



Rapid Technologies to Enhance Quality Control on Asphalt Pavements Infrared (IR) Scanner Workshop

Hosted by:
Illinois DOT
March 7, 2017



U.S. Department of Transportation
Federal Highway Administration

AMERICAN ASSOCIATION
OF STATE HIGHWAY AND
TRANSPORTATION OFFICIALS



Our Focus for Today



Workshop Objective ...

1. Describe the Infrared Scanner Technology (What is it and Why it is needed?)
2. Understand how to use the IR Equipment & Software
3. Discuss the results from the Illinois DOT and other field demonstration projects
4. Discuss the Contractor's and Agency's Perspective on using the IR Scanner
5. SHRP 2 Products and Lessons Learned

Infrared Scanner Workshop

AGENDA:

Time	Topic/Presentation	Speaker
10:30	Call to Order	Zehr (Illinois DOT); Moderator
10:30 to 10:45	Welcome and Introductions	Trepainer (IDOT); Burke (IAPA)
10:45 to 11:15	Introduction to Infrared Technology: What is it and Why is it Needed?	Reiter (ARA)
11:15 to 11:30	Equipment and Software: How to use it? Getting Real Time Information for Decision Making	Dalbey (ARA)
11:30 to 12:00	Data Analyses and Findings: What was learned from the Demonstration Projects; Outcome and Lessons Learned from the Field Demonstration Projects	Reiter (ARA)
12:00 to 12:15	Lunch Break (Catered for workshop)	
12:15 to 12:45	Agency Perspective: Agency overview of the technology in ensuring a higher uniformity of the mat, and its use in comparing and evaluating an additional MTD.	Hill (IDOT)
12:45 to 1:15	Contractor's Perspective as a QC Tool: Contractor overviews their points and advantage of the technology in minimizing the penalties and maximizing their incentive.	Proctor (UCM)
1:15 to 1:30	Implementation Strategies: 1. Products and Application of Products ○ Case Studies from Demonstration Projects ○ Lessons Learned	Reiter (ARA)
1:30 to 1:45	Questions/Answers and Closing Comments	Zehr (IDOT) Moderator
1:45 to 1:50	IR Workshop Wrap-Up	Zehr (IDOT) & Reiter (ARA)



Infrared Technology (IR)

What is it and why use it?

March 7, 2017



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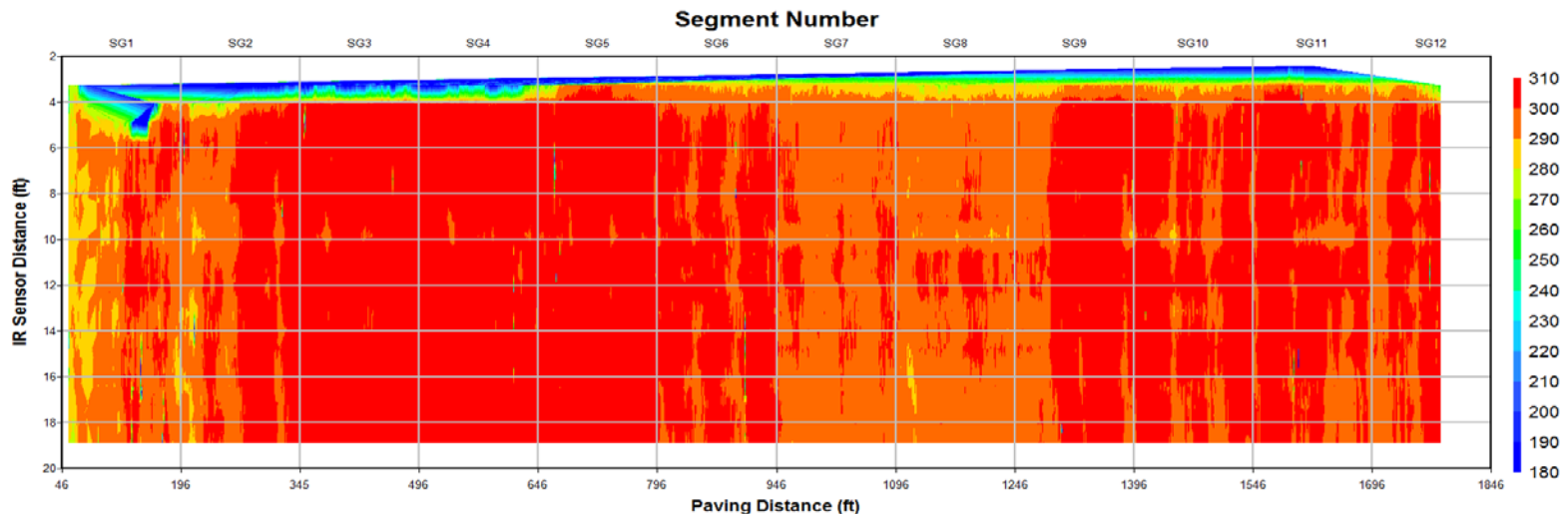
IR – What is it & why use it?

1. IR - Defined.
2. How is it measured?
3. Why is it important?

IR – What is it & why use it?

Infrared Thermography:

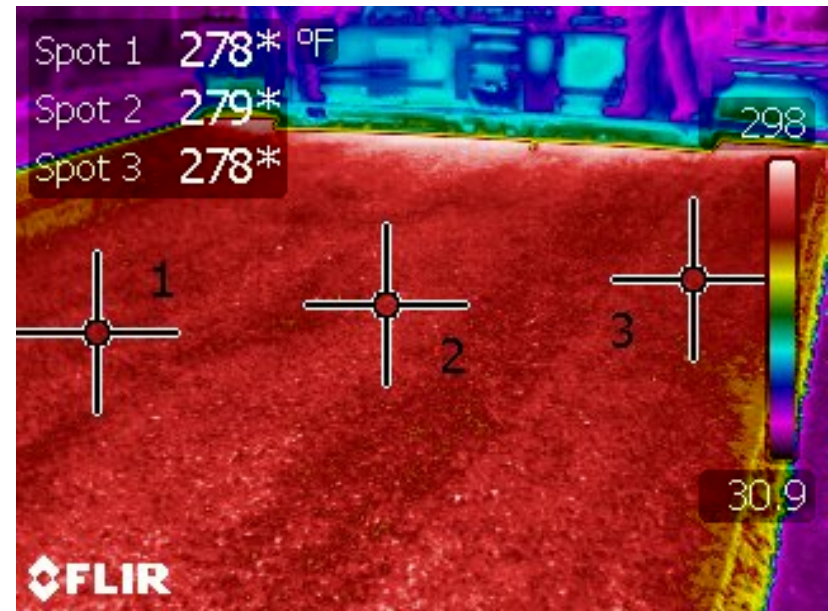
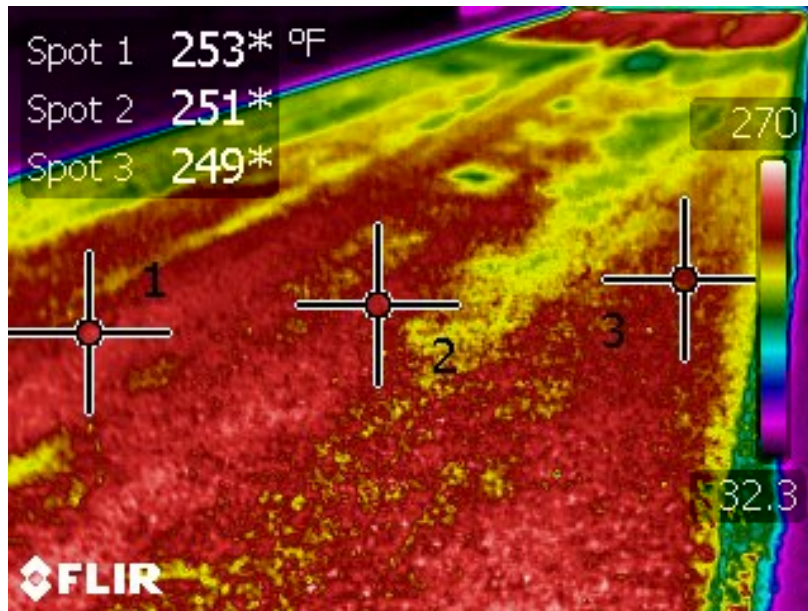
- The mapping of temperature contours (equal temperature) over the surface of a material.
- Contours are used to evaluate materials by measurement of their surface temperature and its variation.



IR – What is it & why use it?

Temperature segregation (differential):

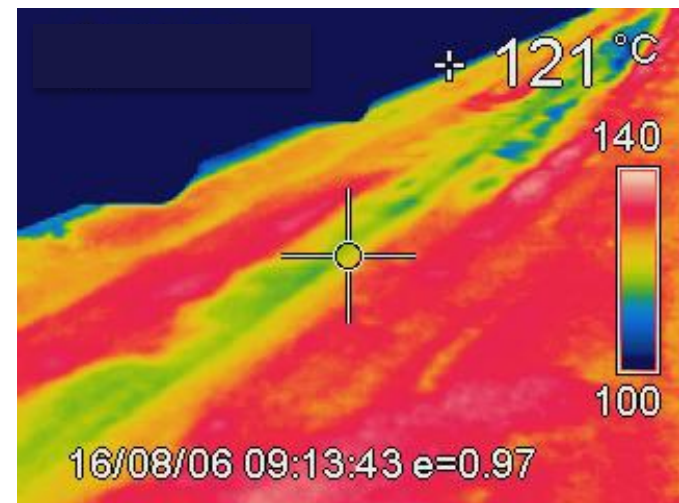
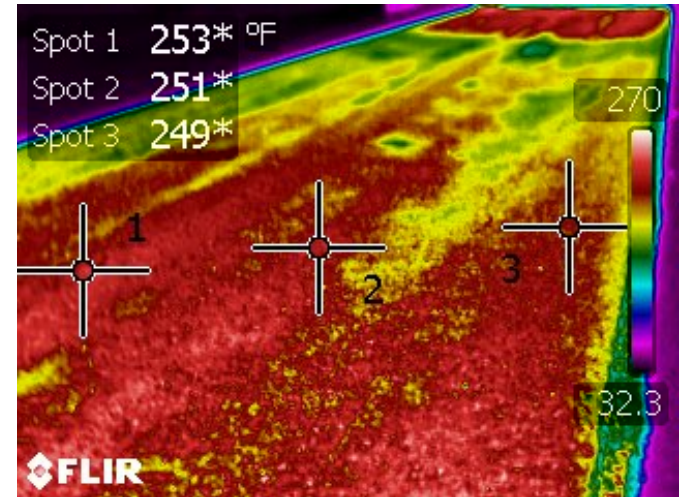
- More than 25 °F difference in mat temperature behind screed.



IR – What is it & why use it?

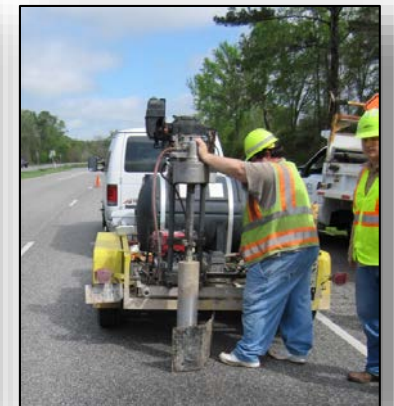
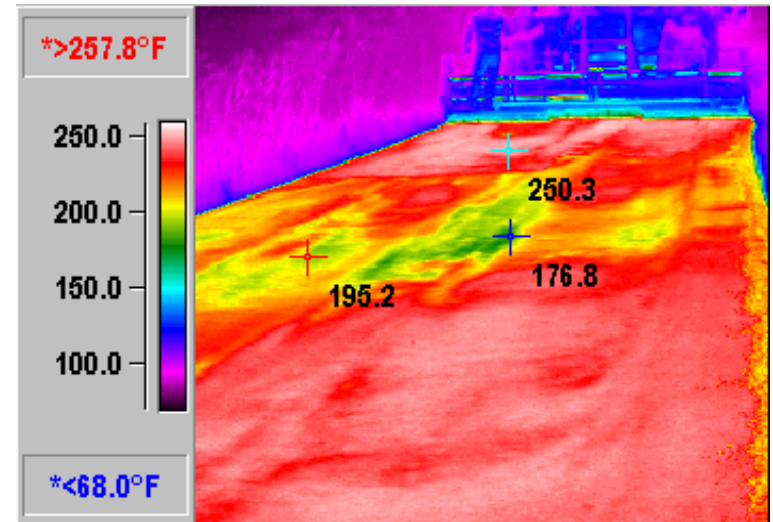
Types of Temperature Differences:

1. Cold spots
 - Truck to truck temperature differences
 - Improper loading and unloading of trucks
2. Thermal streaks
 - Longitudinal segregation
 - Inadequate or non-uniform amount of material across the mat



IR – What is it & why use it?

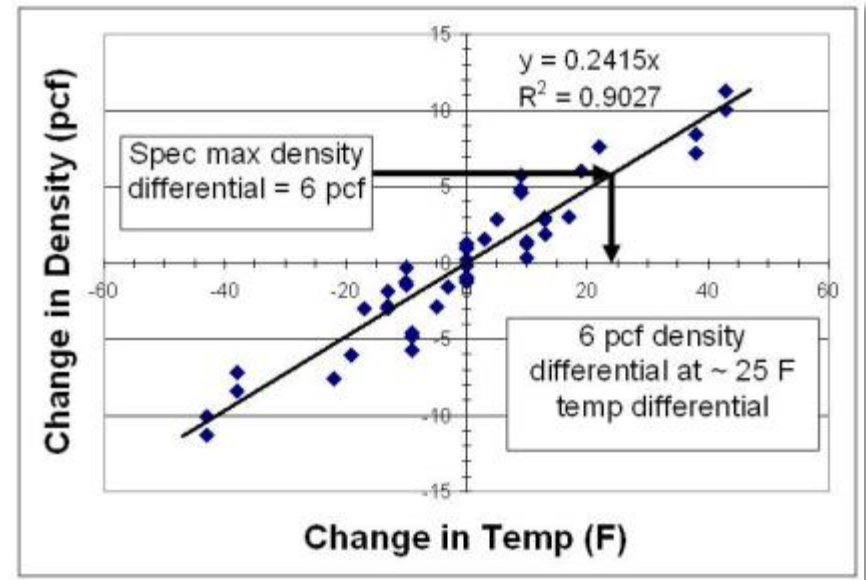
- Cold spots
 - Temperature difference of mat between truck exchanges – common.
 - Areas with higher air voids
- Focused testing have validated higher air voids
 - Coring
 - Radar (full coverage)
 - Nuclear gauge



IR – What is it & why use it?

Background

- 1996 through 2000s – field work concluded temperature differences could be accurately detected and quantified:
 - Low temperatures result in low density zones in mat
 - A few States adopt temperature uniformity specification



Temperature profile criteria based on desired density uniformity.

IR – What is it & why use it?

1. IR - Defined.
2. How is it measured?
3. Why is it important?

IR – What is it & why use it?

History; Mat Temperature Measurements

- Temperature guns
 - Point readings
- Temperature cameras
 - Time specific to identify areas with cold spots or thermal streaks



IR – What is it & why use it?

History; Mat Temperature Measurements

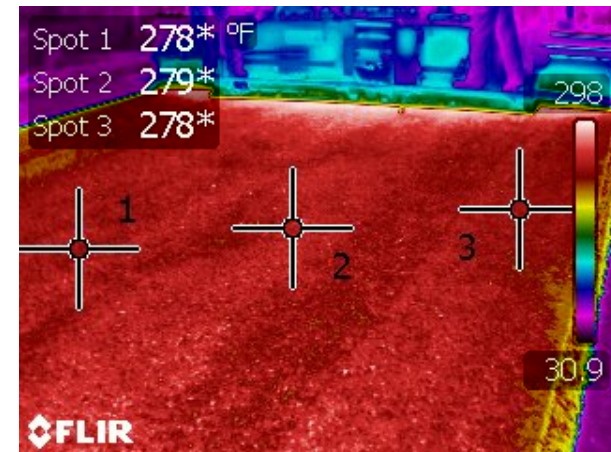
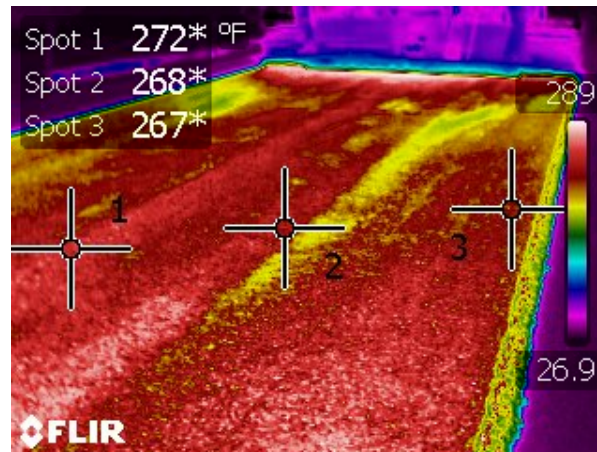
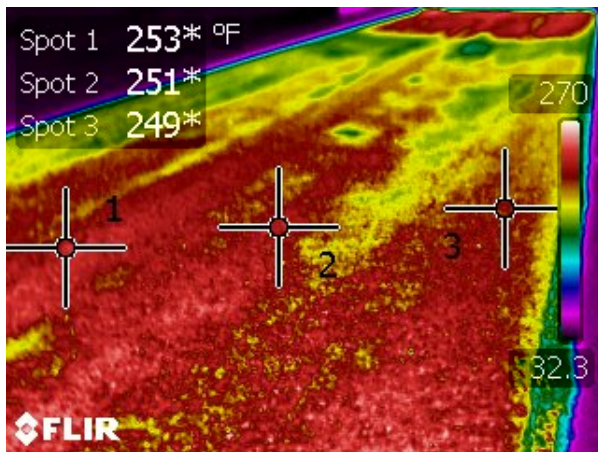
- IR sensors, IR-Bar; first device for continuous readings
- Pave-IR Scanner; second generation device for continuous readings



IR – What is it & why use it?

