Building a GPR Based Bridge Deck Preservation Program

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Outline

A. MDSHA Bridge Program
   1. Background
   2. Bridge Preservation in MDSHA
   3. Why is this Innovative?

B. Production Level Data Collection
   1. Method
   2. 2015 and 2016 Data Collection
   3. Lessons Learned

C. Data Processing
   1. Quality Control
   2. Standard Operating Procedures
   3. Results

D. Conclusions

A. MDSHA Bridge Program

Ross Cutts and Rodney Wynn
Maryland State Highway Administration (MDSHA)

A.1. Background

- Inventory of 2,500 Bridges
- Worst first methodology is no longer economical or feasible with the level of degradation and limited state resources and budgets.
- Agencies require an efficient, repeatable/automated bridge deck survey tool.
- MDSHA has worked with academia and industry to address existing GPR limitations, and to develop a bridge deck network level survey and analysis program.

A.2. Bridge Preservation in MDSHA

Historic Bridge Deck Inspection Program

- 30-40 structures per year using traditional testing methods (Coring, Chain drag, Chlorides, Visual).
- Historic Cost of approx. $20K-$25K per structure.

Current GPR Inspection Program

- 117 scanned and processed structures in 2015
- 2015 Cost approx. $10K - $15k per structure
- Projecting 250 scanned and processed structures in 2016
- Expecting cost to drop to around $5K - $7K per structure.

Anticipated GPR Inspection Program

- 300+ structures scanned annually at higher speeds (30 to 40 mph)
- Annual network level trending of all collected structures

A.3. Why is this innovative?

- Production-Level Data Collection:
  - Allows us to collect a significantly larger number of structures, safer,
  - faster, and cheaper.
  - Reduces impact to traveling public by 80%. (2 weeks vs 2 days per structure)
  - Technology is capable of collecting data at even higher speeds to further eliminate public delays and MOT.

- Production-Level Data Processing:
  - Automated process generates results that are repeatable and comparable year over year.
  - Traditional processing is a time intensive process we have reduced the processing time from 1 structure per week to 20 structures per week.
  - Provides OOS fast turnaround (1 day for collection, and 1 week for processing).

B. Production Level Data Collection

David Hollens
Maryland Environmental Service (MES)

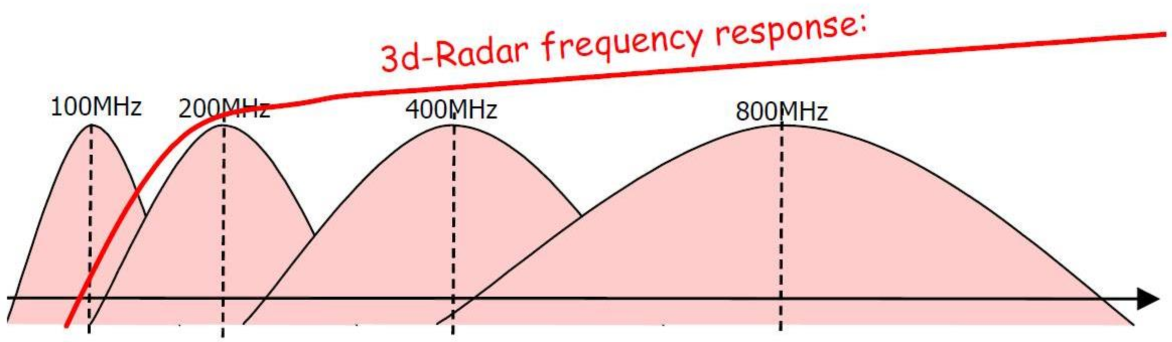
B.1 Method

- Equipment Specifications
  - Custom trailer with 6' near ground-coupled antenna array.
  - Longitudinal Sampling Interval (LSI) 1.5" for 20 transmitter/receivers lines spaced Transversely (TSI) at 3.75".
  - Registration using raised GPS (RTK) located above vehicle sight line to improve signal strength.
  - Maximum scan resolution at 8 mph. Speed is inversely linear to sampling interval and number of lines.
  - TSI of 7.5" and LSI of 4" at 43MPH.

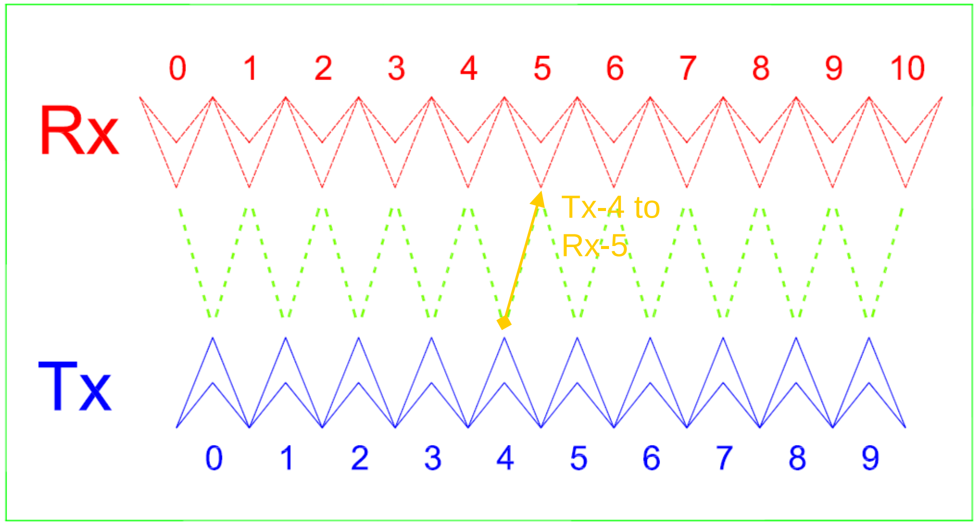
Source: Maryland Environmental Service

B.1 Method

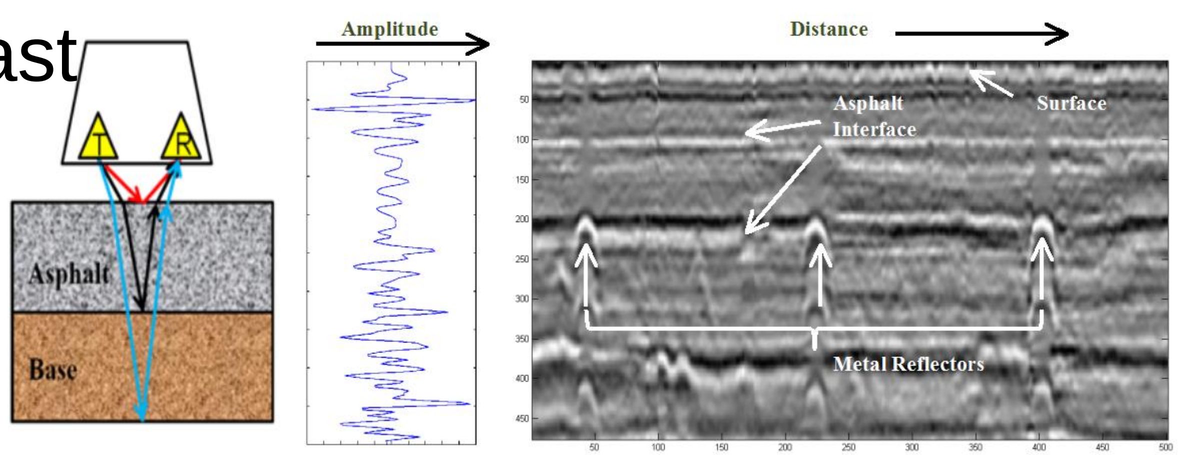
- Bandwidth (150MHz to 3GHz)



- Compact Array Configuration (20 lines spaced at 3.75 inches)



