# Improving Density, State of Practice: Dielectric (Density) Profiling System

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DEPARTMENT OF TRANSPORTATION

# Background

DPS for Continuous Asphalt Mixture Compaction Assessment

National Pooled Fund TPF-5(443)

DPS Pooled Fund | Contact Us | National Road Research Alliance | MnROAD Home

## Continuous Asphalt Mixture Compaction Assessment Using Density Profiling System (DPS) [TPF-5(443)]

### Objective

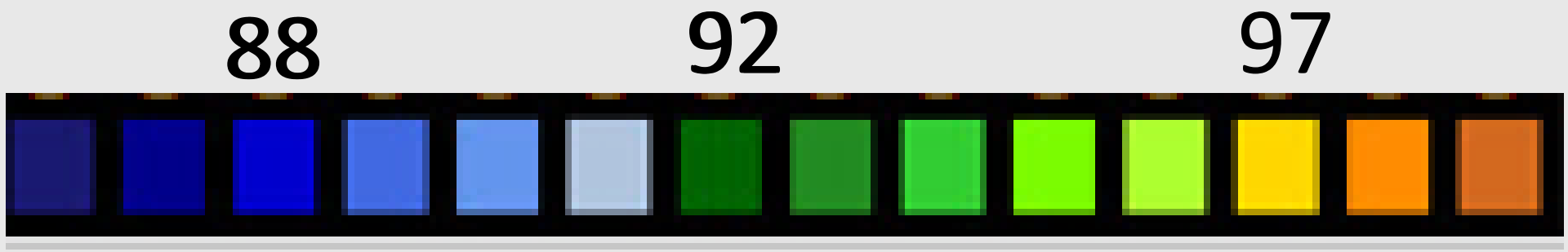
The goal of this pooled fund project is to establish a research consortium focused on:

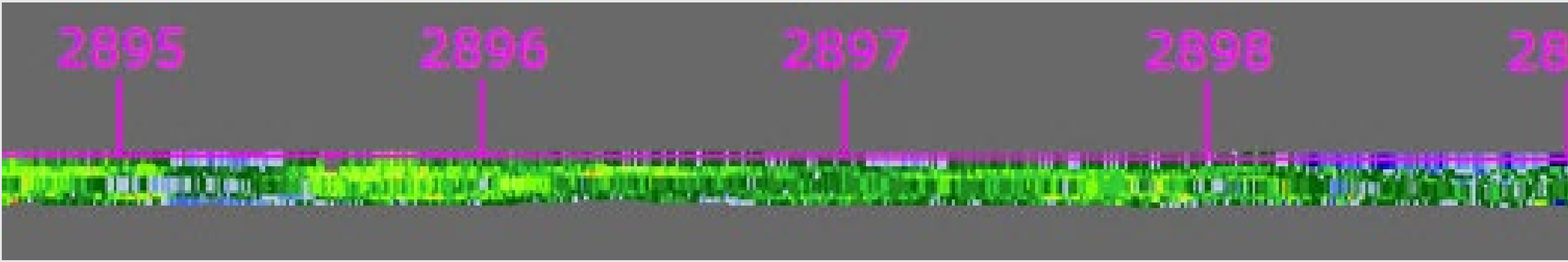
A) further advancing and improving the system based on experience and needs from participants so that the system can effectively and efficiently support their Quality Assurance Programs;
B) support communication;
C) provide training and technical assistance that includes providing support for specification development and strategies for agency full implementation; and
D) conduct technology promotion and marketing for the system.

- DPS Pooled Fund Started in 2020
  - 13 States and FHWA
- Density Profiling Systems (DPS) provide real-time continuous density assessment of the placed asphalt pavement mat after the finish roller.
  - Measures the dielectric constant of the plant-mixed production mix samples to convert dielectric to asphalt density for the given mix
  - Measures the dielectric constant of the top layer of the placed asphalt pavement Mat.
- Goal: Use the DPS method to improve asphalt pavement density
  - Improved coverage and comprehensiveness of assessment
  - Improved feedback
  - Reduce coring

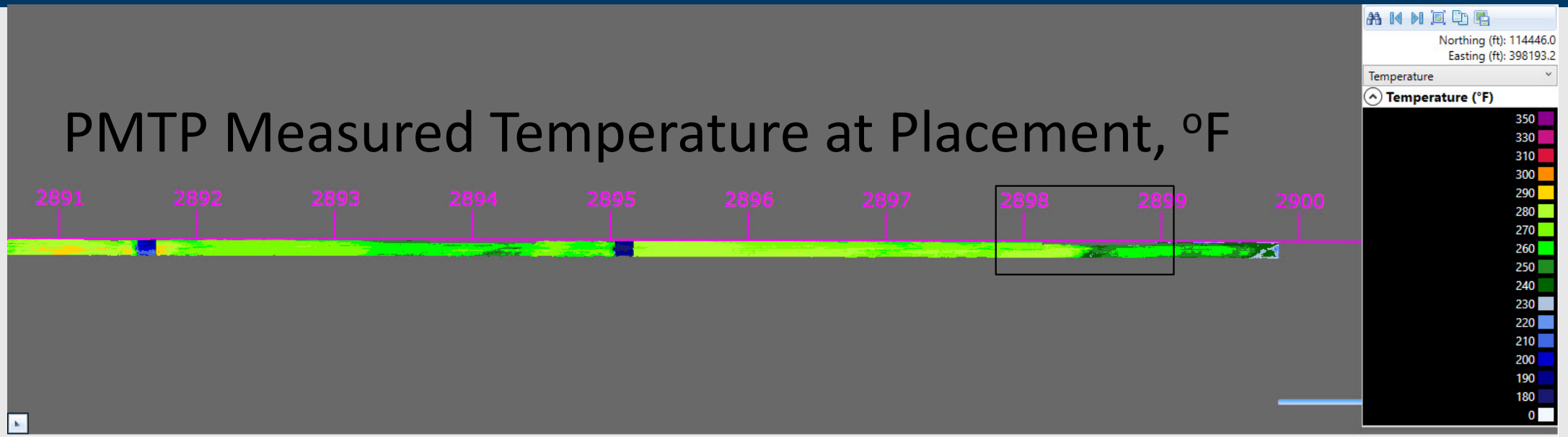
# What DPS Provides: Full Coverage Density Map

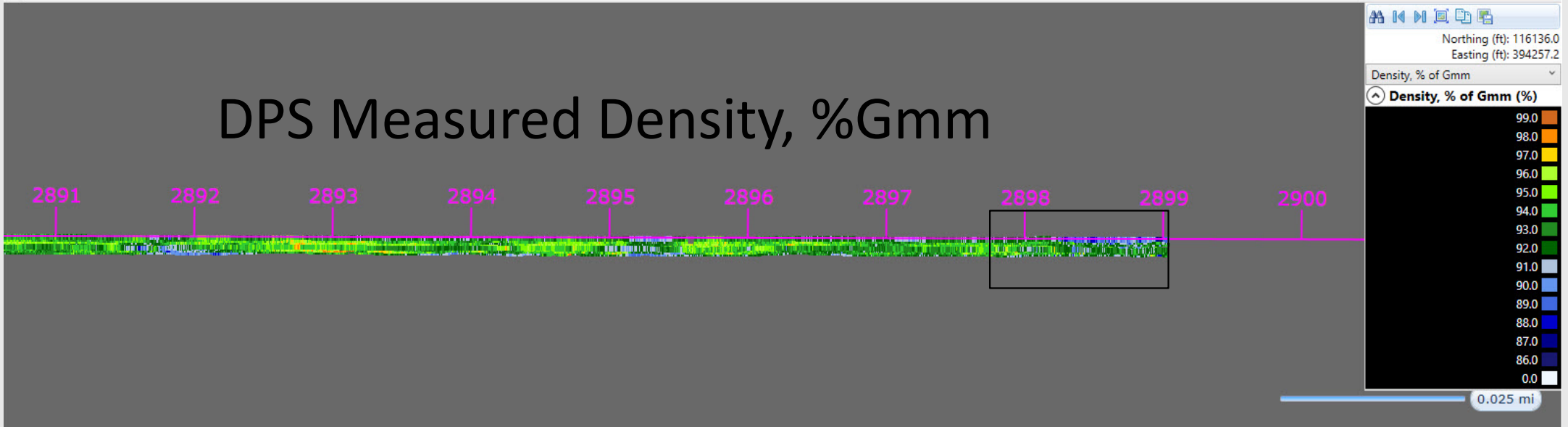
DPS Measured Density, %Gmm



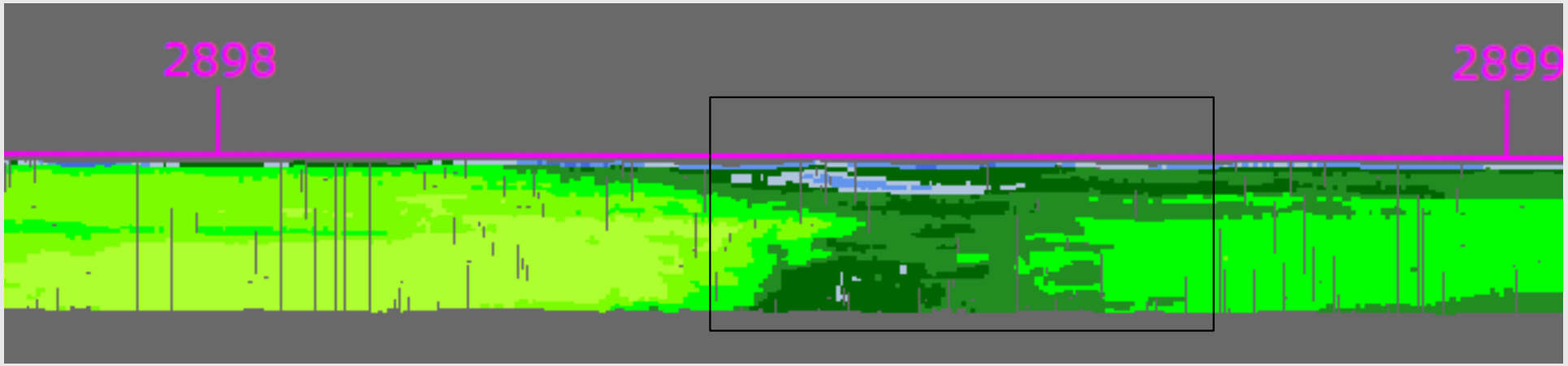
# Comparison with the PMTP (and other ICT)