Application & use of temperature cameras

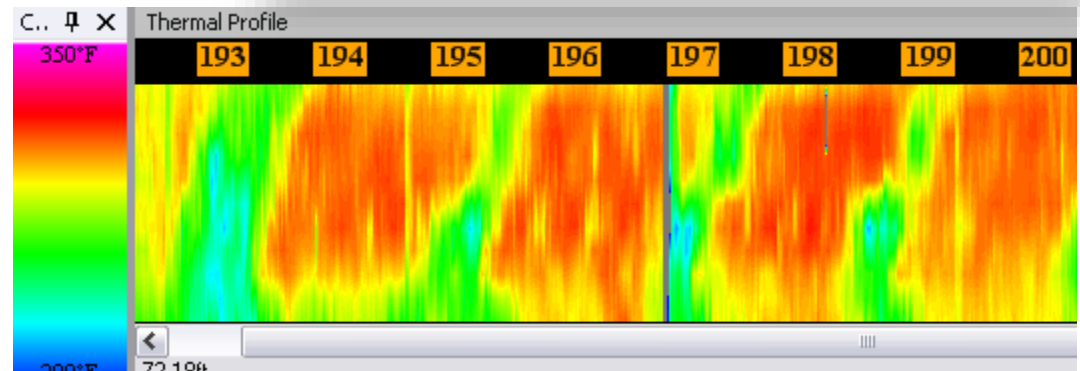
- Identify areas with cold spots for biased sampling in density specification
- Identify thermal streaks



IR – What is it & why use it?

Application & use of IR-Bar and Scanner

- Continuous readings to evaluate mat uniformity through temperature uniformity.
- Non-uniform temperatures usually mean, non-uniform densities.

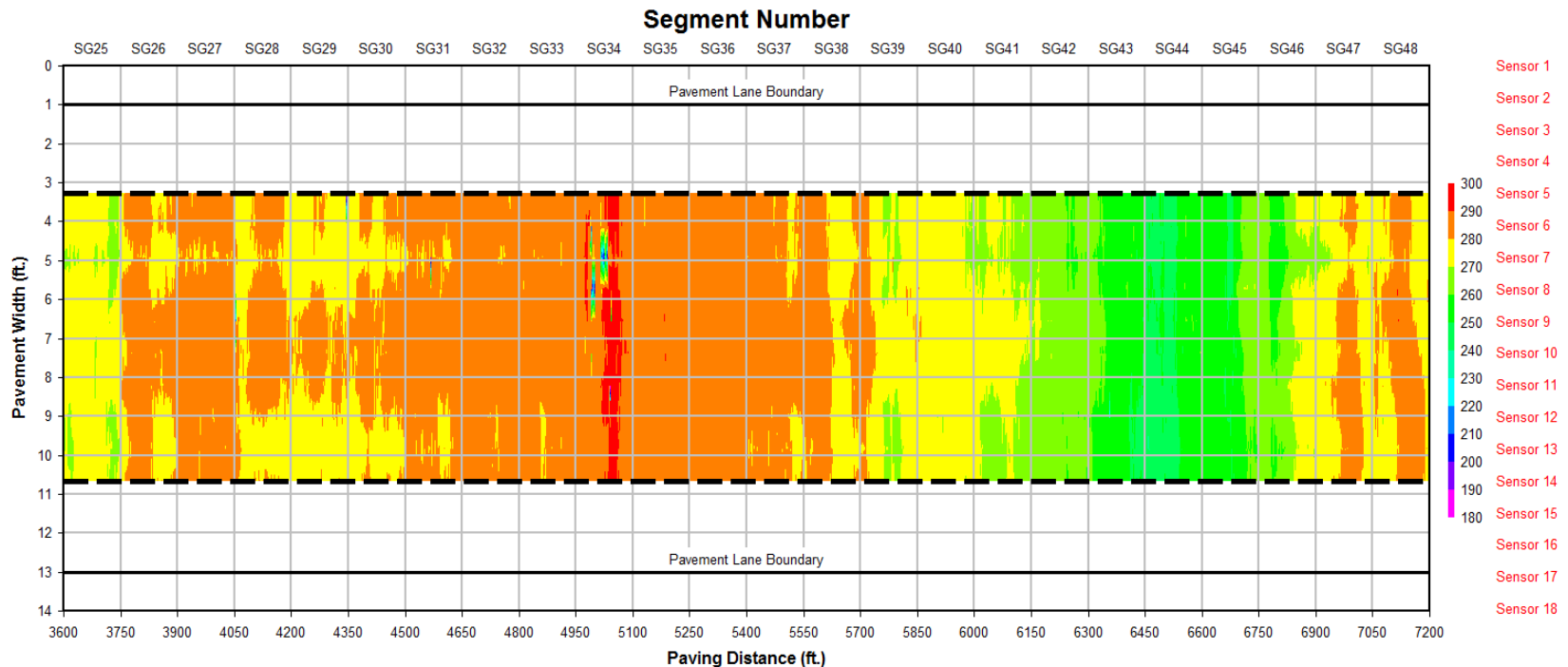


IR – What is it & why use it?

1. IR - Defined.
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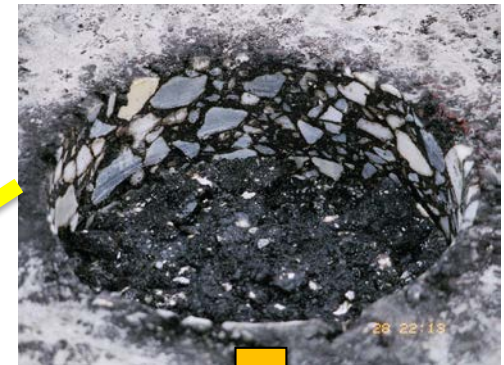
IR – What is it & why use it?

- Aggregate segregation in mat = temperature segregation
- Non-uniform temperatures usually result in non-uniform densities



IR – What is it & why use it?

Segregation – A difficult issue to resolve, when it is difficult to identify or confirm.



IR – What is it & why use it?

- *Truck to truck segregation* results in cold spots; IR can accurately identify these areas.



IR – What is it & why use it?

- Both sided longitudinal and centerline segregation result in thermal streaks; IR can identify these areas.



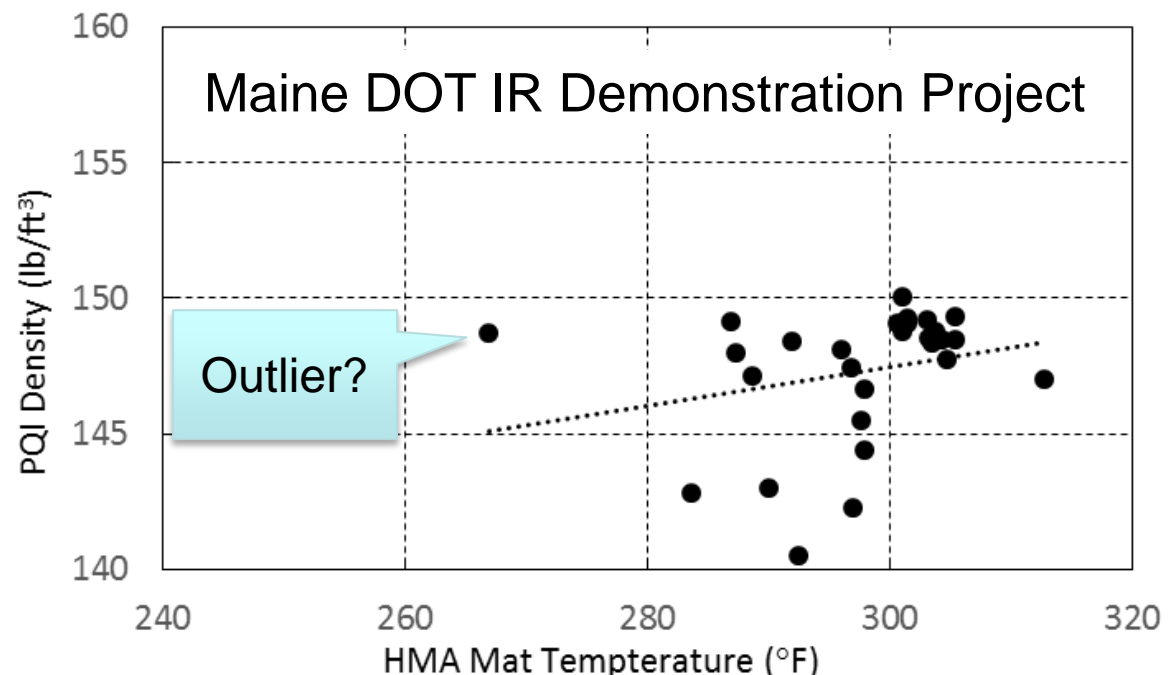
IR – What is it & why use it?

- Effect of cold spots, low mat temperatures on percent compaction; densities are:
 - Lower
 - More variable



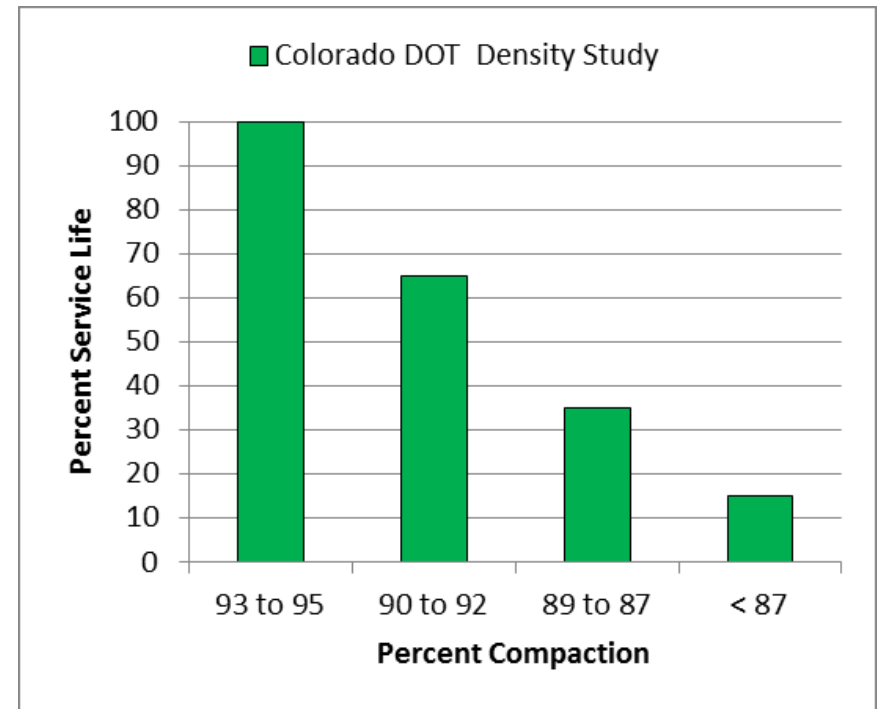
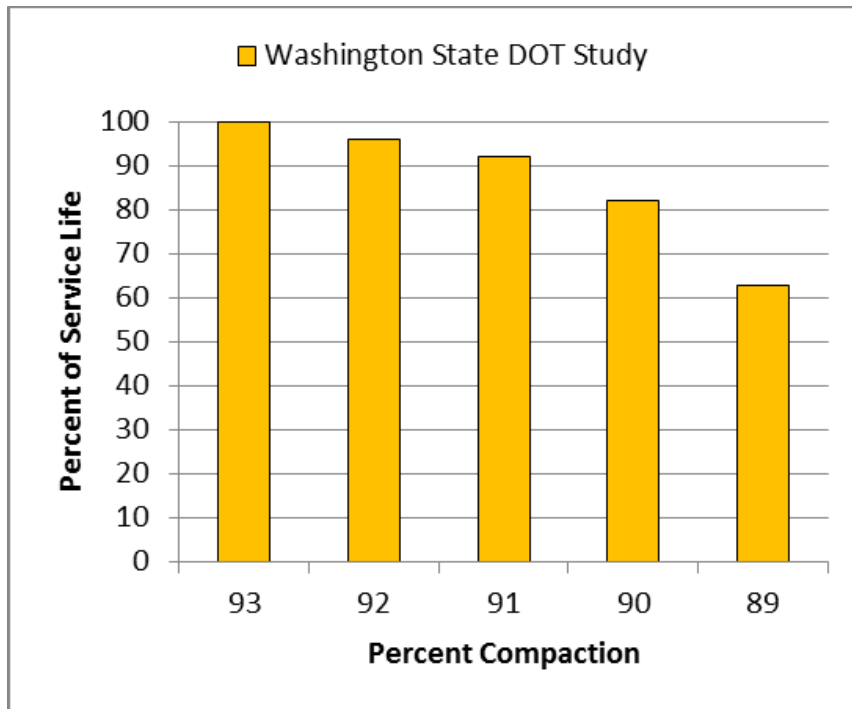
TTI Study:
 $\Delta 25\text{ }^{\circ}\text{F} \sim \Delta 6\text{ pcf}$

Maine DOT:
 $\Delta 20\text{ }^{\circ}\text{F} \sim \Delta 4\text{ pcf}$



IR – What is it & why use it?

- Effect of reduced compaction because of lower mat temperatures or inadequate rolling.



IR – What is it & why use it?

Impact of temperature differences or areas with low temperatures.



IR – What is it & why use it?

Cold spots; areas with increased potential for:

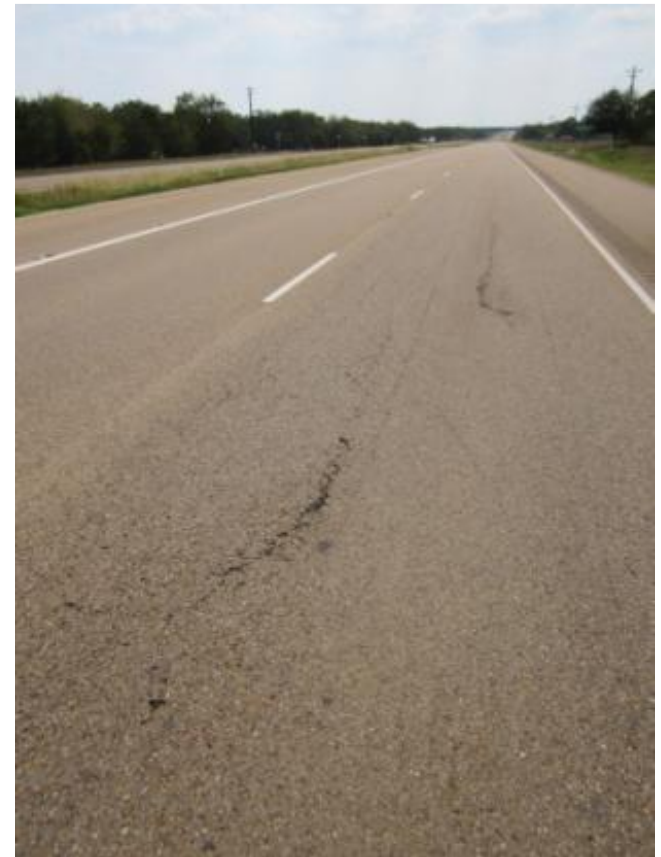
- Fatigue cracks
- Raveling
- Pot holes



IR – What is it & why use it?

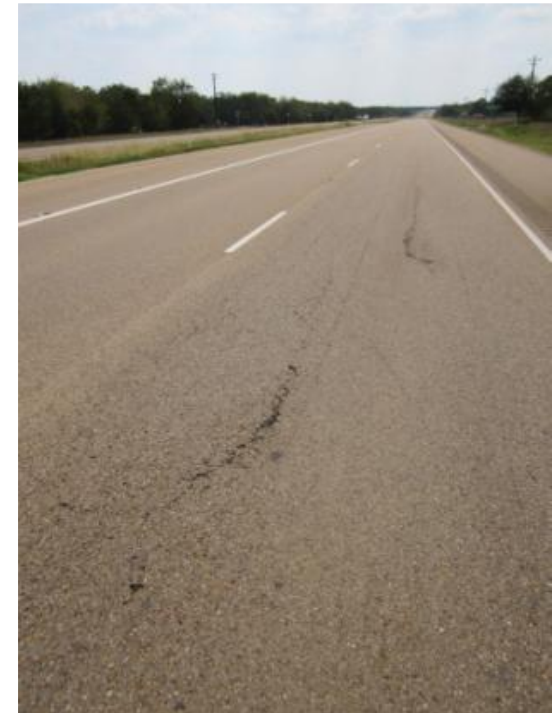
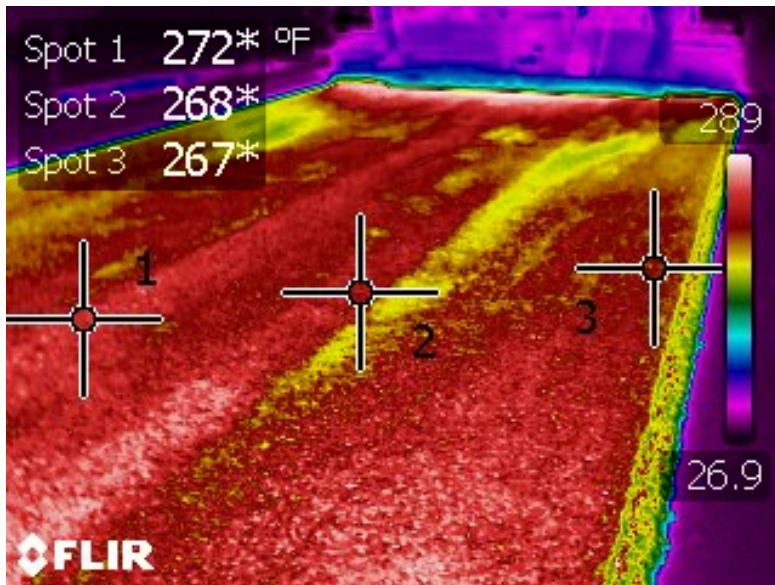
Thermal streaks; longitudinal areas with increased potential for:

- Longitudinal cracking



IR – What is it & why use it?

