
# Alaska Department of Transportation & Public Facilities

## Continuous, Full-Coverage Asphalt Pavement Density Testing

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# Continuous Full Coverage (CFC)

- Why use CFC testing technology?


# Donald M. Burmister (1948)

- “The primary problem is not so much to determine the average conditions, as it is to make reasonably certain that possibly the most unfavorable conditions are known over a given area that may give rise to soft spots.”

# When to use Random Testing

- Factory Production Quality Control
- Good QC method for homogeneous materials
- Statistical methodology well suited for checking parts coming off an assembly line
- Good for determining the average value

# When to Avoid Random Testing

- Not suitable for heterogeneous materials
- Not suitable for finding defects on paving projects as there is almost zero probability of locating pot hole size defects


# Systematic Testing

- Uses multiple inputs to “look for” failure zones
- High probability of detecting defects

# IC, PaveIR, PaveScan-AK History

- Alaska DOT began using Intelligent Compaction (IC) at Sitka Airport 2013
- Following demonstration projects in 2011 with the PaveIR Bar and in 2015 with the PaveIR Scanner, PaveIR was specified on the Glenn Highway-Hiland to Eklutna Project in 2016
- First demonstration of PaveScan RDM was performed in September 2016

# Pave IR Bar (2011)


# PaveIR Scanner (2015)


# Intelligent Compaction (IC)

- Intelligent Compaction provides:
  - Geo-located Data
  - Pass Coverage
  - Relative Stiffness
  - Temperature mapping at time of roller pass


# Infrared Scanner

- PaveIR provides
  - Geo-located Data
  - Complete map of asphalt mat surface temperature
  - Viewable in real time
  - Calculates degree of thermal segregation / 150’
  - Provides a permanent temperature record

# PaveScan RDM

- PaveScan Rolling Density Meter Provides:
  - Geo-located Data
  - 10 dielectric readings per foot of travel
  - 5 consecutive readings are averaged every 6” to graphically plot color coded “Density” blocks
  - 3 Antennas can be spaced from 1’ to 2’ apart, thus density block can range from 6”x12” to 6”x24”
  - 1584 density tests per minute walking at 3 mph

# PaveScan RDM-Night Paving


# What is Dielectric?

- Related to Speed of RADAR through a Material

$$e = C^2 / V^2 \quad \text{or} \quad V = C / \sqrt{e}$$

Where: V = velocity of RADAR in material

C = Speed of light in a vacuum

e = Dielectric

# Relative Speeds of RADAR

RADAR is fastest in Air e = 1

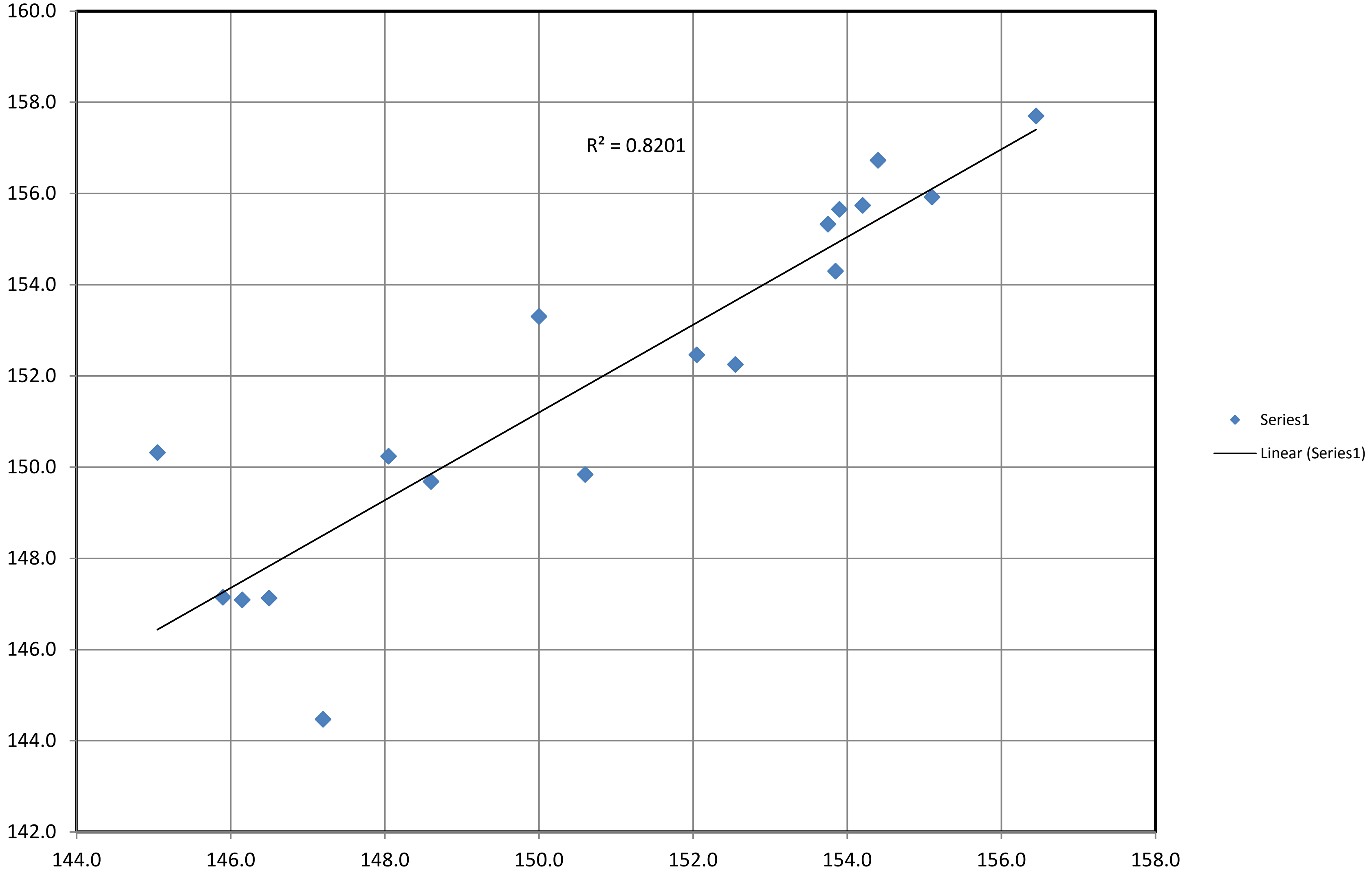
RADAR is slowest in Water e = 81

Asphalt Concrete e = 4 to 7

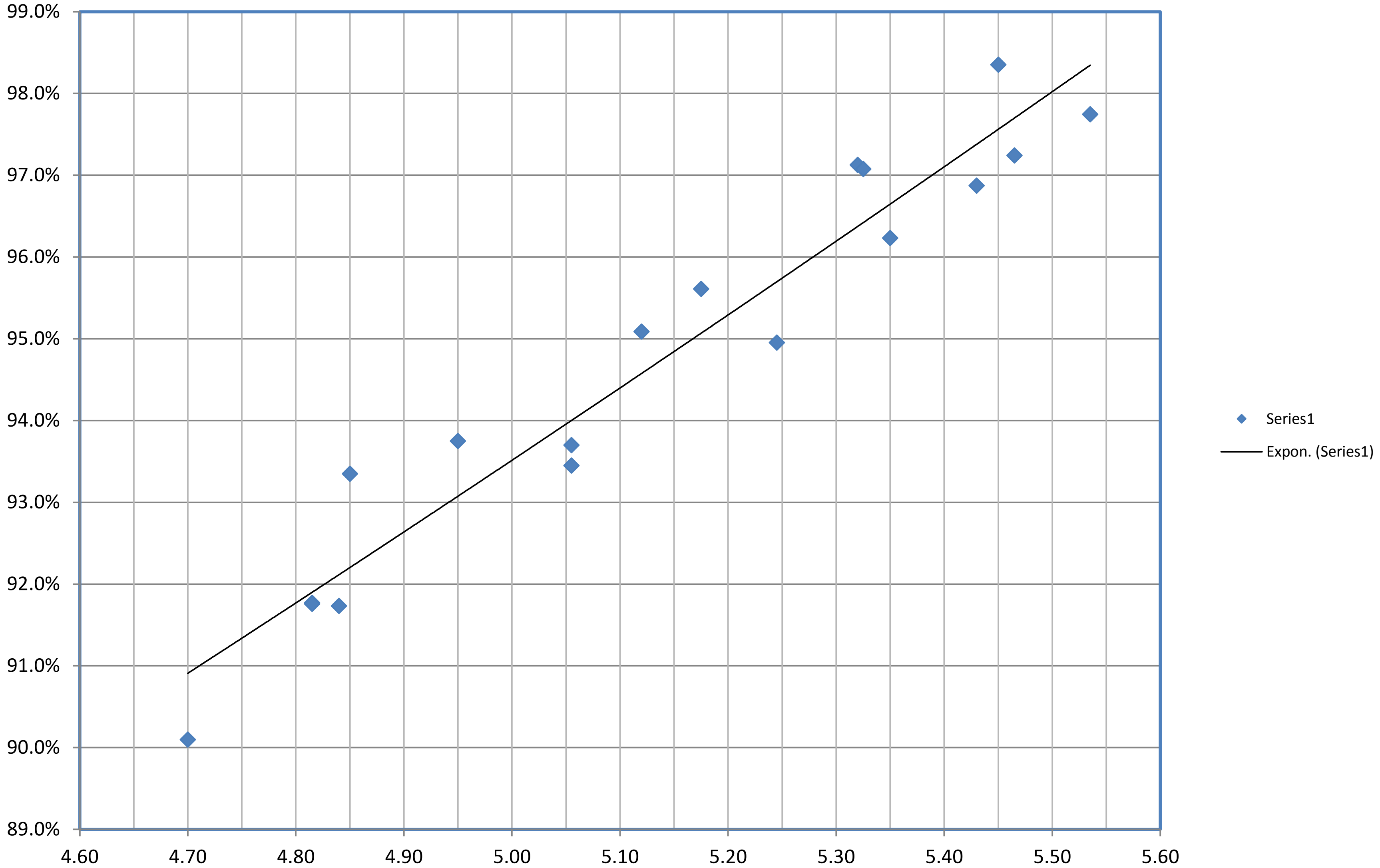
(note more air gives lower dielectric, i.e. RADAR passes through porous asphalt faster)