- Better Feature Contrast



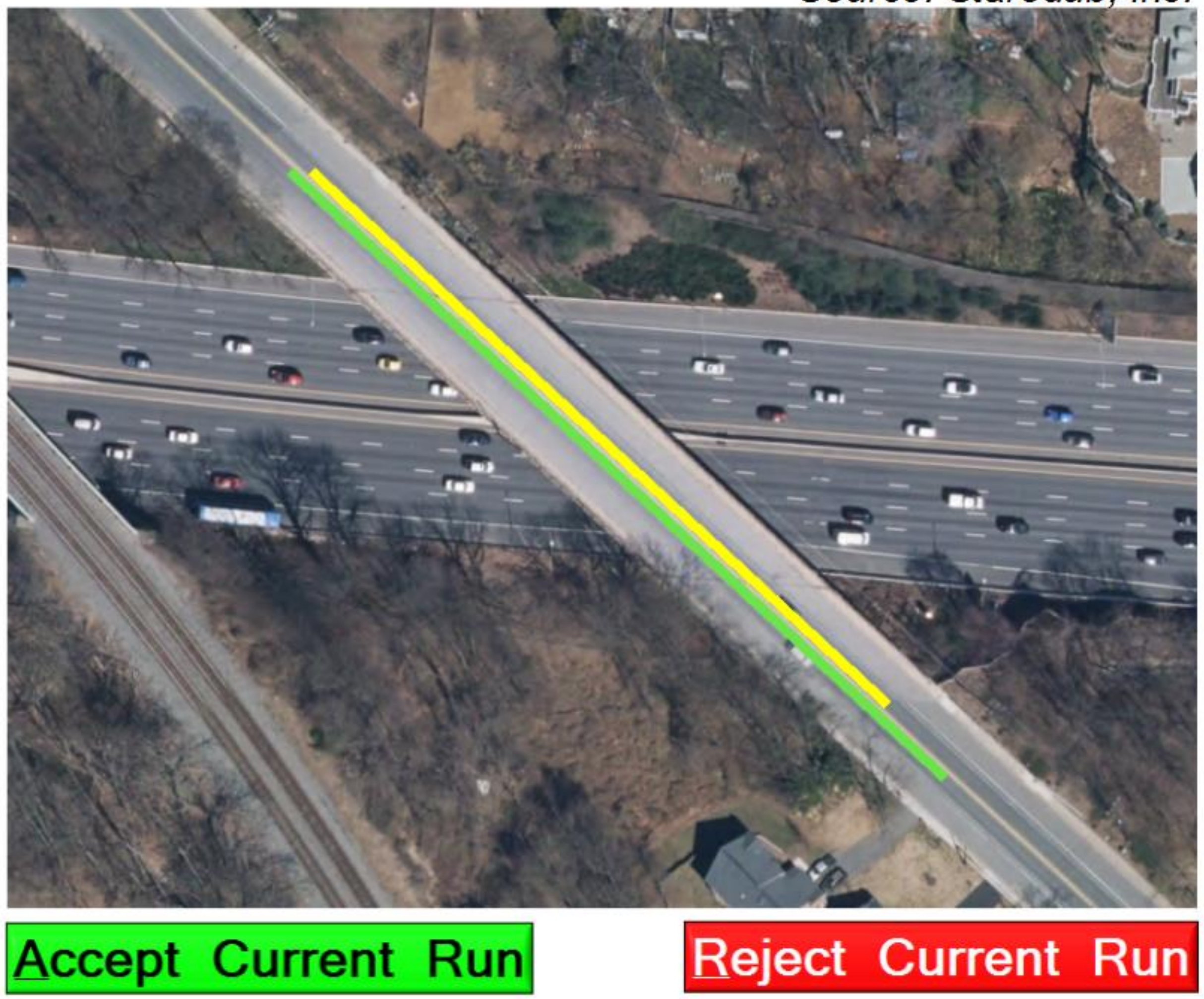
(a) GPR Setup (b) GPR Time Domain Waveform (c) Time Domain Field Data

B.1 Method

Computer-Assisted Data Collection

- Establish Scan Settings
  - For deep scans of bridge deck or similar features, the following settings work well:
    - Trigger Spacing: 1.52 inches (Note: great for identifying individual rebar curves)
    - Time Window: 62 ns
    - Dwell Time: 2.0 us
    - Max Speed: 7.4 mph
    - Integration Time: 712 us
    - GPS Baud Rate: 9800 bps

Source: Starodub, Inc.



In review mode, extent of current run overlaid in yellow with previously accepted runs at current location. User prompted to accept or reject it.

Real-Time Quality Assurance

MARYLAND ENVIRONMENTAL SERVICE

B.2 2015 and 2016 Databases

- Safety Management Considerations (MOT, Permitting)
- Managing Weather Conditions (Moisture - How wet is the pavement?)
- Managing GPS (Signal Variance in time)
- Completeness of Data (3-D Coverage across width)
- 117 Bridge Decks in 2015
- In-Progress – 250 Bridge Decks in 2016

B.3 Lessons Learned

- Plan travel routes: long stretches
- Coordination, coordination, coordination
- Obtain all necessary permits and authorizations before starting work
- Maintain equipment and perform all repairs/modifications before starting work
- Perform "control" test runs
- Use three (3) TMAs for slow speed highway applications
- Stay in vehicle; accidents do occur
- Perform rolling starts and stops during data collection
- Developed Standard Operating Procedures

C. Data Processing

Nicolas Gagarin
Starodub, Inc.

C.1. Analysis of SF-GPR Database

- Quality Control
  - Environmental Effects
  - Interference Removal
- Project Definition using GPS Clustering
- Analysis Pipeline
  - Data Elements
  - Summary Tables
- Visualization and Project Template
- GIS files
- Interpretation of Results
  - Defects and Deterioration within a project
  - Ranking of Condition among projects

Notes:
Boundary Markers in white detected in GPR data.
Sections are numbered per inventory.
Data coverage outline shown.

0 100 200 Feet

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Boundary Markers in white detected in GPR data.
Sections are numbered per inventory.
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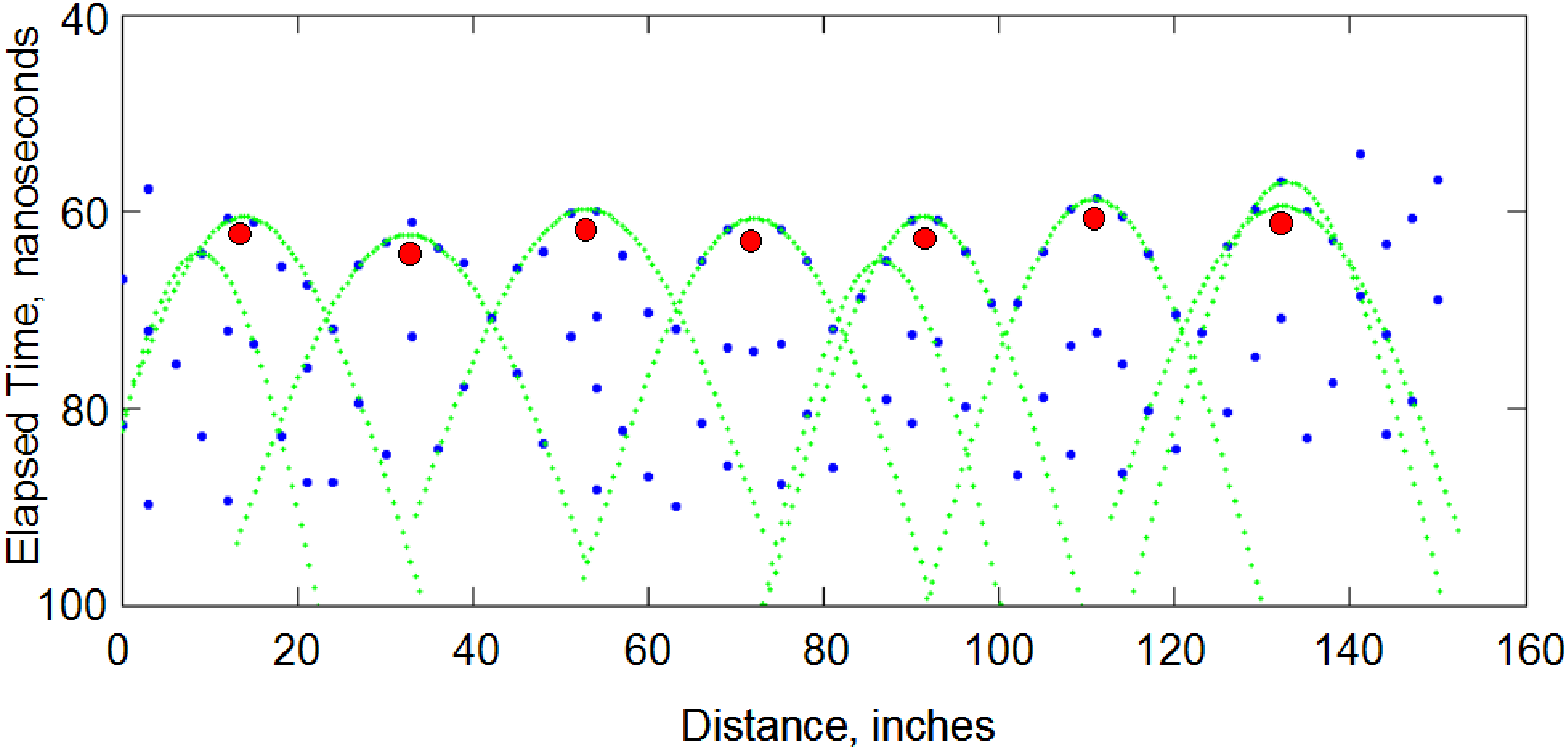
0 100 200 Feet

