



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

Hosted by Maine DOT
April 28, 2016



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 Maine DOT
4. Discuss the Contractor's and Agency's Perspective as a QC or QA Tool
5. Know Implementation Strategies

Infrared Scanner Workshop

AGENDA:

8:30 to 8:45	<ul style="list-style-type: none">• Welcome and Introductions
8:45 to 9:15	<ul style="list-style-type: none">• Introduction to Infrared Technology: What is it and Why is it Needed?
9:15 to 9:30	<ul style="list-style-type: none">• Equipment and Software: How to use it?
9:30 to 10:00	<ul style="list-style-type: none">• Data Analyses and Findings
10:00 to 10:15	Break
10:15 to 10:45	<ul style="list-style-type: none">• Agency Perspective as a QA Tool
10:45 to 11:15	<ul style="list-style-type: none">• Contractor's Perspective as a QC Tool
11:15 to 12:00	<ul style="list-style-type: none">• Implementation Strategies
12:00 to 12:25	<ul style="list-style-type: none">• Questions/Answers and Closing Comments
12:25 to 12:30	<ul style="list-style-type: none">• IR Workshop Wrap-Up
12:30 to 1:00	<ul style="list-style-type: none">• Presentation and Demonstration of GPR Equipment



Infrared Technology (IR)

What is it and why use it?

April 28, 2016



U.S. Department of Transportation
Federal Highway Administration



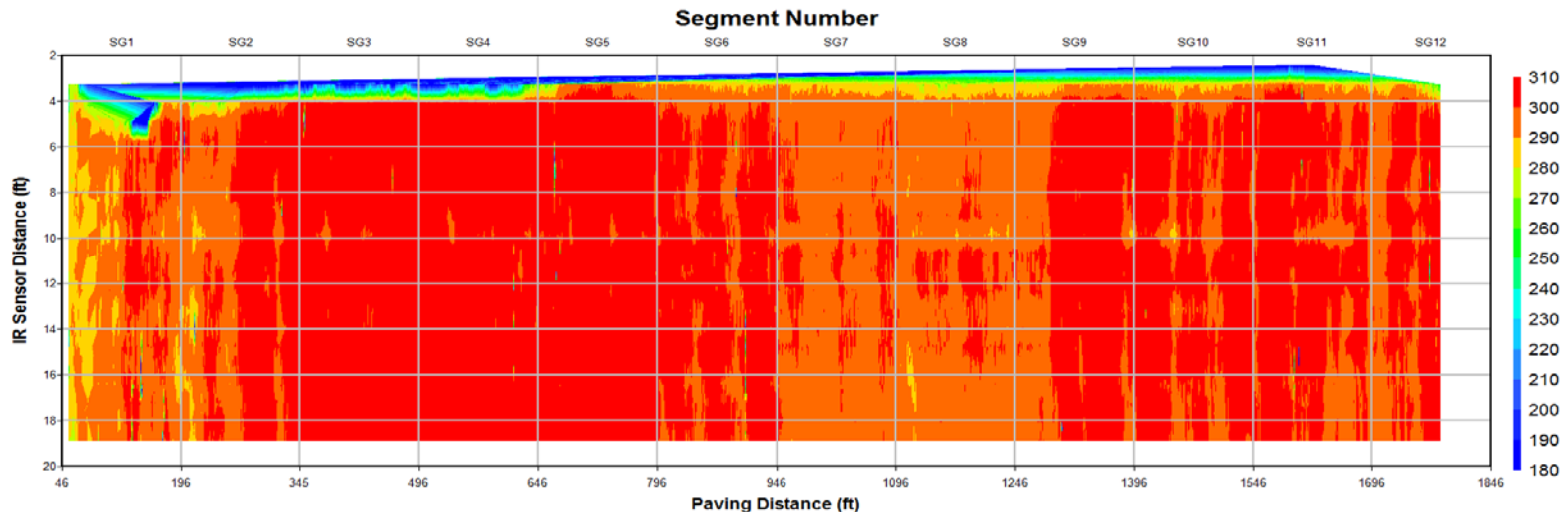
IR – What is it & why use it?

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

IR – What is it & why use it?

Infrared Thermography:

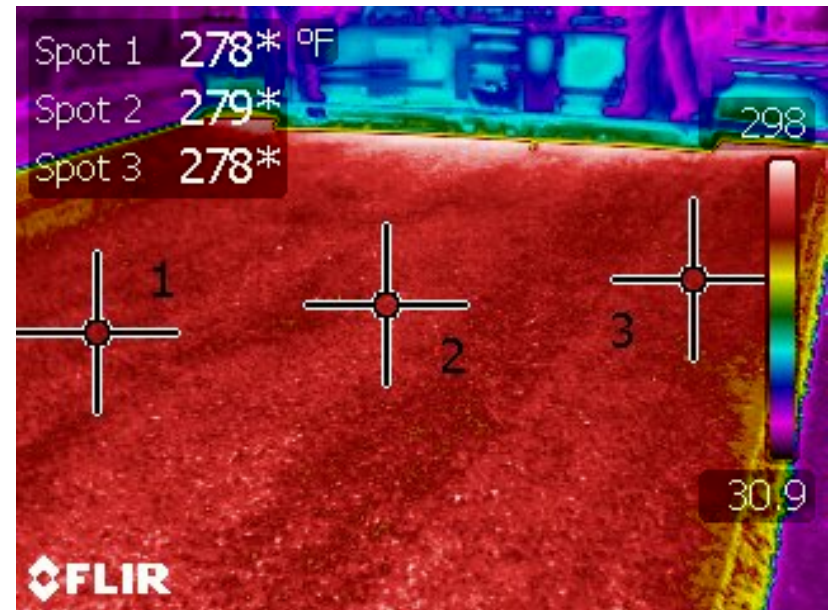
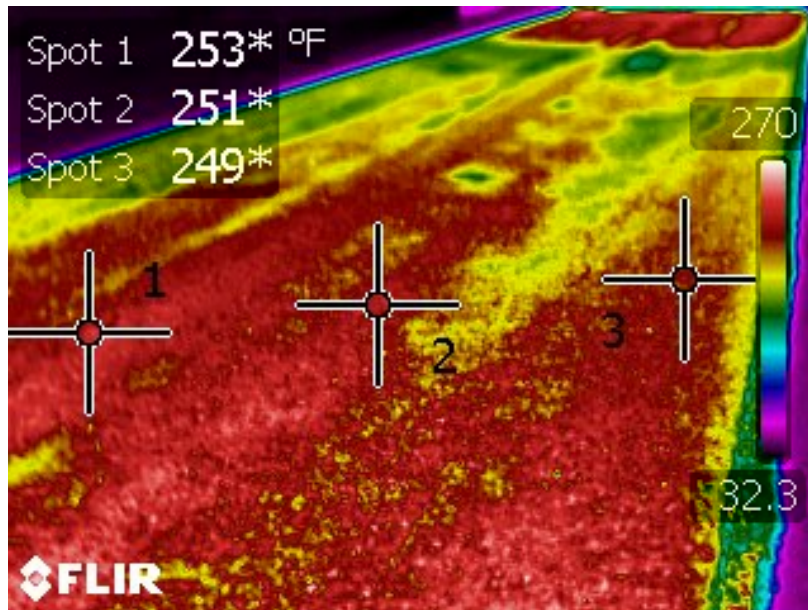
- The mapping of temperature contours (equal temperature) over the surface of a material.
- Contours are used to evaluate materials by measurement of their surface temperature and its variation.



IR – What is it & why use it?

Temperature segregation (differential):

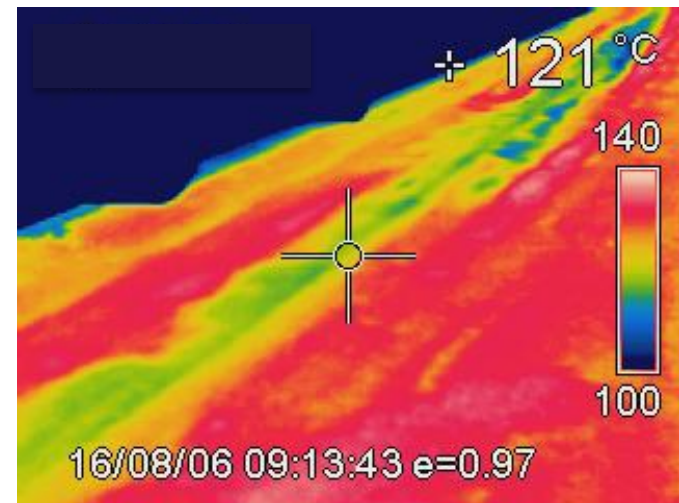
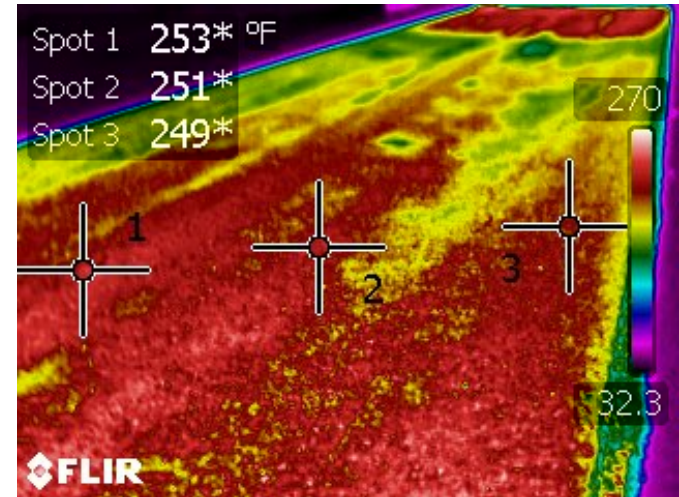
- More than 25 °F difference in mat temperature behind screed.



IR – What is it & why use it?

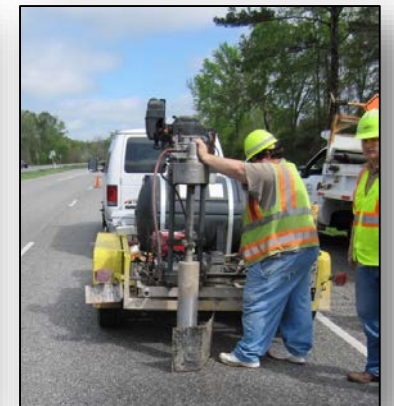
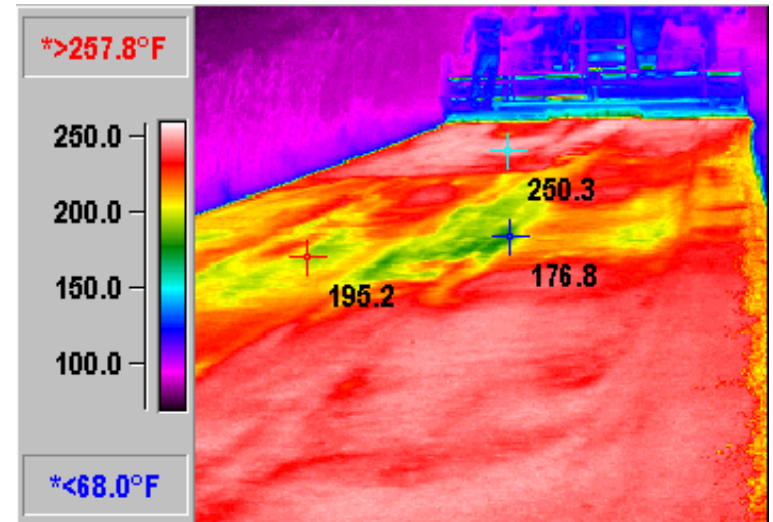
Types of Temperature Differences:

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?

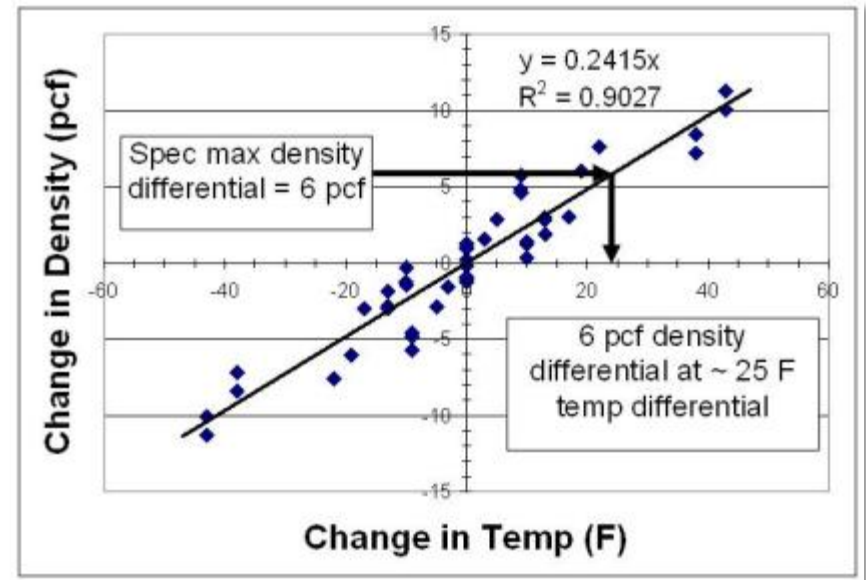
- Cold spots
 - Temperature difference of mat between truck exchanges – common.
 - Areas with higher air voids
- Focused testing have validated higher air voids
 - Coring
 - Radar (full coverage)
 - Nuclear gauge



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

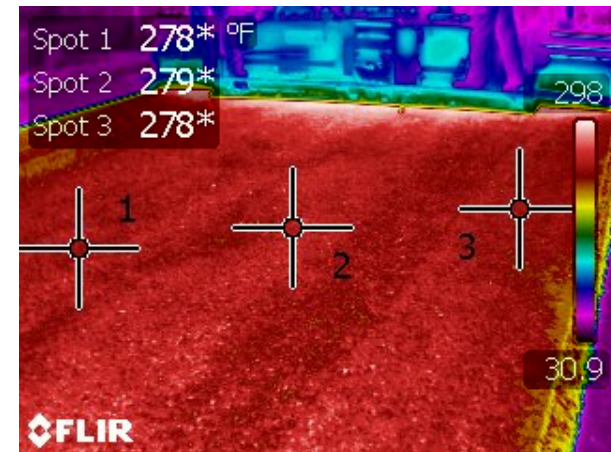
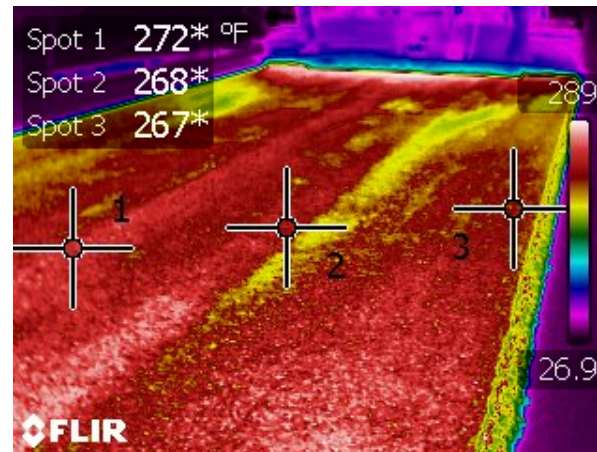
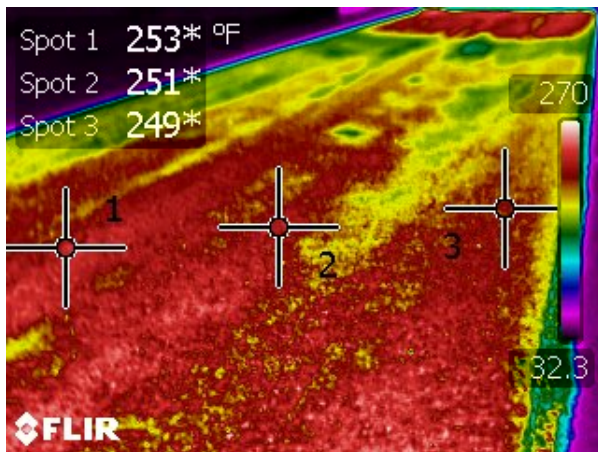
- IR sensors, IR-Bar; first device for continuous readings
- Pave-IR Scanner; second generation device for continuous readings