- Thermal streaks can be very damaging, depending on the level of density achieved in localized areas.
- Measuring the density, accurately, in a localized area is complicated.



Questions?



NEXT:

- Equipment and Software: How to use it?



Infrared Technology (IR)

IR Equipment and Software: How to Use It?

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IR Equipment and Software

1. Equipment and Installation
2. Software and Its Features

IR Equipment and Software

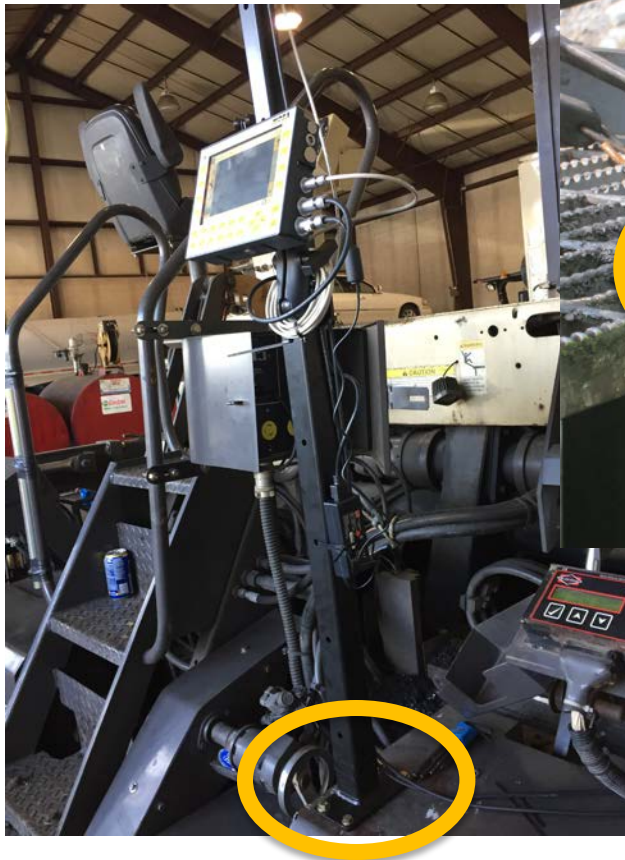
Equipment

- Mast Base
- Mast Extension
- Mast Arm
- IR Scanner
- DMI
- GPS Unit
- Wiring
- Connection bolts & materials



IR Equipment and Software

IR mast base and extension
attached to paver.



Mounted Directly to Screed



Mounted Directly to Work
Platform



Mounted to a Steel Plate
Attached to Work Platform

IR Equipment and Software



- IR Scanner attached to paver; scans mat behind screed in one direction.
- GPS attached to the mast arm.



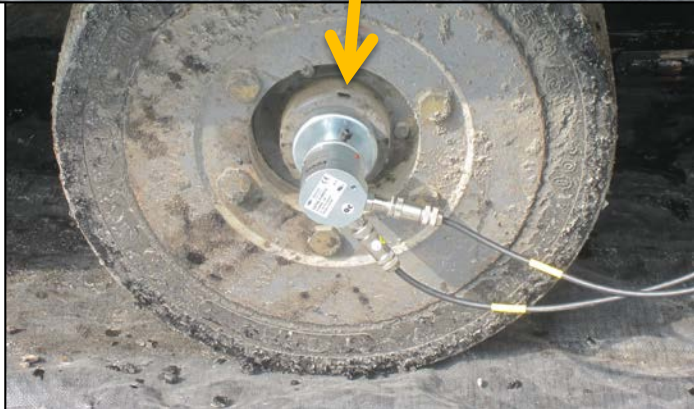
IR Equipment and Software

IR scan screen used to see/monitor mat temperatures in real time; attached to the mast post or extension.



IR Equipment and Software

DMI placed on wheel hub to measure distance during paving operation.



IR Equipment and Software

1. Equipment and Installation
2. Software and Its Features

IR Equipment and Software

Two models of data transfer and extraction



IR Equipment and Software

- Online Web App: <https://eroutes.info/paveappweb/>
- Login is user specific

eRoutes^{MC}
Open a new session

minds
MINDS AT WORK, FOR THE ROADS OF THE WORLD

Username:

Password: [extended validation certificate](#)

Domain:

Remember my username and domain

YOUR INFORMATION, IN REAL TIME

If you have come to this page while trying to access another then you do not have the proper security for the other page or you have not logged in yet. Please log in if you haven't. If you feel you should access an area but you can't, contact [support](#) immediately.

IR Equipment and Software

Explore Data: MOBA Pave Project Manager Main Screen

The screenshot displays the MOBA Pave Project Manager software interface. The main window is titled "Pave Project Manager - Pave_2015-09-16-110725.paveproj (Finished on 9/16/2015 9:22 AM)". The interface is divided into several sections:

- Color Map:** A vertical bar on the left side of the main window, showing a color gradient from blue at the bottom to red at the top. A callout box labeled "Color Map" points to this bar.
- Thermal Profile:** A large central area displaying a heatmap of temperature data. The top of this area is labeled with station numbers from 969 to 955. A callout box labeled "Thermal Profile" is centered over this area.
- Properties:** A panel on the right side of the window, titled "Properties". It contains a "Thermal Profile" section with the following details:

Thermal Profile	
Actions	
Interpolation	Linear
Sample Spots of Interest	Enabled
Stations	Show
Tooltip	Visible
Profile View	
Ignored Sensors	
Length	1513.78ft
Start	0.33ft
Units	Feet
Zoom	100.0%

A callout box labeled "Properties" is positioned below this panel.
- Diagrams and project information:** A bottom section containing a "Project Properties" tab and a "Meta Information" section. The "Meta Information" section displays the following data:

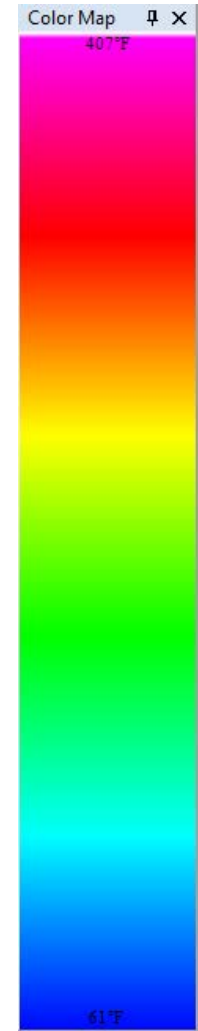
Meta Information	Value
Beginning location	houltou off ramp
Comment	passing lane w/4shld
Ignored Sensors	
Layer thickness	1.5in
Lift	1
Measure height	9.58ft
MINDS Upload	No
Operator Name	paul
Paving width	11.48ft
Project ID	6700ef1e9424b24a0353a7f46367793

A callout box labeled "Diagrams and project information" is positioned over this section.

IR Equipment and Software

Color Map and Properties for Screen

Properties	
Color Map	
▲ Temperature range	
Max	407°F
Min	61°F



IR Equipment and Software

Thermal Profile Properties Screen

The screenshot displays the 'Thermal Profile Properties' screen in the Pavement Project Manager software. The main window shows a thermal profile heatmap with a color scale from 61°F to 407°F. The heatmap is divided into vertical lanes labeled with station numbers: 969, 968, 967, 966, 965, 964, 963, 962, 961, 960, and 959. A properties panel on the right lists settings for the Thermal Profile:

Thermal Profile	
Actions	
Interpolation	Linear
Sample Spots of Interest	Enabled
Stations	Show
Tooltip	Visible
Profile View	
Ignored Sensors	
Length	1513.78ft
Start	0.33ft
Units	Feet
Zoom	100.0%

The bottom panel shows project metadata for 'houlton off ramp' with the following details:

Meta Information	Value
Beginning location	houlton off ramp
Comment	passing lane w/4shld
Ignored Sensors	
Layer thickness	1.5in
Lift	1
Measure height	9.58ft
MINDS Upload	No
Operator Name	paul
Paving width	11.48ft
Project ID	670f0ef1e942-4b24-a035-3a7f46367793

The 'Beginning location' field is defined as 'The name of the location where the project began.' A 'Save' button is visible at the bottom right of the metadata panel.

IR Equipment and Software

Project Properties Screen

The screenshot displays the 'Pave Project Manager' software interface. The main window shows a 'Thermal Profile' with a color map on the left and a data grid on the right. The data grid has columns labeled 969 through 955. A 'Project Properties' dialog box is open in the foreground, showing various project details.

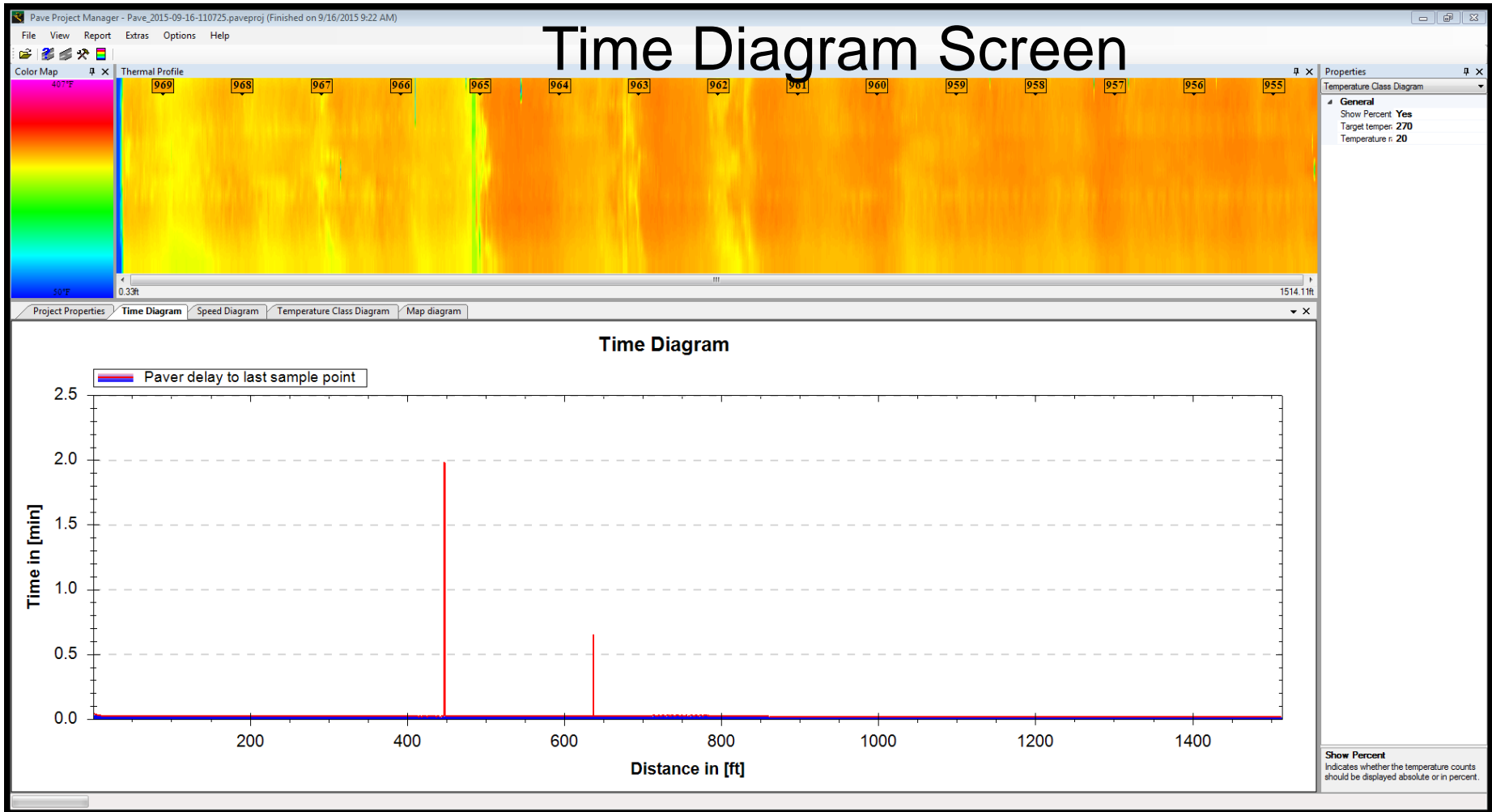
Project Properties Dialog Box:

- Meta Information:**
 - Beginning location: **houlton off ramp**
 - Comment: **passing lane w/4shld**
 - Ignored Sensors: (empty)
 - Layer thickness: **1.5in**
 - Lift: **1**
 - Measure height: **9.58ft**
 - MINDS Upload: **No**
 - Operator Name: **paul**
 - Paving width: **11.48ft**
 - Project ID: **670f0ef1-e942-4b24-a035-3a746367793**
- Metrics:**
 - Project Duration**
 - Paver Stop Time**
 - Average Paver Speed**

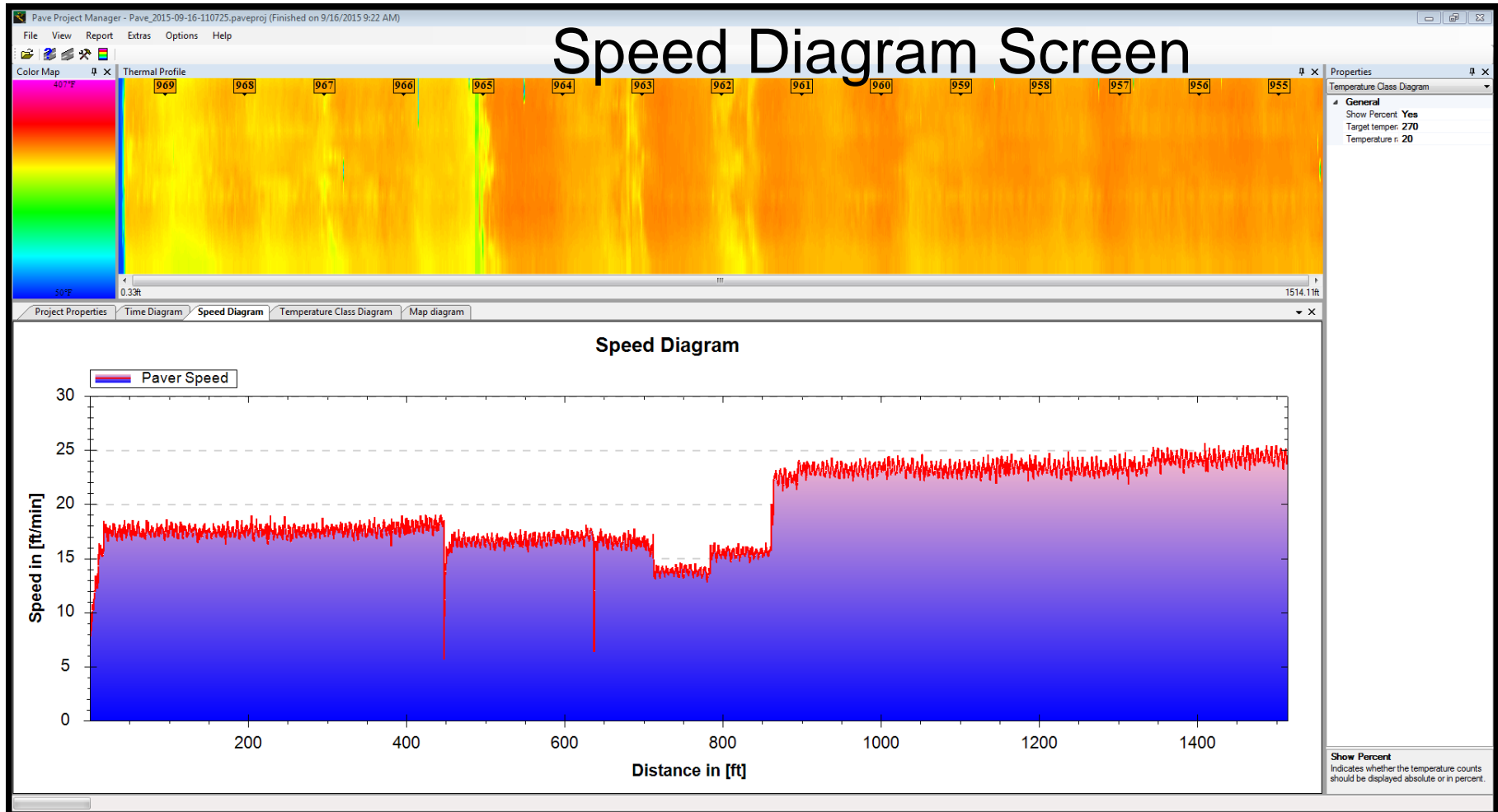
Thermal Profile Data (Approximate):

Station	Temperature (°F)
969	~100
968	~100
967	~100
966	~100
965	~100
964	~100
963	~100
962	~100
961	~100
960	~100
959	~100
958	~100
957	~100
956	~100
955	~100

