Intelligent Compaction and Pave-IR in Minnesota

2012 North Dakota Asphalt Conference

April 4, 2012

Greg Johnson

Mn/DOT – Asst. Bituminous Engr.

Intelligent Compaction
(Video)

MnDOT Intelligent Compaction Projects

- 2004
  - District 3, Mn/ROAD, Demo
- 2005
  - District 1, US 53, Duluth, Granular (Taconite)
  - District 7, US 14, Janesville, Non-Granular, Granular
  - District 8, US 12, Atwater, Base
- 2006
  - District 2, TH 64, Bemidji, Granular
  - District 3, Mn/ROAD, Misc – Non-Granular
  - Metro District, I-494 Valley Creek Road, Granular Shoulders
- 2007
  - District 3, US 10, Staples, Granular
  - District 4, US 10, Detroit Lakes, Non-Granular, Granular
  - District 7, TH 60, Worthington, Non-Granular, Granular
  - Metro District, TH 36, St. Paul, Non-Granular, Granular
- 2008
  - Olmsted County, CSAH 2, Non-Granular, Base
  - Kandiyohi County, CSAH 4, Base, HMA (Breakdown)

- 2008 (cont)
  - Kandiyohi County, CSAH 40, HMA (Breakdown)
  - District 3, Mn/ROAD, Non-Granular, Granular, Base, Base, FDR, SFDR
  - District 7, TH 60, Worthington, Non-Granular, Granular
  - District 8, TH 71, Wilmar, HMA (Breakdown)
- 2010
  - District 3, TH169, Garrison, HMA (Breakdown)
  - District 7, TH 13, Albert Lea, HMA (Breakdown)
  - District 6, TH16, Hokah, SFDR
  - Metro District, TH 610, Granular
  - Olmsted County, CSAH 10, Granular (Compactor Rejected)
- 2011
  - Metro District, TH35, HMA (Pneumatic, Vibratory)
  - District 7, TH 30, Amboy, FDR, SFDR (Padfoot)
  - District 7, TH 83, Waldorf, FDR (Padfoot)
  - District 8, TH 212, FDR (Padfoot)
  - District 8, TH 23, Granular (Compactor Rejected)

Total IC Projects = 25

Mn/DOT Priorities

- **Uniform Compaction** - All rollers in a train having a display showing # of passes (GPS)

- **Uniform Temperature** - Surface Temperature behind Screed (Pave-IR)

1989 – “Effect of Compaction on Asphalt Concrete Performance”

Each 1% increase in air voids (over 7 percent) tends to produce ~10 percent loss in pavement life (~1 year less life)

IC Roller Components

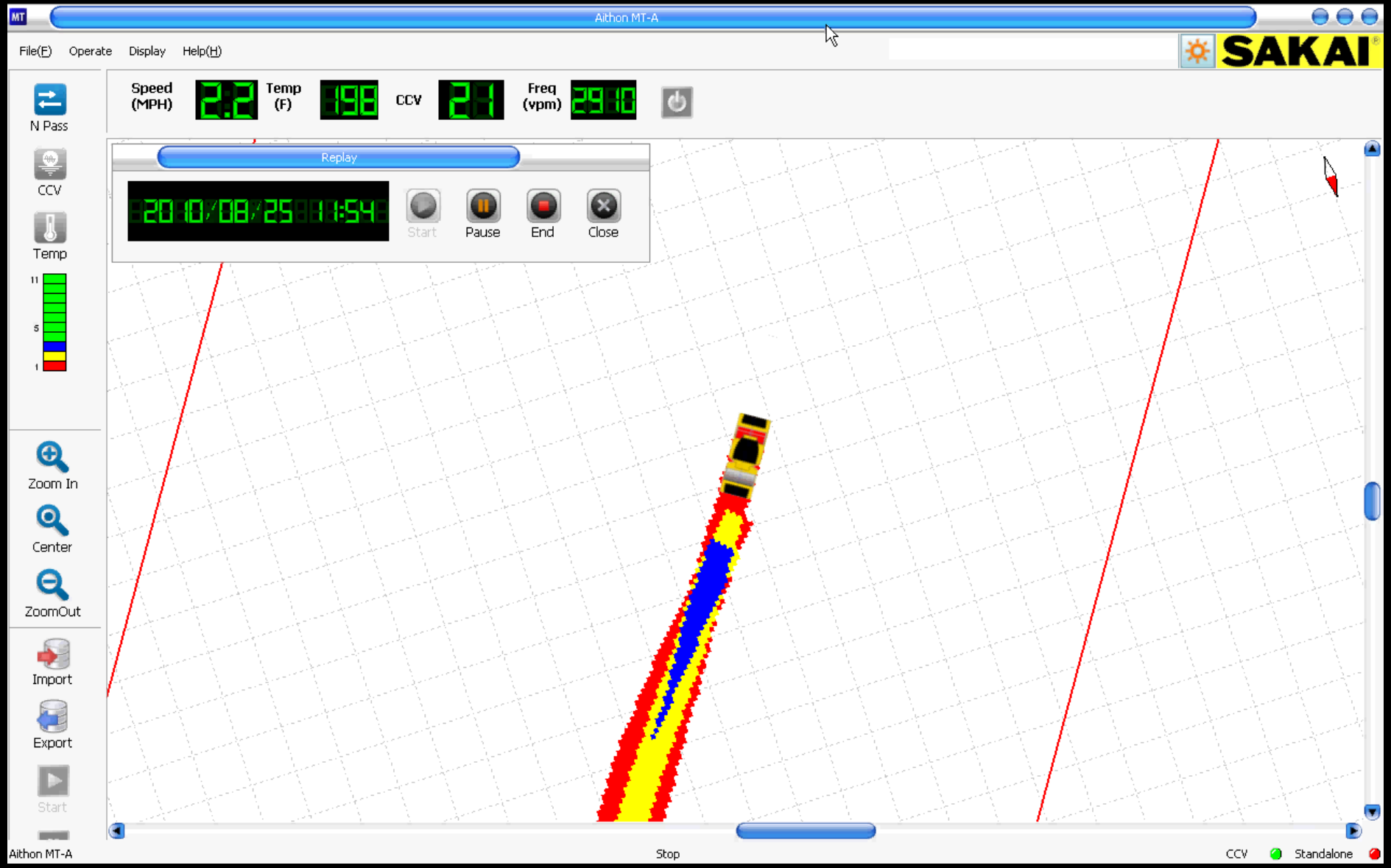
- GPS Tracking
- Roller Settings
- Surface Temperature
- Accelerometer

