

# RUTGERS Asphalt Paving Conference

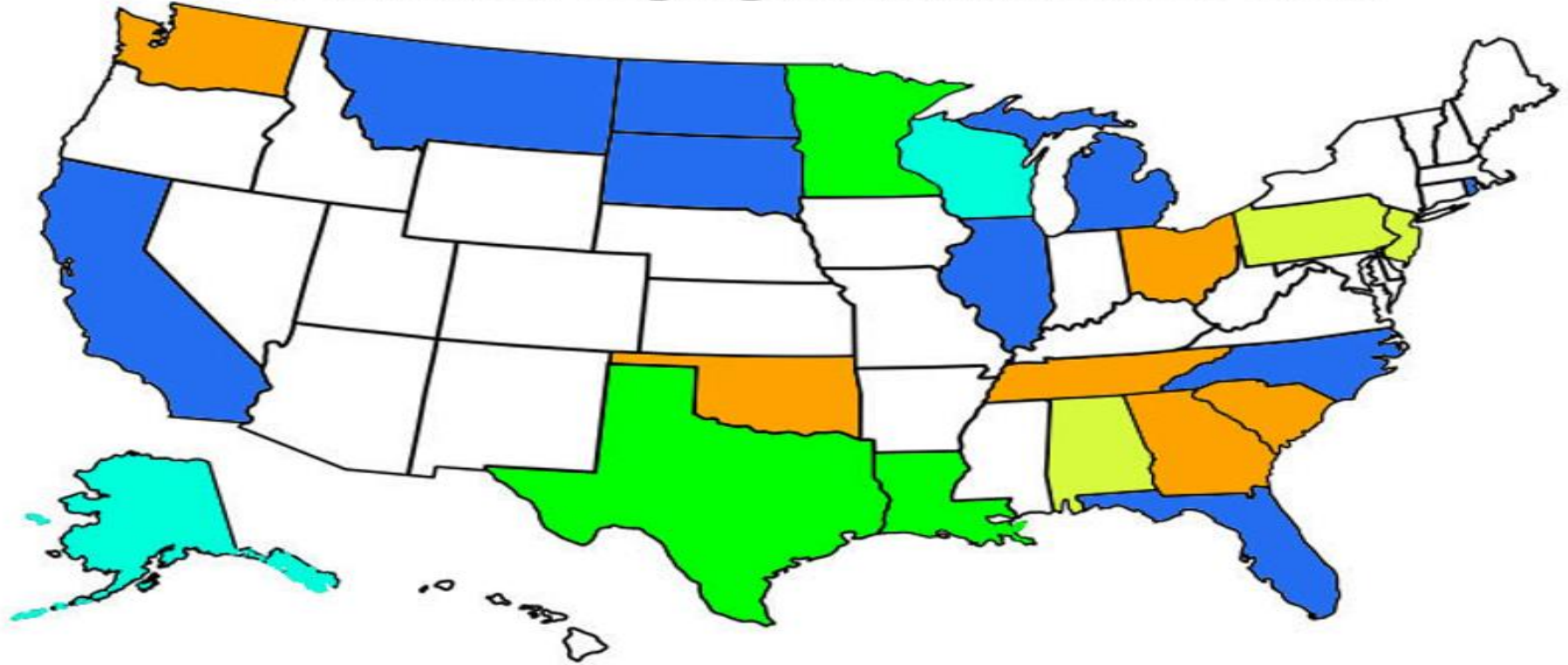
March 24-25, 2014

# PAVE IR UPDATE

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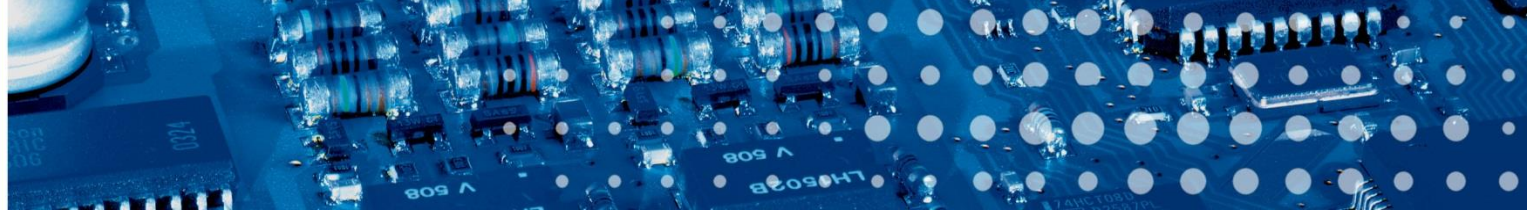


## U.S. Thermal Segregation Initiative Status



-  Pave-IR Specified
-  Pilot Projects
-  System Demonstrations

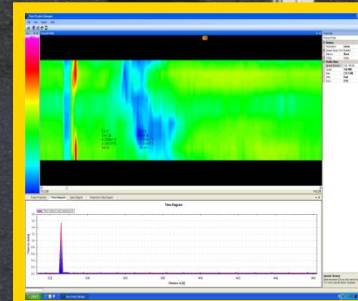
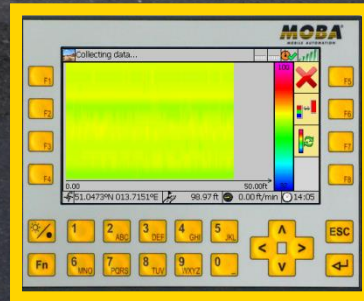
-  Specification in Progress
-  University Research



New QC/QA Technology for Asphalt Contractors/DOTs

# *Thermal Segregation (unseen enemy)*

**PAVE-IR  
Update**



# Topics

- The Problem
- Time line: A ten year journey on identifying the problem and how to fix it
  - 1995-1996
  - 1998
  - 1999
  - 2000
  - 2001-2006
- Washington DOT study
- 64 Projects

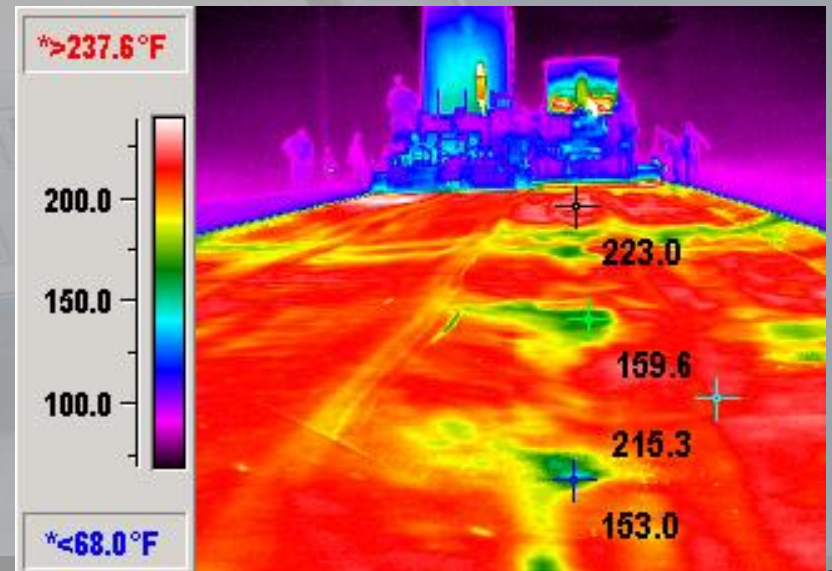
# The Problem

- Localized “spots” of coarse surface texture
- Premature failure due to fatigue cracking, raveling, and moisture damage
- Increased roughness



# The Problem

- Cooling of mix during transport is not remixed during the laydown process.
- Paver Set-up
- Results in erratic mat temperatures that are not apparent to the laydown crew.



