



SHRP2 SOLUTIONS
STRATEGIC HIGHWAY RESEARCH PROGRAM

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

Hosted by:
West Virginia DOT
March 1, 2017

U.S. Department of Transportation
Federal Highway Administration

American Association of State Highway and Transportation Officials
AASHTO

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 Virginia DOT and Eastern Federal Lands Demonstration Projects

4. Discuss the Contractor’s and Agency’s Perspective as a QC or QA Tool

5. Know Implementation Strategies

Infrared Scanner Workshop

AGENDA:

Time	Topic/Presentation
12:30	**Registration**
1:00	**Call to Order**
1:00 to 1:15	**Welcome and Introductions**
1:15 to 1:45	**Introduction to Infrared Technology: What is it and Why is it Needed?**
1:45 to 2:00	**Equipment and Software: How to use it?** Getting Real Time Information for Decision Making
2:00 to 2:30	**Data Analyses and Findings**: What was learned from the Demonstration Project; Outcome and Lessons Learned from the Field Demonstration Projects
2:30 to 3:00	**Agency Perspective as a QA Tool:** Agency overview of the technology in ensuring a higher uniformity of the mat, as well as how the agency plans to implement the technology in the short-term.
3:00 to 3:30	**Contractor's Perspective as a QC Tool:** Contractor overviews their points and advantage of the technology in minimizing the penalties and maximizing their incentive.
3:30 to 3:45	**Implementation Strategies (focus on Agency use):** 1. Products and Application of Products 2. Trouble Shooting Guide Lead Agency Strategies/Specifications Lessons Learned
3:45 to 4:30	**Questions/Answers and Closing Comments**
4:30 to 5:00	**IR Workshop Wrap-Up**
5:00 to 5:25	**Presentation and Demonstration of Ground Penetrating Radar Equipment**

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Infrared Technology (IR)

What is it and why use it?

March 1, 2017

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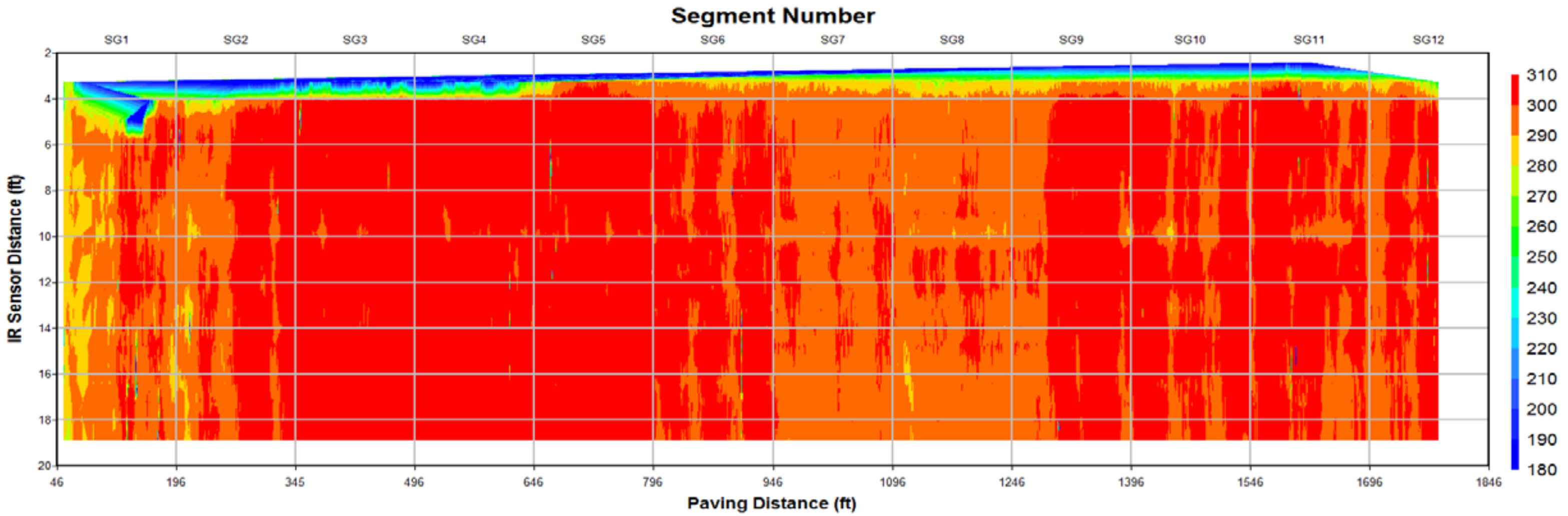
IR – What is it & why use it?

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

IR – What is it & why use it?

Infrared Thermography:

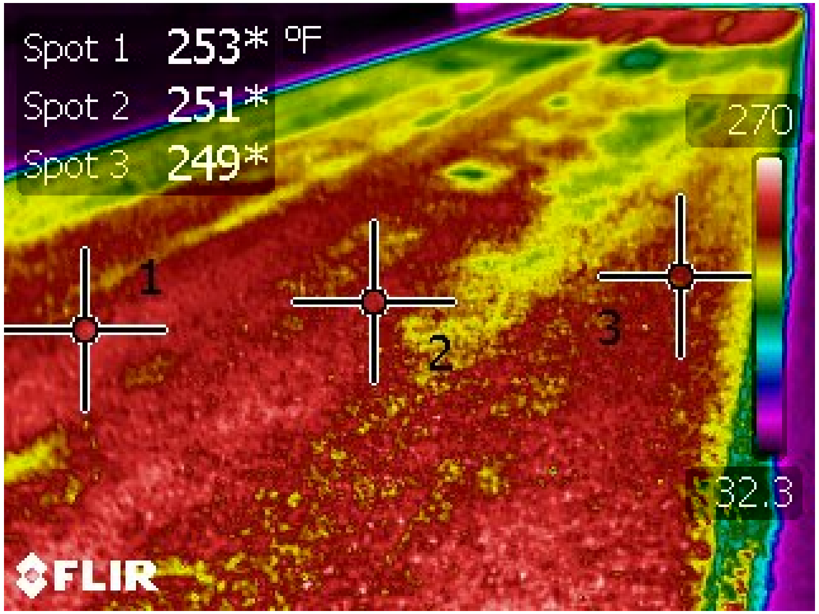
- The mapping of temperature contours (equal temperature) over the surface of a material.
- Contours are used to evaluate materials by measurement of their surface temperature and its variation.

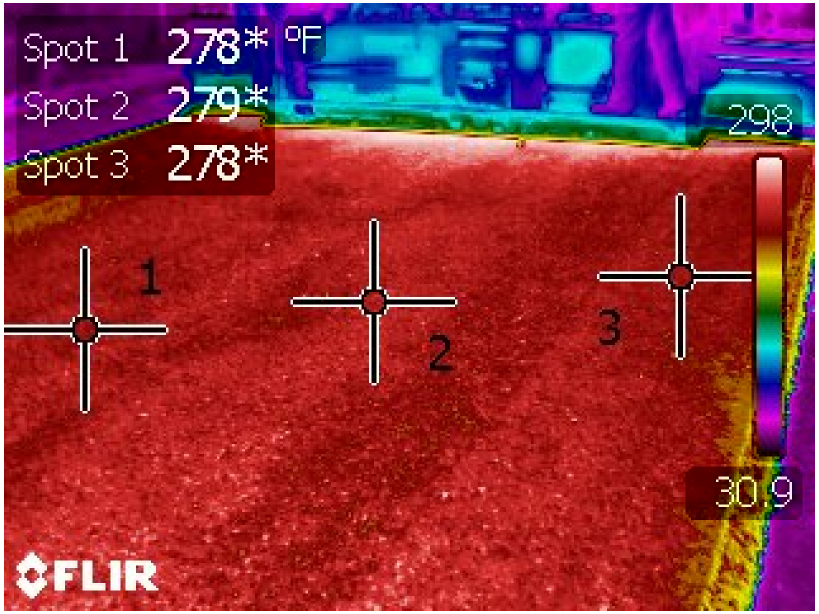


IR – What is it & why use it?

Temperature segregation (differential):

- More than 25 ºF difference in mat temperature behind screed.

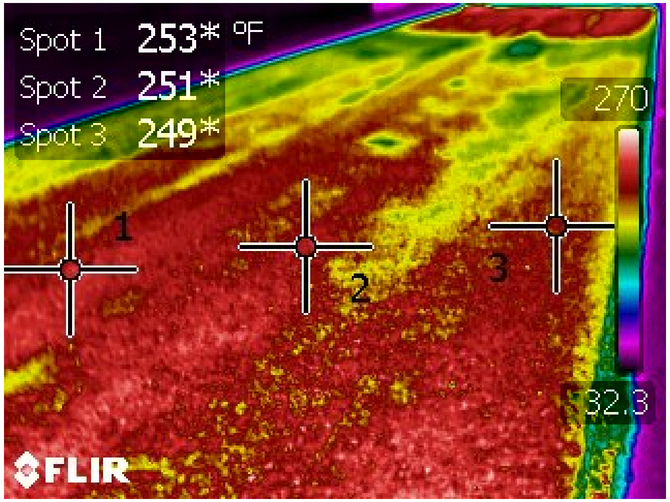


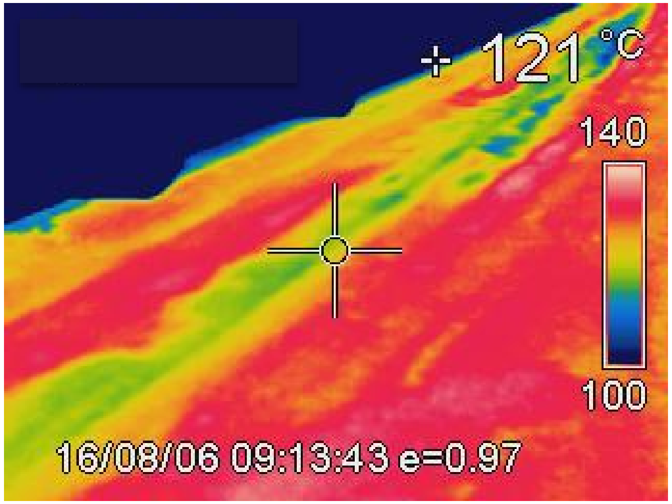


IR – What is it & why use it?

Types of Temperature Differences:

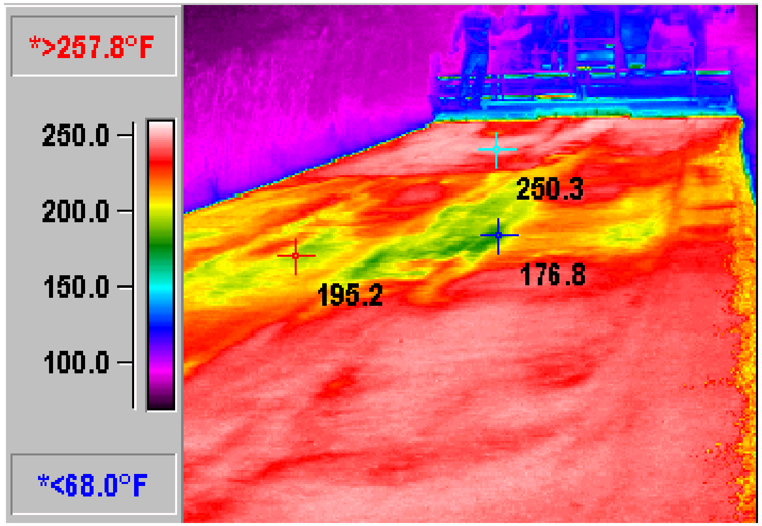
1. Cold spots
   – Truck to truck temperature differences
   – Improper loading and unloading of trucks
2. Thermal streaks
   – Longitudinal segregation
   – Inadequate or non-uniform amount of material across the mat





IR – What is it & why use it?

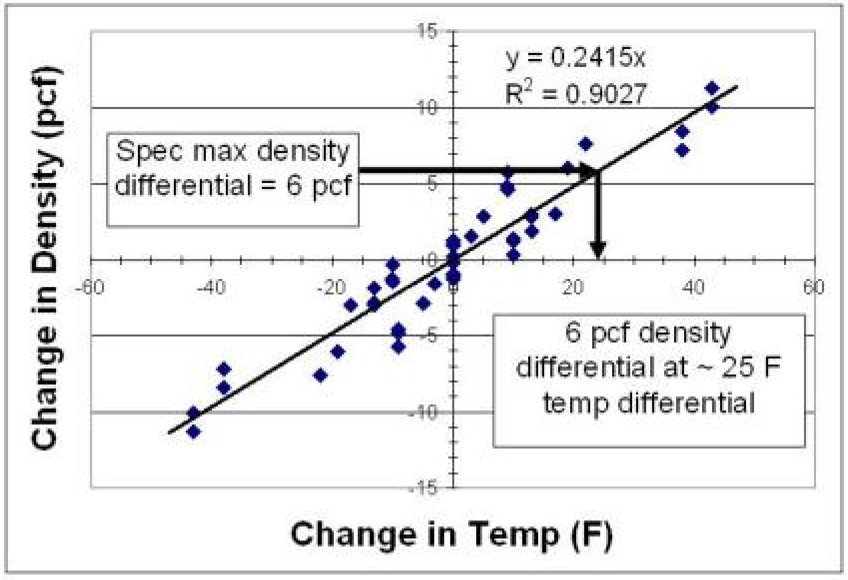
- Cold spots
  - Temperature difference of mat between truck exchanges – common.
  - Areas with higher air voids
- Focused testing have validated higher air voids
  - Coring
  - Radar (full coverage)
  - Nuclear gauge



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?

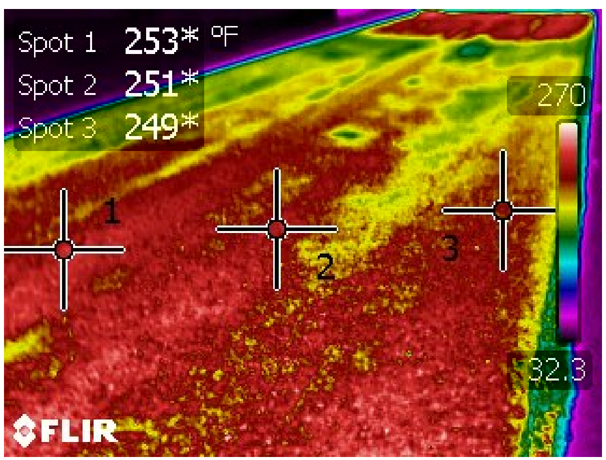
History; Mat Temperature Measurements

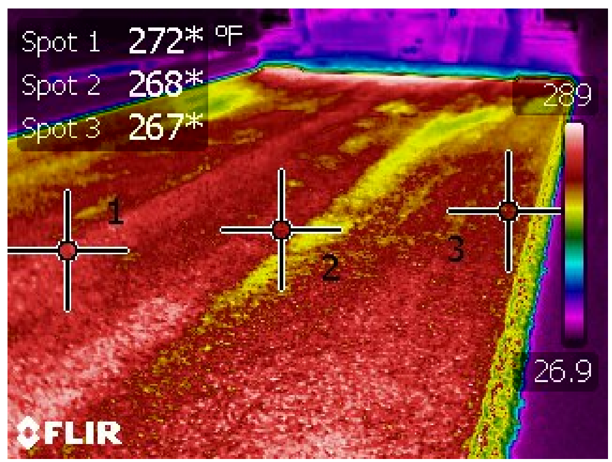
- IR sensors, IR-Bar; first device for continuous readings
- Pave-IR Scanner; second generation device for continuous readings

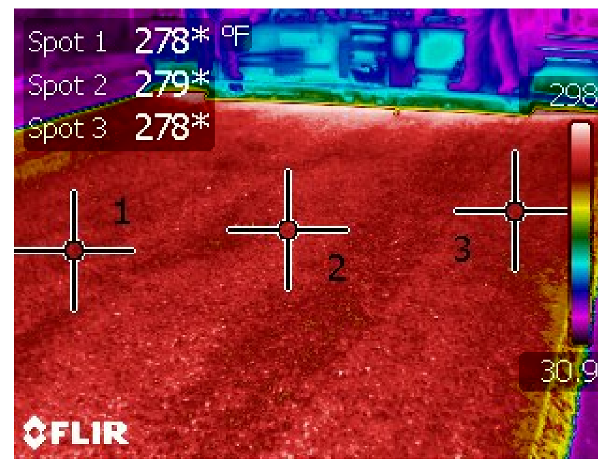
IR – What is it & why use it?

