Pavement Density Evaluation using Ground Penetrating Radar (GPR)

by

Ken Maser, President

Infrasense, Inc.

NESMEA 2013
Portsmouth, NH

INFRASENSE, Inc.

Presentation Outline

- Background and Basic Principles
- Results of Previous Studies
  - (FDOT, MnDOT)
- Evaluation Rt. 125 in Lee NH
- FHWA IC Demo in Maine

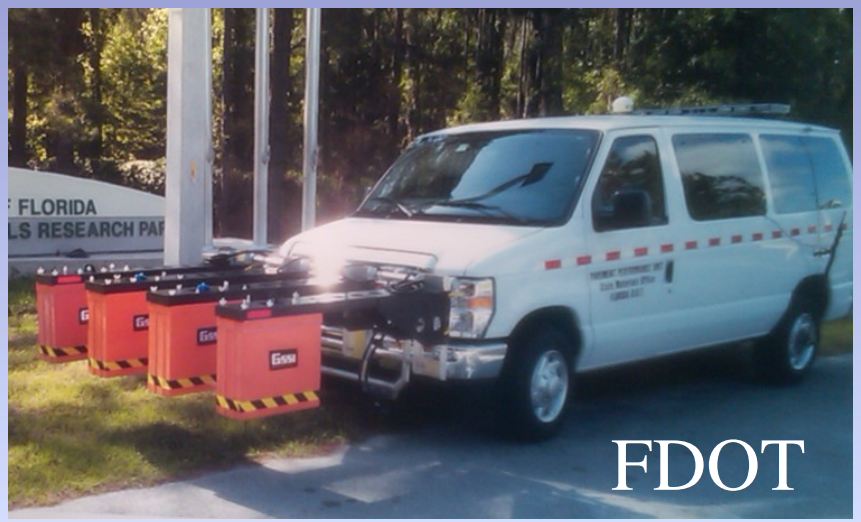
INFRASENSE, Inc.

Technical Background

- GPR commonly used for layer thickness, bridge deck evaluation
- Horn antenna can measure pavement dielectric
- Dielectric is directly related to density, assuming material composition is uniform
- This relationship has been confirmed in previous studies

INFRASENSE, Inc.

GPR Horn Antenna Equipment

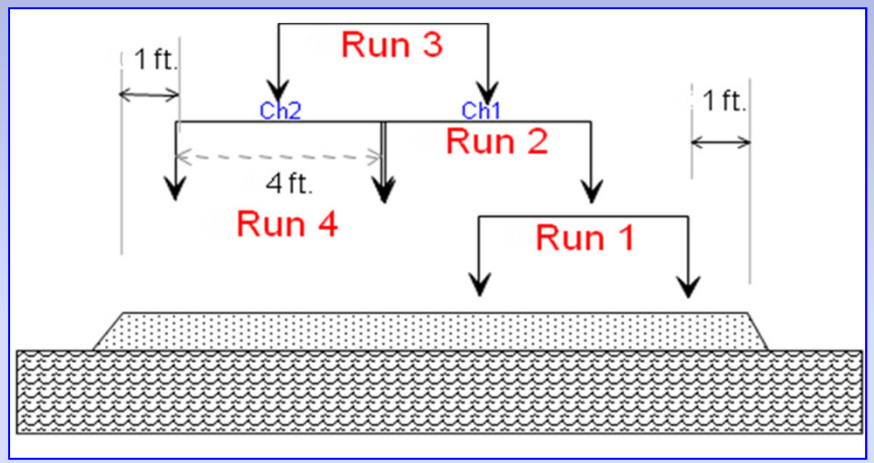


INFRASENSE, Inc.

Survey Procedure

Laser switch

Marker cone

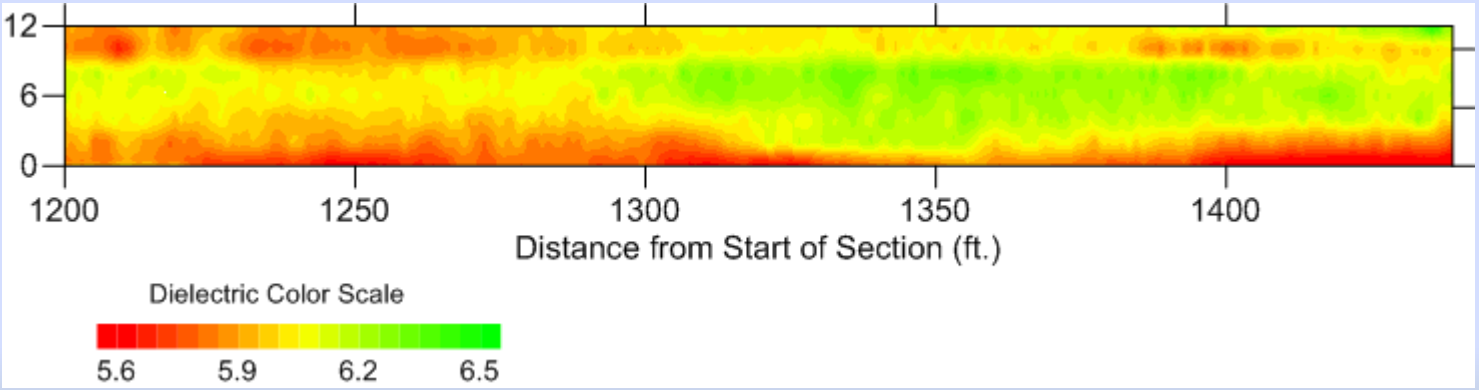


Dual Antenna Survey Layout

INFRASENSE, Inc.

