SHRP2 SOLUTIONS
STRATEGIC HIGHWAY RESEARCH PROGRAM

Infrared Technology: Its Application and Benefit

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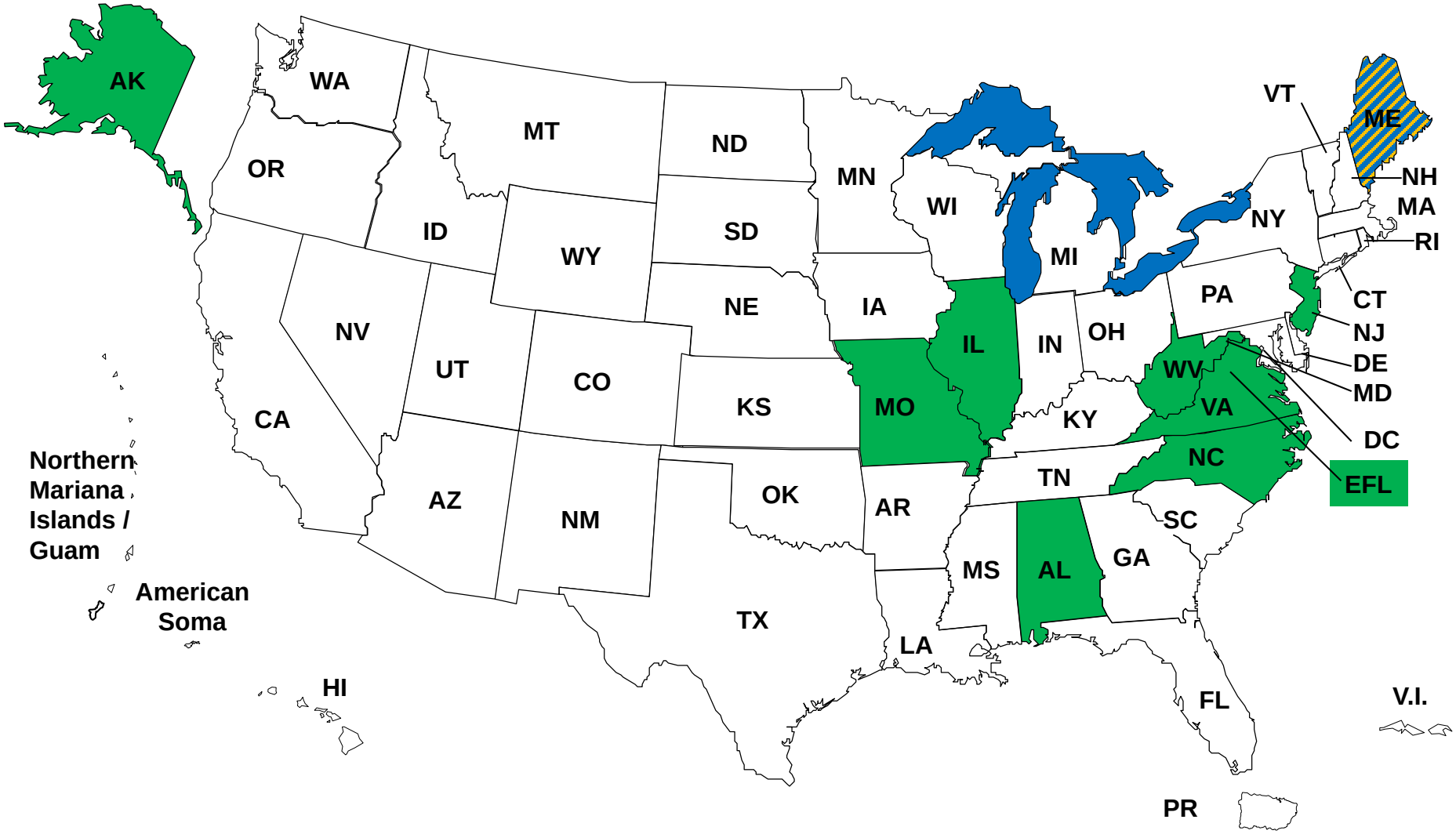
U.S. Department of Transportation
Federal Highway Administration

American Association of State Highway and Transportation Officials
AASHTO

Demonstration Projects



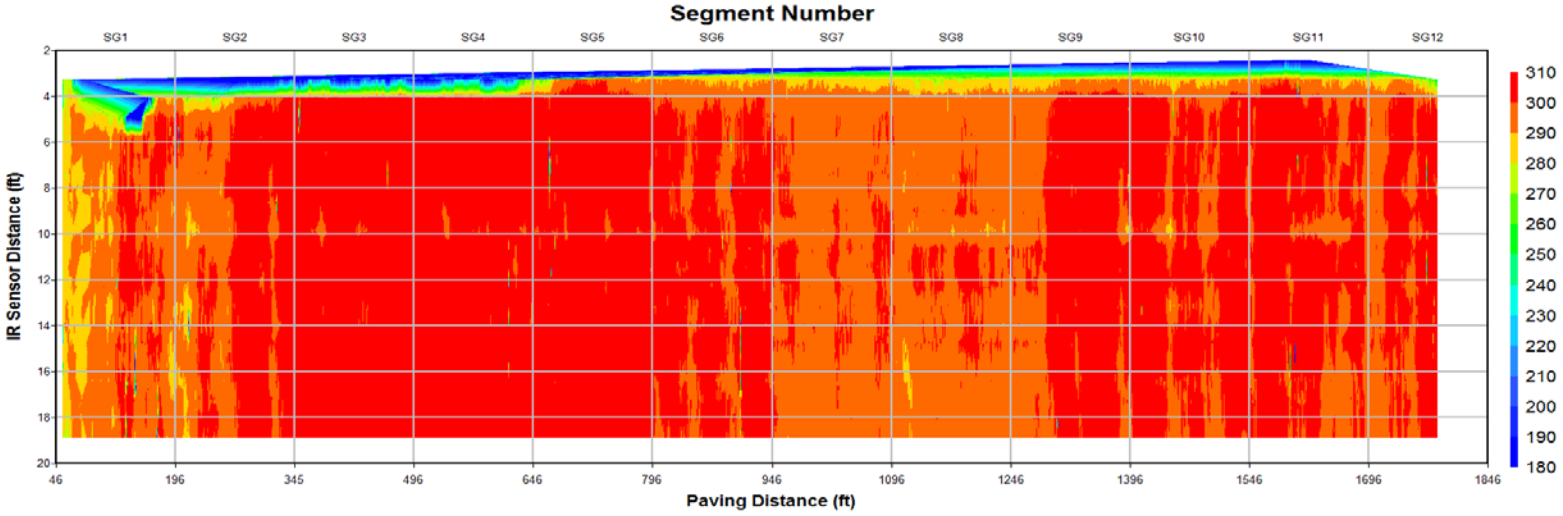
Thermal Profiling to Increase Pavement Life

1. IR Defined.
2. Why is it important?
3. How is it measured?
4. Data Analysis
5. IR Benefits

IR Defined

Infrared Thermography:

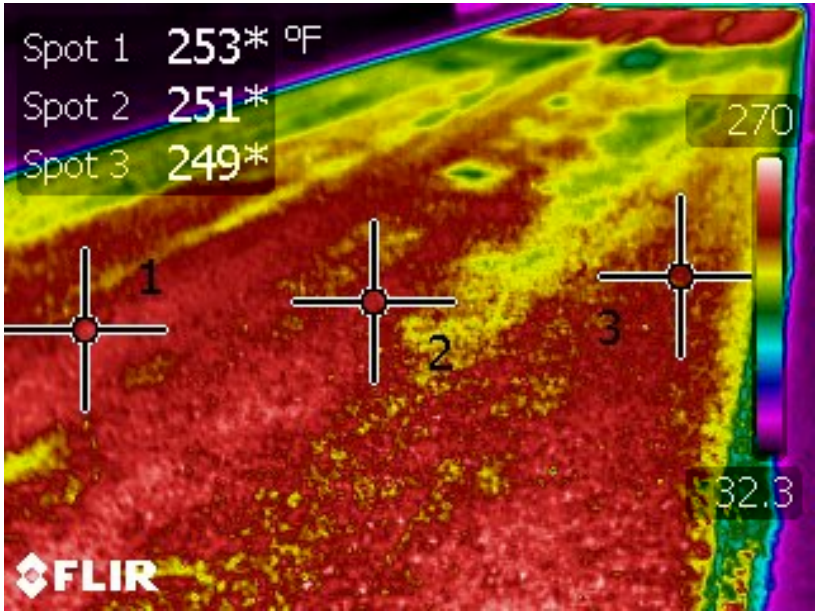
- The mapping of temperature contours (equal temperature) over the surface of a material.
- Contours are used to evaluate materials by measurement of their surface temperature and its variation.