Application & use of temperature cameras

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



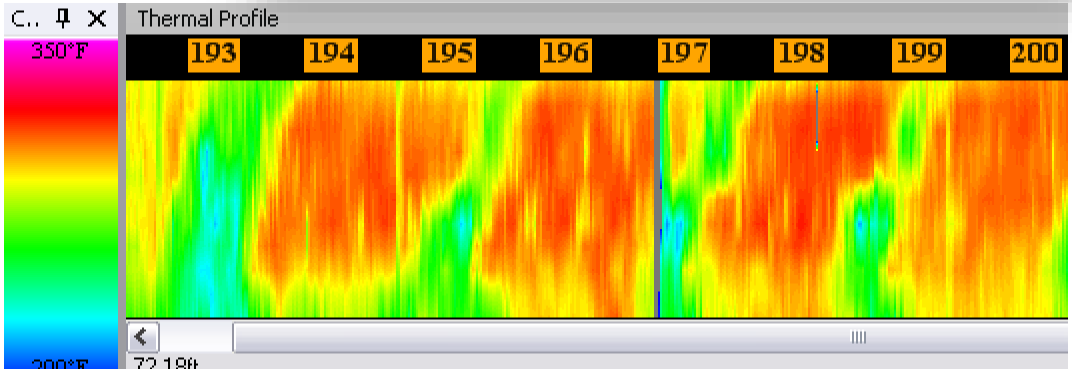




IR – What is it & why use it?

Application & use of IR-Bar and Scanner

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

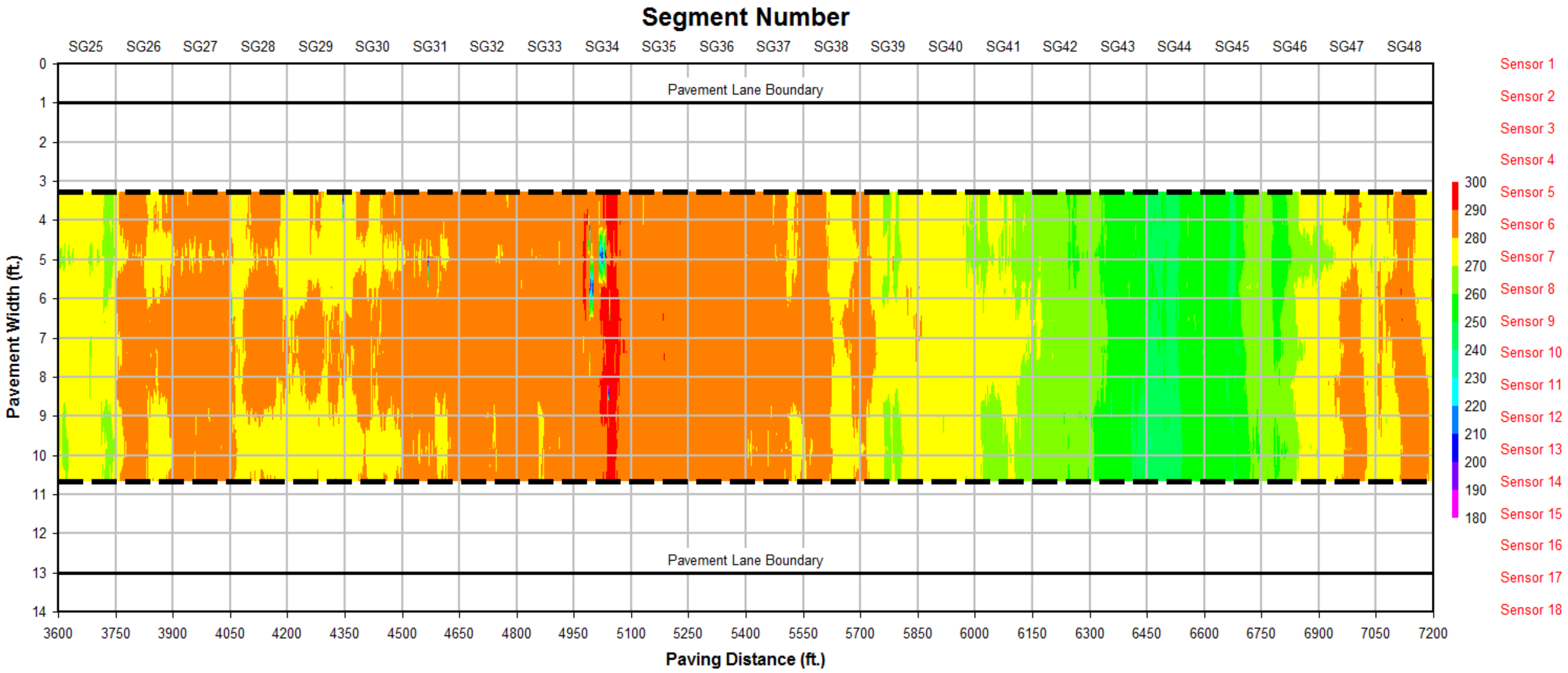


IR – What is it & why use it?

1. IR - Defined.
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?

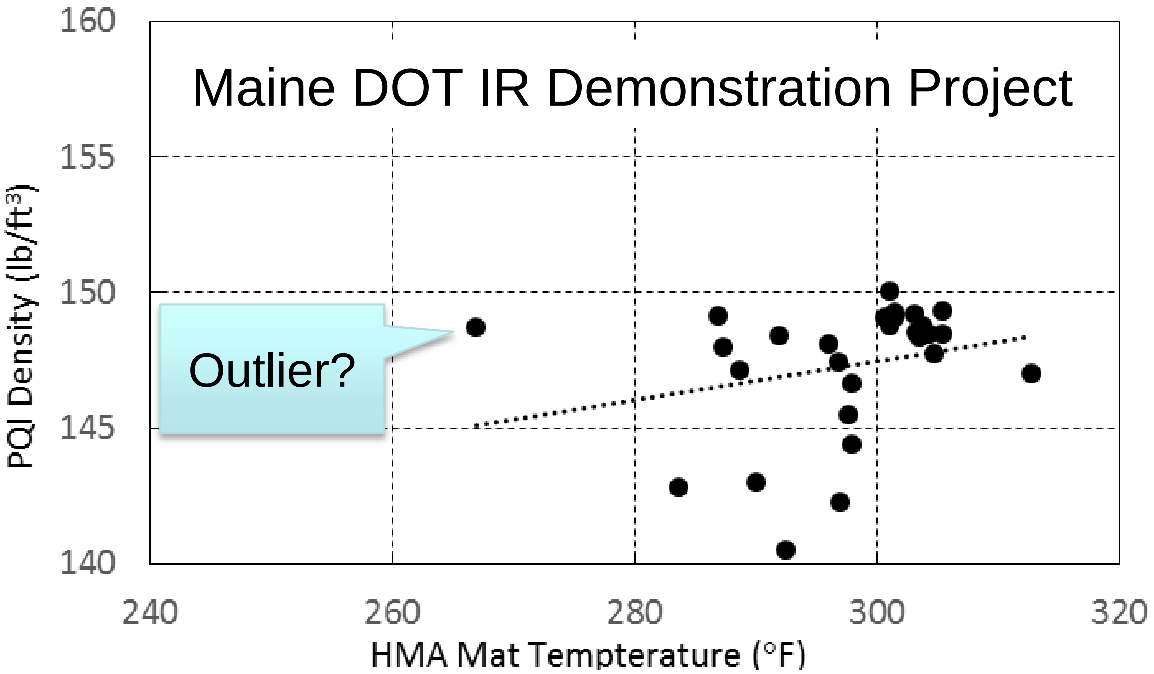
- Both sided longitudinal and centerline segregation result in thermal streaks; IR can identify these areas.

IR – What is it & why use it?

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

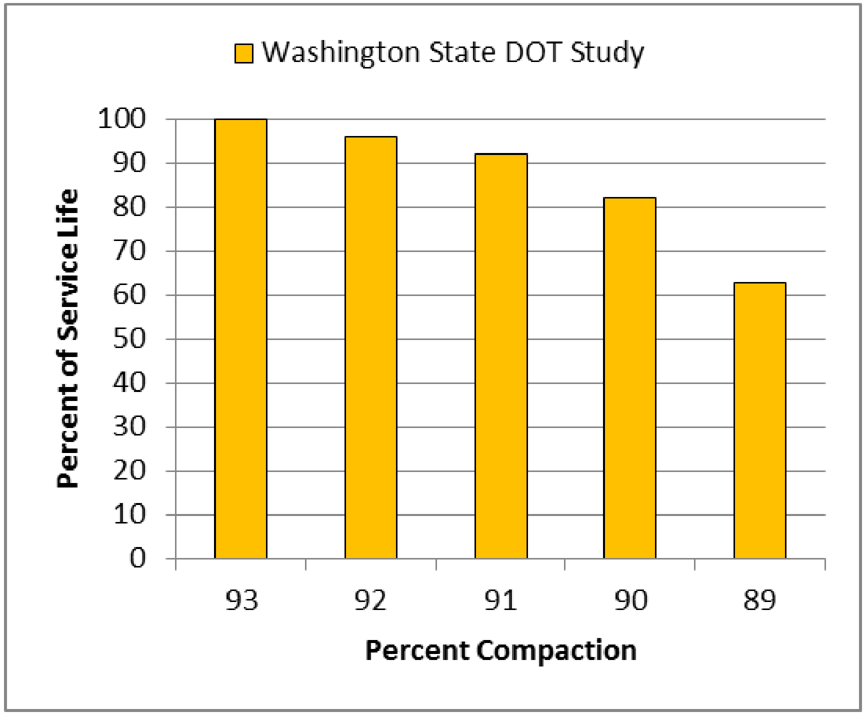
TTI Study:
Δ25 ºF ~ Δ6 pcf

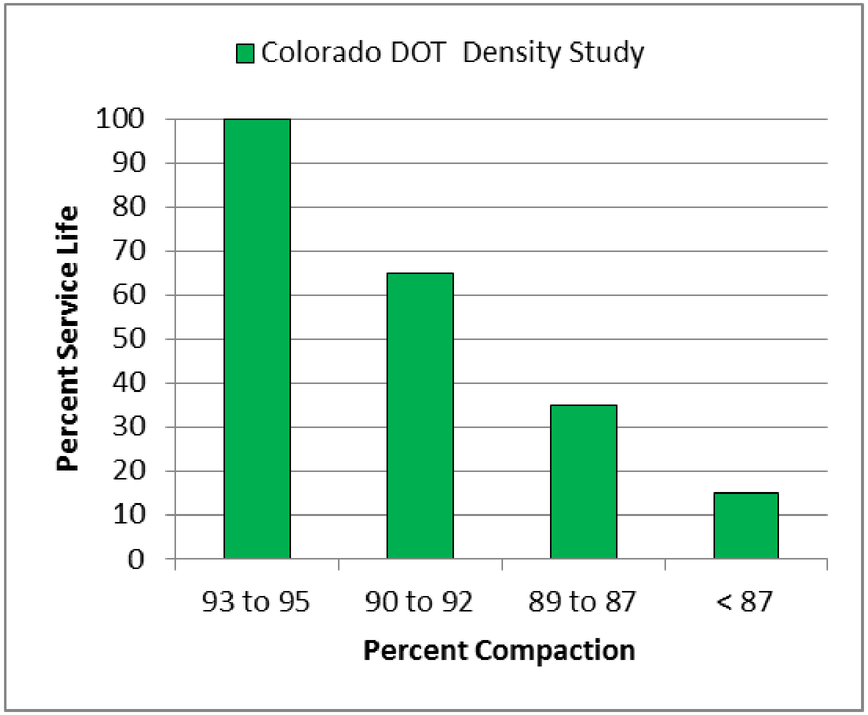
Maine DOT:
Δ20 ºF ~ Δ4 pcf



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.

Loss of service life or increase in maintenance costs.

IR – What is it & why use it?

Cold spots; areas with increased potential for:

- Fatigue cracks
- Raveling
- Pot holes



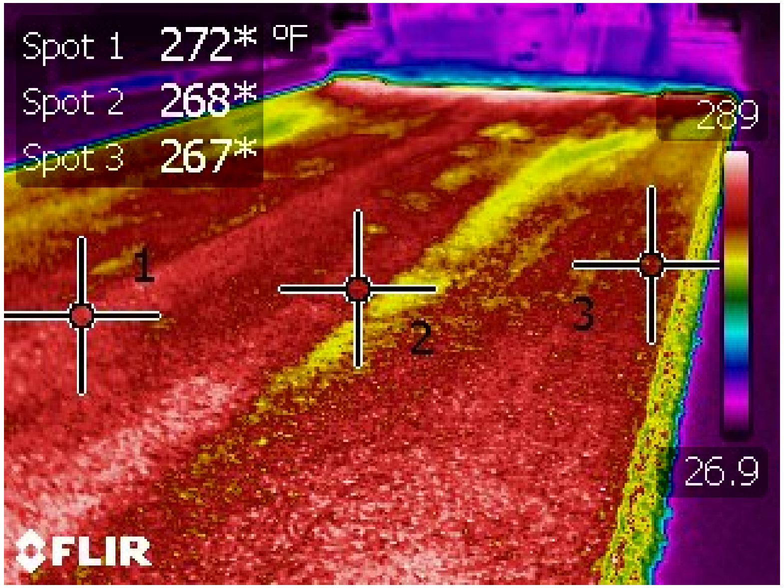
IR – What is it & why use it?

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?

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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

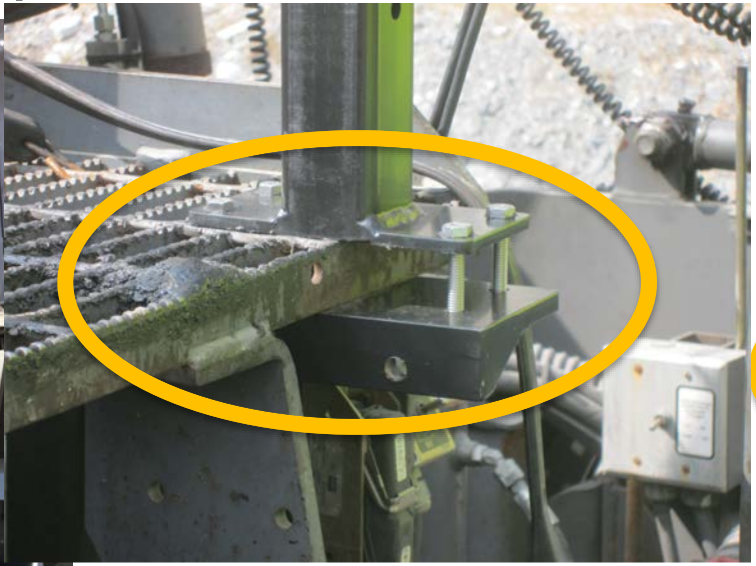
Equipment

- 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

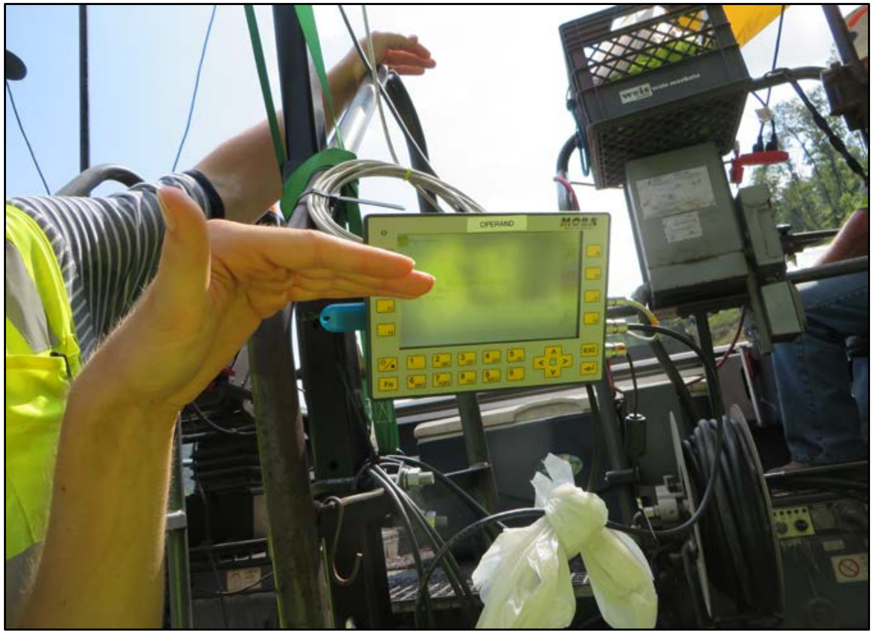
Mounted to a Steel Plate Attached to Work Platform