## LOW DIELECTRIC = LOW DENSITY

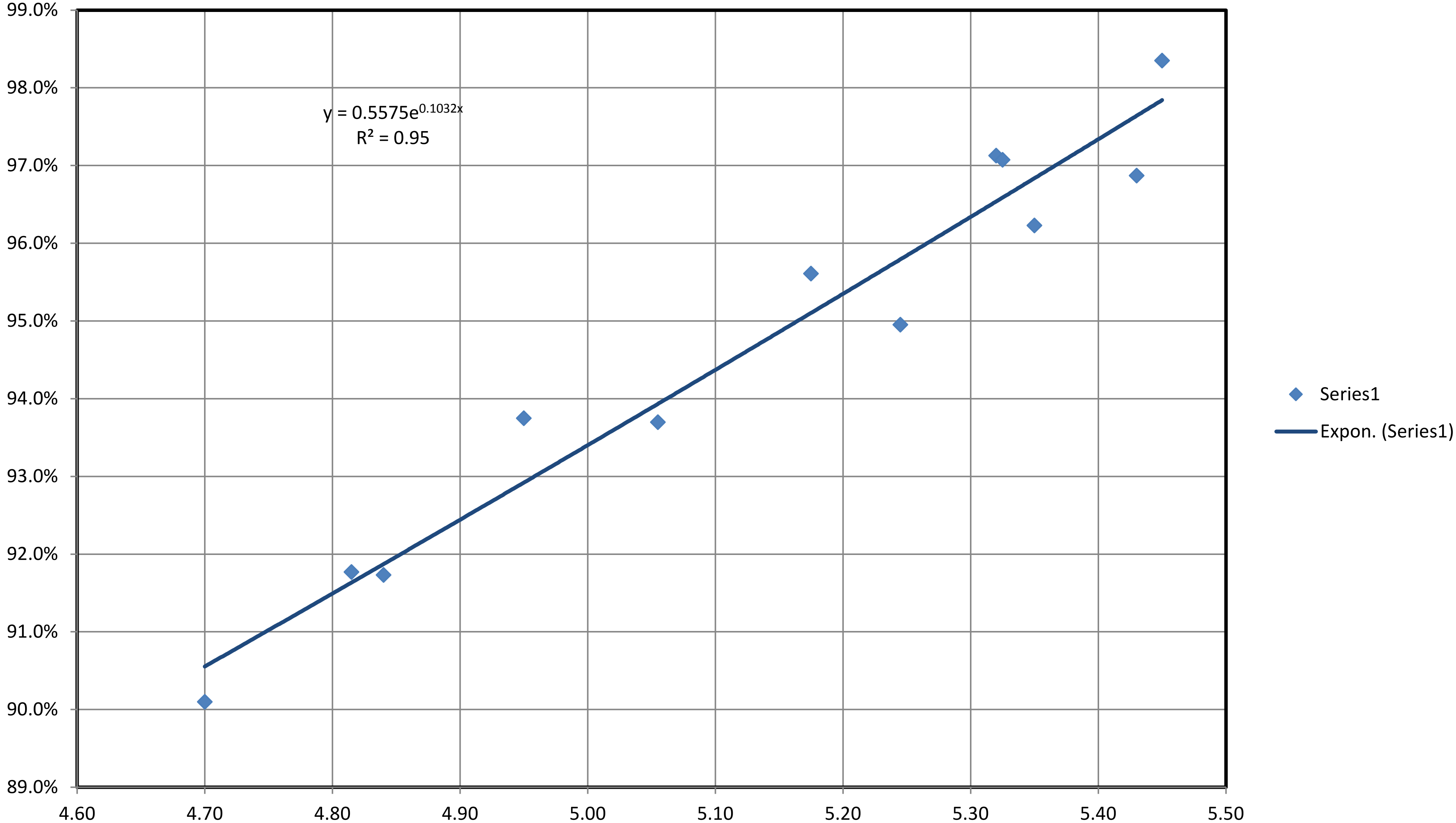
# Calibration: Cores vs Nuke, $R^2 = 0.82$



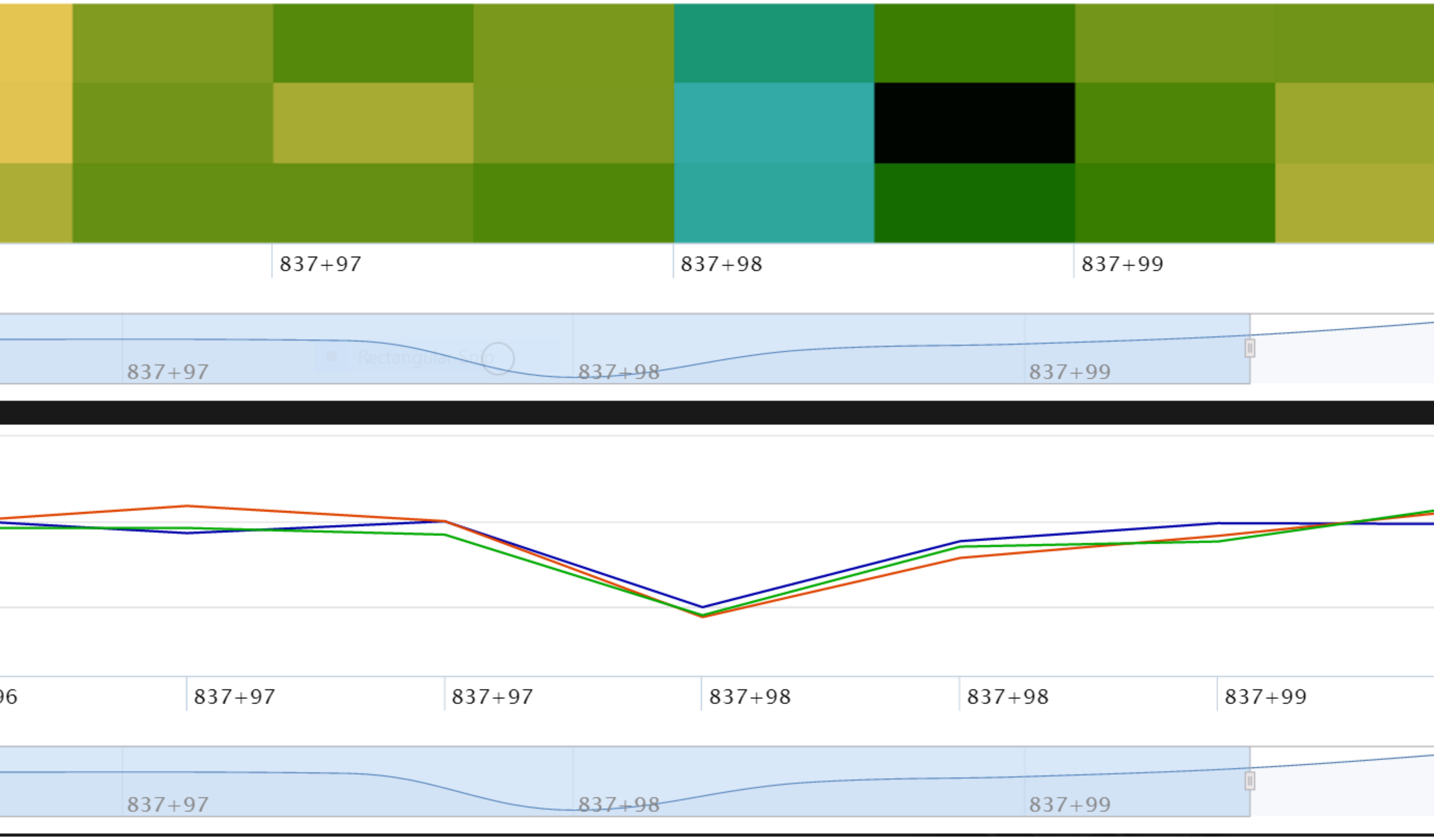
# Calibration: Cores vs RDM, $R^2 = 0.93$



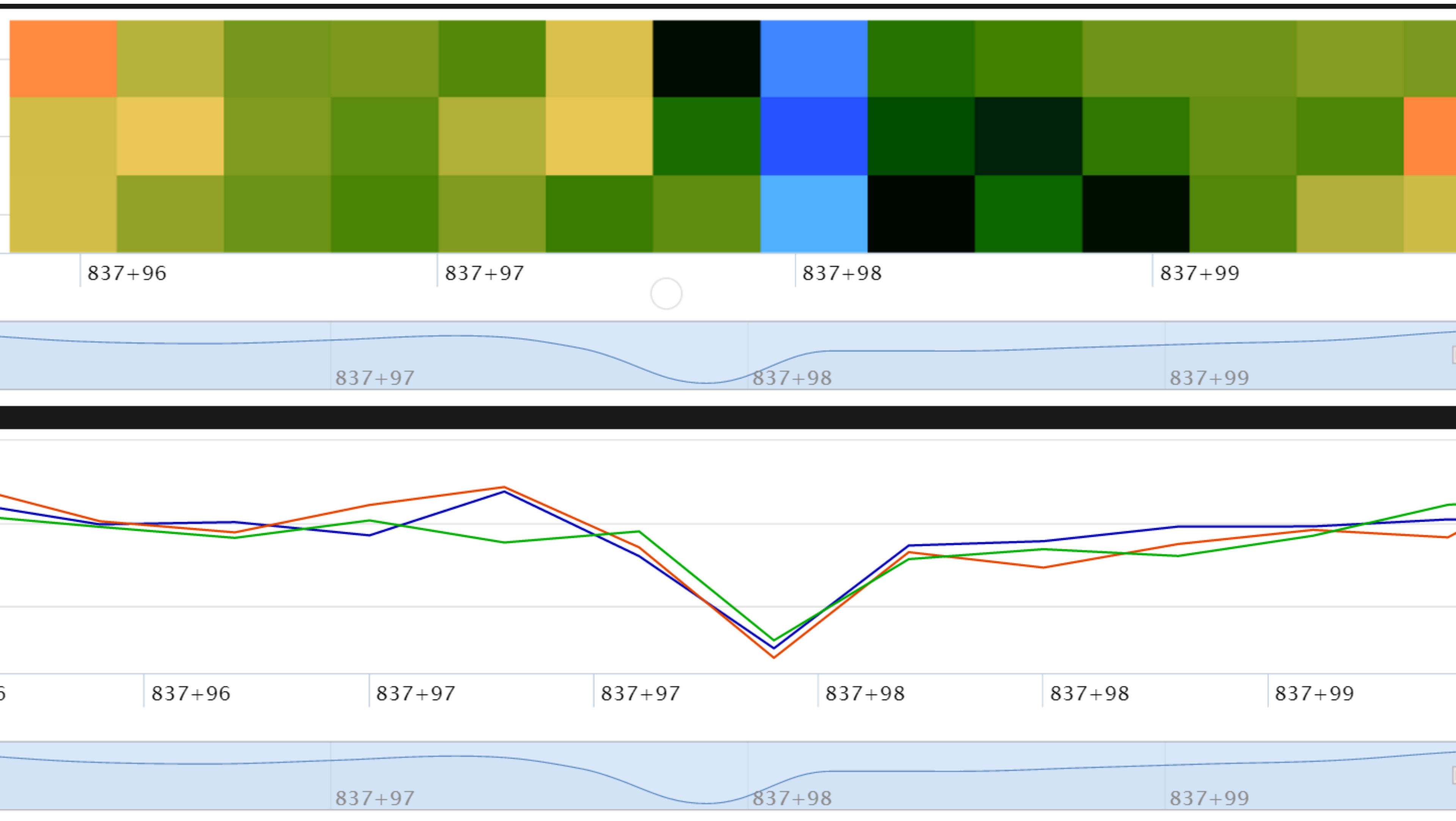
# Calibration w/ Next Day Cores
# $R^2 = 0.95$



