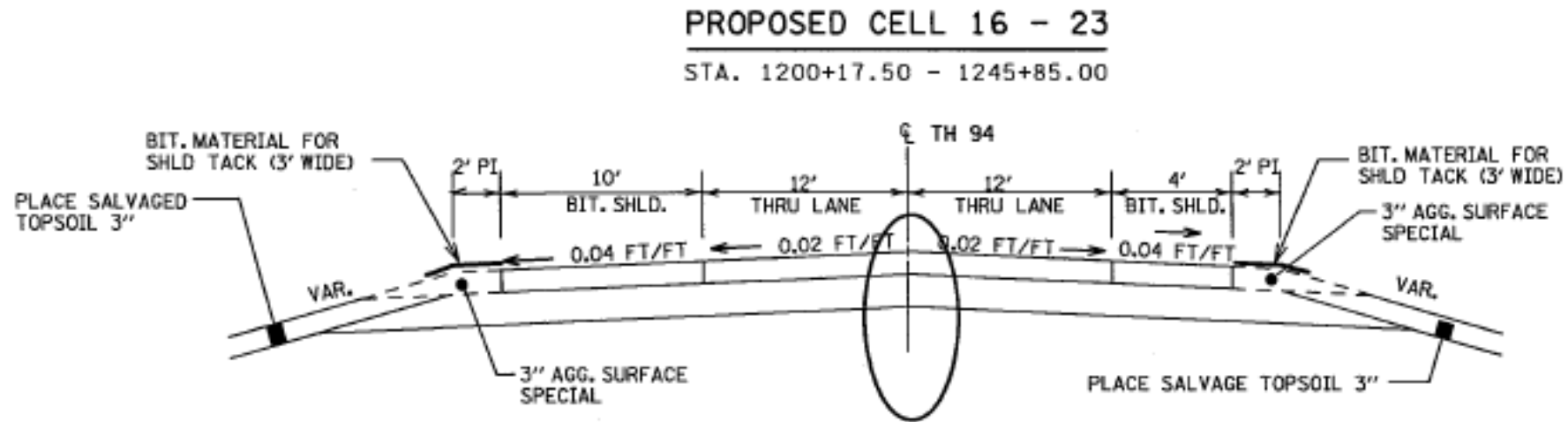


Pavement Design Inputs

- WB I-94 average daily traffic volume
 - ~30,000 vehicles
 - ~13% HC
- Flexible ESALs
 - ~800k per year (design lane)
 - ➔ Traffic level 5
- Soils:
 - USDA – Clay Loam, Loam
 - AASHTO – A-6
 - USCS – Lean Clay (CL)
- Expected life ~10 yrs



Constructed Section Typical



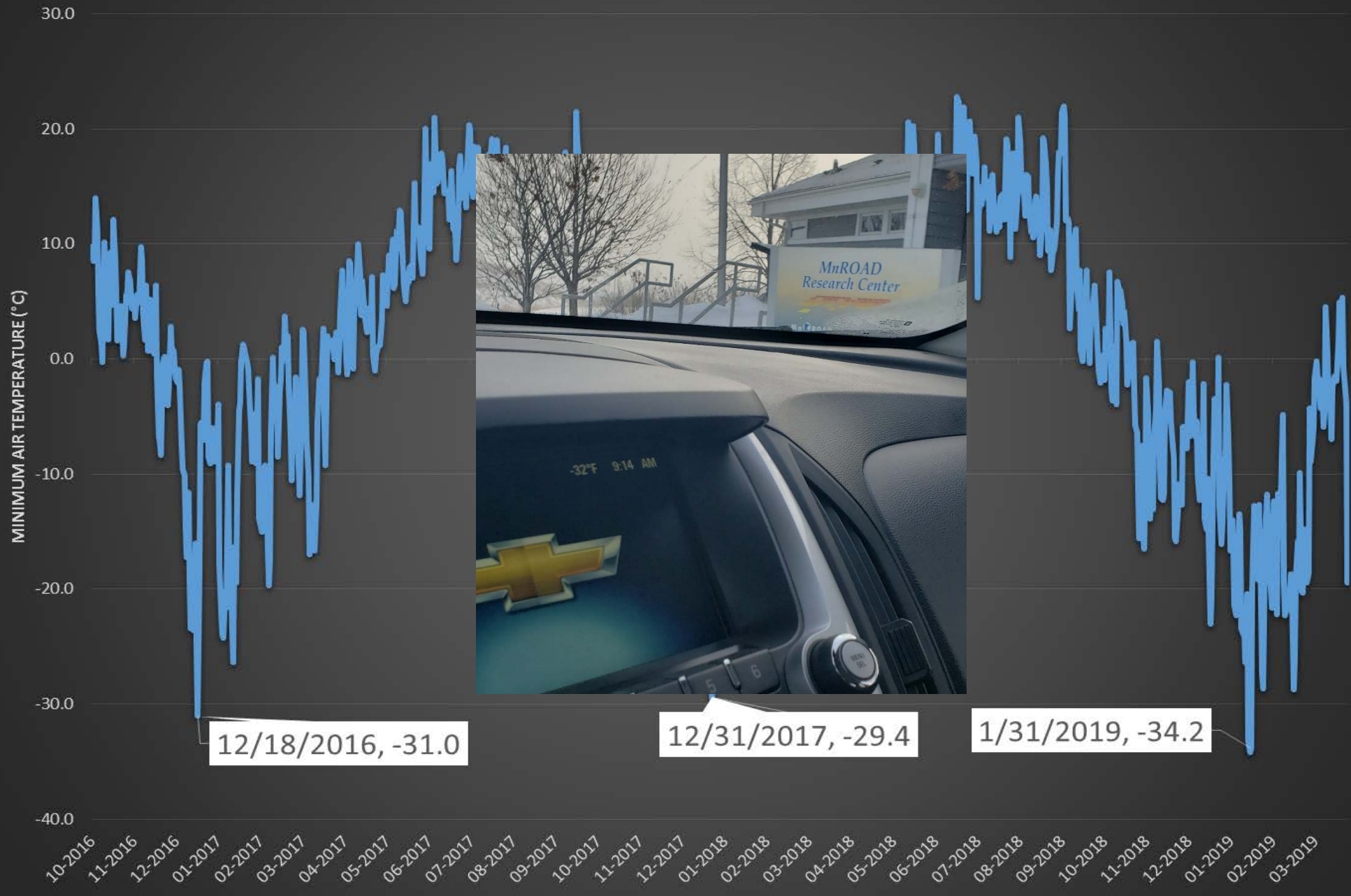
Mixture Overview

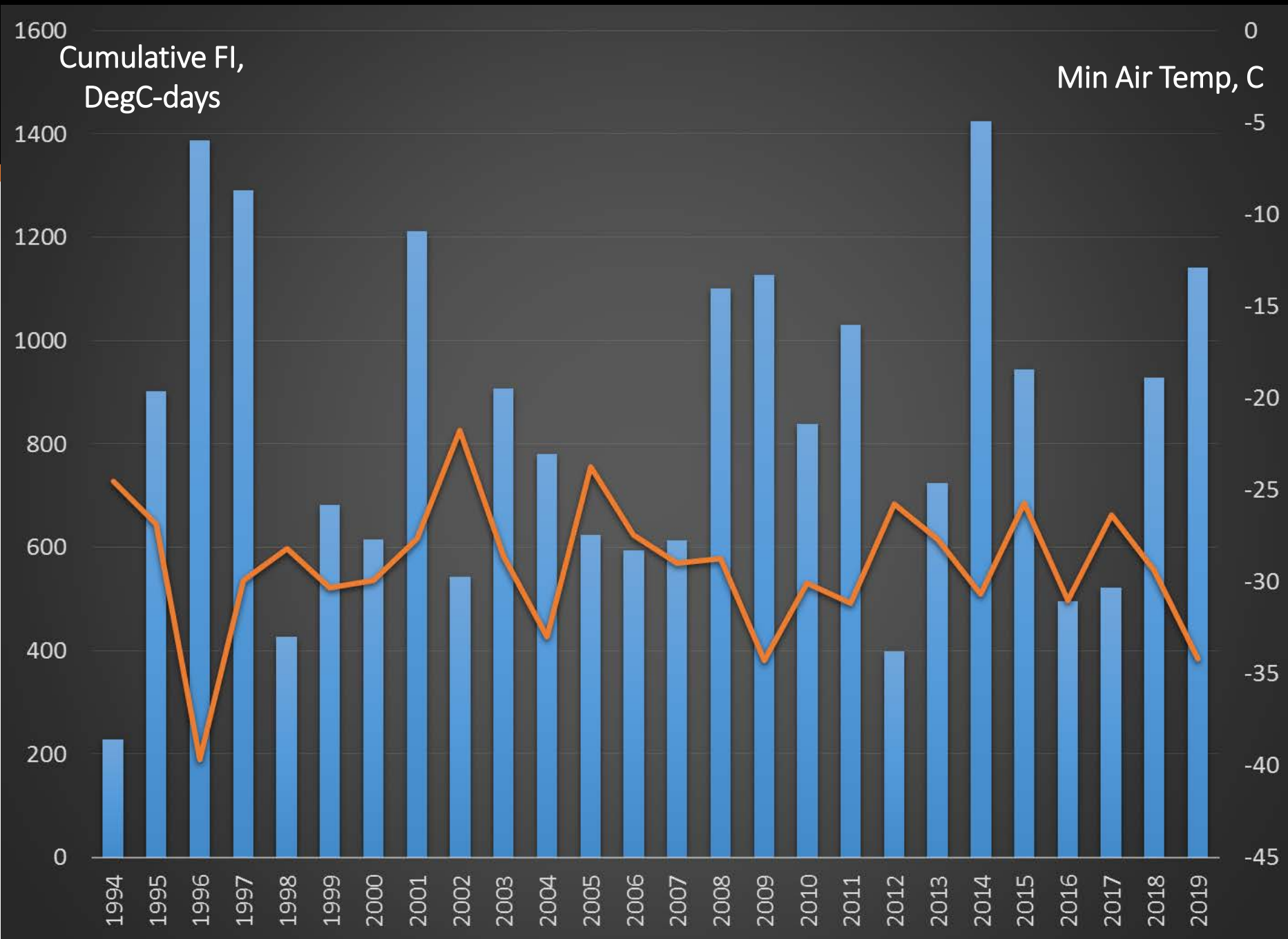
Cell	Key Mix Factors	Virgin PG	RAP Content	RAS Content
16	Moderate RAP + RAS	64S -22	20	5
17	Low RAP + RAS	64S -22	10	5
18	Moderate RAP	64S -22	20	0
19	Moderate RAP, extra AC	64S -22	20	0
20	High RAP, softer binder	52S -34	30	0
21	Moderate RAP, softer binder	58H -34	20	0
22	Limestone agg. and 9.5 mm NMA S	58H -34	20	0
23	Moderate RAP, Highly mod. Binder	64E -34	15	0