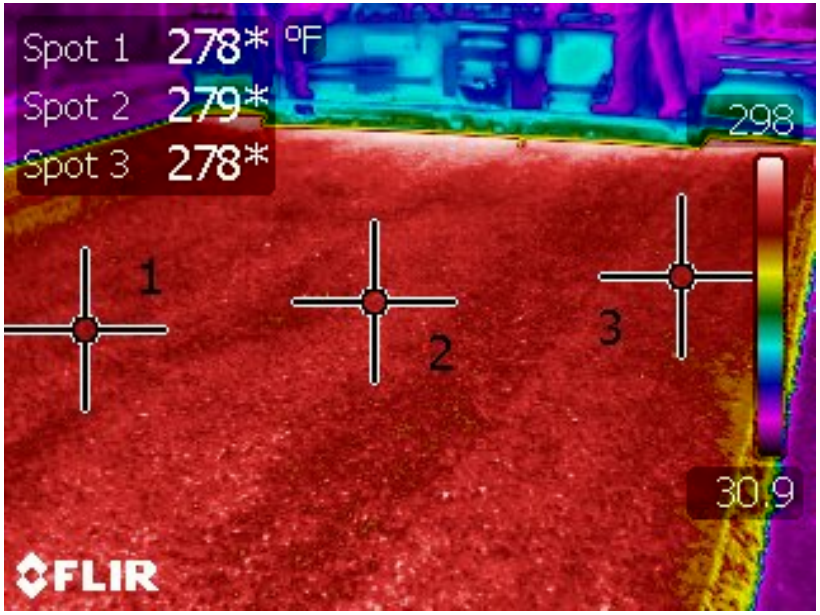


IR – Defined

Temperature segregation:

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

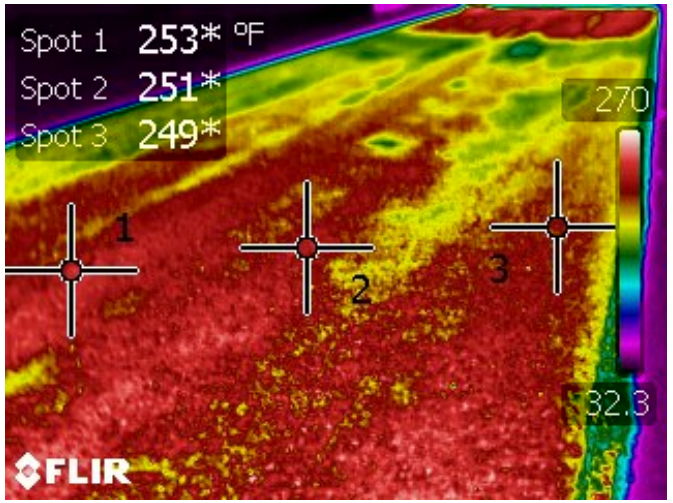


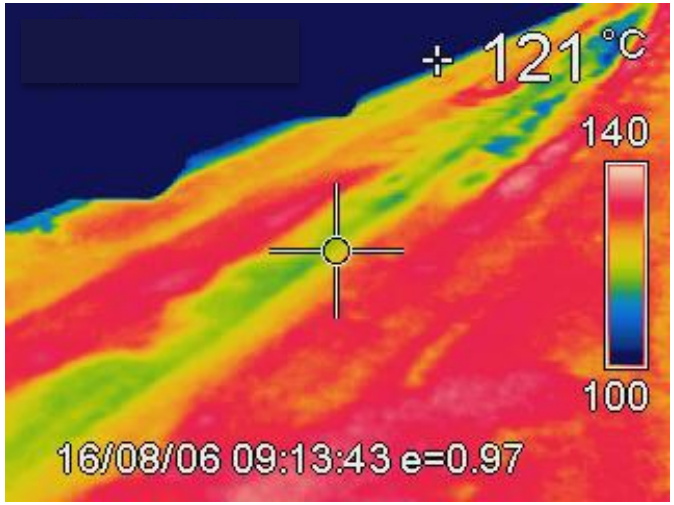


IR – Defined

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

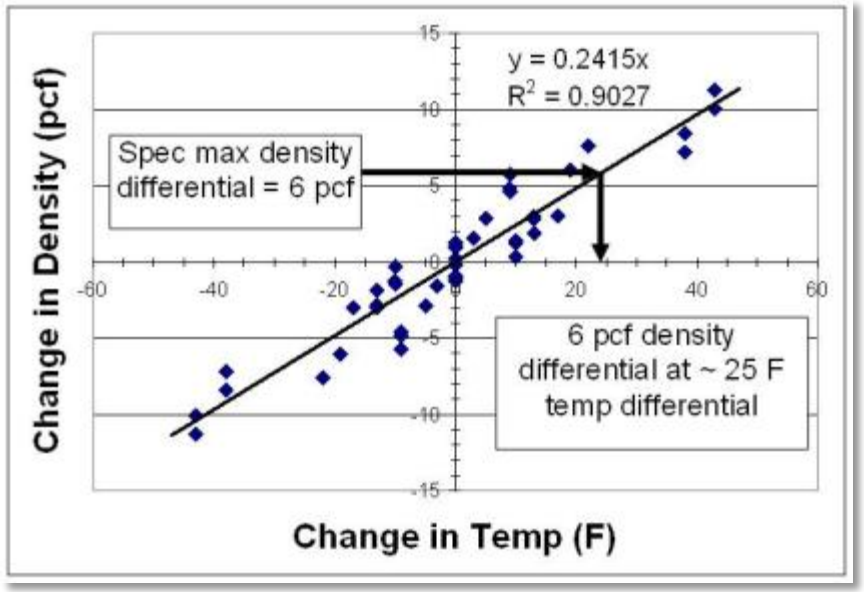




IR – Defined

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.