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

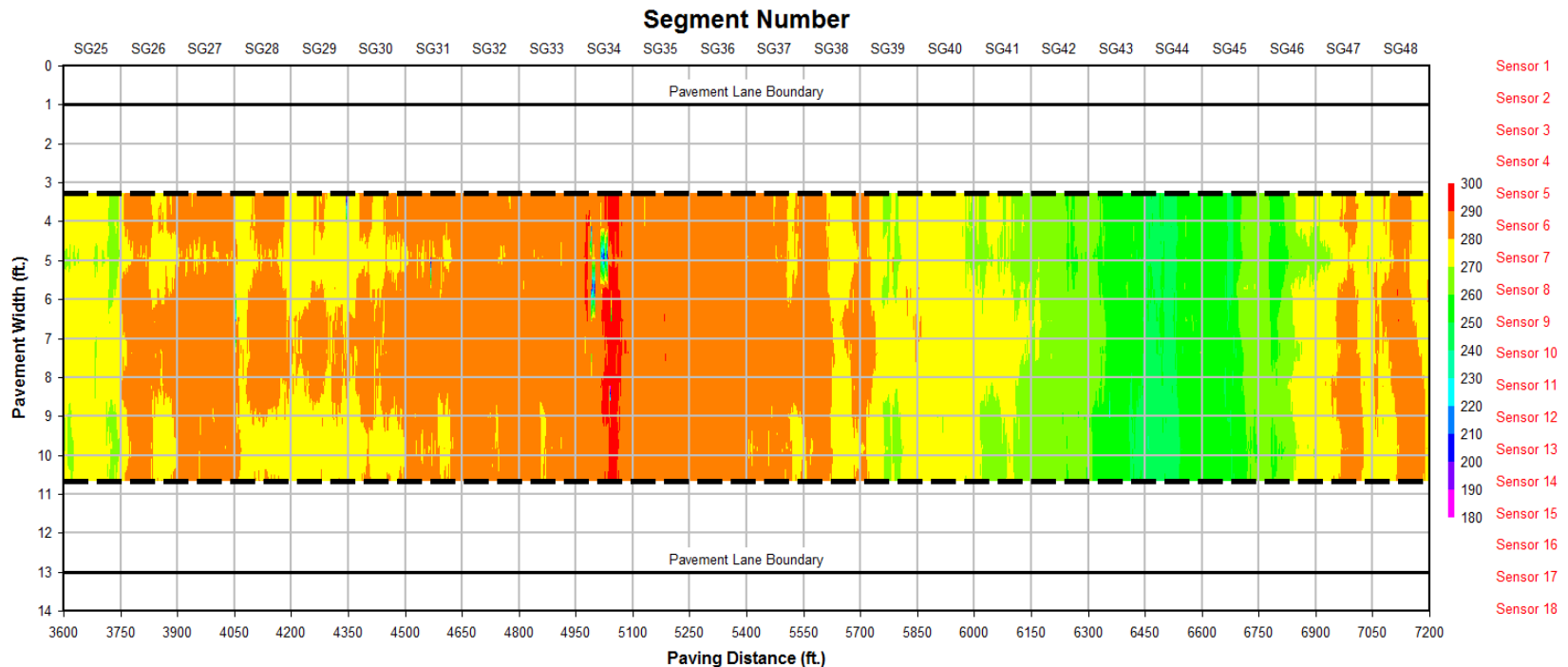


IR – What is it & why use it?

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

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.



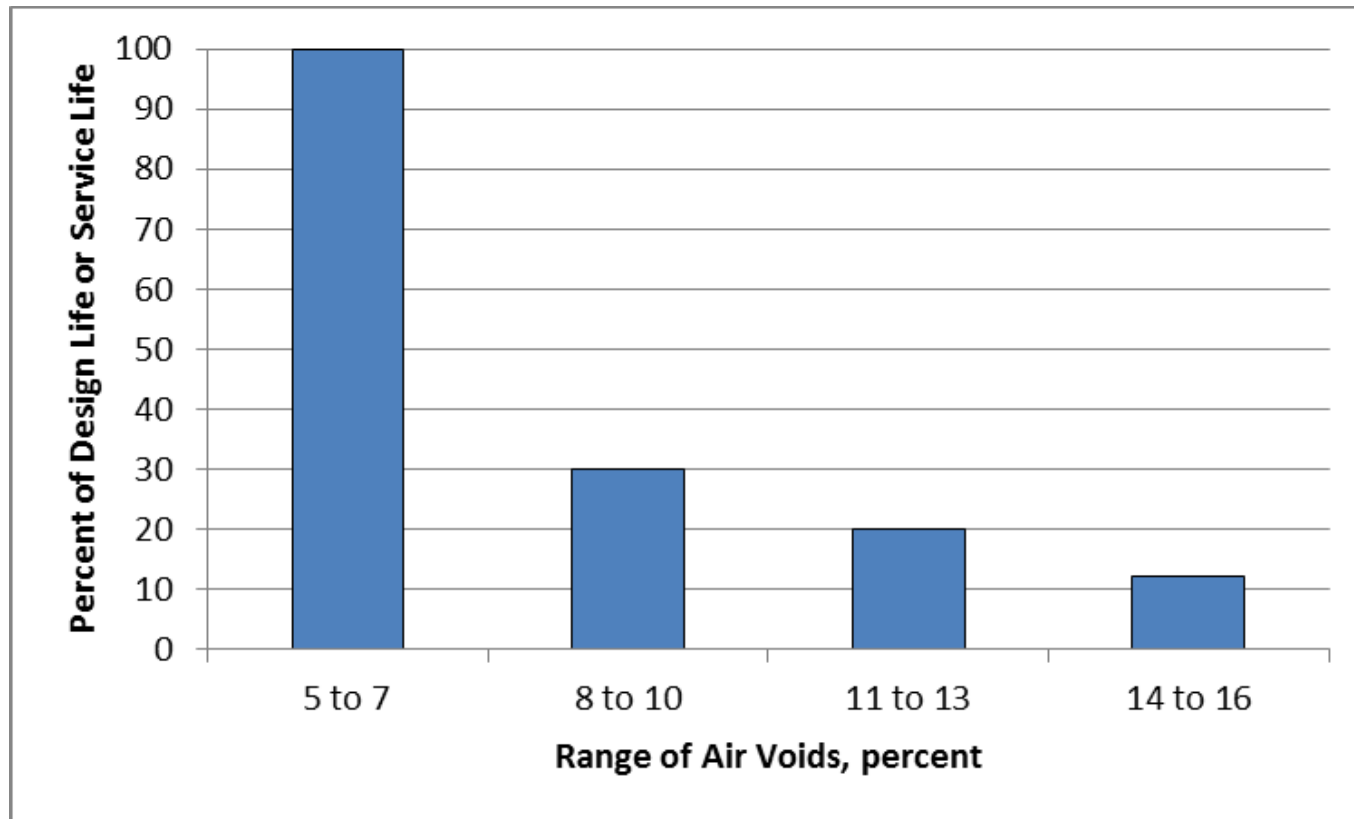
IR – What is it & why use it?

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



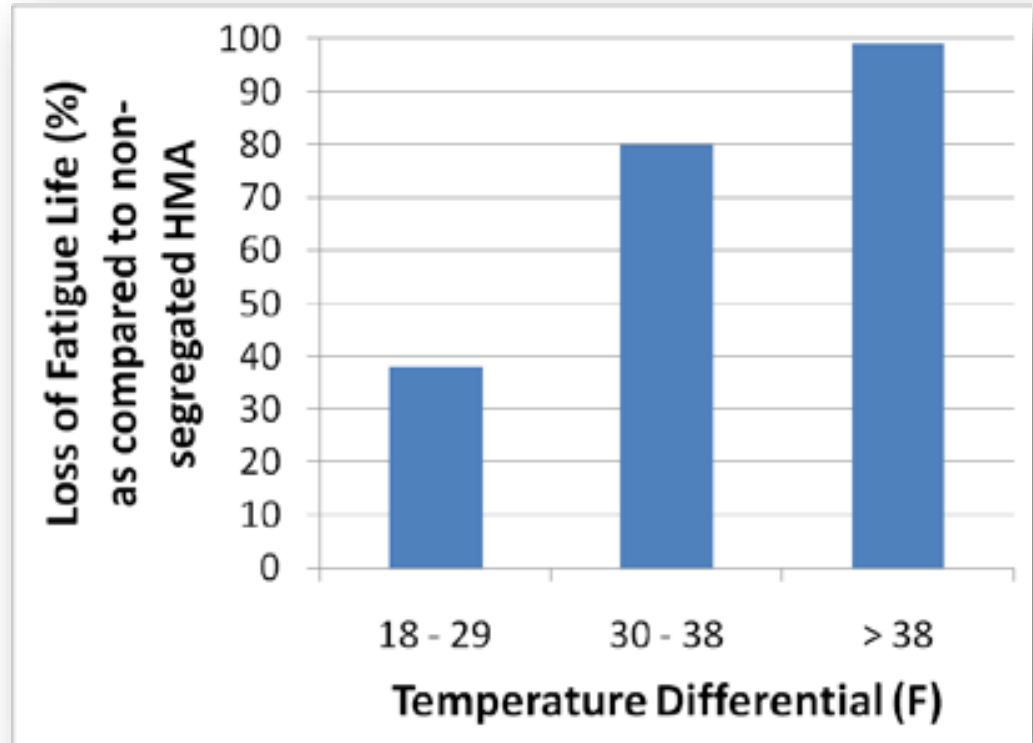
IR – What is it & why use it?

- Effect of reduced compaction or higher air voids because of lower mat temperatures.



IR – What is it & why use it?

- Fatigue life can be substantially reduced, as a result of lower densities because of lower mat temperatures.



Source: NCAT (2000)

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:

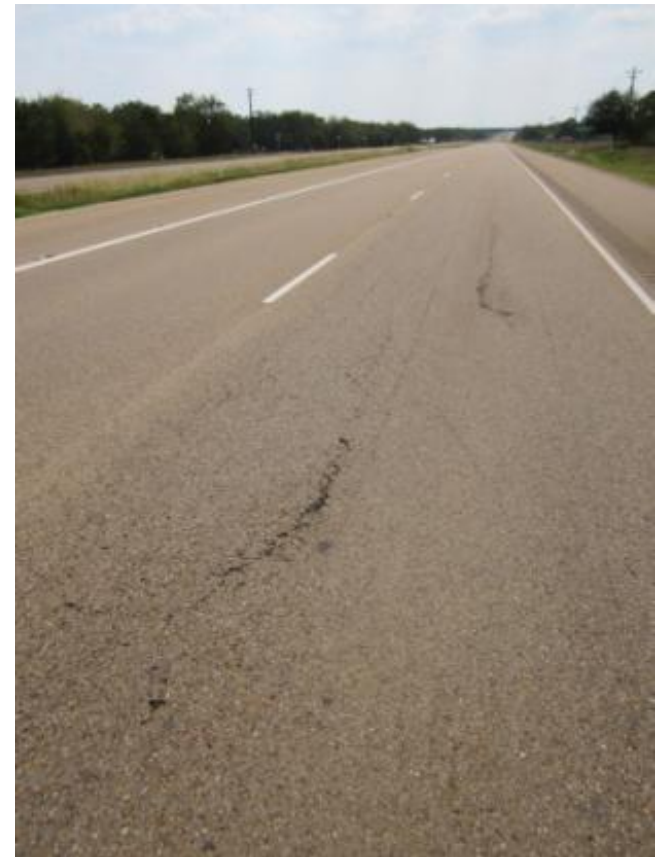
- Fatigue cracks
- Raveling
- Pot holes



IR – What is it & why use it?

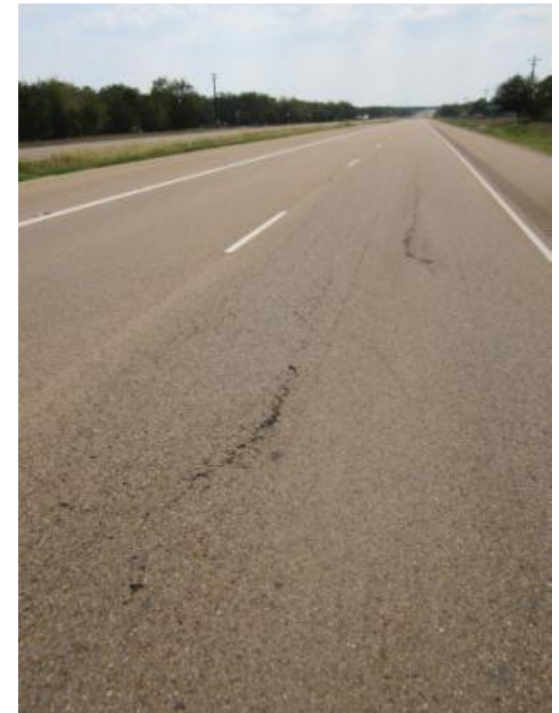
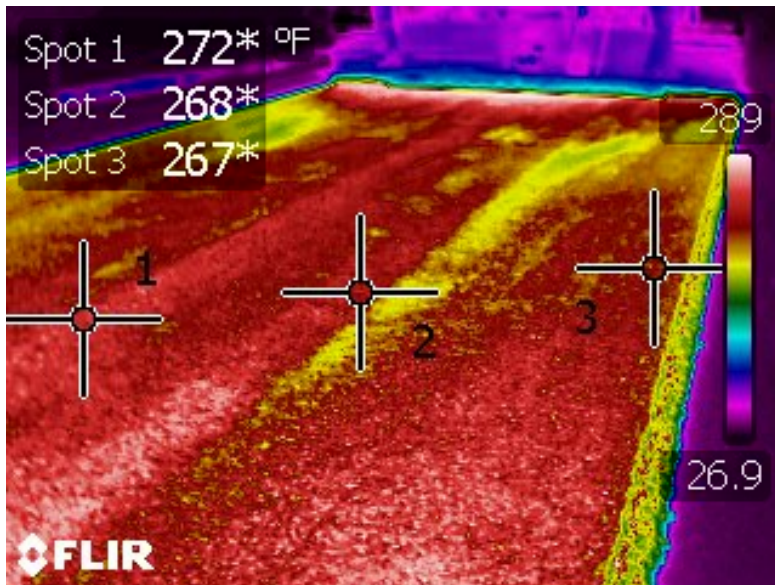
Thermal streaks; longitudinal areas with increased potential for:

- 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?