MnROAD CG Section Traffic

- Open to traffic - November 2, 2016
- MnROAD 2017 NRRA construction
 - No traffic from June 5 thru September 19, 2017
- ~3,300,000 ESALs
- Very limited distress through Fall 2018
- Cracking increased in early 2019

MINIMUM AIR TEMPERATURES / Oct-2016 through Mar-2019

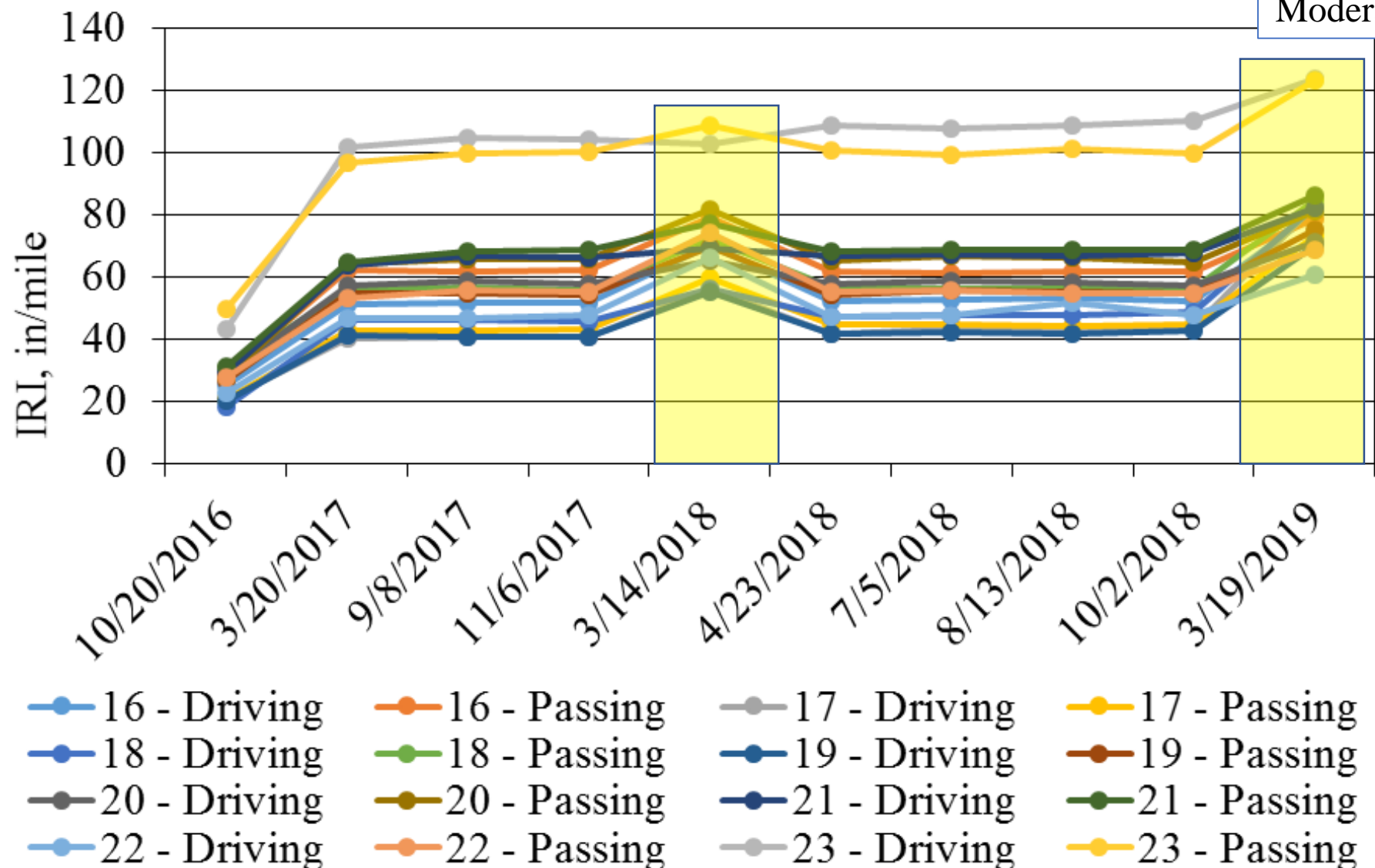




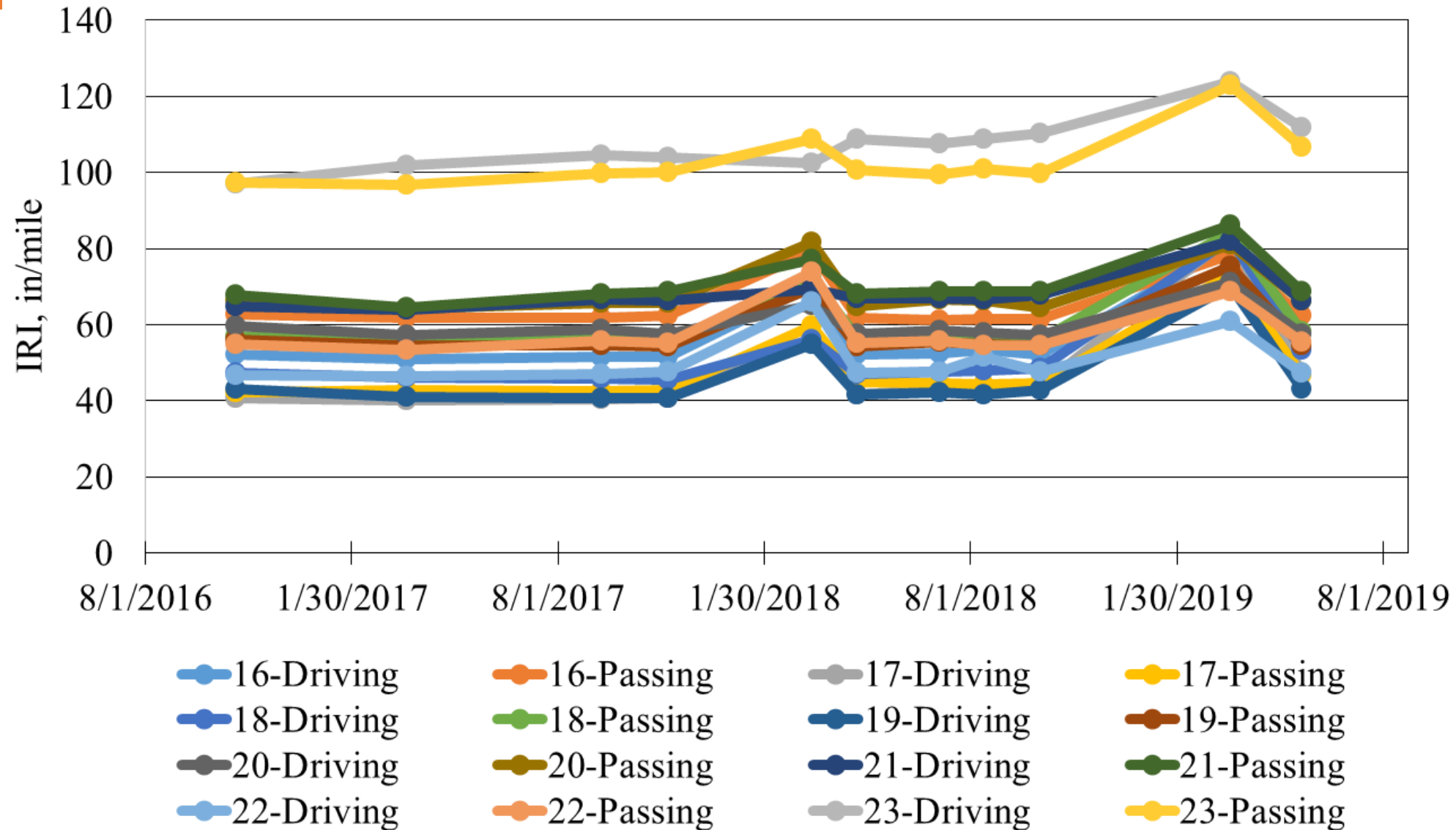
Performance - Ride

Cell 23

Moderate RAP, Highly mod. binder



Performance - Ride



Performance Summary

- Good ride performance
 - Good rutting performance
 - Cracking has greatly increased in early 2019
 - Cracking steady since April 2019
- Cracking
 - Separate cracking by type to determine cause
 - Load, construction, environment
 - Destructive forensics
 - Coring
 - Non-destructive forensics
 - FWD analysis
 - Consult available construction information
 - RDM, FWD, IC, IR, GPR, etc.
 - Consider whether these will spread
 - Pre-emptive measures?