Dedicated IC Roller

Retrofit IC Rollers

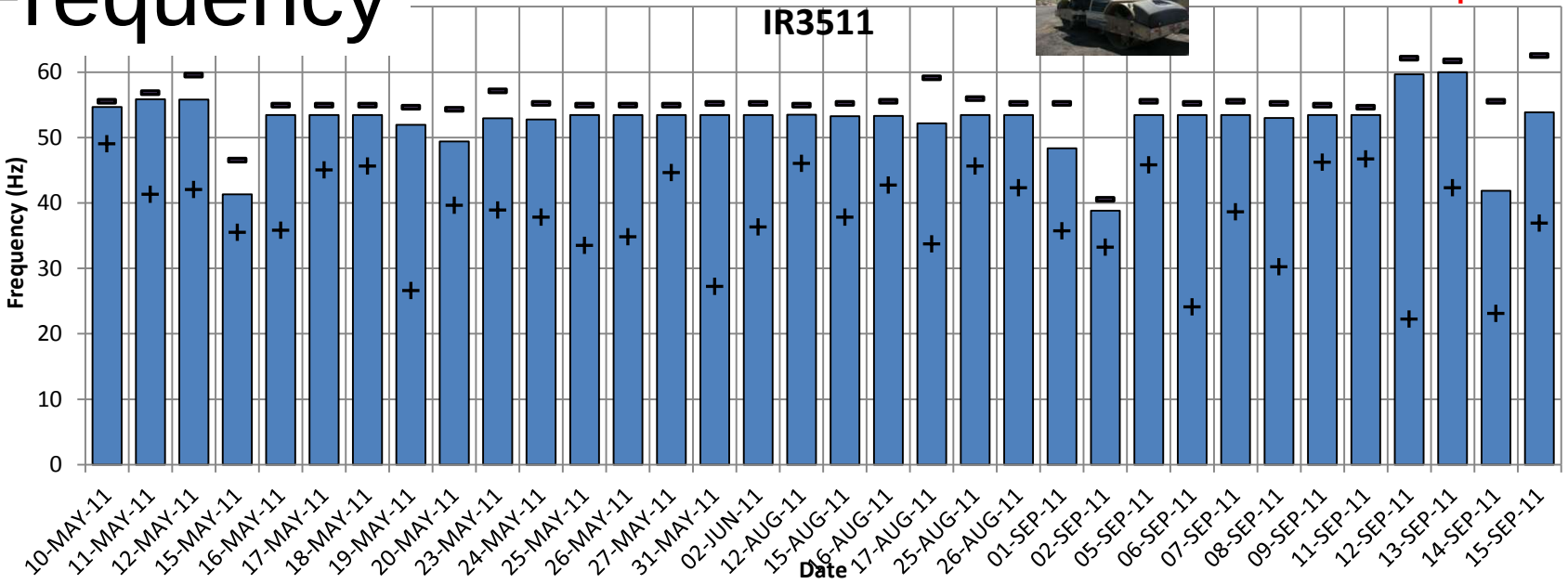
Operator Display

Roller – Number of Passes

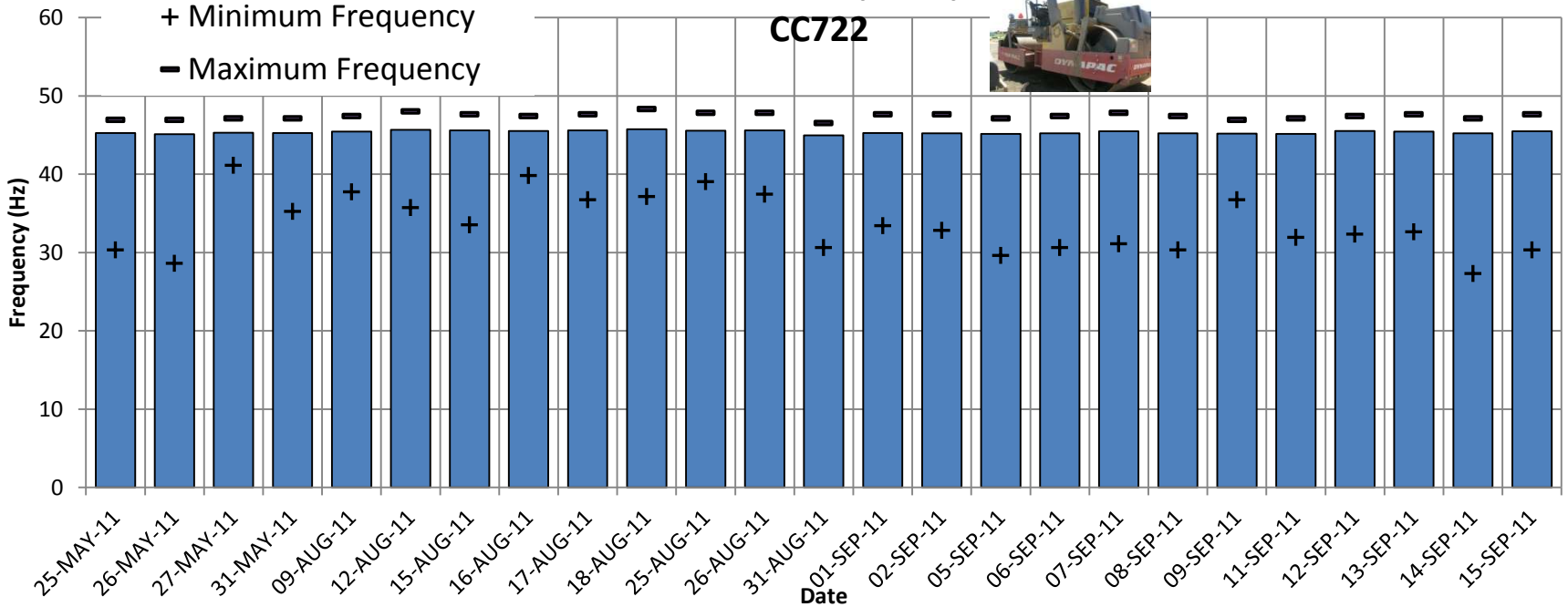


Frequency

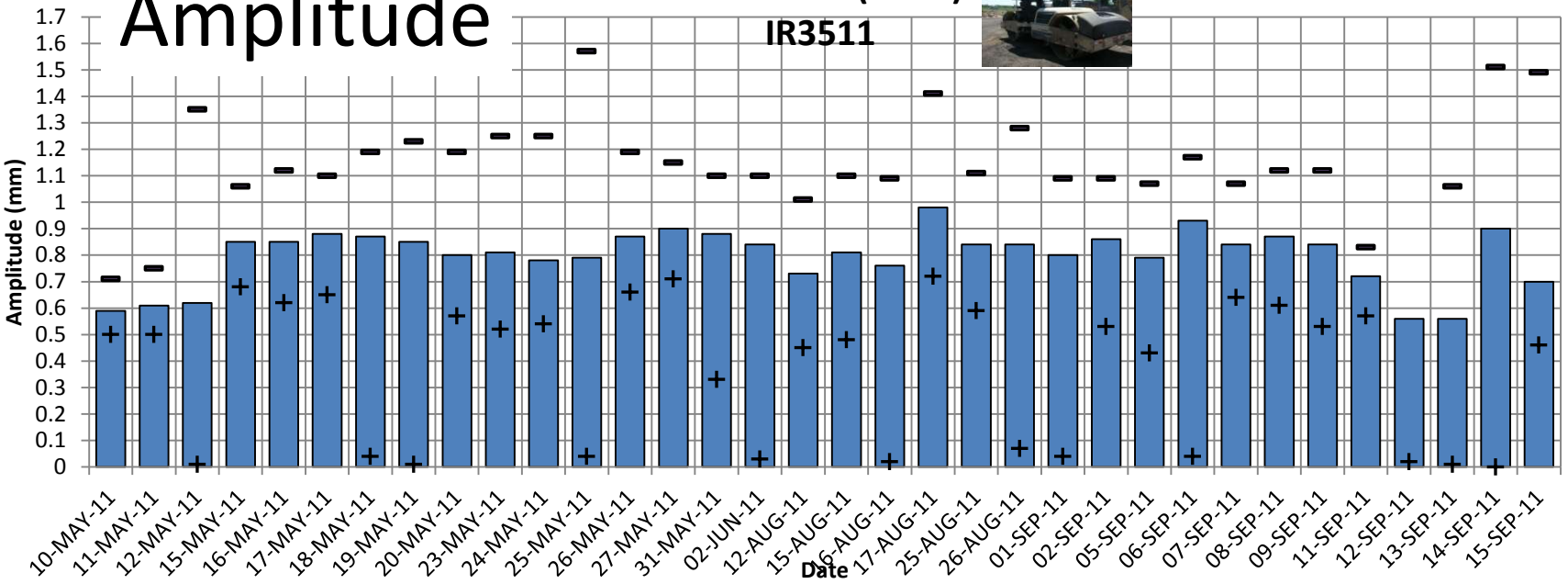
Filtered: 11 impacts/foot

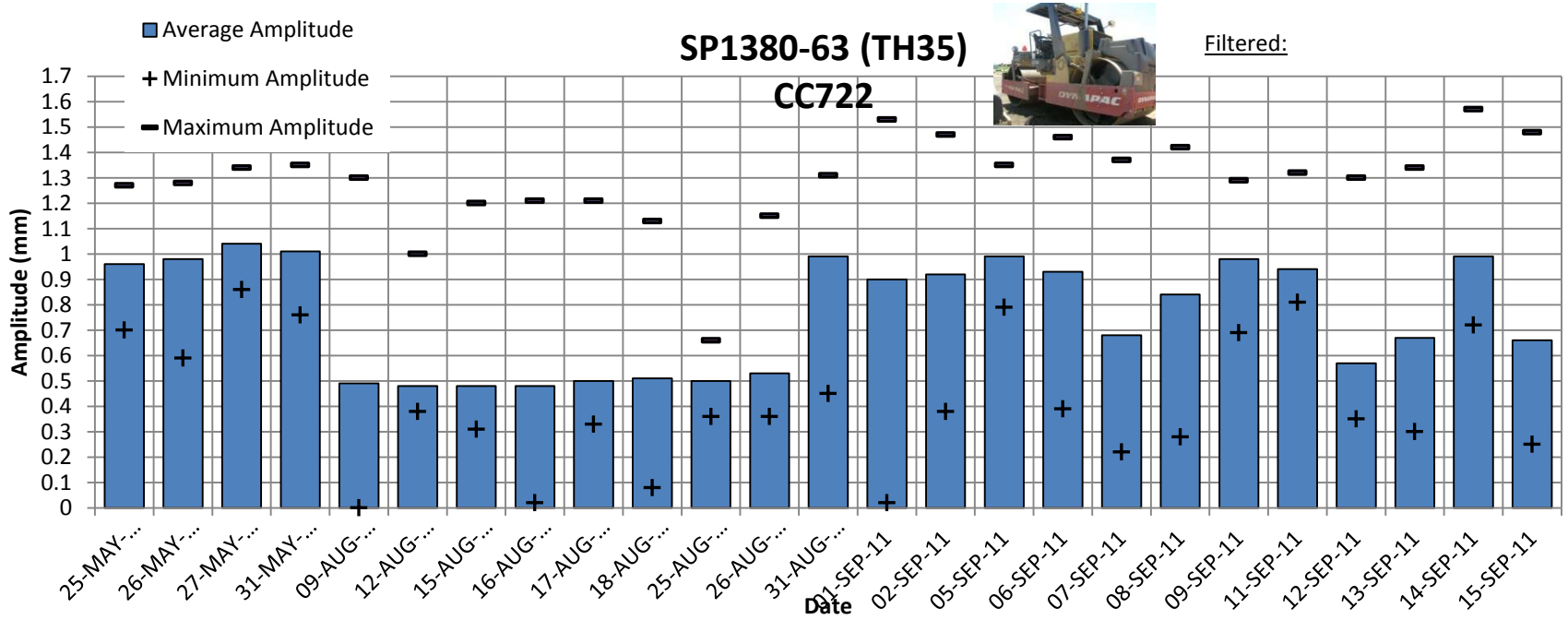


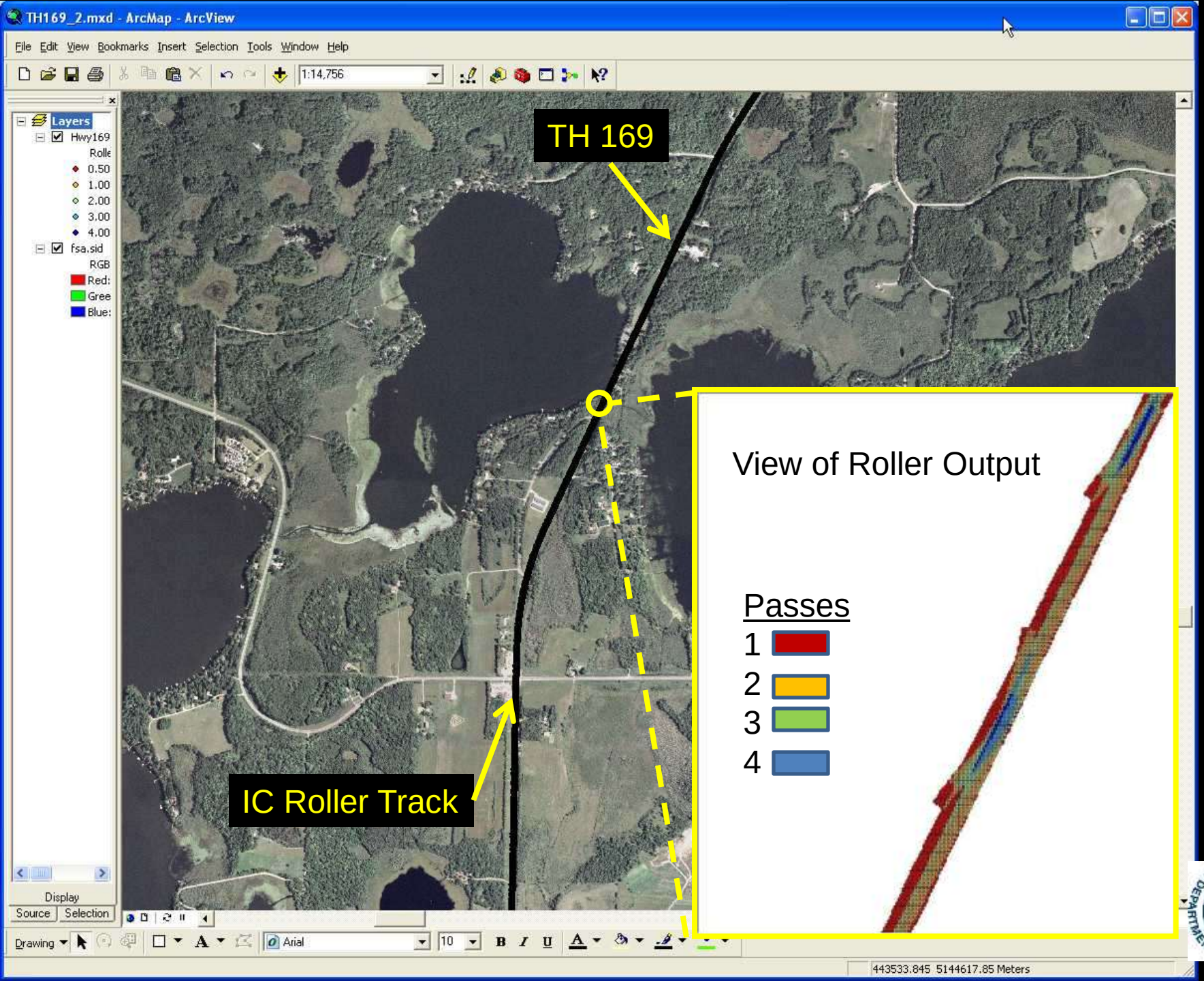
Filtered: 9 impacts/foot



Amplitude


SP1380-63 (TH35)
IR3511
Filtered:
Amplitude (mm)
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
10-MAY-11
11-MAY-11
12-MAY-11
15-MAY-11
16-MAY-11
17-MAY-11
18-MAY-11
19-MAY-11
20-MAY-11
23-MAY-11
24-MAY-11
25-MAY-11
26-MAY-11
27-MAY-11
31-MAY-11
02-JUN-11
12-AUG-11
15-AUG-11
16-AUG-11
17-AUG-11
25-AUG-11
26-AUG-11
01-SEP-11
02-SEP-11
05-SEP-11
06-SEP-11
07-SEP-11
08-SEP-11
09-SEP-11
11-SEP-11
12-SEP-11
13-SEP-11
14-SEP-11
15-SEP-11
Date


Average Amplitude
Minimum Amplitude
Maximum Amplitude
SP1380-63 (TH35)
CC722
Filtered:
Amplitude (mm)
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
25-MAY-...
26-MAY-...
27-MAY-...
31-MAY-...
09-AUG-...
12-AUG-...
15-AUG-...
16-AUG-...
17-AUG-...
18-AUG-...
25-AUG-...
26-AUG-...
31-AUG-...
01-SEP-11
02-SEP-11
05-SEP-11
06-SEP-11
07-SEP-11
08-SEP-11
09-SEP-11
11-SEP-11
12-SEP-11
13-SEP-11
14-SEP-11
15-SEP-11
Date


TH169_2.mxd - ArcMap - ArcView
File Edit View Bookmarks Insert Selection Tools Window Help
1:14,756
Layers
Hwy169
Rolle
0.50
1.00
2.00
3.00
4.00
fsa.sid
RGB
Red:
Gree
Blue:
Display
Source Selection
Drawing
Arial
10
TH 169
IC Roller Track
View of Roller Output
Passes
1
2
3
4
443533.845 5144617.85 Meters

What is Involved

- Training
- Computer Equipment
- Compactor Placement
- Data Transfer
- Base Station / Repeaters Preparation

