New Asphalt Technologies

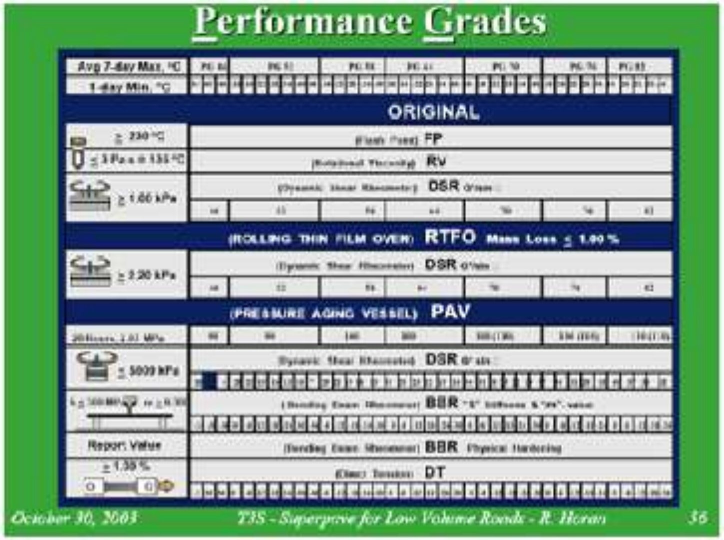
North Dakota Asphalt Conference
April 3, 2012
Bismarck, ND

Ken Swedeen, Dakota Asphalt Pavement Assoc.

New Asphalt Technologies

How can we use existing and new technology to make our pavements BETTER?

Recent HMA Developments

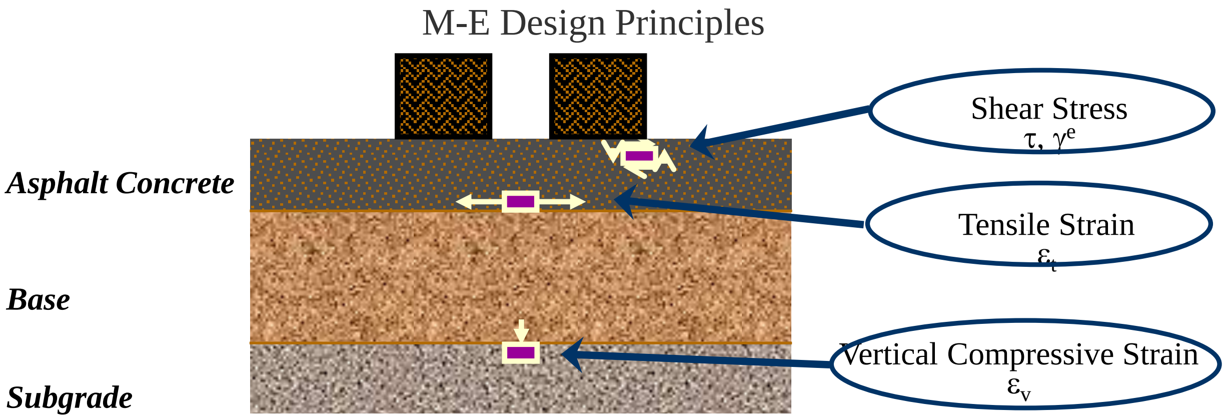


Performance Graded Binder

(Modified Binder)

Warm Mix Asphalt

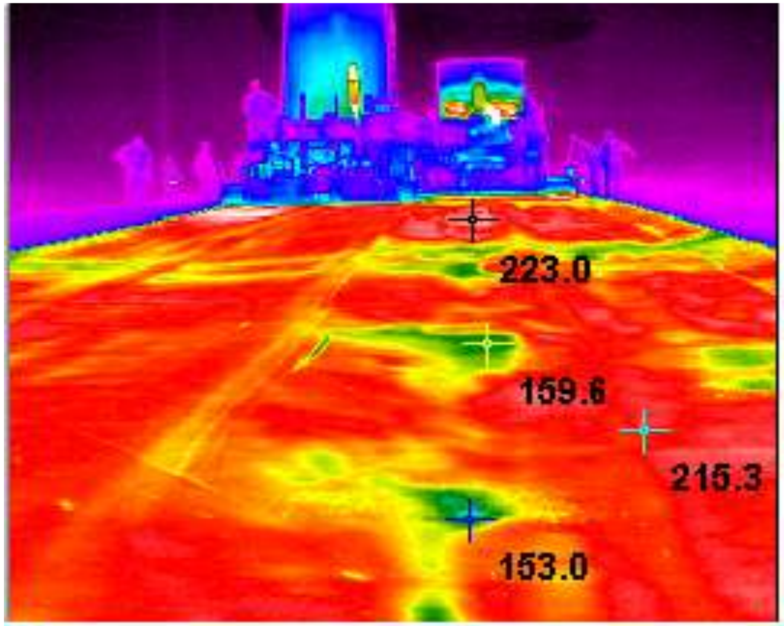
Recent HMA Developments (Con't)



Perpetual Pavement

Porous Asphalt Pavement

Recent HMA Developments (Con't)



Thermal & Compaction Control

SMA (Stone Matrix Asphalt) & Wearing Course Alternatives

Performance Graded Binder

Superpave performance grading (PG) is based on the idea that an HMA asphalt binder's properties should be related to the conditions under which it is used. For asphalt binders, this involves expected climatic conditions as well as aging considerations.

This may require modifiers be added to the asphalt cement or binder

PG Binder Specification

- Developed out of SHRP in 1990's
- Addressed the weakness of prior Specifications (e.g. Penetration, Viscosity, etc.)
- Modeled on the Engineering Properties of the Binder (and Mixture) at binder storage conditions, plant conditions, aged pavement conditions and pavement service conditions (high pavement temperature~summer, cold pavement temperature~winter)

Pre-Superpave Shortcomings

- Viscosity
  - viscous effects only
- Penetration
  - empirical measure of viscous and elastic effects
- No Low Temperature Properties Measured
- Problems with Modified Asphalt Characterization
- Specification Proliferation
- Long Term Aging not Considered

Superpave Asphalt Binder Specification

- Grading System Based on Climate

PG 58-28

Performance Grade (PG)

Average 7-day max pavement design temp (58)

Min pavement design temp (-28)

Is a PG a Modified Binder ?

Effect of Loading Rate

Reliability

"Rule of 90"

PG 64 - 34 > 64 - - 34 = 98

Probably modified !!

(Depends on Asphalt Source!)

Rounding

Effect of Traffic

PG Binder/Crude Impact

High Temperature, °C

Low Temperature, °C	52	58	64	70	76
-16	52-16	58-16	64-16	70-16	76-16
-22	52-22	58-22	64-22	70-22	76-22
-28	52-28	58-28	64-28	70-28	76-28
-34	52-34	58-34	64-34	70-34	76-34
-40	52-40	58-40	64-40	70-40	76-40

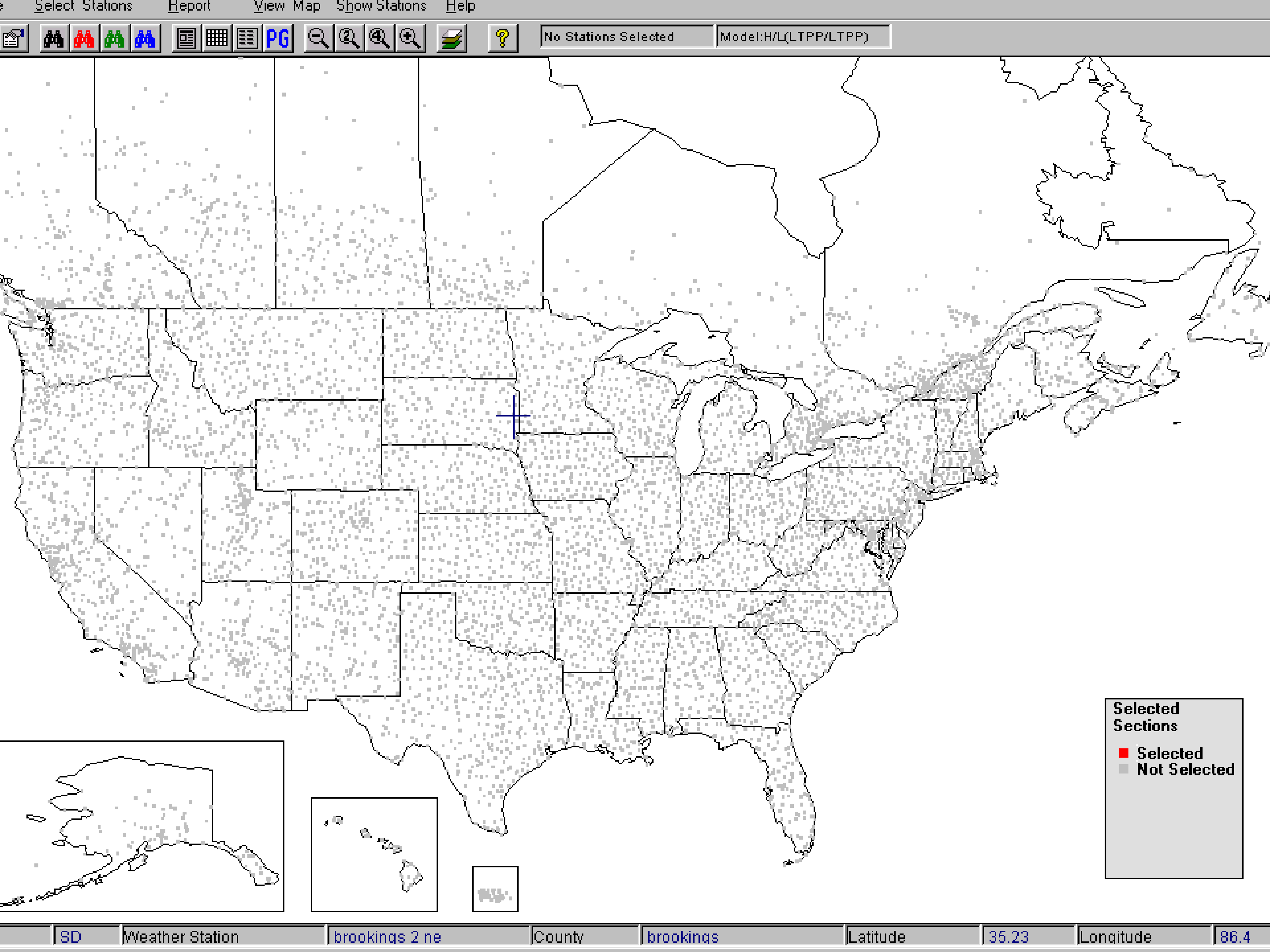
= Crude Oil

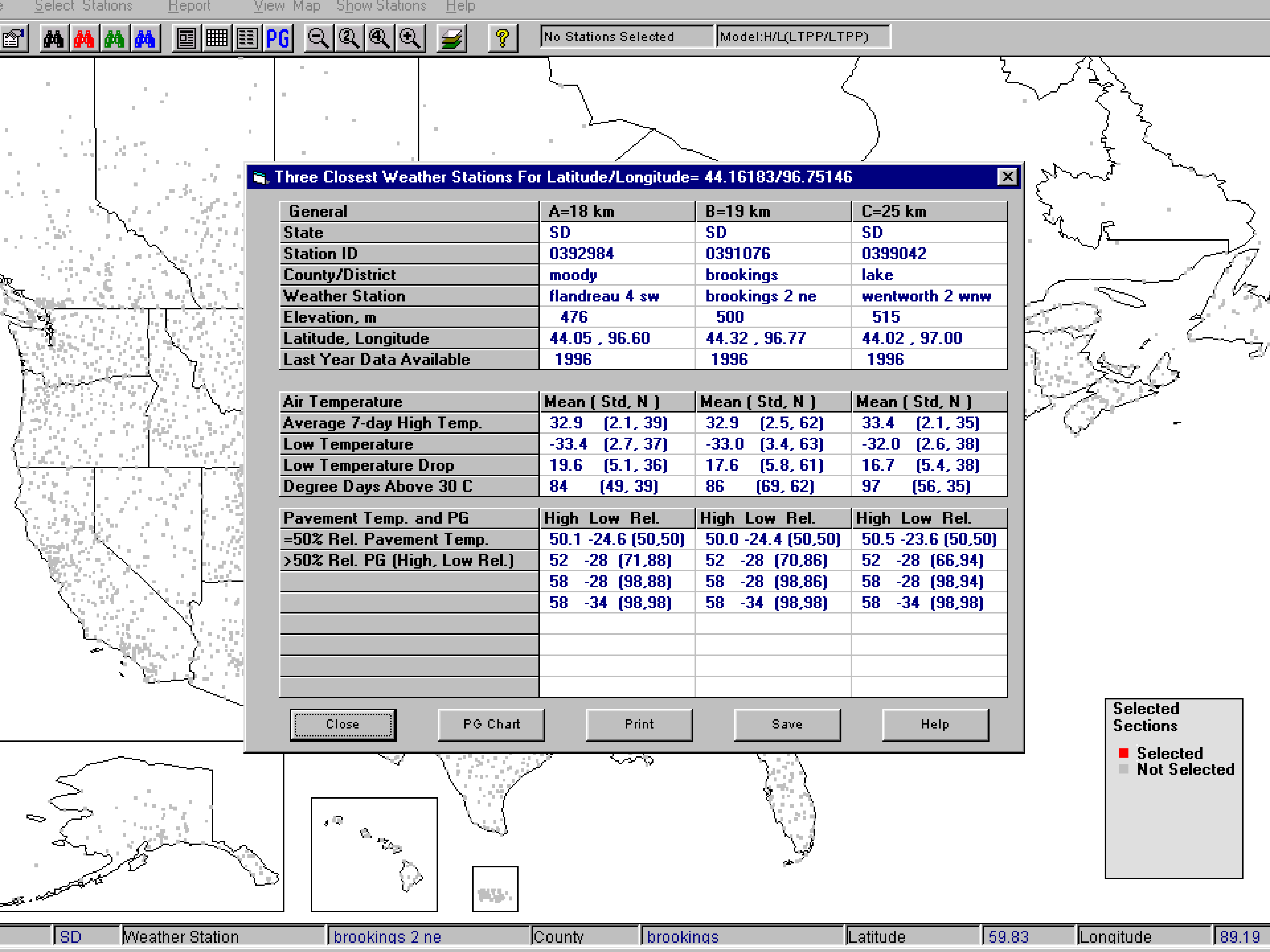
= High Quality Crude Oil

= Modifier Required

PG Binder Selection

- Select Binder (PG) Based on Climate (Location)
- Select Binder (PG) Based on Mix Type, Utilization of RAP and Pavement Design
- Account for Risk Tolerance (e.g. Functional Classification)
- Account for Economics (LCCA)
- Account for Loading/Rate of Loading


Select Stations
Report
View Map
Show Stations
Help
No Stations Selected
Model:H/L(LTPP/LTPP)
Selected Sections
Selected
Not Selected
SD
Weather Station
brookings 2 ne
County
brookings
Latitude
35.23
Longitude
86.4



Three Closest Weather Stations For Latitude/Longitude= 44.16183/96.75146

General	A=18 km	B=19 km	C=25 km
State	SD	SD	SD
Station ID	0392984	0391076	0399042
County/District	moody	brookings	lake
Weather Station	flandreau 4 sw	brookings 2 ne	wentworth 2 wnw
Elevation, m	476	500	515
Latitude, Longitude	44.05 , 96.60	44.32 , 96.77	44.02 , 97.00
Last Year Data Available	1996	1996	1996