April 28, 2015



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IR Equipment and Software

1. Equipment and Installation
2. Software and Its Features

IR Equipment and Software

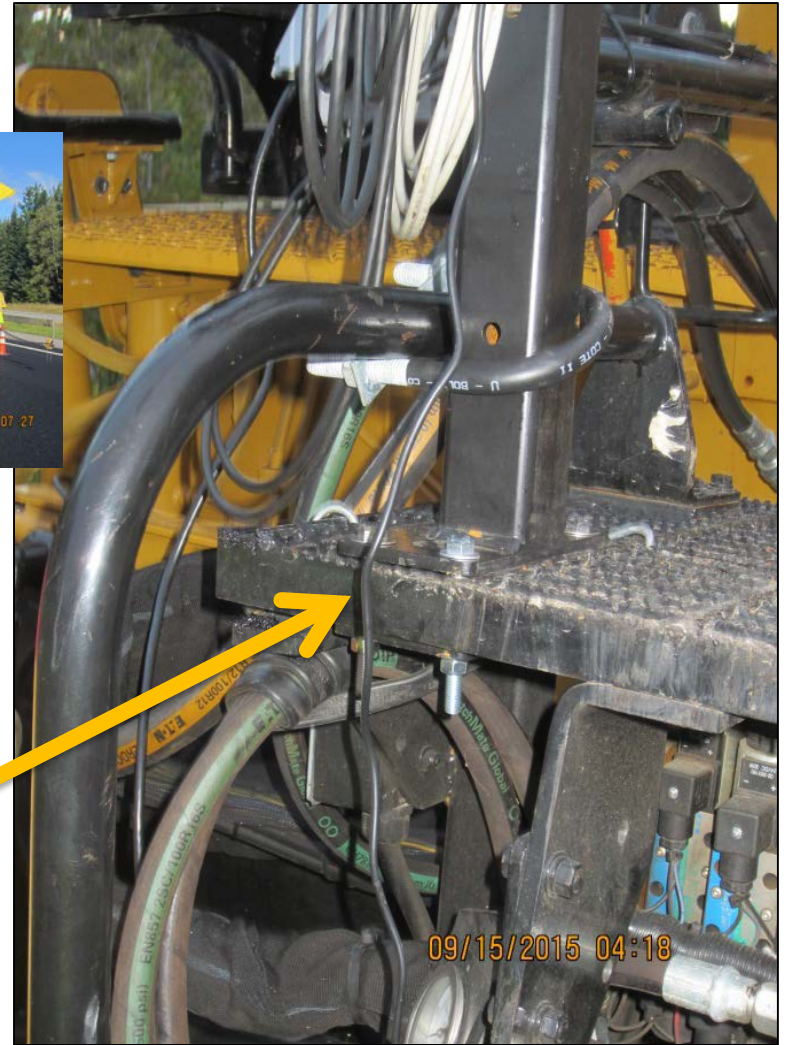
Equipment

- 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.



IR Equipment and Software



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



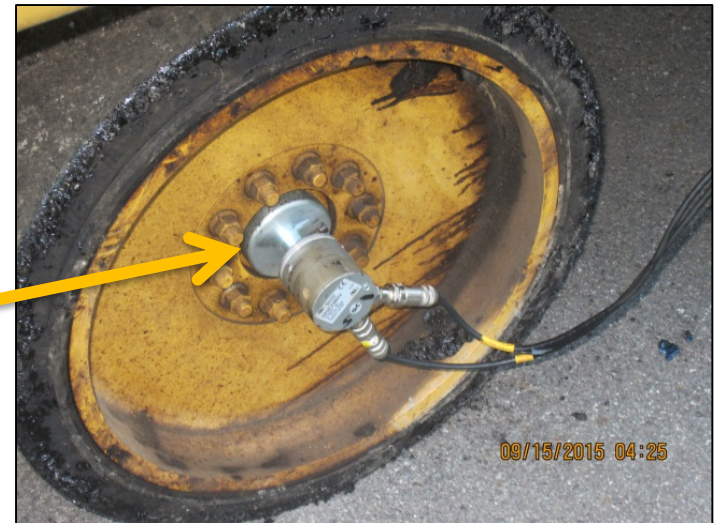
IR Equipment and Software

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.

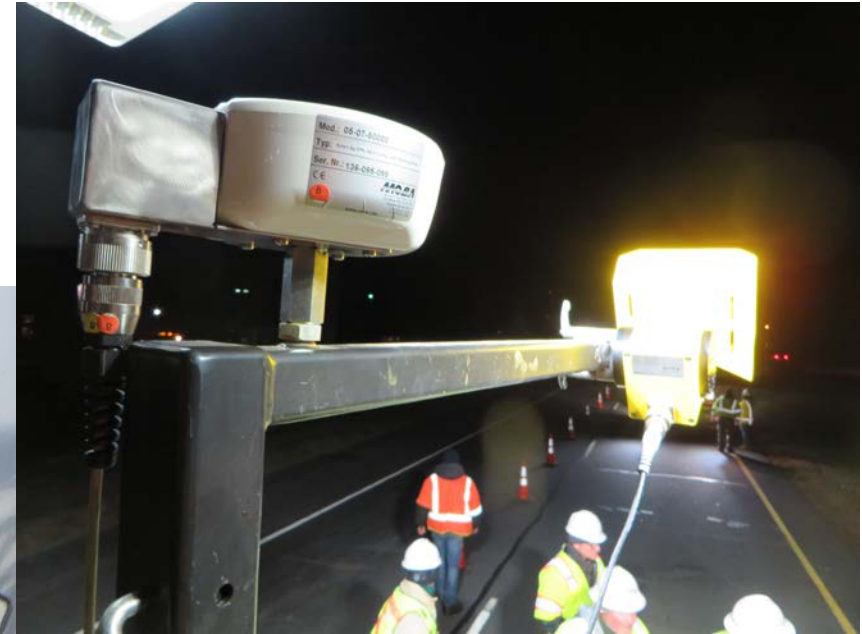


IR Equipment and Software

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 OF 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 titled "Project Properties" with tabs for "Time Diagram", "Speed Diagram", and "Temperature Class Diagram". The "Project Properties" tab is active, showing a table of project data:

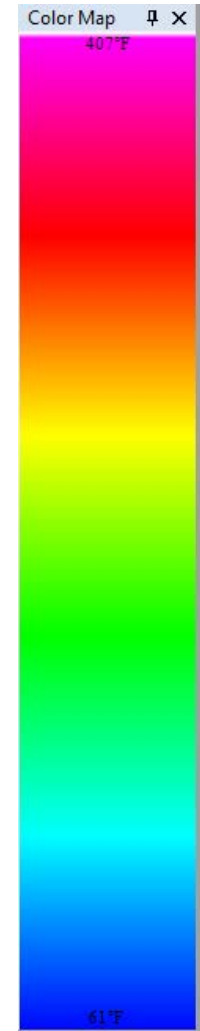
Meta Information	Value
Beginning location	houltou off ramp
Comment	passing lane w/4shld
Ignored Sensors	
Layer thickness	1.5in
Lift	1
Measure height	9.58ft
MINDS Upload	No
Operator Name	paul
Paving width	11.48ft
Project ID	6700ef1e9424b24a0353a7f46367793

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

Properties

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%**

Project Properties | Time Diagram | Speed Diagram | Temperature Class Diagram

Meta Information

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	670f0ef1e942-4b24-a035-3a7f46367793

Beginning location
The name of the location where the project began.

Interpolation
Determines the kind of algorithm used when displaying the Profile.

Save

IR Equipment and Software

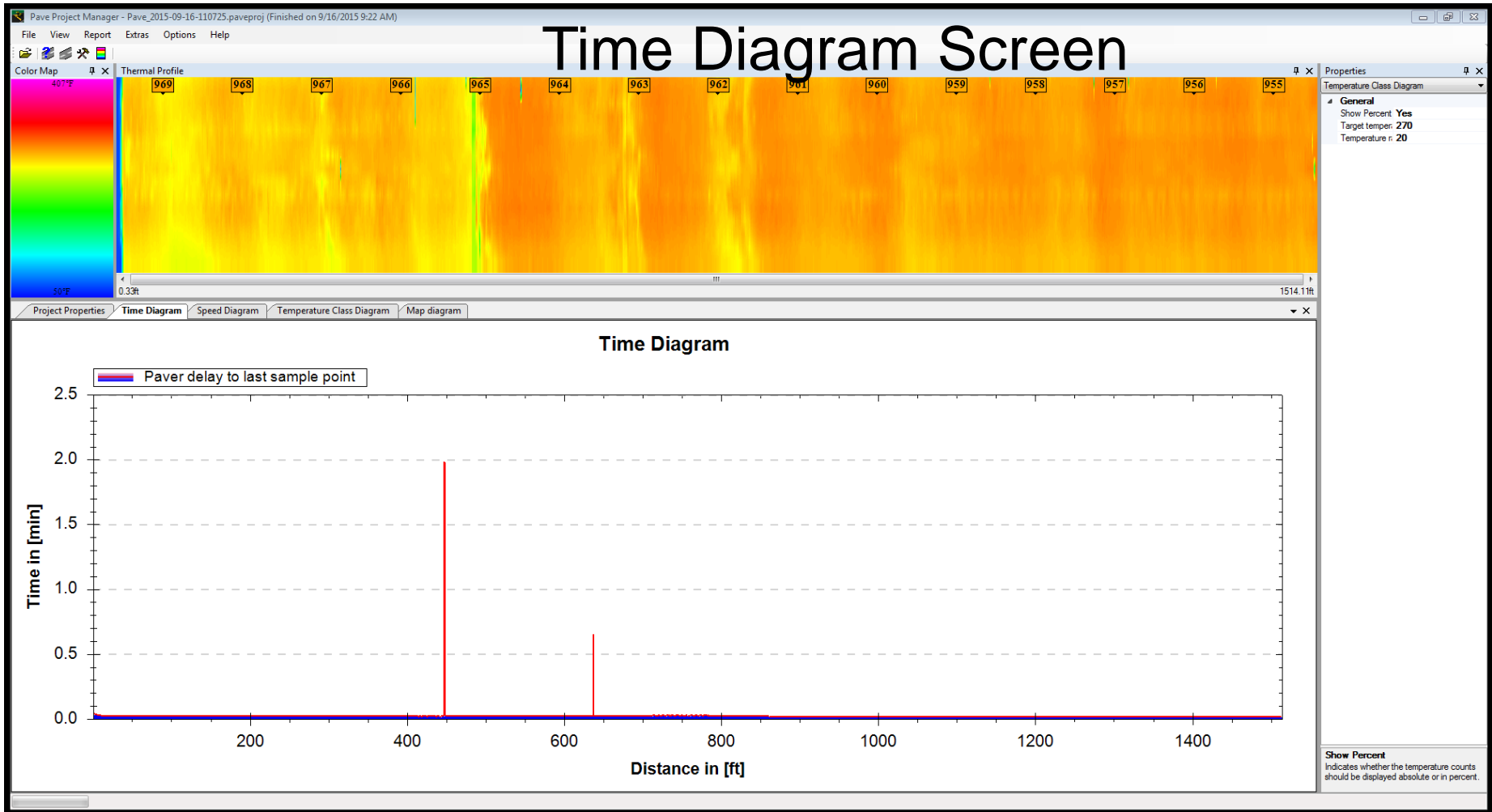
Project Properties Screen

The screenshot displays the 'Project Properties' screen in the Pavement Project Manager software. The main window shows a thermal profile heatmap with station markers from 969 to 955. A color map on the left indicates temperature from 40°F to 61°F. The Project Properties panel is open, showing a table of project details and a description for the 'Beginning location'.

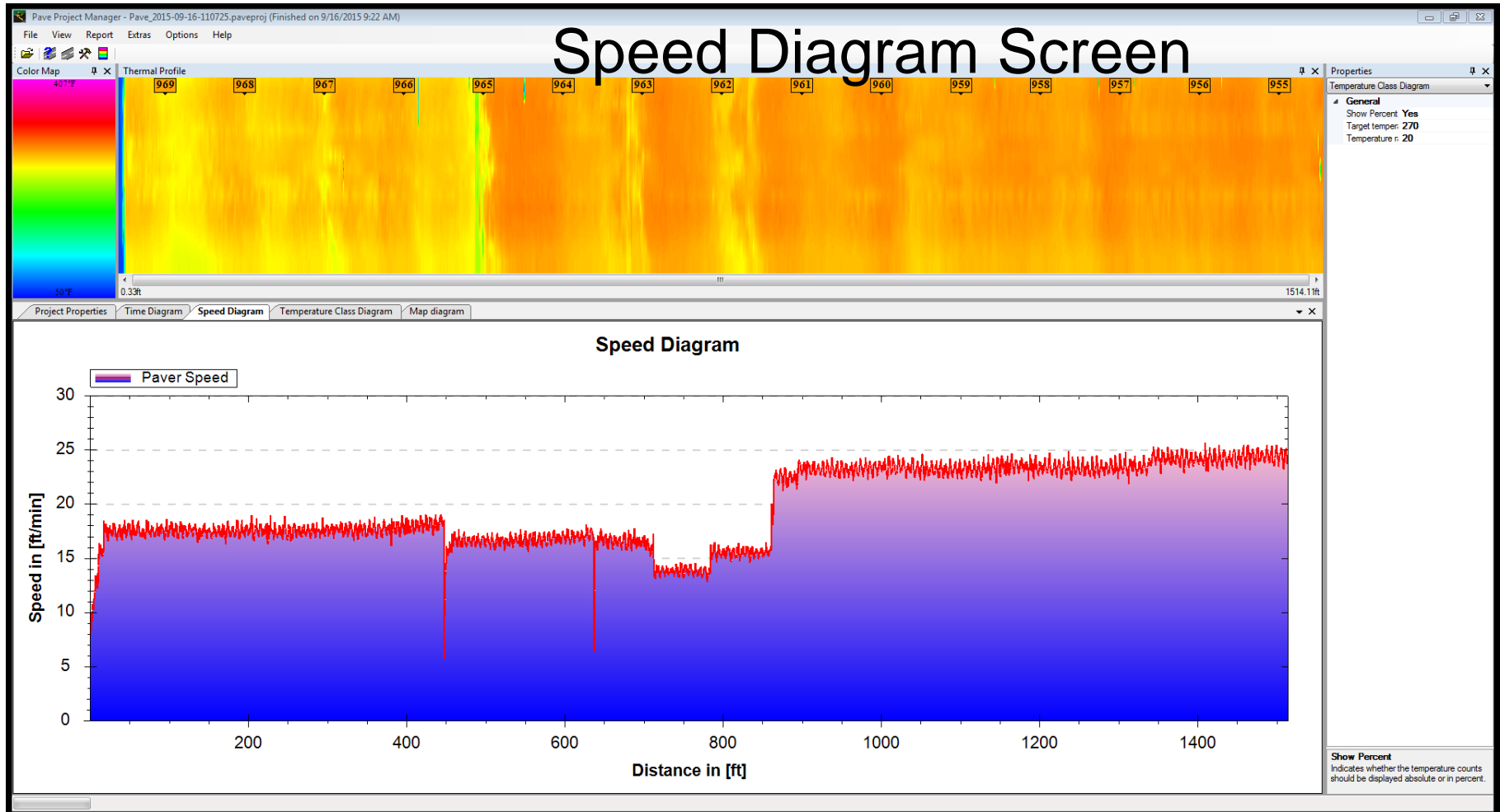
Property	Value
Beginning location	houlton off ramp
Comment	passing lane w/4shld
Ignored Sensors	
Layer thickness	1.5in
Lift	1
Measure height	9.58ft
MINDS Upload	No
Operator Name	paul
Paving width	11.48ft
Project ID	670f0ef1-e942-4b24-a035-3a746367793

Beginning location
The name of the location where the project began.