# Data Collected

- Haul distance and time
- Weather conditions
- Equipment
  - Type of truck
  - MTV/MTD
  - Paver
  - Roller
- Nuclear density data
- Temperature data
  - Infrared camera
  - Probes
  - Hand held infrared thermometer
- Plant information
  - Temperature of mix
  - Loading operations
- Mat Placement

# 1998 Conclusions

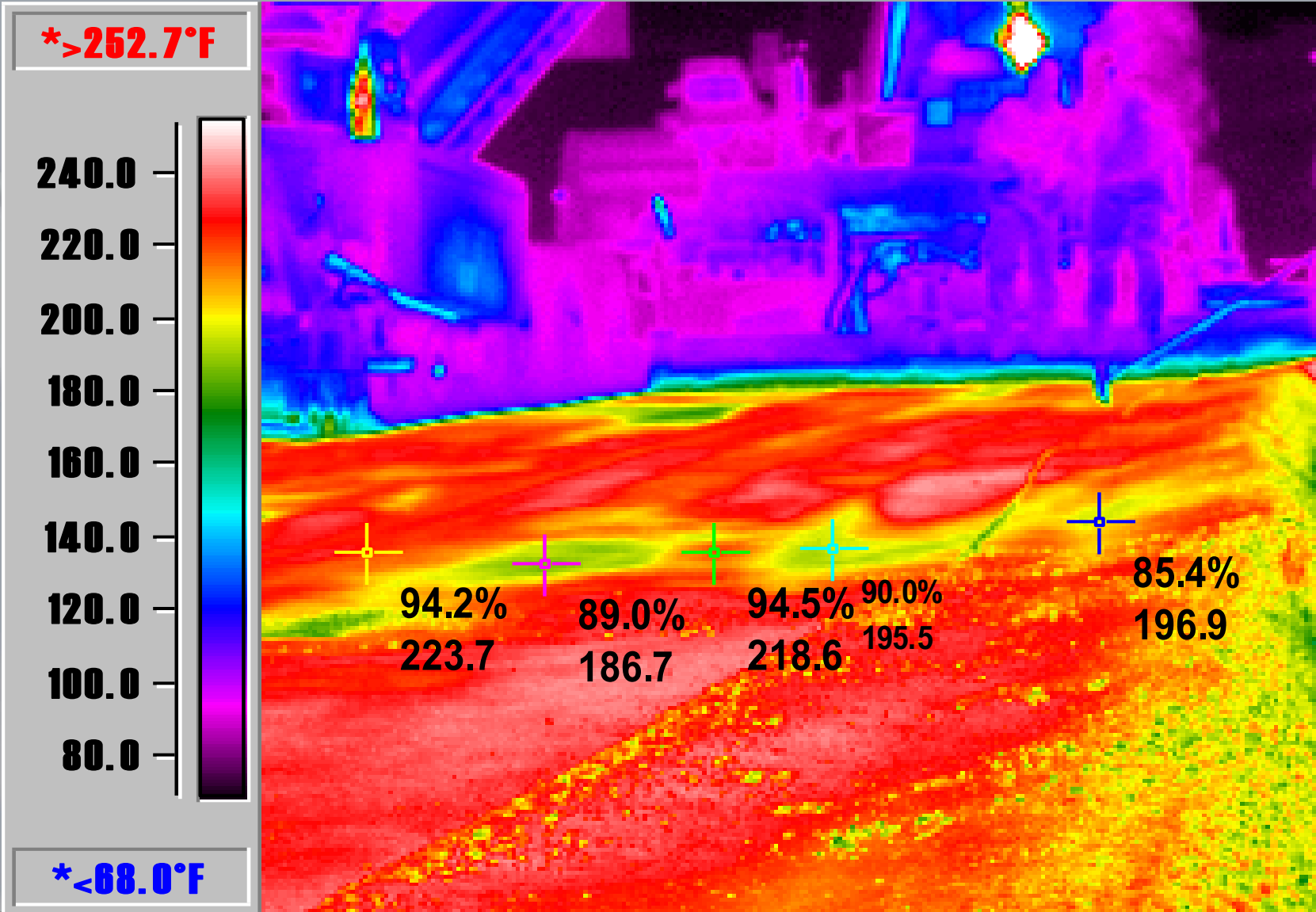
- None of the 4 projects experienced significant aggregate segregation.
- All 4 projects experienced significant temperature differentials.
- Concentrated areas of significantly cooler HMA generally resulted in lower than desirable compaction of those areas.



# 1998 Conclusions (cont.)

- Concentrated areas of cooler HMA commonly occur during construction (based on this study and others).
- Good rolling practices can partially offset temperature differential related compaction problems.
- MTVs not specifically examined.
- Temperature differentials are easily identified by infrared imaging.