Performance - Cracking

		Load Related		Construction Related		LTC
		Fatigue (ft ²)	Longitudinal Wheel Path (ft)	Center Line Joint (ft)	Shoulder Joint (ft)	Transverse* (ft)
23	Moderate RAP, Highly mod. binder	1458	334	500	500	43
22	Limestone and 9.5 mm NMA	229	258	500	500	50
21	Moderate RAP, softer binder	85	47	500	68	28
20	High RAP, softer binder	14	11	172	0	0
19	Moderate RAP, extra AC	17	35	464	437	61
18	Moderate RAP	363	87	500	500	35
17	Low RAP + RAS	673	79	490	500	70
16	Moderate RAP + RAS	57	119	400	450	58

* Transverse cracking greater than 4'

Performance - Cracking

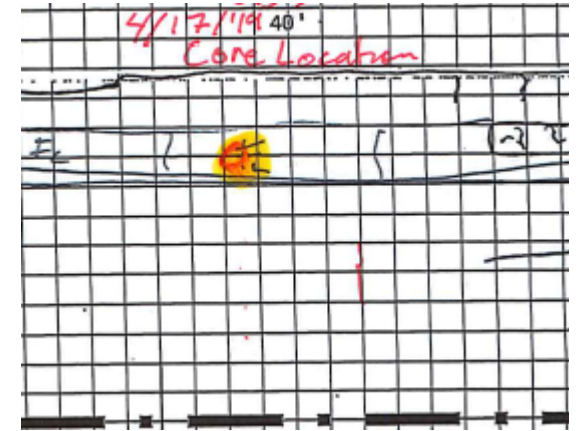
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* Transverse cracking greater than 4'

Performance – Cell 23

Moderate RAP, Highly mod. binder

- Largest amount of load related distress
- Delamination under surface lift (2/3 cores)
- Lower lift has no signs of distress in cores



Driving Lane



Performance - Cracking

		Load Related		Construction Related		LTC
		Fatigue (ft ²)	Longitudinal Wheel Path (ft)	Center Line Joint (ft)	Shoulder Joint (ft)	Transverse* (ft)
23	Moderate RAP, Highly mod. binder	1458	334	500	500	43
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17	Low RAP + RAS	673	79	490	500	70
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* Transverse cracking greater than 4'

Performance – Cell 17

Low RAP + RAS

- Largest amount of LTC and fa
- Delamination under surface l
- Lower lift has no signs of dist



Fatig

17-4

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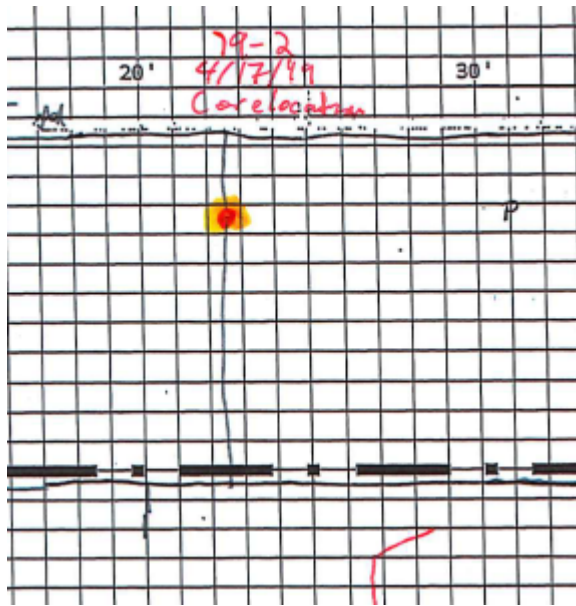
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Performance - Cracking

		Load Related		Construction Related		LTC
		Fatigue (ft ²)	Longitudinal Wheel Path (ft)	Center Line Joint (ft)	Shoulder Joint (ft)	Transverse* (ft)
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* Transverse cracking greater than 4'

- Some LTC
- Low fatigue



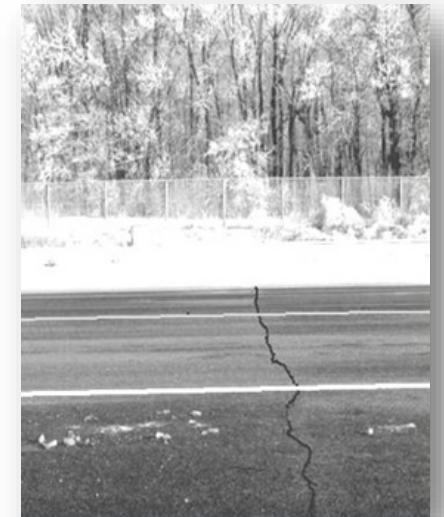
What to do?

		Load Related		Construction Related		LTC
		Fatigue (ft ²)	Longitudinal Monitor Path (ft)	Center Line Joint (ft)	Shoulder Joint (ft)	Wait for more...
23	Moderate RAP, Highly mod. binder	1458	334	500	500	43
22	Limestone and 9.5 mm NMA	229	258	500	500	50
21	Moderate RAP, softer binder	85	47	500	68	28
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* Transverse cracking greater than 4'