IR Equipment and Software

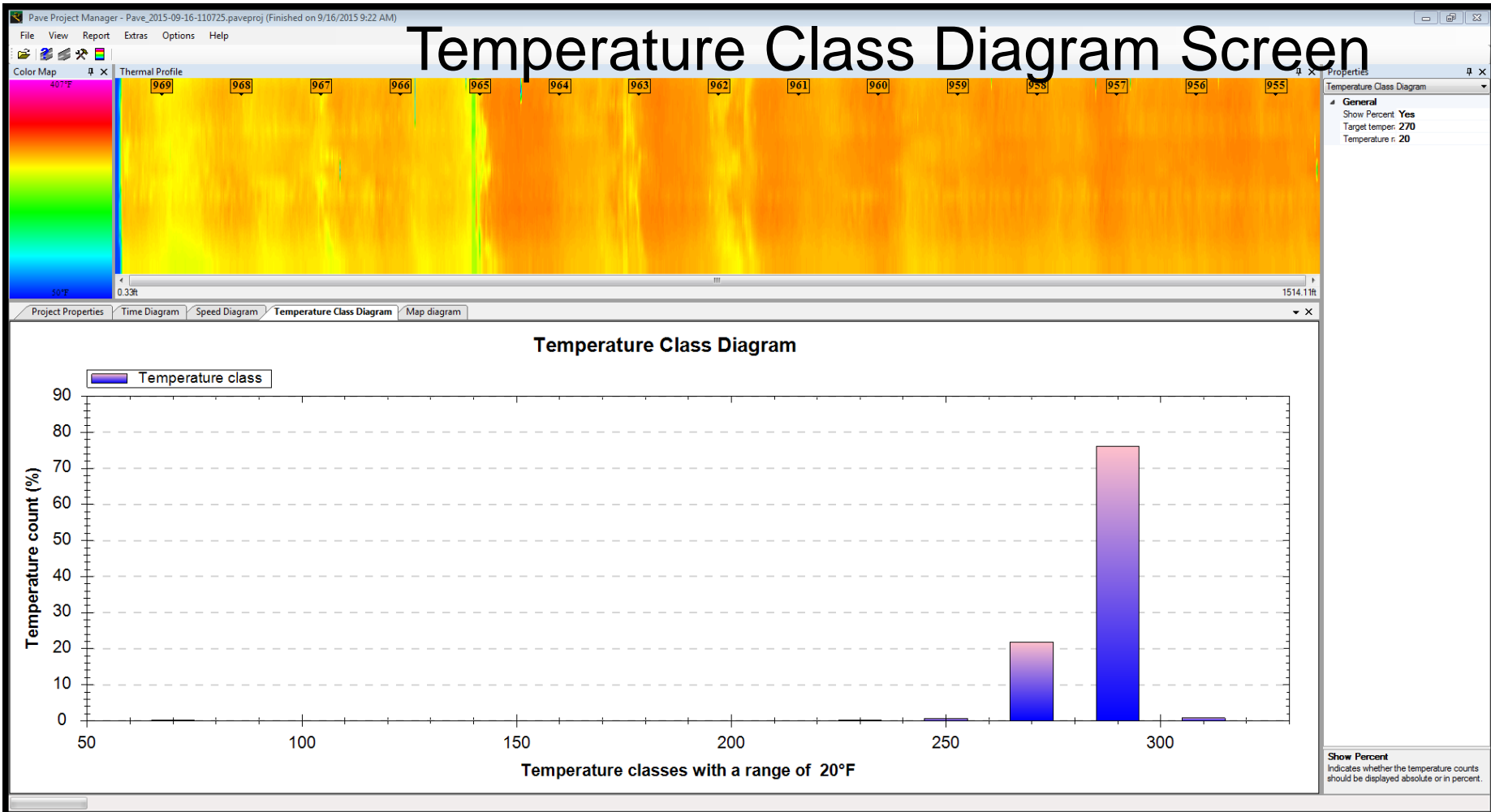


IR Equipment and Software



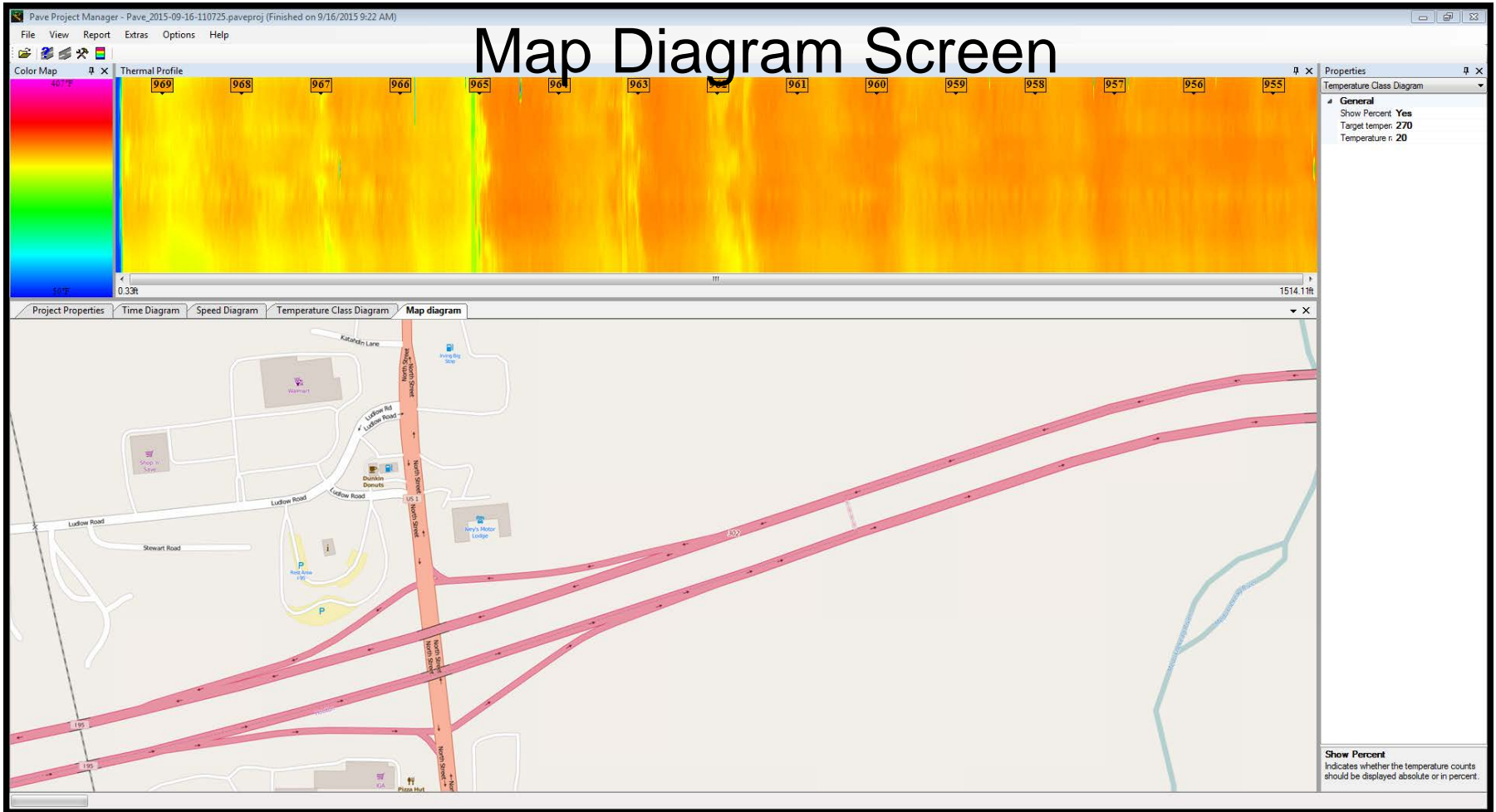
IR Equipment and Software

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 'Pave Project Manager' software interface. The main window shows a 'Thermal Profile' with a color scale on the left ranging from 407°F (red) to 166°F (blue). The profile is divided into sections labeled 960 through 955. Several data points are overlaid on the profile, each showing temperature, elevation, coordinates, and satellite count. A semi-transparent text box in the center of the profile reads 'Click any location on the thermal profile'. Below the profile is a 'Map diagram' showing a road layout with red pins indicating the locations of the sensors. The bottom right corner features an 'Ignored Sensors' section with instructions.

Temperature (°F)	Elevation (ft)	Coordinates (W, N)	Satellites
283	232.9	67.83365311°W, 46.14118346°N	10
223	451.1	67.83446667°W, 46.14099723°N	10
278	767.4	67.83564739°W, 46.14072025°N	9
271	776.2	67.83368142°W, 46.14071210°N	9
280	410.4	67.83431842°W, 46.14103203°N	11
261	85.6	67.83309890°W, 46.14131155°N	11
276	767.4	67.83564739°W, 46.14072025°N	9
295	1100.7	67.83691530°W, 46.14042614°N	11

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

IR Equipment and Software

Generating Reports

The screenshot displays the Pavement Project Manager software interface. The main window shows a thermal profile map with a color gradient from blue to red. 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 dropdown are 'Generate' and 'Cancel' buttons. A large black arrow points from the 'Generate' button to a light blue callout box on the right that says 'Generates PDF Report'. In the background, a 'Tex-244-F Part II Input' form is visible, containing various fields for report generation, such as Report Name, Profile ID, Profile Number, Status, County, Tested By, Test Location, Material Code, Material Name, Producer, Area Engineer, Profile Date, Letting Date, Controlling CSJ, Spec Year, Spec Item, Special Provision, Mix Type, and Project Manager. The form is titled 'Tex-244-F Part II Input' and includes instructions: '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.' The form fields are as follows:

Report Name	Tex 244-F
Profile ID	95sb
Profile Number	Not availble
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 availble
Controlling CSJ	
Spec Year	Not availble
Spec Item	
Special Provision	
Mix Type	
Project Manager	

At the bottom of the form, there is a button labeled 'Confirm Inputs and generate report'. The software interface also includes a 'Properties' panel on the right showing 'Thermal Profile' settings like Interpolation (Linear), Sample Spots (Enabled), Stations (Show), and Tooltip (Visible). A 'Map diagram' panel at the bottom shows a map with several red location markers. The status bar at the bottom indicates '0.33ft' and '1514.1ft'.

IR Equipment and Software

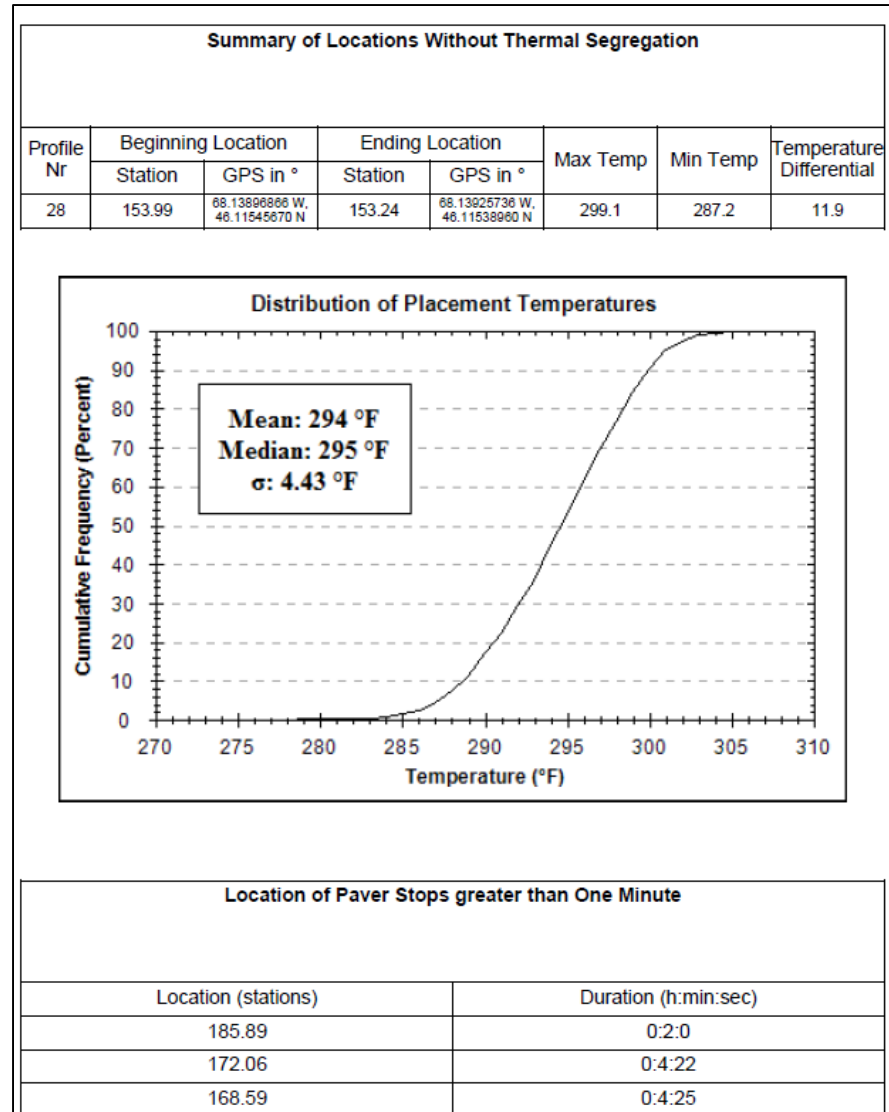
Generating Reports

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	88.12418985 W, 46.11878960 N	191.50	88.12476079 W, 46.11866149 N	304.9	289.6	15.3
3	191.49	88.12476285 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	88.12758889 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, 46.11753966 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, 46.11739235 N	302.0	288.0	14.0
13	176.49	88.13042482 W, 46.11739148 N	175.00	88.13099093 W, 46.11725309 N	301.8	289.2	12.6
14	174.99	88.13099275 W, 46.11725265 N	173.50	88.13155886 W, 46.11712703 N	302.2	288.0	14.2
15	173.49	88.13155263 W, 46.11712618 N	171.99	88.13212684 W, 46.11699931 N	303.6	286.3	17.3
16	171.99	88.13212071 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, 46.11674286 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	88.1343973 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	88.13612059 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	88.13782221 W, 46.11571525 N	301.6	287.4	14.2
26	156.99	88.13782599 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: I-95 Rehabilitation;
Houlton, ME



Infrared Technology (IR)

Data Analyses and Findings: I-95 Rehabilitation; Houlton, ME

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Data Analyses & Findings

I-95 Houlton, ME

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

Data Analyses & Findings

I-95 Houlton, ME



Data Analyses & Findings

I-95 Houlton, ME

Northbound and Southbound Lanes; Canadian Border to the South



Data Analyses & Findings

I-95 Houlton, ME



Mixture delivered to site with end dump and horizontal discharge trucks.

Mixture placed with Caterpillar paver and Weiler material transfer vehicle.