Automated (GPRQA) Analysis

	A	B	C
1	Station	Offset	Dielectric
2	0.25026	0	5.73877
3	0.50052	0	5.565659
4	0.75078	0	5.418099
5	1.00104	0	5.602684
6	1.25131	0	5.569718
7	1.50157	0	5.620329
8	1.75183	0	5.499176
9	2.00209	0	5.551801
10	2.25235	0	5.576707
11	2.50261	0	5.528082



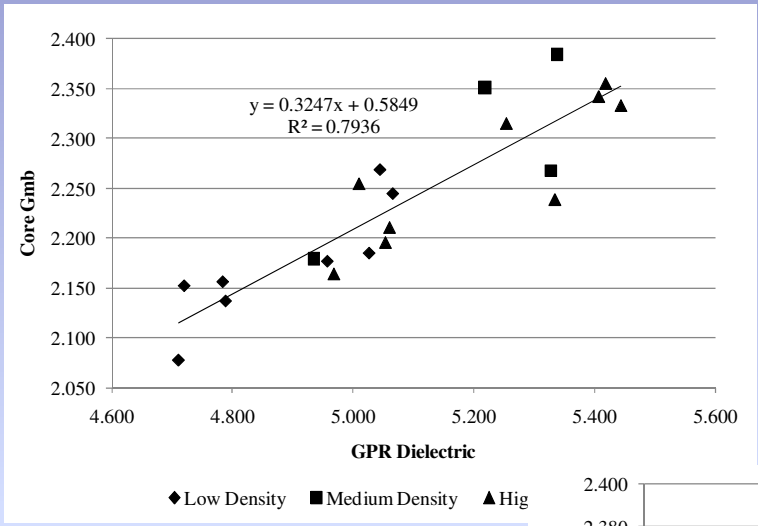
INFRASENSE, Inc.

FDOT Field Validation Testing (2008)

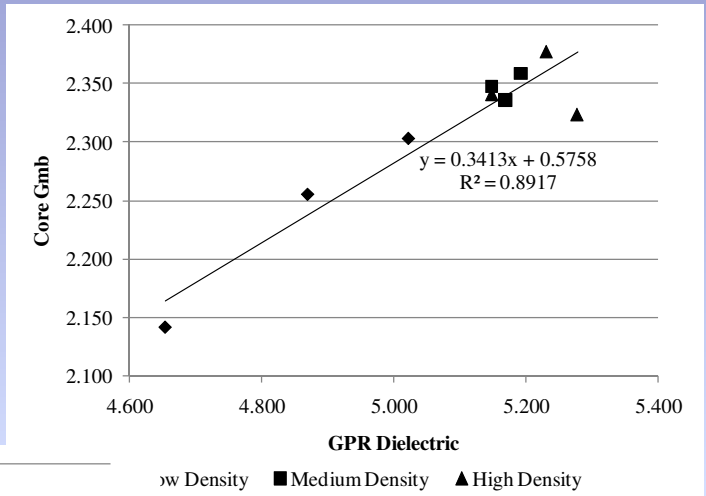
- Field Validation Trials were completed on three different construction projects.
  - New Construction Projects:
    - State Road 20 (Town of Interlaken)
    - State Road 23 (Duval County)
  - Asphalt Resurfacing Project:
    - State Road 222 (City of Gainesville)

INFRASENSE, Inc.

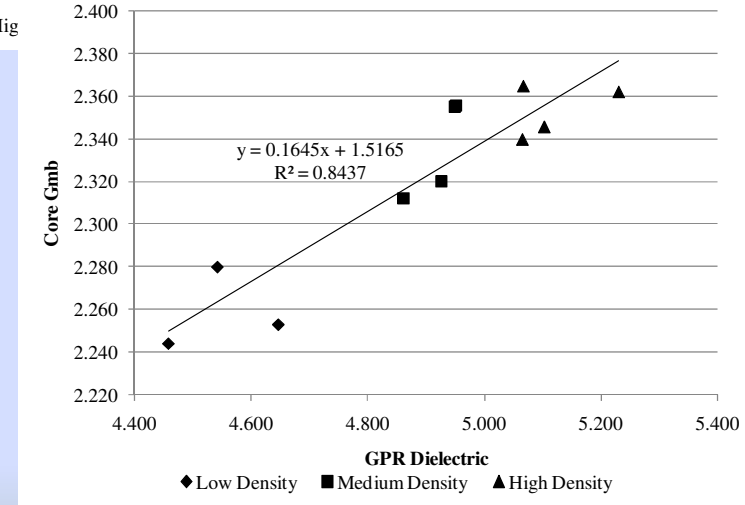
Overall Correlation for 3 FDOT Projects



SR 20 Results
$R^2 = 0.79$



SR 23 Results
$R^2 = 0.89$



SR 222 Results
$R^2 = 0.84$

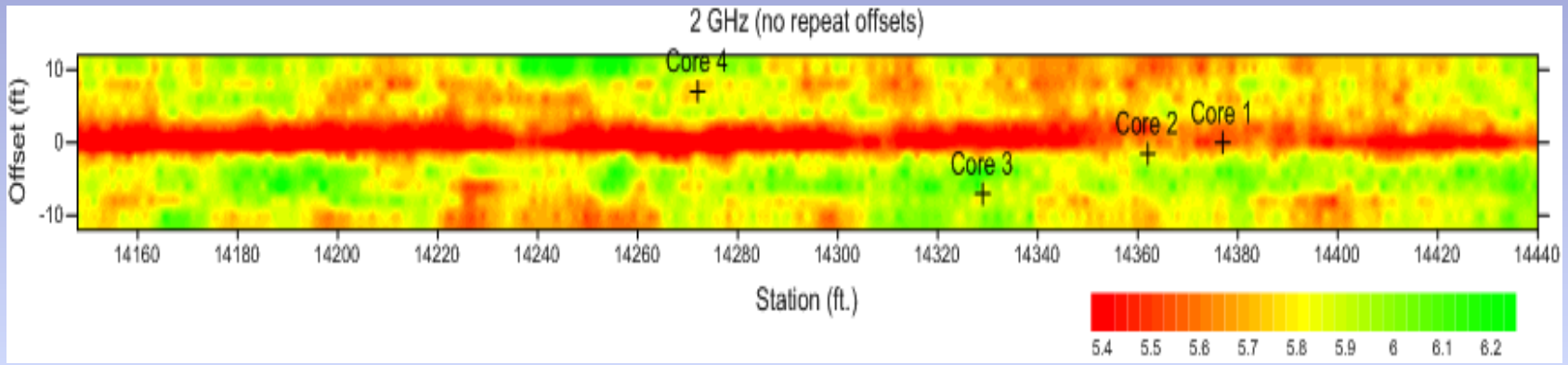
INFRASENSE, Inc.