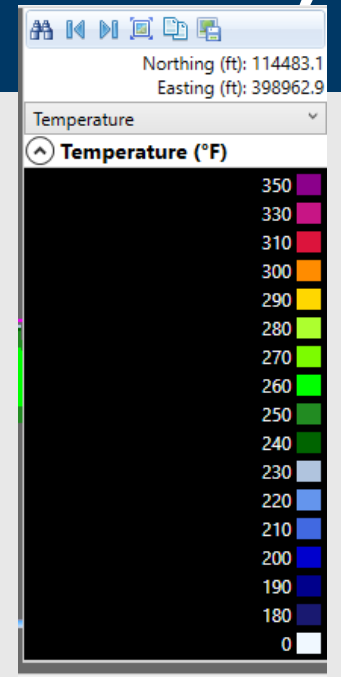


# Comparison with the Paving Process (other ICT)

## PMTP Measured Temperature at Placement, ºF

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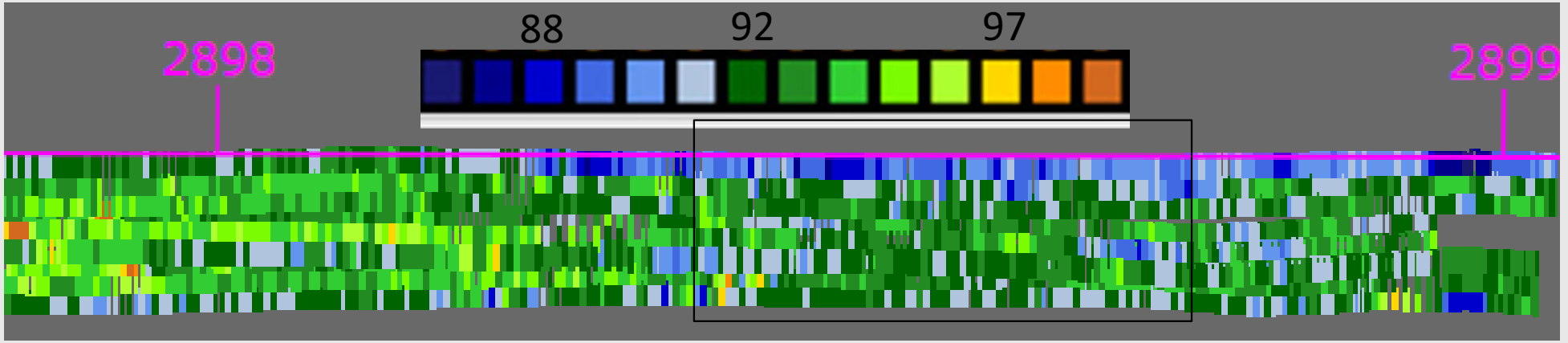


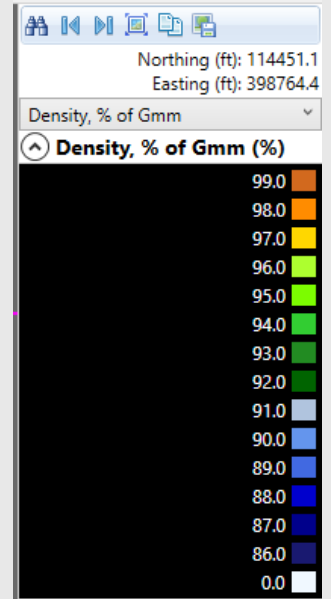

# Data Collection Techniques

# On Site Density Assessment – Percent Conformance

## Joint/Mat % conforming

| | |
|---|---|
| Mat PWL Upper Limit (%) | 99 |
| Mat PWL Lower Limit (%) | 93 |
| Joint PWL Upper Limit (%) | 99 |
| Joint PWL Lower Limit (%) | 92 |
| Joint Line Max. Dist. from Closest Lane Extent (ft) | 0.5 |
| Mat Line Min. Dist. from Closest Lane Extent (ft) | 1 |
| Histogram Bin Interval (%) | 0.1 |
| Histogram Maximum Value (%) | 98 |
| Histogram Minimum Value (%) | 88 |

## Project Information:

| | |
|---|---|
| Project ID | SP1909-99 |
| Route Designation | TH55-WB |
| Material | HMA |
| Divided Highway | Yes |
| Date Paved | 05/10/2022 |
| Lift Thickness (in) | 2 |

## Lane Extents

| Lane # | Near Offset Dist | Near Offset Joint Type | Far Offset Dist | Far Offset Joint Type |
|---|---|---|---|---|
| 1 | 0 | Confined | 12L | Confined |
| 2 | 0 | Confined | 12R | Confined |

# On Site Density Assessment – Percent Conformance

Summary Statistics PaveScan RDM Statistics Loaded

| Distance Range | Start Station | End Station | Min Lat Offset | Max Lat Offset | Mat PWL | Joint PWL | Mat Median | Joint Median | Mat St Dev | Joint St Dev |
|---|---|---|---|---|---|---|---|---|---|---|
| Segment | 76+00 | 77+00 | 0 | 12R | 53.39 | 60.61 | 92.09 | 91.38 | 1.09 | 1.33 |
| Segment | 76+00 | 77+00 | 0 | 12L | 84.15 | 69.82 | 92.99 | 91.62 | 1.04 | 1.1 |
| Segment | 77+00 | 78+00 | 0 | 12R | 70.64 | 74.45 | 92.68 | 92.42 | 1.25 | 1.65 |
| Segment | 77+00 | 78+00 | 0 | 12L | 61.33 | 74.95 | 92.3 | 91.79 | 1.16 | 1.13 |
| Segment | 78+00 | 79+00 | 0 | 12R | 60.9 | 70.53 | 92.36 | 91.95 | 1.27 | 1.57 |
| Segment | 78+00 | 79+00 | 0 | 12L | 75.53 | 62.38 | 92.68 | 91.46 | 1.01 | 1.28 |
| Segment | 79+00 | 80+00 | 0 | 12L | 42.89 | 66.37 | 91.8 | 91.64 | 1.05 | 1.31 |
| Segment | 79+00 | 80+00 | 0 | 12R | 49.97 | 49.23 | 91.99 | 90.97 | 1.06 | 1.13 |
| Segment | 80+00 | 81+00 | 0 | 12R | 70.41 | 24.82 | 92.51 | 90.18 | 0.98 | 1.52 |

# On-Site Density Assessment – Process Control

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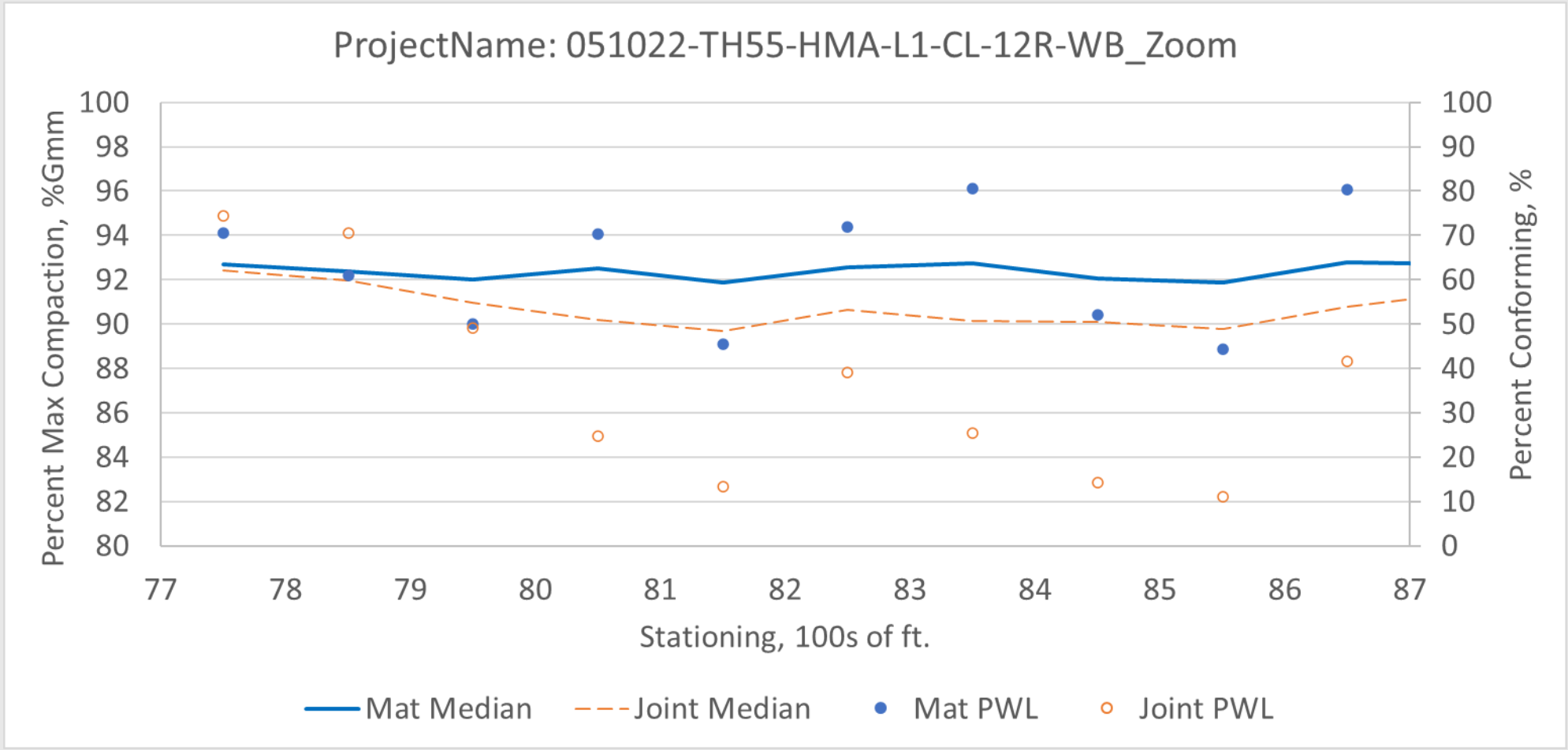

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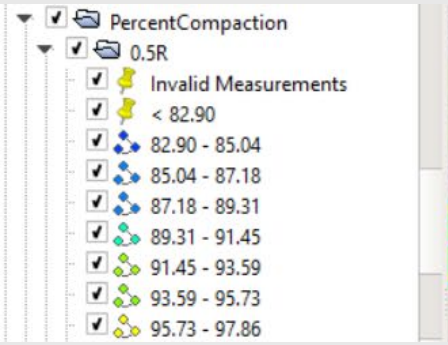