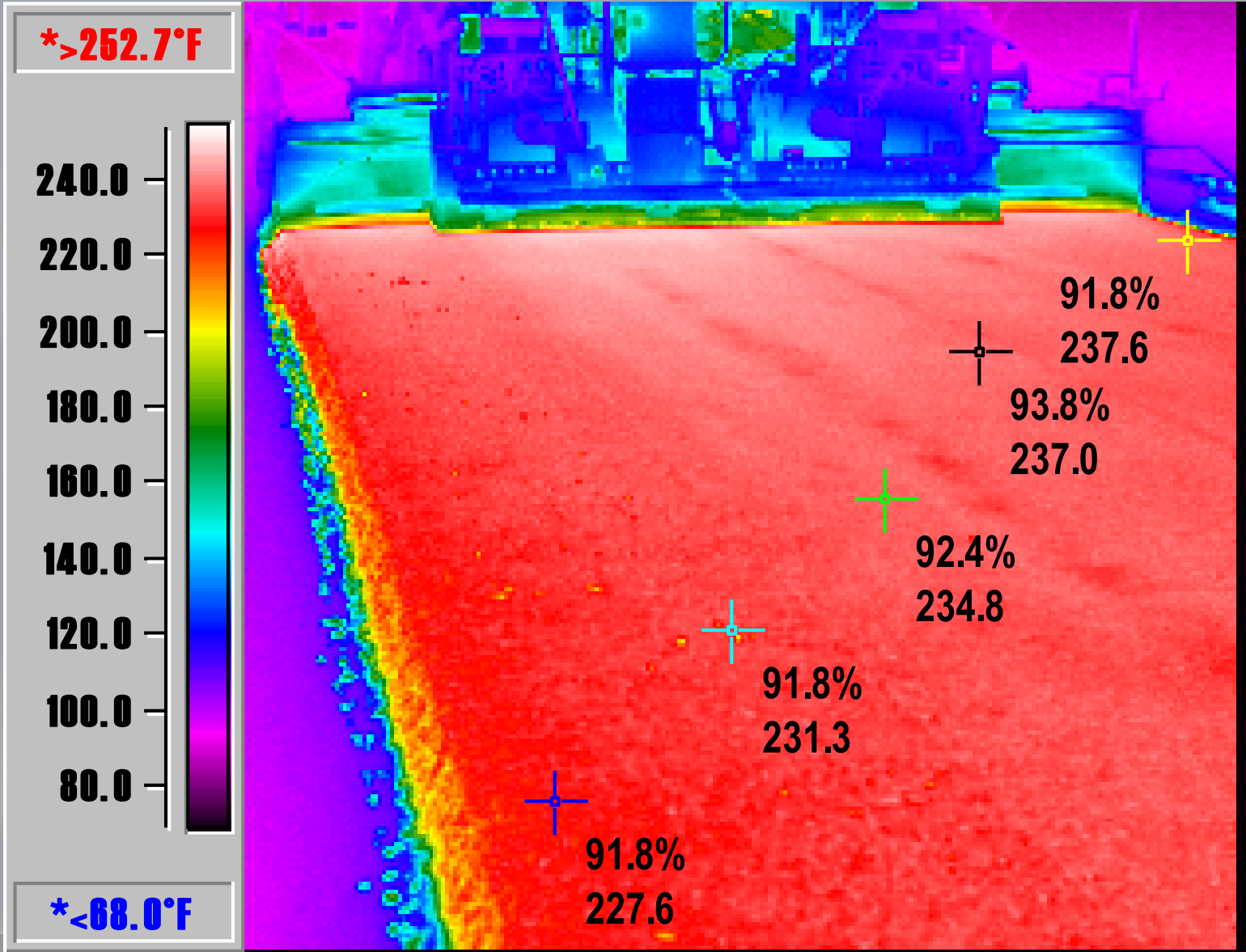
# End Dump/No MTV



# 1999 Study Objectives

- Investigate the effectiveness of different MTVs and remixing devices/methods
- Investigate other possible mitigation techniques
- Reexamine criteria for when and where to use MTV's
- 64 Projects Studies

# End Dump/ MTV



SR 12

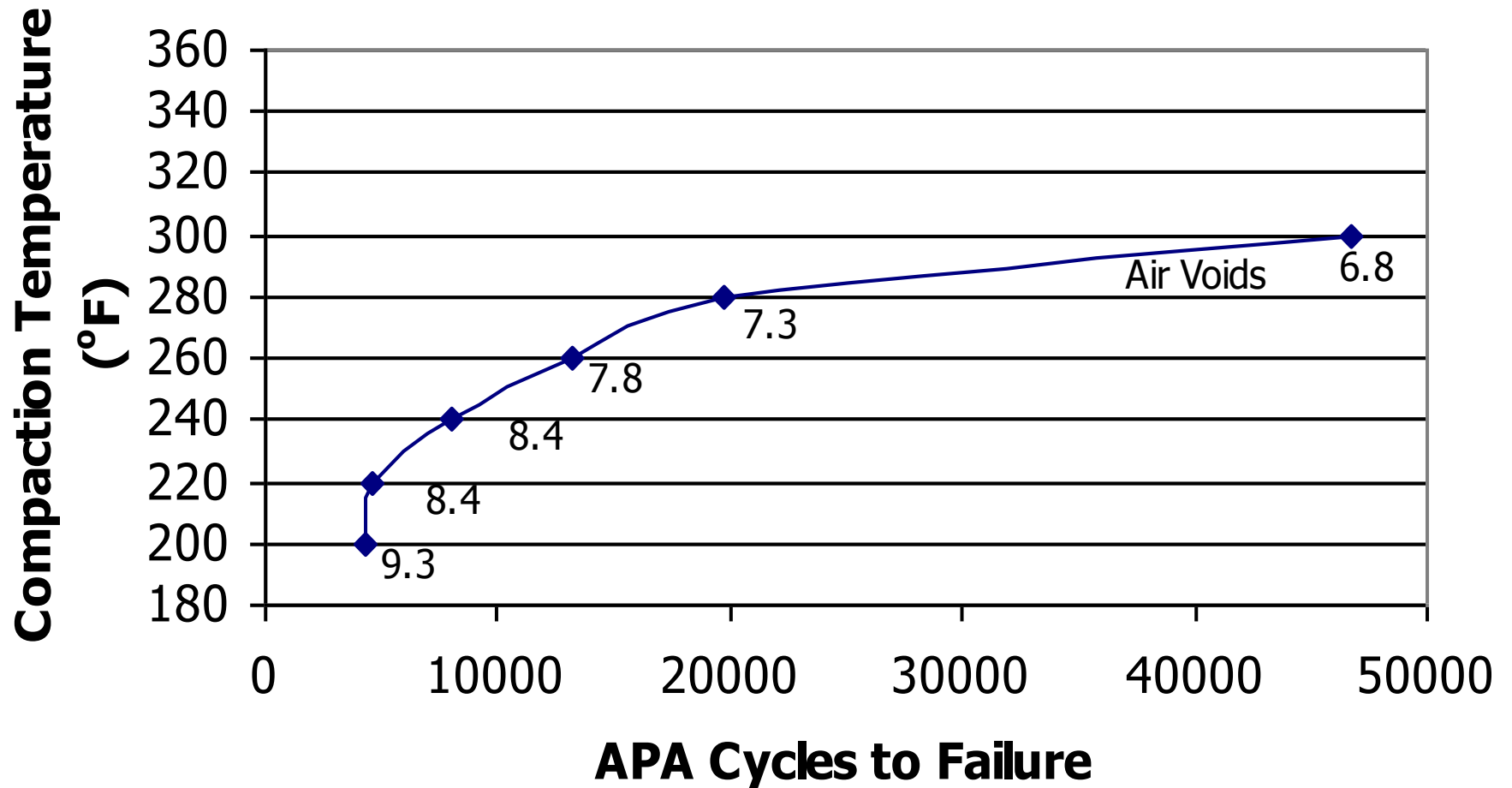
# Effects on Pavement

- Same as insufficient compaction
  - Increased raveling and moisture damage
  - Reduced fatigue life
  - Increased roughness
- One percent increase in air voids results in a minimum of 10% reduction in pavement life (a rule of thumb)
- 25° F Differential = 1 to 2% more air voids





## 3/8" HMA APA Fatigue Results



Courtesy of PTI and Ron Collins

- A number of State DOTs have developed and implemented specifications to address this issue.
- WSDOT's current specification
  - Cyclic density areas are defined as less than **89.0** percent of maximum density.
  - If **four or more** low cyclic density areas are identified in a lot, a price adjustment will be assessed for that lot (a lot is 400 tons).
  - The price adjustment will be calculated as **15%** of the unit bid price of HMA represented by that lot.
  - This assessment starts with examining the mat for temperature differences of 25°F or greater. If these do not exist, then no further special density testing is performed.