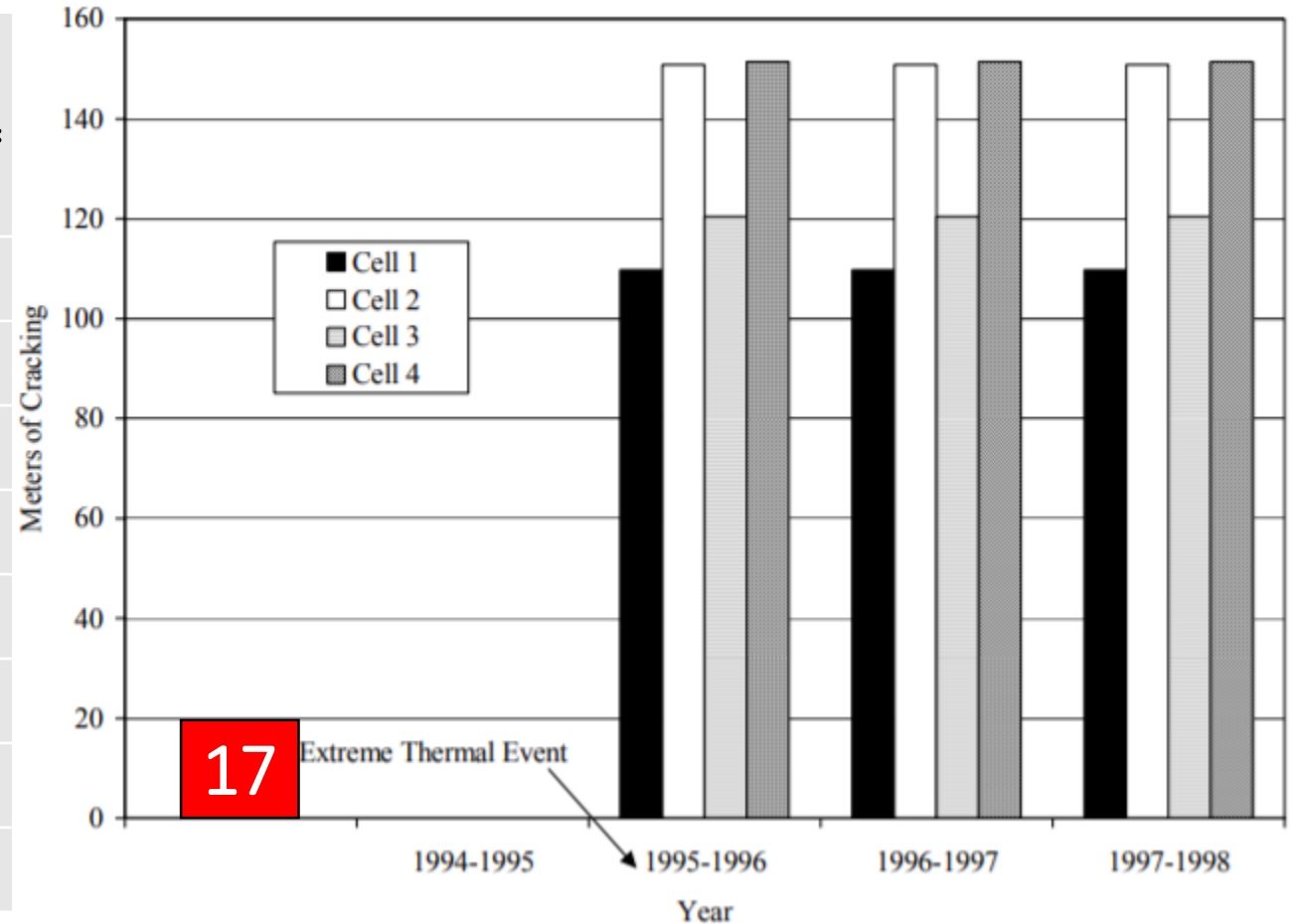
Performance - Cracking

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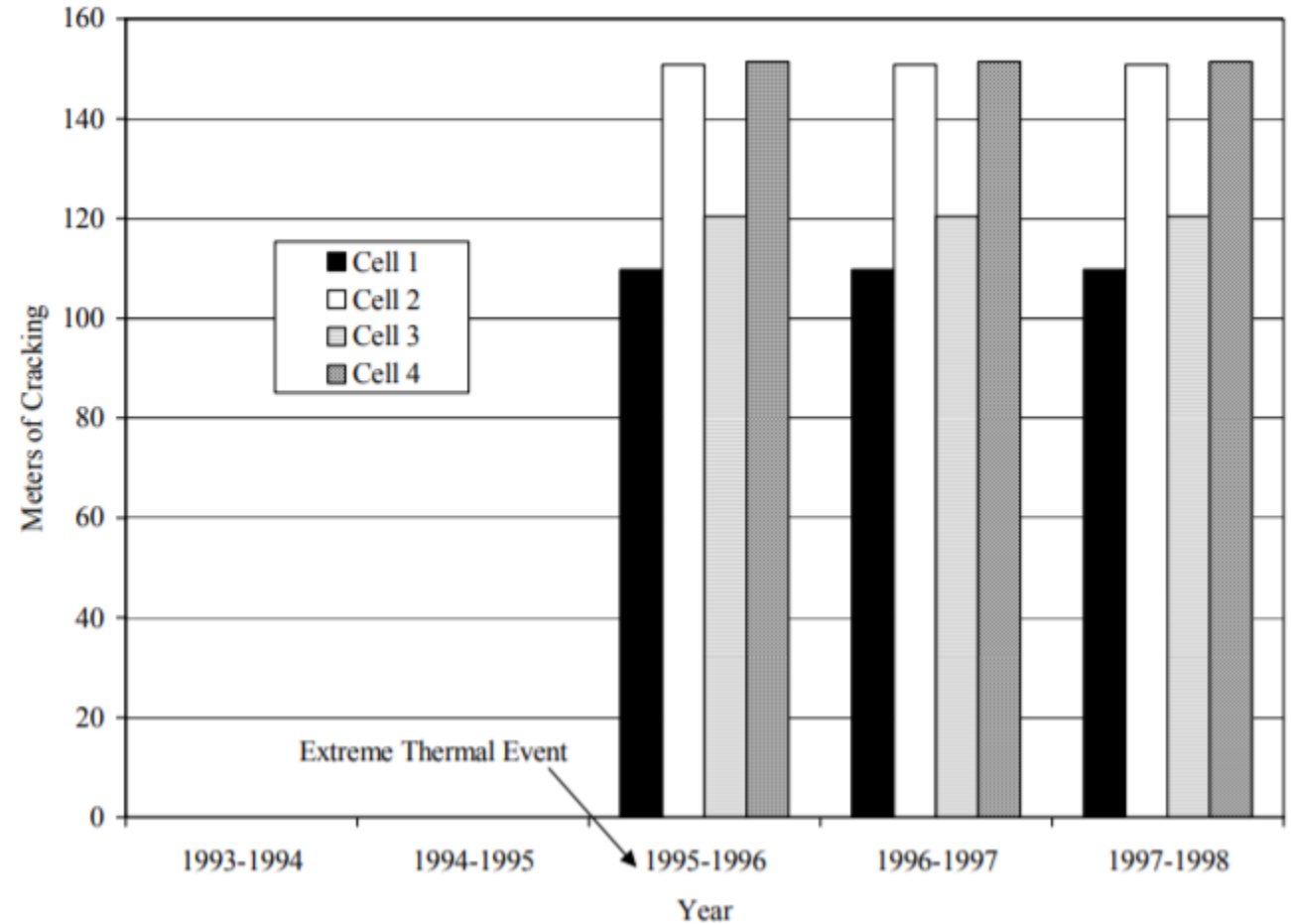
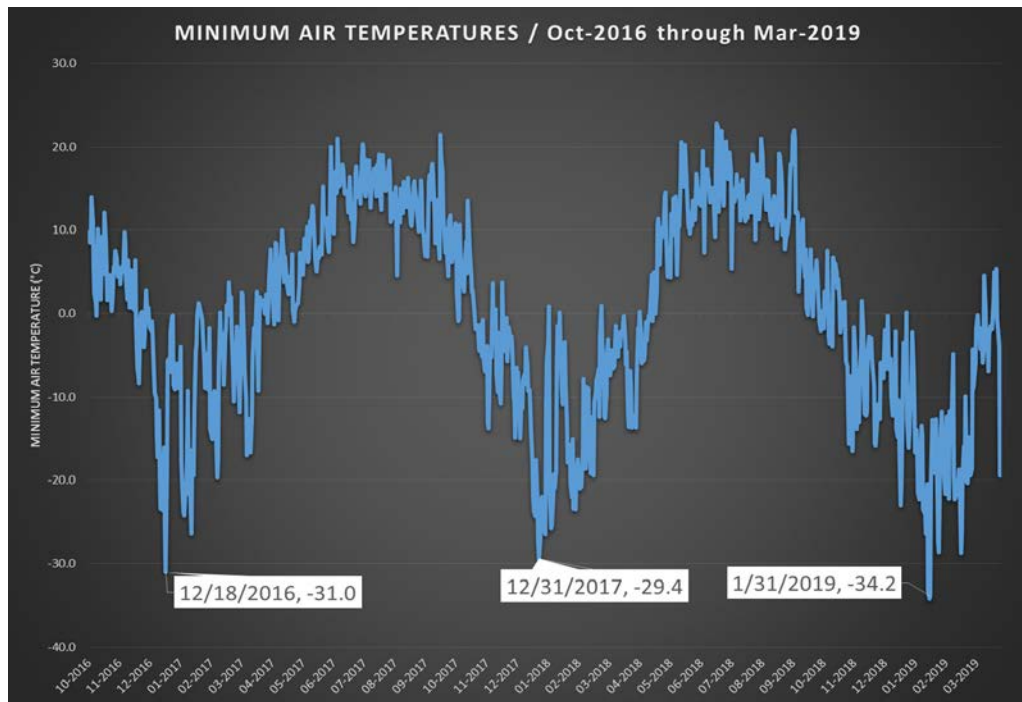
Previous Low Temperature Cracking Studies at MnROAD

		Transverse* (ft)
23	Moderate RAP, Highly mod. binder	43
22	Limestone and 9.5 mm NMA	50
21	Moderate RAP, softer binder	28
20	High RAP, softer binder	0
19	Moderate RAP, extra AC	61
18	Moderate RAP	35
17	Low RAP + RAS	70
16	Moderate RAP + RAS	58



Previous Low Temperature Cracking Studies at MnROAD

- Cells constructed in 1992
- Thermal occurred in 4th winter



Crack Sealing on Longitudinal Joint

- Crack sealing on longitudinal cracks due to construction joints
 - Fall 2019
 - All cells 16-23
 - Centerline and Driving lane edge stripe



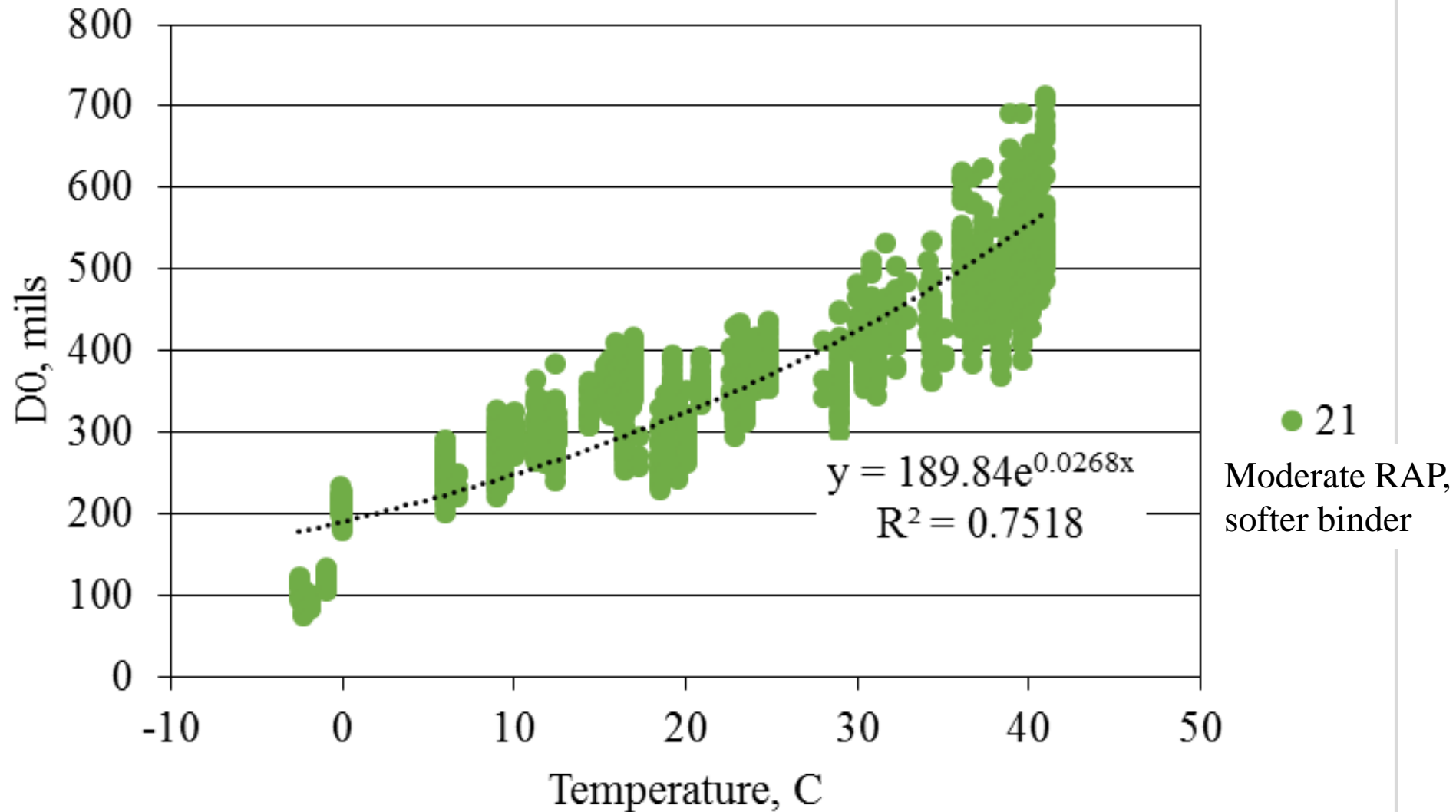
FWD Testing

- Monthly testing (March- November)
- Testing at fixed stations every 50 feet
 - Driving and Passing Lanes
 - Inside wheelpath, outside wheelpath, between wheelpaths
- 9 drops per locations
 - 6,000, 9,000, and 12,000 lb
- Data analyzed globally
 - Need localized investigation into cracking