IR Equipment and Software

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

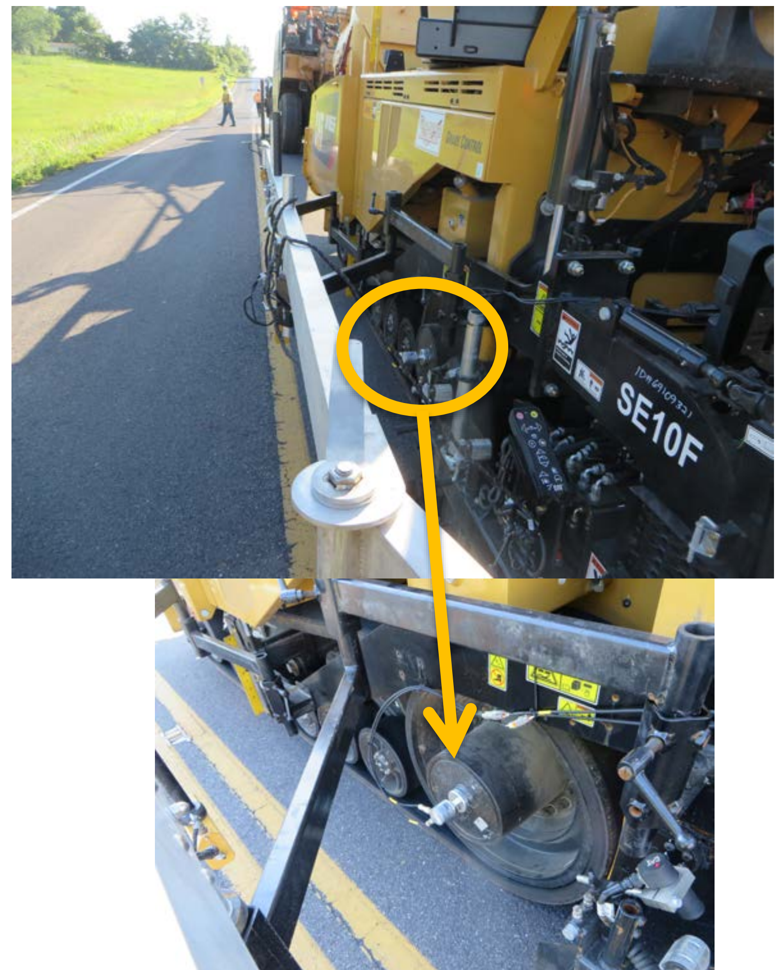
IR Equipment and Software

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

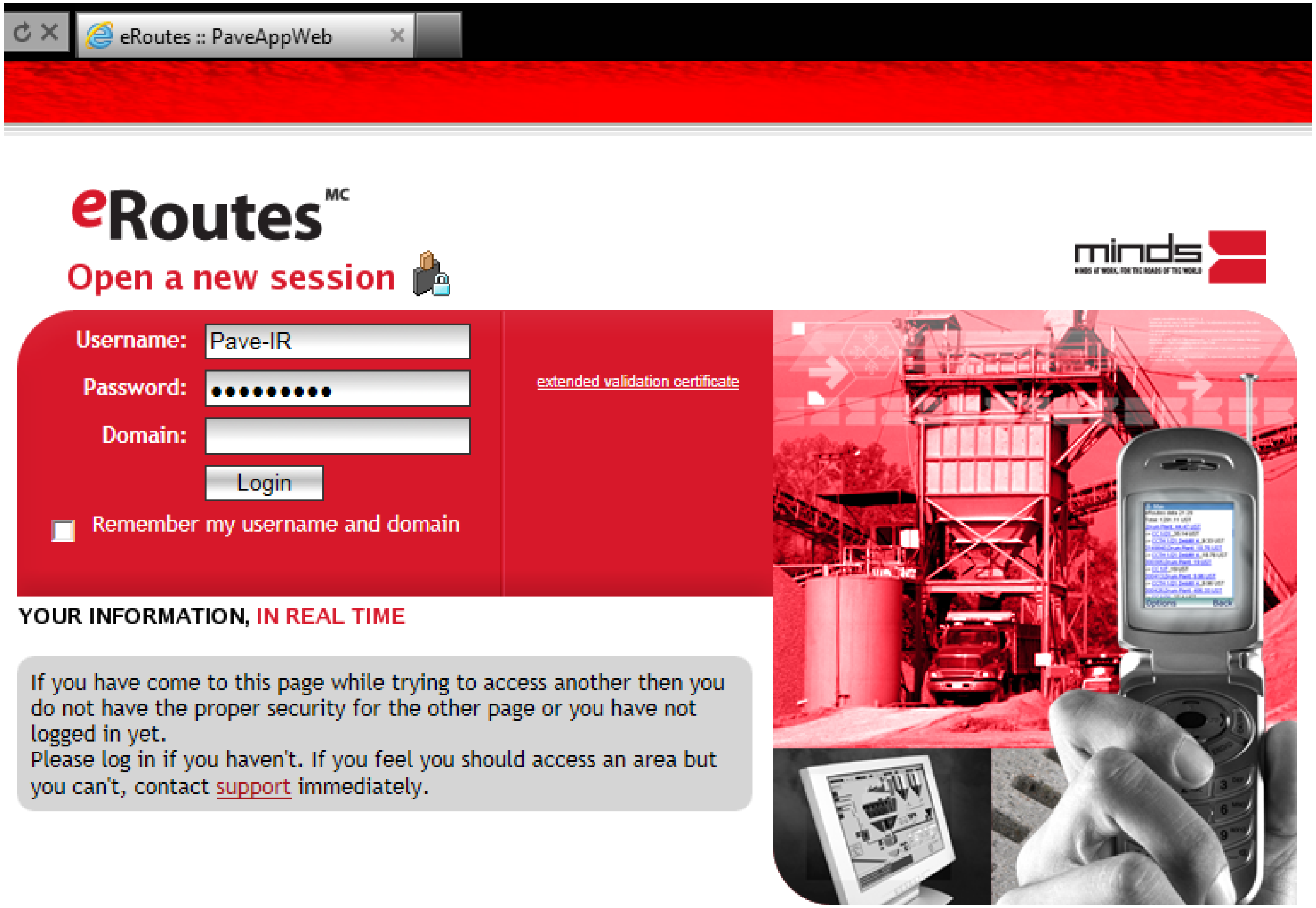
1. Equipment and Installation
2. Software and Its Features