# 50% Increase in HMA Pavement Life





**Washington State**

**US Highway 12 (MP 102 – 118)**

**Approximately 32 lane miles**



**Thermal segregation resulted in failure five years prior to anticipated 20 year life**

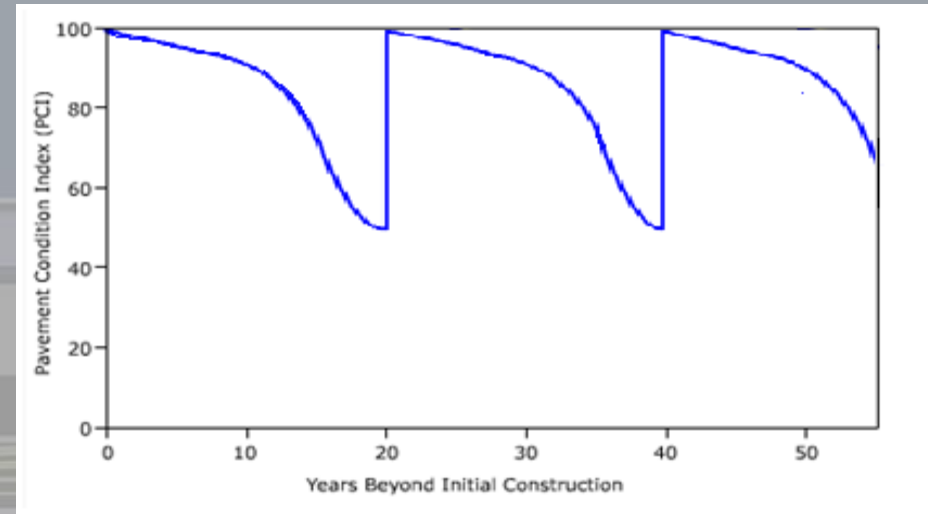




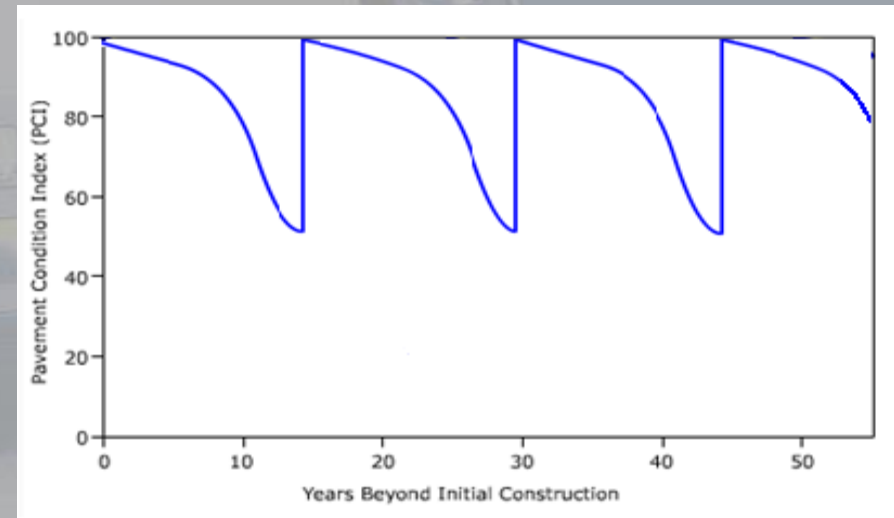
## Calculations:

- If this trend continues, over a 60 year period, an entire additional overlay will be needed
- Mill and Overlay of 1.8” on average cost of about \$200,000 per lane mile
- For this stretch of highway, thermal segregation risks a cost increase of:
  - \$2.4 million in present dollars
  - or -
  - \$24.9 million in year 60 dollars

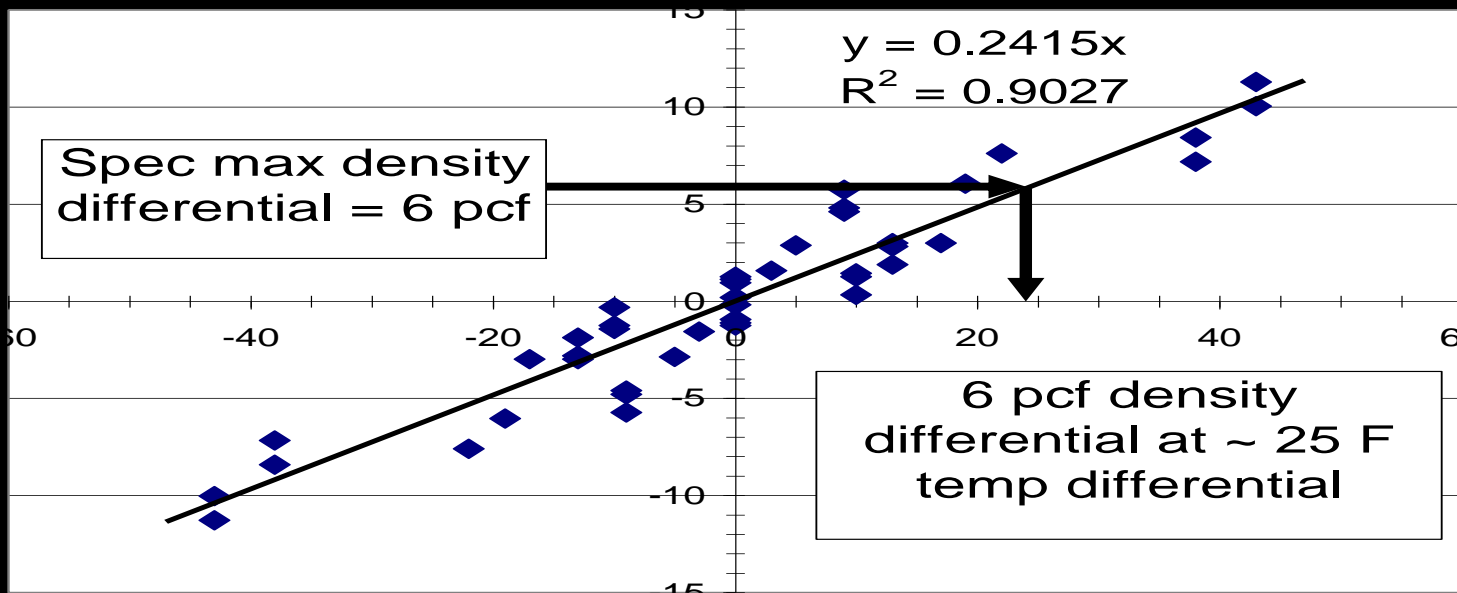
## Without thermal segregation



## With thermal segregation



- NCAT (2000) and TTI (2002) similarly found thermal uniformity suitable for detecting segregation
  - NCAT – low severity segregation/density when  $\Delta t > 18$  °F
  - TTI – when  $\Delta t > 25$  °F, TxDOT density uniformity requirements not met



TxDOT funded research conducted by Texas Transportation Institute (TTI) to study the relationship between thermal segregation and density, in addition to developing a method for practical data collection.



Initial research included the use of a thermal camera operated by a researcher in the back of a pickup truck. In addition to obvious safety considerations, this initial method was found not to be practical. A series of infrared images had to be manually combined to produce a complete profile. Distance and position data were also difficult to incorporate.