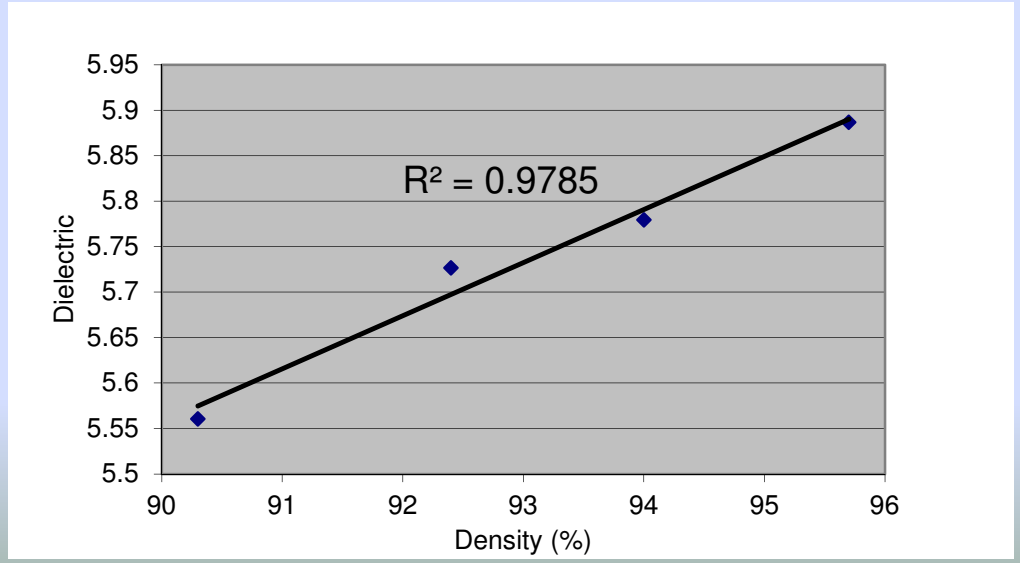
MnDOT Testing – Summer 2012

INFRASENSE, Inc.

Example MnDOT Results

TH13 (June 27-28, 2012)





INFRASENSE, Inc.

Rt. 125 in Lee, NH

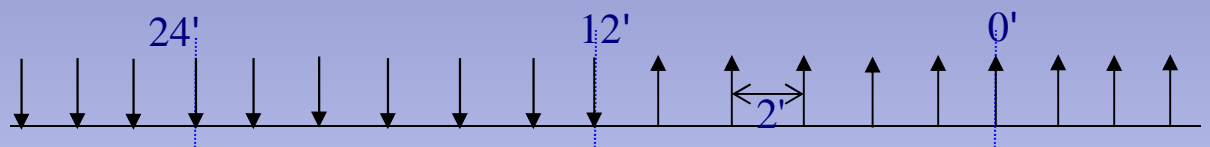
- 4-mile paving project (Aug-Sept, 2013)
  - Leveling course plus 1¼" wearing course
  - 2 travel lanes and 2 shoulders
- Partial use of Intelligent Compaction
  - Southern half conventional
  - Northern half IC
- GPR included in project to map density variations
  - Conventional vs. IC
  - Other spatial variations
  - Correlate GPR dielectrics to core densities

INFRASENSE, Inc.

GPR Equipment for Lee Project

INFRASENSE, Inc.