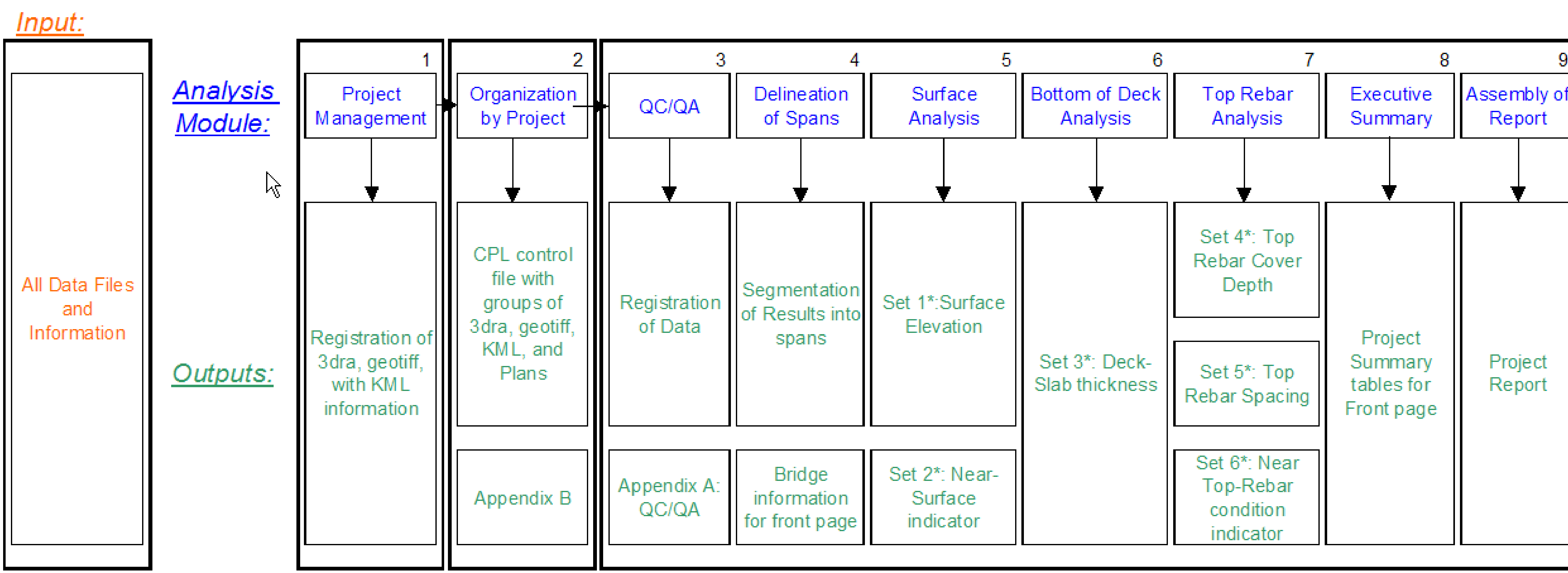
C.2. Automated Data Processing

- Automation of Data Processing, Visualization and Report Preparation
- Data Management (linked to Computer-Assisted Data Collection)
- Modular Analysis with Embedded Quality Control
- Verification, Validation, and Evaluation using Cores



C.2. Analysis Pipeline

- Data Elements
  - Surface Condition using Amplitude of First Surface Reflection
  - Surface Elevation using Time to First Surface Reflection
  - Concrete Cover using results of detection of transverse top rebar
  - Deck Thickness using detection of bottom of deck
  - Top Rebar condition using signal strength, estimated dielectric constant, and depth at apex of the SAR signature of each top rebar



C.2. Analysis Pipeline

- For Asphalt Overlay over Concrete Slab
  - Thickness of Asphalt
  - Signal Characteristics at Asphalt/Concrete interface
  - Combined Asphalt/Concrete Cover

- Buried Object near Abutments

- Contour Plots/Summary Tables/GIS files

- Production Rates of 20 Project Reports per week by two engineer team.

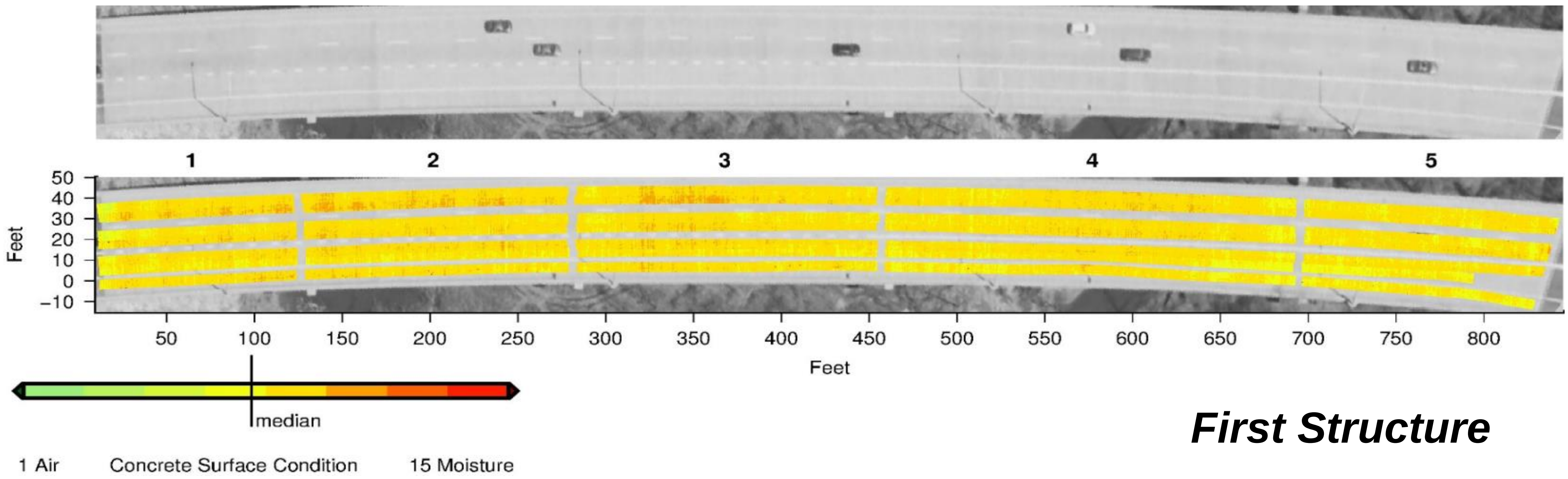
C.3. Results

1. Comparing a bridge deck in good condition with one showing signs of defects and deterioration using elements of report template

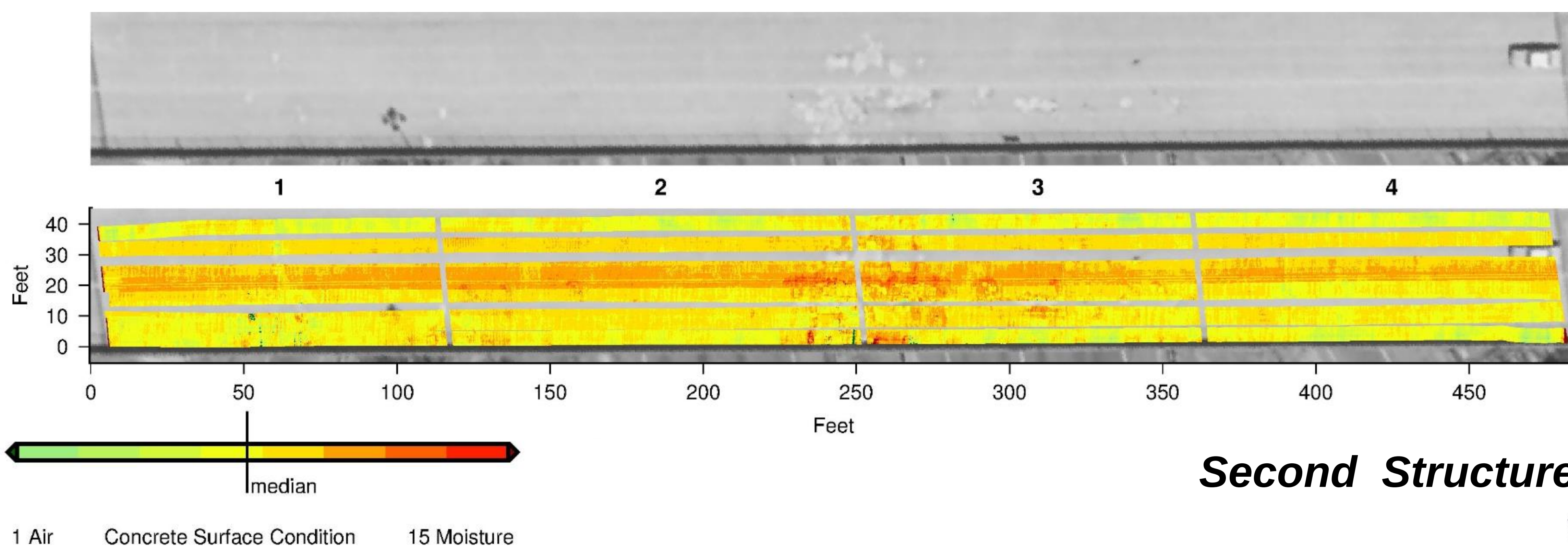
2. Distribution plots (histograms) to review sets of projects annually and cumulatively