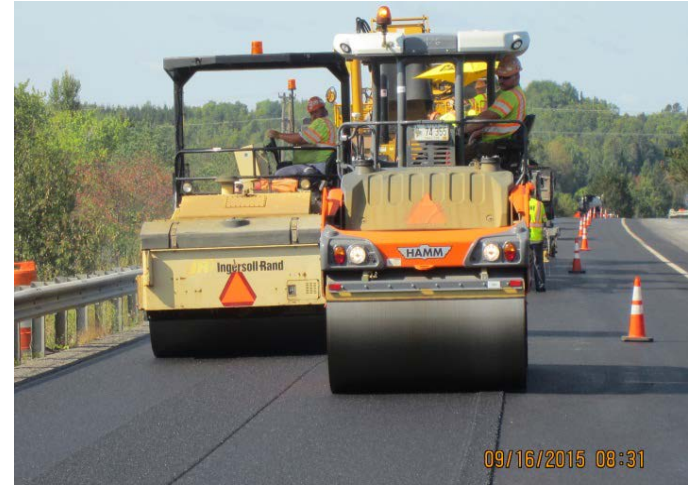


Data Analyses & Findings

I-95 Houlton, ME

Compaction Train:

- Breakdown: Volvo & Ingersoll-Rand Vibratory rollers, & Hamm steel wheel oscillatory roller. Two used in echelon.
- Intermediate; Caterpillar rubber tired roller
- Finish; Caterpillar static steel wheel drum



Data Analyses & Findings

I-95 Houlton, ME

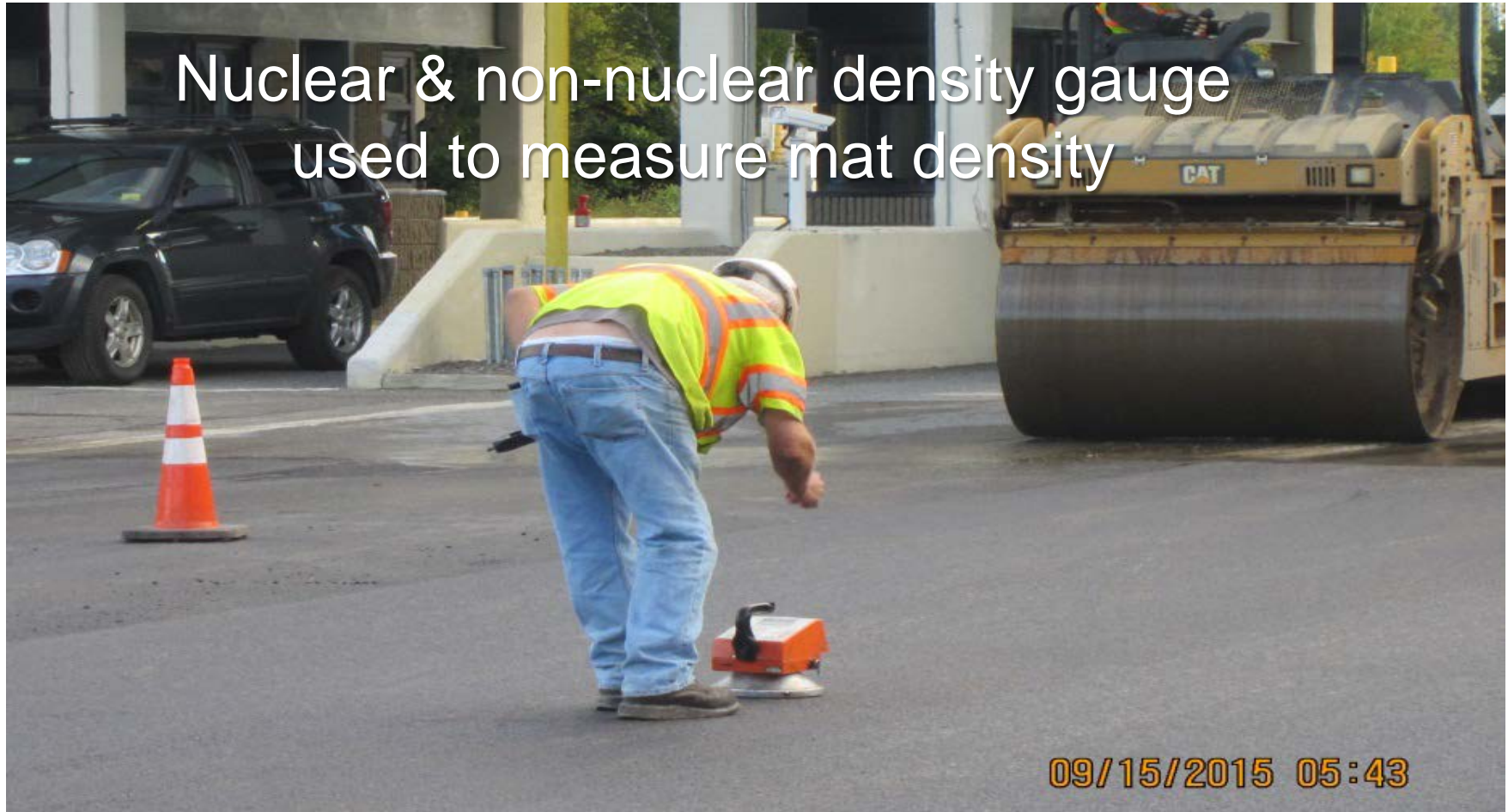
Four steel wheel rollers used, including: Caterpillar, Volvo & Ingersoll-Rand Vibratory rollers, & Hamm steel wheel oscillatory roller.



Data Analyses & Findings

I-95 Houlton, ME

Nuclear & non-nuclear density gauge
used to measure mat density



Data Analyses & Findings

I-95 Houlton, ME

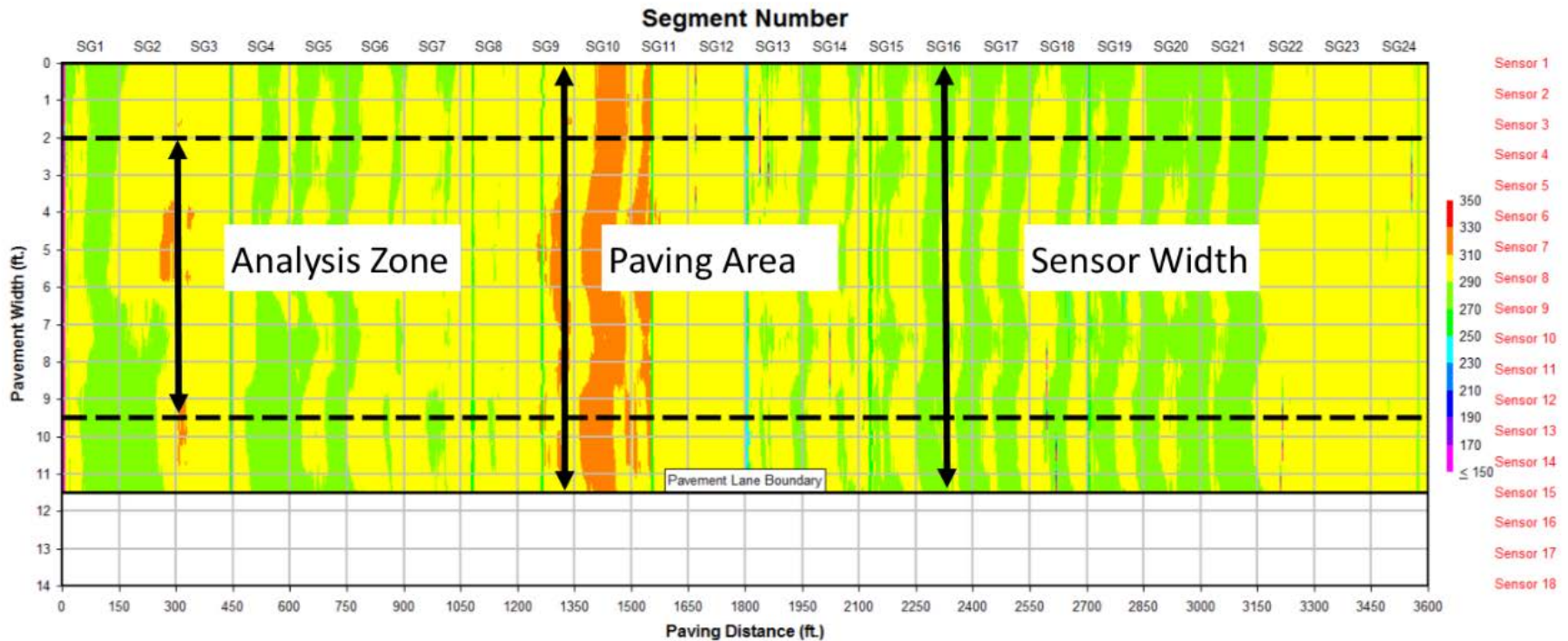


1. Project Overview
2. Data Collection
3. Data Processing
4. Data Summary

Data Analyses & Findings

I-95 Houlton, ME

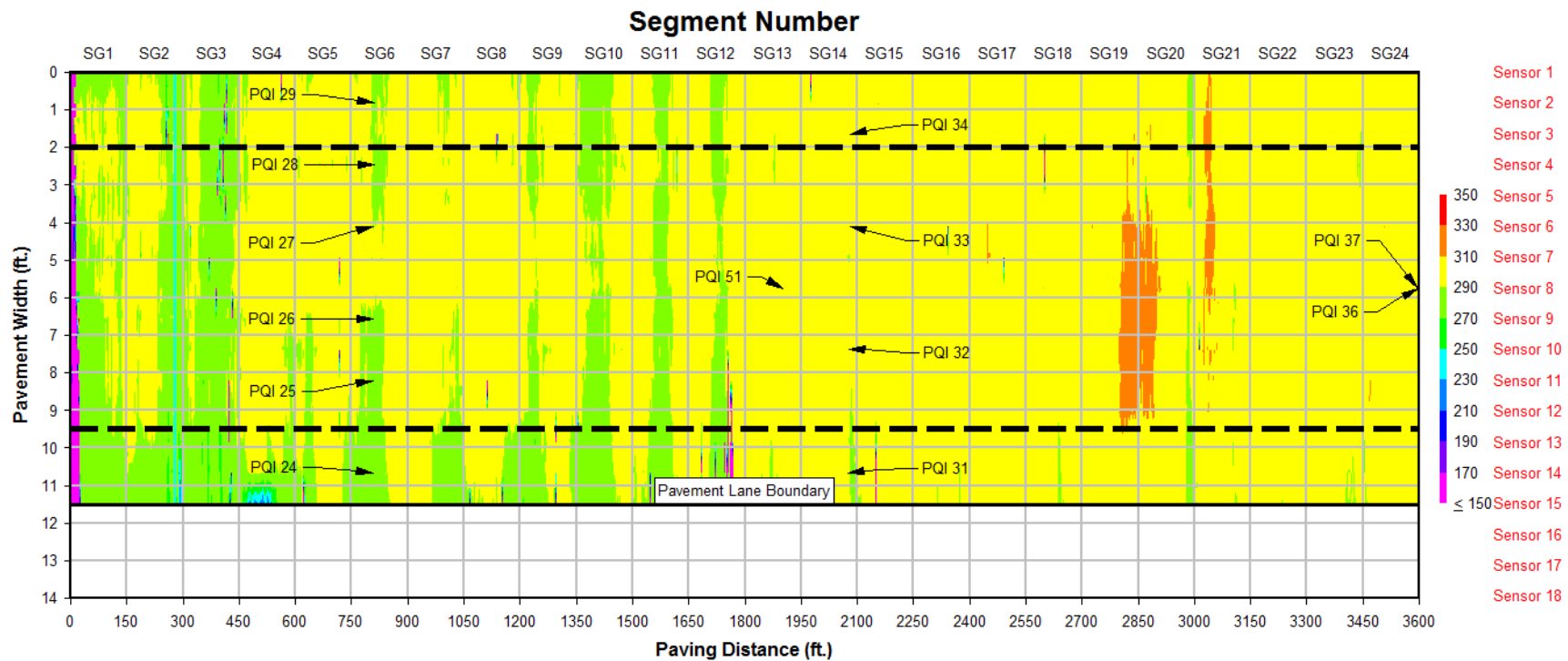
Raw Temperature Profile for first part of the southbound lane.



Data Analyses & Findings

I-95 Houlton, ME

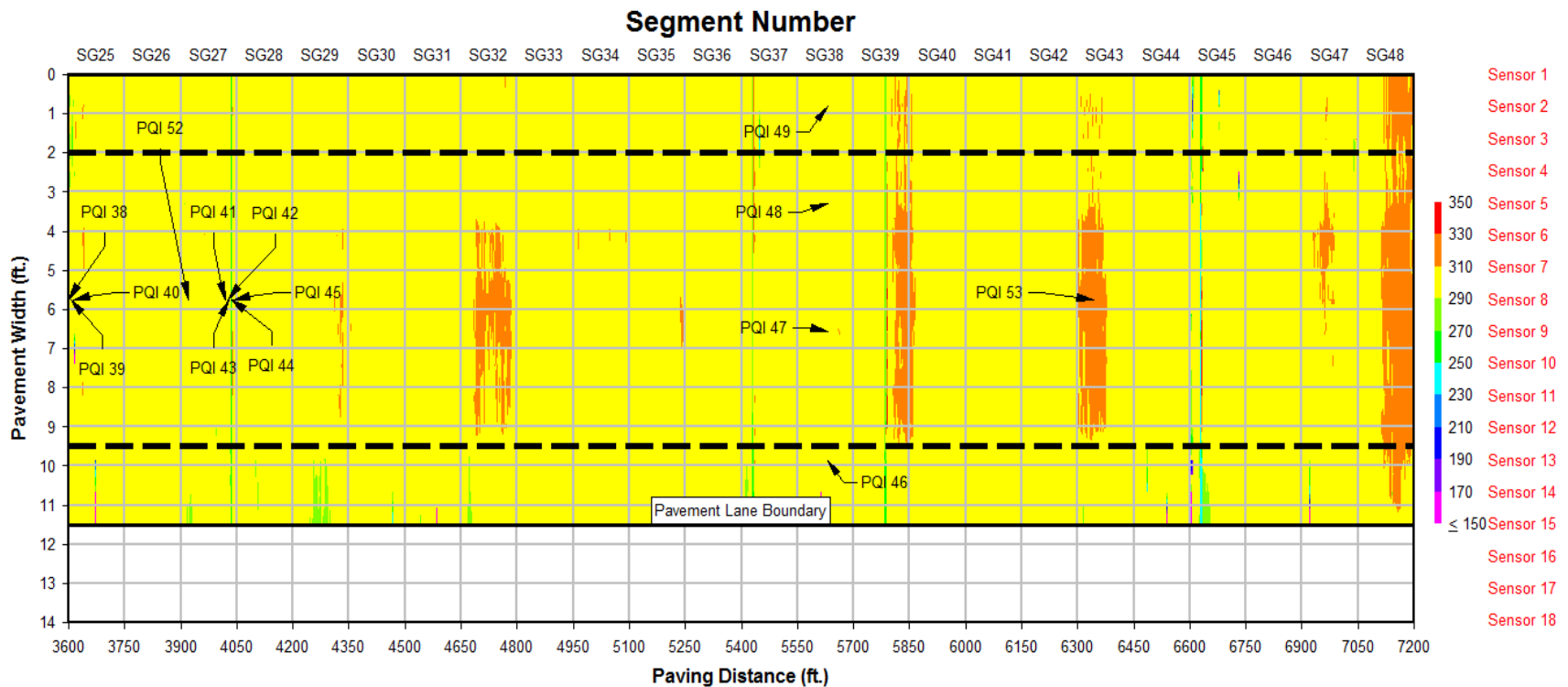
Raw Temperature Profile for center part of the southbound lane.



Data Analyses & Findings

I-95 Houlton, ME

Raw Temperature Profile for latter path of the southbound lane.

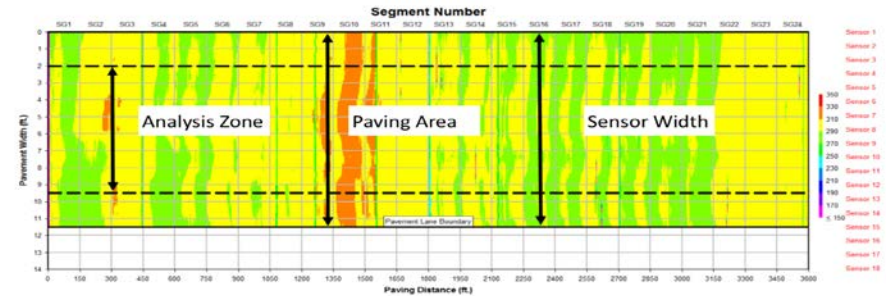


Data Analyses & Findings

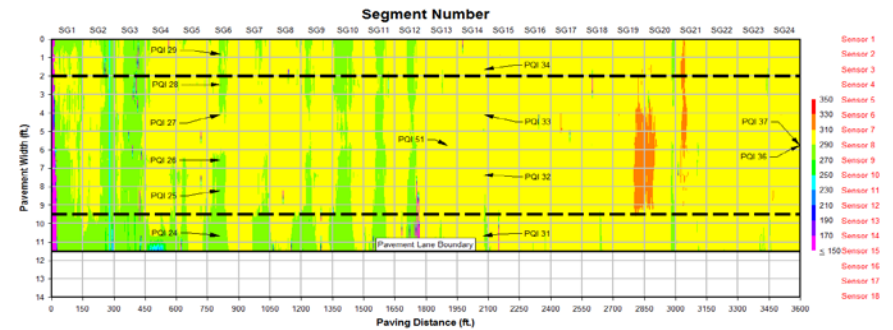
I-95 Houlton, ME

Raw Temperature Profile showing continuous improvement or more uniform mat temperatures along the southbound lane.