Thermal Profiling to Increase Pavement Life

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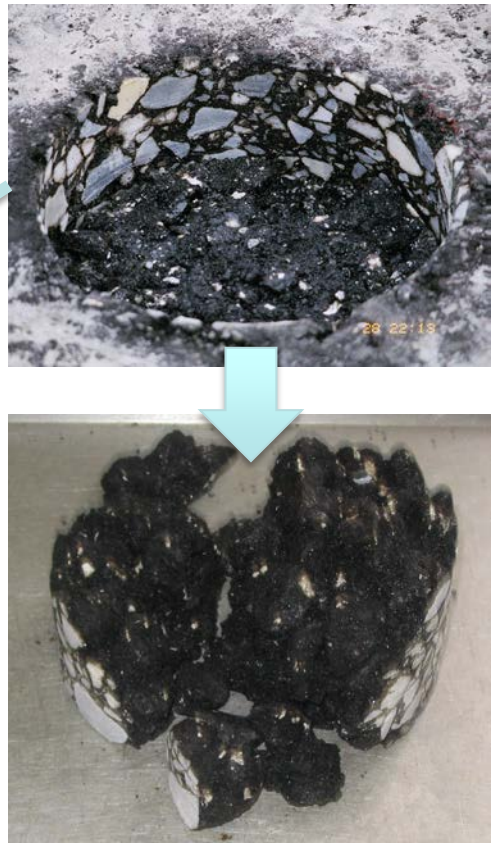
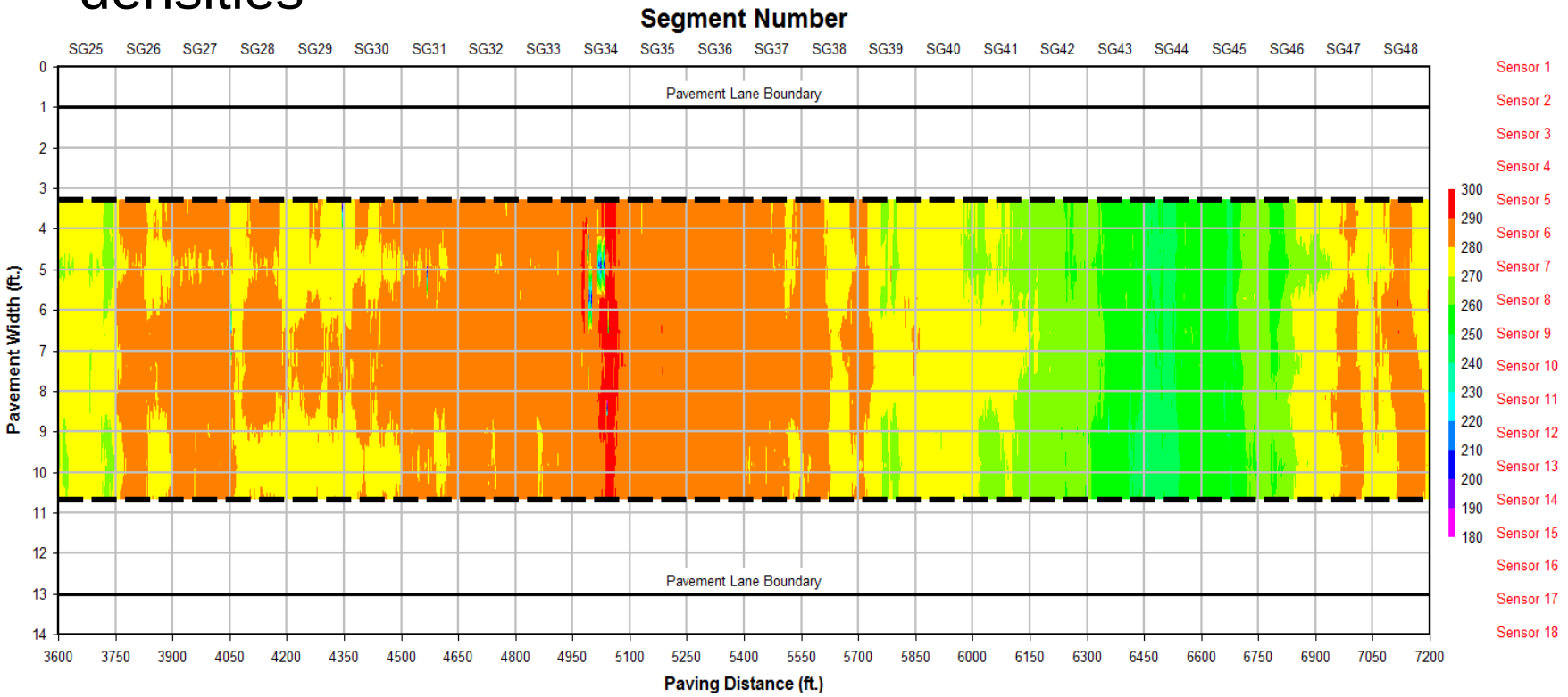
IR – Why use it?

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



IR – Why use it?

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



IR – Why use it?

Impact of temperature differences or areas with low temperatures.

IR – Why use it?

Cold spots; areas with increased potential for:

- Fatigue cracks
- Raveling
- Pot holes

IR – Why use it?

Thermal streaks; longitudinal areas with increased potential for:

- Longitudinal cracking

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IR – Measurements

Mat Temperature Measurements

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

IR – Measurements

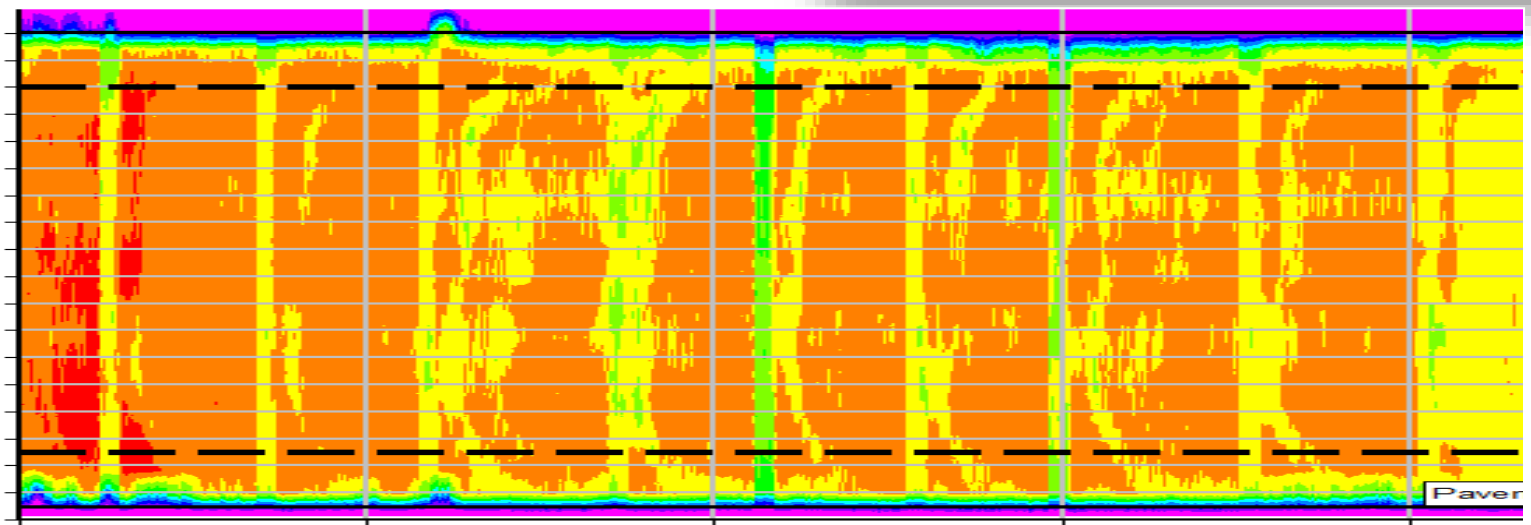
- IR Scanner attached to paver and scans mat behind screed in one direction.
- GPS attached to the scanner arm.

IR – Measurements

IR scan screen to monitor mat temperatures on real time basis; attached to the scanner post.