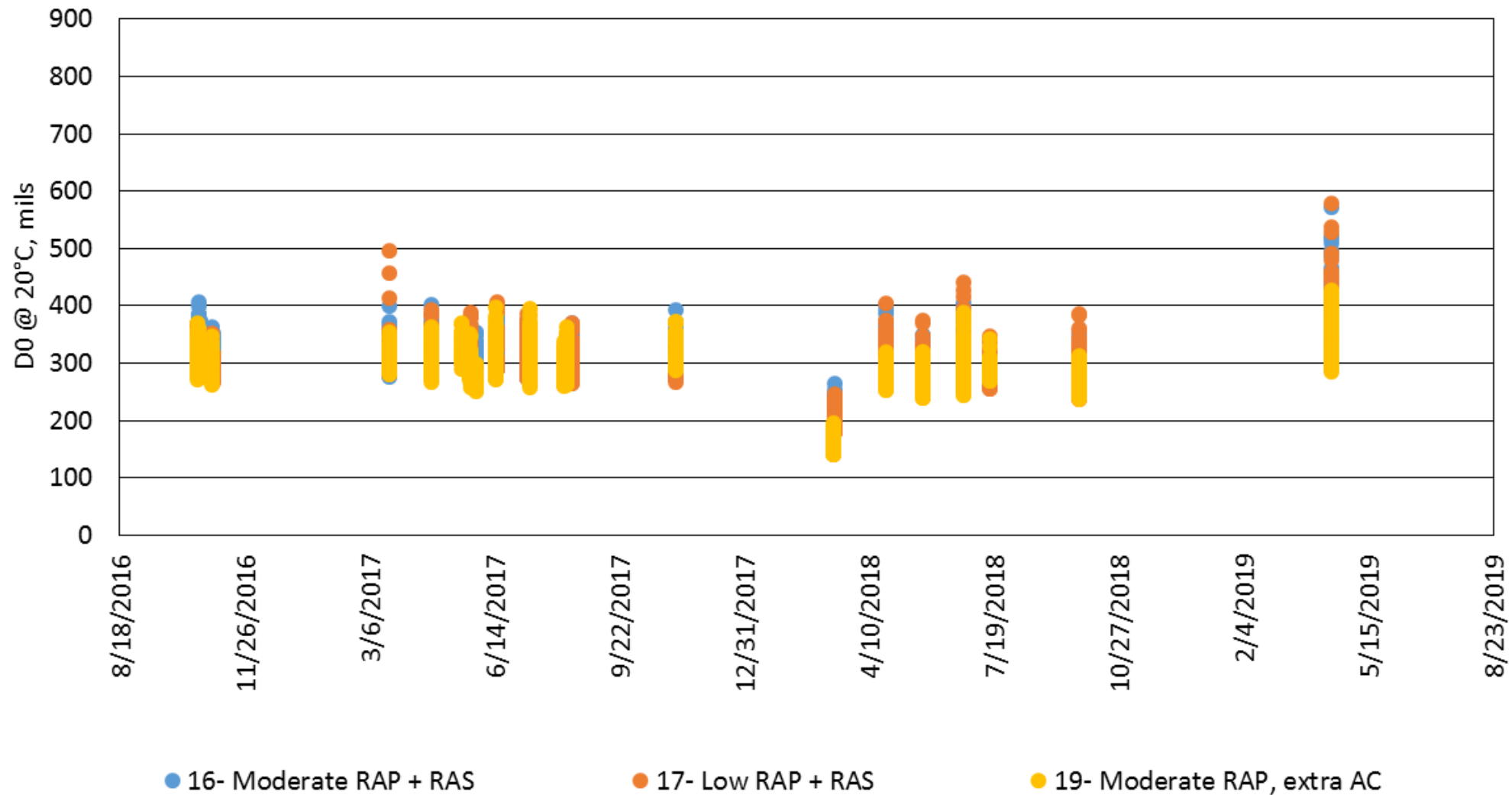
Deflection Analysis

- In progress – Deflection Basin Parameters
 - In lieu of backcalculation
- Address temperature effects on center deflection and deflection basin parameters (e.g., surface curvature)
 - Examine seasonal changes
- Apply to special tests within distressed areas to correlate deflections to measured in situ strains
- Forensic investigation of distress areas