3. Documenting patterns related to defects and deterioration within one project

C.3.1. Comparing Two Structures



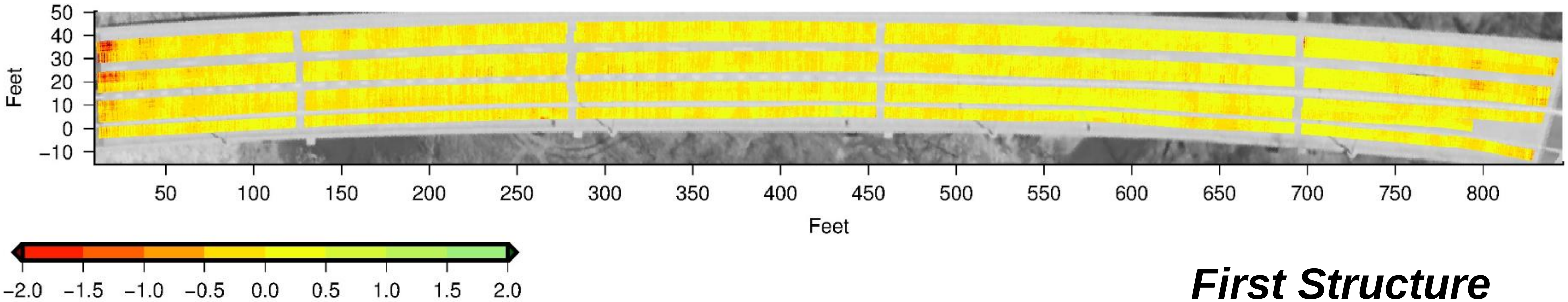
First Structure



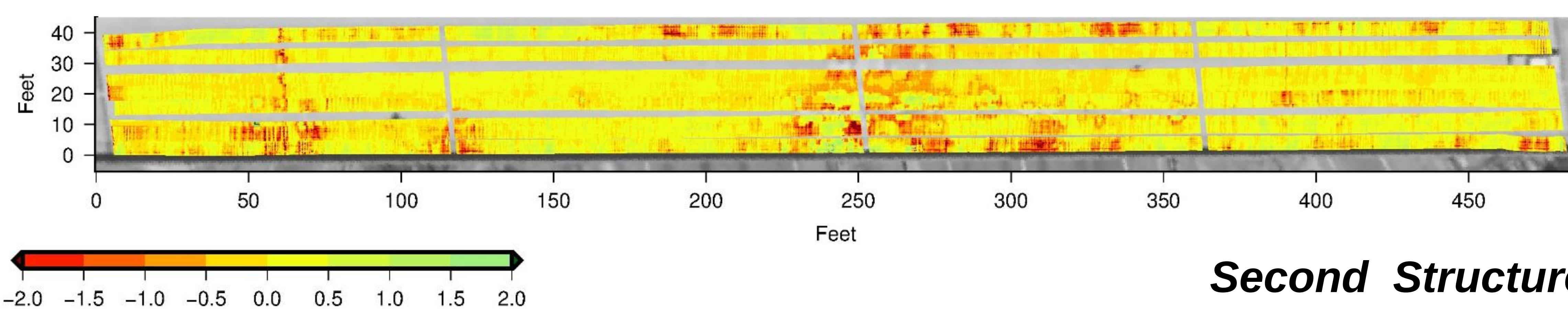
Second Structure

Concrete Surface Condition

C.3.1. Comparing Two Structures



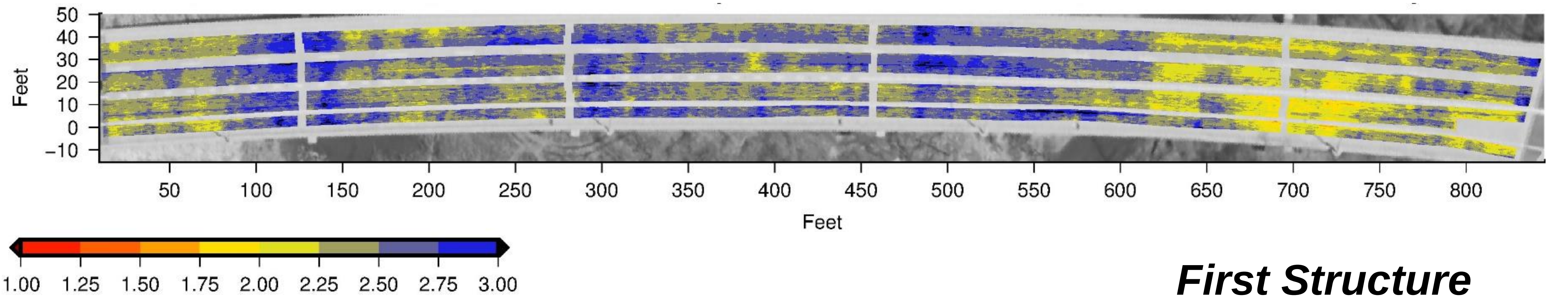
First Structure



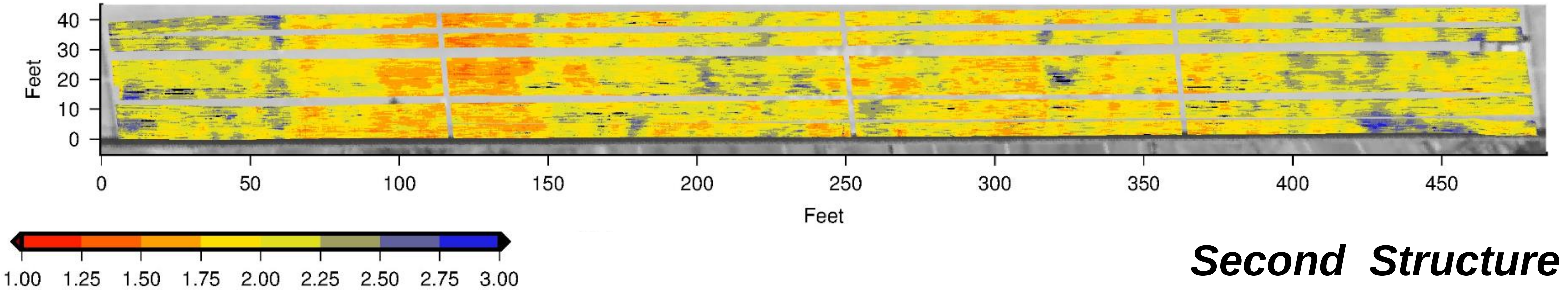
Second Structure

Surface Elevation, inches

C.3.1. Comparing Two Structures



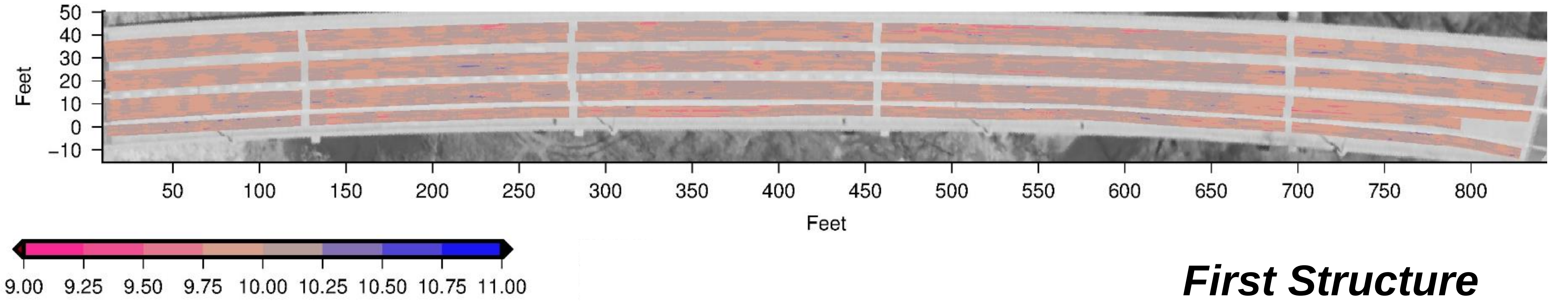