Pneumatic

Vibratory Steel

Example of Large Data Volume from our 2011 Asphalt IC Project

- 15.42 Miles
- 3 Compactors
- 11,207 Export Files
- 17,271,460 Rows (Raw Data)
- 7,750,844 Rows (Valid Data)

Massive Amounts

Not including Temperature Bar Data

File Characteristics

Daily Data Submittal (Contractor)

- Raw Data File
- dBase Data File

Cloud

Agency

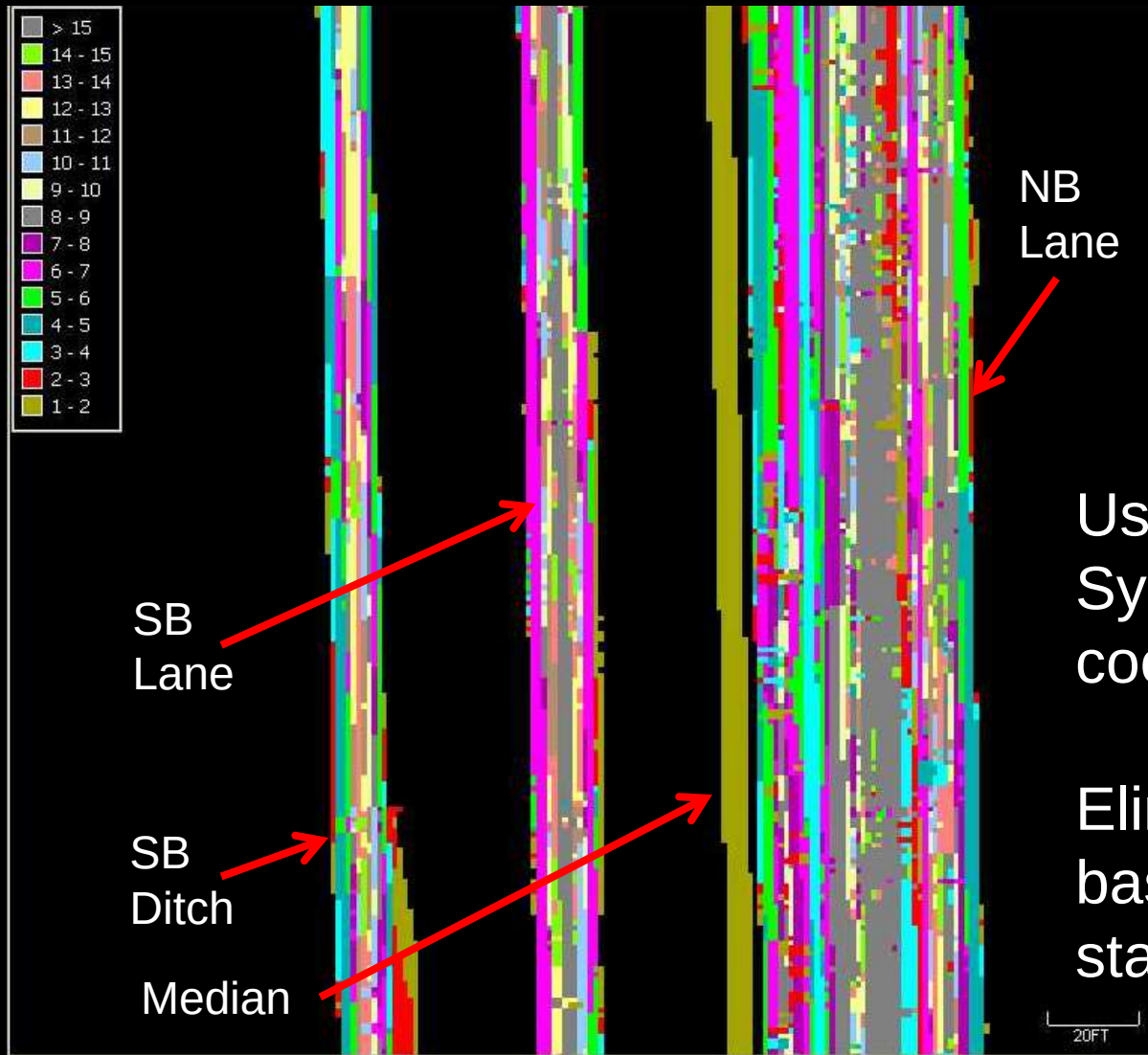
- Non-Proprietary Viewing Software
  - Veda
  - ArcGIS
- Proprietary Software

Storage

- Database
  - Oracle
  - Microsoft Access (Not Recommended)

Challenges/Solutions

Incorrect Coordinates

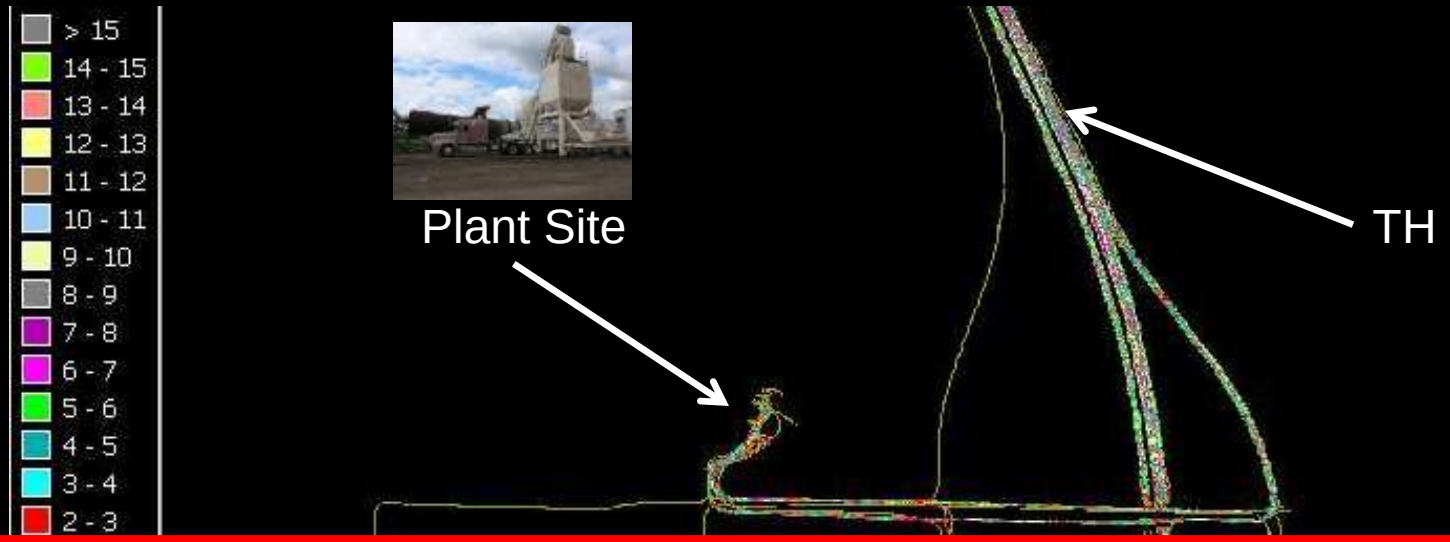


Use VRS System for coordinates.

Eliminate base stations.

Challenges/Solutions

Not Turning Off the GPS System



Implement Better QC Requirements

Compaction Measurement Value (CMV) differences (same time/location)

IR3511

54 Hz
0.80 mm

Pass	CMV IR3511	CC722
1	57	-
2	68	-
3	-	29
4	-	27
5	50	-
6	75	-

CC722

45 Hz
0.93 mm

No standardization or calibration of compactive energy

Influences: direction, temperature, weight, speed, etc.