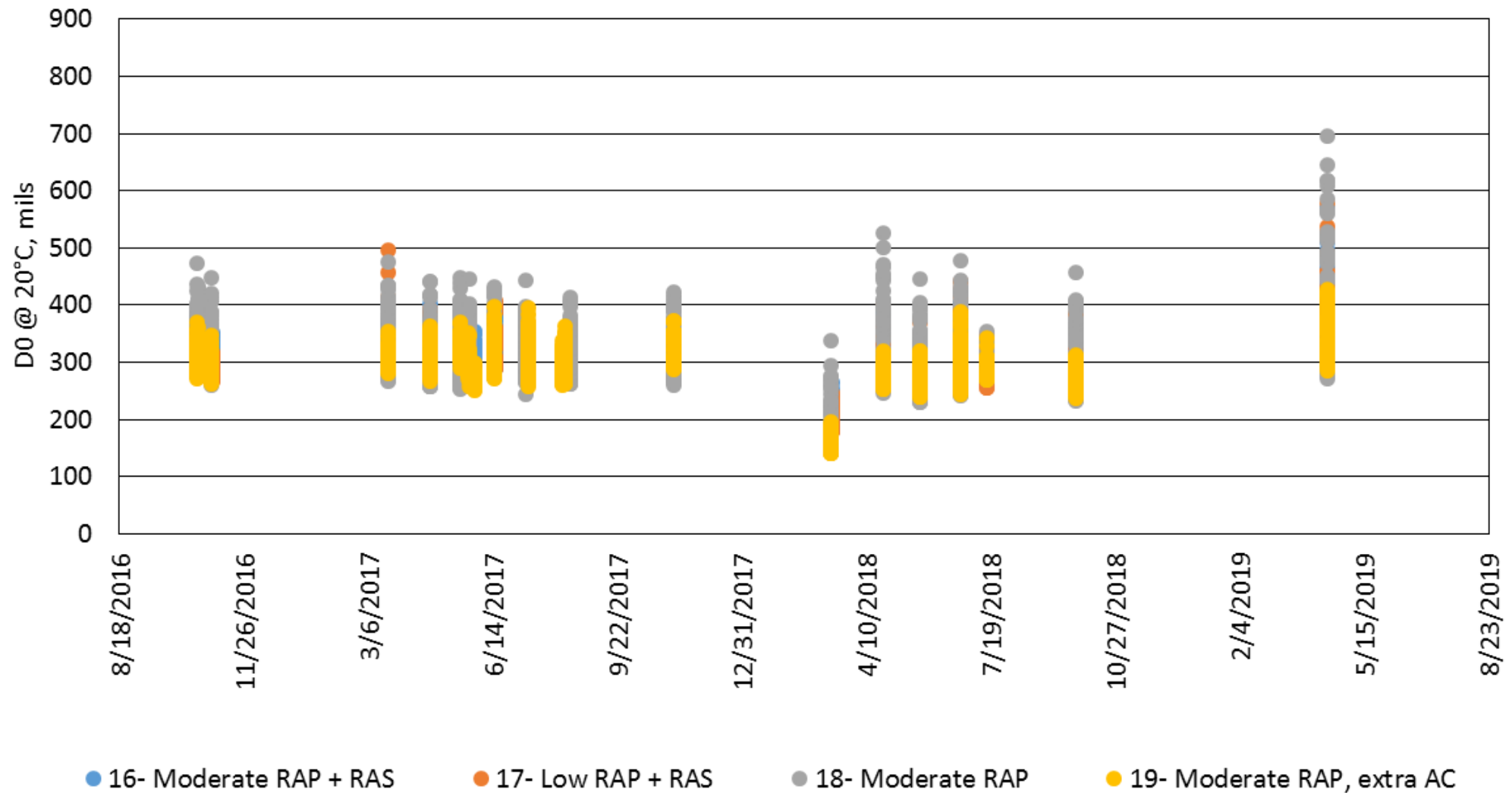
Deflection Analysis



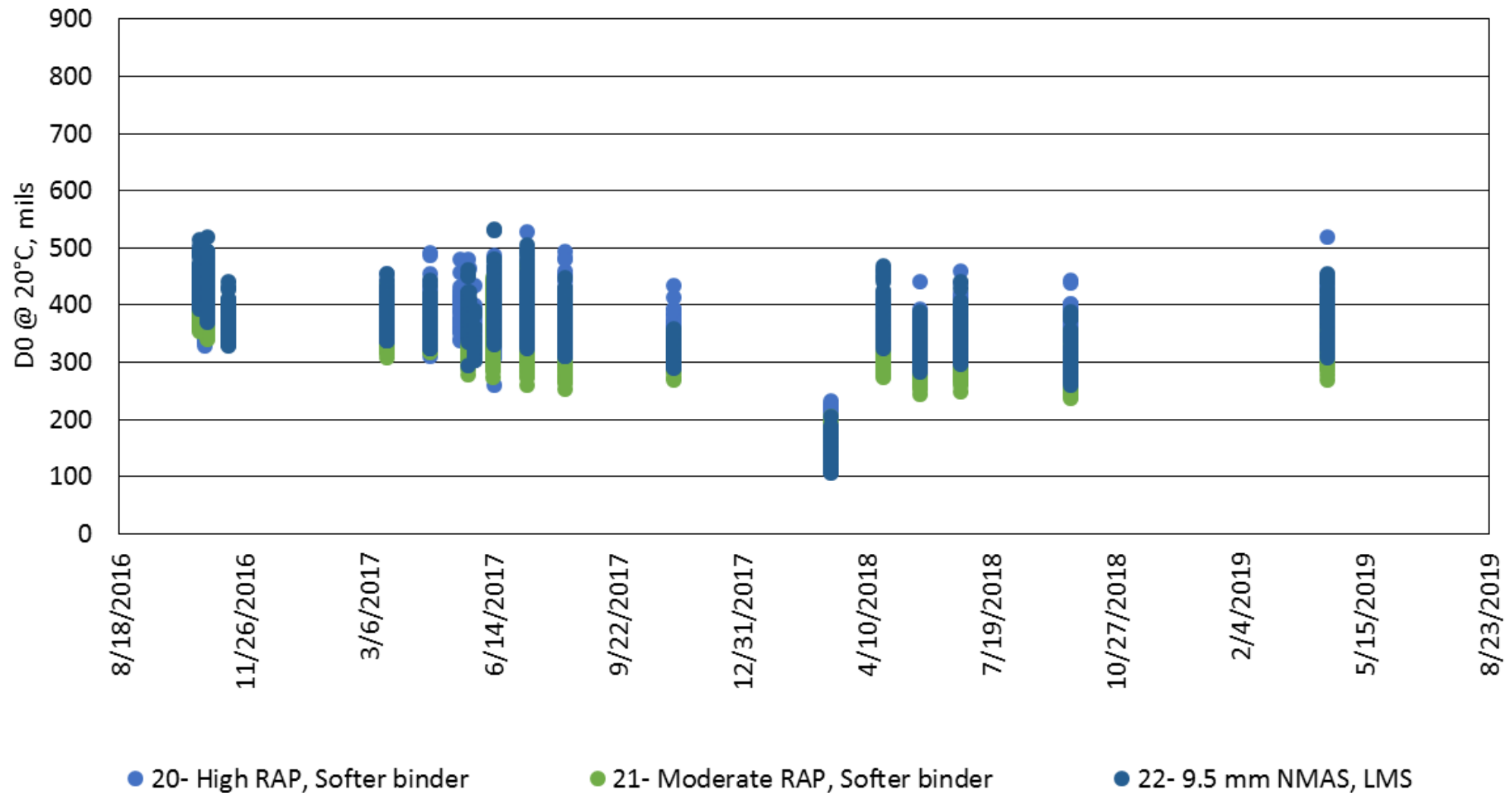
Deflection Analysis XX -22



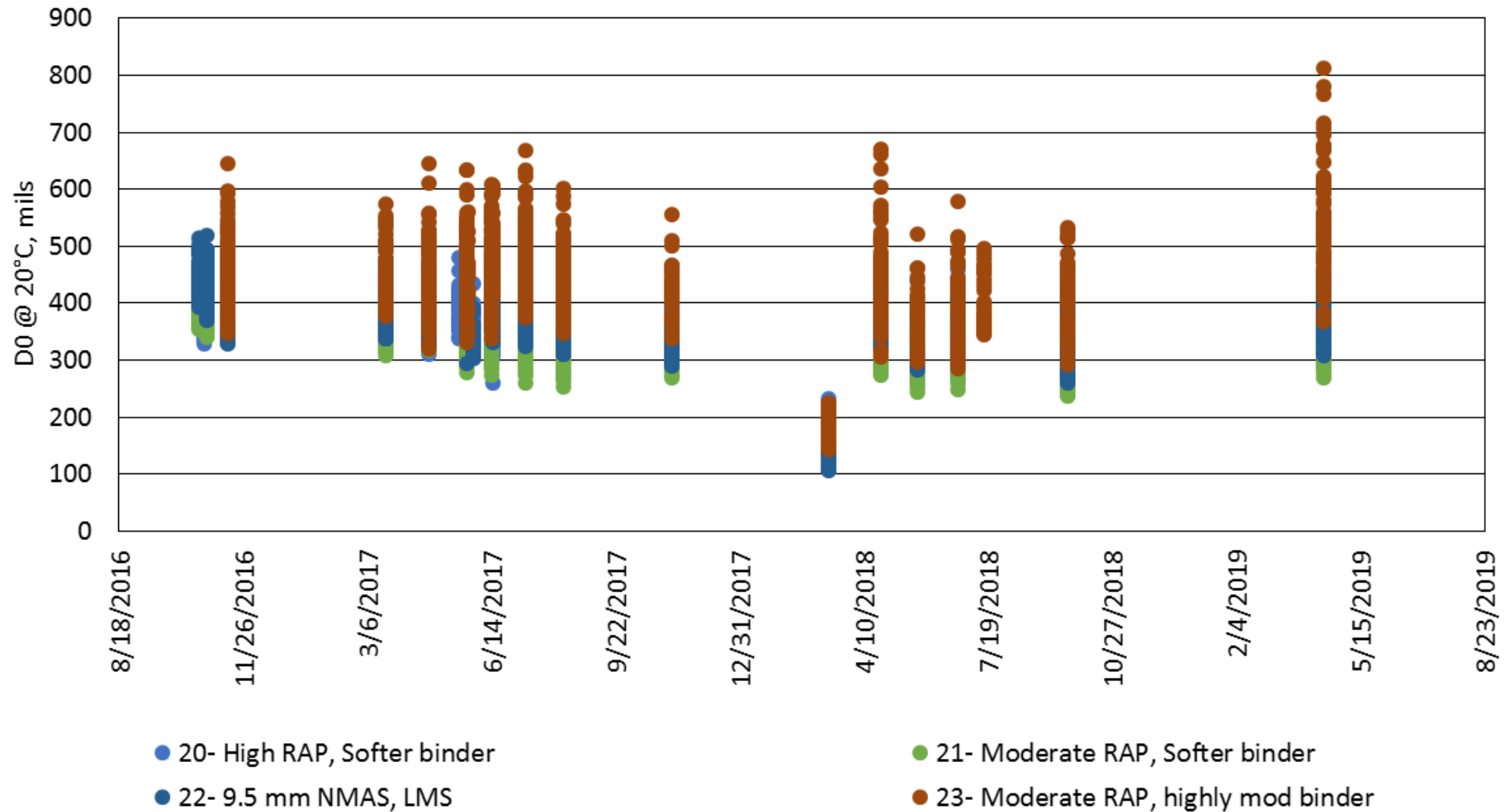
Deflection Analysis XX -22



Deflection Analysis XX -34



Deflection Analysis XX -34



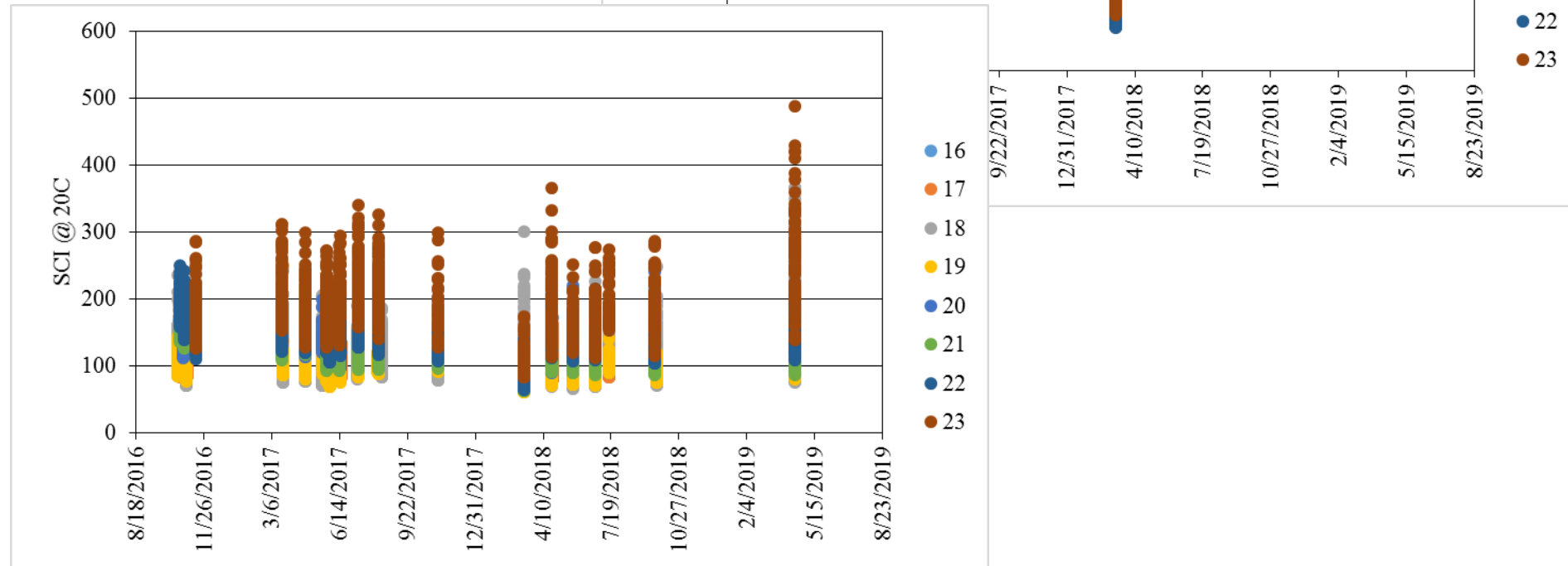
Deflection Analysis

Other Deflection Basin

Parameters

tell show same trends:

- Cell 23 has largest magnitude
- Cell 23 has largest spread in data

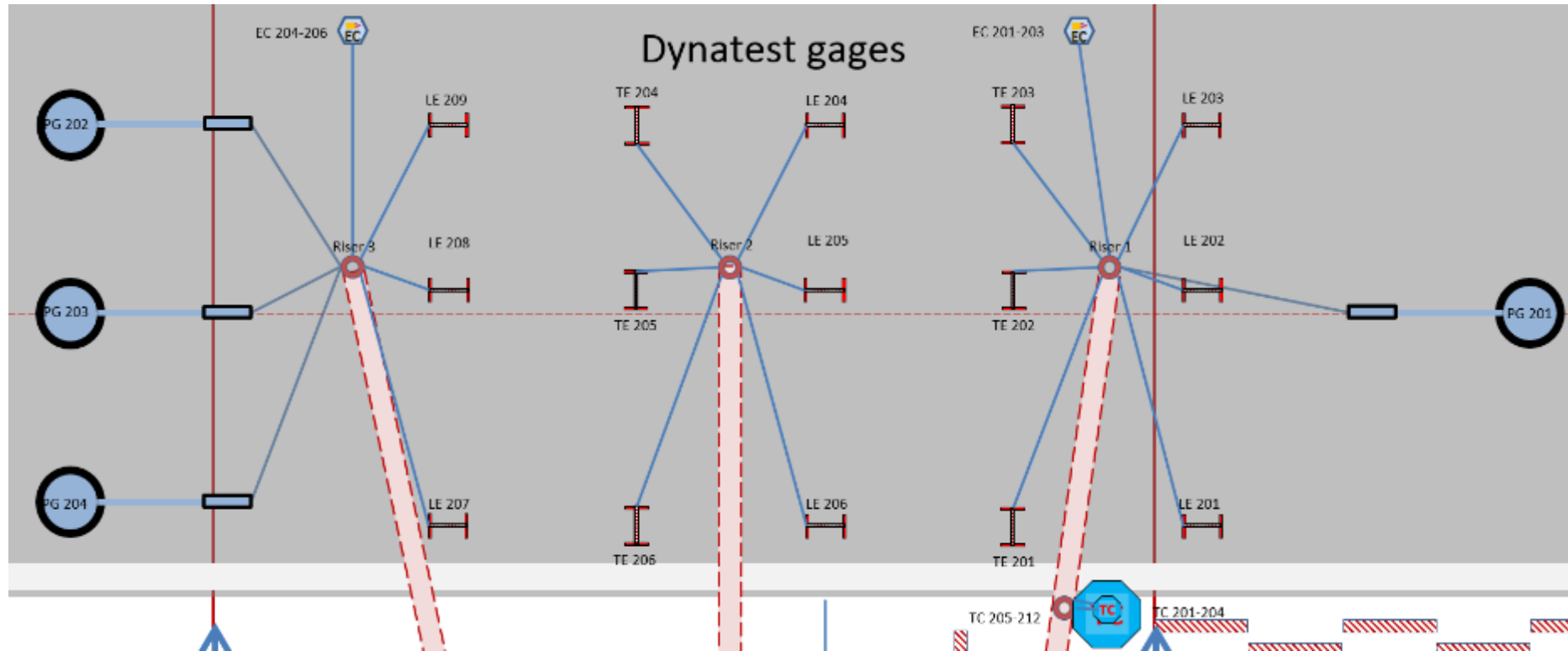


Dynamic Data Processing Goals

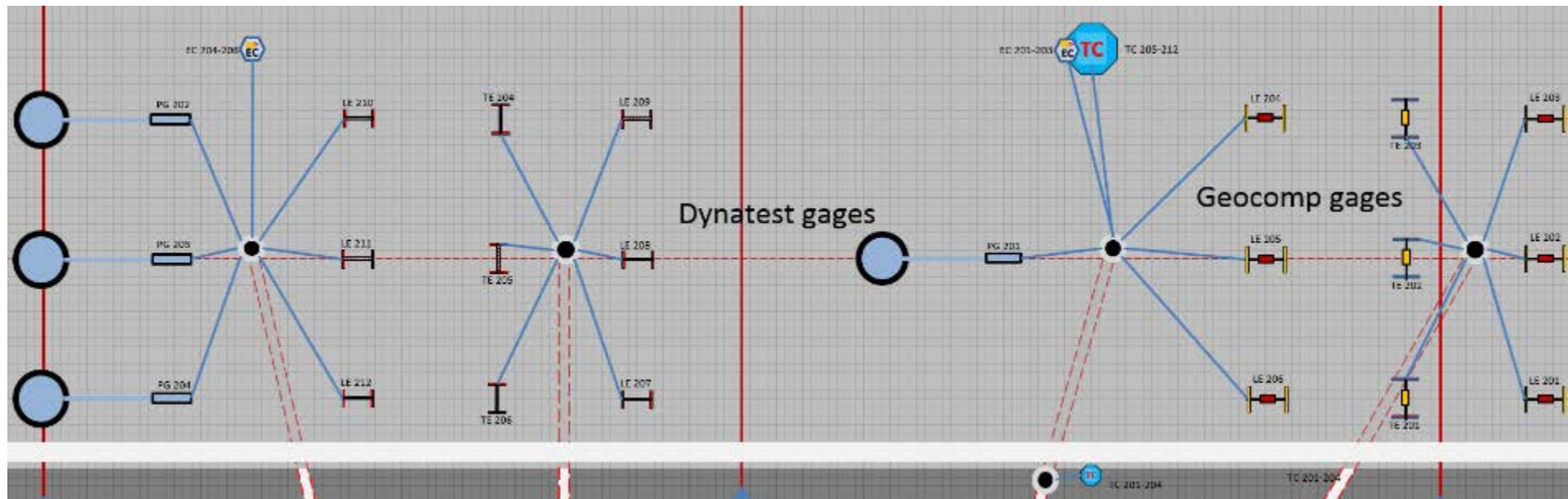
- Dynamic Data Processing Goals
 - Provide common platform between NCAT and MnROAD
 - DADiSP Software interface developed by Dr. Dave Timm
 - User-friendly
 - Visual quality checks
 - Rapidly build databases
- Pavement Response Data
 - Dynatest FWD
 - MnROAD Truck
 - Conducted monthly (March-November)
 - Slow speed (5 mph)
 - Intermediate speed (35 mph)



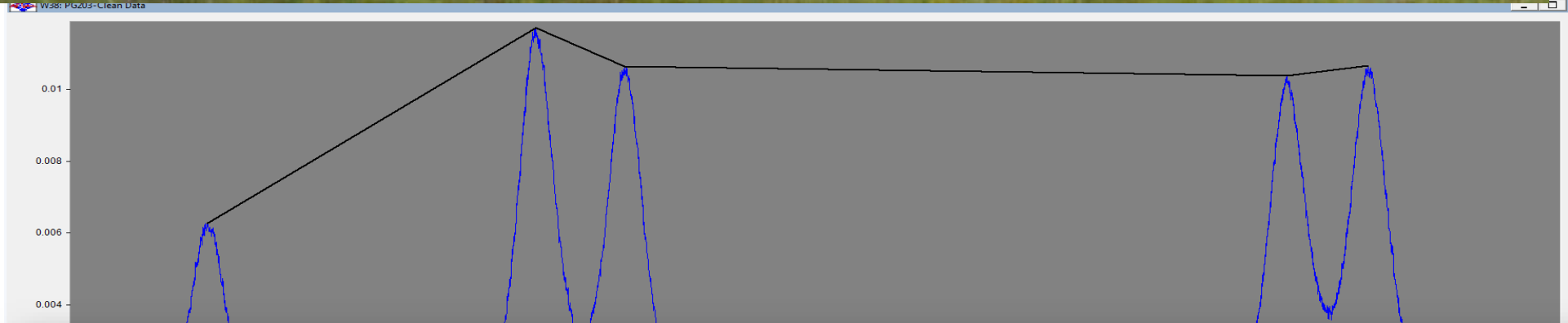
Typical sensor layout – Cells 17, 19, 21