IR Equipment and Software

Two models of data transfer and extraction

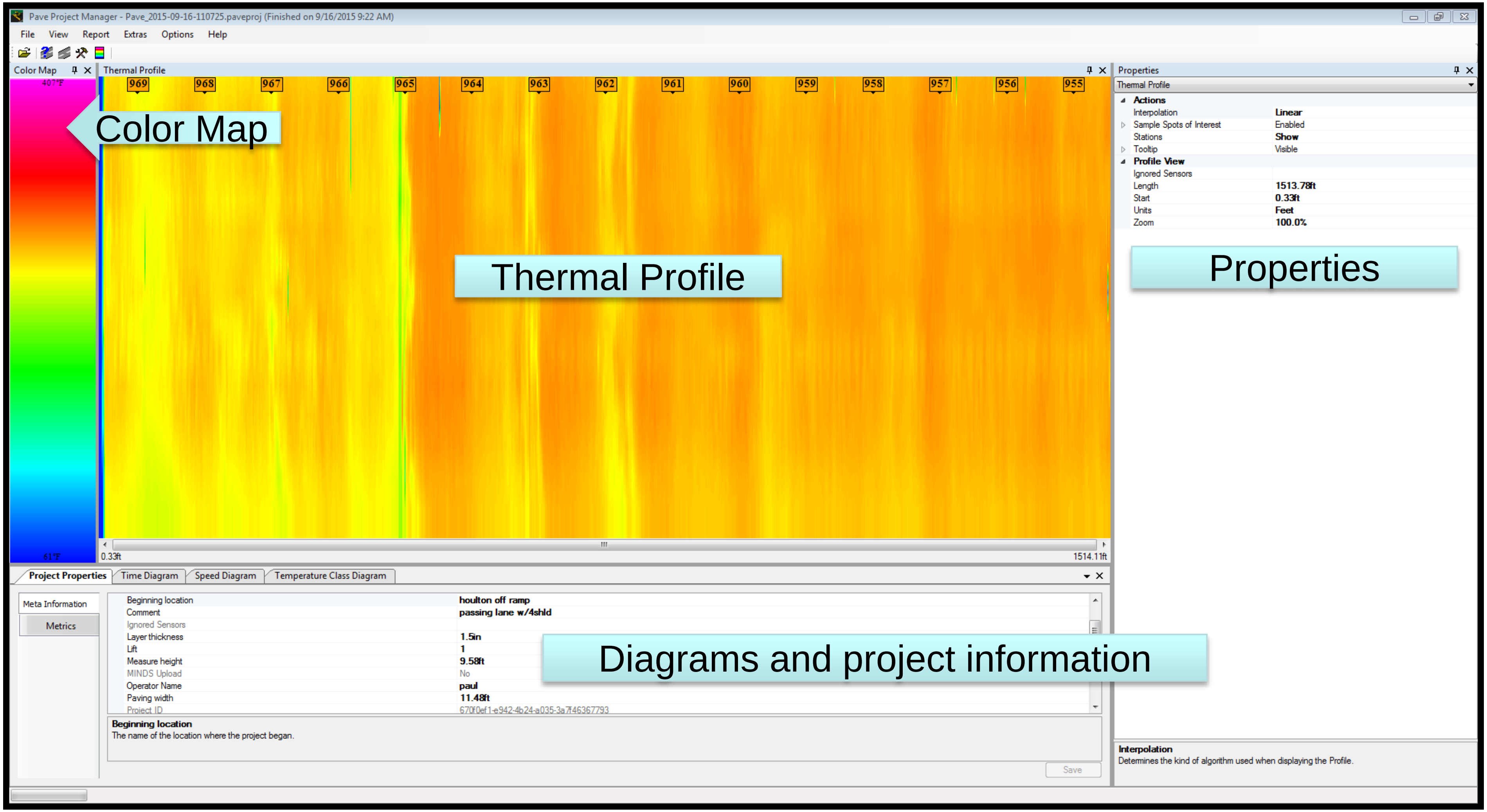
IR Equipment and Software

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



IR Equipment and Software

Explore Data: MOBA Pave Project Manager Main Screen



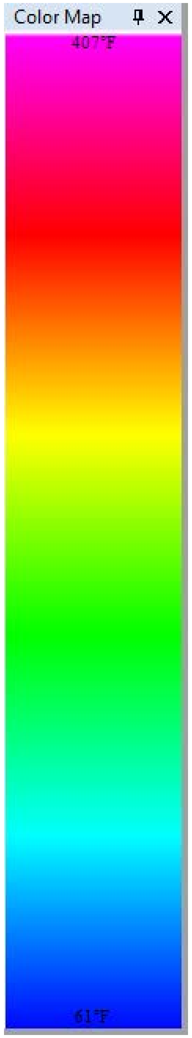
IR Equipment and Software

Color Map and Properties for Screen

Properties

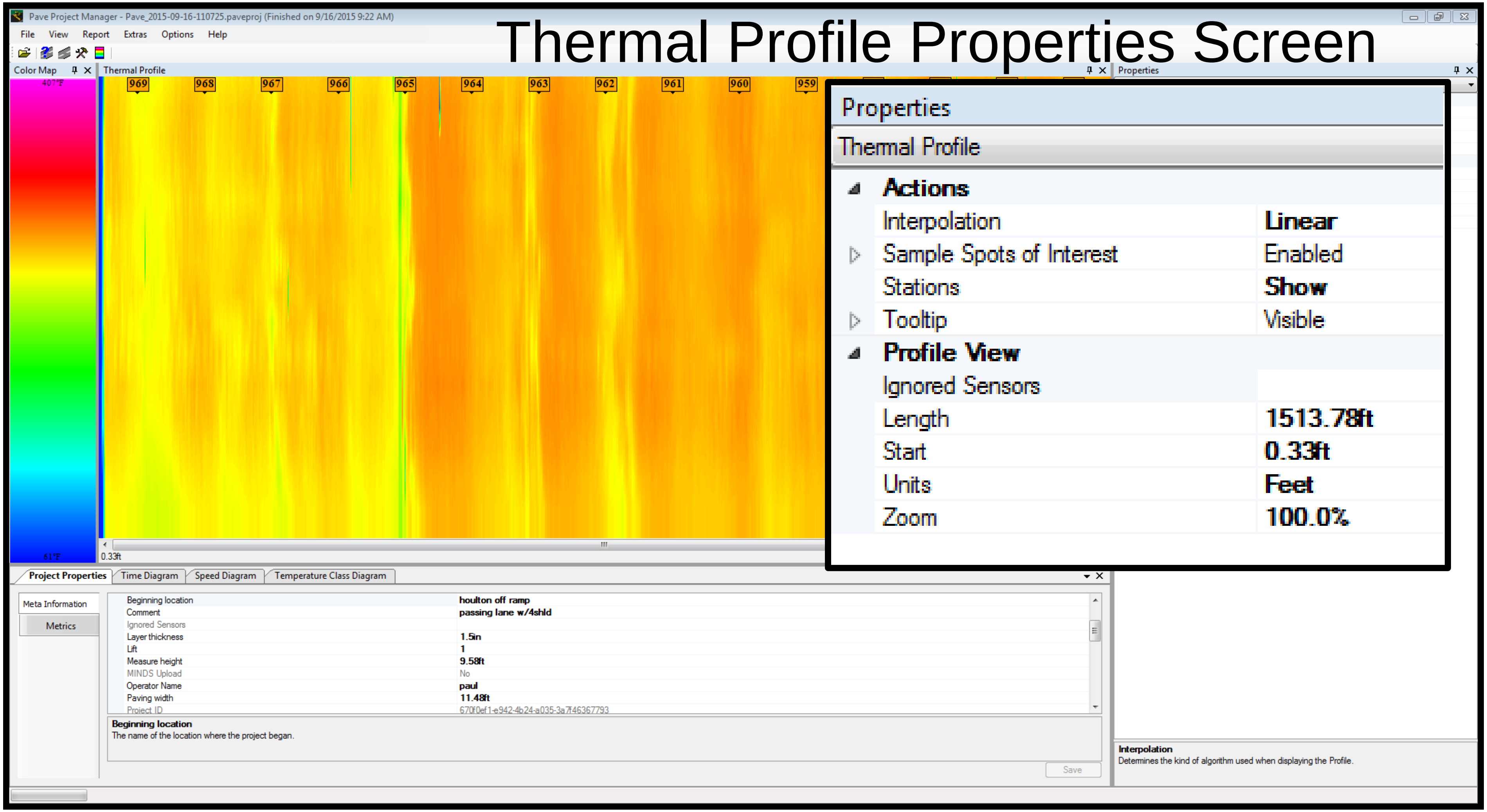
Color Map

Temperature range	
Max	407°F
Min	61°F



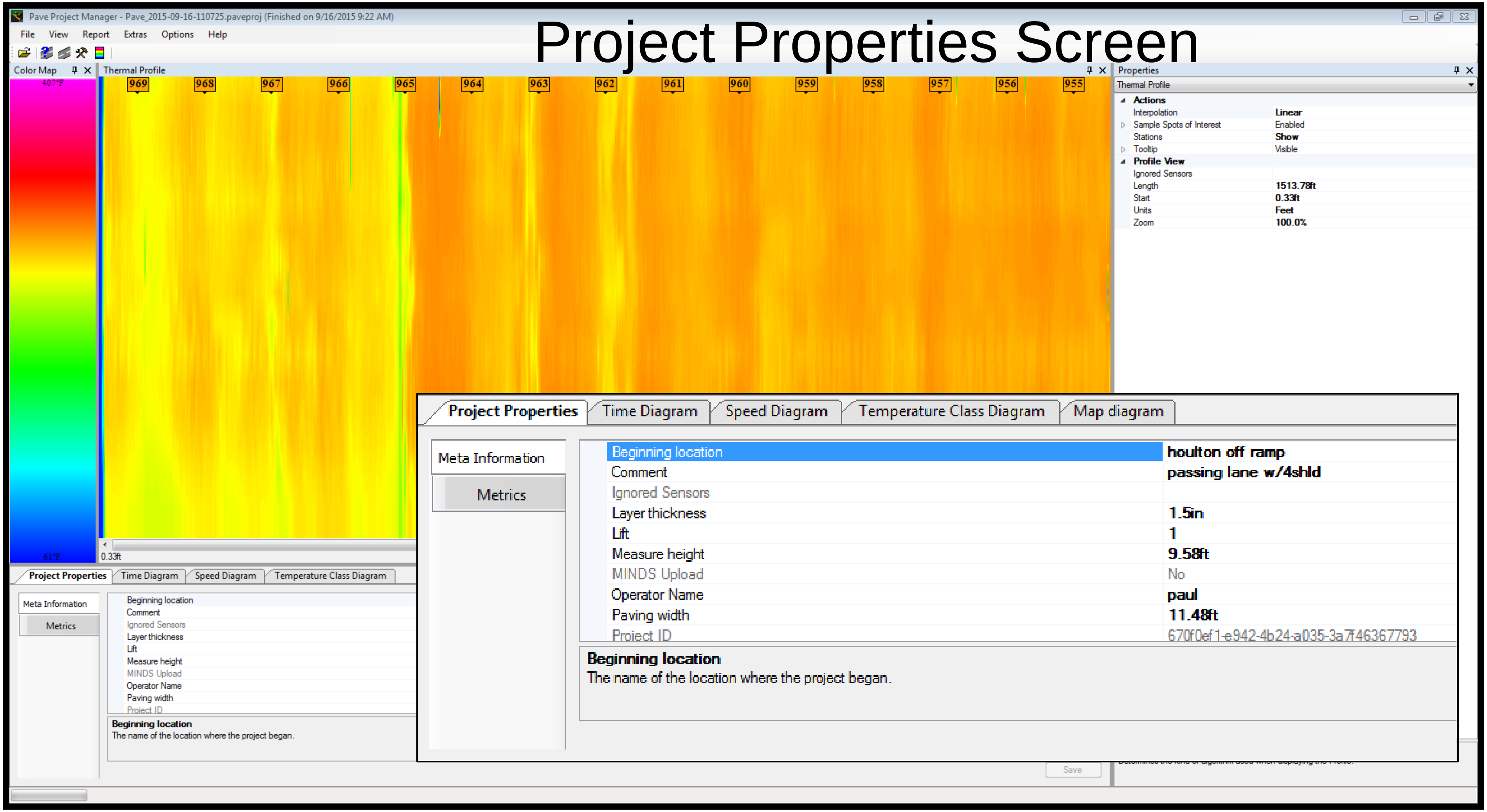
IR Equipment and Software

Thermal Profile Properties Screen

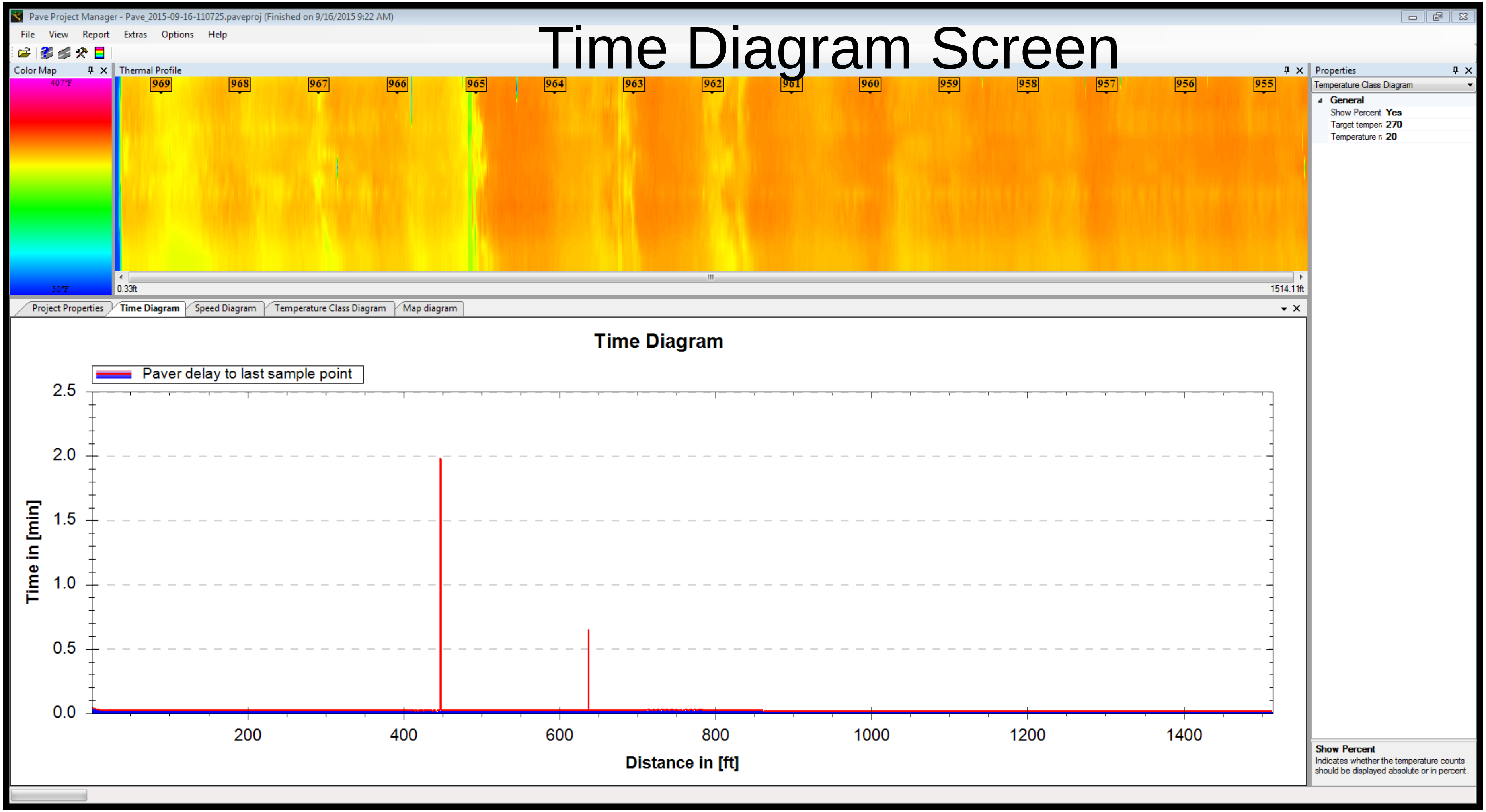


IR Equipment and Software

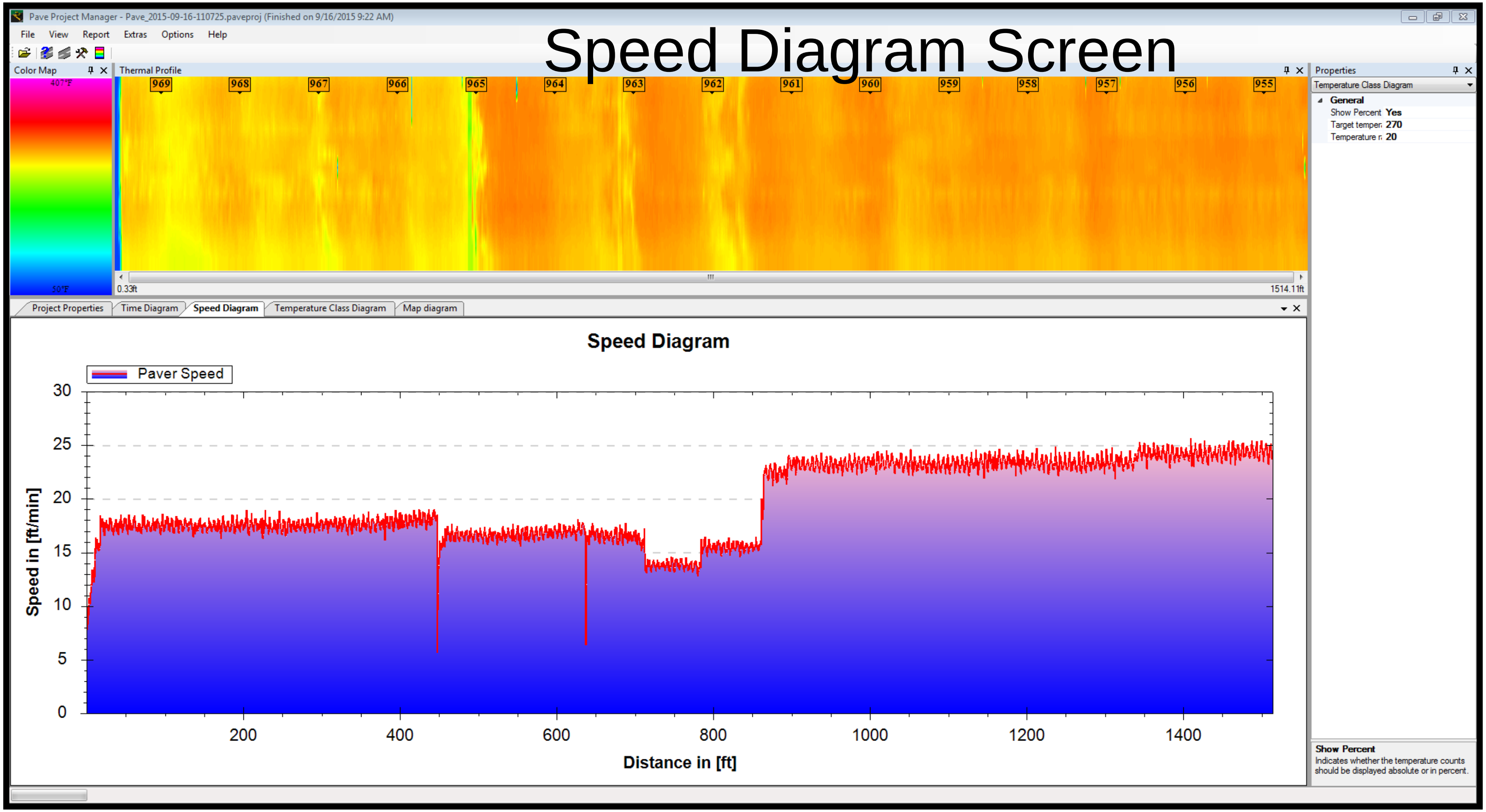
Project Properties Screen



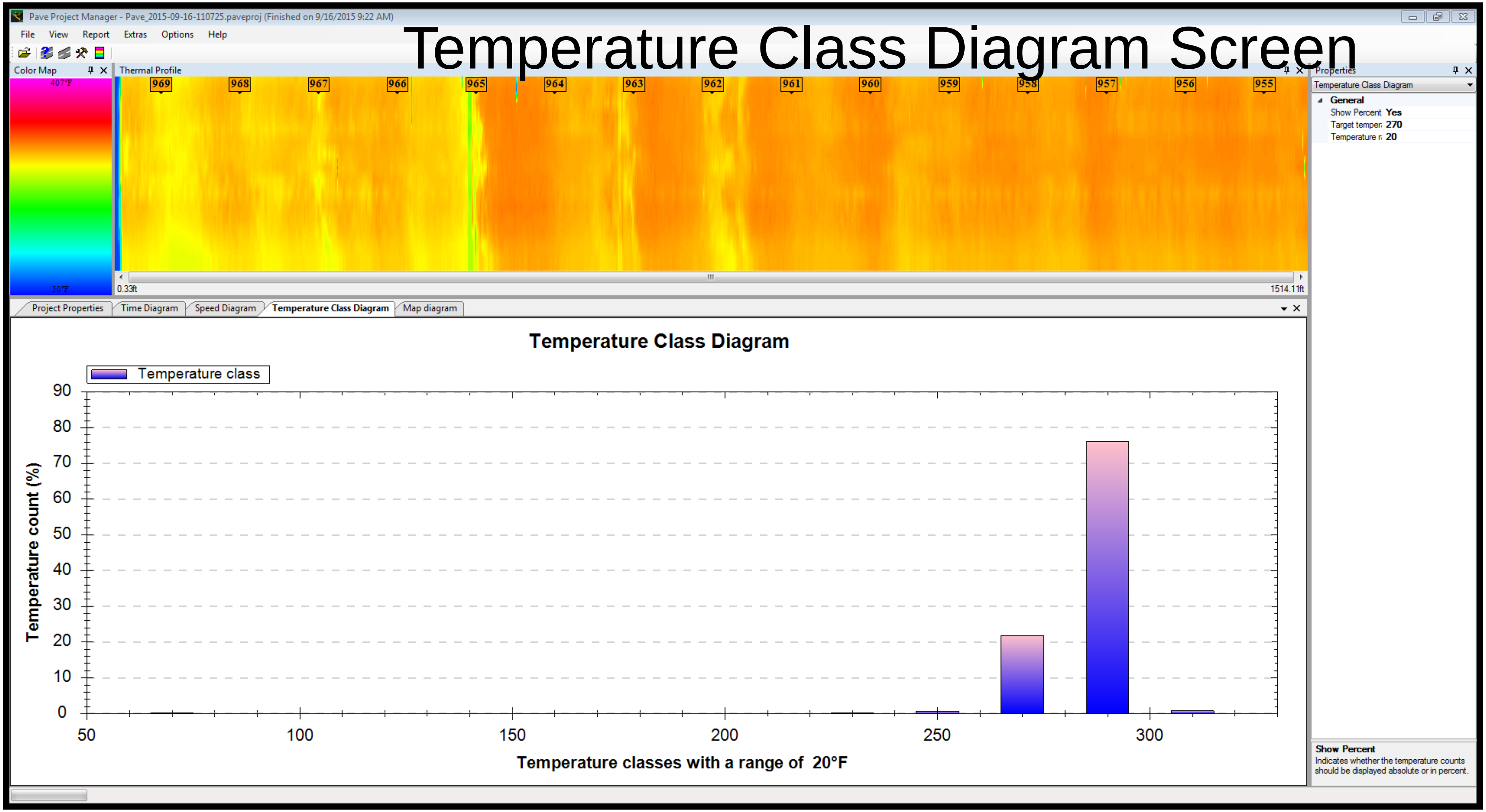
IR Equipment and Software



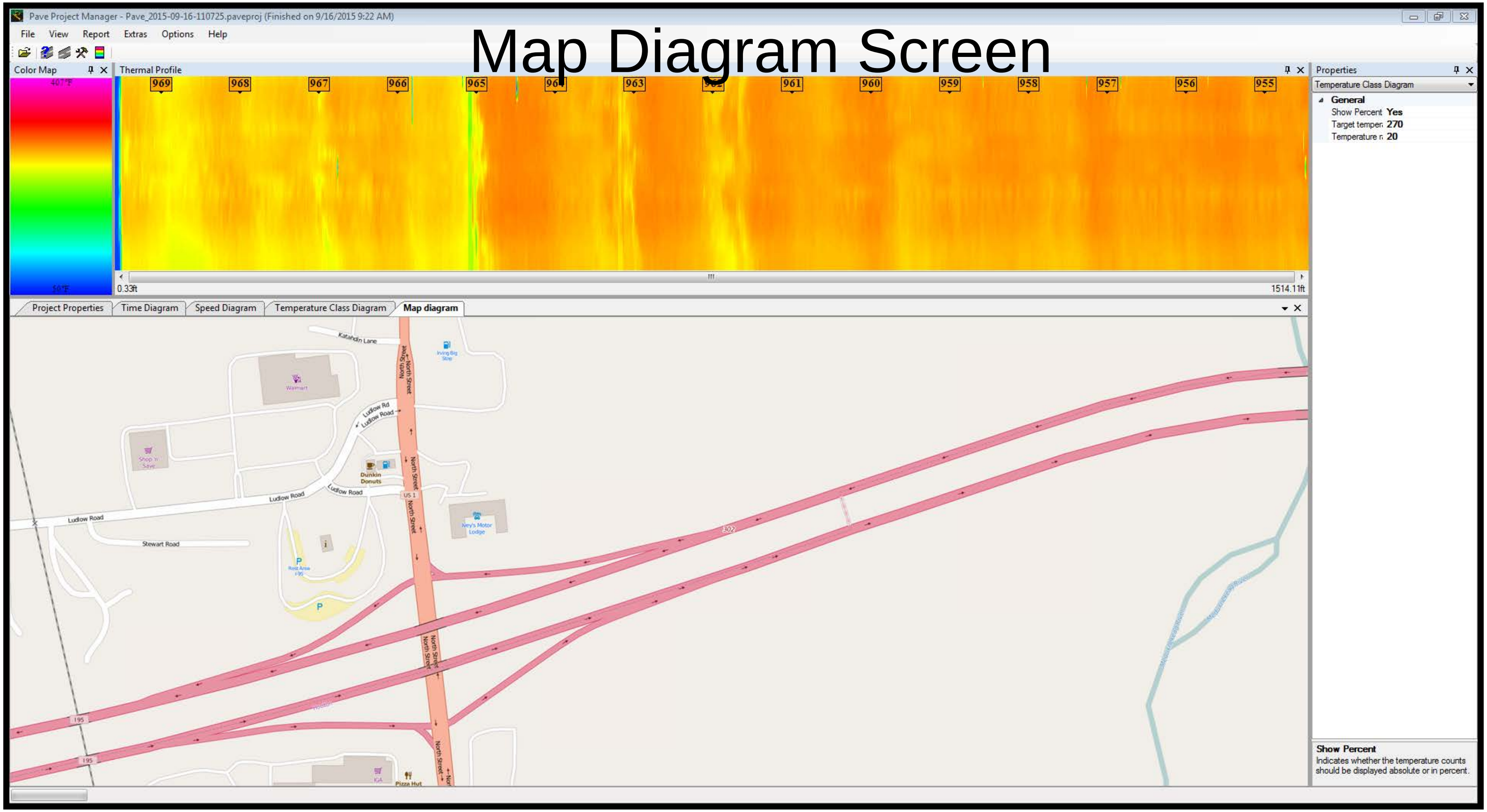
IR Equipment and Software



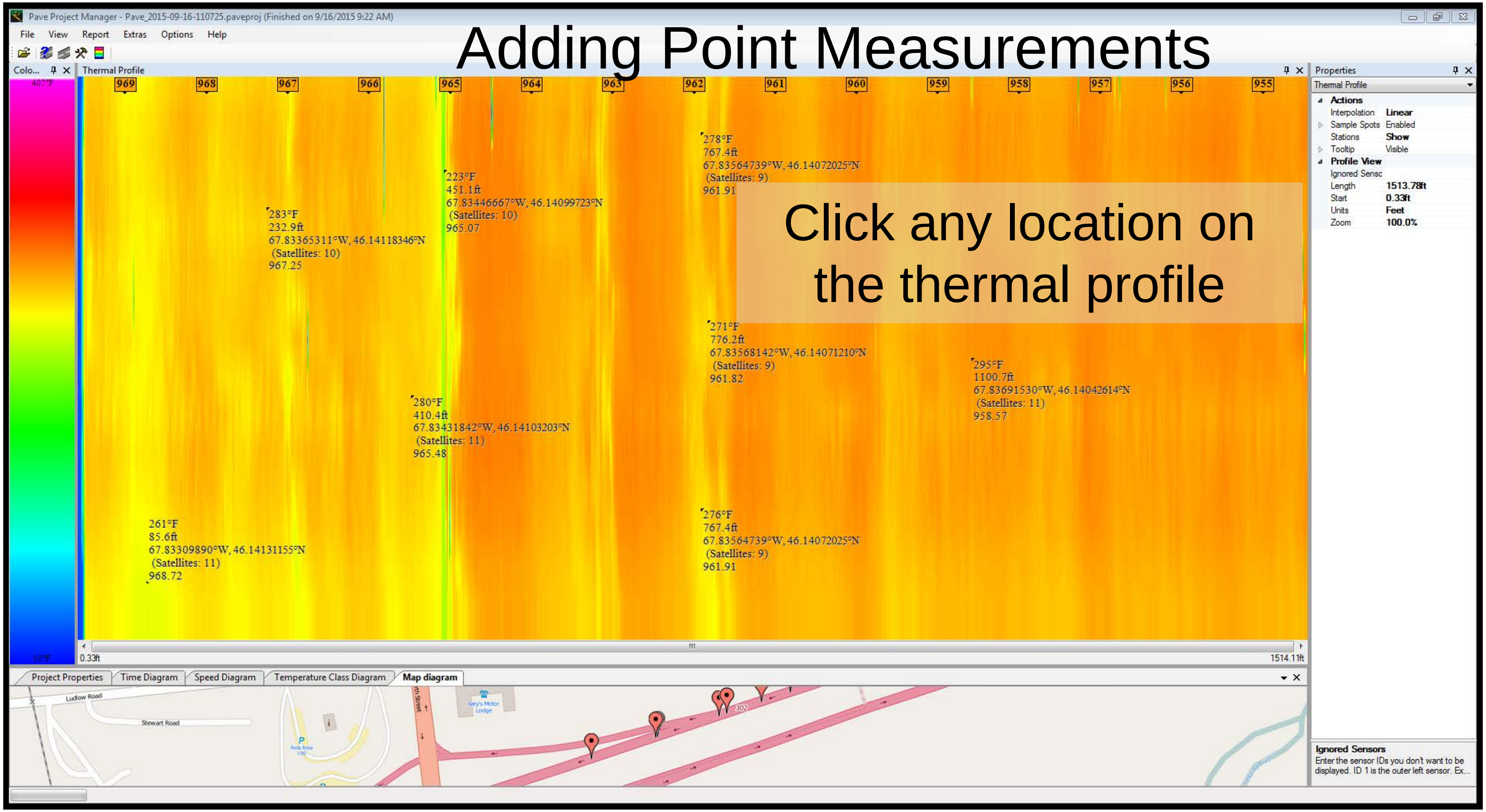
IR Equipment and Software



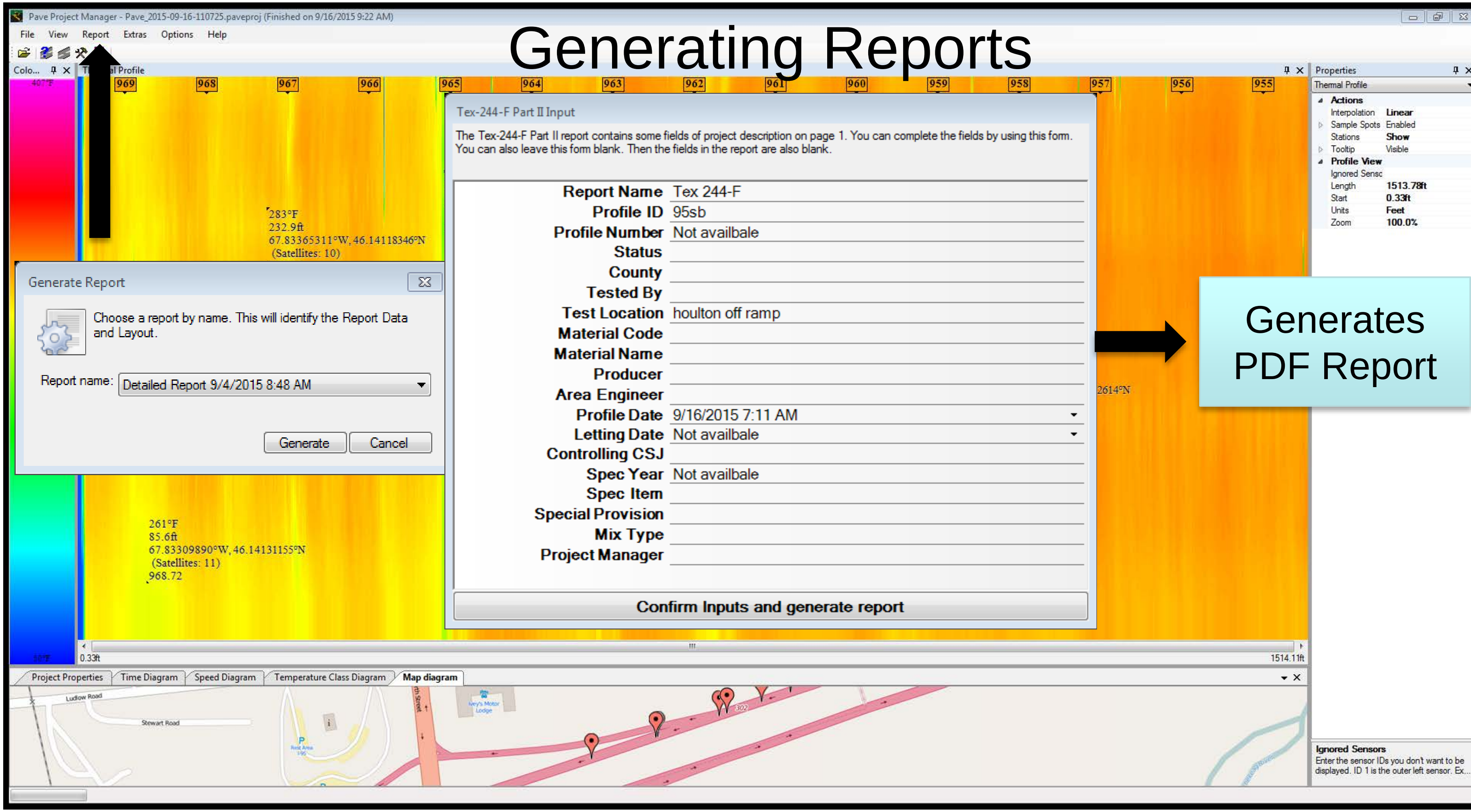
IR Equipment and Software



IR Equipment and Software



IR Equipment and Software



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

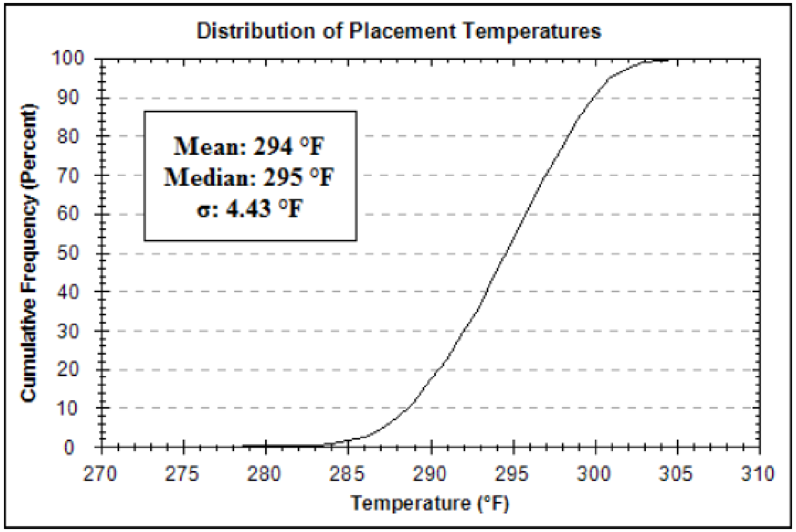
Profile Nr	Beginning Location		Ending Location		Max Temp	Min Temp	Temperature Differential
	Station	GPS in °	Station	GPS in °			
1	194.49	68.12363437 W, 46.11892049 N	193.00	68.12419593 W, 46.11879052 N	303.4	287.8	15.7
2	192.99	68.12419985 W, 46.11878960 N	191.50	68.12476079 W, 46.11866149 N	304.9	289.6	15.3
3	191.49	68.12476285 W, 46.11866104 N	190.00	68.12532427 W, 46.11853654 N	301.1	286.3	14.8
4	189.99	68.12533012 W, 46.11853523 N	188.50	68.12589203 W, 46.11840836 N	299.3	285.8	13.5
5	188.49	68.12589363 W, 46.11840800 N	187.00	68.12645526 W, 46.11828259 N	297.7	285.4	12.2
6	186.99	68.12645906 W, 46.11828176 N	185.49	68.12702186 W, 46.11815402 N	298.9	283.5	15.5
7	185.49	68.12702379 W, 46.11815360 N	183.99	68.12758506 W, 46.11802607 N	302.2	283.8	18.4
8	183.98	68.1275889 W, 46.11802512 N	182.49	68.12815126 W, 46.11789818 N	303.1	292.6	10.4
9	182.49	68.12815319 W, 46.11789773 N	181.00	68.12871395 W, 46.11777111 N	306.1	288.1	18.0
10	180.99	68.12871621 W, 46.11777052 N	179.50	68.12928274 W, 46.11764036 N	302.2	284.4	17.8
11	179.49	68.12928577 W, 46.11763966 N	178.00	68.12985205 W, 46.11751058 N	302.9	287.6	15.3
12	177.99	68.12985387 W, 46.11751020 N	176.50	68.13042113 W, 46.11738235 N	302.0	288.0	14.0
13	176.49	68.13042482 W, 46.11738148 N	175.00	68.13099093 W, 46.11725309 N	301.8	289.2	12.6
14	174.99	68.13099275 W, 46.11725265 N	173.50	68.13155886 W, 46.11712703 N	302.2	288.0	14.2
15	173.49	68.13156263 W, 46.11712618 N	171.99	68.13212684 W, 46.11699931 N	303.6	286.3	17.3