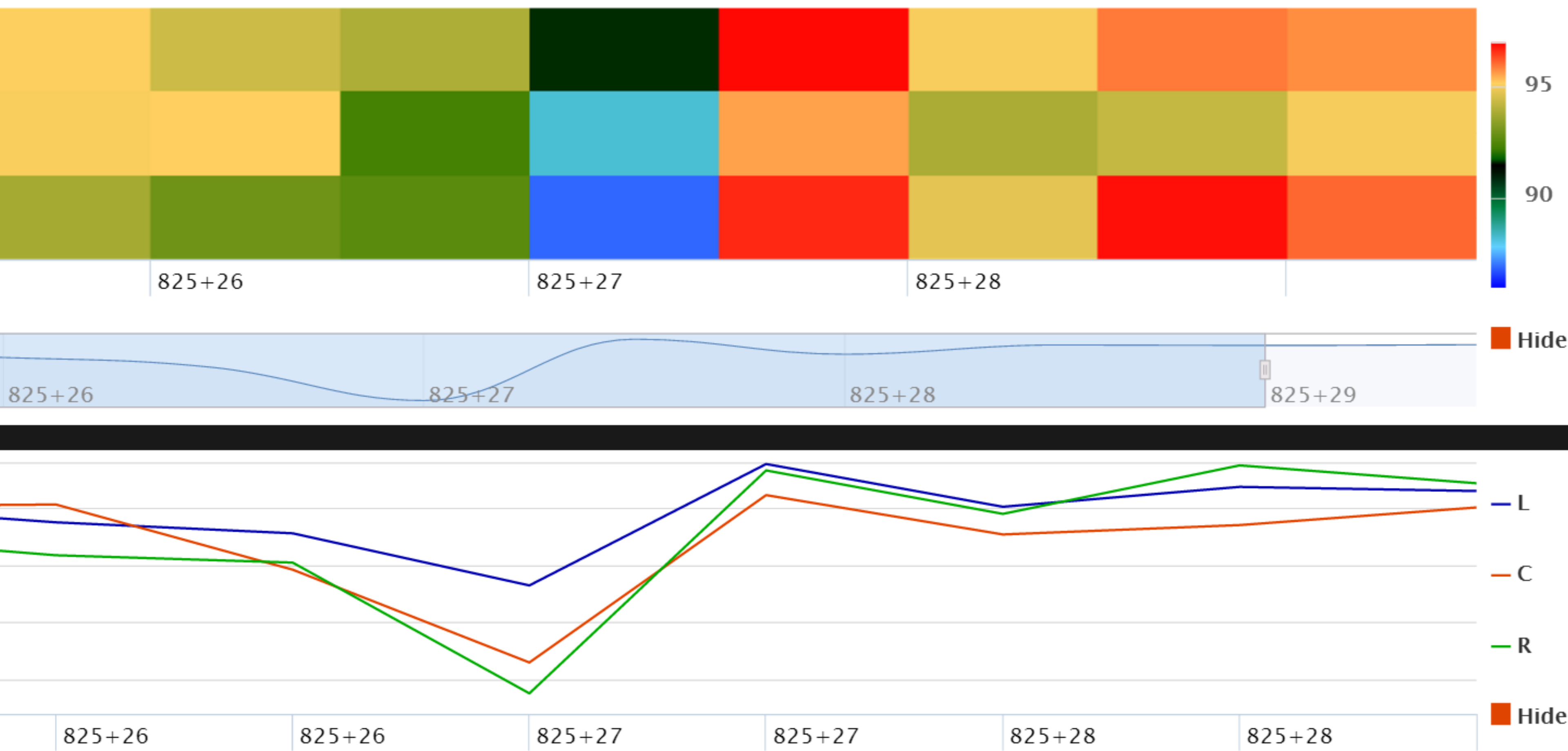
# Core 69J – Resolution 0.5 ft



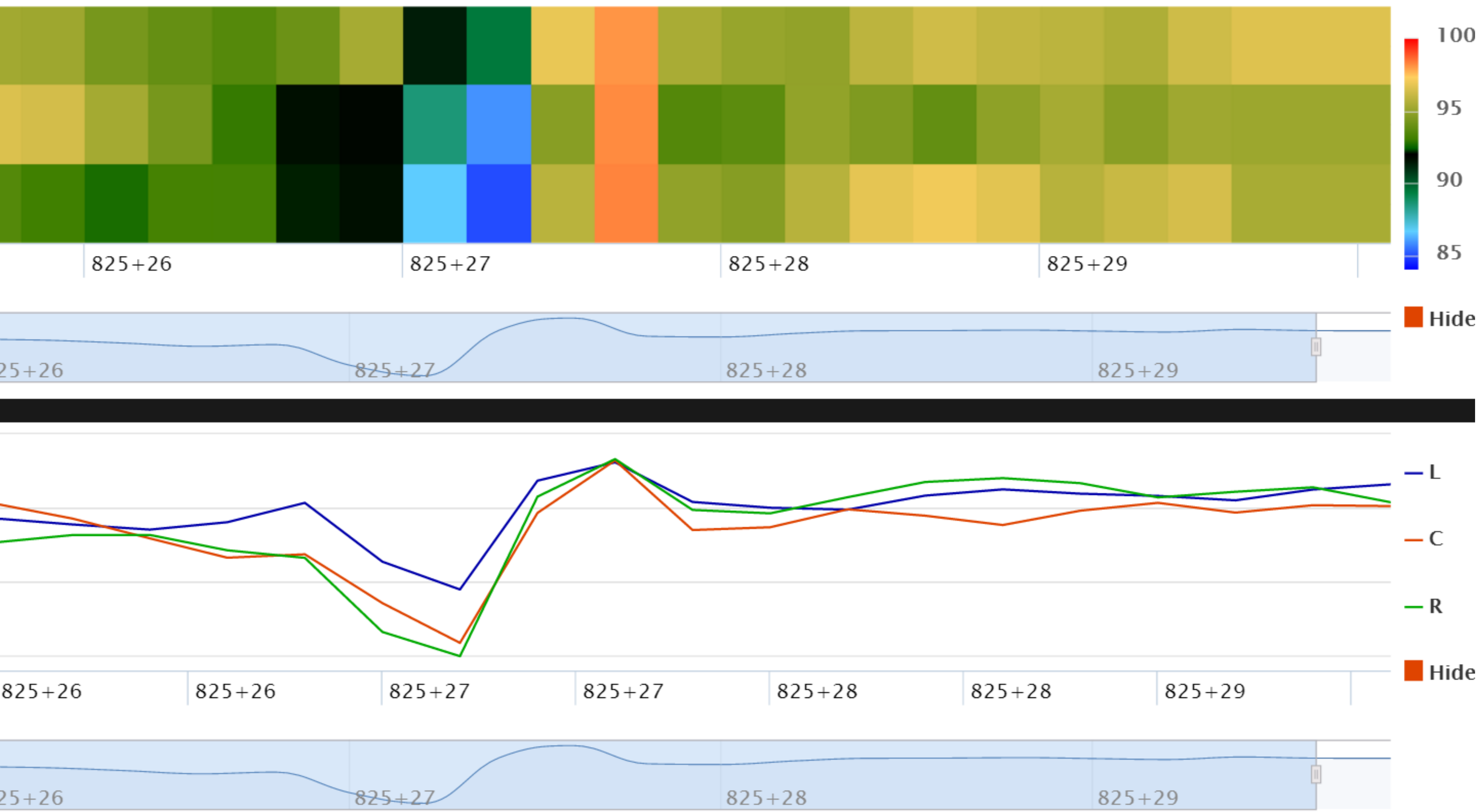
# Core 69J (92.9%) – Resolution 0.25 ft



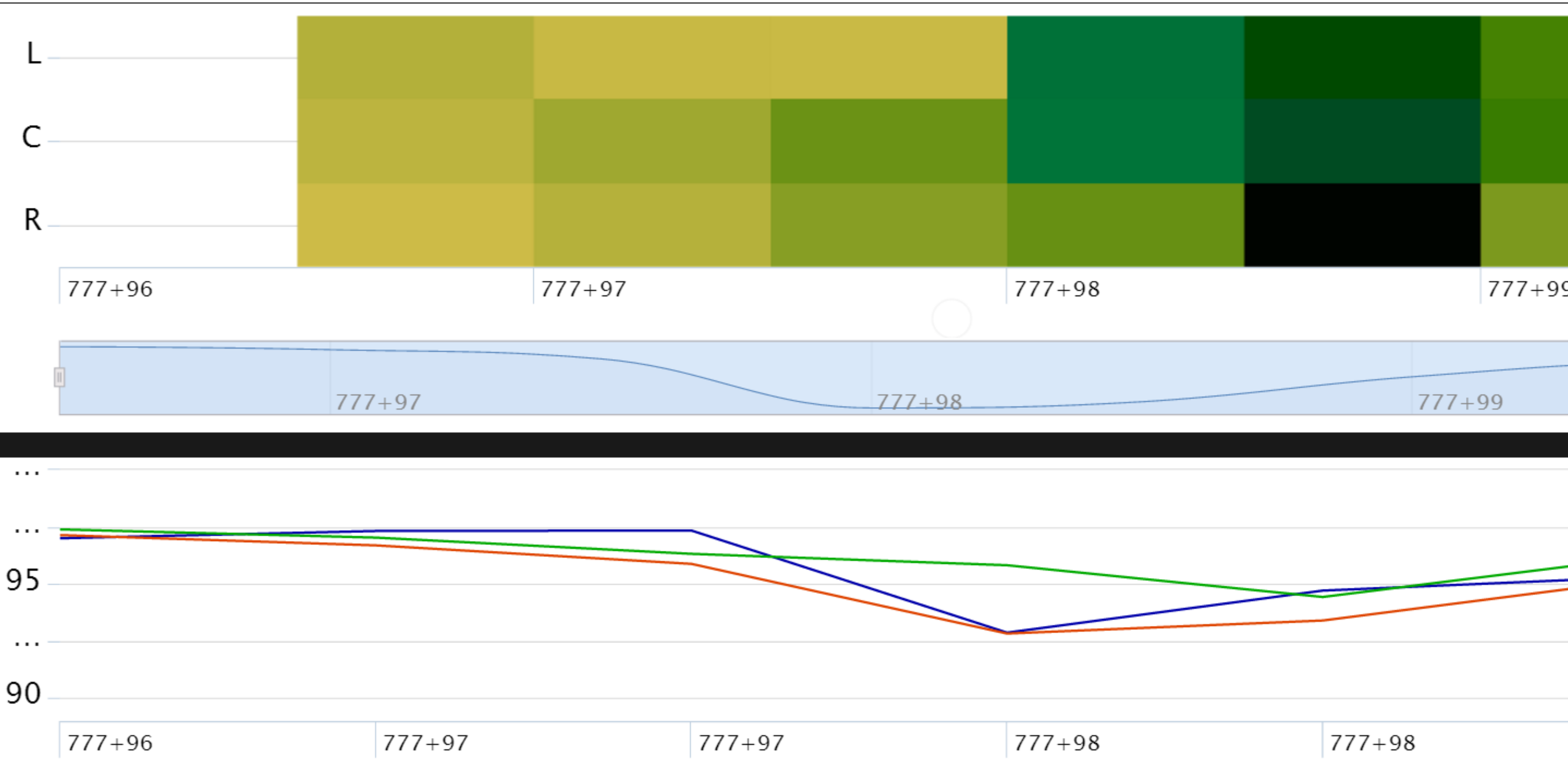
# Core 70J (91.7%) – Resolution 0.5 ft



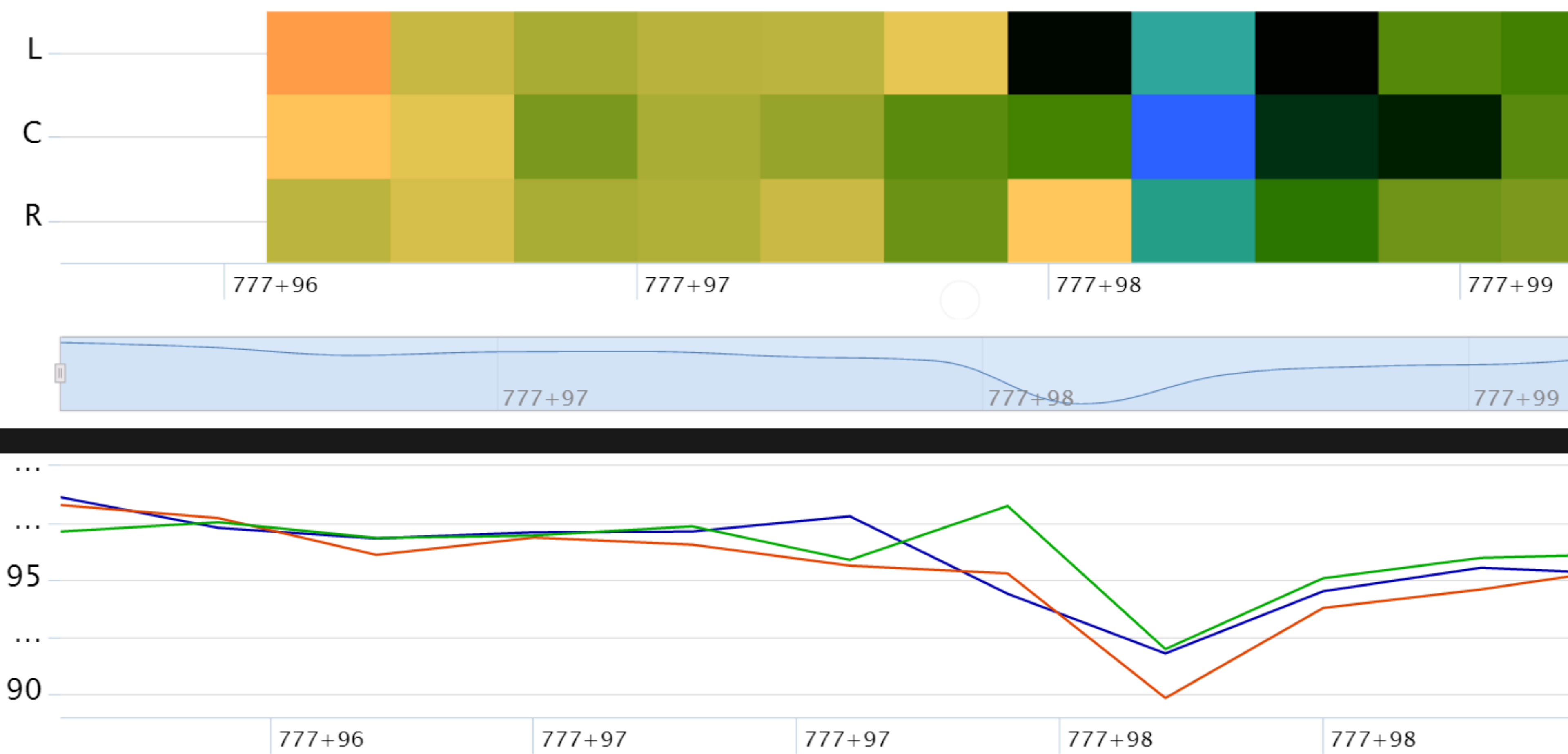
# Core 70J (91.7%) – Resolution 0.25 ft



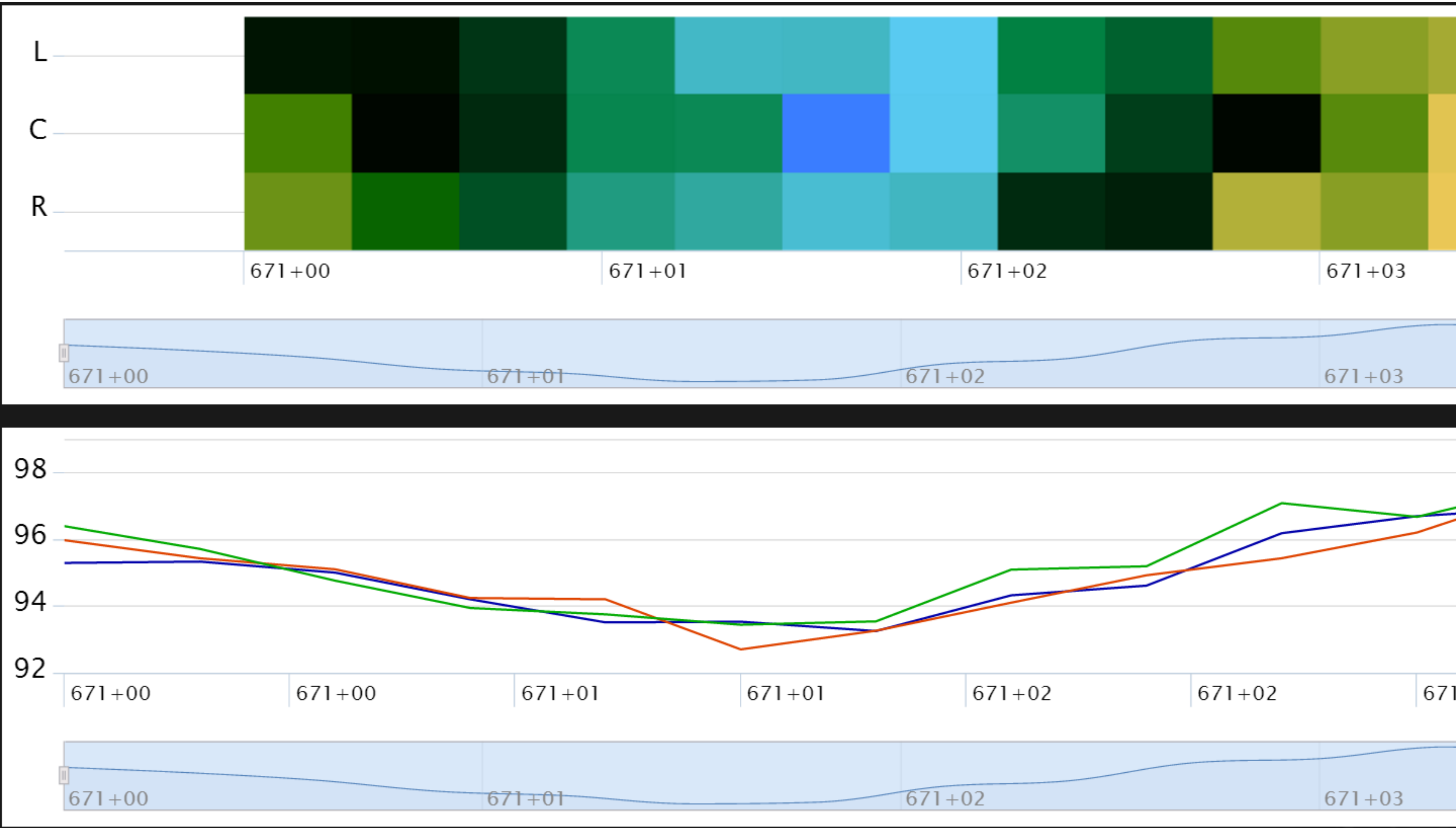
# Core 72J (94.5%) – Resolution 0.5 ft



# Core 72J (94.5%) – Resolution 