IR – Measurements

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



Thermal Profiling to Increase Pavement Life

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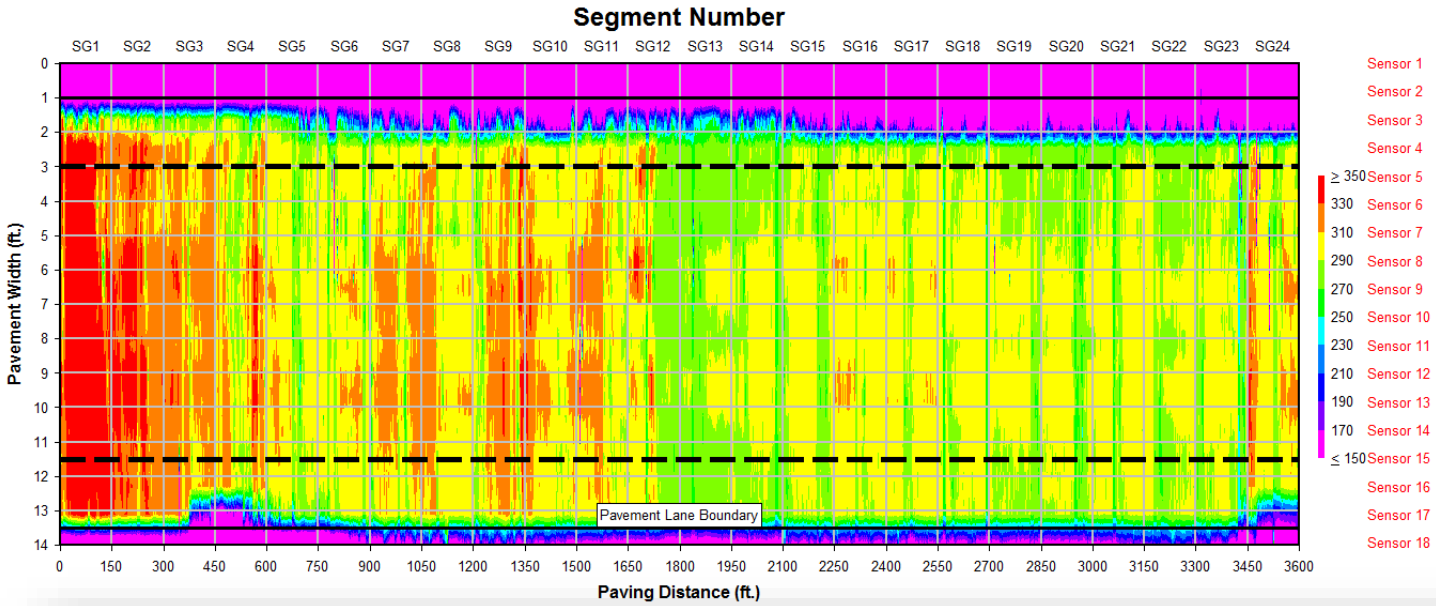
Location of WV Project