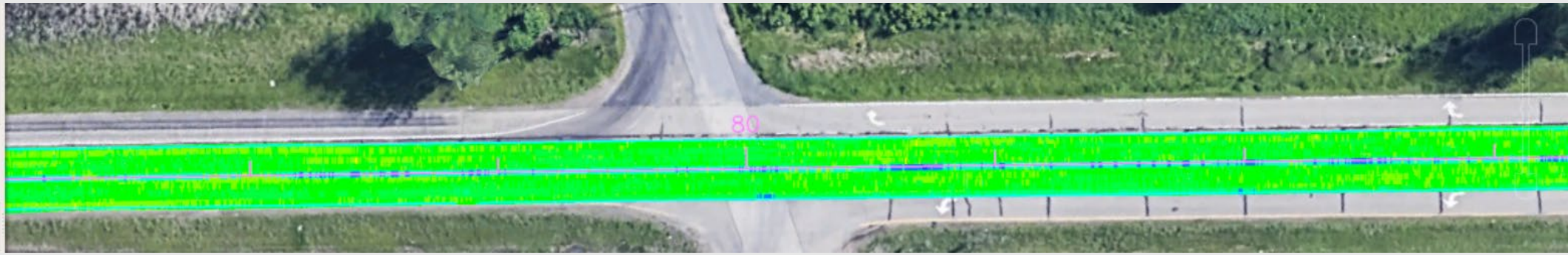

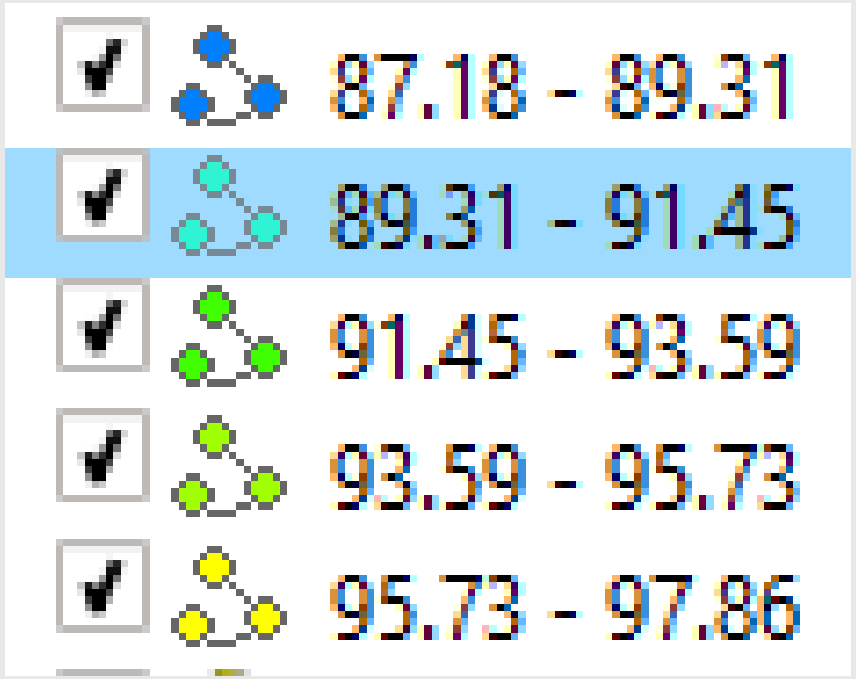


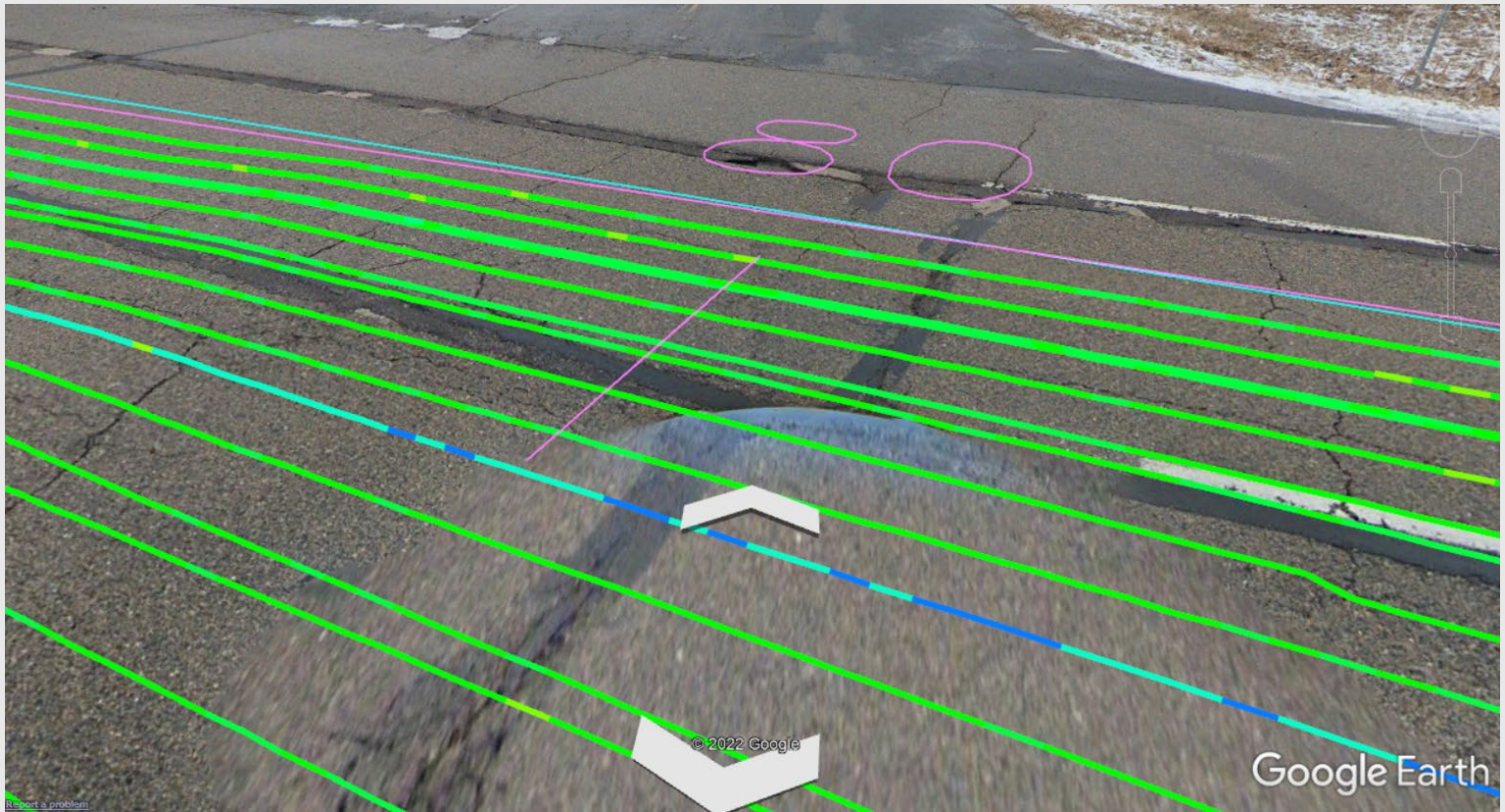


3/16/2023

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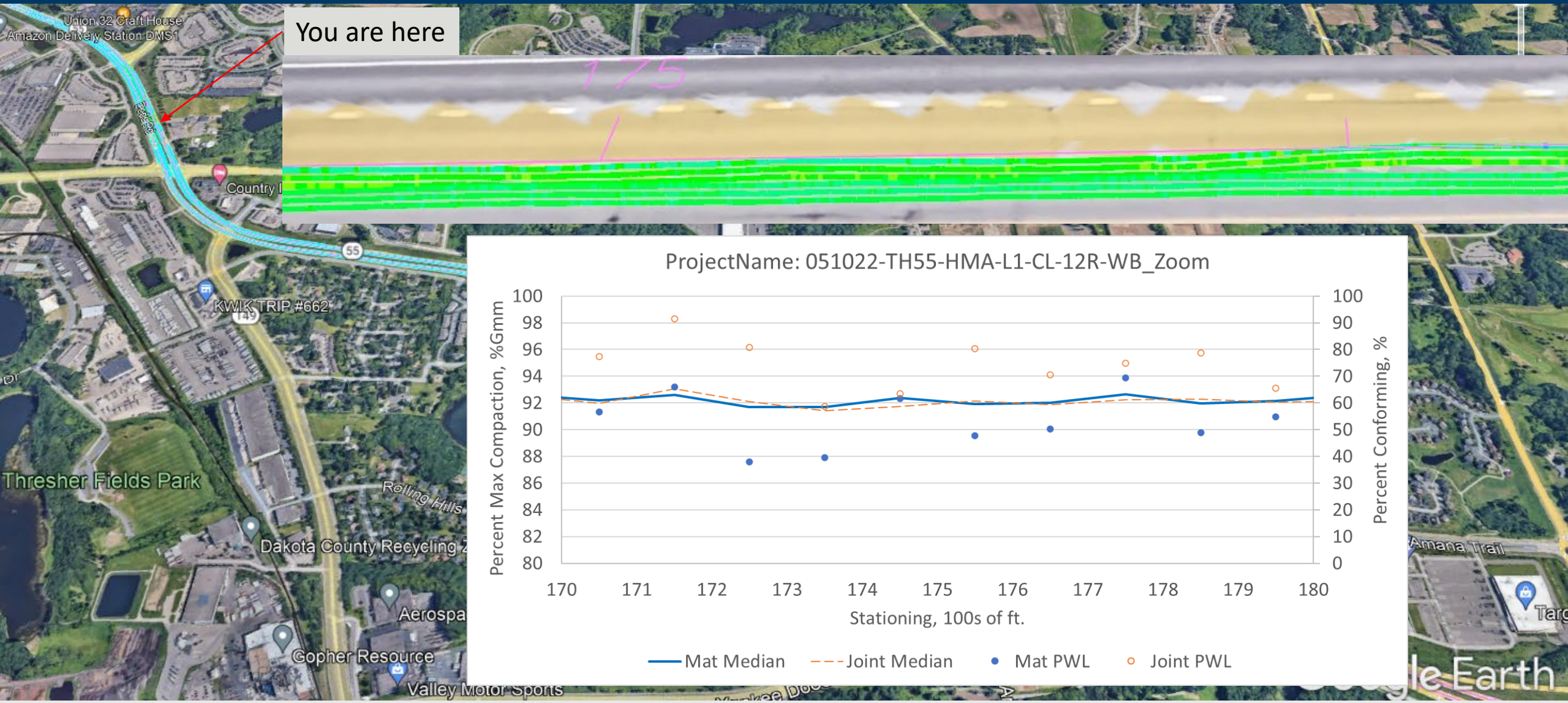