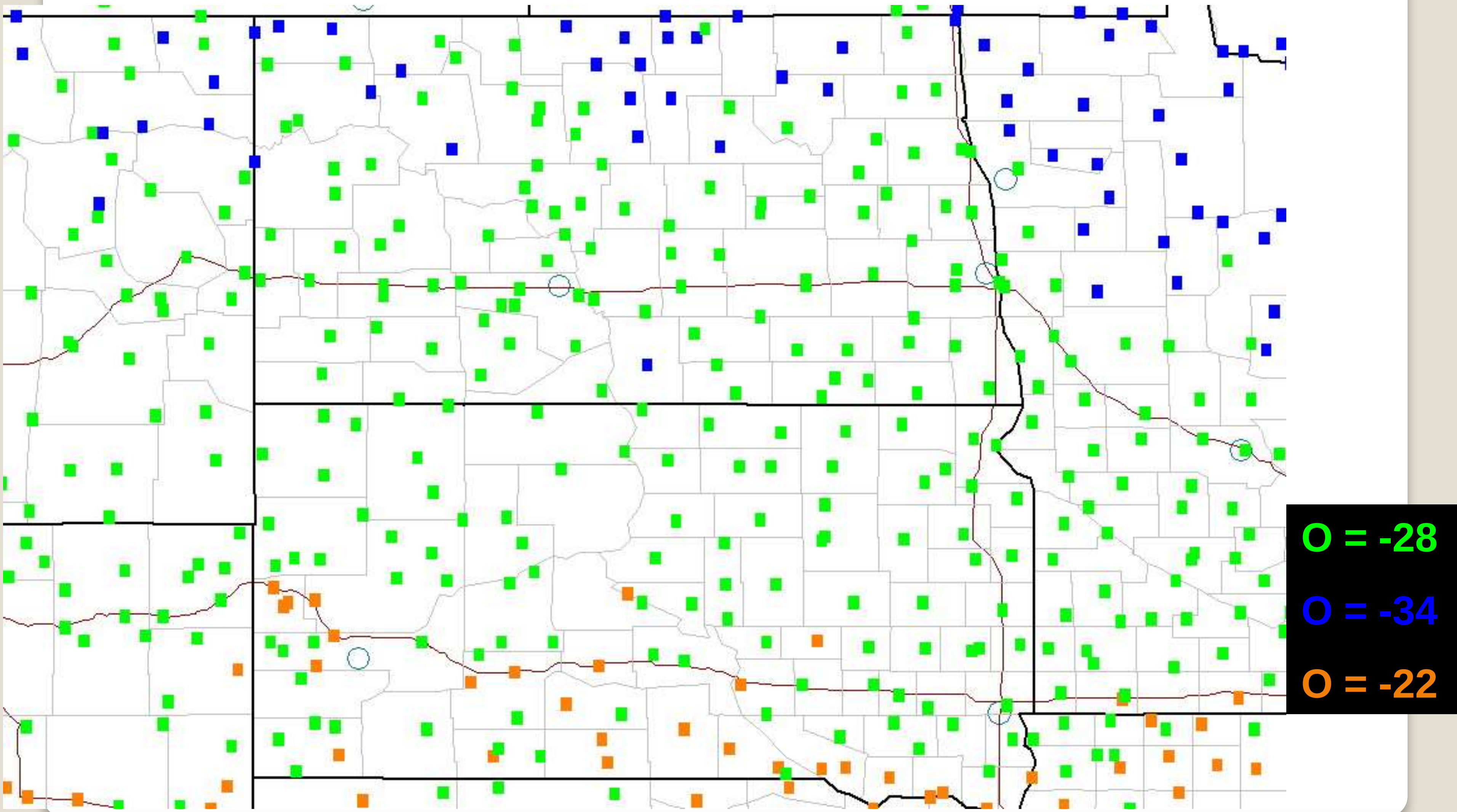
Air Temperature	Mean (Std, N)	Mean (Std, N)	Mean (Std, N)
Average 7-day High Temp.	32.9 (2.1, 39)	32.9 (2.5, 62)	33.4 (2.1, 35)
Low Temperature	-33.4 (2.7, 37)	-33.0 (3.4, 63)	-32.0 (2.6, 38)
Low Temperature Drop	19.6 (5.1, 36)	17.6 (5.8, 61)	16.7 (5.4, 38)
Degree Days Above 30 C	84 (49, 39)	86 (69, 62)	97 (56, 35)

Pavement Temp. and PG	High Low Rel.	High Low Rel.	High Low Rel.
=50% Rel. Pavement Temp.	50.1 -24.6 (50,50)	50.0 -24.4 (50,50)	50.5 -23.6 (50,50)
>50% Rel. PG (High, Low Rel.)	52 -28 (71,88)	52 -28 (70,86)	52 -28 (66,94)
	58 -28 (98,88)	58 -28 (98,86)	58 -28 (98,94)
	58 -34 (98,98)	58 -34 (98,98)	58 -34 (98,98)

Close | PG Chart | Print | Save | Help

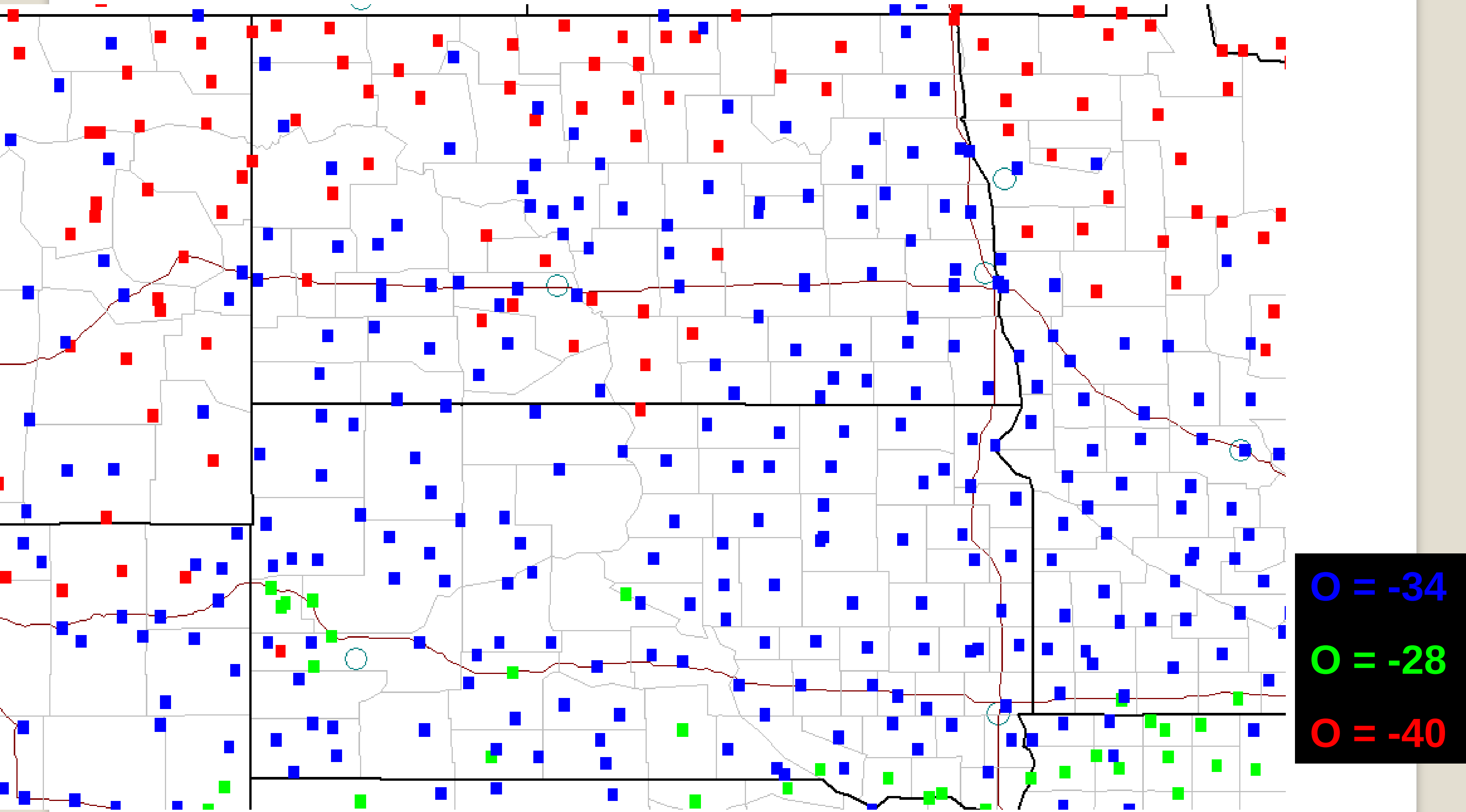
ND PG Binder Selection

(Low Temp-50% Reliability)



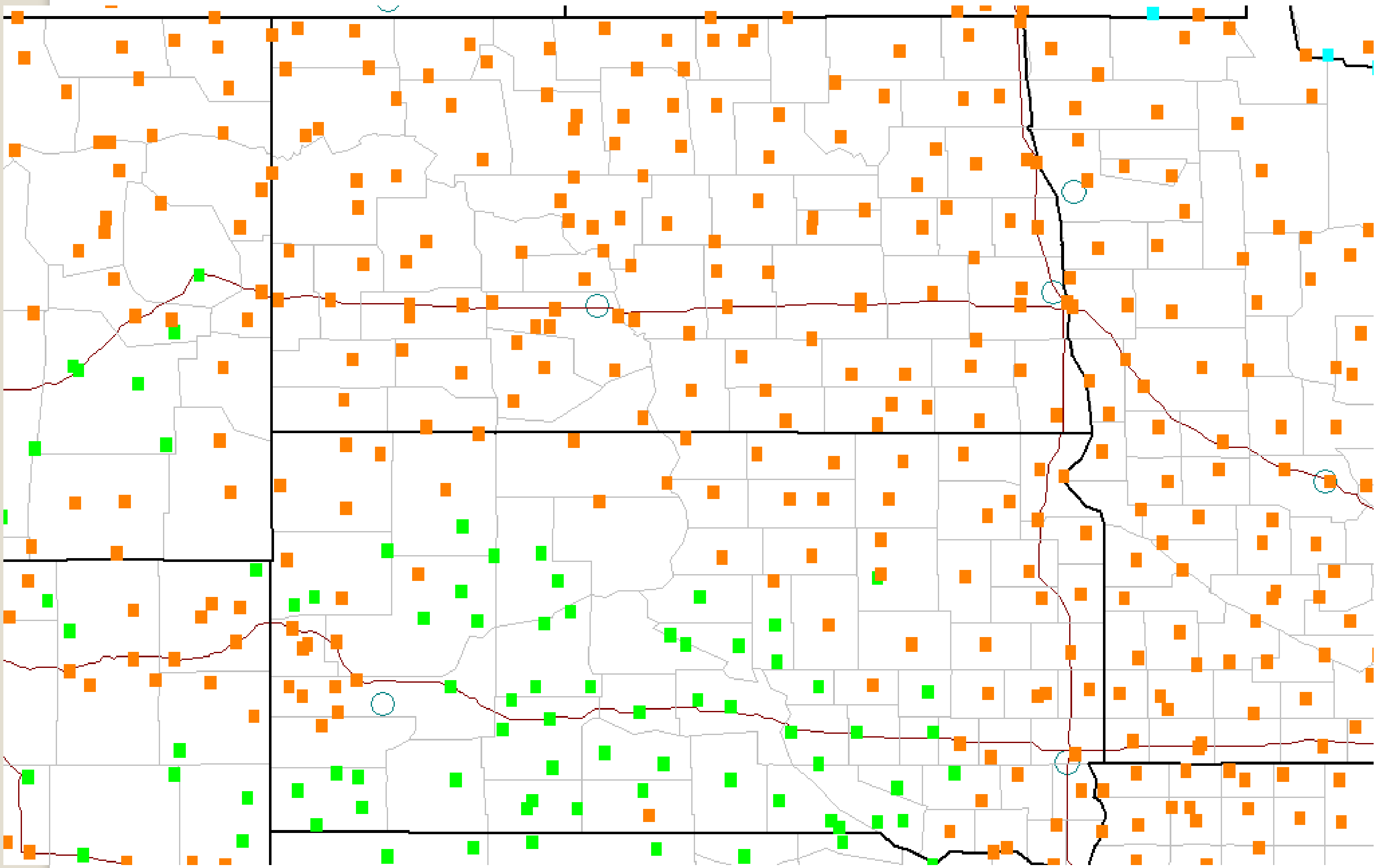
ND PG Binder Selection

(Low Temp-98% Reliability)



ND PG Binder Selection

(High Temp-50% Reliability)

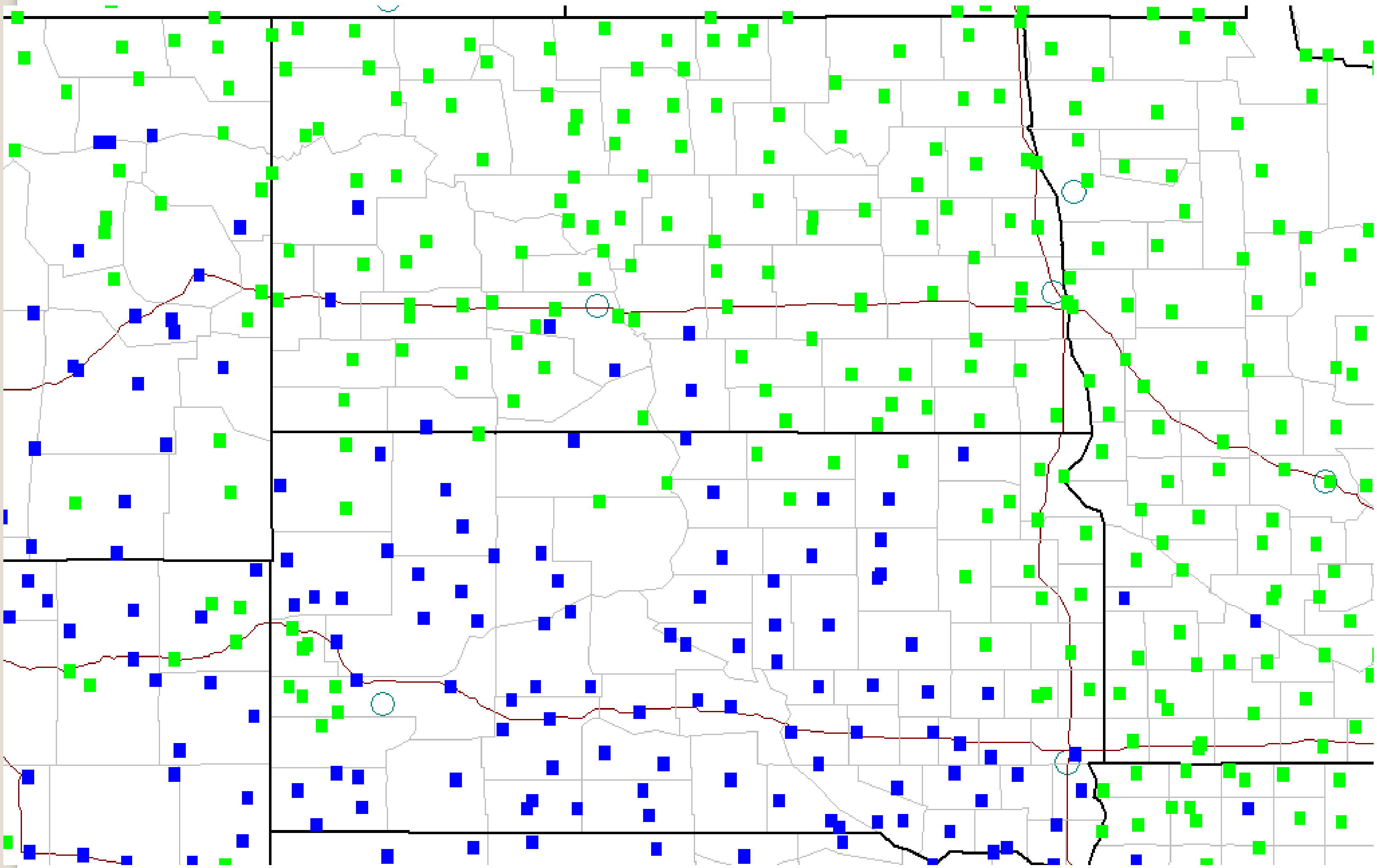


O = 52

O = 58

ND PG Binder Selection

(High Temp-98% Reliability)