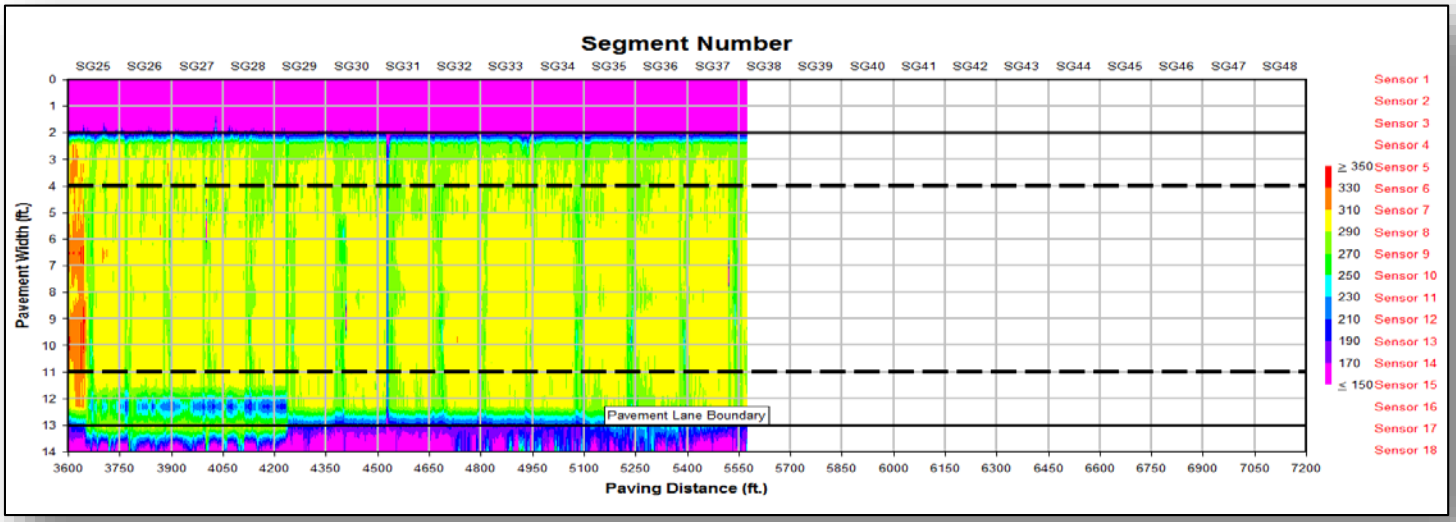
West Virginia Route 10 near Logan, WV

New Construction of 4 lane Highway

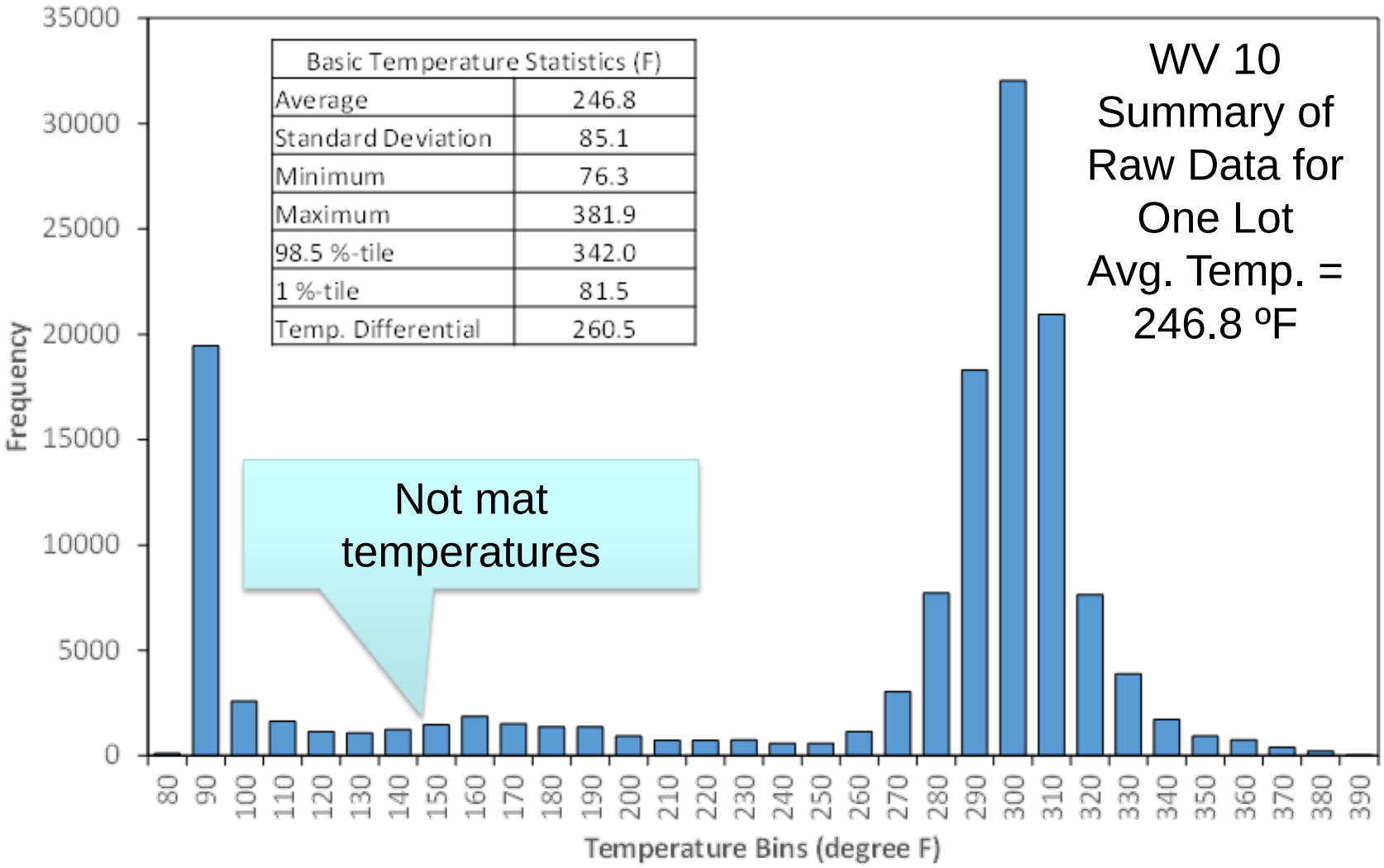
Data Analyses



July 27, 2016



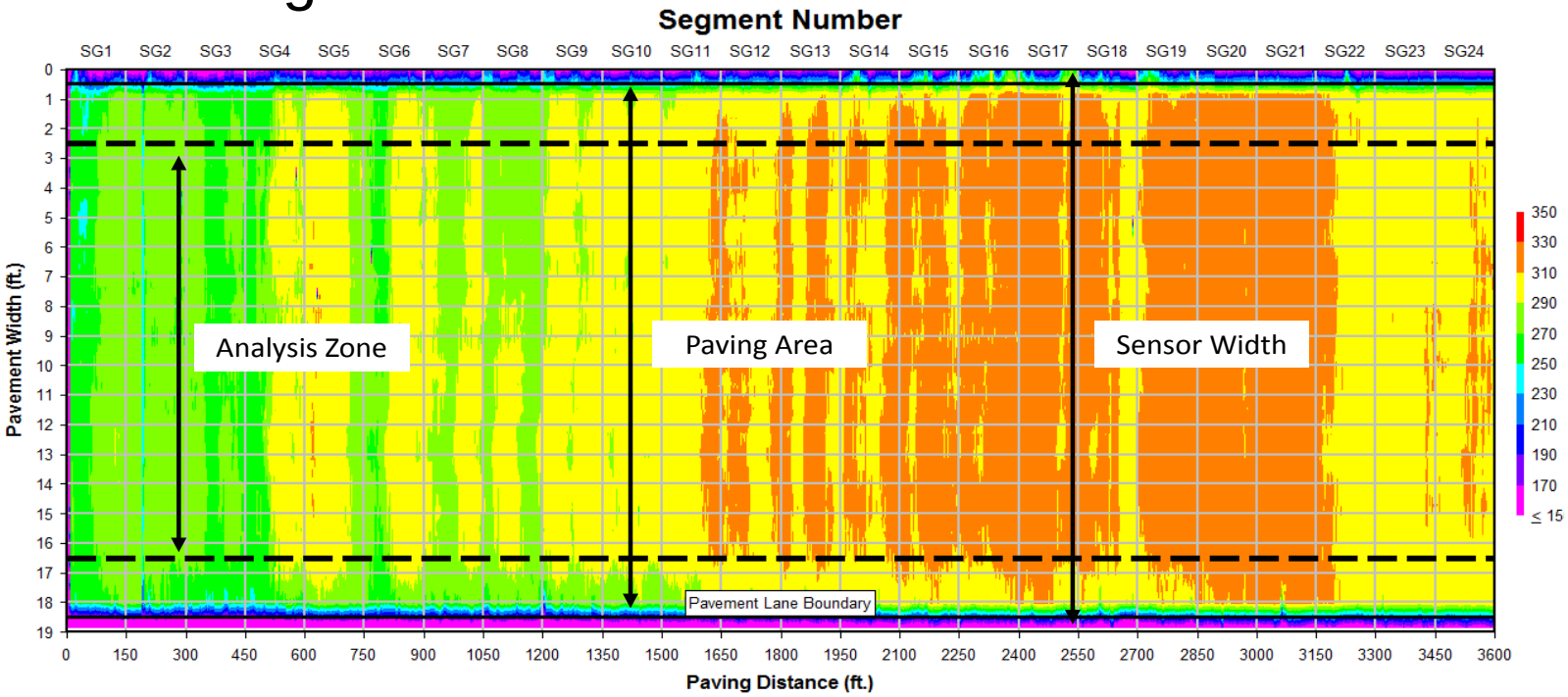
Data Analyses & Findings



Data Analyses & Findings

Data Processing—eliminate invalid temperature measurements:

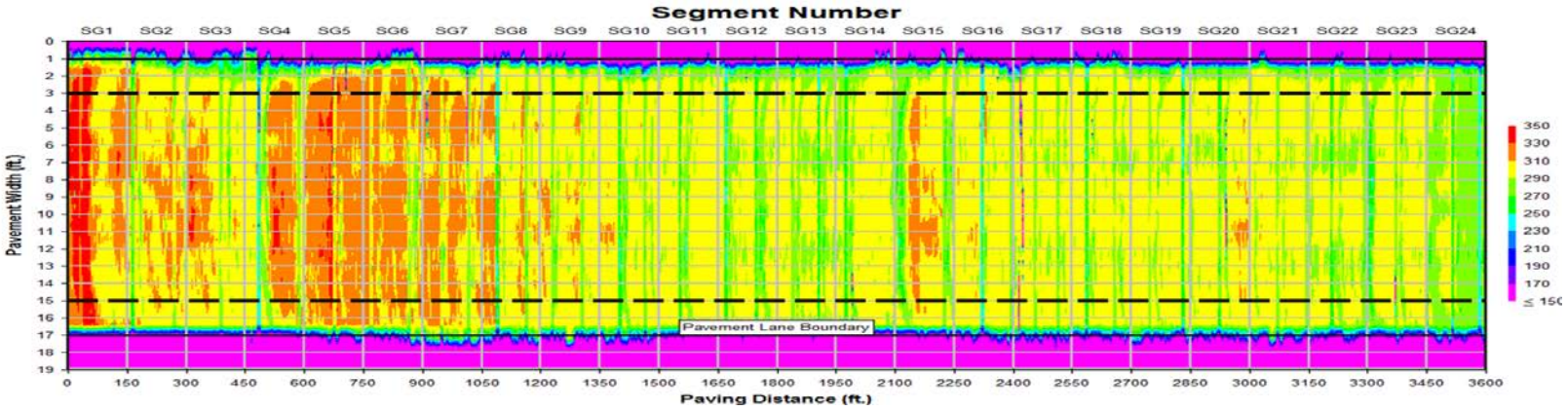
1. Eliminate measurement locations within 2 feet of the mat's edge.