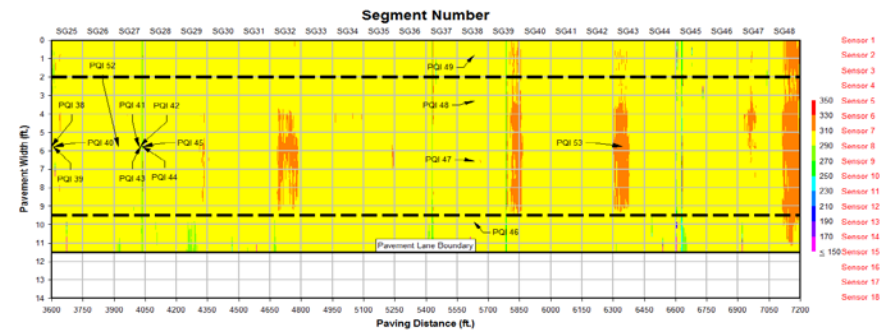
Near Start of Lot



Near Center of Lot

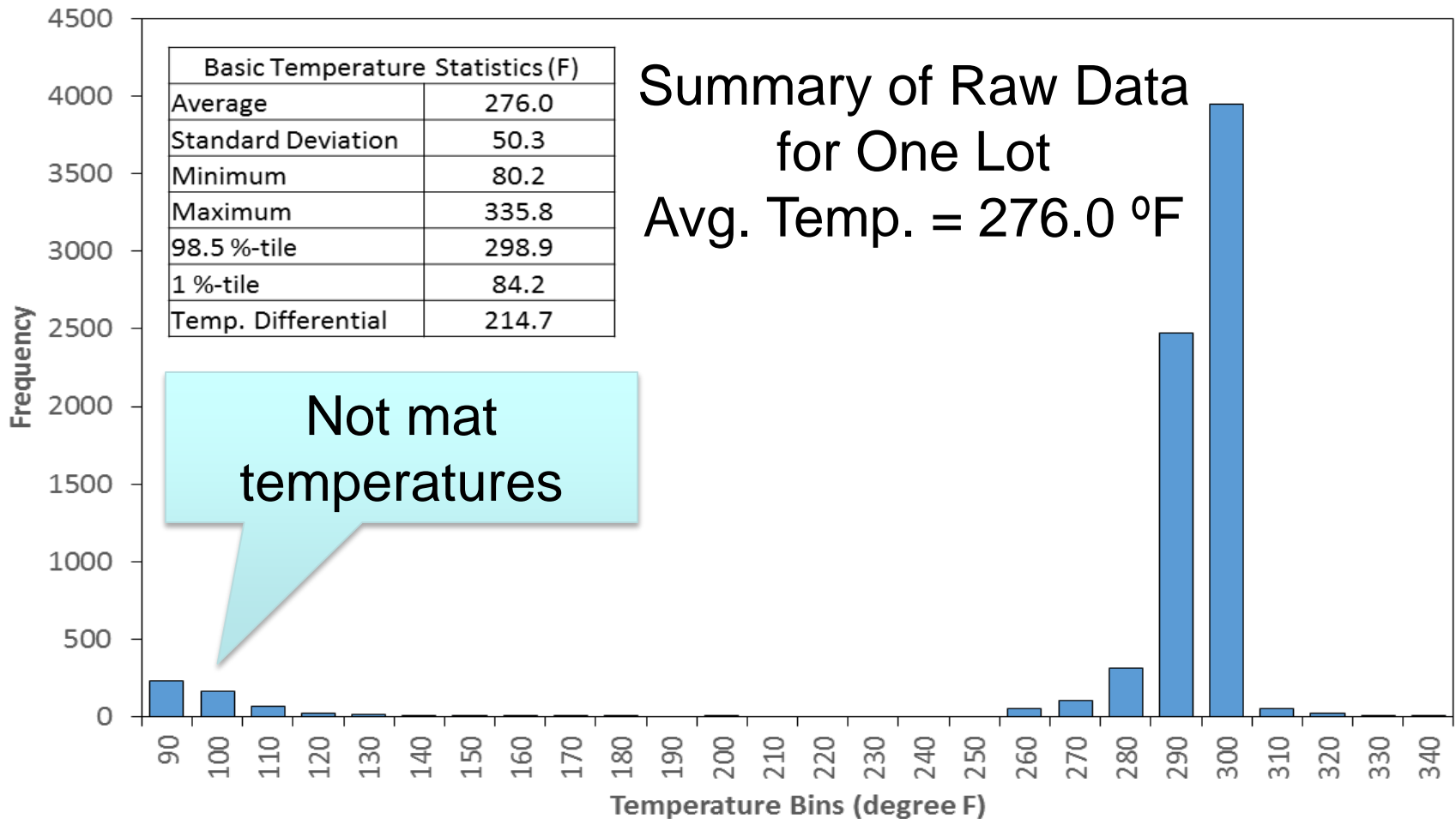


Near End of Lot



Data Analyses & Findings

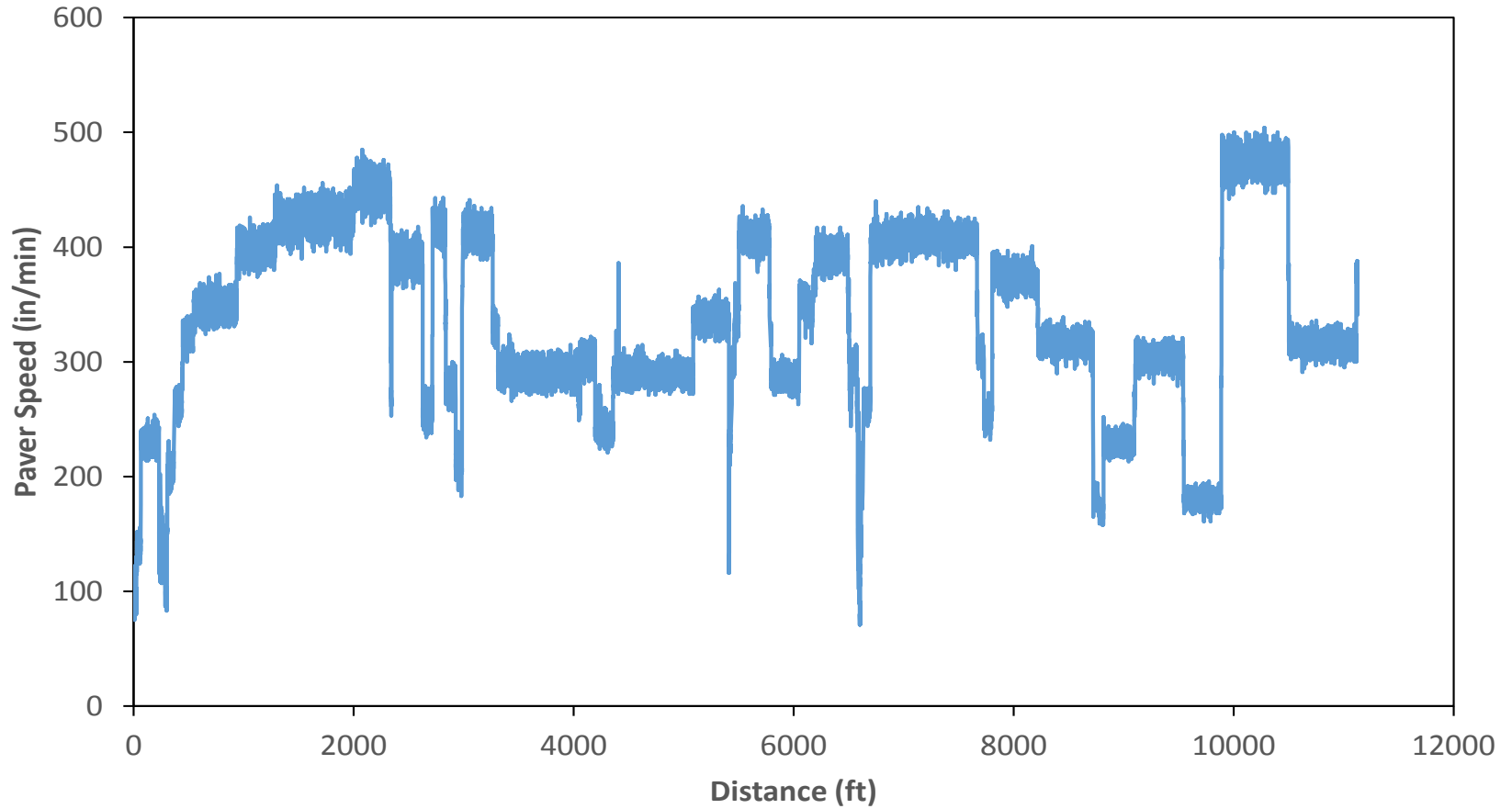
I-95 Houlton, ME



Data Analyses & Findings

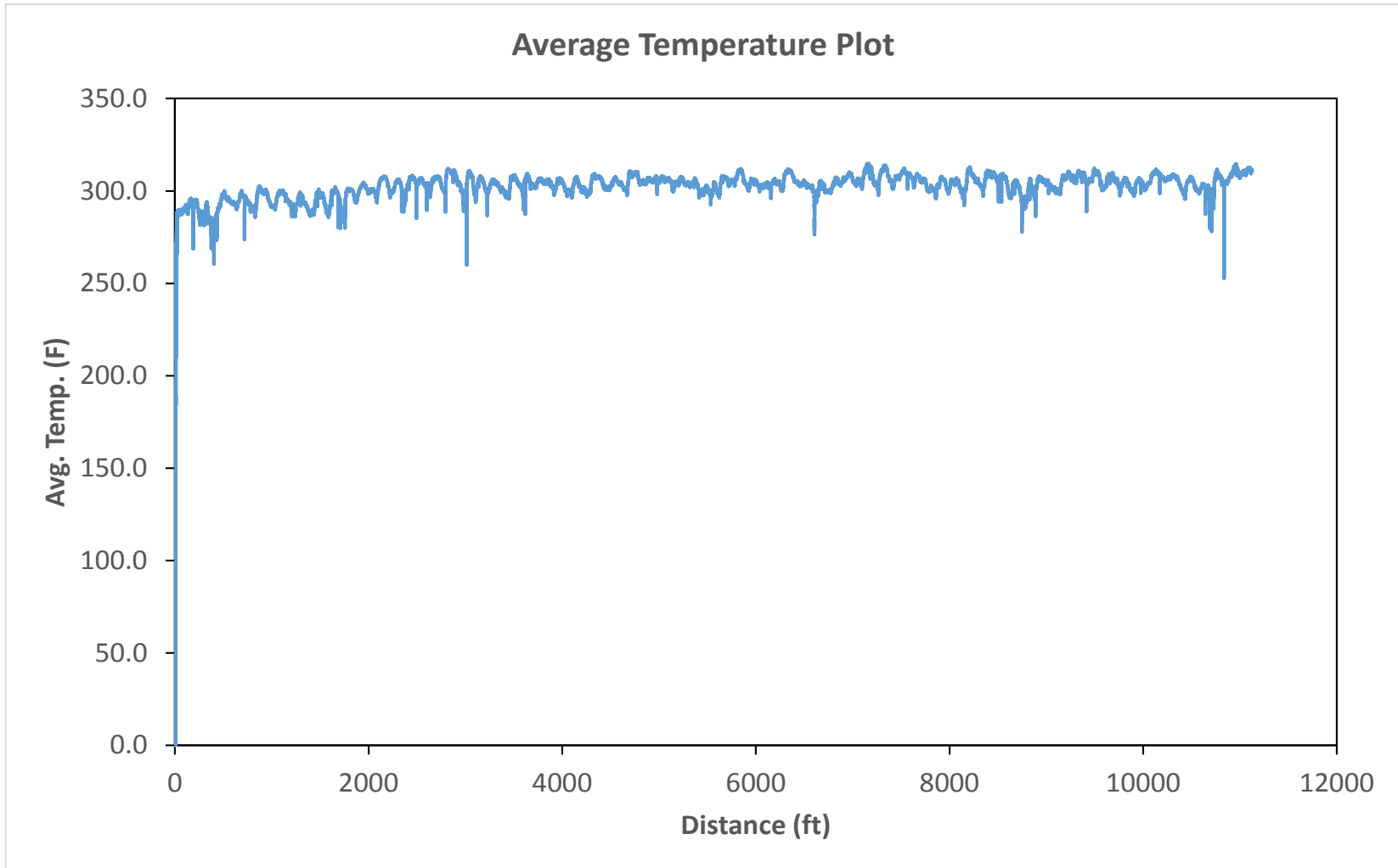
I-95 Houlton, ME

Paver Speed Diagram



Data Analyses & Findings

I-95 Houlton, ME



Data Analyses & Findings

I-95 Houlton, ME



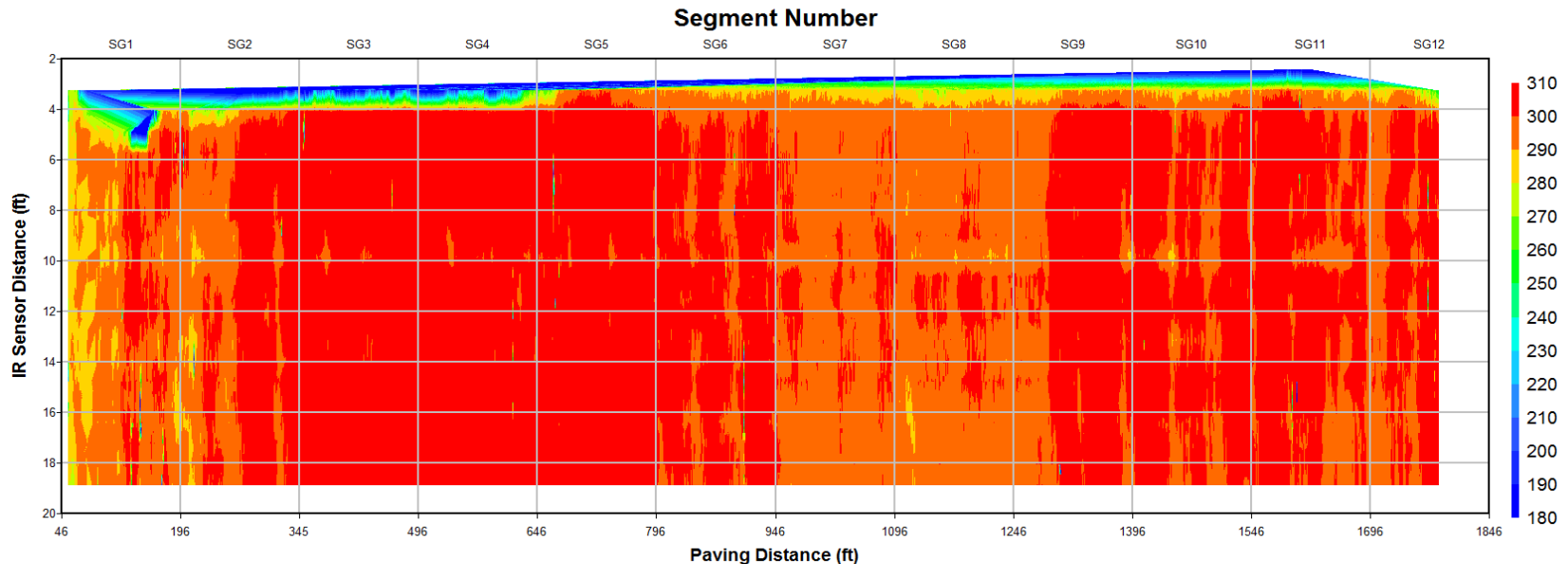
1. Project Overview
2. Data Collection
3. Data Processing
4. Data Summary