**First generation Pave-IR system was first used in October 2003.**

- Propelled manually
- Long setup time
- Loose connection wires
- Unstable wheel design
- Battery powered
- Required two operators



**Third generation Pave-IR system was first used in January 2005.**

## **IMPROVEMENTS**

- Paver mounted
- Rapid setup time
- Central master control
- No dedicated operator

## **CHALLENGES**

- Battery powered
- Distance measuring wheel
- Components not suitable for everyday use on heavy equipment.





- In 2005 TTI published research reports outlining the relationship between thermal segregation and density. These reports also outline the methods used for thermal data collection supporting Pave-IR as the preferred tool for thermal data collection.

Reports available online at:

<http://tti.tamu.edu/documents/0-4577-2.pdf>

<http://tti.tamu.edu/documents/5-4577-01-1.pdf>

- Following the completion of this research, TTI & TxDOT were interested in finding a commercial partner for development and production of Pave-IR systems for future implementation into TxDOT specifications.



## MOBA PAVE-IR SYSTEM COMPONENTS

- **12 – Infrared sensors (standard)**
- **Absolute encoder used for distance measurement**
- **MOBA OPERAND™ computer**
- **GPS antenna**
- **Includes PAVE PROJECT MANAGER™ software for post analysis and reports**
- **Kit includes system cabling and all necessary screed mounting hardware.**



- **Paver mounted system used to identify thermal segregation in newly placed asphalt surfaces.**
- **Uses a series of infrared, GPS, and distance measuring sensors.**
- **Sensors are networked together and connected to a mobile computer with color display.**
- **Computer processes and displays data from all sensors.**
- **Areas where thermal segregation is present are displayed in real-time.**
- **Data stored on flash drive for post processing on PC**



The MOBA Operand™ computer attaches to sensor beam.

GPS antenna mounts above the Operand™ computer.

Memory drive connects directly to Operand™ computer

System is powered by machine voltage (10-28 VDC).

Sensor beam is hinged in center for easy setup and storage.



The PAVE-IR™ system mounts to the screed walkway by bolting or welding.



The distance encoder mounts to the wheel or torque hub using a magnet.







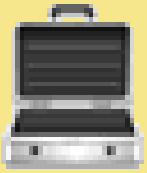
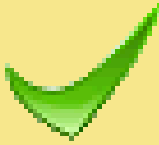

- **Provides full coverage of entire paved surface.**
- **Ensures compliance with most existing DOT temperature specification requirements.**
- **Data is logged automatically and can be stored permanently.**
- **More cost effective versus infrared cameras.**
- **System also records paving speed and paver stops.**
- **System can be moved from one machine to another.**
- **System is scaleable from 2-8 meters depending on paving width**

- **Next Generation PAVE-IR(I)**

- Real-time (pre-compacted) IRI smoothness measurement.
- Network (wireless) to onboard compaction systems.
- **Wireless transmission of job data to QC office or plant.**
- Grade and slope control monitoring.
- Material control (auger/conveyor) system monitoring.
- **Infrared scanner mounted above paver deck.**





	Choose project	
	Roadway ID: sh6 Start location: n of sta550 Lift: 1	
	Creation date: 11.06.2009 10:18	
		
		
		 10:20



Edit log file

**Operator:** AUSTIN BRIDGE

**Roadway ID:** SH-114

**Start location:** WALNUT HILL LN

**Comment:** PAVE-IR DEMO

q	w	e	r	t	y	u	i	o	p
a	s	d	f	g	h	j	k	l	
	z	x	c	v	b	n	m	Back	
Shift	áü	Space				/-	Del		

17:01



The screenshot displays the MOBA Data Collection interface. At the top, it shows 'Collecting data...' and a progress bar. The main area features a color-coded data plot with a scale from 0.00 to 50.00ft. A vertical color scale legend is positioned to the right of the plot, ranging from blue (0) to red (100). The plot area contains the text 'Collected Data coded with actual Color Scale' and 'Not available'. The bottom status bar displays coordinates (51.0472°N 013.7151°E), driven distance (109.76 ft), current speed (0.00 ft/min), and current time (09:56). The interface includes a numeric keypad and function keys (F1-F8) on the right side.

**MOBA**  
MOBILE AUTOMATION

Collecting data...

Sensor Bar Online State

Odometer Online State

GPS Quality

Stop Data Acquisition (Return to project.. dialog)

Activate Full Screen View

Change Color Scale

Current Time

Collected Data coded with actual Color Scale

Actual Color Scale

Current GPS Position

Driven Distance

Current Speed

0.00 50.00ft

100

Not available

51.0472°N 013.7151°E 109.76 ft 0.00 ft/min 09:56

F1 F2 F3 F4 F5 F6 F7 F8

ESC

Fn 6 MNO 7 PQRS 8 TUV 9 WXYZ 0

MOBA<sup>®</sup>  
MOBILE AUTOMATION

Collecting data...

100

32

0.00 50.00ft

51.0473°N 013.7151°E 98.97 ft 0.00 ft/min 14:05

F1 F2 F3 F4 F5 F6 F7 F8

ESC

MOBA PAVE-IR



Viewing...

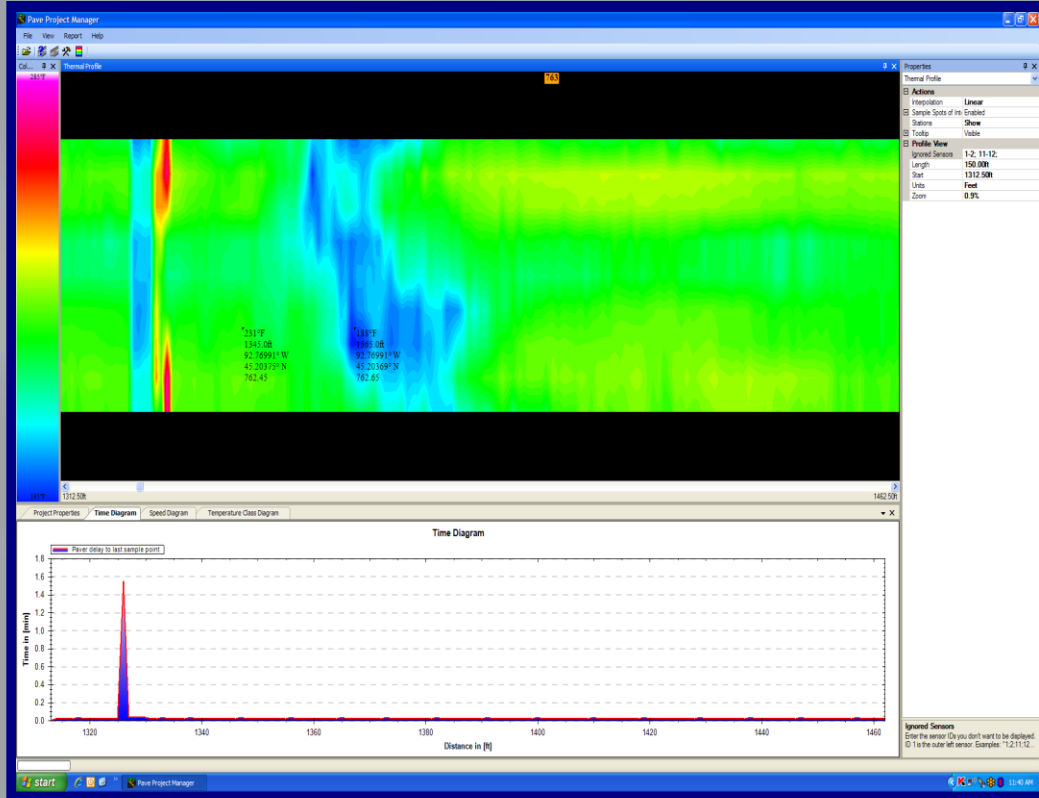
Thermal Profile Results Summary

Number of Profiles	Moderate ]25°F;50°F]		Severe >50°F		Status
	Number	Percent	Number	Percent	
54	6	11	9	17	✓