Pass Layout



west shoulder seam

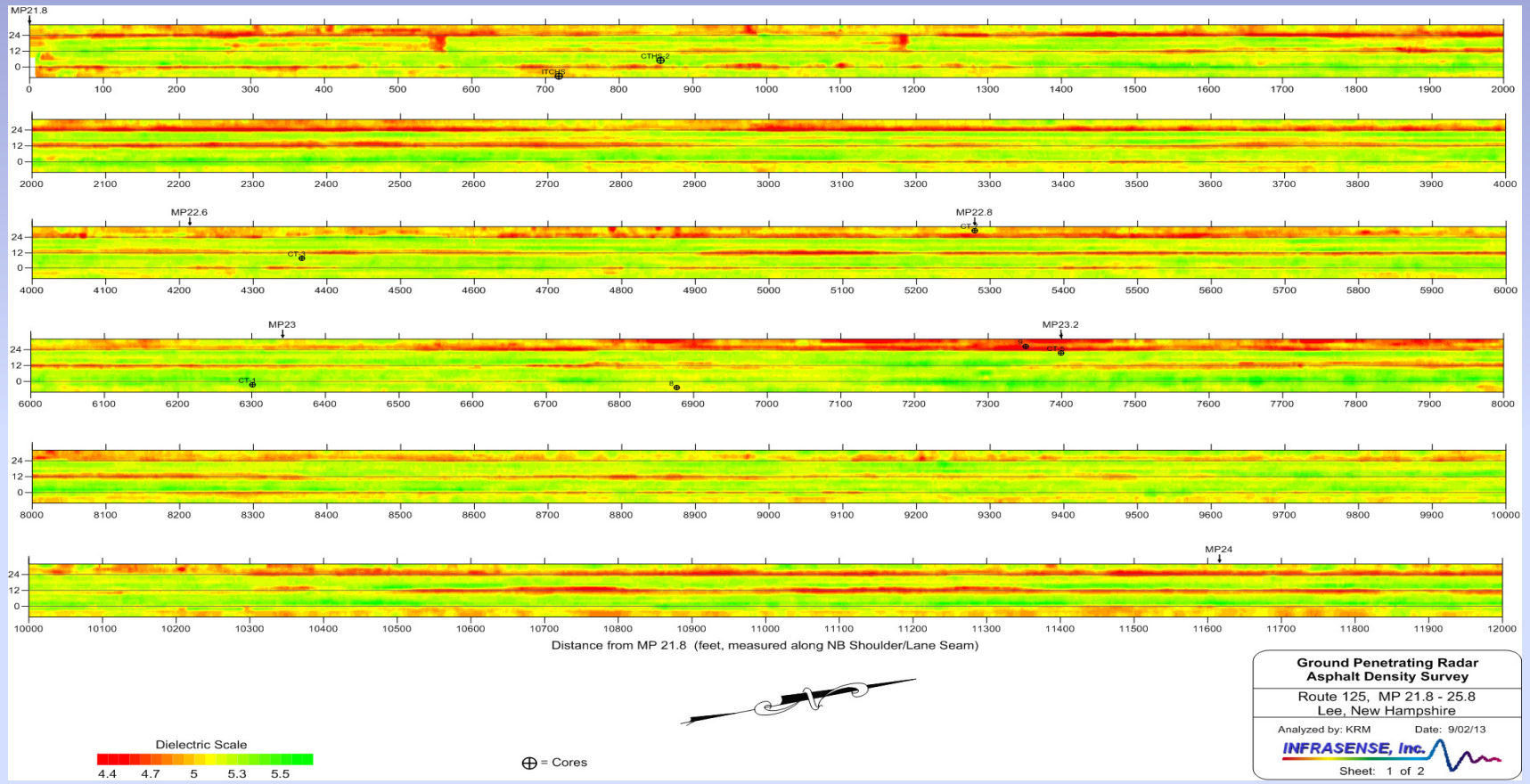
center seam

east shoulder seam

= offset and direction of GPR data line

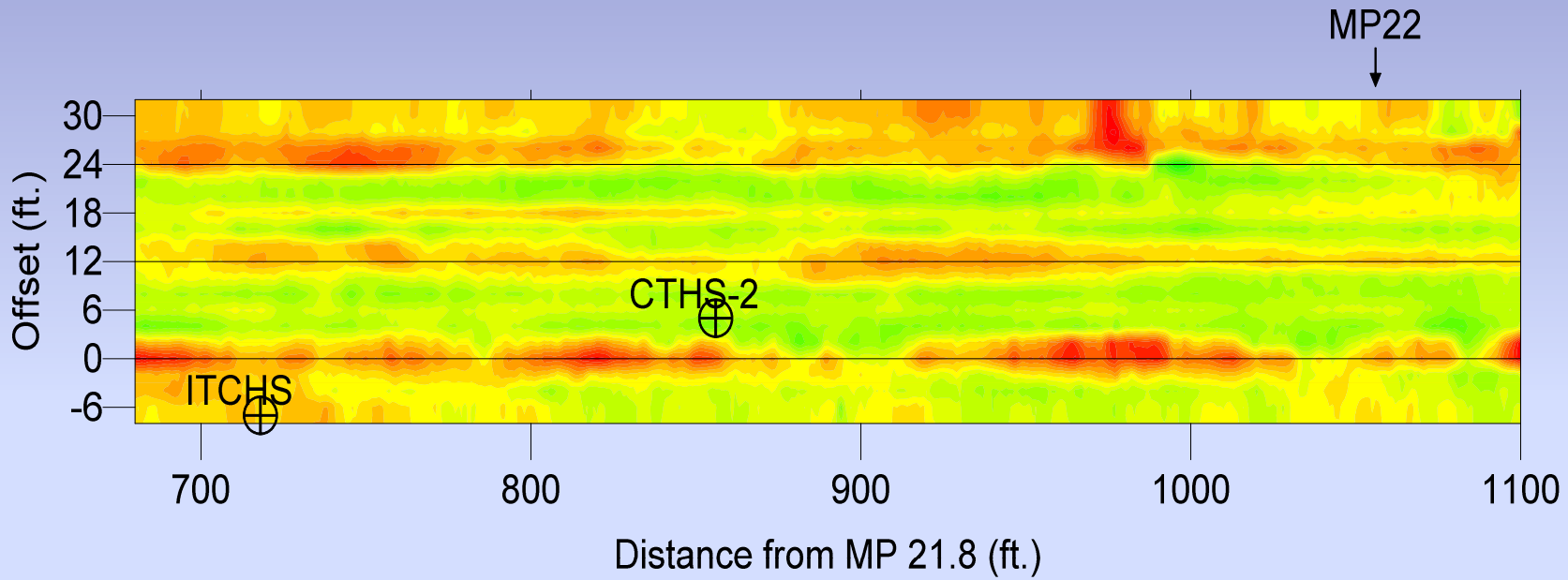
INFRASENSE, Inc.

Dielectric Map



INFRASENSE, Inc.