Sensor layout – Cell 23



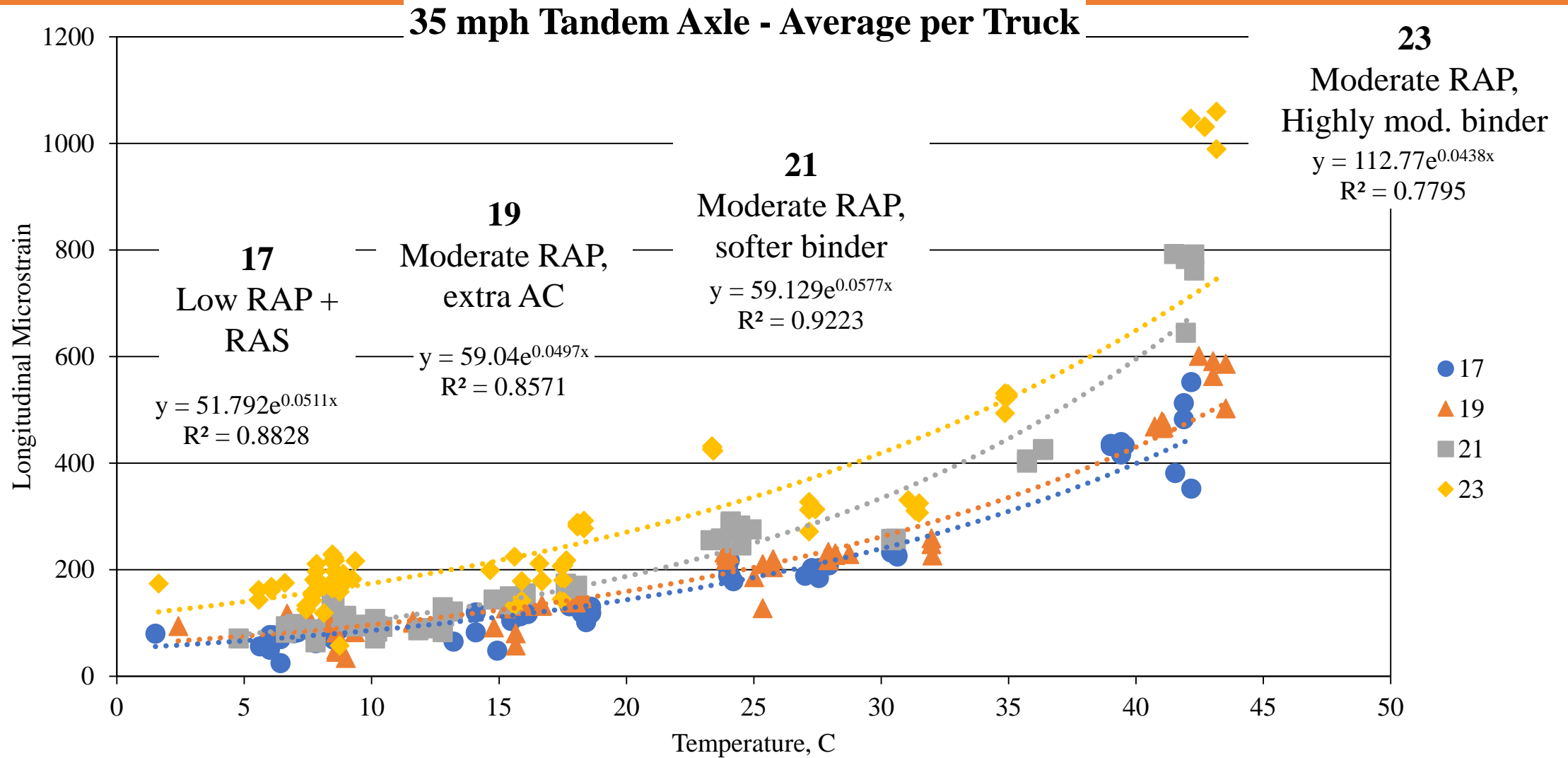
Dynamic Loading



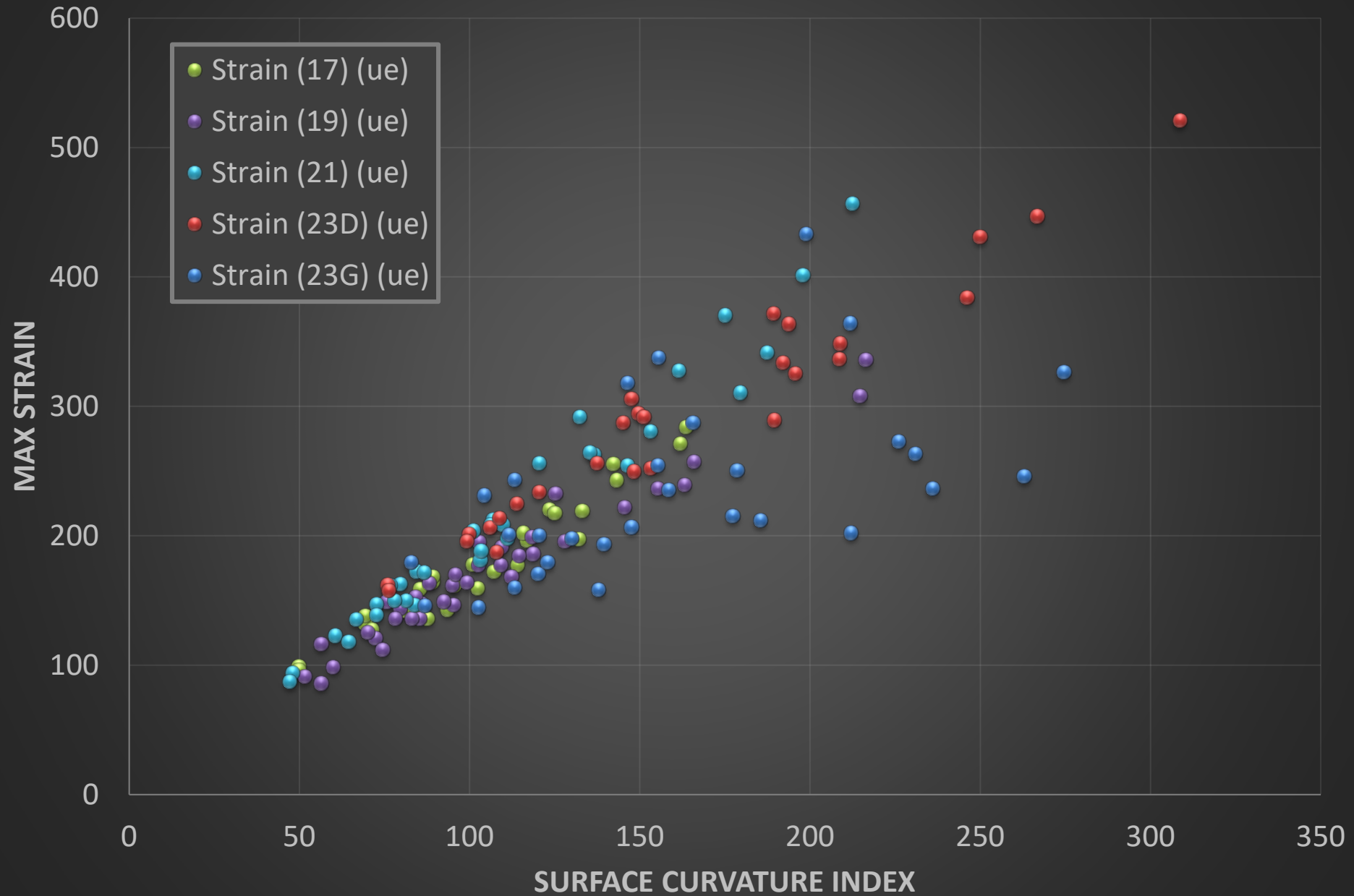
W41: Summary Output Data

	1: Cell	2: Truck ID	3: Axle	4: Speed, mph	5: Axle Spacing, in.	6: LE201
1:	19.000000	1.000000	1.000000	4.282778	0.000000	-0.000080
2:	19.000000	1.000000	2.000000	4.266697	206.295401	-0.000091
3:	19.000000	1.000000	3.000000	4.270260	55.442414	-0.000072
4:	19.000000	1.000000	4.000000	4.100751	413.186401	-0.000102
5:	19.000000	1.000000	5.000000	4.072988	49.702871	-0.000113

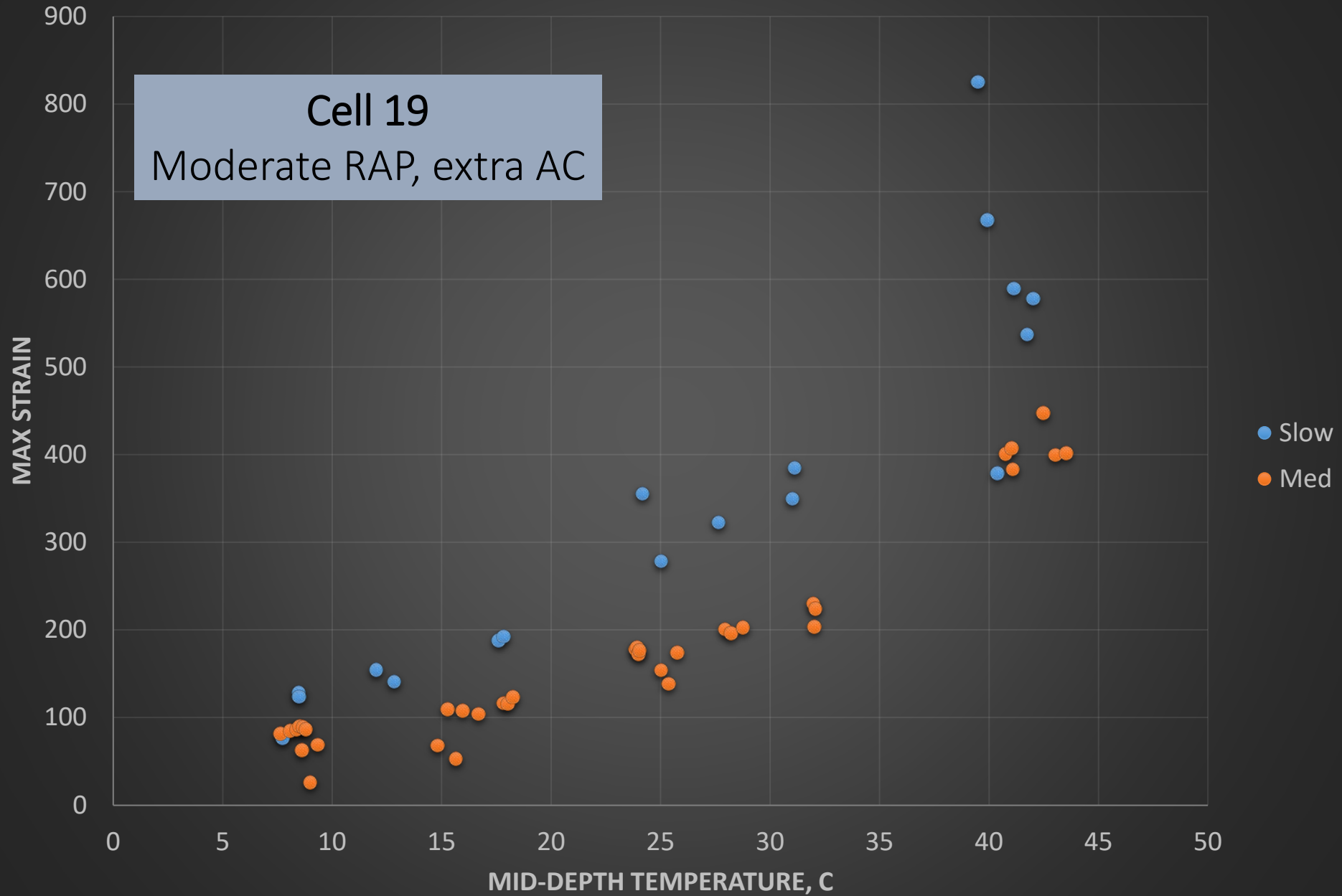
Horizontal Strain



MAX STRAIN vs. SCI



MAX STRAIN vs. PAVEMENT TEMPERATURE



Cell 23

Moderate RAP, Highly mod. binder



- Moisture issues during construction
- Less drainage available
- Large “dip” in transition prior to section
 - Continuously patched through 2018
 - Removed October 2018 during MnROAD transition reconstruction



Moisture Sensors

- Is Cell 23 performance due to high moisture contents in granular layers?
- Decagon Moisture gauges used in all instrumented cells (17, 19, 21,23)
- Comprehensive review of moisture data
 - MnDOT's new Geomechanics Research Engineer, Dr. Raul Velasquez



Summary

- Ride performance is good
- New cracking observed in early 2019
 - Primarily load and construction related cracking
- Limited LTC performance observed to date
 - Current LTC much less than previous MnROAD LTC experiments
- Pavement sensor responses follow anticipated trends with respect to speed and temperature
 - Magnitudes also reflect anticipated mixture stiffness results
- Deflection indices correlate well with maximum strains
- FWD/strain shows Cell 23 not behaving like others

Next Steps

- Continue monitoring and testing according to experiment plan
- Analyze cracking measured by digital inspection vehicle
- More forensic work to determine type/cause of all cracking observed
- Evaluate moisture gauges to investigate influence on Cell 23

Acknowledgements/ Questions???

- Pooled-fund sponsor states
- Hardrives, Inc.
- Ingevity (anti-strip additive)
- WSB and Associates, Inc.
- MnDOT:
 - District 3
 - MnROAD staff
 - Ben Worel, P.E.
 - Dave Van Deusen, P.E.
 - Len Palek, P.E.
 - OMRR staff
- NCAT personnel
- Dr. Dave Timm