Data Analyses & Findings

I-95 Houlton, ME

Data Processing—eliminate invalid temperature measurements:

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

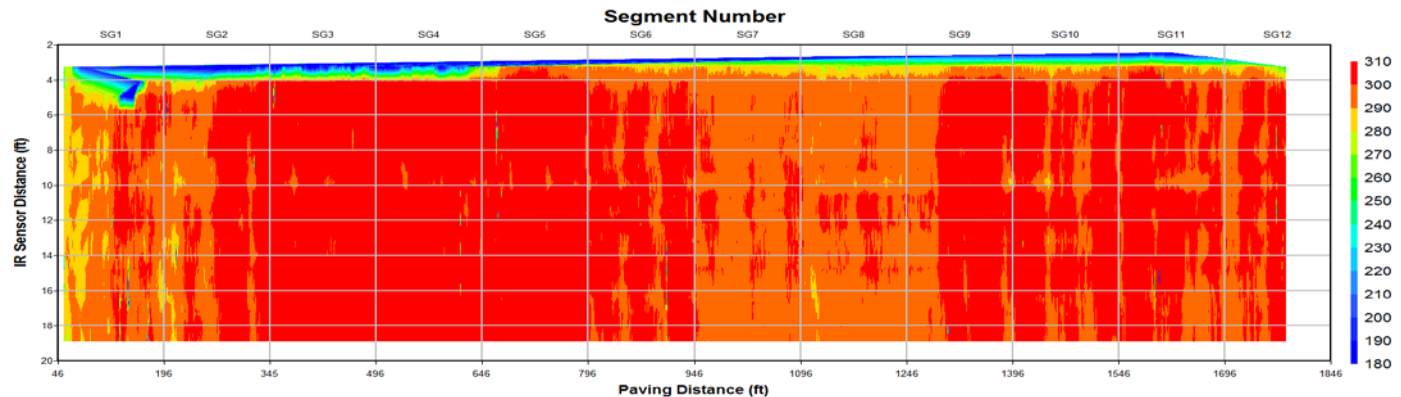


Data Analyses & Findings

I-95 Houlton, ME

Data Processing—eliminate invalid temperature measurements:

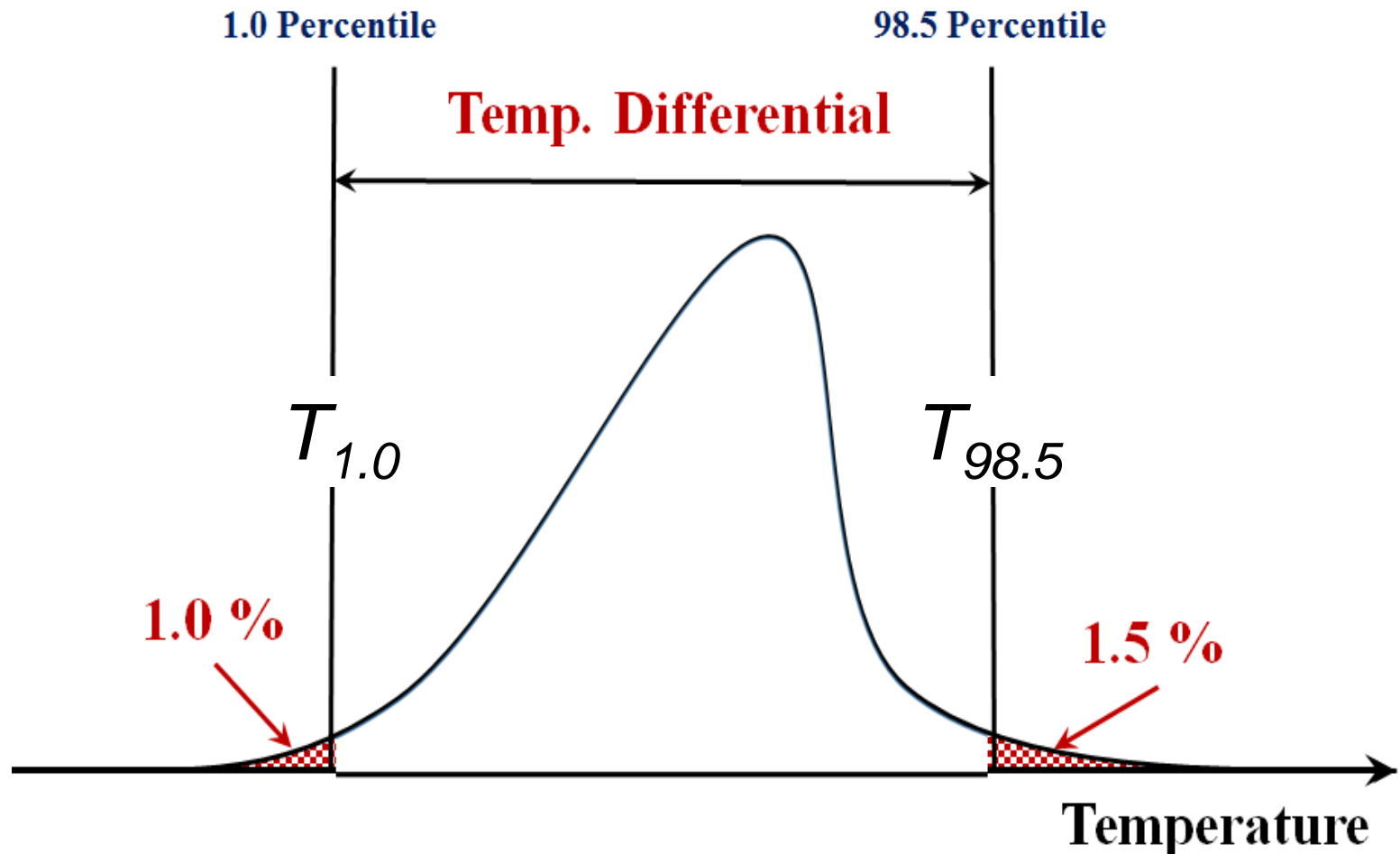
2. Eliminate data with paver stops greater than 10 seconds, between locations:
 - 2 feet behind measurement location of stop
 - 8 feet in front of measurement location of stop
3. Eliminate temperature readings < 170 °F and > 400 °F.



Data Analyses & Findings

I-95 Houlton, ME

- Temperature Differential, each 150 foot segment

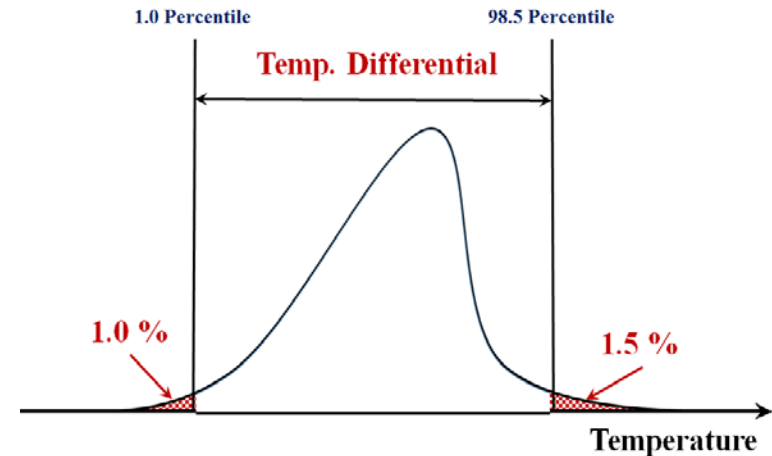


Data Analyses & Findings

I-95 Houlton, ME

- 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

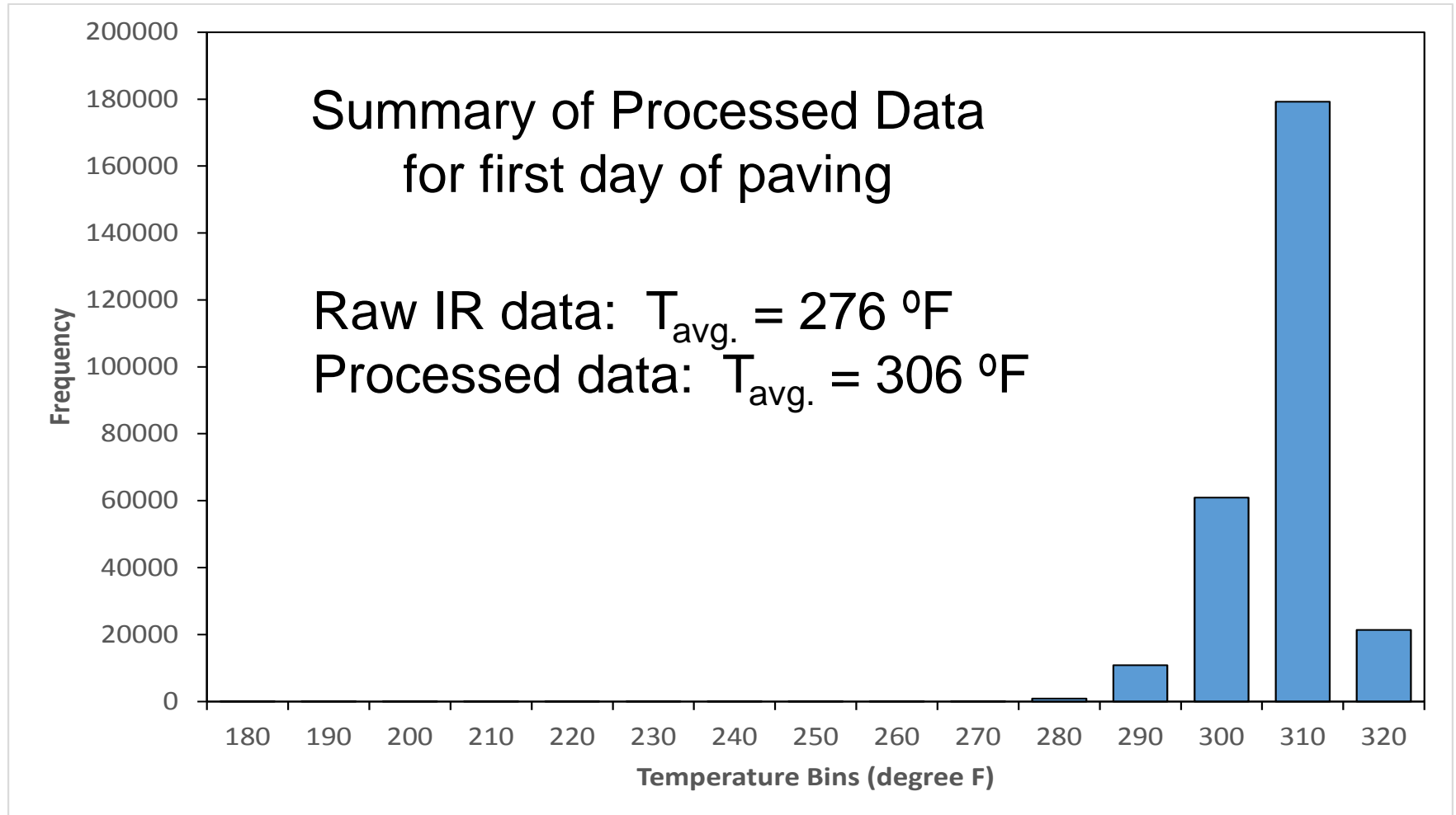
No temperature difference

Moderate temperature difference

Severe temperature difference

Data Analyses & Findings

I-95 Houlton, ME



Data Analyses & Findings

I-95 Houlton, ME



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

Data Analyses & Findings

I-95 Houlton, ME

Processed Data

Paver Stops	Total Number of Increments	Number of Increments within Temp. Regimes			Thermal Streaking
		Minor	Moderate	Severe	
Exclude	579	546	25	8	None
Include	579	494	56	29	None

To include or exclude paver stops?

If paver stop cause severe temperature differences:
they should be included. However:

Data Analyses & Findings

I-95 Houlton, ME

Required paver stops due to sampling should be eliminated from temperature difference profiles.



Data Analyses & Findings

I-95 Houlton, ME

Processed Data

Paver Stops	Total Number of Increments	Number of Increments within Temp. Regimes			Thermal Streaking
		Minor	Moderate	Severe	
Exclude	579	546	25	8	None
Include	579	494	56	29	None

Minnesota DOT's specification:

- Minor Temperature Difference: +\$20 per Increment
- Moderate Temperature Difference: \$0 per Increment
- Severe Temperature Difference: -\$20 per Increment

**Total Incentive to Contractor: \$9,300 for the project section.
[Including paver stops]**

Data Analyses & Findings

I-95 Houlton, ME

In summary: very good temperature consistency along the I-95 Houlton, ME rehabilitation project.



Data Analyses & Findings

I-95 Houlton, ME

Contact Information:

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- Paul Dalbey; pdalbey@ara.com

Questions?



NEXT:

- Implementation: Maine DOT and Contractor
Points of View



Infrared Technology (IR)

Implementation: Maine DOT and Contractor Points of View

April 28, 2015



U.S. Department of Transportation
Federal Highway Administration

AMERICAN ASSOCIATION
OF STATE HIGHWAY AND
TRANSPORTATION OFFICIALS

AASHIO

Agency/Contractor Deployment

1. Agency; Maine DOT

- Reasons for deploying IR Technology
- Benefits – Agency points of view
- Plans to implement IR Technology; short-term plans
- Schedule for deployment

2. Contractors: Lane & Pike

- 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

April 28, 2016



U.S. Department of Transportation
Federal Highway Administration

AMERICAN ASSOCIATION
OF STATE HIGHWAY AND
TRANSPORTATION OFFICIALS

AASHIO

Implementation Products and Strategies



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

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
 - Enhance the deployment and use of the IR technology.
 - Identify/summarize lessons learned from field trials.
 - Confirm Pave-IR can identify the different types of temperature differentials that affect mat density and pavement performance.

Demonstration Projects and Products



1. Field Demonstration Projects and Case Study Report, continued:
 - Outcome
 - Case Study Report
 - Information for showcase
 - Workshops for individual field demonstration projects
 - Demonstrate and discuss value added using IR technology to agency and contractor.

Demonstration Projects and Products

2. Showcase:

- Showcase for IR Technology
 - Missouri DOT is the host agency
 - June 1, 2016
- Purpose
 - Highlight IR technology, provide training & operation.
 - Attendance includes agencies, contractors, industry, consultants and academia.
- Outcome
 - Report to document showcase

All participating agencies in IR demonstration projects have received an invitation.

Demonstration Projects and Products



3. Trouble Shooting and Best Practices Guide

- Purpose of Guide

- Provide guidance on:

- Setting up the equipment and getting started.

- Interpreting the raw data for making decisions.