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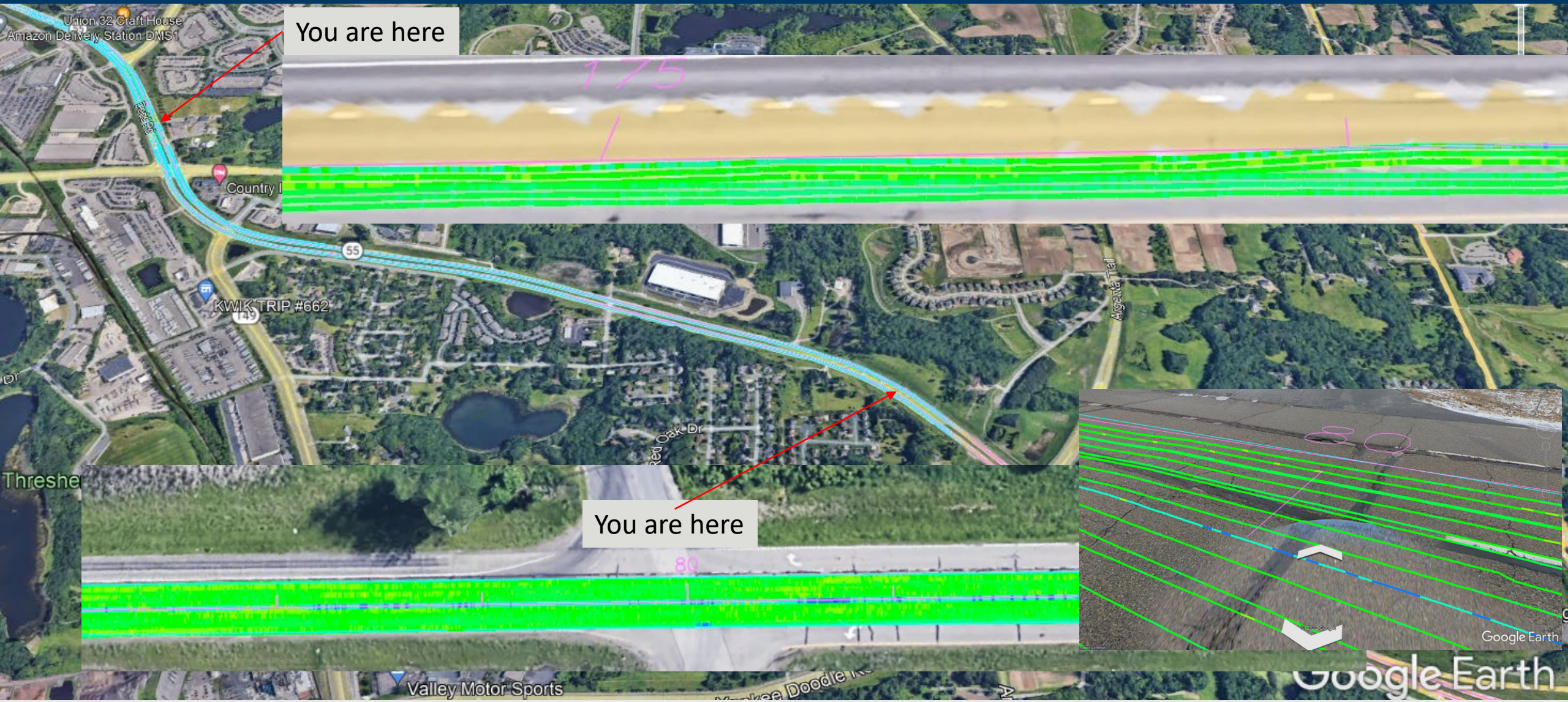

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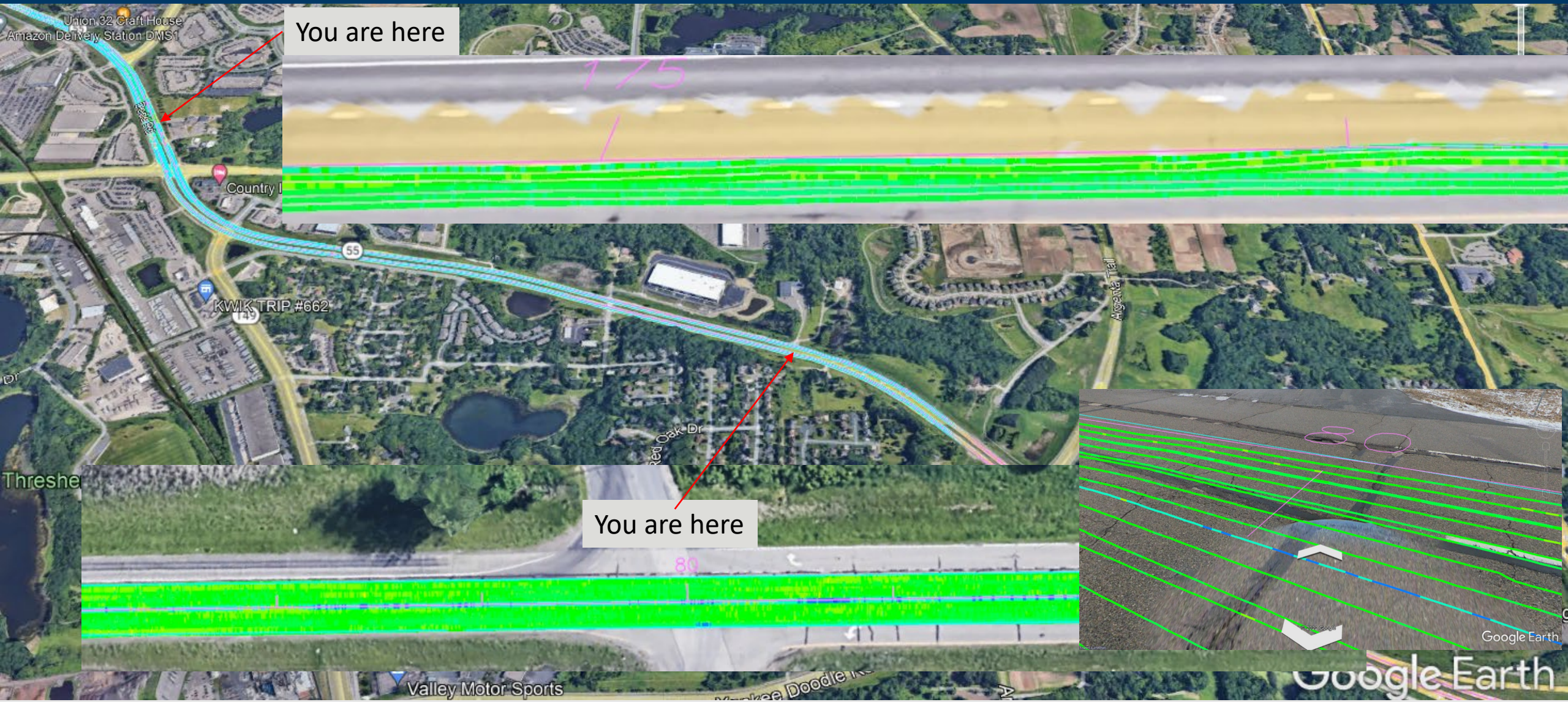

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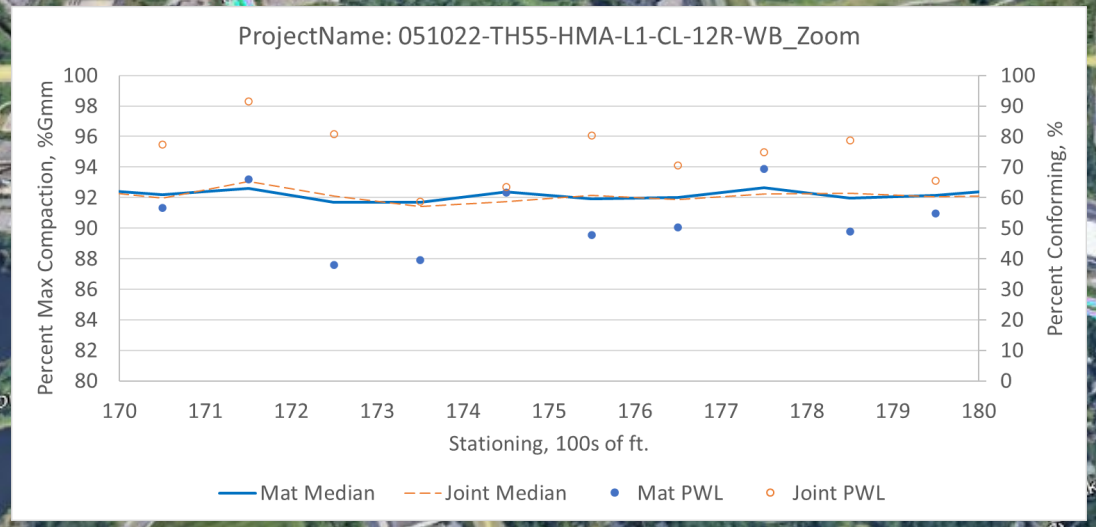


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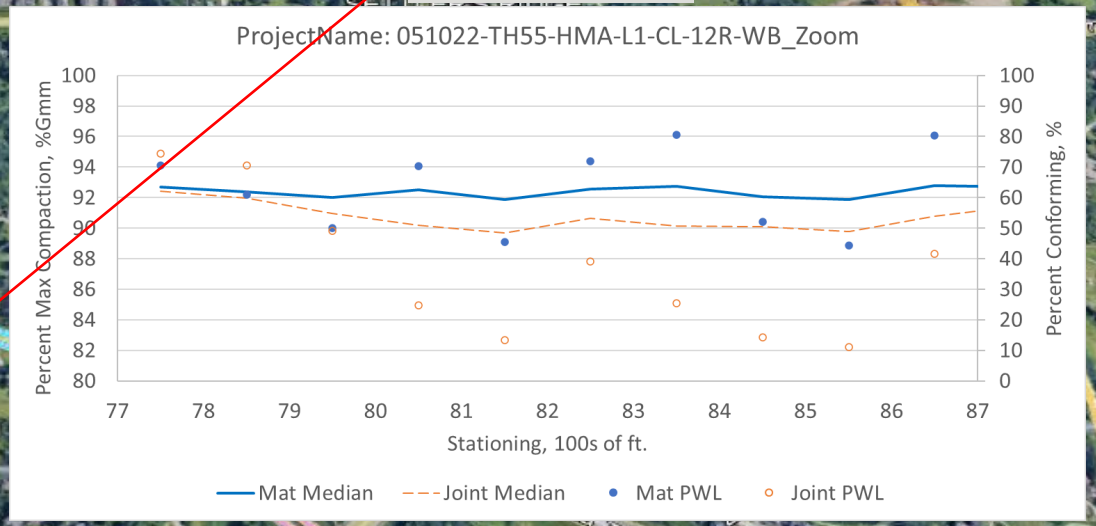