16	171.99	68.13212971 W, 46.11699866 N	170.49	68.13269254 W, 46.11687031 N	302.9	286.5	16.4
17	170.48	68.1326963 W, 46.11686947 N	169.00	68.13325913 W, 46.11674378 N	305.8	288.9	16.9
18	168.99	68.13326314 W, 46.11674285 N	167.50	68.13382973 W, 46.11661558 N	302.0	286.0	16.0
19	167.49	68.13383168 W, 46.11661512 N	166.00	68.1343973 W, 46.11648481 N	298.6	284.2	14.4
20	165.99	68.13440119 W, 46.11648392 N	164.50	68.13497078 W, 46.11635549 N	298.4	282.9	15.5
21	164.49	68.13497271 W, 46.11635503 N	163.00	68.13554162 W, 46.11622699 N	297.5	282.4	15.1
22	162.99	68.13554551 W, 46.11622616 N	161.49	68.13611883 W, 46.11609795 N	296.1	283.6	12.4
23	161.49	68.13612069 W, 46.11609752 N	160.00	68.13668796 W, 46.11596968 N	301.6	277.2	24.5
24	159.99	68.13669173 W, 46.11596883 N	158.49	68.13725615 W, 46.11584140 N	299.7	281.1	18.5
25	158.49	68.13725879 W, 46.11584082 N	157.00	68.1378221 W, 46.11571525 N	301.6	287.4	14.2
26	156.99	68.13782589 W, 46.11571440 N	155.50	68.13839327 W, 46.11558715 N	302.2	288.5	13.7
27	155.49	68.13839721 W, 46.11558631 N	154.00	68.1389655 W, 46.11545741 N	302.2	289.8	12.4

IR Equipment and Software

Generating Reports

Summary of Locations Without Thermal Segregation

Profile Nr	Beginning Location		Ending Location		Max Temp	Min Temp	Temperature Differential
	Station	GPS in °	Station	GPS in °			
28	153.99	68.13896866 W, 46.11545670 N	153.24	68.13925736 W, 46.11538960 N	299.1	287.2	11.9



Location of Paver Stops greater than One Minute

Location (stations)	Duration (h:min:sec)
185.89	0:2:0
172.06	0:4:22
168.59	0:4:25

IR Equipment and Software

Exporting Data

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

Questions?

NEXT:

- Data Analyses and Findings: US-1 Fort Belvoir, VA; and US Route 15, Culpeper, VA





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Infrared Technology (IR)

Data Analyses and Findings:
West Virginia Route 10, Logan, WV

March 1, 2017

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Data Analyses & Findings

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

Data Analyses & Findings

West Virginia Route 10 near Logan, WV

New Construction of 4 lane Highway

Data Analyses & Findings

Mixtures placed with Wirtgen Vogele Rubber Tired Paver

Mixture delivered to site with end dump discharge trucks.

Data Analyses & Findings

Compaction Train; all steel wheel rollers

Data Analyses & Findings

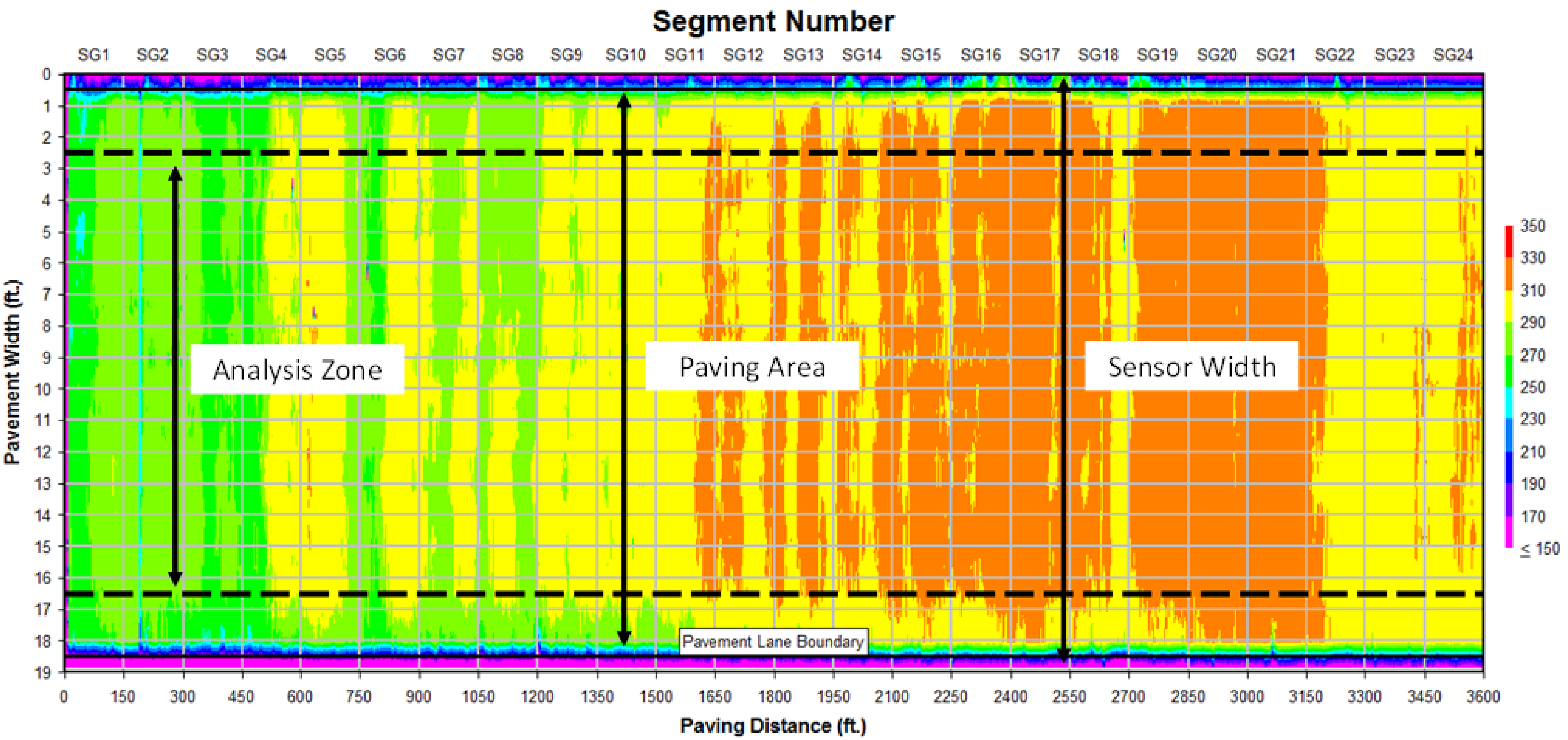
Cores, Nuclear & non-nuclear density gauge used to measure mat density and superimposed on temperature profiles.

Data Analyses & Findings

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

Data Analyses & Findings

Raw Temperature Profile for first part of the first lot.