IR Equipment and Software

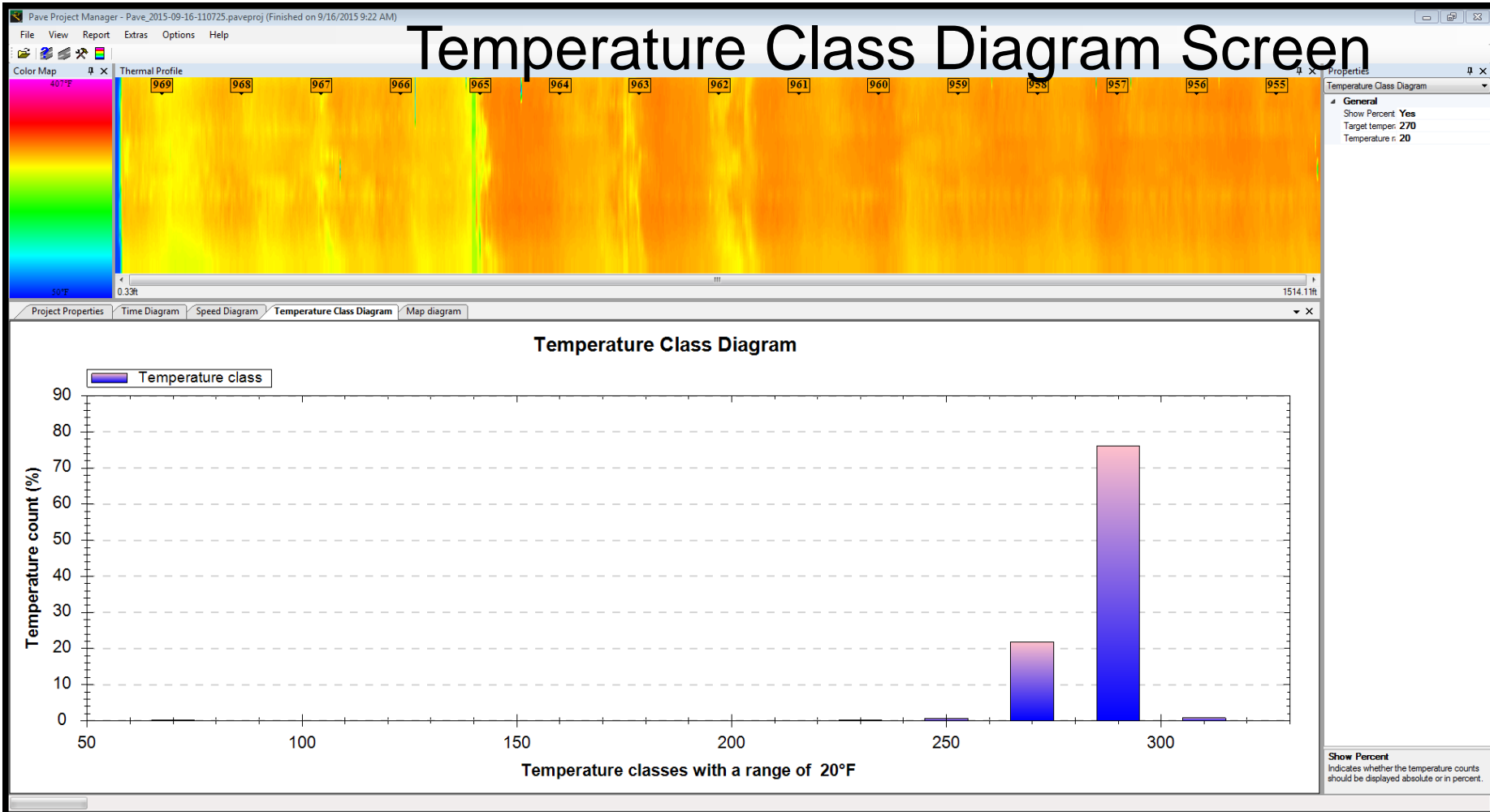


IR Equipment and Software



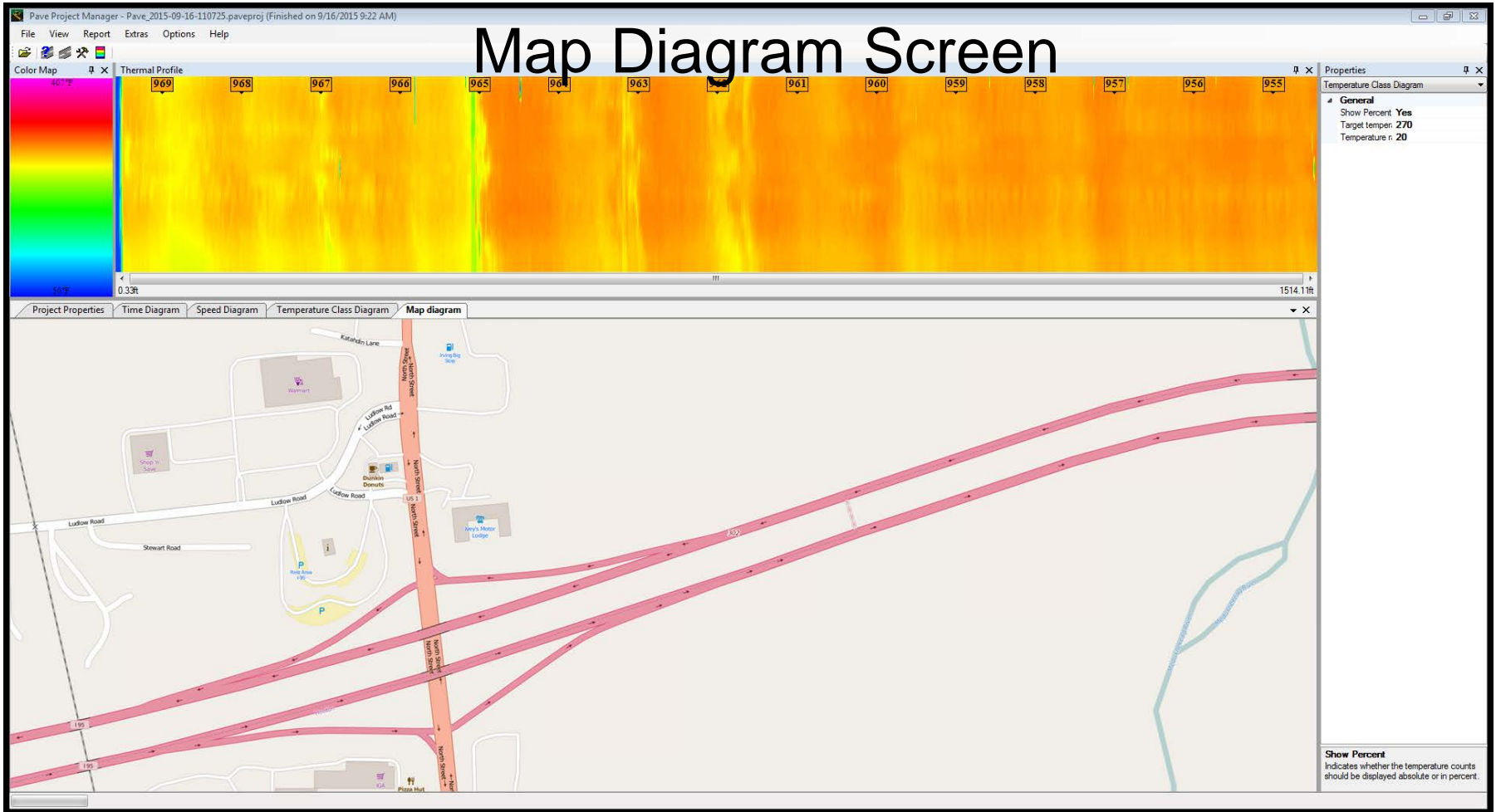
IR Equipment and Software

Temperature Class Diagram Screen



IR Equipment and Software

Map Diagram Screen



IR Equipment and Software

Adding Point Measurements

Click any location on the thermal profile

The screenshot displays the Pavement Project Manager software interface. The main window shows a thermal profile with a color scale on the left ranging from 40°F (red) to 140°F (blue). The profile is divided into sections labeled 965 through 969. Several point measurements are overlaid on the profile, each showing temperature, height, coordinates, and satellite count. A semi-transparent box with the text 'Click any location on the thermal profile' is positioned over the right side of the profile. Below the profile is a 'Map diagram' showing a road layout with red pins indicating the locations of the measurements. The bottom right corner contains an 'Ignored Sensors' section with instructions.

Point ID	Temperature (°F)	Height (ft)	Coordinates (W, N)	Satellites
967.25	283	232.9	67.83365311°W, 46.14118346°N	10
965.07	223	451.1	67.83446667°W, 46.14099723°N	10
965.48	280	410.4	67.83431842°W, 46.14103203°N	11
961.91	278	767.4	67.83564739°W, 46.14072025°N	9
961.82	271	776.2	67.83568142°W, 46.14071210°N	9
961.91	276	767.4	67.83564739°W, 46.14072025°N	9
958.57	295	1100.7	67.83691530°W, 46.14042614°N	11
968.72	261	85.6	67.83309889°W, 46.14131155°N	11

Ignored Sensors
Enter the sensor IDs you don't want to be displayed. ID 1 is the outer left sensor. Ex...

IR Equipment and Software

Generating Reports

The screenshot shows the Pavement Project Manager software interface. The main window displays a color-coded map of a road profile with stationing from 969 to 955. A 'Generate Report' dialog box is open, allowing the user to select a report name from a dropdown menu. The selected report name is 'Detailed Report 9/4/2015 8:48 AM'. Below the dialog box, the 'Tex-244-F Part II Input' form is visible, containing various fields for report generation. A callout box with an arrow points to the form, stating 'Generates PDF Report'.

Generate Report

Choose a report by name. This will identify the Report Data and Layout.

Report name:

Tex-244-F Part II Input

The Tex-244-F Part II report contains some fields of project description on page 1. You can complete the fields by using this form. You can also leave this form blank. Then the fields in the report are also blank.

Report Name	Tex 244-F
Profile ID	95sb
Profile Number	Not availale
Status	
County	
Tested By	
Test Location	houlton off ramp
Material Code	
Material Name	
Producer	
Area Engineer	
Profile Date	9/16/2015 7:11 AM
Letting Date	Not availale
Controlling CSJ	
Spec Year	Not availale
Spec Item	
Special Provision	
Mix Type	
Project Manager	

Generates PDF Report

IR Equipment and Software

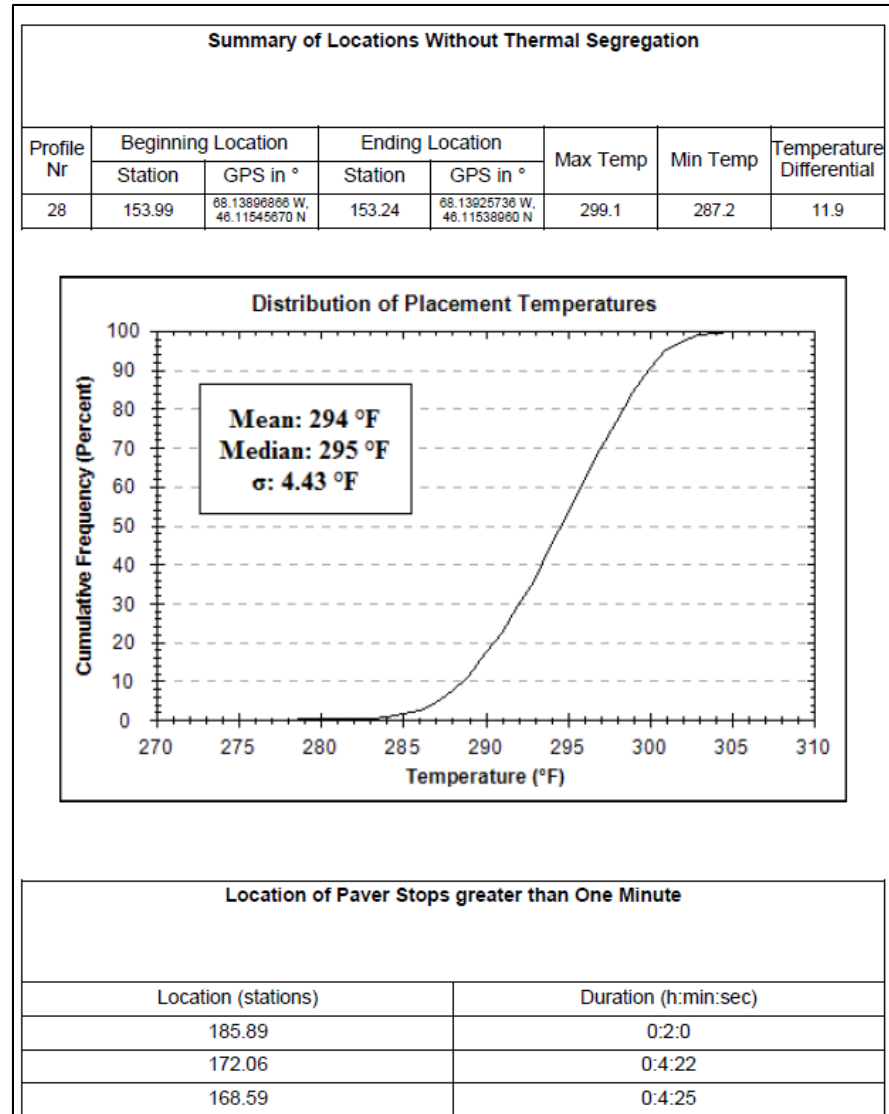
Generating Reports

Tex 244-F				
Thermal Profile Summary Report				
Profile ID:	95sb	Profile Date:	9/24/2015 9:18:13 AM	
Profile Number:		Letting Date:		
Status:		Controlling CSJ:		
County:		Spec Year:		
Tested By:		Spec Item:		
Test Location:	194	Special Provision:		
Material Code:		Mix Type:		
Material Name:				
Producer:				
Area Engineer:		Project Manager:		
Course/Lift:	3	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
28	0	0	0	0

Summary of Locations Without Thermal Segregation							
Profile Nr	Beginning Location		Ending Location		Max Temp	Min Temp	Temperature Differential
	Station	GPS in °	Station	GPS in °			
1	194.49	88.12363437 W, 46.11892049 N	193.00	88.12418593 W, 46.11879052 N	303.4	287.8	15.7
2	192.99	88.12419985 W, 46.11878960 N	191.50	88.12478079 W, 46.11866149 N	304.9	289.6	15.3
3	191.49	88.12478285 W, 46.11866104 N	190.00	88.12532427 W, 46.11853654 N	301.1	286.3	14.8
4	189.99	88.12533012 W, 46.11853523 N	188.50	88.12589203 W, 46.11840836 N	299.3	285.8	13.5
5	188.49	88.12589363 W, 46.11840800 N	187.00	88.12645626 W, 46.11828259 N	297.7	285.4	12.2
6	186.99	88.12645906 W, 46.11828176 N	185.49	88.12702186 W, 46.11815402 N	298.9	283.5	15.5
7	185.49	88.12702379 W, 46.11815360 N	183.99	88.12758506 W, 46.11802607 N	302.2	283.8	18.4
8	183.98	88.1275889 W, 46.11802512 N	182.49	88.12815126 W, 46.11789818 N	303.1	292.6	10.4
9	182.49	88.12815319 W, 46.11789773 N	181.00	88.12871395 W, 46.11777111 N	306.1	288.1	18.0
10	180.99	88.12871821 W, 46.11777052 N	179.50	88.12928274 W, 46.11764036 N	302.2	284.4	17.8
11	179.49	88.12928577 W, 46.11763968 N	178.00	88.12985205 W, 46.11751058 N	302.9	287.6	15.3
12	177.99	88.12985387 W, 46.11751020 N	176.50	88.13042113 W, 46.11738235 N	302.0	288.0	14.0
13	176.49	88.13042482 W, 46.11738148 N	175.00	88.13099093 W, 46.11725309 N	301.8	289.2	12.6
14	174.99	88.13099275 W, 46.11725266 N	173.50	88.13155886 W, 46.11712703 N	302.2	288.0	14.2
15	173.49	88.13156283 W, 46.11712618 N	171.99	88.13213684 W, 46.11699931 N	303.6	286.3	17.3
16	171.99	88.13213071 W, 46.11699898 N	170.49	88.13269254 W, 46.11687031 N	302.9	286.5	16.4
17	170.48	88.1326963 W, 46.11686947 N	169.00	88.13325913 W, 46.11674378 N	305.8	288.9	16.9
18	168.99	88.13326314 W, 46.11674285 N	167.50	88.13382973 W, 46.11661558 N	302.0	286.0	16.0
19	167.49	88.13383168 W, 46.11661512 N	166.00	88.13439373 W, 46.11648481 N	298.6	284.2	14.4
20	165.99	88.13440119 W, 46.11648382 N	164.50	88.13497078 W, 46.11635549 N	298.4	282.9	15.5
21	164.49	88.13497271 W, 46.11635503 N	163.00	88.13554162 W, 46.11622699 N	297.5	282.4	15.1
22	162.99	88.13554551 W, 46.11622616 N	161.49	88.13611883 W, 46.11609795 N	296.1	283.6	12.4
23	161.49	88.13612069 W, 46.11609752 N	160.00	88.13668796 W, 46.11596968 N	301.6	277.2	24.5
24	159.99	88.13669173 W, 46.11596883 N	158.49	88.13725815 W, 46.11584140 N	299.7	281.1	18.5
25	158.49	88.13725879 W, 46.11584082 N	157.00	88.1378221 W, 46.11571525 N	301.6	287.4	14.2
26	156.99	88.13782589 W, 46.11571440 N	155.50	88.13839327 W, 46.11558715 N	302.2	288.5	13.7
27	155.49	88.13839721 W, 46.11558631 N	154.00	88.1389655 W, 46.11545741 N	302.2	289.8	12.4

IR Equipment and Software

Generating Reports



IR Equipment and Software

Exporting Data

- Export to .txt (semicolon separated)
- Save as .paveproj

Questions?