O = 58

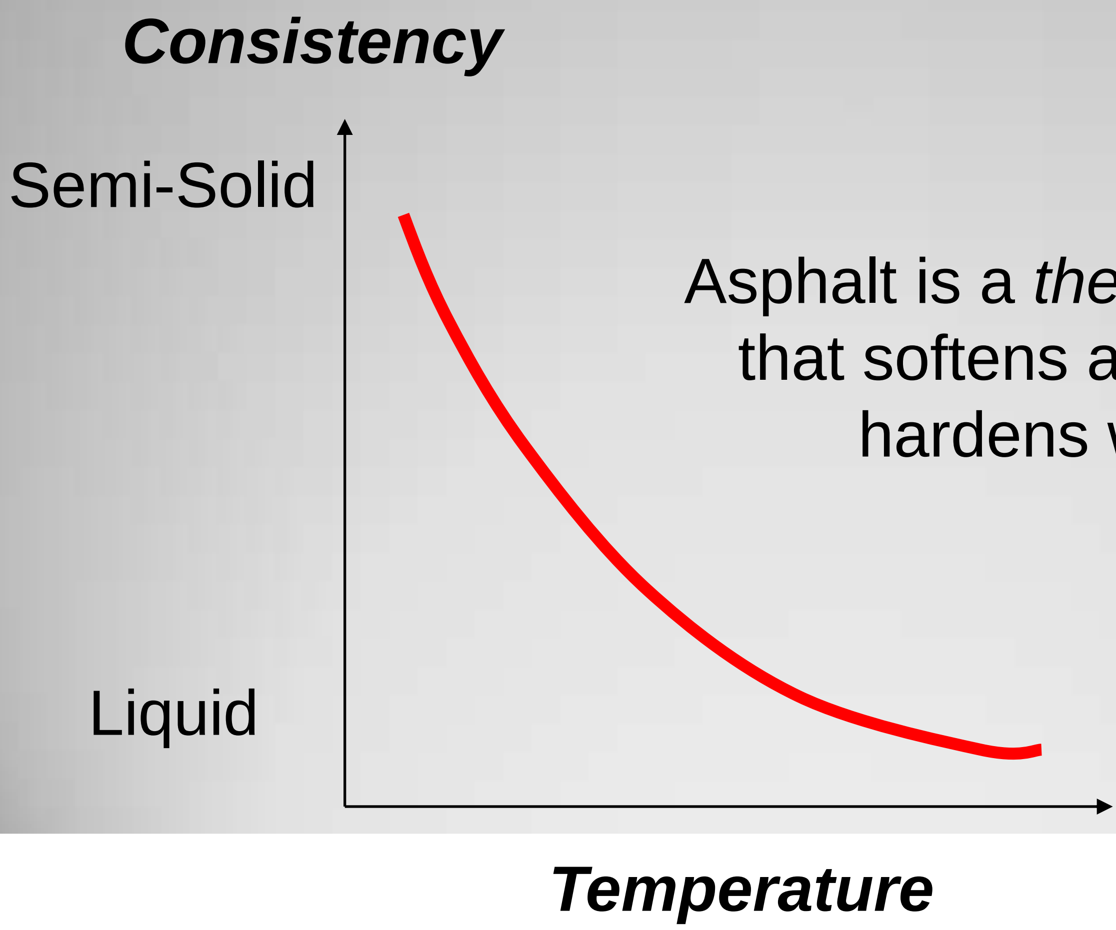
O = 64

PG Binder Considerations

- For new, resurfaced or reconstructed surfaces design the pavement and the asphalt binder
- If a polymer modified binder is called for…."don't step over dollar bills to pick up pennies". About $50/ton of liquid asphalt ($3/ton of mix) for upgrade 58-28 to 64-28
- A properly designed pavement and binder WILL:
  - Reduce thermal cracking and fatigue cracking saving future maintenance costs for crack sealing, pot hole patching, and associated problems
  - Provide and sustain better ride quality
  - Reduce aging and oxidation
  - Reduce rutting, particularly "green season" rutting (1^{st} or 2^{nd} year summer peak temperatures)

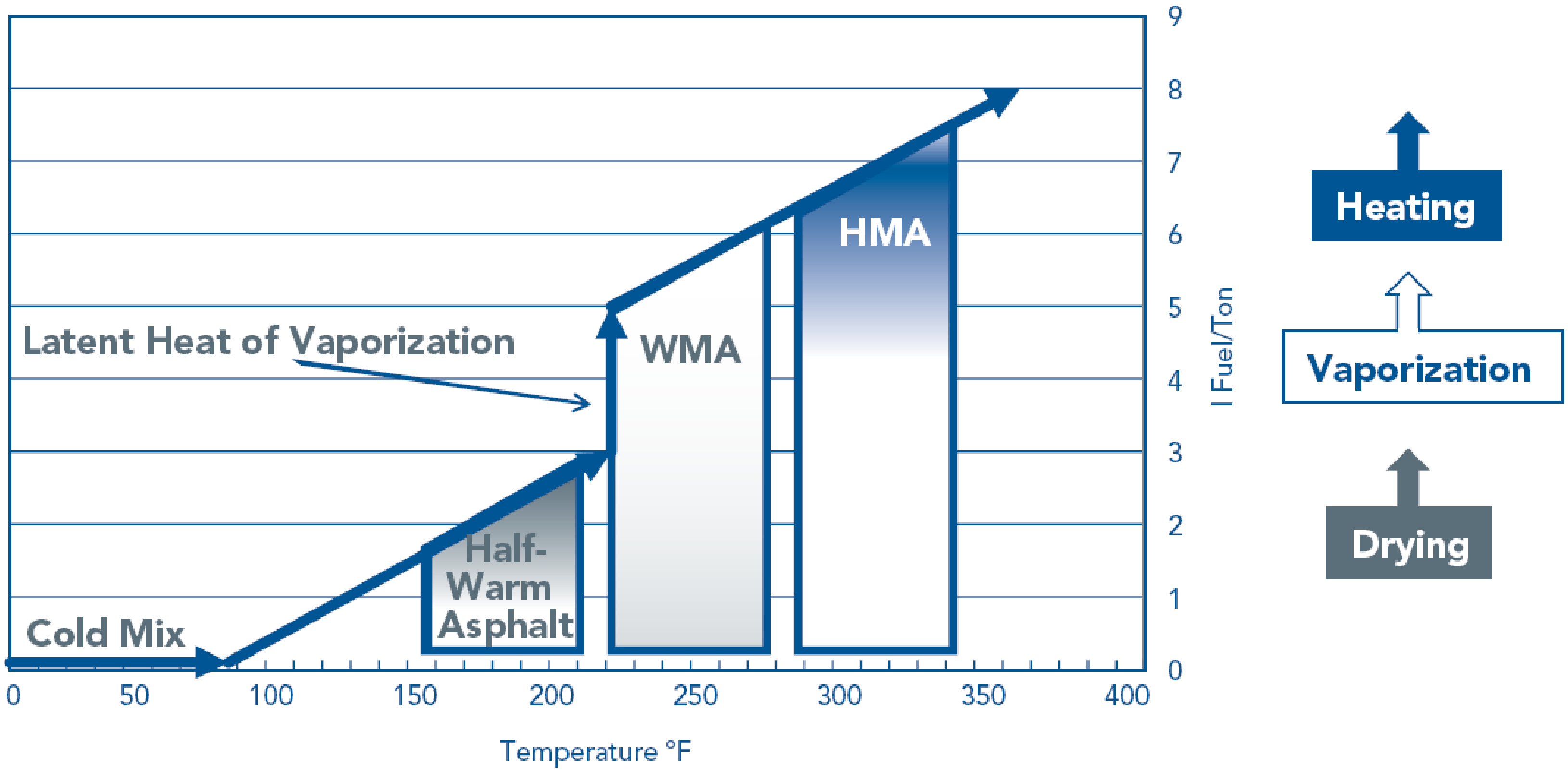
What is Warm Mix Asphalt (WMA)???

Asphalt Binder Properties



Asphalt is a *thermoplastic* material that softens as it is heated and hardens when cooled.

WMA Definition



WMA Types

- Asphalt Viscosity-reducing Organic Additives
- Water-bearing Additives
- Water-based Technologies
- Chemical Additives

Review

- WMA is a process of producing bituminous mixture for pavements at a significantly lower temperature than conventional HMA.
- There are more than 20 WMA technologies currently available, at least 15 in the US.
  - Fiber/Organic
  - Chemical
  - Physical
  - Foamed/Foaming Agents
- Goal: Reduce temperature requirements in production from 275-325 deg. F. (HMA) to 200-275 deg. F. (WMA)

Warm Mix Asphalt (WMA)

- Possible Benefits
  - Allowance for Construction Season & Environment
    - More Effective Late Season Paving
    - Portable Plant Setups…Long Hauls
  - Cost Savings: Lower Burner Fuel Usage, Less Waste, Less Equipment Fuel Usage??, More Flexible Project Planning
  - Improve Pavement Quality by Increasing Density Compliance
  - Possible Winter Season Wearing Course?
  - Environmental & Personal Protection
  - Urban Pavement Alternative

Goals

- Evaluate the suitability of using Warm Mix Asphalt (WMA)
- Assess WMA suitability in all paving applications (e.g. overlays, leveling interim, etc.)
- Evaluate WMA properties (binder, aggregate & mixture)
- Evaluate WMA pavement integrity & durability characteristics w/ HMA
- Emissions evaluation (benefits) of WMA during paving & production

Conventional HMA

WMA

130 deg. Mat Temp >


140 deg. Mat
Temp >

SD2008-03
Anderson Western, Inc. (Bismarck, ND)
May 2010 - South Dakota Highway 20

Perpetual Pavements

www.AsphaltAlliance.com

Introduction

- Not a new concept
  - Full-Depth
  - Deep Strength
  - Mill & Fill

Why consider Perpetual Pavements????

Because of this…..

And this…..

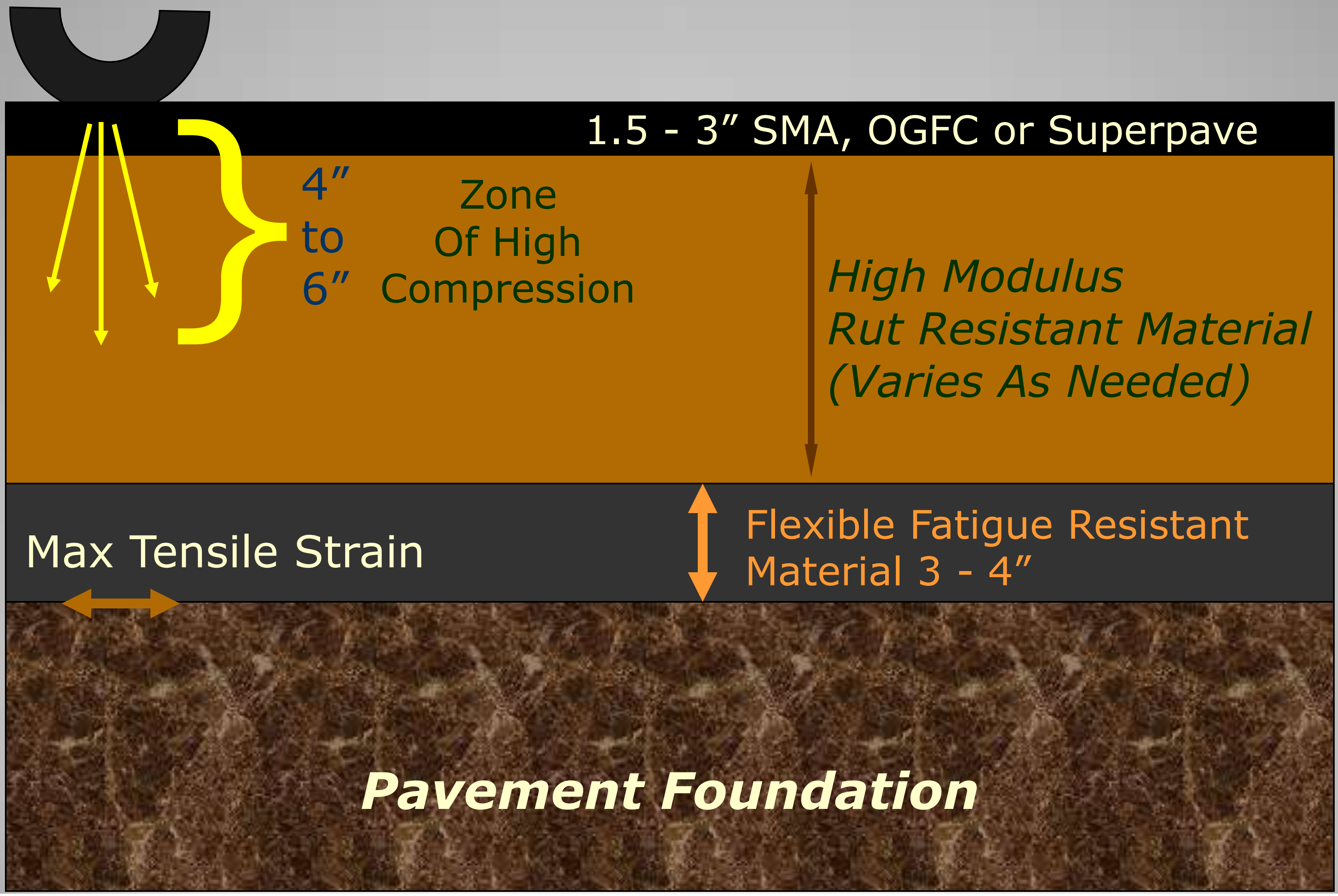
And this…..

And this…..

And this…..

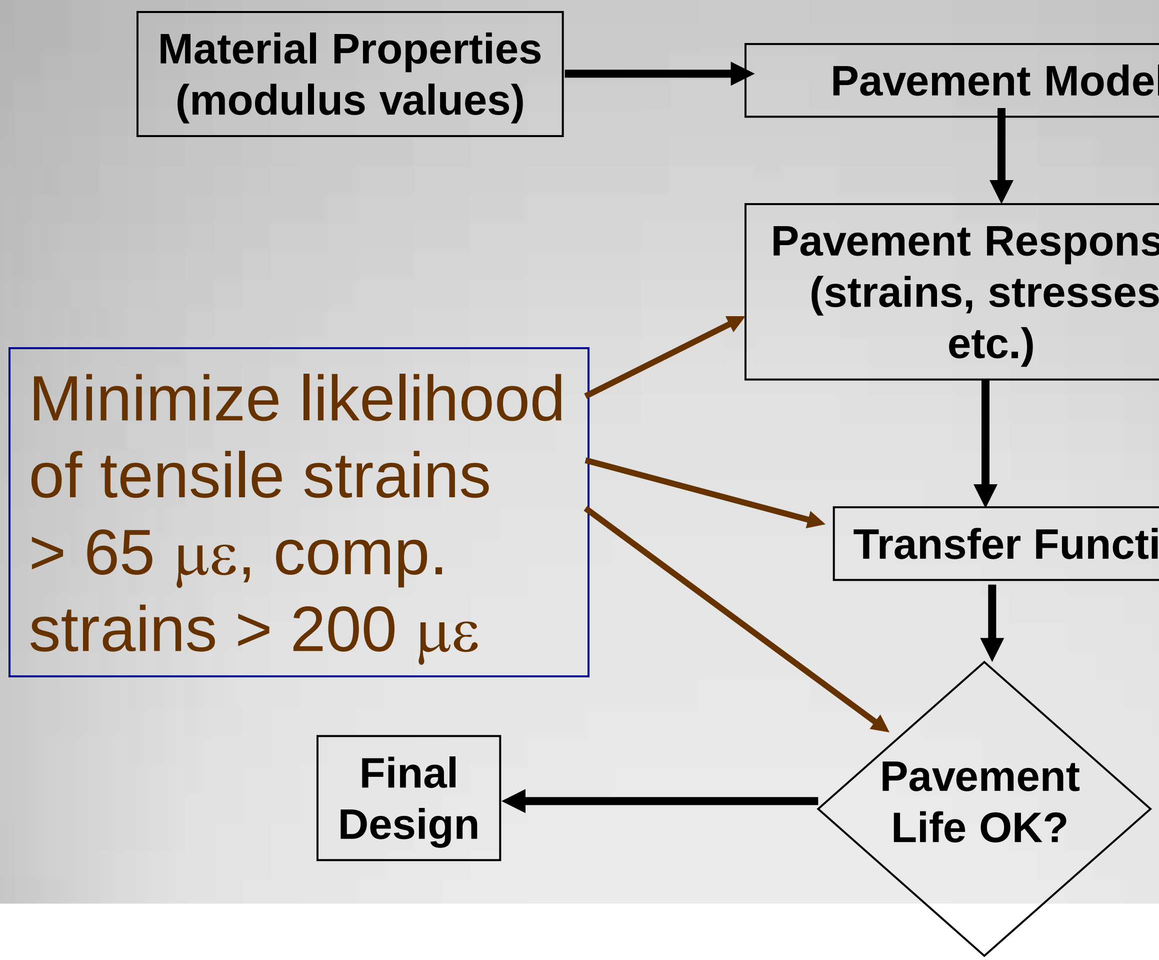
And this…..

And this…..probably not so much!!!