Dielectric Map Detail



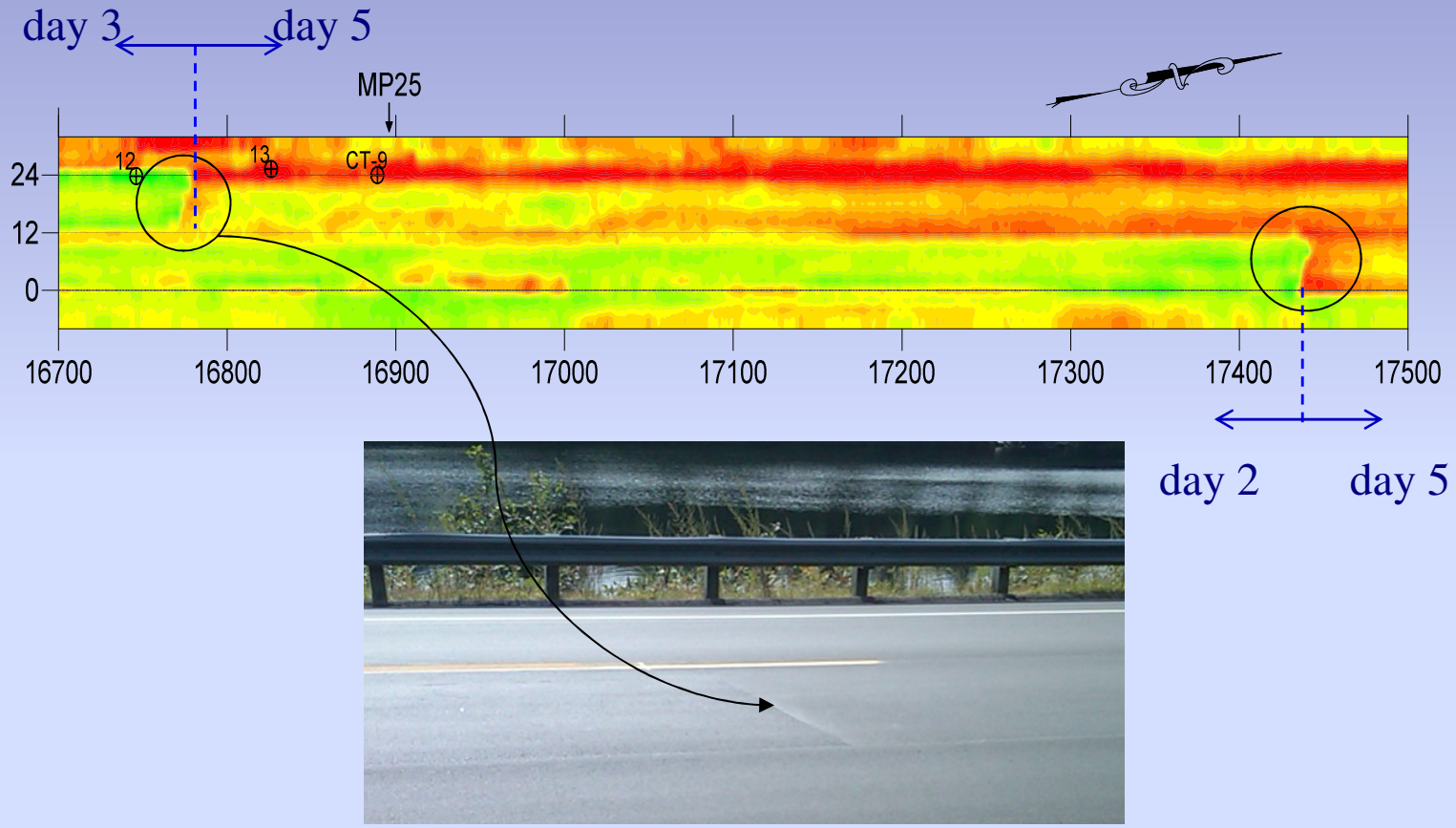
Dielectric Scale

4.4 4.7 5 5.3 5.5

⊕ = Cores

INFRASENSE, Inc.

Paving Features Revealed



INFRASENSE, Inc.

Observations from Dielectric Map

- Low density observed along the seams
- Start/stop discontinuities show up clearly
- Area paved during 5th day has lower density
- No distinct difference between area paved with IC and area paved with conventional procedure
- SB shoulder has large area of low density.
  - MTV not used in this shoulder

INFRASENSE, Inc.

Correlation with Core Density

- Cores taken as part of normal QC process
  - 1 core per 750 tons of mix
- Cores taken at selected locations
- Density/air void measured from cores
- Core density correlated with GPR dielectric

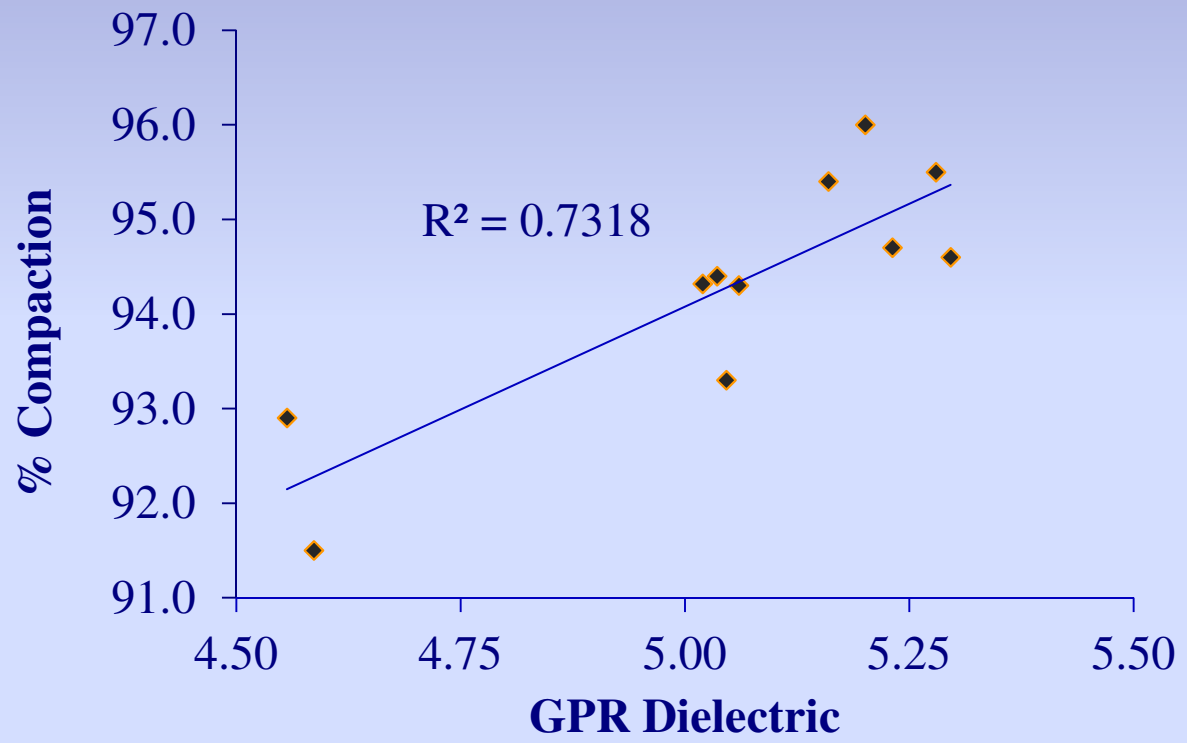
INFRASENSE, Inc.