First Structure



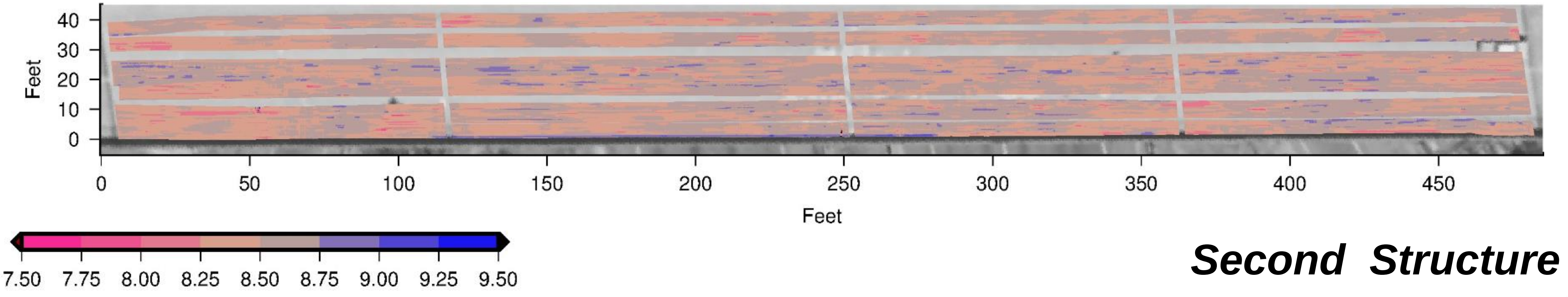
Second Structure

Concrete Cover, inches

C.3.1. Comparing Two Structures



First Structure

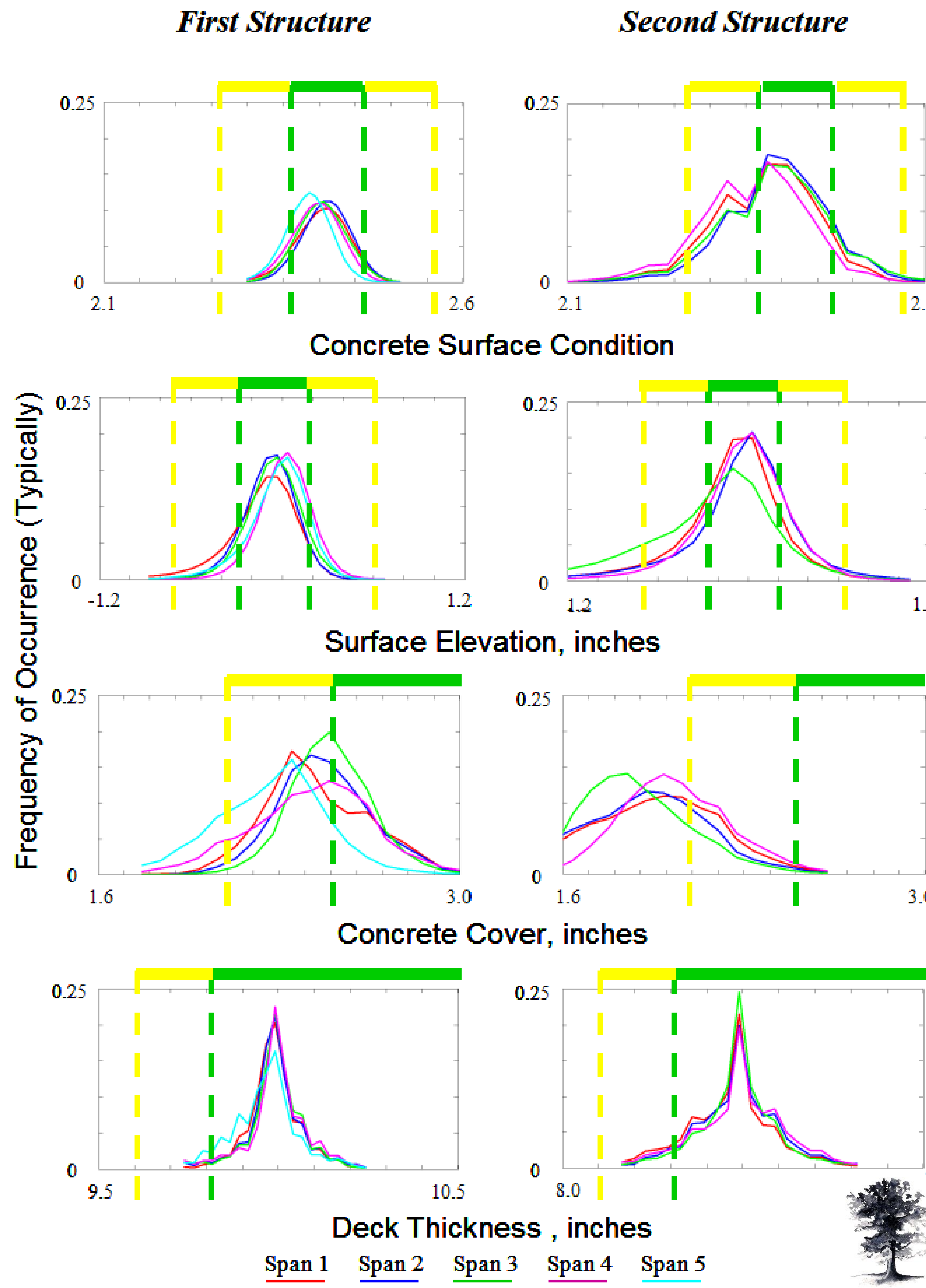


Second Structure

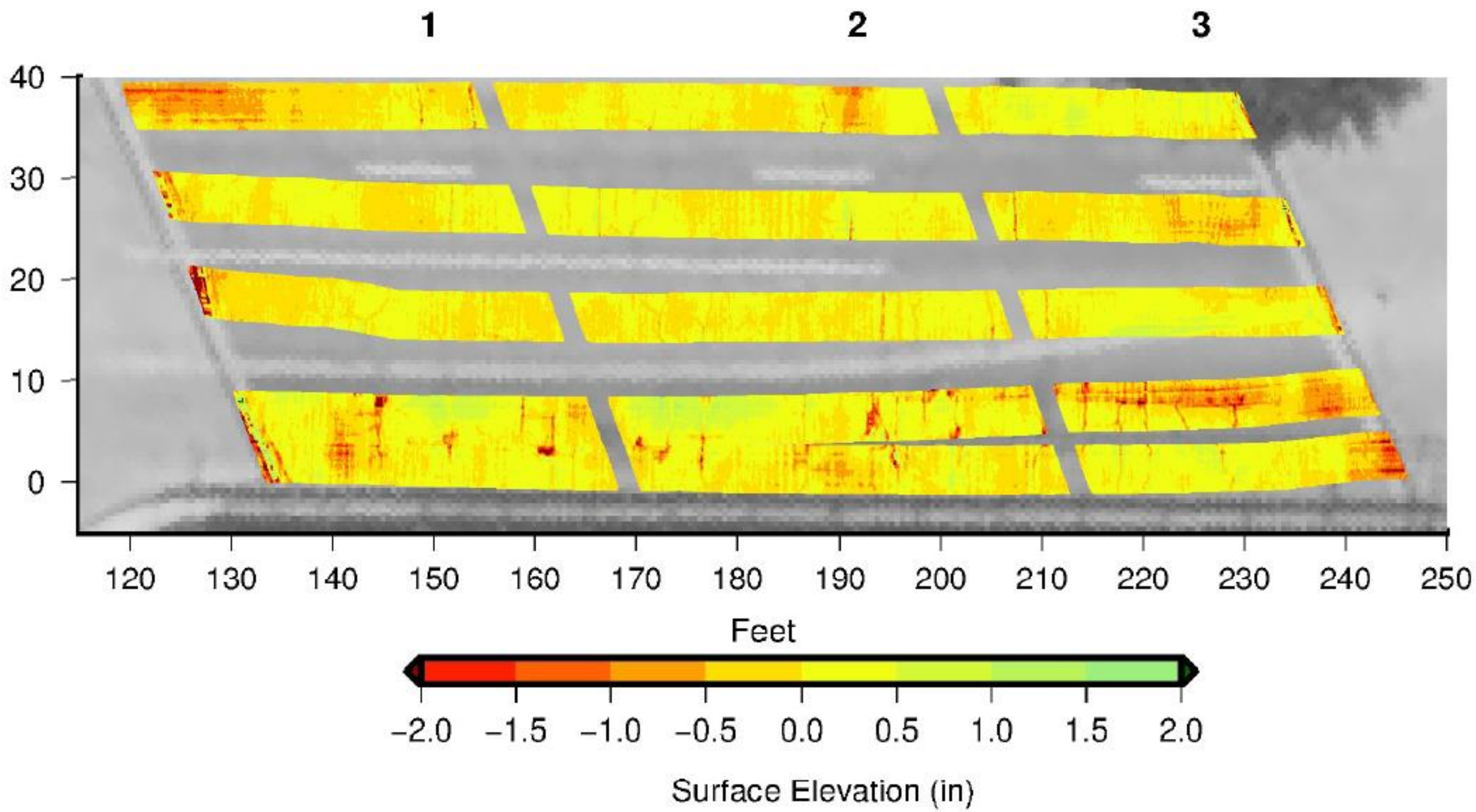
Deck Thickness, inches

C.3.2. Comparing Two Structures: Distributions

- Using histograms of a selection of data elements for each span
- Compare statistics of histograms
- Establish ranges of ***acceptable*** and ***marginal*** values
- Rank condition using statistics