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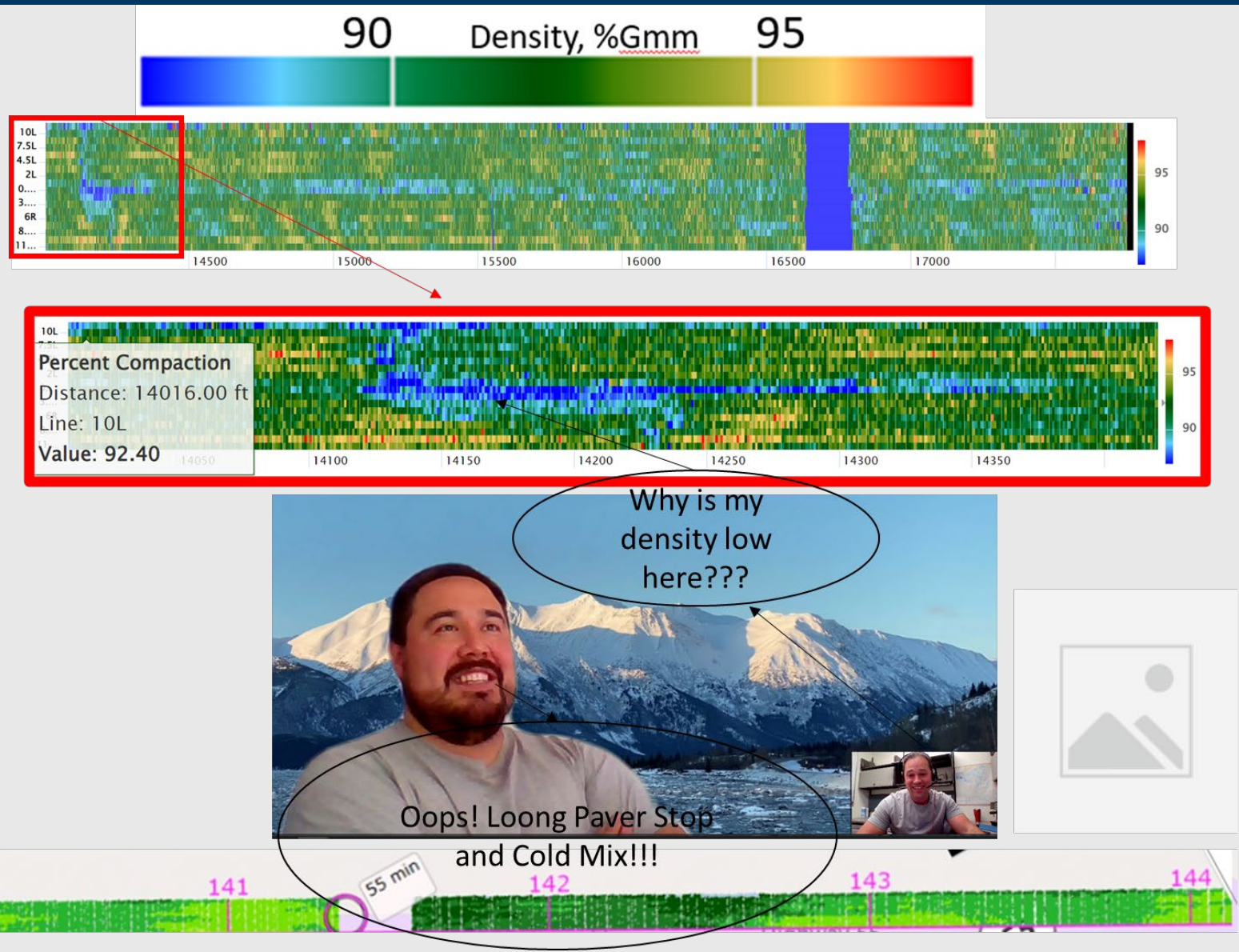


# Case Study – Process Improvement

**DPS DIGEST**

SEPTEMBER 2022

## Contractors, ask yourselves one question: Do you feel lucky?

CONTRACTORS ROUTINELY cut cores from the roadway after construction to verify the pavement meets minimum density requirements. These singular random coring locations are used as the basis for acceptance of a larger portion of the pavement. The density results affect contractors and owners alike; for owners such as transportation agencies, a good core result can foretell the road's long-term durability, while contractors often have conditional financial incentives built into their contracts. However, since these cores represent only a small portion of the pavement and not the entire paved area, a core that passes or fails density requirements may be more indicative of a contractor's good or bad luck than of a well-compacted pavement.

*By rolling a DPS unit over the newly paved roadway, crews measured the pavement's density in real time.*

A dielectric profiling system (DPS), sometimes referred to as a density profiling system, can give all stakeholders assurance that a core sample taken from anywhere in the pavement is representative of the larger portion of pavement. To test the capabilities of DPS technology in the field, the Minnesota Department of Transportation (MnDOT) collaborated with a team of contractors on a recent state highway repair and rehabilitation project. Working together, the groups used DPS to monitor compaction and map areas of high and low density in real time, giving crews the opportunity to determine optimal rolling configurations and operational strategies.

### THE CHALLENGE

Traditionally, once the compaction equipment has completed its final pass over an asphalt pavement a contractor's role in the road construction process ends. However, acceptance and final payment remain in play, hinging on the results of a relatively small group of randomly selected cores that are tested by the owner to validate whether density meets specifications.

If all goes well, cores tested the next day will show whether the finished pavement meets the minimum requirements for density,



typically between 92% and 96% depending on specification requirements. But if the cores indicate the pavement is less dense than it should be, the contractor may be subject to reduced payment, or in some cases, may be required to remove and replace the sub-standard pavement. With so much time and money on the line, the process can feel like a high-stakes game of chance.

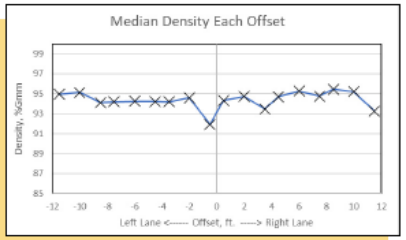
DPS can give contractors more control over this outcome. By measuring and mapping the density of the entire pavement during construction, the contractor can spot deficiencies in their practices and make improvements in real time.

### THE EVIDENCE

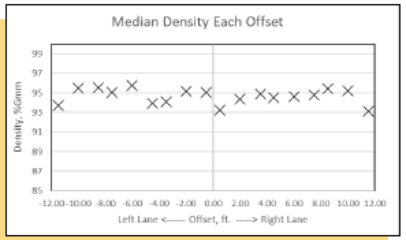
Construction of a 12-mile stretch of a multi-lane highway in Minnesota took place during the summer of 2022. As the road's owner and lead state of the pooled fund investigating and advancing DPS technology, MnDOT identified this project for a case study to test DPS technology and its ability to improve construction practices in the field.

MnDOT employed a rolling DPS unit to accurately measure the pavement's density. DPS results were interpreted by MnDOT engineers using the on-site software to give feedback to the contractor about the density achieved during paving.

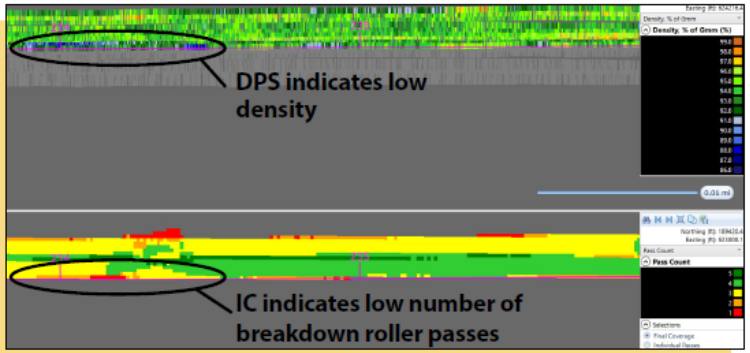
The data collected by the DPS unit generally indicated a median pavement density between 94% and 95%. However, there were sections of lower density along the left lane longitudinal joint. Mapping the pavement's density provided a more complete picture that allowed for determination of specific construction practices that could be improved.




*DPS data collected during initial paving identified areas of lower density at the longitudinal joint.*




*DPS results showing the density improvement after the contractor made their proposed adjustments.*




*Use of Veta software to compare DPS measured density maps (top) with intelligent construction measured breakdown roller vibratory passes (bottom) to identify opportunities for construction process improvements.*

**DPS DIGEST** September 2022

*Collected data is shown on the equipment's screen, allowing for compaction adjustments in real time.*

Comparing the DPS data with information collected from other intelligent construction (IC) technologies, engineers verified the lower density locations were often caused by a reduced number of vibratory roller breakdown passes. MnDOT presented the findings to the contractor, who diagnosed potential causes and proposed plans for improving operations.

The contractor suggested operator inexperience as one possible cause that could be improved upon through coaching by an experienced colleague. Another possibility noted by the contractor was inconsistent distance between pavers on this echelon paving project. Ideally, during echelon paving, two pavers work simultaneously to pave both lanes as close to one-another as practical. Due to logistical challenges, the distance between the pavers varied at times up to 250 ft. The contractor suggested always keeping the second paver within 150 ft. of the first paver to help improve the compaction results.

MnDOT used DPS to measure an adjacent section of pavement on the same project after the contractor incorporated these lessons learned. The DPS results showed that the lower density locations associated with an inexperienced roller operator and inconsistent distance between echelon pavers were significantly improved.

### THE MAJOR ACCOMPLISHMENTS

This project demonstrated the value that DPS technology can bring to asphalt pavement construction. While DPS continues to evolve, the tools available on the market today can provide insight to help and improve construction practices. The case study from this tech brief gave an example where the DPS information was used along with other IC technology to target two construction practices to improve density on the longitudinal joint. This is just one example of many possible refinements that could lead to better compaction through more widespread use of DPS technology.

And when the inspector arrives onsite to take core samples of the finished pavement, DPS can provide something even more valuable: peace of mind.