Dielectrics vs. QA Cores

Core ID	Station (ft. from MP 21.8)	Offset (ft. from NB Shldr Seam)	Density (Gmb/Gmm) %	Dielectric from GPR
CT-1	6301	-2.5	94.6	5.30
CT-2	12611.5	-1	94.4	5.04
CT-3	4366	8	96	5.20
CT-4	13723.5	4	94.7	5.23
CT-5	7399	21.5	93.3	5.05
CT-6	14744.5	20.4	95.4	5.16
CT-7	5279	29	94.3	5.06
CT-8	19838.75	12	91.5	4.59
CT-9	16889	24	92.9	4.56
ITCHS	718	-7	94.3	5.02
CTHS-2	856	5	95.5	5.28

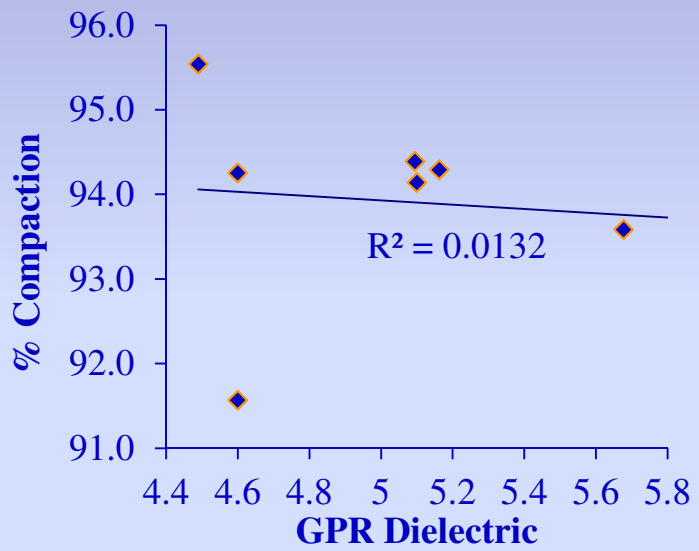
INFRASENSE, Inc.

Dielectric/Density Correlation: QA Cores

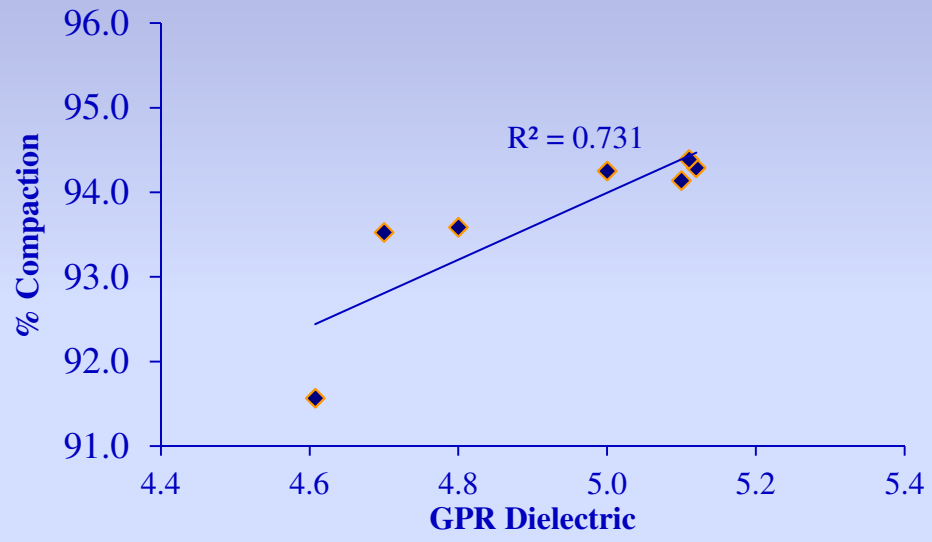


INFRASENSE, Inc.