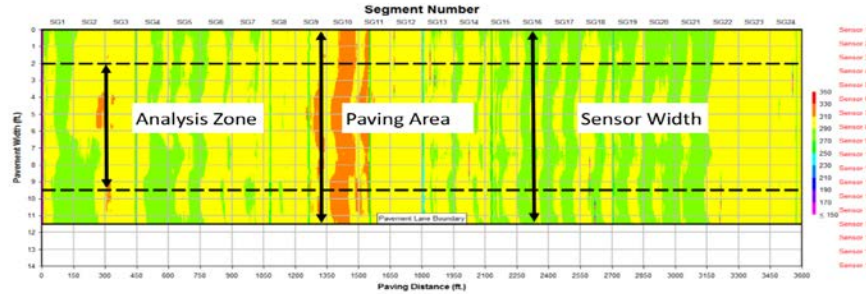


Data Analyses & Findings

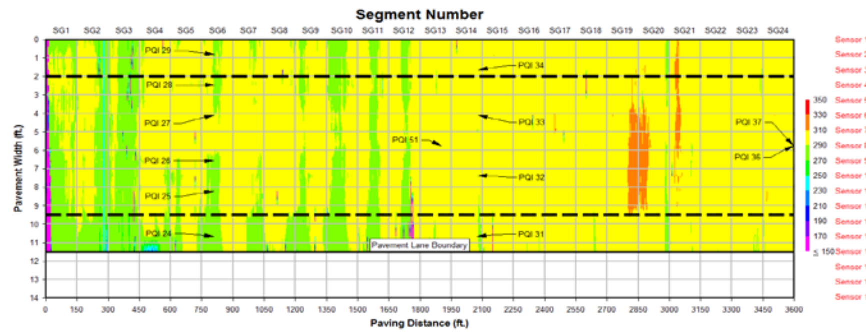
Raw Temperature Profile showing continuous improvement or more uniform mat temperatures as paving progresses.

Example from Maine demonstration project.

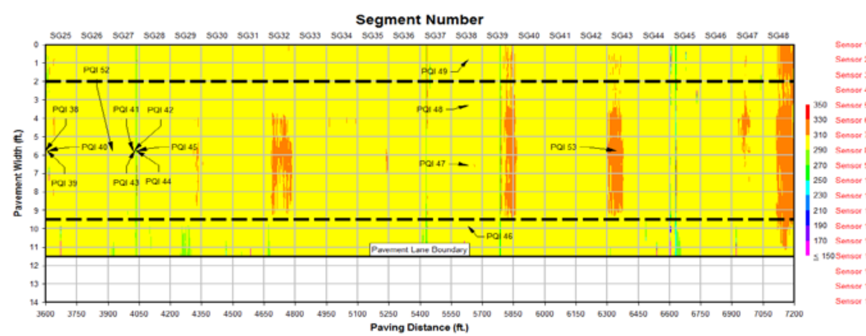
Near Start of Lot



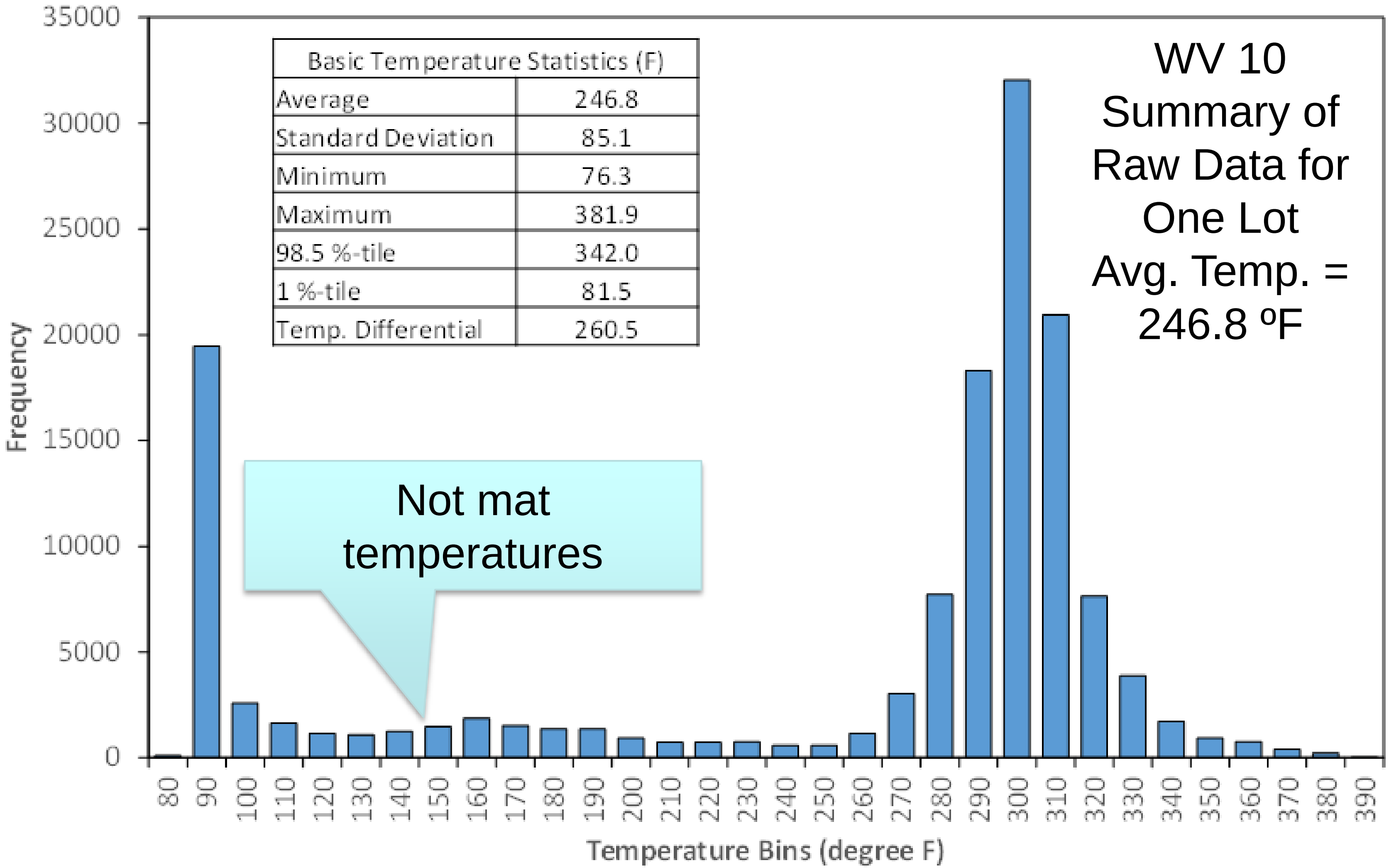
Near Center of Lot



Near End of Lot



Data Analyses & Findings



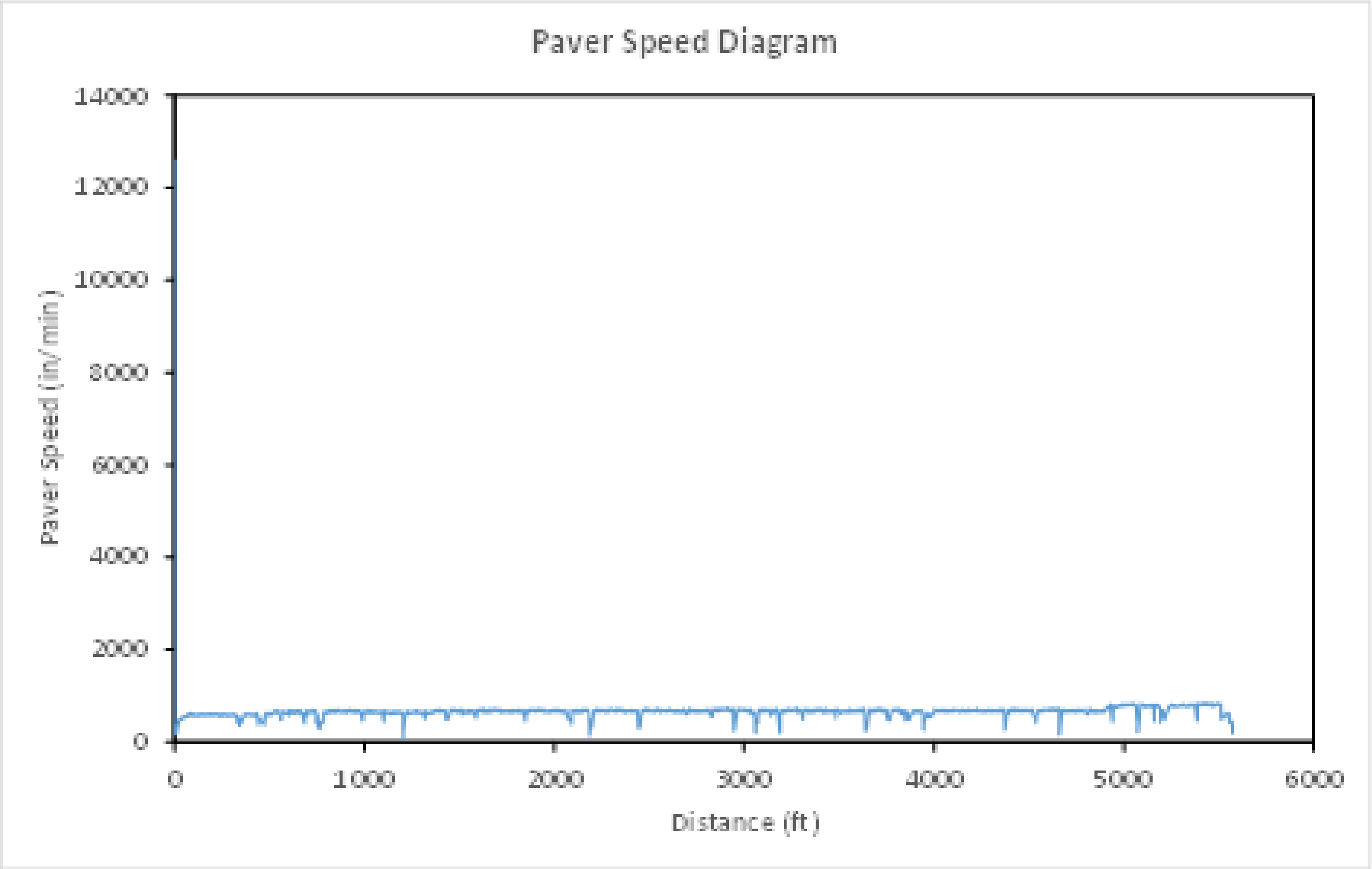
Basic Temperature Statistics (F)	
Average	246.8
Standard Deviation	85.1
Minimum	76.3
Maximum	381.9
98.5 %-tile	342.0
1 %-tile	81.5
Temp. Differential	260.5

Data Analyses & Findings

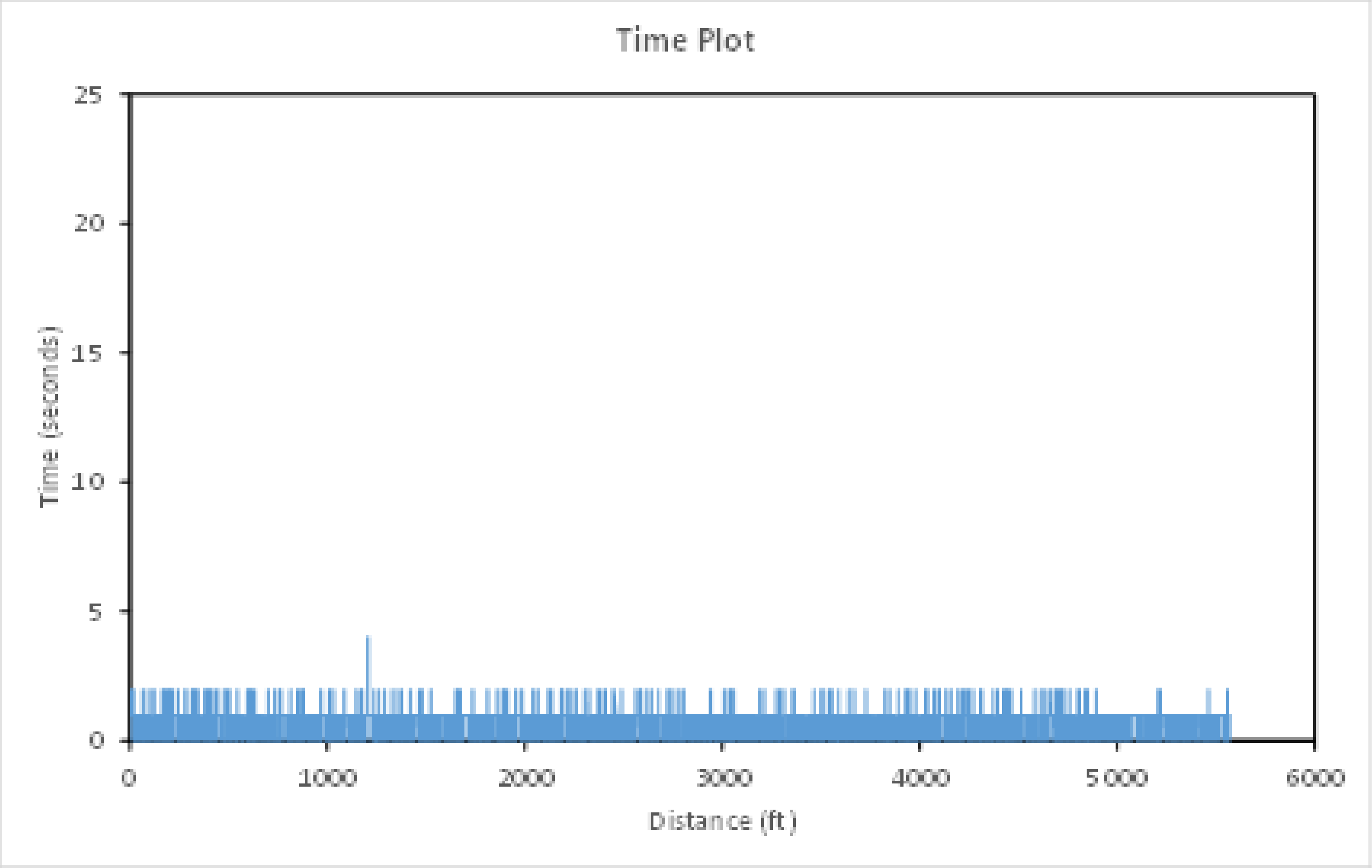
Data diagrams reviewed during production:

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

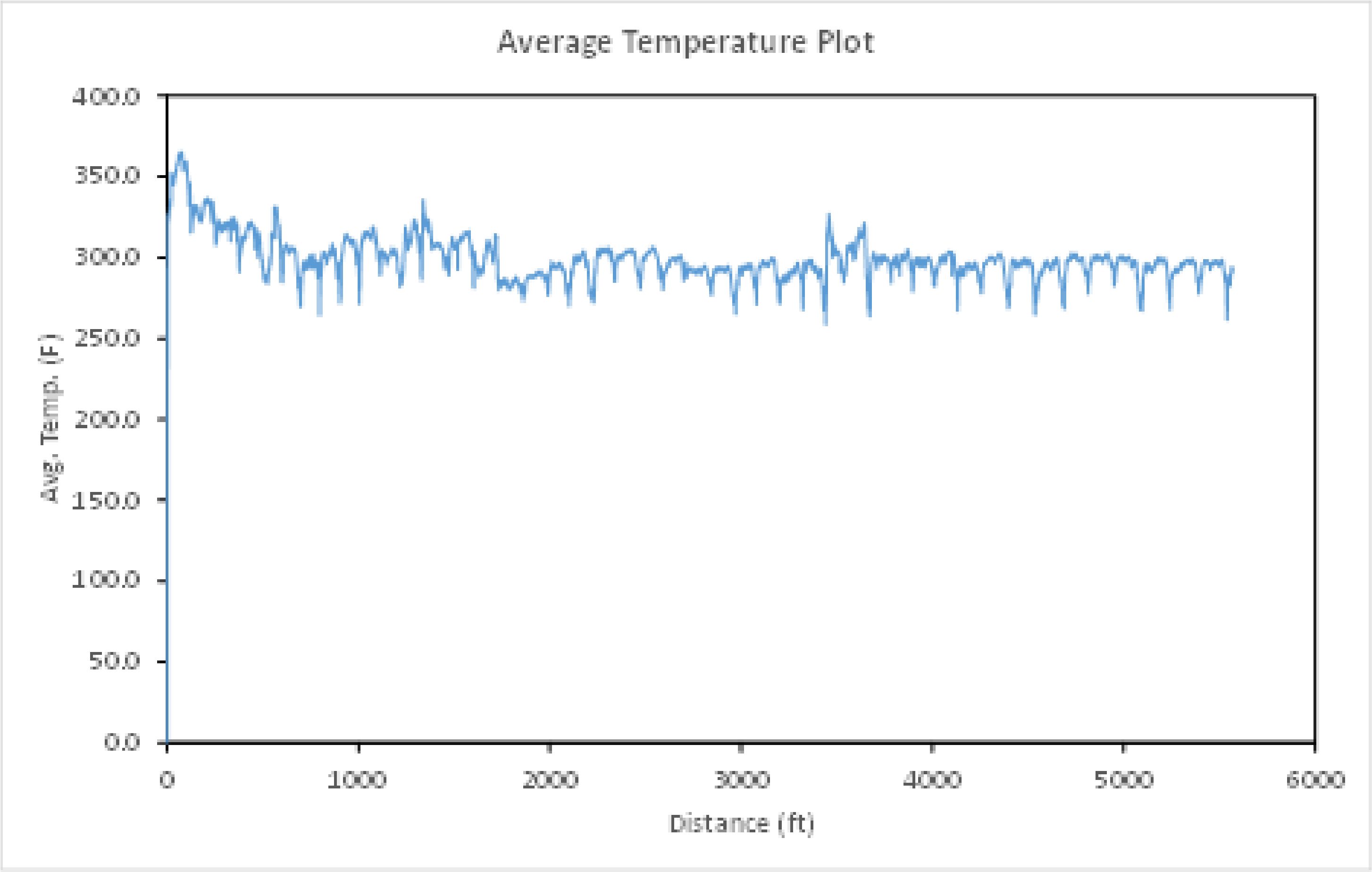
Data Analyses & Findings



Data Analyses & Findings



Data Analyses & Findings



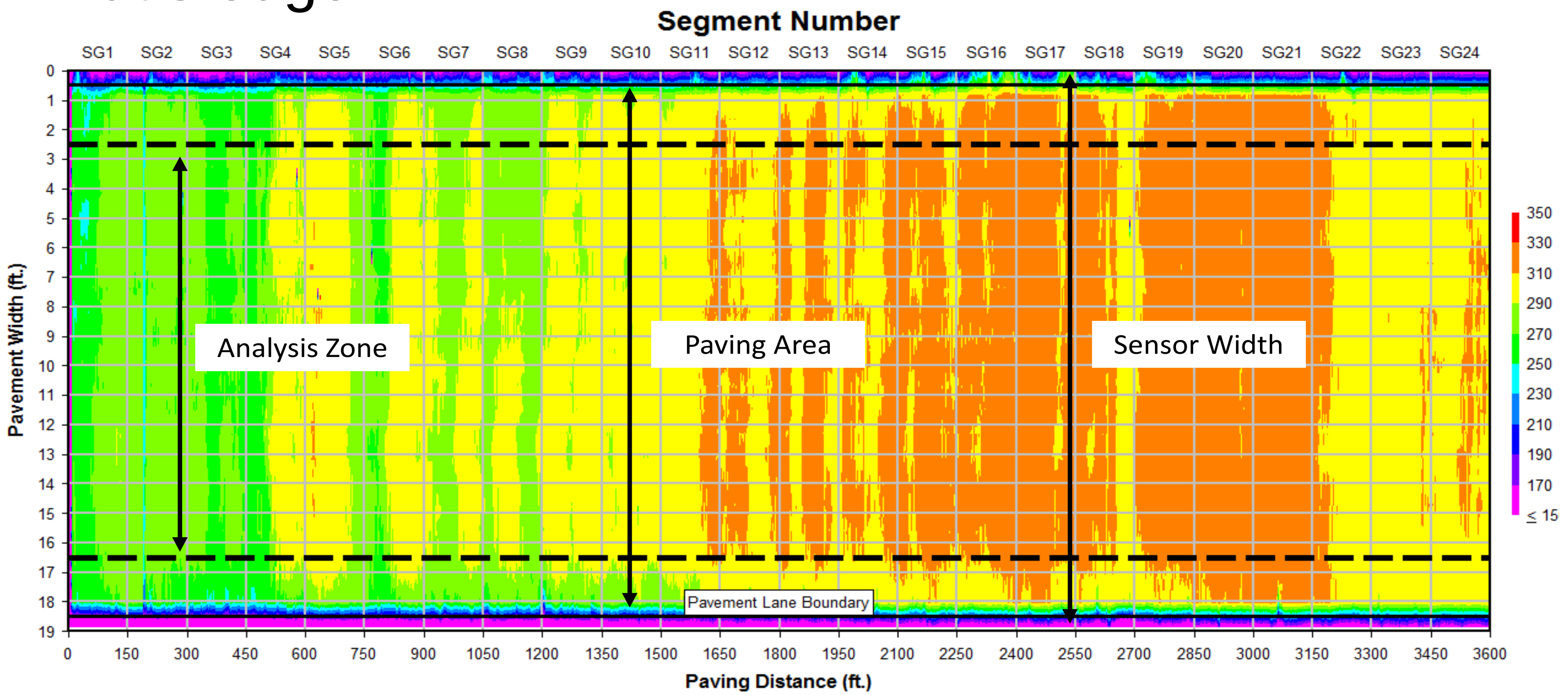
Data Analyses & Findings

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

Data Analyses & Findings

Data Processing—eliminate invalid temperature measurements:

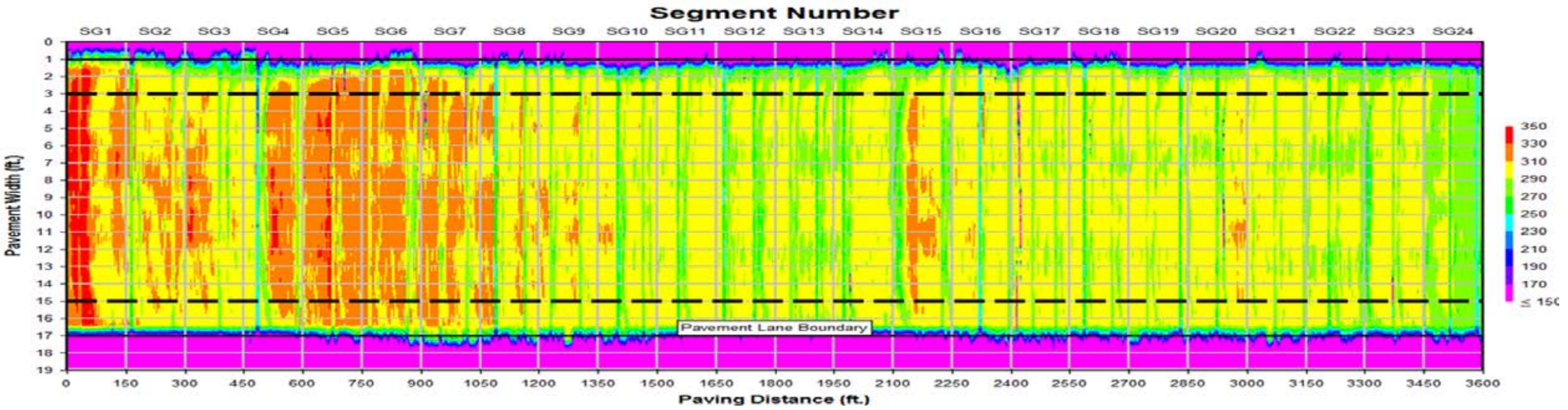
1. Eliminate measurement locations within 2 feet of the mat's edge.



Data Analyses & Findings

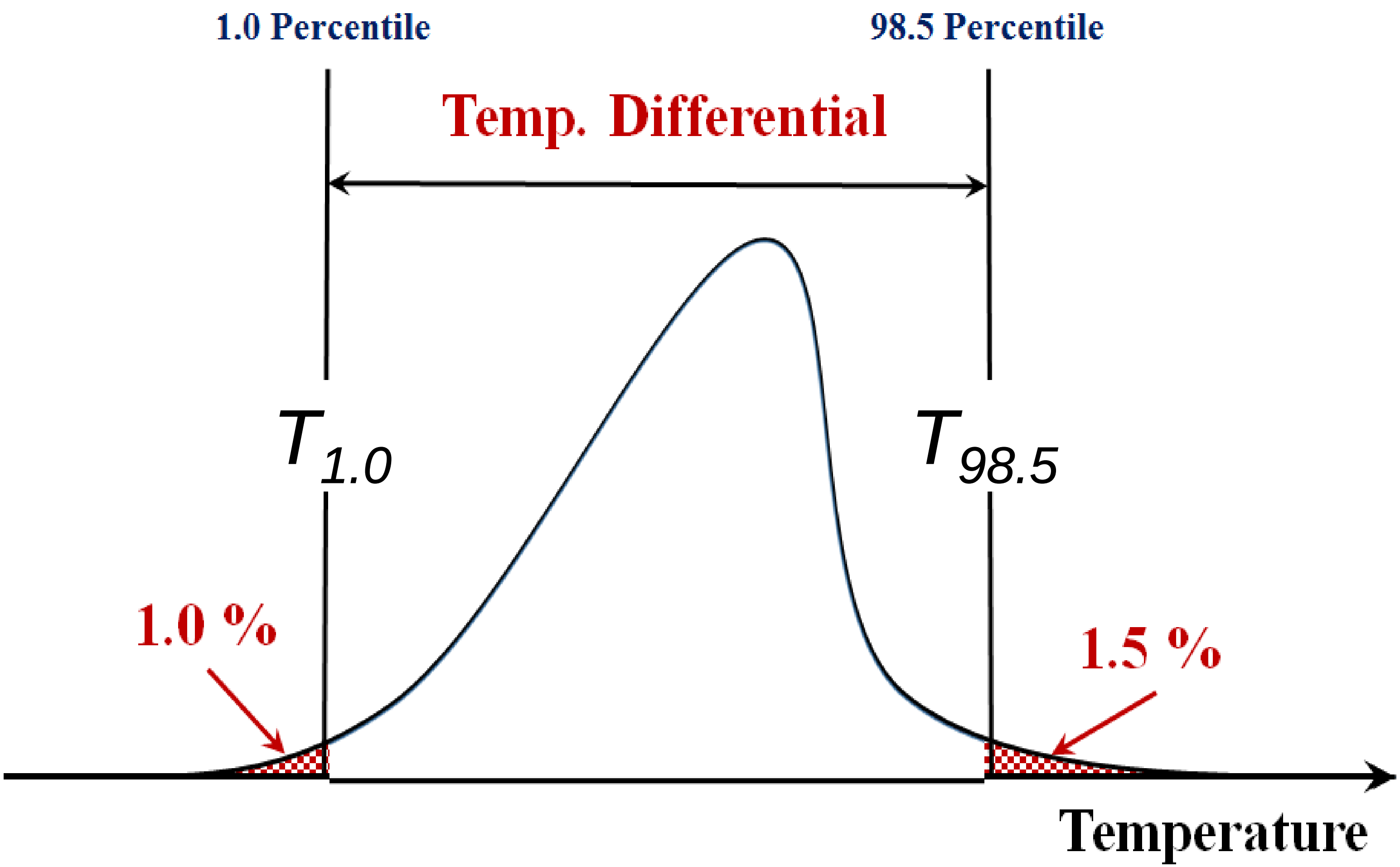
Data Processing—eliminate invalid temperature measurements:

2. Eliminate data with paver stops greater than 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 ºF and > 400 ºF.



Data Analyses & Findings

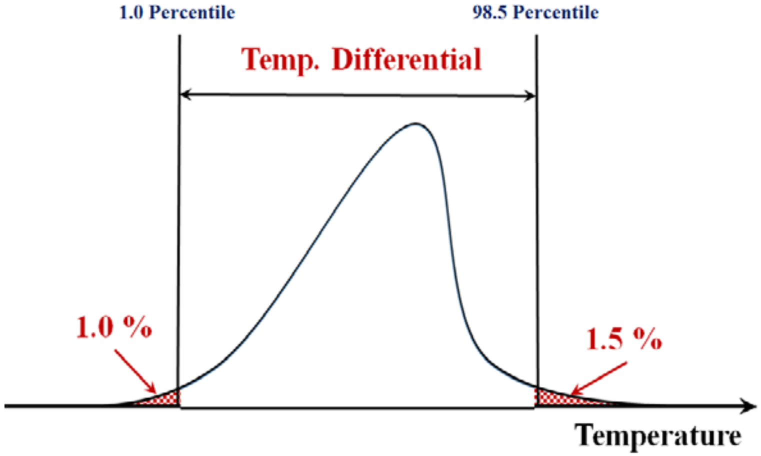
- Temperature Differential, each 150 foot segment



Data Analyses & Findings

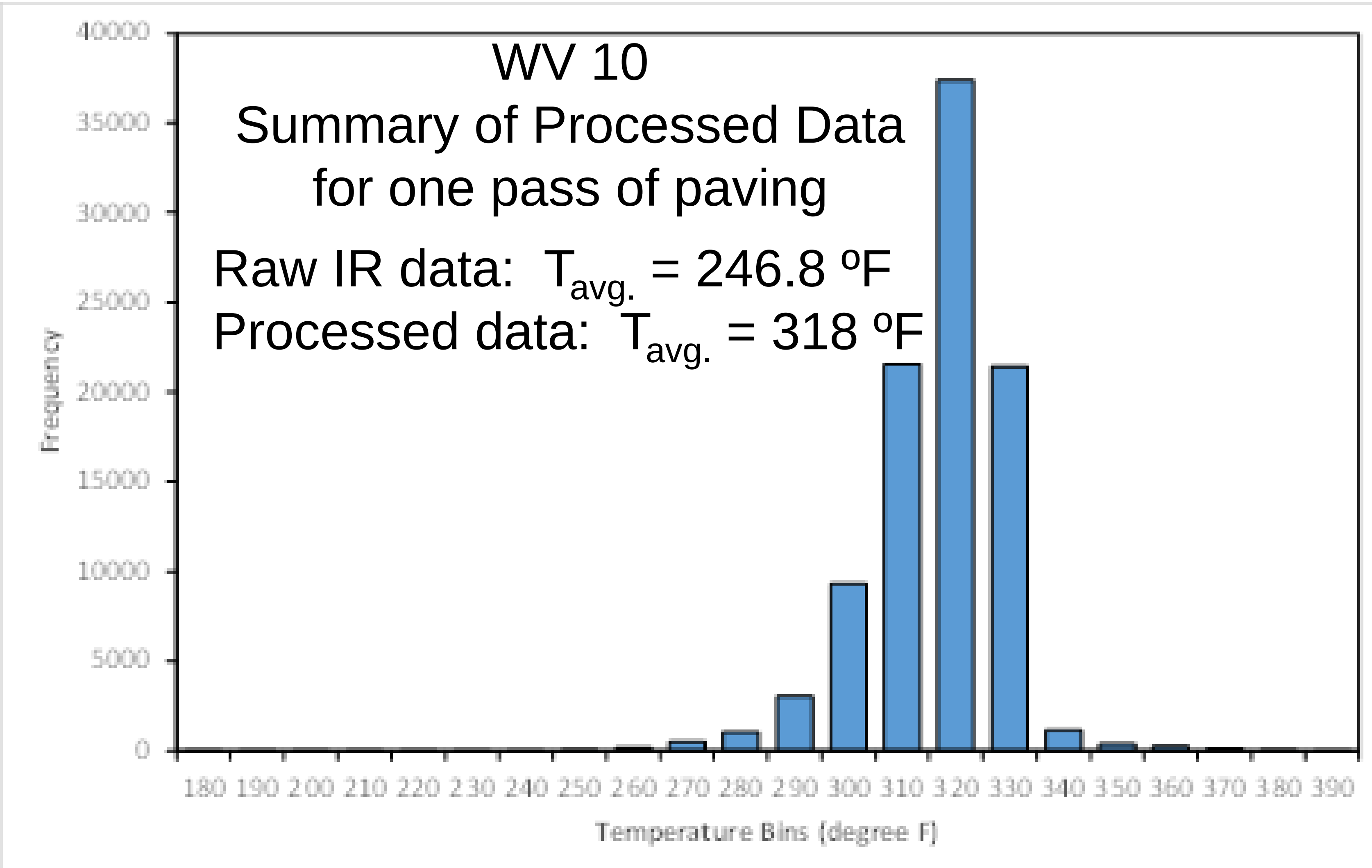
- Temperature Differential Criteria, each 150 foot segment:

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



- **$T_{diff} \leq 25\ ^{o}F$** — **No temperature difference**
- $25\ ^{o}F < T_{diff} \leq 50\ ^{o}F$ — Moderate temperature difference
- **$T_{diff} > 50\ ^{o}F$** — **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

WV 10

US 1 - EFL

Data Analyses & Findings

Processed Data

Paver Stops	Total Number of Increments	Number of Increments within Temp. Regimes			Thermal Streaking
		Minor	Moderate	Severe	
WV 10 Project AC Base					
Exclude	99	0	74	25	None
Include	99	0	58	41	None

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

Data Analyses & Findings

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

Data Analyses & Findings

Processed Data for WV 10

Paver Stops	Total Number of Increments	Number of Increments within Temp. Regimes			Thermal Streaking
		Minor	Moderate	Severe	
Exclude	99	0	74	25	None
Include	99	0	58	41	None

Minnesota DOT's specification:

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

Total Disincentive to Contractor:
-$820 for the project segment [Including paver stops].

Data Analyses & Findings

Processed Data – Include Additional Data

With and Without an MTV

Condition	Total Number of Increments	Number of Increments within Temp. Regimes			Thermal Streaking
		Minor	Moderate	Severe	
Excludes Paver Stops[1]	273	133	99	41	None
Without MTV[2]	99	0	74	25	None
With MTV[3]	159	133	19	7	None
Includes Paver Stops[1]	274	105	112	57	None
Without MTV[2]	99	0	58	41	None
With MTV[3]	159	104	47	8	None

[1]Data from all dates (7/26, 7/27, 7/28, 8/3, 8/4)
[2]Data collected on 7/27/2016 and 7/28/2016 only
[3]Data collected on 8/3/2016 and 8/4/2016 only

Data Analyses & Findings

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

Data Analyses & Findings

Contact Information:

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- Joe Reiter; jreiter@ara.com
- Harold Von Quintus; hvonquintus@ara.com

Questions?