0.25 ft



# Core 85J (92.4%) – Resolution 0.25 ft



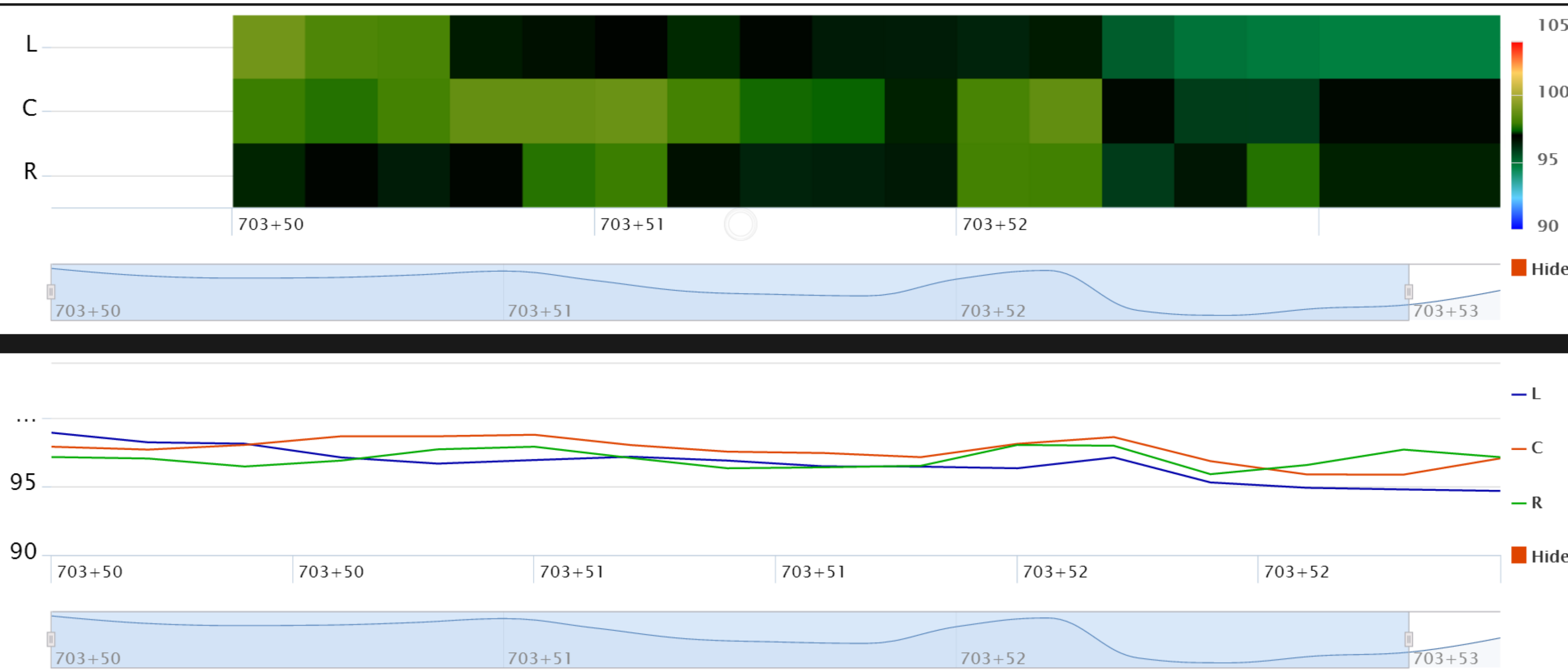
# Core 85J – Distance Statistics

| Sensor Position | Total Dist | Median | Average | Min | Max | Standard Dev |
|---|---|---|---|---|---|---|
| Center | 4.3 | 95.2377 | 95.1644 | 92.0473 | 98.6728 | 1.44811 |
| Left | 4.3 | 95.1536 | 95.1277 | 92.6158 | 98.0502 | 1.31434 |
| Right | 4.3 | 95.7133 | 95.6349 | 93.0337 | 99.1354 | 1.63348 |