NEXT:

- Data Analyses and Findings: IL 116 near Hanna City, IL and I-155 near Hopedale, IL



Infrared Technology (IR)

Data Analyses and Findings: IL 116 and I-155

March 7, 2017



U.S. Department of Transportation
Federal Highway Administration

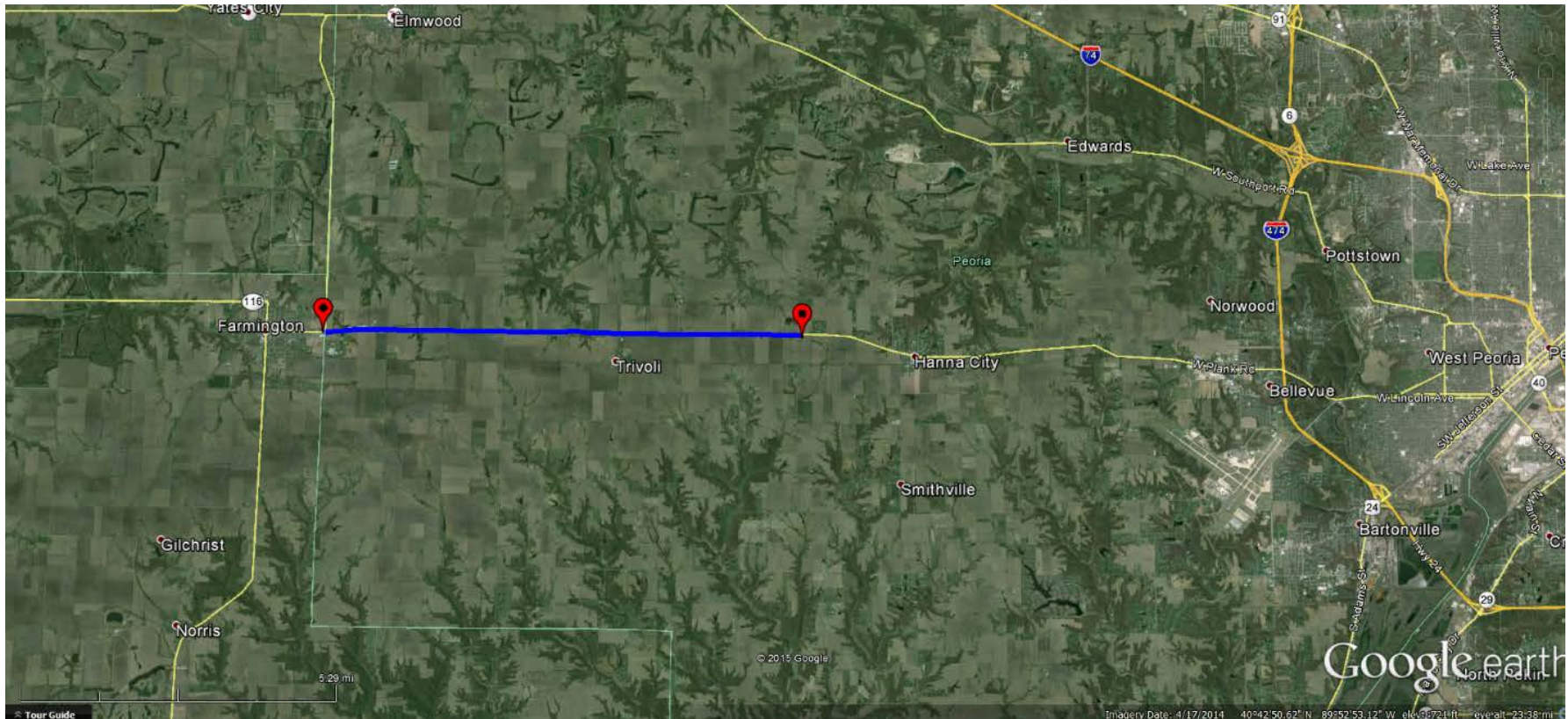


Data Analyses & Findings

1. Project Overview
2. Data Collection
3. Data Processing
4. Data Summary

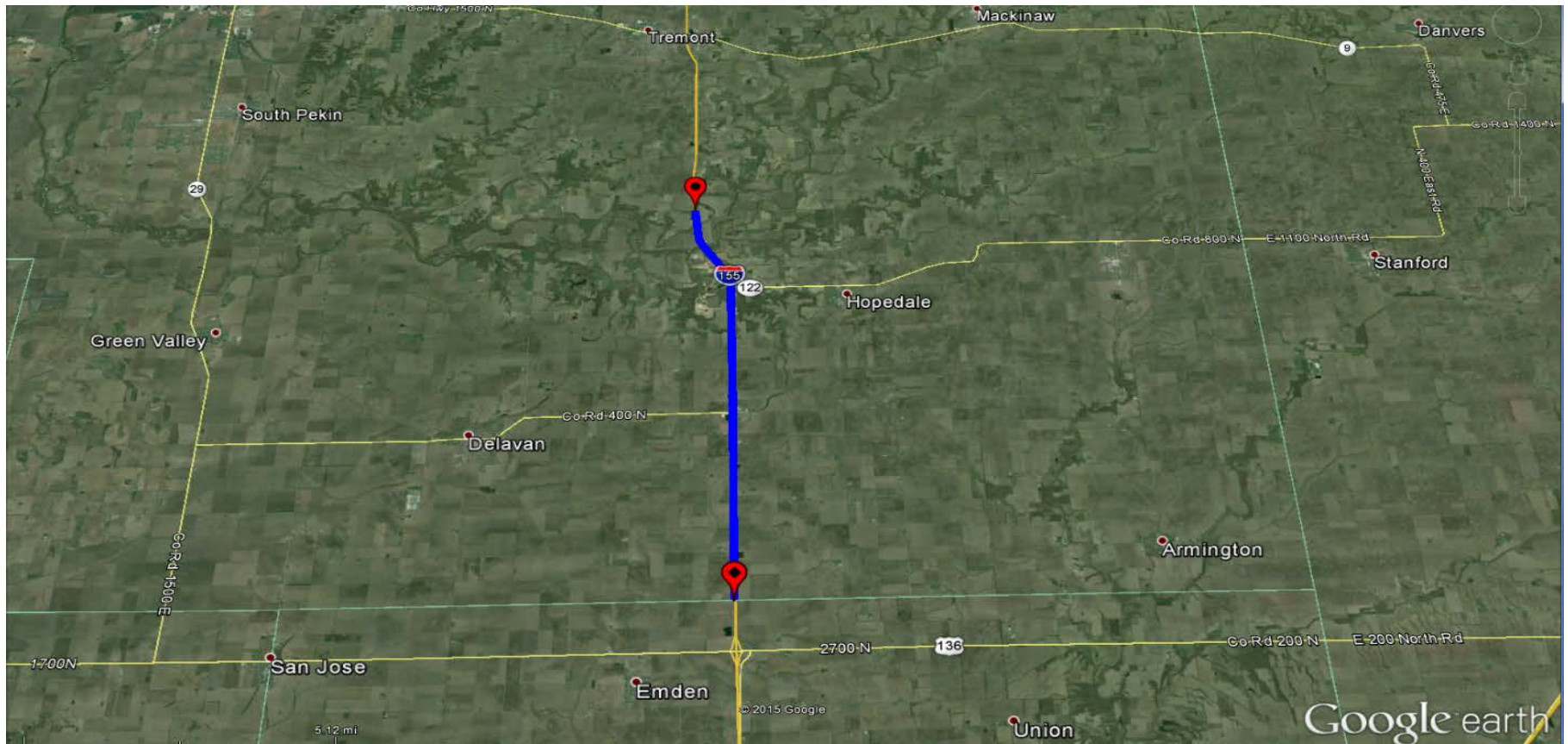
Data Analyses & Findings

IL 116 near Hanna City, IL



Data Analyses & Findings

I-155 near Hopedale, IL



Data Analyses & Findings



Mixtures placed with
Caterpillar Rubber
Tracked Paver

Mixture delivered to site with
end dump discharge trucks.



Data Analyses & Findings

Compaction Train; all steel wheel rollers



Data Analyses & Findings

Cores, Nuclear & non-nuclear density gauge used to measure mat density and superimposed on temperature profiles.

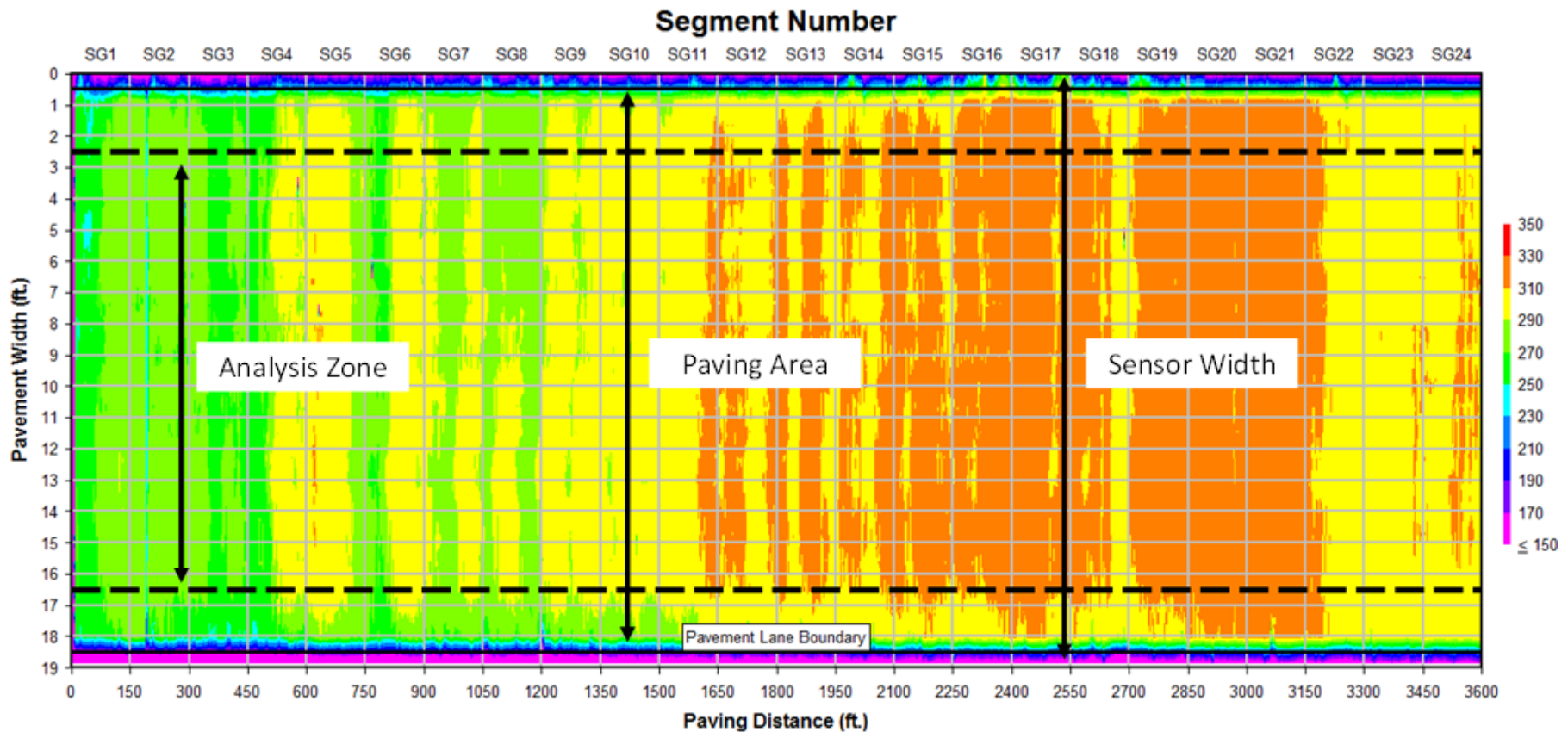


Data Analyses & Findings

1. Project Overview
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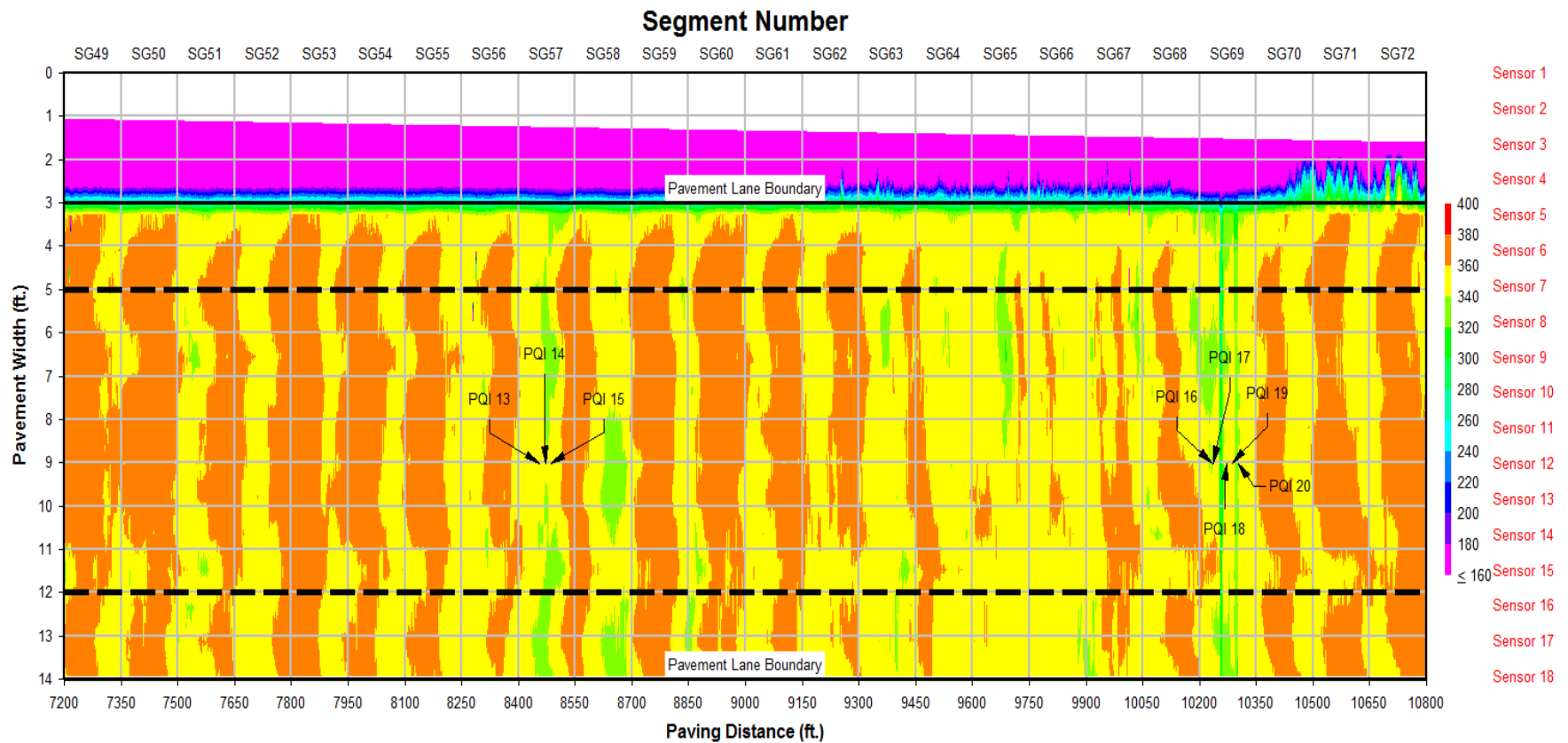
Data Analyses & Findings