Dielectric vs. Density: Selected Cores



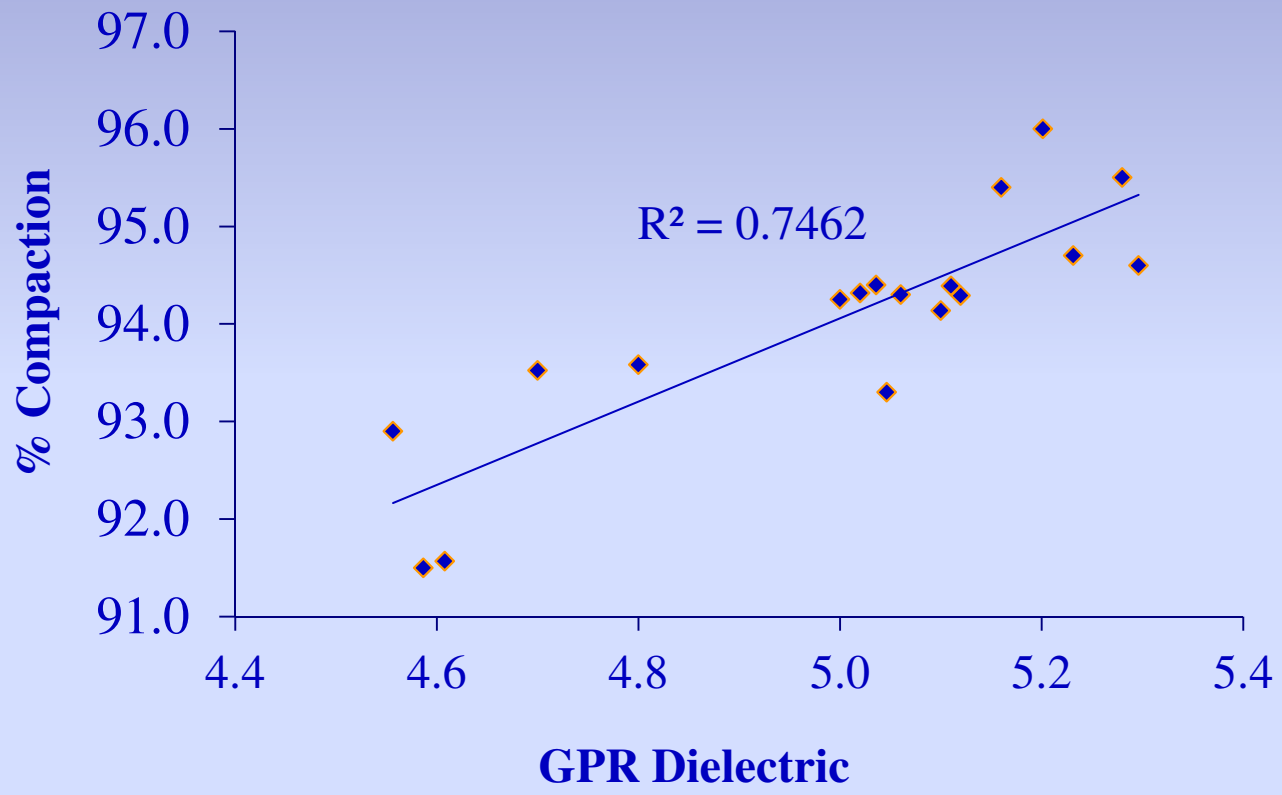
Raw



With Offset Adjustment

INFRASENSE, Inc.

Dielectric vs. Density: All Cores with Adjustment



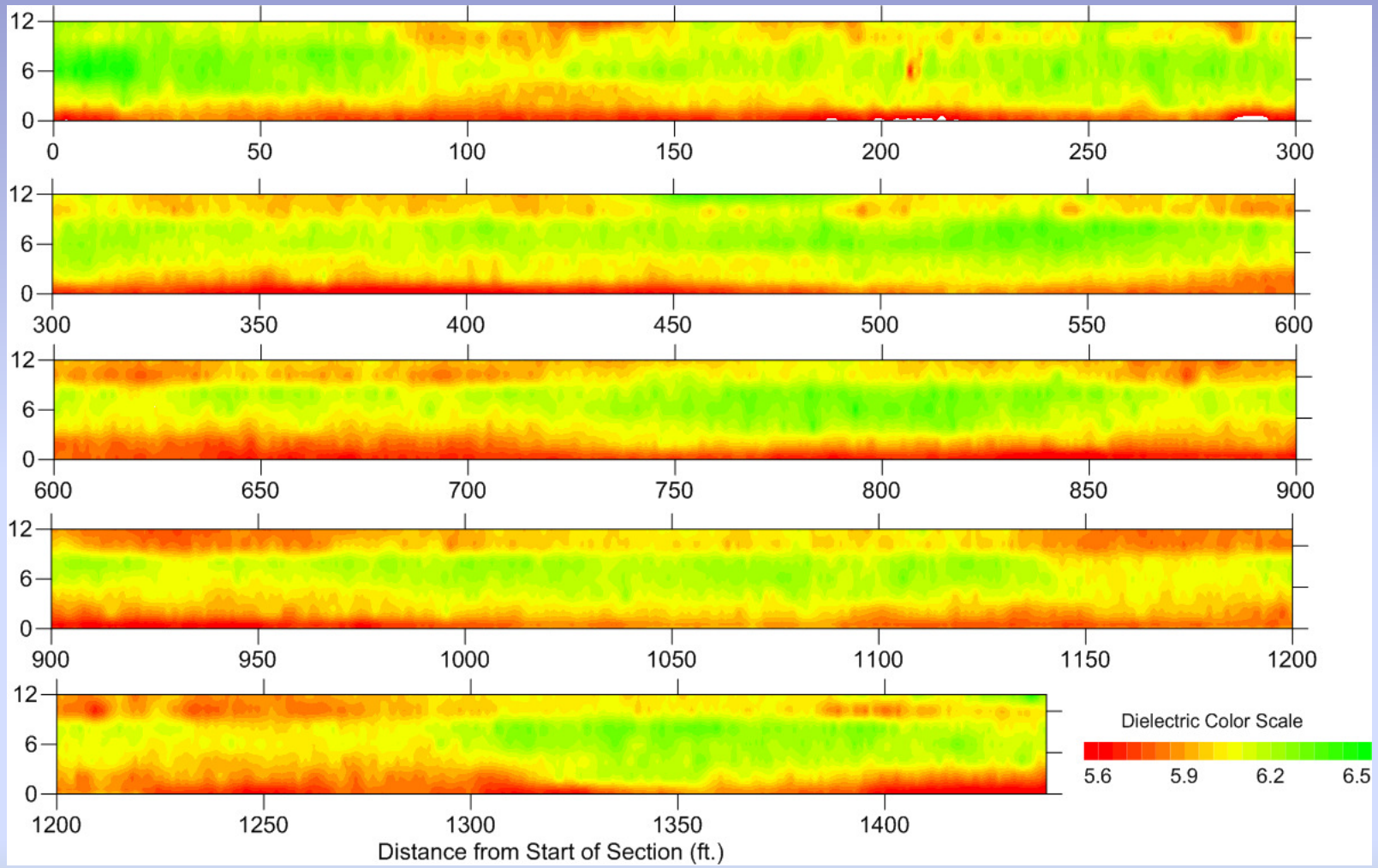
INFRASENSE, Inc.