# Core 85J – Time Statistics

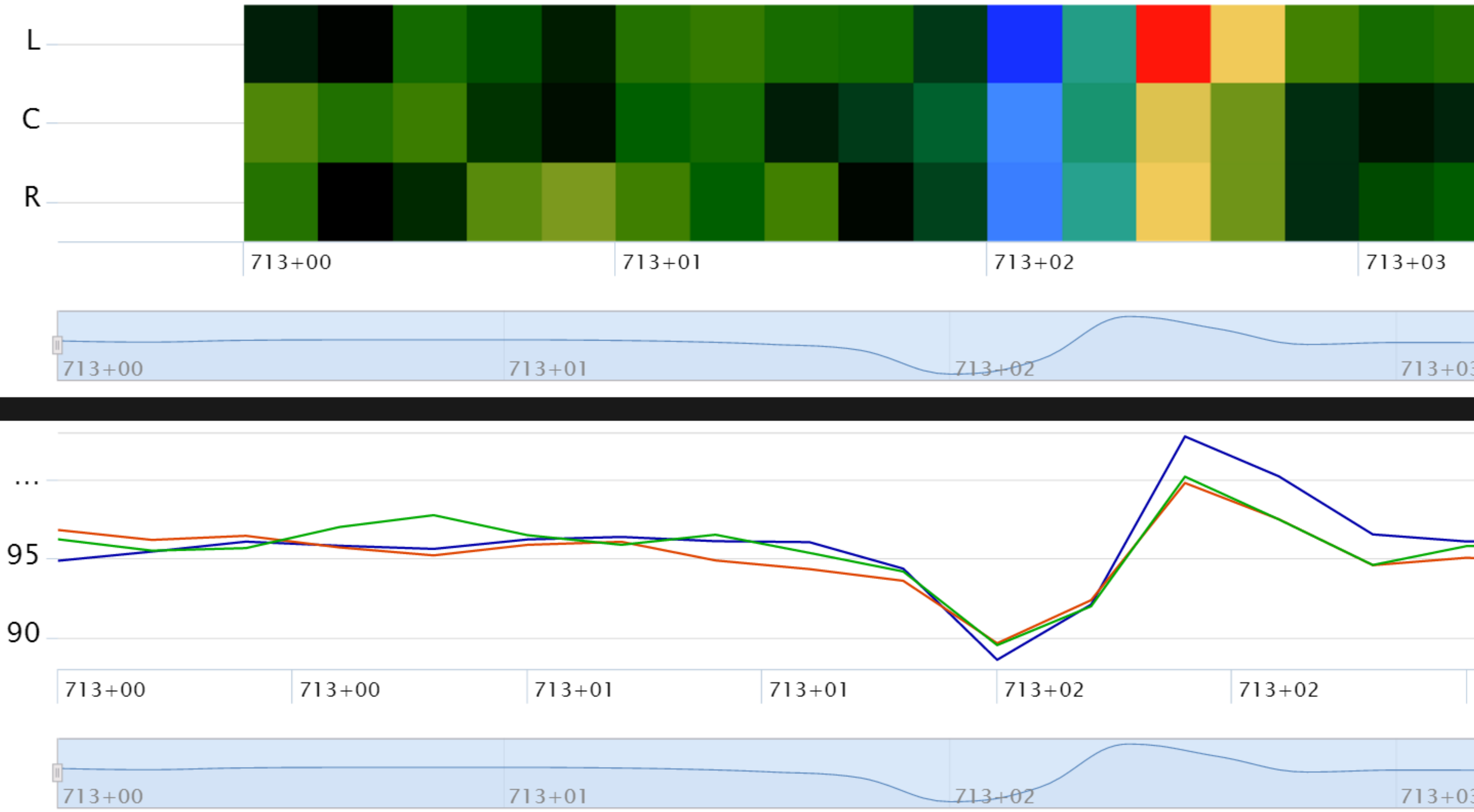
| Sensor Position | Total Dist | Median | Average | Min | Max | Standard Dev |
|---|---|---|---|---|---|---|
| Center | 1406 | 94.93 | 95.0007 | 93.6112 | 98.9016 | 0.496972 |
| Left | 1406 | 94.3386 | 94.3408 | 92.922 | 97.3542 | 0.426824 |
| Right | 1406 | 94.8968 | 94.874 | 92.179 | 96.719 | 0.47235 |

# Calibration Core 19J (96.2%)

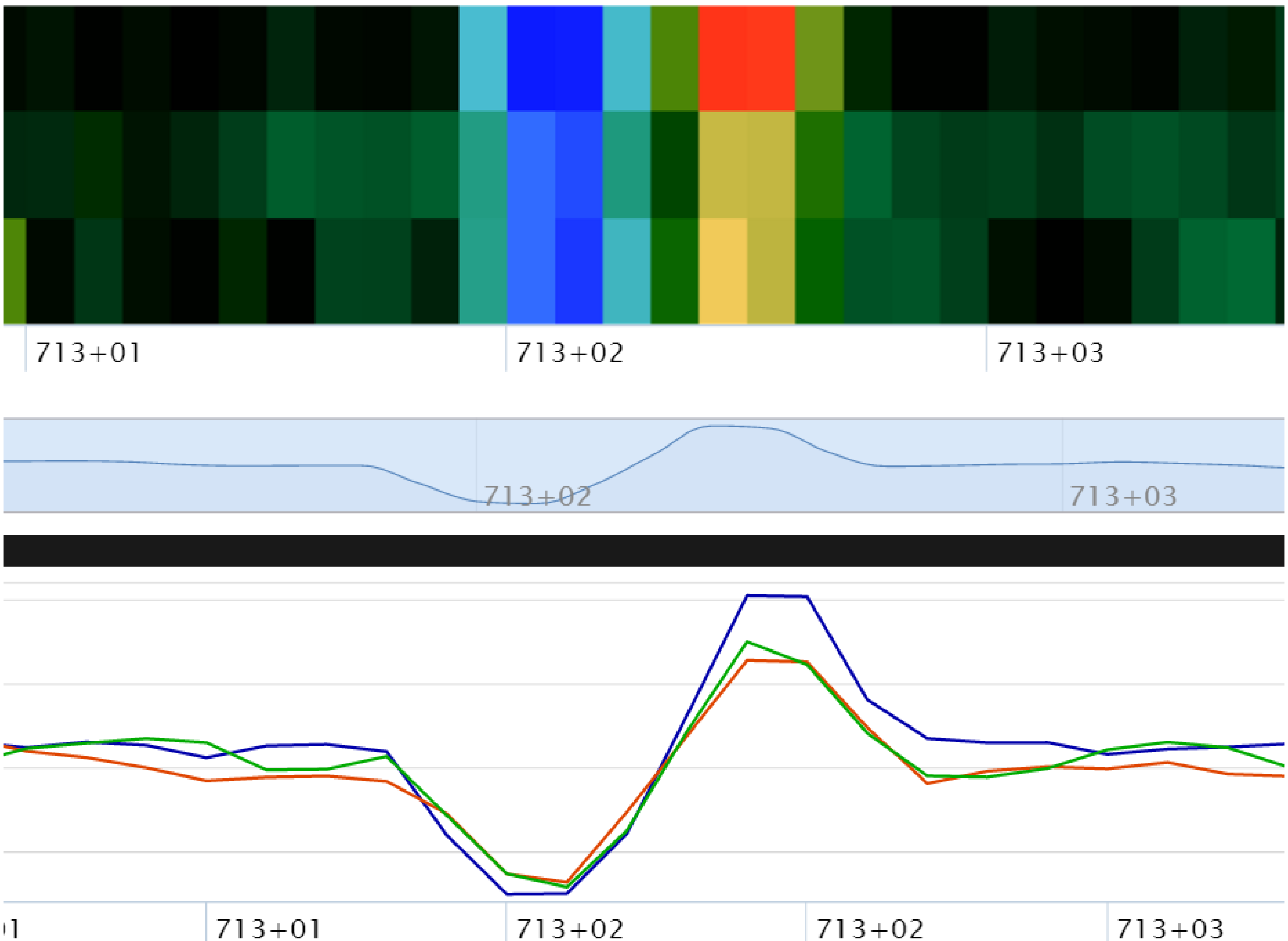


# Good Longitudinal Joint

# Core 87J (94.9%) – Resolution 0.25 ft



# Core 87J (94.9%) – Resolution 0.10 ft



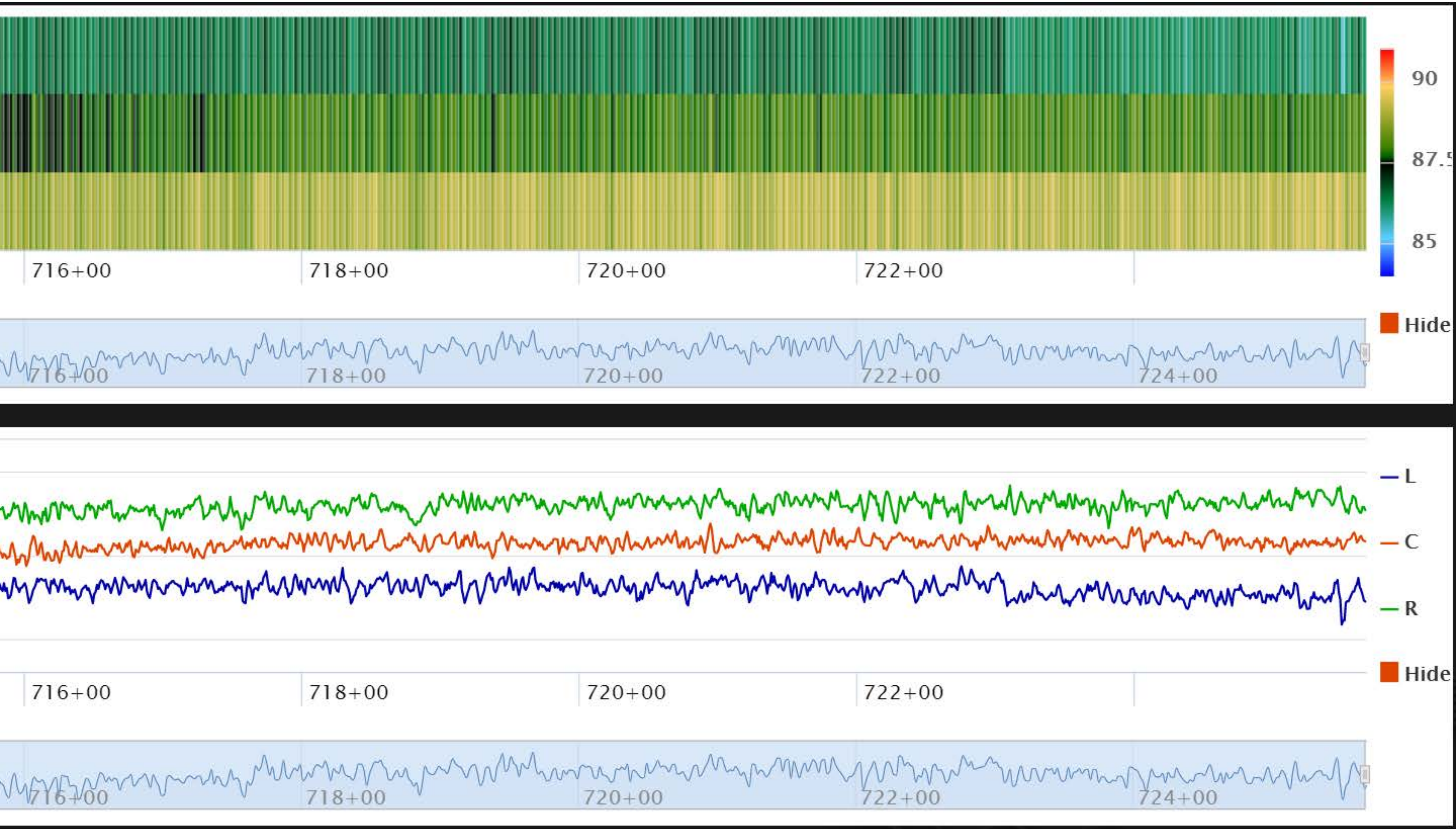
# Core 87J – Distance Statistics

| Sensor Position | Total Dist | Median | Average | Min | Max | Standard Dev |
|---|---|---|---|---|---|---|
| Center | 4.2 | 95.2647 | 95.2054 | 88.1275 | 101.343 | 2.28774 |
| Left | 4.2 | 96.161 | 95.9437 | 87.4141 | 105.199 | 3.10059 |
| Right | 4.2 | 96.0255 | 95.6037 | 87.8418 | 102.452 | 2.49736 |