Raw Temperature Profile Example



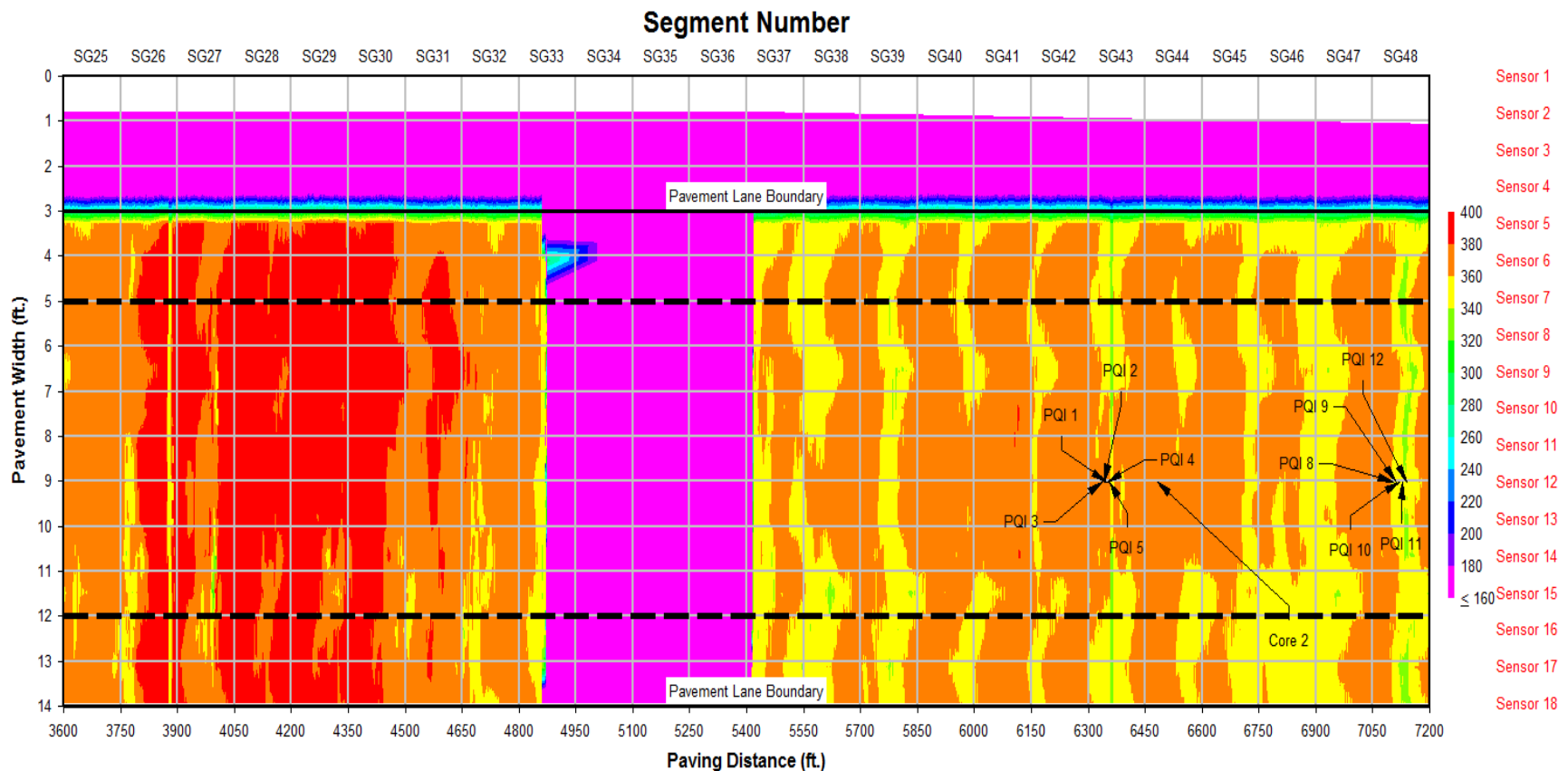
Data Analyses & Findings

Raw Temperature Profile

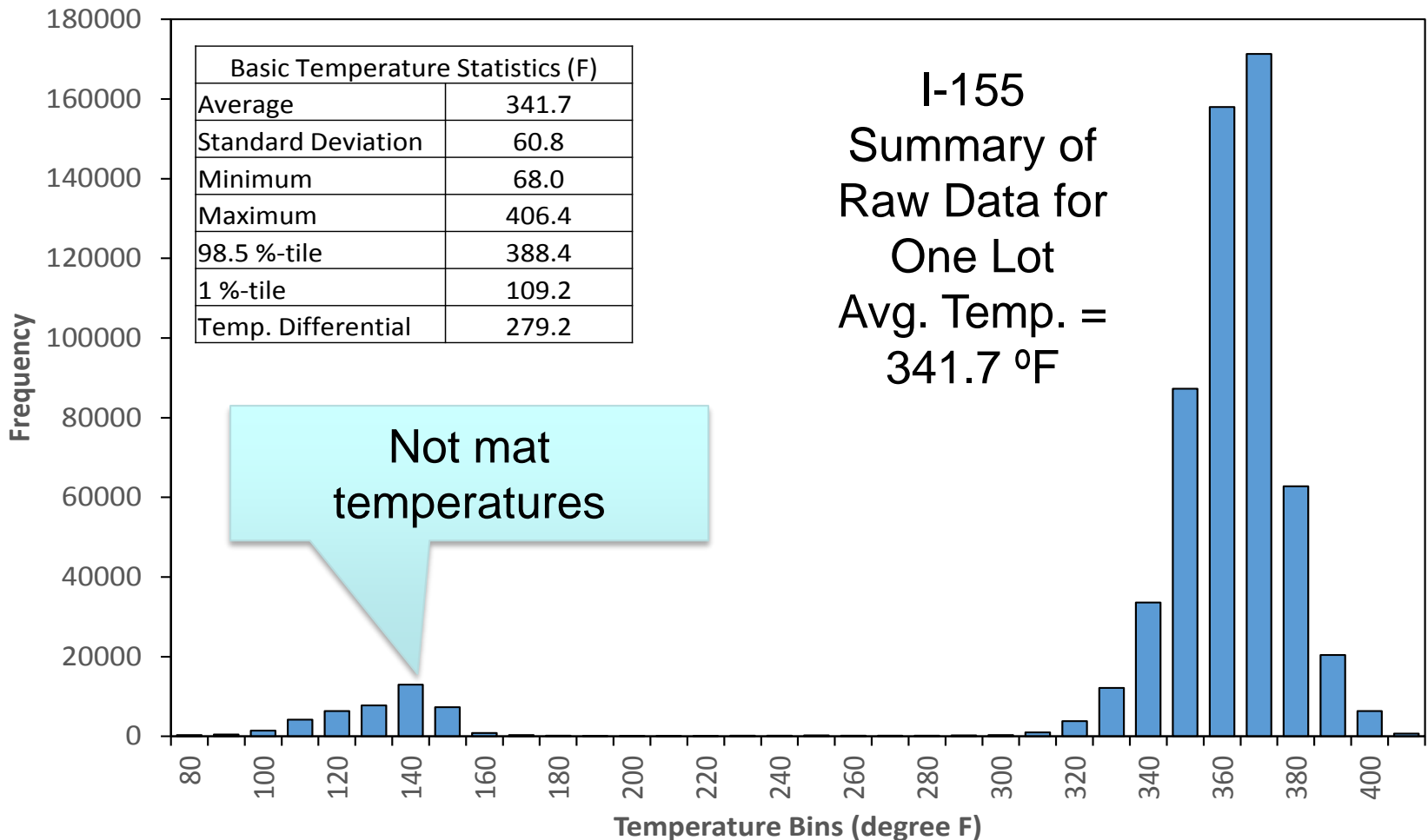


Data Analyses & Findings

Raw Temperature Profile – What's the cool spot?



Data Analyses & Findings

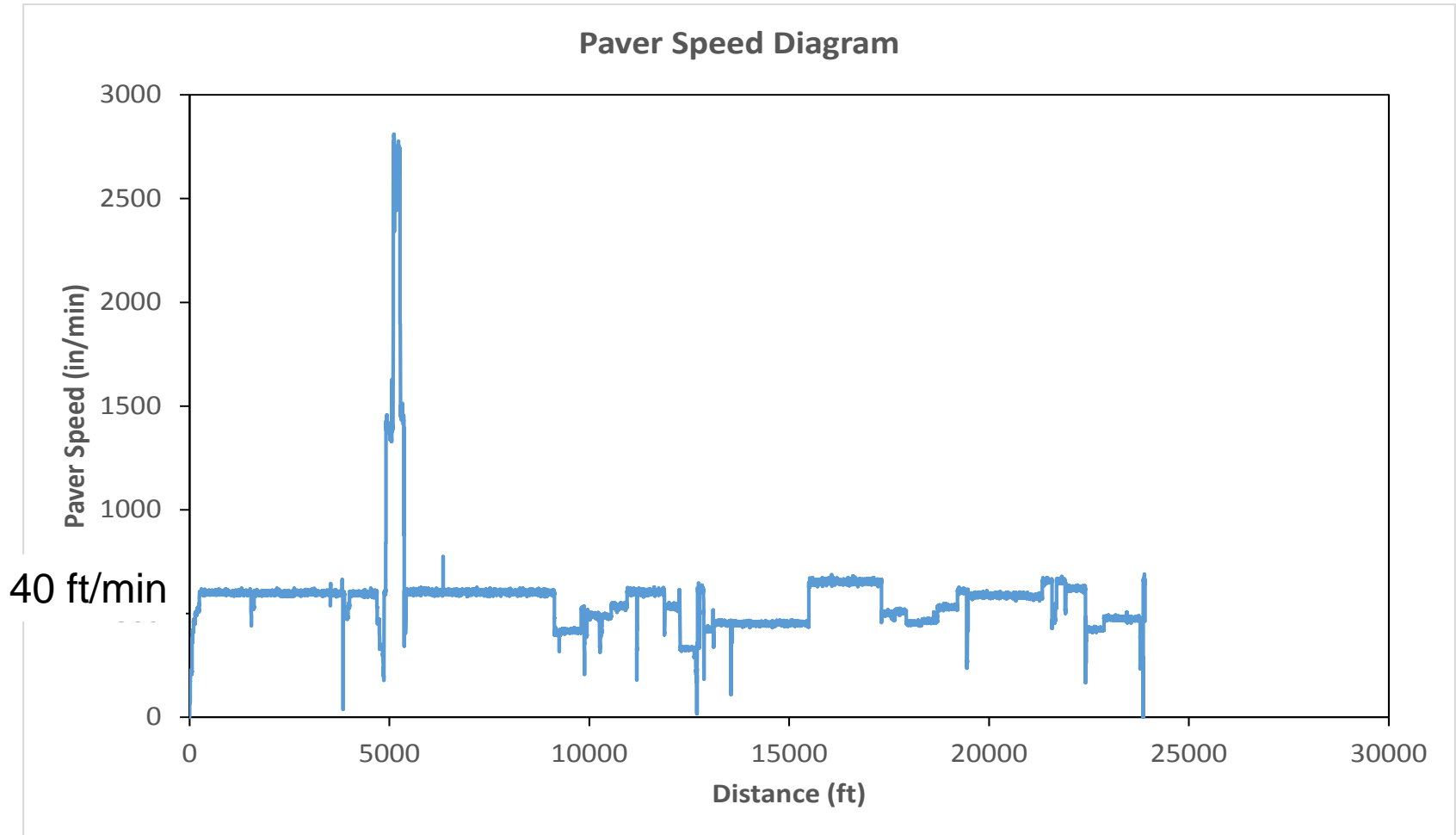


Data Analyses & Findings

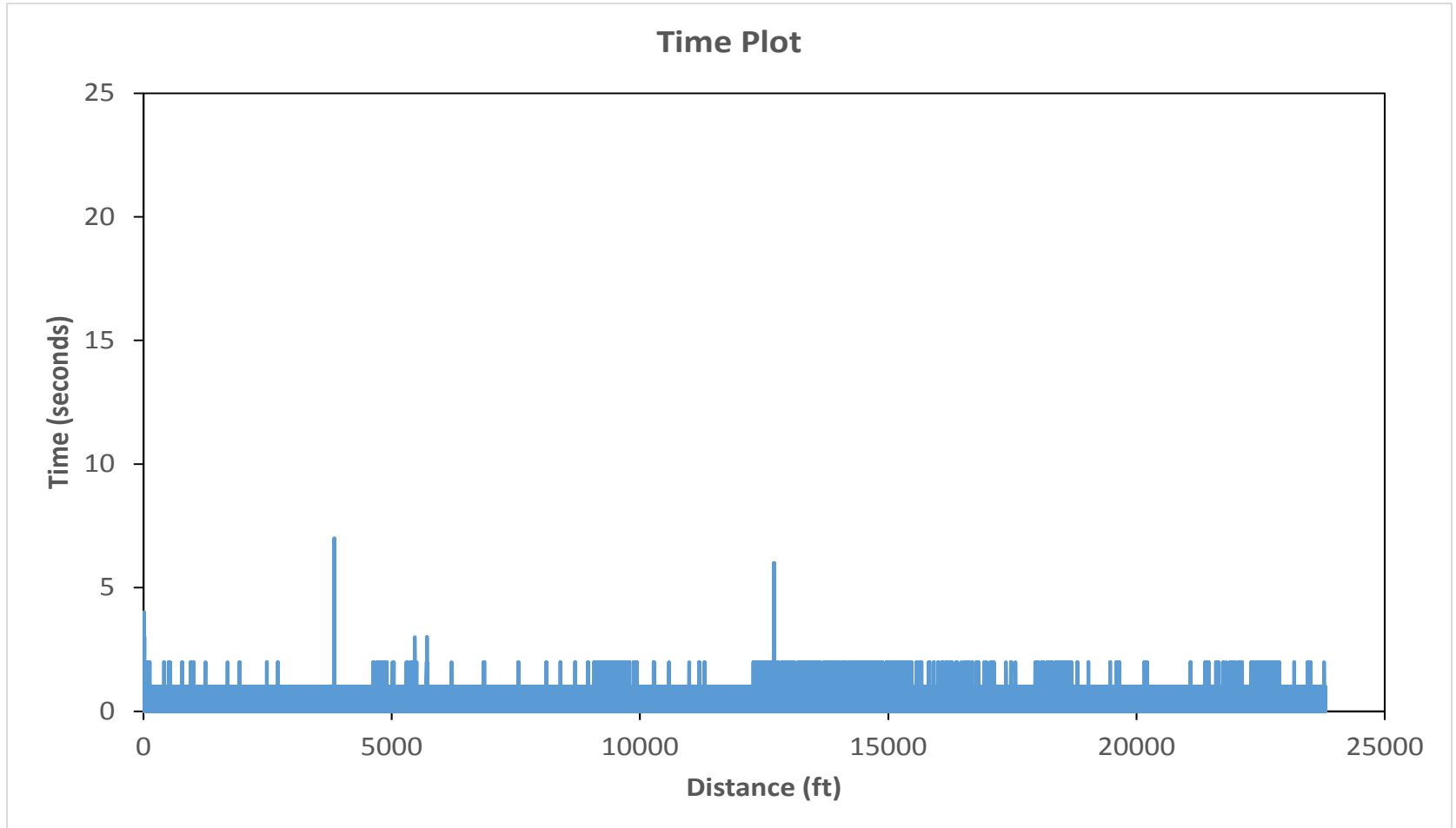
Data diagrams reviewed during production:

1. Paver speed diagram
2. Time plot
3. Average temperature plot

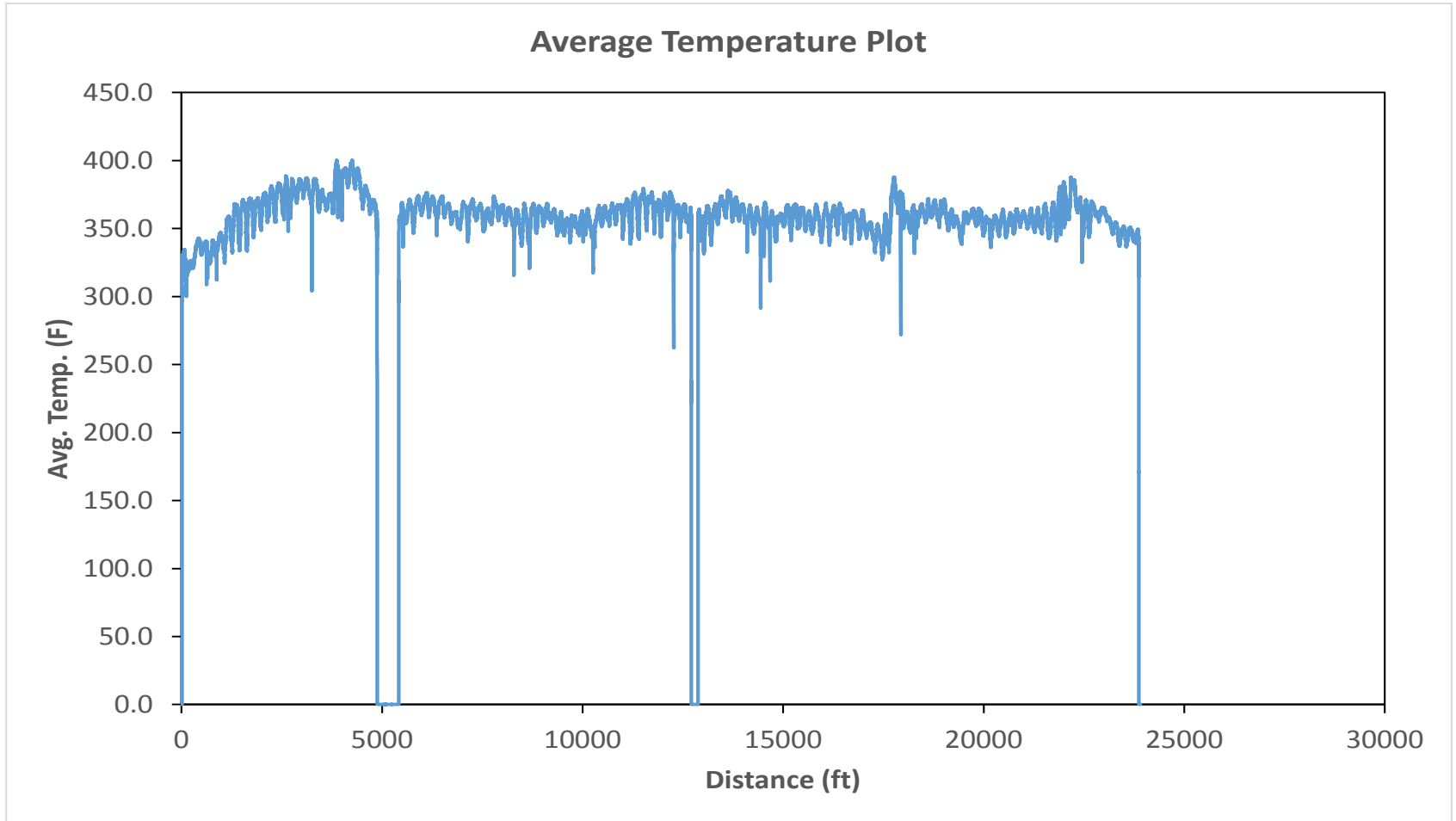
Data Analyses & Findings



Data Analyses & Findings



Data Analyses & Findings



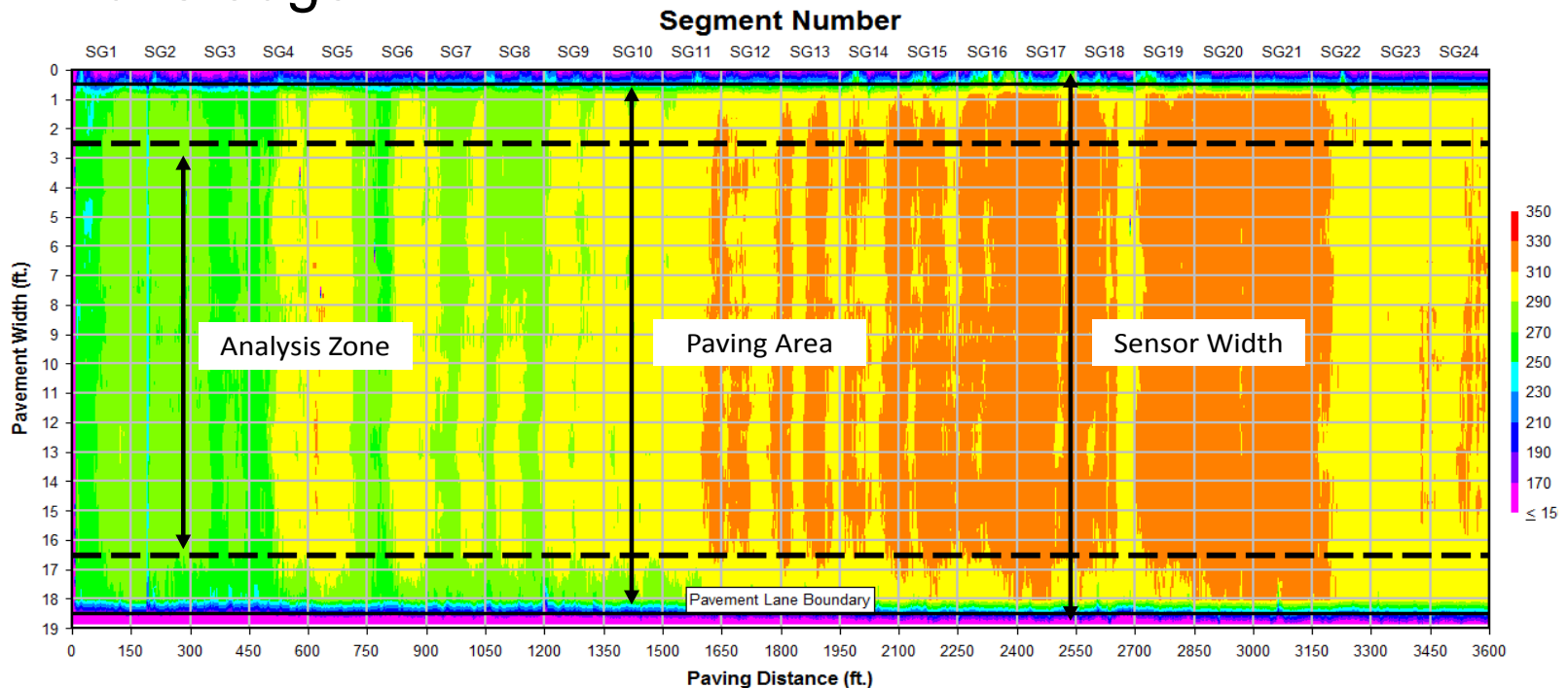
Data Analyses & Findings

1. Project Overview
2. Data Collection
3. Data Processing
4. Data Summary

Data Analyses & Findings

Data Processing—eliminate invalid temperature measurements:

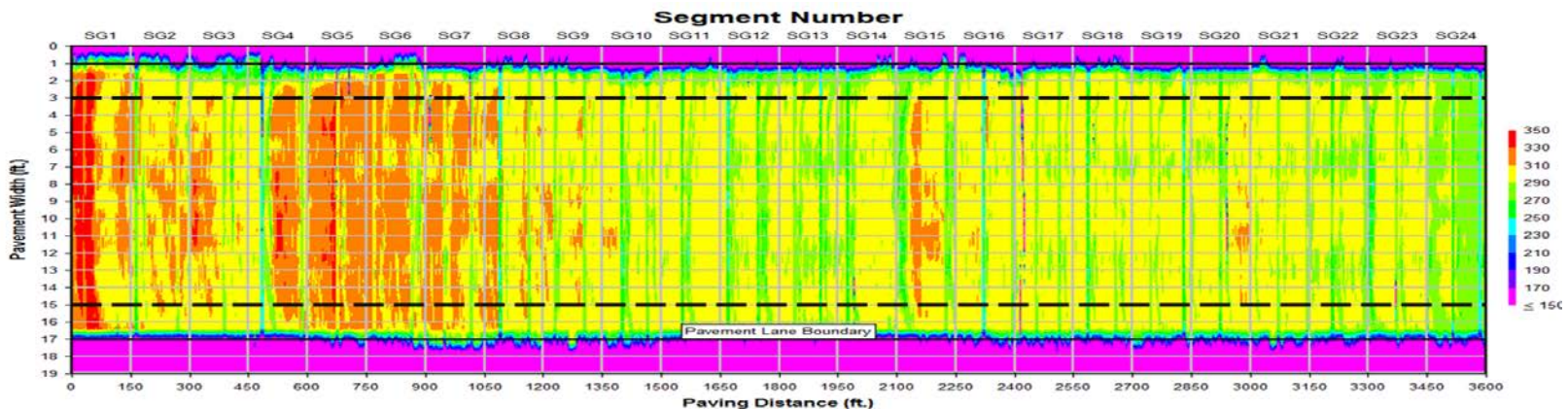
1. Eliminate measurement locations within 2 feet of the mat's edge.



Data Analyses & Findings

Data Processing—eliminate invalid temperature measurements:

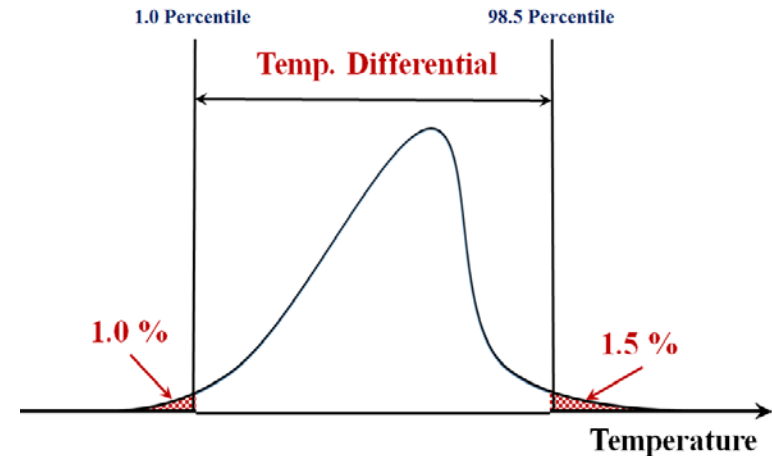
2. Eliminate data with paver stops greater than 60 seconds, between locations:
 - 2 feet behind measurement location of stop
 - 8 feet in front of measurement location of stop
3. Eliminate temperature readings < 170 °F and > 400 °F.



Data Analyses & Findings

- Temperature Differential Criteria, each 150 foot segment:

$$T_{Diff} = T_{98.5} - T_{1.0}$$



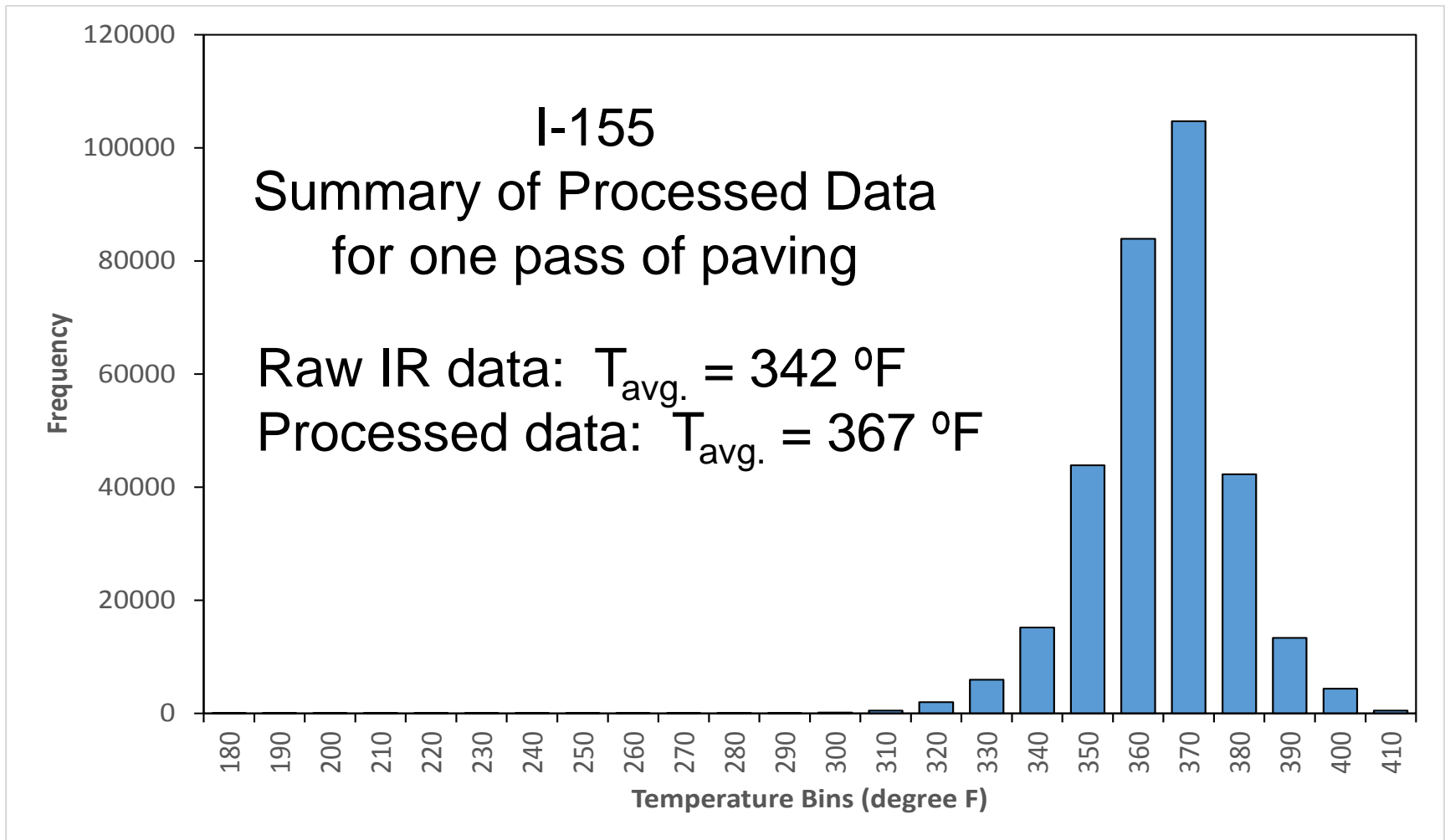
- $T_{diff} \leq 25$ °F
- 25 °F $< T_{diff} \leq 50$ °F
- $T_{diff} > 50$ °F

No temperature difference

Moderate temperature difference

Severe temperature difference

Data Analyses & Findings



Data Analyses & Findings

1. Project Overview
2. Data Collection
3. Data Processing
4. Data Summary

Data Analyses & Findings

Difference in Traffic Levels – Haul Time



IL 116



I-155

R06C-IR Demonstration Projects

Paver Stops	Total Number of Increments	Number of Increments within Temp. Regimes			Thermal Streaking
		Minor	Moderate	Severe	
Illinois DOT Project					
Excluded	1,520	218	761	541	None
Included	1,502	196	708	598	None

To include or exclude paver stops?
 If paver stop cause severe temperature differences:
 they should be included

Data Analyses & Findings

Processed Data – WV Data Comparison With and Without an MTV

Condition	Total Number of Increments	Number of Increments within Temp. Regimes			Thermal Streaking
		Minor	Moderate	Severe	
Excludes Paver Stops¹	273	133	99	41	None
Without MTV²	99	0	74	25	None
With MTV³	159	133	19	7	None
Includes Paver Stops¹	274	105	112	57	None
Without MTV²	99	0	58	41	None
With MTV³	159	104	47	8	None

¹Data from all dates (7/26, 7/27, 7/28, 8/3, 8/4)

²Data collected on 7/27/2016 and 7/28/2016 only

³Data collected on 8/3/2016 and 8/4/2016 only

R06C-IR Demonstration Projects

Paver Stops	Total Number of Increments	Number of Increments within Temp. Regimes			Thermal Streaking
		Minor	Moderate	Severe	
Alaska DOT Project					
Excluded	36	27	9	0	None
Included	36	22	8	6	None
Maine DOT Project					
Excluded	579	546	25	8	None
Included	579	494	56	29	None
Virginia DOT Project					
Excluded	84	72	10	2	None
Included	84	71	9	4	None

R06C-IR Demonstration Projects

Paver Stops	Total Number of Increments	Number of Increments within Temp. Regimes			Thermal Streaking
		Minor	Moderate	Severe	
Eastern Federal Lands					
Excluded	108	2	24	82	None
Included	108	2	16	90	None
New Jersey DOT Project					
Excluded	262	188	49	25	None
Included	262	163	43	56	None
Missouri DOT Project					
Excluded	816	648	135	33	None
Included	816	440	170	206	None

R06C-IR Demonstration Projects

Paver Stops	Total Number of Increments	Number of Increments within Temp. Regimes			Thermal Streaking
		Minor	Moderate	Severe	
North Carolina DOT Project					
Excluded	126	95	24	7	None
Included	126	79	24	23	None
West Virginia DOH Project; without MTV					
Excluded	99	0	74	25	None
Included	99	0	58	41	None
West Virginia DOH Project; with an MTV					
Excluded	159	133	19	7	None
Included	159	104	47	8	None

R06C-IR Demonstration Projects

Paver Stops	Total Number of Increments	Number of Increments within Temp. Regimes			Thermal Streaking
		Minor	Moderate	Severe	
Illinois DOT Project					
Excluded	1,520	218	761	541	None
Included	1,502	196	708	598	None
Excluded					
Included					
Excluded					
Included					

R06C-IR Demonstration Projects

Percentage of Segments with Severe Temperature Differentials

Project	Delivery Truck Type	MTV Included	Percent Severe Temp. Differentials	Thermal Streaking
Alaska	Bottom-Dump	Windrows	17	None
<i>EFL</i>	<i>End Dump</i>	<i>No</i>	<i>83</i>	<i>None</i>
<i>Illinois</i>	<i>End Dump</i>	<i>No</i>	<i>40</i>	<i>None</i>
Maine	End Dump	Yes	5	None
Missouri	End Dump & Flow Boys	Yes	25	None
NJ	End Dump	Yes	21	None
Virginia	End Dump	Yes	5	None
NC	End Dump	Yes	18	None
<i>WV</i>	<i>End Dump</i>	<i>No</i>	<i>41</i>	<i>None</i>
WV	End Dump	Yes	5	None

Above include paver stops.

R06C-IR Demonstration Projects

Minnesota Acceptance Specification: Summary

Project	Delivery Truck Type	MTV Included	Incentive/Disincentive	
			Stops Included	Stops Excluded
Alaska	Bottom-Dump	Windrows	+\$17,778	+\$30,000
<i>EFL</i>	<i>End Dump</i>	<i>No</i>	<i>-\$32,593</i>	<i>-\$29,630</i>
<i>Illinois</i>	<i>End Dump</i>	<i>No</i>	<i>-\$10,706</i>	<i>-\$8,500</i>
Maine	End Dump	Yes	+\$32,124	+\$37,168
Missouri	End Dump & Flow Boys	Yes	+\$11,471	+\$30,147
NJ	End Dump	Yes	+\$16,336	+\$24,885
Virginia	End Dump	Yes	+\$31,905	+\$33,333
NC	End Dump	Yes	+\$17,778	+\$27,937
<i>WV</i>	<i>End Dump</i>	<i>No</i>	<i>-\$16,566</i>	<i>-\$10,101</i>
WV	End Dump	Yes	+\$24,151	+\$31,698

Based on 2,000 IR segments for each project.

Data Analyses & Findings

In summary: infrared scanner identified areas or locations with higher temperature differences.



Questions?



NEXT:

- Implementation: Illinois DOT and Contractor
Points of View



Infrared Technology (IR)

Implementation: Illinois DOT, and Contractor Points of View

March 7, 2017



U.S. Department of Transportation
Federal Highway Administration

AMERICAN ASSOCIATION
OF STATE HIGHWAY AND
TRANSPORTATION OFFICIALS

AASHIO

Agency/Contractor Deployment

1. Agency:

- Benefits – Agency points of view
- Plans to utilize IR Technology?

2. Contractor:

- Reasons for using IR Technology
- Benefits – Contractor points of view
- Making decisions in real time to minimize penalties
- Use of future projects

Agency/Contractor Deployment

Some Typical Questions for Deployment:

1. How many projects has Pave-IR Scan™ been used on?
2. How many projects were for quality assurance?
3. What percent of profiles exhibited medium & severe temperature differences?
4. How easy is it to set up the project in Pave-IR Scan™?
5. Any problems experienced with the equipment?
6. Has the Pave-IR system changed daily practice?
7. Has use of the Pave-IR system changed interaction between the owner & contractor?
8. How easy is the IR data to extract and process?
9. Do you review the Pave-IR reports at the end of the day?
10. Do you think you are getting a higher quality mat at the end of the day using the Pave-IR system?