### ABOUT THIS POOLED FUND

**Continuous Asphalt Mixture Compaction Assessment using Density Profiling System (DPS)**

**TPF-5(443)**

#### Program Managers

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#### Participating Agencies

FINANCIAL CONTRIBUTORS
Federal Highway Administration
Idaho DOT
Maine DOT
Maryland DOT
Michigan DOT
Minnesota DOT
Mississippi DOT
Missouri DOT
New York DOT
North Dakota DOT
Ohio DOT
Pennsylvania DOT
Utah DOT
Washington DOT
Wisconsin DOT

TECHNICAL CONTRIBUTORS
Alaska DOT&PF
Florida DOT
Nebraska DOT

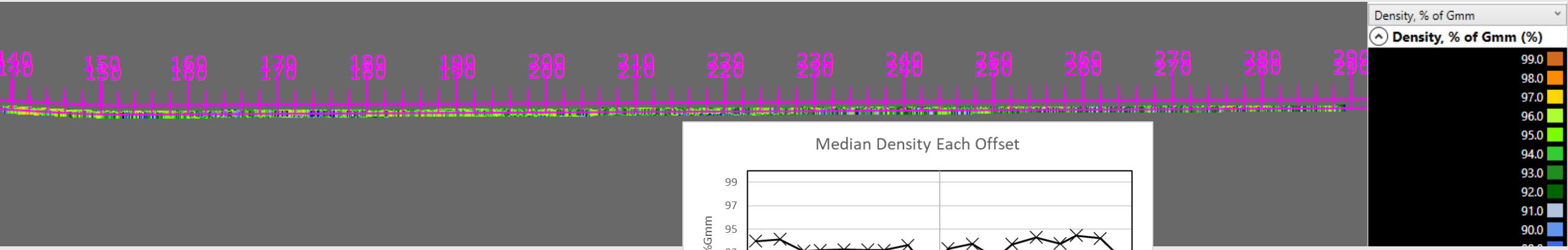
#### Related Resources

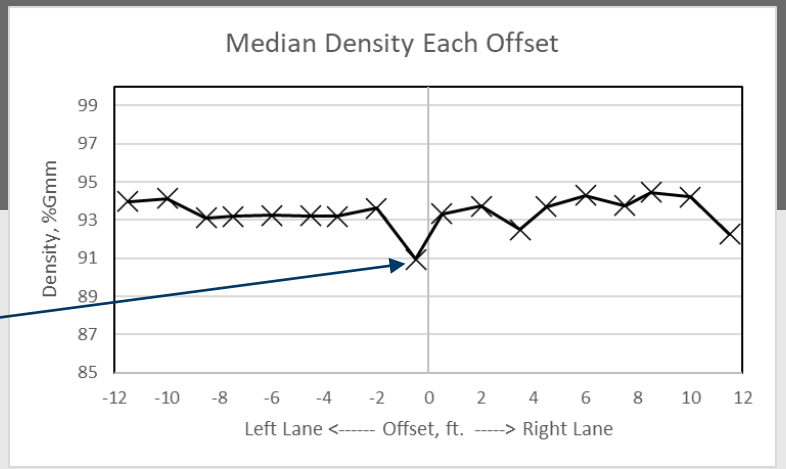
*DPS Digest: States Pool Resources to Advance Pavement Density Research*
*DPS Digest* on Dielectric Measurements (Forthcoming)
DPS Pooled Fund YouTube Channel
DPS Pooled Fund Website
DPS Pooled Fund Page on FHWA's Pooled Fund Program Website

Produced by CTC & Associates LLC

# Case Study – Process Improvement

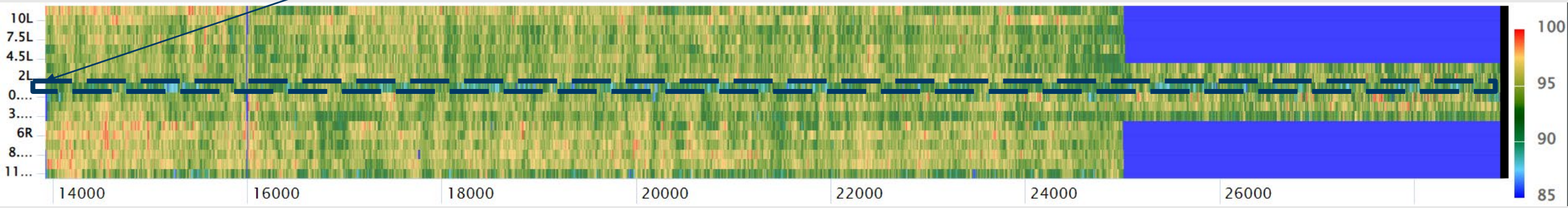
Veta




Occasional low density 6” Left of CL joint

PaveScan: On-Site Software



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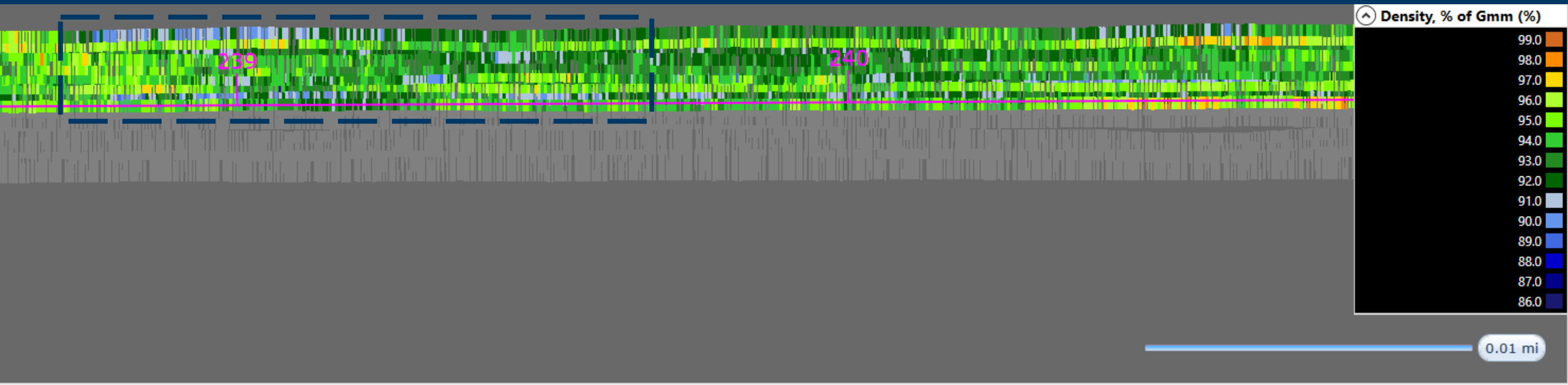
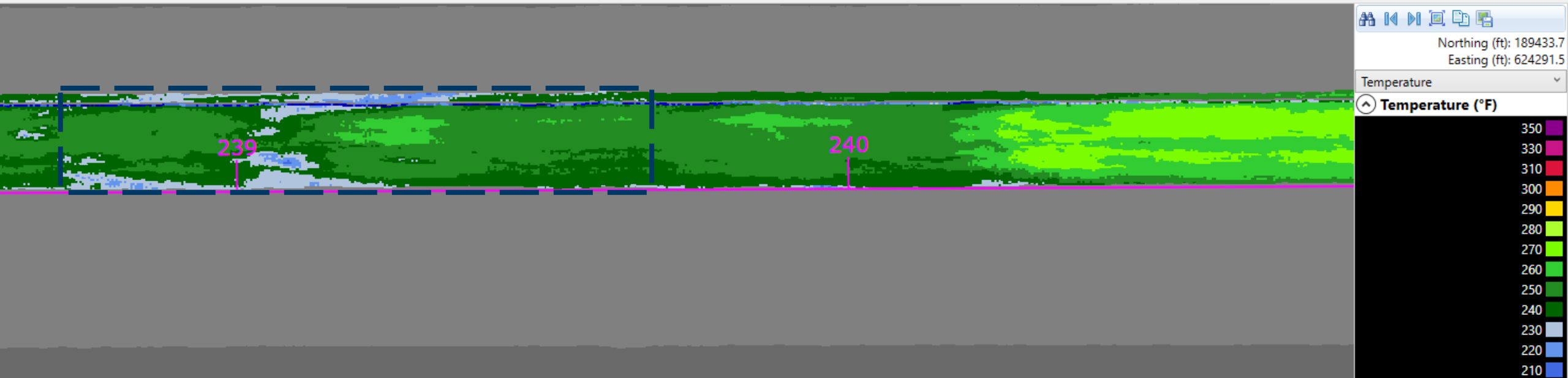
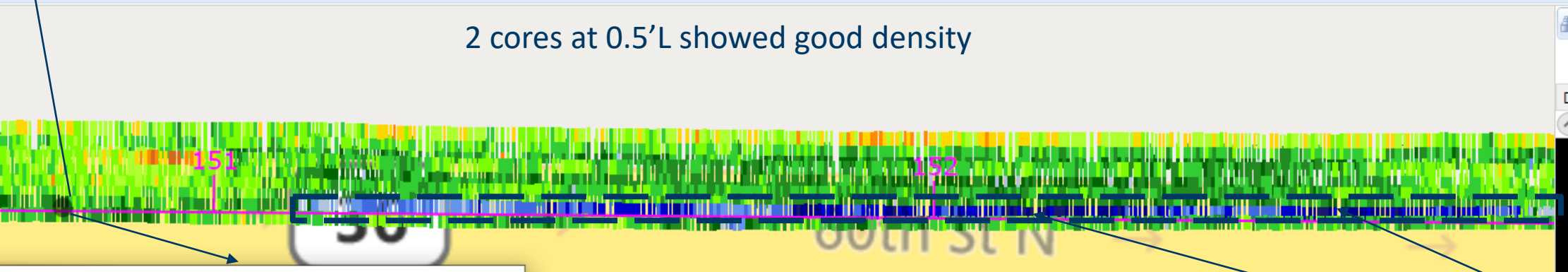


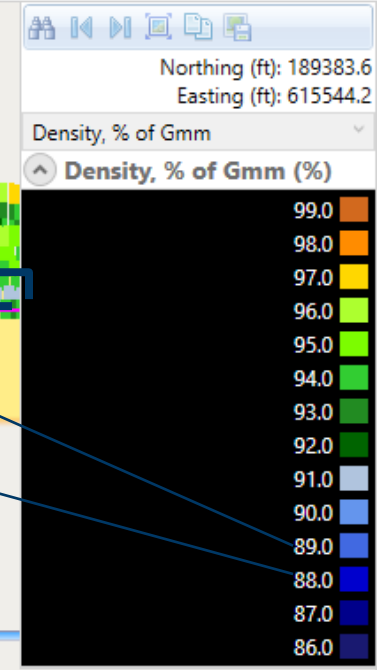



# Case Study – Process Improvement

| Value | Alignment file | Alignment | Line | Station file | Station alignment | Region | Station (ft) | Offset (ft) |
|---|---|---|---|---|---|---|---|---|
| 92.6 | Intelligent_Construction_.xml | ST36EB | ST36EB | Intelligent_Construction_.xml | ST36EB | Region 4 | 150+79 | -0.5 |
| 93.2 | Intelligent_Construction_.xml | ST36EB | ST36EB | Intelligent_Construction_.xml | ST36EB | Region 4 | 233+96.61 | -0.5 |