Recent Test Result

Beginning Location	Ending Location	Temp Differential	Status
0	150	20.3	✓

15:31



After data collection, the project file is transferred to PC via USB cable.

PPM allows contractor to evaluate the project in detail.

PPM displays thermal data, stations, paving speed, paver stops, and GPS location for any position in the project.

QC/QA reports are generated by PPM.

## PROJECT PROPERTIES WINDOW (Meta Information)

The screenshot shows the Pave Project Manager interface. The main window displays a thermal profile with a color map on the left and a thermal profile plot. The plot shows temperature variations across a distance, with two specific data points highlighted:

- Point 1: 181°F, 1013.0ft, 92.76968° W, 45.20466° N, 759.13
- Point 2: 244°F, 1097.0ft, 92.76973° W, 45.20442° N, 759.97

The Project Properties window is open, showing the following meta information:

Category	Property	Value
File	Creation date	10/28/2009
	File name	C:\Documents and Settings\jano\Desktop\James Lano Files\TTI\Pave_2009102872510.log
	Version	4.0
Project	Beginning location	north of stillwater
	Comment	demo
	Layer thickness	1.5in
	Lift	1
	Measure height	0ft
	Operator Name	paul
	Paving width	12.5ft
	Roadway ID	95 southbound
Stations	Beginning number	749 (Ascending), 0.00ft, 100.00ft:
	Interval	100ft
	Order	Ascending
	Project offset	0ft
System	Data Collect Beginning	8:06 AM
	Rolling radius	14.882in
	Sample rate	12m
	Sensor space	1.083ft
	Sensors	12

Additional information from the Properties window:

- Actions:** Interpolation (Linear), Sample Spots of Interest (Enabled), Stations (Show), Tooltip (Visible)
- Profile View:** Ignored Sensors (1-2; 11-12;), Length (200.00ft), Start (950.76ft), Units (Feet), Zoom (1.2%)

The Project Properties window also includes a 'Save' button at the bottom right.

## PROJECT PROPERTIES WINDOW (Metrics)

The screenshot displays the Pave Project Manager software interface. The main window shows a thermal profile with a color scale on the left ranging from 300°F (red) to 100°F (blue). The profile itself is a horizontal heatmap with two data points highlighted:

- Point 1:** 244°F, 1097.0ft, 92.76973° W, 45.20442° N, 759.97
- Point 2:** 181°F, 1013.0ft, 92.76968° W, 45.20466° N, 759.13

At the bottom of the main window, there are tabs for "Project Properties", "Time Diagram", "Speed Diagram", and "Temperature Class Diagram". The "Project Properties" tab is active and contains a "Metrics" section, which is highlighted with a red box. The metrics listed are:

- Project Duration: 9:58:43 h:m:s
- Paver Total Stop Time: 4:50:53 h:m:s
- Paver Average Speed: 27.26 ft/min

On the right side of the interface, there is a "Properties" window for the "Thermal Profile". It includes sections for "Actions" and "Profile View".

Actions	
Interpolation	Linear
Sample Spots of Interest	Enabled
Stations	Show
Tooltip	Visible

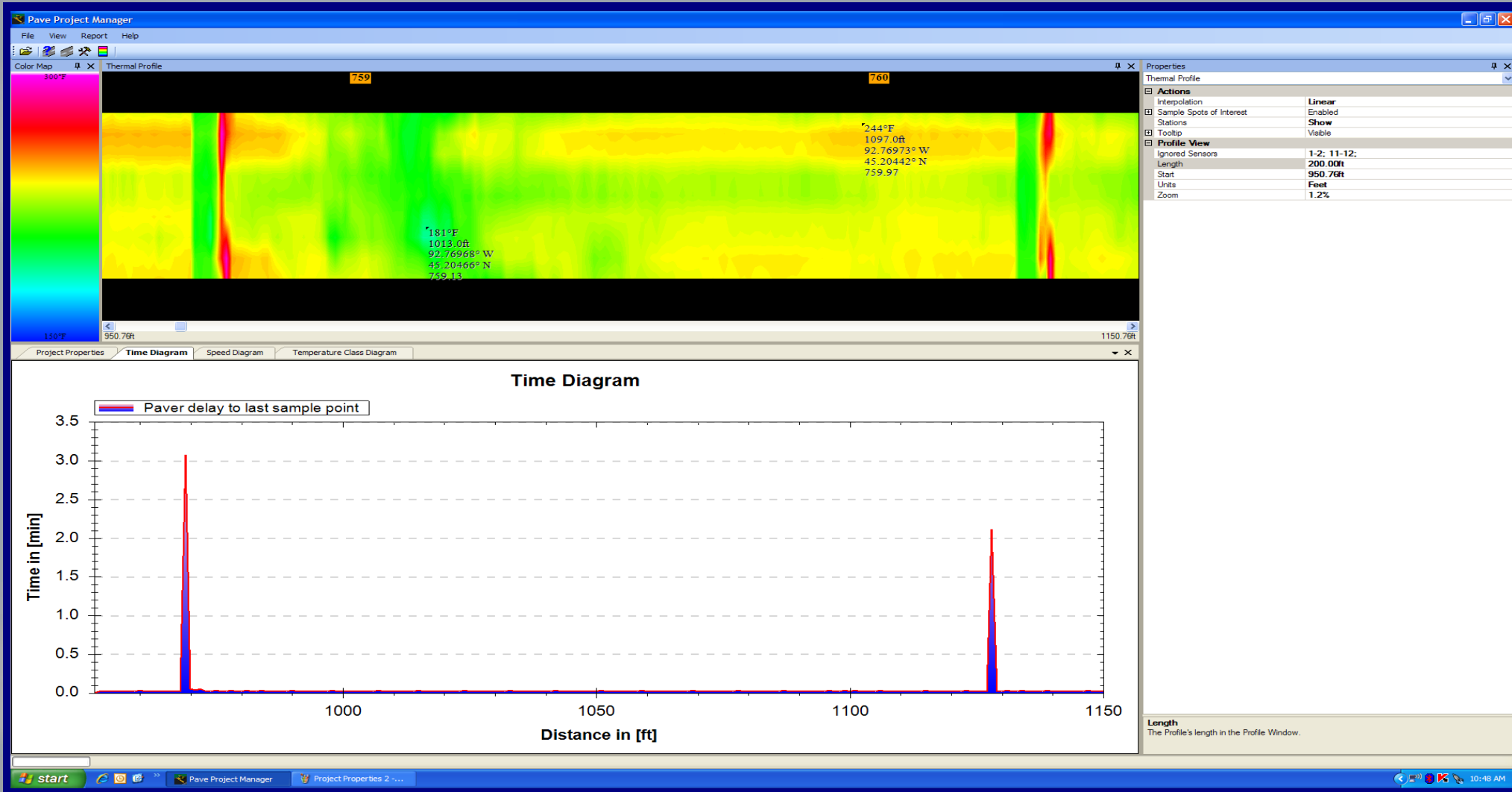
  

Profile View	
Ignored Sensors	1-2; 11-12;
Length	200.00ft
Start	950.76ft
Units	Feet
Zoom	1.2%