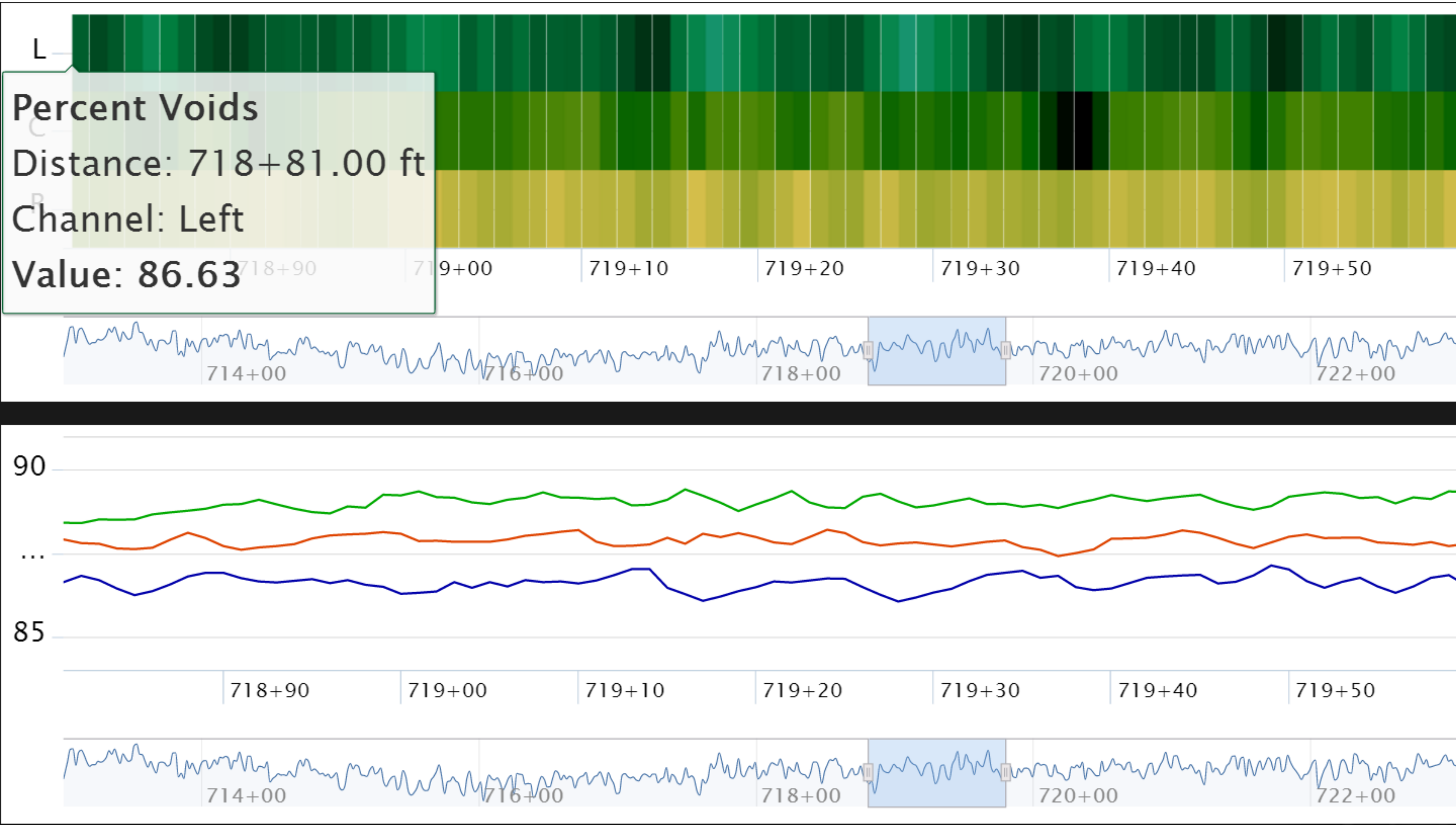
# Core 87J – Time Statistics

| Sensor Position | Total Dist | Median | Average | Min | Max | Standard Dev |
|---|---|---|---|---|---|---|
| Center | 1269 | 87.8607 | 87.8692 | 86.8951 | 88.8963 | 0.306642 |
| Left | 1269 | 86.557 | 86.5422 | 84.4503 | 87.6718 | 0.34858 |
| Right | 1269 | 88.985 | 88.9778 | 87.8945 | 90.2777 | 0.352063 |

# Core 87J – Time Graphic



# Core 87J – Time Segments



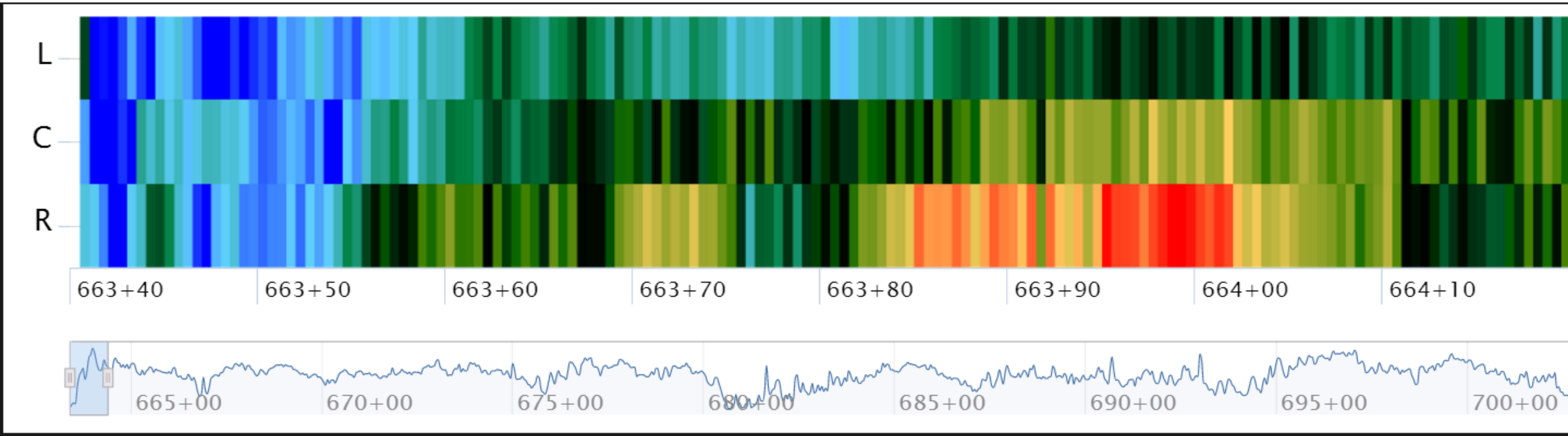
# Core Densities

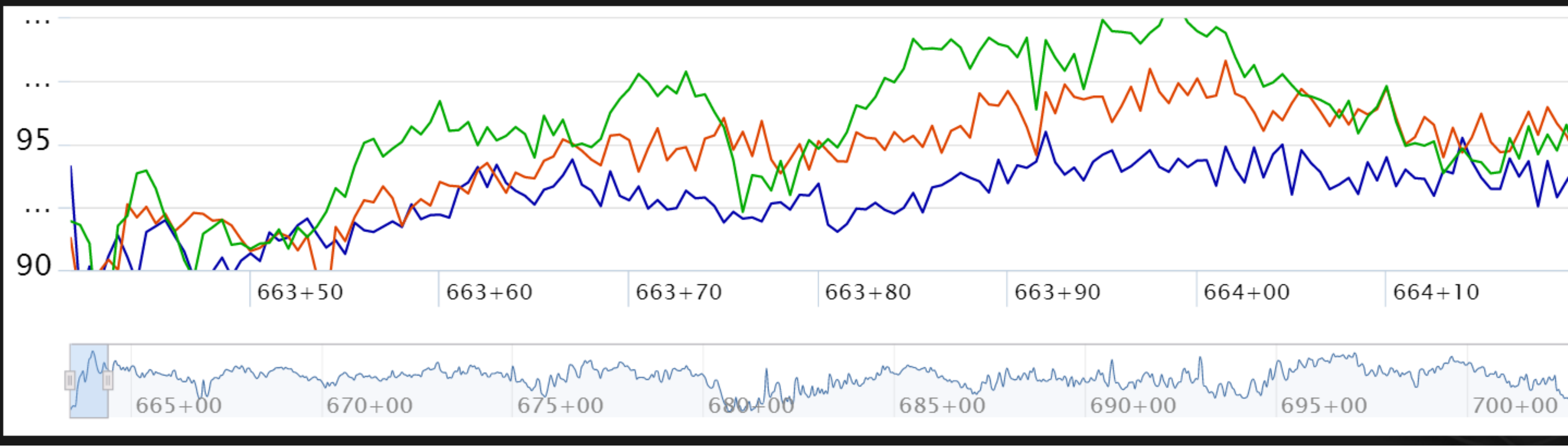
| Summary of % Asphalt, MSG, % Compaction, % Voids - 2017 Data | | | | | | | % Compaction | |
|---|---|---|---|---|---|---|---|---|
| Date Placed | Core # | Station MSG, Oil, Grad | Station Core | % Asphalt | Bulk SpG Panel | Bulk SpG Joint | Bulk/MSG Panel | Bulk/MSG Joint |
| 6/10/2017 | 69 | 839+50 22'LT | 838+00 22'LT | 5.02 | 2.481 | 2.398 | 96.1 | 92.9 |
| 6/11/2017 | 70 | 818+00 22'LT | 825+25 21.5'LT | 5.16 | 2.419 | 2.369 | 93.7 | 91.7 |
| 6/13/2017 | 71 | 789+50 22'LT | 803+00 21.5'LT | 5.03 | 2.501 | 2.445 | 96.9 | 94.7 |
| | | Lot 9 MSG = | 2.580 | 5.06% Asphalt | | | | |
| 6/13/2017 | 72 | 788+75 22' LT | 778+00 14.5'LT | 5.06 | 2.462 | 2.438 | 95.4 | 94.5 |
| 6/13/2017 | 73 | 752+00 22'LT | 765+50 23'LT | 5.11 | 2.447 | 2.453 | 94.8 | 95.1 |
| 6/13/2017 | 74 | 723+00 22'LT | 740+50 33'LT | 4.99 | 2.425 | 2.409 | 94.0 | 93.4 |
| 6/13/2017 | 75 | 698+00 22'LT | 717+25 28'LT | 4.99 | 2.431 | 2.434 | 94.2 | 94.3 |
| 6/14/2017 | 76a | 668+00 22' LT | 675+75 21.5'LT | 5.26 | 2.484 | 2.467 | 96.3 | 95.6 |
| 6/14/2017 | 77 | 666+00 22'LT | 665+75 27.5'LT | 5.21 | 2.491 | 2.466 | 96.5 | 95.6 |
| 6/14/2017 | 78 | 626+50 22'LT | 642+25 21'LT | 5.12 | 2.487 | 2.459 | 96.4 | 95.3 |
| 6/14/2017 | 79 | 602+00 22'LT | 607+50 21'LT | 5.25 | 2.481 | 2.396 | 96.2 | 92.9 |
| 6/14/2017 | 80 | 577+00 22'LT | 580+75 21'LT | 5.15 | 2.482 | 2.477 | 96.2 | 96.0 |
| 6/14/2017 | 81 | 575+00 22'LT | 567+75 22'LT | 5.04 | 2.485 | 2.451 | 96.3 | 95.0 |
| | | **SB-L2 Core Summary Average Mat and Joint Densities** | | | | | **94.9** | **94.1** |
| | | Lot 10 MSG = | 2.578 | 5.01% Asphalt | | | | |
| 6/15/2017 | 82 | 595+00 34'LT | 529+75 26'LT | 5.01 | 2.476 | 2.459 | 96.0 | 95.4 |
| 6/15/2017 | 83 | 590+00 34'LT | 588+00 34'LT | 5.08 | 2.508 | 2.420 | 97.3 | 93.9 |
| 6/15/2017 | 84 | 567+00 34'LT | 555+00 40'LT | 5.13 | 2.406 | 2.344 | 93.3 | 90.9 |
| | | **SB-L3 Core Summary Average Mat and Joint Densities** | | | | | **95.5** | **93.4** |
| | | | | | | | | |
| 6/16/2017 | 85a | 674+00 22' RT | 671+00 19'RT | 4.95 | 2.456 | 2.383 | 95.3 | 92.4 |
| 6/16/2017 | 86 | 683+00 22' RT | 702+50 18.5'RT | 5.04 | 2.418 | 2.415 | 93.8 | 93.7 |
| 6/16/2017 | 87 | 721+50 22' RT | 720+00 22'RT | 5.11 | 2.394 | 2.446 | 92.9 | 94.9 |