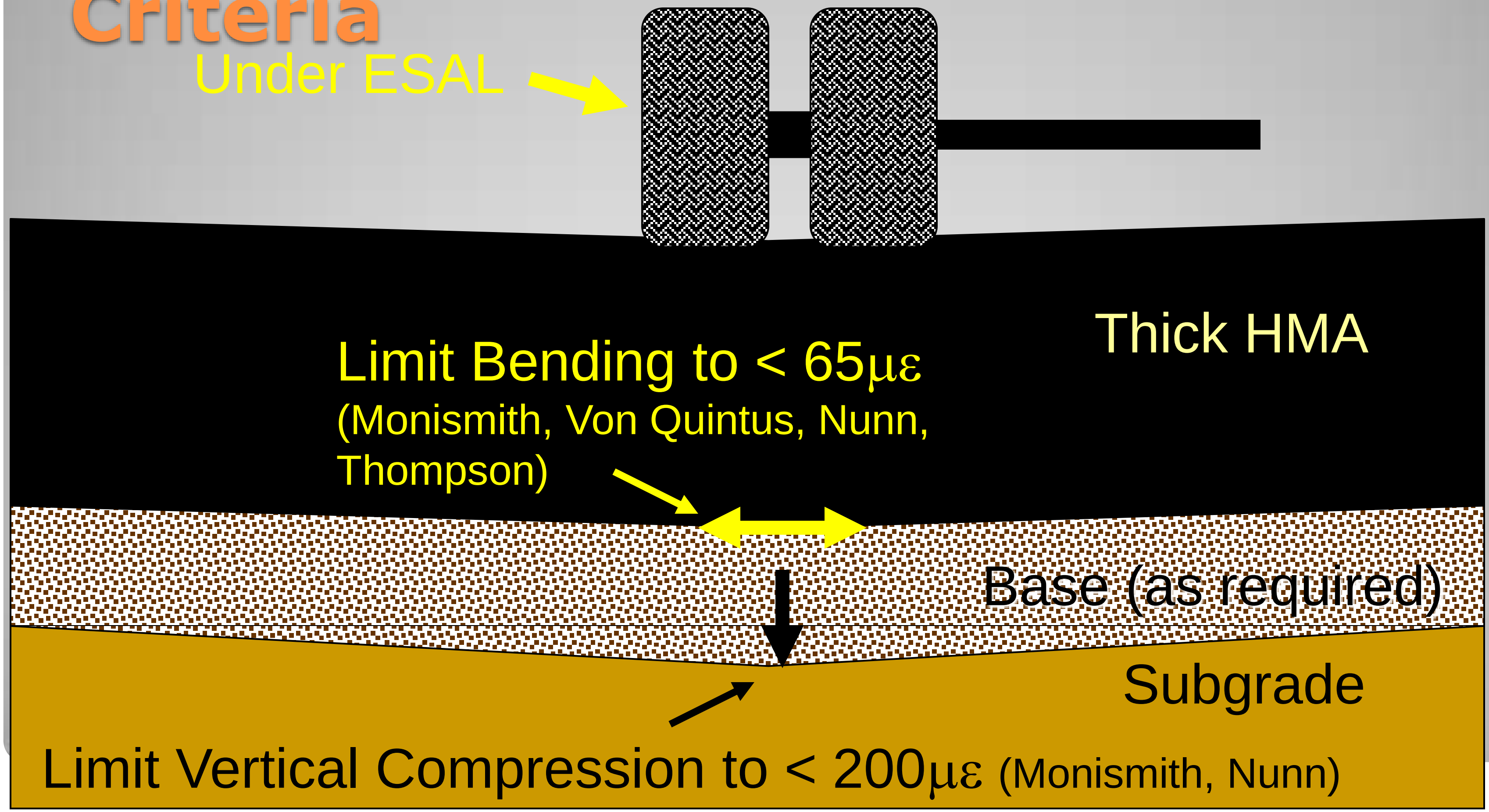

1.5 - 3″ SMA, OGFC or Superpave
4″
to
6″
Zone
Of High
Compression
High Modulus
Rut Resistant Material
(Varies As Needed)
Max Tensile Strain
Flexible Fatigue Resistant
Material 3 - 4″
Pavement Foundation

- Bottom-up Design and Construction
- Foundation
  - **Stable Paving Platform**
  - **Minimize Seasonal Variability and Volume Change in Service**
- Fatigue Resistant Lower Asphalt Layer
- Rut Resistant Upper Asphalt Layers

Mechanistic-Based Design



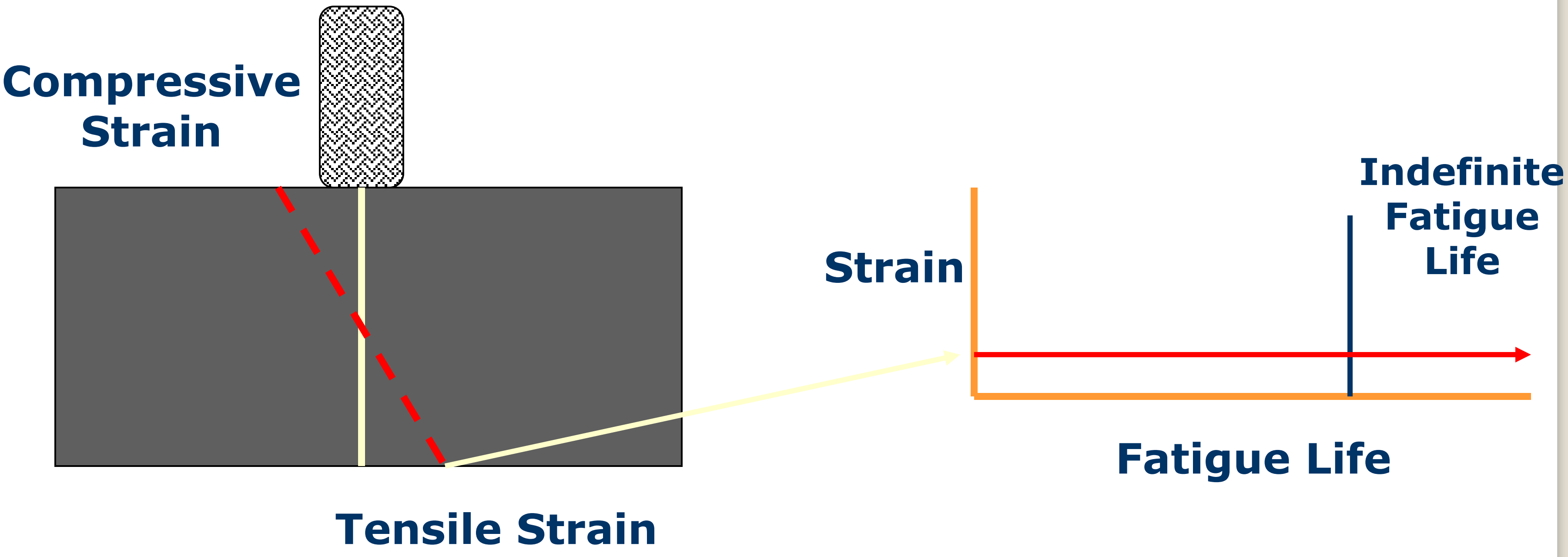
Mechanistic Performance Criteria



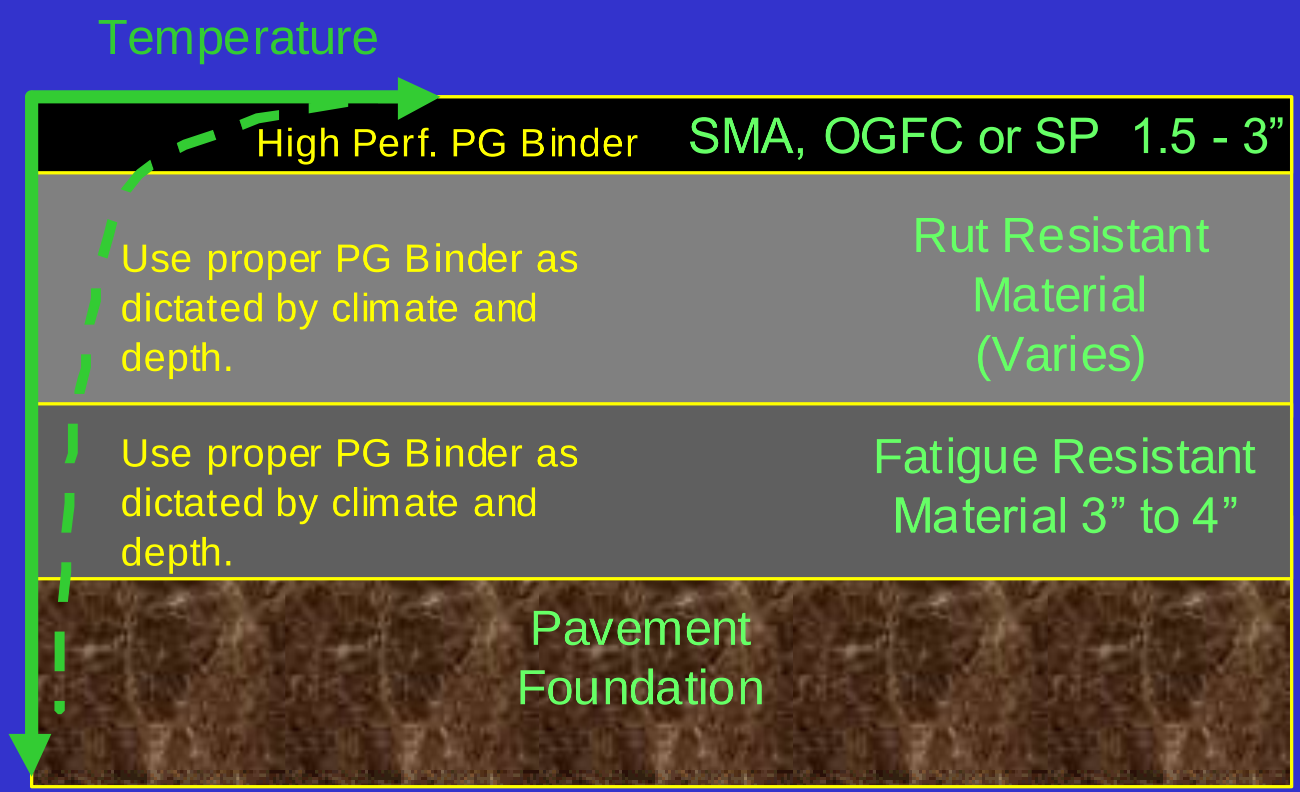
HMA Considerations

- HMA Base Layer
- Intermediate Layer
- Wearing Surface

- Fatigue Resistant Asphalt Base
  - Minimize Tensile Strain with Pavement Thickness
  - Thicker Asphalt Pavement = **Lower Strain**
  - Strain Below Fatigue Limit = **Indefinite Life**



- Rut Resistant Upper Layers
  - **Aggregate Interlock**
    - ***Crushed Particles***
    - ***Stone-on-Stone Contact***
  - **Binder**
    - ***High Temperature PG***
    - ***Polymers***
    - ***Fibers***
  - **Air Voids**
    - ***Avg. 4% to 6% In-Place***
  - **Surface**
    - ***Renewable***
    - ***Tailored for Specific Use***



Impact of Temperature Gradient on Asphalt Grade.

Performance of Washington Interstate Flexible Pavements (based on 180 miles)

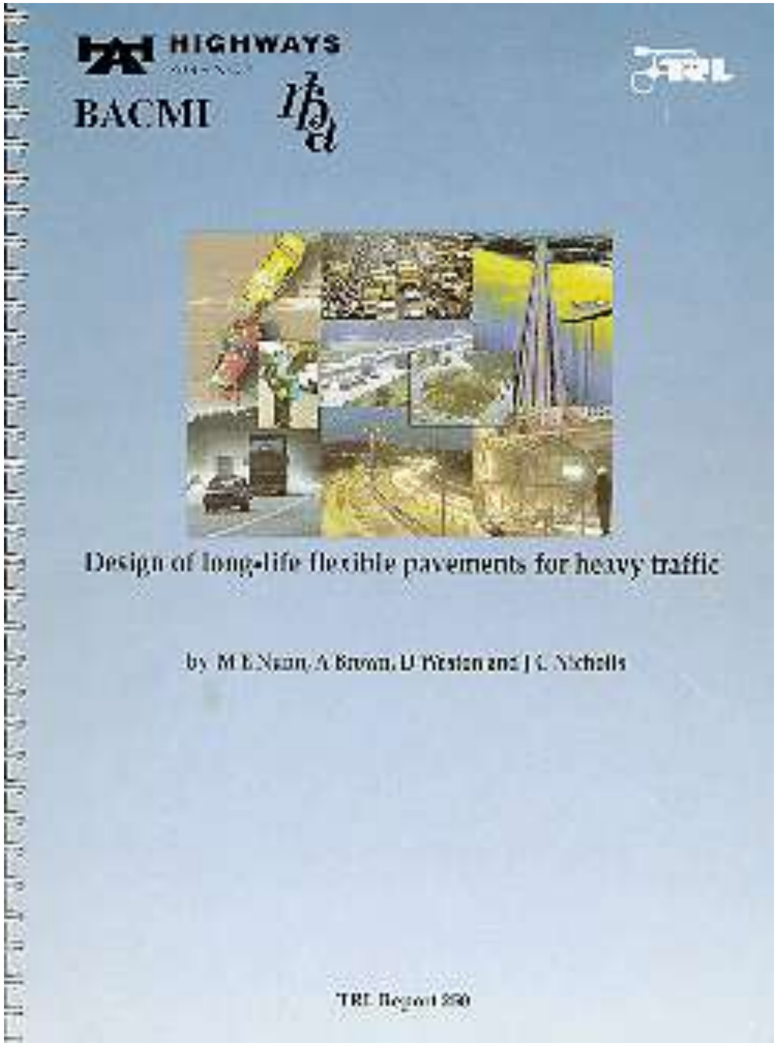
Statistic	Time Since Original Construction (years)	Thickness of Original AC (mm (in.))	Time from Original Construction to First Resurfacing (years)
Average	31.6	230 (9.2)	12.4
Range	23 to 39	100 to 345	2 to 25

Ohio Study of Flexible Pavements

- Examined Performance on 4 Interstate Routes
  - HMA Pavements - Up to 34 Years without Rehabilitation or Reconstruction
  - "No significant quantity of work . . . for structural repair or to maintain drainage of the flexible pavements."
  - Only small incremental increases in Present Cost for HMA pavements.

FHWA - Data from Long-Term Pavement Performance Study

- **Data from GPS-6 (FHWA-RD-00-165)**
- **Conclusions**
  - ***Most AC Overlays ≥ 15 years before Rehab***
  - ***Many AC Overlays > 20 years before Significant Distress***
  - Thicker overlays mean less:
    - Fatigue Cracking
    - Transverse Cracking
    - Longitudinal Cracking



TRL Report 250
Nunn, Brown, Weston
& Nicholls

Design of Long-Life Flexible Pavements for Heavy Traffic

http:\\www.trl.co.uk

Overall Summary

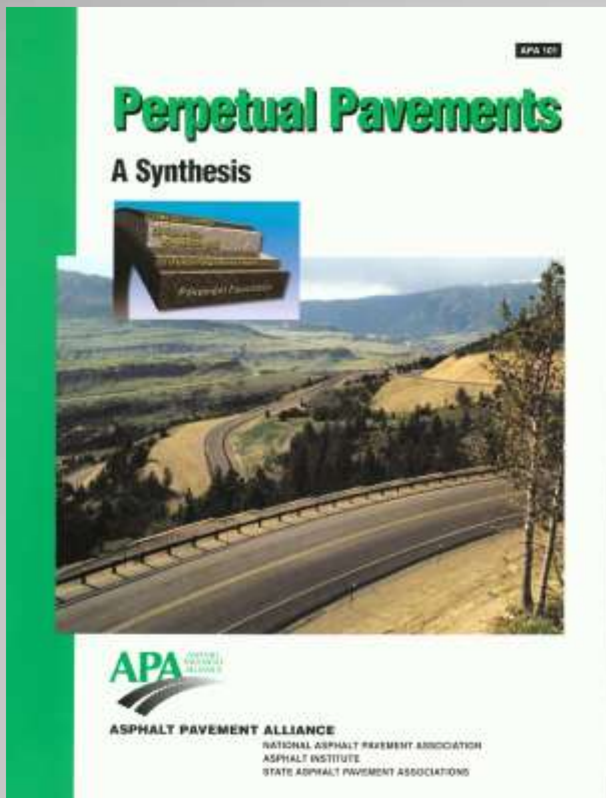
- No structural deformation or roadbase fatigue cracking.
- Distresses confined to surface
  - Rutting
  - Cracking
- Roadbase stiffens with age and reduces deflection.