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

- Outcome

- Based on all 10 demonstration projects

- Experience of agencies & consultants

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

- Advance standardization of IR equipment and testing protocols through AASHTO.
- Agencies can customize it to their needs

- Outcome

- Revised/Enhanced AASHTO PP 80-14

- Based on:

- 10 Demonstration Projects
- Agency Experience: Minnesota DOT, Texas DOT, etc.

Demonstration Projects and Products



5. IR Guide/Primer

- Purpose

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

- Outcome

- Based on all 10 demonstration projects.

Implementation Products and Strategies

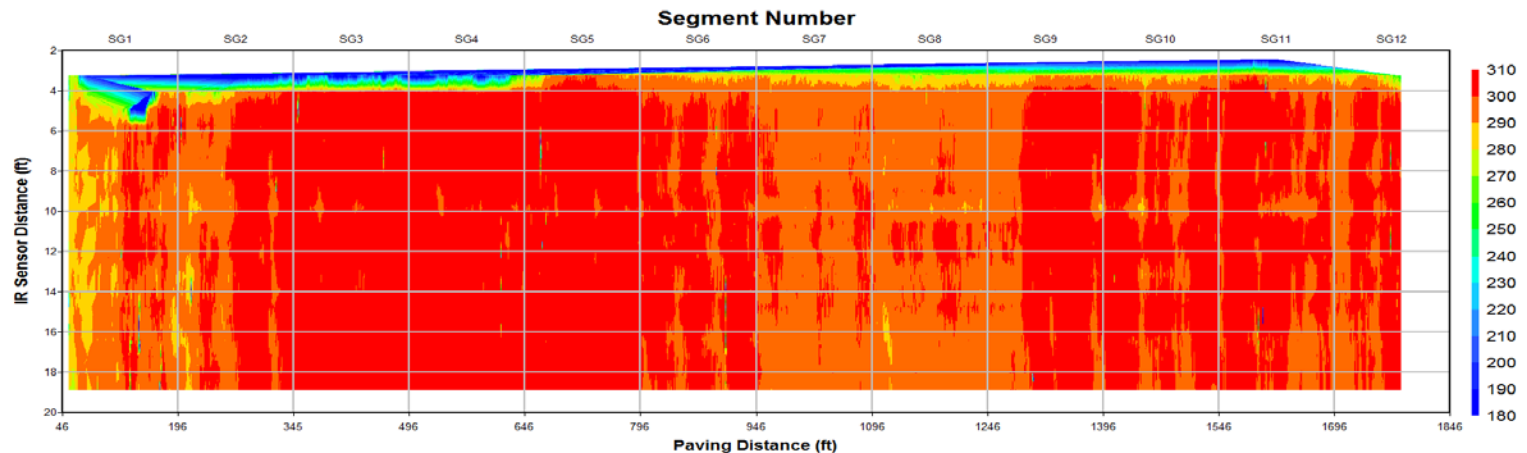


1. Field Demonstration Projects and Products
2. Application and Use: Examples
3. Questions and Answers

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
 - Monitor production/placement operations to minimize temperature differentials of mat.
 - Use data 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; 3 examples

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

Application and Use: Examples

1. Missouri demonstration project
 - Communication between plant and paver; monitoring production/placement operations to minimize temperature differentials of mat.



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

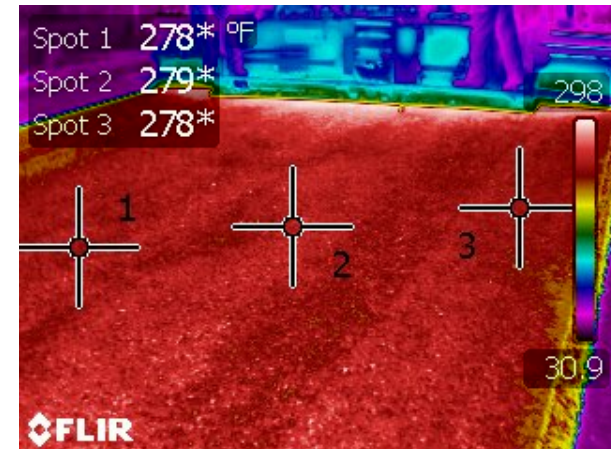
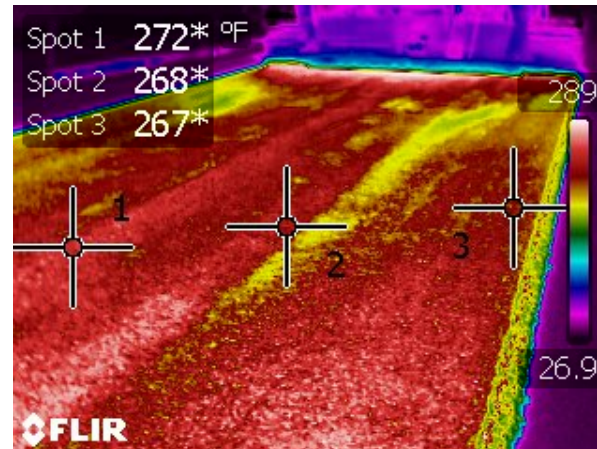
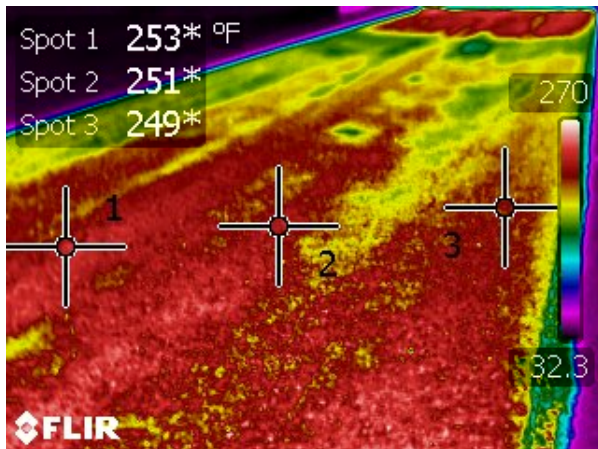
- Identify reason for severe temperature differentials and take action; loading of trucks.
 - One dump of mix in truck bed – severe temp. differential
 - Two dump, no stockpile – reduced temp. differential.



Application and Use: Examples

IR Role in Acceptance Plan; examples:

- Identify cold spots
 - Colorado, Michigan, Minnesota, Quebec, Texas, Washington
- Identify thermal streaks
 - Quebec



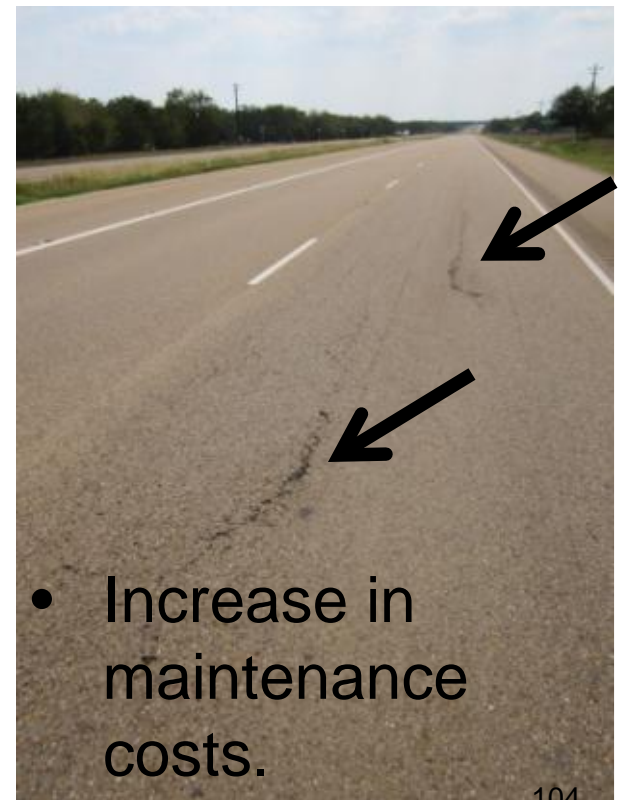
Application and Use: Examples

Cold spots; areas with increased potential for:

- Fatigue cracks
- Raveling
- Pot holes



- Loss of service life



- Increase in maintenance costs.

Application and Use: Examples

Thermal streaks; areas with increased potential for longitudinal cracking.



Application and Use: Examples

Specification Guide; AASHTO PP 80-14

1. Scope
2. Referenced Document
3. Terminology
4. General Thermal Profile Requirements
5. Hardware
6. Data File Format
7. Calibration
8. Profiler Accuracy
9. References
10. Appendices (Non-mandatory)
 1. Example Acceptance Criteria
 2. Terminology
 3. Criteria
 4. Monetary Adjustment

Standard Practice for

**Continuous Thermal Profile of
Asphalt Mixture Construction**

AASHTO Designation: PP 80-14¹



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444 North Capitol Street N.W., Suite 249
Washington, D.C. 20001

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Application and Use: Examples

IR Role in Acceptance Plan

- Determine biased areas for sampling and testing
 - Washington DOT
- Determine pay factors
 - Minnesota DOT
 - Quebec
- Minnesota pay factors for each 150 foot segment:
 - \$20 bonus; $<25^{\circ}\text{F}$
 - \$20 penalty; $>50^{\circ}\text{F}$



WSDOT SOP 733

Determination of Pavement Density Differentials Using the Nuclear Density Gauge

1. Scope

This test method describes the procedure for locating and testing areas of suspected low cyclic density. Lower pavement density has been related to temperature differentials and areas of "spots, streaks" or visual pavement irregularities. This method uses infrared detection devices and visual inspection to identify areas of potentially low cyclic density.

2. Definitions

- Temperature Differential Area- Any area where the temperature of the newly placed HMA pavement is **greater than** 25°F different than the surrounding area.
- Aggregate segregation- "Spots, streaks" or visual pavement irregularities in the newly placed HMA pavement that has a significant difference in texture when compared to the surrounding material.
- Systematic Density Testing - the testing of temperature differential areas or areas of aggregate segregation to determine if there is a pattern of low cyclic density.

3. Equipment

- An approved infrared camera OR a handheld noncontact infrared thermometer (features for both should include continuous reading, minimum, maximum, and average readings, laser sighting, and a minimum distance to spot size ratio (D:S) of 30:1.
- Nuclear moisture-density gauge.
- Tape measure.
- A can of spray paint for marking test locations.
- Required report form.

4. Testing Criteria

- Where temperature differentials are 25°F or greater a systematic HMA compaction test is required.
- Where temperature differentials are less than 25°F a systematic HMA compaction test is not required unless, an area shows signs of visual pavement irregularities, surface segregation or a significantly different texture.

5. Determination of Systematic Density Testing Locations

Use either an infrared camera or a handheld non-contact infrared device to locate temperature differential areas as follows:

Application and Use: Examples

Washington State DOT; WSDOT SOP 733

- Aggregate segregation: spots and streaks defined by visual inspection
- Equipment for measuring temperature differentials:
 - Infrared camera
 - Handheld noncontact infrared device
 - IR-Bar or IR-Scanner not identified
- Temperature Differential Area: $> 25^{\circ}\text{F}$ and paver stops are included
 - Measured prior to compaction
- In temperature differential areas; systematic compaction test is required for all areas.

Application and Use: Examples

Alaska DOT; Special Provision draft

- IR and IC added to Glenn Hwy project
- After test strip is completed, monitor is covered for first lot, then removed for latter lots and compared to the first:
 - IR-Scanner
- Temperature Differential Area: $> 25^{\circ}\text{F}$ and paver stops are included
 - Measured prior to compaction
- In temperature differential areas:
 - Perform density profiles
 - Adjust compaction and paving equipment operation to eliminate temperature differential areas.

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:
 - $< 25^{\circ}\text{F}$ is minor thermal segregation
 - 25°F to 50°F moderate thermal segregation
 - $> 50^{\circ}\text{F}$ 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

Deployment Strategy, Common Steps/Tasks:

1. Define temperature differences that cause significant distress, increasing maintenance cost & reducing service life (Minnesota, Ontario, Texas, Washington).
 - a) Many published reports that document the importance of temp.
2. Identify mat property changes between areas with severe temperature differentials (Ontario, Texas).
 - a) Many research reports that identify how density affects the mat's properties related to performance.
3. Draft IR specification (Minnesota, Ontario, Texas, Washington)
4. Obtain comments from industry for revising specification; getting input from other partners (Ontario, Minnesota, Texas).
5. Host/sponsor training sessions with equipment/software

Application and Use: Examples

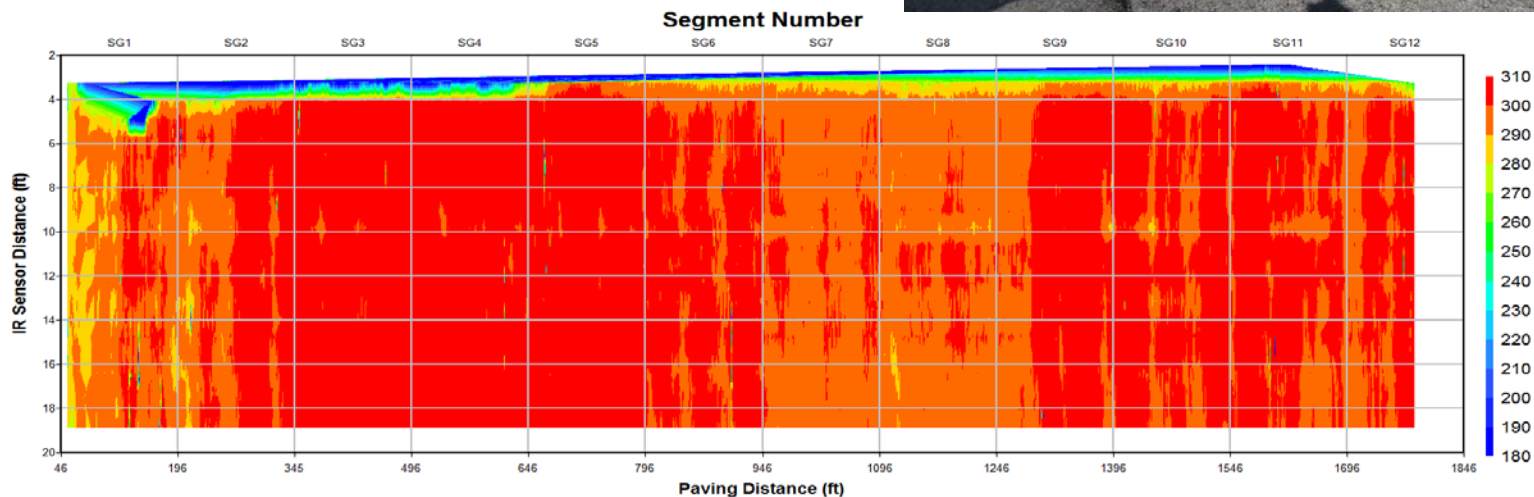
Deployment Strategy, Common Steps/Tasks:

6. Execute pilot projects over 1 to 2 years (Minnesota, Ontario)
7. Educate industry/agency personnel on results (Ontario).
8. Update/revise specification (Minnesota, Ontario, Texas, Washington)
9. Establish actions based on temperature profile differences (all)
 - a) Increased density testing (Texas)
 - b) Biased testing (Washington)
 - c) Incentives/disincentives based temperature differentials (Minnesota, Ontario)
10. Confirm appropriateness of acceptance plan (Ontario)
11. Full deployment

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

Agency/Contractor Deployment

Some 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?
11. How have agencies/contractors used the IR products?

Workshop Wrap-Up



Complete workshop forms.

NEXT:

- Presentation and Demonstration of Ground Penetrating Radar Equipment