9/1/2011 8:55 to 9:05 PM

10FT

Benefits of Intelligent Compaction - Contractor

- Real-time feedback to operators
  - Coverage
    - Prevent Gaps between passes
  - Compaction Curves
    - ↓ Number of Passes
  - Identify Weak Areas
  - View Temperature
  - Operator accountability
- GPS System Transferrable

Benefits of Intelligent Compaction – Agency

- Improved uniformity –better performance/longevity
- Increase information – better QC/QA
- Decreased maintenance
- Decreased sampling/testing (taking cores)
- Shortcomings of density acceptance process
  - Limited number of locations
  - After compaction is complete

Pave-IR Purpose

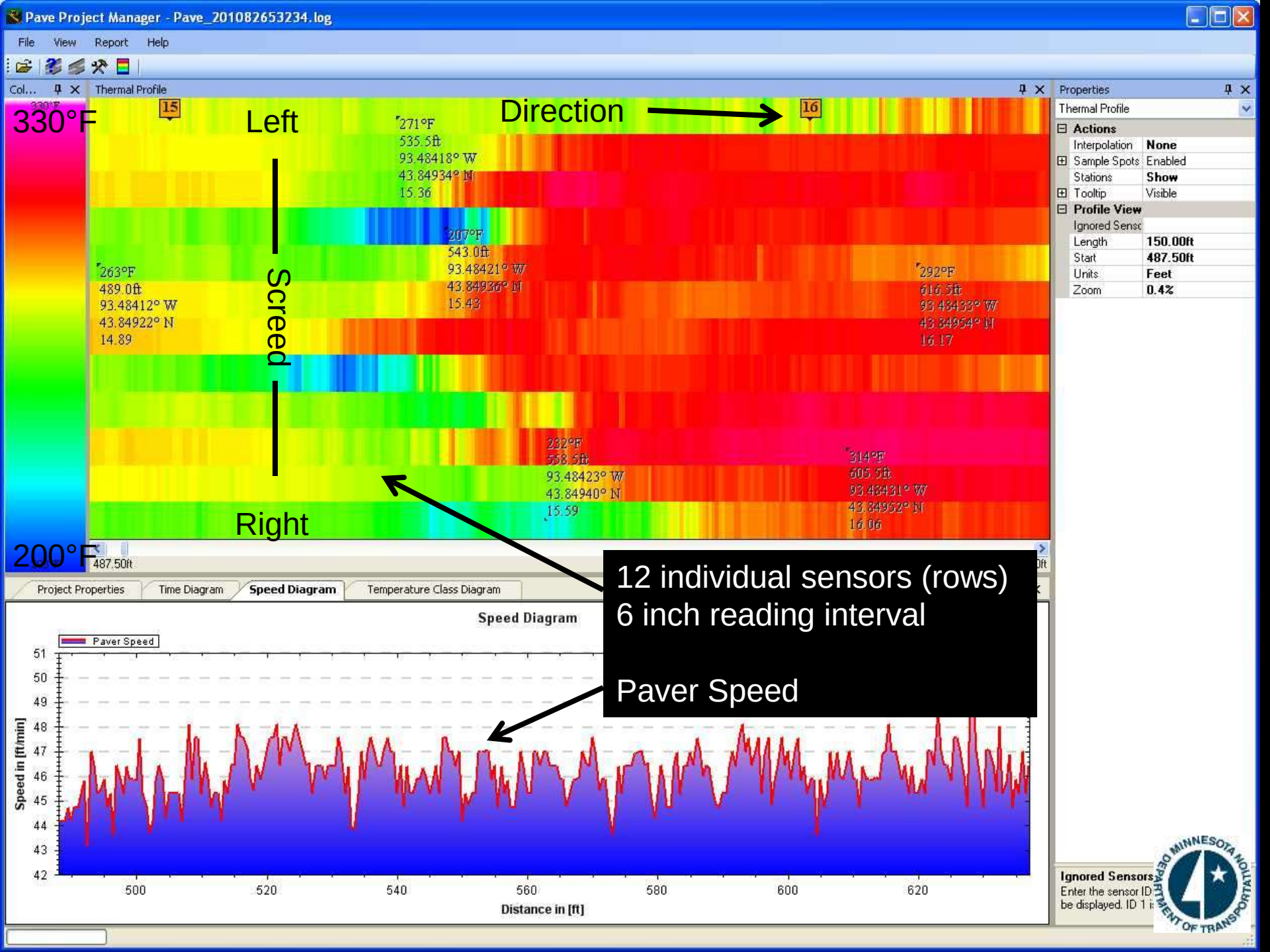
- Promote more uniform, higher quality pavements
- WADOT, NCAT, And TTI found thermal uniformity useful for detecting segregation.
- A segregated mat increases the contractor's chances of QC/QA core being in a poor/low density area.
- A segregated mat increases agency's risk of early distress

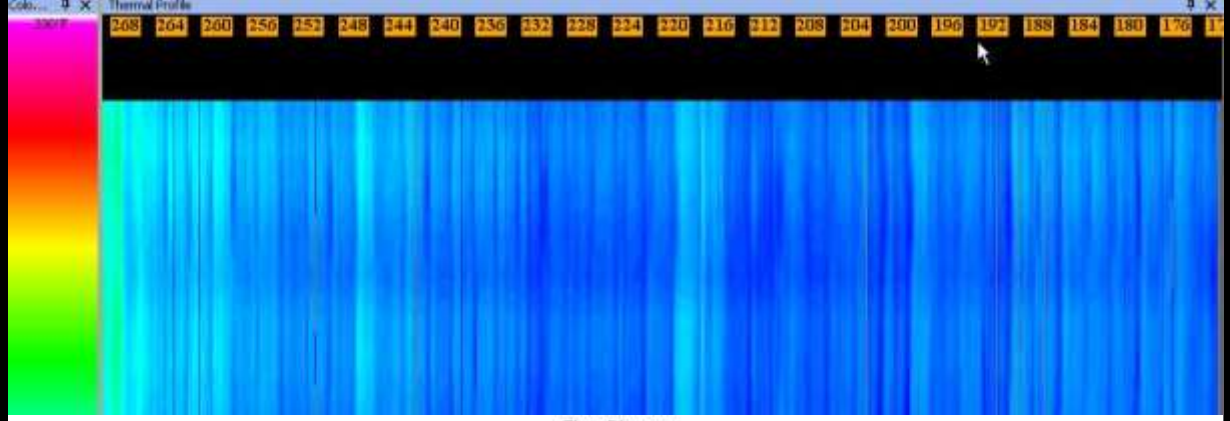
What will this technology do for you?

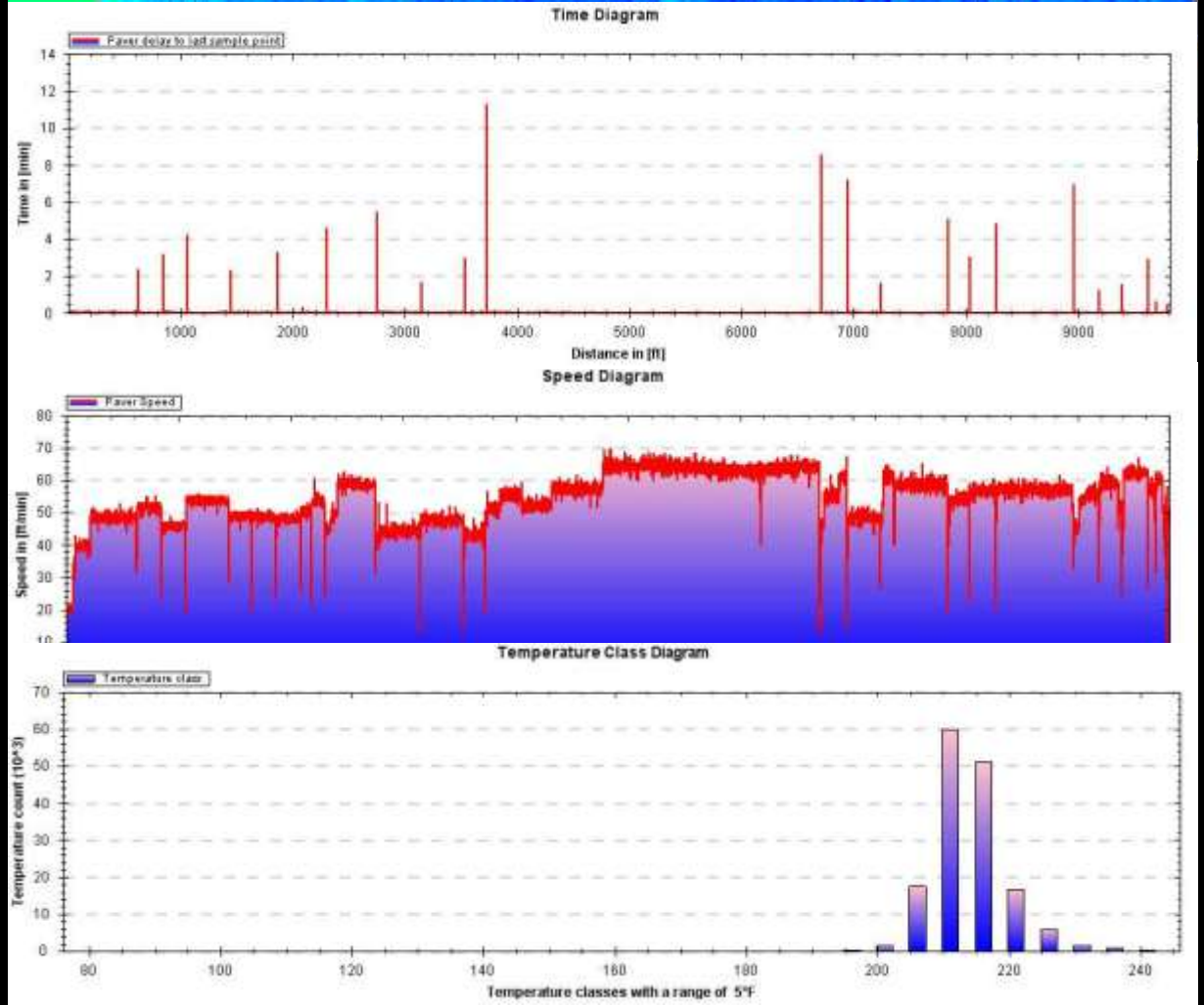
- Identify in real time if you have temperature segregation related issues due to:
  - End of truck
  - Streaks – paver/plant adjustments
  - Random – small clumps
  - Production temperature