Data Analyses & Findings

Data Processing—eliminate invalid temperature measurements:

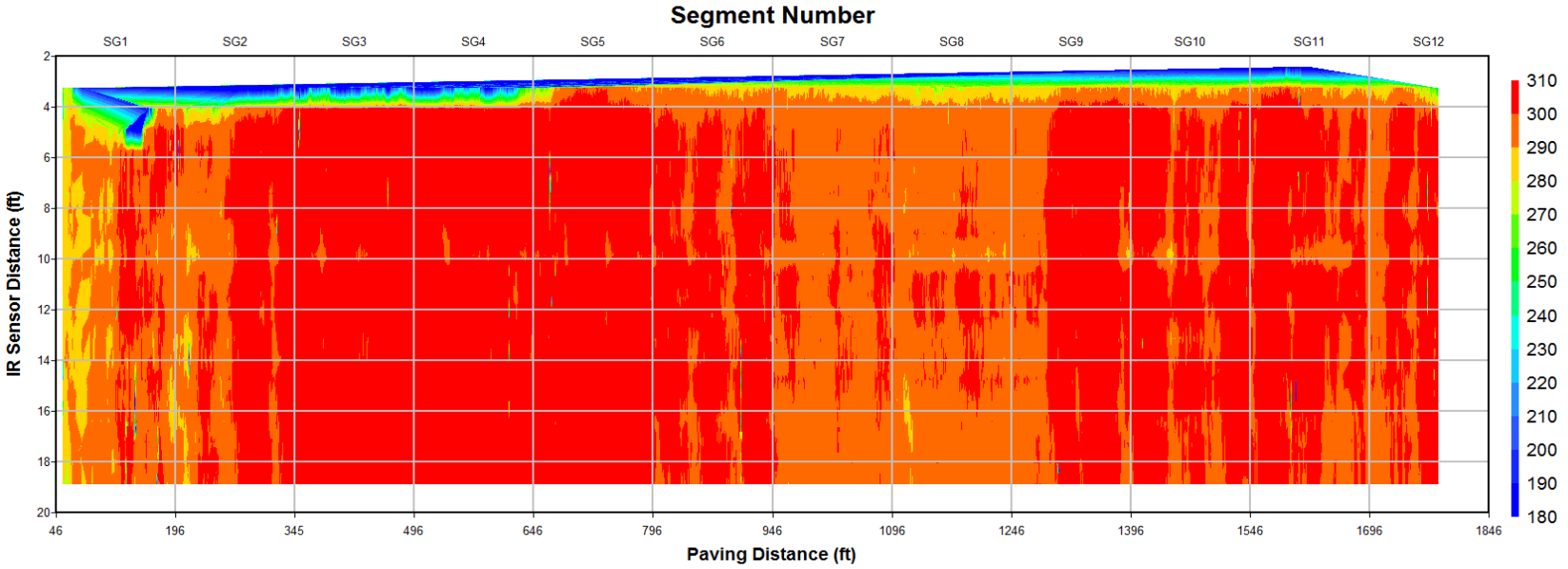
2. Eliminate data with paver stops greater than 10 seconds, between locations:
   - 2 feet behind measurement location of stop
   - 8 feet in front of measurement location of stop
3. Eliminate temperature readings < 170 ºF and > 400 ºF.



Data Analyses

Data Processing—eliminate invalid temperature measurements:

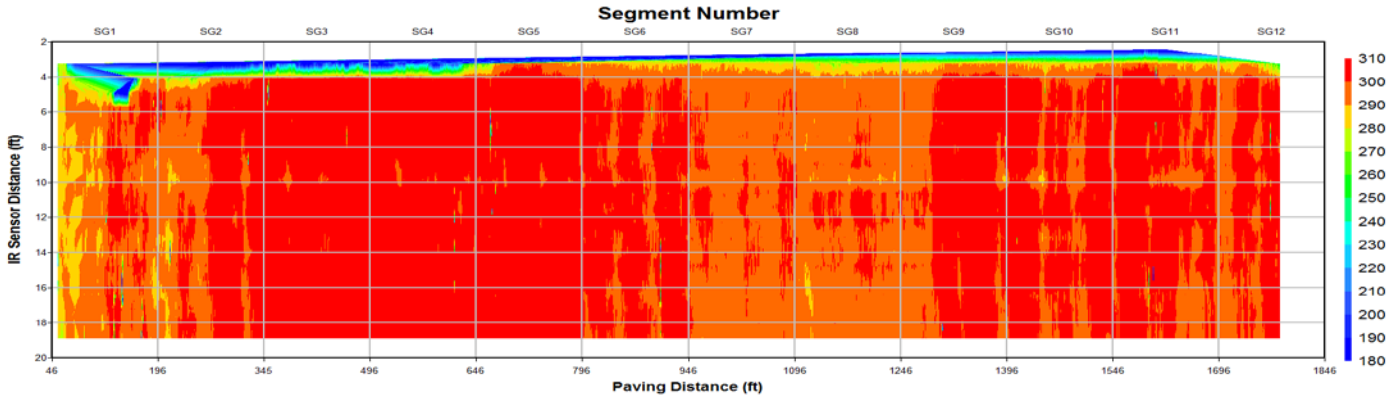
1. Eliminate measurement locations within 2 feet of the mat's edge.



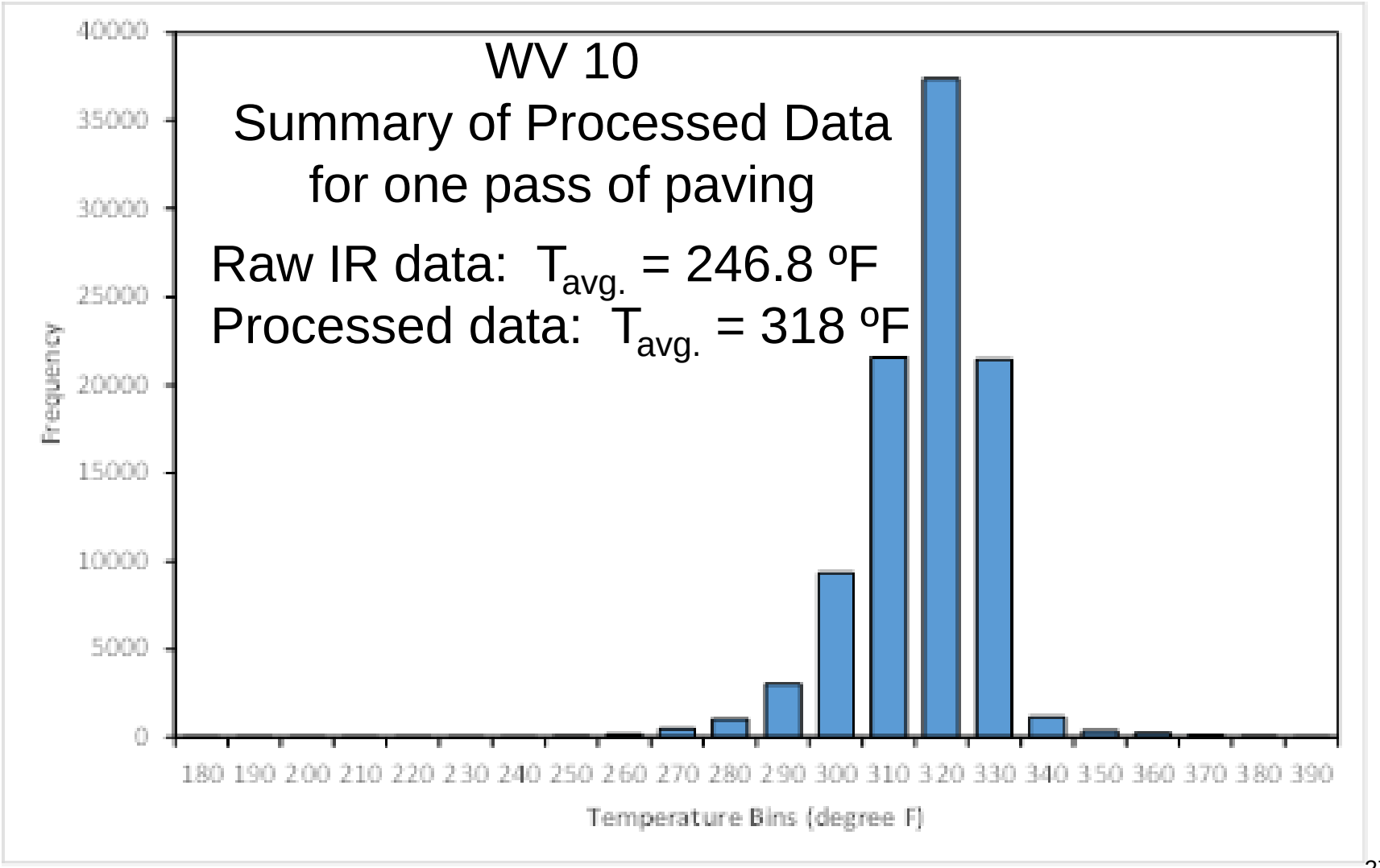
Data Analyses

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 ºF and > 400 ºF.