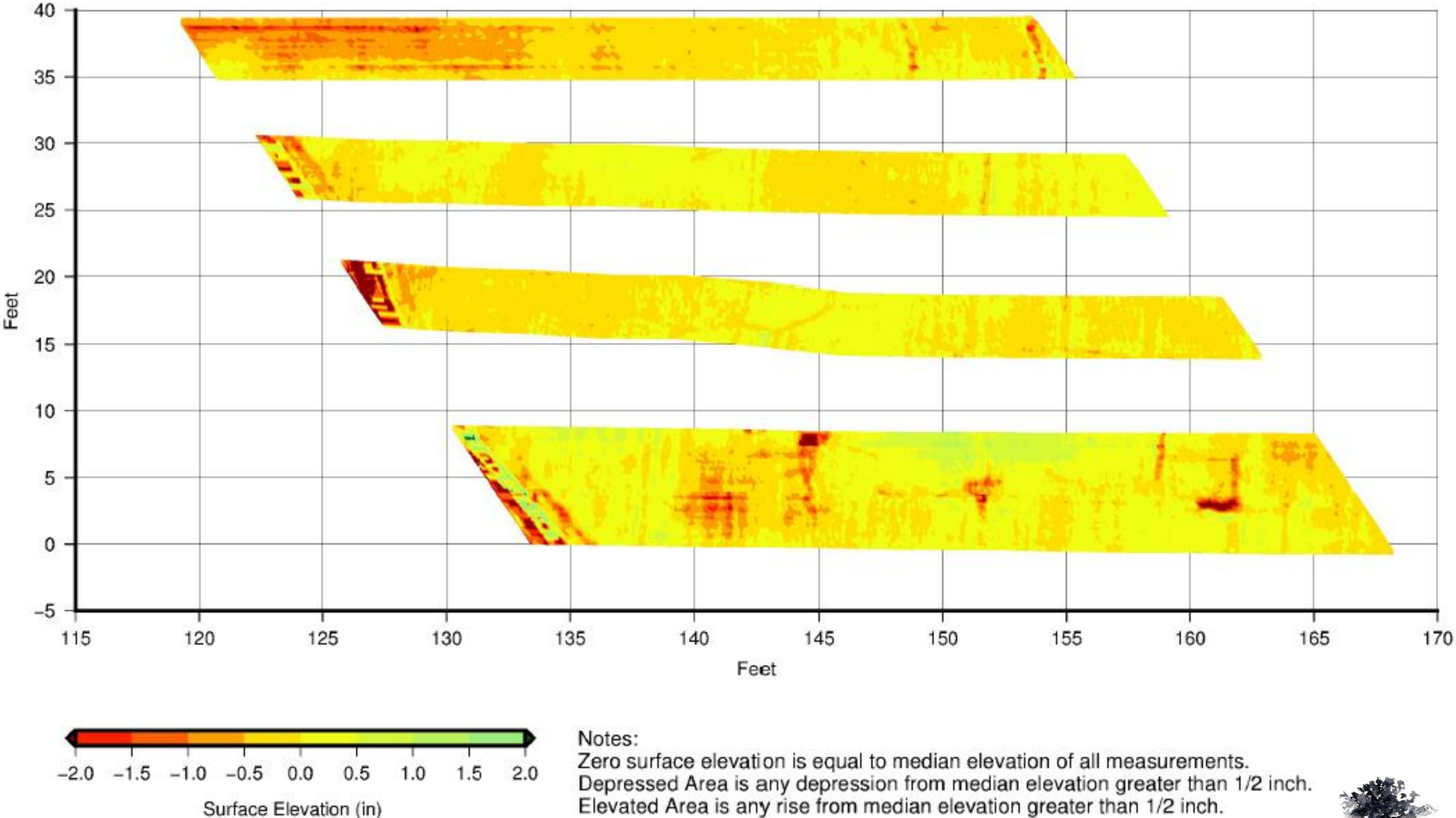


C.3.3. Overlay Patterns: Plan View



Asphalt Overlay – (a) All Spans

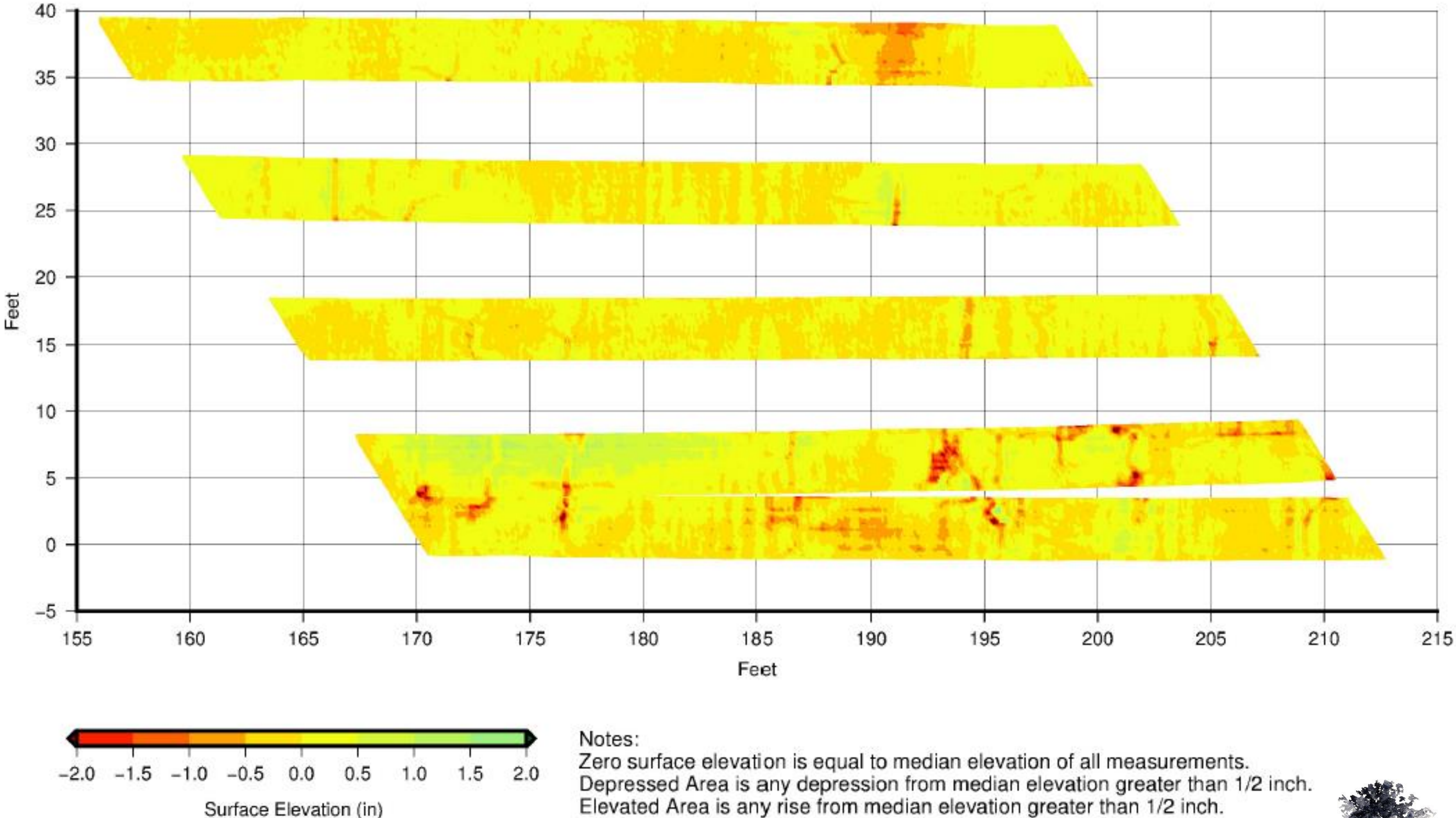
C.3.3. Overlay Patterns: Plan View



Notes:
Zero surface elevation is equal to median elevation of all measurements.
Depressed Area is any depression from median elevation greater than 1/2 inch.
Elevated Area is any rise from median elevation greater than 1/2 inch.