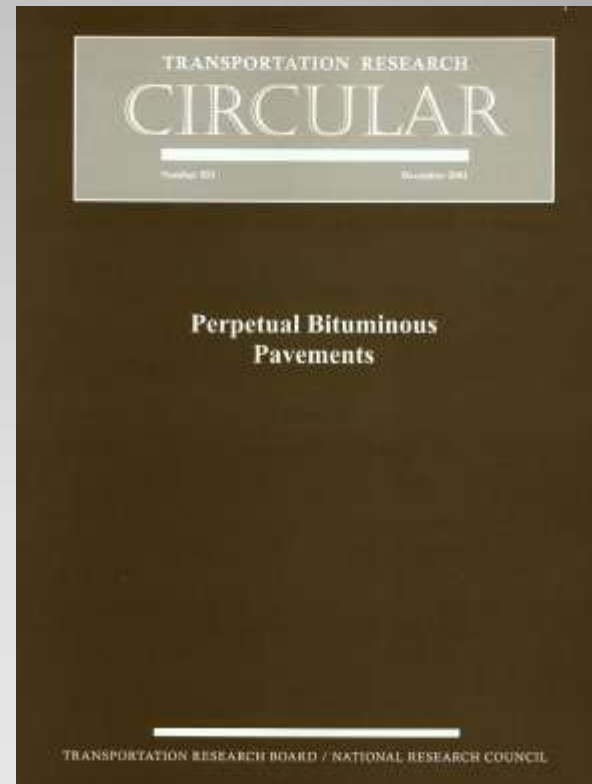

TRL

Perpetual Pavement

- Structure Lasts 50+ years.
  - Bottom-Up Design and Construction
  - Indefinite Fatigue Life
- Renewable Pavement Surface.
  - High Rutting Resistance
  - Tailored for Specific Application
- Consistent, Smooth and Safe Driving Surface.
- Environmentally Friendly
- Avoids Costly Reconstruction.

References

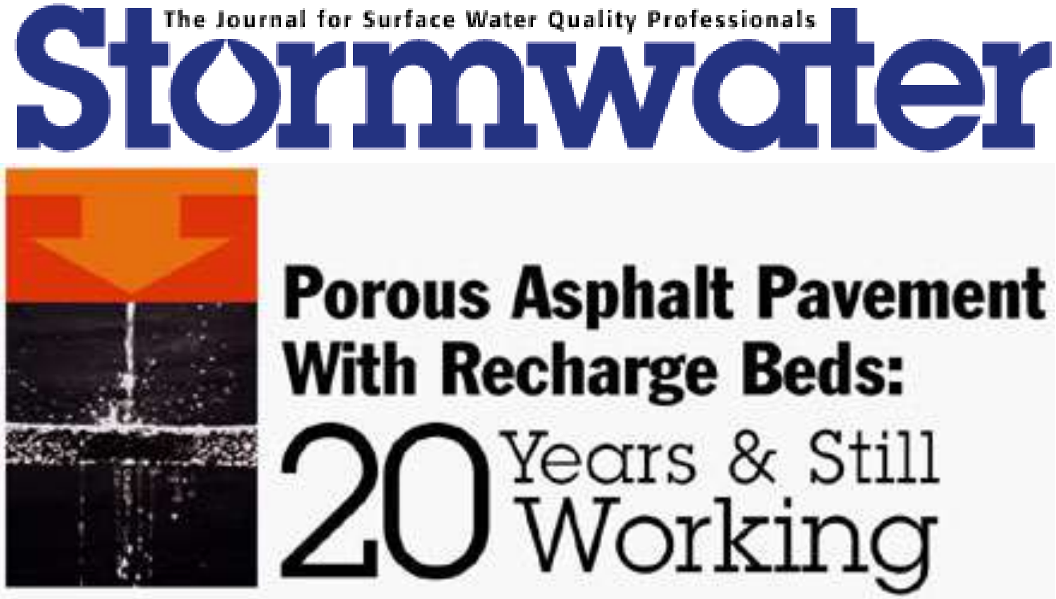




TRB Circular No. 503

On-line at www4.nas.edu

Porous Asphalt Pavement



"Is it possible to have a stormwater best management practice (BMP) that reduces impervious areas, recharges groundwater, improves water quality, eliminates the need for detention basins, and provides a useful purpose besides stormwater management? This seems like a lot to expect from any stormwater measure, but porous asphalt pavement on top of recharge beds has a proven track record."

Porous Asphalt Pavement

Gap Graded, Fines Starved, High A/C Content HMA

On Infiltration Bed/Drain Rock

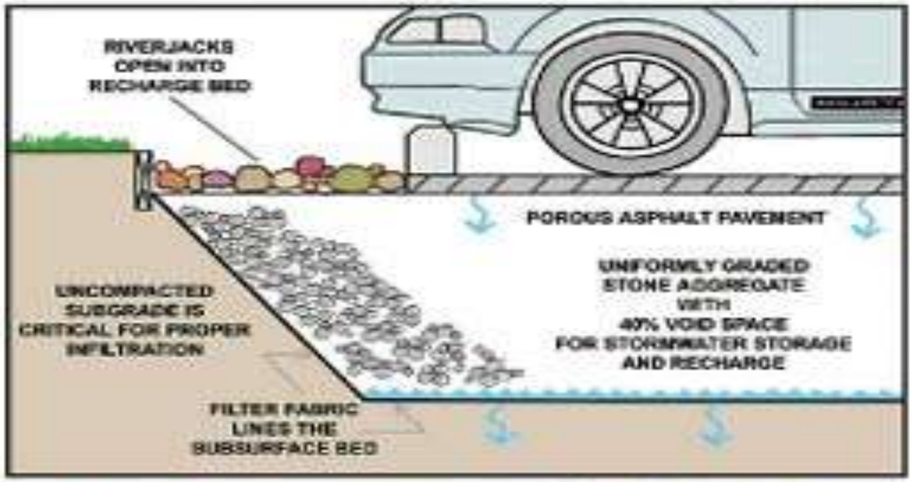
Standard Porous Asphalt Mixes

Sieve Size	% Passing
1/2 in.	100
3/8 in.	95
#4	35
#8	15
#16	10
#30	2

Percent bituminous 5.75-6.0% by weight

Infiltration Bed

Recharge Trench


RIVERJACKS OPEN INTO RECHARGE BED
POROUS ASPHALT PAVEMENT
UNIFORMLY GRADED STONE AGGREGATE WITH 40% VOID SPACE FOR STORMWATER STORAGE AND RECHARGE
UNCOMPACTED SUBGRADE IS CRITICAL FOR PROPER INFILTRATION
FILTER FABRIC LINES THE SUBSURFACE BED


porous asphalt
standard asphalt

Deicing and Freezing Issues

“One of the most common questions relates to concerns about freezing conditions. Freezing has not been an issue, even in very cold climates. We were quite surprised when the owners of early installations first told us that there was less need to snowplow on the porous pavement surfaces. The underlying stone bed tends to absorb and retain heat so that freezing rain and snow melt faster on the porous pavement. The water drains through the pavement and into the bed below with sufficient void space to prevent any heaving or damage, and the formation of "black ice" is rarely observed. The porous surfaces tend to provide better traction for both pedestrians and vehicles than does conventional pavement. Not a single system has suffered freezing problems”

Thermal & Compaction Technology

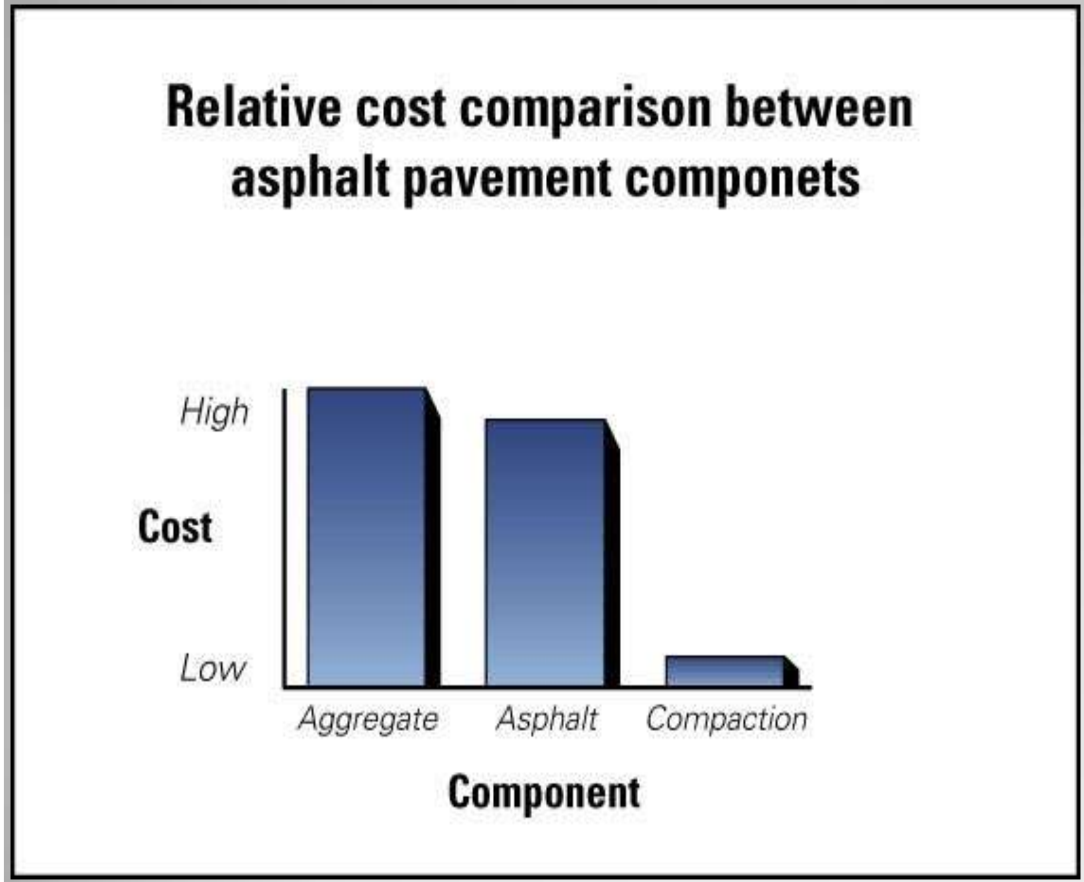
Temperature Control
Intelligent Compaction

www.AsphaltAlliance.com

Mix Temperature

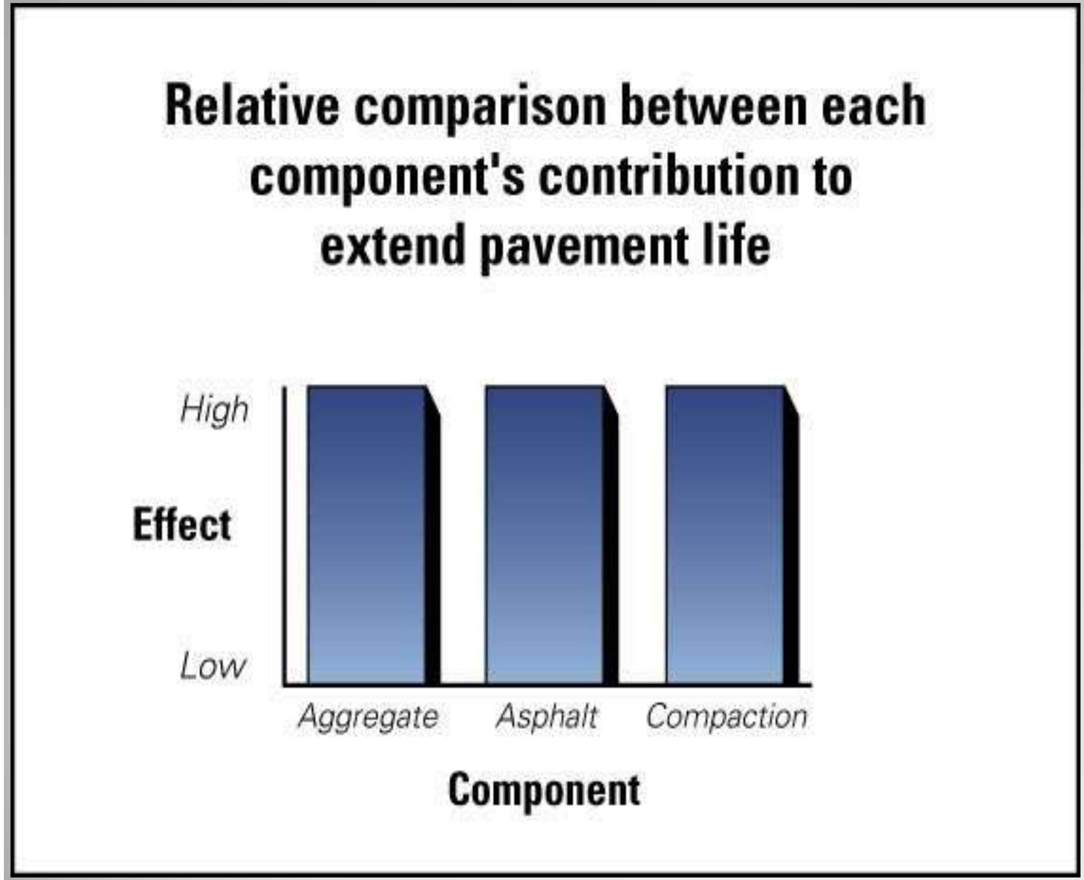
- Major Factor in Compaction/Density
- Compaction/Density Major Factor in Pavement Durability
- Uniformity & Consistency, as in all paving operations, are equally important in the final operation: Rolling
- Segregation (mechanical) and Longitudinal Joint Failures are two major contributing factors on premature failure or reduction of pavement life

Cost of Compaction



- Least expensive part of the paving process
- Aggregates and oil are expensive in comparison
- Compaction adds little to the cost of a ton of asphalt

Effect of Compaction



- Compaction is equally important in extending pavement life
- Saves money in maintenance costs
- Understanding compaction is very important

Importance of Compaction

- Improve Mechanical Stability
- Improve Resistance to Permanent Deformation
- Reduce Moisture Penetration
- Improve Fatigue Resistance
- Reduce Low-Temperature Cracking Potential

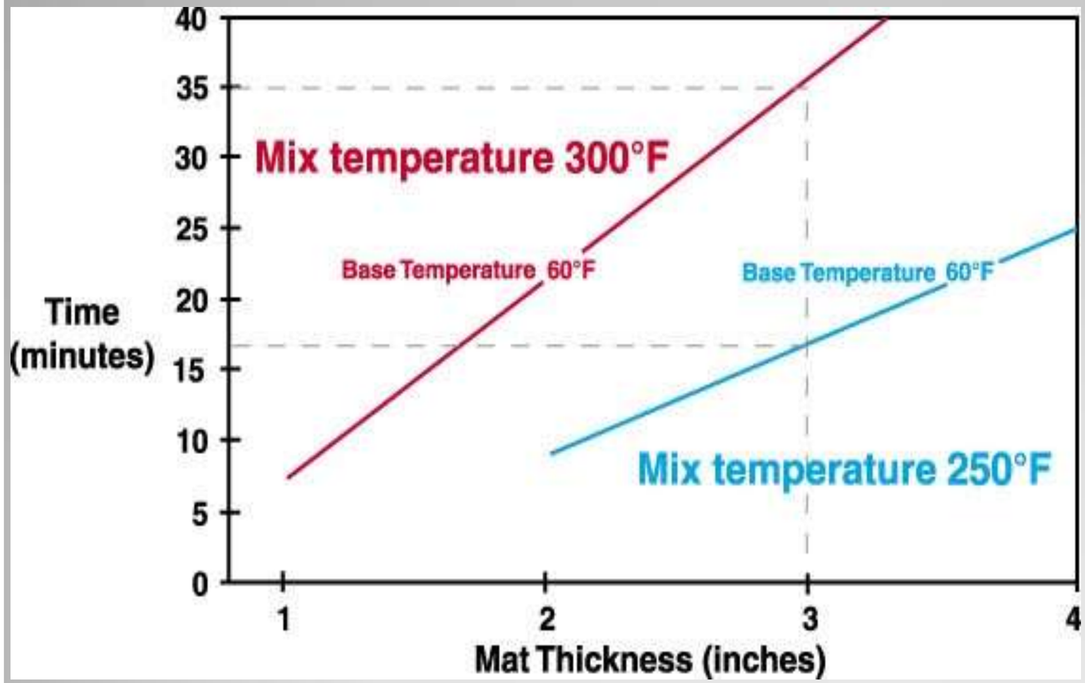
Factors Affecting Compaction

- Properties of the Materials
- Environmental Variables
- Laydown Site Conditions