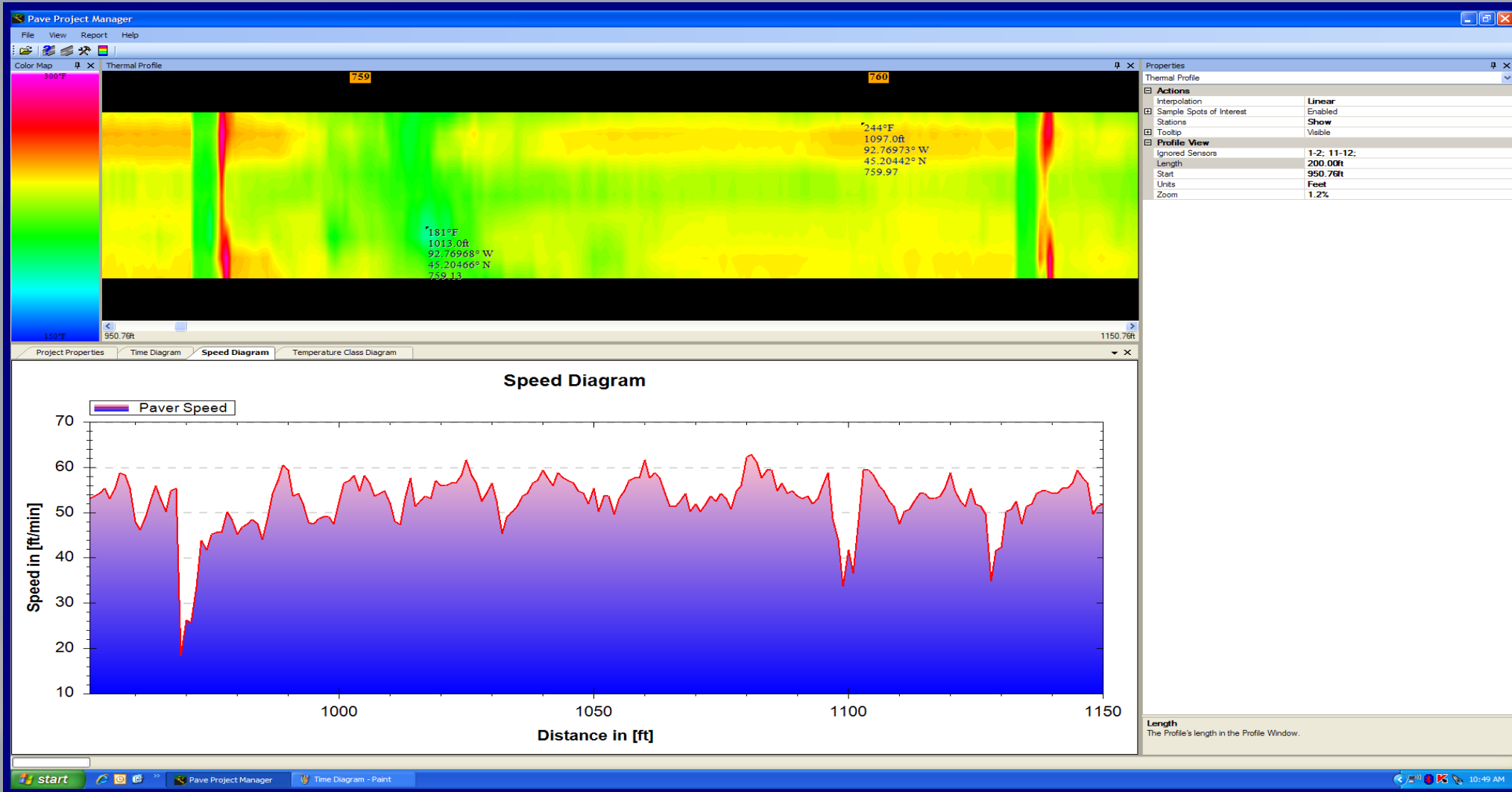
At the bottom right of the Properties window, there is a note: **Length** The Profile's length in the Profile Window.

The Windows taskbar at the bottom shows the Start button, system tray icons, and the time 10:47 AM.