MOBA Pave-IR

12 sensors spaced 1 foot apart,
reading interval = every 6 inches


Pave Project Manager - Pave_201082653234.log
File
View
Report
Help
Thermal Profile
330°F
200°F
Left
Direction
Screed
Right
15
16
271°F
535.5ft
93.48418° W
43.84934° N
15.36
207°F
543.0ft
93.48421° W
43.84936° N
15.43
263°F
489.0ft
93.48412° W
43.84922° N
14.89
292°F
616.5ft
93.48433° W
43.84954° N
16.17
232°F
558.5ft
93.48423° W
43.84940° N
15.59
314°F
605.5ft
93.48431° W
43.84952° N
16.06
487.50ft
Properties
Thermal Profile
Actions
Interpolation None
Sample Spots Enabled
Stations Show
Tooltip Visible
Profile View
Ignored Sensc
Length 150.00ft
Start 487.50ft
Units Feet
Zoom 0.4%
Project Properties
Time Diagram
Speed Diagram
Temperature Class Diagram
Speed Diagram
Paver Speed
Speed in [ft/min]
Distance in [ft]
12 individual sensors (rows)
6 inch reading interval
Paver Speed
Ignored Sensors
Enter the sensor ID
be displayed. ID 1 i
MINNESOTA DEPARTMENT OF TRANSPORTATION