Mix Temperature

- Major effect on compaction
- Must compact while oil is still fluid enough to allow aggregate movement
- When oil is stiff, aggregates lock

Time Available for Compaction



- Temperature of mat passing under screed affects mat workability
- Work close to paver when mat is cool
- Add rollers when mat is cool
- Use more force if possible

Intelligent Compaction

- Proper in-place density is vital for good performance
- Conventional compaction equipment and procedures have limitations…

- **Intelligent compaction technology goal is to find *"a better way"***

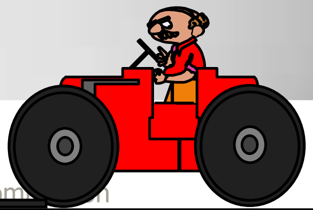
Conventional Limitations

- Provides little or no “on the fly” feedback for roller operator
  - Better if constant feedback is provided during the compaction process
- Over or under-compaction often occurs
  - Better if operator can tell when and if density has been obtained

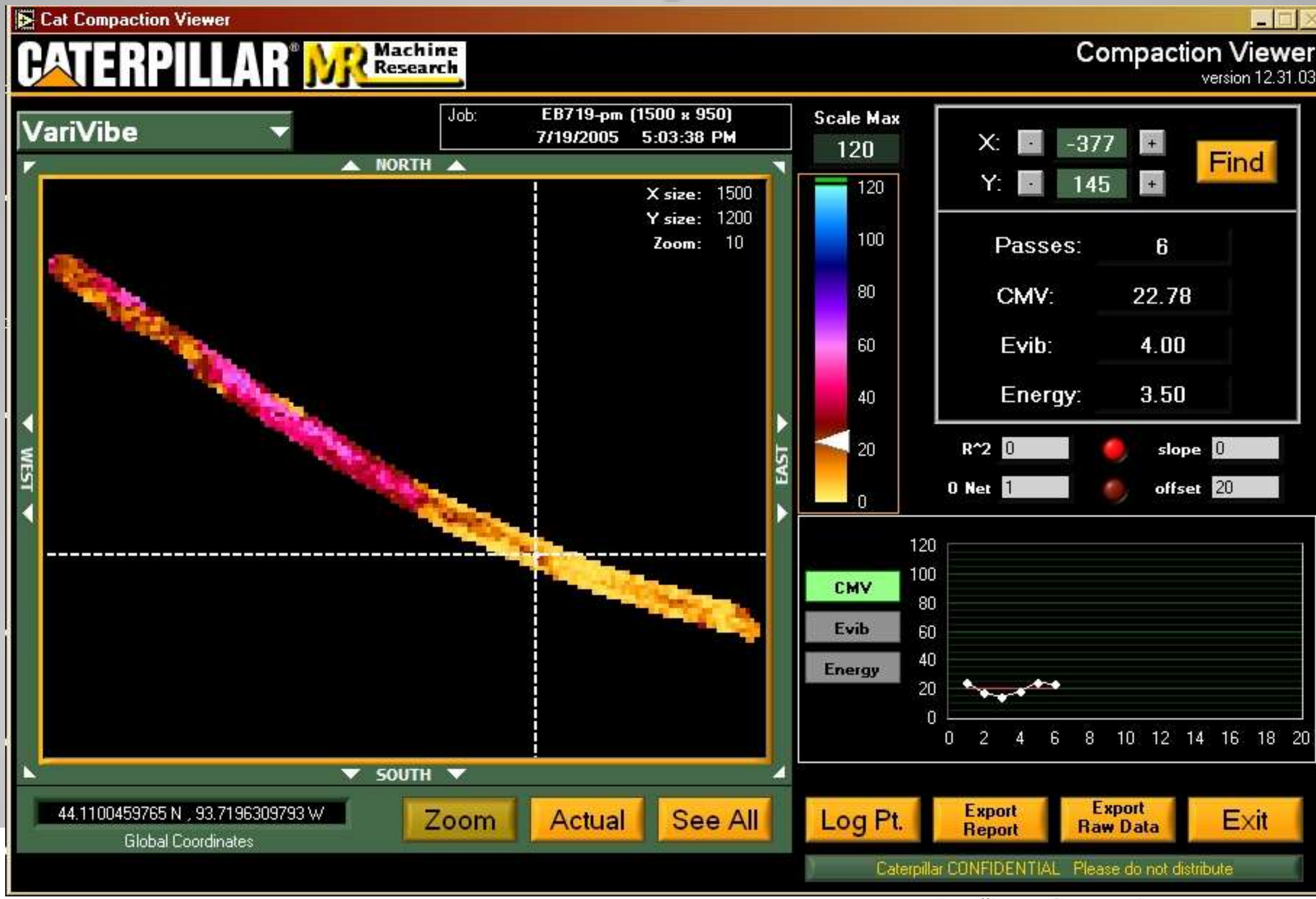
IC TPF / FHWA Definition

GPS-based documentation systems

- Continuous recordation of materials stiffness
- Continuous recordation of corresponding roller location
- Color-coded mapping of stiffness, temperature and number of passes



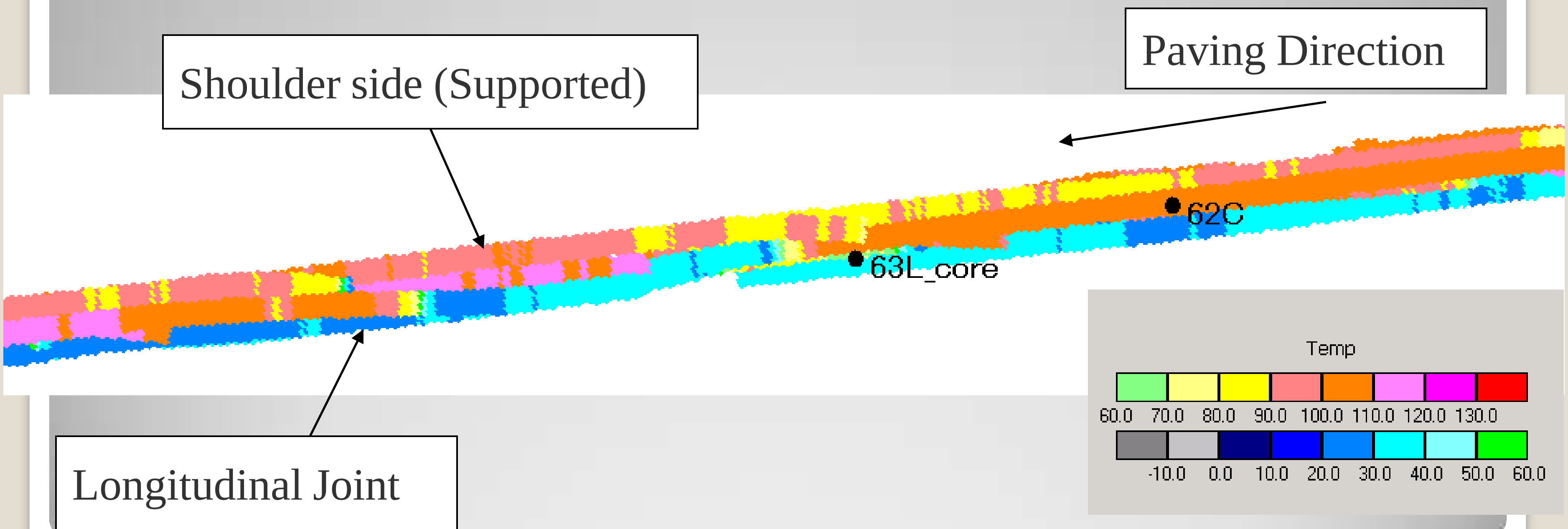
Caterpillar



Courtesy of Caterpillar

Sakai IC Roller Project

- Temperature



Common Methods of Measuring Thermal Segregation

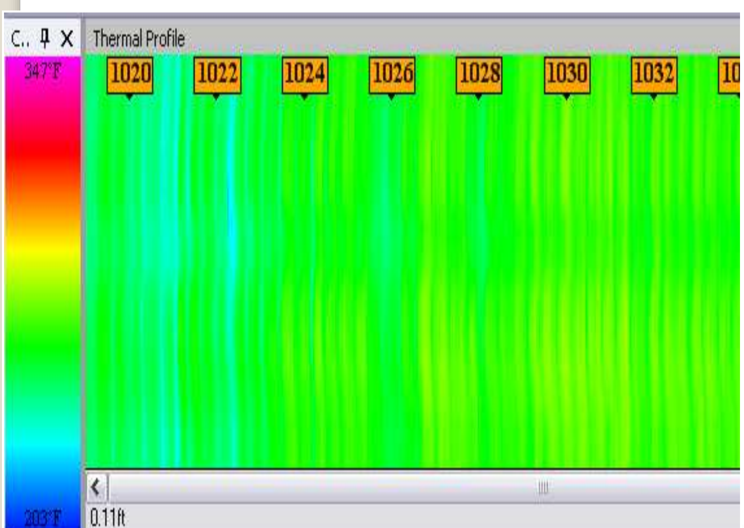
- *Infrared Thermometers – less than $200*
- *Infrared Cameras – less than $5K*
- *Pave-IR System – less than $30K*



Comparison of Thermal Profiling Techniques

Test Device	Strengths	Weaknesses
Handheld IR Thermometer	Inexpensive. Simple to use. Tests independent of paving train.	Requires constant operator attendance. May miss localized defects. No permanent record.
IR Camera	Inexpensive. Simple to use. Tests independent of paving train. More coverage than thermometer.	Requires constant operator attendance. May miss localized defects. No permanent record (usually).
Pave-IR	Does not require constant operator attendance. Provides real-time feedback. Tests virtually full-coverage. Automated data reduction. Permanent record.	Most costly device. Testing coverage could impact risk of finding defects. May include artificial cold spots in data set.

Example report from project with minimal thermal segregation



Tex-244-F Part II

Thermal Profile Summary Report

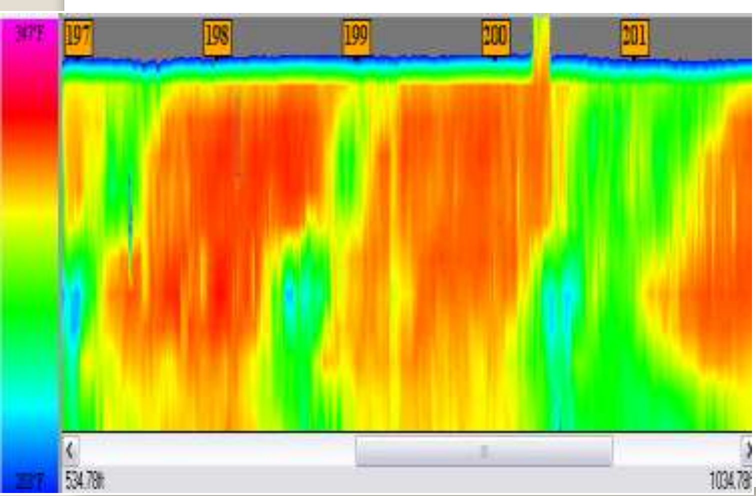
Profile ID:	Demo - minimal thermal segregation	Profile Date:	9/10/2009 5:13:42 PM
Profile Number:	1	Letting Date:	
Status:	Demonstration	Controlling CSJ:	
County:		Spec Year:	
Tested By:	SDS	Spec Item:	
Test Location:	1019	Special Provision:	
Material Code:	TY C HMA	Mix Type:	
Material Name:			
Producer:			
Area Engeneer:		Project Manager:	

Course/Lift:	1	Temperature Differential Threshold:	25.0
Segment Length (ft):	150	Sensors Ignored:	-

Thermal Profile Results Summary

Number of Profiles	Moderate 25.0°F < differential <= 50.0°F		Severe differential > 50.0°F	
	Number	Percent	Number	Percent
46	8	17	0	0

Example report from project with severe thermal segregation



Tex-244-F Part II

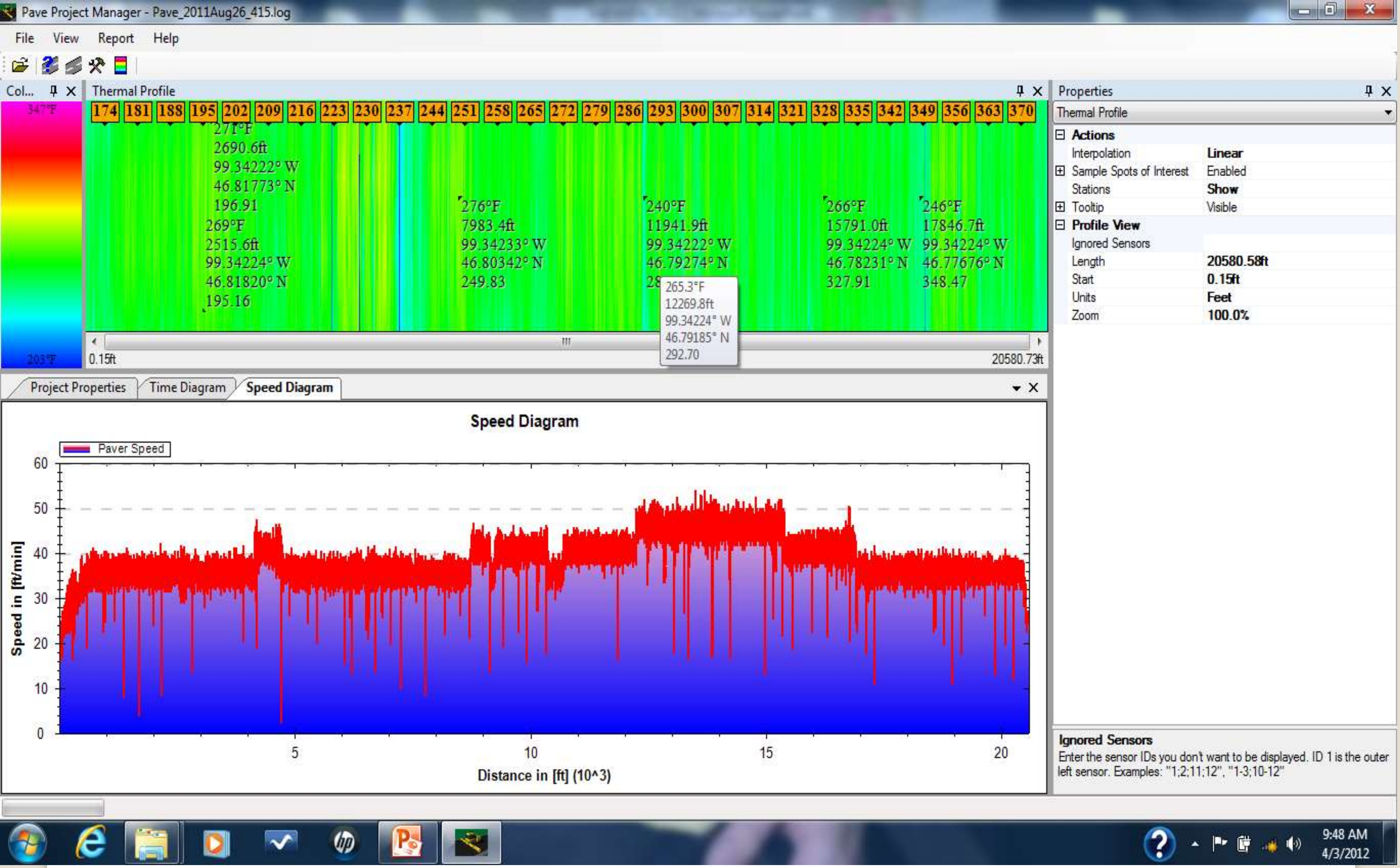
Thermal Profile Summary Report

Profile ID:	Demo - severe thermal segregation	Profile Date:	6/16/2010 5:07:33 AM
Profile Number:	1	Letting Date:	
Status:	severe	Controlling CSJ:	
County:	Demonstration	Spec Year:	
Tested By:	SDS	Spec Item:	
Test Location:	eb	Special Provision:	
Material Code:	SP 12.5	Mix Type:	
Material Name:	Superpave 12.5 PG 64-22		
Producer:			
Area Engeneer:		Project Manager:	

Course/Lift:	1	Temperature Differential Threshold:	25.0
Segment Length (ft):	150	Sensors Ignored:	-