Asphalt Overlay – (b) Span 1

C.3.3. Overlay Patterns: Plan View



Notes:
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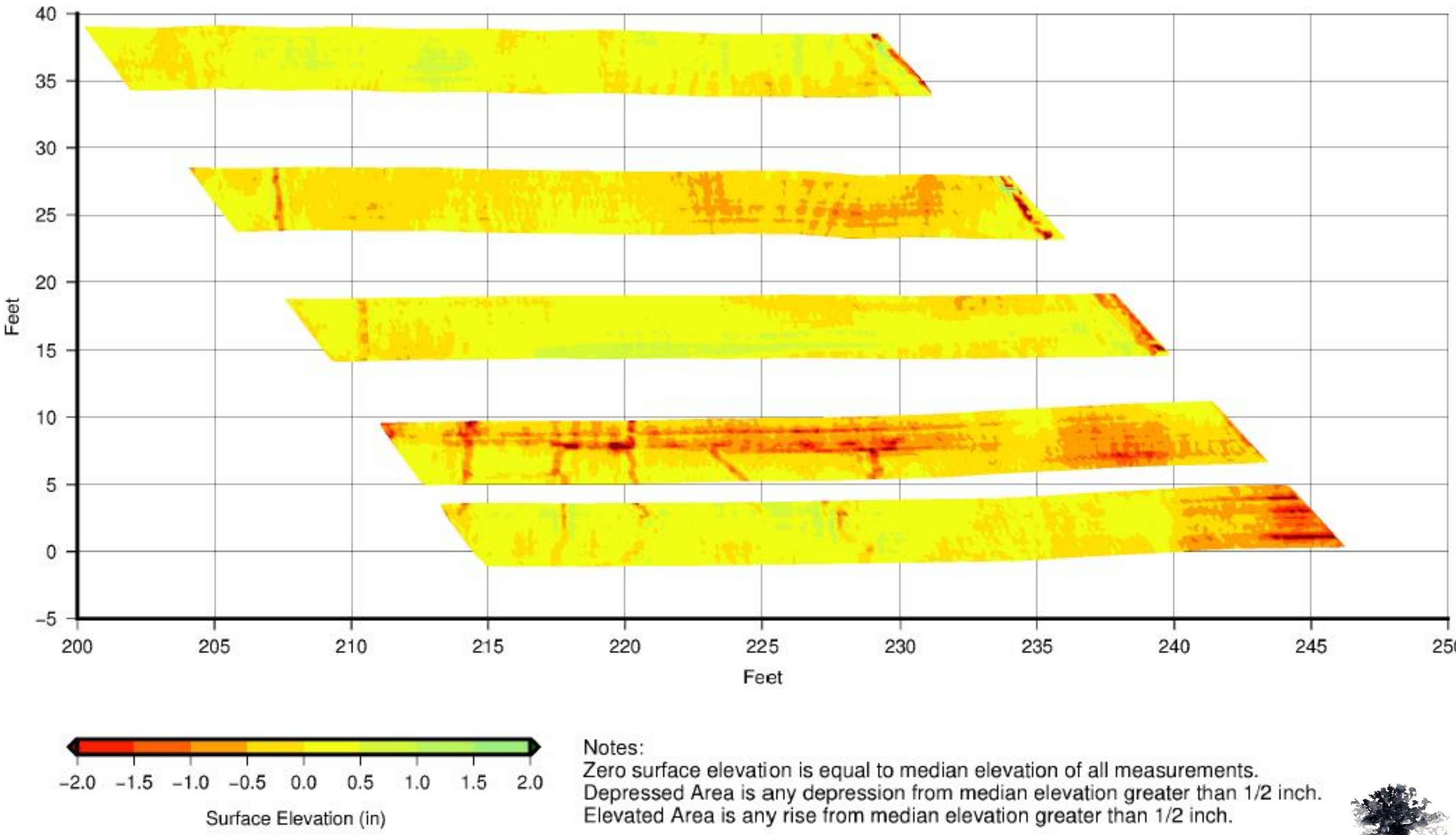
Asphalt Overlay – (c) Span 2

C.3.3. Overlay Patterns: Plan View



Notes:
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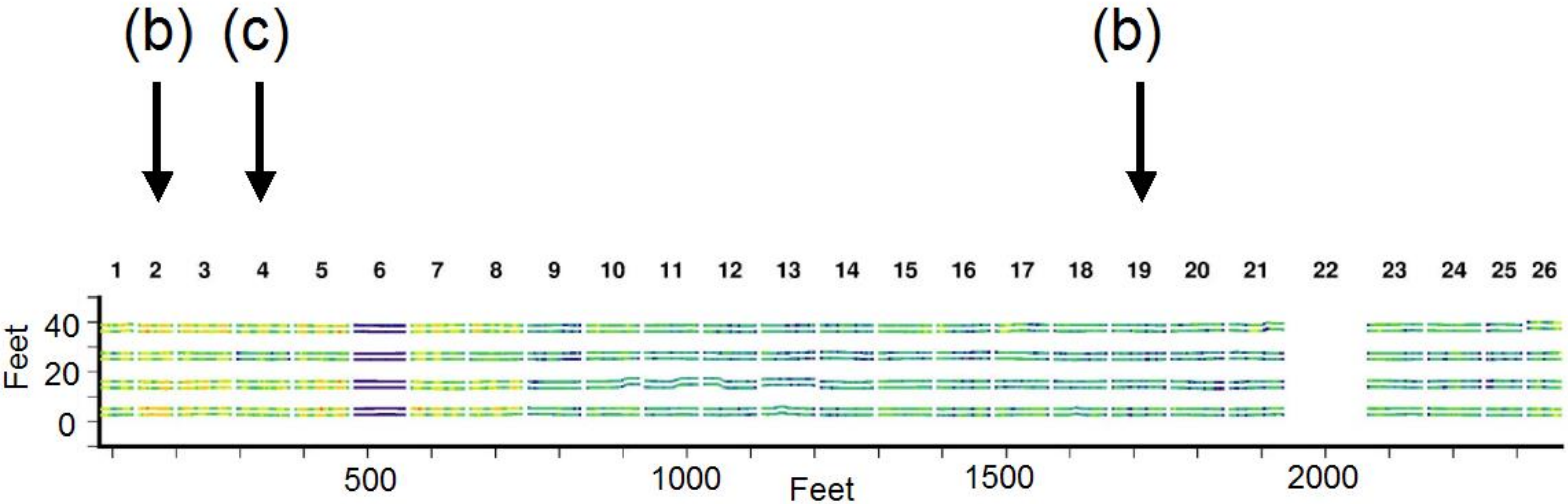
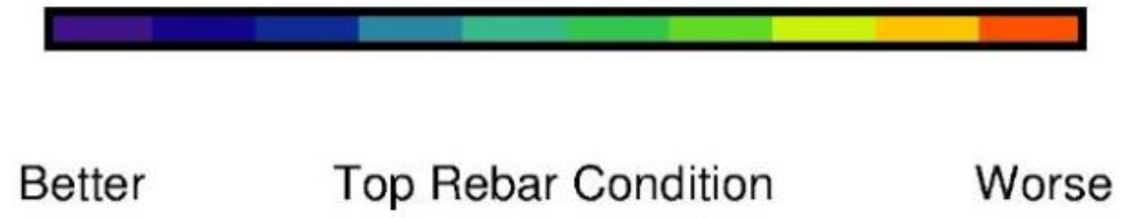
Asphalt Overlay – (d) Span 3