Infrared Technology (IR)

Implementation Products and Strategies

March 7, 2017



U.S. Department of Transportation
Federal Highway Administration



Implementation Products and Strategies



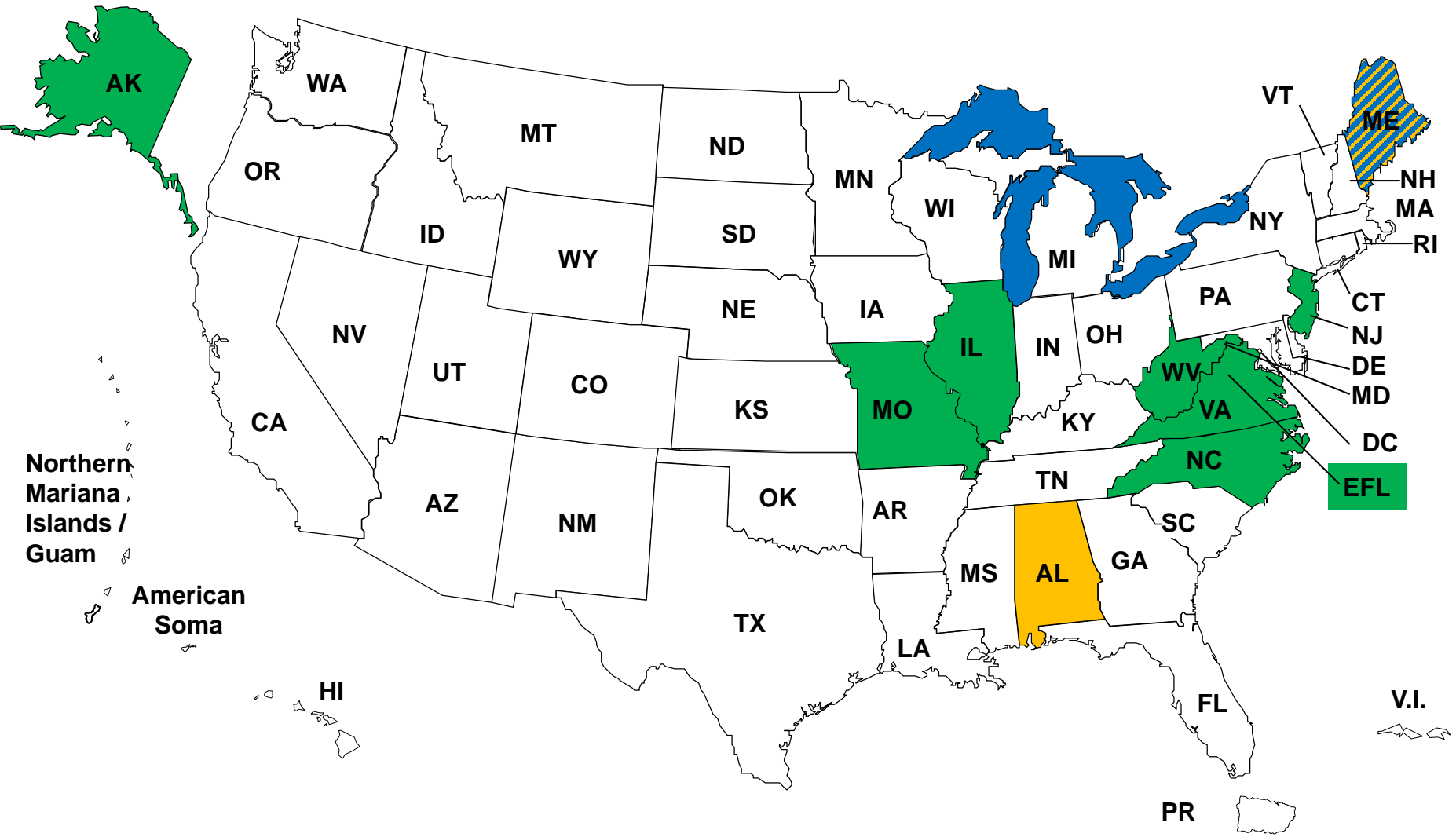
1. Field Demonstration Projects and Products
2. Application and Use: Examples
3. Questions and Answers

Workshop Wrap-Up



- R06C: additional information on Infrared Tech.
 - AASHTO Site: <http://shrp2.transportation.org>
 - FHWA Site: www.fhwa.gov/goshrp2

Demonstration Projects and Products



Demonstration Projects and Products



1. Case Study/Demonstration Report
2. Showcase
3. Trouble Shooting and Best Practices Guide
4. Specification Guide
5. IR Guide/Primer

Demonstration Projects and Products



1. Field Demonstration Projects and Case Study Report:
 - Purpose/Focus
 - a) Enhance the deployment and use of the IR technology.
 - b) Identify/summarize lessons learned from field trials.
 - c) Confirm Pave-IR can identify the different types of temperature differentials that affect mat density and pavement performance.
 - d) Demonstrate and discuss value added using IR technology to agency and contractor

Demonstration Projects and Products

2. Showcase:

- Purpose/Focus
 - a) Highlight IR technology, provide training & operation.
 - b) Attendance includes agencies, contractors, industry, consultants and academia.
- Missouri DOT Hosted
- June 1, 2016

Demonstration Projects and Products

3. Trouble Shooting and Best Practices Guide

- Purpose/Focus

- a) Provide guidance on:

- Setting up the equipment and getting started.
 - Interpreting the raw data for making decisions.

- b) Identify data collection and maintenance issues with the equipment and software.

Demonstration Projects and Products

4. Specification Guide; AASHTO PP 80-14

Standard Practice for
Continuous Thermal Profile of
Asphalt Mixture Construction

AASHTO Designation: PP 80-14¹

11/15/14 10:00 AM



American Association of State Highway and Transportation Officials
444 North Capitol Street N.W., Suite 249
Washington, D.C. 20001

Demonstration Projects and Products

4. Specification Guide, continued

- Purpose/Focus

- a) Advance standardization of IR equipment and testing protocols through AASHTO.
- b) Agencies can customize it to their needs
- c) Revised/Enhanced AASHTO PP 80-14
- d) Agency Experience: Minnesota DOT, Texas DOT, etc.

Demonstration Projects and Products

5. IR Guide/Primer

- Purpose/Focus

- a) Introduce the Pave-IR method to transportation agencies and contractors.
- b) Increase awareness of how IR can improve paving operations and increase uniformity of mat.
- c) Demonstrate use of Pave-IR as a QC Tool.

Implementation Products and Strategies

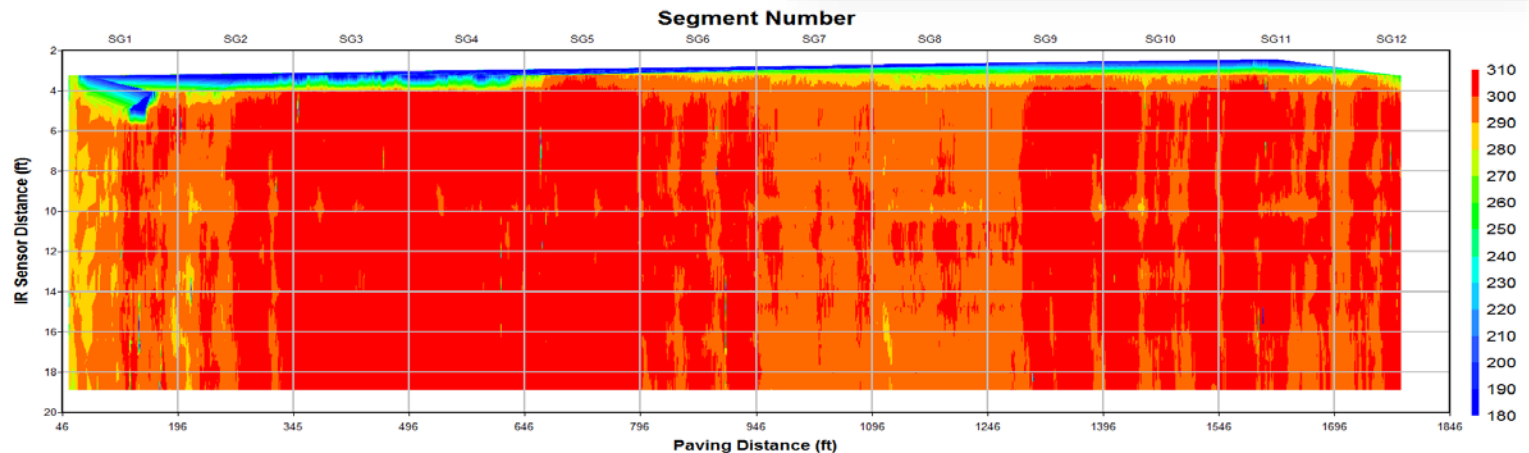


1. Field Demonstration Projects and Products
2. Application and Use: Examples
3. Questions and Answers

Application and Use: Examples

Application & Use, WHY:

- Continuous readings to evaluate mat uniformity through temperature uniformity.
- Non-uniform temperatures imply non-uniform densities, which usually mean higher maintenance.



Application and Use: Examples

Role of IR in Quality Assurance Programs

1. Quality control plan; contractor
 - Improve communication between personnel
 - Reduce risk of being penalized
 - Forensic tool to trouble shoot low or non-uniform densities
2. Acceptance plan; agency
 - Reduce future distress and maintenance costs
 - Dispute resolution

Application and Use: Examples

IR Role in Quality Control Plan; 4 examples

1. Missouri demonstration project
2. Virginia demonstration project
3. Federal Lands demonstration project

Application and Use: Examples

1. Missouri demonstration project

- Increased communication between plant and paver to minimize temperature differentials of mat.



Application and Use: Examples

1. Missouri demonstration project

- Use of laboratory facilities to monitor paving in real time to adjust plant on the fly

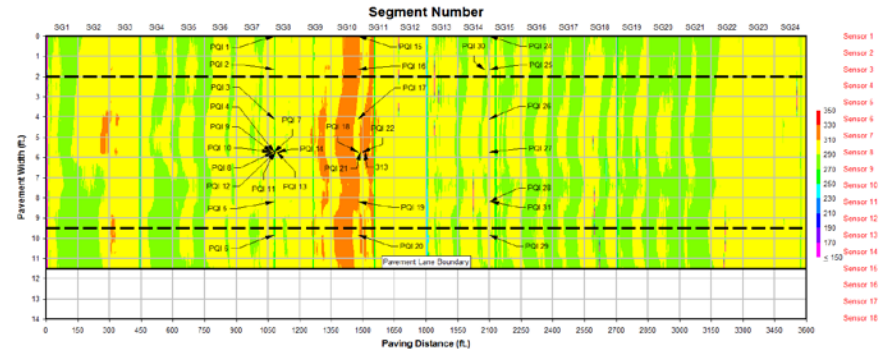


Application and Use: Examples

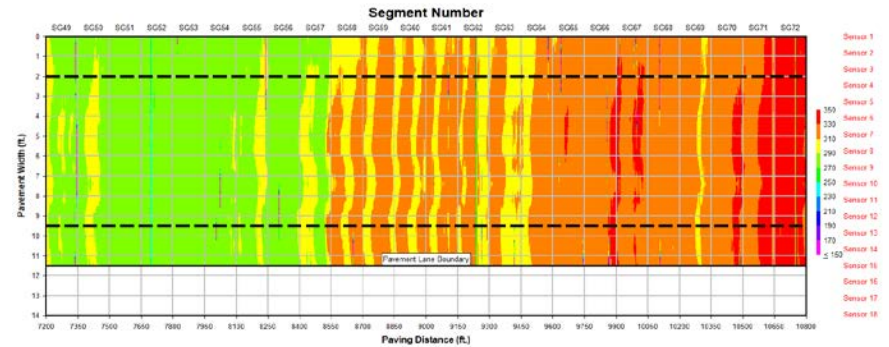
Raw Temperature Profile showing continuous improvement or more uniform mat temperatures as paving progresses.

Example from Missouri demonstration project.

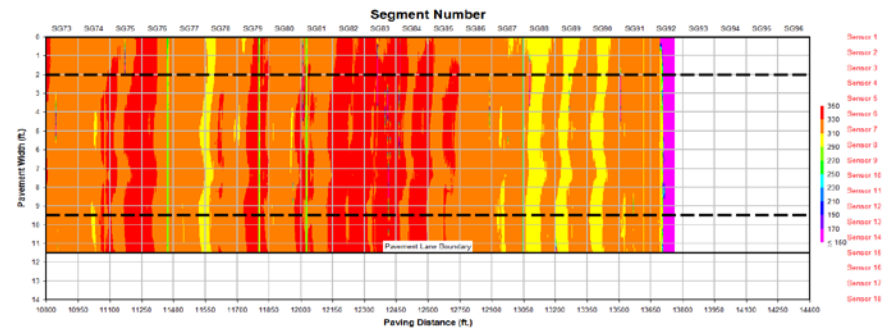
Near the beginning



Near Center of Lot



Near End of Lot



Application and Use: Examples

2. Virginia demonstration project

- Identify reason for severe temperature differentials and take action.
 - Avg. temperature differential at start of paving project; about 30 °F.
 - Avg. temperature differential after adding two trucks; about 15 °F.



Application and Use: Examples

3. Federal Lands demonstration project

- Identify reason for severe temperature differentials and take action; loading of trucks.
- One dump of mix in truck bed – severe temp. differential
- Two dump, no stockpile – reduced temp. differential.

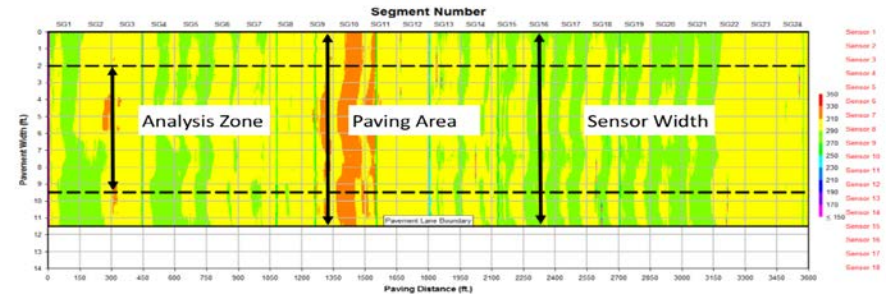


Application and Use: Examples

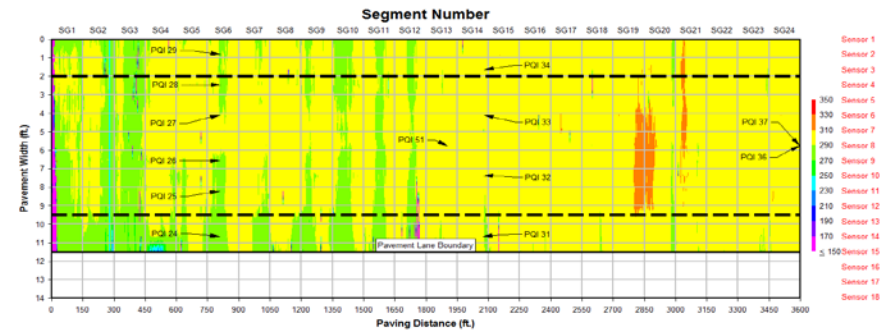
Raw Temperature Profile showing continuous improvement or more uniform mat temperatures as paving progresses.

Example from Maine demonstration project.

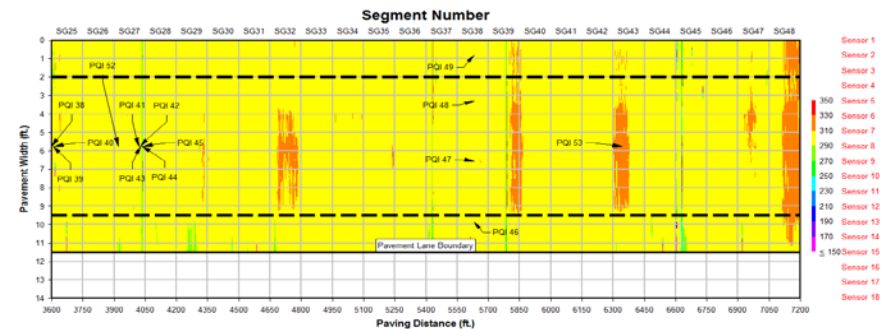
Near Start of Lot



Near Center of Lot



Near End of Lot



Application and Use: Examples

Texas DOT; Item 341, Tex-244-F

- Equipment for measuring temperature differentials:
 - Infrared camera
 - IR-Bar or IR Scanner
- Temperature Differential Category, behind paver and paver stops are excluded:
 - < 25°F is minor thermal segregation
 - 25°F to 50°F moderate thermal segregation
 - > 50°F is severe thermal segregation
- In areas with severe temperature differential:
 - Eliminate or remove and replace.
 - Density profile not required when using IR devices

Application and Use: Examples

Minnesota DOT

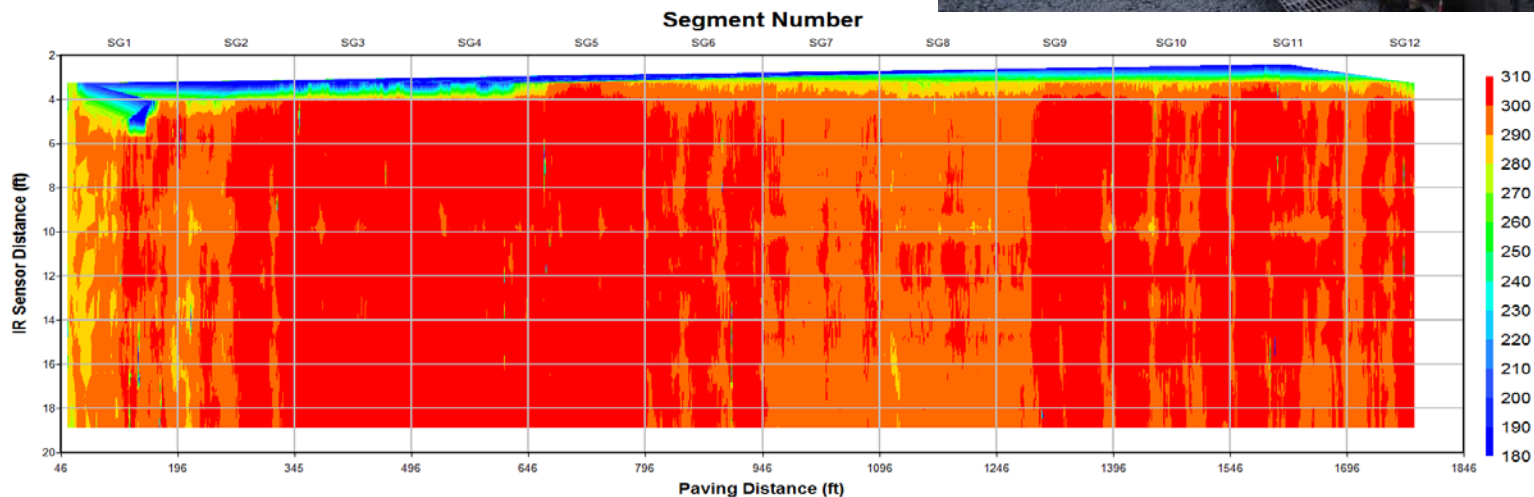
- Equipment for measuring temperature differentials:
 - IR Scanner
- Temperature Differential Category and acceptance:

– $< 25^{\circ}\text{F}$ is minor thermal segregation;	\$20 bonus/sect.
– 25°F to 50°F moderate thermal segregation	\$0 bonus
– $> 50^{\circ}\text{F}$ is severe thermal segregation	\$20 penalty/sect.

Application and Use: Examples

Conclusion from demonstration projects, to-date:

- Pave-IR scanner is one tool to confirm a uniform, high-quality mat.



Implementation Products and Strategies



1. Field Demonstration Projects and Products
2. Application and Use: Examples
3. Questions and Answers

Workshop Wrap-Up



Final Questions

Complete workshop forms

- R06C: additional information on Infrared Tech.
 - AASHTO Site: <http://shrp2.transportation.org>
 - FHWA Site: www.fhwa.gov/goshrp2