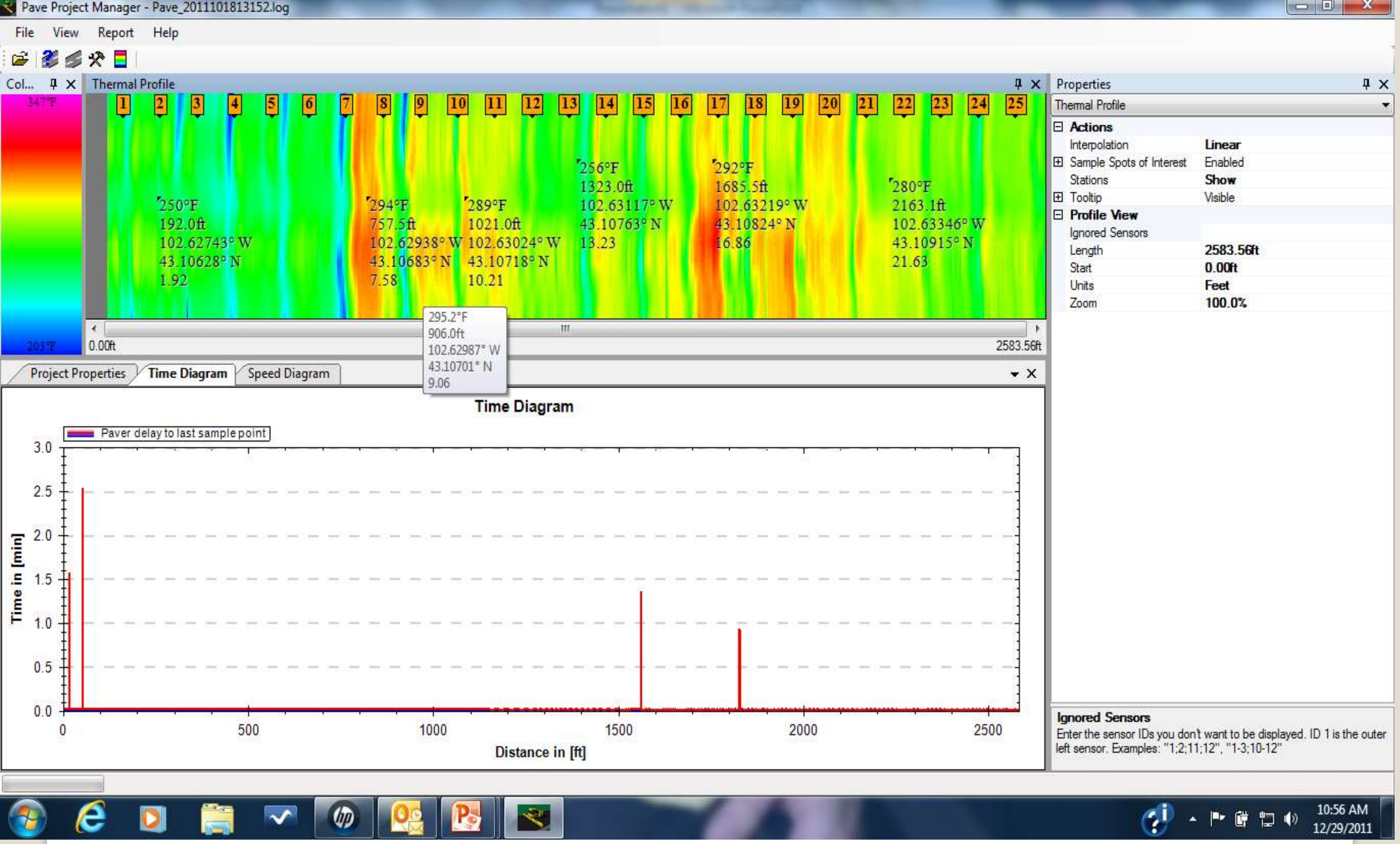
Thermal Profile Results Summary

Number of Profiles	Moderate 25.0°F < differential <= 50.0°F		Severe differential > 50.0°F	
	Number	Percent	Number	Percent
9	0	0	9	100

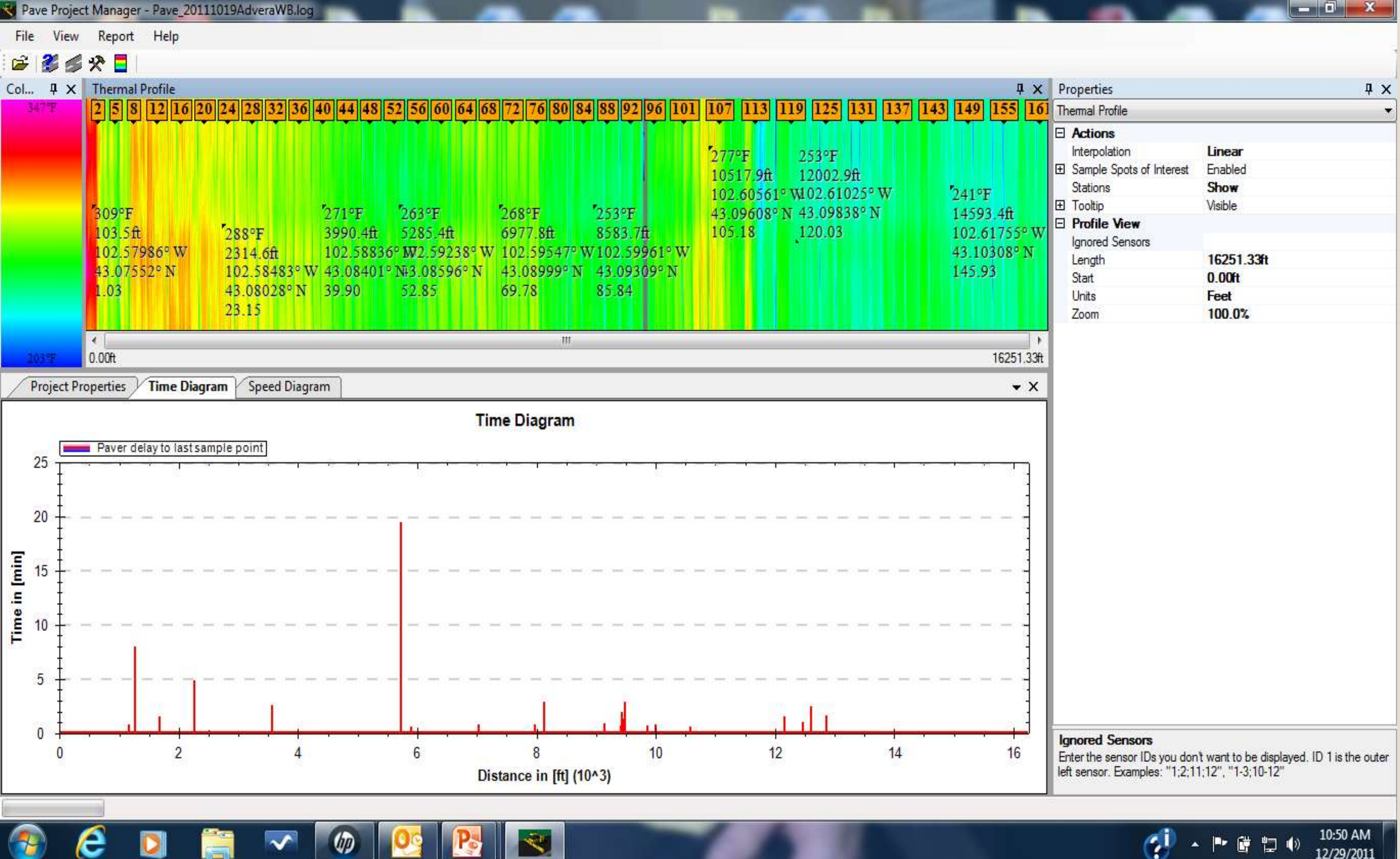


Data from ND 30

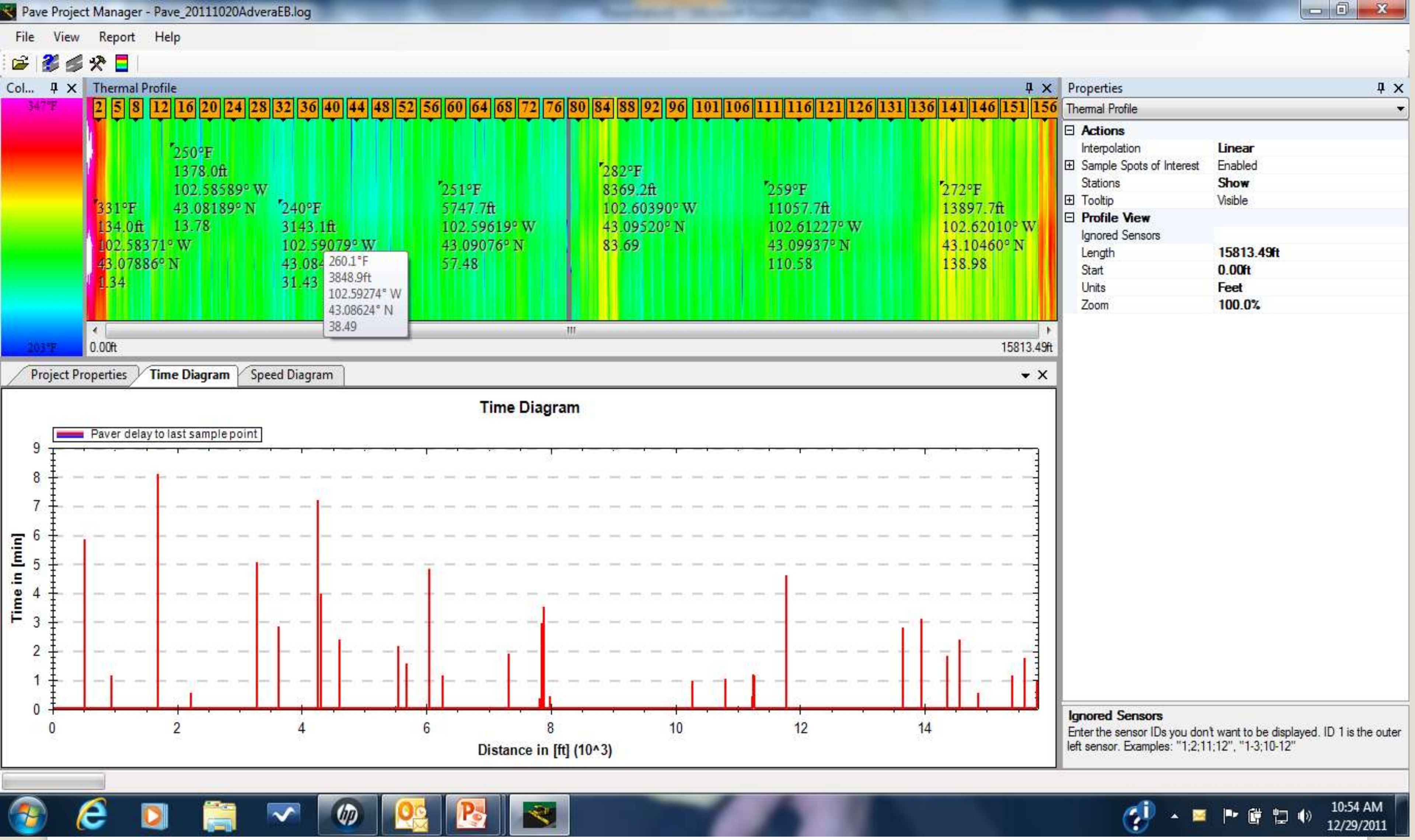
Border States Paving: 8/26/2011 (Conv. HMA)



Data from US 18 Oglala-Pine Ridge
Border States Paving: 10/18/2011 (Conv. HMA)



Data from US 18 Oglala-Pine Ridge WBL
Border States Paving: 10/19/2011 (Advera WMA)



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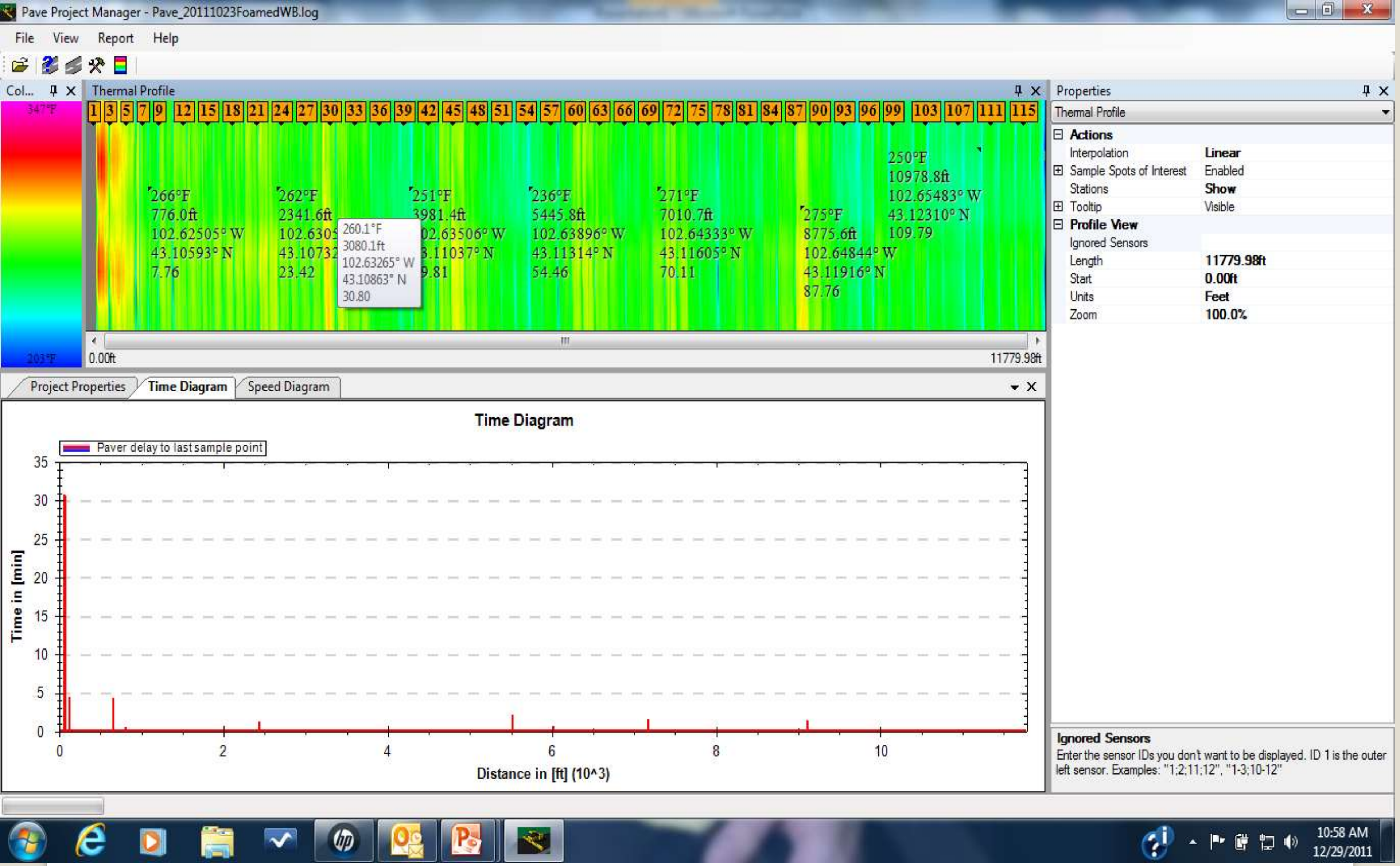
Border States Paving: 10/20/2011 (Advera WMA)