2 cores at 0.5’L showed good density



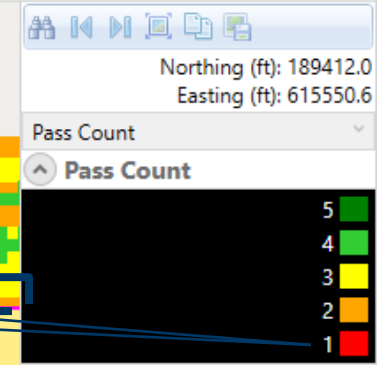




DPS Measurements

| Dielectric Height (in) | Dielectric Quality | Density, % of Gmm (%) | Air voids (%) |
|---|---|---|---|
| 8.96 | 89 | 92.6 | 7.4 |
| 8.93 | 89 | 92.9 | 7.1 |
| 9.01 | 89 | 92.3 | 7.7 |
| 9.01 | 89 | 92.1 | 7.9 |

Core located in good spot according to core and DPS data, but 50 to 150 ft up station would have been much lower

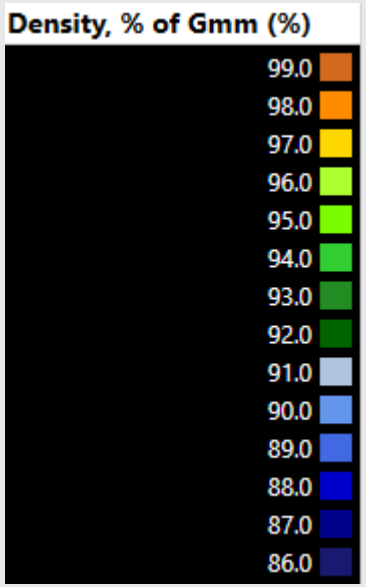
- May want to look at operations in low spots vs high spots
- Reduce risk of 0.5’L core for WB paving.
- Breakdown roller vib passes near joint seems to be correlated well with result (less than 3 passes near joint in bad spots)

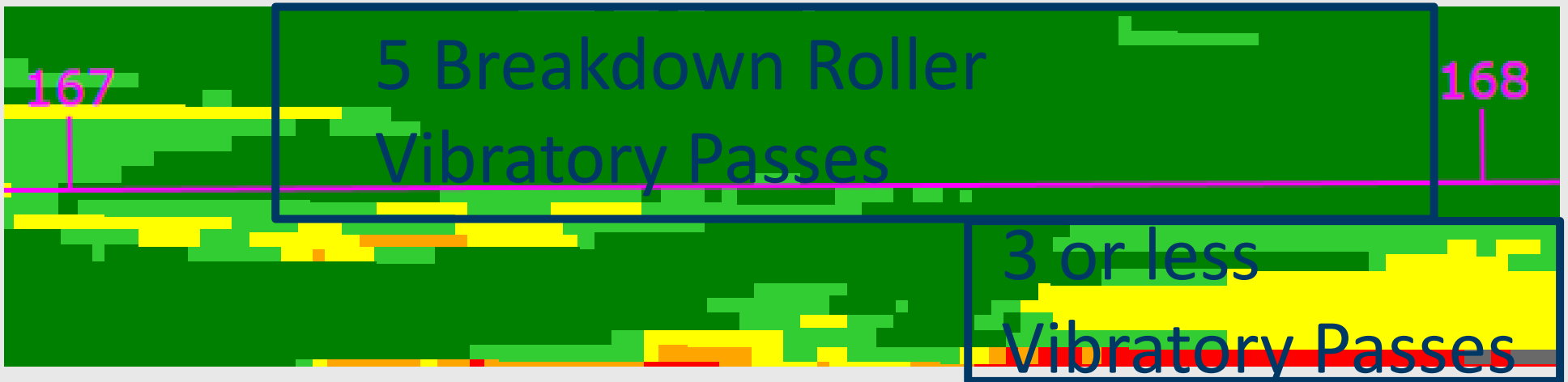
# Case Study – Process Improvement

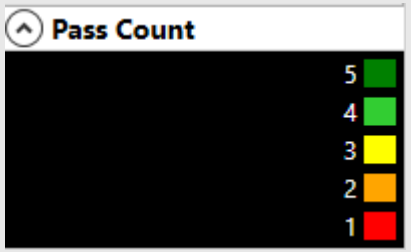
Primary Correlation with Consistent High Density: Breakdown Roller Pass Count

DPS Measured Density


IC Measured Breakdown Roller Pass Count

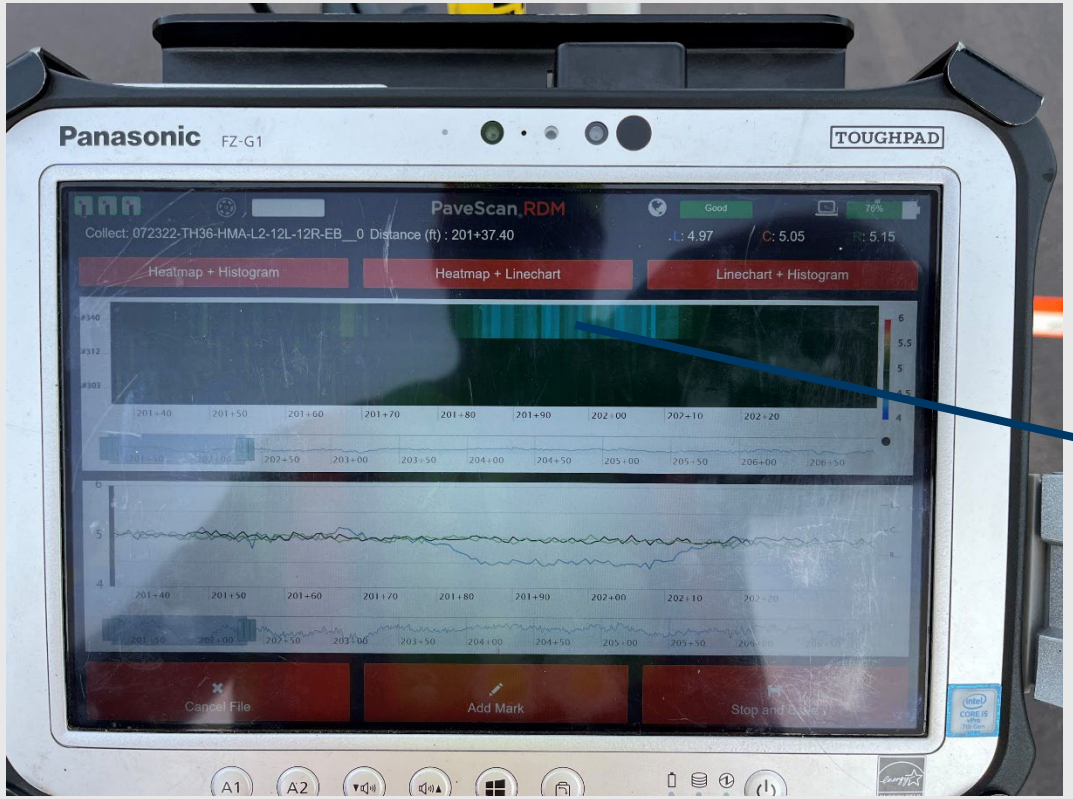


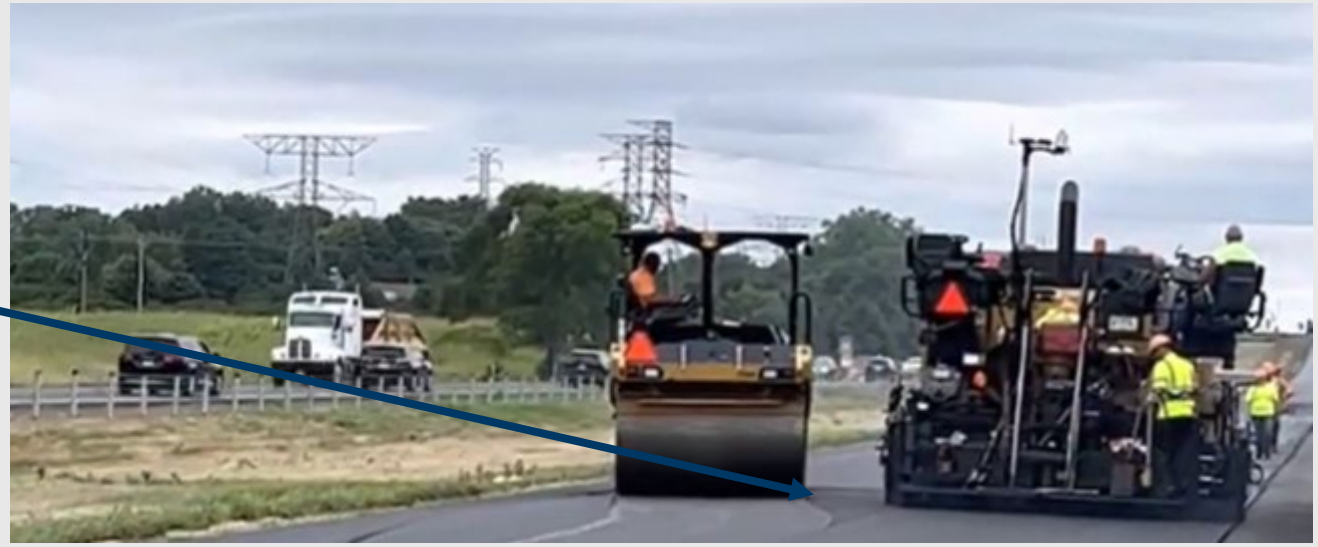



# Case Study – Process Improvement

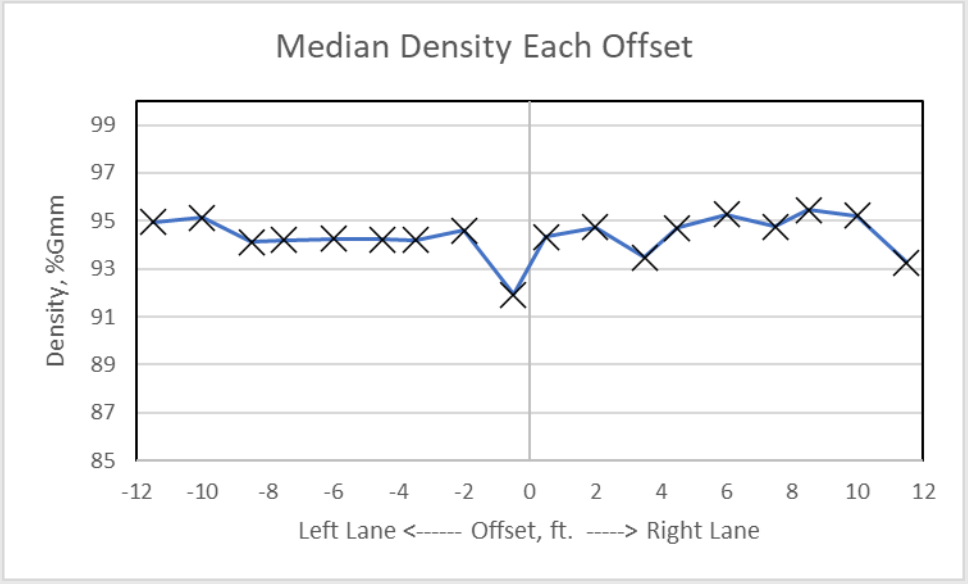
- Contractor took the feedback and produced the following possible problems and solutions to improve the density
  - They had a new breakdown roller operator who didn't know how close he was supposed to get to the joint before they mash the echelon edge (will train/coach new roller operator about best practice)
    - Keep 6 in. away, but if you have both lanes you can run closer if adjacent lane is paved
  - Left Lane paved first and 2nd paver in right lane was back about 250 ft. at times. This caused reduced passes until later since the breakdown is going around and staying away so they can mash as echelon edge later after both lanes are paved. (will try to keep pavers within 100/150 ft)
  - Breakdown in left lane less passes than right lane. Left lane did 2 passes. (Left lane was also busy with shoulder work which will get corrected, so it is dedicated to the mainline)