## TIME DIAGRAM DISPLAYS PAVER STOPS

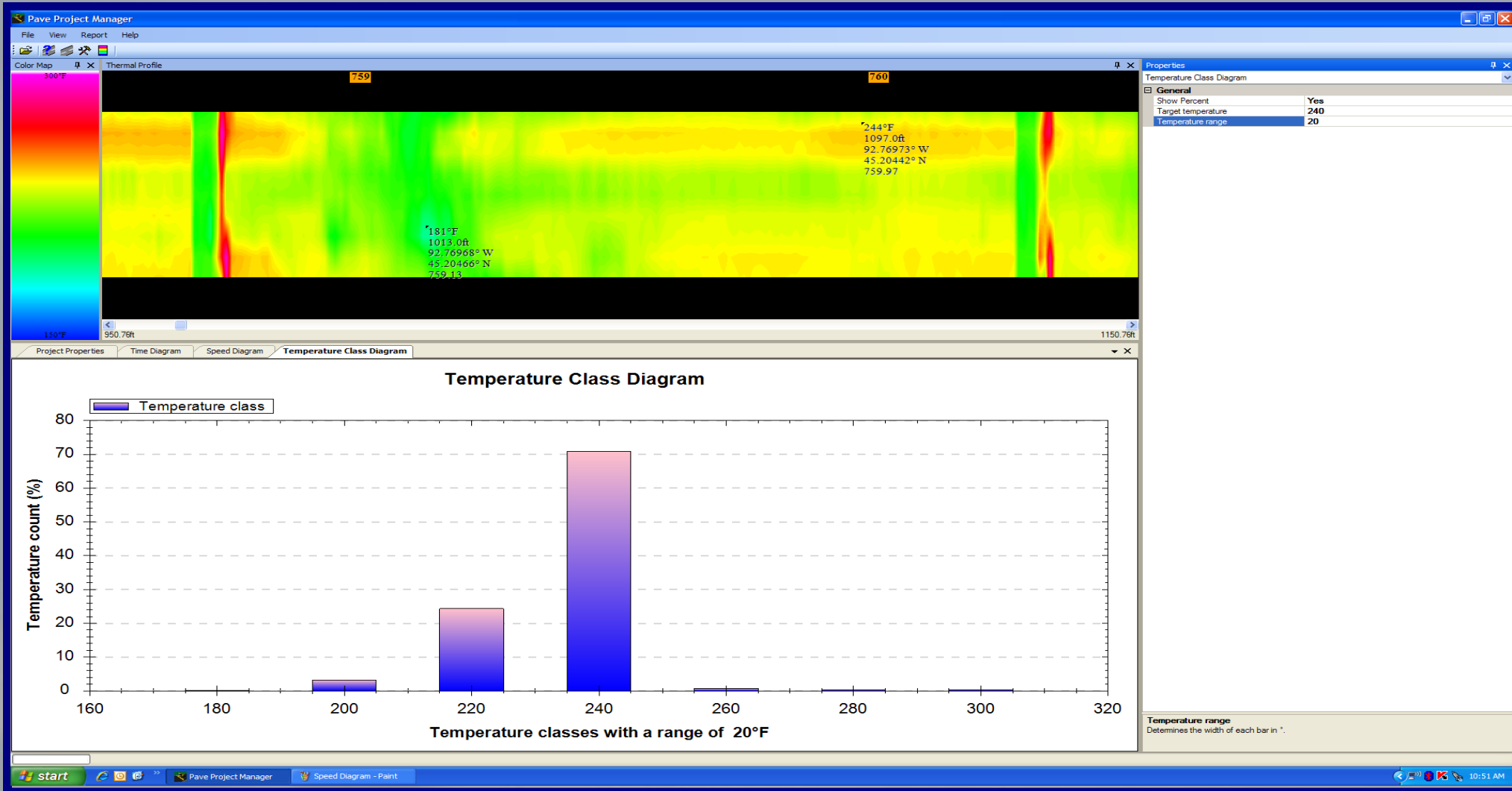


## SPEED DIAGRAM DISPLAYS PAVING SPEED





## TEMPERATURE DIAGRAM DISPLAYS TEMPERATURE GRAPH



## Tex-244-F Part II

### Thermal Profile Summary Report

Profile ID:	SH-114	Profile Date:	11/16/2009 7:38:53 PM
Profile Number:	1	Letting Date:	10/5/2009
Status:		Controlling CSJ:	
County:	Dallas	Spec Year:	2009
Tested By:	J. Lano (MOBA)	Spec Item:	
Test Location:	WALNUT HILL LN	Special Provision:	341-024
Material Code:	FC12	Mix Type:	
Material Name:			
Producer:	ABR		
Area Engineer:		Project Manager:	

Course/Lift:	2	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
55	6	11	10	18

Reports specific to various DOT specifications can be generated in PPM.

This report is based on TxDOT thermal specification Tex-244-F

### Summary of Locations with Thermal Segregation

Profile Nr	Beginning Location		Ending Location		Max Temp	Min Temp	Temperature Differential
	Distance (ft)	GPS in °	Distance (ft)	GPS in °			
2	150.50	96.95501 W, 32.88593 N	300.00	96.95462 W, 32.88572 N	309.9	283.8	26.1
20	2850.07	96.94865 W, 32.88120 N	2999.58	96.94837 W, 32.88087 N	316.8	257.9	58.9
21	3000.08	96.94837 W, 32.88087 N	3149.58	96.94813 W, 32.88054 N	311.2	248.9	62.3
23	3300.09	96.94787 W, 32.88020 N	3449.56	96.94762 W, 32.87986 N	327.2	297.3	29.9
31	4500.17	96.94655 W, 32.87720 N	4649.61	96.94649 W, 32.87680 N	324.1	296.6	27.5
33	4800.06	96.94645 W, 32.87639 N	4949.50	96.94642 W, 32.87600 N	310.1	284.5	25.6
36	5250.39	96.9464 W, 32.87519 N	5399.84	96.94639 W, 32.87480 N	318.9	291.4	27.5
47	6900.28	96.94559 W, 32.87085 N	7049.73	96.94546 W, 32.87045 N	336.7	307.0	29.7
48	7050.23	96.94546 W, 32.87045 N	7199.67	96.9452 W, 32.87014 N	351.7	294.1	57.6
49	7200.17	96.9452 W, 32.87014 N	7349.62	96.94497 W, 32.86979 N	351.0	284.7	66.2
50	7350.12	96.94497 W, 32.86979 N	7499.56	96.94474 W, 32.86944 N	349.7	264.4	85.3
51	7500.06	96.94474 W, 32.86943 N	7649.50	96.94451 W, 32.86909 N	348.8	268.3	80.5
52	7650.00	96.94451 W, 32.86909 N	7799.95	96.94425 W, 32.86876 N	349.7	257.9	91.8
53	7800.45	96.94425 W, 32.86876 N	7949.89	96.94399 W, 32.86842 N	352.0	247.3	104.8
54	7950.39	96.94399 W, 32.86842 N	8099.84	96.9437 W, 32.86809 N	348.4	262.9	85.5

### Summary of Locations with Thermal Segregation

Profile Nr	Beginning Location		Ending Location		Max Temp	Min Temp	Temperature Differential
	Distance (ft)	GPS in °	Distance (ft)	GPS in °			
55	8100.34	96.9437 W, 32.86809 N	8214.80	96.94349 W, 32.86786 N	328.8	243.9	85.0

### Summary of Locations Without Thermal Segregation

Profile Nr	Beginning Location		Ending Location		Max Temp	Min Temp	Temperature Differential
	Distance (ft)	GPS in °	Distance (ft)	GPS in °			
1	0.00	96.95544 W, 32.88615 N	150.00	96.95501 W, 32.88593 N	295.9	275.5	20.3
3	300.50	96.95462 W, 32.88572 N	450.00	96.95423 W, 32.88550 N	311.9	288.1	23.8
4	450.50	96.95422 W, 32.88550 N	599.50	96.95384 W, 32.88529 N	318.4	305.1	13.3
5	600.00	96.95383 W, 32.88529 N	749.51	96.95344 W, 32.88507 N	319.6	305.2	14.4
6	750.01	96.95344 W, 32.88507 N	899.51	96.95303 W, 32.88485 N	317.3	303.3	14.0
7	900.01	96.95303 W, 32.88485 N	1049.52	96.95262 W, 32.88462 N	313.0	290.1	22.9
8	1050.02	96.95262 W, 32.88462 N	1199.52	96.95223 W, 32.88441 N	300.9	283.5	17.5
9	1200.02	96.95222 W, 32.88441 N	1349.53	96.95182 W, 32.88418 N	303.1	285.6	17.5
10	1350.03	96.95182 W, 32.88418 N	1499.53	96.95145 W, 32.88394 N	305.1	291.7	13.3
11	1500.03	96.95145 W, 32.88393 N	1649.54	96.95109 W, 32.88368 N	308.3	294.6	13.7

- Specified in Texas, Ohio, Louisiana, Minnesota, Washington
- SHRP 2 Study completed(Recommend Implementation)
- SHRP 2 Research extension of 18 month to help states implement
- EveryDayCounts/IC
- NCAT Alabama Study
- AASHTO Spec Draft

# Thank You!

# Questions?



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