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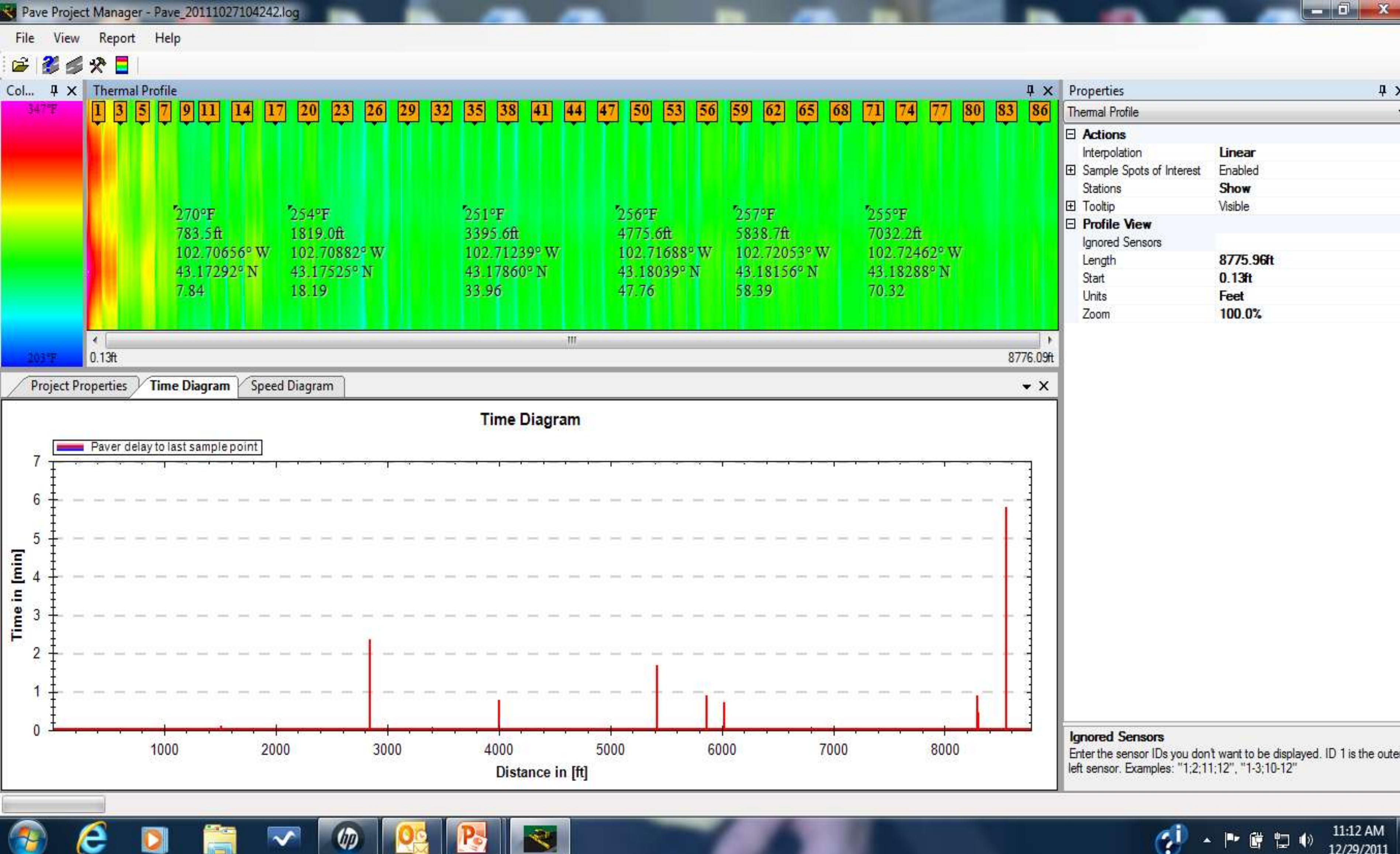
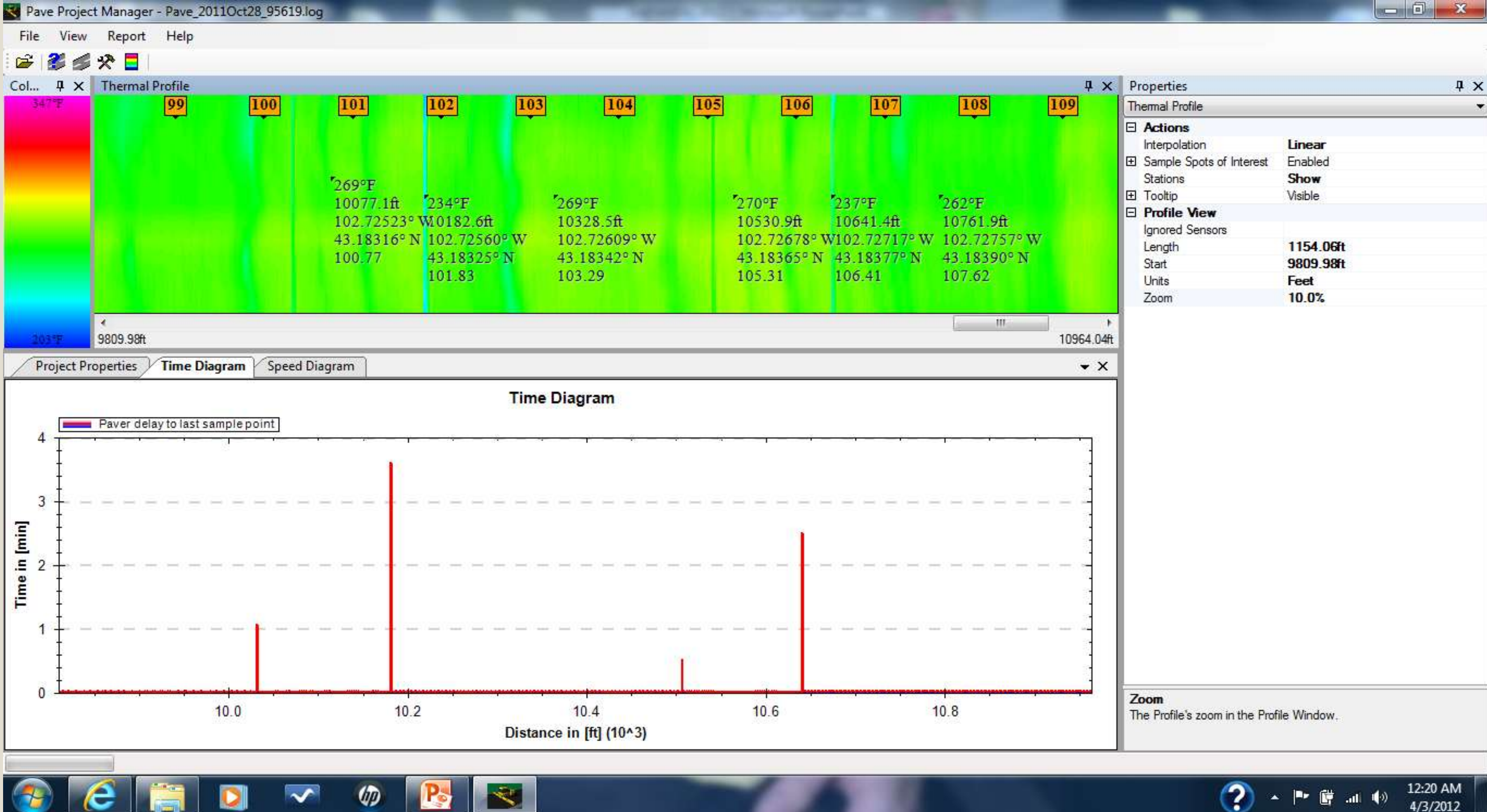
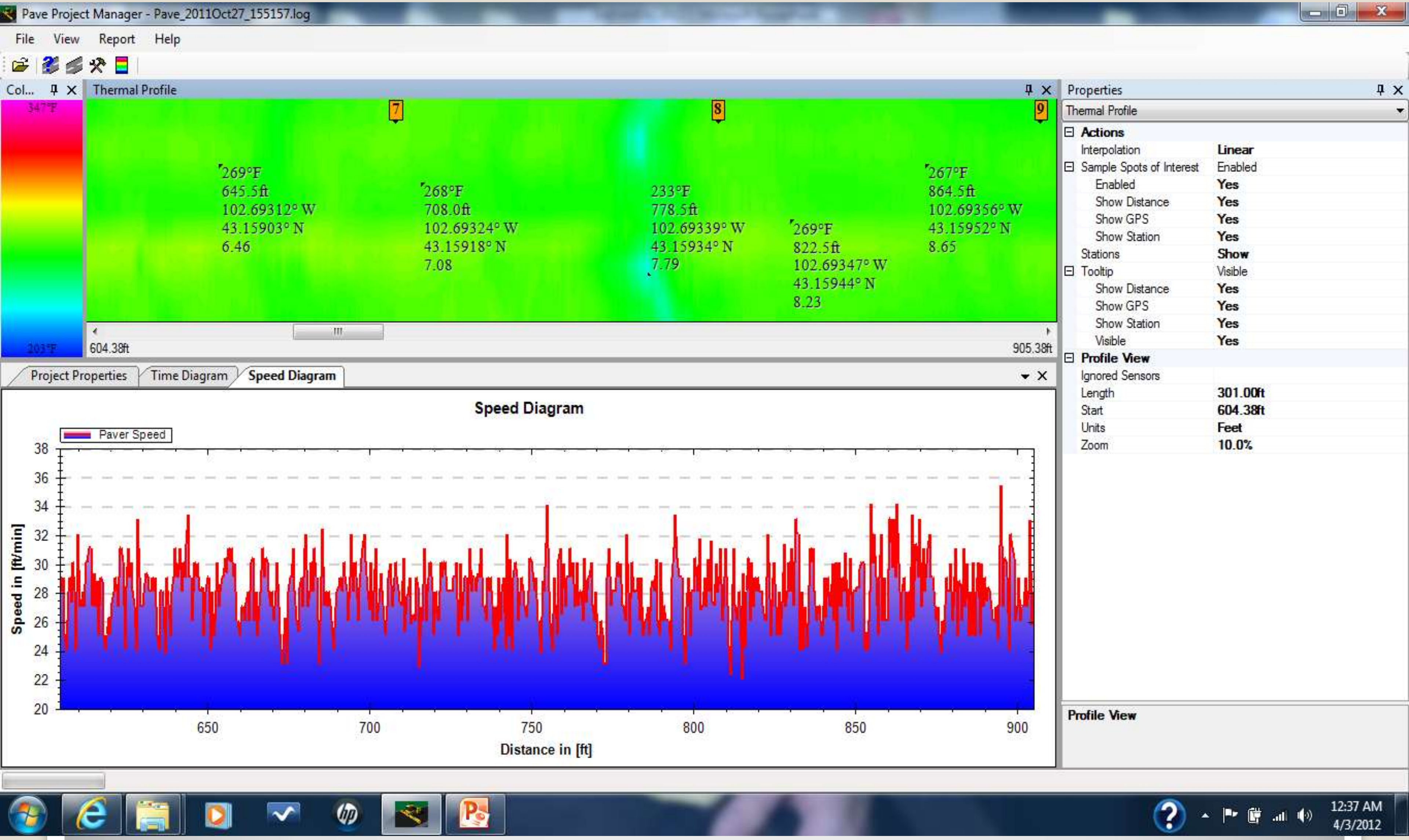
Border States Paving: 10/23/2011 (Foamed WMA)



Data from US 18 Oglala-Pine Ridge WBL
Border States Paving: 10/27/2011 (Evotherm WMA)



Data from US 18 Oglala-Pine Ridge EBL Border States Paving: 10/28/11 (Evotherm WMA)



Data from US 18 Oglala-Pine Ridge EBL
Border States Paving: 10/27/11 (Evotherm WMA)

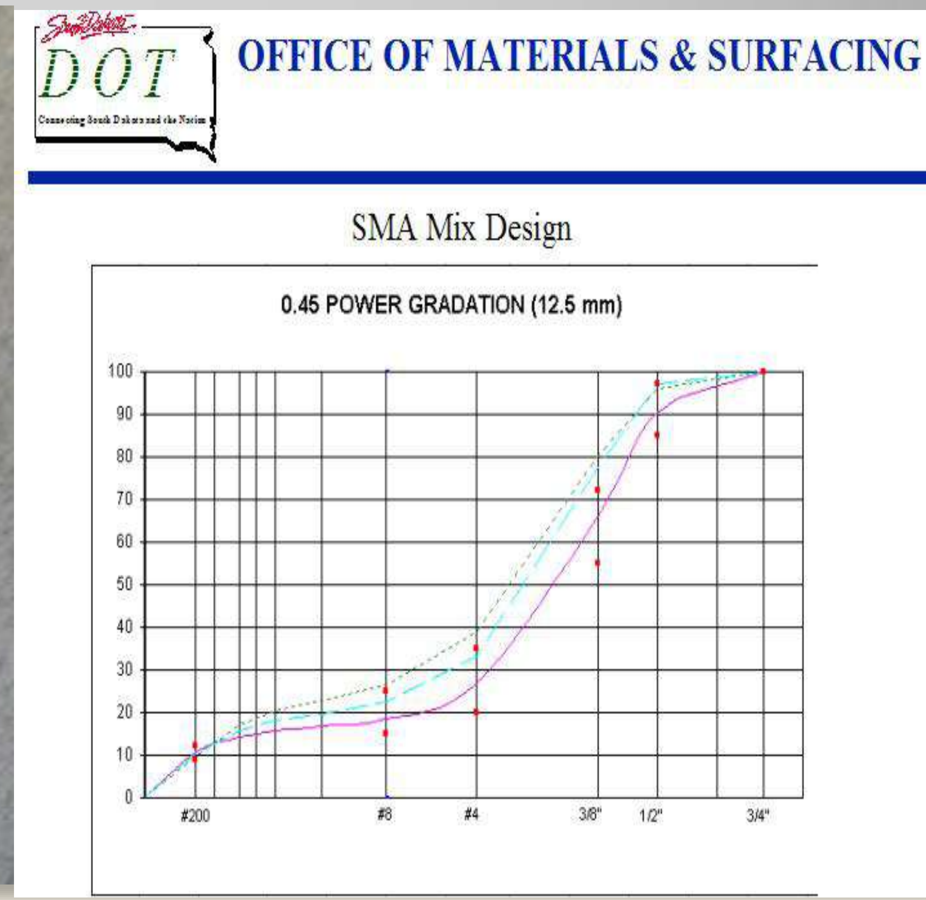
Conclusions

- *Physical & thermal segregation are the "Cancer of HMA Paving Industry"*
- *You cannot always see it. It grows with time. It often results in the early death of the pavement - often the only reason some HMA pavement are in need of rehabilitation*
- *There are many known & suspected causes & cures – No consensus*
- *Identifying & Eliminating Thermal Segregation is a Major Goal for Quality Paving*

Wearing Course Alternatives

- Chip Seal
- Slurry Seal
- Microsurfacing
- Dense Graded Hot Mix Asphalt
- “Engineered” Wearing Course

SMA (Stone Matrix Asphalt) & Smaller Aggregate Size (NMAS) Durable Wearing Courses



Rut Resistant Wearing Course?

I-29 Sioux Falls South SMA

Review of HMA Research Projects at UND Funded by NDDOT

Presented to the DAPA Annual Meeting, Deadwood, SD

January 8-9, 2009

Presented by

Nabil Suleiman, Ph.D.
Civil Engineering Department
University of North Dakota

Evaluation of North Dakota’s 4.75 mm Local Gyratory Mixtures for Thin Overlay Applications

4.75 mm Mix Project

- Objectives
  - To evaluate the rutting resistance performance of the 4.75 mm mixes
  - To evaluate benefits/impacts of the 4.75 mm mixes as thin overlays or as maintenance appl. for med. to low vol. highways
  - To show that the 4.75 mm NMAS mixtures are useful in providing utility for fine aggregate stockpile screenings

Original Scope

- Prepare local Superpave samples (4.75 mm NMAS)
  - Binder: ....PG 64-28, PG 58-28
  - Aggregate blend (%NF/%CF): ..100/0;80/20;60/40
  - Aggregate gradation: ....4.75 (#4) NMAS
  - Mix Design Air Voids: 4%
  - APA Air Voids: 7%
- Perform volumetric analysis
- Conduct rut tests using the APA .. Dry and wet

Gradations

Aggregate	Nat. Fines	Crushed Fines
Sieve Size	% Passing	% Passing
5/8" (16mm)	100.0	100.0
1/2" (12.5mm)	100.0	100.0
3/8" (9.5mm)	100.0	99.0
#4 (4.75mm)	96.2	94.9
#8 (2.36mm)	86.1	71.8
#16 (1.18mm)	71.3	47.1
#30 (0.6mm)	50.7	31.0
#50 (0.3mm)	25.4	18.8
#100 (0.15mm)	8.5	11.9
#200 (0.075mm)	5.5	8.9

4.75 mm Mix Project

- **Issues**
  - Realizing the utility of the 4.75 mm mixes as low-cost rut-resistant thin overlays for med. or LVR
  - A cost-effective maintenance treatment alternative
  - Providing use for CFs and NFs
  - Benefit to roadway agencies, local HMA producers, and local aggregate producers on issues regarding aggregate availability and specification compliance

4.75 mm Mix Project

- **Implementation**
  - If research study is successful, thin-lift applications of the 4.75 mm mixes can be implemented as cost-effective overlays for medium and LVR roads.
  - The 4.75 mm mixtures can also be implemented as a low-cost maintenance treatment alternative for almost all pavement types

- Thanks!
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