FHWA IC Demo in Maine

- Carried out on August 21, 2013
- 1500 Foot Section on I-95 in Island Pond, ME
- GPR Survey by Maine DOT personnel and equip.
- Data analysis by Infrasense
- Density cores at FWD test locations
  - Every 50 feet at offsets 3 and 9 (wheelpaths)
- Dielectric mapped and correlated with core density

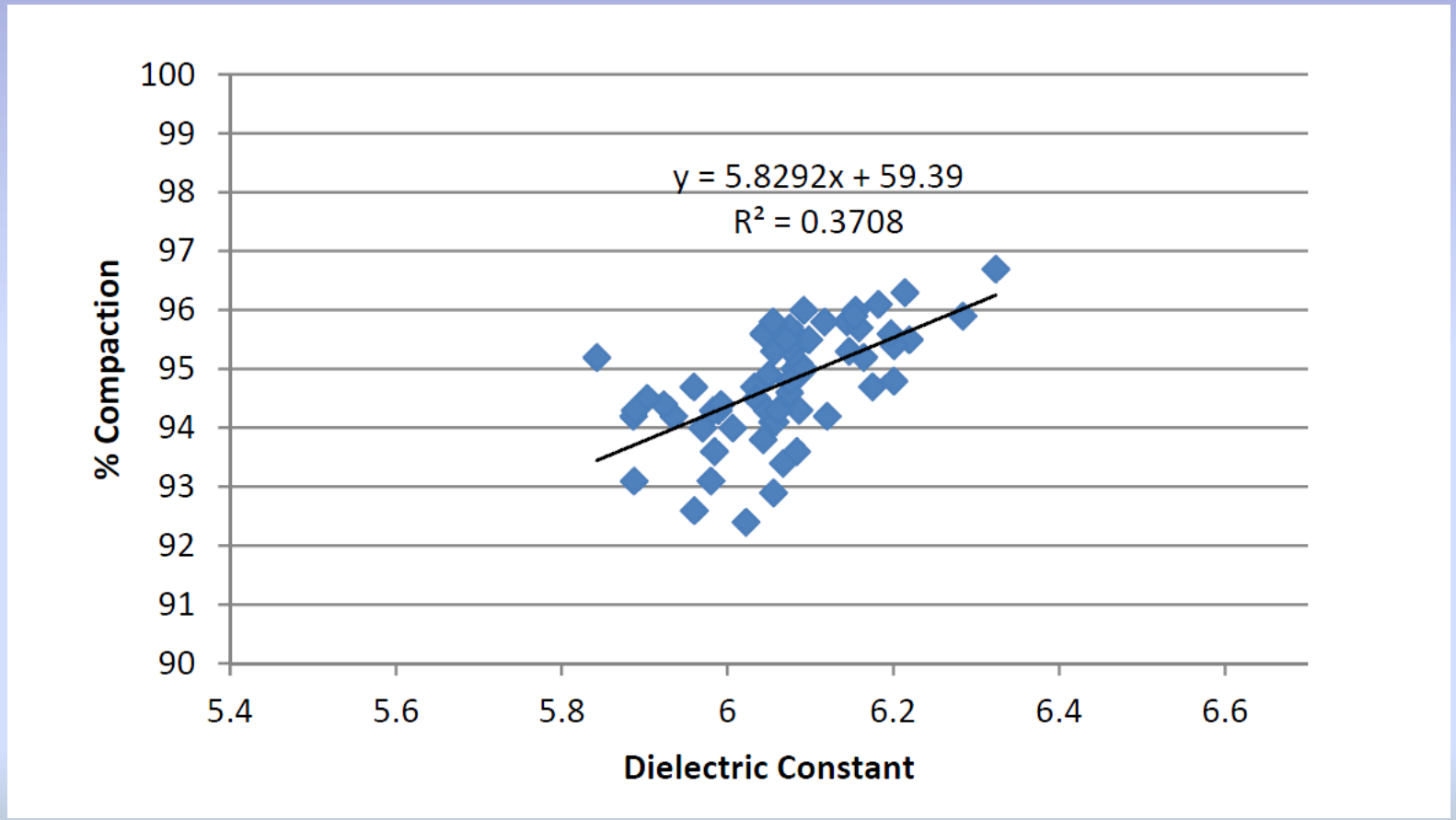
INFRASENSE, Inc.

I-95 IC Demo Dielectric Map



INFRASENSE, Inc.

Dielectric vs. Density
FHWA IC Maine Demo



INFRASENSE, Inc.

Summary

- GPR dielectric data reveals density variations that are not apparent from random coring
- Data can be collected at normal driving speed
- Calibration of dielectric data to density requires:
  - A controlled calibration section (500 – 1000 feet)
  - Precise positioning of the GPR and core data (e.g. GPS with base station or RTK correction)
  - Careful selection of locations for coring to obtain a full range of dielectric and density values.

INFRASENSE, Inc.