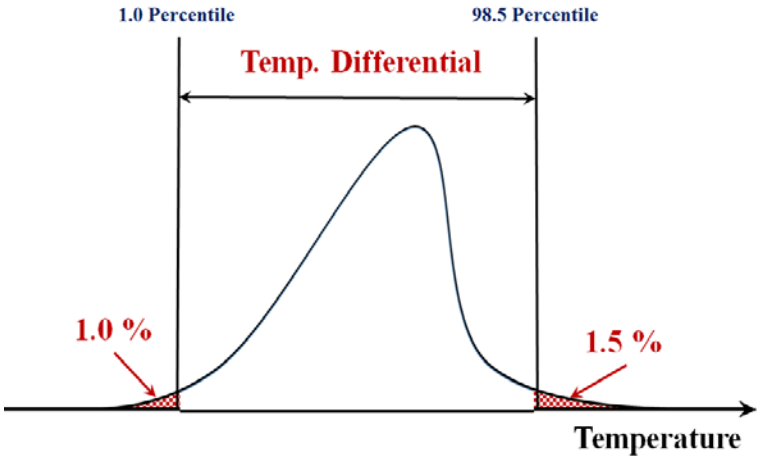
Data Analyses & Findings



Data Analyses & Findings

- Temperature Differential Criteria, each 150 foot segment:

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



- **$T_{diff} \leq 25$ ºF** — **No temperature difference**
- 25 ºF < $T_{diff} \leq 50$ ºF — Moderate temperature difference
- **$T_{diff} > 50$ ºF** — **Severe temperature difference**

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

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

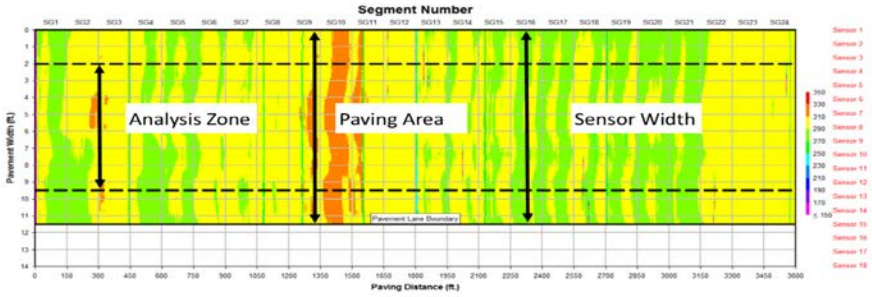
[1]Data from all dates (7/26, 7/27, 7/28, 8/3, 8/4)
[2]Data collected on 7/27/2016 and 7/28/2016 only
[3]Data collected on 8/3/2016 and 8/4/2016 only

Data Analyses & Findings

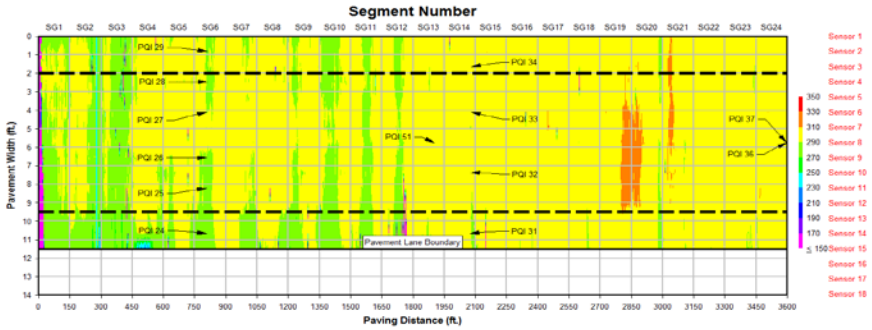
Raw Temperature Profile showing continuous improvement or more uniform mat temperatures as paving progresses.

Example from Maine demonstration project.