C.3.3. Rebar Patterns: Plan View

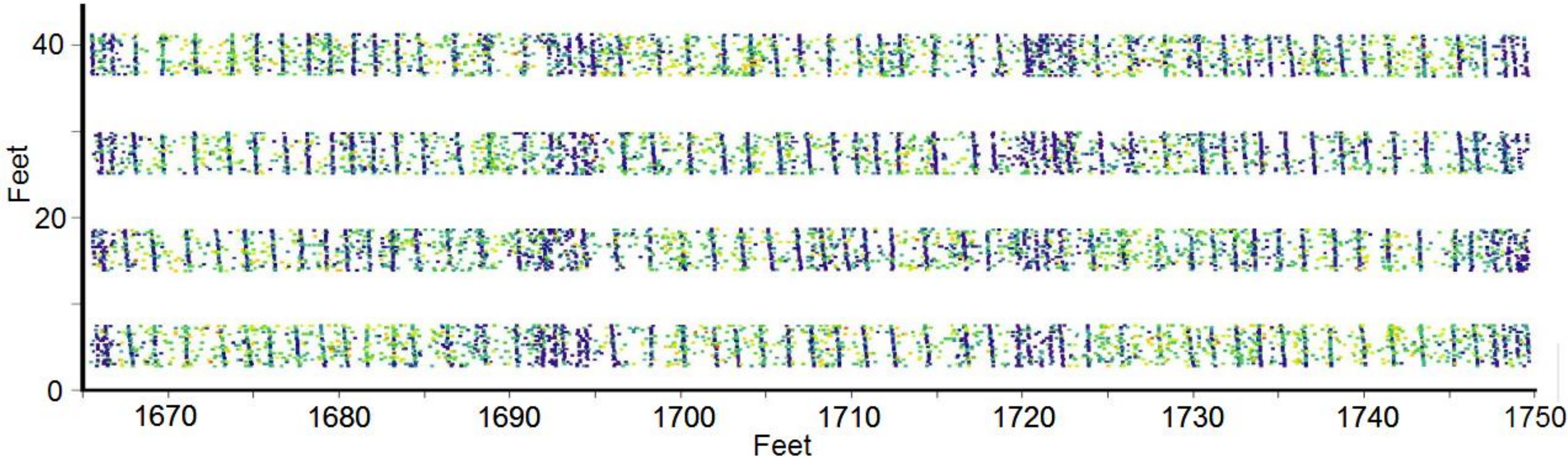


(a) All Sections

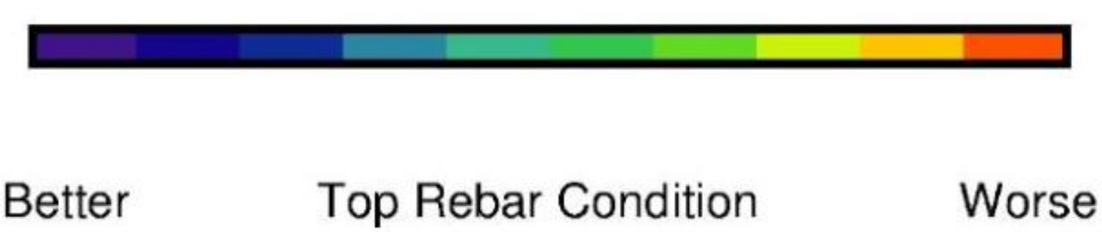


C.3.3. Rebar Patterns: Plan View

Section 19

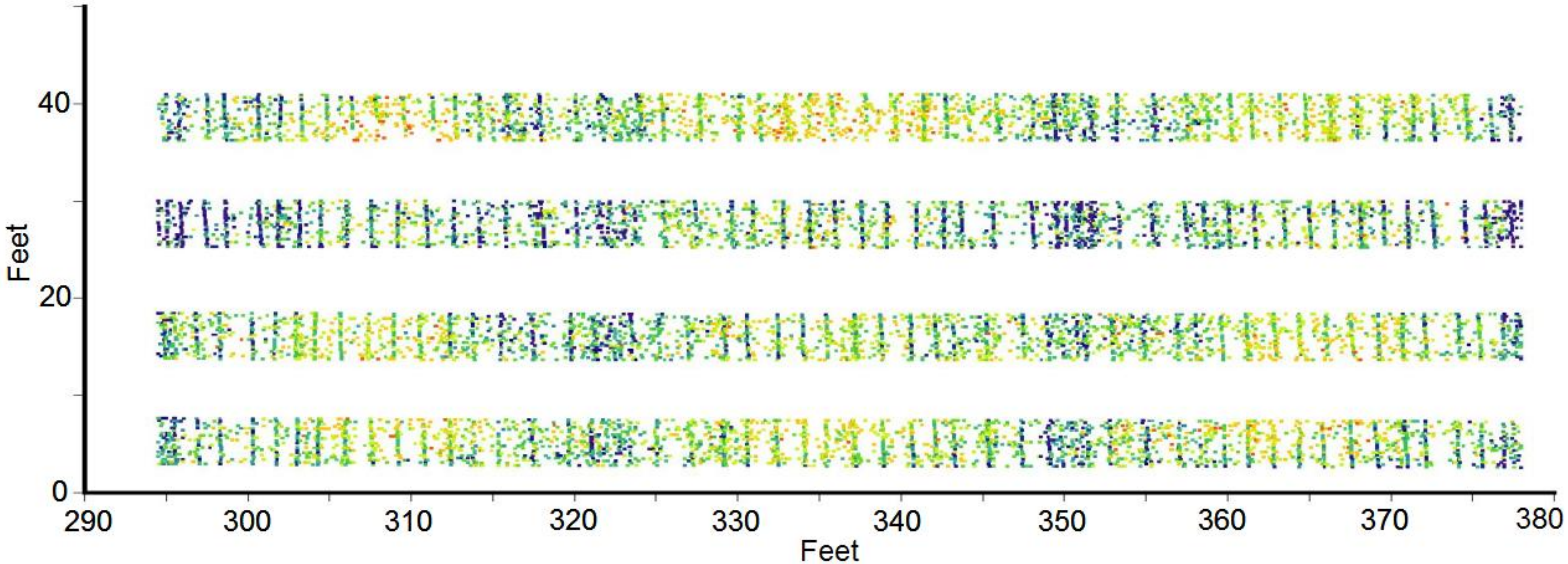


(d) Good Condition

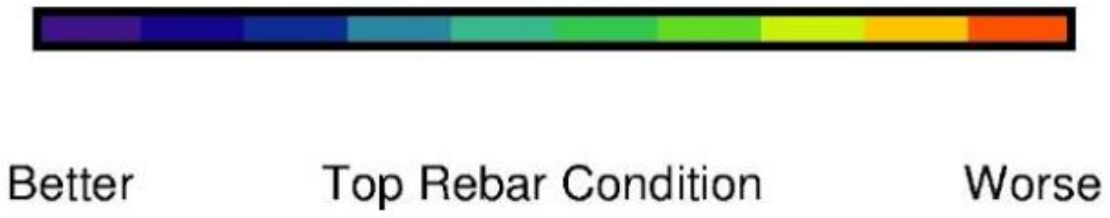


C.3.3. Rebar Patterns: Plan View

Section 4

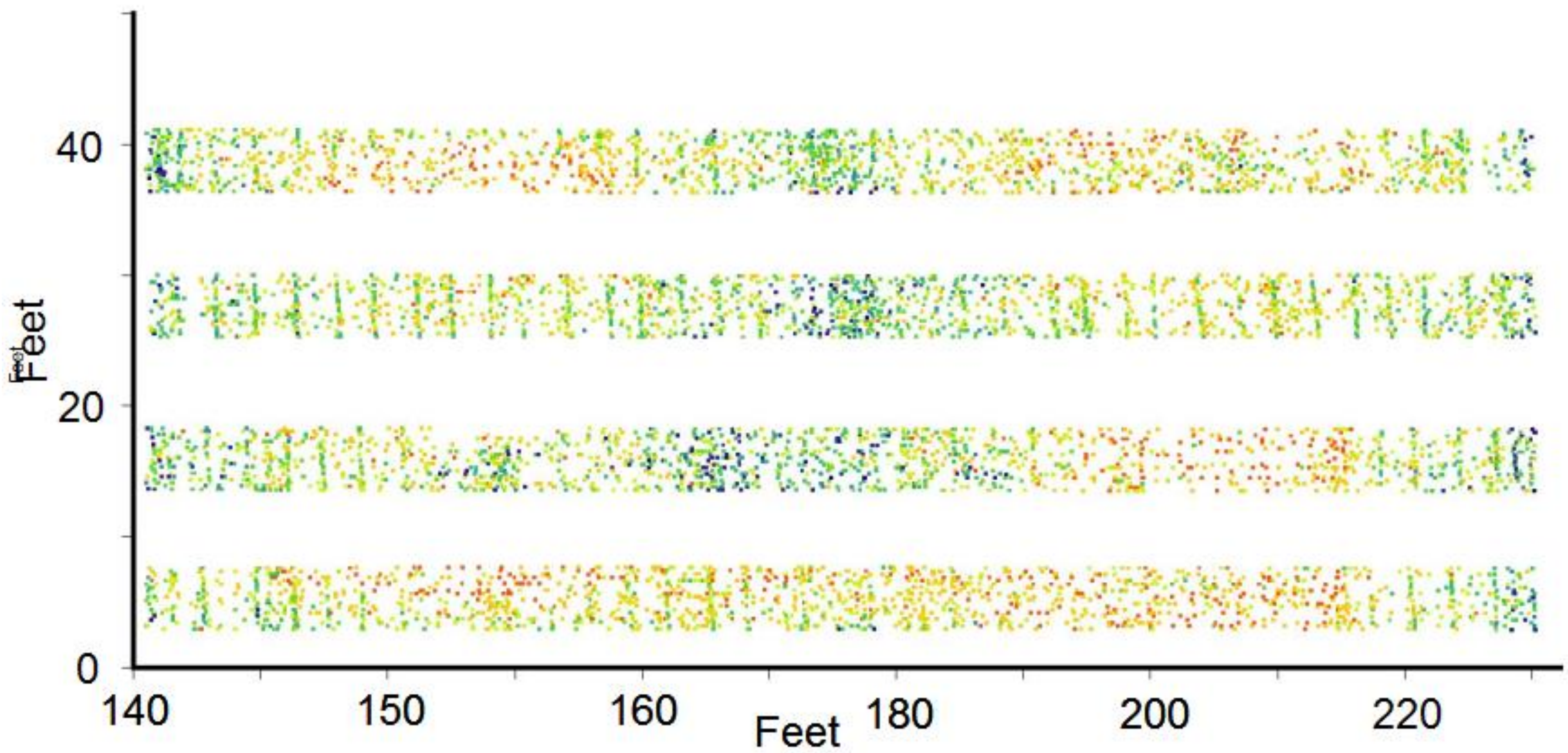


(c) Acceptable Condition

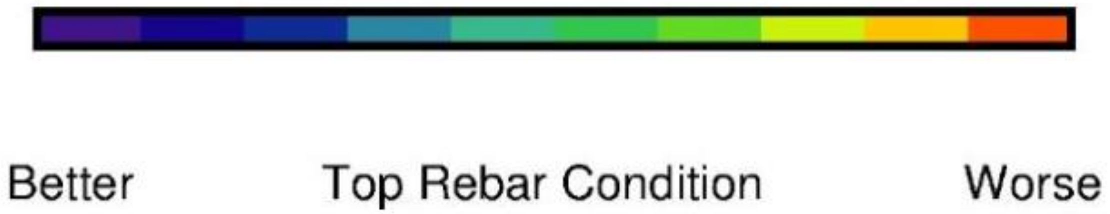


C.3.3. Rebar Patterns: Plan View

Section 2



(b) Marginal Condition



D. Conclusions

Ross Cutts
Maryland State Highway Administration (MDSHA)

D. Conclusions

- Over the past 3 years MDSHA has been working to develop a successful GPR based bridge deck preservation program. Over this time the following has occurred:
  - This project was awarded AASHTO's 2015 Sweet 16 High Value Research Project Award and was identified as the top project in Region1.
  - This project is transitioning from research into a critical component into MDSHA's bridge deck evaluation program.
  - We are producing repeatable results that are GIS based and trend able over time that enable our engineers to make better decisions.
- We are excited for the future and are grateful for the support provided by MDSHA, FHWA, AASHTO, UMD, MES, and Starodub.

Thank you

Questions?