# Core Densities (2)

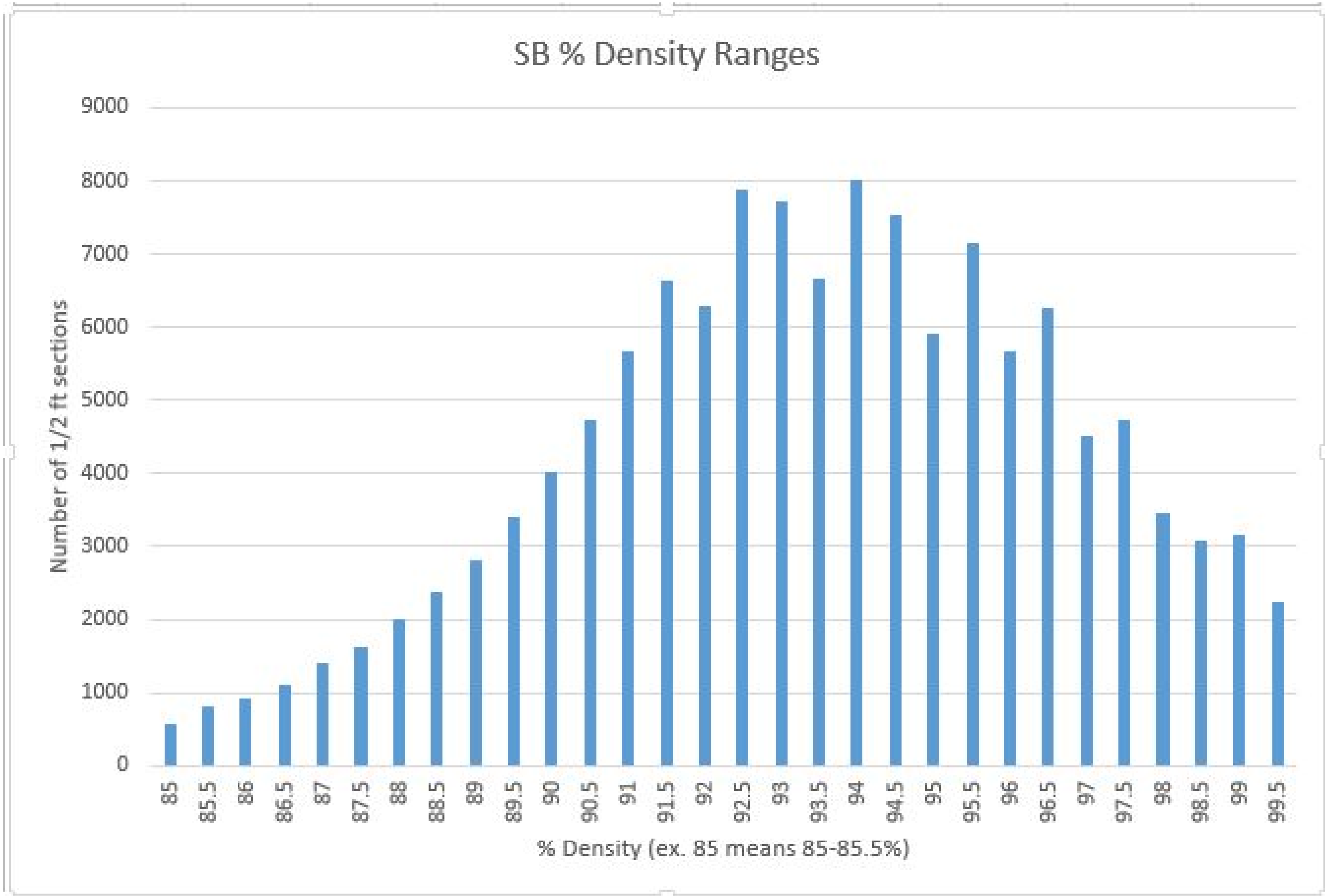
| **Summary of % Asphalt, MSG, % Compaction, % Voids - 2017 Data** | | | | | | | % Compaction | |
|---|---|---|---|---|---|---|---|---|
| Date | Core # | Station | Station | % Asphalt | Bulk SpG | Bulk SpG | Bulk/MSG | Bulk/MSG |
| Placed | | MSG, Oil, Grad | Core | | Panel | Joint | Panel | Joint |
| | | | | | | **Project Averages** | **94.9** | **94.5** |
| **Note:** | | | | | | | **Mat** | **Joint** |
| 50 of 101 (50%) of Mat Cores 95.0% or Higher | | | | 0.495 | | Max | 97.6 | 97.8 |
| 26 of 64 (41%) of Joint Cores 95.0% or Higher | | | | 0.406 | | Min | 92.3 | 90.9 |
| | | | | | | | | |
| | | | **Average Oil % :** | **5.10** | | | | |
| | | | Max | 5.34 | | | | |
| | | | Min | 4.88 | | | | |
| Notes: | A = Assurance test | | MSG = Maximum Specific Gravity | | | | | |
| | MD = Mix Design | | | | | | | |
| | FS = Field Sample | | | | | | | |