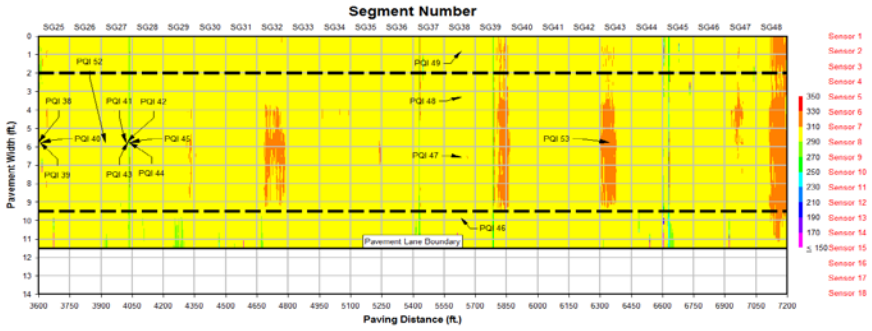
Near Start of Lot



Near Center of Lot



Near End of Lot



Thermal Profiling to Increase Pavement Life

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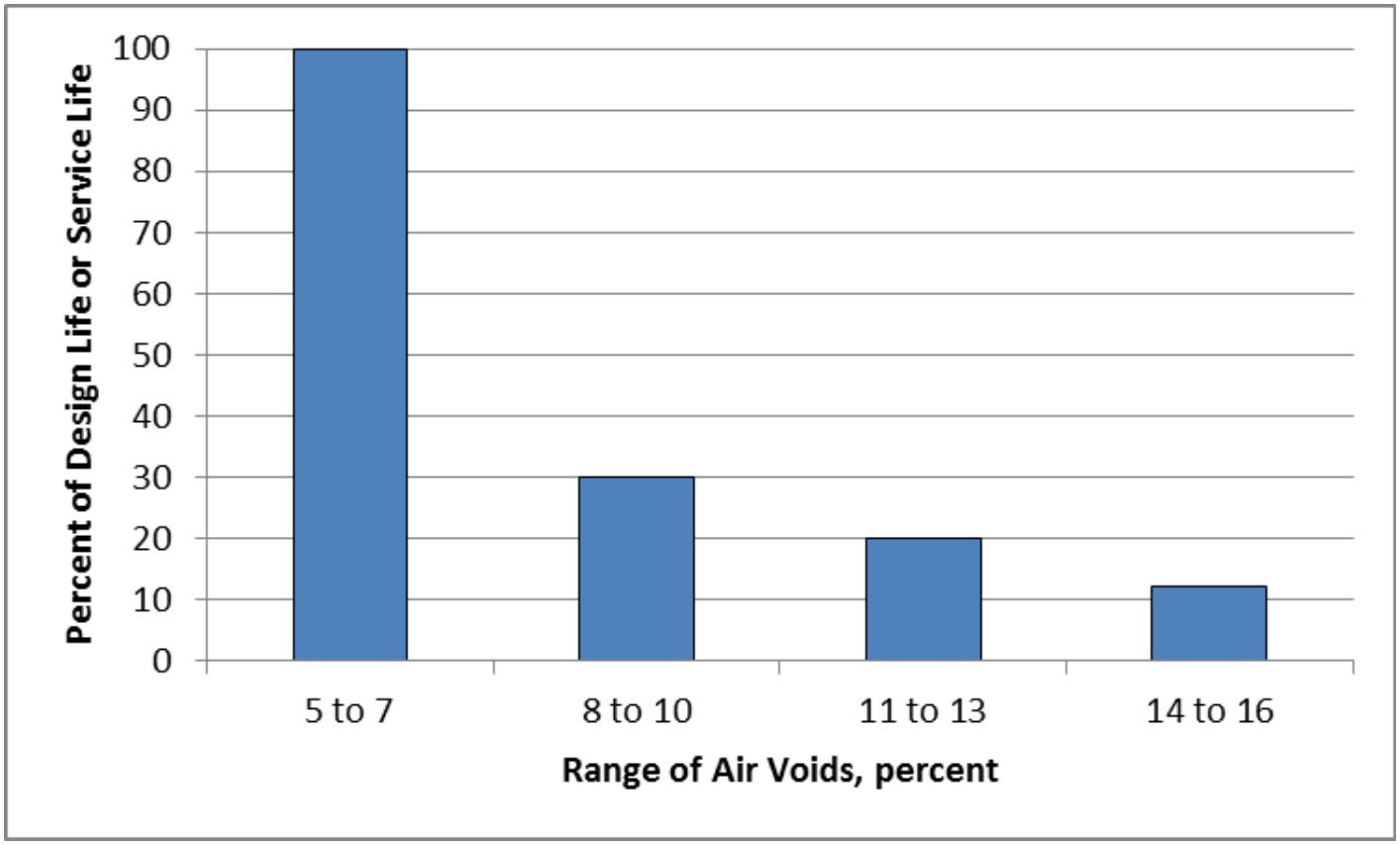
IR – Why use it?

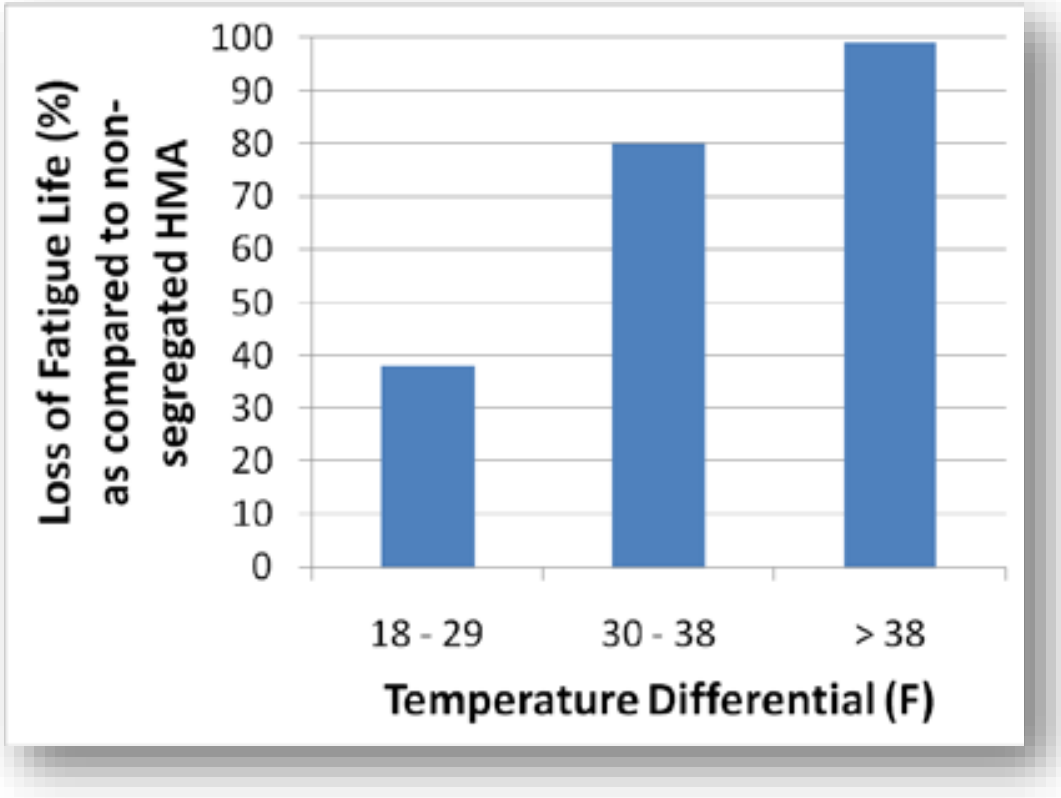
- Effect of cold spots, low mat temperatures on percent compaction; densities are lower:



Source: NCAT (2000)

IR – Why use it?

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

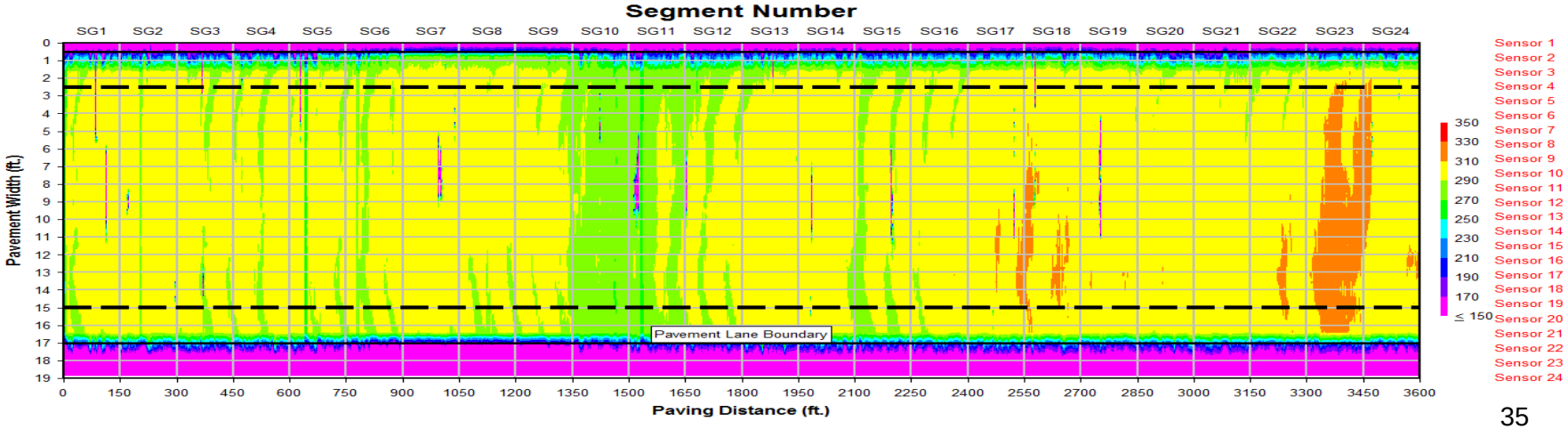


Source: NCAT (2000)

Thermal Profiling to Increase Pavement Life

Conclusion from demonstration projects, to-date:

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



Thermal Profiling to Increase Pavement Life

Role of IR in Quality Assurance Programs

1. Quality control plan; contractor
   - Monitor production/placement operations to minimize temperature differentials of mat.
   - Trouble shooting
2. Acceptance plan; agency
   - Reduce future distress and maintenance costs
   - Dispute resolution

Infrared Technology:
It's Application and Benefit

QUESTIONS