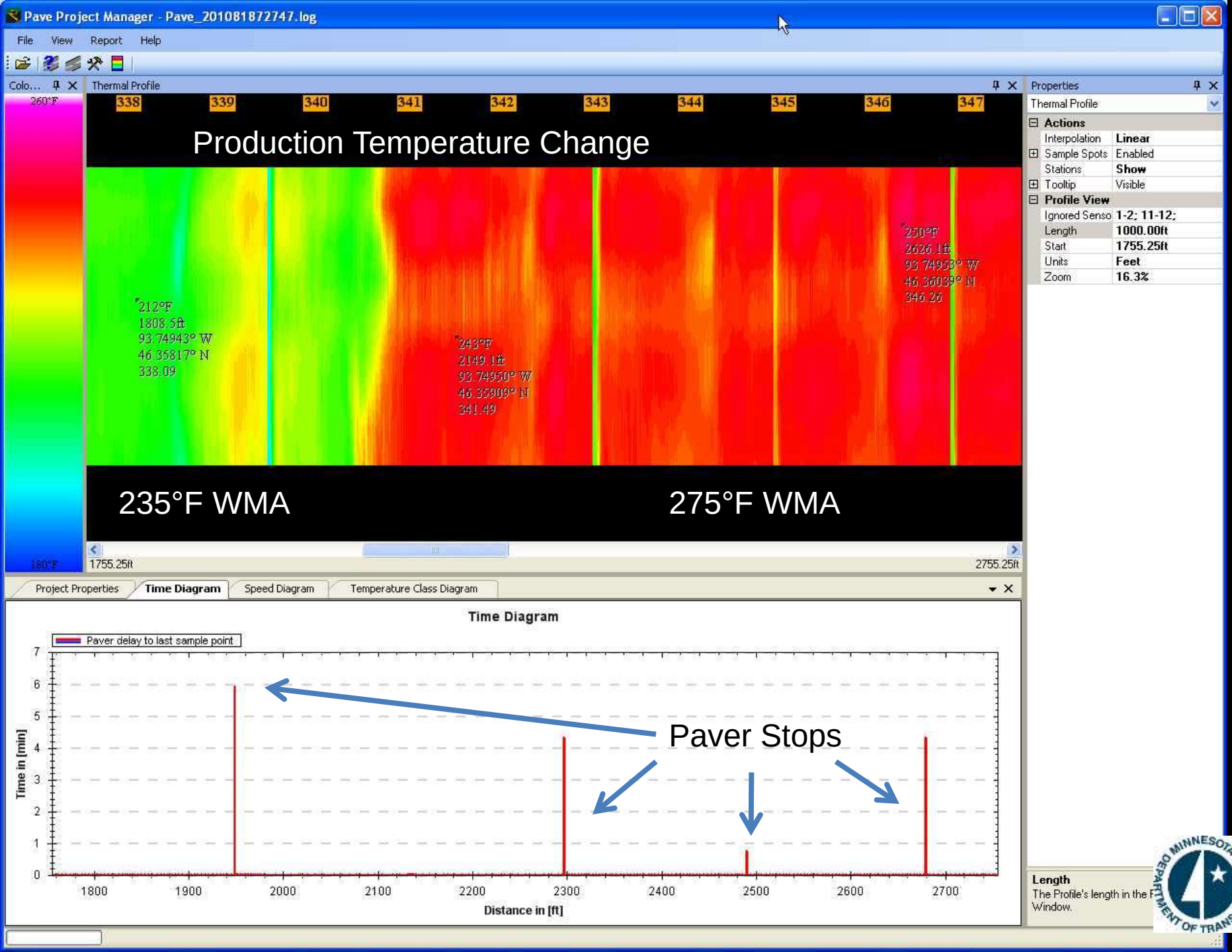


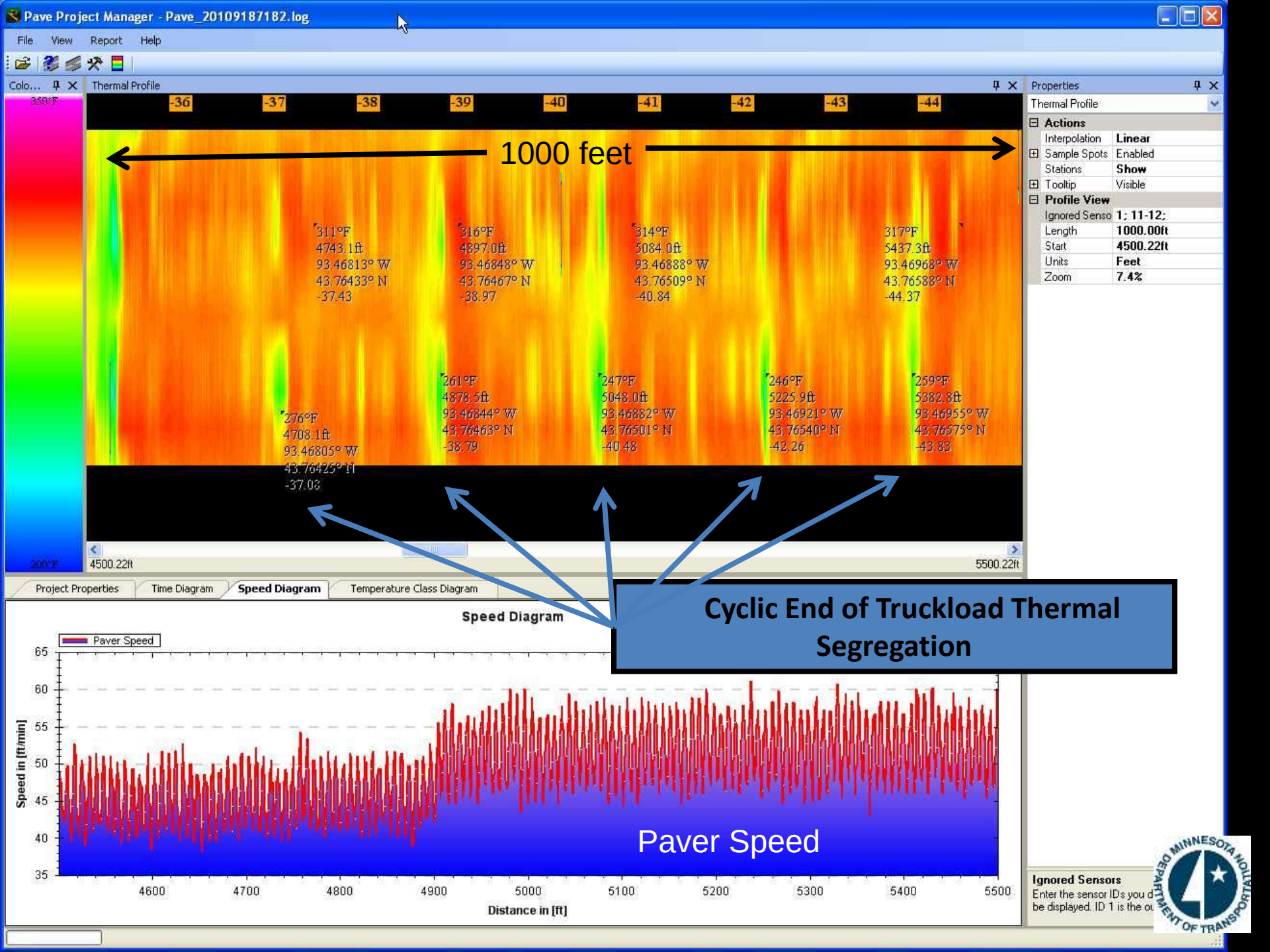
Duration
4 hr 30 min

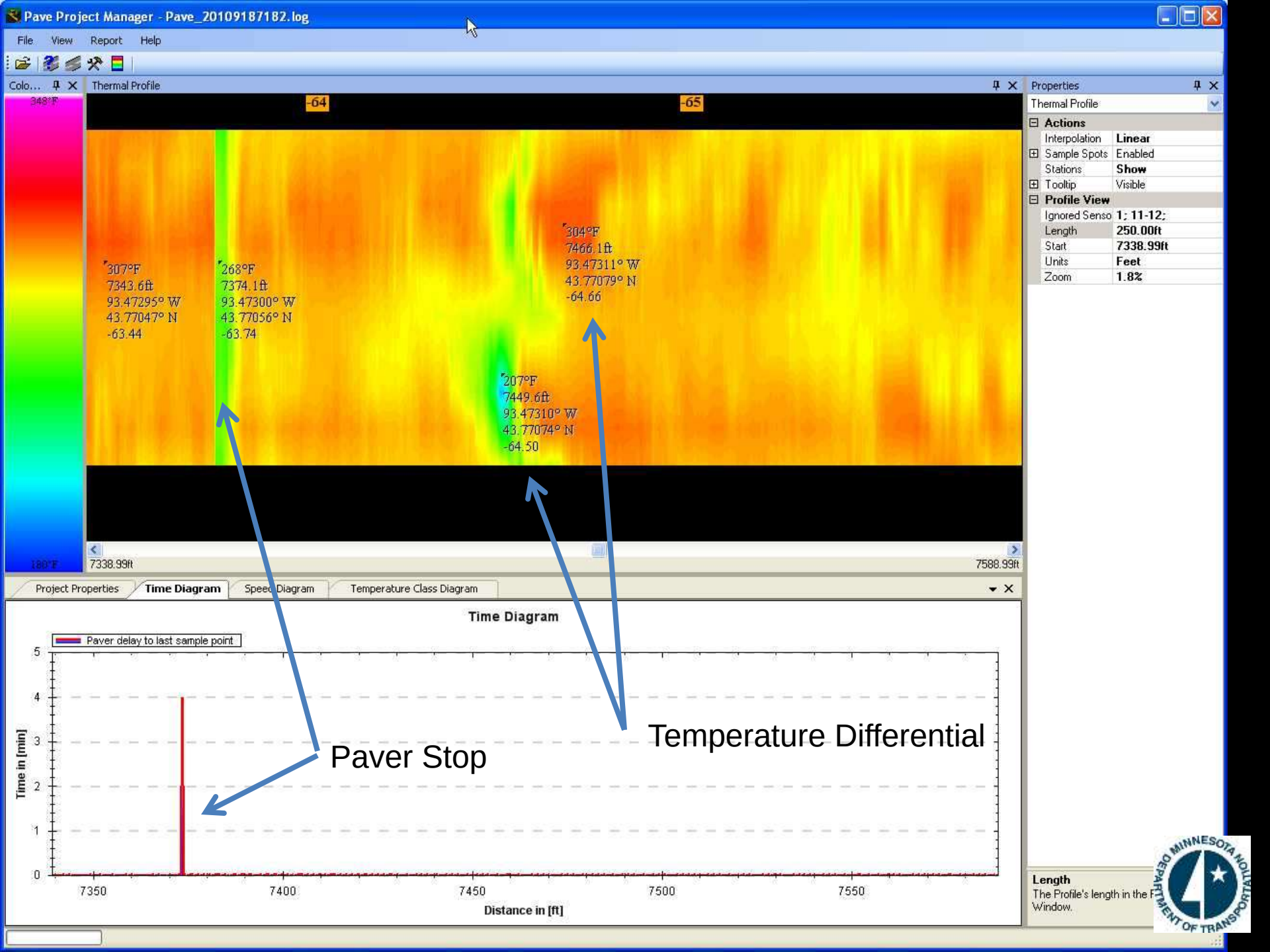
Paver Stops Total
1 hr 25 min

Avg. Paver Speed
36 ft./min

Surface Temp


Pave Project Manager - Pave_201081872747.log
File View Report Help
Thermal Profile
338 339 340 341 342 343 344 345 346 347
Production Temperature Change
212°F
1808.5ft
93.74943° W
46.35817° N
338.09
243°F
2149.1ft
93.74950° W
46.35909° N
341.49
250°F
2626.1ft
93.74953° W
46.36039° N
346.26
235°F WMA
275°F WMA
1755.25ft
2755.25ft
Properties
Thermal Profile
Actions
Interpolation Linear
Sample Spots Enabled
Stations Show
Tooltip Visible
Profile View
Ignored Senso 1-2; 11-12;
Length 1000.00ft
Start 1755.25ft
Units Feet
Zoom 16.3%
Project Properties
Time Diagram
Speed Diagram
Temperature Class Diagram
Time Diagram
Paver delay to last sample point
Time in [min]
Distance in [ft]
Paver Stops
Length
The Profile's length in the P
Window.