# Case Study – Process Improvement

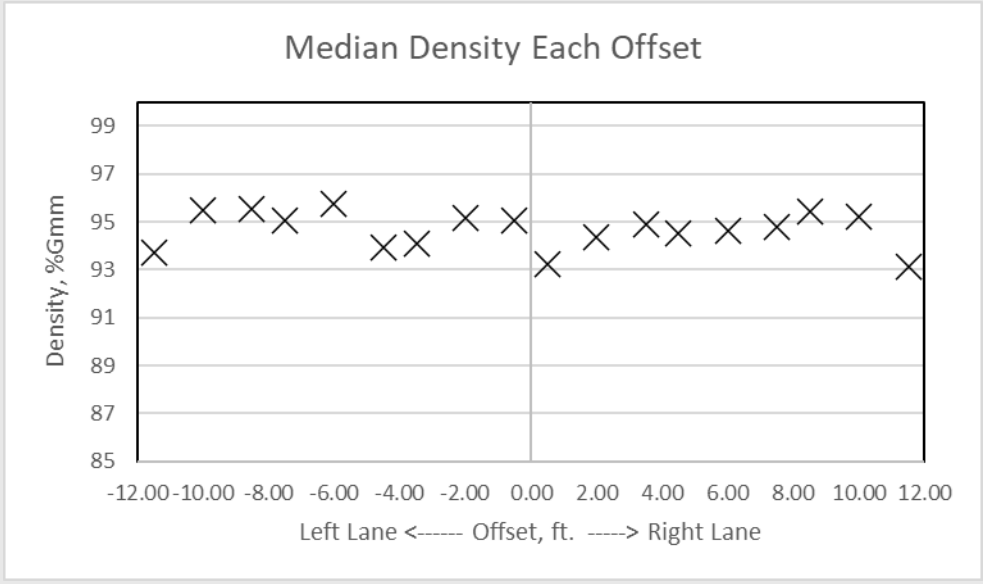


# Case Study – Process Improvement




mndot.gov



ISIC

INTERNATIONAL SOCIETY FOR INTELLIGENT CONSTRUCTION

# ISIC Webinar No. 5

# How Veta Leverages the Values of Intelligent Construction Technologies


**March 30th, Thursday, 2023**
**9 AM to 11 AM US CST**
**(2 PM WET, 10 PM Beijing Time)**


George K. Chang
Transtec Group

THE TRANSTEC GROUP
The World's Pavement Engineering Specialists

Rebeca Embacher
MnDOT

DEPARTMENT OF TRANSPORTATION

Michael Johnson
MnDOT

DEPARTMENT OF TRANSPORTATION

Forrest Hierholzer
Granite Construction

GRANITE

# DPS National Pooled Fund Program

SCAN ME: Contact Us

**Continuous Asphalt Mixture Compaction Assessment Using Density Profiling System (DPS) [TPF-5(443)]**

- **Objective:** Use the DPS method to improve asphalt pavement density
  - Increased coverage and comprehensiveness of assessment
  - Timely information to improve construction process
  - Reduce coring
- **Lead Agency:** MnDOT
  - Contact: Kyle Hoegh, kyle.hoegh@state.mn.us (MnDOT)
- **Committed agencies: MN, FHWA, GA, ID, MD, ME, MO, MS, ND, NY, OH, PADOT, UT, WA, WI**
- **100% SP&R Approval:** Approved
- **Commitment level**: $25K/year

U.S. Department of Transportation
Federal Highway Administration

+

DEPARTMENT OF TRANSPORTATION

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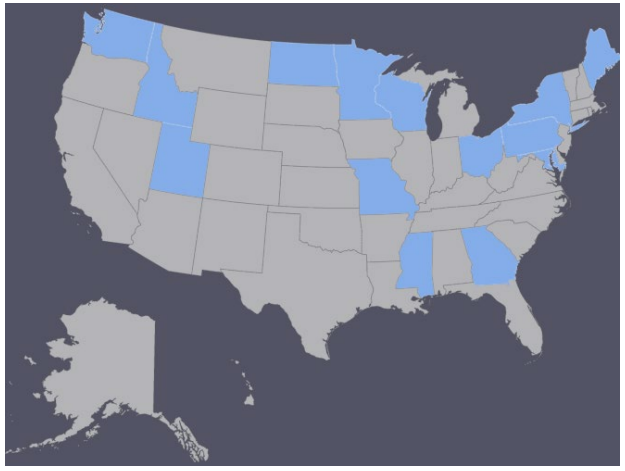

SCAN ME
Official TPF

SCAN ME
MnDOT TPF

# DPS National Pooled Fund Program

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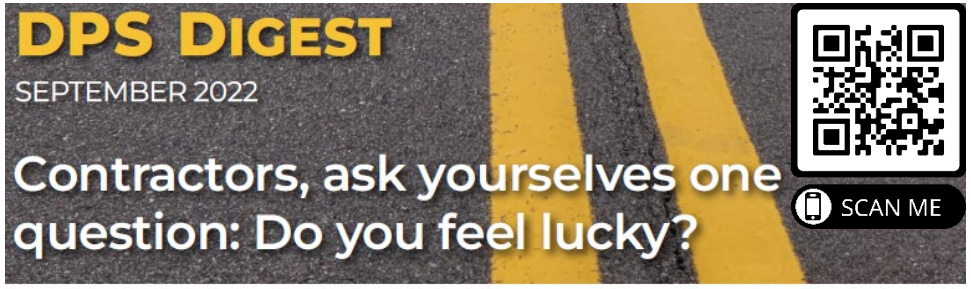
## Informational Materials



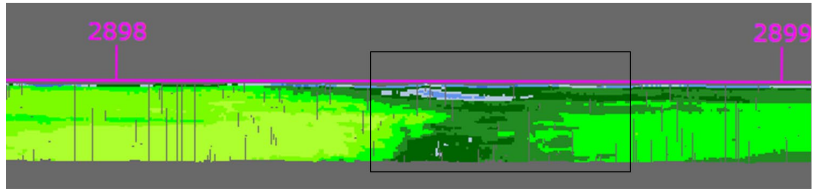

CONTRACTORS ROUTINELY cut cores from the roadway after construction to verify the pavement meets minimum density requirements. These singular random coring locations are used as the basis for acceptance of a larger portion of the pavement. The density results affect contractors and owners alike; for owners such as transportation agencies, a good core result can foretell the road's long-term durability, while contractors often have conditional financial incentives

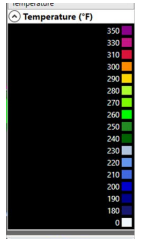
*By rolling a DPS unit over the newly paved roadway, crews measured the pavement's density in real time.*

## Training/Peer Exchange Opportunities

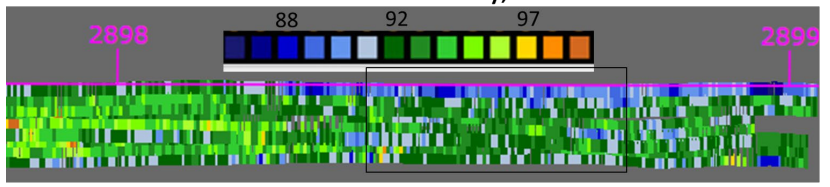
## Process Improvement: Leveraging ICT technologies

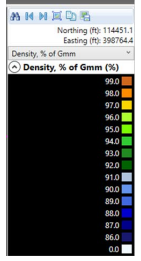
PMTP Measured Temperature at Placement, °F

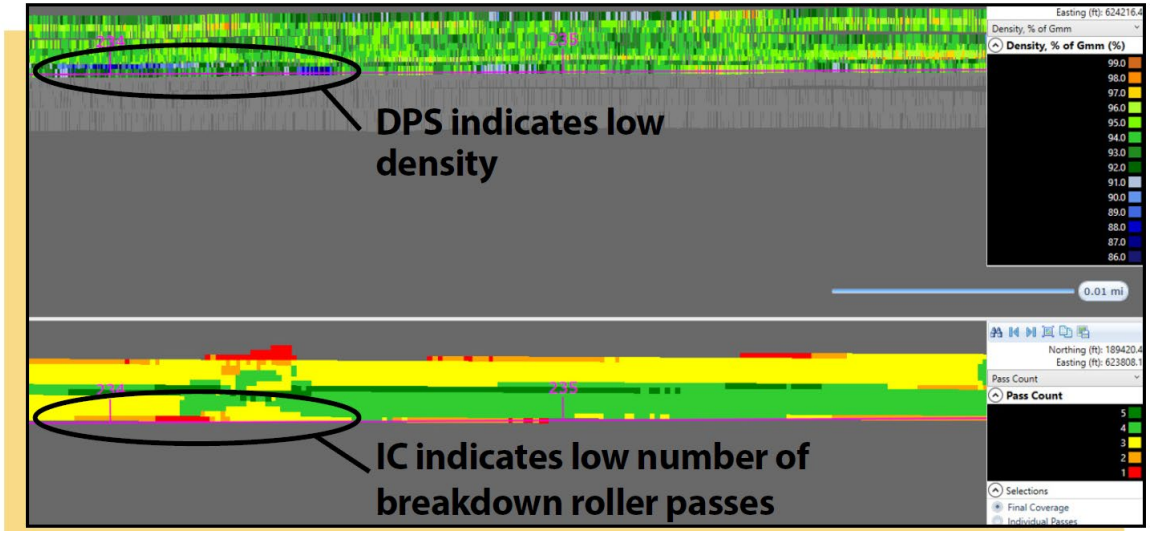



DPS Measured Density, %Gmm



# Thank you again!

**Kyle Hoegh**

*kyle.hoegh@state.mn.us*

507-398-2669