NEXT:

- Implementation: West Virginia DOT and Contractor Points of View

SHRP2 SOLUTIONS
STRATEGIC HIGHWAY RESEARCH PROGRAM

Infrared Technology (IR)

Implementation: West Virginia DOT, and Contractor Points of View

March 1, 2017

U.S. Department of Transportation
Federal Highway Administration

American Association of State Highway and Transportation Officials
AASHTO

Agency/Contractor Deployment

1. Agency:
   - Reasons for deploying IR Technology
   - Benefits – Agency points of view
   - Plans to implement IR Technology; short-term plans
   - Schedule for deployment
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^{TM} 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^{TM}?
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?





SHRP2 SOLUTIONS
STRATEGIC HIGHWAY RESEARCH PROGRAM

Infrared Technology (IR)

Implementation Products and Strategies

March 1, 2017

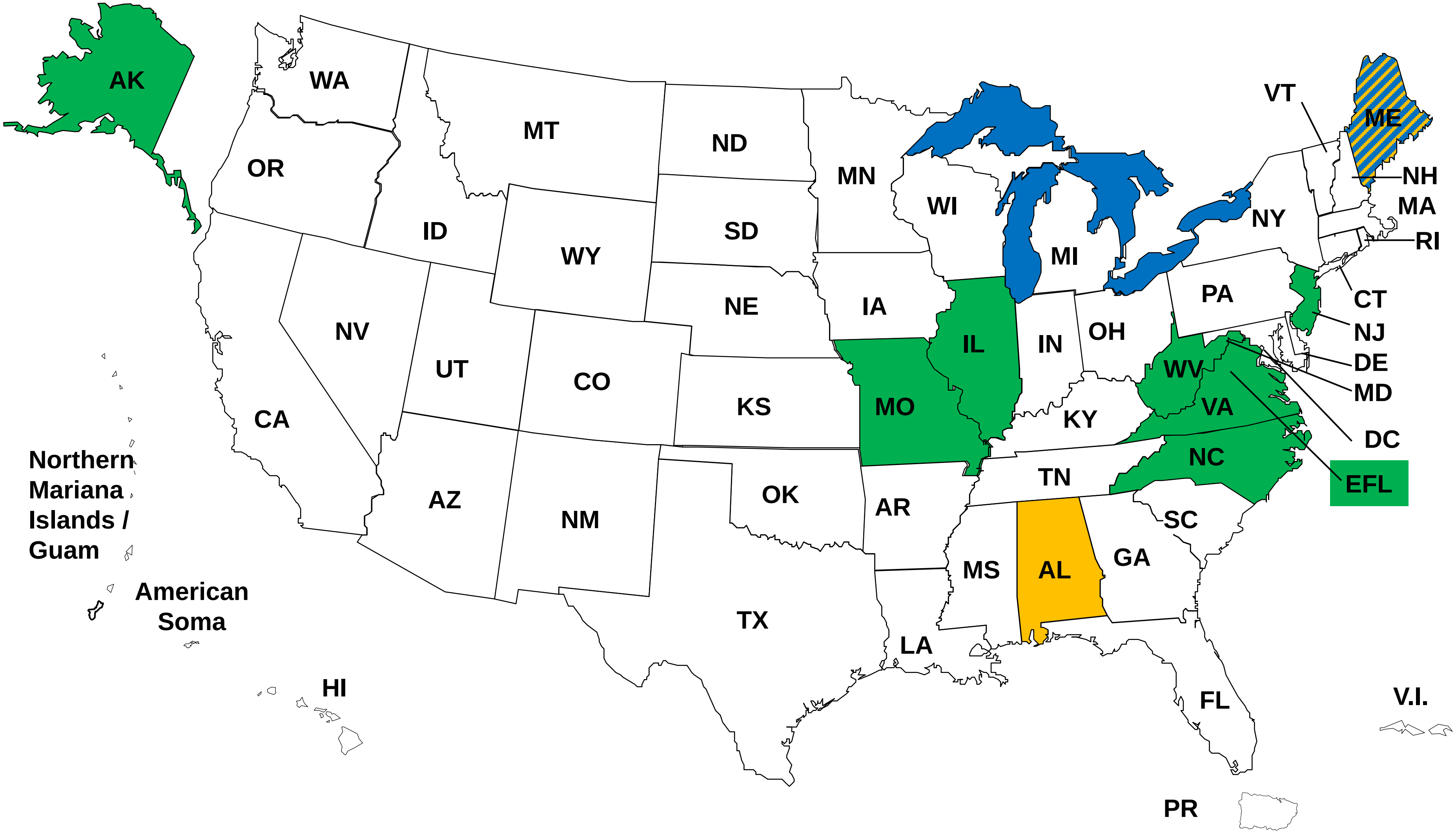
U.S. Department of Transportation
Federal Highway Administration

American Association of State Highway and Transportation Officials
AASHTO

Implementation Products and Strategies

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

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

Attended by Mike Pumphrey of WVDOT and Joey Farrell of Jobsite Technologies

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 80-14[1]

AASHTO
THE VOICE OF TRANSPORTATION

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.

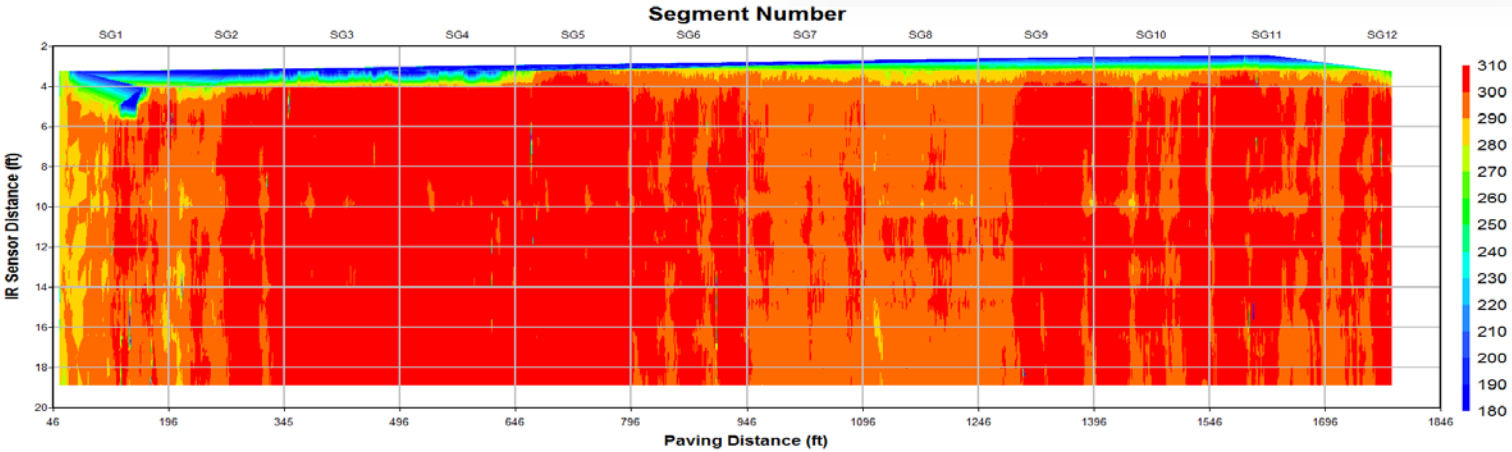
Implementation Products and Strategies

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. Maine demonstration project
3. Virginia demonstration project
4. Federal Lands demonstration project

Application and Use: Examples

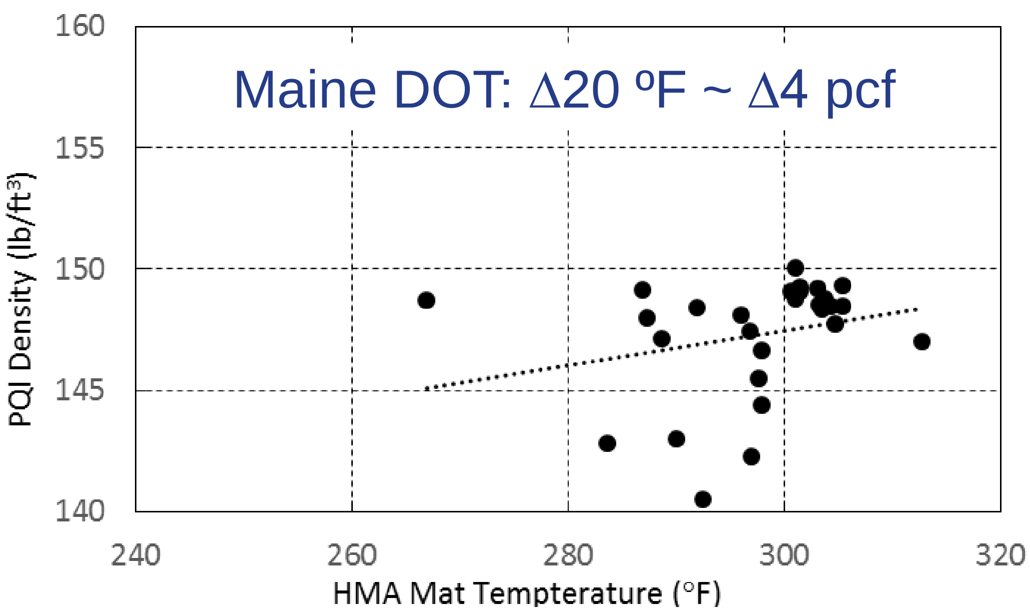
1. Missouri demonstration project
   - Increased communication between plant and paver to minimize temperature differentials of mat.

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

2. Maine demonstration project
   - Monitor average temperature differential on a lot by lot basis for identifying need to take action.
   - 85 percent of segments exhibited < 25 ºF.
   - If average temperature differential exceeds 15 ºF, risk for penalty increases.



Application and Use: Examples

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

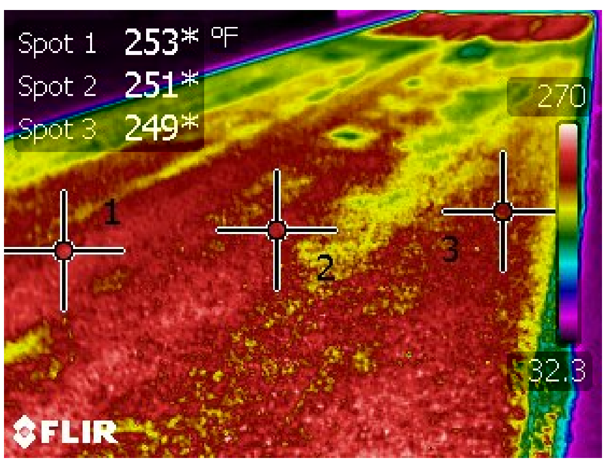
Application and Use: Examples

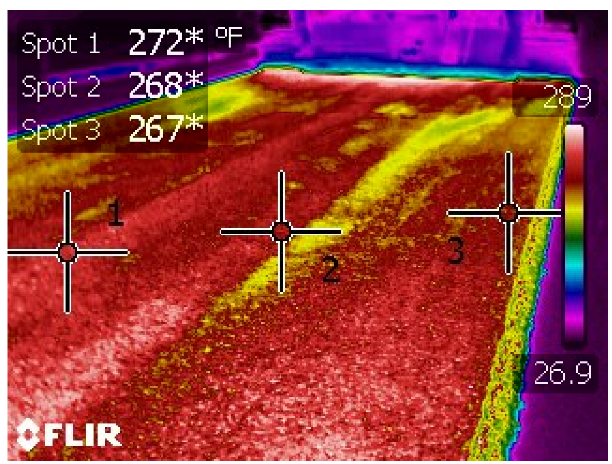
4. Federal Lands demonstration project
   - Identify reason for severe temperature differentials and take action; loading of trucks.
     - One dump of mix in truck bed – severe temp. differential
     - Two dump, no stockpile – reduced temp. differential.

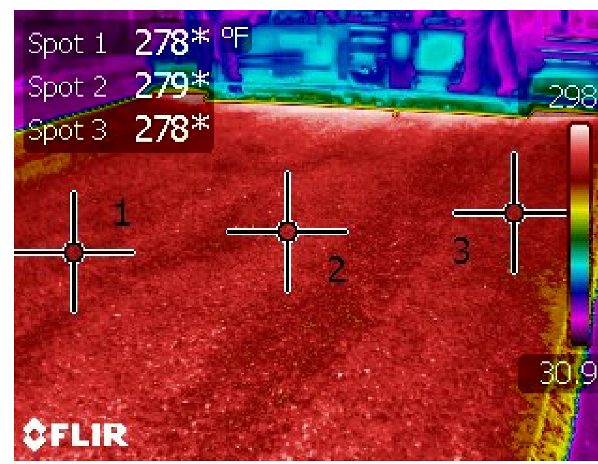
Application and Use: Examples

IR Role in Acceptance Plan; examples:

1. Identify cold spots
   – Colorado, Michigan, Minnesota, Quebec, Texas, Washington
2. 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.

Loss of service life & increase in maintenance costs.

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; <25ºF
  - \$20 penalty; >50ºF

Washington State Department of Transportation

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

   a. Temperature Differential Area- Any area where the temperature of the newly placed HMA pavement is greater than 25° F different than the surrounding area.

   b. 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.

   c. 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

   a. 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.

   b. Nuclear moisture-density gauge.

   c. Tape measure.

   d. A can of spray paint for marking test locations.

   e. Required report form.

4. Testing Criteria

   a. Where temperature differentials are 25° F or greater a systematic HMA compaction test is required.

   b. 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 and infrared camera or a handheld non-contact infrared device to locate temperature differential areas as follows:

WSDOT Materials Manual M 46-01.07
January 2011
Page 1 of 4

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: > 25ºF 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:
  - < 25ºF is minor thermal segregation
  - 25ºF to 50ºF moderate thermal segregation
  - > 50ºF 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:
  - < 25ºF is minor thermal segregation; $20 bonus/sect.
  - 25ºF to 50ºF moderate thermal segregation $0 bonus
  - > 50ºF 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

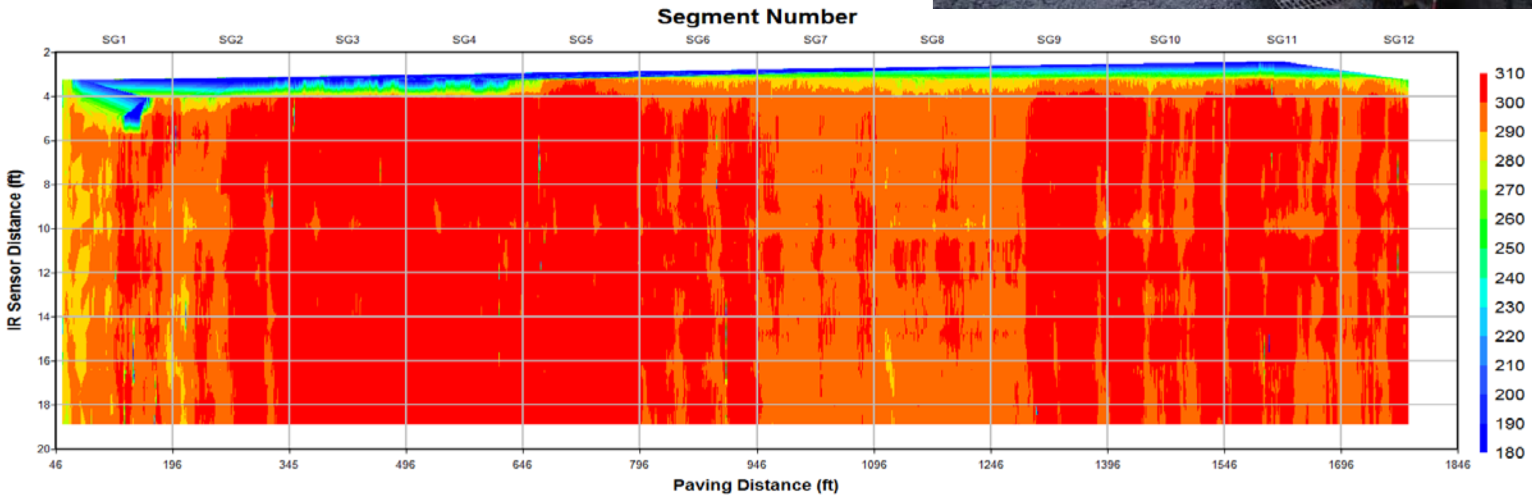
Deployment Strategy, Common Steps/Tasks:

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.



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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

NEXT:

- Presentation and Demonstration of Ground Penetrating Radar Equipment

Break and GPR presentation

Rob Sommerfeldt

GSSI

Workshop Wrap-Up

- Complete Workshop Forms – Right Pocket
  - Photo Release Form
  - Workshop Evaluation
  - PDH