Pave Project Manager - Pave_20109187182.log
File
View
Report
Help
Thermal Profile
-36
-37
-38
-39
-40
-41
-42
-43
-44
1000 feet
311°F
4743.1ft
93.46813° W
43.76433° N
-37.43
316°F
4697.0ft
93.46848° W
43.76467° N
-38.97
314°F
5084.0ft
93.46888° W
43.76509° N
-40.84
317°F
5437.3ft
93.46968° W
43.76588° N
-44.37
276°F
4708.1ft
93.46805° W
43.76425° N
-37.03
261°F
4878.5ft
93.46844° W
43.76463° N
-38.79
247°F
5048.0ft
93.46882° W
43.76501° N
-40.48
246°F
5225.9ft
93.46921° W
43.76540° N
-42.26
259°F
5382.8ft
93.46955° W
43.76575° N
-43.83
4500.22ft
5500.22ft
Properties
Thermal Profile
Actions
Interpolation
Linear
Sample Spots
Enabled
Stations
Show
Tooltip
Visible
Profile View
Ignored Senso
1; 11-12;
Length
1000.00ft
Start
4500.22ft
Units
Feet
Zoom
7.4%
Project Properties
Time Diagram
Speed Diagram
Temperature Class Diagram
Speed Diagram
Paver Speed
Speed in [ft/min]
65
60
55
50
45
40
35
4600
4700
4800
4900
5000
5100
5200
5300
5400
5500
Distance in [ft]
Paver Speed
Cyclic End of Truckload Thermal Segregation
Ignored Sensors
Enter the sensor IDs you d
be displayed. ID 1 is the ou
MINNESOTA DEPARTMENT OF TRANSPORTATION


Pave Project Manager - Pave_20109187182.log
File
View
Report
Help
Thermal Profile
-64
-65
307°F
7343.6ft
93.47295° W
43.77047° N
-63.44
268°F
7374.1ft
93.47300° W
43.77056° N
-63.74
304°F
7466.1ft
93.47311° W
43.77079° N
-64.66
207°F
7449.6ft
93.47310° W
43.77074° N
-64.50
7338.99ft
7588.99ft
Properties
Thermal Profile
Actions
Interpolation
Linear
Sample Spots
Enabled
Stations
Show
Tooltip
Visible
Profile View
Ignored Senso
1; 11-12;
Length
250.00ft
Start
7338.99ft
Units
Feet
Zoom
1.8%
Project Properties
Time Diagram
Speed Diagram
Temperature Class Diagram
Time Diagram
Paver delay to last sample point
Time in [min]
Distance in [ft]
7350
7400
7450
7500
7550
Paver Stop
Temperature Differential
Length
The Profile's length in the P
Window.

Temperature Characteristics

2011 Mill & Overlay on TH 35

- May – June (Produced at Plant A)
  - Max. as high as 380°F
  - Mean 313°F
- August – September (Produced at Plant B)
  - Min. 200°F
  - Mean 268°F

Comparison to Texas Thermal Spec Summary

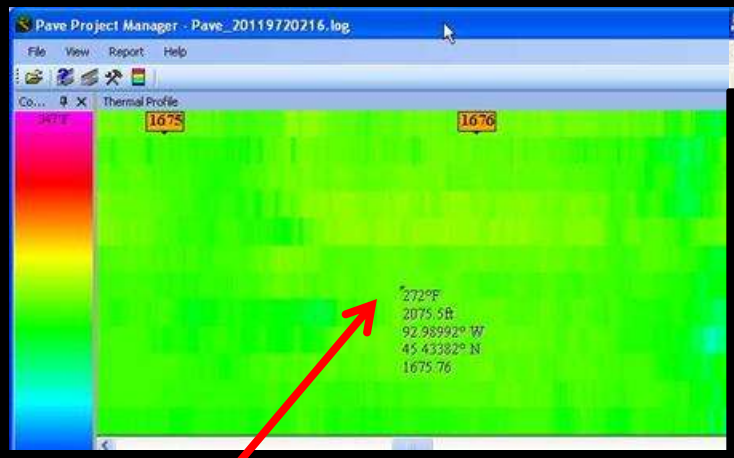
- # of 150 foot profiles = 3448
- May – June
  - 1491 profiles
    - 70% Moderate (25-50°F)
    - 27% Severe (> 50°F)
- August – September
  - 1957 profiles
    - 52% Moderate (25-50°F)
    - 18% Severe (> 50°F)

Pave-IR Benefits

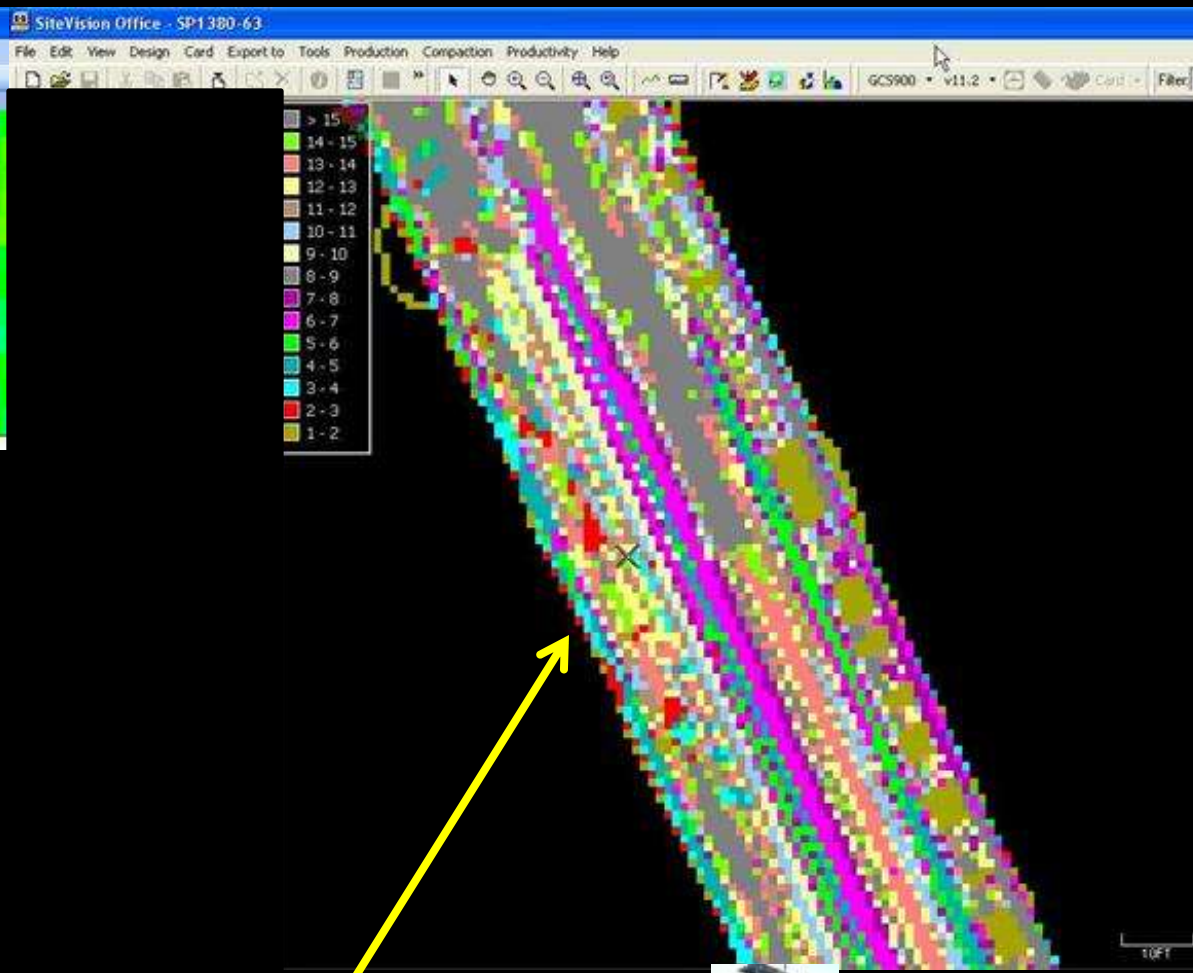
- Real-time feedback to the contractor so needed changes can be made
- Tracks placement characteristics (paver speed, stops, temperature)
- Collects where low/high temperature regions are located
- Improves pavement quality and performance

Putting it Together

Screed Temp – Pass Count- Density



Behind Screed
Temperature =272°F



Density = 95.3%

9/8/2011
10:20 PM – 4 passes CC722
10:42 PM – 4 passes 3105
X=523200.03 y=158977.08

Lot 151.1

Conclusion

IC and Pave-IR together can provide:

- Feedback and control of the paving process
- Increase uniformity of mix placement and compaction
- Increase the performance of our pavements
- Ability to decrease the amount of QC/QA testing needed
- Proof of quality placement and compaction
- Increased accountability

TH 18 (169) Elk River, 1920's

Thank You