# Start of Paving = Low Density

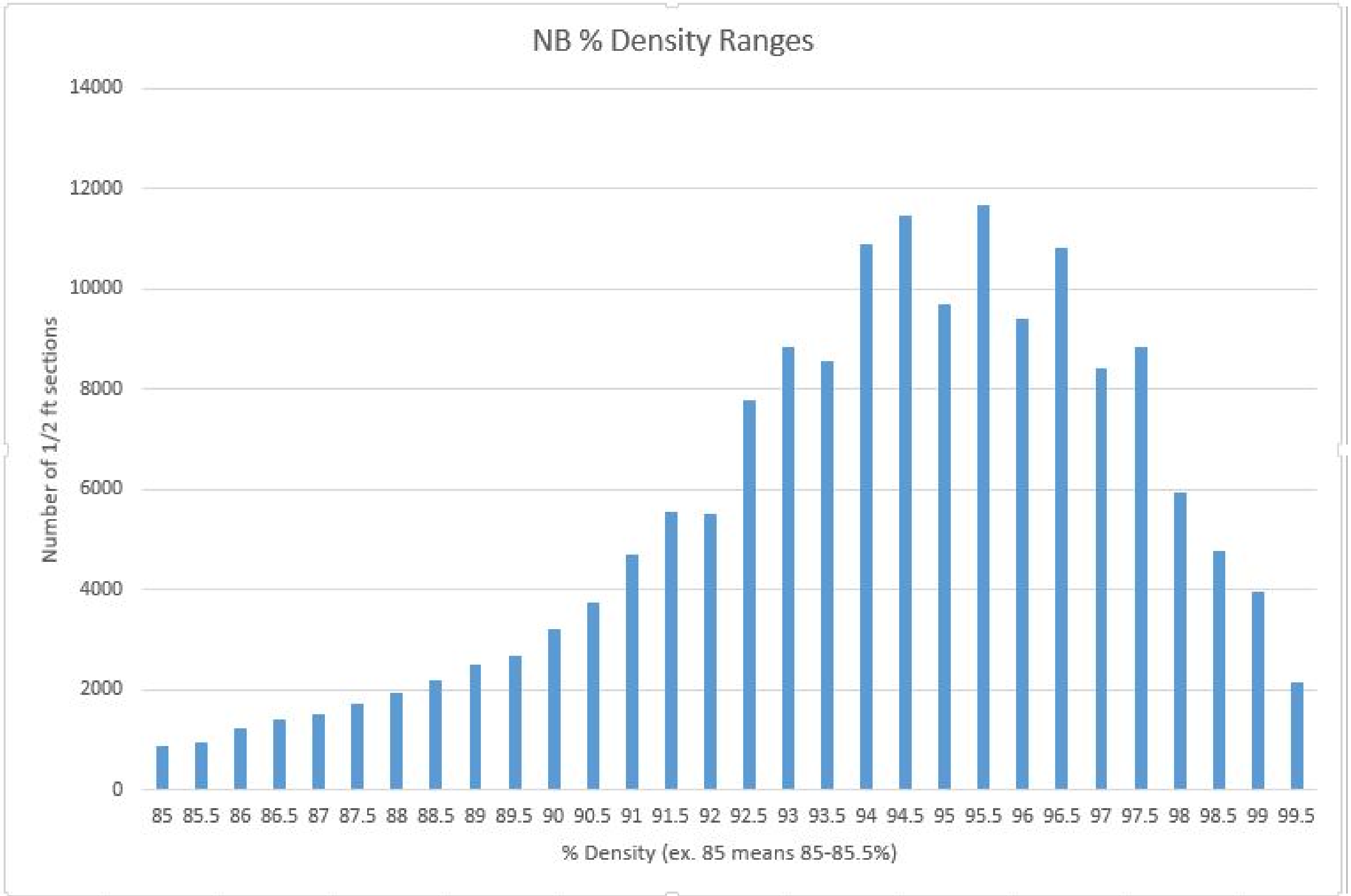


# SB(Joint CL) Density Histogram



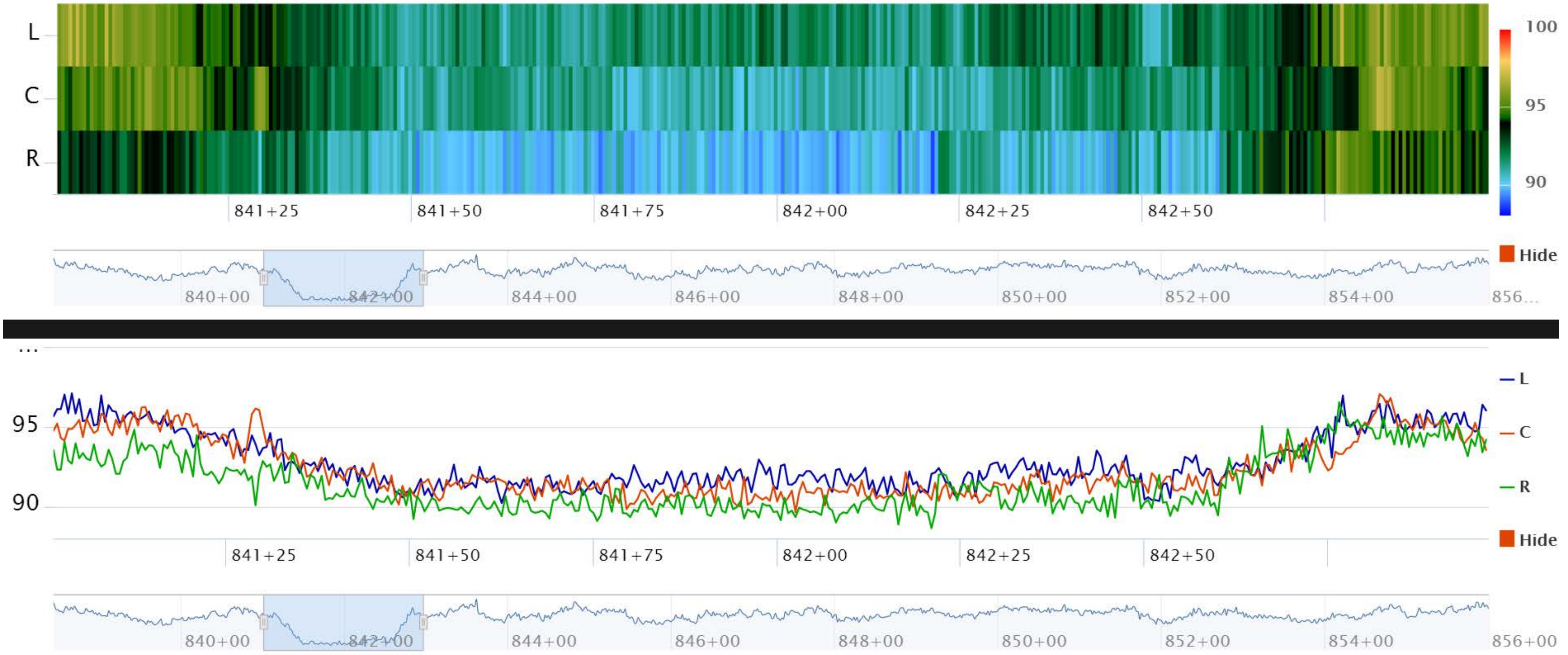
# NB(Hot Side) Density Histogram



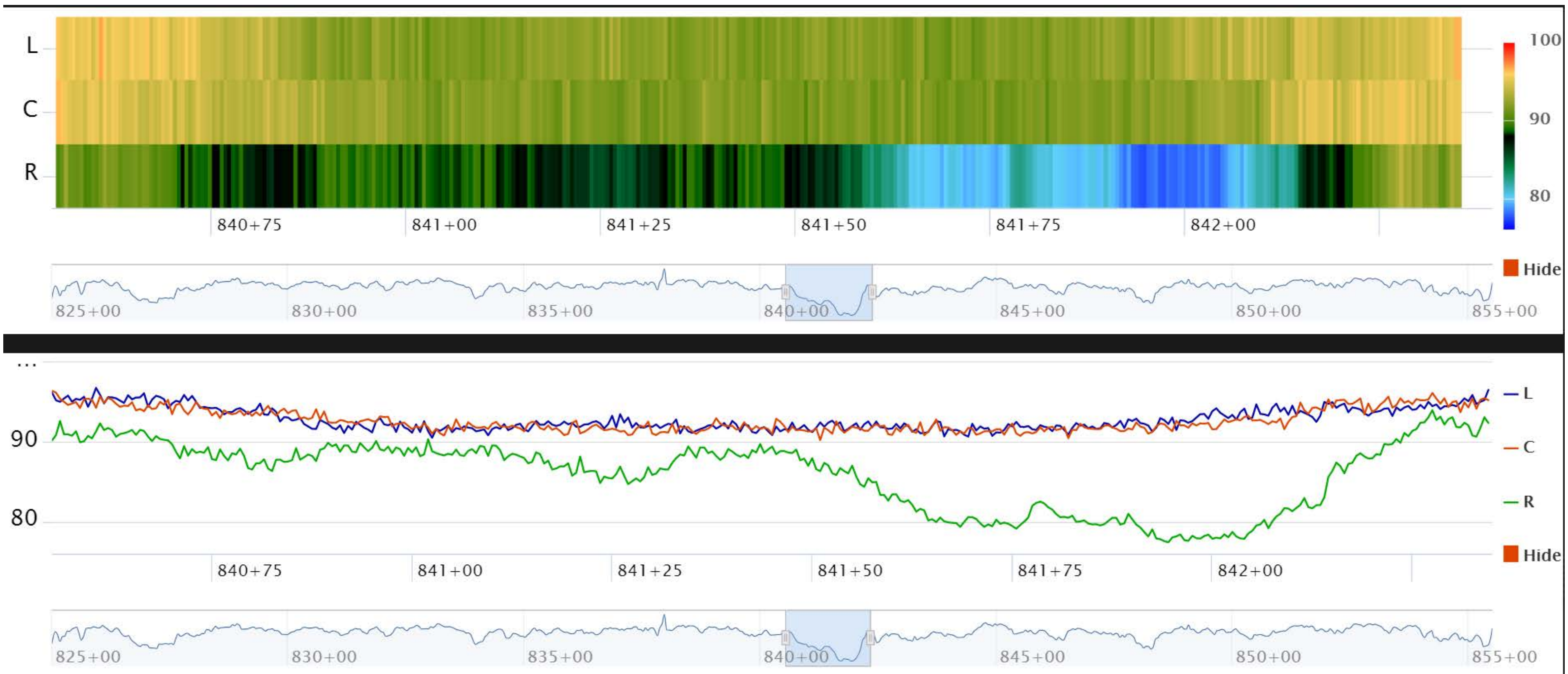
# Joint Density Summary

| | | | |
|---|---|---|---|
| South Bound Joint Density | | | |
| Distance (ft) | | % Compaction | |
| Station | DMI | | Joint Ave |
| 75,810 ft | 75,686 ft | RDM Raw Data | 94.0 |
| 14.36 miles | | | |
| RDM Filtered Data (85-100%) | | | **93.6** |
| 36 SB Joint Cores = | | | **94.1** |
| North Bound Joint Density | | | |
| 53,860 ft | 53,624 ft | RDM Raw Data | 94.0 |
| 10.2 miles | | | |
| RDM Filtered Data (85-100%) | | | **94.2** |
| 28 NB Joint Cores = | | | **95.0** |

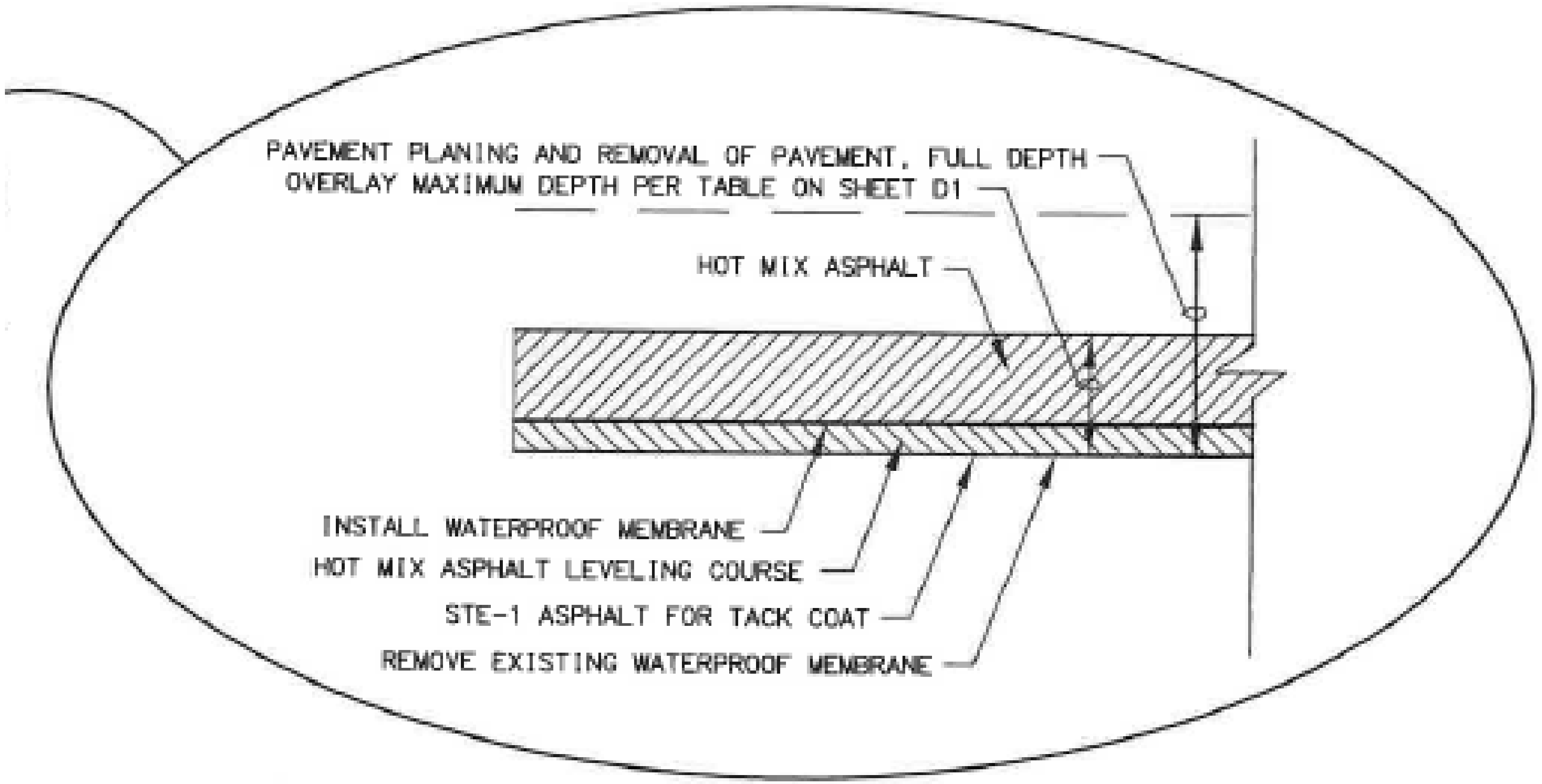
# S. Birchwood Bridge, SB Lane 2, 18-24’ LT



# S. Birchwood Bridge, SB Lane 2, 12-18' LT



# Advice on Bridges
# Never use this detail!



# Next Steps

- Increase joint bonus to $2.00/ft but raise the bar to 96% compaction for the full bonus

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- Increase joint bonus to $2.00/ft but raise the bar to 96% compaction for the full bonus
- Raise the minimum joint density to 92.0%
- Have joint bonus increase linearly from minimum acceptable value to 96.0% in 0.1% increments.

# Next Steps

- Increase joint bonus to $2.00/ft but raise the bar to 96% compaction for the full bonus
- Raise the minimum joint density to 92.0%
- Have joint bonus increase linearly from minimum acceptable value to 96.0% in 0.1% increments.
- Require sealant application on all mat sections and joints below 92.0%, including Bridges